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**Development and Implementation of Utility Relocation Cost Estimation  
System**

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**Development and Implementation of Utility Relocation Cost Estimation  
System**

**by**

**Yang Xu**

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## **Abstract**

# **Development and Implementation of Utility Relocation Cost Estimation System**

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This thesis explores how to leverage information management techniques in developing a database system which can store, access and query data to generate preliminary cost estimate reports for utility relocations in highway construction projects. Although cost estimation for utility relocation is an essential part of most transportation projects, there are very few ready-to-use cost database or software platform available to fulfill this purpose for state DOTs personnel. Therefore, the research aimed to develop a database system that can provide estimates with historical cost data. The unit cost data used in this database are derived either from the executed utility agreements between TxDOT office and utility owners or a publicly available open source database. The estimated costs are computed with these pre-stored data. As a result of the research, the Utility Relocation Cost Estimation Database system was completed and has been handed over to TxDOT Austin District for further tests and implementations.

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# Chapter 1 Introduction

## 1.1 RESEARCH MOTIVATION

With the rapid development of transportation infrastructure systems, conflicts between public utility facilities and transportation projects are becoming more and more common. Utility relocation happens when it is not feasible to solve utility conflicts by making changes in transportation designs. Although utility companies share the right of way with the state department of transportation (DOT), they are responsible for moving their facilities to accommodate significant changes on roadways. If a utility relocation is inevitable for the transportation project and the cost is at the expense of the state, then the cost is defined as reimbursable cost. Utility relocation is identified as reimbursable, only under one of the following two circumstances (Garcia, 2017):

- “1. Improved segments on a state highway facility will occupy the compensable property of a utility. This includes the extension of a highway in an urban area;
2. The highway is designated as part of the National System of Interstate and Defense Highways. Relocation is eligible for federal participation.”

On reimbursable utility relocation projects, State DOTs are responsible not only for coordinating the utility relocation procedure but also for paying the final relocation cost. In general, utility companies and State DOTs are required by law to enter into agreements describing the scope of work and responsibilities for financing and accomplishing the work. In most utility relocations on TxDOT highway projects, the expenses are at least partially reimbursable. That usually means TxDOT has a financial obligation to pay for the relocation of utility facilities affected by the transportation project. Unfortunately, however, so far there are very few preliminary cost estimation tools in hand for personnel in the TxDOT Austin District. Consequently, the district has little information on the expenditure of the utility relocation project except the cost estimations made by utility

companies themselves. In such a case, it is difficult for the district to play an active role in coordination with multiple parties involved in utility relocation throughout the entire project. On the contrary, if there were a customized tool that could enable the district to obtain additional information about cost estimation in advance, then the district would be able to make more favorable decisions and also be more competent to coordinate the utility relocation.

## **1.2 RESEARCH OBJECTIVES**

This research project aimed to develop an effective cost estimation database system for utility relocation in highway construction projects. The system developed through this research provides reliable cost estimation for utility relocation projects with historical cost data. To be specific, two data sources were employed to generate the final relocation estimates. The first one comes from previously executed Utility Agreements between TxDOT and utility companies. Cost data from agreements are the most valuable information for implementing cost estimation when adjusted for inflation because these data came directly from local projects. In this respect, unit costs from agreements are the ideal data for reference. However, sometimes there might not be records for a certain type of utility facility, which needs to be relocated in a transportation project. In such a case, extra data sources are necessary. Therefore, in the Utility Relocation Cost Estimation database, another type of historical cost data, was used as an alternative data source. With these cost references, the TxDOT personnel could have a general idea about the price range for a variety of utility facilities in advance. In addition to the features mentioned above, the system was also developed with easy-to-use interfaces, which provide utility engineers with a user-friendly working environment and maximize the efficiency of generating the cost estimation reports.

### **1.3 RESEARCH SCOPE AND LIMITATIONS**

The database system was developed mainly to generate cost estimation reports for utility relocation projects. The uppermost objective of the system is to conduct cost estimation for any given utility facility by querying and retrieving cost information pre-stored in the database. Therefore, all the entities in the system were created to fulfill the cost estimation goal. Some entities in the system, such as *Project*, *Company*, *Facility*, etc., were largely simplified - only those features relevant to cost estimation were reserved. For example, there is only one field - Company Name - in the *Company* form. Additionally, the Utility Relocation Cost Estimation system is a highly customized tool that was mainly designed to provide services to TxDOT personnel. In this respect, this database may lack certain sophisticated features/functions, when compared with other professional cost estimation software on the market.

### **1.4 STRUCTURE OF THE THESIS**

This thesis is organized into six chapters. Chapter 1 discusses the research motivation, objectives, scope, and the overall structure of the thesis. Chapter 2 provides the research methodology to accomplish the Utility Relocation Cost Estimation system. Chapter 3 presents a thorough literature review on utility relocation, and construction cost estimation. Chapter 4 reviews the development of the Utility Relocation Cost Estimation system. Chapter 5 elaborates on the implementation of the Utility Relocation Cost Estimation system. Ultimately, Chapter 6 presents a conclusion and points out potential improvements for future work.

## Chapter 2 Research Methodology

The research discussed in this thesis was completed through five major phases, as shown in Figure 2-1: (1) Conduct Literature Review; (2) Decide Database Platform; (3) Develop the Utility Relocation Cost Estimation System; (4) Implement the Utility Relocation Cost Estimation System; (5) Draw Conclusions and Recommendations.

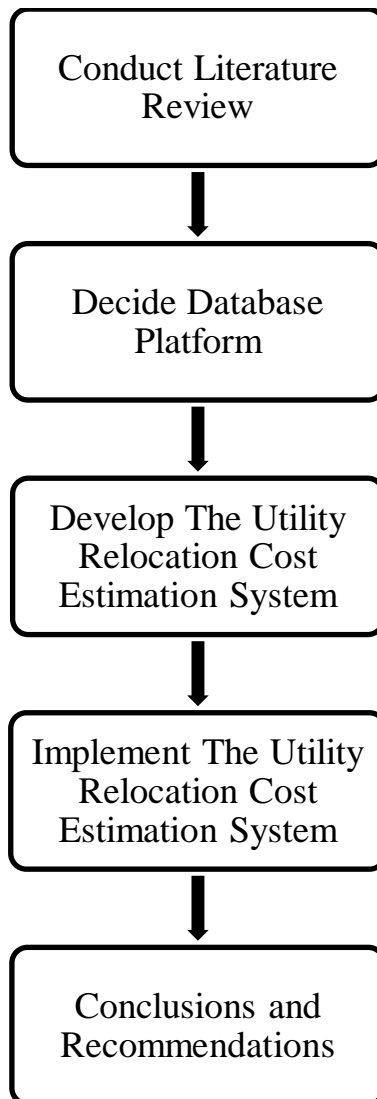


Figure 2-1: Flow Chart of Research Methodology

## **2.1 CONDUCT LITERATURE REVIEW**

A comprehensive literature review provides knowledge and an overview of current practices regarding utility relocation processes and cost estimation in construction projects. To be specific, the review of TxDOT's Utility Manual, Project Development Process Manual and the chapter of Utility Relocations in Caltrans' Right of Way Manual contributes largely to a broad understanding of the utility relocation process. In addition to utility relocation, the review of Project Management for Construction - Fundamental Concepts for Owners, Engineers, Architects, and Builders provides comprehensive knowledge of cost estimation, especially in the construction industry. An overview of cost estimation and the role it plays in construction projects are elaborated. Then, common methods used to compute cost estimates are discussed. Finally, the implementation of computer-aided cost estimation systems and the influence of these platforms are introduced.

## **2.2 DECIDE DATABASE PLATFORM**

Another work that occurs in parallel with the literature review is an analysis of database platform options. Since, in this case, user needs are quite clear and straightforward, the final deliverable should be a usable database tool that can generate detailed cost estimation reports with basic data input by end users. With this objective, the first thing is to decide what platform the research team will work on to develop the cost estimation database system. Although there is a variety of database platforms on the market, Microsoft Access was ultimately chosen to develop our system after a series of comparisons between different options. Microsoft Access is easy to install and use, both for developers and users. In addition, it is the most popular desktop database system



throughout the world. The robust compatibility provided by Microsoft Access allows the Utility Relocation Cost Estimation system to be integrated into the TxDOT IT system as a sub-module.

### **2.3 DEVELOP THE UTILITY RELOCATION COST ESTIMATION SYSTEM**

After the literature review and technical preparation, the feasibility of the Utility Relocation Cost Estimation system was fully confirmed by the research group. With consideration of the selected database platform, the architecture of the system was divided into two layers: (1) Database – The back-end data access layer; (2) User interface – The front-end presentation layer. Then, several rounds of brainstorming and discussion sessions were conducted, which primarily focus on technical details, such as what entities should be included in the system, what attributes should be assigned to a specific entity, and what types of relationships should be established between two given entities. In general, the development of the database could be divided into six steps by time:

1. Determining *entities* involved in the Utility Relocation Cost Estimation database
2. Selecting *attributes* for each entity
3. Discovering *relationships* between entities
4. Creating *tables* and *queries* to store and retrieve data
5. Designing *forms* and *reports* to interact with users
6. Implementing the *database* into practice

The procedure for developing the Utility Relocation Cost Estimation system will be introduced in detail in Chapter 4.

## **2.4 IMPLEMENT THE UTILITY RELOCATION COST ESTIMATION SYSTEM**

Several rounds of testing and debugging were conducted to ensure the robustness and usability of the Utility Relocation Cost Estimation system. In brief, during the development phase, testing data were used as placeholders in the system to ensure the workflow and usability of the database. Right after the completion of all function modules, real data derived from utility agreements, such as facility and cost information, were used to test the database. There are two major benefits of using real data at this stage. For one, the validity of the database is confirmed by real data. For another, real data are stored in the database to serve as historical records for future cost estimations. Furthermore, when all the tests were done, the system was handed over to TxDOT personnel for third-round on-site testing. Later, feedback on the system test was collected, with which the database was updated and adjusted to accommodate new user needs. After all the updates were completed, the revised version was submitted to TxDOT. The implementation of the Utility Relocation Cost Estimation system will be discussed and reviewed in Chapter 5.

## **2.5 CONCLUSIONS AND RECOMMENDATIONS**

Chapter 6 summarizes research on the development and implementation of the database and draws conclusions based on the outcomes. This chapter also elaborates on how we can further develop this cost estimation system and provides recommendations for future research.

## **Chapter 3      Literature Review**

A preliminary review of the literature was conducted in the early stages of the research. This review focused on finding information related to two major areas: 1. reviewing basic concepts and general processes of utility relocations; and 2. gaining a comprehensive understanding of cost estimation. This chapter begins with a glossary of terms concerning utility relocations. Then, an overview of cost estimation and the role it plays in construction projects are elaborated. Common methods used to compute cost estimates are introduced. Also, the implementation of computer-aided cost estimating systems and the influence of these platforms are discussed. Ultimately, an integration of both utility relocations and cost estimation are presented.

### **3.1 AN OVERVIEW OF UTILITY RELOCATION**

Utility relocation refers to the adjustment applied to a utility facility which conflicts with a proposed transportation project. When a utility conflict cannot be solved by making changes in the transportation design, the utility company is responsible for relocating their facilities to accommodate the transportation project. The operational function of utilities is to provide the public with a variety of services. In a utility relocation project, if the utility company wants to get reimbursement for the relocation cost, the utility should either have a compensable interest in its present location or be compensable under another state statute (Cannon, 2017).

## **Basic Concepts**

### ***Utility Companies and Owners***

Utility companies are often used as a synonym for utility owners, which refer to private entities or public organizations who own utility facilities. Utility companies also operate their utility facilities to provide the public with directly or indirectly services for a charge. In most utility relocations, the involved utility companies are responsible for the design of their utility facility relocations (Caltrans, 2018).

### ***Utility Facilities***

In this thesis, utility facilities are specially referred to those facilities that conflict with the proposed transportation project. It could be underground or overhead pole, pole-line, pipe, pipeline, conduit, cable, aqueduct, or other structures that are used to provide services to its members (Caltrans, 2018).

### ***Utility Agreements***

Utility Agreements are specific documents to record utility relocations that are reimbursed by the State. The agreement defines the rights and responsibilities of each party involved in the relocation. In general, a utility agreement includes information as the following (Garcia, 2017):

1. Standard Utility Agreement Forms
2. Detailed Relocation Plans, Specifications, and Cost Estimates
3. Proof of Reimbursable Interest
4. Joint-use Agreement.

### ***Reimbursable Cost***

If the state reimburses a utility company for the expense of the utility relocation, the relocation expense is deemed as reimbursable cost. Generally, agreements between DOTs and utility companies would specify the reimbursement of utility relocation, if the state paid the relocation costs.

### ***Eligibility***

The utility's eligibility ratio determines its eligibility. Typically, the utility's assembly package includes the specific formula to compute the eligibility ratio. Eligibility issues should be addressed before the approval of the utility agreement assembly. (Cannon, 2017).

### **Procedures for Utility Relocation**

In general, the utility relocation procedures consist of plenty of activities. The major activities are utility verification, identifying conflict, requesting conflict resolution plan, liability determination, notifying owners, right of way utility clearance memo, managing the physical relocation, managing relocation invoice, and utility records keeping. The following illustrates the figure flow framework of utility relocation procedures in current practice:

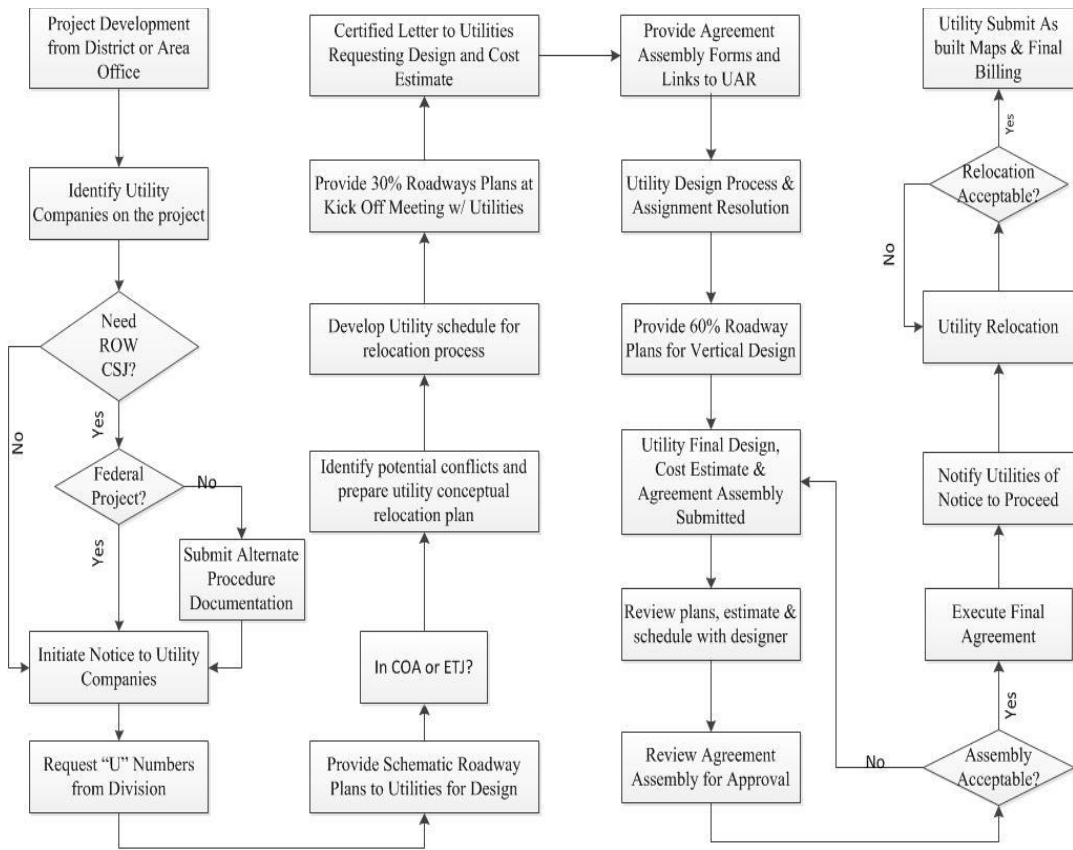


Figure 3-1: Current Utility Relocation Process Flow Framework (Kraus, Texas. Department of Transportation. Research and Technology Implementation, & Texas Transportation, 2007)

### 3.2 AN OVERVIEW OF COST ESTIMATION

Costs and schedules are two paramount factors for construction projects. As discussed above, cost estimation plays a vital role in utility relocations because it has significant impacts on utility coordination decisions made by the state DOTs. This section presents the essential knowledge for cost estimation in construction projects.

## **Construction Costs**

In most budgets, the expense of an infrastructure system (e.g., buildings, bridges, and highways, etc.) are made up of two components: one is the initial capital investment for constructing the structure, and the other is the subsequent operational cost. The initial investment usually consists of the expenses come from each activity before the facility is formally turned over to the owner. Examples of such activities can be land acquisition, feasibility studies, preliminary planning, architectural design, and project construction, etc.

After a facility has been put into service, new costs will be generated from operation and maintenance activities. This kind of expense will exist throughout the entire lifecycle of the facility until it has been demolished. These costs usually are made up of various expenses, which may include operating staff, repairs, renovations, insurance and taxes, utilities, as well as other expenses.

In addition to the cost components mentioned above, another ingredient that contributes to the overall project costs is the allowance for contingencies, which stands for the expense generated by unexpected events or accidents during the construction phase. The total contingency amount could be either added to each cost item or be considered as an individual cost category. Good examples of these cost influence factors can be change orders, schedule adjustments, external environmental impacts, severe weather, etc.

## **Cost Estimation Approaches**

As noted earlier, cost estimation is an essential component of project management. There are a wide variety of methods for conducting project cost estimation in the construction industry. The specific methods utilized to estimate project costs may vary from project to project. However, almost all cost estimations are accomplished through one or multiple combinations of the following essential approaches (Hendrickson & Au, 1989):

**Method 1:** Unit Cost \* Item Quantity. In this approach, the overall construction process is broken down into a series of activities/items. Then, the cost estimator computes and assigns a unit cost to each activity/item. The total cost for each activity/item is the product of the quantities multiplied by its unit cost. The total cost for the entire project is the summation of all the item costs.

**Method 2:** Empirically-based Cost Estimation. The theory of empirically-based cost models began to appear since the 1970s (McGibbon, 1997). The data used to build the cost estimation model come from previous projects and reasonable assumptions. Empirically-based cost estimation employs statistical approaches (e.g., regression analysis) to integrate the construction or maintenance expenses of a facility with several significant attributes of the system. The ultimate goal of a cost model is to find the optimum values for each parameter in an assumed cost function with the help of statistical methods.

**Method 3:** Production Function method. A production function is used to express the relationship between a series of input factors and the output production. In construction, especially, the production function is deemed as the relationship between the construction productivity and various inputs such as labor, materials, tools, and equipment, etc. Therefore, for any given output, the objective of a production function is to optimize the array of input values minimizing the overall cost of multiple inputs.

**Method 4:** Joint Costs Allocation. Joint cost is a kind of cost that exists in a joint production process. A joint process takes one input and automatically generates a variety of outputs known as joint-products. Usually, joint costs are allocated based on several units. The principle of this method is to assign particular features of the operation to each cost item causally.



## **Historical Cost Data**

As stated in the previous chapter, historical data has a significant impact on cost estimation. However, it is not always available or usable. In some cases, even no historical data exists. In other cases, the only historical record available is not decipherable. Historical data would turn into an ineffective reference for future cost estimation unless the data were collated in an explicable way. Therefore, the format of unit costs for various items should be treated effectively and purposefully.

In fact, there are a variety of publicly open sources which offers construction cost information. Common sources to acquire cost data are catalogs of vendors' data, periodicals, commercial cost reference manuals for estimating guides, digests of actual project costs, etc.

These cost data are excellent references for cost estimators. However, one should always be cautious when using open sources cost data for cost estimation. Although it is relatively easy to access these data, it can be fairly difficult to know how these data are obtained. Thus, it is likely to introduce uncertainty to cost estimates by using historical data without judgment and verification. In addition, any slight change in one of the cost components can have a deep impact on the overall construction costs. Moreover, some external factors, such as design changes and severe weather, also have an influence on the accuracy of cost estimations, which can add extra expenses to the original cost estimate.

## **Computer Aided Cost Estimation**

Computer-aided cost estimation software has become increasingly sophisticated and versatile over the past twenty years. Depending on the specific purpose, the complexity of the cost estimation process may vary from tool to tool. For instance, some are just simple spreadsheet calculation tools, while others are complicated systems which can

automatically come up with cost estimates based on design plans. With the development and implementation of these tools, the efficiency and accuracy of cost estimations have been largely boosted.

### **3.3 COST ESTIMATION FOR UTILITY RELOCATION**

#### ***Utility Cost Estimation***

In general, the utility coordinator, who acts as a liaison with utility owners, is responsible for preparing cost estimation throughout the utility relocation. The relocation cost estimation could be based on previously relevant relocation costs, facility unit costs, information from utility owners, etc. In addition, the escalation rates ought to be taken into consideration when conducting cost estimation. There are a wide variety of methods to measure it. For example, one feasible way is to identify industry-wide rates of increases in materials, labor, and equipment rentals, etc. In an effort to estimate the inflation, one can investigate current labor rates, collect cost information online, as well as consult with utility companies or experts.

In order to prepare the utility cost estimation, the utility coordinator should be responsible for the following actions (Caltrans, 2018):

- Review all the proposed project routes on site.
- Identify all affected utilities, inform utility companies, and prepare relocation cost estimation for each utility.
- Integrate utility cost estimations and come up with a total cost estimate for the overall relocation project.
- Communicate with utility companies to find out the work scope and provide relevant support and coordination.

- Investigate potential design changes that can avoid utility relocation or minimize the impacts.
- Plan project schedules and estimate workload for all WBS codes.
- Prepare the R/W Data Sheet(s) and submit to R/W Estimating.

## Chapter 4      Development of the Utility Relocation Cost Estimation System

### 4.1 AN OVERVIEW OF THE COST ESTIMATION SYSTEM

In general, the development of the Utility Relocation Cost Estimation system could be roughly divided into six steps by time:

1. Determining *entities* involved in the Utility Relocation Cost Estimation database
2. Selecting *attributes* for each entity
3. Discovering *relationships* between entities
4. Creating *tables* and *queries* to store and retrieve data
5. Designing *forms* and *reports* to interact with users
6. Implementing the *database* into practice

The ultimate output of this system is a cost estimation report for a particular utility relocation project. In order to generate this estimation report, the system should be properly designed to store relevant data as well as to present data in a well-organized way. Before storing data, the first thing was to determine what kind of data is needed in this cost estimation system. Therefore, the first task was to decide how many entities will be in the system. In the database management system, an entity is a digital representation of a particular type of object in the real world. (Coronel & Morris, 2018).

In a database system, tables are used to store data for entities. Each table is a two-dimensional data structure which stores all the relevant data for a particular entity. Each column in the table is an attribute of the entity which describes particular characteristics of that entity. Each row in the table is a specific instance of that entity. With these tables, all the information could be well-organized in the system.

<b>Sl. No.</b>	<b>Entity</b>	<b>Information represented</b>
1	DOT_PROJ	Highway Projects
2	UTIL_CMPNY	Utility Companies
3	UTIL_FCLTY	Utility Facilities
4	AGREEMENT	Agreements
5	AGR_ITEM	Agreement Items
6	UTIL_ESTMT	Cost Estimations
7	ESTMT_ITEM	Estimation Items

Table 4-1: Tables in the Utility Relocation Cost Estimation System

The supreme purpose of the database system, however, is not only to store data but also to take advantage of the data records. Hence, coming along with tables, queries are used in the database to retrieve specific information, which users are interested in, from the large collections of data. In other words, a query is a user request that asks the database to execute a specific data manipulation instruction.

<b>Sl. No.</b>	<b>Name of Query</b>	<b>Function</b>
1	qry_PROJ	Request listing all project records stored in the system
2	qry_CMPNY	Request listing all utility company records
3	qry_FCLTY	Request listing all utility facility records
4	qry_AGRMT	Request listing all utility agreement records
5	qry_AgrmtItem	Request listing all agreement item records for a given utility agreement
6	qry_ESTMT	Request listing all cost estimate records
7	qry_EstItemLists	Request listing all estimate item records for a given cost estimate
8	qry_AvgAgrsUnitCost	Calculate the average agreement unit cost for a given estimate item
9	qry_FindAgreements	Find all the stored agreements for a given estimate item
10	qry_RPT_EstItemLists	Generate the final report for a selected cost estimate

Table 4-2: Queries in the Utility Relocation Cost Estimation System


Although with well-designed tables and queries, the database can be free from problems regarding data storing and retrieving, it is unrealistic to ask users to work directly on the tables. In this respect, forms are employed to provide end users with visualized user interfaces (UI) which allows end users work on the database to be more efficient. Each form is an individual window that allows users to input information. After receiving user inputs, the system will give timely responses. For example, some inputs may add new records into a table, and other inputs may trigger a command to open a new form or a report.

<b>Sl. No.</b>	<b>Name of Form</b>	<b>Function</b>
1	fm_MainMenu	Navigational panel to switch to other forms
2	fm_PROJ	UI for data manipulations on utility projects
3	fm_CMPNY	UI for data manipulations on utility companies
4	fm_FCLTY	UI for data manipulations on utility facilities
5	fm_AGRMT	UI for data manipulations on utility agreements
6	fm_agrItem	UI for data manipulations on agreement items
7	fm_ESTMT	UI for data manipulations on cost estimates
8	fm_estimateItem	UI for data manipulations on estimate items
9	fm_RPT	UI for data manipulations on estimate reports
10	fm_LookupFacID_ArgItem	A sub-list located in fm_agrItem to display information for a particular utility facility
11	fm_LookupFacID_EstItem	A sub-list located in fm_estimateItem to display information for a particular utility facility

Table 4-3: Forms in the Utility Relocation Cost Estimation System

Other than forms, which both enable inputs and outputs, reports provide a unidirectional mode to display organized information. Each report is pre-designed with fields and titles. These fields in the report will be filled in with a value directly or indirectly

come from data stored in the system. Direct data may derive from a simple query, while indirect ones may be a result of a numerical calculation.



**Utility Relocation Cost Estimate**

**SH 789**

**Construct Grade Separation over NH 2017**

CCSJ: 0015-17-616      ROW CSJ: 0015-17-617      Count    Hays      Length: 4500    ft    0.8523    mi

LIMITS FROM: 3,500' North of FM 3407      TO: 3,500' South of FM 3407      Station #'s From 65+00      To: 110+00

Item	Type of Facilities	Size	OH/UG	UG Tech	Qty	Unit	Unit Cost	Percentage for Urban %	Estimated Relocation Cost	Eligibility Ratio %	Reimbursable Relocation Costs
1	Electric Distribution	N/A	OH	N/A	1000	LF	60.00	20	\$72,000.00	100	\$72,000.00
2	Gas	2	UG	wB&C	150	LF	90.00	16	\$15,660.00	100	\$15,660.00
3	Gas	24	UG	wB&C	550	LF	875.00	15	\$553,437.50	100	\$553,437.50
4	Gas	6	UG	wT/C	1000	LF	111.00	5	\$116,550.00	100	\$116,550.00
5	Waterline	10	UG	wT/C	500	LF	90.00	10	\$49,500.00	100	\$49,500.00
6	Waterline	36	UG	wB&C	550	LF	695.00	15	\$439,587.50	100	\$439,587.50
7	Waterline	8	UG	wT/C	550	LF	45.00	15	\$28,462.50	100	\$28,462.50

DATE of ESTIMATE: Wednesday, May 2, 2018

Total Relocation Estimate: \$1,275,197.50

Contingency (%): 50

Total Reimbursable Relocation Costs: \$1,912,796.25

Figure 4-1: Cost Estimate Report on the Utility Relocation Cost Estimation System

## 4.2 BACK-END OF THE SYSTEM

This section talks about the data logic and structure behind the Utility Relocation Cost Estimation System.

### 4.2.1 Entities, Attributes, Relationships, and ER Diagram

Entity relationship diagram (ERD) is a diagram that simultaneously illustrates entities, attributes, and relationships in the system. An individual rectangle represents an entity, which composes of two parts – an upper one and a lower one. The name of the entity

is displayed in the upper part of the rectangle, while attributes belonging to the entity are listed on the lower part. In each rectangle, there is a key symbol on the left side of one of the attributes. That marked attribute is the primary key of the entity, which works as an identifier for any given entity instance. As shown in Figure 4-2, a solid line expresses the relationship between two entities. There are three kinds of relationships in a relational database – one to one, one to many, and many to many.

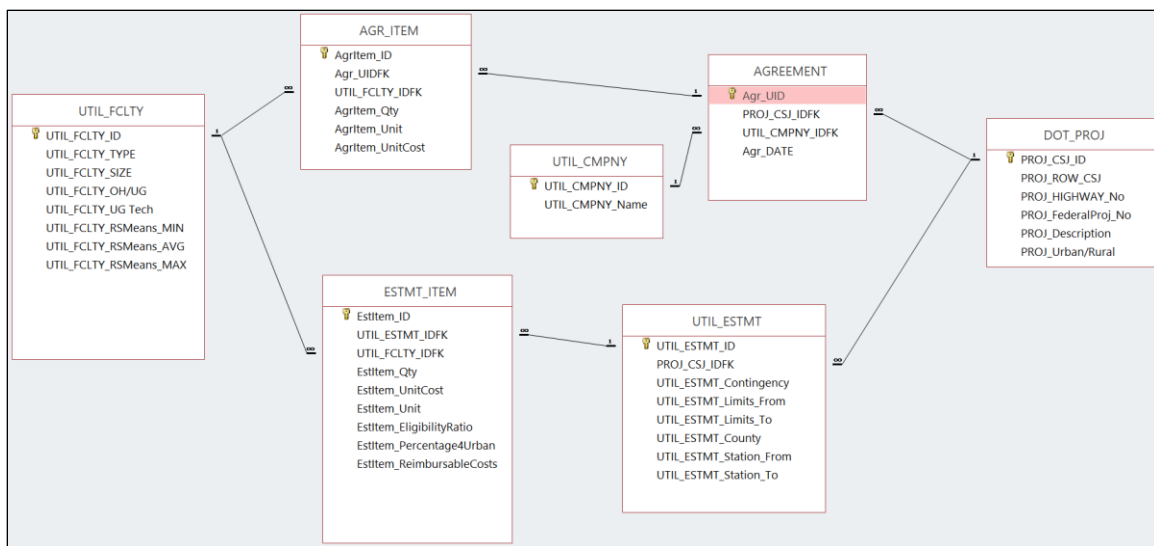


Figure 4-2: Entity Relationship Diagram for the Utility Relocation Cost Estimation System

#### 4.2.2 Tables: Representative of Entities

A table is a two-dimensional structure which consists of intersectional rows and columns. Tables are a basic data structure in the relational database management system. In a table, each row lists an entity instance; each column represents an attribute of the entity. Tables are connected to each other by sharing same attributes (Coronel & Morris,



2018). With tables, data stored in the database could not only be organized independently by entity classification but also be connected by common attributes. There are seven tables in the Utility Relocation Cost Estimation System. The following sections provide an overview of each form and its screenshots.

***Project Table***

*Project Table* stored data regarding highway projects. The Project CSJ No. is the primary key for this table. Except for the Project CSJ No., other attributes in the project table are ROW CSJ, Highway No., Federal Project No, Description, and Urban/Rural feature. The Project Table was connected to Agreement Table and Cost Estimate Table by the Project CSJ No. key.

PROJ_CSJ_ID	PROJ_ROW_CSJ	PROJ_HIGHWAY_I	PROJ_FederalProj	PROJ_Description	PROJ_Urban
0000-10-334	0000-11-337	IH 35	NA	None	Urban
0015-17-616	0015-17-617	SH 789	NA	Construct Grade Separation over NH 2017	Rural
0366-01-066	0366-01-069	SH 123	FM 3407	Construct Grade Separation over FM 3407	Urban
1058-07-168	1058-07-169	IH 35	NH 2017	Construct Grade Separation over NH 2017	Urban

Figure 4-3: Project Table in the Utility Relocation Cost Estimation System

***Company Table***

*Company Table* stored data regarding utility companies. An identity number will be automatically assigned to a new company at the first time it was created, which serves as the primary key for this table. Except for Company ID, another attribute in the Company Table is Company Name. The Company Table was connected to Agreement Table by the Company ID key.

UTIL_CMPNY_Name
1 Century Link
2 Grande Communications
3 Time Warner Cable
4 Bluebonnet Electric
5 City of Denison
6 Oncor Electric
7 Charter Facility
8 Atmos Energy
12 Center Point Energy
13 City of San Marcos
14 AT&T Austin

Figure 4-4: Company Table in the Utility Relocation Cost Estimation System

**Facility Table**

*Facility Table* stored data regarding utility facilities. An identity number will be automatically assigned to a new facility at the first time it was created, which serves as the primary key for this table. Except for the Facility ID, other attributes in the Facility Table are size, underground or overhead, underground technique, Minimum Unit Cost from Historical Data, Average Unit Cost from Historical Data, and Maximum Unit Cost from Historical Data. The Facility Table was connected to Agreement Item Table and Estimate Item Table by the Facility ID key.

FCLTY_ID	UTIL_FCLTY_TYPE	UTIL_FCLTY_SI	UTIL_FCLTY_U	UTIL_FCLTY_UG T	UTIL_FCLTY_RSMeans_MIN	UTIL_FCLTY_RSMeans_AVG	UTIL_FCLTY_RSM
0286 Waterline	8	UG	wB&C		\$167.00	\$180.00	\$193.00
0285 Waterline	8	UG	wT/C		\$58.00	\$71.00	\$83.00
0284 Waterline	6	UG	wB&C		\$133.00	\$143.00	\$152.00
0283 Waterline	6	UG	wT/C		\$43.00	\$53.00	\$62.00
0282 Waterline	4	UG	wB&C		\$108.00	\$116.00	\$124.00
0281 Waterline	4	UG	wT/C		\$38.00	\$46.00	\$54.00
0280 Gas	24	UG	wB&C		\$1,064.00	\$1,213.00	\$1,361.00
0279 Gas	24	UG	wT/C		\$648.00	\$797.00	\$945.00
0278 Gas	16	UG	wB&C		\$591.00	\$660.00	\$729.00
0277 Gas	16	UG	wT/C		\$304.00	\$372.00	\$442.00
0276 Gas	8	UG	wB&C		\$258.00	\$280.00	\$302.00

Figure 4-5: Facility Table in the Utility Relocation Cost Estimation System

### ***Agreement Table***

*Agreement Table* stored data regarding agreements between TxDOT and utility companies. The U Number is the primary key for this table. Except for the U Number, other attributes in the Agreement table are Project CSJ, utility Company ID, and Date information. The Agreement Table was connected to Project Table by Project CSJ, and connected to Company Table by Company ID. Besides, it also connected to Agreement Item Table by U Number.

Agr_UID	PROJ_CSJ_IDFK	UTIL_CMPNY	Agr_DATE
U_10007	0366-01-066	1	12/21/2008
U_10288	0000-10-334	13	12/20/2016
U_10306	1058-07-168	7	12/15/2016
U_10951	0000-10-334	2	12/5/2015
U_11075	0366-01-066	3	12/19/2014
U_11199	0015-17-616	3	12/18/2007
U_11467	0000-10-334	14	1/5/2017
U_11721	0015-17-616	5	12/7/2016
U_11727	0000-10-334	7	4/12/2015
U_11773	0366-01-066	6	1/18/2011

Figure 4-6: Agreement Table in the Utility Relocation Cost Estimation System

### ***Agreement Item Table***

*Agreement Item Table* stored facility items regarding a particular agreement between TxDOT and utility companies. An identity number will be automatically assigned to a new agreement item when it was created, which serves as the primary key for this table. Except for the Agreement Item ID, other attributes in the Agreement Item Table are agreement U Number, Facility ID, Agreement Quantity, Agreement Unit, and Agreement Unit Cost. The Agreement Item Table was connected to Agreement Table by U Number, and to Facility Table by Facility ID.

AgrItem_ID	Agr_UIDFK	UTIL_FCLTY_IDFK	AgrItem_Qty	AgrItem_Unit	AgrItem_UnitCost
AgrItem_00454	11835	0324	2952 LF		\$52.00
AgrItem_00438	11836	0304	50 LF		\$59.00
AgrItem_00448	11841	0320	4976 LF		\$87.00
AgrItem_00442	11906	0320	18638 LF		\$65.00
AgrItem_00435	12182	0290	220 LF		\$207.00
AgrItem_00443	12398	0320	13000 LF		\$62.00
AgrItem_00424	12557	0272	600 LF		\$254.00
AgrItem_00436	12574	0290	1044 LF		\$303.00
AgrItem_00446	12579	0320	1455 LF		\$29.00
AgrItem_00449	12579	0321	326 LF		\$46.00
AgrItem_00450	12579	0322	326 LF		\$341.00

Figure 4-7: Agreement Item Table in the Utility Relocation Cost Estimation System

***Estimate Table***

*Estimate Table* stored data regarding utility relocation cost estimates. An identity number will be automatically assigned to a new cost estimate when it was created, which serves as the primary key for this table. Except for the Estimate ID, other attributes in the Estimate Table are Project CSJ, Estimate Contingency, Estimate Limits From, Estimate Limits To, Estimate County, Estimate Station North From, and Estimate Station To. The Estimate Table was connected to Project Table by Project CSJ, and to Estimate Item Table by Estimate ID.

UTIL_ESTMT_ID	PROJ_CSJ_IDFK	UTIL_ESTMT_Contingency	UTIL_ESTMT_Limits_Fr	UTIL_ESTMT_Limits_To	UTIL_ESTMT	UTIL_ESTMT	UTIL_ESTMT
0006 0015-17-616			50 3,500' North of FM 3407	3,500' South of FM 3407	Hays	6500	11000
0008 0366-01-066			10 3,100' North of FM 3407	3,100' South of FM 3407	Hays	5500	11700
0015 0000-10-334			25 8,500' North of FM 3407	8,500' South of FM 3407	Travis	5500	11500
0046 0015-17-616			15 5,500' North of FM 3508	5,500' South of FM 3508	Travis	8500	11500

Figure 4-8: UTIL\_ESTMT Table in the Utility Relocation Cost Estimation System

***Estimate Item Table***

*Estimate Item Table* stored facility items regarding a particular cost estimate. An identity number will be automatically assigned to a new estimate item when it was created, which serves as the primary key for this table. Except for the Estimate Item ID, other attributes in the Estimate Item Table are Estimate ID, utility Facility ID, Estimate Quantity,

Estimate Unit, Estimate Unit Cost, Estimate Eligibility, and Estimate Percentage for Urban. The Estimate Item Table was connected to Estimate Table by Estimate ID, and to Facility Table by Facility ID.

EstItem_ID	UTIL_ESTMT_ID	UTIL_FCLTY_ID	EstItem_Qty	EstItem_UnitCost	EstItem_Unit	EstItem_Eligibility	EstItem_Percentage
EstItem_00298	0046	0328	600	\$30.00	LF	100	10
EstItem_00273	0015	0327	1500	\$70.00	LF	100	14
EstItem_00256	0008	0325	160	\$150.00	LF	100	15
EstItem_00264	0006	0320	1000	\$60.00	LF	100	20
EstItem_00254	0008	0320	190	\$60.00	LF	100	12
EstItem_00232	0008	0320	500	\$0.45	LF	100	14
EstItem_00227	0008	0306	1000	\$101.00	LF	100	10
EstItem_00299	0046	0303	400	\$50.00	LF	100	20
EstItem_00235	0006	0298	550	\$695.00	LF	100	15

Figure 4-9: ESTMT\_ITEM Table in the Utility Relocation Cost Estimation System

### 4.3 FRONT-END OF THE SYSTEM

Forms are employed to provide user interfaces (UI) which allows the end users work on the database more efficiently. There are eight major forms in the Utility Relocation Cost Estimation database. The following section demonstrates each form in detail.

#### 4.3.1 Forms: User Interfaces

##### *Main Menu Form*

*Main Menu* is the first interface that users interact with after opening the Utility Relocation Cost Estimation system, as shown in Figure 4-10. Main Menu screen is primarily a navigational form that makes it easy to switch to the options available. The options are: (1) Projects; (2) Companies; (3) Facilities; (4) Agreements; (5) Estimates; (6) Reports; and (7) Quit.

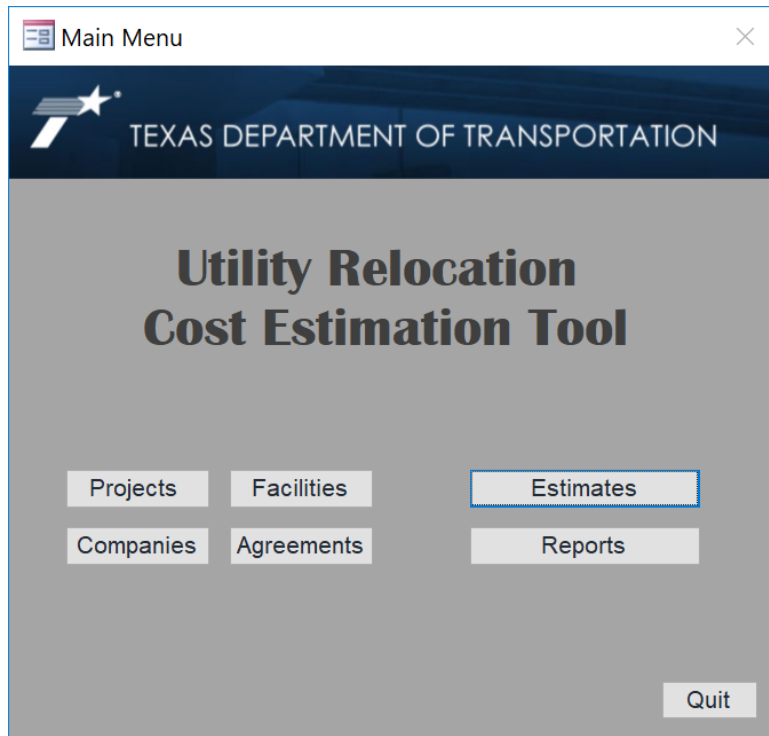


Figure 4-10: Main Menu

### ***Projects Form***

*Projects* form allows users to add, edit or delete data that defines the proposed highway project, as shown in Figure 4-11.

The screenshot shows a web application window titled "Projects" with the Texas Department of Transportation logo. The main content is a table with the following data:

CSJ	ROW CSJ	Highway No.	Federal No.	Urban/Rural	Project Description
0000-10-334	0000-11-337	IH 35	NA	Urban	None
0015-17-616	0015-17-617	SH 789	NA	Rural	Construct Grade Separation over NH 2017
0366-01-066	0366-01-069	SH 123	FM 3407	Urban	Construct Grade Separation over FM 3407
1058-07-168	1058-07-169	IH 35	NH 2017	Urban	Construct Grade Separation over NH 2017

Below the table is a form for adding or editing a project with the following fields:

- \*CSJ: 0366-01-066
- ROW CSJ: 0366-01-069
- Highway No.: SH 123
- Federal Project No.: FM 3407
- Urban/Rural: Urban (dropdown menu)
- Description: Construct Grade Separation over FM 3407

At the bottom of the form are four buttons: "New", "Delete", "Refresh", and "Main Menu".

Figure 4-11: Projects Form

The form is divided into two parts: (1) Project list box section and (2) Add/Edit/Delete section. The project list box section is on the top half of the form, which allows users to toggle between project information that is stored in the system. The fields of project information screen are explained below:

*CSJ* – a text box field where the Construction Section Job (CSJ) number of the project is entered.

*ROW CSJ* – a text box field where the Right-of-Way Construction Section Job number of the project is entered.

*Highway No.* – a text box field where the highway number of the project is entered.

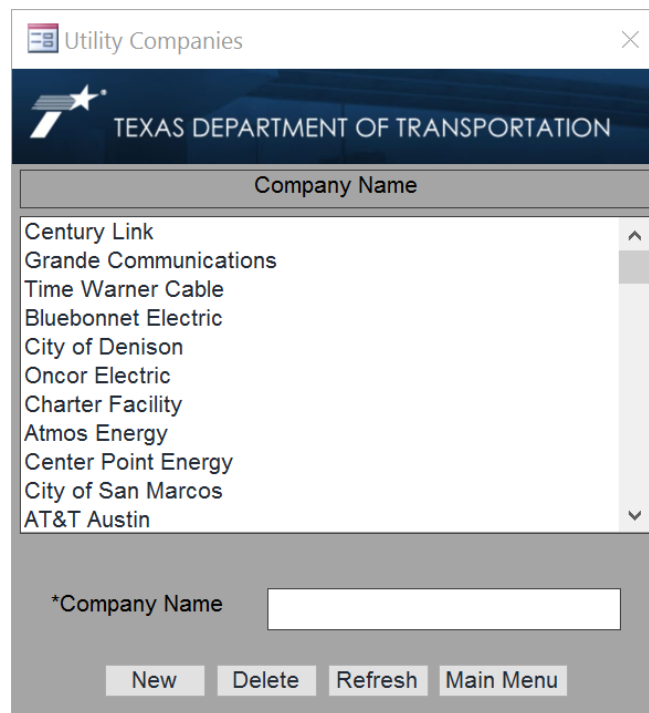
*Federal Project No.* – a text box field where the federal project number of the project is entered.

*Urban/Rural* – a text box field where the location the project is entered.

### ***Utility Companies Form***

*Utility Companies* form allows users to manage data regarding utility companies, as shown in Figure 4-12. The form is divided into two parts: (1) Company list box section and (2) Add/Edit/Delete section. The company list box section is on the top half of the form, which allows users to toggle between company information that is stored in the system. The fields of the utility companies screen are explained below:

*Company Name* – a textbox field where the utility company name is entered.



The screenshot shows a web application window titled "Utility Companies" with a close button (X) in the top right corner. Below the title bar is a dark blue header with the Texas Department of Transportation logo (a white star and a stylized road) and the text "TEXAS DEPARTMENT OF TRANSPORTATION". Underneath the header is a section titled "Company Name" containing a scrollable list of utility company names: Century Link, Grande Communications, Time Warner Cable, Bluebonnet Electric, City of Denison, Oncor Electric, Charter Facility, Atmos Energy, Center Point Energy, City of San Marcos, and AT&T Austin. Below the list is a text input field with the label "\*Company Name". At the bottom of the form are four buttons: "New", "Delete", "Refresh", and "Main Menu".

Figure 4-12: Utility Companies Form



## Facilities Form

Facilities form allows users to add, edit or delete data that relevant to the utility facility which will be relocated for the proposed highway project, as shown in Figure 4-13.

Type of Facilities	SIZE	OH/UG	UG Tech	Avg HIST. data	Min HIST. data	Max HIST. data
Gas	24	UG	wT/C	\$797.00	\$648.00	\$945.00
Gas	4	UG	wB&C	\$144.00	\$134.00	\$152.00
Gas	4	UG	wT/C	\$49.00	\$40.00	\$51.00
Gas	6	UG	wB&C	\$208.00	\$193.00	\$222.00
Gas	6	UG	wT/C	\$81.00	\$66.00	\$96.00
Gas	8	UG	wB&C	\$280.00	\$258.00	\$302.00
Gas	8	UG	wT/C	\$121.00	\$100.00	\$143.00
Telephone	N/A	OH	N/A	\$80.00	\$60.00	\$120.00
Wastewater	10	UG	wB&C	\$174.00	\$166.00	\$182.00
Wastewater	10	UG	wT/C	\$44.00	\$37.00	\$53.00
Wastewater	12	UG	wB&C	\$218.00	\$206.00	\$231.00

\*Type: Gas  
 \*Size: 6  
 \*OH/UG: UG  
 \*UG Tech: wT/C

HIST. data Unit Cost  
 Average: \$81.00  
 Min: \$66.00  
 Max: \$96.00

New Delete Refresh Main Menu

Figure 4-13: Facilities Form

The form is divided into two parts: (1) Facility list box section and (2) Add/Edit/Delete section. The facility list box section is the on top half of the form, which allows users to toggle between facility information that is stored in the system. The fields of facility information screen are explained below:

*Type of Facility* – a combo box field to add/edit the facility type.

*Size* – a combo box field to add/edit the facility size, if not applicable choose “N/A.”

*OH/UG* – a combo box field to add/edit overhead or underground status for the facility, if not applicable choose “N/A.”

*UG Tech* – a combo box field to add/edit the particular underground technology for the facility, if not applicable choose “N/A.”

*Average Unit Cost from Historical Data*– a text box field where the average unit cost of the facility recorded in historical data is entered.

*Min Unit Cost from Historical Data* – a text box field where the minimum unit cost of the facility recorded in historical data is entered.

*Max Unit Cost from Historical Data* – a text box field where the maximum of the facility unit cost recorded in historical data is entered.

### ***Agreements Form***

Agreements form allows users to add, edit or delete data that relevant to agreements between TxDOT and utility companies, as shown in Figure 4-14. The form is divided into two parts: (1) Agreement list box section and (2) Add/Edit/Delete section. The agreement list box section is on the top half of the form, which allows users to toggle between agreement information that is stored in the system. The fields of agreement information screen are explained below:

*U Number* – a textbox field where U/Permit number of an agreement is entered.

*Project CSJ* – a textbox field where the Construction Section Job (CSJ) number of the project is entered. (Note: A Project CSJ number should be entered in Projects form before using for an agreement in Agreement form.)

*Company ID* – a combo box field displaying both company ID and its name to help users to select a particular utility company engaged in an agreement.

*Date* – a text box field to add/edit the date when the selected agreement was signed.

The screenshot shows a web application window titled 'Agreements' with the Texas Department of Transportation logo. It contains a table of agreement records and a form for editing a selected record.

U Number	Project CSJ	Company Name	Date
U_00013	0015-17-616	AT&T Austin	2/13/2013
U_00111	0366-01-066	Bluebonnet Electric	12/6/2016
U_03755	0000-10-334	Grande Communications	1/24/2017
U_10007	0366-01-066	Century Link	12/21/2008
U_10288	0000-10-334	City of San Marcos	12/20/2016
U_10306	1058-07-168	Charter Facility	12/15/2016
U_10951	0000-10-334	Grande Communications	12/5/2015
U_11075	0366-01-066	Time Warner Cable	12/19/2014
U_11199	0015-17-616	Time Warner Cable	12/18/2007
U_11467	0000-10-334	AT&T Austin	1/5/2017
U_11721	0015-17-616	City of Denison	12/7/2016

The form below the table is for editing the selected item (U\_10007):

- \*U Number: 10007
- \*Project CSJ: 0366-01-066
- \*Company ID: 1 (Century Link)
- Date: 12/21/2008

Buttons at the bottom include: New, Delete, Refresh, Main Menu, and Item Details.

Figure 4-14: Agreements Form

### ***Agreement Details Form***

*Agreement Details* form allows users to add, edit or delete data that relevant to agreement items involved in a particular agreement, as shown in Figure 4-15. To view agreement detail information, users firstly select a particular agreement listed on the top part in Agreement form and then click on the “Item Details” command on Agreements form. The form is divided into two parts: (1) Agreement Items section and (2) Facility Looking Up section. The agreement items section is on the top half of the form, which allows users to add or edit agreement items. The fields of agreement item are explained below:

*U Number* – a combo box field where U/Permit number of an agreement is selected.

*Facility No.* – a combo box field where the facility number is selected. (Note: This number could be looked up by successively selecting facility Type, Size, OH/UG, and UG Tech on the bottom part of this form.)

*Qty* – a text box field where the quantity of the agreement item is entered.

*Unit* – a text box field where the unit of the agreement item is entered.

*Unit Cost* – a text box field where the unit cost of the agreement item is entered.

Agreement Details

TEXAS DEPARTMENT OF TRANSPORTATION

U Number	Facility No.	Type of Facility	Size	OH/UG	UG Tech	Qty	Unit	Unit Cost
10306	0289	Waterline	12	UG	wT/C	130	LF	\$279.00
10306	0291	Waterline	16	UG	wT/C	130	LF	\$393.00

\*U Number: 10306 Qty: 130

\*Facility No.: FCLTY\_0289 Unit: LF

Unit Cost: \$279.00

New Delete Refresh Main Menu

Look up Facility No.

ID	Type of Facilities	SIZE	OH/UG	UG Tech
[Empty Search Row]				

Refresh

Type: [Dropdown] OH/UG: [Dropdown]

Size: N/A UG Tech: N/A

Facility No.: [Text Box]

Figure 4-15: Agreement Details Form

## Cost Estimates Form

*Cost Estimates* form allows users to add, edit or delete data that relevant to cost estimates generated by a particular utility relocation, as shown in Figure 4-16.

CSJ	Contingency	Limits From	Limits To	County	Station From	Station To
0015-17-616	50	3,500' North of FM 3407	3,500' South of FM 3407	Hays	65+00	110+00
0366-01-066	10	3,100' North of FM 3407	3,100' South of FM 3407	Hays	55+00	117+00
0000-10-334	25	8,500' North of FM 3407	8,500' South of FM 3407	Travis	55+00	115+00
0000-10-334	20	5,500' North of FM 3508	5,500' South of FM 3508	Travis	65+00	110+00
0015-17-616	15	5,500' North of FM 3508	5,500' South of FM 3508	Travis	85+00	115+00

\*Project CSJ: 0366-01-066    \*Contingency: 10    Station From: 55+00  
 Limits From: 3,100' North of FM 3407    County: Hays    Station To: 117+00  
 Limits To: 3,100' South of FM 3407    [Item Details](#)

New   Delete   Refresh   Main Menu

Figure 4-16: Cost Estimates Form

The form is divided into two parts: (1) Cost Estimate list box section and (2) Add/Edit/Delete section. The cost estimate list box section is on the top half of the form, which allows users to toggle between cost estimate information that is stored in the system. The fields of cost estimate information screen are explained below:

*Project CSJ* – a text box field where the Construction Section Job (CSJ) number of the project is entered. (Note: A Project CSJ number should be entered in Projects form before using for a cost estimate in Cost Estimate form.)

*Limits From* – a text box field where the limits beginning is entered.

*Limits To* – a text box field where the limits ending is entered.

*Contingency* – a text box field where the contingency of the cost estimate is entered.

*County* – a text box field where the located county name is entered.

*Station From* – a text box field where the station beginning is entered.

*Station To* – a text box field where the station ending is entered.

### ***Estimate Details Form***

*Estimate Details* form allows users to add, edit or delete data that relevant to estimate items involved in a particular cost estimate, as shown in Figure 4-17. To view estimate detail information, users first select a particular cost estimate listed on the top part in Cost Estimates form and then click on the “Item Details” command on Cost Estimates form. The form is divided into two parts: (1) Estimate Items section and (2) Facility Looking Up section. The estimate items section is on the top half of the form, which allows users to add or edit estimate items. The estimate items list box allows users to toggle between estimate items that are stored in the system. The bottom facility looking up section is used to look up the facility number and unit cost information for a particular estimate item. The fields of agreement item are explained below:

*Estimate No.* – a combo box field where the number of the estimate which contains the item is selected.

*Facility No.* – a combo box field where the facility number is selected. (Note: This number could be looked up by successively selecting facility Type, Size, OH/UG, and UG Tech in the bottom part of this form.)

*Estimate Qty* – a text box field where the quantity of the estimated item is entered.


*Estimate Unit* – a text box field where the unit of the estimated item is entered.

*Estimate Unit Cost* – a text box field where the unit cost of the estimated item is entered.

*Eligibility Ratio* – a text box field where the eligibility ratio of the estimated item is entered.

*Percentage for Urban* – a text box field where the percentage for adjustment cost estimate in an urban area is entered.

Cost Estimate Details
✕



**TEXAS DEPARTMENT OF TRANSPORTATION**

Est. No.		Facility No.				Estimate Information				
Est. No.	Fac. No.	Type of Facility	Size	OH/UG	UG Tech	Qty	Unit	Unit Cost	Eligibility %	Urban %
0006	0273	Gas	6	UG	wT/C	1000	LF	\$111.00	100	5
0006	0287	Waterline	10	UG	wT/C	500	LF	\$90.00	100	10
0006	0298	Waterline	36	UG	wB&C	550	LF	\$695.00	100	15
0006	0285	Waterline	8	UG	wT/C	550	LF	\$45.00	100	15
0006	0280	Gas	24	UG	wB&C	550	LF	\$875.00	100	15
0006	0270	Gas	2	UG	wB&C	150	LF	\$90.00	100	16
0006	0320	Electric Distribution	N/A	OH	N/A	1000	LF	\$60.00	100	20

\*Estimate No.  \*Estimate Qty  Eligibility Ratio (%)

\*Facility No.  Estimate Unit  Percentage for Urban (%)

Estimate Unit Cost

---

**Look up Facility No.**

Type of Facilities	SIZE	OH/UG	UG Tech	Avg HIST. data	Min HIST. data	Max HIST. data	Agreement Cost
							<input type="button" value="Refresh"/>

Type  OH/UG

Size  UG Tech

Facility No.

Figure 4-17: Estimate Details Form

## Reports Form

*Reports* form provides an interface for users to choose a report for a particular cost estimate, as shown in Figure 4-18. The form is divided into two parts: (1) Cost Estimate list box section and (2) Navigation section. The cost estimate list box section is on the top half of the form, which allows users to select a report for a particular cost estimate. The bottom half of the screen is navigation section. The textbox shows the selected cost estimate number for which the report will be generated.

Est. No.	CSJ	Contingency	Limits From	Limits To	County	Station From	Station To
ESTMT_0006	123417116	50	3,500' North of FM 3407	3,500' South of FM 3407	Hays	6500	11000
ESTMT_0007	220154612	8	2,500' North of FM 1460	2,500' South of FM 1460	Travis	8500	11500
ESTMT_0008	222211123	10	3,100' North of FM 3407	3,100' South of FM 3407	Hays	5500	11700
ESTMT_0010	234512356	20	4,500' North of FM 5623	4,500' South of FM 5623	Travis	4500	11000
ESTMT_0011	123417116	15	3,700' North of FM 3407	3,700' South of FM 3407	Guadalupe	3500	11000
ESTMT_0012	112057236	50	1,500' North of FM 4509	1,500' South of FM 4509	Guadalupe	8500	11500
ESTMT_0013	112078002	0	3,500' North of FM 3407	3,500' South of FM 3407	Travis	6500	11500
ESTMT_0014	112078003	0	7,500' North of FM 3850	7,500' South of FM 3850	Guadalupe	7500	11000
ESTMT_0015	112078004	25	8,500' North of FM 3407	8,500' South of FM 3407	Travis	5500	11500
ESTMT_0016	110378005	1	1,500' North of FM 3407	1,500' South of FM 3407	Guadalupe	6500	11000
ESTMT_0017	110378006	0	3,500' North of FM 3407	3,500' South of FM 3407	Travis	4500	10000

Report for  based on estimate unit cost entered by users


Figure 4-18: Reports Form

### 4.3.2 Reports: Organized Outputs

The Estimate Reports was designed to display all the information related to a cost estimate in a well-organized way, as shown in Figure 4-19. The upper part of the report lists the transportation project information – CSJ, ROW CSJ, County, Length, Limits, and Stations. The lower part of the report lists cost estimation information in detail. Each row in the lower part is a specific cost estimate item, for which the facility information and cost estimation information was displayed. Regarding facility property information, the type,



size, OH/UG, and UG Tech were listed. Likewise, the Quantity, Unit, Unit Cost, Percentage for Urban, Estimated Relocation Cost, Eligibility Ratio, and Reimbursable Relocation Costs were estimation relevant information. Finally, the sum of all estimations – Total Reimbursable Relocation Costs – was shown on the bottom part of the report. Besides, the structure of the cost estimate report comes from a normal cost estimation spreadsheet received from TxDOT, as shown in Figure 4-20.



### Utility Relocation Cost Estimate

#### SH 789

#### Construct Grade Separation over NH 2017

CCSJ: 0015-17-616      ROW CSJ: 0015-17-617      Count    Hays      Length: 4500    ft    0.8523    mi

LIMITS FROM: 3,500' North of FM 3407      TO: 3,500' South of FM 3407      Station #'s From 65+00      To: 110+00

Item	Type of Facilities	Size	OH/UG	UG Tech	Qty	Unit	Unit Cost	Percentage for Urban %	Estimated Relocation Cost	Eligibility Ratio %	Reimbursable Relocation Costs
1	Electric Distribution	N/A	OH	N/A	1000	LF	60.00	20	\$72,000.00	100	\$72,000.00
2	Gas	2	UG	wB&C	150	LF	90.00	16	\$15,660.00	100	\$15,660.00
3	Gas	24	UG	wB&C	550	LF	875.00	15	\$553,437.50	100	\$553,437.50
4	Gas	6	UG	wT/C	1000	LF	111.00	5	\$116,550.00	100	\$116,550.00
5	Waterline	10	UG	wT/C	500	LF	90.00	10	\$49,500.00	100	\$49,500.00
6	Waterline	36	UG	wB&C	550	LF	695.00	15	\$439,587.50	100	\$439,587.50
7	Waterline	8	UG	wT/C	550	LF	45.00	15	\$28,462.50	100	\$28,462.50

DATE of ESTIMATE: Wednesday, May 2, 2018

Total Relocation Estimate: \$1,275,197.50

Contingency (%): 50

Total Reimbursable Relocation Costs: \$1,912,796.25

Figure 4-19: Estimate Reports

Utility Relocation Cost Estimate																				
SH 123																				
Construct Grade Separation over FM 3407																				
CCSJ:		0366-01-066		ROW CSJ:		0366-01-069		County:		Hays		Length:		6,200' 1.174 Miles						
LIMITS FROM: 3,100' North of FM 3407				To: 3,100' South of FM 3407				Station #'s:				55+00 to 117+00								
Facility Type	Item	Utility Owner	Type of Facilities	Size	Lateral / Crossing	Start Direction	Ending Direction	Qty	Unit Cost	Estimated Relocation Cost	Eligibility Ratio	Non-Reimbursable Relocation Costs	Non-Reimbursable w/Contingency (by Company)	Reimbursable Relocation Costs	Total Reimbursable w/Contingency (by Company)					
10	1	Century Link	Telephone (OH)	DH	Crossing	62+00	to 62+00	450	\$50	\$27,000	0%	\$27,000		\$0	\$0					
9	2	Century Link	Telephone (OH)	DH	Lateral	85+00	to 114+00	RT	2,900	\$60	\$174,000	0%	\$174,000		\$0					
14	3	Century Link	UG Communications w/B&C	24"	Crossing	84+00	to 84+00	450	\$400	\$180,000	0%	\$180,000		\$0	\$0					
13	4	Century Link	UG Communications	24"	Lateral	61+00	to 114+00	RT	5,300	\$200	\$1,060,000	0%	\$1,060,000	\$1,595,100	\$0					
2	5	Grande Communications	Communications (OH)	DH	Crossing	85+00	to 85+00	450	\$50	\$22,500	0%	\$22,500		\$0	\$0					
1	6	Grande Communications	Communications (OH)	DH	Lateral	86+00	to 114+00	RT	2,800	\$50	\$140,000	0%	\$140,000	\$178,750	\$0					
6	7	Time Warner Cable	Communications (OH)	DH	Crossing	85+00	to 85+00	450	\$50	\$27,000	0%	\$27,000		\$0	\$0					
5	8	Time Warner Cable	Communications (OH)	DH	Lateral	86+00	to 114+00	RT	2,800	\$50	\$168,000	0%	\$168,000	\$214,500	\$0					
24	9	Bluebonnet Electric	Electric Distribution (OH)	DH	Crossing	64+00	to 64+00	450	\$50	\$27,000	0%	\$27,000		\$0	\$0					
24	10	Bluebonnet Electric	Electric Distribution (OH)	DH	Crossing	85+00	to 85+00	450	\$50	\$27,000	0%	\$27,000		\$0	\$0					
23	10	Bluebonnet Electric	Electric Distribution (OH)	DH	Lateral	86+00	to 114+00	RT	2,800	\$50	\$168,000	0%	\$168,000		\$0					
24	11	Bluebonnet Electric	Electric Distribution (OH)	DH	Crossing	87+00	to 87+00	450	\$50	\$27,000	0%	\$27,000	\$458,700	\$0	\$0					
36	12	Center Point Energy	Gas w/B&C	4"	Crossing	87+00	to 87+00	450	\$175	\$78,750	0%	\$78,750		\$0	\$0					
55	13	City of San Marcos	Water	12"	Lateral	85+00	to 114+00	RT	2,900	\$150	\$435,000	100%	\$0	\$435,000	\$0					
55	14	City of San Marcos	Water	12"	Lateral	96+00	to 105+00	W/W	900	\$150	\$135,000	0%	\$135,000		\$0					
56	14	City of San Marcos	Water w/B&C	12"	Crossing	85+00	to 85+00	450	\$200	\$90,000	10%	\$81,000	\$237,600	\$9,000	\$488,400					
67	15	City of San Marcos	Force Main	20"	Lateral	62+00	to 114+00	RT	5,200	\$200	\$1,040,000	100%	\$0	\$0	\$1,040,000	\$1,144,000				
DATE of ESTIMATE August 14, 2013									Total for All Relocations		Non-Reimbursable Relocation Costs		Non-Reimbursable w/Contingency (by Company)		Reimbursable Relocation Costs		Total Reimbursable w/Contingency (by Company)			
Notes & Assumptions:									Section Estimate		\$3,826,250		\$2,342,250		\$1,484,000					
1 Does not include Easement Costs									Contingency 10%		\$382,625		\$234,225		\$148,400					
2 Estimates from SUE files.																				
3 Project is non-reimbursable.									Total Section Relocation Estimate		\$4,208,875		\$2,576,475		\$2,674,650		\$1,632,400		\$1,632,400	

Figure 4-20: Utility Relocation Cost Estimation spreadsheet from TxDOT

## **CHAPTER 5      Implementation of the Utility Relocation Cost Estimation System**

The implementation of the Utility Relocation Cost Estimation system has been executed since the development phase. Several rounds of testing and debugging were carried out to test the validity and usability of the system. During the development phase, the first test was implemented with test data served as placeholders to test the validity of the system. For example, whether the designed queries can come out with expected results, if not the incompetent query was modified and tested again.

Right after the completion of all functions in database development, real data derived from utility agreements, such as facility information and cost information, were adopted to carry out the second round of testing. In fact, the impacts of this process were significant. For one thing, the validity of the database was confirmed with these test data. For another, these data were stored in the database to work as historical records for future cost estimation.

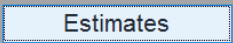
Furthermore, when the second-round test was done, the system was handed over to TxDOT personnel to get the third-round on-site test. Later, feedback on the system from TxDOT was collected. With the feedback, the research team updated database to accommodate new user needs. Finally, the updated version was submitted to TxDOT. This chapter mainly illustrates the typical procedure to create a cost estimate with the Utility Relocation Cost Estimation system. In addition to that, some useful functions such as facility lookup function and agreement lookup function were also discussed in detail.

This chapter focuses primarily on the essential workflow of the cost estimation system. Thus, the test case introduced in this section is under an assumption that all the data needed to generate a cost estimate were already saved in the system. A lot of work regarding data preparation were omitted from this chapter. For example, before creating a

cost estimate, a project entry should be built in advance. An effective cost estimate needs a project CSJ number to be one of its attributes. Similarly, an estimate item needs Add/Edit/Delete to input a particular facility number. Therefore, a record of that particular facility should be stored in the system before applying it to an estimated item. Meanwhile, all the relevant utility agreements should be entered in advance for deriving an average cost form them. With all the data needed fully prepared, a new cost estimate could be easily created by following the steps described in the next section of this chapter.

### 5.1 CREATE A NEW COST ESTIMATE

Forms are employed to provide user interfaces (UI) which allows the end users work on the database more efficiently. There are eight major forms in the Utility Relocation Cost Estimation database system. The following section demonstrates each form in detail.

Step 1. Open Cost Estimates form by clicking on  command on Main Menu screen.

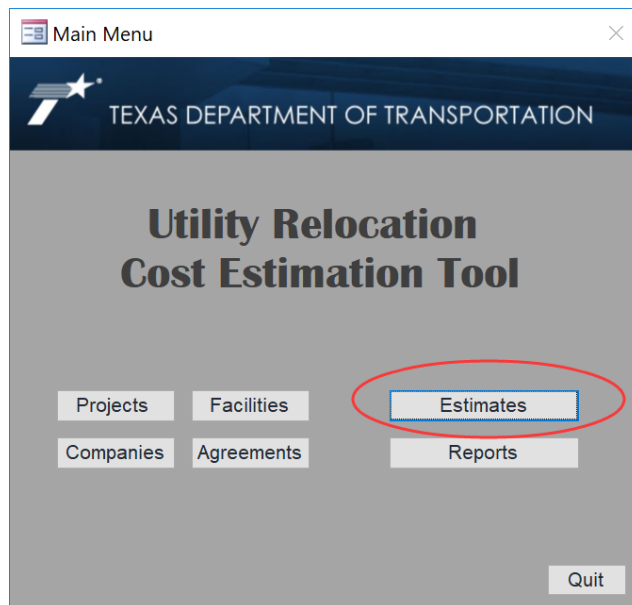


Figure 5-1: Open Cost Estimates Form

Step 2. Click on **New** command and enter cost estimate information using textbox fields.

The screenshot shows the 'Cost Estimates' application window. At the top, there is a header for the Texas Department of Transportation. Below the header is a table with the following data:

CSJ	Contingency	Limits From	Limits To	County	Station From	Station To
0015-17-616	50	3,500' North of FM 3407	3,500' South of FM 3407	Hays	65+00	110+00
0366-01-066	10	3,100' North of FM 3407	3,100' South of FM 3407	Hays	55+00	117+00
0000-10-334	25	8,500' North of FM 3407	8,500' South of FM 3407	Travis	55+00	115+00
0000-10-334	20	5,500' North of FM 3508	5,500' South of FM 3508	Travis	65+00	110+00
0015-17-616	15	5,500' North of FM 3508	5,500' South of FM 3508	Travis	85+00	115+00

Below the table is a form for adding a new entry. The form includes the following fields:

- \*Project CSJ:
- \*Contingency:
- Station From:
- Limits From:
- County:
- Station To:
- Limits To:

At the bottom of the form, there are buttons for 'New', 'Delete', 'Refresh', and 'Main Menu'. The 'New' button is circled in red.

Figure 5-2: Add a Cost Estimate Entry

Step 3. Complete all the data entry on the bottom part of the form.

The screenshot shows the 'Cost Estimates' application window with the same table as in Figure 5-2. The form fields are now filled out, and a red box highlights the form area. The form fields are:

- \*Project CSJ:
- \*Contingency:
- Station From:
- Limits From:
- County:
- Station To:
- Limits To:

At the bottom of the form, there are buttons for 'New', 'Delete', 'Refresh', and 'Main Menu'.

Figure 5-3: Input Cost Estimate Information

Step 4. Click on **Refresh** command to save and display the new cost estimate on the list box.

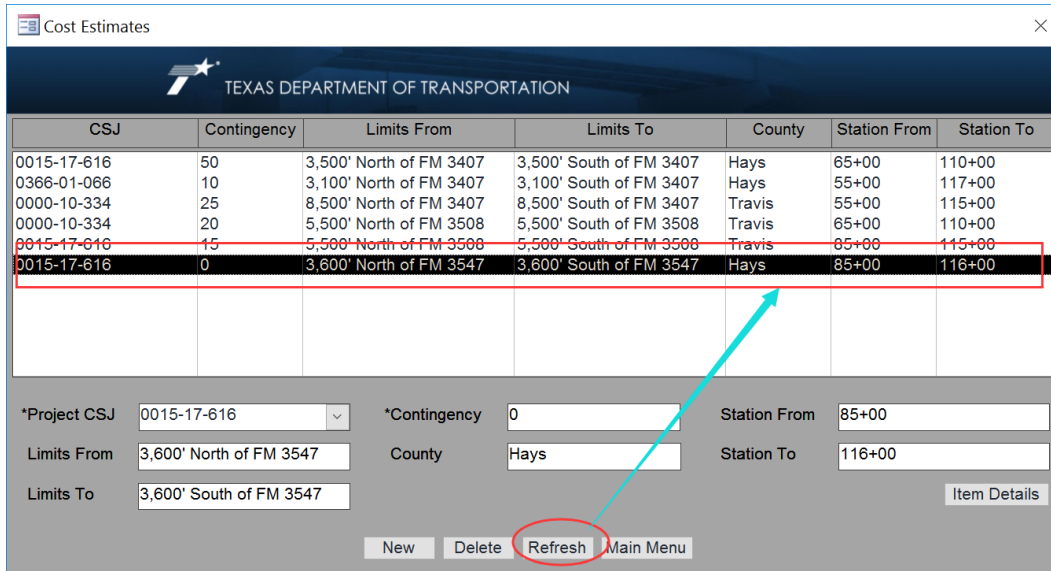


Figure 5-4: Display the new Cost Estimate Entry

Step 5. Select the new cost estimate and click on **Item Details** command to open Estimate Details form.

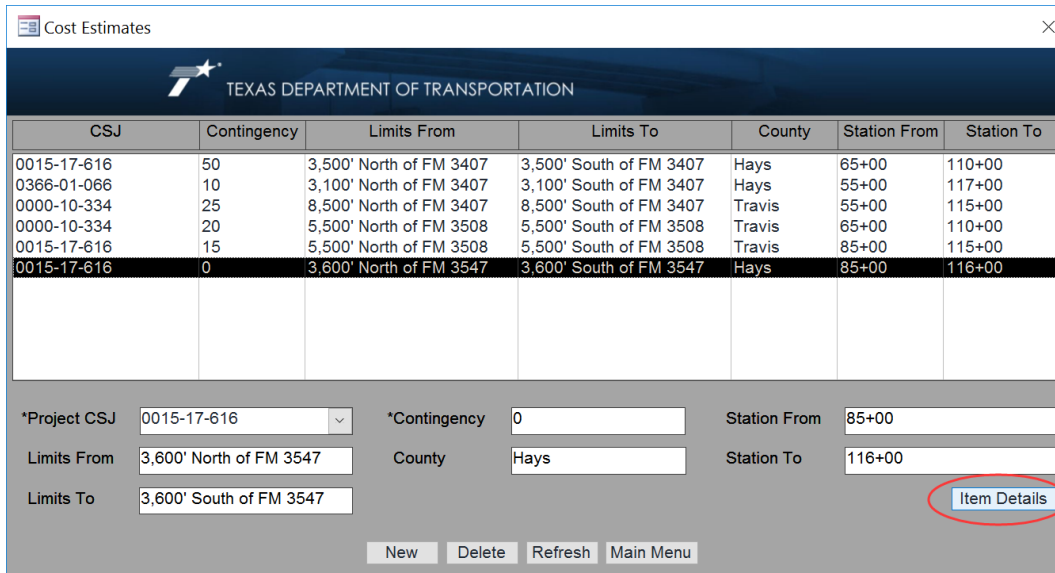


Figure 5-5: Open the Estimate Details Form

Step 6. Click on the **New** command and enter estimate item information using textbox fields.

The screenshot shows a web application window titled "Cost Estimate Details" with the Texas Department of Transportation logo. The form is divided into several sections:

- Table Header:** A table with columns for Est. No., Facility No., and Estimate Information. The Estimate Information sub-header includes Qty, Unit, Unit Cost, Eligibility %, and Urban %.
- Form Fields:**
  - \*Estimate No.: ESTMT\_0046 (dropdown)
  - \*Estimate Qty.: 1 (dropdown)
  - Eligibility Ratio (%): 100 (text input)
  - \*Facility No.: FCLTY\_0000 (dropdown) with a "Look up Qty" button.
  - Percentage for Urban (%): 0 (text input)
  - Est. Unit: LF (text input)
  - Est. Unit Cost: \$0.00 (text input)
- Buttons:** "Get Qty", "New" (circled in red), "Delete", "Refresh", "Main Menu", and "Agreements".
- Look up Facility No. Section:** A table with columns: Type of Facilities, SIZE, OH/UG, UG Tech, Avg HIST. data, Min HIST. data, Max HIST. data, and Agreement Cost. Below this table is a "Refresh" button.
- Additional Fields:**
  - Type: (dropdown)
  - OH/UG: (dropdown)
  - Size: N/A (dropdown)
  - UG Tech: N/A (dropdown)
  - Facility No.: (text input)

Figure 5-6: Add an Estimate Item in the Estimate Details Form

Step 7. Looking up Facility No. with the bottom half part of the form. Specifically, selecting Type, Size, OH/UG, and UG Tech one by one, and the Facility No. will be queried and displayed in the bottom text box automatically.

The screenshot shows a web application window titled "Cost Estimate Details" with the Texas Department of Transportation logo. The main content area is divided into several sections:

- Table Header:** A table with columns for Est. No., Facility No., and Estimate Information (Qty, Unit, Unit Cost, Eligibility %, Urban %).
- Form Fields:**
  - \*Estimate No. (dropdown: ESTMT\_0046)
  - \*Estimate Qty. (dropdown: 1)
  - Eligibility Ratio (%) (input: 100)
  - \*Facility No. (dropdown: FCLTY\_0000) with a "Look up Qty" button
  - Percentage for Urban (%) (input: 0)
  - Est. Unit (input: LF)
  - Est. Unit Cost (input: \$0.00)
  - "Get Qty" button
- Navigation:** "New", "Delete", "Refresh", "Main Menu", and "Agreements" buttons.
- Look up Facility No. Section (highlighted in red):**
  - Table with columns: Type of Facilities, SIZE, OH/UG, UG Tech, Avg HIST. data, Min HIST. data, Max HIST. data, Agreement Cost.
  - "Refresh" button
  - Type (dropdown)
  - OH/UG (dropdown)
  - Size (dropdown: N/A)
  - UG Tech (dropdown: N/A)
  - Facility No. (input field)

Figure 5-7: Look up Facility Number



Step 8. Selecting Facility No. with the drop-down box on the top part of the form.

**Cost Estimate Details**

TEXAS DEPARTMENT OF TRANSPORTATION

Est. No.		Facility No.				Estimate Information				
Est. No.	Fac. No.	Type of Facility	Size	OH/UG	UG Tech	Qty	Unit	Unit Cost	Eligibility %	Urban %

\*Estimate No. ESTMT\_0046 \*Estimate Qty. 1 Eligibility Ratio (%) 100

\*Facility No. **FCLTY\_0000** Look up Qty Percentage for Urban (%) 0

Est. Unit 0284 Est. Unit Cost \$0.00

Get Qty

New Delete Refresh Main Menu Agreements

**Look up Facility No.**

Type of Facilities	SIZE	OH/UG	UG Tech	Avg HIST. data	Min HIST. data	Max HIST. data	Agreement Cost

Refresh

Type Waterline OH/UG UG

Size 6 UG Tech WB&C

Facility No. 284

Figure 5-8: Select Facility Number

Step 9. To verify facility information, please click on **Refresh** command between the list and the combo boxes on the bottom part.

The screenshot shows a web application window titled "Cost Estimate Details" with the Texas Department of Transportation logo. The main area contains a table with columns for Est. No., Facility No., and Estimate Information. Below the table are input fields for Estimate No. (ESTMT\_0046), Estimate Qty. (1), Eligibility Ratio (%) (100), Facility No. (FCLTY\_0284), Est. Unit (LF), and Est. Unit Cost (\$0.00). A "Look up Qty" button is next to the Facility No. field. At the bottom, there are buttons for "New", "Delete", "Refresh", "Main Menu", and "Agreements".

Below the main form is a section titled "Look up Facility No." containing a table with the following data:

Type of Facilities	SIZE	OH/UG	UG Tech	Avg HIST. data	Min HIST. data	Max HIST. data	Agreement Cost
Waterline	6	UG	wB&C	\$143.00	\$133.00	\$152.00	104

Below the table are input fields for Type (Waterline), OH/UG (UG), Size (6), UG Tech (wB&C), and Facility No. (284). A "Refresh" button is located below the table.

Figure 5-9: Display Information for the selected Facility

Step 10. After completing estimate Qty, Unit, and Unit Cost, click on **Refresh** command to save the estimated item in the system. Meanwhile, the new estimate item appears on the list box.

**Cost Estimate Details**

TEXAS DEPARTMENT OF TRANSPORTATION

Est. No.		Facility No.				Estimate Information				
Est. No.	Fac. No.	Type of Facility	Size	OH/UG	UG Tech	Qty	Unit	Unit Cost	Eligibility %	Urban %
0046	0284	Waterline	6	UG	wB&C	1	LF	\$0.00	100	0

\*Estimate No. ESTMT\_0046    \*Estimate Qty. 1    Eligibility Ratio (%) 100

\*Facility No. FCLTY\_0284    Look up Qty    Percentage for Urban (%) 0

Est. Unit LF    Est. Unit Cost \$0.00

Get Qty

New    Delete    **Refresh**    Main Menu    Agreements

**Look up Facility No.**

Type of Facilities	SIZE	OH/UG	UG Tech	Avg HIST. data	Min HIST. data	Max HIST. data	Agreement Cost
Waterline	6	UG	wB&C	\$143.00	\$133.00	\$152.00	104

Refresh

Type Waterline    OH/UG UG

Size 6    UG Tech wB&C

Facility No. 284

Figure 5-10: Display the new Estimate Item

Step 11. After all the estimate items are added, go back to Main Menu and open Reports to view the final cost estimate results.

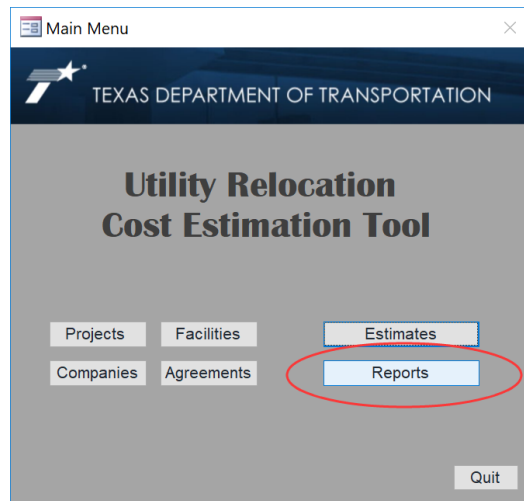


Figure 5-11: Open Reports Form

Step 12. Clicking on **Report** command to open the report for the selected cost estimate.

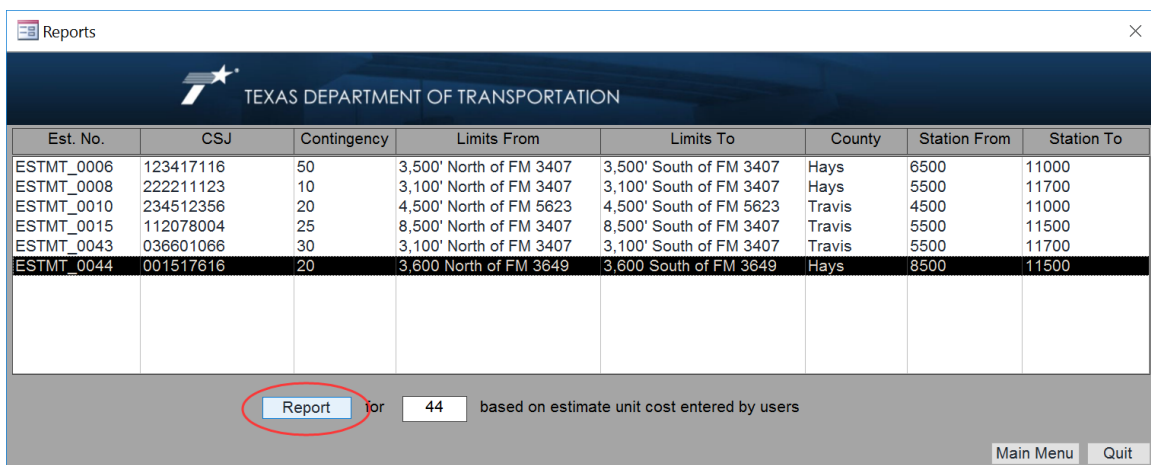



Figure 5-12: Open a Cost Estimate Report for the selected Estimate Entry



## Utility Relocation Cost Estimate

**IH 35**  
**None**

CCSJ: 0000-10-334      ROW CSJ: 0000-11-337      Count    Travis      Length: 6000 ft    1.1364 mi

LIMITS FROM: 8,500' North of FM 3407    TO: 8,500' South of FM 3407      Station #'s From 55+00    To: 115+00

Item	Type of Facilities	Size	OH/UG	UG Tech	Qty	Unit	Unit Cost	Percentage for Urban %	Estimated Relocation Cost	Eligibility Ratio %	Reimbursable Relocation Costs
1	Communication	Large	UG	wB&C	1500	LF	70.00	14	\$119,700.00	100	\$119,700.00
2	Gas	4	UG	wB&C	200	LF	260.00	20	\$62,400.00	100	\$62,400.00
3	Gas	8	UG	wB&C	1000	LF	420.00	10	\$462,000.00	100	\$462,000.00
4	Waterline	30	UG	wB&C	1200	LF	500.00	15	\$690,000.00	100	\$690,000.00
5	Waterline	6	UG	wB&C	100	LF	70.00	10	\$7,700.00	100	\$7,700.00

DATE of ESTIMATE:       Total Relocation Estimate:      

Contingency (%)   
Total Reimbursable Relocation Costs

Figure 5-13: Utility Relocation Cost Estimation Report

## 5.2 ADDITIONAL FUNCTIONS

There are several additional functions in the Utility Relocation Cost Estimation system to provide looking up services for end users.

### 5.2.1 Facility Looking Up Function

The Facility Looking Up Function is designed to help users find the Facility ID which is a prerequisite for creating an agreement item or a cost estimate item. The Facility Looking Up Function was integrated into both the Agreement Item table and the Estimate Item table. The following steps illustrate how to use the Facility Looking Up Function in the Estimate Item table. The Facility No. looking up module was located on the bottom

section in the Estimate Item form. After successively selecting Type, Size, OH/UG, and UG Tech, the Facility No. will be displayed automatically.

The screenshot shows the 'Cost Estimate Details' window for the Texas Department of Transportation. It features a header with the department logo and name. Below the header is a table with columns for Est. No., Station No. and Direction, and Estimate Information. The main area contains several input fields for Estimate No., Station Start, Station Ending, Station Direction, Estimate Unit, Estimate Unit Cost, Eligibility Ratio (%), and Percentage for Urban (%). A 'Look up Facility No.' section is highlighted with a red oval, containing a table with columns for ID, Type of Facilities, SIZE, OH/UG, UG Tech, RS Means Avg, RS Means Min, RS Means Max, and Agreement Unit Cost. Below the table are dropdown menus for Type, OH/UG, Size, and UG Tech, and a text field for Facility No. The table shows one result for FCLTY\_0064, which is a Communication facility with a size of 4, OH/UG of UG, and UG Tech of wT/C. The table also includes a 'Refresh' button and a 'Main Menu' button.

Est. No.	Est. No.	Station No. and Direction	Estimate Information											
Item No.	Estimate No.	Fac. No.	Type of Facility	Size	OH/UG	UG Tech	Start	Ending	Direction	Qty	Unit	Unit Cost	Eligibility %	Urban %

Estimate No.	<input type="text"/>	Station Start	<input type="text"/>	Estimate Unit	<input type="text" value="LF"/>
Facility No.	<input type="text" value="FCLTY_0000"/>	Station Ending	<input type="text"/>	Estimate Unit Cost	<input type="text" value="\$0.00"/>
Estimate Qty	<input type="text" value="1"/>	Station Direction	<input type="text"/>	Eligibility Ratio (%)	<input type="text" value="100"/>
				Percentage for Urban (%)	<input type="text" value="0"/>

**Look up Facility No.**

ID	Type of Facilities	SIZE	OH/UG	UG Tech	RS Means Avg	RS Means Min	RS Means Max	Agreement Unit Cost
FCLTY_0064	Communication	4	UG	wT/C	\$60.00	\$50.00	\$80.00	130

Type	<input type="text" value="Communication"/>	OH/UG	<input type="text" value="UG"/>
Size	<input type="text" value="4"/>	UG Tech	<input type="text" value="wT/C"/>

Facility No.

Figure 5-14: Additional Functions: Looking Up Facility Number

### 5.2.2 Agreements Looking Up Function

Except for the Facility Looking Up Function, the Agreements Looking Up Function provides a way for end users to get references regarding unit cost from historical data and average unit cost from relevant agreements.

**Cost Estimate Details**

TEXAS DEPARTMENT OF TRANSPORTATION

Est. No.		Facility No.				Estimate Information				
Est. No.	Fac. No.	Type of Facility	Size	OH/UG	UG Tech	Qty	Unit	Unit Cost	Eligibility %	Urban %
0015	0296	Waterline	30	UG	wB&C	63888	LF	\$500.00	100	15
0015	0272	Gas	4	UG	wB&C	200	LF	\$260.00	100	20
0015	0284	Waterline	6	UG	wB&C	100	LF	\$70.00	100	10
0015	0327	Communication	Large	UG	wB&C	40656	LF	\$250.00	100	12
0015	0300	Wastewater	4	UG	wT/C	9504	LF	\$35.00	100	10
0015	0342	Gas	2	UG	wT/C	61248	LF	\$60.00	100	16

\*Estimate No. ESTMT\_0015 \*Estimate Qty. 40656 Eligibility Ratio (%) 100

\*Facility No. FCLTY\_0327 Look up Qty Percentage for Urban (%) 12

Est. Unit LF Est. Unit Cost \$250.00

Get Qty

New Delete Refresh Main Menu **Agreements**

Look up Facility No.

Type of Facilities	SIZE	OH/UG	UG Tech	Avg HIST. data	Min HIST. data	Max HIST. data	Agreement Cost

Refresh

Type OH/UG

Size N/A UG Tech N/A

Facility No.

Figure 5-15: Additional Functions: Looking Up Relevant Agreements

Likewise, the Agreements Looking Up Function in the Estimate Item table enables end users to know all the relevant agreement records for a selected estimate item. The followed steps illustrated the basic workflow of this function.

Step 1. Select the desired estimate item from the company list box. The information of selected estimate item appears on the Add/Edit/Delete section.

Step 2. Click on **Agreements** command to view relevant agreements for the selected estimate item.

Agreements

TEXAS DEPARTMENT OF TRANSPORTATION

U Number	Utility Owner	Type of Facilities	Size	OH/UG	UG Tech	Unit	Unit Cost
10013	Grande Communications	Electric Distribution	N/A	UG	wB&C	LF	90.00
10014	Grande Communications	Electric Distribution	N/A	UG	wB&C	LF	100.00
10015	Bluebonnet Electric	Electric Distribution	N/A	UG	wB&C	LF	80.00

Figure 5-16: Additional Functions: Looking Up Estimate Quantity

### 5.2.3 Estimate Quantity Looking Up Function

In addition to the functions mentioned above, the database also provides end users with another useful service - Estimate Quantity Looking Up Function. The following steps show how to look up estimate quantity for a given utility facility. The assumption behind this method is that the route of the estimated facility has already been known.

Step 1. Click on **Look up Qty** command to open Google Maps window.

The screenshot shows a web application window titled "Cost Estimate Details" for the Texas Department of Transportation. It contains a table with the following data:

Est. No.		Facility No.				Estimate Information				
Est. No.	Fac. No.	Type of Facility	Size	OH/UG	UG Tech	Qty	Unit	Unit Cost	Eligibility %	Urban %
0046	0284	Waterline	6	UG	wB&C	1	LF	\$0.00	100	0

Below the table are several input fields and buttons:

- \*Estimate No. (dropdown): ESTMT\_0046
- \*Estimate Qty. (dropdown): 1
- Eligibility Ratio (%) (input): 100
- \*Facility No. (dropdown): FCLTY\_0272
- Look up Qty** (button, highlighted with a red circle)
- Percentage for Urban (%) (input): 0
- Est. Unit (input): LF
- Est. Unit Cost (input): \$0.00
- Get Qty (button)
- New, Delete, Refresh, Main Menu (buttons)
- Agreements (button)

At the bottom, there is a section titled "Look up Facility No." containing a table with historical data:

Type of Facilities	SIZE	OH/UG	UG Tech	Avg HIST. data	Min HIST. data	Max HIST. data	Agreement Cost
Gas	4	UG	wB&C	\$144.00	\$134.00	\$152.00	258.5

Below this table are additional input fields:

- Type (dropdown): Gas
- OH/UG (dropdown): UG
- Size (dropdown): 4
- UG Tech (dropdown): wB&C
- Facility No. (input): 272
- Refresh (button)

Figure 5-17: Open Google Maps Window



Step 2. Select the start point on the map by right clicking mouse and choosing “Directions from here.”

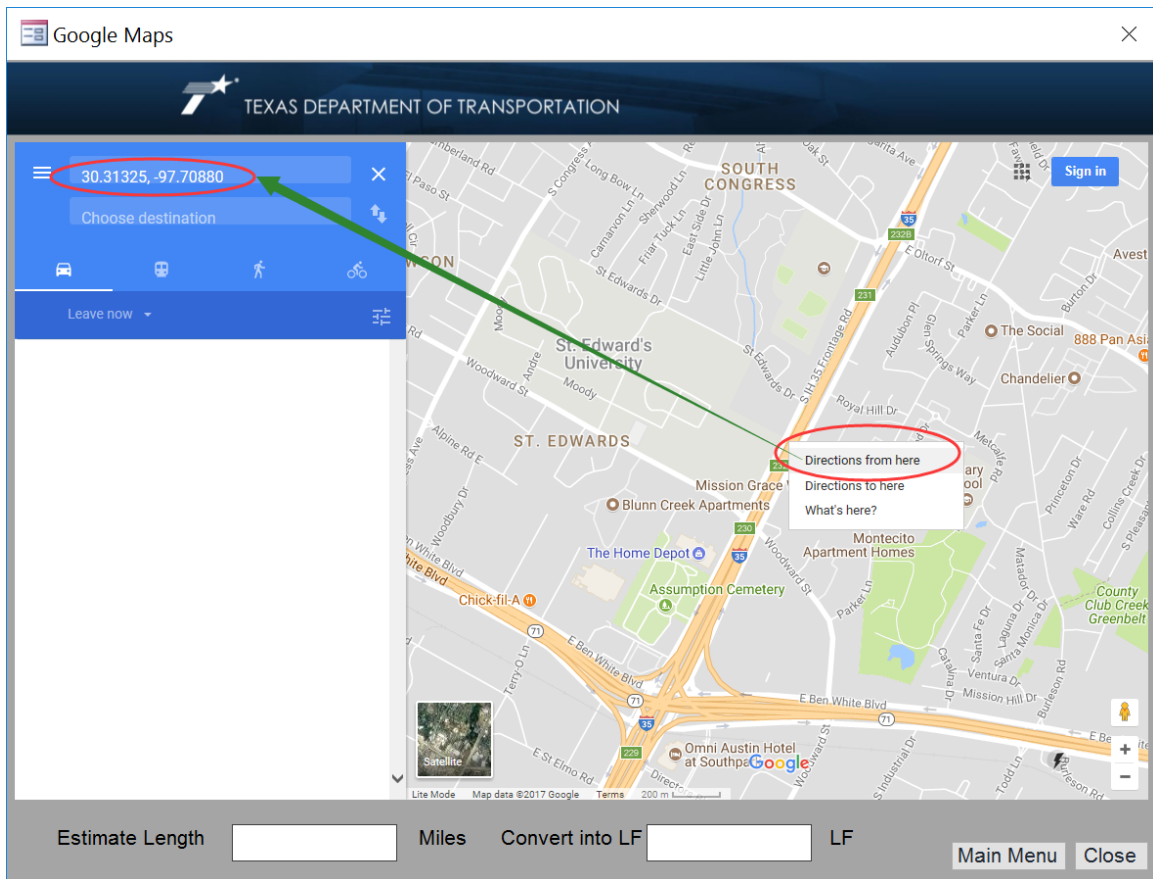


Figure 5-18: Select the Start Point

Step 3. Select the destination on the map by right clicking mouse and choosing “Directions to here.” Then, the distance will be computed automatically.

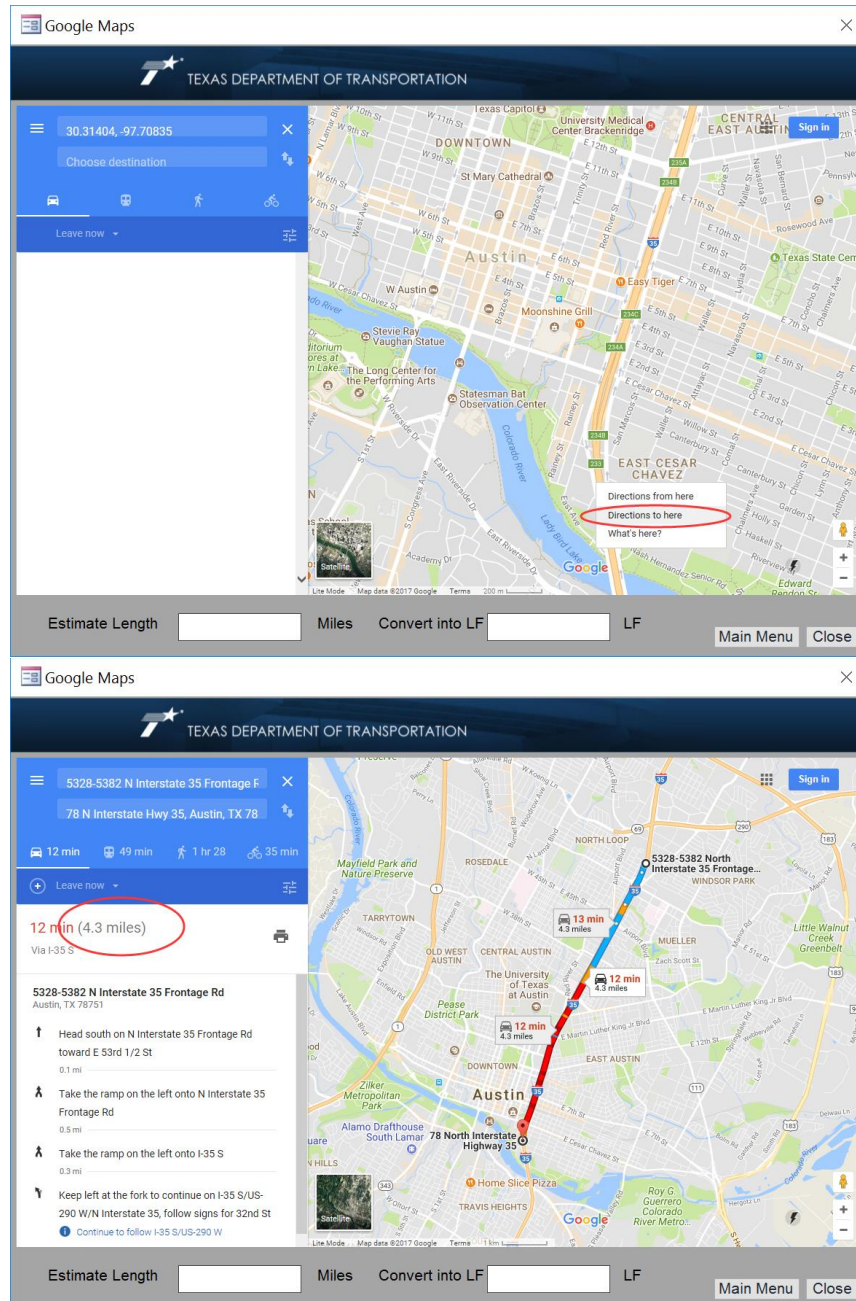


Figure 5-19: Select the End Point

Step 4. Convert the distance from miles to linear feet by entering the value in the left bottom text box. Then, the distance will be converted to linear feet.

The screenshot shows the Google Maps interface with a route from 5328-5382 N Interstate 35 Frontage Rd to 78 N Interstate Hwy 35, Austin, TX 78. The route is highlighted in red and blue, with a total distance of 4.3 miles and a travel time of 12 minutes. The bottom of the screen features a conversion tool with the following text: "Estimate Length 4.30 Miles Convert into LF 22,704.00 LF". The value "22,704.00" is circled in red. The interface also includes a "Main Menu" button and a "Close" button.

Figure 5-20: Convert the Length

## **CHAPTER 6      Conclusions and Recommendations**

The research aimed to develop a database system which stores historical cost information from reliable data sources and provides end users with cost estimations according to the records. The data sources come either from previously executed utility agreements between TxDOT office and utility owners or publicly available open source historical cost data. Finally, the system was fully completed and has been handed over to TxDOT for further tests and implementations. This chapter focuses on the conclusions derived from this research and discusses the benefits, limitations, future research recommendations of the Utility Relocation Cost Estimation database system.

### **CONCLUSIONS**

This section of the chapter summarizes the conclusions derived from the successful completion of the Utility Relocation Cost Estimation database.

First of all, the most important work in this research is to design and optimize the structure of the system. The basic logic to compute cost estimates is not complicated. However, it is not easy to make decisions on the components of the system. The objective of this research is to develop a cost estimation system for utility relocation. Thus, every entity relevant to cost estimation in the utility relocation process was involved in the database. Moreover, the attributes of each entity were defined and initiated. Meanwhile, the relationships between various entities were set up, which maintained the data integrity of the database. In fact, with the development of the database, these attributes were adjusted for many times. In some cases, the modifications were made to accommodate new user needs. In other cases, the adjustments were conducted to make certain functions work more

efficiently. Just as the nature of software development, a lot of work in this research was done on debugs and tests to ensure the usability and validity of the system.

In addition, communication and feedback play a vital role in the successful completion of the database. Weekly internal meetings were held to discuss progress, resolve issues, and plan the next research tasks. During these meetings, the research team exchanged weekly achievements and got comments and suggestions to continue new tasks. Furthermore, periodical meetings were held with TxDOT personnel. The latest achievements were presented at these meetings, and feedback was gathered from TxDOT. The feedback gave new directions on the further updates to the system. In fact, the feedback from TxDOT enables the Utility Relocation Cost Estimation database to be more user-friendly. The first deliverable version was turned over to TxDOT personnel during summer 2017. Two weeks later, the research team got feedback and comments from them. Then, the system was partially modified and updated, which ultimately became the latest version.

### **BENEFITS OF UTILITY RELOCATION COST ESTIMATION SYSTEM**

This section sums up the major benefits of the Utility Relocation Cost Estimation system.

The system is one of the few tools designed especially for utility relocation cost estimation. With this system, utility coordinators can make easy cost estimations with reliable data sources. This system also enables the DOT offices to play a more active role in coordination with multiple stakeholders in utility relocation.

Due to the Utility Relocation Cost Estimation system, previous cost information from agreements between TxDOT office and utility companies was organized and recorded

in electronic format. Before this system, agreements only existed in the form of hard copy, which makes it difficult for future use.

This database is designed for utility coordinators who may not be professional cost estimators. Thus, the first principle is to make it easy to use. The user-friendly principle was applied both to the cost estimation workflow and user interfaces. As illustrated in both Chapter 4 and Chapter 5, the basic logic is straightforward, end users can create a cost estimation by entering the necessary information, and a report will be automatically generated for review. Moreover, user interfaces followed the style in normal systems used by TxDOT, which can provide end users with a familiar work environment. With these features, the learning curve has been largely reduced.

#### **LIMITATIONS OF UTILITY RELOCATION COST ESTIMATION SYSTEM**

The system worked as a pioneer in the field of utility relocation cost estimation. It was developed by the research team in the hope that it was as complete as possible. However, there are some limitations in this database.

Due to the limited number of available agreements, at the current stage, the facility information and cost data derived from previous agreements are restricted. Although data obtained from historical data served as substitutions, the estimation based on agreements is more accurate than that from the open source database.

#### **FUTURE RESEARCH RECOMMENDATIONS**

During the late stage of the development, the research team proposed an additional function - the Estimate Quantity Looking Up Function, which facilitates users to obtain estimate quantity information. This function aimed to integrate Google Maps into the

Utility Relocation Cost Estimation system. With this function, the end users click two points on the map, and the distance between the selected points will be computed and automatically passed to the active estimate quantity field. However, due to the accessibility of Google Maps APIs, the research team didn't get any valid methods to obtain coordinates of selected points on Google Maps. As an alternative, the research team integrated Google Maps into the database, which enables the system to display the distance between two selected points. However, users need to manually enter the quantity data into the field instead of automatically collecting data by the system. Therefore, the next development may focus on how to make the current semi-automatic process become a fully automatic one.

In addition, another possible direction for future research is to focus on how to integrate the Utility Relocation Cost Estimation with GIS platform. The success of the integration will also enable the database to accomplish the fully automatic goal, which will largely boost the efficiency of preliminary cost estimates for utility relocation in transportation projects.

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