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Avoiding Underground Utility Conflicts

Using subsurface utility engineering and 3-dimensional underground imaging before construction can be a smart, cost-effective design move

ByJames R. Allen, PE, and Nicholas M. Zembillas, Senior Vice President/Principal, TBE Group

Imagine this scenario: A power generating plant's planned environmental upgrade includes the installation of new concrete support foundations. The most recent records of existing underground facilities are not recent enough and fail to show a fire protection water main installed during a plant upgrade. A backhoe hits and cuts the water main securing the fire protection in that area, nearly washing out a road. The result: work stoppage at the construction site, a major safety concern at the plant and a costly construction delay while the water main is repaired.

Whether performing environmental upgrades, installing new underground utilities or adding new security facilities, many power generating plants are embarking on construction projects that present potential conflicts with existing underground utilities.

Experience has shown that relying on information from old plans and records regarding the location of underground utilities may not be the wisest decision. Often, these subsurface facilities are not where records say they are, or, as in the scenario outlined above, they are not shown on the records at all. Once construction begins, this inaccurate information can result in costly conflicts, damage, delays, service disruptions, redesigns, claims and even injuries and lost lives should a backhoe hit an underground electrical line.

Damage can be minimized by incorporating a technological procedure called "subsurface utility engineering" as part of the design and/or pre-construction process. For construction areas that may include a high concentration of underground facilities or potentially unknown underground obstacles and structures, a new technology, 3-dimensional underground imaging (3D-UI), provides a complete view of what lies beneath the surface.

Nondestructive vacuum excavation equipment verifies the vertical and horizontal locations of underground utilities where proposed concrete support foundations will be constructed for an environmental upgrade at the Seminole Generating Station. Photo courtesy of TBE Group.

Subsurface Utility Engineering

Subsurface utility engineering (SUE) is a highly efficient, nondestructive engineering process. It incorporates civil engineering, surface geophysics, surveying and mapping, nondestructive vacuum excavation and asset management technologies. Put to use it identified and classifies quality levels of existing subsurface utility data as well as maps the locations of underground utilities. The data allow for developing strategies and informed design decisions to manage risks and avoid conflicts and delays. If a utility conflict does exist, viable alternatives can be found to resolve the conflict before any damage is done.

In 2003, the American Society of Civil Engineers (ASCE) published and distributed a document entitled "Standard Guideline for the Collection and Depiction of Existing Subsurface Utility Data." This standard formally defined SUE and set forth standard guidance for collecting and depicting SUE information, elevating SUE to a new level.

The ASCE standard presents a system of classifying the quality of existing subsurface utility data. Such a classification allows project owners, engineers and constructors to develop strategies to reduce or allocate risks due to existing subsurface utilities in a defined manner. As a handout or as part of a specification, it helps engineers, owners and contractors understand utility quality level classifications and their allocations of risk. The standard closely follows concepts in place in the SUE profession. Therefore, many states are already in "compliance" with this standard through their use of SUE or through their inclusion of SUE specifications in their engineering contracts.

While the SUE process itself is tailored to each project, it typically includes the following field activities:

- Scope of Work – The process of developing a written project-specific work plan package that consists of scope of work, levels of service vs. risk allocation, project schedule and desired project delivery method. The SUE work plan package (which describes the work to be performed) is agreed on by the SUE provider and the client.
- Records Research – Quality Level D: The process of collecting all known utility as-built drawings or plans from all known utility owners that may be involved within the proposed project limits. This vital investigative process includes field reviews, interviewing key utility personnel, reviewing government permitting agencies and conducting a web-based search for any unknown utilities that may have been recently permitted and installed.
- Field Observation – Quality Level C: The process of surveying visible above-ground utility facilities, such as manholes, valve boxes, posts, and so on and correlating this information with existing utility records.
- Designating – Quality Level B: The process of using a surface geophysical method (or methods) to interpret the presence of a subsurface utility and mark its horizontal position – its "designation"– on the ground surface. Surface geophysical methods include any of those designed to use

At the Seminole Generating Station Quality Level A locates are marked on the asphalt to verify the vertical and horizontal locations of the existing underground utilities and foundations. Photo courtesy of TBE Group.

and interpret ambient or applied energy fields to identify properties of, and structures within, the earth. Such methods typically include variants of electromagnetic, magnetic, elastic wave, gravitational and chemical energies.

- Locating – Quality Level A: The process of exposing and recording the precise vertical and horizontal location of an underground utility. This typically involves nondestructive digging equipment, such as vacuum excavation, at critical points along an underground utility's path to determine the precise horizontal and vertical position, size and material composition of the underground utility line. By locating the utility's precise horizontal and vertical position, project participants can plan for proper protection, eliminate potential damage and safety hazards during construction and avoid unnecessary – and costly – utility relocations.
- Data Collection and Asset Management – The process of surveying the designating and locating utility data and entering it into a computer-aided design (CAD) system, geographical information system (GIS) or other data representation system.
- Conflict Analysis – The process of using engineering judgment, based on engineering and design best practices, to evaluate and compare depicted utility designating and locating information with proposed plans to inform all stakeholders of potential conflicts, potential resolutions and costs to cure.

The Plant Crist Station

In 2003, the Southern Co./Gulf Power Co.'s coal-fired Plant Crist generating station in Pensacola, Fla., embarked on a major environmental upgrade to reduce emissions. The upgrade required constructing a dozen separate concrete support foundations dispersed within the existing plant to support the massive new pollution control equipment.

The conceptual design phase for this project included underground discovery – identifying and verifying the location of underground utilities before the design and installation of the new support foundations. Locating these underground utilities to a depth of 10 feet using conventional excavation methods, such as a backhoe, would be costly, time-consuming and result in numerous large holes. SUE's nondestructive vacuum excavation process provided the same underground utility verification and was quicker and less disruptive.

"Using the vacuum excavation method, we were able to verify to a depth of 10 feet by means of 4-to-6-inch-diameter holes versus the 20-foot-diameter holes that would have been created using conventional excavation," said William Fuller, Southern Co./Gulf Power Co. Construction Site Manager.

"We were looking for ways to save time and money," he said. "We were able to verify underground utilities with the vacuum excavation process in two to three weeks, whereas conventional excavation methods would have taken two to three months. SUE provided us with an extremely efficient method for verifying underground obstructions."

Vogtle Generating Plant

After the September 11, 2001, terrorist attacks, the Nuclear Regulatory Commission ordered all nuclear power plant operators to implement additional security upgrades at their facilities. At the Southern Nuclear Operating Co.'s Alvin W. Vogtle Electric Generating Plant, near Waynesboro, Ga., these security upgrades included three new security fences.

Before these fences could be constructed, however, design engineers had to locate and identify any existing underground utilities that might present a conflict. The first fence circled the entire complex and also supported the plant's grounding grid. Caution was required to prevent cutting any portion of the grid when the fence poles were installed. The second fence surrounded the plant's multiple utility facilities, including fire water, potable water, sewer, communications, plant control and security electrical circuits. The third fence enclosed the reactor building, auxiliary facilities and control room.

Incorporating SUE into the upgrade process, plant engineers identified and located conflicting underground utilities that could have resulted in construction delays as well as serious operational or safety issues. To resolve the conflicts, the engineers either relocated the utilities or adjusted the fence design.

"With all of the digging and drilling we had to complete during the project, we had thousands of opportunities to strike buried piping and other underground commodities," said Chris Eckert, Site Security Project Coordinator at Plant Vogtle-Southern Nuclear Co. "We still took all of the normal safety precautions, but we never struck an underground commodity. We also took this opportunity to document, in a graphic display of the area, the locations and depths of all of the buried items, for future use."

Seminole Generating Station

The Seminole Generating Station in Palatka, Fla., owned and operated by the Seminole Electric Cooperative, has been in operation since 1983. The plant includes two 650 MW coal-fired, steam-electric generating units that require upgrading to meet pollution control standards. Upgrades include a new selective catalytic reduction system and upgrades to the existing wet flue gas desulphurization system.

Foundations have been designed to support the new equipment. As with Plant Crist, designers included SUE in the design process to detect and verify existing underground utilities and other foundations that might create conflicts with the new foundations. A total of 135 nondestructive vacuum excavation test holes provided precise vertical and horizontal data on the underground facilities, allowing for the completion of the final foundation and underground utility design that would avoid conflicts and damage to the existing facilities.

"It is common with most existing power plants that a complete record of as-constructed information on underground utilities and foundation limits is not always available," said Gregory Trupp, PE, Senior Associate Structural Engineer at Burns & McDonnell Engineering Co. "SUE allowed us to verify locations of existing underground utilities and foundations with the accuracy necessary to avoid potential redesign and construction schedule delays due to unforeseen conditions."

3D Underground Imaging

3D underground imaging (3D-UI) adds another dimension to SUE's locating and mapping capabilities. In areas with a high volume of known underground utilities or with the potential for unknown non-utility subsurface features, 3D-UI offers the advantage of being able to "see" in three dimensions, providing a full "cubed" view of the subsurface. For example, it can identify "stacked" underground utilities and such unknown anomalies as buried concrete structures, metallic debris or voids.

Furthermore, in situations where large, multiple-acre underground areas require investigation, 3D-UI offers more efficient, cost-effective imaging. Unlike conventional ground penetrating radar (GPR), 3D-UI includes 14 radar channels, not just one. 3D-UI data are collected in 5.12-foot-wide swaths at speeds up to five miles an hour, recording in one-inch increments – or 1.6 million radar scans per acre – resulting in 100 percent coverage of the area being investigated. While traditional designating and locating methods efficiently find underground utilities in many situations, 3D-UI is an alternative that may prove ideal in larger or wider areas where approximately one acre of data can be collected in a day.

In the post-processing phase, geophysicists use state-of-the-art proprietary software to convert the results of their data analysis to standard CADD/GIS format, which can be customized for compatibility with clients' internal databases.

Allen Power Station

A flue gas desulphurization retrofit at Duke Energy's Allen Steam Power Station in Belmont, N.C. involved major excavation and construction, including installing more than 70 36-inch-diameter concrete caissons. The design engineers Shaw Stone & Webster wanted to account for all known and unknown subsurface utilities as well as other potentially unknown underground obstacles and structures that would negatively impact the construction process.

While SUE's nondestructive vacuum excavation was used to identify and locate underground utilities, the designers also chose to incorporate 3D-UI at selected sites that would be impacted by significant construction activities. The 3D-UI process generated three-dimensional, or "cubed," data identifying more than 120 distinct targets. Some corresponded to known features on available maps, but some did not appear on any records and included such features as buried rebar, railroad ties, reinforced concrete, and other disturbed areas representing trenched and/or backfilled areas.

The designers incorporated the 3D-UI data into the later stages of the design phase to adjust their initial design. By bridging or moving several of the caissons, they hoped to avoid several certain subsurface conflicts and significantly reduce construction time and cost.

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