

PRACTICAL GUIDE TO COST ESTIMATING



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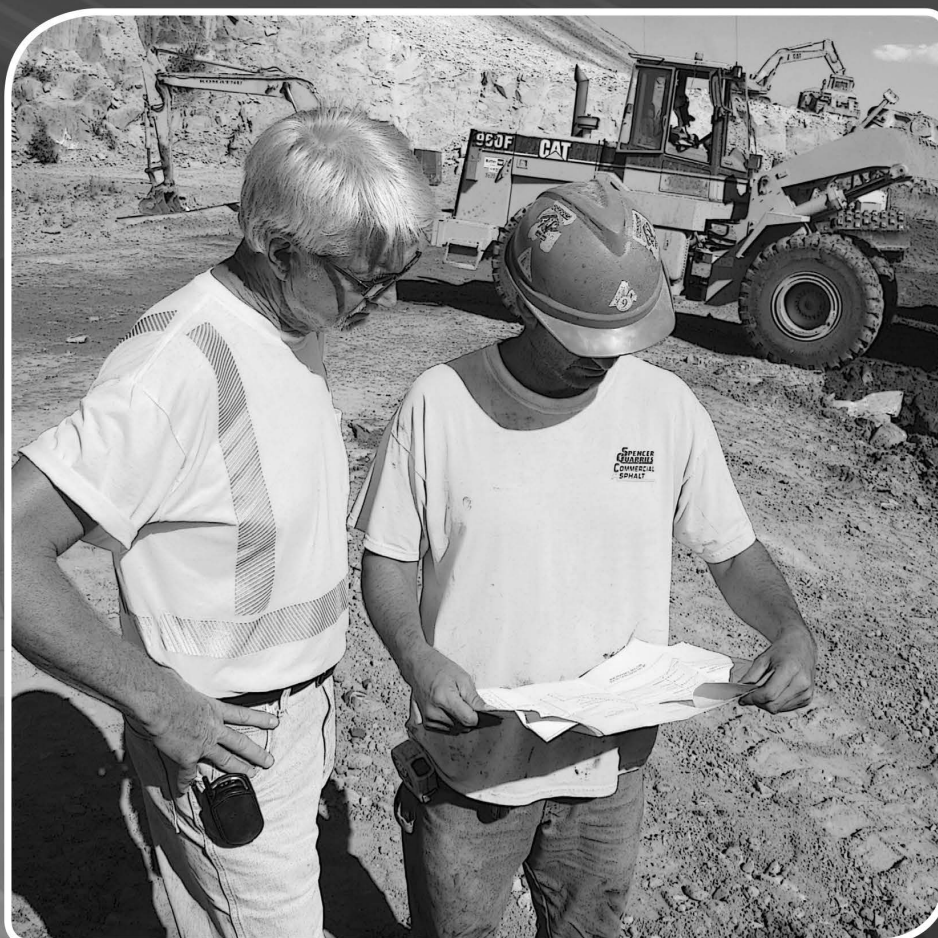
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AASHTO
THE VOICE OF TRANSPORTATION

PRACTICAL GUIDE TO COST ESTIMATING



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This guidance is the result of several years of hard work that began with the AASHTO Subcommittee on Design Technical Committee on Cost Estimating (TCCE). TCCE members drafted the content of the guidance in 2004, working on two to three chapters a year based on personal experience as cost estimators, while continuing to do their full-time jobs. In an effort to expedite the production of the document, TCCE utilized the NCHRP 20-7 process, specifically Tasks 278 and 308, to take the initial guidance and complete the guide. TCCE would like to thank Keith Molenaar and Christofer Harper from University of Colorado, Stuart Anderson from Texas Transportation Institute, and Clifford Schexnayder from Arizona State University for their contributions and co-authoring the completed guide. TCCE would also like to thank Andrew Lemer from NCHRP. This guide would not be in existence today without the dedication and passion from both the past and current TCCE members who often worked nights and weekends to make the publication of this document possible.

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Summary

AASHTO “PRACTICAL GUIDE TO COST ESTIMATING”

A state department of transportation’s (DOT) ability to successfully manage and deliver its program is largely dependent on an ability to develop realistic estimates of project cost. Cost estimating involves not only the collection of relevant factors relating to the scope of a project and the cost of resources, but it also requires anticipating cost impacts that may occur due to changes in project scope, available resources, and national and global market conditions.

Responding to this need for accurate cost estimates, the American Association of State Highway and Transportation Officials (AASHTO) Technical Committee on Cost Estimating (TCCE) was charged with developing “practical” guidance on preparing estimates. Once their work began, it became apparent that little existing guidance was available to aid their efforts. The TCCE had to prepare guidance from scratch calling on the expertise of the various members and their agencies to document the best practices in use by DOTs.

At the same time the TCCE began its work, the National Cooperative Highway Program (NCHRP) was focusing on the issue of project cost escalation and published Report 574. That Report, *Guidance for Cost Estimation and Management for Highway Projects During Planning, Programming, and Preconstruction*, provides appropriate strategies, methods, and tools to develop, track, and document realistic cost estimates during each phase of the project development process. It is a strategic view of how to produce project estimates.

Since the publication of the NCHRP Report 574, two other NCHRP estimating projects have produced reports on the subject. NCHRP Report 625, *Procedures Guide for Right-of-Way Cost Estimation and Cost Management* and NCHRP Report 658, *Guidebook on Risk Analysis Tools and Management Practices to Control Transportation Project Cost*. Both reports provide special topic information that supports development of accurate and reliable cost estimates.

All of these parallel cost estimating guidance efforts and knowledge bases were married together to produce this “practical” guidance that serves those charged with the development of DOT cost estimates and with the management of the estimating process. This guidebook has two parts. Part I focuses on key cost-estimate techniques and Part II focuses on cost management activities.

KEY ESTIMATE TECHNIQUES

Part I of this guide covers in separate stand-alone chapters the following cost estimating techniques:

- Conceptual Estimating
- Bid-based Estimating
- Cost-based Estimating
- Risk-based Estimating

Conceptual or parametric estimating techniques are primarily used to support development of planning or early scoping phase estimates when minimal project definition is available. Statistical relationships or non-statistical ratios, or both, between historical data and other project parameters are used to calculate the cost of various items of work (i.e., center lane miles or square foot of bridge deck area).

Historical bid-based estimating relies heavily on element or bid items, or both, with quantities and good historical bid data for determining item cost. The historical data normally is based on bids from recent projects. The estimator must adjust the historical data to fit the current project characteristics and location. The historical data must also be adjusted to reflect current dollars. With the use of historical bid data, estimators can easily and quickly prepare estimates.

Cost-based estimating considers seven basic elements: time, equipment, labor, subcontractor, material, overhead, and profit. Generally, a work statement and set of drawings or specifications are used to “take off” material quantities required for each discrete work task necessary to accomplish the project bid items. From these quantities, direct labor, materials, and equipment costs are calculated based on calculated or assumed production rates. Contractor overhead and profit are then added to this direct cost.

Risk-based estimating combines (1) traditional estimating methods for known items and quantities with (2) risk analysis techniques to estimate uncertain items, uncertain quantities, and risk events. The risk-based portion of the estimate typically focuses on a few key elements of uncertainty and combines Monte Carlo sampling and heuristics (rules of thumb) to rank critical risk elements. This approach is used to establish the range of total project cost and to define how contingency should be allocated to critical project elements.

Each of these four techniques is discussed in detail in Chapters 2, 3, 4, and 5, respectively.

COST MANAGEMENT

Cost estimating is closely tied to cost management. Part II of this guide covers the following topic areas:

- Inflationary considerations
- Letting strategies for cost control
- Analysis of contractor bids
- Performance measures for cost estimating

Inflation is critical to estimating costs in the future. Inflation covers changes in cost over time. Adjustments for inflation include converting historical data to current dollars. Adjustments for inflation also include converting current dollars to future dollars based on a rate of inflation and the midpoint of construction expenditures. Indexing uses several tools such as cost indices, statistical analysis, and other modeling techniques. Experts in economics should be consulted when establishing future inflation rates.

Letting strategies are an important component of the estimating process. The use of both short- and long-term strategies will improve project bids and the validity of cost estimates. Long-term strategies are fundamental changes in the bid letting process and include timing of lettings, balancing of lettings, and packaging of projects for letting. Short-term strategies include such actions as contractor-selected packaging of projects, contractor self-imposed award limits, flexible notice to proceed, and contractor use of construction alternatives.

Analysis of contractor bids by a state department of transportation is a significant component of the competitive bidding process. To ensure a competitive contracting environment, agencies must have effective and consistent bid review and award recommendation procedures. The procedures must be transparent in a manner that is publicly understandable, economically efficient, legally defensible, and socio-politically acceptable.

Performance measures entail the use of tools to better understand and control cost estimating outcomes. Cost estimating performance measures track the attainment of cost estimating and project delivery functions. Tracking and evaluating cost estimating data allow efficient allocation of estimating resources while assisting in the development and justification of budgets and project proposals.

AUDIENCE

This guide offers comprehensive, consistent, and proven guidance on structured approaches to project cost estimation. It sets forth practical steps for preparing estimates during the planning and preconstruction phases of project development, and summarizes information from the main findings of the previous NCHRP studies combined with the information provided by the AASHTO TCCE.

The intended primary users of this guide are estimators that prepare estimates during specific project phases or across the entire project development process. An estimator would use Chapters 2, 3, 4, and 5. Managers involved in project development should review Chapter 1 to gain an overall perspective of project cost estimating. Further, there may be others who require knowledge of the cost estimating process but do not necessarily prepare cost estimates. As such, the guide is a resource for professionals involved in project development.

Agency management and project managers should read Chapter 7 to determine bidding strategies that will aid in controlling costs. Chapter 8 should be of interest to construction engineers and estimators, as evaluation of bids can aid in cost control as well as provide valuable information for estimating future projects. Finally, agency management would be interested in Chapter 9, which provides insights into program and project management by providing concepts around performance measures.

Practical Guide to Cost Estimating Overview

1.1 INTRODUCTION

Project cost estimating is a major challenge for state departments of transportation (DOTs). This challenge is the result of four critical project management and development issues. First, definitive project solutions are difficult to define for many of the questions that arise early in project development. Second, it is often difficult to quantify major areas of variability and uncertainty in project scope and cost. Third, it is difficult to evaluate the completeness and quality of early project estimates. And fourth, it is difficult to track the cost impact of scope development that occurs between cost estimates. These four challenges are amplified because many factors, such as insufficient knowledge about right-of-way costs and project location characteristics, environmental mitigation requirements, traffic control requirements, or work-hour restrictions, influence project cost estimates, especially during the early stages of project development. Moreover, there are other process-related factors that make cost estimation a challenge, such as assessment of the cost impact of engineering complexities and constructability issues, changes in economic and market conditions, changes in regulatory requirements, local governmental and stakeholder interests, and community expectations.

Historically, cost escalation or increases have been problematic within the DOT environment. One significant reason behind this problem is attributed to poor estimating practices including the inconsistent application of contingency. The National Cooperative Highway Research Program (NCHRP) Project 8-49, completed in 2007, focused on the issue of cost escalation and produced a guidebook on highway project cost estimating and cost estimating management aimed at achieving greater estimating consistency and accuracy. The Project 8-49 guidebook, NCHRP Report 574, provides appropriate strategies, methods, and tools to develop, track, and document realistic cost estimates during each phase of the project development process (Anderson et al. 2007). In parallel with the NCHRP work, the American Association of State Highway and Transportation Officials (AASHTO) Subcommittee on Design's Technical Committee on Cost Estimating has developed this manual, which specifically serves those charged with developing and managing estimates for DOTs.

1.1.1 Background

Estimating the cost of transportation projects is a critical function that supports the project development process. The cost estimation process not only involves the collection of relevant factors relating to the scope of a project and the expected resource costs, but it requires anticipating impacts to project costs over time caused by changes related to project scope, available resources, and national and global market conditions. A DOT's ability to successfully manage and deliver its program is largely dependent on its ability to realistically estimate project costs early in the conceptual development stage before final engineering has been completed. Cost estimates are the basis for many key financial decisions. Thus, the inability to accurately estimate project costs can result in poor financial decisions as follows:

- Overrun budgets—fewer projects in program can be developed.
- Underrun budgets—could have developed more projects.
- Cost too high—reduced benefit-to-cost ratio that may lead to rejecting a project that should be accepted.
- Cost too low—high benefit-to-cost ratio that may lead to accepting a project that should not be accepted.

Poor financial decisions ultimately lead to a lack of confidence in the DOT's ability to meet its project and program commitments.

Because of the specialized nature of many transportation projects, accurately estimating project cost requires a very specific skill set. A successful estimator will need expertise in translating early project concepts into costs and visualizing completed facilities from drawings at different levels of completion, a thorough knowledge of construction methods and equipment, and an excellent understanding of economics and how market conditions (i.e., bidding environment) impact construction costs. The application of these estimating skills requires training and experience at a localized level. Very little training or guidance is available nationally on how to develop transportation project cost estimates, and most DOT's have been forced to develop their own estimating processes based on history, experience, and available resources.

1.1.2 Purpose

With increasing transportation needs, funding limitations at both the federal and state levels, and the high cost of transportation improvement projects, it is important to have a toolbox of techniques that support accurate estimation of project costs. There is no single “right way” to prepare an estimate, and these guidelines are not intended to promote one technique over another. The purpose of this guide is to provide a nationally recognized and accepted set of cost estimation and cost management practices that each DOT can draw from and use appropriately to its situation.

1.1.3 Audience

The primary users of this guide are estimators within DOTs that prepare estimates during specific project phases or across the entire project development process. Some of these estimators may have other responsibilities, such as being project managers, lead designers, or staff involved in planning. Further, there may be others who require knowledge of the cost estimating process but do not necessarily prepare cost

estimates. As such, this guide is intended to be a resource for professionals involved in the preconstruction phases of project development where key financial decisions are made based on project cost estimates.

1.2 PROJECT DEVELOPMENT PHASES

Due to slight variations in the terms used by the state department of transportation to describe their project development phases, a generic set of terminologies is presented in this guide consistent with other published documents. These project development phases are described in Table 1-1 and shown in Figure 1-1. To ensure the applicability of terms, DOTs from across the country participated in a vetting of the four phases. Typically, a DOT will prepare project cost estimates during each of the four phases of project development.

Figure 1-1 depicts the various plans and programs that each project development phase supports. Sometimes, there is overlap between phases as needs and deficiencies are converted into specific projects, alternative project solutions are assessed, and the preferred alternative is selected. When federal money is involved, DOTs are required to have fiscally constrained long-range plans and a State Transportation Improvement Program (STIP). Some agencies also have an intermediate-range plan (IRP), such as a 10-year improvement plan. When DOTs do not have an IRP, projects often move from planning directly into the STIP.

Table 1-1. Development Phases and Typical Activities

Development Phases	Typical Activities
Planning	Purpose and need; improvement or requirement studies; environmental considerations; right-of-way considerations; schematic development; project benefit/cost feasibility; public involvement/participation; interagency conditions.
Scoping	Environmental analysis; alternative analysis; preferred alternative selection; public hearings; right-of-way impact; environmental clearance; design criteria and parameters; funding authorization (programming).
Design	Right-of-way development and acquisition; preliminary plans for geometric alignments; preliminary bridge layouts; surveys/utility locations/drainage.
Final Design (aka PS&E)	Plans, specifications, and estimate (PS&E) development—final right-of-way acquisition; final pavement and bridge design; traffic control plans; utility drawings; hydraulics studies/final drainage design; final cost estimates.

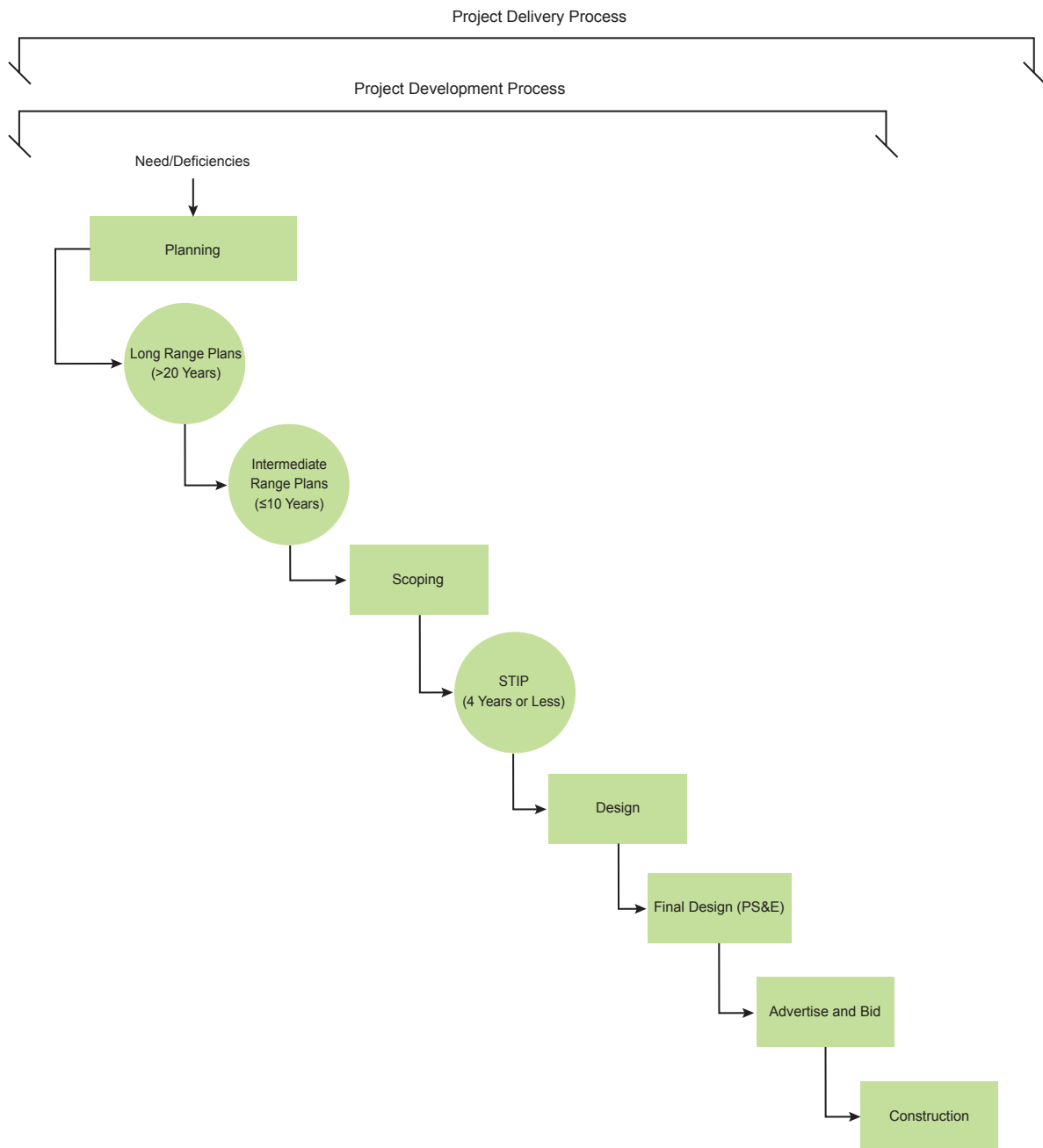


Figure 1-1. Project Development Phases (NCHRP 8-49)

As projects progress through the project development process, cost estimates are required. The types of estimates and their purpose will vary according to project phase and the level of project maturity. Table 1-2 captures the various estimate types, their purposes, and the agency plans/programs the estimates support during project development. Further, Table 1-3 shows level of project maturity (definition) and implies uncertainty through the use of methods and possible ranges related to estimate types.

Table 1-2. Estimate Types and Purposes

Project Development Phase	Estimate Type, Purpose, and Plan/Program Supported
Planning	Conceptual Estimating— Estimate Potential Funds Needed (20-Plus-Year Long-Range Plan)
	Prioritize Needs for Long-Range Plans (Intermediate-Range Plan—10 years)
Scoping	Scope Estimating— Establish a Baseline Cost for Project and Program Projects (IRP and STIP)
Design	Design Estimating— Manage Project Budgets against Baseline (STIP)
Final Design	Plans, Specifications, and Estimate Estimating— Compare with Bid and Obligate Funds for Construction

The information shown in Tables 1-2 and 1-3 emphasizes that cost estimates have different purposes in support of project development, different methods are used during project development, and estimate ranges start off very wide on the early stages of a project and become very tight at full definition (i.e., completed plans and specifications). Thus, appropriate estimate techniques and tools vary based upon the project development stage.

Table 1-3. Cost Estimating Classification

Project Development Phase	Project Maturity (% project definition completed)	Purpose of the Estimate	Estimating Methodology	Estimate Range
Planning	0 to 2%	Conceptual Estimating—Estimate Potential Funds Needed (20-year plan)	Parametric (Stochastic or Judgment)	–50% to +200%
	1% to 15%	Conceptual Estimating—Prioritize Needs for Long-Range Plans (IRP—10-year plan)	Parametric or Historical Bid-Based (Primarily Stochastic)	–40% to +100%
Scoping	10% to 30%	Design Estimating—Establish a Baseline Cost for Project and Program Projects (IRP and STIP)	Historical Bid-Based or Cost-Based (Mixed, but Primarily Stochastic)	–30% to +50%
Design	30% to 90%	Design Estimating—Manage Project Budgets against Baseline (STIP, Contingency)	Historical Bid-Based or Cost-Based (Primarily Deterministic)	–10% to +25%
Final Design	90% to 100%	PS&E Estimating—Compare with Bid and Obligate Funds for Construction	Cost-Based or Historical Bid-Based Using Cost Estimate System (Deterministic)	–5% to +10%

1.2.1 Cost Estimating Process

As identified in NCHRP Report 574, cost estimating is a process comprised of a series of steps, as shown in Figure 1-2 (Anderson et al. 2007). Each step is critical to developing consistent and accurate estimates during each phase of project development. The steps in the process are supported by key inputs such as historical data, market and macro-environment conditions, cost estimating techniques and tools, and third-party requirements. The cost estimating process is initiated with input from the project development phases including project definition requirements (aka scope), project characteristics, and functional

group inputs/requirements. The output of the process is approved estimate packages that support the various plans/programs shown in Figure 1-2 and described in Table 1-1.

In the early phases of project development, DOTs must prepare estimates that characterize total project cost (TPC). The main components of TPC are engineering/design, right-of-way, and construction. Included in these general components would be costs related to environmental mitigation and utility relocation requirements. The estimating tools and techniques differ depending on the component of TPC being estimated. This guide covers key techniques and tools used to estimate these component costs.

At a point in the project development process, the estimated project cost must be used to set a baseline cost for management purposes. This baseline cost is tied to a baseline project definition and construction letting date. The baseline project definition, cost, and schedule should be set prior to programming a project into the IRP or no later than before a project is included in the STIP. DOTs have different policies on which total project cost components are included in the STIP and how these components are included in this document. In any case, the baseline cost should incorporate all project costs or total project costs regardless of how individual components are programmed. Cost management will not be effective if there is no confirmed baseline cost.

Cost Estimating Process

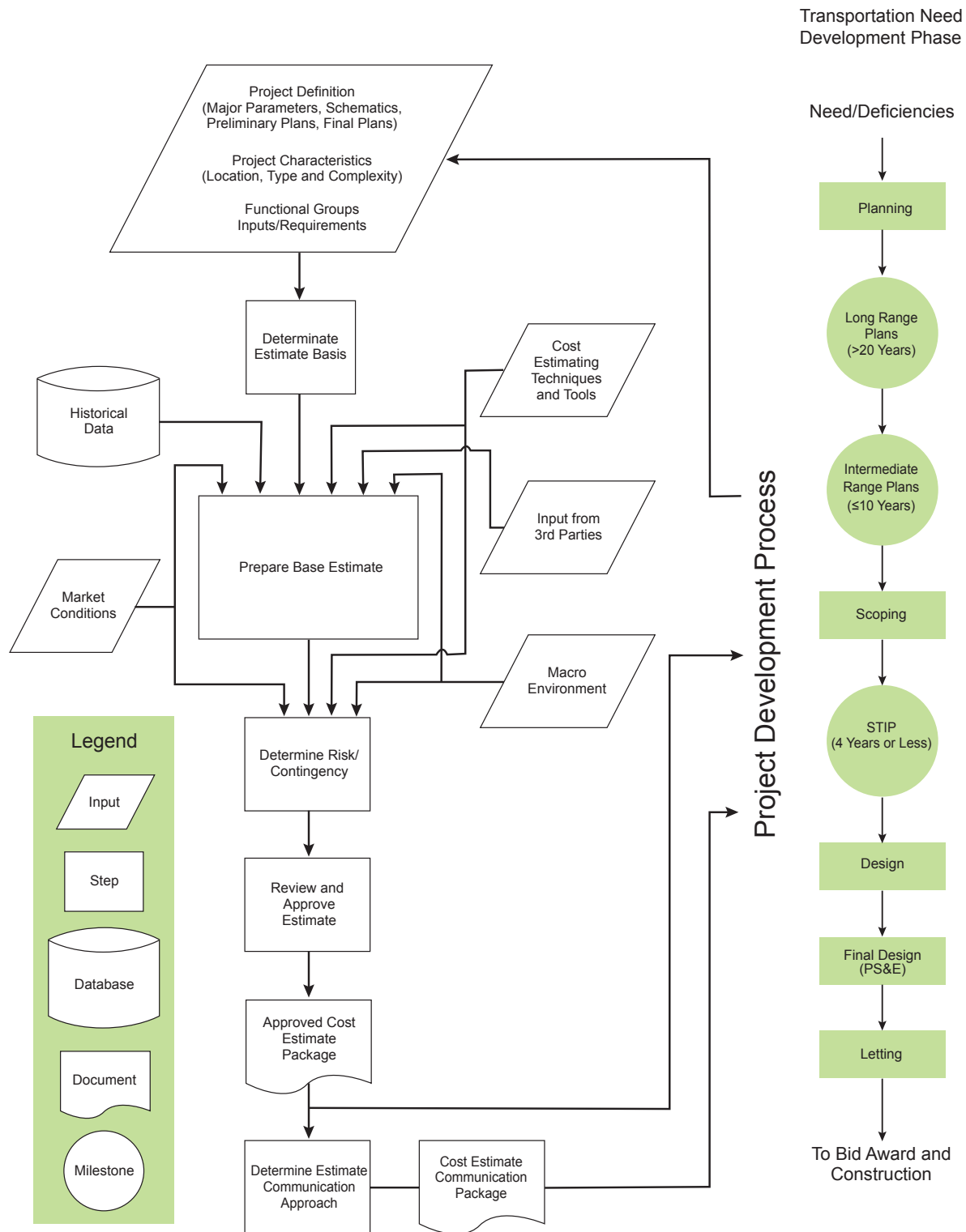


Figure 1-2. General Cost Estimating Process

1.2.2 Estimating Focus

This guide focuses on two of the cost estimating process steps shown in Figure 1-2: (1) prepare base estimate; and (2) determine risk and set contingency. These critical steps are supported by estimating techniques and tools that are used throughout the transportation industry. The steps demand that a project cost estimate be composed of a base estimate and a contingency. The base estimate is defined as the most likely project cost estimate in any phase, which normally includes all estimated known project costs. Project contingency is defined as an estimate of costs associated with identified risks, the summation of which is added to the base estimate. The sum of the base estimate and contingency reflects the total project cost estimate (also adjusted for inflation).

As shown in Figure 1-3, the relative magnitude of the base and contingency costs changes over time. During planning, there are numerous unknowns, and quite often the base estimate is less than the contingency dollar estimate. Over the duration of the project development process, the base estimate increases while the contingency amount decreases. The shift between the base and contingency relates to the level of project maturity; that is, as project definition advances, the level of unknowns or risks should decrease. Some of the risk dollars are shifted into the base estimate work items as quantities are defined, while other risk dollars may be mitigated.

In this guide, the techniques and tools described include those used to prepare conceptual estimates and those used to prepare construction estimates, such as bid-based and cost-based estimating. The relationships between the estimate technique and historical data are discussed. These techniques and tools are presented in the context of the Prepare Base Estimate step. The Determine Risk and Set Contingency step is described in the context of risk-based estimating. Different types of risk/contingency techniques and tools, including top-down percentage and bottom-up risk-based estimating, are presented.

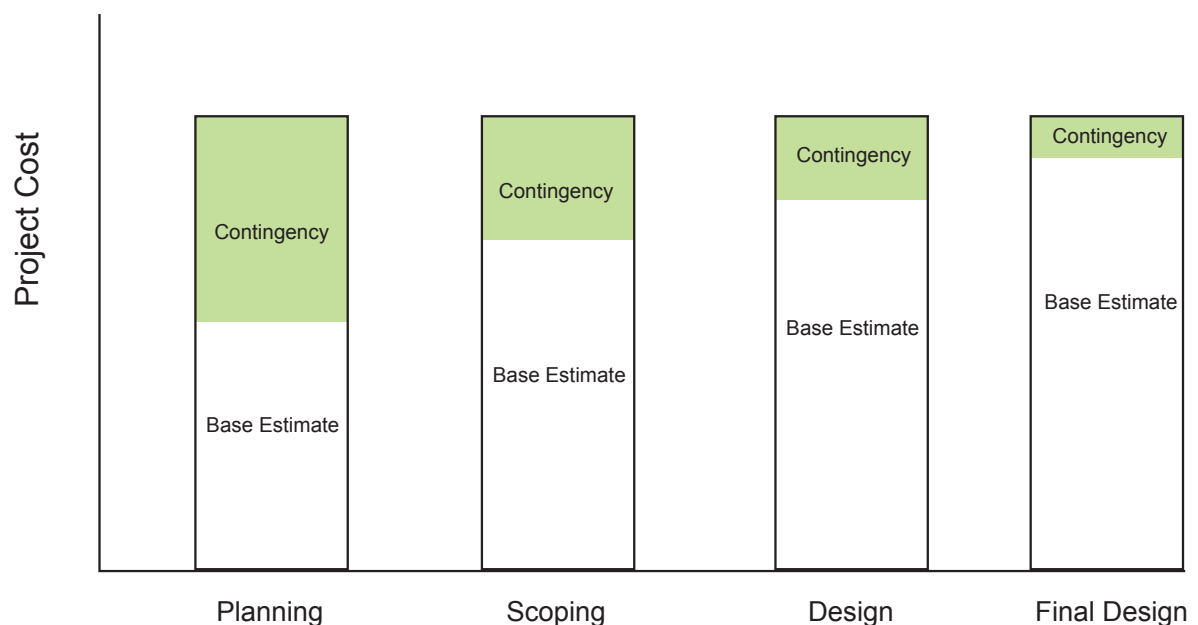


Figure 1-3. Application of Contingency

The cost estimating process shown in Figure 1-2 has other steps that are critical to preparing accurate and consistent total project cost estimates. These steps are:

- Determine estimate basis
- Review and approve estimate
- Communicate estimate

Determining the estimate basis includes collection of information about the project definition, project characteristics, and input/requirements of different functional disciplines involved in the project. Specific information might include drawings, design parameters, project complexity, and project location (i.e., rural or urban, or both). The cost estimator uses this information to prepare the base estimate.

Reviewing and approving the estimate involves completing an unbiased analysis of estimate basis and assumptions to include the estimate methods used and completeness of the estimate in terms of covering the project's definition, verifying cost data, quantities, and calculations; and understanding differences between the current estimate and previous estimates. The approval component of this step ensures management accountability for the final cost estimate, noting any changes from previous estimates.

Determining the estimate communication approach is the final estimating process step. This step involves communication of key information to both internal and external project stakeholders. This communication is critical to achieving estimate transparency and credibility. The communicated information should explain the estimate basis, estimated costs including key assumptions, and estimate uncertainty. The communication document should be very concise with only key information provided to the reader.

1.3 OVERALL GUIDEBOOK STRUCTURE

This guidebook has two parts. Part I focuses on key cost-estimate techniques. Part II focuses on cost management activities.

1.3.1 Part I—Key Estimate Techniques

Part I of this guide covers in separate chapters the following cost estimating techniques:

- Conceptual Estimating
- Bid-based Estimates
- Cost-based Estimates
- Risk-based Estimates

Conceptual or parametric estimating techniques are primarily used to support development of planning or early scoping phase estimates when minimal project definition is available. Statistical relationships or non-statistical ratios, or both, between historical data and other project parameters are used to calculate the cost of various items of work (i.e., center lane miles or square foot of bridge deck area).

Historical bid-based estimating is an approach that relies heavily on elements or bid item, or both, with quantities and good historical bid data for determining item cost. The historical data normally is

based on bids from recent projects. The estimator must adjust the historical data to fit the current project characteristics and location. The historical data must also be adjusted to reflect current dollars. With the use of historical bid data, estimators can easily prepare cost estimates. This approach is the most commonly used method for DOTs in developing cost estimates for their transportation projects.

Cost-based estimating considers seven basic elements: time, equipment, labor, subcontractor, material, overhead, and profit. Generally, a work statement and set of drawings or specifications are used to “take off” material quantities required for each discrete task necessary to accomplish the project bid items. From these quantities, direct labor, materials, and equipment costs are calculated based on assumed production rates. Contractor overhead and profit are then added to this direct cost. The total cost divided by the quantity gives the estimated unit price for the work item.

Risk-based estimating combines (1) traditional estimating methods for known items and quantities with (2) risk analysis techniques to estimate uncertain items, uncertain quantities, and risk events. The risk-based portion of the estimate typically focuses on a few key elements of uncertainty and combines Monte Carlo sampling and heuristics (rules of thumb) to rank critical risk elements. This approach is used to establish the range of total project cost and to define how contingency should be allocated among the critical project elements.

Each of these four techniques is discussed in detail in Chapters 2, 3, 4, and 5, respectively.

1.3.2 Part II—Cost Management

Cost estimating is closely tied to cost management. Part II of this guide covers the following topic areas:

- Inflationary considerations
- Letting strategies for cost control
- Analysis of contractor bids
- Performance measures for cost estimating

Inflation is critical to estimating costs in the future. Inflation covers changes in cost over time. Adjustments for inflation include converting historical data to current dollars. Adjustments for inflation also include converting current dollars to future dollars based on a rate of inflation and the midpoint of construction expenditures. Indexing uses several tools such as cost indexes, statistical analysis, and other modeling techniques. Experts in economics should be consulted when establishing future inflation rates.

Letting strategies are an important component of the estimating process. The use of both short- and long-term strategies will improve project bids and the validity of cost estimates. Long-term strategies are fundamental changes in the bid letting process and include timing of lettings, balancing of lettings, and packaging of projects for letting. Short-term strategies include such actions as contractor-selected packaging of projects, contractor self-imposed award limits, flexible notice to proceed, and contractor use of construction alternatives.

Analysis of contractor bids by a state department of transportation is a significant component of the competitive bidding process. To ensure a competitive contracting environment, agencies must have effective and consistent bid review and award recommendation procedures. The procedures must be

transparent in a manner that is publicly understandable, economically efficient, legally defensible, and socio-politically acceptable.

Performance measures are tools to better understand and control outcomes of cost estimating. More generally, performance measures are broad classifications of DOT organizational outcomes for the efficiency of services and programs. Performance measures must align with the strategic goals and performance objectives of the DOT. Cost estimating performance measures track the attainment of cost estimating and project delivery functions. Tracking and evaluating cost estimating data allow efficient allocation of estimating resources while assisting in the development and justification of budgets and project proposals.

1.4 ROADMAP FOR GUIDE USE

This guide can be used by different agencies and consulting professionals in a number of ways. The primary user would likely be the agency estimator who is involved in preparing cost estimates across the project development process. Such an estimator would use Chapters 2, 3, 4, and 5. If the estimator is involved in only one phase, such as final design (PS&E), the use of the bid-based or cost-based, or both, estimating techniques would likely be the estimator's focus chapters. Alternatively, estimators involved in planning would use conceptual estimating techniques such as parametric estimating found in Chapter 2. Other professionals such as project managers and lead design engineers would likely want to refer to Chapters 3, 4, and 5 depending on how much direct estimating they must perform. These professionals should read Chapter 1 to gain a basic understanding of the cost estimating process and what aspects of the process are covered in the guide. Managers involved in project development should review Chapter 1 to gain an overall perspective of project cost estimating.

In addition to the cost estimating chapters, the estimator should refer to Chapter 6 if adjusting historical data and cost estimates to reflect either current dollars or future dollars. Agency management and project managers should read Chapter 7 to determine letting strategies that will aid in controlling costs. Chapter 8 should be of interest to construction engineers and estimators, as evaluation of bids can aid in cost control as well as provide valuable information for estimating future projects. Finally, agency management would be interested in Chapter 9, which provides insights into program and project management by providing concepts around performance measures for cost estimating.

All users of this guide are encouraged to refer to the references listed at the end of each chapter. These references provide more specific information concerning the various techniques and tools discussed in each chapter.

1.5 CHAPTER 1 REFERENCES

Anderson, S., K. Molenaar, and C. Schexnayder. *NCHRP 574: Guidance for Cost Estimation and Management for Highway Projects During Planning, Programming, and Preconstruction*, Transportation Research Board of the National Academies, Washington, DC, 2007. http://onlinepubs.trb.org/onlinepubs/nchrp/nchrp_rpt_574.pdf (Mar. 29, 2011).

Conceptual Estimating

2.1 OVERVIEW

The use of conceptual estimating techniques is primarily for supporting the preparation of planning and early scoping estimates when very little project definition is available. These techniques assist in estimating total project cost by major components:

- Right-of-way (ROW)
- Construction (CN)
- Engineering/Design (often termed preliminary engineering [PE])
- Construction engineering (CE)

A number of estimating techniques are conceptual by classification. The basis of these techniques is either statistical relationships or ratios between project definition information/data and historic costs. For a particular facility type, the development of a gross estimate of a project using statistically derived relationships between key dimensional information and historical costs is often referred to as parametric conceptual estimating. One approach is to use the relationship between facility type and dimensions and costs as reflected in statistically derived equations from historical data. The other common approach is to use ratios between historical data and key project parameters to calculate the cost of work elements.

Because these are estimates prepared early in project development when specific work items are undefined or unquantifiable, it becomes very difficult to estimate costs in detail. Therefore, both approaches use major project features that reflect a specific type of facility (i.e., centerline miles for pavements and square feet of deck area for bridges) to develop the cost relationships. Further, estimators use historical percentages to estimate construction elements that are difficult to quantify early in a project. Historical percentages are also used for total project cost components such as engineering/design, construction engineering, and right-of-way.

2.1.1 What Is It?

Conceptual cost estimation is a methodology used to estimate total project cost when a project is in its earliest stages of development. The techniques described here are straight forward, but a DOT should have its own historical cost database to support development of these estimates based on minimal defini-

tion of project parameters or facility components. DOTs consider these techniques sophisticated if statistical relationships are used, but when using ratios or percentages, the techniques are relatively simple.

Early in project development, a project's definition is usually very ambiguous. However, newly developed projects are often similar to previous projects that are under design, under construction, or recently completed by the agency. Historical cost data from these past projects can serve as a basis for developing a uniform, repeatable, conceptual estimating approach. Conceptual estimating approaches provide reasonably accurate estimates in a timely manner. Statistical relationships or non-statistical, ratios, or both between historical data and other parameters form the basis for conceptual estimating.

2.1.2 Why Use It?

The purpose of conceptual estimating is to develop early projections of project cost when limiting information to only gross dimensions reflecting key facility features. The time and effort required to prepare a conceptual estimate should be minimal. The techniques provide simplified, reliable, early estimates based on historical data and adjusted to current costs. Because of these attributes, decision-makers use conceptual estimates to develop long-range plans, assess benefit-to-cost ratios for prioritizing projects, and compare the cost of different project alternatives.

2.1.3 When to Use It?

Estimators use conceptual estimating in the planning phase of project development to support long-range plans (i.e., >20 years) and early in the scoping phase of project development to support intermediate-range plans (i.e., 10 years). The best instance to use conceptual estimating is on less complex projects that tend to be standard in terms of project components, such as preservation projects (overlays) or bridge rehabilitation projects. Complex projects can also utilize conceptual estimating; however, using conceptual estimating for highly complex projects often requires greater project definition and therefore a more detailed assessment of quantities and unit prices even in the earliest phases of project development.

2.2 KEY INPUTS

The two key pieces of data needed to develop a conceptual cost estimate are (1) good historical cost data; and (2) project-related information matched to cost data. To analyze historical price data effectively, it is critical that projects and work items be properly classified. Further, it is vital to normalize cost data to a specific point in time (i.e., 2011 dollars) and location (i.e., statewide average costs). The historical cost data must be qualified in relation to what the data covers from a project definition perspective. This section covers these issues.

2.2.1 Project Definition

The exactitude and work description detail during early project definition can vary greatly. At a high level, project definition reflects the general components of a facility, such as construction, engineering/design, construction engineering, and right-of-way. Simply stated, specific project details are frequently in terms of project boundaries, such as between milepost A and milepost B. Some descriptive information usually included is whether the project is a preservation (i.e., overlay), rehabilitation (remove and replace),

reconstruction (add capacity) project, or new construction (new roadway/bridge). Estimators then use general descriptions of the project elements such as pavement width or lane widths, bridge deck dimensions, and possible drainage requirements. In addition, some assumptions are made regarding the pavement or bridge type.

Estimators at the conceptual stage regularly develop the project definition using sketches or schematic drawings with approximate dimensional information. In addition, there should be some idea of whether or not right-of-way is required, as well as a statement about potential environmental impacts. However, in most instances, there is a lack of specificity around details. In general, the level of project definition varies depending on when in the project development process the conceptual estimate is being prepared; that is, early in the planning phase or early in the scoping phase or at some point between. Project complexity also affects the level of project definition. To prepare a credible conceptual estimate for more complex projects, there needs to be an increased level of definition details.

2.2.2 Project Characteristics

Since project definition is incomplete, estimators most likely cannot define specific work characteristics. Thus, the estimate focus must be on the “larger picture” characteristics such as project location, potential environmental issues and utility impacts, and the extent of right-of-way required. Depending on project complexity, consideration should be given to traffic management and major drainage issues. Thus, the project’s level of complexity would be the principle driver that defines specific project characteristics. It is highly recommended that the estimator visit the project site to comprehend the project’s definition in relation to existing site characteristics and in consideration of major constructability issues that might be relevant to the project (i.e., significant potential material logistic and traffic management issues). If a physical visit is not possible, utilizing technology such as Google Street View or Google Earth in many cases aids the estimator in gaining an understanding of site conditions.

2.2.3 Historical Database Requirements

The DOT historical database to support conceptual estimating should have data corresponding to construction and non-construction components of total project cost. In the construction area, cost factors are required for pavements and bridges and in some cases a combination of both categories. Often, it is advisable to use percentages to estimate elements of work not covered by construction cost factors for pavements and bridges. Computer software is typically used to store and access historical data. Historical percentages are necessary cost factors for non-construction elements such as right-of-way, preliminary engineering, and construction engineering.

Database requirements to support conceptual estimating can take different forms. Unlike bid-based estimating where capturing historical bid data comes directly from the letting process, the DOT must assemble a database for conceptual estimating by using multiple pieces of information. The use of actual bid data or project cost data matched to physical project data allows for the development of different types of conceptual estimating cost factors, such as dollars per centerline mile or dollars per square foot of bridge deck area, under specified conditions. Similar projects can also be a source of cost data for conceptual estimating. A similar project can form the basis for calculating average lane-mile or bridge deck costs. Project

type and the elements that define the project such as ROW, environmental requirements, utility adjustments, and urban or rural location influence the development of a historical database. Separate datasets are usually required and developed for a variety of project types. Because such databases will improve the accuracy of early estimates and save time in preparing future estimates, the DOT should commit time and money to develop accurate supporting information. Estimating software can help with creating the databases. Moreover, DOTs can use estimating software to prepare conceptual estimates.

Typically, the data required to develop the necessary historical cost factors come from the DOT's financial management system responsible for processing project expenditures. To facilitate the capturing of this project-specific data, it is necessary that unique expenditure accounts and respective activity codes (PE, ROW, and CE) be assigned to a project as soon as expenditures begin accruing during project development. Standard pay items typically capture construction costs. DOT program or project managers, or both, along with business managers, should be well versed in the structure of their DOT's coding system and should be excellent resources in the initial setup of queries for data retrieval. It is likely the project/contract award amounts will require further analysis to become useful historical data for conceptual estimating purposes.

A project that has experienced a cradle-to-grave life cycle is typically a viable candidate for analysis in deriving respective non-statistical cost relationships. These relationships can be used as a sample for generating the work-type-specific global cost relationships needed when using the conceptual cost estimating techniques. To ensure correct processing of all construction-related costs, it may be necessary to use past projects completed one to five years prior to the date of analysis. Additionally, based on the historical nature of these data, a DOT-specific or more generic means of correcting the expenditures for inflation is required to normalize the dataset to the analysis year. In terms of reliability and statistical significance, the more relevant the samples are, the better the global analytical dataset will be.

2.2.3.1 Construction Cost Factors

DOTs define basic cost elements with the activities associated with traditional project development processes. Cost data for the construction component starts with the lowest level of cost details and pay items from contractor bids. These construction costs reflect the anticipated contract award amount represented by a responsive low-bid construction contractor. Actual construction bids for a project are aggregated to reflect a fundamental parameter associated with the project type (i.e., \$/mile or \$/square foot) in combination with other factors for cost elements, such as but not limited to roadway approaches for bridge projects or utilities, large culverts, or bridges, or some combination thereof, within a roadway project. The sum of these construction cost elements becomes the fundamental basis for estimating the remaining project components (i.e., ROW, PE, and CE). Current conceptual cost factors developed from historical data might not include newly enacted project requirements. For example, conceptual cost factors will likely not capture any new costs imposed by a recently legislated environmental regulation. Therefore, an appropriate contingency will need to account for these new project requirements until estimators receive and analyze data associated with the actual cost of this work and can then assign it a cost element or assume these costs are captured by the conceptual cost factor.

2.2.3.1.1 Lane-Mile Cost Factors

A DOT develops lane-mile cost factors based on the concept of using typical sections representing common types of facilities and historical cost data to derive key cost factors. For example, estimators can use typical lane configurations and pavement type sections as the basis for estimating pavement construction cost for a given length of roadway, pavement thickness, and typical shoulder width. Often, cost estimators develop costs per lane mile using specific pay items from historical bid data and typical sections. Historical data may reflect weighted costs for a given time period and are not necessarily specific to any one area or district within a state. However, it is beneficial to use data from a specific district to provide a location-specific cost factor. Based on the typical section as depicted in Figure 2-1, Table 2-1 shows an example of developing a lane-mile cost factor using weighted average unit prices per pay item.

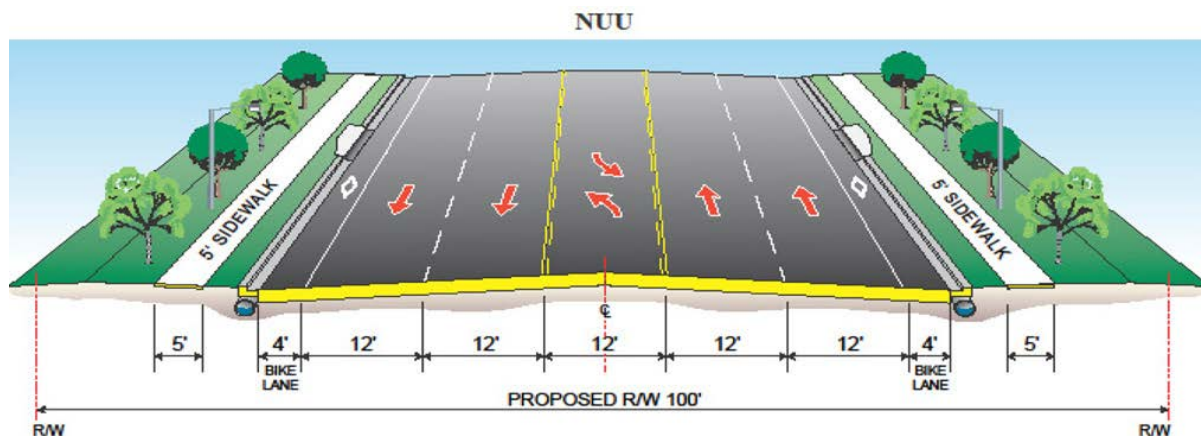


Figure 2-1. Typical Section (NUU = New Construction Undivided Urban)

Source: Florida Department of Transportation Specifications & Estimates Office <http://www.dot.state.fl.us/specificationoffice/Estimates/LRE/Default.shtm>

Table 2-1. Development of Lane-Mile Cost Factor

Pay Item	Description	Total Quantity	Unit	Weighted Avg. Unit Price	Total Amount
0101 1	Mobilization	10.00	%*		\$419,501.06
0102 1	Maintenance of Traffic	7.00	%*		\$274,439.94
0104 10 3	Sediment Barrier	10,560.00	LF	\$.84	\$8,870.40
0104 11	Floating Turbidity Barrier	250.00	LF	\$7.76	\$1940.00
0104 12	Staked Turbidity Barrier-Nylon Reinforced PVC	250.00	LF	\$3.75	\$937.50
0104 15	Soil Tracking Prevention Device	1.00	EA	\$2,154.40	\$2,154.40
0104 18	Inlet Protection System	53.00	EA	\$35.52	\$1,882.56
0107 1	Litter Removal	1.20	AC	\$16.66	\$19.99
0107 2	Mowing	1.20	AC	\$29.11	\$34.93
0110 1 1	Clearing and Grubbing	20.18	AC	\$4,832.63	\$97,522.47
0120 1	Regular Excavation	19,360.00	CY	\$3.54	\$68,534.40
0120 6	Embankment	103,851.73	CY	\$4.96	\$515,104.58
0160 4	Type B Stabilization	42,920.53	SY	\$2.35	\$100,863.25
0285709	Optional Base, Base Group 09	39,893.33	SY	\$10.66	\$425,262.90
0334 1 24	Superpave Asph Conc, Traf D, Pg76-22	6,582.40	TN	\$86.37	\$568,521.89
0337 7 20	Asph Conc Fric Course, Inc Bit, Fc-12.5, Fc6, Pg76-22	3,191.47	TN	\$140.75	\$449,199.40
0400 2 2	Concrete Class II, Endwalls	36.00	CY	\$795.54	\$28,639.44
0425 1351	Inlets, Curb, Type P-5, <10"	36.00	EA	\$3,061.55	\$110,215.80
0425 1451	Inlets, Curb, Type J-5, <10"	10.00	EA	\$4,602.64	\$46,026.40
0425 1521	Inlets, DT Bot, Type C, <10"	5.00	EA	\$1,899.03	\$9,495.15
0425 1541	Inlets, DT Bot, Type D, <10"	1.00	EA	\$2,404.23	\$2,404.23
0425 2 41	Manholes, P-7, <10'	5.00	EA	\$2,589.96	\$12,949.80
0425 2 71	Manholes, J-7, <10'	1.00	EA	\$4,477.67	\$4,477.67
0430171103	Pipe Culvert Optional Material, Round-Shape, 37–48", Storm Sewer	5,056.00	LF	\$137.23	\$693,834.88
0430171104	Pipe Culvert Optional Material, Round-Shape, 49–60", Storm Sewer	200.00	LF	\$195.73	\$39,146.00
0430175112	Pipe Culvert, Optional Material, Round, 12"S/CD	2,328.00	LF	\$43.82	\$102,012.96
0430175130	Pipe Culvert, Opt Material, Round, 30"S/CD	208.00	LF	\$66.39	\$13,809.12
0520 1 10	Concrete Curb and Gutter, Type F	10,560.00	LF	\$12.68	\$133,90.80
0522 1	Sidewalk Concrete, 4" Thick	5,866.67	SY	\$26.49	\$155,408.09
0550 10220	Fencing, Type B, 5.1–6.0, Standard	1,180.00	LF	\$8.56	\$10,100.80
0550 60234	Fence Gate, Type B, Sliding/Cantilever, 18.1–20.0' Opening	1.00	EA	\$1,871.04	\$1,871.04
0570 1 1	Performance Turf	31,680.00	SY	\$.62	\$19,641.60
0570 1 2	Performance Turf, Sod	18,197.33	SY	\$1.58	\$28,751.78
0700 20 11	Single Post Sign, F&I, Less Than 12 SF	20.00	AS	\$239.28	\$4,785.60
0700 20 12	Single Post Sign, F&I, 12-20 SF	2.00	AS	\$671.53	\$1,343.06
0700 21 11	Multi-Post Sign, F&I, 50 SF or Less	2.00	AS	\$2,879.36	\$5,758.72
0706 3	Retro-Reflective Pavement Markers	810.00	EA	\$3.31	\$2,681.10
0711 4	Directional Arrows-Thermoplastic	18.00	EA	\$71.33	\$1,283.94
0711 11111	Thermoplastic, Standard, White, Solid, 6"	4.00	NM	\$2,891.87	\$11,567.48
0711 11131	Thermoplastic, Standard, White, Skip, 6"	4.00	GM	\$907.97	\$3,631.88
0715 1 13	Lighting Conductors, F&I, Insulated, No 4 to No 2	19,284.00	LF	\$1.42	\$27,383.28
0715 2 11	Lighting—Conduit, F&I, Underground	5,280.00	LF	\$3.49	\$18,427.20
0715 2 12	Lighting—Conduit, F&I, Under Existing Pavement Sawcut	1,048.00	LF	\$11.43	\$11,978.64

Table 2-1. Continued

Pay Item	Description	Total Quantity	Unit	Weighted Avg. Unit Price	Total Amount
0715 14 11	Lighting—Pull Box, F&I, Roadside-Moulded	35.00	EA	\$347.86	\$12,175.10
0715500 1	Pole Cable Distribution System, Conventional	35.00	EA	\$743.44	\$26,020.40
0715511140	Light Pole Complete—Special Design, F&I, Single Arm Shoulder Mount, Aluminum, 40'	35.00	EA	\$4,000.00	\$140,000.00
0999 25	Initial Contingency Amount (Do not bid)	1.00	LS	\$50,000.00	\$50,000.00
TOTAL					\$4,664,511.63

Description: Configuration—New Construction 5-Lane Undivided Urban Arterial with Center Turn Lane and 4 ft Bike Lanes

Basis—Typical Roadway Configuration and Section for 1 mi and Bid Pricing. **Cost per Mile Factor—\$4,700,000**

*For Mobilization and Maintenance of Traffic, a percent of total construction cost. Source: Florida DOT Specifications & Estimates website—
<http://www2.dot.state.fl.us/SpecificationsEstimates/costpermile.aspx>

An alternative approach is to develop lane-mile cost factors based on the concept of using the actual cost of completed or ongoing projects. The data should represent typical DOT projects. These completed or ongoing projects have known costs and definitions. The completed project cost becomes dollars per centerline mile by dividing the cost of the completed project by the total centerline miles for the project. The cost per centerline miles reflects a specific location and time period. The compiler of these gross cost numbers should note the location and time information. This cost per centerline mile factor allows estimators to estimate a similar project that has the same types of construction categories. Table 2-2 illustrates this approach.

Table 2-2. Illustration of Construction Cost per Centerline Mile Based on Similar Project

ITEM DESCRIPTION CATEGORY	TOTAL COST \$ × 1000 (early 2007 Cost)
Preparation	882
Excavation/Grading	5,560
Drainage/Storm Sewer	1,229
Structures	4,574
Pavement (bituminous)	12,926
Erosion Control and Planting	2,716
Traffic	5,937
Other Items	1,249
Mobilization	2,454
Total Construction	37,527
Cost per Lane Mile Calculation: Cost per Mile—Construction = \$37,527,000/(59.72 – 54.75) = \$7,550,000 per centerline mile in 1st Quarter 2007 Dollars	

Source: Minnesota DOT Training Course

Descriptor:

- City 1 on Trunk Line X to Interstate-Z Interchange

Location:

- County T
- Milepost 54.75 to Milepost 59.72

Existing:

- Two-lane undivided highway

Definition:

- Add two lanes between Trunk Line Y and Interstate I-Z to create a four-lane divided highway
- Replace one bridge over creek
- Remove and replace bridge at Trunk Line X and Trunk Line Y
- Build two new bridges at Road 3 and the Trunk Line X and Interstate I-Z interchange
- Implement full, partial, and modified limited access along the project limits
- Add turn lanes and acceleration lanes at various locations
- Resurface existing lanes

Current Estimate:

- The construction cost-estimate summary above was prepared when letting Project B for construction. Costs reflect early 2007 dollars.

2.2.3.1.2 Bridge Cost Factors

DOTs derive bridge costs based on deck area (usually in \$/SF) in a manner similar to the lane-mile approach for roadways. They build this cost factor using bid data for typical bridge types and span lengths together with location characteristics (over land or water). Since cost per square foot of deck area varies, it is important to provide a range for the deck cost factor. Again, one must specify the time period and project location to create the cost factors. It is also important to state the dimensional data (width and length) used to calculate the deck area (“Recording...” 1995). Table 2-3 provides an example of bridge cost factors including a reference to deck area calculations and other qualifications regarding the cost data.

Table 2-3. \$/SF of Bridge Deck—Statewide Average Historical Ranges in 2011 Dollars

Type of Bridge	Measure (SF Bridge Deck)	Low (\$/unit)	Average (\$/unit)	High (\$/unit)
Prestressed Concrete Girders—Span 50-175 ft				
Water Crossing w/Piling	SF	150	175	200
Water Crossing w/Spread Footings	SF	140	165	190
Dry Crossing w/Piling	SF	120	155	180
Dry Crossing w/Spread Footings	SF	110	145	160
Reinforced Concrete and Post-Tensioned Concrete Box Girder—Span 50-200 ft				
Water Crossing w/Piling	SF	200	250	300
Water Crossing w/Spread Footings	SF	175	225	275
Dry Crossing w/Piling	SF	160	200	250
Dry Crossing w/Spread Footings	SF	150	190	230
Concrete Bridge Removal	SF	20	35	50
Widening Existing Concrete Bridges (including Removal)	SF	175	200	300
SE Wall Precast Concrete Panels	SF	30	40	50
SE Wall Welded Wire	SF	20	30	40

Source: Washington State Department of Transportation (Design Manual 2011).

NOTES: Bridge areas are computed as follows:

Typical Bridges: Width × Length

Length:

- Distance between back of pavement seats, or for a bridge having wingwalls, 3'-0" behind the top of the embankment slope; typically end of wingwall to end of wingwall.

Special Cases:

- Widening—actual area of new construction

Figure 2-2 illustrates incorporating an increased level of detail into a database of bridge cost factors. As noted in Figure 2-2, comparative bridge costs provide guidance on where in the cost factor range the estimator may want to select from based on general bridge dimensional information and typical location characteristics. An approach defined by the Federal Highway Administration (FHWA) helps in calculating the cost factors ("Recording..." 1995).

2.2.3.1.3 Historical Percentage Cost Factors

Historical percentages are often used to estimate costs for construction elements that are not typically defined at the planning phase and are not covered in historical data sources (i.e., lane-mile cost factors). A percent is developed based on historical cost information from past projects to cover very specific construction elements such as drainage and environmental mitigation. This percentage is based on a relationship between the selected construction elements and the total construction cost category.

The projects from which historical percentages are developed should be very similar in definition and complexity to the project being estimated. The elements that are represented by the percentage should

be based on a similar set of standard pay item numbers. Several projects should be used to develop the percentages so that a range of percentages can be reviewed prior to selecting the specific percentage that is applied by the estimator. As the dollar size of the project increases, historical percentages for elements normally decrease.

Developing a historical percentage starts with identifying construction elements that can be estimated using a percentage. Then, several different projects are identified that are similar to the project being estimated. From those projects, the estimator determines the standard item numbers for the elements of interest and the actual cost for those item numbers. The sum of the cost of these item numbers is calculated. The percent of this sum to the total construction cost for each project is calculated (i.e., percent of project construction cost without the elements). The estimator selects the percent that best fits the project being estimated.

2.2.3.1.4 Computer-Generated Cost Factors

Computer software is often used to aid in storing and sorting historical cost data and other pertinent project details. In its most elementary form, one can use a spreadsheet to store historical lane-mile information based on different types of projects. Table 2-2 provides an example of the calculated lane-mile cost based on a completed project. Figure 2-3 shows a typical spreadsheet of lane-mile costs. The estimator preparing a conceptual estimate can retrieve the lane-mile data from a spreadsheet. Alternatively, computer software, such as the AASHTOWare Project BAMS/DSS, and ExeVision's integrated Project Delivery (iPD) allow users to store bid data. These systems provide structured classification of bid items used by a DOT, and they allow for classification of contracts based on work type.

Historical data from the DOT database, such as AASHTOWare Project BAMS/DSS data, used with other programs helps to develop lane-mile costs, as illustrated in Table 2-1. To refresh the lane-mile cost, estimating personnel update the calculations based on current bid data. Finally, historical cost data can be stored within an estimating program along with other project type elements and dimensional information. An example of such a program is the AASHTOWare Project TRACER. AASHTOWare Project Cost Estimation also helps to develop conceptual estimates. Rather than developing templates for typical sections in order to establish cost factors for lane miles, using these same templates helps with developing cost groups in AASHTOWare Project Cost Estimation to represent elements of work. These cost groups could then be included within the estimate when one needs the work elements. The resulting estimate would more closely resemble that of a detailed estimate, but it would include higher contingencies due to the greater uncertainties in the earlier stages of the project.

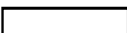
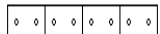
COMPARATIVE BRIDGE COSTS					
JANUARY 2011					
The following tabular data gives some general guidelines for structure type selection and its relative cost. These costs should be used just for preliminary estimates until more detailed information is developed. These costs reflect the ' bridge costs ' only and do not include items such as: bridge removal, approach slabs, slope paving, soundwalls or retaining walls.					
The following factors must be taken into account when determining a price within the cost range:					
Factors for Lower End of Price Range			Factors for Higher End of Price Range		
Short Spans, Low Structure Height, No Environmental Constraints, Large Projects, No Aesthetic Issues, Dry Conditions, No Bridge Skew			Long Spans, High Structure Height, Environmental Constraints, Small Projects, Aesthetic Issues, Wet Conditions (cofferdams required), Skewed Bridges		
Urban Location			Remote Location		
Seat Abutment			Cantilever Abutment		
Spread Footing			Pile Footing		
No Stage Construction			2-Stage Construction		
Factors That Will Increase the Price Over the High End of the Price Range 25%-150%					
Structures with More than 2 Construction Stages					
Unique Substructure Construction					
Widenings Less Than 15 ft.					
Structural Section	(Str. Depth/Max Span)		Common Span Range (feet)	**Cost Range (\$/FT ²)	Remarks
	Simple	Continuous			
RC SLAB 	0.06	0.045	16–44	100–300	These are the most common types and account for about 80% of bridges on California state highways.
RC T-BEAM 	0.07	0.065	40–60	100–200	
RC BOX 	0.06	0.055	50–120	110–180	
CIP/PS SLAB 	0.03	0.03	40–65	90–200	
CIP/PS BOX 	0.045	0.04	100–150	90–170	
PC/PS SLAB 	0.03 (+3" AC)	0.03 (+3" AC)	20–50	100–250	No falsework required
PC/PS 	0.06 (+3" AC)	0.055 (+3" AC)	30–120	120–230	
BULB T GIRDER	0.05	0.045	90–145	120–200	
PC/PS I 	0.055	0.05	50–120	110–190	
PC/PS BOX 	0.06	0.045	120–200	140–250	
STRUCT STEEL I-GIRDER 	0.045	0.04	60–300	170–425	

Figure 2-2. Bridge Cost Factors

Source: Caltrans Bridge Cost Estimating

NOTE: Removal of a box girder structure costs from \$8–\$15 per square foot.

**Cost Range/SQFT is calculated using "Bridge Costs Only" as defined by the FHWA.

Reconstruction						
T.H. #	Length in miles	Location	Contract Amount \$	\$ per Mile	Type of Repair/Costs/Other	Year
2	4.5	Bemidji-Grace Lake	3,734,756.99	829,946.00	Grade and pave to four lanes	1995-1996
32	1.69	In Thief River Falls 5703-33	3,275,825.00	1,938,357.99	Reconstruct	1992
32	3.135	In Red Lake Falls	3,315,468.00	1,057,565.55	Reconstruct	1992
75, 175	1.56	Hallock	3,476,319.00	2,228,409.62	58-34 Oil	2002
1	1.214	In Thief River Falls	1,664,879.00	1,371,399.51	58-34 Oil	2002
2	0.765	In East Grand Forks	4,014,751.67	5,248,041.40		2002
2		Jct. 222 to 3.6 miles E.	3,131,000.00	869,722.00	Unbonded; overlay Str Conc 98.65/sq.m, Lane Pavement 250mm 9.35/sq.m, Lane Pavement 20mm 5.85/sq.m	
11		Roseau 1.12 miles	3,493,950.00		S.P. 12.5; 3.F; 14,079 ton, - \$42/ton, (3,F), Common ex. \$5.30/yd.	2005
64	3.9	Akeley to Co Rd 33	3,026,749.00	776,089.00	3,C \$24/ton; 44,961 ton, Subgrade Ex \$1.50/cubic yd, 51,000 cubic yds, Common Ex \$1.50/cubic yd; 240,452 cubic yds, Much Ex \$1.70/cubic yd, 112,379 cubic yds	2005
64	5.986	Jct. 87 to Co. Rd 33	2,851,304.00	476,169.00	SP 12.5; 26,426 ton @ 30.21 Select Gran. 96,230 @ 1 cent/yd cubed	
2	0.5	In Crookston 6002-54 Main to Robert	2,046,183.00	4,092,366.00	Reconstruct	1997
2	0.786	Crookston 6002-56 Groveland to Broadway	3,256,000.00	4,142,493.64	Reconstruct	1998
2	0.75	Crookston 6002-59 E. end Bridge to 1.2 Km E.	1,998,000.00	2,664,000.00	Reconstruct	1999

Figure 2-3. Lane-Mile Costs Based on Completed Projects

Source: Cost Estimation... 2008

2.2.3.2 Cost Factors for Non-Construction Components of Total Project Cost

When focusing on total project cost, a common conceptual estimating technique is to estimate non-construction cost components as percentages of the calculated construction cost. Estimators typically relate these percentages to construction costs where the percentage comes from historical expenditures using activity codes (ROW, PE, and CE).

2.2.3.2.1 Preliminary Engineering

The scope of PE includes all data acquisition and design activities from the time the project is programmed at the scoping phase through the time the project is awarded. PE covers all resource identification and environmental permitting activities. All activities undertaken by contract administration necessary to process the project for award are included in PE costs. Finally, the PE covers all activities that involve the resolution of utility conflicts, relocation, or access management.

Table 2-4 is an example of percentages for various activities under the PE component. These percentages come from the historical relationships between the activity and construction costs.

PE percentage considerations are as follows:

Table 2-4. Preliminary Engineering Costs' Average Percentage Ranges (% of Construction)

Activity	Low	Average	High
Survey/Data Collection	2%	3%	6%
Design	2%	4%	6%
Environmental	2%	3%	6%
Utilities	2%	3%	5%
Contract Admin	2%	2%	2%
Totals	10%	15%	25%

Source: AASHTO Subcommittee on Design—Technical Committee on Cost Estimating

- **Level of data acquisition:** surveys—digital and field enhancements; type of topography (mountainous, rolling, or flat); coastal or other waterways; rural, suburban, or city (central business district). The more field enhancement or specialized surveys required, the higher the PE percentage.
- **Level of design engineering:** new location, widening of roadway corridors, interchanges or urban/city locations. Minimal constraints would generally have a lower percentage; increased design effort because of city location complexities may require higher percentages due to more conflicts or constraints and specifications.
- **Length, size of project:** every project requires the basic effort to ensure all aspects are completed. Longer or larger projects usually mean repeated or prolonged tasks, but the effort becomes more cost effective and can lower the PE percentage of construction costs.
- **Level of environmental documentation (CE, EA, or EIS):** level of public involvement. An Environmental Assessment (EA) or Environmental Impact Statement (EIS) with an above-average level of public involvement requires a higher PE percentage.

2.2.3.2.2 Right-of-Way

Right-of-way includes all activities associated with the assessment and acquisition of property for a project. The ROW components cover all costs associated with the acquisition of all easements and property parcels necessary to construct a project. ROW percentages, as depicted in Table 2-5, consider the local real estate market—such as rural, suburban, or central city—and the type of acquisition, such as minimal frontage take (strip); partial take, rendering the parcel uneconomical; or total take. Uneconomical or total takes may then require relocation or other compensation as a part of acquisition.

For non-complex or minor projects with minimal ROW requirements, the use of percentages of construction costs to estimate ROW is usually acceptable. However, moderately complex and major projects need at least a limited definition of scope to identify real estate requirements before preparing an accurate ROW conceptual estimate. Chapter 4 of NCHRP Report 625, *Procedures Guide for Right-of-Way Cost Estimation and Cost Management*, describes procedures for completing conceptual ROW cost estimates (Anderson et al. 2009).

Table 2-5. Average Percentage Ranges for Right-of-Way Costs (% of Construction)

Factor	Low	Average	High
Location	15%	40%	75%
Type of Take	15%	35%	75%
Totals	30%	75%	150%

Source: AASHTO Subcommittee on Design—Technical Committee on Cost Estimating

2.2.3.2.3 Construction Engineering

Construction engineering covers the cost of all activities associated with administering a project from the date of award until final acceptance or the time the construction engineering expenditure account is closed. This cost includes, but may not be limited to, payroll and expenses accrued by DOT or consultant inspection forces, or both; material testing and evaluation by the DOT or consultant forces, or both; central office administrative and business-related efforts; and field reviews by the DOT or design staff, or both.

In the case of conceptual estimates, the estimator should calculate CE costs as a percentage of total construction costs. The percentage will vary with the type and complexity and net dollar size of the project. According to the Washington State DOT, the percent could be as low as 8 percent for large (\$10,000,000 or greater) roadway or structure preservation projects and as high as 20 percent for small (\$250,000 or less) preservation projects (“Contract Estimate,” 2011). Alternatively, for small highway improvement projects in an urban environment, CE could be as high as 26 percent and as low as 10 percent for large improvement projects. The WSDOT average for CE across all improvement and preservation program projects is 15 percent.

2.2.4 Macro-Environment and Market Conditions

Planning estimates are too many years from letting dates to consider adjustments to the base estimate for macro-environmental and market conditions.

2.3 PREPARE BASE ESTIMATE

Preparing a base estimate for conceptual estimating requires that estimators determine the basis from which the estimate will be prepared (see Figure 1-2). The basis of the estimate mainly comes from the project definition and project characteristics (see Section 2.2). The challenge when preparing a conceptual estimate is to ensure that the estimate covers all categories of each major project component, that is, construction, right-of-way, preliminary engineering, and construction engineering. At this level of estimating, defining the construction effort is often very difficult due to lack of project information. The estimator should visit the project site to confirm the completeness of project definition requirements and assess potential constructability (i.e., material storage locations, haul routes, and construction staging issues). Further, a site visit can help detect potential environmental mitigation, utility relocation, and right-of-way issues that might influence cost. After establishing the estimate basis, the estimator can prepare the base estimate (see Figure 1-2). There are six general steps for preparing a base estimate (Anderson et al. 2008):

1. Select appropriate estimating approach.
2. Determine estimate components and quantify.
3. Develop estimate data.
4. Calculate cost estimate.
5. Document estimate assumptions and other estimate information.
6. Prepare estimate package.

2.3.1 Select Appropriate Estimating Approach

There are a number of approaches to conceptual estimating based on the project's definition and the type of past data available. For example, if the project does not have structures and only represents pavement activities, the estimator should utilize the lane-mile estimate. If the project is a bridge rehabilitation project, the estimator should use the bridge-cost-per-square-foot-of-deck-area approach. If the project has pavement and bridge construction work, then the estimator should use both sources of historical data. Alternatively, if there are similar past projects in terms of both project definition and project characteristics, then using a lane-mile approach based on the similar project might be the best approach. If using a computer-based conceptual estimating tool (i.e., TRACER), then the project definition must define key project parameters that serve as inputs to the estimating software. Then, the estimator should use percentages for the other components of total project cost including right-of-way, preliminary engineering, and construction administration. Estimators should estimate right-of-way by using the techniques described in NCHRP Report 625, *Procedures Guide for Right-of-Way Cost Estimation and Cost Management*. Chapter 4 of that guide is dedicated to conceptual ROW cost estimation (Anderson et al. 2009). The estimator must select the approach that best reflects the project definition and historic cost database developed by the DOT. If the appropriate historic cost database is not available, the estimator must develop the requisite historic cost data.

If using a conceptual estimating software tool, it will guide the process for steps 2, 3, and 4. For example, TRACER's output includes quantities for various items of work, unit prices, and calculations to derive a construction base cost estimate. This tool uses a parametric approach for conceptual estimating. The database that supports this tool is the *RS Means Heavy Construction Cost Data* manual. TRACER uses statistical relationships between major highway project systems, termed modules, and the details that describe the system. For example, a bridge module is available to estimate the cost of a bridge. The user then provides the system definition for the bridge. In this case, three basic elements are required for inputs into TRACER—bridge size (length and width), separation type (over highway and height), and definition (superstructure and substructure type). TRACER then generates all direct construction costs. Next, the user should add the contractor overhead and profit based on project location and insert these values with the provided template. TRACER is an estimating tool that incorporates historical cost data and statistical relationships and can adjust costs for different locations. Figures 2-4 to 2-6 show an illustration of how this tool works to estimate all the construction costs for a component of a project, such as bridges (Anderson et al. 2007). Figures 2-4 and 2-5 show the types of project definitional input needed, while Figure 2-6 illustrates typical cost-estimate output.

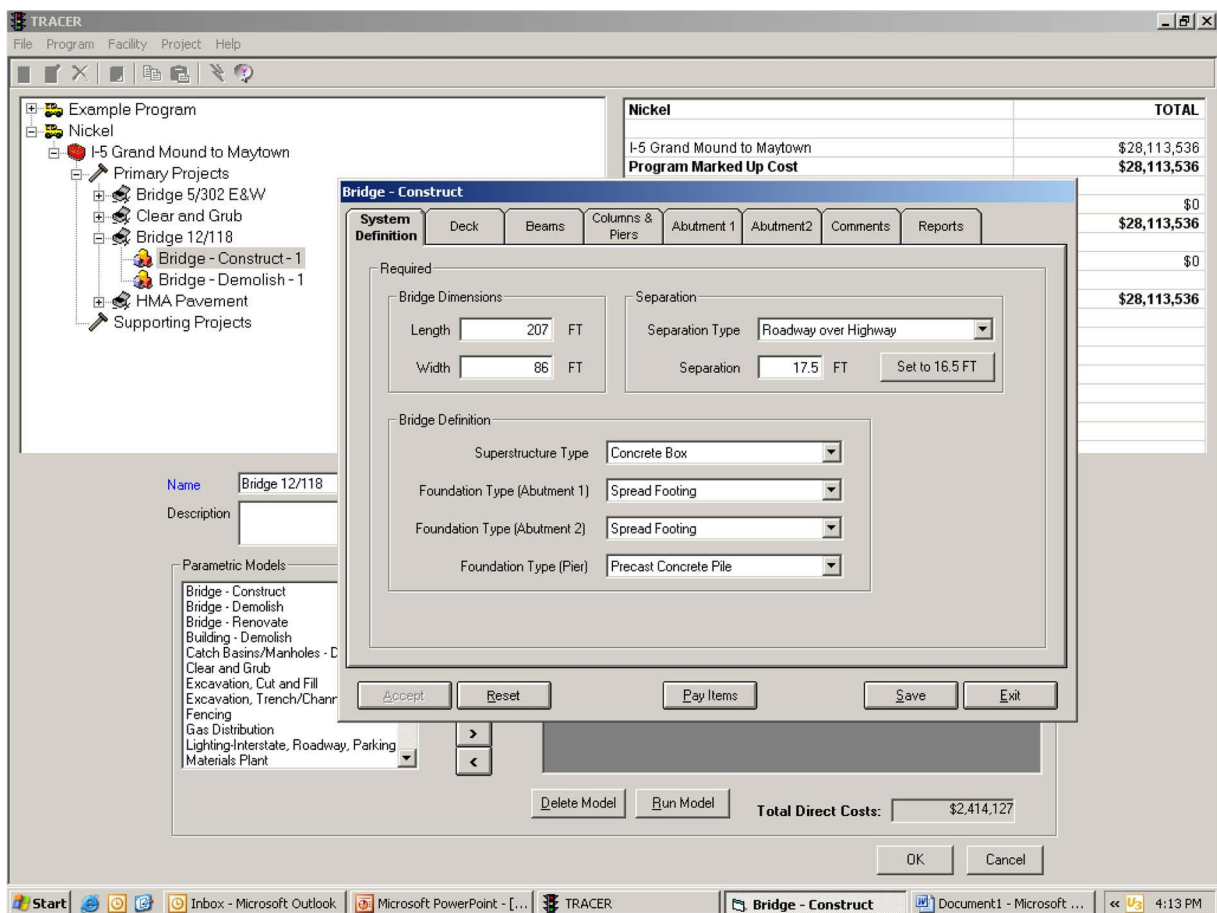


Figure 2-4. Typical TRACER System Input for a Bridge

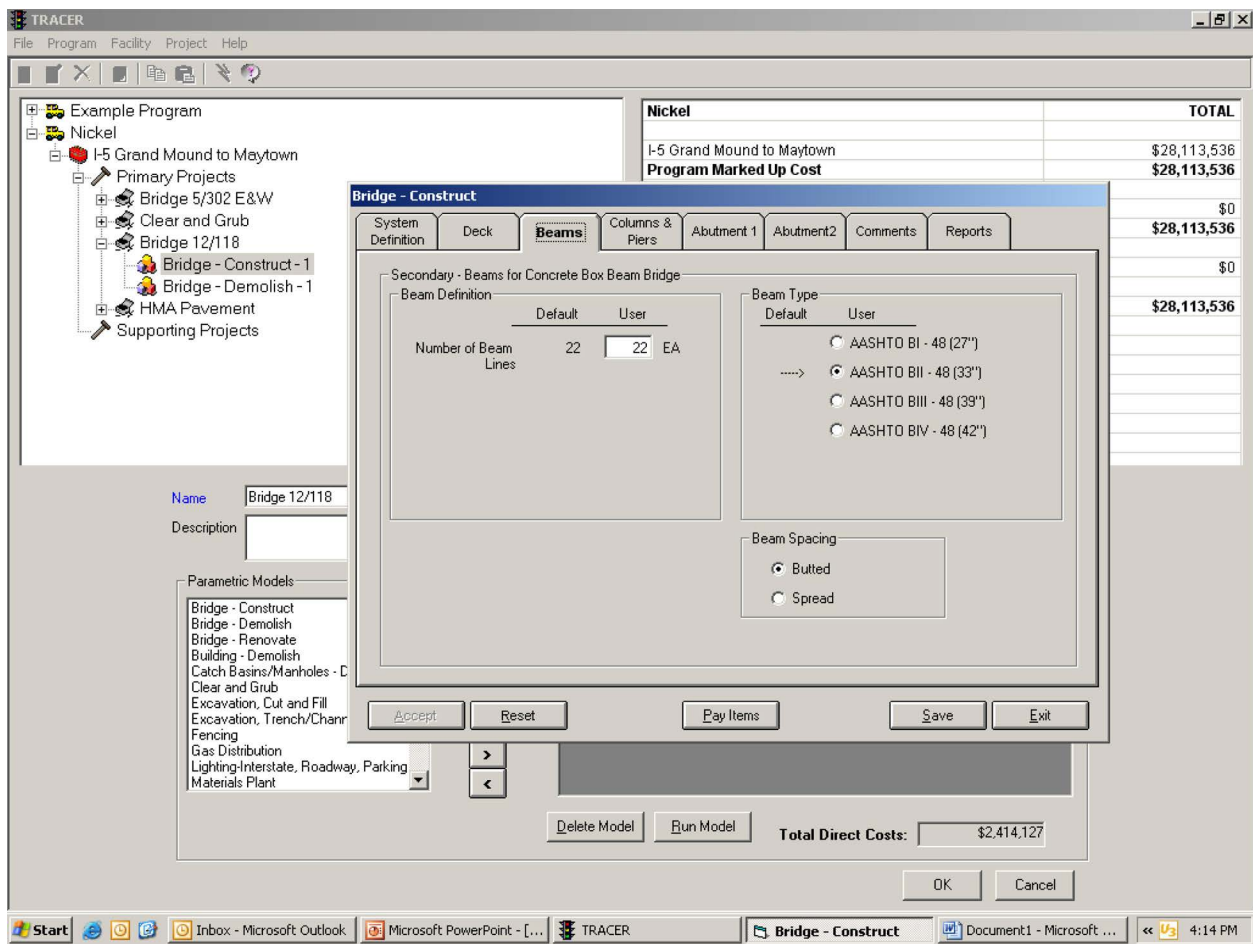


Figure 2-5. Typical TRACER Beam Input for a Bridge

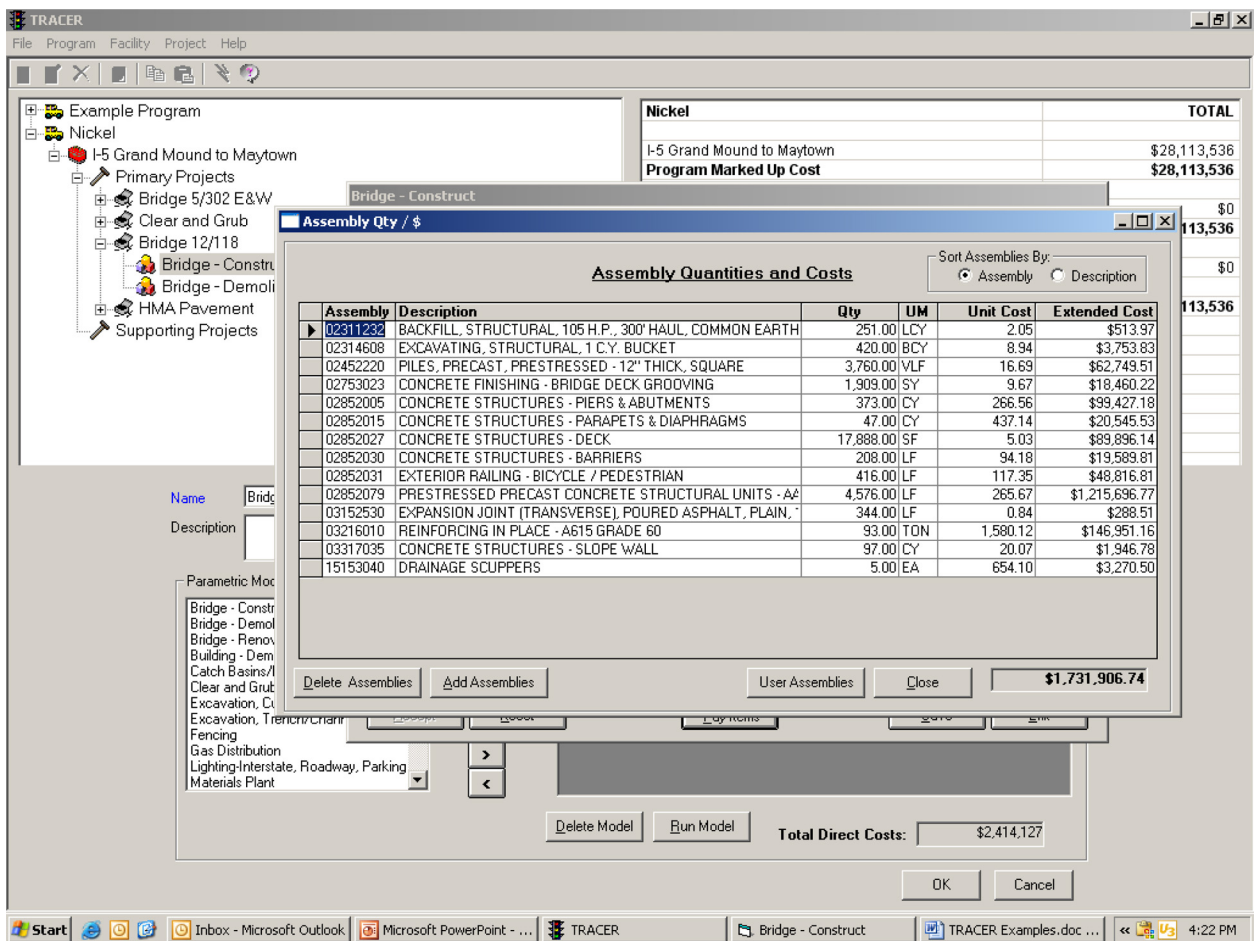


Figure 2-6. Typical TRACER Output for a Bridge

If such a software program is not used, then the estimator has to perform steps 2, 3, and 4 as discussed in the following sections.

2.3.2 Determine Estimate Components and Quantify

Conceptual estimating requires the estimator to determine what components are required to estimate total project cost. This effort is straightforward for most non-complex projects where ROW is not required. The more difficult requirement is determining the work categories needed for the construction component. For example, if the project requires both structures and pavement construction, estimators will then derive quantities for the major parameters such as lane miles and square foot of bridge deck area or retaining wall area. The estimator must define the lane mile as centerline or project lanes for estimating purposes only. If using centerline, then estimators should identify mileposts at the project boundaries. The difference between the mileposts represents the centerline distance. If project lane miles are used, the estimator needs to know how many lanes are involved in construction. This may include existing lanes plus new lanes added if the project is a capacity expansion. Next, the estimator should calculate the total project lane miles. If the project involves bridges or other major structures, then the basic dimensions of the replacement or new bridges must be determined (i.e., deck width, length, height above water or land).

If estimators choose to use true parameter estimating software, such as TRACER, then the inputs are element types plus dimensional information. More design assumptions are necessary to adequately describe the pavement structure or bridge type and configuration (see Figures 2-4 and 2-5 for examples). The program calculates quantities based on statistical models (see Figure 2-6).

2.3.3 Develop Estimate Data

In this step, the estimator has to match the types of quantities developed in the previous step with the construction cost data available in the DOTs historical cost database. Then, the estimator has to ensure proper adjustments of historical data to fit the current estimate. Adjusting historical data depends upon the type of project, its definition, and specific site characteristics, as these attributes relate to the current estimate. In addition, the estimator must decide on the percentage to use in calculating ROW, PE, and CE costs, again from the data in the DOT's historical cost database. It might be necessary to develop the appropriate cost data if the DOT database does not cover the items needed to complete the project estimate.

2.3.3.1 Selecting Historical Cost Data

Selecting the appropriate historical data for estimating a project is vital. The estimator must ensure that the data selected represents the type of project for which an estimate is being prepared. As an example, if the project relates to pavement work only, then a lane-mile approach is appropriate. In this case, the estimator can select the appropriate project type and the corresponding cost factor (i.e., dollars per lane mile). Bridge estimating takes a similar approach. The bridge type selected from DOT charts must be similar to the current bridge estimate. The estimator then selects the corresponding cost factor. If the project has both pavement and bridge categories, the estimator may select cost factors developed from similar past projects.

In selecting the cost factor, the estimator should be clear about the project definition or scope covered by the cost factor (i.e., does the factor include substantial environmental mitigation costs or costs for relocating utilities?). This is critical information to know when adjusting historical cost factors to fit the project for which an estimate is being prepared. Other adjustments will also likely be necessary.

2.3.3.2 Adjustments to Cost Data

There are several areas where the estimator should consider adjusting the historical cost factors selected when developing the cost data for estimating a new project. These factors include:

- Time—age of historical data impacts its validity.
- Location of project versus location basis for cost factors.
- Unique project location characteristics (geography).
- Scope—evaluating the extent to which the cost factors cover the specific project.
- Unique project definition requirements.

2.3.3.2.1 Time

The estimator must note the time basis related to the cost factor selected. For example, in Table 2-3, the cost factors represent 2007 dollars. If an estimator uses these data to estimate bridge costs for a project, then he/she must adjust the cost factor selected to current dollars using the DOT's highway cost index.

2.3.3.2.2 Location

Cost factors are often developed based on statewide averages. In some states, construction costs are different by district or region depending on location. Cost differentials may be due to labor wage changes. Typically, an urban area has higher wage rates than a rural area. Other differentials in costs resulting from location could affect both materials and construction equipment (e.g., typical haul distances). In all cases, the estimator has to evaluate cost differentials between statewide averages and costs for the actual project location. Thus, estimators must make appropriate increase or decrease adjustments as necessary.

2.3.3.2.3 Unique Project Location Characteristics

Estimators should take into consideration the location of the project in relation to such issues as terrain, batch plants, and haul distances. Flat terrain normally improves contractor productivity, so costs should be lower compared to terrain characterized by hills or mountains. If distance influences the transportation of materials, then costs are likely higher than the average. The estimator must use judgment to adjust cost factors so they reflect these types of location characteristics. The estimator may need input from construction engineers in developing adjustments for such factors.

2.3.3.2.4 Scope

The estimator has to develop percentages to cover work elements not covered by the basic cost factor. For example, if the cost factor for a bridge (i.e., dollars per bridge deck area) does not cover the approach slabs, then the estimator has to add this cost. Developing percentages should help estimate these types of additional costs. The database of cost factors should clearly identify what is included in the standard cost factor so estimators can make any appropriate adjustments when applying the cost factor on a current project estimate.

2.3.3.2.5 Unique Project Definition

In some instances, a project has unique project scoping issues. For instance, if a project adds lanes using an existing grass center median, the amount of drainage required will increase substantially in terms of catch basins, pipe, and retention ponds. If the pavement cost factor assumes a grass center median, but with the new lanes located on the outside of the existing pavement structure, then the estimator has to make an adjustment for the cost of additional drainage work. The estimator could develop a percentage of other construction costs to apply to the lane-mile factor to capture added drainage requirements. Alternatively, the estimator could make some assumptions about the likely scope of the drainage and ponds and then calculate costs by developing quantities and using bid prices. Cost adjustments are sometimes required for wetlands and other environmental impacts not clearly identified in cost factors.

2.3.3.3 Summary

There is an argument for including various adjustments to cost factors for contingencies, especially cost factors related to location characteristics, project definition, and project complexity. This approach is certainly acceptable as long as the contingency estimate can clearly identify costs related to these types of adjustments. The cost-estimate documentation should describe all adjustments and how the estimator calculated the costs for any adjustments. If data reflect historical cost factors as a range, the estimator may use a cost factor on the higher end of the range to incorporate the impact of the adjustments discussed.

2.3.4 Compile Cost Estimate

Once the quantity information is calculated for major construction categories (i.e., centerline miles or bridge deck area) and a unit cost is derived for those components (i.e., dollars per centerline mile or dollars per bridge deck area), estimators can use spreadsheets to calculate the costs for each category. In addition to construction cost, the estimator has to select the appropriate percentage for ROW, PE, and CE to reflect the level of effort for each of these components. These percentages are used to calculate the ROW, PE, and CE costs. If the estimator uses a computer software program, then the program makes the calculations and generates cost details and a cost summary for the project (see Figure 2-5).

2.3.5 Document Estimate Assumptions and Other Estimate Information

Support documentation includes project work narratives and schedule, backup data, and sketches. This documentation must be in a form that is understandable, checkable, verifiable, and easily correctable. Estimators must make sure to document the reasons for all cost adjustments and clearly detail any computations of the adjustments made.

2.3.5.1 Estimate Basis

References to sketches, basic descriptions of the project's definition, and any assumptions used to develop a project's definition should be included in the documentation. In addition, the project location and any unique project conditions that affect the estimate should also be included in the documentation, as discussed in Section 2.2.3.

2.3.5.2 Estimate Supporting Data

Estimators draw data from multiple sources when creating a conceptual estimate, so estimators need to document these sources together with notes supporting any adjustments made based on engineering judgment or experience. Estimators should back up data by documenting the following estimate-related information:

- Quantity computations: The quantities for major parameters should reference sketches or information provided by the planning staff. Estimators must show dimensional information clearly in the documentation, using sketches as necessary to support quantity calculations.

- Estimated cost factor: The source of historical cost factors used to develop major categories of work should be explained and documented (i.e., source and rationale for selecting the cost factor). So, estimators will document the rationale for adjusting a base cost factor, such as for geographical location, quantity considerations, scope differences, impact of unique project definition requirements, and difficult site conditions or constraints, or some combination thereof. Finally, they must remember to document all adjustments made to estimated cost factors for current market conditions and any macro-environmental conditions.

2.3.6 Prepare Estimate Package

All estimate-related information should be included in a project estimate file that organizes estimate information for use in preparing a risk analysis to set contingency options, for estimate reviews, and for estimate approval by planning or program delivery management. For an outline format for such a suggested project estimate file, see Figure 2-7. The estimate basis details are oriented toward the types of information available in planning. The cost-estimate section should reflect typical types of conceptual estimating detail.

2.4 DETERMINE RISK AND SET CONTINGENCY

Estimators need to separately develop a contingency amount for the project based on the risk analysis process discussed in Chapter 5. They should expect to have larger contingency percentages for conceptual estimates based on both the lack of detailed project definition and the types of conceptual estimating techniques used to prepare conceptual estimates. Also, conceptual estimates are often prepared quickly, so the estimator may not have time to carefully analyze and make all the necessary adjustments to the base estimate; therefore, a larger contingency percentage becomes appropriate. For more information on specific risk analysis techniques, refer to Chapter 5.

2.4.1 Contingency

Conceptual cost estimates have substantial uncertainty associated with the completeness of the project's definition as well as the techniques used to prepare these estimates. They require considerable estimator judgment to ensure complete project definition and to determine the most appropriate historical cost data to use for estimating purposes. A risk analysis, as discussed in Chapter 5, covers estimate variability associated with the level of definition and cost factors used in preparing the conceptual estimate.

The estimator is probably in the best position to assess the uncertainty associated with cost factors, while planners/designers can assess the completeness of the project definition.

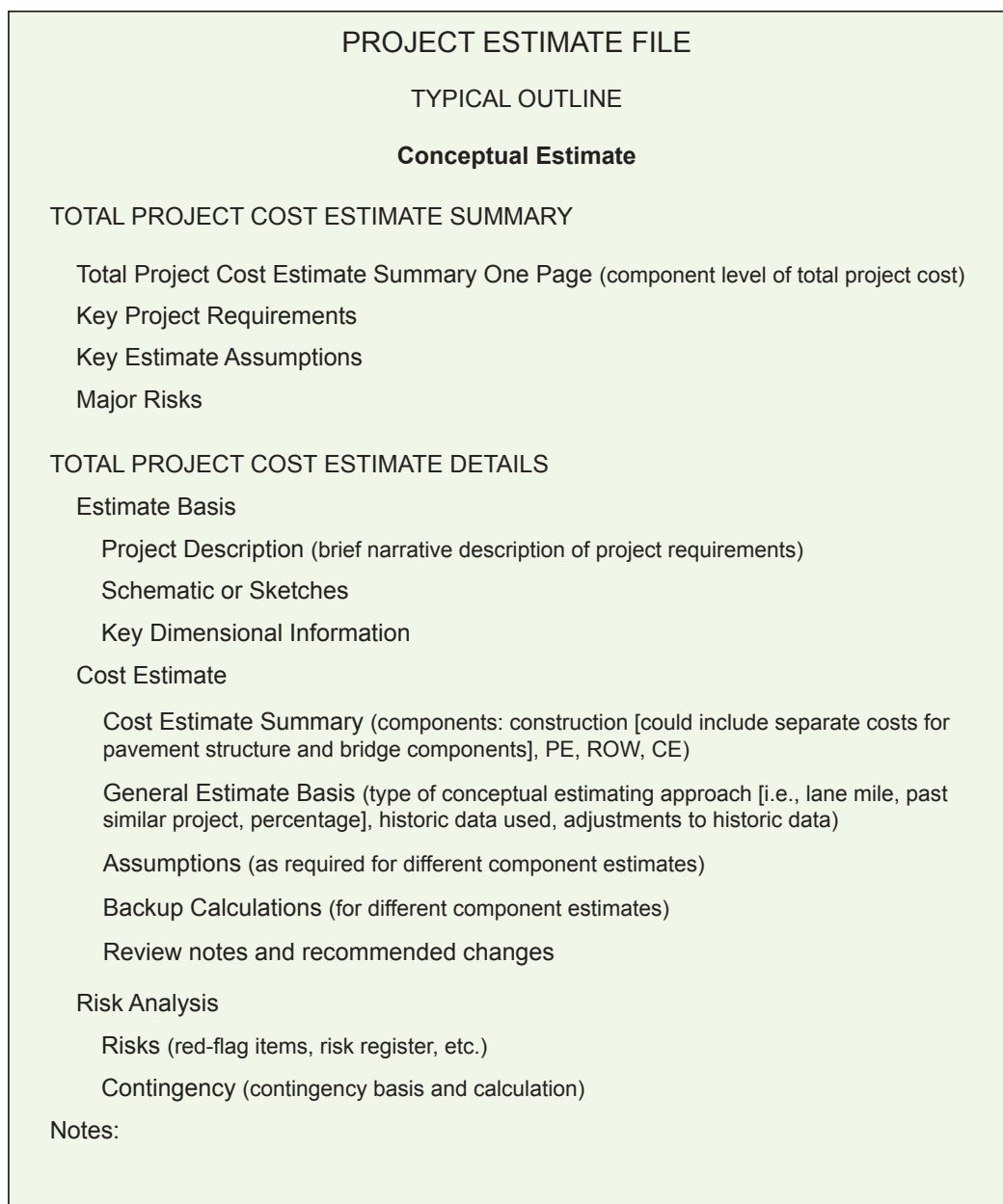


Figure 2-7. Project Estimate File Outline
Source: Adapted from: Cost Estimation... 2008

2.5 QUALITY ASSURANCE AND QUALITY CONTROL

Completing a quality assurance and quality control review assists in validating all conceptual estimates. A key issue of quality is to ensure the project's definition is fully covered and the estimated costs are representative of the level of project definition associated with project planning.

The review of a conceptual estimate, at a minimum, should examine the sources of cost factor data, the fit with the project type, and all adjustments to costs made to account for project-specific definition and condition requirements. The detail and depth of a review will vary depending on the type of project,