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Analysis of Cost Estimation Disclosure in Environmental Impact Statements for Surface Transportation Projects

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ANALYSIS OF COST ESTIMATION DISCLOSURE IN ENVIRONMENTAL IMPACT STATEMENTS FOR SURFACE TRANSPORTATION PROJECTS

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ABSTRACT

Cost estimates are a vital component of any transportation project, but they are particularly significant at the environmental review stage. The accuracy of these estimates in publicly-accessible environmental documents is important for decision making and public trust and is necessary for transportation agencies to make the best available decision to help an area address its transportation needs. However, national trends show that early cost estimates are systematically underestimated and rarely align with the actual future construction. This thesis contains five overlying objectives.

- Determine how costs are presented in environmental impact statements
- Find if costs are updated during the different review stages of the environmental impact statement
- Identify projects with little differences in their estimate over the life of environmental impact statements
- Provide a framework for selecting which cost estimation technique to use
- Identify various estimating techniques used nationally for transportation projects

These objectives were met by utilizing a sample of one hundred transportation projects to discover the extent and accuracy of cost estimation disclosure in draft environmental impact statements (DEIS) and final environmental impact statements (FEIS). Each of the projects' environmental impact statements (EIS) was examined to see what type of early estimation occurred and how it was disclosed. The author also conducted interviews with personnel from a small sample of the selected projects to gain further insight into the project's cost estimate and the state's cost estimation strategies.

In a number of the projects reviewed for this study, the costs were underestimated and barely mentioned during the project development stage. These understated estimates can trigger serious cost overruns resulting in a lack of public trust and confidence in the transportation agencies generating the estimates. Future projects may be substantially delayed or trimmed because of the unavailability of funds from these cost overruns. Better financial stewardship is desired by the public and improved cost estimating methods appear to be needed. From analysis of these transportation projects and interviews with various people who worked on them, it was found that improvements in disclosing project costs in environmental documents are needed. These changes will ultimately help to build public trust and confidence in the cost estimates of transportation projects.

DEDICATION

I dedicate this work to my family.

ACKNOWLEDGMENTS

I am deeply indebted to Dr. Mashrur Chowdhury who provided his expertise in helping me with this thesis. Dr. Anne Dunning and Dr. Jennifer Ogle also assisted me to make this thesis become a reality. I also acknowledge my colleagues at the Federal Highway Administration in guiding me in my research. Thanks go to Harold Peaks and Marlys Osterhues. Lastly, I want to acknowledge all those who provided support in getting me through this process.

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INTRODUCTION

1.1. Problem Statement

Cost estimation during early stages of project planning is complex because there is vast uncertainty associated with much of the available information and data that goes into the estimate. Much of the public may not realize the large number of decisions that can greatly influence the outcome of a project. Additionally, the National Environmental Policy Act (NEPA) does not address cost estimates. This omission from NEPA allows project managers to disregard cost disclosure during a period that incorporates public involvement. The estimated cost of an alternative for a project is one of the many important metrics for decision making during project development. Decision makers use the estimate as a tool to decide if the generated benefit is worth the funds it would require to construct the needed transportation project.

National trends have shown that early estimates are systematically underestimated giving more of a representation of a best-case scenario rather than a realistic expectation (Flyvbjerg, 2002). While there may also be a lack of detail in the cost estimate during the environmental stage of project development, the trends show that significantly larger numbers of projects have cost escalation than over estimation. For years, these estimates have overlooked or under-estimated delays and issues that constantly hinder project completion.

Many projects have had cost escalations during their development and construction phases. The Central Artery Project (or Big Dig) in Boston, for example, has had some highly visible overruns resulting in bad publicity. The project involved tunneling a 3.5 mile long, 8 to 10 lane expressway under the city of Boston to carry the traffic of Interstate 93 and the construction of the widest-ever cable-stayed bridge (Massachusetts Turnpike Authority, 2007). The scope of this project was so large that no single firm would take it on. The complexity of the project site can be seen in Figure 1.1. Since 1985, the cost of the Big Dig has escalated from $2.5 billion to over $14 billion (Sangrey, 2005).

Figure 1.1: *Complexity of the Central Artery Project*

The cost of the Rhode Island Route 195 relocation project has also escalated since its start in 1993 (Landis, 2006). The project involves constructing the Route 95 and Route 195 interchange and replacing many surrounding bridges. Figure 1.2 shows the construction of one of the many replaced bridges involved with this project. The initial estimate during preliminary engineering for the entire project was $299 million, but it is currently assessed at $776 million with much of the construction complete. Much of this increase was due to unforeseen and unprecedented cost upsurges of materials, such as steel and concrete, and fluctuations in the financial markets that govern the cost of borrowing funds. Many transportation projects, like the ones mentioned above, involve cost overruns that hurt public relations with transportation agencies. Without improved cost disclosure throughout project development, public relations concerning project funds will continue to be problematic.

Figure 1.2: *RI Route 195 Relocation Project*

1.2. Objectives

The broad objectives of this research were to identify how early types of cost estimation are disclosed and to obtain a national snapshot of the various estimating techniques used for transportation projects. More narrowly, the objectives were to:

- Determine how costs are presented in environmental impact statements
- Find if costs are updated during the different review stages of the environmental impact statement
- Identify projects with little differences in their estimate over the life of environmental impact statements
- Provide a framework for selecting cost estimation technique

- Identify various estimating techniques used nationally for transportation projects

These objectives were established so that improvements in cost disclosure could be identified during the environmental review stage of project development. The improvements will be used to achieve the obtainable goal of building and sustaining public trust.

1.3. Public Accountability

Public accountability is an important facet of the modern participatory planning process. Modern planning methods incorporate an iterative process with many stages of close public interaction and approval phases. The public should be able to expect local, state, and federal leaders in the public sector to perform as conscientious stewards of scarce funds. In addition, governmental agencies and leaders must often trust the private sector's performance creating many different layers and expectations. When cost increases or overruns for a major project occur, the public immediately begins to criticize public sector employees. Often, the adherence to a project budget and timeline, however inaccurate a measure, may be the only means for the public to judge the merit of the project before it can be completed. Furthermore, the long term effects of a failed or poorly executed project could cause public groups, organizations, and citizen initiatives to reject future proposals. Accurate and simple to understand financial estimations provide an opportunity for the public to contribute to the project in a meaningful manner, enable government leaders to make informed decisions, and allow private companies to avoid costly litigation.

1.4. Background on the National Environmental Policy Act

The National Environmental Policy Act of 1969 (NEPA), formally signed into law as of January 1, 1970, requires federal agencies to consider environmental impacts prior to approving a project to receive federal funding. Where a project will have significant impacts, the policy requires documentation, in the form of an environmental impact statement (EIS), to be completed for all major federal actions. If it is unclear whether or not a federal action will have significant environmental impacts, then an environmental assessment may be completed instead. The environmental assessment has fewer requirements than the EIS and may be easier to complete. Where it has been determined that a project is not environmentally damaging, a categorical exclusion may be the appropriate environmental documentation.

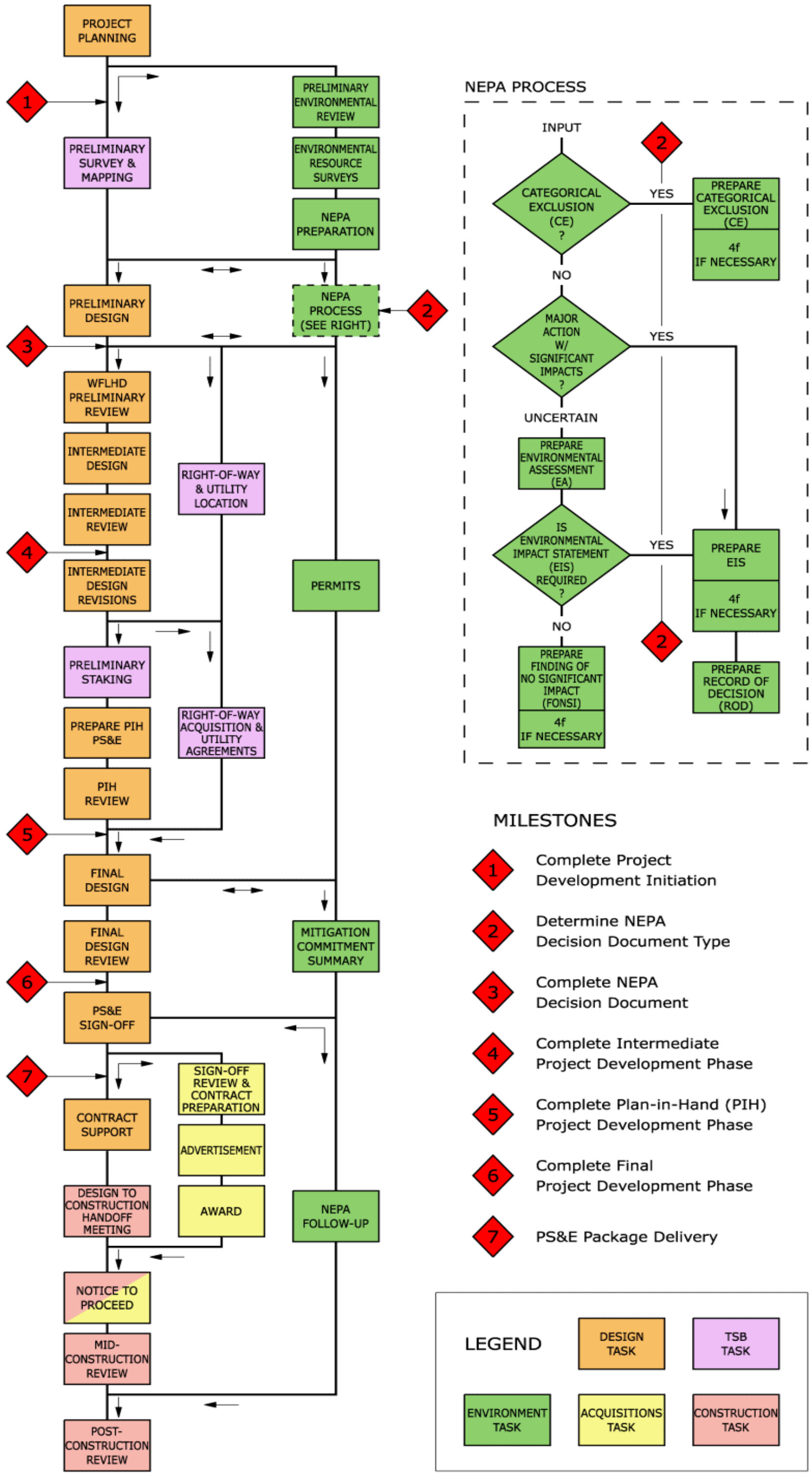
Projects causing significant environmental impacts require greater environmental analysis and documentation to aid the decision making process. The EIS outlines feasible project alternatives and gives the benefits and weaknesses of each potential outcome. The public will have time during the scoping process and between the draft environmental impact statement (DEIS) and the final environmental impact statement (FEIS) to express their concerns about the proposed project. This process is completed in the hopes that the best solution for the public will be produced. It does not guarantee that the least environmentally damaging alternative will be chosen, because other factors may greatly influence the decision. It only guarantees, however, that the decision involved reasonable prudence.

The National Environmental Policy Act does not provide any guidance on cost estimates in environmental documents nor does it require alternative cost estimates. Many of the documents entirely omit cost estimates for the various alternatives, even though the estimates can be a determinant in the decision making process. These early and sometimes vague estimates influence the alternatives under consideration and could determine if the project will move forward into construction. However, many complex projects do provide detailed cost estimates throughout the planning and construction process. Often this is because of the large amounts of funding required, their controversial alternatives, or their high visibility.

1.5. Background on Project Development

As the NEPA process occurs, which is located on the right side of Figure 1.3, the preliminary design of the project is taking place. The planners and engineers working on the preliminary design for a project give quantifiable information for various alternatives to the personnel conducting the NEPA process and vice versa. The coordinated information sharing and communication between all parties are vital for each group to perform well.

During preliminary design the necessary details to provide an accurate cost estimate are being formulated, so the estimate includes much uncertainty. The estimate presented in the environmental impact statement (EIS) can only be a preliminary estimate because of its place in the development of the project. Updates to the estimate during later stages of development, therefore, cannot be displayed in the EIS.



Source: Western Federal Lands Highway Division

Figure 1.3: *Project Development Flow Chart*

1.6. Expectations of This Research

Because of the emphasis on public accountability and the cost overruns on many high-profile projects, many methods are being examined to improve the project development process. Cost disclosure is a central topic of consideration regarding potential improvements. From the 100 analyzed case examples, the amount and content of disclosed information was documented. The information includes (1) whether or not cost was included in the document, (2) how costs were disclosed in the document, (3) what level of detail was provided regarding the estimate, and (4) what updates were included to the estimate during the documentation at different stages (i.e. the DEIS, the FEIS, and the record of decision (ROD)). In addition, a select few cases were chosen for an interview process to reveal more information not included in the EIS. All of this information will lead to recommendations on improving cost estimation disclosure and, ultimately, to help build public trust on future transportation projects.

LITERATURE REVIEW

The estimated cost of a project is one of the most important metrics against which the success of the project is measured (Major Project Program Cost Estimating Guidance, 2004). Yet people have long treated cost estimates with apprehension because there is little certainty that the estimate will eventually correspond to the actual events. The problem with underestimation stretches into all types of construction projects, not just in surface transportation systems. The construction of the Panama Canal, which was completed in 1914, had cost escalations in the range of 70 to 200 percent (Summers, 1967). Additionally, the actual cost of the Concorde supersonic aircraft climbed twelve times higher than originally predicted (Hall, 1980). Even more importantly, roadway transportation projects have seen their share of cost escalation occurrences. The most notable example is perhaps the Boston Big Dig, which, as mentioned earlier, escalated from $2.5 billion dollars to over $14 billion in its 20 years of planning and construction (Sangrey, 2005). The causes for the Big Dig's drastic underestimation are primarily the changes in scope and schedule which consequently provided the necessary means for inflation.

Unfortunately, the Big Dig's cost overruns were not unprecedented, and it is not the last project to exceed early cost estimates. Bent Flyvbjerg, et al., postulate that project promoters routinely ignore, hide, or otherwise leave out important project costs in order to make the total costs appear low (2002). This underestimation works in the favor of the promoters because the project is more likely to be selected. The researchers further claim that cost estimates are initially overly optimistic and represent a best-case scenario.

The findings show that 9 out of every 10 projects have cost escalation and that the actual cost of the average project is 28 percent more than the initial estimate (Flyvbjerg et al., 2002). This suggestion led to a further study that investigated the effect of the length of project implementation as related to the accuracy of cost estimates. For every passing year from the decision to build until operations begin, the average increase in cost escalation is five percent (Flyvbjerg et al., 2004). This statistic implies that sluggishness may be extremely expensive for the involved parties.

Flyvbjerg, et. al., also found that cost escalation has not decreased over the last 70 years and occurs in countries across the world (2003). They further claim that there are strong incentives and weak disincentives for cost underestimation. The promoters benefit from "lowballing" or severely undervaluing the cost estimate. The researchers concluded that underestimated costs plus overestimated benefits equal project approval. Because this formula results in an inverted Darwinism, the "survival of the unfittest," which transpires to the detriment of the social and economic welfare (Flyvbjerg et al., 2005), adjustments to offset underestimation are critical to mitigate the harm caused by allocating scarce resources to complete an unfinished project.

According to Jim Sinnette, a Federal Highway Administration (FHWA) official, the most critical steps in overhauling cost estimation are conveying honesty and transparency. This openness, in actions and in words, is aimed to provide full and credible information along the entire process (2004). Public trust ultimately relies on a reasonable anticipation of project costs, which cannot be maintained without effective cost estimation (Gabel, 2006). Better estimating techniques, such as the cost estimate validation process (CEVP) that was developed by the Washington State Department of Transportation, can serve as the model to maintain that trust. The CEVP is an intense workshop that provides an external validation of costs and assesses risks to each cost (Sangrey et al., 2003; Sinnette, 2004; Gabel and Reilly, 2006). Because of the many uncertainties in a cost estimate, the produced estimate is in the form of a range of plausible costs instead of a single value.

John Reilly identifies that risk based approaches, like the cost estimate validation process, may help mitigate historical estimating problems by quantifying actual project cost uncertainty within a probabilistic cost model. Therefore, the uncertainties are de-biased, assessed and incorporated (2006). Reilly also says that the following metrics can help to improve the historical estimating problem. These include:

- identifying and prioritizing cost risks
- quantifying the costs and benefits of proposed mitigation strategies
- improving communication and the decision making process

If these steps are taken, then risk management techniques also can help to minimize uncertainty and assist with keeping projects on track, on time, and under budget (Barry, 2006).

Keith Molenaar adds that no industry standard stochastic estimating practice is currently available (2005). Engineers rely on traditional methods, which take a deterministic approach to project cost estimating and add a varying contingency factor. Molenaar states that this approach falls short because considerable cost overruns exist. He reviewed nine projects that underwent the CEVP workshop in 2002 and identified 23 significant risk factors. Even though the workshop is completed in the time period of a week at a high cost, there is a fundamental trade-off between providing a sophisticated risk model and providing quick and effective feedback to the project team (Molenaar, 2005). Molenaar makes this claim because of the need for more advanced models for risk items.

Stuart Anderson, et. al., provide recommendations for further strategies to improve the momentous cost estimation problem for transportation projects (2007). They outline a plan of action that includes eight overarching or global strategies that can affect the accuracy and consistency of project estimates and costs. The eight strategies are as follows:

- Better management throughout project development
- Improved control of scope and schedule
- Further utilization of third party auditors
- Improved risk management
- Improved delivery and procurement methods
- Enhanced document quality
- Improved estimate accuracy
- Assured overall integrity

A quality document that fully discusses costs will help to inform everyone involved and help them to understand what was incorporated into the estimate. Furthermore, the utilization of external participants will make certain that honesty and integrity are vital to the estimate, while the devotion to integrity will ensure that checks and balances are in place to maintain estimate accuracy. Integrity will minimize the impact of outside pressures that can cause optimistic biases in estimates (Major Project Program Cost Estimating Guidance, 2004; Anderson, et al., 2007).

Garold Oberlender and Steven Trost developed an estimate scoring system which measures the impact of a variety of factors on estimate accuracy, including who was involved in producing the estimate (2001). Using the generated computer program from this research will give desired confidence intervals for the produced cost estimate based on the quality of the estimate. Steven Trost and Oberlender later refined the model using more advanced statistics that provide a better representation of the estimate score (2003). The program provides quick feedback for cost estimate expectations, and the produced score provides insight into the quality of the estimate.

Environmental considerations have been shown to increase costs when the original scope is not clearly defined. A project that has potentially significant effects or impacts on environmental resources tends to include more environmental mitigation than other projects which results in high costs (Major Project Program Cost Estimating Guidance, 2004). Since environmental concerns can greatly affect the cost estimate, it is imperative to understand what environmental costs are likely to occur. Environmental costs can be separated into two main categories: compensatory costs and avoidance costs (United States House of Representatives Report 108-792, 2006; Crossett and Secrest, 2006). While compensatory costs are relatively easy to identify because they are measures to counterbalance negative effects, avoidance costs are much more challenging to grasp. This difficulty exists because activities that avoid or minimize environmental impacts are not discrete efforts that are readily separable from the core scope of the project (Crossett and Secrest, 2006). Additionally, environmental costs can substantially affect the cost estimate, so it is necessary to place risk factors on possible environmental concerns (Reilly, 2006). This effort will ensure that they are accounted for should they arise during the project.

It is necessary to show the public that the highway agencies and state Departments of Transportation are acting as good financial stewards of public monies. Financial stewardship and transparency are essential to building and keeping public trust. However, the long history of inaccuracy and the inability to put much faith in cost estimates makes building that public trust difficult. Furthermore, the misrepresentation of costs is likely to lead to the misallocation of limited resources, which, in turn, will produce losers among those financing the projects, be they taxpayers or private investors (Flyvbjerg et al, 2002). Full disclosure of cost estimates for the project, though, provides evidence to the public that financial stewardship is occurring (Anderson, 2007). Even if some changes occur in both the scope and schedule during the life of the project, it is always best to show the public the complete picture throughout the project life cycle. They will be more likely to accept these changes when they are informed of the cause that necessitated the changes. However, the question should be asked, what is the level of disclosure that is currently revealed to the public and how do the state Departments of Transportation currently present their cost estimate information to the public? Are project risk and the level of certainty being revealed in these estimates?

2.1. Public-Private Partnerships

Although the transportation industry garners significant government money, it still cannot satisfy all of the needed services. Public-private partnerships allow the public sector to make up this deficit by taking advantage of private resources to maximize the objectives of many projects. However, the focus for most private investors is on value for money rather than reductions in cost. Therefore, expanded partnership arrangements often provide increased flexibility to employ innovative approaches of cost estimation.

Public-private partnerships (PPP) refer to contractual agreements formed between a public agency and a private sector entity that allow for greater private sector participation in the delivery of transportation projects. Traditional private sector participation has been limited to separate planning, design, or construction contracts on a fee for service basis – based on the public agency's specifications. Expanding the role of the private sector allows the public agencies to tap private sector financial resources in new ways to achieve certain public objectives.

Normally, public agencies and the private sector share separate objectives and separate goals when entering into any partnership agreement. Public agencies make the most efficient use of public resources in an equitable manner and provide standardized public services and facilities. Private businesses provide an attractive return on company resources by providing needed services to clients and by making strategic investment decisions. Public-private partnerships, in their various forms, allow public agencies the flexibility to allocate roles, risks, and rewards to the entity while still achieving their public objectives. These partnerships also offer the private sector opportunities to expand markets and to provide better value for the public partner. The possibility of saving some public funds means that some localities can deliver essential services with the limited resources available.

Although public-private partnerships bring a lot of benefits to both the public and private sectors, there are continuing disputes over the appropriateness of the guidelines designed to reduce debt instead of providing value for money. Many state Departments of Transportation rely predominately on the low-bid approach to award highway and transit construction contracts. The main intent of the low-bid approach is to save tax revenue, which provides value for money, and to protect the public interest. This bidding format, though, is not an advantageous use of these public-private partnerships. Public systems are often slow and require deliberate input from various groups affected by the effort which does not favor private business-cycles and cost approaches.

2.2. Property Acquisition

In the majority of transportation projects requiring land acquisition, there is a mix of acquisitions involving willing sellers, eminent domain acquisitions because of an unresolved selling price, and purchases with other reluctant sellers. Because of the varied types of property transactions that might be required and the fact that each property owner could potentially be an individually specific case, the cost of property acquisition is difficult to determine. In addition, standard property equations used in cost estimates leave considerable room for error. While a very loose “ball park figure” might be obtainable by understanding property values, this does not include holdouts by owners and other legal and procedural costs.

The impact formed from the complexity of estimating the costs of property acquisition is a likely cause of difficulty during the environmental review stage. In addition, the data for specific costs of right-of-way and individual properties may be either too difficult or too unattainable during potential alternatives analysis. Legal fees, procedural fees, higher than expected compensations, and basic delays can hold up projects and thus lead to a higher cost before the project even begins construction. These difficulties could lead many public and private entities either to omit or seriously underestimate the true costs of property acquisition.

METHODOLOGY

The methodology employed to reach the research objectives is presented in this section. This section reveals the analysis of data, the methods of collecting data, and the sample selection that was used to make recommendations on improving cost disclosure and public trust in environmental impact statements.

3.1. Analysis of Data

Many steps were taken to meet the objectives of this research. It was first desired to identify various estimating techniques utilized in early transportation cost estimates. The various methods being utilized by state Departments of Transportation were found through interviews and in literature. It was further desired to determine if cost estimates were underestimated from the very beginning of the environmental review process, with increases in the estimate during each subsequent piece of documentation. To discover this information, environmental documents of a project were viewed at various stages of its development. When the cost estimates were included at the different stages of environmental documentation, the estimates were compared. If multiple stages of environmental documentation for the same project were not available, then only the FEIS was used. This set of data was gathered solely for the amount of cost disclosure in the document. A statistical test was applied to the data to determine if the results were significant. The utilized test was a two-sample t-test using the Satterthwaite method (Moore and McCabe, 2003). All of the data and information was gathered and organized using a spreadsheet software.

3.2. Data Sources

Data was gathered from two primary sources: environmental documents and interviews with personnel who worked closely on the project (see Figure 3.1 below). The environmental impact statements were chosen as a main data source because they are decision making documents that are made publicly available during the pre-construction phases of a project. Success during this stage of project development is important for building and sustaining a positive public attitude towards the project.

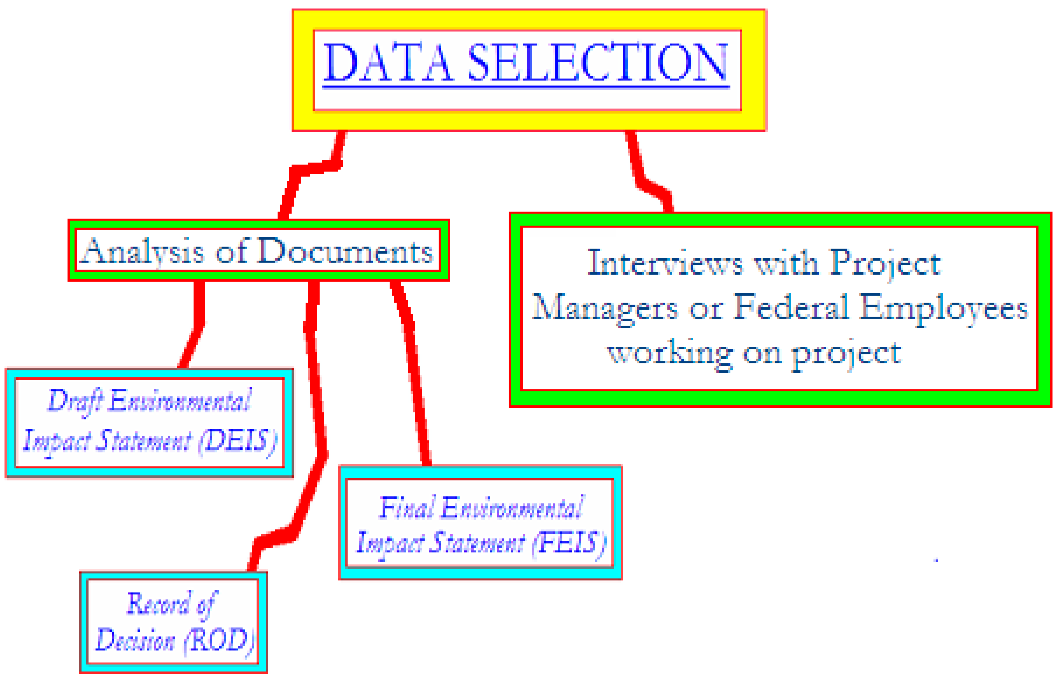


Figure 3.1: *Data Selection*

3.2.1. Environmental Impact Statements at Various Stages

The environmental impact statements (EIS) of the selected projects were the primary sources of data for this study. Seventy of the 100 projects had both the draft environmental impact statement (DEIS) and final environmental impact statement (FEIS) completed and available for review. An EIS is a document that presents the analysis of the environmental impacts of a proposed federal action and presents possible alternatives for the decision making process. The EIS provides information for both government officials and the affected public. The documents evaluate the potential for significant environmental effects, consider possible alternatives, and explore mitigation measures for the adverse environmental effects. The DEIS generally allows readers to comment on the proposed action before any preferred alternative is selected. Having the DEIS and the FEIS to consult for data provided cost estimates at different stages of the environmental process.

In addition to the DEIS and FEIS, some supplemental environmental impact statements were analyzed. Supplemental environmental impact statements are often needed if there are changes to the proposed action that may create environmental impacts not reviewed in the original EIS, or if new information on its impacts would result in new significant environmental impacts not previously evaluated. Other environmental issues may arise during the entire process that necessitates additional documentation for alternatives and mitigation.

Many projects also had an available record of decision (ROD) to consult for another time sensitive estimate. The ROD is a federally required environmental decision document that explains the reasons for the project decision and summarizes the mitigation measures required by the project. It is issued only after the FEIS has explored all the necessary information pertaining to the project. This document, if a cost estimate is presented, could reveal a more in depth cost summary of the chosen alternative.

3.2.2. Final Environmental Impact Statements Only

Since the availability of environmental impact statements (EIS) at multiple stages of the project development process was limited online and in the Federal Highway Administration (FHWA) headquarters, many projects were solely analyzed according to their FEIS. These 30 projects could not be compared against their other environmental documents, but they could be analyzed to see the level of disclosure that occurred at this final environmental stage. Keeping the large focus of this research in mind, the level of disclosure in the FEIS provides additional meaningful data.

3.2.3. Interviews

A select number of the analyzed transportation projects were chosen for additional detailed information regarding their cost estimate. These projects were chosen to be part of the cost estimate study but were also able to provide additional information through an interview process. The projects were first examined according to their DEIS and FEIS, and then interviews were conducted with people who worked directly on the projects to get a more in-depth analysis of their early cost estimates. The personnel who worked on each project not only provided more insight into the project's cost estimate but also provided information regarding their state's requirements and practices regarding estimates.

3.3. Sample Selection

The surface transportation projects that were selected to be included in this research effort are spread across the entire United States. They were evaluated based on a number of factors, including (1) their location in the country, (2) their location in an urban or rural environment, (3) the size and scope of the project, and (4) the availability of environmental documentation online and at the Federal Highway Administration's (FHWA) headquarters. The sample ranged the entire spectrum of size and scope while also equally representing urban and rural America across each of the regions of the United States (see Figure 3.2 below). It is important to note that these regions do not influence how cost estimates are performed, but they are established so that each geographic area of the nation is represented in this research effort.

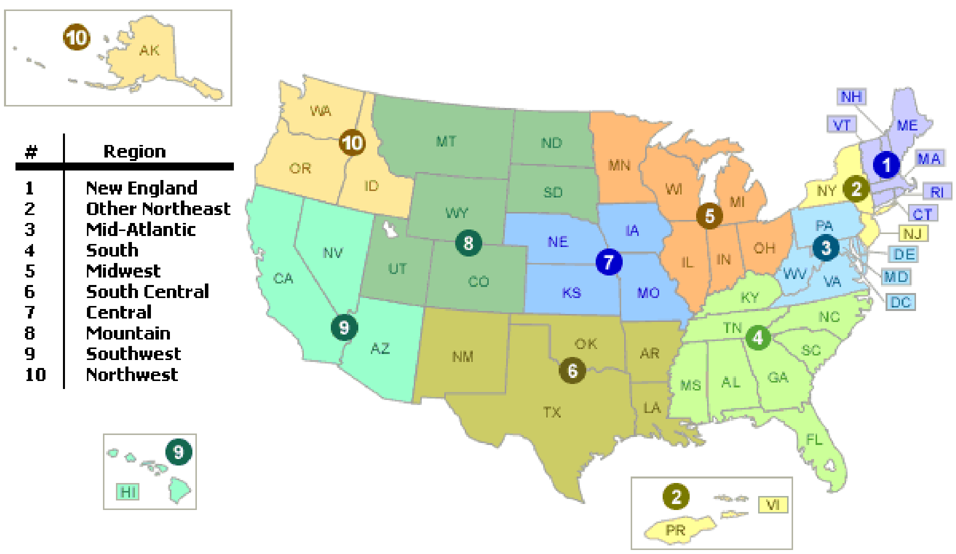


Figure 3.2: *Regions of the United States*

The size and scope of the project was determined by the estimated cost in the environmental impact statement. For the purpose of this thesis, the projects were grouped into three categories: small, medium, and large. Small projects that ranged from as low as $6.8 million to large projects that cost upwards of $8 billion were included in the analysis. A balance between the amount of small, medium, and large projects was sought so as to show the cost estimating disclosure for a full range of projects occurring in the United States. Large projects are classified similar to major projects in that their costs are greater than or equal to $500 million. Additionally, medium projects range from $100 million to $500 million, and small projects cost less than or equal to $100 million.

Projects are classified as urban if they are located in a metropolitan area and rural if they are not in a metropolitan area. This grouping is not based on population but rather on the perceived social environment that it affects. Furthermore, some projects, because of their large scope, encompassed rural and urban areas. In these projects, they were classified according to the location in which the majority of the project occurred.

RESULTS

4.1. Gathered Data

A comprehensive list of all projects included in this research effort is in Appendices A and B. Appendix A lists the projects that have at least a draft and final environmental impact statement, and Appendix B includes projects that have only the FEIS.

The thesis involved six interviews with people or groups that worked closely on the project. The projects that included interviews are as follows: (1) the Appalachian Corridor Project, (2) the Cooper River Bridge Replacement Project, (3) the Inter-County Connector, (4) the New Mississippi River Bridges Project, (5) the St. Croix River Crossing Project, and (6) the US 2 Project. Each project can be found in Appendix C for more information related to its EIS. All of the collected data is provided in Appendix C and Appendix D in this report. Appendix C contains cost information for projects with multiple documents from the environmental review stage, and Appendix D contains information for projects with only a FEIS.

4.2. Trends and Analysis

Each of the 70 projects that were analyzed at multiple stages of the environmental process are displayed (see Table 4.1) in relation to the project's area of the country, size of project, and its distinction between rural and urban environments. The thirty additional projects that were analyzed only at the FEIS level are not included in Table 4.1.

Table 4.1: *Environmental Impact Statements by Region, Location Size, and Project Size*

EPA Region	# total	# Urban	#Rural/ Mostly Rural	#Major	#Medium	#Small	#Unknown
New England	4	4	0	1	3	0	0
Other Northeast	6	3	3	1	3	2	0
Mid-Atlantic	7	5	2	6	1	0	0
South	6	4	2	2	2	2	0
Midwest	15	5	10	5	5	4	1
South Central	4	2	2	1	2	1	0
Central	3	2	1	2	1	0	0
Mountain	10	3	7	2	4	3	1
Southwest	7	4	3	1	5	1	0
Northwest	8	1	7	1	3	3	1
sum	**70**	33	37	22	29	16	3
	percentage	47.1%	52.9%	31.4%	41.4%	22.9%	4.3%
	sum	**70**		**70**			

As can be seen by Table 4.1, each category is represented, with the most projects occurring in the Midwest. The flux of projects in this area is primarily due to the availability of environmental documentation and, to a lesser extent, is due to its increase in travel demand.

Various cost findings from the raw data are depicted below in Table 4.2. These findings summarize the data collected in the EIS. Some of the data includes all of the 100 observed projects and some only include data where multiple stages of environmental documents for the same project were examined. Other pieces of data could only be found in a smaller number of projects because every document did not present all aspects of a cost estimate.

Table 4.2: *Cost Findings*

Category	Amount	Number of Projects	Percentage of Projects
Median Time Between DEIS and FEIS (approx. months)	16.0	70	n/a
Average Time Between DEIS and FEIS (approx. months)	22.0	70	n/a
Median Time Between FEIS and ROD (approx. months)	3.0	25	n/a
Average Time Between FEIS and ROD (approx. months)	4.4	25	n/a
Number of Projects that do NOT give Cost Estimate in EIS	11	100	11.0%
Number of Projects that Reference Another Document for Costing Information	3	100	3.0%
Median Percent Difference in Cost from DEIS to FEIS	0.00%	53	n/a
Average Percent Difference in Cost from DEIS to FEIS	6.49%	53	n/a
Median Percent Difference in Cost from DEIS to FEIS (only including Projects with Cost Updates)	2.39%	32	n/a
Average Percent Difference in Cost from DEIS to FEIS (only including Projects with Cost Updates)	10.75%	32	n/a
Median Percent Difference in Cost from FEIS to ROD	0.00%	8	n/a
Average Percent Difference in Cost from FEIS to ROD	0.33%	8	n/a
Median Percent Difference in Cost from FEIS to ROD (only including Projects with Cost Updates)	2.61%	1	n/a
Average Percent Difference in Cost from FEIS to ROD (only including Projects with Cost Updates)	2.61%	1	n/a
Number of Projects with Cost Estimate that do NOT Disclose Costs for All Studied Alternatives	15	89	16.9%
Number of Projects with Cost Estimate that do NOT Break Down the Costs	29	89	32.6%
Number of EIS Disclosing Percentage of Cost Allotted for Contingency	7	100	7.0%
Median Percent Allocated for Contingency *	15.00%	12	n/a
Average Percent Allocated for Contingency *	14.58%	12	n/a
Number of Projects that do NOT Address How the Estimation was Formed	87	100	87.0%
Number of Projects that Report the Preferred Alternative's Estimate as a Single Value	85	89	95.5%
Number of Projects that Report the Preferred Alternative's Estimate as a Probabilistic Range	4	89	4.5%

* All contingencies utilized are not found in the EIS. Some were gathered from the interview process.

Table 4.2 shows that the median value for percent difference in cost between the draft and final environmental impact statement is zero. This result suggests that many projects do not update the estimates during the environmental process even though a substantial period of time elapses. The median time between the draft and final environmental impact statement is approximately 16 months and the average time is 22 months. Even projects that are fast tracked through the environmental process usually necessitate at least one year to meet all requirements. During this time between documents, most projects could develop additional details which would improve the cost estimate. If the estimate is changed, though, there needs to be a discussion of the reasons for the change.

The average increase in cost from the DEIS to the FEIS is 6.49 percent. Only nine of the 54 projects where an estimate was disclosed in both the DEIS and FEIS had a reduced estimate. This result indicates that when estimates are updated, cost escalation tends to be involved. To examine this finding more closely, the differences in cost were examined for projects that only included a cost update. The average increase in cost for these 32 projects was found to be 10.75 percent while the median increase totaled 2.39 percent. The median value is much lower than the average value which signifies that there are some projects with drastic cost escalation during the environmental phases. However, the majority of projects still incorporated some sort of cost escalation.

The same result of zero percent difference in cost occurred for the median value between the FEIS and the record of decision (ROD). This result, however, should be tested further because only 21 projects could be found that had the DEIS, the FEIS, and the ROD. Out of these 21 projects, only 8 records of decision mentioned cost. Most of these 8 records of decision restated the estimate that occurred in the FEIS, but one project revealed a new estimate, which incurred cost escalation. This finding of most documents restating the previous estimate was expected because the median time between the FEIS and the ROD is approximately 3 months and the average time is approximately 4.4 months. It would be difficult to revamp an estimate during this quick turnaround. However, as the environmental decision document, the ROD should always state the estimate of the chosen alternative. More data should be checked, though, to verify if such a large percentage of records of decision omit cost estimates.

Many of the results from Table 4.2 suggest that disclosure is currently lacking in environmental documents. Eleven percent of the projects do not even mention project cost in the document. A document without a cost estimate, even for the preferred alternative, eliminates a major portion of public involvement and comparative alternative analysis. The cost estimate could be a major factor that greatly affects public approval and their comments during the environmental process. Additionally, only three percent of the documents referenced another document for their cost estimate. All of these projects were complex, multi-billion dollar ventures, and they all gave a summary of the estimate in their EIS. Referencing another document for cost estimation is only an advisable suggestion if a summary is included in the original document. Moreover, 87 percent of the documents do not inform readers of the performed estimation method. While many readers in the public do not need to know or comprehend the method, it can be helpful to decision makers to understand how much trust can be placed in the value and how much detail was used in its creation.

A further look at the information from Table 4.2 suggests a need to improve cost disclosure in environmental documents. Approximately 16.9 percent of the 89 projects that have a cost estimate presented in their EIS do not disclose costs for all of the alternatives. The additional data would allow the public an extra measure of evaluation in understanding the purpose and need of the project. Additionally, 32.6 percent of projects with a disclosed cost estimate do not breakdown costs. This is a substantial portion of the data, and it suggests that many projects display little of the cost estimate. A breakdown informs all stakeholders in the project of the major expense items, and readers can better grasp the reasons for the expenditures. Another 93 percent do not disclose the percent allotted for contingency, but the designated amount varies widely. Most of the seven percent of projects that do disclose the contingency amount allocate 15 percent of the entire cost for unexpected items, but this amount varied from 4.5 percent to 25 percent.

Risk levels are also rarely included due to the fact that many projects do not perform a risk analysis. With the many uncertainties at the beginning of a project, single value estimates cannot capture an accurate representation. Risk analysis accounts for many scenarios or outcomes that affect a project's completion. In this study, only 4.5 percent of the projects report the estimate as a probabilistic range of anticipated values. These projects that used a risk analysis all had high visibility and much controversy. The actual number of projects using risk based estimates, though, is affected by the number of projects that performed a risk analysis but did not express the estimate as a range. For example, the Inter-County Connector performed a risk based analysis but still reported the estimate as a single value. Because of the small number of reviewed projects that utilized risk based estimation, it is difficult to formulate any inferences about this type of estimation during the environmental process until more data can be gathered. With more data involving a larger sample of projects with risk based estimates, comparisons with projects using unit costs can be made to discover their effectiveness during the environmental process.

Table 4.3 displays some information gathered through the interview process. It suggests that unit costs / historical costs method is primarily used, which is strengthened by the observation of data from the EIS and the judgment in literature. Many projects also do not update estimates during the life of the project's environmental review stage. A sample interview form is included in appendix E.

Table 4.3: *Interview Results*

Data	Number of Interviewees
Lack of Standard Cost Estimation Manual for Early Estimates	6 / 6
Unit Costs / Historical Costs Used as the Method for Early Cost Estimation	6 / 6*
Revised Estimate between DEIS and FEIS	4 / 6

*1 of 6 used Risk Based methods for high profile projects.

The histogram below (see Figure 4.1) shows the percent difference in cost between the draft environmental impact statement (DEIS) and the final environmental impact statement (FEIS). The distribution of the percent difference in cost shows that the values are centered around a mean greater than zero. This mean is a 6.49 percent increase in cost. If costs were underestimated and overestimated at the same rate, then the mean would be zero. However, the histogram visually illustrates the initial cost underestimation.

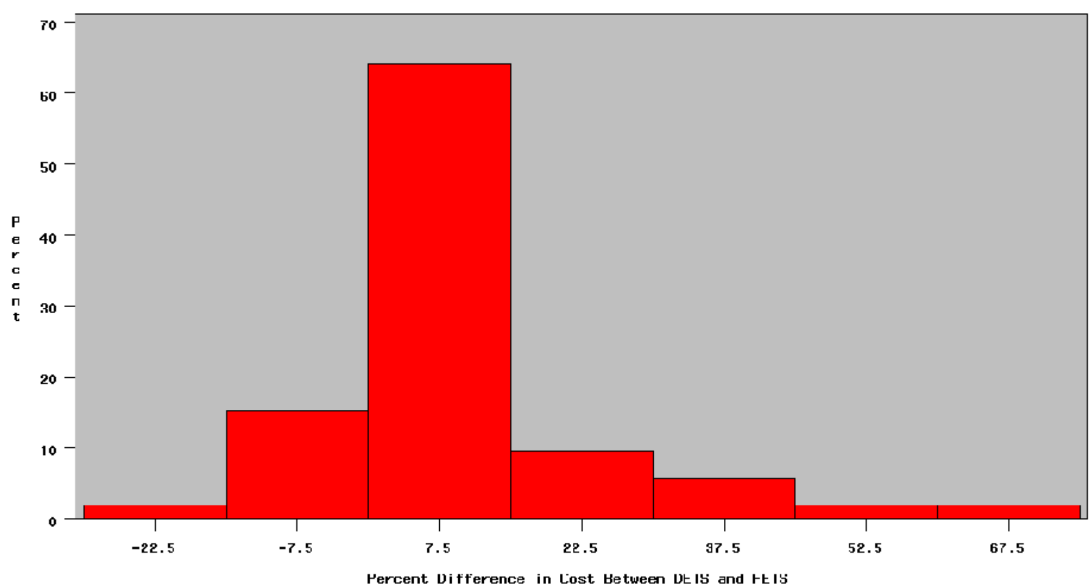


Figure 4.1: *Histogram of Cost Difference between the Sample of DEIS and FEIS*

A basic correlation between the actual cost estimate differential between the DEIS and the FEIS, the percent cost difference between the two EIS, and the time between the EIS is analyzed in Table 4.4.

Table 4.4: *Cost Correlation Table*

Data	*Time Between DEIS and FEIS*	*Cost Difference in millions*	*Percent difference in cost from DEIS to FEIS*
Time Between DEIS and FEIS	1		
Cost Difference in millions	0.2088	1	
Percent difference in cost from DEIS to FEIS	0.2598	0.5531	1

The analysis illustrates that the time between the draft and final environmental impact statement showed a weak to moderate correlation with the increased estimated cost difference. This observation is supported in literature at other stages of a projects development (Flyvbjerg et al., 2004). To test this theory further, a two sample t-test was performed. The sample of percent difference in cost from the draft environmental impact statements (DEIS) to the final environmental impact statements (FEIS) was grouped into two categories. The first category included projects that took greater than one year to complete the FEIS from the issue of the DEIS. The second category included the projects that required one year or less between the publication of the documents. The t-test was arranged to examine if the mean percent difference in cost is greater for projects that take greater than one year between the DEIS and FEIS than for projects that take one year or less. The Satterthwaite method (Moore and McCabe, 2003) was used because the variances were shown to be unequal ($\alpha = 0.05$, p-value = 0.0477).

$$H_0 = \mu_1 - \mu_2 = 0$$
$$H_a = \mu_1 - \mu_2 > 0$$

where

$\mu_1 =$ Mean % difference in cost from DEIS to FEIS for projects with greater than one year between publications of documents.

$\mu_2 =$ Mean % difference in cost from DEIS to FEIS for projects with one year or less between publications of documents.

The test statistic, t_{obs}, was then calculated to be 2.16. The number of projects in samples one and two are 34 and 19, respectively. The average increase for sample one is 9.28 percent while sample two only increased 1.50 percent. The standard deviation of the two samples was 19.99 for sample one and 4.89 for sample two.

$$t_{obs}' = \frac{(\bar{y}_1 - \bar{y}_2) - D_0}{\sqrt{\frac{s_1^2}{n_1} + \frac{s_2^2}{n_2}}} = \frac{(9.28 - 1.50) - 0}{\sqrt{\frac{19.99^2}{34} + \frac{4.89^2}{19}}} = 2.16$$

The test used 39 degrees of freedom according to the Satterthwaite method (Moore and McCabe, 2003) and were calculated based on the following formulas.

$$df = \frac{(n_1 - 1)(n_2 - 1)}{(1 - c^2)(n_1 - 1) + (c^2)(n_2 - 1)} = \frac{(33)(18)}{(1 - 0.9033)^2(33) + (0.9033^2)(18)} = 39$$

where

$$c = \frac{\frac{s_1^2}{n_1}}{\frac{s_1^2}{n_1} + \frac{s_2^2}{n_2}} = \frac{\frac{19.99^2}{34}}{\frac{19.99^2}{34} + \frac{4.89^2}{19}} = 0.9033$$

The null hypothesis was rejected with certainty because the p-value was found to be 0.0185 ($\alpha = 0.05$). Therefore, there is sufficient evidence to suggest that the mean percent difference in cost from the DEIS to the FEIS is greater for projects with more than one year between the documents than for projects that take one year or less between the documents. As more time lapses between various stages of a project, it is more likely the project will have cost overruns.

When making inferences on two population means, two important assumptions must be met.

- The samples from each population must be independent.
- Each population must have a normal distribution.

The two samples from the projects' environmental impact statements are independent because neither one depends on the other to occur. However, it is unclear if the populations follow a normal distribution. According to D. S. Moore and G. P. McCabe, the t procedures can also be used for clearly skewed distributions when the sample is large (2003). Large refers to a sample size of roughly $n \geq 40$ for one-sample t-tests, but the procedure can be adapted for two-sample t-tests where $n = n_1+n_2$. The sample in environmental impact statements is $n_1 + n_2 = 53$; therefore, it is not imperative to know if the distribution is normal.

4.3. Framework for Deciding Risk Based Estimation vs. Traditional Estimation

Many risk factors are prevalent during the life of a project; however, all of the risks may not necessarily affect the type of cost estimate to be performed. Factors such as variability in cost of materials and bond rates are not attributed to a single project, but they are instead involved with the totality of projects occurring at that time. These factors, therefore, should not affect the consideration of estimate type at the beginning of project development. Other project specific factors should influence which type of cost estimation is performed. Based on the author's analysis of projects and risk factors outlined in literature (Akinci, 1998 and Molenaar, 2005), the framework for deciding which estimate type to utilize was developed as shown in Table 4.5.

As the project team places a higher importance on items in Table 4.5, the need to use risk based estimating techniques increases. A higher importance in this framework is denoted by a higher number. The framework can be filled out by the project team to determine the average of the nine importance factors. If a certain item is of higher importance than other items as deemed by the project team, it can be correspondingly weighted. For example, if the project under consideration is a small project, then the available funds for estimating will be small. The project team could then decide that this factor is X times as important as the others. The computed average of the importance factors will give an inclination of the type of estimation to be performed. If the average is above 4, then the project has a strong need for risk based estimation. Correspondingly, if the average is below 2, then the project could use a traditional estimating technique such as unit costs.

Table 4.5: *Sample Framework for Deciding Estimate Type*

	Item	*Importance Factor* (1 to 5, with 5 being most important)
1	Accuracy of Estimate	TO BE FILLED OUT BY PROJECT TEAM!
2	Available Monetary Resources for Estimating (higher importance corresponds to more available funds)	
3	Public Visibility of Project	
4	Size and Scope (larger size and scope corresponds to higher importance)	
5	Geotechnical Conditions	
6	Seismic Conditions	
7	Political Risk Factors	
8	Right-of-way Issues	
9	Staging Operations	

4.4. Cost Estimation Strategies

This research, which focused on 100 transportation projects having an EIS, identified only five cost estimation strategies currently being used by state Departments of Transportation. The following list of cost estimation strategies includes techniques that were observed during this study, and, consequently, may not include every available procedure.

4.4.1. Unit Costs / Historical Costs

From interviews with personnel working closely on projects included in this study and observations on the way costs are presented in EIS, most state Departments of Transportation use unit costs (or historical costs) as the sole early estimation practice for their transportation projects. This method separates quantifiable pieces of a project into distinct areas and applies an estimate based on historical data and inflation. Though this method is suitable in later stages of a project when more reliable quantities of resources are known, many uncertainties are prevalent in the beginning stages of a project. It is fairly simple to estimate each item, i.e. cubic yards of aggregate, but it is the amount of the item that is of concern. Such items like pavement, earthwork, and right-of-way can greatly vary at early stages based on decision making. Even though there is significant risk with each variable, this method does not associate any risk with it. Each variable is assessed as being a single, unchanging value.

4.4.2. Cost Risk Assessment / Cost Estimate Validation Process

The Washington State Department of Transportation developed a Cost Risk Assessment (CRA) and Cost Estimate Validation Process (CEVP) to offset the shortcomings of the unit costs method. These methods both consider cost estimates as a range of costs and not as a single value. Each item in the estimate is evaluated and given a range of likely costs, depending on risks. At early stages this range is large, which accounts for the vast uncertainty. As the project progresses, the estimate becomes narrower because more information becomes known. Probabilities can also be associated with the estimate to give the likelihood of the estimate falling in certain areas. These methods allow the estimators to give a more realistic expectation for the cost and schedule, including the effects of inflation. Improvements result in better decision making and risk management.

4.4.3. SCoRE

The Washington State Department of Transportation also created SCoRE, a stream-lined method of the cost estimate validation process, as a peer level review that identifies risk factors at the beginning of the project and places values of uncertainty on each factor. Because this method requires less time to complete than other risk based methods and because the Federal Highway Administration (FHWA) is focused on making the environmental process more time sensitive, this method can be very useful during the environmental process. It gives a more accurate description of possible costs than using unit costs alone, and it is more time sensitive than other risk based estimation methods.

4.4.4. LWD

The LWD method, an acronym for length (L) of project, width (W) of pavement surface, and depth (D) of pavement, is used in the Minneapolis/St. Paul area by the Minnesota Department of Transportation (MnDOT) as a quick way for early stage cost estimating. It is a form of the unit costs / historical costs method, but it is performed at early stages when evaluating alternatives. When the environmental process begins, other methods are more formally completed.

CONCLUSION AND RECOMMENDATIONS

5.1. Conclusion

This thesis reveals six primary conclusions. (1) There is currently a lack of cost disclosure in environmental impact statements (EIS). Approximately 16.9 percent of projects do not include a cost estimate for all of the alternatives reviewed in the EIS, and 11 percent of the documents do not even provide a cost estimate. (2) Much of the time, the cost estimate is not updated during the life of the environmental impact statement. This fact is illustrated by the 0 percent median cost difference between all three studied documents: the draft environmental impact statement, the final environmental impact statement, and the record of decision (ROD). (3) When the costs were updated, there was an average cost increase of about 10.75 percent from the DEIS to the FEIS (only including projects with cost updates) suggesting that costs are underestimated from the very beginning of project development. This finding closely matches the trend found during later stages of a project that is shown in literature. (4) Many of the projects did not provide an estimate in the ROD, so differences could not be identified over the life of the EIS. Only one ROD provided an updated estimate from the final environmental impact statement. (5) Because of the lack of provided detail in the documents and the evidence that costs are underestimated during the environmental process, a decision making framework is needed for selecting the right cost estimation type. This framework was produced allowing decision makers to choose if risk based estimates are appropriate for their project. (6) Out of the five estimating techniques encountered during this research, the unit costs / historical costs method is the most widely used and provides the basis for other methods.

5.2. Recommendations

Decision makers sometimes use early cost estimates, along with other metrics such as project need, affected population, congestion relief, and so forth as major determinants for which alternative will get funded and advanced. In order for the cost estimates to be utilized effectively by decision makers, though, sufficient detail must be placed in them. The results of this study have shown that current cost estimates as presented during the environmental review stage are lacking detail. Because of these reasons, improved cost disclosure with better detail is needed. Some recommendations based on the findings of this research are as follows.

1. **Always perform and disclose the cost estimate for the studied alternatives in a project's environmental impact statement.**

Beneficiary: decision makers, transportation agencies, and the general public

The cost estimate is one of the many important tools for decision makers in weighing potential outcomes of a proposed project. Without accurate estimates, the decision makers could potentially choose a project that requires a greater cost than another alternative while still meeting the same purpose and need and reaching a similar amount of the population. This research shows that 16.9 percent of projects do not disclose costs for the various studied alternatives, and 11 percent of the projects do not even mention costs in the EIS.

Making full disclosure of available cost estimates a priority will give decision makers and the general public a more comprehensive understanding of the alternatives. Depending on the amount of documentation of the cost estimate, the full disclosure may need to be summarized in the EIS and referenced in another document for all of the details. If another document is referenced, however, some summary should be included in the EIS so that casual readers from the public may obtain a brief understanding of the cost estimate. Keeping very large estimates separate from the environmental document will allow the document to focus on the environmental issues, but fully disclosing all of the cost estimate information will also give transportation agencies a means of tracking costs at later stages. If a project later goes off schedule or has changes in the cost estimate, then the involved transportation agencies can communicate to the public what caused the change and why it was not a part of the original estimate.

Additionally, many of the records of decision (ROD) did not include a cost estimate (13 out of 25). It is important to inform the public how much the selected alternative's cost estimate is, so that it can be tracked throughout the life of the project. Full disclosure at all stages will generate better financial stewardship.

2. Clearly explain the uncertainties of the cost estimation process in the environmental document.

Beneficiary: the general public

It is human nature to desire expectations to be met. However, the accuracy of early cost estimates is affected by a variety of factors. This research shows that the average increase in the cost estimate is 10.75 percent from the DEIS to the FEIS (only including projects with cost updates) and the median value for this increase is 2.39

percent. These percentages suggest that underestimation is occurring during the environmental review stage.

In most other areas of people's lives, they can expect to pay the amount of funds that is estimated. Many of these areas, such as home or auto repair, even guarantee their estimate. Because of these other area's meeting cost estimates, citizens put faith in early estimates for transportation projects and may feel mislead when their expectations are not met. The typical examples that citizens encounter in their lives, like the example mentioned above about home or auto repair, are a different type of estimate because the problem usually has a repeatable solution that has been performed many times. Complex transportation projects, on the other hand, typically involve a variety of alternatives that must be decided upon and require innovative solutions that have not previously been performed. Many citizens do not realize the difference between the two estimates.

As a way to help citizens understand the cost estimate and its role in a transportation project, a cautionary message about early cost estimates should be placed in the EIS where the estimate is presented. The message should mention controversial issues that could alter the estimate and address decisions that may change the project. Each project's cautionary message will have its own topics, but they should all inform the public of the high volatility of early estimates.

3. Focus on public accountability.

Beneficiary: the general public

Since cost escalation may cause a decrease in the public's trust in government abilities, it is important to have accurate information on cost estimation. This information enables government leaders to make informed decisions about projects and to be good financial stewards of public funds. Better financial stewardship will also give citizens assurance that funds are being dealt with in prudence. Additionally, displaying estimates in year-of-expenditure dollars more accurately depicts what may be spent. This form of disclosure facilitates public involvement and encourages better financial stewardship. Ultimately, the best way to focus on public accountability is to disclose all available knowledge about the project to the public when it is first known.

4. Convert every estimate to year-of-expenditure dollars.

Beneficiary: decision makers, transportation agencies, and the general public

The construction life of most transportation projects is usually measured in years rather than months, and the value of a dollar is constantly changing. Because of the length of projects and the variability in the dollar, the final cost of a project will vary from its estimate solely on inflation. To counteract this effect, monetary inflation and the project schedule can also be estimated to predict the cost of the project for the time period of construction. Many projects already display estimates in the year-of-expenditure, but it is not standard practice to place them in every project. Major project guidance already requires that every project valued above five hundred million dollars should give the estimate in the year-of-expenditure, but there is no requirement for projects below this plateau. Additionally, disclosing the current value of the project allows all readers to grasp what the project is worth. Readers could then see how much money is needed for inflation.

Placing the cost estimate at the midpoint of construction, as it is performed now for year-of-expenditure, may be too optimistic. Since many transportation projects have substantial unforeseen delays, placing the year-of-expenditure later in the project eliminates the estimation being a best-case scenario. More resources would be needed in this area to see how far into the project the year-of-expenditure should be placed and how much delay is typical for various sizes of projects. The non-median year-of-expenditure would be based on the amount of risk that is associated with the project.

5. Break down the cost to major areas of expenditure.

Beneficiary: decision makers, transportation agencies, and the general public

From interviews, the analysis of environmental impact statements, and an examination of literature, it can be seen that unit costs are used throughout the transportation industry. This method separates project items into distinct parts and produces a price based on historical values. Since this process is already widely performed, it would be simple to display the breakdown in the EIS. This research, however, shows that 32.6 percent of projects that mention costs do not break down the cost into separate areas.

A breakdown of cost for many elements associated with the project would give the public and decision makers an idea of the work to be completed. Particular elements can be different for each project, but the majority of the highest costing areas should be outlined. Many of the EIS already separated the major cost items, but, as stated previously, over a quarter of the projects did not break down the cost. The items could potentially be construction, right of way, utility relocation, bridge or structural work, earthwork, environmental mitigation, or others. This information will give the reader an understanding of where the costs are being expended. Moreover, decision makers and the public can easily distinguish between the positive and negative areas of each alternative's cost, and alternatives could feasibly be combined to merge the attractive areas of each option with regard to its cost.

6. State the cost estimation method.

Beneficiary: decision makers and transportation agencies

By stating the cost estimation method, decision makers can understand the level of detail that was placed in the estimate and how the estimate was formed. This research shows that 87 percent of the projects do not state the estimation method. If future projects include the estimation method, it will eliminate confusion when a range of cost values is presented. A cost range could signify that a risk analysis was performed on the estimate, or it could indicate the variety of results for a number of unresolved alternatives. The method of estimation should at least be stated, but it does not have to be described in detail. The environmental document can refer the reader to another reference for information on the estimation method to avoid making the documents unnecessarily cumbersome. This information would primarily benefit decision makers and transportation agencies rather than the general public because most citizens will not have a learned knowledge of estimating techniques.

7. Utilize risk based estimates when they are beneficial.

Beneficiary: decision makers, transportation agencies, and the general public

Risk based estimates require more time and resources to complete than traditional methods because they are based on more information; however, these estimates give a more realistic representation of the completed project. Literature suggests that a probabilistic cost range provides more accuracy than a single value estimate due to the high level of uncertainty at the beginning of a project. Over time, this increased accuracy will improve public confidence in the transportation agencies.

Depending on the risk based estimation method, an additional piece of information may be possible to help decision makers. Each item in the breakdown of costs could include the probability that the item will occur at various levels in the range. This improvement would also help transportation agencies in the tracking of costs and greatly aid the objective of building public trust and confidence in the public sector.

This research shows that only 4.5 percent of projects report the estimate as a probabilistic range. Because only a small number of projects in this sample use a probabilistic cost analysis, further research is needed in the area of risk based estimation at the environmental review stage. The questions should be asked: what is the cost of performing a risk based estimate as opposed to a traditional estimate, how much are projects utilizing risk based estimates more apt to saving money in the long term, and can risk based estimates become more widespread without negatively affecting future projects?

8. Form cost disclosure guidance.

Beneficiary: decision makers, transportation agencies, and the general public

Each project has its own intricacies and challenges, but each one has similar aspects that must be thoroughly analyzed. Creating guidance for information and presentation of cost estimates in EIS will help to ensure that each future project completes a thorough and reliable estimate. It will also ensure that the project leaders maintain an effort to be accountable to the public. More accurate information related to each step of the project can be shown in a formal way to readers. Moreover, when the estimate does change, the appropriate officials can point to the cause of the change. Further research and resources are needed in this area to address the guidance on cost estimation in EIS. The guidance should take all of these recommendations into account to form the best available estimates with regard to all the involved stakeholders.

9. Perform future research.

Beneficiary: decision makers, transportation agencies, and the general public

Many of the projects studied for this research effort have yet to be completed. In order to further discover the cost estimation problem during the environmental impact statement, the cost estimates for projects used as samples in this research should be compared to the actual costs of completed projects. When these data become available, the estimates presented in the environmental impact statements can then be compared.

The sample of projects for this research included only four projects that disclosed a risk based estimate. Another sample incorporating more projects that use risk based estimates would establish the effectiveness of risk based estimates during the environmental process. Significant comparisons between risk based and traditional estimates could then be made.

APPENDICES

A: Projects with Cost Escalation

Title	Available Documents (DEIS, FEIS, ROD)	Does it have Cost Escalation?
ICC I-270 to US 1	(DEIS, FEIS, ROD)	No
Improvements to the US Route 6 / Route 10 Interchange	DEIS, FEIS, ROD	No
Interstate 93 Improvements Salem to Manchester IM-IR-93-1(174)0, 10418-C	DEIS, FEIS	Yes
St. Croix River Crossing Project	SDEIS, SFEIS	No
US Highway 93 Somers to Whitefish	DEIS, FEIS, ROD	No
Interstate 86 / Route 15 Interchange and Route 15 / Gang Mills Interchange	DEIS, FEIS	Yes
Cumberland Head Connector Road	DEIS, FEIS	Yes
T-REX, Southeast Corridor	DEIS, FEIS, Draft Cost Methodology Report	Yes
US 412 Springdale Northern Bypass	DEIS, FEIS	Yes
Interstate 69 (SIU 13) El Dorado to McGehee Arkansas	DEIS, FEIS	Yes
Woodrow Wilson Bridge Improvement Study	DEIS, FEIS	Yes
San Francisco-Oakland Bay Bridge East Span Seismic Safety Project	DEIS, FEIS	Yes
Appalachian Corridor I-66	DEIS, FEIS	No
Interstate 29 Reconstruction	DEIS, FEIS	No
Fayetteville Outer Loop Corridor Study	DEIS, FEIS	No
Interstate 70 Corridor: Kansas City to St. Louis, Missouri	First Tier: DEIS, FEIS	No
M-59 Livingston County Widening Project	Tier Two: DEIS, FEIS (Tier One: FEIS)	No
Louisville-Southern Indiana: Ohio River Bridges Project	DEIS, FEIS	Yes
U.S. Route 219 Springville to Salamanca	DEIS, FEIS	Yes
Route 9A Project Lower Manhattan Redevelopment	SDEIS, SFEIS	No
State Route 120 Oakdale Expressway Project	DEIS, FEIS	No
Interstate 215 Improvements	DEIS, FEIS	Yes
Highway 9 Frisco to Breckenridge	DEIS, FEIS	No
Hampton Roads Crossing Study	DEIS, FEIS	No
Interstate 95 New Haven Harbor Crossing Project	DEIS, FEIS	Yes
Mississippi River Crossing: Relocated I-70 and I-64 Connector	DEIS, FEIS, ROD	No

Title	Available Documents (DEIS, FEIS, ROD)	Does it have Cost Escalation?
Replacement of the Cooper River Bridges on US 17 Over Cooper River and Town Creek Charleston County, South Carolina	DEIS, FEIS, ROD	No
I-405 Congestion Relief and Bus Rapid Transit Program	DEIS, FEIS	No
Willis Avenue Bridge Reconstruction	DEIS, FEIS	No
I-15, 31st St to 2700 North, Weber County, UT	DEIS, FEIS	No
Gravina Access Project	DEIS, FEIS	No
Eastern Corridor Multi-Modal Project	Tier 1: DEIS, FEIS, ROD	No
Kansas Lane Connector: Monroe, Louisiana	DEIS, FEIS, ROD	Yes
Boulder City Corridor	DEIS, FEIS, ROD	No
Vancouver Rail Project	DEIS, FEIS	No
Southern Corridor	DEIS, FEIS, ROD	No
Sakonnet River Bridge Project	DEIS, FEIS	Yes
Legacy Parkway Project	SDEIS, SFEIS, ROD	Yes
Capital Beltway Study	DEIS, FEIS, ROD	No
US 6	DEIS, SDEIS, FEIS, ROD	No
Cross Base	SDEIS, FEIS	Yes
United States Highway 2 US Highway 85 to West of US Highway 52	DEIS, FEIS	No
Nelsonville Bypass	DEIS, FEIS	Yes
U.S. 287/26	DEIS, FEIS	No
Fernan Lake Road Safety Improvement Project	DEIS, FEIS, ROD	No
U.S. Route 20	DEIS, FEIS, ROD	No
Wisconsin State Highway 83 Corridor Study	DEIS, FEIS	No
Bridge of Lions	DEIS, FEIS	Yes
Southern Beltway Transportation Project US 22 to I-79	DEIS, FEIS	Yes
I-75 From M-102 to M-59	DEIS, FEIS, ROD	Yes
State Highway 121	DEIS, FEIS	Yes
South Medford Interchange Project	DEIS, FEIS, ROD	No
Winston Salem Northern Beltway	DEIS, FEIS*	Yes
I-81 Corridor Improvement Study	Tier 1: DEIS, FEIS	No
Boardman River Crossing Mobility Study	FEIS (with summary of DEIS)	No
11th Street Bridges	DEIS, FEIS	No

Title	Available Documents (DEIS, FEIS, ROD)	Does it have Cost Escalation?
US 31 Study: Plymouth to South Bend	DEIS, FEIS, ROD	No
I-94 and Highway 10 Interregional Connection	DEIS, FEIS	Yes
California District 4 Devil's Slide Project	DEIS, FEIS	Yes
Carman Road to Monmouth, Illinois U.S. 34	DEIS, FEIS	No
Chicago - St. Louis High-Speed Rail Project	DEIS, FEIS	No
Spencer Creek Bridge: US Highway 101	DEIS, FEIS, ROD	No
Blowing Rock US 321 Improvements Project	DEIS, FEIS	No
I-29/I-35 Project	DEIS, FEIS, ROD	No
Round Lake Bypass	DEIS, FEIS, ROD	No
US 24: Napoleon to Toledo	DEIS, FEIS	No
Highway 1 Improvements at Pitkins Curve and Rain Rocks	DEIS, FEIS	Yes
California Route 905	DEIS, FEIS	Yes
Juneau Access Improvements	SDEIS, FEIS, ROD	Yes
Highway 371 North Improvement Project	DEIS, FEIS	No

B: Projects with Only a Final Environmental Impact Statement

Title
Butte 70, 149, 99, 191 Highway Improvement Project
El Dorado 50
I-94 Rehabilitation Project
Wisconsin State Trunk Highway 26
Milan Beltway Extension
US 89 Browning to Hudson Bay Divide
US 41 Expansion - Oconto to Peshtigo
US 67 Macomb Area Study
Lincoln Bypass, State Route 65
FAP 340 (I-355 South Extensión)
Interstate 69, Section of Independent Utility #9
Interstate 880, State Route 92 Interchange Reconstruction Project
Route 52 Causeway Bridge Replacement
Route 238 Hayward Bypass Project
Tacoma to Edgewood New Freeway Construction
Proposed US-31 Freeway Connection to I-94
I-73 Location Study Between Roanoke and the North Carolina State Line
Syracuse Road, 1000 West to 2000 West, Syracuse
SR-26 Riverdale Road from 1900 West to Washington Boulevard
Highway 23 Paynesville Bypass
State Route 22 / West Orange County Connection
US 395 North Spokane Corridor
Augusta River Crossing Study
Marin 101 HOV Lane Gap Closure Project
State Route 99 Safety and Operational Improvement Project
Route 46 Corridor Improvement Project
Los Angeles Union Station Run-Through Tracks Project
State Route 138 Widening Project from Avenue T to State Route 18 Junction
Lewis Road Widening Project (from Ventura Boulevard to Hueneme Road Bridge)
Third Main Track and Grade Separation Project on the Burlington Northern Santa Fe Railway Company East-West Main Line Railroad Track

C: Cost Estimation Data

All of the material in Appendix C is contained in the supplemental files.

D: FEIS Only Cost Estimation Data

All of the material in Appendix D is contained in the supplemental files.

E: Sample Interview Questions

1.) Could you explain the cost estimation process that is common for your state?

2.) Do you have a cost estimation manual to follow for transportation projects in general?

3.) Is there a cost methodology report for this project (*or any equivalent document that primarily describes costs that was released around the time of environmental documentation*)?

    If so, was it available for public review as the EIS were?

    If so, what criteria must be met for a project to get this special type of documentation?

4.) What was the project award cost?

5.) What percentage of the cost was allocated for contingency?

6.) How was the estimate revised from DEIS to FEIS?

7.) Are stochastic or risk-based or statistical estimating ever performed on transportation projects in your state?

    If so, how do these projects qualify for this form of estimating and how are the costs reported (as a range, range with probabilities of finishing within the given range, single value, etc.)?

    If there was a range in the final estimated cost for this project, how was the range determined? If it was risk-based, what probability range was selected?

8.) Are cost over-runs common on projects on which you work?

    Roughly, what percentage of projects would you say fits in this category?

9.) Are major projects estimated differently than minor projects? If so, in what ways do they differ?

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