Capital Tree Service Inc.

Capital Tree Service Inc. (CTS) was retained by Sean Rorison (Client), a representative of BC Housing regarding the construction of a new supportive housing building at 722 and 726 Discovery St (the Site) in the City of Victoria. Following the initial development application, the City of Victoria requested that the client retain the three (3) large Garry oak (*Quercus garryana* trees (tagged 151-153) along the property frontage(s). To determine the feasibility of retaining these trees, ScanPlus Ltd was contacted to utilize Ground Penetrating Radar (GPR) to locate the tree roots. On December 8, 2022, Keegan Durovich, a consulting arborist and representative of CTS, met with ScanPlus Ltd representatives, to determine the extent area to be scanned, and Grassroots Drilling Inc., to determine borehole locations (to determine the depth and quality of soil).

ScanPlus Ltd. scanned from 14m north of the property line to the retaining wall on the southern property line of the site. This area encompasses the Protected Root Zone (PRZ) of each of the three (3) large Garry Oaks on the site. The report with the results of ScanPlus Ltd.'s is included as Appendix A. As seen in Figure 1. several concentrations of roots can be seen, especially within 5m of the trees. Considering the proposed site development all the shown rooting concentrations will be destroyed. Tree 152 is within the footprint of the building, Tree 153 is within the footprint of the driveway, and the center of Tree 151 is just 1.5m from the side of the planned site development.

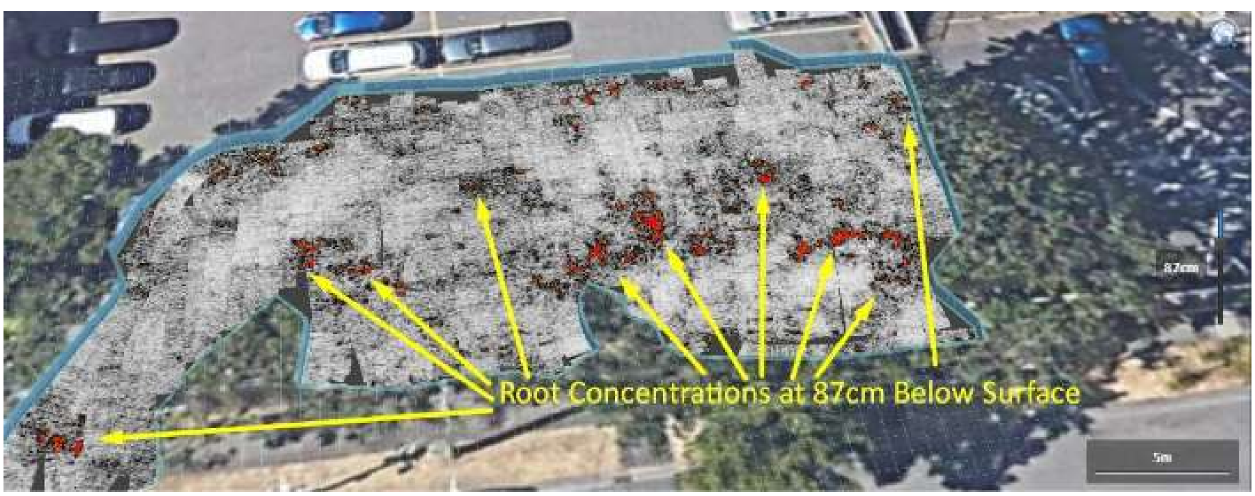


Figure 1. Root concentration locations (Bigman Geophysical ScanPlus Root Investigation report, Appendix A)

Considering the results of the scans (Figure 1), a minimum of an 8m set back from the trees would be required. This would require a redesign of the project. There appear to be several rooting areas outside or on the very edge of the PRZ of these trees that would require a 10-12m set back from the trees to protect these areas. An 8m set back would not likely impact more than 30% of the actual rooting areas of these trees, judging from Figure 1, and would therefore be within sound arboricultural practices.

Borehole test pits were drilled approximately 10m North of the southern property line. Every borehole location was cleared by ScanPlus Ltd. to ensure that no utilities or significant roots were encountered. Three different bore holes were drilled for tree 151, two (2) were limited at 40cm and the last hole was limited at 30cm. This indicates that the soil in this area is either quite shallow or contains large rocks or concrete slabs that the drilling rig could not move aside or destroy. Soil from these holes was composed of sandy loam with some organics.

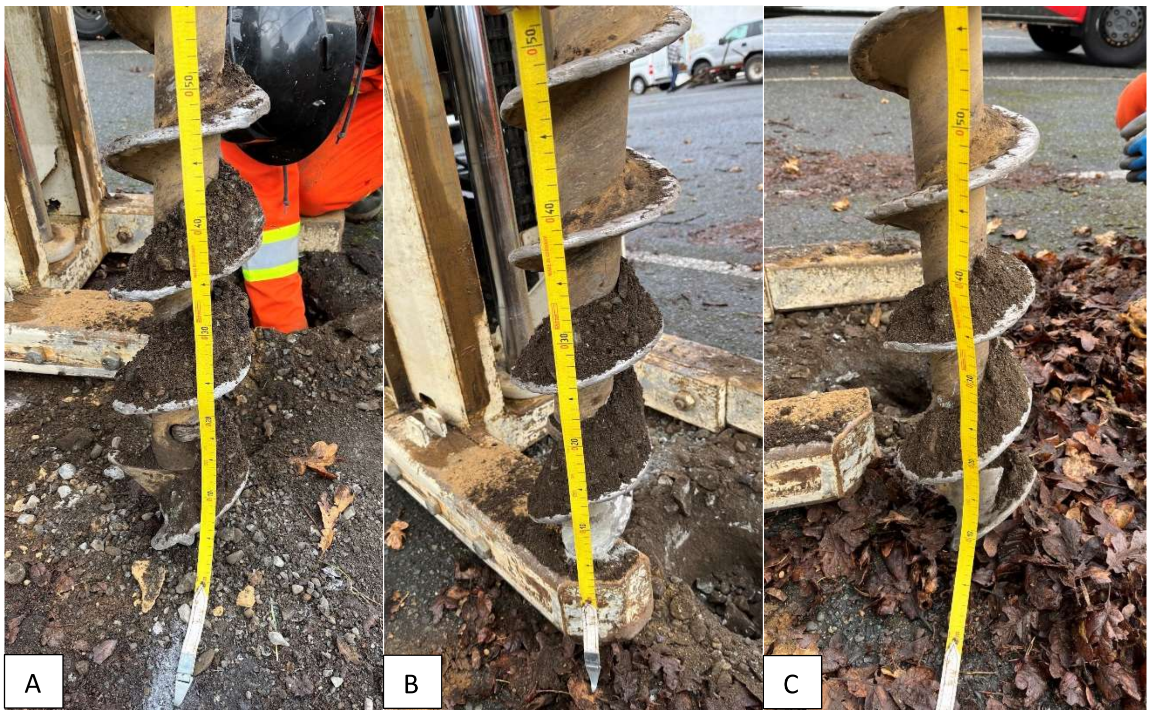


Figure 2. Tree 151 Test holes.

Two test boreholes were drilled about 10m from the stem of tree 152 (Figure 3a and 3b). The initial borehole for reached a depth of 0.95-1m. The second borehole was limited at 50cm, an indication of a large rock or piece of concrete. One borehole was drilled for Tree 153, which reached a depth of 1.3m. Soil from these boreholes was comprised of sandy loam with minimal organics.

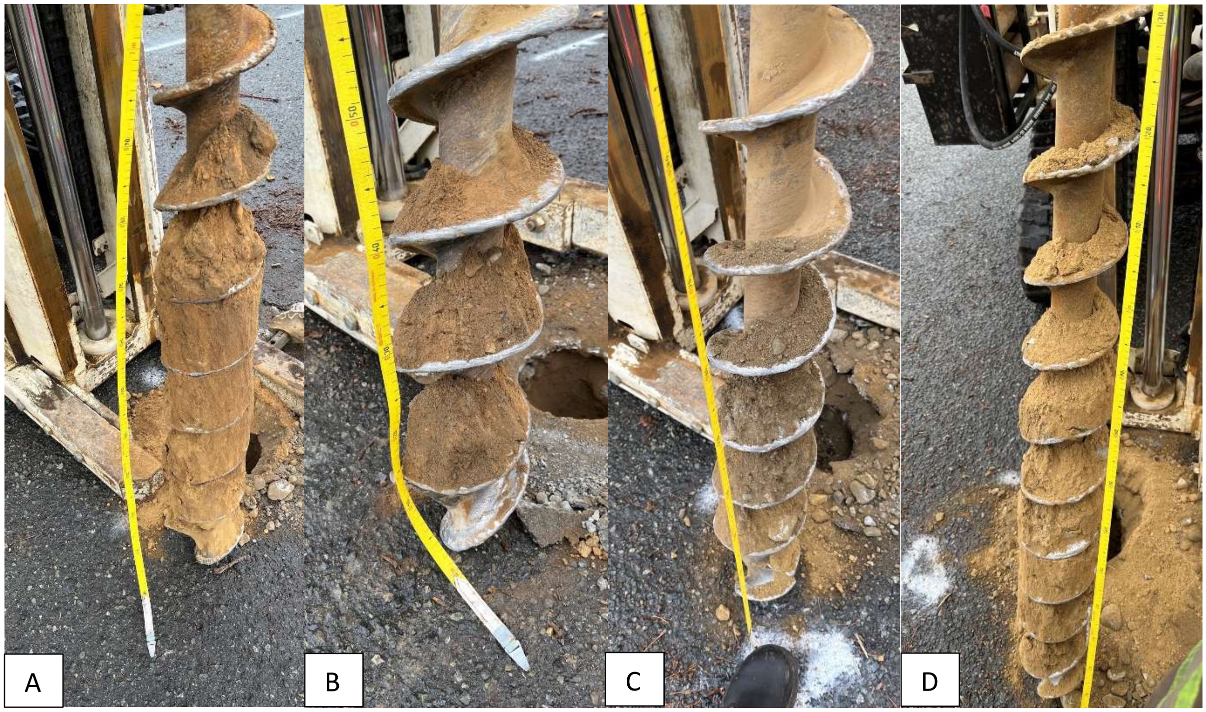


Figure 3. Tree 152 Boreholes are shown in photos A and B. The borehole from Tree 153 is shown in two photos, C and D. The initial drill hole attempt, C, was limited at 55cm, however the second attempt in the same hole reached a depth of 1.3m, D. Note the lighter colour of the soil, lack of organics, compared to Figure 2.

CTS has considered three different building setbacks (5m, 8m, and 10m), from the southern property line, to determine the effectiveness of each in preserving trees 151-153. Considering the presence of a retaining wall that ranges from 1m-~2m in height along the property line, CTS does not consider the area below the wall, City property, to be viable rooting area. For the purposes of this report, the Protected Root Zones of trees 151-153 are limited to private property, for tree 151 this does include part lot at 740 Discovery St. The calculations also assume that the building would be constructed across the entire property. This assumption only affects tree 153 as over excavation from all the current plans would extend to the property line with 740 Discovery. Impacts, shown in the tables below, are therefore exaggerated for tree 153. Finally, roughly half of the PRZ of tree 151 that is on private property is across the property line with 740 Discovery, the tables below reflect this.

Impact to more than 35% of the Canopy or PRZ is considered to be very high impact and likely not survivable for the tree per Best Management Practices. With a set back of 5m from the property line, only tree 152 would be impacted beyond this threshold of impact to its PRZ (Table 1). A setback of 5m would also remove most of the root concentrations identified in Figure 1 and require pruning more than 35% of the canopy of each tree. Therefore, despite sufficient soil volume for these trees (Table 2), CTS cannot recommend the retention of these trees with a 5m setback.

Table 1. Protected Root Zone Impacts due to different Building Setbacks. Impact to more than 35% of a Protected Root Zone, less than 65% remaining, would be considered a very high impact and not within Best Management Practices. Setbacks are measured from the Southern property line.

	Private PRZ Area (m2)				Percent of the Onsite PRZ Area (m2)		
Tree Area ID	Private PRZ area m2	Private PRZ Area with 10m setback	Private PRZ Area with 8m setback	Private PRZ Area with 5m setback	Remaining with 10m Setback	Remaining with 8m Setback	Remaining with 5m Setback
Tree 151	227	208	192	164	92%	84%	72%
Tree 152	223	188	154	98	84%	69%	44%
Tree 153	141	141	138	96	100%	97%	68%
Average	197	179	161	120	91%	82%	61%

Table 2. Soil Volume Impacts due to different Building Setbacks. Calculated by using the protected root zone, on private property, multiplied by the depth of the soil determined by the boreholes. Per the City of Victoria Tree Bylaw 35m^3 is required per large tree (including Garry oaks).

		Estimated Remaining Soil Volume				Percent of the Onsite PRZ Soil (m3)		
Tree ID	Drilled Soil Depth	Estimated soil volume on Private Property	with 10m Setback	with 8m Setback	with 5m Setback	Remaining with 10m Setback	Remaining with 8m Setback	Remaining with 5m Setback
Tree 151	0.4	91	83	77	66	92%	84%	72%
Tree 152	1	223	188	154	98	84%	69%	44%
Tree 153	1.3	184	184	179	125	100%	97%	68%
Average	0.9	177	161	145	108	91%	82%	61%

An 8m setback from the property line would protect sufficient rooting are from each tree to likely preserve these each tree. Impact to PRZ of tree 152 would still be considered to be high (31%) with moderate impacts to trees 151 (16%) and 153 (3%). The most significant impact to trees 151 and 153 would be the necessary crown reductions which could be greater than 20% depending on the design of the building and the clearances required. CTS believes that this would be the minimum building set back necessary to retain these trees.

If retaining these trees is a primary goal, CTS recommends a building setback of 10m. This would only affect 16% of the PRZ of tree 152 and 8% of the PRZ for tree 151. Additionally, no major pruning would likely be required, and a crown compression on the North side of the trees would likely suffice. Additionally, this would protect most, if not all, of the root concentrations detected by the GPR.

If a taller building is the solution, due to a setback, there could be adverse abiotic affects to these trees. With the increasing height of the Victoria skyline, the amount of light reaching these trees is beginning to be reduced. While the proposed development is on the northern side of the trees, reflected light could cause sun scalding depending on the angles of reflection. Another abiotic change caused by the changing skyline of the tree is an increase of wind funneling. It is important to note that these trees are rooted close to a large retaining wall, decreasing the trees' holding strength on the opposite side of the planned development.

Building closer than 10m, and 8m to these trees would be theoretically possible through the using a pier and beam style of construction. This would effectively float the building above the rooting area of these trees. If this option was selected, CTS recommends only a single story within 10m of the property line to reduce the amount of pruning required. Care and forethought would be required to place this story onto the beams, as the tree canopies would interfere with crane placement of the modules. While this is theoretically possible, it would greatly increase the difficulty of accessing the tree for pruning, treatment, and eventually removal.

If any or all these trees are to be retained, remediation would likely increase the survivability of these trees. Before the project begins, CTS would recommend the removal of all of the hardscapes in the areas that will be within the footprint of the foundation (not including any piers if grade beams are used). Once hardscapes have been removed, air spading should be conducted for each tree, with the trenches backfilled with a high-quality topsoil. Deep root fertilization in the spring of 2023 would also likely increase the vigour and health of the trees. Depending on the amount of encroachment and the timeline of construction, slowly reducing the rooting area of the trees through root pruning would be recommended.

If these trees are retained, during construction care should be taken to mitigate all impacts to the trees. This would, but not be limited to, Tree Protection Fencing on the edge of construction, keeping ALL equipment, material, and personnel outside of the fencing, and watering these trees through the dry periods. All excavation would need to be under the supervision of the project arborist, who should wrap all roots greater 2cm with burlap (and kept wet during hot summer months). Post-construction, CTS would recommend on going watering during summer months, deep root fertilizations for two following springs (and as necessary there after), and air spading if any compaction within the retained PRZs occurred.

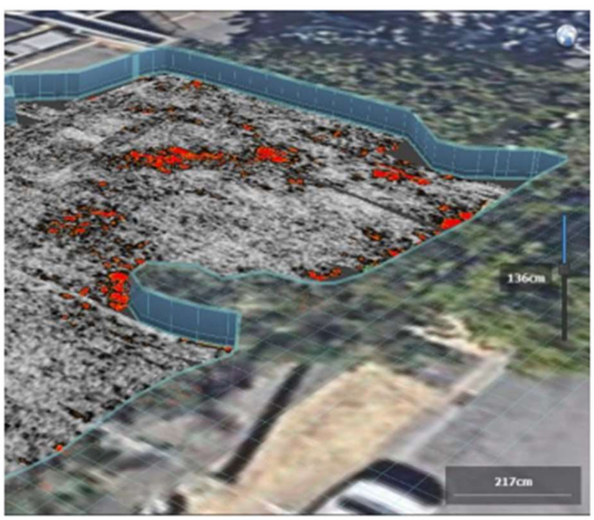
Although this site has been assessed trees in the landscape are dynamic and changes could occur. This report is a static representation of the site during our assessment.

Keegan Durovich 12/15/2022
Capital Tree Service Inc.
ISA Certified Arborist TRAQ PN-9272A
B.A.Sc.

Appendix A – Ground Penetration Radar Report

BIGMAN GEOPHYSICAL

ScanPlus Root Investigation



Dec. 2022

Prepared By:
Sean McConnel & Robert Theberge

INTRODUCTION

Bigman Geophysical, LLC was contracted to process ground-penetrating radar data that was collected in Victoria, Canada concerning the locations of tree root structures beneath a paved surface. The purpose of the investigation was to record the densest locations of tree roots which are likely to impact future construction at the site.

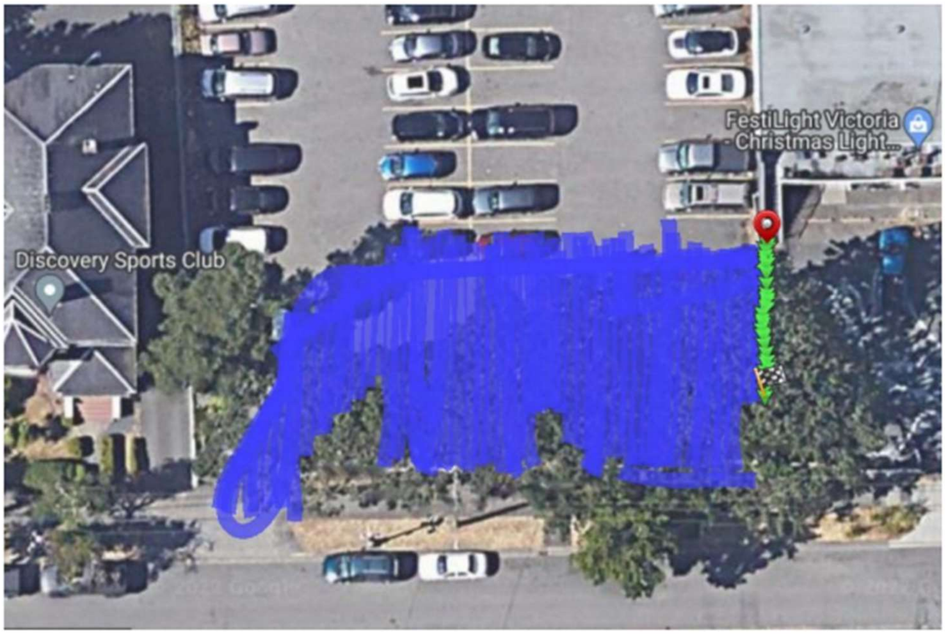


Figure 1: The area of investigation, with data collected in "swaths" shown in blue. The density of GPS points is shown with the highlighted line of green points on the right.

METHODS

Ground Penetrating Radar (GPR)

This survey utilized GPR to image the subsurface and evaluate the presence or absence of human burial and other underground features of interest. GPR sends electromagnetic pulses to a transmitting antenna at the ground surface which produces a radio wave that travels through the subsurface (Koppenjan 2009). Wave speed depends on the ability of a given medium to transfer energy (Annan 2009, Conyers 2004). When an approaching wave encounters a discontinuity in the physical properties of the soil and the wave's speed changes, some of the wave front's energy is reflected back toward the ground surface (Annan 2009). According to classic works by Borne and Wolf (1959) and Crawford (1968), the amount of energy that will be reflected when an approaching wave encounters a contrast in dielectric permittivity will vary based on how different the two materials are on either side of the interface. A large difference in dielectric permittivity will result in a large amount of energy reflected off the interface whereas a small difference on either side of the boundary will result in a small amount of energy being reflected. The two-way travel time (usually recorded in nanoseconds) and the amplitude of the reflection is recorded at the surface by a receiver antenna. Each traverse with the GPR provides a two-dimensional profile of the subsurface. When traverses are collected adjacent to each other, then data can be resampled to create pseudo-3D visuals called time-slices (Conyers 2004).

GPR is a popular and often successful technique for identifying utilities and other manmade subsurface features (Hebsur 2013, Metwaly 2015, Rashed 2013, Wai-Lok Lai 2018, Wei Jaw 2013). However, there are limits to the resolution of any non-destructive testing and the physical properties of subsurface materials, surface conditions at a site, and the complexity or orientation of targets can impact the overall quality of results from a GPR survey.

DATA COLLECTION AND FILTERING PARAMETERS

Data collection was performed by ScanPlus using an IDS Stream C, a multichannel device with 30 active antennas, all with 600 MHz as their central bandwidth size. The tight antenna spacing and high frequency of the antennas, which are oriented in both directions of travel (cross-polarized) allow the creation of highly detailed tomography. This equipment was chosen for its quality of output, to allow for the highest resolution of subsurface features at the site location, while still typically penetrating about 2m below surface.

Figure 2: An Example of the Stream C multichannel device.

The software program used to process data was IQ maps, a proprietary software package made by IDS specifically for their multichannel devices.

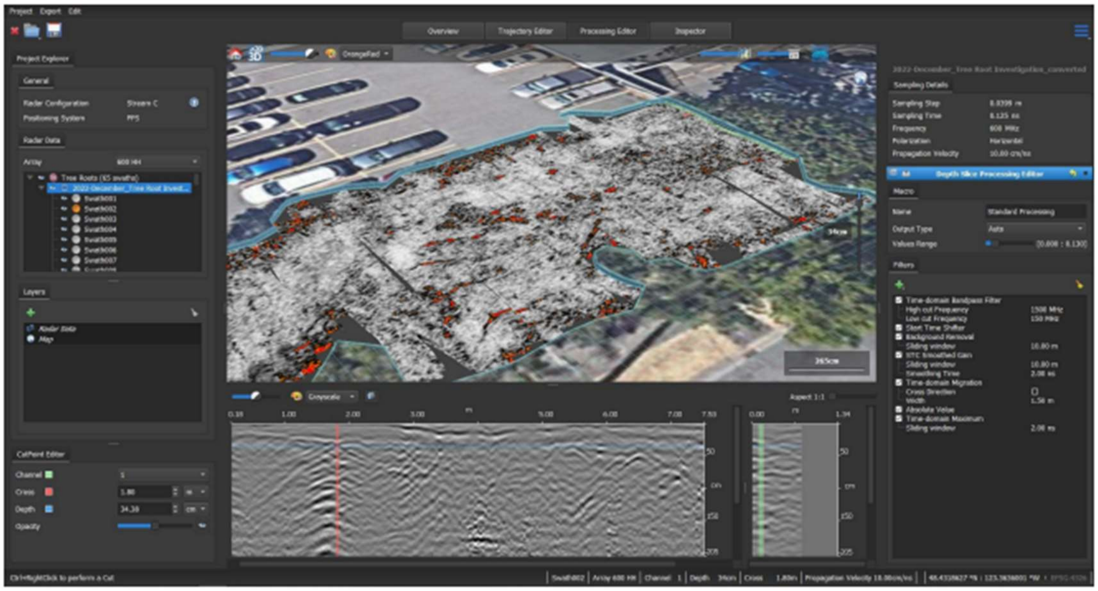


Figure 3: The three-dimensional computer modeling of the subsurface environment in IQ maps.

RESULTS

The GPR recorded areas where clusters of relatively high amplitude and hyperbolic responses indicate probable tree root locations. Subsurface testing can never present interpretations with 100% accuracy, however, finds were highly consistent with the normal characteristics produced by tree roots in radargrams. In profile, typical characteristics of tree-roots are hyperbolic reflections at higher amplitude than surrounding soils, with a pattern where reflections originate at a point near the surface where the trunk is (or was) located, and radiates out and down from there (Figure 4). When viewed as a time slice (a top-down image at a particular depth), signatures appeared semi-circular clusters of signatures, again originating out from a central location. Taproots typically grow directly under a tree, and depths beyond what the Stream C would be expected to image, and likewise each of the identified root concentrations shows signatures as far as the signal propagates.

Signal loss occurred at about 2m of depth, such that the GPR investigation recorded the locations of potentially problematic root structures, but not their total depth.

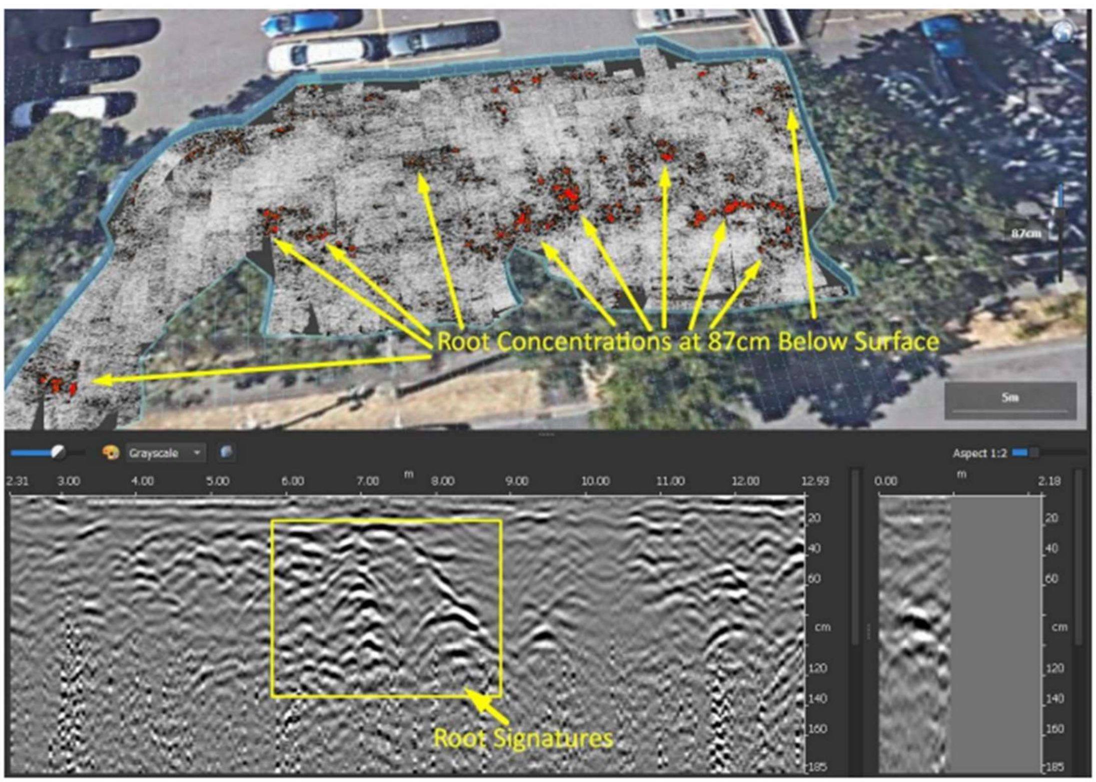


Figure 4: Detected tree root locations.

CONCLUSION

The GPR recorded ten signatures whose characteristics match those of tree roots. Those anomalies were outlined with polygons, and exported as opensource .KML files and shapefiles, which are compatible with Google Earth and other GIS software packages. The tomography was likewise output as TIFF files, so that the client could review individual slices and preserve them for future use.

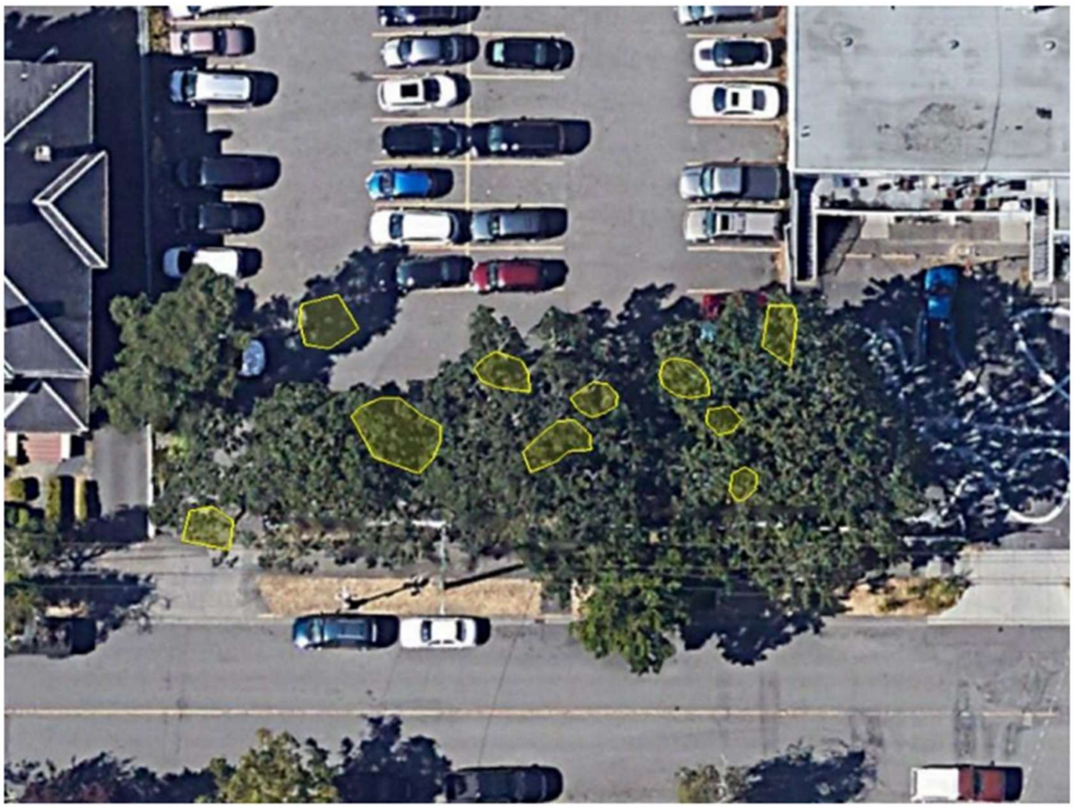


Figure 5:The output polygons showing where root concentrations were detected.

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