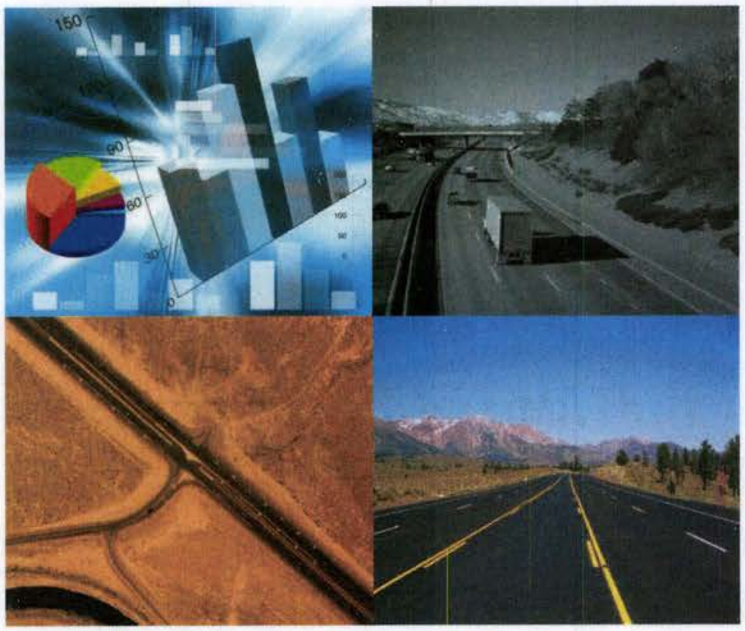
PROJECT COST ESTIMATION FOR PLANNING

NDOT P348-07-803



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EXECUTIVE SUMMARY

For Nevada Department of Transportation (NDOT), there are far too many projects that ultimately cost much more than initially planned. Because project nominations are linked to estimates of future funding and the analysis of system needs, the inaccurate cost estimates lead to overloading the Statewide Transportation Improvement Program (STIP) with many projects that are underfunded. This often leads to misallocating design resources and creating false expectations with the public and other stakeholders. The focus of this study is on improving early project cost estimation to reduce the variance between estimates when projects are initially programmed and the final construction costs. The major objective was to provide recommendations to NDOT to enhance the project cost estimation process for transportation planning documents. Sierra Transportation Engineers, Inc. (STE) was hired as the consultant to conduct this research.

An extensive literature review of other agencies' cost estimating practices revealed that the most significant policy decision to improve the planning cost estimation is to make the estimation process a high "priority" for the agencies involved. Investing time and resources in training, tracking cost and schedule changes, updating unit prices, quality control checklists, and developing uniform manuals and practices for cost estimating are all critical to improving early project cost estimates. Based on the review of available documents and interviews with agencies involved in early cost estimation, STE concluded that many good practices are already in place at various groups and divisions of NDOT and partnering agencies. However, more communication, coordination, and enhancement of the procedures in place are needed.

Based on the findings of the literature review, STE developed a data request template and requested project specific data related to planning cost, award cost, and final cost. NDOT personnel provided full support in acquiring data on forty five projects. However, the degree of difficulty in assembling the data revealed that at the time of this research there was no cost tracking system to quickly query and obtain the needed information. The development of an electronic cost and schedule tracking system is essential in understanding why and how a project is underestimated.

STE utilized its literature review findings to develop a template for cost and schedule tracking system to identify major risk factors that impact a project cost and schedule during various stages of a project life from planning to final construction. STE identified the following eight risk factors: 1) Insufficient Knowledge of Right-of-Way Factors, 2) Environmental Mitigation Requirements, 3) Unforeseen Engineering Complexities / Constructability Issues, 4) Changes in Traffic Control Needs due to Design or Traffic Growth, 5) Increased Local Government, Community, and Stakeholders Expectations, 6) Unforeseen Events, 7) Changes in Market Conditions, and 8) Utilities. STE developed project risk factors from the NDOT provided database using simulation techniques. It was found that STIP to Award risk factors were significantly higher than anticipated due to the initial STIP not being a complete project cost. STE analysis revealed that many of the projects that were first entered into the STIP did not have a complete project cost including right of way, utility relocation, environments mitigation, etc. This made the comparison of initial cost as entered into the STIP with the Award and Final cost difficult. Project cost parameters such as utility relocation, right of way, and environmental mitigation are quite unknown at the early project cost estimation stage. However, many state agencies have begun to capture those costs, as much as possible, in the early planning stage. The results of literature review revealed that many agencies have set policies to report the early project cost estimate as a "total" cost representing the total project purchase price.

Award and Final costs were represented in the NDOT database as total costs and therefore, STE was able to capture reasonable risk factors. The data revealed that on average projects ultimately cost approximately 12% more than was anticipated at the time of award.

STE analyzed over 60,000 project cost records in an NDOT Microsoft (MS) Excel spreadsheet called "currentrespuwokall.xls" to develop cost indices for those items with the most impact on cost. This spreadsheet had work unit costs from 1985 to 2009 (partial). In addition, STE utilized the cost indices to investigate historical inflation rates. The analysis reported in this study shows that NDOT can utilize the existing dataset to develop and maintain major cost indices to track historical trends and gather valuable insight on changes in market conditions including inflation trends.

STE also reviewed the parametric cost estimating tool recently developed for NDOT to make recommendations on how to include the results of this study. STE concluded that the methodologies developed in this research can be utilized to develop contingency and inflation rates for the parametric cost estimating tool. However, the first step is for NDOT and partnering agencies to track project cost and schedule changes using a tracking system similar to what was developed in this research. STE believes that within three to five years after implementation of a tracking system there will be an adequate amount of data for a comprehensive evaluation of contingencies and inflation rates.

Finally, STE has made recommendations for implementation of study findings in areas of policies, procedures, and software development. Those recommendations are: 1) Create a cost estimating group consisting of key staff involved in planning cost estimation at NDOT, RTC's, and local agencies, 2) Develop a vision statement for making cost estimation a priority, 3) Develop a comprehensive cost estimating manual for planning stage, 4) Develop a quality control/quality assurance (QC/QA) program for cost estimation process, 5) Finalize the parametric cost estimating tool for use by everyone involved, 6) Create a uniform cost/schedule tracking system to capture risk factors, 7) Track and report inflation trends through cost indexing practices and national data, 8) Establish a routine training program on cost estimating practices and policies, and 9) Improve communications within agencies and among agencies for estimators.

1.0 INTRODUCTION

NDOT, Regional Transportation Commission (RTC) of Washoe County, RTC of Southern Nevada, Clark County, and several local cities in southern and northern Nevada are involved in project cost estimating for planning. STE identified a series of activities that needed to be accomplished in order to make recommendations on how to enhance the project cost estimation process at the planning stage. Those activities include the following (Figure 1):

- A nationwide literature review
- Review of existing NDOT and partnering agencies cost estimating practices
- Develop a procedure to capture historical risk factors
- Develop cost indexing methodology to capture changes in market conditions including inflation
- Review NDOT's recently developed parametric cost estimating tool
- Make final recommendations
- Develop an implementation plan

This final report describes work accomplished.

Figure 1.1 Final Report Activities.

2.0 LITERATURE REVIEW

Cost and schedule overrun of transportation projects has become a critical problem not only in the United States but also worldwide. The literature review included examining published reports abroad and reviewing cost estimating practices of many US agencies and departments of transportation (DOTs). In the US, there are ongoing research by the Federal Highway Administration (FHWA) and almost every agency within the country including:

- Washington Department of Transportation (WSDOT)
- California Department of Transportation (Caltrans)
- Oregon Department of Transportation (ODOT)
- Florida Department of Transportation (FDOT)
- Minnesota Department of Transportation (Mn/DOT)
- Virginia Department of Transportation (VDOT)
- Montana Department of Transportation (MDT)
- Nevada Department of Transportation (NDOT)

Other efforts include the work of the American Association of State Highway and Transportation Officials (AASHTO) Technical Committee on Cost Estimating (TCCE) that is tasked to create recommended policy on best practices for developing estimates. In addition, the National Cooperative Highway Research Program (NCHRP) recently published a report on Project 8-49 "Guidance for Cost Estimation and Management for Highway Projects During Planning, Programming, and Preconstruction." STE also conducted a recently published research project called "Highway Project Cost Estimating and Management" for the State of Montana.

2.1 OVERVIEW OF COST & SCHEDULE OVERRUN

A recent study (Flyvbjerg et al. 2002) of infrastructure project costs sampled 258 projects worldwide worth $90 billion. The study revealed that costs are underestimated in nine out of ten transportation infrastructure projects. Actual costs are on average 34% higher than estimated costs for tunnels and bridges and 20% higher for road projects. The study also revealed that there is a lack of comprehensive project management plans to mitigate the occurrence of cost underestimation. The study concluded that agencies should develop institutional checks and balances for accountability by increasing transparency, using performance specifications, and developing comprehensive systems for the cost estimation process.

For a transportation agency, cost overruns can lead to adverse consequences, including:

- Disruption of plans, postponing, or canceling scheduled projects to satisfy budgetary constraints
- Reduction in project scope, resulting in projects that do not fully provide the service initially intended
- Extension in construction duration until additional funds become available
- The public losing faith in the agency's competency, or worse, trustworthiness

Inaccurate cost estimates lead to overloading the STIP with many projects that are underfunded. This often leads to misallocating design resources and creating false expectations with the public and other stakeholders. For example, in January 2001, Virginia's Joint Legislative Audit and Review Commission (JLARC) reported that the state's six year, $9 billion transportation plan may have underestimated the costs of projects by up to $3.5 billion (JLARC 2001). The report identified project scope creep, lack of adjustment for inflation, and design errors and omissions as the most significant factors for underestimating costs.

In a 2002 audit of the Springfield Interchange project in Northern Virginia, the Office of the Inspector General reported that VDOT had to postpone or cancel 166 projects due to lack of funding (FHWA 2002). Project cost underestimation was reported as the primary reason for funding issues.

During STE's work with MDT, analysis of a small data sample revealed that initial and latest revised costs varied by 181% for the Statewide and Urban Section Projects. For MDT highway projects, the analysis of very limited data revealed that final construction costs were 46% higher than anticipated at the time of STIP.

In 2003, the General Accounting Office (GAO) reported to Congress that unreliable initial cost estimates have significantly contributed to the cost growth observed on major highway and bridge projects (US GAO 2003). Initial estimates were modified to reflect more detailed plans and specifications as projects were designed and the costs were affected by, among other things, inflation and changes in scope to accommodate economic development over time.

2.2 Example Policy to Follow – Minnesota Model

STE's review of literature revealed that many agencies are struggling with developing policies and procedures to deal with issues described above. The most critical reason behind cost and schedule overrun is a lack of clear commitment and a policy on how to make estimates a priority. Accurate and complete cost estimates should become a high priority for every agency.

A great example of such commitment is the ongoing effort by Mn/DOT. According to Mn/DOT, escalations in the cost of transportation projects have resulted in the postponements of many important projects. This situation impacts Mn/DOT's credibility with many of its stakeholders. In 2007, Mn/DOT developed the following vision statement entitled, "Cost Estimation Process Improvements and Organizational Integration" (Mn/DOT 2007):

> "Mn/DOT will manage and control costs through a department-wide priority on cost estimating and cost management, reliable and accurate estimates, statewide uniformity and consistency, improved communication and credibility with external stakeholders, and clear accountability."

Mn/DOT has identified the following key components for their vision statement (Mn/DOT 2007):

- Department wide priority on estimating, managing, and controlling costs
  - Fully developed and integrated policies, processes, and tools for cost estimation, management, and control
  - Baseline estimates that align with early project scope development and include an initial assessment of risk and uncertainty

  - Clearly defined and documented cost management approval processes to authorize changes in scope and cost after the baseline estimate is established
  - Dedicated resources that are focused on effective scoping, project cost estimating, and cost management

- Reliable and accurate estimates
  - Well documented and complete cost estimates
  - Clearly spelled out assumptions and risks that can be easily communicated

- Statewide uniformity and consistency
  - Uniform application and consistent statewide use of well-documented processes and tools
  - Use of processes and tools during planning, scoping, design, and letting phases

- Improved communication and credibility with external stakeholders
  - Consistent and clear communication of cost estimates to external stakeholders at milestone points
  - The ability to communicate cost estimates with confidence, leading to stronger relationships with external stakeholders, greater possibility for collaboration, and increased funding support of transportation initiatives

- Clear accountability
  - Accountability for cost estimating and cost management at all levels of the organization
  - Defined roles and responsibilities for every person involved
  - Accountability that is tracked at key points in the process

Mn/DOT has recently restructured its organization and has established the Office of Project Scope and Cost Management, which is responsible for project scoping, cost estimating, and cost management.

2.3 REPORTING TOTAL PROJECT COST ESTIMATE

At the planning stage, it is difficult to provide cost estimates for some of the project cost items such as right of way, utility relocation, and traffic control. This has led to a common practice of providing incomplete cost estimates by many agencies. Those agencies have, however, found it very difficult to capture historical trends in their projects cost escalations because those escalations are not well documented. Without "total" initial cost estimate, a baseline estimate cannot be established and therefore comparison of final as constructed cost with initial planning cost becomes difficult. STE observed this problem during its review of construction cost data provided by NDOT as well.

To remedy this problem many states are now requiring that the initial project cost estimates have to be complete and be reported as "total" project cost estimates. For example, Mn/DOT has a new requirement that an estimate should be expressed as a Total Project Cost Estimate (TPCE), which includes non-construction cost items such as right of way costs and contingencies.

A quality control checklist can be developed to ensure that all major project elements have been considered during the initial scoping process. Elements that can be considered include:

- Grading
- Aggregates
- Paving
- Bridge Approach Panels
- Mobilization
- Removal/Salvage
- Drainage
- Traffic Control
- Turf/Erosion
- Signing
- Lighting
- Temporary Construction
- Utilities
- Aesthetics
- Retaining Walls
- Noise Walls
- Bridges
- Signals/Traffic
- Management Systems
- Right of Way
- Project Development/ Delivery

2.4 NCHRP PROJECT 8-49 & FHWA MAJOR PROJECT COST ESTIMATING GUIDANCE

In 2007, NCHRP published the results of NCHRP 8-49 project on "Guidance for Cost Estimation and Management for Highway Projects During Planning, Programming, and Construction" in NCHRP Report 574. NCHRP 8-49 cites four factors that create distinct challenges to the development of early and accurate project cost estimates (Anderson et al. 2007, pp. 1):

1. Difficulty in evaluating the quality and completeness of early project cost estimates
2. Difficulty in describing scope solutions for all issues early in project development
3. Difficulty in identifying major areas of variability and uncertainty in project scope and cost
4. Difficulty in tracking the cost impact of design development that occurs between major cost estimates

According to NCHRP 8-49, an agency should adopt a cost estimation process that effectively manages the internal and external factors causing cost escalation. Those factors individually or in combination can increase project cost significantly. Internal factors are detailed in Table 2.1 and external factors in Table 2.2 (Anderson et al. 2007, pp. 13-18). Ineffective management of those factors comes from the following (Anderson et al. 2007, pp. 13-18):

- Lack of a thorough understanding of unknown (risk) factors
- Lack of realization that unknown (risk) factors change over time
- Lack of communication of information about unknown (risk) factors among the key stakeholders involved in various phases of project development
- Lack of common practices for cost estimation between bureaus/divisions/sections of an agency

The FHWA report on "Major Project Cost Estimating Guidance" (FHWA 2007) provides a series of key principles for successful cost estimating. Those principles are:

- Integrity – This principle discusses high standard of ethical integrity and a transparent cost estimating process.

Table 2.1 Internal Cost Escalation Factors.

Factors	Description
Bias	To insure a project remains in the program, project costs are purposefully underestimated. DOTs can mitigate bias by making the cost estimation process a priority and transparent.
Delivery/Procurement Approach	"The decision regarding which project delivery approach, (i.e.) design-bid-build, design-build, or build-operate-transfer, and procurement methodology, (i.e.) low bid, best value, or qualifications based selection effects the transfer of project risks. Lack of experience with a delivery method or procurement approach can also lead to underestimation of project costs." While these approaches may get projects constructed quickly, each comes with a set of risks "in terms of DOT responsiveness, expectations, and time."
Project Schedule Changes	Budget constraints or design challenges—e.g. change orders—will increase the construction duration, leading to increased inflation effects. "Estimators frequently do not know what expenditure timing adjustments will be made."
Engineering and Construction Complexities	Early design difficulties can lead to cost increases, lengthened schedules, and internal coordination errors between project components such as "conflicts or problems between the various disciplines involved (with) a project. Constructability problems… may also be encountered as the project develops."
Scope Changes	"Such changes may include modifications in project construction limits, alterations in design and/or dimensions of key project items such as roadways, bridges, or tunnels, adjustments in type, size, or location of intersections, as well as other increases in project elements."
Poor Estimation (errors and omissions)	"Poor estimation includes general errors and omissions from plans and quantities as well as general inadequacies and poor performance in planning and estimation procedures and techniques." DOTs can mitigate estimating errors by instituting a consistent process, including continuous monitoring, verifying, and correcting.
Inconsistent Application of Contingencies	"Misuse and failure to define what costs contingency amounts cover can lead to estimation problems. In many cases it is assumed that contingency amounts can be used to cover added scope and planners seem to forget that the purpose of the contingency amount in the estimate was lack of design definition."
Faulty Execution	"This factor can include the inability of the DOTs representatives to make timely decisions or actions, to provide information relative to the project, and failure to appreciate construction difficulties cause by coordination of connecting work or work responsibilities."
Ambiguous Contract Provisions	"When the core assumptions underlying an estimate are confused by ambiguous contract provisions," such as "providing too little information in the project documents," estimators cannot accurately forecast project costs or schedules.
Contract Document Conflicts	Conflicting documents "lead to errors and confusion while bidding and later during project execution they cause change orders and rework.

Table 2.2 External Cost Escalation Factors.

Factors	Description
Local Government Concerns and Requirements	Typically, scope changes are negotiated by either scaling down or scaling up a project.
Effects of Inflation	Projects with long development and construction durations can encounter unanticipated inflationary effects. DOT estimators should "think in terms of the time value of money," including the inflation rate and expenditure timing. Inflation affects projects when: • Project estimates are not communicated in year-of-construction costs. • The project completion is delayed and therefore the cost is subject to inflation over a longer duration than anticipated. • The rate of inflation is greater than anticipated in the estimate.
Scope Creep	Similar to changes in scope by causing cost and schedule overruns.
Market Conditions	Changes in the regional, national or global economies can affect the costs of a project by causing unanticipated escalation in cost of asphalt, steel, and labor.
Unforeseen Events	Typically these are called "acts of God," and may include fires, floods, hurricanes, tornadoes, earthquakes, terrorism, labor strikes, and sudden changes in financial or commodity markets. These acts can bring construction to a standstill and require extensive rework or repair.
Unforeseen Conditions	"There are a multitude of problems that are simply unknown during the planning stage" but "become apparent during construction." For example, soil contamination, soil compaction factors, and utilities may not be accurately described on preliminary drawings.

- Contents of a Cost Estimate – This principle emphasizes the importance of a "complete" cost estimate, the equivalent of the total project purchase price. As such, the project cost estimate should include all costs including right-of-way, environmental mitigation, construction, public outreach, project management, etc.
- Year of Expenditure Dollars – This principle emphasizes the assignment of an inflation rate per year to the proposed midpoint of construction.
- Basis of a Cost Estimate – This principle discusses how a project cost should be developed based on best information available (e.g., bid based estimating is only good if the historic prices are for similar work and similar sized projects).
- Risk and Uncertainty – This principle states that costs should be determined for uncertainties within an estimate. To account for larger degree of uncertainty, early cost estimates can be expressed with an indication of the confidence level.
- Project Delivery Phase Transition – This principle emphasizes the importance of tracking cost estimates and changes throughout the life of the project and documenting assumptions and estimate information along the way.
- Team of Experts – This principle states that a skilled, interdisciplinary team should produce cost estimates using a clearly identified scope of work. For example, the right-of-way acquisition costs should be determined by the agency's right-of-way office.
- Validation of Estimates – This principle states that a competent unbiased team should validate the cost estimates.
- Revalidation of Estimates – This principle recognizes that situations may change over time and estimates need to be refreshed to account for those changes.
- Release of Estimates and Estimating Information – This principle emphasizes that only thoroughly reviewed, complete, and accurate cost estimates should be released to the public or be the basis for project approval.

NCHRP 8-49 and FHWA report on "Major Project Cost Estimating Guidance" (FHWA 2007) provide comprehensive lists of strategies and principles for system-wide cost estimating improvements. In order to enhance an agency's cost estimation process, NCHRP 8-49 suggests the adoption of the following eight strategies (Anderson et al. 2006, pp. 57):

1. Management Strategy – Manage the estimation process and cost through all stages of project development
2. Scope/Schedule Strategy – Formulate definitive processes for controlling project scope and schedule changes
3. Off-Prism Strategy – Use proactive methods for engaging those external participants and conditions that can influence project costs
4. Risk Strategy – Identify risks, quantify their impact on cost, and take actions to mitigate the impact of risks as the project scope is developed
5. Delivery and Procurement Method Strategy – Apply appropriate delivery methods to better manage cost, as project delivery influences both project risk and cost
6. Document Quality Strategy – Promote cost estimate accuracy and consistency through improved project documents
7. Estimate Quality Strategy – Use qualified personnel and uniform approaches to achieve improved estimate accuracy

8. Integrity Strategy – Insure checks and balances are in place to maintain estimate accuracy and minimize the impact of outside pressures that can cause optimistic biases in estimates

To ensure consistent and accurate estimates, NCHRP 8-49 concluded that the following cost estimation management and practice principles should be followed by agencies (Anderson et al. 2006, pp. 125-126):

Cost Estimation Management

- Make estimation a priority by allocating time and staff resources
- Set a project baseline cost estimate during programming or early in preliminary design and manage to it throughout project development
- Create cost containment mechanisms for timely decision making that indicate when projects deviate from the baseline
- Create estimate transparency with disciplined communication of the uncertainty and importance of an estimate
- Protect estimators from internal and external pressures to provide low cost estimates

Cost Estimation Practice

- Complete every step in the estimation process during all phases of project development
- Document the estimate basis, assumptions, and back-up calculations thoroughly
- Identify project risks and uncertainties early and use these explicitly identified risks to establish appropriate contingencies
- Anticipate external cost influences and incorporate them into the estimate
- Perform estimate reviews to confirm the estimate is accurate and fully reflects project scope

2.5 SUCCESSFUL PRACTICES BY OTHER STATE AGENCIES

As stated earlier, many agencies across the nation have taken steps to enhance their cost estimation and management procedures. Those agencies have assigned resources to advance their cost estimation practices. The following sections contain examples of such agencies.

2.5.1 State of California

Currently, Caltrans Division of Design and Division of Engineering Services are performing a review of their cost estimating tools and practices. The Division of Design has established a website (http://www.dot.ca.gov/hq/oppd/costest/costest.htm) to disseminate information and provide updates on Caltrans' cost estimating practices. Guidelines for cost estimation are contained in Project Development Manual "Appendix AA-Cost Estimates, Preparation Guidelines for Project Development Cost Estimates." Cost estimation procedures for both the planning and design stages are discussed. "Previous bid" method and "complete analysis" method are two methods for cost estimation. Previous bid method is to use previous bid prices as a basis for establishing prices on the proposed project. Complete analysis method is based on complete analysis of production rates, labor costs, and material costs. These methods may be used individually or in combination. However, the previous bid method is the most common approach. The complete analysis method is considered practical for only select items in certain projects, draws upon materials and price lists, assesses production rates, and analyzes operation to include overhead costs and profit needs.

Caltrans has concluded that reasons for poor estimating include (Caltrans 2006a):

- Estimates that are not updated and are old and out of date
- Estimates that are based on historic and not forecasted information
- Estimates that are prepared by staff with limited estimating experience
- Estimates that are based on low quality or high risk plans and specifications,
- Estimates that are not tailored to project construction schedule
- Estimates that are prepared without quality control/ quality assurance
- Estimates that are constraints by programmed funding level

To remedy poor cost estimation practices at each district Caltrans is establishing cost estimating centers of expertise, developing and implementing quality control/quality assurance processes, utilizing consultant contracts for independent analysis of cost estimates, and making district directors accountable for accuracy of cost estimates (Caltrans 2006b). For example, for projects with an engineer's estimate greater than $5 million, the district director will be required to certify that the estimate is complete and accurate, reflects the true scope of work to be performed, and accounts for current market trends. This certification is required before a project can achieve "Ready to List" status. In addition, engineer's estimates that are more than three months old must be updated and recertified.

2.5.2 State of Washington

The Strategic Analysis Estimating Office (SAEO) of WSDOT Design Office is tasked with providing technical support for estimating, risk analysis, value engineering, and project development. WSDOT has a well established cost estimating process that includes developing scope, base estimate, review of base estimate, analysis of risks and contingencies, communication, independent review of total estimate, and management endorsement.

WSDOT has also established Cost Estimating Guidelines that describe various steps of the cost estimation process. The guidelines clearly state that "the estimators should be shielded from pressures to keep estimates within programmed or desired amounts based on funding availability (WSDOT 2007a, pp. iii)." This is very much in line with NCHRP 8-49 recommendations of protecting the estimators from internal and external pressures to produce low estimates.

WSDOT also provides readily available cost estimating modeling tools (i.e., worksheets) on its website (http://www.wsdot.wa.gov/Design/SAEO/) to be used by project estimators. The cost estimating methodologies supported in WSDOT guidelines are parametric, historical bid-based, cost based, and risk-based. WSDOT guidelines provide a comprehensive description of each methodology and describe the appropriateness of their use for various project stages. For example, parametric methodologies (i.e., techniques that use historical data to define the cost of typical transportation facility segments, such as cost per lane mile, cost per interchange, cost per square foot, and cost per intersection) are used in planning, scoping, or early design stages (WSDOT 2007a, pp. 8-10). Historical bid-based methods are commonly used to develop WSDOT engineering estimates. Cost based estimates are very time consuming and require highly experienced estimators. WSDOT limits the use of cost based estimates to project items with the largest dollar value, typically 20% of items of work containing 80% of the project costs (WSDOT 2007a, pp. 8-10).

WSDOT policy requires a Cost Risk Assessment (CRA) workshop for projects over $25 million and a more detailed Cost Estimating and Validation Process (CEVP) workshop for projects over $100 million (WSDOT 2005). WSDOT developed the CRA and CEVP workshops to improve cost and schedule estimates by identifying and capturing risk events. Modeling techniques (e.g., Monte Carlo Simulation) are utilized to express cost and schedule estimates as a range of values rather than the conventional single point value. WSDOT's Policy for CRA also suggests that other types of unique or unusual projects, or projects with certain attributes (e.g., projects with high degree of political interest, major structures, projects with multiple stages, etc.) that are typically over $5 million may benefit from a CRA workshop (WSDOT 2005). CEVP and CRA workshops are usually conducted at 30% of the design stage, which may not make them useful for cost estimating at the planning stage.

2.5.3 State of Ohio

The Ohio Office of Estimating, a unit of Division of Construction Management, provides support, guidance, and training for project cost estimating. ODOT has developed a cost estimating manual that contains its best recommended practices. It also maintains trends and forecast for inflation and historical bid item data on its website at http://www.dot.state.oh.us/Divisions/ConstructionMgt/Estimating/, which is available to ODOT estimators and also the public. ODOT's cost estimation procedure is a ten step process that provides guidance on critical issues such as contingencies, inflation, and quality review (ODOT 2008).

2.5.4 State of Florida

In Florida, the Estimate Section of the Office of Specifications and Estimates sets policies and procedures for the statewide estimating process. The Estimate Section is responsible for reviewing the estimates for Florida's 5-Year Work Program, conducting post-bid reviews, publishing Florida's Basis of Estimates Manual, providing user support and training for the Long Range Estimates (LRE) and Trns*port estimating systems, and producing a variety of cost history reports.

2.5.5 Other DOTs

In 2006, the Project Delivery Subcommittee of the AASHTO Standing Committee on Quality (SCOQ) conducted a nationwide survey to investigate the best practices for project cost and plan quality. Twenty agencies provided information on their project cost estimating practices. The survey results indicated that all agencies acknowledge the problems associated with developing early and accurate cost estimates. Table 2.3 illustrates examples of agencies that are taking definitive actions to improve their cost estimating practices (AASHTO 2006). The actions shown in Table 2.3 are in agreement with the recommendations presented in the literature review.

Table 2.3 Example of Agencies Taking Actions According to SCOQ National Survey.

Actions	Agencies
Developing Cost Estimating Manual	Maryland, Minnesota, Virginia, Washington, California
Developing Systems for Capturing Risk Factors	Washington, Florida
Developing Cost Estimate Training Program or Workshops	Virginia, Washington, Michigan
Establishing Cost Estimating Section	Louisiana, Nevada
Development of Estimate Quality Control Program	Indiana, Maine, Virginia, Washington, Wyoming

2.6 POTENTIAL SOLUTIONS DISCUSSED IN LITERATURE REVIEW

Based on its literature review, STE concluded that the most fundamental management policy is to make estimation a priority. Allocating time and staff resources is the first step for implementing the strategies and principles discussed. One great way to make estimation a priority is to create a cost estimation section with full time estimators. Other key practices that are necessary are shown Figure 2.1.

These recommended solutions were compared with the ten cost estimation management and practice principles identified in NCHRP 8-49. Table 2.4 illustrates the applicability of the recommended solutions to the cost estimation management and practice principles.

In recent years NDOT has been moving in the direction of implementing many of the recommendations identified in the literature review. NDOT Design Division including the Project Scheduling/Estimating Section, Project Scoping Section; and Project Management Division are actively involved with enhancing the cost estimation procedures at NDOT. This will be further discussed Section 3.0 Interviews.

Figure 2.1 Other Key Practices in Cost Estimation.

Table 2.4 Comparison of Recommended Solutions.

Cost Estimation Management and Practice Principles	**Solutions**				
	Cost Estimation Section	Comprehensive Cost Estimating Manual	Comprehensive System for Capturing Risk Factors	Cost Estimating Training Program	Quality Control Program
Make estimation a priority by allocating time and staff resources	√			√	√
Set a project baseline cost estimate during programming or early in preliminary design and manage to it throughout project development	√	√	√		√
Create cost containment mechanisms for timely decision making that indicate when projects deviate from the baseline	√		√		√
Create estimate transparency with disciplined communication of the uncertainty and importance of an estimate	√	√	√	√	√
Protect estimators from internal and external pressures to provide low cost estimates	√			√	√
Complete every step in the estimation process during all phases of project development	√	√	√	√	√
Document the estimate basis, assumptions, and back-up calculations thoroughly	√	√		√	√
Identify project risks and uncertainties early and use these explicitly identified risks to establish appropriate contingencies	√	√	√	√	√
Anticipate external cost influences and incorporate them into the estimate	√	√	√		√
Perform estimate reviews to confirm the estimate is accurate and fully reflects project scope	√	√			√

3.0 INTERVIEWS

STE conducted a series of interviews with personnel from NDOT, RTC Washoe, RTC Southern Nevada, Clark County, and the City of Las Vegas involved in developing cost estimates for transportation planning documents. At NDOT, personnel from Program Development Division, Project Management Division, and Design Division were interviewed. At RTCs and local agencies, senior planners, director of engineering services, division managers, principal engineers, and program managers were interviewed.

The focus of the interviews was to determine what methods are currently used to develop cost estimates for projects in the planning stage, and to better identify the concerns and limitations that create deficient estimates.

STE structured the interview questions to delineate the strengths and weaknesses of current cost estimating process. The emphasis of the interviews was on the following items:

- Project cost estimating at planning stage
- Tracking project cost estimates through various project development stages
- Gathering information on enhancing the current cost estimation at the planning stage

NCHRP Web-Only Document 98, a supplement to NCHRP Project 8-49, provides examples of interview questions to capture the strengths and weaknesses of project cost estimating practices (Anderson et al. 2006). It states that the focus of the interview should be to assemble state of practice estimating information and to understand what factors cause estimating accuracy problems.

STE followed the guidelines of the NCHRP 8-49 report to develop a set of interview questions for the personnel involved in the cost estimating process. A copy of the on-site interview questions is presented in Appendix A.

3.1 PROJECT COST ESTIMATING PRACTICES AT PLANNING STAGE

The discussion that follows is based on the interviews conducted in 2008 and early 2009 and may not express accurately the current practices.

3.1.1 NDOT

Depending on the year, approximately 60 to 80 percent of projects that enter STIP are developed at NDOT. At the time of this study, there was no formal cost estimating manual (procedure) for estimating the project cost at the planning stage (i.e., before a project is added to STIP). However, NDOT has written policies and procedures for cost estimation at the design stage that are described in NDOT's Project Design Development Manual (PDDM). Section 2.7 of the PDDM describes the philosophy of project estimation process and provides cost estimation policies and procedures. Appendix J of the PPDM provides a complete reference to the project estimation portion of the Contract Management Subsystem (CMS) of the Integrated Financial System (IFS) for the State of Nevada. CMS is Oracle based and is created specifically for the purpose of preparing estimates for transportation improvement projects.

As shown in Figure 3.1, CMS has four modules: project estimation module, construction module, retention module, and contractor payment module. CMS is designed by American Management System (AMS). The issue with CMS is that it is not "supported" by its developers anymore. This makes CMS an unstable system. NDOT is currently exploring for a new cost estimating system that is compatible with IFS to replace CMS.

Figure 3.1 CMS Modules.

3.1.1.1 NDOT Design Division

At the time of this study, the planning cost estimates for NDOT projects were done within the Design Division. Depending on the availability of time and resources, some or all of the Design Division procedures are followed for cost estimation at the planning stage. There are eighteen design squads, each with three personnel. As shown in Figure 3.2, the primary functions of the design squads are plans, specifications, and estimates including cost estimation. Design squads develop quantities using various in house spreadsheets and cost estimates using the CMS system. The Design Division also maintains a database of the engineer's unit price and a reasonable price for each work unit in every contract ever let. Unit prices are accessible from CMS (IFS/CMS RESP table). The RESP database tracks every unit price back to 1988. There are two files, one with unit cost information that goes back to 1988 and the other file contains the last five years. The senior design engineer, in cooperation with the designer, is responsible for updating the database while producing the agreement estimate. The unit prices get updated quite frequently. In CMS, one can go to reasonable price table and sort by demography, district, and also urban or rural and get the historical reasonable bid prices. The bid items have a date that shows when they were reported.

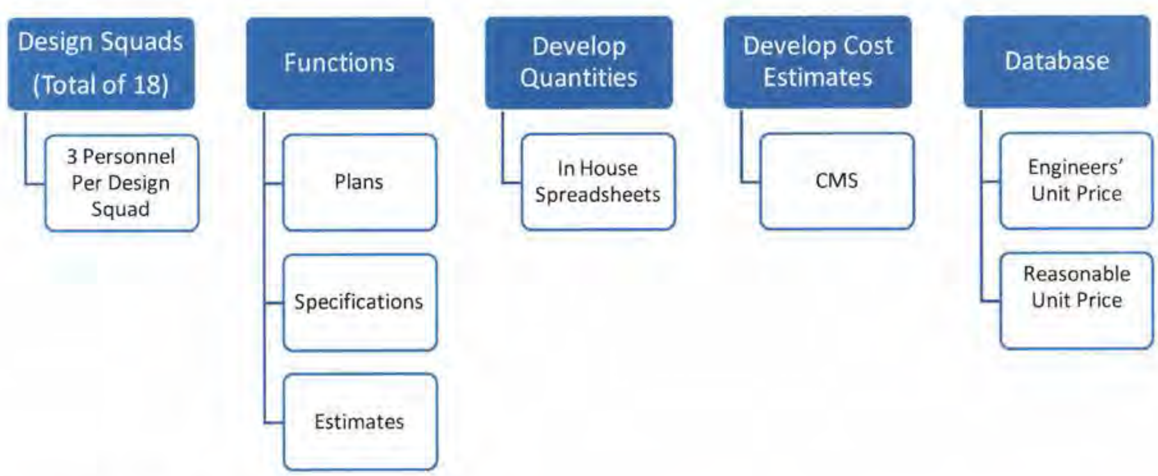


Figure 3.2 NDOT Design Division Activities.

3.1.1.2 NDOT Project Scheduling/Estimating Section

Creating a project estimating section (group) within an agency was one of the top recommendations out of the literature review. NDOT does have a Project Scheduling/Estimating Section within the Design Division, which plays a key role in improving project scheduling and cost estimating at NDOT. The Project Scheduling/Estimating Section reviews the estimates in CMS for completeness to ensure that all project related information is completed properly but does not check the quantities of various items. Other activities performed by the Project Scheduling/Estimating Section include providing training in the use of the CMS system and updating the cost estimating information in PDDM. For example, this section provides a four day class on how to use CMS. The Project Scheduling/Estimating Section also updates the RESP table on a monthly basis. In addition, ongoing market prices of critical materials such as fuel, asphalt, and steel are gathered and reported to all managers on a monthly basis. At the time of this study, the Project Scheduling/Estimating Section was in the process of customizing CEVP for implementation at NDOT.

3.1.1.3 NDOT Project Scoping Section

The Project Scoping Section of NDOT's Design Division is another very important entity in developing good early cost estimates. The Project Scoping Section Manager is involved in scoping projects at early stages, where projects are being proposed for inclusion into the Transportation System Projects (TSP) as a STIP project and/or a project on the Annual Work Program (AWP). The Project Scoping Section Manager is directly involved in scoping projects at the planning stage. When a proposed project is "flagged" to be included into the STIP, the Project Scoping Section Manager works closely with the Planning Division and the Project Manager to begin the scoping process and develop a schedule. A scoping team is formed and a tentative project schedule is established. For a given project schedule, a series of milestones for major events such as Value Engineering, National Environmental Policy Act (NEPA), Preliminary Design, Right of Way, Final Design, Right of Way Certification, Advertising, and Construction are set. The Project Scoping Section Manager is actively involved with a project from inception to about 30% of the design stage and the completion of NEPA requirements.

3.1.1.4 NDOT Project Management Division

At the time of this study, the Project Management Division was actively involved in developing a series of policies and procedures for project development including cost estimating. Examples of those efforts were the "Project Development and Scoping Guidelines, Linking Planning and NEPA Processes", "Project Cost, Scope & Schedule Development and Reporting Guideline", and the development of a parametric MS Excel based estimating tool that could be used for project cost estimation at the time of planning. In addition, this division was involved in implementing CEVP type workshops for major projects at NDOT. The efforts were clearly intended to identify major project risks early, prior to entering STIP. They were also diligently working on developing realistic cost/schedule estimates for the STIP and future project stages (e.g., Award and Final Construction). At the time of this study, those documents and tools were "works in progress" and were not finalized nor adopted.

3.1.1.5 NDOT Program Development Division

The Program Development Division is responsible for the STIP but does not directly perform any cost estimation. The initial planning costs are performed by NDOT designers/estimators and staff from partnering agencies (i.e., RTCs). This division keeps track of available STIP funds and through communication with project managers makes decisions on scope and schedule changes to accommodate available funds.

Not all projects end up in STIP because of funding issues. Local entities prioritize their projects and some projects will be dropped because of limited funding. Budgets are roughly predefined for each entity. Based on the Regional Transportation Plan (RTP) list, projects get prioritized into STIP depending on available funds. One of the problems identified is that NDOT does not have a feel for how accurate planning cost estimates are in the RTP documents. Historically, the RTP cost estimates have been accepted as is.

3.1.1.6 Project Cost, Scheduling, & Reporting Systems

The CMS cost estimating tool has already been described earlier in this report. For scheduling of projects, many of the project managers use either the MS Project or Sciforma PS8 to produce detailed project schedules. At the time of this study, NDOT was working towards standardizing their process by using MS Project exclusively.

There are three other reporting systems that are used during a project life. These are Project Scheduling and Management System (PSAMS), Preconstruction Engineering Management System (PCEMS) and DASHBOARD Project Reporting System. Project timelines and milestones are shown on PCEMS and PSAMS. DASHBOARD is housed on NDOT's intranet and it utilizes project management and PCEMS data to report charts of project status and cost, including: completion year, district type, category, responsible division, monetary fund used, county comparison, design phases, and principal engineer. DASHBOARD also designates on-schedule, behind-schedule, and projects in danger of running behind schedule by different colors for ease of project tracking. Figure 3.3 is an example of the status screen of NDOT DASHBOARD (Dashboard, NDOT Centerline, 2008).

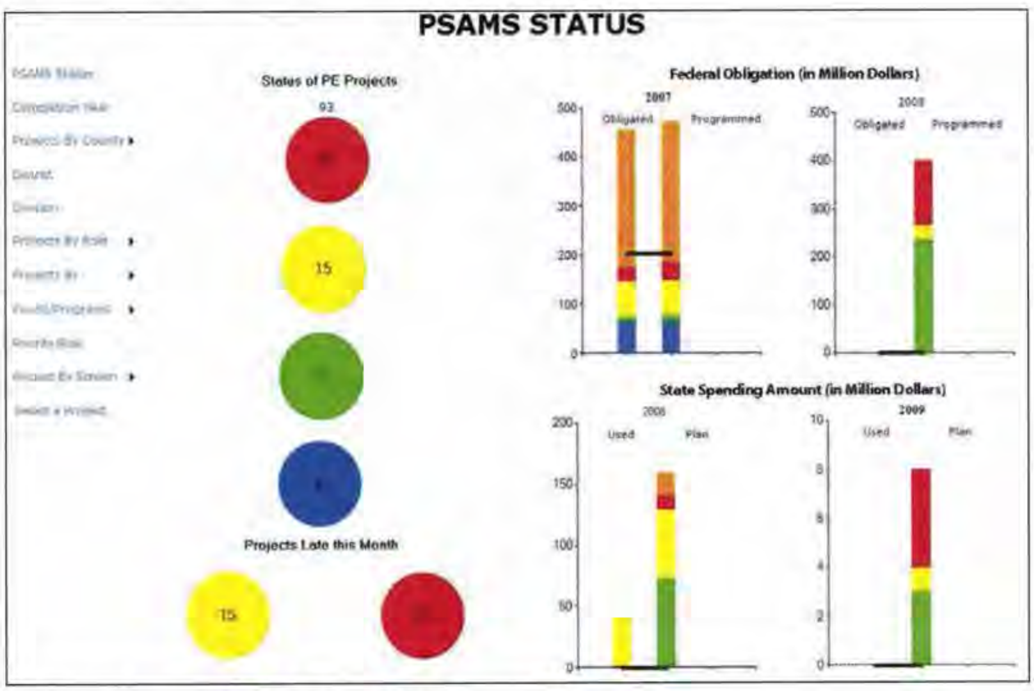


Figure 3.3 Status Screen of NDOT DASHBOARD.

3.1.2 RTCs & Local Agencies

Based on the interviews conducted with RTC of Washoe County, RTC of Southern Nevada, Clark County Public Works, and the City of Las Vegas, STE concluded that there was no uniform methodology in cost estimation at the planning stage within the agencies. At the time of this study, there were also no written procedural manuals for planning cost estimation. Agencies have established formats for quantity, cost, and schedule estimates that are guided by the Regional Impact Fee (RIF) ordinance but have no written procedures. For example, the RTP documents cover the why and the how to do a long range plan. Within the RIF, there is a general administrative manual, which lays out how the RIF fees are established.

Unit costs are routinely updated at RTCs and local agencies in a series of locally developed and held MS Excel spreadsheets. For example, at RTC of Washoe County the pricing MS Excel spreadsheet contains over forty categories of various items. Each entity has developed its own spreadsheets for recording estimated quantities and calculating projects costs. For example, the following is a description of the general cost estimation practices for various regional plans at RTC of Washoe County.

3.1.2.1 Regional Transportation Plan (RTP)

RTP is revised every four years by regulation, three years by practice. The document is the (minimum twenty year) long range plan required of all MPOs by FHWA. First, the estimator receives a list of nominal improvements with segment limits and then an MS Excel worksheet is created listing the improvements. The estimator researches each improvement to fill in the following information:

- Gross length
- Net length
- Signalized intersections
- Functional class
- Existing and needed right of way widths
- Development density assignment

The estimator will then get the most up to date unit cost data from RTC engineering to place in the "unit costs capacity improvement" worksheet. Once the formulas are in place and linked to the cost worksheet, the cost is calculated for right of way, signalized intersections, and roadway segments. In addition, a total cost is calculated. This process is for the regional road system, arterials, collectors, freeways and ramps.

The estimator will then sort the improvements and report the costs for various time horizons. The improvements and cost are then included in the RTP. The cost includes nominal utility adjustments, right of way, all construction costs including traffic control during construction, a 5% planning/project management cost, a 5% administration cost, and a 15% contingency.

3.1.2.2 Regional Road Impact Fee/Capital Improvement Plan (RRIF / CIP)

Regional Road Impact Fee/Capital Improvement Plan (RRIF/CIP) document is revised every two years and is used to establish fee rates on new development. The list of needed improvements is a ten year horizon, which includes capacity improvements for streets only. Freeway needs are not included. The process to establish cost is very similar to the method described for the RTP. Once the estimator receives a list of needed improvements, quantities are estimated and linked to a unit cost worksheet to produce a list of improvements with costs. The cost items included are the same as what was described for the RTP. The cost of the ten year program is used to revise the RRIF rates, which are reflected in a new RRIF and CIP published every two years.

3.1.2.3 Regional Transportation Improvement Plan (RTIP)

Regional Transportation Improvement Plan (RTIP) is a five year plan revisited every two years. The RTIP is developed by RTC and given to NDOT to be included in the STIP. Amendments to the RTIP occur on an as-needed basis. Some plans may show one or two amendments within two years, some as many as ten to twelve amendments. RTC planning staff are responsible for the RTIP. The cost for the project comes from many sources. If the project had a recent study (e.g., NEPA, feasibility, corridor), the cost data from that study is used in the RTIP. If not, the cost is either taken from the most recent RTP and adjusted for inflation, or the RTP cost may be updated by the engineering project manager and a new cost given to planning for the RTIP. These costs include all of the items mentioned in RRIF and RTP and may include environmental mitigation if known at the time.

3.1.2.4 Program of Projects (POP)

Program of Projects (POP) consists of three types of projects characterized by fund type and purpose. Those project types are:

- **Fuel Tax POP** – This is for pavement reconstruction and rehabilitation and is a two year horizon list of projects, updated every year.
- **Regional Road Impact Fee POP** – This is for capacity improvements and is updated yearly. Therefore, the program estimates are originally developed in year one for construction two years out. Then one year later the estimate is confirmed or adjusted prior to being constructed the next year. Since capacity projects usually include right of way and often have more development complexities, some projects will be on the POP several years until construction occurs. Each year project managers provide updates on program estimates for the new POP.
- **Sales Tax POP** – This is for preventive maintenance with a one year horizon, updated annually.

Other cost estimates include the engineer's estimate, where a draft estimate is supplied by a consultant at 90% design stage and a final estimate when the project is advertised. At award, RTC tracks two costs, one the award amount and the other is the contract price of RTC related improvements. RTC often receives funds from the jurisdiction for improvements beyond the original scope called "reimbursable work." Therefore, the second bid price RTC tracks is an award price minus reimbursable work. RTC's Costpoint Accounting System tracks such costs by project number.

3.1.2.5 RTC & Local Agencies in Southern Nevada

As stated earlier, agencies in southern Nevada do not have any written procedure or manual for cost estimating at the planning stage. However, they do have set in place practices that they follow for early cost estimation. At RTC of Southern Nevada, planning cost estimates are done in the Director's office. At the other local agencies, there are one or two planners involved in early cost estimation. Since these are only small groups involved in the planning cost estimation, there is "consistency" in their practices.

At the early planning stage, there is little information on the projects and not enough time to spend on a detailed cost estimate. Therefore, the early cost estimates are generally rough. Each agency has its own bid database. The bid tables get updated very frequently due the large number of projects that are let in southern Nevada. For RTP projects, a fixed 4% annual inflation rate has been used for a number of years.

Project underestimation has not been a significant problem in southern Nevada because traditionally there has been enough money in the RTC and flood control budgets to cover the additional costs without dropping projects. Project scope and cost are checked at various project stages including 30% and 60% design. At 30% design stage, the project is still several months away from being let and there has been adequate time in the past to fund any increases accordingly.

At the City of Las Vegas, standard bid prices are used by three design teams in the engineering section to refine the estimates during the design stage. The City of Las Vegas is moving towards refining the scope, schedule, and cost at 30% design by involving all the stakeholders including right of way staff. For larger projects, the City of Las Vegas involves the services of consulting firms during the design stage. The City of Las Vegas has an American Public Works Association (APWA) certification that discusses items such as contingencies. The contingencies used at the City of Las Vegas are 30% at the planning stage, 20% through 90% design and then the contingency is reduced to 10%. Clark County uses a 25% to 30% contingency at the planning stage and 15% during the design stage.

3.2 TRACKING OF PROJECT COST ESTIMATES

As discussed in the literature review section, documenting every step of the cost estimation process throughout the life of a project is the key to understanding what factors are responsible for cost overruns. In the past three years, a formal process is followed at NDOT for any request for budget changes over $250,000. Those requests are through a scope/schedule/budget change form, copies of which are available at the NDOT Program Development Division. However, there are no electronic media that can provide readily available information on specific cost/schedule changes throughout the lifespan of a project from planning stage to award and then to final as built stage. . It took over five months of continuous effort by NDOT staff to sort through projects and provide STE with specific project cost data for forty five transportation projects. Similarly, current processes at RTCs and local agencies for tracking cost changes do not readily produce key data and information on cost, schedule, and scope changes

Detailed historical data on cost, schedule, and scope changes are essential for thoroughly understanding the underlying problems with the existing project development process. The historical data is also critical for capturing risk factors by project type and for each region. For future tracking, NDOT and RTCs will need to systematically track all cost, scope, and schedule changes in an electronic media, where data can be readily extracted for analysis purposes.

3.3 COST ESTIMATION PROBLEMS IDENTIFIED FROM PERSONNEL INTERVIEWS

As part of the interview process, STE asked the staff to identify the problems they see with the current planning cost estimation process. STE has categorized the issues identified by NDOT and other agencies involved in cost estimation at the planning stage into four categories; namely, Management, Process, Communication, and Data. In some cases the issues are interrelated among categories. The following presents the findings separated into NDOT and other agencies responses.

3.3.1 NDOT

Note: The following are based on the interviews conducted in 2008 and early 2009 and may not reflect current practices.

Management

- Scope creep is a problem
- RTP adopted cost estimates are often low balled
- Management needs to double check project costs before they enter STIP
- Unclear scope is a problem
- Unclear project schedule is a problem
- Political struggle is one of the worse ones. Every city and county wants their projects to be built first.
- Spending resources on projects that may not be the highest priority
- There are a lot of projects but not enough money
- Delay getting approvals, decisions
- Functional units not available, overloaded
- Unanticipated workload
- Complex internal funding procedures
- Priorities change on existing program
- Losing critical staff at crucial point of the project
- Insufficient time to plan
- Funding changes for fiscal year
- Political factors change
- Stakeholders request late changes
- New stakeholders emerge and demand new work
- Influential stakeholders request additional needs to serve their own commercial purposes
- Too many projects
- Unplanned work that must be accommodated
- Pressure to deliver project on an accelerated schedule
- Local agency issues
- Problems with inter-local agreements

Process

- There is no single uniform procedure for estimating quantities and costs at planning stage
- All designers use different spreadsheets to come up with calculations. There are 18 design squads and 18 ways of doing things. It would be good to create a uniform system and coordinate their activities.
- Project purpose and need is poorly defined
- Project scope definition is poor or incomplete
- Consultant or contractor delays
- Inexperienced staff assigned
- Technical analysis/work incomplete or in error
- Inexperienced workforce, inadequate staff/resource availability

- Change in key staffing throughout the project
- Project scope, schedule objectives, cost and deliverables are not clearly defined or understood
- Consultant design not up to department standards
- Coordinators and managers need to put the correct information in PSAMS
- Theoretically after 60% design we should not have any scope changes but we do and it affects budget/schedule
- Coordinators giving realistic milestone date information at the monthly status meeting for the PCEMS portion of the program
- There is no quality assurance check of project cost at the time of STIP

Communication

- Lack of coordination/communication
- Communication breakdown with project team
- Local communities pose objections
- Need to get all the stakeholders together at the time of scoping to get a good product out
- Improve communications between Cost/Schedule Estimation Section and Project Management Division
- Other divisions involved with cost/schedule of a project are not obligated to follow Design Division's cost estimating policies and procedures. This impacts both cost and schedule preparation of the projects.
- Inter-divisional communication and cooperation is difficult to achieve at NDOT

Data

- Estimating and/or scheduling errors
- Inaccurate assumptions on technical issues in planning stage
- No consistency in reporting reasonable unit cost data among managers
- Better handle of inflation, contingency and risk factors

3.3.2 RTCs & Local Agencies

Note: The following are based on the interviews conducted in 2008 and early 2009 and may not reflect current practices. In addition, all responses have been combined and may not reflect the current practices of each individual agency.

Management

- We do not have a project management system that captures milestones and decisions points.
- We do not have a project scheduling tool. It is all on paper.
- Las Vegas valley has had such a growth rate that there is not enough time for the utility/ROW people to walk the job at the planning stage.
- We know that some RTP projects are not realistic projects and are not what is going to be built. We do not have the resources or management interest to look into those projects more deeply.

Process

- Right way, easement cost, utility relocation costs are the issues. We do not put enough money because we do not know enough design information at the planning stage.
- ROW and utility are big issues because the quantities are unknown. There is not enough design information at the planning stage to come up with estimates.
- Getting accurate project schedules from entities is a problem at times.
- Because of the first come first serve practice for the flood money, entities front load their projects and their schedules.
- We have not looked at the difference between initial planning costs and final project costs. We do not have a readily accessible cost/schedule tracking system.

Communication

- Suggest more effort to build trust and comfort levels among NDOT, RTCs, counties, and cities

Data

- Suggest more effort to update unit prices

3.4 RECOMMENDATIONS BY PERSONNEL

STE also asked the interviewed personnel to provide recommendations on how to improve the cost and schedule estimation process. STE has categorized the recommendations identified into four areas; namely, Management, Process, Communications, Data. In some cases the recommendations are interrelated among categories. The following presents the staff recommendations:

Management

- Implement cost, scope, schedule and quality procedures/agreements
- Establish a Project Management Office
- Do not get the projects into STIP until 30% design
- Make sure that a scoping team reviews projects before they enter STIP
- Put the effort into reevaluating the cost of projects that are candidates for STIP at least once a year in advance of their entrance into the STIP
- I like the legislative approval of the whole STIP program. This way politics will be taken out at NDOT/agency level. But this will never happen.
- Put more effort in accurately prioritizing our top projects; what will get done this year and what will not.
- Contain and resist scope creep
- Continue looking at RTP to better define project scope for RTIP

Process

- Implement CEVP
- Develop and implement "Project Management/Development Guidelines" for planning, environmental, engineering, right of way and construction phases
- Develop a process to monitor and report inflation factors on a routine basis
- Double check project costs before they get into STIP
- For accountability purposes, project cost should be submitted to Transportation Planning Division with the name and signature of the estimator
- For accountability purposes, include a handout on how the cost estimate was achieved with the project submission to the Transportation Planning Division
- Get everyone to use the same estimating software
- Linking planning and NEPA is a good idea
- Create a checklist for all major elements of a project at the planning stage including utility and right of way and make sure that all elements are considered. Hence, develop a "total" cost for the project.
- Use consistent contingencies for items such as road side safety, environmental issues, hydraulics, right of way, and utilities
- Have everyone use the newly developed parametric cost estimation tool for developing planning cost estimates
- Need to replace the IFS/CMS system as it is outdated and unstable (i.e., no support from the developer)
- Develop more realistic policies for standard contingencies
- We need a better way to produce realistic project design schedules that are based on resource availability and workflow management.

Communications

- Provide training for all NDOT/MPO staff involved in cost estimating at the planning stage to enhance consistency in the process
- NDOT needs to develop a level of comfort with RTCs and local agencies, either by creating a uniform process for all, or by better understanding of how MPOs come up with their cost/schedule estimates.
- MPOs need more communication with NDOT.
- More effort is needed to built trust and comfort levels among NDOT, RTCs, counties, and cities.

Data

- Track cost/schedule changes and their reasons for all projects from planning to final construction in an easily accessible electronic media
- Modify PSAMS to track project cost/schedule changes
- Update unit costs more frequently
- Need better handle on inflation rates for construction related items

3.5 SUMMARY RECOMMENDATIONS

The interviews revealed that many of the recommendations discussed in the literature review will enhance the early cost estimation practices at both NDOT and local agencies. Firstly, STE suggests a cost estimating group be created. The group consists of key NDOT, RTCs, and local agencies staff involved in planning cost estimation. The group's responsibilities would include:

- Developing and implementing policies and uniform practices that will enhance the cost estimation process for all agencies involved. The first activity would entail developing a vision statement for making the cost estimation a priority. A good example has been provided in the literature review from Mn/DOT.
- Finalizing the parametric cost estimating tool being developed by NDOT and gathering support for its use by all agencies.
- Developing a cost estimation manual for projects at the planning stage that is acceptable to all agencies. The cost estimation manual would discuss all aspects of cost estimation including a quality control checklist, updating unit bid prices, reporting initial cost as a "total" cost, quality assurance reviews of the project scope, cost, and proposed schedule.
- Creating a uniform cost/schedule tracking system to gather historical data on various risks during a project life cycle. This data can be used to develop risk factors as described later in this report. The cost/schedule tracking template developed by STE can be developed into a user friendly application for this purpose.
- Improving communication among NDOT, RTCs, and local agencies staff.
- Developing a dynamic process for reporting inflation trends through cost indexing and following national and regional forecasts. The cost indexing process has been thoroughly discussed later in this report.
- Developing and implementing a training program for all staff.

4.0 RISK FACTOR ANALYSIS

STE desired to review as much historical cost estimating data as possible to thoroughly understand agencies' cost estimating strengths and deficiencies and also to attempt to quantify the various uncertainties (i.e., risk categories) that impact a project cost. Based on the findings of the literature review and close consultation with the NDOT project panel, STE developed a series of risk categories that may impact a project cost and/or schedule. Those risk categories are as follow:

- Insufficient Knowledge of Right-of-Way Factors
- Environmental Mitigation Requirements
- Unforeseen Engineering Complexities / Constructability Issues
- Changes in Traffic Control Needs due to Design or Traffic Growth
- Increased Local Government, Community, and Stakeholders Expectations
- Unforeseen Events
- Changes in Market Conditions
- Utilities

The risk categories were further broken down into subcategories that were specific to NDOT projects as shown in Table 4.1.

STE further developed a "data request template" in MS Excel to capture the above mentioned risk factors. Appendix B contains a copy of the data request template used for this study. The data request template was provided to NDOT and other partnering agencies in MS Excel. The data request template was expected to be populated with project cost data, which could be under, over, and/or close to their original estimate. The template covered different types of NDOT projects (i.e., capacity, preservation, local public agency project, study, maintenance, permits, etc.), project categories (i.e., category 1, category 2, or category 3), project districts, and various uncertainties (i.e., risk categories). The data request template was also designed to compare cost estimates at various stages; namely, STIP, Preliminary Agreement Estimate (PAE), Award, and Final cost.

4.1 INITIAL RISK FACTOR RANKING

Recognizing that the data gathering process by NDOT and agency staff would take time and effort, STE utilized a subjective methodology to assess the relative importance of the identified risk factors as a starting point. STE developed and distributed a survey to NDOT and local agency personnel to evaluate the impact of risk factors on cost and schedule of transportation projects. A copy of this survey is presented in Appendix A

Based on this subjective survey, Table 4.2 lists the risk factors by order of significance from one to eight, where one is the most significant risk. It is important to recognize that delays in schedule can impact a project cost. For example, delay caused by environmental mitigation requirements, which is ranked as the number two risk factor for schedule delays, can be compounded by changes in market condition (inflation) to cause significant project cost increase.

Table 4.1 Risk Categories & Subcategories.

Risk Categories	Right-of-Way	Environmental	Engineering / Constructability	Traffic	Stakeholders	Unforeseen Events	Market	Utilities
Subcategories	Delay in utility relocation	Permits or agency actions delayed or took longer than expected	Sufficiency of plans and specifications	Design change	Objections posed by local communities	Floods	Labor	Coordination with local utilities efforts
	Disagreement on freeway access	New information required for permits	Change in seismic criteria	Traffic growth	Late changes requested by stakeholders	Other weather related incidents	Fuel	Utility negotiations with owner
	Railroad involvement	Environmental regulations change	Soil conditions	Extended closure	Emergence of new stakeholders demanding new work	Legislative action	Materials	Delay
	Objections to ROW appraisal	Water quality regulation change	Soil contamination	Multiple mobilization	Threats of lawsuit		Land	Railroad involvement
	Acquisition problems	New issues in dealing with historic or archeological site, endangered species, wetland	Subcontractors capability		Stakeholders choose time and/or cost over quality			
	Billboard relocation	Additional environmental analysis required	Work zone safety and mobility					
	Changes in Design due to ROW issues	Erosion control	Work rules					
		Construction noise control	Geotechnical conditions					
		Permanent noise control						
		Buried hazardous issues						

The results of the survey suggest that the eight risk factors identified originally from the literature and discussions with the NDOT project panel are all relevant to NDOT cost/schedule overruns. The only way to quantify the historical risks is to gather and analyze NDOT specific project data using the data request template.

Table 4.2 Ranking of Risk Factors by Order of Significance Based on Staff Surveys.

Risk Category	Ranking of Impact on Cost Increases	Ranking of Impact on Schedule Delays
Insufficient Knowledge of Right-Of-Way Factors	1	1
Unforeseen Engineering Complexities / Constructability Issues	2	6
Environmental Mitigation Requirements	3	2
Utilities	4	3
Increased Local Government, Community, and Stakeholders Expectations	5	4
Unforeseen Events	6	5
Changes in Traffic Control	7	7
Changes in Market Conditions	8	8

4.2 DATA RECEIVED FROM AGENCIES

STE received a total of forty five datasets from NDOT, four from the City of Las Vegas, and two from RTC of Washoe County. The RTC datasets were incomplete (i.e., missing critical information such as initial STIP cost) and could not be used for analysis. In addition, simulation analysis becomes very unstable with just a few datasets and therefore, the City of Las Vegas data, even though complete, could not be utilized. Based on correspondence with NDOT, it took a knowledgeable staff member close to five months of continuous effort to populate the STE provided MS Excel data request template with forty five projects. This clearly shows the need for a better electronic tracking system as discussed in the literature review and interview sections of this study.

Originally, STE was tasked to observe and report the cost differences between STIP, PAE, Award, and Final milestones of a project. However, no cost information was provided for the PAE stage and therefore analysis was limited to understanding the cost differences between STIP, Award, and Final project stages.

4.3 STIP & AWARD RISK FACTOR ANALYSIS

Model

The model used for the STIP & AWARD comparison is as follows:

$$(AWARD - STIP) / STIP = R_1 + R_2 ... + R_8 + Other \quad \text{(eq. 4.1)}$$

where,

(AWARD – STIP) / STIP represents the change in Award cost as compared to STIP cost,
STIP represents the original STIP and not the programmed STIP,
AWARD is the Award cost,
'Other' represents risks that were not identified and is defined as AWARD minus STIP minus $\Sigma RISKS_{(BETWEEN\ STIP\ \&\ AWARD)}$, and
Risk factors in the equation (i.e., R1, R2, ...,R8) represent the dollar amount for each risk factor divided by the STIP.

The risk factors are shown below:

- R_1 is (ROW$ / STIP)
- R_2 is (ENVIRONMENTAL$ / STIP)
- R_3 is (ENGINEERING$ / STIP)
- R_4 is (TRAFFIC$ / STIP)
- R_5 is (STAKEHOLDERS$ / STIP)
- R_6 is (UNFORESEEN$ / STIP)
- R_7 is (MARKET$ / STIP)
- R_8 is (UTILTIES$ / STIP)
- Other is (OTHER$ / STIP)

Number of Datasets

As stated before, NDOT provided forty five datasets using the data request template. The information in each dataset was reduced and moved to a summary database. In order to analyze the information, several datasets were removed from analysis due to lack of information (i.e., missing STIP values) or because the dataset was an outlier (i.e., project 3238/72642 skewed results because STIP cost was $195,500 and Award cost was $18,400,477). Table 4.3 represents the datasets used in the analysis and Table 4.4 represents the datasets that were removed from the analysis. The total number of datasets available for the analysis was thirty eight.

Table 4.3 Datasets Used in STIP & AWARD Analysis.

Project Name/ID	
2593 Readv / 71472, 72052	3150 / 72400
2830 / 71976 / 71304 / IDR-DPC-9(3)043	3154 / 60108; 70858
2853 / 72031	3161 / 60158; 72807; 72657; 72493
2861 / 20134	3167 / 60188, 72805, 72493 Phase 3A
2957 / 72024 ; 72382	3187 / 60179; 72498
2995 / 60090; 72154	3193 / 60208; 72806; 72657
2996 / 72356, 72357, 72572	3201 / 60117 ; 72829 ; 72927 ; 72684
2999 / 72491 ; 72541 ; 72537	3209 / 60208 / 72806 / 72657
3003 / 72281	3215 / 60169, 72805, 72657
3038 - 60093; 72641	3217 / 72962
3039 / 72686	3237 / 60088; 72596; 72597
3052 / 72637	3241 / 72853
3053 / 60101 ; 72564 Phase 2A	3246 / 73137
3055 / 60103 ; 72657	3260 / 60207, 72806, 72807, 72657
3090 / 60099; 60125; 71394; 72610; 72711; 72720; 72355; 72410	3262 / 73133
3110 / 60106 ; 72564 Phase 2B	3266 / 73027
3120 / 60155 ; 72097	3267 / 60250, 60249, 72880, 72592, 72877
3127 / 60159; 72498	3297 / 60264 ; 73221
3130 Readv / 72800; 72471	3311 / 73156

Table 4.4 Datasets Removed from STIP & AWARD Analysis.

Project Name/ID	
2567 / 71565	3169 / 60189, 72805, 72493
3035 / 72619	3238 / 72642
3036 / 60083	3271 / 73225
3042 Readv / 72201	

Assumptions for Analysis

Sampling is the process by which values are randomly drawn from input probability distributions. Sampling in a simulation is done, repetitively, with one sample drawn every iteration from each input probability distribution. With enough iterations, the sampled values for a probability distribution become distributed in a manner which approximates the known input probability distribution (Palisade, 2007). The statistics of the sampled distribution (e.g., mean, standard deviation) approximate the true statistics input for the distribution.

The two methods of sampling used in @RISK are Monte Carlo and Latin Hypercube sampling, which differ in the number of iterations required until sampled values approximate input distributions. Monte Carlo sampling often requires a large number of samples to approximate an input distribution, especially if the input distribution is highly skewed or has some outcomes of low probability. Latin Hypercube sampling, a new sampling technique used in @RISK, forces the samples drawn to correspond more closely with the input distribution, and thus converges faster on the true statistics of the input distribution (Palisade, 2007). .

In addition, in the datasets received from NDOT, there were several risk factors with no cost information. The risk factors with no values were environmental mitigation requirements; changes in traffic control needs due to design or traffic growth; increased local government, community, and stakeholders expectations; unforeseen events, and changes in market conditions. Because those had no values, the data could not be fitted to any distribution and could not be simulated. The lack of data for those risk categories is most definitely due to current insufficient ways of tracking cost and schedule changes. STE removed environmental, traffic, stakeholders, unforeseen, and market risk factors from the analysis.

For simulation purposes, STE assumed the following for each risk factor:

- Data was assumed to be sample data
- Data was assumed to be continuous
- Used Latin Hypercube sampling
- Removed environmental, traffic, stakeholders, unforeseen, and market risk factors

4.3.1 Risk Factors Fitted to Best Fit Distribution

STE used the chi-squared statistic, which is the best known "goodness-of-fit" statistic available to fit the data to a distribution. To calculate the chi-squared statistic, the x-axis data must first be divided into several "bins". The chi-squared statistic is then defined as:

$$\chi^2 = \sum_{i=1}^{K} \frac{(N_i - E_i)^2}{E_i} \quad \text{(eq. 4.2)}$$

where K = the number of bins, N_1= the observed number of samples in the i^{th} bin, and E_1= the expected number of samples in the i^{th} bin.

Based on the smallest chi-squared statistic, one of the following available distributions in @Risk was chosen:

Beta General	Logistic	Pearson Type V
Exponential	Log Logistic	Pearson Type VI
Extreme Value	Log Normal	Triangular
Gamma	Normal	Uniform
Inverse Gaussian	Pareto	Weibull

Simulation Results

Table 4.5 presents the risk factors that were available for simulation, the type of best fit distribution, the mean, and the standard deviation. The results indicate that 'Other' is the dominant risk factor as expected since many categories of risks did not have specific cost information in the datasets. In addition, the standard deviation is greater than the mean for each risk factor. The large standard deviations can be due to a number of factors including inaccuracy in historical data reported for some risk factors and STE's observation that in many cases the initial STIP cost was not a complete and total cost. Therefore, comparisons with the Award and Final costs, both reported as "total" costs, can be highly variable. The reporting of STIP cost as a total cost was discussed thoroughly in the literature review section of this report and is one of the key recommendations of this study.

Table 4.5 Risk Factors for All Data Using Best Fit Distribution.

Risk Factors		Graph	Distribution	Mean	Standard Deviation
R_1	ROW$ / STIP		Inverse Gaussian	4.3%	8.5%
R_3	ENGINEERING$ / STIP		Extreme Value	11.0%	24.3%
R_8	UTILTIES$ / STIP		Beta General	0.1%	0.2%
Other	OTHER$ / STIP		Pearson Type V	84.0%	112.9%

4.3.2 Risk Factors Fitted to Normal Distribution

In the first scenario, STE used the best fit distribution available in @Risk to simulate each risk factor. Because of limited number of datasets (i.e., 38), the best fit distribution may not be the most realistic distribution to simulate an event. STE utilized the Normal Distribution as a comparison to best fit analysis with the following assumptions:

- Data was assumed to be sample data
- Data was assumed to be continuous
- Used Latin Hypercube sampling
- Used Normal Distribution
- Removed environmental, traffic, stakeholders, unforeseen, and market risk factors

Simulation Results

Table 4.6 presents the risk factors that were available for simulation, the distribution, the mean, and the standard deviation. Again, the results indicate that 'Other' is the dominant risk factor. The standard deviation is also greater than the mean for each risk factor.

Table 4.6 Risk Factors for All Data Using Normal Distribution.

Risk Factors		Graph	Distribution	Mean	Standard Deviation
R_1	ROW$ / STIP		Normal	4.3%	13.3%
R_3	ENGINEERING$ / STIP		Normal	13.7%	42.1%
R_8	UTILTIES$ / STIP		Normal	0.04%	0.17%
Other	OTHER$ / STIP		Normal	85.6%	120.0%

4.4 CUMULATIVE RISK FACTOR FOR STIP & AWARD COMPARISON

STE conducted another simulation analysis using all cost increases between STIP and Award stages as one cumulative risk factor. Based on the information presented in Table 4.7, historically a project cost at the time of award is 103% more than what was estimated at the STIP stage. This is mostly due to the fact that for most projects the STIP cost was not reported as a total cost. This is a practice that needs to change if a more realistic cost at the time of STIP is desired.

Table 4.7 Cumulative Risk Factor for STIP & AWARD Comparison.

Distribution	Mean	Standard Deviation
Best Fit	103.6%	144.9%
Normal	103.7%	146.4%

STE also evaluated the cumulative risk factor for capacity projects, which revealed that a typical capacity project would cost 112% more at the time of award as compared to its original STIP estimate. Capacity analysis is provided in Appendix C. Again, a major reason for this large difference is the reported partial project costs at the time of STIP. STE recommends the development of a comprehensive system for capturing risk factors with the capability of sorting and simulating cost data by district, type of project or project category. As discussed previously, STE developed a data request template for NDOT, which could be utilized to track cost and schedule changes throughout the life cycle of a project. This template shown in Appendix B can be the framework for an NDOT cost/schedule tracking system.

4.5 AWARD & FINAL RISK FACTOR ANALYSIS

Model

The model used for the AWARD & FINAL comparison is as follows:

$$(FINAL - AWARD) / AWARD = R_1 + R_2 \ldots + R_8 + Other \qquad \text{(eq. 4.3)}$$

where,

(FINAL – AWARD) / AWARD represents the change in Final cost as compared to Award cost,
AWARD is the Award cost,
FINAL is the project as built total cost,
'Other' represents risks that were not identified and is defined as FINAL minus AWARD minus $\Sigma RISKS_{(BETWEEN\ AWARD\ \&\ Final)}$, and
Risk factors in the equation (i.e., R1, R2,...,R8) represent the dollar amount for each risk factor divided by the award.

The risk factors are shown below:

- R_1 is (ROW$ / AWARD)
- R_2 is (ENVIRONMENTAL$ / AWARD)
- R_3 is (ENGINEERING$ / AWARD)
- R_4 is (TRAFFIC$ / AWARD)
- R_5 is (STAKEHOLDERS$ / AWARD)
- R_6 is (UNFORESEEN$ / AWARD)
- R_7 is (MARKET$ / AWARD)
- R_8 is (UTILTIES$ / AWARD)
- Other is (OTHER$ / AWARD)

Number of Datasets

As stated before, NDOT provided forty five datasets using the data request template. The information in each dataset was reduced and moved to a summary database. All forty five datasets were used in the analysis. Table 4.8 presents the datasets.

Table 4.8 Datasets Used in AWARD & FINAL Analysis.

Project Name/ID	
2567 / 71565	3150 / 72400
2593 Readv / 71472, 72052	3154 / 60108; 70858
2830 / 71976 / 71304 / IDR-DPC-9(3)043	3161 / 60158; 72807; 72657; 72493
2853 / 72031	3167 / 60188, 72805, 72493 Phase 3A
2861 / 20134	3169 / 60189, 72805, 72493
2957 / 72024 ; 72382	3187 / 60179; 72498
2995 / 60090; 72154	3193 / 60208; 72806; 72657
2996 / 72356, 72357, 72572	3201 / 60117 ; 72829 ; 72927 ; 72684
2999 / 72491 ; 72541 ; 72537	3209 / 60208 / 72806 / 72657
3003 / 72281	3215 / 60169, 72805, 72657
3035 / 72619	3217 / 72962
3036 / 60083	3237 / 60088; 72596; 72597
3038 - 60093; 72641	3238 / 72642
3039 / 72686	3241 / 72853
3042Readv / 72201	3246 / 73137
3052 / 72637	3260 / 60207, 72806, 72807, 72657
3053 / 60101 ; 72564 Phase 2A	3262 / 73133
3055 / 60103 ; 72657	3266 / 73027
3090 / 60099; 60125; 71394; 72610; 72711; 72720; 72355; 72410	3267 / 60250, 60249, 72880, 72592, 72877
3110 / 60106 ; 72564 Phase 2B	3271 / 73225
3120 / 60155 ; 72097	3297 / 60264 ; 73221
3127 / 60159; 72498	3311 / 73156
3130 Readv / 72800; 72471	

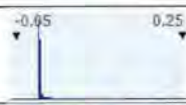
4.5.1 Risk Factors Fitted to Best Fit Distribution

Simulation Results

Table 4.9 presents the risk factors that were available for simulation, the type of best fit distribution, the mean, and the standard deviation. The results indicate that "Unforeseen Engineering Complexities/Constructability Issues" is the dominant risk factor followed by "Insufficient Knowledge of Right of Way" factor. It is interesting to note that the subjective survey results presented in Table 4.2 also identified the right of way and engineering factors as the top two risks.

For this analysis, the standard deviation is greater than the mean for each risk factor. The use of cost/schedule tracking template in the future will increase the number of datasets available for simulation analysis. STE believes that increase in number of datasets with more accurate cost information will allow simulation analysis of various projects by type, category, and/or districts. This will reduce the standard deviation values as more projects of similar type, category, and by region are being analyzed.

Table 4.9 Risk Factors for All Data Using Best Fit Distribution.

Risk Factors		Graph	Distribution	Mean	Standard Deviation
R_1	ROW$ / AWARD		Log Normal	8.1%	49.5%
R_2	ENVIRONMENTAL$ / AWARD		Logistic	0.002%	0.125%
R_3	ENGINEERING$ / AWARD		Log Logistic	9.5%	18.4%
R_4	TRAFFIC$ / AWARD		Gamma	0.3	1.3%
R_5	STAKEHOLDERS$ / AWARD		Exponential	0.3%	0.3%
R_6	UNFORESEEN$ / AWARD		Log Logistic	0.2%	0.8%
R_7	MARKET$ / AWARD		Logistic	0.03%	0.25%
R_8	UTILTIES$ / AWARD		Log Logistic	0.1%	0.2%
Other	OTHER$ / AWARD		Logistic	-4.6%	9.7%

4.5.2 Risk Factors Fitted to Normal Distribution

STE utilized the normal distribution as a comparison to best fit analysis with the following assumptions:

- Data was assumed to be sample data
- Data was assumed to be continuous
- Used Normal Distribution
- Used Latin Hypercube sampling

Simulation Results

Table 4.10 presents the risk factors that were available for simulation, the distribution, the mean, and the standard deviation. Again, the results indicate that "Unforeseen Engineering Complexities/Constructability Issues" is the dominant risk factor. The standard deviation is also greater than the mean for each risk factor.

Table 4.10 Risk Factors for All Data Using Normal Distribution.

Risk Factors		Graph	Distribution	Mean	Standard Deviation
R_1	ROW$ / AWARD		Normal	4.6%	9.3%
R_2	ENVIRONMENTAL$ / AWARD		Normal	0.000%	0.203%
R_3	ENGINEERING$ / AWARD		Normal	9.8%	18.6%
R_4	TRAFFIC$ / AWARD		Normal	0.3%	1.3%
R_5	STAKEHOLDERS$ / AWARD		Normal	0.3%	0.7%
R_6	UNFORESEEN$ / AWARD		Normal	0.5%	2.1%
R_7	MARKET$ / AWARD		Normal	0.04%	0.37%
R_8	UTILTIES$ / AWARD		Normal	0.2%	1.0%
Other	OTHER$ / AWARD		Normal	-3.3%	15.1%

4.6 CUMULATIVE RISK FACTOR FOR AWARD & FINAL COMPARISON

STE conducted simulation analysis using all cost increases between Final and Award stages as one cumulative risk factor. Based on the information presented in Table 4.11, historically Final cost is approximately 12% more than Award cost. This is mostly due to the number of "change orders" observed during this time period. STE also evaluated the cumulative risk factor for capacity projects, which revealed that a typical capacity project would cost 16.6% more than what was expected at the time of award. Capacity analysis is provided in Appendix C.

Table 4.11 Cumulative Risk Factor for AWARD & FINAL Comparison.

Distribution	Mean	Standard Deviation
Best Fit	11.4%	24.1%
Normal	12.7%	24.5%

4.7 STIP & FINAL RISK FACTOR ANALYSIS

Model

The model used for the STIP & FINAL comparison is as follows:

$$(FINAL - STIP) / STIP = R_1 + R_2 \ldots + R_8 + Other \qquad \text{(eq. 4.4)}$$

where,

(FINAL – STIP) / STIP represents the change in Final cost as compared to STIP cost,
STIP represents the original STIP and not the programmed STIP,
FINAL is the project as built total cost,
'Other' represents risks that were not identified and is defined as FINAL minus STIP minus $\Sigma RISKS_{(BETWEEN\ STIP\ \&\ FINAL)}$, and
Risk factors in the equation (i.e., R1, R2,...,R8) represent the dollar amount for each risk factor divided by the STIP.

The risk factors are shown below:

- R_1 is (ΣROW$ from STIP to AWARD and AWARD to FINAL / STIP)
- R_2 is (ΣENVIRONMENTAL$ from STIP to AWARD and AWARD to FINAL / STIP)
- R_3 is (ΣENGINEERING$ from STIP to AWARD and AWARD to FINAL / STIP)
- R_4 is (ΣTRAFFIC$ from STIP to AWARD and AWARD to FINAL / STIP)
- R_5 is (ΣSTAKEHOLDERS$ from STIP to AWARD and AWARD to FINAL / STIP)
- R_6 is (ΣUNFORESEEN$ from STIP to AWARD and AWARD to FINAL / STIP)
- R_7 is (ΣMARKET$ from STIP to AWARD and AWARD to FINAL / STIP)
- R_8 is (ΣUTILTIES$ from STIP to AWARD and AWARD to FINAL / STIP)
- Other is (ΣOTHER$ from STIP to AWARD and AWARD to FINAL / STIP)

Number of Datasets

As stated before, NDOT provided forty five datasets using the data request template. Similarly to the other analysis that included the STIP value, several datasets were removed from analysis due to lack of information (i.e., missing STIP values) or because the dataset was an outlier (i.e., project 3238/72642 skewed results because STIP cost was $195,500 and Award cost was $18,400,477). Table 4.12 presents the datasets used in the analysis and again the number of datasets available for analysis was thirty eight.

Table 4.12 Datasets Used in STIP & FINAL Analysis.

Project Name/ID	
2593 Readv / 71472, 72052	3150 / 72400
2830 / 71976 / 71304 / IDR-DPC-9(3)043	3154 / 60108; 70858
2853 / 72031	3161 / 60158; 72807; 72657; 72493
2861 / 20134	3167 / 60188, 72805, 72493 Phase 3A
2957 / 72024 ; 72382	3187 / 60179; 72498
2995 / 60090; 72154	3193 / 60208; 72806; 72657
2996 / 72356, 72357, 72572	3201 / 60117 ; 72829 ; 72927 ; 72684
2999 / 72491 ; 72541 ; 72537	3209 / 60208 / 72806 / 72657
3003 / 72281	3215 / 60169, 72805, 72657
3038 - 60093; 72641	3217 / 72962
3039 / 72686	3237 / 60088; 72596; 72597
3052 / 72637	3241 / 72853
3053 / 60101 ; 72564 Phase 2A	3246 / 73137
3055 / 60103 ; 72657	3260 / 60207, 72806, 72807, 72657
3090 / 60099; 60125; 71394; 72610; 72711; 72720; 72355; 72410	3262 / 73133
3110 / 60106 ; 72564 Phase 2B	3266 / 73027
3120 / 60155 ; 72097	3267 / 60250, 60249, 72880, 72592, 72877
3127 / 60159; 72498	3297 / 60264 ; 73221
3130 Readv / 72800; 72471	3311 / 73156

4.7.1 Risk Factors Fitted to Best Fit Distribution

Simulation Results

Table 4.13 presents the risk factors that were available for simulation, the type of best fit distribution, the mean, and the standard deviation. The results indicate that 'Other' is the dominant risk factor as expected since many categories of risks did not have specific cost information in the datasets from STIP to AWARD. In addition, the standard deviation is greater than the mean for each risk factor. The large standard deviations can be due to a number of factors including inaccuracy in historical data reported for some risk factors and STE's observation that in most cases the initial STIP cost was not a complete and total cost. Similar to the previous cases, the results also indicate that "Unforeseen Engineering Complexities/Constructability Issues" is an influential risk factor followed by "Insufficient Knowledge of Right of Way".

Table 4.13 Risk Factors for All Data Using Best Fit Distribution.

Risk Factors[a]		Graph	Distribution	Mean	Standard Deviation
R_1	ROW$ / STIP		Inverse Gaussian	12.7%	23.6%
R_2	ENVIRONMENTAL$ / STIP		Logistic	0.01%	0.14%
R_3	ENGINEERING$ / STIP		Inverse Gaussian	30.7%	42.3%
R_4	TRAFFIC$ / STIP		Logistic	0.5%	2.6%
R_5	STAKEHOLDERS$ / STIP		Exponential	0.4%	0.4%
R_6	UNFORESEEN$ / STIP		Log Logistic	0.6%	2.2%
R_7	MARKET$ / STIP		Logistic	0.04%	0.32%
R_8	UTILTIES$ / STIP		Logistic	0.2%	0.8%
Other	OTHER$ / STIP		Log Logistic	86.8%	183.4%

[a]*The risk factor value represents the dollar amount from STIP to AWARD and AWARD to FINAL.*

4.7.2 Risk Factors Fitted to Normal Distribution

STE utilized the normal distribution as a comparison to best fit analysis with the following assumptions:

- Data was assumed to be sample data
- Data was assumed to be continuous
- Used Normal Distribution
- Used Latin Hypercube sampling

Simulation Results

Table 4.14 presents the risk factors that were available for simulation, the distribution, the mean, and the standard deviation. The results indicate that 'Other' is the dominant risk factor as expected since many categories of risks did not have specific cost information in the datasets from STIP to AWARD. In addition, the standard deviation is greater than the mean for each risk factor. The large standard deviations can be due to a number of factors including inaccuracy in historical data reported for some risk factors and STE's observation that in many cases the initial STIP cost was not a complete and total cost. Similar to previous cases, the results also indicate that "Unforeseen Engineering Complexities/Constructability Issues" is an influential risk factor followed by "Insufficient Knowledge of Right of Way".

Table 4.14 Risk Factors for All Data Using Normal Distribution.

Risk Factors[a]		Graph	Distribution	Mean	Standard Deviation
R_1	ROW$ / AWARD		Normal	12.7%	20.6%
R_2	ENVIRONMENTAL$ / AWARD		Normal	0.05%	0.23%
R_3	ENGINEERING$ / AWARD		Normal	30.7%	41.0%
R_4	TRAFFIC$ / AWARD		Normal	1.0%	4.4%
R_5	STAKEHOLDERS$ / AWARD		Normal	0.4%	1.3%
R_6	UNFORESEEN$ / AWARD		Normal	1.2%	4.4%
R_7	MARKET$ / AWARD		Normal	0.02%	0.46%
R_8	UTILTIES$ / AWARD		Normal	0.5%	1.4%
Other	OTHER$ / AWARD		Normal	78.4%	118.3%

[a]The risk factor value represents the dollar amount from STIP to AWARD and AWARD to FINAL.

4.8 CUMULATIVE RISK FACTOR FOR STIP & FINAL COMPARISON

STE conducted another simulation analysis using all cost increases between Final and STIP stages as one cumulative risk factor. Based on the information presented in Table 4.15, historically Final cost is approximately 125% more than what was estimated at the time of STIP. This is mostly due to the fact that for many projects the STIP cost was not reported as a total cost. STE also evaluated the cumulative risk factor for capacity projects, which revealed that a typical capacity project would cost approximately 132% more than what was estimated at the time of STIP. Capacity analysis is provided in Appendix C.

Table 4.15 Cumulative Risk Factor for STIP & FINAL Comparison.

Distribution	Mean	Standard Deviation
Best Fit	140.4%	304.1%
Normal	124.9%	146.9%

4.9 FRAMEWORK FOR CAPTURING RISK FACTORS

As discussed previously, STE developed a data request template for NDOT, which can be utilized to track cost and schedule changes throughout the life cycle of a project. This template shown in Appendix B can be the framework for an NDOT cost/schedule tracking system. As a summary, STE recommends the following steps:

Step 1. Make the cost estimating tracking system an integrated part of every project from the time of STIP to final construction cost. The cost estimating tracking system can remain Excel based or it can become a "module" in NDOT's database. The tracking system can also be further developed into a user friendly program. The system should include risk factor categories as defined by NDOT during this project or "new" categories, which better fit the future parametric cost estimating tool. The risk factor categories should be understandable and clear so personnel can readily input costs into a category.

Step 2. A commercial simulation package such as @Risk or Crystal Ball should be purchased to support the simulation analysis. These readily available packages can be run as an add-on to an Excel spreadsheet and are reasonably priced (i.e., below $2,000).

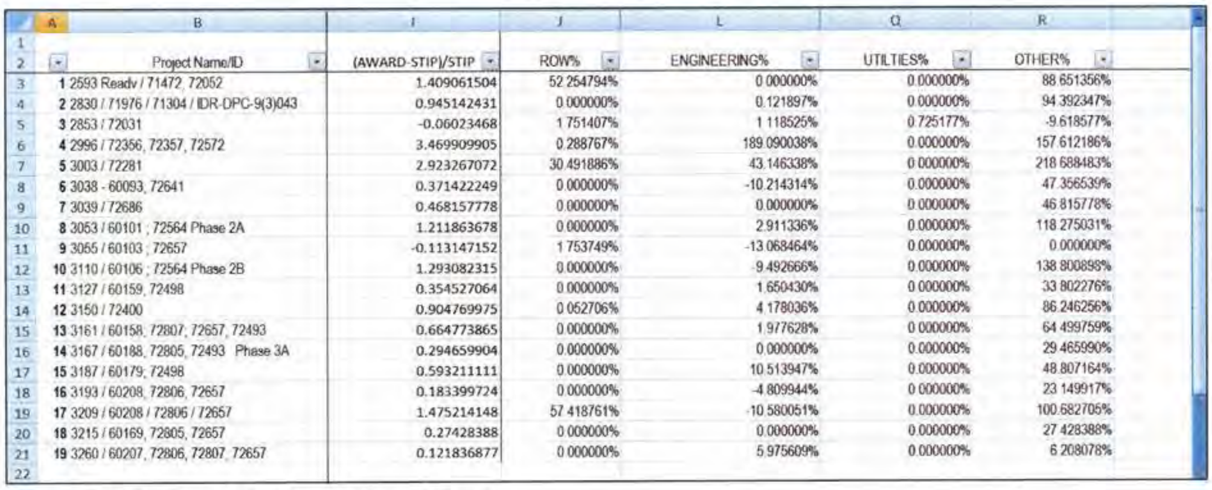
Step 3. Review and reduce data from cost estimating tracking system. As shown in the analysis performed by STE, the data must be reviewed thoroughly prior to conducting risk factor analysis by personnel.

Step 4. Create risk factor analysis database, where simulation calculations occur. The following example was developed using @RISK. STE created a spreadsheet with the risk factors based on equations 4.1, 4.3, and 4.4 depending on which risk factor analysis period one is simulating. The database format should resemble the example provided in Figure 4.1.

Step 5. Using @RISK, an estimator can fit a specific risk category's data to a statistical distribution. In this example, "Insufficient Knowledge of Right of Way" data was fitted to an Inverse Gaussian distribution as shown in Figure 4.2. Several simulation decisions should be made:

- Decide on type of data (most likely sample data and continuous)
- Decide on type of simulation (Monte Carlo, Latin Hypercube)
- Decide on type of statistical distribution (best fit versus most realistic)

In this example, 1,000 simulations were performed on each risk category. Based on the fitted distributions, an estimator can calculate a category's most likely risk factor. Once the data has been fitted to a statistical distribution, @RISK can be used to perform the sampling simulation. The simulation process further refines the calculated risk factor. For example, a Latin Hypercube simulation on the "Insufficient Knowledge of Right of Way" data gave a most likely value of 4.3% as shown in Figure 4.3.



	Project Name/ID	(AWARD-STIP)/STIP	ROW%	ENGINEERING%	UTILTIES%	OTHER%
3	1 2593 Readv / 71472, 72052	1.409061504	52.254794%	0.000000%	0.000000%	88.651356%
4	2 2830 / 71976 / 71304 / IDR-DPC-9(3)043	0.945142431	0.000000%	0.121897%	0.000000%	94.392347%
5	3 2853 / 72031	-0.06023468	1.751407%	1.118525%	0.725177%	-9.618577%
6	4 2996 / 72356, 72357, 72572	3.469909905	0.288767%	189.090038%	0.000000%	157.612186%
7	5 3003 / 72281	2.923267072	30.491886%	43.146338%	0.000000%	218.688483%
8	6 3038 - 60093, 72641	0.371422249	0.000000%	-10.214314%	0.000000%	47.356539%
9	7 3039 / 72686	0.468157778	0.000000%	0.000000%	0.000000%	46.815778%
10	8 3053 / 60101 ; 72564 Phase 2A	1.211863678	0.000000%	2.911336%	0.000000%	118.275031%
11	9 3055 / 60103 ; 72657	-0.113147152	1.753749%	-13.068464%	0.000000%	0.000000%
12	10 3110 / 60106 ; 72564 Phase 2B	1.293082315	0.000000%	-9.492666%	0.000000%	138.800898%
13	11 3127 / 60159, 72498	0.354527064	0.000000%	1.650430%	0.000000%	33.802276%
14	12 3150 / 72400	0.904769975	0.052706%	4.178036%	0.000000%	86.246256%
15	13 3161 / 60158, 72807, 72657, 72493	0.664773865	0.000000%	1.977628%	0.000000%	64.499759%
16	14 3167 / 60188, 72805, 72493 Phase 3A	0.294659904	0.000000%	0.000000%	0.000000%	29.465990%
17	15 3187 / 60179, 72498	0.593211111	0.000000%	10.513947%	0.000000%	48.807164%
18	16 3193 / 60208, 72806, 72657	0.183399724	0.000000%	-4.809944%	0.000000%	23.149917%
19	17 3209 / 60208 / 72806 / 72657	1.475214148	57.418761%	-10.580051%	0.000000%	100.682705%
20	18 3215 / 60169, 72805, 72657	0.27428388	0.000000%	0.000000%	0.000000%	27.428388%
21	19 3260 / 60207, 72806, 72807, 72657	0.121836877	0.000000%	5.975609%	0.000000%	6.208078%

Figure 4.1 Format of Database Spreadsheet.

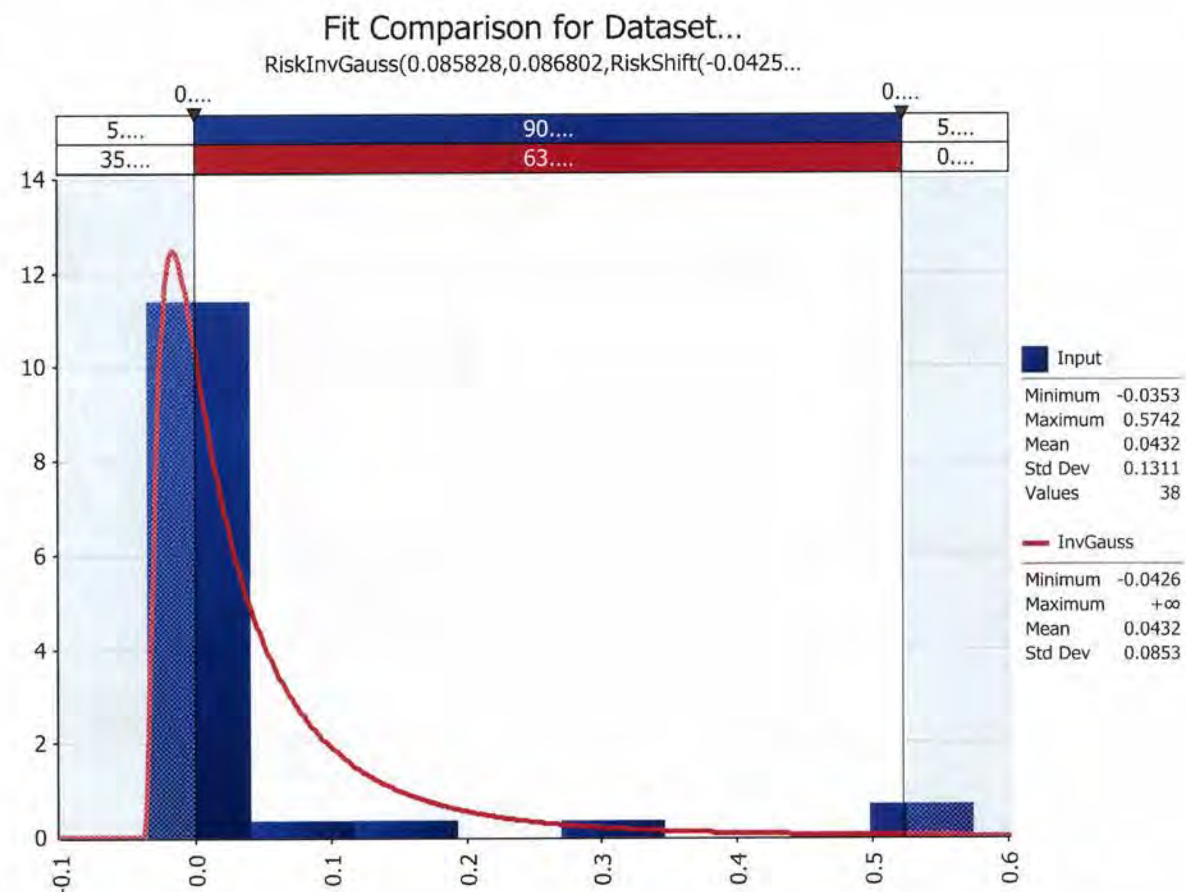


Figure 4.2 Data Fitting Curve for Insufficient Knowledge of Right of Way Data.

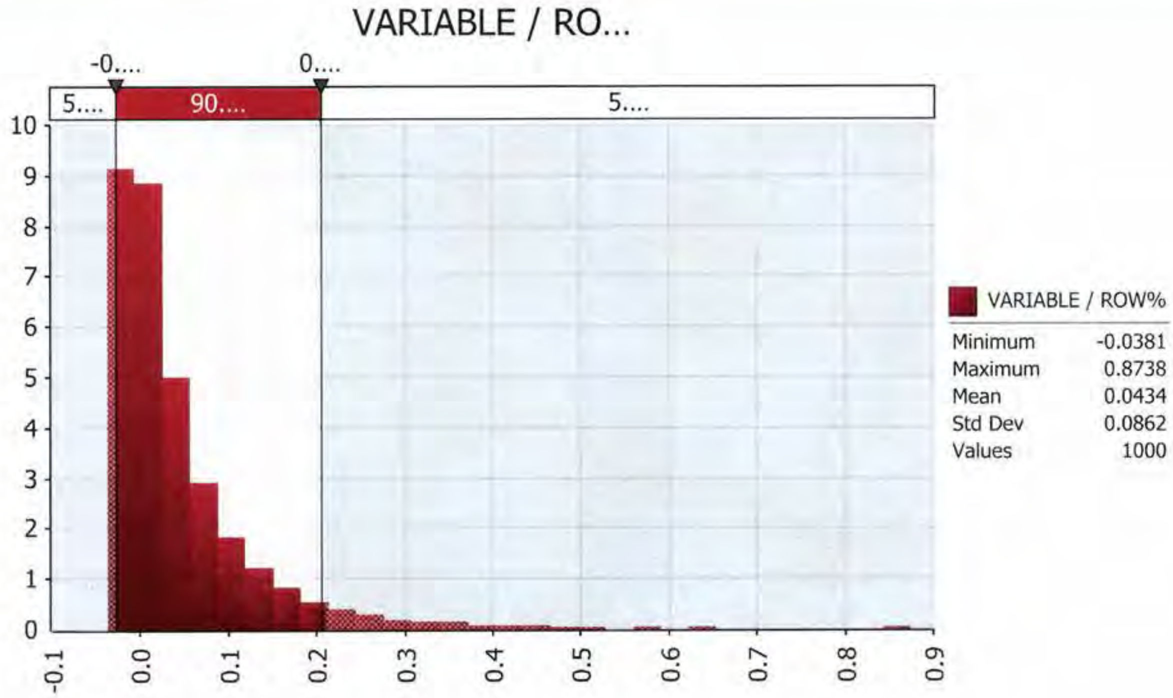


Figure 4.3 Simulation Output.

Step 6. The risk factors obtained in Step 5 for each category and type of project could be used to replace the unknown portion of existing contingencies in NDOT's cost estimating practices (e.g., future parametric cost estimating tool).

Step 7. A yearly update of risk factors could be conducted using the most up to date data from the cost estimating tracking system. NDOT could then evaluate risk factors by project type, category, and districts.

5.0 COST INDEXING

As part of this project, STE was tasked to evaluate cost indexing. The cost of construction materials is a major component of highway project costs. It is important for an agency to track the cost of construction materials and study trends in costs as they impact the delivery of a project within its scope, schedule, and budget. STE evaluated the construction costs to identify key parameters that influence project costs. The remainder of this section describes our analysis efforts.

5.1 DATABASE

STE used a spreadsheet called "currentrespuwokall.xls" provided by NDOT. This spreadsheet has work unit costs from 1985 to 2009 (partial). STE analyzed this historical database to discover which factors were most influential to the construction cost. In addition, STE developed a framework for computing cost indices and investigated historical inflation rates.

5.2 DATA REDUCTION

The database had over 60,000 records. STE reduced the data into "work units" or "line items" and further reduced the data by unit of measure. The number of distinct line items was 4,341 records, which were used to identify the most influential factors impacting project costs. Cost was computed by multiplying quantity by engineering unit price.

5.3 DATABASE ISSUES

STE's quality assurance check of the dataset identified seventeen records with issues as shown in Table 5.1. The primary issue occurred with the "eng unit price" for records where the "unit of measure" was "LS" (lump sum) and "FA" (force account). The issue was that the "eng unit price" was the full lump sum price instead of a price per unit. For those records, STE inserted the "reasonable unit price" value for "eng unit price." Another issue occurred for work unit, 6900100 Design Build, which had two entries with the same value. For this record, STE removed the duplicate record.

Table 5.1 Edited or Removed Records.

Cont	Work Unit	Work Unit Description	Award Date	Action
03001	2010012	REMOVE TREES	1/31/2000	Edited
02997	2020020	REMOVAL OF PORTION OF BRIDGE	2/24/2000	Edited
02910	2120088	PLANT ESTABLISHMENT WORK	10/20/1998	Edited
02997	2120101	REMOVE AND REPLACE LANDSCAPING	2/24/2000	Edited
03001	2130212	ADJUST IRRIGATION SYSTEM	1/31/2000	Edited
02997	5020017	CONCRETE BRIDGE DECK REPAIR	2/24/2000	Edited
02997	5030012	PRESTRESSING CAST-IN-PLACE CONCRETE	2/24/2000	Edited
02997	6230764	REMOVAL OF EXISTING LIGHTING SYSTEM	2/24/2000	Edited
03001	6240160	RENT TRAFFIC CONTROL DEVICES	1/31/2000	Edited
03020	6240160	RENT TRAFFIC CONTROL DEVICES	5/12/2000	Edited
03035	6240160	RENT TRAFFIC CONTROL DEVICES	8/11/2000	Edited
02910	6370000	TEMPORARY POLLUTION CONTROL	10/20/1998	Edited
02929	6370000	TEMPORARY POLLUTION CONTROL	1/25/1999	Edited
02997	6370000	TEMPORARY POLLUTION CONTROL	2/24/2000	Edited
03012	6370000	TEMPORARY POLLUTION CONTROL	4/10/2000	Edited
02764	6370010	TREATMENT SYSTEM, CONTAMINATED GROUND WATER	7/16/1996	Edited
03313	6900100	DESIGN BUILD	7/5/2007	Removed

5.4 MOST INFLUENTIAL FACTORS

STE ranked all costs (i.e., 4,341 records that correspond to work units) from largest to smallest cost. The total cost computed from the database was $5,330,268,251. STE observed that a significant percentage (i.e., approximately 47%) of the total cost from 1985 to 2009 (partial) could be attributed to seventy five work units as shown in Table 5.2. This is approximately 1.7% (75 / 4,341 = 1.7%) of the number of work units used in NDOT construction projects. If NDOT could capture and utilize the inflationary information for these seventy five work units, it could improve its cost estimates significantly.

Exclusions

STE excluded "LS" (lump sum) items from cumulative tally because of the lack of a true unit of measure. For example, an item that attributed the second most to NDOT's total cost was work unit 6900100, which refers to Design Build. In year 2007, approximately half of the reported $495,260,380 cost was due to one design build project for $242,337,447. The Design Build project was excluded from STE analysis due to incompatible unit price.

STE also excluded work units, which could not be readily converted into same units of measure. For example, work unit, 2022136, Remove Bituminous Surface (Cold Milling) was in square yards. However, most other asphalt materials are in tons or metric tons.

In the database provided to STE, the year 1997 only had a total cost of $573,035 and none of the expenditures were in the seventy five work units used by STE. Follow up discussions with NDOT revealed that "currentrespuwokall.xls" database only had partial information for 1997 and 1998. STE excluded the 1997 and 1998 data from its analysis.

Table 5.2 Most Influential Factors - 75 Work Units from 1985 to 2009 (Partial).

Work Unit	Work Unit Description	Unit of Measure	Total Cost
4026002	PLANTMIX SURFACING (TYPE 2C)(WET)	TON	$ 225,149,188
4020572	PLANTMIX BITUMINOUS SURFACE AGGREGATE (TYPE 2)	TON	$ 137,172,274
4026000	PLANTMIX SURFACING (TYPE 2)(WET)	TON	$ 127,646,881
4020636	ASPHALT CEMENT, GRADE AC-20P	TON	$ 98,417,514
3020500	TYPE 1 CLASS B AGGREGATE BASE	TON	$ 92,848,336
5020828	CLASS A CONCRETE, MODIFIED (MAJOR)	CUYD	$ 84,920,626
2030540	BORROW EMBANKMENT	CUYD	$ 83,463,200
4036000	PLANTMIX OPEN-GRADED SURFACING (3/8-INCH)(WET)	TON	$ 76,658,688
2030508	ROADWAY EXCAVATION	CUYD	$ 72,271,714
3022000	TYPE 1 CLASS B AGGREGATE BASE	MTON	$ 65,086,961
4052016	EMULSIFIED ASPHALT, TYPE SS-1H (DILUTED)	MTON	$ 61,532,117
5050500	REINFORCING STEEL	POUND	$ 59,546,434
4020576	PLANTMIX BITUMINOUS SURFACE AGGREGATE (TYPE 2)(COARSE)	TON	$ 58,391,723
5022332	CLASS A CONCRETE, MODIFIED (MAJOR)	CUM	$ 58,218,610
4026008	PLANTMIX SURFACING (TYPE 2C)(WET)	MTON	$ 54,586,480
5020840	CLASS AA CONCRETE, MODIFIED (MAJOR)	CUYD	$ 44,005,500
5052000	REINFORCING STEEL	KG	$ 43,778,815
4022302	PLANTMIX SURFACING (TYPE 2) (WET)	MTON	$ 41,919,985
4020516	ASPHALT CEMENT GRADE AR-4000	TON	$ 39,319,050
4022132	ASPHALT CEMENT, GRADE AC-20P	MTON	$ 37,916,929
3070500	SHOULDERING MATERIAL	TON	$ 36,428,955
4022072	PLANTMIX BITUMINOUS SURFACE AGGREGATE (TYPE 2)(COARSE)	MTON	$ 36,363,185
4022300	PLANTMIX SURFACING (TYPE 2C)(WET)	MTON	$ 33,264,260
4010500	MINERAL FILLER	TON	$ 32,074,891
2032008	ROADWAY EXCAVATION	CUM	$ 31,954,563
4030544	PLANTMIX BITUMINOUS OPEN-GRADED SURFACE AGGREGATE (3/8-INCH)	TON	$ 30,812,462
2060500	STRUCTURE EXCAVATION	CUYD	$ 29,275,115
2062000	STRUCTURE EXCAVATION	CUM	$ 29,116,381
4036002	PLANTMIX OPEN-GRADED SURFACING (1/2-INCH)(WET)	TON	$ 28,532,125
5022361	CLASS DA CONCRETE, MODIFIED (MAJOR) (SPECIAL)	CUM	$ 27,399,460
4020632	ASPHALT CEMENT, GRADE AC-20	TON	$ 26,169,619
5020864	CLASS EA CONCRETE, MODIFIED (MAJOR)	CUYD	$ 24,309,690
5022368	CLASS EA CONCRETE, MODIFIED (MAJOR)	CUM	$ 23,729,054
5022360	CLASS DA CONCRETE, MODIFIED (MAJOR)	CUM	$ 23,469,320

Table 5.2 (Continued)

Work Unit	Work Unit Description	Unit of Measure	Total Cost
2030528	BORROW EXCAVATION	CUYD	$ 21,757,511
4022068	PLANTMIX BITUMINOUS SURFACE AGGREGATE (TYPE 2)	MTON	$ 21,596,696
2070504	GRANULAR BACKFILL	CUYD	$ 21,461,721
4090520	PORTLAND CEMENT CONCRETE PAVEMENT (11-INCHES)	SQYD	$ 20,123,011
3072000	SHOULDERING MATERIAL	MTON	$ 19,908,811
4090540	PORTLAND CEMENT CONCRETE PAVEMENT (10-1/2-INCHES)	SQYD	$ 19,519,160
2032036	BORROW EMBANKMENT	CUM	$ 18,652,520
5022344	CLASS AA CONCRETE, MODIFIED (MAJOR)	CUM	$ 18,607,675
5052004	REINFORCING STEEL (EPOXY COATED)	KG	$ 18,581,227
2072004	GRANULAR BACKFILL	CUM	$ 18,023,754
4050516	EMULSIFIED ASPHALT, TYPE SS-1H (DILUTED)	TON	$ 17,977,949
2032012	ROADWAY EXCAVATION (TYPE A)	CUM	$ 17,813,138
4030564	ASPHALT CEMENT, GRADE AC-20P	TON	$ 17,686,635
4090512	PORTLAND CEMENT CONCRETE PAVEMENT (9-INCHES)	SQYD	$ 17,391,848
5050504	REINFORCING STEEL (EPOXY COATED)	POUND	$ 14,548,756
4030548	PLANTMIX BITUMINOUS OPEN-GRADED SURFACE AGGREGATE (1/2-INCH)	TON	$ 14,233,417
4020624	ASPHALT CEMENT, GRADE AC-10	TON	$ 14,145,360
4032080	PLANTMIX OPEN GRADED SURFACING (9.5-MM)(WET)	MTON	$ 12,911,235
6402048	MECHANICALLY STABILIZED EARTH BACKFILL	CUM	$ 12,541,376
4090536	PORTLAND CEMENT CONCRETE PAVEMENT (9-1/2-INCHES)	SQYD	$ 12,347,407
2030548	SELECTED BORROW EMBANKMENT	CUYD	$ 12,113,776
2032033	EMBANKMENT	CUM	$ 11,973,960
4032040	PLANTMIX BITUMINOUS OPEN-GRADED SURFACE AGGREGATE (9.5-MM)	MTON	$ 11,757,822
4026006	PLANTMIX SURFACING (TYPE 2)(WET)	MTON	$ 11,522,020
6400148	MECHANICALLY STABILIZED EARTH BACKFILL	CUYD	$ 11,459,255
4020648	ASPHALT CEMENT, GRADE AC-30	TON	$ 10,103,245
3020524	TYPE 2 CLASS B AGGREGATE BASE	TON	$ 9,377,550
4090516	PORTLAND CEMENT CONCRETE PAVEMENT (10-INCHES)	SQYD	$ 8,914,720
4092026	PORTLAND CEMENT CONCRETE PAVEMENT (330-MM)	SQM	$ 8,307,560
4030568	ASPHALT CEMENT, GRADE AC-20 (RUBBERIZED)	TON	$ 8,057,980
2030520	CHANNEL EXCAVATION	CUYD	$ 7,835,971
4012000	MINERAL FILLER	MTON	$ 7,510,754
5020512	CLASS AA CONCRETE (MAJOR)	CUYD	$ 6,867,405
5022370	CLASS EA CONCRETE, MODIFIED (MAJOR) (SPECIAL)	CUM	$ 6,865,300
4032044	PLANTMIX BITUMINOUS OPEN-GRADED SURFACE AGGREGATE (12.5-MM)	MTON	$ 6,802,150
4036006	PLANTMIX OPEN-GRADED SURFACING (12.5-MM)(WET)	MTON	$ 6,771,830
2032044	SELECTED BORROW EMBANKMENT	CUM	$ 6,447,868
3020584	TYPE 1 CLASS A AGGREGATE BASE	TON	$ 6,293,378
5022348	CLASS AA CONCRETE, MODIFIED (MINOR)	CUM	$ 6,207,845
4070508	LIQUID ASPHALT, TYPE MC-250	TON	$ 5,949,760
4036004	PLANTMIX OPEN-GRADED SURFACING (9.5-MM)(WET)	MTON	$ 5,841,940

5.5 COST INDEXING FRAMEWORK

5.5.1 Categorization

STE reduced the database to just the seventy five work unit items which attributed approximately 47% of total cost reported from 1985 to 2009 (partial). This reduced the number of records from 60,716 to 6,750. Agencies typically develop cost indices for the most significant construction categories. For example, Figure 5.1 illustrates categories used by WSDOT and MDT.

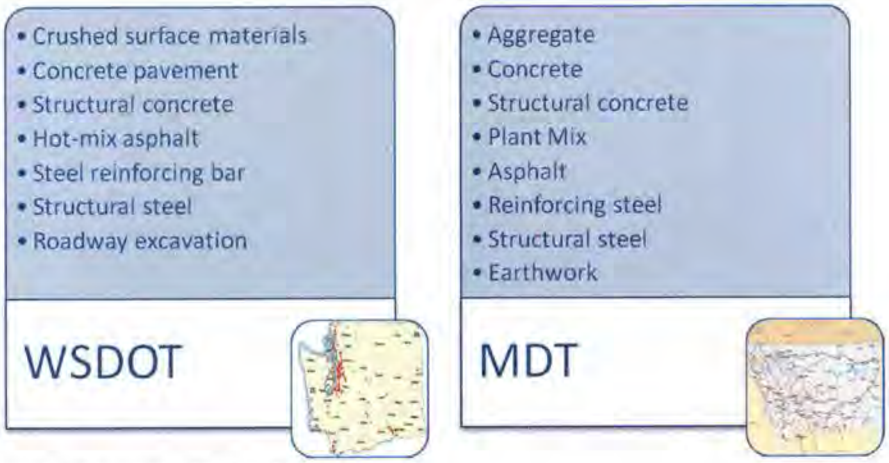


Figure 5.1 Example Categories for Cost Indexing.

<u>Example NDOT Categorization</u>

STE used the categories from WSDOT for the NDOT cost indexing analysis. STE reviewed the seventy five work units and placed them into the representative categories shown in Table 5.3. Table 5.4 represents the seventy five work units and their new categorization. In addition, STE converted any SI units to US Customary units, such as square meter to square yard, metric ton to ton, cubic meter to cubic yard, and kilogram to pound. This was done in order to have a single unit of measure and to summarize quantities for each category. From the top seventy five work units, there were no work units that fit into the structural steel category, which means that this category is not represented in the analysis. NDOT could decide to select work units that fit in the structural steel category based on staff experience or drop the category from indexing completely.

Table 5.3 Categories for NDOT Example.

Categories		Code	Units of Measure
1	Crushed Surface Materials	CSM	ton
2	Concrete Pavement	CP	yd^2
3	Structural Concrete	SC	yd^3
4	Hot-Mix Asphalt	HMA	ton
5	Steel Reinforcing Bar	SRB	lb
6	Structural Steel[a]	SS	ln ft
7	Roadway Excavation	RE	yd^3

[a]There were no representatives from the seventy five work units.

Table 5.4 75 Work Units with Category and Quantity.

Category	Work Unit	Work Unit Description	Quantity	Unit of Measure
CP	4090512	PORTLAND CEMENT CONCRETE PAVEMENT (9-INCHES)	1287796	SQYD
CP	4090516	PORTLAND CEMENT CONCRETE PAVEMENT (10-INCHES)	532735	SQYD
CP	4090520	PORTLAND CEMENT CONCRETE PAVEMENT (11-INCHES)	959006	SQYD
CP	4090536	PORTLAND CEMENT CONCRETE PAVEMENT (9-1/2-INCHES)	904535	SQYD
CP	4090540	PORTLAND CEMENT CONCRETE PAVEMENT (10-1/2-INCHES)	1064800	SQYD
CP	4092026	PORTLAND CEMENT CONCRETE PAVEMENT (330-MM)	192508	SQM
CSM	3020500	TYPE 1 CLASS B AGGREGATE BASE	10717034	TON
CSM	3020524	TYPE 2 CLASS B AGGREGATE BASE	1173267	TON
CSM	3020584	TYPE 1 CLASS A AGGREGATE BASE	796084	TON
CSM	3022000	TYPE 1 CLASS B AGGREGATE BASE	5157665	MTON
CSM	3070500	SHOULDERING MATERIAL	5302036	TON
CSM	3072000	SHOULDERING MATERIAL	2316425	MTON
CSM	4010500	MINERAL FILLER	254170	TON
CSM	4012000	MINERAL FILLER	51611	MTON
HMA	4020516	ASPHALT CEMENT GRADE AR-4000	258537	TON
HMA	4020572	PLANTMIX BITUMINOUS SURFACE AGGREGATE (TYPE 2)	9958834	TON
HMA	4020576	PLANTMIX BITUMINOUS SURFACE AGGREGATE (TYPE 2)(COARSE)	4402043	TON
HMA	4020624	ASPHALT CEMENT, GRADE AC-10	96019	TON
HMA	4020632	ASPHALT CEMENT, GRADE AC-20	165650	TON
HMA	4020636	ASPHALT CEMENT, GRADE AC-20P	449282	TON
HMA	4020648	ASPHALT CEMENT, GRADE AC-30	61124	TON
HMA	4022068	PLANTMIX BITUMINOUS SURFACE AGGREGATE (TYPE 2)	991554	MTON
HMA	4022072	PLANTMIX BITUMINOUS SURFACE AGGREGATE (TYPE 2)(COARSE)	1688088	MTON
HMA	4022132	ASPHALT CEMENT, GRADE AC-20P	149786	MTON
HMA	4022300	PLANTMIX SURFACING (TYPE 2C)(WET)	1029250	MTON
HMA	4022302	PLANTMIX SURFACING (TYPE 2) (WET)	1253395	MTON
HMA	4026000	PLANTMIX SURFACING (TYPE 2)(WET)	2276677	TON
HMA	4026002	PLANTMIX SURFACING (TYPE 2C)(WET)	4575001	TON
HMA	4026006	PLANTMIX SURFACING (TYPE 2)(WET)	312120	MTON
HMA	4026008	PLANTMIX SURFACING (TYPE 2C)(WET)	1011025	MTON
HMA	4030544	PLANTMIX BITUMINOUS OPEN-GRADED SURFACE AGGREGATE (3/8-INCH)	1714264	TON
HMA	4030548	PLANTMIX BITUMINOUS OPEN-GRADED SURFACE AGGREGATE (1/2-INCH)	810141	TON
HMA	4030564	ASPHALT CEMENT, GRADE AC-20P	73038	TON
HMA	4030568	ASPHALT CEMENT, GRADE AC-20 (RUBBERIZED)	31320	TON
HMA	4032040	PLANTMIX BITUMINOUS OPEN-GRADED SURFACE AGGREGATE (9.5-MM)	430527	MTON

Table 5.4 (Continued)

Category	Work Unit	Work Unit Description	Quantity	Unit of Measure
HMA	4032044	PLANTMIX BITUMINOUS OPEN-GRADED SURFACE AGGREGATE (12.5-MM)	239222	MTON
HMA	4032080	PLANTMIX OPEN GRADED SURFACING (9.5-MM)(WET)	345192	MTON
HMA	4036000	PLANTMIX OPEN-GRADED SURFACING (3/8-INCH)(WET)	1128360	TON
HMA	4036002	PLANTMIX OPEN-GRADED SURFACING (1/2-INCH)(WET)	520775	TON
HMA	4036004	PLANTMIX OPEN-GRADED SURFACING (9.5-MM)(WET)	91990	MTON
HMA	4036006	PLANTMIX OPEN-GRADED SURFACING (12.5-MM)(WET)	139290	MTON
HMA	4050516	EMULSIFIED ASPHALT, TYPE SS-1H (DILUTED)	75955	TON
HMA	4052016	EMULSIFIED ASPHALT, TYPE SS-1H (DILUTED)	248836	MTON
HMA	4070508	LIQUID ASPHALT, TYPE MC-250	21578	TON
RE	2030508	ROADWAY EXCAVATION	14947878	CUYD
RE	2030520	CHANNEL EXCAVATION	1758079	CUYD
RE	2030528	BORROW EXCAVATION	4558341	CUYD
RE	2030540	BORROW EMBANKMENT	16850426	CUYD
RE	2030548	SELECTED BORROW EMBANKMENT	1934989	CUYD
RE	2032008	ROADWAY EXCAVATION	3375229	CUM
RE	2032012	ROADWAY EXCAVATION (TYPE A)	3847330	CUM
RE	2032033	EMBANKMENT	2993490	CUM
RE	2032036	BORROW EMBANKMENT	2135926	CUM
RE	2032044	SELECTED BORROW EMBANKMENT	547626	CUM
RE	2060500	STRUCTURE EXCAVATION	2031521	CUYD
RE	2062000	STRUCTURE EXCAVATION	1307782	CUM
RE	2070504	GRANULAR BACKFILL	1256917	CUYD
RE	2072004	GRANULAR BACKFILL	684064	CUM
RE	6400148	MECHANICALLY STABILIZED EARTH BACKFILL	550248	CUYD
RE	6402048	MECHANICALLY STABILIZED EARTH BACKFILL	501166	CUM
SC	5020512	CLASS AA CONCRETE (MAJOR)	15818	CUYD
SC	5020828	CLASS A CONCRETE, MODIFIED (MAJOR)	300823	CUYD
SC	5020840	CLASS AA CONCRETE, MODIFIED (MAJOR)	121186	CUYD
SC	5020864	CLASS EA CONCRETE, MODIFIED (MAJOR)	62204	CUYD
SC	5022332	CLASS A CONCRETE, MODIFIED (MAJOR)	142316	CUM
SC	5022344	CLASS AA CONCRETE, MODIFIED (MAJOR)	34579	CUM
SC	5022348	CLASS AA CONCRETE, MODIFIED (MINOR)	3319	CUM
SC	5022360	CLASS DA CONCRETE, MODIFIED (MAJOR)	32229	CUM
SC	5022361	CLASS DA CONCRETE, MODIFIED (MAJOR) (SPECIAL)	18206	CUM
SC	5022368	CLASS EA CONCRETE, MODIFIED (MAJOR)	34315	CUM
SC	5022370	CLASS EA CONCRETE, MODIFIED (MAJOR) (SPECIAL)	10562	CUM
SRB	5050500	REINFORCING STEEL	81284158	POUND
SRB	5050504	REINFORCING STEEL (EPOXY COATED)	15107310	POUND
SRB	5052000	REINFORCING STEEL	28401594	KG
SRB	5052004	REINFORCING STEEL (EPOXY COATED)	7231282	KG

5.5.2 Average Prices

For each year, STE computed the quantity and cost for each category. A summary is provided in Appendix D. The average price was calculated by summarizing the costs for each category and dividing by their quantity. Table 5.5 presents the average price for each year and each category.

Table 5.5 Yearly Average Price Per Category.

	Categories						
	Crushed Surface Materials	Concrete Pavement	Structural Concrete	Hot-Mix Asphalt	Steel Reinforcing Bar	Structural Steel[a]	Roadway Excavation
	1	2	3	4	5	6	7
	Units						
Year	ton	yd²	yd³	ton	lb	ln ft	yd³
1985	$7.24		$247.48	$21.44	$0.55		$4.39
1986	$11.53	$17.50	$226.50	$23.24	$0.49		$4.30
1987	$8.33	$14.06	$242.59	$21.90	$0.49		$3.42
1988	$9.90	$11.00	$260.28	$23.52	$0.57		$4.86
1989	$8.18	$13.63	$255.00	$22.07	$0.50		$5.29
1990	$10.79		$245.49	$25.52	$0.51		$4.57
1991	$8.39	$13.48	$215.21	$28.24	$0.47		$3.72
1992	$8.88	$18.75	$276.50	$26.46	$0.52		$4.41
1993	$9.18	$20.46	$265.95	$26.75	$0.55		$3.92
1994	$10.09	$17.00	$336.58	$27.40	$2.32		$5.12
1995	$13.14		$297.47	$28.15	$0.60		$6.07
1996	$11.99	$22.58	$456.47	$28.32	$0.69		$7.15
1997[b]							
1998[b]							
1999	$10.01	$25.00	$451.45	$48.47	$1.01		$9.58
2000	$13.34	$35.52	$333.23	$32.79	$0.65		$9.45
2001	$12.50	$37.63	$332.21	$28.43	$0.70		$6.97
2002	$8.24		$389.07	$33.73	$0.73		$9.59
2003	$8.74	$24.00	$387.56	$34.41	$0.61		$7.10
2004	$10.81	$30.06	$300.23	$42.60	$0.87		$9.52
2005	$10.63		$382.71	$50.73	$0.96		$10.94
2006	$11.34	$35.10	$610.27	$66.54	$1.12		$6.38
2007	$11.86	$55.00	$501.85	$73.41	$1.30		$11.17
2008	$10.33	$40.00	$567.37	$71.19	$1.23		$8.51
2009[c]							

[a]There were no representatives from the seventy five work units.
[b]Issue extracting bid history from parts of 1997 and 1998.
[c]Partial data for 2009.

5.5.3 Index

STE selected year 2000 as the "index" year. All category values were then divided by the index year value and multiplied by 100. This makes the categories for the index year to be a 100. The other years vary from 100. Table 5.6 presents the cost indices for each category.

Table 5.6 Cost Indices Per Category (Index Year 2000).

	Categories						
	Crushed Surface Materials	Concrete Pavement	Structural Concrete	Hot-Mix Asphalt	Steel Reinforcing Bar	Structural Steel[a]	Roadway Excavation
	1	2	3	4	5	6	7
	Units						
Year	ton	yd^2	yd^3	ton	lb	In ft	yd^3
1985	54.3		74.3	65.4	84.5		46.4
1986	86.5	49.3	68.0	70.9	75.6		45.5
1987	62.4	39.6	72.8	66.8	76.4		36.1
1988	74.2	31.0	78.1	71.7	87.9		51.4
1989	61.3	38.4	76.5	67.3	76.8		56.0
1990	80.9		73.7	77.8	78.7		48.4
1991	62.9	37.9	64.6	86.1	73.3		39.4
1992	66.6	52.8	83.0	80.7	80.9		46.6
1993	68.8	57.6	79.8	81.6	84.4		41.4
1994	75.6	47.9	101.0	83.6	358.8		54.2
1995	98.5		89.3	85.8	92.8		64.2
1996	89.9	63.6	137.0	86.4	106.3		75.6
1997[b]							
1998[b]							
1999	75.0	70.4	135.5	147.8	155.9		101.3
2000	100.0	100.0	100.0	100.0	100.0		100.0
2001	93.7	105.9	99.7	86.7	108.0		73.7
2002	61.8		116.8	102.8	113.1		101.5
2003	65.5	67.6	116.3	104.9	94.0		75.1
2004	81.0	84.6	90.1	129.9	133.9		100.7
2005	79.7		114.8	154.7	148.6		115.7
2006	85.1	98.8	183.1	202.9	172.2		67.5
2007	88.9	154.8	150.6	223.9	201.2		118.1
2008	77.4	112.6	170.3	217.1	189.9		90.0
2009[c]							

[a]There were no representatives from the seventy five work units.
[b]Issue extracting bid history from parts of 1997 and 1998.
[c]Partial data for 2009.

5.5.4 Weighted Prices

STE computed the historical distribution of costs for the example categories as shown in Table 5.7. This distribution was then multiplied by the index for each category and each year. The summation of each year represents the index for that year and is presented in Table 5.8.

Table 5.7 Historical Distribution of 75 Work Units.

Categories		Average
1	Crushed Surface Materials	10.77%
2	Concrete Pavement	3.46%
3	Structural Concrete	12.97%
4	Hot-Mix Asphalt	51.12%
5	Steel Reinforcing Bar	5.45%
6	Structural Steel[a]	
7	Roadway Excavation	16.23%
	Total	100.00%

[a]*There were no representatives from the seventy five work units.*

Table 5.8 Weighted Price Per Year (Index Year 2000).

	Categories[c] - Indexed Input Price x Historical Percent of Total Costs x 10							Sum	Index
	Crushed Surface Materials	Concrete Pavement	Structural Concrete	Hot-Mix Asphalt	Steel Reinforcing Bar	Structural Steel[a]	Roadway Excavation		
	1	2	3	4	5	6	7		
	Units								
Year	ton	yd²	yd³	ton	lb	ln ft	yd³		
1985	58.4		96.3	334.2	46.1		75.3	610.4	**61.0**
1986	93.1	17.1	88.2	362.2	41.2		73.8	675.5	**67.6**
1987	67.2	13.7	94.4	341.4	41.6		58.6	617.0	**61.7**
1988	79.9	10.7	101.3	366.6	48.0		83.4	689.9	**69.0**
1989	66.0	13.3	99.3	344.0	41.9		90.8	655.3	**65.5**
1990	87.2		95.6	397.7	42.9		78.5	701.9	**70.2**
1991	67.7	13.1	83.8	440.1	40.0		63.9	708.6	**70.9**
1992	71.7	18.3	107.6	412.4	44.1		75.7	729.8	**73.0**
1993	74.1	19.9	103.5	416.9	46.0		67.2	727.7	**72.8**
1994	81.4	16.6	131.0	427.1	195.7		87.9	939.7	**94.0**
1995	106.1		115.8	438.8	50.6		104.2	815.5	**81.6**
1996	96.8	22.0	177.7	441.5	57.9		122.8	918.6	**91.9**
1997[b]									
1998[b]									
1999	80.8	24.4	175.7	755.6	85.0		164.4	1285.8	**128.6**
2000	107.7	34.6	129.7	511.2	54.5		162.3	1000.0	**100.0**
2001	100.9	36.7	129.3	443.2	58.9		119.6	888.6	**88.9**
2002	66.5		151.4	525.7	61.7		164.7	970.0	**97.0**
2003	70.6	23.4	150.9	536.4	51.3		121.9	954.4	**95.4**
2004	87.3	29.3	116.9	664.0	73.0		163.4	1133.8	**113.4**
2005	85.8		149.0	790.7	81.0		187.8	1294.3	**129.4**
2006	91.6	34.2	237.5	1037.1	93.9		109.5	1603.9	**160.4**
2007	95.8	53.6	195.3	1144.2	109.7		191.7	1790.4	**179.0**
2008	83.4	39.0	220.8	1109.6	103.5		146.1	1702.5	**170.2**
2009[d]									

[a]There were no representatives from the seventy five work units.
[b]Issue extracting bid history from parts of 1997 and 1998.
[c]Indexed Input Price x Historical Percent of Total Costs x 10.
[d]Partial data for 2009.

5.6 INFLATION

Based on the interviews conducted, NDOT has been utilizing a 3% annual inflation rate. RTC of Washoe County has recently been using a 7.5% annual inflation rate. RTC of Southern Nevada has been using a 4% annual inflation rate.

A survey conducted by the WSDOT Office of Research and Library Services in February of 2007 showed that there is "no consistent approach to capturing inflation amongst agencies (WSDOT 2007b)." A copy of this survey is presented in Appendix E. The reported annual inflation rates varied from 3% to 6% and are estimated based on a number of different approaches. Producer Price Index (PPI), Consumer Price Index (CPI), FHWA Construction Cost Index, historical inflation trends, and commercial forecasting services such as Moody's and Global Insight are being used in various ways to forecast inflation by agencies around the nation.

As stated earlier, there is no consistent approach to forecasting inflation. In addition, NCHRP 8-49 and other literature provide general discussions on inflation and lack specificity. A recently prepared MDT report entitled "Highway Construction Cost Trends" describes past and present inflation trends and a methodology for developing Montana specific highway cost indices (Fossum 2007). Figure 5.2, which is reproduced from the MDT report, shows the major increase in inflation trends in highway construction costs starting in 2004. Prior to 2004, Consumer Price Index-Urban (CPI-U) and Producer Price Index (PPI) for highway construction followed the same trend. Recent inflation trends in highway construction costs are captured in PPI for highway construction after 2004. The Global Insight baseline inflation projection of 2% for highway construction is shown on Figure 5.2 as well.

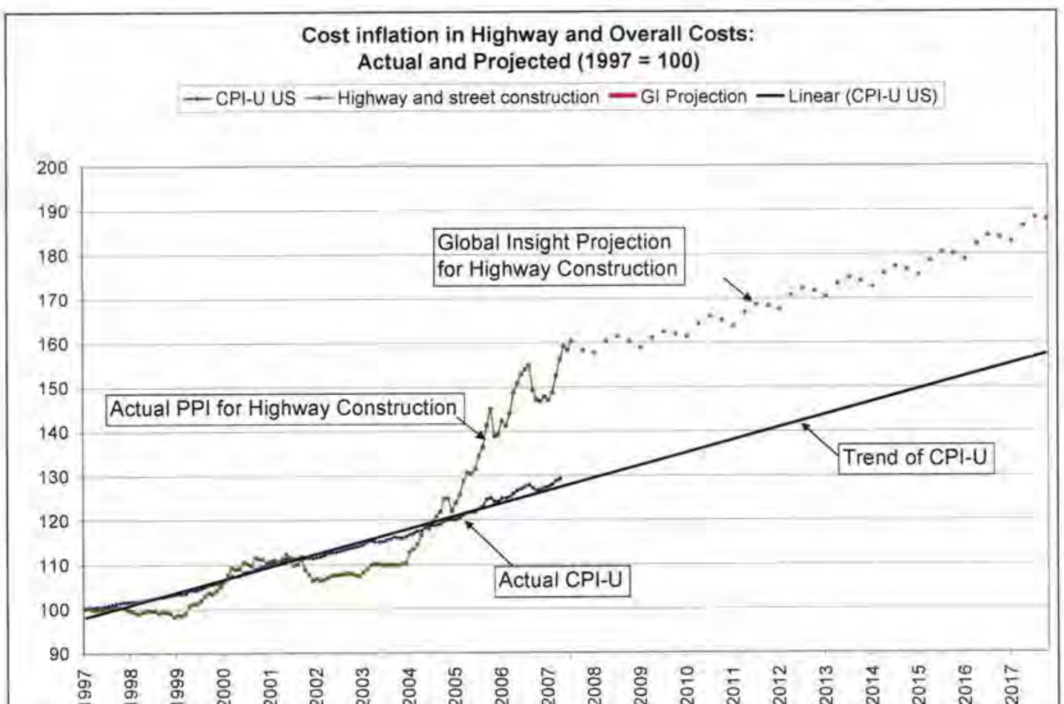


Figure 5.2 Comparison of Various Indices as Related to Highway Construction Costs (Fossum 2007).

5.6.1 Inflation Computed from NDOT Weighted Cost Indices

Table 5.9 presents the inflation trends for NDOT using the weighted cost indices (i.e., index in Table 5.8). STE calculated yearly inflation trends by evaluating the percent change in cost index from one year to the next. The inflation rates reported in Table 5.9 confirm that in recent years highway project cost estimates have been adversely impacted by higher than expected (i.e., higher than 3%) inflation rates.

Table 5.9 NDOT Computed Construction Cost Indices and Calculated Inflation Rates.

Year	NDOT Weighted Cost Index	Inflation Rate
1985	61	
1986	68	10.67%
1987	62	-8.66%
1988	69	11.81%
1989	66	-5.03%
1990	70	7.12%
1991	71	0.95%
1992	73	2.99%
1993	73	-0.28%
1994	94	29.14%
1995	82	-13.22%
1996	92	12.64%
1997[a]		
1998[a]		
1999	129	
2000[b]	100	-22.23%
2001	89	-11.14%
2002	97	9.16%
2003	95	-1.61%
2004	113	18.80%
2005	129	14.16%
2006	160	23.91%
2007	179	11.63%
2008	170	-4.91%
2009[d]		
	Arithmetic Average[c]	4.30%
	Standard Deviation[c]	13.02%

[a]Issue extracting bid history from parts of 1997 and 1998.
[b]Cost indexed to year 2000.
[c]Average and standard deviation exclude years 1997, 1998, and 2009.
[d]Partial data for 2009.

5.6.2 Inflation Forecasting

It is recognized that the future volatility in the market may have very little to do with the past inflation rates. However, nationally available inflation trends (e.g., Moody's and Global Insight) in combination with historical state and regional trends can be evaluated on an annual basis to set forecasted inflation for the year. For example, Figure 5.3 shows a simple regression of indices versus year from Table 5.9. The slope of the regression line represents the average inflation and is shown to be 4.2%. Similar analysis can be performed for each NDOT district to evaluate regional differences.

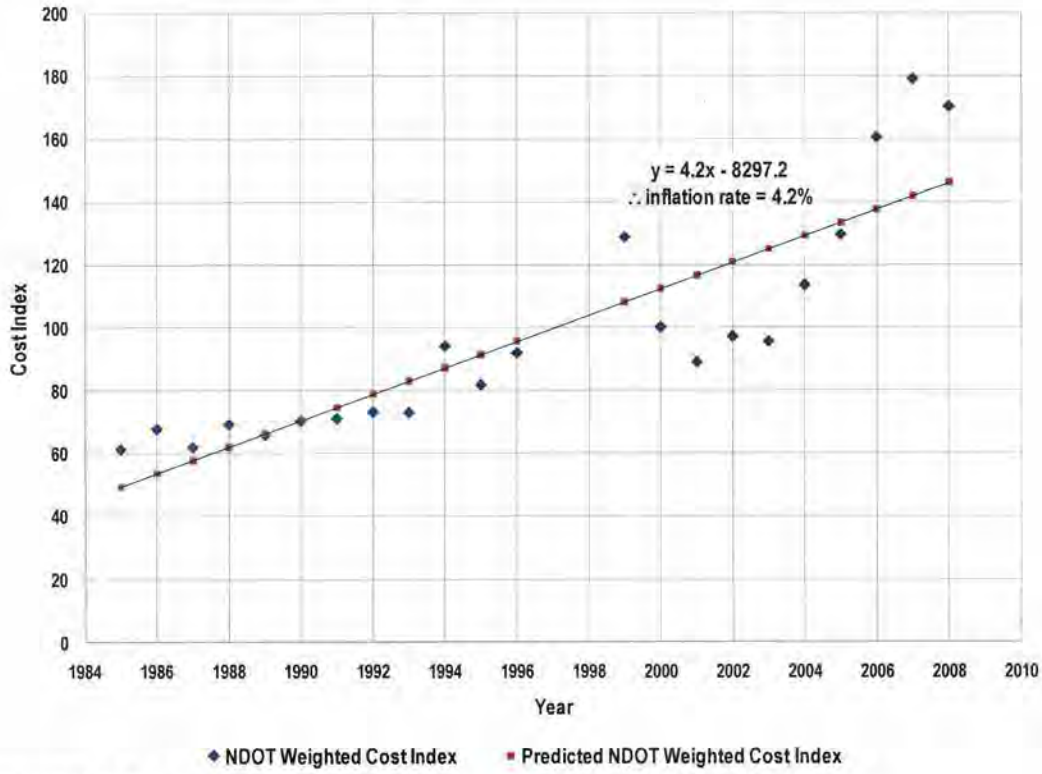


Figure 5.3 NDOT Weighted Cost Indices Over Time.

5.6.3 Capturing Inflation Framework for NDOT

STE proposes the following step by step approach to capture inflation:

Step 1. For long term planning (e.g., five years and longer), use the national forecasted trends.

Step 2. For short term planning, capture the inflation trends for the most volatile highway construction items (e.g., seven categories used by STE in the example or NDOT desired categories) utilizing the inflation rates established from cost indices as described previously. The following are two potential methods:

- The first method is to develop an annual inflation rate for each volatile construction item individually based on year to year cost index fluctuations.

- The second method (preferred for simplicity) is to calculate one "aggregate" inflation rate for "all" major construction items as shown previously.

Step 3. The inflation rates developed in Step 2 are historical and future volatility in the market may have very little to do with the past. STE recommends evaluating nationally available inflation trends (e.g., Moody's and Global Insight) in combination with historical state and regional trends and also any known market condition (e.g., shortage of materials or labor) on an annual basis to set forecasted inflation rates.

Step 4. STE recommends that NDOT continues updating and fine tuning its cost indices for volatile construction items annually.

Step 5. For the remaining total highway construction costs (i.e., the other work units not represented by the seventy five work units STE identified), NDOT can choose to use the national forecasted trends.

6.0 REVIEW PARAMETRIC COST ESTIMATING TOOL

NDOT has been working diligently with its consultant to develop a parametric estimating tool for early cost estimation. The tool is designed to prepare estimates at the STIP stage. STE focused on identifying areas where the results of this study could be applied. Contingency and inflation factors are two areas where the results of this study could be utilized in the parametric cost estimating tool.

6.1 CONTINGENCIES

The parametric cost estimating tool has "allowance" factors for a number of parameters that are difficult to quantify accurately at the early stages of the cost estimation process (i.e., pre STIP). Those factors include erosion control/temporary drainage, traffic control, roadside safety, landscaping/aesthetics, and mobilization. Allowance factors are shown as a range and as a percentage of total cost of itemized work units.

In addition to the allowance factors, contingency factors have been developed for the unknown risks as a range for STIP, PAE, Award, and Final costs. Table 6.1 represents the contingency factors available in the parametric cost estimating tool.

Table 6.1 Contingency Factors Reported in the Parametric Cost Estimating Tool.

Contingency	Minimum	Maximum
Preliminary Estimate	25%	30%
STIP Estimate	20%	25%
PAE Estimate	15%	20%
Award Estimate	3%	10%
Final Estimate	0%	5%

In Section 4 of this report, STE developed risk factors for various stages in a project life cycle namely STIP to Award, Award to Final, and STIP to Final. The risk factors developed by STE were based on historical datasets of completed projects. The datasets were limited to only forty five projects as it took NDOT five months of significant effort to gather the information. As stated earlier, STE did not develop risk factors for PAE since no PAE cost data was available at the time of this study. Based on STE analysis of available historical data, risk factors were determined for STIP, Award, and Final stages as shown in Table 6.2.

Table 6.2 STE Determined Risk Factors Based on Historical Data.

Risk Factors	Analysis Period	Percentage
STIP Estimate	STIP to Final	140%
PAE Estimate	PAE to Final	N/A
Award Estimate	Award to Final	12%
Final Cost	Final to Final	0%

As discussed in Section 4, the STIP estimated risk factor of 140% is extremely high due to the fact that on most past projects, the STIP estimates were partial cost estimates and did not include important cost parameters such as right of way, utilities, environmental mitigation, traffic control, etc. In addition, many of the originally reported STIP costs were adversely affected by numerous changes in project scope (i.e., scope creep). As stated in Section 4, reporting the STIP cost as a "total" cost (i.e., a reasonable estimate of project purchase price) will reduce the risk factor significantly. The risk factor developed for the award estimate was approximately 12%. This means that on the average, a project final cost was 12% higher than anticipated at the time of award. STE's 12% risk factor for the award cost is similar to the maximum 10% contingency reported in the cost estimating tool shown in Table 6.1. STE did not associate risks with the final project cost as this cost is not an estimate but a factual final figure.

Following STE's recommendation of implementing a tracking system for cost and schedule changes, NDOT and partnering agencies will be able to gather accurate data for future analysis of risk factors in the next three to five years. Using a template similar to what is shown in Appendix B (i.e., data request template) will allow agencies to further group the projects by type, category, and region and then develop specific risk factors for each group. For example, capacity projects in District 1 can have a different risk factor than preservation projects in District 3. Once a more accurate dataset becomes available, NDOT and partnering agencies can follow STE's procedure described in Section 4 to develop a series of risk factors replacing the contingency factors of the parametric cost estimating tool. The new risk factors can be reported with a mean and a standard deviation. Alternatively, the mean and standard deviation can be used to develop a range (i.e., minimum and maximum values). Future standard deviations should be much smaller than what is reported in this study because there should be a larger population of projects with more accurate cost/schedule data.

6.2 INFLATION

The cost indexing methodology described in Section 5 can be used to provide the inflation information for the parametric cost estimating tool. The most significant work units can be grouped into a number of categories such as crushed surfaced materials, concrete pavement, structural concrete, hot mix asphalt, steel reinforcing bar, structural steel, and roadway excavation. For those categories, annual inflation rates can be developed based on annual cost indices. NDOT's "currentrespuwokall.xls" database can be utilized to develop statewide and regional (i.e., district) inflation rates based on cost indices for most significant work units. The inflation rates for STIP projects should be updated on an annually basis before a new STIP is adopted.

7.0 RECOMMENDATIONS

The following recommendations are made based on STE's review of literature and evaluation of current practices by NDOT and its partnering agencies:

- Create a cost estimating group consisting of key staff involved in planning cost estimation at NDOT, RTCs, and local agencies
- Develop a vision statement for making cost estimation a priority
- Develop a comprehensive cost estimating manual for planning stage
- Develop a quality control/quality assurance (QC/QA) program for cost estimation process
- Finalize the parametric cost estimating tool for use by everyone involved
- Create a uniform cost/schedule tracking system to capture risk factors
- Track and report inflation trends through cost indexing practices and national data
- Establish a routine training program on cost estimating practices and policies
- Improve communications within agencies and among agencies for estimators

This section thoroughly discusses the recommendations.

7.1 COST ESTIMATING GROUP

STE suggests that a cost estimating group consisting of key staff involved in planning cost estimation at NDOT, RTCs, and local agencies be established. The group's responsibilities would include:

- Developing and implementing policies and uniform practices that will enhance the cost estimation process for all agencies involved. The first activity would entail developing a vision statement for making the cost estimation a priority. A good example has been provided in the literature review from Mn/DOT.
- Finalizing the parametric cost estimating tool being developed by NDOT and gathering support for its use by all agencies involved in cost estimation of transportation projects.
- Routine update of unit cost data and disseminating the information to all estimators through agencies' intranet systems.
- Developing a cost estimation manual for projects at the planning stage that is acceptable to all agencies involved. The cost estimation manual would discuss all aspects of cost estimation including a quality control checklist, updating unit bid prices, reporting initial cost as a "total" cost, quality assurance reviews of the project scope, cost, and proposed schedule.
- Continuous updates to the cost estimation manual.
- Developing standardized formats for reporting project cost estimates.
- Conducting cost validation checks (quality assurance checks) of project costs at the time of STIP.
- Creating a uniform cost/schedule tracking system to gather historical data on various risks during a project life cycle. This data can be used to develop risk factors as described earlier in this report. The cost/schedule tracking template developed by STE can be developed into a user friendly application.
- Improving communication among NDOT, RTCs, and local agencies involved with project cost estimation activities at the planning stage.

- Developing a dynamic process for reporting inflation trends through cost indexing and following national and regional forecasts.
- Developing and implementing a training program for all staff involved in project cost estimation activities at the planning stage.

As indicated by the activities listed above, the cost estimating group will be the champions of promoting, enhancing, and advancing the cost estimation practices at NDOT and partnering agencies. The cost estimating group will act as a "hub" for disseminating information to and enhancing communication amongst current staff involved in cost estimating.

7.2 COST ESTIMATING MANUAL

STE recommends developing a comprehensive cost estimating manual for the planning stage that contains the following elements:

- Estimating Policies
- Estimating Procedures
- Defining Contingency
- Risk Analysis
- Documentation of Estimates
- Defining Roles and Accountability
- Quality Control and Quality Assurance
- Approval of Estimates
- Training Tools

In addition, "cost based" estimating, although very time consuming, should be considered on major projects and only on items with largest dollar value. WSDOT's policy on cost based estimating, which was described earlier in the literature review, can be considered. WSDOT limits the use of cost based estimates to project items with the largest dollar value, typically 20% of items of work containing 80% of the project costs.

7.3 QUALITY CONTROL & QUALITY ASSURANCE PROGRAM

A Quality Control and Quality Assurance (QC/QA) Program should be developed to improve the cost estimation process. This program should be included in the cost estimating manual. The QC program should include a checklist of all items necessary for the estimate. A QC checklist ensures that all the major project elements have been considered during the initial scoping process. The QA program will describe the process and policies for cost estimation review and approval.

7.4 RISK ANALYSIS PROGRAM

STE recommends the development of a comprehensive system for capturing risk factors. As discussed previously, STE developed a data request template for NDOT, which can be utilized to track cost and schedule changes throughout the life cycle of a project. This template shown in Appendix B can be the framework for a cost/schedule tracking system. The tracking system with the inclusion of an Excel based simulation tool (e.g., @Risk) can be further developed into a user friendly computer program. The development of usable risk factors will take a few years. Data is needed to generate specific risk factors for various project types and categories. Section 4 of this report provides a comprehensive overview of the tracking system and risk factor analysis.

7.5 CAPTURING INFLATION

Section 5 of this report provides a comprehensive overview of cost indexing methodology and how to capture inflationary trends over time. STE recommends that NDOT and partnering agencies use the suggested procedures as described in Section 5 to report inflationary trends on an annual basis. STE recommends that the costs of all projects in STIP be revaluated on an annual basis with the new inflation rates. The inflation rates should be applied to a project cost all the way to the mid-point of construction.

7.6 ESTABLISH ROUTINE TRAINING PROGRAM

As discussed earlier, the cost estimating group will be in charge of developing and conducting a comprehensive cost estimating training program. The goals of a cost estimating training program are to:

- Improve the flow of information on factors affecting the cost estimation process among staff
- Introduce new practices
- Reinforce the commitment of the agencies to improving cost estimation

STE recommends that the training course be divided into 1) organizational information and 2) manuals, tools, & software instruction. The following describes the training course.

7.6.1 Organizational Information

The organizational information portion of the training course should be approximately one day and should focus on NDOT/agency structure, operations, and current cost estimating process. STE believes that NDOT/agency staff should understand all project cost estimation and development stages and realize their interconnected roles in the cost estimating operation. Training materials should include background information on NDOT/agency organization and divisions and information on RTP, RTIP, and STIP programs.

7.6.2 Manuals, Tools, & Software Instruction

The training needs to be comprehensive and cover all aspects of cost estimation including software, procedures, and reporting. STE recommends creating a training manual composed of materials from all the tools and software used by NDOT/agency cost estimating staff. This manual should explain how each tool/software operates and how to use it. Typically, these documents will describe features of a program and the various steps required to operate it. STE envisions a two day training seminar for manuals, tools, and software. The software training can be customized to emphasize applications that are more commonly used by individuals.

7.6.3 Review Training

STE recommends that the organizational information portion of the training course be conducted bi-annually. All estimators involved in the cost estimating operation should attend. STE recommends that the manuals, tools, and software instruction portion of the training course be conducted annually. All NDOT/agency staff using the cost estimating manuals, tools, and software should attend. The training course should also be routinely updated to reflect the latest cost estimation procedure, changes in software, and tools.

8.0 IMPLEMENTATION

The implementation plan and suggested timeline are described in Section 8.1. The performance measure indicators are described in Section 8.2.

8.1 IMPLEMENTATION PLAN & TIMELINE

Figure 8.1 and the following list present the suggested timelines for implementing the recommendations and procedures described in Section 7 of this report.

- Create Cost Estimating Group – Within the next six months
  - Develop vision statement – Two months thereafter
  - Develop/implement policies and uniform practices – Six months thereafter
  - Develop cost estimating manual – Within twelve months thereafter
- Develop a Comprehensive System for Capturing Risk Factors
  - Within the next eighteen months NDOT/agencies should complete and make operational the system for capturing risk factors as described in Section 4.5.
- Create Procedures for Managing Inflation
  - Within the next twelve months NDOT/agencies should establish procedures for managing inflation based on procedures described in Section 5.
- Establish Routine Training Program
  - Within the next eighteen months NDOT/agencies should establish a routine training program as described in Section 7.6. NDOT/agencies should conduct the first round on training within eighteen months from the completion of this report.

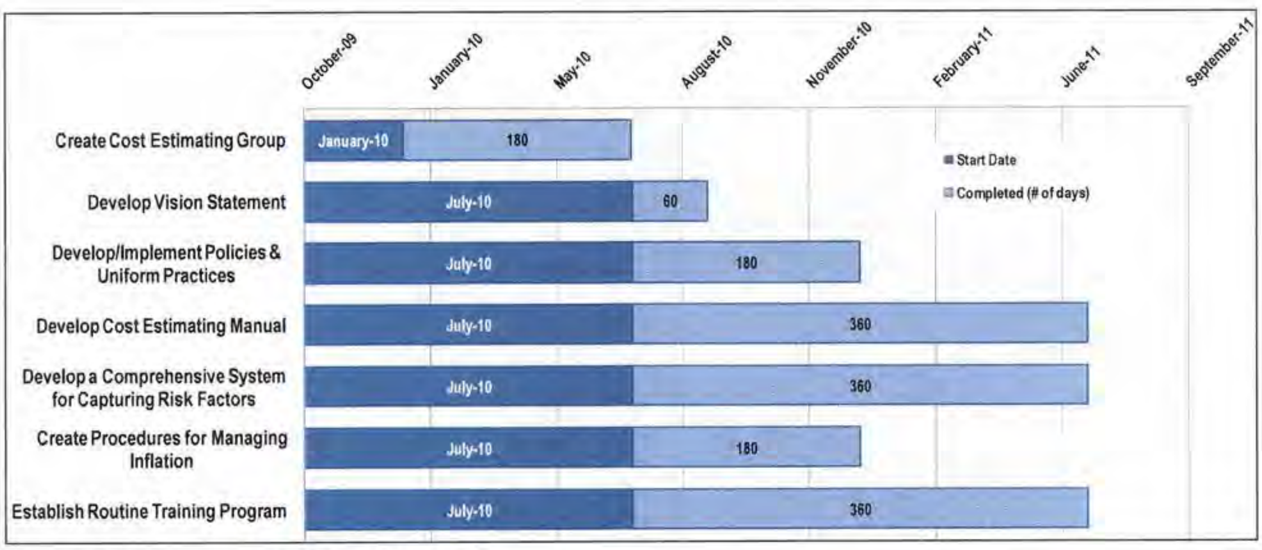


Figure 8.1 Implementation Plan & Timeline.

8.2 PERFORMANCE INDICATORS

The most significant performance indicator is to get cost/schedule estimates that more accurately reflect the final construction cost/schedule. This evaluation will take time as necessary data on cost and schedule have to be gathered. Using the risk analysis procedure, comparisons can be made over time between the STIP, Award, and Final cost/schedule. STE anticipates that it will take three to five years to gather enough information to conduct a full evaluation.

Another performance indicator that can be monitored is the reduction in historical risk factors over time. STE believes that the implementation of its recommendations will result in across the board reductions in risk factors over time. Again, STE anticipates that it will take three to five years to assess improvements.

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APPENDIX A. STAFF INTERVIEW MATERIAL

Name	
Title	
Department/Division	
Phone	
E-mail	
Fax	

Q1.	Please describe your role in the cost/schedule estimation process. If not a direct role, what inputs do you provide that impact a project cost and/or schedule?
RESPONSE	

[redacted]

Q2.	When encountering a previously unaccounted project condition -
Q2a.	How do you communicate this information with the original estimators?
RESPONSE	

Q2b.	Do you follow a prescribed procedure to document and communicate those unforeseen conditions? If so, please describe the process.
RESPONSE	

Q3.	How does your group seek additional funding and authorization for the necessary cost/schedule changes due to a newly discovered project condition? How has this cost/schedule overrun impacted other projects?
RESPONSE	

Q4.	What management system(s) or planning/engineering software do you use to provide information for the cost/schedule estimation process?
RESPONSE	

Q5.	What issues does your group face in providing information for the cost/schedule estimation process? Please provide as much detail as possible.
RESPONSE	

Q6.	What recommendations/suggestions do you have for improving the cost/schedule estimation process?
RESPONSE	

Name:	
Title:	
Department/Division:	
Phone:	
E-mail:	
Fax:	

	Rank According to Significance (with 1 being the most significant and 8 being the least significant)	
Categories	Cost	Schedule
Insufficient Knowledge of Right-Of-Way Factors		
Environmental Mitigation Requirements		
Unforeseen Engineering Complexities / Constructability Issues		
Changes in Traffic Control		
Increased Local Government, Community, and Stakeholders Expectations		
Unforeseen Events		
Changes in Market Conditions		
Utilities		

In the following worksheets, project risks are categorized into several groups. Based on your professional experience, please rate the significance of risks on past/current NDOT projects from "high" to "low". Please note that this is a subjective survey and therefore provide your best opinion (i.e., rating) based on your own experience. You may leave the events that you have not encountered blank.

Insufficient Knowledge of Right-Of-Way Factors

Rate cost significance in the following subcategories:

Subcategories	High Significance	Medium Significance	Low Significance
a. Delay in utility relocation			
b. Disagreement on freeway access			
c. Railroad involvement			
d. Objections to ROW appraisal			
e. Acquisition problems			
f. Billboard relocation			
g. Changes in design due to ROW issues			
h. Others (please specify)			

Rate schedule significance in the following subcategories:

Subcategories	High Significance	Medium Significance	Low Significance
a. Delay in utility relocation			
b. Disagreement on freeway access			
c. Railroad involvement			
d. Objections to ROW appraisal			
e. Acquisition problems			
f. Billboard relocation			
g. Changes in design due to ROW issues			
h. Others (please specify)			

Environmental Mitigation Requirements

Rate cost significance in the following subcategories:			
Subcategories	**High Significance**	**Medium Significance**	**Low Significance**
a. Permits or agency actions delayed or took longer than expected			
b. New information required for permits			
c. Environmental regulations change			
d. Water quality regulations change			
e. New issues in dealing with historic site, endangered species, or wetland			
f. Additional environmental analysis required			
g. Erosion control			
h. Construction noise control			
i. Permanent noise control			
j. Buried hazardous issues			
k. Others (please specify)			

Rate schedule significance in the following subcategories:			
Subcategories	**High Significance**	**Medium Significance**	**Low Significance**
a. Permits or agency actions delayed or took longer than expected			
b. New information required for permits			
c. Environmental regulations change			
d. Water quality regulations change			
e. New issues in dealing with historic site, endangered species, or wetland			
f. Additional environmental analysis required			
g. Erosion control			
h. Construction noise control			
i. Permanent noise control			
j. Buried hazardous issues			
k. Others (please specify)			

Unforeseen Engineering Complexities / Constructability Issues

Rate cost significance in the following subcategories:

Subcategories	High Significance	Medium Significance	Low Significance
a. Sufficiency of plans and specifications			
b. Change in seismic criteria			
c. Soil conditions			
d. Soil contamination			
e. Subcontractors capability			
f. Worker and site safety			
g. Work rules			
h. Geotechnical conditions			
i. Others (please specify)			

Rate schedule significance in the following subcategories:

Subcategories	High Significance	Medium Significance	Low Significance
a. Sufficiency of plans and specifications			
b. Change in seismic criteria			
c. Soil conditions			
d. Soil contamination			
e. Subcontractors capability			
f. Worker and site safety			
g. Work rules			
h. Geotechnical conditions			
i. Others (please specify)			

Changes in Traffic Control

Rate cost significance in the following subcategories:

Subcategories	High Significance	Medium Significance	Low Significance
a. Design change			
b. Traffic growth			
c. Extended closure			
d. Multiple mobilizations			
e. Others (please specify)			

Rate schedule significance in the following subcategories:

Subcategories	High Significance	Medium Significance	Low Significance
a. Design change			
b. Traffic growth			
c. Extended closure			
d. Multiple mobilizations			
e. Others (please specify)			

Increased Local Government, Community, and Stakeholders Expectations

Rate cost significance in the following subcategories:

Subcategories	High Significance	Medium Significance	Low Significance
a. Objections posed by local communities			
b. Late changes requested by stakeholders			
c. Emergence of new stakeholders demanding new work			
d. Threats of lawsuit			
e. Stakeholders choose time and/or cost over quality			
f. Others (please specify)			

Rate schedule significance in the following subcategories:

Subcategories	High Significance	Medium Significance	Low Significance
a. Objections posed by local communities			
b. Late changes requested by stakeholders			
c. Emergence of new stakeholders demanding new work			
d. Threats of lawsuit			
e. Stakeholders choose time and/or cost over quality			
f. Others (please specify)			

Unforeseen Events

Rate cost significance in the following subcategories:			
Subcategories	**High Significance**	**Medium Significance**	**Low Significance**
a. Floods			
b. Other weather related incidents			
c. Legislative action			
d. Others (please specify)			

Rate schedule significance in the following subcategories:			
Subcategories	**High Significance**	**Medium Significance**	**Low Significance**
a. Floods			
b. Other weather related incidents			
c. Legislative action			
d. Others (please specify)			

Changes in Market Conditions

Rate cost significance in the following subcategories:

Subcategories	High Significance	Medium Significance	Low Significance
a. Labor			
b. Fuel			
c. Materials			
d. Land			
e. Others (please specify)			

Rate schedule significance in the following subcategories:

Subcategories	High Significance	Medium Significance	Low Significance
a. Labor			
b. Fuel			
c. Materials			
d. Land			
e. Others (please specify)			

Utilities

Rate cost significance in the following subcategories:

Subcategories	High Significance	Medium Significance	Low Significance
a. Coordination with local utilities efforts			
b. Utility negotiations with owner			
c. Delay			
d. Railroad involvement			
e. Others (please specify)			

Rate schedule significance in the following subcategories:

Subcategories	High Significance	Medium Significance	Low Significance
a. Coordination with local utilities efforts			
b. Utility negotiations with owner			
c. Delay			
d. Railroad involvement			
e. Others (please specify)			

APPENDIX B. DATA REQUEST TEMPLATE

Major Terms	
Phrase / Word	**Definition**
STIP Cost	Cost as entered into STIP Total project cost includes ROW, Environmental, Engineering, Traffic, Construction, etc.
Total Project Cost at Award Date	Total project cost at the date of award, which includes ROW, Environmental, Engineering, Traffic, Construction, etc.
Final Cost	Final voucher costs (total project cost includes ROW, Environmental, Engineering, Traffic, Construction, etc.)
Project Type	Capacity, Preservation, Local Public Agency Projects, Study, Maintenance, Permits, Other Type
Project Category	Category 1, Category 2, Category 3
Category 1	3R, 4R, CMAQ, New Construction, Widening, Betterment, Enhancement, Structures, Right-of-Way, Safety, Landscape, Architecture, Hydraulics, Environmental, Traffic, Corridor, Other Category
Category 2	Rural Interstate, Rur Princpl Arterial, Rural Minor Arterial, Rur Major Collector, Rur Minor Collector, Rural Local, Urban Interstate, Urb Other Freeway, Urb Princpl Arterial, Urban Minor Arterial, Urban Collector, Urban Local, Off-System
Category 3	A-Pavement, C-Pavement, Interchange, Tunnel, Bridge, Grade Separation, Retaining Walls, Sound Walls, Landscaping, Lighting, Traffic Signals, Roundabouts, Drainage Structures, Bicycle, Buildings

Other Terms	
Phrase / Word	**Definition**
3R	Resurfacing, Restoration & Rehabilitation projects
4R	Resurfacing, Restoration, Rehabilitation & Reconstruction projects
A-Pavement	Asphalt Pavement
Architecture	Architecture projects
Barriers	Barrier rail, guardrail, island, raised delineators, etc.
Betterment	District Betterment projects
Bicycle	Bike paths and/or routes
Bridge	Bridge structures
Buildings	Retrofitted or new NDOT facilities
CMAQ	Congestion Mitigation/Air Quality projects
Corridor	Corridor study for a specific route and/or for NEPA
C-Pavement	Concrete Pavement
Enhancement	Enhancement projects
Environmental	Environmental mitigation projects
Grade Separation	Grade separation structures
Hydraulics	Erosion Control projects
ITS	Intelligent Transportation Systems
Landscape	Landscape Design projects
Lighting	Overhead Lighting
LPAP	Local Public Agency Projects
NEPA	National Environmental Policy Act
Off-System	Off-System roads and bridges
Other Category	Other-could be anything, but not usually classified
Other Type	Other-could be anything, but not usually classified
PAE	Total Project Cost at Preliminary Agreement Estimate
Ped Facilities	Sidewalks, ADA ramps, refuges, ped crossings, etc.
Permits	District Oversight of Permit Projects
Princpl	Principal
Project District	NDOT district
Project Name/ID	Name or ID used by agency
ROW	Right-of-Way
RTIP	Regional Transportation Improvement Plan
Rur	Rural
Safety	Safety projects
STIP	Statewide transportation improvement plan
Structures	Bridge, soundwalls, retaining walls, overhead signs, etc.
Traffic	Traffic improvement projects
Urb	Urban

Project Description	
Project Name/ID	
Project District	
Project Type	
Category 1	
Category 2	
Category 3	
Schedule and Cost Information	
Planning Schedule	
Date Project Programmed in RTIP	
Date Project Entered in STIP	
Date Project Programmed in STIP	
Expected Project Award Date	
Actual Date Project Awarded	
Number of Qualified Bidders	
Construction Schedule	
Starting Date of Construction	
Expected Completion Date	
Actual Completion Date	
Project Cost	
STIP Estimated Cost	
Total Project Cost at Award Date	
Final Cost	

Known Contingencies included in STIP Cost

NOTES/DETAILS:

Provide break down of contingencies included in the STIP cost:

Contingencies	Considered	($)	(%)
a. Right-of-way factors			
b. Environmental mitigations			
c. Unforeseen engineering			
d. Traffic control			
e. Stakeholders expectations			
f. Unforeseen events			
g. Market conditions (e.g., inflation)			
h. Utilities			
i. Others (please specify)			

Provide break down of contingencies included in the STIP schedule:

Contingencies	Considered	(months)	(%)
a. Right-of-way factors			
b. Environmental mitigations			
c. Unforeseen engineering			
d. Traffic control			
e. Stakeholders expectations			
f. Unforeseen events			
g. Market conditions (e.g., inflation)			
h. Utilities			
i. Others (please specify)			

Insufficient Knowledge of Right-Of-Way Factors

NOTES/DETAILS:

	($)	
Change in Project Cost		
If available break down this cost change in the following subcategories:		
Subcategories	($)	(%)
a. Delay in utility relocation		
b. Disagreement on freeway access		
c. Railroad involvement		
d. Objections to ROW appraisal		
e. Acquisition problems		
f. Billboard relocation		
g. Changes in design due to ROW issues		
h. Others (please specify)		

	(months)	
Change in Project Schedule		
If available break down this schedule change in the following subcategories:		
Subcategories	(months)	(%)
a. Delay in utility relocation		
b. Disagreement on freeway access		
c. Railroad involvement		
d. Objections to ROW appraisal		
e. Acquisition problems		
f. Billboard relocation		
g. Changes in design due to ROW issues		
h. Others (please specify)		

Insufficient Knowledge of Right-Of-Way Factors

NOTES/DETAILS:

	($)	
Change in Project Cost		
If available break down this cost change in the following subcategories:		
Subcategories	($)	(%)
a. Delay in utility relocation		
b. Disagreement on freeway access		
c. Railroad involvement		
d. Objections to ROW appraisal		
e. Acquisition problems		
f. Billboard relocation		
g. Changes in design due to ROW issues		
h. Others (please specify)		

	(months)	
Change in Project Schedule		
If available break down this schedule change in the following subcategories:		
Subcategories	(months)	(%)
a. Delay in utility relocation		
b. Disagreement on freeway access		
c. Railroad involvement		
d. Objections to ROW appraisal		
e. Acquisition problems		
f. Billboard relocation		
g. Changes in design due to ROW issues		
h. Others (please specify)		

Insufficient Knowledge of Right-Of-Way Factors

NOTES/DETAILS:

	($)	
Change in Project Cost		
If available break down this cost change in the following subcategories:		
Subcategories	($)	(%)
a. Delay in utility relocation		
b. Disagreement on freeway access		
c. Railroad involvement		
d. Objections to ROW appraisal		
e. Acquisition problems		
f. Billboard relocation		
g. Changes in design due to ROW issues		
h. Others (please specify)		

	(months)	
Change in Project Schedule		
If available break down this schedule change in the following subcategories:		
Subcategories	(months)	(%)
a. Delay in utility relocation		
b. Disagreement on freeway access		
c. Railroad involvement		
d. Objections to ROW appraisal		
e. Acquisition problems		
f. Billboard relocation		
g. Changes in design due to ROW issues		
h. Others (please specify)		

Environmental Mitigation Requirements

NOTES/DETAILS:

	($)	
Change in Project Cost		
If available break down this cost change in the following subcategories:		
Subcategories	($)	(%)
a. Permits or agency actions delayed or took longer than expected		
b. New information required for permits		
c. Environmental regulations change		
d. Water quality regulations change		
e. New issues in dealing with historic site, endangered species, or wetland		
f. Additional environmental analysis required		
g. Erosion control		
h. Construction noise control		
i. Permanent noise control		
j. Buried hazardous issues		
k. Others (please specify)		

	(months)	
Change in Project Schedule		
If available break down this schedule change in the following subcategories:		
Subcategories	(months)	(%)
a. Permits or agency actions delayed or took longer than expected		
b. New information required for permits		
c. Environmental regulations change		
d. Water quality regulations change		
e. New issues in dealing with historic site, endangered species, or wetland		
f. Additional environmental analysis required		
g. Erosion control		
h. Construction noise control		
i. Permanent noise control		
j. Buried hazardous issues		
k. Others (please specify)		

Environmental Mitigation Requirements

NOTES/DETAILS:

	($)	
Change in Project Cost		
If available break down this cost change in the following subcategories:		
Subcategories	($)	(%)
a. Permits or agency actions delayed or took longer than expected		
b. New information required for permits		
c. Environmental regulations change		
d. Water quality regulations change		
e. New issues in dealing with historic site, endangered species, or wetland		
f. Additional environmental analysis required		
g. Erosion control		
h. Construction noise control		
i. Permanent noise control		
j. Buried hazardous issues		
k. Others (please specify)		

	(months)	
Change in Project Schedule		
If available break down this schedule change in the following subcategories:		
Subcategories	(months)	(%)
a. Permits or agency actions delayed or took longer than expected		
b. New information required for permits		
c. Environmental regulations change		
d. Water quality regulations change		
e. New issues in dealing with historic site, endangered species, or wetland		
f. Additional environmental analysis required		
g. Erosion control		
h. Construction noise control		
i. Permanent noise control		
j. Buried hazardous issues		
k. Others (please specify)		

Environmental Mitigation Requirements

NOTES/DETAILS:

	($)	
Change in Project Cost		
If available break down this cost change in the following subcategories:		
Subcategories	**($)**	**(%)**
a. Permits or agency actions delayed or took longer than expected		
b. New information required for permits		
c. Environmental regulations change		
d. Water quality regulations change		
e. New issues in dealing with historic site, endangered species, or wetland		
f. Additional environmental analysis required		
g. Erosion control		
h. Construction noise control		
i. Permanent noise control		
j. Buried hazardous issues		
k. Others (please specify)		

	(months)	
Change in Project Schedule		
If available break down this schedule change in the following subcategories:		
Subcategories	**(months)**	**(%)**
a. Permits or agency actions delayed or took longer than expected		
b. New information required for permits		
c. Environmental regulations change		
d. Water quality regulations change		
e. New issues in dealing with historic site, endangered species, or wetland		
f. Additional environmental analysis required		
g. Erosion control		
h. Construction noise control		
i. Permanent noise control		
j. Buried hazardous issues		
k. Others (please specify)		

Unforeseen Engineering Complexities / Constructability Issues

NOTES/DETAILS:

	($)	
Change in Project Cost		
If available break down this cost change in the following subcategories:		
Subcategories	($)	(%)
a. Sufficiency of plans and specifications		
b. Change in seismic criteria		
c. Soil conditions		
d. Soil contamination		
e. Subcontractors capability		
f. Worker and site safety		
g. Work rules		
h. Geotechnical conditions		
i. Others (please specify)		

	(months)	
Change in Project Schedule		
If available break down this schedule change in the following subcategories:		
Subcategories	(months)	(%)
a. Sufficiency of plans and specifications		
b. Change in seismic criteria		
c. Soil conditions		
d. Soil contamination		
e. Subcontractors capability		
f. Worker and site safety		
g. Work rules		
h. Geotechnical conditions		
i. Others (please specify)		

Unforeseen Engineering Complexities / Constructability Issues

NOTES/DETAILS:

	($)	
Change in Project Cost		
If available break down this cost change in the following subcategories:		
Subcategories	($)	(%)
a. Sufficiency of plans and specifications		
b. Change in seismic criteria		
c. Soil conditions		
d. Soil contamination		
e. Subcontractors capability		
f. Worker and site safety		
g. Work rules		
h. Geotechnical conditions		
i. Others (please specify)		

	(months)	
Change in Project Schedule		
If available break down this schedule change in the following subcategories:		
Subcategories	(months)	(%)
a. Sufficiency of plans and specifications		
b. Change in seismic criteria		
c. Soil conditions		
d. Soil contamination		
e. Subcontractors capability		
f. Worker and site safety		
g. Work rules		
h. Geotechnical conditions		
i. Others (please specify)		

Unforeseen Engineering Complexities / Constructability Issues

NOTES/DETAILS:

	($)	
Change in Project Cost		
If available break down this cost change in the following subcategories:		
Subcategories	($)	(%)
a. Sufficiency of plans and specifications		
b. Change in seismic criteria		
c. Soil conditions		
d. Soil contamination		
e. Subcontractors capability		
f. Worker and site safety		
g. Work rules		
h. Geotechnical conditions		
i. Others (please specify)		

	(months)	
Change in Project Schedule		
If available break down this schedule change in the following subcategories:		
Subcategories	(months)	(%)
a. Sufficiency of plans and specifications		
b. Change in seismic criteria		
c. Soil conditions		
d. Soil contamination		
e. Subcontractors capability		
f. Worker and site safety		
g. Work rules		
h. Geotechnical conditions		
i. Others (please specify)		

Changes in Traffic Control

NOTES/DETAILS:

	($)	
Change in Project Cost		
If available break down this cost change in the following subcategories:		
Subcategories	($)	(%)
a. Design change		
b. Traffic growth		
c. Extended closure		
d. Multiple mobilizations		
e. Others (please specify)		

	(months)	
Change in Project Schedule		
If available break down this schedule change in the following subcategories:		
Subcategories	(months)	(%)
a. Design change		
b. Traffic growth		
c. Extended closure		
d. Multiple mobilizations		
e. Others (please specify)		

Changes in Traffic Control

NOTES/DETAILS:

	($)	
Change in Project Cost		
If available break down this cost change in the following subcategories:		
Subcategories	($)	(%)
a. Design change		
b. Traffic growth		
c. Extended closure		
d. Multiple mobilizations		
e. Others (please specify)		

	(months)	
Change in Project Schedule		
If available break down this schedule change in the following subcategories:		
Subcategories	(months)	(%)
a. Design change		
b. Traffic growth		
c. Extended closure		
d. Multiple mobilizations		
e. Others (please specify)		

Changes in Traffic Control

NOTES/DETAILS:

	($)	
Change in Project Cost		
If available break down this cost change in the following subcategories:		
Subcategories	($)	(%)
a. Design change		
b. Traffic growth		
c. Extended closure		
d. Multiple mobilizations		
e. Others (please specify)		

	(months)	
Change in Project Schedule		
If available break down this schedule change in the following subcategories:		
Subcategories	(months)	(%)
a. Design change		
b. Traffic growth		
c. Extended closure		
d. Multiple mobilizations		
e. Others (please specify)		

Increased Local Government, Community, and Stakeholders Expectations

NOTES/DETAILS:

	($)	
Change in Project Cost		
If available break down this cost change in the following subcategories:		
Subcategories	**($)**	**(%)**
a. Objections posed by local communities		
b. Late changes requested by stakeholders		
c. Emergence of new stakeholders demanding new work		
d. Threats of lawsuit		
e. Stakeholders choose time and/or cost over quality		
f. Others (please specify)		

	(months)	
Change in Project Schedule		
If available break down this schedule change in the following subcategories:		
Subcategories	**(months)**	**(%)**
a. Objections posed by local communities		
b. Late changes requested by stakeholders		
c. Emergence of new stakeholders demanding new work		
d. Threats of lawsuit		
e. Stakeholders choose time and/or cost over quality		
f. Others (please specify)		

Increased Local Government, Community, and Stakeholders Expectations

NOTES/DETAILS:

	($)	
Change in Project Cost		
If available break down this cost change in the following subcategories:		
Subcategories	($)	(%)
a. Objections posed by local communities		
b. Late changes requested by stakeholders		
c. Emergence of new stakeholders demanding new work		
d. Threats of lawsuit		
e. Stakeholders choose time and/or cost over quality		
f. Others (please specify)		

	(months)	
Change in Project Schedule		
If available break down this schedule change in the following subcategories:		
Subcategories	(months)	(%)
a. Objections posed by local communities		
b. Late changes requested by stakeholders		
c. Emergence of new stakeholders demanding new work		
d. Threats of lawsuit		
e. Stakeholders choose time and/or cost over quality		
f. Others (please specify)		

Increased Local Government, Community, and Stakeholders Expectations

NOTES/DETAILS:

	($)	
Change in Project Cost		
If available break down this cost change in the following subcategories:		
Subcategories	($)	(%)
a. Objections posed by local communities		
b. Late changes requested by stakeholders		
c. Emergence of new stakeholders demanding new work		
d. Threats of lawsuit		
e. Stakeholders choose time and/or cost over quality		
f. Others (please specify)		

	(months)	
Change in Project Schedule		
If available break down this schedule change in the following subcategories:		
Subcategories	(months)	(%)
a. Objections posed by local communities		
b. Late changes requested by stakeholders		
c. Emergence of new stakeholders demanding new work		
d. Threats of lawsuit		
e. Stakeholders choose time and/or cost over quality		
f. Others (please specify)		

Unforeseen Events

NOTES/DETAILS:

	($)	
Change in Project Cost		
If available break down this cost change in the following subcategories:		
Subcategories	($)	(%)
a. Floods		
b. Other weather related incidents		
c. Legislative action		
d. Others (please specify)		

	(months)	
Change in Project Schedule		
If available break down this schedule change in the following subcategories:		
Subcategories	(months)	(%)
a. Floods		
b. Other weather related incidents		
c. Legislative action		
d. Others (please specify)		

Unforeseen Events

NOTES/DETAILS:

	($)	
Change in Project Cost		
If available break down this cost change in the following subcategories:		
Subcategories	($)	(%)
a. Floods		
b. Other weather related incidents		
c. Legislative action		
d. Others (please specify)		

	(months)	
Change in Project Schedule		
If available break down this schedule change in the following subcategories:		
Subcategories	(months)	(%)
a. Floods		
b. Other weather related incidents		
c. Legislative action		
d. Others (please specify)		

Unforeseen Events

NOTES/DETAILS:

	($)	
Change in Project Cost		
If available break down this cost change in the following subcategories:		
Subcategories	**($)**	**(%)**
a. Floods		
b. Other weather related incidents		
c. Legislative action		
d. Others (please specify)		

	(months)	
Change in Project Schedule		
If available break down this schedule change in the following subcategories:		
Subcategories	**(months)**	**(%)**
a. Floods		
b. Other weather related incidents		
c. Legislative action		
d. Others (please specify)		

Changes in Market Conditions

NOTES/DETAILS:

	($)	
Change in Project Cost		
If available break down this cost change in the following subcategories:		
Subcategories	($)	(%)
a. Labor		
b. Fuel		
c. Materials		
d. Land		
e. Others (please specify)		

	(months)	
Change in Project Schedule		
If available break down this schedule change in the following subcategories:		
Subcategories	(months)	(%)
a. Labor		
b. Fuel		
c. Materials		
d. Land		
e. Others (please specify)		

Changes in Market Conditions

NOTES/DETAILS:

	($)	
Change in Project Cost		
If available break down this cost change in the following subcategories:		
Subcategories	($)	(%)
a. Labor		
b. Fuel		
c. Materials		
d. Land		
e. Others (please specify)		

	(months)	
Change in Project Schedule		
If available break down this schedule change in the following subcategories:		
Subcategories	(months)	(%)
a. Labor		
b. Fuel		
c. Materials		
d. Land		
e. Others (please specify)		

Changes in Market Conditions

NOTES/DETAILS:

	($)	
Change in Project Cost		
If available break down this cost change in the following subcategories:		
Subcategories	($)	(%)
a. Labor		
b. Fuel		
c. Materials		
d. Land		
e. Others (please specify)		

	(months)	
Change in Project Schedule		
If available break down this schedule change in the following subcategories:		
Subcategories	(months)	(%)
a. Labor		
b. Fuel		
c. Materials		
d. Land		
e. Others (please specify)		

Utilities

NOTES/DETAILS:

	($)	
Change in Project Cost		
If available break down this cost change in the following subcategories:		
Subcategories	($)	(%)
a. Coordination with local utilities efforts		
b. Utility negotiations with owner		
c. Delay		
d. Railroad involvement		
e. Others (please specify)		

	(months)	
Change in Project Schedule		
If available break down this schedule change in the following subcategories:		
Subcategories	(months)	(%)
a. Coordination with local utilities efforts		
b. Utility negotiations with owner		
c. Delay		
d. Railroad involvement		
e. Others (please specify)		

Utilities

NOTES/DETAILS:

	($)	
Change in Project Cost		
If available break down this cost change in the following subcategories:		
Subcategories	($)	(%)
a. Coordination with local utilities efforts		
b. Utility negotiations with owner		
c. Delay		
d. Railroad involvement		
e. Others (please specify)		

	(months)	
Change in Project Schedule		
If available break down this schedule change in the following subcategories:		
Subcategories	(months)	(%)
a. Coordination with local utilities efforts		
b. Utility negotiations with owner		
c. Delay		
d. Railroad involvement		
e. Others (please specify)		

Utilities

NOTES/DETAILS:

	($)	
Change in Project Cost		
If available break down this cost change in the following subcategories:		
Subcategories	($)	(%)
a. Coordination with local utilities efforts		
b. Utility negotiations with owner		
c. Delay		
d. Railroad involvement		
e. Others (please specify)		

	(months)	
Change in Project Schedule		
If available break down this schedule change in the following subcategories:		
Subcategories	(months)	(%)
a. Coordination with local utilities efforts		
b. Utility negotiations with owner		
c. Delay		
d. Railroad involvement		
e. Others (please specify)		

APPENDIX C. RISK ANALYSIS FOR CAPACITY PROJECTS

C.1 STIP & AWARD Risk Factor Analysis for Capacity Projects

Number of Datasets

For this scenario, STE reduced the number of datasets from thirty eight to twenty five based on being "Capacity" type projects. Table C.1 presents the datasets used in the analysis.

Table C.1 Capacity Datasets Used In STIP & AWARD Analysis.

Project Name/ID	
2593 Readv / 71472, 72052	3110 / 60106 ; 72564 Phase 2B
2830 / 71976 / 71304 / IDR-DPC-9(3)043	3127 / 60159; 72498
2853 / 72031	3150 / 72400
2957 / 72024 ; 72382	3154 / 60108; 70858
2995 / 60090; 72154	3161 / 60158; 72807; 72657; 72493
2996 / 72356, 72357, 72572	3167 / 60188, 72805, 72493 Phase 3A
3003 / 72281	3187 / 60179; 72498
3038 - 60093; 72641	3193 / 60208; 72806; 72657
3039 / 72686	3209 / 60208 / 72806 / 72657
3052 / 72637	3215 / 60169, 72805, 72657
3053 / 60101 ; 72564 Phase 2A	3237 / 60088; 72596; 72597
3055 / 60103 ; 72657	3260 / 60207, 72806, 72807, 72657
3090 / 60099; 60125; 71394; 72610; 72711; 72720; 72355; 72410	

Assumptions for Analysis

For simulation purposes, STE assumed the following for each risk factor:

- Data was assumed to be sample data
- Data was assumed to be continuous
- Used Latin Hypercube sampling
- Removed environmental, traffic, stakeholders, unforeseen, and market risk factors

C.1.1 Risk Factors Fitted to Best Fit Distribution for Capacity Projects

Simulation Results

Table C.2 presents the risk factors that were available for simulation, the type of best fit distribution, the mean, and the standard deviation. The results indicate that 'Other' is the dominant risk factor. In addition, the standard deviation is greater than the mean for each risk factor.

Table C.2 Risk Factors for Capacity Projects Using Best Fit Distribution.

Risk Factors		Graph	Distribution	Mean	Standard Deviation
R_1	ROW$ / STIP		Beta General	12.5%	18.6%
R_3	ENGINEERING$ / STIP		Log Logistic	8.7%	40.4%
R_8	UTILTIES$ / STIP		Beta General	0.14%	0.25%
Other	OTHER$ / STIP		Log Logistic	97.7%	152.1%

C.1.2 Risk Factors Fitted to Normal Distribution for Capacity Projects
STE utilized the normal distribution as a comparison to best fit analysis with the following assumptions:

- Data was assumed to be sample data
- Data was assumed to be continuous
- Used Latin Hypercube sampling
- Used Normal Distribution
- Removed environmental, traffic, stakeholders, unforeseen, and market risk factors

Simulation Results
Table C.3 presents the risk factors that were available for simulation, the distribution, the mean, and the standard deviation. Again, the results indicate that "Other" is the dominant risk factor. The standard deviation is also greater than the mean for each risk factor. In addition, the mean and standard deviation for each risk factor is greater than the mean and standard deviation for each risk factor in the best fit distribution scenario.

Table C.3 Risk Factors for Capacity Projects Using Normal Distribution.

Risk Factors		Graph	Distribution	Mean	Standard Deviation
R_1	ROW$ / STIP		Normal	6.5%	16.0%
R_3	ENGINEERING$ / STIP		Normal	14.2%	49.3%
R_8	UTILTIES$ / STIP		Normal	0.06%	0.21%
Other	OTHER$ / STIP		Normal	90.8%	96.8

C.2 AWARD & FINAL Risk Factor Analysis for Capacity Projects

Number of Datasets

For this scenario, STE reduced the number of datasets from forty five to twenty eight based on being "Capacity" type projects. Table C.4 presents the datasets used in the analysis.

Assumptions for Analysis

For simulation purposes, STE assumed the following for each risk factor:

- Data was assumed to be sample data
- Data was assumed to be continuous
- Used Latin Hypercube sampling

Table C.4 Capacity Datasets Used In AWARD & FINAL Analysis.

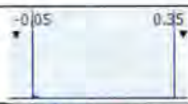
Project Name/ID	
2567 / 71565	3110 / 60106 ; 72564 Phase 2B
2593 Readv / 71472, 72052	3127 / 60159; 72498
2830 / 71976 / 71304 / IDR-DPC-9(3)043	3150 / 72400
2853 / 72031	3154 / 60108; 70858
2957 / 72024 ; 72382	3161 / 60158; 72807; 72657; 72493
2995 / 60090; 72154	3167 / 60188, 72805, 72493 Phase 3A
2996 / 72356, 72357, 72572	3169 / 60189, 72805, 72493
3003 / 72281	3187 / 60179; 72498
3038 - 60093; 72641	3193 / 60208; 72806; 72657
3039 / 72686	3209 / 60208 / 72806 / 72657
3052 / 72637	3215 / 60169, 72805, 72657
3053 / 60101 ; 72564 Phase 2A	3237 / 60088; 72596; 72597
3055 / 60103 ; 72657	3238 / 72642
3090 / 60099; 60125; 71394; 72610; 72711; 72720; 72355; 72410	3260 / 60207, 72806, 72807, 72657

C.2.1 Risk Factors Fitted to Best Fit Distribution for Capacity Projects

Simulation Results

Table C.5 presents the risk factors that were available for simulation, the type of best fit distribution, the mean, and the standard deviation. The results indicate that "Unforeseen Engineering Complexities/Constructability Issues" and "Insufficient Knowledge of Right of Way" are the dominant risk factors.

Table C.5 Risk Factors for Capacity Projects Using Best Fit Distribution.

Risk Factors		Graph	Distribution	Mean	Standard Deviation
R_1	ROW$ / AWARD		Beta General	9.7%	11.2%
R_2	ENVIRONMENTAL$ / AWARD		Extreme Value	0.06%	0.26%
R_3	ENGINEERING$ / AWARD		Log Logistic	10.7%	18.9%
R_4	TRAFFIC$ / AWARD		Extreme Value	0.4%	0.7%
R_5	STAKEHOLDERS$ / AWARD		Exponential	0.3%	0.3%
R_6	UNFORESEEN$ / AWARD		Log Logistic	0.04%	1.5%
R_7	MARKET$ / AWARD		Logistic	0.04%	0.31%
R_8	UTILTIES$ / AWARD		Extreme Value	0.2%	0.4%
Other	OTHER$ / AWARD		Logistic	-5.0%	11.6%

C.2.2 Risk Factors Fitted to Normal Distribution for Capacity Projects

STE utilized the normal distribution as a comparison to best fit analysis with the following assumptions:

- Data was assumed to be sample data
- Data was assumed to be continuous
- Used Latin Hypercube sampling
- Used Normal Distribution

Simulation Results

Table C.6 presents the risk factors that were available for simulation, the distribution, the mean, and the standard deviation. Again, the results indicate that "Unforeseen Engineering Complexities/Constructability Issues" and "Insufficient Knowledge of Right of Way" are the dominant risk factors. The standard deviation is also greater than the mean for each risk factor.

Table C.6 Risk Factors for Capacity Projects Using Normal Distribution.

Risk Factors		Graph	Distribution	Mean	Standard Deviation
R_1	ROW$ / AWARD		Normal	7.2%	11.0%
R_2	ENVIRONMENTAL$ / AWARD		Normal	0.03%	0.20%
R_3	ENGINEERING$ / AWARD		Normal	11.0%	19.4%
R_4	TRAFFIC$ / AWARD		Normal	0.4%	0.9%
R_5	STAKEHOLDERS$ / AWARD		Normal	0.3%	0.6%
R_6	UNFORESEEN$ / AWARD		Normal	0.7%	2.6%
R_7	MARKET$ / AWARD		Normal	0.04%	0.45%
R_8	UTILTIES$ / AWARD		Normal	0.3%	1.2%
Other	OTHER$ / AWARD		Normal	-3.0%	18.6%

C.3 STIP & FINAL Risk Factor Analysis for Capacity Projects

Number of Datasets

For this scenario, STE reduced the number of datasets from thirty eight to twenty five based on being "Capacity" type projects. Table C.7 presents the datasets used in the analysis.

Assumptions for Analysis

For simulation purposes, STE assumed the following for each risk factor:

- Data was assumed to be sample data
- Data was assumed to be continuous
- Used Latin Hypercube sampling

Table C.7 Capacity Datasets Used In AWARD & FINAL Analysis.

Project Name/ID	
2593 Readv / 71472, 72052	3110 / 60106 ; 72564 Phase 2B
2830 / 71976 / 71304 / IDR-DPC-9(3)043	3127 / 60159; 72498
2853 / 72031	3150 / 72400
2957 / 72024 ; 72382	3154 / 60108; 70858
2995 / 60090; 72154	3161 / 60158; 72807; 72657; 72493
2996 / 72356, 72357, 72572	3167 / 60188, 72805, 72493 Phase 3A
3003 / 72281	3187 / 60179; 72498
3038 - 60093; 72641	3193 / 60208; 72806; 72657
3039 / 72686	3209 / 60208 / 72806 / 72657
3052 / 72637	3215 / 60169, 72805, 72657
3053 / 60101 ; 72564 Phase 2A	3237 / 60088; 72596; 72597
3055 / 60103 ; 72657	3260 / 60207, 72806, 72807, 72657
3090 / 60099; 60125; 71394; 72610; 72711; 72720; 72355; 72410	

C.3.1 Risk Factors Fitted to Best Fit Distribution for Capacity Projects

Simulation Results

Table C.8 presents the risk factors that were available for simulation, the type of best fit distribution, the mean, and the standard deviation. The results indicate that 'Other' is the dominant risk factor as expected since many categories of risks did not have specific cost information in the datasets from STIP to AWARD. The results also indicate that "Unforeseen Engineering Complexities/Constructability Issues" is an influential risk factor followed by "Insufficient Knowledge of Right of Way".

Table C.8 Risk Factors for Capacity Projects Using Best Fit Distribution.

Risk Factors[a]		Graph	Distribution	Mean	Standard Deviation
R_1	ROW$ / STIP		Beta General	22.2%	25.1%
R_2	ENVIRONMENTAL$ / STIP		Normal	0.08%	0.27%
R_3	ENGINEERING$ / STIP		Gamma	31.8%	44.2%
R_4	TRAFFIC$ / STIP		Logistic	0.6%	2.5%
R_5	STAKEHOLDERS$ / STIP		Exponential	0.6%	0.6%
R_6	UNFORESEEN$ / STIP		Extreme Value	1.2%	3.1%
R_7	MARKET$ / STIP		Normal	0.02%	0.56%
R_8	UTILTIES$ / STIP		Inverse Gaussian	0.6%	1.2%
Other	OTHER$ / STIP		Log Logistic	94.5%	172.0%

[a]The risk factor value represents the dollar amount from STIP to AWARD and AWARD to FINAL.

C.3.2 Risk Factors Fitted to Normal Distribution for Capacity Projects

STE utilized the normal distribution as a comparison to best fit analysis with the following assumptions:

- Data was assumed to be sample data
- Data was assumed to be continuous
- Used Latin Hypercube sampling
- Used Normal Distribution

Simulation Results

Table C.9 presents the risk factors that were available for simulation, the distribution, the mean, and the standard deviation. The results indicate that 'Other' is the dominant risk factor as expected since many categories of risks did not have specific cost information in the datasets from STIP to AWARD. The results also indicate that "Unforeseen Engineering Complexities/Constructability Issues" is an influential risk factor followed by "Insufficient Knowledge of Right of Way".

Table C.9 Risk Factors for Capacity Projects Using Normal Distribution.

Risk Factors[a]		Graph	Distribution	Mean	Standard Deviation
R_1	ROW$ / STIP		Normal	17.7%	23.1%
R_2	ENVIRONMENTAL$ / STIP		Normal	0.08%	0.27%
R_3	ENGINEERING$ / STIP		Normal	31.8%	45.4
R_4	TRAFFIC$ / STIP		Normal	1.5%	4.8%
R_5	STAKEHOLDERS$ / STIP		Normal	0.6%	1.6%
R_6	UNFORESEEN$ / STIP		Normal	1.5%	5.3%
R_7	MARKET$ / STIP		Normal	0.02%	0.56%
R_8	UTILTIES$ / STIP		Normal	0.6%	1.7%
Other	OTHER$ / STIP		Normal	83.6%	94.1%

[a]*The risk factor value represents the dollar amount from STIP to AWARD and AWARD to FINAL.*

APPENDIX D. SUMMARY OF AVERAGE PRICES

Table D.1 1985 Summary

	Code	Categories	Units	Quantity	Cost	Cost / Unit	Percentage
1	CSM	Crushed Surface Materials	ton	182,781	$ 1,322,790	$ 7.24	10.32%
2	CP	Concrete Pavement	yd^2	-	$ -		
3	SC	Structural Concrete	yd^3	2,443	$ 604,590	$ 247.48	4.72%
4	HMA	Hot-Mix Asphalt	ton	298,110	$ 6,391,890	$ 21.44	49.89%
5	SRB	Steel Reinforcing Bar	lb	497,150	$ 272,208	$ 0.55	2.12%
6	SS	Structural Steel	ln ft	-	$ -		
7	RE	Roadway Excavation	yd^3	961,898	$ 4,221,410	$ 4.39	32.95%
				Total	$ 12,812,888		100.00%

Table D.2 1986 Summary.

	Code	Categories	Units	Quantity	Cost	Cost / Unit	Percentage
1	CSM	Crushed Surface Materials	ton	509,986	$ 5,882,565	$ 11.53	11.35%
2	CP	Concrete Pavement	yd^2	132,360	$ 2,316,300	$ 17.50	4.47%
3	SC	Structural Concrete	yd^3	27,647	$ 6,262,030	$ 226.50	12.09%
4	HMA	Hot-Mix Asphalt	ton	987,546	$ 22,948,169	$ 23.24	44.29%
5	SRB	Steel Reinforcing Bar	lb	5,290,106	$ 2,590,426	$ 0.49	5.00%
6	SS	Structural Steel	ln ft	-	$ -		
7	RE	Roadway Excavation	yd^3	2,749,845	$ 11,815,310	$ 4.30	22.80%
				Total	$ 51,814,800		100.00%

Table D.3 1987 Summary.

	Code	Categories	Units	Quantity	Cost	Cost / Unit	Percentage
1	CSM	Crushed Surface Materials	ton	542,995	$ 4,521,980	$ 8.33	7.67%
2	CP	Concrete Pavement	yd^2	1,176,725	$ 16,546,313	$ 14.06	28.07%
3	SC	Structural Concrete	yd^3	23,690	$ 5,747,055	$ 242.59	9.75%
4	HMA	Hot-Mix Asphalt	ton	700,901	$ 15,350,905	$ 21.90	26.04%
5	SRB	Steel Reinforcing Bar	lb	3,712,970	$ 1,837,369	$ 0.49	3.12%
6	SS	Structural Steel	ln ft	-	$ -		
7	RE	Roadway Excavation	yd^3	4,375,538	$ 14,943,028	$ 3.42	25.35%
				Total	$ 58,946,649		100.00%

Table D.4 1988 Summary.

	Code	Categories	Units	Quantity	Cost	Cost / Unit	Percentage
1	CSM	Crushed Surface Materials	ton	683,781	$ 6,766,860	$ 9.90	11.57%
2	CP	Concrete Pavement	yd²	374,550	$ 4,120,050	$ 11.00	7.04%
3	SC	Structural Concrete	yd³	6,497	$ 1,691,030	$ 260.28	2.89%
4	HMA	Hot-Mix Asphalt	ton	1,530,684	$ 36,004,407	$ 23.52	61.55%
5	SRB	Steel Reinforcing Bar	lb	1,135,860	$ 647,196	$ 0.57	1.11%
6	SS	Structural Steel	ln ft	-	$ -		
7	RE	Roadway Excavation	yd³	1,907,503	$ 9,266,511	$ 4.86	15.84%
				Total	$ 58,496,053		100.00%

Table D.5 1989 Summary.

	Code	Categories	Units	Quantity	Cost	Cost / Unit	Percentage
1	CSM	Crushed Surface Materials	ton	1,400,615	$ 11,450,090	$ 8.18	13.05%
2	CP	Concrete Pavement	yd²	1,027,070	$ 13,995,845	$ 13.63	15.95%
3	SC	Structural Concrete	yd³	32,401	$ 8,262,400	$ 255.00	9.42%
4	HMA	Hot-Mix Asphalt	ton	2,062,465	$ 45,523,789	$ 22.07	51.89%
5	SRB	Steel Reinforcing Bar	lb	5,804,706	$ 2,886,585	$ 0.50	3.29%
6	SS	Structural Steel	ln ft	-	$ -		
7	RE	Roadway Excavation	yd³	1,059,680	$ 5,605,458	$ 5.29	6.39%
				Total	$ 87,724,167		100.00%

Table D.6 1990 Summary.

	Code	Categories	Units	Quantity	Cost	Cost / Unit	Percentage
1	CSM	Crushed Surface Materials	ton	509,000	$ 5,494,601	$ 10.79	10.40%
2	CP	Concrete Pavement	yd²	-	$ -		
3	SC	Structural Concrete	yd³	20,392	$ 5,006,035	$ 245.49	9.47%
4	HMA	Hot-Mix Asphalt	ton	1,126,566	$ 28,747,955	$ 25.52	54.40%
5	SRB	Steel Reinforcing Bar	lb	4,031,461	$ 2,056,688	$ 0.51	3.89%
6	SS	Structural Steel	ln ft	-	$ -		
7	RE	Roadway Excavation	yd³	2,524,264	$ 11,541,702	$ 4.57	21.84%
				Total	$ 52,846,980		100.00%

Table D.7 1991 Summary.

	Code	Categories	Units	Quantity	Cost	Cost / Unit	Percentage
1	CSM	Crushed Surface Materials	ton	1,098,959	$ 9,214,912	$ 8.39	11.29%
2	CP	Concrete Pavement	yd^2	597,173	$ 8,047,469	$ 13.48	9.86%
3	SC	Structural Concrete	yd^3	46,694	$ 10,049,180	$ 215.21	12.31%
4	HMA	Hot-Mix Asphalt	ton	1,331,487	$ 37,598,337	$ 28.24	46.06%
5	SRB	Steel Reinforcing Bar	lb	6,880,212	$ 3,267,726	$ 0.47	4.00%
6	SS	Structural Steel	ln ft	-	$ -		
7	RE	Roadway Excavation	yd^3	3,615,908	$ 13,450,916	$ 3.72	16.48%
				Total	$ 81,628,539		100.00%

Table D.8 1992 Summary.

	Code	Categories	Units	Quantity	Cost	Cost / Unit	Percentage
1	CSM	Crushed Surface Materials	ton	1,148,105	$ 10,195,318	$ 8.88	14.49%
2	CP	Concrete Pavement	yd^2	183,611	$ 3,441,815	$ 18.75	4.89%
3	SC	Structural Concrete	yd^3	12,764	$ 3,529,195	$ 276.50	5.02%
4	HMA	Hot-Mix Asphalt	ton	1,588,650	$ 42,028,500	$ 26.46	59.75%
5	SRB	Steel Reinforcing Bar	lb	2,351,483	$ 1,232,683	$ 0.52	1.75%
6	SS	Structural Steel	ln ft	-	$ -		
7	RE	Roadway Excavation	yd^3	2,249,912	$ 9,917,713	$ 4.41	14.10%
				Total	$ 70,345,223		100.00%

Table D.9 1993 Summary.

	Code	Categories	Units	Quantity	Cost	Cost / Unit	Percentage
1	CSM	Crushed Surface Materials	ton	1,433,123	$ 13,150,098	$ 9.18	9.97%
2	CP	Concrete Pavement	yd^2	713,143	$ 14,589,474	$ 20.46	11.06%
3	SC	Structural Concrete	yd^3	49,645	$ 13,203,256	$ 265.95	10.01%
4	HMA	Hot-Mix Asphalt	ton	2,453,306	$ 65,614,378	$ 26.75	49.74%
5	SRB	Steel Reinforcing Bar	lb	9,739,661	$ 5,324,527	$ 0.55	4.04%
6	SS	Structural Steel	ln ft	-	$ -		
7	RE	Roadway Excavation	yd^3	5,112,821	$ 20,024,281	$ 3.92	15.18%
				Total	$131,906,014		100.00%

Table D.10 1994 Summary.

	Code	Categories	Units	Quantity	Cost	Cost / Unit	Percentage
1	CSM	Crushed Surface Materials	ton	1,443,049	$ 14,555,363	$ 10.09	13.72%
2	CP	Concrete Pavement	yd^2	109,500	$ 1,861,500	$ 17.00	1.76%
3	SC	Structural Concrete	yd^3	5,577	$ 1,877,120	$ 336.58	1.77%
4	HMA	Hot-Mix Asphalt	ton	2,862,638	$ 78,438,365	$ 27.40	73.96%
5	SRB	Steel Reinforcing Bar	lb	1,288,348	$ 2,995,141	$ 2.32	2.82%
6	SS	Structural Steel	ln ft	-	$ -		
7	RE	Roadway Excavation	yd^3	1,236,059	$ 6,329,536	$ 5.12	5.97%
				Total	$106,057,025		100.00%

Table D.11 1995 Summary.

	Code	Categories	Units	Quantity	Cost	Cost / Unit	Percentage
1	CSM	Crushed Surface Materials	ton	585,943	$ 7,700,367	$ 13.14	12.42%
2	CP	Concrete Pavement	yd^2	-	$ -		
3	SC	Structural Concrete	yd^3	12,140	$ 3,611,250	$ 297.47	5.82%
4	HMA	Hot-Mix Asphalt	ton	1,638,112	$ 46,117,464	$ 28.15	74.36%
5	SRB	Steel Reinforcing Bar	lb	2,257,740	$ 1,357,727	$ 0.60	2.19%
6	SS	Structural Steel	ln ft	-	$ -		
7	RE	Roadway Excavation	yd^3	532,689	$ 3,232,036	$ 6.07	5.21%
				Total	$ 62,018,843		100.00%

Table D.12 1996 Summary.

	Code	Categories	Units	Quantity	Cost	Cost / Unit	Percentage
1	CSM	Crushed Surface Materials	ton	651,757	$ 7,811,357	$ 11.99	13.36%
2	CP	Concrete Pavement	yd^2	11,370	$ 256,780	$ 22.58	0.44%
3	SC	Structural Concrete	yd^3	4,759	$ 2,172,325	$ 456.47	3.72%
4	HMA	Hot-Mix Asphalt	ton	1,546,049	$ 43,787,484	$ 28.32	74.89%
5	SRB	Steel Reinforcing Bar	lb	1,192,699	$ 821,206	$ 0.69	1.40%
6	SS	Structural Steel	ln ft	-	$ -		
7	RE	Roadway Excavation	yd^3	506,667	$ 3,622,548	$ 7.15	6.20%
				Total	$ 58,471,700		100.00%

Table D.13 1997 Summary.

	Code	Categories	Units	Quantity	Cost	Cost / Unit	Percentage
1	CSM	Crushed Surface Materials	ton	-	$ -		
2	CP	Concrete Pavement	yd^2	-	$ -		
3	SC	Structural Concrete	yd^3	-	$ -		
4	HMA	Hot-Mix Asphalt	ton	-	$ -		
5	SRB	Steel Reinforcing Bar	lb	-	$ -		
6	SS	Structural Steel	ln ft	-	$ -		
7	RE	Roadway Excavation	yd^3	-	$ -		
				Total	$ -		0.00%

Table D.14 1998 Summary.

	Code	Categories	Units	Quantity	Cost	Cost / Unit	Percentage
1	CSM	Crushed Surface Materials	ton	711,846	$ 5,766,409	$ 8.10	13.41%
2	CP	Concrete Pavement	yd^2	-	$ -		
3	SC	Structural Concrete	yd^3	9,161	$ 3,432,310	$ 374.66	7.98%
4	HMA	Hot-Mix Asphalt	ton	956,804	$ 28,407,999	$ 29.69	66.06%
5	SRB	Steel Reinforcing Bar	lb	1,749,959	$ 1,097,414	$ 0.63	2.55%
6	SS	Structural Steel	ln ft	-	$ -		
7	RE	Roadway Excavation	yd^3	815,476	$ 4,300,593	$ 5.27	10.00%
				Total	$ 43,004,725		100.00%

Table D.15 1999 Summary.

	Code	Categories	Units	Quantity	Cost	Cost / Unit	Percentage
1	CSM	Crushed Surface Materials	ton	1,809,992	$ 18,110,119	$ 10.01	10.74%
2	CP	Concrete Pavement	yd^2	11,080	$ 277,000	$ 25.00	0.16%
3	SC	Structural Concrete	yd^3	7,665	$ 3,460,400	$ 451.45	2.05%
4	HMA	Hot-Mix Asphalt	ton	2,848,942	$138,099,659	$ 48.47	81.90%
5	SRB	Steel Reinforcing Bar	lb	1,752,181	$ 1,769,666	$ 1.01	1.05%
6	SS	Structural Steel	ln ft	-	$ -		
7	RE	Roadway Excavation	yd^3	720,884	$ 6,903,029	$ 9.58	4.09%
				Total	$168,619,872		100.00%

Table D.16 2000 Summary.

	Code	Categories	Units	Quantity	Cost	Cost / Unit	Percentage
1	CSM	Crushed Surface Materials	ton	1,114,339	$ 14,862,901	$ 13.34	14.14%
2	CP	Concrete Pavement	yd^2	168,657	$ 5,990,555	$ 35.52	5.70%
3	SC	Structural Concrete	yd^3	36,219	$ 12,069,265	$ 333.23	11.48%
4	HMA	Hot-Mix Asphalt	ton	1,684,803	$ 55,251,822	$ 32.79	52.58%
5	SRB	Steel Reinforcing Bar	lb	9,076,595	$ 5,880,477	$ 0.65	5.60%
6	SS	Structural Steel	ln ft	-	$ -		
7	RE	Roadway Excavation	yd^3	1,167,398	$ 11,035,530	$ 9.45	10.50%
				Total	$105,090,550		100.00%

Table D.17 2001 Summary.

	Code	Categories	Units	Quantity	Cost	Cost / Unit	Percentage
1	CSM	Crushed Surface Materials	ton	877,398	$ 10,963,420	$ 12.50	16.10%
2	CP	Concrete Pavement	yd^2	61,580	$ 2,317,005	$ 37.63	3.40%
3	SC	Structural Concrete	yd^3	11,442	$ 3,801,050	$ 332.21	5.58%
4	HMA	Hot-Mix Asphalt	ton	1,414,652	$ 40,224,640	$ 28.43	59.06%
5	SRB	Steel Reinforcing Bar	lb	3,138,487	$ 2,196,789	$ 0.70	3.23%
6	SS	Structural Steel	ln ft	-	$ -		
7	RE	Roadway Excavation	yd^3	1,235,257	$ 8,607,960	$ 6.97	12.64%
				Total	$ 68,110,864		100.00%

Table D.18 2002 Summary.

	Code	Categories	Units	Quantity	Cost	Cost / Unit	Percentage
1	CSM	Crushed Surface Materials	ton	1,688,218	$ 13,907,445	$ 8.24	12.24%
2	CP	Concrete Pavement	yd^2	-	$ -		
3	SC	Structural Concrete	yd^3	42,195	$ 16,416,689	$ 389.07	14.45%
4	HMA	Hot-Mix Asphalt	ton	1,877,199	$ 63,312,692	$ 33.73	55.74%
5	SRB	Steel Reinforcing Bar	lb	7,717,847	$ 5,654,933	$ 0.73	4.98%
6	SS	Structural Steel	ln ft	-	$ -		
7	RE	Roadway Excavation	yd^3	1,489,726	$ 14,289,673	$ 9.59	12.58%
				Total	$113,581,431		100.00%

Table D.19 2003 Summary.

	Code	Categories	Units	Quantity	Cost	Cost / Unit	Percentage
1	CSM	Crushed Surface Materials	ton	2,139,192	$ 18,690,763	$ 8.74	8.20%
2	CP	Concrete Pavement	yd^2	148,300	$ 3,559,200	$ 24.00	1.56%
3	SC	Structural Concrete	yd^3	178,754	$ 69,277,510	$ 387.56	30.39%
4	HMA	Hot-Mix Asphalt	ton	1,568,344	$ 53,968,452	$ 34.41	23.67%
5	SRB	Steel Reinforcing Bar	lb	41,071,420	$ 25,023,939	$ 0.61	10.98%
6	SS	Structural Steel	ln ft	-	$ -		
7	RE	Roadway Excavation	yd^3	8,087,214	$ 57,442,405	$ 7.10	25.20%
				Total	$227,962,269		100.00%

Table D.20 2004 Summary.

	Code	Categories	Units	Quantity	Cost	Cost / Unit	Percentage
1	CSM	Crushed Surface Materials	ton	812,263	$ 8,778,569	$ 10.81	6.64%
2	CP	Concrete Pavement	yd^2	64,290	$ 1,932,300	$ 30.06	1.46%
3	SC	Structural Concrete	yd^3	97,738	$ 29,344,255	$ 300.23	22.20%
4	HMA	Hot-Mix Asphalt	ton	1,150,328	$ 49,003,434	$ 42.60	37.06%
5	SRB	Steel Reinforcing Bar	lb	19,003,772	$ 16,483,736	$ 0.87	12.47%
6	SS	Structural Steel	ln ft	-	$ -		
7	RE	Roadway Excavation	yd^3	2,802,177	$ 26,668,111	$ 9.52	20.17%
				Total	$132,210,405		100.00%

Table D.21 2005 Summary.

	Code	Categories	Units	Quantity	Cost	Cost / Unit	Percentage
1	CSM	Crushed Surface Materials	ton	2,244,612	$ 23,863,230	$ 10.63	13.35%
2	CP	Concrete Pavement	yd^2	-	$ -		
3	SC	Structural Concrete	yd^3	55,670	$ 21,305,300	$ 382.71	11.92%
4	HMA	Hot-Mix Asphalt	ton	1,791,364	$ 90,873,160	$ 50.73	50.85%
5	SRB	Steel Reinforcing Bar	lb	10,966,119	$ 10,556,793	$ 0.96	5.91%
6	SS	Structural Steel	ln ft	-	$ -		
7	RE	Roadway Excavation	yd^3	2,936,425	$ 32,121,897	$ 10.94	17.97%
				Total	$178,720,380		100.00%

Table D.22 2006 Summary.

	Code	Categories	Units	Quantity	Cost	Cost / Unit	Percentage
1	CSM	Crushed Surface Materials	ton	2,681,201	$ 30,416,729	$ 11.34	9.86%
2	CP	Concrete Pavement	yd^2	137,200	$ 4,816,400	$ 35.10	1.56%
3	SC	Structural Concrete	yd^3	119,951	$ 73,202,340	$ 610.27	23.73%
4	HMA	Hot-Mix Asphalt	ton	1,275,197	$ 84,846,790	$ 66.54	27.50%
5	SRB	Steel Reinforcing Bar	lb	26,557,485	$ 29,636,382	$ 1.12	9.61%
6	SS	Structural Steel	ln ft	-	$ -		
7	RE	Roadway Excavation	yd^3	13,416,209	$ 85,569,335	$ 6.38	27.74%
				Total	$308,487,976		100.00%

Table D.23 2007 Summary.

	Code	Categories	Units	Quantity	Cost	Cost / Unit	Percentage
1	CSM	Crushed Surface Materials	ton	910,930	$ 10,804,090	$ 11.86	9.38%
2	CP	Concrete Pavement	yd^2	2,380	$ 130,900	$ 55.00	0.11%
3	SC	Structural Concrete	yd^3	41,911	$ 21,033,000	$ 501.85	18.27%
4	HMA	Hot-Mix Asphalt	ton	706,635	$ 51,874,398	$ 73.41	45.06%
5	SRB	Steel Reinforcing Bar	lb	6,581,783	$ 8,579,100	$ 1.30	7.45%
6	SS	Structural Steel	ln ft	-	$ -		
7	RE	Roadway Excavation	yd^3	2,032,882	$ 22,703,327	$ 11.17	19.72%
				Total	$115,124,815		100.00%

Table D.24 2008 Summary.

	Code	Categories	Units	Quantity	Cost	Cost / Unit	Percentage
1	CSM	Crushed Surface Materials	ton	994,440	$ 10,268,810	$ 10.33	10.96%
2	CP	Concrete Pavement	yd^2	60,120	$ 2,404,800	$ 40.00	2.57%
3	SC	Structural Concrete	yd^3	10,735	$ 6,090,700	$ 567.37	6.50%
4	HMA	Hot-Mix Asphalt	ton	789,484	$ 56,200,230	$ 71.19	59.97%
5	SRB	Steel Reinforcing Bar	lb	2,402,960	$ 2,956,197	$ 1.23	3.15%
6	SS	Structural Steel	ln ft	-	$ -		
7	RE	Roadway Excavation	yd^3	1,854,445	$ 15,785,829	$ 8.51	16.85%
				Total	$ 93,706,566		100.00%

Table D.25 2009 (Partial) Summary.

	Code	Categories	Units	Quantity	Cost	Cost / Unit	Percentage
1	CSM	Crushed Surface Materials	ton	363,732	$ 5,030,850	$ 13.83	4.38%
2	CP	Concrete Pavement	yd^2	-	$ -		
3	SC	Structural Concrete	yd^3	4,316	$ 3,152,200	$ 730.40	2.74%
4	HMA	Hot-Mix Asphalt	ton	1,169,964	$ 98,595,600	$ 84.27	85.83%
5	SRB	Steel Reinforcing Bar	lb	747,508	$ 1,330,328	$ 1.78	1.16%
6	SS	Structural Steel	ln ft	-	$ -		
7	RE	Roadway Excavation	yd^3	630,299	$ 6,763,685	$ 10.73	5.89%
				Total	$114,872,663		100.00%

APPENDIX E. INFLATION ESTIMATING SURVEY BY WSDOT

Table E.1 Responses to WSDOT Cost/Inflation Estimating Survey – February 2007.

Questions sent out to AASHTO/RAC List Serve	**1. What do you use for inflation estimating?**	**2. Do you use a commercial forecast or in-house/agency assumed rates?**	**3. If using a commercial forecast, what service or product are you using?**	**4. Are there other approaches you are investigating or feel have merit for transportation capital projects?**
Survey Responses				
Alaska Jeff Ottesen Alaska Department of Transportation jeff_ottesen@dot.state.ak.us	We have started to use the FHWA guidance as to inflating to the year of construction on major projects. This is currently 4% per year, which is certainly not consistent with recent inflation we have seen, or that experienced across the US. In the development of a new electronic STIP tool, we hope to have an automatic tie to the "Scope, Schedule and Estimate" sheet prepared for each project, so that as updated SSE sheets are prepared for any given project, the numbers in the STIP are linked. We are currently asking project engineers to update the SSE sheets for projects at the time of each STIP, and each major amendment for the STIP. But these sheets are normally based on an immediate year of construction, rather than a delayed year which is often the case as the balancing between costs and funding resources is accomplished. This is a paper intensive process and the quality of and thought that goes into each SSE varies considerably. In short, we are pretty low on the technology curve on this issue.	No	NA	Other than what I discuss in the answer to #1, no.

Questions sent out to AASHTO/RAC List Serve	1. What do you use for inflation estimating?	2. Do you use a commercial forecast or in-house/agency assumed rates?	3. If using a commercial forecast, what service or product are you using?	4. Are there other approaches you are investigating or feel have merit for transportation capital projects?
Arkansas Ed Hoppe Division Engineer Programs and Contracts Arkansas State Highway and Transportation Department 501-569-2262 Hoppe.Ed@arkansashighways.com	The Department maintains a Construction Cost Index for highway projects based on the FHWA CCI (1987 base = 100, by quarter past 6 years plus annual back to 1971). In estimating inflation we use the AR CCI in developing the rate. At present we have been using 6% per year inflation to estimate the increase in the cost of construction.	Same as 1.	While we do not specifically use a commercial forecast, we have access to AGC's The Data Digest and trade publications, such as , ENR, Roads & Bridges, Better Roads, etc., that report extensively on the trends and factors relating to highway construction inflation.	The information above relates to estimating for planning/programming purposes such as development of the STIP. PS&E estimate increases are handled on a project basis by the Department's design divisions.
Illinois Jerry D. Cameron Illinois Department of Transportation Jerry.Cameron@illinois.gov	We use a price index from our bidding data	We use a system built in house that calculates an index similar to the federal price index	NA	Risk in Estimating utilizing a task force made up of IDOT and Industry
Iowa Sandra Q. Larson, P.E. Research and Technology Bureau Director Highway Division Iowa Department of Transportation 515-239-1205 sandra.larson@dot.iowa.gov	We use a 4.5% annual program cost increase factor, which is an estimate of both inflation and "project scope creep".	In-house/ agency	NA	No

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Kansas Dick McReynolds Engineer of Research Kansas DOT dick@ksdot.org	On construction projects, the "Engineer's Estimate" uses the historical prices for each individual bid item for the region that the project happens to be. They use the TrnsPort software through AASHTO to compile and generate the estimate. The estimators get the "suggested" price for each bid item and they have the discretion of adjusting it. Recent historical prices are used to reflect the current inflation. The basis for the forward look the state uses is Moody's which is used to provide economic data and forecasts including inflation.	Both-see 1.	See 1.	NA
Massachusetts One Hwang Massachusetts Department of Transportation One.Hwang@state.ma.us	I derive my inflation rates from BLS's PPI indices because it's free, but I am hoping that MassHighway will purchase a copy of R.S. Means to explore the possibility of using values more specific to the transportation industry and to our region.			
Mississippi Paul Loper Mississippi Department of Transportation ploper@mdot.state.ms.us	A 3% rate is used for short term project planning. This rate was derived from the methods shown in question #2.	The rate approximates the historical increase in the construction index computed each year by the MDOT Construction Division. The computation method for the index is similar to the one used by the FHWA to obtain the price trends for federal aid construction.	Do not use commercial forecast.	A trend line of the Construction Index mentioned will be updated each year. The projection method will utilize a second degree polynomial equation.
Missouri Travis Koestner, PE TSE - Contract Services Missouri Department of Transportation 573-526-2923	MoDOT uses 4% in its Statewide Transportation Improvement Program (STIP)	MoDOT's Resource Management and Transportation Planning Groups recommend a rate to use based on historical averages from FHWA and PPI rates.	NA	NA

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Montana Lesly Tribelhorn, PE Highways Bureau Montana Department of Transportation 406-444-6242 ltribelhorn@mt.gov	We use a straight inflation rate of 3% per year, compounded annually. We inflate the total estimated construction cost after adding in contingencies. (Note: Lesly's perspective is from the engineering end of the process which uses the rate provided by the Planning Office to estimate construction costs)	We use an in-house assumed rate (from Global Insight Inc.) However, we have initiated the process to have an economist within our planning division determine appropriate inflation rates based on a market analysis.	See below	We have initiated the process to have an economist within our planning division determine appropriate inflation rates based on a market analysis.
Montana (continued) Paul Johnson, PE Project Analysis Bureau Montana Department of Transportation 406-444-7259 paujohnson@mt.gov	The Montana Department of Transportation (MDT) utilizes the services of Global Insight Inc. to determine inflationary factors for highway construction costs. The Highway Construction Cost Index provided by Global Insight provides MDT with historical values as well as future forecasts. (Note: Paul's perspective is from the planning end of the process which uses the rate provided by Global Insight, and incorporates current local data)	As mentioned previously, MDT utilizes Global Insight Inc. as a source for inflationary information. Global Insight is considered an official source of economic information for the State of Montana.	The Highway Construction Cost Index provided by Global Insight Inc.	MDT would like to develop a procedure for determining inflationary factors at the state level. (Presently, our best available data source is the national/regional information provided by Global Insight.) Additionally, MDT would like to evaluate the factors that cause our state rate to vary from the national average. However, it would require a substantial reallocation of resources within the department to make this happen. So while we are steering our efforts in this direction, it will take time to see meaningful results.

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North Dakota James Rath Design Division North Dakota Department of Transportation 701-328-1722 jrath@nd.gov	4%	In-house assumed rates	NA	None
Oregon John Riedl, PE Senior Cost Engineer Oregon Department of Transportation 503-986-3886 John.J.RIEDL@odot.state.or.us	Inflation estimating is performed in house through the ODOT office of economics with Dave Kavanaugh together with information provided by the office of spec's, estimating and office of prelet (SOEPL).	The office of economics uses a number of services - including commercial services as well as in house forecasting expertise. Several commercial services are available - I so not have a list but can give you contact names for that information if desired.	Cost forecasting for smaller STIP projects is quite different than costs for mega projects as defined by FHWA. ODOT does follow the CEVP and CRA program protocols to a degree - depending on the order and magnitude of the work and risk. The recent OTIA III program was just evaluated for risk via a multi level risk analysis based upon work type, level of scoping based upon project bundles, market sector analysis of bid trends over the last 3 years and work sector workforce saturation.	The recently developed market sector analysis tool was copied and given to Jay Drye in WsDOT at this years TCCE meeting at AASHTO - he should have a copy available for you.

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Saskatchewan, Canada Allan Widger Executive Director, Engineering Standards Branch Saskatchewan Highways and Transportation 306-787-4858 awidger@highways.gov.sk.ca	I received your questions through the AASHTO Committees so decided to respond. I was surprised to receive this question from Washington State since Saskatchewan just had a consultant review our Construction Bid Price Trends and estimating for our Department and most of the information they quoted was from your web site which I had given to them as a good reference. They included it as being one of the best sources of information.	Everybody is having the same problem with increasing construction costs and what to use as inflation rates. Historically there has been a slow continuous increase and predictions of things like bid price trends have been possible. With the cost increases of 50% or more in the last two years we are asking the same questions you are and have been unable to determine what to expect.	Saskatchewan has been trying to use the same approach that you do of breaking down the major construction components into the inputs and predicting the inputs such as labour/fuel/materials/equipment cost/profit separately since there does seem to be information available on each of the input factors for our small market.	The Saskatchewan report has temporarily been pulled from our web site http://www.highways.gov.sk.ca/docs/reports_manuals/reports/report_transition.asp but should be posted again in the very near future.
Texas Jack Foster, P.E. Director, Systems Planning Transportation Planning and Programming Division Texas Department of Transportation 512-486-5024 jfoster@dot.state.tx.us	Currently TxDOT uses four percent as our inflation rate.	TxDOT uses rates derived in-house.	Not applicable.	TxDOT is not currently investigating other approaches.
Virginia John W. Lawson Director of Financial Planning Virginia Department of Transportation 804-786-2454 John.Lawson@VDOT.Virginia.gov	We inflate construction projects to the year of advertisement. If a project is to begin in FY 2010, it would be inflated from the current years estimate by a factor representing the forecasted cumulative growth for fiscal years 2007, 2008, 2009 and 2010. We include an inflation factor for the current year since our project estimating tool is based on historical costs from the prior year. The inflation rates are applied by the agency's cost estimating tool.	We obtain our inflation forecast through the Virginia Department of Taxation. They have worked with Moodys.com to develop a construction forecast for this purpose.	The custom forecast from Moodys.com explained above is a blended forecast based on PPI for transportation construction and materials.	We have looked at using ENR or just the PPI for land transportation, but they have not tracked well for us.

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West Virginia Robert Watson ,P.E Budget Division West Virginia Division of Highways 304-558-9623 rcwatson@dot.state.wv.u	Federal-Aid Construction Price Index (national values) 10-year rolling average.	In-house	N/A	We are not evaluating any at this time.
Wisconsin Steven Krebs Wisconsin Department of Transportation steven.krebs@dot.state.wi.u	The Wisconsin Construction Cost Index	In House Agency assumed rate and/or CPI.	Sometimes CPI	We are currently investigating this very question. At this time we don't have information to add.

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Washington Aaron Butters Systems Analysis and Program Development Manager Washington State Department of Transportation 360-705-7153 ButterA@wsdot.wa.gov Eric Meale Economics Manager Washington State Department of Transportation 360-705-7942 MealeE@wsdot.wa.gov	WSDOT currently uses a private service to supply this information. The construction forecast assumptions have been taken from an index prepared and maintained by Global Insight. Global Insight is an economics and forecasting consulting firm.	Global Insight provides inflation estimates for 10 years and the last year's inflation rate is used to project to 50 years.	Global Insight Highway Construction Cost Index	In its 2007-09 biennial budget request, WSDOT updated estimates on a project-by project basis to reflect current costs (June 2006). Some project cost updates merely reflect the increased cost escalation of the project from the date of the last estimate, while others also reflect the continued engineering refinement of design details. From there, WSDOT has applied an inflation factor for each of the project phases of Project Engineering, Right of Way, and Construction to year of expenditure, as follows: • Project Engineering cost projections include a general measure of inflation (the Implicit Price Deflator for personal consumption). • Right of Way cost growth through 2007 reflect assumptions based on a forecast of the market value of real and personal taxable property prepared by the state's Economic and Revenue Forecast Council, and for 2008 and beyond, the forecast is derived from a forecast of assessed property value (Puget Sound baseline) prepared by Conway Pederson Economics. • The construction forecast assumptions have been taken from an index prepared and maintained by Global Insight.

Survey conducted by WSDOT Office of Research and Library Services, February 2007.