Initial Project Estimates for Design, Right of Way, Utilities, and Construction

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

in cooperation with
Kentucky Transportation Cabinet
Commonwealth of Kentucky

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University of Kentucky

Research Report
KTC-21-01/SPR17-545-1F

Initial Project Estimates for Design, Right of Way, Utilities, and Construction

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Estimating the cost of highway construction projects is among the more challenging tasks state transportation agencies routinely deal with. Developing accurate estimates is a particularly fraught exercise during the planning and scoping phases, when projects have not been thoroughly defined and information on specifics is in short supply. While the Kentucky Transportation Cabinet (KYTC) has used several methodologies to generate initial cost estimates for design, right of way, utilities, and construction (DRUC), approaches vary between the agency's districts. This report proposes a framework for estimating DRUC-related expenses that can be adopted throughout the state. Kentucky Transportation Center (KTC) researchers developed the framework after investigating the Cabinet's current approaches to estimation and the limitation of those methods. In addition to the challenges introduced by incomplete project scopes, often staff have insufficient access to historical information, property records, and utility inventories. In many cases they also have too little time to prepare estimates. The proposed framework draws on best practices used at other state transportation agencies as well as those documented in research publications from AASHTO and the National Cooperative Highway Research Program. To speed adoption of the proposed estimation process, researchers helped KYTC set up and implement the AASHTOWare Project PreConstruction software package. Additionally, a comprehensive user manual and video tutorial were completed to help project managers transition to the new estimation framework and AASHTOWare Project Estimation.</td></tr>
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Executive Summary

Developing accurate cost estimates for highway construction projects is challenging, especially during the planning and scoping phases, when project definitions are incomplete and specifics are lacking. Historically, the Kentucky Transportation Cabinet (KYTC), has used several methods to prepare initial cost estimates for design, right of way, utilities, and construction (DRUC). Additionally, methodological approaches have varied between Districts. And some methods have been found to produce more accurate estimates than others. To improve the consistency of project cost estimates throughout the organization, KYTC asked researchers at the Kentucky Transportation Center (KTC) to analyze estimation procedures used across the agency and — based on a review of practices in use at other transportation agencies — document best practices for estimation and produce guidance which can be used to help the Cabinet's project managers apply estimation techniques uniformly.

As a starting point, researchers collected materials from each KYTC District that summarize methods, procedures, and rules of thumb for estimating DRUC costs. The level of detail in these documents varies. Several Districts have issued memos which lay out per-mile costs for design, right-of-way acquisition, utilities, and construction for two-lane and four-lane projects in urban and rural areas. When preparing estimates, most Districts rely on historical baselines (e.g., projects which are similar to the one for which an estimate is being developed) and cost worksheets. Estimates are adjusted based on project-specific contingencies the baseline data do not account for. Interviews with District personnel revealed the difficulties confronted most often when crafting estimates. Often, the amount of time afforded to create an estimate is limited, which impacts the levels of detail and quality which can be obtained. Developing an initial estimate is particularly fraught because often the project scope is not understood. Also, staff need to quickly identify field data like utilities; telephone, gas, and water lines; and other features that must be addressed during project development. Geospatial data sourced from Kentucky's Lidar database and Google Earth can accelerate the estimation process and help staff identify properties and existing features along a corridor that may complicate project work. Staff noted that improving access to historical information, property records, and utility inventories could help streamline estimation processes.

Having catalogued the estimation methods employed by Cabinet staff, researchers turned their attention to methods laid out elsewhere, including National Cooperative Highway Research Program (NCHRP) reports, guidance published by the American Association of State Highway Transportation Officials (AASHTO), and approaches used at other state departments of transportation (DOTs). While precise methods of course vary between DOTs, most agencies apply broadly similar frameworks to guide estimation activities throughout project development. During planning, which is typically 10-20 years removed from final development and letting, estimates are conceptual and intended to help an agency evaluate long-term funding requirements. Because there is considerable uncertainty in project definition at this stage, the estimate envelopes tend to be quite wide, which demands the incorporation of significant contingencies — in some cases approaching the baseline estimate. Parametric estimation techniques are most commonly used at this stage. As a project transitions through the scoping, design, and letting phases, project managers and estimators gradually accumulate more data, which can be used to generate more incisive estimates. During these phases, agencies shift to cost-based or historical bid-based estimation procedures because they allow for greater accuracy and enable more precise estimates of contingencies. Leveraging information gleaned from the literature and other agencies, researchers developed a proposed KYTC estimation process. Table E1 summarizes the key features of this framework. For each phase, it presents information on when an estimate is developed (level of project maturity), project estimate designations (what the estimate is named), the purpose of the estimate, the method(s) used to prepare the estimate, and the estimate range.

During conversations with other state DOTs, agency personnel stressed the importance of having a systematic way of implementing new estimation procedures. To facilitate adoption of the proposed estimation process, researchers assisted the Cabinet in setting up and implementing AASHTOWare Project Estimation. This software will help KYTC prepare, organize, and update estimates throughout project development. As part of this effort, researchers developed a comprehensive manual that walks users step-by-step through AASHTOWare Project Estimation's use and produced a brief video tutorial that illustrates how to navigate the software. Both deliverables were submitted to the Cabinet, and the user's manual is included in this report as Appendix D.

Table E1 Recommended Project Estimation Process for KYTC

Project Development Phase	Project Maturity (% project definition completed)	Project Estimate Designations	Purpose of the Estimate	Estimating Methodology	Estimate Range	
Planning	0 to 5%	Project Identification Estimate	Conceptual Estimating Screening & Feasibility. Estimate Potential Funds Needed (20-year plan)	Parametric	-50% to +200%	Project Cost Planning
	3% to 15%	Conceptual Project Estimate	Conceptual Estimating Prioritize Needs for Long Range Plans (10-year plan)	Historical Bid-Based with some Parametric	-40% to +100%	
Scoping	10% to 30%	Preliminary Line and Grade Estimate	Scope Estimating Establish a Baseline Cost for Project and Program Projects (SYP and STIP)	Historical Bid-Based or Cost-Based	-30% to +50%	Project Cost Management
Design	30% to 90%	Design Estimate	Design Estimating Manage Project Budgets Against Baseline (SYP, STIP, & Contingency)	Historical Bid-Based or Cost-Based	-10% to +25%	
Letting	90% to 100%	Final Plans Estimate and Engineer's Estimate	PS&E Estimating Obligate Construction Funds & Compare with Bid	Cost-Based or Historical Bid-Based Using AASHTOWare Project Software	-5% to +10%	

Chapter 1 Introduction

1.1 Study Overview

Methods used by Kentucky Transportation Cabinet (KYTC) staff to develop initial project estimates for design, right of way, utilities, and construction (DRUC) vary throughout the agency's 12 district offices. Historically, some of these methods have proved more accurate than others, resulting in inconsistent budget estimates. Because all highway design projects must include at least one alternative that meets the scope, schedule, and budget criteria laid out in the approved highway plan, developing project estimates in a consistent and accurate manner is imperative. Wanting to establish a uniform method or framework for preparing initial project cost estimates that enhances current practices, the Cabinet asked Kentucky Transportation Center (KTC) researchers to document KYTC estimation methods, investigate estimation strategies adopted by other state transportation agencies, and propose a new framework based on accepted best practices.

1.2 Research Objectives

When it KYTC commissioned SPR 17-545, three research objectives were identified: (1) with the assistance of KYTC personnel, identify all methods and templates currently used to generate initial project estimates; (2) develop a method and template to generate and present uniform estimates for (DRUC) phases; and (3) begin development of a searchable database to assist users in preparing initial project estimates.

1.3 Structure of the Report

The main portion of this document is divided into four additional chapters, the contents of which are summarized in Table 1.1.

Table 1.1 Report Structure

Chapter	Contents
1. KYTC Estimating Procedures	• Discusses forms and policies which underwrite current estimation practices, interviews with staff in several districts, and estimation methods
2. Literature Review	• Offers a general introduction to project cost estimates, synthesizes estimation practices used at 11 state transportation agencies, and reviews the results of an AASHTO survey focused on cost estimates
3. Best Practices and Potential Estimating Tools	• Reviews best practices and proposes an estimation framework to be implemented at KYTC
4. Conclusion	• Offers final thoughts on the proposed estimation framework and implementation of AASHTOWare

Four appendices include supplemental information, including a draft version of the AASHTOWare manual which Cabinet staff may use to guide implementation of the proposed estimation framework (Appendix D).

Chapter 2 Kentucky Transportation Cabinet Estimating Procedures

This chapter summarizes KYTC forms and policies to which underwrite current estimation procedures. Its focus scales from pre-design activities to broader issues related to broader project design and delivery

In the Highway Design Manual, Exhibit 200-01, the Project Delivery Core Processes Flowchart shows project identification and scope all the way through construction and maintenance, which is a broader overview of essential functions that comprise project delivery. Exhibit 200-07 Preliminary Design Example Flow Chart for Projects with a Finding of No Significant Impact (FONSI) shows “steps that may occur during the preliminary design process” which include those noted previously and listed in the Highway Design Manual (HD 203.2). The key decision points are listed in HD 203.2 as follows: purpose and need, public meeting (first), review of alternatives, scope of impacts, public meeting (second), preliminary line and grade meeting, finalize environmental assessment, public hearing, alternative confirmed, FONSI and location approval, and final design.

Narrowing the focus to pre-design, the Highway Design Manual, HD-202, details a number of activities. According to the KYTC Highway Design Manual (HD-202.1): “Projects may be proposed by various entities including area development districts (ADDs), district offices, and local officials to address safety, operational, or other transportation system needs.”[1] At this point a Project Identification Form (PIF), described in Table 14 below, is completed; this includes DRUC estimates. PIFs contain a preliminary cost estimate (see the Highway Design Manual Exhibit 200-02 for an example). A Legislators’ Official Request for Project Cost Estimate and Consideration may also be the vehicle for inclusion in the plan.

Figures 2.1 and 2.2 and were constructed in consultation with the Study Advisory Committee (SAC) and represent the project development processes that lead to the development of a project schedule and funding, and the process that results in a project estimate including the request, receipt of the request, and development of estimate, respectively.

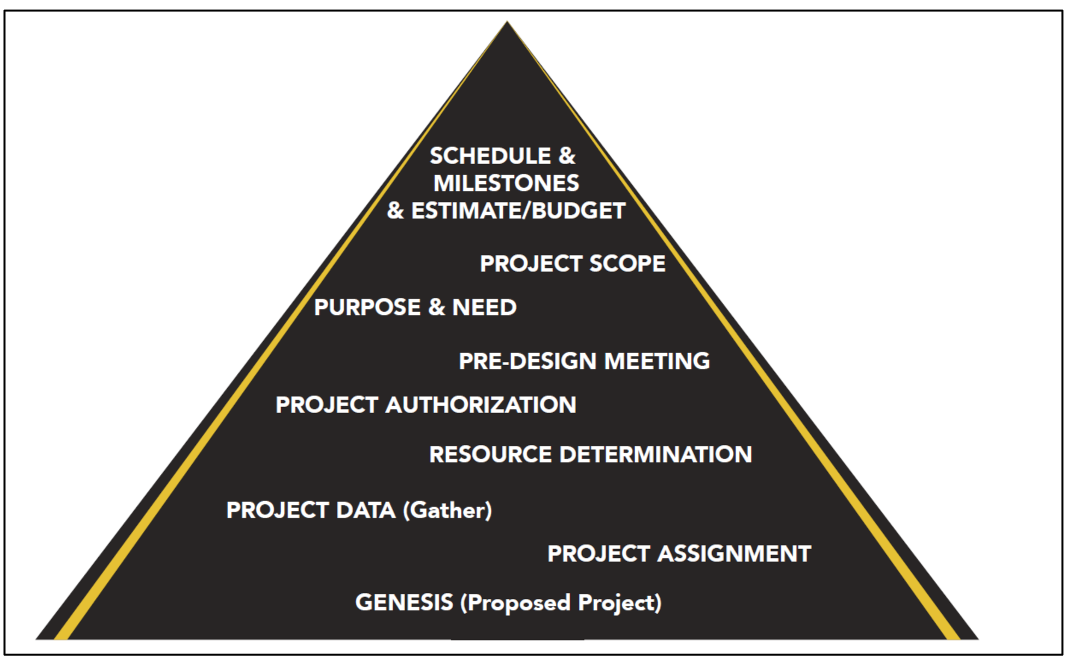

Figure 2.1 Project Development Path to Project Estimates

[1] http://transportation.ky.gov/Organizational-Resources/Policy%20Manuals%20Library/Highway%20Design.pdf

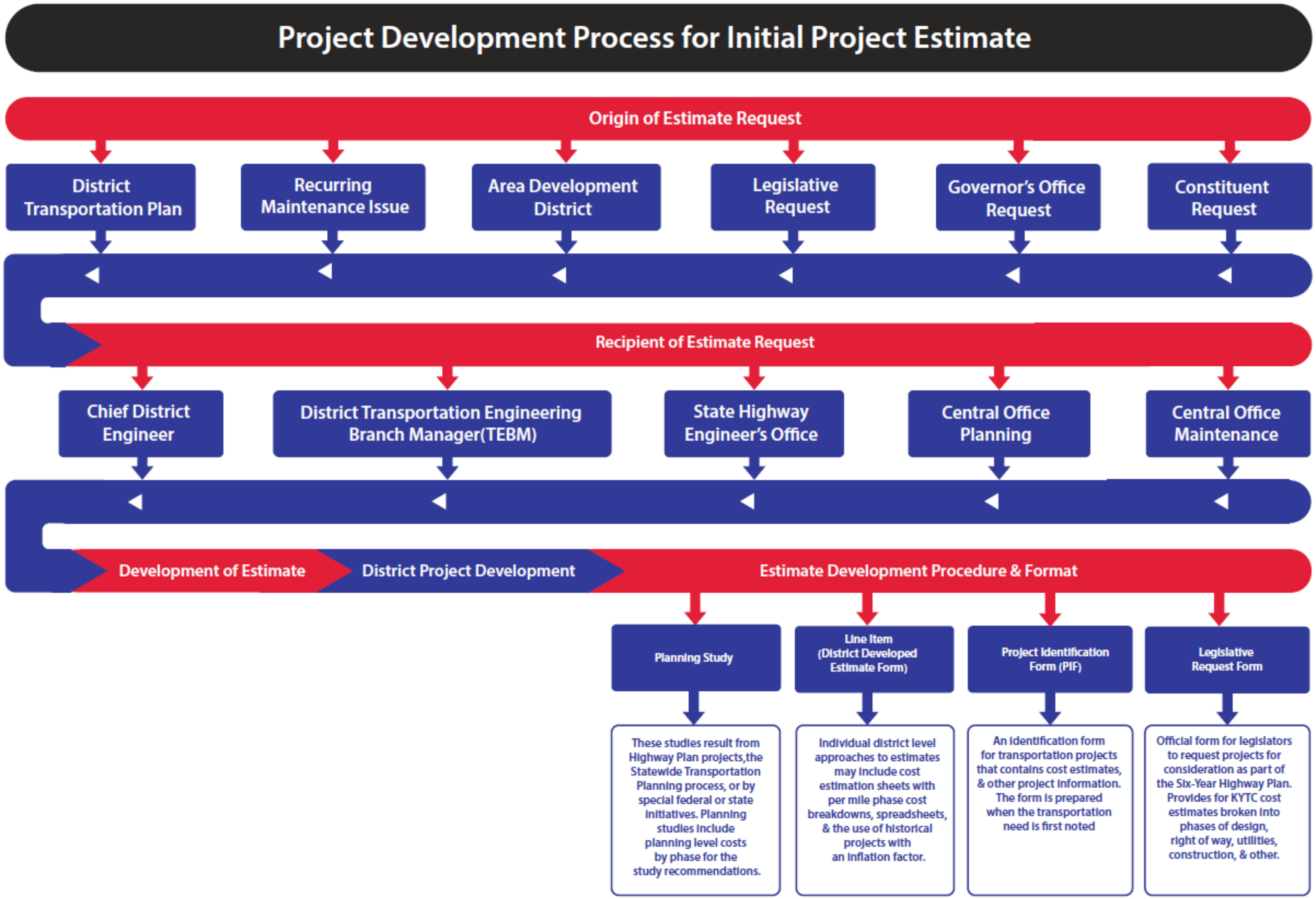

Figure 2.2 Project Development Process for Initial Project Estimate

The Division of Program Management then develops a recommended Highway Plan for the legislature in even-numbered years. An enacted Highway Plan emerges from the legislature that includes proposed projects and estimated costs for the DRUC phases. A sample page from the 2016 Highway Plan[2] is shown in Figure 2.3.

[2] http://transportation.ky.gov/Program-Management/Highway%20Plan/2016HighwayPlanAll.pdf

KENTUCKY TRANSPORTATION CABINET
SIX YEAR HIGHWAY PLAN

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18 MAY 2016

FY - 2016 THRU FY - 2022

COUNTY	ITEM NO. & PARENT NO.	ROUTE	LENGTH	DESCRIPTION	FUND-SCHEDULING INFORMATION
FAYETTE	2006 07 - 8341.00 Parent No.: 2006 07 - 8341.00	US-60	5.850	SCOPING STUDY TO RECONSTRUCT/WIDEN US-60/WINCHESTER ROAD FROM MAN-O-WAR BOULEVARD TO THE CLARK COUNTY LINE. (06CCN)(12CCR) Milepoints: From:13.4 To: 19.25 Purpose and Need: RELIABILITY / SCOPING STUDY(O)	FUNDING PHASE YEAR AMOUNT SP P 2016 $280,000 Total $280,000
FAYETTE	2006 07 - 8342.00 Parent No.: 2006 07 - 8342.00	KY-4	3.300	SCOPING STUDY TO RECONSTRUCT/WIDEN KY-4/NEW CIRCLE ROAD FROM NEWTOWN PIKE TO WINCHESTER ROAD. (06CCN)(12CCR) Milepoints: From:9.4 To: 12.7 Purpose and Need: RELIABILITY / SCOPING STUDY(O)	FUNDING PHASE YEAR AMOUNT SP P 2016 $340,000 Total $340,000
FAYETTE	2008 07 - 8507.00 Parent No.: 2008 07 - 8507.00	CS-2548		COMPLETE CONSTRUCTION ON POLO CLUB BOULEVARD AT DEERHAVEN LANE AND TODDS ROAD. (08CCN)(FUNDING SUBJECT TO FISCAL CONSTRAINT PENDING MPO TIP) Milepoints: From: To: Purpose and Need: RELIABILITY / NEW ROUTE(O)	FUNDING PHASE YEAR AMOUNT SLX C 2016 $1,550,000 Total $1,550,000
FAYETTE	2014 07 - 8801.00 Parent No.: 2014 07 - 8801.00	KY-4	1.219	SOUND BARRIERS ALONG OUTER LOOP OF NEW CIRCLE ROAD BETWEEN TATES CREEK ROAD AND NICHOLASVILLE ROAD. (14CCN) Milepoints: From:17.778 To: 18.997 Purpose and Need: RELIABILITY / TRANSP ENHANCEMENT(P)	FUNDING PHASE YEAR AMOUNT SPP C 2016 $4,600,000 Total $4,600,000
FAYETTE	2014 07 - 8804.00 Parent No.: 2014 07 - 8804.00	KY-4	1.636	SOUND BARRIERS ALONG INNER LOOP OF NEW CIRCLE ROAD BETWEEN TATES CREEK ROAD AND ALUMNI DRIVE. (14CCN) (16CCR) Milepoints: From:16.142 To: 17.778 Purpose and Need: RELIABILITY / TRANSP ENHANCEMENT(P)	FUNDING PHASE YEAR AMOUNT SPP C 2017 $5,000,000 Total $5,000,000
FAYETTE	2014 07 - 8805.00 Parent No.: 2014 07 - 8805.00	KY-4	1.219	SOUND BARRIERS ALONG INNER LOOP OF NEW CIRCLE ROAD BETWEEN TATES CREEK ROAD AND NICHOLASVILLE ROAD. (14CCN) Milepoints: From:17.778 To: 18.997 Purpose and Need: RELIABILITY / TRANSP ENHANCEMENT(P)	FUNDING PHASE YEAR AMOUNT SP C 2018 $5,000,000 Total $5,000,000
FAYETTE	2014 07 - 8806.00 Parent No.: 2014 07 - 8806.00	KY-4	1.636	SOUND BARRIERS ALONG OUTER LOOP OF NEW CIRCLE ROAD BETWEEN TATES CREEK ROAD AND ALUMNI DRIVE. (14CCN) Milepoints: From:16.142 To: 17.778 Purpose and Need: RELIABILITY / TRANSP ENHANCEMENT(P)	FUNDING PHASE YEAR AMOUNT SP C 2019 $5,000,000 Total $5,000,000
FAYETTE	2014 07 - 8812.00 Parent No.: 2014 07 - 8812.00	KY-57	.380	SIDEWALK INSTALLATION ON BRYAN STATION ROAD FROM PREAKNESS DRIVE TO HERMITAGE DRIVE. (14CCN) Milepoints: From:.912 To: 1.292 Purpose and Need: RELIABILITY / TRANSP ENHANCEMENT(P)	FUNDING PHASE YEAR AMOUNT SPP C 2016 $250,000 Total $250,000
FAYETTE	2016 07 - 8901.00 Parent No.: 2016 07 - 8901.00	-		EXTEND CITATION BLVD. (16CCN) Milepoints: From: To: Purpose and Need: NEW ROUTES / NEW ROUTE(O)	FUNDING PHASE YEAR AMOUNT SPP D 2017 $1,000,000 SP R 2018 $1,300,000 SP U 2019 $1,100,000 SP C 2020 $8,100,000 Total $11,500,000

Figure 2.3 Sample Page from 2016 Highway Plan

The Project Development Branch Manager (PDM) assigned to an individual project then gathers existing data from various sources, including Planning Study results. Once this is done the PDM uses the Request for Funding Authorization (TC 90-122) and Project Spend-Down (see Exhibit 200-04 in the Highway Design Manual for an example) to request funds. A Design Funds Documentation Summary to develop estimates of funds is also needed. Design Memorandum No. 4-98 notes that, "All projects shall be scoped at least one year prior to the authorization of project design."[3] The Division of Program Management prepares the Project Authorization form (TC 10-1). Funding may be authorized for activities including planning and DRUC phases. After authorization, activities such as the pre-design meeting, purpose and need, project scope, schedule and milestones, and environmental overview are set or conducted.

2.1 KYTC Forms and Policy

KYTC policy manuals were searched using keywords such as "estimates" and "estimating" to gather documentation and forms related to the estimating process. This includes estimating that is done outside of the initial project estimates but is useful for understanding KYTC's guidance on the entire process. A list of the forms and studies and a brief description are in Table 2.1, while the relevant sections from various policy manuals are noted in Appendix B along with links to the appropriate manuals.

Table 2.1 KYTC Forms and Studies

Form/Study	Description
Data Needs Analysis (DNA) Studies	DNAs are brief, limited, small scale studies used to gather basic existing data; to identify potential project development concerns; and to better define the project purpose, need, and scope. They provide basic planning-level information on all smaller projects, such as bridge replacements or intersection realignments that do not require lengthy, detailed planning studies. DNAs include planning level cost estimates for design, ROW, utilities, and construction, and are historically done for consultant projects. DNAs are recommended on projects that have not had a planning phase, and they are required on all consultant projects that lack a planning study. Occasionally, DNAs are completed for larger, unexpected projects.
Planning Studies	These studies result from Highway Plan projects, the Statewide Transportation Planning process, or by special federal or state initiatives. Several key elements have been included within the study process. These include preliminary purpose and need, public input, project alternatives, socioeconomic and environmental impacts, cost-effectiveness, and scheduling. Planning studies also include planning level costs by phase for the study recommendations.
Project Identification Form (PIF)	An identification form developed by KYTC Division of Planning for all transportation projects that contains a problem statement, project description, specific geometric and analytical data, preliminary cost estimates (includes itemized and per mile options for DRUC), and assumptions for the project. The form is prepared when the transportation need is first noted and the information is entered into the Unscheduled Project List database and is updated periodically. Maps and pictures for the project may also be attached. (See Exhibit 200-02 in the Highway Design Manual for an example).
Purpose and Need Statement	The Purpose and Need Statement has three parts: The Purpose, the Need, and Goals and Objectives. The Purpose defines the transportation problem to be solved. The Need provides data to support the problem statement (Purpose). The Goals and Objectives describe other issues that need to be resolved as part of a successful solution to the problem. It is necessary for developing all projects, is used to guide the development of alternatives, and it will be a fundamental element when developing criteria for selection between alternatives.

[3] http://transportation.ky.gov/Highway-Design/Memos/Design%2004-98.pdf

Project Scoping Summary (TC 61-6)	Provides information on: project description (justification, project length, classification, proposed design speed, current and projected ADT, etc. The project description should include a draft purpose and need statement.), roadway characteristics, potential alternatives, design criteria, proposed access control, cost estimates, possible funding types, potential environmental actions, right-of-way requirements, number of types of drainage structures anticipated, work to be performed by KYTC, and other comments. Prepared by or for the district preconstruction engineer on every Six-Year Highway Plan project one year prior to the authorization of project design.
Request for Funding Authorization (TC 90-122)	Includes project information and funding requests for planning and design, right of way, and utilities phases along with relevant information for these phases. (See Exhibit 200-03 in the Highway Design Manual for an example).
Right of Way Cost Estimate (TC 62-203)	Includes estimated costs for acquisitions and court costs, relocation assistance, property management, and known environmental mitigation. The form can be used for estimates for pre-study, update for inspection, request funds, or request additional funds.
Utility Estimate Form	Allows for estimates (pre-study, update for inspection, request funds, or request additional funds) across classes (A- Final Plans, B- Final Joint Inspection, C- Preliminary Line Inspection, D- Study, E- Pre-Study); includes basic project information and allows for alternates.
Legislators' Official Request for Project Cost Estimate and Consideration	Official form for legislators to request projects for consideration as part of the Six-Year Highway Plan. Includes location, purpose, and scope. Provides for KYTC cost estimates for legislators broken into phases of design, right of way, utilities, construction and other.
Project Authorization (TC 10-1)	Upon project initiation cost estimates for various phases are included; as noted in the Highway Design Manual "higher-quality initial cost estimates will reduce changes to the *Project Authorization* during project development." (See Exhibit 200-06 in the Highway Design Manual for an example).
Design Funds Documentation Summary	Provides general costs associated with a design project including project management, environmental analysis, bridges, geotech, design, planning, and other areas such as lighting and legal activities. (See Exhibit 200-05 in the Highway Design Manual for an example).
Expedited Bridge Replacement Program (EBRP)	A preprogramming activity used for simple bridge replacement projects on roads classified as local or collector with ADT < 1,500. Proposed bridges will have no major environmental impacts, exhibit minimal drainage issues, and induce minimal scour. Proposed projects should not encroach on a regulatory floodplain; if they do, further analysis is warranted. Final study functions as a scoping document, environmental document, and DES for qualifying bridges.

KYTC Central Office staff have also begun developing a cost per mile report that includes details from six years of past projects such as authorized and expended funds for each phase of DRUC. This spreadsheet is available on the KYTC Program Management intranet site and continued development and refinement of such tools is likely to provide valuable cost information to project managers. A snapshot of this tool is shown in Figure 2.4

District	Item No.	County	RouteNo.	BMP / EMP	Length	No. of Lanes	Type of Work	Description	Road Engineer	Bridge Engineer	ROW Total Parcels	ROW Relocations Complete	Utility Agreements Initiated	Utility Relocations Initiated	D Phase Authorized Amount	D Phase Funds Expended	ROW Phase Authorized Amount	ROW Phase Funds Expended	U Phase Authorized Amount	U Phase Funds Expended	C Phase Authorized Amount	C Phase Funds Expended	Award Amount	Award Date
1	902.00	BALLARD	US-51	5.1 / 5.2	0.1		SAFETY-HAZARI	21),MARSHALL US641(MP 0-5) US68(MP 27-28),KY348(MP 6.35-6.49) KY348(MP 5.8-6.0),MCCRACKEN US45(MP 0.0-5.0),TRIGG US68(MP 8-19).(2011BOP)													890000	185484.14	159009.25	3/1/2013
1	1143.00	BALLARD	KY-358	14.03 / 14.07	0.04		BRIDGE REPLACE	CREEK APPR. 0.5	E A PARTNERS	HAWORTH, MEYER	4				370000	307029.16	150000	28155.41	170000	28155.41	847680	672197.29	706335.74	2/26/2016
1	8501.00	BALLARD	US-60	9.55 / 10.2	0.655		SAFETY-HAZARI	ALLARD COUNTY	QUEST ENGINEER	N/A	7	0	4	4	250000	183061.95	100000	60649.52	560000	60649.52	989993	1076346.83	899994.06	3/28/2012
1	900.00	CALLOWAY	KY-1327	0.4 / 0.8	0.4		SAFETY(P)	AY COUNTY SCH	HDR/STATEWIDE		11				280000	241033.22	250000	66119.22	380000	66119.22	969853	768091.23	843350.2	2/11/2015
1	909.00	CALLOWAY	KY-94	7.6 / 7.7	0.1		SAFETY(P)	I660 IN CALLOWAY COUNTY, AND US 45 AND KY 1276 IN GRAVES COUNTY. (2014BOP)											4000		197294	225796.74	179358.13	4/5/2016
1	1061.00	CALLOWAY	KY-1536	0.27 / 0.34	0.07		BRIDGE REPLACE	CLAYTON CREEK	DEPARTMENT-D01	DEPARTMENT-WOL	6		5	4	250000	141776.62	530000	52457.06	75000	52457.06	677702	632937.78	564752.04	6/11/2014
1	1132.00	CALLOWAY	KY-893	22.87 / 22.97	0.1	2	BRIDGE REPLACE	REPLACE BRIDGE ON KY-	JOHNSON, DEPP & QUISENBERRY		2				260000	236821.99	175000	20188.29	170000	20188.29	887227	743838.53	739356.05	8/28/2015
1	1136.00	CALLOWAY	CR-1464	0.09 / 0.19	0.1		BRIDGE REPLACE	REPLACE BRIDGE ON CR-	Bacon, Farmer, W	DEPARTMENT-KILG	1				200000	166750.71	60000	1426	75000	1426	354672	293852.8	283737.92	11/5/2014
1	9000.00	CALLOWAY	KY-280	0 / 9.21	9.209		SAFETY-HAZARI	Y 94 EAST OF MU	HAWORTH, MEYER & BOLEYN, INC.						250000	203160.68					1692516	1449688.5	1538651.28	10/2/2015
1	905.00	CRITTENDEN	US-60	21.7 / 21.9	0.2		SAFETY-HAZARI	URCH ROAD (MP 21.7) TO 0.351 MILES WEST OF TRADEWATER BOTTOMS ROAD (MP 21.9) (2012BOP)													150000	66367.77	62624	10/9/2013
1	1144.00	FULTON	KY-1909	0.71 / 0.75	0.04		BRIDGE REPLACE	CHIEN CREEK S (	J.M.C.		1				260000	204025.43	100000	9631.19		9631.19	526764	479888.16	438970	10/2/2015
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1	901.00	GRAVES	KY-994	3.81 / 3.9	0.092		SAFETY-HAZARI	INAWAY LANE T	Department-D01	N/A									8000		251000	192085.22	162472.46	12/16/2011
1	904.00	GRAVES	US-45	25.34 / 25.39	0.05		SAFETY-HAZARI	E INTERSECTION OF US 45 AND KY 408 (M.P. 25.361). 2012BOP											2124		182333	200679.68	129403.51	1/3/2014
1	1041.00	GRAVES	CR-1430	0.64 / 0.86	0.22		BRIDGE REPLACE	REPLACE BRIDGE OVER P&L RAILWAY (C179) 0.2MI E	DEPARTMENT-D01	WMB, INC., ENGINE	6		0	0	335835	313956.47	320000	29746.02	325000	29746.02	1215858	1112144.33	972686.31	11/28/2012
1	1056.00	GRAVES	KY-97	8.08 / 8.15	0.068		BRIDGE REPLACE	EEK (B52) 0.13 M	DEPARTMENT-D01	Department-CO	4				250000	244099.68	160000	10769.26	160000	10769.26	670678	506604.07	558898.07	11/30/2015
1	1058.00	GRAVES	KY-945	5 / 5.08	0.088		BRIDGE REPLACE	K (B187) 0.13 MI	BFW, Inc.	BFW, INC.	3	0	3	3	260000	253307.6	200000	11075.21	225000	11075.21	807174	1079402.2	1061739.37	10/9/2013
1	1060.00	GRAVES	KY-97	16.59 / 16.65	0.062		BRIDGE REPLACE	K (B46) 0.5 MILE	BFW, Inc.	BFW, INC.	5	0	4	4	250000	223717.07	250000	33653.13	300000	33653.13	1129125	963894.03	903300	12/4/2013
1	1134.00	GRAVES	KY-1748	3.81 / 3.91	0.1		BRIDGE REPLACE	REPLACE BRIDGE ON KY-	Bacon, Farmer, W	HAWORTH, MEYER	2				305000	237770.45	100000	7516.5	195000	7516.5	599098	560575.65	499248.06	11/5/2014
1	1137.00	GRAVES	CR-1194	0.62 / 0.72	0.1		BRIDGE REPLACE	REPLACE BRIDGE ON CR-	JOHNSON, DEPP & QUISENBERRY		3				240000	225562.54	75000	6136.63		6136.63	487576	451924.72	406313.22	8/28/2015
1	1138.00	GRAVES	KY-1241	10 / 10.2	0.2		BRIDGE REPLACE	MAYFIELD CREEK	DEPARTMENT-D01	DEPARTMENT-VAN	0		0	0	25000	64098.05	10000	0	10000	0	900000	900225.99	803766.14	5/2/2012
1	1146.00	GRAVES	KY-945	7.2 / 7.24	0.04		BRIDGE REPLACE	REPLACE BRIDGE ON KY	E A PARTNERS		3				270000	255524.76	150000	2325.83		2325.83	513366	452104.55	427804.65	5/4/2015
1	1155.00	GRAVES	CR-1381	0.6 / 0.7	0.1		BRIDGE REPLACE	D (CR 1381) 0.6 (	CRAWFORD, J.M. AND ASSOCIATES,		4				250000	173878.71	75000	7606.59	50000	7606.59	1330667	1164134.45	1108889.44	11/4/2015
1	2041.00	GRAVES	KY-97	/			PAVEMENT REHA	STATE LINE TO THE COOTER CREEK BRIDGE NORTHWEST OF BELL CITY. (2012BOP)													196969	193128.1	372578.2	7/23/2014
1	2042.00	GRAVES	KY-121	/			PAVEMENT REHA	.069 MILE NW OF KY 80 INTERSECTION TO KY 58 IN MAYFIELD. (2012BOP)													212867	236774.85	372578.2	7/23/2014
1	1018.00	HICKMAN	KY-307	4.51 / 4.92	0.406		BRIDGE REPLACE	(SR=15.4)(INCLUD	CRAWFORD, J.M.	DEPARTMENT-WOLFE					615175	360154.91					5503636	5448429.16	4785770	4/3/2013
1	1057.00	HICKMAN	KY-1037	0.45 / 0.51	0.062		BRIDGE REPLACE	ERN RAILROAD (I	Florence & Hutche	FLORENCE & HUTC	2				360000	359396.32	150000	32001.75	350000	32001.75	1799781	1518791.24	1439825	9/4/2012
1	1059.00	LIVINGSTON	KY-453	14.13 / 14.2	0.064		BRIDGE REPLACE	RANCH (B29) 0.1	ICA ENGINEERING	ICA ENGINEERING	10				325000	322467.61	240000	155543.67	400000	155543.67	1325663	1109004.92	1104719.49	11/5/2015

Figure 2.4 KYTC Cost Per Mile Spreadsheet

There are also some relevant sections from the Kentucky Revised Statutes that pertain to estimating. KRS 176.440 provides that the state highway engineer "shall provide a cost estimate for any project that a member of the General Assembly desires to be considered for advancement or inclusion in the six (6) year road plan." KRS 176.430 pertains to the six-year road plan and requires that each project include estimated costs for each phase as well as an estimated cost to complete the project. The full text of these statutes is included in the Appendix C.

2.2 District Interviews

To better understand KYTC's current approach to estimating, interviews were conducted with three district offices, Districts 1, 7, and 12. The results of those interviews are summarized here and generally focused on two estimating scenarios: estimates that were required to be done quickly (usually same day or next day) and estimates that allowed for proper preparation (approximately 10 working days). The other districts were queried for information on any documentation or tools that they use to generate estimates. District 5 provided detailed information regarding their estimating procedures, thus their response is also included here.

District 12 staff commented that they usually do not have much time to prepare an estimate. Often, they are asked to assemble estimates quickly, although ideally two weeks would provide more accurate estimates. Staff rely a lot on historical experiences and intuition when developing initial estimates, especially when there are time constraints. When the district receives a request for an initial project estimate, they will begin by examining the project scope and the amount of time they have been allocated to prepare the estimate. The amount of time they have to develop the estimate influences its quality and the amount of detail that goes into it. They also look at the office's records to see what information on the request exists. If Planning does not have information, the design team and project managers will be consulted to estimate costs (a parametric estimate). Quick estimates can be aided by the use of Lidar and Google Earth. When projects are well-defined, better estimates can be prepared, otherwise costs may be inflated due to many unknowns. PIF's are generally not being created since new estimates are rarely asked for, although some have been compared and adjusted based on historical data.

District 7 staff noted that first estimates often pose the most challenges because staff must identify what utilities, telephone and water lines, and other features will need to be accounted for and dealt with. If staff are given several days they will develop a line item estimate, using photographs, Google Earth, or other materials related to the proposed project. They will also study property types and consult the Property Valuation Administrator's records. When estimates must be done quickly, then cost per mile or historical bid-based techniques will be utilized. In this scenario, right of way and utility costs are based on the number of miles and either high, medium, or low impacts. If similar projects exist and line items are up to date, then an estimate can be done relatively quickly, however if there is no prior information the tendency is to lean towards a high-end estimate to allow for contingencies. Staff indicated they would like to have better access to historical data. Estimates can also be done quickly if the project is fairly simple, such as a bridge project with only a handful of parcels. Digital copies of estimates are sometimes maintained, so staff noted that having a more comprehensive approach to storing past estimates for future reference would be useful. PIF's can either be dated or relatively accurate, however a number of projects in the six-year plan have older PIF's which may require new estimates for accuracy. PIF's were also mentioned as a potentially good place to document estimates and project information, if kept up to date. Finally, DNAs generally have better estimates but staff must estimate alternatives in the DNA as well and would prefer a cost per mile estimate as opposed to alternatives.

District 1 utilizes a cost estimate sheet that has per mile average costs for each phase based on different project types as well as on different elements of each phase, such as types of utilities. The numbers from the sheet are based on District 1 projects and allow planning staff to generate quick estimates without having to consult other areas. Most estimates will conform to the sheet unless it is a rare project type. The district will have meetings to discuss high-priority projects in which they will review the project on Google Earth, review as a group, and develop a rough estimate such as cost per mile. When examining projects via Google Earth, staff will look for particular features such as property and utility types that may indicate if an estimate will fall on the low or high end of estimate ranges. If a request for an estimate requires a quick turnaround of a few days, then staff will attempt to visit the site and identify any potential red-flag issues. Estimates that are done in a few hours are based on knowledge of similar previous projects and the cost estimates sheet. Staff noted that underestimating costs is not infrequent in design, especially on smaller bridge projects. In terms of documentation, local Area Development District projects will be entered as a PIF with information on how the estimate was generated and the individual responsible. However, staff mentioned that the PIF system can be cumbersome and does not allow attachments, which could be useful. If estimates are produced via the Legislative Request Form, then no additional recordkeeping is done which underlies the difficulty that staff often face for many estimates in backtracking from a dollar amount to determine how it was developed.

District 5 provided comprehensive information on their estimating process, broken apart into design, right of way, utilities, and construction. The district does maintain a cost estimate sheet similar to other districts with per mile average costs across phases. Generally, design costs are estimated to be approximately 10 percent of the construction estimate with a minimum of $200,000 for consultant contracts. If similar projects are available for comparison, they will examine those design costs using per mile comparisons. District personnel will also account for any potential large structures or unique features that may impact costs. Right of way estimates involve first examining the number of parcels potentially affected using Property Valuation Administrator plans if available. Lacking any old plans or PVA information, the district will examine the corridor and make an assumption regarding the amount of right of way that will be needed. Once this is done, estimates of the price per square foot for property in the area is generated using projects in the same area or the cost estimate sheet and classification of the area as residential, commercial, or rural. To complete the right of way estimate, a $7,000 per parcel administrative fee and 40 percent legal fee is added. To begin a utility estimate, staff take inventory of resources that could be used such as Kentucky Infrastructure Authority maps, pipeline maps, water company maps, and other documents. This, along with on-site inspections of overhead lines, water meters, and manholes, can provide good information regarding potential issues. Generally, a worst case scenario is used for utilities in which KYTC pays for many or for all the utilities to be relocated, with unit prices being derived from the district's per mile cost estimates sheet. Finally, construction costs are estimated using similar, recent projects. For example, bridge replacements are done using a spreadsheet with various categories of square footage to help generate estimates.

2.3 District Cost Estimating Strategies

After interviewing District 1 and receiving their cost estimation sheet, KYTC district offices were asked about their initial estimating practices; specifically, about whether they use a standard set of tools, forms, or methods to generate initial estimates. Table 2.2 summarizes the responses. A number of districts (e.g., 1, 4, 5, 8) have developed cost estimation sheets, which provide a baseline for developing initial estimates. These sheets contain both high-level guidance and detailed cost breakdowns. A number of districts also have spreadsheets that are used to facilitate estimation; many of these contain fields prepopulated with multipliers, which enable them to automatically calculate the price of specific items (e.g., a water line of a specified diameter). Districts' estimating practices are informed by historical projects in most cases. For a proposed project, staff identify similar previous projects as a starting point. They examine the costs of those projects and generate estimates in light of these comparisons, knowledge of current construction pricing, and other contextual factors that can influence total expenses. Several of the districts keep their cost estimation sheets or spreadsheets up-to-date, although the frequency of updates is dictated in part by how quickly, and to what extent, construction costs fluctuate.

Table 2.2 Strategies for Preparing Initial Estimates Across Districts

District	Tools and Methodologies
1	• Uses a cost estimation sheet that contains high-level information for four categories: per mile costs for construction, right-of-way, utilities, and design • Sheet contains detailed price breakdowns of key items in each category • Estimates are adjusted to factor in project context, inflation, and contingencies
2	• Most estimates prepared using historical or currently under design projects as a baseline
3	• Bases estimates on similar historical projects • Documents the information used for, and justification underlying, estimate in a spreadsheet that narrates different aspects of a project (e.g., average daily traffic; assumptions about right-of-way, utilities, and design; key structures; project context; and environmental impacts)
4	• Uses a cost estimation sheet that contains high-level information for four categories: per mile costs for construction, right-of-way, utilities, and design

	• Sheet contains detailed price breakdowns of key items in each category • Maintains a separate spreadsheet with cost per mile estimates for several project types (e.g., two-lane rural major/minor widening, three- and five-lane urban) • Maintains another spreadsheet to prepare detailed estimates of items (e.g., right-of-way for a variety of parcel types, water and gas lines with different characteristics); o Spreadsheet automatically calculates prices
5	• Uses a cost estimation sheet that contains high-level information for four categories: per mile costs for construction, right-of-way, utilities, and design • Maintains a spreadsheet that assists with the calculation of detailed estimates for each category (e.g., right-of-way according to parcel type, water and gas lines with different characteristics, construction of particular features, material costs, excavation, and borrow)
6	• Maintains a spreadsheet that contains information on historical projects o Items include: original and ultimate design costs, utility costs, right-of-way cost, actual construction costs, information on consultants, and roadway attributes • Estimates prepared using historical data — analogous estimates are the principal method, with appropriate inflation and scaling factors accounted for
7	• Maintain a cost estimation sheet on file that contains high-level information for four categories: per mile costs for construction, right-of-way, utilities, and design • Most estimates prepared using historical projects as a baseline o Many estimates are line-item estimates that consider individual project components
8	• Uses a cost estimation sheet that contains high-level information for four categories: per mile costs for construction, right-of-way, utilities, and design • Sheet contains detailed price breakdowns of key items in each category • Prices are updated on a project-by-project basis to account for inflation and contingencies
9	• Begins with baseline figures (based on previous projects) to estimate construction costs; prices are adjusted based on project location and job type • Design estimate is developed after construction estimate, taking into account project type and size, environmental challenges, and geotechnical considerations • Right-of-way — Google Maps is used to count houses and structures (for rural projects); for urban projects, staff make field visits to judge impacts • Maintains a list of average utilities costs (e.g., power, water, gas, telephone, cable, sewer, and fiber)
10	• Develops estimates based on similar historical projects • Maintains a price list of geotechnical costs for various items
11	• Prepares detailed estimates for nearly every project • Lidar data and Inroads used to produce approximate excavation numbers and estimates for structural costs, pavement, and drainage • Prices based on costs of recently constructed projects in the area, with additional contingency added in (approximately 30 percent) • A worksheet is used to estimate utility costs • Right-of-way is estimated based on recent projects in the area
12	• Maintains documents with details on average cost per mile • Costs are adjusted to account for project type, location, and contingencies

Chapter 3 Literature Review

3.1 Introduction

This chapter reviews the project cost estimating methodologies used by eleven state departments of transportation (DOT). Our focus rests mainly on the methods each DOT has implemented and how methodologies vary according the project context or where a project is in the project development process. It serves as an introduction to different cost estimating techniques[4] as well. Most of the information presented in this chapter draws from state DOT guidance and manuals on project estimating and a recent AASHTO synthesis on project estimating methodologies (2013), however, content from NCHRP reports and other documents (e.g., Anderson et al., 2007, Molenaar et al., 2011) have informed its development as well. Molenaar's (2011) report directly informed the AASHTO report discussed in-depth below. The chapter opens by defining and explaining the estimating techniques that are most commonly used by state DOTs; it then provides detailed overviews of individual state DOT practices. The length of the state summaries vary based on the amount of information agencies have made publicly available. Several states have compiled extremely detailed cost estimation manuals that walk readers through the specifics of different estimation techniques and how they are applied at different project stages (e.g., Minnesota, Washington). The guidance from other states is more laconic, presenting readers with only skeletal outlines of the processes they use, or are primarily devoted to explaining the functionality of in-house or proprietary estimation software. Our focus rests principally on the longer, more detailed manuals because they offer the most fully articulated ideas, which could be used to organize a cost estimation manual for KYTC.

Although DOTs have developed a variety of methods and systems to estimate project costs, estimating follows the same general guidelines irrespective of state — early in project development (5-20 years from letting), DOTs rely on conceptual estimates that incorporate significant contingencies, which reflect inherent uncertainties with factors such as project definition, inflation, and market conditions; as a project moves toward letting, DOTs progressively refine their estimates to bolster their precision and accuracy. While planning-level estimates tend to be parametric (e.g., cost per mile, cost per square yard), estimates prepared during design; scoping; and plan, specifications, and estimate (PS&E) often combine historical bid-based estimates and cost based estimates (Table 3.1 defines estimating terms; see the next section for an in-depth discussion of different techniques) that are commonly employed in the manuals reviewed). There is also considerable variability in who is responsible for estimating project costs. During early stages of project development, this responsibility often lies with the designer or an estimator based in the project's home district. But in some states high-level estimates are developed by the central office. Estimates developed later in project development, as a project nears letting (e.g., PS&E estimates, engineer's estimates), are generally prepared by the central office with input from district staff. One important point to keep in mind is that terminology differs among DOTs, as do the number and type of estimates prepared during the final stages of project development. For example, the Kentucky Transportation Cabinet (KYTC) develops two final estimates, a field estimate and an engineer's estimate. Conversely, Minnesota's DOT produces an *engineer's estimate* immediately prior to letting and Montana's DOT describes its final cost estimate as the *final plans estimate*. Accordingly, if readers consult the individual state manuals summarized in this report, they should be attentive to the terminology used.

Developing accurate and realistic project cost estimates serves many purposes, however, perhaps the most important of these is that state DOTs will be unable to manage and deliver its transportation program if they do not produce estimates which align with the final project cost (AASHTO, 2013). Preparing cost estimates helps DOTs manage costs, track project development, understand how contingencies evolve over time and affect the total price tag, and hold project managers accountable for the progress and delivery of projects. At the long-term planning stage, estimating also plays a critical role in helping DOTs prioritize transportation needs. And as a project moves through development, continuously updating estimates helps stakeholders manage project scope, schedule, and cost. Producing accurate estimates is important because under- or overestimating total project costs negatively impact not only individual projects, but potentially hampers a DOT's ability to deliver its transportation program. When project costs are overestimated for a project, it leads to the over-allocation of funding, which in turn deprives other projects of funding or prevents them from ever getting off the ground (FHWA, 2015). Conversely,

[4] Throughout this document *technique* and *methodology/method* are used interchangeably.

underestimating costs leaves projects in a financially precarious position and forces DOTs to reallocate money from ongoing or future projects.

In addition to discussing estimating methodologies, we also review key factors that project managers, designers, and estimators should consider when developing their estimates. A diverse range of issues — from soil conditions and materials availability, to contractor work schedules and site constraints — significantly impact a project's final cost. If an estimator inaccurately judges how these factors affect project delivery, the result is a flawed estimate. Most states rely on some combination of proprietary software and databases containing historical project data to prepare estimates. AASHTOWare (previously AASHTO Trns*port) has been adopted by several DOTs. Other states, such as California, have developed in-house systems to organize and prepare estimates. A full review of AASHTO's software is beyond the scope of this chapter, however, each summary notes what procedures and software a state has implemented.

This chapter does not exhaustively describe each step in the estimating process. As a high-level overview, it surveys a wide terrain and brings attention to critical issues KYTC should address when analyzing the strengths and weaknesses of its current estimating procedures. Additionally, there are several highly specific topics it does not touch on, but which may be explored in further detail through numerous guidance documents produced on the topic of project estimating over the past 15 years. For example, Paulsen et al. (2008) laid out a comprehensive process for estimating the environmental costs associated with a project. Their document can be used to estimate the cost of items such as environmental mitigation, the construction of structures intended to protect ecological processes (e.g., ensuring a culvert allows for the passage of fish, or preparing environmental assessments. Anderson et al. (2016) advocated for a detailed project scoping process, which can be used to plan project work and avoid potential scope creep. While not focused entirely on estimating, the suite of tools it outlined to perform major activities of the project scoping process — project development, analysis and documentation of alternatives, and development of the recommended alternative — can benefit transportation agencies in their efforts to prepare accurate cost estimates. Another critical estimating activity is determining the cost of preconstruction services, using either a top-down or bottom-up approach. Gransberg et al. (2016a, b) developed a guidebook on these topics. Preconstruction services include items such as feasibility studies, attaining environmental clearances, preliminary design and approval, right-of-way acquisition, utility relocation, and developing advertisements, among others. Top-down estimates are prepared when little is known about project details, while bottom-up estimates are helpful when a transportation agency outsources preconstruction design and planning to an outside consultant. Although having reliable procedures established to develop project estimates is critical, it is equally important for transportation agencies to have the organizational structure in place to support staff when they prepare estimates. Paulsen et al. (2008) adopted a holistic approach in their guidance on improving cost estimating procedures at the organizational, program, and project levels. At the organizational level, for example, agencies should make available the resources and consultant support necessary to develop timely estimates. DOTs should also strive to integrate the estimating process, enabling the staff from multiple departments (e.g., right-of-way, environment, construction, utilities) to collaborate with one another. A full discussion of these recommendations is beyond the scope of this document, however, Paulsen et al.'s (2008) work should be viewed as complementary to the estimating methodologies we explore below.

Table 3.1 Definition of Estimating Methodologies

Bid Type	Description
Cost Per Element/Parameter Using Similar Projects (i.e., Parametric/Conceptual)	• Estimators identify completed projects similar to the one being estimated. Those projects are converted to a cost parameter (cost per centerline mile, cost per square yard). Estimates for the new project are then based on this cost parameter. • Use is generally restricted to during the early stages of project development.

Cost Per Parameter Using Typical Sections (i.e., Parametric/Conceptual)	• Estimators develop a cost parameter using typical items which describe a standard section of a given length (e.g., one mile). Cost parameters are used with approximate quantities to prepare an estimate. • Use is generally restricted to during the early stages of project development.
Analogous/Similar Project	• Estimators identify one or several projects similar to the project being estimated. Items, quantities, and unit costs from the historical projects are then used to estimate the price of the current project. • Some DOTs (e.g., Montana) reserve this method for smaller projects that are not complex.
(Historical) Bid-Based	• Estimators research historical data, unit prices, and quantities from previous projects. Pricing is then adjusted based on factors such as location, market conditions, and quantities to estimate the total project cost.
Cost-Based	• Estimators base their estimate on knowledge of variables related to work that will be performed. Cost based estimates account for the cost of labor, materials, event sequencing, production rates, and contractor overhead and profit. Estimators must possess a good working knowledge of construction industry practices and current market trends to generate a reliable estimate.
Historical Percentages	• Estimators develop a percent based on historical cost information. It is typically used for project elements that are not defined early in the project development process. Historical percentages are based on the relationship between the total cost of a group of items and a total cost category.
Combined	• Some DOTs combine multiple estimating techniques (generally historical bid based and cost based). States such as Oregon and Minnesota use cost-based estimates for major items (e.g., Portland cement concrete, structural steel, embankments, asphalt concrete pavement). Smaller items are estimated based on historical prices adjusted to the project context.

Sources: Minnesota DOT, Washington DOT, Oregon DOT, Montana DOT

3.2 Cost Estimation Techniques

In 2013 AASHTO issued a report on best practices for project cost estimating. While the report synthesized the methodologies used by numerous state DOTs to estimate costs, it did not offer detailed treatments of individual state practices. This section complements the brief introduction to the relationship between estimating strategies and project stage provided above. Most of the ideas presented in this section reappear throughout the state summaries. At the risk of repetition, briefly discussing AASHTO's report is worthwhile because it neatly summarizes many of the challenges DOTs confront and various approaches agencies leverage to prepare accurate estimates. The report also covers topics such as the effects of inflation on project delivery and options to account for it, cost control, and strategies for analyzing contractor bids. However, because those topics fall beyond the remit of the current project, the discussion is restricted to only those chapters dealing with estimating methodologies (readers should consult Chapters 6-9 of AASHTO [2013] for information on the aforementioned subjects).

AASHTO distinguishes four project development phases — planning, scoping, design, and final design (Figure 4.1). The estimates prepared during different phases differ from one another in terms of the methodology used, purpose, and the program they support. Estimates at the planning stage are generally conceptual and used to evaluate long-term funding needs. During later project development phases, when it is imperative that estimates be more accurate and include less contingency, states typically rely on some combination of cost-based or historical-bid based methods. Shifting to these methods lets estimators gradually reduce the amount set aside for contingency (i.e., over time, the relative magnitude of the base estimate [which excludes contingencies] increases).

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

Figure 3.1 AASHTO Cost Estimating Classification

Conceptual estimating techniques facilitate long-term planning and project prioritization, and as such are used during the earliest project development stages when projects are still incompletely defined. These techniques derive an estimation by investigating the statistical relationships (or ratios) between a project's definition and historical costs (which originate from projects that have already been completed to let). AASHTO suggests using conceptual estimates on low to moderately complex projects. While it is possible to use conceptual estimating on projects with a high degree of complexity, estimators will garner better results if they perform in-depth assessments of quantities and unit prices on them. Estimators require two pieces of data to prepare a conceptual estimate: 1) sound historical cost information, and 2) project-related information matched to cost data. If an estimator lacks accurate historical data it is extremely challenging, if not impossible, to develop a reasonably precise estimate. To ensure historical data are available to agency staff, AASHTO recommends that state DOTs invest the time and money necessary to assemble and maintain a comprehensive database of historical costs. This database should house data on construction cost factors, lane-mile cost factors, bridge cost factors, historical percentage cost factors, computer-generated cost factors, right-of-way acquisition, and preliminary and construction engineering costs. To prepare a conceptual base estimate, estimators must be sufficiently knowledgeable about the project's definition and characteristics. With this information in hand, AASHTO prescribes a six-step procedure to generate base estimates:

1. Select appropriate estimating approach.
2. Determine estimate components and quantify.
3. Develop estimate data.
4. Calculate cost estimate.

5. Document estimate assumptions and other estimate information.
6. Prepare estimate package.

Along with the base estimate, estimators should also evaluate risk and set contingency (i.e., prepare a risk-based estimate; see discussion at the end of this section). Because of the significant uncertainty associated with conceptual estimates, in some instances the contingency will exceed 20 percent. The final step in conceptual estimating is the completion of a quality assurance and quality control check to ensure the final estimate has accounted for all project characteristics, and that the estimated costs accurately represent the level of effort needed to complete the project.

Moving on from conceptual estimates, the report examines bid-based estimates, which AASHTO regards as an empirically sound estimating methodology because it relies on data from past projects. An estimator's first step in developing a bid-based estimate is to calculate the appropriate quantities for items listed in the project plans. With this data in hand they estimate the cost of each item using historical unit bid prices (or average historical unit bid prices). State DOTs need to maintain comprehensive databases of historical pricing data to use this technique. Most often, estimators use data extending back 3–5 years, although in some cases estimators limit this to one or two years. AASHTO recommends that DOTs establish a standard method to adjust historical prices for inflation (see p. 2-4), however, it does not prescribe a specific way to accomplish this. Estimators typically leverage historical bid-based estimating procedures beginning with the scoping phase. Many DOTs use some variant of bid-based estimating from scoping onwards (i.e., through project letting), although it may be combined with cost-based estimating. As long as a project is conceptualized in terms of quantifiable items, bid-based estimating is a feasible option.

Bid-based estimates require several inputs. First, a project must be well defined. By scoping, project development managers will have schematic plans and a complete design basis from which to construct an estimate. Second, project characteristics must be sharply delineated. Estimators preparing bid-based estimates must scrutinize the local contingencies that will affect delivery (e.g., location, construction season, work restrictions, challenges presented by utilities). AASHTO provides an in-depth discussion of these factors, however, because later portions of this chapter detail these, we omit a full summary here (see AASHTO 2013, p. 3-9–3-18). The third requirement is an encyclopedic database of bid data. AASHTO recommends that state DOTs develop and maintain a bid line-item database for this purpose. Table 3.2 lists information AASHTO suggests including in a historical bid-based database. State DOTs must decide which bids to populate the database with as they are constructing it. Five possibilities exist: 1) low bid only, 2) low and second bid, 3) three lowest bids, 4) all bids (potentially excluding outliers), 5) all bids except high and low. To obtain the most accurate results, outliers should be removed from datasets using statistical techniques (e.g., weighted averages, regression analysis). Once these have been eliminated the estimator can derive a unit price that accurately accounts for a contractor's actual costs and a reasonable profit. If the estimator uses weighted averages, they must factor in how seasonality influences pricing. Agencies need to be consistent in their methodological choices. If procedural changes do occur the entire database should be updated regularly, and in accordance with new data processing standards. The fourth item for state DOTs to consider is the macro-environment and prevailing market conditions. Specific variable estimators need to factor into their calculations the work season, availability of contractors, level of competition among contractors, the number of concurrent projects underway in close proximity to one another (as this can impact contractor availability and the cost of labor and materials), and whether specialty work is necessary.

As the estimator begins to prepare the base estimate, they quantify the items they are estimating the cost of and develop estimate data. The first step in developing an estimate is accessing historical unit prices; the second step is to adjust those unit prices to reflect the quantities and contingencies of the project at hand. Estimators also need to understand the impact of market volatility (e.g., sharp increases or decreases in the cost of labor or materials) and adjust their prices accordingly. After they have determined unit quantities and prices, the estimate is prepared, usually with the aid of in-house or proprietary software packages (e.g., AASHTOWare). The final estimate should be presented in a standard format, with prices broken out into multiple levels of detail and cost categories. As with conceptual estimating, the last step of bid-based estimating is development of a risk analysis, which aids the estimator in setting the contingency.

Table 3.2 Information to Include in Historical Bid-Based Database

• File Number	• Contractor Name and Address
• County	• Type(s) of Work
• District	• Funding
• Bid Item Number	• Completion Data
• Item Description	• Working Days
• Item Quantity	• Estimate Preparer
• Item Account	• NPDES Acreage
• Unit of Work	• Hourly Work Restrict ions
• Letting Data	• A+B Bidding
• Estimated Construction Start Date	• Road/Route
• Number of Bidders	• Project Number
• Low Bidder Amount	• Warranty
• Second Bidder Amount	• Staging Area
• Third Bidder Amount	• Stage Construction/Number of Stages
• Estimated Unit Price	• ROW Restrictions
	• Urban vs. Rural
	• Special Construction Area
	• Project Limits
	• Bridge Type (If Applicable)

Source: AASHTO (2013)

AASHTO recognizes two critical limitations on historical bid-based estimating. First, creating and maintaining a database with historical bid data is a resource-intensive activity, demanding considerable financial investments and dedicated personnel. Second, DOTs need to use consistent bid items for all contracts, and the work covered by the bid items have to be consistent. Challenges also emerge if a project has a large number of specialty items or items rarely used on other projects. Generally, there are insufficient historical data on specialty and rarely-used items, and estimators will need to identify alternative estimating strategies to avoid producing a skewed bid.

Whereas historical bid-based estimating uses data from previous projects to forecast total project cost, cost-based estimating uses the recent and current pricing data on materials, equipment, and labor to develop estimates. This technique is particularly well-suited to situations where significant market volatility exists and historical bid data either do not accurately capture current pricing (or cannot be used to develop reliable future projections). Similar to historical bid-based estimating, estimators start by developing line item estimates. To accomplish this, they will break each work item into a detailed list of task activities. Estimators then assign a price for each activity, taking care to include separate costs for labor, equipment, subcontractors, and material components. Cost-based estimating is generally reserved for the PS&E and engineer's estimate, although some DOTs use it during the design and scoping phases to value major items — if there is enough known about quantities and project conditions.

Estimators use several inputs to generate cost-based estimates. A historical database that includes information on productivity and pricing resources is critical. Cost-based estimates do not rely entirely on historical bid data (but in some cases, historical data on major items such as steel and structural concrete are incorporated into the estimate). Historical data on productivity are essential for understanding the requirements of a specific project and the amount of time and resources needed to complete an activity (e.g., the productivity of a paver). Estimators must also have recourse to accurate data on labor costs. Using these data, they can determine the crew size and composition needed to perform an activity. Thorough data on equipment costs inform estimators about the combination of machinery needed to complete a job. As they investigate what equipment is necessary for a job, estimators should keep in mind factors that impact equipment usage, including job production rates, space availability and machine mobility and size, equipment capabilities, the distance material has to be moved, grade steepness and direction, weather conditions, hauling restrictions, and the cost to mobilize and demobilize equipment. Another area of special consideration is small power tools, hand tools, and other non-capitalized equipment and supplies; typically these are estimated as a percentage of the total labor cost.

Macro-environmental factors can influence a project if they: 1) go unrecognized by project managers and estimators, or if 2) conditions external to the project begin to impinge upon and affect its execution. If estimators do not correctly assess and factor into their work the influence of market conditions they are unlikely to generate sound cost estimates — market volatility affects the labor force, commodity prices, equipment availability, and how many major projects are taking place in a region or locality. Additional variables that should be factored into estimates include equipment and material pricing; subcontractor pricing; contractor overhead and profit; and pricing adjustments that are based on project location, work methodology and quantity, and anything else that has the potential to influence price (e.g., size of project, unit cost, waste). AASHTO recommends that state DOTs maintain production logs that document productivity under different working conditions. With this information, estimators can adjust their estimates to fit the expected working conditions throughout the project. All pricing data — whether historical or based on current and recent costs — must be calibrated to project location and work methodology and quantity. As with conceptual and bid-based estimating, the final steps are performing quality assurance and quality control checks and generating a risk analysis and contingency (see below). The nature and content of project reviews vary according project type and complexity. On large projects, reviews should be conducted by an external group of qualified professionals, although this is probably unnecessary on less complex projects.

Irrespective of the estimating technique chosen, state DOTs must identify the risks associated with a project and establish a contingency accordingly. AASHTO describes this as risk-based estimating, however, many of the state DOTs we looked at do not classify risk assessment as such — all estimates assess risk and set contingencies based on risk evaluation. Thus, it is an ongoing activity enfolded into a broader set of estimation activities. The purpose of risk-based estimates is to understand how unknown or uncertain items and events can potentially affect total cost. There are two methods for setting contingency, a top-down and a bottom-up approach. Top-down estimates use historical data to relate risk to a range of contingency, while bottom-up estimates draw on information gleaned from statistical analyses and simulations to gauge the likelihood of a risk event occurring, its magnitude, and probable impact. Bottom-up estimates also account for uncertainties in costs or quantities by establishing a range of values for each. Figure 4.2 depicts the relationship between the base estimate and contingency at various project phases. Notice that for projects in the planning stage the contingency is significant, and sometimes nearly equals the base estimate. This is because projects are incompletely defined at this stage. As a project moves forward and it is defined in more concrete terms, contingency shrinks as does the potential range of values. Although this conceptualization implies that final design estimates have no built-in contingency, a number of state DOTs preserve a small contingency to offset the impact of unforeseen risks.

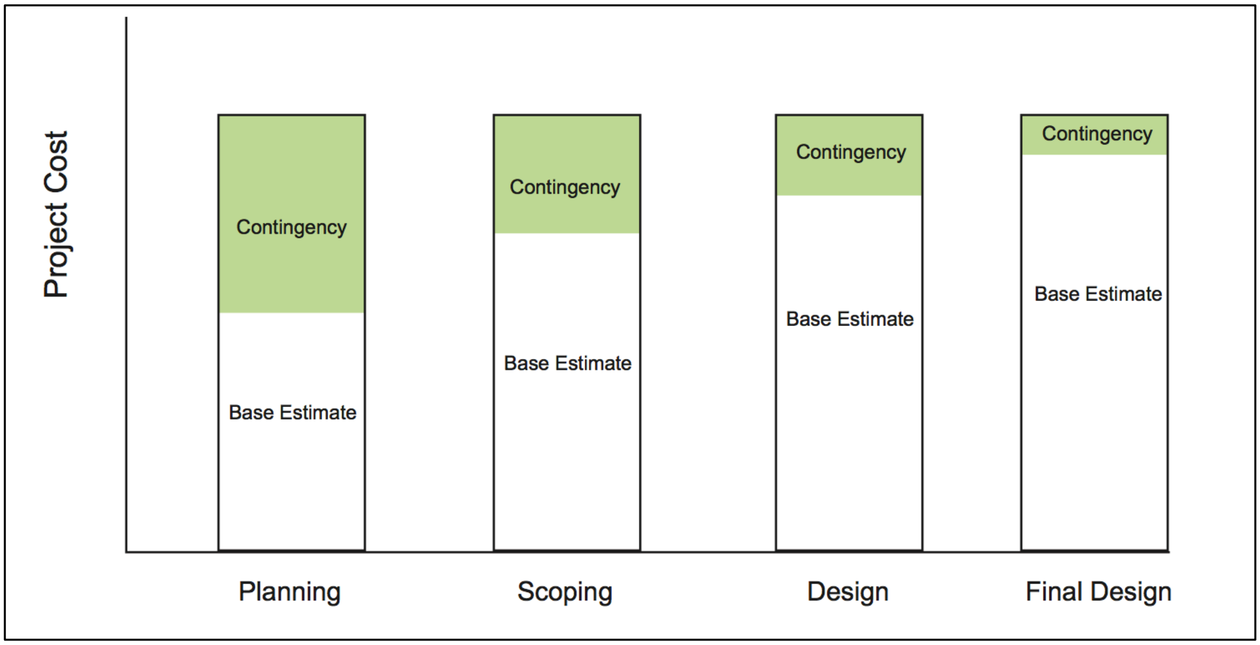

Figure 3.2 Relationship Between Contingency and Base Estimates at Different Project Stages

A risk-based estimate has two inputs: 1) a definition of project complexity, and 2) a summary of assumptions and concerns pertaining to design and estimating. Understanding the level of complexity associated with a project helps estimators select an appropriate method to assess risk. Although it is possible to define complexity in myriad ways, AASHTO offers a tripartite classification scheme (Figure 4.3). A bottom-up, probabilistic risk assessment method is best suited for estimating contingency on the most complex projects. On smaller projects, DOTs need not use overly elaborate techniques. For projects where only minor risks have been identified, a top-down, high-level approach is a satisfactory option (e.g., listing red-flag risks). Moderately complex projects warrant a qualitative risk assessment and top-down estimating approach (see also Anderson et al., 2007). The second input — knowledge of assumptions and concerns related to project estimating and design — is also critical. When estimators have a deep understanding of the assumptions and concerns embedded in project designs they are better able to identify potential risks and set an appropriate contingency. Although estimators should focus on the project under consideration, they will benefit from access to historical risk checklists and past risk analyses of other projects. These must be used with caution, and ideally only after an estimator has reviewed details of the project at hand.

Most Complex (Major)	Moderately Complex	Non-Complex (Minor)
• New highways; major relocations • New interchanges • Capacity adding/major widening • Major reconstruction (4R; 3R with multi-phase traffic control) • Require congestion management studies	• 3R and 4R projects that do not add capacity • Minor roadway relocations • Certain complex (non-trail enhancement) projects • Slides, subsidence	• Maintenance betterment projects • Overlay projects, simple widening without right-of-way (or very minimum right-of-way take) and little or no utility coordination • Non-complex enhancement projects without new bridges (i.e., bike trails)

Figure 3.3 AASHTO Classification of Project Complexity

Any risk analysis must begin with the estimator (along with the project team) identifying what risks have the potential to impact a project. Holding meetings which bring all of the project's stakeholders together will facilitate this process, as will having recourse to tools such as risk analysis checklists. The objective of risk identification is twofold: 1) pinpoint and categorize potential risks, and 2) document risks. When mapping out potential risks, the project team and estimator should trace the key drivers of each risk, determine their significance, and brainstorm potential strategies to mitigate and manage them should they arise. Risk generally has a negative connotation, however, *risk* encompasses all uncertain events — both positive *and* negative. Thus, when identifying risks, project stakeholders should also precisely characterize them and develop a classification table that distinguishes positive from negative risks. Figure 4.4 presents risks that state DOTs often confront on transportation projects (AASHTO 2013). While AASHTO (2013) also acknowledges the possibility of positive risks (or opportunities), it does not list any positive risks in its catalogue of potential risks. Some examples of positive risks may include an unanticipated reduction in the cost of materials, learning that only a simplified environmental process is required (cutting back on how much documentation is required as well as review time), or a contractor being able to coordinate multiple projects simultaneously, thus reducing the time to completion. Project teams should work throughout the project development process to identify new risks — positive or negative — that could have an impact.

Environmental Risks	External Risks
• Delay in review of environmental documentation • Challenge in appropriate environmental documentation • Defined and non-defined hazardous waste • Environmental regulation changes • Environmental impact statement (EIS) required • NEPA/404 Merger Process required • Environmental analysis on new alignments required	• Stakeholders request late changes • Influential stakeholders request additional needs to serve their own commercial purposes • Local communities pose objections • Community relations • Conformance with regulations/guidelines/design criteria • Intergovernmental agreements and jurisdiction
Third-Party Risks	**Geotechnical and Site Risks**
• Unforeseen delays due to utility owner and third-party • Encounter unexpected utilities during construction • Cost sharing with utilities not as planned • Utility integration with project not as planned • Third-party delays during construction • Coordination with other projects • Coordination with other government agencies	• Unexpected geotechnical issues • Surveys late or in error, or both • Hazardous waste site analysis incomplete or in error • Inadequate geotechnical investigations • Adverse groundwater conditions • Other general geotechnical risks
Right-of-Way/Real Estate Risks	**Design Risks**
• Railroad involvement • Objections to ROW appraisal take more time or money, or both • Excessive relocation or demolition • ROW Acquisition problems • Difficult or additional condemnation • Accelerating pace of development in project corridor • Additional ROW purchase due to alignment change	• Design is incomplete/design exceptions • Scope definition is poor or incomplete • Project purpose and need are poorly defined • Communication breakdown with project team • Pressure to deliver project on an accelerated schedule • Constructability of design issues • Project complexity (scope, schedule, objectives, cost, and deliverables are not clearly understood)
Organizational Risks	**Construction Risks**
• Inexperienced staff assigned • Losing critical staff at crucial point of the project • Functional units not available or overloaded • No control over staff priorities • Lack of coordination/communication • Local agency issues • Internal red tape causes delay getting approvals, decisions • Too many projects/new priority project inserted into program	• Pressure to deliver project on an accelerated schedule • Inaccurate contract time estimates • Construction QC/QA issues • Unclear contract documents • Problem with construction sequencing/staging/phasing • Maintenance of traffic/work zone traffic control

Figure 3.4 AASHTO Key Transportation Project Risks

Using the project complexity classification described above, AASHTO lays out three approaches for estimating contingencies: 1) Type I (for non-complex, minor projects), 2) Type II (for moderately complex projects), and 3) Type III (for major projects). The basic outlines of these estimating strategies were alluded to above. A Type I analysis produces a risk-based percentage contingency estimate. This simple analysis requires the estimator to use a list of risks and a top-down percentage of project costs to arrive at a contingency estimate. Type II estimates are risk-based deterministic estimates. The primary benefit of preparing a deterministic contingency estimate is that it lets the estimator quantify a risk's potential impact in monetary terms (by multiplying the probability of an event by its expected impact). Although it also entails the use of a top-down percentage contingency estimate, this is accompanied by bottom-up estimates, usually of major contingency items. Type III estimates are risk-based probabilistic contingency estimates. Reserved for the most complex projects, estimators will develop a probabilistic estimate using sophisticated statistical techniques (e.g., Monte Carlo simulations) to set the contingency. The kinds of risks estimators need to account for vary by project type. For example, on the most complex projects, estimators should pay careful attention to risks introduced by design complexity, unresolved constructability issues, political factors, and complicated environmental regulations. Risks that deserve special treatment on moderately complex projects include geotechnical issues, changes in materials/foundation, delays in permitting, and bridge redesign and analysis. The most important risks on minor projects include contractor delays, changes in program priorities, errors in cost estimating, and inaccurate technical assumptions (AASHTO 2013, p. 5-9). Certainly, it bears remembering that these risks are representative; nor are they mutually exclusive. Major projects could encounter problems with, for example, contractor delays, although AASHTO generally views risks such as these as less likely to afflict larger projects.

As with other estimation techniques, risk-based estimations conclude with a quality assurance and quality control check. This may involve peer review, where an estimator who did not contribute to the project under consideration analyzes the contingency estimate. Risk checklists can also assist with this process. AASHTO argues the best way to ensure the quality of an estimate is through comprehensive peer review; this gives other estimators the opportunity to apply their professional expertise and judgment, and it increases the likelihood of the estimate being accurate. While this section has not catalogued every piece of information on AASHTO's discussion of project cost estimating, it should provide readers with a solid foundation to approach the ensuing state summaries.

3.3 State Practices

3.3.1 New Jersey

The New Jersey Department of Transportation's (NJDOT) cost estimating process is divided into four stages. As project development moves forward, the amount of detail and precision required of estimates increases (NJDOT, 2016). Estimates generated during the Programming and Planning Stage, for example, have less specificity (e.g., cost per mile) than estimates developed during the Plan, Specification, and Estimate Stage. As a project evolves, estimates are continually updated based on new information. These updates continue through project letting. There are several divisions within NJDOT that participate in the development of project estimates (e.g., highway, structures). As such, the agency emphasizes the importance of clearly documenting the process and preserving — in file accessible to all stakeholders — supporting documents used to develop the estimate. Documentation must include all of the assumptions that inform an estimate as well as justifications for the quantities, prices, allowances, and contingencies. Additionally, sound documentation gives reviewers the information they need to accurately evaluate a project and can later be archived so it may be consulted when future projects are in development.

Table 3.3 describes the NJDOT's estimating stages and Table 3.4 summarizes the procedures used to make or review an estimate during each stage of a project. At the Programming and Planning Stage, estimates are high-level and conceptual. Estimates are generally based on cost data derived from historic lane-mile cost averages from projects with a comparable scope. Estimators also should include estimates for items such as utility and mitigation work and maintenance of traffic. Although it is critical for estimators to determine potential costs associated with acquiring the right-of-way, these costs are not included in construction cost estimates. The next stage is a scoping-level estimate. Scoping-level estimates establish a project's baseline cost. All subsequent estimates are compared to the estimate produced during the Scoping Stage. At this stage of the project, enough data should be available to estimate the material quantities (e.g., asphalt, concrete pavement, structures, excavations) necessary to proceed with construction. Estimates for quantifiable items leverage historical bids to develop base unit prices. These prices are then adjusted for project-based contingencies. The cost estimates produced at the Scoping Stage are used to compare alternative project delivery options to determine which will most effectively address transportation needs.

By the time a project reaches the Design Development, a preliminary alternative method has been selected and is used to begin NEPA (National Environmental Policy Act) analysis. As design work moves forward during this stage, construction cost estimates are refined using AASHTOWare, which is software a number of state DOTs use to estimate project costs. More precise estimates are compared against the funding which have been programmed for the project. As the design begins to take its final form, the estimate will include finalized items and quantities and all contingencies should be accounted for. During this period, final utility estimates are prepared. Estimators analyze market conditions to identify their potential impact on unit prices (and therefore the total project cost). Immediately prior to final submission of the project design, NJDOT again uses AASHTOWare to create a detailed itemized estimate, using both contract qualities and historical bid item prices. As a project enters the final estimating stage — Plan, Specifications, and Estimate — the Engineer's Estimate is prepared. This estimate is used to allocate funds for construction and evaluate contractor bids.

NJDOT identifies numerous cost drivers that can produce minor or significant impacts on construction costs. The quantity of materials for a project affects the unit cost of supplying or constructing a particular item. For example, if a project requires large quantities of a material, suppliers may offer discounts because their overhead and labor costs are more distributed. However, in some cases the need for larger quantities can drive up prices, such as when a project includes many structures that demand the input of vast resources (e.g., steel, labor) that increases their market scarcity. When a project requires smaller quantities, higher unit prices result because transporting and constructing them is less efficient. Another cost driver is the type of work being performed. Jobs performed by hand (rather than by machines or other automated technologies) or those that call for greater precision are more expensive to complete. A volatile market for a particular kind of material can also significantly influence prices, as can the overall availability of materials. NJDOT recommends monitoring the availability of materials (e.g., stock inventory, production rates, limits of current supply) when developing price estimates. Similarly, where a project is being constructed influences unit bid prices. As such, estimators should factor in a project's location (urban, suburban, or rural setting) when they assemble construction cost estimates. The time of year when project construction is slated to occur is also a key factor. Estimates should account for seasonal adjustments. For example, it is ideal to begin a project during the early part of construction season (i.e., early spring) to ensure there is sufficient time to complete it before the onset of cold weather. If activity is planned into the winter, estimators need to account for the added costs related to winter overhead, heating of materials, and any damage that could be exacted by hazardous conditions. Project type is another important variable to consider. On new highway projects, right-of-way acquisition may drive up the price, whereas more efficient construction access can reduce contractor expenses. Conversely, reconstruction projects take place along existing alignments which limits access for construction equipment. Estimators must price this into their estimates as well as expenses associated with construction phasing and maintaining traffic. Cost drivers are specific to individual projects. Therefore, estimators need to bear these points in mind when they begin to develop estimates, systematically working through each driver that may be a factor.

Table 3.3 Summary of New Jersey DOT Project Estimating Stages

Estimating Stage	Estimate Type	Estimate Method	Estimate Developed or Updated	Source of Estimate
Programming and Planning	Conceptual/planning-level estimate	Similar Projects Historical Percentages	• TIP Estimate	• Capital Project Management
Scoping	Baseline estimate	Similar Projects Historical Percentages	• Preliminary Construction Cost Estimate	• Designer • Division of ROW

			• Concept Development ROW • Access Cost Estimate	
Design Development (Preliminary Engineering)	Mid-level estimate	Cost Estimation System software	• Construction Cost Estimate	• Designer
Design Development (Final Design Phases)	Detailed itemized estimate	Cost Estimation System software	• Construction Cost Estimate	• Designer
PS&E	Completed detailed itemized estimate	AASHTOWare Project Software	• Engineer's Estimate	• Designer • Finalized by NJDOT Estimators

Although the use of lump sum items is discouraged because the challenges they introduce for estimators, often they cannot be excluded entirely. NJDOT defines lump items as "an item that does not have a detailed quantity specified and 100% payout of the item is virtually guaranteed (2016, p. 16). NJDOT recommends, if possible, breaking lump sum items into smaller work packages that historical data are available for and then tallying the sump of individual components (i.e., cost-based estimation). This approach results in more accurate and precise estimates. Because this can be time consuming, percentages or ranges based on historical data are often applied. Some items amenable to this estimation procedure include the maintenance and protection of traffic; bridge demolition; and removal, mobilization, and clearing and grubbing.

Table 3.4 New Jersey DOT — Steps Used to Make or Update Estimates at Each Stage

Estimating Step	Description of Activities
Determine (or review and update) estimate basis	Document or update project type and scope, including: • Scope documents • Available drawings (which define the percentage of engineering and design completed) • Project design parameters • Project complexity • Unique project location characteristics • Disciplines required to prepare cost estimate
Prepare (or update) base estimate	Prepare or update estimate, including: • Documentation of estimate assumptions, types of cost data, and adjustments to cost data • Application of appropriate estimation techniques, parameters, and cost data consistent with level of scope definition • Coverage of all known project elements • Coverage of all known project conditions • Verify estimates are consistent with past experience
Review total estimate	Review estimate basis and assumptions, including: • Methods to develop estimate parameters (e.g., quantities) and associated costs

	- Completeness of estimate relative to project scope - Application of cost data, including project-specific adjustments - Reconciliation of current estimate with previous estimate(s) - Preparation of an estimation file

Note: Estimates at each stage must follow this sequence of steps

3.3.2 Washington

Project cost estimates for the Washington Department of Transportation (WSDOT) include all direct capital outlay costs (e.g., right-of-way, structures, landscaping), but generally exclude indirect costs (WSDOT, 2014). The guidelines have been written for project designers and project managers (hereafter referred to as *estimators*). Figure 4.5 summarizes the workflow implemented during each phase of project development to generate estimates. Estimates are refined throughout the project as project scopes are defined more clearly. There are four phases of the project development — Planning; Scoping; Design; and Plans, Specifications, and Estimates (PS&E). This section first discusses the generalized workflow used during each phase's cost estimating process and then looks at considerations specific to each phase.

The first step in WSDOT's workflow is determining the Basis of Estimate. This is a comprehensive description of the project, including assumptions, notes, and exclusions. It contains project information and data on the scope and schedule. The level of detail presented in the Basis of Estimate is contingent on the phase as well as the type and complexity of the project. It includes a history of the estimating process. Thus, a Basis of Estimate document that is produced during the PS&E stage will retrace the evolution of the estimate during each project development phase. After the Basis of Estimate is in place, a baseline estimate is developed. This consists of the estimated costs for each item (or aggregate of items) necessary to complete the project. Project scope, magnitude, and complexity dictate the estimation technique. When putting together a baseline estimate, estimators consult historical databases as well as internal subject-matter experts to ensure accuracy. Early phase estimates will include key milestones as well as the anticipated duration of the environmental, design, right-of-way, ad/bid/award, and construction phases. Once an estimate has been made, it undergoes review. This review analyzes the project and estimate assumptions to verify they are appropriate for the project; determines whether the baseline estimate accurately reflects the project scope; evaluates whether the scope, schedule, and cost items have been accounted for correctly; and confirms that historical (and other) data have been used in a suitable manner. After concluding the review, a risk assessment is undertaken to look at the influence of uncertainties on project cost and schedule. Risk analysis focuses on market conditions and inflation to evaluate assumptions built into the estimate; subject-matter experts are also consulted to highlight issues that maybe problematic. The potential consequences of uncertainties are documented and used during subsequent design phases. Once risk assessment has wrapped up, the estimate is sent to internal and external stakeholders — the estimators decide to whom information on the estimate should be communicated. Before estimates are conveyed to WSDOT management, independent reviewers examine them and estimators revise based on review comments. After management has studied an estimate, it will again be revised to reflect comments or concerns that management expressed.

As noted previously, WSDOT has four overlapping project development phases (Planning, Scoping, Design, and PS&E); the estimating workflow described above is iterated for each phase. Planning phase estimates are developed to estimate funding needs for long-range planning and for prioritizing needs identified in the Highway System Plan. Because this is the earliest phase, estimates are based on a limited amount of project information. The techniques employed during this phase are parametric estimating, historical bid prices and historical percentages, and analogous project estimating. Often the project scope is incompletely defined as this stage. As such, it is incumbent upon the estimator to flesh out the project scope in order to put together an accurate estimate. WSDOT recommends a field review of the project site during this stage to better understand project demands and identify and document potential high-cost items (e.g., hazardous waste or environmental mitigation, utility relocation, installation of noise barriers, traffic management needs). Estimators should also determine the worst case scenario and bear in mind issues such as market volatility when developing initial estimates. Because projects may languish for extended periods before they move onto the scoping phase, estimates should be periodically revisited and updated to reflect changing market conditions and other issues that may impact construction.

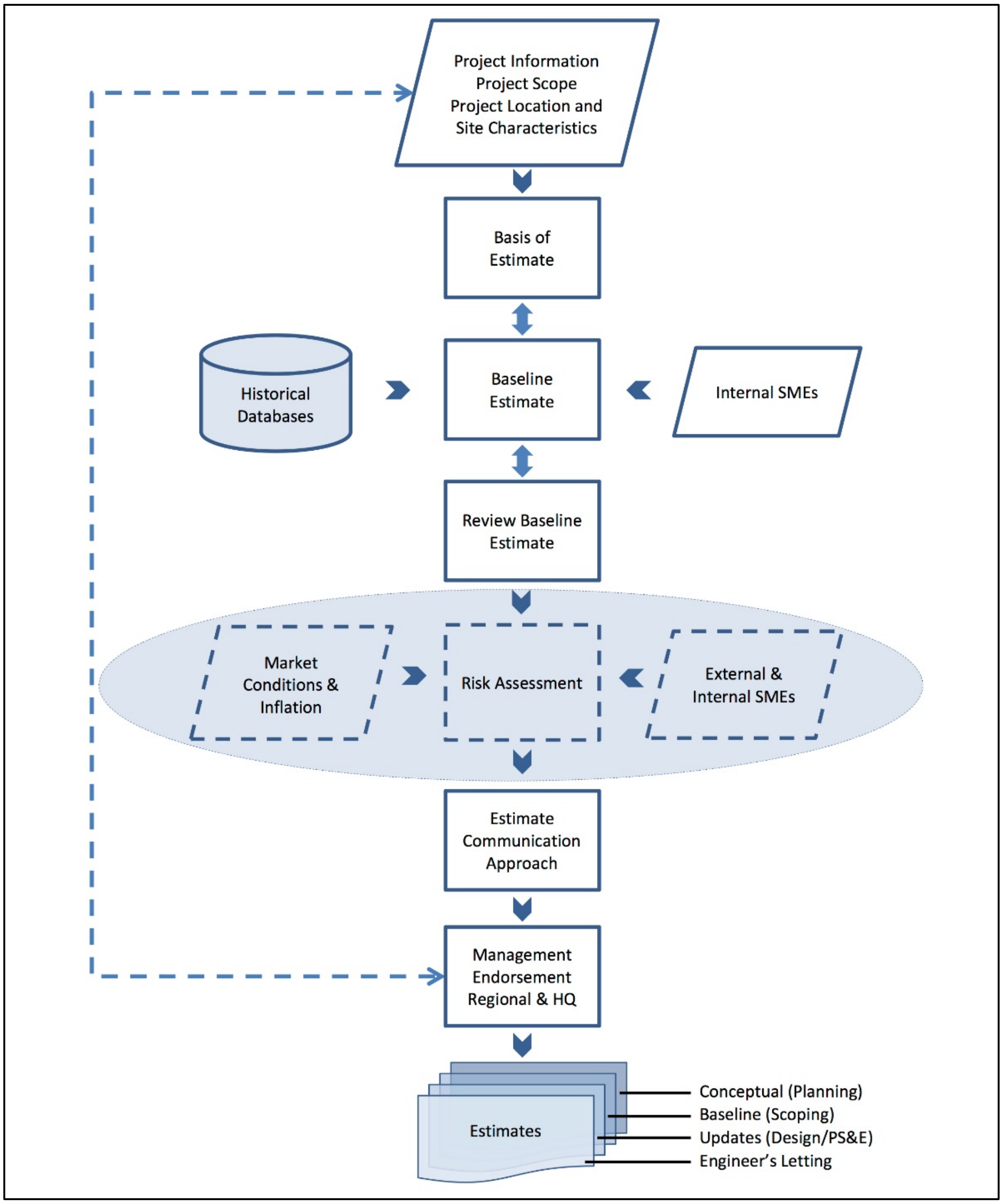

Figure 3.5 Washington DOT Project Estimating Workflow

Estimates made during the Scoping phase serve as the baseline estimate for the remainder of the project, which means the Washington State Legislature will use this number to set the budget. Estimators can make use of historical bid-based estimating, parametric estimating, or cost-based estimating — in some cases, separate approaches may be used depending on the item(s) being priced. WSDOT recommends that estimators perform in-depth research to understand the full scope of work that is necessary and, if warranted, contact other stakeholders (e.g., suppliers, city or county engineers) to discuss issues that may significantly impact project costs. Making visits to the project site is important in order to document obstructions that could impede construction work. The estimate made during the Scoping phase should account for and quantify existing structures, utilities, and obstructions. Paying special attention to utility impacts and potential risks is also critical. It is helpful to include perspectives beyond those of the personnel who originally scope a project in order to identify problems or concerns that previously went unnoticed.

Estimates are generally updated several times throughout the Design phase, during geometric review, general plans review, and preliminary contract review. When an estimate is made or updated during the Design phase, the estimator should not assume estimates put together during the Scoping phase are correct (or that the project is sufficiently defined). Rather, they need to approach the estimate with fresh eyes. When estimates are revised, the revisions are documented and a written explanation is composed that describes the reasons for significant changes. At this stage, the techniques used are historical bid-based estimating, cost-based estimating, and risk-based estimating. The purpose of risk-based estimating is to account for uncertainties in a project's cost and schedule. When an estimator uses cost-based estimation techniques, they need to record their assumptions about factors such as crew size, production rates, and types of equipment that will be used. At this point, the estimator should begin considering the timing of project advertisement — projects advertised in the late fall or winter may elicit lower bid due to market softness and the greater availability of crews. Estimators should not hesitate to frequently consult experts when preparing or revising estimates, as the information they offer can help the estimator better anticipate local contingencies that influence project cost.

When a project reaches the PS&E phase, the engineer's estimate is readied for the final contract review. This estimate is used to allocate construction funding and assess contractor bids. There is no set technique for estimating project costs at this stage, with historical bid-based estimating, cost-based estimating, and risk-based estimating all being sanctioned by WSDOT. The agency recommends drawing on historical information from the region where a project is located because often, historical bids are from the same contractors that will bid on the new project. Estimators should acquire guidance from construction staff to assess how factors such as staging, materials storage, hauling of materials, location of batch plants, and other constructability issues will impact project delivery. Generating accurate estimates at this stage requires estimators to *think like a contractor*; elements and categories used during earlier phases are disaggregated into individual items. Figure 4.6 summarizes the cost estimating project by phase. It notes the percentage of a design completed at each stage, what purpose an estimate serves, the most commonly used risk estimation techniques, tools, and the acceptable estimate range. Note that from the Scoping phase forward, WSDOT leverages a software package — BidTabs Pro — to analyze standard bid items and contractor bid data. Users can look at data from earlier projects to generate more precise and accurate bid-based estimates.

Project Development Phase	Percentage of Design Completed	Purpose of Estimate	Methodology	Tools	Estimate Range
Planning Washington Transportation Plan Highway System Plan Design Studies Route Dev. Plans	0% to 2%	Screening or Feasibility WTP/HSP (20-Year Plan) WTP – Washington Transportation Plan HSP – Highway Systems Plan	Parametric	PLCE and/or MP3	-50% to +200%
	1% to 15%	Concept Study or Feasibility Implementation Plan (10 Yr. Plan)	Parametric Risk-Based	PLCE and/or MPE Risk assessment models	-40% to 100%
Scoping Project Summary (PD, DDS)	10% to 30%	Budget Authorization or Control Capital Improvement & Preservation Plan (CIPP)	Parametric Historical Bid-Based Risk-Based	PLCE and/or MP3 UBA, BidTabs Pro Risk assessment models	-30% to +50%
Design Design Documentation I/S Plans for Approval Design Approval	30% to 90%	Design Estimates (Project Control of Scope Schedule Budget)	Historical Bid-Based Cost-Based Risk-Based	UBA, BidTabs Pro Risk assessment models	-10% to +25%
PS&E Plans, Specs, Estimate (R/W Plans approved)	90% to 100%	Engineer's Estimate (prior to bid)	Historical Bid-Based Cost-Based Risk-Based	EBASE, UBA, BidTabs Pro, Risk assessment models	-5% to +10%

Figure 3.6 Cost Estimating Matrix for Washington DOT

Specialty groups within WSDOT generate estimates for projects in which they have expertise. Accordingly, project managers play an important role in coordinating estimates that originate from specialty groups and ensuring that estimates are received in a timely manner. Different groups become involved at various points of a project. For example, the Utilities Office should be involved during the earlies stages of project development to prevent conflicts from arising later on. Likewise, environmental staff should be consulted early in the process to analyze the environmental impacts of construction and determine legal or regulatory hurdles that need to be navigated. Other offices that participate in the process are the Bridge and Structures, Right-of-Way, and Traffic Design and Operations.

WSDOT has identified a number of cost drivers that can impact total project cost. Table 3.5 lists each driver and briefly summarizes their influence. Arguably, these cost drivers have broad applicability and should be considered by project estimators irrespective of what state transportation agency they work for.

Table 3.5 Washington DOT Cost Drivers and Descriptions

Cost Driver	Description of Effects
Geographic Contingencies	• When establishing bid prices, it is important to consider whether a project is located in an urban, rural, or suburban area. • Projects in urban locations have to deal with confined work spaces, limited hours of operation, but may benefit from the ready availability of contractors and materials. • Projects in rural settings benefit from expansive work spaces and little traffic, however, materials, equipment, and labor must be transported long distances, which drive up costs. • Terrain and local hydrological conditions affect the cost to perform work.
Construction Contingencies	• This pertains to all risks or events which are not explicitly quantified in an estimate, such as uncertainty over quantities and minor risk events, work elements, and other project requirements.
Restrictive Work Hours	• When work can only be done at night, estimates should reflect additional expenses associated with nighttime operations.
Material Quantities	• In some cases, the unit price for a material falls when large quantities are necessary, however, in some cases (e.g., a project that requires building numerous structures), large quantities can increase the price. • Suppliers generally charge higher prices when smaller quantities are requested.
Material Shortages	• Material shortages will increase costs. • If a particular material is in acutely short supply, it may be worth exploring whether a change in design is appropriate.
Standard Items	• Standard items are commonly used information related to quantities and quantities are well-known to contractors and the DOT. Information on their historical prices is readily available. • The use of standard items should be encouraged to keep costs down.
First-Time-Use Items	• When an item is required that has not been used on a previous project, estimators need to conduct extensive research to develop accurate pricing. • Estimators should not rely on a single contractor to obtain pricing — multiple sources should be consulted.
Separate Operations	• Separate operations typically increase item costs. This is particularly true if work units are spatially dispersed throughout the project site.
Handwork	• Specialized work performed by hand has higher united costs than work that is mass produced or done through automated means.
Specialty Work	• Specialty items differ from the majority of work on a project. Estimating their cost requires that the estimator understand the nature of the work and what resources are needed to complete it.
Item Availability	• Items that have widespread availability are less expensive than specialty materials or materials that are in short supply.
Scheduling, Lead Time	• Contractors tailor their bids based on how work is distributed across the project. Estimates need to consider lead time and how to maximize resources.

Site Constraints	• Site constraints (e.g., installing piles under water, working near railroads or historical buildings, dealing with environmental hazards, working in areas with limited room) or difficult work conditions increase costs.
Soil Conditions	• Assumptions about geotechnical considerations made early in project development may be inaccurate. Estimates should be updated to reflect the project's team evolving knowledge of soil conditions. • Many estimates do not properly account for the shrinkage and swelling of materials. Estimators need to pay close attention to shrink and swell factors as they can significantly influence the cost of a project.
Estimating Lump Sums	• Lump sum items reduce the administrative cost of contract administration, but they transfer risk to the contractor, potentially leading to higher bids. • The use of lump sum items should be restricted to a small number of circumstance.
Force Account	• This is a method of payment in which WSDOT pays contractors the actual expenses for all labor, materials and equipment. It is typically used for unforeseen work and work items that are poorly defined. • Use of this method should be limited because it can drive up costs.
Timing of Advertisement	• The timing of a project's advertisement impacts bid prices. The ideal time to advertise is several months before the work season in which a project is to be completed. • If project work is to occur during the peak season, it should be advertised as soon as possible before it begins in order to ensure a competitive bidding environment.
Expected Competition and Contractor Availability	• If a project is advertised after contractors have scheduled their work for the season, bid prices will be higher than they otherwise would be. • The number of contractors bidding on a project will influence the price — project costs decrease when three or more contractors bid.
Other Contracts	• If multiple projects are advertised simultaneously, it will have an effect on bid prices. • Multiple projects happening in a single area can reduce the availability of skilled labor or materials, driving up costs.
Permit Conditions	• Estimators should consult with the appropriate environmental personnel in the main office or regional offices to understand the current permit conditions. • Several issues warrant close attention, such as stormwater collection and treatment, wetland protection and mitigation, hazardous materials testing, and containment and treatment.
Inflation	• Estimates anticipate project costs at the time they are created. When estimates are updated, they need to account for inflation.
Other Funding Sources, Agreement of Work for Others	• It is critical to document all sources of funding early in the project development phase to identify problems that may arise later on.

3.3.3 Montana

The Montana Department of Transportation (MDT) develops project estimates at each of its five key design stages — Nomination/Preliminary Field Review (PFR), Alignment and Grade, Scope of Work, Plan-in-Hand, and Final Plan Review/Contract Plans. Estimates made during the Nomination/PFR stage are high-level; as project development proceeds, estimates are refined and elaborated based on the agency's evolving understanding of the project requirements. Table 7 summarizes the strategies used to prepare cost estimates during each design stage, including the cost estimating method used, allowable contingency, and the amount of inflation built into the estimate. MDT cautions that estimators will have to rely on extensive engineering judgment to determine the best cost estimating methodology at each stage and decide which method yields the most reliable estimate.

Estimates developed at the Nomination/PFR stage are preliminary and do not include exact quantities. Because of the inherent uncertainty of project specifics during this stage of development, estimators should use more than one method to estimate costs and then compare the results of different methods. Estimators must document all of their assumptions and produce a written estimate that contains all of the items which have factored into the estimate. Cost estimate methods appropriate for this stage include:

- Cost per mile (using similar projects within a region let in the previous 6–12 months)
- Cost per square yard
- Cost estimate spreadsheet (includes approximations of the quantities of major bid items and average bid prices)
- HEAT's (Highway Economic Analysis Tool) Cost Estimation Module
- Analogous estimating (recommended for small, specialized projects)

When assembling Nomination/PFR estimates, estimators should also factor in items that can influence the cost (Table 3.6). Along with bid items, it is also important to consider contingency and risk to understand what known and unknown conditions have the potential to slow project delivery. The agency defines contingency as the amount of funding added to the project to offset the effects of incorrect unit costs, the possibility of unknown events impacting project delivery, unforeseen project requirements, and other risks. Some risk factors MDT suggests looking at include: schedule time, traffic control issues, the effects of project letting on construction and constructability, rail and utility issues, environmental mitigation, availability of materials and labor, geotechnical problems, project size, unknown risks, and the potential influence of change orders.

Table 3.6 Items Factored into Montana DOT Nomination/PFR Estimates

Guardrails	Traffic signals, Lighting, ITS
Large culverts and irrigation facilities	Turn bays and other isolated widening
ADA ramps, curbs and gutters, sidewalk work	Environmental mitigation, wildlife crossings, wildlife fencing
Bridge surveying, work, and adoption	Unique or idiosyncratic fencing needs
Retaining structures	Constructability issues
Public relations (key factor on urban projects)	Training programs
Weed control	Railroad involvement
Extensive utility workarounds	

At the Nomination/PFR estimating stage, contingencies of 10% to 25% should be built into the project budget. Project scope influences contingency — while it is reasonable for a minor project, such as a seal and cover, to have a 5–10% contingency, major projects are likely to have much larger contingencies built in. As Table 3.7 shows, the maximum allowable contingency declines for each proceeding stage. Inflation is set at 3% per year regardless of the cost estimating stage.

At the Alignment and Grade stage, estimators develop more accurate estimates for grading, surfacing, and large drainage facilities. While there may still be quantities unknown, the precision of estimates at this stage are much greater than at the Nomination/PFR stage. Projects with estimates above $15 million require the involvement of a Cost Estimate Review team, which reviews the bid prices assumed by the estimate and looks at known and unknown issues to identify where significant risks may exist. The Cost Estimate Review team is interdisciplinary, and draws from all functional areas of MDT. Appropriate cost estimate methods at this stage include the cost per mile, cost per square yard, and a cost estimate spreadsheet. The spreadsheet accommodates quantity estimates for major bid items — taken together, these items are responsible for 65–85% of the total project cost. Cost per square yard should not be the primary estimating used at this stage; rather, estimators should rely on it to validate estimates developed using other methods.

At the Scope of Work stage, estimators should have knowledge of all major items. Quantities typically have not been finalized, however. Cost estimating methodologies used at this stage include the cost estimating spreadsheet. Along with the major bid items included during the previous stage, it is updated to contain estimates from additional design areas, including Bridges, Traffic, and Geotechnical. During later stages of project cost estimating MDT is reliant on AASHTO software (e.g., AASHTOWare; see New Jersey write-up).

Once the project reaches the Final Plan Review/Contract Plans stage, estimators will have quantified all bid items. If necessary, the Cost Estimate Review team will reconvene to examine any issues that have developed such as scope adjustments, discovery of previously unknown site problems, and constructability issues. Estimators adjust pricing for large items based on regional factors. Estimators also study the effects of big-ticket items on constructability and project costs and obtain prices for similar items with verified bid histories. The cost estimating methods used at this stage include the cost estimate spreadsheet and AASHTO software.

Table 3.7 Cost Estimating Methods for Montana DOT Project Development Stages

Design Stage	Cost Estimating Methods	Contingency	Inflation
Nomination/PFR	• Cost per mile • Cost per square yard • Estimated quantities (cost estimate spreadsheet) • HEAT module • Analogous estimating	10%–25%	3%
Alignment and Grade	• Cost estimate spreadsheet • Cost per mile • Cost per square yard	10%–25%	3%
Scope of Work	• Cost estimate spreadsheet • AASHTO software	10%–20%	3%
Plan-in-Hand	• Cost estimate spreadsheet • AASHTO software	5%–10%	3%
Final Plans	• Cost estimate spreadsheet • AASHTO software	0%–5%	3%

3.3.4 California

The California Department of Transportation (Caltrans) applies the term *project cost estimate* to all capital outlay costs (e.g., right-of-way, structures, and landscape) incurred during a project. It does not usually encompass support costs. Caltrans splits project cost estimates into two categories: project planning cost estimates and project design cost estimates. Project planning cost estimates are used to justify a project, for programming, during the analysis of alternatives, and to obtain approval. Project design cost estimates summarize the cost of contract item and generate the bid item list in construction contract documents. Consistent methodologies and formatting must be used when preparing estimates. Caltrans has developed standard formats to perform cost estimates. Project engineers update estimates throughout project development, while project managers review and approve all estimates. But this is not to suggest project engineers generate estimates without external input. Other stakeholders who participate in this process include:

- Headquarters Division of Engineering Services — Structure Design
- Headquarters Division of Design
- Headquarters Division of Project Management — Project Delivery and Workload Development
- Headquarters Management
- District Right-of-Way
- District Project Management
- District Director

It falls within the ambit of Headquarters Division of Engineering Services — Structure Design to produce all estimates related to structures, while District Right-of-Way formulates all estimates related to right-of-way. It is the project engineer's responsibility to combine estimates generated by individual functional units into a composite estimate.

After the initial creation of estimates, they are updated at regular intervals. All estimates receive annual updates. These generally focus on revising unit costs based on current market conditions (as long as no major changes to the project scope have been made). Estimates are also required at the beginning of each programming cycle. These are prepared biennially. Once a project has been authorized, project development reports are generated which include the project cost estimates. Caltrans also requires project engineers to update estimates if a particular work item needs a more detailed cost estimate than is currently available, or if project costs have changed significantly. Estimates also require updates after the Plans, Specifications, and Estimate milestone.

Project planning cost estimates are created before project approval. There are four subcategories of estimates that fall under the heading of project planning cost estimates — project feasibility, project initiation, draft project report, and project report. Project feasibility cost estimates are high-level estimates sometimes used by management to decide whether project development should move forward. Because projects are not clearly defined at this juncture, estimators typically rely on analogous estimating, assuming the worst probable case. The estimate must include quantified estimates of high-cost items, environmental mitigation, utility relocation, noise barriers, transportation management plan, structures, and major storm drains. A contingency of 30% to 50% is appropriate at this stage. Project initiation cost estimates must be completed before a project is initialized. They include more details and serve as baseline estimates against which future estimates are compared. Project initiation cost estimates account for additional factors such as forecasted traffic volume, geotechnical design considerations, information on materials and pavement, advance planning studies for new and existing structures, environmental mitigation, right-of-way and utilities data sheets, and traffic management. Draft project report cost estimates add significant detail to estimates produced during earlier stages of the project. Estimators update estimates for all project alternatives using data they have received from other functional units. This final estimate developed during planning is the project report cost estimate. It is readied after public hearings have been held, the preferred alternative selected, and completion of the environmental document. However, it does not serve as a baseline unless Caltrans uses it to establish a new programmed cost. Contingencies are to be approximately 15% at this stage.

Once a project has received approval from management, it transitions to the project design phase. Cost estimates moving forward are prepared using the Basic Engineering Estimating System (BEES), a proprietary system that is used to communicate information about projects. The project cost estimate includes the district cost estimate and structure cost estimate (if applicable). The district cost estimate encompasses all highway contract items of work and the costs associated with them. As estimators identify contract items of work and quantities they are incrementally entered into BEES. This facilitates development of the final engineer's cost estimate. Two estimates are produced during this phase — the preliminary engineer's cost estimate and the final engineer's cost estimate. The preliminary engineer's cost estimate is the fair and reasonable price the State of California should expect to pay for a project. It is updated regularly during the design phase as knowledge of a project evolves. The final engineer's cost estimate is completed as PS&E development concludes. It contains all contract items and quantities. Contingencies should be less than 5% by this point.

3.3.5 Connecticut

The Connecticut Department of Transportation (CTDOT) mandates biannual updates of project construction cost estimates, at significant design milestones — Preliminary Design, Semi-Final Design, Final Design for Review, and Final Design Plans — and when the scope undergoes significant changes (CTDOT, 2016). Figure 3.7 illustrates the relationship between project development phase and estimated contract costs at various project stages. During early stages of project development, estimators lack the knowledge needed to make precise estimates for items and minor item allowances (i.e., the base estimate). The base estimate is the estimated cost of anticipated contract work — it encompasses total construction expenses, including the price of individual work items. Estimators can use catalog pay items, aggregate cost factors, or other approved methods (e.g., cost basis). However, most often, estimates are based on recent bid prices (within the past three years), although these can be adjusted based on inflation. During the early stages of project development, uncertainties are most pronounced. Early stage base estimates have significant contingencies built in to account for these uncertainties. Contingencies are the costs driven by risk and uncertainty in the project. As project timelines are often unknown during the early stages of project development, it is important for estimators to build in a suitable level of inflation to account for changes in work items. CTDOT recommends an inflation rate of 5% beginning in 2016. As project development moves forward, the base estimate constitutes a larger and larger proportion of the estimated contract cost. By the time designs have been finalized, estimated contract costs have two components — identified items and contingency. Final design plan estimates include contact costs, non-contract costs, and contingencies.

CTDOT makes heavy use of AASHTOWare's Estimator module. Thus, a considerable portion of its guidance relates to using it for developing estimates. A thorough review of AASHTOWare is beyond this chapter's scope, however, CTDOT uses the software to generate precise and accurate estimates for unit-based items. Estimates generated by Estimator leverage historical pricing. However, the Estimator module has several key limitations. It does not do the following: generate estimated prices for lump sum or estimated items, generate estimated non-contract costs, or generate estimated prices for unit-based items unless an item has been used on at least two previous construction contracts. Additionally, if the bid history catalog selected by the estimator contains 2–14 instances of an item being used, Estimator averages those prices to produce an estimate. If a bid history catalog includes more than 15 uses of an item, it employs regression analysis to estimate the price using factors such as quantities, location, letting type, and work type. CTDOT staff must be willing to use engineering judgment to validate the quality of Estimator's pricing.

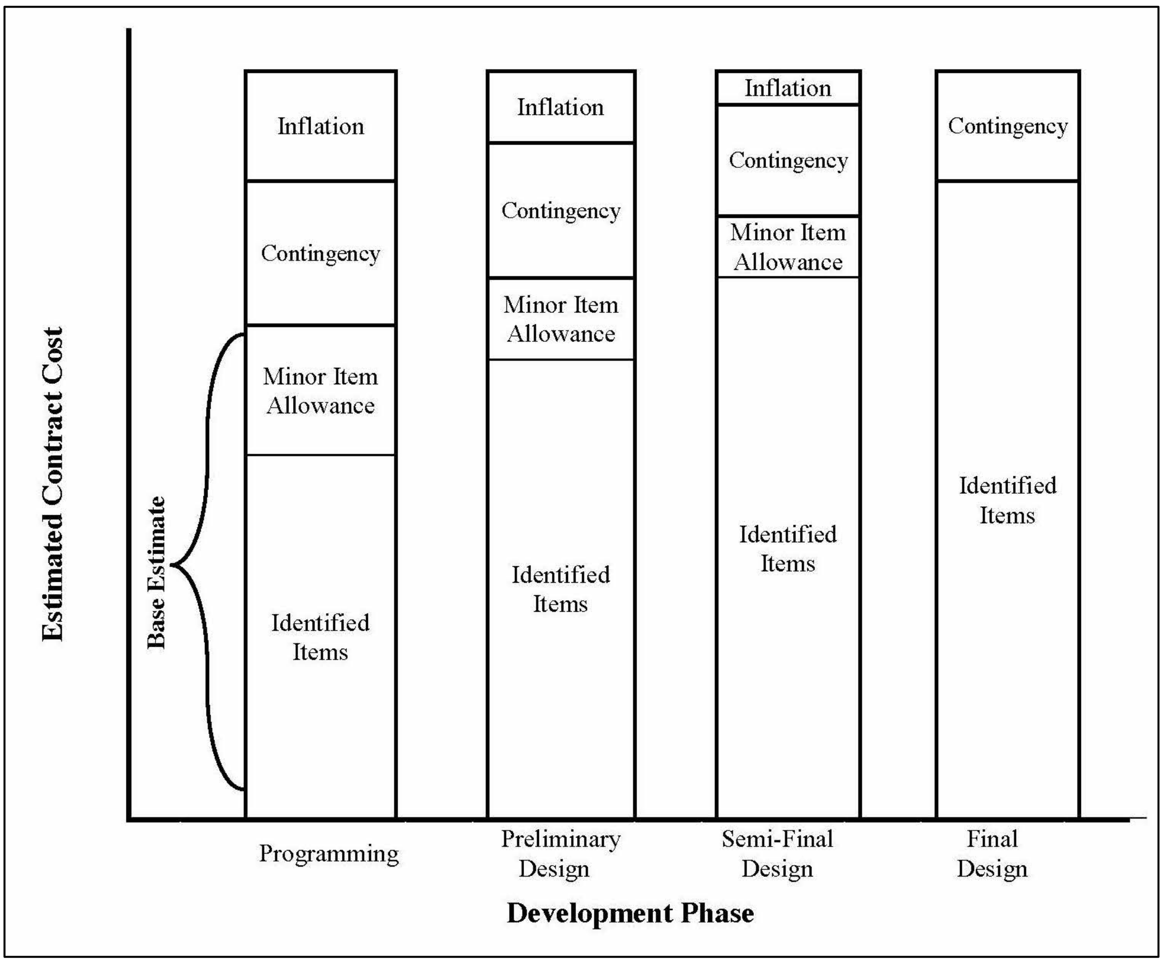

Figure 3.7 Connecticut DOT Project Cost Estimating Stages

3.3.6 Indiana

Indiana's Department of Transportation (INDOT) requires cost estimate updates at various stages in the project development process. The first of these is the Project Initiation Estimate, which is produced by district offices after they have nominated a project for inclusion in the agency's multi-year highway improvement program. This first high-level estimate uses broad units of cost, such as cost per mile or cost per square mile. District offices also review similar projects that have recently been completed in the area to make estimates. Next, the Preliminary Engineering Study Estimate is generated by the centrally located Environmental Policy Team. This team relies on input from the district to prepare a more detailed cost estimate. Unit prices form the basis of this estimate, however, if quantities have been specified they should be used. Table 3.8 summarizes the items factored into this estimate and what offices are responsible for providing estimates for each item.

Table 3.8 Items in Indiana DOT Estimates

Item	Basis of estimate	Source of Estimate
Roadway items	• Cost per mile per roadway width (encompasses earthwork, pavement, structures, drainage, and other items)	• EPT
Structure items	• Cost per square yard based on the price of similar structure type, work type, and crossing type	• EPT
Traffic-Signal Items	• For signal installation, cost per intersection • For signal-interconnect system, cost per installation	• Traffic Signals Team
Traffic-Signs Items	• Cost per sign	• Signing and Lighting Team
Lighting Items	• Cost per mile or cost per interchange where lighting will be installed	• Signing and Lighting Team
Traffic Maintenance	• Parametric estimation based on a comparison with past projects of similar size, type, and complexity	• EPT
Right-of-Way	• Estimate of land costs, damages, and administration costs	• Office of Real Estate • Administrative Services Team
Contingencies	• Contingency factor for miscellaneous and lump sum items based on 20%–30% of roadway/bridge construction items	• EPT
Preliminary Engineering	• On road projects, a markup of 3%–6% based on the first eight items in this table (excluding Right-of-Way) • On bridge projects, a markup of 5%–8%	• EPT
Unit Costs	• Quantities and average weighted unit prices	• CES/Estimator Software

After the Preliminary Engineering Study Estimate, the designer assumes responsibility for refining cost estimates. The first estimate they generate, which is also included in the Design Summary, occurs during the Preliminary Field Check stage. Once project development has reached this stage, the designer should be able to approximate some of the quantities. Averaged unit weight prices are used to generate this bid. Designers need to be attentive to factors which can affect unit prices, including:

- Geographic location
- Similarity of recent construction projects used as a basis of comparison
- Inflation
- Reliability of recent construction cost data
- Recent trends in the cost of materials, labor, and equipment
- Proposed project schedule
- Anticipated difficulty of construction
- Environmental mitigation
- Use of experimental materials (requires coordination with Office of Research and Development)
- Project size relative to size of similar projects

Designers use the Cost Estimation System and Estimator (a software program used to generate estimates) to prepare their estimates. Estimator requires the input of quantities to produce a cost estimate. Based on these quantities, it generates a cost estimate using historical data from earlier projects. Based on engineering judgement, a designer should factor a 10%–25% contingency into the total cost to account for unknown quantities. At the Design Approval Plans stage, the designer should know all of the major quantities. However, if some quantities remain unknown, they should build in an appropriate contingency. All plans should be completed by the Final Check Prints stage, and all quantities should be input into the Estimator software. At Submission of Final Tracings, the designer should have a cost estimate in hand based on final plans and quantities. The final Engineer's Estimate is used to evaluate bids and determine whether the lowest bid is fair and reasonable given the amount of work requested. Although INDOT takes a staged approach to the development of cost estimates, it mandates that designers revise or prepare new cost estimates if there is a project scope change or project delay.

3.3.7 Georgia

Georgia's Department of Transportation (GDOT) has adopted a six-phase approach to estimating project costs (summarized in Table 3.9). From a project's outset, the state's Cost Estimating System (CES) and Right-of-Way and Utility Cost Estimating System are used to generate estimates. Initial project estimates are the responsibility of the office or department (i.e., source) that identifies a candidate project. There are four principal sources in Georgia — the Office of Planning, District Offices, Metropolitan Planning Organizations, and the Office of Traffic Operations and Maintenance). During the Concept Development Phase, the source office first has staff inspect the field site before it documents the basis and justification of its cost estimate. Estimates made at this point also include costs for scoping or preliminary engineering. The source office also produces an updated construction cost estimate based on data collected during the field visit as well as conceptual studies. Once preliminary engineering has been authorized, a project manager assumes responsibility for developing and coordinating activities related to estimation until the final estimate is prepared (this falls to the Office of Engineering Services). Divisions throughout GDOT collaborate to assemble estimates. As such, the Office of Right of Way prepares cost estimates using approved right-of-way plans. The Office of Utilities is responsible for cost estimates for utility relocations. Estimates are updated on a regular basis in the CES.

Contingencies vary based on project type (Table 10). For example, low-risk projects such as adding a bicycle facility or reconstructing part of a road without adding capacity have a 5%–10% contingency added in during the Concept Development Phase. Although by the time a project reaches the Preliminary Field Plan Review stage, contingencies should be in the range of 0%–5%. Conversely, more complex projects (e.g., new construction) require the inclusion of greater contingencies in the early phases of project development. By the time the projects are in the final stages of development, however, their contingencies should also be approximately 0%–5%.

Table 3.9 Georgia DOT Estimation Phases and Descriptions

Estimation Phase	Description
Concept Development	• Prepared by source office • Estimate based on field data collection and conceptual studies • Source office provides justification for proposed project
Preliminary Field Plan Review	• Prepared by project manager • Includes more detailed information on earthwork, drainage, staging, and erosion control quantities
Right-of-Way	• Prepared by Office of Right of Way • Uses detailed right-of-way plans to estimate the amount necessary to obtain right-of-way authorization
Utility Relocation Plans	• Prepared by Office of Utilities • Estimate based information in utility relocation plans
Final Field Plan Review	• Prepared by project manager • Estimate based on project quantities as well as information about signing and marking, staging, utilities, right-of-way, bridge, earthwork, and paving quantities • Submitted to Office of Engineering Services
Final Engineer's Construction Cost Estimate	• Prepared by the Office of Engineering Services • Final estimate that serves as basis for comparing bids received at letting

Source: Georgia DOT (2014)

The project manager is responsible for integrating estimates from outside offices into a single estimate. For example, when the Office of Right of Way estimates the amount of funding necessary to acquire the right-of-way, this information is communicated to the project manager. The project manager incorporates that estimate into the overall project estimate. Phases described in Table 3.10 are not strictly sequential. During the Concept Development phase, for instance, the project manager requests estimates from the Offices of Right of Way and Utilities. Estimates for projects outsourced to external contractors are the responsibility of the designer of record. Although GDOT makes no specific recommendations about the prudence of using lump sum items, project managers should reach out to the Office of Engineering Service's Estimating Section for help preparing them.

Table 3.10 Contingency by Phase for Georgia DOT Projects

Project Type	Risk	Contingency		
		Concept	PFPR	FFPR
• Enhancement • Bicycle • Pedestrian facility • Safety	Low	5%–10%	0%–5%	0%–5%
• Reconstruction or rehabilitation w/no added capacity	Low	5%–10%	0%–5%	0%–5%
• Maintenance-restoration and rehabilitation	Medium	5%–15%	0%–7%	0%–5%
• New or replacement bridge	Medium/High	10%–15%	0%–7%	0%–5%
• New construction	High	10%–20%	5%–10%	0%–5%

• Reconstruction or rehabilitation w/added capacity	High	10%–20%	5%–10%	0%–5%

(PFPR = Preliminary Field Plan review; FFPR = Final Field Plan Review)

3.3.8 Illinois

The Illinois Department of Transportation (ILDOT) divides project cost estimation into four phases — Project Initiation Estimate, Phase I Estimate, Phase II Estimate, and Engineer's Estimate. Estimating activities kick off once a project has been nominated for inclusion in ILDOT's Multi-Year Highway Improvement Program. The Office of Planning and Programming, with assistance from district programming engineers and/or estimating engineers, assembles the initial estimate. The Project Initiation Estimate is a very high-level document. This estimate is based on units of cost (e.g., cost per mile, cost per square yard) and an examination of previous projects which had a comparable scope and magnitude. More specifically, at this stage highway project estimates use a cost per mile per roadway width and include the cost of earthwork, pavement, drainage, and other items. Estimates for structural projects hinge on a calculation of cost per square foot, and traffic signal project estimates are based on the number of signals installed per intersection. Quantities are not required at this stage of estimation, however, if they are known they should be included, as should a contingency factor of 10%–20%. Because many contingencies influence project outcomes, ILDOT advises estimators to determine unit costs based on a consideration of these variables:

- Geographic location (e.g., urban or rural setting, location within the state, district project will occur in)
- Similarity of recent construction projects
- Inflation
- Reliability of recent construction cost data
- Trends in the cost of materials, labor, and equipment
- Difficulty of construction
- Constructability issues that may arise
- Proposed project schedule
- Anticipated construction staging
- Right-of-way acquisition
- Presence of railroads
- Utilities and utility relocations
- Environmental problems

District programming engineers, with the aid of estimating engineers, assume responsibility for preparing Phase I Estimates. On projects outsourced to a consultant, it is up to the consultant to develop quantities and determine unit pricing. Staff preparing the estimate should request information on quantities that remain unknown, although it is possible some quantities will not be available at this stage. As they attempt to resolve breakdowns, estimators need to consider the influence of major items (e.g., interchanges, bridges), whether a project will potentially span two construction seasons, and the sources and utilization of project funding. For the latter item, estimators identify costs associated with construction, right-of-way acquisition, utility adjustments, local participation, and consultants.

Multiple estimates may be prepared during the Phase II project stage. These are put together by estimators in local offices with the assistance of designers. Table 3.11 lists the stages or events that should trigger the development of a new or revised estimate during Phase II.

Table 3.11 Illinois DOT Phase II Estimates

Reason for Estimate	Description
Preliminary Plan Review	• Revised cost estimates used to set preliminary Disadvantaged Business Enterprises requirements • Sometimes revised cost estimates are prepared to ensure the program funding is appropriate for the project.
Project Scope Change	• Designers will obtain a new construction cost estimate if the project scope changes. Changes are based on approximate quantities.
Project Delay	• A significant delay in project delivery should prompt development of a new estimate so that it reflects current rates of inflation, materials and equipment costs, and contractor workloads.
Final Plan Submittal	• District estimating engineers produce a cost estimate based on final plans. Once complete, it is sent to the Bureau of Design and Environment, which assembles the Engineer's estimate.
Engineer's Estimate	• This is ILDOT's official project estimate. It is used to evaluate contractor bids and determine if the low bid is fair and reasonable.

Estimating engineers use a variety of information furnished by designers to create estimates, including plans, quantities (this encompasses breakdowns and lump sum items), specifications, and cost estimates prepared by other divisions within ILDOT (e.g., Bureaus of Bridges and Structures, Operations, Electrical Operations). If lump sum items are required by a contact, estimating engineers break these items into their component parts and estimate the price of each separately — estimators arrive at the lump sum by adding these prices together.

Estimators leverage the agency's Contract Maintenance System to develop estimates. This system houses worksheets, historical pricing information, and other resources used to prepare estimates. Generally, estimates are based on quantities and unit prices. While ILDOT's guidance contains detailed instructions on how to fill out worksheets, this information is omitted here (see ILDOT, 2016, p. 19-22).

3.3.9 Minnesota

Minnesota's Department of Transportation (MnDOT) has adopted a combined cost estimating/cost management (CE/CM) program. After the agency identifies a transportation need, CE and CM processes begin. The agency breaks project development into four phases — planning, scoping, design, and letting. Estimates are prepared at critical points throughout project development. There are seven critical points (some phases require the development of estimates at more than one point. Figure 3.8 illustrates where each phase is located relevant to the beginning of construction, while Figure 3.9 summarizes estimating activities according to project development phase. The agency refines its estimates throughout the project development process as more information about a project becomes available. The state relies on AASHTO software to prepare PS&E estimates, specifically its Cost Estimating System and Proposal Estimating System. However, software-based estimates can be prepared as soon as the scoping/design phase. District offices also rely on a number of spreadsheet templates to organize and develop early phase estimates.

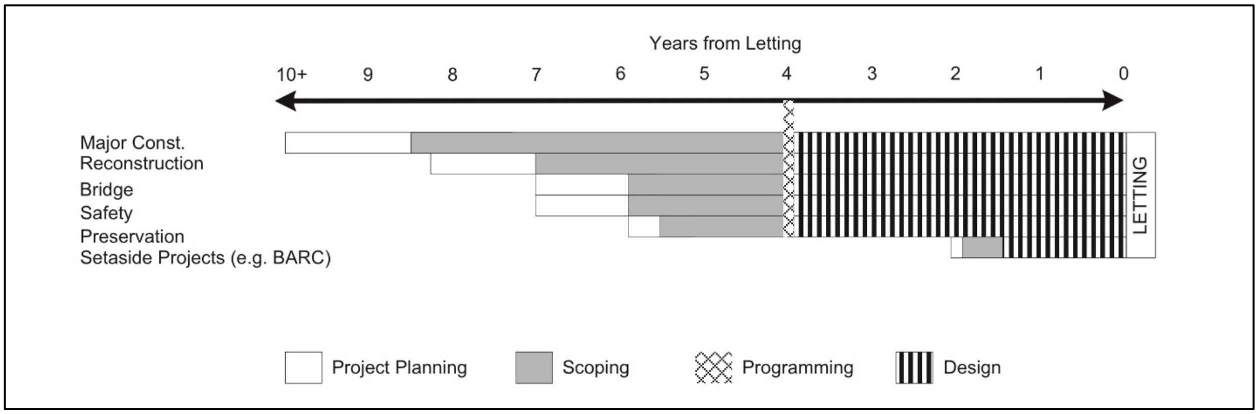

Figure 3.8 Minnesota DOT Project Development Process Timeline

Planning estimates are conceptual and inform development of the 20-year Transportation System Plan and 10-year Highway Investment Plan. Although the conceptual nature of planning phase estimates is well recognized, they are nonetheless critical for assisting the agency in judging alternatives and deciding which transportation needs are most urgent. Conceptual estimates are based on parametric estimation techniques. Under this framework, past project performance is used to understand the potential economic impacts of future projects. Two estimation techniques are commonly employed during planning — cost per parameter using similar projects and cost per parameter using typical sections. Because much uncertainty exists during planning, estimates are reported in ranges (i.e., not point estimates). Estimators located in district offices are tasked with estimating project costs during planning, although district planners and staff in the central Office of Project Scoping and Cost Management provide assistance as well.

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

Figure 3.9 Minnesota DOT Cost Estimate Classification System

Figure 3.10 illustrates the planning phase estimate work breakdown structure (WBS). First, the estimator determines the estimate basis. During this task, stakeholders assisting with the estimate collect and document all of the information which will go into the planning cost estimate. Five sub-processes fall under this heading — 1) review concept definition, which includes key project parameters identified during early planning stages; 2) identify alternatives to estimate (excluded if there are no alternatives); 3) review of site characteristics, which includes a narrative of the project type and complexity, site location analysis, and key influences on the estimate; 4) determine if clarification is needed; and 5) document estimate basis. Although the WBS lists these items sequentially, in most cases they will be performed concurrently and repeated as warranted. Functional groups within the agency (e.g., Structures, Right-of-Way) offer guidance and estimates for work items which fall under their purview.

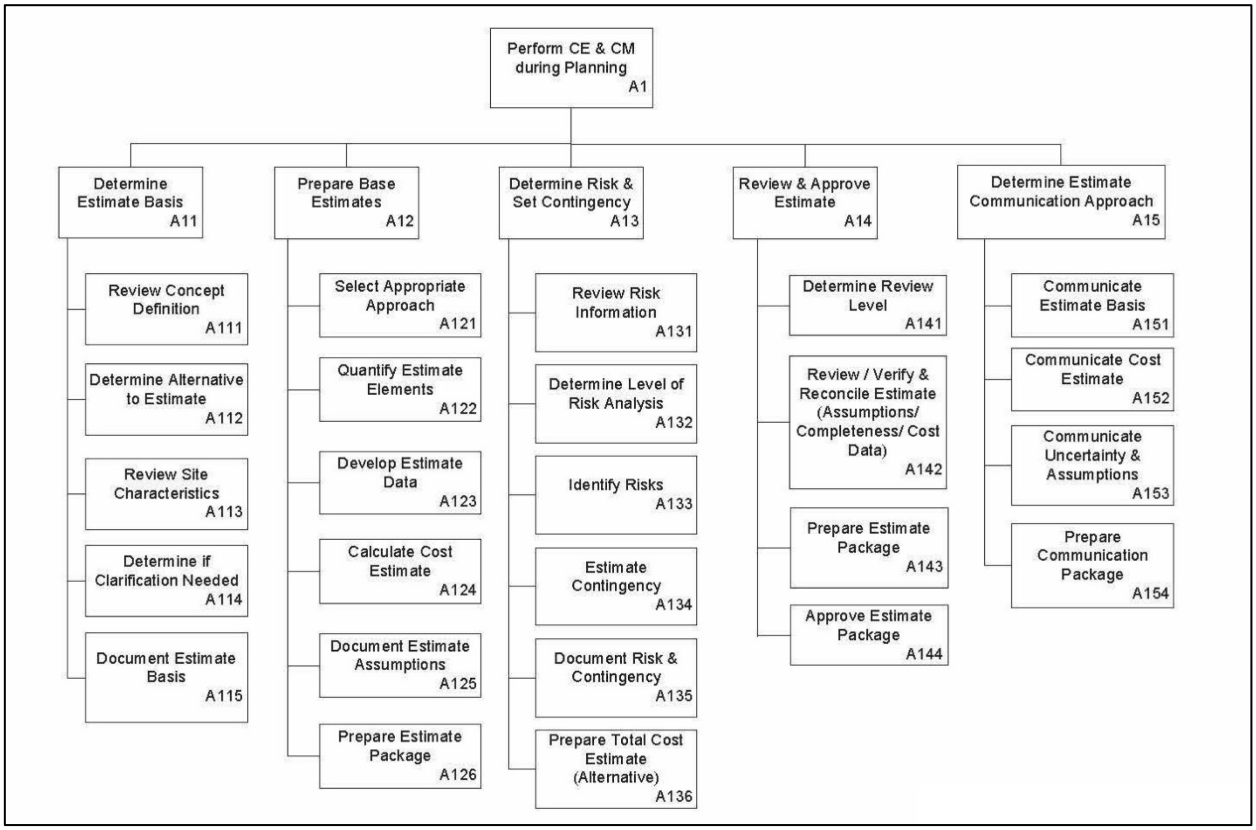

Figure 3.10 Minnesota DOT Work Breakdown Structure for Planning Phase Estimates

The estimator's next step is to determine the base estimate. The goal of this process is to develop the most likely cost estimate without contingency. Estimators confront two significant challenges at this stage — first, information on the project may be scarce, which forces estimators to rely on a large number of assumptions and base their estimate on previous projects; second, because a long period of time separates planning from the actual construction (up to 20 years), it is difficult to accurately forecast inflation, market impacts, or how the project will be redefined. Estimates generated during this phase are used to facilitate long-term transportation planning and set priorities based on anticipated funding. Once the base estimate has been prepared, estimators move on to analyze risk and contingency. Risk assessments are built using information from assumptions about a project's definition, an evaluation of assumptions included in the estimate, and subject-matter expertise. Another factor is project complexity. All projects are assigned to one of three classes of complexity — risk tools and analytical techniques are selected based on this categorization (see below). The outputs of this process vary according to project complexity. For some projects, the output will be a red flag item list, while more complex projects require the development of more complex risk analysis and contingency estimates. For the latter projects, estimators may prepare detailed three-point estimates or use Monte Carlo simulations to forecast contingencies. After risk and contingency analyses have been completed, the estimate is reviewed and submitted for approval. The level of review is a product of project complexity, with more complex projects demanding more in-depth reviews. After being approved, a communication package is assembled and distributed to key stakeholders. The purpose of these documents is to present information about projects in a fair and objective light. Generally, these packages contain the following items: the project basis (what the project includes and what it does not); the total project cost range; uncertainties regarding total project cost; assumptions underlying the project and estimate; project schedule; and the project development status. Along with the estimate details, this package includes a one-page summary which highlights the most critical facets of a project. Communications packages keep stakeholders informed about projects and where they stand in the development process. All estimating routines used in later phases (e.g., scoping/design, PS&E) culminate with the production of a communications package. Admittedly, this is a high-level description of an extremely intricate and complex process. We do not review subsequent estimating phases in the same level of detail — readers should refer to MnDOT's guidebook and the detailed work breakdown structures that are contained therein[5].

Scoping/design estimates are extremely critical because they are used to establish the baseline project definition, cost, and schedule. All project-related costs are managed against the baseline estimate. After being set, the baseline estimate remains unchanged. If significant project changes are required after the baseline has been established that will impact the cost, the project must go through a formal review process. Estimating techniques used during this phase vary according to project type and complexity, and in some instances estimators elect to use AASHTO software beginning at this stage. MnDOT lists six estimating techniques appropriate for scope/design estimates — analogous or similar project, cost based, historical bid based, historical percentages, parametric estimating, and a combined approach. The combined approach blends different techniques, applying them based on the nature of a work item. Scope/design estimates are point estimates (i.e., they are not reported as a cost range). Like planning estimates made, scoping/design estimates have contingencies built in to account for project uncertainties.

PS&E estimates are based on definitive contract documents, which themselves are based on the project final design. These estimates are used to finalize project funding before the project is advertised and to evaluate the bids which are received. MnDOT uses three approaches for PS&E estimating — cost based, historical bid based, and combined. The combined estimate adopts a bottom-up approach to estimate the cost of the items that account for a significant fraction of the project's total construction cost (e.g., Portland cement concrete pavement, structural steel). All other item costs are estimated using historical bid prices. PS&E estimates include contingencies, but they are embedded at the item level.

MnDOT uses a sophisticated three-tiered approach to estimate contingencies. The level of project complexity dictates what type of risk analysis is employed. Projects are grouped into three categories — non-complex (minor) projects; moderately complex projects, and most complex (major) projects. Risk analysis is matched to project complexity. And while all types of risk analyses are built upon a common foundation, the tools and level of effort depend on the type of project being appraised. For minor projects, the agency uses a Type 1 Risk Analysis. This entails developing a list of risks and estimating contingencies as a percentage of the project cost. Moderately complex projects undergo Type 2 Risk Analysis. Using this method, estimators take advantage of more robust risk identification tools. It also requires consideration of specific contingency items. To thoroughly understand the nature of risks which can impact a project, a probability-impact matrix is prepared to qualitatively rank risks. Type III Risk Analysis is reserved for major projects and leverages quantitative risk management. This analysis begins with a risk analysis workshop that brings together key team members to discuss and identify project risks. Based on these discussions, estimators develop a stochastic estimate of the cost, schedule, and contingency, all of which are updated continually throughout project development. MnDOT's guidebook includes a detailed appendix that describes numerous risk assessment tools and under what circumstances each should be used (2008, p. 335-486).

3.4 Additional States

We reviewed publicly available materials from a number of other states. Many of these states, however, provide a less detailed overview of the estimation process. Rather than presenting step-by-step guidelines for developing estimates, their main focus is on systems and software packages that are used to prepare estimates. In some cases, the software is sourced from AASHTO, but a number of states — in addition to those already mentioned — have created proprietary software to estimate project costs. This section briefly touches on several states that have

[5] MnDOT's guidebook contains exhaustive descriptions of estimating phases and the sub-processes required to assemble an estimate for each phase.

project estimating manuals which concentrate on using project cost estimating software. The focus is limited to what the manuals say about the estimation process per se, rather than the mechanics of software use.

3.4.1 Nevada

The Nevada Department of Transportation (NVDOT) assigns responsibility for project estimates to the Roadway Design Division. Throughout project development, cost estimates are updated to reflect current knowledge. During the earliest phases of development — the planning and scoping phases — the agency uses risk-based parametric estimates. This is a form of analogous estimating that bases the estimate on comparable past projects and historical pricing data. As a project moves into the design phase, more accurate estimates are necessary to ensure the agency budgets for it appropriately. Estimators prepare estimates at six stages during this phase: 1) Engineer's Estimate; 2) Intermediate Review Estimate (60% plans); 3) Quality Assurance Estimate (checking phase); 4) Final Engineer's Estimate (plan, specifications, and estimate); 5) Preliminary Estimate; and, if necessary 6) a New Bid Item Version Number Estimate. NVDOT views the engineer's unit price as the foundation of a project estimate. The engineer's unit price is the price of a unit of work. It should be adjusted based on project-specific contingencies. As such, it is critical for the estimator to account for a project's local context — they should proceed with caution when they compare prices from other regions, are dated, are influenced by a special circumstance, when there is little historical data available, or if the price of some component is vulnerable to market fluctuations. Estimators must also be attentive to economies of scale, the proximity of material resources, and other trends that may affect a project. Like other states, NVDOT recommends basing estimates for lump sum items on each component necessary for an item of work. During preliminary design, estimators should aim for a project contingency of 15%. This number should fall to 10% by the end of the intermediate design stages. At final design, projects less than $3 million should have a 7% contingency; projects between $3 million and $25 million should have a 5% contingency, and projects estimated to cost more than $25 million should have a contingency of less than 3%.

3.4.2 Utah

The Utah Department of Transportation's (UDOT) method for estimating costs is straightforward. Estimates are updated throughout project development, with accuracy and precision increasing as the project approaches letting. UDOT has four types of estimate, which correspond to project development stage — concept estimates; scoping estimates; plan in hand estimates; and the final engineer's estimate (prepared at the plan, specification, and estimate stage). Proprietary worksheets and a database of historical project information are used to develop estimates. And while it is the responsibility of the project designer to compile estimates and keep them up-to-date, individual design groups are tasked with completing estimates for their area of responsibility (e.g. structural designers estimate the cost of structural items, the utilities engineer estimates the cost of utilities). UDOT's estimates incorporate two types of contingency: project contingency and change order contingency. Project contingency is built into an estimate to account for things such as minor work items and inaccuracies in project design. For this form of contingency, UDOT's rule of thumb is 25% at the concept stage, 15% at scoping stage, and 10% at the plan in hand stage. Change order contingencies are included to account for any changes which arise during construction. This form of contingency is generally set at 10% of the construction amount and remains in the project estimate through advertisement. Table 3.12 lists the general steps UDOT recommends for preparing the engineer's estimate.

Table 3.12 Utah DOT Procedure for Developing an Engineer's Estimate

Step	Notes (If Applicable)
1. Compile quantities	• The accuracy of quantity estimates should align with the current level of design
2. Calculate unit bid prices	• Maintain documentation that specifies how unit prices were developed
3. Individual departments provide quantities and costs for their work items	• n/a
4. Develop estimate for each department's work items	• n/a
5. Add contingencies	• This includes contingencies for unknown items, miscellaneous items, and inflation

6.	Perform a Red Flag Analysis	• This analysis increases or decreases the estimate based on project characteristics
7.	Verify estimate is sufficient for project delivery; identify outstanding areas of concern	• Estimators should confirm there is enough funding to cover all project elements • Determine whether scope modification or additives/alternate bidding will overshoot the allocated funding
8.	Conduct quality control/quality assurance	• Follow UDOT procedures and back up all documentation

UDOT identifies a number of contingencies estimators should bear in mind when estimating unit bid prices (Table 3.13).

Table 3.13 Key Factors Identified by Utah DOT Affecting Unit Bid Prices

Factor	Considerations and Questions to Address
Location	• Is the project in an urban or rural setting? • Do projects in the area typically generate many or few bidders?
Time of Year	• Contractors build up a backlog for the summer months during the winter. • Projects that are advertised during the summer will elicit higher bids because equipment, labor, and materials can be in short supply.
Constructability	• Are there project items which are unique, new or innovative which may affect cost? • Are contractors sufficiently familiar with the required construction methods?
Item Quantities	• Smaller unit quantities usually equate to higher unit prices.
Limitation of Operations	• Are there limitations on working hours? • Will lane closures or traffic control affect project work?
Availability of Materials	• Are key materials such as cement, steel, or oil in short supply? • What is the distance from the project site to the nearest aggregate pits or hot mix asphalt plants?
Process Familiarity	• New or innovative processes can increase construction costs.
Specialty Equipment	• Do contractors have the necessary equipment to complete the project, or will they have to acquire it special?
Construction Schedule	• Do special contract provisions give the contractor leeway to modify the start the date, enabling them to coordinate resources across projects? • Letting contractors use flexible scheduling can reduce their risk and yield significant cost savings.
Contractor Risk	• Excessive risk may be a disincentive to contractors that would otherwise bid.

3.5 AASHTO Survey Results

The AASHTO Subcommittee on Design queried other states regarding their process for developing estimates and related issues. The states that responded offered a variety of insights that can inform KYTC's efforts in this area and the detailed research on state practices. The first question asked was how do you create and maintain estimates for design, right of way, utilities and construction? Who is responsible for this? How are they tied to a schedule or duration of time? Related to these questions is the software or other tools used. What software do DOT's utilize in developing PE estimates/budgets? When do you finalize your PE estimate/budget (what stage of project development)? Do you allow the PM to change a budget once finalized and if so, under what conditions? Summaries of state DOT answers to these questions are documented below.

Alabama relies on the design lead for maintaining estimates along with right of way and utility experts for those estimates respectively. Statewide estimates for various components are also available as shown in Appendix A. Excel is first used for estimates and then AASHTOWare Project Estimator when defined quantities are available. Estimates are finalized when final plans are submitted for letting, although project managers can request budget changes if needed. Arkansas also uses a cost per mile sheet (see Appendix A) to develop early construction cost estimates, with the sheet containing information based on projects let over the last three years. When a project has assigned quantities, then a more detailed estimate is developed using historical pricing data. Design estimates are based on a percentage of the construction cost estimate with later estimates done based on man-hours charged. Right of way and utilities estimates are done by the division based on a proposed right of way layout. Arkansas does not use any software early in the process but eventually uses Preconstruction as the project gets closer to letting.

Florida develops construction estimates using an internal Long Range Estimating (LRE) system which uses a parametric approach drawing from historical bid data. Design estimates are generated using the Design Quantities and Estimates (DQE) system which uses historical data as well. Estimates are updated every 6 months, at defined milestones, or when a scope change is approved. Florida uses Excel along with project scope and staff hours to build estimates. If changes are needed the project manager can use contract amendments and a negotiation process is undertaken. While responsibility for estimates in Florida lies at the district level, Georgia's construction cost estimates are done by the central office to increase consistency. Overall, the Office of Program Delivery handles the budget but relies on subject matter offices for estimates of design, right of way, and utilities.

Louisiana confers responsibility for all estimates to the project manager. Parametric estimates are the most common approach relying on a per mile basis. When a project is in a "feasibility state" contingencies of 25 percent of the construction cost are added. Estimates are revised during and after the NEPA process with various subject matter experts weighing in. Further revisions are done at defined milestones and in some cases the Cost Estimating Engineer will review. Right of way relies on field reviews to develop estimates with updates done as needed. Utility coordinators in each district work with utility companies and generate estimates based on the project impacts from the right of way plans. Louisiana uses AASHTOWare and relies on the cost estimating engineer for expertise. Estimates are refined throughout the development process and finalized when final plans are completed. Budgets may be changed by project managers during the bidding process based on contractor comments that result in plan revisions. Major revisions result in the project being withdrawn and re-bid at a later date. Mississippi uses a consultant-developed Excel spreadsheet to estimate construction costs. The spreadsheet uses historical project data and generates quantities and prices based on the type of project selected. As more design work is done, assumptions are adjusted to yield a more accurate estimate. As final pay items and quantities become clear, the project is priced and then updated in the Excel file. Budget changes are negotiated with consultants based on the scope of the project.

North Carolina's initial estimate for DRUC arises as part of the State Transportation Improvement Plan and is developed by a feasibility study or the Strategic Prioritization Office, also referred to as SPOT. Right of way estimates are done by the right of way unit when preliminary alternatives are available and right of way plans complete, with updates every two years. Utility estimates are done by the utilities unit as each phase is completed and updated every two years. Construction estimates are done by the Roadway Design Unit during several phases including scoping, functional design, preliminary design, when right of way plans are complete, and final plans. The final estimate is done collectively by individual unites when the final plan is ready to be turned in. North Carolina uses Excel with historical data, bid average, and market analysis. Estimate stages are feasibility study, functional, preliminary, right of way, and final plans. South Carolina maintains an internal database using Access, Visual Basic, and Excel for historical data. Using this data and comparable projects, they develop DRUC estimates. Specifications and Estimates Unit creates the estimate while project managers then maintain the estimate and update it as needed. South Carolina has its own database but is examining other software applications. Final engineer's estimate is done before federal authorization, which is about two months before letting. Changes to a finalized budget can be made if the estimate comes in higher than anticipated and funding is available. Any change would have to fall within an acceptable range according to the State Transportation Improvement Plan. Tennessee's initial estimate falls to the design staff during a preliminary stage (a prior estimate is generated in the planning report). Right of way field review yields further information and that, along with utilities, is sent with a request for funding. At this point, the design staff must update the estimate on an annual basis, however, if significant changes occur that affect the estimate, then a new estimate needs to be developed. Tennessee uses a program that was internally developed called Average Unit Price Program for estimates. The program uses historical data and can filter based on certain criteria.

Virginia's Project Cost Estimating System (PCES) program uses historical bid data and lane mile costs to generate estimates. Various factors are available for certain designs such turn-lanes, pedestrian facilities, etc. Modifications are made to PCES when the difference in actual bids is greater than 10 percent. Inflation adjustments are made annually with data from the federal government. West Virginia develops construction estimates on annual average unit bid prices. Data quality and updates are the responsibility of individual divisions. Design estimates are based on estimated times for plan development while utility companies provide utility estimates and right of way cost estimates are based on non-appraisal expected costs.

The final question asked was what challenges are other DOTs encountering in dealing with Preliminary Engineering estimates/budgets on projects? Specifically, how do you compensate for fluctuations in cost and scope throughout the life of the project? Some states reported a process in place to deal with such issues, while others indicated cost fluctuations have not been a significant problem due to various mitigating factors. Answers are summarized in Table 3.14.

Table 3.14 Methods for Addressing Preliminary Engineering Estimate/Budget Changes

State	Answer
Alabama	Budgets are adjusted as needed based on cost and scope
Georgia	Initial budget based on preliminary project scope and scale; when project is assigned a manager, then a more defined scope will be developed and additional funds requested if needed
Louisiana	Project managers expected to update costs throughout the development process; cost estimate engineer will track price trends and run simulations if needed
Mississippi	Budget increased are generally allowed and work has not been stopped due to budget issues
North Carolina	Formal review process for cost estimate increases and scope change requests; flowchart shows appropriate points for updated construction and right of way costs; if scope change results in cost increase that exceeds a certain level then meetings will be held with Cost Review Committee
South Carolina	Reliable estimates are not available until unknowns are addressed such as utility impacts, right of way, mitigation impacts, etc.); locally funded projects require greater scrutiny

3.6 Conclusion

Most states adopt a phased — or staged — approach to the development of project cost estimates. During the programming phase (i.e., before a project receives formal approval), estimates are generally high level and lack precise information about quantities. After project approval, more detailed cost estimates are generated. These estimates are updated routinely throughout the project development cycle, with estimators gradually adding in more details about unit item prices and quantities. As the specificity of the estimate increases, the amount of contingency built into it should decline. During early stages, most state DOTs recommend building in a contingency of 20%-30%. The final engineer's estimate typically has a contingency of 3%-5%. Likewise, most states use an inflation adjustment factor of 3%-5%. In addition to updating estimates at defined milestones, most state DOTs require that estimates be updated when major changes are made to a project's scope or if a project encounters significant delays.

Preparing cost estimates is messy and complex; it requires both a firm grasp of engineering principles and artful intuition about how different factors influence project costs — many cost estimating manuals acknowledge in their opening pages that developing estimates is as much a science as it is an art. It is a process that often involves the coordination of multiple branches across a state DOT. During the early stages of project development, many state DOTs assign cost estimating to personnel in district offices. Estimators leverage the expertise of individual branches (e.g., Right of Way, Utilities, Structures) to produce accurate estimates. In some states, these branches prepare an estimate for all activities related to their domain, which is then forwarded to the estimators. Estimators then compile this information into a single estimate. Accordingly, estimators must be willing to collaborate across disciplinary lines. Assembling strands of information from various sources is a complex and time-consuming task and should be undertaken with care and exacting attention to detail. Central offices generally prepare the final estimate, which is used to appraise the bids received from contractors.

DOTs benefit from applying a set of consistent, straightforward methodologies to estimates across all phases of project development. Although not stated explicitly in any of the guidance reviewed, consistent, straightforward methodologies have another benefit — state DOTs beleaguered by rapid turnover in staff benefit from having clear guidance on estimating procedures, as new estimating personnel will be able to quickly learn how to prepare an accurate estimate. Most state DOTs rely on proprietary or commercial software to develop cost estimates. A number of states have created in-house systems to aid with estimation activities. In some cases, these systems are quite sophisticated, but some states use more basic pre-formatted Microsoft Excel workbooks to do estimates. Other states make use of AASHTO's cost estimating software (previously this was known as Trns*port; it has rebranded as AASHTOWare) to store information on historical pricing/bid data and produce new estimates. Maintaining a historical database of previous projects, their characteristics, and estimating and bid information is critical for developing accurate and precise estimates for new projects.

State DOTs encourage estimators to identify project-specific contingencies that may influence construction costs. Projects located in rural areas may be more expensive than those situated in urban areas due to the added expense of securing adequate labor and hauling materials to the project site. It is also critical to factor into the estimate how geological, hydrological, and geomorphic conditions will influence construction. For example, a high water table could introduce geotechnical challenges and add time to the project duration. Estimators should also consider required material quantities and the prevailing market conditions, the level of specialty work necessary, and the season in which construction is to occur. Paying close attention to contingencies that influence construction costs will result in more accurate estimates. Although many state DOTs advise against the use of lump sum items, most recognize that incorporating them to some extent is unavoidable (for items such as traffic control). If possible, estimators should break lump sum items into their constituent parts and estimate the price of each component separately. Once all components of a lump sum item have been estimated they can be added together. Using this method to estimate lump sum items will generally yield more accurate results.

Chapter 4 Best Practices and Potential Estimating Tools

4.1 Best Practices

Cost estimates are an important tool for DOTs, helping manage costs, track project progress, monitor contingencies and estimate variability, inform long term planning and prioritization, and improve accountability for project delivery. If costs are overestimated, then other projects may not receive funding and if costs are underestimated, then funds may have to be reallocated from other projects or the project in question may be delayed. As seen in Chapter 2, other state DOT approaches to estimating vary in some respects but there are enough similarities to draw some best practices to help guide KYTC's efforts to improve estimates. Most states used a phased approach to developing project cost estimates. Early estimates in the project development process have little definition and the projects are often 10-20 years from final development and letting. Estimates often reflect this reality with a wide range and greater contingency for unknowns. Parametric estimating is a methodology often used at this stage. The evolution of estimates over time allows for increasing precision through the project development process. As more project definition is known, it reduces the impact of potential risks, which decreases the variability in the estimate, the needed contingency, and ultimately helps DOTs better allocate limited budgets. Phases often include an initial planning/programming estimate before the project has been officially approved and then proceed to scoping/preliminary design, design/semi-final design, and final design/plans, specifications, and estimate/final engineer's estimate/letting. For the sake of uniformity, we recommend referring to AASHTO's (2013) best practices phases as shown in Figure 4.1. It lists purpose, level of development, estimate ranges, and potential approaches that may be considered to generate the estimate (these phases, or similar ones, are noted in Chapter 3 in reviews of Washington and Montana's estimating approach although many states use similar phases for estimating such as Minnesota).

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

Figure 4.1 AASHTO Cost Estimating Classification

The phases as defined by AASHTO are planning, scoping, design, and final design. Each phase is tied to a range of project completion percentage and a range for the estimate, which become more precise as more information is available. Each phase also has a purpose behind the estimate starting with conceptual and moving to design and finally plans, specifications, and estimates. Planning phase estimates are used for longer term funding needs such as a 10 or 20-year plan with estimate ranges and contingencies that match the uncertainty present in a potential long-term project with limited definition. This phase is characterized by parametric or historical bid-based cost estimates, although MTDOT recommends using more than one method and then comparing results for consistency. As phases proceed and project definition becomes clearer, the methodologies generally consist of cost-based or historical-bid based which are defined in Table 4.1, given their importance to understanding estimating approaches and define.

Table 4.1 Definition of Estimating Methodologies

Bid Type	Description
Cost Per Element/Parameter Using Similar Projects (i.e., Parametric/Conceptual)	• Estimators identify completed projects similar to the one being estimated. Those projects are converted to a cost parameter (cost per centerline mile, cost per square yard). Estimates for the new project are then based on this cost parameter. • Use is generally restricted to during the early stages of project development.
Cost Per Parameter Using Typical Sections (i.e., Parametric/Conceptual)	• Estimators develop a cost parameter using typical items which describe a standard section of a given length (e.g., one mile). Cost parameters are used with approximate quantities to prepare an estimate. • Use is generally restricted to during the early stages of project development.
Analogous/Similar Project	• Estimators identify one or several projects similar to the project being estimated. Items, quantities, and unit costs from the historical projects are then used to estimate the price of the current project. • Some DOTs (e.g., Montana) reserve this method for smaller projects that are not complex.
(Historical) Bid-Based	• Estimators research historical data, unit prices, and quantities from previous projects. Pricing is then adjusted based on factors such as location, market conditions, and quantities to estimate the total project cost.
Cost-Based	• Estimators base their estimate on knowledge of variables related to work that will be performed. Cost based estimates account for the cost of labor, materials, event sequencing, production rates, and contractor overhead and profit. Estimators must possess a good working knowledge of construction industry practices and current market trends to generate a reliable estimate.
Historical Percentages	• Estimators develop a percent based on historical cost information. It is typically used for project elements that are not defined early in the project development process. Historical percentages are based on the relationship between the total cost of a group of items and a total cost category.
Combined	• Some DOTs combine multiple estimating techniques (generally historical bid based and cost based). States such as Oregon and Minnesota use cost based estimates for major items (e.g., Portland cement concrete, structural steel, embankments, asphalt concrete pavement).

	Smaller items are estimated based on historical prices adjusted to the project context.

Sources: Minnesota DOT, Washington DOT, Oregon DOT, Montana DOT

In order to develop parametric and historical bid-based estimates, data are needed. Thus, AASHTO recommends that state DOTs develop and maintain databases of historical costs and line item bid data along with pricing resources if one does not already exist. Important data points may include construction cost factors, lane-mile cost factors, bridge cost factors, historical percentage cost factors, computer-generated cost factors, right-of-way acquisition, and preliminary and construction engineering costs.

AASHTO (2013) provides a simple six-step approach to generating base estimates, which was detailed in Chapter 3. Base estimates are estimates that do not include contingencies and risks and include all costs associated with the project at that point in time. They are the best estimate given the scope, location, and other project information. It is worth listing the process again as part of a best practices approach to estimating.

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

When developing or updating estimates at each defined phase, NJDOT provides several steps and a description of activities in each step to develop or update estimates in Table 3.4 The steps are determining (or review/update) estimate basis, prepare or update base estimate, and review total estimate. Within each step the activities such as referring to scoping documents, estimation techniques, project conditions, and reconciliation of previous estimates can be used as a checklist for the estimating process. Such a template that provides a more detailed checklist of activities to undertake accompanying AASHTO's six steps builds a comprehensive, easy to follow process.

Once estimates are developed in each phase, review may be a useful step to include. Reviewing an estimate focuses on the project and assumptions used in the estimate in order to gauge whether the estimate accurately reflects the scope, schedule, and verifies that the appropriate historical data or any other data is used correctly. WSDOT builds a review process into its estimating workflow before risk analysis, market conditions and inflation, and subject matter experts are consulted on the estimate (see Figure 3.5) MnDOT dictates the level of review is dependent on project complexity. Additionally, they solicit stakeholder feedback by issuing a communications package.[6]

Contingencies to allow for risks and uncertain or unexpected costs are generally included as part of estimating processes. As shown in Figure 3.2 the total project estimate is comprised of the base estimate and contingency with a potential range into which the total project estimate is expected to fall (Figure 3.15). Contingencies follow a similar path as the estimate range, with greater contingencies assigned for planning and decreasing to final design as more specificity is required and less contingency allowed. AASHTO refers to this as risk-based estimating, although most state DOTs do not classify their approach in this way, rather assessing risk and building in appropriate contingencies as part of their standard estimating processes. No matter how they are classified, risk identification allows estimators to define project complexity and categorize, document, and summarize potential project risks. AASHTO lists numerous potential risks by category (environmental, design, right-of-way, etc.) (Figure 3.4). Contingencies may be project specific such as location, length of the construction season, potential work restrictions, and utility and right of way issues. Estimators can set contingencies using a top-down or bottom-up approach. Top-down uses historical data to denote a range for the relative risk of the project and bottom-up uses a statistical and/or simulation to measure the likelihood of various risks occurring and the magnitude of those risks. These approaches fall into a

[6] In addition to a one-page summary these packages include: project basis, project cost range, cost uncertainties, estimate assumptions, schedule, and status.

three-tiered approach used by AASHTO as well as MnDOT, which matches AASHTO's project classification in Table 4.2. Tiers are based on project complexity, with more complex projects receiving more in-depth risk analysis.

Table 4.2 AASHTO Three-Tier Approach

Tier	Level of Complexity	Approach
Type I	Minor	Risk-based percentage contingency estimate (top-down, list of risks)
Type II	Moderate	Risk-based deterministic estimates (probability-impact matrix; bottom-up estimates of major contingency items)
Type III	Major	Risk-based probabilistic contingency estimates (quantitative approach using statistical techniques)

Unlike state DOTs reviewed in Chapter 3 that had similar phases to estimating, contingencies were generally more scattered and not uniform in terms of matching with phases. Connecticut and Montana match closely with the AASHTO phases while other states may have reported a contingency for only one phase; however, many of these fall within the ranges provided by Connecticut and Montana shown in Table 4.3. The contingency level chosen may depend on accuracy of previous estimates and confidence level in estimates moving forward.

Table 4.3 Contingencies by Project Phase

Phase	Connecticut DOT Contingency	Montana DOT Contingency
Planning	20-30%	10-25%
Scoping	15-25%	10-20%
Design	10-20%	5-10%
Final Design	0-10%	0-5%

Attention should be given to risk variables or cost drivers such as equipment and material prices, quantities, contractor overhead/profit, project location, project type, project size, seasonal impacts, and anything else that may impact the cost of the project. AASHTO notes that complexity can often dictate the types of factors that should be considered such as design complexity, political factors, and environmental impacts on the most complex projects. Moderately complex project risks may involve geotechnical issues, material changes, and permitting delays while minor project risks could be contractor delays, overall program priority changes, estimating errors, and inaccurate technical assumptions.

Several state DOTs list variables that need to be considered during the estimating process. WSDOT lists several cost drivers and describes their impacts on estimates. Cost drivers are listed below; for more detail regarding each see Table 3.5.

- Geographic Contingencies
- Construction Contingencies
- Restrictive Work Hours
- Material Quantities
- Material Shortages
- Standard Items
- First-Time-Use Items
- Separate Operations
- Timing of Advertisement
- Expected Competition and Contractor Availability
- Other Contracts
- Handwork
- Specialty Work
- Item Availability
- Scheduling, Lead Time

- Site Constraints
- Soil Conditions
- Estimating Lump Sums
- Force Account
- Permit Conditions
- Inflation
- Other Funding Sources, Agreement of Work for Others

Indiana provides a list of factors that estimators may need to consider in terms of unit prices:

- Geographic location
- Similarity of recent construction projects used as a basis of comparison
- Inflation
- Reliability of recent construction cost data
- Recent trends in the cost of materials, labor, and equipment
- Proposed project schedule
- Anticipated difficulty of construction
- Environmental mitigation
- Use of experimental materials (requires coordination with Office of Research and Development)
- Project size relative to size of similar projects

Utah identifies factors along with considerations and potential questions for estimators to consider when estimating unit bid prices. To add to the factors already noted, Utah's are listed below.

- Location
- Time of year
- Constructability
- Item Quantities
- Limitation of Operations
- Availability of Materials
- Process Familiarity
- Specialty Equipment
- Construction Schedule
- Contractor Risk

Finally, Illinois DOT also provides a list of potential cost considerations for estimators, with many of these matching factors identified by DOTs in Indiana, Utah, and Washington.

- Geographic location (e.g., urban or rural setting, location within the state, district project will occur in)
- Similarity of recent construction projects
- Inflation
- Reliability of recent construction cost data
- Trends in the cost of materials, labor, and equipment
- Difficulty of construction
- Constructability issues that may arise
- Proposed project schedule
- Anticipated construction staging
- Right-of-way acquisition
- Presence of railroads
- Utilities and utility relocations
- Environmental problems

While not all these cost drivers or factors may be relevant to every project, being aware of potential impacts on the estimate will help improve accuracy. As a best practice, we recommend keeping a checklist of the most relevant cost drivers as part of the review process. Such a checklist could be gleaned from past projects, a database that contains various cost factors as mentioned previously in this chapter (or is subsequently developed), and experienced estimators that have dealt with various factors as part of the estimating process before.

Additionally, current market and economic conditions, which may influence the availability of contractors and equipment, competition, other projects underway in the same area, and the complexity of the work that may require contractor specialization. Market volatility, in particular, can significantly impact estimates if certain costs such as materials experience sharp increases or decreases. Cost-based estimating is useful when volatility is present and historical data from previous projects does not accurately measure up to the current environment. By using recent and current pricing data on inputs such as materials and labor, a more accurate estimate can be developed.

Finally, inflation needs to be accounted for when preparing an estimate. Time value of money can make a significant impact on project estimates, particularly longer-term estimates. However, as estimates progress and improve with accuracy, the project moves closer to letting, which reduces the impact of inflation as it does with contingencies. In fact, CTDOT shows how inflation decreases as part of the estimate through its four phases (Figure 3.7). State DOTs reviewed generally used three to five percent for an inflation factor, although using an index to track inflation would also be acceptable and would account for the decreasing impact of inflation as a project moves closer to letting. Kentucky has a construction cost index, which uses average unit bid prices for each year to develop a metric that is used to track construction costs. Such an index could also be used to set inflation when preparing estimates.

It is also essential to determine which personnel are responsible for estimates, where the estimates originate at each phase, and who is responsible for updating estimates at predetermined times or milestones. Often planning estimates may be generated by the district (planners, estimators, etc.), Central Office area where the project originates, or an individual responsible for design or estimating. As more of the project detail is defined estimates may fall under the purview of the central office or a project manager, with input from districts. In Georgia, project managers are responsible after preliminary engineering is complete and is responsible for integrating estimates from various offices such as Right-of-Way. Keeping estimates up to date ensures that both long and short-term planning efforts that rely on estimates continue to be realistic. For example, Caltrans first generates estimates when projects are programmed, which is done biennially. Then, Caltrans updates estimates at least annually. CTDOT requires biannual updates of estimates, updates at significant design milestones, and if the scope is significantly changed. Regardless of the time frame chosen, ensuring estimates are updated on a regular basis is good practice.

4.2 AASHTOWare Project Estimation

Most state DOTs reviewed in Chapter 3 use some type of software along with databases of historical data to produce estimates. Proprietary software or Excel were common approaches as was the use of AASHTOWare Project Estimation. Several DOTs also utilize internal expertise and in some cases have an estimating engineer on staff to help refine estimates. Regardless of how responsibility for the estimate is assigned, it is imperative for DOTs to ensure coordination between the central office and districts and subject-matter experts from both. As subject-matter experts are housed in different divisions, ensuring coordination at KYTC among Highway Design, Planning, Structural Design, Environmental Analysis, Right of Way and Utilities, and Professional Services divisions will improve the estimating process and knowledge across the Cabinet, specifically the Office of Project Development which houses these divisions. Certainly having an individual with expertise in estimating would be of great benefit, but equally important is ensuring input from subject-matter experts on staff to generate the most accurate estimate. Finally, generating complete documentation of an estimate is important for reviewers who may evaluate a project and for potential use when estimating future projects.

AASHTOWare is an enterprise software suite with programs on Bridges, Pavements, Safety, Right of Way, and Project. Each, with the exception of Right of Way, contains modules such as Project Estimation, which is a web-based module in AASHTOWare Project. AASHTOWare Project "enables you to manage information throughout the entire contract and construction cycle–from cost estimation to proposal preparation, letting bids, construction and material management and data collection."[7] AASHTOWare Project Estimation "includes estimating in and through all phases of the project development lifecycle, and interacting with various other applications utilized by agencies for project processing."[8] Project Estimation has a single point of entry to help streamline workflow and allows users control over estimating parameters, making changes as needed. Project Estimation allows for bid-based, cost-based, reference-based (based on prices stored in reference items), parametric, ad hoc pricing (personal experience), and collection based (grouping a collection of pricing tasks together for various methodologies) approaches. "AASHTOWare Project Estimation includes the assessment and assignment of risk contingency, life cycle analysis tools, expansion of existing import/export capabilities, inclusion of non-bid costs, non-construction costs and markups, and the ability to utilize snapshots in creation of an audit trail for the agency's estimates."[9] Project Estimation uses a cradle-to-grave process to prevent redundancy and that is shown in Figure 4.2, as provided by AASHTOWare.

[7] http://www.aashtoware.org/Project/Pages/default.aspx
[8] http://www.aashtoware.org/Project/Pages/default.aspx
[9] http://www.aashtoware.org/Documents/E-FY2018_Catalog-Final.pdf

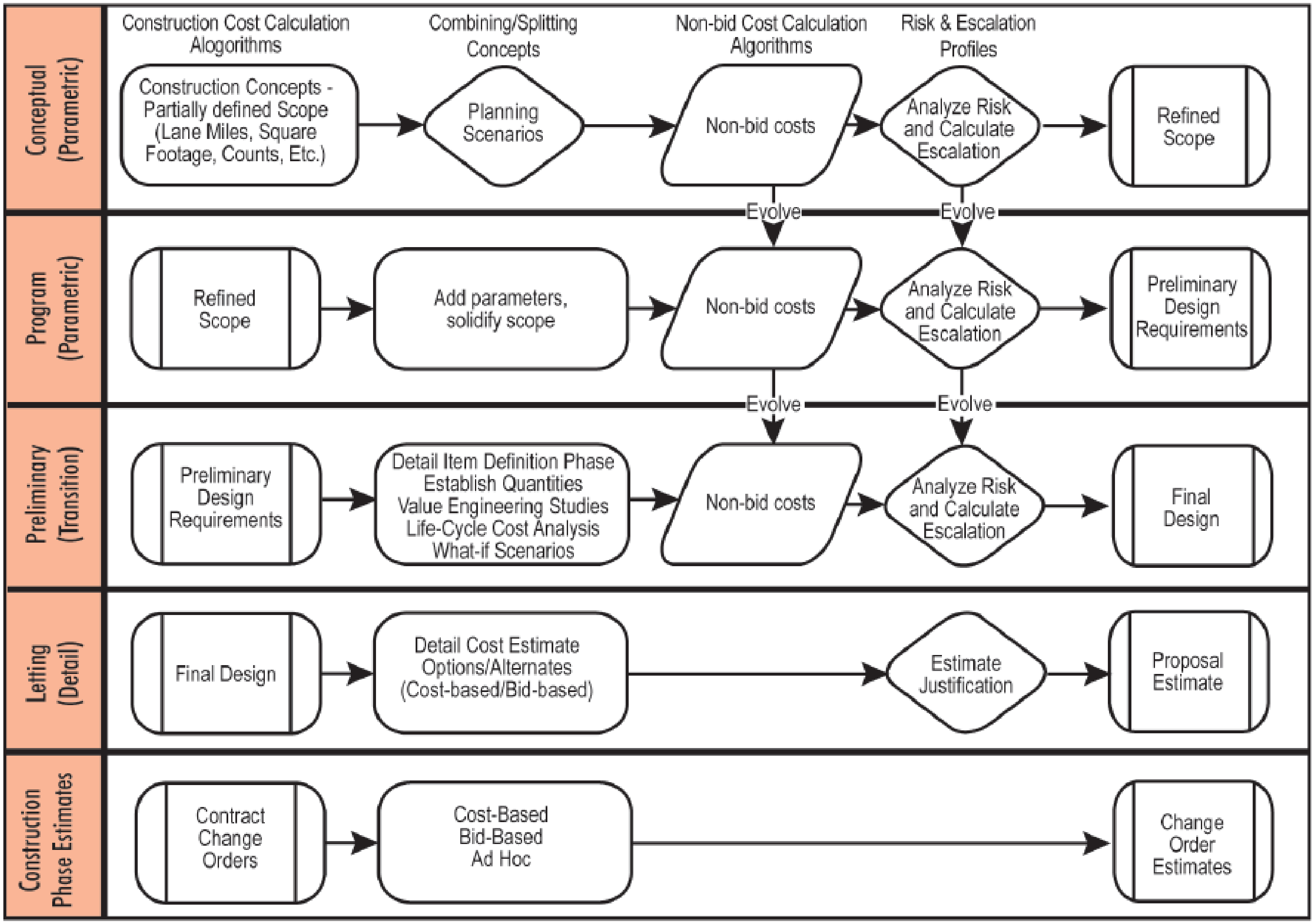

Figure 4.2 AASHTOWare Project Estimation Estimate Evolution

There are several resources available to state DOTs using AASHTOWare. The AASHTO Technical Committee on Cost Estimating helps review and provide recommendations for AASHTO's positions on estimating in order to keep guidance current, with the objective of disseminating information to a wider audience. The committee also maintains the AASHTO Practical Guide to Estimating, develops guidance and tools for estimates, provides networking related to estimating, and collects questions on guidance.

The Project Users Group (PUG) serves as a forum for helping guide AASHTOWare; identifies training, maintenance, and support needs; and provides product recommendations. Within the PUG there are several Technical Advisory Groups (TAG) including Civil Rights and Labor Management, Construction Management, Cost Estimation, Data Analytics, Data Warehouse, Field Management, Information Technology, Materials, and Preconstruction. The Cost Estimation TAG's mission is to provide a forum for AASHTOWare users and discuss problems and make recommendations. The TAG has a set of short and long-term goals as well. The short-term goals are to:

- Encourage users to post problems and/or solutions
- Maintain a dialog with TEA to promote AASHTOWare estimating tools
- Ensure future estimation tools comply with methods prescribed by the AASHTO Practical Guide to Estimating
- Recommend that quarterly meetings are held to discuss maintenance and enhancements to Estimation[10]

The long-term goals prescribed by the TAG are:

- Promote the use of AASHTOWare Project Estimation
- Provide expertise to Technical Review Team for development of estimating function in AASHTOWare
- Assist in education AASHTO community about products and their use[11]

The Transportation Estimators Association (TEA) shares resources and information about events for estimating personnel. The objectives of the TEA are:

- Improve cost estimating techniques and publish guidelines used by transportation estimators (cost based, historical based and parametric)
- Develop innovate new cost estimating techniques
- Disseminate experiences in cost estimating and new practices through yearly meetings
- Publish a newsletter to transportation cost estimators
- Sponsor a yearly cost estimating workshop[12]

If using an AASHTOWare product like Project Estimation, being involved in and keeping track of these groups and resources would be useful for staying up to date on the software and interacting with others using the software.

In order to better gauge the potential use of AASHTOWare Project Estimation for KYTC, interviews were conducted with several other state DOTs that are using or planning to use the software. Montana has begun implementation of the software and it is now in production. The planning division has not begun using yet as the current focus is on design and passing for bid letting. Consultants should be able to access by spring of 2018. Nebraska is conducting a six-month evaluation and possible implementation. Currently, they use a spreadsheet for planning and design along with Preconstruction which requires four construction estimators to enter projects. Moving to Project Estimation will spread out this activity. New Jersey has the software in production for new projects. Their Preconstruction software and database has been hosted by InfoTech and has yielded faster access than when the state maintained the servers. New Jersey has also published a step by step guide for using Estimation including transitioning from a

[10] https://pug.cloverleaf.net/TagLists/CEMission.htm
[11] https://pug.cloverleaf.net/TagLists/CEMission.htm
[12] https://tea.cloverleaf.net/default.htm#whatsnew

concept to a project.[13] As with Nebraska, planning is not currently involved, the focus is design. When a project is in production, a consultant completes the final PS&E and then DOT staff moves to Preconstruction. Generally, these states reported some advantages to Project Estimation and felt they would be moving to implement the software.

4.3 Proposed KYTC Project Estimation Process

A review of cost estimation approaches from 11 state departments of transportation (DOTs) and national sources, such as National Cooperative Highway Research Program (NCHRP) reports and American Association of State Highway Transportation Officials (AASHTO) guidance, found that while there is some variety in their methods, many state DOTs use broadly similar frameworks to prepare initial project estimates. Estimates made during the early stages of project development, when a project is often 10-20 years from final development and letting, have little definition, adopt a wide price range, and include greater contingency for unknowns. Since projects have little definition during this phase, Initial Project Estimates usually rely on parametric techniques to extrapolate the costs of future projects from past project experience. As project development moves forward and project definitions become more complete, agencies generate more precise estimates. Having more exhaustive knowledge of a project reduces the impact of potential risks, which decreases the variability in estimates and contingency, and ultimately helps DOTs better allocate limited budgets. Most agencies develop estimates at several points in the project development process. An initial planning/programming estimate is typically put together before a project is officially approved. Additional estimates are prepared during the following stages: scoping/preliminary design; design/semi-final design; final design/ plans, specifications, and estimate/final engineer's estimate/letting.

Estimates produced during different phases vary in terms of the methods used, purpose, and the program they support. Estimates at the planning stage are generally conceptual, having the goal of evaluating long-term funding needs. In addition to the base estimate, estimators should also evaluate risk and establish a figure for contingency that accounts for project complexity (AASHTO has a three-tier system for evaluating complexity). During the planning stages the amount set aside for contingency is significant and can nearly equal the base estimate. During later phases of project development, when it is imperative that estimates be more accurate, more precise, and include less contingency, states typically rely on some combination of cost-based or historical-bid based methods. Shifting to these methods lets estimators gradually reduce the amount set aside for contingency (i.e., over time, the relative magnitude of the base estimate [which excludes contingencies] increases).

AASHTO issued a report in 2013 on best practices for estimating project costs. The report synthesized the methods used by numerous state DOTs to develop estimates but did not offer detailed treatments of individual state practices. However, our review indicated that many state DOT frameworks contain aspects of AASHTO's best practices. As such, the AASHTO model was used as the foundation for the proposed KYTC Project Estimation Process (Table 4.4). The proposed process distinguishes four project development phases — planning, scoping, design, and letting. Every estimate should contain the probable future costs of the project, which may include (depending on the project and its development stage) environmental, design, right-of-way, utility, and construction costs (DRU&C). Starting with the Project Nomination, project-related costs will be expressed as DRU&C Project Cost Estimates in year-of-expenditure dollars. Project cost estimates are integrally tied to scope and are continually verified throughout project development. If an updated estimate exceeds the current approved Project Baseline Cost/Budget, the project will not proceed with design until the cost estimate is brought back in line with the current Baseline Cost/Budget or it receives an approved change request.

13 http://www.state.nj.us/transportation/business/aashtoware/pdf/AASHTOWareprojectforConstructionManagement.pdf

Table 4.4 KYTC Project Estimation Process

Project Development Phase	Project Maturity (% project definition completed)	Project Estimate Designations	Purpose of the Estimate	Estimating Methodology	Estimate Range	
Planning	0 to 5%	Project Identification Estimate	Conceptual Estimating Screening & Feasibility. Estimate Potential Funds Needed (20-year plan)	Parametric	-50% to +200%	Project Cost Planning
	3% to 15%	Conceptual Project Estimate	Conceptual Estimating Prioritize Needs for Long Range Plans (10-year plan)	Historical Bid-Based with some Parametric	-40% to +100%	
Scoping	10% to 30%	Preliminary Line and Grade Estimate	Scope Estimating Establish a Baseline Cost for Project and Program Projects (SYP and STIP)	Historical Bid-Based or Cost-Based	-30% to +50%	Project Cost Management
Design	30% to 90%	Design Estimate	Design Estimating Manage Project Budgets Against Baseline (SYP, STIP, & Contingency)	Historical Bid-Based or Cost-Based	-10% to +25%	
Letting	90% to 100%	Final Plans Estimate and Engineer's Estimate	PS&E Estimating Obligate Construction Funds & Compare with Bid	Cost-Based or Historical Bid-Based Using AASHTOWare Project Software	-5% to +10%	

Chapter 5 Conclusion

Adopting the estimation framework described in the previous chapter is the first step KYTC can take to achieve more uniform and accurate project cost estimates — across the state. Because it is possible that some district-level staff will be hesitant to leverage this method, it is critical that proponents of the framework (in the Central Office in districts) advocate for widespread implementation. Piecemeal adoption is insufficient to realize the hoped-for results. To solve the challenge of implementing the new framework, researchers helped the Cabinet set up a new app — AASHTOWare Project Estimation. This package serves as a replacement for the app that has been used for estimates. In addition to tailoring the app to meet KYTC criteria, the Center produced guidance in the form of a user's manual and accompanying video tutorial (Appendix D). The user's manual introduces readers to the app, describes procedures for navigating menus and toolbars, lays out how to establish a new project or import a project, defines required inputs, and provides succinct step-by-step instructions for preparing and estimate.

Rapid implementation of AASHTOWare Project Estimation will accelerate the transition to the new framework. Because the app is intuitive and easy to navigate, project managers can quickly learn its features and begin using it. At the outset, implementation of AASHTOWare Project Estimation will target the design portion of highway project development, although the Cabinet expects that it will eventually be used during planning. Project Estimation links to other AASHTOWare software suite apps and makes use of data retrieved from construction items. Estimates for construction elements are dynamic and remain up-to-date through this linkage. Information on design fees, right-of-way purchases, and utility relocations are not catalogued in AASHTOWare, meaning it must be entered manually for each project. In the coming years, dynamically integrating the latest cost data for these elements into AASHTOWare should be a priority as it will benefit project managers developing estimates and further reduce the amount of time which is dedicated to estimation procedures. Even with these — temporary — shortcomings, project managers now have recourse to an app that facilitates the seamless production and communication of more organized and consistent estimates, which will enhance KYTC's ongoing efforts to improve project delivery.

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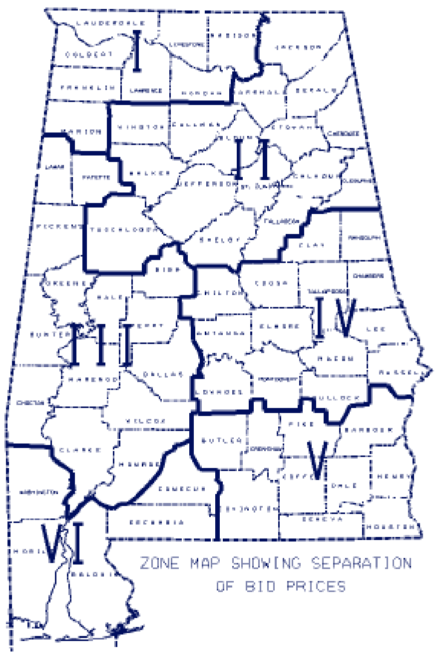
Appendix A Alabama and Arkansas Estimating Costs

TO BE USED FOR PRELIMINARY COST ESTIMATES ONLY

CHART UPDATED NOVEMBER 2010 (MAJOR UPDATE 2007)

	GRADE AND DRAIN PER MILE COST X $1000								BASE AND PAVE PER MILE COST X $1000	
	2 LANE NEW CONSTRUCTION				4 LANE NEW CONSTRUCTION				2 LANE NEW CONSTRUCTION	4 LANE NEW CONSTRUCTION
ZONE	F	R	H	M	F	R	H	M		
I	803	1177	1648	2077	1420	2104	2923	3975	1507	2731
II	720	983	1385	1690	1186	1720	2555	3574	1352	2418
III	609	762	1177	1385	919	1420	2171	2939	1220	2130
IV	651	1011	1454		1169	1754	2321		1412	2551
V	540	845	1274		969	1536	2037		1232	2286
VI	443	720	1094		785	1319	1837		1077	1684

F - FLAT TERRAIN
R - ROLLING TERRAIN
H - HILLY TERRAIN
M - MOUNTAINOUS TERRAIN



SIGNING

INTERCHANGE (URBAN INTERSTATE)	$60,000	EACH
INTERCHANGE (RURAL INTERSTATE)	$70,000	EACH
INTERSECTION (4 LANE X 4 LANE)	$40,000	EACH
INTERSECTION (4 LANE X 2 LANE)	$30,000	EACH
INTERSECTION (2 LANE X 2 LANE)	$20,000	EACH

TRAFFIC HANDLING

5 LANE (WIDEN TO ONE SIDE)	$30,000	MI
5 LANE (WIDEN SYMMETRICAL)	$60,000	MI
4 LANE (2 LANES EXISTING)	$12,500	MI
EXISTING INTERSECTION	$3,500	EACH
CROSSOVERS	$12,000	EACH
NEW LOCATION INTERSECTION	$2,500	EACH
ADVANCE WARNING SIGNS	$10,000	EACH

UTILITY COST*

2 LANE RURAL	$540,000	MILE
2 LANE URBAN	$1,700,000	MILE
4 LANE RURAL	$850,000	MILE
4 LANE URBAN	$3,125,000	MILE

RIGHT OF WAY COST**

2 LANE RURAL	$550,000	MILE
2 LANE URBAN	$1,500,000	MILE
4 LANE RURAL	$1,400,000	MILE
4 LANE URBAN	$2,900,000	MILE

* UTILITY COST ESTIMATES FROM UTILITY SECTION
** ROW COSTS ESTIMATES FROM THE ROW BUREAU IF TIME IS A FACTOR, JUST USE THE ABOVE DATA.

ADDITIONAL OVERHEAD (add to subtotal for total construction cost)
1.3% ENGINEERING CONTROLS
9.7% MOBILIZATION
15% E & I

PRELIMINARY ENGINEERING IS 15% OF TOTAL CONSTRUCTION COST
BREAKDOWN FOR P.E. 3% FOR CORRIDOR STUDY
5% FOR SURVEY
5% FOR GRADE AND DRAIN PLANS
2% FOR BASE AND PAVE PLANS
INDIRECT COST 13.63%

URBAN SECTION

BASE & SURFACE (4" SURFACE)	$96	YD^2
GRADE AND DRAIN	$38	YD^2
CURB AND GUTTER	$15	L.F.
SIDEWALK	$35	YD^2
STORM DRAIN	$60	L.F.
INLETS	$3,750	EA
BASE (ONLY)	$15	YD^2
1" SURFACE (OVERLAY)	$15	YD^2
8" CONCRETE PAVEMENT	$50	YD^2
BORROW (IN-PLACE)	$20	YD^3
SIGNALIZED INTERSECTION	$150,000	EA
BARRIER RAIL	$100	LF
TEMPORARY BARRIER RAIL	$65	LF
RETAINING WALL	$40	FT^2

G&D 2' BACK OF CURB OR BACK EDGE OF SIDEWALK
B&P 1.5' BACK OF CURB

Factors

	GD	BP
3-Lane**	1.2	1.4
5-Lane*	0.9	1.1
6-Lane*	1.3	1.5
7-Lane*	1.1	1.8
8-Lane*	1.6	1.9
2-Lane to 3-Lane**	0.85	0.75
2-Lane to 5-Lane**	1.1	1.3
2-Lane to 7-Lane**	1.4	1.7
16' Ramp**	0.85	0.75
Add 12' Lane**	0.85	0.75

*Apply to 4-Lane New Location Cost **Apply to 2-Lane New Location Cost

RAILROADS

SIGNALS	$200,000	EA
CROSSING SURFACE	$2,000	T.F.
RELOCATE TRACK	$300	T.F.
SWITCHES	$1,500	EA
R.R. BRIDGE OVER ROADWAY	$5,000	L.F.

BRIDGES

SMALL	$85	FT^2
RIVER	$125	FT^2
CULVERT	$325	YD^3 Concrete
REMOVE OLD BRIDGE	$10	FT^2
DETOUR (26' WIDE)	$50	FT^2
RIP RAP	$30	YD^2
WIDENING	$75	FT^2

SECONDARY ROADS

GRADE AND DRAIN	$195,000	MI
BASE AND PAVE	$110,000	MI
GRAVEL OVERLAY	$8	YD^2
BASE AND PAVE OFF SITE DETOUR:		
TRAVEL WAY	$25	YD^2
SHOULDERS	$15	YD^2
REMOVE PAVEMENT	$6	YD^2
REMOVE DETOUR	2 % G,D,B,&P COST	

ESTIMATED COSTS PER MILE

(REVISED JULY 2014)

THIS SHEET IS INTENDED TO AID PLANNERS IN OBTAINING A ROUGH ESTIMATE FOR PROJECTS IN EARLY PLANNING PHASES. THE FIGURES ARE AVERAGES FOR THE PAST 2 YEARS AND SHOULD BE ADJUSTED IF YOUR JOB IS OUTSIDE THE ORDINARY SCHEME OF WORK. **CALL AMY MARTINOUS AT 2325 FOR ASSISTANCE.**

NOTE: CHECK THE LABEL ON THE FIGURE YOU ARE USING. SOME ARE "PER LANE MILE."

NEW ROADS (TURNKEY PROJECTS ON NEW LOCATION WITH "AVERAGE" DRAINAGE WITHOUT BRIDGE QUANTITIES) PER MILE

ROAD TYPE	URBAN AREAS	RURAL-MOUNTAINS	RURAL-OTHER
6 LANE FREEWAY	$ 10,850,000	N/A	N/A
4 LANE FREEWAY	$ 8,800,000	$ 10,400,000	$ 6,750,000
4 LANE WITH PAINTED MEDIAN	N/A	$ 5,675,000	$ 4,725,000
4 LANE UNDIVIDED	$ 5,525,000	N/A	N/A
4 LANE DIVIDED	$ 5,675,000	$ 6,400,000	$ 4,725,000
4 LANE ARTERIAL*	N/A	N/A	$ 10,375,000
2 LANE ARTERIAL	$ 3,175,000	$ 2,975,000	$ 2,750,000
2 LANE COLLECTOR	$ 2,100,000	$ 1,900,000	$ 1,700,000

* IN A FLOODPLAIN WITH BORROW DITCHES

BRIDGES AND BOX CULVERTS (DOES NOT INCLUDE APPROACH ROADS. USE SQ. FT. OF FINAL STRUCTURE.)

NEW BRIDGE	$ 121	PER SQ. FT. DECK AREA (MORE IN SEISMIC AREAS)
WIDEN EXISTING BRIDGE	$ 69	PER SQ. FT. DECK AREA (OLD DECK REMOVED & REPLACED)
REPLACE EXIST. DECK	$ 63	PER SQ. FT. DECK AREA (NO NEW SUBSTRUCTURE)
REMOVAL OF BRIDGE	$ 15	PER SQ. FT. DECK AREA
BOX CULVERT	$ 69	PER SQ. FT. BOX TOP AREA
DETOUR BRIDGES	$ 65	PER SQ. FT. (MORE IN SEISMIC AREAS)
HYDRODEMOLITION	$ 35	PER SQ. FT. DECK AREA

WIDENING EXISTING ROADWAY

	URBAN		RURAL	
2 LANES TO 3 LANES (PASSING LANES-RURAL)	$ 3,450,000	PER MILE	$ 1,850,000	PER MILE
2 LANES TO 4 LANES	$ 4,450,000	PER MILE	$ 3,175,000	PER MILE
2 LANES TO 4 LANES DIVIDED*	$ 4,560,000	PER MILE	$ 3,875,000	PER MILE
2 LANES TO 5 LANES	$ 4,725,000	PER MILE	$ 3,375,000	PER MILE
2 LANES TO 5 LANES**	N/A	PER MILE	$ 8,075,000	PER MILE
3 LANES TO 5 LANES	$ 4,675,000	PER MILE	N/A	
4 LANES TO 5 LANES	$ 3,150,000	PER MILE	N/A	
3R WIDENING (2 LANES)	$ 1,500,000	PER MILE	$ 1,050,000	PER MILE

* 4 LANE DIVIDED HWY. USING EXISTING LANES AS TWO OF THE LANES ** IN A FLOODPLAIN WITH BORROW DITCHES EXISTING

RECONSTRUCTION (NEW DRAINAGE, BASE, SURFACING, MINOR WIDENING)

NON-FREEWAY	$ 1,650,000	PER LANE MILE	$ 1,500,000	PER LANE MILE
FREEWAY (BOND ISSUE JOBS)	$ 1,600,000	PER LANE MILE (RUBBLIZE & OVERLAY - NO BRIDGES)		
	$ 150,000	PER LANE MILE (COLD MILL & INLAY - NO BRIDGES)		
	$ 1,200,000	PER LANE MILE (CONCRETE OVERLAY - NO BRIDGES)		

FREEWAY PATCHING & REHABILITATION (FULL DEPTH PATCHING, MINOR DRAINAGE & BASE REPAIRS, SHOULDER REPAIR, CLEAN & FILL JOINTS, ETC.)

$ 895,000 PER LANE MILE

FREEWAY PAVEMENT FRICTION PROJECTS

$ 65,000 PER LANE MILE

OVERLAYS (11 - 12 FOOT LANES, AVERAGE ACHM DEPTH = 2")

	PG 64-22		PG 70-22 & PG 76-22	
PERFORMANCE GRADE ACHM	$ 88,000	PER LANE MILE	$ 93,000	PER LANE MILE
	SINGLE		DOUBLE	
ASPHALT SURFACE TREATMENT	$ 13,500	PER LANE MILE	$ 16,000	PER LANE MILE

PHASE WORK BREAKOUTS (USE WHEN PROJECTS WILL BE DONE IN PHASES OR PARTS OF A PROJECT ARE COMPLETE AND ADDITIONAL WORK IS BEING PROGRAMMED: PAVE GRAVEL ROAD, PLACE BASE & SURFACING, ETC.)

GRADING AND DRAINAGE (NO STRUCTURES, BASE OR SURFACING - NEW LOCATIONS)

	MOUNTAINOUS AREAS		OTHER AREAS	
FREEWAY & PRIMARY	$ 1,425,000	PER LANE MILE	$ 1,025,000	PER LANE MILE
OTHER ROADS	$ 950,000	PER LANE MILE	$ 815,000	PER LANE MILE

SURFACING (INCLUDES BASE & SHOULDERS ON NEW LOCATION. INCLUDES BASE PREPARATION, DRAINAGE & MINOR WIDENING ON EXISTING GRAVEL ROADS)

	PG 64-22		PG 70-22 & PG 76-22 & CONCRETE LANES	
FREEWAY & PRIMARY	$ 700,000	PER LANE MILE	$ 1,000,000	PER LANE MILE
	PG 64-22		DOUBLE A.S.T.	
OTHER ROADS	$ 570,000	PER LANE MILE	$ 450,000	PER LANE MILE

INTERCHANGES (TRUMPET OR DIAMOND LAYOUT)

ADDED TO EXISTING	$ 9,450,000	EACH
NEW ROUTE	$ 5,850,000	EACH

SIGNALS

$ 180,000 PER INTERSECTION

CABLE BARRIER PROJECTS - $190,000 PER MILE ($36) PER FT.

SIGNALS WITH RADIUS IMPROVEMENTS

$ 280,000 PER INTERSECTION

(FOR ADD'L. CAPACITY, USE WIDENING SECTION)

BICYCLE LANES (4' ON BOTH SIDES) - $265,000 PER MILE

Appendix B Kentucky Transportation Cabinet Policy Manuals

Manual	Chapter(s)	Subject(s)
Highway Design	HD 202 Administrative Procedures	Pre-Design Activities
Right of Way	ROW 300 Project Development	Policy, Studies
Traffic Operations	TO 700 Lighting	Plan Development
Professional Services	PS 15-05 Contracting	Preparation of Cabinet Estimate for Contracts with Professional Firms
Environmental Analysis	EA 200 Administration	Environmental Consultants
	EA 400 Environmental Document Types	Governing Documents and Authorities, Introduction, Environmental Overview, Categorical Exclusion, Environmental Assessment, Finding of No Significant Impact (FONSI), Draft Environmental Impact Statement, Final Environmental Impact Statement (FEIS), Record of Decision (ROD), Reevaluation of Environmental Documents
	EA 500 Noise Impact Analysis	Governing Documents and Guidance, Introduction, Traffic Noise Analysis
	EA 600 Air Quality Analysis	Governing Documents and Guidance, Introduction, Air Quality Impact Analysis
	EA 700 Socioeconomic Impact Analysis	Governing Documents, Introduction, Socioeconomic Assessment, Community Impact Assessment, Environmental Justice Analysis, Section 4(f) Evaluation, Section 6(f) Evaluation
	EA 800 Ecological Impact Assessment	Governing Documents and Requirements, Introduction, Ecological Overview, Habitat Assessment (No Effect Finding), Ecological Base Studies, Biological Assessment
	EA 900 Cultural Resource Assessment	Governing Documents, Introduction, Section 106, Archaeological Overviews, Archaeological Investigation Form, Archaeological Phase I Intensive Survey, Archeological Phase II Testing, Archaeological Phase III Data Recovery, Historic Architectural Overviews, Historic Architectural Investigation Form, Historic Architectural Survey, Section 4(f) Documents
	EA 1000 UST and Hazardous Materials Impact Assessment	Governing Documents and Requirements, Introduction, Environmental Site Assessment Overview, Phase I Environmental Site Assessment (ESA), Phase II Environmental Site Assessment, Phase III Environmental Corrective Action
Utilities and Rail	UR 600 Utility Estimating and Programming Funds	General, Estimate Development Procedures, Utilizing Non-Utility Phase Funding
	UR 700 Project Authorization Letters	Format Requirements
	UR 1000 Utility Company Submissions	Utility Cost Estimate Review

Appendix C Kentucky Revised Statutes

176.440 State highway engineer to provide cost estimate for any project that legislator desires in six-year road plan.

The state highway engineer shall provide a cost estimate for any project that a member of the General Assembly desires to be considered for advancement or inclusion in the six (6) year road plan

176.430 Transportation Cabinet to study needs of highways and develop recommended six (6) year road plan that identifies individual transportation projects — Proposed biennial highway construction plan — Factors to be considered in development of each project — Monthly transmission of project data to General Assembly — Cabinet may expend funds necessary to complete authorized projects — Digitized maps.

(1) The Transportation Cabinet shall undertake a continuing study of the needs of the highways under its jurisdiction for the purpose of bringing existing facilities to acceptable standards or for the replacement of existing facilities when required.

(2) The Transportation Cabinet shall develop a recommended six (6) year road plan that identifies the individual transportation projects or portions thereof that are scheduled to be constructed in each county. The recommended six (6) year road plan shall include a recommended biennial highway construction plan. The recommended six (6) year road plan and recommended biennial highway construction plan shall be submitted to the General Assembly as required by KRS 48.110(6)(f). The six (6) year road plan shall include but shall not be limited to the following information for each project:

(a) The county name;
(b) The Kentucky Transportation Cabinet project identification number;
(c) The route where the project is located;
(d) The length of the project;
(e) A description of the project and the scope of improvement;
(f) The type of local, state, or federal funds to be used on the project;
(g) The stage of development for the design, right-of-way, utility, and construction phase;
(h) The fiscal year in which each phase of the project should commence;
(i) The estimated cost for each phase of the project; and
(j) The estimated cost to complete the project.

(3) The Transportation Cabinet shall identify projects in the six (6) year road plan that may, in accordance with this section, be advanced from later years, to maximize the use of all funds available to the cabinet, and to plan for the historical precedent of projects being delayed due to unforeseen circumstances. As required by KRS 48.110, the Governor shall submit to the General Assembly, as part of the proposed biennial highway construction plan, a list of projects from the last four (4) years of the six (6) year road plan, not to exceed ten percent (10%) of the recommended biennial highway construction appropriation, which can be advanced if additional money is received and all projects included in the enacted biennial highway construction plan have been advanced or completed to the extent possible.

(4) In developing the design, right-of-way, utility, and construction phase of each project, the following factors shall be considered but are not exclusive:
(a) Alignment of existing roads;
(b) The width or elevation of existing roadways and shoulder surfaces;
(c) The width of rights-of-way;
(d) The cost of each phase of the project plus a separate identification of the cabinet's administrative costs for each phase;
(e) The type and volume of traffic;
(f) The condition of structures and drainage;

(g) The accident rate;
(h) The geographic distribution of roadways to be constructed or reconstructed; and
(i) The social, economic, and environmental impact of the proposed project.

Appendix D Draft KYTC AASHTOWare Manual

KYTC

AASHTOWare Project Manual (Project Level)

Creating a Project in AASHTOWare Project Based on version 4.3.023

AASHTOWare Project ,PreConstruction/Estimation
Ver *4.3.023*
Updated July 21, 2020

Adapted July 21, 2020

Table of Contents

FORWARD: BEFORE YOU BEGIN

You will need the following information:

1. Prelimnary list of items and quantities or estimated amount for major items such as Bridges, Signals, Waterlines, etc.

   Note: Group jobs require quantities divided into separate projects and estimates for each county.

2. SYP Item Number and county name, if known

3. Route Name and Number and type of Road: State, US Route, County Road, etc.

4. Long project description from the *Status Report if SYP* or description

5. Beginning and end Mile Points from the *Status Report,* if known

6. Length in miles from the Plan Layout sheet or the *Status Report*

7. Completion Date and Liquidated Damages rate if different than the Spec Book provision

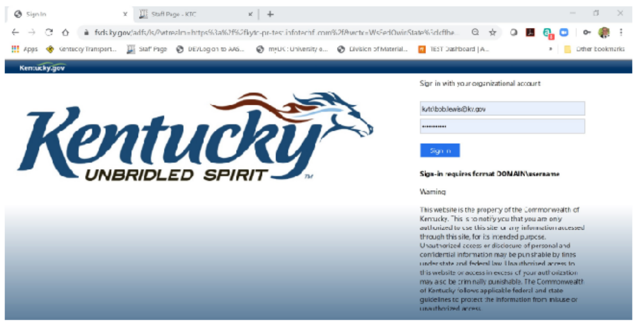
8. Accurate and up-to-date funding number, which may have changed from the Design funding number, if known

9. The project number; if not already established, one must be assigned. (See information in the table for the PCN field under the General tab.)

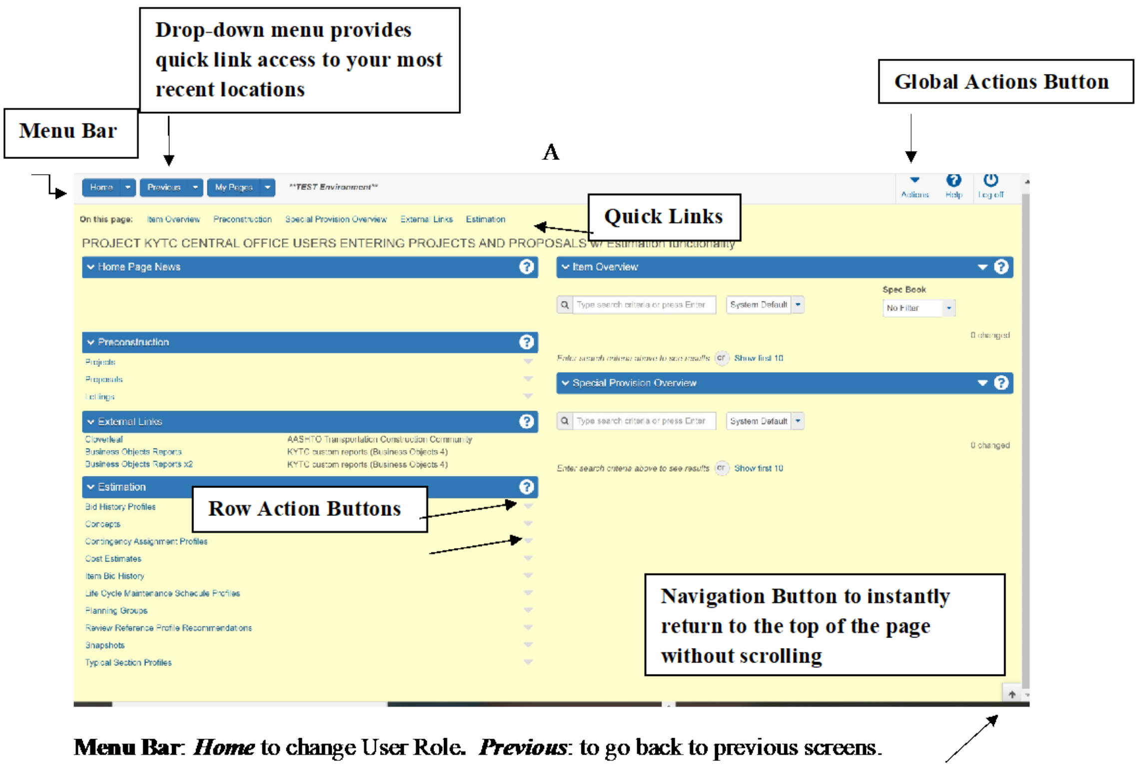
10. For Construction Procurement: Proposal # (ContractID). *Determine the Contract ID number. (Six-digit number beginning with two-digit year, then your two-digit unique individual project designer number followed by your two-digit sequential number. ("141799" means the ninety-ninth contract in 2014 built by John Doe whose unique number is 17.*)

ACCESS AASHTOWARE PROJECT

Before using AASHTOWare Project PreConstuction (APP) for the first time, you need to request access to the software. If you are a KYTC employee, you will use your network user ID and password. Consultants currently use AASHTOware Project Estimator but transition to using APP. They will need access to APP & AASHTOWare Project Estimation (APE) to build projects; they will be assigned a username and password to access the system.



AASHTOWARE PROJECT DASHBOARD



Menu Bar: ***Home*** to change User Role. ***Previous***: to go back to previous screens.

My Pages: Bookmarks

Quick Links: page specific links

Global Actions Button: Role specific actions like import file or Open Process History

Row Action Button: Roll specific action for the listed Link

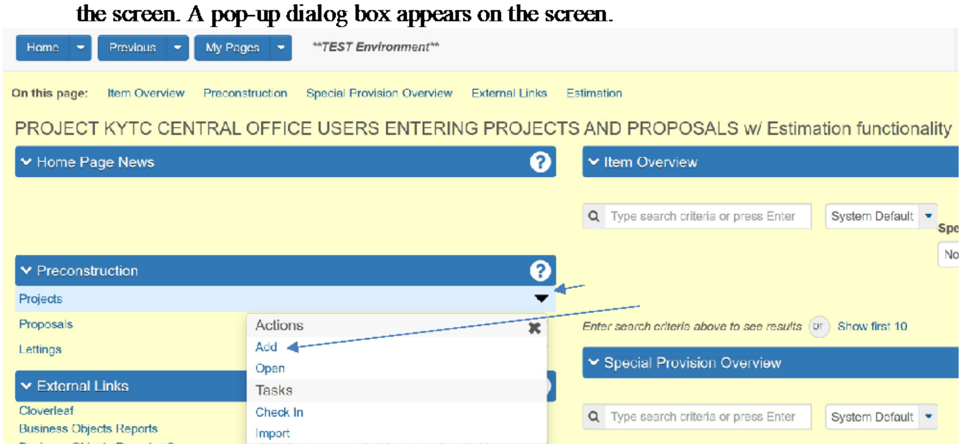
Navigation Button: Returns to top of page

- Always enter data in ALL CAPS.
- Spell out all words if there is room (DRIVE, not DR, AVENUE, not AV)
- Do not use symbols such as "@" for "at" or "&" for "and".

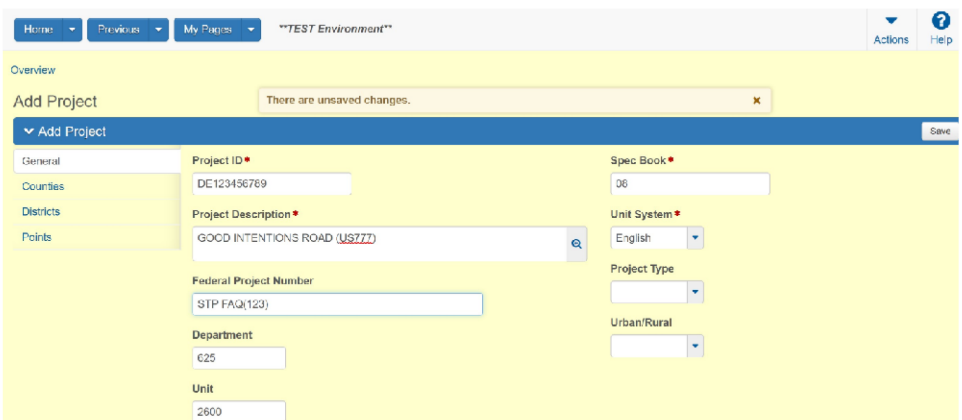
CREATE A NEW PROJECT

Creating a New Project *without* Importing the Estimator file:

- Click on the Row **Actions** button under the **Preconstruction, Projects** tabs at the left of the screen. A pop-up dialog box appears on the screen.



- Click **Add** under the **Actions** Button and the **General** tab description page opens with all blank fields. Notice the incomplete list of tabs at the left of the screen which is missing the **ROADWAY SEGMENTS, BRIDGE SEGMENTS** and **WORKFLOW** tabs. Also there are a limited number of project information fields.

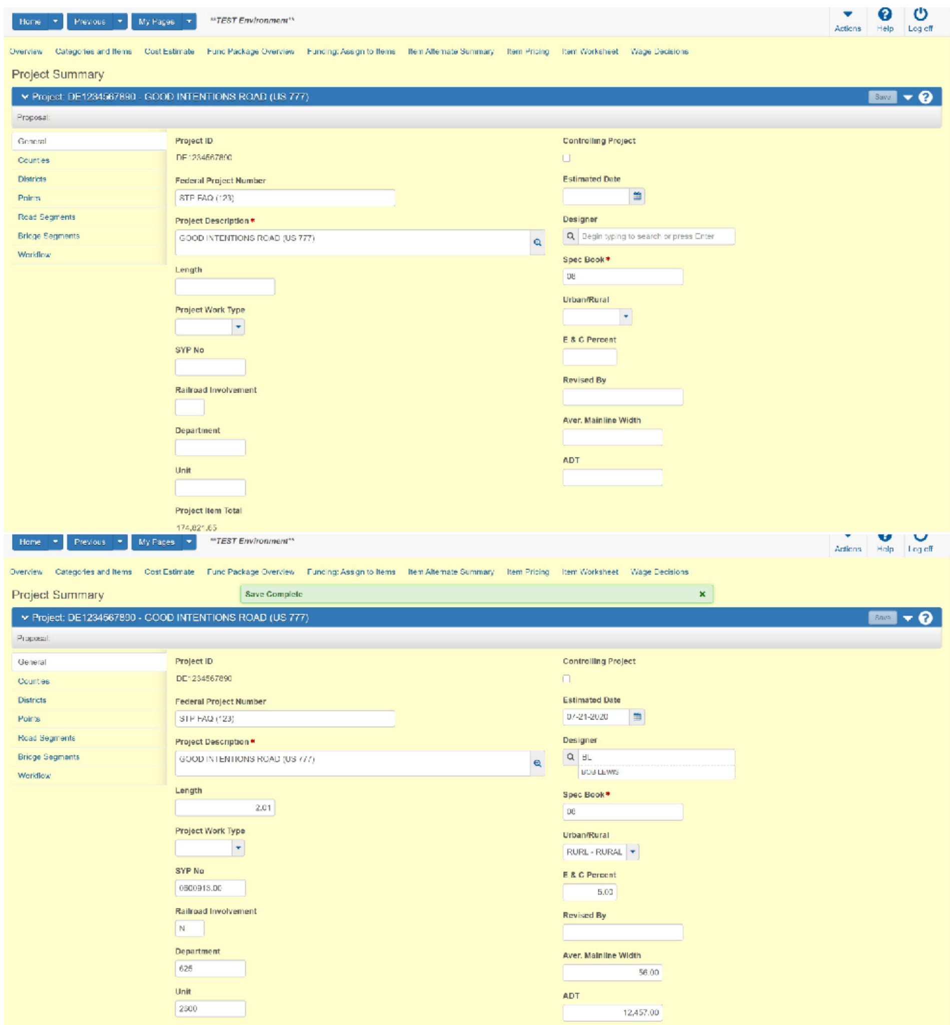


- **Project ID:** Enter a 13 alpha/numeric character designation. The first 2 characters designate the division or district in which the project is being created, followed by a 3-digit county code, a 4-digit route number, a 2-digit calendar year, and a 2-digit sequential number that is unique to the individual entering the project/proposal into AASHTOWare. (DE1220034190l)
- **Project Description:** Enter the fund number for the project, Federal Project Number (i.e., BRZ 1203 (145)) or the State Project Number (i.e., FD04 098 1428 001-003).
- **Spec Year:** Should be autopopulated to 08 for year bid item list started (NOT current Spec book year).

- Click **Save.**
- Open to Project Summary General Tab.

GENERAL TAB

- Enter Fields for Project (see the following page for details required for each field).
-



FIELDS FOR GENERAL SCREEN

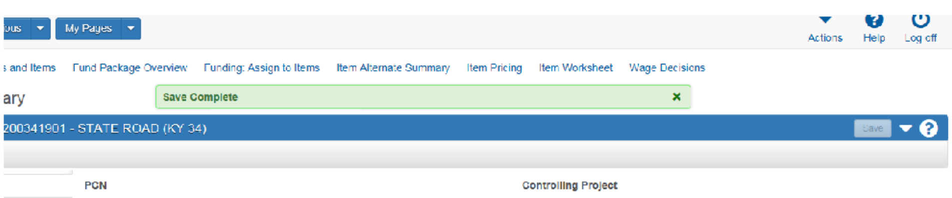
- Complete the required fields on the General tab screen per the following table.

FIELD	INSTRUCTIONS / EXAMPLES
PCN (Project Number)	Enter a 13 alpha/numeric character designation. The first 2 characters designate the division or district in which the project is being created, followed by a 3-digit county code, a 4-digit route number, a 2-digit calendar year, and a 2-digit sequential number that is unique to the individual entering the project/proposal into AASHTOWare. (DE12200341901) DE – Construction Procurement (formerly Highway Design) RR – Rural Roads MP – Maintenance, Projects & Products MB – Maintenance, Bridge Maintenance ME – Maintenance, Environmental & Roadside 01-12 – Traffic, for the corresponding district If building a project from an imported estimate file, this field will be populated with the name on the "fixed" .xml file.
Federal/State Project Number	Enter the fund number for the project, Federal Project Number (i.e., BRZ 1203 (145)) or the State Project Number (i.e., FD04 098 1428 001-003). Be sure to use the dash between the mile points as in the state funded number example. On federally funded group jobs, this number will be identical on each county project within the project.
Project Description	Enter route name followed by the route number in parentheses. (i.e., RICHMOND-LANCASTER ROAD (KY 25))
*Length	Enter miles from the printed *Status Report* to the hundreds place, or two places right of the decimal.
*Project Work Type	This field will be populated from the estimate file data but verify that they type populated is what is required. There are fewer choices in Estimator than there are available in AASHTOWare Project. This work type should match exactly with that used on the Proposal in AASHTOWare. See Addendum 1 for complete list of all available work types.
**SYP No	This field displays the 10 digit version of the Six-Year Plan Item Number: 2 digits (district), 5 digits, a decimal point, and 2 digits (i.e., 2-3055.00 is entered as 0203055.00).
*Railroad Involvement	Enter **Y** or **N** depending on whether the project has railroad involvement.
*Department	Enter **625**. The field is auto-populated for Construction Procurement unless estimate has been imported. May be different if not a KYTC Department. of Highways project.
*Unit	Enter **2600**. The field is auto-populated for Construction Procurement unless estimate has been imported. May be different if not KYTC Department of Highways project
Project Item Total	Auto-populated
*Controlling Project	Check the box. On group jobs, one, and only one, of the projects can be designated as the controlling project.
*Estimate Date	Select today's date from the drop-down calendar.

*Designer	**If creating a new project without importing:** You will not be able to enter and save the screen with the designer code until you have saved the screen for the first time with all of the required information fields completed. AFTER you have saved this screen for the first time, enter your four-character designer code name (i.e., YN01 Your Name). **If importing the Estimator file to create the project:** enter your four-character designer code name (i.e., YN01).
Unit System	Defaults to **E** for English unit of measure.
Spec Book	Auto-populated with **08.** Bid Based pricing uses this number.
Urban/Rural	**If creating a new project without importing:** Choose from the drop-down menu. **If importing the Estimator file to create the project:** This field will be auto-populated.
*E & C Percent	Enter contingency percent from estimate, either 10% for projects over $1M or 15% for projects less than $1M.
Revised By:	Ignore. This field will auto-populate later.
Aver. Mainline Width	Enter for FD05, paving rehab and all other contracts without plans. This includes the shoulder width. Use information in the Typical Sections plan sheets.
ADT(Average Daily Traffic)	Enter for paving rehab and all other contracts without plans. See http://maps.kytc.ky.gov/photolog/?config=TrafficCounts

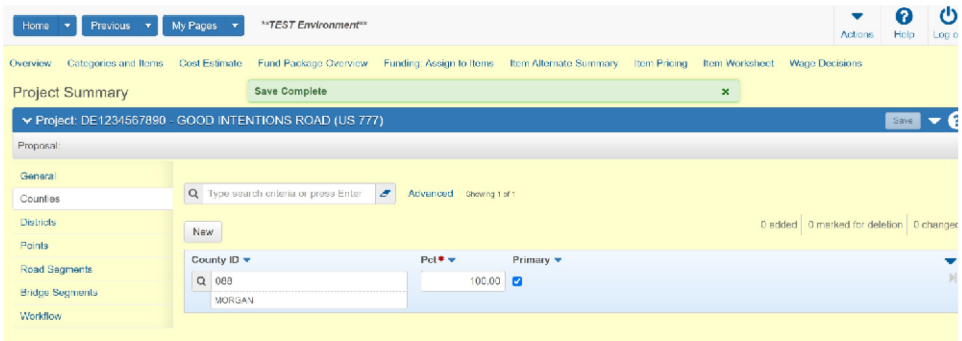
*Required Fields
** SYP only on SYP projects.

- When the data entry is complete, click the **Save** button in the upper right of the screen. Remember that when saving changes, nothing has been saved until the green bar with the message ***Save Complete*** appears at the middle top of the screen.



COUNTIES TAB

- Click the **Counties** tab.

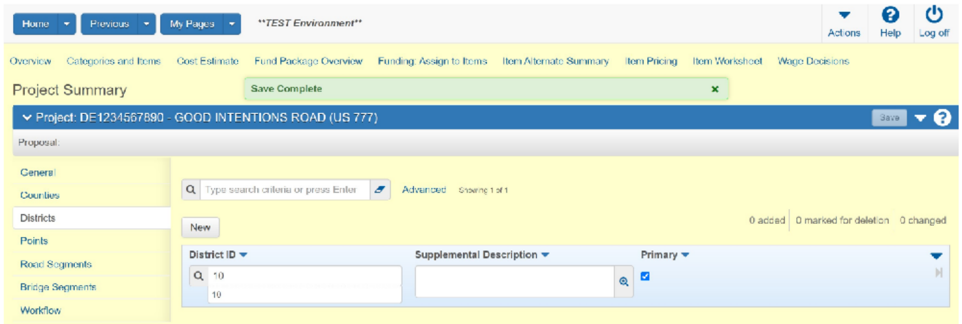


- Verify that the imported information is correct. If building the project without importing, enter the correct data by the following steps:

1. Click the **New** button.
2. Enter the three-digit county number in the **County ID** field.
3. **Pct.** (percent) is always 100.
4. **Primary** should always have a check mark.
5. Click the **Save** button.

DISTRICTS TAB

- Click the **Districts** tab

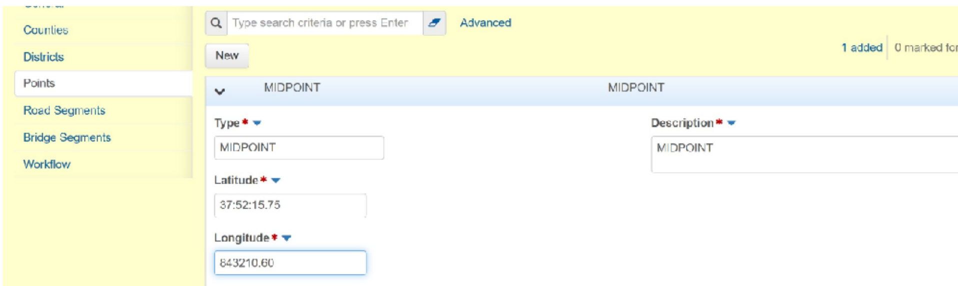


- Verify that the imported information is correct. If building the project without importing, enter the correct data by the following steps:

1. Click the **New** button.
2. Enter the two-digit district number in the **District ID** field.
3. Leave the **Supplemental Description** field blank.
4. **Primary** box should have a check mark.
5. Click the **Save** button.

POINTS TAB

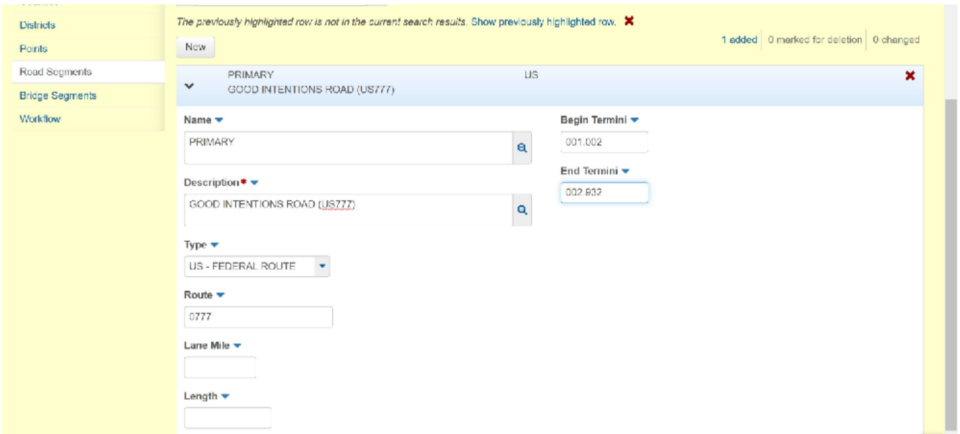
- ➢ Click the **Points** tab.



- ➢ **Type** is MIDPOINT (this is required for all projects for location on a map)
- ➢ Verify that the imported Latitude and Longitude information is correct or complete the following steps.
- ➢ Enter **Latitude** from the Plan Sheet Layout page or use Construction Procurement Earth or other online map to locate approximate project midpoint. Do not use the county midpoint. Enter in degrees, minutes and seconds, DDMMSS.ss
- ➢ Enter **Longitude** from the Plan Sheet Layout page or use Construction Procurement Earth or other online map to locate approximate project midpoint. Do not use the county midpoint. Enter in degrees, minutes and seconds, DDMMSS.ss
- ➢ *Enter the long project **Description** from printed *Status Report* in all capital letters. Put a period at the end if there are no mile points reported on the project.
- ➢ Click the **Save** button.

ROAD SEGMENTS TAB

- Click the **Road Segments** tab.



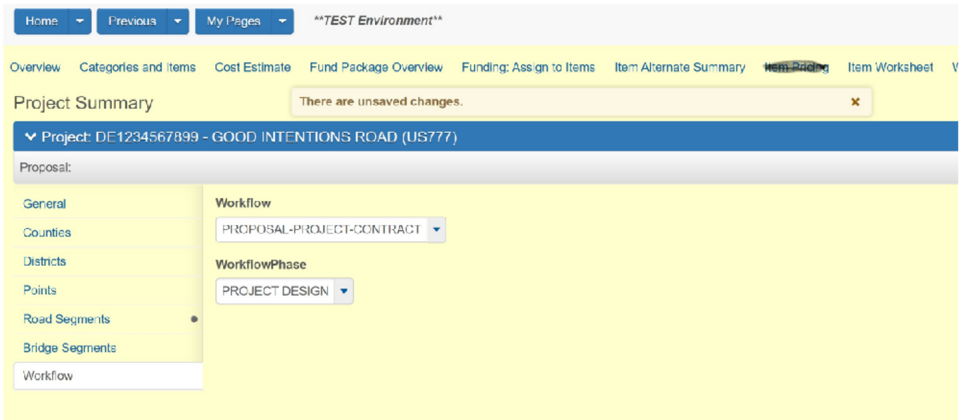
- Click the **New** button.
- Enter "PRIMARY" in the **Name** field.
- Enter the **Description** (same as the Description on the General Tab: Route name & number).
- Choose the road **Type** from dropdown menu. (i.e., KY, Interstate, US, etc.)
- Enter the **Route** number.
- Ignore the **Lane Mile** field.
- Enter the **Length** to three digits to the right of the decimal point.
- Enter the Beginning Mile Point to three digits to the right of the decimal. Find this on the printed *Status Report* in the **Begin Termini** field.
- Enter the End Mile Point to three digits to the right of the decimal. Find this on the printed *Status Report* in the **End Termini** field.
- Click the **Save** button.

BRIDGE SEGMENTS TAB

- Skip the **Bridge Segments** because Construction Procurement does not currently use this component. This will be implemented soon to track bridges by bridge ID.

WORKFLOW TAB

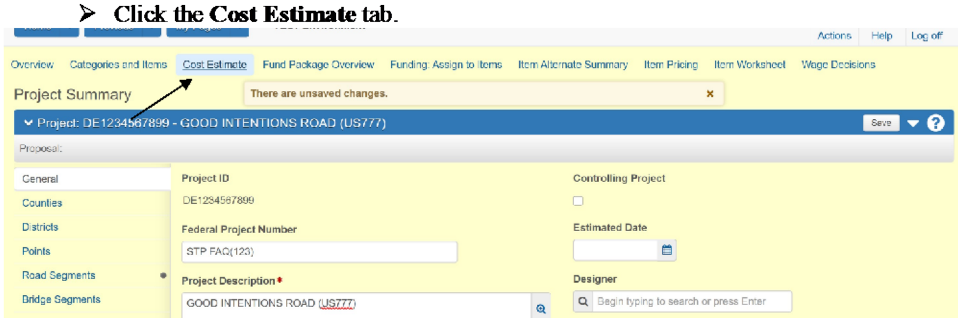
- Click the **Workflow** tab.



- In the **Workflow** drop-down menu select **PROPSAL-PROJECT-CONTRACT**.
- In the **Workflow Phase** drop-down menu select **PROJECT DESIGN**.
- Click the **Save** button.

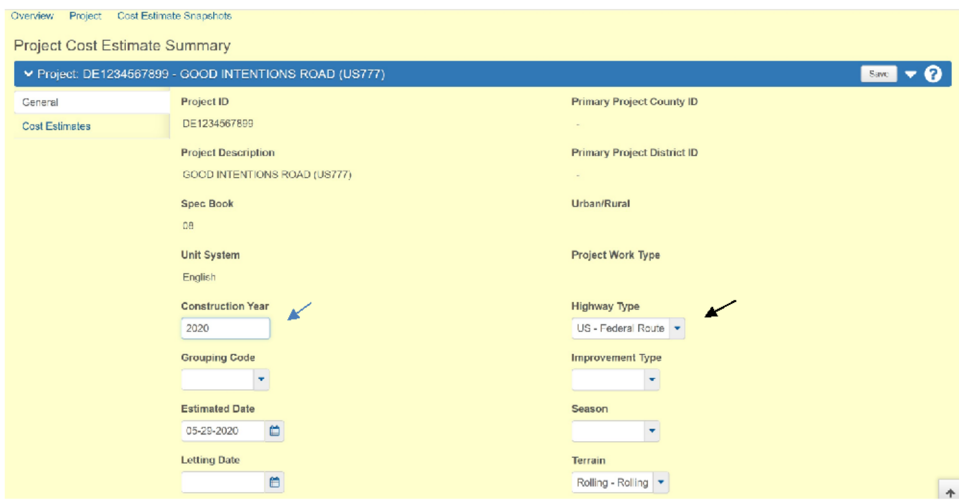
COST ESTIMATION

- Click the **Cost Estimate** tab.



COST ESTIMATION PROJECT GENERAL SUMMARY

- Populate the **General Summary** fields as applicable.

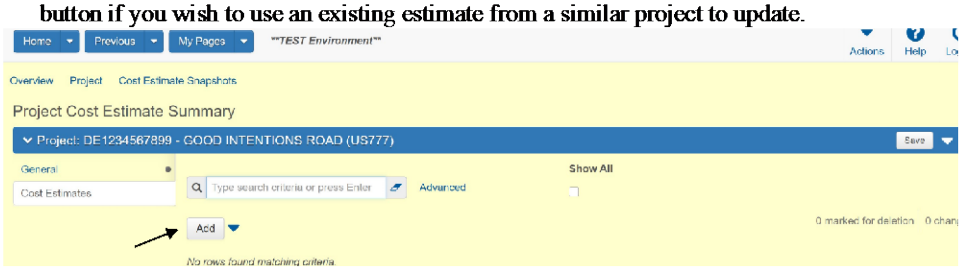


- Enter the correct data by the following steps:

1. **Construction Year** is optional. If known, populate.
2. **Grouping Code** is not used at this time.
3. **Letting Date** is optional. If known, populate.
4. **Highway Type** (required).
5. **Improvement Type** is not used at this time.
6. **Terrain**: rolling, level or mountainous.
7. Click **Save.**

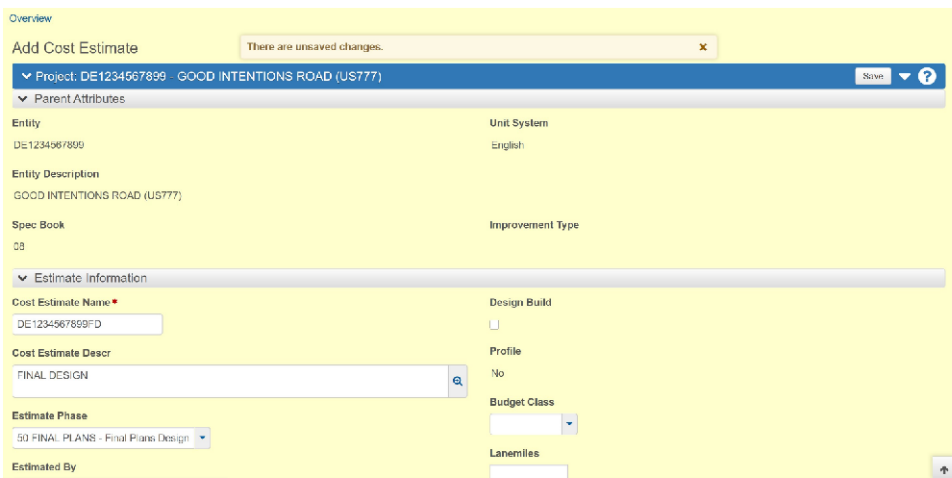
ADD COST ESTIMATE

- Click on **Cost Estimates** Tab to Add or copy an existing estimate. Use Row Action button if you wish to use an existing estimate from a similar project to update.



COST ESTIMATE SUMMARY

- **Cost Estimate Name** should have **Project Name** with code at end.

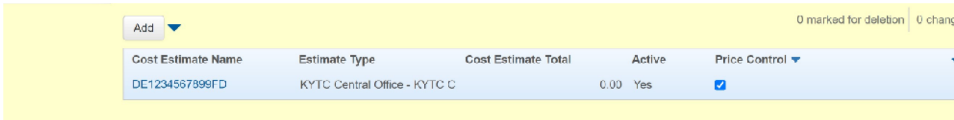


- For **Cost Estimate Names**, include codes after Project Name: **Scoping SC, Design DE, Final Design FD, Engineer Final Official Estimate EE**. For Example, DE123456789SC for **Scoping Estimate** (note use can use highlight Entity and Ctrl C (copy) for Project Name).

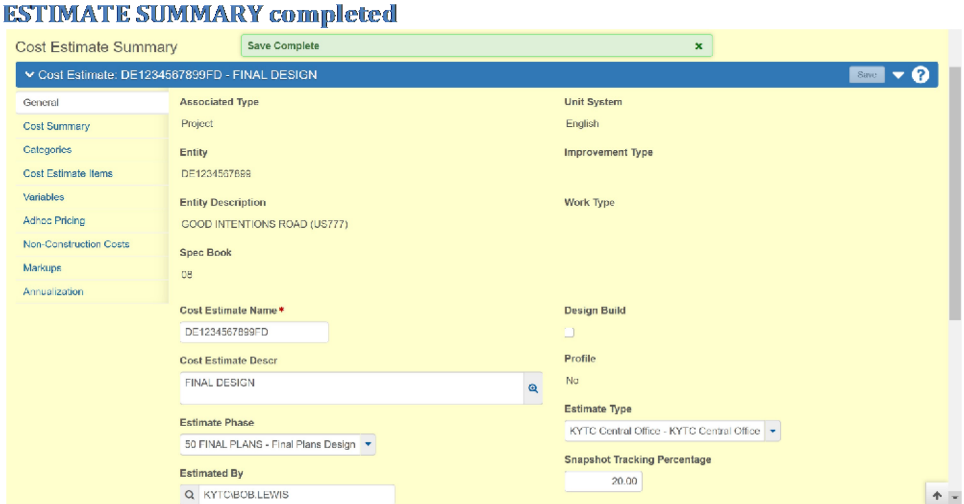
- Select **Estimate Phase**, **Estimate Type** & **Estimated by** from pull down menus. Enter values lookup tables.

- Click **Save**.

OPEN ESTIMATE



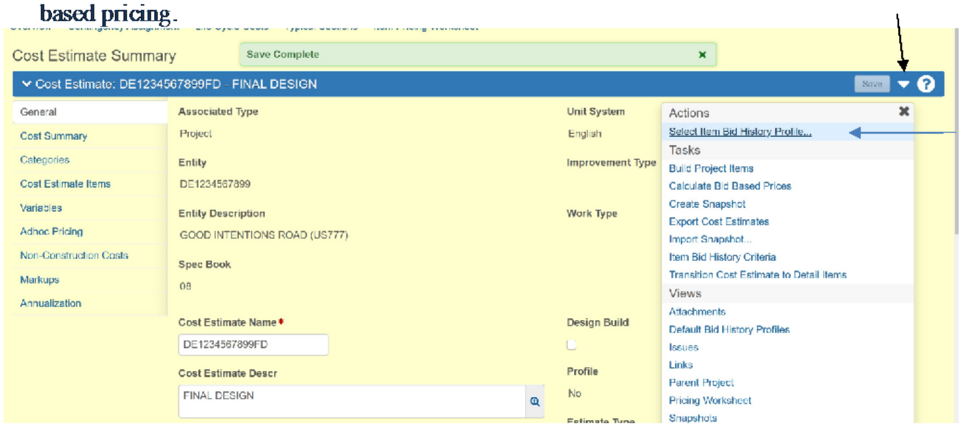
COST ESTIMATE SUMMARY completed



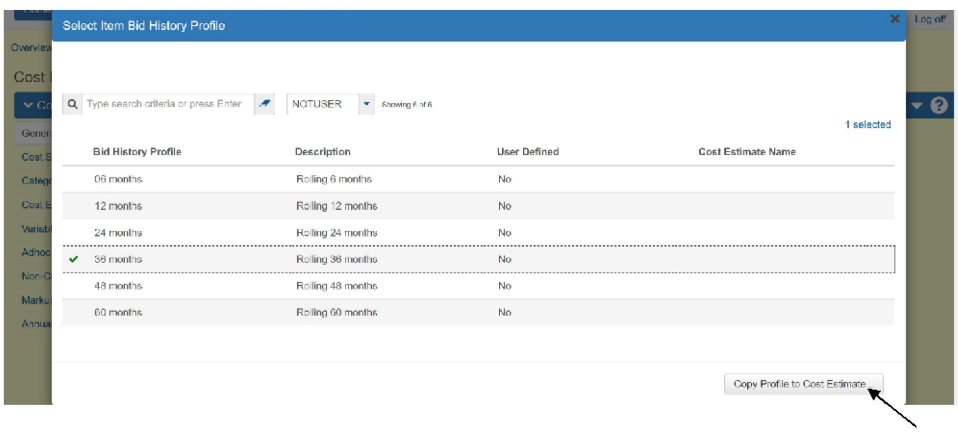
- Enter **Snapshot Tracking Percentage** (percent to Final Design Estimate).
- Click **Save**.

ADDING BID ITEM HISTORY PROFILE

➢ From **Cost Estimate Action Menu**, add a **Bid Item History Profile** to calculate bid based pricing.

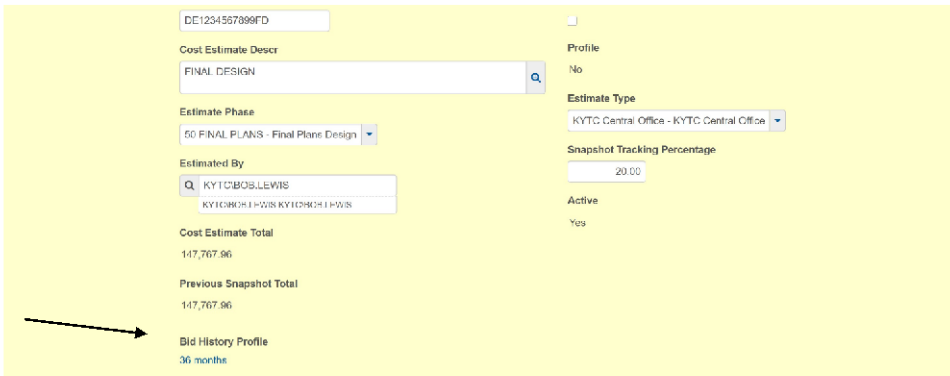


SELECT COPY PROFILE TO COST ESTIMATE (NOT USER FILTER TO DISPLAY NO USER DEFINED)



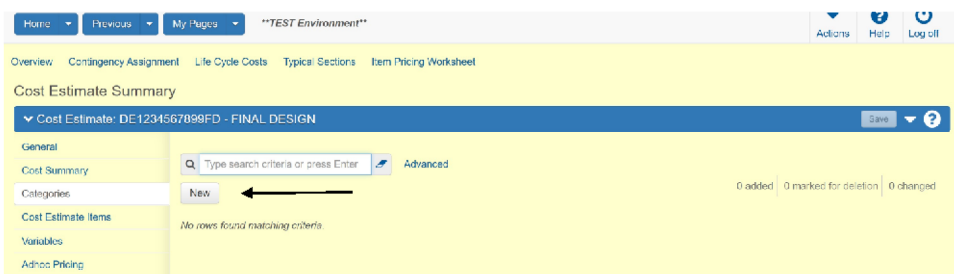
SELECTED BID HISTORY PROFILE

This is displayed at the bottom of the **Cost Summary** screen.



CATEGORY IN COST ESTIMATE

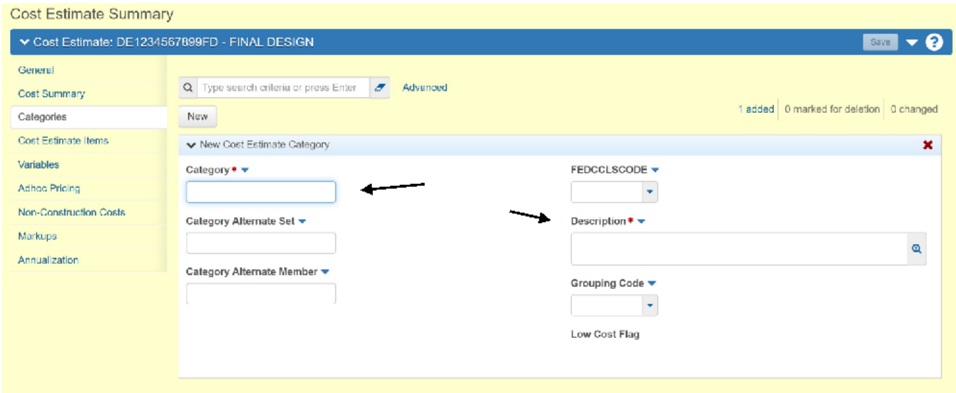
Categories must be added at **Cost Estimate Level** before Build Project Items process.



Note: after "Build Project Item Process" update Categories and Items at Project Level and price at Cost Estimation Level.

CATEGORY AND DESCRIPTION

This is required. The description should be from the below list of Categories. Additional information can be added if needed. (i.e., Bridge Drawing Number).

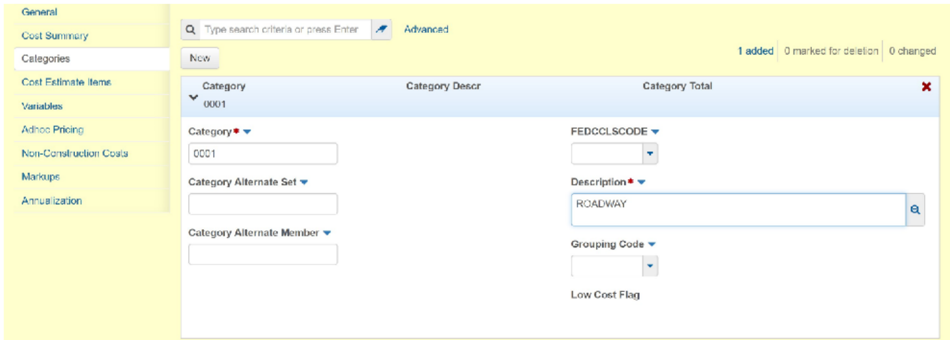


- Choose **Category** as a number starting at 0001. Choose **Description** from the list below.

KYTC STANDARD CATEGORIES

PAVING
ROADWAY
DRAINAGE
BRIDGE
UTILITY
SEWER
SIGNING
SIGNALIZATION
LIGHTING
TRAFFIC LOOPS

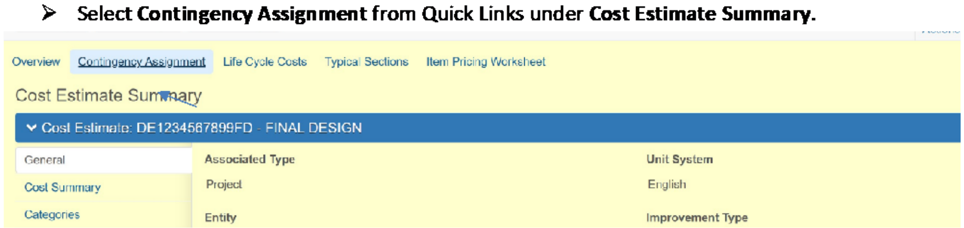
INTELLIGENT TRANSPORTATION SYSTEMS
WATERLINE
LANDSCAPING
MOWING
MISCELLANEOUS
TRAINEES
DEMOBILIZATION &/OR MOBILIZATION
WARRANTY
GUARDRAIL
AIR PORT CONSTRUCTION
DESIGN BUILD



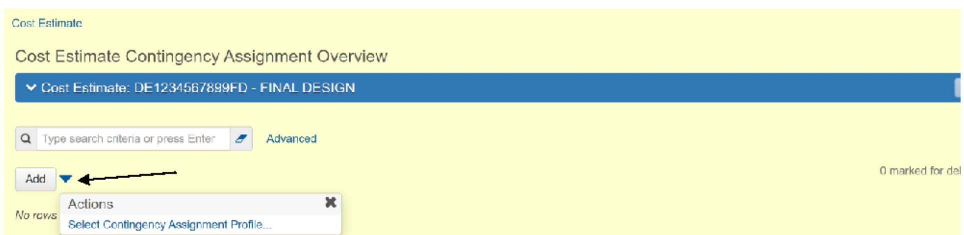
CONTINGENCY ASSIGNMENT

Contingency should be assigned before beginning cost estimate.

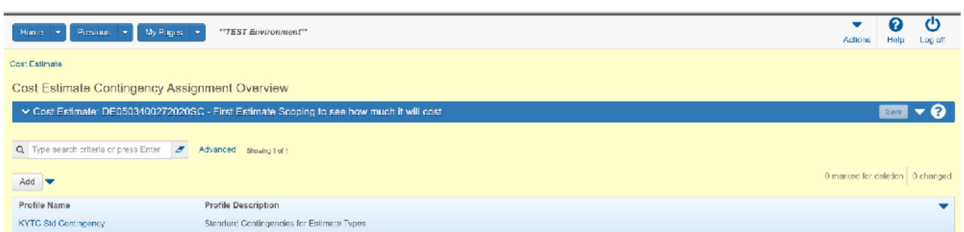
- Select **Contingency Assignment** from Quick Links under **Cost Estimate Summary.**



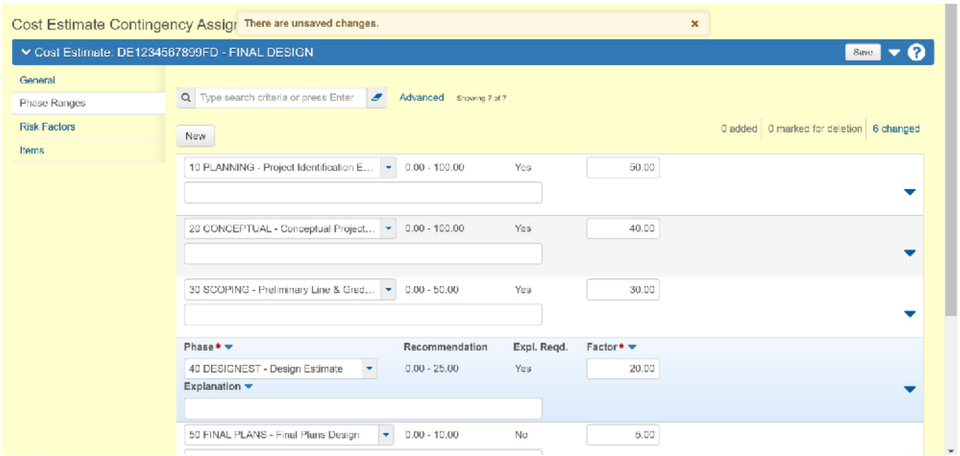
- Select **Contingency Assignment Profile** from Open Action Menu beside the **Add** button.



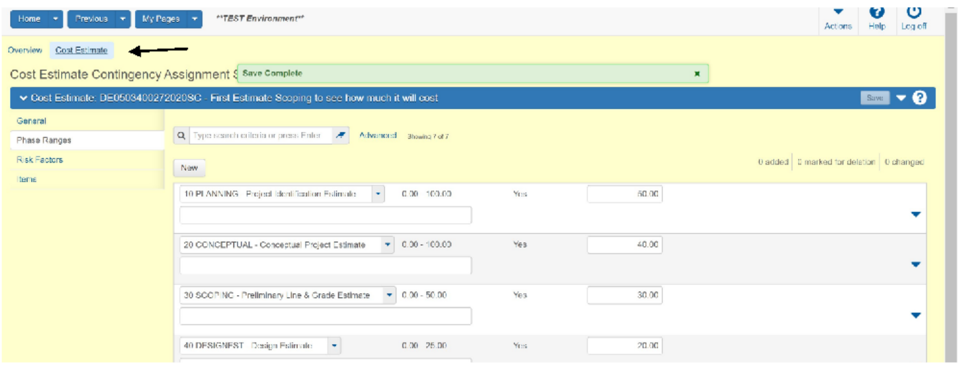
- Add to **Cost Estimate "KYTC Std Contingency".**
- Open **KYTC Std Contingency** to add **Percent Contingency** of Phase Ranges.



- Review percent of each phase.



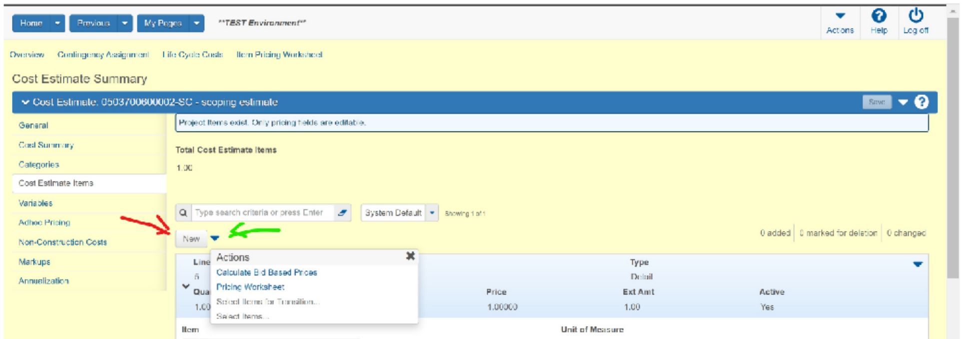
- Click **Save**.
- Click **Return to Cost Estimate**.

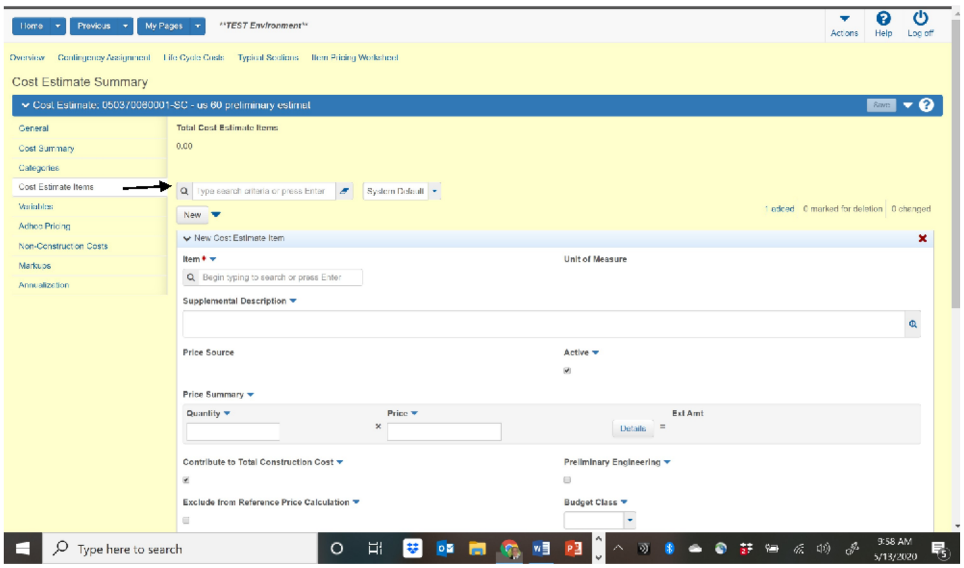


Cost Estimate Items

- Enter these from **Cost Estimate Items** tab or **Item Pricing Worksheet.**

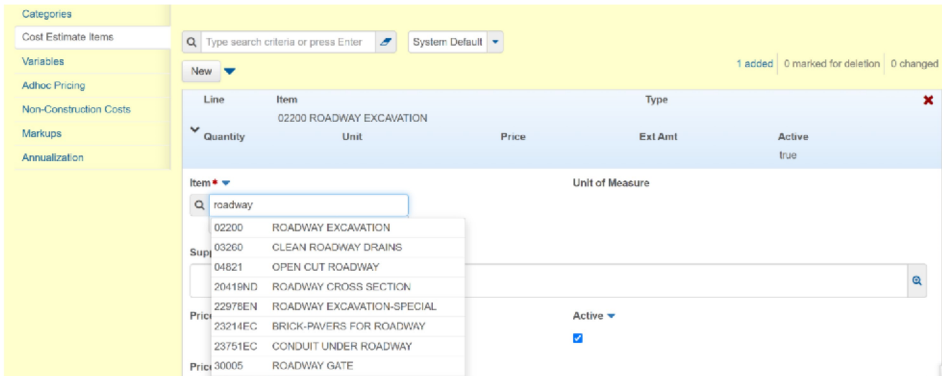
Cost Estimate Items entry can be done either with the **New** Button or the **Action** Button.



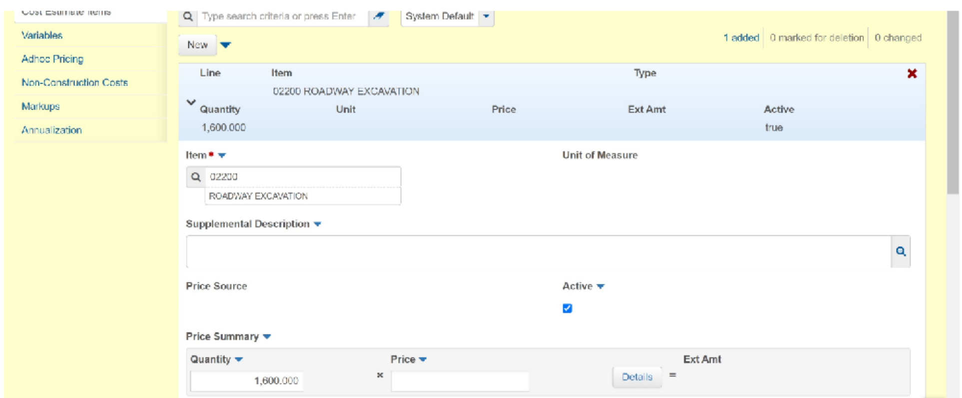


- Retrieve items by **Item Number** or **Description**.
- Enter **Quantity**, and if using ADHOC pricing, it can be added at this time.

Note: Pricing done in other step of "Calculate Bid Based Prices".
Note: Bid based pricing will calculate, if bid history has enough prices for NON Lump Sum prices.
Note: Items with Unit of Lump Sum are not in Bid History Profile and will need to be entered as ADHOC prices, with the exception of Demobilization and Mobilization.



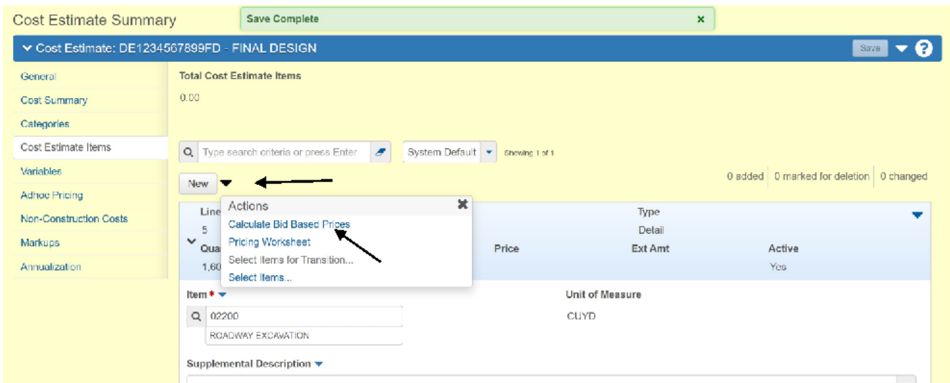
- Enter Quantity of Selected Item.



- Click **Save**.

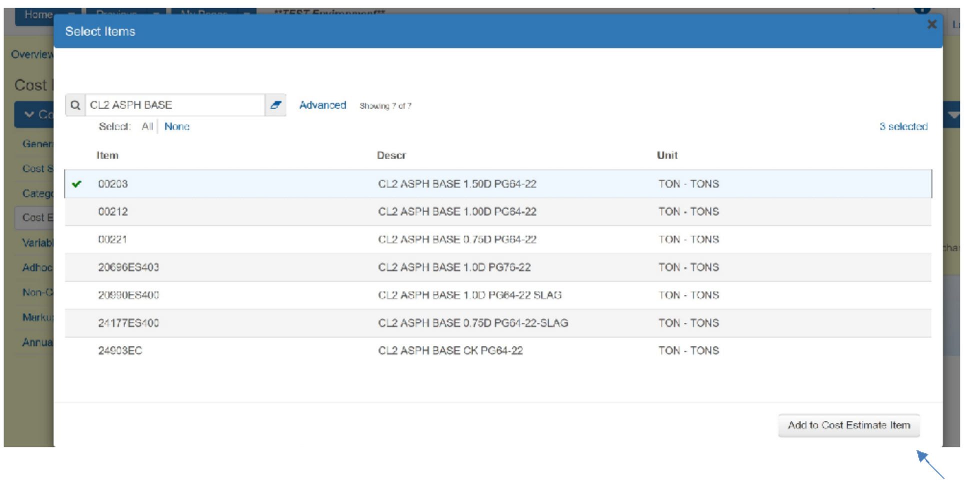
COST ESTIMATE ITEM ACTION BUTTON

Using the Cost Estimate Items **Action** button allows access to **Calculate Bid Based Prices**.

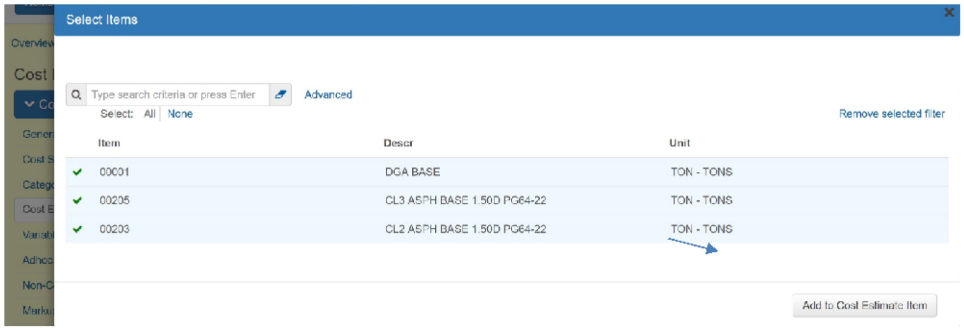


To Add Multiple Items at once:

- From Action Button, click **Select Items,** which allows you add multiple items to the cost estimate. Look up items by **Bid Item Number** or **Description**.
- Add quantities after all items are selected.

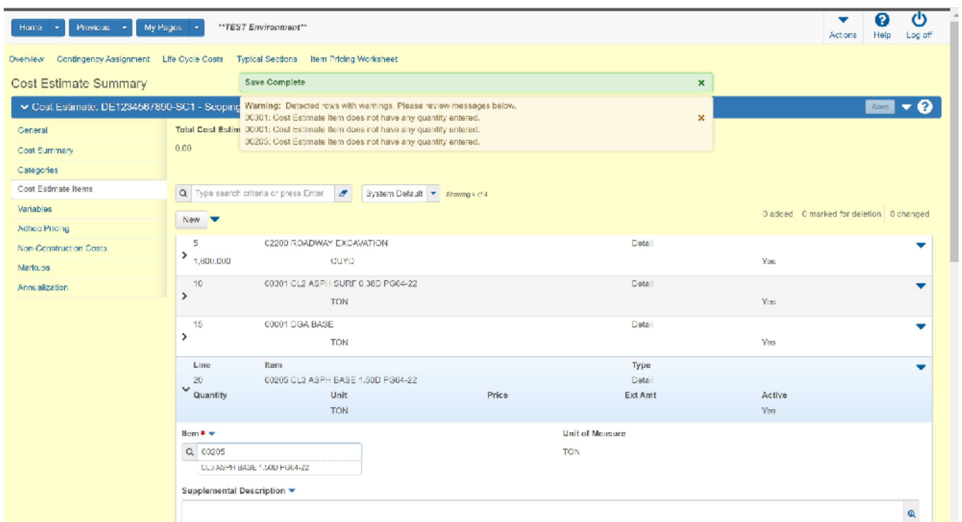


- Click on the number selected to see what has been chosen.
- Select **Add to Cost Estimate** button when finished with the list.



ADD QUANTITIES

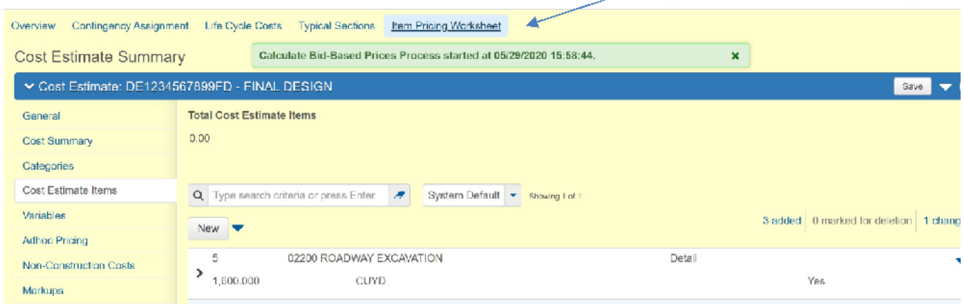
- Add quantities after adding and saving the list of items.



- Select **Calculate Bid Base Prices** to update new items.

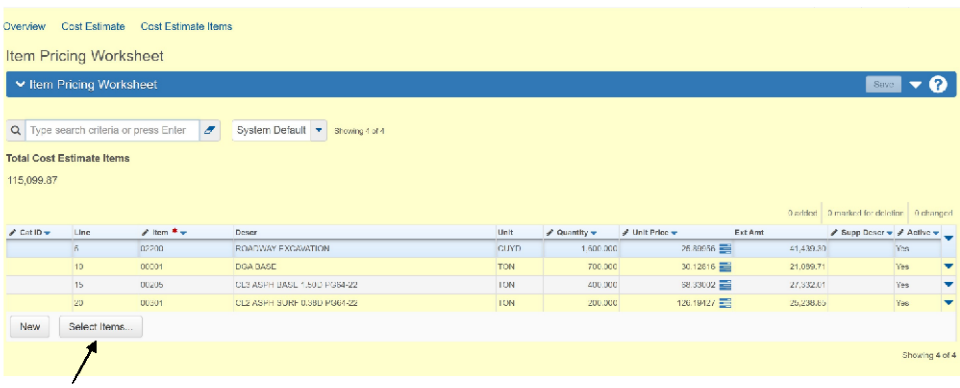
Note: "Item Pricing Worksheet" is another way to add items and view item information.

ITEM PRICING WORKSHEET TAB



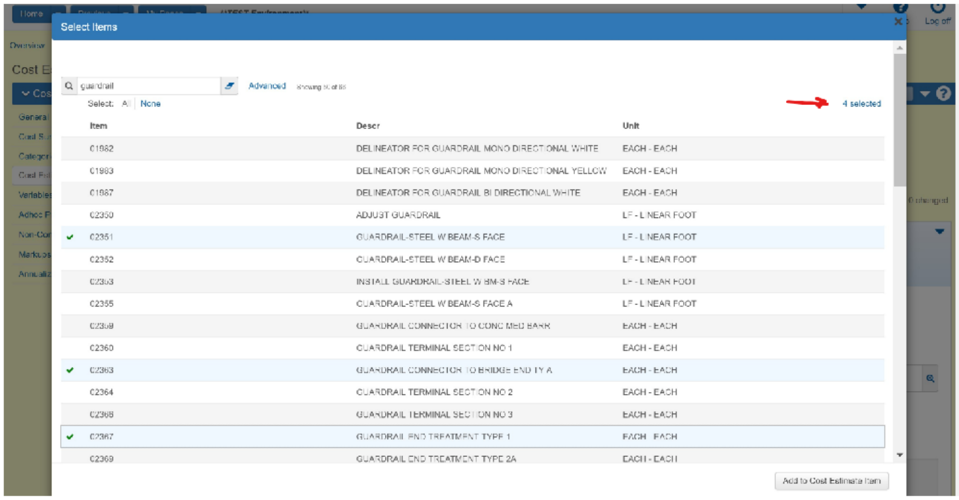
SELECT ITEMS FROM ITEM PRICING WORKSHEET

➤ **From Item Pricing Worksheet, click Select Items.**

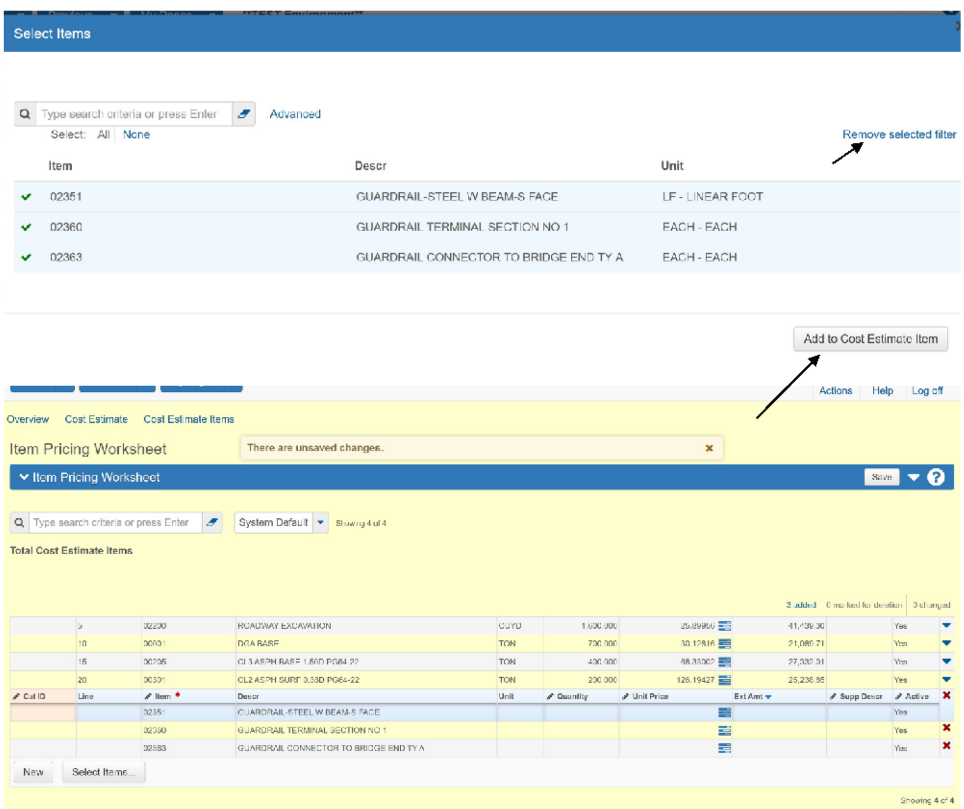


Note: By clicking on the number at the top right of the window, only the selected will be displayed.

➤ Click **Add to Cost Estimate Item** button when finished selecting. Quantities can now be added to new items.



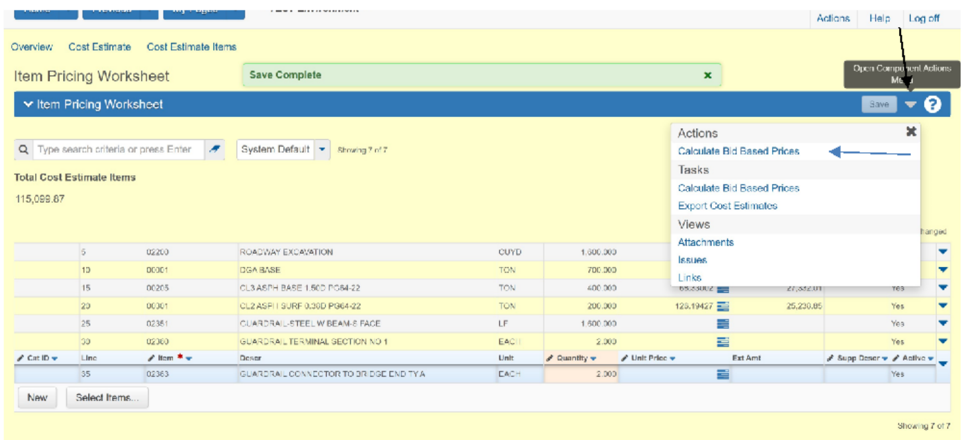
- Once items are selected, click **Add to Cost Estimate Items.**

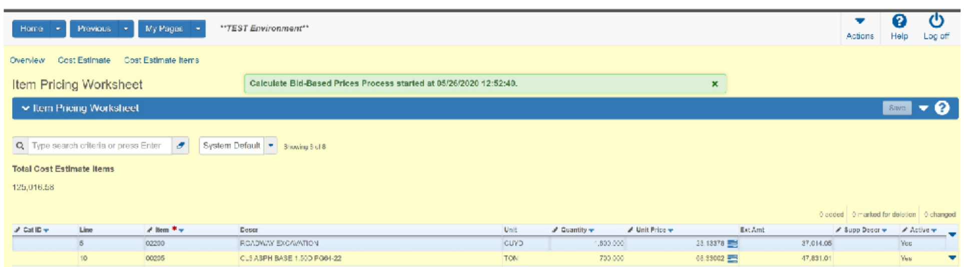


ADD QUANTITIES

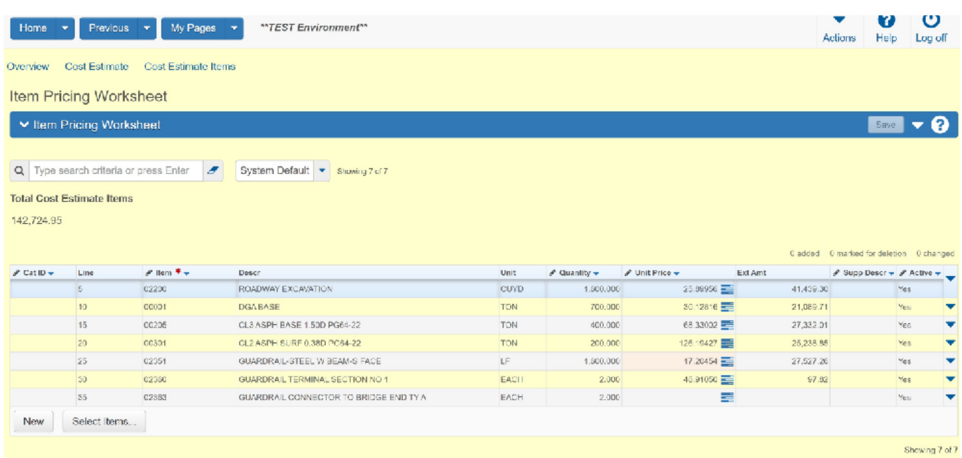
CALCULATE BID BASE PRICES

After adding quantities go to the Action button and select Calculate Bid Base Prices.





➢ **Click Ctrl R to refresh prices.**



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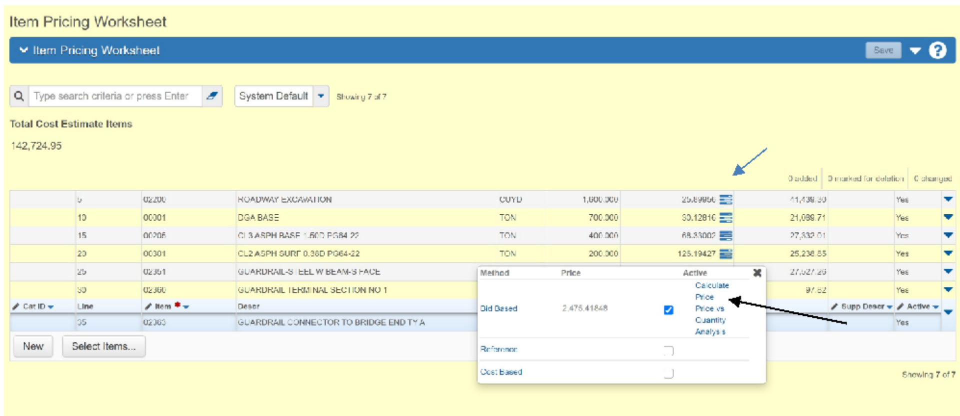
PRICE NOT RETURNED FROM CALCULATE BID BASE PRICE

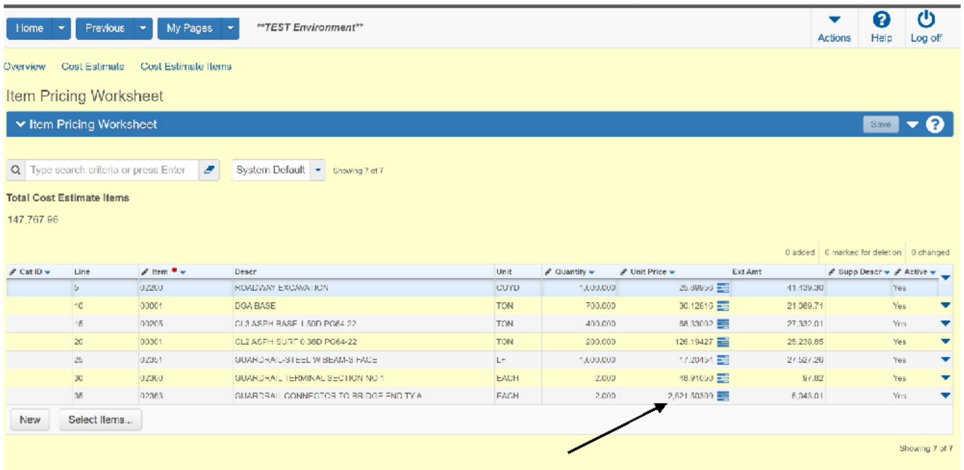
If aprice was not returned from Calculate Bid Base Price, it means there was not enough history for that item to do a regression price.

- Select pull down menu beside the price to access **Price Quantity** graph.



- From there, change the **Bid History Profile** to a longer time period.

The screenshot below shows the updated price applied.

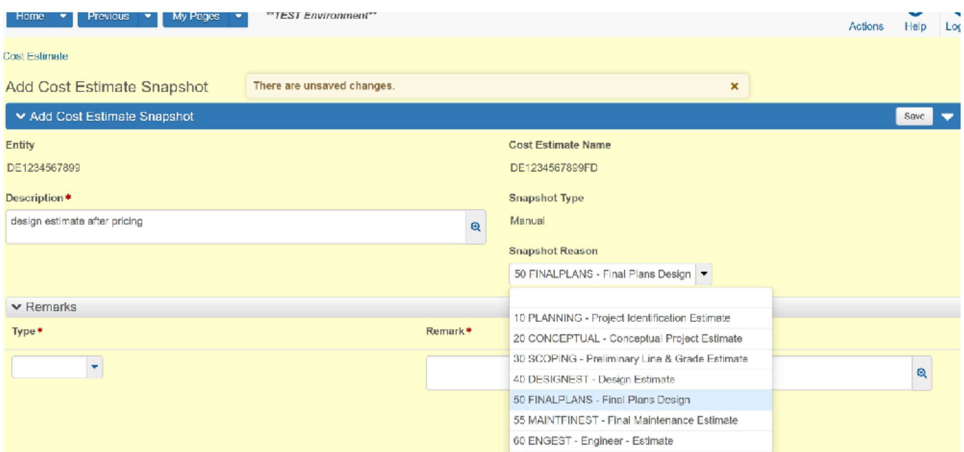


SNAPSHOT

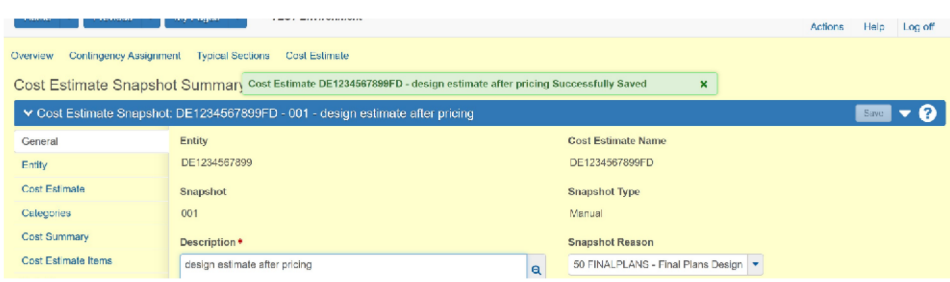
A snapshot (copy) of an estimate can be taken any time. Automatic snapshots are taken when transitioning from **Detail Items to Project Items.**

➢ Open **Component Creation Menu** and Select **Create Snapshot**.

➢ Add **Description** and use drop down menu for **Snapshot Reason**.



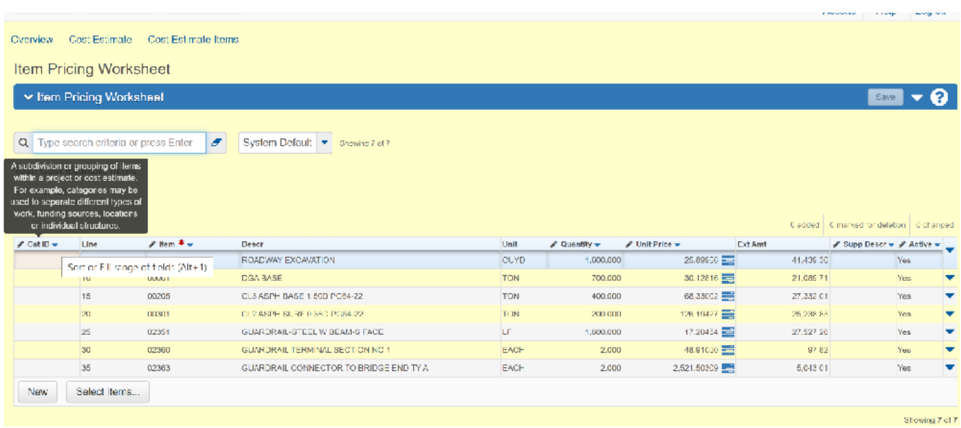
➢ Return to Cost Estimate for further processing.



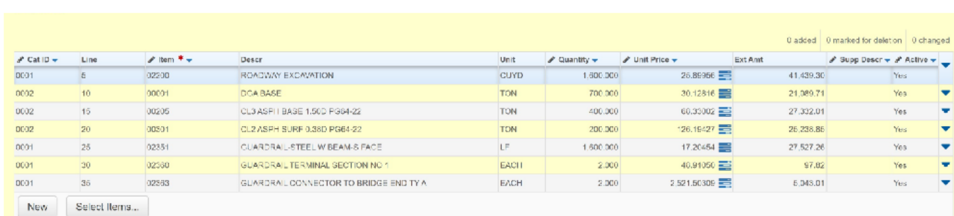
ASSIGN CATEGORIES IN ITEM PRICING WORKSHEET

- Assign categories to Items to utilize the **Build Project Items** process.

- Use **Sort & Range Fill** to copy multiple items to one category.



Below is a screenshot that shows items with Quantities, Prices and Categories added.

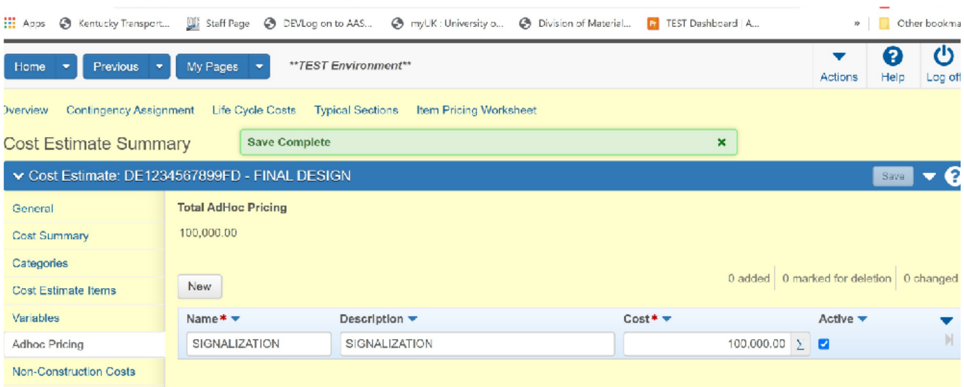


ADHOC PRICES & NON-CONSTRUCTION PRICES

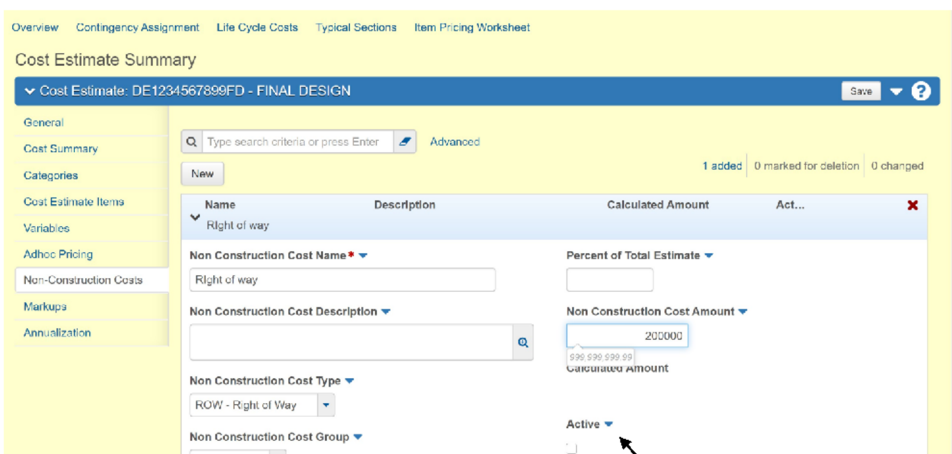
- Return to Cost Estimate Summary

Cost Estimate Prices for Items or Categories not yet completed can be accounted for as adhoc items. Additionally, Non-Construction prices can be added in that category.

- Select **New** to add a new adhoc item.



- Select **New** to add a new non-construction item.
- Populate either **Percent of Total Estimate** or **Non Construction Amount**. Both cannot be used at the same time.



- Select **Active** to reflect the items in Cost Summary.

Some examples of Non-Construction cost would be right of way or utilities to be moved before construction contract.

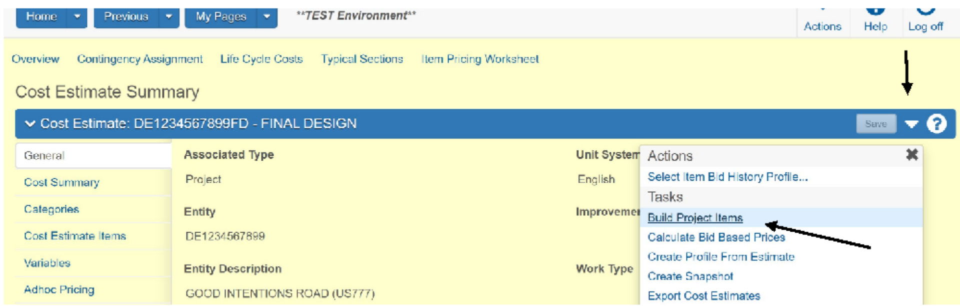
COST ESTIMATE SUMMARY BEFORE BUILD ITEMS

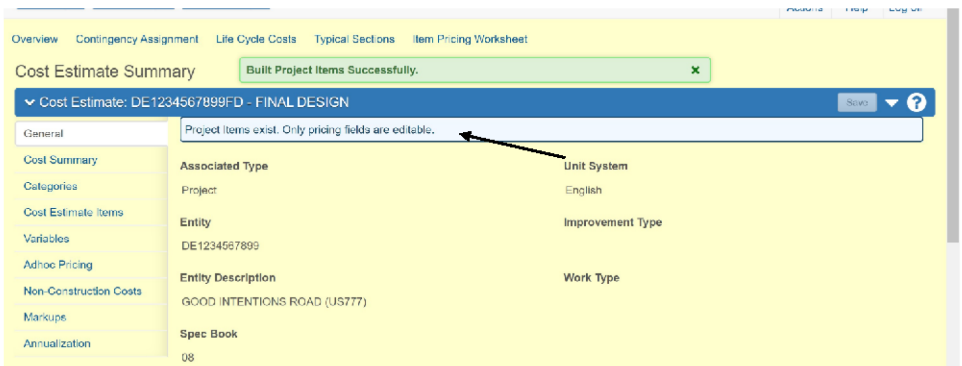
"Cost Estimate Total" includes active prices for this estimate. (Cost Estimate Items, Total Adhoc Pricing and Total Contingency)

NOTE: Non-Construction Costs were not "active" and not therefore included in the total. AdHoc Pricing items were marked as "active".

Go back to Cost Estimate Summary General tab to open Action Menu to

BUILD PROJECT ITEMS



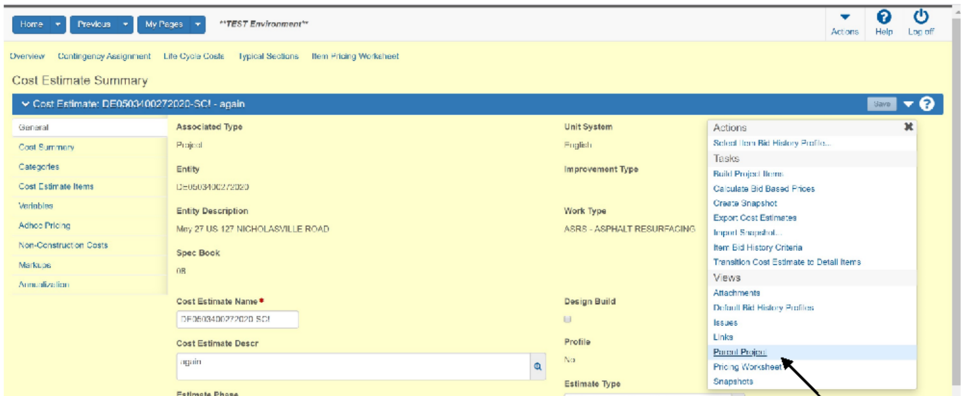


After "Build Project Items" process run only pricing can be done in Estimation. Project controls any updates to Categories or Items or Item Quantities.

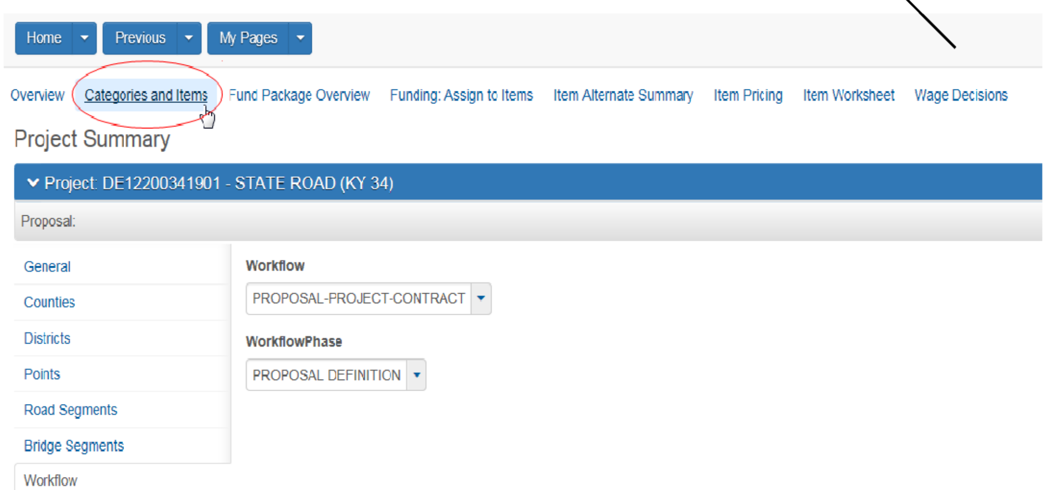
Message displayed "Project Items exist. Only pricing fields are editable"

CATEGORIES AND ITEMS at PROJECT LEVEL.

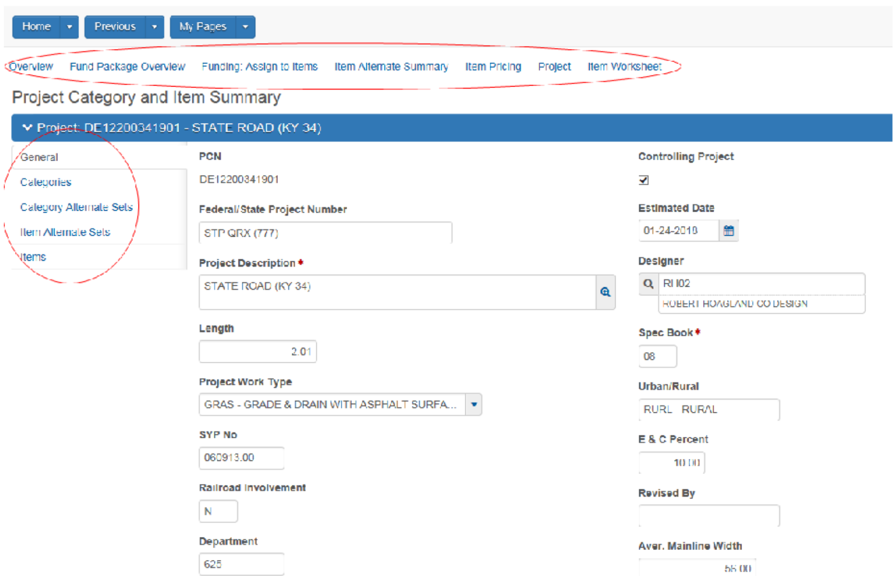
Return to Parent Project from Action Menu or Previous "Dropdown"



➢ Click "**Categories and Items**" in the **Quick Links** at the top left of the page.

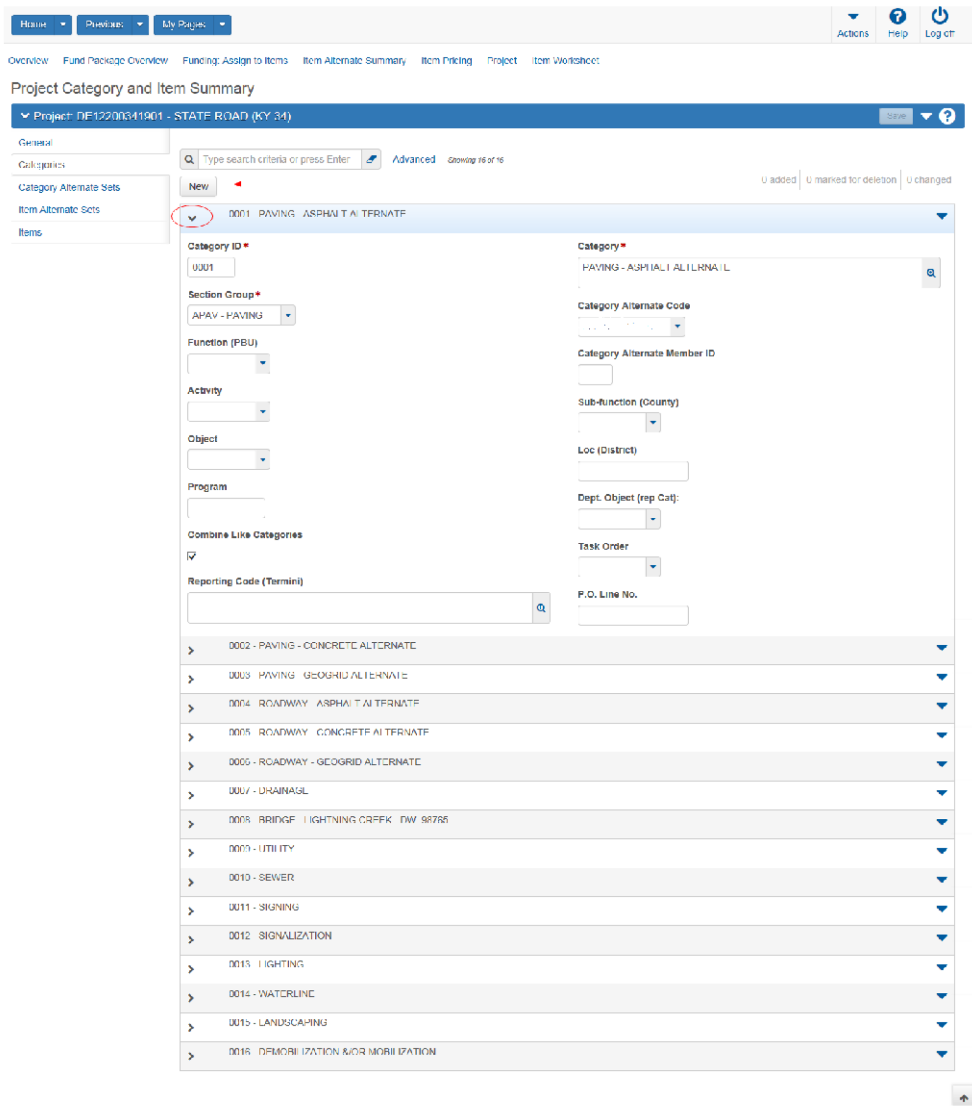


The **General** tab and screen returns with a different set of **Quick Links** at the top of the screen and new tabs down the left side of the screen



CATEGORIES TAB

➤ Click the "**Categories**" tab.



➤ Click the "**New**" button to add a new category or use the drop-down arrow to open up an existing category.

CATEGORY FIELDS

- Complete the fields as follows in the table.

FIELD	INSTRUCTIONS / EXAMPLES
Category ID	Four-digit entry, i.e., **0001**, **0002**. Ensure that the categories are in numerical order with no gaps in the sequence of numbers.
Section Group	Four-character code corresponding to the category. Auto-populated by the **Fix Estimator XML** program when importing **.xml** files. Otherwise select from the drop-down menu to match the **Category** field.
*Function (PBU)	Select from the drop-down menu based on the funding (i.e., **FD52** or **FD04**).
*Activity	Select **4580 Construction Contracts** from the drop-down menu.
*Object	Select **E797-Highway Construction** from the drop-down menu.
Program	Leave blank; used by Const Procrement.
Combine Like Categories	Defaults with the box checked. For Bridge Categories, uncheck box.
Reporting Code (Termini)	Leave blank; used by Maintenance.
Category	Auto-populated when importing the estimate file. Otherwise type in the appropriate name for the category which should correspond with the **Section Group**.
Category Alternate Code	Leave blank unless there are alternate bid categories such as Concrete and Asphalt Surfacing. Enter **AA1** for the first Alternate Code Category and **AA2** for the second alternate code category and so on as needed.
Category Alternate Member ID	Leave blank. If Category Alternate Sets are used this field will auto-populate.
*Sub-function (County)	Select the county number from the drop-down menu.
*Loc (District)	Select the district number from the drop-down menu.
Dept. Object (rep. Cat)	Leave blank; used for Mowing & Striping contracts.
Task Order	Leave blank.
P.O. Line No.	Leave blank.

- Click the "**Save**" button.

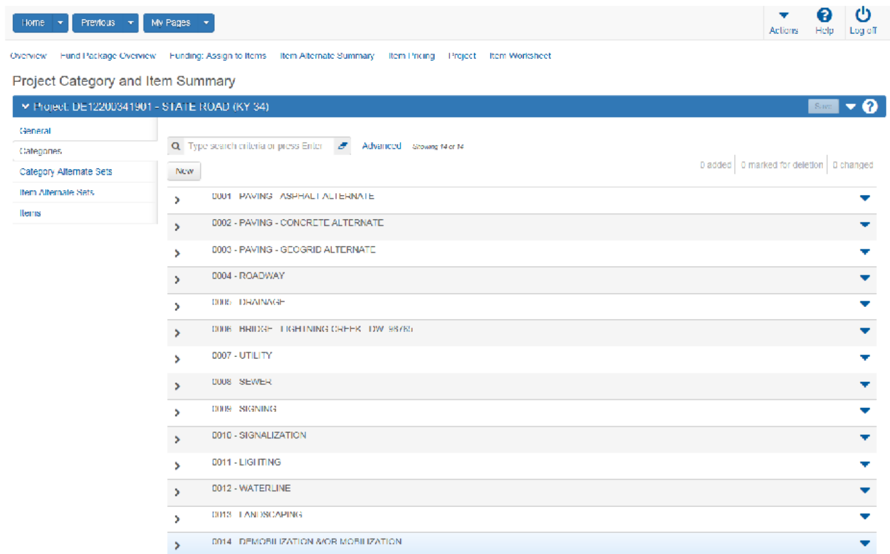
- Repeat for each category in the project.

CATEGORY AND ITEM ALTERNATES

Project proposals may occasionally include bidder options for accomplishing the work. There may be entire category options, such as the choice between Asphalt and Concrete Paving, in which each category includes an entire group of bid items. Or there may be individual bid item options such as between types of fencing. The Category Alternate Sets and Item Alternate Sets tabs allow for these alternates. Although it comes first in the column of tabs on the left of the screen, the Item Alternate Sets tab will be discussed after the section below on the Items tab.

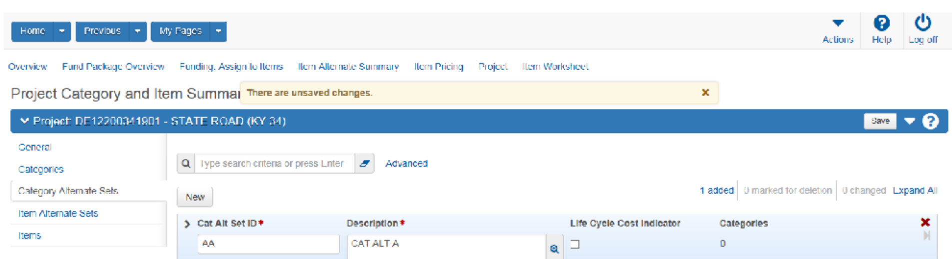
Before beginning this process, the categories for each of the alternates must be created if they were not included in the imported Estimator file. Creating the alternates on the Estimate will save some time and eliminate the following extra steps.

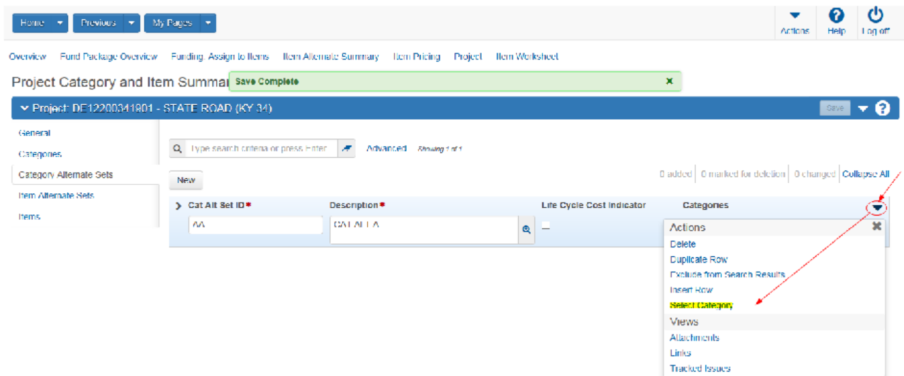
- In the "**Categories**" tab, change the four-digit Category ID number to make room for the Category Alternate Sets to be added so that the Categories are in numerical sequence. You will have to begin by renumbering the Category ID number starting with the last one and working backward, saving after each Category ID number change.
- Click the "**New**" button and create the new Categories for the Alternate Set.
- Click the "**Save**" button.
- Repeat for each Category Alternate Set.
- If one of the previously existing categories is to be an alternate, be sure the change the **Description** field to reflect the alternate status as shown below.



CATEGORY ALTERNATE SETS TAB

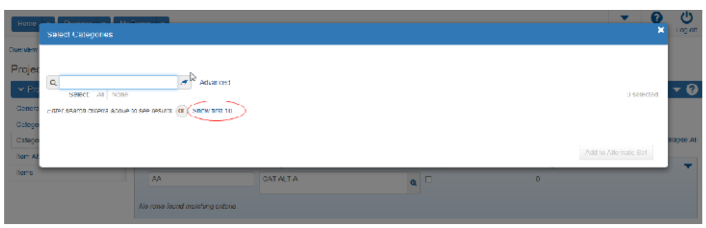
- Click the "**Category Alternate Sets"** tab.
- In the **Cat Alt Set ID** field enter **AA**.
- In the **Description** Field enter **CAT ALT A**.
- Ignore the **Life Cycle Cost Indicator** check box.
- Click the **"Save"** button.



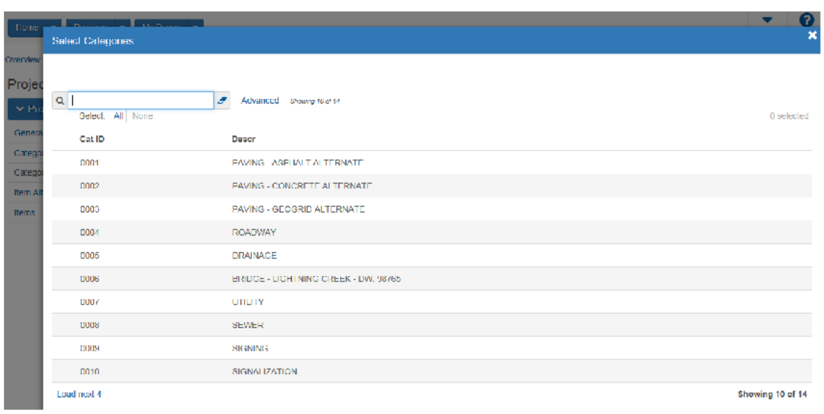


➤ Click the "**Actions**" Button to the right of **Categories** and a selection menu appears.

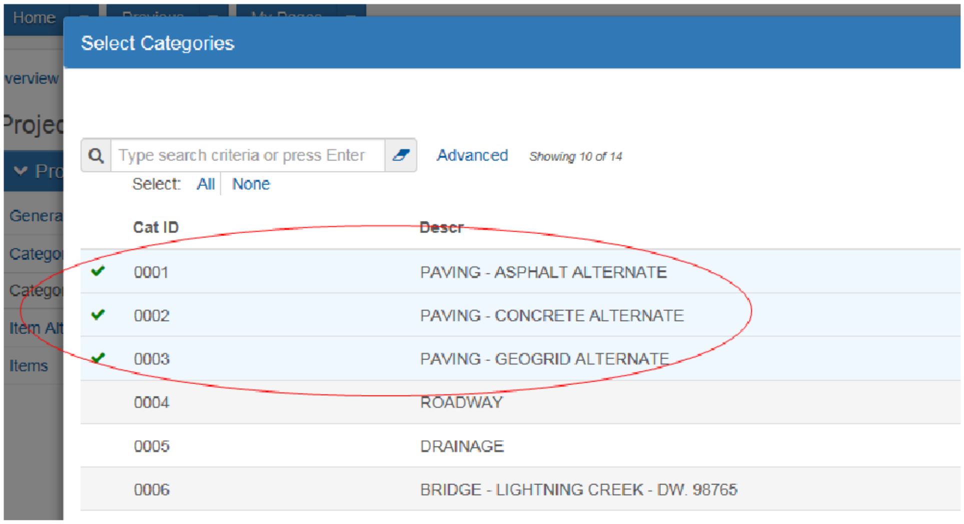
➤ Click "**Select Category**" and the following screen appears.



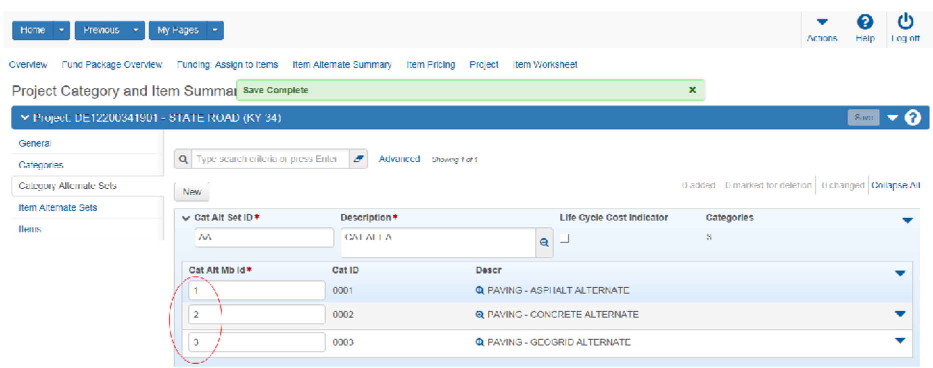
➤ Click on "**Show first 10**" and a pop-up menu appears.



➤ Click on the appropriate alternate category row(s).



➤ Click the "**Add to Alternate Set** button and the following screen now appears.
"

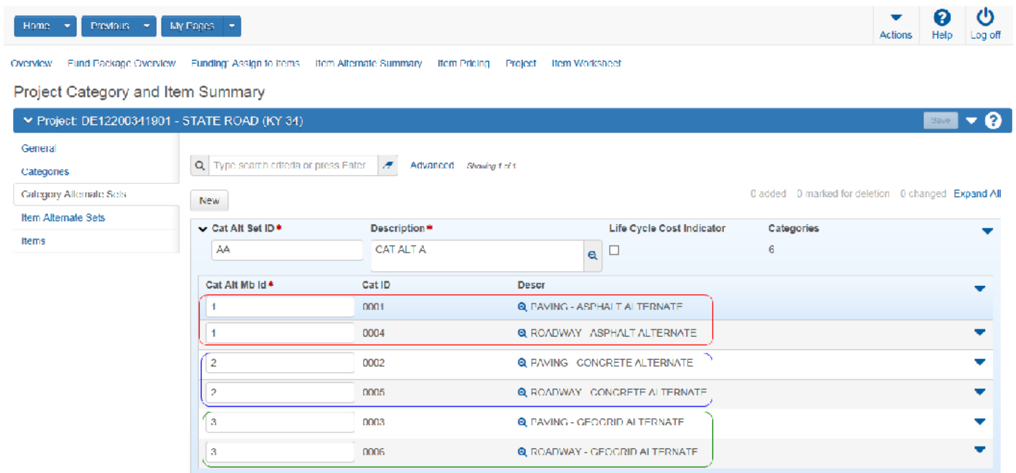


➤ In the **Cat Alt Mb ID** field enter **1** for the first alternate. Each subsequent alternate will be in numerical order; i.e., **2** for the second alternate and **3** for the third alternate and so on as needed.

➤ Click the "**Save**" Button. Category Alternates have now been successfully added.

ASSOCIATE TWO DIFFERENT CATEGORY ALTERNATES

Occasionally a project will have multiple categories that need to be associated together into one alternate, such as Paving and Roadway Asphalt Alternate and Paving and Roadway Concrete Alternate. In this instance, the Roadway items changed due to the particular Paving items and the categories need to be bid together. For this circumstance, the **Cat Alt Mb ID** field will have the same number for the categories to be bid together as in the example below.

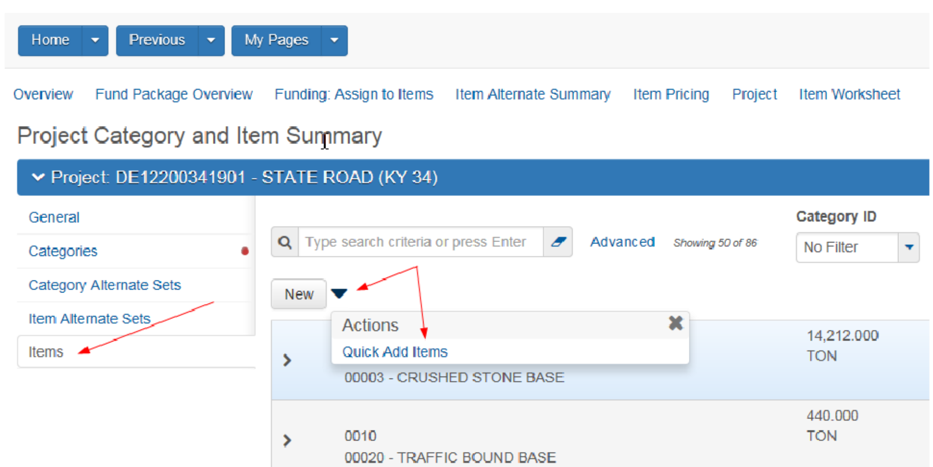


ITEMS TAB

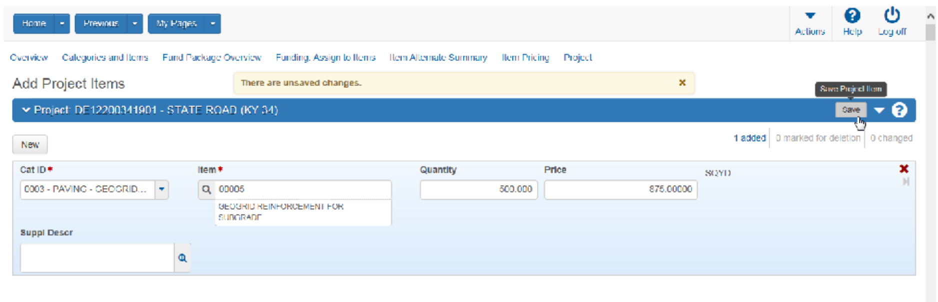
➢ Click the **"Items Tab"** at the left of the screen.

a. Add Project Items

- Select "**Items**" Tab Component **Actions** button.
- Select "**Quick Add Items**" on the pop-up menu.



- Enter the required data in the fields.



- Select the appropriate **Category ID** from the drop-down menu for the bid item.

- In the **Item** field enter the bid item code, which has a minimum of five digits. Use "0's" at the beginning of item codes with less than five numbers, i.e., 00001 DGA BASE.

- Enter **Quantity** from the estimate/plans.
- Enter bid item **Price** rounded to hundreds place. Use the previous year's Average Unit Bid Price if no price has been supplied in the estimate.
  Enter a **Supplemental Description** only if needed. A complete list of bid items which require supplemental descriptions can be found in **Addendum 2**. A few specifics:

  - 02545 Clearing and Grubbing requires a Supplemental Description specifying the acreage. This bid item is used on almost every project.

  - 08160 Structural Steel requires a Supplemental Description specifying the approximate weight.

  - Except for 02569 Demobilization and 02568 Mobilization, ***all Lump Sum Items on group jobs require the appropriate county name in the Supplemental Descriptions*** to make them unique and keep the bid item quantities from rolling together.

- Click the "**Save**" button.

- Click the "**New**" button and repeat the process above for each additional bid item to be added.

NOTE: The last **Category ID** used will default to the next bid item to be entered IF YOU DO NOT SAVE BETWEEN CREATING EACH BID ITEM so be sure you enter the correct **Category ID** for each item you are adding.

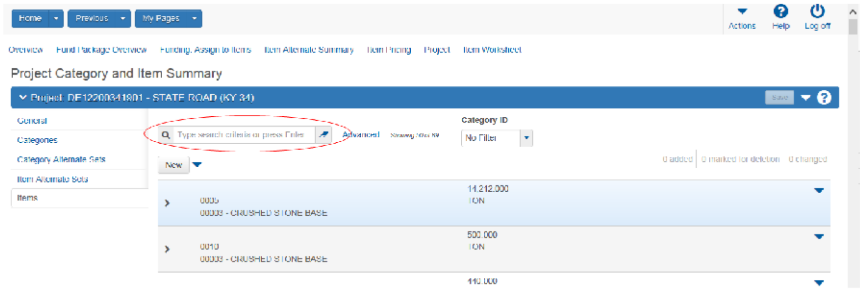
b. Specific Bid Item Notes

Be sure to check for the following specific bid items and issues:

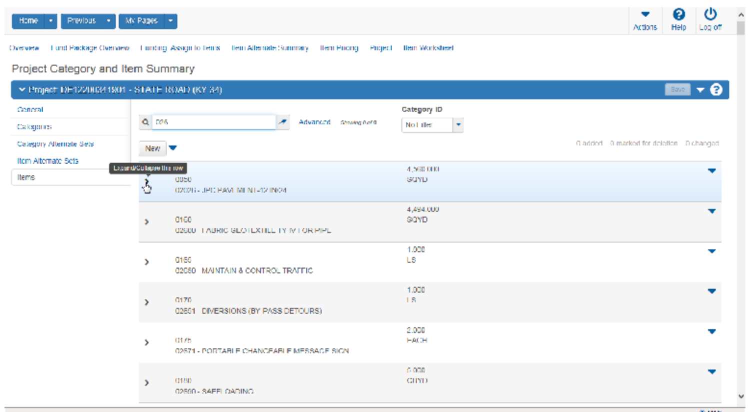
- 02545 Clearing and Grubbing required on all projects with over 1 acre of disturbed area.
- 02562 Temporary Signs should be on most projects. Expection would be if included as incidental to Maintainence of Traffic Bid Item
- 02600 Geotextile Fabric for Pipe has a fixed price of exactly $2.00.
- 02650 Maintain and Control Traffic should be on EVERY project.
- 02651 Diversions (By-Pass Detours) is a lump sum item. Verify with Plan Processing personnel that there is an individual bid item for each Diversion on the project. If there are multiple Diversions, they need to be broken out in the plans and in the proposal bid items, one bid item for each diversion/bypass.
- 02568 Mobilization is only used on projects with a total cost of over $2M.
- 02569 Demobilization should be on EVERY project.
- 02726 Staking should be on EVERY project.
- 06405 and 06408 Panel Signs **do not** require Barcode Sign Inventory.
- 06406 and 06407 Sheet Signs require corresponding bid item 24631EC Barcode Sign Inventory.
- 10020NS Fuel Adjustment and 10030NS Asphalt Adjustment should **never** be used on contracts with Paving Alternates.

c. Modify an Existing Bid Item

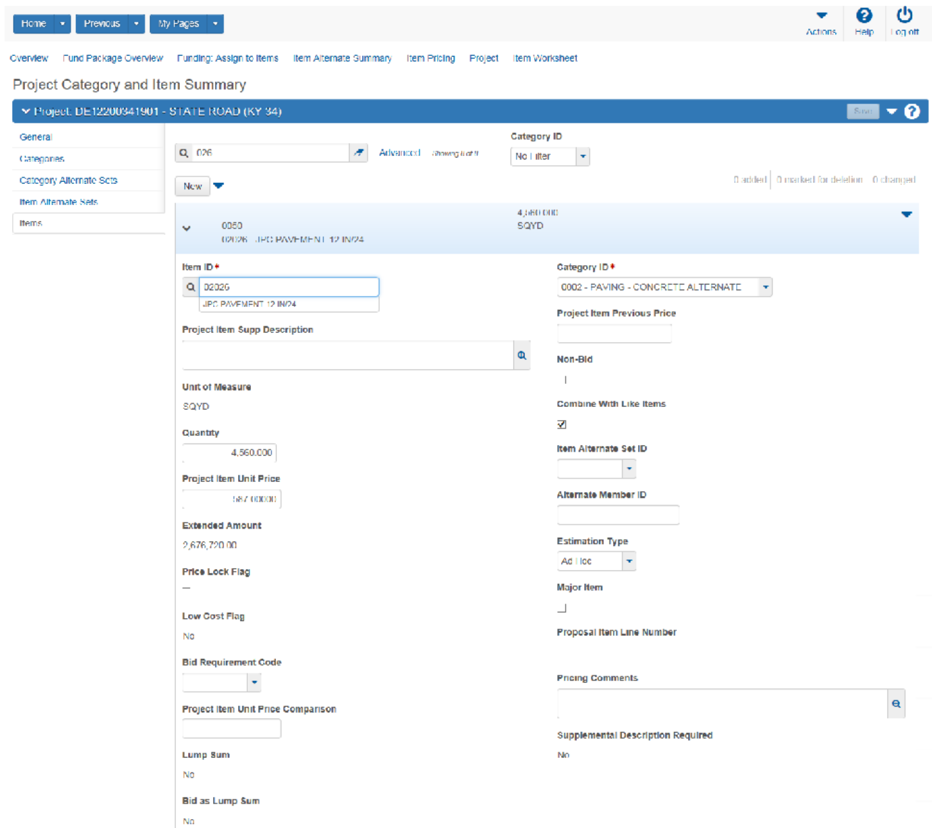
If you are not on the **Items** tab screen, click on "**Categories and Items**" in the **Quick Links** at the top of the page. Then click the **Items** tab at the left of the screen. You can search for the item you need to edit by entering the bid item code or the name in the search box near the top left of the screen.



To expand the collapsed row click on the arrow beside the item.



When the row is expanded a detailed view of the individual bid item information is displayed.



From this screen, the **Quantity**, **Unit Price** and **Project Item Supplemental Description** can be entered or edited. No other changes should be made to the other fields except for using the **Price Lock Flag** and **Bid Requirement Code** for certain bid items as described below. **NOTE Pricing in COST ESTIMATION**

NOTE: ON EVERY CONTRACT be sure to put a check mark on the box for **Price Lock Flag** and select **FIXED** from the drop-down menu under **Bid Requirement Code** for the following items:

02600 Fabric Geotextile TY IV for Pipe

10020NS Fuel Adjustment

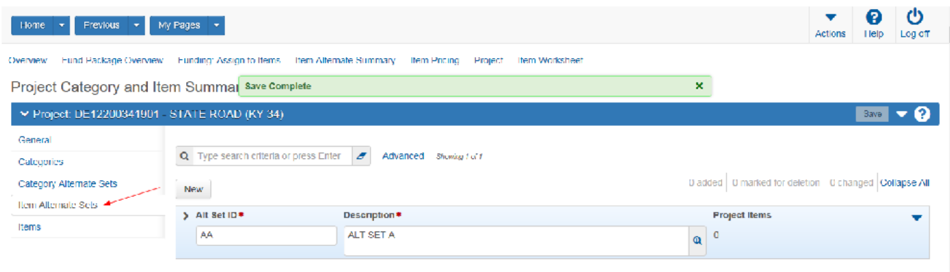
10030NS Asphalt Adjustment

10203ND Pavement Adjustment when used in **Category Alternate Sets**.

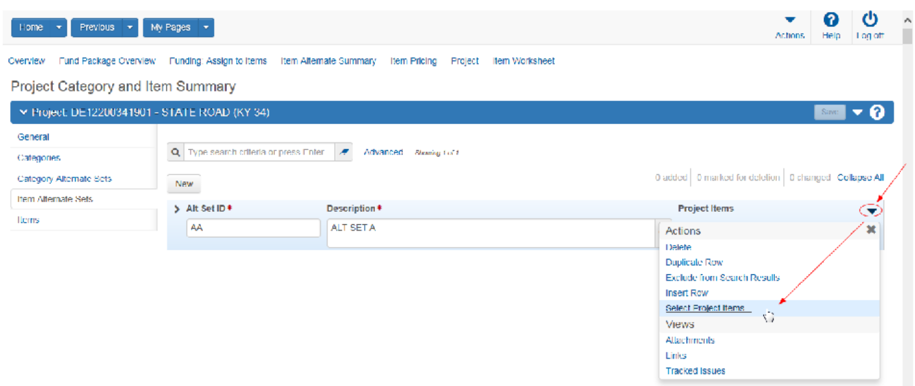
ITEM ALTERNATE SETS TAB

Project proposals may occasionally include bidder options for accomplishing the work. There may be entire category options or individual bid item options. The Category Alternate Sets and Item Alternate Sets tabs allow for these alternates. As with the **Category Alternate Sets**, the bid items to be selected for alternates have to have been previously entered into the **Items** in order for them to appear on the list of items to be selected. See the section on the Items tab for instructions on adding bid items.

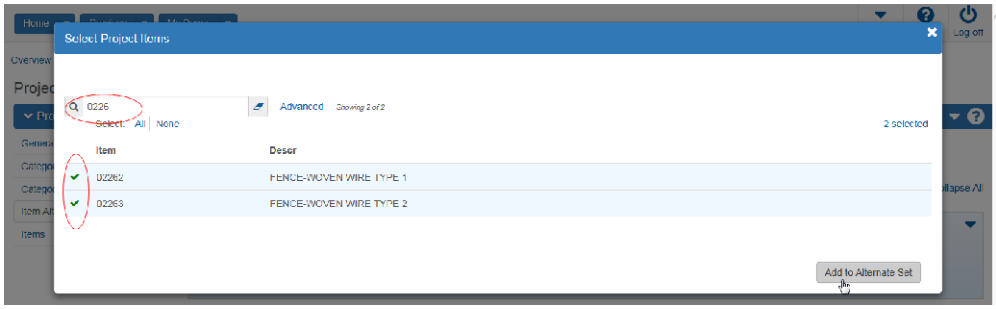
- Click the "**Item Alternate Sets**" tab.
- In the **Alt Set ID** field enter **AA**.
- In the **Description** field enter **ALT SET A**.
- Click the "**Save**" button.



- Click on the row "**Actions**" button on the right and a pop-up menu appears.
- Click on "**Select Project Items**".

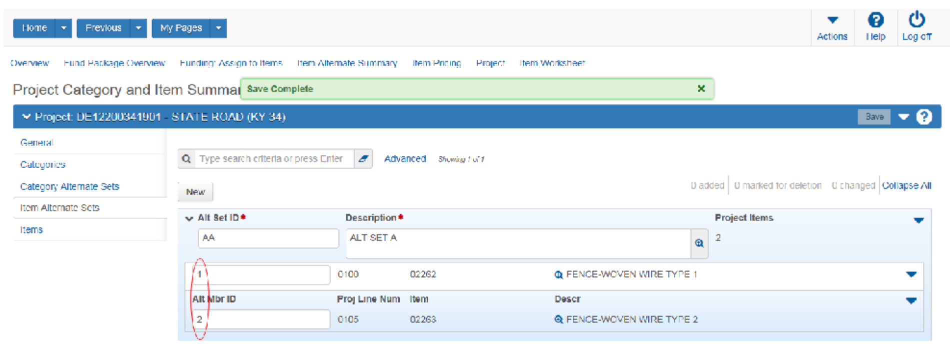


- Enter the bid item code in the search field or part of it or use the **Show first 10** feature to locate the bid items to be included in the alternates



- Click on the rows of all of the bid item alternates needed.

- Click the "**Add to Alternate Set**" button.

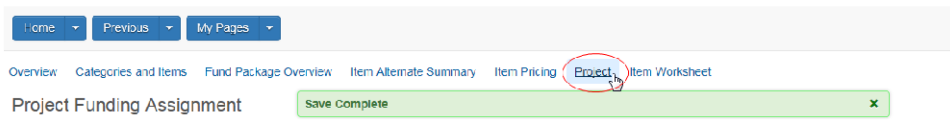


- In the **Alt Member ID** field enter **1** for the first alternate. Each subsequent alternate will be in numerical order, i.e., **2** for the second alternate and **3** for the third alternate.

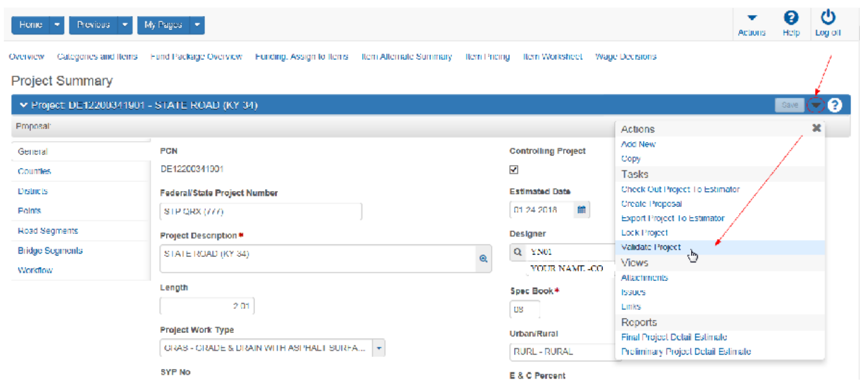
- Click the "**Save**" button.

VALIDATE PROJECT

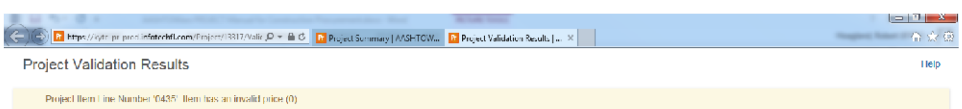
- Click on "**Project**" in the **Quick Links** on the same screen.



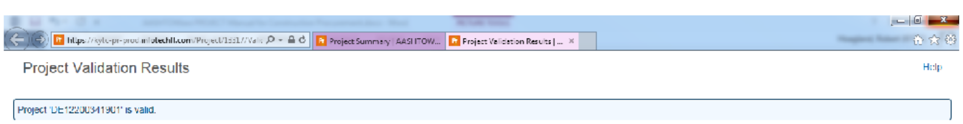
The **General** tab view now appears.



- Click on the Row "**Actions**" button on project specific tool bar at the right of the screen.
- Click "**Validate Project**".
- A report is generated as a pop-up screen which lists issues that need to be addressed.



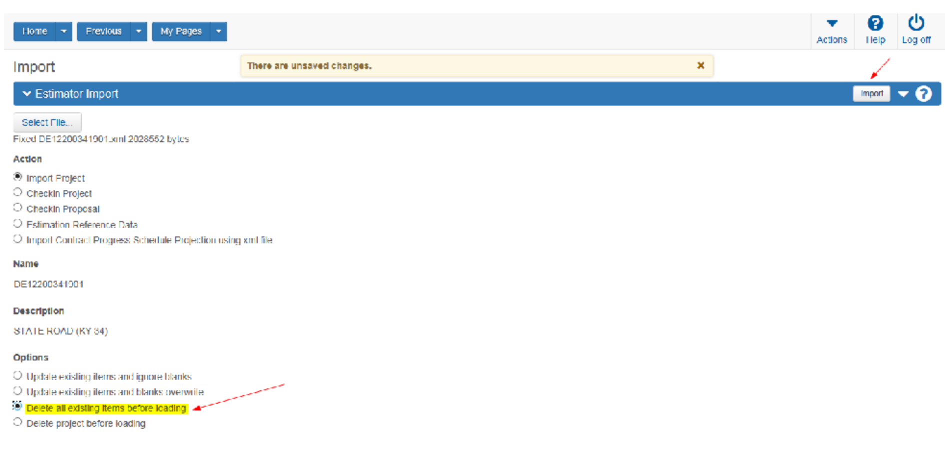
- Correct any errors found.
- Re-run the report to verify that there are no remaining issues.



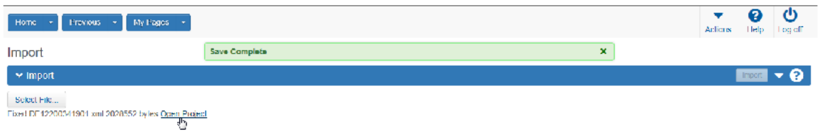
UPDATE BID ITEMS FROM ESTIMATOR AFTER PROJECT CREATION

Sometimes an additional category or two needs to be added to a project, such as bridge, traffic loops or waterline items, after the rest of the project has been built in AASHTOWare. However, it is not possible to accurately import only one or two groups into the existing project with the current version of AASHTOWare. But all of the existing groups and bid items can be re-imported along with the new ones. The re-import process works the same as the original import process except for the one setting change. You will need to modify the original Estimator file to include the new group(s) and bid items according to the **Estimator Manual for Construction Procurement Branch**. After exporting the XML file, be sure to run the **.xml** file through the **Fixed Estimator XML** application before importing it into AASHTOWare. The Fixed Estimator XML application available from Division of Design and "fixes" Category names to Standard list.

- Navigate to the **Home** page and import group Estimator file:
- On the Home page chose "**Import File**" from the Global "**Actions**" button on the menu bar at the top of the screen.
- Click the "**Select File**" button on the top left of the next screen.
- A local computer interface opens allowing you to locate the **Fixed Estimator XML** version of the estimate that you have edited and saved. Highlight the file name and click the **Open** button.
- Select the **Options** radio button for **Delete all existing items before loading**. This is the setting change which will allow you to retain all of the existing project information while re-importing all of the bid items, both old and new.



- Click the **"Import"** button on the **Estimator Import** row.
- Click "**View Project"** and proceed to work from there.



After the new category and items have been added you will edit the category according CATEGORY FIELDS on Page 42 of this manual. Add funding to the new items and validate the project again.

- Click the "**Category"** tab.
- Click on the drop-down arrow for the new category.
- Enter data in the following fields for the new categories as you did for the original categories when the project was imported the first time:

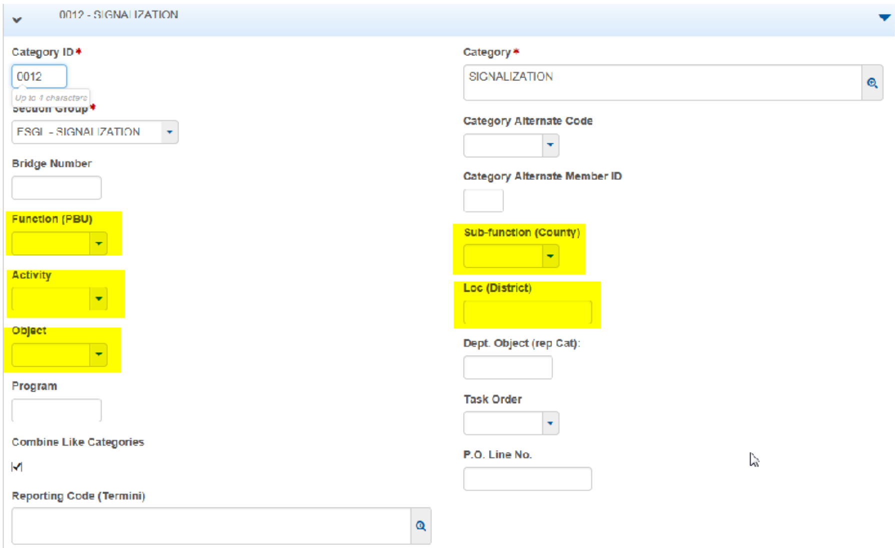
Function (PBU)

Activity

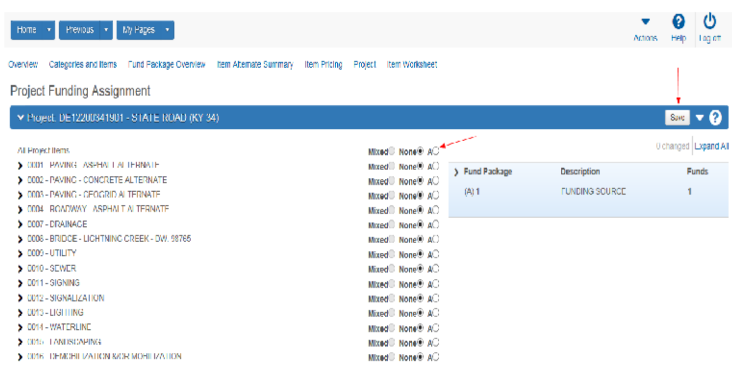
Object

Sub-function (County)

Loc (District)

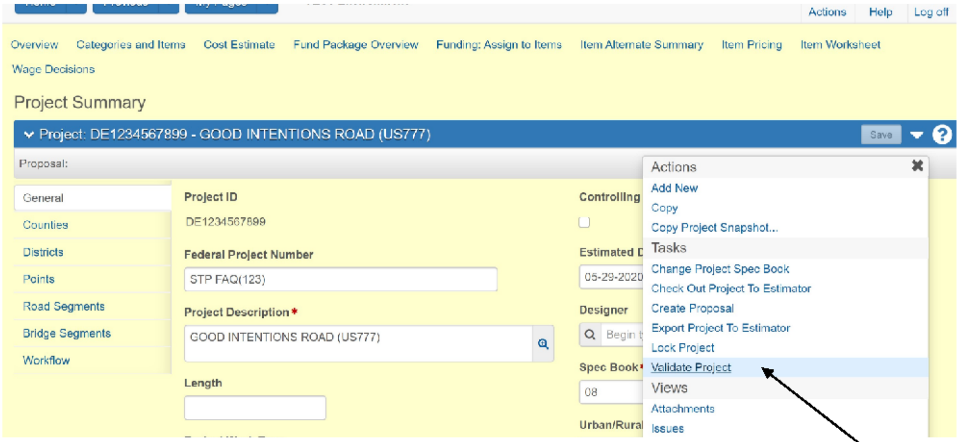


- Add funding to the bid items as above:
  - Click on "**Funding: Assign to Items**" in the **Quick Links**.
  - Click the radio button under the **A** in the **All Project Items** row.
  - Click the **Save** button.

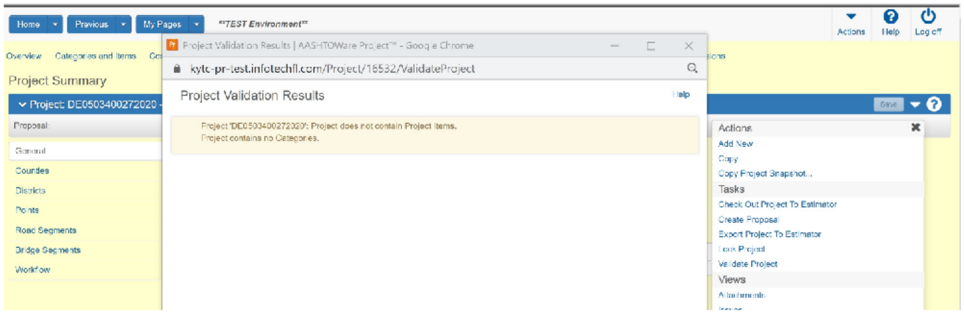


VALIDATE A PROJECT **Checks for some errors**

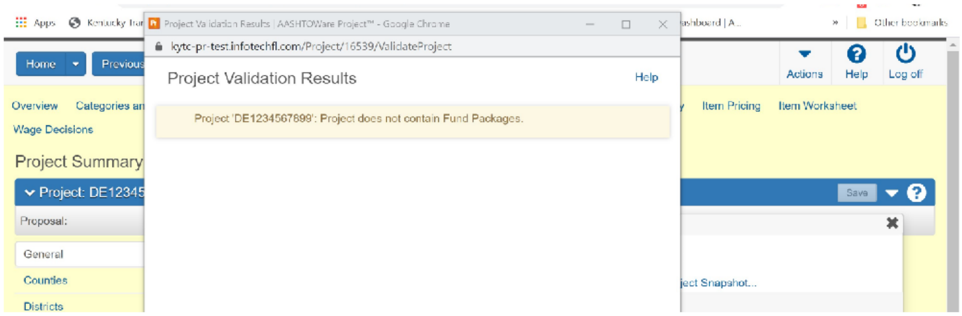
- **Re-validate project**



- Verify your data entry and funding assignment by running the **Validate Project** function.



- Correct any issues and re-run the report.
- Note: Funding Packages added in Construction Procrement so this validates okay to date.



AASHTOWare Project Preconstruction & Estimation *Revised January 4, 2021*

ADDENDUM 1: TABLE OF AVAILABLE PROJECT WORK TYPES

Please note that the work types in the drop-down menu within AASHTOWare Project are not in alphabetical order by code or description. They are presented here in alphabetical order by the description to clearly present the choices available within similar types.

AIRPORT CONSTRUCTION	AIR
ASPHALT INITIAL TREATMENT	ASIT
ASPHALT PAVEMENT & ROADWAY REHAB	ARHR
ASPHALT PAVEMENT PATCHING	ASPP
ASPHALT REHAB INTERSTATE/PARKWAY	ASRH
ASPHALT REHAB WITH BRIDGE (S)	ARHB
ASPHALT REHAB WITH DIAMOND GRINDING	ARHD
ASPHALT REHAB WITH GRADE & DRAIN	ARHG
ASPHALT RESURFACING	ASRS
ASPHALT SHOULDERS	ASSH
ASPHALT SURFACE & JPC INLAY	ASJP
ASPHALT SURFACE WITH BRIDGE	ASBR
ASPHALT SURFACE WITH GRADE & DRAIN	ASGD
ASPHALT SURFACE WITH GUARDRAIL	ASGR
ASPHALT SURFACING NEW CONSTRUCTION	ASNW
ASPHALT SURFACING ULTRA THIN	ASUS
ASPHALT WATERPROOFING	ASWP
BRIDGE	BRID
BRIDGE BEARING REPAIR	BRBR
BRIDGE CLEANING	BRCL
BRIDGE CLEARANCE GUAGE PAINTING	BCGP
BRIDGE DECK OVERLAY	BROL
BRIDGE DECK RESTORATION & WATERPROOFING	BRRW
BRIDGE DEMOLITION	BRDM
BRIDGE PAINTING & CLEANING	BRPT
BRIDGE REPAIR MISCELLANEOUS WORK	BRMW
BRIDGE REPAIRS	BRRP
BRIDGE REPAIRS EXPANSION JOINTS	BRJT
BRIDGE REPLACEMENT	BRRL
BRIDGE SCOUR MITIGATION	BRSC
BRIDGE STEEL REPAIRS	BRSR
BRIDGE SUBSTRUCTURE REHAB	BRSB
BRIDGE SUPERSTRUCTURE REHAB	BRSU
BRIDGE TEMPORARY REPLACEMENT	BRRT

BRIDGE WITH GRADE & DRAIN	BRGR
BRIDGE WITH GRADE, DRAIN & SURFACE	BRGS
CONSTRUCTION IN A WEIGH STATION	CONW
CONSTRUCTION OF BUILDINGS IN REST AREAS	CONB
COVERED BRIDGE RESTORATION	BRCV
CRASH CUSHIONS	OPCC
CULVERT REPLACEMENT	OPCU
DITCHING	DTCH
DRAIN CLEANING	OPDC
DURABLE PAVEMENT STRIPING TAPE	TRDT
EMBANKMENT DAM MOWING	OPMD
EXPERIMENTAL	EXPR
FENCE	FENC
FERTILZIATION	OPFT
FINE TURF MOWING	OPMF
FLOOD REPAIR FOR FEMA	OPFL
GEOTECHNICAL	GEOT
GRADE & DRAIN	GRDR
GRADE & DRAIN AND PAVEMENT ALTERNATES	GRPA
GRADE & DRAIN LESS THAN MILLION CY	GRLT
GRADE & DRAIN WITH ASPHALT SURFACE	GRAS
GRADE & DRAIN WITH BRIDGE	GRBR
GRADE & DRAIN WITH INCIDENTAL SURF	GRIS
GRADE & DRAIN WITH PCC PAVEMENT	GRPC
GRADE HEAVY (OVER MILLION CY)	GRHV
GRADE, DRAIN & SURFACE WITH BRIDGE	GDSB
GUARDRAIL	GUAR
HERBICIDE APPLICATION	OPHS
HIGH FRICTION SURFACE	HFRS
HIGHWAY SWEEPING	OPSW
INC GRADE & DRAIN W/ PAVEMENT ALTERNATES	GDPA
INTELLIGENT TRANSPORTATION SYSTEMS	ITS
INTERSECTION MARKINGS- INSTALL-RETRACE	TRIN
JPC PAVEMENT	JPC
JPC PAVEMENT INLAY	JPCI
JPC PAVEMENT REPAIRS	JPCR
JPC PAVEMENT REPAIRS - DIAMOND GRINDING	JPCD
JPC PAVEMENT REPAIRS-GUARDRAIL INSTALL	JPGL
JPC PAVEMENT WITH GRADE & DRAIN	JPGR
LANDSCAPING	LAND
LIGHTING	LIGH

LITTER REMOVAL	OPLR
MAINTENANCE	OPER
MEDIAN	MEDN
MEDIAN REMOVAL	MEDR
MICROSURFACING	MICR
MILLLED RUMBLE STRIPS	TRMR
MOWING BEHIND GUARDRAIL	OPMG
PAINTED PAVEMENT STRIPING	TRPT
PARKING LOT SEALING	SEAL
PAVEMENT (WITH ALTERNATIVES)	PALT
PAVEMENT MARKERS & REFLECTORS	PAVM
PAVEMENT REHAB WITH PAVING ALTERNATES	PRPA
PIPE REPLACEMENT	OPPI
REST AREA DEMOLITION	RADM
RETAINING WALL	BRWA
RIGHT OF WAY MOWING	OPMW
RIGHT OF WAY MOWING - LITTER REMOVAL	OPML
ROAD WEATHER INFORMATION SYSTEM	RWIS
ROCKFALL MITIGATION	ROCK
RUMBLE STRIPS & PAVEMENT STRIPING	TRPM
SIDEWALK CONSTRUCTION	SWCN
SIGN REFURBISH	SIRF
SIGNS	SIGN
SIGNS-LIGHTING-SIGNALS	SLS
SLIDE REPAIR	OPSR
SLOPE STABILIZATION	SLST
SOUND BARRIER WALL	OPSB
THERMOPLASTIC PAVEMENT INTERSECTION MAR	TRTM
THERMOPLASTIC PAVEMENT STRIPING	TRTS
TRAFFIC COUNTING INDUCTANCE LOOPS	TRCL
TRAFFIC SIGNAL LOOP DETECTORS	TRLO
TRAFFIC SIGNAL SYSTEMS	TRSG
TRIM & REMOVAL OF TREE & BRUSH	OPTR
UNKNOWN	UNKN
UTILITY ADJUSTMENT	UADJ
WATERBOURNE PAINT STRIPING	TRWB
WETLAND MITIGATION	WET
WIDENING	WIDN

ADDENDUM 2: TABLE OF BID ITEMS REQUIRING A SUPPLEMENTAL DESCRIPTION

BID ITEM CODE	DESCRIPTION	UNIT
02545	CLEARING AND GRUBBING	LS
02742	TRAINEE PAYMENT REIMBURSEMENT	HOUR
03000	PRECAST CONC BOX SECT	LF
08160	STRUCTURAL STEEL	LS
10070NS	NON-SPEC MATERIAL	DOLL
10299N	REIMBURSEMENT	DOLL
21354ND	CUT CAP AND BLOCK FORCE MAIN	EACH
21526ND	ANCHOR TEE AND BLOCK	EACH
21661ES706	BORE AND JACK PIPE	LF
21679EN	FIBERGLASS DRAIN PIPE	LF
21787ED	OPEN CUT W/ PVC ENCASEMENT	LF
21788ED	OPEN CUT W/ STEEL ENCASEMENT	LF
22012NN	CUT AND CAP WATERLINE	EACH
22139NN	CONNECT TO SEWER MAIN	EACH
23055N	REMOVE	LS
23279EC	RETROFIT	EACH
23280EC	RETROFIT	LS
23281EC	RETROFIT	SQFT
23282EC	RETROFIT	LF
23283EC	RETROFIT	SQYD
23286EC	RETROFIT	CUFT
23294EC	TIE	LS
23310EC	VALVE BOX	EACH
23532EC	INSTALL MANHOLE	EACH
23696EC	BARRIER WALL	LF
24020EC	PVC TEE	EACH
24295EC	CONNECTOR	LS
24451EC	CONCRETE	CUYD
24456EC	EXPAN JOINT REPLACE 5 ½ IN	LF
24478EC	TEMP BLOW OFF	EACH
24481ED	PVC CASING PIPE	LF
24485ED	CUT AND BLOCK	EACH
24486ED	TEE	EACH
24492EC	CLEAN	LS
24518EC	CAP AND ABANDON	EACH
24521EC	REPAIR	EACH
24522EC	REPAIR	LS
24542EC	REPAIR	LF
24543EC	CLEAN	LF
24544EC	REMOVE	LF
24564EN	PVC PIPE	LF
24575ES610	HEADWALL	EACH

24580EC	CHAIN LINK FENCE	LF
24583EC	HDPE PIPE LINER	LF
24595EN	ELASTICIZED EPS	SQYD
24601EC	INSTALL	EACH
24605ED	RELOCATE	EACH
24617EC	INSTALL	LF
24632EC	WATER MAIN	LF
24633EC	CAP AND PLUG	EACH
24634EC	BEND	EACH
24644EC	SERVICE TAPPING TEE	EACH
24645EC	MDPE PIPELINE	LF
24646EC	STEEL PIPELINE	LF
24647EC	RESILIENT SEAT GATE VALVE	EACH
24648EC	FOSTER ADAPTER	EACH
24662EC	CLEAN	EACH
24668EC	STEEL ENCASEMENT PIPE	LF
24688EC	REMOVE AND REINSTALL	LS
24714EC	SANITARY SEWER PIPE	LF
24731EC	REMOVE AND RESET	EACH
24746EC	STUB OUT	EACH
24751ED	REMOVE STORE & REINSTALL	EACH
24753ED	CAMERA POLE LOWERING DEVICE	EACH
24770EC	METER VAULT AND BYPASS ASSEMBLY	LS
24771EC	SEWER LATERAL REPLACEMENT W/CLEANOUT	EACH
24772EC	SEWER LATERAL REHABILITATION W/CLEANOUT	EACH
24773EC	METER SETTING	EACH
24774EC	MJ OFFSET FITTING	EACH
24775EC	CLEAR BRIDEG	EACH
24776EC	REPOINT STONE MASONRY	SQFT
24777EC	SQUARE HINGED LIGHT POLE REPLACEMENT	EACH
24778EC	BRIDGE DRAMATIC LIGHTING REPLACEMENT	EACH
24786EN	HDPE PIPE	LF
24810ED	SIDEWALK FLUME	EACH
24826EC	TEMPORARY ARCH SUPPORTS	LS
24884ED	PERMANENT STEEL CASING	LF
24884ED	FLAP GATE	EACH
24894ED	REMOVE	EACH
24897ED	EXPAN JOINT REPLACE ¾ IN	LF
248979ED	REGRADE	EACH
24981EC	BRIDGE CLEANING	LS
24982EC	CONCRETE COATING	LS
24989EC	TEMPORARY RAMP	LS
25045ED	ABC CONSTRUCTION COST	LS
30063	ADDITIVE ALTERNATE	LS
30077	ROCK DOWELS	EACH