Risk-Based Project Development

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Kentucky Transportation Center
College of Engineering, University of Kentucky, Lexington, Kentucky

in cooperation with
Kentucky Transportation Cabinet
Commonwealth of Kentucky

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Research Report

KTC-22-13/SPR21-609-1F

Risk-Based Project Development

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16. Abstract

Risk management is integral to highway project development. Managing risk entails identifying uncertainties which could influence project activities, understanding how they can be mitigated or eliminated, and monitoring risk during project development. Many state transportation agencies have introduced methods for identifying risks, determining whether risks are high impact or low impact, and generating response strategies. These methods are often qualitative or semi-quantitative in nature due to the challenge of quantifying the likelihood of a risk and its effects. These approaches are nonetheless valuable for helping designers and project development teams remain mindful of negative risks which could pose significant hurdles. Building on recent work for the Kentucky Transportation Cabinet (KYTC) on risk-based construction inspection, this report discusses the creation of an Excel tool for managing risk on highway projects. Leveraging information gathered via interviews with KYTC stakeholders, subject-matter experts, and consultants, the tool identifies risks associated with key decision points and key execution points for four project types: new road and expansion, road rehabilitation and resurfacing, new or replacement bridge, and bridge rehabilitation. Embedded in the tool are high-level discussions of risks often confronted when completing different activities as well as best practices for mitigating or eliminating those risks. The tool has been designed to accommodate periodic updates, which can ensure material reflects the most up-to-date thinking about risk management and recent agency experiences.

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Executive Summary

Sound risk management practices accelerate highway project delivery and reduce the probability of cost overruns and delays. Risk are uncertainties that can have a positive or negative impact on project outcomes. Many factors influence risk on highway projects — including project context, project complexity and duration, project delivery method, stakeholder involvement, project team composition, and constructability issues. Recognizing it is critical to proactively manage risk, a growing number of state departments of transportation (DOTs) have adopted methods and tools to characterize and control risk on highway projects, ranging from Excel-based workbooks and qualitative risk matrices to detailed risk registers (see Appendix 2A). When developing methods to assess, monitor, and manage risk, it is important to adopt scalable yet flexible processes which are responsive to different levels of project complexity, context, and cost. Equally important is tailoring approaches to the unique attributes and circumstances of DOTs. This report summarizes the development of an Excel-based tool the Kentucky Transportation Cabinet (KYTC) can implement to strengthen risk management.

To understand the types and severity of risks encountered on KYTC projects, researchers administered a survey to Cabinet staff (both Central Office and District Offices) and consultants. Stakeholders were asked to evaluate (1) the overall levels of risk associated with key decision points (KDPs) and key execution points (KEPs), as well as (2) the amount of risk outsourcing generates, for four project types — new road construction or expansion, roadway rehabilitation and resurfacing, new or replacement bridge, and bridge rehabilitation. Included under the heading of KDPs are preliminary design activities (stretching from development of a purpose and need statement through assessment of impacts). KEPs encompass aspects of the final design process (e.g. pavement design, right-of-way [ROW] acquisition, roadside safety design, maintenance of traffic). When rating risks, respondents used a scale of 1 – 5 (1 = low risk, 5 = high risk). The survey found that Central Office and District Office personnel generally agree in their evaluations. Both groups view new road and expansion projects as carrying the highest overall risk. In terms of KDPs, they rate ROW impacts, project scope, and utility impacts as the most risk laden. For KEPs they see the most risk associated with ROW acquisition, utility relocation, railroad coordination, and subsurface utility engineering. Across all project types, railroad coordination and maintenance of traffic consistently garnered the highest risk rankings. Consultant perceptions generally align with those of KYTC personnel. These stakeholders ascribe the highest risk to new road and expansion projects. Among KDPs, ROW impacts, utility impacts, and project scopes are seen as the riskiest. With respect to KEPs, railroad coordination, utility relocation, subsurface utility engineering, and ROW acquisition earned the highest risk ratings.

Using information on KDPs and KEPs generated through surveys, researchers designed an Excel-based tool KYTC staff can use to understand (1) what elements of project development are most fraught with risk and (2) identify appropriate mitigation strategies. Researchers developed flowcharts to map workflows for KDPs and KEPs. Next, both KDPs and KEPs were decomposed into smaller work units and activities. Based on the survey, literature review, and consultations with other subject-matter experts, researchers assigned a risk level to each work unit (ranging from low to high). These flowcharts lie at the heart of the Excel tool. When users open the tool, they select one of the four project types listed above. Once a project type is chosen, they can view all KDPs and KEPs and their attendant risk levels. Users can open discussion boxes for high-level work units by clicking within the flowcharts. These boxes provide a brief overview of the work unit, list common risk factors, and outline risk mitigation strategies and best practices. The tool, which has been delivered to the Cabinet, should be updated routinely to keep its information up to date and reflective of experiences and lessons learned on recent projects. Doing so will ensure the tool continues to serve as a valuable knowledge management asset.

Chapter 1 Introduction

The one constant in highway project management is risk. Risks are uncertain positive or negative events that can affect project delivery. While risks may never materialize, project managers (PMs) and project development teams (PDTs) need a good understanding of what risks could impact different facets of project work and how those impacts can influence project delivery. The Kentucky Transportation Cabinet's (KYTC) *Highway Design Manual* encourages PMs to be mindful of risks when analyzing alternatives during preliminary design, however, it does not offer much guidance on how to systematically evaluate risks, nor does it offer in-depth recommendations on strategies for eliminating, minimizing, or mitigating the impacts of risks. The goal of this report is to provide Cabinet PMs and PDTs with practical knowledge and tools to implement risk-based project development framework.

One way to get a handle on the way in which risks are distributed throughout project development is to break down the project development process into small pieces (or activities) and identify the risks associated with each. We accomplish this by first dividing project development into key decision points (KDPs) and key execution points (KEPs). KDPs include preliminary design activities, while KEPs encompass work done during final design. Figure 1.1 depicts a conventional workflow for project development along with individual KDPs and KEPs.

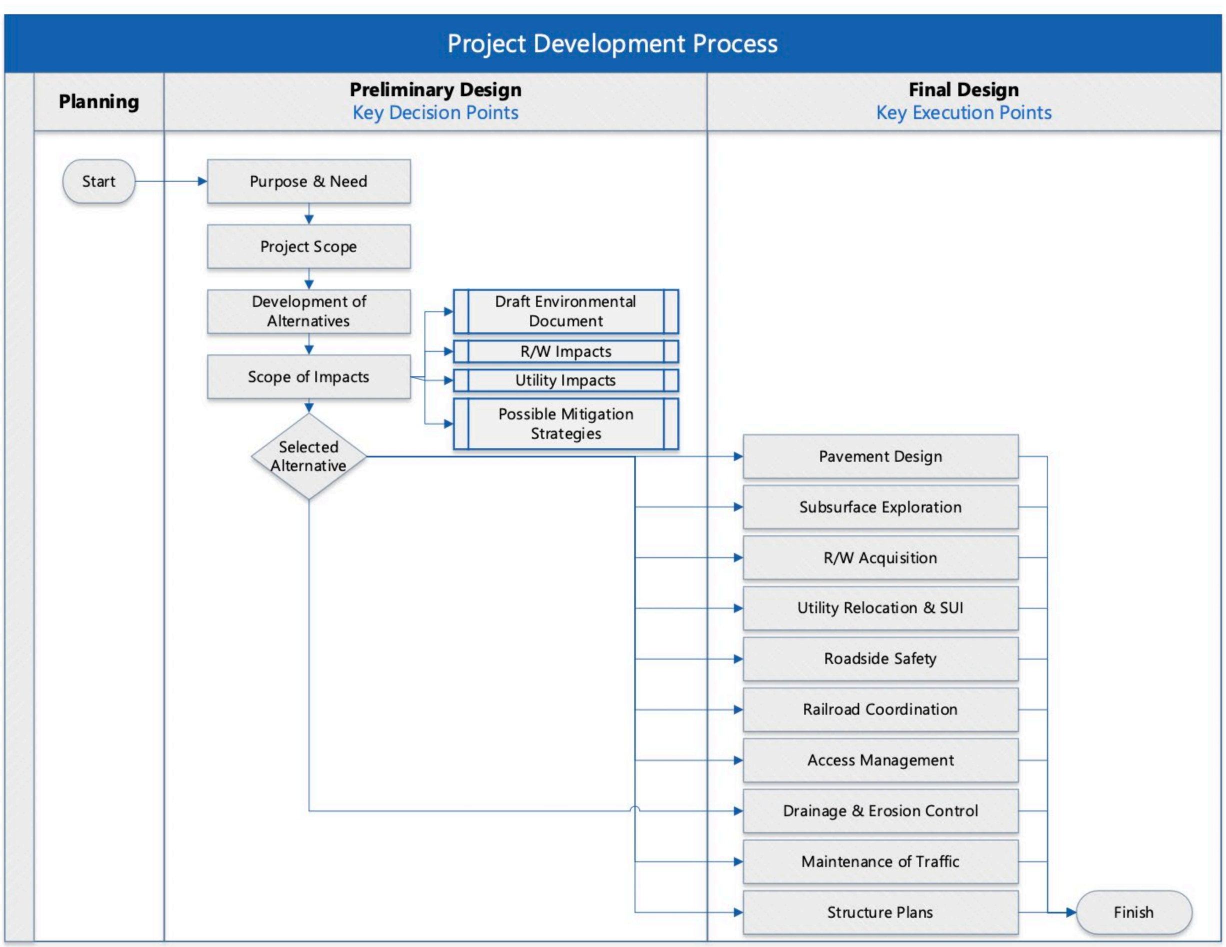

Figure 1.1 Key Decision and Execution Points on KYTC Highway Projects

KDPs are junctures during preliminary design at which the PM and PDT make key decisions about the project. As such, they should be incorporated into consultant contracts as scheduled milestones. Although Figure 1.1 represents KDPs as occurring sequentially, in practice they typically overlap. The first KDP project teams confront is the purpose and need. Ideally, the purpose and need is set before moving on to address other KDPs. The draft purpose and need statement describes the scope of required work, study area, and expected project outcomes. Once the purpose and need and scope have been established, the PM and PDT develop a range of alternatives capable of fulfilling the purpose and need. PDT members usually begin by looking at alternatives previously evaluated. Before alignment studies commence key environmental features on the corridor should be mapped. The PM and PDT can remove alternatives from further consideration at this stage. But they must document a justification for this action.

Once the list of alternatives has been narrowed down, they are submitted to subject-matter experts (SMEs) (e.g., right-of-way [ROW] specialists, utilities experts) for review during the scope-of-impacts phase. When evaluating alternatives SMEs adopt a corridor-based analytical framework to increase the likelihood of avoiding or minimizing impacts. For each alternative, SMEs submit to the project team baseline studies and a review of impacts to the study area. They should provide an assessment of the levels and types of risks associated with each alternative and potential mitigation strategies. In addition to SME input, the project team must consider total projects costs when appraising each alternative as well as methods for avoiding, minimizing, mitigating, or enhancing impacts. The main products of the scope-of-impacts phase are (1) draft environmental assessment or categorical exclusion, (2) preliminary alternative plans, (3) ROW/utility impacts and associated costs, and (4) possible mitigation measures. This process culminates in selection of a preferred alternative based on a consideration of environmental, economic, and engineering issues, performance, and public input. The final environmental document is prepared and approved once the preferred alternative is selected.

With a selected alternative established, the PM and PDT transition to final design. KEPs are elements of the final design process. The outputs of each execution point must be integrated to form a cohesive project ready to move on to advertising, letting, and construction. HD-204 of KYTC's *Highway Design Manual* gives high-level definitions of each KEP. Individual topics receive chapter-length treatments in the manual.

To strengthen KYTC's capacity to carry out risk-based project development, this report exhaustively documents key sources of project risk, discusses methods other state departments of transportation (DOTs) adopt to systematically analyze risks, and reviews the development of an Excel-based tool Cabinet PMs and PDTs can use to identify potential sources of risks and best practices for minimizing or eliminating risks. Our research team built the Excel-based tool using information derived from a statewide survey of KYTC personnel and outside consultants, interviews with KYTC PMs, and a literature review. Table 1.1 lists the topics addressed in each chapter.

The Excel tool and report will help PMs and PDTs develop a greater awareness of project risks and build their intuition about how risk can be effectively dealt with throughout project development to accelerate project delivery.

Table 1.1 Report Structure

Chapter	Content
2	• Reviews approaches used at other state DOTs for risk identification, monitoring, and management • Synthesizes risk management best practices • Presents a comprehensive risk register that catalogues risks encountered during project development and areas most likely to endure impacts (scope, cost, schedule, quality)
3	• Discusses survey results
4	• Describes methods used to develop KDP and KEP workflows and conduct risk assessments of work units • Presents sample flowcharts and discussion boxes
5	• Contains detailed instructions for navigating the Excel-based tool and updating discussion boxes

Chapter 2 State Approaches to Risk-Based Project Management

Sound risk management practices accelerate project delivery and reduce the probability of cost overruns and delays. Transportation agencies have implemented an array of tools and strategies to optimize risk management. Agencies generally view risk management as an iterative process conducted throughout project development; it stretches from the earliest planning stages through closeout. The term *risk* encompasses both threats — which can imperil a project — and opportunities, which open the door to more efficient project delivery. While risk often has a negative connotation, it is important to identify risks that carry benefits. Risks identified early on and monitored during the entire project life cycle can be harnessed and controlled.

This chapter reviews some of the methods employed by state DOTs to manage risk. Our focus slants toward the tools agency staffers use to document risks, measure their likelihoods and potential impacts, and identify response strategies. Common tools of the trade include Excel-based workbooks and simple risk registers that can be revised as project development proceeds. The level of risk analysis is contingent on project complexity and budget. Low-risk, low-budget projects warrant qualitative forms of risk assessment, whereas high-profile projects demand more intensive study, including focus groups and workshops with subject-matter experts (SMEs) and quantitative analysis. Regardless of project complexity, maintaining strong communication between all project stakeholders is critical for keeping them aware of what risks have been identified, their potential impacts on a project, and how they are being managed. Although the overall goal of risk management is to strengthen project delivery outcomes, the Oregon DOT (2019, p. 2) cites a range of additional benefits:

- Significantly reduces avoidable changes
- Helps justify an elective (opportunity risk) or unanticipated (threat or opportunity risk) change during project development
- Lessens the probability of contract change orders or contractor claims during the construction phase
- Demonstrates a project is well-managed and builds agency credibility
- Improves risk appetite or tolerance and enables strategic risk-taking behaviors
- Recognizes uncertainty
- Improves project monitoring and control
- Provides objective forecasts of possible outcomes and facilitates more informed decision making
- Fosters creative thinking and innovation
- Allows agencies to identify and manage project-related enterprise risks

Appendix 2A lists risks commonly encountered on projects, broken down by discipline or functional area. These risks were identified by other state DOTs. While they may not apply to all KYTC projects, having a catalogue of potential risks to draw on can improve the discernment of project teams as they move through project development.

2.1 North Carolina (NCDOT)

Risk management entails (1) identifying uncertainties, (2) assessing the potential probabilities and impacts of risks, (3) developing response strategies, and (4) continuously managing and monitoring risks. NCDOT embraces a scalable approach to risk management that demands collaboration and coordination across multiple disciplines. During the Project Initiation Stage, the focus of risk management is identifying at a high level uncertainties that could impact project scope, schedule, budget, quality, or commitments. Initial risk screening is done using a checklist incorporated into the Project Scoping Report (PSR). NCDOT's Value Management Office evaluates PSRs to determine if projects warrant a formal risk assessment.

During subsequent stages of project development — Alignment Defined, Plan-In-Hand, PS&E — project managers (PMs) assume the lead on risk management. Along with identifying potential risks, PMs fill out and update a Risk Assessment Worksheet. This functions as a risk register and provides space in which to identify and evaluate risks, document response strategies, and document the management and monitoring plan. PMs and their project teams evaluate each risk based on (a) how likely it is to occur (Table 2.1) and (b) the potential impact of a risk were it to materialize or be accepted (Table 2.2). Assessments are qualitative/semi-quantitative. For each risk, the PM and project team settle on response strategies and define what tactics they will use to minimize obstacles or enhance opportunities. The Risk Assessment Worksheet gives examples of risks that emerge from different functional areas (e.g., environmental, external, technical, procurement) (Figure 2.1). As a project proceeds, PMs monitor the status of each risk and determines in consultation with their project team whether risk-coping strategies are proving effective, or if adjustments are needed. Continuously monitoring and attending to risk gives the project team an opportunity to pinpoint emergent risks, determine whether the likelihood or probability of a risk materializing has changed, and craft strategies to improve project delivery.

Table 2.1 North Carolina DOT Method of Rating Risk Probabilities

Ranking	Probability (Verbal)	Probability (Numerical)
Very Low	Remote	≤ 14%
Low	Unlikely	15% – 39%
Moderate	Likely	40% – 59%
High	Highly Likely	60% – 84%
Very High	Near Certainty	≥ 85%

Table 2.2 North Carolina DOT Method of Rating Risk Impacts

	Impacts to Project Features and Objectives			
Ranking	Cost	Schedule Impact (Critical Path)	Scope & Project Commitments	Quality
Very Low	Almost none	Almost none	Negligible modifications	Negligible
Low	5% – 10% increase	2 – 4 week impact on PS&E Milestone	Minor modifications to project limits or project commitments	Minor
Moderate	10% – 25% increase	1 – 2 month impact on PS&E Milestone	Moderate modifications to project limits or project commitments	Moderate
High	25% – 35% increase	3 – 6 month impact on PS&E Milestone	Major modifications to project limits or project commitments	Major
Very High	> 35% or $25 million increase	> 6 month impact on PS&E Milestone	Scope does not match original purpose and need	Severe

Risk Assessment Worksheet Project # : R-2553

Risk Identification					Risk Assessment			Response Strategy				Management & Monitoring Plan	
Risk #	Risk Description IF	Risk Description THEN	Threat / Opp.	Status	Probability	Impact	Score	Strategy	Action Plan	Risk Owner	Follow-up Date	Update Frequency	Update & Comments
Example	If 4f properties are involved in the project area,	then delays to the project schedule may occur if potential impacts and avoidance options are not proactively and realistically identified and assessed.	T	Active	Moderate	Moderate	●						
Long Range Planning													
Environmental													
Regulatory													
Organizational Risks													
Project Management													
External Risks													
Right of Way / Utilities / Railroad													
Technical													
Procurement													
Construction/Constructability													

Figure 2.1 North Carolina DOT Risk Assessment Worksheet Template

2.2 Montana (MDT 2016)

The agency has a five-step process for risk management: (1) risk management and planning, (2) identification of risk events, (3) risk analysis, (4) risk response planning, and (5) risk control and monitoring. Risk management and planning entails determining what level of risk analysis is needed on a project. For low-risk projects, PMs or the project team identify risks and document them in a Risk Management Plan (RMP) — an Excel-based workbook — or Project Risk Documentation sheet. On medium- and high-risk projects, PMs and project teams conduct formal risk analysis, determine the likelihood and potential impacts of each risk, and document all risks. Qualitative analysis is reserved for medium-risk projects and is best suited to initial screenings and quick assessments, whereas quantitative risk analysis is used for high-risk projects. MDT recommends integrating risk management into the project management plan and budget and that several factors be considered when deciding on what level of risks analysis and management is appropriate:

- Political sensitivity
- Type and complexity of project
- Location of project and the community it serves
- Project duration
- Stakeholder involvement
- Project delivery method selected

RMPs facilitate all stages of risk management and are drafted early in the project life cycle so that all risk-related assumptions that influence cost estimates are recorded. Table 2.3 lists RMP worksheet elements. Identifying risks is listed as the second step in risk management, however, this process goes on throughout the project life cycle as pinpointing some risks may not be possible until later stages. Several methods and tools are available to identify risks: documentation reviews (e.g., studies, preliminary plans, estimates), field reviews, data collection (e.g., group brainstorming, analysis of past projects with similar characteristics, checklists).

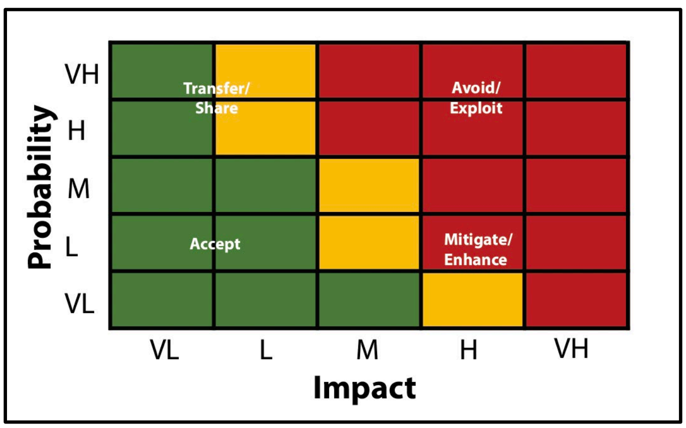

Figure 2.2 Montana DOT Risk Response Matrix

Like risk identification, risk analysis is an iterative exercise that occurs throughout project development. This can take the form of PMs periodically reviewing the RMP and routinely discussing with team members the statuses of different risks and mitigation (or exploitation) strategies. A key goal of analysis is determining the likelihood that a risk will materialize and its level of impact. Analytical results influence what type of response is selected. A matrix that relates probability and impact provides guidance (Figure 2.2). For example, risks that have low impacts and a low probability of occurring can be accepted, whereas high-impact, high-probability risks need to be avoided (i.e., threats) or exploited (i.e., opportunities). Getting input from consultants and contractors on risk allocation is a key step in developing an effective risk management strategy. Best practices for risk allocation include:

- Allocate risks to the entity best able to manage them and in a manner that aligns with project goals
- Share risks when it is appropriate to accomplishing project goals

- Allocate risks in a manner that encourages team alignment with customer-oriented performance goals

Risk monitoring is critical because project risk profiles are in continual flux. As project teams negotiate risks and gain more knowledge about a project, exposure to risk tends to wane. Monitoring requires risk owners to report on the effectiveness of responses, unanticipated consequences of those responses, and adjustments. At MDT, based on this information PMs update the RMP. Keeping this spreadsheet up to date illuminates a project's health.

Table 2.3 Montana DOT Elements of Risk Management

Element	Comment
Risk Number	Unique ID
Risk Status	• Active — Risk is being actively monitored and controlled • Dormant — Risk is currently low priority but may receive higher priority in the future • Retired — Risk is managed or conditions have changed, eliminating the risk
Risk Breakdown Structure (RBS) Group	Assigns risks to functional areas
RBS Code	Used to categorize RBS elements into subgroups
Project Phase/Date Identified	Date and project phase in which the risk was first identified
Functional Assignment	Functional area that is responsible for risk response actions
Summary Description and Risk Type	• Name assigned to risk • Indication of whether the risk presents a threat or opportunity
Description of Risk Event	Clear description of risk and its implications for project objectives and outcomes
Risk Trigger	Warning signs or triggers that indicate a risk is materializing
Type	Identify if risk affects project cost, schedule, or both
Response Actions	Document potential response actions (e.g., avoid, transfer, or mitigate threats; exploit, share, or enhance opportunities)
Probability	The likelihood a risk will materialize. Qualitative assessments are acceptable for small projects or minor risks. Major risks on complex projects require input from SMEs.
Risk Impact	Monetary and time impacts of the risk event
Expected Impact	Quantitative evaluation of the expected impact — calculated using the Program Evaluation Review Technique Formula (PERT), which accounts for lowest, highest, and most likely costs
Risk Matrix	A field automatically populated based on entries in the Probability and Impact columns
Priority	Priority is based on risk matrices and risk impacts
Strategy	Select from one of the following strategies — avoid, transfer, mitigate, accept, exploit, share, enhance
Risk Response Owner	The person who is responsible for the response action(s). They should be located in the functional area under which the risk falls.
Risk Review Dates	Deadline for implementation or completion of risk response
Date, Status, Review Comments	Information on actions taken and their outcomes
Near or Long Term?	Time horizon in which the risk should be addressed (near or long)
Response Cost and Cost Avoidance	Estimated cost to respond to the risk. The minimum, maximum, and most likely costs are used to inform strategic planning

2.3 Florida (FDOT 2021)

FDOT uses a four-step protocol for risk management: (1) risk identification, (2) assessment and analysis, (3) response planning, and (4) monitoring and control. How risk management is approached varies by project cost and complexity (Table 2.4). On less expensive projects with fewer risks, a risk register can serve as the only formal risk management plan, while projects that are more expensive and complex demand a plan that integrates quantitative risk-based modeling. Key elements of FDOT risk management plans include:

- Identification, evaluation, and qualitative or quantitative analysis of risks
- Information on responses, ownership, communication strategies, and monitoring protocols
- Supporting documentation and reports (e.g., workshop output, photos, meeting minutes)
- The benefits of addressing, mitigating, or exploiting potential risks

Table 2.4 Florida DOT Typology of Risk Management

Risk Range	Description
Low	**Projects costing up to $20 million** • Use qualitative risk-based analysis • Internal design team reviews risks • PM leads on risk updates • PM conducts self-modeling (Risk-Based Graded Approach) • Quantify risks, update risk mitigation strategies during regular project meetings • Can be used on projects up to $50 million, depending on technical complexities and risk modeling opportunities
Medium	**Projects costing between $20 million and $100 million** • Use quantitative risk-based modeling • Internal project design team leads on cost and schedule risk updates • 1- or 2-day workshop led by internal risk team to quantify risks • Update risk register as needed (at least once prior to the Work Program update) • Mainly reserved for $50 million – $100 million projects, but can be used on projects < $50 million, depending on technical complexities and risk modeling opportunities
High	**Projects costing > $100 million and FHWA Major Projects (> $500 million)** • Use quantitative risk-based modeling with workshop • Internal and external teams lead on risk updates • Cost and schedule risks quantified during a 2- to 4-day workshop led by an external risk team (or internal risk team for non-FHWA Major Projects) • Annual updates just prior to Work Program update and as needed • Can be used for projects < $100 million, depending on technical complexities and risk modeling opportunities

Before risk identification starts, the PM and project team establish the project baseline, which includes the project description, scope, strategy/status, key conditions/assumptions, and initial cost estimates and design/construction schedules without contingencies.

As a starting point for risk identification, project teams can use checklists (see Appendix 2A) to identify potential issues. This is supplemented by the experiences of the PM and team and data from and studies conducted of similar projects. Through this process, a risk register is drafted. FDOT cautions PMs about the importance of distinguishing between events (fixed circumstances which engender uncertainty, such as needing to use a new technology), risks, and impacts. Impacts are unplanned variations from project objectives produced by risks. For example, completing a milestone early, exceeding the authorized budget, and failing to meet quality targets.

The goal of assessment and analysis is to evaluate the severity of risks and prioritize them based on a consideration of probability and impact (Severity = Impact x Probability). Table 2.5 is FDOT's qualitative risk matrix used to determine the potential consequences of positive and negative risks. Project teams have the option to create their own matrices attuned to individual projects. Qualitative risks assessments present challenges, however. Descriptions (e.g., low) are vague and subject to varying, sometimes divergent interpretations, which can generate inaccuracies or conflicting ideas regarding prioritization.

Table 2.5 Florida DOT Qualitative Risk Matrix

	Impact				
	Very Low (1)	**Low (2)**	**Medium (3)**	**High (4)**	**Very High (5)**
Cost Impact of Threat	Insignificant cost increase	< 5% cost increase	5% – 10% cost increase	10% – 20% cost increase	> 20% cost increase
Cost Impact of Opportunity	Insignificant cost reduction	< 1% cost decrease	1% – 3% cost decrease	3% – 5% cost decrease	> 5% cost decrease
Schedule Impact of Threat	Insignificant delay	< 1 month delay	1 – 3 month delay	3 – 6 month delay	> 6 month delay
Schedule Impact of Opportunity	Insignificant improvement	< 1 month improvement	1 – 2 month improvement	2 – 3 month improvement	> 3 month improvement
	1% – 9%	**10% – 19%**	**20% – 39%**	**40% –5 9%**	**≥ 60%**
	Probability				

Quantitative risk analysis mitigates some interpretive fuzziness associated with qualitative assessments, however, it is generally reserved for projects which are more expensive (> $20 million) and complex. Quantitative analysis is built on probability distributions that are developed to estimate uncertainty associated with each schedule activity and line-item cost element. Based on this exercise, three-point estimates (i.e., optimistic, pessimistic, most likely values for cost and time) are generated to further quantify risks. The idea behind quantitative analysis is to adopt a numerically-driven approach to decision making when uncertainty is high. Thus enabling probabilistic scrutiny and the establishment of achievable cost, schedule, or scope targets. But it is worth noting quantitative analysis relies on subjective — albeit expert — opinions. The numbers underpinning quantification come from somewhere, and if they are not carefully vetted can potentially lead to inaccurate risk assessments.

Risk response planning is done iteratively throughout the project life cycle. Each risk is assigned to an owner who is responsible for implementing the response. Planning adopts a hierarchical focus, with high-priority risks receiving the most attention, and medium- and low-priority risks garnering attention as time permits. As strategies are chosen the PM and project team update the scope, project cost, and schedule. Ideally, PMs review the risk register at each meeting. Figure 2.3 provides sample response strategies for risks encountered during different project phases. These options illustrate that responses can sometimes be quite simple and straightforward. Like planning, monitoring and controlling risks are ongoing processes that extend throughout the project life cycle. Their purpose is to document and understand the outcomes of response actions, identify emergent risks, and update contingencies. Monitoring and updating of risks is done at project status meetings and at the following project milestones:

- Scoping field review
- Design field review
- Constructability review
- Value engineering
- 90% plans

RISK RESPONSE EXAMPLES		
Phase	**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 review 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 may delay construction during the nesting season.	**Mitigate**: Schedule contract work to avoid the nesting season or remove nesting habitat before starting work.
Right of Way	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 right of way certification.
	Due to the large number of parcels and businesses, the condemnation process may have to be used to acquire right of way, which could delay start of construction by up to one year, increasing construction costs and extending the time completion.	**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 and include disposal costs.
	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.

Figure 2.3 Florida DOT Sample Risk Response Strategies

2.4 Washington (WSDOT 2018)

Risk management unfolds in six steps: (1) risk management planning, (2) risk identification, (3) qualitative risk analysis, (4) quantitative risk analysis (if applicable), (5) risk response, and (6) risk monitoring and control. WSDOT emphasizes that risk management hinges on sound engineering judgement, understanding the project context, engaging SMEs where necessary, and knowing where to focus energy and resources. The agency has developed scalable and flexible tools to facilitate risk management, including qualitative risk matrices, a risk management plan spreadsheet template, a self-modeling tool for quantitative risk analysis, and workshops.[1] For project that cost less than $10 million, qualitative analysis is sufficient. Projects that exceed this cost threshold require quantitative risk analysis; formal risk analysis workshops are conducted for projects above $25 million (Table 2.6).

Table 2.6 Risk Assessment Levels and Associated Activities

	Project Size ($M)	Risk Assessment Level	Notes
Less Formal Risk Assessment	0 – 10	Project Team Risk Assessment • Risk Management Plan • Qualitative Tool	• Probability and impact of risks on project objectives evaluated • SMEs or functional units may assist with risk assessment
	10 – 25	Project Team Risk Assessment • Self-Modeling Spreadsheet • Quantitative Tool	
More Formal Risk Assessment	25 – 100	Cost Risk Assessment Workshop • Quantitative Tool	• Project team works with independent SMEs to review and/or validate cost and schedule estimates and analyze risks • Workshops adopt a structured format
	> 100	Cost Estimate Validation Process Workshop • Quantitative Tool	

Users of WSDOT's Excel-based workbook for qualitative risk analysis generate a risk assessment by rating the impact and probability posed by risks on a 1 – 10 scale (Figure 2.4). Based on these results, an X is placed on a heat map to inform response strategies. Threats within the region shaded red have high probabilities and significant impacts, and therefore warrant a mitigation strategy. Conversely, threats in the green-shaded region have less severe outcomes and can be accepted. Similar logic applies to positive risks. The tool also provides space to specify the action required of the risk owner and the current status of monitoring and controlling.

Quantitative analysis begins with qualitative risk screening before going more in-depth. Common tools used for data collection are interviews, SME input, and the representation of data based on probability and impact. Monte Carlo simulations are commonly used to generate probability distributions for cost and schedule. Cost Risk Assessment and Cost Estimate Validation workshops involve the PM and project team, SMEs (internal and external), and cost-risk team members. The workshop-based process adheres to the following workflow:

- Project and method selection
- Structure the collaborative team effort
- Define and evaluate base cost estimate and schedule
- Identify and characterize project risk and uncertainty
- Confirm quantified risk and uncertainty in the project cost and schedule
- Probabilistic analysis and documentation
- Implement and measure risk response actions; monitor and control

[1] WSDOT maintains a website with risk assessment guidance, workbooks, and templates: https://wsdot.wa.gov/engineering-standards/project-management-training/project-management/cost-risk-assessment

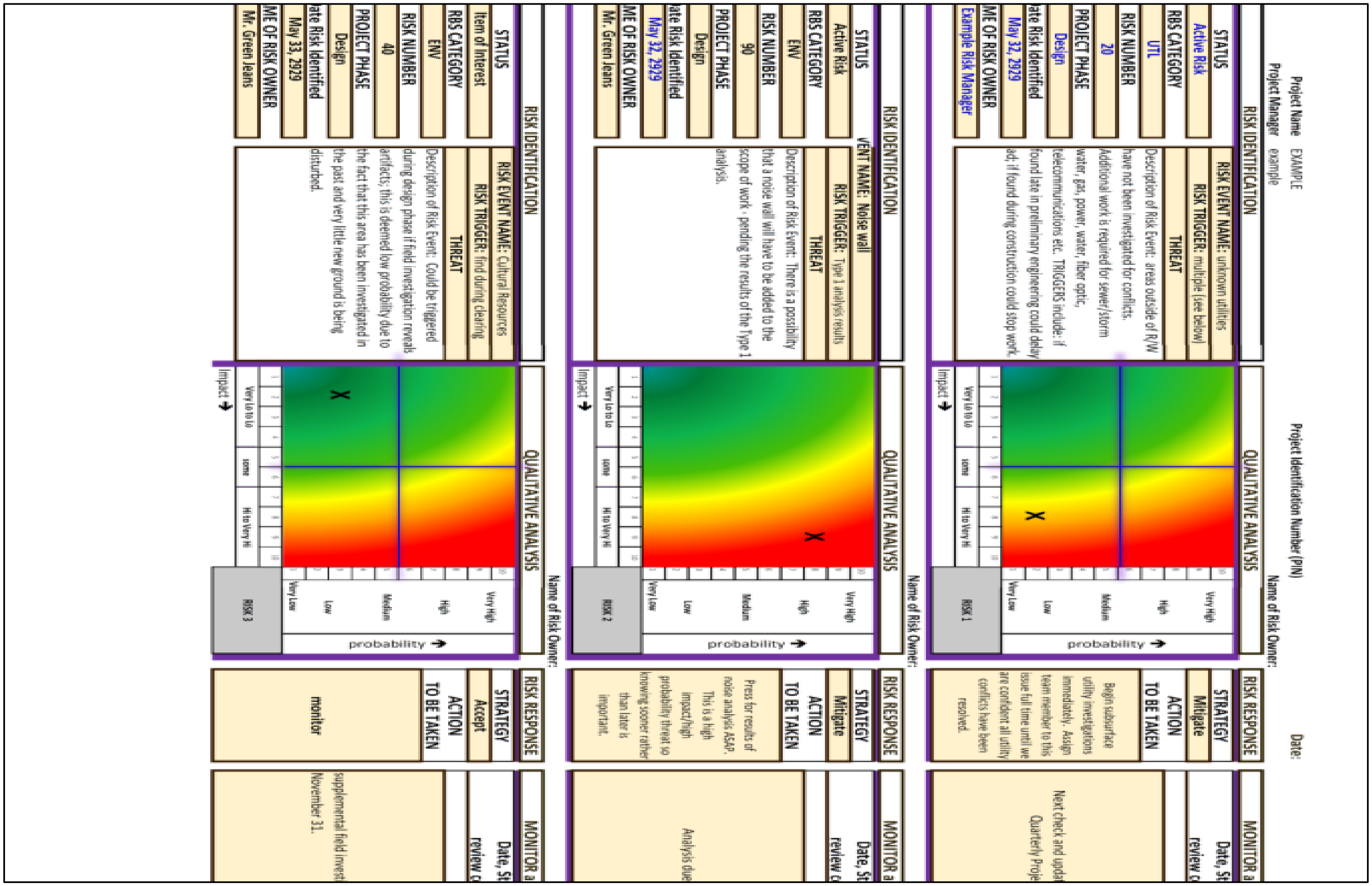

Figure 2.4 Washington DOT Qualitative Risk Assessment Workbook

2.5 New York (NYSDOT 2009)

Risk management follows a trajectory comparable to other DOTs: (1) identification, (2) analysis, (3) mitigation, (4) monitoring and control. NYSDOT is particularly concerned with determining how risks impact scope, cost, schedule, and quality (the template for the checklist in Appendix 2A borrows from NYSDOT, although the substantive content is drawn from several sources). Identifying risks is an increasingly challenging task. One reason for this is that risk events are often interrelated, which makes it difficult to prise apart different sources and triggers of risk. Another reason is the complexity of transportation projects is on an upward trajectory. Factors which contribute to project complexity include:

- Heightened stakeholder awareness
- Stakeholder desire to participate in decision making
- New or changing state and federal regulations
- Sensitive environmental conditions and project-specific contextual factors
- Challenging constructability issues
- Problems related to scheduling and coordination
- Resource constraints

Several organizational factors, according to NYSDOT, are critical for successfully managing risk: (1) an agencywide commitment to risk management, from leadership down; (2) strong communication between agency and industry partners; and (3) proactive implementation of risk management to improve performance and outcomes.

The agency's first step in risk management is risk identification. During identification, the project team should do its best to *not analyze* risk as this could hinder attempts to uncover minor risks. A number of sources can be drawn upon to identify risks: the project description, work breakdown structure, cost estimate, design and construction schedule, procurement plan, general risk checklists, site visits, brainstorming, and interviews with stakeholders who can offer insights into the project context and its potential influence on risk. It is important to not become too reliant on pre-established checklists because they can lead project teams to neglect project specific risks. Agencies which maintain risk checklists can benefit from keeping them updated and adding new risks when they are encountered on projects. Once risks are identified, project teams group them by discipline or thematic area (e.g., external risks, environmental risks). On less complex, lower cost projects, it may be sufficient to keep identified risks on a list of red flag items to monitor. Responsibility for each risk is then assigned to project team members. This process facilitates establishment of proper contingencies and control of risk, and keeps risks front and center in the minds of project team members.

Once risk identification is complete, qualitative risk analysis ensues for smaller, less complex projects, with project team members evaluating risks in terms of likelihood of occurrence and impact (Tables 2.7 and 2.8). Risks are sorted into three categories: low, moderate, and, high (Figure 2.5, Table 2.9). NYSDOT presents a few different risk matrices. It sourced the matrix illustrated in Figure 2.5 from the US Department of Energy. More complex and higher-priced projects demand more rigorous risk management due to having greater uncertainty, and thus a mode of analysis is needed that simultaneously evaluates the impact of all identified and quantified risks to generate a probability distribution of the project's cost and completion date. Tools commonly used for quantitative risk analysis include first-order second-moment methods, probability or decision trees, tornado diagrams, Monte Carlo simulations, and specialized software.

Table 2.7 New York State DOT Risk Likelihood Assessment Scale

Level	Likelihood
A	Remote
B	Unlikely
C	Likely
D	Highly Likely
E	Near Certainty

Table 2.8 New York State DOT Risk Impact Assessment Scale

Level	Schedule	and/or	Cost
A	• Minimal or no impact		Minimal or no impact
B	• Additional resources required • Able to meet need date		< 5%
C	• Minor slip in key milestones • Not able to meet need date		5% – 7%
D	• Major slip in key milestone or critical path impacted		7% – 10%
E	• Cannot achieve key team or major program milestone		> 10%

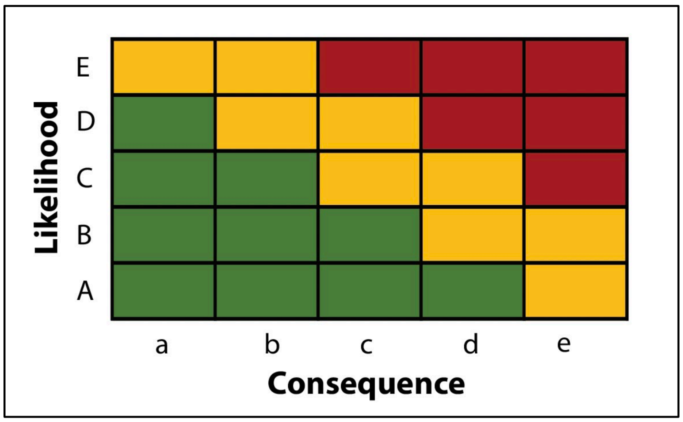

Figure 2.5 New York State Qualitative Risk Assessment Matrix

Table 2.9 New York State DOT Risk Assessment Levels

Risk	Description
Low	Unacceptable. Major disruption likely. Different approach required. Priority management attention required
Moderate	Some disruption. Different approach may be required. Additional management attention may be needed.
High	Minimum impact. Minimum oversight needed to ensure risk remains low.

NYSDOT's monitoring process is similar to agencies discussed above, however, a best practice not yet mentioned is capturing lessons learned to inform future projects. This is critical for building up institutional knowledge of risks and can help project teams more adroitly leverage opportunities or mitigate risk. Another useful strategy is developing and tracking risk management performance measures. Potential metrics include:

- Percentage of projects with risk management plans during the initial project phase
- Number and types of risks identified during each project phase
- Change and variability in risk profiles throughout project development
- Percentage of change requests caused by unidentified risks (measure of project quality)
- Number and magnitude of risks successfully mitigated or leveraged

2.6 Other States

An appraisal of risk management guidance leads to the inescapable conclusions that most agencies leverage similar methods to handle risks. As methods are broadly similar in their contours, information saturation is reached rather quickly. This is also apparent because most agencies rely on the Project Management Body of Knowledge (PMI 2021) as their lodestar. What primarily differentiates agencies is the simplicity and elegance of their tools. For example, Oregon DOT's (2019) risk management processes mirrors those used at other agencies, but its risk register provides a good model because of its clean and uncluttered layout (Figures 2.6, 2.7). Each aspect of risk management is given its own section and content is easy to interpret and navigate. The agency has a baseline qualitative risk assessment method that differs slightly from those presented above (Table 2.10); values can be modified based on the needs of individual projects. Irrespective of what type of risk assessment scales are adopted, it is critical for agencies to settle on a method that will be used agencywide — this enables comparisons between different projects and establishes a universal vocabulary for understanding project risk.

Table 2.10 Oregon DOT Qualitative Risk Analysis Scale

Value	Occurrence Probability	Schedule Impact	Cost Impact	Qualitative Impact
1	< 10%	0 – 9 days	\$0 – \$50k	Negligible
2	10% – 20%	9 – 18 days	\$50k – \$100k	Very Low
3	20% – 30%	18 – 45 days	\$100k – \$250k	Low
4	30% – 40%	45 days – 2.1 months	\$250k – \$350k	Moderately Low
5	40% – 50%	2.1 months – 3 months	\$350k – \$500k	Moderate
6	50% – 60%	3 months – 3.9 months	\$500k – \$650k	Moderately High
7	60% – 70%	3.9 months – 4.5 months	\$650k – \$750k	High
8	70% – 80%	4.5 months – 5.1 months	\$750k – \$850k	High
9	80% – 90%	5.1 months – 6 months	\$850k – \$1m	Very High
10	> 90%	> 6 months	> \$1m	Extremely High

Some agencies have created methods to examine risk within a functional area. For instance, the Wisconsin DOT has developed a template for risk-based environmental scoping to project managers and teams identify environmental risks and coordinate responses. For potential risks, users indicate the level of risk (low, high, none) and provide a brief description.

Project Risk Register

Key# & Project Name:	K12345 Example	Total Project Cost:	$15,000,000
TPM/RE-CP:		Construction Cost:	$12,500,000
Area Manager:		Project Schedule:	36 Mths

Design Sched. Risk =
Const. Sched. Risk =
Total Schedule Risk =

Risk Identification								Cost Impact - In Thousands				Schedule Impa	
Risk No.	Date Id.	Risk Title	Phase that it impacts	Critical Path?	Nature	Detailed Description of Risk Event	Probability	Min $	Max $	Expected Value $	$ Impact	Min ⌛	Max ⌛
1	7/1/20	Design exception approval	Design	yes	Threat	The project assumes design exception approval for substandard super-elevation of 13% and a substandard spiral length of 200' for the Exit 400 SB off ramp. If the design exception is not granted the ramp would have to be reconstructed to a max 12% super-elevation for a 2-lane ramp and a min. spiral length of 240'. This would be a substanstial increase in the projects scope. Design phase impacts would be additional PE cost and design schedule for design/re-design.	10%	$75 K	$100 K	$14.4 K	Very Low	2.0 Mths	4.0 Mths
2	7/1/20	Design exception approval	Construction	yes	Threat	The project assumes design exception approval for substandard super-elevation of 13% and a substandard spiral length of 200' for the Exit 400 SB off ramp. If the design exception is not granted the ramp would have to be reconstructed to a max 12% super-elevation for a 2-lane ramp and a min. spiral length of 240'. This would be a substanstial increase in the projects scope. Construction phase impacts include reconstructing the ramp and lengthing the spiral. This would trigger widening of the hwy 999 o'xing structure.	10%	$2.5 Mil	$5.0 Mil	$687.5 K	High	2.0 Mths	4.0 Mths
3	9/10/20	Bidding Climate - Volume of Work	Construction	no	Threat	High quantity of ODOT statewide projects being bid for 2022 construction may result in higher than expected bid prices due to capacity of industry and availability of contractors.	50%	$100 K	$1.0 Mil	$437.5 K	High	0.0 Mths	0.0 Mths
4	9/20/20	Value Engineering study @10% design	Construction	yes	Opportunity	VE studies on average reduce project cost 20% and commonly produces construction schedule savings. If a VE study is conducted then the project cost and schedule may decrease.	50%	$0 K	$5.0 Mil		‹›	0.0 Mths	6.0 Mths

Figure 2.6 Oregon DOT Project Risk Register (a)

Project Risk Register

3.3 Mths	Cost Risk* =	$2.16 Mil	*Cost Risk based on identified risk.
0.9 Mths	Risk-Based Cont.		
4.2 Mths	=	17.3%	

ct - In Months			Risk Response Plan					Monitor and Review	
Expected Value	Impact	Bid Date Variability	Status	Rank	Strategy	Risk Owner	Response action(s) to be taken	Date, Status, and Review Comments	Date Updated
0.6 Mths	Very Low	Green	Active	7	Avoid	Roadway Designer	1) Conduct pre-coordination with SPDB to obtain buy-off to minimize the likelihood of rejection. 2) Provide updates/coordination with SPDB as design progresses. 3) Document necessary information regarding Design Exceptions to facilitate communications/understanding. 4) Manage internal resources to ensure timelines for submittals can be achieved.		
0.6 Mths	Very Low		Active	1	Avoid	Roadway Designer	1) Conduct pre-coordination with SPDB to obtain buy-off to minimize the likelihood of rejection. 2) Provide updates/coordination with SPDB as design progresses. 3) Document necessary information regarding Design Exceptions to facilitate communications/understanding. 4) Manage internal resources to ensure timelines for submittals can be achieved.		
0.0 Mths	Very Low		Active	2	Mitigate	TPM	1) Coordinate with Constructability Review program to engage AGC on direct project review and comment 2) Conduct evaluation of anticipated material volumes for timing of construction and perform outreach to suppliers.		
	‹›		Retired		Enhance	TPM	Coordinate with VE program to conduct value engineering study.	Value engineering study conducted at 10% design. 6 VE alternatives accepted for a total of $3.2 million in cost savings and 4 months of construction schedule reduction	2/8/21

Figure 2.7 Oregon DOT Project Risk Register (b)

2.7 Key Takeaways — A Concise Approach to Risk Management

Risk management is an iterative activity that occurs throughout a project's life cycle whose goal is to expedite the production of quality deliverables while minimizing cost overruns and delays. Valuable for all transportation projects, agencies benefit from developing risk management processes that are scalable and responsive to varying levels of complexity and cost. While it is critical for agencies to establish foundational processes and templates for carrying out risk management, project teams should be able to adapt methods to address the unique requirements of various project contexts. Table 2.10 synthesizes best practices for each phase of risk management, identifying key activities, methods, responsible personnel, and other considerations.

Table 2.11 Risk Management Best Practices

Risk Management Planning

• Systematically deciding how to approach, plan, and execute risk management activities throughout the project life cycle
 	
Considerations when deciding how to approach risk management
• Political sensitivity
• Type and complexity of project
• Location of project and the community it serves
• Project duration
• Stakeholder involvement
• Project delivery method (e.g., design-build, design-bid-build)
 	
Methods
• Analyze project baseline to identify appropriate level of risk management
    ○ For projects with minimal complexity and modest budgets, a risk register may suffice as the risk management plan
    ○ For projects that have a higher degree of complexity and larger budgets, a formal plan is needed that includes:
        ▪ Project overview
        ▪ Strategies for handling risk management (e.g., roles and responsibilities)
        ▪ Risk register
        ▪ Approach to monitoring, updating, and controlling risks
        ▪ Supporting documentation
• Integrate risk management activities and allocate time for status updates into the project schedule
• Establish protocols for documenting and communicating risks to stakeholders
• Build a project culture that emphasizes the importance and benefits of ongoing risk management
 	
Responsible Personnel
• The project manager develops and implements the plan. Project team members assist throughout.

Risk Identification

• Document risks (i.e., uncertainties) that could impact the project scope, budget, schedule, quality, and/or commitments
 	
Approach
• Use a risk register to document the following information about each risk:
    ○ Date identified
    ○ Classification — whether the risk is a threat or opportunity
    ○ A clear and specific description that includes:
        ▪ Characteristics
        ▪ Potential impacts on project scope, cost, schedule, quality, and/or commitments
        ▪ Risk triggers

- Disciplines or functional areas impacted (e.g., Environmental, Right of Way)
- Risk status — dormant, retired, active

Methods, Strategies, and Resources

- Review general risk checklists
- Site visits
- Project team meetings and brainstorming
- Documentation reviews
- Interview with officials, residents, and other stakeholders familiar with the project context
- Review lessons learned database
- Scenario planning
- Nominal group method
- Delphi method
- Workshops and focus groups
- SMEs

Responsible Personnel

- The project manager creates, updates, and monitors the risk register. Project team members provide input throughout.

Qualitative and/or Quantitative Risk Analysis

- Risk analysis evaluates the potential effects of risk on project outcomes. Data on risk probabilities and consequences are used to determine the influence of risk on budgets and schedules. Qualitative analysis is reserved for less expensive, less complex projects. It can also be used to perform an initial screening for projects that require more in-depth quantitative analysis. Beyond analyzing risks individually, it is critical to evaluate how risks interrelate and how they can attenuate or amplify one another's impacts.

Methods Informing Qualitative Analysis

- Brainstorming and project team meetings
- Use of simple scales and heuristics (e.g., 1 – 5; Low, Medium, High) to rate risk probability and impacts
- Development of risk matrices to characterize outcomes

Methods Informing Quantitative Analysis

- Interviews and SME input
- Cost Risk Assessment and Cost Estimate Validation workshops
- Monte Carlo simulations
- Probability trees and decision trees
- Tornado diagrams

Responsible Personnel

- The project manager leads analysis with input from project team members and SMEs. If formal workshops are required, these may be coordinated with other agency divisions.

Prioritize Risks

- Using the findings of qualitative and/or qualitative analysis, develop lists that prioritize each risk. If qualitative risk matrices are used, priorities can be assigned based on where risks are located in a matrix. Project managers and project teams should be attentive to sequencing (i.e., what project phases are affected by a risk), risk interdependencies (e.g., if one risk materializes does it make other risks more or less likely to occur), and overall impacts.

Methods

- Use output of risk analysis
- Brainstorming sessions with project team

Responsible Personnel

- The project manager leads prioritization with input from project team members and SMEs.

Risk Response Planning

- The results of analysis and prioritization inform risk response planning. This activity consists of (a) establishing the risk response strategy that will be used, (b) identifying a risk owner, and (c) explicitly stating what actions will be taken to deal with the risk.

Establishing the Strategy

- For negative risks (i.e., threats) determine whether to (a) avoid, (b) transfer, or (c) mitigate the risk
    - Avoid — Eliminate the risk trigger or adjust project execution to prevent confronting the risk
    - Transfer — Shift responsibility for and management of the risk to a third party (e.g., a contractor). This may involve a financial commitment, potentially increasing project costs.
    - Mitigate — Reduce the probability and/or impact of a risk to a specified threshold. This can require additional resource allocations (e.g., staff time, funding).
- For positive risks (i.e., opportunities) determine whether to (a) exploit, (b) share, or (c) enhance the risk
    - Exploit — Do everything possible to realize the opportunity as it will benefit the project.
    - Share — Transfer risk ownership to a third party best positioned to maximize the benefits of a risk if it occurs.
    - Enhance — Pursue actions to increase the probability and/or impact of a risk event.
- Another option for both threats and opportunities is acceptance. This is the acknowledgement of a risk but without taking action to deal with it.

Determining Response Actions

- Develop a list of specific activities the agency can execute to enact the chosen strategy. For example, if the project team decides to exploit a risk it must lay out what steps it will take to make this happen.

Methods

- All strategies and response actions are recorded in the risk register and/or risk management plan.

Responsible Personnel

- The project manager leads response planning with input from project team members.

Risk Monitoring and Control

- Monitoring and control involves (a) tracking and documenting response actions taken and their outcomes, (b) evaluating residuals risks following responses, (c) identifying new risks, (d) assessing if risk profiles have changed, and (e) communicating updates to stakeholders.

Methods

- Iterating risk management processes specified above
- Updating the risk register and/or risk management plan

Responsible Personnel

- The project manager leads monitoring and controlling with input from project team members.

Although the risk management activities discussed above are presented sequentially, each one is done throughout project development. A more succinct way of summing up the narrative above is — always be mindful of risks and how they can influence a project. Having that awareness makes it easier to cope with risks when they emerge.

Appendix 2A Risk Catalogues and Checklists

The potential risks that could impact a project are seemingly endless. Any attempt to catalogue potential risks is incomplete because previously unforeseen risks will eventually materialize. Nonetheless, being aware of risks that can impact a project serves a valuable function, helping PMs and project teams determine from the earliest project stages what to be on the lookout for. The tables below list potential risks across several functional categories and identifies areas most likely to be impacted. Material was primarily drawn from risk management guidance issued by the North Carolina, Montana, and New York DOTs.

Organizational Risks				
	Areas Impacted			
Description	**Scope**	**Cost**	**Schedule**	**Quality**
Assignment of inexperienced staff			✓	✓
Insufficient staff assigned to the project			✓	✓
Loss of critical staff at a critical point			✓	✓
Insufficient time to plan project				✓
Delays in approvals and decisions		✓	✓	
Support units unavailable or overburdened			✓	✓

External Risks				
	Areas Impacted			
Description	**Scope**	**Cost**	**Schedule**	**Quality**
ROW delays resulting from court actions			✓	
Project reprioritization			✓	
Objections lodged by RPOs, MPOs, local communities, or other groups	✓	✓	✓	
Changes in project funding and financing	✓	✓	✓	
Changes in political conditions	✓		✓	
Stakeholders make late requests for changes	✓	✓	✓	
Emergence of new stakeholders and new demands (e.g., request design changes)	✓	✓	✓	
Objections raised by influential interests	✓		✓	
Lawsuits result in project stoppage or modifications	✓	✓	✓	
Pressure to privilege time considerations over cost or quality		✓	✓	✓
Agreements with local agencies, railroads, other entities are delayed			✓	
Utility relocations delayed			✓	
Permitting issues			✓	

Environmental Risks				
	Areas Impacted			
Description	**Scope**	**Cost**	**Schedule**	**Quality**
Delays in permit approvals			✓	
Changed requirements for permits		✓	✓	
New or altered environmental regulations	✓	✓		
Determination of significance requires and Environmental Impact Statement		✓	✓	
Reviewing agencies require a higher-level review than expected		✓	✓	
Lack of specialized staff to perform environmental analysis		✓	✓	✓
Discovery of previous unidentified special-interest sites (e.g., historical, archaeological, endangered species habitat)		✓	✓	
Environmental class of action			✓	
Public controversy over environmental issues	✓		✓	
Modified alignment or design changes requires new environmental analysis	✓	✓	✓	
New alternatives required to avoid, minimize, or mitigate impacts	✓	✓	✓	
Involvement of Section 4(f) lands			✓	
Pressure to compress environmental analysis schedule				✓
Formal NEPA or Section 404 Process			✓	
Restoration or off-site mitigation require to compensate for impacts	✓	✓		
Additional impacts to historic and/or archaeological preservation sites identified (Section 106)		✓	✓	
Project located in a floodplain or regulatory floodway	✓	✓		
Project does not conform to state air quality implementation plans		✓		
Negative community impacts expected			✓	
Site contamination and/or hazardous waste analysis unfinished		✓	✓	
Hazardous materials located on project site		✓	✓	
Noise mitigation or additional sound abatement measures required		✓		
Design changes initiated by resource agencies		✓	✓	
Environmental justice issues and/or tribal-related concerns	✓	✓	✓	
Seasonal construction required to address wildlife impacts (e.g., bat habitat)		✓	✓	
Project requires a US Coast Guard Section 9 permit			✓	

Right of Way (ROW), Utility, Railroad Risks				
	Area Impacted			
Description	**Scope**	**Cost**	**Schedule**	**Quality**
ROW				
• Design modifications alter ROW needs	✓	✓	✓	
• ROW studies are inaccurate		✓	✓	
• Expensive, time-consuming legal and compensatory challenges during ROW acquisition		✓	✓	
• Freeway agreements			✓	
• Landowners unwilling to sell and/or condemnation proceedings		✓	✓	
• Additional ROW costs due to development annexation, rezoning, other changes		✓		
• Property owners object to ROW appraisal		✓	✓	
• Temporary and/or permanent easements needed		✓		
• Disagreements over access management	✓			
• Volatile real estate market		✓		
• Access to adjacent properties needed to resolve constructability requirements	✓	✓	✓	✓
• Inadequate pool of qualified appraisers		✓		✓
Utilities				
• Variable conditions at utility sites			✓	✓
• Coordination and agreements with local utilities delayed			✓	
• Negotiations with utilities			✓	
• Design modifications impact utility relocations		✓	✓	
• Delays in utility relocation		✓	✓	
• Additional costs for utility relocations		✓		
• Utility conflicts			✓	
• Utility company workload, financial condition, or timeline		✓	✓	
• Overhead wires conflict with construction		✓	✓	
Railroad				
• Railroad involvement			✓	
• Special railroad requirements not identified during preliminary design	✓		✓	
• Utility conflicts with railroad(s)		✓	✓	

	Areas Impacted			
Description	**Scope**	**Description**	**Scope**	**Description**
• Cost of railroad flaggers		✓		
• Delays in agreements with railroad(s)		✓	✓	

Consultant Project Management Risks				
	Areas Impacted			
Description	**Scope**	**Cost**	**Schedule**	**Quality**
Incomplete or inaccurate scope of services	✓	✓	✓	✓
Scope creep	✓	✓	✓	
Unrealistic budget or schedule		✓		
Inappropriate, unnecessary, or conflicting comments during agency review			✓	✓
Late comments on submittals			✓	
Unexpected increases in firm overhead		✓		
Unresponsive subconsultant(s)			✓	✓
Assessment of errors and omissions claims			✓	
Change in agency PM			✓	

Agency (Internal) Project Management Risks				
	Areas Impacted			
Description	**Scope**	**Cost**	**Schedule**	**Quality**
Limited availability of specialized staff				✓
Poorly defined purpose and need	✓		✓	
Project cost, scope, objectives, schedule, and deliverables are not clearly defined or understood	✓	✓	✓	
Selection of substandard consultant, subconsultants, and/or contractors				✓
Quality of work delivered by consultants and/or subconsultants does not meet agency standards			✓	✓
PM has no control over staff priorities			✓	
Too many ongoing projects			✓	✓
Estimating and/or scheduling errors		✓		
Poor team communication			✓	✓
Unrealistic schedule			✓	
Lack of coordination among support units			✓	✓
Lack of management support				✓
Modified schedule			✓	

	Areas Impacted			
Description	**Scope**	**Cost**	**Schedule**	**Quality**
Changes in key staff members and/or availability			✓	✓
PM workload is too high				✓
Coordination with nearby projects required			✓	✓
Scope changes result in the need for additional funding, approvals, and result in project delays	✓	✓	✓	
Inaccurate cost and/or schedule estimates		✓	✓	
Incorporation of experimental and/or research features into the project			✓	✓
Unforeseen aesthetic requirements		✓		
Traffic design changes (e.g., ITS, illumination, signals, intersections)	✓	✓	✓	
Impacts to bicycle/pedestrian facilities		✓	✓	
Impacts to ADA-compliant facilities (e.g., curb ramps)		✓	✓	
Bureaucratic red tape delays decision making and approvals			✓	

Technical Risks				
	Areas Impacted			
Description	**Scope**	**Cost**	**Schedule**	**Quality**
Project deliverables from preceding phase are incomplete			✓	
Reports and/or plans from preceding phrase contain errors			✓	
Environmental analysis is incomplete or inaccurate			✓	
Unexpected geological issues		✓	✓	
Inaccurate design assumptions in Project Development and Environment report		✓	✓	
Surveys are late or inaccurate		✓	✓	
Geotechnical reports are inaccurate		✓	✓	
Hazardous waste analysis is incomplete or inaccurate		✓	✓	
Design variations and/or exceptions required	✓	✓	✓	
Design delayed by adoption of context sensitive solutions		✓	✓	✓
Changes to structural designs (e.g., bridges, walls)		✓	✓	
Subgrade issues		✓	✓	
Changes in pavement specifications		✓	✓	✓
Opportunity to recycle existing roadway as base		✓		✓

Constructability Risks				
	Areas Impacted			
Description	**Scope**	**Cost**	**Schedule**	**Quality**
Sufficiency of plans and specifications			✓	
Constructability issues		✓	✓	✓
Work zone safety and mobility issues			✓	
Inaccurate contract time or construction cost estimates		✓	✓	
Permit work windows			✓	
Project located in a complex operating environment		✓	✓	✓
Buy American provisions apply		✓		
Issues related to material and construction equipment staging areas		✓	✓	
Availability of qualified bidders for special construction			✓	
Soil contamination and/or handling of hazardous materials (e.g., lead paint)		✓		
Drainage and/or hydraulic complexities		✓	✓	
Change in seismic criteria		✓	✓	
Unresolved constructability review items			✓	
Change orders resulting from variable site conditions		✓	✓	✓
Encounter unidentified utilities		✓	✓	
Street or ramp closures not coordinated with local communities			✓	
Coordination with adjacent projects		✓	✓	✓

Procurement Risks				
	Areas Impacted			
Description	**Scope**	**Cost**	**Schedule**	**Quality**
Long-lead items		✓	✓	
Contract unknowns associated with being a unique/new procurement type		✓	✓	✓
Modifications to project delivery method		✓	✓	✓
Specialized materials and/or equipment needed		✓	✓	
Discrepancies between estimates and bids		✓		
Increase/decrease in material costs due to market variability		✓		✓
Cash flow restrictions		✓	✓	
Delays in advertisements, bids, and/or awards		✓	✓	
Bond terms and availability		✓		

Chapter 3 Survey of KYTC Staff and Consultants

Our team surveyed KYTC staff and consultants to better understand the risks involved project development. For four project types — (1) new road construction or expansion, (2) roadway rehabilitation and resurfacing, (3) new or replacement bridge, and (4) bridge rehabilitation — survey respondents evaluated the levels of risk associated with key decision points (KDPs) and key execution points (KEPs). Recall that KDPs are associated with preliminary design and encompass activities from developing the purpose and need statement through alternative selection (Table x.x). At major decision points, project managers are required to make design assumptions and manage the use of consultants. KEPs are elements of the final design process and include a range of activities (e.g., pavement design, ROW acquisition, structure plans).

Table 3.1 List of Key Decision and Execution Points

Key Decision Points	Key Execution Points
Purpose and Need	Pavement Design
Project Scope	Subsurface Exploration
Development of Alternatives	ROW Acquisition
Scope of Impacts • Draft Environmental Document • ROW Impacts • Utility Impacts • Possible Mitigation Strategies	Utility Relocation and SUI
	Roadside Safety
	Railroad Coordination
	Access Management
	Drainage and Erosion Control
	Maintenance of Traffic
	Structures

When assigning levels of risk to each KDP and KEP, we asked survey respondents to consider safety, quality (design documents and constructed project), time, and cost (including design cost, construction cost, and programmatic fiscal impact). Respondents used a five-point scale to appraise risk, where 1 = low risk and 5 = high risk. Ultimately, we received 45 completed surveys. Of these, 14 were submitted by consultants and the rest came from KYTC staff. Responses from KYTC personnel were equally distributed between District Offices (n = 16) and the Central Office (n = 15). We summarize key findings gleaned from the survey in four brief sections. The first examines the overall risk levels perceived by Central Office and District Office staff; the second section looks at outsourcing, drawing only on KYTC responses; the third summarizes aggregate KYTC data on outsourcing and overall risk; and the final section is concerned with consultant responses. In our discussion we keep our focus on the most conspicuous trends. Because respondents provided risk score for 68 items it is easy to potentially get lost in the weeds. Keeping our summaries at a high level avoids this possibility and lets us highlight issues that provided the foundation for the risk mapping presented in subsequent chapters.

Overall Risk — KYTC Central Office and District Offices (Tables 3.2 and 3.3)
For KDPs and KEPs, we see good agreement between the Central and District Office staff. Personnel generally view new road and expansion projects as carrying the most risk. In terms of KDPs, the most pronounced risks are associated with developing project scopes, ROW impacts, and utility impacts. Staff in District Offices rated these elements as being slightly riskier. But the differences in ratings are statistically indistinguishable (less 0.2 points). We observe a similar pattern for KEPs, with ROW acquisition, utility relocation and SUI, and railroad coordination all regarded as activities especially fraught with risk on new road and expansion projects. Across all project types, railroad coordination, maintenance of traffic, and structures pose moderate to moderate-high risk. In a few cases, District staff ascribe significantly higher risk to a KEP than Central Office staff (e.g., structures on new road and expansion projects; subsurface exploration on new and replacement bridges). Larger discrepancies may be due to personnel located in the Districts being able to observe day-to-day project dynamics more closely than Central Office staff and having a better sense of where risks tend to be more acute.

Risk Associated with Outsourcing — KYTC Central Office and District Offices (Tables 3.4 and 3.5)
Compared to scores for overall risk, both District and Central Office staff perceive greater risks in outsourcing KDPs and KEPs to consultants. We see good correspondence between how staff in different offices quantify risk. For KDPs new road and expansion projects and bridge rehabilitation projects garner the highest risk scores, while among the decision points project scope generally receive the highest scores. Slight discrepancies are apparent. For example, on new road and expansion projects District personnel assign considerably higher risk to outsourcing work on utility impacts and ROW impacts than Central Office staff. This may be the result of District staff being closer to day-to-day project work and having closer, more sustained interactions with consultants. With respect to KEPs, we observe somewhat consistent responses from District and Central Office staff. Both groups view new road and expansion projects as most freighted with risk. Across all project types, railroad coordination merits the highest risk scores. Interestingly, compared to District Office staff, Central Office personnel tend to regard pavement design, subsurface exploration, and some types of drainage and erosion control work as carrying more risk. For these elements, differences in risk scores are generally less than .75 points. Although noticeable, it is challenging to say whether these discrepancies translate to significantly divergent perspectives. They could signify that Central Office personnel, being less entrenched in everyday, on-the-ground project operations, harbor greater skepticism of outsourcing than District staff — who negotiate the process routinely and have fewer concerns.

Aggregated KYTC Score for Overall Risk and Outsourcing (Tables 3.6 and 3.7)
The aggregate scores combine rankings for the Central Office and District Office levels. Looking at KDPs for overall risk, new road and expansion projects elicit the highest across-the-board risk scores, with project scope, ROW impacts, and utility impacts posing the greatest risk — all > 4.0, which indicates moderate-high risk. The other project types, although not risk free, generally score in the low to medium range. For KEPs, new projects consistently generate the highest risk scores, with ROW acquisition, utility coordination and SUI, and railroad coordination being points of especial concern. Across all project types, survey respondents ascribe a high degree of risk to railroad coordination; maintenance of traffic tends to carry greater risk as well. Activities related to structures on new and replacement bridge projects, as well as bridge rehabilitation, are also perceived as generating moderate to moderate-high risk. On the question of outsourcing, new road and expansion projects are seen as having the most risk for both KDPs and KEPs. Across all project types, outsourcing development of project scopes is associated with moderate to moderate-high risk. Railroad coordination is a thorny execution point for all project types, while outsourcing ROW acquisition, utility relocation and SUI, and access management on new and expansion projects brings moderate levels of risk.

Consultant Scores for Overall Risk (Table 3.8)
Consultant perceptions of overall risk broadly align with those of KYTC personnel for different project types as well as individual KDPs and KEPs. Respondents score new road and expansion projects as carrying the most risk. On the KDP front, developing project scopes and handling utility impacts are considered moderately high risk activities, especially on new road and expansion projects and new and replacement bridge projects. The remaining decision points are viewed as carrying more modest risks. For KEPs, on new road and expansion projects, ROW acquisition, railroad coordination, utility relocation and SUI, and subsurface exploration all rate as moderate to moderate-high risk activities. Across all project types, consultants perceive railroad coordination and maintenance of traffic as conveying relatively high risks, while for bridge projects dealing with structures pose moderate-high risk.

Key Takeaways

- KYTC Central Office and District Office personnel generally agree on where the most pressing risks lie. New road and expansion projects score highly across KDPs and KEPs. For these projects, ROW impacts, project scope, and utility impacts carry the most risk; on the KEP side of the ledger, ROW acquisition, utility relocation and SUI and railroad coordination introduce the greatest risks. Looking across all project types, railroad coordination and maintenance of traffic are the most risk-fraught execution points.
- On a few items, scores for Central Office and District Office staff diverge. In most cases, differences in scores are small (e.g., < 0.75 point). However, these differences may speak to how perspectives on risk are shaped by proximity to everyday project activities (e.g., district-level staff could have sharper insights into some facets as

they observe them routinely). One thing to keep in mind is that small divergences in score may not indicate substantive differences in risk perception. Using a five-point Likert scale to rate risk helps us understand the risks involved throughout project development, but scoring is subjective and the level of risk that corresponds to a score of 4 in one person's mind may be scored as a 3 by another person.

- Risk scores submitted by consultants generally lined up with those from KYTC staff, ascribing the greatest risk to new road and expansion projects. For KDPs, ROW impacts, utility impacts, and project scopes receive the highest scores, while railroad coordination, utility relocation and SUI, and ROW acquisition are the riskiest KDPs. Regardless of project type, consultants view railroad coordination and maintenance of traffic as having the most risk.

Table 3.2 Overall Risk — Central Office

	Key Decision Points							Key Execution Points									
	Purpose & Need	Project Scope	Development of Alternatives	Draft Environmental Document	R/W Impacts	Utility Impacts	Possible Mitigation Strategies	Pavement Design	Subsurface Exploration	R/W Acquisition	Utility Relocation & SUI	Roadside Safety	Railroad Coordination	Access Management	Drainage & Erosion Control	Maintenance of Traffic	Structures
New Road & Expansion	3.73	4.13	3.87	3.60	4.40	4.33	3.33	3.33	3.47	4.40	4.20	3.20	4.47	3.27	3.53	3.13	2.80
Roadway Rehabilitation & Resurfacing	2.07	2.80	2.40	1.73	2.20	2.80	2.13	3.13	2.20	2.53	2.87	3.60	3.53	3.07	3.07	3.87	2.33
Bridge New & Replacement	3.00	3.33	3.13	3.20	3.20	4.00	3.33	2.27	3.07	3.40	3.40	2.87	4.13	2.20	3.07	3.80	4.13
Bridge Rehabilitation	2.53	2.60	2.27	1.93	2.07	2.67	1.93	2.13	1.93	2.00	2.33	2.67	3.67	2.00	2.53	3.93	3.93

Table 3.3 Overall Risk — District Offices

	Key Decision Points							Key Execution Points									
	Purpose & Need	Project Scope	Development of Alternatives	Draft Environmental Document	R/W Impacts	Utility Impacts	Possible Mitigation Strategies	Pavement Design	Subsurface Exploration	R/W Acquisition	Utility Relocation & SUI	Roadside Safety	Railroad Coordination	Access Management	Drainage & Erosion Control	Maintenance of Traffic	Structures
New Road & Expansion	3.79	4.36	3.93	3.57	4.50	4.57	3.86	3.21	3.64	4.50	4.43	3.71	4.64	3.79	3.36	3.50	3.64
Roadway Rehabilitation & Resurfacing	2.07	2.71	2.43	1.64	1.86	2.29	1.79	3.43	2.36	2.14	2.64	2.71	3.07	2.29	2.14	3.79	2.57
Bridge New & Replacement	2.71	3.07	3.07	2.71	3.36	3.43	2.79	2.14	3.64	3.36	3.36	2.93	3.93	1.93	3.07	3.64	4.07
Bridge Rehabilitation	1.86	2.07	2.00	1.36	1.71	2.00	1.71	1.86	2.14	1.64	2.14	1.93	3.29	1.36	1.93	3.50	3.79

Table 3.4 Risk Associated with Outsourcing — Central Office

	Key Decision Points							Key Execution Points									
	Purpose & Need	Project Scope	Development of Alternatives	Draft Environmental Document	R/W Impacts	Utility Impacts	Possible Mitigation Strategies	Pavement Design	Subsurface Exploration	R/W Acquisition	Utility Relocation & SUI	Roadside Safety	Railroad Coordination	Access Management	Drainage & Erosion Control	Maintenance of Traffic	Structures
New Road & Expansion	3.64	4.27	3.45	2.91	3.09	3.00	3.27	2.82	2.73	3.55	3.18	2.64	3.82	3.36	2.73	2.55	2.82
Roadway Rehabilitation & Resurfacing	2.55	2.91	2.27	2.18	2.36	2.64	2.45	3.00	2.45	2.09	2.73	2.55	3.09	2.45	2.45	2.82	2.09
Bridge New & Replacement	3.18	3.73	3.09	2.45	2.82	3.09	3.00	2.18	2.91	3.09	2.73	2.09	3.55	2.00	2.36	2.36	2.91
Bridge Rehabilitation	2.55	3.00	2.18	2.00	2.00	2.45	2.00	2.00	2.18	1.82	2.36	1.82	3.18	1.91	1.91	2.73	2.64

Table 3.5 Risk Associated with Outsourcing — District Offices

	Key Decision Points							Key Execution Points									
	Purpose & Need	Project Scope	Development of Alternatives	Draft Environmental Document	R/W Impacts	Utility Impacts	Possible Mitigation Strategies	Pavement Design	Subsurface Exploration	R/W Acquisition	Utility Relocation & SUI	Roadside Safety	Railroad Coordination	Access Management	Drainage & Erosion Control	Maintenance of Traffic	Structures
New Road & Expansion	2.73	4.09	2.73	2.45	3.64	4.09	2.82	2.09	2.36	3.55	3.45	2.55	4.00	3.27	2.27	3.00	2.64
Roadway Rehabilitation & Resurfacing	2.27	3.64	2.27	2.00	2.09	2.64	1.82	2.27	2.00	2.09	2.00	1.82	3.55	2.09	1.73	2.91	1.91
Bridge New & Replacement	2.36	3.55	2.64	2.09	3.00	3.18	2.18	1.73	2.27	3.00	2.73	2.27	3.82	2.18	2.18	2.73	2.82
Bridge Rehabilitation	2.18	3.09	2.09	1.64	1.64	2.09	1.64	1.73	1.91	1.64	1.91	1.64	3.36	1.45	1.64	2.55	2.55

Table 3.6 Overall Risk — Aggregated KYTC Responses

	Key Decision Points							Key Execution Points									
	Purpose & Need	Project Scope	Development of Alternatives	Draft Environmental Document	R/W Impacts	Utility Impacts	Possible Mitigation Strategies	Pavement Design	Subsurface Exploration	R/W Acquisition	Utility Relocation & SUI	Roadside Safety	Railroad Coordination	Access Management	Drainage & Erosion Control	Maintenance of Traffic	Structures
New Road & Expansion	3.74	4.19	3.90	3.61	4.48	4.42	3.55	3.19	3.61	4.48	4.29	3.42	4.48	3.48	3.39	3.29	3.26
Roadway Rehabilitation & Resurfacing	2.00	2.65	2.32	1.65	1.97	2.52	1.90	3.16	2.23	2.26	2.71	3.10	3.23	2.61	2.55	3.87	2.39
Bridge New & Replacement	2.84	3.16	3.10	2.97	3.29	3.68	3.03	2.16	3.26	3.39	3.32	2.87	3.94	2.03	3.06	3.65	4.10
Bridge Rehabilitation	2.19	2.26	2.10	1.74	1.87	2.29	1.87	1.94	1.97	1.81	2.19	2.23	3.39	1.65	2.19	3.71	3.74

Table 3.7 Risk Associated with Outsourcing — Aggregated KYTC Responses

	Key Decision Points							Key Execution Points									
	Purpose & Need	Project Scope	Development of Alternatives	Draft Environmental Document	R/W Impacts	Utility Impacts	Possible Mitigation Strategies	Pavement Design	Subsurface Exploration	R/W Acquisition	Utility Relocation & SUI	Roadside Safety	Railroad Coordination	Access Management	Drainage & Erosion Control	Maintenance of Traffic	Structures
New Road & Expansion	3.26	4.22	3.17	2.78	3.43	3.52	3.04	2.39	2.57	3.61	3.30	2.61	3.87	3.39	2.43	2.78	2.74
Roadway Rehabilitation & Resurfacing	2.35	3.17	2.22	2.04	2.17	2.57	2.09	2.57	2.17	2.04	2.30	2.13	3.22	2.22	2.04	2.96	1.96
Bridge New & Replacement	2.78	3.61	2.87	2.22	2.91	3.04	2.61	1.91	2.61	3.04	2.74	2.22	3.57	2.04	2.22	2.57	2.87
Bridge Rehabilitation	2.39	2.96	2.09	1.78	1.78	2.22	1.87	1.83	2.00	1.70	2.09	1.70	3.17	1.65	1.74	2.74	2.52

Table 3.8 Overall Risk —Aggregated Consultant Responses

	Key Decision Points							Key Execution Points									
	Purpose & Need	Project Scope	Development of Alternatives	Draft Environmental Document	R/W Impacts	Utility Impacts	Possible Mitigation Strategies	Pavement Design	Subsurface Exploration	R/W Acquisition	Utility Relocation & SUI	Roadside Safety	Railroad Coordination	Access Management	Drainage & Erosion Control	Maintenance of Traffic	Structures
New Road & Expansion	3.14	4.07	3.79	3.36	3.64	4.14	3.21	2.62	3.69	3.92	3.69	2.85	4.31	3.46	3.23	3.23	3.23
Roadway Rehabilitation & Resurfacing	1.86	2.93	2.29	1.64	1.79	2.43	1.93	3.15	1.92	1.69	2.00	3.15	3.31	2.46	2.15	4.00	2.54
Bridge New & Replacement	2.86	3.57	3.57	3.00	3.29	3.64	3.00	1.62	3.69	2.85	3.15	2.77	4.15	2.15	3.08	3.38	4.15
Bridge Rehabilitation	1.64	3.07	2.71	1.64	1.43	2.21	2.00	1.46	1.69	1.46	1.77	2.46	2.92	1.46	1.62	3.77	3.54

Chapter 4 Documenting and Resolving Risks on KYTC Projects

Survey results provided valuable high-level information on what KDPs and KEPs Cabinet personnel and consultants view as most fraught with risk. However, surveys did not offer insights into drivers of negative risks and mitigation strategies. Lacking this information, project stakeholders have limited ability to manage risk throughout the project life-cycle. To redress this issue, we decomposed each KDP and KEP into smaller pieces, identifying risk factors and best practices for mitigating or eliminating risks. This chapter works through the output of this exercise for one KDP (Development of Alternatives) and one KEP (Structure Plans). We focus on one of each because material generated through this process was used to develop the Excel-based tool discussed in the next chapter, which can be used by project managers to explore risks for several project types. Risk assessments and mitigation strategies for activities associated with KDPs and KEPs were developed by reviewing KYTC manuals, interviewing Cabinet stakeholders, and interviewing subject-matter experts.

4.1 KDP Analysis for Development of Alternatives

Project designers generate alternative solutions to identify the best method for addressing the project purpose and need. Alternatives are evaluated based of factors such as geometric configuration, environmental requirements and constraints, safety, and access management. To document risks we broke the process into small steps, developed flowcharts that capture workflows and activities, and evaluated the level of risk associated with each work unit. Each KDP was decomposed in three levels — *Identify*, *Analyze*, *Develop*. The *Identify* level for Development of Alternatives includes: (1) Assess Corridor Characteristics, (2) Evaluation of Alternatives, and (3) Development of Considerations for Alternatives (Table 4.1). Each item at the *Identify* level is divided into analytically-oriented activities. For example, *Assess Corridor Characteristics* is split into (1) Elimination of Alternatives, (2) Investigation of Relevant Issues and Impacts, and (3) Establish Review and Evaluation. Individual items at this level are broken down into sub-activities. Elimination of Alternatives consists of developing all supporting documentation and ensuring that all information is considered during the decision-making process. Items located at lower levels can be thought of as the constitutive work units of activities at higher levels.

Table 4.1 KDP Risk Summary for Development of Alternatives

Identify	Analyze	Develop
Assess Corridor Characteristics	Elimination of Alternatives	- Supporting Documentation - All Information Considered
	Investigation of Relevant Issues and Impacts	- Identification and Mapping of Key Environmental Issues - Avoid Early Recommendation
	Establish Review and Evaluation	- Consideration of Entire Corridor - Determine SME Review
Evaluation of Alternatives	Environmental Document	- 4f Involvement
	Preliminary Plans	- Major Features Mapped
	ROW and Utility Impacts	- Anticipated Property Acquisition - Communications Utilities - Estimated Time to Relocate Utilities
	Cost and Schedule Impacts	- Preliminary Cost Estimate - Budget Available - Anticipated Completion Date
	Possible Mitigation Measures	
Development of Considerations for Alternatives	Geometric Design	
	Lane Number Determination	
	Safety	- Data-Driven Safety Analysis (DDSA) - Level of Safety Analysis

Identify	Analyze	Develop
	Roadside Design	- Capacity Analysis - Site and Crash Data Analysis
	Intersection Design	
	Access Management	
	Pedestrian and Bike Facilities	- Public and Political Expectations
	Maintenance of Traffic and Constructability	
	Railroad Coordination	- Direct Impact - Ancillary Impact
	Interchange Justification Studies and Interstate Modification Reports	- Preliminary Engineering and Operational Acceptability - Level of Traffic Operation and Safety Analysis

Once we identified work units for each level in the hierarchy we laid out flowcharts that are included in the Excel-based tool and assigned a level of risk to each item. Risk could take one of five values: (1) Low, (2) Moderately Low, (3) Medium, (4) Moderately High, or (5) High. Figure 4.1 provides a sample layout for Access Corridor Characteristics. Shading indicates risk level. So, the risk level of *Elimination of Alternatives* is Moderately High (orange); *Supporting Documentation* is a high-risk activity (red). In keeping risk evaluations qualitative, our goal was to help designers and project development teams develop a mental map of what issues they need to be on the lookout for and offer a starting point from which they can prioritize risks. Risks, of course, vary from project to project, so generalized risk assessments captured in Figure 4.1 and in all of the flow charts in the Excel-based tool can help can be thought of as baseline diagnosis for activities most likely to pose negative risks. Project development teams must be attentive to the project context they are working within to understand where there may be divergence from the risk evaluations documented here.

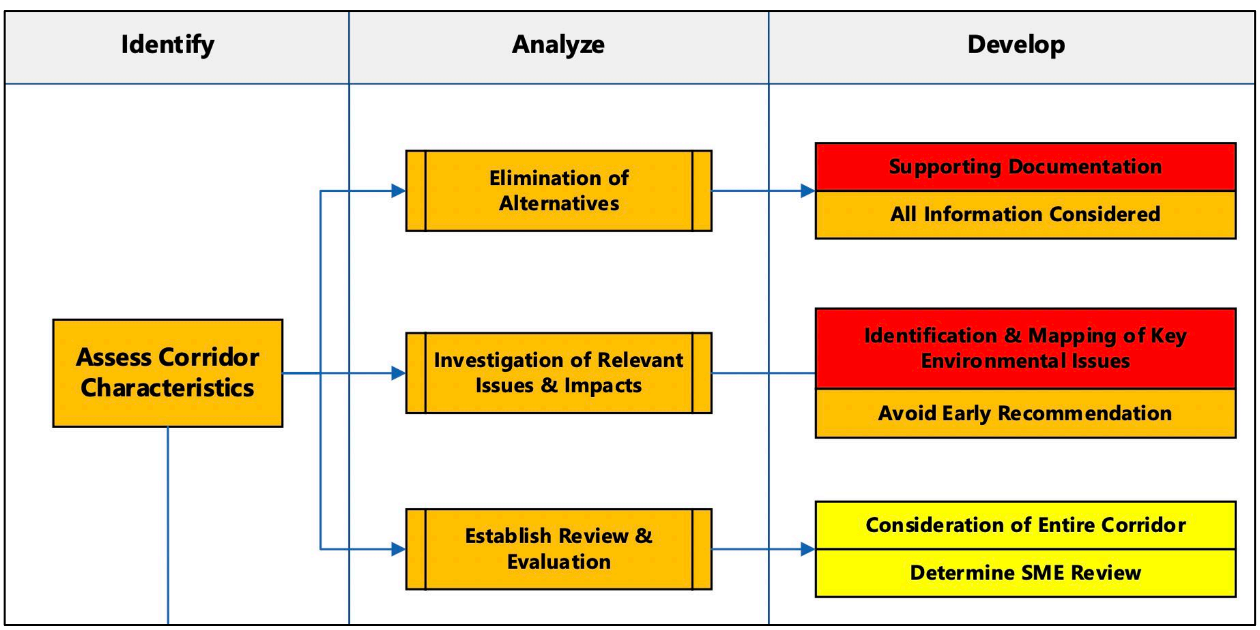

Figure 4.1 Workflow and Risk Evaluations for Access Corridor Characteristics

4.1.1 KDP Discussion Boxes

For each work unit at the level of *Identify* we produced discussion boxes to populate the Excel-based tool. The goal of these boxes is to define the activity's purpose, identify common risk factors, and provide some ideas for how to mitigate these risks. In the Excel-based tool these boxes are accessed by clicking on the rectangle of interest in the

Identify column — as such, three discussion boxes are available for Development of Alternatives. Discussion boxes are not meant to be exhaustive, however, KYTC will benefit from periodically updating their information to ensure they remain current.

Table 4.2 Discussion Box Contents for Assess Corridor Characteristics

Discussion

This is a *red flag study* in which the project team identifies factors that significantly affect the project's scope, schedule and budget. Examples include topography, geology, environmental (e.g., threatened and endangered species, special use waters, historic, archaeology, environmental justice, noise).

Common Risk Factors
• Topography is difficult (expensive) to build on (e.g., presence of hills, valleys, streams) • Poor geology to build on (e.g., bad shales, unstable areas) • Environment concerns (e.g., historic property, archaeology sites)

Risk Mitigation Considerations and Best Practices

Similar to the environmental process's mitigation sequence, make every attempt to avoid, minimize, and then mitigate risks. Avoidance of red flag items is a best practice. If this is not possible, minimize the effects and be prepared to mitigate (usually pay) for the impacts

Investigation of Relevant Issues & Impacts
• Investigate corridor area to determine key issues related to the environment, topography, and expectations.
Establish Review & Evaluation
• Review corridor holistically to determine impacts on overall transportation system.
• Determine what types of expertise are needed to thoroughly evaluate each alternative.

4.2 KEP Analysis for Structure Plans

Risk summaries for KEPs adopt a hierarchical template similar to the one used for KDPs, but with column names tweaked reflect work units. Each KEP is decomposed into three levels: (1) Submittal Phase, (2) Individual Step, and (3) Individual Step Components. We do not give a full breakdown here as we did with Development of Alternatives, but note instead the five work units the Submittal Phase encompasses:

- Advance Situation Survey
- Subsurface Exploration
- Federal and State Agency Approvals
- Preliminary Plans
- Final Plans

As was done for KDPs, we created flowcharts for the Excel-based tool and assigned a level of risk to each item. Figure 4.2 is an extract of the Advance Situation Survey workflow. Again, shading corresponds to the qualitative risk level. Rectangles shaded dark green are low-risk elements (e.g., Single Span), while lighter green boxes indicate moderately low risk (e.g., PCI Beam). Orange and red denote higher risk. Recall that project context will influence risk. It is therefore critical to evaluate projects independently to assess risk at the project level to determine which elements could be the most problematic.

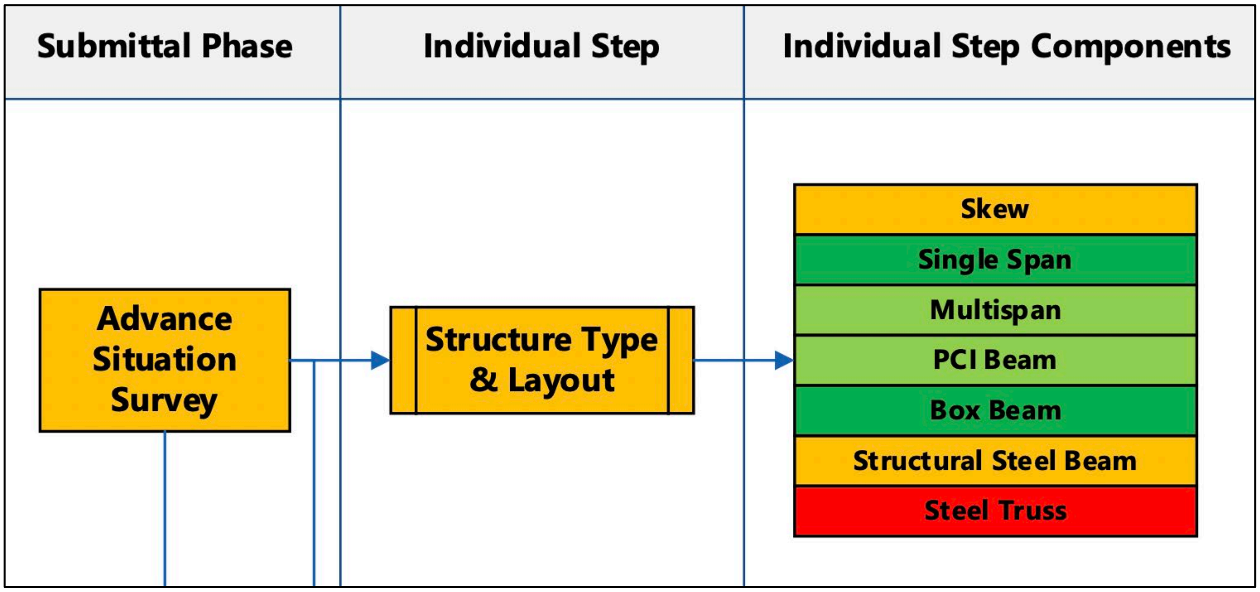

Figure 4.2 Workflow and Risk Evaluations for Advance Situation Survey (Structure Plans)

4.2.1 KEP Discussion Boxes

We produced discussion boxes for KEPs at the level of Submittal Phase whose layout and content mirror those of KDP discussion boxes. Taking Structure Plans as an example, users of the Excel-based tool click on one of the five boxes in the Submittal Phase column to retrieve information on the activity's purpose, risk factors, and mitigation considerations and best practices. Table 4.3 contains information in the Advance Situation Survey discussion box. Similar to KEP discussion boxes, those for KDPs should be updated routinely so project managers and designers are well-positioned to handle risks on their projects.

Table 4.3 Discussion Box Contents for Advance Situation Survey (Structure Plans)

Discussion

The Advance Situation Survey serves as an official request for a set of structure plans. The **submittal's timing** is very important should be timed to allow development of the structure plans to meet the schedule. The survey should be submitted at least 10 months before the scheduled letting date.

Common Risk Factors

- Schedule Impacts
- Impacts to design and construction costs
- Changes to design criteria
- Site conditions (e.g., overhead utilities, pile driving, stream impacts, drainage area)
- Increase in required design technical expertise

Risk Mitigation Considerations and Best Practices

Information from the Advanced Situation Survey is used to identify options for structure type and layout and substructure type. These decisions impact the project schedule and cost. Carefully review the survey and verify the information's accuracy.

Selecting Structure Type & Layout
• Evaluate impacts to project costs and the schedule when selecting structure type and layout.
• Increasing span length to use integral end bents is often cheaper than using a shorter span with a tall abutment. It may also eliminate the need for a cofferdam.
• Skewed and multi-span structures require more detailed design and construction procedures, which may increase design time and construction costs.
• Selection of structural steel beams increases the time and cost of design, introduces fabrication considerations, and requires more complex construction methods.
• Curved bridges and phased construction requirements increase design time and construction costs, regardless of structure type. Investigate using a straight bridge if curvature is slight.
• Steel truss bridges require specialized design expertise (possibly necessitating a design consultant), introduce stringent permit requirements, and most likely demand out-of-state steel fabrication and specialized construction contractors.
Selecting Substructure Type
• Cost and constructability are the main considerations when selecting a substructure type.
• Before selecting a substructure type, consider access and staging requirements for construction equipment and materials.
• Investigate stream mitigation requirements, utility impacts, and environmental restrictions.
• Consider formwork requirements, particularly for larger pier cap overhangs.

The next chapter provides a walkthrough of the Excel-based tool.

Chapter 5 Instructions for Risk-Based Project Development Excel Tool

5.1 Step 1 – Opening the File

The Excel-based tool has built-in Macros that must be enabled. When the Excel workbook opens, click on *Enable Content* (Figure 5.1).

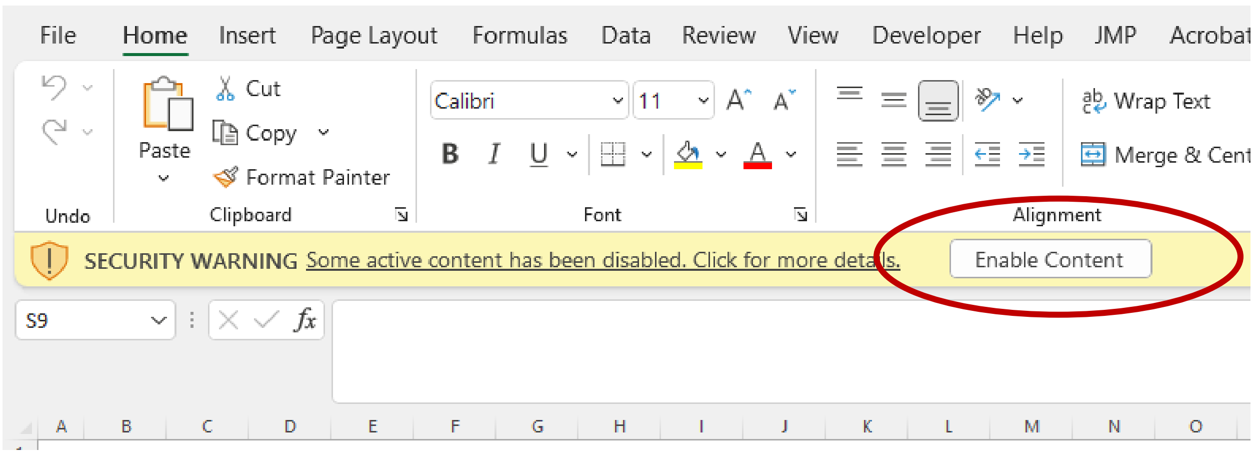

Figure 5.1 Excel Pop-up to Enable Content

5.2 Step 2 – Select Project Type

Once the Macros have been enabled, a pop-up window appears. Click the radio button next to the project type you want to explore (Figure 5.2). Once you have chosen a project type, click on the *See Risk Ratings* button at the bottom of the window.

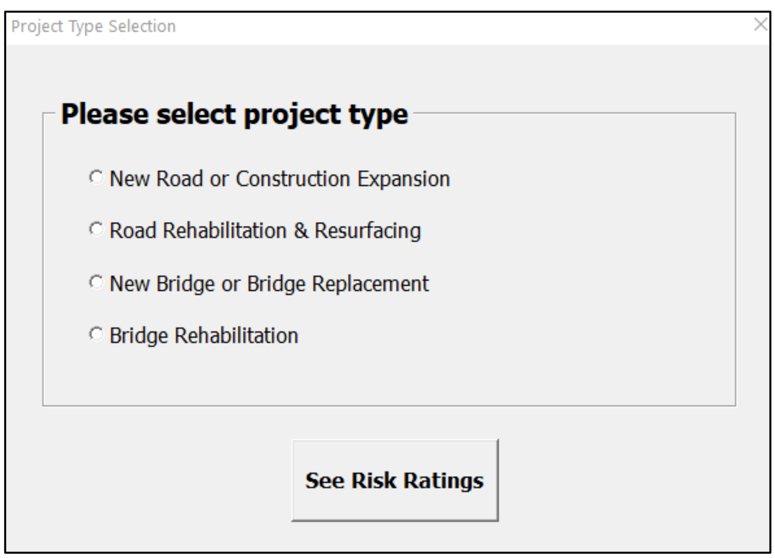

Figure 5.2 Project Type Selection Screen

5.3 Step 3 – Risk Ratings of Key Decision Points and Key Execution Points

Once you select a project type, the next screen that opens is a flowchart which depicts Key Decision Points (KDPs) and Key Execution Points (KEPs). Shading is used to indicate the level of risk associated with KDPs and KEPs. These risk levels represent the perceptions and experiences of KYTC personnel captured through the survey described in Chapter 3. Figure 5.3 shows the flowchart for a *New Road or Construction Expansion* project. If you want to explore another project type, click on the *Select Another Project Type* button in the upper-right corner. This opens the pop-up window described in Step 2.

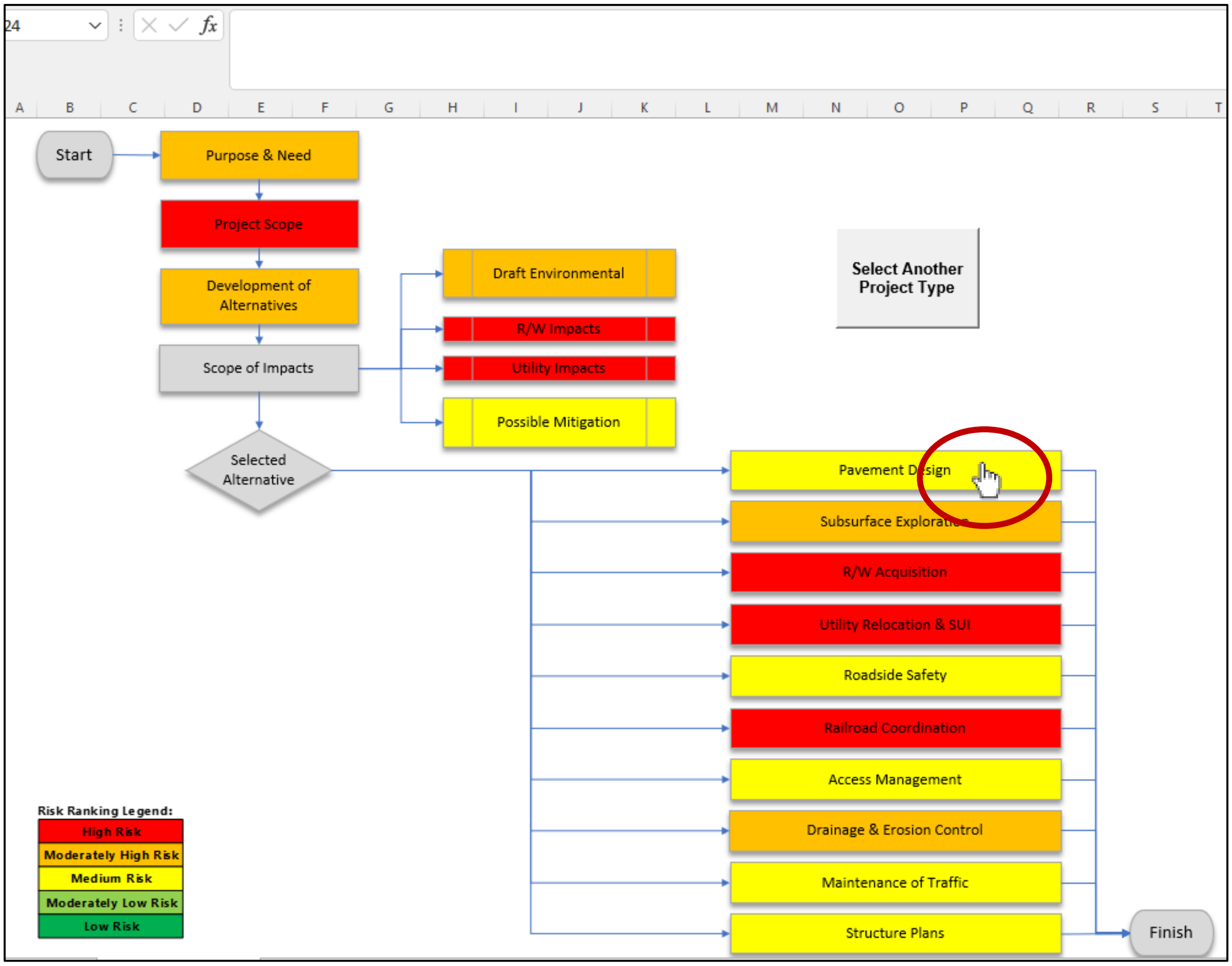

Figure 5.3 Color Coded Project Development Flowchart for Selected Project Type

5.4 Step 4 – Further Breakdown of Key Decision Points and Key Execution Points

If a more detailed breakdown is available for a KDP or Key Execution Point KEP, when you hover the cursor over a box a hand appears (Figure 5.3, red circle). Use the left button on your cursor to click on the box. This opens a *Risk Summary* flowchart that breaks the process down into three categories — Submittal Phase, Individual Step, and Individual Step Components. Figure 5.4 is an example of the *Risk Summary* flowchart for Structure Plans. Shading is again used to denote the level of risk. Use your mouse wheel or trackpad to scroll up and down the flowchart. To the right of the *Risk Summary* is a window that indicates the Selected Project Type and the overall level of risk for the KDP or KEP.

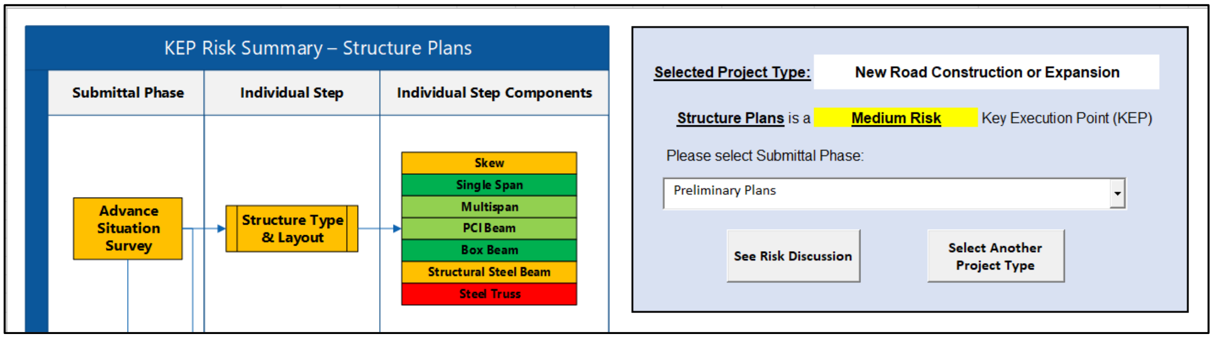

Figure 5.4 Further Breakdown Structure of the "Structure Plans" Key Execution Point

5.5 Step 5 – Further Breakdown of Key Decision Points and Key Execution Points

The window to the right of the Risk Summary can be used to access risk discussions boxes that review risks at the level of the Submittal Phase. To access a risk discussion box, click the arrow on the dropdown menu that is below the text which reads *Please Select Submittal Phase*. The number of risk discussion boxes varies by KEP and KDP. For Structure Plans, there are five submittal phases, and thus five risk discussion boxes (Figure 5.5). Choose the submittal you are interested in. Next, click on the *See Risk Discussion* button that is below the dropdown menu. This will open up the risk discussion box for the requested KEP or KDP.

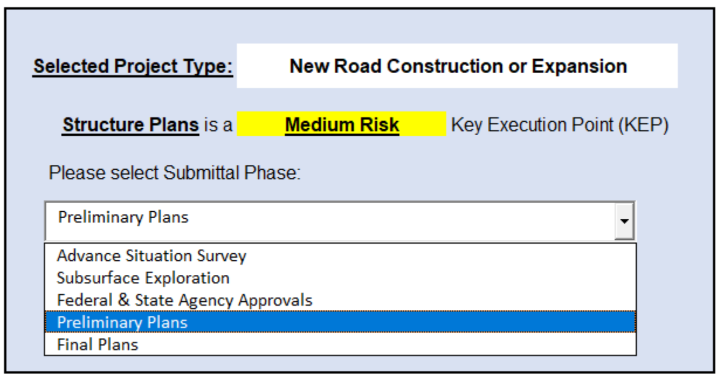

Figure 5.5 Submittal Phase Selection Screen

5.6 Step 6 – Risk Discussion Box

The risk discussion box provides an overview of the submittal phase, identifies key risks, and discusses risk mitigation considerations and best practices (Figure 5.6). Project stakeholders can use this information to avoid costly design errors and omissions. Once you are finished viewing a risk discussion box, close it by clicking the X in the box's upper-right corner. You can select another risk discussion box to view from the dropdown menu.

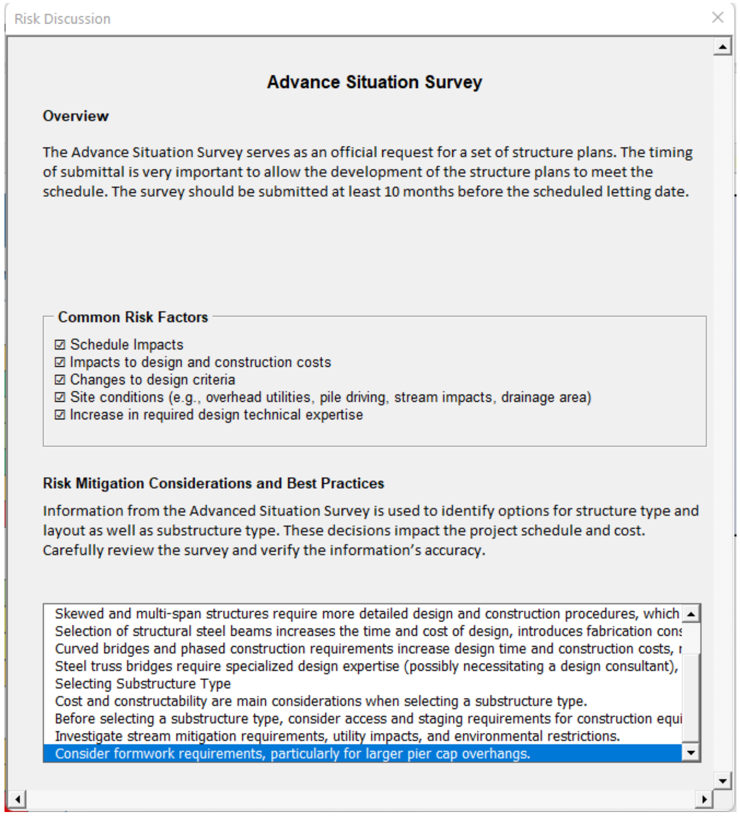

Figure 5.6 Risk Discussion Box for "Advanced Situation Survey" Submittal Phase

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