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**INFORMATION AND SPECIAL INSTRUCTIONS:**

Attached is the 2018 Edition of the Estimating Manual. The 2018 Edition removes Chapter 7 - Construction Scheduling. All scheduling policy is now incorporated into the new edition of Publication 615. Other general updates were made throughout to reflect current estimating practices. Appendices A and C were also made interactive.

All District Offices should distribute this Manual to the appropriate staff within their organization responsible for preparing project cost estimates. District Contract Management Offices should assure that all bid package estimates are in compliance with this Manual.

**CANCEL AND DESTROY THE FOLLOWING:**

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**ESTIMATING MANUAL**  
2018 Edition

# ESTIMATING MANUAL

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# CHAPTER 1

## INTRODUCTION

### 1.1 GENERAL

The purpose of this Manual is to provide policies and procedures to guide Department employees and others in the methodology and milestones for developing, documenting and reviewing construction cost estimates throughout the project development process. The Estimating Manual and the policies and procedures by which the Bureau of Project Delivery (BOPD) and Engineering District Offices operate were developed in accordance with Federal regulations, research of National Cooperative Highway Research Program (NCHRP) studies, and guidance developed by the American Association of State Highway and Transportation Officials (AASHTO) Technical Committee on Cost Estimating.

In order to successfully address transportation needs, the Department must have reliable construction cost estimate factors, and associated construction cost estimate documentation that support the development of the construction cost estimate from early conceptual alternatives through project Plans, Specifications and Estimate (PS&E). Construction cost estimates are first developed in early project planning (prior to the Transportation Improvement Program (pre-TIP)) and updated at the project milestones of TIP development, Engineering and Environmental Scoping, National Environmental Policy Act (NEPA) Approval, Design Field View, Final Design Office Meeting, and the PS&E. This guidance document contains the cost estimating guidance and milestones to track estimates from planning through Final Design Office Meeting.

Some of the typical causes of construction cost uncertainty are incomplete scope definition, multiple alternatives, and insufficient information about factors outside the roadway (e.g., right-of-way, community, cultural, environmental, and construction cost escalation). Two specific tools, Appendix A, *Cost Driver Analysis Documentation Template*, and Appendix C, *Estimate Review Report*, are provided to enhance the Department's ability to identify and address the factors that drive construction costs and to assure quality of estimates through a proper review.

### 1.2 ESTIMATING MILESTONES THROUGHOUT PROJECT DEVELOPMENT

To successfully address transportation needs, the designers must follow construction cost estimate development procedures, and provide associated construction cost estimates for the five main estimating milestones. At a minimum, the construction cost estimate should be recorded and updated at each project milestone noted in parenthesis.

1. Planning (TIP development)
2. Scoping (Engineering and Environmental Scoping or other milestones that affect the estimate due to the nature of the project such as NEPA Approval)
3. Design Field View (or other design milestones that affect the estimate due to the nature of the project such as TS&L (Type, Size and Location) or Line and Grade Approval)
4. Final Design Office Meeting
5. PS&E (Engineer's Estimate)

The estimate for each level of project development has a specific purpose, methodology, and is expected to have a certain level of accuracy. As the project progresses, more of the project's parameters will be defined and the expected accuracy of the estimate will increase.

**A. Planning.** The planning level estimate is used during the Project Definition and Initiation phases to estimate probable funds needed for long range planning and prioritization for the TIP. At the planning level, estimates are



prepared with minimal project definition.

**B. Scoping.** A scoping level estimate is used to set the baseline cost for the project against which all future estimates will be compared. It is important to clearly document the scope definition and assumptions during this phase so that all future construction cost estimate changes can be accurately compared to this estimate. At the time of project scoping, the project should begin to have sufficient project definition in order for the estimator to develop approximate quantities based on overall project length and or structure sizes for items such as asphalt, concrete pavement, structures, or roadway excavation. For such quantifiable items, historical bids are often used to develop a base unit price that is then adjusted for potential cost driver impacts.

**C. Design Field View.** Throughout the project design process, additional construction cost estimates will be prepared and updated at various design milestones, including Design Field View, Final Design Office Meeting, and Preliminary PS&E Review. At each of these milestones, the known project work items and associated quantities and unit prices will be used to develop a more refined construction cost estimate. These milestone estimates will be used to compare against the current programmed amount. This will solidify many items in the scope such as right-of-way, likely permit conditions, environmental mitigation, and quantities of major items of work. The estimate may need to be updated along with NEPA Clearance with respect to environmental clearance, commitments, and mitigation as well as any changes to the scope of the project. As scope definition improves, the accuracy of the estimate will likewise improve. The work effort required to prepare, document and review the estimate also increases.

**D. Final Design Office Meeting.** As items and quantities become finalized, most of the contingencies will also be accounted for within the estimate. Unit prices should begin to be compared or updated for current market conditions. The estimator should also account for escalating costs on price-volatile items.

**E. PS&E.** The Engineer's Estimate is developed for the Bid Package Review in preparation for advertisement. In addition, the Engineer's Estimate is used to obligate construction funds and to evaluate contractor's bids.

At this point, the project is now fully defined so that design engineers and estimators are able to specify all items of work that will be required for the project and estimate quantities and unit prices. Historical bid-based methodologies should be used for most items of work where historical data is available. Cost-based estimating methodologies should be used to check major items of work that pose significant impact on total project cost. Refer to Publication 51, *Plans, Specifications and Estimate Package Delivery Process Policies and Preparation Manual* for information on the PS&E process.

### 1.3 CONTENTS OF THE ESTIMATING MANUAL

The *Estimating Manual* contains eight chapters. This section provides a brief summary of each chapter.

1. Chapter 1, *Introduction*. This chapter introduces the *Estimating Manual*, how it was developed, and introduces each of the chapters.
2. Chapter 2, *Cost Management Process*, discusses the steps to follow within each estimate review, as well as the relationship of estimates between the project milestones of TIP development, Engineering and Environmental Scoping, Design Field View, Final Design Office Meeting, and Final PS&E Estimate. The chapter also discusses the importance of documenting the assumptions made throughout the project development process with respect to key items of work.
3. Chapter 3, *Cost Estimating Methods*, discusses parametric, historical, and cost-based estimating methods.
4. Chapter 4, *Cost Estimating Factors*, discusses cost drivers, cost escalation, contingencies, and inflation and the impact that each has on the construction cost estimate throughout the project development process, especially at the project milestones.
5. Chapter 5, *Estimate Review*, discusses the review process that is to be used by the project team, District,

and Central Office.

6. Chapter 6, *Cost Estimating Tools*, contains guidance on the tools available that support the development of costs estimates such as the Engineering and Construction Management System (ECMS) Bid Item History.
7. Chapter 7, *Bid Analysis*, discusses the parameters programmed in ECMS to analyze bids from total project bid amount to individual items.
8. Chapter 8, *Bid Collusion*, provides the guidance on methods to detect bid collusion and the policy for confidentiality of Department Estimates.

## CHAPTER 2

### COST MANAGEMENT PROCESS

#### 2.1 ESTIMATING PROCESS BACKGROUND

Regardless of the estimate update milestone (i.e., Planning, Scoping, Design Field View (DFV), Final Design Office Meeting (FDOM), PS&E), the preparation of an initial estimate or the update of an estimate at subsequent milestones should follow the basic process shown in Table 2.1, Estimating Steps.

**Table 2.1**  
**Estimating Steps**

Step	Description
Determine (or review and update) estimate basis	Document (or update) project type and scope, including: <ul style="list-style-type: none"> <li>• scope documents</li> <li>• drawings that are available (defining percent engineering and design completion)</li> <li>• project design parameters</li> <li>• project complexity</li> <li>• unique project location characteristics</li> <li>• disciplines required to prepare the cost estimate</li> </ul>
Prepare (or update) base estimate	Prepare (or update) estimate, including: <ul style="list-style-type: none"> <li>• documentation of estimate assumptions, types of cost data, and adjustments to cost data</li> <li>• application of appropriate estimation techniques, parameters, and cost data consistent with level of scope definition</li> <li>• coverage of all known project elements</li> <li>• coverage of all known project conditions</li> <li>• ensure that estimates are consistent with past experience</li> </ul>
Determine risk and set contingency	Identify and quantify areas of uncertainty related to: <ul style="list-style-type: none"> <li>• project knowns and unknowns</li> <li>• potential risks associated with these uncertainties</li> <li>• appropriate level of contingency congruent with project risks</li> </ul>
Review total estimate	Review estimate basis and assumptions, including: <ul style="list-style-type: none"> <li>• methods used to develop estimate parameters (e.g., quantities) and associated costs</li> <li>• completeness of estimate relative to the project scope</li> <li>• application of cost data, including project-specific adjustments</li> <li>• reconciliation of current estimate with the previous estimate (explain differences)</li> <li>• preparation of an estimation file that compiles information and data used to prepare the project estimate</li> </ul>

Table 2.2, Cost Estimating Process, provides a review of the estimate development, contingency, inflation and associated estimate documentation (see Section 2.3 for documentation guidance) for the key project milestones. Table 2.3, Construction Estimate Milestones, also provides an overview of what is to occur for each milestone with respect to developing and documenting the construction cost estimate.

Table 2.2  
Cost Estimating Process

Estimate Process	Develop / Update Estimate			Capture Estimate Documentation		Miscellaneous Items	Apply Contingencies	Apply Inflation Factor	Review Estimate	Approve Estimate	Communicate Estimate
	Type	Method	Tool	Document	Cost Drivers Analysis						
Planning	-Conceptual planning estimate	-Parametric estimating -Similar projects	-Lane-mile cost -Square foot bridge costs	-Project parameters	-Assumptions -Risks -Long range forecast of trends in highway construction sectors	-Ensure that lane-mile cost is adequate to support miscellaneous items (including general items and incidentals)	-Validate that MPMS inflation factor is sufficient of construction				
	-Baseline estimate	-Parametric estimating -Lane item estimate -Historical percentages -Similar projects -Historical bid	-Lane-mile cost -Square foot bridge costs	-Cost variances from TIP estimate -Additional details for project parameters -Costs for environmental and context sensitive solutions	-Assumptions -Risks -Reexamine long range trends in highway construction sectors	-Refine percentage based on total cost -Build lump sum costs or percentages to account for general and incidental construction items	-Update for midpoint of construction	-Perform reviews at each milestone Estimate Review Report and Checklists in Appendix C	-Approval based on revised estimate ranges in accordance with the cost containment policy		
Scoping											
	-Mid-level itemized estimate	-Further define and develop cost categories and major items (20/80 rule) -Scratch estimating -Historical bid prices	-ECMS design items	-Account for cost variances from Scoping Field View estimate -Most assumptions should now be defined -Checklists	-Quantify assumptions -Quantify risks -Examine price trends for high cost items	-Account for items that have not been identified or quantified	-Refine for multi-season projects	-Report and Checklists in Appendix C			
Design Field View											
	-Itemized estimate	-Refine items/unit costs -Historical bid prices	-ECMS design items	-Account for cost variances from Design Field View estimate -Checklists	-Quantify assumptions -Account for risks price volatile items -Monitor and adjust prices based on recent bid data	-Check for any remaining items identified but not fully quantified	-Review inflation percentage				
Final Design Office Meeting											
	-Complete itemized estimate	-Further refine items/unit costs -Historical bid prices	-ECMS design items	-Account for cost variances from 75% Plans Estimate -Checklists	-Design items reflect all work detailed in plans and specifications						
PS&E											

**2.2 ESTIMATE MILESTONES**

The Project Manager, working in conjunction with the project team, is responsible for overseeing the development and refinement of the construction cost estimate at the construction estimate milestones of Planning, Engineering Scoping, Design Field View, Final Design Office Meeting, and PS&E. The process and tools to be used for each milestone are identified in this Chapter with more detailed information presented in Section 2.3, Estimate Documentation and Chapter 4, *Cost Estimate Factors*.

**Table 2.3  
Construction  
Estimate Milestones**

	Construction Estimate Milestones				
Construction Estimate Estimate Date	Planning	Scoping	Design Field View*	Final Design Office Meeting	PS&E
<b>A) Base Cost Estimate</b>					
<b>B) Contingency**</b>					- N/A -
<b>C) Subtotal Project Cost (A+B)</b>					
<b>D) CENG***</b>					
<b>Total Estimate (C+D)</b>					
<b>Comments</b>					

\* An estimate update at NEPA approval is the latest milestone for adding construction funding to the TIP. See Section 2.2A. Other milestones may be appropriate as well such as TS&L or Line and Grade Approval, depending on project type.

\*\* See Section 4.8 for a complete discussion on Contingency. Contingencies (and any unknowns) should be fully addressed within the estimate at PS&E.

\*\*\* Calculate Construction Engineering (CENG) based on percentages shown in Section 4.10 multiplied by project subtotal.

In order to facilitate the traceability and review of estimates, Table 2.3, Construction Estimate Milestone, is a tool to record the estimate value at various milestones for all types of projects. This table is also included in the *Estimate Review Report* (Appendix C).

The development of cost estimates for each step in the project development process should consist of two components: known (or base) amounts and unknown (risk and contingency) costs. Understanding the risks associated with each step of the project development and having a clear definition of contingency coverage is very important.

**A. Planning Estimate Development.** The Planning and Programming cost estimates are most often developed using the parametric or similar project estimating methods (see Sections 3.2 and 3.3). During the planning phase, the management of the construction cost estimate is focused on verifying or updating planning dollar amounts.

In programming, federal law requires the transportation improvement program (TIP) for a regional planning area to become part of the state's transportation improvement program (STIP). Therefore the Department, Metropolitan Planning Organization (MPO) and Rural Planning Organization (RPO) work closely to identify the design and construction costs associated with candidate projects to create the TIP. Construction cost estimates prepared during programming of the TIP is critical in terms of setting funding, schedule, and scope for managing project development.

A cost estimate for large projects (Environmental Assessment (EA) or Environmental Impact Statement (EIS) level projects) must also be developed when there is money on the TIP for design of projects but the construction of the project is not contemplated until later in the Long Range Plan. It is important to complete a detailed cost estimate in the planning stage for these types of projects which includes inflation to make sure PennDOT could afford to construct the project when the project is projected to be let.

The funding level in the TIP sets the budget, and typically includes a target date for construction. For additional information regarding PennDOT's Planning and Prioritization and Programming Phases, see Publication 10, Design Manual Part 1, *Transportation Program Development and Project Delivery Process*, Chapter 2. The TIP cost estimate is to be developed using either Parametric Estimating or Similar Project Estimating taking into consideration appropriate cost adjustments cost inflation.

Once the base TIP Development construction cost estimate has been developed, then the estimator will need to consider what effects the cost drivers, contingency, and inflation will have on the construction cost estimate. As a part of the cost driver analysis, the estimator should consider long-term trends of the various highway construction sectors such as asphalt paving.

Planning Contingency - At the TIP development step, the contingency covers the variety of possible events and problems that are not specifically identified and to account for a lack of project definition known during the preparation of the estimate. Contingency does not include inflation rates (see Section 4.8). Note that the inflation factor can be added by the District Planning and Programming Manager (see Section 4.9).

**B. Scoping Estimate Development.** For the Engineering and Environmental Scoping construction cost estimate, the goal is to review the construction cost estimate developed during the TIP development and determine what additional information is now known regarding the construction cost estimate. The Engineering and Environmental Scoping cost estimate is to be developed using Parametric Estimating or Similar Project Estimating.

To assist with the development of the construction cost estimate at the Engineering and Environmental Scoping, the construction cost estimate should be broken down into approximately 15-25 broad categories (e.g., structure, roadway, drainage).

Once the Engineering and Environmental Scoping construction cost estimate has been developed, the estimator must again consider what effects the cost drivers, contingency, and inflation will have on the current construction cost estimate. The estimator should also reexamine any amount applied to the TIP estimate that accounted for long-term trends in the various highway construction sectors.

Updated cost estimates should be distributed to the MPOs, RPOs and the Planning personnel within the District to communicate the status of the estimate.

Scoping Contingency - At the Engineering and Environmental Scoping step, the contingency still covers the variety of possible events and problems that are not specifically identified and to account for portions of the project that are not fully defined and the resulting impact on the construction cost estimate.

**C. Design Field View Estimate Development.** Estimate updates at Design Field View, or at the approval of

the NEPA document if necessary, are mid-level itemized estimates. These mid-level estimates will further define and develop the cost categories of the major items for the project, the so called 80/20 rule, where 20% of the project items will contain 80% of the construction cost estimate. The construction cost estimate is to be developed in a minimum of 30 to 40 categories or items and potentially up to all known design items. The Design Field View cost estimate is to be developed using Historical Bid-based Estimating, Historical Percentages Estimating, or Cost-based (Scratch) Estimating.

Historical Bid-based Estimating uses Bid Tabs from ECMS for the specific District and/or for the specific County, the designer can develop the construction cost estimate for major elements of work so that quantities and historical unit prices can be applied to these line items. Percentages may be used to estimate items where little or no definition is available.

Historical Percentages Estimating is used in conjunction with the historical bid-based estimating, historical percentages are used to estimate items such as contractor mobilization costs. The percentage is developed based on historical cost information that can be derived from ECMS bid tabs to cover certain items. This percentage is based on a relationship between the selected items and a total cost category such as direct construction.

Cost-based (Scratch) Estimating should be used on high cost impact items. A high cost impact item is an item on a project that represents a substantial percentage of the total project estimate. Items with large quantities also require greater attention because a slight variation in the low bid unit price versus the estimate could cause the bid to fail.

Once the Design Field View construction cost estimate has been developed, then the designer will need to consider what effects the cost drivers, contingency, and inflation will have on the construction cost estimate. The estimator should also convert any amount included in previous estimates into a documented escalation factor for line items in the estimate. The escalation factor is to be developed by performing a market analysis of the various highway construction sectors.

The TIP must include construction funding no later than at NEPA approval. Therefore it is critical at this time to update the previous scoping estimate with the available project information as well as review cost contingencies. The amount of effort to update the estimate at the end of the Design Field View stage will depend on the amount of time elapsed since the NEPA approval estimate update and the impact of additional project information.

Design Field View construction cost estimate is to be compared against the construction cost estimate developed at the Engineering and Environmental Scoping, and if necessary, updates must be made to the construction cost estimate through the District's Planning and Programming process.

Updated cost estimates should be distributed to the MPOs, RPOs and the Planning personnel within the District to communicate the status of the estimate.

Design Field View Contingency - For the estimate at Design Field View, the contingency covers the possible events and problems that have not yet been identified and to account for any portions of the project that have not yet been fully defined.

**D. Final Design Office Meeting Estimate Development.** For the Final Design Office Meeting construction cost estimate, an itemized estimate is to be developed by the designer. The construction cost estimate will be developed for all known design items. The Final Design Office Meeting cost estimate is to be developed using Historical bid-based Estimating, Historical Percentages Estimating, or Cost-based Estimating.

Once the Final Design Office Meeting (FDOM) construction cost estimate has been developed or at 90% plans completion for projects without a FDOM, the estimator will need to consider what effects the cost drivers, contingency, and inflation will have on the construction cost estimate. As the project design phase nears the development of the PS&E package, the estimator will take a closer look at specific items that may be susceptible to uncertainties.

The Final Design Office Meeting construction cost estimate is to be compared against the construction cost estimate developed at the Design Field View with the necessary updates made to the construction cost estimate through the District's Planning and Programming process.

Updated cost estimates should be distributed to the MPOs, RPOs and the Planning personnel within the District to communicate the status of the estimate.

Final Design Office Meeting Contingency - The contingency covers the possible events or unresolved risk elements that continue from the Final Design Office Meeting and Letting of the project.

**E. PS&E Development.** For the Bid Package construction cost estimate, an itemized estimate is to be developed by the designer. The Bid Package construction cost estimate is to be developed using Historical bid-based Estimating, Historical Percentages Estimating, or Cost-based Estimating.

Once the Bid Package construction cost estimate has been developed, the estimator will need to consider what effects the cost drivers, contingency, and inflation will have on the construction cost estimate. The estimator must be cautious when updating design items that have been identified as "price volatile." While it is a good practice to update unit prices with the most recent bid data available, the estimator also must consider short-term trends on price volatile items based on the construction schedule and adjust the estimate accordingly.

The Bid Package construction cost estimate is to be compared against the construction cost estimate developed at the Final Design Office Meeting with the necessary updates made to the construction cost estimate through the Program Management Committee's (PMC) process.

PS&E Contingency - Contingencies should have been fully addressed within the estimate at this point. The Bid Package construction cost estimate should have no contingencies included at PS&E.

### 2.3 ESTIMATEDOCUMENTATION

Documenting the construction cost estimate is important in order to clearly understand what is included in the estimate, what the contingencies represent and the associated inflation considered. Proper documentation will allow estimates to be easily checked, verified, and corrected.

To develop a construction cost estimate that is in line with market considerations and eventually the low bid for the project, proper documentation of the estimate throughout the project development process is critical. This documentation is important as project team members contributing to the construction cost estimate are aware of the assumptions that have been made throughout the project and the assumptions that need to be resolved to further refine the construction cost estimate. This includes all assumptions for estimated quantities and unit prices throughout project development, and how the project specific conditions do affect quantities and unit prices for certain types of work on the project. The cost estimating factors presented in Chapter 4, *Cost Estimating Factors*, can help address concerns with respect to determining more prices for items given the project's conditions.

The estimate is an integral part of the project need and scope, and together cost and scope drive many of the project team's design decisions. All project team members must understand the importance of cost estimation if costs are to be managed appropriately. The project team must avoid misrepresenting the project, in both terms of scope and cost, throughout project development.

Changes in scope or other issues that affect project cost must be documented and resolved in the estimate at key milestones in the project development process. In addition, the estimator must document all estimate assumptions as well as maintain the estimate data and information that supports the quantities, prices, allowances, assumptions and contingencies.

**A. Documentation Steps.** Table 2.4 outlines the basic steps for performing a review and/or update of the construction cost estimate and can be applied at each phase of the project development process.



**Table 2.4 Estimate Documentation Steps**

Documentation Step	Description
Monitor project scope and project conditions	Identify any potential deviation from the current construction cost estimate, including: <ul style="list-style-type: none"> <li>• Changes in project scope</li> <li>• Changes due to design development</li> <li>• Changes due to external conditions</li> <li>• The nature and description of the potential deviation</li> <li>• Whether the deviation impacts the project budget and/or schedule (potential increase or decrease)</li> </ul>
Evaluate potential impact of change	Assess potential impact of change, including: <ul style="list-style-type: none"> <li>• Cost and time impact of the deviation</li> <li>• Recommendation as to whether to modify the project scope, budget, and/or schedule due to change</li> </ul>
Adjust cost estimate	Document changes to the baseline estimate, including: <ul style="list-style-type: none"> <li>• Appropriate approval of the deviation</li> <li>• The new project scope, new budget, and/or new schedule</li> <li>• Notification of the change to project personnel</li> </ul>
Obtain appropriate approvals	Obtain District PMC authorization to proceed by: <ul style="list-style-type: none"> <li>• Review of current project scope and estimate basis</li> <li>• Securing approvals from appropriate management levels</li> <li>• Approval of current estimates, including any changes from previous estimates</li> <li>• Release of estimate for its intended purpose and use</li> </ul>

1. Planning and Programming Phase for Planning Estimate Milestone. During the early steps of project development, few specifics are known about a project, so identification and documentation of the project uncertainties and the associated impacts that the unknowns will have on project scope and construction costs will help to manage project expectations and costs. Documenting the cost uncertainty can also aid in defining the unknown elements and lead to mitigating the unknown aspects of the project by engineering and construction approaches. This process of documenting project construction cost uncertainties must be done throughout the project development cycle.

2. Preliminary Design Phase for Scoping and Design Field View Estimate Milestones. Cost documentation is also very important during preliminary design, as the project scope is refined at the Engineering and Environmental Scoping phase. As a result of the Engineering and Environmental Scoping, there is a need to determine whether any scope changes have occurred that increase the construction cost estimate above the programmed fund resulting in the need to manage the budget. Further, to effectively manage overall project cost, any changes in scope, design development, project site conditions and/or market conditions must be evaluated in relation to construction cost and time impact.

- Scoping Documents – Based on the project need, the scoping document creates a baseline scope for the project and any changes to the scope are to be measured against this baseline-scoping document. This baseline scope document is an effective cost management method when addressing many cost overrun factors including scope changes, project schedule changes, and engineering and construction complexities. Explicitly defining the scope of the project early in the project development cycle allows for better scope control and identification of any scope changes, which may translate to changes in project construction cost and schedule.
- Scope/Schedule Control – During the preliminary design phase, definitive processes for controlling scope and schedule changes must be formulated. Through proper scope management, changes to

the project can be identified, evaluated, coordinated, controlled, reviewed, approved, and documented in a manner that best serves the defined project need. Projects often take years to move through the project development process. As a result, this introduces more opportunities for external and internal parties to suggest changes in scope especially when the development time frame extends past the baseline development schedule. In addition, if the construction schedule is extended there will be cost impacts resulting from increases in land costs and effects from inflation. Early in project development, before estimates are prepared, a change in scope can have a minimal effect, while changes late in project development can increase project cost significantly. Note that cost is also an engineering consideration in the Environmental and Engineering scoping process.

- Documentation of Uncertainty – Throughout preliminary design, there is a need to document specifically how the design process has removed the cost uncertainty and identified cost drivers. For construction cost estimates, the Project Manager must document the identified costs for the unknowns. Documentation of construction cost estimate uncertainty can be conveyed by stating the assumptions, allowances, unknowns, and contingencies included in an estimate.

3. Final Design Phase for Final Design Office Meeting and PS&E Estimate Milestones. The final design phase represents the phase in the project development process when plans and specifications are being finalized for letting. Prior to final approval of the project design, the development of the PS&E package is initiated, including the engineer's construction cost estimate. The construction cost estimate at the end of final design will provide cost data for comparing bid prices with estimated costs. The construction cost estimate will provide the Department with a reference for determining whether a project should be awarded for construction. The engineer's estimate is a detailed line-item estimate of project costs based on bid items and their corresponding quantities in the Engineering and Construction Management System (ECMS). The items that make up this estimate are the same as those in the contract documents that serve as the basis for bidding the project. Cost estimate documentation at this phase focuses on comparing the engineer's construction cost estimate with the current STIP estimate prior to bidding. In addition, the engineer's construction cost estimate can be used as a comparison to the contractor's bid price once the bids have been received.

**B. Cost Driver Analysis.** The Appendix A, *Cost Driver Analysis Documentation Template*, supports the construction cost estimate at the following key cost estimating milestones:

1. Planning
2. Scoping
3. Design Field View
4. Final Design Office Meeting
5. PS&E

The cost driver analysis contains items to consider as well as when those items will become defined during the design development based on the milestones above. The cost driver form is divided into the following categories:

- Materials
- Economics
- Project Type
- Schedule
- Plans and Specifications

- Project Location
- Project and Site Restrictions

**C. Project Estimate File.** Estimates are created by the collaborative effort of many units (e.g., highway, structures, traffic). To be able to follow the assumptions upon which the construction cost estimate is based and to preserve the information for future projects, all estimates and their supporting documentation must be stored in the project estimate file that can be easily accessed by hard-copy or electronically as a folder within the general project file.

A project estimate file provides a record that documents the basic reasons behind the original estimated construction cost, as well as reasons for subsequent construction cost revisions. The project estimate file should, at a minimum, contain the Cost Driver Analysis Form of appropriate categories of work at each project milestone for each cost estimate developed including any assumptions that have been made, the current project scope, and a copy of or reference to the cost data that were used to develop the construction cost estimate. This information should be included in the project estimate file regardless of project development stage—the creation of the file begins with the very first estimate. When items are estimated by percentages or other costs, as is often done for miscellaneous and utility costs, the percentage should also be documented in the project estimate file.

Depending on the point in time in the project development cycle, the amount and type of documentation contained in the project estimate file will vary. Information used to develop the funding estimate, such as cost-per-mile factors or other parametric estimates, should be well documented, and included in the project estimation file. Additionally, any line item prices that are higher or lower from the bid item history costs must be well documented in the project estimate file. Information that may be included in the project estimate file may consist of references to bid tabulation data, unit bid price book data, or some other reputable resources. The estimate file can also provide other project descriptive information, such as trends that affect item(s) cost, cost from similar past projects, and external factors that limit construction operations.

Good documentation supports the cost estimate's credibility, aids in the analysis of changes in project cost, enables reviewers to effectively assess the construction estimate, and contributes to the collection of information for estimating the cost of future projects. Each project's construction cost estimate will be a well-documented history of the assumptions, methods, and procedures used to estimate the costs associated with the project's specific scope of work.

**D. Design-Build Cost Estimates.** Cost estimating for Design-Build projects will typically including lump sum items for design and construction as well as other services. Applicable cost estimating methods can include analogous projects and historical percentages (see Sections 3.3 and 3.5). Design-Build cost estimates should include back-up information on how the lump sum costs are derived, as well as information on cost escalation and contingency.

For projects that conceptual plans were developed for the construct Design-Build item of work, the Department designer is required to provide a breakdown of the lump sum items of work. This breakdown includes item quantities and unit prices based on the conceptual drawings. This information is required to be attached in ECMS to the Project Development Checklist (PDC). Contractor and owner risks should be accounted for in the contingency amount. See Section 4.3 for a discussion on lump sum items.

For additional information and guidance, refer to Publication 448, *Innovative Bidding Toolkit*.

**E. Other Estimate Documentation.** At each project development milestone, the level of information must be documented regarding how the estimated cost was obtained to allow an independent reviewer to determine whether the estimate is complete, accurate, and realistic. The following information should be provided at each milestone:

- Item number, name, item description and any tailoring used for this estimate.

- Methodology. Describe how the item's costs were estimated (e.g., historical costs, similar project, conceptual costs, parametric estimating).
- The use of unit prices from the Department's historical bid tabs. Under this approach, bid data are summarized and adjusted for project conditions (project location, size, quantities, etc.) and the general market conditions.
- How lump-sum items are handled.
- Detailed, clear environmental items (requirements).
- How indirect costs are determined.
- Each contingency allowance assigned to the various parts of the estimate. If extraordinary conditions exist that call for higher contingencies, the rationale will be documented.
- All uncertainties and risks associated with the estimate.
- Level of knowledge about scope.
- Level of estimate detail.
- Techniques used to complete the estimate.
- Experience of those who developed the estimate.
- Cost traceability. When a prior cost estimate exists, a description of the cost should provide a concise explanation for any cost change to an item from the prior estimate.
- Document the names of participants who developed the estimate.

Each construction cost estimate placed in the project estimate file should be identified by the date and current project milestone that the construction cost estimate is changed, updated, or reviewed.

#### **2.4 MAJOR PROJECT PROGRAM COST ESTIMATING (>\$500M)**

The FHWA provides guidance for Major Project Program Cost Estimating available on their website at [http://www.fhwa.dot.gov/ipd/project\\_delivery/tools\\_programs/cost\\_estimating/guidance.aspx](http://www.fhwa.dot.gov/ipd/project_delivery/tools_programs/cost_estimating/guidance.aspx). A major project is defined as a project that receives any amount of Federal financial assistance and has an estimated total program cost greater than \$500 million (expressed in year-of-expenditure dollars). The total program cost estimate includes construction, engineering, acquisition of right-of-way, and related costs. In order to fully represent costs for delivering the project, adjustment for utility and railroad, transportation system management, public outreach, and construction contingencies to allow for additional work and cost growth during construction should all be included as cost elements on major projects. The key principles stressed in the FHWA guidance also apply to other PennDOT projects such as documentation, review, and validation of the estimate, updating the estimate at various development phases of the project, and relying on experts for input into various elements of the estimate.

## CHAPTER 3

### COST ESTIMATING METHODS

#### 3.1 INTRODUCTION

The use of cost estimating methods will depend on the milestone in the project development process, the level of project scope definition, the project type, and the complexity of the project. Additionally, there are a variety of cost estimating tools that can be used to support construction cost estimating for each of the methods.

#### 3.2 PARAMETRIC ESTIMATING

A parametric estimate can be developed in support of programming or early scoping when limited project scope definition is available (i.e., only major project parameters are known). Statistical relationships and/or nonstatistical ratios between historical data and other parameters (e.g., quantity of asphalt or area of bridge deck) can be used to calculate the construction cost estimate. The AASHTO Tracer Estimating software is an example of a product that is based on parametric estimating techniques. See Section 6.5 for a discussion on AASHTO Tracer.

#### 3.3 ANALOGOUS OR SIMILAR PROJECT ESTIMATING

Analogous project estimating is an estimate that relies heavily on one project that is very similar to the project construction cost that is being estimated. The similar project being used was either previously constructed; is currently under construction; is bid for construction; or has a completed PS&E level estimate. Line items, quantities, and unit costs are used as a basis for estimating the current project prior to adjusting the construction cost estimate for different project features.

#### 3.4 HISTORICAL BID-BASED ESTIMATING

The use of historical data from recently bid contracts is the most common state highway agency estimation approach. Under this approach, bid data are summarized with line items developed for major elements of work so that quantities and historical unit prices can be applied to these line items. The designer can use Bid Tabs from ECMS for the District and/or for the specific County, to develop the construction cost estimate for major elements of work so that quantities and historical unit prices can be applied to these line items. See Section 6.4 for a discussion on ECMS Bid Item History.

#### 3.5 HISTORICAL PERCENTAGES ESTIMATING

This method is used in conjunction with historical bid-based estimation. Historical percentages are used to estimate costs for items that are not typically defined early in project development or for lump sum items. A percentage is developed based on historical cost information from past projects to cover certain items that can be derived from ECMS bid tabs to cover certain items. This percentage is based on a relationship between the selected items and a total cost category such as direct construction. For example, contractor mobilization is often estimated based on a historical percentage of construction. See Section 4.3 for a discussion on Lump Sum Items.

#### 3.6 COST-BASED ESTIMATING

**A. Introduction.** This method relies on the cost-based estimation approach, where the construction cost estimate can be developed based on a projected productivity, along with estimated labor, material, equipment, contractor overhead, and contractor profit for each major cost category or line item.

Cost-based estimating, also known as "scratch" estimating, is a method to estimate the cost of each component to complete a work item and then adding an amount for contractor's overhead and profit. A cost-based estimate can be developed based on a projected productivity, along with estimated labor, material, equipment, contractor overhead, and contractor profit for each major cost category.

A cost-based estimating approach can take into account the unique character of projects, geographical influences, market factors and the volatility of material prices. When an estimate for an item is separated into labor, material,

equipment, overhead and profit, it is easier to account for unique project characteristics. For example, special equipment needs or factors that address labor productivity can be documented in a cost-based estimate as opposed to a random increase or decrease of an average unit cost of an item. Since contractors generally utilize a cost-based estimating approach to prepare bids, this method can provide more accurate and defensible costs to support the decision for contract award/rejection.

Properly prepared cost-based estimates require significantly more in terms of effort, time and skill to prepare than historic bid-based estimating. This type of estimate can provide the Department and estimate reviewers a better idea of how much a project should cost but takes a greater commitment of resources to produce the estimate. See Section 3.6.E. on the process for identifying items for cost-based estimating.

Even agencies that routinely utilize cost-based estimates typically do so for only those items that comprise the largest dollar value of the project. Cost-based estimating can be used to check major items of work that pose significant impact on total project cost. In order to successfully implement cost-based estimating, the estimators must have expertise in construction methodologies. The estimator should have a good working knowledge of construction techniques and construction equipment, proposed project work and how it will most likely be accomplished, labor requirements, equipment production rates, scheduling, how much to adjust quotes from material suppliers, potential locations of material sources. Keeping detailed records of actual equipment and manpower production rates on past construction contracts are also helpful for providing data from which to base estimating assumptions for contracts being let.

**B. Cost-Based Process.** The following steps are a recommended sequence of activities to be used in determining the estimated cost of an item of work.

1. Identify Items for Cost-Based Estimating Approach (see Section 3.6.E.).
2. Collect Data-Investigate, in detail, identified items to be estimated. Review Plans, Specifications, and Special Provisions and Contingencies.
3. Define and List Work Associated with Identified Items.
4. Review construction schedule information.
5. Determine material requirements.
6. Determine equipment requirements.
7. Determine labor requirements.
8. Time (Establish anticipated progress rate).
9. Compute base cost of labor, materials and equipment.
10. Add overhead.
11. Add profit.
12. Compute unit price.

**C. Cost-Based Examples and Forms.** For cost-based estimating examples, see Appendix E, *Cost-Based Estimate Example* and Appendix F, *Cost-Based Estimating Form and Example*.

The Department's forms that are used for Estimated Force Account on construction projects could also serve as a template for cost-based estimating. The series of forms includes worksheets for Labor, Equipment, and Material cost breakdowns as well as summary sheets. The form number and descriptions are:

- CS-4347AA Final Summary
- CS-4347CJ Force Account Estimate
- CS-4347AS Subcontractor Summary
- CS-4347BA Material/Service By Others Breakdown
- CS-4347CA Labor Breakdown
- CS-4347D Daily Labor Breakdown
- CS-4347F Daily Equipment Breakdown

Electronic versions of these forms, in Microsoft Word and Excel formats, have been developed by the BOPD and are available on the Department's webpage for forms, publications, and maps. Further guidance on the estimating for Force Account is provided in Publication 2, *Project Office Manual*, Section B.3.1.G.

**D. Sources of Estimating Data and References.** The major reference materials and resources that support the cost-based estimating approach are listed as follows. Internal PennDOT estimating references include:

- Construction and Maintenance Personnel
- Central Office Personnel
- Previous construction project data

When working with construction personnel and previous construction data, the documentation for Force Account work may provide relevant cost data with respect to material, labor, and equipment rates.

Estimating information is also available through these publications, associations, and other entities external to the Department:

- RSMMeans Heavy Construction Cost Data, [www.rsmeans.com](http://www.rsmeans.com) (publisher of construction cost data.)
- Rental Rate Blue Book, Green Guide, [www.equipmentwatch.com](http://www.equipmentwatch.com) (the Blue Book and the Green Guide list daily, weekly and monthly rental rates for various pieces of equipment as well as the operating cost for the equipment.)
- Transportation Estimators Association, (TEA), [www.tea.cloverleaf.net](http://www.tea.cloverleaf.net)
- AASHTO Technical Committee on Cost Estimating, [design.transportation.org](http://design.transportation.org) (the committee authored A Practical Guide to Estimating, 2013 Edition. Information provided in this workbook and some of the estimating examples are based on the AASHTO guide, which is available through the AASHTO website.)
- Suppliers

**E. Identify and Prioritize Items for Cost-Based Estimating.** Time is limited in the estimating process to give equal consideration to every element of design and construction and to every aspect of cost on any given project. Cost-based estimating should be used on high cost impact items that represents a substantial percentage of the total project estimate. Items with large quantities require greater attention because a slight variation in the estimated unit costs can make a significant change to the estimate and result in out of accepted bid metric tolerance when compared to the low bid.

1. 80/20 Rule. The Pareto Principle or 80/20 Rule can be employed to identify potential items to use cost-based estimating.

The 80/20 Rule means that in anything a few (20%) are vital and many (80%) are minor. In terms of estimating, a minority of the items of work in any project will generate the majority of costs for that project (i.e., 20% of the work will generate 80% of the cost, and vice versa).

Particular care must be taken to clearly identify and accurately estimate the cost of those few items that will contribute most of the cost, while relatively less attention may be paid to the remaining more abundant but less significant items of work and cost. The typical items that would be estimated using the cost-based approach are excavation, embankment, bituminous pavements, portland cement concrete pavements, drainage, structural concrete, and structural steel. The items to cost-based estimate will vary depending on the type of project. For example, guide rail could be the major item on a safety improvement project. The remaining items, even though they may be a significant number, could be estimated based on historical data prices and adjusted as necessary for the individual project.

2. Estimating Project Specific, Unique, or First Time Used Items. Some items of work may be significant to the bid, but have little or no historical data to aid in establishing unit prices. Similar items may provide some guidance supplemented by additional cost research. The following list provides potential resources to reference when determining a cost:

- Suppliers
- Other state departments of transportation
- Transportation Estimators Association (TEA)
- RSMeans Publications
- Contractors

Be wary in relying on estimates from a single contractor or supplier; multiple sources should be utilized if available.

**F. Elements of a Cost-Based Estimate.** Each item of work on a project can be broken up into tasks that it takes to complete the item of work. Each of these tasks contains the six basic elements that result in the cost for the project.

Cost-Based Estimates contain six basic elements to be considered in computing the unit cost to be used in the estimate: cost of labor, cost of equipment, cost of materials, overhead, profit and time (anticipated rate of progress).

1. **Material.** The element of material is simply the material that it takes to build the item of work, whether it is material left in place permanently or needed to construct the item such as formwork. (See Section 3.6.G).
2. **Equipment.** Typically the mechanically operated machinery and items which are either rented or owned but does not include small tools. (See Section 3.6.H).
3. **Labor.** The element labor establishes the personnel, hours of effort, and pay scales to build the work. (See Section 3.6.I).
4. **Time.** The time that it takes to complete the work item will drive the cost of the equipment, labor and any temporary material rental. (See Section 3.6.J).
5. **Overhead.** The administrative functions of the company are commonly referred to as overhead and are needed to organize the time, equipment, labor, and material. (See Section 3.6.K).
6. **Profit.** Contractors factor in a margin of profit to make the work worthwhile to the company owners.



(See Section 3.6.K).

**G. Material Cost-Based Element.** Materials required in highway construction can be placed in two broad categories. One category is the material that stays in place when a project is complete. Most items in highway construction require purchase of materials from a source of supply with an associated cost to deliver. The second category is material needed to build the work. Prices for temporary items such as concrete formwork and shoring need to be included. Temporary material items might be reused or rented while other materials may only be used once and require the full price be applied to the item cost. In the process of identifying required material, for many items this can be as simple as counting up the number of items needed but for other items this may require more extensive work. Items such as pavements need to be broken down into elements of that pavement such as aggregate, cement, asphalt, sand and any other ingredients in the pavement mix.

1. **Material Quantity Take-off.** Once materials are identified, the estimator must quantify the amount of materials required. Quantities are both the real materials and the areas that require work, such as the finishing of concrete. When calculating soil excavation quantities, the estimator must factor volume of undisturbed earth, account for shrinking, swelling and compaction while the soil is handled by the equipment. Quantity take-off can be supported by computer-generated quantities for areas calculation within Microstation.
2. **Procedure for Material Quantity Take-off.**
  - a. Listing in an order which permits easy back-checking.
  - b. Identify by drawing sheet, detail number or other identifying location.
  - c. Capture dimensions in this order: length, width (or thickness) and height. List walls by length, thickness and height consecutively; list slabs by length, width and thickness.
  - d. Use different take-off sheets for different trades (e.g., excavation, concrete, guiderail).
  - e. Number the take-off sheets.
  - f. Color code, or use special number applied to drawings to match items on the take-off.
  - g. If possible, have all extensions and additions checked for correctness by someone other than the person capturing the original quantity or spot check math if an independent take off cannot be accomplished.
3. **Material Cost Factors.** Accurate estimating of materials depends upon:
  - a. **An Accurate Take-off.** The take-off is a matter of skilled plan reading and measuring. If the quantities are incorrect, the entire estimate is incorrect.
  - b. **Specifications.** The cost estimator should recognize that the requirements in a material specification are important since each requirement generally adds cost to the material.
  - c. **Sales Tax.** Sales taxes are a direct part of material costs. They are not usually included in quotations, so the estimator must add them to the net prices, but there are exceptions so their inclusion or exclusion should always be confirmed.
  - d. **Delivery to the Jobsite, Unloading, Storing and Protecting.** It is important that the estimator indicates if the quotes received are FOB (freight on board) source or FOB jobsite. Whenever possible the estimator should ask for a delivered price from the material supplier, but in many cases the estimator will have to establish a separate hauling cost. Call to trucking companies that haul material for heavy construction jobs to determine hauling cost. Costs as unloading from carriers, conveying to storage and protecting are a separate cost from the delivery.
  - e. **Waste Allowance.** The amount of waste should also be accounted for on projects, as a bidder will

have to compensate for the additional expense of the material wasted. Estimating the quantity of waste is a matter of judgment and experience. The amount of waste can vary from 2-10% depending on the item of work in question. The maximum amount of waste (in terms of percentages) occurs in over excavation for slabs and trenches and in small quantity items; the least amount of waste occurs in large quantities of simple and precisely constructed formwork. Paving and base items will result in higher waste amounts due to the nature of the work and the rigidity of the specifications. An item of work that uses pre-manufactured products such as pipe placement and signals/signing will have little if any wasted material. Pre-manufactured products such as pipe may only be available in standard sizes; waste will be determined from these standard sizes.

4. **Material Take-off Resources.** Job mixes for pavements can assist in formulating what percentage of volume of material is made up of certain materials. Materials and construction records will also show the amounts and sources of material on past projects.

5. **Sources of Materials and Material Price.** Records from past construction projects can be used to identify sources. Contact sources for the materials to get an average price. If at all possible more than one source should be identified and queried for prices to obtain a competitive look at the market. When obtaining prices from suppliers, indicate that the price quotes are kept confidential. Price quotes should never be shared with other suppliers and should always be kept confidential to ensure that no negotiation of prices takes place. When obtaining quotes have pertinent information at hand such as the specifications of material needed, location of the project, quantity and when the material will be needed.

Keep a quote log of quotes received for materials over time. It should not be necessary to get a new quote for every job for every item. However for large quantity materials such as aggregate, asphalt, cement and steel quotes should be updated on a per job basis due to variability in supply and project characteristics.

For an example of calculating material cost, see Appendix E, *Cost-Based Estimate Example*, Section E.1.

**H. Equipment Cost-Based Element.** Most all highway work takes a significant amount of high cost equipment and contractors take the risk of initial investment and the need to keep the equipment busy to maximize its useful life. The estimate for an item of highway work should not only include the time that the equipment will be needed for that task but also if that task will fully utilize that piece of equipment. Rental or leased equipment will incur costs even when idle on the jobsite.

Estimating the cost of equipment involves: choosing the proper type of equipment, judging the time it will be used and applying the correct rental rate.

For example, the time to compact earth (backfill) around foundations varies considerably in different conditions. The estimator's background and knowledge will be used to select a production rate at some point between the lowest (mostly hand work) and the highest (mostly machine work).

1. **Identify Required Equipment.** To establish what type of equipment the task needs, the estimator will have to work off their experience or the experience of field personnel. Some items such as scaffold may not fit the definition of the mechanical equipment used in construction, but are related more closely to equipment than to labor or material.

Identifying equipment is hypothetical; ideal equipment might not be available when needed, or actual conditions affecting the type of equipment might differ from the estimator's conceptions. The choice is that type of equipment which the estimator thinks will probably be used. The estimator's selection of equipment may not be identical to the contractor, but should be a logical similarity and a cost equivalent.

The work can indicate the equipment needed. For example, demolition of concrete suggests concrete saws, jackhammers, compressors, loaders and trucks.

Structural excavation suggests trenchers, backhoes and excavators; depositing of concrete in forms suggests buggies, conveyor belts, cranes or concrete pumps.

2. **Equipment Cost Factors.** For the purpose of estimating the Department's construction contracts, equipment is classified as bare equipment (without operator or fuel), ownership cost of the contractor including depreciation, cost of money, indirect costs, and major repairs. The equipment will also have operating costs in fuel, lubricants, tires, field repairs and maintenance, and operator expenses.

The Blue Book contains both ownership costs, and hourly operation costs.

3. **Equipment Usage.** Estimate the rental cost for equipment down to cost per day or even per hour basis by evaluating the scale of use of the equipment.

If the equipment will be needed on a regular basis on the project the estimator should not use the published daily rate but rather use the monthly rate multiplied by the appropriate regional factors and divided by 176 hour/month because the Blue Book bases monthly rates on 176 hours.

The estimator should only use the daily or hourly rate if they know that the use of the equipment will be limited to only one specific operation for a short period of time. This is done due to the fact that most equipment is owned or long term leased by the contractor.

4. **Equipment Rate Procedure.**

- a. Establish the desired production (i.e. cubic yards per hour).
- b. Find the equipment, which has a maximum production capability well above the desired level.
- c. If the desired production rate is greater than the capability of any one piece of equipment, choose two or more pieces.
- d. Estimate the probable production.
- e. Divide the quantity by the probable production rate and find the number of hours that the equipment will be used.
- f. Apply the owner's rate (complete with operating costs).
- g. Round out to the next higher half or whole day.

5. **Resources.** Once the amount of equipment has been established the estimator needs to know how much it cost to have this equipment on the job. Resources for identifying necessary equipment include construction inspection staff and even interviews with contractors that perform that type of work. The estimator could also witness some similar work in action to capture amount of equipment resources that the contractor has for the operation. Pertinent information includes brand name, model number, number of operators and general information regarding maintenance.

While it is not practical for the estimator to formulate this information on their own there are publications that have equipment prices broken down to a per day "rental" cost. The Blue Book and the Green Book are two such publications.

- The Rental Rate Blue Book contains information on newer equipment that is not at a high level of depreciated value.
- The Green Guide Handbook of New and Used Construction Equipment Values contains used equipment values.

These publications list a daily, weekly, and monthly rental rate for various pieces of equipment as well as the operating cost for the equipment. Both of these publications contain introduction sections that indicate how to use the equipment information as well as what is included in the operation costs. For example, fuel cost is generally included in operating cost but the fuel cost at the time of publication may not match present fuel prices. Items such as routine maintenance and oiling are included but wear on some ground or pavement-

engaging equipment is not.

The RSMean's *Heavy Construction Cost Data* publication lists crews including equipment for typical tasks.

For an example of calculating equipment rates, see Appendix E, *Cost-Based Estimate Example*, Section E.2.

**I. Labor Cost-Based Element.** Labor costs are determined by the personnel, hours of effort, and pay scales. The estimator must again reference experience to determine the amount of labor necessary to accomplish the construction activity. When the quantity takeoff is completed, the estimator must determine the number of man-hours and trades necessary to perform the work. This is accomplished by using experience and/or standards.

1. Labor Cost Factors. The cost of labor is determined by many factors including the following:

a. Wage Rates. After the amount and type of labor is established the pay level for the labor must be found. Pennsylvania has a prevailing wage law that requires employers on department projects have a minimum wage rate. The funding of the project must also be considered. The Federal Government publishes prevailing wages by geographic region to be included in all contracts with any amount of Federal funding. The prevailing wage rates will also list the fringe benefit amounts that the employers must pay for the workers insurance and retirement. In areas with no prevailing wage rates there should still be a published minimum pay rate for heavy highway workers that can be used for a baseline.

For contracts that are entirely state funded, wages paid to employees are determined in accordance with the provisions of the Pennsylvania Prevailing Wage Act 43 P.S. 165-1. This Act establishes, by regions, the predetermined wage rates including fringe benefits and an allotment allowance for apprenticeship training fund, specified for the class of work performed. The predetermined prevailing minimum wage can be obtained from the Commonwealth of Pennsylvania, Department of Labor and Industry, Prevailing Wage Division, Harrisburg, PA, through the "Request for Prevailing Wage Determination" form. The form is available online as well as a search of the prevailing wage rates at <http://www.dli.pa.gov/Individuals/Labor-Management-Relations/lc/prevailing-wage/Pages/default.aspx>.

The payment of predetermined minimum wages on Federal-aid contracts is derived from the Davis-Bacon Act of 1931 as is prescribed by 23 U.S.C. 113. It applies to all Federal-aid highway construction projects exceeding \$2,000 and to all related subcontracts, except for projects located on roadways classified as local roads or rural minor connectors, which are exempted: Notice of the wage rate decision is published in the Federal Register and the wage rates for Pennsylvania are posted at <https://www.wdol.gov/dba.aspx>.

In many cases, the market conditions dictate that the contractor pay the labor force more than the published minimum wage rate.

b. Availability of Labor. Existing construction work within the region of the proposed construction contract will determine the availability of local citizenry for employment by the contractor, if the contractor has to hire people to supplement his own staff. If the contractor has to hire from outside the region, the contractor will probably have to pay a higher wage to get the proposed worker to work in the region of the project.

c. Location of the Project. Prevailing wages vary by regions, so the location of the project has to be a factor in determining wage rates.

d. Overtime. Overtime pay should be considered possible for the following circumstances:

- Tight Schedule-Due to some particular situations, the contract may be scheduled on a fast-track work effort.
- Location-Because of the location of certain particular construction work, the contractor may

have access to the area only at certain times of the day or night requiring work to extend beyond the normal 8-hour workday.

- e. Night. Shift differential pay due to crews working night construction. Night construction may also impact the production rate.
  - f. Specialized Trades. The type of work to be performed within the project may require the use of specially trained workers whose wage rates may be higher than wage rates anticipated for most other elements of the contract.
2. Labor Indirect Costs and Benefits. The contractor pays different amounts of fringe benefits, taxes and insurance to various agencies on the workers behalf. These indirect costs that are not paid directly to the employee may be applied as a percentage of labor costs and must be added to the base rate. Following is a listing of taxes and insurance paid by the contractor:

Labor Indirect Costs and Benefits:

- Social security
- Health insurance
- Federal unemployment compensation
- Pension
- State unemployment compensation
- Vacation
- Worker's compensation insurance
- Holidays
- General liability insurance
- Sick leave

Items such as insurance may also vary based upon the contractor's safety record or the type of project. Labor rates obtained from Union organizations or posted prevailing wages may have fringe benefit costs that cover all except for workmen's compensation, social security and unemployment insurance. The estimator must determine the best way to account for these costs. A percentage of total labor cost is one way to handle this.

3. Resources to Identify Labor Requirements. Possible resources for identifying labor requirements are the construction inspectors, contractors and observation of construction operations in the field. When logging the labor force to be used, be sure to classify the type of labor doing the work. Using crew hours and appropriate pay scales are recommended. An item of work may include much labor effort that is indirect and time-consuming. For example, the cost to install drainage pipes includes receiving, unloading from trucks, storing, protecting, distributing, installing and adjusting.

For an example of calculating labor rates, see Appendix E, *Cost-Based Estimate Example*, Section E.3.

**J. Time Cost-Based Element.** Contract time is the time in which all physical project work, including any authorized additional or extra work, is to be completed. It involves detailing construction operations and applying anticipated rates of production to the construction operations to estimate their durations. This determination requires close coordination between the Engineering District Office Design, Contract Management and Construction personnel for completion of the project schedule.

If the allowed contract time is too short, bid prices may be higher, quality may be reduced and the number of legal disputes may increase. If the contract time is too long, the public will endure unnecessary inconvenience and local businesses may suffer excessively. Optimal contract times balance project cost against project quality and public costs. Ultimately, this depends on accurate estimates of construction costs. The cost increases if there is too little time or if there is too much time. If the contract time is too short, the estimator must figure overtime and other production-increasing methods. If more time is figured than is actually required, the general conditions costs are excessive.

The Department utilizes a completion date to set contract time. The required completion date is the date by which all work is to be completed as shown in the proposal plus any time extensions less any time reductions issued by the Department.

1. Schedule. The construction project schedule will be broken down into activities with relationships. The basic assumptions for creating a network schedule are:

- The project can be broken down into a group of activities
- Each activity can be assigned a duration
- The logical relationship among activities is known and fixed in the network.

Critical Path Method (CPM) schedules are developed based on productivity rates accompanied by labor, equipment and material acquisition time needed for specific activities. In either case, productivity rates are matched against project operations to determine the time to complete or duration of the operations.

2. Time Cost Factors.

a. Material Acquisition Times. The estimator should evaluate the times necessary to obtain materials for the construction project. Fabricated materials, such as pipe, steel beams and prestressed concrete beams, may require additional time to manufacture and be delivered to the job site. Special materials or material shortages may also prolong contract time.

b. Other Projects in the Area. Accurate information of construction time is important, especially when a series of independent projects planned in the same area may be contingent on one another. A potential interference may occur where the start of one project depends on the completion of another. Examples include: (1) when large quantities of soil removed from one project must be used as fill material in another project; (2) when traffic control measures from one project significantly affect traffic control in another project; and (3) when a number of contracts working simultaneously result in shortages of materials, equipment and labor.

c. Resources. Project reports from previous projects are an excellent resource along with people who have witnessed the operations. Another helpful tool is to establish a production log for different types of work under different types of conditions. This can be as simple as how many feet of pipe per day can be installed in a low, medium or high production situation.

3. Production Rates.

a. Establish Production Rate. Once the activities are established, the estimator should develop production rates and work quantities based on the duration for each activity in the project schedule. The estimator must establish a realistic production rate, or rate of how many units of the item of work can be complete per hour or day.

Production rate is usually defined as a quantity of production accomplished over a specific time period (e.g., yd<sup>3</sup> of concrete placed per day). The estimator should make an independent judgment of the ideal time period from the contractor's (rather than the Department's) viewpoint.

The production rate used should factor in the conditions of the project such as terrain, traffic level, day or night work, possible utility conflicts and weather.

b. Adjust Production Rate. Once a production rate is established the estimator factors the length of time that it will take to complete a task with the rate per hour for the labor and equipment. Cost considerations will include overtime pay and different labor rates if the work will be done at night or on weekends.

The estimator can take the total quantity of an item divided by the production rate of an item to establish

the length of time that it will take to do the work. Rounding may be necessary due to the fact that a contractor will most likely have to pay the labor for full day increments along with the equipment rate. For example, if the item quantity divided by the production rate yields 8 and 2/3 days the estimator should use 9 days.

For an example of calculating equipment and labor production and cost, see Appendix E, *Cost-Based Estimate Example*, Section E.4.

**K Overhead and Profit Cost-Based Elements.**

1. Overhead. The cost-based elements above cover the majority of the cost associated with an item of work but the contractor still has realized costs that have not been included in the price for the item. Items such as cost of ownership of office and plant property such as insurance, taxes, utilities and building maintenance; office labor including estimators, clerical, human resources and compliance personnel; cost of processing paperwork for labor, equipment and materials; management cost such as division managers.

The percentage of overhead may range from 7-20% of volume of work based on the size of the contractor. Contractors may also just factor an overhead cost on labor and equipment and have a separate mark-up rate for materials. The estimator should decide on the level of overhead and apply consistently to the estimate.

The Table 3.1, Indirect Project Site Expenses, can be used to review the many possible general and special conditions. Few projects will require all of the items. The estimator should thoroughly review the contract documents because some of the costs listed below in Table 3.1 are occasionally specified under sections within the technical specifications. Average costs for many of these indirect job expenses can be determined by RSMMeans cost data publications.

**Table 3.1 Indirect Project Site Expenses**

<b>Indirect Project-Site Expenses</b>		
<b>General Conditions Expenses</b>		
Surveying	Layout for structures	Contractor's office trailer
Inspector's office trailer	Portable toilets	Telephone service
Water hookup	Water monthly charges	Electric service
Security yard fence and gates	Project and safety signs	Office equipment, supplies and printing
Small tools	Miscellaneous equipment rental	Oil, fuel, tires, repairs, servicing
Pickup trucks	Project superintendent vehicle	First aid and fire equipment
Dust control and noise control	Progressive cleanup	Final cleanup
Superintendent		
<b>Special Conditions Expenses</b>		
Travel expenses	Freight costs to jobsite	Generator for electric power
Barricades and pedestrian canopies	Scaffolding	Lights, flagmen

Sewer connection and service	Plan checking fees and permits	Professional services and engineering fees
Progress schedules, CPM network analyses	Special insurances and taxes	Dewatering
Premium for hot or cold weather work	Temporary access roads, detours and restoration of area	Overtime work
Extra drawings and specs, not supplied by A & E	Photographs	Underpinning
Watchmen	Office clerk	Timekeeper
Project Manager	Draftsman	Safety Engineer
Bonding of subcontractors	Extra foreman	Special equipment
Environmental protection	Safety provisions	Maintenance and protection of existing utility facilities

2. Profit. Profit is difficult to specifically quantify. Profit margins generally range from 3-10% of the sum of the direct and indirect costs, but this level can vary greatly depending on the risk of the project and the actual time that it takes the contractor to complete a project. Estimators should keep a consistent benchmark and estimate profit at the same level on all items on all projects.
  
3. Application of Profit and Overhead. Along with keeping the percentage of profit and overhead constant the estimator must also be consistent with where the profit and overhead are accounted for in the estimate. Contractors vary regarding where they place their overhead and profit dollars. Some put the price in each item of work; others put the price in overhead while others do some combination of both. It is recommended that the department account for profit and overhead on a per item basis. The reason for this is the fact that the estimator may not have a cost-based estimate for every item on the project so if a global profit and overhead are used the mark-ups may inadvertently be applied twice on the same project due to historic bids having mark-up in individual items. Also to truly have a benchmark cost per item all costs of that item should be included. Having all of the mark-up in one pay item such as the mobilization pay item is not an accurate depiction of how the cash flow for the project will actually occur.

For an example of calculating overhead and profit, see Appendix E, *Cost-Based Estimate Example*, Section E.5.



## CHAPTER 4

### COST ESTIMATING FACTORS

#### 4.1 INTRODUCTION

Construction cost estimates are developed for key milestones in the project development process. These estimates are then used in support of the funding and program decisions. The cost estimate process that is used for each project development milestone must conform to the information that is available at that time. For example, when only preliminary information is available for a project, then conceptual estimation methods must be used to determine planning-level cost projections. Additional cost estimates must be performed as the project is better defined and there are fewer unknowns. Project construction cost estimation is critical during programming because this is when a baseline scope, cost, and schedule are determined. Throughout the remainder of the project development process, the cost estimation tools must produce consistent and accurate estimates.

Development of construction cost estimates for each milestone consists of two components: known (or base) amounts and unknown (risk and contingency) costs. Understanding the risks associated with the project, as well as having a clear definition of contingency is very important.

#### 4.2 COST DRIVERS

Cost drivers are various activities associated with a project that can have an impact, either minimally or significantly, in the construction cost estimate development. The Project Manager must accurately understand and document the impacts that cost drivers are anticipated to have on the construction cost estimate. The following are common cost drivers that must be examined to determine whether they impact a project's construction cost estimate.

##### A. Quantity of Materials.

1. Description. The quantity of a given material on a project affects the unit cost of constructing and/or supplying that item. This is not just a supply and demand issue, but also one of production efficiency and economy of scale.
  - a. Large Quantities. Typically, the unit price for larger quantities of a given material will be less than smaller quantities. Suppliers offer discounts for larger quantity orders, as mobilization, overhead and profit are spread out over a larger quantity, thereby reducing the cost on each unit. Larger quantities also give rise to efficiency by gaining experience and expertise in completing the work. However, for very large quantities of certain materials may actually cause an increase to the unit bid price. For example, a project with numerous or large structures may affect the market for a particular type of steel, availability of cement, or even tie up a region's labor resources. Also, the phasing of the project may also negate the cost efficiency of large quantities when those quantities are split between construction project phases.
  - b. Small Quantities. Small quantities of items of work are less cost effective to construct and lead to higher unit prices. Not only do suppliers charge more for smaller purchases, in some instances, the lot size or the amount that has to be purchased is greater than the needed quantity. Small quantities do not generally allow for high production rates or other efficiencies, again causing a higher unit cost. Smaller quantity items are also frequently subcontracted out, this practice increases a contractor's overhead and they usually apply a markup to those items.
2. Cost Considerations. The following items related to quantity of materials need to be examined to determine whether they were considered as part of the development of the construction cost estimate:
  - Large quantity vs. Small quantity

- Operation Specific considerations
  - Earthwork
    - Unsuitable material removal and replacement using borrow
    - Borrow cap for non-stabilized soils
    - Additional excavation for storm water management, slope rounding, borrow cap, and driveway connections
    - Grading considerations (classes of excavation, types of borrow excavation)
  - Structures
    - Retaining walls / noise walls by ft<sup>2</sup> area of wall
    - Bridges - individual location by ft<sup>2</sup> area of bridge
    - RC box culverts (individual location, square footage of box culvert)
    - Structure height above grade - bridges over 20 ft above grade require additional substructure
    - Piling
    - Temporary sheeting and shoring
  - Paving / Roadway
    - Number of lanes and width (2-lane, 4-lane, divided highway)
    - Length - number of miles
    - Median barriers / guide rails
    - Sidewalks
    - Pavement marking materials
    - Shoulder paving
  - Drainage / Pipes
    - Excavation / backfill
    - Concrete / miscellaneous structures
    - Pipe / structure cleaning
    - End walls and end sections
    - Inlets and manholes
    - Subsurface drains slope and channel linings
    - Miscellaneous stone items

**B. Classification of Work.**

1. Description. Work that must be performed by hand will be more expensive than similar work that can be completed by machine. In addition, separated operations will be more costly than contiguous operations. Finally, precise work, such as fine grade, will cost more per unit than bulk work, such as large fills.
2. Cost Considerations. The following types of work conditions must be considered for items and how the

items will be placed / finished when developing the construction cost estimate:

- Hand work vs. machined
- Continuous vs. separated operations
- Precise vs. bulk work
- Operation Specific considerations
- Paving / Roadway (Reinforced Concrete Pavement vs. Bituminous Pavement)

### C. Price-Volatile Materials.

1. Description. Materials are considered price-volatile when:

- Based on monitoring of recent contracts, the price trend is extremely volatile.
- Suppliers provide a price quotation for a limited time frame that is shorter than the duration of the contract.
- The price quote may be based on date of delivery or spot market conditions.
- Potential shortages are possible.

There are times when fuel prices may be considered as volatile. The types of work that are most fuel-intensive are excavation and embankment, aggregate hauling and paving. The cost of asphalt can also be volatile. Also, construction contract terms typically incorporate adjustment factors to account for the volatility of fuel and asphalt prices.

2. Cost Considerations. In developing the construction cost estimate, consideration should be given to the impact that the price-volatile materials could have on the construction cost estimate. Typically, the impact on the construction cost estimate could be significant when there are large amounts of the following materials on the project:

- Asphalt
- Cement
- Structural Steel

### D. Availability of Materials.

1. Description. The availability or shortage of materials can have a great effect on the cost of a project when developing the construction cost estimate. Material sources should be checked for stock inventory, production rates and limits of supply (e.g., manufactured items such as pipe and traffic signals should be checked for availability and delivery time). Provisions should be made in the construction schedule for sufficient time for the successful bidder to order materials that are known to not be readily available such as steel fabrications, pre-stressed concrete I-beams, pre-stressed concrete box beams, and steel sheet piling.

Material shortages can increase costs, cause construction delays and increase overhead by lengthening the contract time. Surpluses in materials can drive costs down due to competition between suppliers.

2. Cost Considerations. For certain projects, the availability of materials will have an impact on the construction cost estimate. The following items should be considered:

- Material shortage
- Material acquisition time

- Material cost increases for multiple season projects (note that the contractor's may only receive supplier quotes for a limited time and will encounter risk for a cost increase on these short-term quotes on materials)

#### **E. Location.**

1. Description. The location of a project can also affect the unit bid prices. A project's location, whether in an urban, suburban, or rural setting should be considered in establishing the construction cost estimate.

Depending on the specifications associated with the project, some of the cost considerations relating to a project's location may be accounted for in the mobilization bid item.

a. Rural. Projects located in rural settings have factors that affect the unit bid prices contrary to projects located in urban settings. Construction operations may have less restricted work areas, less traffic to contend with, and additional hours to complete the work; all factors that increase productivity. On the other hand, materials, equipment and personnel may all have to be brought to the project site from out of the area, which may increase those costs related to transportation, support, wages, and per diem.

Remote locations usually result in higher prices. When developing the construction cost estimate, consider sources of material, mobilization costs to the project site, and availability of local labor.

b. Urban. In congested urban areas, the storage space for contractor's equipment and stored materials must be considered, along with borrow and waste areas if required and haul distances when developing the construction cost estimate. Work that is to be completed while public traffic is maintained will require adjusted rates of progress.

A project in an urban setting generally has to contend with construction operations occurring in more confined work spaces, greater volumes of traffic, limited hours of operations, and night time work that can affect production rates and impact the construction cost estimate. Some of these factors may be offset by availability of local contractors, materials, equipment and personnel.

c. Other Locations. Consider any unusual conditions such as accessibility to work, unstable soil conditions (i.e., wetlands or landfill), and work areas subject to flooding.

Terrain may also be a consideration in establishing an items cost. Mountainous terrain and steep grades cause production rates to fall whereas level terrain and straight roadways generally have the opposite effect.

2. Cost Considerations. In developing the construction cost estimate, the location of the project will impact the construction cost estimate. The following items should be considered when developing the construction cost estimate for the various categories of work:

- New location vs. existing location
- Day vs. night work
- Restricted hours
- Project duration (fast track or multi-season project) based on completion date
- Phased construction
- Remote location (higher mobilization costs and higher material transportation costs)
- Urban location (higher costs)

#### **F. Time of the Year.**

1. Description. The estimate should reflect prices that are realistic for the areas, times and characteristics

of the work to be done to account for a seasonal adjustment. The month of the year that work will proceed has a definite effect on the construction cost estimate for the project. It is best to start projects in early spring and/or can be finished before cold weather sets in. If the project cannot be completed before cold weather, rates of progress must be adjusted downward and the construction cost estimate revised upward. In addition, added costs, such as winter overhead, heating of materials and winter damage, must be considered when developing the construction cost estimate. For certain operations, temperature extremes will cause delays and raise costs, therefore, the construction cost estimate must be examined to determine if certain operations will be impacted by temperatures and the cost estimate adjusted appropriately.

2. Cost Considerations. From the pre-bid construction schedule, the impact of the anticipated time of year for the project, the following items should be considered when developing the construction cost estimate:

- Winter work
- Availability of some materials is seasonal
- Environmental permitting date restrictions

### G. Phasing of Operations.

1. Description.

d. Efficient Scheduling. Scheduling segments of work in the most efficient and orderly fashion will aid contractors in achieving efficiencies that increase their profit and cut expenses. Any restrictions on the timing of operations will cause delays and increase costs.

e. Project Start. Timing of the start of work will also have a major effect on the cost of a project. If the construction cost estimate is based on an early spring letting and the project is not let until fall, the estimate will need to be revised to reflect the new phasing of operations that is required due to the weather and season. The project will need to be examined for any restriction or reason that will affect the phasing of operations and the estimate should be adjusted accordingly.

f. Dominant Activities. In most complex projects, one dominant activity, phase or controlling operation has substantial influence on the contract time. The types of phases or operations that are considered dominant include bridges, roads, resurfacing, and traffic operations. Structures phases will most often be dominant in determining total contract time in most complex projects. As a result, certain portions of the project will be constructed in a specific order, which may bring into effect other cost drivers.

g. Permit Restrictions. As part of developing the PS&E package, appropriate permits should be obtained. Environmental permits and/or mitigation commitments are among those that may require special attention when determining contract time. These permits or mitigation commitments may contain restrictions to be considered when developing the construction cost estimate. Mitigation commitments may also require coordination for NEPA and threatened and endangered species.

2. Cost Considerations. In reviewing the pre-bid construction schedule, the impact of the phasing of operations should be considered when developing the construction cost estimate:

- Start of work (anticipated start from developed pre-bid construction vs. anticipated Notice to Proceed)
- Idle time
- Conflicts between construction activities and nearby community/business activities
- Local ordinances
- Permits

- Winter Shutdown

#### **H. Project Type.**

1. **Description.** In the context of cost estimating, project type will influence the associated cost drivers. While new highway construction projects may have additional costs associated with right-of-way acquisition, it may provide more efficient construction access and allow the contractor to use larger equipment. In contrast, reconstruction projects on existing alignment pose construction access restriction and other costs associated with construction phasing and maintaining traffic.
2. **Cost Considerations.** In developing the construction cost estimate, the type of project will impact the construction cost estimate. The following items should be considered when developing the construction cost estimate for the various categories of work:
  - Small vs. Large (potential economies of scale for larger projects)
  - New (planning, design, construction, right-of-way acquisition, annual maintenance, and operation costs)
  - Resurfacing / Reconstruction
  - Bridge rehabilitation or replacement (new)
  - Drainage issues (Pipe/Structure Cleaning)
  - Subsurface Drains Slope and Channel Linings
  - Operation Specific considerations
    - Base repair quantities
    - Pavement Removal
      - Milling or grinding of existing pavement when resurfacing existing roadway
      - Removal of existing pavement, curb and gutters, and sidewalks
    - Structures
      - Removal of existing structures
      - Substructure Repairs
      - Cleaning and Painting Structural Steel
    - Paving / Roadway
      - Resurfacing existing pavement on widening projects
      - Removal of existing concrete barriers

#### **I. Maintenance and Protection of Traffic.**

1. **Description.** Construction in high-volume traffic areas will add substantially to project duration and construction cost estimate. Similar projects with low-volume traffic areas will have generally shorter contract times. During construction, Maintenance and Protection of Traffic (MPT) should be designed and implemented to minimize the inconvenience placed on motorists driving in high or low-volume traffic areas.

When new roadways are constructed, contractors may build with little interference from existing traffic

areas. This situation permits the contractor to generally maximize production rates and minimize expenditures. MPT costs become pertinent when the roadway project requires traffic to be shifted or detoured around the construction site.

Cost-effective MPT must allow the contractor procedures that maximize production rates and work zone safety, while minimizing contract time and impacts on the motoring public. When preparing effective MPT for a project, costs associated with the following items must be considered:

- Half-Width vs. Open Area Construction
  - Night vs. Day Construction
  - Lane Closures
  - Detours
  - Mobilization, Demobilization and Remobilization
2. Cost Considerations. The maintenance and protection of traffic through the project is a key consideration and can have a significant impact on the construction cost estimate, depending on the traffic volumes impacted, and the road user liquidated damages associated with the project. If the Department feels that certain limitations are of significant importance, then those limitations need to be identified and stated in the special provisions/specifications for that project. Items such as when lane restrictions can be imposed, duration that a detour can be in place, maximum length of work zone, etc., will all have a bearing on the minimum number and type of devices that are necessary to prosecute the work. The following items should be considered when developing the construction cost estimate for the various categories of work:
- Detours
  - Night work vs. day and weekend work
  - Cost to maintain equivalent number of open lanes during construction
  - Complexity of traffic control
  - Lane closures / restrictions
  - Quantity of mobilizations (demobilization and remobilization)
  - Operation Specific considerations
    - Structures - Maintenance of traffic costs for work done on existing bridges
    - Paving / Roadway
      - Full depth shoulders on roadways with high truck volumes
      - Traffic barrier
    - Traffic
      - Special traffic requirements
      - Number of signals
      - Special requirements for signals
      - ITS components

#### **J. Permit Conditions and Requirements.**

Permits (e.g., PADEP, Army Corps of Engineers) are included as contract documents and are reviewed by contractors to determine the cost impact for a project such as permit conditions, environmental mitigation, and community impact commitments. Other requirements that affect costs could occur due to local

policies, taxes, restrictions, air and water quality. In addition, locally specific rules and regulations governing noise, pollution, disposal of materials, and working hours can all increase the cost of construction.

#### **K. Additional Items to Consider for Construction Cost Estimate.**

The following items may become defined and recognized as part of the project scope during the design phase. However, these items may also have a large impact on the project estimate and therefore must be considered and included as a cost in the estimate as early in the design phase as possible.

##### **1. Description.**

###### **a. Earthwork.**

- Unsuitable Material Removal - estimate using Class 1A Excavation and estimate replacement of unsuitable material removed using borrow
- Borrow cap for non-stabilized soils - estimate using Type 2 or 3 Borrow
- Additional excavation for storm water management, slope rounding, borrow cap, and driveway connections
- Milling of existing pavement when resurfacing existing roadway
- A cost for drying the soil when cuts go below the water table
- Removal of existing pavement, curb and gutters, and sidewalks

###### **b. Structures.**

- Bridging wetlands
- Electrification, signing and lighting
- Stream maintenance for all box culverts and bridges over moving water
- Linear foot cost for stream relocation, i.e. streams that have to be rerouted out of their existing streambed
- Noise walls; assume an average height - cost per ft<sup>2</sup>
- Higher unit costs for bridges over 20 feet above grade as these bridges require additional substructure
- Bridge piling
- Higher unit costs for curved bridges
- Dredging for bridge construction
- Maintenance of traffic costs for work done on existing bridges
- Retaining walls
- Cost for removal of existing structures
- Over an active rail line
- Temporary sheet piling during construction
- Temporary bridges
- Bridge approach adjustments
- Temporary causeways/diversion devices

###### **c. Paving.**



- Resurfacing existing pavement on widening projects
  - Access roads to properties that are cut off by proposed improvement
  - Chemically treated subgrade for soil stabilization
  - Access roads to properties that are cut off by proposed improvement
  - Fencing for access control projects
- d. Shoulders.
- Full depth shoulders on roadways with high truck volumes
  - Median barriers / guide rails
  - Sidewalks
  - Fencing for access control projects
  - Removal of existing concrete barriers
- e. Landscaping.
- Cost per acre for reforestation
  - Cost per acre for wetland replacement
  - Double the acreage for wooded wetlands
  - Temporary seeding and temporary wood cellulose
  - Mulching and straw mulching
  - Turf establishment, sodding
  - Woody shrub seeding, wildflower seeding
  - Additional landscaping in historic areas
- f. Maintenance and Protection of Railroad Traffic (i.e., flagging).
- Costs could be significant
  - Consider impacts construction schedule
  - Structures
  - With or without gates
  - May require expert input
- g. Utilities.
- Manhole adjustments
  - Structure attachments
  - Underground facilities
  - Project cost adjustment factors and contingency factors
  - Total replacement cost
  - May require expert input
- h. Right-of-Way Impacts.

- Driveway and curb adjustments
  - May require expert input
- i. Other Items.
- Wider sidewalks in commercial areas
  - Bicycle trails
  - Improvement of intersecting roads
  - Pedestrian access
  - Auxiliary lanes (continuity, turning, and entrances)
  - Frontage or service roads
  - Park and ride lots
  - Pedestrian overpass/underpass
2. Cost Considerations. In addition to the items to consider for the previous cost drivers, the following items should be considered when developing the construction cost estimate for the project:
- Inflation rate for longer projects
  - Use of special equipment
  - Access to the work site

### 4.3 LUMP SUM ITEMS

The most difficult items to estimate on a project are the lump sum pay items. A lump sum item can be defined as an item that does not have a detailed quantity specified and 100% payout of the item is virtually guaranteed. Fortunately lump sum items are usually structured so they cannot be overrun. Unfortunately it can be difficult to estimate what cost should go into a lump sum item and what cost a bidder has put into a lump sum item.

From an estimating standpoint, lump sum bid items should not be used. If the work to be performed can easily be quantified, then a payment method that includes a quantity should be used. However, lump sum bid items are often used when an item of work can be defined by a transportation agency in general terms, (i.e., the finished product can be easily defined but not all the components or details can be easily determined). This fact can make estimating lump sum items difficult for the estimator. The more information and breakdown of a lump sum item that an estimator has to work with, the greater the likelihood that an accurate lump sum estimate can be developed. In any case, an estimator should try and define a lump sum in terms of its simplest, most basic components and should consider other factors that may not be easily estimated. By breaking out a lump sum item into smaller items of work that an estimator may have historical data on, and then applying reasonable estimated prices to those sub units, the estimator can more accurately establish a price for the overall lump sum item.

Since breaking out a lump sum item into smaller components is difficult and time consuming, many transportation agencies apply percentages or ranges to some lump sum items based upon historical data for similar project conditions. When determining estimates in these instances, the more consideration that can be given to an item's many components, the greater confidence in determining a reasonable estimated price could be realized.

Cost-based estimating can be very beneficial for lump sum items such as MPT, Bridge Demolition and Removal, Mobilization, and Clearing and Grubbing. To formulate a reasonable cost, the lump sum item has to be broken down into what work is included in that item so a cost can be associated. Lump sum traffic control, for example, can be broken down into how many laborers, equipment and materials will be needed for how long and a cost for the elements considered. The following points should be considered when estimating lump sum items:

- Estimating methods other than historical bid based techniques may be more applicable for lump

sum items.

- Using lump sum items typically transfers risk to a Contractor. Contractors cannot necessarily rely on overruns to cover work that they (and possibly the transportation agency) did not foresee.

**A. Mobilization.** A difficult lump sum item to estimate is mobilization. Mobilization's purpose can be defined as an item for the bidder to cover the cost of transferring equipment and resources to a project, but the cost is generally not directly tied to doing this. Other than those relatively standard mobilization items the rest of the item can be a multitude of other costs which may include: corporate overhead, project overhead, contract bond, specialized project expenses like railroad liability insurance, sub-contractor mobilization, sub-contract mark-up, profit, overhead, costs for items not included but needed on the project, up front start-up, possible unbalancing and numerous other items.

Mobilization is a contract pay item used to cover a Contractor's pre-construction expenses and the costs of preparatory work and operations. Since there is no clear list as to what this work effort is and each Contractor has the ability to adjust their bid as needed to cover these expenses, there are no true rules as to what percentage or value should be used per Contract. Mobilization costs are most often dependent on the amount and size of equipment and staff the contractor will need to relocate for the project. Many projects will require that the contractor mobilize the crew and equipment multiple times.

Another major factor to consider when estimating mobilization costs is the contract specifications in regards to mobilization. Do the specifications include payment restrictions or limits? When will the contractor receive partial or full payment for mobilization? How much of the mobilization cost will the contractor be required to finance? The specifications may play a significant role in determining an estimated value for mobilization.

Consideration should also be given to the location of a project, the complexity of a project, the need for specialized equipment, the type of work and the working season. If the project will extend over more than one construction season, this should be considered when determining mobilization costs as the Contractor may demobilize for the winter and remobilize in the spring. Rural projects vs. urban, projects with multiple work sites, projects with a lot of preparatory removal items, projects with large quantities of excavation or projects extending over two seasons where the Contractor would be expected to shut down operations and move out will typically require a higher mobilization percentage.

To adequately estimate mobilization costs on a project utilizing historical based data, the overall project must be very comparable in size, location, and work involved. For this reason, organizations that rely on historical based estimating methods often use a parametric figure to estimate mobilization costs.

A roadway project typically involves the mobilization of several pieces of medium sized equipment to a temporary or mobile location. A structures project often involves the relocation of significant large pieces of equipment to a fixed location and most often require that large pieces of equipment be mobilized and demobilized multiple times depending upon the staging of the project. Each time equipment has to be mobilized to a project or to a different site within a project, there is an associated cost to the contractor to relocate the equipment and resources.

Other major factors to consider when estimating mobilization are project location, multiple construction seasons and winter shutdowns. Projects in remote locations have higher costs to relocate equipment, labor, and other resources to the site. Adjustments for these costs need to be made to historical data prior to applying the price to a new estimate. If a project carries over multiple construction seasons and will be shutdown for the winter or other environmental restrictions, the costs need to be accounted for in the estimate. Can it be anticipated that the contractor will mobilize the equipment to another project and have to remobilize, or will the equipment and resources be idle during the shutdown. These factors need to be considered and appropriate adjustments made to accurately estimate the true mobilization costs for a project.

**B. Maintenance and Protection of Traffic.** The construction of nearly all projects can be executed in numerous ways. Each contractor will attempt to determine the most efficient and economical approach based upon the given project and the experience and resources he has available. Contractors will have different ideas on how to prosecute the work to their advantage.

By breaking out the larger lump sum item into its anticipated core components, the estimator can rely on historic bid data for those items and the given limitations to come up with a reasonable lump sum cost. The estimator should establish and identify the amounts of the following items:

- Portable precast concrete barrier rail
- Number of changeable message signs
- Arrow panels
- Truck mounted impact attenuators
- Consideration of the anticipated phasing/staging of the work along with imposed limitations
- Approximate types and numbers of other anticipated traffic control devices

**C. Clearing and Grubbing.** Clearing and grubbing is used to remove and dispose of all vegetation, trash, natural and manmade objects that need to be removed from a project's worksite in order to allow construction of the anticipated improvements. Although payment for clearing and grubbing is sometimes measured by square yard or acre, it is also frequently paid for on a lump sum basis. When payment is made on a lump sum basis, the estimator needs to have knowledge of the area to be cleared. The size of the area to be cleared, the type of terrain, types of obstructions to be removed or filled in, density of brush, trees, rocks, etc., will aid in estimating. By analyzing this information and comparing to previous projects with similar characteristics, the estimator can determine a reasonable estimate.

If the breadth or scope of a project is unique, then breaking the item out into smaller components may aid in determining an estimated cost to perform the work. By breaking the area to be cleared into quantifiable segments that may be similar to clearing & grubbing that has been previously performed, an estimator can add up the segments to produce a reasonable estimate. Similarly, if the area is broken out into smaller categories or units that historical data may be available for; the individual units can be estimated and summed to form a reasonable estimate.

**D. Demolition and Bridge Removal.** Estimating demolition lump sum items again requires that the estimator understand the work involved and the commonalities between the work proposed and the historical bid items. Many times demolition work is similar in nature involving an excavator and trucks with trash trailers. This type of operation is the most common and the difference in bid item price is determined based on the number of days the operation will take to remove the necessary items. Special care should be taken when known environment hazards exist within the demolition area. The hazardous material removal and remediation needs to be accounted for in the bid item depending on what the material is and the significance to the contractors operations. Bridge demolition and removal is directly impacted by the features below a structure. Demolition restrictions will vary based on whether the bridge crosses a railroad, another roadway, or water.

#### 4.4 INNOVATIVE BID PROCEDURES

"Innovative" contracting methods are designed primarily to reduce construction time of projects. These methods rely on motivating the contractor to complete work quickly and cause minimal disruption to ongoing community activities. Before any innovative bid procedures are implemented, the Department must evaluate the benefits and drawbacks.

There are various innovative construction procedures that have been successfully applied by PennDOT and other public agencies. It is important to note that these innovative methods are not recommended for all projects. For estimating purposes, you may need to fund several of the contracting methods above and beyond the cost of the construction items.

See Publication 448, *Innovative Bidding Toolkit* for detailed guidance on innovation contracting methods.

### 4.5 SUBCONTRACT ITEMS

It is likely that several items of work in a bid proposal will be subcontracted by the prime to another contractor. The prime contractor will request quotes from subcontractors on certain items and they will use that price when they decide that it is more efficient to subcontract the work. Depending on the structure of the contract and the breakdown of major types of work, this may lead to subcontractor mark-up on certain items. While some contractors opt to mark up certain subcontracted items, other contractors will not in an attempt to avoid negotiation conflicts with the subcontractor. For example if the project consists of equal amounts of grading, paving and a bridge items the estimator will have to decide if it is reasonable to assume that bidders will be able to self-perform all of the work. Prime contractors that choose to mark-up the price for subcontract work use a range of anywhere from 5-10% depending on the size of the subcontract and comfort level of the prime with the subcontracting company. If the subcontract is a large percentage of the total project the mark-up may be small, but if the subcontract is small or the contractor is unfamiliar with the subcontractor, the mark-up may be higher.

### 4.6 COST DRIVER ANALYSIS

The Project Manager will use the Cost Driver Analysis Documentation Template to document and track the consideration of cost drivers at each estimating milestone. For estimate reviews, the cost driver analysis documentation can serve to support their estimate and provide the documentation necessary for an estimate review. The Appendix A, *Cost Driver Analysis Documentation Template*, is shown in Figure 4.1 and consists of four parts.

**Part A - Project Information** – provides basic information on project name, location, project number, and the dates when the cost driver analysis is performed and updated at each construction estimating milestone.

**Part B - Cost Driver Summary** – is the minimum required documentation for cost driver analysis on all projects. Space is provided on Part B to document cost driver details and assumptions. Part B consists of the major cost driver categories.

**Part C - Cost Driver Impacts Specific to Major Categories of Work** – depending on the project characteristics, Part C may be an efficient way to document how cost drivers are addressed with respect to major categories of work such as paving, drainage, and pile driving.

**Part D - Detailed Cost Driver Analysis** – is required for all moderate and complex projects, as well as projects over \$10 million (construction phase amount). Part D categorizes each cost driver and provides a checkbox to indicate if the cost driver applies to the project and if that cost driver has a major impact to the estimate. If so, space is provided to summarize the cost drivers checked for each category to document how each cost driver is addressed in the estimate.

**Figure 4.1 Cost Driver Analysis Documentation Template**

PROJECT LOCATION	Planning		Scoping		Design Field View		Final Design Office Meeting		PS&E	
	Cost Driver	Major Impact	Cost Driver	Major Impact	Cost Driver	Major Impact	Cost Driver	Major Impact	Cost Driver	Major Impact
<b>COST DRIVER CATEGORY</b>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
New location vs. existing road in developed area										
Adequate areas for contractor's staging, storage of equipment										

### 4.7 COST ESCALATION

Cost escalation factors attempt to forecast why a construction cost estimate changes in the future. These factors can be managed throughout the project development process through understanding the construction cost estimate tools, cost drivers and impacts of inflation.

The decision regarding which project delivery approach (e.g., design-bid-build, or design-build) and procurement methodology (e.g., low bid, or best value) affects the transfer of project risks. When risk is shifted to a party that is unable to control it, project cost will likely increase, therefore, it is important for the Department to have the project scope well defined (i.e., bid document) in order to balance project risk between the contractor and the

Department.

Project schedule changes, particularly extensions, caused by budget constraints, timing of fund allocations, environmental impacts, or construction challenges can result in increases in project costs. The project costs would be impacted through the cost of inflation and current cost driver price trends. Additional project overhead costs can be incurred by both the Department and the consultants and contractors. Project schedule changes can be viewed in terms of the time value of money. There are two primary components to the issue: (1) the inflation rate and (2) the timing of the expenditures. The Department has a fixed annual budget, and project schedules must often be adjusted to ensure that project funding is available as needed for all projects.

Potential constructability issues need to be addressed prior to bidding, because if not addressed prior to bidding, the construction cost estimate will not accurately reflect the effort necessary by the contractor to construct the project.

The following cost escalation factors have been identified as impacting construction cost estimates. These factors can be managed throughout the project development process either through cost estimate development or cost estimate documentation.

**A. Project Scope.** Additions or deletions to the project scope, even when controlled by the Department, can still happen, and as a result can lead to construction cost estimate escalation. Such changes throughout the project development cycle may include the addition of a lane to the project scope or increasing the project right-of-way.

**B. Scope Creep.** The tendency for the accumulation of many minor scope changes to a project can occur and lead to an increase in the construction cost estimate. While individual scope changes may have only minimal cost effects, the accumulation of these minor changes, which are often not essential to the intended function of the facility, can result in a significant cost increase over time. Projects seem to often grow naturally as the project progresses from inception through development to construction.

**C. Ambiguous Contract Provisions.** Specifications that are not clear in the bid documents can cause a misunderstanding between the Department and the contractor. Providing too little information in the bid documents can lead to cost overruns during the execution of the contract. When the core assumptions underlying the construction cost estimate are confused by ambiguous contract provisions, it can be difficult to achieve the construction cost estimate in construction and cause change orders and rework during project construction.

**D. Project Document Quality.** In conjunction with ambiguous contract provisions, contract document quality is important to controlling project cost and development of the construction cost estimate. Document quality assurance begins early in the project development process and continues through the bid document development and into construction. As part of its design process, the Department has multiple design reviews to promote uniformity and enhance the overall quality of highway design project documents, including plans and specifications. Document quality also affects development of the construction cost estimate. Therefore, document quality needs to be given careful consideration during all phases of project development.

**E. Local Concerns and Requirements.** Actions by the Department are often required to alleviate perceived negative impacts of construction on the community, as well as on the environment. Context Sensitive Solution concerns and requirements can affect the construction cost estimates during any project development phase, especially as legislatures seek to add specific scope to a project. Similar to the effects during the planning phase, mitigation actions imposed by the local government, neighborhoods, and businesses as well as local and national environmental groups during the construction of a project can extend the project duration, thereby affecting inflation allowances, and can add direct cost. By not anticipating these changes, the Department can be plagued by project cost increases.

**F. Market Conditions or Changes.** The size of the project affects competition for a project and the number of bids that a state highway agency receives for the work. Inaccurate assessment of the market conditions can lead to an incorrect construction cost estimate. Changing market conditions during the development of a project can reduce the number of bidders, affect the available labor force, or result in increased commodity prices, all of which can disrupt the project schedule and budget. When contractors decide to bid a project, the major influences can include location of the project, size of the project, type of construction, and the contractor's current workload.

The state of the economy and the availability of work will have major effects on the prices bid for a job. If work is abundant and all contractors have sufficient work in progress, contractors may not bid or if they bid their prices will generally be high. These conditions would produce a "contractor's market." Typical contractors may add a high margin of profit to their unit prices so that if they get the job, they will be able to add labor and equipment to increase the size of their operation. The contractor must also compete for materials, equipment and labor the costs of which will be higher. The reverse of a "contractor's market" is an "owner's market." When there is a shortage of work and contractors are actively seeking projects to keep their labor and equipment operating, an "owner's market" exists.

**G. Contractor Factors.** Contractors have continuing expenses regardless of the work status of their forces. The wages of skilled personnel, which make up the nucleus of the contractor's staff, must be paid even when they are not productive or these people will seek other employment. Equipment depreciates and the costs of ownership continue even when the equipment is idle. It is imperative that contractors keep their forces active; therefore, when an "owner's market" exists, bids will generally be low. In addition, costs of materials will generally be lower in an "owner's market" since the supply will exceed the demand.

**H. Site Investigation and Research.** There are a multitude of problems that are unknown during the early project phases that can increase project cost when they become apparent during construction. However, by conducting diligent investigation and research during design, items such as locating subsurface utilities or determining the extent of unsuitable materials on a project site can lessen project cost overruns, as long as these items are discovered before construction has started.

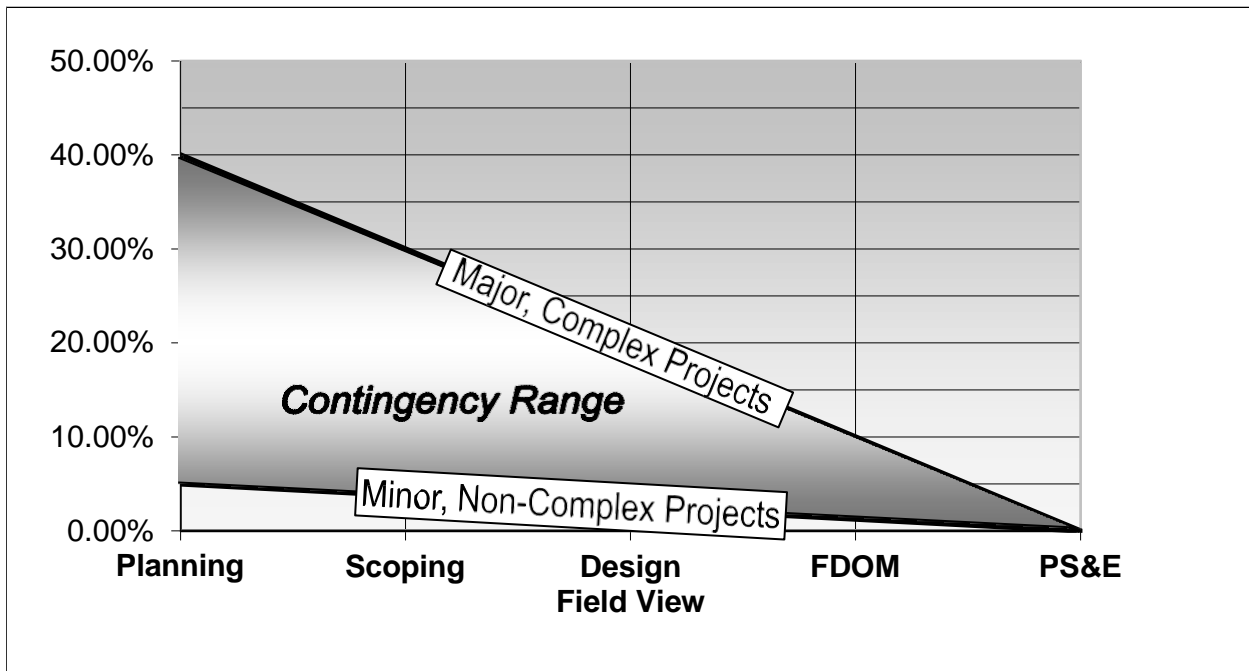
#### 4.8 CONTINGENCY

Contingency funds are typically meant to cover a variety of possible events and problems that have not yet been specifically identified or to account for a lack of project definition during the preparation of the construction cost estimate throughout project development. Contingency funds are not to cover added scope or project cost overruns. Misuse and failure to define what costs the contingency covers can lead to problems with developing the construction cost estimate. Inconsistent application of the contingency throughout the project development can cause confusion as to exactly what is included in the line items of an estimate and what is covered by contingency amounts.

As shown in Figure 4.2, Contingency Chart, the range of cost or schedule uncertainty will decrease as a project proceeds through the project development process (i.e., higher contingency at the Planning and Scoping Estimate Milestones and lower to zero contingency as you reach the PS&E Estimate Milestone). The following contingency levels are provided as guidelines when determining a contingency percentage for a project. However, the Project Manager must consider the project characteristics as well as how well the project is defined at each estimating milestone in order to apply a contingency percentage. For some projects, the contingency determination by the Project Manager may fall outside of the range provided below.

Note that less complex projects such as a betterment or overlay project are typically easier to define and will have fewer unknowns early in the design process and therefore require a smaller contingency. Conversely, major, complex projects typically have more unknowns early in the project development process and also contain higher risk. Refer to Publication 10C, Design Manual Part 1C, *Transportation Engineering Procedures*, Chapter 2 for tables listing project attributes of non-complex and most complex projects.

**Figure 4.2**  
**Contingency Chart**



#### 4.9 INFLATION FACTOR

The effects of inflation will add to the cost of a project, independently from contingency costs and cost drivers. The time value of money can adversely affect projects when the:

- Project estimates are not communicated in year-of-construction costs,
- Project completion is delayed, and, therefore, the cost is subject to inflation over a longer duration than anticipated, and/or
- Rate of inflation is greater than anticipated in the estimate.

The Project Manager and the District Planning and Programming Manager should communicate the inflation factor applied to an estimate. A 3% inflation factor, compounded annually, can be added to the Project Phase estimate in the MPMS system. The MPMS system calculates the inflation factor to the year of expenditure (letting), not the mid-point of construction.

If the Project Manager determines that an inflation factor that is different from the MPMS inflation factor of 3%, the difference from the MPMS inflation factor will need to be factored into the base cost estimate. For construction estimated developed for projects that have the construction phase on the long year plan (before the construction phase is placed on the TIP and the MPMS factor is applied), the inflation factor should be compounded annually using the mid-point of the construction duration as the end-point of the inflation calculation.

This inflation factor does not include the escalating costs, price-volatile items or price-trends of individual items, materials and supplies that impact project cost. Those individual item cost drivers should be examined as a part of the cost-driver analysis that is discussed in Section 4.1, Cost Drivers and Section 4.5, Cost Driver Analysis.

#### 4.10 CENG COSTS



The construction engineering (CENG) costs should be included in the estimate by calculating the project cost by the maximum CENG percentage:

<b>Project Cost</b>	<b>CENG as % of Total</b>
Less Than \$1 Million	15% Max
\$1 Million to \$5 Million	12% Max
Greater Than \$5 Million	10% Max

The District has the ability to request a maximum of 15% on all projects. For projects above \$1,000,000, approval from the Program Center is needed to make this adjustment.

## CHAPTER 5

### ESTIMATE REVIEW

#### 5.1 INTRODUCTION

All project estimates should be reviewed for the validity of their basis; however, the formality and depth of the review will vary depending on the type of project and its complexity. Reviews of construction cost estimates will determine that estimation criteria and requirements have been met and that a well-documented estimate has been developed. In addition, an estimate review can establish that the construction cost estimate accurately reflects the project's scope, items are not missing, that historical data reasonably reflects project scope and site conditions, and that cost driver assumptions are appropriate for the project.

All reviews must closely examine the assumptions that form the basis of the estimate, internal logic, completeness of scope, and estimation methodology. Performing estimate reviews as part of project milestone reviews is an effective method for validating the construction cost estimate and associated assumptions. In addition, it establishes the accuracy and completeness of the estimate. As part of the project milestone reviews, the cost drivers, contingencies, and cost escalation factors must be examined based on guidance given in Chapter 4, *Cost Estimating Factors*.

The same 80/20 rule utilized in the selection items of work for cost-based estimating (see Section 3.5.D.) can be applied as a method to select items for review. Depending on the size of the project and the limited time available for estimate review, the 80/20 rule can be applied to focus on the 20 percent of items on a project that have the greatest cost impact overall.

#### 5.2 ESTIMATE REVIEW

**A. Estimate Milestones.** Estimate reviews must be conducted at strategic times during estimate preparation to improve accuracy and completeness. Estimate/document reviews should be conducted at each design development phase (Planning, Scoping, Design Field View, Final Design Office Meeting, PS&E). These earlier reviews can provide real benefit because they often discern cost drivers that can be addressed by design changes and, in so doing, reduce project cost. A cost estimate should be provided along with the intermediate design phase documents. All projects receive an originator review; however, larger projects usually warrant additional reviews in the District and by Central Office. The first review of the estimate should be conducted by the team that prepared the estimate. This is essentially a screening review that ensures that the math is correct, the estimate is documented, and estimating guidelines were followed.

Construction cost estimate reviews should be conducted at each project milestone during the project development process. The depth of the estimate review at each milestone in project development will vary depending on the type of project and project complexity.

**B. Design Document Quality.** The plans presentation and quality of the bid documents has a direct impact on the cost estimate. Therefore estimate review should consider project constructability from a contractor's perspective of risk.

The Project Manager should resolve issues if any review comments indicate a conflict between the design documents and the project's scope and/or standards of practice or conflicts within the documents.

The Project Manager should provide a written response to all project estimate/document review comments. Responses to all project estimate/document review comments must be submitted prior to production of the bid documents so as to allow sufficient time for the estimators to properly prepare the PS&E.

Each contract requirement should be stated only one time and in the most logical location in the contract documents. Information in one document should not be repeated in any of the other documents. Each document has a specific purpose and should be used precisely for that purpose. This simplifies the retrieval of information and substantially reduces the possibility of conflicts and discrepancies. Everyone involved with a project benefits from this

standardized approach to the placement of information within the construction documents.

During the estimate review, there should also be a check on the quality of any documents used to prepare the estimate, even if the documents are considered preliminary. This is perhaps more important as preliminary design progresses and the plans and specifications are approved. A very effective management approach for establishing the reliability of a cost estimate is to subject the estimate to review and verification.

**C. Team Approach.** A team approach may also provide a more unbiased review. An independent review by an individual is often appropriate for specialized construction methods.

Reviews may be conducted by the District review team, the Highway Design and Technology Section (HDTS) Project Development Engineer, or jointly performed by both parties. The participation of BOPD personnel, including a Structural Engineer, right-of-way personnel, and other project core team members, should be required as appropriate.

### 5.3 ESTIMATE REVIEW PROCESS

The following are steps to be followed in performing the review of a construction cost estimate:

**A. Determine Level of Review.** The level of estimate review is generally related to project size and complexity and the resources available to perform these reviews. In this step, the Project Manager must determine who should review the construction cost estimate and at what level these reviews should occur. See Appendix B, *Estimating Review Responsibility Matrix*.

**B. Review of Estimate and Assumptions.** The first component of the review will focus on understanding how the construction cost estimate was developed. General assumptions should be reviewed. This information sets the context in which the estimated costs were prepared.

- 1. Verify Completeness and Use of Estimating Information and Data.** The estimate scope should be verified so that every item of work to complete the project is captured in the estimate. This step focuses on ensuring that the estimate reflects the scope of the project as described when the construction cost estimate was prepared.

Further, the review should assess whether quantities, unit prices, and percentages reflect the scope of work, project site conditions, and market conditions. Quantities, calculations and applied unit costs and percentages should be evaluated focusing on the major contributors to the project cost. As part of the project milestone review, the cost drivers, contingencies, cost escalation factors and inflation factors must be reviewed.

- 2. Reconcile the Current Estimate.** Differences between a project's current construction cost estimate and previous construction cost estimates must be explained. This is particularly critical when cost increases have occurred. Doing this will address the "Why has project cost increased?" question from Program Management Committee (PMC).

**C. Review of Estimate Documentation.** Traceability between the funding construction cost estimate and the current construction cost estimate is critical for explaining why there are changes in project construction costs. This traceability with the funding cost estimate is imperative if changes from the funded estimate require that the programmed cost be adjusted to reflect current estimated construction cost of the project.

This step focuses on compiling all estimate documents and organizing them into a single package to include cost summaries, detailed estimates, estimate basis and assumptions, and quantity calculations of the project. This step also contains a review that the estimating process is followed and the estimate methodology follows department guidelines.

**D. Estimate Review Checklists.** Both District and Central Office review documentation can be facilitated by using the review checklists found in Appendix C, *Estimate Review Report*. The Estimate Reviewer can use their own method for documenting review findings. The level of review is commensurate with the complexity and cost of the project. Not all checklists or items in the review report regardless of the how the Estimate Review

is documented; a thorough estimate review should contain the following review categories:

- Scope
- Estimate Management
- Estimate Documentation
- Cost Estimate Calculations
- External Factors
- Schedule
- Site Conditions
- Cost Driver
- Assumptions
- Contingency, Cost Escalation and Cost Factors

#### 5.4 ESTIMATE REVIEW RESPONSIBILITIES

The review responsibilities matrix is provided in Appendix B, *Cost Management Review Responsibilities*. That table shows the type of review to be performed by the reviewer along with what information to document and the tools available to conduct the Estimate Review.

**A. Estimate Originator Review.** As part of the estimate development process and associated review, the following construction cost estimate items must be resolved in addition to bid package requirements as defined in Publication 51, *Plans, Specifications and Estimate Package Delivery Process Policies and Preparation Manual*.

1. **Confirm Cost Matches Scope.** Gain a comprehensive understanding of the project scope, limits, major items of work such as structures, excavation construction staging, and traffic phasing. The review should ensure that the estimate conforms to the project scope and design documents. Validate that the scope description, drawings, and estimate match in terms of work items and associated project scope or specification. Consult expertise to validate the design elements (e.g., if there is a curved bridge has the team assumed steel girders and factored that into the unit price).
2. **Confirm Unit Prices are Valid.** Based on experience, bid tab data, and recent projects in the area and the documented cost drivers for the project, validate unit prices. This also includes confirming mobilization markup. Bid histories are useful but not the final answer, especially if bid histories are more than three months old; in such cases care and judgment must be used to ascertain the appropriate and valid current unit prices.
3. **Identify / Understand Contingency.** During the design phase of the project, the estimator will include contingency for project costs that will become evident during the design development. The estimator may also need to account for project risks in the estimate through contingency. If these risks are mitigated through the design process, the estimator must also "back out" any contingency that was used to cover a risk.

**B. District Office Review.** All estimates must be reviewed to ensure that they do not contain any discrepancies, errors, or omissions. District peers or subject matter experts are able to add value to an estimate and can identify possible weaknesses. Estimates are based on many assumptions, and these assumptions need to be justified as the estimate is reviewed. Reviews provide feedback to estimators about the completeness and accuracy of their work.

District peer reviewers must have adequate expertise and credibility based on previous project experience. There should be little tolerance for any compromise on the results of internal review evaluations. Reviewers should ensure that all costs include future inflation to the midpoint of construction.

1. **Estimate Quality Control.** One method for maintaining the consistency of the estimates and their documentation within each District is to establish a District Cost Estimate Quality Control Review Team that can implement a plan to ensure quality control of all project estimates. It is recommended this team include

the District's Portfolio Manager, Contract Management Engineer, Right-of-Way Administrator, Project Managers, and other personnel deemed necessary. This team is not expected to inspect each estimate in detail, but rather ensure consistent procedures for the appropriate preparation and updating of the project estimates.

2. **Project Complexity.** In the case of an uncomplicated overlay project, the review may be limited to verification that all elements are accounted for by the use of the Estimate Review checklist. However, as project complexity and scope increase, it is necessary to conduct more formal reviews. Complex projects may have several cost elements that estimators are unfamiliar with and require an expert opinion. Estimate reviews provide the opportunity to minimize ambiguities by imparting appropriate expertise from within the agency.

For moderately complex projects, an objective estimate review will be performed by the District Contract Management Unit, since they typically do not participate in the detailed development of the construction cost estimate. For large or complex projects, the review is to be conducted in conjunction with the project team so that the Contract Management Unit can better understand the project's specifications, scheduling, and requirements in order to review the construction cost estimate.

3. **Document the Review Findings.** The findings of the estimate review must be documented. The reviewer may use an estimate review checklist (Appendix C, *Estimate Review Report*) or prepare a concise written report that documents the findings.

**C. Central Office Review.** Central Office will perform cost estimate reviews for the project types that are identified in Appendix B, *Cost Management Review Responsibility Matrix*, for Estimates prior to PS&E. For each of these projects, the current cost estimate will be reviewed at each of the cost estimating milestones that are identified in Table 2.2, Cost Estimating Process. The Central Office review of the major cost items associated with the project will be performed by the Reviewer from the Project Schedules, Specifications and Constructability Section.

In the case of a minor project that is within the Review Responsibility Matrix for Estimates prior to PS&E, a determination will be made at the Scoping Field View as to whether further formal review by Central Office will be necessary during the project's development. In the case where Central Office review will not occur, the District will need to perform and document a separate cost estimate review.

For very complex projects or projects involving new construction methods that are being estimated, in addition to BOPD, HDTS reviews, construction cost estimate reviews may also be performed by other BOPD Divisions and Sections, as appropriate, including Bridge Design and Technology Division, and Project Schedules, Specifications and Constructability Section.

1. **Project Complexity.** The formality of a project estimate review and the depth of the review at any stage in project development will vary depending on the type of project and project complexity. When very complex projects or projects involving new construction methods are being estimated, management should require that there be an external review of the estimate by qualified professionals. This external review should include a risk analysis that identifies the critical elements of the estimate, identifies the high and low cost limits for each critical element, and assigns a probability to the actual cost.

2. **Quality Assurance.** The most effective means of improving estimate quality is not to refine estimation methods or computer software, but to refine the methods of identifying errors and omissions. A quality assurance program can ensure that estimation criteria and requirements have been met and that well-documented, defensible estimates are being developed by the Department. This can be accomplished through periodic reviews of selected project estimate files, the District's project estimation process, and the District's quality control plan.

## 5.5 LARGE, COMPLEX PROJECTS REVIEW

The design and contract documents for all projects should be subjected to an internal review and compared with the estimate assumptions; however, in the case of very large and complex projects, per Publication 10A, Design Manual Part 1A, *Transportation Engineering Procedures*, the design drawing and contract documents should

additionally be subjected to an external review through the use of Value Engineering/Accelerated Construction Technology Transfer (VE/ACTT) sessions. VE/ACTT sessions can be applied at any time during the project development but are typically most beneficial near the Design Field View Submission.

## CHAPTER 6

### COST ESTIMATING TOOLS

#### 6.1 INTRODUCTION

The following estimating tips and practices, compiled from commercially available construction cost data, contain useful information that will help to ensure items are not overlooked in the project information and documents.

#### 6.2 HISTORICAL BID ANALYSIS

Bid history is information that has been derived by statistically analyzing past bids for an item and can be used to predict future bid prices for an item. Historical bid-based estimating is typically the most efficient method for developing an estimate for items of proposed work using a minimum of resources as long as there is adequate and comparable historical data available. Similar projects with similar items, quantities, and locations can generally be estimated quickly utilizing historical bid data and engineering judgment. However, there are many factors that need to be considered to develop an accurate letting estimate using historical bid prices. The cost-driver analysis can contain information to consider when developing a unit price based on bid history. Common sense, experience and judgment all play a role in using historical bid prices to determine what a reasonable unit bid price and overall final contract estimate may be.

The estimator must use historical information carefully and keep in mind the following points:

- The work covered by standard items must be consistent.
- Unique or seldom used items are also difficult to estimate utilizing this approach due to the lack of available historic data.
- Historical prices can be susceptible to individual project conditions that may or may not apply to the project being estimated.
- Unbalanced bids have the potential to skew the bid history.
- Inconsistencies in projects and non-typical projects are opportunities for inaccuracies in historical bid based estimates.
- Utilizing historical bid estimating techniques is difficult for lump sum items. Most lump sum items are very different from one project to another. For that reason, utilizing past bid history is often not a good indicator of the future bid price for lump sum items.

#### 6.3 ESTIMATING SOFTWARE

The following estimating software is available for development of PennDOT cost estimates:

- ECMS - PennDOT Software

Bid Item history search functions. Force Account data is also available on construction projects in ECMS. The Force Account data can include information on labor, material, and equipment rates.

- Tracer - AASHTO Software

A parametric cost estimating system that requires minimal user input to create cost estimates. The costs in Tracer are based on RSMeans cost data. Tracer has cost models developed for new and renovations of road and bridge as well as sitework and excavation models. Tracer can report on items and quantities that are derived from the input of project parameters (i.e., road length, width, number of lanes). Other

costs factors such as contingency and overhead rates can be adjusted as well.

- Crystal Reports

## 6.4 ECMS FUNCTIONS FOR ITEM PRICE HISTORY

### A. Getting Started.

1. Log into ECMS.
2. From the menu click on Construction Projects.
  - a. Click on Resources.
  - b. Select Item Price History.
  - c. Select Advanced Search.

### B. Basic Search. (Item Prefix, Item Type and District(s) are required)

1. In the **Item Prefix** field enter the first four digits of the item number. Search by click on magnifying glass.
2. Select an **Item Type** from the Bid, CIS, Work Order or Bid & Work Order drop down menu. One Item Type must be selected.
  - a. Bid – Lists the items that the contractor will bid on.
  - b. CIS (Component Item Schedule) – Break down of the lump sum items.
3. Select **District(s)** which are to be considered for price history. At least one District must be selected.
4. Choose **Report Type**, either summary or detail.
  - a. Summary – gives the average unit price and quantity of all occurrences of the item in the selected District.
  - b. Detail – gives the actual unit price and quantity for all occurrences of the item in the selected District.

### C. Advanced Search.

1. In the **Item Number** field enter the last four digits of the item number to choose a specific item.
2. In the **Item Description** field, all or part of the item description may be entered to search for an item number. When entering part of the description, %-% or \*-\* format must be used. Example: When searching for Concrete Pipe. Enter 0601 in the Item Prefix field and %Concrete% or \*Concrete\* in the Item Description field.
3. **Roll Up Results** – When two or more Districts are selected, this option will give you the average unit price and quantity of the item from all selected Districts. The result is represented as "District 00" (Only used with Summary Report Type).
4. **Bid Type**.
  - a. Low Only – Gives only the price history for the lowest bidder.
  - b. Low 3 – Takes the average price from the three lowest bidders.



5. **State type of work-** Only items in the selected "State Type of Work" field will be considered for the report.
6. **Total Bid From/To** – Allows for a low and high bid amount to be entered. Any bids lower or higher than these amounts will not be considered for the report. Only the lowest bid will be considered, even if Low 3 is selected.
7. In the **Date From/To** fields select the beginning and ending date for the report. The beginning date may not be more than five years prior to the current date. Enter the dates in mm/dd/yyyy format, or a date may be selected from the pop-up calendar icon.
8. **Qty Range From/To** – Allows for a low and high quantity to be entered. Any bids with item quantities lower or higher than these amounts will not be considered for the report.

## 6.5 TRACER SOFTWARE

AASHTO's Tracer is a parametric cost estimating system that requires minimal user input to create cost estimates. The costs in Tracer are based on RSMeans cost data. Tracer has cost models developed for new and renovations of road and bridge as well as sitework and excavation models.

Tracer can report on items and quantities that are derived from the input of project parameters (i.e., road length, width, number of lanes). Other costs factors such as contingency and overhead rates can be adjusted as well.

## 6.6 ECMS PROJECT CHARACTERISTICS

The ECMS Project Characteristics screen is a part of the consultant agreement function in ECMS. Data is entered into this screen when a consultant agreement part or work order is closed out in ECMS. The project characteristics engineering information such as total project length and number of lanes, structures information, and environmental information including the classification, resources, archeology, and wetlands impact. This data can be used for developing the design lump sum costs for design-build projects. Once a similar project is identified for estimating purposes, the project characteristics can be a method to quickly determine if a project is suitable to be used as a basis for estimating design costs.

## CHAPTER 7

### BID ANALYSIS

#### 7.1 INTRODUCTION

All contracts shall be awarded on the basis of the lowest responsive and responsible bid. Procedures are in place for issuing concurrence in award or rejection of the bids.

Bid analysis is the process performed to justify the award or rejection of the bids and is an examination of the unit bid prices for reasonable conformance with the engineer's estimated prices. The bid analysis is programmed in ECMS. The purpose of a bid analysis is to ensure that the contract is awarded to the lowest responsive bid submitted by a bidder meeting the criteria of responsibility. During analysis, the low bid unit prices are examined for reasonable conformance with the engineer's estimated prices. When variations or indications of possible unbalancing of unit prices are found, a justification of the bid for evaluation purposes is required. It is during this evaluation that a decision is made to award or reject the low bidder or the project.

Beyond the comparison of prices, other factors in the bid analysis include:

- Number of bids
  - Distribution or range of the bids
  - Unbalancing of bids (see Section 7.1.C below).
  - Identity and geographic location of the bidders
  - Urgency of the project
  - Current market conditions and workloads
  - Comparison of bid prices with similar projects in the letting
  - Justification for significant bid price differences
  - Potential for savings if the project is re-advertised
  - Accuracy/inconsistency of proposal specifications and plans
- A. Adequacy of Competition.** Competition should be considered good or acceptable when three or more bidders on the project. Fewer competitive bids should require evaluation to determine whether competition was adequate, and whether additional competition or better prices could be obtained.
- B. Deferral of Bids.** Some projects are considered so essential that deferral would not be in the public interest. Projects which are considered essential are the following:
1. Safety projects to correct an extremely hazardous condition where the traveling public is in danger.
  2. Emergency repairs or replacement of damaged facilities.
  3. Projects to close substantial gaps in otherwise completed highway facilities to allow opening to traffic.
  4. Projects that are critical to staged or phased construction where a delay would mean a substantial impact on the completion date of the project.
- C. Unbalanced Bids.** Unbalanced bidding becomes a problem if the Department believes that the bidder who submitted the apparent low bid in all probability will ultimately perform the project at a higher cost than the second bidder. In other words, the idea is that the low bidder has managed to "trick" the system by managing to be evaluated as low at bid opening, but through an unbalancing strategy has made it likely

that the bidder will be paid more than it appears.

The two types of unbalanced bids are as follows:

**5. Mathematically Unbalanced Bid.** This is a bid that contains lump sum or unit bid items that do not reasonably reflect the actual costs (plus reasonable profit, overhead costs and other indirect costs) to construct the item.

a. To detect mathematical unbalancing, the unit bid items should be evaluated for reasonable conformance with the engineer's estimate and compared with the other bids received. There are no definitive parameters (e.g., an amount or percent of variance from the engineer's estimate) that constitutes an unbalanced bid. The degree of unbalancing of a bid may depend on the reason for the unbalancing such as the following:

(1) "Front Loading" the Contract. This is accomplished by the bidder overpricing the work done early in the project which provides more cash flow at the beginning of the project.

(2) Maximize Profits. This is accomplished by overpricing bid items the Contractor believes will be used in greater quantities than estimated in the proposal and underpricing items the Contractor thinks will be used in significantly lesser quantities.

(3) The contract may include bid items that lend themselves to unbalancing.

b. The final analysis should not preclude the use of sound engineering judgment. Care must also be exercised to ensure that unit bids for mobilization do not mask unbalancing. Also, "Token Bids" (i.e., bids with large variations from the engineer's estimate) should be considered as mathematically unbalanced bids.

**6. Materially Unbalanced Bid.** A bid that generates reasonable doubt that award to that bidder would result in the lowest ultimate cost. A bid is materially unbalanced when it is based on prices significantly less than cost for some work and prices which are significantly overstated in relation to cost for other work. There is a reasonable doubt that the bid will result in the lowest overall cost to the Department even though it may be the low evaluated bid.

There may be situations where the quantity of an item could vary due to inaccuracies in the estimating, errors in the plans, changes in site conditions or design. In such situations, the bids should be further evaluated to determine if the low bidder will ultimately yield the lowest cost. If unbalancing creates reasonable doubt that award would result in the lowest cost, the bid is materially unbalanced and should be rejected.

## 7.2 REQUIREMENTS

*Federal Guidelines on Preparing Engineer's Estimate, Bid Reviews and Evaluation* (January 20, 2004) specify that for 50% of Federally-funded projects and for all Federal Oversight projects, the engineer's estimate should be no more than 10% over or under the low bid. If these requirements are not met, the Department must complete a bid justification and provide the results to the FHWA for review and approval.

For projects involving state funds, the Department's requirements specify the engineer's estimate should be no more than 10% over or 15% under the low bid.

## 7.3 BID JUSTIFICATION

The BOPD, HDD, Contract Management Section (CMS), Contract Awards Unit determines which bids need justification prior to recommending award or rejection. Following the bid opening, the District may access the unit prices of the three low bidders of the selected projects.

The purpose of bid justification is to compare unit bid prices to determine if the prices are consistent with price history and current market conditions, the accuracy of the estimate and whether adequate competition was obtained.

The justification is also used when additional funding is needed for a project and is reviewed by the Program Management Committee (PMC) and FHWA for concurrence to award approval. It is imperative to submit complete and detailed information in the justification for the project and the bid items as requested.

When the low bid differs from the engineer's estimate, a thorough analysis is required to justify award of the contract. Under these circumstances, the following questions are considered:

- Was the competition adequate?
- Is the timing of the project award critical?
- Would deferral for the following project types be contrary to the public interest?
  - Safety projects to correct an extremely hazardous condition which endangers the traveling public
  - Emergency repairs or replacement of damaged facilities
  - Projects to close substantial gaps in otherwise completed facilities
  - Projects that are critical to staged or phased construction such that delaying this element will adversely impact the completion of the project.
- Would re-advertisement result in higher or lower bids or better competition?
- Was there an error in the engineer's estimate?

The influence of any one of the above factors may or may not be too meaningful. However, when considered in combination, the results could be significant.

The bid items identified in ECMS will be justified by the Consultant, the District, the Contractor and Central Office. All unit bid prices for which "token bids" were received (i.e., \$0.01) should be evaluated/justified. The following areas must be considered by each representative when preparing the justification:

- Project specifics
- Technical requirements
- Construction methods and any alternatives considered
- Methodology of unit price calculation
- Influencing factors effecting cost
  - Project schedule changes
  - Constructability issues
  - Market conditions or changes
- Item complexity
- Verification of quantities for all non-lump sum items showing a significantly higher bid price

A complete justification will include the designer/consultant name, the description of the project, general comments on any of the areas mentioned above and detailed information regarding all items. Any estimate reviews and subsequent changes to the estimate will require documentation regarding when it was reviewed and what factors influenced any changes made.

The information submitted using these guidelines will provide a standardized process for bid justification which will in turn offer the information necessary for additional funding and expedite the award of contracts.

Further information and guidance can be obtained through FHWA's *Contract Administration Core Curriculum Participants Manual* (<http://www.fhwa.dot.gov/programadmin/contracts/coretoc.cfm>) and 23 CFR.

Line item profiles are used to analyze unit costs of bidders versus the estimate. Typically, the Department uses line item profiles of 0.0 and 1.0%. The percentage represents the difference in the amount between the estimated price and the bid price. For example, if an item had an estimated unit price of \$50.00, then the 1% line item profile is \$49.50 - \$50.50.

The Contract Awards Unit generates 1.0% line item profiles for all the projects. For Federal projects, a 0% line item profile is saved in ECMS. For projects over \$20 million, a 0.5% line item profile is generated and projects over \$100 million, a 0.4% line item profile is generated. The District can then prepare and submit the bid justification.

The Contract Awards Unit has developed numerical criteria for evaluating the need for bid justification. These observations can also be used to perform the initial screening analysis of all contracts and identify the bid rigging suspects to be examined in more detail.

**A. Process.** The bid justification process consists of the following steps:

1. Contract Awards Unit reviews the Line Item Profile (LIP) screen in ECMS.
2. Contract Awards Unit determines the projects requiring justification by:\*
  - a. Percent difference of low bid from estimate
  - b. Dollar value of project

\*Individual items may require justification even if the project does not. Contract Awards evaluates every line item on every project.

3. Contract Awards Unit identifies items that require justification on the Line Item Profile (LIP) screen in ECMS.
4. District evaluates the bid compared to the estimate, obtains comments from the low bidder and consultant (for consultant design projects).
5. District submits the justification to the Contract Awards Unit on the form provided by the Contract Awards Unit.
6. Contract Awards Unit evaluates the justification and routes for approval.
7. Contract Awards Unit writes the concurrence in award letter for Federal Oversight projects and routes for approval.
8. For concurrence in award for all projects, the Chief, CMS recommends concurrence and the Director, BOPD gives concurrence. For Federal Oversight projects, the Deputy Secretary for Highway Administration must also give concurrence. For rejections, Legal Counsel might also sign the letter.

**B. Concurrence in Award and Rejection of Bids.** The recommendation to award or reject a bid is probably one of the most important areas of contract administration. Careful consideration and analysis should be given to the particulars of each project before arriving at a recommendation to award or reject bids. Therefore, regardless of the variation between the approved engineer's estimate and the low bid, a justification supporting award or rejection of a bid is required.

A concurrence in award should contain the following elements and documents:

1. Bid Tabulations
2. Bid opening date.
3. Low bid, name and address of low bidder.
4. Approved engineer's estimate.
5. Percentage difference between the low bid and the approved estimate.
6. Justification of the unit prices which deviate significantly from the estimate and why award or rejection is recommended. For unbalanced bidding, are any unit prices unbalanced for items whose quantities could result in substantial overruns? Quantities should be verified and be a factor in the recommendation. If there is no obvious unbalancing, it should be so stated. Justification should be specific and detailed.
7. Number of bids, bid range, and difference (dollar and percentage between the first and second bidders).
8. Contract Completion Date.
9. Where applicable, a statement that the BOPD has on file an updated Right-of-Way Certificate. (ECMS fulfills this requirement and Contract Awards Unit will provide for Federal Oversight projects.)
10. As applicable, a statement that there are no changes in the information contained in the Utility Clearance Assurance Statement 419 issued (Date) and signed by the Director, BOPD; or that such changes have been or will be submitted by the District's Utility Relocation Unit on an updated Form 419 to the BOPD, Right-of-Way and Utilities Section, Utility Relocation Unit will be provided by ECMS or by Contract Awards Unit for Federal Oversight projects.
11. A statement that the Bureau of Project Delivery is attaching the Staffing Letter and, if applicable, the Municipal Agreement or any required legal agreement and other pertinent documents.
12. Standard PMC funding wording will be added by Contract Awards Unit for Federal Oversight projects. For rejection of bids letters, disregard Items 9 through 11.

For the concurrence in award, the Chief, Contract Management Section recommends concurrence. The Director, BOPD gives concurrence.

The concurrence in rejection must be signed by Chief Counsel if rejection is for reasons other than financial.

For Municipal projects, the basic format is similar, except that certain elements and documentation may vary to fit local methods and procedures, including a statement or resolution by the local government (reference Publication 740, *Local Project Delivery Manual*).

Please direct any questions to the BOPD, CMS, Contract Awards Unit.

**C. Bid Analysis J-Sheet.** The J-Sheet report generated in ECMS is an online report that serves as a bid analysis tool. The J-Sheet compares the lowest bids (up to 5) with the estimated project cost and displays the percentage difference between the low bid and the estimate as well as between the low bid and every other bid.

The J-Sheet is part of the Bid Justification checklist item on the Contract Awards screen and can be accessed by clicking the J-Sheet link on the Bid Justification checklist item. The J-Sheet is always created, even when no bid justification is required. The report is read from the Bid Justification – J-Sheet tables, which are populated after Bid Opening by the Create Contract Awards Checklist program. When the apparent low bidder is rejected or withdraws their bid and the next low bidder enters the contract award process, the J-Sheet is generated for that bidder and assigned a new score based on the new apparent low bidder and the new number of bids (excluding the rejected or withdrawn bid).

**D. Line Item Profiles and Analysis.** Line item profiles are used to analyze unit costs of bidders versus the

estimate. Line item profiles may identify unbalanced bids, errors in item quantities, errors in unit estimated prices, and contractor strategy of construction for individual projects.

All let projects should have a generation of line item profiles produced and used to analyze the bids. Normally, 1.0% (difference between estimate bid amounts) line item profiles are generated after each bid opening. For Federal projects, 0.0% line item profiles are saved in ECMS. Factors that are used include:

1. Comparing item bids of the three lowest bidders with the item estimates.
2. Proportioning their difference with the total project estimate, i.e., percent weighted difference.
3. Spotting deviant bid items.
4. Identifying early (front) items, potential over-run items and extent of unbalancing.
5. Determining the low bids that need justification from these factors.

## CHAPTER 8

### BID COLLUSION

#### 8.1 INTRODUCTION

Bid collusion or bid rigging can be defined as a conspiracy to disrupt or avoid the competitive bidding environment by establishing a competitive advantage for certain bidders. Some common bid collusion activities are:

*Complementary Bids.* A pattern of consistently high bids, or bidders who do not respond (e.g., unqualified bidders or incorrectly submitted bids).

*Territorial Allocation.* A pattern of consistent wins by a vendor within a specific area (e.g., county or multiple county area).

*Joint Ventures.* Submission of a complimentary bid or other noncompetitive behavior by an eventual partner (i.e., subcontractors, suppliers, etc.) to the successful bidder.

*Bid Rotation.* A coordinated pattern of bid responses, both winning and losing.

#### 8.2 CONFIDENTIALITY

**A. Policy.** The Department's policy regarding the confidentiality of estimates both before and after bidding is as follows:

"It shall be the Department's policy to regard the construction cost estimate as confidential at all times regardless of whether it is prepared by Department personnel or an engineering consultant in the employ of the Department. That is, cost estimates are not to be divulged to anyone outside the Department or the Federal Highway Administration, and are to be made available only to those persons who have a need to know."

Procedures and policies concerning confidentiality range from including the total estimate construction cost in the bid proposal to keeping the estimate confidential from the public. Confidentiality is required even after the project has been constructed and opened to traffic. The Department's policy is to maintain the confidentiality of the contractor's unit bid prices from bid opening (let) to award in order to protect the unit bid prices in the event that the project is rejected and re-bid. ECMS security restricts access to this sensitive data. Also, the Department's policy for the engineer's estimate (both unit prices and total estimate amount) is to keep the estimate confidential and to remain confidential even after a project is let.

The contractor's total bid price is public information and can be accessed from the ECMS website. Data that is viewable on ECMS *without being logged in* is public information. When the contract is awarded, the unit prices for the three lowest bidders (bid tabs) become accessible to the public from ECMS.

No non-Department organizations are to be given access to the Contract Award Checklist in the Engineering and Construction Management System (ECMS) at any time unless approved by the Deputy Secretary for Highway Administration. Approved non-Department organizations shall be limited to specific inquiry capability to the system.

No employee of the Department is now nor has ever been authorized to disclose either the bidder's unit prices prior to award or the Department's estimate. The Department takes these policies very serious. Employees divulging this confidential information will be subject to disciplinary action up to and including termination.

**B. Discussion.** FHWA's guidance indicates that the primary reason for maintaining confidentiality of the estimate would be to reduce the possibility of collusion by preventing bidders from knowing the approximate amount that the contracting agency is willing to pay for the project. Confidentiality of the estimate obviously will not by itself, successfully deter a firm from conspiring with other bidders. However, it does prevent bidders from knowing



what approximate amount the Department is willing to accept. As a minimum attempt of confidentiality, a range for the estimated project cost is provided and included in the bid proposal document.

The concerns that negate the advantages to releasing the Department estimate include the following:

- Releasing the estimate creates an enhanced opportunity for collusion among bidders. The opportunity to accurately determine pre-bid what the state is willing to pay for a project would make collusion simpler to implement.
- Releasing the estimate could potentially undermine the competitive bidding process because contractors will bid to the amount we have available for each project. Over time this could erode our price history and our ability to determine a fair unit price for a particular item.
- May encourage contractors to throw in a bid on a project or "bid the estimate" without putting sufficient thought into the bid if they are short on time which could negatively impact the construction process. The declining average number of bids per project basis could exacerbate the impact of an irresponsible bid.
- Releasing the estimate could potentially decrease the number of bidders when their estimate is much higher than ours. Higher bids could be received when the bidder knows or thinks there will be little or no competition.
- Releasing the estimate could create a temptation to publish an unusually low estimate, just to try to drag the bidders down to a lower price than what they should likely be bidding and this would create a problem in construction later.
- Additional staff time would have to be delegated to perform added reviews to detect collusion.
- Releasing the estimate may weed out the non-serious bidders from those who are serious but could also drive away competition.
- Releasing the estimate could assist contractors to make business decisions and save some money relative to bidding costs. However, publishing a cost range also provides the same assistance.

**C. Project Cost Ranges.** Because project costs have increased since the original project cost ranges were determined and there are more projects greater than \$1 million, the upper ranges were narrowed. The project cost ranges provided in the advertisement to bidders are listed below.

\$0.00	-	\$99,999.99	\$35,000,000.00	-	\$39,999,999.99
\$100,000.00	-	\$199,999.99	\$40,000,000.00	-	\$44,999,999.99
\$200,000.00	-	\$499,999.99	\$45,000,000.00	-	\$49,999,999.99
\$500,000.00	-	\$999,999.99	\$50,000,000.00	-	\$59,999,999.99
\$1,000,000.00	-	\$2,499,999.99	\$60,000,000.00	-	\$69,999,999.99
\$2,500,000.00	-	\$4,999,999.99	\$70,000,000.00	-	\$79,999,999.99
\$5,000,000.00	-	\$7,499,999.99	\$80,000,000.00	-	\$89,999,999.99
\$7,500,000.00	-	\$9,999,999.99	\$90,000,000.00	-	\$99,999,999.99
\$10,000,000.00	-	\$12,499,999.99	\$100,000,000.00	-	\$124,999,999.99
\$12,500,000.00	-	\$14,999,999.99	\$125,000,000.00	-	\$149,999,999.99
\$15,000,000.00	-	\$19,999,999.99	\$150,000,000.00	-	\$174,999,999.99
\$20,000,000.00	-	\$24,999,999.99	\$175,000,000.00	-	\$199,999,999.99
\$25,000,000.00	-	\$29,999,999.99	\$200,000,000.00	-	\$224,999,999.99
\$30,000,000.00	-	\$34,999,999.99	\$225,000,000.00	-	\$249,999,999.99

\$250,000,000.00 - \$274,999,999.99	\$500,000,000.00 - \$599,999,999.99
\$275,000,000.00 - \$299,999,999.99	\$600,000,000.00 - \$699,999,999.99
\$300,000,000.00 - \$349,999,999.99	\$700,000,000.00 - \$799,999,999.99
\$350,000,000.00 - \$399,999,999.99	\$800,000,000.00 - \$899,999,999.99
\$400,000,000.00 - \$449,999,999.99	\$900,000,000.00 - \$999,999,999.99
\$450,000,000.00 - \$499,999,999.99	

### 8.3 DETECTION METHODOLOGY

**A. General.** To detect bid collusion, a conscientious effort should be made through a post-award bid evaluation. An adequate number of projects awarded over a sufficient period (e.g., five (5) years) should be selected to detect if any abnormal competitive bid patterns exist. Abnormal bid patterns to consider are:

1. Number of contract awards to a specific firm;
2. Project bid tabulations;
3. Firms that submitted a bid and later become a subcontractor on the same project;
4. Rotation of firms being the successful bidder;
5. Consistent percentage differential in the bids;
6. Consistent percentage of the available work in a geographic area to one firm or to several firms over time;
7. Consistent percentage differential between the successful bid and the engineer's estimate;
8. Location of the successful bidder's plant versus location of the other bidders' plants;
9. Variations in unit bid prices submitted by a bidder on different projects in the same letting;
10. Type of work involved;
11. Number of plans and proposals taken out versus the number of bids submitted;
12. Any other items that suggest noncompetitive bidding; and
13. On readvertised projects, if the eventual successful bidder was also low-bidder on the first letting.

**B. Technical Manuals and Procedures.** Two key references are also available. One reference is the 1981 AASHTO publication *Suggested Guidelines for Strengthening Bidding and Contracting Procedures*. The other reference is the 1983 Federal Justice/Transportation interdepartmental guidance *Suggestions for the Detection and Prevention of Construction Contract Bid Rigging*.

**C. Initial Screening.** The 1983 Federal Justice/Transportation interdepartmental guidance, *Suggestions for the Detection and Prevention of Construction Contract Bid Rigging*, provides details on analyzing bid collusion based on costs. An initial screening might consist of reviewing all bid tabulations, then selecting those projects that involved five or fewer bidders and where the low bid exceeded or was within 5% of the Department's estimate. On these state and Federally-funded contracts, the following analysis might be done:

1. Compute the percentage difference between the second place bidder and the winning bid;
2. Compute the percentage difference between the third place bidder and the winning bid; or
3. Compute the percentage difference between the first and last place bidder.

If the difference between the winning bidder and the second place bidder is within 6%, and the difference between the winning bidder and the third place bidder is less than 9%, and there is no more than 17% difference between the first and last place bidders, there is a significant possibility that the bids were rigged.

The contracts that meet the percentage difference criteria should be considered suspect and should be examined in more detail. This information would include at a minimum:

1. A list of all prequalified bidders and their capabilities;
2. Line item prices on suspect jobs;
3. Identity of all subcontractors on suspect jobs;
4. A list of each company that received bid packages on the suspect jobs; and
5. Location and capacity of each contractor's asphalt plants.

**D. Secondary Analysis.** Having determined that the potential for bid rigging may exist, a closer examination should be made to figure out if any of the following bidding practices are present. These practices have, in the past, indicated collusion:

1. Failure of qualified bidders to bid;
2. Certain contractors repeatedly bid against one another or, conversely, certain contractors do not bid against one another;
3. The successful bidder repeatedly subcontracts work to companies that submitted higher bids on the same projects or that picked up bid packages but did not submit bids;
4. Different groups of contractors appear to specialize in Federal, state or local jobs exclusively;
5. An unusual disparity in front-end or lump sum payment items among the bidders;
6. A particular contractor always winning in a certain geographical area;
7. Contractors who bid frequently but never win;
8. Identical bid amounts on a contract line item by two or more contractors (Some instances of identical line item bids are explainable, as suppliers often quote the same prices to several bidders. But a large number of identical bids, or identical bids on any service related item, should be viewed critically.);
9. Contractors previously convicted of bid rigging in other states who are operating in Pennsylvania;
10. Joint venture bids where either contractor could have bid individually as a prime;
11. Failure of original bidders to rebid, or an identical ranking of the same bidders upon rebidding, where original bids were rejected for being too far over estimate; or
12. Discrepancies in similar line items bid by a given firm on different projects in the same general area at the same letting or on comparable projects at different lettings within a relatively short time.

Additional insight on bidding patterns/activities can be gained by:

1. Plotting suspect contracts in relation to fixed asphalt plants. This can be accomplished by assigning each vendor a different color and making the appropriate notation on a state map. This can be useful in detecting the existence or territorial division by contractors. Keep in mind, though, that there are natural limits, usually 18.5 to 40 mi, to the transport of hot-mix asphalt.

2. Preparing a competition matrix by year for a 5-year period. This matrix would include the major contractors, the number of contracts they were awarded during the period, the dollar volume these contracts represented, the percentage of the total contracts and the total dollar volume won by each vendor, and the ranking of the contractors based on the above. Additional information may be included in the matrix. However, it should, at this time, be kept simple enough so that it can be manually compiled in the shortest time. Once it has been decided to proceed to the investigative stage, a more complex matrix can be developed.
3. Reviewing the state's prequalified bidders list, which indicates the extent of a contractor's capabilities (i.e., design, grading, total project, etc.). When reviewing bids, it is important to note the qualifications of each bidder, not merely the low bidder. Cases have been recorded where the low bidder was fully qualified. Some bidders, however, could not complete the entire project though they bid on it.
4. Analyzing changes in the financial position of companies over the last five years.
5. Determining the degree of influence that suppliers (e.g., liquid asphalt, aggregate, prestressed concrete, pipe, etc.) have on contract awards. Investigations have suggested that prices quoted (or not quoted) for materials can be the determining factor in the eventual low bid. A supplier may refuse to quote material prices to potential bidders or may quote higher prices to some potential bidders. Price quotes can have a significant impact on the degree of competition on a particular contract.

**E. Determination.** Once the above steps are completed, the investigation team can probably determine the potential for bid rigging. Also, the team could recommend whether an investigation should be initiated.

While the indicators and analyses described above have proven to be valuable in successful bid rigging investigation, they are not sufficient to prove collusion. They merely suggest where to look. They provide the background information and marketplace knowledge that enable investigators to conduct detailed interviews and ask specific questions of contractors. It must be remembered that successful prosecutions have resulted principally from the testimony of individuals who were directly involved in the bid rigging schemes. This analysis can lead to those individuals.

This template is designed to identify and document cost drivers that will affect the project estimate. The cost driver analysis is a continuous process to track project characteristics that impact the estimate throughout the project development cycle. The cost driver analysis can also support the estimate contingency in situations where a major cost driver is identified early in design, but further design development and detail is required in order to estimate the cost.

Cost Driver Analysis	Project Type	Description
Part A and B	Required-All Projects	Provides the minimum level of cost driver analysis and must be completed on all projects.
Part C	As needed-All Projects	Complete Part C as warranted by the project characteristics.
Part D	Required for: Moderate, Complex, >\$10M in Construction Phase	Provides a more detailed analysis and documentation of the cost driver categories listed in Part B. Part D is required for all moderate and complex projects, as well as projects over \$10 million (construction phase amount).

**Part A - Project Information**

Project Name		Anticipated Year of Construction	
Project #		Description	
Project Type		District	
SR (Sec)		County	

**Cost Driver Analysis Dates**

Planning	Scoping	Design Field View	Final Design Office Meeting	PS&E

**Background Data and Conditions**

<b>Part B - Cost Driver Summary / Estimating Judgement</b>					
	Planning	Scoping	Design Field View	Final Design Office Meeting	PS&E
<b>Cost Driver Category</b> -See Part D for characteristics of each category if applicable	Check if Cost Driver impacts the project and is reflected in the estimate				
Materials	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Economics	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Project Type	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Schedule	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Plans/Specifications	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Project Location	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Project and Site Restrictions	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
<b>Cost Driver Summary</b> (Narrative for Comments, Assumptions, and Documentation of how cost drivers are addressed in the Estimate)					

<b>Part C - Cost Driver Impacts Specific to Major Categories of Work</b>	
<b>Work Category</b>	<b>Comments/Assumptions for Cost Driver Impact by Work Category</b>
<b>Building demolition and asbestos removal</b>	
<b>Grading and excavation</b>	
<b>Pavement</b>	
<b>Drainage, water main, storm sewer</b>	
<b>Guide rail, steel median barrier, fences</b>	
<b>Curbs, sidewalks, inlets, manholes</b>	
<b>Slabjacking, subsealing</b>	
<b>Landscaping</b>	
<b>Building construction and related trades</b>	
<b>Pavement markings</b>	
<b>Highway/sign lighting, traffic signal control</b>	
<b>Maintenance and protection of traffic</b>	
<b>Sign placement [post/structure mounted]</b>	
<b>Cement concrete bridges</b>	
<b>Steel bridges</b>	
<b>Pile driving</b>	
<b>Steel painting</b>	
<b>Miscellaneous items</b>	
<b>Specialty items</b>	

**Part D - Detailed Cost Driver Analysis**

Materials	Planning		Scoping		Design Field View		Final Design Office Meeting		PS&E	
	Cost Driver	Major Impact	Cost Driver	Major Impact	Cost Driver	Major Impact	Cost Driver	Major Impact	Cost Driver	Major Impact
Do market prices have the potential to fluctuate for:							<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
o Asphalt							<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
o Cement							<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
o Structural Steel							<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
o Fuel							<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
o Other							<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Material shortages ( <i>pipe, traffic signals, steel fabrications, steel sheet pilings, precast concrete items</i> )							<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Material acquisition time ( <i>some materials require significant lead times for fabrication or manufacture. Costs will be higher if the completion date does not allow for sufficient lead time for such items since the contractor will have to pay a premium for getting early delivery or may increase their prices to cover anticipated liquidated damages.</i> )							<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Transportation of materials, proximity to major routes ( <i>long haul</i> )			<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Storage of materials					<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Proprietary items					<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Traffic items ( <i>consider all traffic items in terms of new items and replacement of old if changes are needed, especially signals and pavement markings.</i> )					<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Landscape items ( <i>Obtain a separate estimate from landscape expert for landscape beautification and reforestation using their guidance as a start.</i> )					<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

**Note** - Shaded areas represent cost drivers that are typically not considered or known until milestones that occur later in the estimate development process.



Materials	Planning		Scoping		Design Field View		Final Design Office Meeting		PS&E	
	Cost Driver	Major Impact	Cost Driver	Major Impact	Cost Driver	Major Impact	Cost Driver	Major Impact	Cost Driver	Major Impact
Soil conditions - unsuitable soils, unstable soil conditions					<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Excavated materials such as soil, old asphalt and concrete, disposed on-site or off-site ( <i>if off-site, where is it hauled to</i> )					<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Special requirements and/or locations to obtain fill material, topsoil, etc. relative to project site					<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Storm Water Management ( <i>Additional costs for storm water management facilities</i> )			<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Use of technology/equipment ( <i>rate of return on investment such as material transfer vehicles</i> )			<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
<b>Cost Driver Analysis</b> (Comments, Assumptions, and Documentation of how cost drivers are addressed in the Estimate)										

**Note** - Shaded areas represent cost drivers that are typically not considered or known until milestones that occur later in the estimate development process.

Economics	Planning		Scoping		Design Field View		Final Design Office Meeting		PS&E	
Cost Driver Category	Cost Driver	Major Impact	Cost Driver	Major Impact	Cost Driver	Major Impact	Cost Driver	Major Impact	Cost Driver	Major Impact
Road user liquidated damages							<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Wage changes							<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Inflation rate for longer projects	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
State of Economy ( <i>shortage of contractors and workers, including specialty areas-If there is a shortage of work for contractors, bid may be low. If there is an abundance of work for contractors, bids may be high</i> )									<input type="checkbox"/>	<input type="checkbox"/>
<b>Cost Driver Analysis</b> (Comments, Assumptions, and Documentation of how cost drivers are addressed in the Estimate)										

**Note** - Shaded areas represent cost drivers that are typically not considered or known until milestones that occur later in the estimate development process.

Project Type	Planning		Scoping		Design Field View		Final Design Office Meeting		PS&E	
Cost Driver Category	Cost Driver	Major Impact	Cost Driver	Major Impact	Cost Driver	Major Impact	Cost Driver	Major Impact	Cost Driver	Major Impact
Small project <i>(increases overhead)</i>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Large project	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Specialty work	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Widening projects <i>(consider signal reconstruction on widening projects)</i>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
New project on new location	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Resurfacing, Restoration and Rehabilitation project	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Bridge rehabilitation project	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

**Cost Driver Analysis** (Comments, Assumptions, and Documentation of how cost drivers are addressed in the Estimate)

**Note** - Shaded areas represent cost drivers that are typically not considered or known until milestones that occur later in the estimate development process.

Schedule	Planning		Scoping		Design Field View		Final Design Office Meeting		PS&E	
Cost Driver Category	Cost Driver	Major Impact	Cost Driver	Major Impact	Cost Driver	Major Impact	Cost Driver	Major Impact	Cost Driver	Major Impact
Schedule logic	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Restrictions and tightness of construction schedule ( <i>consider restriction in the estimated length of construction</i> )					<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Complexity of traffic control and maintenance and protection of traffic			<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Impact of other projects in the area ( <i>roadway, maintenance, local. When the potential for conflicting construction operations exists, the scheduler should adjust schedules if possible to avoid these conflicts and possibly increase contract time to compensate for likely delays. Similar response may be required when conflicts between construction activities and nearby community and business activities are likely.</i> )			<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Phasing of operations and construction sequencing, including special equipment ( <i>idle time</i> )					<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Mobilization, demobilization and remobilization for winter and daily basis			<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Winter work ( <i>More costly. Availability of some materials is seasonal and requiring work to be done "out of season" will significantly increase the cost. For example, hot mix asphalt is not readily available in the winter because most plants are shut down.</i> )			<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
<b>Cost Driver Analysis</b> (Narrative for Comments, Assumptions, and Documentation of how cost drivers are addressed in the Estimate)										

**Note** - Shaded areas represent cost drivers that are typically not considered or known until milestones that occur later in the estimate development process.

Plans and Specifications	Planning		Scoping		Design Field View		Final Design Office Meeting		PS&E	
	Cost Driver	Major Impact	Cost Driver	Major Impact	Cost Driver	Major Impact	Cost Driver	Major Impact	Cost Driver	Major Impact
Special conditions that impact the project					<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Work needed to be performed by hand <i>(more expensive if performed by hand)</i>					<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Precise work <i>(fine grade)</i>			<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Use of special equipment			<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Special conditions in environmental permits <i>(not working in streams at certain times due to spawning requirements)</i>					<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Major changes to standard special provisions					<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Potential for over-run of item quantity					<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Component item schedule changes							<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

**Cost Driver Analysis** (Narrative for Comments, Assumptions, and Documentation)

**Note** - Shaded areas represent cost drivers that are typically not considered or known until milestones that occur later in the estimate development process.

Project Location	Planning		Scoping		Design Field View		Final Design Office Meeting		PS&E	
Cost Driver Category	Cost Driver	Major Impact	Cost Driver	Major Impact	Cost Driver	Major Impact	Cost Driver	Major Impact	Cost Driver	Major Impact
New location vs. existing road in developed area	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Adequate areas for contractor's staging, storage of equipment			<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Urban location ( <i>Work in urban areas costs more than work in rural areas. Storage space for equipment and materials may be at a premium. Borrow and waste areas may be further away - longer haul distances.</i> )			<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Remote location ( <i>mobilization and transporting materials may be more costly</i> ) ( <i>consider temporary concrete plant or temporary asphalt plant</i> )	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Local ordinances ( <i>hours of work, noise levels</i> )	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Right-of-Way ( <i>Ensure right-of-way estimate covers storm water management, wetland mitigation, utility relocations and other unknowns. This is to be done in concert with the District right-of-way personnel.</i> )	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

**Cost Driver Analysis** (Narrative for Comments, Assumptions, and Documentation of how cost drivers are addressed in the Estimate)

**Note** - Shaded areas represent cost drivers that are typically not considered or known until milestones that occur later in the estimate development process.

Project and Site Restrictions	Planning		Scoping		Design Field View		Final Design Office Meeting		PS&E	
Cost Driver Category	Cost Driver	Major Impact	Cost Driver	Major Impact	Cost Driver	Major Impact	Cost Driver	Major Impact	Cost Driver	Major Impact
Restrictive conditions ( <i>existing utilities, existing traffic, conflicting construction operations, all restrictive conditions will increase costs</i> )	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Utilities ( <i>Rates of progress must be adjusted for all work under restricted conditions such as utility relocations, which involve special work rules and delays.</i> )	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Working hours ( <i>Most construction workers get paid for an 8-hour day even if they work less. Therefore, costs will be more on a project that requires the work to be carried out in less than 8-hour shifts.</i> )					<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Access to the work site ( <i>the more access is restricted, the higher the cost of doing the work</i> )			<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Stage construction ( <i>the more complicated the construction staging the higher the cost</i> )					<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Maintenance of traffic ( <i>Additional maintenance of traffic in urbanized areas. Working in close proximity to traffic costs more. The closer the proximity and the higher the traffic volume, the higher the cost. Consult with the district traffic personnel on all maintenance of traffic issues and ideas and relevant costs.</i> )	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Night work ( <i>work done at night usually costs about 30% more than the same work done during the day</i> )					<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Completion date					<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Low productivity and labor intensive work					<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
<b>Cost Driver Analysis</b> (Narrative for Comments, Assumptions, and Documentation of how cost drivers are addressed in the Estimate)										

**Note** - Shaded areas represent cost drivers that are typically not considered or known until milestones that occur later in the estimate development process.

<b>Reviewer</b>	<b>Originator Review</b>	<b>District Office Peer Review</b>	<b>Central Office*</b>
<b>Projects</b>	<ul style="list-style-type: none"> <li>All</li> </ul>	<ul style="list-style-type: none"> <li>All projects</li> </ul>	<ul style="list-style-type: none"> <li>All projects in accordance with the Federal Highway procedures for Projects of Division Interest (PoDI).</li> <li>Quality Assurance review of District</li> </ul>
<b>Items Review</b>	<ul style="list-style-type: none"> <li>All</li> </ul>	<ul style="list-style-type: none"> <li>Costliest items that represent 80% of total project cost</li> <li>Other items as warranted</li> <li>Check takeoff for omissions or oversights</li> </ul>	<ul style="list-style-type: none"> <li>Items as warranted by cost driver sheets</li> </ul>
<b>Estimate Review</b>	<ul style="list-style-type: none"> <li>Math, Calculations</li> <li>Quantities</li> <li>Estimate matches project schedule and specifications</li> </ul>	<ul style="list-style-type: none"> <li>Check the calculations of the indirect costs</li> <li>Examine the estimate for buried contingency</li> <li>Estimate cost differences between estimate updates</li> </ul>	<ul style="list-style-type: none"> <li>Estimate cost differences between estimate updates</li> <li>Central Office review coordinated by HDTS may also include review and input from PSSCS and BDTD</li> </ul>
<b>Documentation Review</b>	<ul style="list-style-type: none"> <li>Cost driver analysis documentation</li> </ul>	<ul style="list-style-type: none"> <li>Estimate file</li> <li>Project schedule</li> <li>Project specifications</li> <li>Cost driver analysis documentation</li> <li>Identify uncertainties</li> </ul>	<ul style="list-style-type: none"> <li>Cost driver analysis documentation</li> <li>Estimate file</li> <li>Review estimating process</li> <li>Review estimating methodology</li> </ul>
<b>Review Tools (see Appendix C)</b>	<ul style="list-style-type: none"> <li>Review checklist</li> <li>Price history in ECMS</li> </ul>	<ul style="list-style-type: none"> <li>Review checklist</li> <li>Price history in ECMS</li> </ul>	<ul style="list-style-type: none"> <li>District Estimate Review Report or alternative estimate review documentation</li> <li>Price history Crystal Reports</li> <li>Price history in ECMS</li> </ul>

\*Central Office review at PS&E will follow Bureau of Project Delivery, Highway Delivery Division, Project Schedules, Specifications and Constructability Section procedures for Projects of Division interest.



### ESTIMATE REVIEW REPORT

**General Project Information**

Project Name:

Project Type:

Project Size:

District:

County:

Program Year:

Background Data and Conditions:

**Estimate Review Information**

Review Date:

Review Location:

Reviewer's Names and Organizations:

Review Responsibilities:

- **Determine whether the estimate satisfies the project criteria:** Ensure that the estimate conforms to the project scope and design documents.
- **Appraise the estimate methodology:** Reviewer must be able to follow and check the estimate methodology. Steps to do this would include verifying estimation techniques and sources of estimate data. The reviewer should be able to clearly understand the origin of all numerical data in the estimate.
- **Identify uncertainties:** The review should confirm all uncertainties documented in the estimate and identify other uncertainties in the estimate that were missed or not substantiated.
- **Document the finding:** The findings of the estimate review must be documented. Complete the estimate review checklist and attach written documentation for additional findings not covered by the checklist.

**Project Estimate Information**

Current Estimate:

Current Programmed Amount:

Is Current Estimate greater than 15% or over \$500,000 of Current Programmed Amount?

Yes                       No

{ If yes, take appropriate action }

Current Project Estimate Approval?     Approved                       Disapproved

If disapproved, state reasons why.

Milestone Estimate					
Construction Estimate	Planning	Scoping	Design Field View*	Final Design Office Meeting	PS&E
Estimate Date					
A) Base Cost Estimate					
B) Contingency**					
C) Subtotal Project Cost (A+B)					
D) CENG***					
Total Estimate (C+D)					
Comments					

\* An estimate update at NEPA approval is the latest milestone for adding construction funding to the TIP. See [Section 2.1.C](#). Other milestones may be appropriate as well such as TS&L or Line and Grade Approval, depending on project type. See [Section 2.1.A](#).

\*\* See [Section 4.7](#) for a complete discussion on Contingency.

\*\*\* Calculate CENG based on percentages shown in [Section 4.9](#) multiplied by project subtotal.

**Item Review (80/20 Rule for Design Field View Estimate)**

Item Number:

Item Description:

Item is:  >1% of Estimate  Cost Driver Impact?

Current Quantity:

Current Item Price:

Price Range for Item:  From ECMS  From Other:

Price Range From:  To:

Item Price Approved?  Yes  No

If no, comments

Item Number:

Item Description:

Item is:  >1% of Estimate  Cost Driver Impact?

Current Quantity:

Current Item Price:

Price Range for Item:  From ECMS  From Other:

Price Range From:  To:

Item Price Approved?  Yes  No

If no, comments

Item Number:

Item Description:

Item is:  >1% of Estimate  Cost Driver Impact?

Current Quantity:

Current Item Price:

Price Range for Item:  From ECMS  From Other:

Price Range From:  To:

Item Price Approved?  Yes  No

If no, comments

Repeat for additional items as necessary

### Scope Checklist

- Estimate consistent with project scope? Is the technical scope for the estimate consistent with the site, regulatory requirements and constraints (e.g., permit conditions, regulations) identified during the planning process?
- Does the technical scope documentation for the estimate include descriptions of support associated with the work to be performed?
- Are activities associated with the work to be performed clearly identified and defined in the cost estimate?
- Does the current scope of the work match the scope that the funding estimate is based on?

Is there complete technical scope documentation, including the following elements?

- Description of the work to be performed
- Performance criteria and requirements
- Discrete tasks and deliverables
- Resource requirements
- Sequence of events and discrete milestones
- Work not included in the scope
- Unforeseen engineering complexities

### Review Comments:

**Estimate Management Checklist**

- Has the cost estimate been updated in a timely manner in response to relevant changes in its basis, background data, or assumptions?
- Have the findings and recommendations of the prior estimate reviews been documented?
- Are prior estimate review documents included with the cost estimate documentation?
- Have the findings of the prior estimate reviews been addressed in revisions to the cost estimate?

**Review Comments:**

**Estimate Documentation Checklist**

- Are estimate summary and detailed reports included, and do they provide cost totals for each cost element in the estimate?
- Are an appropriate change control document and an estimate development history attached to the cost estimate?
- Are significant estimator findings identified during preparation of the estimate documented?
- Does the estimate development history include an itemized and chronological list of the changes made to the cost estimate since initiation of its preparation, and the rationale for each change?

**Review Comments:**

**Cost Estimate Calculations Checklist**

- Are direct costs that are associated with individual activities included in the cost estimate clearly and individually identified?
- Are indirect, overhead, or other costs clearly and individually identified? Check the calculations of the indirect costs.
- Are quantities and unit costs associated with the work to be performed clearly identified and defined in the cost estimate?
- Correctness of quantities - Check mathematical extensions and correctness.
- Check takeoff for omissions or oversights.
- Are appropriate historical cost data used in the estimate?
- Appropriateness of unit cost. Do unit prices correlate to similar scope projects in the area? Are they truly comparable?

**Review Comments:**

**External Factors Checklist**

- Consideration of external market factors that could affect cost (this is critically important in the cast of large, complex projects).
- Changes in economic and market conditions.
- Changes in regulatory requirements.
- Pressures by local government or other stakeholders.

**Review Comments:**

**Schedule Checklist**

- Is a schedule included with the estimate?
- Are activities included in the schedule consistent with those included in the technical scope documentation and estimate?
- Are the activity durations in the schedule consistent with the estimated cost? Check for conformity between amounts of work (item quantities) with the schedule durations to determine correctness.
- Are milestones and deliverables included in the schedule consistent with those included in the technical scope documentation and the estimate?
- How long have similar projects taken?
- Has mobilization and demobilization time been included in the schedule? How many workers are assumed to be working on the project at the peak of construction?
- Does the construction phasing and traffic management plan match the schedule assumptions (assumptions for maintenance of traffic, staging of construction, needed temporary barriers, ramps, bridges, supports, technology).
- How many concurrent work areas are assumed? Are there crews available to staff all of those areas?
- Production rates assumed? Is this work similar to other work done in area? What are the assumed production rates for each of the major elements, earthwork, foundations, piers, beams, deck, sub-base, base, paving, etc.?
- What season is it expected that the Notice To Proceed (NTP) will be issued? Will certain months be lost due to the start date?

**Review Comments:**

**Site Conditions Checklist**

- What is the accuracy of the survey data?
- What field investigations have been done, existing conditions analysis?
- What geotechnical work has been done to date? Is there data from past projects in the area?
- Cuts and Fills: What has been assumed for reuse, import, export and disposal, temporary stockpiling, haul distances, location of imported materials?
- Validity of assumed construction method, considering site conditions and project phasing?
- Assumptions on compaction? Seasonal variability?
- Assumptions on stability of cuts, sheeting, retaining walls, slope protection during construction?
- Maintenance of excavations during construction?
- Erosion protection?

**Review Comments:**

**Cost Driver Checklist (see cost driver analysis)**

- Has a cost driver analysis been completed for each estimate milestone?
- Does the estimate include an allowance for cost-drivers that have not been fully estimated for impact?
- Have cost drivers identified in initial project development phases been carried forward until resolved or placed in the estimate?
- Have all cost drivers identified been accounted for in the estimate?

**Review Comments:**



**Assumptions Checklists**

- What is the basis for the assumptions made in developing the estimate?
- Are cost estimate assumptions of cost drivers documented?
- Are the assumptions and exclusions upon which the cost estimate is based clearly identified and defined in the estimate?
- Are the assumptions made in the estimate consistent with the technical scope/specifications and schedule of the project?
- Are time and cost assumptions and cost elements associated with each activity clearly identified, defined, and documented in the estimate?

**Review Comments:**

**Contingency, Cost Escalation and Cost Factors Checklist**

- Is there a concise explanation of how contingency amounts were developed?
- Have factors been used to adjust the costs? If so, have they been adequately documented and appropriately applied?
- Does estimate include construction administration?
- Have escalation factors been used to escalate the estimate?
- Are the escalation factors adequately documented and appropriately applied? Concise explanation of how contingency amounts were developed - Examine the estimate for buried contingency.
- Are indirect rates used in the estimate adequately documented and appropriately applied?
- Is estimate inflation to year of expenditure dollars for each element of the project?
- Are indirect rates, escalation factors, and other factors used appropriately?
- Have all "percentage of total costs" estimates been reviewed?

**Review Comments:**

## APPENDIX D

### COST ESTIMATING PRACTICES

#### D.1 RULES FOR ROUNDING

An estimate is an approximation of costs; it cannot be an exact calculation. Therefore, it is necessary for practical reasons to round-off numbers. In the interest of uniformity, rules have been established to standardize rounding of numbers in Department estimates.

**A. Significant Figures.** Numbers should be rounded so that they do not imply accuracy which is greater than that which the source data and method of calculation can yield:

1. The rule for multiplication and division is that the product or quotient shall contain no more significant digits than are contained in the number with the fewest significant digits used in the multiplication or division.

2. The rule for addition and subtraction is that the answer shall contain no significant digits farther to the right than occurs in the least precise number.

3. The following illustration highlights this difference:

a. Multiplication:

$$113.2 \times 1.43 = 161.876, \text{ rounded to } 162$$

b. Division:

$$113.2 \div 1.43 = 79.16, \text{ rounded to } 79.2$$

c. Addition:

$$13.2 + 1.43 = 14.63, \text{ rounded to } 14.6$$

d. Subtraction:

$$113.2 - 1.43 = 111.77, \text{ rounded to } 111.8$$

e. The above product and quotient are limited to three significant digits since 1.43 contains only three significant digits. In contrast, the rounded answers in the addition and subtraction examples contain four significant digits.

**B. Whole Numbers.** It is preferable to express quantities as whole numbers and avoid the use of decimals. For example, it is better to round 11.6 to 12 rather than allow the possibility of an error if the decimal point is dropped and the quantity is mistaken as 116. The exception to this is guide rail, which is usually expressed in increments of 12.5 feet.

#### C. Rounding

1. When the first digit discarded is less than 5, the last digit retained should not be changed. For example, 3.46325, when rounded to three digits, is 3.46; when rounded to four digits, is 3.463.

2. When the first digit discarded is greater than 5, or if it is a 5 followed by at least one digit other than 0, the last digit retained should be increased by one unit. For example, 8.37652, when rounded to three digits, is 8.38; when rounded to four digits, is 8.377.

3. When the first digit discarded is exactly 5, followed only by zero, the last digit retained should be rounded upward if it is an odd number, but no adjustment made if it is an even number. For example,

4.365, when rounded to three digits, becomes 4.36. The number 4.355 would also round to the same value, 4.36, if rounded to three digits.

## D.2 QUANTITY TAKE OFFS AND CALCULATIONS

- Use pre-printed or columnar forms for orderly sequence of dimensions and locations and for recording telephone quotations.
- Use only the front side of each paper or form except for certain pre-printed summary forms.
- Be consistent in listing dimensions: For example, length x width x height. This helps in rechecking to ensure that, the total length of partitions is appropriate for the building area.
- For taking off quantities, use printed (rather than scaled) dimensions when available. Measure all other dimensions carefully.
- Use each set of dimensions to calculate multiple related quantities.
- Convert foot and inch measurements to decimal feet when listing. Memorize or have reference to decimal equivalents to .01 parts of a foot (1/8" equals approximately .01').
- Do not "round off" quantities until the final summary.
- Mark features on the drawings with different colors as items are taken off.
- Identify location and drawing numbers to aid in future checks for completeness.
- Quantify and list everything on the drawings or mentioned in the specifications.
- It may be necessary to list and quantify items that are not called for but are necessary to make the job complete.
- Be alert for: notes on plans such as N.T.S. (not to scale); changes in scale throughout the drawings; reduced sized drawings; discrepancies between the specifications and the drawings.
- Develop a consistent pattern to take off plan quantities in order to prevent missing an item or feature on a plan. For example:
  - Start the quantity takeoff from the beginning of the construction plans and move through project.
  - Complete mainline then take off side roads and ramps.
  - Proceed from south to north or vice versa, clockwise or counterclockwise.
  - Take off plan view quantities first, elevations and cross sections next, and then detail drawings.
- Do not convert units until the final total is obtained. For instance, when estimating concrete work, keep all units to the nearest cubic foot, add appropriate waste factors, and then summarize and convert to cubic yards.
- Remember to:
  - Take into consideration which items have been marked up and by how much.
  - Read the background information on techniques and technical matters that could impact your project time span and cost.
  - Include all components of your project in the final estimate.

- Double check your figures for accuracy.
- Costs of equipment are a combination of ownership/rental rates and operation rates. Ownership/rental rates will apply to equipment for the entire duration of time that the equipment is located on the job site, regardless of down time or periods of inactivity. The amount of time equipment will be required on the job site must be used to estimate equipment costs, not just the production rates of the equipment.
- Remember to account for waste.
- Blue book monthly rates are based on 176 hours/month.
- Published minimum wage rates may not accurately reflect the actual market value of skilled construction labor. Ensure that you compare wage rates with certified payroll information from recent projects in the geographic locality.
- Utilize hourly labor rates including all fringe benefits.
- The monthly asphalt cement and diesel fuel price indices provide reduction to risk for dependent items.
- Supplier quotes-compare what is listed and excluded by the supplier and account for any excluded items or work.
- When creating a cost-based estimate for an item of work, it is good practice to check the total by comparing to another estimating method, such as a historical bid-based price from an item.
- Develop a deep familiarity with the project including plans, specifications, and project site. "Build" the project on paper and use project documentation when formulating costs. Talk to project team members and discuss issues that affect the costs. Own the project!

### **D.3 EXISTING CONDITIONS**

- In preparing estimates on structures involving earthwork or foundations, all information concerning soil characteristics should be obtained. Look particularly for hazardous waste, evidence of prior dumping of debris, and previous stream beds.
- Historic preservation often requires that the contractor remove materials from the existing structure, rehab them, and replace them. The estimator must be aware of any related measures and precautions that must be taken when doing selective demolition and cutting and patching. Requirements may include special handling and storage, as well as security.

### **D.4 CONCRETE**

- Always obtain concrete prices from suppliers near the job site. A volume discount can often be negotiated, depending upon competition in the area. Remember to add for waste, particularly for slabs and footings on grade.
- Concrete accessories for forming and placing depend upon the systems used. Study the plans and specifications to ensure that all special accessory requirements have been included in the cost estimate, such as anchor bolts, inserts, and hangers.
- Verify your reinforcing steel take-off includes all accessories, cutting, bending, and an allowance for lapping, splicing, and waste. A good rule of thumb is 10% for lapping, splicing, and waste. Also, 10% waste should be allowed for welded wire fabric.
- When estimating structural concrete, pay particular attention to requirements for concrete additives,

curing methods, and surface treatments. Special consideration for climate, hot or cold, must be included in your estimate. Be sure to include requirements for concrete placing equipment, and finish.

- For accurate concrete estimating, the estimator must consider each of the following major components individually: forms, type of reinforcing steel (plain, epoxy coated or galvanized), ready-mix concrete, placement, and finish.
- The cost of hauling precast concrete structural members is often an important factor. For this reason, it is important to obtain a quote from the nearest supplier. Suppliers quote should be FOB (Freight On Board) job site. It may become economically feasible to set up precasting beds on the site if the hauling costs are prohibitive.

## **D.5 EARTHWORK**

- Estimating the actual cost of performing earthwork requires careful consideration of the variables involved. This includes items such as type of soil or rock, whether water will be encountered, dewatering operations, whether banks need bracing, disposal of excavated earth, swell factors, length of haul to fill or spoil site, regrading at spoil site, etc. If the project has large quantities of cut or fill, consider raising or lowering the site to reduce costs, while paying close attention to the effect on site drainage and utilities.
- If the project has large quantities of fill, creating a borrow pit on the site can significantly lower the costs.
- It is very important to consider what time of year the project is scheduled for completion. Bad weather can create large cost overruns from dewatering, site repair, and lost productivity from cold weather.
- Look at moisture content of earth to see if it will be suitable for use as embankment or if additional wetting or drying of the soil will be required. It may be cheaper to waste the material and use borrow rather than relying on on-site soil for fill.
- Computerize earthwork quantities by phase to ensure more accurate costs for labor and required equipment.

## **D.6 PAVING**

- When estimating paving, keep in mind the project schedule. If an asphaltic paving project is in a colder climate and runs through to the spring, consider placing the base course in the autumn and then topping it in the spring, just prior to completion. This could save considerable costs in spring repair. Keep in mind that prices for asphalt and concrete are generally higher in the cold seasons.

## **D.7 SUBCONTRACT ITEMS**

- It is likely that several items of work in a bid proposal will be subcontracted by the prime to another contractor. When a contractor makes the decision that it is more efficient for a subcontractor to do the actual work on a certain item they will use that price.
- Some contractors opt to not use any mark-up for subcontracts to avoid negotiation conflicts with the subcontractor but some will opt for mark up to administer the subcontract.
- Prime contractors that choose to mark-up the price for subcontract work use a range of anywhere from 5- 10% depending on the size of the subcontract and comfort level of the prime with the subcontracting company. If the subcontract is a large percentage of the total project the mark-up may be small, but if the subcontract is small or the contractor is unfamiliar with the sub the mark-up may be higher.

## APPENDIX E

### COST-BASED ESTIMATING EXAMPLE

The following examples have been adapted from *A Practical Guide to Estimating*, AASHTO Technical Committee on Estimating, October 25, 2007.

#### E.1 COST-BASED ESTIMATING EXAMPLE BACKGROUND – CULVERT PIPE

The following sections will break down the elements of a Cost-Based estimate into further detail. To help clarify these elements and how they fit into a task of completing an item of work, an example of replacing a crossroad drainage pipe will be broken down and each element for this task identified.

The task of replacing a culvert pipe beneath 10 ft of fill will be analyzed. This replacement will be performed with a road closure at night and liquidated damages will be assessed if the roadway is not back open to traffic by 6:30 a.m. The working hours allowed are from 7:30 p.m. to 6:30 a.m.

The project is on a 2-lane roadway and 115 ft of pipe will be replaced with 125 ft of 36" reinforced concrete pipe. This example will focus on the task of removing and replacing the pipe, and will not include any of the ancillary items such as traffic control, seeding etc. The pay item for doing the work is per linear foot of 36" pipe with the bedding, excavation, pipe, removal and flared end sections considered incidental to this task.

#### E.2 CALCULATING MATERIAL COST

Assuming pipe and flared end section quotes obtained are FOB jobsite and aggregate bedding is FOB quarry. The quarry is 20 miles from the project site. Pipe is manufactured in 6 ft lengths and Flared End Sections contain 2 ft of pipe each. Therefore the contractor will need to buy  $(125-4)/6 = 20.6$  pieces or in other words 21 six-foot sections of pipe or 126 ft.

Description	Calculation	Subtotal
126 LF of 36" Reinforced Concrete Pipe	$\$53.50/\text{LF} \times 1.06 (\text{tax}) \times 126$	\$7,145.46
2 Reinforced Concrete Flared End Sections	$\$750/\text{EA} \times 1.06 \times 2$	\$1,590.00
35 CY of Aggregate Bedding, 1.7 tons/CY	$[(\$4.50/\text{ton} \times 1.06) + \$3.25/\text{ton haul}] \times (35 \times 1.7)$	\$477.19
	<b>Total</b>	\$9,212.65
<b>Note:</b> tax has been included only on the material items. The haul rate of \$3.25/ton was taken from a hauling rate chart for a 20-mile haul with a 12% surcharge included due to current fuel prices.		

#### E.3 CALCULATING EQUIPMENT RATES

(monthly rate/hrs/month) + operating cost

Description	Calculation	Subtotal
Trackhoe with a 1.25 CY bucket	$(\$6280/176) + \$26.80$	\$62.48/hr
Skid Steer Loader	$(\$1690/176) + \$7.90$	\$17.50/hr
Trench Box	$(\$99/176) + \$1.00$	\$1.56/hr
Trench Compactor/Roller 33.5"	$(\$3065/176) + \$7.65$	\$25.06/hr
	<b>Total</b>	\$106.60/hr
The prices listed are from the Blue Book using the monthly rental rates factored for a 176-hour month.		

**E.4 CALCULATING LABOR RATES**

For this example use a 20% labor burden, or labor overhead rate to develop a rate for the crew.

Crew

1 Foreman \$37.50/hr

2 Operators

\$32.50/hr 2 Skilled

Laborers

\$28.50/hr 2 Laborers

\$26.50/hr Straight Time

Crew \$212.50/hr Burdened

Rate Crew \$255.00/hr

**E.5 CALCULATING EQUIPMENT AND LABOR PRODUCTION AND COST**

Assume established daytime rates for removal of pipe in 10 ft of fill is 250 LF/day and for placement of 36" pipe in 10 ft of fill is 150 LF/day.

The work will be during off peak traffic times, but one cannot expect the same production at night as during the day. The project imposes liquidated damages for failing to have all lanes back open to traffic by morning rush hour, therefore the pipe will have to be replaced and the roadway operational prior to 6:30 a.m.

Assuming that a contractor will not risk trying to replace the entire length of pipe in one night, 2 shifts of work can be estimated for the pipe replacement item. In many cases, a shift for a heavy highway contractor is 10 hours due to lost time for start up and shut down of heavy construction operations and the need to get good production hours in. In the area of this project labor forces are paid time and one-half for any shift over 8 hours and are also paid an additional \$2.00/hour for working at night. Therefore the calculations for materials, labor and equipment are as follows:

Straight Night Labor Rate = Labor, Straight Time Day + 7 persons x 2.00= 212.50 + 14 (2.00) = 240.50

Description	Calculation	Subtotal
2 shifts for pipe placement	16 hours at straight time + 4 hours at time and one-half	20 hours
Equipment	106.60/hr x 20 hrs	\$2,132.00
Labor	((240.50/hr x 16) + (360.75 x 4)) x 1.20	\$6,349.20
	<b>Total</b>	<b>\$8,481.20</b>



**E.6 CALCULATING OVERHEAD AND PROFIT**

**Jobsite overhead** includes costs pertaining exclusively to the project General Conditions (contractor's on-site costs) and do not include any of the contractor's general business overhead. The size of a project (total cost in dollars) and the length of time for its completion are the main factors determining the cost of the general conditions.

**General business overhead** is the contractor's cost to operate the overall business.

**Special Conditions** are costs that are peculiar to a particular project.

1. Consider the pipe relocation as part of a larger project that specifies a completion date resulting in 510 calendar days; the estimator judges 450 calendar days are necessary (2 months less). The general conditions are estimated at \$10,000/month.

The general conditions cost are reduced by: 2 months @ \$10,000 = \$20,000.

2. Assume a construction company limited to bonding and organizational capacity of approximately \$15,000,000 gross, average complexity, construction work annually and an overhead of \$300,000. If the company could be assured of obtaining that full volume of work, the amount to be included in each bid for general business overhead would be:

$$\$300,000/\$15,000,000 = 0.02 \text{ or } 2\%.$$

However, maximum procurement is uncertain, so assume half and use:

$$\$300,000/\$7,500,000 = 0.04 \text{ or } 4\%$$

3. Assume 10% overhead and 5% profit:

Description	Calculation	Subtotal
Total of Materials, Equipment and Labor		\$17,693.85
Overhead	10%	\$19,463.24
Profit	5%	\$20,436.40
The pay item was for the LF of pipe with the bedding, excavation and flared end sections included, Price per unit:	\$20,436.40/125	\$163.49/LF

Project: _____	Sheet: _____ Of _____
Activity: _____	Project No.: _____
Checked by: _____	Date: _____

Spec Sect.:	Means Ref.# or Source:	Schedule Reference #:
Crew: _____	Unit _____ Daily Production: _____ Hours per shift: _____	Quantity required: _____ Shifts/Day: _____ Task: _____ Shift(s) Round to: _____ Shift(s) Duration: _____ Day(s)

<b>Labor</b>			
<u>Qty</u>	<u>Craft</u>	<u>Rate</u>	<u>Daily Rate</u>
_____		hrs @ _____ /hr	Daily Labor Cost _____ times _____ (cost per day) (days)  Estimated Labor Cost: _____  Estimated Manhours: _____
_____		hrs @ _____ /hr	
_____		hrs @ _____ /hr	
_____		hrs @ _____ /hr	
_____		hrs @ _____ /hr	
_____		hrs @ _____ /hr	
_____		hrs @ _____ /hr	
_____		hrs @ _____ /hr	
_____		hrs @ _____ /hr	
Daily Manhours: _____		Total Crew Rate: _____	

<u>Qty</u>	<u>Equipment</u>	<u>Rate</u>	<u>Daily</u>	
_____		x _____ /Day	0.00	Daily Equipment Cost _____ 0 times _____ 0 (cost/day) (days)  Estimated Eqpt. Cost: _____
_____		x _____ /Day	0.00	
_____		x _____ /Day	0.00	
_____		x _____ /Day	0.00	
_____		x _____ /Day	0.00	
_____		x _____ /Day	0.00	
_____		x _____ /Day	0.00	
_____		x _____ /Day	0.00	

<b>Material</b>			
		<input type="checkbox"/> From Means Data	Material Cost  Estimated Mat'l Cost: _____
		<input type="checkbox"/> From Other	
<u>Quantity</u>	<u>Unit (LF,SY, etc.)</u>	<u>At</u> <u>Rate per Unit Price</u>	
_____	LF	@ _____ per unit	
_____		@ _____ per unit	
_____		@ _____ per unit	
_____		@ _____ per unit	

NOTES: \_\_\_\_\_

	<u>Materials</u>	<u>Labor</u>	<u>Manhours</u>	<u>Equipment</u>	<u>Total</u>
<b>SUMMARY:</b>					
Factor(s): City _____					
	<b>TOTALS:</b>				
	<b>ROUNDED TOTALS:</b>				
				Overhead @ Subtotal Profit @	
<b>SPECIFICATION ITEM TOTAL:</b>					