Subsurface Utility Engineering
A White Paper
1.0 Description

Subsurface Utility Engineering (SUE) is an engineering practice for accurately establishing the location of buried utilities within a project area, which is critical to developing options for construction. It provides a foundation for decision-making around construction design, allowing a design to manage risk related to utility coordination, utility accommodation and utility relocation at the outset. This document outlines the process and considerations involved in the practice of SUE at the pre-detailed design stage. SUE is based on the CI/ASCE 38-02 Standard Guideline for the Collection and Depiction of Existing Subsurface Utility Data, which provides a framework for evaluating the integrity of data based on four Quality Levels (Quality Levels D, C, B & A). The purpose of this document is to define the SUE scope of work and provide practical guidance on the application of SUE.

Furthermore, there are several utility data acquisition activities that lie outside the scope of SUE but are closely related and may overlap. These include chamber investigations, Closed Circuit Television (CCTV) Camera Inspections, Sonde Locating, Pole Camera Inspections, and Confined Space Entry (CSE). As such, this document also provides a description of these activities and key considerations around incorporating them into a SUE investigation.

2.0 Considerations for Determining the SUE Scope of Work

The SUE scope of work can vary greatly from project to project, and there are some key considerations for defining the scope of work. Ask these questions at the outset, and you’ll be able to tailor a SUE program to your project-specific requirements.

1. What are the potential project risks associated with utility location information? Will utilities be involved directly or indirectly with the project?

2. What level of utility information should be obtained to adequately manage risks such as project cost overruns, construction and design delays, stakeholder impact, etc.?

3. Has an “impacted area” been defined within the project area? The entire project area may not require a SUE investigation based on the project specifications.

4. At a project level, is there evidence to suggest the presence of buried objects or subsurface infrastructure?

5. Do the existing records contain inconsistencies? Is there evidence of additional utilities or buried structures not on record?

6. Do the anomalies identified require further investigation to understand the potential for site design and construction challenges?

7. If utilities are not in the exact location as shown on the records, what risk might this pose on the project site?

8. Will the project involve excavation and if so, what is the depth?

9. Is information on the vertical position (depth) of subsurface utilities or buried structures required to minimize risk or will information on the horizontal position suffice?

10. Are there proposed grade changes that could require utilities to be moved or affect sufficient depth for existing or future utilities?

11. Is the project high risk for utility conflicts with existing or future utilities? e.g., new bridge construction or bridge widenings where footings are placed; projects involving daylighted utilities that will clearly conflict and require rework?
3.0 Approach

Certifications

SUE consultants must have a Certificate of Authorization from the Association of Professional Engineers of Ontario (PEO). As SUE involves geophysical activities, it is recommended, but not mandatory, that the consultant also have a Certificate of Authorization from the Association of Professional Geoscientists of Ontario (APGO). A Professional Engineer is required to approve, sign and seal SUE deliverables and a Professional Geoscientist oversees geophysical activities that comprise the SUE scope, for example, the application of Ground Penetrating Radar (GPR) and subsequent analysis of GPR data.

SUE consultants should have experience locating all utility types required within the impacted area and also have verifiable experience completing projects of similar size and scope.

Utility Management Standards & Practices

CI/ASCE 38-02 Standard Guideline for the Collection and Depiction of Existing Subsurface Utility Data

Subsurface Utility Engineering was introduced by the American Society of Civil Engineers (ASCE) in 1996 and is based on CI/ASCE 38-02 Standard Guideline for the Collection and Depiction of Existing Subsurface Utility Data. SUE is comprised of four Quality Levels ascribed by this standard. Quality Levels define degrees of risk and provide a method to categorize the level of utility-related information required to design and construct a project. The four Quality Levels that comprise SUE are as follows:

- **Quality Level D (QL-D):** Information derived from existing records or oral recollections.
- **Quality Level C (QL-C):** Information obtained by surveying and plotting visible above-ground utility features and using professional judgment to correlate this information to Quality Level D information.
- **Quality Level B (QL-B):** Involves the application of surface geophysical methods to determine the existence and horizontal position of subsurface utilities within a project’s limits. Non-destructive technologies including Ground Penetrating Radar (GPR) and Electromagnetic (EM) tools are leveraged at this stage to accurately detect conductive and non-conductive underground assets. Quality Level B information is correlated with Quality Levels C & D to provide a comprehensive subsurface utility dataset that includes abandoned lines and other discrepancies, while confirming the accuracy of record data.
- **Quality Level A (QL-A):** Also known as daylighting, provides the precise horizontal and vertical location of utilities along with type, size, condition and material, obtained by the actual exposure (or verification of previously exposed and surveyed utilities) usually through vacuum excavation.
3.0 Approach

CSA S250-11 Mapping of Underground Utilities

This standard sets out requirements for generating, storing, distributing and using mapping records to ensure underground utilities are readily identifiable and locatable. The main objective of the standard is to provide governance for utility infrastructure records management and mapping; procedures for improved mapping accuracy; a uniform format for utility feature descriptions; and processes for notification of Geographic Information System (GIS) errors and practices when sharing data.

CSA S250-11 is primarily leveraged as a guideline for developing as-built drawings and as such is not always applicable to SUE. The level of detail required, (utility type, composition, depth, etc.) can only be achieved through a Quality Level A investigation, and therefore, the standard does not apply to SUE projects that only involve Quality Levels D-B.

Examples of pertinent standards of utility management:

- CI/ASCE 38-02 Standard Guideline for the Collection and Depiction of Existing Subsurface Utility Data
- CSA S250-11 Mapping of Underground Utilities
- North American Datum (NAD) 83 (2011) Survey Standard

4.0 Application of SUE Quality Levels

A SUE investigation involves the collection of utility data through four (4) quality levels, or activities, and the subsequent comparison and analysis of these data to compile the most complete and accurate composite data set for making informed decisions within a project or impact area. Factors to consider when making decisions around the application of SUE Quality Levels include the availability, completeness and quality of existing utility data, including topographic maps and records; whether data discrepancies are revealed when correlating this data; and the level of risk that will be incurred if utilities are not precisely located within the impacted area.

Quality Levels D-B

QL-D and QL-C should be applied to the entire project area including areas not expected to be affected by future construction, (e.g., temporary staging areas) whereas QL-B can be targeted to the impacted area. The project area refers to the entire expanse that resides within the defined project boundaries whereas the impacted area refers only to the area that will be directly impacted by planned construction. QL-D and QL-C should be completed prior to the commencement of a QL-B investigation, and data gleaned from should be provided to the SUE consultant so that datasets can be integrated and analyzed, and QL-B scope of work adjusted accordingly.

A SUE investigation is the analysis of data collected from each Quality Level. A QL-B investigation, for example, conducted in the absence of QL-D and/or QL-C data, does not constitute a SUE investigation. The QL-B investigation scope should be defined partly by the analysis of utility records and surface utility appurtenances surveyed in QL-D & C. QL-D is vital to project planning because it offers preliminary insights into the approximate location of utilities, their proximity to proposed construction, and level of utility congestion.

Also, integrating QL-D with the results of a QL-C investigation can be effective at revealing underground utilities that may have been omitted from records or erroneously plotted. Upon integrating and evaluating collected data from each Quality Level, a list of data conflicts can be compiled for evaluation.

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Furthermore, when QL-D is completed in isolation, there lacks a method to verify the accuracy of existing records, with respect to completeness and location. As-builts can be outdated, and are generally intended to approve a project design rather than provide a georeferenced utility record. For each level of SUE that is not applied to a project, risk increases and is absorbed back into the project.

**Quality Level A**

QL-A investigations are required when depth data or precise horizontal location must be obtained to achieve project goals. For example, high risk civil infrastructure projects such as a new urban bridge design, grade separations or a Light Rail Transit (LRT) track design along with social infrastructure projects that include the construction or expansion of hospitals, bus stations, community centres, etc.

Quality Level A should also be considered when the results of a QL-B investigation appear to be conflicting with existing utility records in key or critical project areas.

**Key Considerations:**

1. Establish if the project should be considered “high risk” for utility conflicts. For example, are grade changes required that might affect the sufficient depth of buried utilities?

2. Ascertain whether discrepancies were uncovered in the correlated Quality Level D, C & B data that can’t be resolved through professional judgement

3. Determine if depth data is required to sufficiently minimize risk or if horizontal data will suffice to achieve project goals

4. Consider whether there may be buried foundations and tanks not shown on utility records which could add risk to the project

5. Consider the proximity of suspected utilities to the project area and determine if areas of potential conflict are critical to project design

6. Determine, based on available data, if there is reason to suspect that utilities could be shallower or deeper than anticipated

7. Consider the impact to the project if utilities are not precisely located where they are shown to be on utility records and could not be field verified through QL-B activities

8. Consider the overall cost of the project and how the cost of the QL-A investigation will impact the bottom line

9. Consider the costs and risks involved with utility relocation for the particular utility types suspected to be in the project area. e.g., gas utilities take longer and are more costly to relocate

10. Consider the severity of the existing utility conflict(s) as in some cases, relocation will be necessary
5.0 SUE Timing

The delivery of a SUE program will vary based on project specifications. There are several factors that can affect the SUE schedule which should be considered in relation to the project’s overall timeline. Examples of these factors include:

- Requesting data acquisition activities that reside outside the scope of SUE may result in project delays. For example, chamber investigations may require traffic control, night work, special permits and on-duty police scheduling and fees. The value of the desired data to the project’s goals should be weighed against potential project risk, (added costs, delays, etc.)

- When scheduling a SUE program, other activities occurring on the project site should be taken into account, for example, topographical surveying, geotechnical or environmental assessments. Assess subcontractor project schedules for potential site access conflicts. Also data gathered, such as a topographic map generated by a Surveyor, can supplement the SUE Quality Level C scope of work if it occurs prior to the planned SUE investigation.

- The location of a SUE investigation, (Quality Levels B & A) can vastly affect the project timeline. For example, if the investigation occurs within a rail or congested vehicle corridor, traffic control and closures may be required. However, the investigation is related to a boulevard or private construction land, there will be far fewer time constraints.

- Determining the necessity, quantity and location of test pits usually occurs after reviewing the completed QL-B investigation and subsequent CAD utility drawing. The timing necessary to effectively review, and then schedule test pit activities should be considered. The turnaround time required to complete this exercise should be factored into the SUE schedule.

6.0 SUE Scope

Each SUE project should commence with a project kick off meeting that includes stakeholders such as the SUE Project Manager, Project Engineer, and Field Supervisor. If the client possesses a topographic survey and base plan of the project area, these should be supplied to the SUE consultant at the kick off meeting. Where a topographic survey exists that was completed by an engineer or Ontario Land Surveyor, QL-C can typically be considered complete as surface utility data is often captured during a topographic survey. Topics to be discussed at the meeting should include but not be limited to:

- Any knowledge or documentation of existing or future utilities within the project area
- Proposed limits of the SUE investigation
- SUE investigation requirements and expected deliverables
- Proposed SUE investigation timelines
- Proposed SUE investigation methodology
- Project-specific Quality Management and Health & Safety Plan
- Roles & responsibilities

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7.0 Deliverables

SUE deliverable formats can vary from project to project based on client standards and project specifications. It is the client’s responsibility to precisely articulate their desired deliverable format in the SUE Investigation Request for Proposal (RFP). Municipalities, for example, each have their own CAD standards, and CAD drawings are submitted through the municipality’s quality checker: a software tool that scans the submitted drawings to ensure they comply with the requirements of these standards.

This process is in place to ensure consistency among submissions and enable drawings to be readily used by various city departments. Considerations will include: whether data is to be reflected on separate layers or a single layer, labelling conventions, CAD software format (MicroStation or AutoCAD), digital submissions vs. hard copy, colour conventions, etc. The SUE report format may also vary based on whether the client desires photographs of test pits, test pit sketches, field sketches of utility locations, etc. Below is a description of typical SUE deliverables.

**CAD/MicroStation Drawing**
A draftsperson consolidates all collected field data using AutoCAD or MicroStation as per project and client specifications. The drawings are reviewed by a professional engineer to ensure accuracy, completeness and adherence to all intended standards. The drawings reflect all field located utilities along with utilities that could not be located using additional techniques but were obtained through records research. As discussed in the above paragraph, the format of the drawing will depend on the client’s standards and requirements, (hard copy vs. digital, number of layers, and labelling conventions).

**SUE Report**
A report is created by a Professional Engineer that includes, at a minimum, the following:

- Cover Page
- Table of Contents
- Executive Summary
- Project Overview

- An overview of the CI/ASCE 38-02 Standard
- Survey procedures and methodology
- Discussion of findings
- Field notes and sketches of utility locations, test hole data sheets, designating forms, data of all points, and drawings that depict the location of utilities within the project area at the appropriate Quality Level
- Summary of findings including project issues, limitations, and record betterment (data that was uncovered which was originally unknown)
- Summary, conclusions and recommendations on possible methods to resolve any outstanding items that may be crucial to project completion
- Closing/signing

The information is stamped and signed by a Professional Engineer licensed to practice in the Province of Ontario and the report is submitted to the Sponsor/Co-Sponsor in conformance with their specified standards.

**QL-A Photo Report**
QL-A deliverables include a photo report where pictures are taken of the exposed underground assets. The report includes a description of the project scope of work, a map depicting the test pit locations, an explanation of equipment and techniques used and an overview of collected data including: utility description, test pit location, XYZ coordinates, excavation dimensions, and depth to top and bottom of utility.
8.0 SUE Related Data Acquisition Activities

The following activities reside outside the scope of SUE as defined by CI/ASCE 38-02 but may be added to the scope of work when additional data is required. These activities should not be assumed to be part of the SUE scope of work, and must be requested separately by the client. Several considerations should be taken into account when requesting these activities such as cost vs. risk and the impact on project schedule. For example, if the activity can only occur between certain hours, such as at night, project delays may be incurred. These activities include:

• **Invert investigations:** Invert information is collected within the chamber from the surface. Inspections are leveraged to identify the sewer type, invert elevation, pipe material and diameter, chamber size, chamber offsets and chimney size (where applicable). Large offsets or excessively deep chambers may require confined space entry (CSE) specific to each chamber. Access to several chambers may require significant traffic control, including night work, special permits and On-Duty Police scheduling and fees.

• **Closed Circuit Television (CCTV) Camera Inspection:** CCTV equipment is leveraged to investigate sewers, maintenance holes, chambers and other underground features from the surface. A CCTV camera travels along the sewer mains and provides video footage for inspection. It can determine the alignment of the main sewer and locations of lateral connections while side launching capabilities can determine the alignment of the lateral connections. A sonde can be used to map sewer alignment on the surface using electromagnetic designating equipment.

• **Pole Camera Techniques:** Pole camera equipment can be utilized to investigate sewers, maintenance holes, chambers and other underground features from the surface. The pole cameras are to be inserted from the surface with zoom lenses. Photographs are taken to assist in the investigation of underground features. This technology can inspect chamber configurations, pipe alignments and the presence of utilities can be inspected using this technology. Cameras are to be fitted with automatic compensation for low light conditions typically found in subsurface investigations.

• **Electromagnetic Sonding for Sewer Locating:** The alignment of non-toneable sewers can be verified by pushing a sonde through the pipe. This is then mapped on the surface using electromagnetic designating equipment. Chamber depths, pipe configuration and the presence of debris may influence the effectiveness of this technique.

• **Confined Space Entry for Chamber Data:** Where Confined Space Entry (CSE) is required, personnel must have fall protection training and equipment, gas monitors, and respiration equipment. CSE may be required to obtain chamber information that is not available from the surface due to offset features, excessively deep chambers or visual obstructions specific to each chamber.
9.0 SUE Technology

The CI/ASCE 38-02 Standard stipulates that “appropriate geophysical methods” be leveraged to carry out the Quality Level B aspect of a SUE program. As this is a generic statement, there is room for interpretation. The geophysical method that is primarily leveraged to carry out the Quality Level B aspect of a SUE program is Electromagnetic (EM) Induction – otherwise known as pipe and cable locating. This technique is extremely effective at locating utilities comprised of electrically conductive material or those that contain an intact tracer wire. However, this technique is incapable of locating non-conductive utilities or those that contain a broken tracer wire.

When data collected at the Quality Level D and C stages of a SUE program reveals likeliness that non-conductive utilities reside on the project site, such as concrete or plastic pipes, buried trunk sewers, etc. other geophysical methods can be leveraged to supplement the SUE scope of work. These methods might include Ground Penetrating Radar (GPR), CCTV Sewer Inspection, Sonding, or Confined Space Entry (CSE), to name a few.

Costs associated with these additional methods must be weighed against risk. By analyzing data that has been collected and integrated at the Quality Level D and C stages of the SUE program, the project Sponsor/Co-Sponsor can determine the likeliness that non-conductive utilities are present in the project area and/or impacted area, and assess the level of risk that will be incurred should these utilities not be located.