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16. Abstract Reducing the duration from planning to delivery of major highway projects is a major goal of the Texas Department of Transportation. A key component of this is the quantification of duration of the Utility Adjustment process. This study quantified durations of historical utility adjustment projects to provide guidelines in estimating future utility adjustment project durations, modeled the TxDOT utility adjustment process, and compiled key lessons learned for transportation project planners to better understand and improve efficiency in utility adjustments.		
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Duration Quantification and Opportunities for Improvement in the Texas Department of Transportation's Utility Adjustment Process

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Chapter 1. Introduction

1.1 Need

As population has increased in the state of Texas, so has the demand for efficient delivery of infrastructure construction projects. In order to deliver projects in a more timely fashion, it is imperative that the processes that occur between initial conception of a project and its completion be understood. There are many such processes that are all integral parts of project development and delivery.

The Texas Department of Transportation's (TxDOT's) *Project Development Process Manual* includes a diagram that displays the following major processes that occur on a highway construction project: planning and programming; preliminary design; environmental; right-of-way (R/W) and utilities; plans, specifications and estimate (PS&E) development; and letting (TxDOT, 1999). Each of these major processes consists of a number of sub processes. The same chart indicates that projects may range from 3 to 20 years to develop depending on the successful completion of the processes. Understanding how each process can affect overall project development is crucial to improving project delivery.

1.2 Objectives

This research was undertaken in order to fulfill two objectives. The first was to investigate TxDOT's utility adjustment process and to develop a model of the overall process. Possible improvements in the utility adjustment process have been identified during model development and analysis.

The second objective of this study was to quantify the duration of utility adjustment on projects. A tool for duration prediction has been developed from this data analysis. The tool will be for the use of project planners in TxDOT during the early phases of project development in order to estimate the amount of time that will be required to relocate utilities.

1.3 Scope of Study

The scope of this study included the development of comprehensive process models for the TxDOT right-of-way and utility adjustment processes; development of duration metrics for critical tasks within the right-of-way and utility adjustment processes; and identifying recommendations for process and/or policy changes. This report focuses on the utility adjustment aspects while another report (Chang, 2005) reports on right-of-way aspects.

This study focused on TxDOT processes. While some of the background work examined transportation agencies in other states, the findings of this report are intended for (but not necessarily limited to) application in Texas.

It is recognized that right-of-way acquisition and utility adjustment are processes that are not only interdependent with each other, but are integral parts of overall project delivery and depend heavily on such other processes as design, environmental clearance, and project prioritization, among others. However, this study is limited to investigating utility adjustment and areas of other processes that directly affect or are directly affected by activities within the utility adjustment process.

1.4 Structure of Report

This report presents the findings of research regarding utility adjustments on highway projects. This first section is an introduction to the report and the need for the study.

Chapter 2 of the report consists of a review of current literature and research from a variety of sources regarding utility adjustment. A review of current practices by TxDOT is also included in the section and is based on documentation provided by TxDOT.

Chapter 3 provides an overview of the research methodology. Included in this section are discussions of the steps that were taken to perform the investigation of utility adjustment. Also included in the methodology section is a description of the data analysis that was performed, a characterization of the complete data sample, and an overview of the main factors that were investigated during this study.

Chapter 4 of the report presents the process model that was developed during this study. The main points of the model are discussed along with the diagram. The key milestones that were identified by the parties interviewed for this project are also discussed. The final part of this chapter describes the main utility durations that have been examined.

Chapters 5 through 7 present the findings of the data analysis. One chapter is devoted to the data for each of the three durations investigated. In each chapter, the data analysis is presented in the following order: analysis for all projects, analysis by project factor, and finally, a characterization of the length of typical utility adjustments by factor.

Chapter 8 is devoted to the proposed framework for the duration prediction tool that is being developed based on the data analysis findings. The discussion of the proposed advisory tool is not overly specific, but rather provides a general overview of the contents of the data prediction advisory tool.

The final chapter of this report will present the conclusions of the data analysis and recommendations for future activity.

Chapter 2. Background

2.1 Literature Review

Understanding why utility adjustment is an important issue to transportation planners is important in understanding how to improve utility adjustment. There are many components of a transportation project that impact the amount of time that it takes to deliver a project from planning to completion. Utility adjustment is one of the processes in a transportation project that, in conjunction with other processes, can impact overall project duration. In particular, utility adjustment depends on timely acquisition of right-of-way, which is discussed in another report (Chang 2005).

Transportation personnel were asked by researchers in TxDOT research project 0-4386 to identify methods to expedite different phases of highway construction projects. One of the methods identified in the project planning phase was expediting utility adjustment, where it was said that "Adjustment of utilities…can greatly affect project delivery times. Methods should be implemented to expedite this process." (Gibson 2002). Subsequent surveys of 62 TxDOT employees showed that, in their assessment, utility adjustment had one of the highest rated positive impacts, a rating of 2.85 out of a possible 3, as well as a relevancy rating of 2.95 out of a possible 3. While expediting utility adjustment was identified as a method that would positively impact project delivery, it was also recognized that improvements to utility adjustment may not be as doable as improvements in other processes during the project planning phase. The rating for utility adjustment improvements doability was 1.68 out of 3 (Gibson 2002).

The federal government has also recognized the importance of utility adjustment to project duration. Faced with increasing demand for highway funds directed towards utility adjustment, the General Accounting Office (GAO) performed a study that investigated the impact of utility adjustment-related delays on federal-aid highway projects. The study found that there were increasing delays due to utility adjustment and utility-related issues on federal-aid highway projects. The report makes note that the number of projects for which there were reported utility adjustment delays varied by state. The state of Texas, for example, reported utility related delays on no more than 20 percent of federal-aid highway construction projects, while some other states reported delays on more than 30 percent of such projects (Williams 1996).

Utility adjustment-related conflicts can have a great impact on highway contractors. A presentation at the 89th Annual Road School conference at Purdue University outlined the contractor's perspective of utility adjustment. From the contractor's perspective, utility-related contracts are very problematic. Contractors wary of potential utility-related conflicts often compensate for future lost-time by increasing their bids. However, since most highway contracts are awarded based on lowest bid, contractors "do not have the ability to put in significant contingencies and get the project" (Blair 2003). Qualified contractors may also choose not to bid on projects if they feel that there is a high likelihood of encountering utility conflicts, which has the potential to affect the quality of the work performed. After the award of a contract, unresolved utility conflicts can lead to lost time and productivity, and can also lead to subsequent damage claims against the state and an increased overall project cost.

It is worth mentioning as well that in addition to affecting highway contractors and state transportation agencies, utilities can have conflict with other utilities. Researchers at the

University of Florida looking into the existing best practices of state transportation agencies made note that "a utility company… may have to coordinate with other utility agencies within the same proximity and governmental entities" (Ellis 2004). The researchers also found that while project personnel may be able to resolve utility conflicts at the project level, there is a large consumption of management and supervisory time in the process.

In addition to understanding why utility adjustment is an important aspect of highway construction, it is important to understand the major causes of utility-related delays.

Looking at the causes of utility adjustment delays on federal-aid highway projects, the GAO found that the most commonly cited causes were: quick design/planning time frames, lack of resources to perform utility work, and poor timing and sequencing of adjustment work. The complete list of the reasons given for utility delays is presented in Table 2.1 (GAO 1999).

Table 2.1 Summary of Causes for Utility Adjustment Delays on Federal-Aid Projects

Reason	Number of States
Utility Lacked Resources	34
Short time frame for state to plan and design project	33
Utilities gave low priority to relocations	28
Increased workload on utility relocation crews because highway/bridge construction had increased	28
Delays in starting utility relocation work: some utilities would not start until construction contract was advertised or let	28
Phasing of construction and utility relocation work out of sequence	26
Inaccurate locating and marking of existing utility facilities	23
Delays in obtaining rights-of-way for utilities	23
Shortages of labor and equipment for utility contractor	19
Project design changes required changes to utility relocation designs	19
Utilities were slow in responding to contractors' requests to locate and mark underground utilities	16
Inadequate coordination or sequencing among utilities using common poles/ducts	13

The GAO also found that different states took different approaches to alleviating conflicts. The most commonly cited methods of managing utilities in public rights-of-way were: computer-aided design and drafting (CADD), geographical information systems (GIS), monetary incentives and penalties, special contracting, and in a few cases, legal action. The study found that monetary incentives were not contingent on timely completion of adjustments, that penalties were assessed on a case by case basis, and that only a couple of states (including Texas) had taken legal action to coerce utilities to relocate their facilities (GAO 1999).

The philosophy of how and where to accommodate utilities on public rights-of-way has changed several times historically. Recognizing an economic benefit to the public, utilities were allowed to occupy public rights-of-way in the early twentieth century, except along controlled access roads. After 1988, utilities were also allowed by the federal government to longitudinally occupy interstate highway rights-of-way, at the discretion and under the supervision of individual states. A National Highway Cooperative Research Program synthesis of existing practices in the mid 1990s offers a look at the different approaches and philosophies that state departments of transportation (DOTs) have taken to managing utilities in their rights-of-way.

In Texas, utilities have been only allowed to longitudinally occupy freeway rights-of-way if:

- The utilities met the policy exception put forth by the American Association of State Highway and Transportation Officials (AASHTO)
- The utilities could demonstrate that they could access their facilities from outside of the controlled portion of the freeway.
- It could be demonstrated that facilities located within freeway rights-of-way would not interfere with future roadway expansions. (Williams 1996)

TxDOT has also required all utilities occupying the freeway rights-of-way to locate their facilities in strips near the outer limits of rights-of-way. There was also concern noted about potential conflicts created by slow-moving utility equipment on the main lanes of the freeway, necessitating the requirement that facility access for maintenance and construction occur outside of the controlled lanes.

Looking for innovative approaches to managing utilities and utility adjustment in public rights-of-way, a delegation of U.S. transportation officials observed European right-of-way and utility management practices in early 2000. The delegation consisted of officials from the Federal Highway Administration (FHWA), AASHTO, the Transportation Research Board, the Michigan, Maine, and Washington State Departments of Transportation, a consulting firm, and representatives from the International Right-of-Way Association. The delegation visited England, Germany, the Netherlands, and Norway, and found that "While their governments and cultures differ, the countries share basic principles that guide the [Right-of-Way and Utility Adjustment] process" (Moeller 2002). The findings of the report were intended to shape the manner in which the FHWA and state DOTs work to resolve utility related disputes on highway construction projects.

During the survey, the delegation made note of seven practices by the different European transportation agencies that were either new to or non-uniform in U.S. state DOTs. In Europe, "Most of the countries make special efforts to enhance relationships between highway and utilities officials" (Moeller 2002); in other words, European transportation agencies stated that they placed an emphasis on developing good working relationships with utility companies. An example of this was in England, where the official procedures strongly emphasized face to face meetings between DOT and utility company officials rather than electronic correspondence. The delegation reported that coordination, cooperation, and communication with utility companies modeled after the approaches in Europe would greatly benefit U.S. transportation agencies.

Another practice that the delegation made note of is the increasing use of utility corridors. Utility corridors may include conduit placed under a roadway (either longitudinally or at crossing points) or joint trenches that may be used concurrently by multiple utilities. If a conduit is used, it may be installed by the highway contractor and the utility companies may place their facilities within it at a later date, reducing time delays for adjustment. These corridors provide an alternative in some cases to the traditional approach of requiring utilities to locate as close as possible to the right-of-way limits, and may be a better method of managing crowded rights-of-way.

Making great effort towards accommodation of existing utilities was a third approach towards managing utilities that the delegation noted. This approach involves making every effort during the design phase of a highway project to design around existing utilities, reducing the number of conflicts between highway design and utility facilities and leading to a reduction in necessary utility adjustments. An essential prerequisite for this is obtaining high quality, accurate information about the locations of existing utility structures within the right-of-way limits. One practice employed to keep current records of utility locations is the use of Geographic Information Systems (GIS). While programs are under way in the U.S. to implement GIS for utility-related applications, the programs are much more mature in Europe.

Other approaches to reducing the problems involved with utility adjustment and management included the use of Master Utility Agreements. These agreements are standardized agreements outlining the rights and responsibilities of both the transportation agency and the utility company, and are used in lieu of individual project agreements. The use of these agreements reduces the amount of time spent on developing and approving utility agreements on a highway construction project.

Locating utilities underground was also another practice that became a point of emphasis of the delegation. This practice improves a highway's safety and aesthetic appeal. The report did make note that, "Locating utilities underground… would be costly and difficult in areas with rocky or unfavorable soil conditions… Even so, European countries have proven it can be done…" (Meoller 2002). The report also made note that in 40 years of locating utility facilities underground, the Netherlands has made utility pole collisions virtually non-existent.

Having highway contractors perform utility work was another practice that impressed the delegation. In many cases a highway contractor's labor force can perform the required work, and in other cases the contractor may make use of pre-approved utility subcontractors. Another practice involved considering pipelines as a mode of transportation, since "using pipelines instead of trucks to transport essential products may be beneficial [in reducing highway congestion]" (Moeller 2002). Additionally, considering pipelines a mode of transportation may allow transportation agencies more latitude in highway design and utility accommodation. Still other practices involved minimizing pavement cuts for utility work to increase pavement service life and designating highways as "protected" to preclude new utility installations. The European survey team concluded that State DOTs should strongly consider adopting or expanding the practices that were observed in Europe.

In late 2003, AASHTO approved revised guidelines and best practices for utility adjustment. These guidelines are based on field experience and research investigations into the methods that different entities have chosen to accomplish utility adjustment. In addition, they incorporate the recommendations of the International Right-of-Way and Utilities European team and the Federal Highway Administration Utility Program. There are several guidelines and associated best practices presented (and later adopted) in the Best Practices draft report, pages 31 through 56 which are summarized below:

Guideline 1: Use current available technology to the greatest extent possible.

- State transportation departments should initiate more research and expand their use of GIS to map utilities.
- Collect Subsurface Utility Engineering (SUE) information early in the development of all highway projects, as well as:
    - Encourage the FHWA to continue its support of SUE
    - Keep good records of cost and time savings due to SUE
    - Follow the guidelines for SUE that has been established by the American Society of Civil Engineers.

Encourage the development of a CADD database and electronic transfer systems for permitting, and the transfer of plans and other documents between transportation departments and utility companies (Martin 2003).

Guideline 2: Encourage frequent coordination and communication with local governmental agencies to reduce delivery time, reduce costs, and improve quality in the utilities process.

- Minimize utility pavement cuts on State-maintained roads and streets. Additionally, better efforts need to be made to utilize non-destructive techniques to perform utility work where utilities are located underneath paving.
- Coordination with local agencies is critical as they have the ultimate responsibility for seeing that pavement cuts made for utility work are restored properly.
- Transportation agencies should work with local jurisdictions to ensure that utility work involving pavement cuts is efficiently carried out (Martin 2003).

Guideline 3: Encourage frequent coordination and communication with utility companies to reduce delivery time, reduce costs, and improve quality in the utilities process.

- Provide utility companies with long-range highway construction schedules.
- Host meetings with utility companies to discuss future highway projects.
- Recognize the importance of long-range highway/utility coordination.
- Organize periodic (monthly, quarterly, annual) meetings with utility owners within a municipality, county, or geographic or highway-planning region.
- Solicit information on utility owner’s capital construction programs, particularly where a utility’s planned expansion or reconstruction may encroach on and coincide with a planned highway project.
- Consider using the long-range planning meeting as a convenient forum to discuss other highway/utility issues, including accommodation policies, reimbursements, etc.
- Provide utility companies with a notice of proposed highway improvements and preliminary plans as early in the development of highway projects as possible.
    - This will allow utilities to budget for future adjustments

    - Transportation agencies must insure that utility companies understand that the dates of work outlined may be subject to change, and that no adjustment work should commence until a firm letting date has been established.

- Involve utility companies in the design phase of highway projects where major adjustments are anticipated.
    - Meet often throughout project development to coordinate ongoing activities.
    - Conduct on-site or plan-in-hands meetings with utilities in order to identify conflicts and propose resolutions.
    - Conduct a minimum of monthly meetings to keep all parties abreast of the status and latest developments in a highway project.
    - Cost effective advance planning is essential to utility companies now that competition exists under deregulation.
    - Engineers from state transportation agencies should meet individually with representatives from every utility company to minimize the possibility of a rejection of a utility's proposed adjustment plans and design.
- Involve utilities in the right-of-way design phase to assure that utility companies have room between the construction limits and the new right-of-way in which to relocate facilities.
    - Participate in local one-call notification programs to the maximum extent practicable per state law.
    - One-call centers should be utilized at an appropriate level of participation in order to protect underground facilities.
    - State transportation departments should become members of local one-call centers, even if not legally bound, if they own utility facilities for lighting, signalization, etc.
    - Damage prevention is considered by the FHWA to be a two part process involving SUE during the planning phase and One-Call notification during the construction phase of a highway project.
    - Invite utility companies to preconstruction meetings and encourage or require utility companies, contractors, and project staff to hold regular meetings, as deemed appropriate, during the construction phase of a project. The purpose of the utilities inclusion is to: establish contact with the transportation department's project manager and the contractor's organization, confirm the utility's physical adjustment plans, verify the utility's adjustment schedule, and to resolve other coordination details. Utility owners should be given sufficient advance notification of said meetings in order to facilitate their attendance. Separate pre-construction meetings involving department of transportation officials and utility companies and/or utility subcontractors may be held in order to address utilities' concerns.
- Take the lead in developing and supporting utilities coordinating committees (Martin 2003).

Guideline 4: Use or consider establishing utility corridors for utilities crossing major highways or located longitudinally along highway.

- Conduit can be placed within these corridors for future use by multiple utilities and/or joint trenching can be used to systematically arrange multiple utilities in the same trench.
- Continue to enhance utility pole safety programs by locating utilities underground. Currently many utilities are located underground for aesthetic reasons, but there are safety concerns that make underground location a sensible option.
- Consider utilizing pipelines along highway rights-of-way as a mode of transportation to carry freight.
- Consider cost sharing for utility adjustment expenses.
- Consider protected highway designation as a method to reduce and/or eliminate new utilities from occupying a highway right-of-way.
- Consider accommodating fiber optics and wireless telecommunications towers on highway rights-of-way for the purpose of enhancing the development and implementation of Intelligent Transportation Systems.
- Use standardized utility agreements that eliminate the need for approvals on each and every contract, therefore reducing the amount of time it takes to formalize agreements.
- Initiate separate contracts for advance roadway work on selected projects prior to utility adjustment. This may consist of, but is not limited to: clearing and grubbing, slope staking, monumentation, demolition of buildings, and advance grading. This would be particularly advantageous in the cases where utility adjustment work cannot begin until the advance roadway work has been performed, meaning that a separate contract for the advance work would allow utility adjustments to be performed prior to the letting of the final highway contract.
- Set forth responsibilities for appropriate action to reduce delays to contractors.
  - Rights and responsibilities of all involved parties should be clearly outlined and supported.
- Provide utility special provision language in the construction contract.
  - The special provisions outline the responsibilities of the department of transportation contractor in regards to cooperation with utility owners.
  - Special provisions provide a formal statement of the timing schedule and work windows between the contractor and the utility owner in cases where utility work will continue after the letting date of the highway project.
  - Statewide uniformity can be attained through standardized special provisions.
- Avoid late plan changes.
  - Late plan changes greatly impact the ability of utilities to perform adjustment work, often requiring changes in the accepted adjustment designs and materials ordering.

- Plan changes due to right-of-way acquisition have a similar effect on utilities.
  - Have highway contractors relocate utility and municipal facilities when possible.
- This option is not always practical, but it does offer potential advantages when it is available including: greater utilization of contractor's equipment and manpower, less duplication of effort on items such as traffic control, and lower bid prices by consolidating items such as excavation under a single contract.
- Considerations as to whether this is a valid option include the following: whether the utility work must be performed prior to or concurrent with highway work, whether the highway contractor can be reasonably expected to perform the utility work or if a pre-qualified utility subcontractor may be available, whether the utility work substantially alters the planned scope of the highway project, whether the utility owner and/or labor union policies allow a highway contractor to perform the work, whether or not there are potential efficiencies to be gained by consolidating the work, and if the necessary funding can be put into place.
- Issues such as work performance, standards, payment, inspection, and liability must be agreed upon and established prior to the contract award.

- Have highway contractors place conduit for utility companies during construction that can be utilized by utility owners at a later date for adjustment.
- Acquire sufficient right-of-way for utilities purposes.
  - When utilities are accommodated in a highway right-of-way, their needs should be considered in planning for land acquisition.
- Provide training to Department of Transportation utility staff and utility companies' staff.
  - Department of Transportation utility staff should be trained in and familiar with utility company design, estimating, billing, placement etc. to avoid confusion during utility adjustments.
  - Utility company staff should be trained in the processes and requirements of a Department of Transportation in order to facilitate future adjustment work.
- Highway designers should endeavor to avoid forcing utilities to relocate when they design a highway project, recognizing the impact on costs and timing of highway projects that adjustments have.
- Departments of Transportation should consider including utilities in design-build contracts (Martin 2003).

The University of Florida researchers reviewed and reported many of the same best practices as the International Right-of-Way Scan team and AASHTO. From the available data the researchers made the following conclusion: "… it should be clear that there is no single solution for solving the utility conflict and delay problem." (Ellis 2004). Rather than trying to find a "one size fits all" approach to resolving utility conflicts, the researchers felt that adopting guiding principles such as making utility adjustments "Safer, Simpler, and Smarter" (Ellis 2004) would be the best approach, and that best practices should be followed when possible.

Since many of the recommended best practices have been known for at least a few years, making note of the progress and effects of implementing the practices is important. Different State transportation agencies in the U.S. have been implementing the different best practices, and research is beginning to be published about the effects of the practices on utility adjustment.

Tracking the progress and effects of SUE implementation has been going on for a period of time. In the year 2000, an FHWA funded study was released from Purdue University that investigated the cost savings of using SUE on highway construction projects. The study investigated 71 total projects in Virginia, North Carolina, Ohio, and Texas that included the use of SUE. Test projects in Wyoming, Puerto Rico, and Oregon were reviewed as well. The projects investigated were both rural and urban projects.

There were several aspects to the SUE evaluation performed in this project. For a broad based picture, an analysis of each state's overall SUE program was performed. Input from State DOT officials was then solicited in order to select individual projects involving the use of SUE for study. In order to have control data to compare with, projects not using SUE that were of similar nature to the selected projects were studied. Once the projects were selected they were evaluated by the researchers looking at the following metrics: the number of change orders, the number of extra work orders, the number of delay and other claims, and any time extensions granted on projects.

One of the main problems identified by the researchers was the incompleteness/ inaccuracy of many utility drawings that were on record. This problem was more prevalent on older sites, where utility ownership had changed hands several times. In each state, contractors were required to notify utility owners prior to starting work (the "one-call") and give adequate time for utility owners to mark their facilities in the field. The field markings utility owners place for damage prevention often disagreed with the record drawings made available to the contractors. As the study says "Contractors know this will happen and typically increase their bid price…" (FHWA 1999). The impact of increasing bid prices have already been discussed as being problematic.

The benefits of using SUE that were identified by the study included, but were not limited to, the following:

- Reduction in unforeseen utility conflicts and adjustments;
- Reduction in project delays due to utility relocates;
- Reduction in claims and change orders;
- Reduction in delays due to utility cuts; and
- Reduction in project contingency fees.

At the time of the study Texas had only recently initiated a SUE program. The initial SUE contract in the state was for \$4 million over 2 years, but after initially positive results the contract was extended to \$9 million over 28 months. The SUE contract was limited to Interstate (on-system) projects with no municipal or local projects involved. At the close of the study in late 1999, 146 SUE projects had been accomplished in Texas. The researchers found that for every \$1 spent on SUE in Texas, there was an estimated savings of over \$4 during construction. The researchers calculated an annual savings from the use of SUE to be an estimated \$66 million (FHWA 1999).

The FHWA study found that while savings due to the use of SUE were less than some earlier DOT studies had concluded, the savings were still significant. The study also found that

SUE is a viable technology for use by State DOTs, and increased use “should result in a minimum national savings of approximately $1 billion per year” (FHWA 1999).

One of the other methods recommended as a best practice by AASHTO is the use of GIS and technology in the management of utilities in highway rights-of-way. The Texas Department of Transportation has decided to initiate a program that would use GIS to track installations of utility facilities. The program was developed under TxDOT research project 2110-1. The researchers evaluated existing TxDOT sources of information on existing utility locations, consisting mainly of drawings submitted with installation notices. What the researchers found is that, “There was considerable variability in the amount of information and level of detail included in the drawings,” (Quiroga 2002). The research also noted that even in the cases where drawings contained detail, it was still difficult to locate the exact locations of the facilities in the field. Because of this, the researchers developed a system to input utility installation spatial information into GIS based systems. At present this program is still in the implementation phase.

Other research sponsored by TxDOT also looks to address the use of the recommended best practices. TxDOT project 4149-1 investigated the potential use of utility corridor structures and other alternatives for accommodating utilities in TxDOT right-of-way. While the research was mainly concerned with the use of utility corridor structures, the use of multi-duct conduit and joint use trenching were also investigated. The study found that several states have used utility corridor structures, often in special situations, while other states have used joint occupancy trenches. The researchers did find that there are some statutory obstacles to implementing the use of utility corridor structures. The main obstacle noted in the research report is, “…the inability of TxDOT to purchase [right-of-way] for anything other than transportation purposes.” (Kuhn 2002). Other statutory obstacles exist that prevent TxDOT from implementing a program of using utility corridor structures *longitudinally* within state rights-of-way, although it may be possible to use such structures at locations where utilities cross a highway perpendicularly. In addition to looking at the possibility of whether or not TxDOT could use various alternative methods of accommodation, the researchers also looked at the costs vs. the benefits of each method they reviewed. The benefits that were common to the different methods of accommodation included: accurate knowledge of the location of utility facilities, reduction in space required for utilities within State right-of-way, and lower costs to individual utility companies. There were also disadvantages that were common to each method, especially the need for much better coordination between utilities. The study concluded that there are a number of cases and situations in Texas where the use of utility corridor structures or other accommodation methods would be practical and beneficial, but that there may need to be legislative change for some of these options to be used.

2.2 Problem Statement

Reducing the duration from planning to construction completion of a highway project can ensure that the benefits of the project are available sooner to the traveling public. The proposed effort described here involves a comprehensive process review and evaluation, development of a duration prediction tool, and identification of additional strategic advancements designed to expedite the TxDOT utility adjustment process.

In its August, 2001 report, the Texas Transportation Commission put forth the goal to streamline project delivery from project conception to ribbon cutting by 15 percent in five years (TxDOT 2001). Among others, two key recommended actions in that report were to anticipate right-of-way needs for future transportation expansion and streamline internal project delivery processes. Utility adjustment is a key process involved with reaching these goals.

2.3 Overview of TxDOT Utility Adjustment Process(es)

2.3.1 The Cooperative Management Process

The TxDOT utility adjustment manual provides a guideline for performing a utility adjustment project. This process, known as the Cooperative Management Process, is provided as a guideline to ROW personnel on managing utilities that occupy TxDOT rights-of-way. It outlines how to develop agreements, how to determine eligibility, and how to secure funding. The Cooperative Management Process in the utility manual is based on the Coordinated Solutions to Utility Conflicts course that TxDOT has been using in its training program for several years. There are four different processes that can be followed based on what type of adjustment project a particular utility falls under. These processes are the following: federal utility procedure, state utility procedure, local utility procedure, and non-reimbursable utility procedure.

2.3.2 Federal Utility Procedure

The Federal Utility Procedure is mainly intended for use on Interstate Highway projects. Under this procedure, utilities that have a compensable interest are typically fully reimbursed for in-kind adjustment work. The procedure involves nine steps. The steps are a combination of processes that are undertaken as well as specific events, such as securing certain documents. With no specified decisions in the process, it is the most streamlined of the processes that involve reimbursement to utilities by TxDOT. There are four documents that are required by the process: an early right-of-way release for utilities, an FHWA letter of authorization, the R/W release, and the FHWA Alternate Procedure approval. The processes that occur in between and after the securing of the documents are: field verification, prepare utility adjustment assembly for approval, perform utility adjustment, and the utility payment process. Complete descriptions of the documents and processes are available in the TxDOT ROW[1] Utility Manual (TxDOT 2004).

2.3.3 State Utility Procedure

The TxDOT State Utility Procedure may be applied on projects both with and without federal aid. This procedure removes the responsibility of handling utility adjustment work from any involved Local Public Agency (LPA). In addition, this procedure allows a Local Public Agency to escrow funds until the project is completed. TxDOT considers this procedure advantageous since right-of-way and utility adjustment activities remain the responsibility of TxDOT as opposed to the LPA. The procedure is slightly more complicated than the federal procedure, and involves either 10 or 12 steps, depending on whether or not federal aid is present. Of the 12 steps involved in this procedure, there are 6 processes, 2 or 4 documents needed, and 2 decisions. The processes involved are: field verification, LPA agreement to contribute funds, prepare utility adjustment assembly for approval, assembly approval, perform utility adjustment, and the utility payment process. The documents that are involved with this procedure are: early

[1] [1] The acronym "R/W" will be used to designate right of way when used as a common noun. "ROW" will be used when referring to the TxDOT Division or when used as a proper noun/adjective.

right-of-way release for utilities, FHWA letter of authorization and alternate procedure approval (federal-aid projects), and the right-of-way release. Complete descriptions of the documents and processes are available in the TxDOT ROW Utility Manual (TxDOT 2004).

2.3.4 Local Utility Procedure

Under the Local Utility Procedure, a Local Public Agency retains responsibility for acquiring rights-of-way and relocating utilities. If there is to be state or federal compensation or if TxDOT will assume responsibility for the maintenance of the roadway, the Local Public Agency must ensure that the work complies with TxDOT regulations. The Local Utility Procedure is the most complex of any of the major procedures both in the number of documents and the number of processes involved. In addition to the documents required in either the federal or state utility procedure, the local utility procedure requires a TxDOT-LPA R/W contract early in the process. The processes that are involved that differ from either the federal or state procedure are: eligibility determination, district approves utility consultant contract (if retained), LPA authorizes work, and determination of upper limit. Complete descriptions of the documents and processes are available in the TxDOT ROW Utility Manual (TxDOT 2004).

2.3.5 Non-Reimbursable Utility Procedure

Utilities that are required to relocate but have no compensable property interest are handled by the Non-Reimbursable Utility Procedure. Due to the lack of cost participation by TxDOT, there are not as many guidelines for the District Office to follow, and there is less documentation required. In these cases, however, it is still required that TxDOT and the utilities involved sign Joint Use Agreements accompanied by accurate drawings and construction schedules. In these cases the agreement is executed at the TxDOT District office only, except under a very few circumstances (e.g., exceptions for Utility Adjustment Process [UAP] and Utility Accommodation Rules [UAR]). Further information is available in the TxDOT ROW Utility Manual (TxDOT 2004).

Chapter 3. Methodology

3.1 Overview Flow Chart

Figure 3.1 displays the process that was followed on this research project. A detailed discussion of the tasks follows on the next several pages.

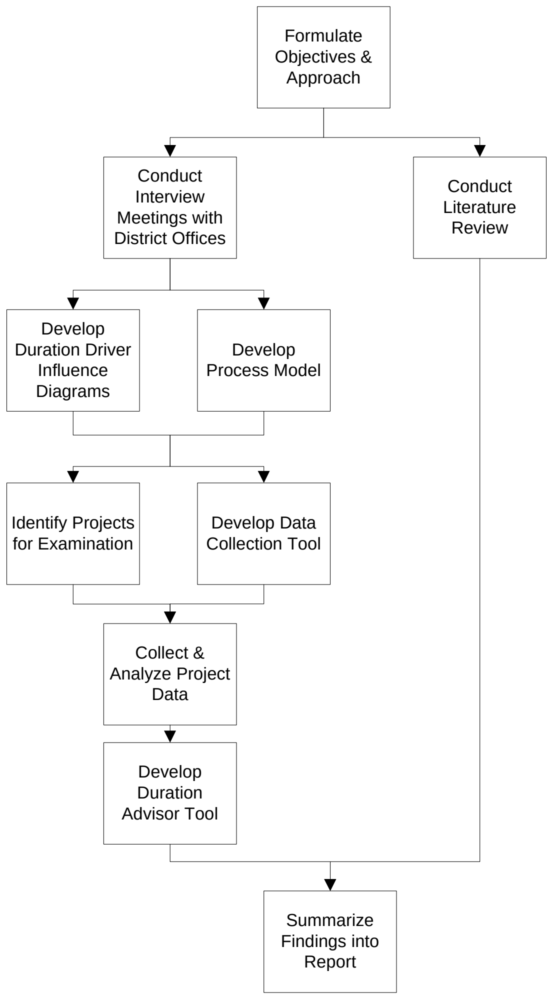


Figure 3.1. Research Methodology

3.2 Formulate Objectives and Approach

The initiation of this project consisted of the formulation of a research plan based on the objectives of the study. The objectives of the study came from a combination of the project proposal and feedback from the project sponsors at the initial project status meeting. It was decided at that meeting that this project would define a utility adjustment project as the adjustment of all appropriate utilities on a highway construction project, as opposed to that for a single utility adjustment. Other decisions made at the initial meeting also affected the direction of the research. It was decided that there would be no interviews with DOT officials in other states, as this study was designed to focus on how utility adjustments are performed in the state of Texas, which may be different both in practice and in statutory law from other states. The committee did, however, encourage the research team to examine publications from the FHWA and AASHTO that might be beneficial.

3.3 Conduct Literature Review

In order to understand the nature of utility adjustment, an extensive literature review was undertaken to review current practices and research related to utilities management and utility adjustment in public rights-of-way. A summary of the literature that was pertinent to the research is presented in Chapter 2.

3.4 Conduct Preliminary Interviews With District Offices and Utilities Personnel

The next step after reviewing a significant amount of literature was to schedule interviews with TxDOT district offices. From these interviews a process map would be developed that would record the actual steps taken to complete a utility adjustment project. This process map would be a comprehensive model that would incorporate the activities that utility companies and other third parties pursue in the course of utility adjustment. The interviewees were also asked to identify critical and problematic activities within the utility adjustment process. The initial contacts for these interviews were TxDOT district R/W and design personnel; in many of the meetings, however, representatives of some of the larger utility companies in the state and some utility adjustment consultants attended as well. This representation provided perspectives on trouble areas and factors that affect the utility companies themselves.

Overall, there were seven meetings at six different district offices with the intent to develop or revise the process model. The offices visited were mainly urban/metropolitan districts, although there was a meeting held at a primarily rural district as well. In addition, there was an interview conducted with the head of the TxDOT Map, Survey, and Utility section of the ROW Division office, and interviews with members of the State Highway 130 project.

3.5 Develop Utility Adjustment Process Model

The aforementioned process model was developed based on feedback from the district meetings. The development underwent several iterations, as there were minor differences in how utility adjustments were performed in each district visited. The model also incorporated portions of the Cooperative Management Process detailed in the revised TxDOT ROW Utility Manual

[TxDOT 2004]. The model is intended to complement rather than replace the TxDOT utility adjustment process. The final process model is found in Chapter 4.

Three key utility adjustment durations were also identified from the new model with the assistance of the project sponsors. These durations serve as the basis for the prediction tool.

3.6 Develop Duration Driver Influence Diagrams

During the development of the process model, meeting attendees were asked to identify key activities and strings of activities. Once these had been identified the interviewees were then asked to provide information as to the major drivers of duration for the activities that had been identified. From this information several influence diagrams were developed that helped to identify drivers and potential factors for analysis. The influence diagrams are located in Appendix E.

3.7 Identify Utility Adjustment Projects for Study

After the utility adjustment model had been refined and the key durations identified, a survey was developed and sent to all TxDOT district offices, soliciting three “quick” and three “slow” utility projects (designated by right-of-way control-section-job [CSJ] numbers) that had been completed in each respective district in the past five years. The survey also requested that the district office provide a list of factors that influenced the duration of each project, either shortening or lengthening the amount of time the project took. The survey (and subsequent follow-up correspondence) originated from the TxDOT ROW Division office at the TxDOT Riverside campus in Austin but directed that responses be sent to the University of Texas research team. As the responses were accumulated, a list of projects to investigate was assembled.

3.7.1 Sampling Techniques

The projects that were studied during this research were selected based upon the projects identified in the district office survey rather than being randomly selected. The districts were asked to identify projects that were considered either “quick” or “slow”, in order that the extreme cases of utility adjustment could be studied.

3.7.2 Characterization of Sample

In all, 82 projects were identified from the surveys that were sent to district offices around the state. The sample can be distinguished by a number of different factors, based on data collected from utility project files in the ROW Division office. Table 3.1 provides the characterization for all projects that were identified in the survey and subsequently examined.

Table 3.1 Characterization of All Examined Projects

By Districts	n	% of total	By Projects	n	% of total
Total Districts Responding	16	100	**Total Number of Projects Surveyed**	83	100
Rural Districts	7	43.75	Total Number of "Quick" Projects	34	41.0
Urban or Metro Districts	9	56.25	Total Number of "Slow" Projects	49	59.0

The dates required for duration calculation did not exist in all examined project files; therefore, not all examined projects were used for further data analysis. Table 3.2 is the characterization of the examined projects for which there was sufficient data to calculate at least one of the three key durations.

Table 3.2 Characterization of All Projects with Duration Data

	n	% of total
Total Number of Projects	67	100
"Quick" Projects with Duration Information	25	37.3
"Slow" Projects with Duration Information	42	62.7
Reimbursable Projects	55	82.1
Non-Reimbursable Projects	12	17.9
By Project Location Category		
Rural	24	35.8
Urban	22	32.8
Metro	21	31.3
By Highway Type		
Farm-to-Market/Ranch-to-Market Road (FM/RM)	21	31.3
State Highway	13	19.4
US Highway	22	32.8
Interstate	9	13.4
Other	2	3.0
By TxDOT Project Type		
BR (Bridge Replacement)	3	4.5
CNF (Convert Non-Freeway to Freeway)	6	9.0
HES (Hazard Elimination & Safety)	3	4.5
INC (Interchange - New or Reconstructed)	5	7.5
MSC (Miscellaneous)	6	9.0
NLF (New Location Freeway)	1	1.5
NNF (New Location Non-Freeway)	3	4.5
OV (Overlay)	2	3.0
RER (Rehabilitation of Existing Road)	9	13.4
UGN (Upgrade to Standards Non-Freeway)	2	3.0
UPG (Upgrade to Standards Freeway)	1	1.5
WF (Widen Freeway)	2	3.0
WNF (Widen Non-Freeway)	20	29.9
Unverifiable	4	6.0

	n	% of total
By Funding / Agreement Method		
Projects with at least 1 Date of Eligibility	36	53.7
Reimbursable Projects with NO Date of Eligibility	19	28.4
Unverifiable / Nonreimbursable	12	17.9
Projects with Local Public Agency Funding	36	53.7
Projects without Local Public Agency Funding	15	22.4
Unverifiable / Nonreimbursable	16	23.9
Federally Funded Projects	11	16.4
Non-Federally Funded Projects	41	61.2
Unverifiable / Nonreimbursable	15	22.4
By Number of Involved Utilities		
1 Agreement Only	12	17.9
2 Agreements Only	13	19.4
3 Agreements Only	8	11.9
4 Agreements Only	7	10.4
5 Agreements Only	5	7.5
>5 Agreements	11	16.4
Unverifiable	11	16.4
Average Number of Utilities: 4.5		
By Different Types of Utilities Involved on a Project		
Extend Casing	11	16.4
High Pressure Gas	20	29.9
Liquefied Petroleum	7	10.4
Low Pressure Gas	6	9.0
Overhead Power	35	52.2
Sanitary Sewer	8	11.9
Underground Communications	25	37.3
Underground Power	7	10.4
Water	32	47.8

3.8 Develop Data Collection Tool

Prior to investigating the projects identified from the survey, it was necessary to develop a plan and a data collection tool based on information available from TxDOT. An initial investigation of a few of the project files was conducted with the intent to identify what data would be reliably available from the utility adjustment files at the ROW Division office in Austin. Based on the results of the initial investigation and an interview with members of the Map, Survey and Utilities section of the ROW Division, a collection tool was developed (Appendix C). This form was used to collect utility-related project data. Since most utility adjustment projects involve more than one utility agreement/adjustment, a second page was used in order to track the data collected and compare recorded dates.

The project files were examined for data that would allow for the calculation of three key durations as identified by the research committee. In order to calculate these durations it was necessary to obtain the R/W Release date, the date of the final agreement execution, and the date of the final adjustment completion. The durations of interest involved the difference in time between these dates. A detailed discussion of the three durations is provided in Chapter 4.3, as well as a visual representation of the meaning of the durations.

Hypothesized duration-affecting factors that were actually analyzed are presented in Table 3.3. In addition to the factors analyzed, the possible options for each factor are also included.

Table 3.3 Data Analysis Factors

Factor	Possible Selection
Duration Assessment	Quick or Slow
Highway Type	Interstate, US Highway, State Highway, FM/RM
Location Category	Urban, Metro, Rural
TxDOT Project Type	BR, INC, WF, WNF, CNF, NNF, BWR, NLF, UGN, UPG, OV, MSC, SC, RER
Length of Project	Length in Miles
Federally Funded	Yes or No
Local Public Agency Funded	Yes or No
Reimbursable	Yes or No
Date of Eligibility Used	Yes or No
Number of Involved Utilities	The number of different agreements involved
Types of Utilities	Cap & Removal Pipeline, Extend Casing, High Pressure Gas, Irrigation Pipeline, Liquid Petroleum Line, Low Pressure Gas, Microwave Tower, Overhead Communications, Overhead Power, Sanitary Sewer, Sewer Line, Transmission Pole, Transmission Tower, Underground Communications, Underground Power, Utility Joint Use Agreement Only, Wastewater, Wastewater Pump Station, Water, Other

Table 3.4 provides an explanation of the abbreviations for the different construction project types listed in the factor options.

Table 3.4 TxDOT Construction Project Types

Abbreviation	Explanation
BR	Bridge Replacement
BWR	Bridge Widening or Rehabilitation
CNF	Convert Non-Freeway to Freeway
HES	Hazard Elimination & Safety
INC	Interchange - New or Reconstructed
MSC	Miscellaneous
NLF	New Location Freeway
NNF	New Location Non-Freeway
OV	Overlay
RER	Rehabilitation of Existing Road
SC	Seal Coat
UGN	Upgrade to Standards Non-Freeway
UPG	Upgrade to Standards Freeway
WF	Widen Freeway
WNF	Widen Non-Freeway

3.9 Collect and Analyze Data

From June 2004 through February 2005 a number of visits were made to the TxDOT ROW Division office in Austin in order to collect duration and factor data for the targeted projects. The data was gathered from three different sources at the TxDOT office. The first source of data collected was the ROW Division's utility database, which is recorded in Microsoft Access. Updated copies of the database were provided through October 2004. Following initial screening of the CSJ-related data in the database, the utility agreement paper files were reviewed. Since some factor-related data was not available from the agreement files, the TxDOT Design and Construction Information System (DCIS) database was also reviewed to fill in missing data. Following collection of data onto the data collection forms, the data was entered into Microsoft Excel for analysis. A specific description of the analysis performed follows.

Three key utility durations of interest were calculated using the DATEDIF Excel function. Projects with insufficient data for calculating any of the three major durations were not considered for any subsequent analysis. Following the calculation of the key durations, the data was then sorted according to the different analysis factors and further specific analyses were conducted.

All factor data was characterized with three descriptive statistics: mean, minimum, and maximum. Provided the sample investigated was sufficiently large, the standard deviation and specific percentile values were calculated as well. Specifically, the following guidelines were used: for $7 \leq n \leq 15$ the standard deviation and quartiles were computed, for $n \geq 16$ the standard deviation, deciles, and quartiles were calculated.

With the descriptive statistics completed, cumulative duration plots were made. These plots were only made for factors with an $n \geq 7$ and provide a visual representation of the data. In addition, the cumulative duration plots are included for all three calculated durations without regard to factor.

For the duration between the R/W Release date and the completion of the final adjustment, difference in means testing was also performed for selected factors. The specific test used was the Analysis of Variance (ANOVA), and was used only when comparisons could be made between factors with $n \geq 9$ for the samples being compared. The actual computation was performed using the Excel add-in program StatPro. ANOVA is the appropriate test to apply when comparing the means of two or more samples for statistical difference (Albright 2003).

3.10 Development of Duration Advisor Tool

A key product of this research is the development of a utility adjustment duration advisor tool. This tool will be available to TxDOT personnel to use in making utility adjustment duration estimates for future projects. Tool development steps included conceptual tool design, tool creation, and tool testing.

3.11 Summarize Findings into Report

In order to communicate the results of the research an organized report was written. This report summarized the findings from the literature review, district interviews, the district CSJ project survey, and data analysis.

Chapter 4. Utility Adjustment Project Process

4.1 Process Model from Research (Deployment Format)

When this research was initiated, there was no comprehensive diagrammatic utility adjustment process model within TxDOT. The Utility Adjustment Process presented in this chapter was developed from information gathered from several interviews with TxDOT officials and representatives from utility companies from around the state. There are tie-ins within this model to TxDOT's documented Cooperative Management Process (TxDOT 2004), and this model is meant to supplement rather than replace existing process models. The model is presented in deployment form as Figures 4.1 and 4.2, with the activities organized vertically by the responsible party. A full-size version of the process is included as an enclosure within the report.

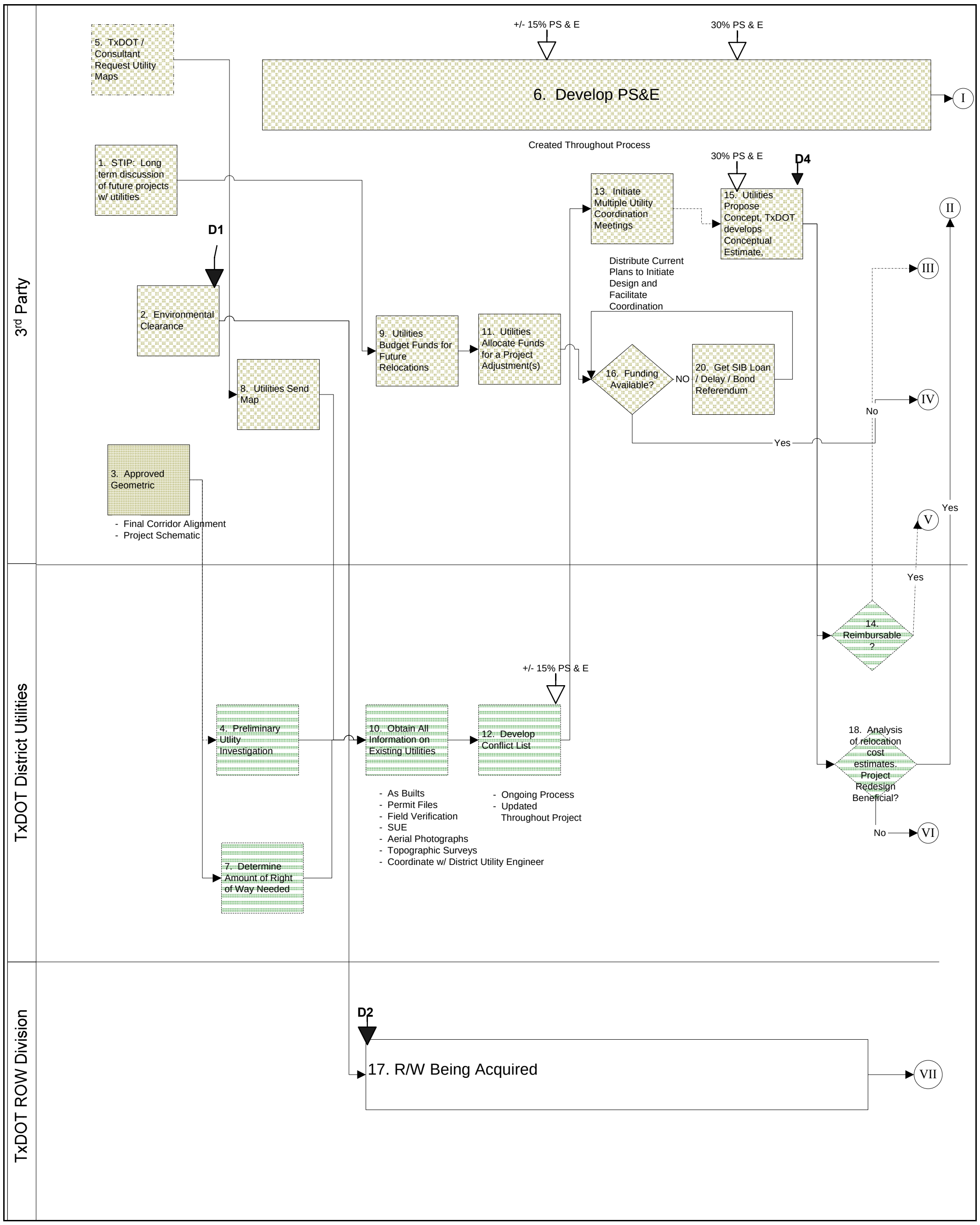


Figure 4.1. Utility Adjustment Process Model Part A

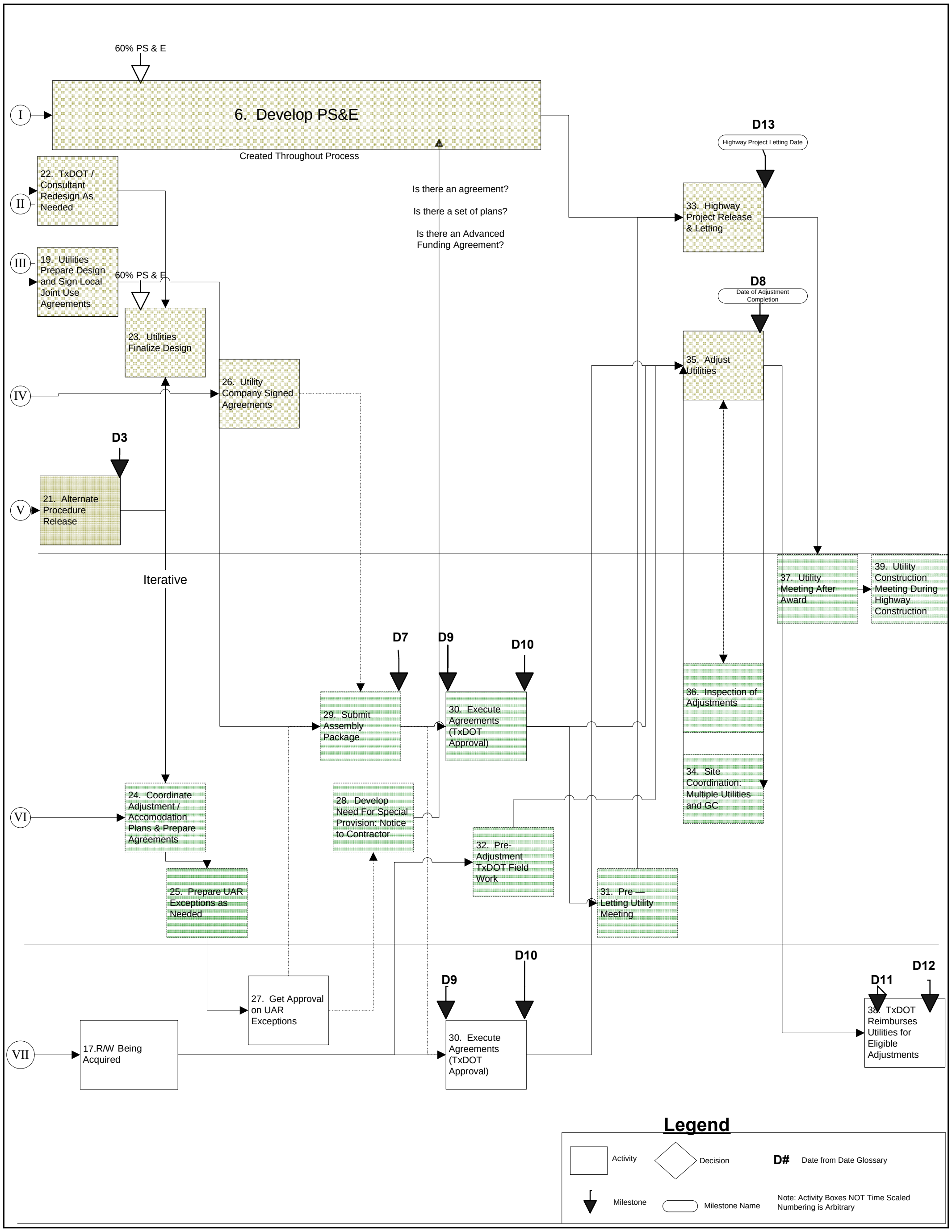


Figure 4.2. Utility Adjustment Process Model Part B

The process model flows from left to right across the page, with the activities on the left occurring before the activities on the right. As part of the comprehensive view of the utility adjustment process, and how it ties in to other TxDOT processes, some of the first activities depicted include the Strategic Transportation Improvement Plan (STIP), the environmental clearance process, and utility budgeting. These processes were included as activities to show that utility adjustment does not occur in a vacuum during project development, but rather is an integral part of project development. Another process that is partially represented that in many ways parallels utility adjustment is the right-of-way acquisition process. It was important to include this as utilities typically cannot relocate facilities until sufficient additional right-of-way has been purchased by TxDOT.

The starting point for the process can be considered to be the point at which there is an approved highway schematic/geometric. At this point, much subsequent work can commence. Even though officially the environmental clearance formally occurs after the approved geometric, the project alignment is fairly certain at this point.

Another key observation from the model is that much of the adjustment-related activity occurs outside of the control of TxDOT district and division personnel. Because of this, it is essential that there be good coordination and communication between TxDOT and involved third parties, such as utility companies, municipal agencies, and design consultants. On the process diagram, any time a handoff in responsibility occurs, the connecting line between activities is dashed; representing that control over the process at that point is passed between entities.

There are several decision activities in the process that were identified by district R/W and utility company representatives. The first decision is whether or not a utility adjustment is reimbursable. If it is not reimbursable, the number of activities that will be involved decrease, as the main action following this decision is the execution of joint use agreements. Another decision that is made involves evaluating the costs of redesigning a highway system prior to construction versus the costs of relocating utilities. It was mentioned in the district interviews that in the cases where forcing a utility to relocate its facilities is more costly than the proposed construction project, then the highway project is redesigned in order to accommodate the existing utility. This may also be done in cases where the involved utility companies either do not have the resources to perform necessary work, or when the anticipated duration of the utility work will significantly impact the ability of TxDOT to let the project for construction in a timely manner.

Another decision that is depicted in the process involves the cases when utilities do not have adequate funding to perform an adjustment. If this is the case, extra time will be required for the utilities to obtain funding. One method that has been implemented by the State of Texas to help alleviate this problem is the creation of the State Infrastructure Bank (SIB), which provides loans for such work from the state's general fund. The SIB was developed primarily for such cases when the utility involved is a municipality or county, for which the only other option for obtaining needed funding is holding a bond election. District personnel expressed that SIB loans have helped to alleviate this problem somewhat.

As depicted in the model, toward the end of the utility adjustment process the responsibility for many activities returns to TxDOT. Execution of utility agreements occurs at both the district and division levels, at which point utility companies are able to initiate their physical adjustments. The responsibility for inspecting utility installations for compliance with the Utility Accommodation Rules (UAR) lies with TxDOT. TxDOT is also responsible for continuing the multiple utility coordination meetings after a project is let. The overall adjustment project ends when reimbursements have been made for eligible adjustments; however, the actual date at which a project is considered complete for highway construction purposes is the date that the last utility adjustment is completed. The payment process may take months (or even years) after the last adjustment is completed, depending on the timeliness of billing submittals.

It is important to note that there has been no depiction of the Date of Eligibility (DOE) procedure on the process diagram. This is because the DOE procedure is considered a non-traditional emergency procedure that is to be used only in situations such as the uncovering of an unknown/unidentified utility during highway construction. The use of the DOE procedure in comparison with past practice is now highly restricted by TxDOT's ROW Division.

4.2 Key Milestones within the Process

During the district interviews portion of this study, participants were asked to identify key milestones in the utility adjustment process. The milestones that were identified are presented in Table 4.1 with accompanying explanations. In addition, the milestones are identified on the process model with their "D" numbers (the letter "D" represents "Date").

Table 4.1 Key Milestones from the Utility Adjustment Process

Number	Name	Definition
D1	FONSI	Finding of No Significant Impact - the date at which environmental clearance is granted.
D2	Right-of-Way Release Date	The earliest date (with a few exceptions) that TxDOT can officially begin logging work hours on a right-of-way or Utility Adjustment Project.
D3	Alternate Procedure Date	This is the date of approval for the federal alternate procedure on a highway project.
D4	Initial Estimate Submitted	The date that the utility company submits an initial estimate of cost and schedule, this may accompany an agreement submittal.
D5	Estimated Date of Agreement Submittal	The estimated date that the utility will have an agreement ready for submittal to TxDOT.
D6	Estimated Start Date of Adjustment	The estimated start date of physical work on a utility adjustment.
D7	Actual Date of Agreement Submittal	The date that a utility agreement assembly was submitted to TxDOT by a utility.
D8	Actual Date of Adjustment Completion	The completion date of any utility work in the field.
D9	Date Agreement Review Started	The date that TxDOT begins reviewing a submitted utility agreement assembly. This happens at both the district and division level.
D10	Date of Agreement Approval	The date that TxDOT approves a utility agreement, allowing a utility to begin field work. This occurs at both the district and division level.
D11	90% paid date	Following the submittal of a final bill to TxDOT, the date of initial payment (10% of payment is withheld pending audit).
D12	Final Payment Date	The date that TxDOT pays the remainder of any reimbursable utility costs post audit.
D13	Highway Project Letting Date	The date that TxDOT lets a highway construction project.

4.3 Utility Adjustment Durations

Initial Analysis of project-specific utility adjustment data targeted four durations of key interest. These durations are designated as U1, U2, U3, and U4. Each of these durations was obtained by computing the difference in time between three different milestone dates (when available): R/W project release date (D2), the date the last utility agreement assembly was executed (D7), and the date of the final utility adjustment completion (D8). Table 4.2 explains the key durations in detail while Figure 4.3 presents the key durations visually. The research committee later decided to drop calculation of U4, due in large part to difficulty in obtaining information (although some preliminary calculation is summarized in Appendix D).

Table 4.2 Key Durations Definitions

Duration	*Explanation*	*Time Computation*
U1	Time between Right-of-Way Project Release Date and the Final Agreement Execution Date	D10 – D2
U2	Time between the Final Agreement Execution Date and the Final Adjustment Completion Date - Traditional Projects	D8 – D10
U3	Time between the Right-of-Way Project Release Date and the Final Adjustment Completion Date	D8 – D2
U4	Time between the Final Adjustment Completion Date and the Final Agreement Execution Date – when DOE Adjustments are the Final Completed Adjustment	D10 – D8

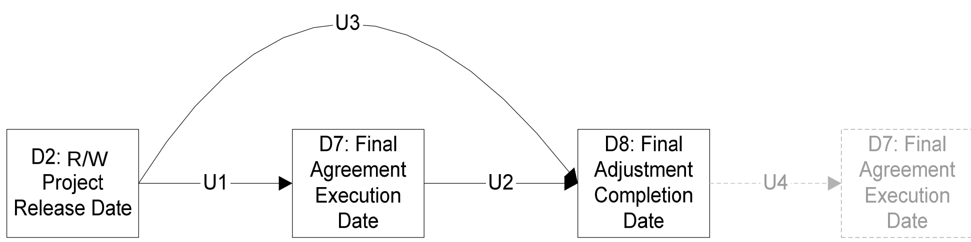


Figure 4.3. Key Durations Visual Representation

4.4 District Interview Results

The district office interviews were productive not only in developing the previously discussed utility adjustment process model, but also provided a wealth of information as to the main issues, drivers, and factors affecting the utility adjustment process. The information from the meetings is arranged according to whether it applies to utility adjustment planning, design, construction, or close-out phase, or if it applies generally to the whole process.

General Notes on Utility Adjustments:

- A good working relationship with utility companies greatly facilitates coordination and cooperation. Familiarity between utility company personnel and TxDOT ROW Division staff is essential.

- There can be significant difference between two utility adjustment projects; therefore, it is unlikely that there is a “one size fits all” approach to performing adjustment work, although there should be a guiding philosophy and a framework for performing the work that can be adapted to meet the needs of each project.
- The Date of Eligibility procedure that was intended to expedite utility adjustment when uncharted utilities are uncovered during highway construction has been overused by districts in non-emergency situations to the point that it has become very problematic.
- The use of the Date of Eligibility procedure is being strongly discouraged by the ROW Division office, which is being much stricter on the granting of Date of Eligibilities.
- Given that some Date of Eligibility causes will always exist, it may be wise to revise and rename the procedure in ways that more accurately reflect its purpose.
- TxDOT’s Cooperative Management process is used as a guideline for how to develop assembly packages, but a strict adherence to the process is sometimes difficult given the unique nature of each utility adjustment project.
- Much of the work that TxDOT does on an adjustment project is performed at Area Offices. Coordination between the District Office and Area Engineers is, therefore, important to a successful adjustment project.
- It is much easier for utility companies to perform work if the adjustments are fully reimbursable.
- TxDOT encourages its District Offices to follow AASHTO’s best practices for utility adjustments.
- TxDOT has set a goal for the completion of 75% of all utility adjustments prior to highway construction letting, consistent with AASHTO guidelines.
- The following have been identified as major drivers of utility adjustment projects:
    - The level of congestion (improvements, utilities, businesses, etc.) existing within project right-of-way.
    - The presence of experienced and knowledgeable personnel in TxDOT District and Area Offices.
    - The number of public agencies that are involved with utility adjustments, such as municipal governments, county utility coordination boards, etc.

Utility Adjustment Planning Phase:

- It is much easier to expend resources in tracking all necessary utility-related information (maps, plans, and design information) before submitting an assembly package than it is to submit an incomplete assembly package, have it rejected, and have to perform extra work and re-submit the package.
- One of the most difficult steps in the adjustment process for both TxDOT and utility companies is obtaining information on what utility facilities are located in an right-of-way project.

- Utility “permit” files are a first stop for obtaining information; however, the records are often incomplete and/or out-of-date. Another difficulty with “permits” is the manner in which they are filed, by date rather than by location.
- On more complex projects some utility companies may be willing to assist in hiring a SUE contractor, as utilities have conflicts not just with TxDOT but with each other as well.
- Highway designers can better identify conflicts and plan accommodation if they have accurate information about utilities early in a project.
- Splitting a highway project into multiple segments creates difficulties for utilities, as they may be unable to phase their adjustment work to match the phasing of the highway construction.
- TxDOT can and should perform more preliminary utility work during the time period that environmental clearance is being obtained. Within six weeks of the issue of a FONSI (Finding of No Significant Impact) the final corridor should be well defined, so preliminary investigation and initial information exchanges with utility companies can and should occur. Several utilities complained about receiving such information too late in the overall process, which causes subsequent delays.
- It is important during preliminary project planning to ascertain whether or not any endangered/protected species occupy the area affected by a construction project. Even when this is done, problems may be encountered if such species take up residency in the area after the environmental clearance has been issued.
- Utility companies typically operate on a different fiscal calendar than TxDOT, creating some challenges in funding adjustments.
- Since TxDOT cannot purchase right-of-way for the sole purpose of accommodating utilities, multiple-utility-coordination is critical to project success.
    - The following has been identified as a major driver of the utility adjustment planning phase: Ability to acquire accurate information about utilities within a project corridor.

Utility Adjustment Design Phase:

4.4.1 ROW Division personnel (who are the main point of contact with utilities) are often not given information about proposed drainage design until late in a project, even though drainage design work is done throughout the design process. Earlier communication of hydraulic design to ROW personnel and utilities would help to expedite utility adjustment work.

4.4.2 Utilities will not commit to a design until highway hydraulic designs are complete (the so-called “plans adequate for design” stage). Designing hydraulics earlier in a project, or communicating the finished design sooner would allow utilities to begin their work earlier as well.

4.4.3 Even if all work is done well and coordinated with utilities, politics can affect the schedule of a project by limiting the amount of available right-of-way (as evidenced by late design additions such as sound walls) and necessitating a redesign of utilities to be relocated.

4.4.4 TxDOT will redesign a project if the financial impact to a utility is so great that adjustment is impractical, or if it can be demonstrated that the safety of the public will not be jeopardized by leaving the utility in place and a policy exception is granted. This is not a common occurrence.

4.4.5 Communicating highway design changes electronically greatly reduces the amount of time required for utilities to adapt their designs.

4.4.6 Late additions of drainage facilities such as detention ponds can impact the ability of certain utilities to perform adjustment work in the allotted timeframe.

4.4.7 The duration of an adjustment project can be greatly extended due to utility need to either redesign their project or the need for TxDOT to redesign the highway/highway features.

4.4.8 Design consultants for TxDOT have the responsibility to notify utilities of new highway design, but that is not always done in a timely manner.

4.4.9 Tracking the progress of utility agreements and plans greatly assists coordination efforts.

4.4.10 Under certain circumstances, some utilities should be able to determine new horizontal alignments based on highway project schematics and do not need to wait for the hydraulic design to be complete.

4.4.11 The following have been identified as key drivers of the utility adjustment design phase:

- Possession of accurate information about utilities within a project corridor.
- The completeness of the TxDOT project design and its availability to utility designers.
- Utility design performed in-house by the utility company or out-sourced to consulting firms.
- The completeness and communication of hydraulic design.

Utility Adjustment Construction Phase:

- The time of year a utility adjustment occurs can affect its duration as it is more difficult for utilities to relocate facilities during peak demand seasons (summer for electric, winter for gas, etc.).
- On complex, large projects the use of a GEC (General Engineering Consultant) can alleviate problems with utility/contractor coordination.
- Having contractors install utility conduit at major intersections and interchanges may help alleviate work schedule conflicts between contractors and utility companies, as the utilities can run cable, etc. through the conduit at a subsequent date that is convenient to all parties.
- Different types of utilities take different amounts of time to physically relocate, due in part to legal regulations, operational constraints, and fiscal budgeting constraints.
- Utility companies have an easier time relocating their facilities if they are reimbursed as work is completed.
- The physical length of a construction project appears to have little impact on utility adjustment duration.
- Having a team of full-time utility inspectors greatly assists with quality and plan control.

- The following have been identified as key drivers of the utility adjustment construction phase:
  - Work phasing on TxDOT projects.
  - The amount of time required to acquire or by other means obtain right-of-way drives the duration of utility adjustment, as no adjustments can be completed until all right-of-way has been procured.

Utility Adjustment Close-Out Phase:

- Ensuring and documenting that utilities locate their facilities where they have indicated they will is important, as improperly relocated utilities create subsequent conflicts and delays, which can lead to legal action by TxDOT or other entities.

Many of the points in the above list were brought up in discussions at multiple districts. This indicates that while individual offices may differ slightly in how they handle utility adjustments, there is some consensus on the factors that affect utility adjustment, and associated opportunities for adjustment performance advances.

Chapter 5. Data Analysis for Duration U1

The data analysis for duration U1 is presented in this chapter. As is defined in Chapter 4.3, duration U1 is the time between the R/W Release Date and the Last Agreement Execution Date.

5.1 All Projects

Looking at the total sample of projects with data for duration U1 yielded the statistics presented in Table 5.1.

Table 5.1 Descriptive Statistics for All Projects

Statistic	Duration (n=51)	
	Days	Years
Mean	1331	3.64
Standard Deviation	1488	4.07
Minimum	8	0.02
Maximum	6683	18.30

As is shown in Table 5.1, there was an overall duration mean of 1331 days (3.64 years) from a sample population of 51 projects. The quickest project duration for U1 was 8 days, while the slowest duration for U1 was 6683 days (18.30 years).

Figure 5.1 displays the frequency distribution of all U1 durations in the sample. The duration distribution does indicate a pattern. Since projects with extreme durations were solicited in the surveys for this research, a higher frequency of durations at the low and high duration categories were expected.

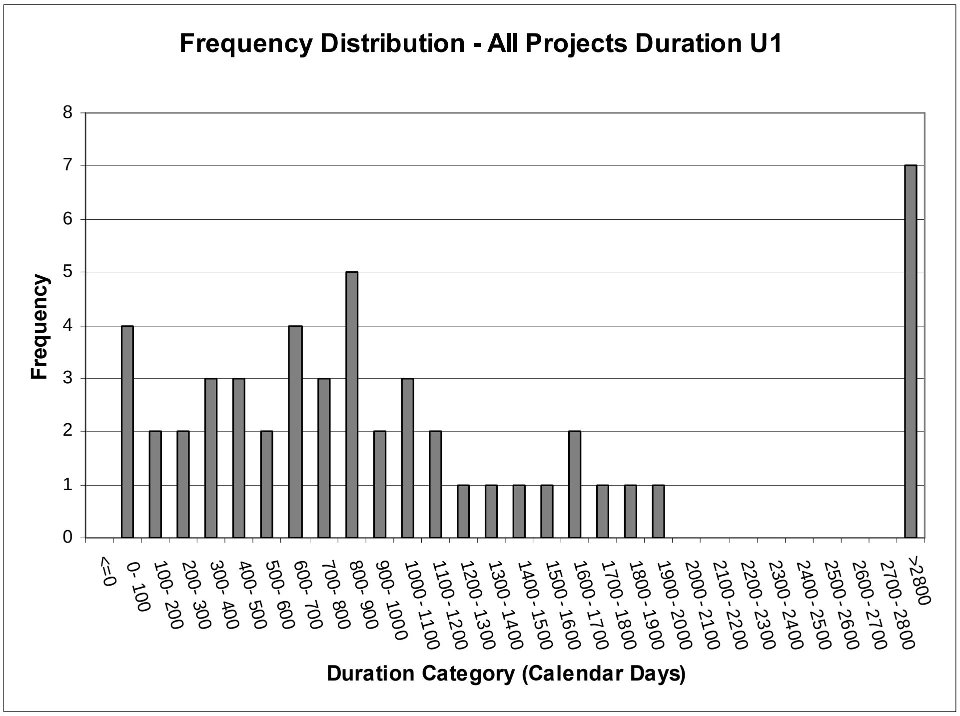


Figure 5.1. Frequency Distribution – All Projects Duration U1

Percentile values were calculated from the data sample of 51 projects with the following results: the 10th percentile of durations was 134 days (0.37 years), the median value was 869 days (2.38 years), and the 90th percentile was 3654 days (10 years). Table 5.2 contains the calculated percentile values. The data is also presented visually in Figure 5.2, which is a cumulative plot of time versus the percentage of projects with corresponding durations completed.

Table 5.2 U1 Duration Percentiles for All Projects

Percentile	Duration (n=51)	
	Days	Years
0th	8	0.02
10th	134	0.37
20th	351	0.96
30th	535	1.46
40th	731	2.00
50th	869	2.38
60th	1002	2.74
70th	1203	3.29
80th	1660	4.54
90th	3654	10.00
100th	6683	18.30

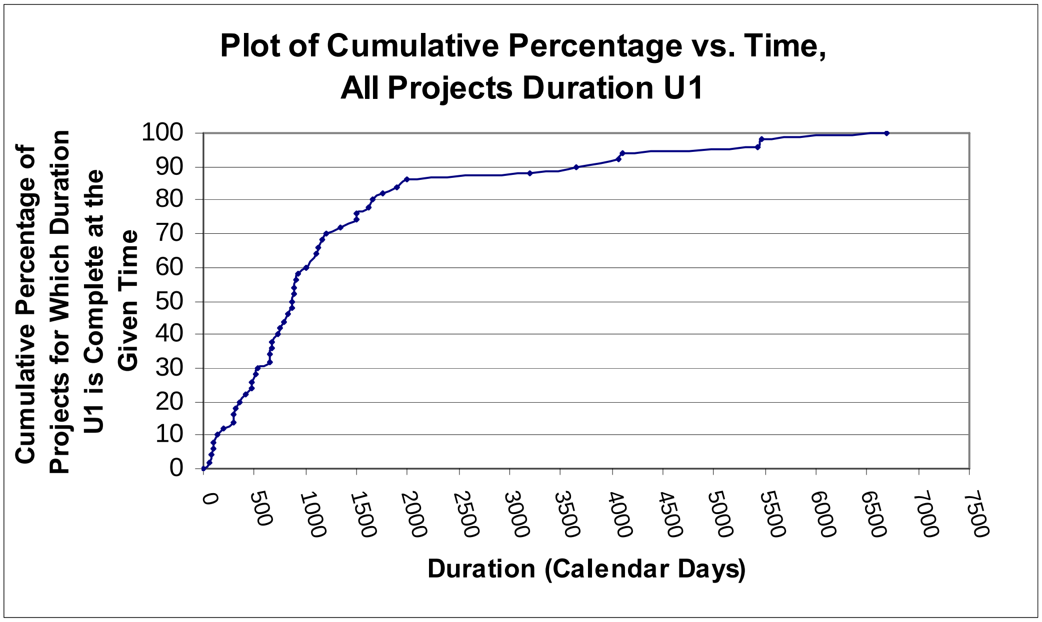


Figure 5.2. Cumulative U1 Duration Plot for All Projects

5.2 Quick vs. Slow Projects

The first factor analyzed was project classification (i.e., "Quick" or "Slow"), as recorded in the survey responses. Table 5.3 displays the results of the analysis.

Table 5.3 U1 Durations for Quick vs. Slow Projects

Statistic	Quick Projects (n=19)		Slow Projects (n=31)	
	Days	Years	Days	Years
Mean	779	2.13	1709	4.68
Standard Deviation	894	2.45	1680	4.60
Minimum	8	0.02	80	0.22
Maximum	4062	11.12	6683	18.30

There were 51 total sample projects with available data. For "Quick" projects there was a mean U1 duration of 779 days (2.13 years) from a sample size of 19 projects. For "Slow" projects there was a mean U1 duration value of 1709 days (4.68 years) from a sample size of 31 projects. The quickest project was a "Quick" project at 8 days, whereas the slowest project was a "Slow" project at 6683 days. Figure 5.3 displays the frequency of U1 durations by "Quick" and "Slow" classifications.

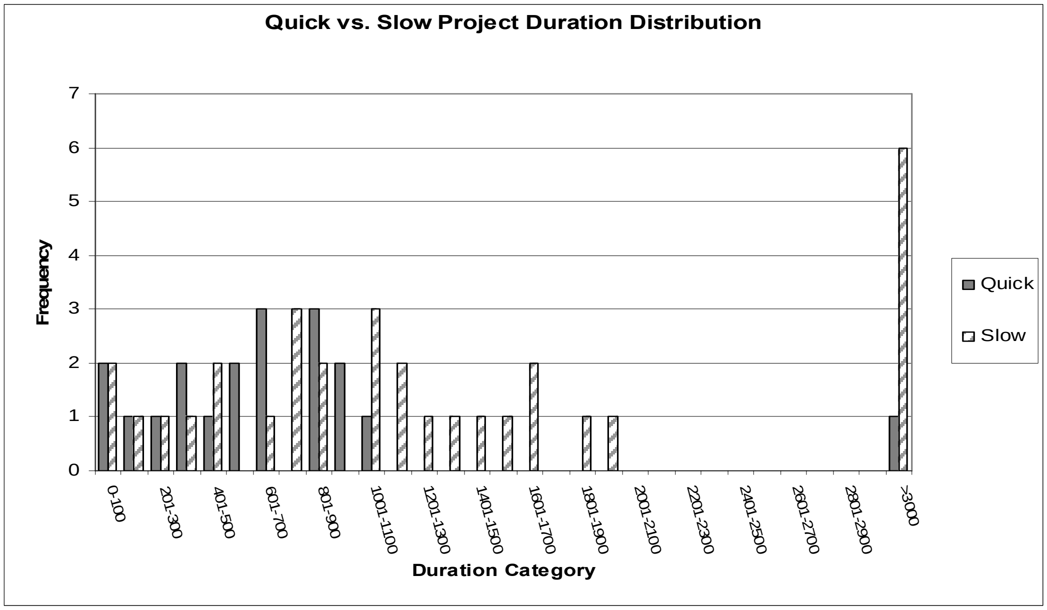


Figure 5.3. U1 Duration Distributions for Quick vs. Slow Projects

As expected, there was a higher frequency of "Quick" projects in the lower duration categories with a corresponding increase in the number of "Slow" projects in the higher duration categories. Interestingly, there was a fair amount of overlap of "Quick" and "Slow" projects with a number of "Slow" U1 durations occurring in the same duration categories as "Quick" U1 durations.

Percentile values were calculated from the same sample of projects. The 10th percentile for "Quick" projects was 95 days (0.26 years), the median was 652 days (1.79 years), and the 90th percentile was 1090 days (2.98 years). The 10th percentile for "Slow" projects was 301 days (0.82 years), the median was 1125 days (3.08 years), and the 90th percentile was 4114 days (11.26 years). The calculated percentile values are displayed in Table 5.4, and a cumulative U1 duration plot of "Quick" vs. "Slow" Projects is displayed in Figure 5.4.

Table 5.4 U1 Duration Percentiles for Quick and Slow Projects

Percentile	Quick Projects (n=19)		Slow Projects (n=31)	
	Days	Years	Days	Years
0th	8	0.02	80	0.22
10th	95	0.26	301	0.82
20th	272	0.74	663	1.82
30th	401	1.10	789	2.16
40th	513	1.40	1002	2.74
50th	652	1.79	1125	3.08
60th	675	1.85	1351	3.70
70th	860	2.35	1616	4.42
80th	896	2.45	1986	5.44
90th	1090	2.98	4114	11.26
100th	4062	11.12	6683	18.30

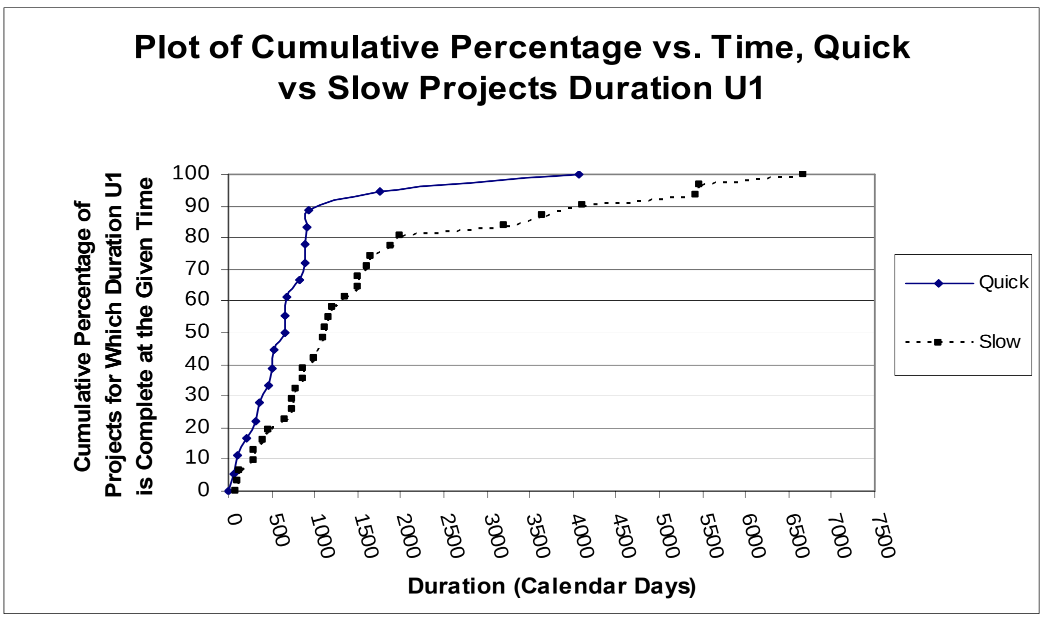


Figure 5.4. Cumulative Duration Plot for Quick vs. Slow Projects

5.3 Highway Type

Highway type was another factor that was analyzed as a potential duration "driver". Table 5.5 presents the results of the U1 duration analysis based on the type of highway.

Table 5.5 U1 Durations by Highway Type

Statistic	FM / RM (n=15)		Interstate (n=7)		US Highway (n=18)		State Highway (n=8)	
	Days	Years	Days	Years	Days	Years	Days	Years
Mean	890	2.44	1098	3.01	1480	4.05	2473	6.77
Standard Deviation	756	2.07	1309	3.58	1556	4.26	2170	5.94
Minimum	57	0.16	80	0.22	202	0.55	408	1.12
Maximum	3204	8.77	3654	10.00	6683	18.30	5461	14.95

There were 48 total projects with available data that fit into the above categories. For FM/RM projects there was a mean U1 duration value of 890 days (2.44 years) from a sample size of 15 projects. For Interstate projects there was a mean U1 duration value of 1098 days (3.01 years) from a sample size of 7 projects. For US Highway projects there was a mean U1 duration value of 1480 days (4.05 years) from a sample size of 18 projects. For State Highway projects there was a mean U1 duration value of 2473 days (6.77 years) from a sample size of 8 projects. The quickest U1 duration was on an FM/RM project at 57 days, whereas the slowest U1 duration was on a US Highway project at 6683 days.

Selected percentile values were calculated from the same sample of projects. The 10^{th} percentile for FM/RM projects was 221 days (0.61 years), the 50^{th} percentile was 731 days (2.00 years), and the 90^{th} percentile was 1420 days (3.89 years). Only quartiles were calculated for Interstate Highway projects because of limited sample size, and the 25^{th} percentile was 193 days (0.53 years), the 50^{th} percentile was 465 days (1.27 years), and the 75^{th} percentile was 1550 days (4.24 years). The 10^{th} percentile for US Highway projects was 465 days (1.27 years), the 50^{th} percentile was 962 days (2.63 years), and the 90^{th} percentile was 2468 days (6.76 years). Only quartiles were calculated for State Highway projects because of sample size, and the 25^{th} percentile was 818 days (2.24 years), the 50^{th} percentile was 1449 days (3.97 years), and the 75^{th} percentile was 4403 days (12.06 years). The calculated percentile values are displayed in Table 5.6, and a cumulative duration plot of U1 duration vs. Highway Type is displayed in Figure 5.5.

Table 5.6 U1 Duration Percentiles by Highway Type

Percentile	FM / RM (n=15)		Interstate (n=7)		US Highway (n=18)		State Highway (n=8)	
	Days	Years	Days	Years	Days	Years	Days	Years
0th	57	0.16	80	0.22	202	0.55	408	1.12
10th	221	0.61	*	*	465	1.27	*	*
20th	451	1.23	*	*	688	1.88	*	*
25th	492	1.35	193	0.53	755	2.07	818	2.24
30th	536	1.47	*	*	797	2.18	*	*
40th	670	1.83	*	*	879	2.41	*	*
50th	731	2.00	465	1.27	962	2.63	1449	3.97
60th	850	2.33	*	*	1204	3.30	*	*
70th	979	2.68	*	*	1482	4.06	*	*
75th	1050	2.87	1550	4.24	1503	4.12	4403	12.06
80th	1103	3.02	*	*	1598	4.38	*	*
90th	1420	3.89	*	*	2468	6.76	*	*
100th	3204	8.77	3654	10.00	6683	18.30	5461	14.95

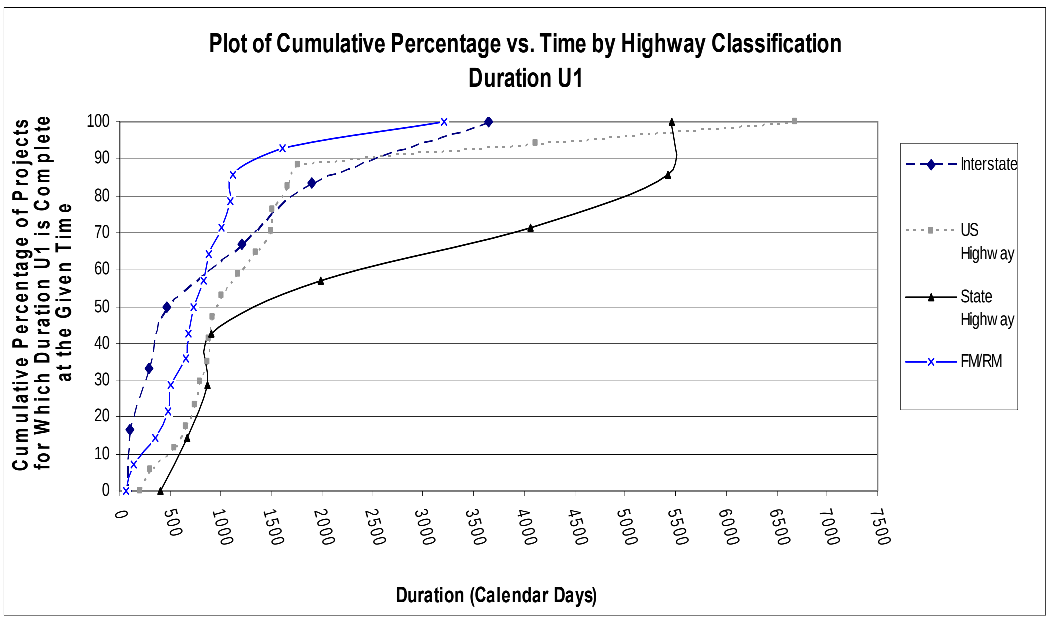


Figure 5.5. Cumulative U1 Duration Plot by Highway Type

5.4 Location Category

Location Category was another factor that was analyzed. Table 5.7 presents the results of the analysis based on the location category of the projects.

Table 5.7 U1 Duration Statistics by Location Category

Statistic	Rural (n=17)		Metro (n=20)		Urban (n=14)	
	Days	Years	Days	Years	Days	Years
Mean	754	2.06	1441	3.95	1875	5.13
Standard Deviation	494	1.35	1723	4.72	1763	4.83
Minimum	8	0.02	80	0.22	351	0.96
Maximum	1660	4.54	5461	14.95	6683	18.30

There were 51 total projects with available data that fit into the above categories. For Rural projects there was a mean U1 duration of 754 days (2.06 years) from a sample size of 17 projects. For Metro projects there was a mean U1 duration value of 1441 days (3.95 years) from a sample size of 20 projects. For Urban projects there was a mean U1 duration value of 1875 days (5.13 years) from a sample size of 14 projects. The quickest U1 duration was on a Rural project at 8 days, whereas the slowest U1 duration was on an Urban project at 6683 days.

Selected percentile values were calculated from the same sample of projects. The 10th percentile for Rural projects was 103 days (0.28 years), the 50th percentile was 826 days (2.26 years), and the 90th percentile was 1413 days (3.87 years). The 10th percentile for Metro projects was 104 days (0.28 years), the 50th percentile was 735 days (2.01 years), and the 90th percentile was 4245 days (11.62 years). Given its smaller sample size, only quartiles were calculated for Urban projects, and from the data the 25th percentile was 785 days (2.15 years), the 50th percentile was 1185 days (3.24 years), and the 75th percentile was 1863 days (5.10 years). The calculated percentile values are displayed in Table 5.8, and a cumulative U1 duration plot by location category is displayed in Figure 5.6.

Table 5.8 U1 Duration Percentile by Location Category

Percentile	Rural (n=17)		Metro (n=20)		Urban (n=14)	
	Days	Years	Days	Years	Days	Years
0th	8	0.02	80	0.22	351	0.96
10th	103	0.28	104	0.28	*	*
20th	243	0.67	298	0.82	*	*
25th	408	1.12	314	0.86	785	2.15
30th	487	1.33	421	1.15	*	*
40th	684	1.87	511	1.40	*	*
50th	826	2.26	735	2.01	1185	3.24
60th	876	2.40	875	2.40	*	*
70th	938	2.57	1272	3.48	*	*
75th	1002	2.74	1709	4.68	1863	5.10
80th	1079	2.95	2230	6.11	*	*
90th	1413	3.87	4245	11.62	*	*
100th	1660	4.54	5461	14.95	6683	18.30

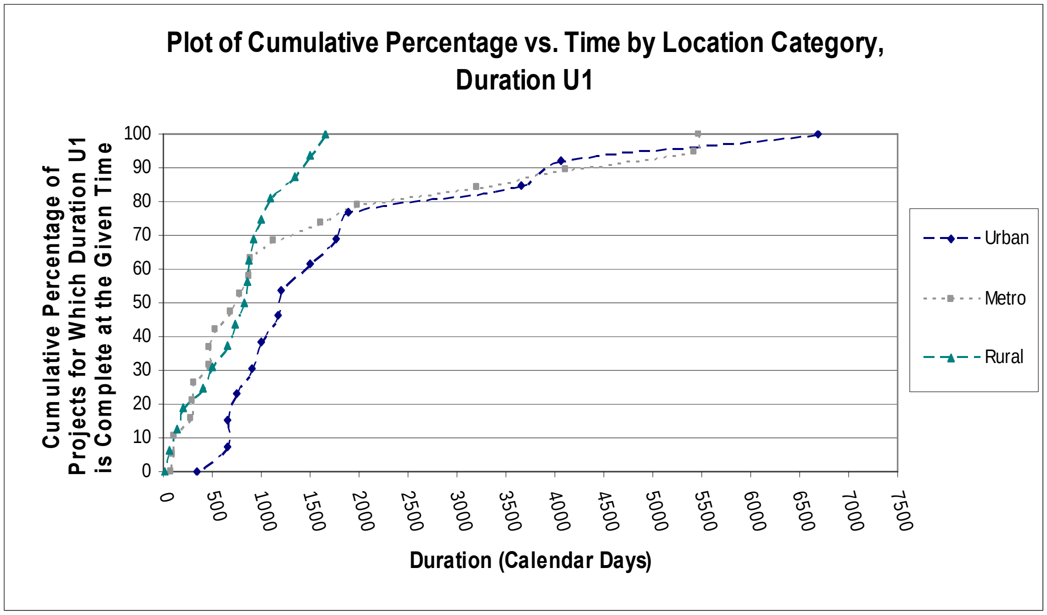


Figure 5.6. Cumulative U1 Duration Plot by Location Category

Figure 5.7 provides a visual representation of the association of location on U1 duration.

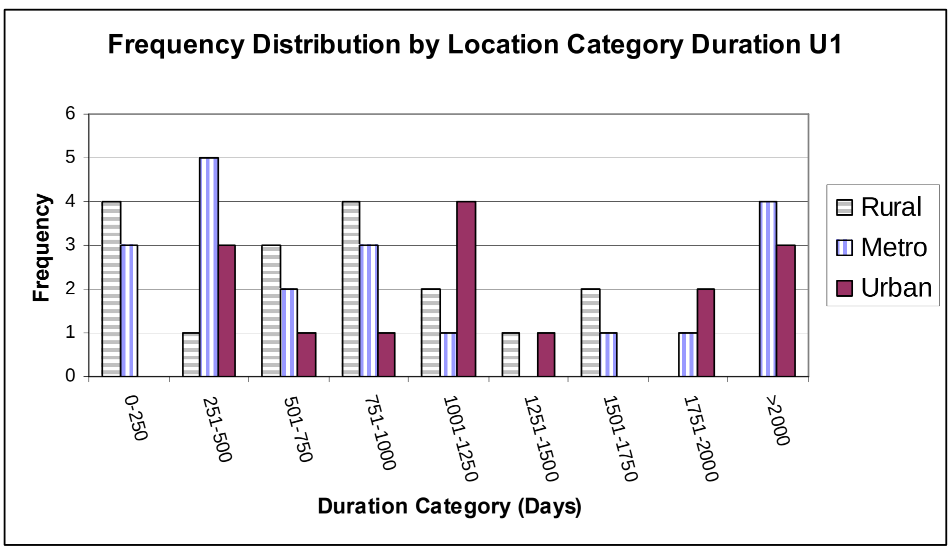


Figure 5.7. Frequency Distribution of Project Duration by Location Category

5.5 U1 for TxDOT Project Type

The next factor analyzed was TxDOT project type. While project type categorization was performed on nearly all of the projects with available duration data, the small samples for most project types reduced the amount for further analysis to the 25 projects in the three categories in Table 5.9. As defined in Chapter 3.8, RER is Rehabilitate and Repair, WNF is Widen Non-Freeway, and CNF is Convert Non-Freeway to Freeway. For RER projects there was a mean U1 duration value of 850 days (2.33 years) from a sample size of 8 projects. For WNF projects there was a mean U1 duration value of 1386 days (3.79 years) from a sample size of 12 projects. For CNF projects there was a mean U1 duration value of 2342 days (6.41 years) from a sample size of 5 projects. The quickest U1 duration was on an RER project at 8 days, whereas the slowest U1 duration was on a CNF project at 5425 days.

Table 5.9 U1 Duration Statistics by TxDOT Project Type

Statistic	RER (n=8)		WNF (n=12)		CNF (n=5)	
	Days	Years	Days	Years	Days	Years
Mean	850	2.33	1386	3.79	2342	6.41
Standard Deviation	571	1.56	1065	2.92	2252	6.17
Minimum	8	0.02	202	0.55	301	0.82
Maximum	1616	4.42	4062	11.12	5425	14.85

Selected percentile values were calculated from the same data; however, the small sample sizes resulted in only quartiles being calculated. The 25th percentile for RER projects was 707 days (1.94 years), the 50th percentile was 890 days (2.44 years), and the 75th percentile was 1105 days (3.03 years). The 25th percentile for WNF projects was 718 days (1.97 years), the 50th percentile was 902 days (2.47 years), and the 75th percentile was 1510 days (4.13 years). The calculated percentile durations are displayed in Table 5.10, and a cumulative U1 duration plot by TxDOT Project Type is displayed in Figure 5.8.

Table 5.10 U1 Duration Percentiles by TxDOT Project Type

Percentile	RER (n=8)		WNF (n=12)	
	Days	Years	Days	Years
0th	8	0.02	202	0.55
25th	707	1.94	718	1.97
50th	890	2.44	902	2.47
75th	1105	3.03	1510	4.13
100th	1616	4.42	4062	11.12

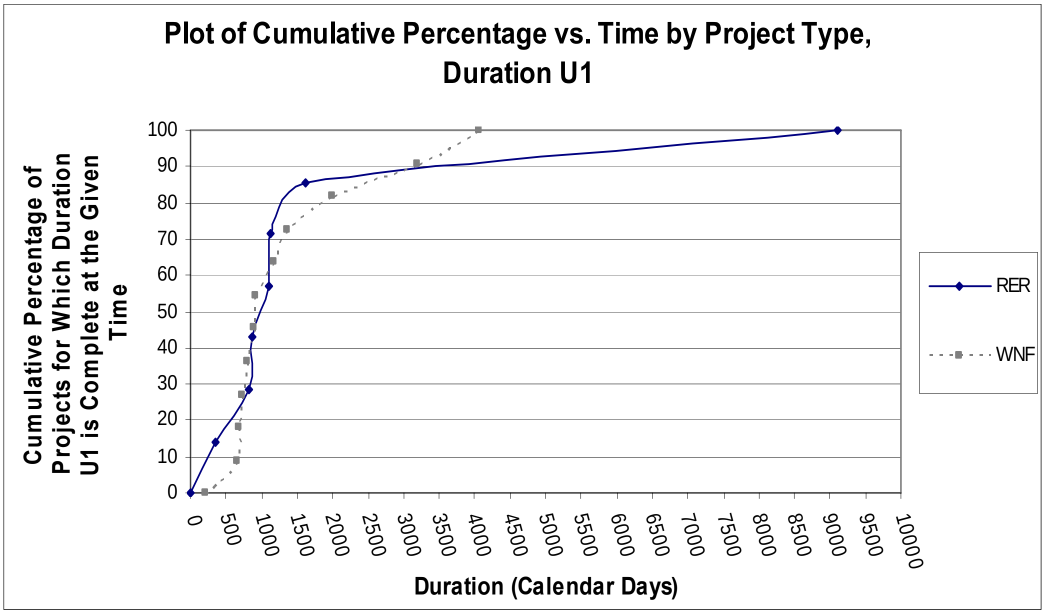


Figure 5.8. Cumulative U1 Duration Plot by TxDOT Project Type

5.6 U1 for Construction Project Length

Construction Project Length was also considered a potential "driver" of utility adjustment duration U1. Since length is a continuous variable, a scatter-plot (Figure 5.9) was created for analysis.

Once the data points had been plotted a trend-line was computed to determine whether or not further regression analysis would be beneficial. If the displayed R^2 would be large enough, the regression would be performed. Based on the resulting R^2 value, less than 1% of the duration variability can be explained by construction project length. Therefore, no further regression analysis was performed.

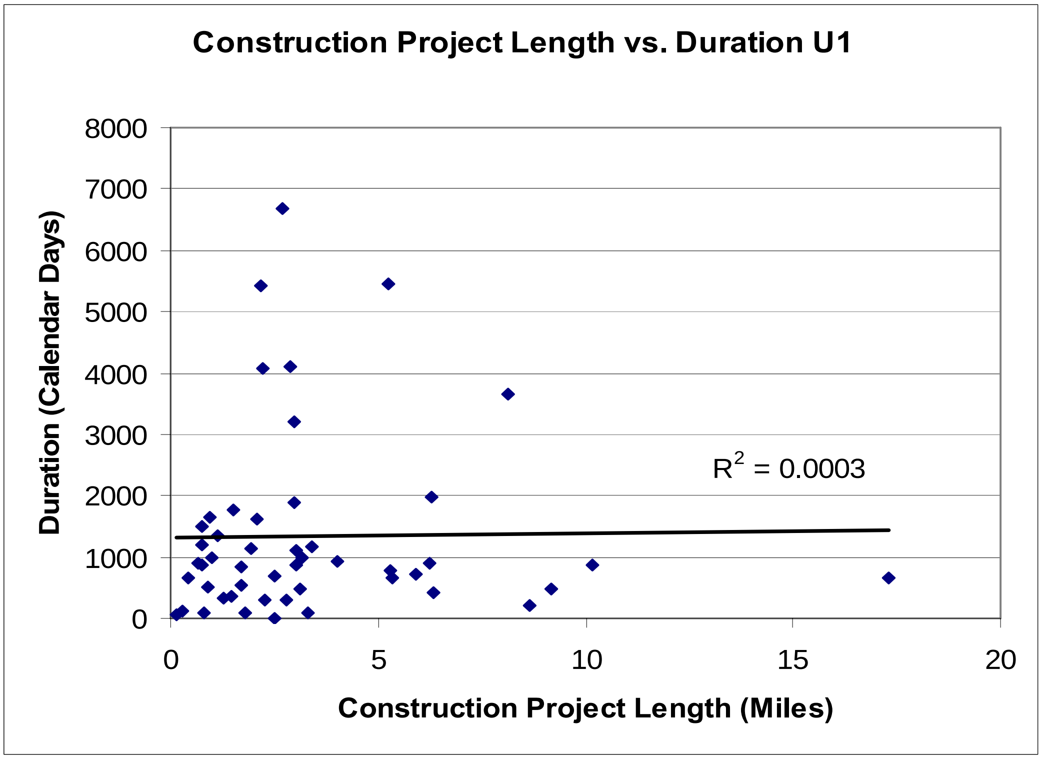


Figure 5.9. Construction Project Length vs. Duration U1

5.7 Federally Funded vs. Non-Federally Funded

Another of the factors that was analyzed as a potential duration driver was whether or not there was Federal participation in the reimbursement of utility adjustment expenses. Table 5.11 presents the result of the analysis.

Table 5.11 U1 Duration Statistics for Federally Funded vs. Non-Federally Funded

Statistic	Federally Funded (n=11)		Non-Federally Funded (n=35)	
	Days	Years	Days	Years
Mean	1178	3.23	1480	4.05
Standard Deviation	1239	3.39	1639	4.49
Minimum	80	0.22	8	0.02
Maximum	3654	10.00	6683	18.30

For Federally Funded projects there was a mean U1 duration value of 1178 days (3.23 years) from a sample size of 11 projects. For Non-Federally funded projects there was a mean U1 duration value of 1480 days (4.05 years) from a sample size of 35 projects. The quickest U1 duration was on a Non-Federally Funded project at 8 days, as was the slowest U1 duration at 6683 days.

Selected percentile values were calculated from the same sample of projects. Given its smaller sample size, only quartiles were calculated for Federally Funded projects, and from the data the 25th percentile was 303 days (0.83 years), the 50th percentile was 867 days (2.37 years), and the 75th percentile was 1550 days (4.24 years). The 10th percentile for Non-Federally Funded projects was 242 days (0.66 years), the 50th percentile was 912 days (2.50 years), and the 90th percentile was 4093 days (11.21 years). The calculated U1 duration percentile values are displayed in Table 5.12, and a cumulative U1 duration plot according to Federal Funding Participation is displayed in Figure 5.10.

Table 5.12 U1 Duration Percentiles by Federally Funded vs. Non

Percentile	Federally Funded (n=11)		Non-Federally Funded (n=35)	
	Days	Years	Days	Years
0th	80	0.22	8	0.02
10th	*	*	242	0.66
20th	*	*	501	1.37
25th	303	0.83	594	1.63
30th	*	*	659	1.80
40th	*	*	811	2.22
50th	867	2.37	912	2.50
60th	*	*	1040	2.85
70th	*	*	1468	4.02
75th	1550	4.24	1561	4.27
80th	*	*	1681	4.60
90th	*	*	4093	11.21
100th	3654	10.00	6683	18.30

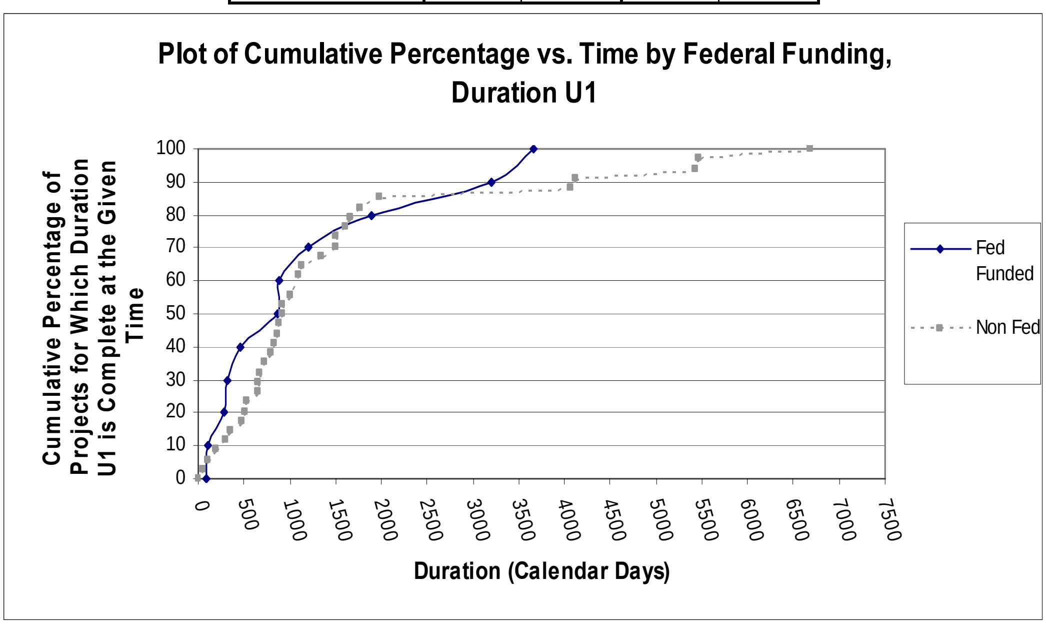


Figure 5.10. Cumulative U1 Duration Plot by Federally Funded vs. Non-Federally Funded

5.8 U1 by LPA Funding

Local Public Agency (LPA) participation in reimbursement costs was also investigated as a potential duration "driver." Table 5.13 presents the results of the analysis of LPA funding.

Table 5.13 U1 Duration Statistics by LPA Involvement

Statistic	Non-LPA-funded (n=14)		LPA Funded (n=31)	
	Days	Years	Days	Years
Mean	797	2.18	1727	4.73
Standard Deviation	954	2.61	1687	4.62
Minimum	99	0.27	8	0.02
Maximum	3654	10.00	6683	18.30

There were 45 total projects with available data that fit into the above categories. For Non-LPA-funded projects there was a mean U1 duration of 797 days (2.18 years) from a sample size of 14 projects. For LPA-funded projects there was a mean U1 duration of 1727 days (4.73 years) from a sample size of 31 projects. The quickest U1 duration was on an LPA-funded project at 8 days, as was the slowest duration at 6683 days.

Selected percentile values were calculated from the same sample of projects. Given its smaller sample size, only quartiles were calculated for Non-LPA-funded projects, and from the data the 25th percentile was 295 days (0.81 years), the 50th percentile was 486 days (1.33 years), and the 75th percentile was 825 days (2.26 years). The 10th percentile for LPA-funded projects was 476 days (1.30 years), the 50th percentile was 1002 days (2.74 years), and the 90th percentile was 4114 days (11.26 years). The calculated U1 duration percentiles are displayed in Table 5.14, and a cumulative U1 duration plot by LPA Funding is displayed in Figure 5.11.

Table 5.14 U1 Duration Percentiles by LPA Funding

Percentile	Non-LPA-funded (n=14)		LPA Funded (n=31)	
	Days	Years	Days	Years
0th	99	0.27	8	0.02
10th	*	*	476	1.30
20th	*	*	731	2.00
25th	295	0.81	808	2.21
30th	*	*	867	2.37
40th	*	*	912	2.50
50th	486	1.33	1002	2.74
60th	*	*	1351	3.70
70th	*	*	1616	4.42
75th	825	2.26	1712	4.69
80th	*	*	1986	5.44
90th	*	*	4114	11.26
100th	3654	10.00	6683	18.30

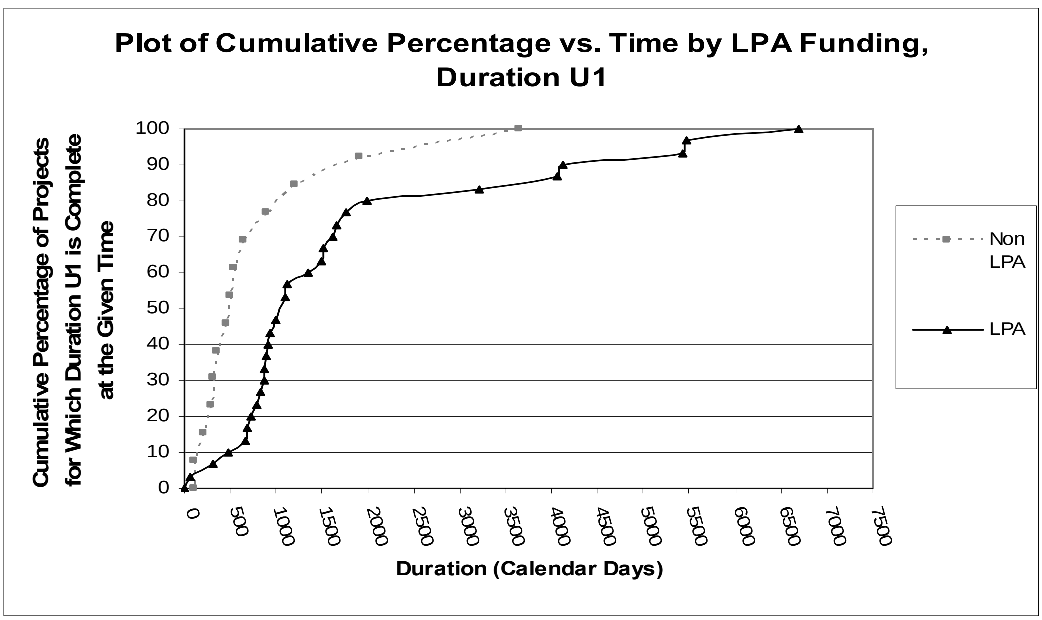


Figure 5.11. Cumulative U1 Duration by LPA-funded

5.9 U1 by Reimbursable vs. Non Reimbursable

Reimbursable and Non-Reimbursable project U1 durations are reported in Table 5.15.

Table 5.15 Descriptive Statistics Reimbursable vs. Non-Reimbursable Projects

Statistic	Non Reimbursable (n=4)		Reimbursable (n=47)	
	Days	Years	Days	Years
Mean	593	1.62	1394	3.82
Standard Deviation	*	*	1531	4.19
Minimum	134	0.37	8	0.02
Maximum	1167	3.20	6683	18.30

For Non-Reimbursable utility adjustments there was a mean U1 duration of 593 days (1.62 years) from a sample size of 4 projects. For Reimbursable utility adjustment there was a mean U1 duration value of 1394 days (3.82 years) from a sample size of 47 projects with. The quickest U1 duration was on a Reimbursable utility adjustment at 8 days, as was the slowest U1 duration at 6683 days.

Selected percentile values were calculated from the same sample of projects. Because of its small sample size, no percentile values were calculated for Non-Reimbursable utility adjustments. For Reimbursable utility adjustments the 10th percentile was 163 days (0.45 years), the 50th percentile was 882 days (2.41 years), and the 90th percentile was 3817 days (10.45 years). The calculated percentile values are displayed in Table 5.16, and a cumulative U1 duration plot for Reimbursable utility adjustments is displayed in Figure 5.12. No statistical comparison could be made because of the small sample size for non-reimbursable projects.

Table 5.16 U1 Duration Percentiles for Reimbursable Projects

Percentile	Reimbursable (n=47)	
	Days	Years
0th	8	0.02
10th	163	0.45
20th	374	1.02
30th	629	1.72
40th	761	2.08
50th	882	2.41
60th	1002	2.74
70th	1380	3.78
80th	1742	4.77
90th	3817	10.45
100th	6683	18.30

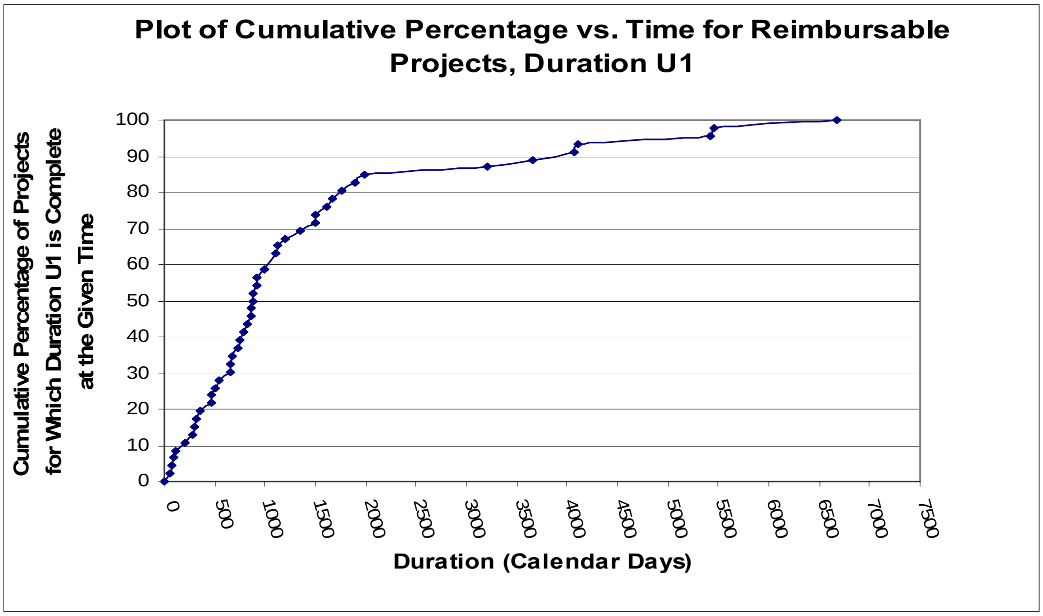


Figure 5.12. Cumulative U1 Duration Plot for Reimbursable Projects

5.10 U1 for Date of Eligibility Procedure Applicability

Another funding mechanism issue that was investigated as a potential duration "driver" was the use of TxDOT's Date of Eligibility (DOE) Procedure. Utility adjustments for which *any* of the individual adjustments were conducted under the DOE procedure were considered to be DOE projects. The following are the results of the analysis.

Table 5.17 U1 Duration Statistics for Date of Eligibility vs. Non-Date of Eligibility Projects

Statistic	Non DOE (n=16)		DOE (n=31)	
	Days	Years	Days	Years
Mean	1009	2.76	1593	4.36
Standard Deviation	1596	4.37	1484	4.06
Minimum	8	0.02	80	0.22
Maximum	6683	18.30	5461	14.95

For Non-DOE projects there was a mean U1 duration value of 1009 days (2.76 years) from a sample size of 16 projects. For DOE projects there was a mean U1 duration value of 1593 days (4.36 years) from a sample size of 31 projects. The quickest U1 duration was a Non-DOE project at 8 days, as was the slowest U1 duration at 6683 days.

Selected percentile values were calculated from the same sample of projects. Given its smaller sample size, only quartiles were calculated for Non-DOE projects, and from the data the 25th percentile was 266 days (0.73 years), the 50th percentile was 667 days (1.83 years), and the 75th percentile was 915 days (2.51 years). The 10th percentile for DOE projects was 351 days (0.96 years), the 50th percentile was 1002 days (2.74 years), and the 90th percentile was 4062 days (11.12 years). The calculated percentile values are displayed in Table 5.18, and a cumulative U1 duration plot of DOE vs. Non-DOE is displayed in Figure 5.13.

Table 5.18 U1 Duration Percentiles for DOE vs. Non DOE Projects

Percentile	Non DOE (n=16)		DOE (n=31)	
	Days	Years	Days	Years
0th	8	0.02	80	0.22
10th	*	*	351	0.96
20th	*	*	652	1.79
25th	266	0.73	667	1.83
30th	*	*	731	2.00
40th	*	*	867	2.37
50th	667	1.83	1002	2.74
60th	*	*	1351	3.70
70th	*	*	1616	4.42
75th	915	2.51	1712	4.69
80th	*	*	1896	5.19
90th	*	*	4062	11.12
100th	6683	18.30	5461	14.95

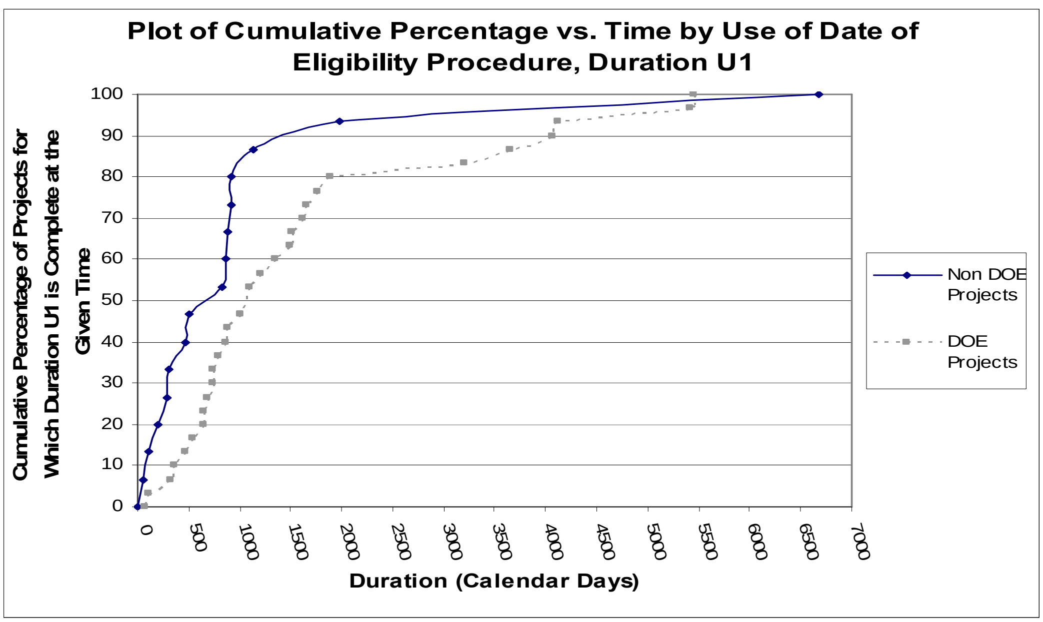


Figure 5.13. Cumulative U1 Duration Plot for DOE vs. Non-DOE Projects

5.11 U1 for Number of Utility Agreements Involved

The number of utility agreements involved on a project was also investigated as a potential duration "driver". If two agreements existed for the same utility, this analysis treated it as two utilities. The result of the analysis is presented in table 5.19.

Table 5.19 Mean U1 Durations by Number of Utility Agreements

Number of Agreements	Sample Size (n)	Mean Duration	
		Days	Years
1	10	690	1.89
2	8	582	1.59
3	7	865	2.37
4	6	919	2.52
5	5	2174	5.95
>5	11	2737	7.49

The data sample contained 10 projects for which there was only one utility agreement, with a mean U1 duration of 690 days (1.89 years). There were eight projects with two utility agreements, and the mean U1 duration was 582 days (1.59 years). For projects with three utility agreements there was a sample of seven projects with a mean U1 duration of 865 days (2.37 years). For projects with four utility agreements there was a sample of six projects, with a mean U1 duration of 919 days (2.52 years). There were five projects with five utility agreements, for which the mean U1 duration was 2174 days (5.95 years). There were 11 projects with more than five utility agreements, and their mean U1 duration was 2737 days (7.49 years).

A scatter plot of duration by number of utilities is shown in Figure 5.14. Included in the figure is the calculated trend-line.

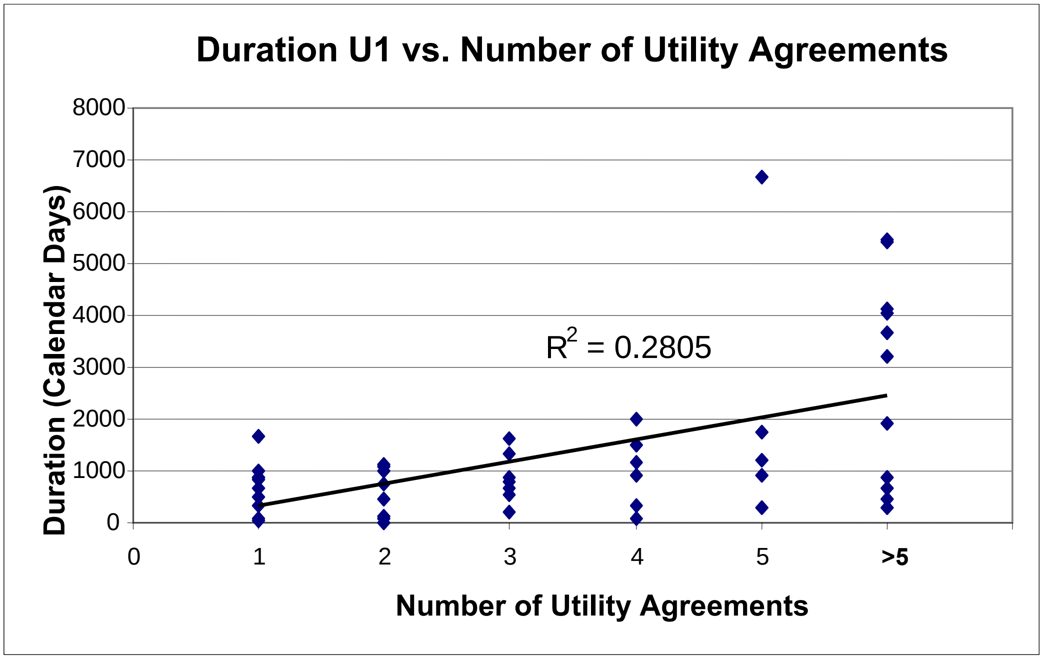


Figure 5.14. Duration U1 vs. Number of Utility Agreements

The linear coefficient, R^2, is equal to 0.2805. This value suggests that a portion of the duration can be explained by the number of utility agreements and its relationship to the amount of time it takes to develop and execute all agreements.

In addition to performing the analysis of categories shown in Figure 5.14, another regression was performed based on all possible numbers of utility agreements. Figure 5.15 displays the results of the scatter plot and the calculated regression line.

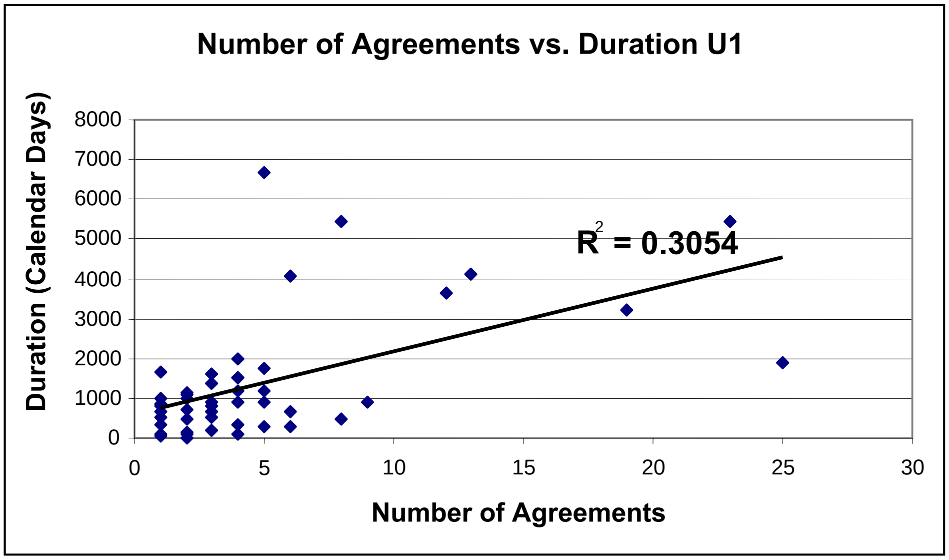


Figure 5.15. Regression Plot for Number of Agreements vs. Duration U1

The regression for U1 duration by number of agreements did slightly increase the R^2 value, further indicating that some relationship exists between duration U1 and the number of utility agreements.

5.12 U1 for Type of Utility

Type of utility was identified as a potential duration "driver". Due to the fact that more than one type of utility can be involved in a single utility adjustment project (as defined for this study), there is a significant amount of overlap in the data samples. Table 5.20 displays the duration findings by type of utility involved.

Table 5.20 Mean U1 Duration by Type of Utility

Type of Utility	Sample Size (n)	Mean Duration	
		Days	Years
Underground Power	7	903	2.47
Underground Communications	18	1234	3.38
Overhead Power	26	1306	3.58
Liquid Petroleum	7	1366	3.74
Low Pressure Gas	4	1474	4.04
Sanitary Sewer	5	1580	4.33
High Pressure Gas	18	1780	4.87
Water	26	1869	5.12
Extend Casing	9	2117	5.80

The apparent quickest type of utility adjustment project involved Underground Power adjustments, with a mean duration of 903 days (2.47 years) from a sample of 7 projects. Next in duration were projects with Underground Communications adjustments with a mean U1 duration of 1234 days (3.38 years) from a sample of 18 projects.

The second slowest projects were projects with Water adjustments, with a mean duration of 1869 days (5.12 years) from a sample of 26 projects. The slowest projects were projects with Extend Casing adjustments with a mean U1 duration of 2117 days (5.80 years) from a sample of 9 projects.

U1 Duration percentiles were calculated by type of utility and are displayed in Table 5.21.

Table 5.21 Duration U1 Percentiles by Type of Utility

Percentile	Underground Power (n=7)		Underground Communications (n=18)		Overhead Power (n=26)		Liquid Petroleum (n=7)		High-Pressure Gas (n=18)		Water (n=26)		Extend Casing (n=9)	
	Days	Years	Days	Years	Days	Years	Days	Years	Days	Years	Days	Years	Days	Years
0th	287	0.79	8	0.02	8	0.02	301	0.82	287	0.79	99	0.27	535	1.46
10th	*	*	118	0.32	102	0.28	*	*	445	1.22	294	0.80	*	*
20th	*	*	236	0.65	301	0.82	*	*	663	1.82	351	0.96	*	*
25th	437	1.20	295	0.81	341	0.93	662	1.81	707	1.94	470	1.29	912	2.50
30th	*	*	333	0.91	437	1.20	*	*	799	2.19	659	1.80	*	*
40th	*	*	678	1.86	652	1.79	*	*	907	2.48	869	2.38	*	*
50th	1002	2.74	896	2.45	875	2.39	1351	3.70	1024	2.80	1050	2.87	1497	4.10
60th	*	*	1174	3.21	912	2.50	*	*	1527	4.18	1351	3.70	*	*
70th	*	*	1468	4.02	1302	3.56	*	*	1748	4.79	1941	5.31	*	*
75th	1133	3.10	1503	4.12	1699	4.65	1690	4.63	1863	5.10	2900	7.94	3204	8.77
80th	*	*	1740	4.76	1896	5.19	*	*	2681	7.34	3654	10.00	*	*
90th	*	*	3339	9.14	3858	10.56	*	*	4507	12.34	4770	13.06	*	*
100th	1896	5.19	4062	11.12	5425	14.85	301	0.82	5461	14.95	6683	18.30	5425	14.85

For projects with Underground Power adjustments the 25th percentile was 437 days (1.20 years), the 50th percentile was 1002 days (2.74 years), and the 75th percentile was 1133 days (3.10 years). For projects with Underground Communications adjustments the 10th percentile was 118 days (0.32 years), the 50th percentile was 896 days (2.45 years), and the 90th percentile was 3393 days (9.14 years). For projects with Overhead Power adjustments the 10th percentile was 102 days (0.28 years), the 50th percentile was 875 days (2.39 years), and the 90th percentile was 3858 days (10.56 years). For project with Liquid Petroleum adjustments the 25th percentile was 662 days (1.81 years), the 50th percentile was 1351 days (3.70 years), and the 75th percentile was 1690 days (4.63 years). For projects with High-Pressure Gas adjustments the 10th percentile was 445 days (1.22 years), the 50th percentile was 1024 days (2.80 years), and the 90th percentile was 4507 days (12.34 years). For projects with Water adjustments the 10th percentile was 294 days (0.80 years), the 50th percentile was 1050 days (2.87 years), and the 90th percentile was 4770 days (13.06 years). For projects involving Extend Casing adjustments the 25th percentile was 912 days (2.50 years), the 50th percentile was 1497 days (4.10 years), and the 75th percentile was 3204 days (8.77 years).

The quickest U1 25th percentile durations are associated with Underground Communications and Overhead Power adjustments, at 0.81 and 0.93 years, respectively. The slowest 75th percentile durations are associated with Water and Extend Casing adjustments, at 7.94 and 8.77 years, respectively.

Figure 5.16 is a plot of cumulative U1 duration by type of utility.

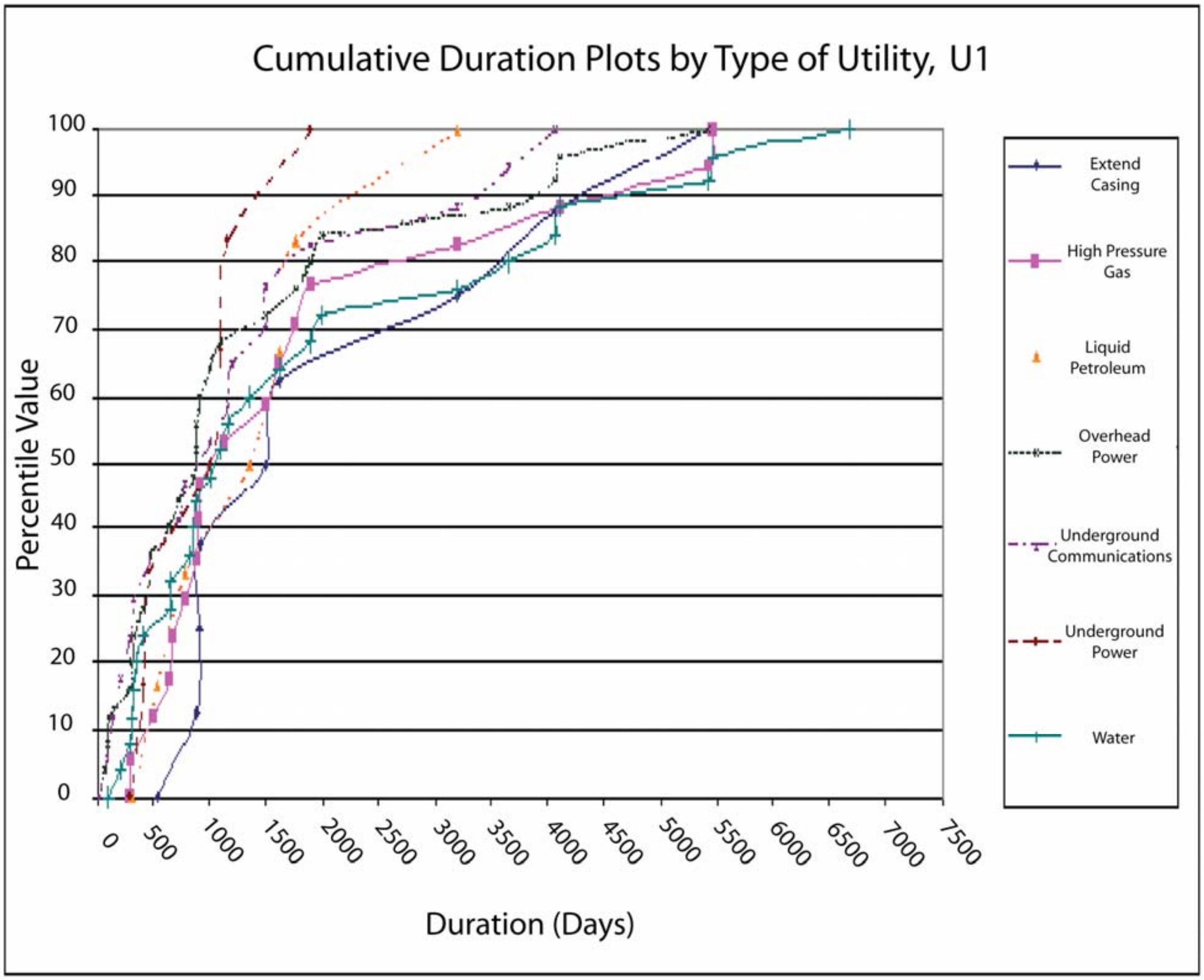


Figure 5.16. Cumulative U1 Duration Plot by Type of Utility

5.13 Factor Influence on Duration U1

In addition to reporting duration data in statistical form, comparisons were made between factors based on mean U1 durations. Table 5.22 shows a partial listing of different categories of projects.

Table 5.22 Factor Influence on Duration U1

Quick Mean Duration ≤ 2.5 yrs	Moderate 3.5 yrs ≤ Mean Duration ≤ 4.0 yrs	Slow Mean Duration ≥ 5 yrs
Bridge Replacement Projects	Projects with Overhead Power Adjustments	Projects with Water Adjustments
Non-Reimbursable Projects	All Projects	Urban Projects
Rural Projects	Projects with Liquid Petroleum Adjustments	Miscellaneous Highway Projects
Non-LPA Projects	Widen Non-Freeway Construction Projects	Projects with Extend Casing Adjustments
Rehabilitate and Repair Projects	Reimbursable Projects	Convert Non-Freeway to Freeway Projects
FM/RM Projects	Metro Projects	State Highway Projects
Projects with Underground Power Adjustments		

In order to categorize the different types of factors as either quick, moderate, or slow in duration all factors were first sorted by mean duration. From the list of sorted factors, the quickest and slowest factors were chosen for this sample. For quick projects, there were several factors with a mean duration of about 2.5 years. Conversely there were about as many factors with mean durations greater than 5 years. Following the identification of the quick and slow factors, a few moderate factors were identified with mean durations roughly half way between the quick and slow factors.

Chapter 6. Data Analysis for Duration U2

The data analysis for duration U2 is presented in this chapter. As defined in Chapter 4.3, duration U2 is the time between the last agreement execution and the last adjustment completion. As has been stated elsewhere in this report, utility adjustments cannot be completed until sufficient right-of-way has been purchased, making duration U2 dependant on timely acquisition of right-of-way parcels.

6.1 All Projects U2 Duration Information

The total sample of projects with data for duration U2 yielded the statistics presented in Table 6.1.

Table 6.1 U2 Duration Statistics for All Projects

Statistic	Duration (n=34)	
	Days	Years
Mean	222	0.61
Standard Deviation	212	0.58
Minimum	3	0.01
Maximum	710	1.94

As is shown in Table 6.1, there was an overall U2 duration mean of 222 days (0.61 years) from a sample population of 34 projects. The quickest U2 duration was 3 days, while the slowest U2 duration was 710 days.

Figure 6.1 displays the frequency distribution of U2 durations in the sample. The bi-modal pattern that was observed for duration U1 is not apparent in this figure. For U2 there is a high frequency among shorter durations but there no corresponding high frequency among longer duration categories. This may be due to the nature of duration U2 as an intermediate duration that can occur substantially later after the initiation of utility adjustment planning.

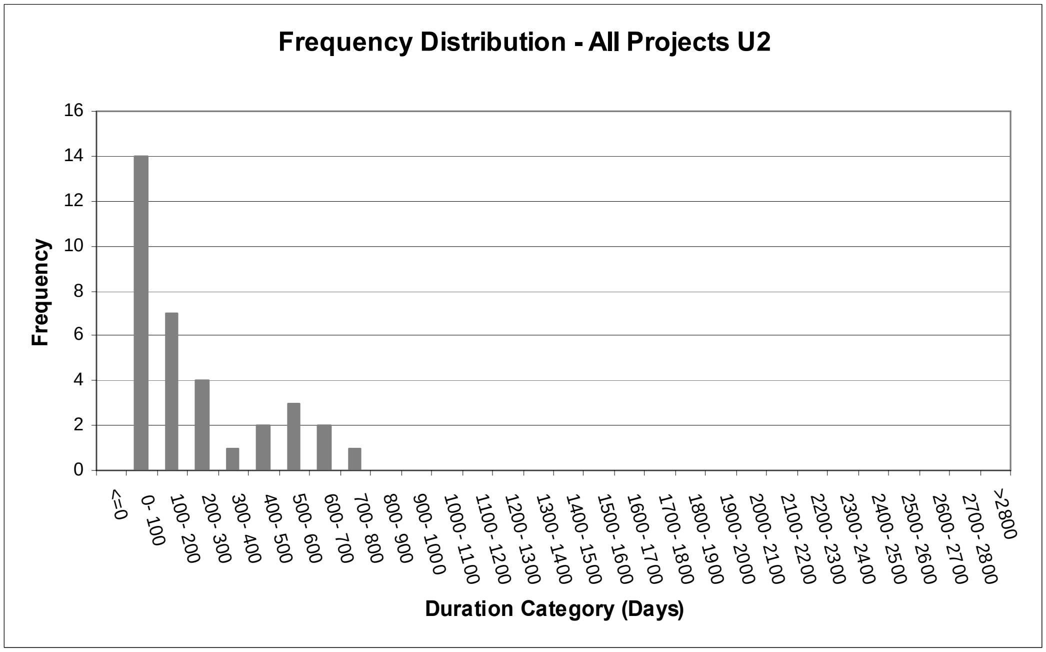


Figure 6.1. Frequency Distribution for All Projects

Percentile values were also calculated from the data sample with the following results: the 10th percentile was 30 days (0.08 years), the 50th percentile was 138 days (0.38 years), and the 90th percentile was 540 days (1.48 years). Table 6.2 presents the calculated percentile values. The data is presented visually in Figure 6.2, a plot of time versus the cumulative percentage of projects with corresponding U2 durations.

Table 6.2 U2 Duration Percentiles for All Projects

Percentile	Duration (n=34)	
	Days	Years
0th	3	0.01
10th	30	0.08
20th	44	0.12
30th	78	0.21
40th	94	0.26
50th	138	0.38
60th	192	0.53
70th	247	0.68
80th	458	1.26
90th	540	1.48
100th	710	1.94

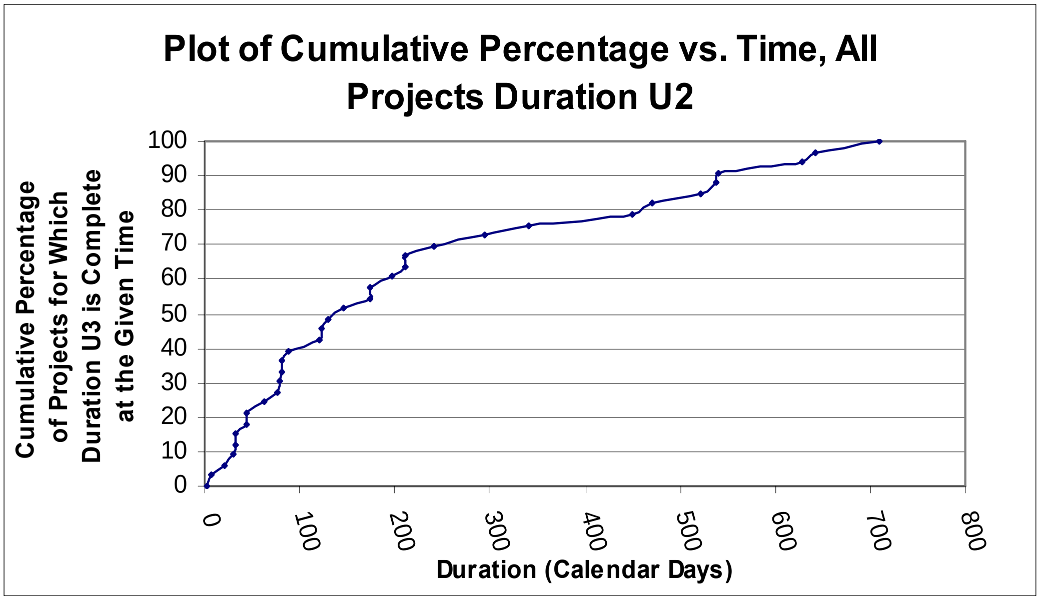


Figure 6.2. Cumulative U2 Duration Plot for All Projects

6.2 U2 for Quick vs. Slow Projects

The first factor analyzed was project classification (i.e., "quick" vs. "slow" utility adjustments), as recorded in the survey responses. Table 6.3 presents the results of the analysis.

Table 6.3 U1 Duration Statistics for Quick vs. Slow Projects

Statistic	Quick Projects (n=13)		Slow Projects (n=21)	
	Days	Years	Days	Years
Mean	134	0.37	276	0.76
Standard Deviation	191	0.52	210	0.57
Minimum	6	0.02	3	0.01
Maximum	710	1.94	643	1.76

For "Quick" utility adjustments there was a mean U2 duration of 134 days (0.37 years) from a sample size of 13 projects. For "Slow" utility adjustments there was a mean U2 duration of 276 days (0.76 years) from a sample size of 21 projects. Oddly, the quickest U2 duration was on a "Slow" utility adjustment at 3 days, whereas the slowest U2 duration was on a "Quick" project at 710 days. Figure 6.3 displays the frequency of U2 durations by project classification.

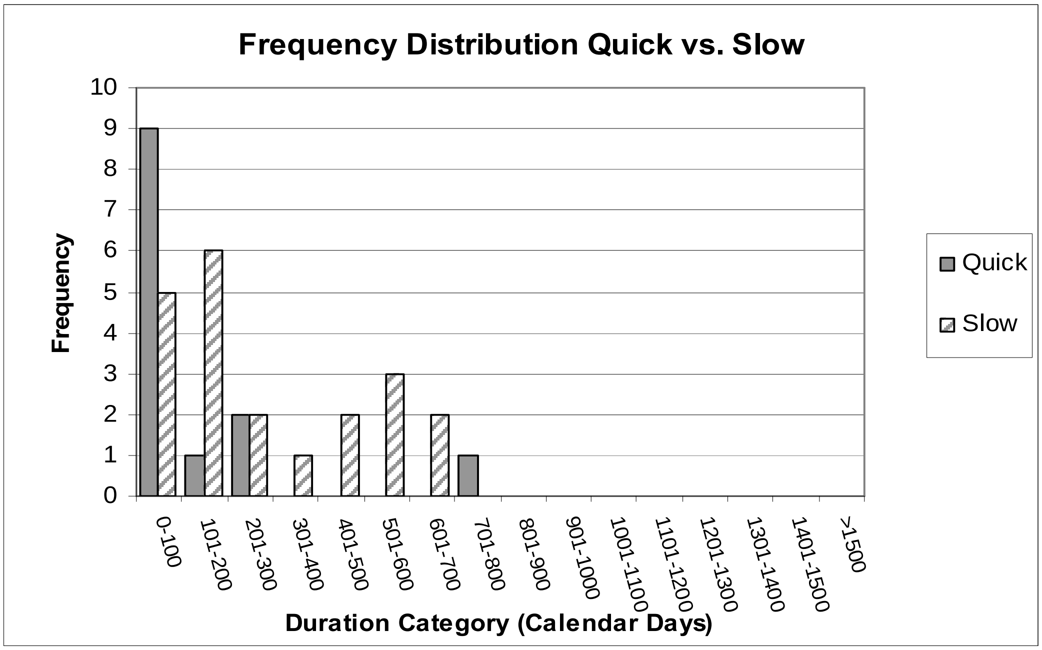


Figure 6.3. Duration U2 Frequency Distribution for Quick vs. Slow Projects

As expected, there is a higher frequency of “Quick” projects in the lower duration categories with a corresponding increase in “Slow” projects in the higher duration categories. Interestingly, there is a fair amount of overlap of “Quick” and “Slow” projects, with a number of “Slow” durations occurring in the same duration categories as “Quick” project durations.

The percentile values were calculated from the same sample of projects. Due to the smaller sample size, only quartiles were calculated for “Quick” projects. The data shows that the 25th percentile for “Quick” projects was 32 days (0.09 years), the 50th percentile was 77 days (0.21 years), and the 75th percentile was 120 days (0.33 years). The 10th percentile for “Slow” projects was 59 days (0.16 years), the 50th percentile was 204 days (0.56 years), and the 90th percentile was 549 days (1.50 years). The calculated percentile values are displayed in Table 6.4, and a cumulative U2 duration plot of “Quick” vs. “Slow” Projects is displayed in Figure 6.4.

Table 6.4 U2 Duration Percentiles for Quick and Slow Projects

Percentile	Quick Projects (n=13)		Slow Projects (n=20)	
	Days	Years	Days	Years
0th	6	0.02	3	0.01
10th	*	*	59	0.16
20th	*	*	86	0.24
25th	32	0.09	115	0.31
30th	*	*	139	0.38
40th	*	*	175	0.48
50th	77	0.21	204	0.56
60th	*	*	281	0.77
70th	*	*	456	1.25
75th	120	0.33	484	1.32
80th	*	*	525	1.44
90th	*	*	549	1.50
100th	710	1.94	643	1.76

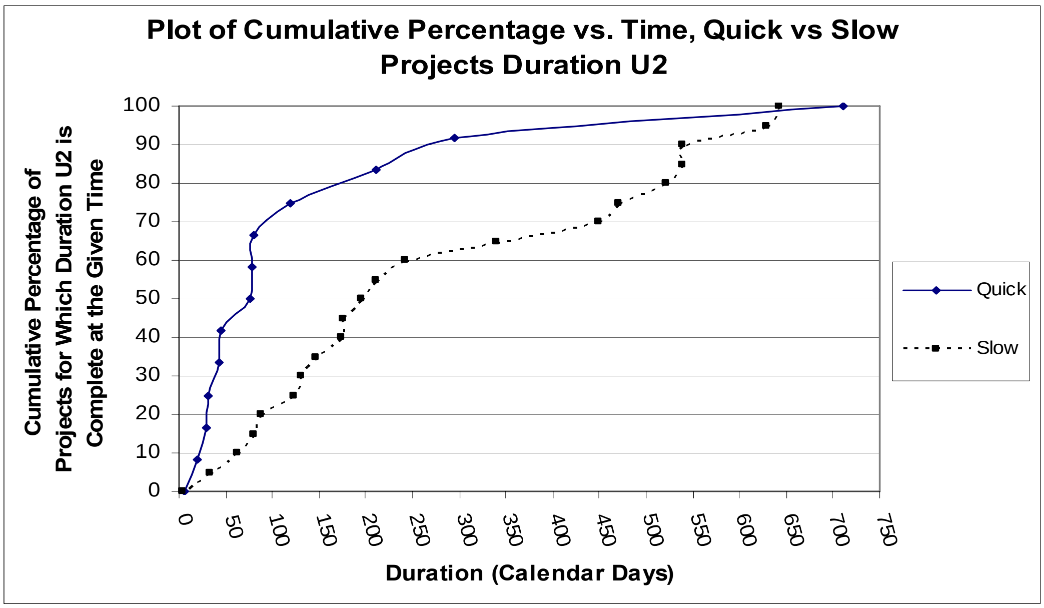


Figure 6.4. Cumulative U2 Duration Plot for Quick vs. Slow Projects

6.3 U2 by Highway Type

Highway type was a factor that was analyzed as a potential duration “driver”. Table 6.5 presents the results of the analysis based on the type of highway.

Table 6.5 U2 Duration Statistics by Highway Type

Statistic	FM / RM (n=14)		Interstate (n=4)		State Highway (n=4)		US Highway (n=11)	
	Days	Years	Days	Years	Days	Years	Days	Years
Mean	143	0.39	240	0.66	263	0.72	317	0.87
Standard Deviation	155	0.42	*	*	*	*	247	0.68
Minimum	6	0.02	3	0.01	124	0.34	33	0.09
Maximum	471	1.29	629	1.72	540	1.48	710	1.94

There were 33 total projects with available data that fit into the above categories. For FM/RM projects there was a mean U2 duration of 143 days (0.39 years) from a sample size of 14 projects. For Interstate projects there was a mean U2 duration of 240 days (0.66 years) from a sample size of 4 projects. For State Highway projects there was a mean U2 duration of 263 days (0.72 years) from a sample size of 4 projects. For US Highway projects there was a mean U2 duration of 317 days (0.87 years) from a sample size of 11 projects. The quickest U2 duration was on an Interstate project at 3 days, whereas the slowest U2 duration was on a US Highway project at 710 days.

Selected percentile values were calculated from the same sample of projects. Due to the small sample sizes the only calculated percentile values were quartiles for FM/RM projects and US Highway Projects. The 25th percentile for FM/RM projects was 35 days (0.10 years), the 50th percentile was 81 days (0.22 years), and the 75th percentile was 175 days (0.48 years). The 25th percentile for US Highway projects was 99 days (0.27 years), the 50th percentile was 211 days (0.58 years), and the 75th percentile was 531 days (1.45 years). The calculated percentile values are displayed in Table 6.6, and a cumulative duration plot U2 Duration vs. Highway Type is displayed in Figure 6.5.

Table 6.6 U2 Percentile Durations by Highway Type

Percentile	FM / RM (n=14)		US Highway (n=11)	
	Days	Years	Days	Years
0th	6	0.02	33	0.09
25th	35	0.10	99	0.27
50th	81	0.22	211	0.58
75th	175	0.48	531	1.45
100th	471	1.29	710	1.94

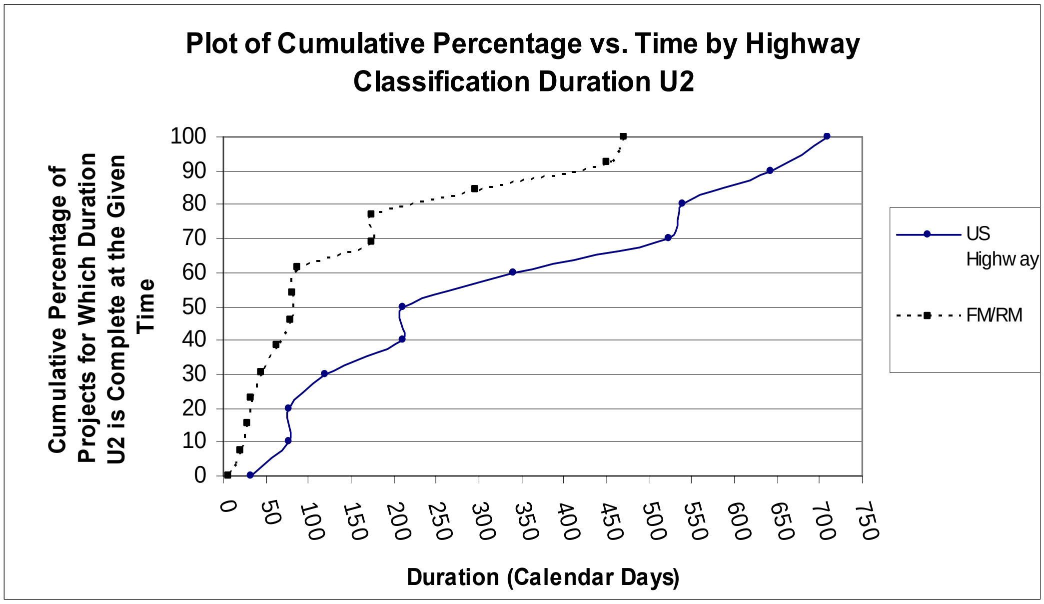


Figure 6.5. Cumulative U2 Duration Plot by Highway Type

6.4 U2 by Location Category

Location Category was identified as another potential duration driver. Table 6.7 presents the results of the analysis based on location category.

Table 6.7 U2 Duration Statistics by Location Category

Statistic	Rural (n=15)		Metro (n=11)		Urban (n=8)	
	Days	Years	Days	Years	Days	Years
Mean	122	0.33	237	0.65	388	1.06
Standard Deviation	120	0.33	200	0.55	269	0.74
Minimum	6	0.02	3	0.01	29	0.08
Maximum	471	1.29	540	1.48	710	1.94

For Rural projects there was a mean U2 duration of 122 days (0.33 years) from a sample size of 15 projects. For Metro projects there was a mean U2 duration of 237 days (0.65 years) from a sample size of 11 projects. For Urban projects there was a mean U2 duration value of 388 days (1.06 years) from a sample size of 8 projects. The quickest U2 duration was on a Metro project at 3 days, whereas the slowest U2 duration was on an Urban project at 710 days.

Selected percentile values were calculated from the same sample of projects. The 10th percentile for rural projects was 25 days (0.07 years), the 50th percentile was 78 days (0.21 years), and the 90th percentile was 229 days (0.63 years). Given its smaller sample size, only quartiles were calculated for Metro projects, and from the data the 25th percentile was 84 days (0.23 years), the 50th percentile was 130 days (0.36 years), and the 75th percentile was 395 days (1.08 years). Given its smaller sample size, only quartiles were calculated for Urban projects, and from the data the 25th percentile was 184 days (0.50 years), the 50th percentile was 375 days

(1.03 years), and the 75th percentile was 633 days (1.73 years). The calculated percentile values are displayed in Table 6.8, and a cumulative U2 duration plot by location category is displayed in Figure 6.6.

Table 6.8 U2 Duration Percentiles by Location Category

Percentile	Rural (n=15)		Metro (n=11)		Urban (n=8)	
	Days	Years	Days	Years	Days	Years
0th	6	0.02	3	0.01	29	0.08
10th	25	0.07	*	*	*	*
20th	41	0.11	*	*	*	*
25th	44	0.12	84	0.23	184	0.50
30th	48	0.13	*	*	*	*
40th	71	0.19	*	*	*	*
50th	78	0.21	130	0.36	375	1.03
60th	96	0.26	*	*	*	*
70th	163	0.45	*	*	*	*
75th	175	0.48	395	1.08	633	1.73
80th	182	0.50	*	*	*	*
90th	229	0.63	*	*	*	*
100th	471	1.29	540	1.48	710	1.94

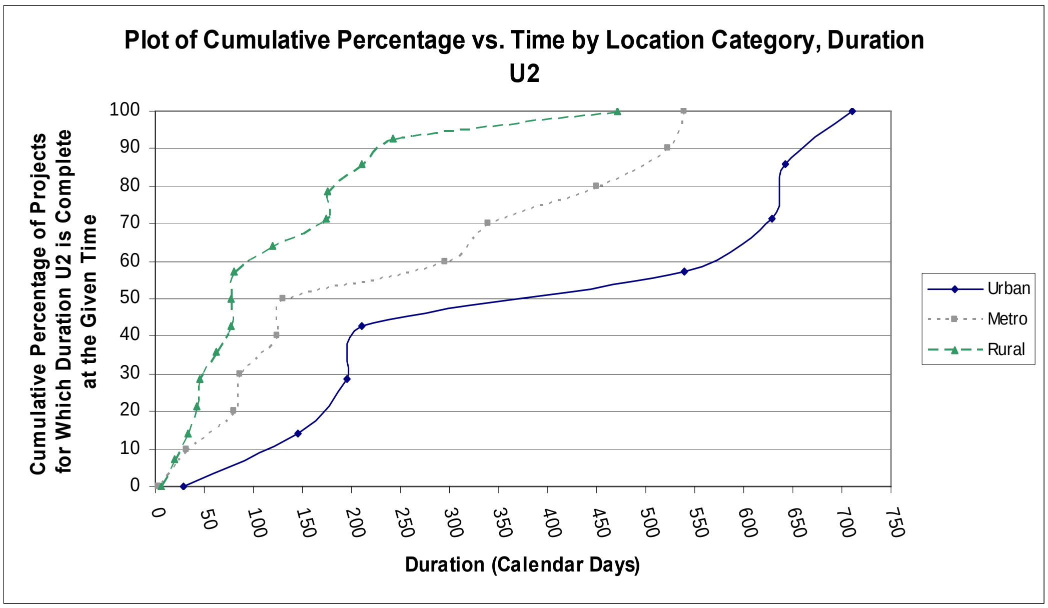


Figure 6.6. Cumulative U2 Duration Plot by Location Category

A frequency distribution (Figure 6.7) was created for U2 durations by location category in order to provide a visual representation of the association of location with utility adjustment duration.

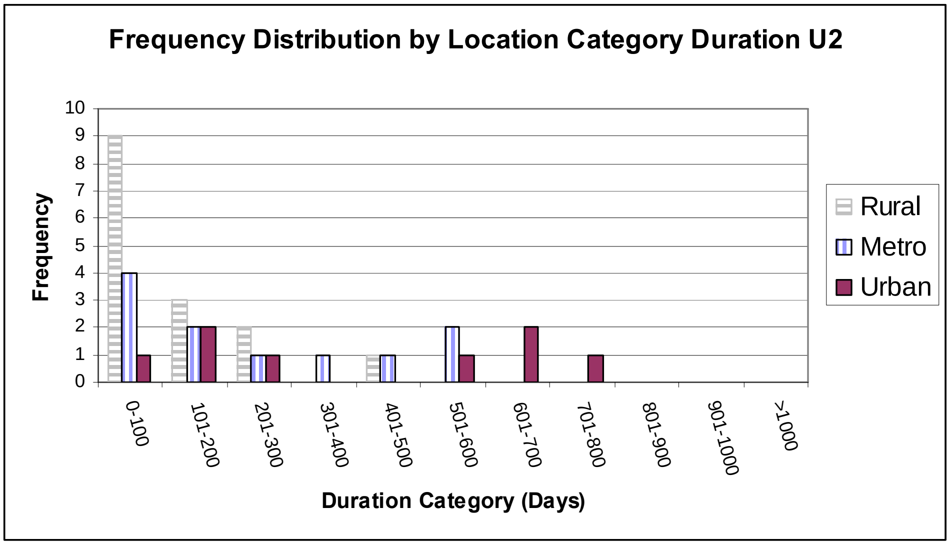


Figure 6.7. Frequency Distribution of Duration U2 by Location Category

6.5 U2 by TxDOT Project Type

The next factor analyzed was TxDOT project type. Table 6.9 presents the results of the analysis of duration by project type. As defined in Chapter 3.8, RER is Rehabilitation and Repair and WNF is Widen Non-Freeway.

Table 6.9 U2 Duration Statistics by TxDOT Project Type

Statistic	RER (n=6)		WNF (n=10)	
	Days	Years	Days	Years
Mean	62	0.17	187	0.51
Standard Deviation	54	0.15	122	0.33
Minimum	6	0.02	77	0.21
Maximum	174	0.48	450	1.23

While project type categorization was performed on nearly all of the projects with available duration data, the small samples for most project types reduced the scope of further analysis to the 16 projects in the two categories in Table 6.9. For RER projects there was a mean U2 duration of 62 days (0.17 years) from a sample size of 6 projects. For WNF projects there was a mean U2 duration of 187 days (0.51 years) from a sample size of 10 projects. The quickest U2 duration was on an RER project at 6 days, whereas the slowest U2 duration was on a WNF project at 450 days.

Selected percentile values were calculated from the same data; however, the small sample sizes resulted in only quartiles being calculated, and then only for WNF projects. The 25th percentile for WNF projects was 91 days (0.25 years), the 50th percentile was 150 days (0.41 years), and the 75th percentile was 211 days (0.58 years). The calculated percentile durations are displayed in Table 6.10, and a cumulative U2 duration plot by TxDOT Project Type is displayed in Figure 6.8.

Table 6.10 U2 Duration Percentiles for WNF Projects

Percentile	WNF (n=10)	
	Days	Years
0th	77	0.21
25th	91	0.25
50th	150	0.41
75th	211	0.58
100th	450	1.23

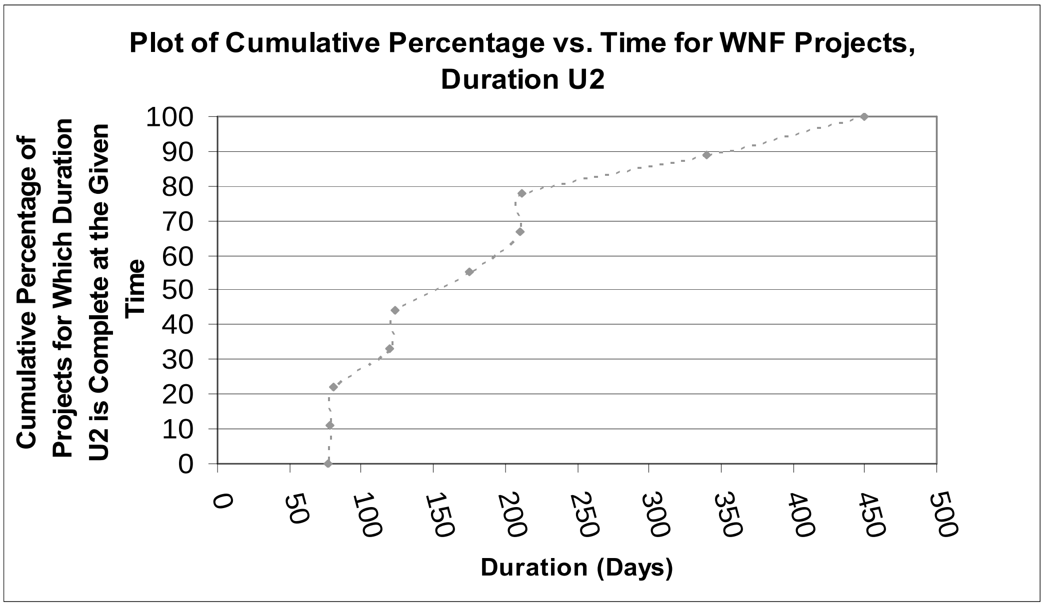


Figure 6.8. Cumulative U2 Duration Plot for WNF Projects

6.6 U2 vs. Construction Project Length

Construction Project Length was also examined as a potential “driver” of utility adjustment duration. Since length is a continuous variable, a scatter-plot (Figure 6.9) was created for analysis.

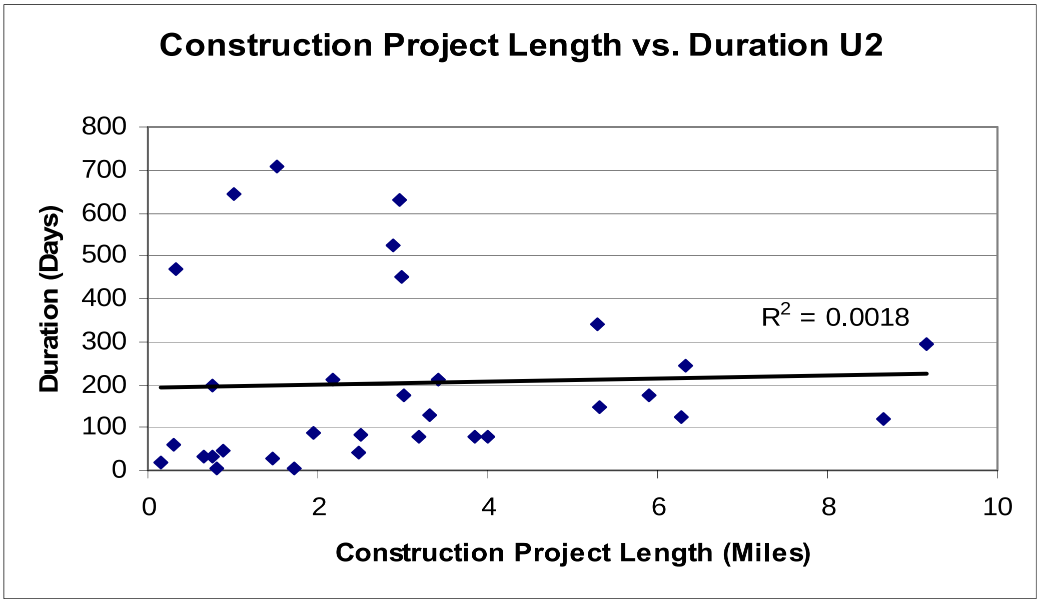


Figure 6.9. Scatter Plot of Construction Project Length vs. Duration U2

Once the data points had been plotted a trend-line was computed to determine whether or not further regression analysis would provide insight. If the displayed R^2 would be large enough, the regression would be performed. Based on the resulting R^2 value of 0.0018, less than one percent of the duration variability can be explained by construction project length. Therefore, no further regression analysis was performed.

6.7 U2 for Federally Funded vs. Non-Federally Funded

Another factor that was analyzed as a potential duration "driver" was whether or not there was federal participation in the reimbursement of utility adjustment expenses. Table 6.11 displays the results of the analysis.

Table 6.11 U2 Duration Statistics for Federally Funded vs. Non-Federally Funded

Statistic	Non-Federally Funded (n=21)		Federally Funded (n=6)	
	Days	Years	Days	Years
Mean	185	0.51	240	0.66
Standard Deviation	206	0.56	248	0.68
Minimum	6	0.02	3	0.01
Maximum	710	1.94	629	1.72

For Non-Federally Funded projects there was a mean U2 duration of 185 days (0.51 years) from a sample size of 21 projects. For Federally funded projects there was a mean U2 duration of 240 days (0.66 years) from a sample size of 6 projects. The quickest U2 duration was on a Federally Funded project at 3 days, whereas the slowest U2 duration was on a Non-Federally Funded project at 710 days.

Selected percentile values were calculated from the sample of Non-Federally Funded projects. The 10th percentile for Non-Federally Funded projects was 29 days (0.08 years), the 50th percentile was 87 days (0.24 years), and the 90th percentile was 522 days (1.43 years). The calculated U2 percentile values are displayed in Table 6.12, and a cumulative U2 duration plot for Non-Federally Funded Projects is displayed in Figure 6.10.

Table 6.12 U2 Percentiles for Non-Federally Funded

Percentile	Non-Federally Funded (n=21)	
	Days	Years
0th	6	0.02
10th	29	0.08
20th	43	0.12
30th	77	0.21
40th	80	0.22
50th	87	0.24
60th	124	0.34
70th	175	0.48
80th	295	0.81
90th	522	1.43
100th	710	1.94

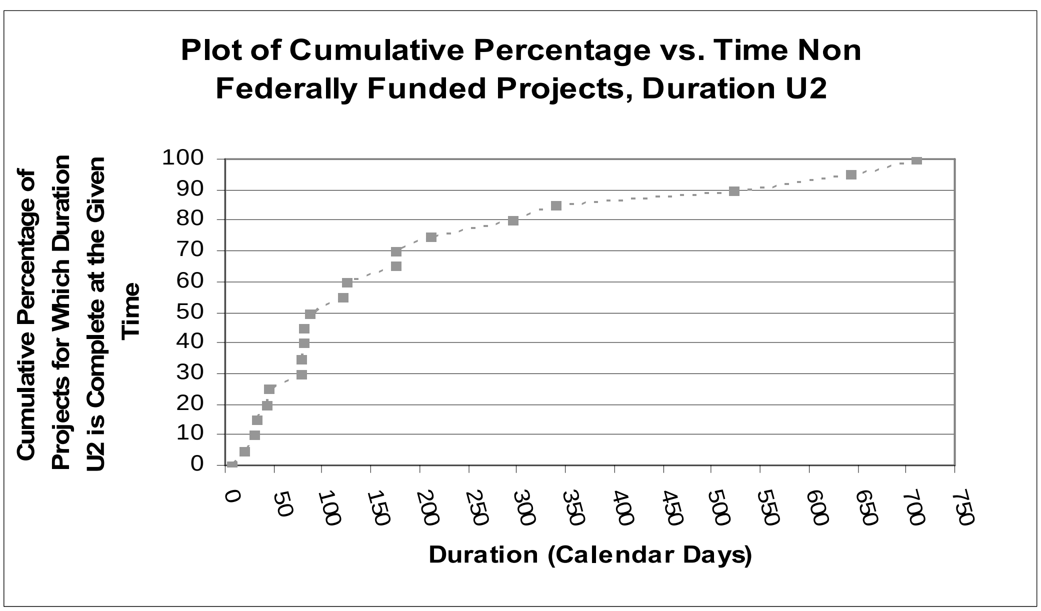


Figure 6.10. Cumulative U2 Duration Plot of Non-Federally Funded Projects

6.8 U2 by LPA Fund Participation

Local Public Agency (LPA) participation in reimbursement costs was also investigated as a potential duration “driver”. Table 6.13 displays the results of the analysis of LPA-funded vs. Non LPA Funded.

Table 6.13 U2 Duration Statistics LPA vs. Non-LPA Projects

Statistic	Non-LPA-funded (n=6)		LPA-funded (n=20)	
	Days	Years	Days	Years
Mean	192	0.53	226	0.62
Standard Deviation	223	0.61	227	0.62
Minimum	29	0.08	6	0.02
Maximum	629	1.72	710	1.94

There were 26 total projects with available data that could be characterized by LPA funding participation. For Non-LPA-Funded projects there was a mean U2 duration of 192 days (0.53 years) from a sample size of 6 projects. For LPA-Funded projects there was a mean U2 duration of 226 days (0.62 years) from a sample size of 20 projects. The quickest U2 duration was on an LPA-Funded project at 6 days, as was the slowest U2 duration of 710 days.

Sufficient sample data to calculate percentiles existed only for LPA-Funded projects. The 10th percentile for LPA-Funded projects was 31 days (0.08 years), the 50th percentile was 106 days (0.29 years), and the 90th percentile was 550 days (1.51 years). The calculated percentile U2 durations are displayed in Table 6.14, and a cumulative U2 duration plot of LPA-Funded projects is displayed in Figure 6.11.

Table 6.14 U2 Duration Percentiles for LPA-funded Projects

Percentile	LPA-funded (n=20)	
	Days	Years
0th	6	0.02
10th	31	0.08
20th	41	0.11
25th	69	0.19
30th	78	0.21
40th	81	0.22
50th	106	0.29
60th	174	0.48
70th	309	0.85
75th	368	1.01
80th	464	1.27
90th	550	1.51
100th	710	1.94

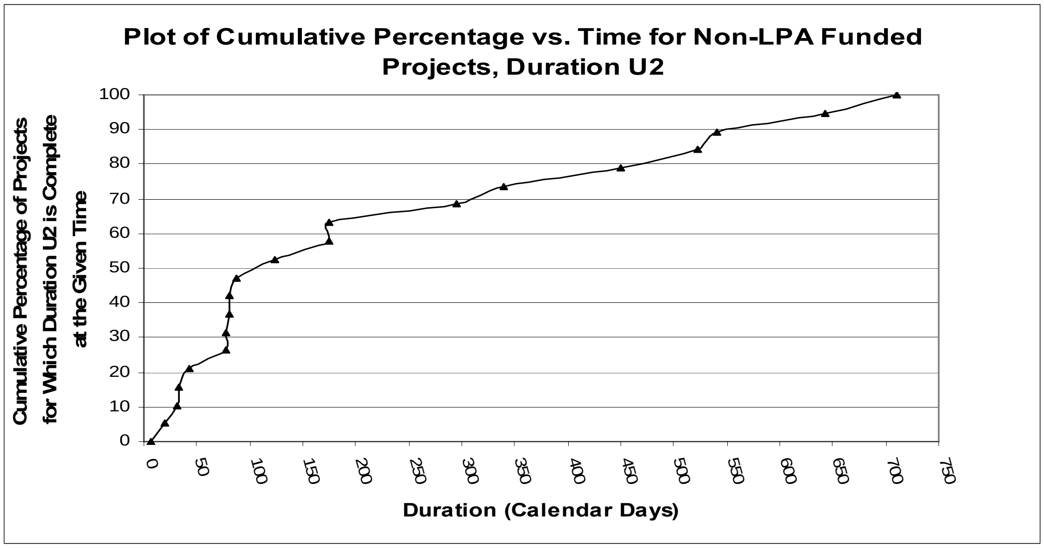


Figure 6.11. Cumulative U2 Duration Plot of LPA-funded Projects

6.9 U2 for Reimbursable vs. Non-Reimbursable

U2 durations for Reimbursable projects were compared to those for Non-Reimbursable projects in order to determine whether reimbursability is a duration “driver”. Table 6.15 displays the results of the analysis.

Table 6.15 U2 Duration Statistics for Reimbursable vs. Non

Statistic	Reimbursable (n=29)		Non-Reimbursable (n=5)	
	Days	Years	Days	Years
Mean	221	0.61	226	0.62
Standard Deviation	222	0.61	*	*
Minimum	3	0.01	62	0.17
Maximum	710	1.94	471	1.29

For Reimbursable projects there was a mean U2 duration of 221 days (0.61 years) from a sample size of 29 projects. For Non-Reimbursable utility adjustment projects there was a mean U2 duration of 226 days (0.62 years) from a sample size of 5 projects. The quickest U2 duration was on a Reimbursable project at 3 days, as was the slowest U2 duration at 710 days.

Selected percentile values were calculated from the same sample of projects. Because of its small sample size, no percentile values were calculated for Non-Reimbursable utility adjustment projects. For Reimbursable projects the 10^{th} percentile was 27 days (0.07 years), the 50^{th} percentile was 124 days (0.34 years), and the 90^{th} percentile was 558 days (1.53 years). The calculated percentile values are displayed in Table 6.16, and a cumulative U2 duration plot for Reimbursable utility adjustment projects is displayed in Figure 6.12.

Table 6.16 U2 Percentiles for Reimbursable Projects

Percentile	Reimbursable (n=29)	
	Days	Years
0th	3	0.01
10th	27	0.07
20th	39	0.11
30th	77	0.21
40th	82	0.22
50th	124	0.34
60th	175	0.48
70th	261	0.71
80th	479	1.31
90th	558	1.53
100th	710	1.94

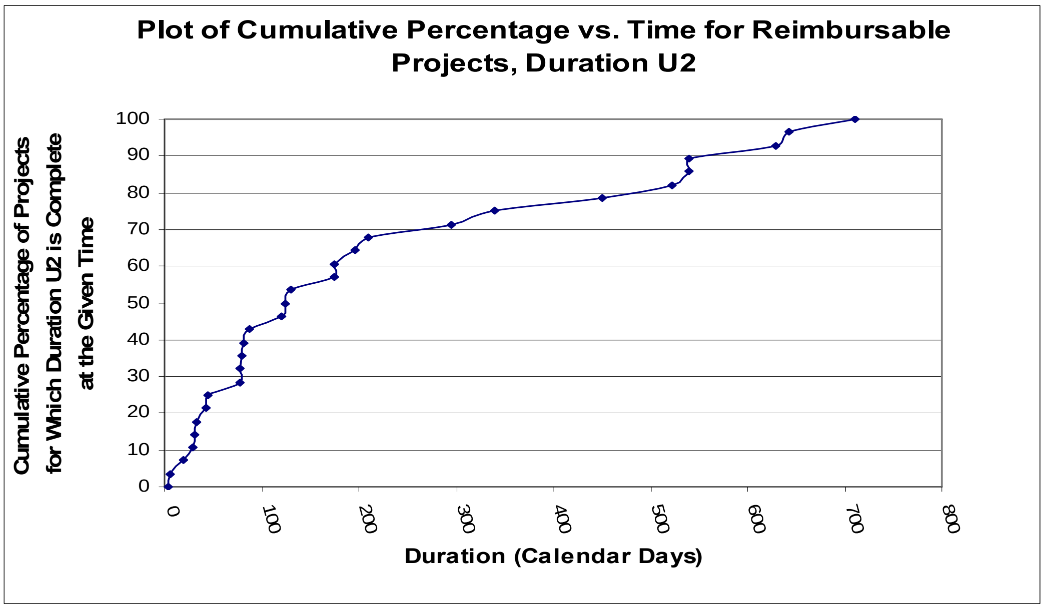


Figure 6.12. Cumulative U2 Duration Plot for Reimbursable Projects

6.10 Date of Eligibility (DOE) Procedure Applicability

Another funding mechanism that was investigated as a potential duration "driver" was the use of TxDOT's Date of Eligibility (DOE) Procedure. Utility adjustment projects for which *any* of the individual adjustments were conducted under the DOE procedure were considered to be DOE projects. Table 6.17 displays the results of the analysis.

Table 6.17 U2 Duration Statistics DOE vs. Non-DOE

Statistic	Non-DOE (n=12)		DOE (n=17)	
	Days	Years	Days	Years
Mean	115	0.31	296	0.81
Standard Deviation	145	0.40	240	0.66
Minimum	6	0.02	3	0.01
Maximum	540	1.48	710	1.94

For Non-DOE projects there was a mean U2 duration of 115 days (0.31 years) from a sample size of 12 projects. For DOE projects there was a mean U2 duration of 296 days (0.81 years) from a sample size of 17 projects. The quickest U2 duration was on a DOE project at 3 days, as was the slowest U2 duration at 710 days.

Selected percentile values were calculated from the same sample of projects. Given its smaller sample size, only quartiles were calculated for Non-DOE projects, and from the data the 25^{th} percentile was 40 days (0.11 years), the 50^{th} percentile was 78 days (0.21 years), and the 75^{th} percentile was 121 days (0.33 years). The 10^{th} percentile for DOE projects was 31 days (0.08 years), the 50^{th} percentile was 196 days (0.54 years), and the 90^{th} percentile was 635 days (1.74 years). The calculated percentile values are displayed in Table 6.18, and a cumulative U2 duration plot of DOE vs. Non-DOE is displayed in Figure 6.13.

Table 6.18 U2 Percentiles for DOE vs. Non

Percentile	Non-DOE (n=12)		DOE (n=17)	
	Days	Years	Days	Years
0^{th}	6	0.02	3	0.01
10^{th}	*	*	31	0.08
20^{th}	*	*	80	0.22
25^{th}	40	0.11	81	0.22
30^{th}	*	*	120	0.33
40^{th}	*	*	174	0.48
50^{th}	78	0.21	196	0.54
60^{th}	*	*	322	0.88
70^{th}	*	*	464	1.27
75^{th}	121	0.33	522	1.43
80^{th}	*	*	536	1.47
90^{th}	*	*	635	1.74
100^{th}	540	1.48	710	1.94

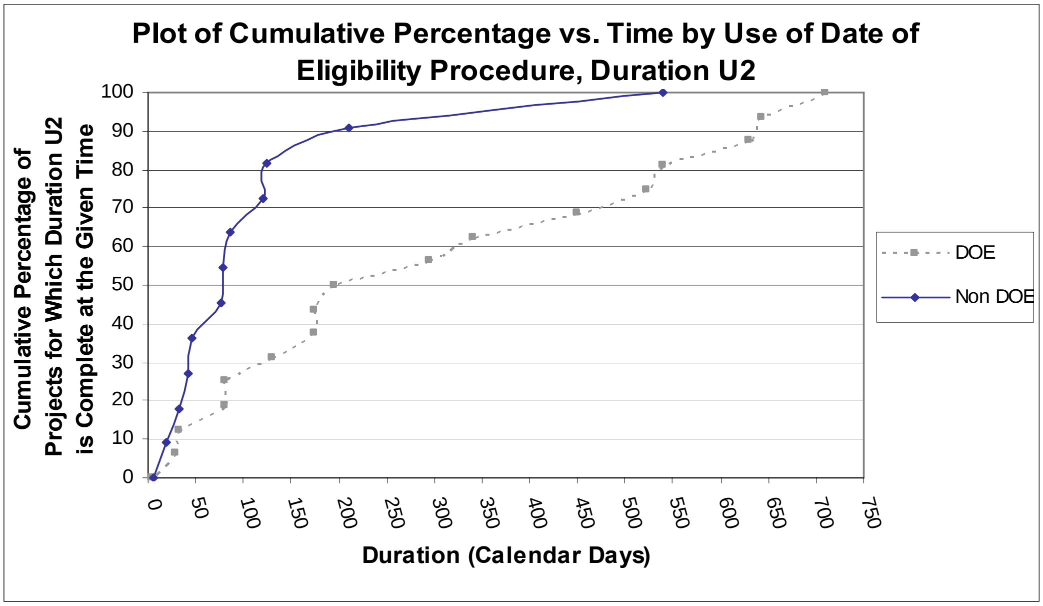


Figure 6.13. Cumulative U2 Duration Plot for DOE vs. Non-DOE Projects

6.11 U2 by Number of Utility Agreements

The number of utilities involved on a project was also investigated as a potential duration "driver". If two agreements existed for the same utility, the analysis treated it as two utilities. Table 6.19 displays the results of the analysis.

Table 6.19 Mean U2 Duration by Number of Utility Agreements

Number of Agreements	Sample Size (n)	Mean Duration	
		Days	Years
1	7	188	0.51
2	10	121	0.33
3	4	143	0.39
4	3	155	0.42
5	3	328	0.90
>5	3	534	1.46

The data sample contained seven projects with only one utility agreement, with a mean U2 duration of 188 days (0.51 years). There were 10 projects with two utility agreements, for which the mean U2 duration was 121 days (0.33 years). For projects with three utility agreements there was a sample of four projects with a mean U2 duration of 143 days (0.39 years). For projects with four utility agreements there was a sample of three projects with a mean U2 duration of 155 days (0.42 years). There were three projects with five utility agreements, for which the mean U2 duration was 328 days (0.90 years). There were three projects with more than five utility agreements, with a mean U2 duration of 534 days (1.46 years).

Based on the apparent association of the number of utilities with U2 duration, a scatter plot (Figure 6.14) was made of number of utilities vs. duration.

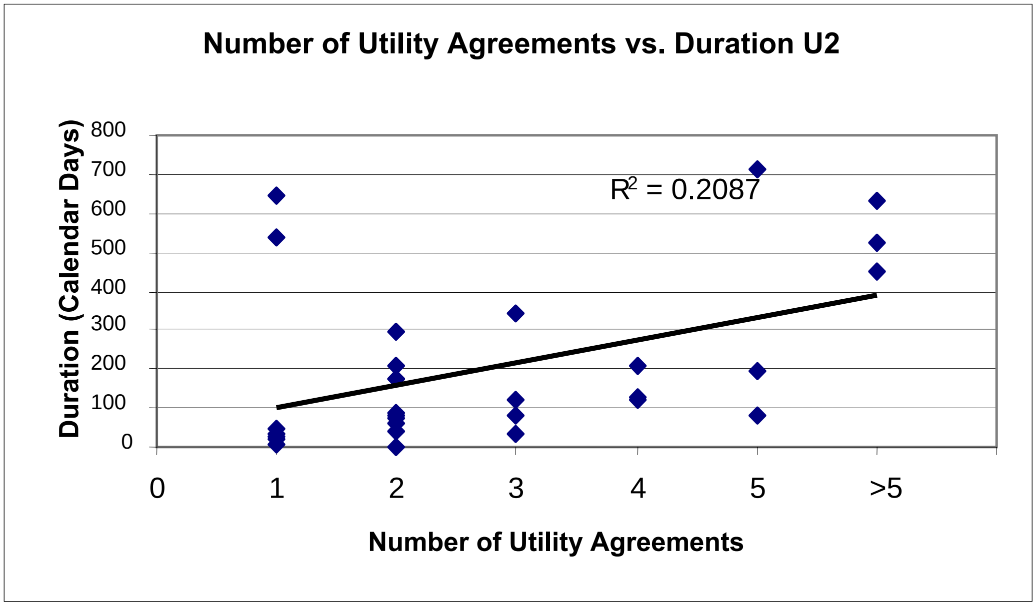


Figure 6.14. Number of Utility Agreements vs. Duration U2

After the data points were plotted, a regression trend-line was calculated to ascertain whether further analysis would be beneficial. While the regression coefficient of R^2 does seem to indicate a relationship, its relatively low value of 0.2087 means that the number of utility agreements only explains approximately 20 percent of the variability in duration U2.

In addition to performing the analysis of categories as shown in Figure 6.14, another regression was performed based on all possible numbers of utility agreements. Figure 6.15 displays the results of the scatter plot and the calculated R^2 value.

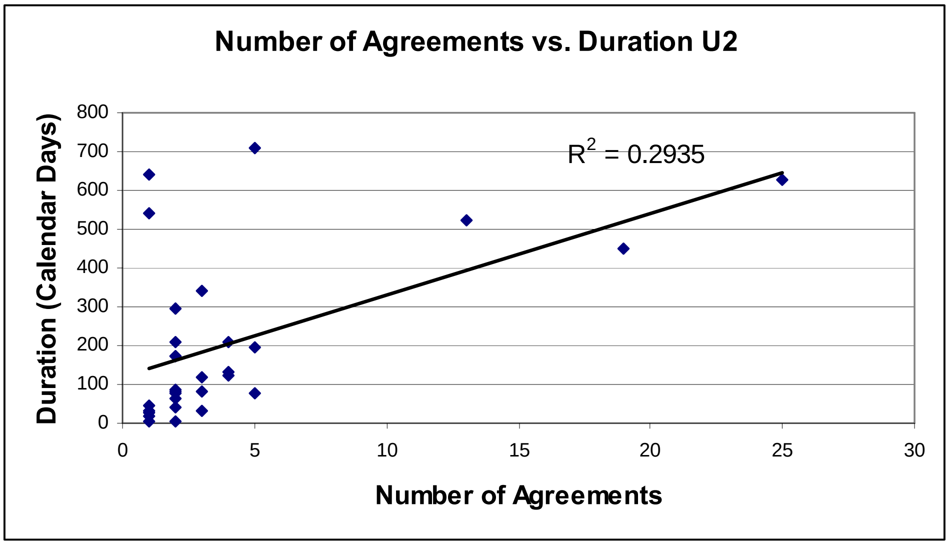


Figure 6.15. Regression Plot for Number of Agreements vs. Duration U2

The regression for duration by number of agreements did increase the R2 value, further indicating that some relationship exists between duration U2 and the number of utility agreements; however, the small sample sizes for larger numbers of agreements certainly reduces the power of the prediction.

6.12 U2 by Type of Utility

Type of utility was identified as a potential duration "driver". Due to the fact that more than one type of utility can be involved in a single utility adjustment project (as defined for this study), there is a significant amount of overlap in the data samples. Table 6.20 displays the results of the analysis.

Table 6.20 Mean U2 Duration by Type of Utility

Type of Adjustment	Sample Size (n)	Mean Duration	
		Days	Years
Extend Casing	4	204	0.56
Water	15	224	0.61
Overhead Power	16	243	0.67
Underground Communications	11	261	0.71
Underground Power	5	267	0.73
High-Pressure Gas	10	297	0.81

Projects with Extend Casing adjustments were the quickest with a mean U2 duration of 204 days (0.56 years) from a sample of 4 projects. Projects with Water adjustments were next with a mean U2 duration of 224 days (0.61 years) from a sample of 15 projects. For Overhead Power there was a mean duration of 243 days (0.67 years) from a sample of 16 projects. For Underground Communications there was a mean duration of 261 days (0.71 years) from a sample of 11 projects. Projects with Underground Power adjustments were next with a mean U2 duration of 267 days (0.73 years) from a sample of 5 projects. The slowest projects involved High Pressure Gas adjustments, and had a mean U2 duration of 297 days (0.81 years) from a sample of 10 projects.

In addition to the descriptive statistics, percentile values and a cumulative duration plot were made for U2 duration by type of utility. The percentile values are displayed in Table 6.21 and the plot is displayed in Figure 6.16.

Table 6.21 U2 Percentile Values by Type of Utility

Percentile	Water (n=15)		Overhead Power (n=16)		Underground Communications (n=11)		High-Pressure Gas (n=10)	
	Days	Years	Days	Years	Days	Years	Days	Years
0th	6	0.02	20	0.05	3	0.01	32	0.09
10th	*	*	33	0.09	*	*	*	*
20th	*	*	43	0.12	*	*	*	*
25th	100	0.27	71	0.19	91	0.25	79	0.22
30th	*	*	102	0.28	*	*	*	*
40th	*	*	130	0.36	*	*	*	*
50th	146	0.40	175	0.48	196	0.54	214	0.58
60th	*	*	210	0.57	*	*	*	*
70th	*	*	269	0.74	*	*	*	*
75th	346	0.95	339	0.93	395	1.08	504	1.38
80th	*	*	471	1.29	*	*	*	*
90th	*	*	576	1.58	*	*	*	*
100th	629	1.72	710	1.94	643	1.76	710	1.94

For projects involving Water adjustments the 25th percentile was 100 days (0.27 years), the 50th percentile was 146 days (0.40 years), and the 75th percentile was 346 days (0.95 years). For projects involving Overhead Power adjustments the 10th percentile was 33 days (0.09 years), the 50th percentile was 175 days (0.48 years), and the 90th percentile was 576 days (1.58 years). For projects involving Underground Communications adjustments the 25th percentile was 91 days (0.25 years), the 50th percentile was 196 days (0.54 years), and the 75th percentile was 395 days (1.08 years). For projects involving High-Pressure Gas adjustments the 25th percentile was 79 days (0.22 years), the 50th percentile was 214 days (0.58 years), and the 75th percentile was 504 days (1.38 years).

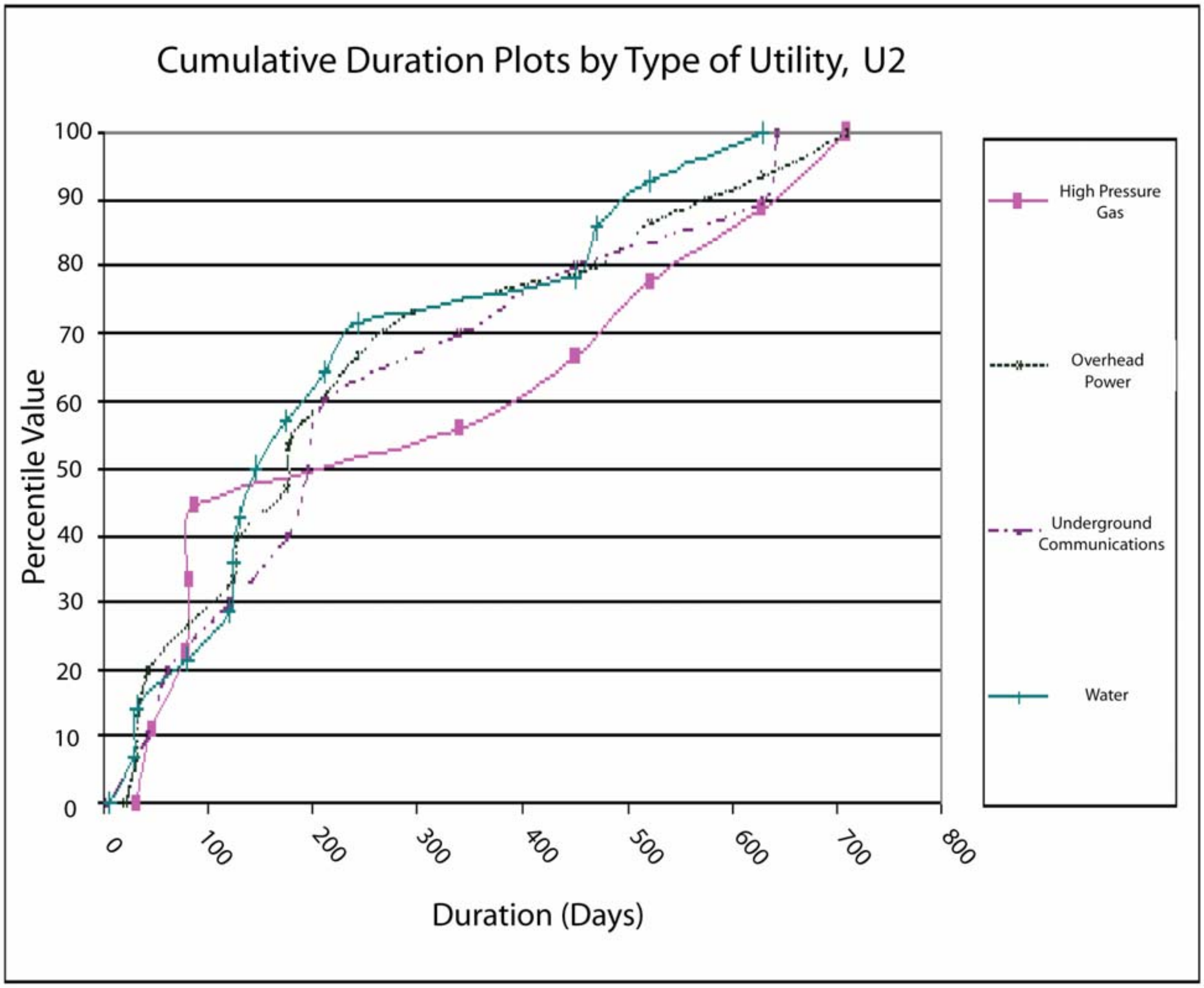


Figure 6.16. Cumulative U2 Duration Plot by Type of Utility

6.13 Factor Influence on Duration U2

In addition to reporting duration data in statistical form, comparisons were made between factors based on mean U2 durations. Table 6.22 shows a partial listing of different categories of projects.

In order to categorize the different types of factors as either quick, moderate, or slow in duration all factors were first sorted by mean duration for the sample. From the list of sorted factors, the quickest and slowest factors were chosen. For quick projects, there were several factors with a mean duration of about 0.5 years. At the opposite end of the spectrum there were about as many factors with mean durations greater than 0.75 years. Following the identification of the quick and slow factors, a few moderate factors were identified with mean durations roughly halfway between the quick and slow factors.

Table 6.22 Factor Influence on Duration U2

Quick Mean Duration ≤ 0.5 yr	Moderate 0.5 yr ≤ Mean Duration ≤ 0.75 yr	Slow Mean Duration ≥ 0.75 yr
RER Construction Projects	Non-Federally Funded Projects	DOE Projects
Non-DOE Projects	WNF Construction Projects	Projects with High-Pressure Gas Adjustments
Rural Projects	Non-LPA Projects	US Highway Projects
FM/RM Projects	Projects with Extend Casing Adjustments	Urban Projects
	Reimbursable Projects	
	All Projects	
	Projects with Water Adjustments	
	LPA Projects	
	Non-Reimbursable Projects	
	Metro Projects	
	Interstate Highway Projects	
	Federally Funded Projects	
	Projects with Overhead Power Adjustments	
	Projects with Underground Communications Adjustments	
	State Highway Projects	
	Projects with Underground Power Adjustments	

Chapter 7. Data Analysis for Duration U3

The data analysis for duration U3 (defined in Chapter 4.3) is presented in this chapter. As defined in Chapter 4.3, duration U3 is the time from the R/W Release date to the Last Adjustment Completion date. As has been stated elsewhere in this report, utility adjustments cannot be completed until sufficient R/W has been purchased, making duration U3 dependant on timely acquisition of right-of-way parcels.

7.1 U3 for All Projects

Table 7.1 the results of the data analysis for the complete sample of utility adjustment projects with data for duration U3.

Table 7.1 U3 Duration Statistics for All Projects

Statistic	Duration (n=53)	
	Days	Years
Mean	1159	3.17
Standard Deviation	1176	3.22
Minimum	51	0.14
Maximum	6511	17.83

As is shown in Table 7.1, there was an overall U3 mean duration of 1159 days (3.17 years) from a sample population of 53 projects. The quickest U3 duration was 51 days, while the slowest U3 duration was 6511 days. Figure 7.1 displays the frequency distribution of all durations in the sample.

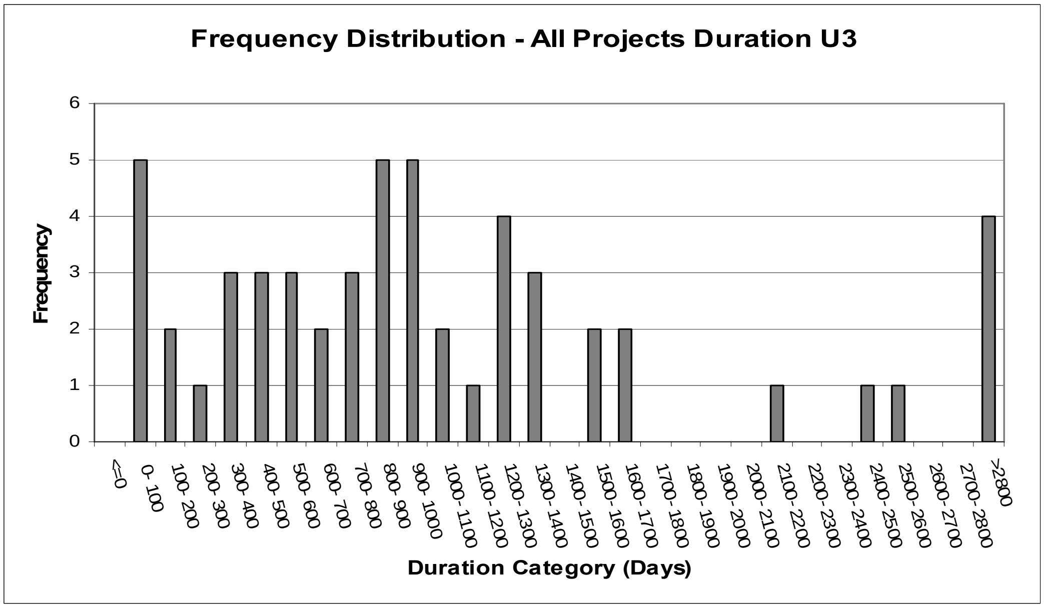


Figure 7.1. Frequency Distribution Duration U3 All Projects

The duration data for U3 was more uniformly distributed than the data for durations U1 and U2. Still, there was a higher frequency of projects at the low end of the duration categories, and likewise there was a slight increase in frequency in the highest duration categories.

Percentile values were also calculated from the data sample of 53 projects with the following results: the 10^{th} percentile of durations was 149 days (0.41 years), the 50^{th} percentile was 900 days (2.46 years), and the 90^{th} percentile was 2400 days (6.57 years). Table 7.2 contains the calculated values for selected percentiles, and Figure 7.2 is the plot of cumulative U3 percentage vs. duration for all projects.

Table 7.2 U3 Duration Percentiles for All Projects

Percentile	Duration (n=53)	
	Days	Years
0^{th}	51	0.14
10^{th}	149	0.41
20^{th}	400	1.10
30^{th}	538	1.47
40^{th}	769	2.11
50^{th}	900	2.46
60^{th}	1016	2.78
70^{th}	1274	3.49
80^{th}	1485	4.07
90^{th}	2400	6.57
100^{th}	6511	17.83

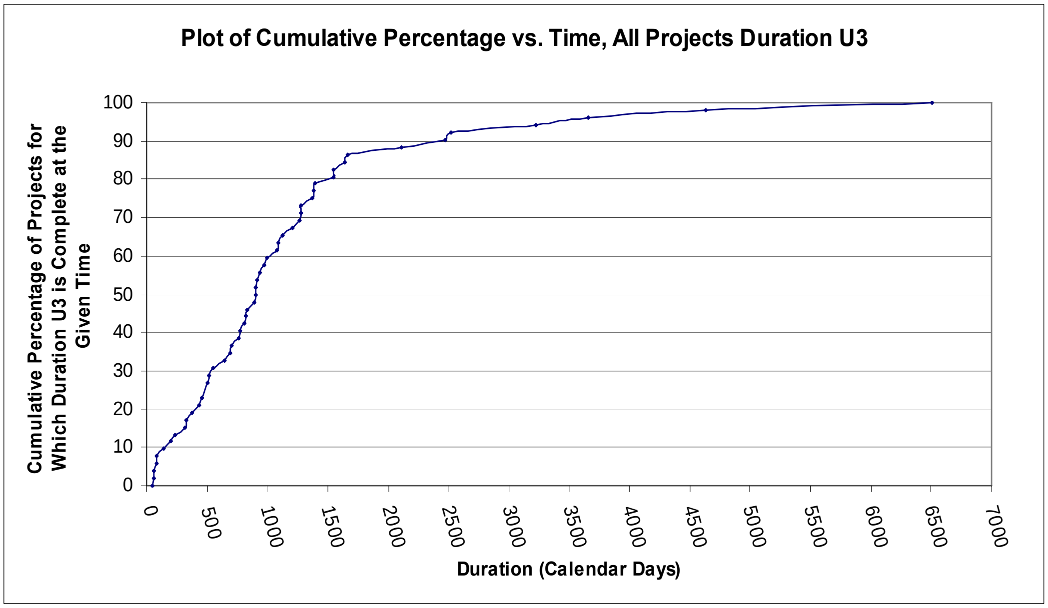


Figure 7.2. Cumulative U3 Duration Plot for All Projects

7.2 Duration U3 by Quick vs. Slow

The results of the analysis of the duration data by project classification are displayed in Table 7.3.

For "Quick" projects there was a mean U3 duration value of 754 days (2.06 years) from a sample size of 20 projects. For "Slow" projects there was a mean U3 duration value of 1441 days (3.95 years) from a sample size of 32 projects. The quickest U3 duration was on a "Quick" project at 51 days, whereas the slowest U3 duration was on a "Slow" project at 6511 days. Figure 7.3 displays the frequency of U3 durations by project classification.

Table 7.3 U3 Duration Statistics for Quick vs. Slow Projects

Statistic	Quick Projects (n=20)		Slow Projects (n=32)	
	Days	Years	Days	Years
Mean	754	2.06	1441	3.95
Standard Deviation	810	2.22	1305	3.57
Minimum	51	0.14	83	0.23
Maximum	3226	8.83	6511	17.83

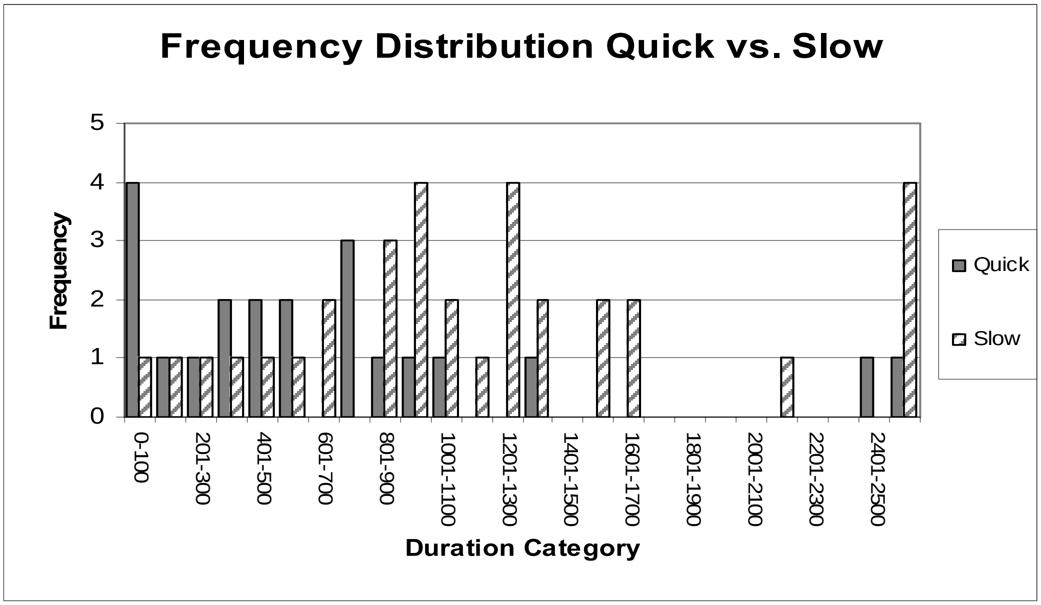


Figure 7.3. U3 Duration Frequency Distribution Quick vs. Slow Projects

As expected, there is a higher frequency of "Quick" projects in the lower duration categories with a corresponding increase in "Slow" projects in the higher duration categories. There was, however, overlap of "Quick" and "Slow" projects in nearly every duration category.

Selected percentile values were calculated from the same sample of projects. The data shows that the 10th percentile for "Quick" projects was 60 days (0.16 years), the 50th percentile was 527 days (1.44 years), and the 90th percentile was 1481 days (4.05 years). The 10th percentile for "Slow" projects was 463 days (1.27 years), the 50th percentile was 1112 days (3.04 years), and the 90th percentile was 2484 days (6.80 years). The calculated percentile values are displayed on the next page in Table 7.4, and a cumulative U3 duration plot of "Quick" vs. "Slow" Projects is displayed in Figure 7.4.

Table 7.4 U3 Duration Percentiles for Quick vs. Slow Projects

Percentile	Quick Projects (n=20)		Slow Projects (n=32)	
	Days	Years	Days	Years
0th	51	0.14	83	0.23
10th	60	0.16	463	1.27
20th	125	0.34	711	1.95
30th	363	0.99	897	2.46
40th	447	1.22	955	2.61
50th	527	1.44	1112	3.04
60th	730	2.00	1275	3.49
70th	789	2.16	1393	3.81
80th	934	2.56	1626	4.45
90th	1481	4.05	2484	6.80
100th	3226	8.83	6511	17.83

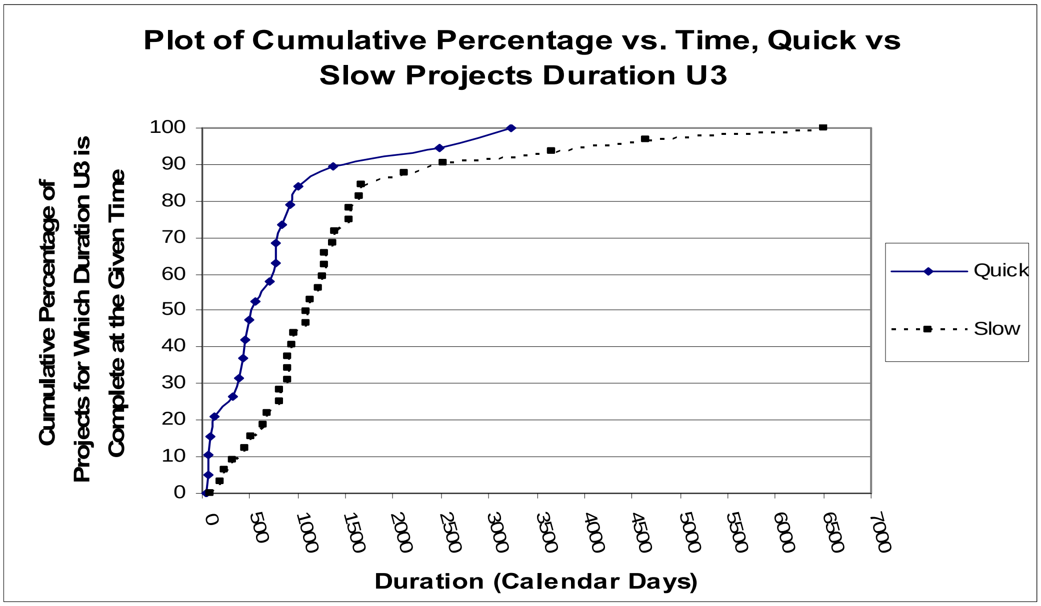


Figure 7.4. Cumulative U3 Duration Plot Quick vs. Slow Projects

7.3 U3 by Highway Type

Highway type was a factor that was analyzed as a potential duration "driver". Table 7.5 presents the results of the U3 duration analysis based on type of highway.

Table 7.5 U3 Duration Statistics by Highway Type

Statistic	FM / RM (n=20)		State Highway (n=8)		Interstate (n= 5)		US Highway (n=18)	
	Days	Years	Days	Years	Days	Years	Days	Years
Mean	966	2.64	1129	3.09	1157	3.17	1507	4.13
Standard Deviation	768	2.10	1006	2.75	1012	2.77	1616	4.42
Minimum	77	0.21	457	1.25	83	0.23	57	0.16
Maximum	3654	10.00	3226	8.83	2525	6.91	6511	17.83

There were 51 total sample projects with available data that fit into the categories in Table 7.5. For FM/RM projects there was a mean U3 duration of 966 days (2.64 years) from a sample size of 20 projects. For State Highway projects there was a mean U3 duration of 1129 days (3.09 years) from a sample size of 8 projects. For Interstate projects there was a mean U3 duration of 1157 days (3.17 years) from a sample size of 5 projects. For US Highway projects there was a mean U3 duration value of 1507 days (4.13 years) from a sample size of 18 projects. The quickest U3 duration was on a US Highway project at 57 days, as was the slowest U3 duration at 6511 days.

Selected percentile values were calculated from the same sample of projects. The 10th percentile for FM/RM projects was 316 days (0.87 years), the 50th percentile was 869 days (2.38 years), and the 90th percentile was 1554 days (4.25 years). Given its small sample size only quartiles were calculated for State Highway projects, and from the data the 25th percentile was 490 days (1.34 years), the 50th percentile was 730 days (2.00 years), and the 75th percentile was 1144 days (3.13 years). The 10th percentile for US Highway projects was 243 days (0.67 years), the 50th percentile was 1048 days (2.87 years), and the 90th percentile was 3122 days (8.55 years). The calculated percentile values are displayed in Table 7.6, and cumulative plot U3 duration by Highway Type is displayed in Figure 7.5.

Table 7.6 U3 Duration Percentiles by Highway Type

Percentile	FM / RM (n=20)		State Highway (n=8)		US Highway (n=18)	
	Days	Years	Days	Years	Days	Years
0th	77	0.21	457	1.25	57	0.16
10th	316	0.87	*	*	243	0.67
20th	421	1.15	*	*	695	1.90
25th	495	1.35	490	1.34	756	2.07
30th	541	1.48	*	*	896	2.45
40th	767	2.10	*	*	959	2.63
50th	869	2.38	730	2.00	1048	2.87
60th	927	2.54	*	*	1160	3.18
70th	1121	3.07	*	*	1362	3.73
75th	1227	3.36	1144	3.13	1376	3.77
80th	1273	3.49	*	*	1538	4.21
90th	1554	4.25	*	*	3122	8.55
100th	3654	10.00	3226	8.83	6511	17.83

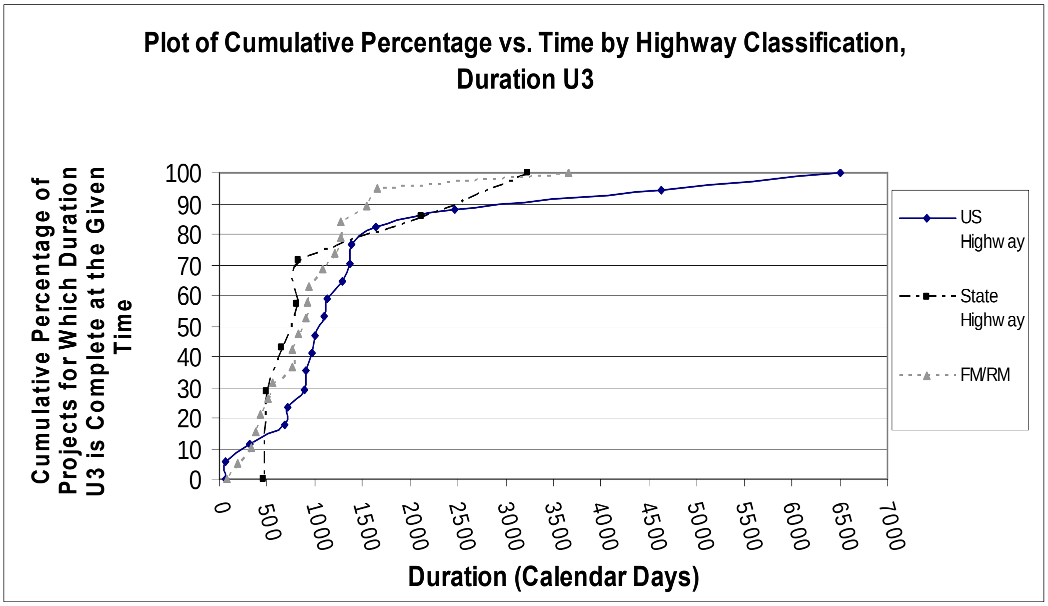


Figure 7.5. Cumulative U3 Duration Plot by Highway Type

7.4 U3 by Location Category

Location Category was identified as another potential duration "driver." Table 7.7 presents the results of the U3 duration analysis based on location category.

Table 7.7 U3 Duration Statistics by Location Category

Statistic	Rural (n=22)		Metro (n=13)		Urban (n=18)	
	Days	Years	Days	Years	Days	Years
Mean	744	2.04	1326	3.63	1546	4.23
Standard Deviation	444	1.22	1404	3.84	1482	4.06
Minimum	51	0.14	60	0.16	380	1.04
Maximum	1661	4.55	4636	12.69	6511	17.83

For Rural projects there was a mean U3 duration of 744 days (2.04 years) from a sample size of 22 projects. For Metro projects there was a mean U3 duration of 1326 days (3.63 years) from a sample size of 13 projects. For Urban projects there was a mean U3 duration of 1546 days (4.23 years) from a sample size of 18 projects. The quickest U3 duration was on a Rural project at 51 days, whereas the slowest U3 duration was on an Urban project at 6511 days.

Selected percentile values were calculated from the same sample of projects. The 10th percentile for Rural projects was 89 days (0.24 years), the 50th percentile was 864 days (2.37 years), and the 90th percentile was 1254 days (3.43 years). Given its smaller sample size, only quartiles were calculated for Metro projects, and from the data the 25th percentile was 229 days (0.63 years), the 50th percentile was 917 days (2.51 years), and the 75th percentile was 1542 days (0.4.22 years). The 10th percentile for Urban projects was 449 days (1.23 years), the 50th percentile was 1280 days (3.50 years), and the 90th percentile was 2735 days (7.49 years). The calculated percentile values are displayed in Table 7.8, and a cumulative plot of U3 duration by Location Category is displayed in Figure 7.6.

Table 7.8 U3 Duration Percentiles by Location Category

Percentile	Rural (n=22)		Metro (n=13)		Urban (n=18)	
	Days	Years	Days	Years	Days	Years
0th	51	0.14	60	0.16	380	1.04
10th	89	0.24	*	*	449	1.23
20th	323	0.88	*	*	481	1.32
25th	372	1.02	229	0.63	559	1.53
30th	516	1.41	*	*	698	1.91
40th	674	1.85	*	*	819	2.24
50th	864	2.37	917	2.51	1280	3.50
60th	904	2.48	*	*	1382	3.78
70th	964	2.64	*	*	1536	4.21
75th	994	2.72	1542	4.22	1622	4.44
80th	1066	2.92	*	*	2142	5.86
90th	1254	3.43	*	*	2735	7.49
100th	1661	4.55	4636	12.69	6511	17.83

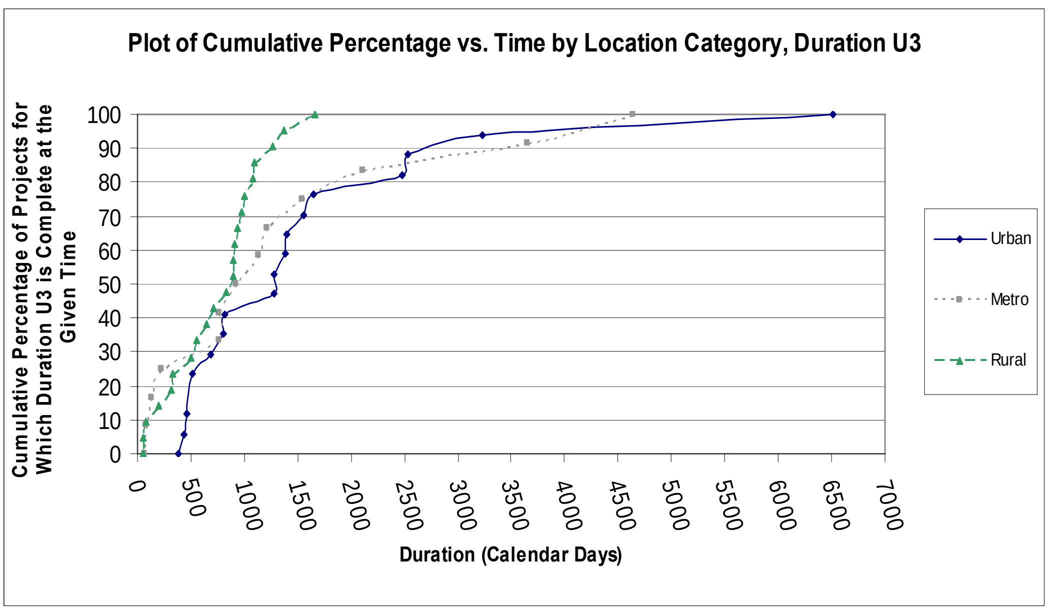


Figure 7.6. Cumulative U3 Duration Plot by Location Category

A frequency distribution (Figure 7.7) was created for utility adjustment duration by location category in order to provide a visual representation of the association of location with U3 duration.

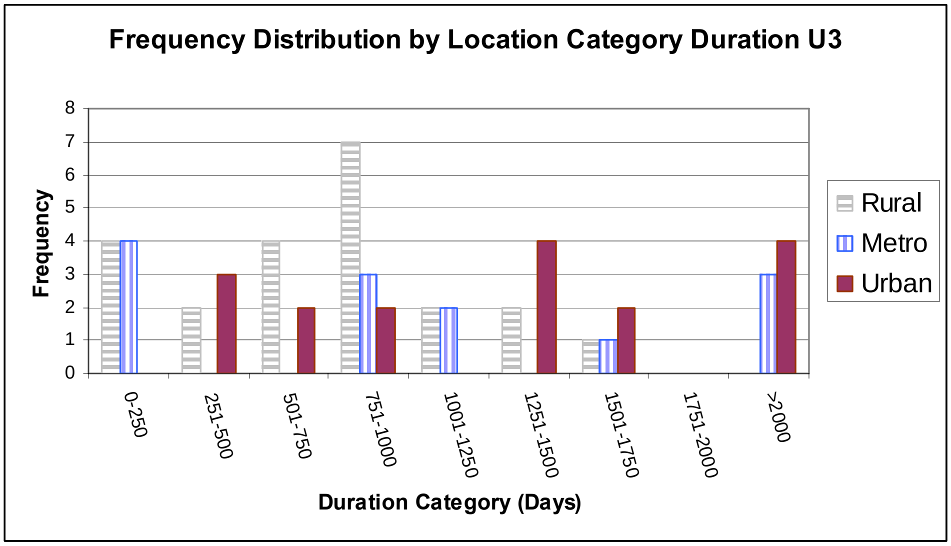


Figure 7.7. Frequency Distribution of Duration U3 by Location Category

7.5 U3 by TxDOT Project Type

The next factor analyzed was TxDOT Project Type. Table 7.9 presents the results of the U3 duration analysis based on TxDOT project type. As defined in Chapter 3.8, RER is Rehabilitate and Repair, INC is Interchange, WNF is Widen Non-Freeway, and MSC is Miscellaneous projects.

Table 7.9 U3 Duration Statistics by TxDOT Project Type

Statistic	RER (n=8)		INC (n=5)		WNF (n=18)		MSC (n=6)	
	Days	Years	Days	Years	Days	Years	Days	Years
Mean	836	2.29	992	2.72	1196	3.27	1653	4.53
Standard Deviation	574	1.57	941	2.58	965	2.64	2206	6.04
Minimum	51	0.14	60	0.16	57	0.16	83	0.23
Maximum	1542	4.22	2525	6.91	3654	10.00	6511	17.83

While TxDOT project type categorization was performed on nearly all of the projects with available duration data, the small samples for most project types reduced the amount for further analysis to the 37 projects in the four categories in Table 7.9. For RER projects there was a mean U3 duration of 836 days (2.29 years) from a sample of 8 projects. For INC projects there was a mean U3 duration of 992 days (2.72 years) from a sample of 5 projects. For WNF projects there was a mean U3 duration of 1196 days (3.27 years) from a sample of 18 projects. For MSC projects there was a mean U3 duration of 1653 days (4.53 years) from a sample of 6 projects. The quickest U3 duration was on an RER project at 51 days, whereas the slowest U3 duration was on an MSC project at 6511 days.

Selected percentile values were calculated from the same data however the small sample sizes meant that values were only calculated for RER and WNF projects. The 25th percentile for RER projects was 471 days (1.29 years), the 50th percentile was 866 days (2.37 years), and the

75th percentile was 1227 days (3.36 years). The 10th percentile for WNF projects was 417 days (1.14 years), the 50th percentile was 924 days (2.53 years), and the 90th percentile was 2445 days (6.69 years). The calculated percentile durations are displayed in Table 7.10, and a cumulative plot of U3 duration by; TxDOT Project Type is displayed in Figure 7.8.

Table 7.10 U3 Duration Percentiles by TxDOT Project Type

Percentile	RER (n=8)		WNF (n=18)	
	Days	Years	Days	Years
0th	51	0.14	57	0.16
10th	*	*	417	1.14
20th	*	*	593	1.62
25th	471	1.29	722	1.98
30th	*	*	767	2.10
40th	*	*	880	2.41
50th	866	2.37	924	2.53
60th	*	*	1026	2.81
70th	*	*	1262	3.46
75th	1227	3.36	1348	3.69
80th	*	*	1375	3.76
90th	*	*	2445	6.69
100th	1542	4.22	3654	10.00

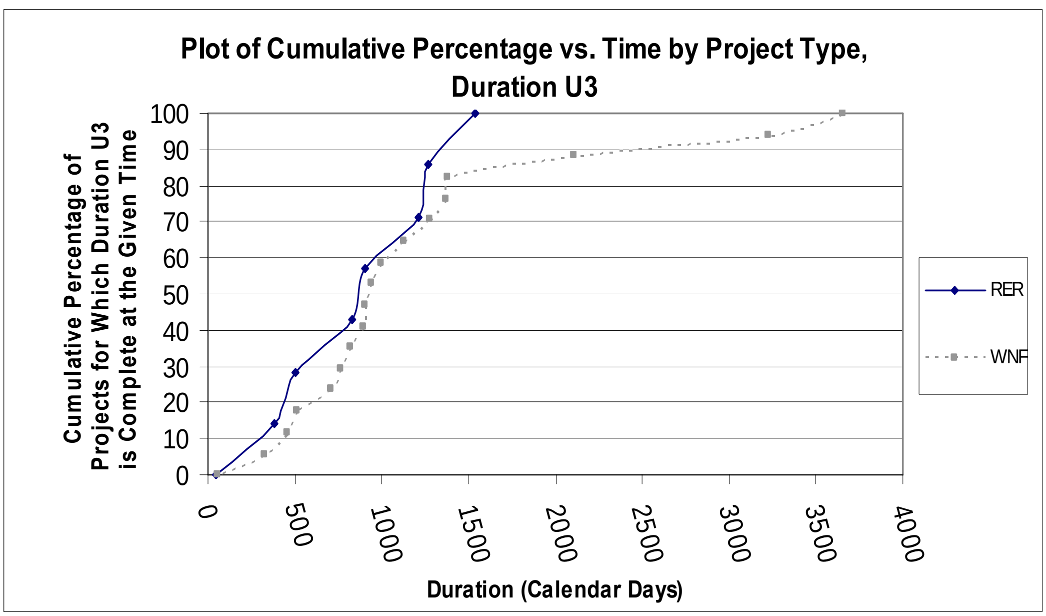


Figure 7.8. Cumulative U3 Duration Plot by TxDOT Project Type

7.6 U3 by Project Length

Construction Project Length was also considered a potential "driver" of utility adjustment duration. Since length is a continuous variable, a scatter-plot (Figure 7.9) was created for analysis.

Once the data points had been plotted a trend-line was computed to determine whether or not further regression analysis would be beneficial. Based on the resulting R^2 value, significantly less than one percent of the duration variability is explained by construction project length. No further regression analysis was performed.

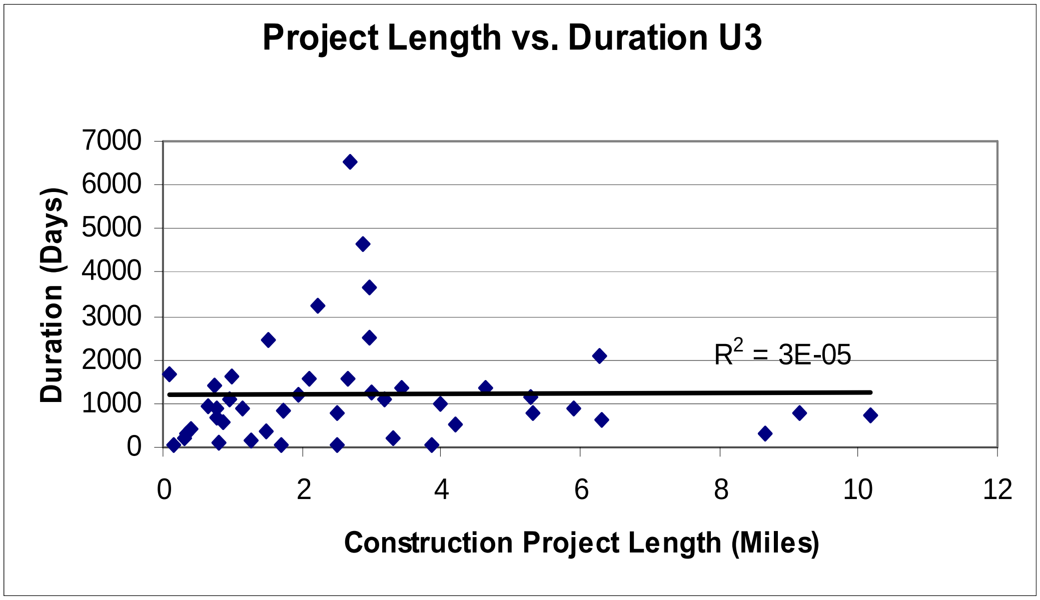


Figure 7.9. Construction Project Length vs. Duration U3

7.7 U3 by Federally Funded vs. Non-Federally Funded

Another factor that was analyzed as a potential duration "driver" was whether or not there was federal participation in the reimbursement of utility adjustment expenses. Table 7.11 displays the results of the analysis.

Table 7.11 U3 Duration Statistics for Federally Funded vs. Non-Federally Funded

Statistic	Federally Funded (n=8)		Non-Federally Funded (n=32)	
	Days	Years	Days	Years
Mean	1205	3.30	1318	3.61
Standard Deviation	248	0.68	1339	3.67
Minimum	83	0.23	51	0.14
Maximum	3654	10.00	6511	17.83

For Federally Funded projects there was a mean U3 duration of 1205 days (3.30 years) from a sample of 8 projects. For Non-Federally funded projects there was a mean U3 duration value of 1318 days (3.61 years) from a sample of 32 projects. The quickest U3 duration was on a Non-Federally Funded project at 51 days, as was the slowest U3 duration at 6511 days.

Selected percentile values were also calculated from the data sample. Given its small sample size, only quartiles were calculated for Federally Funded projects, and from the data the 25th percentile was 206 days (0.56 years), the 50th percentile was 805 days (2.20 years), and the 75th percentile was 1681 days (4.60 years). The 10th percentile for Non-Federally Funded projects was 102 days (0.28 years), the 50th percentile was 987 days (2.70 years), and the 90th percentile was 2437 days (6.67 years). The calculated U3 duration percentiles are displayed in Table 7.12, and a cumulative plot of U3 duration for Federally Funded vs. Non-Federally Funded projects is displayed in Figure 7.10.

Table 7.12 U3 Duration Percentiles for Federally Funded vs. Non-Federally Funded

Percentile	Federally Funded (n=8)		Non-Federally Funded (n=32)	
	Days	Years	Days	Years
0th	83	0.23	51	0.14
10th	*	*	102	0.28
20th	*	*	455	1.25
25th	206	0.56	653	1.79
30th	*	*	764	2.09
40th	*	*	899	2.46
50th	805	2.20	987	2.70
60th	*	*	1115	3.05
70th	*	*	1341	3.67
75th	1681	4.60	1544	4.23
80th	*	*	1626	4.45
90th	*	*	2437	6.67
100th	3654	10.00	6511	17.83

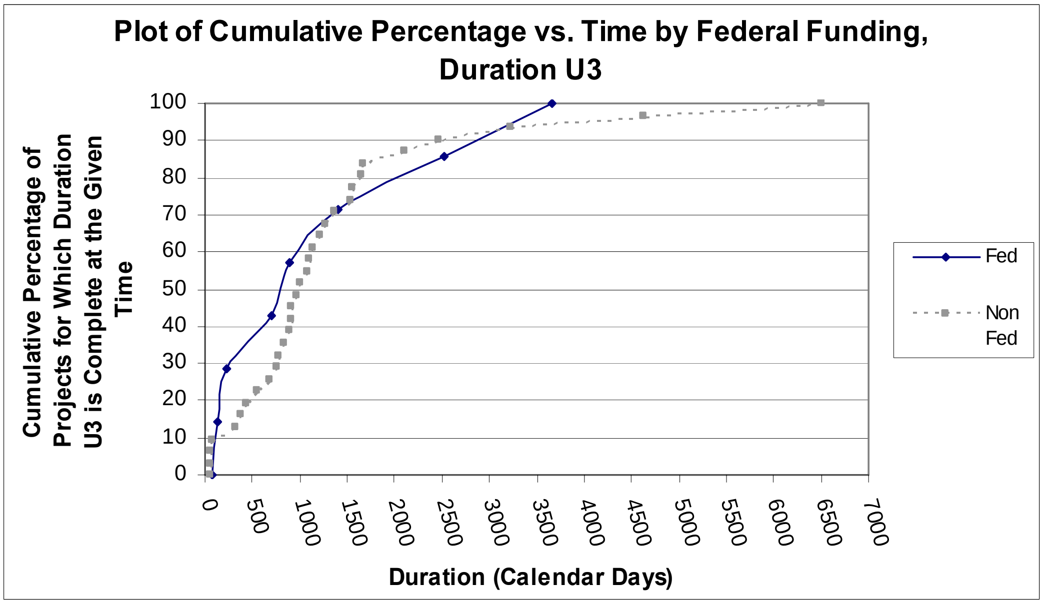


Figure 7.10. Cumulative U3 Duration Plot for Federally Funded vs. Non-Federally Funded

7.8 LPA Fund Participation

Local Public Agency (LPA) participation in reimbursement costs was also investigated as a potential duration "driver." Table 7.13 displays the results of the analysis of LPA funding.

Table 7.13 U3 Duration Statistics by LPA Involvement

Statistic	NON LPA-funded (n=9)		LPA-funded (n=30)	
	Days	Years	Days	Years
Mean	701	1.92	1514	4.15
Standard Deviation	793	2.17	1390	3.81
Minimum	60	0.16	51	0.14
Maximum	2525	6.91	6511	17.83

There were 39 total projects with available data that could be characterized by LPA fund participation. For Non-LPA-funded projects there was a mean U3 duration of 701 days (1.92 years) from a sample size of 9 projects. For LPA-funded projects there was a mean U3 duration of 1514 days (4.15 years) from a sample size of 30 projects. The quickest U3 duration was on an LPA-funded project at 51 days, as was the slowest U3 duration of 6511 days.

Selected percentile values were calculated from the same sample. Given its small sample size, only quartiles were calculated for Non-LPA-funded projects, and from the data the 25th percentile was 229 days (0.63 years), the 50th percentile was 380 days (1.04 years), and the 75th percentile was 709 days (1.94 years). The 10th percentile for LPA-funded projects was 396 days (1.08 years), the 50th percentile was 1089 days (2.98 years), and the 90th percentile was 3269 days (8.95 years). The U3 duration percentiles are displayed in Table 7.14, and a cumulative plot of duration U3 by LPA involvement is displayed in Figure 7.11.

Table 7.14 U3 Duration Percentiles by LPA Involvement

Percentile	NON-LPA-funded (n=9)		LPA-funded (n=30)	
	Days	Years	Days	Years
0th	60	0.16	51	0.14
10th	*	*	396	1.08
20th	*	*	769	2.11
25th	229	0.63	848	2.32
30th	*	*	899	2.46
40th	*	*	951	2.60
50th	380	1.04	1089	2.98
60th	*	*	1236	3.38
70th	*	*	1545	4.23
75th	709	1.94	1622	4.44
80th	*	*	1751	4.79
90th	*	*	3269	8.95
100th	2525	6.91	6511	17.83

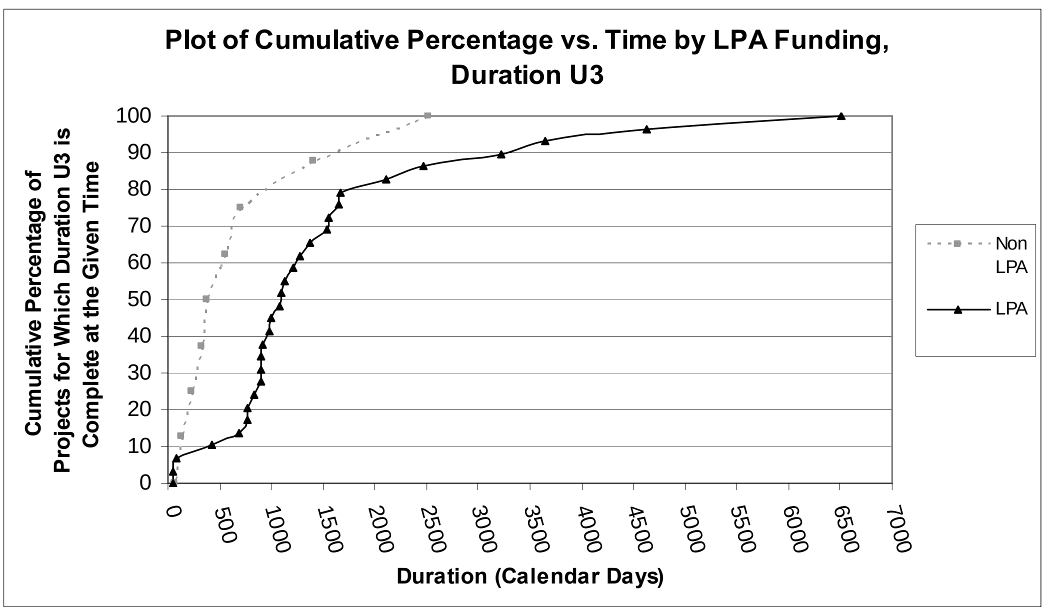


Figure 7.11. Cumulative U3 Duration Curves by LPA Involvement

7.9 U3 for Reimbursable vs. Non-Reimbursable Projects

Reimbursable projects were compared to Non-Reimbursable projects in order to determine if reimbursability could be a duration "driver." Table 7.15 displays the results of the analysis.

Table 7.15 U3 Duration Statistics for Reimbursable vs. Non

Statistic	Non Reimbursable (n=12)		Reimbursable (n=41)	
	Days	Years	Days	Years
Mean	695	1.90	1295	3.55
Standard Deviation	365	1.00	1296	3.55
Minimum	196	0.54	51	0.14
Maximum	1378	3.77	6511	17.83

For Non-Reimbursable projects there was a mean U3 duration of 695 days (1.90 years) from a sample size of 12 projects. For Reimbursable utility adjustment projects there was a mean U3 duration of 1295 days (3.55 years) from a sample size of 41 projects. The quickest U3 duration was on a Reimbursable project at 51 days, as was the slowest U3 duration at 6511 days.

Selected percentile values were calculated from the same sample of projects. Because of its small sample size, only quartile values were calculated for Non-Reimbursable utility adjustment projects. The 25th percentile for Non-Reimbursable projects was 457 days (1.25 years), the 50th percentile was 583 days (1.60 years), and the 75th percentile was 852 days (2.33 years). For Reimbursable projects the 10th percentile was 83 days (0.23 years), the 50th percentile was 974 days (2.67 years), and the 90th percentile was 2525 days (6.91 years). The calculated U3 duration percentiles are displayed in Table 7.16, and a cumulative plot of U3 duration by Reimbursability is displayed in Figure 7.12.

Table 7.16 U3 Duration Percentiles for Reimbursable vs. Non

Percentile	Non-Reimbursable (n=12)		Reimbursable (n=41)	
	Days	Years	Days	Years
0th	196	0.54	51	0.14
10th	*	*	83	0.23
20th	*	*	380	1.04
25th	457	1.25	552	1.51
30th	*	*	709	1.94
40th	*	*	895	2.45
50th	583	1.60	974	2.67
60th	*	*	1129	3.09
70th	*	*	1371	3.75
75th	852	2.33	1542	4.22
80th	*	*	1645	4.50
90th	*	*	2525	6.91
100th	1378	3.77	6511	17.83

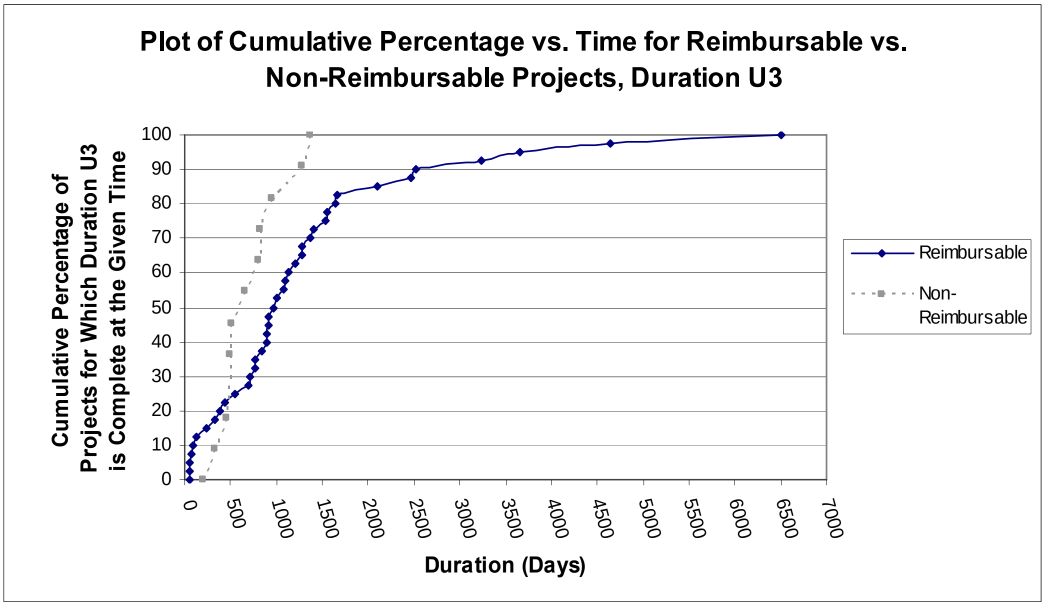


Figure 7.12. Cumulative U3 Duration Plot by Reimbursability

During the course of this study the researchers heard that reimbursable utility adjustments were easier to perform than non-reimbursable adjustments. However, the data somewhat contradicts this assertion by showing that reimbursable adjustments appear to be *slower* than non-reimbursable adjustments. This is not necessarily contradictory, however, as this may be due (though not limited) to the following possible causes:

- Reimbursable utility adjustment projects may be a proxy for longer and more-complicated adjustment projects.
- Securing state funding for reimbursable adjustments can be difficult in certain cases and at certain times in the fiscal calendar.
- Many non-reimbursable utility adjustment projects do not involve right-of-way acquisition, which can add significantly to the duration of a utility adjustment project.
- Reimbursable adjustments require much more paperwork to be developed, including title work for utility property interest(s), which can add duration to a project.

7.10 U3 for Date of Eligibility Procedure Applicability

Another funding mechanism that was investigated as a potential duration "driver" was the use of the Date of Eligibility (DOE) Procedure. Utility adjustment projects for which *any* of the individual adjustments were conducted under the DOE procedure were considered to be DOE projects. Table 7.17 displays the results of the U3 duration analysis.

Table 7.17 U3 Duration Statistics for DOE vs. Non-DOE

Statistic	Non-DOE (n=11)		DOE (n=30)	
	Days	Years	Days	Years
Mean	1240	3.40	1316	3.60
Standard Deviation	1853	5.07	1063	2.91
Minimum	51	0.14	60	0.16
Maximum	6511	17.83	4636	12.69

There were 41 projects for which the use or non-use of the Date of Eligibility procedure could be verified. For Non-DOE projects there was a mean U3 duration of 1240 days (3.40 years) from a sample size of 11 projects. For DOE projects there was a mean U3 duration of 1316 days (3.60 years) from a sample size of 30 projects. The quickest U3 duration was on a Non-DOE project at 51 days, as was the slowest U3 duration at 6511 days.

Selected percentile values were calculated from the same sample of projects. Given its smaller sample size, only quartiles were calculated for Non-DOE projects, and from the data the 25th percentile was 200 days (0.55 years), the 50th percentile was 832 days (2.28 years), and the 75th percentile was 1106 days (3.03 years). The 10th percentile for DOE projects was 220 days (0.60 years), the 50th percentile was 1089 days (2.98 years), and the 90th percentile was 2595 days (7.10 years). The calculated U3 duration percentiles are displayed in Table 7.18, and a cumulative plot of U3 duration by DOE vs. Non-DOE is displayed in Figure 7.13.

Table 7.18 U3 Duration Percentiles DOE vs. Non-DOE

Percentile	Non-DOE (n=11)		DOE (n=30)	
	Days	Years	Days	Years
0th	51	0.14	60	0.16
10th	*	*	220	0.60
20th	*	*	635	1.74
25th	200	0.55	722	1.98
30th	*	*	768	2.10
40th	*	*	904	2.48
50th	832	2.28	1089	2.98
60th	*	*	1276	3.49
70th	*	*	1442	3.95
75th	1106	3.03	1549	4.24
80th	*	*	1648	4.51
90th	*	*	2595	7.10
100th	6511	17.83	4636	12.69

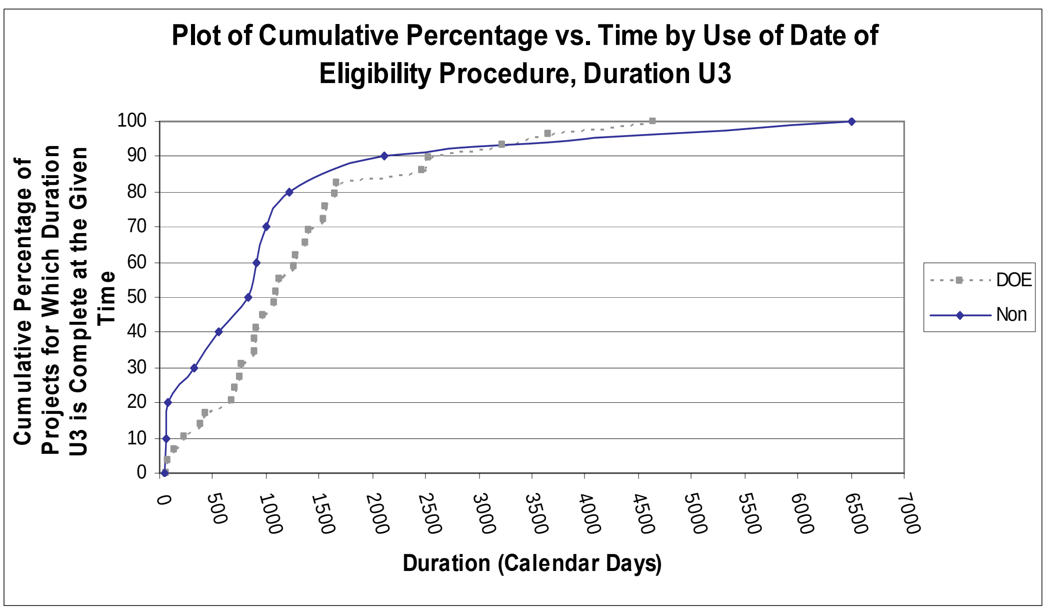


Figure 7.13. Cumulative U3 Duration Plot for DOE vs. Non-DOE

7.11 U3 by Number of Utility Agreements

The number of utility agreements involved on a project was also investigated as a potential duration "driver." If two agreements existed for the same utility, this analysis treated them as two utilities. Table 7.19 displays the results of the U3 duration analysis.

Table 7.19 Mean U3 Duration by Number of Utility Agreements

Number of Agreements	Sample Size (n)	Mean Duration	
		Days	Years
1	8	739	2.02
2	12	764	2.09
3	7	804	2.20
4	6	919	2.52
5	4	2846	7.79
>5	5	2950	8.08

The data sample contained eight projects with only one utility agreement, with a mean U3 duration of 739 days (2.02 years). There were 12 projects with two utility agreements, and the mean U3 duration was 764 days (2.09 years). For projects with three utility agreements there was a sample of seven projects with a mean U3 duration of 804 days (2.20 years). For projects with four utility agreements there was a sample of six projects, with a mean U3 duration of 919 days (2.52 years). There were four projects with five utility agreements, for which the mean U3 duration was 2846 days (7.79 years). There were five projects with more than five utility agreements, and their mean U3 duration was 2950 days (8.08 years). A scatter plot (Figure 7.14) was created to compare duration U3 to the number of utility agreements.

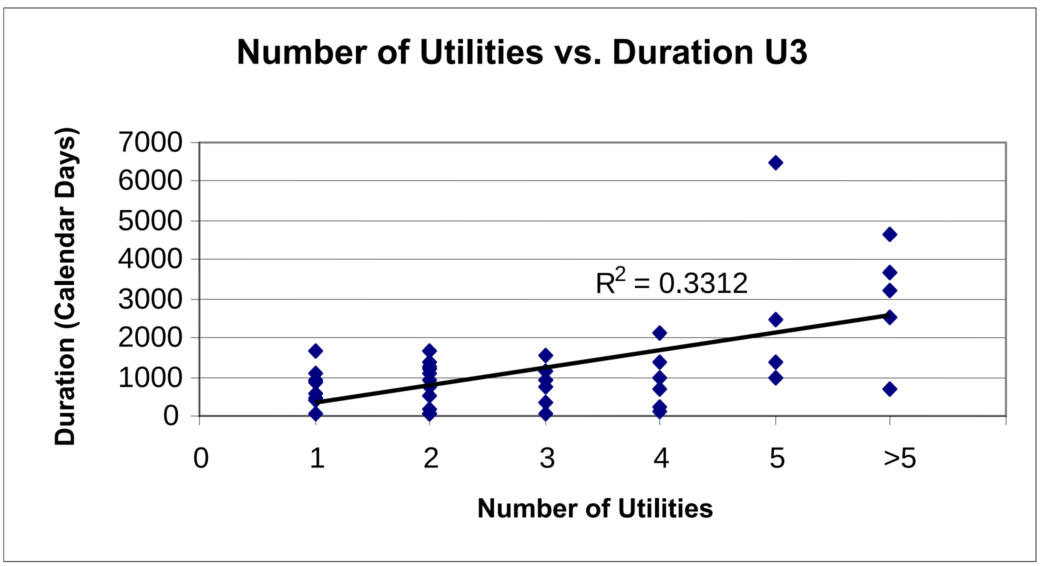


Figure 7.14. Duration U3 by Number of Utility Agreements

Since the R^2 value indicates that a relationship may exist between the number of utilities and duration U3, a regression analysis was performed. The results of the regression are shown in Table 7.20.

Table 7.20 Results of Regression Analysis, Number of Utilities vs. Duration U3

Results of simple regression for U3

Summary measures

Multiple R	0.5755
R-Square	0.3312
StErr of Est	1072.8300

Analysis of Variance (ANOVA) table

Source	df	SS	MS	F	p-value
Explained	1	22795429.1526	22795429.1526	19.8055	0.0001
Unexplained	40	46038570.7522	1150964.2688		

Regression coefficients

	Coefficient	Std Err	t-value	p-value	Lower limit	Upper limit
Constant	-124.0697	349.6181	-0.3549	0.7245	-830.6741	582.5346
Number of Utility Agreements	453.2199	101.8394	4.4503	0.0001	247.3948	659.0450

From the analysis an equation for duration U3 could be constructed as follows:

Duration U3 = -124.0697 + 453.2199 (Number of Utility Agreements)

The constructed regression line can be said to explain about 33 percent of the observed variance in the duration of U3. Looking at the ANOVA table, from the analysis it reveals an F-ratio equal to 19.8055 with a p-value that is well below the maximum allowable threshold of 0.05. This implies that the number of utility agreements has some explanatory power in predicting duration U3, but when coupled with the R^2 value it can be concluded that the number of utilities is not a very strong predictor. While in statistical terms there is not a strong correlation between the number of utilities and duration U3, there is some relationship.

In addition to the regression performed on the aforementioned categories, a regression was also performed to investigate the relationship of duration U3 to the number of agreement for all possible number of agreements. Figure 7.15 displays the plotted regression line.

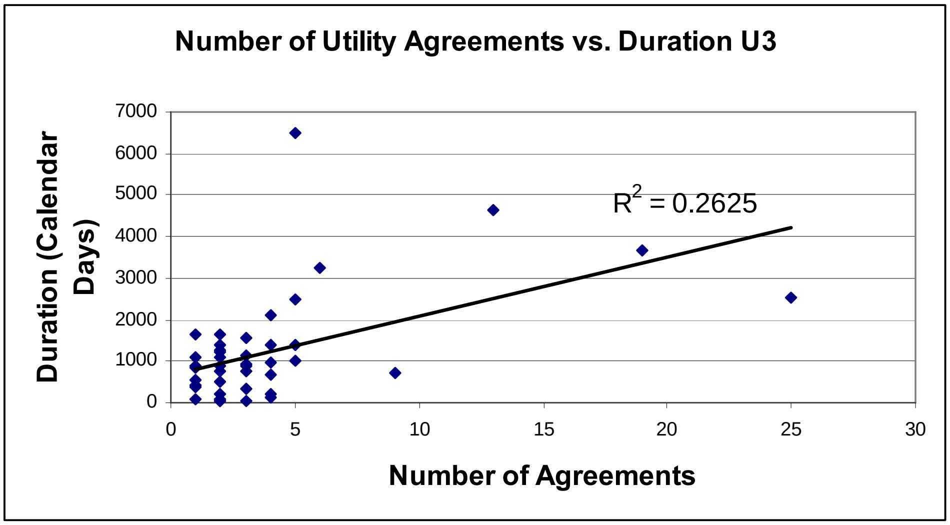


Figure 7.15. Plot of Duration U3 by Number of Agreements

Interestingly, for duration U3, the R2 value decreased slightly when the regression line was calculated by total number of agreements as opposed to the categories of 1, 2, 3, 4, 5, >5 (see Table 7.21). As with the other durations it is difficult to make final conclusions from this second plot since the sample of projects with larger numbers of agreements is very small.

7.12 U3 by Type of Utility

Type of utility was identified as a potential duration "driver". Due to the fact that more than one type of utility can be involved in a single utility adjustment project (as defined in this study), there is a significant amount of overlap in the data samples. Table 7.21 displays the results of the analysis.

Table 7.21 Mean U3 Duration by Type of Utility

Type of Adjustment	Sample Size (n)	Mean Duration	
		Days	Years
Sanitary Sewer	5	829	2.27
Underground Communications	22	1108	3.03
Overhead Power	25	1215	3.33
Extend Casing	8	1367	3.74
Underground Power	5	1381	3.78
Water	26	1468	4.02
Liquid Petroleum	6	1626	4.45
High-Pressure Gas	14	1674	4.58
Low-Pressure Gas	4	1681	4.60

The quickest types of projects were those with Sanitary Sewer adjustments, with a mean U3 duration of 829 days (2.27 years) from a sample of 5 projects. For projects with Underground Communications adjustments there was a mean U3 duration of 1108 days (3.03 years) from a sample of 22 projects. For projects with Overhead Power adjustments there was a mean U3 duration of 1215 days (3.33 years) from a sample of 25 projects. For project with Extend Casing adjustments there was a mean U3 duration of 1367 days (3.74 years) from a sample of 8 projects. For projects with Underground Power adjustments there was a U3 mean duration of 1381 days (3.78 years) from a sample of 5 projects. For projects with Water adjustments there was a mean U3 duration of 1468 days (4.02 years) from a sample of 26 projects. For projects with Liquid Petroleum adjustments there was a mean U3 duration of 1626 days (4.45 years) from a sample of 6 projects. For projects with High-Pressure Gas adjustments there was a mean U3 duration of 1674 days (4.58 years) from a sample of 14 projects. The slowest type of projects, projects with Low Pressure Gas adjustments, had a mean U3 duration of 1681 days (4.60 years) from a sample of 4 projects.

In addition to the descriptive statistics, percentile values were calculated and a cumulative duration plot was made for duration vs. type of utility. The percentiles are displayed in Table 7.22.

Table 7.22 U3 Duration Percentiles by Type of Utility

Percentile	Underground Communica-tions (n=9)		Overhead Power (n=25)		Extend Casing (n=9)		Water (n=26)		High-Pressure Gas (n=14)	
	Days	Years	Days	Years	Days	Years	Days	Years	Days	Years
0th	51	0.14	51	0.14	57	0.16	137	0.38	516	1.41
10th	143	0.39	174	0.48	*	*	326	0.89	*	*
20th	349	0.96	431	1.18	*	*	431	1.18	*	*
25th	468	1.28	516	1.41	530	1.45	472	1.29	931	2.55
30th	506	1.38	662	1.81	*	*	583	1.60	*	*
40th	740	2.03	848	2.32	*	*	822	2.25	*	*
50th	924	2.53	917	2.51	855	2.34	906	2.48	1171	3.20
60th	1067	2.92	1017	2.79	*	*	1082	2.96	*	*
70th	1348	3.69	1276	3.49	*	*	1460	4.00	*	*
75th	1394	3.82	1551	4.25	1963	5.37	1549	4.24	2243	6.14
80th	1521	4.16	1751	4.79	*	*	2110	5.78	*	*
90th	2437	6.67	2504	6.86	*	*	3440	9.42	*	*
100th	3654	10.00	4636	12.69	3654	10.00	6511	17.83	4636	12.69

For projects involving Underground Communications the 10th percentile was 143 days (0.39 years), the 50th percentile was 924 days (2.53 years), and the 90th percentile was 2437 days (6.67 years). For projects involving Overhead Power the 10th percentile was 174 days (0.48 years), the 50th percentile was 917 days (2.51 years), and the 90th percentile was 2504 days (6.86 years). For projects involving Extend Casing the 25th percentile was 530 days (1.45 years), the 50th percentile was 855 days (2.34 years), and the 75th percentile was 1963 days (5.37 years). For projects involving Water the 10th percentile was 326 days (0.89 years), the 50th percentile was 906 days (2.48 years), and the 90th percentile was 3440 days (9.42 years). For projects involving High-Pressure Gas the 25th percentile was 931 days (2.55 years), the 50th percentile was 1171 days (3.20 years), and the 75th percentile was 2243 days (6.14 years). The percentiles are displayed in a cumulative plot of duration U3 by type of utility in Figure 7.16.

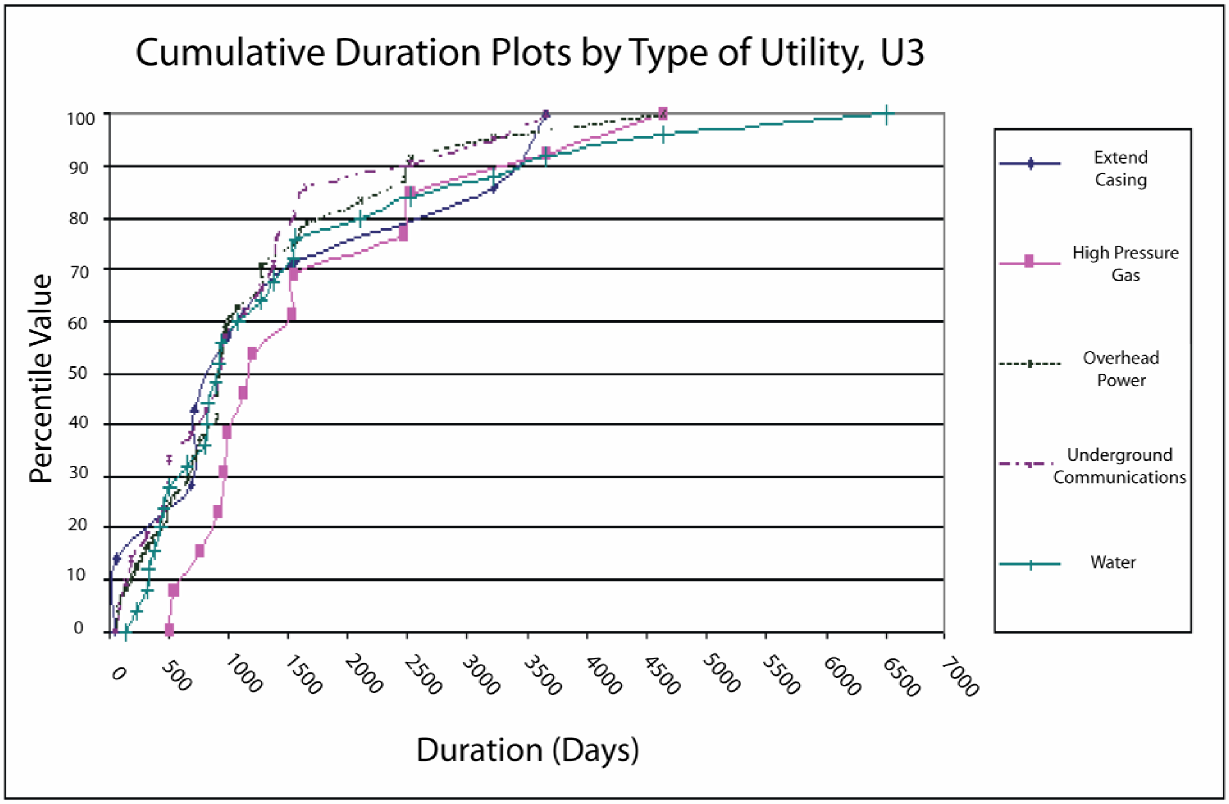


Figure 7.16. Cumulative U3 Duration Plot by Type of Utility

7.13 Factor Influence on Duration

In order to categorize the different types of factors as either quick, moderate, or slow in duration, all factors were first sorted by mean duration. From the list of sorted factors, the quickest and slowest factors were chosen. For quick projects, there were several factors with a mean duration of about 2.5 years. At the opposite end of the spectrum there were about as many factors with mean durations greater than 4 years. Following the identification of the quick and slow factors, a few moderate factors were identified with mean durations roughly halfway between the quick and slow factors (see Table 7.23).

Table 7.23 Factor Influence on Duration U3

Quick Mean Duration ≤ 2.5 yrs	Moderate 3 yrs ≤ Mean Duration ≤ 3.5 yrs	Slow Mean Duration ≥ 4 yrs
Non-Reimbursable Projects	Projects with Underground Communications Adjustments	Projects with Water Adjustments
Non-LPA Projects	State Highway Projects	US Highway Projects
Rural Projects	Interstate Highway Projects	LPA Projects
Projects with Sanitary Sewer Adjustments	All Projects	Urban Projects
RER Construction Projects	WNF Construction Projects	Projects with Liquid Petroleum Adjustments
	Federally Funded Projects	MSC Construction Projects
	Projects with Overhead Power Adjustments	Projects with High-Pressure Gas Adjustments
	Non-DOE Projects	Projects with Low-Pressure Gas Adjustments

7.14 Comparative Statistics

Difference-in-means testing was performed for selected factors from the data for Duration U3. First, DOE projects were compared to Non-DOE projects. Table 7.24 displays the results of the Analysis of Variance (ANOVA).

Table 7.24 ANOVA Results for DOE vs. Non-DOE Duration U3

Results of One-Way ANOVA

Summary Stats for Samples

	DOE	Non-DOE
Sample sizes	30	11
Sample means	1315.500	1240.091
Sample standard deviations	1062.799	1853.412
Sample variances	1129542.121	3435136.491
Weights for pooled variance	0.744	0.256

Number of samples	2
Total sample size	41
Grand mean	1295.268
Pooled variance	1720720.164
Pooled standard deviation	1311.762

One-Way ANOVA Table

Source	SS	df	MS	F	p-value
Between variation	45769.640	1	45769.640	0.027	0.8713
Within variation	67108086.409	39	1720720.164		
Total variation	67153856.049	40			

Confidence Intervals for Mean Differences

Confidence level	95.0%

Tukey Method

Difference	Mean diff	Lower	Upper	Significant
DOE - Non-DOE	75.409	-860.635	1011.453	No

The ANOVA result of p = 0.8713 indicates that there is no statistical difference in duration U3 between DOE and Non-DOE projects. Given the small sample size it can not be definitively concluded that there is no difference in mean U3 duration between these two categories. However, the rather large p-value would seem to indicate that there most likely is not any statistical difference.

Reimbursable projects were compared to Non-Reimbursable projects for Duration U3 as well. Table 7.25 displays the results of the analysis.

Table 7.25 ANOVA Results for Non-Reimbursable vs. Reimbursable Duration U3

Results of One-Way ANOVA

Summary Stats for Samples

	Non-Reimbursable	Reimbursable
Sample sizes	12	41
Sample means	694.500	1295.268
Sample standard deviations	364.728	1295.703
Sample variances	133026.455	1678846.401
Weights for pooled variance	0.216	0.784

Number of samples	2
Total sample size	53
Grand mean	1159.245
Pooled variance	1345434.256
Pooled standard deviation	1159.929

One-Way ANOVA Table

Source	SS	df	MS	F	p-value
Between variation	3350450.763	1	3350450.763	2.490	0.1207
Within variation	68617147.049	51	1345434.256		
Total variation	71967597.811	52			

Confidence Intervals for Mean Differences

Confidence level 95.0%

Tukey Method

Difference	Mean diff	Lower	Upper	Significant
Non-Reimbursable - Reimbursable	-600.768	-1366.232	164.696	No

From the ANOVA it would appear that there is no statistical difference in mean duration between Reimbursable and Non-Reimbursable utility adjustments (p = 0.1207, which is greater than 0.05). It should be noted that neither sample was randomly selected, nor was either sample normally distributed, and therefore it cannot be concluded with great certainty that there is no statistical difference between these types of projects. More data is needed for a more conclusive analysis.

A third comparison analysis was performed based on Highway Types. In this case US Highway projects were compared to FM/RM projects for duration U3. Table 7.26 displays the results of the analysis.

Table 7.26 ANOVA Results for Highway Type Comparison Duration U3

Results of One-Way ANOVA

Summary Stats for Samples

	US Hwy	FM/RM
Sample sizes	18	20
Sample means	2007	966
Sample standard deviations	2559	768
Sample variances	6546221	589556
Weights for pooled variance	0.472	0.528

Number of samples	2
Total sample size	38
Grand mean	1459
Pooled variance	3402425
Pooled standard deviation	1845

One-Way ANOVA Table

Source	SS	df	MS	F	p-value
Between variation	10273027.368	1	10273027	3.019	0.0908
Within variation	122487315.500	36	3402425		
Total variation	132760342.868	37			

Confidence Intervals for Mean Differences

Confidence level 95.0%

Tukey Method

Difference	Mean diff	Lower	Upper	Significant
US Hwy - FM/RM	1041.333	-175.705	2258.372	No

As in the other ANOVA results, the p-value is greater than the desired test statistic of 0.05 and, therefore, it appears that there may not be a statistical difference between these types of projects. Again the lack of sufficiently large samples and the non-normality of the samples are causes for caution in drawing final conclusions from the data. If the acceptable error value is increased to 10%, however, the p-value of 0.0908 does indicate that the two samples have statistically different mean values.

Difference in means testing was also performed for duration U3 by number of utility agreements. The categories that were compared were projects with less than five agreements and projects with five or more agreements. Table 7.27 presents the results of the comparison.

Table 7.27 ANOVA by Number of Utility Agreements Duration U3

Results of One-Way ANOVA

Summary Stats for Samples

	< 5 Agreements	5 or more Agreements
Sample sizes	33	9
Sample means	794.394	2903.667
Sample standard deviations	549.399	1861.254
Sample variances	301839.621	3464265.500
Weights for pooled variance	0.800	0.200

Number of samples	2
Total sample size	42
Grand mean	1246.381
Pooled variance	934324.797
Pooled standard deviation	966.605

One-Way ANOVA Table

Source	SS	df	MS	F	p-value
Between variation	31461008.026	1	31461008.026	33.672	0.0000
Within variation	37372991.879	40	934324.797		
Total variation	68833999.905	41			

Confidence Intervals for Mean Differences

Confidence level	95.0%

Tukey Method

Difference	Mean diff	Lower	Upper	Significant
< 5 Agreements – 5 or more Agreements	-2109.273	-2844.373	-1374.173	Yes

The value of the test statistic is less than the allowable maximum of 0.05 and, therefore, it can be concluded from the ANOVA that there is a statistical difference in mean duration between projects with less than five agreements and those with five or more agreements.

Chapter 8. RUDI: Duration Advisor Tool

A key outcome of this research is a right-of-way acquisition and utility adjustment duration advisor tool titled RUDI. This tool was developed using historic duration data that was collected during the course of this research and was developed for TxDOT project planners and ROW personnel to use when deciding how much time to allow for right-of-way acquisitions and utility adjustments on a highway project. This tool was intentionally designed to be "static," is based solely on historic data, and has no mechanism for incorporating new data.

8.1 Need for and Purpose of RUDI

RUDI is needed for the following purposes:

- To facilitate data-driven, fact-based estimation of right-of-way acquisition and utility adjustment durations. TxDOT has never had such a tool and most duration estimates have been "wild guesses."
- Important and useful information from this research are scattered throughout this report. RUDI consolidates this information into one accessible system. Users can easily navigate through the system to find the information needed. Thus, RUDI acts as a centralized research documentation system, incorporating both duration estimation advisory information, tools to guide users through the estimating process, and process charts. Electronic versions of such information are important since paper versions require storage space and are not transferable easily. RUDI acts as an electronic documentation system for this research project.
- To improve duration estimation accuracy and estimation productivity. RUDI should enable the estimation of more accurate durations in a shorter amount of time.

8.2 RUDI Components

The format for the data collection advisor tool is a computer program with a user interface. The program allows the user to view duration data for right-of-way parcel acquisition or utility adjustment. Through a series of selections, the user may access the duration data for right-of-way acquisition or utility adjustment based on the same factors that were analyzed in the previous chapters. It is also possible for the user to print out such information for easy reference and note-keeping. However, RUDI will not allow live updating at this time.

RUDI is built using the Visual Basic Application that is embedded in MS Excel. The reason for using this programming language is that: (1) All TxDOT computers have MS Excel; (2) Most TxDOT users are familiar with MS Excel; (3) VBA is abundantly available as it's embedded in all Microsoft programs.

8.2.1 Major Components

There are five components in RUDI:

- System guide: A system guide called the *RUDI User Guide* provides information to users on how to use the system.

- Tools: Two tools are provided. The first tool is a *form* for the user to record useful information from RUDI that will later be used for duration estimation at a later stage. The second tool is a process model that summarizes the entire TxDOT process of right-of-way acquisitions and utility adjustments.
- Duration estimation advisory data: This is the major component of RUDI. Duration findings from this project are presented in two formats: graphical plots and statistical information.
- Other Information: Information about the research is also documented in RUDI. Such information includes research team members, purposes of research, and copyright issues.

RUDI also incorporates additional functions like printing, navigation buttons and exit the system.

8.3 Navigating RUDI

If RUDI is stored on a CD-Rom, the user can run the CD on their machine by clicking on the filename "RUDI.xls." If RUDI is stored on a server, the user has to obtain the directory of the server from the server support staff.

Users should run RUDI like any MS Excel™ file. If the user's computer is set to "enable macros," RUDI's Introductory Page will be displayed immediately after clicking on the file. If the user's computer is not set to "enable macro," the computer will ask whether macros should be enabled or disabled. Users should choose to enable macros.

Once enabling macros, the user immediately sees a window interface showing the RUDI Introduction Page. Click on any button to access labeled information. Users should read the information on the RUDI introductory window and the entire *User Guide* to understand the purpose of the tool and how to use the system before proceeding further.

8.3.1 RUDI Introduction Page

The RUDI Introduction Page is shown in Figure 8.1:

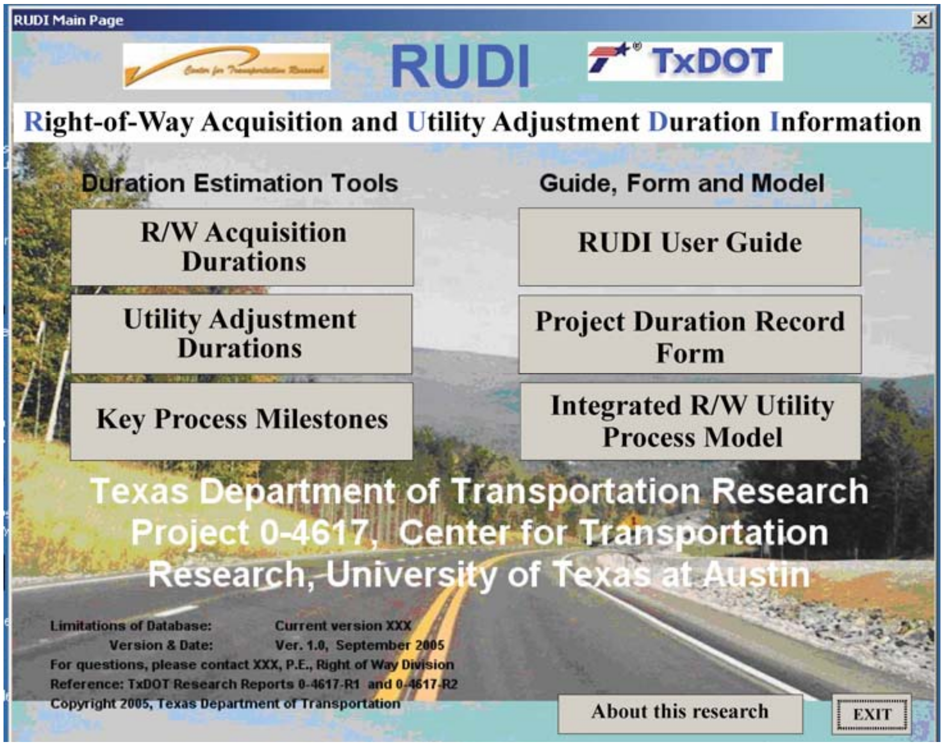


Figure 8.1. RUDI Main Page

There are eight buttons on this screen. The one on the bottom right hand corner allows the user to exit the system and the one beside it provides some information about the research. The "R/W Acquisition Durations" button takes the use to the right-of-way duration information, while the "Utility Adjustment Durations" button takes the user to the utility adjustment information. The "Key Process Milestones" takes the user to a plot of process milestones for right-of-way acquisitions and utility adjustments. The "RUDI User Guide" button takes the user to summarized instructions pertaining to the usage of RUDI. The "Project Duration Record Form" contains a form for manually recording information from RUDI. The "Integrated R/W Utility Process Model" button contains a complete process map of how right-of-way acquisition and utility adjustment usually occur on Texas Department of Transportation projects.

8.3.2 Right-of-Way Acquisitions Durations and Utility Adjustment Durations information

Upon clicking the "R/W Acquisition Durations," following window will appear (Figure 8.2).

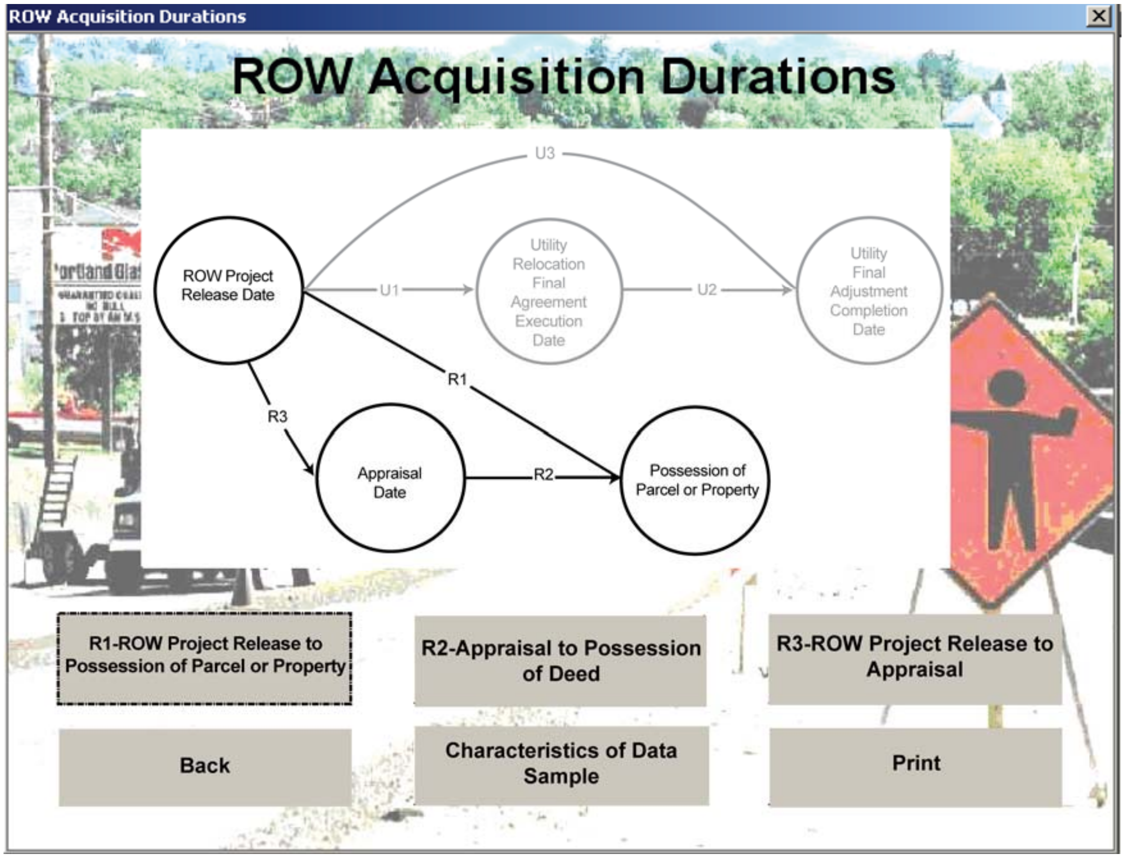


Figure 8.2. Right-of-Way Acquisition Durations screen

There are six buttons in this window. The set of buttons on the top provide access to the information pertaining to durations of R1, R2 and R3 of the right-of-way acquisition process. The "Back" button allows the user to go back to RUDI main page, the "Print" button allows the user to print the current screen. The user must set the default printer to "Landscape" as the information in RUDI has to be printed in this format. The "Characteristics of Data Sample" button shows the nature of the basis data drawn from actual projects and presented in this tool.

The user can access a wide variety of information by pressing on the appropriate button. For example, if the user clicked on "R1 – ROW Project Release to Possession of Parcels or Property" the following window will appear (Figure 8.3).

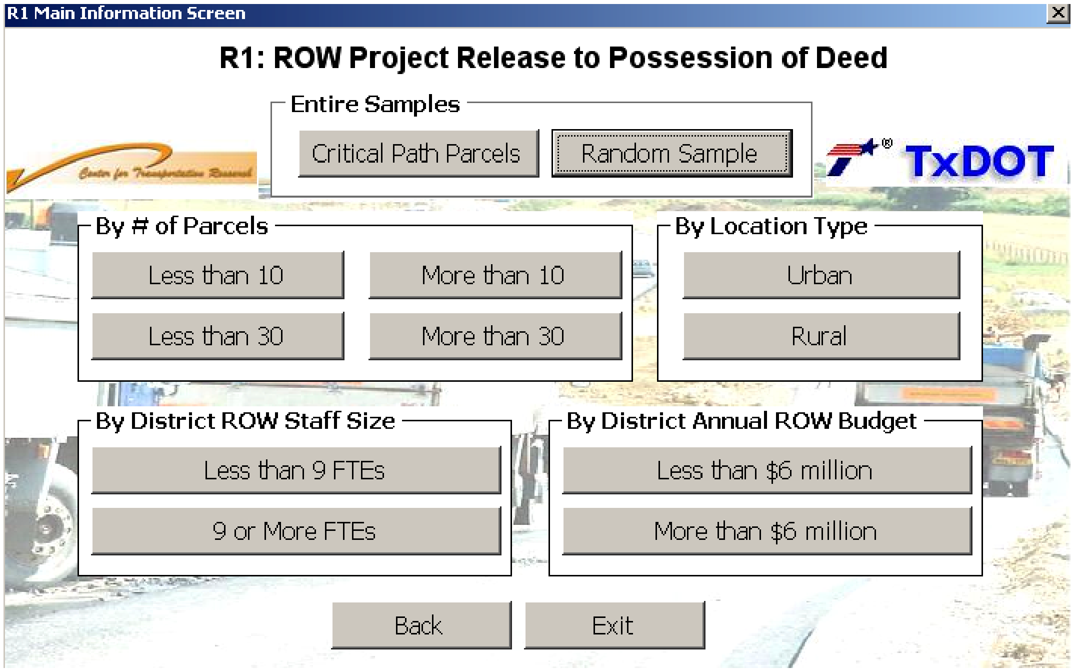


Figure 8.3. R1 Main Information Screen

Once this selection has been made, the user will be prompted to make further selections based on the factors that they are interested in viewing. This window lists all factors found in this research for right-of-way. The user should first identify relevant factors for the project which he/she is preparing an estimate of time. For example, if the user is estimating right-of-way durations for a project that is located in an Urban Area in a district with less than 9 full-time equivalent employees (FTEs), the user can access related information by choosing the two buttons "Urban" and "Less than 9 FTEs." Upon clicking on the button for "Urban" the following window will appear (Figure 8.4).

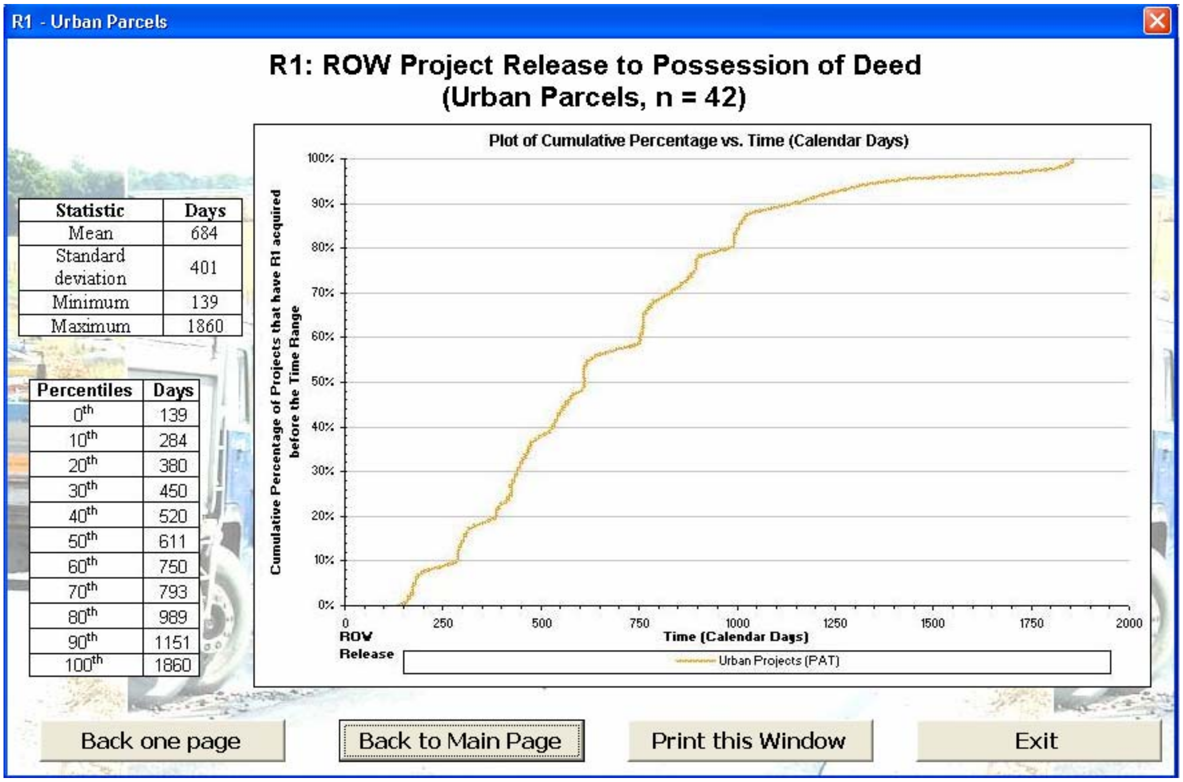


Figure 8.4. R1's Urban Parcels Information Screen

The user can obtain statistical information and graphical plot of 'Urban Parcels' durations from this window. The mean R1 duration for 'Urban Parcels' is 684 days with a standard deviation 401 days. The user can choose between 0^{th} to 100^{th} percentiles. If he/she feels that the process for this project will be fast, 380 days (20^{th} percentile) may be appropriate. However, if he/she feels that his/her district is usually slow, 989 days (80^{th} percentile) may be appropriate. Thus planners must apply judgment in deciding what percentile duration is most appropriate.

Standard deviation is defined as the positive square root of the variance. The variance is a measure in squared units and has little meaning with respect to the data. Thus, the standard deviation is a measure of variability expressed in the same units as the data. The standard deviation is very much like a mean or an "average" of these deviations. In a normal (symmetric and bell-shaped) distribution, about two-thirds of the scores fall between +1 and -1 standard deviations from the mean and the standard deviation is approximately 1/4 of the range (the difference between highest and lowest values).

There are four buttons at the bottom of the screen. The "Back One Page" button brings the user back to the previous page; the "Back to Main Page" button brings the user back to the RUDI main page; the "Print this Window" screen allows the user to print the information on the current page and the "Exit" button allows the user to exit the program.

When the user clicks on the "Utility Adjustment Durations" button on the RUDI main page, the window displayed in Figure 8.5 appears.

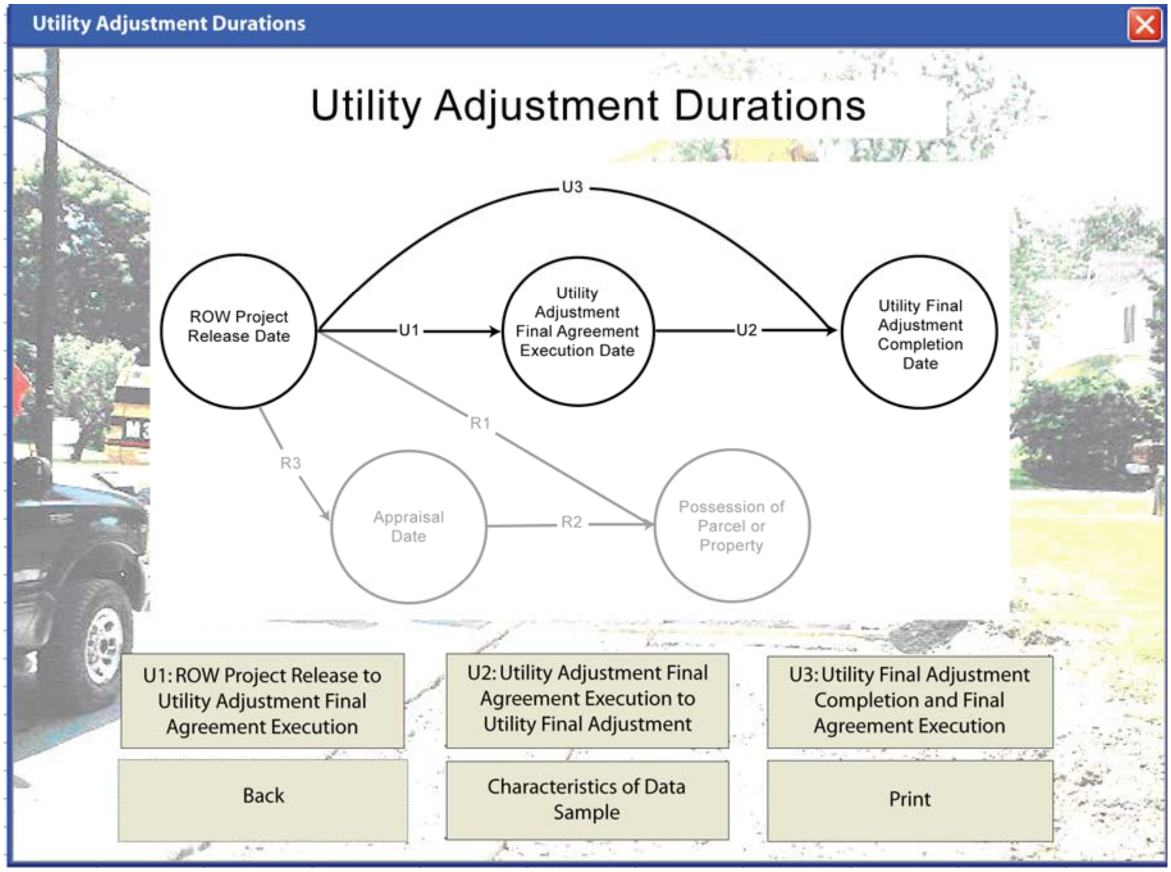


Figure 8.5. Utility Adjustment Durations screen

The Utility Adjustment Durations screen is arranged similarly to the Right-of-Way Acquisition Durations screen, as shown in Figure 8.6.

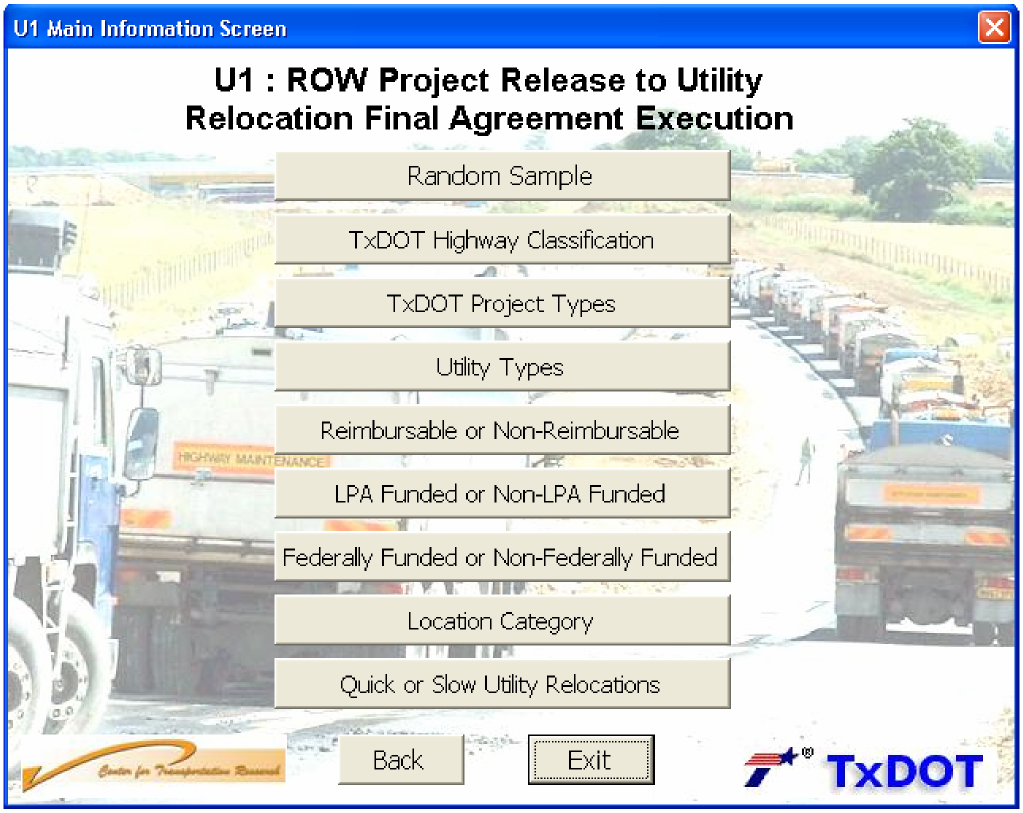


Figure 8.6. U1 Main Information Screen

There are 9 factors for Utility Adjustments. Similarly, the user can choose factors that are relevant to their project. For example, if the project is federally funded, the user can click on the "Federally Funded or Non-Federally Funded" button to access information of interest (see Figure 8.7).

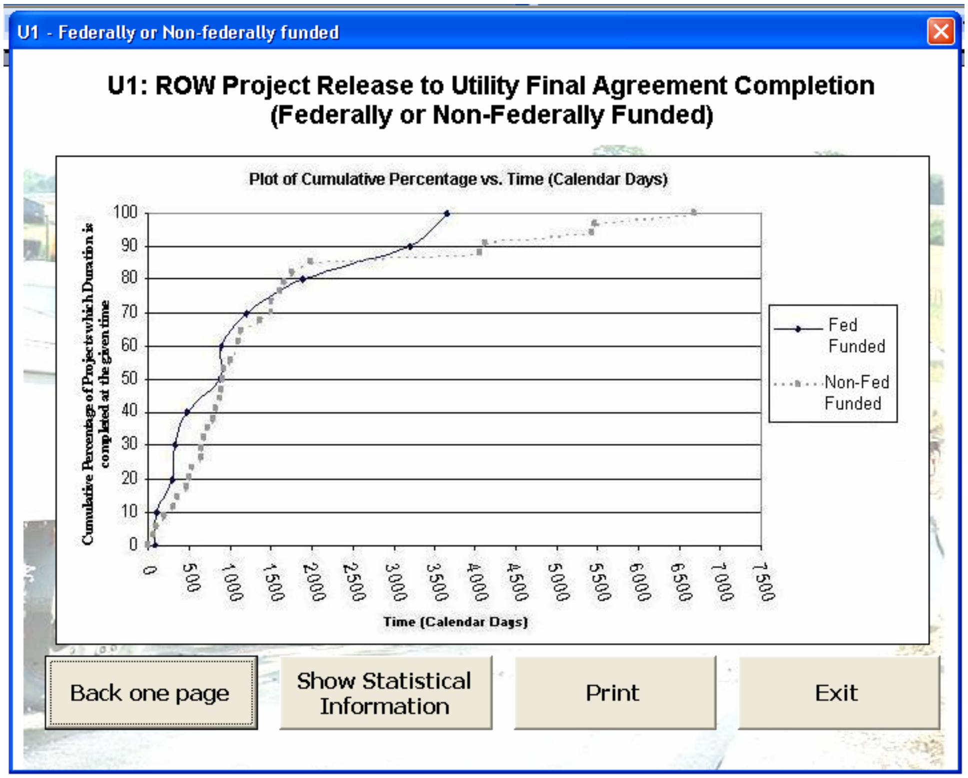
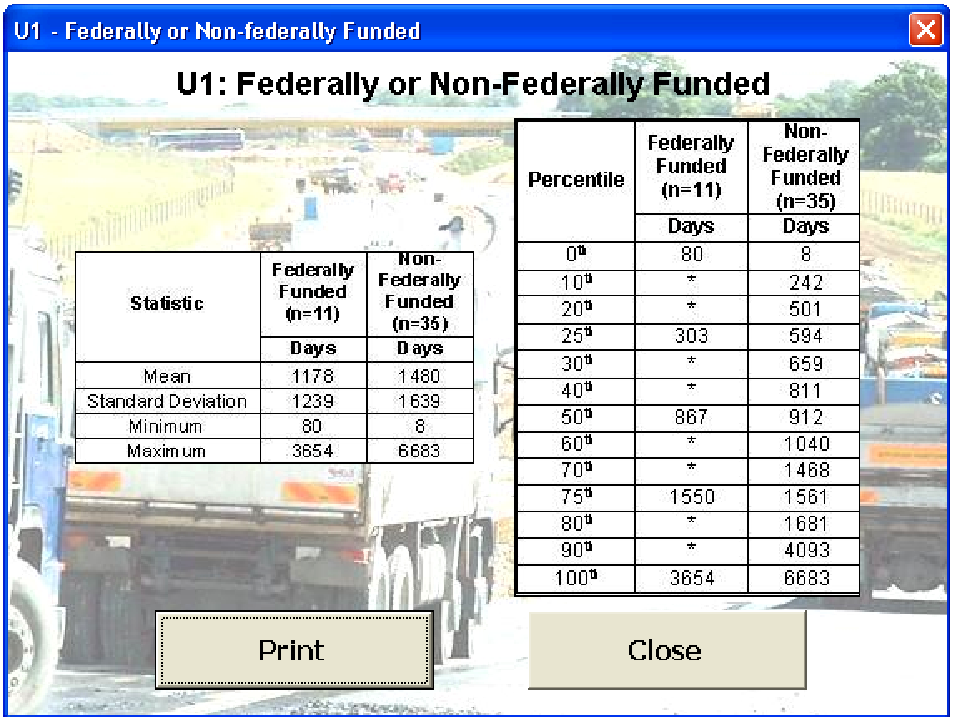


Figure 8.7. U1's Federally or Non-Federally Funded Duration Graphical Plot Information Screen

The user will first see the graphical plot after clicking on this button. To access relevant statistical information, the user should click on the "Show Statistical Information" button; Figure 8.8 displays sample results.



U1 - Federally or Non-federally Funded

U1: Federally or Non-Federally Funded

Statistic	Federally Funded (n=11) Days	Non-Federally Funded (n=35) Days
Mean	1178	1480
Standard Deviation	1239	1639
Minimum	80	8
Maximum	3654	6683

Percentile	Federally Funded (n=11) Days	Non-Federally Funded (n=35) Days
0^{th}	80	8
10^{th}	*	242
20^{th}	*	501
25^{th}	303	594
30^{th}	*	659
40^{th}	*	811
50^{th}	867	912
60^{th}	*	1040
70^{th}	*	1468
75^{th}	1550	1561
80^{th}	*	1681
90^{th}	*	4093
100^{th}	3654	6683

Figure 8.8. U1 Federally or Non-Federally Funded Statistical Information Screen

Similar to right-of-way information, a statistical information table and a percentile table will appear. The user can print or close this page by clicking on the appropriate button located on the bottom of the window.

8.3.3 Interpreting Graphical Plots

Many graphical plots are presented in RUDI. All plots are a presentation of historical calendar days of duration required versus cumulative percentage likelihood. The user who does not like to use the statistical tables can rely on the graphical plots to ascertain historical durations.

8.3.4 Interpreting Statistical Information

Statistical information contained in RUDI is presented in two different tabular formats. The first table shows the mean, standard deviation, and minimum and maximum values of historical duration, while the second table shows the percentiles (i.e. deciles) of these data.

The percentiles to be selected require judgment and can involve such factors as schedule priorities and pressures, and resources to be applied, among others. For instance, if the user picks the 90^{th} percentiles for a certain condition, this will give him/her an estimated duration with a 90 percent probability that the active duration will be at or faster than the time chosen, based on the given historical sample of past project data. It is probably best to look at several charts before choosing a duration. For instance, for a rural project with 8 parcels, data showing 50^{th} and 90^{th} percentiles for rural projects with 9 or less parcels could be picked from the charts/tables. Based on the user's knowledge (or lack of knowledge) about local conditions, a duration value or range could be chosen for right-of-way release to parcel possession for the project, for example.

8.4 Terminology

There are many terms used in RUDI. Some explanations of selected terms are provided in this section:

Critical Path Parcels

The one parcel in a project that is the final acquired property for the project before construction letting.

Full-Time Equivalent(FTE)

An employee who works the standard hours in a time period; FTE is used to quantify right-of-way manpower in TxDOT Districts.

Local Public Agency (LPA)

Any political subdivision of the State such as a city, county or other public agency with legal authority to acquire right-of-way for highways or public roads and to provide adjustment benefits to utilities.

Mean

A statistical measurement of the central tendency, or average, of a set of values.

Median

The midpoint value in a series; the median is not necessarily the same as the mean value.

Percentiles

The percentage of data points (historical durations in the case of RUDI) that are below a particular value.

Random Sample

A sample selected from a statistical population such that each selected member of the sample has an equal probability of being selected.

Range

In descriptive statistics, the range is the length of the smallest interval which contains all the data. It is calculated by subtracting the smallest observation from the greatest and provides an indication of statistical dispersion.

Right-of-Way (R/W)

A general term denoting land, property or interest therein, usually in a strip acquired for or devoted to transportation purposes.

Standard Deviation

Standard deviation is defined as the positive square root of the variance and is a measure of variability expressed in the same units as the data. The standard deviation is very much like a mean or an "average" of all data deviations from the mean value. In a normal (symmetric and bell-shaped) distribution, about two-thirds of the scores fall between +1 and -1 standard deviations from the mean and the standard deviation is approximately 1/4 of the range.

TxDOT Highway Categories

The terms and definitions used by TxDOT to describe its construction projects are listed in Table 8.1:

Table 8.1 TxDOT Construction Project Types

Abbreviation	Explanation
BR	Bridge Replacement
BWR	Bridge Widening or Rehabilitation
CNF	Convert Non-Freeway to Freeway
HES	Hazard Elimination & Safety
INC	Interchange - New or Reconstructed
MSC	Miscellaneous
NLF	New Location Freeway
NNF	New Location Non-Freeway
OV	Overlay
RER	Rehabilitation of Existing Road
SC	Seal Coat
UGN	Upgrade to Standards Non-Freeway
UPG	Upgrade to Standards Freeway
WF	Widen Freeway
WNF	Widen Non-Freeway

Utility Analysis Factors

Utility adjustment durations are presented according to many factors, as indicated in Table 8.2:

Table 8.2 Utility Factors

Factor	**Possible Selection**
Duration Assessment	Quick or Slow
Highway Type	Interstate, US Highway, State Highway, FM/RM
Location Category	Urban, Metro, Rural
TxDOT Project Type	BR, INC, WF, WNF, CNF, NNF, BWR, NLF, UGN, UPG, OV, MSC, SC, RER
Length of Project	Length in Miles
Federally Funded	Yes or No
Local Public Agency Funded	Yes or No
Reimbursable	Yes or No
Date of Eligibility Used	Yes or No
Number of Involved Utilities	The number of different agreements involved
LPA-funded	Yes or No
Types of Utilities	Cap & Removal Pipeline, Extend Casing, High Pressure Gas, Irrigation Pipeline, Liquid Petroleum Line, Low Pressure Gas, Microwave Tower, Overhead Communications, Overhead Power, Sanitary Sewer, Sewer Line, Transmission Pole, Transmission Tower, Underground Communications, Underground Power, Utility Joint Use Agreement Only, Wastewater, Wastewater Pump Station, Water, Other

Chapter 9. Conclusions & Recommendations

9.1 Summary of Research Objectives

This research was undertaken in order to fulfill two objectives: 1) Investigate TxDOT's utility adjustment process, develop an overall work process model, and identify opportunities for improvement; and 2) Quantify the duration of utility adjustments and create a related duration advisor tool.

9.2 How Objectives Were Accomplished

These objectives were accomplished through a large number of personal and team-based interviews of knowledgeable individuals from the ROW Division, many TxDOT districts, and many utility organizations. In addition, the research was accomplished from extensive review and analysis of much documentation and database contents maintained by either the ROW Division offices or district offices.

9.3 Conclusions

The following conclusions are based on findings regarding the modeled utility adjustment process:

- In looking to reduce the duration of utility adjustments it must be remembered that utilities often cannot relocate facilities until right-of-way has been purchased and / or TxDOT is in possession of deed(s) or has obtained a right to occupy. Because of this, reducing the duration of utility adjustment is greatly dependant on reducing the duration of right-of-way acquisition.
- Utility adjustment generally can not proceed until environmental clearance is issued, meaning that delays in obtaining environmental clearance will create delays in utility adjustment and subsequent processes.
- The over-use of the Date-of-Eligibility (DOE) procedure has been very problematic for TxDOT. While some District Offices may feel that the DOE procedure saves work, it is actually associated with extended durations in utility adjustment.
- Utility Adjustment is a very complex process with ample opportunity for delay. Early, timely communication, cooperation, and coordination are essential between TxDOT and the affected utilities. Processes are in place to ensure that these happen – but such processes often are not being followed.
- There are many activities in the utility adjustment process that are performed by entities outside of the TxDOT ROW Division and District Offices. In some cases TxDOT R/W personnel or the other entities may not be aware of the activities being performed by other parties. All affected parties need to be familiar with the process map developed from this research, along with the Department's published coordination process.

- Many utilities are notified of highway projects too late in the PS & E phase – and are unable to perform adjustment work in a timely fashion.

Other conclusions were drawn from analysis of the duration data. Certainly collecting data for this study was very difficult due to the fact that the data did not exist in entirety in any single location, but rather had to be collected from three different sources including within lengthy paper agreement files. Specifically, the most difficult factors to track were: Construction Project Limits (when not provided in the Right-of-Way Information System [ROWIS]), use of Subsurface Utility Engineering (SUE), and indications of multiple adjustments for individual utilities.

An overview of key duration findings pertaining to utility adjustment is presented in Table 9.1.

Table 9.1 Overview of Utility Adjustment Durations

Project/Adjustment Category		Mean Duration (Cal. Days)			90th Percentile Duration (Cal. Days)		
Factor	Condition	U1	U2	U3	U1	U2	U3
All Projects		1331	222	1159	3654	540	2400
Highway Type	FM/RM	890	143	966	1420	---	1554
	U.S. Highways	1480	317	1507	2468	---	3122
Location Category	Rural	754	122	744	1413	229	1254
	Urban	1875	388	1546	---	---	2735
	Metro	1441	237	1326	4245	---	---
Project Type	WNF	1386	187	1196	---	---	2445
Funding Source or Type	Non-Federal	1480	185	1318	4093	522	2437
	Local Public Agency	1727	226	1514	4114	550	3269
	Reimbursable	1394	221	1295	3817	558	2525

U1: Right-of-Way Release to Last Agreement Date
U2: Last Agreement Date to Last Adjustment Completion
U3: Right-of-Way Release to Last Adjustment Completion
---Indicates insufficient data

Specific conclusions drawn from analysis of the duration data include the following:

- The quickest utility adjustments are associated with projects that are Rural, take place in conjunction with Rehabilitation and Repair TxDOT projects, are on FM/RM roads, or that do not involve Local Public Agencies. It is logical that Location Category is a major factor for durations since rural projects and corridors tend to be less complicated than those in urban or metro areas.
- The slowest utility adjustment projects are associated with projects that involve Water or High-Pressure Gas adjustments that occur in conjunction with Miscellaneous TxDOT projects that occur on US Highway projects, or that are in Urban areas.
- Data analysis showed that there are perceivable differences in durations by different factor types. Specifically, for duration U1 the major factors are: Location Category, Highway Type, Local Public Agency Funding, Reimbursability, use of the Date-of-Eligibility Procedure, and the Number of Utility Agreements. For duration U2, the major factors are: Location Category and use of the Date-of-Eligibility Procedure. For duration U3 the major factors are: Local Public Agency Funding, Reimbursability, TxDOT Project Type, Location Category, and Highway Type.
- From statistical regression analysis it is clear that some form of relationship exists between the number of utility agreements on a project and duration U3. A statistical difference in mean values was found between projects with less than five agreements and projects with five or more agreements. Some possible explanations for this may include the following:
  - A greater number of agreements require more resources from TxDOT, which may or may not be in place in the district office.
  - The greater the number of agreements, the more likely it is that there are multiple types of utilities occupying the right-of-way, and the chance of adjustment extending into multiple utilities' peak demand seasons is increased, increasing the amount of time and the cost of adjustments.
  - With a greater number of agreements it is more likely that there will be conflicts between utilities, necessitating extra coordination.
  - There may be multiple agreements per utility in some cases, which may be due to work phasing by TxDOT, and may have an effect on the ability of utilities to budget for, mobilize, and perform adjustment work.
- To a lesser degree there is a statistical difference in the U3 (Right-of-Way Release date to Last adjustment completed) duration mean by highway type (specifically US Highways vs. FM/RM roads).
- While there were differences associated with other factors, the differences were not as great or the small sample sizes were inadequate for analysis.
- While non-reimbursable utility adjustments are often apparently shorter in duration than for reimbursable adjustments, this may be due to the fact that there may or may not be right-of-way acquisition on non-reimbursable projects, as well as the fact that no funding agreements are developed or executed. In addition, the shear amount of paperwork required for reimbursable adjustments can slow the process down.

- There is, interestingly, a difference in mean duration U3 between projects that were less than two miles in length and those that were greater than or equal to two miles in length, despite there being no statistically significant correlation between project length and duration.

One problem with using the DOE procedure is that large gaps are created in the data that TxDOT collects. This requires additional time to track the data after-the-fact by personnel at both the District and Division Offices.

9.4 Recommendations

9.4.1 Recommendations for TxDOT

The following recommendations are applicable to the TxDOT utility adjustment process:

- Since unidentified utilities will most likely continue to be uncovered during highway construction, the need for a procedure similar to the Date of Eligibility procedure will remain. In order to avoid the over-use of such a procedure, TxDOT should strongly consider revising and renaming the procedure to reflect its true intent. A possible name for the revised procedure could be *Emergency Utility Adjustment Procedure*.
- Since obtaining accurate utility information is critical to project success, the use of Subsurface Utility Engineering should be expanded and perhaps even mandated for highly developed corridors in urban / metropolitan areas.
- TxDOT should continue to expand its GIS utilities database. This inventory should be made available state-wide and could become a very useful first stop for TxDOT district personnel for acquiring information about utility locations.
- TxDOT should continue investigation and evaluation of non-traditional utility-adjustment methods (such as the use of consultants for developing utility agreements and joint-bid of utility adjustment with highway construction contracts). These practices may prove useful in expediting complex utility adjustment projects.
- Where applicable, TxDOT and utilities should consider incorporating multi-use/joint-use conduits and other integrated facilities in project right-of-way. This may help alleviate conflicts between contractors and utility companies, thereby reducing time lost and other problems.
- TxDOT and consultant project designers should determine ways in which to perform hydraulic design earlier as this often causes delays in the utility adjustment process. In addition, project designers should communicate hydraulic designs with utilities in a timely manner. Not communicating such design until the 60 percent PS & E complete phase, as is current practice, greatly inhibits utility designers' ability to complete design in a timely manner.

The following recommendations are intended for TxDOT's utility adjustment data collection and data tracking efforts

- In order to facilitate similar analysis in the future, TxDOT needs to track the following dates and factors in a single location:

— Right-of-Way Release Date. This is tracked in most cases already, although there are occasions when it is not kept together with other utility-related data, and it is not present in the utility database.

— Executed Agreement Dates. Of all of the dates that existed this was the most reliably tracked date, as the Division office kept a copy of all Executed Agreements in its paper file library. This date was not always available in the utility database, however.

— Adjustment Completion Dates. This date is supposed to be submitted with billings to the Division office; however, this is not consistently done. In addition, there are many past projects for which this date is not known and for which inquiries have been sent to District Offices. It is highly recommended that District ROW personnel improve record keeping of this date. Some districts track this well within the Right-of-Way office, however, in other Districts the only notation is made in the construction field logs (which were not available for this study).

- If TxDOT wants to quantify the effects of SUE usage on utility adjustment projects, the utilities database and paper files should record whether or not a SUE contract has been awarded for a project. This should be organized at the CSJ level rather than the individual agreement level.
- Data recording the existence of multiple adjustments for the same utility (as necessitated when either utilities are adjusted improperly or a change occurs) should also be tracked. Interviews indicated that this occurs on a number of projects, but little or no record was found in the database or the files that this had occurred.
- Data for non-reimbursable adjustments should be included in a common data location. Presently the ROW Division is requiring copies of Joint Use Agreements to be sent in for data completion.
- The current utilities database at the ROW Division office contains many data fields that are potentially useful for utility adjustment research. At present, however, many of the fields are left blank for many utility agreements. TxDOT should continue to fill in the missing data, as well as expanding the database to include the previously suggested data fields that do not currently exist.
- There were instances in the utilities database where right-of-way CSJ numbers did not match the right-of-way CSJ numbers from the paper files for specific utility agreements. Efforts to reduce this and other similar errors in the database will facilitate future analysis.

TxDOT may want to reconsider the way that utility “permit” files are organized. Currently the permit files are organized by county highway number and date. It would be much more useful if they were organized by CSJ or some other location parameter.

9.4.2 Recommendations for Researchers

The following recommendations are applicable to researchers focusing on utility adjustment issues:

- The relatively small sample sizes in this study make the results less statistically powerful than if more data were available. However, this study still offers a fair amount of insight into utility adjustment durations and factors affecting duration.
- The test statistic for Reimbursable vs. Non-Reimbursable projects for duration U3 was slightly greater than ten percent; therefore, there was no statistical difference between the two means. Given the low test-statistic value, a larger sample on subsequent investigations may show a statistical difference between Reimbursable and Non-Reimbursable projects at the ten percent error level.
- In addition to the milestone dates that were used in the data analysis calculations, there are other dates that are fairly reliably tracked. In particular, the alternate procedure date (pertaining to Federal-Aid projects) is reliably recorded for Federal-Aid utility adjustment projects. This may prove useful in further research into federally reimbursed utility adjustments.
- Investigate utility adjustments that are handled as right-of-way acquisitions. These cases were not specifically reviewed for this research but may prove useful in future research.
- As is stated in Chapter 8, the RUDI system developed in this research at present does not allow for live updating. It would be beneficial in the future if RUDI were either modified to allow for live updates, or if a system was developed that would incorporate such data in RUDI.

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Appendix A: Project Identifying Survey Form

Utility Relocation Projects for Study
TxDOT / CTR Research Project 0-4617

District:________________________________

Respondant:____________________________ **Phone and/or email:** ________________________________

REIMBURSABLE **Utility Relocations**		
CSJ Number	**Short or Long Utility Duration?**	**Significant Factors Affecting Duration Length (if known)**

Upon Completion Please Return to :

Stephen Hedemann
The University of Texas at Austin
1 University Station Stop C1752
Austin, TX 78712
shedemann@mail.utexas.edu OR Fax 512-471-3191

Appendix B: Data Collection Form

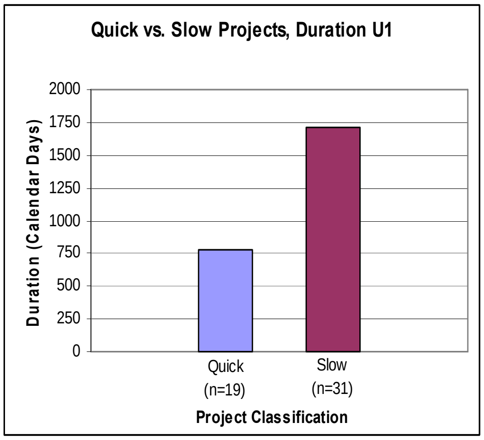
1	Project Information	CSJ Number: ______________________________				
2		District: ______________________________				
3		County: ______________________________				
4		District Duration Assessment:	Short____		Long____	
5	Duration Information	**Date Information**			**Comments**	
6		**D2:** ROW Release Date*:	____________________		______________________________	
7		Plans Adequate 60% PS&E:	____________________		______________________________	
8		**D10:** Agreement Approved:	____________________		______________________________	
9		**D11:** 90% Paid Date:	____________________		______________________________	
10		**or**			______________________________	
11		**D8:** Adjustment Completion:	____________________		______________________________	
12		**D13:** Construction Letting*:	____________________		______________________________	
13		* ROW Release / Construction Letting same for all utilities, other dates listed from last utility adjustment completed				
14	Factors Affecting Overall Project Duration	Highway Type:	Interstate_____	US Hwy____	State Hwy____	FM / RM ____
15		Location Category:	Urban____	Metro____	Rural____	
16		TxDOT Project Type:	BR____	INC____	WF____	WNF____
17			CNF____	NNF____	BWR____	NLF____
18			UGN____	UPG____	OV____	MSC____
19			SC____	RER____		
20		Length of Project:____________				
21		Federally Funded:	Yes____ No____		If Yes, Percentage_________	
22		Local Public Agencies	City____ County____		Other____	None____
23		Names:	____			
24		SUE Performed:	Yes____	No____		
25		Reimbursable____	Non-Reimbursable____			
26		Date of Eligibility Used?	Yes____	No____		
27			Number of Date of Eligibility Agreements_________			
28		Number of Involved Utilities:____________				
29		Types of Utility Adjustments:	Cap & Removal Pipeline____		Extend Casing____	High Pressure Gas____
30			Irrigation Pipeline____		Liquid Petroleum Line____	Low Pressure Gas____
31			Microwave Tower____		Overhead Comm____	Overhead Power____
32			Sanitary Sewer____		Sewer Line____	Transmission Pole____
33			Transmission Tower____		Underground Comm____	
34			Underground Power____		UJUA Only____	Wastewater____
35			Wastewater Pump Station____		Water____	Other____
36		Number of Utilities Outsourcing Work:______				
37		Number of Utilities Performing Work In-House:_______				
38		Legal Action by TxDOT or Utilities:		Yes____	No____	Comment:________________________
39		Utilities Required to Relocate Multiple Times:		Yes____	No____	Comment:________________________
40		UAP / UAR Exceptions Granted:____________________________				

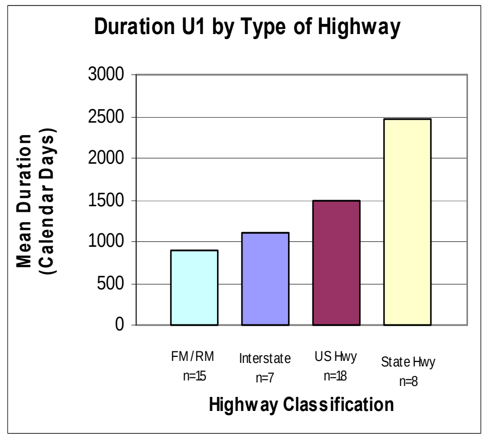
Appendix C: Utility Adjustment Factors

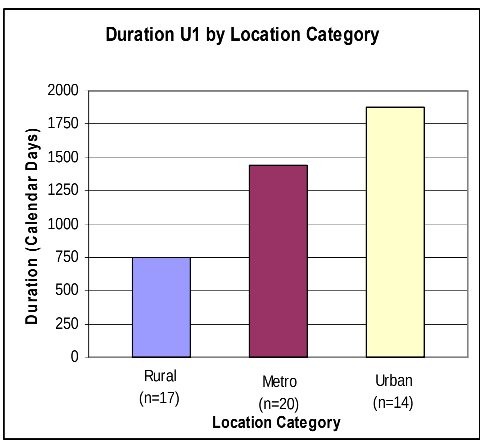
Factor	*Frequency*	*Known Early*	*DB or Paper Files Availability / Comments*
Number of Utilities	5/16	Yes	Yes, indirectly. There should be a folder for all utilities requiring a Joint Use Agreement, including all reimbursable agreements as well as some non-reimbursable agreements.
Project Type	6/16	Yes	Not from the utility agreement files. The information is available in DCIS. However, the system requires construction CSJ numbers.
Coordination w/ Construction	2/16	No	No
Phasing of Construction	3/16	Yes	No
Verification of Utility Property Interest	3/16	Yes	Files include affidavits to effect of property interest, the only indication of delays is if there are multiple memos requesting the information.
Type of Highway	1/16	Yes	Yes, the highway number is supposed to be included in the DB, and is printed on the agreement files.
Utility Coordination / Communication	5/16	No	Correspondences directly related to agreements are found in the files; however, this only relates to communication between the District ROW office and the Division office in Austin.
Availability of Right-of-Way	3/16	Yes	No
Environmental Issues	2/16	Yes	No
Changes in Highway Contract Letting Dates	1/16	No	Possibly, if ROWIS and DCIS printouts are included from different dates that include the original and new letting dates.
Unknown / Unidentified Utilities	4/16	No	Indirectly, in an application for DOE procedure the district MAY give reason as encountering previously unknown utility facility.
Delays in Right-of-Way acquisition	2/16	No	No
Use of SUE	2/16	Yes	No
Design Changes / Completeness	3/16	No	No
Corridor Congestion	2/16	Yes	Indirectly, based on number of utilities and the location of the project.
Location of Utility Facility	3/16	Yes	Yes
Method of Reimbursement	2/16	Yes	There is in some cases codified information as to the payment method; however, due to changes in forms over the past few years this is not uniform.
Multiple occupants of utility poles	1/16	Yes	No
Site Conditions	2/16	Yes	No
Utility Company's Familiarity w/ State Procedures	2/16	Yes	No

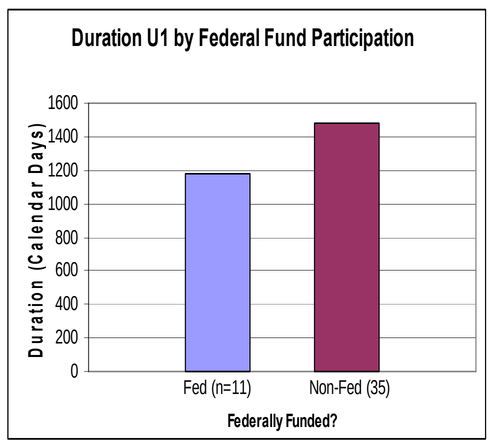
Appendix D: Miscellaneous Graphs and Tables

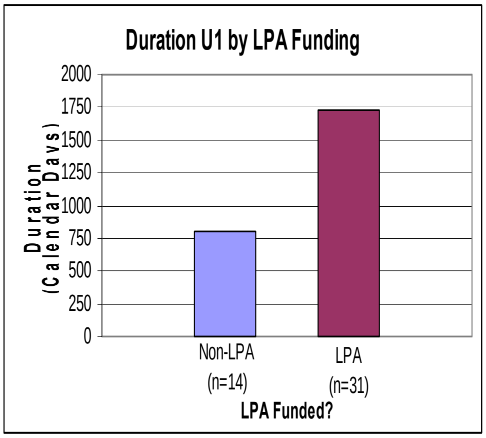
U1: Right-of-Way Release to Last Agreement Executed

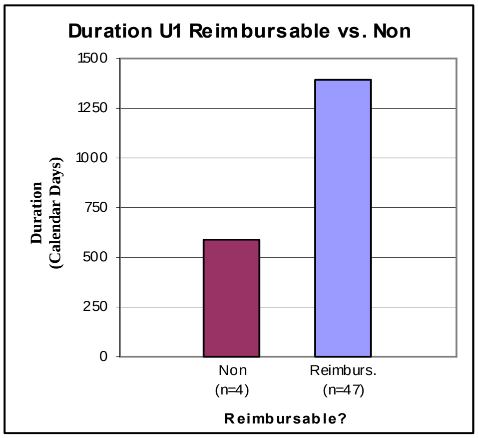


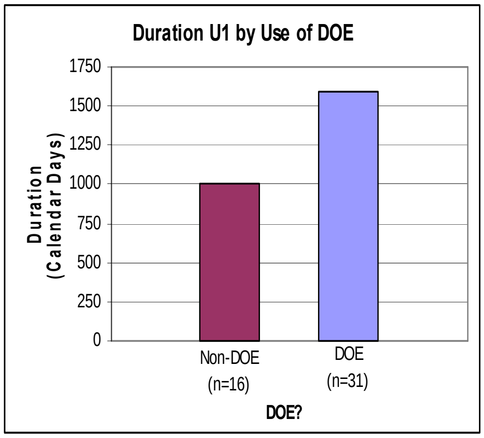




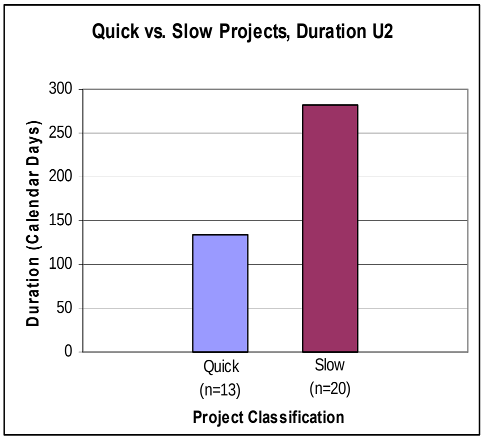


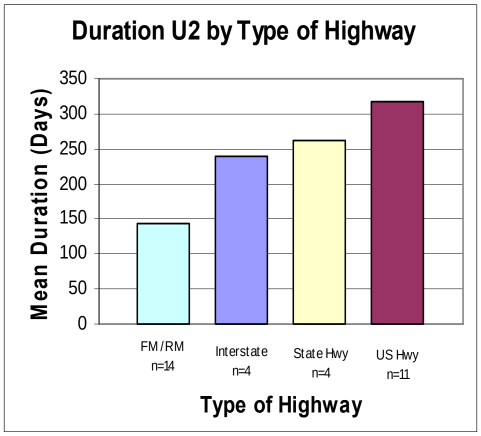


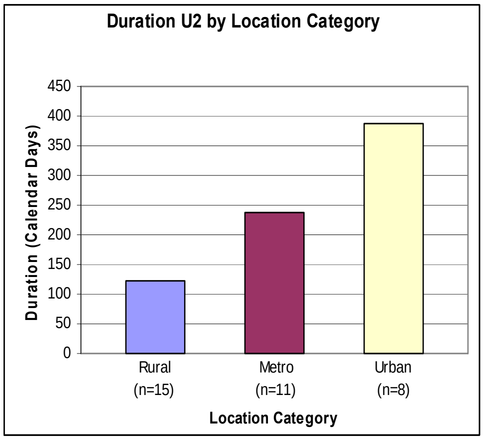


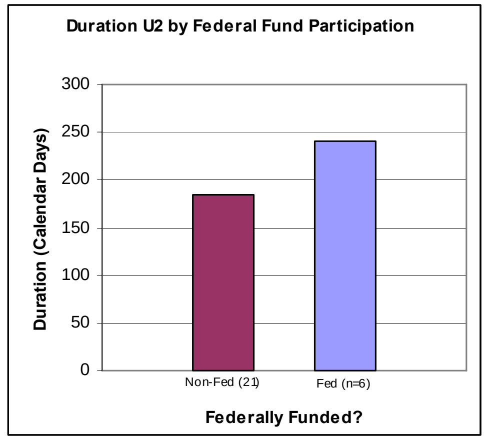


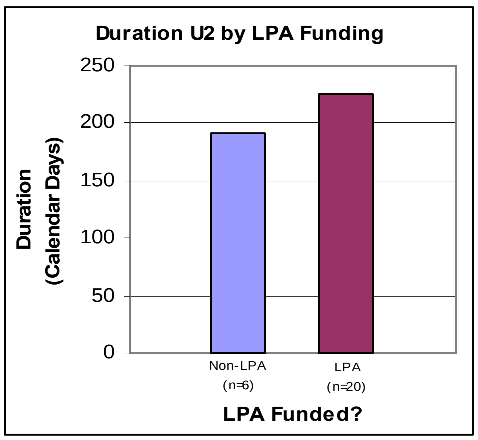
U2: Last Agreement Executed to Last Adjustment Completed

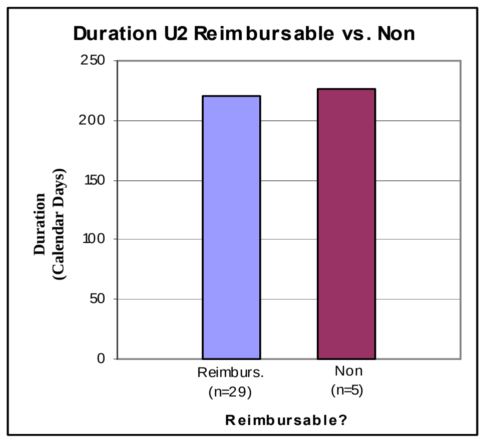


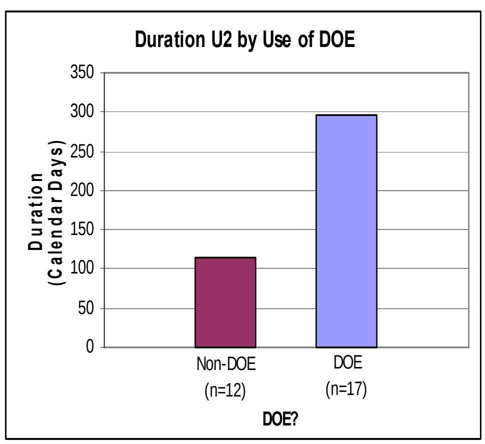



Duration U2 by Location Category
Duration (Calendar Days)
450
400
350
300
250
200
150
100
50
0
Rural
(n=15)
Metro
(n=11)
Urban
(n=8)
Location Category

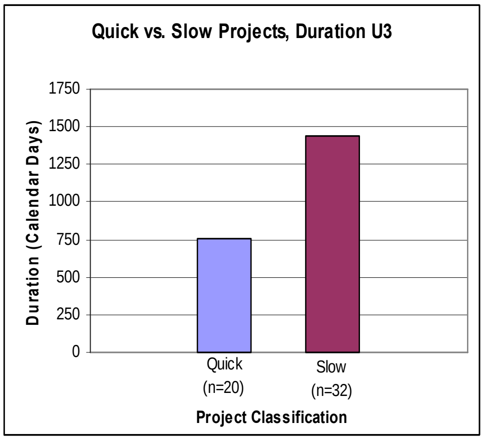

Duration U2 by Federal Fund Participation
Duration (Calendar Days)
300
250
200
150
100
50
0
Non-Fed (21)
Fed (n=6)
Federally Funded?

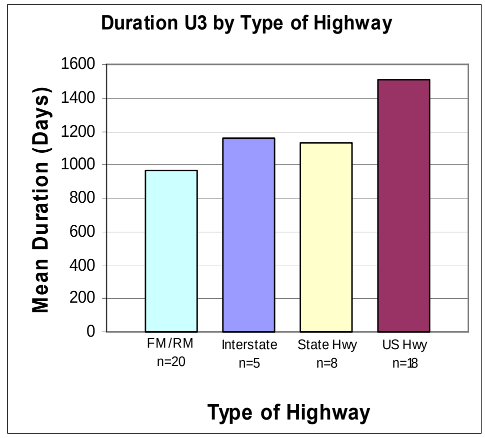

Duration U2 by LPA Funding
Duration
(Calendar Days)
250
200
150
100
50
0
Non-LPA
(n=6)
LPA
(n=20)
LPA Funded?

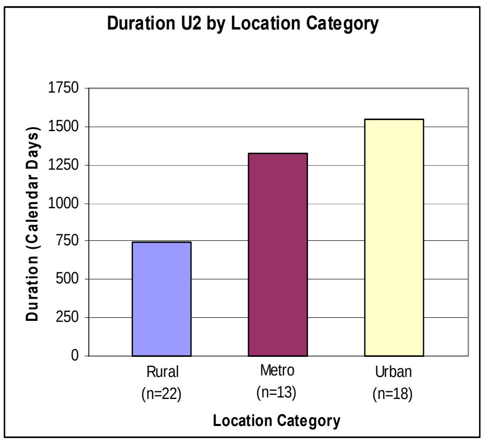

Duration U2 Reimbursable vs. Non
Duration
(Calendar Days)
250
200
150
100
50
0
Reimburs.
(n=29)
Non
(n=5)
Reimbursable?

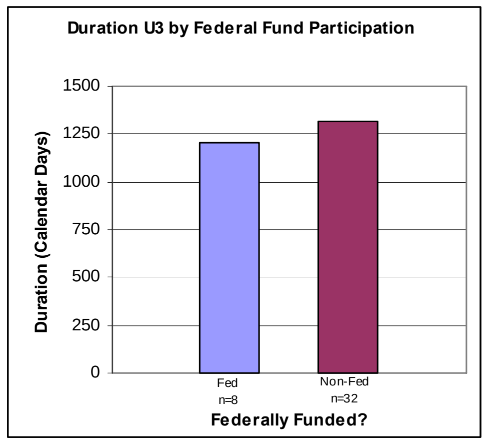

Duration U2 by Use of DOE
Duration
(Calendar Days)
350
300
250
200
150
100
50
0
Non-DOE
(n=12)
DOE
(n=17)
DOE?

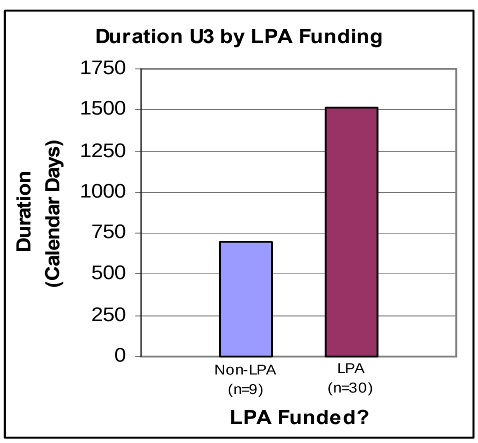
U3 Right-of-Way Release to Last Adjustment Completed

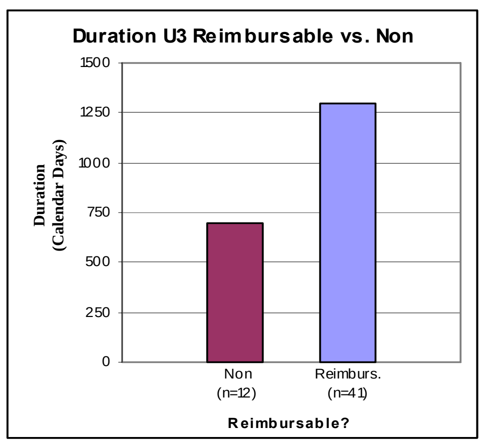


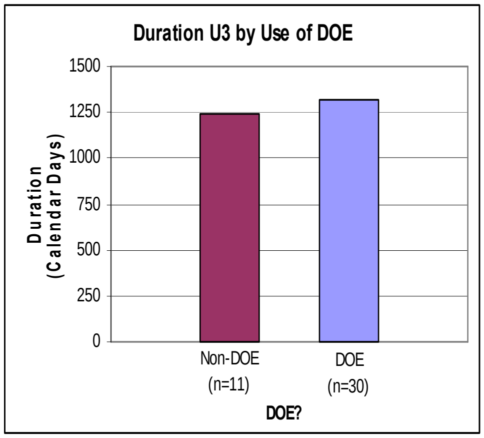












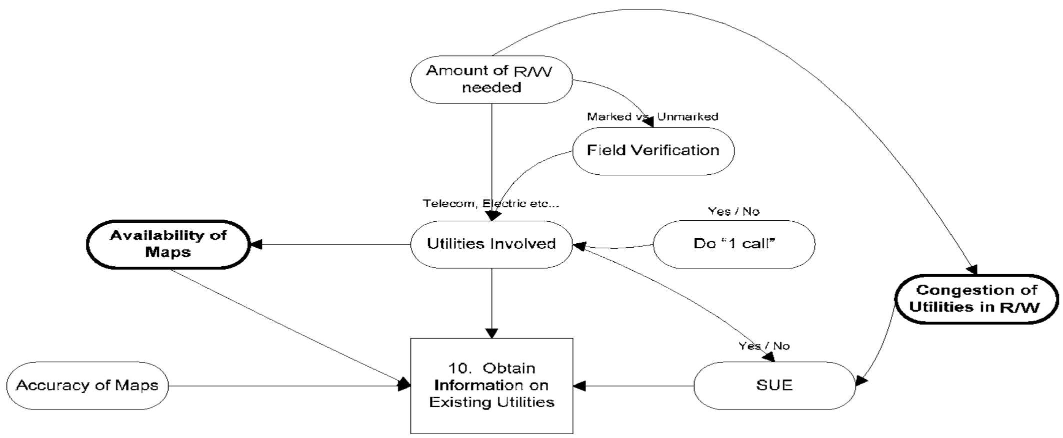
U4: Last Adjustment Completed to Last Agreement Executed (DOE Projects Only)

All Projects		
Statistic	Value (n=13)	
	Days	Years
Mean	396	1.08
Standard Deviation	244	0.67
Minimum	74	0.20
Maximum	836	2.29

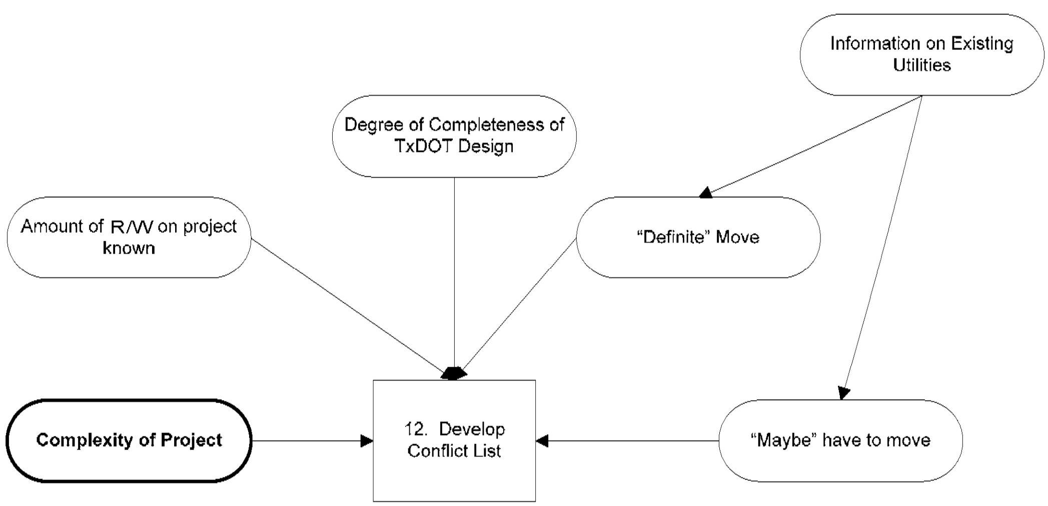
Date of Eligibility Projects		
Statistic	Value (n=12)	
	Days	Years
Mean	415	1.14
Standard Deviation	245	0.67
Minimum	60	0.16
Maximum	4636	12.69

Local Public Agency Projects		
Statistic	Value (n=8)	
	Days	Years
Mean	459	1.26
Standard Deviation	494	1.35
Minimum	74	0.20
Maximum	836	2.29

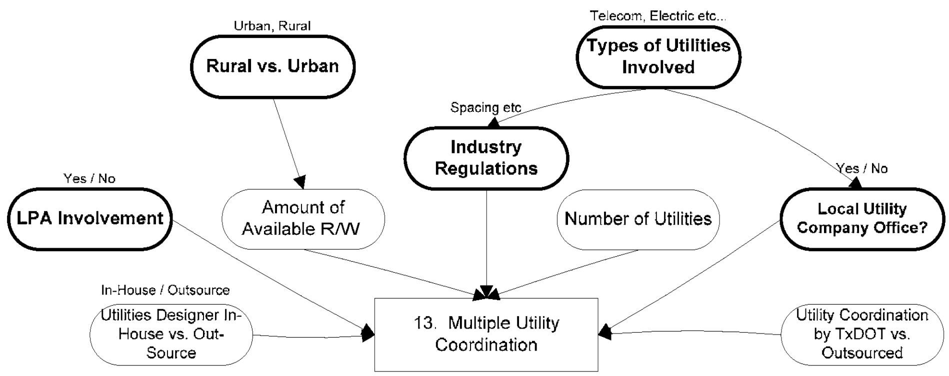
Appendix E: Influence Diagrams for Key Activities



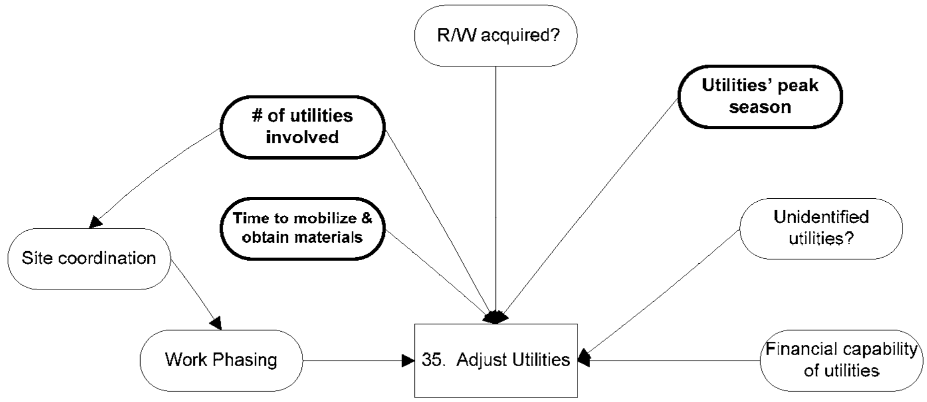
Source		Duration			Conditions
District	**Respondent**	**Short**	**Typical**	**Long**	
Amarillo	TxDOT	1 week	2 weeks	30 days	Unknown utilities or SUE can add 30 days
Austin	TxDOT	1 year	1.25 years	1.5 years	Nominal $10 million Highway project
Houston	SBC	1 week	2 weeks	2 months	SUE adds 1-2 months
	CenterPoint	2 weeks	1 month	2 months	SUE adds 1-2 months
	Range	1 week - 1 year	2 weeks - 1.25 years	30 days - 1.5 years	



Source		Duration			Conditions
District	Respondent	Short	Typical	Long	
Amarillo	TxDOT	1 week	1 month	2 months	need to have adequate design and utility information
Austin	TxDOT	1 month	3.5 months	6 months	
Houston	TxDOT	3 months	4.5 months	6 months	Short, fast-tracked project
	CenterPoint Gas	2 weeks	1.75 months	3 months	
	Range	1 week - 3 months	1 month - 4.5 months	2 months - 6 months	



Source		Duration			Conditions
District	Respondent	Short	Typical	Long	
Amarillo	TxDOT	1 day	1 week	3 months	Need to have adequate design information, can be done in one meeting. Acquiring design information can take as long as 1 month
Austin	TxDOT	1 month	4.5 months	8 months	$10 million highway project, may only take 1 meeting
Dallas	TxDOT	1 month			No further information provided
Houston	TxDOT	1 month	5 months	6 months	Includes time to gather necessary information
	SBC	1 month	3 months	6 months	
	Range	1 day - 1 month	1 week - 5 months	3 months - 6 months	



Source		Duration			Conditions
District	**Respondent**	**Short**	**Typical**	**Long**	
Amarillo	TxDOT	1 day	3 months	1 year	
Austin	Oncor	1 month	5 months	9 months	$10 million highway project, overhead electrical lines
		2 months	10 months	18 months	$10 million highway project, buried electrical
		2 months	10 months	18 months	$10 million highway project, overhead to buried electrical
		3 months	7.5 months	12 months	$10 million highway project, buried gas pipelines
Dallas	Oncor	2 weeks	4 weeks	6 weeks	Electric distribution / transmission the fastest of all utilities for adjustment
	TxDOT	6 months	12 months	18 months	Duration includes mobilization & fabrication times, also considers all utilities
Houston	SBC	2 months	7 months	1 year	duration is longer to re-route service without interruption
	CP Electric	1.5 months	6 months	9 months	
	CP Gas	2 months	9 months	1 year	
	Range	1 day - 6 months	4 weeks - 10 months	6 weeks - 18 months	