

Plotting a Better Way Multipurpose Information Utility Saves Time and Money

Since 2005, the Ontario Ministry of Transportation Geomatics function has been converting its property title records from hardcopy to digital format to provide desktop access to the ministry's property title and jurisdictional information. This is being accomplished through new digital records utilities that accurately reference information by locating units of land through a Geographic Information System accessed by ministry staff at their desks.

Digital Title Records (DTR) depict current and past ownership of ministry property acquired for the construction and operation of provincial highways. They also show the location of survey plans and the extent of ministry corridor control as established by highway designation. The interface assists ministry staff when working on projects and when sharing information with other ministries, agencies and municipalities.

Moving to Digital

Creating DTRs requires ministry staff to accurately create and geo-reference parcels of land, which are termed polygons. Polygons depict ministry property plans, documents and lot fabric. In some remote townships, identifying polygons can involve field work. Field staff conduct surveys to tie in survey monumentation along highway corridors to ensure the accuracy of geographically positioned DTR drawings.

Efficiencies

The ministry has significantly modified its document retrieval process by moving to DTR. Before introducing the DTR process, document retrieval was a physical process where staff went to a document counter, reviewed hardcopy title records books and then requested and reviewed hardcopy records in order to respond to property or jurisdictional queries. In contrast, the new electronic records method reduces record retrieval time by providing plans and documents to staff online at their desks. When identifying a particular area along the ministry's corridor, ministry staff can quickly view the history of past and current land holdings, and retrieve documents and plans associated with that area through embedded hyperlinks. The new digital method also reduces a need for printed copies.

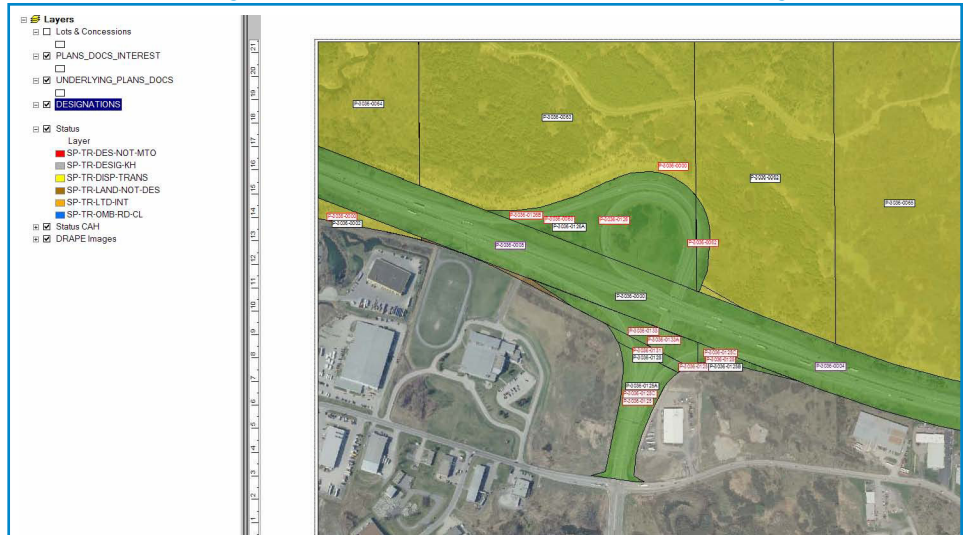


Figure 1: A computer screen shot depicting the Right-of-Way on a provincial highway.

Multipurpose Use

The boundary linework available through the DTR utility can be used for many other Geomatics products, creating additional efficiencies and reducing duplication. Some examples include:

- Engineering drawings and property requests – these drawings depict current limits of ownership.
- Jurisdictional Review Project drawings – the ministry's Geomatics Section merge imagery and DTR records for Jurisdictional Review Project drawings. These drawings assist staff when assessing construction on existing ministry land and improve accuracy and timely decision-making regarding MTO's jurisdiction.
- Overlays and custom sketches for public hearings - DTR linework depicts the impact of the ministry's proposals on adjoining or subject lands to enable effective and timely decisions during public hearings.
- Corridor reviews – The DTR linework is referred to during ministry staff discussions with the adjoining land owners to assess whether a permit will be issued for the proposed construction of signs, buildings and entrances along or in proximity to the highway corridor; also to determine whether development is within the limit of the ministry's corridor control area. >

Multipurpose Information Utility Saves Time and Money, *continued*

Converting to the DTR utility has its challenges, given the province-wide scale of the project; moving to DTR requires years of dedicated time and resources. For example, it took eight years of focussed effort to complete the ministry's eastern region DTR. Currently, the conversion to a ministry-wide DTR utility is in various stages throughout the province.

The ministry's transition to DTR is improving project efficiencies and information accessibility, resulting in a savings of time and money. The ministry anticipates full provincial coverage by the year 2020. ●

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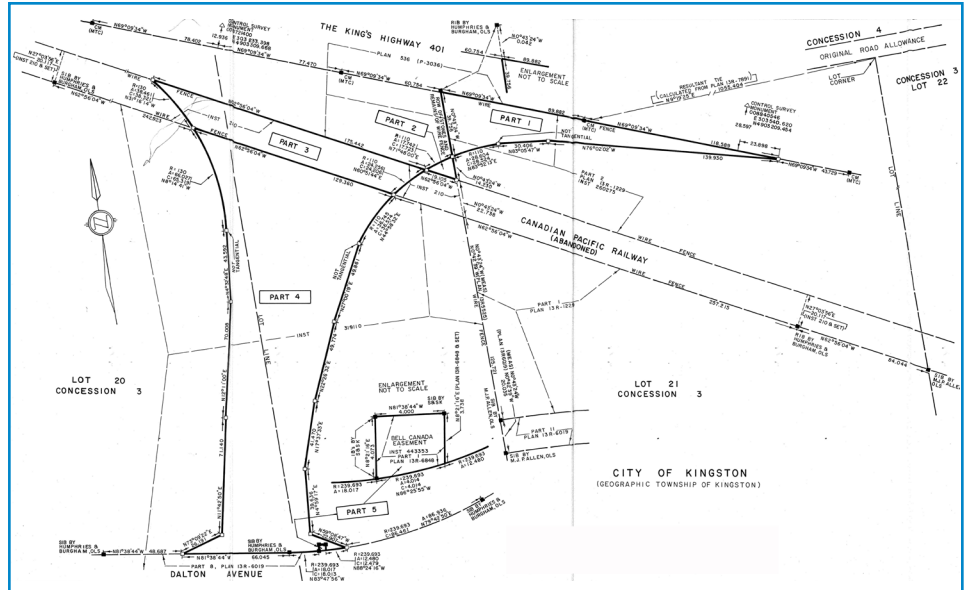


Figure 2: A sample digital reference plan that can be accessed easily from the DTR Information Utility.

Solving a Pavement History Mystery Ground Penetrating Radar Provides Continuous Pavement Condition Analysis

In 2005, the Ontario Ministry of Transportation (MTO) began the pavement rehabilitation and six-laning of the Queen Elizabeth Way (QEW) through the City of St. Catharines, about 8.5 km from Highway 406 to the Garden City Skyway. Preliminary pavement investigations incorporated the use of Ground Penetrating Radar (GPR) to supplement conventional investigation. Approximately 120 linear kilometres of detailed pavement condition data was collected to estimate the thickness and type of layered materials within each pavement structure on the QEW. This data was then used to develop a cost-effective pavement rehabilitation plan for the highway through St. Catharines.

GPR was used to supplement conventional survey methods such as: visual

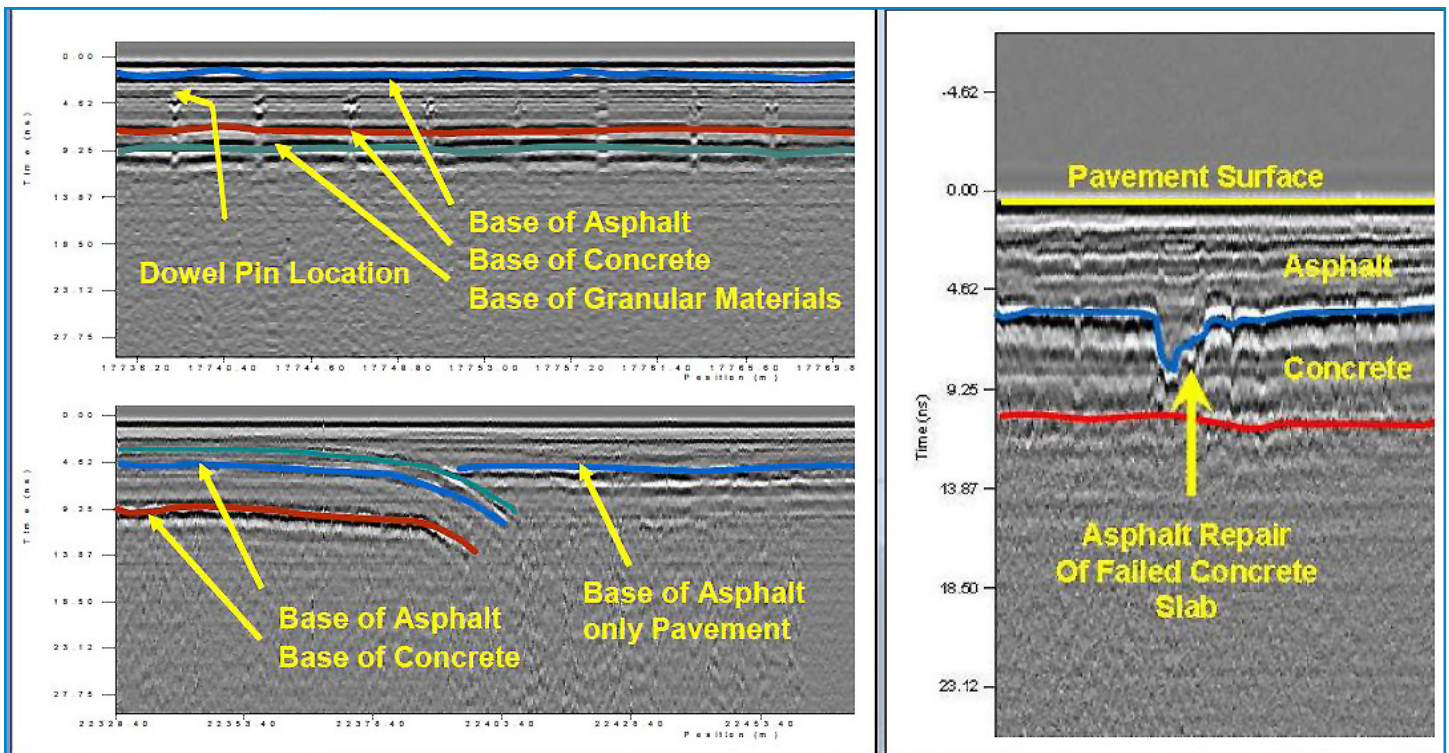
condition surveys, boreholes, Falling Weight Deflectometer analysis, and asphalt coring. Using GPR proved effective in profiling anomalies in the pavement structure, and more importantly, in reducing uncertainty associated with locating changes buried in the pavement. Since then, GPR has been used as a pavement investigation tool on other freeway projects including Highway 401 in Scarborough.

GPR Technology

Improvements in GPR technology over the past 10 years has helped to develop a fast, effective and non-destructive method of transmitting high frequency electromagnetic pulses through the pavement to record a continuous profile of pavement structure. This tool identifies the limits and layer thicknesses of pavements

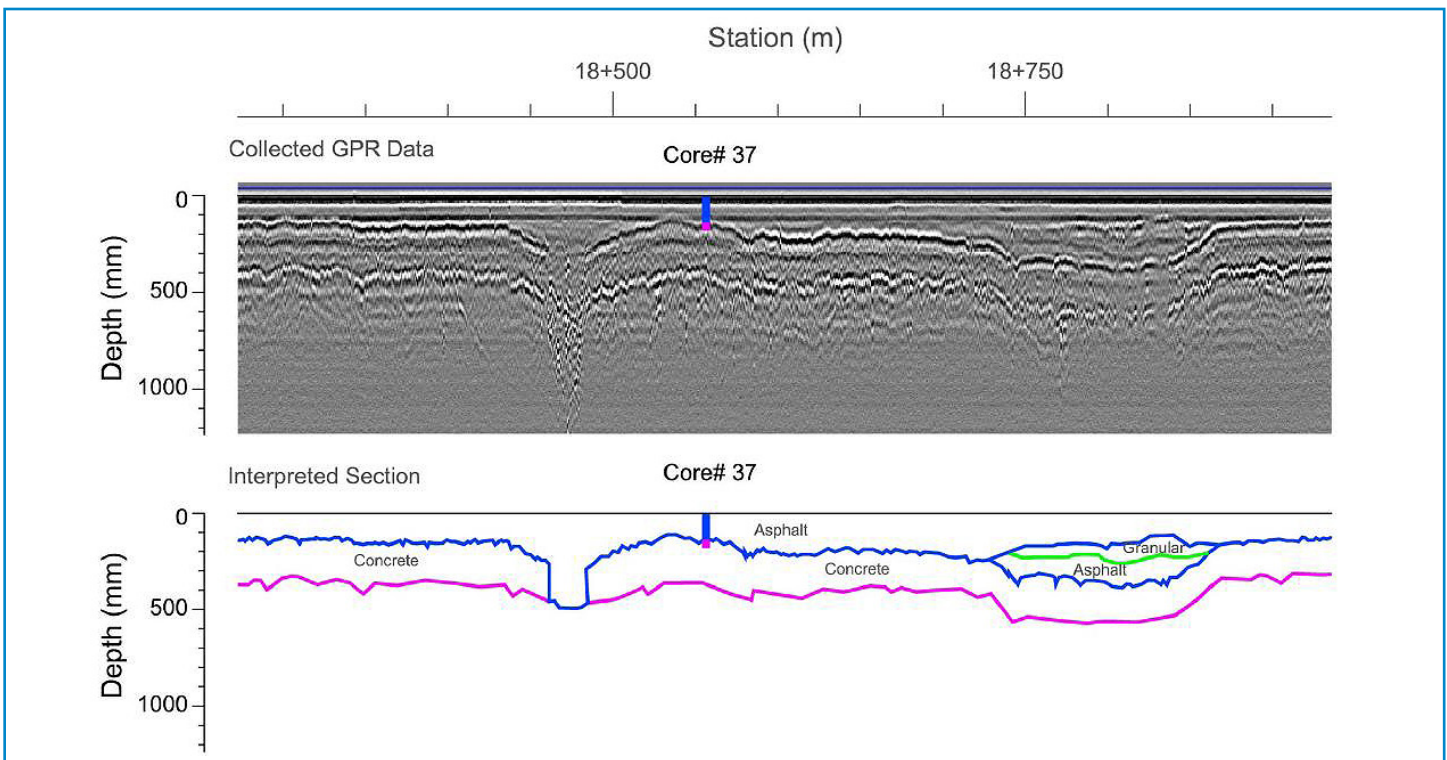
and detects subsurface voids or changes in concrete density which can be indicative of deterioration, enabling proper assessment of structural capacity and rehabilitation needs. Multiple survey lines are carried out across a single lane width, and several passes may be done in each wheel path, to better depict the subsurface conditions.

A typical GPR system is a combination of a transmitter and receiver mounted on a vehicle with an onboard control console and a computer for real-time, graphic display and data recording. In profiling mode, two antennae separated a fixed distance from each other are moved along a survey line and readings are taken at discrete intervals. At each test location, pulses of electromagnetic energy with a frequency in the megahertz range are transmitted. Subsurface reflections occur at



Ground Penetrating Radar data imaging showing layers of asphalt, concrete and granular material during a survey of the Queen Elizabeth Way.

Ground Penetrating Radar Provides Continuous Pavement Condition Analysis, *continued*



Ground Penetrating Radar data imaging and interpretation from a survey of Highway 7.

horizons where there is an abrupt change in material dielectric permittivity, such as at the interface between asphalt and concrete, and between pavement and granular materials. The amplitude of received radar energy is recorded as a function of time, processed in real-time for display purposes, and the raw data recorded digitally for later processing and presentation.

The resolution and penetration of a GPR system depends on the centre frequency of its operation. Typically, antennae having a centre frequency between 250 and 3,100 MHz are used for pavement investigations. Lower frequency antennae penetrate deeper into the subsurface, but have less vertical resolution. It is used to map granular materials, whereas the higher frequency systems can be used to determine the number of asphalt overlays on a road surface.

GPR pavement investigation can:

- Assess limits and layer thickness of flexible and rigid pavement to enable proper rehabilitation and design.
- Determine shoulder pavement structure carrying capacity or strengthening requirement when used for traffic detour during construction staging.
- For cold in-place recycling projects, assess optimal recycling depth to mitigate break through of thinner sections of asphalt that may give rise to a claim.
- Aid in identifying poor or unexpected pavement conditions.

Air-Launched versus Ground-Coupled GPR Systems

The majority of the GPR systems used for pavement investigations are air-launched GPR systems which collect data at survey speeds of up to 100 km/h. These are high frequency systems with greater than 1000 MHz, and typically 2000 to 3000 MHz, mounted on a vehicle at a distance of 0.5 to 1 m above the pavement surface. The

frequency of the system is fixed, and depth of investigation is typically less than 30 cm below ground surface. Significant reflection of transmitted energy from the interface between air and the top of pavement limits investigation depth. Higher frequency waves attenuate quickly in the subsurface; the higher the frequency, the less the depth of effective investigation.

Ground-coupled GPR systems are commonplace in engineering applications, such as determining depth to bedrock, where the desired depth of investigation is significantly greater than 30 cm. To achieve the desired depth of investigation, lower frequency systems of 12.5 to 1000 MHz are used. The transmitter and receiver are coupled directly to the ground to ensure the transmitted signal avoids significant energy loss due to air/ground interface reflection. Ground-coupled GPR systems provide a greater depth of investigation and data with typically better signal-to-noise ratios.

Due to the longer time frame required to collect data from reflections deeper

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Ground Penetrating Radar Provides Continuous Pavement Condition Analysis, *continued*

in the subsurface, ground-coupled systems historically could not be run at similar speeds to air-launched systems. It is only with recent technological advances which increase data acquisition speeds that ground-coupled systems are increasingly being used for pavement investigations.

Challenges of Processing GPR Data

Analysis of GPR data is similar to interpretation of medical imaging such as x-rays or MRI. The ministry recommends that GPR data be processed by someone with specific training and preferably also with an understanding of pavement design. Automatic layer picking software should be used sparingly.

Automated software screens GPR data for reflective pavement layers. These software algorithms provide accurate readings for shallow depth investigation, where materials are man-made, continuous and uniform in composition. The algorithms are also useful when GPR signal strength is high in relation to background noise levels, which is typical of pavement profiling.

Because GPR data is collected as amplitude versus time, a key aspect to interpreting GPR data is to have control at several locations along the survey line to verify the time-depth conversion. It is necessary to confirm GPR interpretations with data from intrusive investigations such as core samples or boreholes, although it is generally reasonable to provide preliminary interpretations of collected data.

GPR data is calibrated and interpreted in conjunction with the point source data, providing accurate data between point source locations on pavement thickness, buried pavement change locations, and localized anomalies.

The GPR antennae, whether shielded or unshielded, tend to pick up false air wave reflections from objects at the surface and in close proximity to the survey line such as light poles and overpasses. These air wave events are distinct in their shape and frequency content as observed on reflection profiles, and can usually be identified with confidence on the GPR sections during interpretation.

Benefits and Ministry Application

Interpreted correctly, GPR can provide a continuous profile of the pavement structure and invaluable information to estimate asphalt pavement thickness, the general condition of underlying concrete pavement, the potential presence of voids or underground services beneath the pavement, the condition of soils overlying culverts, as well as confirm the presence of frost tapers at culverts. In some cases, GPR can provide the thickness of the granular layer.

Compared to conventional borehole and core sampling, GPR can increase the level of accuracy of a pavement investigation by filling in the gaps between point source investigation tools. GPR quickly provides a continuous subsurface profile while supplying the location of localized anomalies, aiding pavement investigation. GPR is non-destructive compared to coring, and eliminates lane closures, GPR saves time and cost.

Despite its benefits, GPR cannot entirely replace conventional pavement investigation methods. It should be considered as a useful supplementary tool for pavement engineers, providing them with the information they need to make improved and sound engineering decisions on pavement design and rehabilitation.

A number of ministry projects will apply GPR technology this year, including: QEW at Centennial Parkway; QEW east of Casablanca Boulevard; Highway 26 from Edenvale to Stayner; and, Highway 12 from Highway 11 to Atherley •

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A Standard You Can Really Dig! New Mapping Standard for Underground Utilities: CSA S250

In the fall of 2011, a new standard was published by the Canadian Standards Association (CSA) that is intended to improve accuracy in locating and mapping underground utilities. The standard, CSA S250, mandates improved and reliable record keeping for underground infrastructure. The new standard can be applied to existing infrastructure or future-use situations to ensure that accurate information about underground utilities is captured and available. Ontario Ministry of Transportation (MTO) staff participated in the development of the new standard.

Utilities that have not been accurately mapped or recorded complicate ministry highway work. Poor utility records can result in risky design, damage or lost services, construction delays, costly overruns, and sometimes personal injury. The ministry has encountered undocumented gas and hydroelectric lines during highway work in the past.

Industry also recognizes the risk posed by poor utility records. Tragic pipeline accidents in the United States have resulted in lives lost, evacuations, lawsuits and costly settlements. In Ontario in 2003, a contractor working on a City of Toronto road pulled an under-sidewalk gas line from a commercial plaza, resulting in a fatal explosion.

Due to inadequate utility mapping in Canada, regional public works engineers enlisted CSA to develop a common national standard through a committee of involved stakeholders. Comprised of representatives from utility, locate, and construction companies, and various municipal, provincial, and federal government levels — about 35 members from Ontario, British Columbia, and Alberta — met over a four-year period to develop the standard for mapping underground utilities. The new standard covers infrastructure at or below grade and does not apply to utilities above ground, such as overhead wires, pole-mounted transformers, antennas, and dishes.

The committee has also established a set of utility management best practices for utility owners, locators, excavators and surveyors. Utility owners are expected to document: their mapping programs, compliance auditing, disaster recovery improvements, and training plans. Use of geographic information systems (GIS) and computer aided design (CAD) for utility management are recommended. The standard mandates that files are to be kept up-to-date and location discrepancies reported to utility owners.

Applying the standard to the creation, storage, distribution, and use of mapping records ensures utilities can be properly considered by designers and builders. Utility owners are expected to provide maps of utility locations in a timely manner with a high level of accuracy. The maps are to be developed from field records and data showing horizontal and vertical location measurements at the time of construction or exposure.



CSA's S250 standard will help utility and road owners get a better handle on underground spaces.

The only reliable way to accurately identify and record the location of underground utility infrastructure is to do so while the utility infrastructure is exposed and available for direct inspection and measurement. In situations where the utility infrastructure is hidden beneath the surface and not exposed, although it might be possible to detect and predict the position of the utility, there will always be a degree of uncertainty as to its identity and exact location. Drawings of existing utilities will now be quantified by an accuracy range using the labelling provided by the standard's mapping accuracy table, as shown below:

Accuracy Level	Specification
1	± 0.025 m in x, y, and z, and referenced to geodetic
2	+/- 0.10 m in x,y,z geodetic ref.
3	+/- 0.3 m in x,y,z geodetic or topographic ref.
4	+/- 1.0 m in x,y,z, geodetic or topographic ref.
5	+/- 1 m horizontal geodetic or topographic ref.
0	No accuracy info available

Mapping Accuracy Table showing degrees of accuracy labelling.

New Mapping Standard for Underground Utilities: CSA S250, *continued*

The new standard went into effect upon its release last fall and applies to proposed, existing, abandoned, or future-use underground utility infrastructure across Canada. Adherence to the new standard is voluntary, unless requested in a contract, permit, or required by regulations, statutes or municipal bylaws.

Application of the new standard ensures that accurate information on the location and nature of the underground utility infrastructure is available when planning future ministry projects. ●

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You may obtain a copy of the CSA Standard for Mapping Underground Utility Infrastructure, here:
<http://shop.csa.ca/en/restofworld/infrastructure-and-public-works/s250-11/invt/27033052011>