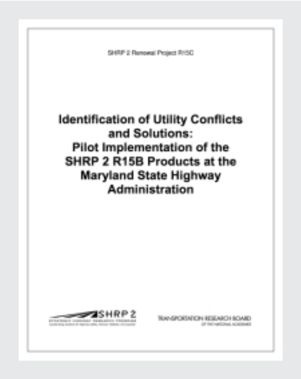
SHRP 2 Renewal Project R15C

Identification of Utility Conflicts and Solutions: Pilot Implementation of the SHRP 2 R15B Products at the Maryland State Highway Administration

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DETAILS

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The pilot implementation reported here was performed by the Texas A&M Transportation Institute (TTI), Texas A&M University System, in collaboration with Cardno and Utility Mapping Systems (UMS). TTI was the prime contractor for this study, with Texas A&M Sponsored Research Services serving as fiscal administrator. Cesar Quiroga, Senior Research Engineer at TTI, was the principal investigator. The other authors of this report are Edgar Kraus Associate Research Engineer at TTI; Jerry Le, Software Applications Developer at TTI; Paul Scott, National Utilities Liaison at Cardno; James Anspach, Director, Utility Market and Practice Development at Cardno; Tom Swafford, Utility Coordination Operations Manager at UMS; and Philip Meis, Principal Engineer and Vice President at UMS.

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NOTICE

The project that is the subject of this document was a part of the second Strategic Highway Research Program, conducted by the Transportation Research Board with the approval of the Governing Board of the National Research Council.

The Transportation Research Board of the National Academies, the National Research Council, and the sponsors of the second Strategic Highway Research Program do not endorse products or manufacturers. Trade or manufacturers' names appear herein solely because they are considered essential to the object of the report.

Contents

EXECUTIVE SUMMARY

Research Project SHRP 2 R15B took place from March 2009 to July 2011 and resulted in three products: Product 1 (stand-alone utility conflict matrix [UCM]), Product 2 (utility conflict data model and database), and Product 3 (one-day UCM training course). In December 2011, the SHRP 2 Oversight Committee authorized a follow-on project to pilot the implementation of the SHRP 2 R15B tools. The follow-on project was SHRP 2 R15C, Pilot Testing of the Utility Conflict Matrix. Its objective was to work with a state department of transportation on the implementation of the stand-alone UCM and the one-day UCM training course as well as on an introduction to the utility conflict data model and database. The pilot implementation took place at the Maryland State Highway Administration (MDSHA) from September 2012 to March 2014.

CONCLUSIONS

Use of the UCM Approach

MDSHA identified six projects to test the implementation of the UCM approach. Lessons learned in connection with the UCM approach included the following:

- The UCM is useful for documenting and resolving utility conflicts.
- The UCM creates a proactive, efficient preconstruction engineering resolution process.
- The UCM helps to avoid utility relocations.
- Using the UCM has resulted in tangible economic and time benefits.
- The UCM enhances coordination and working relationships with utility owners.
- The UCM process facilitates MDSHA internal teamwork.

At the same time, MDSHA officials identified areas in which the UCM approach would need some improvements. A critical issue was that UCM development took longer than originally expected, highlighting the need to provide more guidance on how to identify, characterize, and manage utility conflicts efficiently, with a focus on limiting UCM updates to major milestones as a strategy to reduce required labor effort.

Data Model and Database

The research team updated the UCM data model and Access database to reflect suggestions from MDSHA district officials on the usability of the UCM approach as well as lessons learned by members of the research team as part of other research initiatives, in particular related to the development of generalized inventories of utility facilities within the highway right-of-way. Part of this effort involved developing data entry forms in Access to manage information about projects, utility owners, utility facilities, and utility conflicts. The research team used the physical data model to generate a script to build a version of the UCM database in Access 2010 format. The research team then designed queries and forms for data entry by using custom Visual Basic for Applications code. The main goal of developing the data entry forms was to illustrate the use of the UCM approach in a stand-alone database environment to users who are not information technology professionals. The data entry forms are sufficiently polished and user friendly so that they can be used for actual data entry in a stand-alone environment. From this perspective, the forms provide a unique opportunity for users to become familiar with some of the typical protocols that would take place when managing utility conflicts in a database environment. However, the forms are not envisioned for an enterprise-level environment.

One-Day UCM Training Course

The research team delivered the one-day UCM training course twice as part of the pilot implementation in Maryland. The first training session occurred prior to pilot application by districts on actual projects. A decision was made with MDSHA near the end of the pilot implementation to provide a second training session for users unable to attend the first course. The first course took place in Hanover, Maryland, and included 36 participants representing MDSHA (29 attendees), utility owners (four attendees), consultants (two attendees), and the Federal Highway Administration (one attendee). MDSHA participants included a mix of design, utility, and right-of-way acquisition officials, both from districts and headquarters. The second course took place in Baltimore, Maryland. In total, 40 MDSHA officials representing several disciplines attended this course, although most participants were designers. Originally intending to provide training for District 3 officials and their consultants who were unable to attend the first course, MDSHA subsequently decided to move the course to agency headquarters in Baltimore to provide greater opportunity for more officials to receive UCM training.

The research team updated the training materials to address comments from course participants as well as observations by the research team with respect to ways to improve the effectiveness of the presentation. The materials also reflect feedback from MDSHA staff about ways to provide more guidance on how to identify, resolve, and manage utility conflicts.

RECOMMENDATIONS

Recommendations to implement the project findings include the following:

- Use lessons learned from the pilot implementation in Maryland.
- Monitor and disseminate results of the initial UCM implementation.
- Consider additional strategies to accelerate the deployment of the UCM approach.
- Strongly encourage participation in the one-day UCM training course.
- Make the one-day UCM training course materials available online.
- Strongly encourage the use of the UCM for applicable projects.
- Develop enterprise, centralized UCM database implementations.
- Further evaluate the conflict resolution alternative analysis subsheet.
- Further evaluate utility conflict event tracking.
- Develop tool to streamline and standardize cost estimates and protocols for the submission of estimates and billings.

- Develop module to estimate utility conflict risk levels.
- Monitor the need for a UCM guidebook in addition to the UCM training course.
- Update utility guides and manuals to incorporate the UCM approach.

CHAPTER 1
Background

Utility issues are widely recognized as one of the top reasons for delays in project development and delivery. Two critical factors contributing to inefficiencies in the management of utility issues are (a) the lack of accurate, complete information about utility facilities that might be in conflict with the project and (b) the resolution and overall management of those conflicts. These inefficiencies can result in problems, such as the following:

- Disruptions when utility installations are encountered unexpectedly during construction, either because there was no previous information about those installations or because their stated location on the construction plans was incorrect.
- Damage to utility installations leading to disruptions in utility service, environmental damage, and risks to the health and safety of construction workers and the public.
- Delays that can extend the period of project development and/or delivery and increase total project costs through higher bids, change orders and/or damage or delay claims, redesign, and litigation by utility owners or agencies. These delays also result in frustration for the traveling public and negative public perception about the project.
- Unplanned environmental corrective actions.
- Unnecessary utility relocations and project delivery inefficiencies that occur because adequate information about existing utility facilities was not available to enable stakeholders to apply alternative utility conflict resolution strategies, such as modifying the transportation project design or protecting the utility facilities in place.

Both departments of transportation (DOTs) and utility owners complain about the lack of sufficient communication, scheduling, and coordination in the planning, right-of-way acquisition, design, and construction phases of road construction projects, which in turn inhibit the timely relocation of utility facilities. Designing to limit the impact of utility relocations is the exception rather than the rule. Identifying and resolving potential utility conflicts early in the project development process can minimize the total cost and decrease the time to completion of transportation projects.

One of the projects funded by the second Strategic Highway Research Program (SHRP 2) was Research Project R15B, Identification of Utility Conflicts and Solutions. This project, which took place from March 2009 to July 2011, resulted in three products as follows (*1*, *2*):

- **Product 1 (stand-alone UCM)**. This is a stand-alone product in Microsoft Excel format, which includes a main utility conflict table and a supporting worksheet to analyze utility conflict resolution strategies.

- **Product 2 (utility conflict data model and database)**. This stand-alone product is a scalable UCM representation that facilitates managing utility conflicts in a database environment. To facilitate implementation, the research team used industry-standard protocols for the development of the data model (including a logical model, a physical model, and a data dictionary). The data model is in AllFusion ERwin Data Modeler format, which can be easily exported to formats such as Oracle and Microsoft SQL Server. The data model was tested by developing a series of queries and reports in Microsoft Access to replicate sample utility conflict tables from across the country. The focus of this part of the research was development of the data model, but not a graphical user interface (GUI) to automate data entry, querying, and reporting. GUI development was considered an implementation-level activity.
- **Product 3 (one-day UCM training course)**. This stand-alone product includes a lesson plan and presentation materials to assist with the dissemination of research findings. The one-day UCM training course is divided into six lessons, designed for a total of seven hours and 15 minutes of instruction, from 8:30 a.m. to 3:45 p.m.

In December 2011, the SHRP 2 Oversight Committee authorized a follow-on project to pilot the implementation of the SHRP 2 R15B tools. The follow-on project was SHRP 2 R15C, Pilot Testing of the Utility Conflict Matrix. Its objective was to work with a state DOT on the implementation of the stand-alone UCM and the one-day UCM training course, as well as on an introduction to the utility conflict data model and database. The pilot implementation took place from September 2012 to March 2014.

The research team identified six state DOTs that, based on information gathered during the initial SHRP 2 R15B research, were perceived to have the most potential for a pilot implementation of the research projects: Alabama, Maryland, Montana, New Hampshire, Oregon, and South Carolina. The research team identified three additional state DOTs that did not participate in the original research but appeared to be promising based on previous interactions with members of the research team: Connecticut, Utah, and West Virginia. Four of the nine state DOTs contacted responded indicating interest: Alabama, Maryland, New Hampshire, and Utah. Further discussions with the Transportation Research Board (TRB) on the feasibility of each of the proposed locations led to the decision to select Maryland.

This report summarizes the application of the UCM tools as part of the pilot implementation at MDSHA, including lessons learned, and updates to the three research products. This report is organized as follows:

- Chapter 1 is this introductory chapter.
- Chapter 2 summarizes lessons learned from the use of the stand-alone UCM.
- Chapter 3 describes updates to the UCM data model and database in response to lessons learned by MDSHA officials on the use of the UCM approach.

- Chapter 4 describes lessons learned from the one-day UCM training course as well as updates to the training materials to reflect these lessons learned.
- Chapter 5 includes conclusions and recommendations.

CHAPTER 2
Use of the Stand-Alone UCM in Maryland

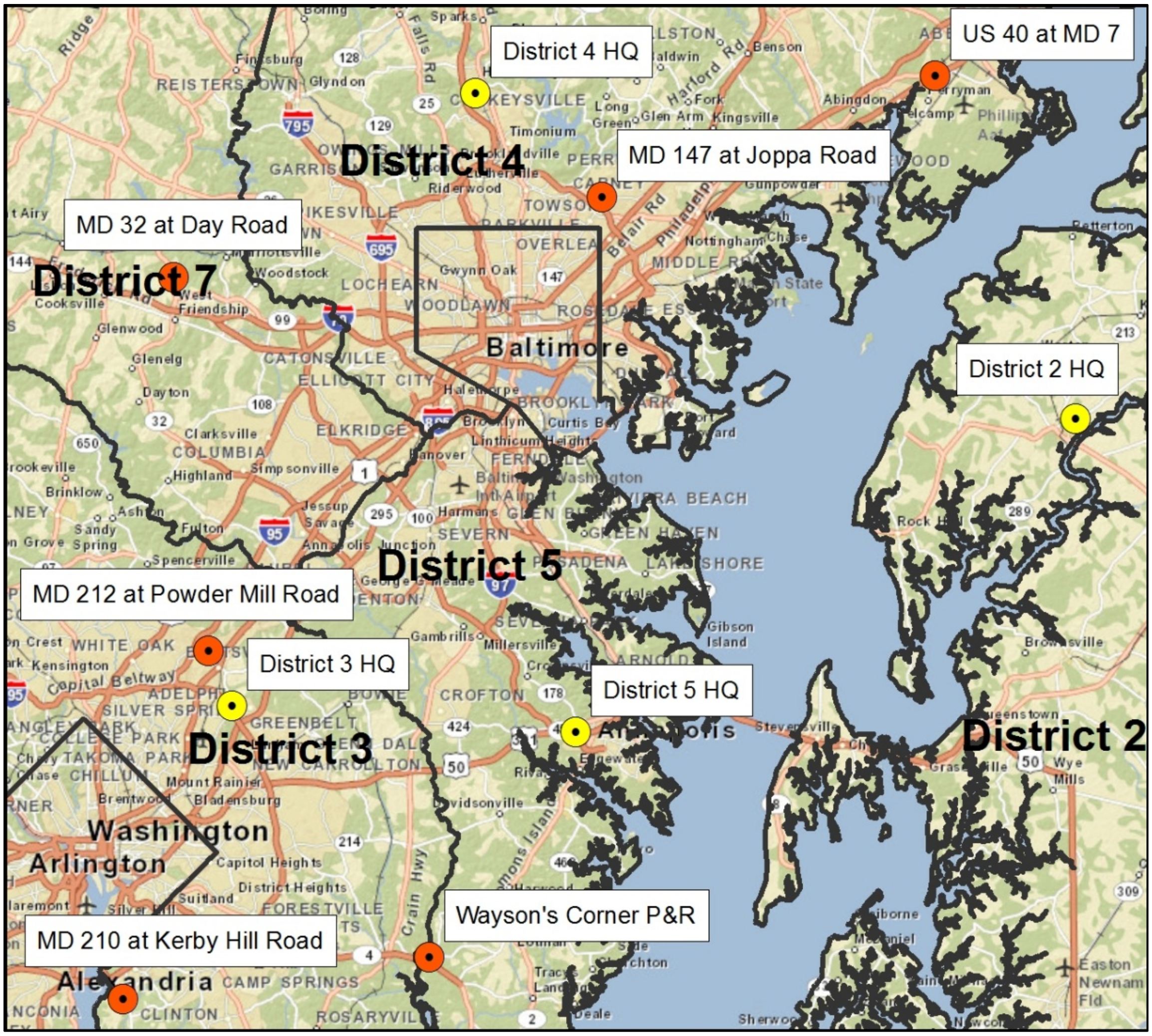
Introduction

The pilot implementation in Maryland involved completing the following major activities:

- Coordinate with MDSHA officials on the identification of projects to conduct the pilot implementation, UCM training opportunities, and technical support logistics.
- Conduct the one-day UCM training course for selected users. This activity took place prior to districts beginning to use the stand-alone UCM on actual projects. Following discussions with MDSHA, the research team scheduled a second one-day UCM training course for additional users toward the end of the pilot implementation. Chapter 4 provides additional information on lessons learned from both training events.
- Interact with district users and provide technical support as needed.

MDSHA identified six projects to test the implementation of the UCM approach. Figure 2.1 shows the location of the projects along with the approximate design status of each project at the beginning of the pilot implementation. Table 2.1 provides a summary on the use of the UCM approach for each of these projects as of December 2013.

This chapter provides a summary of lessons learned from the pilot implementation of the UCM approach at each of these projects. The lessons learned are based on various interactions with district officials over the course of several months as well as on feedback received during meetings and field visits that the research team conducted.



District	Project	Design Stage at the Beginning of the Pilot Implementation
3	MD 210 at Kerby Hill Road and Livingston Road Interchange Project	<30%
3	MD 212 (Powder Mill Road) from Montgomery Road to US 1 (Baltimore Avenue)	<30%
4	MD 147 at Joppa Road Intersection Improvement Project	60%–90%
4	US 40 at MD 7 and MD 159 Intersection Improvement Project	60%–90%
5	Wayson's Corner Park-and-Ride Lot Expansion Project	90%
7	MD 32 Road Widening from Day Road to West Friendship Road	30%–60%

Figure 2.1. Projects selected by MDSHA.

Table 2.1. Project Status and UCM Implementation as of December 2013

District	Project	Project Status	UCM[1]	Comment
3	MD 210	30% design meeting with utilities June 2013. Consultant received order to proceed in October 2013.	Yes	District completed first UCM version. Project is now design–build. MDSHA selected consultant. Consultant provided assessment and updated UCM in December 2013.
3	MD 212	30% design in April 2013. District negotiating with consultant.	No	Project is on hold. MDSHA is hiring consultant for additional design work.
4	MD 147 at Joppa	75% design in October 2013. Utility section working on UCM.	No	Project delayed by design changes. No construction funding yet, but expected soon.
4	US 40 at MD 7	90% design in October 2013.	Yes	District completed first version and revised update of UCM. District ordered and received test holes. Updated plans expected by the end of 2013.
5	Wayson's Corner	100% design. Construction bids opened in June 2013. Notice to proceed issued in November 2013. Construction expected to start in spring 2014.	Yes	District provided final UCM.
7	MD 32	95% design. Advertised in December 2013. Notice to proceed is anticipated in March 2014.	Yes	District completed first and revised update of UCM. Received test hole reports. Utility coordination meetings held in May 2013 and October 2013.

[1] UCM was prepared by the district using the standard UCM template provided by the research team (or the district developed a modified version to suit the needs of the project).

District 3: MD 210 at Kerby Hill Road and Livingston Road Interchange Project

The MD 210 at Kerby Hill Road/Livingston Road interchange project includes construction of a median ramp interchange on MD 210 at Kerby Hill Road/Livingston Road (Figure 2.2 and Figure 2.3). The purpose and need for this project is to improve traffic operations and safety conditions along MD 210. The project was broken out of the MD 210 multimodal study and received separate environmental approval in June 2004. The project was previously advanced to the preliminary investigation (PI) (30%) stage in 2007. Because of revised traffic numbers, a value engineering study was conducted in April 2011. The resulting revised scope includes construction of a median ramp interchange on MD 210 at Kerby Hill Road/Livingston Road.

Figure 2.2. MD 210 at Kerby Hill Road and Livingston Road interchange project location.

Along MD 210, the project extends from 2,500 feet south of the existing intersection to 600 feet north of Wilson Bridge Drive. Along Kerby Hill Road and Livingston Road, the project extends approximately 1,000 feet to the west and to the east of the intersection. The scope of the project includes construction of a full-access median ramp interchange with MD 210 at grade and Kerby Hill Road and Livingston Road over MD 210. MD 210 will be widened to accommodate the ramps in the median but will maintain three through lanes of traffic. The median ramps will be supported by retaining walls. An access road will be built along the west side of MD 210 to provide access from a housing development to Kerby Hill Road. Wilson Bridge Drive will be modified to only allow a right-in movement.

The PI stage utility coordination meeting took place in June 2013. The research team attended this meeting. If fully funded, MDSHA anticipates an advertisement in the fall of 2014, with a notice to proceed in the winter of 2014. The project was changed from design–bid–build to design–build. As a result, MDSHA will not produce further design drawings. A consulting firm was selected as a utility coordination and design consultant to determine utility conflicts, need for quality level B (QLB) utility investigations and quality level A (QLA) test holes, potential conflict resolution strategies, and utility relocation design. The consultant received notice to proceed in October 2013.

Figure 2.3. MD 210 at Kerby Hill Road and Livingston Road.

District officials prepared a first version of the UCM in preparation for the June 2013 utility coordination meeting. On the basis of available information, MDSHA identified 44 conflicts associated with three utility owners, as follows:

- PEPCO Electric: 8 conflicts
- Washington Gas: 16 conflicts
- Washington Suburban Sanitary Commission (WSSC) Sanitary Sewer: 20 conflicts

The consultant reviewed the design plans and the preliminary UCM and provided an updated version of the UCM in December 2103. From the most current design, the consultant identified utility facilities in the initial UCM that were no longer in conflict, identified new utility conflicts not previously identified by MDSHA, revised or provided recommended resolution actions for utility conflicts, and identified utility conflicts that needed further investigation using test holes. The assessment resulted in 107 conflicts, as follows:

- Level 3 Communications: 10 conflicts
- PEPCO Electric: 35 conflicts (added 27 conflicts)
- Verizon Wireless: 13 conflicts
- Washington Gas: 14 conflicts (removed 3 conflicts, added 1 conflict)
- WSSC Sanitary Sewer: 16 conflicts (removed 5 conflicts, added 1 conflict)
- WSSC Water: 19 conflicts

Lessons learned by district staff in connection with the UCM approach include the following:

- **UCM is useful for documenting utility conflicts**. The district utility engineer found the UCM to be helpful in documenting utility conflicts early in the design process. The UCM makes discussing and resolving specific conflicts easier because all parties (designers, utility coordinators, utility owners, and so on) are able to visualize and understand all constraints in one document. It is also much easier to coordinate with utility owners because both sides have the same information and it is easy to point out a conflict by using the conflict identification (ID) and then discussing it. The UCM also helps to avoid situations in which utility conflicts "fall off the radar" and are ignored until they become a major problem. Finally, the UCM enables MDSHA managers above the design level to understand the complexity and costs (time and financial) related to utility impacts.
- **Responsibility for UCM documentation task needs to be clarified**. At the beginning of the UCM development, it was unclear who would be responsible to populate the UCM. District staff decided that it would be best for utility coordinators and designers to develop the first version of the UCM jointly.
- **There is a need for a data quality label in Bentley MicroStation**. District officials recognized that one of the challenges with utility data is that design plans do not show utility investigation quality level data, although MicroStation files include that information as a cell attribute.
- **There is a need for MicroStation training for district staff**. District utility personnel are not sufficiently familiar with MicroStation. This makes it difficult for district staff to determine the quality of the utility investigation data provided in MicroStation files.
- **Prioritization of UCM use might be beneficial**. District staff suggested prioritizing the use of the UCM, focusing on construction, reconstruction, or rehabilitation projects first. Maintenance projects and areawide projects would not be good candidates for using the UCM, at least not until district staff in both design and utility coordination sections are more familiar with the use of the UCM.

- **Not enough information is available yet to quantify benefits**. District officials expected that an assessment of benefits (time or money savings) would be possible once the consultants were onboard and started using the UCM to analyze and manage utility conflicts. The consultants received a notice to proceed in October 2013, which was later than originally anticipated.
- **Development and maintenance of the UCM takes time**. District officials indicated that they spent about four hours of labor (two people working two hours each) to review five plan sheets (30 scale, Arch D size) and develop the first version of the UCM, for an average of 45 minutes of labor per sheet. As a result, district officials indicated they would closely monitor the time and effort the consultant uses to maintain the UCM. This also made it critical to clarify the consultant's scope of work to make sure MDSHA's expectations for deliverables and associated costs were reasonable and consistent with MDSHA's goals and objectives. It also highlights the need to develop software to automate the detection of utility conflicts and populate the UCM.
- **Some modifications to the UCM structure might be useful**. UCM users provided a few recommendations for improving the design of the UCM, including adding a hyperlink to the corresponding drawing or sheet number, providing linkages to design–build contract information, and creating different tabs in Excel for different utility owners. A generic "Unknown" tab could be used for those facilities for which the owner has not been identified.

Despite its limited hands-on experience with the UCM, the consultant indicated that the UCM approach offered the following benefits:

- The UCM is concise and easy to use, particularly when using tabs to group utility conflicts by owner or type. The UCM design also makes it easy to reference existing utility conflict locations.
- The UCM provides a systematic way to inventory and lay out all utility information within the project limits, making it useful for new project manager, project engineer, or consultants who need to work on the project.
- It facilitates the management of further utility investigations, including test holes.
- The UCM is effective for demonstrating cost impacts and savings by recognizing and tracking conflicts up front.

The consultant also highlighted a few challenges and recommendations, including the following:

- The UCM does not provide a direct link to spatial locations on design plans or utility data source, resulting in redundancy between the UCM record and the location of utility conflicts on the plans. It would be beneficial to add a column to identify the source of the utility data (e.g., from a set of as-builts, field locates, utility designation, or geographic information system (GIS) or the actual graphic or picture of the utility in conflict.

- Updating the UCM at every horizontal design change iteration is not practical. A strategy to address this issue is to make it a practice to update the UCM at prespecified milestones. It is worth noting that the updated training materials describe stages and milestones more clearly.
- The UCM does not provide a trigger or a red flag to highlight missing information.
- The UCM does not include a column to identify the design phase or design drawing version or date on which the UCM has been prepared.
- It would be advisable to hide some of the columns to develop executive-level reports that only highlight critical information that depends on the intended recipient of the UCM.
- It would be advisable to include the UCM as part of every project design review process and every communication with utility owners.
- It would be advisable to include the UCM in design–build contract specifications to inform the teams bidding on the contract of the location, magnitude, and type of utilities affected. The result would be more competitive bids.

District 3: MD 212 (Powder Mill Road) from Montgomery Road to US 1 (Baltimore Avenue)

The project involves reconstructing MD 212 (Powder Mill Road) from Montgomery Road to US 1 (Baltimore Avenue), including reconstruction of the roadway, resurfacing, curb and gutter drainage improvements, five-foot-wide concrete sidewalks, street trees, street lighting, pedestrian crossings compliant with the Americans with Disabilities Act, curb cuts and crosswalks, and other aesthetic and landscaping enhancements (Figure 2.4 and Figure 2.5). The current typical road section consists of two 11-foot lanes and shoulders with varying widths. Most of the project length has a concrete curb. The total cost has an upper limit of $5.4 million (2002 dollars), which may increase after adjusting for inflation. The project is funded by MDSHA without local contributions. Prince George's County has accepted maintenance responsibilities after completion of the project. Improvements to Powder Mill Road are related to a nearby project that focuses on a realignment and relocation of MD 212 along the existing Ammendale Road/Virginia Manor Road/Ritz Way corridor.

The project is currently at about 30% design. The project is on hold until Prince George's County and MDSHA agree on changes to the typical section. At the PI meeting, MDSHA presented a concept for a cross section, but the county expressed interest in modifying the typical section, including widening the proposed sidewalk. MDSHA is currently in the process of hiring a consultant to complete the design work. The typical section presented at the PI meeting will no longer be used. In addition, project leadership changed in June 2013, and it was not possible to obtain feedback from either the previous project manager or the new project manager in connection with the use of the UCM approach. The utility coordinator did not use the UCM for this project and, therefore, could not offer lessons learned.

Figure 2.4. MD 212 from Montgomery Road to US 1 project location.

Figure 2.5. MD 212 from Montgomery Road to US 1.

District 4: MD 147 at Joppa Road Intersection Improvement Project

This project involves the addition of a through–right-turn lane on southbound MD 147 and a through–right-turn lane on westbound Joppa Road (Figure 2.6 and Figure 2.7). After these improvements, the configuration for southbound MD 147 will be a single left-turn lane onto eastbound Joppa Road, two through lanes, and a through–right-turn lane. For westbound Joppa Road, there will be two left-turn lanes onto southbound MD 147, two through lanes, and a through–right-turn lane onto northbound MD 147. These additional lanes will converge back to the original road configuration a few hundred feet past the intersection. There will also be improvements to the timing of the signals at the intersection and resurfacing. Previous studies have identified deficient safety and capacity conditions, especially during the peak hours. These conditions are expected to worsen as traffic volumes increase along MD 147 and Joppa Road. Average daily traffic (ADT) on MD 147 and Joppa Road (year 2011) was 33,000 and 27,900, respectively. Projected ADT (year 2031) is 40,300 and 33,500, respectively. The area is heavily urbanized.

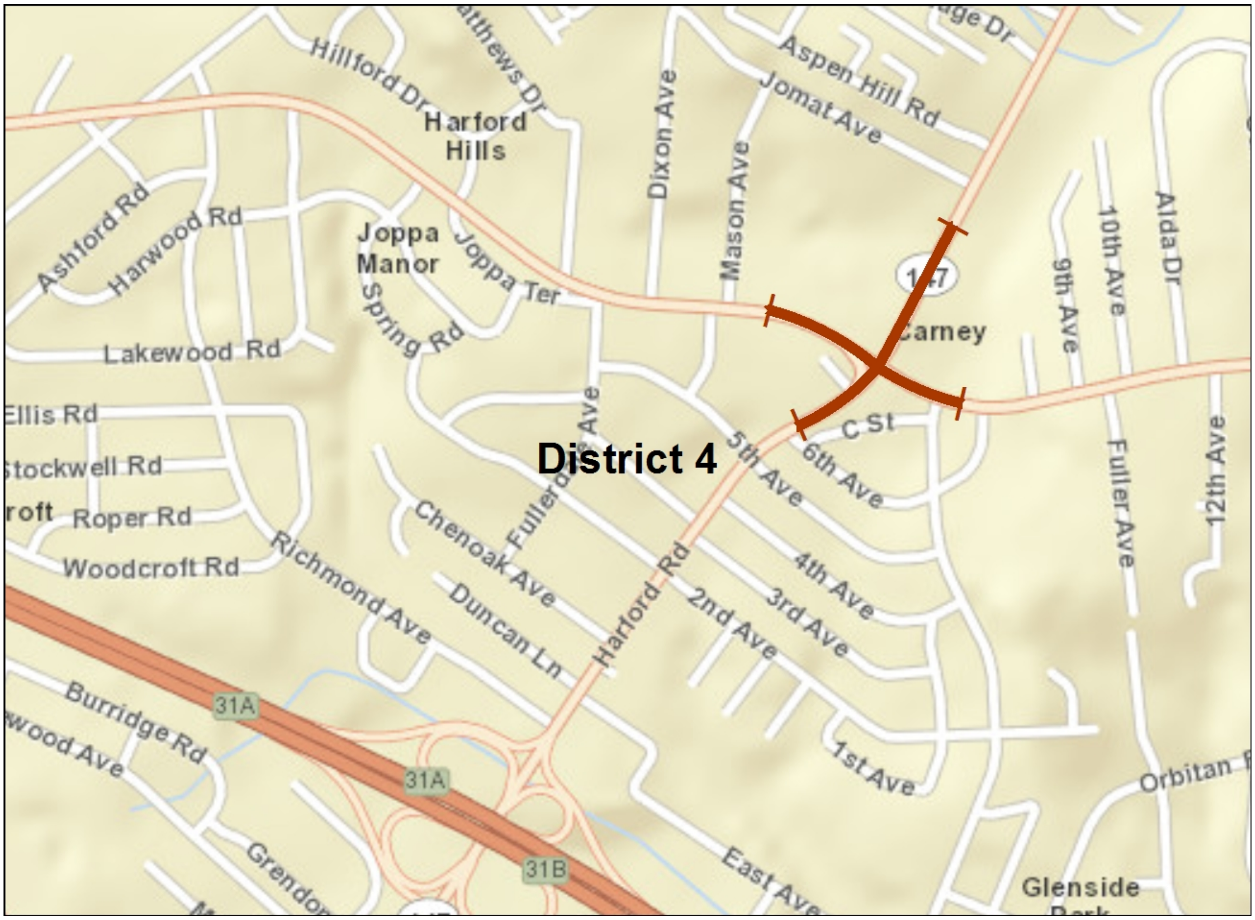


Figure 2.6. MD 147 at Joppa Road intersection improvement project location.

Figure 2.7. MD 147 at Joppa Road.

As of December 2013, the project was between 60% and 90% design level, and the district had prepared semifinal design plans. The project experienced delays awaiting the design of retaining walls on the southwest quadrant of the intersection. The project manager was also in discussions with the county about the feasibility of a number of intersection modifications that the county had requested. As of December 2013, the Joppa project had not been funded for construction, and MDSHA had not yet scheduled a utility coordination meeting.

The district conducted several test holes and placed the corresponding information on the plans. The project manager prepared a UCM by using a spreadsheet that the district had used in the past and found useful, based on information that was available at the time. The project manager did not use the UCM provided by the research team. At the time the project was considered for the UCM pilot implementation, the project plans were considered stable, and design changes to lessen utility impacts would most likely not be considered. Nevertheless, district staff provided the following feedback in connection with the use of the UCM approach:

- **The UCM is helpful for documentation, discussion, and resolution of utility conflicts**. Having designers populate the UCM first gives those designers a greater appreciation for utility issues and helps them to design more effectively earlier in the process. District staff considered the UCM useful to track documentation that would otherwise be lost because of the speed with which projects are developed and built.
- **The UCM is helpful for documenting the need for test holes**. Designers use the UCM to document the need for test holes to assess resolution strategies for utility conflicts.
- **The UCM helps to avoid utility relocations**. With the UCM, the project manager focused on avoiding the relocation of large poles next to the gas station. Utility relocations for other conflicts were more difficult to avoid. From the initial design, it appeared that Baltimore Gas & Electric (BGE) would have to move its poles twice in order to build the planned retaining wall. Following an analysis of utility installations and potential impacts, the district made several design changes. For example, the project manager decided not to affect utility poles north of the intersection along MD 147. District and BGE officials met to discuss impacts to their facilities south of the intersection along MD 147, which helped the district make the decision not to build a retaining wall to the full length of the existing embankment. BGE estimated that this decision saved the utility company several hundred thousand dollars.
- **More guidance on the UCM process would be useful**. At the beginning of the project, it was unclear who would be responsible for populating the UCM. The project manager decided to prepare the first version of the UCM, which worked well, as explained above. For future projects, district officials recommended that a project manager or a designer develop the first version of the UCM and then turn it over to others at the district to maintain it.
- **A database approach is the preferred implementation strategy**. District officials indicated that a database approach is the logical way to move forward with the UCM process. However, it would be critical to have a well-implemented, user-friendly system. The database should not make it harder to use the UCM approach than a stand-alone Excel version, which is very easy to modify.

District 4: US 40 at MD 7 and MD 159 Intersection Improvement Project

This project is located on US 40 at the intersection with MD 7 to the north and MD 159 to the south (Figure 2.8 and Figure 2.9). Following the PI meeting, the project was divided into two phases because of funding constraints. Phase 1 (currently under construction) entails improvements to MD 7. Phase 2 (this project) entails improvements to US 40 and MD 159 and has been designed to tie into the Phase 1 improvements. Phase 2 will involve widening US 40 to provide two additional lanes in each direction from approximately 2,500 feet to the west and 3,000 feet to the east of the intersection. At the eastern limit of work, the additional eastbound lanes will connect with the eastbound US 40 widening being constructed as part of the US 40 at

MD 715 interchange design–build project. The improvements will result in three through lanes, one left-turn lane, and one right-turn lane on westbound US 40 at the intersection with MD 7, as well as three through lanes, one left-turn lane, and one shared through/right lane on eastbound US 40 at the intersection with MD 159. MD 159 will be modified to tie into the eastbound US 40 widening, increase storage for left-turning movements, and accommodate bicycles. The existing 34-inch-tall concrete median barrier along US 40 will be replaced with a 42-inch-tall concrete median barrier.

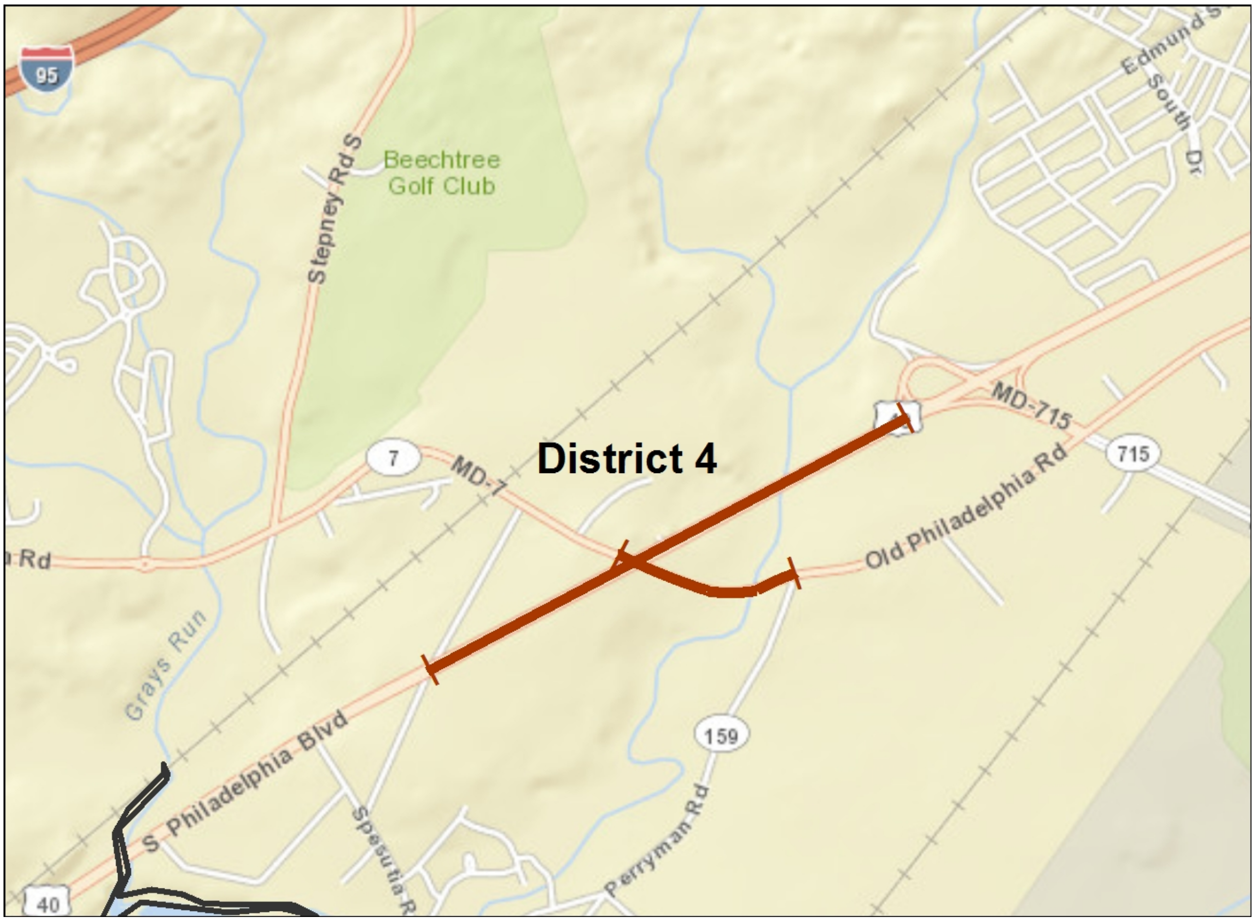


Figure 2.8. US 40 at MD 7 and MD 159 intersection improvement project location.

Figure 2.9. US 40 at MD 7 and MD 159.

The project is currently at the 90% design level and involves nine utility owners with a significant amount of belowground utilities. Because of budget constraints, the project was split off from a larger project. The project is funded and has a June 2015 advertisement date. District officials expect to complete the right-of-way acquisition process during the first half of 2014 (clearance by June 2014) to facilitate utility relocations (expected duration is 14 months).

In July 2013, district officials met with all utility owners involved in the project to discuss utility conflicts that had been identified up to that point. This was the first meeting with all utility owners on this project. The district also has monthly utility meetings for updates on all districtwide projects. Impacts on the existing water line are a top priority along with the existing sewer line.

MDSHA staff began populating the UCM in May 2013 based on final review plans as well as test hole information from Phase 1 and the adjacent design–build project on MD 715. At that point, the district was expecting to conduct test holes within 60 to 90 days, based on which a new set of plans would be prepared and readied for distribution to utility owners. MDSHA staff prepared a revised version of the UCM for the July meeting, at which time the district identified locations where test holes were necessary. Updated plans and cross sections with the test hole results were available in November 2013. District officials will schedule a utility coordination meeting after the utility owners have reviewed the updated plans.

Lessons learned by district staff in connection with the UCM approach include the following:

- **The UCM raises awareness about utility impacts**. The project manager indicated that the UCM has been beneficial in raising awareness among all team members about all of the utility locations and conflicts on the project. The project manager is now much more aware of utility issues on the project.
- **Developing the UCM took longer than originally expected**. One of the challenges of the use of the UCM is the limited amount of time and resources district officials have to prepare the matrix. Using the UCM was time-consuming at the beginning, which highlights the need for software to automate the detection of utility conflicts and populate the UCM. In this regard, district officials found that the method to analyze conflicts and populate the UCM was key to increasing productivity. During the development of the first UCM, the project team made several observations to accelerate UCM development in the future. For example,
    - District officials concluded that the fastest way to identify utility conflicts was to start at the beginning station, pick a utility line, and document all conflicts for that line until the end of the project. Then continue with the next line at the project beginning station.
    - Utility conflict identification was much easier while viewing the project file in MicroStation versus paper drawings, because it allowed project staff to turn levels on and off, zoom in as needed, and quickly measure stations and offsets.
    - The project team deleted the automated drop-down menus and used different tabs for different utility types (water, sewer, communications, and so on). The idea of using a different tab for each company did not work for the group because initially they did not know which company owned which facility. The group also prepared a separate file for water lines with portions that needed to be relocated. In addition, the project team standardized utility conflict descriptions because that made it easy to sort them, and they color-coded utility conflicts to indicate status.
- **More guidance on the definition of utility conflicts would be useful**. Project staff had several questions when they first started using the UCM, including how to define a utility conflict. District officials had a question on whether it would be advisable to group utility conflicts by segments of utility facilities affected in an effort to reduce the number of actual utility conflicts. For instance, if a gas line runs 1,000 feet through the project and is affected at multiple locations, is it advisable to identify multiple utility conflict locations or just one conflict location?

- **Graphical representations of utility conflicts are needed in MicroStation**. For example, conflict outlines or icons could be generated in MicroStation and saved on a separate level.

District 5: Wayson's Corner Park-and-Ride Lot Expansion Project

The Wayson's Corner park-and-ride lot is located between MD 4 and Southern Maryland Boulevard (MD 794), just south of the westbound exit ramp on MD 4 that connects with Southern Maryland Boulevard and Mount Zion Road (MD 408) (Figure 2.10 and Figure 2.11). The proposed expansion on the southeast end of the lot will provide 75 additional spaces and one additional entrance. The expansion is needed because the current number of parking spaces is inadequate for the forecasted demand for commuter parking. The lot currently accommodates 101 parking spaces, one bus shelter, and two entrances. Concrete sidewalks adjacent to the new parking spaces will provide pedestrian access to the existing bus shelter. The project has been studied for various parking lot arrangements and storm water management configurations. Access to the park-and-ride lot is from MD 794.

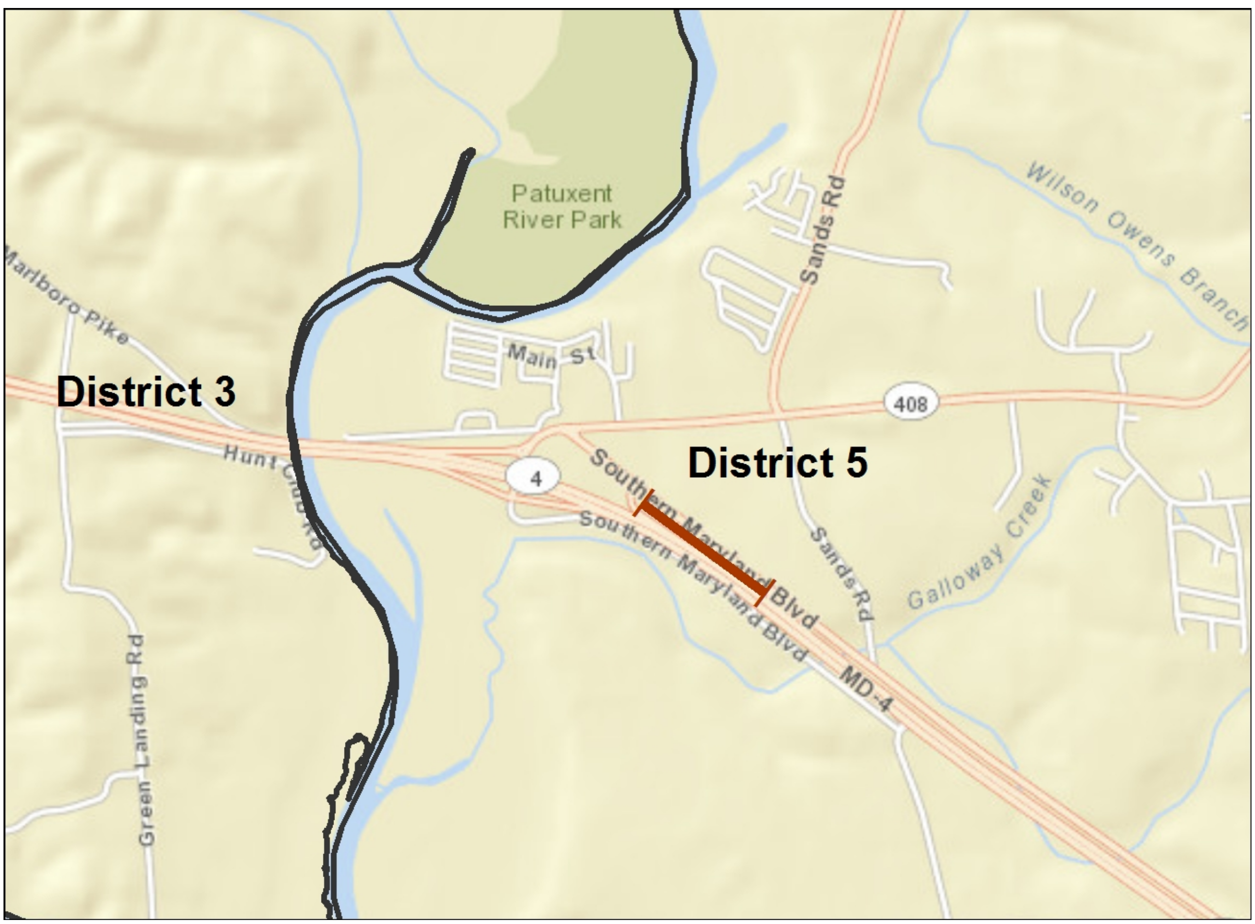


Figure 2.10. Wayson's Corner park-and-ride lot expansion project location.

Figure 2.11. Wayson's Corner park-and-ride lot.

The project design is complete. The notice to proceed was issued in November 2013. Utility relocation work began shortly thereafter without any problems to date. Because of the cold weather approaching and construction material parameters, the construction area engineer expects that actual construction will be delayed until the spring of 2014.

During the design phase, the district identified 15 conflicts and developed strategies to resolve the conflicts. There were two utilities with facilities that potentially conflicted with the roadway project. The district modified the design to avoid these facilities. District officials noted that the design modifications might have taken place even if the UCM had not been used. However, the UCM was useful because it called attention to the intent to make the design changes, which otherwise might possibly have been overlooked.

Lessons learned by district staff in connection with the UCM approach include the following:

- **The UCM is useful to document utilities and related challenges**. District staff mentioned that the UCM could be a useful tool to demonstrate and document project challenges to the MDSHA management, provide explanation for project delays, and help develop action plans to move projects forward.

- **Populating and maintaining UCMs takes time**. The utility coordinator saw potential on the use of the UCM (particularly for other stakeholders such as designers and project managers) but indicated that populating and maintaining UCMs would take up time that they do not have given their current workload. The project manager indicated that this was a good project for trying the UCM approach because there were not many potential conflicts and the project was in the final design stage when the UCM work began, thus allowing ample time to fill out the matrix. However, the project manager was concerned about having enough time to complete the matrix on a project with several hundred potential conflicts. In their view, understanding and analyzing utility conflicts using project plans is straightforward, and there is little need for a process to document that analysis. District utility coordinators prefer using a simple table that shows dates when milestones for individual utility companies are completed (e.g., plans sent, plans returned, prior right forms completed, and so on), instead of tracking details about the utility conflict and plans to resolve it.
- **Limiting UCM updates to major milestones would reduce required labor effort**. If MDSHA makes the use of UCM permanent, district officials suggested updating the UCM only at major project milestones. It would also be the responsibility of the design consultant to keep the UCM up to date. District staff also pointed out that while conflict identification is important, utility owner notification is equally important.
- **Projects with significant utility impacts might be more suitable for the UCM approach**. District officials indicated it might have been more useful to use the UCM approach on a different project on MD 175. On this project, the district ran into a major problem with a communication duct bank that had to be relocated at an estimated cost of $2.5 million because it was too late to redesign hydraulic features.
- **Including a utility relocation schedule would make the UCM more useful**. Utility relocations frequently need to take place at different times. District staff would like to see a schedule showing the order in which utility installations need to move as well as predecessor and successor conditions. To address this issue, district officials added a column labeled “Priority” but never found the time to fill it out. Alternatively, there could be a flowchart of the relocation plan on a separate sheet. The district was also interested in a field providing the relocation duration based on the estimated completion date. The project manager revised the UCM by adding a column indicating when each conflict was reviewed and by whom, instead of tracking changes at the spreadsheet or tab level using the header of the UCM. However, the district staff did not use the column.

District 7: MD 32 Road Widening from Day Road to West Friendship Road

This project involves widening approximately one mile of MD 32 from approximately 750 feet south of Day Road to approximately 500 feet north of West Friendship Road to accommodate a 13-foot-wide continuous center turn lane and shoulders that vary from 6 to 10 feet wide in addition to 11-foot-wide through lanes (Figure 2.12 and Figure 2.13). South of Day Road and north of West Friendship Road, the widening will taper back down and tie into the existing 44-foot pavement section comprised of 12-foot through lanes and 10-foot shoulders. These improvements will provide space for vehicles leaving or entering the roadway to decelerate, accelerate, and/or queue outside of the through lanes. Additionally, the full-width shoulders will be signed and marked as bicycle lanes within the limits of the work. Within the project limits, MD 32 is approximately 44 feet wide. It is open section with drainage ditches on both sides. There are numerous private driveways and three local roads within the project limits, all of which include unsignalized intersections.

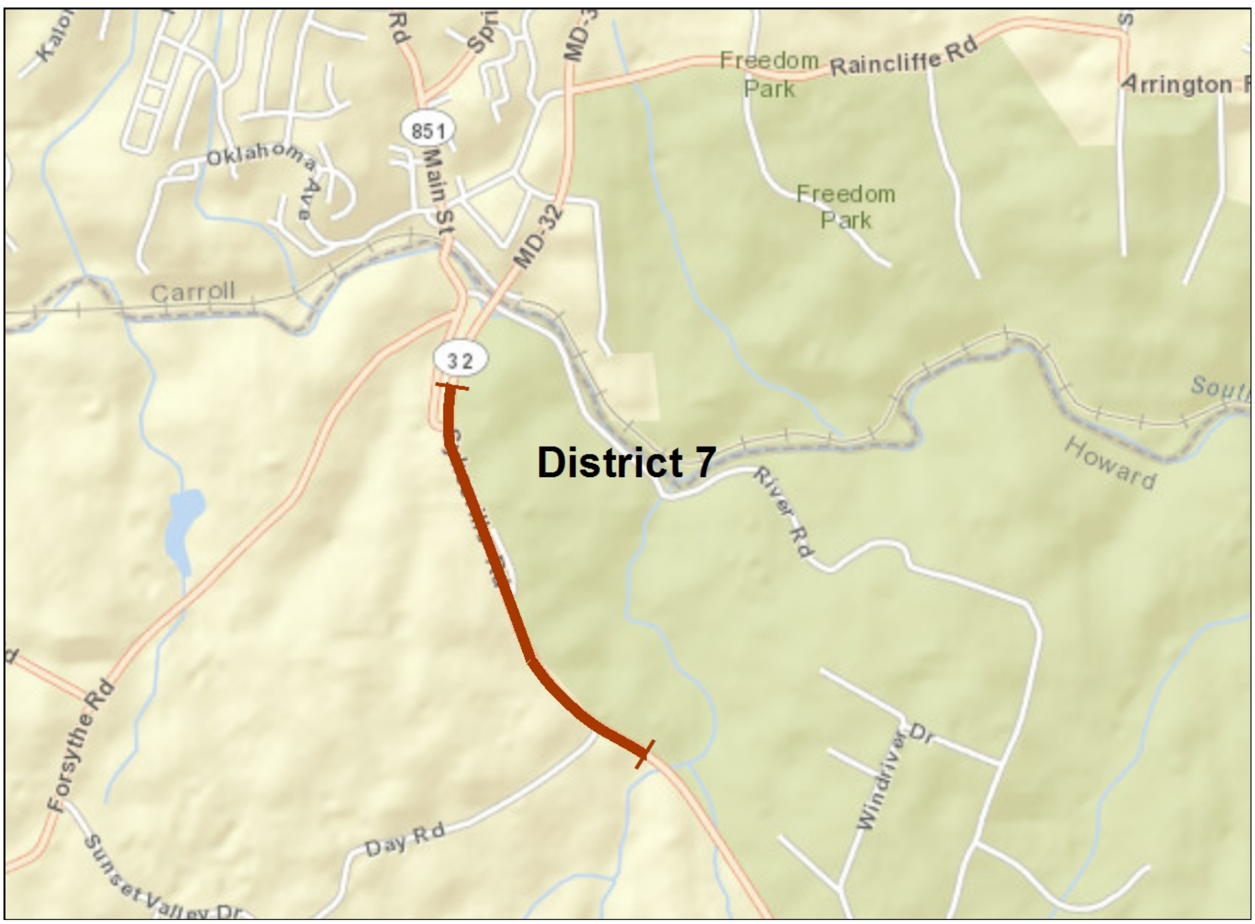


Figure 2.12. MD 32 road widening project location.

Figure 2.13. MD 32 between Day Road and West Friendship Road.

The project design was completed in November 2013. The project was advertised in December 2013, with the notice to proceed anticipated in March or April 2014. District officials started using the UCM in May 2013 and used it for meetings and discussions with utility companies. In preparation for a meeting with utility owners in May 2013, the district identified six utility owners as having facilities along the corridor: Verizon Electric, BGE–Electric, BGE–Gas, Howard County Fiber, Colonial Pipeline, and Comcast. About 114 potential conflicts were identified and documented on the UCM. Many of the potential conflicts were resolved, that is, determined not to be in conflict or avoided by making minor design changes. The May 2013 meeting focused on necessary relocations and conflicts that could not be resolved until more information (i.e., test holes, cross sections, final grades, etc.) were available.

Subsequent test holes confirmed that a gas line was not in conflict with the pavement reconstruction and could remain in place. However, several poles owned by BGE with attachments by Comcast and Verizon Wireless would have to be relocated. The district prepared an updated version of the UCM to include this information in preparation for a second utility coordination meeting with utility owners in October 2013. The anticipated schedule called for BGE to install new poles, after which Comcast would move its facilities from the existing poles to the new poles, and finally Verizon Wireless would relocate its facilities. According to the UCM, this process was estimated to take nine months from February 2014 to October 2014.

At the October 2013 utility coordination meeting, the BGE representative indicated that BGE had four poles that could not be relocated until trees were trimmed and notches were cut in the slope where the new poles were to be placed. The highway contractor would have to perform this work. Because the notice to proceed would not take place until March or April 2014, the BGE relocation start date would need to be pushed back from February to May 2014. The Comcast and Verizon Wireless start dates would need to be modified accordingly. These changes would involve a revision in project phasing to ensure that the highway contractor has enough work to do in other locations while the utility companies relocate their facilities. The project manager and the utility coordinator worked with utilities representatives to clarify the necessary details and updated the UCM to include the new information.

Lessons learned by district staff in connection with the UCM approach include the following:

- **The UCM facilitates communication at utility coordination meetings**. Meeting participants were complimentary of the UCM, which was used during the meetings as different potential conflicts were discussed. District officials stressed to utility representatives that MDSHA wanted to avoid utility relocations as much as possible and urged them to let the district know if there were other potential conflicts that might be avoided by making minor design changes.
- **Using the UCM has resulted in a tangible economic benefit**. The preliminary estimate for utility relocations in the funding request was $1,161,875, including a 25% contingency and 14% overhead. District officials indicated that this estimate would likely decrease by approximately $800,000 because all drainage conflicts with the gas line were avoided through realignment of the proposed drainage pipes, and it was confirmed that BGE-Gas had no conflicts with full-depth pavement reconstruction. Documenting utility conflicts systematically by using the UCM approach was directly responsible for the identification of the resolution strategy, resulting in more than $500,000 in savings. The remaining $300,000 corresponds to lower overall costs than initially estimated and less utility relocation than expected, which became evident after estimating costs but before starting the UCM.
- **Using the UCM has resulted in tangible delay savings**. A rough estimate of time benefits provided by district officials indicated that avoiding the gas line provided a delay savings of about 4 to 6 months.
- **UCM facilitates coordination with utilities and contributes to better working relationships**. According to district officials, the most significant benefit of using the UCM was that it helped them determine that all utility conflicts were on one side of the road and that conflicts could be avoided by changing the sequencing of the work. This made coordination activities with utility owners much easier and created much goodwill

by utility owners. Utility owners noted that MDSHA made a significant effort to avoid unnecessary relocations, which resulted in a much better working relationship with utility owners (and will likely have a positive impact on future projects).

- **The UCM process facilitates MDSHA internal teamwork**. District officials found that the UCM process facilitated teamwork among district staff and brought the district closer together. It also encouraged designers to challenge conventions and think outside the box. Utility coordinators mentioned that the UCM process helped them better understand how designers approach utility conflicts and what process they have to go through to resolve them. The UCM process also helped to make designers aware of where utilities are on the project.
- **Identifying conflicts and populating the UCM take time**. District officials spent a considerable amount of time identifying potential conflicts and populating the UCM. Officials expressed concern about finding the time to populate and manage the UCM on future projects. The time spent to develop the first version of the UCM was about one person for one and a half day, and two persons for about half a day, or about 20 staff-hours total. However, it was not entirely clear if this estimate was just the time to populate the UCM or if it also included the time to review the project for utility conflicts. The time estimate did not include the time to maintain and update the UCM following design changes. Using software to automate the identification of utility conflicts and populating the UCM would likely result in time savings for the agency.
- **Use of the cost alternative subsheet is time-consuming**. The project manager did not find the cost alternative subsheet particularly useful and did not use it. It would have taken too much time to document various alternatives to resolve utility conflicts. However, the sheet might be useful for complex utility conflicts on larger projects.
- **The current UCM process can be tweaked for efficiency gains**. As district officials learned to use the UCM, they identified ways to optimize its use moving forward. For example, utility conflicts could be grouped by station, as in the case of utility poles that are in conflict. At these locations, all utility owners involved would be listed together (although each would have separate conflicts). This would not change the number of conflicts but would list all conflicts at any particular station in one place.
- **There is a need to train district staff on the use of MicroStation and provide easier access to the software**. District staff pointed out that district personnel might not have easy access to MicroStation or might not know how to use it. Similarly, many small utility companies do not use computer-aided design (CAD). To make the UCM process work, it would be extremely beneficial for districts to receive more training on how to use MicroStation.
- **There is a need for a UCM guidebook in addition to the UCM training course**. There was consensus among district staff that, in addition to the UCM training course, there should be guidelines to help stakeholders prepare and maintain the UCM. Staff would also like to see a column or other mechanism to help them identify the order in which

utilities need to relocate. It is worth noting that the updated training materials (see Chapter 4) include a number of changes and additions to the original training course materials (which District 7 officials were exposed to in January 2013). The updated training materials are designed to provide more guidance to users on how to prepare and maintain the UCM. These materials also provide more information on the business process, that is, at what project development and delivery milestones it is recommended to populate or maintain the UCM.

CHAPTER 3
Utility Conflict Data Model and Database

Introduction

The research team updated the UCM data model and Access database to reflect suggestions from MDSHA district officials on the usability of the UCM approach as well as lessons learned by members of the research team as part of other research initiatives, in particular related to the development of generalized inventories of utility facilities within the highway right-of-way. Part of this effort involved developing data entry forms in Access to manage information about projects, utility owners, utility facilities, and utility conflicts. This chapter describes the various components of the UCM data model and database, including the following:

- **Business process model**. This model describes the process to identify and manage utility conflicts.
- **Conceptual model**. This model is a high-level representation of groups of objects or entities that are needed to manage utility conflicts. This model also provides a high-level representation of relationships between those objects or entities.
- **Logical data model**. This model is a representation of data characteristics and relationships at a level that is independent of any physical implementation.
- **Physical data model**. This model is a representation of data characteristics and relationships that depends on the specific physical platform chosen for its implementation. For this project, the research team prepared physical data models in Access and Oracle.
- **Data entry forms**. These Microsoft Access forms enable the management of information about projects, utility owners, utility facilities, and utility conflicts.

Stand-alone versions of these model components have been prepared (delivered separately).

Business Process Model

Figure 3.1 provides a graphical representation of the traditional design-bid-build project development and delivery process. The diagram depicts both phases (planning, preliminary design, and so on) as well as major functional areas (environmental, real property, utilities, and so on). The model corresponds to the general case in which a project goes through all phases of development and delivery. In reality, the type of project drives what phases and activities are involved. Figure 3.1 also shows a zoomed-in view of the project development and delivery process that focuses on utility activities. To function properly, the utility process needs utility data input, which occurs at different times of the process. Typically, as time progresses, utility information becomes more detailed and precise. Other elements of the utility process include coordination of utility relocation activities, preparation and execution of utility agreements, preparation of utility certifications, and monitoring of utility relocations and reimbursement of utility owners.

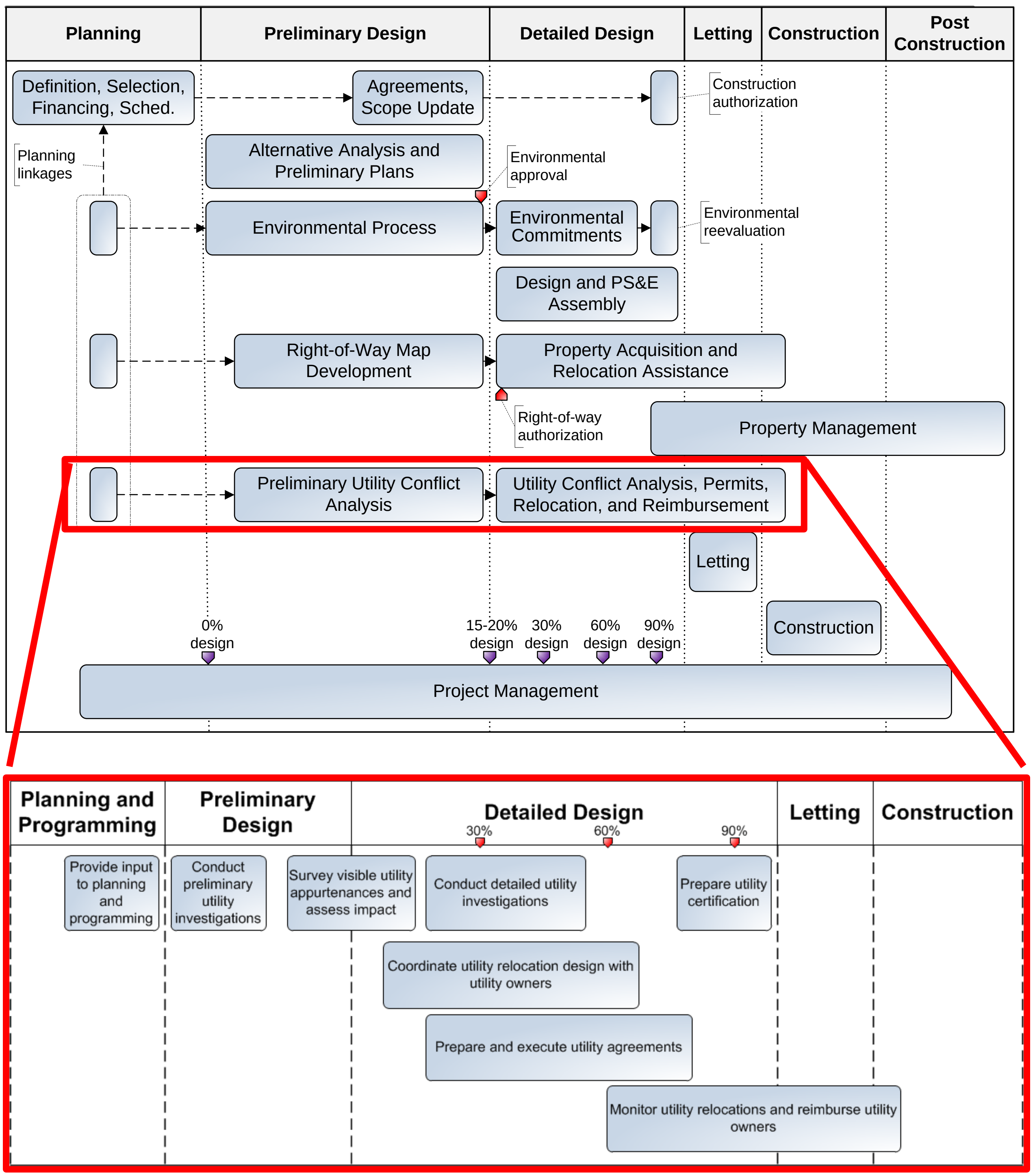


Figure 3.1. Utility process within the project development and delivery process (PS&E = plan, specifications, and estimate).

Utility conflict management is a multistage activity within the utility process. Although every project is different, a generalized description of the major utility process stages follows.

Utility Process: Stage 1

Stage 1 corresponds to the beginning of the process when potential utility conflicts are identified for the first time. It involves the following activities:

- Conduct preliminary investigation based on existing records. This corresponds to a quality level D (QLD) investigation.
- Assess potential impact. For each potential conflict, determine whether the utility is in conflict or whether more accurate data are needed to make a determination. Depending on project specifics, this assessment can occur with input from utility owners or can be performed by an internal DOT review team. An initial utility coordination meeting is advisable at this point. Results of the assessment should be communicated with utility owners.

Utility Process: Stage 2

Stage 2 corresponds to the part of the process (typically at the end of the preliminary design phase or beginning of the design phase) when the agency collects detailed survey data, including visible utility appurtenances. It includes the following activities:

- Survey visible utility appurtenances. The survey should include all aboveground utility facilities, such as poles, guy wires, manholes, and valves. This corresponds to a quality level C (QLC) investigation when correlated to belowground utility facilities.
- Assess potential impacts. For each potential conflict, determine whether the utility is in conflict or whether more accurate data are needed to make a determination. For belowground installations, QLB data might be needed to make that determination. In that case, the assessment should list the locations where the QLB data are needed.
- Analyze and review utility conflict resolution strategies, including the option to make changes to the highway design. Depending on project specifics, this assessment can occur with input from utility owners or can be performed by an internal agency review team. This stage should include a utility coordination meeting to discuss conflicts and potential strategies. Results of the assessment should be communicated with utility owners.

Utility Process: Stage 3

Stage 3 corresponds to the part of the process, around 30% design, when the agency collects detailed information about belowground utility installations and uses the resulting data to identify or confirm utility conflicts as well as analyze and review utility conflict resolution strategies. It includes the following activities:

- Conduct detailed utility investigations with appropriate geophysical methods at QLB for the location and soil conditions of the project to produce a map of horizontal locations of belowground utility installations. QLB investigations often turn up a significant number of previously “unknown” utility facilities, raising the question as to the benefit of limiting investigations to only existing records (i.e., QLD data) or QLC data.
- Assess potential impact. For each potential conflict, determine whether the utility is in conflict or whether QLA test hole data are needed.
- Analyze and review utility conflict resolution strategies, including the option to make changes to the highway design. Depending on project specifics, this assessment can occur with input from utility owners or can be performed by an internal agency review team. This stage should include a utility coordination meeting to discuss utility conflict resolution strategies. Results of the assessment should be communicated with utility owners.
- If a utility installation needs to be relocated, coordinate utility relocation design with utility owners. Coordination with utility owners involves all aspects leading to the identification and design of utility conflict resolution measures and setting dates by which critical milestones must be complete.
- Prepare and execute utility agreements. Preparation and execution of utility agreements is typically required for utilities that will seek reimbursement for their utility relocation costs. These agreements outline the conditions of the utility accommodation, responsibilities of the parties involved, important timelines, and procedures for the relocation.

Utility Process: Stage 4

Stage 4 corresponds to the part of the process, around 60% design (or earlier if possible), when the agency exposes belowground utility installations at specific locations to gather accurate depth data and other critical facility information. At 60% design, critical elements of the project design are in place, including the horizontal and vertical alignments and the drainage design. Stage 4 includes the following activities:

- Conduct detailed utility investigations at QLA at specific locations to gather accurate depth data and other critical facility information.
- Assess potential impact. For each potential conflict, determine whether the utility is in conflict or not.
- Analyze and review utility conflict resolution strategies, including the option to make changes to the highway design. Depending on project specifics, this assessment can occur with input from utility owners or can be performed by an internal DOT review team. This stage should include a utility coordination meeting to discuss utility conflict resolution strategies. Results of the assessment should be communicated with utility owners.

- If a utility installation needs to be relocated, coordinate utility relocation design with utility owners. Coordination with utility owners involves all aspects leading to the identification and design of utility conflict resolution measures and setting dates by which critical milestones must be complete.
- Prepare and execute utility agreements. Preparation and execution of utility agreements is typically required for utilities that will seek reimbursement for their utility relocation costs. These agreements outline the conditions of the utility accommodation, responsibilities of the parties involved, important timelines, and procedures for the relocation.

Utility Process: Stage 5

Stage 5 corresponds to the part of the process, around 90% design, when the agency begins to prepare utility certifications for plan, specifications, and estimate (PS&E) documents. This stage also involves monitoring utility relocations and reimbursing utility owners, as applicable. It includes the following activities:

- Prepare utility certifications. Many agencies include a listing of pending utility relocations in the letting documents to alert potential bidders about utilities that will need to be adjusted during the construction phase of the project.
- Monitor utility relocations and reimburse utility owners. Monitoring utility relocations includes ensuring that (a) relocated utilities are built and surveyed in accordance with standard project survey accuracy requirements and (b) as-changes are made to the design plans to reflect as-built conditions.

Utility Process: Stage 6

Stage 6 corresponds to the part of the process, normally at the beginning of the construction phase, when utilities finish relocating facilities on the ground. Depending on the situation, utility relocations might also be included in the highway contract. This phase also involves managing new utility conflicts that are identified, including conflicts that were missed earlier in the project. It includes the following activities:

- Monitor utility relocations and reimburse utility owners. Monitoring utility relocations includes ensuring that (a) relocated utilities are built and surveyed in accordance with standard project survey accuracy requirements and (b) as-changes are made to the design plans to reflect as-built conditions. Ideally, utility relocations should be completed before the beginning of construction. In reality, some utility installations may need to take place during the construction phase. This part of the process also involves reimbursing utility owners for eligible relocation expenses.
- Analyze, review, and implement utility conflict resolution strategies for conflicts that are identified during construction.

UCM Updates

Effective utility conflict management involves preparing and using UCMs systematically throughout the entire utility process. Using the six-stage process described earlier, UCMs could be updated as follows (or at other critical milestones as needed):

- UCM 1: During preliminary design.
- UCM 2: End of preliminary design or beginning of detailed design.
- UCM 3: Around 30% detailed design.
- UCM 4: Around 60% detailed design.
- UCM 5: Around 90% detailed design.
- UCM 6: During construction.

Conceptual Model

Managing utility conflicts involves managing data about those conflicts as well as all kinds of related data. Conceptually, it is possible to identify six first-level (or core) topics or data objects that pertain to utility conflicts: utility conflict, utility facility, utility agreement, document, project, and user (Figure 3.2). Each of these data objects represents a real-world object that can be characterized by using a set of relevant tables and attributes. The arrows represent high-level relationships between real-world objects. Notice that the real-world objects could be data systems or modules. In this case, the corresponding oval is a placeholder for that data system or module. For example, the project oval would be the placeholder for a project database or system, the utility facility oval would be the placeholder for a computerized inventory of utility facilities, and the utility conflict oval would be the placeholder for a module for managing utility conflicts.

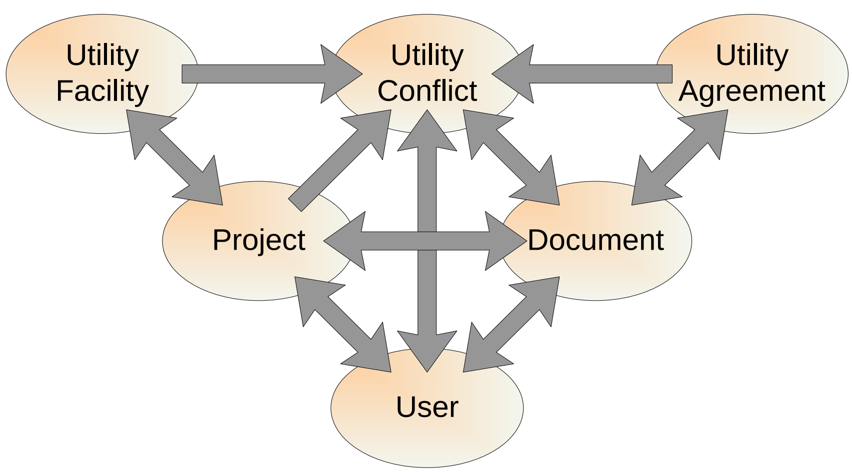


Figure 3.2. Conceptual model for the management of utility conflicts.

Logical Data Model

The research team developed a logical data model using AllFusion ERwin Data Modeler software. To facilitate implementation, the logical data model complied with the following requirements and standards:

- Use of information engineering notation to model entity relationships.
- “Third normal form” normalization level.
- Entity names use alphanumeric (no special) characters, have fewer than six words, and are derived from the data description.
- Attribute names use alphanumeric (no special) characters, have less than six words, and consist of one or more prime words, zero or more qualifier words, and end with one class word. Prime words represent the subject or entity name (e.g., UTILITY CONFLICT). A qualifier word is a descriptive word that further qualifies the prime word (e.g., TYPE). A class word indicates the type of attribute and is chosen from a standardized list of 21 words (e.g., ID, NAME, TEXT) (*3*).
- Attributes use standardized data types. Using standardized data types in the logical data model simplifies compliance with requirements of data types for the physical data model. These requirements can be satisfied by providing a mapping between logical and physical data types.

The logical data model was built around core entities that were identified in the conceptual model. The research team accomplished this objective by using subject areas that provide a coherent view of all the entities associated with their corresponding core entity. Appendix A provides a list of all the entities in the data model. The data model includes eight subject areas, that is, one for each core data object in the conceptual model, as well as one subject area for spatial entities and one subject area for application support entities, as follows:

- Utility conflict,
- Utility facility,
- Utility agreement,
- Project,
- Document,
- User,
- Application support, and
- Spatial entity.

The following sections provide a description of the utility conflict and utility facility subject areas. Other subject areas are not described in more detail in this report, but the data dictionary and other documentation provide additional information as needed. The utility conflict subject area includes all the entities needed to manage utility conflict information as well as information needed to relate utility conflict data to other components of the data model. The utility facility subject area includes a data model to build comprehensive inventories of utility facilities along transportation corridors. Agencies could use this data model not just to provide support to the utility conflict management function but also to develop stand-alone utility inventories.

The design of the data model took into consideration that agencies may already have database systems in place to manage business processes that are related to utility agreements, projects, documents, utility inventories, and system users. During implementation, it may be possible to develop a linking entity between any of the core entities in the data model and a corresponding entity in an existing information system. For example, a linking entity could be developed to link the PROJECT entity in the data model with a corresponding entity in an enterprise system that manages project-related data. It might even be possible to replace an entire subject area in the data model with an existing information system at the agency. In this scenario, each of the subject areas in the logical data model actually becomes a placeholder for an information system. Alternatively, if the agency does not currently have a specific database system in place, the data model can be used to implement a basic tool for the management of these business processes.

Utility Conflict Subject Area

The Utility Conflict subject area consists of the main entity UTILITY CONFLICT, related lookup tables, and linkages to other subject areas (Figure 3.3). Table 3.1 provides a listing of the subject area entities and their definitions. A list of all data model entities and definitions is included in Appendix A. At the lowest level, the primary key for a utility conflict is the UTILITY CONFLICT ID attribute. This ID is unique within the database and should be automatically assigned by the database system to ensure uniqueness. UTILITY CONFLICT also includes an attribute (UTILITY CONFLICT NUMBER), which can be edited by users as needed.

The UTILITY CONFLICT entity has 28 attributes to describe a utility conflict, most of which are optional attributes. Mandatory attributes are DOT PROJECT ID, UTILITY FACILITY ID, UTILITY CONFLICT ID, and UTILITY CONFLICT DESCRIPTION. In addition, a utility conflict requires at least one design plan sheet number indicating where the utility conflict was found. This attribute is stored in table PLAN DOCUMENT (within the DOCUMENT subject area).

UTILITY CONFLICT links to UTILITY CONFLICT EVENT, which stores data about changes to utility conflicts, including the ID of the user who made that change. Examples of events include utility conflict identified, utility conflict revised, permit application, permit approved, and many others that are stored in UTILITY CONFLICT EVENT TYPE.

The Utility Conflict Subject Area also contains several linkages to other core tables and/or subject areas. These linkages resolve many-to-many relationships. Linkages include UTILITY CONFLICT ASSIGNMENT, which links utility conflicts to the system user subject area using SYSTEM USER ID; TEST HOLE UTILITY FACILITY, which links utility investigation test holes to utility facility records; and UTILITY CONFLICT EVENT DOCUMENT, which links utility conflict events to records of documents in the system.

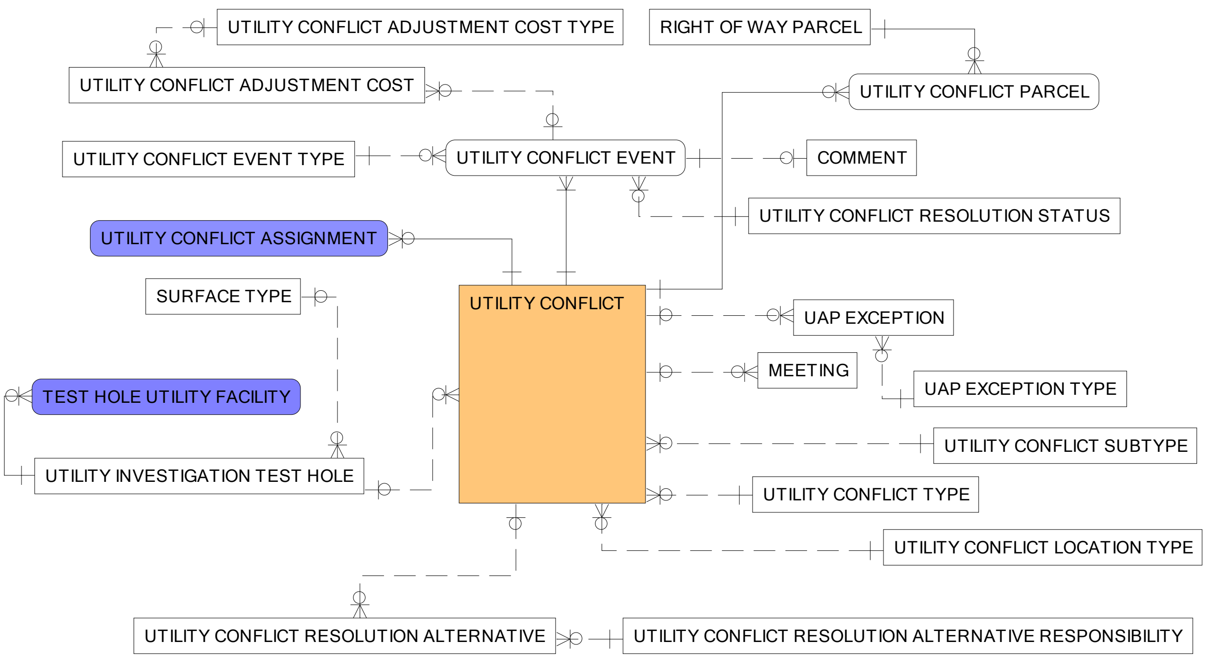


Figure 3.3. Utility conflict subject area (UAP = utility accommodation policy).

Table 3.1. Utility Conflict Subject Area Entities and Definitions

Entity Name	Definition
COMMENT	A COMMENT is miscellaneous information that provides extra detail or description for an event.
MEETING	A MEETING is a gathering of people for the purpose of discussing a typically predetermined topic.
RIGHT-OF-WAY PARCEL	A RIGHT-OF-WAY PARCEL is a parcel that must be acquired as part of a DOT project.
SURFACE TYPE	A SURFACE TYPE is a category that describes a kind of manmade or natural ground surface. Examples of a SURFACE TYPE are asphalt, concrete, or natural ground.
TEST HOLE UTILITY FACILITY	A TEST HOLE UTILITY FACILITY is a mapping that represents the many-to-many relationships between a TEST HOLE and a UTILITY FACILITY. TEST HOLE UTILITY FACILITY enables the identification of UTILITY FACILITIES associated with a TEST HOLE and the identification of TEST HOLES associated with a UTILITY FACILITY.
UAP EXCEPTION	A UAP EXCEPTION is an exemption to the state's utility accommodation policy.
UAP EXCEPTION TYPE	A UAP EXCEPTION TYPE is a category that describes a certain kind of UAP EXCEPTION.
UTILITY CONFLICT	A UTILITY CONFLICT is an instance in which a utility facility is noncompliant with the DOT's utility accommodation policies, is noncompliant with safety regulations, is in conflict with a proposed transportation project feature, or is in conflict with another utility facility. A UTILITY CONFLICT can be resolved by using an appropriate measure such as modifying the proposed transportation design, relocating the utility facility, abandoning the facility in place, protecting the facility in place, or granting an exception to the state's utility accommodation polices or safety regulations.
UTILITY CONFLICT ADJUSTMENT COST	A UTILITY CONFLICT ADJUSTMENT COST is the amount that a utility owner estimates to expend on the removal of a utility conflict by adjusting the utility facility.
UTILITY CONFLICT ADJUSTMENT COST TYPE	A UTILITY CONFLICT ADJUSTMENT COST TYPE is a characterization of a UTILITY CONFLICT ADJUSTMENT COST.
UTILITY CONFLICT ASSIGNMENT	A UTILITY CONFLICT ASSIGNMENT is a designation of a person to a UTILITY CONFLICT for a specific purpose, such as responsibility to manage and resolve the conflict.
UTILITY CONFLICT EVENT	A UTILITY CONFLICT EVENT is the occurrence of a change to a UTILITY CONFLICT.
UTILITY CONFLICT EVENT TYPE	A UTILITY CONFLICT EVENT TYPE is a category that describes a certain kind of UTILITY CONFLICT EVENT.
UTILITY CONFLICT LOCATION TYPE	A UTILITY CONFLICT LOCATION TYPE is a characterization of the location of a utility conflict relative to the surface of the earth. Valid values for a UTILITY CONFLICT LOCATION TYPE are "overhead (aboveground)" and "belowground."

Entity Name	Definition
UTILITY CONFLICT PARCEL	A UTILITY CONFLICT PARCEL is a mapping between a UTILITY CONFLICT and a RIGHT-OF-WAY PARCEL. It identifies all UTILITY CONFLICTS associated with a RIGHT-OF-WAY PARCEL, and all RIGHT-OF-WAY PARCLELS associated with a UTILITY CONFLICT. As such, the table identifies all RIGHT-OF-WAY PARCELS that are affected by a UTILITY CONFLICT.
UTILITY CONFLICT RESOLUTION ALTERNATIVE	A UTILITY CONFLICT RESOLUTION ALTERNATIVE is an option to resolve a utility conflict. Typically, there are multiple resolution alternatives for each utility conflict, which may or may not be feasible.
UTILITY CONFLICT RESOLUTION ALTERNATIVE DECISION	A UTILITY CONFLICT RESOLUTION ALTERNATIVE DECISION is an option for a determination on how to proceed with one of multiple alternatives for the resolution of a utility conflict. Examples of a UTILITY CONFLICT RESOLUTION ALTERNATIVE DECISION are “Rejected,” “Under Review,” and “Selected.”
UTILITY CONFLICT RESOLUTION ALTERNATIVE RESPONSIBILITY	A UTILITY CONFLICT RESOLUTION ALTERNATIVE RESPONSIBILITY is a description of the party that is responsible for resolving a utility conflict. Examples of a UTILITY CONFLICT RESOLUTION ALTERNATIVE RESPONSIBILITY are “DOT,” “Utility Owner,” “Utility Owner and DOT,” and “undetermined.”
UTILITY CONFLICT RESOLUTION STATUS	A UTILITY CONFLICT RESOLUTION STATUS is a definition of the status that a UTILITY CONFLICT can have in the process of resolving the conflict. For example, a UTILITY CONFLICT RESOLUTION STATUS can be “Utility conflict created,” “Utility owner informed of utility conflict,” “Utility conflict resolution strategy selected,” or “Utility conflict resolved.”
UTILITY CONFLICT SUBTYPE	A UTILITY CONFLICT SUBTYPE is a characterization that further describes a kind of UTILITY CONFLICT TYPE. Examples of a UTILITY CONFLICT SUBTYPE are “Finish Grade,” “Pathway,” and “Excavation.”
UTILITY CONFLICT TYPE	A UTILITY CONFLICT TYPE is a characterization that describes a kind of UTILITY CONFLICT. Examples of a UTILITY CONFLICT TYPE are “project feature conflict” and “utility regulation conflict.”
UTILITY INVESTIGATION TEST HOLE	A UTILITY INVESTIGATION TEST HOLE is a small opening in the ground, typically made with a vacuum excavation technique, for the purpose of determining the exact vertical and horizontal position of a buried utility facility.

Utility Facility Subject Area

The utility facility subject area in the original SHRP 2 R15B deliverables only included the minimum number of utility inventory entities needed to manage utility conflicts. As such, those entities were placeholders for a more comprehensive treatment of utility facility-related data within the highway right-of-way. At the time, there were other ongoing utility research initiatives, including SHRP 2 R01A, R01B, and R01C. SHRP 2 R01A, Technologies to Support Storage, Retrieval, and Use of 3D Utility Location Data, was charged with the development of a 3-D platform for developing utility facility inventories. As of this writing, the SHRP 2 R01A products have not been delivered yet. On the basis of preliminary presentations, the products will include a software prototype for building 3-D utility data models with a highly aggregated structure to handle utility data. This structure uses only two feature classes per type of utility (e.g., one point feature class and one linear feature class for water installations, as well as one point feature class and one linear feature class for wastewater installations) using the Spatial Data Standards for Facilities, Infrastructure, and Environment (SDSFIE) (*4*). Differentiation among facilities within a specific utility class is by attribute.

Members of the research team have been involved in a number of other initiatives related to the development of strategies for preparing comprehensive inventories of utility facilities within the right-of-way. Two of those initiatives are a recent study completed for the Florida DOT (FDOT), which involved the use of Bentley MicroStation and GEOPAK files and protocols in conjunction with an Esri ArcGIS platform (*5*), and an ongoing study for FHWA on the use of 3-D platforms for developing utility inventories within the right-of-way.

This section provides a summary of a generalized platform for developing utility inventories that can be used both for managing utility facility information needed to manage utility conflicts (i.e., the main purpose of this pilot implementation) and for developing long-term repositories of utility facility information. The data model is generic and can be used both for 2-D and 3-D applications because the model is based on real-world objects. At the same, the model is platform independent and can be implemented in a variety of platforms such as MicroStation, AutoCAD, and ArcGIS.

The Utility Facility subject area consists of the main entity UTILITY FACILITY, related lookup tables, and linkages to other subject areas (Figure 3.4, Table 3.2). Each record in UTILITY FACILITY represents a utility facility on the ground (or in development), which has several attributes, including utility type (e.g., communication, electric, gas), utility subtype (e.g., communication manhole, communication line), a brief description, whether it is a public or private utility, whether it is an aboveground or belowground facility, and utility owner.

UTILITY FACILITY stores some basic information. Additional attributes (depending on the type of information) are stored in UTILITY FACILITY DETAIL and UTILITY FACILITY FEATURE CLASS. The utility type is stored in FEATURE CLASS SHAPE, while the subtype is stored in UTILITY FACILITY FEATURE CLASS. The latter contains a list of 46 common utility facilities subtypes (e.g., communication pole, electric line) that could be expanded as needed. Although all attributes could have been included in just one entity, UTILITY FACILITY, the researchers used a split-table design because there are many utility facility attributes, and many attributes are specific to a type of utility (e.g., barrel diameter is specific to a manhole). Using just one large entity would have produced a wide, sparsely populated table. The split-table design is intended to reduce the overhead of managing UTILITY FACILITY, which is being used by many tables in the database, making the system more efficient. Appendix B includes a list of attributes associated with all feature classes defined in the database.

Although UTILITY FACILITY DETAIL contains most of the descriptive data about a utility facility, such as length, width, height, and material, another table is used to define which of the attributes in UTILITY FACILITY DETAIL apply to which UTILITY FACILITY FEATURE CLASS. For example, a communication line would be expected to have a depth or a material, but not a barrel diameter. The definition of applicable attributes for each utility facility feature class is provided by FEATURE CLASS ATTRIBUTE. This linking table allows the management of utility facility feature attributes by using a data table instead of hardcoding values. If an agency decides to track and display additional attributes for a particular utility facility feature class, it can do so simply by editing the table instead of rewriting the system code.

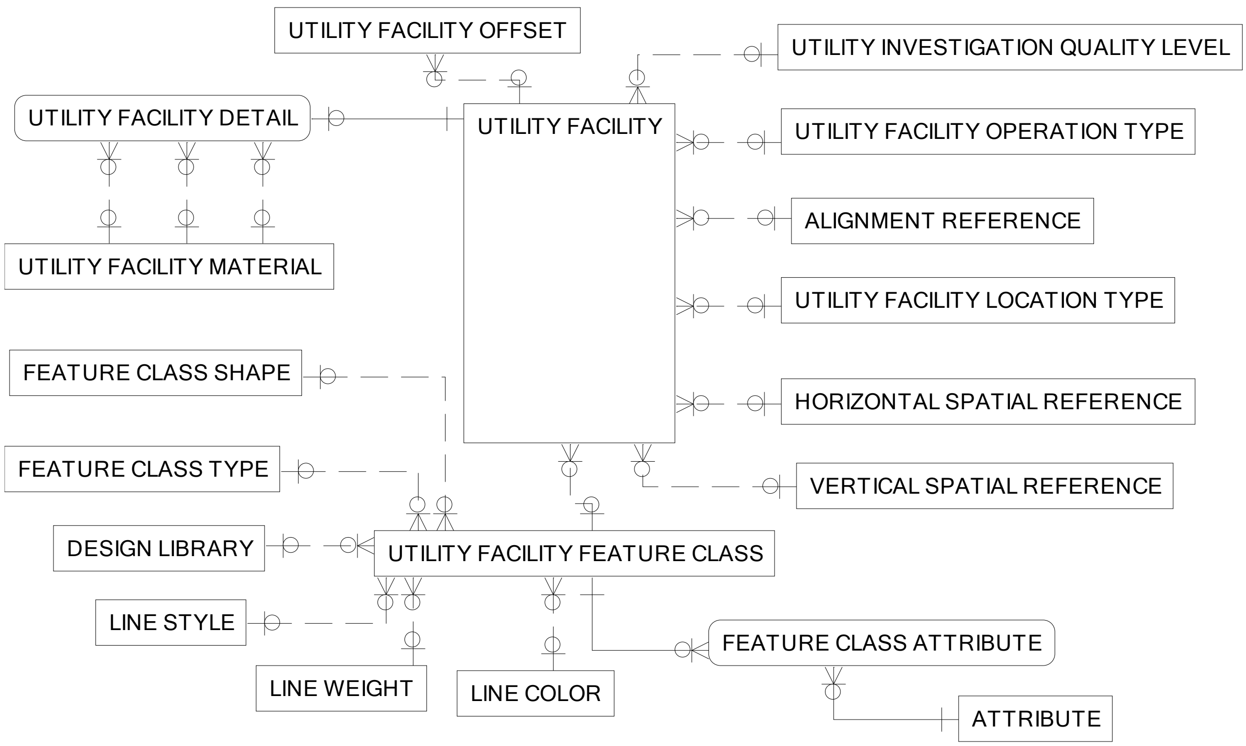


Figure 3.4. Utility facility subject area.

Table 3.2. Utility Facility Subject Area Entities and Definitions

Entity Name	Definition
ALIGNMENT REFERENCE	An ALIGNMENT REFERENCE is a point or line that can be used to define a location in reference to the point or a position on the line. Examples of an ALIGNMENT REFERENCE are “Edge of Pavement,” “Baseline,” “Right-of-Way Line,” “Centerline,” “Back of Curb,” “Survey Hub,” and “Reference Point in Driveway.”
ATTRIBUTE	An ATTRIBUTE is a property or characteristic of a UTILITY FACILITY serving to describe a UTILITY FACILITY.
DESIGN LIBRARY	A DESIGN LIBRARY is a set of style definitions and resources for a MicroStation file. DOTs use design libraries within MicroStation to define standards for cells, levels, level filters, line styles, multiline styles, text styles, dimensions, and several others. DOTs might have different design libraries for different engineering disciplines, including roadway, geotechnical, photogrammetry, and surveying.
FEATURE CLASS ATTRIBUTE	A FEATURE CLASS ATTRIBUTE is a mapping between a UTILITY FACILITY FEATURE CLASS and an ATTRIBUTE. It identifies all UTILITY FACILITY FEATURE CLASSES associated with an ATTRIBUTE, and all ATTRIBUTES associated with a UTILITY FACILITY FEATURE CLASS. As such, the table identifies all ATTRIBUTES that a UTILITY FACILITY FEATURE CLASS can have.
FEATURE CLASS SHAPE	A FEATURE CLASS SHAPE is the form of a FEATURE CLASS in a GIS. For example, a FEATURE CLASS can have the shape of line, point, polygon, or multipoint. The FEATURE CLASS SHAPE is used to define the default or preferred shape of a FEATURE CLASS.
UTILITY FACILITY TYPE	A UTILITY FACILITY TYPE is a characterization of a kind of UTILITY FACILITY. Examples include water utility, gas utility, and communication.
HORIZONTAL SPATIAL REFERENCE	A HORIZONTAL SPATIAL REFERENCE is a coordinate system that describes the horizontal location of a feature. Examples include NAD 1983, UTM Zone 12N, NAVD 1988, and GCS WGS 1984.
LINE COLOR	A LINE COLOR is the appearance of a line in a GIS or CAD environment based on a red, green, and blue value.
LINE STYLE	A LINE STYLE is a part of the symbology of graphic elements in MicroStation that defines a line’s appearance as being continuous, continuous dashes, dots and dashes, and many others.
LINE WEIGHT	A LINE WEIGHT is a number within the range of 0 to 30 that designates the stroke width or thickness of a line in MicroStation that is being used to draw and plot a graphic element.
UTILITY FACILITY	A UTILITY FACILITY is a fixed structure or installation used by a utility owner for the purpose of transporting or delivering a utility.
UTILITY FACILITY DETAIL	A UTILITY FACILITY DETAIL is a record of information about a UTILITY FACILITY. Records in the table FEATURE CLASS ATTRIBUTE define which attributes a utility facility has, and as a result, which columns in UTILITY FACILITY DETAIL can be populated.
UTILITY FACILITY FEATURE CLASS	A UTILITY FACILITY FEATURE CLASS is a grouping of FEATURES of the same kind that have the same set of attributes. Examples of a FEATURE CLASS are “Communication Line,” “Water Manhole,” and “Electric Pedestal.”

Entity Name	Definition
UTILITY FACILITY LOCATION TYPE	A UTILITY FACILITY LOCATION TYPE is a characterization of the site where a UTILITY FACILITY is located. Examples of UTILITY FACILITY LOCATION TYPE include “State Right-of-Way (Permit),” “Private Easement,” and “Franchise.”
UTILITY FACILITY MATERIAL	A UTILITY FACILITY MATERIAL is the matter or substance that a UTILITY FACILITY is composed of.
UTILITY FACILITY OFFSET	A UTILITY FACILITY OFFSET is a description of the distance between a UTILITY FACILITY and a reference line such as edge of pavement or centerline.
UTILITY FACILITY OPERATION TYPE	A UTILITY FACILITY OPERATION TYPE is a characterization of whether the utility company provides services for the public or for a private entity.
UTILITY INVESTIGATION QUALITY LEVEL	A UTILITY INVESTIGATION QUALITY LEVEL is a characterization of the quality and reliability of utility information. Valid values of a UTILITY INVESTIGATION QUALITY LEVEL are “QLD,” “QLC,” “QLB,” and “QLA.”
VERTICAL SPATIAL REFERENCE	A VERTICAL SPATIAL REFERENCE is a coordinate system that describes the vertical location of a feature. Examples include NAD 1983, UTM Zone 12N, NAVD 1988, and GCS WGS 1984.

Physical Data Model

The research team used the AllFusion ERwin Data Modeler to produce a physical data model based on the logical data model described in the previous section. Two versions of the physical data model were produced: Access 2010 and Oracle. As mentioned later, the research team used the Access 2010 version to prepare UCM data entry forms. The research team produced the Oracle version of the database model to prepare an Oracle SQL script and test the functionality of the database in an Oracle environment.

To ensure a consistent conversion of logical data types (i.e., data types in the logical data model) to Microsoft Access physical data types, the research team used a data type conversion standard. The research team also used an extensive glossary of engineering terms to standardize table and column names as well as a name mapping standard to ensure a consistent conversion from logical entity and attribute names to physical tables and columns. The naming conversion process included replacing spaces between logical name words with underscores in the physical model to avoid future implementation issues.

Implementation Using Microsoft Access

The research team used the physical data model to generate a script to build a version of the UCM database in Access 2010 format. The research team then designed queries and forms for data entry using custom VBA code. The main goal of developing the data entry forms was to illustrate the use of the UCM approach in a stand-alone database environment to users who are not information technology (IT) professionals. The data entry forms are sufficiently polished and user friendly so that they can be used for actual data entry in a stand-alone environment. From this perspective, they provide a unique opportunity for users to become familiar with some of the typical protocols that would take place when managing utility conflicts in a database environment. Although the Access forms are not compatible with an enterprise-level environment, they provide a preliminary design based on which enterprise-level forms could be developed.

Initially, the research team designed one physical Access database for the VBA code and the data. However, to facilitate debugging and testing, the research team decided to develop the data entry forms and the VBA code application in one database file (i.e., the front end), while storing all data in a separate database file (i.e., the back end). As a result, the back-end database only includes tables and queries that are required to add, edit, or delete data. By comparison, the front end only includes forms, reports, and queries that are required to execute the forms and reports. Linking the application and the data is maintained by using the Access Linked Table Manager. If either database is moved to a new location, or if the drive letter of a local computer is different from the drive letter stored in Access, the application will not work until all tables have been relinked by using the Linked Table Manager.

The research team prepared several data entry forms in Access 2010. The application includes a main user interface (Figure 3.5), four main forms (to manage projects, utility companies, utility facilities, and utility conflicts), and several subforms within each of the main forms. Figures 3.6 through 3.8 show the three subforms to manage projects, while Figures 3.9 through 3.11 show one example subform of the other main forms. This version of the data entry forms does not include the subsheet to analyze utility conflict resolution alternatives.

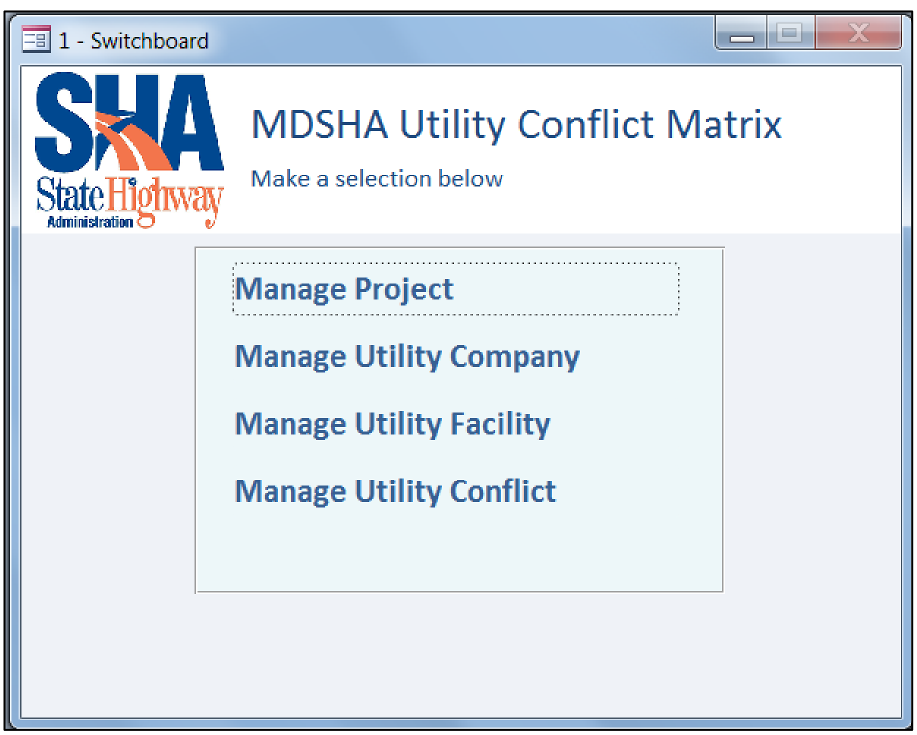


Figure 3.5. Main user interface.

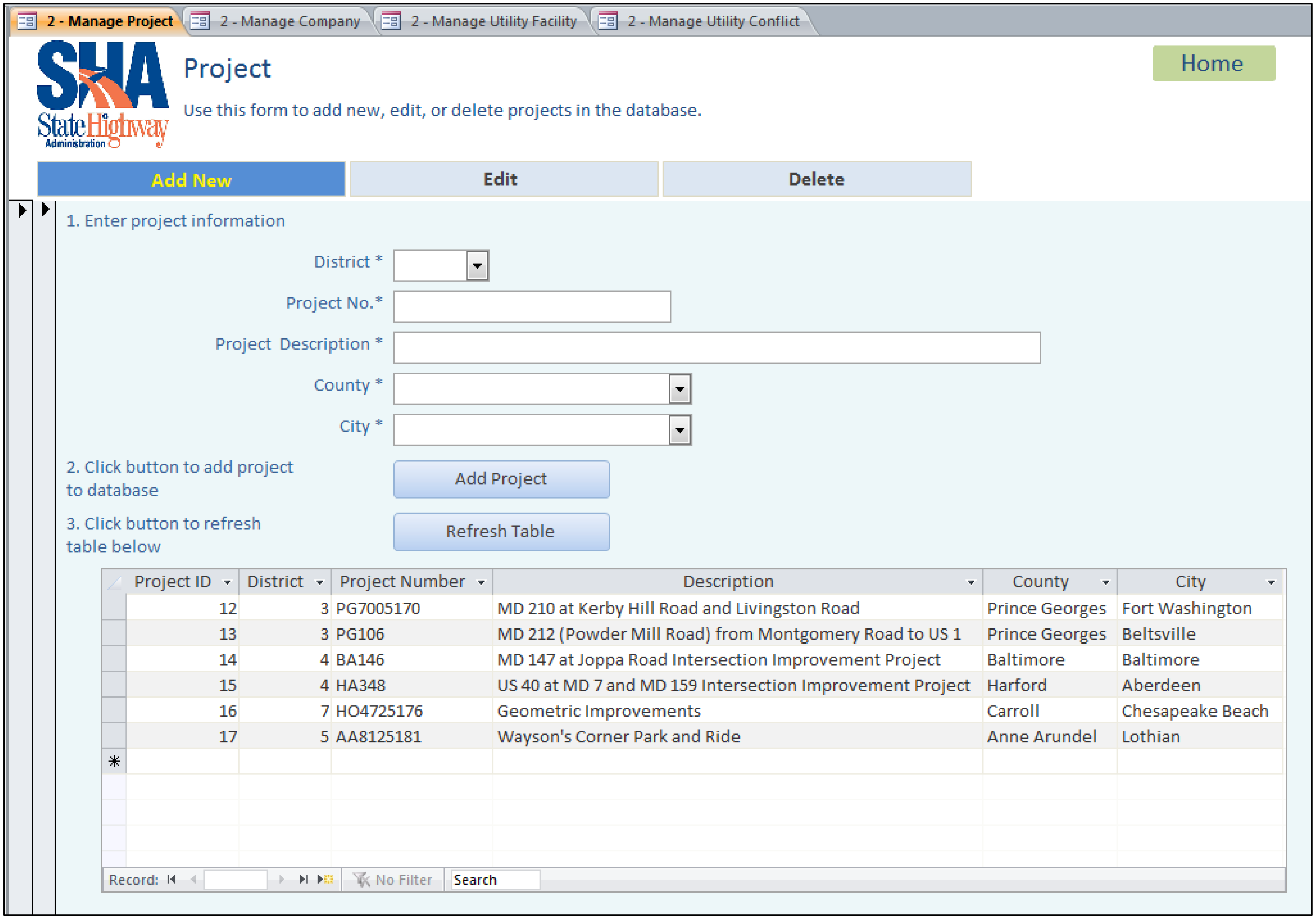


Figure 3.6. Form to manage projects: Add new project.

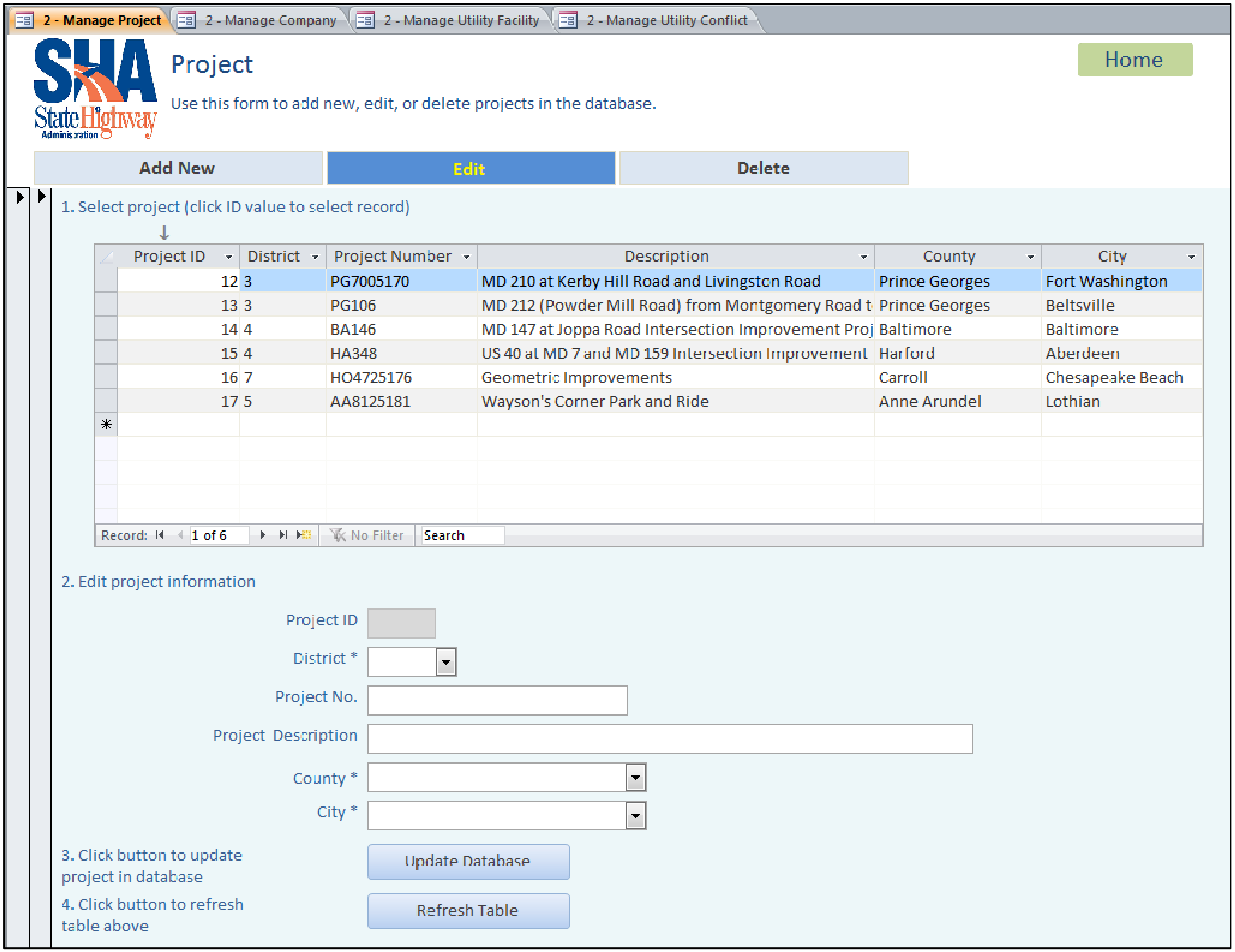


Figure 3.7. Form to manage projects: Edit existing project.

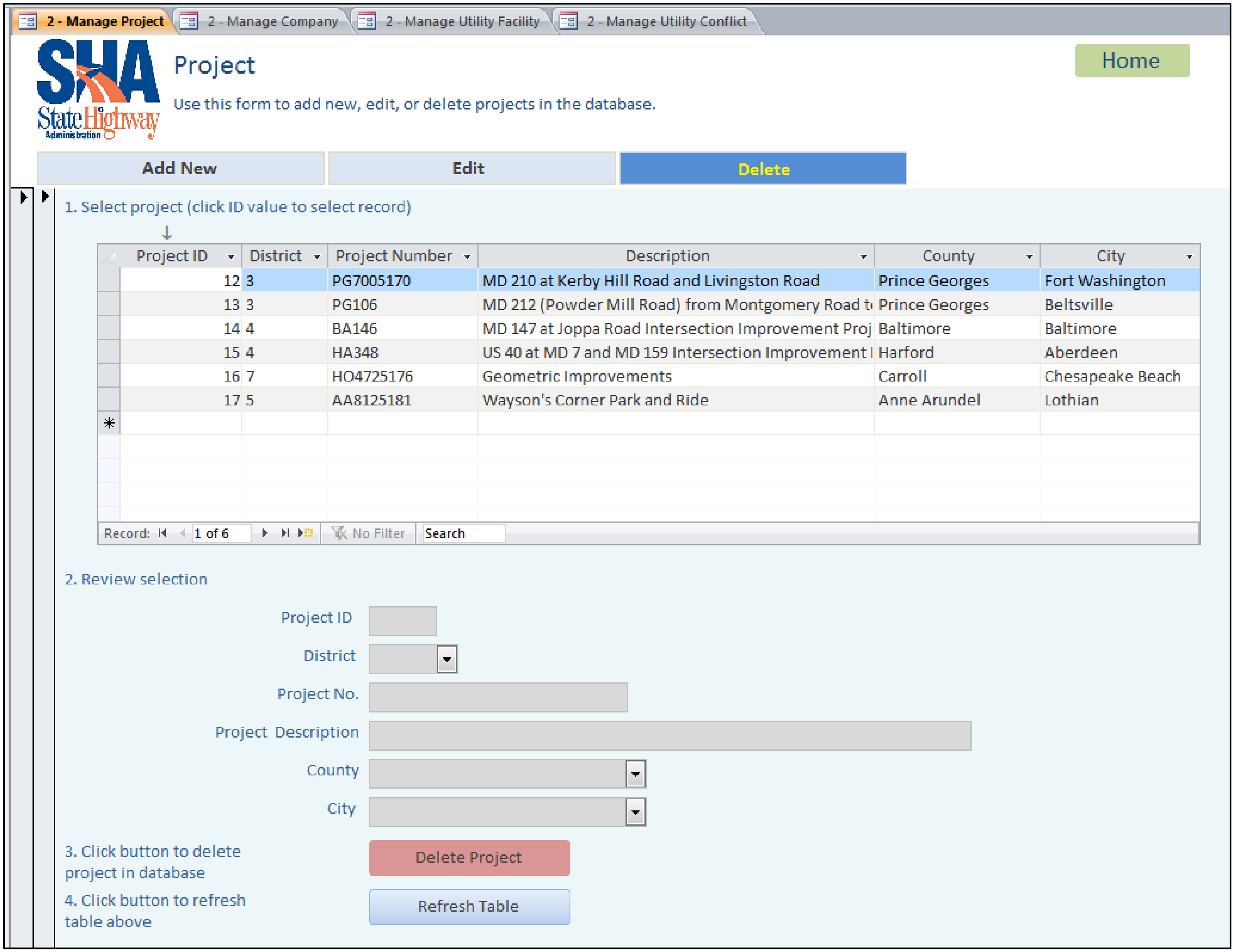


Figure 3.8. Form to manage projects: Delete existing project.

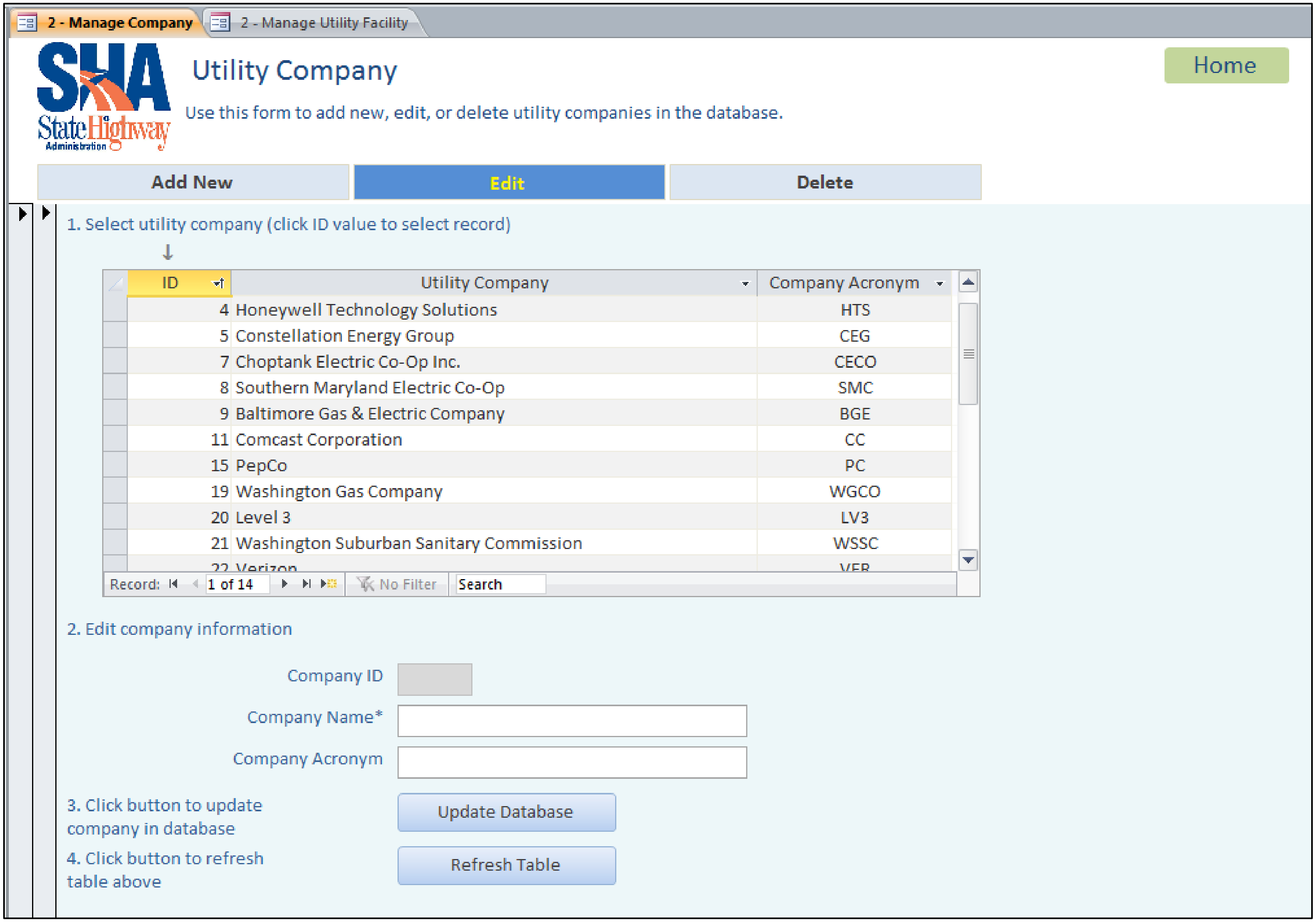


Figure 3.9. Form to manage utility companies: Edit utility company.

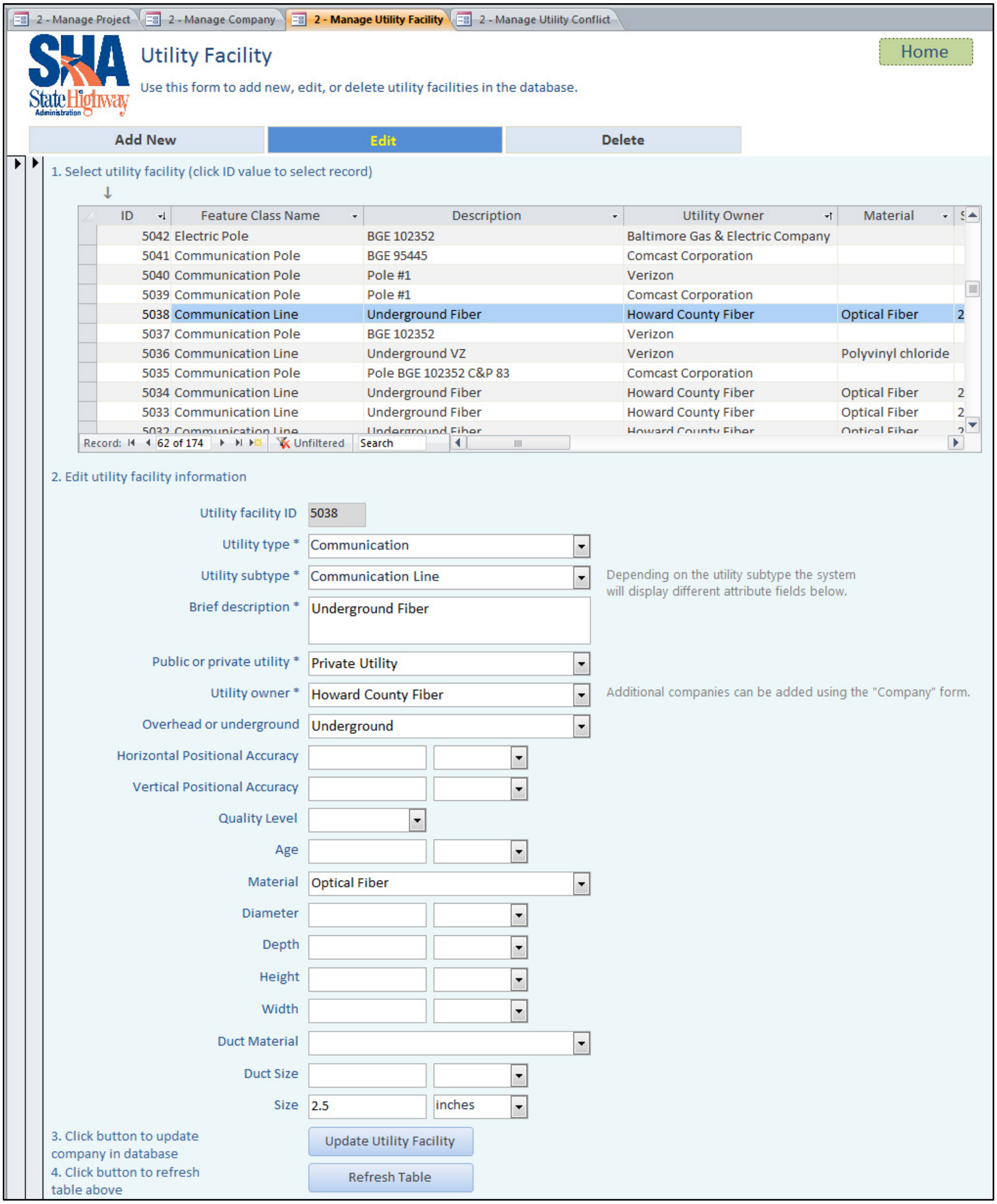


Figure 3.10. Form to manage utility facilities: Edit utility facility.

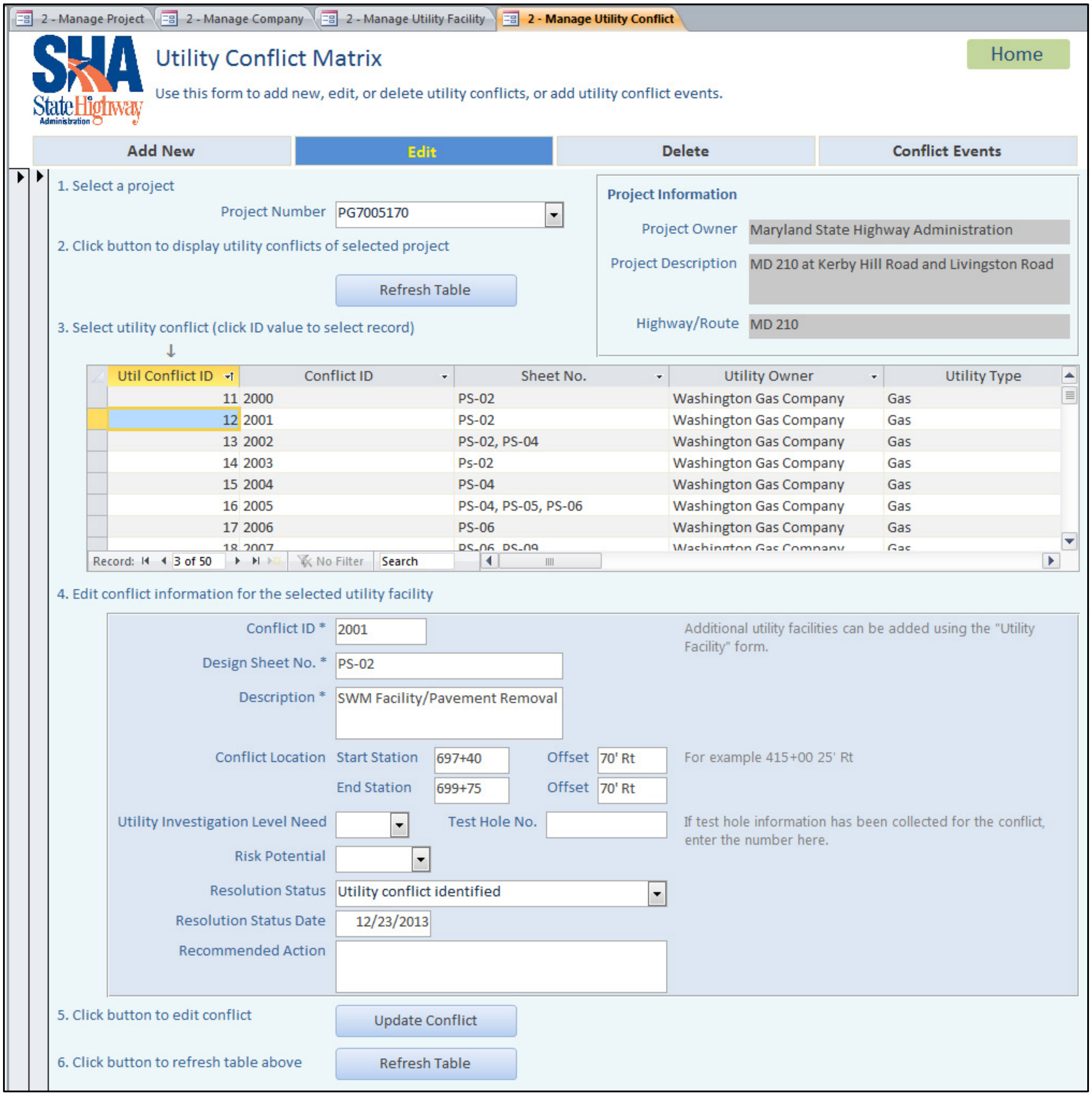


Figure 3.11. Form to manage utility conflicts: Edit utility conflict.

The forms that display utility feature attribute data (e.g., the form to edit features in Figure 3.10) show a different set of attributes depending on the feature class. After considering several options, the research team decided to store a basic set of attributes in the UTILITY FACILITY table and all additional attributes in the UTILITY FACILITY DETAIL table. Basic attributes include utility facility class, company ID, company type, and horizontal and vertical spatial reference and positional accuracy. Mandatory basic attributes include utility facility class, company ID, and company type. The rest of the attributes, as well as all attributes in the UTILITY FACILITY DETAIL table, are optional.

Because the number of possible optional attributes can vary drastically among utility facility classes, the research team wrote code that only displays the attributes that pertain to each facility class. Unfortunately, VBA in Access does not support dynamic controls, which made it necessary to use static controls to simulate this functionality. A table called ATTRIBUTE contains a listing of optional attributes (26 in total). The current version of the code has static controls for 21 optional attributes (five attributes were added to the ATTRIBUTE table after the code had been finalized). When a user opens the form, the static controls are hidden by default. After the user selects a specific feature class (e.g., water line), the corresponding static controls representing each of the optional attributes associated with that feature class become visible. All other static controls remain hidden.

For future implementations, the forms could be rewritten in a different language that supports dynamic controls such as Visual C#. With VBA in Access, the process to add any of the five unused attributes is as follows:

- Add records to table FEATURE CLASS ATTRIBUTE to link the attribute and its display order to each feature class of interest.
- Add a static control for the attribute in the Add Utility Facility, Edit Utility Facility, and Delete Utility Facility forms.
- Modify the code to manage these controls in the Add Utility Facility, Edit Utility Facility, Delete Utility Facility forms.

To add new optional attributes that are not currently listed in the ATTRIBUTE table, the process would be as follows:

- Add new attribute to the logical and physical data models.
- Add new attribute to the ATTRIBUTE table.
- Add column for the new attribute in the UTILITY FACILITY DETAIL table.
- Follow the process above for adding static controls.

The research team conducted some limited testing of the Access data entry forms by entering data that MDSHA districts gathered when they were populating their stand-alone UCMs for the six pilot implementation projects. For the testing, the research team sequentially entered data about projects, utility owners, utility facilities, and utility conflicts. General observations on the use of the Access database approach to complete these activities are as follows:

- **Data entry is time-consuming but cost-effective.** Mirroring what MDSHA officials noted while populating the stand-alone UCMs, the research team noticed that entering data into the database required time and effort. An informal estimate was that it took about 8 hours of effort to enter data for some 60 utility conflicts. While significant, managing utility conflicts is really about making an up-front investment with the expectation of a significant return on that investment during the life of the project. The rate of return of that investment can be huge, possibly by a factor of 100 or more. For example, in the case of the MD 32 project, MDSHA project staff probably spent less than 36 hours, or approximately $3,600 (using an estimated hourly rate of $100), populating the UCM. The estimated economic benefit of using a UCM approach for that project was $500,000, which would translate to a net benefit of about $139 saved for each dollar invested. On the basis of an estimated delay savings of six months (or 960 hours), this would result in a benefit of about 27 project hours saved for each hour invested populating the UCM.

- **Microsoft Access has limitations for managing utility data.** Although Access provides a convenient database platform for managing utility conflicts, Access is really designed for stand-alone implementations. The research team noted that both the query structure and the VBA code pushed the limits of what can be reasonably expected with this kind of database environment. During testing, the research team noted that sometimes it took a few seconds for forms to open or commands to execute. The research team expects these issues to increase in magnitude as the database grows in size, particularly in a multiuser environment.
- **Enterprise, centralized database implementation might be more beneficial in the long term.** By design, Microsoft Access uses a decentralized implementation concept consisting of unlimited copies of the same database to be used at several locations. Using copies of the same data can improve efficiency in the short term. However, there is a risk of data redundancy and loss of quality control. The current application requires access to the physical database either on a local or network drive. A more user-friendly approach would be to develop an enterprise-level application that is accessible via the Internet and uses a database platform such as Oracle or SQL Server. That would also facilitate access and contributions by stakeholders outside of the DOT, including utility companies and consultants.
- **The conflict resolution alternative analysis subsheet should be further evaluated.** MDSHA did not use the conflict resolution alternative analysis subsheet during the pilot implementation. However, comments from stakeholders indicated that this feature might be useful under certain circumstances involving high-impact utility conflict locations.
- **Utility conflict event tracking should be further evaluated.** A major benefit of a database approach is the automated tracking of events associated with utility conflicts. An evaluation of this feature by MDSHA staff was not possible because the application was completed near the end of the pilot implementation.

CHAPTER 4
One-Day UCM Training Course

Introduction

The research team delivered the one-day UCM training course twice as part of the pilot implementation in Maryland. The first time was before the districts started the pilot application of the UCM approach on actual projects. Following discussions with MDSHA near the end of the pilot implementation, the research team scheduled a second one-day UCM training course for additional users who did not have the opportunity to attend the first course. This chapter provides a summary of lessons learned with both training courses and updates to the training materials to reflect these lessons learned.

January 2013 Course

This course took place in Hanover, Maryland. A total of 36 participants attended the course, representing MDSHA (29 attendees), utility owners (4 attendees), consultants (2 attendees), and FHWA (1 attendee). MDSHA participants included design, utility, and right-of-way acquisition officials, both from districts and headquarters. With some minor exceptions, the lesson plan was the same as that developed for the SHRP 2 R15B project, as follows:

Morning Session

- Lesson 1: Introductions and Course Overview
- Lesson 2: Utility Conflict Concepts
- Lesson 3: Utility Conflict Identification and Management

Afternoon Session

- Lesson 4: Hands-On Utility Conflict Management Exercise
- Lesson 5: Use of Database Approach to Manage Utility Conflicts
- Lesson 6: Wrap-Up

The hands-on exercise used sample materials from a Georgia DOT (GDOT) project, which GDOT provided for developing the one-day UCM training course as part of the SHRP 2 R15B research. The 1.8-mile project was a typical road widening project in a suburban environment in Marietta, northwest of Atlanta, and involved 13 utility owners. As part of the project, GDOT conducted a QLB utility investigation and received several data sheets with QLA data.

For the hands-on exercise, participants were divided into seven groups. To maximize group diversity, participants were asked to sequentially pick a number from 1 to 7. Group 1 was composed of all participants who said 1, Group 2 was composed of all participants who said 2, and so on. Instructions to each group included identifying as many utility conflicts as possible from a specific section of the set of plans, manage a sample of conflicts using a UCM, conceptualize a solution strategy for one or two conflicts, and at the end, give a three-minute presentation to all the participants.

Although the time allocated to each of the lessons was generally appropriate, participants spent considerably longer during the hands-on exercise in Lesson 4. All groups were highly involved in their assignments, particularly during the identification of utility conflict resolution strategies and the group presentation, and, therefore, the research team decided to let the groups continue with that lesson for an additional half hour. To keep the course within the allocated schedule, the duration of the data model and database demonstration was shortened. This was an acceptable trade-off considering that the audience was composed mainly of engineers and utility coordinators, but not IT professionals.

Participants were highly satisfied with the course structure and exercise dynamics. Prior to delivering the course, the research team made a few minor changes to the materials that were delivered as part of the SHRP 2 R15B research. The research team's observation was that participants reacted positively to those changes, particularly in Lesson 4. At the same time, participants provided several suggestions for improvements, including providing color plans to help differentiate utility features (the sample plan set was in black and white) and making sure the plan sets were printed to scale (due to a printing error, the scale was slightly off when the plans were printed prior to delivering the course). Other suggestions included using a set of plans from projects that participants were familiar with (instead of using projects or plan symbology from elsewhere that participants would have difficulty recognizing) and emphasizing the utility conflict resolution process. Some participants also recommended reducing the duration of the data model and database presentation (although some other participants recommended the opposite).

September 2013 Course

The research team conducted a second one-day UCM training course in Baltimore. The original intent was to provide UCM training to District 3 officials and their consultants, taking into consideration that most of these officials did not attend the first course. However, MDSHA considered that moving the course to agency headquarters in Baltimore would provide a greater opportunity for a larger number of officials to receive training on the use of the UCM approach. In total, 40 MDSHA officials representing several disciplines attended the course, although most participants were designers. Realistically, this was a strategic move, which will likely accelerate the deployment of the UCM approach in Maryland.

The research team used essentially the same version of the course materials that were used in the first course. The only difference was that plans from the MD 210 project were used instead of the set of plans from GDOT (see Chapter 2). The risk of using MD 210 project files was that the utility investigations (and corresponding documentation) were only preliminary. As a result, it was not possible to demonstrate a complete example of the UCM to manage utility conflicts. However, the significant advantage was that officials were already familiar with

MDSHA file symbology and design standards, and, in several cases, they were also familiar with the project. As a result, the hands-on exercise was extremely effective, particularly during the group presentations at the end of Lesson 4. Feedback from course participants was highly positive. Officials also provided suggestions for changes to the training materials. The research team incorporated these changes, as described in the following section.

Updated UCM Training Materials

The research team prepared an updated set of training materials to support the one-day UCM training course. The changes made addressed comments and recommendations from participants at the two training events, as well as observations by the research team prior to, during, and after those events with respect to ways to improve the effectiveness of the presentation.

The revised one-day UCM training course is divided into six lessons, as follows:

Morning Session

- Lesson 1: Introductions and Course Overview (30 minutes)
- Lesson 2: Utility Conflict Concepts (75 minutes)
- Lesson 3: Utility Conflict Identification and Management (75 minutes)

Afternoon Session

- Lesson 4: Use of Database Approach to Manage Utility Conflicts (20 minutes)
- Lesson 5: Hands-On Utility Conflict Management Exercise (120 minutes)
- Lesson 6: Wrap-Up (10 minutes)

Tables 4.1 through 4.6 provide an overview of each lesson. The course is designed for a total of seven hours and 15 minutes of instruction, from 8:30 a.m. to 3:45 p.m. It includes 5:30 hours (330 minutes) of direct instructor contact and 1:45 hours (105 minutes) of breaks (including lunch). The course provides ample opportunities for participant interaction and enables the instructor to adjust session and lesson start times and durations depending on the audience and the level of participant engagement in the discussions.

Table 4.1. Lesson 1 (Introductions and Course Overview)

Lesson No.	**1**
Lesson Title	**Introductions and Course Overview**
Topics	• Introductions (both instructor and participants). • Overview of course objectives, outcomes, agenda, and reference materials. • Discussion of ground rules, sign-in-sheet, feedback forms, and other housekeeping items.
Instructional Method	*Activity 1:* Instructor welcomes participants, introduces him/herself, and leads participants through introductions. Participants introduce themselves and provide a brief description of their roles and experience in utility coordination, design, or other project development and delivery process matters. *Activity 2:* Instructor provides an overview of the course objectives, outcomes, agenda, and reference materials. *Activity 3:* Instructor discusses ground rules, sign-in sheet, feedback forms, and other housekeeping items as needed.
Instruction Day	Day 1: 8:30 a.m. – 9:00 a.m.
Time Allocation	• *Activity 1:* Introductions 15 minutes • *Activity 2:* Course overview 10 minutes • *Activity 3:* Housekeeping 5 minutes • Total Lesson 1 30 minutes Note: Depending on the course setting and the length of time actually spent on Lesson 1 activities, it might be possible to increase the time allocated to Lessons 2 or 3. In any case, for maximum effectiveness, it is not recommended to extend Lesson 3 beyond noon.
Evaluation Plan	• Instructor uses the instructor review form to take notes on the background, experience, and role of participants in utility coordination, design, or other project development and delivery process matters.
References	• Course binder. • Lesson 1 PowerPoint file and handouts. • SHRP 2 R15B research report (http://www.trb.org/Main/Blurbs/166731.aspx). • SHRP 2 R15C research report (http://www.trb.org/Main/Blurbs/170965.aspx).

Table 4.2. Lesson 2 (Utility Conflict Concepts)

Lesson No.	**2**
Lesson Title	**Utility Conflict Concepts**
Learning Outcomes	• Understanding of relevant concepts related to the management of utility conflicts within the project development and delivery process.
Instructional Method	*Activity 1:* Instructor uses PowerPoint slides to • Describe typical utility conflict management concepts and issues. *Activity 2:* Instructor uses PowerPoint slides and printed UCM materials to • Describe the purpose and main findings of the SHRP 2 R15B project. • Summarize trends and other information gathered through the online surveys and follow-up interviews. • Summarize the process for developing a stand-alone UCM. • Describe UCM data model and Access database application. *Activity 3:* Questions and answers: • Instructor answers questions from participants. As needed, other participants participate in the discussion. • Depending on the course setting, instructor might choose to encourage questions from participants throughout the presentation instead of allocating 10 minutes at the end of the lesson for questions and answers.
Instruction Day	Day 1: 9:00 a.m. – 10:15 a.m.
Time Allocation	• *Activity 1:* Utility conflicts and project development and delivery 25 minutes • *Activity 2:* SHRP 2 R15B research findings 40 minutes • *Activity 3:* Questions and answers 10 minutes • Total Lesson 2 75 minutes
Evaluation Plan	• Instructor uses the instructor review form to summarize the types of questions and comments from participants. Depending on the setting, this activity might need to be completed after the course. • Participants use the participant feedback form to rate the effectiveness of the presentation.
References	• Lesson 2 PowerPoint file and handouts. • Stand-alone and sample UCM printouts.

Table 4.3. Lesson 3 (Utility Conflict Identification and Management)

Lesson No.	**3**
Lesson Title	**Utility Conflict Identification and Management**
Learning Outcomes	• Understanding of the process for developing and maintaining a UCM by using data from a sample project. • Understanding of the types of reporting options available when using a database representation of the UCM.
Instructional Method	*Activity 1:* Instructor uses PowerPoint slides and sample materials to • Demonstrate the process for identifying utility conflicts by using sample project drawings and associated information. • Describe structure and format of the UCM and the process to populate and maintain the UCM using sample project data. *Activity 2:* Discussion, questions, and answers • Instructor answers questions from participants. As needed, other participants participate in the discussion. • Instructor encourages participants to share and discuss real-world examples and/or the applicability of UCMs to real-world situations. • Depending on the course setting, instructor might choose to encourage questions and discussion from participants throughout Activity 1 instead of allocating 30 minutes at the end of the lesson for questions and answers.
Instruction Day	Day 1: 10:30 a.m. – 11:45 a.m.
Time Allocation	• *Activity 1:* Utility conflict management and use of UCM — 65 minutes • *Activity 2:* Discussion, questions, and answers — 10 minutes • Total Lesson 3 — 75 minutes
Evaluation Plan	• Instructor uses the instructor review form to summarize the types of questions and comments from participants. Depending on the setting, this activity might need to be completed after the course. • Participants use the participant feedback form to rate the effectiveness of the presentation.
References	• Lesson 3 PowerPoint file and handouts. • Sample UCM printouts, plan sheets, and test hole reports.

Table 4.4. Lesson 4 (Use of Database Approach to Manage Utility Conflicts)

Lesson No.	**4**
Lesson Title	**Use of Database Approach to Manage Utility Conflicts**
Learning Outcomes	• Understanding of utility conflict data model and database capabilities. • Understanding of the process for developing and using customized queries and reports.
Instructional Method	*Activity 1:* Instructor uses PowerPoint slides, Access database, and sample materials to • Describe data model and database structure and capabilities. • Describe data model connections with other DOT information systems. *Activity 2:* Instructor uses PowerPoint slides, Access database, and sample materials to • Describe how utility conflict data are stored into the database. • Illustrate the process for using Access queries, forms, and reports. *Activity 3:* Questions and answers: • Instructor answers questions from participants. As needed, other participants participate in the discussion. • Depending on the course setting, instructor might choose to encourage questions from participants throughout the presentation instead of allocating 10 minutes at the end of the lesson for questions and answers.
Instruction Day	Day 1: 1:00 p.m. – 1:20 p.m.
Time Allocation	• *Activity 1:* Data model structure — 5 minutes • *Activity 2:* Use of Access database to manage utility conflicts — 10 minutes • *Activity 3:* Questions and answers — 5 minutes • Total Lesson 4 — 20 minutes
Evaluation Plan	Participants' learning will be evaluated by their participation and questions.
References	• Lesson 4 PowerPoint file and handouts. • Printed copies of sample database queries and reports.

Table 4.5. Lesson 5 (Hands-On Utility Conflict Management Exercise)

Lesson No.	**5**
Lesson Title	**Hands-On Utility Conflict Management Exercise**
Learning Outcomes	• Identification of utility conflicts on sample project design drawings. • Use of UCMs to manage utility conflicts.
Instructional Method	For all activities: Instructor uses PowerPoint presentation and other sample materials to • Direct course participants during exercise and answer questions as needed. *Activity 1:* Participants organized in groups use sample project materials and blank UCM template to • Identify as many utility conflicts as possible on sample project materials. • Evaluate potential locations for test holes. • Transcribe utility conflict information into the UCM. *Activity 2:* Instructor hands out test hole data sheets. Participants use test hole data sheets to • Review and assess potential utility conflicts. *Activity 3:* Participants use blank conflict resolution alternatives template to • Choose 1-2 utility conflicts and develop 3-4 utility conflict resolution strategies each, including cost estimates. • Choose the best strategy to resolve the utility conflicts. *Activity 4:* Participants use portable document format (PDF) plan sheets to: • Give a 3-minute group presentation, highlighting a utility conflict, the strategies considered to resolve the conflict, and any other lessons learned.
Instruction Day	Day 1: 1:20 p.m. – 3:35 p.m.
Time Allocation	• *Activity 1:* Identify conflicts 30 minutes • *Activity 2:* Review test hole data and analyze utility conflicts 30 minutes • Afternoon break 15 minutes • *Activity 3:* Develop conflict resolution strategy 30 minutes • *Activity 4:* Group presentations 30 minutes • Total Lesson 5 135 minutes
Evaluation Plan	• Instructor uses the instructor review form to summarize the types of questions and comments from participants. Depending on the setting, this activity might need to be completed after the course. • Participants use feedback form to rate the effectiveness of the presentation.
References	• Lesson 5 PowerPoint file and handouts. • Sample UCM printouts, plan sheets, and test hole reports.

Table 4.6. Lesson 6 (Wrap-Up)

Lesson No.	**6**
Lesson Title	**Wrap-Up**
Topics	• Instructor provides summary of course. • Instructor collects feedback forms.
Instructional Method	*Activity 1:* Instructor summarizes the activities of the course, addresses any final questions of course participants, and provides some closing remarks. Participants fill out the feedback form. The instructor then collects the feedback forms provided by the course participants.
Instruction Day	Day 1: 3:35 p.m. – 3:45 p.m.
Time Allocation	• *Activity 1:* Final questions and closing remarks — 10 minutes • Total Lesson 6 — 10 minutes
References	• Participant feedback form.

The training materials are organized in a folder structure that can be easily disseminated via compact disk or the Internet. Table 4.7 provides a list of all the files.

Table 4.7. One-Day UCM Training Course Materials

Folder Name	File Name	Format[1]
Binder	Training Material Binder Participant	pdf
	Training Material Binder Instructor	pdf
Instructional Materials	Lesson 5 Group 1 Exercise Materials	pdf
	Lesson 5 Group 2 Exercise Materials	pdf
	Lesson 5 Group 3 Exercise Materials	pdf
	Lesson 5 Group 4 Exercise Materials	pdf
	Lesson 5 Group Assignment	pdf
	Lesson 5 Test Hole Forms	pdf
	Lesson 5 Utility Conflict Solution Sheet	pdf
Lessons	Lesson 1	pptx
	Lesson 2	pptx
	Lesson 3	pptx
	Lesson 4	pptx
	Lesson 5	pptx
	Lesson 6	pptx
Stand-alone UCM	Utility Conflict Matrix	xls
Data Model and Database	UCD Data Dictionary	pdf
	UCD Data Model – Access	erwin
	UCD Data Model – Oracle	erwin
	UCD Export Schema Oracle	sql
	UCD Logical Data Model	pdf
	UCD Physical Data Model – Access	pdf
	UtilityConflictDatabase–Application	accdb
	UtilityConflictDatabase–Data	accdb

Note: UCD = user-centered design.

[1] File formats: erwin = Computer Associates ERwin Data Modeler; accdb = Microsoft Access 2010; pdf = Adobe Portable Document Format; pptx = Microsoft PowerPoint 2010; sql = Structured Query Language; and xls = Microsoft Excel 2007.

CHAPTER 5
Conclusions and Recommendations

Utility issues are widely recognized as one of the top reasons for delays in project development and delivery. Two critical factors that contribute to inefficiencies in the management of utility issues are (a) the lack of accurate, complete information about utility facilities that might be in conflict with the project and (b) the resolution and overall management of those conflicts.

Research Project SHRP 2 R15B took place from March 2009 to July 2011 and resulted in three products as follows (*1*, *2*):

- **Product 1 (stand-alone utility conflict matrix)**. This is a stand-alone product in Excel format that includes a main utility conflict table and a supporting worksheet to analyze utility conflict resolution strategies.
- **Product 2 (utility conflict data model and database)**. This stand-alone product is a scalable UCM representation that facilitates managing utility conflicts in a database environment. The data model was tested by developing a series of queries and reports in Access to replicate sample utility conflict tables from across the country. The focus of this part of the research was development of the data model, but not a graphical user interface to automate data entry, querying, and reporting.
- **Product 3 (one-day UCM training course)**. This stand-alone product includes a lesson plan and presentation materials to assist with the training needed to disseminate and implement Products 1 and 2 at transportation agencies.

In December 2011, the SHRP 2 Oversight Committee authorized a follow-on project to pilot the implementation of the SHRP 2 R15B tools. The follow-on project was SHRP 2 R15C, Pilot Application of Products for the Identification of Utility Conflicts and Solutions. Its objective was to work with a state DOT on the implementation of the stand-alone UCM and the one-day UCM training course, as well as an introduction to the utility conflict data model and database. The pilot implementation took place in Maryland from September 2012 to March 2014. Major activities during the pilot implementation included the following:

- Coordinate with MDSHA officials for the identification of projects to conduct the pilot implementation, UCM training opportunities, and technical support logistics.
- Conduct the one-day UCM training course for selected users. This activity took place prior to districts beginning to use the stand-alone UCM on actual projects. Following discussions with MDSHA, the research team scheduled a second one-day UCM training course for additional users toward the end of the pilot implementation.
- Interact with district users and provide technical support as needed.

Conclusions

Use of the UCM Approach

MDSHA identified six projects to test the implementation of the UCM approach. As Figure 2.1 shows, these projects provided a wide range of project types and field conditions. Lessons learned by MDSHA officials in connection with the UCM approach included areas in which officials were highly satisfied with the UCM approach as well as areas in which they identified a need for improvement or clarification in the business process. Areas in which the UCM approach was particularly strong included the following:

- **The UCM is useful for the documentation of utility conflicts**. Users found the UCM approach helpful in documenting utility conflicts early in the design process. The UCM makes discussing and resolving specific conflicts easier because all parties (designers, utility coordinators, utility owners, and so on) are able to visualize and understand all utility constraints in one document. It is also much easier to coordinate with utility owners because both sides have the same information and it is easy to point out a conflict using the conflict ID and then discuss it. The UCM also helps avoiding situations in which utility conflicts “fall off the radar” and are ignored until they become a major problem. Finally, the UCM enables MDSHA managers above the design level to understand the complexity and costs (time and financial) related to utility impacts.
- **The UCM is helpful for discussing and resolving utility conflicts**. Having designers populate the UCM first gives those designers a greater appreciation for utility issues and helps them to design more effectively earlier in the process. District staff considered the UCM useful for tracking documentation that otherwise would be lost because of the speed with which projects are developed and built.
- **The UCM is helpful for documenting the need for test holes**. Designers used the UCM to document the need for test holes to assess resolution strategies for utility conflicts.
- **The UCM raises awareness about utility impacts**. The UCM was beneficial in raising awareness among all team members about all the utility locations and conflicts on the project. Project managers were much more aware of utility issues affecting projects.
- **The UCM helps to avoid utility relocations**. In several instances, district officials were able to find opportunities for which utility relocations were unnecessary, saving the agency and/or utility owners hundreds of thousands of dollars and accelerating project delivery.
- **Using the UCM has resulted in tangible economic and time benefits**. At one of the districts, documenting utility conflicts systematically by using the UCM approach was directly responsible for the identification of a utility conflict resolution strategy that helped the district avoid relocating a gas line, resulting in more than $500,000 in savings. A rough estimate of time benefits provided by district officials indicated that avoiding the gas line provided a delay savings of about 4 to 6 months.

- **UCM facilitates coordination with utilities and contributes to better working relationships**. The UCM made coordination with utility owners much easier and created much goodwill among utility owners. Utility owners noted that MDSHA made a significant effort to avoid unnecessary relocations, which resulted in a better working relationship with utility owners (and will likely have a positive impact on future projects).
- **The UCM process facilitates MDSHA internal teamwork**. District officials found that the UCM process facilitated teamwork among district staff and brought the district closer together. It also challenged designers to examine conventions and think outside the box. Utility coordinators mentioned that the UCM process helped them understand the method designers use to approach and resolve utility conflicts. The UCM process also helped to make designers aware of where utilities are on the project.

Areas in which the UCM approach would need some improvements include the following:

- **Developing the UCM took longer than originally expected**. One of the challenges on the use of the UCM is the limited amount of time and resources district officials have to prepare the matrix. Using the UCM was time-consuming at the beginning. At one of the districts, officials indicated they spent about four hours of labor (two people working two hours each) to review five plan sheets (30 scale, Arch D size) and develop the first version of the UCM, for an average of 45 minutes of labor per sheet. Given that it was the first time that district officials worked with the UCM, officials should require less time to develop the UCM as they become more familiar with the process. District officials indicated they would closely monitor the time and effort consultants use to maintain the UCM, which also made it critical to clarify the consultants' scope of work to make sure MDSHA's expectations regarding deliverables and associated costs were reasonable and consistent with MDSHA's goals and objectives. In this regard, district officials found that the method to analyze conflicts and populate the UCM was key to increase productivity. During the development of the first UCM, the project team made several observations to accelerate UCM development in the future. For example,
    - District officials concluded that the fastest way to identify utility conflicts was to start at the beginning station, pick a utility line, and document all conflicts for that line until the end of the project. Then continue with the next line at the project beginning station.
    - Utility conflict identification was much easier while viewing the project file in MicroStation versus paper drawings, because it allowed project staff to turn levels on and off, zoom in as needed, and quickly measure stations and offsets.
    - The project team deleted the automated drop-down menus and used different tabs for different utility types (water, sewer, communications, and so on). The idea of using a different tab for each company did not work for the group because

initially they did not know which company owned which facility. The group also prepared a separate file for water lines with portions that needed to be relocated. In addition, the project team standardized utility conflict descriptions because that made it easy to sort them and color-coded utility conflicts to indicate status.

- **More guidance on the UCM process would be useful**. At the beginning of the project, it was unclear who would be responsible for populating the UCM. The project manager decided to prepare the first version of the UCM, which worked extremely well, as explained above. For future projects, district officials recommended that the project manager or a designer develop the first version of the UCM and then turn it over to others at the district to maintain it.
- **More guidance on the definition of utility conflicts would be useful**. Project staff had several questions when they first started using the UCM, including how to define a utility conflict. District officials had a question on whether it would be advisable to group utility conflicts by segments of utility facilities affected in an effort to reduce the number of actual utility conflicts. For instance, if a gas line runs 1,000 feet through the project and is affected at multiple locations, is it advisable to identify multiple utility conflict locations or just one conflict location?
- **Limiting UCM updates to major milestones would reduce required labor effort**. If MDSHA makes the use of the UCM approach permanent, district officials suggested updating the UCM only at major project milestones. It would also be the responsibility of the design consultant to keep the UCM up to date. District staff pointed out that while conflict identification is important, utility owner notification is equally important.

Areas that could facilitate the implementation of the UCM approach include the following:

- **There is a need for a data quality label in MicroStation**. District officials recognized that one of the challenges with utility data is that design plans do not show utility investigation quality level data. Although MicroStation files include that information as a cell attribute, it is not visible on printed design plans.
- **There is a need to provide more training to district staff on the use of MicroStation and provide easier access to the software**. District staff pointed out that not all district personnel have easy access to MicroStation or know how to use it. Similarly, many small utility companies do not use CAD. To make the UCM process work, it would be extremely beneficial for districts to receive more training on how to use MicroStation.
- **Some modifications to UCM structure might be useful**. UCM users provided a few recommendations for improving the design of the UCM, including adding a hyperlink to the corresponding drawing or sheet number, providing linkages to design–build contract information, and creating different tabs in Excel for different utility owners. A generic

"Unknown" tab could be used for those facilities for which the owner has not been identified.

- **Including a utility relocation schedule would make the UCM more useful**. Utility relocations frequently need to take place at different times. District staff would like to see a schedule showing the order in which utility installations need to move as well as predecessor and successor conditions.
- **A database approach is the preferred implementation strategy**. District officials indicated that a database approach is the logical way to move forward with the UCM process. However, it would be critical to have a well-implemented, user-friendly system. The database should not to make it harder to use the UCM approach than a stand-alone Excel version, which is very easy to modify.

Data Model and Database

The research team updated the UCM data model and Access database to reflect suggestions from MDSHA district officials for the usability of the UCM approach as well as lessons learned by members of the research team as part of other research initiatives, in particular related to the development of generalized inventories of utility facilities within the highway right-of-way. Part of this effort involved developing data entry forms in Access to manage information about projects, utility owners, utility facilities, and utility conflicts. The various components of the updated UCM data model and database include the following:

- **Business process model**. This model describes the process to identify and manage utility conflicts.
- **Conceptual model**. This model is a high-level representation of groups of objects or entities that are needed to manage utility conflicts.
- **Logical data model**. This model is a representation of data characteristics and relationships at a level that is independent of any physical implementation.
- **Physical data model**. This model is a representation of data characteristics and relationships that depends on the specific physical platform chosen for its implementation.
- **Data entry forms**. These Microsoft Access forms enable the management of information about projects, utility owners, utility facilities, and utility conflicts.

All these components are submitted as a separate, stand-alone deliverable.

The utility process needs utility data input, which occurs at different times of the process. Typically, as time progresses, utility information becomes more detailed and precise. Other elements of the utility process include coordination of utility relocation activities, preparation and execution of utility agreements, preparation of utility certifications, and monitoring of utility relocations and reimbursement of utility owners. Effective utility conflict management involves preparing and using UCMs systematically throughout the entire utility process. UCMs could be updated as follows (or at other critical milestones as needed):

- UCM 1: During preliminary design.
- UCM 2: End of preliminary design or beginning of detailed design.
- UCM 3: Around 30% detailed design.
- UCM 4: Around 60% detailed design.
- UCM 5: Around 90% detailed design.
- UCM 6: During construction.

Managing utility conflicts involves managing data about those conflicts as well as all kinds of related data. Conceptually, it is possible to identify six first-level (or core) topics or data objects that pertain to utility conflicts: utility conflict, utility facility, utility agreement, document, project, and user (Figure 3.2). Each of these data objects represents a real-world object that can be characterized by using a set of relevant tables and attributes. The logical and physical data models were built around these core entities. The research team accomplished this objective by using subject areas that provide a coherent view of all the entities associated with their corresponding core entity. The data model includes eight subject areas, that is, one for each core data object in the conceptual model, as well as one subject area for spatial entities and one subject area for application support entities. The most important subject areas are utility conflict and utility facility. The utility conflict subject area consists of the main entity UTILITY CONFLICT, related lookup tables, and linkages to other subject areas (Figure 3.3). A comprehensive list of all data model entities and definitions is included in Appendix A. The UTILITY CONFLICT entity has 28 attributes to describe a utility conflict, most of which are optional attributes. Mandatory attributes are DOT PROJECT ID, UTILITY FACILITY ID, UTILITY CONFLICT ID, and UTILITY CONFLICT DESCRIPTION. In addition, a utility conflict requires at least one design plan sheet number indicating where the utility conflict was found. This attribute is stored in table PLAN DOCUMENT (within the DOCUMENT subject area).

The utility facility subject area in the original SHRP 2 R15B deliverables only included the minimum number of utility inventory entities needed to manage utility conflicts. As such, those entities were placeholders for a more comprehensive treatment of utility facility-related data within the highway right-of-way. For the last two years, members of the research team have been involved in a number of other initiatives related to the development of strategies for preparing comprehensive inventories of utility facilities within the right-of-way. Two of those initiatives are a recent study completed for FDOT and an ongoing study for FHWA on the feasibility of using 3-D platforms for developing utility inventories within the right-of-way.

This report provides a summary of a generalized platform for developing utility inventories that can be used both for managing utility facility information needed to manage utility conflicts and for developing long-term repositories of utility facility information. The data model is generic and platform independent and can be used both for 2-D and 3-D applications because the model is based on real-world objects. The Utility Facility subject area consists of the main entity UTILITY FACILITY, related lookup tables, and linkages to other subject areas (Figure 3.4). Each record in UTILITY FACILITY represents a utility facility on the ground (or in development) and includes attributes such as utility type (e.g., communication, electric, gas), utility subtype (e.g., communication manhole, communication line), a brief description, whether it is a public or private utility, whether it is an aboveground or belowground facility, and utility owner. UTILITY FACILITY stores some basic information. Additional attributes (depending on the type of information) are stored in UTILITY FACILITY DETAIL and UTILITY FACILITY FEATURE CLASS.

The research team used the physical data model to generate a script to build a version of the UCM database in Access 2010 format. The research team then designed queries and forms for data entry using custom VBA code. The main goal of developing the data entry forms was to illustrate the use of the UCM approach in a stand-alone database environment to users who are not IT professionals. The data entry forms are sufficiently polished and user friendly so that they can be used for actual data entry in a stand-alone environment. From this perspective, they provide a unique opportunity for users to become familiar with some of the typical protocols that would take place when managing utility conflicts in a database environment. Although the Access forms are not compatible with an enterprise-level environment, they provide a preliminary design based on which enterprise-level forms could be developed.

The research team prepared several data entry forms in Access 2010. The application includes a main user interface (Figure 3.5), four main forms (to manage projects, utility companies, utility facilities, and utility conflicts), and several subforms within each of the main forms. Figures 3.6 through 3.8 show the three subforms to manage projects, while Figures 3.9 through 3.11 show one example subform of the other main forms. This version of the data entry forms does not include the subsheet to analyze utility conflict resolution alternatives.

The research team conducted some limited testing of the Access data entry forms by entering data that MDSHA districts gathered when they were populating their stand-alone UCMs for the six pilot implementation projects. For the testing, the research team sequentially entered data about projects, utility owners, utility facilities, and utility conflicts. General observations on the use of the Access database approach to complete these activities are as follows:

- **Data entry is time-consuming but cost-effective.** The research team noticed that entering data into the database required time and effort. An informal estimate was that, for new users, it took about 8 hours of effort to enter data for some 60 utility conflicts. While significant, managing utility conflicts is really about making an up-front investment with the expectation of a significant return on that investment during the life of the project. The rate of return of that investment can be huge, possibly by a factor of 100 or more. For example, in case of the MD 32 project, MDSHA project staff probably spent less than 36 hours, or approximately $3,600 (using an estimated hourly rate of

$100), populating the UCM. The estimated economic benefit of using a UCM approach for that project was $500,000, which would translate to a net benefit of about $139 saved for each dollar invested.

- **Microsoft Access has limitations for managing utility data.** While Access provides a convenient database platform for managing utility conflicts, Access is really designed for stand-alone implementations. Both the query structure and the VBA code pushes the limits of what can be reasonably expected with this kind of database environment. During testing, the research team noted that sometimes it took a few seconds for forms to open or commands to execute. The research team expects these issues to increase in magnitude as the database grows in size, particularly in a multiuser environment.
- **Enterprise, centralized database implementation is more beneficial and cost-effective in the long term.** By design, Microsoft Access uses a decentralized implementation concept consisting of unlimited copies of the same database to be used at several locations. The current application requires access to the physical database either on a local or network drive. A more user-friendly approach would be to develop an enterprise-level application that is accessible via the Internet and uses a database platform such as Oracle or SQL Server. That would also facilitate access and contributions by stakeholders outside of the DOT, including utility companies and consultants.
- **A conflict resolution alternative analysis subsheet should be further evaluated.** MDSHA did not use the conflict resolution alternative analysis subsheet during the pilot implementation. However, comments from stakeholders indicated that this feature might be useful under certain circumstances involving high-impact utility conflict locations.
- **Utility conflict event tracking should be further evaluated.** A major benefit of a database approach is the automated tracking of events associated with utility conflicts. An evaluation of this feature by MDSHA staff was not possible because the application was completed near the end of the pilot implementation.

One-Day UCM Training Course

The research team delivered the one-day UCM training course twice as part of the pilot implementation in Maryland. The first time was before the districts started the pilot application of the UCM approach on actual projects. Following discussions with MDSHA near the end of the pilot implementation, the research team scheduled a second one-day UCM training course for additional users who did not have the opportunity to attend the first course.

The first course took place in Hanover, Maryland. A total of 36 participants attended the course, representing MDSHA (29 attendees), utility owners (4 attendees), consultants (2 attendees), and FHWA (1 attendee). MDSHA participants included design, utility, and right-of-way acquisition officials, both from districts and headquarters. With some minor exceptions, the lesson plan was the same as that developed for the SHRP 2 R15B project. Although the time allocated to each of the lessons was generally appropriate, participants spent considerably longer during the hands-on exercise in Lesson 4. All groups were highly involved in their assignments, particularly during the identification of utility conflict resolution strategies and the group presentation, and, therefore, the research team decided to let the groups continue with that lesson for an additional half hour. To keep the course within the allocated schedule, the duration of the data model and database demonstration was shortened.

Participants were highly satisfied with the course structure and exercise dynamics. Prior to delivering the course, the research team made a few minor changes to the materials that were delivered as part of the SHRP 2 R15B research. The research team's observation was that participants reacted positively to those changes, particularly in Lesson 4. At the same time, participants provided several suggestions for improvements, including providing color plans to help differentiate utility features (the sample plan set was in black and white) and making sure the plan sets were printed to scale (because of a printing error, the scale was slightly off when the plans were printed prior to delivering the course). Other suggestions included using a set of plans from projects that participants were familiar with (instead of using projects or plan symbology from elsewhere that participants would have difficulty recognizing) and emphasizing the utility conflict resolution process. Some participants also recommended reducing the duration of the data model and database presentation (although some other participants recommended the opposite).

The second course took place in Baltimore, Maryland. The original intent was to provide UCM training to District 3 officials and their consultants, taking into consideration that most of these officials did not attend the first course. However, MDSHA considered that moving the course to agency headquarters in Baltimore would provide a greater opportunity for a larger number of officials to receive training on the use of the UCM approach. In total, 40 MDSHA officials representing several disciplines attended the course, although most participants were designers.

The research team used essentially the same version of the course materials that were used in the first course. The only difference was that plans from the MD 210 project were used instead of the set of plans from GDOT. The risk of using MD 210 files was that the utility investigations (and corresponding documentation) were only preliminary. As a result, it was not possible to demonstrate a complete example of the UCM to manage utility conflicts. However, the significant advantage was that officials were already familiar with MDSHA file symbology and design standards, and in several cases, they were also familiar with the project. As a result, the hands-on exercise was extremely effective, particularly during the group presentations at the end of Lesson 4. Feedback from course participants was highly positive. Officials also provided suggestions for changes to the training materials.

The research team prepared an updated set of training materials to support the one-day UCM training course. The changes made addressed comments and recommendations from participants at the two training events, as well as observations by the research team prior to, during, and after those events with respect to ways to improve the effectiveness of the presentation. The revised one-day UCM training course is divided into six lessons, as follows:

Morning Session

- Lesson 1: Introductions and Course Overview (30 minutes)
- Lesson 2: Utility Conflict Concepts (75 minutes)
- Lesson 3: Utility Conflict Identification and Management (75 minutes)

Afternoon Session

- Lesson 4: Use of Database Approach to Manage Utility Conflicts (20 minutes)
- Lesson 5: Hands-On Utility Conflict Management Exercise (120 minutes)
- Lesson 6: Wrap-Up (10 minutes)

The course is designed for a total of seven hours and 15 minutes of instruction, from 8:30 a.m. to 3:45 p.m. It includes 5:30 hours (330 minutes) of direct instructor contact and 1:45 hours (105 minutes) of breaks (including lunch). The course provides ample opportunities for participant interaction and enables the instructor to adjust session and lesson start times and durations depending on the audience and the level of participant engagement in the discussions.

Pilot Implementation Structure

In addition to lessons learned in connection with specific technical areas as described above (i.e., use of the UCM approach, data model and database, and one-day UCM training course), the pilot implementation in Maryland offered a few important lessons on the process to set up an implementation initiative to improve utility conflict management at a transportation agency. Relevant lessons learned include the following:

- **Administration buy-in**. A critical activity at the beginning of the project was a meeting with key MDSHA officials to go over the pilot implementation plan. This meeting was important for gaining support from upper management and included high-level design, construction, and utility staff. Prior to the meeting, there was consensus about the need to improve utility conflict management practices and a high-level understanding of the potential benefits of implementing the SHRP R15B products. However, agency officials did not have a working knowledge of the research products, specific activities that the agency would need to undertake during the pilot implementation, or the role that the research team would play. Critical discussion items included communication and coordination protocols both internally at MDSHA and between MDSHA and the research team, identification of potential dates to conduct the one-day training course, and ideas about the types of projects that might be suitable for the pilot implementation.

  Future implementations should include at least one initial meeting with key agency officials to ensure agency buy-in and facilitate the implementation process.

- **Statewide coordination**. MDSHA set up a working group composed of district utility engineers and headquarters officials. This working group identified the six projects. The statewide utility engineer served as the main point of contact between the research team and MDSHA. However, for project-level technical support and coordination, the research team interacted with the corresponding project managers and/or utility coordinators directly. This communication and coordination protocol provided flexibility and worked well. In a couple of instances, communication was hampered by changes in the project manager position. However, this became a useful discussion topic that highlighted the importance of using UCMs to develop a historical utility conflict management record that all stakeholders could access easily as needed.

  For future implementations, setting up a coordination team at the agency that can operate at two different levels of responsibility (overall coordination and project-level coordination) will provide the necessary oversight and flexibility to ensure the UCM implementation process is effective.

- **Project identification**. The six projects that MDSHA identified to test the implementation of the UCM approach provided a wide range of project types and field conditions. In general, projects in a relatively early design stage benefitted the most from the pilot implementation compared with projects in the final stages of design. The reason is that late in the design phase when the project design is essentially complete, there is little room for flexibility and project managers and designers are less inclined to consider alternative solutions to address utility conflicts.

  For future implementations it will be critical to select projects in early stages of design, ideally less than 30% design, although designs up to 60% complete might be considered, depending on project design constraints.

- **UCM training**. The research team conducted the first UCM training course prior to districts beginning to use the stand-alone UCM on actual projects. MDSHA participants included design, utility, and right-of-way acquisition officials, both from districts and headquarters. A second one-day UCM training course for additional users (mainly designers) took place toward the end of the pilot implementation. In retrospect, the need for a training course at the beginning of the pilot implementation was clear to all stakeholders. Given the project objectives and available budget, scheduling more than one training course at the beginning of the pilot implementation was not a high priority and was not included in the scope of work. However, interest by MDSHA in a second training course made it evident that providing as much UCM training as possible should be a high priority for any UCM implementation.

Future implementations should take this into consideration. Realistically, the number of courses to schedule will likely depend on factors such as agency size, types of projects that the agency handles, and staff interest. Agency participation in this training should include not just utility coordinators but also project managers, designers, and in general, stakeholders who are involved in the management of utility issues during project development and delivery.

- **Technical support**. Project-level communication and coordination with project managers, utility engineers, and other stakeholders took place in a variety of formats, including in-person meetings, conference calls, and e-mail exchanges. In several instances, the research team attended utility coordination meetings to observe the interaction between MDSHA officials and utility owner representatives. These events also provided an opportunity to respond to technical questions or offer advice on how to use the UCM approach. To the extent possible, the research team scheduled monthly conference calls and e-mail exchanges with project representatives to follow up on the progress of the pilot implementation and document lessons learned (although in some cases, in-person meetings would have been more effective). In addition, the research team scheduled a special trip to Maryland half way through the project to meet with representatives from each of the districts as well as headquarters.

  For future implementations, it will be highly advisable to set up a technical support group composed of subject matter experts to provide sound advice on effective UCM usage and strategies. Required qualifications should include expertise on topics such as project development and delivery process integration; project design procedures; and utility accommodation, coordination, and relocation procedures. Qualifications should also include a working knowledge of relevant technologies such as CAD and utility investigation techniques and standards. However, this type of support is technical in nature and should not be confused with other forms of assistance that might be required for communication, meeting facilitation, or outreach activities.

Recommendations

By all accounts, the UCM pilot implementation in Maryland was a success, and the UCM approach that was piloted and updated as part of the SHRP 2 R15C project should be replicated throughout the country. In the short term, FHWA, TRB, and the American Association of State Highway and Transportation Officials are proceeding with an implementation plan for the UCM research products, which is based on the use of lead adopter incentives. These incentives consist of funds for early adopters to offset implementation costs and mitigate risks. As part of the plan, recipients are required to provide specific deliverables designed to further refine the products, and possibly champion the products to other states and agencies.

The research team is not aware of other specific activities being planned to accelerate the implementation of the SHRP 2 R15C research products. It is worth noting that in late 2012, members of the research team were invited to participate in preliminary brainstorming sessions with state and federal stakeholders in which a number of ideas were discussed, including developing business cases, developing UCM competency through training, hosting workshops and peer exchanges, developing a web-based UCM user interface, and developing marketing materials.

The following are recommendations to facilitate the implementation of the three SHRP 2 R15C products throughout the country:

- **Use lessons learned from the pilot implementation in Maryland**. Consider applying the lessons learned in connection with specific technical areas (i.e., use of the UCM approach, data model and database, and one-day UCM training course) as well as the lessons learned on the process to set up an implementation initiative to improve utility conflict management at a transportation agency. Chapters 2, 3, and 4 provide detailed information on the technical areas. In addition, as described above, future implementations should take into consideration issues such as administration buy-in, statewide coordination, project identification, UCM training, and technical support.
- **Monitor and disseminate results of the initial UCM implementation**. Consider sharing the results of the UCM implementation with the transportation community at important implementation milestones. For example, it may be possible to schedule webinars or give presentations at relevant conferences and meetings to discuss partial results and identify lessons learned.
- **Consider additional strategies to accelerate the deployment of the UCM approach**. The initial UCM implementation will cover a limited number of state DOTs. However, the need to improve utility conflict management practices is acute throughout the country. Agencies that already use the UCM approach know that managing utility conflicts systematically can yield huge returns on investment within a short period. The MDSHA pilot implementation clearly demonstrated this benefit. One way to maximize the impact would be to focus on providing training to agencies while leaving the cost for the actual implementation of the UCM approach to individual agencies. The cost of each individual one-day training course is relatively low. However, the impact of the course is huge.
- **Strongly encourage participation in the one-day UCM training course**. The one-day UCM training course could be required training for any designer, project manager, utility coordinator, consultant, or contractor who interacts with utility owners or is in any way involved in the identification and management of utility conflicts. Agencies could implement a certification process to give the requirement to take the course more credence (and teeth). The MDSHA pilot implementation demonstrated that officials who take the one-day UCM training course develop a level of awareness about the importance

of managing utility conflicts systematically that would not be possible without that course. The cost of providing the course is relatively low when compared to the potential payoff, which can be quite significant. Given that a large number of stakeholders could benefit from taking the course, a funding structure might be developed so that all stakeholders involved (including transportation agencies, consultants, contractors, and utility owners) contribute financially to make the course self-sustained.

- **Make the one-day UCM training course materials available online**. Although in-person training is ideal, particularly the interactive hands-on exercise, many of the components of the training course are relatively straightforward and could be posted online so that stakeholders can access and use them at any time.
- **Strongly encourage the use of the UCM for applicable projects**. Agencies could make the use of the UCM mandatory for applicable projects. Considering that different agencies will probably use their own UCM version to satisfy their own needs and requirements, the focus could be on using the UCM systematically, as opposed to requiring the use of a specific template (although the UCM template that was prepared for the SHRP 2 R15C project could be used to help standardize the process).
- **Develop enterprise, centralized UCM database implementations.** Agencies could develop user-friendly, web-based, enterprise-level applications that use a database platform such as Oracle or SQL Server to automate the data entry, reporting, and management of utility conflicts. While Access provides a convenient database platform for managing utility conflicts, Access is really designed for stand-alone implementations. Both the query structure and the VBA code pushes the limits of what can be reasonably expected with this kind of database environment.
- **Further evaluate the conflict resolution alternative analysis subsheet.** MDSHA did not use the conflict resolution alternative analysis subsheet during the pilot implementation. However, comments from stakeholders indicated that this feature might be useful under certain circumstances involving high-impact utility conflict locations.
- **Further evaluate utility conflict event tracking.** A major benefit of a database approach is the automated tracking of events associated with utility conflicts. An evaluation of this feature by MDSHA staff was not possible because the application was completed near the end of the pilot implementation.
- **Develop a tool to streamline and standardize cost estimates and protocols for the submission of estimates and billings**. A frequent source of contention between state DOTs and utility owners is the preparation and review of utility agreements, cost estimates, and billings. Although current regulations provide flexibility to states with respect to what cost estimation methodologies to require and use, current practices lack standardization. As a result, it is common to have estimates for similar types of installations, but because different utility owners are involved, the estimates cannot be compared for consistency. By extension, it is difficult to compare utility relocations done through agreement with those that are included in the highway contract. Another

consequence of the lack of standardization is that state DOT officials must spend more resources than necessary reviewing and checking individual agreements and supporting documentation, not to mention the impact on utility owners because of the need to spend considerable resources (unnecessarily) redoing utility agreements and cost calculations.

- **Develop a module to estimate utility conflict risk levels**. The SHRP 2 R15C pilot implementation highlighted a methodology to identify and resolve utility conflicts systematically. However, the methodology (and by extension the data model) does not currently enable users to explicitly analyze the level of risk associated with individual conflicts. The UCM approach allows users to describe conflicts and outline resolution strategies, but it is up to individual users whether to incorporate uncertainty and risk in the analysis. Such a tool would enable users to explicitly consider and document these factors.
- **Evaluate the need for a UCM guidebook in addition to the UCM training course**. A recommendation from one of the MDSHA districts was that, in addition to the UCM training course, there should be a guideline to help stakeholders prepare and maintain the UCM. The updated training materials (see Chapter 4) include a number of changes and additions to the original training course materials that were developed as part of the SHRP 2 R15B project. The updated training materials are designed to provide more guidance to users on how to prepare and maintain UCMs. These materials also provide more information about the business process—for example, at what project development and delivery milestones it is recommended to populate or update a UCM. As the UCM approach is implemented throughout the country, it would be advisable to survey agencies to determine whether a separate UCM guidebook is necessary beyond what the UCM training course already provides.
- **Update utility guides and manuals to incorporate the UCM approach**. Agencies throughout the country would benefit from the inclusion of the UCM approach as an integral component of their business processes. This report, as well as the UCM training materials, includes specific content that could provide the foundation for the inclusion of the UCM approach in utility guides and manuals (which describe the utility business process) as well as other guidelines and manuals that integrate utilities into the overall project development and delivery process.

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ACRONYMS

ADA	Americans with Disabilities Act
ADT	average daily traffic
BGE	Baltimore Gas & Electric
CAD	computer-aided design
DOT	Department of Transportation
FDOT	Florida Department of Transportation
FHWA	Federal Highway Administration
GDOT	Georgia Department of Transportation
GUI	graphical user interface
IT	information technology
MDSHA	Maryland State Highway Administration
PI	preliminary investigation
PS&E	plan, specifications, and estimate
QLA	quality level A
QLB	quality level B
QLC	quality level C
QLD	quality level D
SHRP 2	Second Strategic Highway Research Program
TTI	Texas A&M Transportation Institute
UCM	utility conflict matrix
UMS	Utility Mapping Systems
VBA	Visual Basic for Applications
WSSC	Washington Suburban Sanitary Commission

APPENDIX A
Data Dictionary

Table A.1 defines the entities in the utility conflict database.

Table A.1. Utility Conflict Database—List of Database Entities

Entity Name	Definition
ACCOUNTING METHOD	An ACCOUNTING METHOD is a process to account for costs incurred during the adjustment of a utility facility, such as the category cost approach or the unit cost approach.
AGREEMENT DOCUMENT	An AGREEMENT DOCUMENT is a document that identifies the relationships, rights, and responsibilities between two or more parties.
AGREEMENT DOCUMENT TYPE	An AGREEMENT DOCUMENT TYPE is a word or phrase that characterizes an AGREEMENT DOCUMENT. Examples of agreement documents in use at the Texas DOT (TxDOT) include Federal Project Authorization and Agreement, LPA Agreement, and Municipal Maintenance Agreement.
ALIGNMENT REFERENCE	An ALIGNMENT REFERENCE is a point or line that can be used to define a location in reference to the point or a position on the line. Examples of an ALIGNMENT REFERENCE are “Edge of Pavement,” “Baseline,” “Right-of-Way Line,” “Centerline,” “Back of Curb,” “Survey Hub,” and “Reference Point in Driveway.”
ATTRIBUTE	An ATTRIBUTE is a property or characteristic of a UTILITY FACILITY serving to describe a UTILITY FACILITY.
CAD DOCUMENT	A CAD DOCUMENT is a document in electronic format that represents entities graphically by using points, lines, or polygons generated in a CAD environment (e.g., MicroStation).
CAD DOCUMENT CELL	A CAD DOCUMENT CELL is the name of a CAD cell used in a CAD document. A CAD document could have zero, one, or many CAD DOCUMENT CELLs.
CERTIFICATION DOCUMENT	A CERTIFICATION DOCUMENT is a LEGAL DOCUMENT that provides certification that a given task is complete for a TxDOT highway improvement project.
CERTIFICATION DOCUMENT TYPE	A CERTIFICATION DOCUMENT TYPE is a word or phrase that characterizes a CERTIFICATION DOCUMENT. Examples of certification documents include Appraisal Report, LPA Resolution, and Negotiator Report.
CITY	A CITY is an incorporated municipality in the United States with definite boundaries and legal powers set forth in a charter granted by the state. Source: *The American Heritage Dictionary of the English Language*, Fourth Edition, 2003. Retrieved December 17, 2013, from http://www.thefreedictionary.com/city.
COMMENT	A COMMENT is miscellaneous information that provides extra detail or description for an event.
COMPANY	A COMPANY is any organization typically external to a DOT that performs a role in the project development process.
COMPANY OFFICE	A COMPANY OFFICE is an organizational subdivision of a COMPANY. An example of a COMPANY OFFICE is a local office of a statewide operating COMPANY.
COMPANY USER	A COMPANY USER is an employee of a company that is registered with the database authentication system.

Entity Name	Definition
COMPOSITE ELIGIBILITY RATIO	A COMPOSITE ELIGIBILITY RATIO is a percentage that describes the relative amount of multiple estimated utility adjustment costs that is eligible for reimbursement by the state. A COMPOSITE ELIGIBILITY RATIO is calculated by dividing the sum of the eligible costs of the adjustments by the sum of the costs of the adjustments.
CONVEYANCE DOCUMENT	A CONVEYANCE DOCUMENT is a document that describes the rights and responsibilities of all the parties in a transaction that involves the transfer of property rights. Examples of a CONVEYANCE DOCUMENT include Standard Deed, Quitclaim Deed, Donation Deed, Agreed Judgment, and Judgment of Court in Absence of Objection.
CONVEYANCE TYPE	A CONVEYANCE TYPE is a word or phrase that characterizes a CONVEYANCE DOCUMENT. Examples of a CONVEYANCE TYPE are Standard Deed, Quitclaim Deed, Donation Deed, Agreed Judgment, and Judgment of Court in Absence of Objection.
COUNTY	A COUNTY is a political division within a STATE.
DESIGN LIBRARY	A DESIGN LIBRARY is a set of style definitions and resources for a MicroStation file. DOTs use design libraries within MicroStation to define standards for cells, levels, level filters, line styles, multiline styles, text styles, dimensions and several others. DOTs might have different design libraries for different engineering disciplines, including roadway, geotechnical, photogrammetry, and surveying.
DISTRICT	A DISTRICT is an administrative division within a STATE defined by a DOT.
DOCUMENT	A DOCUMENT is a tangible product in printed or electronic form produced from, resulting from, or documenting a DOT Project Development Process activity. A DOCUMENT can be indexed or catalogued in terms of business process operations or activities. Examples include forms, chapters, technical memoranda, invoices, and reports (provided the entire report is represented by a single file; otherwise the report would need to be represented by using document sets).
DOCUMENT DATE	A DOCUMENT DATE is a specific point in time that relates to a DOCUMENT and is stored in the database for legal or audit purposes.
DOCUMENT DATE TYPE	A DOCUMENT DATE TYPE is a word or phrase that characterizes a DOCUMENT DATE.
DOCUMENT ROLE	A DOCUMENT ROLE is a role or function that an individual has with respect to a document. Examples of a DOCUMENT ROLE are “reviewer” and “preparer.”
DOCUMENT SET	A DOCUMENT SET is a collection of documents. Examples include PS&E plan sets, proposals, and reports (provided several documents, e.g., chapters in separate files, make up the report; if a report is in a single file, the report is considered a document, not a document set.)
DOCUMENT SET ITEM	A DOCUMENT SET ITEM is a document that is part of a DOCUMENT SET. Examples include each of the chapters that make up a report (if each chapter is a separate document) and each of the plan documents that make up a PS&E plan set.
DOCUMENT SET TYPE	A DOCUMENT SET TYPE is a word or phrase that characterizes document sets with similar attributes and characteristics. Examples include utility agreements, utility agreement assemblies, change orders, PS&E assemblies, and plan sets.

Entity Name	Definition
DOCUMENT SYSTEM USER ROLE	A DOCUMENT SYSTEM USER ROLE is a mapping that represents the many-to-many relationships between a DOCUMENT, a SYSTEM USER, and a PROPERTY ROLE. DOCUMENT SYSTEM USER ROLE enables the identification of system users associated with a DOCUMENT and the PROPERTY ROLE of each SYSTEM USER. DOCUMENT SYSTEM USER ROLE can identify the parties of a legal document and their perspective roles.
DOCUMENT TYPE	A DOCUMENT TYPE is a word or phrase that characterizes a document with similar attributes and characteristics. Examples include plan document, imagery document, and easement document.
DOT OFFICE	A DOT OFFICE is an administrative unit within a DOT that has a specific responsibility in the project development process.
DOT OFFICE TYPE	A DOT OFFICE TYPE is a category of DOT OFFICE that defines its role in a state DOT's business processes.
DOT PROJECT	A DOT PROJECT is a transportation improvement project managed by a state DOT.
DOT PROJECT DATE	A DOT PROJECT DATE is the day, month, and year of an event or milestone associated with a DOT PROJECT.
DOT PROJECT DATE TYPE	A DOT PROJECT DATE TYPE is a characterization of a date or milestone of the project development process that is associated with a DOT PROJECT. Examples of a DOT PROJECT DATE TYPE are “Approved ROW Map Date,” “Letting Date,” and “DOT Estimated Construction Cost Date.”
DOT PROJECT SYSTEM USER	A DOT PROJECT SYSTEM USER is a mapping that represents the many-to-many relationships between a DOT PROJECT and a SYSTEM USER. DOT PROJECT SYSTEM USER enables the identification of SYSTEM USERS associated with a PROJECT and the identification of PROJECTS associated with a SYSTEM USER.
DOT UNIT	A DOT UNIT is an organizational subdivision of a DOT. Examples of a DOT UNIT are Construction Division, Planning Division, and local districts.
DOT UNIT TYPE	A DOT UNIT TYPE is an organization category for a DOT UNIT. Examples for DOT UNIT TYPE are DOT District and DOT Division.
DOT USER	A DOT USER is a DOT employee who is registered with the database authentication system.
EASEMENT DOCUMENT	An EASEMENT DOCUMENT is a document that describes the right to use the real property of another for a specific purpose, mostly in connection with right-of-way needs. The two parties in an easement are the grantor and the grantee.
ELIGIBILITY RATIO	An ELIGIBILITY RATIO is a percentage that describes the relative amount of an estimated utility adjustment cost that is eligible for reimbursement by the state.
ELIGIBILITY RATIO PROPERTY RIGHT OCCUPANCY	An ELIGIBILITY RATIO PROPERTY RIGHT OCCUPANCY is an association of an ELIGIBILITY RATIO with a PROPERTY RIGHT OCCUPANCY. The purpose of this association entity is to resolve many-to-many relationships between the two entities.
ELIGIBILITY RATIO TYPE	An ELIGIBILITY RATIO TYPE is a category that describes a certain kind of ELIGIBILITY RATIO.
ENCUMBRANCE DOCUMENT	An ENCUMBRANCE DOCUMENT is a document that defines the right or interest in a property that is held by someone who is not the legal owner of the property.

Entity Name	Definition
ENCUMBRANCE DOCUMENT TYPE	An ENCUMBRANCE DOCUMENT TYPE is a word or phrase that characterizes an ENCUMBRANCE DOCUMENT. Examples of agreement documents include Control of Access Agreement Document and Height Restriction Document.
ESTIMATE	An ESTIMATE is an approximation of costs for a utility adjustment that a utility provides to a DOT that is part of a UTILITY AGREEMENT in the form of an attachment.
ESTIMATE TYPE	An ESTIMATE TYPE is a characterization of an ESTIMATE. Examples of an ESTIMATE TYPE are “Utility Adjustment Cost” and “Engineering Cost.”
FEATURE CLASS ATTRIBUTE	A FEATURE CLASS ATTRIBUTE is a mapping between a UTILITY FACILITY FEATURE CLASS and an ATTRIBUTE. It identifies all UTILITY FACILITY FEATURE CLASSES associated with an ATTRIBUTE, and all ATTRIBUTES associated with a UTILITY FACILITY FEATURE CLASS. As such, the table identifies all ATTRIBUTES that a UTILITY FACILITY FEATURE CLASS can have.
FEATURE CLASS SHAPE	A FEATURE CLASS SHAPE is the form of a FEATURE CLASS in a GIS. For example, a FEATURE CLASS can have the shape of line, point, polygon, or multipoint. The FEATURE CLASS SHAPE is used to define the default or preferred shape of a FEATURE CLASS.
UTILITY FACILITY TYPE	A UTILITY FACILITY TYPE is a characterization of a kind of UTILITY FACILITY. Examples include water utility, gas utility, and communication.
HIGHWAY FUNCTIONAL CLASS	A HIGHWAY FUNCTIONAL CLASS is the functional classification of the roadway section for a project. Examples of a HIGHWAY FUNCTIONAL CLASS are “Interstate,” “Other Urban Freeway or Expressway,” and “Rural Principal Arterial.”
HIGHWAY SYSTEM	A HIGHWAY SYSTEM is a roadway that can be classified as a roadway that is maintained by a governmental unit such as a state or county.
HIGHWAY SYSTEM STATUS	A HIGHWAY SYSTEM STATUS is the state of a roadway, which can be either “planned,” “under construction,” or “existing.”
HORIZONTAL SPATIAL REFERENCE	A HORIZONTAL SPATIAL REFERENCE is a coordinate system that describes the horizontal location of a feature. Examples include NAD 1983, UTM Zone 12N, NAVD 1988, and GCS WGS 1984.
IMAGERY DOCUMENT	An IMAGERY DOCUMENT is a document that represents entities graphically by using pixel structures.
IMAGERY UNIT	An IMAGERY UNIT is a measurement unit for imagery documents that provides an indication of the image resolution level (or pixel size). Examples include feet, inches, meters, miles, and kilometers.
LEASE AGREEMENT DOCUMENT	A LEASE AGREEMENT DOCUMENT is a document that describes the temporary right to possess and use property (real or personal), usually in exchange for payment. The two parties in a lease are the lessor and the lessee (or tenant).
LINE COLOR	A LINE COLOR is the appearance of a line in a GIS or CAD environment based on a red, green, and blue value.
LINE STYLE	A LINE STYLE is a part of the symbology of graphic elements in MicroStation that defines a line's appearance as being continuous, continuous dashes, dots and dashes, and many others.
LINE WEIGHT	A LINE WEIGHT is a number within the range of 0 to 30 that designates the stroke width or thickness of a line in MicroStation that is being used to draw and plot a graphic element.
MAINTENANCE SECTION	A MAINTENANCE SECTION is an administrative unit of a DOT for the purpose of maintaining a portion of the highway system.

Entity Name	Definition
MEETING	A MEETING is a gathering of people for the purpose of discussing a typically predetermined topic.
ORIENTATION	An ORIENTATION is a compass reading, including north, east, south, and west.
PLAN DOCUMENT	A PLAN DOCUMENT is a document that contains one or more plan sheets. Plan documents normally include graphical elements that facilitate plan sheet printing for document submission purposes, such as title boxes, notes, and annotations.
PLAT	A PLAT is a map of a PARCEL.
PROJECT DEVELOPMENT PROCESS PHASE	A PROJECT DEVELOPMENT PROCESS PHASE is a distinct period in time for the development of a typical highway project, including the phases of planning and programming, preliminary design, design, construction, and postconstruction.
PROJECT DOCUMENT	A PROJECT DOCUMENT is a mapping that represents the many-to-many relationships between a PROJECT and a DOCUMENT. PROJECT DOCUMENT enables the identification of DOCUMENTS associated with a PROJECT and the identification of PROJECTS associated with a DOCUMENT.
PROJECT UTILITY ADJUSTMENT PROCEDURE	A PROJECT UTILITY ADJUSTMENT PROCEDURE is an association of a PROJECT with a UTILITY ADJUSTMENT PROCEDURE. The purpose of this association entity is to resolve many-to-many relationships between the two entities.
PROPERTY DESCRIPTION	A PROPERTY DESCRIPTION is a document that contains the necessary information to locate and survey a piece of property. Property descriptions may include a metes and bounds description and a plat.
PROPERTY DESCRIPTION TYPE	A PROPERTY DESCRIPTION TYPE is a word or phrase that characterizes a PROPERTY DESCRIPTION. An example of a PROPERTY DESCRIPTION TYPE is “Metes and Bounds.”
PROPERTY RIGHT	A PROPERTY RIGHT is an entity that provides information about the legal rights of a utility installation that allow it to occupy the land where it is installed.
PROPERTY RIGHT CLASS	A PROPERTY RIGHT CLASS is a definition of rights associated with a UTILITY FEATURE that provides the utility owner the legal right to occupy land with a utility installation. It is the highest level in the hierarchy of property rights. A PROPERTY RIGHT CLASS provides information about the underlying property rights that enable a utility owner to occupy land—for example, the property rights of a utility company for a utility facility in a particular location on the state ROW. A PROPERTY RIGHT CLASS may have several types to distinguish the property right further. Examples of PROPERTY RIGHT CLASS include “statutory,” “compensable interest,” and “encroachment.”
PROPERTY RIGHT SUBTYPE	A PROPERTY RIGHT SUBTYPE is a subdivision of a PROPERTY RIGHT TYPE. Examples include “private easement” and “public utility easement” for the PROPERTY RIGHT TYPE “easement.”
PROPERTY RIGHT TYPE	A PROPERTY RIGHT TYPE is a subdivision of a PROPERTY RIGHT CLASS. A PROPERTY RIGHT TYPE may have several subtypes to distinguish the property right further. Examples include “lease agreement,” “license agreement,” and “easement” for the PROPERTY RIGHT CLASS “compensable interest.”
PROPERTY ROLE	A PROPERTY ROLE is a role or function that an individual or an agency has with respect to a document that involves the transfer of property rights. Examples of a PROPERTY ROLE are grantor, grantee, lessor, lessee, appraiser, negotiator, and owner.

Entity Name	Definition
RIGHT-OF-WAY PARCEL	A RIGHT-OF-WAY PARCEL is a parcel that must be acquired as part of a DOT project.
ROLE	A ROLE is a function that a SYSTEM USER may perform for a specific project. Examples of a ROLE include “Project Manager,” “Surveyor,” “SUE Provider” and “Utility Coordinator.”
ROW FORM	A ROW FORM is a document in a standard format that a DOT uses for right-of-way purposes.
SELECTION DOT PROJECT	A SELECTION DOT PROJECT is a DOT PROJECT selected by a user while this user is managing utility conflicts (add, edit, delete or conflict event). A user can select a DOT PROJECT for adding a new conflict and a different project for editing or deleting a conflict.
SELECTION STATE	A SELECTION STATE is the STATE selected as current active state. There can be only one selected state at a time.
SELECTION UTILITY CONFLICT	A SELECTION UTILITY CONFLICT is a UTILITY CONFLICT selected by a user while this user is editing or deleting a conflict or managing utility conflict events.
SELECTION UTILITY FACILITY OWNER	A SELECTION UTILITY FACILITY OWNER is the utility facility owner selected by a user when this person is adding a new utility conflict.
SHEET GROUP	A SHEET GROUP is a document category that facilitates plan document grouping. Examples of a SHEET GROUP are typical sections, estimate and quantity sheets, plan and profile, and traffic control plans.
STATE	A STATE is a political division within the United States.
STATE DOT	A STATE DOT is a state department of transportation, which is a state government agency in the United States that focuses on providing transportation solutions for the state.
SURFACE TYPE	A SURFACE TYPE is a category that describes a kind of manmade or natural ground surface. Examples of a SURFACE TYPE are asphalt, concrete, or natural ground.
SYSTEM SETTING	A SYSTEM SETTING is a system parameter necessary for the operation of the application.
SYSTEM USER	A SYSTEM USER is an individual who has an account and the authority to use the database. The prototype allows two types of users: DOT USERs and COMPANY USERs.
TEST HOLE UTILITY FACILITY	A TEST HOLE UTILITY FACILITY is a mapping that represents the many-to-many relationships between a TEST HOLE and a UTILITY FACILITY. TEST HOLE UTILITY FACILITY enables the identification of UTILITY FACILITIES associated with a TEST HOLE and the identification of TEST HOLES associated with a UTILITY FACILITY.
UA CONTRACTING PROCEDURE TYPE	A UA CONTRACTING WORK PROCEDURE is a description of the work procedure used by a utility to adjust its facility that is part of a UTILITY AGREEMENT in form of an attachment.
UA UTILITY ADJUSTMENT TYPE	A UA UTILITY ADJUSTMENT TYPE is a method a utility uses to relocate or remove its facility. An example is a contract in which a utility uses the services of a contractor to relocate its facilities.
UAP EXCEPTION	A UAP EXCEPTION is an exemption to the state's utility accommodation policy.
UAP EXCEPTION TYPE	A UAP EXCEPTION TYPE is a category that describes a certain kind of UAP EXCEPTION.
UNIT	A UNIT is a magnitude of a physical quantity. For example, the units feet, inches, and yards are magnitudes of the physical quantity length. The table includes units that are commonly used to measure physical quantities of utility facilities.
USER EVENT	A USER EVENT is a creation or modification of a SYSTEM USER.

Entity Name	Definition
USER EVENT TYPE	A USER EVENT TYPE is a category that describes a certain kind of a USER EVENT transaction.
UTILITY ADJUSTMENT PROCEDURE	A UTILITY ADJUSTMENT PROCEDURE is a process to accomplish the adjustment and accommodation of reimbursable and nonreimbursable utility facilities on a DOT project.
UTILITY AGREEMENT	A UTILITY AGREEMENT is a contract between a DOT and other agencies in connection with a utility adjustment. A UTILITY AGREEMENT usually consists of a UTILITY AGREEMENT contract form and several attachments, such as engineering estimate, design drawings, and special provisions.
UTILITY AGREEMENT DATE	A UTILITY AGREEMENT DATE is the day, month, and year of an event or milestone associated with a UTILITY AGREEMENT.
UTILITY AGREEMENT DATE TYPE	A UTILITY AGREEMENT DATE TYPE is the characterization of a date or milestone that is associated with the process of completing and approving a UTILITY AGREEMENT. Examples of a UTILITY AGREEMENT DATE TYPE are “Agreement Submittal Date,” “Agreement Returned to Utility for Corrections Date,” and “Agreement Approval or Execution Date.”
UTILITY AGREEMENT REIMBURSEMENT APPROACH	A UTILITY AGREEMENT REIMBURSEMENT APPROACH is one of three allowable processes selected by a utility owner for reimbursement for costs incurred during the adjustment of a utility facility. The utility's selection is recorded in an attachment that is part of a UTILITY AGREEMENT.
UTILITY BILL	A UTILITY BILL is a request for payment that a utility submits to a DOT.
UTILITY BILL DATE	A UTILITY BILL DATE is the day, month, and year of an event or milestone associated with a UTILITY BILL.
UTILITY BILL DATE TYPE	A UTILITY BILL DATE TYPE is a characterization of a date or milestone that is associated with the process of receiving the request for a utility payment and completing the payment process. Examples of a UTILITY BILL DATE TYPE are “Billing Received from Utility Date,” “Billing sent to HQ Date,” and “Utility Paid in Full Date.”
UTILITY BILL TYPE	A UTILITY BILL TYPE is a category that describes a certain kind of UTILITY BILL.
UTILITY CONFLICT	A UTILITY CONFLICT is an instance in which a utility facility is noncompliant with the DOT’s utility accommodation policies, is noncompliant with safety regulations, is in conflict with a proposed transportation project feature, or is in conflict with another utility facility. A UTILITY CONFLICT can be resolved by using an appropriate measure such as modifying the proposed transportation design, relocating the utility facility, abandoning the facility in place, protecting the facility in place, or granting an exception to the state’s utility accommodation polices or safety regulations.
UTILITY CONFLICT ADJUSTMENT COST	A UTILITY CONFLICT ADJUSTMENT COST is the amount that a utility owner estimates to expend on the removal of a utility conflict by adjusting the utility facility.
UTILITY CONFLICT ADJUSTMENT COST TYPE	A UTILITY CONFLICT ADJUSTMENT COST TYPE is a characterization of a UTILITY CONFLICT ADJUSTMENT COST.
UTILITY CONFLICT ASSIGNMENT	A UTILITY CONFLICT ASSIGNMENT is a designation of a person to a UTILITY CONFLICT for a specific purpose, such as responsibility to manage and resolve the conflict.
UTILITY CONFLICT EVENT	A UTILITY CONFLICT EVENT is the occurrence of a change to a UTILITY CONFLICT.
UTILITY CONFLICT EVENT DOCUMENT	A UTILITY CONFLICT EVENT DOCUMENT is a mapping between a UTILITY CONFLICT EVENT and a DOCUMENT.

Entity Name	Definition
UTILITY CONFLICT EVENT TYPE	A UTILITY CONFLICT EVENT TYPE is a category that describes a certain kind of UTILITY CONFLICT EVENT.
UTILITY CONFLICT LOCATION TYPE	A UTILITY CONFLICT LOCATION TYPE is a characterization of the location of a utility conflict relative to the surface of the earth. Valid values for a UTILITY CONFLICT LOCATION TYPE are “overhead (aboveground)” and “belowground.”
UTILITY CONFLICT PARCEL	A UTILITY CONFLICT PARCEL is a mapping between a UTILITY CONFLICT and a RIGHT-OF-WAY PARCEL. It identifies all UTILITY CONFLICTS associated with a RIGHT-OF-WAY PARCEL, and all RIGHT-OF-WAY PARCLELS associated with a UTILITY CONFLICT. As such, the table identifies all RIGHT-OF-WAY PARCELS that are affected by a UTILITY CONFLICT.
UTILITY CONFLICT RESOLUTION ALTERNATIVE	A UTILITY CONFLICT RESOLUTION ALTERNATIVE is an option to resolve a utility conflict. Typically, there are multiple resolution alternatives for each utility conflict, which may or may not be feasible.
UTILITY CONFLICT RESOLUTION ALTERNATIVE DECISION	A UTILITY CONFLICT RESOLUTION ALTERNATIVE DECISION is an option for a determination on how to proceed with one of multiple alternatives for the resolution of a utility conflict. Examples of a UTILITY CONFLICT RESOLUTION ALTERNATIVE DECISION are “Rejected,” “Under Review,” and “Selected.”
UTILITY CONFLICT RESOLUTION STATUS	A UTILITY CONFLICT RESOLUTION STATUS is a definition of the status that a UTILITY CONFLICT can have in the process of resolving the conflict. For example, a UTILITY CONFLICT RESOLUTION STATUS can be “Utility conflict created,” “Utility owner informed of utility conflict,” “Utility conflict resolution strategy selected,” or “Utility conflict resolved.”
UTILITY CONFLICT SUBTYPE	A UTILITY CONFLICT SUBTYPE is a characterization that further describes a kind of UTILITY CONFLICT TYPE. Examples of a UTILITY CONFLICT SUBTYPE are “Finish Grade,” “Pathway,” and “Excavation.”
UTILITY CONFLICT TYPE	A UTILITY CONFLICT TYPE is a characterization that describes a kind of UTILITY CONFLICT. Examples of a UTILITY CONFLICT TYPE are “project feature conflict” and “utility regulation conflict.”
UTILITY FACILITY	A UTILITY FACILITY is a fixed structure or installation used by a utility owner for the purpose of transporting or delivering a utility.
UTILITY FACILITY DETAIL	A UTILITY FACILITY DETAIL is a record of information about a UTILITY FACILITY. Records in the table FEATURE CLASS ATTRIBUTE define which attributes a utility facility has, and as a result, which columns in UTILITY FACILITY DETAIL can be populated.
UTILITY FACILITY FEATURE CLASS	A UTILITY FACILITY FEATURE CLASS is a grouping of FEATURES of the same kind that have the same set of attributes. Examples of a FEATURE CLASS are “Communication Line,” “Water Manhole,” and “Electric Pedestal.”
UTILITY FACILITY LOCATION TYPE	A UTILITY FACILITY LOCATION TYPE is a characterization of the site where a UTILITY FACILITY is located. Examples of UTILITY FACILITY LOCATION TYPE include “State Right-of-Way (Permit),” “Private Easement,” and “Franchise.”
UTILITY FACILITY MATERIAL	A UTILITY FACILITY MATERIAL is the matter or substance that a UTILITY FACILITY is composed of.
UTILITY FACILITY OFFSET	A UTILITY FACILITY OFFSET is a description of the distance between a UTILITY FACILITY and a reference line such as edge of pavement or center line.
UTILITY FACILITY OPERATION TYPE	A UTILITY FACILITY OPERATION TYPE is a characterization of whether the utility company provides services for the public or for a private entity.

Entity Name	Definition
UTILITY INVESTIGATION QUALITY LEVEL	A UTILITY INVESTIGATION QUALITY LEVEL is a characterization of the quality and reliability of utility information. Valid values of a UTILITY INVESTIGATION QUALITY LEVEL are “QLD,” “QLC,” “QLB,” and “QLA.”
UTILITY INVESTIGATION TEST HOLE	A UTILITY INVESTIGATION TEST HOLE is a small opening in the ground, typically made by using a vacuum excavation technique, for the purpose of determining the exact vertical and horizontal position of a buried utility facility.
VERTICAL SPATIAL REFERENCE	A VERTICAL SPATIAL REFERENCE is a coordinate system that describes the vertical location of a feature. Examples include NAD, 1983 UTM Zone 12N, NAVD 1988, and GCS WGS 1984.

Note: LPA = limited partnership agreement; CAD = computer-aided design; DOT = department of transportation; PS&E = plan, specifications, and estimate; ROW = right-of-way; GIS = geographic information system; SUE = subsurface utility engineering; UA = utility agreement; UAP = utility accommodation policy; HQ = headquarters; QLD = quality level D; QLC= quality level C; QLB = quality level B; and QLA = quality level A.

APPENDIX B
Feature Class Attributes

Table B.1 lists the feature class attributes in the utility conflict matrix (UCM) database.

Table B.1. Feature Class Attributes Included in the UCM Database

Feature Class	Company	Description	Operation Type	Location Type	Age	Alignment Reference	Investigation Quality Level	Horizontal Spatial Reference	Vertical Spatial Reference	Horizontal Positional Accuracy	Vertical Positional Accuracy	Material	Depth	Diameter	Size	Duct Material	Duct Size	Width	Length	Height	Barrel Diameter	Barrel Height	Foundation Depth	Foundation Width	Cathodic Protection Flag
Communication Duct Bank	x	x	x	x	x	x	x	x	x	x	x	x	x			x	x	x		x					
Communication Guy	x	x	x	x	x	x	x	x	x	x	x	x		x				x		x					
Communication Handhole	x	x	x	x	x	x	x	x	x	x	x	x	x		x			x		x					
Communication Junction Box	x	x	x	x	x	x	x	x	x	x	x	x	x		x			x		x					
Communication Line	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x		x					
Communication Manhole	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x			x		x	x	x			
Communication Pedestal	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x			x		x					
Communication Pole	x	x	x	x	x	x	x	x	x	x	x	x		x	x			x		x			x	x	
Communication Pull Box	x	x	x	x	x	x	x	x	x	x	x	x	x		x			x		x					
Communication Push Brace	x	x	x	x	x	x	x	x	x	x	x	x		x				x		x					
Communication Splice Enclosure	x	x	x	x	x	x	x	x	x	x	x	x	x		x			x		x					
Communication Tracer Wire Protector	x	x	x	x	x	x	x	x	x	x	x	x	x												
Communication Vault	x	x	x	x	x	x	x	x	x	x	x	x	x					x		x					
Electric Duct Bank	x	x	x	x	x	x	x	x	x	x	x	x	x			x	x	x		x					
Electric Grounding Grid	x	x	x	x	x	x	x	x	x	x	x	x						x	x						
Electric Guy	x	x	x	x	x	x	x	x	x	x	x	x						x							
Electric Handhole	x	x	x	x	x	x	x	x	x	x	x		x					x		x					
Electric Junction Box	x	x	x	x	x	x	x	x	x	x	x	x	x					x		x					
Electric Line	x	x	x	x	x	x	x	x	x	x	x	x		x	x	x	x								
Electric Manhole	x	x	x	x	x	x	x	x	x	x	x			x							x	x			
Electric Pedestal	x	x	x	x	x	x	x	x	x	x	x	x								x					
Electric Pole	x	x	x	x	x	x	x	x	x	x	x	x		x	x			x		x			x	x	
Electric Pull Box	x	x	x	x	x	x	x	x	x	x	x	x	x					x		x					

Feature Class	Company	Description	Operation Type	Location Type	Age	Alignment Reference	Investigation Quality Level	Horizontal Spatial Reference	Vertical Spatial Reference	Horizontal Positional Accuracy	Vertical Positional Accuracy	Material	Depth	Diameter	Size	Duct Material	Duct Size	Width	Length	Height	Barrel Diameter	Barrel Height	Foundation Depth	Foundation Width	Cathodic Protection Flag
Electric Push Brace	x	x	x	x	x	x	x	x	x	x	x	x						x							
Electric Transformer	x	x	x	x	x	x	x	x	x	x	x		x					x		x					
Electric Vault	x	x	x	x	x	x	x	x	x	x	x	x	x					x		x	x	x			
Gas Compressor Station	x	x	x	x	x	x	x	x	x	x	x							x	x						
Gas Custody Transfer Station	x	x	x	x	x	x	x	x	x	x	x							x	x						
Gas Line	x	x	x	x	x	x	x	x	x	x	x	x	x	x											x
Gas Metering Station	x	x	x	x	x	x	x	x	x	x	x							x	x						
Gas Pressure Reducing Station	x	x	x	x	x	x	x	x	x	x	x							x	x						
Gas Valve	x	x	x	x	x	x	x	x	x	x	x				x										
Gas Vent	x	x	x	x	x	x	x	x	x	x	x				x										
Miscellaneous Line	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x					x					x
Miscellaneous Point	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x			x		x					
Nonpotable Water	x	x	x	x	x	x	x	x	x	x	x	x	x	x											
Nonpotable Water Line	x	x	x	x	x	x	x	x	x	x	x	x	x	x											x
Petroleum Custody Transfer Station	x	x	x	x	x	x	x	x	x	x	x							x	x						
Petroleum Line	x	x	x	x	x	x	x	x	x	x	x	x	x	x											x
Petroleum Metering Station	x	x	x	x	x	x	x	x	x	x	x							x	x						
Petroleum Pressure Reducing Station	x	x	x	x	x	x	x	x	x	x	x							x	x						
Petroleum Valve	x	x	x	x	x	x	x	x	x	x	x				x										
Sanitary Sewer Cleanout	x	x	x	x	x	x	x	x	x	x	x	x	x	x											

Feature Class	Company	Description	Operation Type	Location Type	Age	Alignment Reference	Investigation Quality Level	Horizontal Spatial Reference	Vertical Spatial Reference	Horizontal Positional Accuracy	Vertical Positional Accuracy	Material	Depth	Diameter	Size	Duct Material	Duct Size	Width	Length	Height	Barrel Diameter	Barrel Height	Foundation Depth	Foundation Width	Cathodic Protection Flag
Sanitary Sewer Line	x	x	x	x	x	x	x	x	x	x	x	x	x	x											x
Sanitary Sewer Manhole	x	x	x	x	x	x	x	x	x	x	x	x	x					x		x	x	x			
Sanitary Sewer Pump Station	x	x	x	x	x	x	x	x	x	x	x							x	x						
Sanitary Sewer Thrust Block	x	x	x	x	x	x	x	x	x	x	x		x					x	x	x					
Sanitary Sewer Valve	x	x	x	x	x	x	x	x	x	x	x	x	x	x											
Steam Line	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x										x
Steam Valve	x	x	x	x	x	x	x	x	x	x	x	x			x										
Sump Pit	x	x	x	x	x	x	x	x	x	x	x	x	x		x			x		x					
Utility Tunnel	x	x	x	x	x	x	x	x	x	x	x	x						x		x					
Utility Warning Sign	x	x	x	x	x	x	x	x	x	x	x	x			x										
Water Hydrant	x	x	x	x	x	x	x	x	x	x	x				x										
Water Line	x	x	x	x	x	x	x	x	x	x	x	x	x	x											x
Water Manhole	x	x	x	x	x	x	x	x	x	x	x	x	x					x		x	x	x			
Water Pump Station	x	x	x	x	x	x	x	x	x	x	x							x	x						
Water Thrust Block	x	x	x	x	x	x	x	x	x	x	x		x					x	x	x					
Water Valve	x	x	x	x	x	x	x	x	x	x	x	x	x	x											
Wet Well	x	x	x	x	x	x	x	x	x	x	x	x	x		x			x		x					