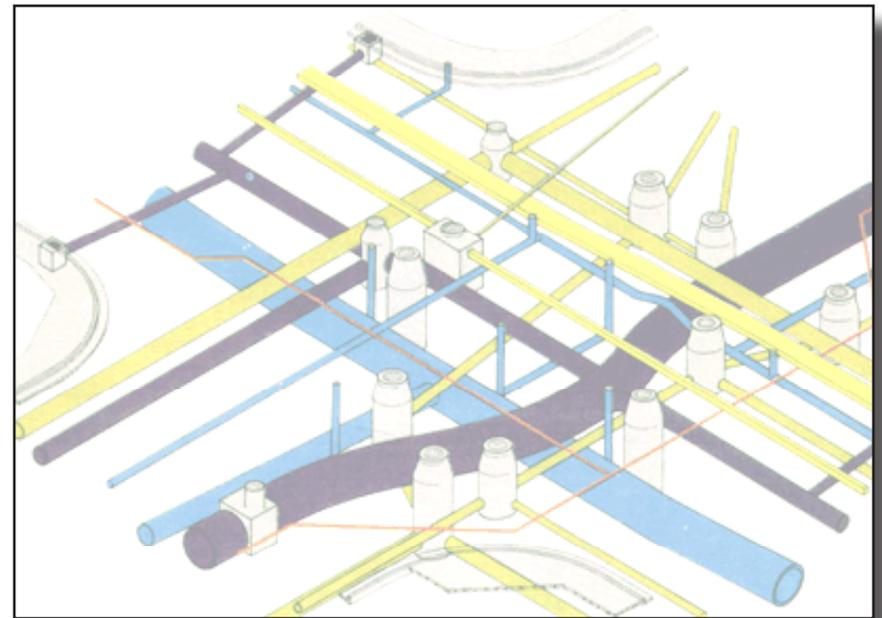


SUBSURFACE UTILITY ENGINEERING IN ONTARIO: CHALLENGES & OPPORTUNITIES

A SUMMARY OF MAIN FINDINGS

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PREFACE

The following report is intended as a succinct summary of the full study entitled 'Subsurface Utility Engineering in Ontario: Challenges & Opportunities'. Several sections of the full study have been omitted and most sections have been greatly reduced in size in order to convey a concise message to the reader. The full study is readily available for download from the Centre's website www.i2c.ca

EXECUTIVE SUMMARY

This report outlines the results of a 12-month study commissioned by the Ontario Sewer & Watermain Contractors Association to investigate the practice of utilizing Subsurface Utility Engineering (SUE) on large infrastructure projects in Ontario. The report includes detailed documentation of nine successful case studies of SUE implementation in Ontario. These case studies were generally characterized by having a value greater than \$500,000, being located in urban settings and having a large number of buried infrastructure systems. The research team documented the qualitative costs and benefits of conducting SUE in these cases. The average Return-On-Investment (ROI) for SUE, for these particular cases, was approximately \$3.41 for each \$1 spent. ROI figures varied considerably across the case studies and ranged from as low as 1.98 to as high as 6.59. All figures indicate a positive ROI. Even though the nine cases are representative of a typical urban project, ROI values reported in this study cannot be considered universal. Every project has its own circumstances that will determine – to a great extent – the expected benefits from performing SUE. As such, this report highlights some of the important project-related characteristics that could make a SUE investigation a worthwhile investment. The report also presents the results of an industry-wide survey that attempts to better understand how inaccurate subsurface utility information impacts project outcomes.

RECOMMENDATIONS

Increasing awareness of SUE: Although most municipalities and utility companies are quite aware of the SUE process and its various quality levels, this is not the case among contractors. Responses to question #9 in the contractor's survey revealed a reluctance to adjust bid contingencies in cases where SUE investigations were performed. It is believed that this is mainly due to the fact that contractors are not entirely aware of the SUE process, how it differs from traditional methods of information collection, and the meaning of the 4 quality levels. This increase in awareness can be achieved through various contractor associations and industry groups.

Explicit transfer of risk pertaining to utility information: In order to leverage the full benefits of SUE, it is believed that project owners should amend contract conditions such that the risk pertaining to inaccurate subsurface utility information is borne by those parties that are best capable of managing it. Traditional contract clauses that transfer all such risks to contractors will eventually prevent contractors from adjusting their bid contingencies in cases where substantial SUE investigations are performed. When a full-scale SUE investigation is performed, the owner and the SUE provider are best fit to assume these risks. Transferring this risk to contractors is unnecessary and this will only lead to higher bid contingencies.

Systematic incorporation of SUE: Conducting a SUE investigation should not be considered an ad-hoc exercise by project owners. In this regard, SUE should be considered as an integral part of the greater process of project risk management (where the risk to be managed is the inaccurate location of subsurface utilities). As such, all project owners should systematically consider the use of SUE on all projects that pose a substantial amount of risk.

Formalizing guidelines for level of SUE utilization: Faced with constrained budgets, municipalities and utility companies will be unable to perform higher quality levels of SUE (QL-A & QL-B) on all high-risk projects. Guidelines are required to assist project owners in allocating limited budgets to projects that will benefit the most from these levels of SUE. This study presented some project-related characteristics that could deem a SUE investigation worthwhile, but much more analysis is needed to create formal guidelines in order to assist project owners in their decision-making process.

Utilizing SUE early along the design process: Based on feedback from organizations that acquired SUE, there was a consensus that if a SUE investigation is performed, it should be brought in as early as possible in the design stage. This will ensure that the information that SUE provides will not lead to substantial amounts of costly re-design. Ideally, SUE should be introduced during the first 30% of the design process. It should be noted that in some cases, the SUE process was extended over a length of time and not performed all at once. This flexibility can provide project owners with the appropriate amount (and quality) of information that is required at each stage of design.

information by the SUE provider to other utility owners who might pursue projects in the same area. Although SUE providers are professionally bound to not disclose this information, some project owners expressed their concerns in this regard.

Need for more competition: The SUE market is currently predominated by one service provider that provides full-scale SUE services. Project owners would like to see more competition in the market.

Overconfidence: Project owners that have acquired SUE services complain of the overconfidence that their design team has felt during the design stage. Although basing designs on confident information allows the design process to proceed smoothly (and hence, saves design time and money), an overconfident design team that believes that all information is precise is more prone to design errors. This issue should be resolved by better education of designers on the meaning of different quality levels and the methods employed in collecting subsurface utility data.

Desiring too much information: One of the project owners indicated that when a SUE investigation is performed, it is likely that the project proponents (especially those with ventured interest in eliminating their risks) might get a 'Craving for Information'. This desire for too much information could cause the scope of the SUE investigation to increase and hence, the cost of SUE to soar. It is imperative that the scope of SUE be fine-tuned to truly reflect the designer's needs as well as the project conditions.

Possibility for work duplication: In a scenario where the design is not performed in-house, some owners expressed concern about the possibility of some work duplication between the SUE provider and the designer. If the interface is not properly managed, and the scopes are not well defined beforehand, the possibility of some work duplication exists amongst the two. This duplication will usually exist in the processes of records research (QL-D) and in some cases may extend to field surveys (QL-C).

Unidentified plant: It should be noted that the accuracy of information revealed by SUE is directly related to the scope of SUE services agreed upon between the project owner and SUE provider. In many cases where only a QL-C is performed, the owner runs the risk of missing some service connections or an abandoned plant.

INTRODUCTION

Buried infrastructures are increasingly impacting the performance of projects. As our population grows, urban cores expand and infrastructure ages, and existing utilities are becoming more prevalent, and in need of repair. As time goes on, records (or knowledge of them) are becoming increasingly irretrievable or difficult to reference. Reliance solely upon existing utility records creates risks. These risks manifest themselves in utility relocation costs, extra work orders, change orders, construction and redesign delays and potential damage to utilities with the resultant consequences of death, injury, property damage, and environmental discharges (ASCE, 1998).

The sole reliance on utility records can lead to the following problems:

- Records were not accurate in the first place. Design drawings are not often "as-built", or installations were "field-run", and no record was ever made of actual locations.
- Even so-called "As-builts" frequently lack the detail and veracity needed for design purposes in a utility-congested environment.
- References are frequently lost. Records show a pipeline offset from buildings that no longer exist or from curbs that have been relocated.
- Problems with abandoned buried facilities. It is very common for a facility to become abandoned, to not be physically removed but to be erased from a company's records. Other problems arise with facilities that are abandoned, physically removed, but not erased from a company's records.

"With the escalating level of congestion in our urban streets and the lack of consistent and reliable data about existing utilities, the value of accurate utility information is growing"

DAMAGE TO UNDERGROUND INFRASTRUCTURE

Excavation has always had the potential to damage buried infrastructure. This potential is manifested in urban cores having dense utility networks and in older areas where utility records are outdated. Damage to buried infrastructure has been reported in several instances, sometimes with catastrophic results (Underground Focus, 2005).

Jasper, Alberta, June 2004: *Excavations by a contractor resulted in damage to a large-diameter water main connecting the town's water supply source with the town's distribution system. The work was being done to tie the water main into a new public works building. Businesses in the industrial area were without water for approximately 5-1/2 hours. The pumps that supply the community and reservoir with water had to be temporarily shut down while the line was repaired. Repairs were expected to take two weeks.*

Toronto, ON, April 2003: *Seven people died and several others were injured in a deadly explosion that leveled a 2-story shopping plaza and surrounding apartments. Fire officials believe that the blast was caused by a construction crew who struck an under*

ground gas main with a backhoe. Natural gas seeped into the plaza's basement, where it ignited. Thick white and black smoke billowed into the sky and could be seen several kilometers away. Some 100 firefighters and 35 fire trucks, other emergency personnel, and the city's urban search and rescue unit were at the scene.

Williams Lake, BC, October 2003: An entire downtown city block, including a hotel, was evacuated by firefighters after a gas main was broken by an excavation crew. Maps indicated that there was a 2-inch line at the site and a 4-inch main in the area. When gas started blowing, workers crimped the 2-inch line in an attempt to shut off the gas, but to no avail. It was then discovered that the problem was with the 4-inch line. A strong wind carried the strong stench of gas for several miles. The wind then shifted and forced further evacuations while firefighters braved the cold and snow to man road barricades in the cordoned-off areas.

Accidents like these can and should be prevented. Locating services have a vital role to play in this regard. The following section presents an overview of underground utility locating services in Ontario.

LOCATING SERVICES

Two distinct underground utility designation/locating services exist in Ontario. The Ontario One-Call system is a centralized pre-construction designating service provided free of charge to excavators (the utility companies pay for the locating service). The Ontario One-Call provides pre-construction locating services prior to any excavation work. On the other hand, SUE has emerged as a pre-design designating and locating service provided by specialized providers. The following sections highlight the main differences between the two services.

Ontario One-Call System

The Ontario One-Call initiative started out in 1995 to act as a single entity responsible for providing utility locates for its member companies. Under the current system, any excavating contractor (or homeowner) should provide One-Call with the exact location of the proposed dig as well as the proposed start date for digging. Ontario One-Call requires a one-week notice before excavation to allow its locating crews to respond. Ontario One-Call operates a call center that has access to spatial databases (or records) and can identify possible conflicts with nearby utilities and notify the affected utility owners. When the utility owner receives notification (called a "ticket") from the One-Call center, they determine if there is a need to send their locating crews (or contracted locators) to the site. Once the locating team is sent to the site, the location of the underground plant is marked on the surface with color coded marking (usually following the American Public Works Association color scheme). The One-Call company will usually provide this service to its member utility companies for an annual fee, the driving factor being the mitigation of utility damage during excavation.

Subsurface Utility Engineering

Just as engineering surveying provides a map of existing features on the ground, SUE maps existing underground utilities/infrastructures. The varying quality of location information was a main driver for standardizing quality levels. The idea of 4 quality levels was first introduced by Anspach (1995) and later formally adopted by the ASCE CI 38/2002 standard (ASCE, 2002). The quality levels differentiate between information based solely on existing records (QL-D) and higher quality levels where a field verification was performed (QL A, B & C). QL-C relies on verifying the records based on in

respondents as to the methods that are employed to acquire subsurface utility information. In this regard, the hardcopy exchange of drawings and surveying of surface features were evidently much more popular among municipalities for information acquisition as compared to a softcopy exchange of drawings, test holes and the use of geophysical techniques (cable locators, GPR, sondes). When used, test holes and geophysical techniques were almost always contracted out rather than performed by in-house capabilities. With regards to spending on the acquisition of subsurface utility information, all respondents indicated that their spending had increased by varying extents over the past 5 years.

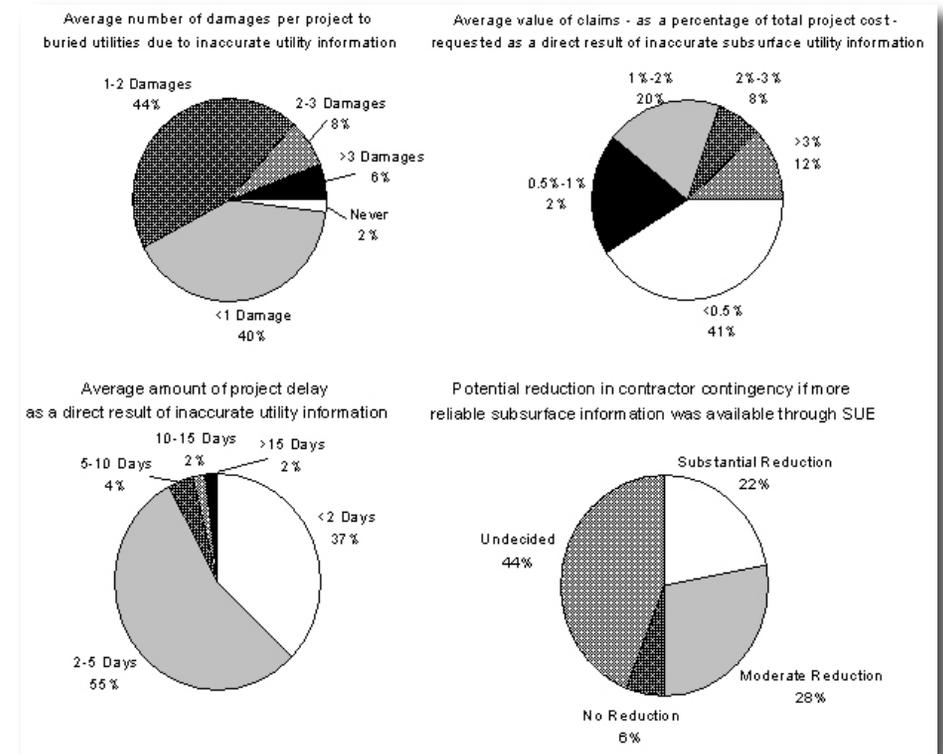


Figure 4 Overview of some of the results collected from the contractors' survey

POSSIBLE IMPROVEMENTS TO THE SUE PROCESS

As part of the investigation, the study team explored the concerns that were expressed by agencies acquiring SUE services. Six main concerns were highlighted:

Need to identify ownership rights: Project owners expressed their concerns over the need to identify proper ownership rights for the information produced by SUE. Owners expressed their concern over the possibility of reselling this detailed

As such, regardless of the encountered scenario, there is a chance that a claim will be filled requesting compensation either in the form of financial reimbursement and/or a time extension. Contractors were asked to estimate the average value of claims (as a percentage of total project cost) that are a direct result of inaccurate subsurface utility information. On average, respondents indicated that the average value of these claims is 1.1% of the project cost. Contractors were also asked how the value of the claims has changed over the last 5 years. 71% of respondents indicated that the value has either greatly increased or somewhat increased, 24% indicated that the value has remained unchanged, while only 4% indicated that it has decreased. With regards to project delays, respondents were asked to estimate the average amount of delay encountered on projects that are a direct result of inaccurate subsurface utility information. Figure 4 shows the responses to this question, and a crude analysis of these figures, by taking mid-range estimators, reveals that on an average project, approximately 3 days are lost due to inaccurate subsurface utility information. Contractors were asked to estimate the potential reduction in bid contingencies if more reliable subsurface utility information was to be made available prior to bidding through SUE. Although 50% indicated that some sort of reduction could be made, a staggering 44% were undecided. It is believed that this is mainly due to the lack of knowledge with regards to the SUE process and its various levels of quality.

Damage to Utilities & Injuries

Damage to utilities and injuries to contractor personnel (and in some cases the public) can occur during underground construction. In response to the escalating number of damages to utilities, the Ontario Regional Common Ground Alliance (ORCGA) has emerged as an industry forum that brings together municipalities, utility companies, excavators and locating contractors to propose industry best practices to mitigate damage to buried utilities during construction. Reasons for damaging utilities are numerous and range from a wrong marking by the pre-construction locating crew, to wrong excavation procedures in the vicinity of susceptible utilities. Analysis of these reasons is beyond the scope of this research. Instead, the study focused on obtaining a reliable estimate for the amount of utility damage that occurs due to inaccurate information. As such, the contractors were asked to estimate the average number of ‘hits’ encountered on a project as a direct result of inaccurate utility information in the past 3 years. Contractors reported an average of 1.2 damages per project with 58% of the respondents indicating that they encounter more than one damage incident per project, and only 2% reported that they did not encounter any damages at all in the last 3 years. With regards to the figures on injuries, only 17% of contractors reported having a lost time injury as a direct result of inaccurate utility information.

Municipality & Utility Owner Survey

Response from the survey disseminated to municipalities and utility companies was very low, with only 12 responses, and as such, the study team was unable to reach conclusive results on many of the questions that were asked. In spite of the low response rate, analysis of the responses did reveal that there was a consensus among

information obtained from visible above-ground utility features (valves, manhole covers, pedestals, etc. . .) as well as using professional judgment in correlating this information to QL-D information. The use of surface geophysical methods to determine the existence and approximate horizontal location of subsurface utilities renders the information QL-B, whereas QL-A requires the actual exposure of the utility and subsequent determination of its vertical location.

SUE services are normally provided during the pre-design stage of projects whereas One-Call is a strictly pre-construction designating service. SUE is now being provided by specialized service providers as well as civil engineering firms. In 1989, a court of competent jurisdiction recognized that SUE services are professional services rather than contractor services (Hyung et al 2004). In Ontario, a SUE provider must have a certificate of authorization from the Professional Engineers of Ontario to provide engineering services.

Comparison of Locating Services

While both services basically use the same technologies, fundamental differences exist in their process, purpose and end-product.

Utilities covered: Ontario One-Call will only issue a ticket to its member utility companies in a particular area. As such, utility companies that are not members will not have their plant located. On the other hand, SUE will locate all buried utilities within the required study area.

Process: One-Call provides a designating service (indicating the horizontal location of utilities), while SUE provides both designating and locating services (indicating the horizontal and vertical location of utilities).

Fee: The pre-construction locating fee provided by One-Call is paid for by the utility companies whereas any SUE services are paid for by the entity requesting the information. This scenario is mainly due to the ventured interest that utility companies have in preventing damage to their facilities that only exists during construction.

Obligation: Excavators are required by law to contact Ontario One-Call, while there is no obligation to perform SUE.

Purpose: One-Call will only be performed at the pre-construction stage of projects. In an effort to cut costs, most utility companies refuse to perform any pre-design designating services. SUE has emerged to fill this gap and provide the designating/locating service at the pre-design stage of projects.

Deliverables: One-Call locates will provide color coded marking on the surface while SUE will survey these markings and transfer them onto project plans.

THE VALUE OF SUBSURFACE UTILITY INFORMATION

The most significant contribution of SUE to the design and operation of an infrastructure project is in the increased reliability of buried utility information. With the escalating level of congestion in our urban streets and the lack of consistent and reliable data about existing utilities, the value of accurate information (that could be provided by SUE) is growing. The decision to take on a SUE study hinges mainly on the value of additional information reliability (provided by SUE) in contrast to traditional methods.

Figure 1 shows the relationship between information reliability and the risks associated with projects. These risks include (but are not limited to) hitting existing utilities, delays in the project schedule, or safety hazards to working crews. As shown in Figure 1, the increased information reliability comes at a cost. Low information reliability (Region ‘a’ on the figure) will normally be associated with higher risks. As information reliability increases (Portion ‘c’ on the figure), project risks decrease and the cost increases.

Portion 'b' in the figure is, theoretically, the optimal region where project risks have been sufficiently reduced (and thus money saved) and the cost of obtaining reliable information is still reasonable.

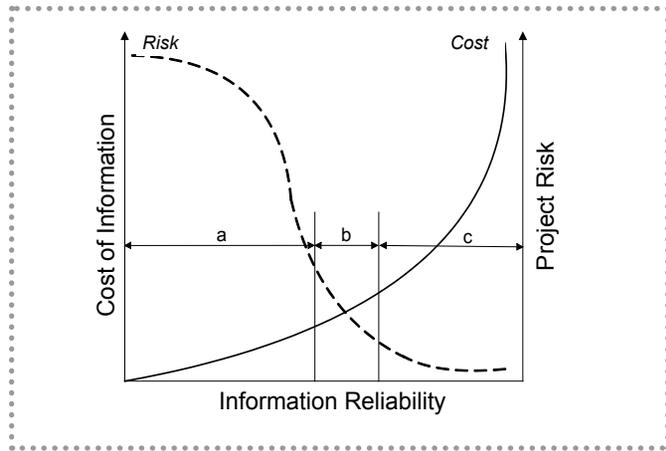


Figure 1 The effect of subsurface utility information on project risks

Figure 2 schematically illustrates how project risk exposure changes with respect to the reliability of utility information. Let us assume that project 'A' takes place in a quiet, new residential suburb with relatively few buried utilities (water, wastewater, and gas), while project 'B' takes place in an old downtown business core that has unreliable utility records and a plethora of congested buried utilities. To realize sufficient information reliability, Project 'A' requires a small amount of information to be collected, whereas project 'B' requires much more detailed information to render the project risks manageable. In order to achieve an acceptable level of risk, Project 'A' will only require a typical topological survey (SUE QL-C), whereas project 'B' will require a greater number of subsurface utility investigations of QL-B or QL-A.

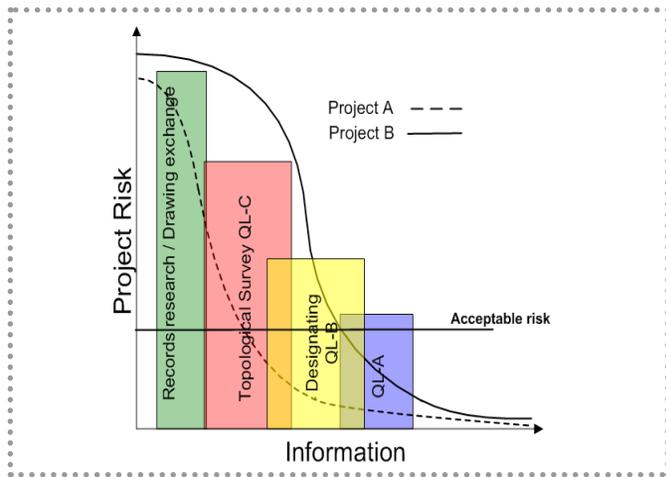


Figure 2 The effect of subsurface utility information on project risks for two types of projects

SURVEY ON THE QUALITY OF SURFACE UTILITY INFORMATION

In an attempt to properly assess the quality of subsurface utility information, an industry-wide survey was disseminated to municipalities, utility owners and contractors involved in the design and construction of urban infrastructure. The purpose of the survey was to 1) Measure the magnitude of the problem of inaccurate location-related information for buried infrastructure, 2) Investigate the relationship between the quality of location-related information for buried infrastructure and inefficient project delivery, and 3) Investigate the different methods used to obtain this information during the planning/design phase of projects.

Two sets of surveys were created, one intended for municipalities and utility owners while the other was intended for contractors. The contractors' survey was disseminated through various Ontario contractor associations (Ontario Road Builders Association, Ontario Sewer and Watermain Contractors Association, Utility Contractors association of Ontario, etc...). The municipality / utility owner survey was disseminated through the Ontario Regional Common Ground Alliance. Both surveys were posted on the Internet for 5 weeks.

Contractor Survey

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Contractor Claims, Contingencies & Delays

Unidentified or misidentified utilities can be encountered at two distinct stages during construction, either during conducting a pre-construction locate or during actual excavation. The later encounter has a much larger impact on the project overall and can potentially lead to devastating consequences. In the first encounter, the discrepancy is often minimal and a quick redesign effort can lead to no disruption of the construction sequence. In other cases, the contractor may have to adjust his schedule to avoid the conflicting area, alter the construction method, or wait for a timely redesign. On the other hand, when the mismatch is encountered during construction, the contractor cannot easily modify the work schedule and/or construction methods without incurring cost and/or schedule overruns.

Analysis of the figures shown in Table 3 and the responses from owners, designers and contractors revealed:

- The bulk of the cost savings (51%) are attained through the reduction of contractor claim costs. 31% of cost savings are attained through reduction in utility relocation costs, while the remaining 18% is attained through all other cost items.
- Figures for ROI varied considerably across projects. This depended to a great extent on the amount of “information gain” provided by SUE. Some projects that were extremely complex did not have substantial cost savings due to the fact that few discrepancies were identified by SUE. This should not indicate that utilizing SUE was unsuccessful, but rather that the information provided was used to confirm what is already known.
- Table 3 illustrates only direct cost saving figures. Project time savings are also realized when SUE is performed. These time savings arise from reduced design times, fewer utility conflicts on site, providing lead time to coordinate utility relocations and the potential for increased contractor productivity. Time savings were not included in the calculation of ROI.
- The 1% figure reported by contractors in the survey (please refer to the following section for details) for the average value of claims resulting from inaccurate subsurface utility information further reinforces the substantial amounts reported in the CCO cost item.
- As most projects were still in the design phase during the collection of information for this study, the value for CCC (Contractor Contingency Cost) was not frequently reported. 50% of the responses from contractors in the survey indicate a potential for reducing bid contingencies in cases where SUE was performed. As such, it is expected that more cost savings will be realized once construction is complete on projects.
- Several cost saving items were realized, but it was not possible to place a dollar value on them through systematic means. Examples include injury costs, impact on businesses, and service interruptions costs. The party investing in SUE does not always directly bear these costs, and hence, it can be argued that a direct return on investment calculation should not include these figures. Nevertheless, reducing impacts on businesses, injuries and service interruptions should be desirable from both from the public and from private sector perspectives. Whether project owners should invest in SUE to achieve these “user-cost savings” remains questionable.
- Interviews with project designers revealed that in cases when SUE was performed early on in the design process, design times for projects decreased. Rough estimates place these savings at 5-10% of the total design time. These savings are achieved due to the greater level of confidence in information and hence, less amount of ‘guess-work’ and ‘planning-for-the-worst’ are involved. In addition, savings in design are realized due to the reduced amount of redesign that is required once utility conflicts are detected. It should be stressed that these savings will not be fully attained if SUE is performed in the later stages of design.

This assumption acknowledges the fact that the mere identification of a utility conflict will not necessarily result in a cost being incurred. A utility conflict encountered during construction on a busy downtown street will be much more critical than one encountered in a quiet residential area in the suburbs. Similarly, damage to a 100 pair fiber optic cable is much more critical (and likely) than damage to a sewer. The relationships represented by the influence diagram emphasize the notion that simply encountering unidentified/misidentified utilities will not necessarily result in a significant cost being incurred. The actual value of costs incurred will depend largely on a great deal of project-specific characteristics (type of business activity, traffic volume, pedestrian volume, number of buried utilities, etc...).

Each of the cost items identified in Eq-1 is directly affected by one or more of the project-specific characteristics as shown in Figure 3. This relationship is multi-faceted and complex; Table 1 illustrates some of these relationships.

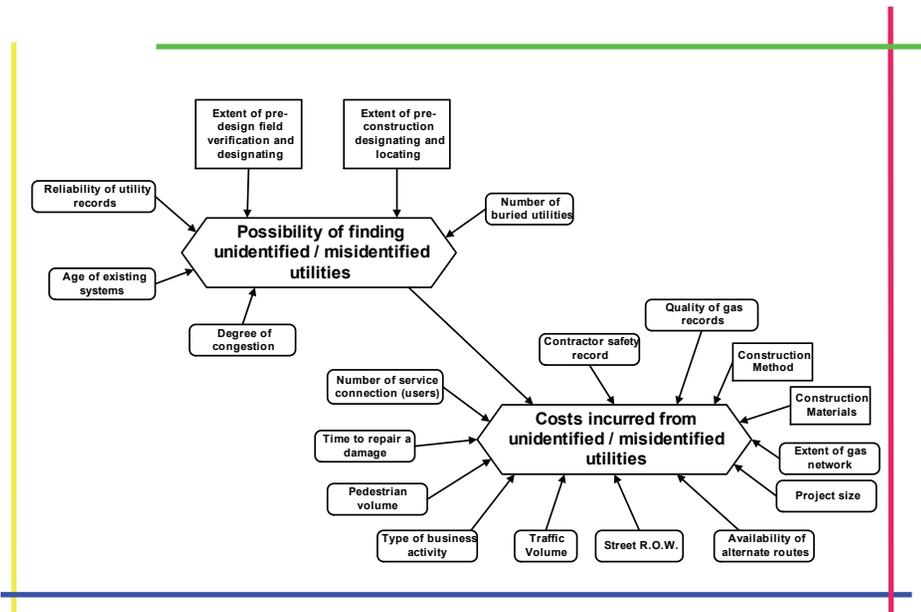


Figure 3 Influence diagram showing the relationship between project characteristics and the costs incurred for not performing SUE

“simply encountering unidentified or misidentified utilities will not necessarily result in a significant cost being incurred. The actual value of costs incurred will depend largely on a great deal of project-specific characteristics”

Cost Saving Item	Project-specific Characteristics
CCO: Contractor Claim Costs	<p><u>Project size</u>: The size of crews and equipment mobilized will have a direct effect on the value of a claim when a utility conflict is discovered during construction.</p> <p><u>Construction material</u>: Some materials are more flexible than others when it comes to performing minor on-site re-routing. For example, the use of pre-cast concrete pipes and manholes allows for very little flexibility in rerouting, and the lead time required for placing new orders make any utility conflict very costly.</p>
CIC: Contractor Injury Cost	<p><u>Extent of gas network</u>: As the main reason for contractor injuries during excavation is due to mistakenly hitting a gas utility, the extent of the gas network in the project area will directly influence the probability of contractor injuries.</p> <p><u>Quality of gas records</u>: The quality/reliability of gas records will directly influence the probability of mistakenly hitting a buried gas utility.</p> <p><u>Construction method</u>: The construction method adopted for utility installation will influence the probability of hitting a buried gas utility. Using open equipment excavation will greatly increase the probability of hitting a gas line.</p>
UDC: Utility Damage Cost	<p><u>Number of service connections</u>: The greater the number of service connections, the greater the opportunity for damage to occur.</p> <p><u>Number of buried utility systems</u>: Generally speaking, water, wastewater and gas are always buried systems. Electricity and telecommunications are sometimes buried. The greater the number of buried systems, the greater the opportunity for damage to occur.</p> <p><u>Utility susceptibility</u>: Depending on the route of the proposed work, some utilities will be more susceptible to damage than others. This becomes a great concern when the susceptible utility is very costly to repair if severed. For example, excavation work planned near a large fiber optic cable would be prone to incurring a large utility damage cost compared to work that is planned near a small sewermain.</p>
TDC: Travel Delay Cost	<p><u>Traffic Volume</u>: The greater the amount of traffic, the greater the number of users who will be affected and hence, the larger the travel delay cost.</p> <p><u>Alternate routes</u>: Presence of alternative routes and/or detours during the closure will alleviate the travel delay costs incurred by users.</p>

Table 1 Relationship between certain potential cost saving items and project-specific characteristics

CASE STUDIES

The following set of case studies present nine successful cases of SUE implementation in Ontario from 2002-2004. The study team selected projects that involved the construction of large infrastructure projects (Value greater than \$500,000). The case studies were investigated by conducting 1 to 2 hour interviews with project owners, and similar interviews were conducted with contractors who worked on the job whenever possible. Project drawings were carefully studied and discrepancies in utility information before and after SUE were compared. These discrepancies were then analyzed, and what-if-scenarios were created to predict the costs that could have been incurred if the SUE investigation had not been carried out. Cost estimates for these scenarios were obtained from the interviewee whenever possible. On projects that did not go to construction, contractor-related costs were estimated through interviews with experienced contractors in the relevant field. In general, most projects were characterized by:

- Projects ranged in value from \$500,000 to \$20,000,000.
- All projects had a relatively large number of buried utility systems.
- All projects except for one were municipal projects.
- The dollar value spent on the SUE investigation varied considerably depending on the extent of the project (from \$9,000 to \$90,000).
- The percentage of expenditures on SUE, as a percentage of total project cost, ranged from 0.125% to 3.5%.
- Projects were located in Central Ontario region.

“The earlier SUE is introduced, the more potential there is for attaining more cost savings”

Cost savings summary

Based on the information collected up until August 2005, the following cost savings have been identified to be a direct result of performing SUE. It is to be noted that due to the difficult nature of the cost saving elicitation process, a dollar value has been placed on those items that are quantifiable. Qualitative benefits such as reduced traffic disruption, impact on local businesses and the environment are evident, but are not included in the figures.

In an effort to quantify some of the less tangible impacts (reduced traffic disruption, impact on local businesses and the environment), the study team utilized a travel delay model based on estimates for average incomes in Canada (Tighe et. al., 2002, Tighe et. al. 1999). Based on an average biweekly income of C\$2000, the delay value per hour assigned would be \$25. To illustrate how the aforementioned model can be utilized, traffic delay costs for the Weston-Walsh case study will be examined. A traffic diversion plan that will result in the closure of a single lane is assumed, along with an estimated delay of 4 days that could have been encountered if the utility discrepancies were met during construction (assuming that no SUE was performed and the branching gas main was discovered during construction. Please refer to Appendix A for more details). Based on AADT values on Weston Rd., traffic delay costs associated with the excessive closure of the street are estimated at approximately \$50,000.