Ontario

GEOPHYSICAL REPORT FOR A

SPARTAN MT SURVEY

OVER THE

TITAN PROPERTY

(ONTARIO, CANADA)

ON BEHALF OF

IMPALA CANADA LTD.

September 15, 2021

CA01284S

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EXECUTIVE SUMMARY

This report presents the results of the analysis and interpretation of the data measured by the Spartan MT survey completed from August 7 to 12, 2021 over the Titan Property by Quantec Geoscience Ltd. on behalf of Impala Canada Ltd. A total of 11 MT sites were surveyed.

This report describes procedures for data analysis and inversion and presents the survey results as sections.

The 2D inversion results show resistivity values generally between 1 kΩ·m and 100 kΩ·m along the survey line. A surficial lower resistivity layer approximately 200 m thick overlies a more resistive layer (~10 kΩ·m). Between -500 m and -1000 m elevations a layer of lower resistivity (< 5 kΩ·m) is resolved, overlying a relatively uniform highly resistive basement (> 50 kΩ·m) below approximately -1500 m elevation.

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1. INTRODUCTION

This report presents the results of the analysis and interpretation of the data measured by the Spartan MT survey completed from August 7 to 12, 2021 over the Titan Property by Quantec Geoscience Ltd. on behalf of Impala Canada Ltd..

1.1. CLIENT INFORMATION

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Address:	1136 Alloy Drive, Suite 100 Thunder Bay, ON Ontario Canada
Representative:	Lionel Djon Phone: (807) 623-8005 Email: ldjon@impalacanada.com

1.2. GENERAL PROJECT INFORMATION

Quantec Project Manager:	Mark Morrison	
Quantec Project Number:	CA01284S	
Report prepared by:	Darcy McGill, Mehran Gharibi	
Project Name:	Titan Property	
Survey Type:	Spartan MT	
General Location:	Approximately 140 km NNW of Thunder Bay, see Figure 1-1 and Figure 1-2.	
	Lat /Long:	49°38'18”N, 89°52’9”E
	UTM:	292848 E, 5502390 N
	Datum:	WGS84, UTM Zone 16N
Survey Period:	from August 7 to 12, 2021	

1.3. SURVEY LOGISTICS

Logistic report:	*Logistic Report for a Spartan MT survey over Titan Property (Ontario, Canada) by Quantec Geoscience Ltd. on behalf of Impala Canada Ltd.*

Figure 1-1: General Location Map.

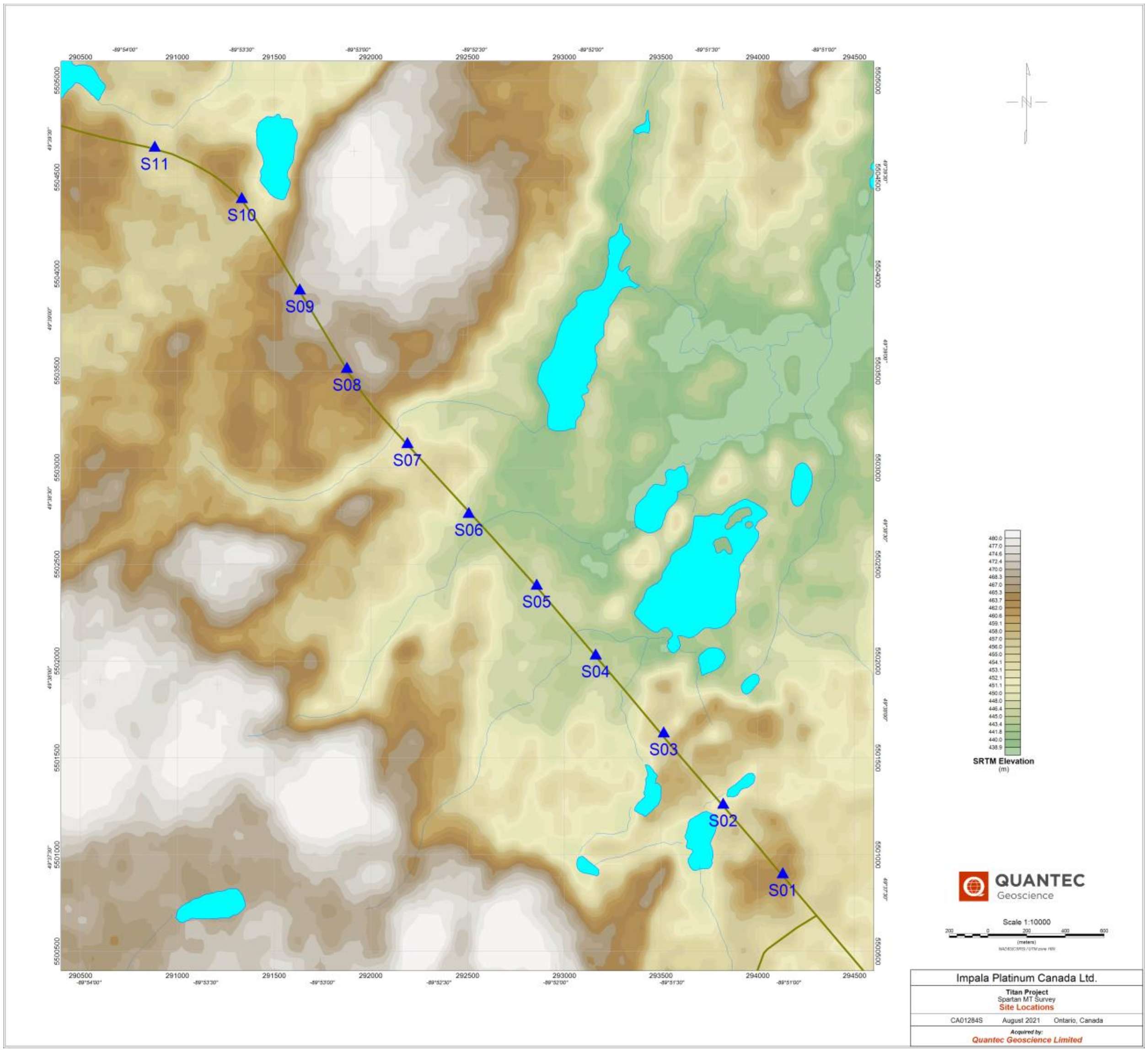

Figure 1-2: MT survey layout map

1.4. DELIVERABLES

The final survey results delivered with this report are:

- 2D inversion products:
    - MT resistivity model(s).
    - Each as Geosoft maps (.MAP), images (.PNG) and ASCII (.XYZ) files.

1.5. DIGITAL ARCHIVE ATTACHED TO THE REPORT

The digital archive accompanying this report contains a copy of all final results, including inversion files and map products. The logistics report and final processed data are also included along with positioning files and field reports.

Table 1-1: Contents of the digital archive attached to the report.

Directory		**Contents**
\Report		Logistics and Geophysical Summary reports (.PDF)
		LOGISTICS
\Data	\Data\EDIs	Final processed MT data (.EDI) – include raw (spectra and impedance) EDI files
	\Data\Remote	Final processed MT data (.EDI) from the remote site, each day processed referenced and unreferenced.
	\Data\GPS	Compilation of site/line survey files – includes location maps (PDF, PNG format) and related database(s), and KML and ASCII exports
		INVERSION RESULTS
\Digital Archive	\GDB	Geosoft .GDB databases of inversion models and positioning.
	\XYZ	ASCII .XYZ files containing inversion models.
\Maps		PDF, PNG and Geosoft .MAP files of the 2D sections and location map.
\Inversions		Archive (zip) related to CGG-Geotools includes zip archives of the EDI for each profile

2. INVERSION PROCEDURES

2.1. MAGNETOTELLURIC INVERSIONS

The Magnetotelluric (MT) method is a natural source EM method that measures the variation of both the electric (E) and magnetic (H) field on the surface of the earth to determine the distribution at depth of the resistivity of the underlying rocks. A complete review of the method is presented in Vozoff (1972) and Orange (1989).

The measured MT impedance Z, defined by the ratio between the E and H fields, is a tensor of complex numbers. This tensor is generally represented by an apparent resistivity (a parameter proportional to the modulus of Z) and a phase (argument of Z). The variation of those parameters with frequency relates the variations of the resistivity with depth, the high frequencies sampling the sub-surface and the low frequencies the deeper part of the earth. However, the apparent resistivity and the phase have an opposite behaviour. An increase of the phase indicates a more conductive zone than the host rocks and is associated with a decrease in apparent resistivity. The objective of the inversion of MT data is to compute a distribution of the resistivity of the surface that explains the variations of the MT parameters, i.e. the response of the model that fits the observed data. The solution however is not unique and different inversions must be performed (different programs, different conditions) to test and compare solutions for artefacts versus a target anomaly.

An additional parameter acquired during MT survey is the Tipper. Tipper parameters Tzx and Tzy (complex numbers) represent the transfer function between the vertical magnetic field and the horizontal X (Tzx), and Y (Tzy) magnetic fields respectively (as the impedance Z represent the transfer function between the electric and magnetic fields). This tipper is a 'local' effect, mainly defined by the lateral contrast of the resistivity. Consequently, the tipper can be used to estimate the geological strike direction. Another important use of the tipper is to display its components as vectors, named induction vectors. The induction vectors (defined by the real components of Tzx and Tzy) plotted following the Parkinson-Real-Reverse-Angle convention will point to conductive zones. The tipper is then a good mapping tool to delineate more conductive zones.

The depth of investigation is determined primarily by the frequency content of the measurement. Depth estimates from any individual sounding may easily exceed 20 km. However, the data can only be confidently interpreted when the aperture of the array is comparable to the depth of investigation.

The inversion model is dependent on the data, but also on the associated data errors and the model norm. The inversion models are not unique, may contain artefacts of the inversion process and may not therefore accurately reflect all the information apparent in the actual data. Inversion models need to be reviewed in context with the observed data, model fit. The user must have an understanding of the model norm used and evaluate whether the model is geologically plausible.

2.1.1.2D inversion parameters

For this project, 2D inversions were performed on the data.

The 2D inversions presented in this report were carried out along the profile using the CGG2D inversion algorithm (see APPENDIX B).

For the profile, we assume the strike direction is perpendicular to the profile for all sites: the TM mode is then defined by the inline E-field (and cross line H-field), and the TE mode is defined by the cross-line E-field (and inline H-field) data. To achieve this, the data were rotated to an angle of X=49.5° for inversion

The 2D inversions were performed using resistivity and phase data interpolated at 6 frequencies per decade, assuming 10% and 5% error for the resistivity and phase respectively, which is equivalent to 5% error on the impedance component Z.

No static shift has been applied to the data.

The topography was included in the inversions of each profile. To accommodate topographic variation, the vertical mesh was set with 20 m thick cells for approximately the first 100 m, and then the thickness of the cells increased logarithmically (factor 1.06) with depth, from 25 m up to 5 km size at depth.

The horizontal mesh was defined with 125 m wide cells to guarantee at least 4 cells between sites. A mesh of 4 cells between sites is used to accommodate topographic variations along the profile.

Each 2D inversion started from a half space model of 1000 Ω·m. Two inversions were run for the single profile acquired, one using both the TE and TM modes as well as Tipper, and a second model using the TM mode and Tipper only.

3. INVERSION RESULTS

The single line acquired during the project is approximately 5 km long, with a nominal site spacing of 500 m, oriented at an azimuth of approximately 139.5° true.

The 2D inversion using TE, TM and Tipper data was run for 50 iterations, with a final RMS misfit of 3.9% (Figure 3-1).

The 2D inversion using TM and Tipper data was run for 50 iterations, with a final RMS misfit of 1.4% (Figure 3-2).

Both models show a range of resisitvity values generally between 1 kΩ·m and 100 kΩ·m. Both models also show similar structures, with a surficial lower resistivity layer approximately 200 m thick, overlying a more resistive layer (~10 kΩ·m). Between -500 m and -1000 m elevation, the models show a layer of lower resistivity (< 5 kΩ·m). Below approximately -1500 m elevation, both models show a highly resistive basement (> 50 kΩ·m).

The lower resistivity layer on the TM and Tipper only model is resolved as slightly shallower and more continuous than the TE+TM and Tipper model.

The higher RMS misfit on the TE+TM and Tipper model is attributed to 3D resistivity variations that the 2D model cannot properly accommodate. Therefore, eliminating the TE mode (sensitive to cross-line variations) produces a better fit to the data, although both models show broadly similar results.

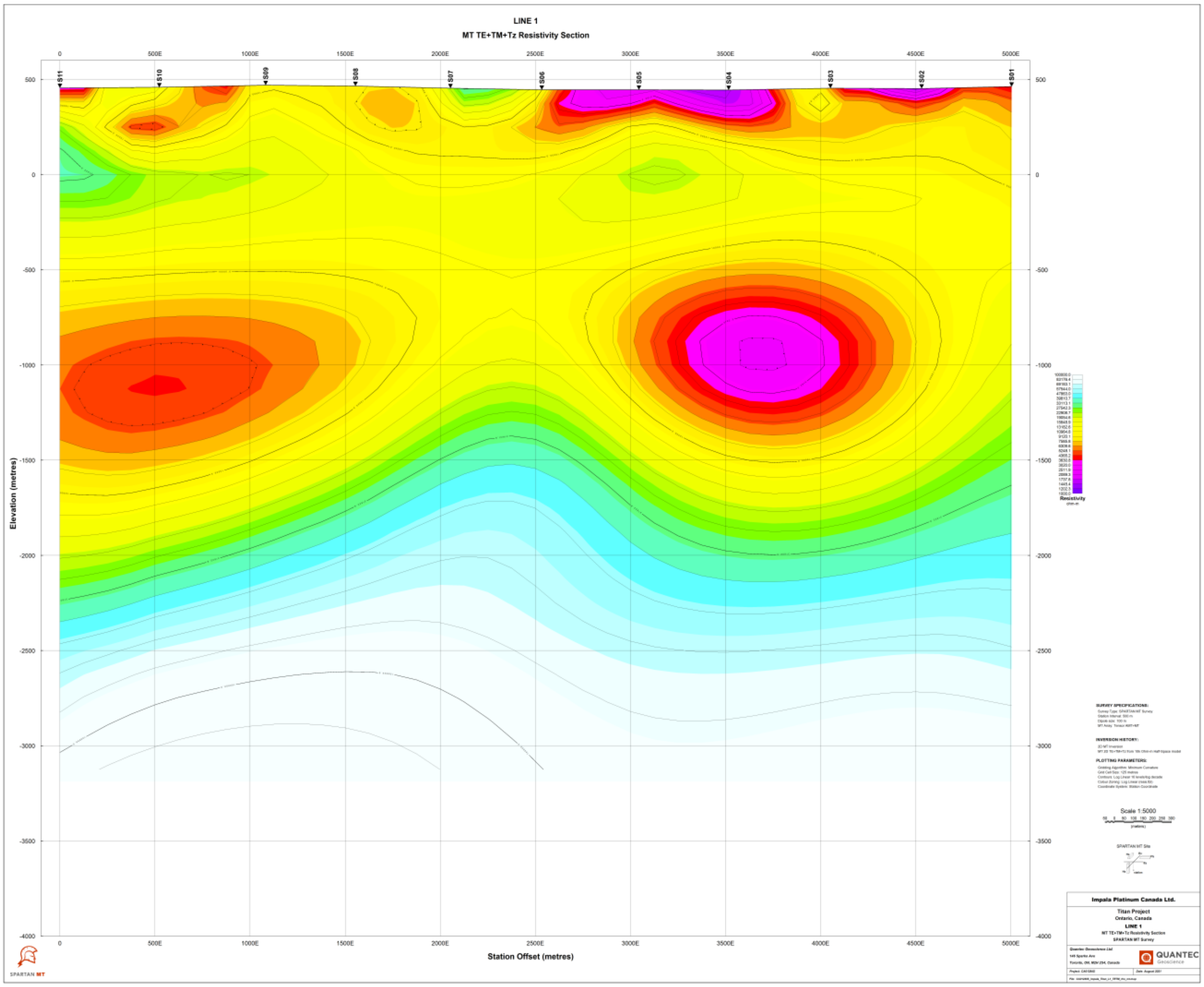

Figure 3-1: Line 1 2D MT resistivity model (TE+TM+Tipper).

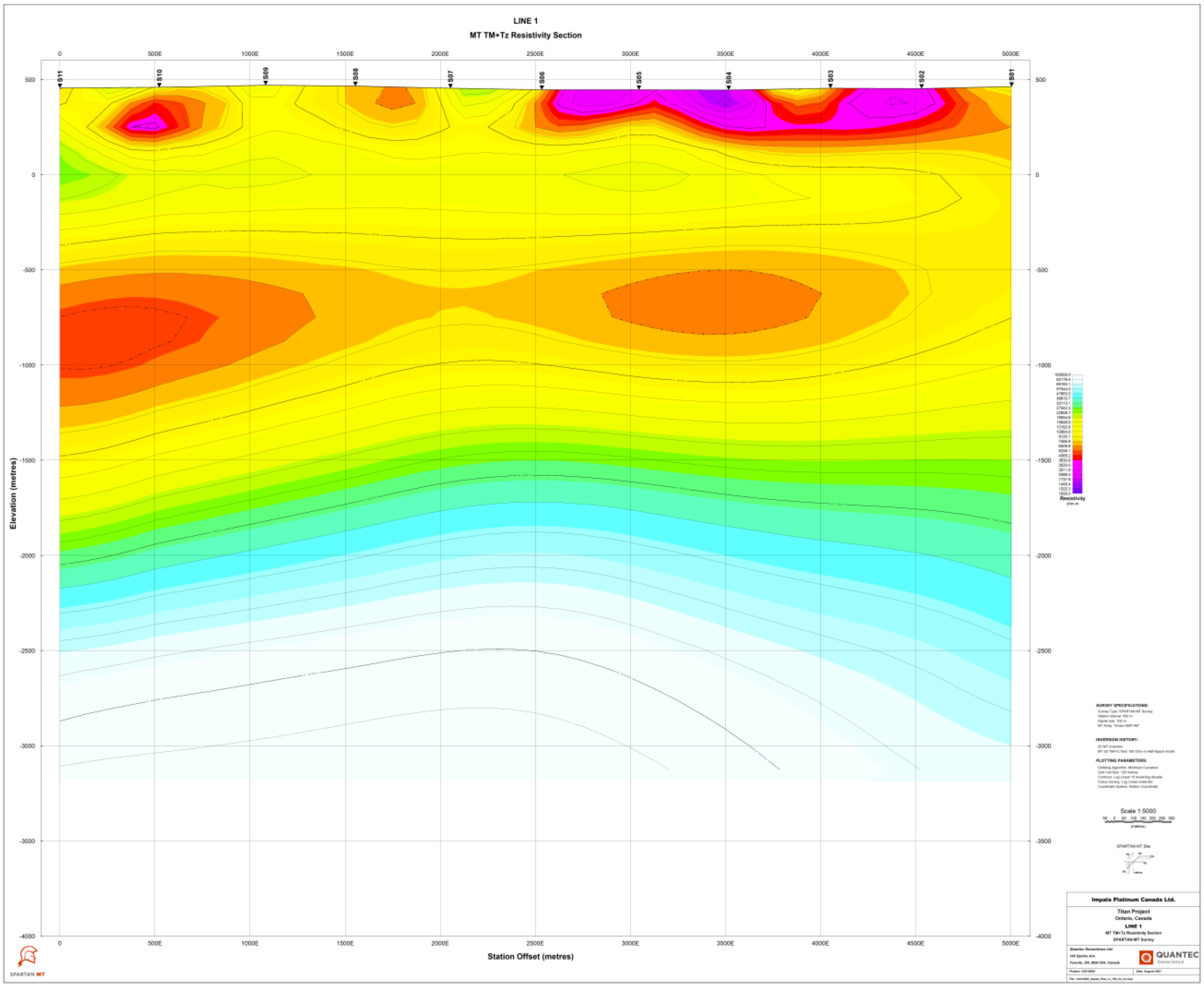

Figure 3-2: Line 1 2D MT resistivity model (TM+Tipper).

4. CONCLUSIONS

The data from the single 5 km profile (11 stations) acquired has been inverted in 2D using the TE+TM and Tipper data and also using TM and Tipper data only.

The results for both models are similar, although the TM and Tipper only model does return a lower RMS misfit compared to the TE+TM and Tipper model, indicating that the subsurface resistivity distribution does have some 3D character which can not be represented by a 2D inversion.

It is recommended that the results of this survey be considered along with all other available geological, geochemical and geophysical data to further guide exploration efforts.

Respectfully submitted by:

Darcy McGill, Mehran Gharibi

Quantec Geoscience Limited

September 15, 2021

APPENDIX A. REFERENCES

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MT 2DInversion codes:

CGG2D: MT2D inversion – see APPENDIX B.

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APPENDIX B. GEOTOOLS 2D (CGG2D) INVERSION CODE

The 2-D MT inversion code was developed by Randall Mackie in late 2012 for CGG. The usual approach to MT inversion, and indeed the approach used in this algorithm is that of Tikhonov regularization (Tikhonov and Arsenin, 1977). This algorithm seeks to find regularized inversion models that fit the data to within the prescribed errors. Typically, the regularization is of the form of minimum-structure models. We use the nonlinear conjugate gradients algorithm (Rodi and Mackie, 2001) to minimize the nonlinear objective function:

$$\psi(m) = (d - F(m))^T V^{-1} (d - F(m)) + \tau_1 m^T L^T L m + \tau_2 (m_0 - m)^T D (m_0 - m)$$

where the first term is the squared L-2 norm of the weighted residuals, the second term is the L-2 norm of the model roughness, and the third term is the squared L-2 norm of the variations away from the a-priori model. In this equation, L is the approximation to the depth weighted Laplacian, and D is a diagonal weighting matrix. If minimizing model variations, the second term is modified by changing m to (m0-m). The inversion is for the complex apparent resistivity and the complex vertical magnetic transfer function (if present).

Doing a 2-D MT inversion requires the solution of hundreds of 2-D MT forward solutions. The new algorithm for 2-D MT forward problems is a finite-difference modeling algorithm based on the network analog to the Maxwell equations (Swift, 1971; Madden, 1972). The model is divided into 2-D rectangular blocks of varying dimensions each with a constant conductivity. Additional air layers are added on top of the earth model for the TE mode solution. In the TM mode (Ey, Ez, Hx), the electric fields are eliminated resulting in a second order system of equations for Hx. In the TE mode (Ex, Hy, Hz), the magnetic fields are eliminated resulting in a second order system of equations for Ex. In both cases, the resulting second order system of equations is solved using a parallel sparse matrix solver (PARDISO), which is fast and efficient, after which electric and magnetic fields can be computed at any point in the model.

B.1. REFERENCES (FROM CGG GEOTOOLS™)

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SUMMARY INFORMATION

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PROJECT INFORMATION	
Client Name:	Impala Canada Ltd.
Project Name:	Titan Property
Project Location:	Ontario, Canada
Project Type:	Spartan MT
Project Number:	CA01284S
Project Manager:	Mark Morrison
Project Period:	from August 7 to 12, 2021
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Template version	Version 2020.07.29