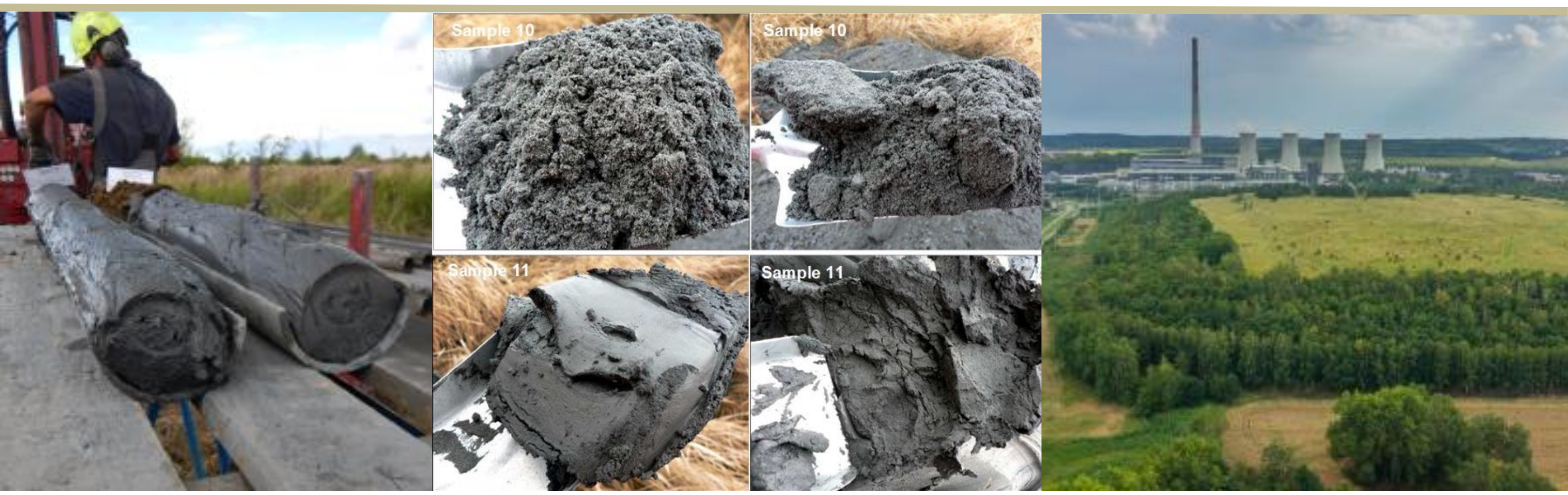
# Technical Report and Mineral Resource Estimate for the Chvaletice Manganese Project, Chvaletice, Czech Republic




PRESENTED TO

**Euro Manganese Inc.**

EFFECTIVE DATE: DECEMBER 8, 2018
RELEASE DATE: JANUARY 28, 2019
704-MIN.VMIN03117-02

QUALIFIED PERSONS:
JAMES BARR, P.GEO.
JIANHUI (JOHN) HUANG, PH.D., P.ENG.

Tetra Tech Canada Inc.
Suite 1000 – 10th Floor, 885 Dunsmuir Street
Vancouver, BC V6C 1N5 CANADA
Tel 604.685.0275 Fax 604.684.6241

This page left intentionally blank.

# TABLE OF CONTENTS





TETRA TECH

TETRA TECH

## LIST OF TABLES

## LIST OF FIGURES

## APPENDICES

# ACRONYMS & ABBREVIATIONS

| Acronyms/Abbreviations | Definition |
|---|---|
| %Mg | percent elemental manganese |
| $(NH_4)_2S$ | ammonium sulphide |
| $(NH_4)_2SO_4$ | ammonium sulfate |
| AAS | atomic absorption spectrometry |
| ABA | acid-base accounting |
| Actlabs | Activation Laboratories Ltd. |
| ALS | ALS Laboratories |
| ARD | acid rock drainage |
| ASTM | ASTM International |
| Ba | barium |
| BaS | barium sulphide |
| BD | bulk density |
| Bpv | Baltic Vertical Datum |
| Ca | calcium |
| $Ca(Mn^{2+}, Mg, Fe^{2+})(CO_3)_2$ | kutnohorite |
| CaO | calcium oxide |
| CIM | Canadian Institute for Mining, Metallurgy and Petroleum |
| Cl | chlorine |
| CMP | Chvaletice Manganese Project |
| CNIF | CINF Engineering Co., Ltd. |
| Cr | chromium |
| CRIMM | Changsha Research Institute of Mining and Metallurgy Co. Ltd. |
| CRM | certified reference material |
| DEM | digital elevation model |
| DTM | digital topographic model |
| E | east |
| EC | electrical conductivity |
| EDS | energy dispersive x-ray spectroscopy |
| EIA | environmental impact assessment |
| EMD | electrolytic manganese dioxide |
| EMM | electrolytic manganese metal |



TETRA TECH

| Acronyms/Abbreviations | Definition |
|---|---|
| EMMP | environmental monitoring and management plan |
| EMN | Euro Manganese Inc. and Mangan Chvaletice sro. |
| Fe | iron |
| Geomin | Geomin s.r.o |
| GET | GET s.r.o |
| Global ARD | Global ARD Testing Services Inc. |
| GPS | global positioning system |
| HPEMM | high-purity electrolytic manganese metal |
| HPMSM | high-purity manganese sulphate monohydrate |
| HR-type | horizontal ring type |
| ICP | inductively coupled plasma |
| ICP-MS | inductively coupled plasma mass spectrometry |
| ISO | International Organization for Standardization |
| Kč | Czech Koruna |
| Kemetco | Kemetco Research Inc. |
| LiDAR | light detection and ranging |
| Longi | Longi Magnet Co., Ltd. |
| Mangan | Mangan Chvaletice s.r.o. |
| MB | master blend |
| Met-Solve | Met-Solve Laboratories Inc. |
| Mg | magnesium |
| MgO | magnesium oxide |
| MKZ | Manganorudné a Kyzové Závody Chvaletice (Manganese and Pyrite Enterprise) |
| ML | metal leaching |
| Mn | manganese |
| $MnCO_3$ | rhodochrosite |
| $MnCO_3$ | manganese (II) carbonate |
| MnO | manganese (II) oxide |
| $MnO_2$ | manganese (IV) oxide |
| MRE | Mineral Resource Estimate |
| N | north |
| NHD | Jiangsu New HondaDa Group |
| NI 43-101 | National Instrument 43-101 |

| Acronyms/Abbreviations | Definition |
|---|---|
| NPR | neutralization potential ratio |
| NSR | net smelter return |
| Orex | Orex Consultants s.r.o. |
| P | phosphorus |
| $P_2O_5$ | phosphorus pentoxide |
| Pb | lead |
| PEA | preliminary economic assessment |
| PMC | Process Mineralogical Consulting Ltd. |
| PSA-H | hydrometer particle-size analysis |
| PSD-LD | laser diffraction particle size analysis |
| QA | quality assurance |
| QC | quality control |
| QP | Qualified Person |
| QQ | quantile-quantile |
| RPD | relative percent difference |
| Se | selenium |
| SEM | scanning electron microscopy |
| SGS | SGS Minerals Services |
| $SiO_2$ | silicon dioxide |
| S-JTSK | System Jednotne Trigonometricke Site Katastralni |
| SLon | SLon Magnetic Separation Ltd. |
| sMn | soluble manganese |
| $SO_2$ | sulfur dioxide |
| SRS | shallow refraction seismic |
| SWOT | strength-weakness-opportunities-threats |
| Tetra Tech Canada Inc. | Tetra Tech |
| the Exploration Licenses | the Chvaletice Property exploration licenses 631/550/14-Hd and MZP/2018/550/386-Hd |
| the JORC Code | Joint Ore Reserves Committee Australasian Code for Reporting of Exploration Results, Mineral Resources and Ore Reserves 2012 Edition |
| the Property | the Chvaletice Property |
| tMn | total manganese |
| TSX | Toronto Stock Exchange |

| Acronyms/Abbreviations | Definition |
|---|---|
| TSXV | TSX Venture Exchange |
| UBC | University of British Columbia |
| US$ | United States Dollar |
| USSR | Union of Soviet Socialist Republics |
| UTM | Universal Transverse Mercator |
| VR-type | vertical ring type |
| VSP | vertical seismic profiling |
| WGS | World Geodetic System |
| XRD | x-ray diffraction |
| XRF | x-ray fluorescence |

# 1.0 SUMMARY

The Chvaletice Manganese Project (CMP) is located in the western area of the Pardubice region of the Czech Republic, approximately 89 km by road east of Prague, on the southern shore of the Labe River (Figure 1-1). The CMP contemplates reprocessing of fine-grained tailings material for production of high-purity, selenium-free, 99.9% electrolytic manganese metal (EMM) and high-purity manganese sulphate monohydrate (HPMSM), at a hydrometallurgical refinery expected to be located adjacent to the tailings cells. The tailings were deposited into three separate above-ground tailings cells, referred to as Cell #1, Cell #2; and Cell #3, from historical mining and processing activities. The Chvaletice Property (the Property) is the subject of two exploration licences, numbered 631/550/14-Hd and MZP/2018/550/386-Hd (together the "Exploration Licences") and a Preliminary Mining Permit, numbered MZP/2018/550/387-HD, which is registered to include mineral rights over an area of 0.98 $km^2$ (the Protected Area, covering approximately 98 ha, encompassing all three tailings cells) (Figure 1-2).

Euro Manganese Inc. and its wholly-owned subsidiary, Mangan Chvaletice s.r.o (Mangan) (collectively referred in this Technical Report as EMN) retained Tetra Tech Canada Inc. (Tetra Tech) to prepare a Technical Report and to undertake a Mineral Resource Estimate (MRE), based on the data generated from work completed on the CMP by EMN to date. This report and MRE has been prepared for the CMP in accordance with National Instrument 43-101 (NI 43-101) guidelines and following Canadian Institute for Mining, Metallurgy and Petroleum (CIM) Best Practices. The effective date for this report is December 8, 2018. In accordance with NI 43-101 guidelines, the Qualified Persons (QPs) for this report are Mr. James Barr, P.Geo., Senior Geologist, and Mr. Jianhui Huang, Ph.D., P.Eng, Senior Metallurgical Engineer, both with Tetra Tech.

The Exploration Licences and the Preliminary Mining Permit are held by Mangan (a private Czech company that was repurposed in 2014, as a partnership between GET s.r.o. (GET), Geomin s.r.o. (Geomin), and Orex Consultants s.r.o. (Orex). Today, EMN owns 100% of Mangan. Terms of the purchase agreement dated May 2016 included transfer of an exploration licence, number 631/550/14-Hd, from GET to Mangan and purchase of 100% of Mangan by EMN. On May 4, 2018, the Czech Ministry of Environment issued Mangan an additional exploration licence, MZP/2018/550/386-Hd, allowing it to drill the slopes on the perimeter of the tailings cells. The additional exploration license became effective May 23, 2018 and is valid until May 31, 2023. Further, in April 2018, Mangan was issued a Preliminary Mining Permit, valid until April 30, 2023, which covers the area included in the Exploration Licences. The Preliminary Mining Permit is a precursor to applying for a Mining Permit and grants EMN the right to conduct an Environmental Impact Assessment. A net smelter royalty (NSR) agreement with a total aggregate amount of 1.2% is held by the original shareholders of Mangan, which was granted as part of the purchase transaction by EMN for 100% ownership of Mangan.

Infrastructure in the vicinity of, and accessible to the CMP includes highways, a major rail corridor, a navigable river, water supply, a natural gas line, a pre-cast concrete plant and a ready-mix concrete plant.

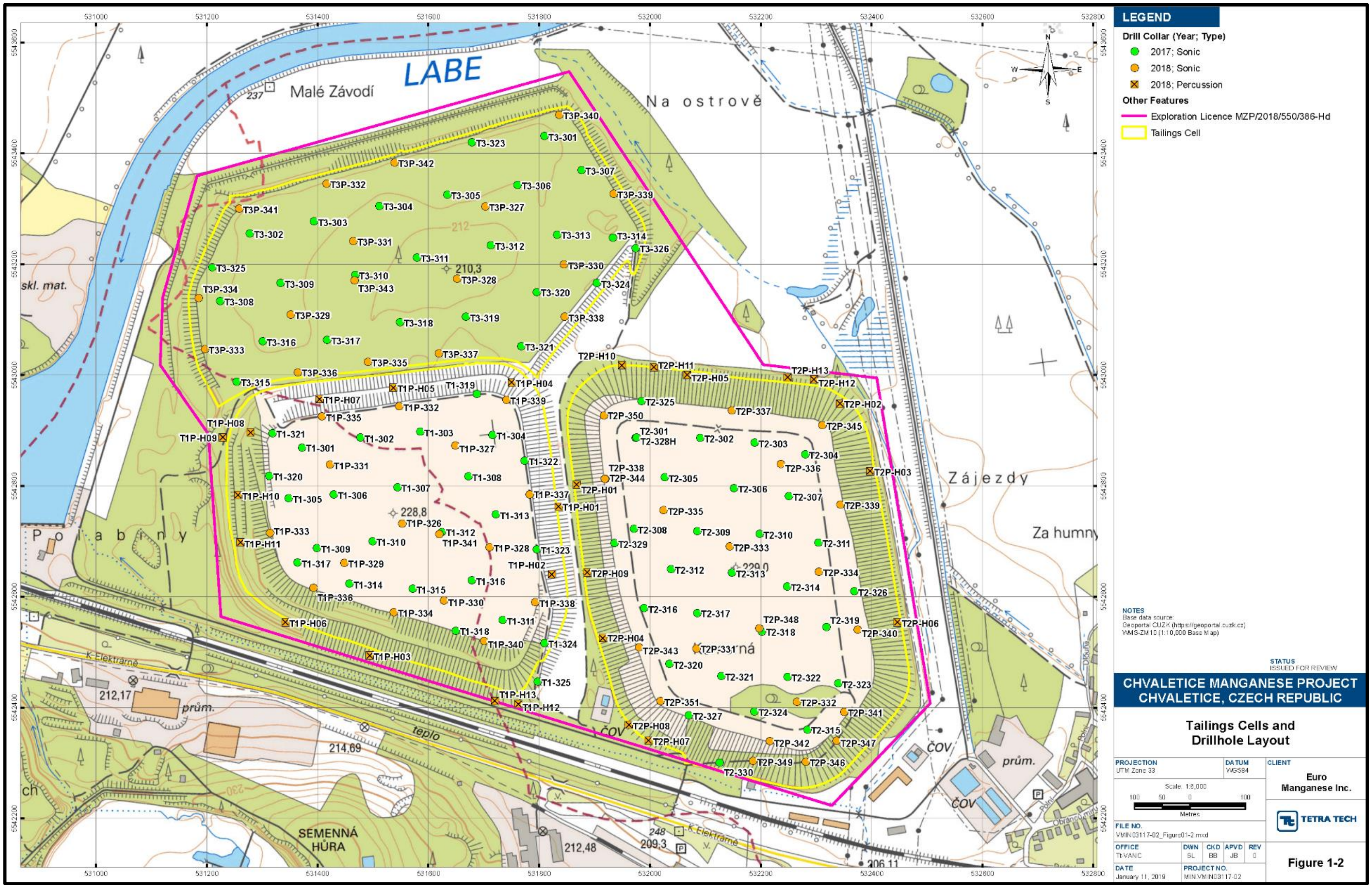
The region surrounding the CMP is rural, yet quite industrialized. Within 25 km of the CMP one can find several automotive plants, chemical plants, metal fabricators and numerous heavy and light industrial facilities. An 820 MW lignite coal-fired power plant is located directly adjacent to the CMP. A significant skilled and trainable labour workforce is accessible in the nearby communities, including the villages of Chvaletice (population of 3,200) and Trnavka (population 250) and the nearby towns and cities of Kutna Hora (population 21,000), Kolin (population 31,000), Pardubice (population 89,000), Hradec Kralove (population 93,000), and Prague (population 1,200,000).

Mining supplies, equipment, services and technical expertise can be found mainly in Ostrava, Prague and Pardubice.

At present, Mangan does not hold surface rights to the CMP area, which are considered as those lands of original ground elevation surrounding, and those parcels of original ground underlying and immediately surrounding, Cells #1, #2, and #3. The area of interest for the CMP overlies 18 privately owned land parcels with surface rights. Mangan received the consent to conduct exploration activities and to access the site from the land owners whose surface properties underlie the tailings.

**Figure 1-1: Location of the Chvaletice Manganese Project**

**Figure 1-2: CMP Tailings Cells: 2017 and 2018 Drillhole Layout**






TETRA TECH

On October 17, 2018, EMN closed an option agreement with EP Chvaletice s.r.o to purchase a 19.94 ha industrial zoned parcel of land located immediately to the south and across the highway from the tailings deposits, and contiguous with a 1.7 ha parcel of land purchased by EMN's Czech subsidiary in November 2017. The aggregated land package now totals 21.64 ha and is the proposed site for the development of the CMP's processing facility.

Planning and preparation of EMN's environmental assessment application has been initiated, with the objective of filing a Project Description/Notification early in 2019. The Project Description/Notification will include a description of:

- Manganese production process
- Project footprint
- Results of baseline and other studies conducted to date
- Health, safety and environmental management plans
- Impact mitigation and avoidance plan/measures
- Socio-economic impacts
- Preliminary reclamation plan/objectives.

These will be made available to local communities, residents and organizations, as well as to regulators, during a public comment and consultation period. Input and comments received, as well as any regulatory requirements for changes or additional studies, will serve to form the basis of an environmental impact assessment (EIA) application, which MCS currently intends to file later in 2019.

## 1.1 History

Historical mining in the region dates back to approximately 677 AD through to medieval times according to records of iron (Fe) production from small local mines. Intermittent mining for iron in the region continued through until the mid-19$^{th}$ Century, when iron and manganese (Mn) minerals near Chvaletice were discovered. Systematic underground mining within the Chvaletice Mine produced manganese ore between the years 1915 and 1945. Thereafter, from 1951 to 1975, open pit mining and milling operations occurred for the recovery of pyrite as basic raw material for the production of sulphuric acid and gave rise to the the three adjacent CMP tailings deposits. Conversion from underground to bulk tonnage open pit mining occurred during this period, during which time an estimated 32 Mt of material was mined for pyrite, with approximately 20 $Mm^3$ of waste rock deposited on the spoil heaps, and over 17 $Mm^3$ of flotation waste was placed into the unlined tailing ponds. These tailings ponds are the target of the CMP and are referred to as Cells #1, # 2, and #3. Mining, milling and production of tailings material was terminated in 1975.

An extensive evaluation of the tailings material was conducted between April 1986 and July 1988 by Bateria Slany, the former Czechoslovakian, State-owned manufacturer of batteries, for the potential manufacture of electrolytic manganese dioxide (EMD). The results from their investigation included a "reserve calculation", currently registered as the "Řečany – Tailings Pond 3" and "Chvaletice – Tailings Ponds 1, 2" as a "State Reserve" with the Czech Republic Government. This historical calculation comprised 27,557,441 t of "reserves", containing 25,496,299 t at a grade of 5.15% leachable manganese (7.06% total manages [tMn) at a "C2" category, and 2,061,143 t of material average grade of 4.97% of leachable Mn (7.39% tMn) at a "C1" category. The definition of C2 and C1 categories references a system developed in the Union of Soviet Socialist Republics (USSR) for classification of mineral "resources" and "reserves", where resources classified as C1 are supported in greater detail than those that are classified as C2. The Czech system differs significantly from the classification system defined under the CIM Terms and Definitions as referenced by NI 43-101 and cannot be misconstrued to imply a similar level of confidence. This historical calculation cannot be relied upon as being accurate, particularly since the raw data that served as the basis for these calculations has not been found by EMN, as it appears to have been lost or destroyed following the end of Communism in the Czech Republic.

## 1.2 Mineral Resources

Based on work conducted by Euro Manganese, under the supervision of Tetra Tech, the three tailings cells are estimated to contain approximately 18.6 $Mm^3$ of material, with approximately 17.8 $Mm^3$ comprised of silt and clay sized particulate tailings material. The remaining estimated 0.8 $Mm^3$ is native soils that were used for dam construction and erosion and dust control, and slope stabilization. Cell #1 averages approximately 26.6 m thick, with a surface area of approximately 326,400 $m^2$, and has a volume of approximately 6,720,300 $m^3$. Cell #2 averages approximately 28.7 m thick, with a surface area of approximately 393,200 $m^2$, and has a volume of approximately 8,035,200 $m^3$. Cell #3 averages approximately 11 m thick, with a surface area of approximately 313,200 $m^2$, and has a volume of approximately 3,035,900 $m^3$.

EMN began recent exploration activity on the Property in 2014, when a series of near surface samples were collected from auger holes and test pits for preliminary materials characterization. In June 2017, EMN initiated an 80-hole Sonic drilling campaign totaling 1,679.3 m within Cells #1, #2, and #3 to evaluate the mineral resource potential both horizontally and vertically through the full tailings profile, referred to as the 2017 Drilling Program. Drillhole spacing was approximately 100 m throughout each cell. The perimeter embankments of each cell were not safely accessible to the sonic drill rig and were not drilled. To verify the composition of the embankments, four additional drillholes were collared on access ramps. Each drillhole intersected a layer of topsoil with average thickness of approximately 1 m, manganese bearing tailings material, and terminated in native basal soils at elevations consistent with other drillholes. During the summer of 2018, EMN conducted a second campaign of drilling at the CMP with a total of 80 drillholes, totalling 1,509.5 m. The program included completion of 35 vertical and 19 inclined 100 mm diameter Sonic holes, totalling 1,409.5 m. An additional 26 mobile percussion drillholes, totalling 100 m, were completed around the perimeter embankments of the tailings piles in areas which were not previously accessed for sampling. The tailings material observed, sampled, and analyzed was generally very consistent in terms of total and soluble manganese grade and mineralogy.

Information collected during these investigations is available for the purposes of mineralogy, hydrological, geotechnical, metallurgical, environmental, and process engineering design.

Samples were collected on intervals ranging from 0.925 to 4.1 m with the average length representative of the 2 m core runs. Each sample was logged for lithology, moisture, particle size, wet mass, and recovery in the field. A total of 1,484 samples were split in the field longitudinally along the core. A 25% sub-sample split of each sample was shipped to SGS Mineral Services (SGS) laboratories in Bor, Serbia, for analysis and testwork. In 2017, the remaining 75% sub-sample was shipped to Changsha Research Institute of Mining and Metallurgy Co. Ltd. (CRIMM) in China, for bulk sample metallurgical and process testwork, respectively. In 2018, the sample was split with a 25% sub-sample collected for testwork in the Czech Republic, and the remaining 75% collected and stored in vacuum-sealed bags, which were then placed in steel barrels, in a warehouse located near the CPM site, in order to remain fresh and unaltered, and available for future metallurgical and pilot plant testing.

A rigorous quality assurance (QA) and quality control (QC) program was implemented by EMN, which included use of field duplicates, lab duplicates, insertion of three certified reference materials (CRMs), and insertion of two certified blank materials. Drillhole twins completed in 2018 were used to verify the 2017 sample database. Quality control methods were reviewed by Tetra Tech QP James Barr, P.Geo., during site visits to the Property, and following receipt of analytical results Tetra Tech undertook compilation of the geological database, the verification of laboratory data, and the QA/QC program for data validation. The QP is satisfied that the sampling method and analytical integrity has been preserved throughout sample handling, preparation, and analytical process.

Analysis and testwork conducted on the samples, included:

- Multi-element assay using aqua regia and four acid digestions as proxy for soluble manganese (sMn) and total manganese (tMn) concentrations
- Whole rock analysis using fusion-x-ray fluorescence (XRF)
- Particle size analysis using laser diffraction and sieve/hydrometer methods
- Mass measurements
- Moisture measurements
- Specific gravity by pycnometer.

A preliminary in situ dry bulk density investigation was conducted by EMN in advance of the 2017 drilling program using a cylinder test method from near surface samples. This work was followed by an in-depth calculation of in situ dry bulk density using core recovery volumes and dry mass using SGS laboratory measurements following both the 2017 and 2018 drilling investigations. Calculated in situ dry bulk density values for individual samples ranged between 0.35 and 3.154 t/m$^3$, with 95 percent probability interval of 0.87 to 2.01 t/m$^3$, and average value of 1.49 t/m$^3$ ±0.017 t/m$^3$ (95% chlorine [CI]).

Manganese is primarily hosted in carbonate minerals with lesser amounts as silicate and oxide minerals, as identified by x-ray diffraction (XRD). Mineralogical studies have been completed by EMN in 2015 and reported by AMEC in their initial investigation in 2016 (AMEC 2016), and by Changsha Research Institute of Mining and Metallurgy Co., Ltd (CRIMM) in 2017. The combined work has identified that 80% of the manganese occurs as carbonate and 19% of the manganese occurred as silicate. The primary manganese carbonate is rhodochrosite ($MnCO_3$), with lesser amounts of manganese bearing carbonates having variable proportions of Fe, Ca and Mg with carbonate to form a wide variety of minerals from the rhodochrosite(Mn)-siderite(Fe)-dolomite(Mg)-calcite(Ca) spectrum. Scanning Electron Microscope investigation work identified a rare and locally named mineral kutnohorite ($Ca(Mn^{2+}, Mg, Fe^{2+})(CO_3)_2$) found with in this spectrum and identified as a significant manganese bearing carbonate. Manganese bearing silicates include spessartine ($Mn_3Al_2(SiO_4)_3$), rhodonite ((Mn, Fe, Mg, Ca)$SiO_3$) and trace concentrations of sursassite ($Mn_2^{2+}Al_3(SiO_4)(Si_2O_7)(OH)_3$). Trace amounts of the manganese oxide pyrolusite ($MnO_2$) were also detected. Predominant gangue minerals are quartz, albite, muscovite, pyrite and apatite.

Total sulphur concentration in the tailings averages approximately 3.4% which is sourced form sulphide, sulphate, and organic sulphur origin. Total carbon concentrations averages approximately 3.5%, which includes contributions from graphite, organic carbon and carbonate origins. Photo 1–1 shows photos of core recovered from drillhole T1-312, near the core of Cell #1.

**Photo 1-1: Core Photos from Drillhole T1-312, from Depths 3 to 4 m, 9 to 10 m and 23 to 25 m**


## 1.3 Mineral Resource Estimate

A three-dimensional model was constructed for Cells #1, #2 and #3 using a digital topographic model (DTM) compiled by GET using data from the 5th generation digital elevation model (DEM) 5G developed by the Land Survey Office in Prague from light detection and ranging (LiDAR) data in the System Jednotne Trigonometricke Site Katastralni (S-JTSK) (Krovak East North) coordinate system and the Baltic Vertical Datum (Bpv). The topography has been used to constrain volume estimates for each cell.

Lithology logs were used to construct an upper contacting surface between tailings and topsoil, then used to construct a lower contact surface between tailings and native subsoil. The intervening volume defined the volume of tailings material in each cell and was used to constrain all laboratory analysis and testwork data that was subsequently used to model various physical and chemical attributes of the tailings material.

Data was analyzed in Phinar X10-Geo v.1.4.15.8, Snowden Supervisor v8.9.0.2 and Seequent Leapfrog® Geo v.4.4.2, and models were developed using Seequent Leapfrog® Geo v.4.4.2. All sample data was composited to 2 m, and each cell was modelled separately. No capping was applied to manganese grades as no outliers were identified on the normally distributed data.

Interpolated block models were developed for physical parameters including grain size, in situ dry bulk density, and moisture content, as well as an additional 18 elements. Grain size was represented using $D_{50}$, $D_{80}$, $D_{90}$, which are the average diameter of the particles at the 50th, 80th and 90th percentiles, respectively, and using $P_{75}$ which is the percentage of the sample that passes a standard 200 mesh, equivalent to a 75 µm nominal mesh. The model results show that particle size transitions from coarse to fine inwards in each. Average $P_{75}$ for each cell ranged from 66.48

to 71.29%, indicating that the bulk of the material is silt size or smaller. In situ dry bulk density varies throughout each cell and is a function of the composite mineral densities in addition to the degree of compaction in the soils. Modelled in situ dry bulk density values ranged from 1.10 to 2.15 t/m$^3$, with an overall average of 1.51 t/m$^3$. Moisture content measured from each sample ranges from approximately 1.2 to 39.3% and averaging 21.14% overall. As with particle size distributions, moisture shows a strong zonation towards the center of each cell where the material is observed to be saturated with above average moisture contents.

Total and soluble manganese concentrations were interpolated using inverse distance (cubed) (ID$^3$) interpolation method into a sub-block model with 50 m by 50 m by 4 m parent blocks, and 12.5 m by 12.5 m by 2 m sub-blocks. The dry in situ bulk density model was applied to the sub-block model to calculate block tonnages. The block model was classified and validated by Tetra Tech QP James Barr, P.Geo., using guidelines set forth by NI 43-101 and CIM Best Practices. The MRE was classified as Measured and Indicated based on sample spacing and variance assessment. Table 1-1 lists the MREs which have an effective date of December 8, 2018. This MRE supersedes the previous MRE with effective date of April 27, 2018.

**Table 1-1: Mineral Resource Estimate for the Chvaletice Manganese Project, Effective December 8, 2018**

| Cell | Class | Volume ('000 m3) | Tonnage (kt) | In Situ Dry Bulk Density (t/m$^3$) | tMn (%) | sMn (%) |
|---|---|---|---|---|---|---|
| #1 | Measured | 6,577 | 10,029 | 1.52 | 7.95 | 6.49 |
| | Indicated | 160 | 236 | 1.47 | 8.35 | 6.67 |
| #2 | Measured | 7,990 | 12,201 | 1.53 | 6.79 | 5.42 |
| | Indicated | 123 | 189 | 1.55 | 7.22 | 5.30 |
| #3 | Measured | 2,942 | 4,265 | 1.45 | 7.35 | 5.63 |
| | Indicated | 27 | 39 | 1.45 | 7.90 | 5.89 |
| Total | Measured | 17,509 | 26,496 | 1.51 | 7.32 | 5.86 |
| | Indicated | 309 | 464 | 1.50 | 7.85 | 6.05 |
| **Combined** | **M&I** | **17,818** | **26,960** | **1.51** | **7.33** | **5.86** |

Notes:

- Estimated in accordance with the CIM Definition Standards on Mineral Resources and Mineral Reserves adopted by CIM council, as amended, which are materially identical to the Joint Ore Reserves Committee Australasian Code for Reporting of Exploration Results, Mineral Resources and Ore Reserves 2012 Edition (JORC Code).
- The Chvaletice Mineral Resource has a reasonable prospect for eventual economic extraction. Mineral Resources do not have demonstrated economic viability, and no Mineral Reserves have been defined for the CMP.
- Indicated Mineral Resources have lower confidence that Measured Mineral Resources. A break-even grade of 3.20% tMn has been estimated for the Chvaletice deposit based on preliminary pre-concentration operating costs of US$5.22/t feed, leaching and refining operating cost estimates of US$173/t concentrate, 63% recovery for magnetic separation derived from the average total manganese recovery of 87.7% on the average head grade, 71% recovery for leaching and refining, and a metal price of US$2.00/kg for 99.7% EMM (Shanghai Metals Market, December 2018). The commodity price for high purity 99.9% EMM is expected to be higher.
- A cut-off grade has not been applied to the block model. The estimated break-even cut-off grade falls below the grade of most of the blocks (excluding 10,000 t which have grades less than 3.20% tMn). It is assumed that material segregation will not be possible during mining due to inherent difficulty of grade control and selective mining for this deposit type.
- Grade capping has not been applied.
- Numbers may not add exactly due to rounding.

## 1.4 Mineral Processing and Metallurgical Testing

Starting from 1986, several metallurgical test programs have been carried out to assess metallurgical responses of recovering manganese from the tailings materials originated from pyrite mining conducted from 1951 to 1975. During 2015, 2017 and 2018, EMN has undertaken further manganese recovery test programs, including semi-continuous pilot plant testing. The testwork conducted before early 2017 has been discussed in the report titled *Technical Report and Mineral Resource Estimate for the Chvaletice Manganese Project, Chvaletice, Czech Republic*, released on June 21, 2018.

A comprehensive test program has been conducted since September 2017 using a total of 743 drilling core interval samples from the 2017 drill program. The main objectives of the test program are to verify the previous test findings and develop and optimize the process flowsheet and conditions for producing high-purity electrolytic manganese metal (HPEMM). A separate testwork program was conducted in 2018 to investigate the generation of HPMSM from the magnetic separation concentrate and from the electrolytic manganese metal flakes.

A total of 25 composite samples were constructed from the 2017 drill core interval samples representing different mineralogical characters, including grade, particle size, and spatial location variations. The total manganese contents of the samples vary from 5.71 to 8.77% tMn. The acid-soluble manganese to total manganese ratio fluctuates in a narrow range of 0.75 to 0.85.

The main 2017-2018 testwork focused on:

- Process mineralogical study
- Pre-concentration of manganese minerals by high-intensity magnetic separation
- Sulfuric acid dissolution of manganese minerals from the magnetic separation concentrate
- Iron and phosphorus removal and related pregnant solution and leach residue separation
- Pregnant solution purification
- Selenium (Se)-free electrowinning followed by chromium (Cr)-free passivation to produce HPEMM
- HPMSM production directly from magnetic separation concentrate and from electrolytic manganese metal flakes
- Ancillary tests, including leach residue washing, manganese recovery from residual washing solution, and magnetic separation tailings, and leach residue dewatering and detoxification.
- Potential equipment vendor verification tests, including magnetic separation, leach residue washing, magnetic separation tailings and leach residue dewatering/solid-liquid separation.

A program of locked-system, semi-continuous pilot plant testing investigated metallurgical performances of the tailings samples for the flowsheet and process conditions developed from the bench tests, and generated sample products, including HPEMM flakes and HPMSM powders.

A process mineralogical study was conducted on the Master Blend (MB) composite sample. The mineralogical characteristic study includes a mineral component determination by optical microscope, XRD diffraction analysis, scanning electron microscopy (SEM), and mineral chemical phase analysis. The study verified the previous findings, indicating that manganese mainly occurs in the form of manganese carbonates, including rhodochrosite and kutnohorite. The manganese carbonates account for approximately 80% of the total manganese. The second main manganese mineral group, approximately 19% of the manganese, is in the form of manganese silicates.

Magnetic separation bench tests were conducted using two types of high-intensity magnetic separation machines, vertical ring type (VR-type) separator and horizontal ring type (HR-type) separator. The test results show that manganese recovery varies from 76.7 to 94.3% tMn, averaging 87.7% tMn, and on average magnetic separation can improve the feed manganese content from 7.2% tMn to approximately 14% tMn, ranging from 12.0 to 15.4% tMn.

Considering the downstream iron/phosphorus (P) removal treatment, the optimized leach conditions were determined as: leach temperature at approximately 90°C with a leach retention time of 5 to 6 hours and 0.42 acid to 1.0 feed ratio. On average, approximately 75% of the manganese can be extracted by sulfuric acid leaching, ranging from 71.9 to 82.8% tMn.

Three semi-continuous pilot plant runs were conducted on the Master Blend composite: a high-grade composite (Composite P1) and a low-grade composite (Composite P2) using the conditions developed from the batch tests. The test flowsheet was based on the batch test results and industrial operation experience. The first pilot plant run on the MB composite sample showed that some of impurity levels of the electrolytic manganese flakes may exceed the customer's requirements (the HPEMM's specifications are confidential and commercially sensitive). A comprehensive testing was further conducted by a quality optimization intervention to optimize solution purification and electrowinning conditions. This optimization testing significantly improved electrowinning circuit performance and electrolytic manganese product quality. It is anticipated that the impurity contents of the HPEMM products should be lower than the criteria required by potential users of HPEMM. With using the optimized process conditions, the subsequent second and third semi-continuous pilot plant runs on Composites P1 and P2 were conducted. According to the assay results by CRIMM, the total manganese contents of the manganese flakes produced were higher than 99.9% (manganese contents were calculated by subtracting impurity contents) and impurity levels are anticipated to be lower than the threshold specified by potential users. Table 1-2 summarizes the key circuit performances.

### Table 1-2 Key Pilot Plant Test Results

| Sample | Magnetic Separation | | Acid Leach Extraction (% tMn) | Electrowinning | |
|---|---|---|---|---|---|
| | Concentrate Grade (% tMn) | Recovery (% tMn) | | Current Efficiency (%) | Power Consumption (kWh/t EMM) |
| Master Blend | 15.1 | 88.3 | 75.6 | 59.7 | 6,900 |
| Composite P1 | 16.0 | 89.1 | 81.8 | 64.2 | 6,200 |
| Composite P2 | 14.8 | 86.4 | 73.5 | 63.4 | 6,400 |

A preliminary test program was conducted to investigate production of HPMSM from the Chvaletice Mineral Resource. Three different process schemes were tested separately, including HPMSM sample production:

- From direct acid leaching of the magnetic concentrate without electrowinning purification
- From 99.9% HPEMM (selenium and chromium free)
- From 99.7% EMM (selenium and chromium containing).

According to the assay by CRIMM, in general, the impurity contents of the HPMSM powders produced from the three process schemes were lower than the target values, excluding the levels of sodium, fluorine, and heavy metals in the HPMSM directly produced from the magnetic concentrate. The best quality HPMSM, containing higher than 32.2% manganese, was produced from the HPEMM flakes generated from the pilot plant runs.

Independent multi-element analysis is currently being conducted to verify the certain assay results reported by CRIMM on both the HPEMM and HPMSM products produced.

## 1.5 Recommendations

### 1.5.1 Mineral Resources

The current Mineral Resource is supported by a comprehensive database and no further delineation drilling is recommended at this time.

Further work totaling approximately US$100,000 is recommended for mineralogical studies to characterize potential acid generation and metal leaching of the tailings material, and for technical consulting services related to further assessment of the multi parameter block model to help inform and optimize future mining, metallurgy and environmental design.

EMN may wish to consider trial mining using an excavator to sample specific blocks for reconciliation of grades reported in the block model, and to generate samples for further metallurgical testwork, as required. Additionally, EMN may wish to consider an assessment of laboratory analytical procedures suitable for operational QA/QC and grade control procedures.

### 1.5.2 Mineral Processing

Further metallurgical testing is recommended to better understand metallurgical performances, optimize processing conditions and generate design-related data using the samples produced from 2017 and 2018 drilling programs, and possibly material generated by test mining. The testwork should include waste material characterization. Further pilot/demonstration plant programs are anticipated to be conducted using the drill core samples generated from the 2018 drilling program and material excavated using an excavator, depending on the ultimate quantities of HPEMM or HPMSM product samples required by customers. The sample products, as requested by potential customers, are expected to be generated from the pilot plant testing.

A total of US$930,000 has been estimated for the further testing program, excluding sample generation and shipment costs and the rental and manufacture costs for the pilot plant test equipment.

Further engineering studies would include hydrogeological investigation, geotechnical and stability assessment in additional to mining and process engineering.

Environmental and baseline studies should continue to characterize the local environment and receiving environment and should include static and kinetic testwork of the tailings to characterize reaction dynamics for potential acid generation and metal leaching.

### 1.5.3 Further Engineering

It is recommended to evaluate the mineral resource using mining, processing, and financial factors in a preliminary economic assessment (PEA) to confirm the CMP as a reasonable prospect for eventual economic extraction. Further engineering studies would also include a hydrogeological investigation for dewatering of the tailings, a geotechnical investigation, and a stability assessment.

Details of the recommended programs and cost breakdowns are included in Section 17.0 of this report.

# 2.0 INTRODUCTION

Euro Manganese Inc. (EMN) (Toronto Stock Exchange Venture Exchange (TSXV): EMN) retained Tetra Tech Canada Inc. (Tetra Tech) to prepare this Technical Report in accordance with National Instrument 43-101 (NI 43-101) guidelines for the Chvaletice Manganese Project (CMP) deposit, located in the Pardubice region of the Czech Republic. Mineral tenure for the Chvaletice Property (the Property) is held by Mangan Chvaletice s.r.o. (Mangan), a 100% owned subsidiary of EMN, based in Prague, Czech Republic. The effective date for this report is December 8, 2018.

The CMP name is derived from the local Chvaletice community, which was the site of historical open pit mining operations and processing of pyrite from 1951 to 1975, which produced nationally owned sulphuric acid from the pyritic shales. No additional mining or metal production is known to have been conducted on the Property since 1975. The mineral deposit being evaluated for the CMP comprises three tailings material stockpiles placed as a by-product of this historical production. These deposits are referred to as Cell #1, Cell #2, and Cell #3. EMN is evaluating the potential of reprocessing this tailings material for potential production of high purity, selenium-free, 99.9% electrolytic manganese metal (HPEMM) and/or high-purity manganese sulphate monohydrate (HPMSM) at a hydrometallurgical refinery.

Since 2014, EMN has conducted various exploration, mineralogical, and materials testing campaigns as part of their preliminary site investigation efforts to characterize the deposits and potential recovery methods. Work to date has confirmed manganiferous mineralization in carbonate form is present within dry to fully saturated compacted predominantly silty soil which comprises the tailings deposit.

The following terms of reference for the CMP are included throughout this report:

- The CMP tailings materials, CMP tailings deposit, and Cells #1, #2, and #3, all refer to the manmade tailings deposits located near the community of Chvaletice, which comprises the mineralized material that is the subject of this report.
- The Chvaletice bedrock deposit refers to the original bedrock material that was mined historically for pyrite and production of sulphuric acid and is not part of EMN's interest in the CMP.

References used for this document include publicly available government documents, existing project testwork, internal company reports, and verbal communication with EMN personnel. Current work being conducted by EMN aims to verify technical information and conclusions previously reported by Bateria Slany (1989). This work is one of a few historical technical references that exists for the CMP and includes a detailed description of technical investigations completed by EMN.

## 2.1 Site Visits

In accordance with NI 43-101 guidelines, the Qualified Persons (QPs) for this report are Mr. James Barr, P.Geo., Senior Geologist (geology QP), and Mr. Jianhui Huang, Ph.D., P.Eng, Senior Metallurgical Engineer (metallurgical QP), both with Tetra Tech.

Mr. James Barr, P.Geo., completed a site visit to the Property from July 1 to 3, 2017, and from July 30 to 31, 2018. During the site visits, Mr. Barr reviewed the Property layout, drill operations, sample collection methods, quality control protocols, and collected independent verification samples. Conversations with on-site EMN technical personnel including Tomas Pechar Jr. (Mining Engineer and Project Implementation Manager); and Jaromir Tvrdý

(Senior Project Geologist) of GET s.r.o. (GET); Joseph Simek (geologist) with Geomin s.r.o. (Geomin), covered topics relating to drilling recoveries, moisture content, soil class interpretation, surface property ownership, mineral tenure, and other project considerations. Mr. Barr is responsible as QP for the preparation of Sections 1.0 (except 1.4) through 12, 14 through 17, 18.1, 19.1, and 20.0.

Mr. Jianhui Huang, Ph.D., P.Eng, visited the Property on February 5, 2018, and visited the Changsha Research Institute of Mining and Metallurgy Co. Ltd. (CRIMM) laboratory and pilot plant facility five times between January 20, 2017 and September 20, 2018 to witness sample preparation and test/assay facilities and to discuss test program and results with CRIMM's technical team. Mr. Huang also visited the SGS Minerals Services (SGS) laboratory on June 29, 2017. Mr. Huang is responsible as QP for the preparation of Sections 1.4, 13.0, 18.2, 19.2 and 20.0.

## 2.2 Project Assumptions for Reporting

The coordinates system used for the CMP is the System Jednotne Trigonometricke Site Katastralni (S-JTSK) (Krovak East North) coordinate system and the Baltic Vertical Datum (Bpv), a system designed for the Czech Republic, as described further in Section 5.5. The accuracy of the topography and surveyed drillhole collar locations as provided is assumed to be reliable. Tetra Tech has approximately verified drill collar surveys in the field using handheld global positioning system (GPS).

Manganese grades are reported as percent elemental manganese (Mn%). Where necessary, they have been converted from manganese (II) oxide (MnO%) using as factor of 1.2912. Manganese grades may not have a direct linear correlation to the amount of manganese product that could be produced. Metallurgical and process engineering is ongoing to evaluate material recovery effectiveness. The assay methods were selected to measure total elemental concentration in addition to measuring partial digestion concentrations of manganese as a proxy for "soluble manganese". In this report, total manganese (tMn) refers to the results of the lithium borate fusion and x-ray fluorescence (XRF) methods, and soluble manganese (sMn) refers to the results of the aqua regia digestion with inductively coupled plasma mass spectrometry (ICP-MS) or atomic absorption spectrometry (AAS).

Observation of sample collection and handling was observed by the geology QP during two separate site visits. It is assumed that the methods and protocols observed during these periods, and as described in this report, were consistent with those used for the whole duration of the drilling investigation.

## 2.3 Effective Date

All information supporting the drilling program and Mineral Resource Estimate (MRE) described in Section 14.0 was received and validated for use in Mineral Resource estimation. The MRE was stated on December 8, 2018.

All information supporting the metallurgical work described in Section 13 was received and has been validated as of December 8, 2018.

An effective date of December 8, 2018, has been applied to this report. Metallurgical testwork has been initiated and is ongoing at the effective date of this report. The QPs are not aware of any new information that is available for this Technical Report as of the effective date.

# 3.0 RELIANCE ON OTHER EXPERTS

EMN provided Tetra Tech with information regarding mineral tenure and ownership of surface rights described in Section 4.0, based on a title opinion provided by PRK Partners s.r.o. in the Czech Republic in a letter dated June 20, 2018. The letter confirms that EMN is the sole shareholder of Mangan, Mangan is registered and in good standing under the laws of Czech Republic, and that Mangan holds valid exploration licences and a Preliminary Mining Permit for the CMP. Tetra Tech has not sought legal verification of the information but believes the information to be true.

The Czech Ministry of Environment approved Mangan's application for a preliminary mining licence in a document dated April 17, 2018, and with reference to MZP/2018/550/387-Hd, ZN/MZP/2018/54. Details of this authorization are included in Section 4.1.

# 4.0 PROPERTY DECRIPTION AND LOCATION

The Property is located in the western area of the Pardubice region of the Czech Republic at approximate latitude-longitude coordinates 15.444279°east (E) and 50.038069°north (N). Communities within the immediate vicinity of the Project include Trnávka, Chvaletice and Řečany nad Labem. Prague is located approximately 75 km due west (Figure 4-1).

The tailings are deposited in three separate facilities, referred to as cells, which were built upon and are elevated with respect to the natural ground elevation in the region. Cell #1, the oldest deposit, covers a total surface area of approximately 326,400 $m^2$, and has an average thickness of approximately 26.6 m. Cell #2 covers a total surface area of approximately 393,200 $m^2$ and has an average thickness of approximately 28.7 m. Cell #3 covers a total surface area of approximately 313,200 $m^2$ and has an average thickness of approximately 11 m. Figure 4-2 shows a plan map of the Property.

## 4.1 Mineral Tenure

Governing authorities that regulate mineral resources and mining activities in the Czech Republic include the Czech Mining Authority, District Mining Authorities, the Ministry of the Industry and Trade, and the Ministry of Environment of the Czech Republic. The CMP lies within the Hradec Králové and Pardubice Region District Mining Authority. These authorities administer the *Mining Act* (44/1988), Mineral tenure is regulated under the *Geological Act* (62/1988) and administered by the Ministry of Environment in consultation with the Ministry of the Industry and Trade and with the Czech Mining Authority.

Application for the mineral tenure of the “Trnávka Exploration Area” was made by GET in April 2014. The area of interest was considered to have been discovered by State Resource which allowed for competing bids. Following the Ministry of Environment’s review of competing bids, exploration license 631/550/14-Hd which encompasses the “Řečany - Tailings Pond 3” and “Chvaletice - Tailings Ponds 1, 2” was awarded to GET.

Mangan is a private company established in the Czech Republic in 1997. Mangan was used as the corporate vehicle for an incorporated partnership between GET (33%), Geomin (33%), and Orex Consultants s.r.o. (Orex) (34%). On December 15, 2014, an Option Agreement was signed between EMN, Mangan, and its affiliates, granting EMN the right to earn an 80% equity interest in Mangan. In May 2016, the Option Agreement was amended and EMN purchased 100% ownership of Mangan from the Mangan shareholders, for an aggregate share value (EMN common shares) of CAD$1,500,000 and future prorated net smelter return (NSR) payments of 1.2% to the original Mangan partners. Conditions precedent to the EMN-Mangan purchase agreement included transfer of the exploration licence number 631/550/14-Hd from GET to Mangan.

Exploration licence number 631/550/14-Hd is registered to include mineral rights on a total area of 0.98 $km^2$ (98 ha), of which 0.82 $km^2$ is located within the Municipality of Trnávka, and 0.16 $km^2$ is located within the Municipality of Chvaletice. Exploration Licence No. 631/550/14-Hd expires May 31, 2023 (extension reference MZP/2018/550/1484-Hd). On May 4, 2018, the Czech Ministry of Environment issued Mangan an additional exploration Licence No. MZP/2018/550/386-Hd allowing it to drill the slopes on the perimeter of the tailings piles. Exploration Licence No. MZP/2018/550/386-Hd became effective May 23, 2018 and is valid until May 31, 2023.

On April 17, 2018, with effect from April 28, 2018, Mangan was issued a Preliminary Mining Permit by the Ministry of Environment, Licence No. MZP/2018/550/387-HD and referred to by the Ministry of Environment as the prior consent with the establishment of the Mining Lease District (the Preliminary Mining Permit). The Preliminary Mining

Permit, valid until April 30, 2023, covers the areas included in the Exploration Licences and secures Mangan's rights for the entire deposit area.

The Preliminary Mining Permit forms one of the prerequisites for the application for the establishment of the Mining Lease District and represents one of the key steps towards final permitting for the project. Based on the Preliminary Mining Permit and other documents, including the Environmental Impact Assessment (which may commence after the Preliminary Mining Permit has been issued), Mangan has until April 30, 2023, to apply for the establishment of the Mining Lease District covering the areas included in the Exploration Licences. The establishment of the Mining Lease District, the application for the final Mining Permit, and applications for permits relating to the construction of infrastructure required for the project, are required prior to mining at the CMP. The Preliminary Mining Permit bounds are shown in Figure 4-32.

In December 2017, the Chvaletice tailings manganese resource was accepted in the Czech national register, confirming Mangan as the recognized administrator of these resources.

### Figure 4-1: Chvaletice Manganese Project Location

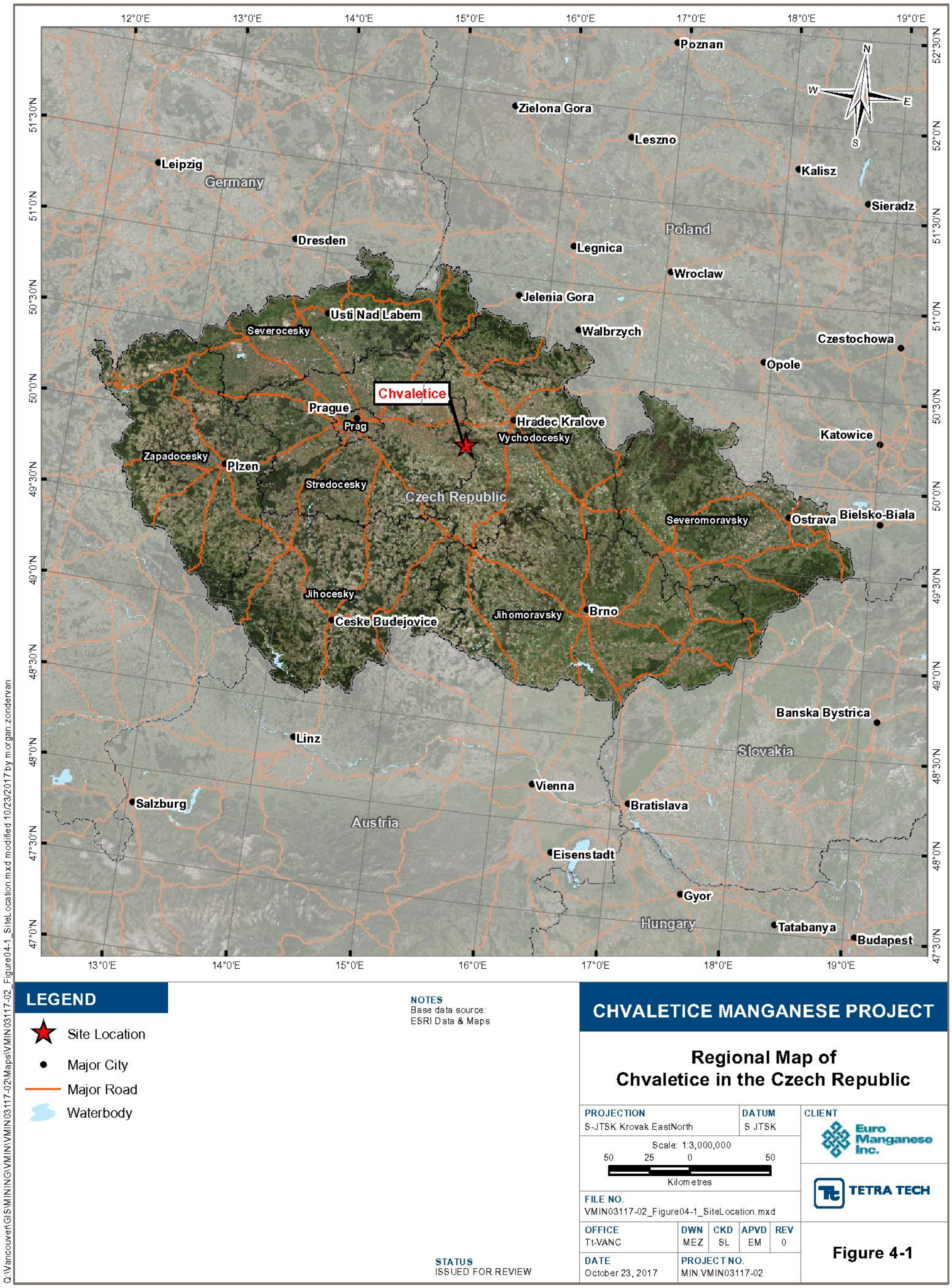
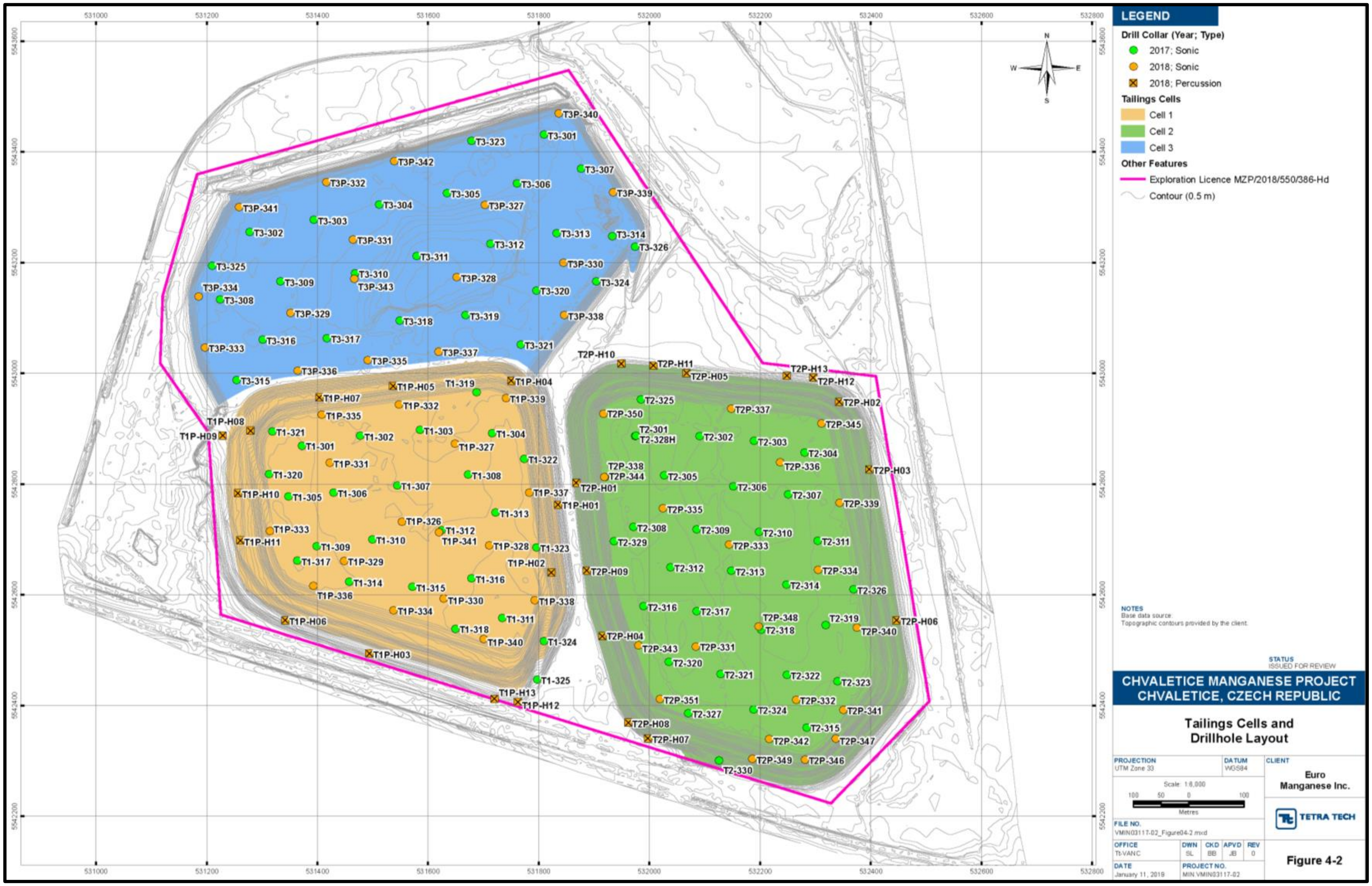


**Figure 4-2: Plan Layout of the Project Tailings Deposits, Cells #1, #2, and #3**



## 4.2 Surface Ownership and Land Access Agreements

At present, Mangan does not hold surface rights to the CMP area, which are considered as those lands of original ground elevation surrounding and immediately underlying the protected area that contains tailings Cells #1, #2, and #3. The area of interest for the CMP overlies and adjoins 18 privately owned land parcels with surface rights described as (Petru 2015), (Figure 4-3):

- The principal plots of land parcels 1170/1, 1170/4, 1170/7, 1217/1, and 1490/2 in the cadastral area of Chvaletice
- The principal plots of land parcels 349/2, 481/1, 613/1, 660/1, 661/1, 661/2, 662/1, 666/4, 1050, 1017/1, 1017/3, 1065, and 1180/30 in the cadastral area of Trnávka.

Land access agreements and permissions were obtained by Mangan from landowners as well as the Trnávka and Chvaletice Municipalities for sampling, surveys, studies, road-building and drilling that were conducted in 2016, 2017, and 2018.

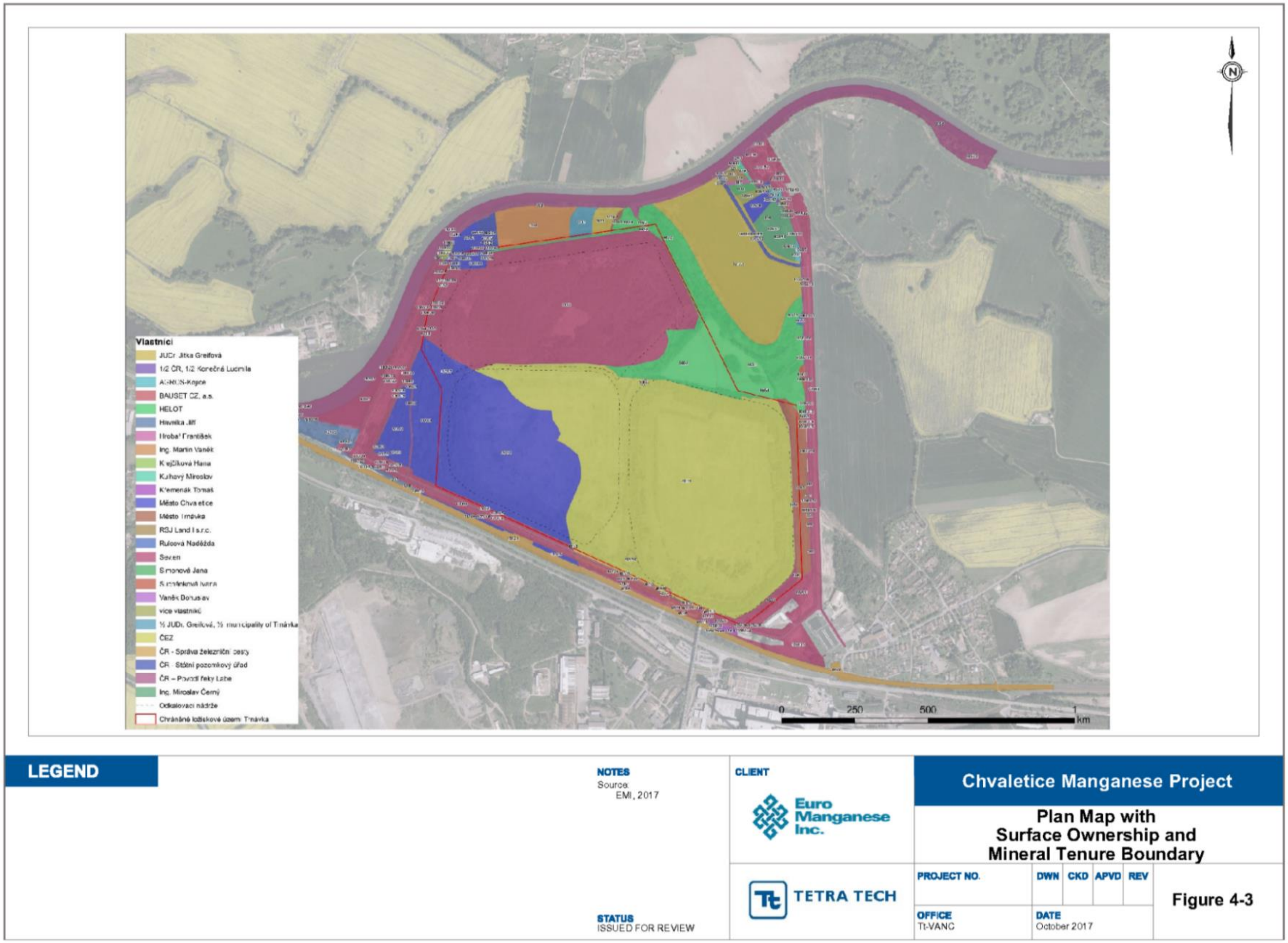
On October 17, 2018, EMN closed an option agreement with EP Chvaletice s.r.o to purchase a 19.94 ha industrial zoned parcel of land located immediately to the south and across the highway from the tailings deposits, and contiguous with a 1.7 ha parcel of land purchased by EMN's Czech subsidiary in November 2017. The aggregated land package totals 21.64 ha. The parcel of land is proposed for development of a high-purity manganese processing facility.

## 4.3 Royalties and Liens

An NSR agreement with total aggregate amount of 1.2% is held by the original shareholders of Mangan, which was granted as part of the purchase transaction by EMN for 100% ownership of Mangan. EMN has informed Tetra Tech that Mangan has not granted any other royalties or liens on the CMP.

Income taxes and fees imposed by the Government of Czech Republic on mineral resource projects is not a clearly defined one fit system. The royalty to the Czech government per tonne manganese produced is 2,308 Kč. Discussions between Mangan/EMN and the Government of Czech Republic are ongoing to clarify the payment structure in regard to potential income taxes and fees as foreign investors for the CMP.

**Figure 4-3: Plan Map with Surface Ownership and Preliminary Mining Permit Boundaries**




Notes:

- Preliminary Mining Permit MZP/2018/550/386-Hd shown as a red line around the perimeter of tailings deposit Cells #1, #2 and #3

# 5.0 ACCESSSIBILITY, CLIMATE, LOCAL RESOURCES, INFRASTRUCTURE AND PHYSIOGRAPHY

## 5.1 Climate

The climate in the western Pardubice region of central Czech Republic is seasonally variable and typical of European continental conditions with warm dry summers and cold winters. It is one of the driest and warmest regions in the Czech Republic. Annual average temperatures are around 8°, and total annual precipitation between 700 to 800 mm (Czech Hydrometeorological Institute). The area experiences a net negative precipitation, after factoring in evaporation. Monthly average temperatures vary from -3.1°C in January to 16.6°C in July.

## 5.2 Physiography

The physiography of Chvaletice region is described as flat lying with some rolling hills. The Property lies immediately south of the Labe River (German: Elbe) which is a regional hydrographic drainage merging with the Vltava River north or Prague. The property is within the Upper and Middle Elbe river Basin which is administered by the Elbe River Board under the Ministry of Agriculture.

Forests in the region are classified as boreal. Well-established vegetation growth on the tailings cells is comprised of grasses and small shrubs on the upper plateau, and juvenile to semi-mature birch trees along the side slopes.

The gentle landscape and moderate climate promotes a healthy agricultural industry, with arable lands that produce corn, barley, sugar beet, canola and other crops, which occupy the majority of the rural landscape.

## 5.3 Local Resources

The Chvaletice deposit is located immediately adjacent to both an 820 MW lignite coal-fired power station operated by Severní Energetická a.s., and a pre-cast concrete plant operated by Eurobeton.

A rail line is located immediately to the south of the Property which acts as main transportation line from Prague to communities of Eastern Czech Republic. Spur lines are used to transport and unload coal to the power station, and to service an adjacent industrial park which is the site of the former processing facilities that produced the deposits.

### 5.3.1 Water

Groundwater supplies the agriculture, urban and industrial water requirements in the region. Water resources in the Czech Republic are jointly managed at the national level by the Ministry of Agriculture (policies and regulates services), the Ministry of Environment (regulates wastewater discharge), National Institute of Public Health (controls drinking water quality) and the Ministry of Finance (regulates tariffs), all in conjunction with local municipalities.

Currently, activities being undertaken on the Property have minimal to no water demand.

### 5.3.2 Power

The Czech electrical grid will supply electrical power supply for the CMP. The Chvaletice power station operates an 820 MW lignite coal-fired power station, which is a key node in the Czech electrical grid. The power station provides power to the Czech electrical grid system.

### 5.3.3 Infrastructure

No infrastructure exists on the Property.

### 5.3.4 Community Services

A significant labour workforce is accessible in the nearby communities, including the villages of Chvaletice (population 3,200) and Trnavka (250), as well as the towns and cities of Kutna Hora (21,000), Kolin (31,000), Pardubice (89,000), Hradec Kralove (93,000), and Prague (1,200,000).

Mining supplies, services and technical expertise can be found mainly in Prague and Pardubice.

## 5.4 Property Access

The Property is located along paved Highway #322 which connects to Prague, approximately 89 km by road, via Kolin and Highway #12. The Property is accessed by a short gravel road and locked gate, which is maintained by Severní Energetická,

## 5.5 Topographic Reference

Spatial survey in Czech Republic is conducted using the S-JTSK (Krovak East North) coordinate system and the Bpv, a system designed for the Czech Republic. Czech transformation key has an average positional error of 0.2 m and height error 0.3 m. The CMP is located with midpoint at approximately -670,860 E, -1,057,920 N and 206 masl (S-JTSK), which would have a Universal Transverse Mercator (UTM) (World Geodetic System (WGS)84) equivalent coordinate of approximately 531,840 E, 5543000 N and 250 masl. The S-JTSK (Bpv) system is used as the base coordinate system and datum for the CMP.

Topography for the CMP was provided by GET using the digital elevation model (DEM) 5G model developed by the Land Survey Office in Prague. A map was provided by GET in MicroStation software format (.dgn file type) using the S-JTSK Bpv coordinate system, which included topographic contours extracted from the DEM 5G model to represent the site. After adjustment, the surface generated from the survey has total standard error of 0.18 m of height in the bare terrain and 0.3 m in forested terrain.

# 6.0 HISTORY

Historically, from 1915 to 1945, several small underground mining operations near Chvaletice produced manganese raw ore and concentrates that were principally shipped to German steel mills. Thereafter, from 1951 to 1975, open pit mining and milling operations occurred for the recovery of pyrite to produce sulphuric acid for the chemical plants in nearby Pardubice which produced the three adjacent tailings deposits.

The following recount was extracted from the Bateria Slany report compiled for the Property in 1989. References to Mineral Resources, Reserves or “ore” in this section are historical, have not been directly verified by the QP and cannot be relied upon.

## 6.1 Mining of Iron Ores

The first mention of iron mining at Chvaletice dates to the year 677. The medieval production of iron in the surrounding area can be linked to the origin of the name of Železné hory (Iron Mountains), whose northwestern tip includes the Chvaletice mining district. Mining took place intermittently until the early 17$^{th}$ century. Mining ceased after the Thirty Years' War (1618 to 1648) and resumed at the end of the 18$^{th}$ century.

In the mid-19$^{th}$ century the Česká Montánní Společnost (Böhmische Montangesellschaft) came into the region and was the leading manufacturer of pig iron, the owner of a foundry and rolling mill and the iron mines in the Czech Lands. Zones of iron and manganese deposits at Chvaletice were found to extend over a length of about 12 km and were relatively well explored. In 1885, mining produced about 400 t of iron oxide from iron cap containing 20% each of iron and manganese.

## 6.2 Mining of Manganese Mineralization

Mining was managed by the Pražská železářská společnost (Prager Eisenindustrie-Gesellschaft), which in 1909 took over the mines. Systematic extraction of metal at Chvaletice began in 1915. After mining out the minor gossan occurrences, mining focused on the west side of Chvaletice, where the No. IX underground mine was built. The annual production of manganese ranged between 10,000 and 50,000 t. After World War II, the Pražská železářská společnost was nationalized, and on January 1, 1946, was incorporated into the state enterprise Středočeské uhelné a železnorudné doly (Central Bohemian Coal and Iron Ore Mines). Small-scale, intermittent surface mining of manganese mineralization continued in Chvaletice until 1952.

## 6.3 Mining of Pyrite 1951-1975

From 1951 onwards, pyrite mined by open pit methods at Chvaletice became the basic raw material for the production of sulphuric acid. Pyrite in Czechoslovakia had been imported mainly from Rio Tinto in Spain and Boliden in Sweden, and from Yugoslavia after the war. After the Communist putsch in February 1948, the shipments of pyrite iron raw material from Western European countries stopped. Since heavy chemical industry and other downstream industries would be jeopardized, alternative sources were then obtained from pyrite shales from the Chvaletice deposit. In 1949, the No. IX mine was re-organized into a separate national enterprise called Manganorudné a Kyzové Závody Chvaletice (Manganese and Pyrite Enterprise (MKZ)). In the following year, a new processing plant and housing for employees was built. Its operation was officially launched on the occasion of the anniversary of the so-called Victorious February on February 25, 1951. Exploration work showed that the processing plant was inappropriately located and obstructed the mining of part of the deposit. The concept of underground mining was abandoned, and the mining method changed to open pit mining.

In the years 1958 to 1960 the Czechoslovak chemical industry began to phase-out Chvaletice pyrite for the production of sulphuric acid, preferring imported sulphur from Poland. The economic production of manganese ore could never be achieved, given the low grade of the open pit ore and the metallurgical challenges of producing a concentrate.

In 1975, the production of pyrite concentrate was terminated. The Manganorudné a kyzové závody changed its name to Energostroj and started manufacturing machinery and equipment for the power industry.

During the entire period 1951 to 1975 the open pit reached 2 km long, 700 m wide, and 150 m deep. Over 32 Mt of pyrite was mined and produced 7,467,000 t of concentrate containing 38.3% of sulphur.

The mining lease for Chvaletice was canceled in 1981. The primary deposit is still recorded as having 108,805 kt of potentially economic “Reserves” (according to the current Czech classification) containing 12.86% of total manganese. The residual “Mineral Resource” of pyrite, estimated to be 39,573 kt, with an average of 12.99% sulphur, is not kept in the State's balance sheet.

**Photo 6-1: Photo of Original Chvaletice Iron and Manganese Mine, circa 1978**

**Photo 6-2: Photo of Original Chvaletice Iron and Manganese Mine, circa 1974**

## 6.4 Elektrárna Chvaletice (Power Station)

After the closure of the mine, the plant site was used for the construction of a power plant. The site was chosen to minimize disturbance of agricultural land and to permit storage of fly ash in the mined-out pit area. The construction of the power plant was carried out in the years 1973 to 1979. The power plant provided employment opportunities not only for the former employees of the MKZ, but also expanded the population and 172 housing units were built. The waste heat from the power plant continues to be supplied as steam to Chvaletice, Trnávka and the adjacent industrial areas.

To supply the power plant with thermal coal, the river Labe from Mělník was made navigable and the Chvaletice port was built. Regular shipping of approximately 3.5 Mt of coal from mines in northern Czech Republic took place from 1977 until 1996, when it was completely transferred to rail.

Chvaletice power station has four generating units with a total installed capacity of 820 MW. The power station stack reaches a height of 303 m, and its cooling towers are approximately 120 m high.

**Photo 6-3: Current Power Plant**

Note: The CMP tailings are to the left in the photo and the historical open pit mine is behind the plant (looking southeast).

## 6.5 Use of Tailings Ponds as a Source of Manganese

The flotation waste was deposited into Cell #1 until 1961, then between 1962 and 1970 into Cell #2, and from 1971 until 1975 into Cell #3. The cessation of the production of pyrite concentrate occurred in 1975.

The waste tailings slurry suspension was placed into the ponds so that the coarser tailings accumulated on the edge, the fine sludge accumulated in the central part of the pond, and water was pumped back into the process plant via a decantation system. The tailings deposit has a volume of over 16 $Mm^3$ registered with the State as potentially economic "Reserves" "Chvaletice – tailing ponds No. 1, 2" and "Řečany – tailing pond No. 3" with estimated Mineral Resources of 29,996 kt (Note: Tetra Tech's current estimates, as documented in Section 14.0, indicate the volume of tailings exceeds 17 $Mm^3$).

A geological evaluation and technological investigation of the three tailings ponds took place in the years 1985 to 1989 to confirm that the raw materials were available for the manufacture of electrolytic manganese dioxide (EMD). The client was the former state-owned manufacturer of batteries, Bateria Slany. An extensive evaluation of the tailings material conducted between April 1986 and July 1988 resulted from their investigation including a "reserve calculation". Raw data has not been sourced by EMN; however, reporting has been recovered and translated into English for reference. The work was stopped due to the collapse of the communist regime in 1989.

In September 2014, the Ministry of the Environment issued an exploration license over the area, following a public tender, which entitles the holder to carry out further exploration and to possess the mineral rights. The rights to the territory called Trnávka was obtained by GET who then they transferred the rights to Mangan in 2015. This transaction is described in Section 4.0.

## 6.6 Construction of Tailings Facility

Construction of the tailings facilities is believed to have commenced in 1950. Cell #1 was the first facility to have been constructed. Historical documentation has indicated that the cell's foundation is built from local native soils, which were also excavated and compacted to form the original perimeter starter dam. The dimensions of the starter dam are reported to have a trapezoidal cross-section being approximately 20 m wide at the base, 5 m wide at the top surface, and with overall height of approximately 3 m. This approach is assumed to be the same for construction of Cells #2 and #3. It is also assumed that the dam raises were constructed in an upstream direction using dried and compacted tailings material. Four Sonic drillholes were completed by EMN in the summer of 2017 and 26 mobile percussion holes were completed in the summer of 2018 to test for these historical structures but were not successful in intersecting them.

Perforated decantation towers (approximately 30 m high), (Photo 6–4) were constructed to channel water into a pit at the tailing pond's edge following the sedimentation of the tailings. The tailings were put in place hydraulically. Pipes or gutters transported tailings along the tailing pond perimeter to fill one-half of the pond while the other half dried. Dam lifts were built by bulldozers that scraped dewatered material away from the center of the tailing cells to the edge, after a pond was filled to the brim with tailings.

**Photo 6-4: Historical Decantation Tower Located on Cell #3, Near Drill Holes T3-310, 311 and-318**

The elevation of the Labe River and the base of the tailing ponds are similar, around 202 masl (Bpv datum). The perimeter of Cell #1 (26.6 m depth by 500 m by 500 m) and Cell #2 (28.7 m depth by 700 m by 550 m) are irregularly shaped polygons and measurements are approximate. Waste crusher fines from a granite aggregate quarry located near Chvaletice were used to cap, stabilize and reclaim the surfaces of Cell #1 (averaging 1.32 m depth with topsoil) and Cell #2 (averaging 1.23 m depth with topsoil). Cells 1# and #2 are mostly vegetated with grasses, and their embankments were planted with trees and grasses.

Construction of Cell #3 did not reach full capacity and reclamation was not fully completed; however, stands of young birch and aspen trees are most prevalent on Cell #3. This cell abuts the northern toe of Cell #1 and is covered with approximately 0.2 m of overburden material. An exception is in the southern area of Cell #3 where there is some old municipal waste and partial backfills of tailings from iron and manganese mineral extraction in Chvaletice.

## 6.7 History in Dates

Table 6-1 sets a chronological order of events related to mineral resource extraction near the Chvaletice region.

### Table 6-1: Chronology of Mineral Resource Extraction in the Chvaletice Region

| Year | Activity |
|---|---|
| est. 677 | ▪ According to the legend in the Hájek Chronicle dated 1541, iron was discovered at Chvaletice in 677 |
| 1143 | ▪ The founding of the Sedlec Monastery, which includes the village of Telčice (a part of today's Chvaletice) in addition to other possessions |
| 1393 | ▪ The first written mention of the fortress Chvaletice |
| 1845 | ▪ Start of the railway Prague-Pardubice |
| 1858 | ▪ The Mining Court in Kutná Hora vested to Count Kinsky a mine area at Chvaletice consisting of four mineral claims |
| 1886 | ▪ Česká montánní společnost (Böhmische Montangesellschaft = Bohemian Mining Company) asks for the conferring of the mining areas Karel (Charles) and Nadeje (Hope) |
| 1909 | ▪ Pražská železářská společnost (Prager Eisenindustrie-Gesellschaft = Prague Iron Company) takes over the mines in Chvaletice mining district |
| 1915 | ▪ Ferro manganese mining by Pražská železářská společnost until 1945 |
| 1946 | ▪ Pražská železářská společnost was nationalized and incorporated into n. p. Středočeské uhelné a železnorudné doly (Central Bohemian Coal and Iron Ore Mines) |
| 1949 | ▪ Founded n. p. MKZ |
| 1951 | ▪ The ceremonial opening of the secondary mining school – because underground mining actually never started, the school never served its purpose, and today is a secondary school of agriculture<br>▪ The new MKZ pyrite mining and processing plant started |
| 1952 | ▪ Manganese mining was discontinued |
| 1973 | ▪ The new Power Plant Chvaletice construction began |
| 1975 | ▪ Pyrite mining ended and the reorganization of the MKZ to Energostroj Chvaletice |
| 1977 | ▪ Start of transport of thermal coal on the Elbe water way<br>▪ Start of trial operations at Chvaletice power plant |
| 1979 | ▪ Full operations at Chvaletice power plant |

*table continues…*



TETRA TECH

| Year | Activity |
|---|---|
| 1981 | ▪ Chvaletice obtained Town status<br>▪ Chvaletice mining lease expired |
| 1989 | ▪ The end of three years of studies by Bateria Slany |
| 1996 | ▪ All transport of coal to the power plant was switched to rail |
| 2013 | ▪ The state-controlled power company České Energetické Závody (CEZ) sells Chvaletice power plant to Severní Energetická Společnost for 4.12 billion crowns |
| 2014 | ▪ GET granted the exploration license Trnávka for the exploration survey of manganese deposit in the tailing ponds Nos. 1 to 3 |
| 2015 | ▪ License transferred to Mangan<br>▪ EMN initiates preliminary studies of the CMP, whose goal is to recycle the Chvaletice tailings to produce EMM |
| 2016 | ▪ EMN acquires Mangan |
| 2018 | ▪ EMN lists on Toronto Venture Exchange and Australian Stock Exchange<br>▪ Preliminary MRE is published<br>▪ EMN is issued a Preliminary Mining Permit |

# 7.0 GEOLOGICAL SETTING AND MINERALIZATION

The following discussion is included to provide context of the geological setting of the original bedrock material that was mined and processed to form the tailings material that is the subject of this report. Due to grinding and flotation processes, none of the original textures that would have characterized the in situ rocks will have been preserved in the tailings material.

Mineralogy, specific to the tailings material, is discussed in Section 7.2.

## 7.1 Regional Geology

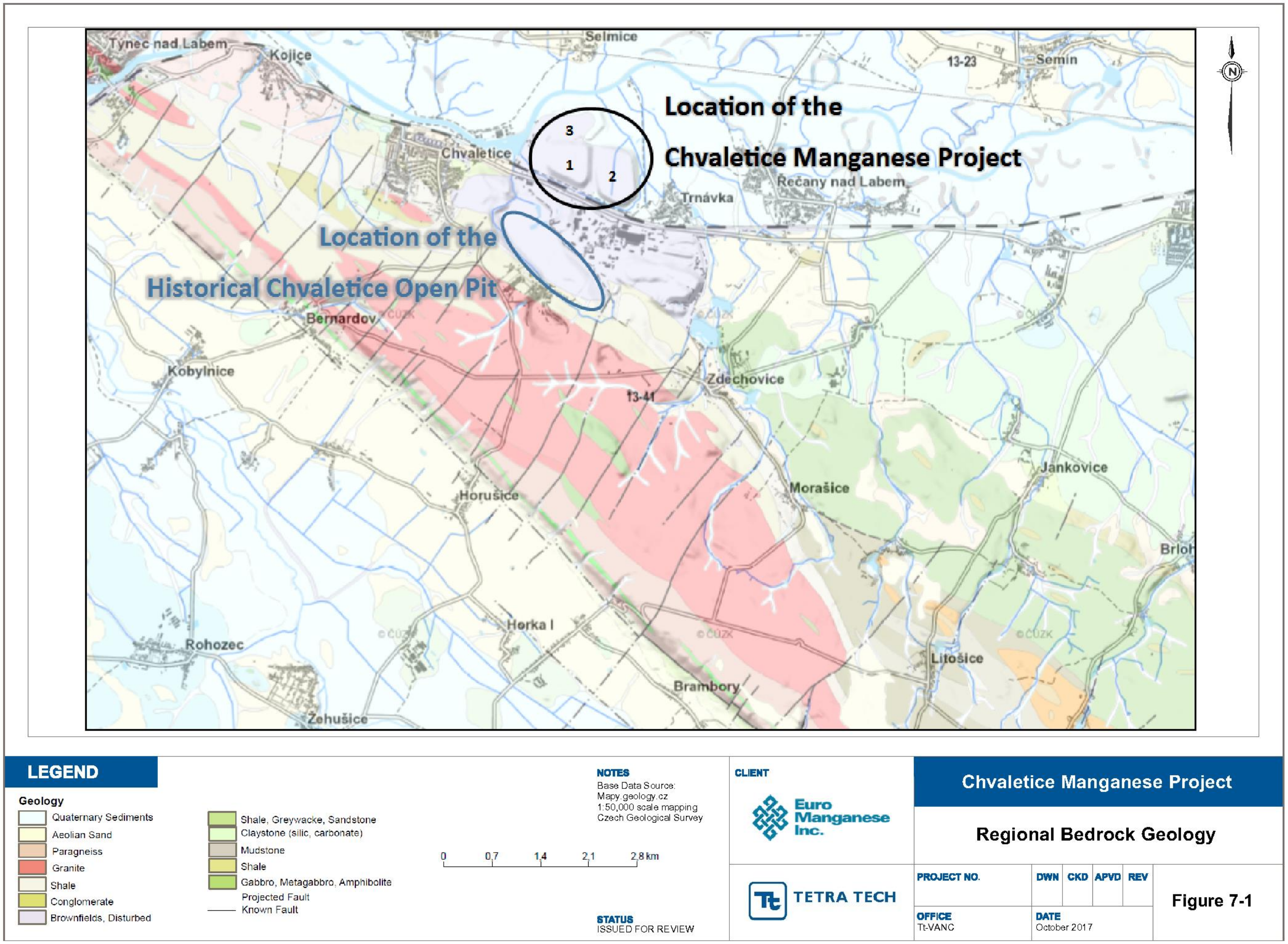
The original Chvaletice bedrock deposit is situated to the south of the CMP by approximately 1 km. Fly ash and other waste products have been used to backfill the original open pit which obscures the majority of exposed bedrock. Here, the bedrock is Proterozoic in age and is comprised of deformed granitic crystalline and overlain meta-sedimentary rocks of the Bohemian Massif, in the marginal area of the Central Bohemian Region.

In the Proterozoic, basement rocks were overlain by the seafloor turbidite sequence off from the continent of Gondwana. Here, the thick layers of fine sediments were deposited in deeper areas of the sea, periodically redeposited by huge subaquatic slumps. At the same time, subaquatic volcanic activity was taking place, associated with extrusions of lavas and assent of hot geothermal fluids. These fluids enriched the host rocks with sulphur, iron and manganese.

At the end of the Proterozoic, rearrangement of lithospheric plates resulted from the Cadomian Orogeny, with related deformation and development of deep tectonic fracture zones. Magma and hydrothermal fluid ascent through fractures thermally affected the ambient rock domains forming weak to moderately metamorphosed phyllitic shales and greywackes. Intense folding and faulting of the sediments was developed during the orogeny as shown in the historical cross section schematic in Figure 7-1. The meta-sedimentary rocks were cut by dykes and sills which are preserved along the northeastern slopes of Zelezne Hory (Iron Mountains) between Týnec nad Labem, Chvaletice and Zdechovice. Locally, a lens-shaped body locally called the Chvaletice Massif is composed of this Proterozoic granite and underlies the area south of Chvaletice and Zdechovice. The granite contains brittle deformation zones, altered to a variable degree. The rock is extracted in two quarries and is utilized as aggregate.

Other pyritic and manganiferous mineralized bodies are aligned along a trend that extends from the western edge of the municipality of Chvaletice to the nearby village of Sovolusky forming a 12 km long belt. In the western part, it creates a synclinorium, while towards the east it has developed into irregular zones that are intruded with porphyries. The maximum thickness of the pyritic schist in the western part is about 90 m, while the minimum is approximately 30 m, thereby with an overall average of thickness of some 60 m.

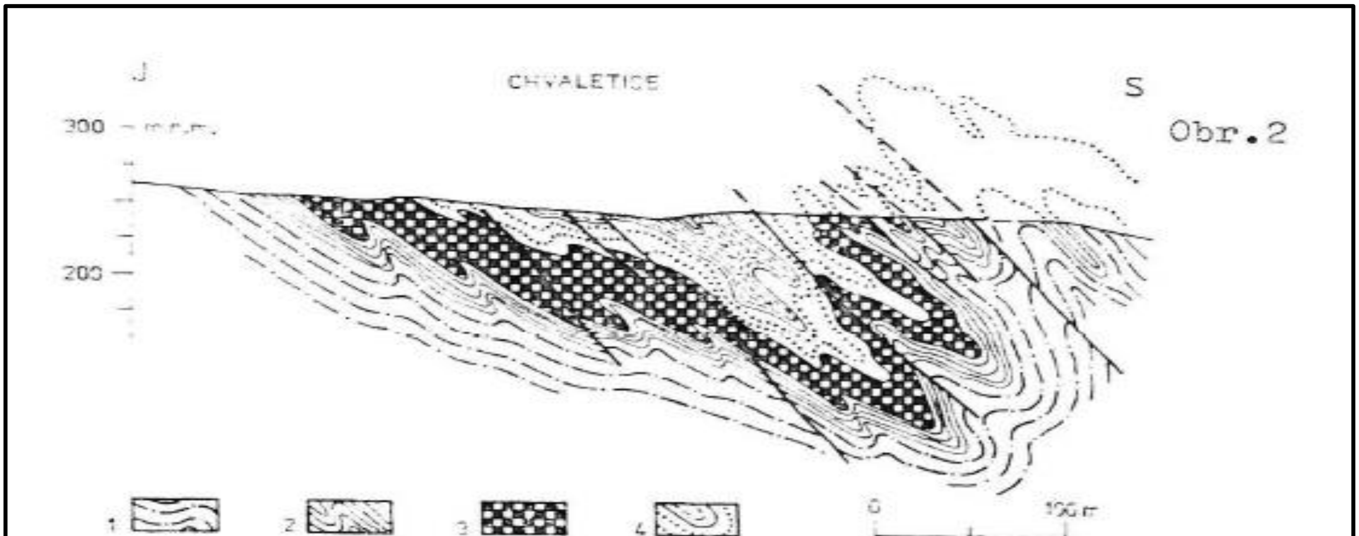
**Figure 7-1: Regional Bedrock Geology**



The syngenetic Chvaletice deposit of pyrite-manganese mineralization is hosted by the intensely southwesterly directed folded and moderately metamorphosed Neoproterozoic sediments located to the north of the southeasterly trending contact with granite. To the northeast, the sediments are overlain by younger Palaeozoic and Cretaceous strata.

Terrestrial fresh-water to marine claystones, siltstones, sandstones, and conglomerates of the Upper Cretaceous immediately underlie the CMP tailings deposits.

**Figure 7-2: A Simplified Schematic of the Geological Section of Pyrite-Manganese Ores in Chvaletice**




66. Schematický řez ložiskem pyrito-manganových rud Chvaletice (upraveno podle M. Mikuše 1960)
1 — podložní břidlice; 2 — podložní kyzové břidlice; 3 — pyrito-manganová ruda; 4 — nadložní kyzové břidlice a sericitické břidlice

Notes: The 1) underlying schist; 2) underlying pyrite schist; 3) pyrite-manganese "ore" (black hatch pattern); and 4) overlying pyrite schist and sericite schist.

Source: Mikuš (1960)

## 7.2 Local Geology

The Chvaletice bedrock deposits of iron and manganese mineralization constitutes one horizon in the meta-sedimentary stratigraphy with variable proportions of carbonate and silicate minerals occurring laterally from west to east. Through mineral processing during historical mining operations, these minerals have been reduced in size and partially blended by grinding and flotation processes.

Through depositionary processes, these mineral particles were distributed throughout the tailings facilities by sedimentation from suspension in a tailings slurry. Thin beds of sediment will have been deposited laterally with a gradation from coarse to fine particles away from the point of deposition. It is then interpreted that grain size and moisture content may have more similarity with materials in a vertical sense and have more variability in a lateral sense. Whereas, mineral and grade distribution, being related more to the process rather than deposition, is interpreted to have more similarity with materials in a lateral sense and less direct similarity with materials in a vertical sense. However, as discussed in Section 13.0, a relationship exists between elevated manganese grade with coarser particle size.

Met-Solve completed x-ray diffraction (XRD) and scanning electron microscopy (SEM)-energy dispersive x-ray spectroscopy (EDS) analyses on behalf of EMN in 2015 using the samples collected from test pits in 2015. The analysis identified the main manganese bearing minerals were rhodochrosite ($MnCO_3$), and kutnohorite ($Ca(Mn^{2+}$, Mg, $Fe^{2+})(CO_3)_2$) which forms a series with dolomite and ankerite. These were classified as the principle manganese (Mn)-carbonate minerals. Additionally, the presence of trace quantities of manganese-silicates such as sursassite (a manganese bearing sorosilicate), and oxides such as pyrolusite (a manganese dioxide ($MnO_2$) and kurchatovite (calcium-magnesium-manganese-iron borate (Ca(Mg, Mn, $Fe^{2+)}B_2O_5$) were identified. Pyrite was noted to be the primary form of sulphide mineral, with concentrations in the samples between 5 to 9%. Gangue mineralogy consists of primarily quartz with moderate amounts of plagioclase, feldspars, micas, and apatite. Low concentrations (less than 5%) of kaolinite clay mineral was identified

Further mineralogy work conducted on a bulk sample by CRIMM on behalf of EMN in 2017, concluded that manganese occurs with variable proportions of iron, calcium, and magnesium with carbonate to form a wide variety of manganese bearing carbonates from the rhodochrosite-siderite-dolomite-calcite spectrum. The work concluded that 80% of the manganese occurred as carbonate and 19% of the manganese occurred as silicate. High concentrations of iron and phosphorus were identified in the gangue minerals which were contained predominantly in pyrite and apatite, respectively.

Whole rock lithogeochemical analysis conducted on Sonic drill samples collected during the 2017 program measured total sulphur concentration in the tailings with an average of approximately 3.1% which is sourced form sulphide, sulphate and organic origin. Total carbon concentrations averages approximately 3.4%, which includes contributions from graphite, organic and carbonate origin.

# 8.0 DEPOSIT TYPES

On the world scale, the most important manganese minerals are oxides, including pyrolusite, a manganese (IV) oxide. Other economically important manganese ores usually show a close relationship to the iron ores. Land-based resources are large but irregularly distributed. About 80% of the known world manganese resources are in South Africa, with other important manganese deposits found in Ukraine, Australia, India, China, Gabon and Brazil. Deposits in China are known to be numerous, with low manganese content, but generally are relatively small.

On a purely descriptive basis, manganese ores can be classed as sediment-hosted, volcanic-hosted, or karst-hosted. Chemical distinctions among these types include:

- much higher silicon dioxide ($SiO_2$) in volcanic rock-hosted deposits, which likely reflects a more oceanic setting with important contributions from pelagic radiolaria and diatoms
- higher phosphorus pentoxide ($P_2O_5$) in sediment-hosted deposits, which may be related to upwelling
- strong enrichment of barium (Ba) and lead (Pb) in karstic deposits, enabled by the open tunnels in the structure of cryptomelane-group minerals.

The mineralization found in tailings at the CMP has been deposited by manmade processes following grinding and flotation processes of black pyritic shale and is therefore not characteristic of a traditional manganese deposits. The material can be physically characterized as a compacted soil, with varying degrees of particle sizes from clay to coarse sand.

There is sorting of the flotation waste by grain size and weight, resulting from the sedimentation from the edge to the center of the tailings deposit (based on other tailing pond borehole sludge studies (Novotny et al. 1972). Subsequently, three zones of grain sizes in the tailing pond can result with:

- An outer zone of fine-grained sand and silty sand
- A central zone of alternating sandy laminae with the outer and inner zone types, and
- An inner zone comprised of silt to slightly clayey silt (finest material of all zones).

This zoning is typical for slurry tailings and results from sedimentation of deposited slurries; from fluctuation of water levels during decantation operations (removal of water) within the central zone, and a gentle slope (1.5%) leaving little to no water in the outer zone (Bateria Slany, Chapter 2 1989).

# 9.0 EXPLORATION

EMN has been conducting exploration and investigation on the Property since 2014, during which time multiple investigations have been conducted to sample and characterize the chemical and physical subsurface conditions of the tailings materials and surrounding ground. A summary of exploration work by year is included in the following subsections, and as shown in Figure 13-1.

## 9.1 Hand Auger Sampling, 2014

Four shallow (2.0 to 2.5 m) hand auger drillings were collected for assay and grain size testwork from the periphery of the tailings deposits on November 7, 2014. The samples were identified as T1 to T4.

Results of the program indicated that total and soluble manganese assay results were comparable to those results reported historically by Bateria Slany (1989), but the sampling was considered to be indicative and not representative of the entire deposit with respect to grade and particle size distribution (AMEC 2016) due to the shallow auger holes testing only near surface material.

## 9.2 Test Pit Sampling, 2015

In 2015, two test pitting programs were conducted using an excavator to collect samples at greater depth, and with more volume than the previous hand auger program. Four pits, identified as T5 to T8, were dug down between 1.8 and 3.1 m deep at the periphery of the cells on November 11, 2015, and three additional pits, identified as T9 to T11, were dug to between 2.5 and 3.8 m deep at the center of each of the cells on December 14, 2015.

Again, results of the program indicated that total and soluble manganese assay results were comparable to those results reported historically by Bateria Slany (1989). With deeper sampling, the small particle size of the tailings in the center of the tailings was identified to be a potential issue for dewatering and further work was recommend (AMEC 2016).

## 9.3 AMEC Foster Wheeler Scoping Study, 2016

With results from the 2014 and 2015 sampling programs, a process evaluation report was completed by AMEC in September 2016, which considered a potential flowsheet for processing of the tailings with production of high purity, selenium-free EMM. The results of the study were positive and were used to develop a strength-weakness-opportunities-threats (SWOT) analysis. A list of detailed recommendations was presented for further material characterization and metallurgical testwork to de-risk and refine the processing flowsheet.

## 9.4 Seismic and Resistivity Geophysical Survey, 2017

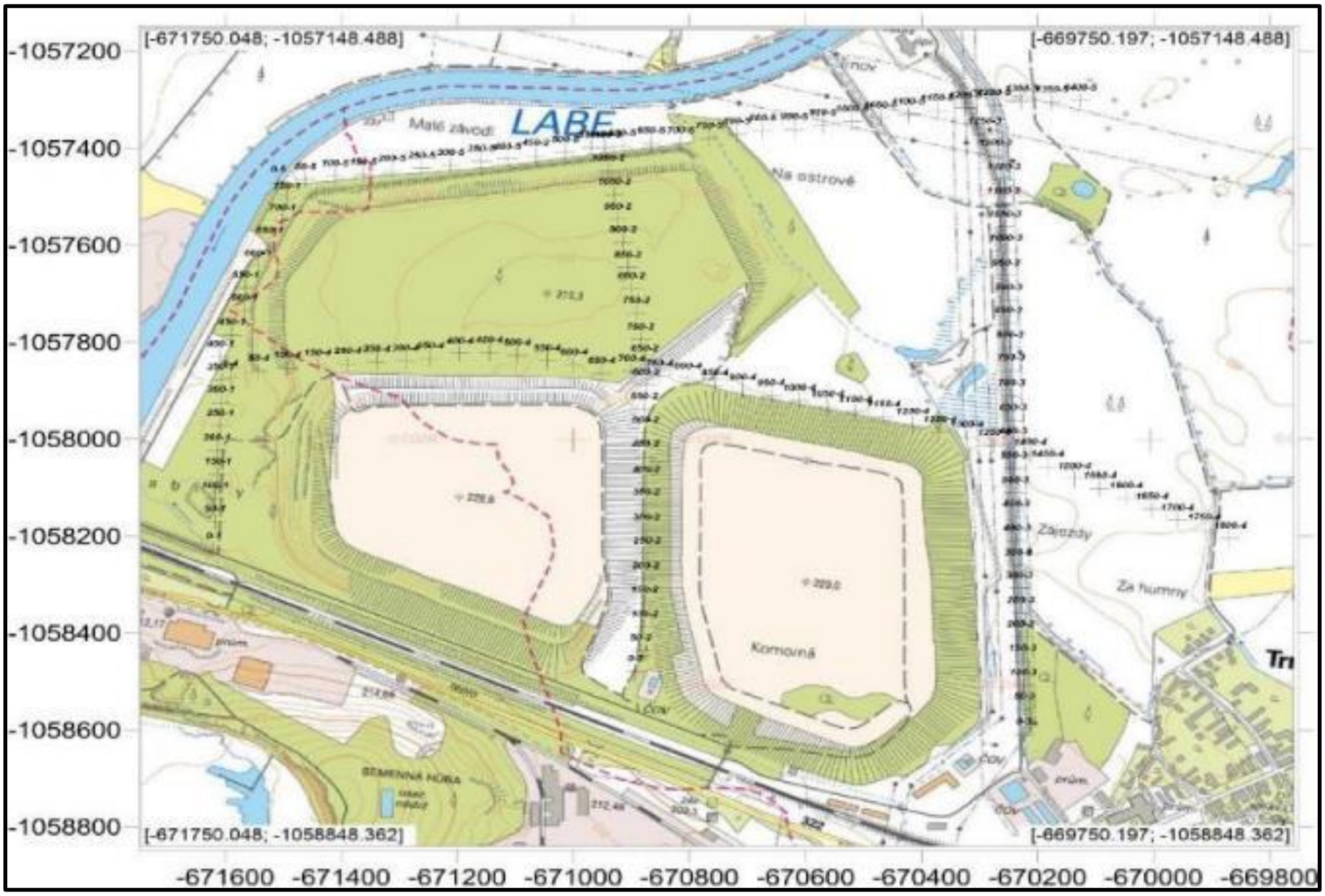
In July of 2017, EMN commissioned a geophysical survey over the tailings. A total of 6.6 km lines of high-resolution electric resistivity tomography (ERT) and seismic refraction was conducted by GImpuls Praha spol. s.r.o.

The purpose of the survey was to enhance the geological knowledge of the area with response from sub-horizontal geological components underlying the surface and to evaluate structures down to a maximum depth of the first tens of metres.

Initial results from ERT measurements show mostly very low resistivity with a maximum of 10 Ωm. According to typical geological ERT results, this may indicate the presence of electrically conductive clay in the rocks (in this case, sandstones with conductive glauconite).

Alternatively, or additionally, the lower measured resistivity values can be attributed to a massive presence of groundwater in the rocks, which, combined with the presence of the chemical infusions from the tailings, could cause low resistivity values. This theory is supported by the results of the seismic refraction that detected bedrock at depths of roughly 5 to 10 m with velocities of approximately 2,000 to 3,000 m/s.

**Figure 9-1: Plan Map of Geophysical Survey Lines and Measurement Stations**




## 9.5 Bulk Sample, 2017

A highly-representative bulk sample weighing approximately fifteen tonnes was collected using a Sonic drill rig from tailings materials during the 2017 drilling investigation. The material was the 75% split of the core samples collected, as discussed in Section 11. The samples were packed individually in plastic sample bags and steel barrels and shipped via rail to the CRIMM laboratory in China. Further description of the bulk sample analyses is discussed in Section 13.0.



TETRA TECH

## 9.6 Bulk Sample, 2018

A second bulk sample was collected from half core splits of the Sonic drilling program. The samples were clearly labelled and are currently securely stored in vacuum packed and sealed plastic bags to preserve original moisture content and prevent sample deterioration. The sample bags have been placed into storage in 55 gal sealed steel drums for future testwork.

## 9.7 Seismic and Downhole Geophysical Survey, 2018

As part of a preliminary geotechnical investigation (cone penetration testing (CPT) investigation described in Section 10.0), shallow refraction seismic (SRS) and vertical seismic profiling (VSP) was conducted on July 13, 2018, on behalf of Mangan by SIHAYA, spol. s.r.o., a geophysical company based in Brno, Czech Republic, specializing in engineering geology and hydrogeology. The survey was conducted from an array of geophones to determine homogeneity and relative density (compactness) and dampness of soils, and the depth and condition of the first 10 m of original soils and bedrock subbase underlying the tailings (SRS survey), and from within three boreholes drilled within the tailings (G 3-7 in Cell #3, GB 1-5 in Cell #1, and GB 2-6 in Cell #2) to determine the to determine S-wave and P-wave velocities of the various soil types within the tailings (VSP survey). The survey resulted in generation of interpreted geology-geophysical section profiles and tabulated measurements and confirmed the presence of native soils comprised of fluvial sands which underlie the tailings deposit.

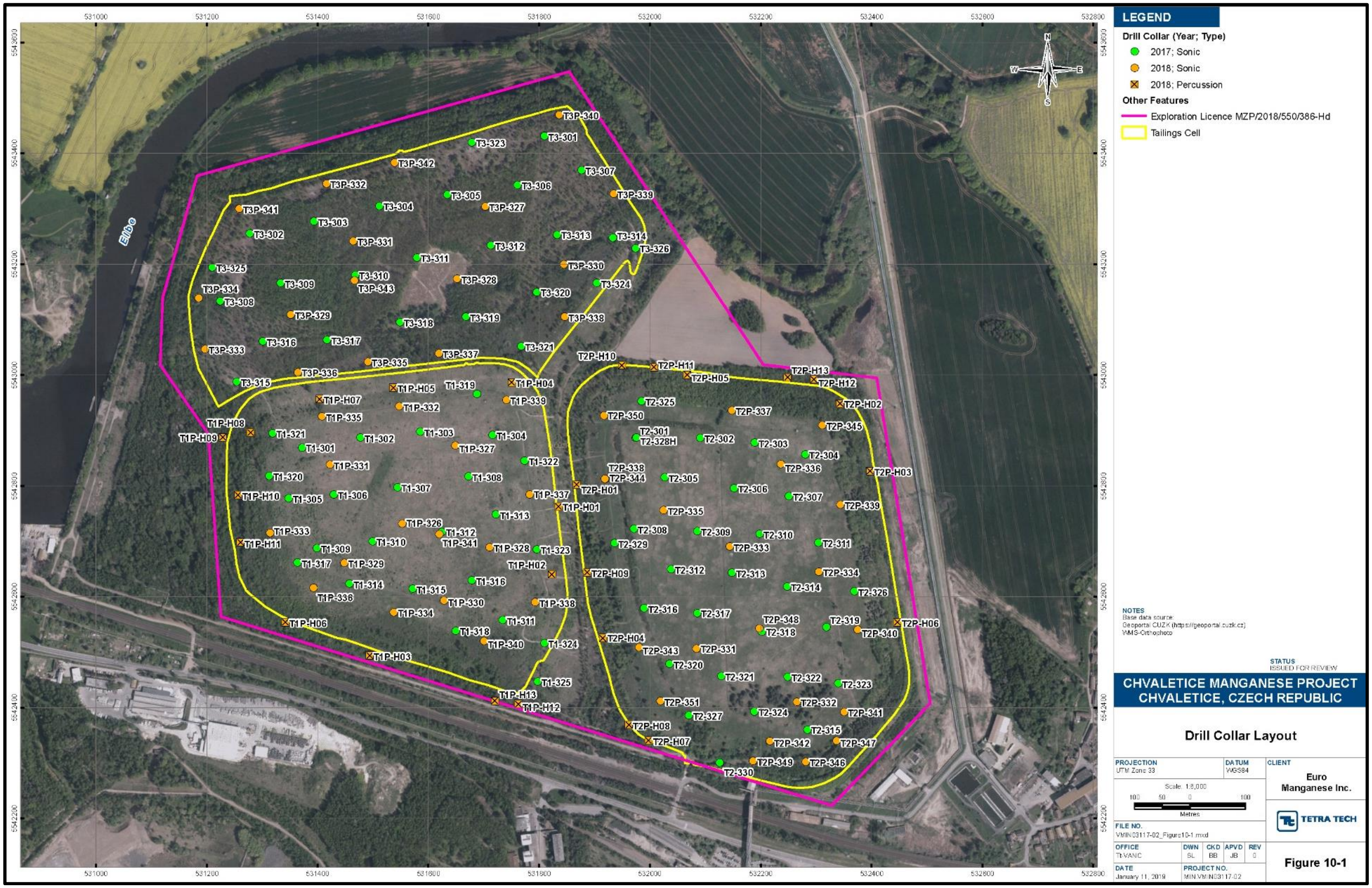
# 10.0 DRILLING

Table 10-1 lists the drilling completed to date by EMN on the CMP by year, cell, and drilling method. A description of the 2017 and 2018 drilling programs follow in Sections 10.1 and 10.2, respectively. Figure 10-1 shows a plan view of the drill collars.

### Table 10-1: CMP Resource Drilling Completed by EMN, Listed by Cell, Year, and Type

| Cell and Year | Drill Type | Number of Holes | Total Metres | Number of Samples |
|---|---|---|---|---|
| **Cell #1** | | | | |
| 2017 | Eijkelkamp SonicSampDrill CRS-V | 25 | 629 | 291 |
| 2018 | Makita HM1317C Mobile Percussion | 13 | 589 | 285 |
| | Eijkelkamp SonicSampDrill SRS | 16 | | |
| **Total** | | **54** | **1,218** | **576** |
| **Cell #2** | | | | |
| 2017 | Eijkelkamp SonicSampDrill CRS-V | 30 | 755.3 | 346 |
| 2018 | Makita HM1317C Mobile Percussion | 13 | 728 | 344 |
| | Eijkelkamp SonicSampDrill SRS | 21 | | |
| **Total** | | **64** | **1,483.3** | **690** |
| **Cell #3** | | | | |
| 2017 | Eijkelkamp SonicSampDrill CRS-V | 25 | 295 | 119 |
| 2018 | Eijkelkamp SonicSampDrill SRS | 17 | 192.5 | 101 |
| **Total** | | **42** | **487.5** | **220** |
| **Grand Total** | | **160** | **3,188.8** | **1,486** |

**Figure 10-1: Plan View of Drill Collar Layout, 80 Holes Totaling 1,679.3 m at Chvaletice Manganese Project**



## 10.1 2017 Drilling

The 2017 drilling and sampling program was carried out between June 12, 2017 and July 19, 2017 utilizing advanced sonic rig technology provided by Eijkelkamp SonicSampDrill B.V. and crews from Giesbeek, the Netherlands (Photo 10-1). The program was supervised in the field by Chris Baldys, P.Geo. (BC), a non-independent QP at the time of the investigation.

A total of 1,679.3 m was drilled in 80 holes, using 100 mm diameter size rods and sonic core barrel advance (Figure 10-1). Twenty-five holes totaling 629 m were completed on Cell #1, 30 holes totaling 755.3 m were completed on Cell #2 and 25 holes totaling 295 m was completed on Cell #3. All holes were drilled vertically; no downhole surveying was completed. Figure 10-1 shows the drillhole layout. Drillholes were spaced evenly at approximately 100 m centers throughout the upper bench of each cell, encompassing a combined area of 1.2 km by 1.2 km (Figure 10-1).

Coring progressed using 2 m core runs. No casing was installed, and drill rods were pulled for each core run. Minor caving and pooling of water is assumed to have occurred on re-entry; however, this material accumulated in the hollow core rods above the core barrel and is believed to have had minimal effect on the integrity of the recovered sample. This material was dumped on surface adjacent the borehole and has been collected by Mangan for future evaluation if required.

Access to the embankment slopes around the perimeter of the tailings was limited due to safety and not included in this investigation. To verify the composition of the embankments, four additional drillholes (DrillholesT1-324, T1-325, T2-330 and T3-326) were collared on access ramps. Each hole intersected a layer of topsoil with average thickness of approximately 1 m, manganese bearing tailings material, and terminated in native basal soils at an elevation consistent with surrounding drillholes. Based on these drill results, the presence of manganiferous tailings material was confirmed within the perimeter embankment and based on the elevation of the basal soil contact, the historical starter dyke was not identified at these locations.

## 10.2 2018 Drilling

A total of 80 holes were drilled in 2018, totalling 1,509.5 m. The 2018 program included completion of 54 Sonic holes, totalling 1,409.5 m, from the top of each cell, and an additional 26 mobile percussion drillholes, totalling 100 m, from the perimeter embankments of each cell in areas which were not previously accessed for sampling. The 2018 drilling and sampling program was carried out between July 10 to August 29, 2018. The program was supervised in the field by Tomas Pechar Jr., Ph.D. (Mining), Project Implementation Manager for Mangan.

### 10.2.1 Sonic Drilling

Sonic boring utilized advanced sonic rig technology provided by Eijkelkamp SonicSampDrill B.V. and crews from Giesbeek, the Netherlands (Photo 10-1). The purpose of the program was to increase the confidence in the distribution and concentrations of tailings geochemistry and physical properties for the purposes of Mineral Resource estimation and ultimately mine planning. This was achieved by conducting infill drilling between holes completed in 2017, and by completion of several holes within the perimeter embankments in areas not sampled during the 2017 program.

**Photo 10-1: Showing Eiikelamp SonicSampDrill B.V. and Drill Crew**

The Sonic program was divided as 35 vertical (660.5 m) and 19 inclined (749 m) holes using 100 mm diameter size rods and sonic core barrel advance (Photo 10-2) with the remote operated Eijkelkamp SonicSampDrill SRS. Twenty-nine holes totaling 589 m were completed on Cell #1, 34 holes totaling 728 m were completed on Cell #2 and 17 holes totaling 192.5 m were completed on Cell #3. Vertical infill holes were placed at mid-points between three existing holes, resulting in new short-range sample spacing of between 50 and 75 m. The inclined holes were drilled at 45° into the outer perimeter of Cells #1 and #2 to collect samples from the benched perimeter embankment. No downhole surveying was completed for the 2018 program; all holes were assumed to be straight given their short length.

Coring progressed using 2 m core runs. No casing was installed, and drill rods were pulled for each core run. Minor caving and pooling of water is assumed to have occurred on re-entry; however, this material accumulated in the hollow core rods above the core barrel and is believed to have had minimal effect on the integrity of the recovered sample. This material was dumped on surface adjacent the borehole and has been collected by Mangan for future evaluation if required. Any lost core was recorded in the field logs with recovery of zero percent; a total of 6.5 m was logged in 2018 as lost core.

**Photo 10-2: Eijkelkamp SonicSampDrill SRS Used for 2018 Sonic Drilling Investigation**

### 10.2.2 Hand Portable Percussion Drilling

A hand portable percussion drill was used to collect samples within the lower benched portions of the perimeter embankment, where mature tree and vegetation growth prevented access by the Sonic rig. The drill rotor was powered by a generator powered Makita HM1317C drill which used a 3-inch hollow core tube configuration for core recovery (Photo 10-3 and Photo 10-4). The drill barrel was manually advanced and recovered by two operators employed by Mangan.

The percussion drilling program included 26 vertical holes, totalling 100 m, spaced at approximately 2 to 3 holes per side of Cells #1 and #2. The program was developed for sampling of the outer perimeter of the embankment in areas not accessed by drilling during the 2017 program to confirm the presence of manganiferous tailings and provide control on the elevation of the original ground elevation. The percussion holes ranged in depth from 1 m to 6 m.

**Photo 10-3: Drilling of Perimeter Embankment Hole using Hand Portage Percussion Drill**

**Photo 10-4: Oxidized Tailings Recovered by Percussion Drill on North Perimeter Embankment Cell #2**

### 10.2.3 Cone Penetration Testing Geotechnical Drilling

Geotechnical investigations using CPT and downhole seismic geophysical testing (geophysics described in Section 9.0) were undertaken in 2018 to characterize existing geotechnical conditions and provide information in support of preliminary economic assessment (PEA)-level mine planning and conceptual design for the CMP. CPT holes were targeted across all three cells to assess the expected variation in material properties from the perimeter (coarser-grained tailings) to the interior (finer-grained tailings, likely softer/wetter layers) of the cells. The program was conducted between December 4, 2017 and January 15, 2018 using a Geoterend Gouda Truck Mounted Geotechnical rig (on Liaz truck) with 200 kN pushing capacity. The program employed continuous CPT drilling in 24 holes totaling 554 m, and collected measurements for tip resistance, sleeve friction, pore water pressure, soil density (by gamma-gamma log), natural radiation (gamma), hydrogen index and soil humidity (neutron neutron log), electric conductivity (dielectric log) to evaluate soil type and physical compaction characteristics. Table 10-2 summarizes the CPT drilling program.

**Table 10-2: Summary of 2018 Geotechnical CPT Boreholes**

| Cell | Number of CPT Holes | Total CPT Length Drilled (m) |
|---|---|---|
| #1 | 8 | 224.3 |
| #2 | 6 | 162.9 |
| #3 | 10 | 126.8 |
| Original Soils* | 4 | 35.5 |
| **Total** | **28** | **549.5** |

Notes: *Testing in original soils was conducted using a Begeman's type mechanical cone.

### 10.2.4 Hydrogeological Drilling

A hydrogeological investigation was conducted at the CMP between December 5 and 13, 2018. Drilling was completed by Intermarket Company using a SOILMEC 65 piloting rig. Eight new hydrogeological boreholes were drilled. Drilled material was logged by the geologist present on site during drilling and samples were collected into plastic buckets after every 3 m for chemical analyzes. A total of 47 samples were collected. In addition, 10 samples were collected for the Institute of Geological Sciences of Masaryk University in Brno for the purpose of specimen processing for models of water element spreading. Table 10-3 summarizes the hydrogeological drilling.

The hydrogeological study of the tailings piles was undertaken to contribute to the monitoring of changes in flow and chemistry of tailing's water over time, the determination of sorption of tailing's material and quaternary collectors, the determination of hydraulic characteristics (storativity, transmissivity, filtration coefficient) in the body of the tailings piles and of the surrounding area, assessment of the infiltration effect of the water from tailings piles to the surrounding quaternary collector, and for assessment of the dynamics and chemical changes of the groundwater water coming in and out of the bodies of tailings piles. The resulting data will be used to create a complex transport and geochemical model using the Modflow mathematical modeling code (GMS software). The collected data will be needed in the case of legislative procedures (EIA, risk analysis) as part of permitting process.

Water testing is being performed on boreholes CHV1, CHV9, CHV10 and CHV13. Hydrodynamic tests and sampling of groundwater from new boreholes will follow in the near future.

**Table 10-3: Summary of 2018 Hydrogeological Boreholes and Groundwater Depth**

| Borehole | Cell | Ø Borehole (mm) | Ø Borehole Equipment (mm) | Depth from Ground (m) | Depth from Top of Casing (m) | Casing Stick-up (m) | Groundwater Depth from Top of Casing (m) |
|---|---|---|---|---|---|---|---|
| CHV6 | II | 600 | 110 | 26.7 | 27.72 | ±1.00 | 27.23 |
| CHV7 | II | 600 | 110 | 26.7 | 27.83 | ±1.00 | - |
| CHV8 | II | 600 | 110 | 21.9 | 22.60 | ±0.70 | 12.83 |
| CHV9 | I | 600 | 110 | 25.8 | 26.95 | ±0.95 | 21.56 |
| CHV10 | I | 600 | 110 | 26.5 | 27.34 | ±0.95 | 21.55 |
| CHV11 | III | 600 | 110 | 11.5 | 12.72 | ±1.00 | - |
| CHV12 | III | 600 | 110 | 11.5 | 12.62 | ±0.86 | - |
| CHV13 | III | 600 | 110 | 11.5 | 12.28 | ±0.85 | 12.20 |

# 11.0 SAMPLE PREPARATION, ANALYSIS AND SECURITY

The sample preparation and analysis program described in this section was developed by EMN for the 2017 drilling campaign, with input from Tetra Tech, and implemented in the field by technical personnel employed by EMN. The program was designed to evaluate chemical and physical characteristics of the tailings material for the purposes of mineralogy; Mineral Resource estimation; and hydrogeological, geotechnical, metallurgical, and process engineering. The protocols established in 2017 were also used during the 2018 campaign for consistency.

Samples were analyzed and tested for manganese and elemental assay, lithogeochemistry, particle size distribution, mass, moisture content, paste pH and electrical conductivity (EC) and specific gravity. Wet and dry in situ bulk density was calculated based on core recovery measured in the field, along with the sample mass and moisture data measured at the lab.

The program is summarized in the following bullet points and details of the analysis are included in the subsequent sections.

- Seven hundred and fifty-five (755) core samples were recovered in 2017, and 730 in 2018, totaling 1,484 samples which were recorded for analyses and material characterization (these exclude field duplicates and other quality assurance (QA)/quality control (QC) samples).
- One hundred and eight (108) control samples were generated in 2017 and 101 in 2018 by EMN to monitor commercial lab performances.
- Seventy-nine (79) laboratory duplicates (21 in 2017, and 58 in 2018) were generated by the primary lab (SGS) for review and analysis.
- Wet sample mass, recovery, and geological data were logged at the drill sites by a qualified team of geologists. Moisture percentage and magnetic susceptibility were measured in 2017.
- Photographs of each core sample were taken for additional reference.
- Shipment to analytical labs was done in accordance with chain of custody.
- Analysis for multi-element assay with aqua regia and 4-acid digestion (inductively coupled plasma (ICP) and AAS) and fusion-XRF.
- Particle size distribution testwork with laser diffraction, and sieve/hydrometer.
- Wet and dry mass, and moisture measurements were collected in field and lab (used for bulk density calculation).
- Specific gravity by pycnometer measured in the laboratory.

The primary lab selected for sample analysis was SGS with facilities in Lakefield, Canada, and Bor, Serbia. The lab, formerly Société Générale de Surveillance, is a multinational company headquartered in Geneva, Switzerland which provides inspection, verification, testing and certification services.

Comparative particle size analysis by sieve and hydrometer methods was completed (only for 2017 investigation) at GEOtest, a.s. located in Brno, Czech Republic.

The 2018 drilling programs are summarized in Figure 11-1 and Figure 11-2, which shows the field and laboratory sampling and analysis flowsheet. Photo 11-1 and Photo 11-2 show core recovered from holes T1-318 and T-312 representing unsaturated materials near the edge of the deposits and saturated materials near the core of the tailings deposits, respectively.

**Figure 11-1: Sample Collection and Subsampling Flowsheet Developed by EMN for 2018 Drill Investigation**

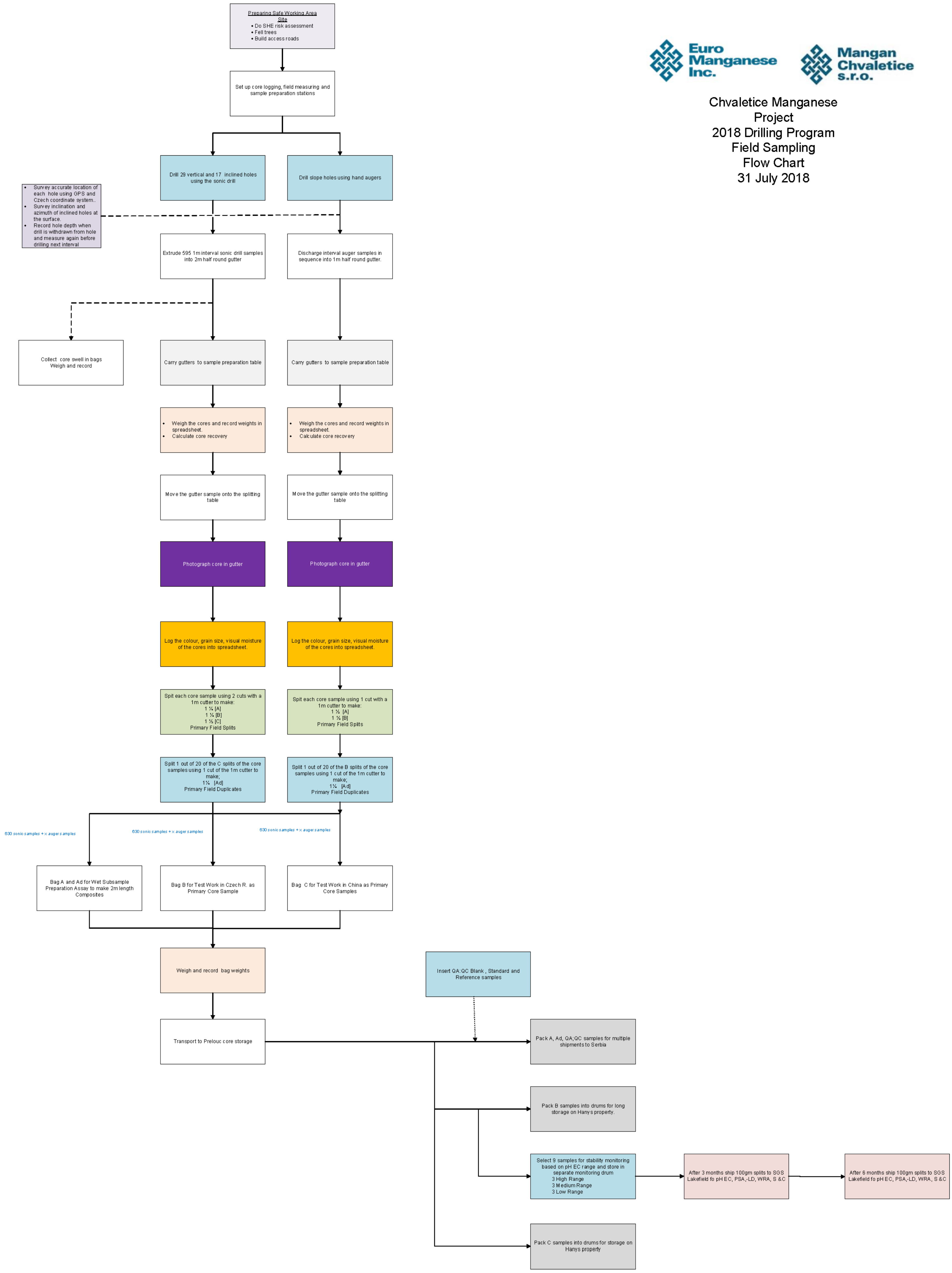


**Figure 11-2: Subsample A Handling and Analysis Flowsheet Developed by EMN for 2018 Drill Investigation**

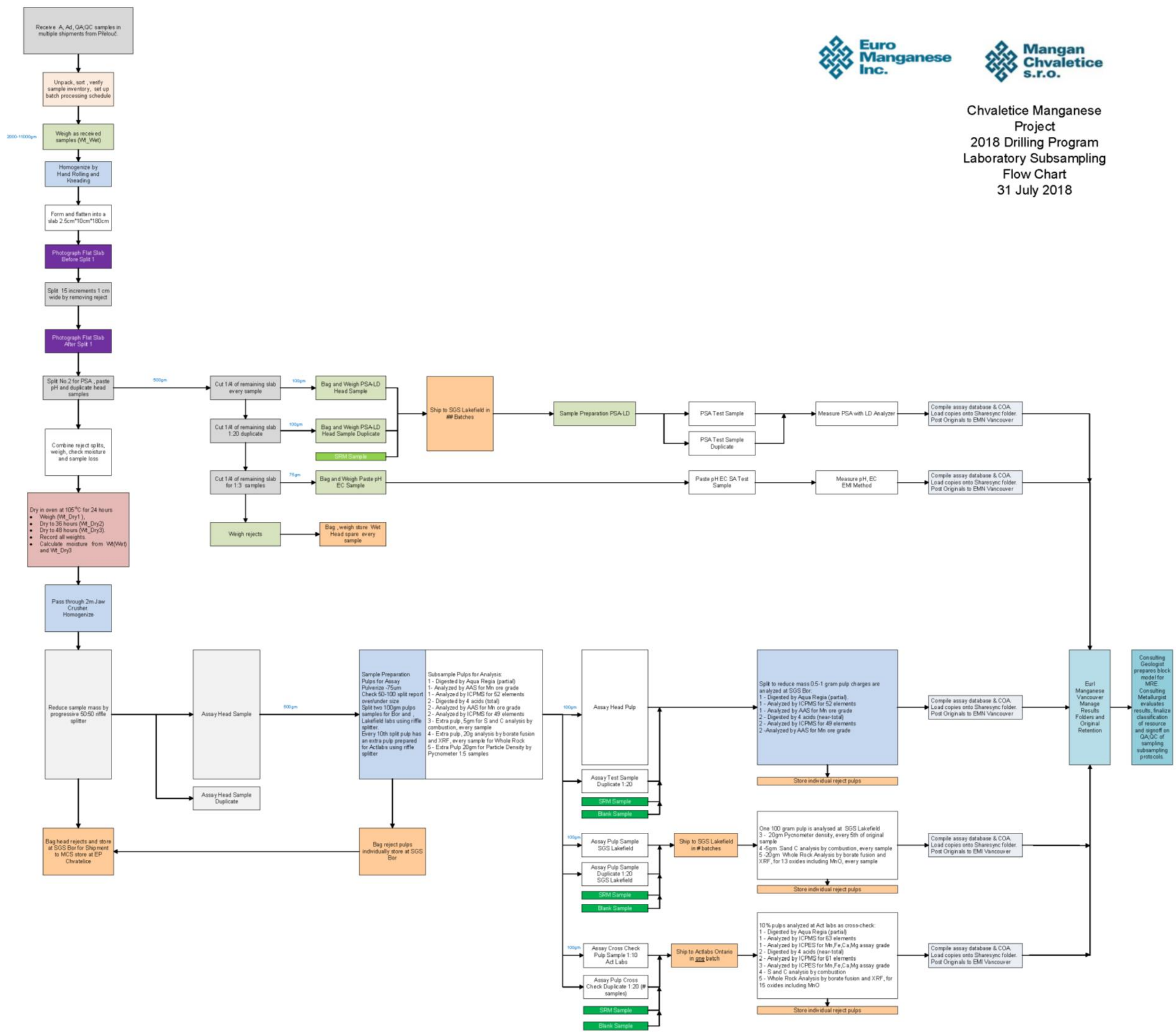


**Photo 11-1: Core Photos from Drill Hole T1-318, from Depths 1-2 m, 19-20 m and 24-25 m**

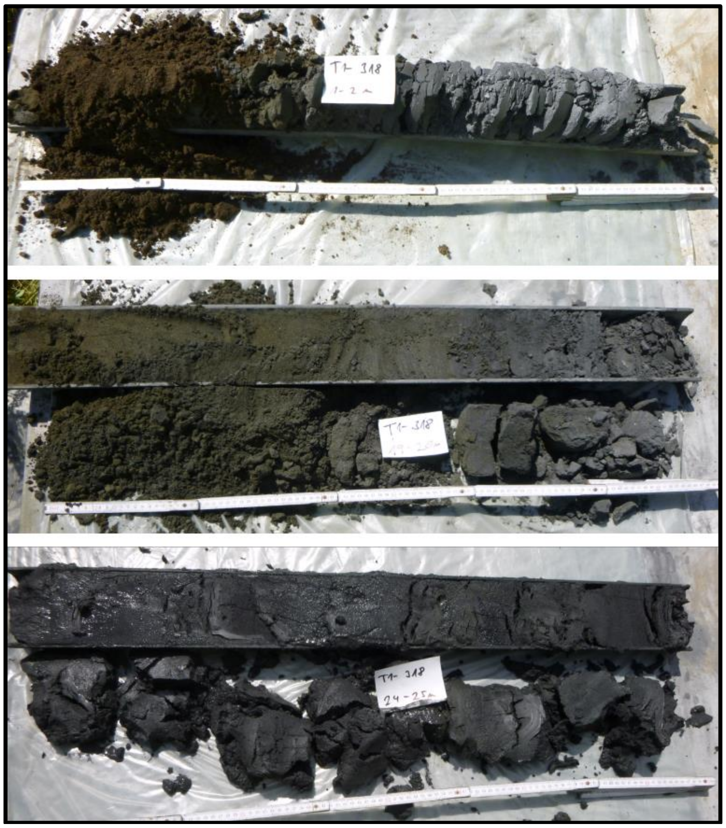
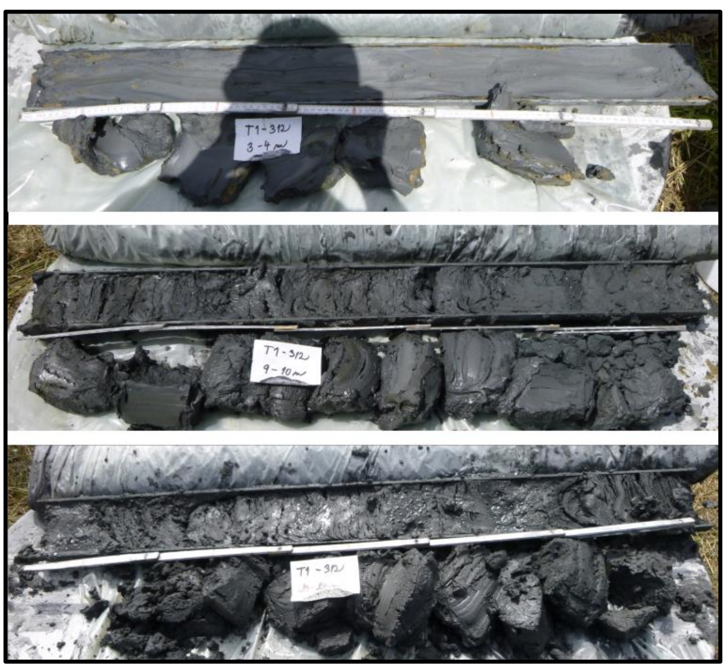



**Photo 11-2: Core Photos from Drill Hole T1-312, from Depths 3-4 m, 9-10 m and 23-25 m**



## 11.1 Sample Collection

Cores samples were collected continuously from the lower topsoil contact to the base of the tailings material at the subsoil contact. Sampling included only tailings material and excluded the upper topsoil and lower subsoil materials. A total of 755 samples with a combined wet weight of 23,521 kg were collected, representing 1,497.8 m in 2017, and a total of 730 samples with a combined total weight of 13,373 kg representing 1,398.7 m of cross stratigraphy tailings material.

The drilling was advanced on 2 m core runs. The core was extracted from the core tube in 1 m intervals into half cylinder core trays. These sub-samples were logged geologically, and field measurements were collected. Field measurements included sample wet mass, recovery, moisture and magnetic susceptibility. Core logs and field measurements were recorded on-site and later merged into a digital database.

Core recovery was measured on one metre sub-samples and ranged from 45 to 110%. Some loss of material was encountered during flushing of drill pipes and likewise some elongation of core resulted due to plasticity if the material at certain locations in the deposit.

Each 1 m sub-sample was then quarter split (25:75) using a cutter along the length of the core axis (Photo 11-3) to preserve the in situ material distribution; the samples were not homogenized in the field. The 25% split was bagged and recombined with the corresponding quarter split from the other remaining one metre core run sub-sample. The 75% split was also bagged and recombined with the corresponding 75% core run sub-sample. Identification tags were included with each sample before the bags were sealed.

**Photo 11-3: Sample Collection**


Notes: A) 1 m core run sub-sample
B) and C) half and quarter splitting or core in field
D) sealed sample bags (bulk samples)

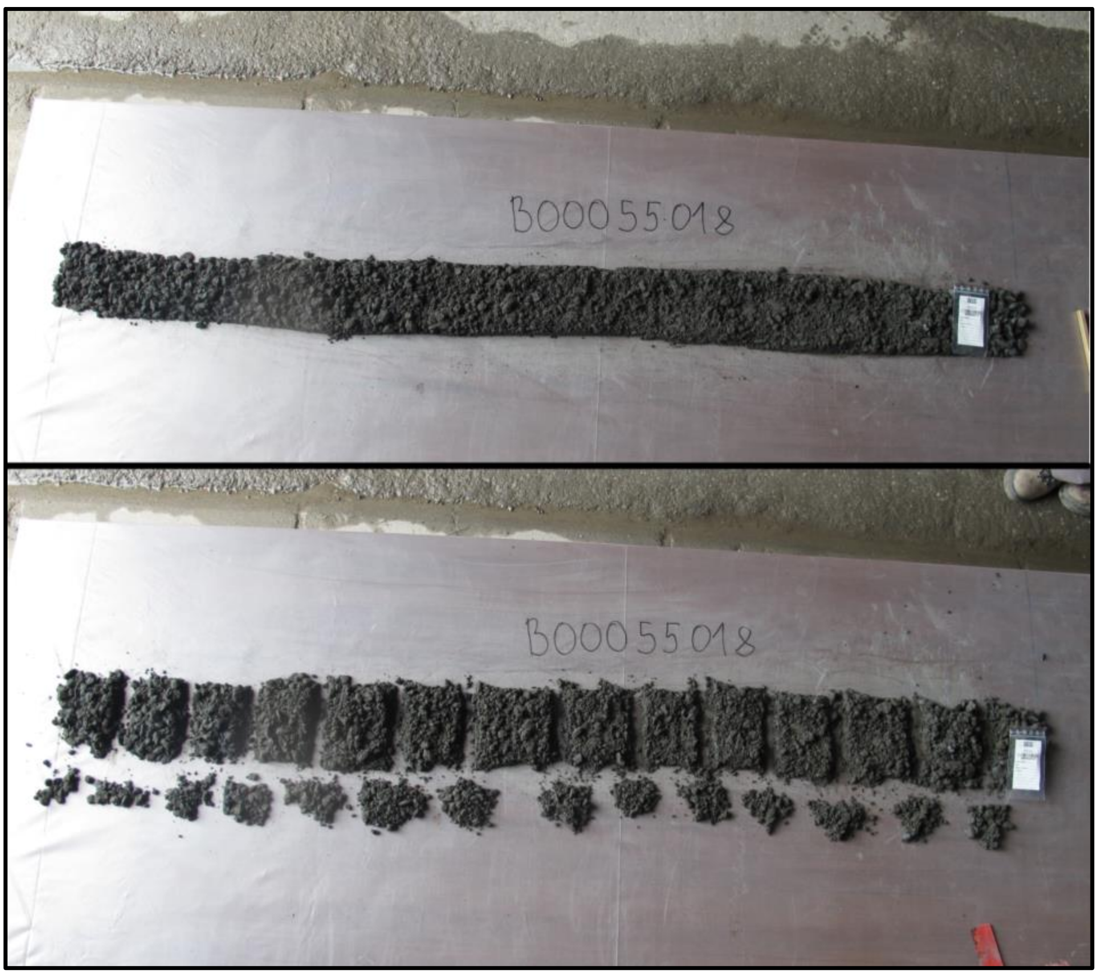
The 25% split samples were assembled for assay and particle size analysis ("assay samples"). The samples were delivered to SGS located in Bor, Serbia, in two shipments, then divided into 19 analytical batches at the lab (7 and 12 batches per shipment respectively). The samples remained in custody of EMN personnel until being delivered by a commercial logistic company to SGS.

In 2017, the remaining 75% sub-sample was shipped to CRIMM in China, for bulk sample metallurgical and processing testwork, respectively. In 2018, the remaining sample was split again with a 25% subsample collected for testwork in Czech Republic, and the remaining half core collected for metallurgical testwork in China. These samples were collected at a field warehouse which is managed by Geomin in Jihlava, inventoried, placed into sealed steel drums strapped to pallets which loaded into a 40 ft shipping container.

## 11.2 Laboratory Preparation and Sample Splitting

Assay samples received at SGS Bor were weighed (wet) and homogenized by hand using the "Japanese slab cake method" of kneading and rolling the sample. The homogenized sample was rolled out into a slab approximately 10 cm by 180 cm and 2.5 cm thick, as shown in Photo 11-4.

**Photo 11-4: Example of Sample Splitting by the Wet Japanese Slab Cake Homogenization Method**



A first split was achieved by forming fifteen smaller slabs from the original sample volume by cutting and removing the reject from around the perimeter of the slabs.

A quarter of each of the small slabs was cut from one to make about 100 g of head sample. This split was not dried and was sent for laser diffraction particle size analysis (PSA-LD) at SGS in Lakefield, Canada. In 2017, one out of twenty (1:20) samples were sent as duplicates to GEOtest (Brno, Czech Republic) for comparative hydrometer particle-size analysis (PSA-H); hydrometer tests were not completed as part of the 2018 test program. Approximately 75 g of materials as extracted for pH and EC measurement using a paste pH method.

The remaining slab material was dried at 105°C and homogenized using standard lab methods.

The wet cut method was selected to preserve the in situ state of the particles for PSA-LD. The total mass of material extracted from the PSA-LD, PSA-H, paste pH and EC splits was approximately 500 g.

Duplicate splits which are master head assay duplicates were again taken 1:20 for heterogeneity/sampling error monitoring. These are identified as “lab duplicates” in the QA/QC assessment in Section 11.9.3.

All reject materials from the PSA splits were recombined, weighed and dried. Moisture content of the sample was determined from the moisture loss measured at this stage of preparation. The sample was again homogenized and approximately 1 kg of material was extracted for assaying. These samples were pulverized to -75 µm.

The remaining head rejects were bagged, inventoried and shipped for storage at the Geomin field warehouse in Jihlava.

## 11.3 Trace Element Assay

A total of 1,694 (863 in 2017 and 831 in 2018, including QA/QC samples) assay samples, averaging approximately four and a half kilograms each (except for 50 g certified reference standards), were delivered to SGS in Bor, Serbia, for assay. The samples were submitted for the analyses listed in Table 11-1. The assay methods were selected to measure total elemental concentration in addition to measuring partial digestion concentrations of manganese as a proxy for “soluble manganese”. Total manganese refers to the results of the 4-acid digestion methods, and soluble manganese refers to the results of the aqua regia digestion.

A sample assay exceeding 10,000 ppm manganese, which is the upper detection limit of the ICP-MS equipment and were submitted for ore grade analysis using AAS. A sample split was digested in four acids (hydrochloric acid, nitric acid, hydrofluoric acid, and perchloric acid) for a near total digestion of the sample and a second split was digested in a weaker aqua regia solvent for partial digestion and as proxy for the “soluble manganese” mineral phases contained in the sample.

**Table 11-1: Tabulated Description of Analytical Methods used for Assay of Tailings Sample**

| Digestion | Finish | SGS Method | Description |
|---|---|---|---|
| Aqua Regia | ICP-MS or AAS | IMS14B, AAS15Q | 52 trace elements, includes analysis for “soluble” manganese |
| 4-acid | ICP-MS or AAS | IMS40B, AAS42S | 49 trace elements |
| Borate Fusion | XRF | GO_XRF76V | Total digestion lithogeochemistry; major cation oxides, includes analysis for “total” manganese |
| Combustion | LECO or SC632 | GE_CSA06V | Inorganic carbon and sulphur assay |

## 11.4 Particle Size Analysis

Particle size distribution throughout the deposit varies significantly due to the processed nature of tailings slurry material and the dynamics during deposition and particle settlement. Grain size may significantly influence the manganese recovery process that is developed for the CMP. As regrinding of the tailings is not envisaged, understanding of particle size distribution is considered a critical variable for the deposit.

The primary method for particle size distribution analysis was by laser diffraction technology (PSA-LD) in a Malvern Mastersizer located at SGS in Lakefield, Canada (SGS method ME-LR-MIN-MET-SC-A03) using wet material. This equipment is able to analyze particle sizes from 0.02 to 2,000 µm, which is ideal for very fine materials such as silt and clays. A total of 830 PSA-LD results were received, which included 720 primary tailings samples. An additional 76 sample duplicates were submitted by EMN, 5 sample duplicates prepared internally by SGS, and 31 internal QC standards.

Particle size distribution analysis was also conducted through sieve and hydrometer methods, using the European standard International Organization for Standardization (ISO) TS 17892-4, at GEOtest located in Brno, Czech Republic. The method includes passing dried material through standard screens, with the smallest screen size at 0.063 mm. Fractions passing this screen are classified as silt and clay and subjected to hydrometer testing. A total of 93 samples were submitted for hydrometer tests.

Grain sizing used for the CMP incorporates both North American standard ASTM International (ASTM) D-422 and the European standard ISO14688-1/-2.

## 11.5 Lithogeochemistry

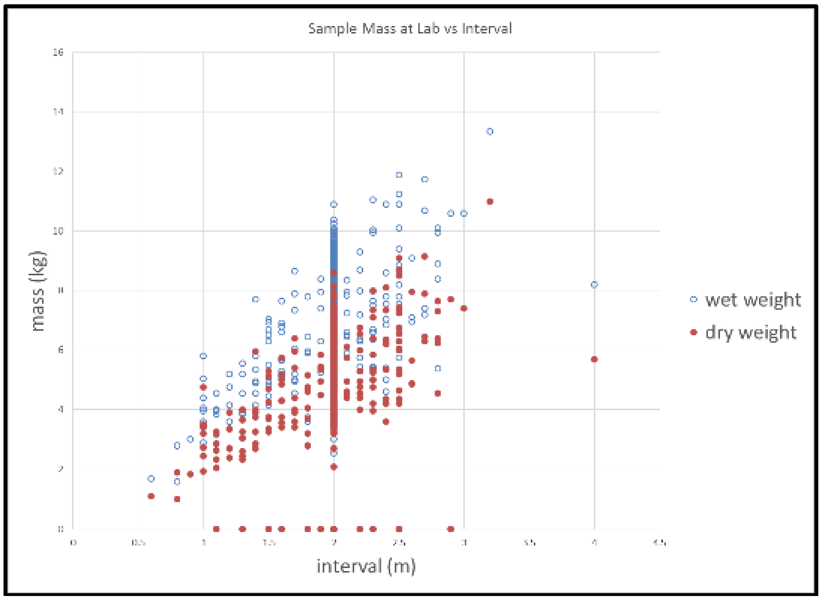
Lithogeochemistry was conducted at SGS in Lakefield using lithium borate fusion with XRF detection of 12 major oxides including manganese (II) oxide. A total of 1,448 (714 in 2017 and 734 in 2018, excluding QA/QC samples) samples were submitted for analysis.

Total inorganic carbon and inorganic sulphur were analyzed at SGS Lakefield using LECO furnace (combustion and infrared detection).

## 11.6 Moisture and Mass

Mass was measured in the field as wet mass on one metre core run sub-samples, and also as wet and dry mass at the SGS laboratory in Bor in Serbia on the 25% split samples which represented the full 2 m core run sample size. Figure 11-3 depicts the relationship between wet and dry mass measured at SGS in Bor with the total represented sample interval length.

**Figure 11-3: Wet and Dry Mass Measured at SGS Bor vs. Sample Interval**




Approximate moisture content was measured in the field during the 2017 drilling program using a Delta-T MT3 soil moisture sensor (Photo 11-5), and at SGS in Bor from the assay samples that were received. The field moisture measurement approximated values ranged from 4 to 33%, with average value of 17.9%. Comparatively, laboratory moisture was calculated from the mass lost after wet samples were dried with values ranging from 5.6 to 27.4%, with average value of 17.4%. This procedure was not implemented during the 2018 field program.

**Photo 11-5: Collection of Moisture and Magnetic Susceptibility Data in the Field**

## 11.7 Specific Gravity

Specific gravity analysis was conducted at SGS Bor on splits from the assay sample using method ME-LR-MIN-MET-DS-A01. The pycnometer tests results are directly proportional to the individual densities of the mineral grains in the sample and can be used in estimating the in situ porosity of the tailings materials. The pycnometer specific gravity results ranged from 2.90 to 3.28 with average value of 3.05.

## 11.8 Bulk Density

Calculation of in situ dry bulk density was based on core recovery estimated in the field and the dry mass weights measured at SGS Bor. Further description of in situ bulk density calculation is included in Section 14.5.6.

## 11.9 2017 Sampling and Laboratory Analysis QAQC Program

A systematic QA/QC program was designed in connection with the 2017 drill-sampling and analytical work. The program consisted of the following:

- Insertion of control samples (certified reference materials (CRMs), duplicates, and blanks) into the analytical sample stream to monitor the performance of the labs, representing 15.7% of overall analytical results
- Review of internal QC data generated by the labs
- Re-analysis or repeat of the testwork on batches and samples that fail the QC criteria
- Independent quality assurance assessment completed by Tetra Tech.

A total of 755 samples were shipped to SGS for elemental analysis. This included 695 assays, 3 CRMs (33 analyses), 35 blanks, and 41 field duplicates. The laboratory included 21 additional lab duplicates. This resulted in a total of 884 assay results reported to EMN.

### 11.9.1 Certified Reference Materials

Three CRMs were inserted in sequence with the samples that were shipped to SGS in Bor. The name of the samples was recorded on the sample tag and was delivered to the lab as a blind sample with composition unknown to the lab. CRM insertions assess the accuracy of the analysis being performed and are intended to be present at a rate of at least one CRM per sample batch. Batch sizes at SGS included approximately 45 samples per batch, including field and laboratory QC sample insertions.

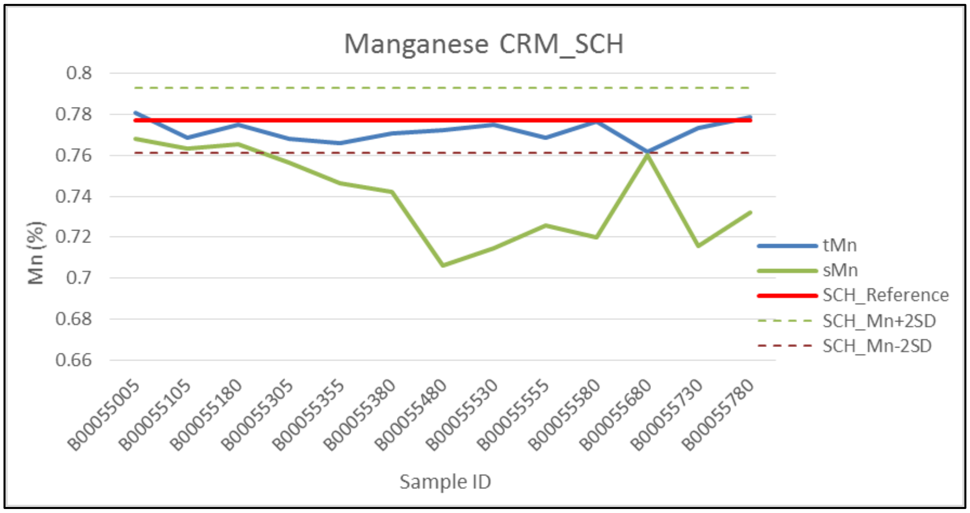
Three reference materials were selected by EMN at the onset of the program to be used as standards: as described in the following sub-sections.

#### 11.9.1.1 Certified Reference Material – NRC-SCH-1

The NRC-SCH-1 reference was supplied by the National Research Council of Canada CANMET and was prepared from iron ore as hematite with various hydrous oxides of iron from the Schefferville Mine in Quebec, Canada. The expected mean manganese grade is 0.777% with 95% confidence interval of 0.008% manganese.

This sample accounted for thirteen analyses. Figure 11-4 shows the performance of the standard, where total manganese grade falls within the confidence interval of ±2 standard deviations. Soluble manganese values fall below the confidence interval, as expected, with somewhat variable correlation to the total manganese values.

**Figure 11-4: CRM_SCH-1 Performance Plot for Total and Soluble Manganese**

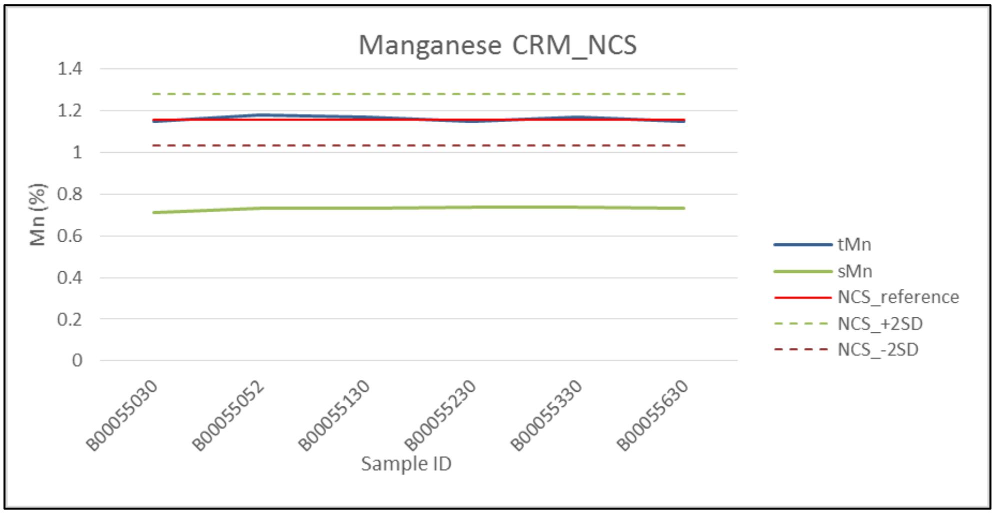



#### 11.9.1.2 Certified Reference Material – NCS-DC-70007

The NCS-DC-70007 reference was supplied by China National Analysis Center for Iron and Steel. The source material is not disclosed in the material datasheet. The expected mean manganese (II) oxide grade of 1.49% (1.154% manganese) and standard deviation of 0.08% manganese (II) oxide (0.062% manganese).

This sample accounted for seven analyses. Figure 11-5 shows the performance of the standard, where total manganese grade falls within the confidence interval of ±2 standard deviations. Soluble manganese values fall below the confidence interval, as expected, with good correlation to the total manganese values.

**Figure 11-5: CRM_NCS Performance Plot for Total and Soluble Manganese**

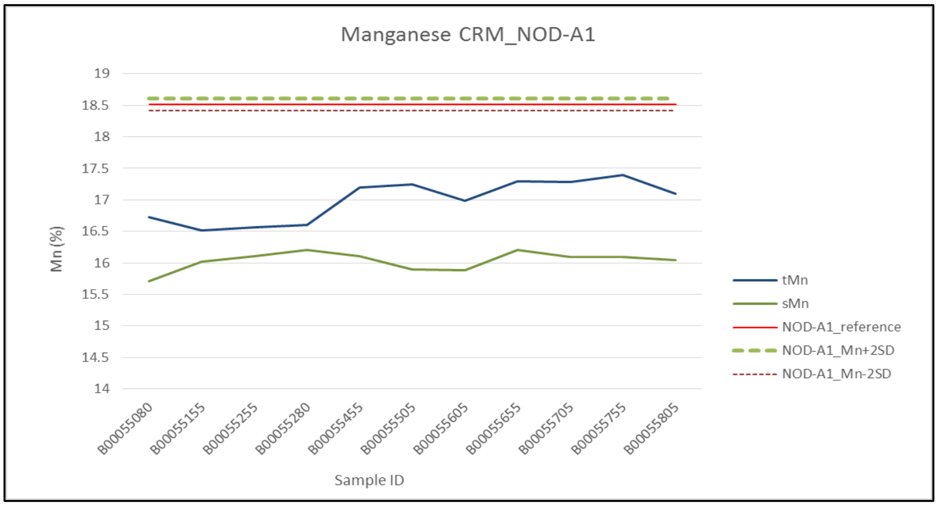


#### 11.9.1.3 Certified Reference Material – NOD-A1

The NOD-A1 reference was supplied by the United States Geological Survey and was prepared from Atlantic Ocean seamount manganifeous nodules from the Blake Plateau. The expected mean manganese (II) oxide grade is 23.9% (18.51% manganese) with standard deviation of 0.065%.

This sample accounted for eleven analyses. Figure 11-6 shows the performance of the standard, where total manganese grade falls below the confidence interval of standard deviations and soluble manganese values falls further below with good correlation to the total values. This performance failure has been identified by others (Cullen et al. 2013) whereby it was concluded that “the primary meta-borate fusion and ME-ICP06 analytical package did not provide sufficient extraction of manganese and iron to match reference material results that were based on XRF analysis”. This CRM is not believed to be a suitable reference standard for control of exploration data as the results of this control measure are considered highly susceptible to analytical method. The materials do not assess, with validity, the digestion and equipment calibration used in this program’s analysis.

**Figure 11-6: CRM_NOD-A1 Performance Plot for Total and Soluble Manganese**




### 11.9.2 Blank Analyses

#### 11.9.2.1 Certified Blank – ST08

The ST-08 Certified Blank was supplied by Sklopísek Strelec, Czech Republic, as a high purity silica sand with low impurity concentration. The standard was manufactured for grain size distribution analysis and reports an expected manganese concentration; however, this is expected to be negligible.

This sample accounted for twenty-three analyses. Figure 11-7 and Figure 11-8 show the performance of the blank for iron and manganese concentrations. One sample failure (B00055034) was observed for manganese with a concentration of 0.77%. The remaining concentrations were below 150 ppm. This ambient concentration may be due to residual manganese within the grinding equipment, but it was determined to be insignificant. Overall sample failure is less than 5% which is interpreted by the QP as acceptable.

**Figure 11-7: Certified Blank – ST08 – Iron**

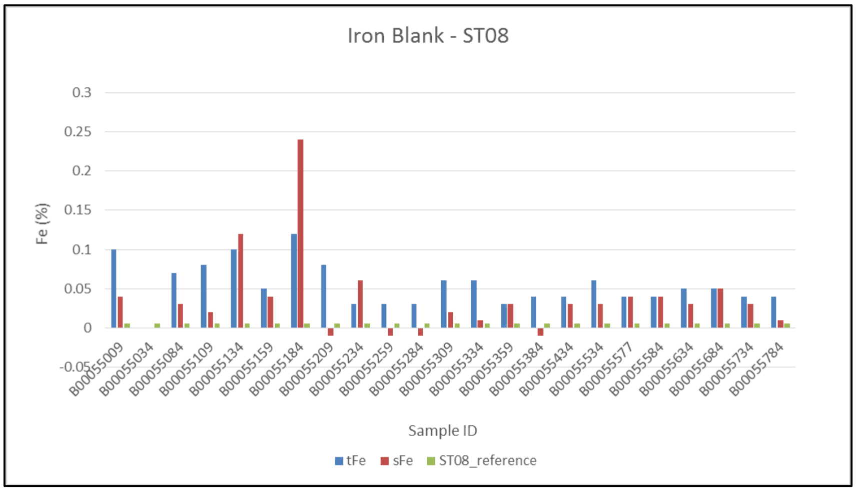
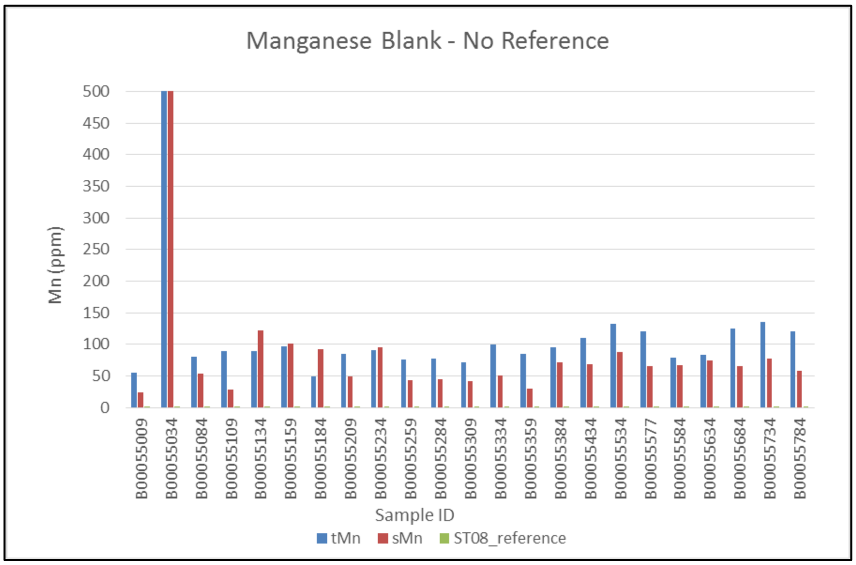



**Figure 11-8: Certified Blank – ST08 – Manganese**

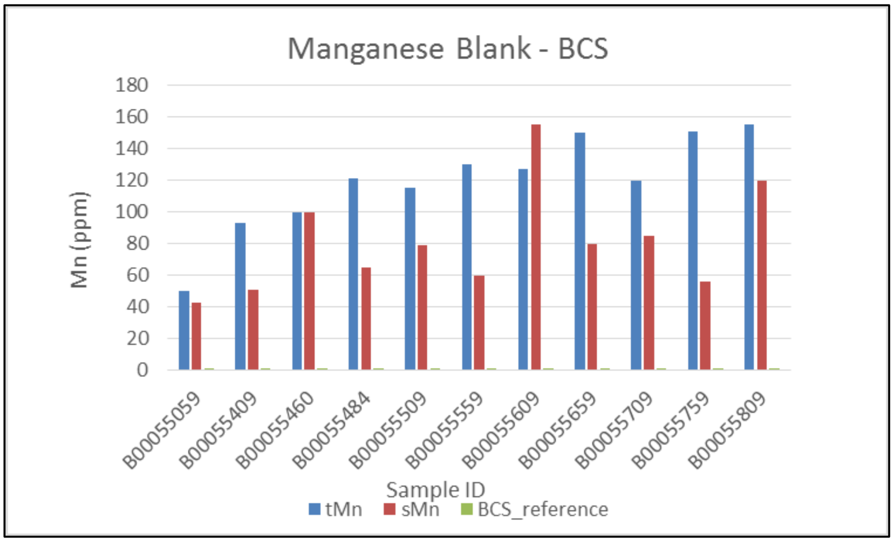



### 11.9.2.2 Certified Blank – BCS

The BCS certified blank was supplied by Bureau of Analysed Samples Ltd, based in England, prepared as low iron sand that passes a nominal 250 µm aperture. The standard has a "certified value" of 0.00014% manganese (II) oxide with 95% confidence interval of 0.0003%.

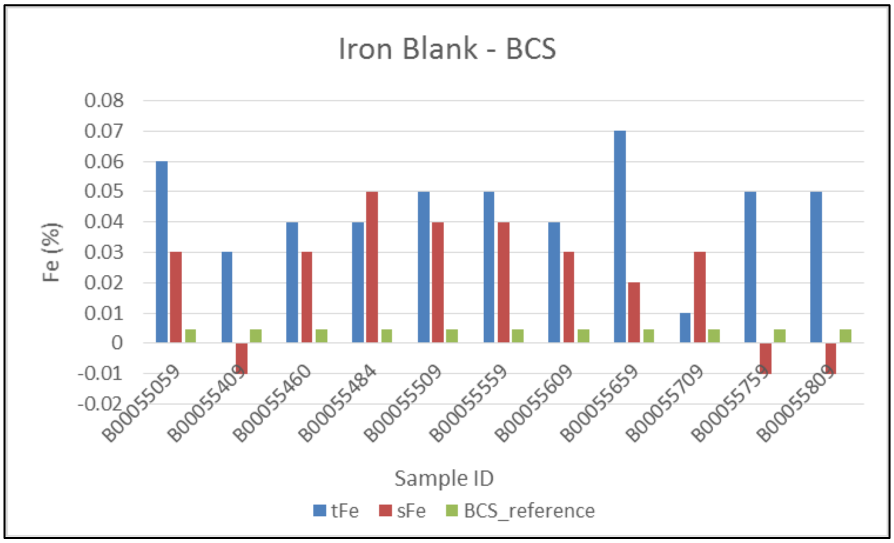
This sample accounted for eleven analyses. Figure 11-9 and Figure 11-10 show the performance of the blank for manganese and iron concentrations. The manganese concentrations were below 150 ppm. This ambient concentration may be due to residual manganese within the grinding equipment, but it was determined to be insignificant.

**Figure 11-9: Certified Blank – BCS – Manganese**




The certified blank, BCS, (green) is consistently shown as having less manganese percentage than the total manganese, 4-acid AAS, (blue) or soluble manganese, aqua regia AAS, (red).

**Figure 11-10: Certified Blank – BCS – Iron**




### 11.9.3 Lab Duplicates

Lab duplicates represent those samples which were homogenized and split from the coarse material into to replicate sub-samples internally by the lab, on request of EMN, prior to being pulverized and analyzed. The results of the lab duplicate assays allow for pairwise assessment of the laboratory's sample preparation, homogenization and splitting procedures prior to pulverization and digestion for analyte.

A total of 20 pairs of lab duplicates were collected, with 16 result pairs for soluble manganese and 18 result pairs for total manganese. In the assay database, each pair was identified with the same sample number with one labelled with DUP as suffix and the second with no suffix. The duplicate sets were evaluated using simple linear regression and the Pearson's coefficient, and also for relative percent difference (RPD) as a measure of precision. An RPD of less than 10% within 90% confidence interval is considered to be a reasonable variation for evaluation of the quality of the data.

Figure 11-11 shows the duplicate regression for soluble manganese (aqua regia AAS) and Figure 11-12 shows the regression for total manganese (4-acid AAS) against a 1:1 unity line in red. The soluble manganese regression indicated a slope of 1.0049 with Pearson's coefficient of 0.83, mainly due to one outlier. Total manganese indicated a slope of 0.9423 with Pearson's coefficient of 0.97.

**Figure 11-11: Linear Regression of Soluble Manganese Assay Lab Duplicate Results**

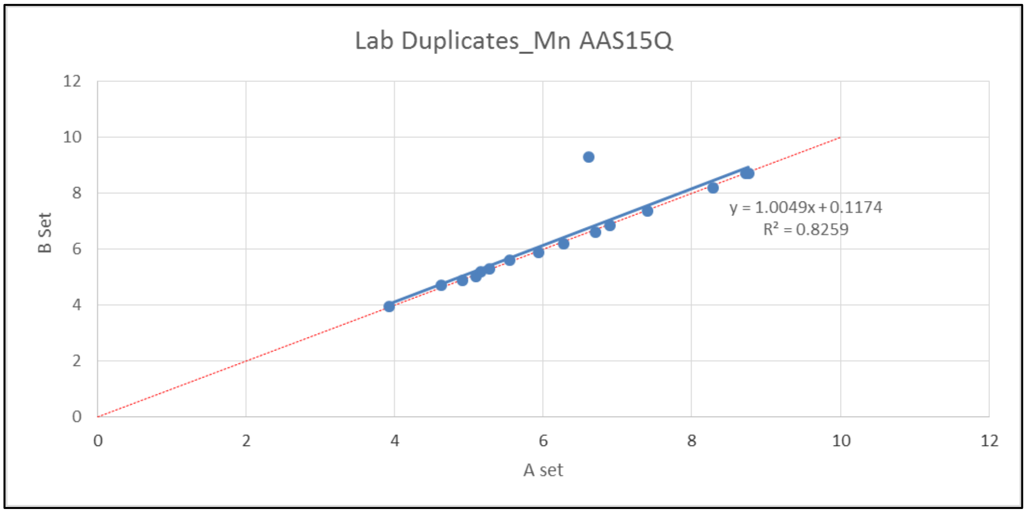
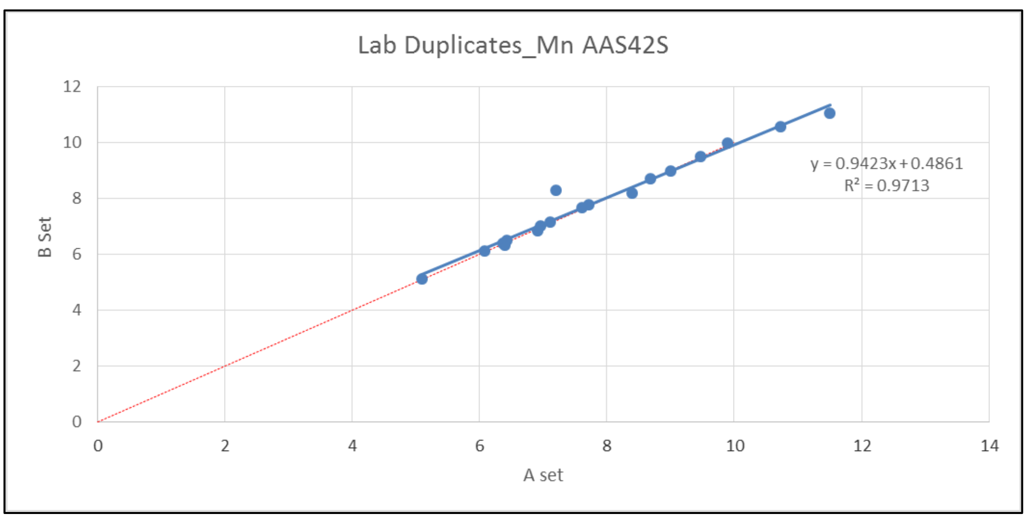



**Figure 11-12: Linear Regression of Total Manganese Assay Lab Duplicate Results**




RPD analysis of the field duplicates results for soluble manganese shows 15 of 16 pairs with a value of less than 1.72% and one sample pair with value of 33.82%. RPD analysis of the lab duplicates results for total manganese show 17 of 18 pairs with a value of less than 3.99% and one sample pair with value of 14.19%. A greater precision was observed for the total manganese assays.

### 11.9.4 Field Duplicates

Field duplicates represent those samples split and collected by EMN field staff at the drill and delivered to the lab as a blind duplicate. The results of the field duplicate assays allow for pairwise assessment of the procedures used in the field to split and collect samples prior to being delivered to the lab for analysis.

A total of 41 pairs of field duplicates were collected with reportable results. In the assay database, each pair was identified with the same sample number with one labelled with A as suffix and the second with B as the suffix. The A and B sets were evaluated using simple linear regression and the Pearson's coefficient, and also for RPD as a measure of precision. An RPD of less than 10% within 90% confidence interval is considered to be a reasonable variation for evaluation of the quality of the data.

Figure 11-13 shows the duplicate regression for soluble manganese (aqua regia AAS) and Figure 11-14 shows the regression for total manganese (4-acid AAS) against a 1:1 unity line in red. The soluble manganese regression indicated a slope of 0.9174 with Pearson's coefficient of 0.94, and total manganese indicated a slope of 0.9977 with slope of 0.98.

**Figure 11-13: Linear Regression of Soluble Manganese Assay Duplicate Results**

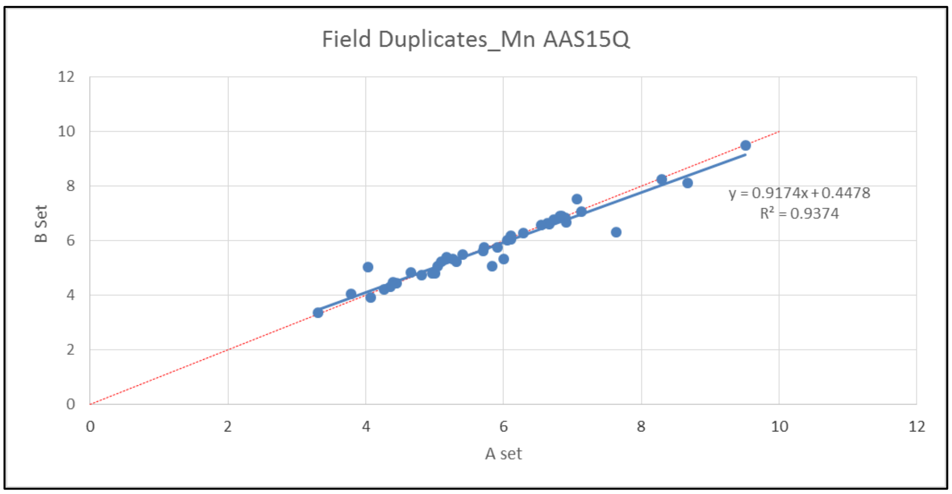
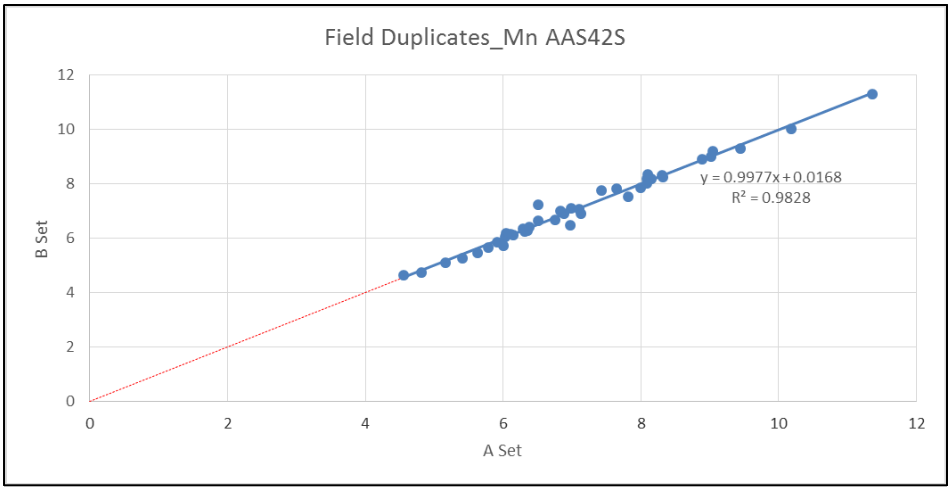


**Figure 11-14: Linear Regression of Total Manganese Assay Duplicate Results**




RPD analysis of the lab duplicates results for soluble manganese show 37 of 41 pairs with a value of less than 6.90% and four samples pair with values between 11.64% and 22.47%. RPD analysis of the lab duplicates results for total manganese show 40 of 41 pairs with a value of less than 7.43% and one sample pair with value of 10.48%. A greater precision was observed for the total manganese assays.

### 11.9.5 SGS Re-Analysis

Upon initial receipt of the laboratory data, instances were observed by EMN whereby concentrations of soluble manganese exceeded the reported concentrations of total manganese. As this is technically not possible, re-analysis of three batches was requested by EMN and completed by SGS. The re-runs were comprised of a split of the pulverized and homogenized sample.

Results of the re-analysis reduced the occurrence of soluble manganese exceeding total manganese to two samples, both of which were blank control samples at or below the detection limit.

### 11.9.6 External Laboratory Assay Verification

An external laboratory was selected by EMN to replicate the assay procedure for verification of assay splits that were prepared at SGS following initial receipt, drying, weighing and pulverizing of the sample. A total of 89 samples were shipped to Activation Laboratories Ltd. (Actlabs), located in Ancaster, Ontario, Canada. Comparison of total manganese grades from Actlabs with the SGS results are shown in Figure 11-15, and comparison of the soluble manganese grades are shown in Figure 11-16.

The results of the external laboratory verification indicate a reasonable comparison for both the total (4-acid) manganese and soluble (aqua regia) manganese data. Total manganese values show a slight scatter around a linear regression with Pearson's coefficient of 0.95, and slight bias to the Actlabs data with and slope of 0.98. A total of 14 total manganese grades, representing 16% of the data, showed RPD values of greater than 10%. Soluble manganese values show a slight scatter around a linear regression with Pearson's coefficient of 0.95, and slight bias to the Actlabs data with and slope of 0.96. A total of 46 soluble manganese grades, representing 51% of the data, showed RPD values of greater than 10%.

**Figure 11-15: Linear Regression of Total Manganese Assay from Umpire Lab**

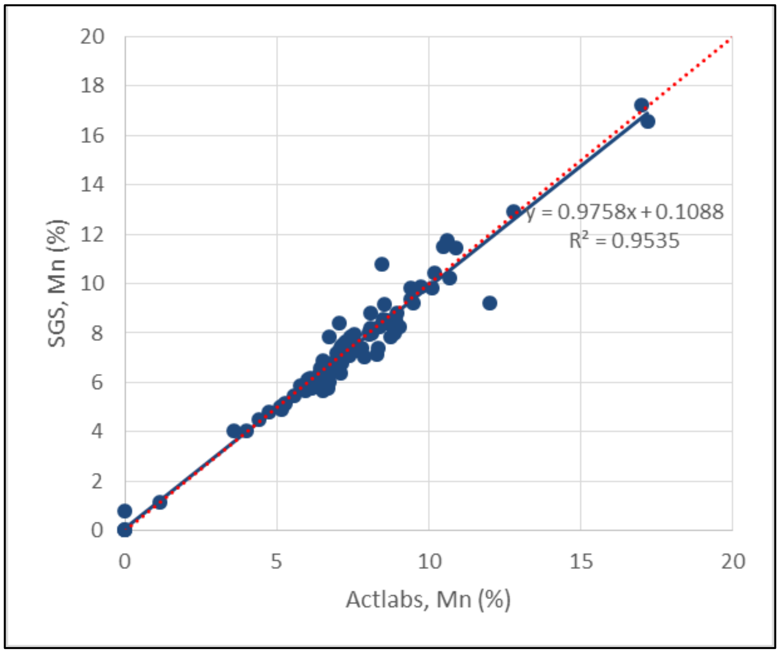
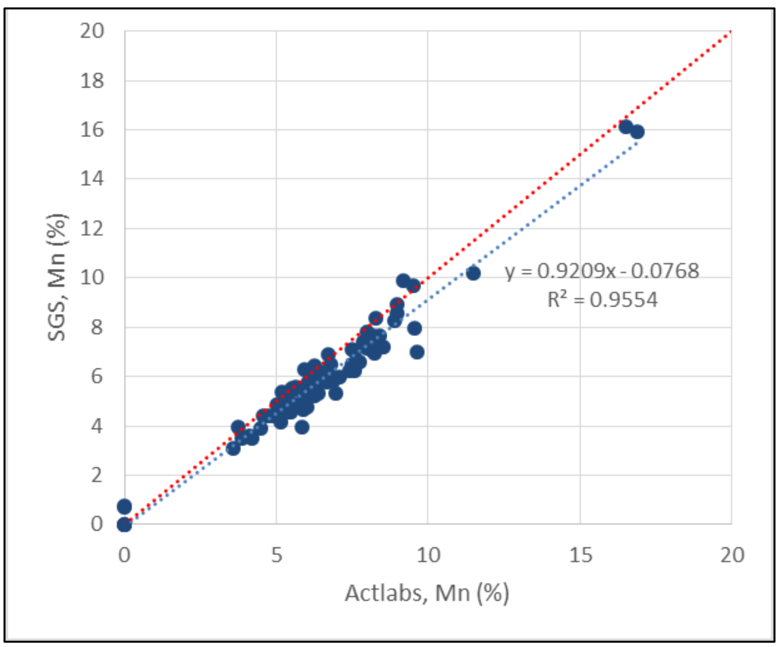



**Figure 11-16: Linear Regression of Soluble Manganese Assay from Umpire Lab**




Linear regression of the external laboratory assay verification supports the manganese grades reported from SGS analysis, however, RPD analysis suggests some variability exists between the laboratory analyses. This may be caused by heterogeneity in sampling in the field.

## 11.10 2018 Sampling and Laboratory Analysis QAQC Program

A systematic QA/QC program was designed in connection with the 2018 drill-sampling and analytical work. The program consisted of the following:

- Insertion of control samples (CRMs, duplicates, and blanks) into the analytical sample stream to monitor the performance of the labs, representing 17.8% of overall analytical results
- Review of internal QC data generated by the labs
- Re-analysis or repeat of the testwork on batches and samples that fail the QC criteria
- Independent quality assurance assessment completed by Tetra Tech.

A total of 830 samples were shipped to SGS laboratories located in Bor, Serbia, for elemental analysis. This included 730 assays, 33 CRMs (3 materials), 30 blanks (2 materials) and 37 field duplicates. The laboratory included 48 additional lab duplicates from preparation and analytical stages. This resulted in a total of 888 assay results reported to EMN.

All analytical certificates were delivered directed to both EMN and to Tetra Tech allowing QA assessments to be conducted by Tetra Tech. A database was compiled, and various checks and measures were performed by Tetra Tech. Tetra Tech did not identify any significant QA concerns; however, high variability was identified in manganese concentrations reported from the partial and near-total digestion methods. Due to this, it was decided that manganese reported by lithium borate fusion and XRF was more reliable and was selected as the basis for total manganese grades for development of the MRE. The compiled database was validated for use in mineral resource estimation.

### 11.10.1 Certified Reference Materials

Three CRMs were inserted in sequence with the samples that were shipped to SGS in Bor. The name of the samples was recorded on the sample tag retained by EMN; the samples were delivered to the lab as a blind control samples with unknown composition. CRM insertions assess the accuracy of the sample solution preparation and accuracy of the analytical equipment being used. CRMs are intended to be present at a rate of at least one CRM per sample batch. Batch sizes at SGS included approximately 45 samples, including field and laboratory QC sample insertions.

Three reference materials were selected by EMN at the onset of the program to be used as standards as described in the following sub-sections.

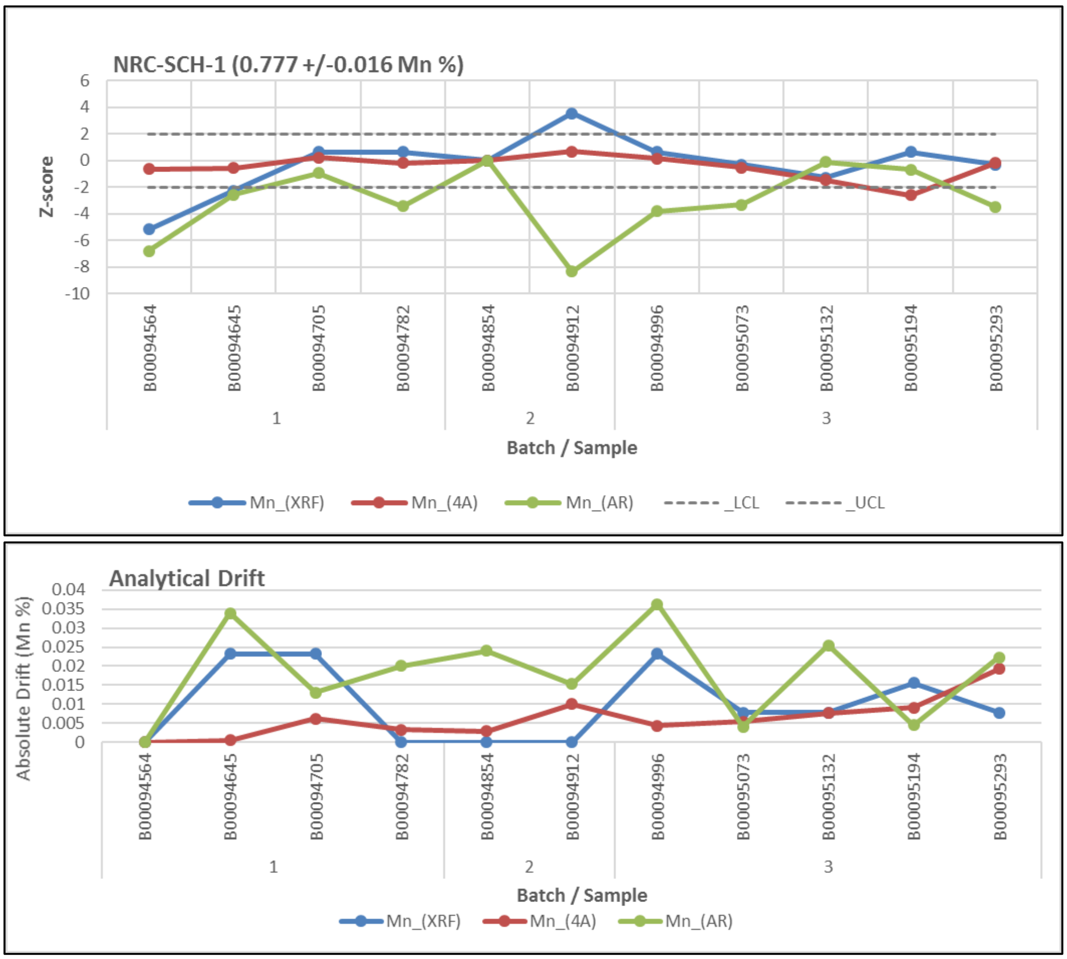
#### 11.10.1.1 Certified Reference Material – NRC-SCH-1

The NRC-SCH-1 reference was supplied by the National Research Council of Canada CANMET and was prepared from iron ore as hematite with various hydrous oxides of iron from the Schefferville Mine in Quebec, Canada. The expected mean manganese grade is 0.777% with 95% confidence interval of 0.008% manganese. This CRM was selected to evaluate samples with manganese concentration less than 1%, which were analyzed using ICP-MS and by XRF.

This sample accounted for eleven analyses. The manganese assays from XRF analysis (Mn_XRF), and both digestions with the ICP methods (4-acid digestion: Mn_4A, and aqua regia digestion: Mn_AR) were transformed to Z-score values and plotted against the expected mean and confidence interval to assess the performance of the CRM. The CRM performance chart and analytical drift chart are shown in Figure 11-17. Sample B00094854 (certificate AV011733) was mislabeled at SGS in Lakefield, Ontario for XRF analysis and has not been shown in Figure 11-17 for CRM performance.

The results show good performance for the XRF analysis where 73% of samples were measured within range, and the 4-acid ICP-MS methods where 82% of samples were measured within range. The aqua regia ICP-MS methods measured 27% of samples within range, which is an expected performance as only a portion of the sample is digested. The aqua regia digestion does have variable performance in relation to the 4-acid digestion suggesting the digestion method has strong influence on measured manganese concentration for this CRM. Overall, elevated variability is observed for manganese concentrations in this “low grade” range.

**Figure 11-17: CRM Performance and Analytical Drift Charts for NRC-SCH-1**



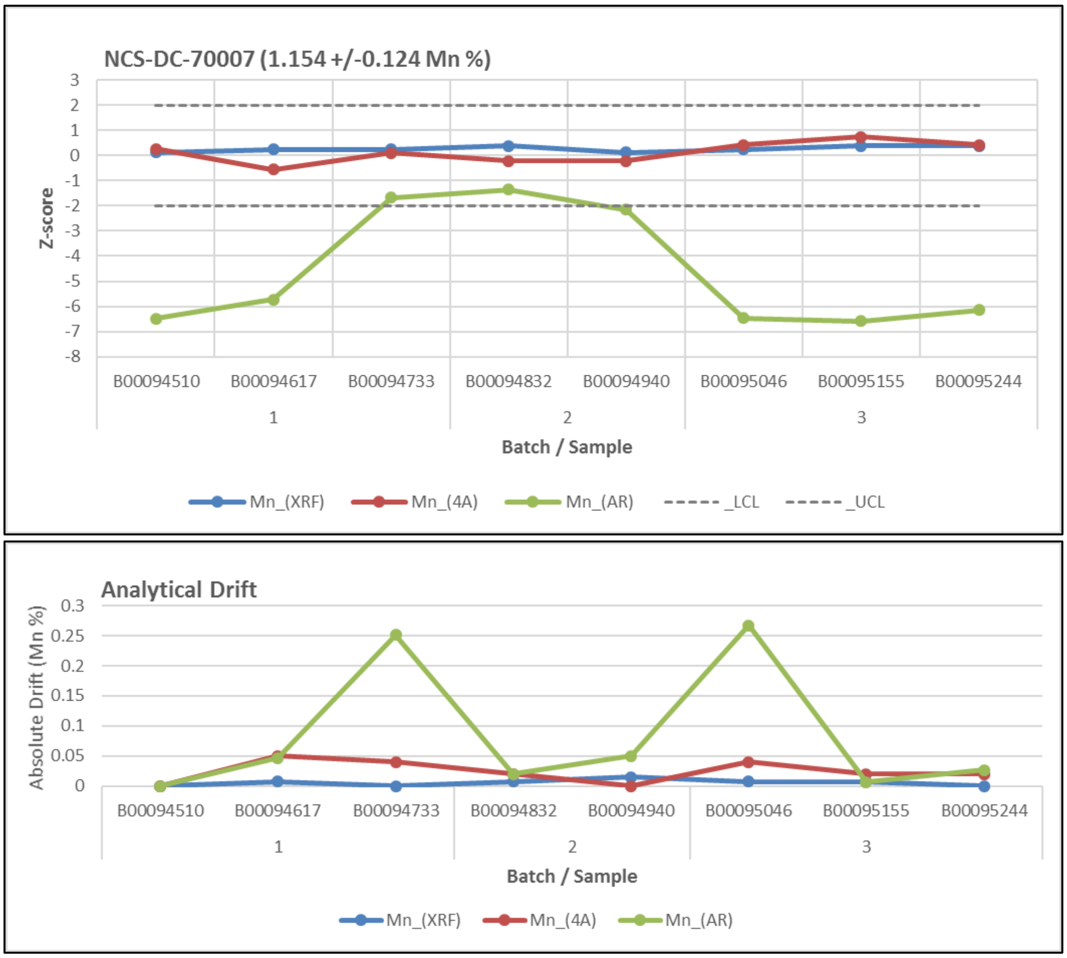

### 11.10.1.2 Certified Reference Material – NCS-DC-70007

The NCS-DC-70007 reference was supplied by China National Analysis Center for Iron and Steel. The source material is not disclosed in the material datasheet. The expected mean manganese (II) oxide concentration is 1.49% (1.154% manganese) with a standard deviation of 0.08% manganese (II) oxide (0.062% manganese). This CRM was selected to evaluate samples with manganese concentration in low range greater than 1%, which were analyzed with “ore grade” methods using AAS and by XRF.

This sample accounted for eight analyses. The manganese assays from XRF analysis (Mn_XRF), and both digestions with the AAS methods (4-acid digestion: Mn_4A, and aqua regia digestion: Mn_AR) were transformed to Z-score values and plotted against the expected mean and confidence interval to assess the performance of the CRM. The CRM performance chart and analytical drift chart are shown in Figure 11-18.

The results show excellent performance for the XRF analysis where 100% of samples were measured within range, and the 4-acid ICP-MS methods where 100% of samples were measured within range. Th aqua regia ICP-MS methods measured 25% of samples within range, which is an expected performance as only a portion of the sample is digested. The aqua regia digestion does have variable performance in relation to the 4-acid digestion suggesting the digestion method has strong influence on measured manganese concentration for this CRM. The measurements by the XRF method were the most accurate.

**Figure 11-18: CRM Performance and Analytical Drift Charts for NCS-DC-70007**



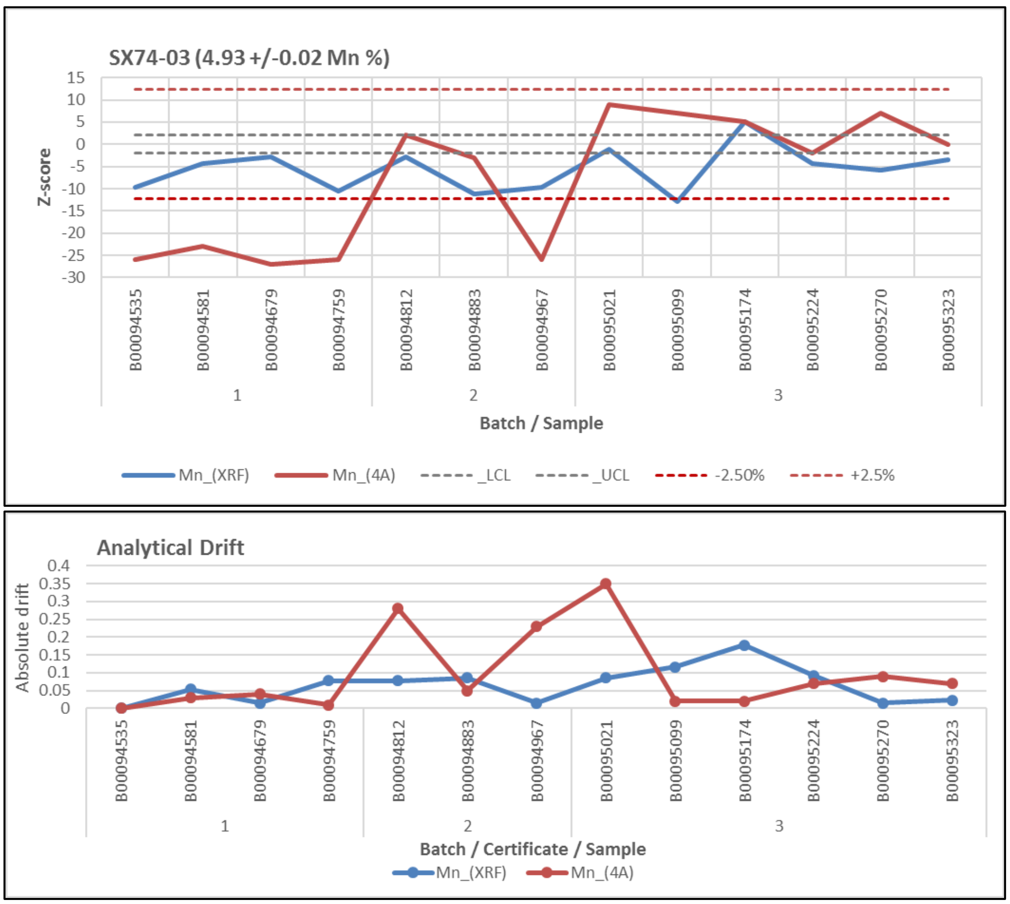

### 11.10.1.3 Certified Reference Material – SX74-03

The SX74-03 reference was supplied by Dillinger Hütte Laboratories, Germany, manufacturers of steel products. The material source is a silicomangenese slag product with expected mean manganese concentration of 4.93% with a reported 95% confidence interval of 0.01%. This CRM was selected to evaluate samples with manganese concentration in mid-range greater than 1%, which were analyzed with “ore grade” methods using AAS and by XRF.

This sample accounted for thirteen analyses. The manganese assays from XRF analysis (Mn_XRF), and only the results of the 4-acid digestion with the AAS analysis (Mn_4A) were transformed to Z-score values and plotted against the expected mean and confidence interval to assess the performance of the CRM. The CRM performance chart and analytical drift chart are shown in Figure 11-19. Twice the original confidence interval of 0.01% is shown in Figure 11-19. The aqua regia digestion with AAS analysis results were not plotted.

The reported confidence interval for the SX74-03 reference is very narrow. The results show good performance for the XRF analysis where 92% of samples were measured within ±2.5% of the expected value, however, only 23% within twice the original confidence interval. The 4-acid AAS methods measure 62% of samples within ±2.5% of the expected value, however, report a higher variability and 30% within twice the original confidence interval. The aqua regia ICP-MS methods did not measure any samples to be within ±2.5% of the expected value and were not plotted. It was observed that the measurements from 4-acid AAS methods had a positive drift over time from below to above the threshold value. The measurements by the XRF method showed least variability and consistently low accuracy, compared to higher variability results of the 4-acid AAS analysis for this CRM.

**Figure 11-19: CRM Performance and Analytical Drift Charts for SX74-03**



### 11.10.2 Certified Blank Materials

#### 11.10.2.1 BCS-CRM-531 Blank

The BCS-CRM-531 certified blank was supplied by Bureau of Analysed Samples Ltd, based in England, prepared as low iron sand that passes a nominal 250 µm aperture. The standard has a “certified value” of 0.00014% manganese (II) oxide within 95% confidence interval of 0.0003%.

Fifteen BCS-CRM-531 blanks were submitted for analysis to SGS. The assays from both 4-acid and aqua regia digestion with AAS analysis of these 15 samples are plotted in Figure 11-20 through Figure 11-22 for manganese, calcium, and iron concentrations, respectively. Three of the 4-acid AAS manganese results were measured above 150 ppm including one with concentration of 217 ppm (B00095250). This ambient concentration may be due to residual manganese within the grinding equipment, but it was determined to be insignificant. The results from the aqua regia AAS preparation appear to have lower overall manganese concentrations; all measured below 150 ppm. Although no specific failure threshold has been applied, the QP interprets that the sample contamination has not been introduced through sample handling and preparation in the lab.

**Figure 11-20: Certified Blank – BCS-CRM-531 – Manganese**

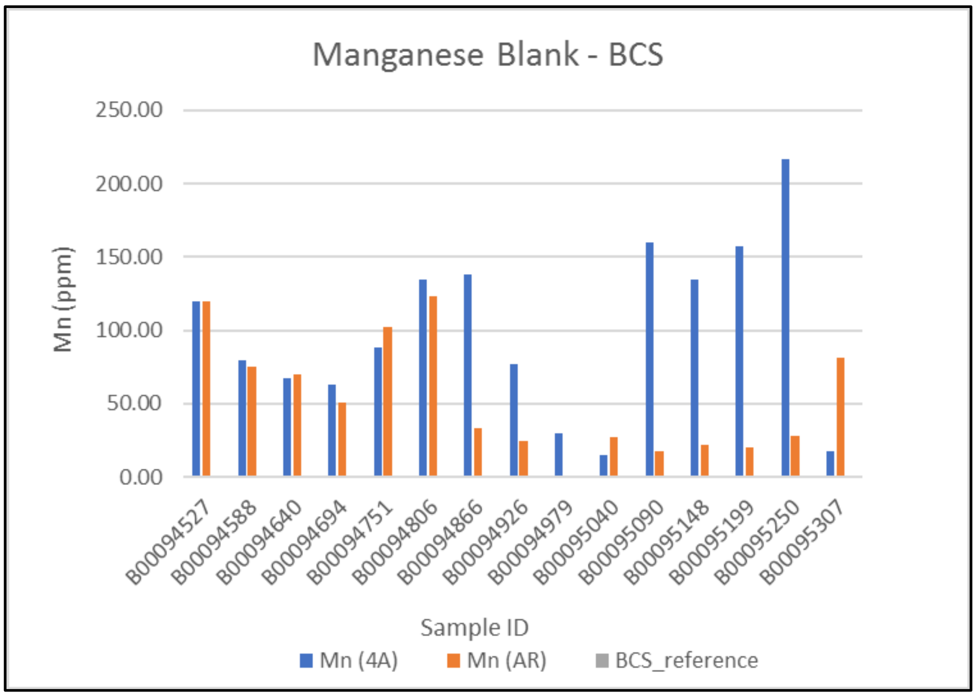


**Figure 11-21: Certified Blank – BCS-ST-531 – Calcium**

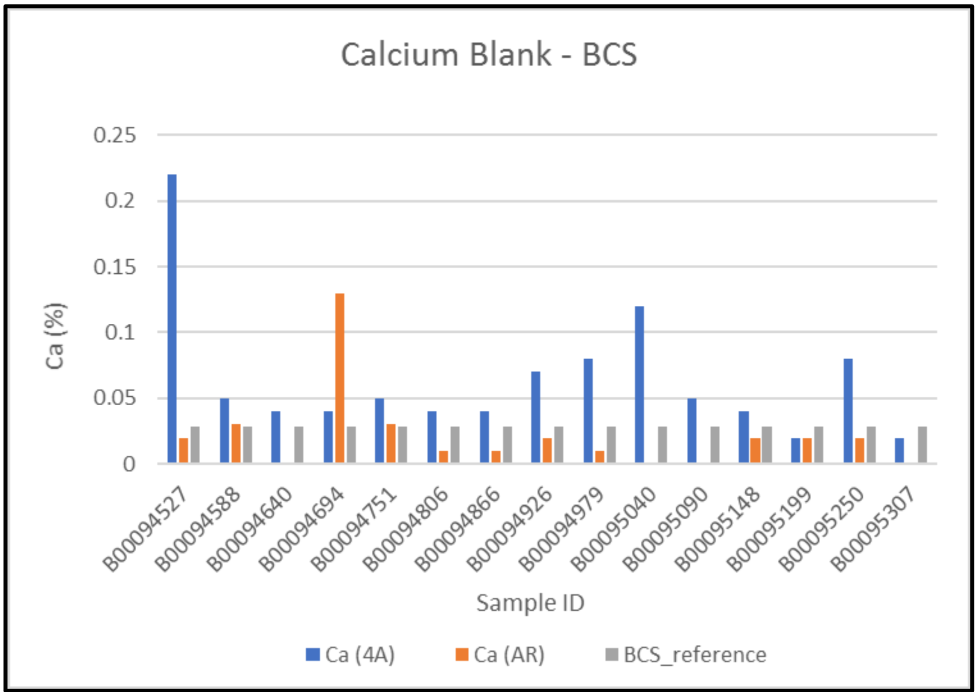
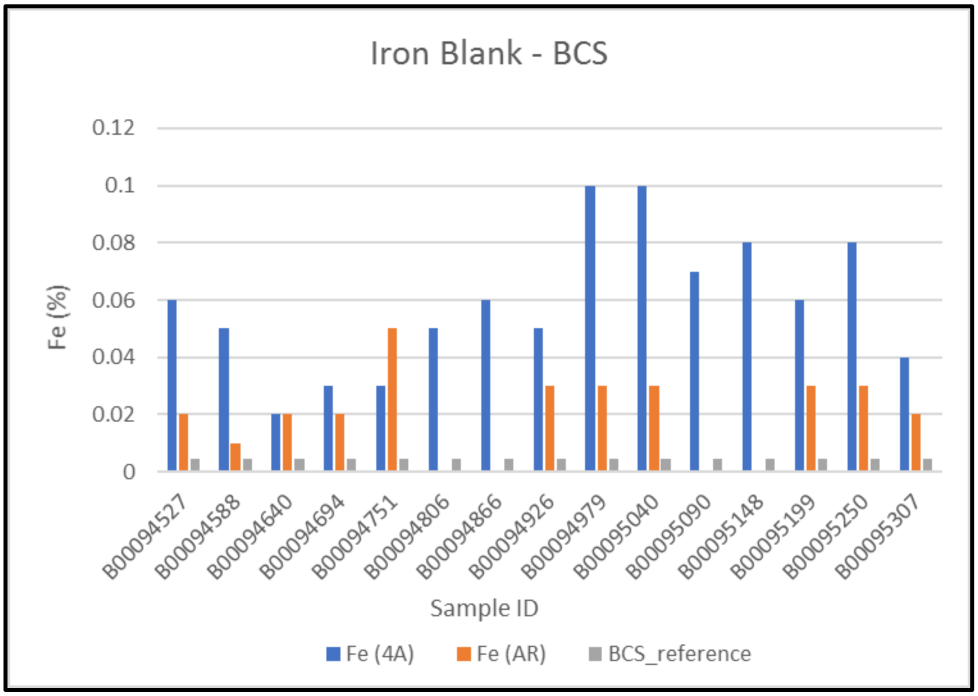



**Figure 11-22: Certified Blank – BCS-ST-531 – Iron**



#### 11.10.2.2 ST-08 Blank

The ST-08 certified blank was supplied by Sklopísek Strelec, Czech Republic, as a high purity silica sand with low impurity concentration. The standard was manufactured for grain size distribution analysis and reports an expected manganese concentration; however, this is expected to be negligible.

Fifteen ST-08 blanks were submitted for analysis to SGS. The assays from both 4-acid and aqua regia digestion with AAS analysis of these fifteen samples are plotted in Figure 11-23 through Figure 11-25 for manganese, iron, and calcium concentrations, respectively. Four of the 4-acid AAS manganese results were measured above 150 ppm and less than 200 ppm, and one aqua regia AAS sample was measured at 150 ppm. This ambient concentration may be due to residual manganese within the grinding equipment, but it was determined to be insignificant. Although no specific failure threshold was applied, the QP interprets that the sample contamination has not been introduced through sample handling and preparation in the lab.

**Figure 11-23: Certified Blank – ST-08 – Manganese**

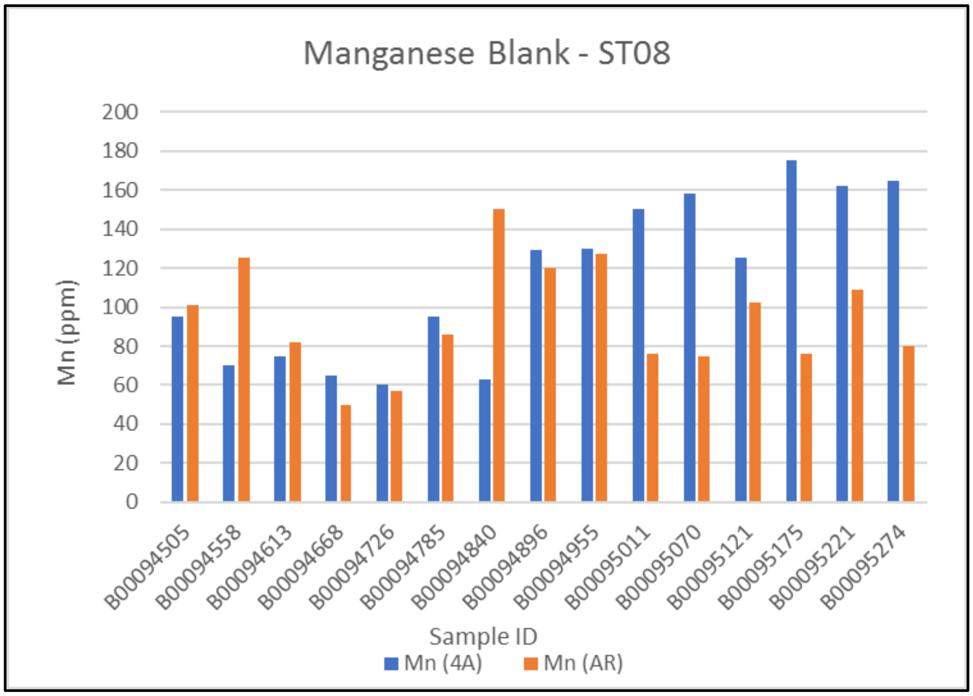


**Figure 11-24: Certified Blank – ST-08 – Iron**

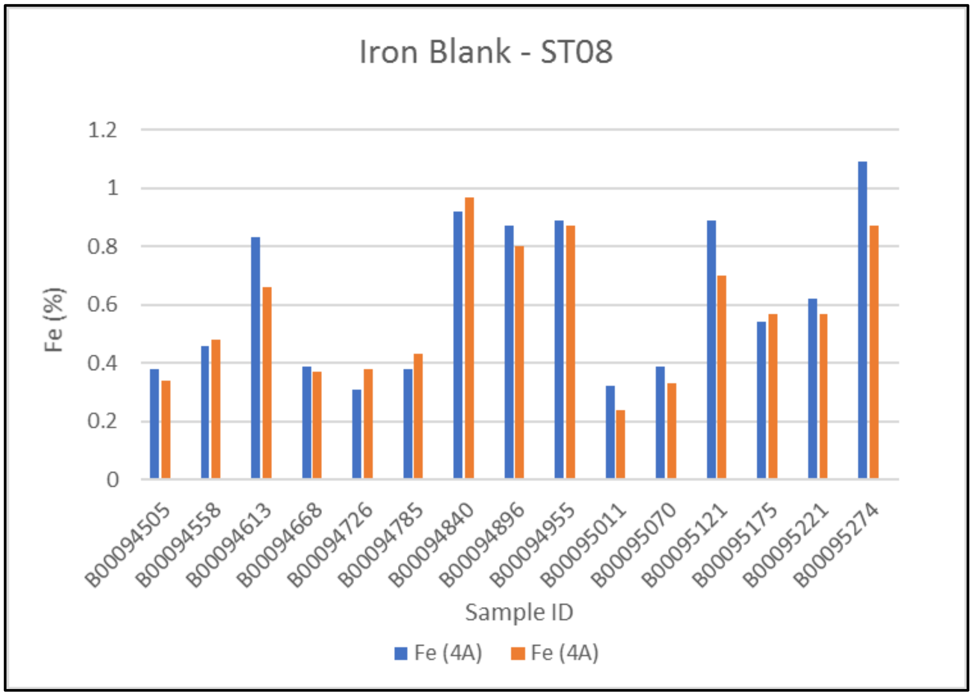
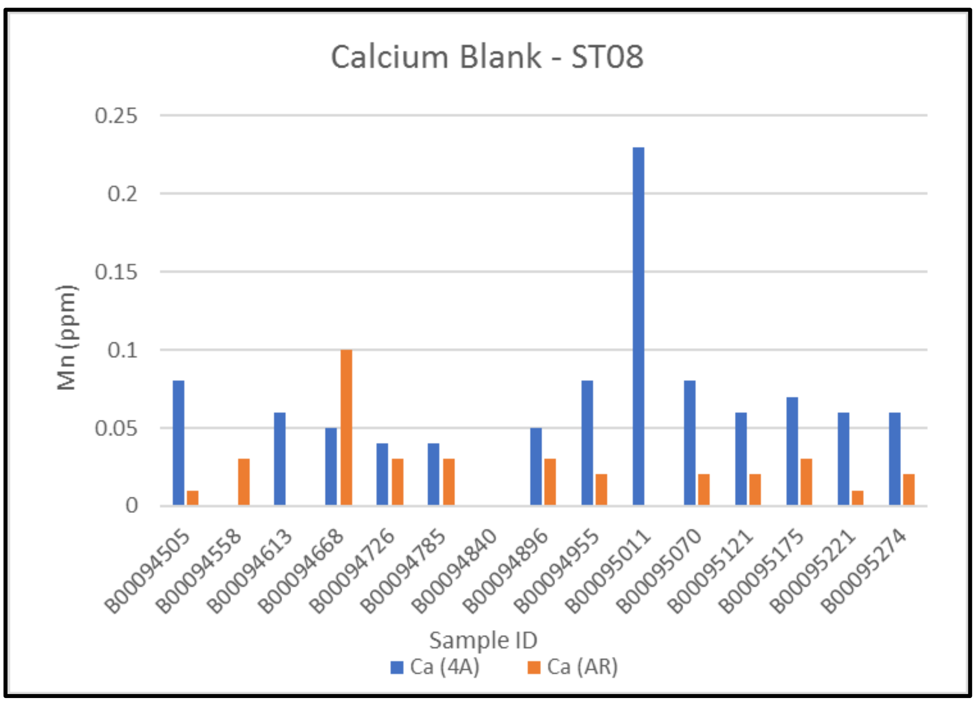



**Figure 11-25: Certified Blank – ST-08 – Calcium**



### 11.10.3 Field Duplicates

Field duplicates represent those samples collected by EMN field staff at the drill and delivered to the lab as a blind duplicate. The results of the field duplicate assays allow for pairwise assessment of analytical reproducibility, or precision.

A total of 37 field duplicate pairs were collected with reportable results. In the assay database, each pair was identified with the same sample number with one labelled with A as suffix and the second with B as the suffix. The A and B sets were evaluated using simple linear regression and the Pearson's coefficient, and also for RPD as a measure of precision. An RPD of less than 30% within 90% of samples is considered to be an acceptable threshold of variation for field duplicates.

Figure 11-26 shows the duplicate regression for manganese measured by 4-acid digestion with AAS and Figure 11-27 shows the regression for manganese measured by aqua regia with AAS against a 1:1 unity line in red. The 4-acid manganese regression indicated a slope of 0.9237 with Pearson's coefficient of 0.7851, and with 97% of samples having RPD less than 30%. The aqua regia manganese indicated a slope of 0.8972 with Pearson's coefficient of 0.7285, and with 95% of the samples having RPD less than 30%.

**Figure 11-26: Linear Regression of 4-Acid AAS Manganese Field Duplicates**

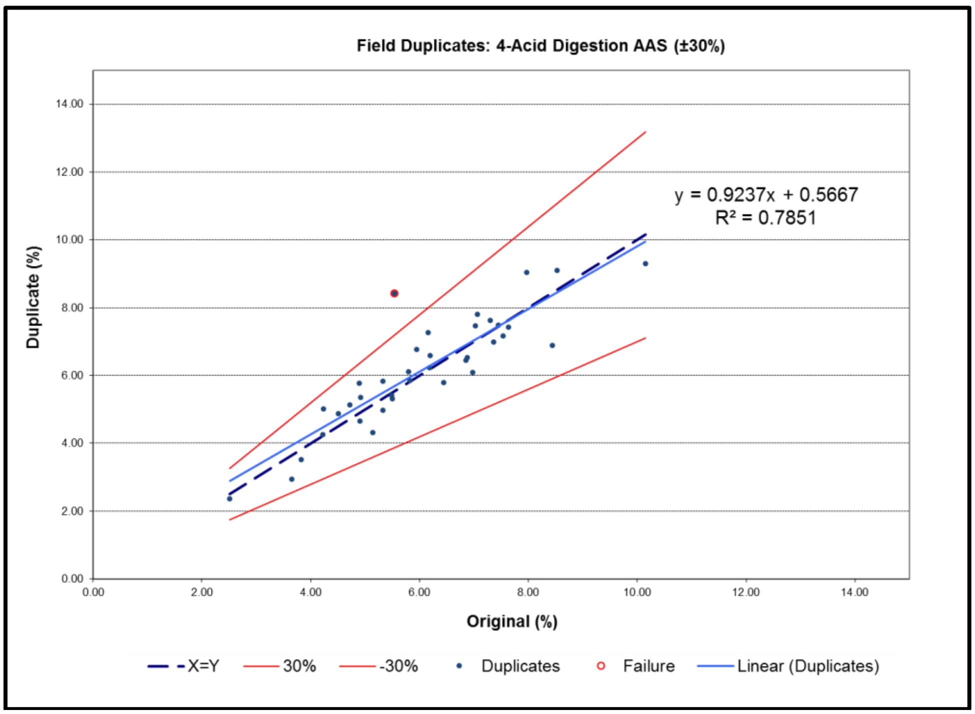
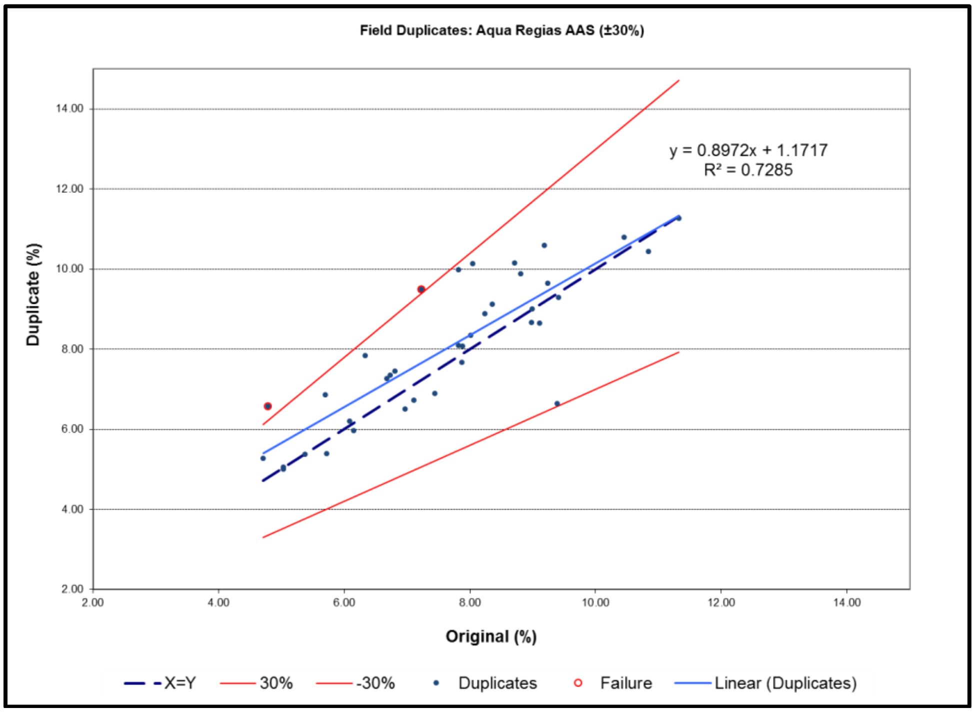


**Figure 11-27: Linear Regression of Aqua Regia AAS Manganese Field Duplicates**




## 11.10.4 Lab Duplicates

Lab duplicates represent those samples analyzed in duplicate internally by the lab, by request of EMN, to assess the precision and quality of the homogenization, sample splitting and preparation methods. EMN directed SGS to collect preparation duplicates (i.e., before pulverizing) and analytical duplicates (i.e., following pulverization) at a frequency of 1:20 samples.

### 11.10.4.1 Preparation Duplicates

A total of 40 preparation duplicate pairs were collected with reportable results. In the assay database, each pair was evaluated using simple linear regression and the Pearson's coefficient and also for RPD as a measure of precision. An RPD of less than 20% within 90% of samples is considered considered to be an acceptable threshold of variation for preparation duplicates.

Figure 11-28 shows the duplicate regression for manganese measured by 4-acid digestion with AAS and Figure 11-29 shows the regression for manganese measured by aqua regia with AAS against a 1:1 unity line in red. The 4-acid manganese regression has a slope of 0.9647 with Pearson's coefficient of 0.9614, and with 95% of samples having RPD less than 20%. The aqua regia manganese has with a slope of 0.984 with Pearson's coefficient of 0.9762, and with 98% of the samples having RPD less than 20%.

**Figure 11-28: Linear Regression of 4-Acid AAS Manganese Preparation Duplicates**

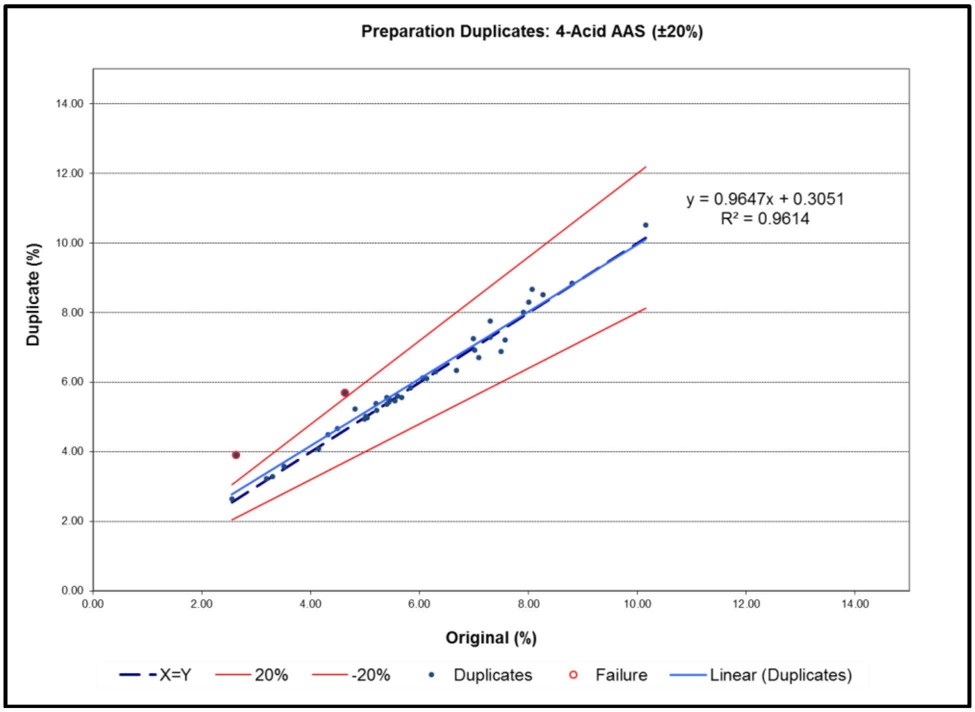
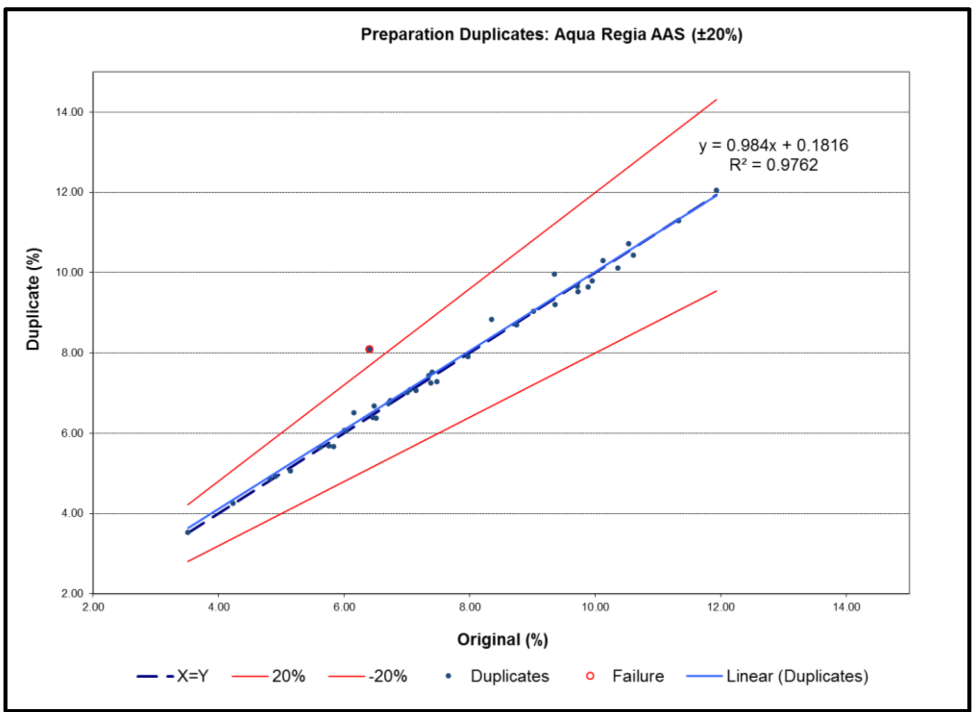



**Figure 11-29: Linear Regression of Aqua Regia AAS Manganese Preparation Duplicates**

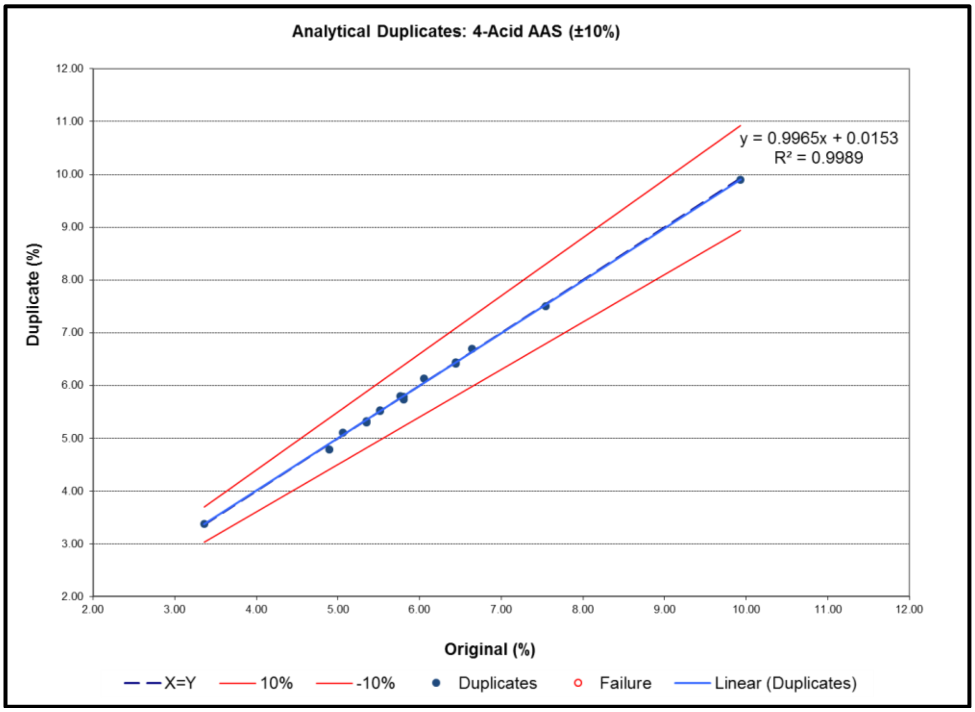


#### 11.10.4.2 Analytical Duplicates

A total of 18 analytical duplicate pairs were collected with reportable results. In the assay database, each pair was evaluated using simple linear regression and the Pearson's coefficient, and also for RPD as a measure of precision. An RPD of less than 10% within 90% of samples is considered considered to be an acceptable threshold of variation for analytical duplicates.

Figure 11-30 shows the duplicate regression for manganese measured by 4-acid digestion with AAS and Figure 11-31 shows the regression for manganese measured by aqua regia with AAS against a 1:1 unity line in red. The 4-acid manganese regression has a slope of 0.9965 with Pearson's coefficient of 0.9989, and with 100% of samples having RPD less than 10%. The aqua regia manganese has with a slope of 0.9936 with Pearson's coefficient of 0.9849, and with 94% of the samples having RPD less than 10%.

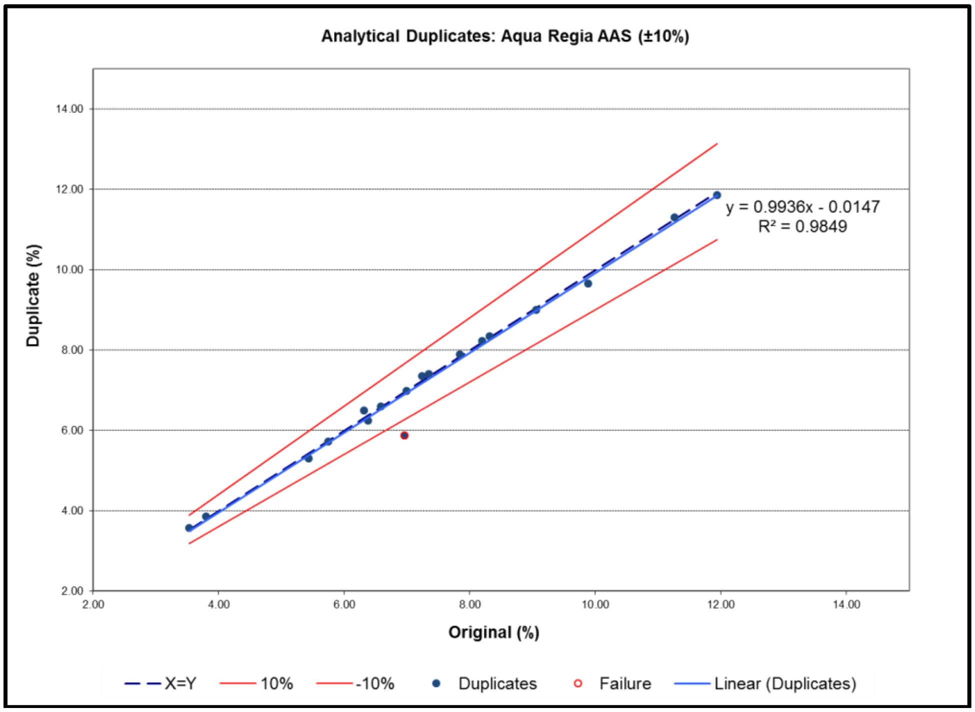
**Figure 11-30: Linear Regression of 4-Acid AAS Manganese Analytical Duplicates**






TETRA TECH

**Figure 11-31: Linear Regression of Aqua Regia AAS Manganese Analytical Duplicates**




### 11.10.5 External Laboratory Assay Verification

External laboratory verification analysis was conducted again in 2018 using Actlabs based in Ancaster, Ontario, Canada. EMN selected Actlabs to replicate the assay procedures for verification of reported SGS analysis results following initial receipt, drying, weighing and pulverizing of the sample. A total of 96 samples were shipped to Actlabs, including QA/QC samples. The suite of analyses included aqua regia and 4-acid digestion using ICP-MS and AAS analysis for trace elements, and XRF for major cations.

Comparison of manganese grades from Actlabs with the SGS results are shown in Figure 11-32 through Figure 11-34 by sample batch, as delivered to the lab.

Manganese assays from XRF analysis show low scatter with Pearson's coefficient ranging from 0.954 to 9987 and RPD ranging between -2.12% to -1.60%, compared to coefficients of 0.8986 to 0.9675 and RPD ranging between -3.99% to 5.57% for 4-acid AAS results, and coefficients of 0.67 to 0.9713 with RPD ranging between -26.54 to -8.52 for the aqua regia AAS results.

The results of the external laboratory verification indicate an excellent correlation from XRF assays, and moderate correlation from both the 4-acid and aqua regia AAS assays. In particular, the 4-acid AAS results reported from Batch 3 revealed possible positive bias in high grade ranges towards the SGS results. The results were assessed, and a selective batch of samples were requested for re-assay at SGS (results discussed in Section 11.10.6).

**Figure 11-32: Linear Regression of Manganese by XRF Assay from Umpire Lab**

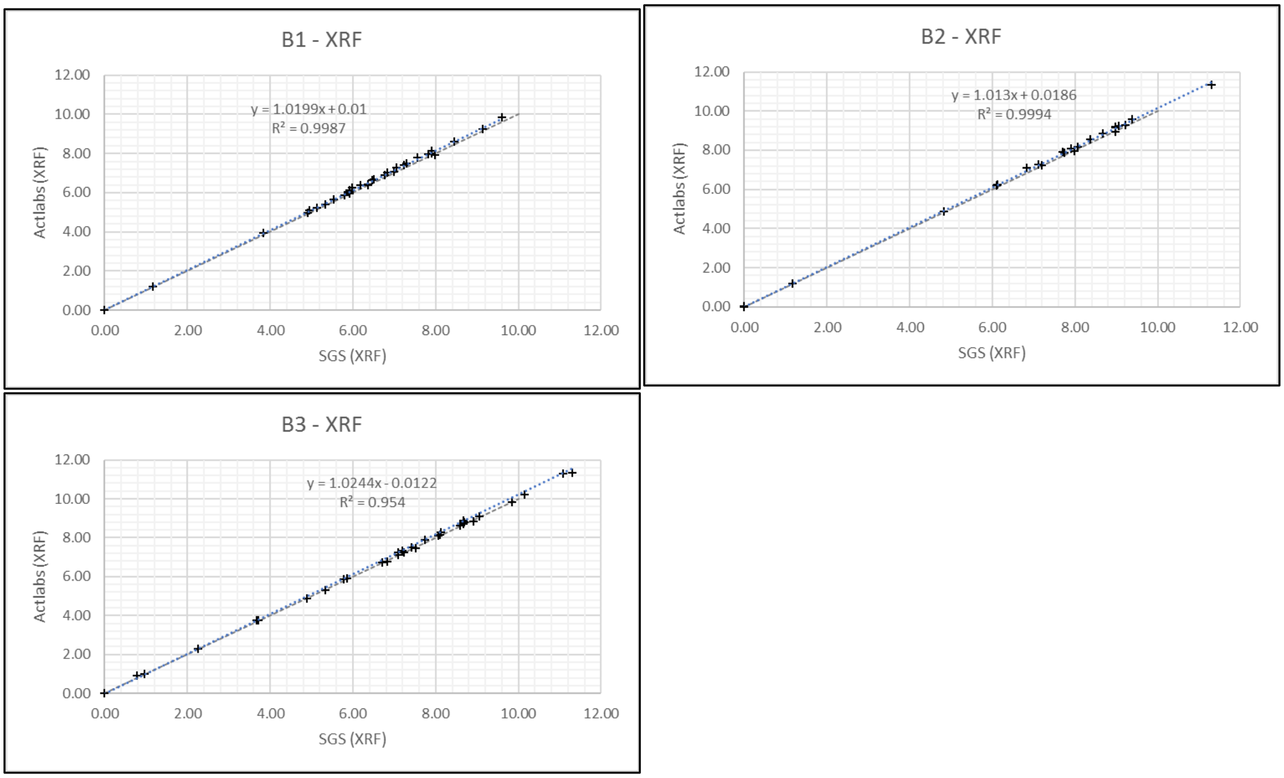



**Figure 11-33: Linear Regression of Manganese by 4-Acid AAS Assay from Umpire Lab**

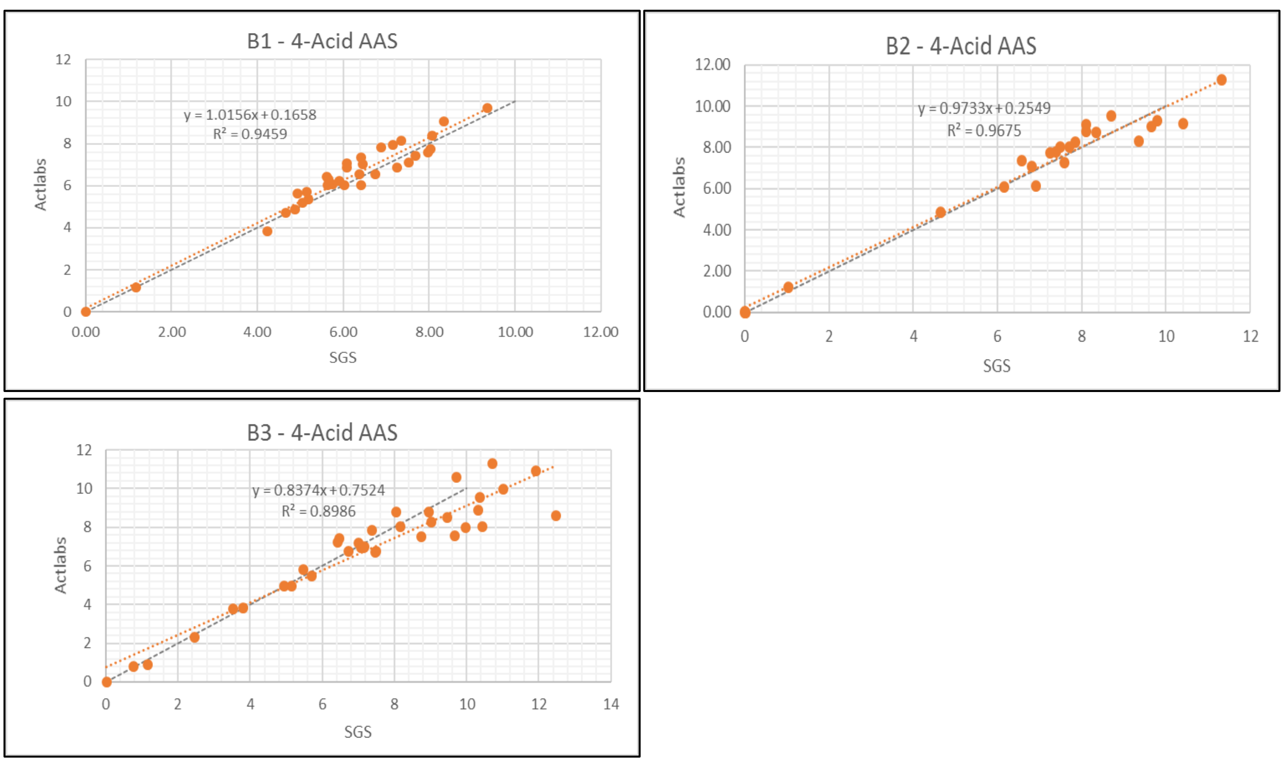
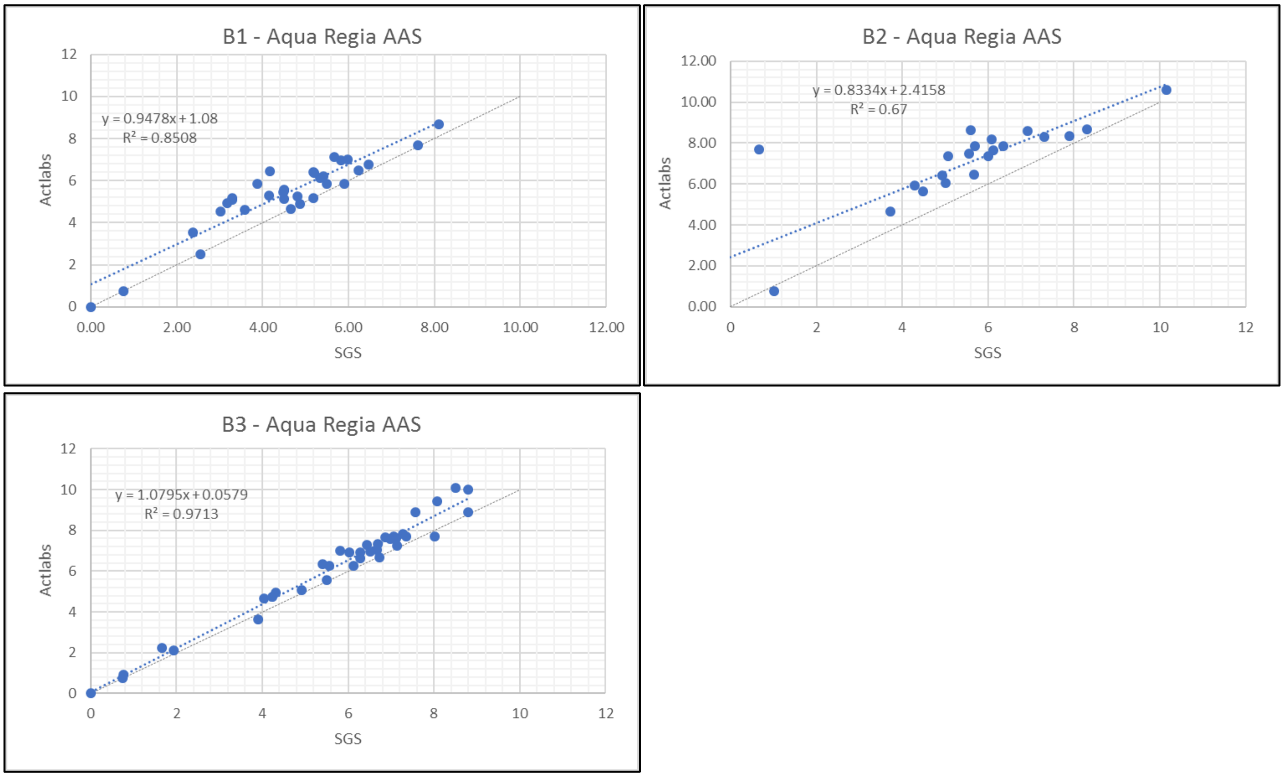


**Figure 11-34: Linear Regression of Manganese by Aqua Regia AAS Assay from Umpire Lab**

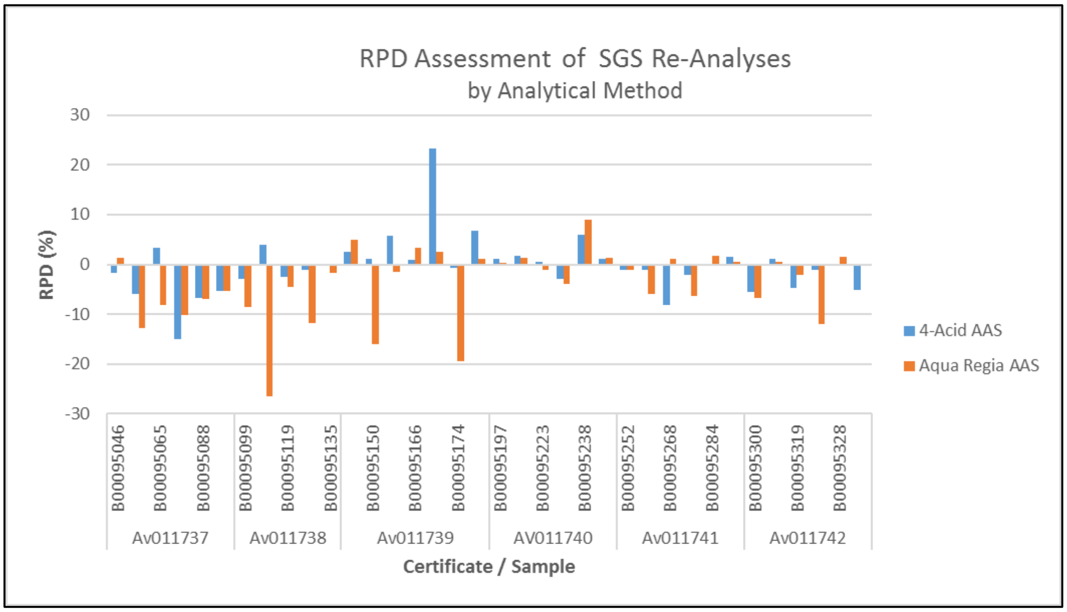



### 11.10.6 SGS Re-analyses

A possible assay bias was identified by external laboratory verification analysis for the reported 4-acid AAS analysis results. A selection of 35 samples from six separate analytical certificates were sent for re-analysis. The results were assessed using RPD and are plotted in Figure 11-35. The RPD results were evaluated to meet analytical duplicate threshold of at least 90% samples having less than 10% RPD. The 4-acid AAS re-assays met the threshold having 94% of samples with less than 10% RPD. The aqua regia re-assays did not meet the threshold having only 80% of samples with less than 10% RPD, with the majority of re-assays having lower assays than the original values.

The re-analysis supported the consistency in assay procedures used by SGS for the 4-acid AAS analysis but did not explain the potential bias identified by external laboratory verification. Examination of internal CRMs used by the laboratories for calibration of equipment for manganese grades above 7% revealed usage of the NOD-A1 produced by United States Geological Survey and the GMN-04 produced by Geostats PTY Ltd. Conclusions from previous QA/QC on the CMP in 2017 concluded that the NOD-A1 CRM is not suitable for wet-digestion analytical procedures such as the 4-acid and aqua regia methods applied to this program.

**Figure 11-35: RPD Assessment of SGS Sample Re-Analysis**




## 11.11 QP Opinion on Sample Collection, Preparation, and Analyses

The methods implemented by EMN for sample collection, preparation and analysis were developed with great detail and with reference to applicable ISO and/or ASTM standards in advance of the drilling investigation. The procedures maximize use of sample volumes to measure physical and chemical parameters relevant to current and future project studies. The labs selected by EMN are recognized accredited laboratories which adhere to recognized ISO, ASTM or internally reproducible standards. The QP feels the collection, analysis and security is reliable and adequate.

Comparison of the various analytical methods for manganese has determined that the results of the XRF analysis provide a more consistent and accurate result compared to the 4-acid AAS methods. An unresolved discrepancy exists with a potential bias between 4-acid AAS results reported for manganese by SGS and Actlabs. The QP concludes that the manganese grades measured by XRF are more reliable measurements as total manganese concentration compared to the measurements from the 4-acid AAS analyses and are thus used as the basis for mineral resource estimation.

More work should be undertaken to establish a suitable and reliable assay method for wet-digestion analytical procedures should EMN choose to use these in the future. In particular, evaluation of equipment calibration at manganese grade above 7% and use of suitable CRMs should be considered. It is recommended that EMN incorporate use of CRM GMN-04 produced by Geostats PTY Ltd, Western Australia, with expected manganese (II) oxide concentration of 17.33%, standard deviation of 0.16 at a 95% confidence interval of ±0.06 (reported by XRF analysis) for calibration of high grade manganese analyses.

# 12.0 DATA VERIFICATION

## 12.1 Audit of the Drillhole Database

### 12.1.1 Collar Survey and Topography

The Property topography was provided by GET as a MicroStation software format, dgn file, based on light detection and ranging (LiDAR) imagery. The contours were extracted from these files and converted to a common .dxf file format. The original data was provided in Czech projection S-JTSK using the Bpv datum.

GET completed drillhole collar surveying on-site using a Trimble model R4 GNSS global positioning system (GPS) receiver equipment. The survey was reported in S-JTSK (Bpv), UTM (WGS84) and Lat-Lon (WGS84). It was observed that the average elevation difference between the Bpv and WGS84 datum equaled approximately 44.25 m. The elevation difference for drillhole T3-319 initially was reported as 46.36 m; however, this was later corrected to accurate Bpv equivalent elevation. The CMP references the S-JTSK (Bpv) coordinate system

A comparison between the corrected collar elevation surveys with the local topographic DEM was undertaken. Of the 80 drillholes completed on the Property, a mean deviation in elevation of 0.049 m was calculated between the collars and the DEM, with values ranging from -0.348 to +0.580 m. The site survey correlates well with the drill collar survey and is considered of high quality for spatial modelling.

### 12.1.2 Downhole Logs and Measurements

GET compiled a drillhole database using the field logs and measurements collected on-site. This database was inspected using digital validation tools within Leapfrog® Geo modelling software. The validation tools assess the data for common errors such as overlapping intervals, major data gaps, drillhole depths versus sample depths, etc. These errors must be corrected prior to modelling to ensure the data is accurately represented.

Errors that were initially identified in the database were mainly due to the consolidated structure of the database that listed data measurements related to intervals for samples (2 m), core runs (1 m), and lithological intervals (variable lengths) on a single master spreadsheet. For modelling purposes, these various interval classes were parsed into three separate data sheets to represent data on 2 m sample intervals, 1 m field measurements, and the logged lithology sub-intervals.

These three subsets were again inspected in Leapfrog® Geo for common errors. This resulted in fewer errors which were corrected in the final database.

### 12.1.3 Geological Database Compilation

Tetra Tech received the raw data from laboratory testwork and analysis. The data was verified for completeness and was then compiled, processed and assessed for use in mineral resource estimation. The analytical data is saved in digital format as a geological database.

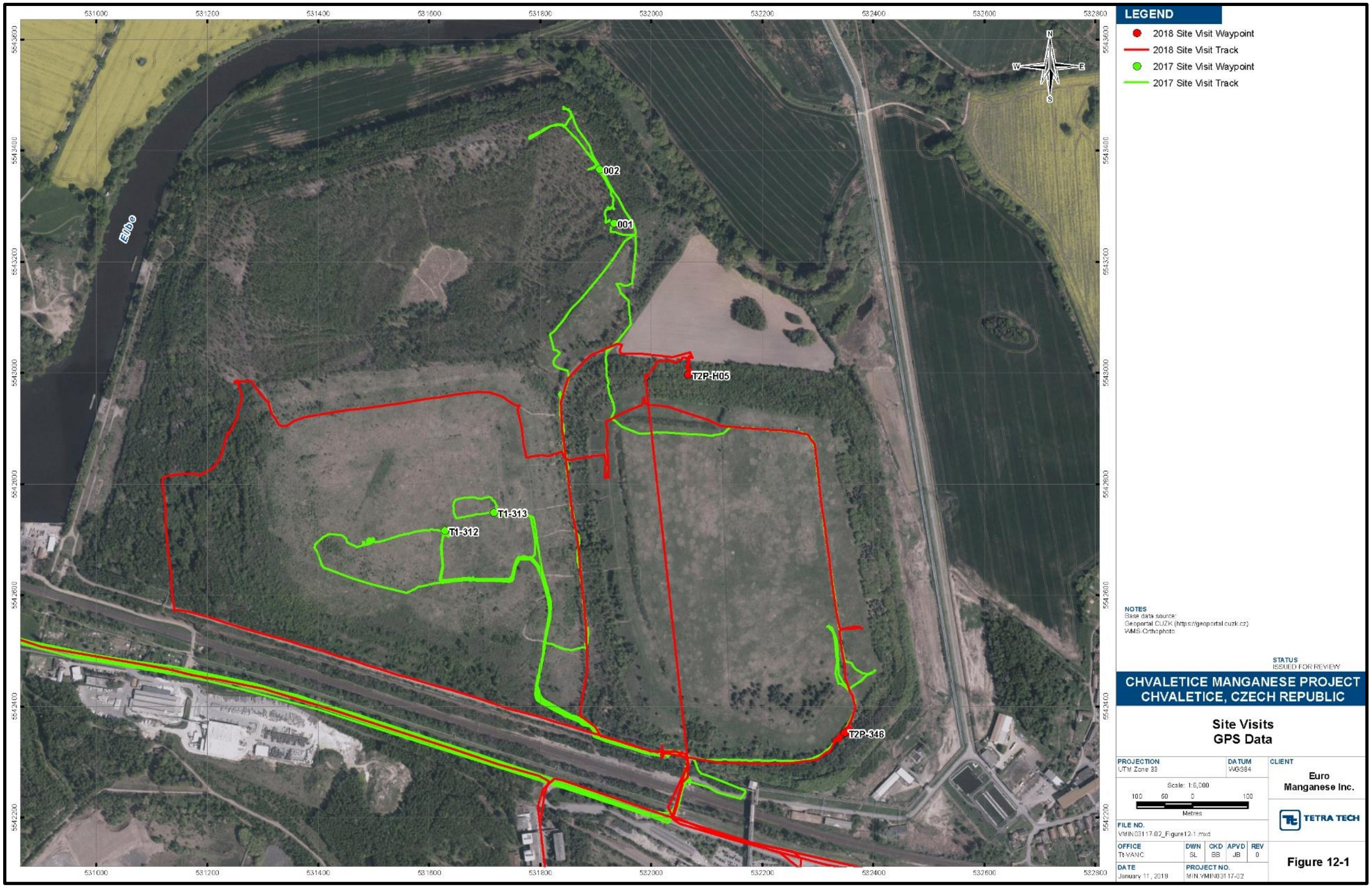
### 12.1.4 Cross Verification of Certificate of Analysis and Digital Data

Tetra Tech undertook verification of the data transfer and compilation process at SGS through visual comparison of the issued certificates of analysis with the digital assay records. This assessment was approached by first comparing the upper $25^{th}$ percentile of assays reported for total manganese (n = 175), followed by a random spot check of an additional 10% of the remaining data (n = 55). No significant reporting errors were identified.

### 12.1.5 Independent QP Site Visits

Two site visits have been completed by the QP, the first between the dates July 1-3, 2017, and again between July 30-31st, 2018. Both visits were coincident with the summer drilling investigations during which time he observed drilling, sample collection and preparation, sample logging and sample storage facilities. An overview of the GPS tracks and sample collection locations are seen in Figure 12-1, this does not include GPS tracking of off-site facilities and locations.

### Figure 12-1: Overview Map of GPS Track and Waypoints from 2017 and 2018 QP Site Visit



#### 12.1.5.1 Independent Check Assay, 2017 Site Visit

Two samples were collected by the Tetra Tech QP geologist during the site visit. The samples were extracted as splits from recovered drill core weighing approximately 3 kg, placed in separate plastic bags, labelled with a generic sample identification and zip tied. One sample was extracted from hole T1-312 between depths of 22 and 23 m (EMN sample B00055404, and the second sample was extracted from hole T1-313 between depths of 22 and 23 m (EMN sample B00055416). Each sample weighed approximately 2 kg.

The samples were then transported by the QP to Prague and delivered to the GET office where shipping via DHL was arranged. Upon receipt of the samples in Canada, the packaging, polyethylene bags, zip ties, and labelling was inspected. Evidence of tampering was not observed.

The samples were submitted to ALS Laboratories (ALS) in North Vancouver, Canada, for a selective leach check analysis. The selective leach analysis progressively dissolved the sample in stages using stronger solvents for digestion. Table 12-1 lists the digestion solvent in successive order. Table 12-2 shows the cumulative percent of the manganese that is dissolved at each stage along with the total manganese grade for the sample. The samples reported 80% and 74% leaching of the total manganese in the first three stages of the selective leach, with the majority of this being dissolved at the aqua regia digestion stage.

Table 12-3 compares the total and soluble manganese concentrations between the Tetra Tech sampling and the EMN reported results. RPD analysis shows some variability in the assay comparisons with values of between 3% and 16% for soluble, and 1 to 13% for total. The check assay does repeat the general magnitude of the manganese assay value within the SGS results.

**Table 12-1: Tabulated Description of Selective Leach Analytical Methods used for Independent Check Assay**

| Digestion | Finish | SGS Method | Mn Detection Limits (ppm) |
|---|---|---|---|
| Aluminum Acetate | ICP-MS | ME-MS04 | 0.05-5,000 |
| Cold Hydroxylamine-Hydrochloride | ICP-MS | MS05 | 0.05-5,000 |
| Aqua Regia | ICP-MS, ICP-AES | MS42 | 5-50,000 |
| 4-acid | ICP-MS, ICP-AES | MS62 | 5-50,000 |

**Table 12-2: Cumulative Leaching Results from Selective Leach Analysis**

| Sample ID | ME-MS04 (cum_Mn%) (%) | ME-MS05 (cum_Mn%) (%) | MS42 (cum_Mn%) (%) | MS62 (cum_Mn%) (%) | Total Mn% (%) |
|---|---|---|---|---|---|
| CT1312 (T1-312, 22-23) | 6 | 9 | 80 | 100 | 10.35 |
| CT1313 (T1-313, 18-19m) | 7 | 11 | 74 | 100 | 6.44 |

**Table 12-3: Independent Check Assay Comparison with EMN Results**

| | CT1312 (B00055404) | CT1313 (B00055416) |
|---|---|---|
| Tetra Tech tMn(%) | 10.35 | 6.44 |
| EMN tMn(%) | 10.42 | 7.36 |
| **RPD (%)** | **1** | **13** |
| Tetra Tech sMn (%) | 9.54 | 5.16 |
| EMN sMn (%) | 8.14 | 5.30 |
| **RPD (%)** | **16** | **3** |

***Acid-base Accounting***

Acid-base accounting (ABA) tests were also performed to measure total sulphide sulphur concentration using LECO furnace and net neutralization potential ratios of the sample. Total sulphide sulphur values for samples CT1312 and CT1313 were measured at 2.48% and 2.45%, respectively, and neutralization potential ratio (NPR) values were reported as 3.11 and 1.94 (using Sobek method). In accordance with standard methodologies and as per guidelines set forth in MEND 1.20.1, Prediction Manual for Drainage Chemistry from Sulphidic Geologic Materials (Price 2009), NPR values greater than 2 indicate the material is not potentially acid generating, materials with NPR between 1 and 2 have uncertain potential for net acid generation and materials with NPR less than 1 indicate they have potential for net acid generation. Based on these results, sample CT1312 does not have potential for acid generation, and sample CT1312 has uncertain potential for acid generation.

Summary of previous acid rock drainage (ARD)-metal leaching (ML) testwork is discussed in Section 13.7. The results of the analysis of two samples identified NPR of 0.94 and 0.4 indicating that the material has potential for acid generation.

The tailings materials, and their processed by-product, should be fully characterized for acid generating potential.

### 12.1.5.2 Independent Check Assay, 2018 Site Visit

One sample was collected by the Tetra Tech QP geologist during the site visit in July 2018. The QP observed drilling advance and recovery of the sample from the core tube, sample logging procedures and sample splitting procedures. The sample was extracted as a quarter split from 1 m of recovered drill core and weighed approximately 1.90 kg. The sample was placed directly in a clear plastic bags, labelled with a generic sample identification, zip tied and kept in possession of the QP.

The sample was collected from hole T2P-346 between depths of 6 and 7 m and was located approximately midway up the southeastern access ramp on the outer perimeter of Cell #2. The material was dark grey to black (when wet) and was comprised of fine- to medium-grained sand, with trace visible amounts of pyrite. The material was considerably drier than those samples observed from the center of Cell #1 during the 2017 QP site visit. Table 12-4 lists the sample and manganese concentrations, which correspond well with the concentrations reported for the sample submitted by EMN. The “soluble” portion of the sample collected by Tetra Tech accounts for 74% of the overall sample, which is slightly lower but generally consistent with the assay results collected by EMN. Trace element concentrations (not shown) are also generally consistent with average values of assay results collected by EMN. Photo 12-1 shows the sample being quarter split and Photo 12-2 shows a close-up of the material.

**Table 12-4: Identification and Mn Concentration of Tetra Tech Check Sample**

| Hole | From (m) | To (m) | Sample Number | Mass (kg) | Mn (Aqua Regia ICP-MS) | Mn (4-acid ICP-MS) |
|---|---|---|---|---|---|---|
| T2P-346 | 6 | 7 | TT18-001 (Tetra Tech) | 1.90 | 4.95 | 6.73 |
| | 6 | 8 | B00094802 (EMN) | 1.99 | 5.18 | 7.46 |

Note: Tetra Tech sample was only 1 m of the overall 2 m interval collected by EMN and sent to SGS for analysis; absolute manganese concentrations may vary due to mineralogical composition of the full 2 m sample.

**Photo 12-1: View of 1m Tailings Core Being Quarter Split (uphole direction is to right), T2P-346, 6-7m**

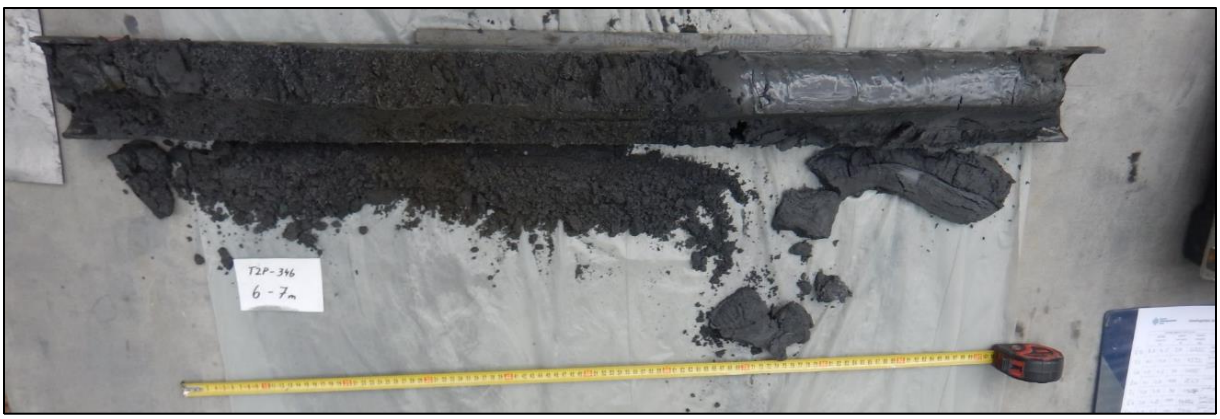



**Photo 12-2: Close-up of Tailings Material, T2P-346, Sample TT18-001**


The sample was submitted by ALS for XRD and Rietveld quantitative analysis at AuTec Innovative Solutions located in Vancouver, Canada, by request of the QP.

The sample was ground for approximately five minutes in a McCrone Micronizing Mill using reagent alcohol. Grinding in the Micronizing Mill reduces particles to between 5 and 10 µm in size without distorting the crystal lattices which are critical for diffraction of X-rays.

Diffraction data was collected over the range of 5-75º2θ with CoKα radiation using a Bruker D8 Focus Bragg-Brentano diffractometer. The diffractometer uses a 0.6mm divergence slit and incident and diffracted-beam Soller slits. The system is equipped with a LYNXEYE-Super Speed Detector.

Diffraction data produced is analyzed and peaks are identified using HighScore Plus software by Panalytical using the Crystallography Open Database. Refinement of diffraction data is done using Topas 5.0 by Bruker AXS.

Detection limits for XRD depend on multiple factors, but as a general rule, if the peak to background ratio is low, the detection limit is approximately 2.0 wt%. For samples in which the peak to background ratio is high and there is good crystallinity, the detection limit can be less than 0.5 wt%. If a phase is present at less than 0.5 wt%, it could still be identified, but confidence decreases. Table 12-5 lists the model abundance derived from the Rietveld Quantitative Analysis. The main manganese bearing mineral was listed as Spessartine, with major gangue minerals being quartz, albiten and kaolinite. Dolomite was the only carbonate mineral listed which may include minor amounts on manganese carbonate not recognized by the XRD.

**Table 12-5: Mineralogy Results of Rietveld Quantitative Analysis**

| Mineral | Ideal Chemical Formula | Modal Abundance (wt%, normalized) |
|---|---|---|
| Quartz | $SiO_2$ | 36.5 |
| Albite | $NaAlSi_3O_8$ | 11.7 |

| | | |
|---|---|---|
| Kaolinite | $Al_2Si_2O_5(OH)_4$ | 0.3 |
| Muscovite | $KAl_2(AlSi_3O_{10})(OH)_2$ | 12.4 |
| Dolomite | $CaMg(CO_3)_2$ | 10.8 |
| Pyrite | $FeS_2$ | 5.4 |
| Fluroapatite | $Ca_5(PO_4)_3F$ | 2.4 |
| Spessartine | $Mn_3Al_2Si_3O_{12}$ | 5.6 |
| Amorphous | - | 14.9 |
| Total | | 100.0 |

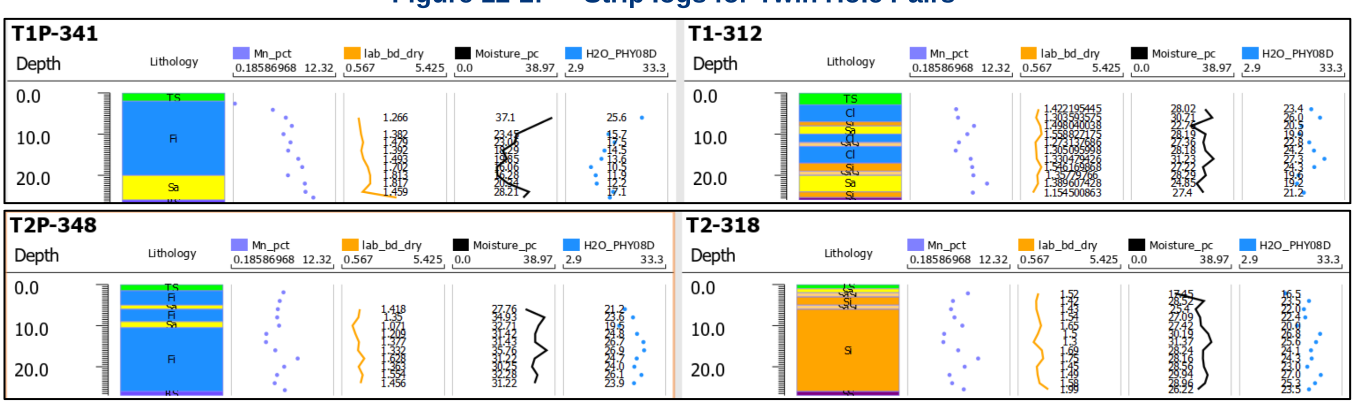
### 12.1.6 Drill Twinning Program, 2018

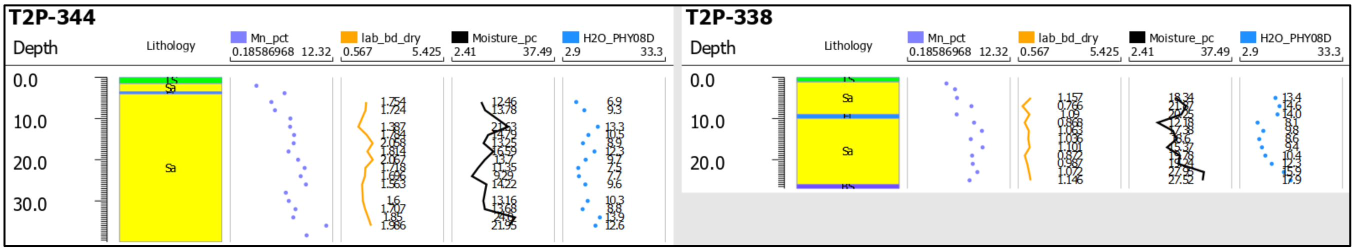
A twin drilling program was executed during the 2018 investigation. Two twin pairs were established in the center of Cell #1 and #2, and a third pair near the northwestern extent of Cell #2. The third pair however was comprised on an include hole and a vertical hole which resulted in a total 30.23 m of horizontal difference at the base of the holes. Table 12-6 lists the holes and Figure 12-2 shows a visual strip log.

**Table 12-6: List of Twin Holes Drilled in 2018**

| Cell | 2017 Original Hole | 2018 Twin Hole | Comments |
|---|---|---|---|
| 1 | T1-312 | T1P-341 | Twin holes located in center of Cell #1 |
| 2 | T2-318 | T2P-348 | Twin holes located in center of Cell #2 |
| 2 | n/a | T2P-344 (inclined)<br>T2P-338 (vertical) | Sonic holes drilled from same collar location at northwest perimeter of Cell #2; results differ due to inclined and vertical orientations |

**Figure 12-2: Strip logs for Twin Hole Pairs**






An RPD comparison was conducted to assess the reproducibility of manganese concentrations, the calculated in situ dry bulk density value (BD) and total moisture content ($H_2O$). The threshold applied to the RPD assessment was 30% as the accepted variability for field replicate samples. The assessment concluded that the manganese concentrations measured by 4A AAS and AR AAS have high variability compared to the results of the XRF analysis. The calculated values for in situ dry bulk density had moderate variability, and the total moisture has the most variability. In situ moisture has seasonal variability and is expected to be different between years; these results were observed from shallow and deep samples. Table 12-7 shows the results of the RPD assessment, where cells highlighted in red have an RPD of greater than 30% and those cells highlighted in green have an RPD of less than -30%.

### Table 12-7: RPD Comparison of Twin Drillholes

| 2018 Twin Hole | | | Relative Percent Difference (2017:2018) | | | | | 2017 Original Hole | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Hole ID | From | To | Mn (4A AAS) | Mn (AR AAS) | Mn (XRF) | BD ($t/m^3$) | $H_2O$ (%) | Hole ID | From | To |
| T1P-341 | 2 | 3.2 | | | | | | | | |
| T1P-341 | 3.2 | 5 | 48.2 | 44.5 | 14.7 | 30.9 | -30.8 | T1-312 | 2.9 | 5 |
| T1P-341 | 5 | 7 | 8.0 | 12.5 | -8.7 | 3.0 | -18.9 | T1-312 | 5 | 7 |
| T1P-341 | 7 | 9 | 16.1 | 24.5 | 8.6 | 71.0 | -30.1 | T1-312 | 7 | 9 |
| T1P-341 | 9 | 11 | 20.7 | 0.2 | 12.7 | 12.1 | 18.4 | T1-312 | 9 | 11 |
| T1P-341 | 11 | 13 | -11.5 | -20.1 | -15.2 | -15.0 | 17.1 | T1-312 | 11 | 13 |
| T1P-341 | 13 | 15 | 2.2 | -6.8 | -17.6 | -6.5 | 42.6 | T1-312 | 13 | 15 |
| T1P-341 | 15 | 17 | -6.1 | -17.2 | -6.7 | -11.5 | 44.6 | T1-312 | 15 | 17 |
| T1P-341 | 17 | 19 | -2.5 | -16.6 | -10.1 | -9.6 | 51.6 | T1-312 | 17 | 19 |
| T1P-341 | 19 | 21 | 46.6 | 42.0 | 14.2 | -28.7 | 53.9 | T1-312 | 19 | 21 |
| T1P-341 | 21 | 23 | 8.5 | 7.5 | 7.1 | -26.6 | 20.0 | T1-312 | 21 | 23 |
| T1P-341 | 23 | 25 | -12.1 | -15.0 | -13.6 | -23.3 | -2.9 | T1-312 | 23 | 25.4 |
| T2P-348 | 0.8 | 3 | 32.9 | 36.5 | 14.1 | 128.5 | -83.3 | T2-318 | 1.2 | 3 |
| T2P-348 | 3 | 5 | 47.6 | 48.6 | -6.4 | 17.7 | -84.7 | T2-318 | 3 | 5 |
| T2P-348 | 5 | 7 | 21.3 | -1.8 | -6.7 | 4.6 | -46.4 | T2-318 | 5 | 7.3 |
| T2P-348 | 7 | 9 | 43.6 | 24.1 | 2.0 | -1.6 | -97.1 | T2-318 | 7.3 | 8.5 |
| T2P-348 | 9 | 11 | 8.7 | 2.0 | 13.1 | 48.8 | -95.1 | T2-318 | 8.5 | 11 |

| 2018 Twin Hole | | | Relative Percent Difference (2017:2018) | | | | | 2017 Original Hole | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Hole ID | From | To | Mn (4A AAS) | Mn (AR AAS) | Mn (XRF) | BD ($t/m^3$) | $H_2O$ (%) | Hole ID | From | To |
| T2P-348 | 11 | 13 | 81.2 | 75.9 | 4.0 | 23.0 | -98.1 | T2-318 | 11 | 13 |
| T2P-348 | 13 | 15 | 74.7 | 63.1 | 2.8 | 44.4 | -89.1 | T2-318 | 13 | 15 |
| T2P-348 | 15 | 17 | 52.4 | 35.4 | 13.4 | 6.9 | -102.5 | T2-318 | 15 | 17 |
| T2P-348 | 17 | 19 | 5.7 | -3.5 | 5.9 | 34.8 | -77.8 | T2-318 | 17 | 18.5 |
| T2P-348 | 19 | 21 | 55.7 | 45.4 | 7.4 | 24.7 | -99.9 | T2-318 | 18.5 | 19.6 |
| T2P-348 | 21 | 23 | 41.0 | 43.1 | -8.5 | 12.5 | -89.8 | T2-318 | 19.6 | 22 |
| T2P-348 | 23 | 25 | 46.1 | 36.7 | 2.4 | 35.7 | -49.9 | T2-318 | 22 | 24 |
| T2P-348 | 25 | 26.4 | 6.2 | -13.8 | 4.6 | -14.7 | -36.8 | T2-318 | 24 | 25.1 |

## 12.2 QP Opinion on Data Verification

The QP has audited the field data and drilling logs, compared digital analytical data to laboratory certificates, compiled the geological database, observed field sample collection and splitting methods, conducted independent sample verification following two site visits, and reviewed the results of a twin drill hole program. The QP is satisfied that the samples have been properly collected, the geological database accurately reflects field observations and laboratory analysis, and that the data is suitable to support mineral resource estimation.

# 13.0 MINERAL PROCESSING AND METALLURGICAL TESTING

Beginning in 1986, several metallurgical test programs have been carried out to assess the metallurgical responses of recovering manganese from tailings materials that originated from pyrite mining conducted from 1951 to 1975. During 2015 and 2018, EMN undertook further manganese recovery test programs, including semi-continuous pilot plant testing. The testwork conducted before early 2017 was discussed in the report titled *Technical Report on Mineral Resource Estimation for the Chvaletice Manganese Project, Chvaletice, Czech Republic*, released on June 21, 2018 (Tetra Tech 2018).

Since September 2017, a comprehensive test program has been conducted on 743 drill core interval samples from the 2017 drilling program. The main objectives of the test program are to verify the previous test findings and to develop and optimize a process flowsheet and conditions for producing HPEMM. A separate testwork program was conducted in 2018 to investigate the production of HPMSM, including HPMSS (high purity manganese solution), from a manganese carbonate intermediate produced from the magnetic separation concentrate and from the electrolytic manganese metal (EMM) flakes.

## 13.1 Metallurgical Test Programs

The CMP plans to recover manganese by reprocessing three adjacent tailings dumps that originated from pyrite mining conducted from 1951 to 1975.

Several metallurgical test programs have been carried out to assess the metallurgical responses of the tailings materials to manganese recovery. From 1986 to 1989, Bateria Slany, a Czechoslovak state battery producer, undertook extensive metallurgical studies and process design work, focused on the production of EMD. The latest test programs were undertaken by EMN from 2015 through 2018, including semi-continuous pilot plant testing.

Table 13-1Table 13-1 lists the recent metallurgical testing programs. Testwork conducted before early 2017 is detailed in Tetra Tech (2018) and summarized below.

The preliminary mineralogical studies indicate that manganese is mainly present as rhodocrosite and as kutnohorite, with lesser amounts as sursassite, pyrolusite, and kurchatovite (grouped as manganese-silicate minerals). The grain size of manganese-carbonates varies significantly with significant amounts occurring as liberated and middling grains. Lesser amounts are present as sub-middling and locked grains. The manganese-carbonates are mainly in complex associations with other carbonates, quartz, and feldspars, or manganese-silicate minerals. On average, approximately 80 to 85% of the manganese is present as acid-soluble manganese. Residual pyrite is also identified by the preliminary mineralogical studies.

The test results show that the mineralization responds well to high-intensity magnetic separation, compared to the other pre-concentration treatments such as flotation and gravity concentration. The investigation shows that when the magnetic field intensity is approximately 1.8 T, approximately 88% of the total manganese, or 87% for acid soluble manganese, reports to an 11% tMn concentrate. The testwork on the overall composite sample generated from the 2017 drilling program shows that approximately 84% of the manganese was recovered into a 15% tMn concentrate at a magnetic field intensity of 1.8 T.

### Table 13-1: Metallurgical Testwork Programs



TETRA TECH

| Year | Program ID | Laboratory | Mineralogy | Pre-concentration | Leaching/EW | Others |
|---|---|---|---|---|---|---|
| 2015 | - | UBC | √ | - | - | - |
| 2016 | 100301 | Kemetco | - | - | √ | - |
| 2016 | Eu Mn J0201 | Kemetco | - | - | - | √ |
| 2016 | - | Kemetco | - | √ | - | - |
| 2016 | 1656 | Met-Solve | √ | √ | - | √ |
| 2017 | - | CRIMM | - | √ | √ | - |
| 2017 | 16204-001 | SGS | √ | - | √ | - |
| 2017-2018 | - | CRIMM | √ | √ | √ | √ |
| 2017-2018 | - | UBC | - | - | - | √ |
| 2018 | - | Slon | - | √ | - | - |
| 2018 | - | Longi | - | √ | - | - |
| 2018 | - | NHD | - | - | - | √ |

Notes:

- Global ARD = Global ARD Testing Services Inc.
- Kemetco = Kemetco Research Inc.
- Met-Solve = Met-Solve Laboratories Inc.
- PMC = Process Mineralogical Consulting Ltd.
- UBC = University of British Columbia
- CRIMM = Changsha Research Institute of Mining and Metallurgy Co.
- SLon = SLon Magnetic Separator Ltd.
- Longi = Longi Magnet Co., Ltd.
- NHD = Jiangsu New HongDa Group

Preliminary acid leaching tests were conducted to investigate the metallurgical response of the manganese minerals to sulphuric acid leaching. The results produced by SGS show that at 50°C, 58 to 79% of the manganese was extracted from the Sample 10 and Sample 11 blended head sample, depending on acid addition dosage. Up to 77% of the manganese in the magnetic concentrate sample was extracted with adding 500 kg/t sulphuric acid. The magnetic separation tailings showed much better metallurgical response.

Preliminary process development studies were conducted by AMEC Foster Wheeler (now Wood plc), Canada and CINF Engineering Co., Ltd. (CINF), China. The proposed flowsheet includes the following main process circuits:

- Whole tailings material acid leaching
- Iron and phosphorous precipitations
- Leaching residue solid and liquid separation
- Residue washing with manganese and ammonia recovery
- Leaching pregnant solution purification, including heavy metal precipitation
- Manganese electrowinning, manganese metal passivation and stripping from cathode plates
- Magnesium removal from spent anolyte.

The latest test program, a comprehensive test program, began in September 2017 using the 2017 drill core samples. The testwork focused on verifying the previous findings and developing and optimizing the process flowsheet and conditions for producing HPEMM metal and HPMSM. The main testwork focused on:

- Further mineralogical studies
- Pre-concentration of manganese minerals by high-intensity magnetic separation
- Sulfuric acid dissolution of manganese minerals from the magnetic separation concentrate
- Iron (Fe) and phosphorus (P) removal and related pregnant solution and leach residue separation
- Pregnant solution purification
- Selenium (Se)-free electrowinning followed by chromium (Cr)-free passivation to produce HPEMM
- HPMSM production directly from magnetic separation concentrate or from EMM flakes without the use of fluorine containing reagents.
- Magnetic separation tailings and leaching residue dewatering and leach residue washing.

## 13.2 2017-2018 Metallurgical Test Samples

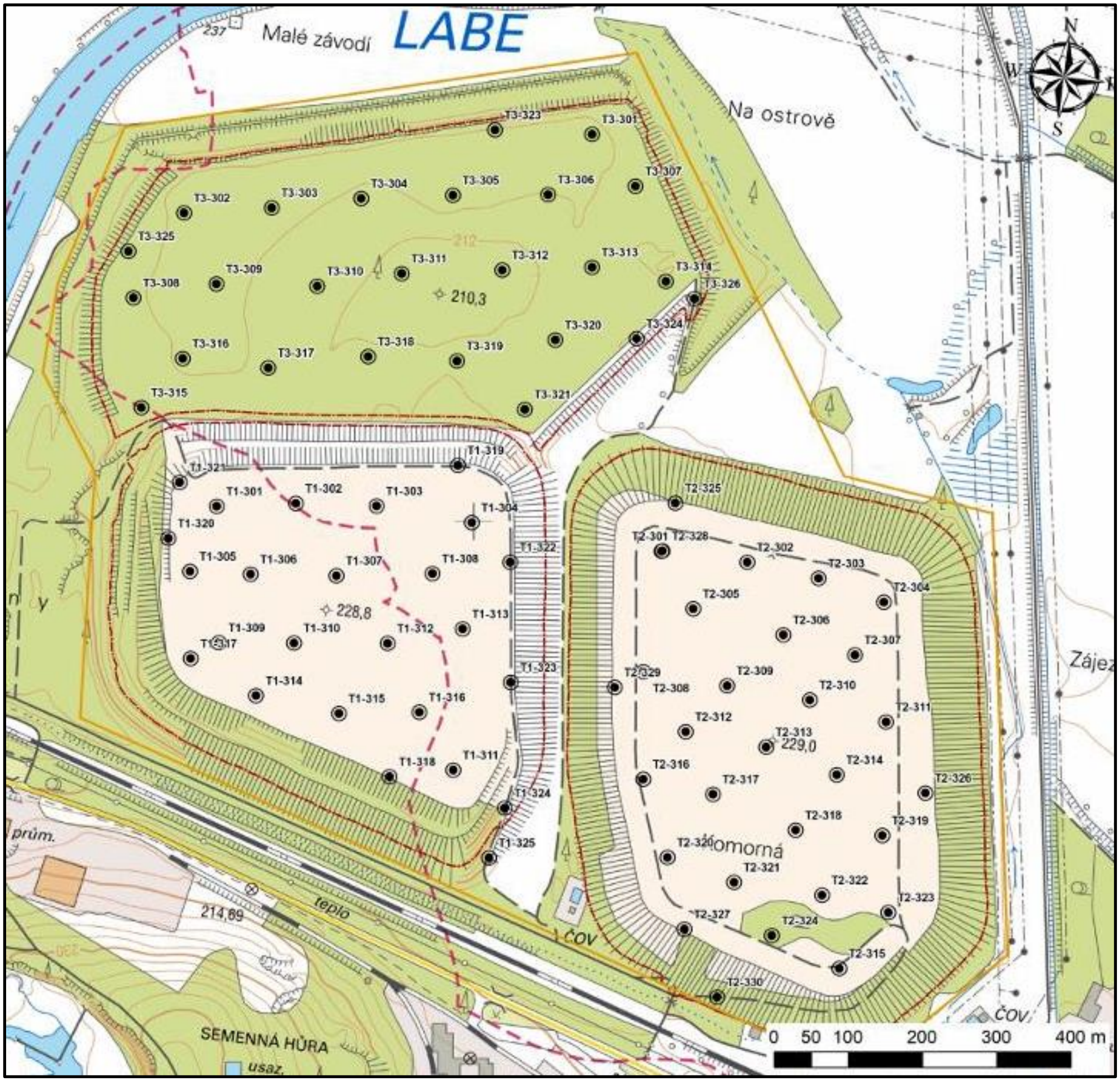
The 2017-2018 test program, which began in September 2017, used a total of 743 drill core interval samples from the 2017 drilling program. Figure 13-1 shows the metallurgical sample drillhole distribution plan. The testwork was mainly conducted by CRIMM, with some verification tests conducted by UBC and potential equipment suppliers.

A total of 25 composite samples were constructed from these drill core interval samples representing different variation characters, including spatial location variation. The test samples generated included:

- One master blend (MB) composite (large sample for test condition optimization testing and pilot plant testing)
- Two grade variation master composites (large samples for pilot plant testing)
- Three particle size variation composites
- Nineteen various spatial location samples, including three samples representing each of the three tailings piles.

The composite samples were thoroughly homogenized by blending prior to being used for the metallurgical tests. Table 13-2 details the sample identifications and related characteristics of theses composites.

**Figure 13-1: Metallurgical Sample Drillhole Location**



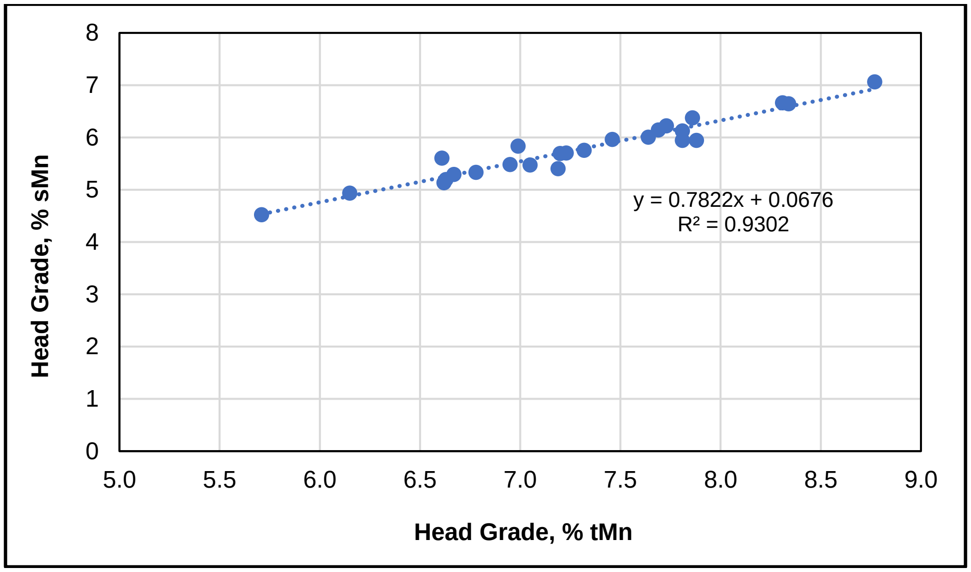
### Table 13-2: Head Assay Data – Master Composite and Variability Test Samples

| Sample ID | Individual Drill Core Samples[1] | Weight (with Moisture) (kg) | Particle Size Distribution (% passing 200 mesh)[2] | Head Grade (%)[4] | | Note |
|---|---|---|---|---|---|---|
| | | | | tMn | sMn | |
| MB | 741 | 5,261 | 79.1[3] | 7.20 | 5.69 | Master Composite |
| HF-V-P1 | 280 | 1,671 | 70.8 | 7.81 | 6.12 | High-grade/Coarse Composite |
| HF-V-P2 | 342 | 2,118 | 77.7 | 6.62 | 5.13 | Low-grade/Fine Composite |
| HF-V-VF | 251 | 371 | 96.4 | 6.61 | 5.60 | Fine Particle Size Composite |
| HF-V-VM | 252 | 367 | 81.1 | 7.23 | 5.70 | Medium Particle Size Composite |
| HF-V-VC | 237 | 354 | 43.5 | 7.81 | 5.94 | Coarse Particle Size Composite |
| HF-V-V1 | 280 | 28.5 | 70.8 | 7.73 | 6.22 | Cell #1 Composite |
| HF-V-V2 | 342 | 26.1 | 77.7 | 6.63 | 5.19 | Cell #2 Composite |
| HF-V-V3 | 119 | 25.9 | 69.6 | 7.32 | 5.75 | Cell #3 Composite |
| HF-V-V4 | 46 | 25.5 | 90.5 | 6.99 | 5.83 | Cell #1 Central Composite |
| HF-V-V5 | 59 | 25.8 | 71.2 | 7.86 | 6.37 | Cell #1 NE Composite |
| HF-V-V6 | 63 | 25.6 | 74.9 | 7.69 | 6.14 | Cell #1 NW Composite |
| HF-V-V7 | 62 | 25.4 | 53.8 | 8.34 | 6.64 | Cell #1 SE Composite |
| HF-V-V8 | 50 | 25.4 | 68.9 | 7.88 | 5.94 | Cell #1 SW Composite |
| HF-V-V9 | 124 | 26.4 | 65.6 | 7.05 | 5.47 | Cell #1 Lower Section Composite |
| HF-V-V10 | 156 | 26.4 | 75.5 | 8.31 | 6.66 | Cell #1 Upper Section Composite |
| HF-V-V11 | 117 | 26.0 | 95.4 | 6.15 | 4.93 | Cell #2 Central Composite |
| HF-V-V12 | 101 | 25.7 | 74.6 | 7.19 | 5.40 | Cell #2 North Composite |
| HF-V-V13 | 124 | 25.6 | 62.1 | 6.78 | 5.33 | Cell #2 South Composite |
| HF-V-V14 | 30 | 25.8 | 93.0 | 6.67 | 5.29 | Cell #3 Central Composite |
| HF-V-V15 | 52 | 25.5 | 63.1 | 7.64 | 6.00 | Cell #3 East Composite |
| HF-V-V16 | 37 | 25.7 | 61.2 | 7.46 | 5.96 | Cell #3 West Composite |
| HF-V-V17 | 248 | 25.2 | 79.6 | 5.71 | 4.52 | Low-grade Sample |
| HF-V-V18 | 251 | 25.9 | 74.1 | 6.95 | 5.48 | Medium-grade Sample |
| HF-V-V19 | 242 | 25.4 | 67.5 | 8.77 | 7.06 | High-grade Sample |

Notes:
- [1]Number of individual drill core samples used for the composite sample preparation
- [2]Estimated from MREs
- [3]Actual screen analysis data

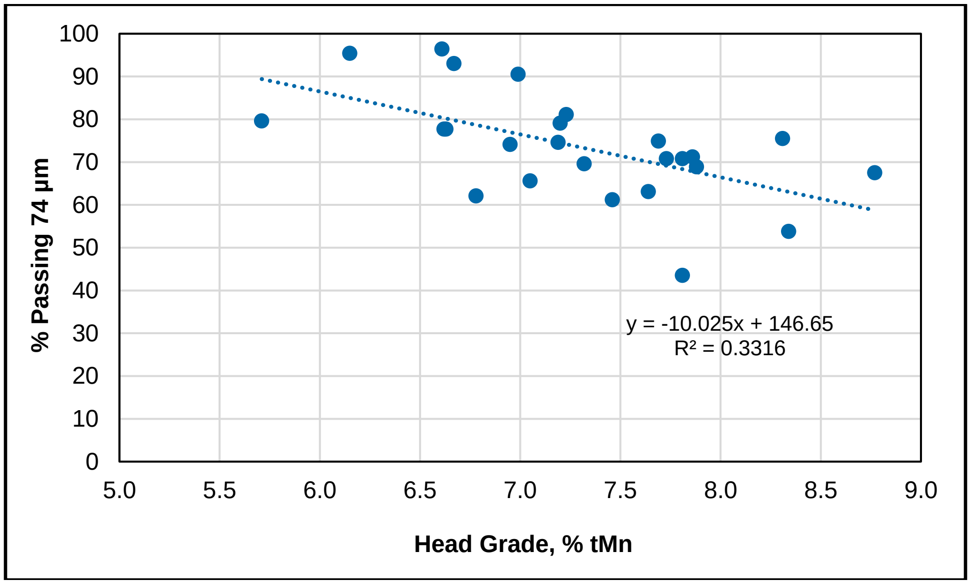
The total manganese content of these composites varies from 5.71 to 8.77% tMn. The acid soluble manganese to total manganese ratio fluctuates in a narrow range of 0.75 to 0.85. Figure 13-2 shows the relationship between total manganese and acid soluble manganese.

**Figure 13-2: Relationship Between Total Manganese Grade and Acid Soluble Manganese Grade**



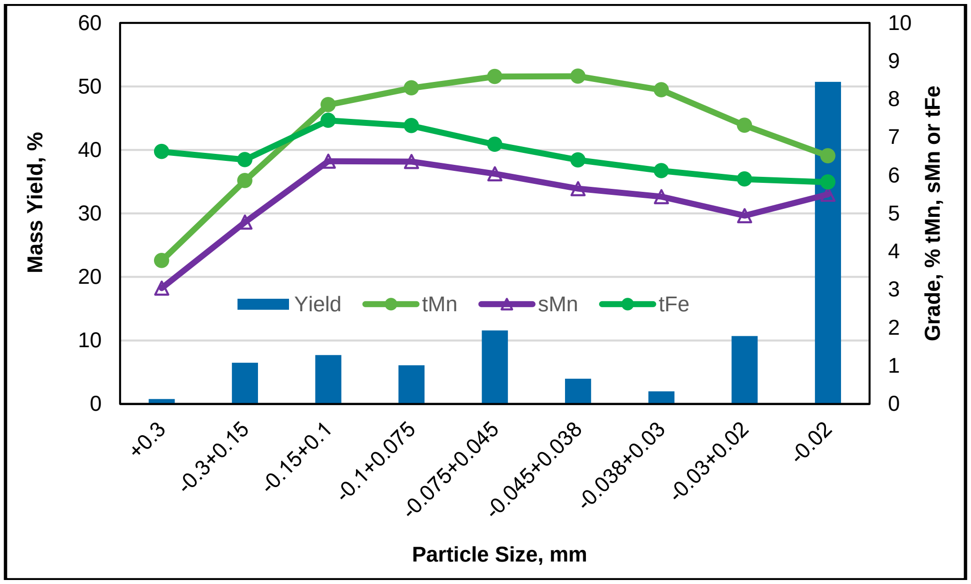

The particle size distribution of the head samples ranges from 200 mesh passing from 43.5 to 96.4% with 79.1% for the MB composite. As shown in Figure 13-3, it appears the higher-grade materials have coarser particle sizes. The

**Figure 13-3: Relationship Between Total Manganese Grade and Acid Soluble Manganese Grade**




The particle size distribution of the MB composite is shown in Figure 13-4. The mass distribution of finer than 200 mesh (74 µm) is approximately 79% while the finer than 20 µm fraction is 50.7%. The data indicates a fine particle size distribution characteristic for the sample.

**Figure 13-4: Particle Size and Metal Distributions – MB Composite**




As reported in the 2017 MRE (Tetra Tech 2018), the particle size distributions for the three CMP tailings piles are shown in Table 13-3. The weight average particle size is 72.6% passing 74 µm (200 mesh).

**Table 13-3: Particle Size Distribution Reported by 2017 Mineral Resource Estimate**

| Cell | Particle Size | | | |
|---|---|---|---|---|
| | D50 (µm) | D80 (µm) | D90 (µm) | P75 (%) |
| T1 | 55.74 | 134.77 | 197.20 | 69.44 |
| T2 | 39.98 | 106.77 | 161.38 | 74.78 |
| T3 | 45.12 | 120.16 | 187.50 | 74.04 |

## 13.3 Mineralogical Study

A mineralogical study was conducted on the MB composite sample by CRIMM. The mineralogical characteristic study included mineral component determination by optical microscope, XRD analysis, SEM, and mineral chemical phase analysis. Table 13-4 shows the manganese mineral occurrence determination results based on chemical speciation.

**Table 13-4: Mineral Phase Analysis Results – Manganese Minerals**

| Mineral Phase | Mn in Carbonates | Mn in Silicates | Mn as Manganese Oxides with High Value | Mn in Ferro-manganese Oxides |
|---|---|---|---|---|
| Content (% tMn) | 5.70 | 1.36 | 0.04 | 0.10 |
| Distribution (%) | 79.2 | 18.9 | 0.5 | 1.4 |

Manganese mainly occurs in the form of manganese carbonates, including rhodochrosite and kutnohorite. The manganese carbonates account for approximately 80% of the total manganese. The second main manganese mineral group is in the form of manganese silicates, approximately 19% of the manganese occurs in the minerals, including spessartine and occasionally rhodonite. The gangue minerals are mainly quartz, followed by feldspar, sericite/muscovite, pyrite, apatite, kaolinite, chlorite, pyroxene, hornblende, andradite, gypsum, dolomite and calcite. Pyrite is the main sulphide mineral and pyrrhotite was occasionally spotted. Metal oxides, including limonite; rutile; and ilmenite, were also observed as trace abundances. Table 13-5 shows the mineral occurrence.

**Table 13-5: Content of Main Minerals – MB Sample**

| Mineral | Manganese Carbonates | Ca/Mn Siderite | Siderite | Spessartite | Rhodonite | Mn/Fe Dolomite |
|---|---|---|---|---|---|---|
| Content (%) | 19.7 | 3.20 | 1.09 | 6.88 | 0.16 | 1.79 |
| Mineral | Calcite | Pyrite | Hematite/ Limonite | Rutile /Ilmenite | Quartz | Sericite/ Muscovite |
| Content (%) | 0.15 | 5.50 | 0.29 | 0.44 | 37.0 | 5.80 |
| Mineral | Feldspar | Apatite | Kaolinite | Chlorite | Hornblende/ Andradite | Others |
| Content (%) | 8.75 | 3.90 | 2.13 | 1.21 | 1.02 | 1.0 |

Approximately 54% of the manganese carbonates and silicates occur in the form of liberated minerals, excluding approximately 23.1% of the manganese minerals slightly/small associated with the minerals. Only 5.3% of manganese carbonates and 7.1% of manganese silicates are closely associated with the other minerals (less than 25% exposed).

In general, manganese carbonate minerals occur as $MnCO_3$-$FeCO_3$ minerals with low calcium oxide (CaO) and magnesium oxide (MgO) contents. High manganese carbonate minerals, mainly in the forms of calcium and iron rhodochrosite, are only approximately 10%. The rest are manganosiderite, ferromanganese dolomite, tetalite. Ferromanganese dolomite contains high calcium oxide and magnesium oxide concentrations. The manganese carbonate minerals are high in iron and low in manganese.

## 13.4 Metallurgical and Process Flowsheet Development Tests – HPEMM

### 13.4.1 Magnetic Separation

Comprehensive magnetic separation testwork was completed by CRIMM and other potential magnetic separator suppliers SLon and Longi.

Different equipment configurations and operation conditions were tested in an effort to optimize the beneficiation of the tailings, including:

- Grain/particle size distribution
- Magnetic field intensity
- Washing water pressure/flowrate

- Feed solid density
- Feed flowrate
- Magnetic separation machine type, vertical ring type separator (VR-type) and horizontal ring type separator (HR-type), including different flowsheet configurations.
- Separation zone gap and separation disc number (horizontal ring type separators).

According to the test results, the following separation conditions were selected as the optimized process conditions for the HR-type machines:

- Magnetic field intensity: 1.8 T
- Washing water pressure: 0.2 MPa with 14 L/min for concentrate and 9.4 L/min for tailings washing
- Feed solid density: 30% w/w
- Feed rate: 5 L/min
- Double separation discs.

Using a HR-type magnetic separator equipped with double separation discs, magnetic separation tests were conducted on the MB composite and 24 variability samples to investigate the effect of head grade, particle size, and sample original spatial location on magnetic separation performance. The test results are plotted in Figure 13-5 and Figure 13-6.

**Figure 13-5: Magnetic Separation Performance vs Head Particle Size - Variability Tests**

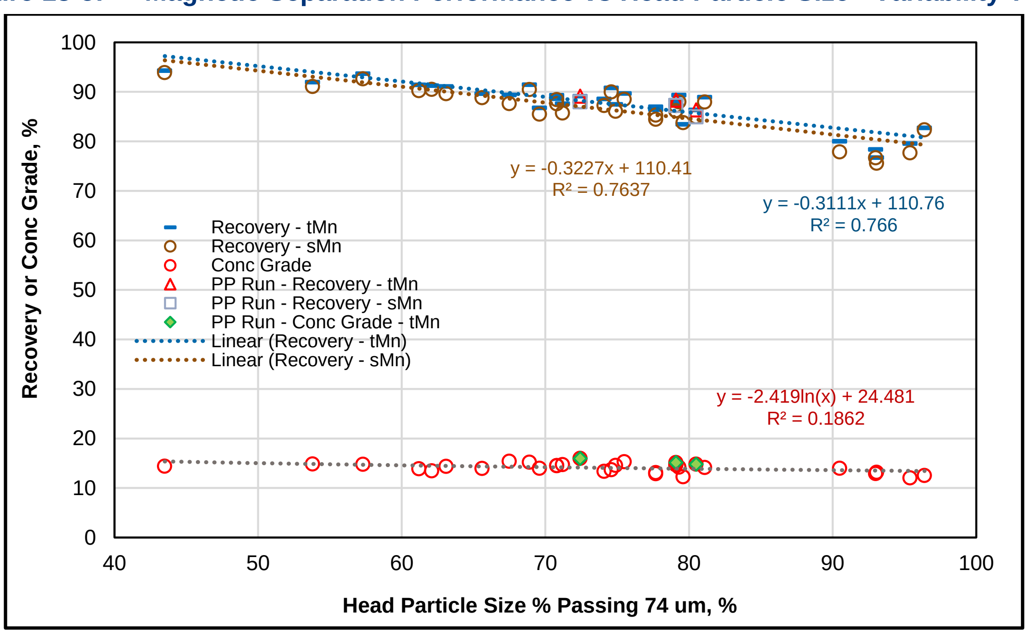
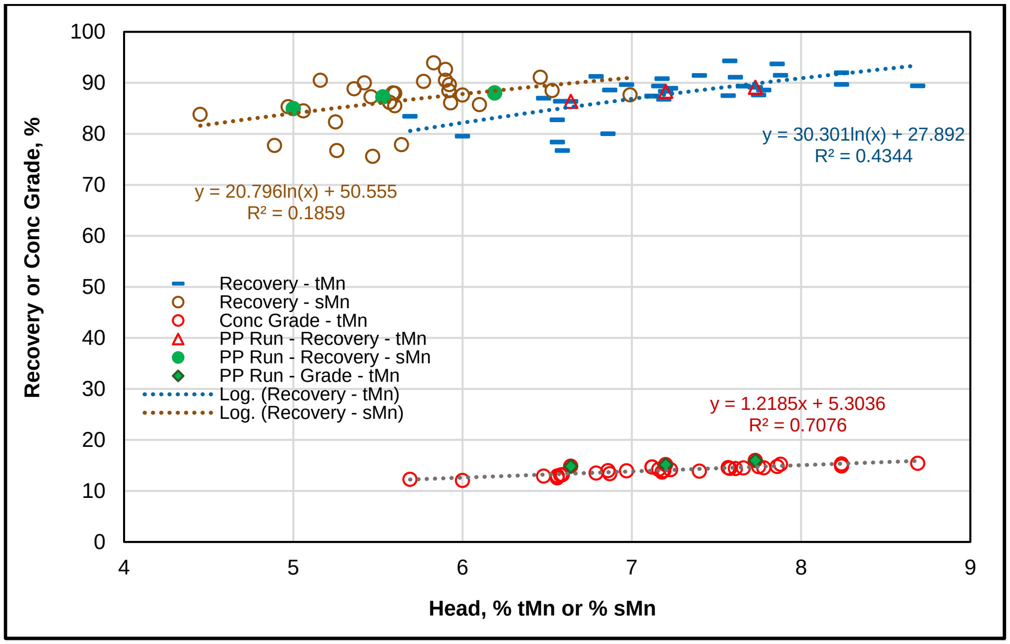


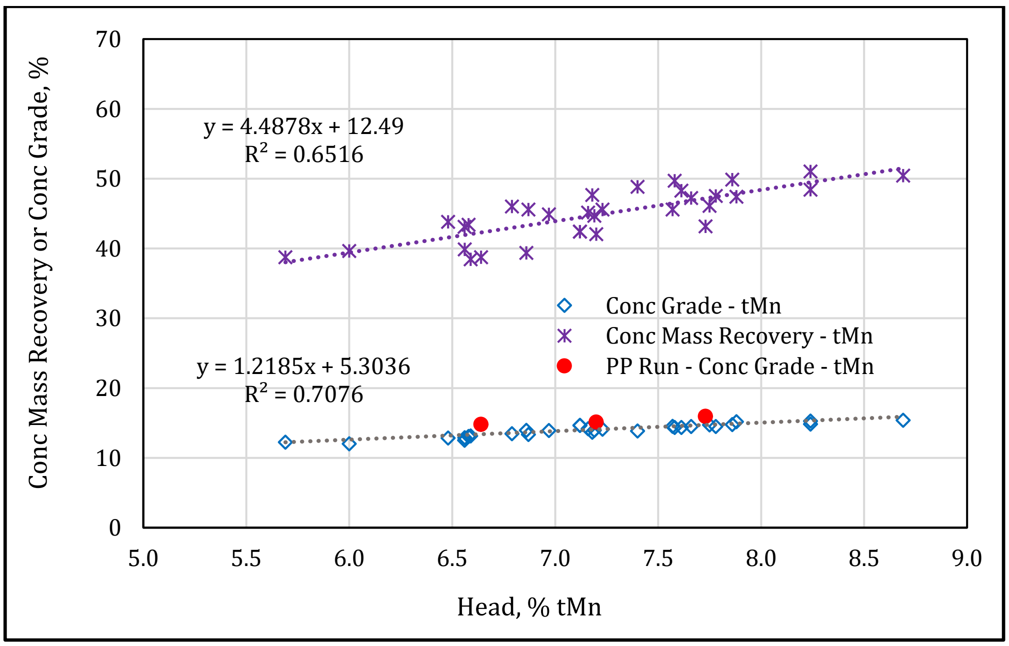
**Figure 13-6: Magnetic Separation Performance vs Head Grade - Variability Tests**




At the test conditions, both the metal recovery and the concentrate grade improve with an increase in feed grade; however, they reduce with an increase in the particle size fineness of the head samples.

The total manganese recovery varies from 76.7 to 94.3%, averaging 87.7%. With the magnetic preconcentration, on average the magnetic concentrate can improve from 7.2% tMn to approximately 14% tMn, ranging from 12.0 to 15.4% tMn.

**Figure 13-7: Concentrate Grade and Mass Recovery vs Head Grade - Variability Tests**



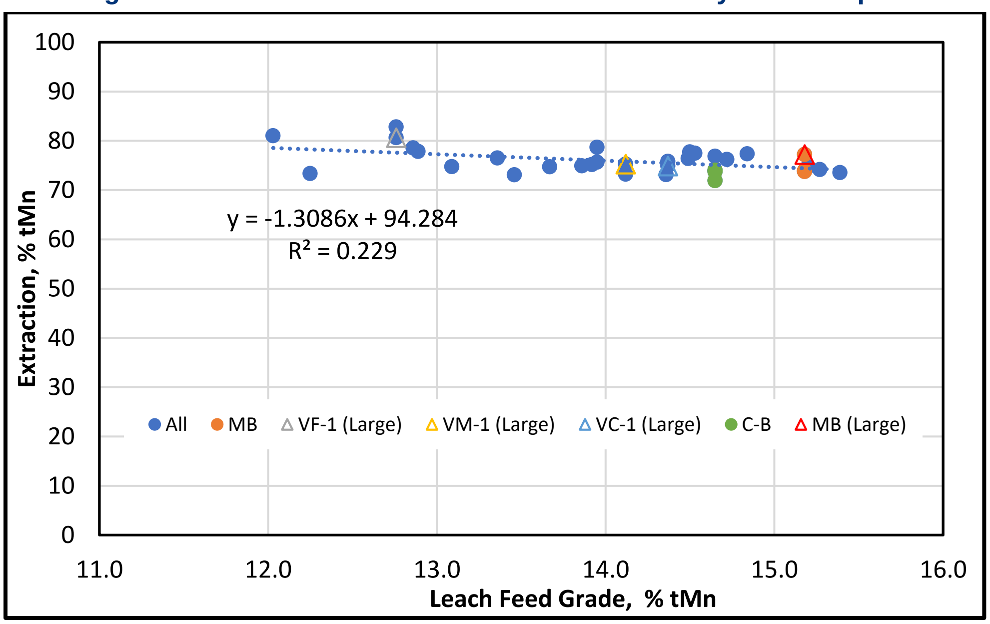
As shown in Figure 13-7, approximately 38 to 51% of the magnetic separation feed was recovered into the magnetic concentrate, or 49 to 62% of the magnetic separation feed can be rejected as a tailings product with the magnetic separation, averaging 55%. At a similar concentrate grade, more tailings material was rejected from the low head grade materials, compared to the high-grade material.

The comparison testing on the effect of the two different types of high-intensity magnetic separators on the feed grade upgrading treatment shows that in general similar metallurgical performances should be produced by the two types of the separators. The VR-type separators produced lower grade concentrates and higher manganese recoveries compared with the HR-type separators. With further optimization of the process flowsheet, the manganese-bearing material should show similar metallurgical responses to both the separators. Further tests should be conducted to optimize the flowsheet.

### 13.4.2 Acid Leaching

A comprehensive sulfuric acid leach testwork program was completed on magnetics separation concentrates produced from the MB composite and variability test samples as well as the MB composite head sample. The leach process conditions tested included acid to feed ratio, leach temperature and leach retention time. Considering the downstream iron/phosphorus removal treatment, the optimized leach conditions were determined as leach temperature at approximately 90°C with a leach retention time of 5 to 6 hours and 0.42 acid to 1.0 feed ratio. Figure 13-8 shows the acid leach test results. On average, approximately 75% of the manganese can be extracted by sulfuric acid leaching, ranging from 71.9 to 82.8%.

**Figure 13-8: Acid Leach Test Results - Variability Test Samples**




### 13.4.3 Impurity Removal and Purification

Multi-stage impurity removal tests were conducted to remove iron, phosphorous, heavy metals, and magnesium which are anticipated to have detrimental effects on HPEMM quality or downstream operation. The test results show that using the goethite method can effectively remove the dissolved iron and reduce the iron content to approximately 1 mg/L or lower. The phosphorous can be co-precipitated together with iron precipitates. The reduced iron and phosphorous concentrations in the leach solution are expected to meet the requirements for plating HPEMM.

Different heavy metal removal tests were conducted using sulfidization treatments. The reagents used included an organic chelating agent and inorganic sulfides, such as ammonium sulfide ($(NH_4)_2S$) and barium sulfide (BaS). The test results indicate that the chelating agent tested can selectively and effectively precipitate the heavy metals from the leach solution and reduce the heavy metal concentrations to approximately 1 ppm or less.

Several magnesium content control methods were studied, including fluoride precipitation, crystallization removal, and a proprietary magnesium removal treatment. The testwork confirms that the tested magnesium content control methods will be able to control the magnesium level lower than the threshold that may cause a detrimental impact on electrowinning. Further optimization investigations using the proprietary magnesium removal technology to control the magnesium levels in electrolytes is recommended.

### 13.4.4 Manganese Electrowinning

The effect of various operation conditions on manganese electrowinning from qualified solutions were investigated. The tested operation conditions included current density, cell temperature, catholyte pH, sulfur dioxide ($SO_2$) dosage, manganese contents in feed solution and in catholyte, ammonium sulfate ($(NH_4)_2SO_4$) concentration and type of cell diaphragm. The optimization tests confirm that selenium-free HPEMM can be produced from the qualified solutions produced from the magnetic separation concentrates. The optimum electrowinning conditions determined are similar to these widely used in the industry. A number of different chromium-free EMM flake passivation methods were also tested.

### 13.4.5 Ancillary Tests

CRIMM and potential equipment suppliers conducted ancillary tests, including bench leach residue washing, manganese recovery from residue washing solution, and magnetic separation tailings and leach residue dewatering. The preliminary test results show that the leach residue responds reasonably well to conventional washing processes. The dewatering test results show that the thickening and filtration rates of the leach residue and the magnetic tailings are expected to be similar to materials typically processed in the mining and minerals processing industries, including the EMM production industry.

Preliminary tests were also conducted to recover the manganese from the leach residue washing solution. The test results show that carbonate precipitation treatment can effectively recover the residual manganese reporting to the washing solution.

### 13.4.6 Pilot Plant Tests

Three semi-continuous pilot plant runs were conducted on the MB composite, high-grade composite (Composite P1) and low-grade composite (Composite P2) using the conditions developed from the batch tests. As shown in Figure 13-9, the test flowsheet is based on the batch test results and industrial operation experience. Figure 13-10 shows the key processing steps used for the pilot plant runs.

**Figure 13-9: Semi-continuous Pilot Plant Run Flowsheet – HPEMM**

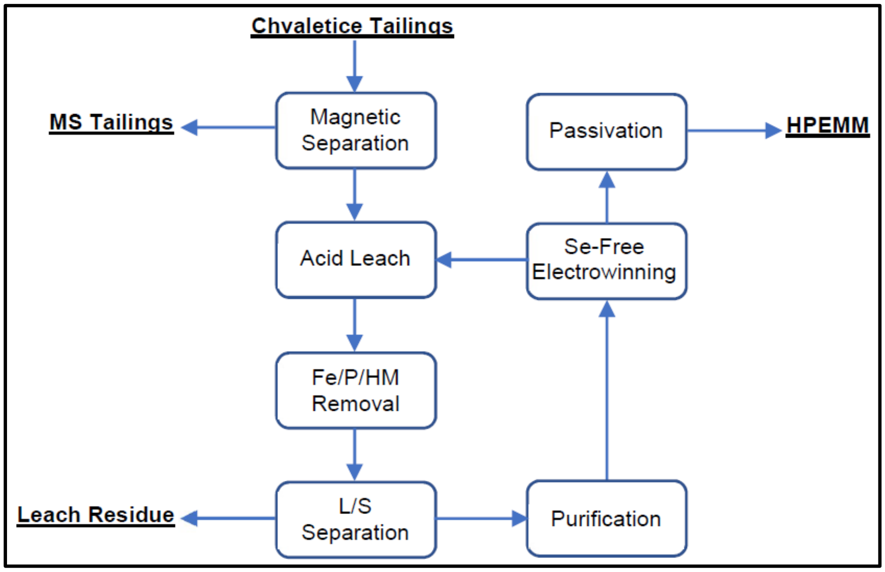
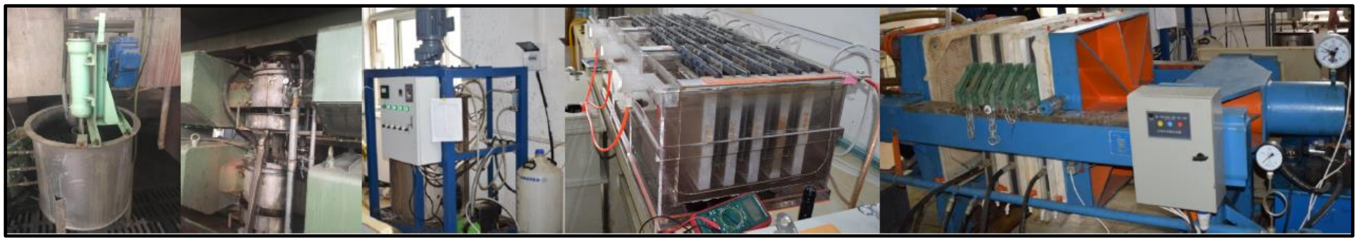



**Figure 13-10: Key Processing Equipment Used for the Pilot Plant Testing**



Magnetic separation tests were conducted using two HR-type high-intensity magnetic separators equipped with dual separation discs at a magnetic field of 1.8 T. The magnetic separation consisted of one stage of rougher separation and one stage of scavenger separation on the rougher separation tailings. Table 13-6 summarizes the test results.

**Table 13-6: Magnetic Separation Test Results - Pilot Plant Runs**

| Sample | Product | Yield (%) | Grade (%) | | | Recovery (%) | | |
|---|---|---|---|---|---|---|---|---|
| | | | tMn | sMn | Fe | tMn | sMn | Fe |
| Composite MB | Rougher Conc | 38.7 | 15.8 | 11.9 | 9.9 | 85.0 | 83.5 | 62.3 |
| | Scavenger Conc | 3.3 | 7.3 | 6.2 | 8.0 | 3.3 | 3.7 | 4.3 |
| | Rougher+ Scavenger Conc | 42.1 | 15.1 | 11.5 | 9.7 | 88.3 | 87.2 | 66.6 |
| | Tailings | 58.0 | 1.45 | 1.22 | 3.55 | 11.7 | 12.8 | 33.4 |
| | Head | 100.0 | 7.20 | 5.53 | 6.16 | 100.0 | 100.0 | 100.0 |
| Composite P1 | Rougher Conc | 40.3 | 16.5 | 13.0 | 9.6 | 85.7 | 84.2 | 62.9 |
| | Scavenger Conc | 2.9 | 9.1 | 8.0 | 8.7 | 3.4 | 3.7 | 4.1 |
| | Rougher+ Scavenger Conc | 43.2 | 16.0 | 12.6 | 9.6 | 89.1 | 88.0 | 67.0 |
| | Tailings | 56.8 | 1.48 | 1.31 | 3.58 | 10.9 | 12.0 | 33.0 |
| | Head | 100.0 | 7.73 | 6.19 | 6.17 | 100.0 | 100.0 | 100.0 |
| Composite P2 | Rougher Conc | 37.0 | 15.2 | 11.2 | 10.0 | 84.8 | 83.3 | 63.8 |
| | Scavenger Conc | 1.7 | 5.9 | 4.8 | 7.9 | 1.5 | 1.6 | 2.3 |
| | Rougher+ Scavenger Conc | 38.8 | 14.8 | 11.0 | 9.9 | 86.4 | 84.9 | 66.1 |
| | Tailings | 61.3 | 1.48 | 1.23 | 3.22 | 13.6 | 15.1 | 33.9 |
| | Head | 100.0 | 6.64 | 5.00 | 5.82 | 100.0 | 100.0 | 100.0 |
| **Average** | **Rougher Conc** | **38.7** | **15.8** | **12.0** | **9.8** | **85.2** | **83.7** | **63.0** |
| | **Scavenger Conc** | **2.6** | **7.4** | **6.3** | **8.2** | **2.7** | **3.0** | **3.6** |
| | **Rougher+ Scavenger Conc** | **41.4** | **15.3** | **11.7** | **9.7** | **87.9** | **86.7** | **66.6** |
| | **Tailings** | **58.7** | **1.47** | **1.25** | **3.45** | **12.1** | **13.3** | **33.4** |
| | **Head** | **100.0** | **7.19** | **5.57** | **6.05** | **100.0** | **100.0** | **100.0** |

The testwork produced very encouraging results, indicating the preconcentration treatment can effectively reject more than 58.7% of the magnetic separation feed and approximately double the leach feed manganese grade. On average, approximately 87.9% of the manganese was recovered with the concentrate grade of 15.3% tMn. The high-grade feed shows a better metallurgical performance.

The magnetic separation concentrates, approximately 430, 340 and 510 kg respectively, produced from the magnetic separation pilot plant campaigns, were used for the acid leaching, pregnant solution purification and selenium-free electrowinning tests. On average, manganese leach recovery was approximately 77%. The current efficiency by the selenium-free electrowinning process ranged from 59% to 65%, while the direct current electricity consumption varied from 6,200 to 6,900 kWh/t EMM. A current efficiency of 68.7% was achieved when the electrowinning circuit reached its stable state.

Figure 13-11 shows the HPEMM plates produced from the stable pilot plant runs and typical HPEMM surface micro-structures. Table 13-7 summarizes the average key circuit performance results.

**Figure 13-11: Freshly Harvested HPEMM Cathodes and Metal Microstructures from the Pilot Electrowinning Cells**

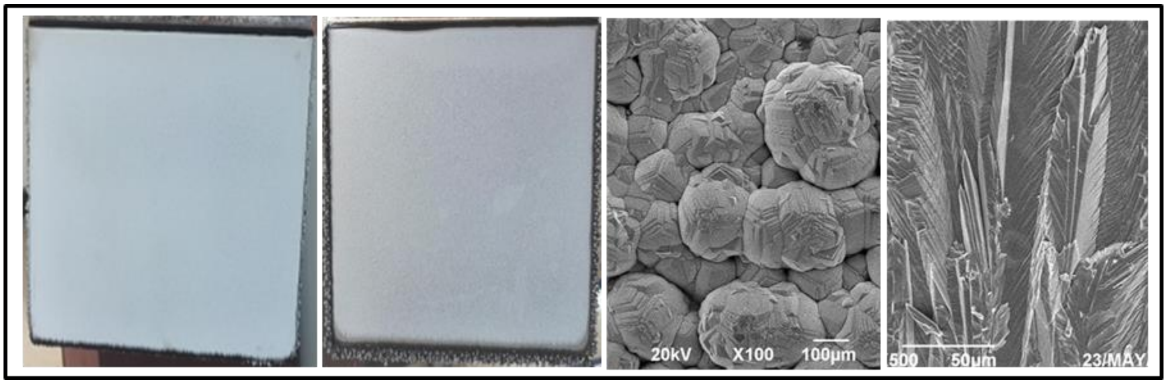


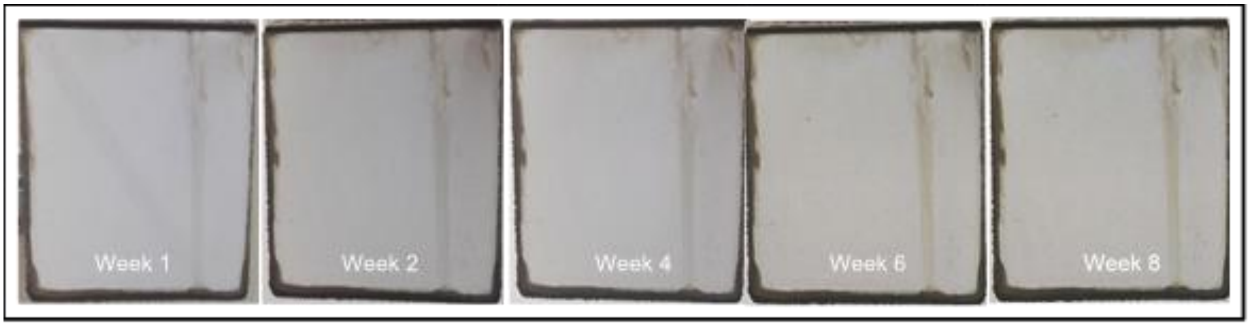

**Table 13-7: Average Leaching and Electrowinning Circuit Key Parameters – Pilot Plant Runs**

| Sample | Leach Extraction (% tMn) | Electrowinning DC Current Efficiency (%) | Electrowinning DC Power Consumption (kWh/t EMM) |
|---|---|---|---|
| Master Blend | 75.6 | 59.7 | 6,900 |
| Composite P1 | 81.8 | 64.2 | 6,200 |
| Composite P2 | 73.5 | 63.4 | 6,400 |

The first pilot plant run on the MB composite sample showed that some of impurity contents of the electrolytic manganese flakes may exceed the customer's requirements (the HPEMM's specifications are confidential and commercially sensitive). A program of further bench scale tests was conducted to optimize solution purification and electrowinning conditions. This optimization testwork significantly improved electrowinning circuit performance and electrolytic manganese product quality in the subsequent second and third semi-continuous pilot plant runs over 7 days each on composites P1 and P2. As reported by CRIMM, the total manganese contents of the manganese flakes produced were higher than 99.9% (manganese contents were calculated by subtracting impurity contents). It is anticipated that the impurity concentrations of the optimized HPEMM products will be lower than the criteria typically specified for manganese metal products. Independent lab analysis is currently being conducted to verify the certain results reported by CRIMM.

Several chromium-free cathode passivation tests were also preliminarily investigated. Compared to the conventional chromium-passivation treatment, the developed chromium-free passivation treatment was able to protect cathode surfaces from severe oxidation. The surface oxidation progress for a chromium-free passivated cathode was recorded weekly and is shown in Figure 13-12.

**Figure 13-12: Eight Week Surface Aging Observation of HPEMM Plates with Chromium-free Passivation Treatment**




## 13.5 Metallurgical and Process Flowsheet Development Tests – HPMSM

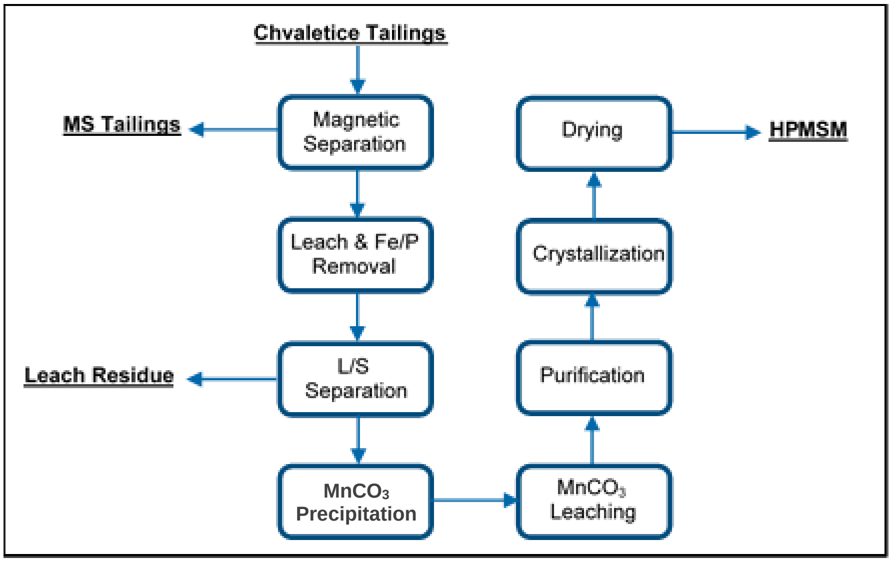
A test program was conducted to investigate production of HPMSM from the Chvaletice resource. Three different process schemes were tested separately. The test program also included producing samples of HPMSM and HPMSS for evaluation by potential customers.:

- From direct acid leaching of a manganese carbonate product produced from the leaching of magnetic concentrate to avoid the manganese electrowinning process.
- From 99.9% HPEMM (selenium and chromium free; from the Chvaletice mineral samples)
- From 99.7% EMM (selenium and chromium containing; from a Chinese EMM plant).

The proposed flowsheet for HPMSM production directly from the magnetic concentrate, as shown in Figure 13-13, includes:

- Magnetic concentration
- Concentrate acid leaching
- Iron/phosphorus removal
- Liquid/solid separation
- Manganese (II) carbonate ($MnCO_3$) precipitation from pregnant solution
- Manganese (II) carbonate redissolution by sulfuric acid leaching
- Pregnant solution deep purification
- Mother solution evaporation and crystallization
- HPMSM crystal drying.

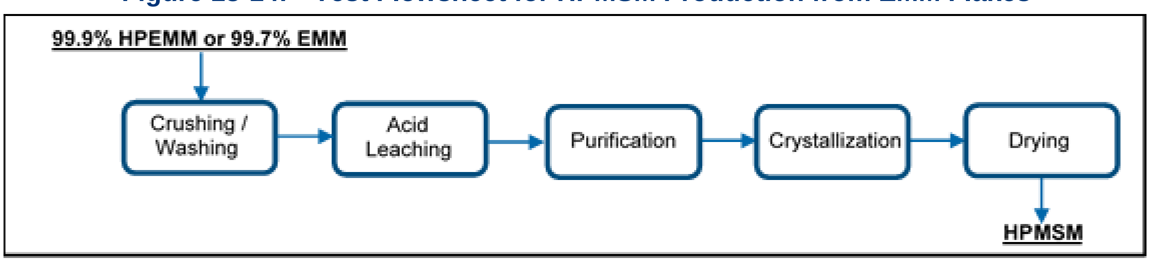
**Figure 13-13: Test Flowsheet for HPMSM Production – Directly from Magnetic Concentrate**




The test results show that high-quality HPMSM can be produced directly from the Chvaletice tailings. As identified, sodium and fluorine contents in the HPMSM produced directly from the Chvaletice tailings may exceed the requirements by some of users.

Two additional tests were conducted to produce HPMSM from two types of EMM flakes. One type of the flakes is the HPEMM (99.9% manganese) produced from the Chvaletice HPEMM pilot plant campaigns and the other type is a low quality EMM (99.7% manganese) produced from a selenium-containing EMM product produced from a Chinese EMM plant. Figure 13-14 shows the flow sheet used for the testing.

**Figure 13-14: Test Flowsheet for HPMSM Production from EMM Flakes**




The test results show that higher quality HPMSM products were produced from the two types of EMM flakes than the manganese carbonate produced from the magnetic concentrate from the CMP tailings. Compared to the HPMSM directly produced from the Chvaletice tailings material (without electrowinning), the impurity content levels in the HPMSM products from the EMM flakes improved substantially, in particular, the levels of sodium, fluorine and heavy metals. As assayed by CRIMM, the HPMSM produced from the HPEMM flakes which were generated from the pilot plant runs shows the best product quality. Independent lab analysis is currently being conducted to verify the certain assay results reported by CRIMM.

**Figure 13-15: HPMSM Produced from the Selenium- and Chromium-free 99.9% HPEMM Flakes**

## 13.6 Testwork Recommendations

Further metallurgical testing is recommended to better understand product quality, metallurgical performances, optimize processing conditions, and generate process design data using the samples produced from 2017 and 2018 drilling programs and further bulk sampling as required. The recommended testwork is detailed in Section 17.2.

# 14.0 MINERAL RESOURCE ESTIMATES

## 14.1 Basis of Current Mineral Resource Estimate

The current MRE was based on 1,485 samples taken from a total of 160 drillholes collected by EMN in the summer of 2017 and 2018. Samples were collected from three tailings cells within an above ground tailings facility. Tailings were generated from historical mining operations.

Data was analyzed in Phinar X10-Geo v.1.4.15.8, Snowden Supervisor v8.9.0.2 and Leapfrog® Geo v.4.4.2, and models were developed using Seequent Leapfrog® Geo v.4.4.2.

A MRE was developed for total and soluble manganese concentrations and is effective December 8, 2018. All technical and scientific data that is relevant to the MRE and made available to the QP up to an including the effective date has been incorporated into this report. Additional geochemical and physical parameters have been included in the modelling process to help characterize and inform interpretation of the tailings material; these variables include 18 trace and major elements, in situ dry bulk density, total moisture, and various grain size indicators. These additional parameters are not reported as part of the MRE.

## 14.2 Historical Mineral Resource Estimates

Two historical MREs reported by Bateria Slany are described in this section as they are considered relevant to the Mineral Resource presented herein. The key assumptions, parameters, and methods used to prepare the estimates is unknown and the results cannot be relied upon. Neither Tetra Tech nor EMN accepts these historical estimates as a current Mineral Resource or Mineral Reserves estimate.

Upon transfer of the Chvaletice mine from the federal government to the Chvaletice Energy Company in 1978, an estimation of “reserves” within the tailings facility, identified as “flotation sludge”, totaled 26,600,000 t at a grade of 7.09% Mn (tMn). The “reserve” was considered uneconomic, however, research into possible processing technologies was initiated.

From 1985 to 1989, Bateria Slany completed 956.3 m of drilling to characterize the physical and chemical properties of the tailings sludge, in addition to over 200 $m^3$ of trenching. Extensive testing and analysis of the samples was undertaken by Bateria Slany, who in 1989, evaluated that the tailings deposits comprised 27,557,441 t of “reserves”, containing 25,496,299 t at a grade of 5.15% leachable manganese (7.06% tMn) at a C2 category, and 2,061,143 tonnes of material at an average grade of 4.97% of leachable manganese (7.39% total Mn) at a C1 category. The definition of C2 and C1 categories references a system developed in the Czech Republic for classification of mineral “resources” and “reserves”, where resources classified as C1 are supported in greater detail than those classified as C2. The Czech system differs significantly from classification defined under the CIM Terms and Definitions as referenced by NI 43-101 and cannot be misconstrued to imply a similar level of confidence.

## 14.3 Previous NI 43-101 Mineral Resource Estimate

A MRE with an effective date of April 27, 2018, was developed for the CMP using data from samples collected by EMN during the summer of 2017. The MRE was based on 755 samples from 80 vertical Sonic drillholes completed within the three tailings cells.

The block model was classified with Indicated and Inferred Resources in accordance with CIM Definitions Standards (2014). Inferred blocks were those located around the perimeter embankments of the tailings deposits which were untested and unable to be verified as being comprised of manganiferous material. Indicated blocks were those that were able to be tested by drilling from the upper bench, with average spacing of approximately 100 m. Table 14-1 shows the previous MRE, which is superseded by the current MRE stated in Section 14.8 and should no longer be relied upon as being accurate.

**Table 14-1: Previous Mineral Resource Estimate for the Chvaletice Manganese Project, Effective April 27, 2018**

| Cell | Class | Volume ('000 m$^3$) | Tonnes (kt) | Bulk Density (t/m$^3$) | Total Mn (%) | Soluble Mn (%) |
|---|---|---|---|---|---|---|
| T1 | Indicated | 5,684 | 8,832 | 1.55 | 8.08 | 6.46 |
| | Inferred | 1,004 | 1,497 | 1.49 | 8.60 | 6.87 |
| T2 | Indicated | 6,773 | 10,567 | 1.56 | 6.86 | 5.48 |
| | Inferred | 996 | 1,648 | 1.65 | 7.90 | 6.05 |
| T3 | Indicated | 2,772 | 3,973 | 1.43 | 7.34 | 5.78 |
| | Inferred | 250 | 363 | 1.46 | 7.84 | 6.14 |
| **Total** | **Indicated** | **15,229** | **23,372** | **1.53** | **7.40** | **5.90** |
| **Total** | **Inferred** | **2,250** | **3,508** | **1.56** | **8.21** | **6.43** |

Notes:

- Mineral Resources do not have demonstrated economic viability but have reasonable prospects for eventual economic extraction. Inferred Resources have lower confidence than Indicated Resources. The estimate of Mineral Resources may be materially affected by environmental, permitting, legal, title, taxation, sociopolitical, marketing, or other relevant issues.
- A cut-off grade has not been applied. No capping has been applied.
- Numbers may not add exactly due to rounding.

## 14.4 Reconciliation with Previous Resource Estimate

Overall, the 2018 model shows a good reconciliation with the previous model. Differences between the models are largely the result of additional drilling information and modelling approaches. The most significant changes are observed in blocks located in the perimeter slopes where sampling was not conducted in 2017. The data acquired in 2018 from additional Sonic and hand-portable percussion drilling conducted within the perimeter slopes has increased the density of samples and confidence in interpolated grades in the perimeter slope.

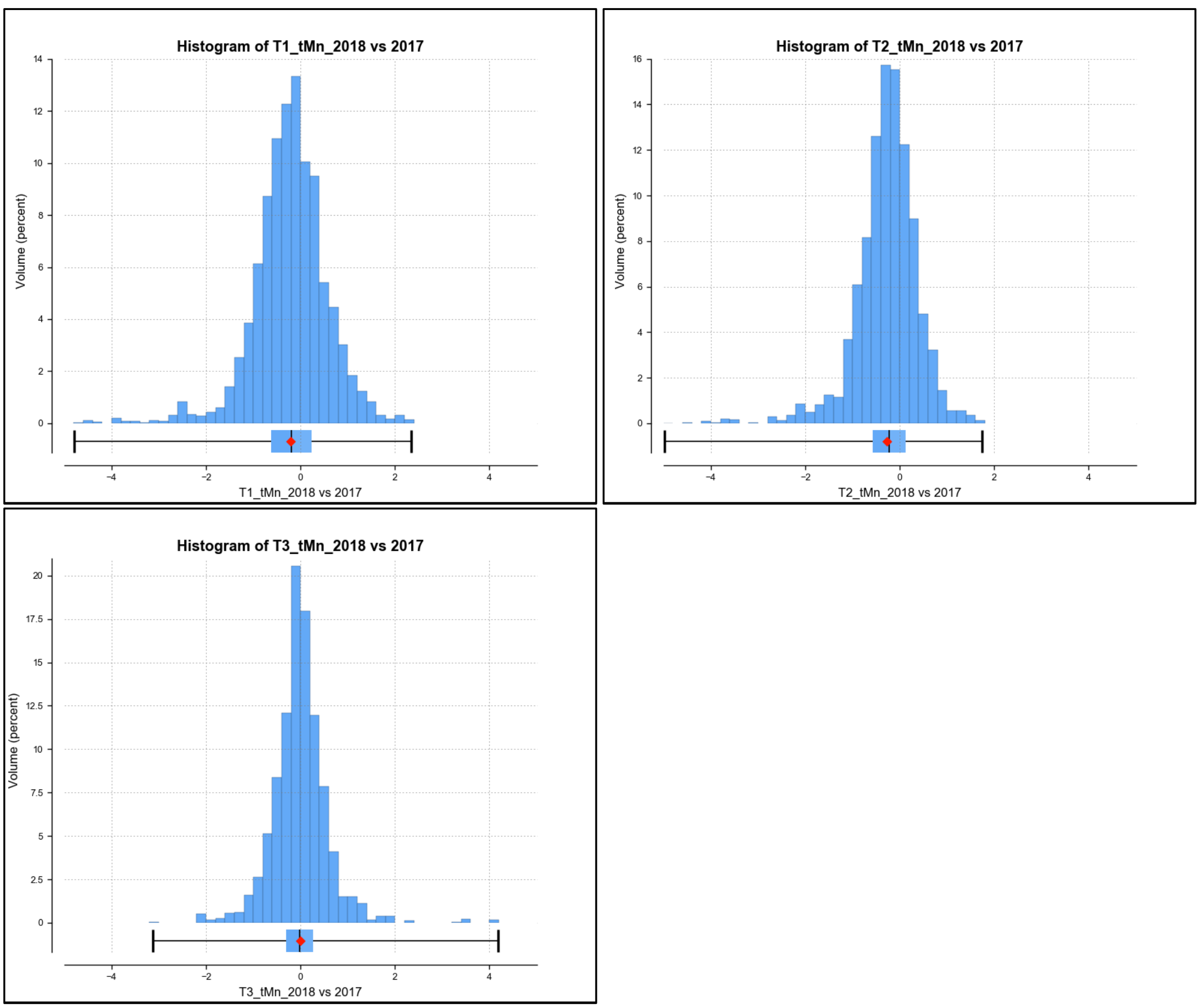
Table 14-2 lists the percentage change observed in the 2018 block model compared to the 2017 block model. It was observed that the slight changes in modelled volume and interpolated bulk density together have influenced the reported tonnages.

### Table 14-2: Percentage Change in 2018 Block Model Compared with 2017 Block Model

| Cell | Volume (%) | Tonnage (%) | Insitu Dry Bulk Density ($t/m^3$) | tMn (%) | sMn (%) |
|---|---|---|---|---|---|
| #1 | 101 | 99 | 99 | 98 | 100 |
| #2 | 104 | 101 | 97 | 97 | 98 |
| #3 | 98 | 99 | 101 | 100 | 97 |
| **Total** | **102** | **100** | **98** | **98** | **98** |

Figure 14-1 shows a histogram distribution, by cell, of the changes in total manganese block grades and Figure 14-2 depicts the location of all blocks where a decrease of more than 1% total manganese (left, red) and an increase of more than 1% total manganese (right, green) are observed.

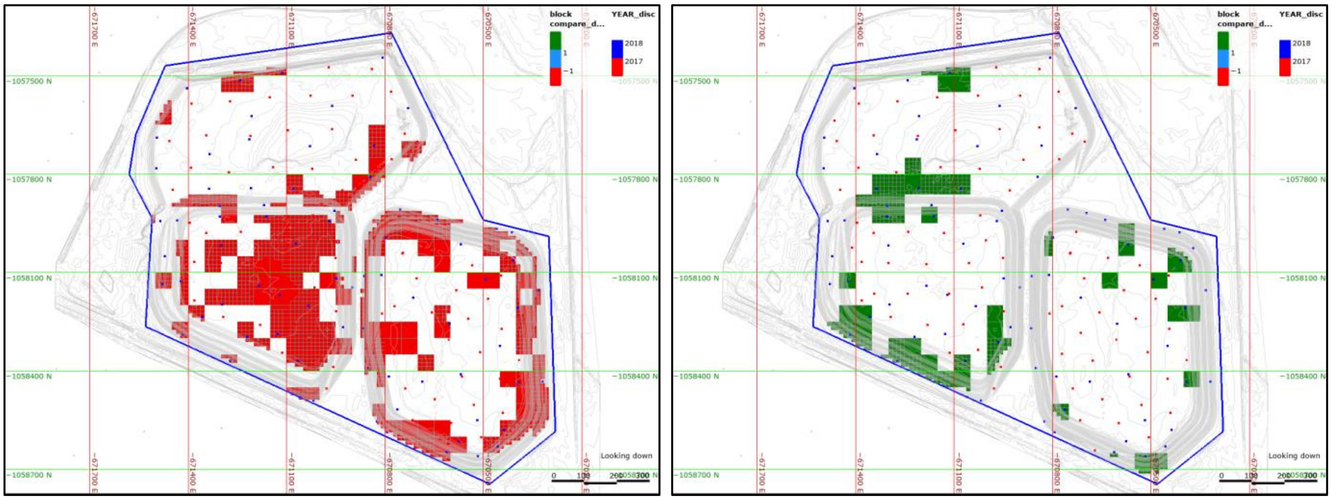
### Figure 14-1: Frequency Distributions for Change in Total Manganese Block Grades






TETRA TECH

**Figure 14-2: Plan View Showing Changes in 2018 Total Manganese Block Model Grades**



Notes:

- Left image: blocks with decrease greater than 1% manganese
- Right image: blocks with increase greater than 1% manganese

## 14.5 Input Data and Analysis

### 14.5.1 Compositing

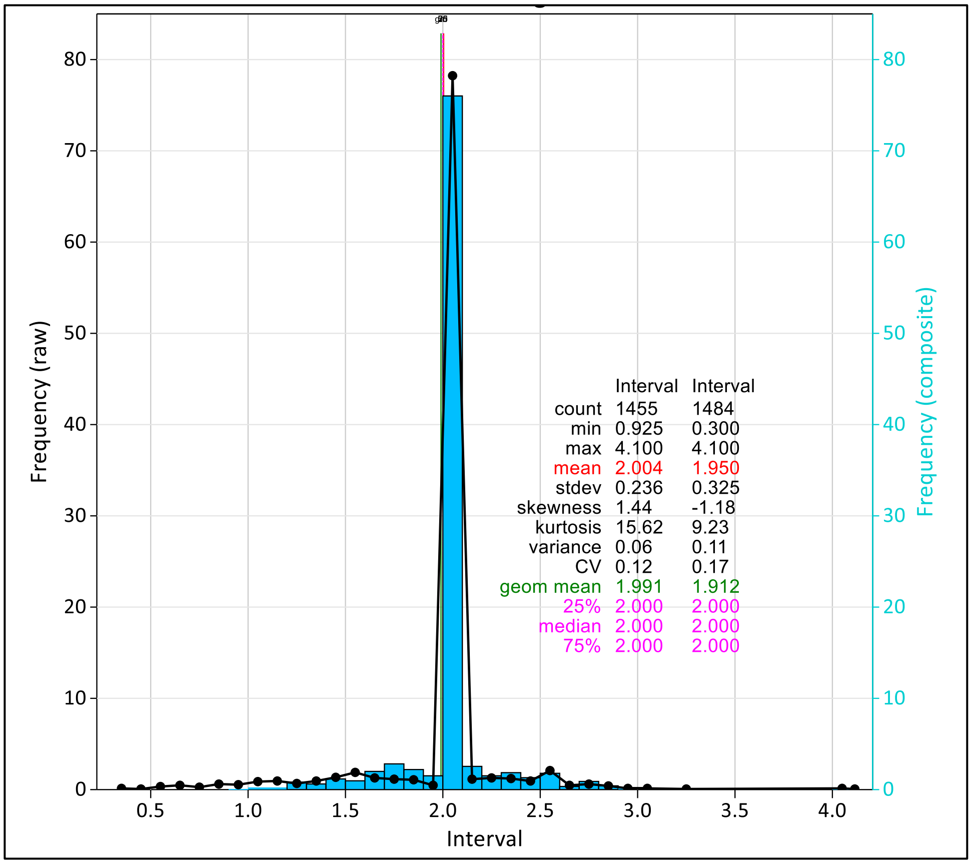
Samples were collected from drill core at an average of 2 m interval lengths equal to each drill run, or the proportion of each drill run at the top and bottom of each hole which was comprised of tailings material. The raw assay data was then composited to 2 m sample lengths. This resulted in a decrease from 1,485 raw samples to 1,456 composite samples (Table 14-3). A total of 183 composite sample lengths (12.5%) were less than 2 m, ranging from 0.3 to 1.99 m. The mean manganese values and overall sample distribution was not significantly impacted by the compositing process.

**Table 14-3: Descriptive Statistical Comparison of Raw Data and 2 m Composite Data for Total Manganese**

| Dataset | Count | Mean | Geometric Mean | Standard Deviation | Coefficient of Variation | Minimum | Maximum |
|---|---|---|---|---|---|---|---|
| Raw Data | 1,484 | 7.261 | 6.982 | 1.722 | 0.24 | 0.186 | 12.32 |
| 2 m Composites | 1,455 | 7.328 | 7.160 | 1.519 | 0.21 | 1.371 | 11.69 |

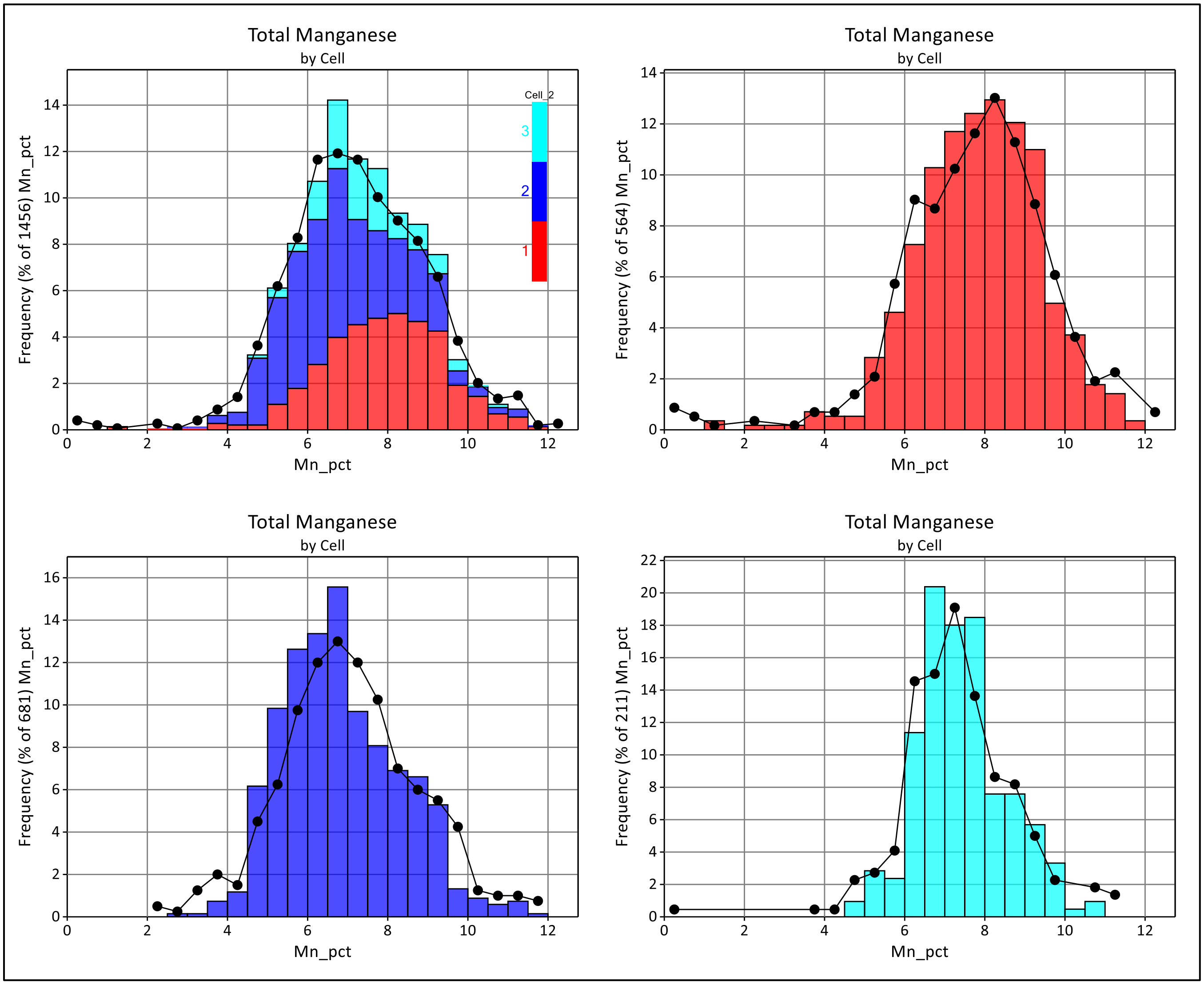
In Figure 14-3, the predominant sample length is 2 m, with range from 0.6 to 4.0 m with standard deviation of ±0.3 m.

**Figure 14-3: Frequency Distribution Comparing Raw and Composite Sample Lengths**




Histogram comparison of the raw assay values versus the composited assay values show excellent reproduction and confirm that no bias has been introduced in the compositing procedure (Figure 14-4).

**Figure 14-4: Frequency Distribtution Comparison Between Raw Assay (Black Line) and 2 m Composites (Coloured Bars) for Total Manganese Concentrations by Cell**




## 14.5.2 Capping Analysis

Manganese grades are normally distributed with low to negligible positive skew. It was observed that values occurring on the high and low ends of the grade distribution tails were located within zones of similar grade trends. It was interpreted that these grades are representative of the natural variance within the deposit and no grade capping was applied.

## 14.5.3 Variogram Assessment

Variogram analysis was undertaken for each cell using the 2 m composite drillhole sample data using Snowden Supervisor v.8.9.0.2. Downhole variograms used a lag of 2 metres to determine if a nugget ($C_0$) exists for total and soluble manganese, and horizontal variograms used a lag of 40 m to assess reasonable search radius parameters. These parameters were used only as a guide since kriging was not selected as the interpolation method for the

MRE. The modelled nugget values were identified ranging from 0.05 to 0.38 for total manganese and from 0.05 to 0.40 for soluble manganese. Horizontal major and semi-major axis ranges were defined using spherical models with two internal structures. The first spherical structure of the major axis had ranges between 137 to 188 m and the second structure from 166 to 298 m for total manganese. Soluble manganese ranged between 73 and 135 m for the first structure and between 276 and 549 m for the second structure. Minor axis ranges were between 7 and 17 m. (Table 14-4).

### Table 14-4: Summary of Major and Minor Axis Variogram Parameters

| | Nugget | Major Structure 1 | Major Structure 2 | Minor Structure |
|---|---|---|---|---|
| **Cell #1** | | | | |
| Total Mn | 0.20 | 137 | 249 | 17 |
| Soluble Mn | 0.05 | 73 | 276 | 7 |
| **Cell #2** | | | | |
| Total Mn | 0.38 | 188 | 298 | 9 |
| Soluble Mn | 0.40 | 135 | 549 | 17 |
| **Cell #3** | | | | |
| Total Mn | 0.05 | 165 | 166 | 6 |
| Soluble Mn | 0.23 | 112 | 331 | 7 |
| Model | n/a | 150 | n/a | 8 |

Drillhole and corresponding assay data within the model is spaced at approximately 75 m on the horizontal plane. Experimental variogram analysis had moderate to good fit for spherical models, with the 2018 drilling allowing for greater short-range variability analysis than the 2017 dataset alone. It was concluded from the variogram analysis that some nugget exists related to the manmade nature of the tailings deposits. A range of 150 m for the major and semi-major axes, and 8 m for the minor axis was selected as an overall range for all cells within which spatial continuity exists for the total and soluble manganese grades.

**Figure 14-5: Major Axis Variograms for Total Manganese, Normal Scores, by Cell**

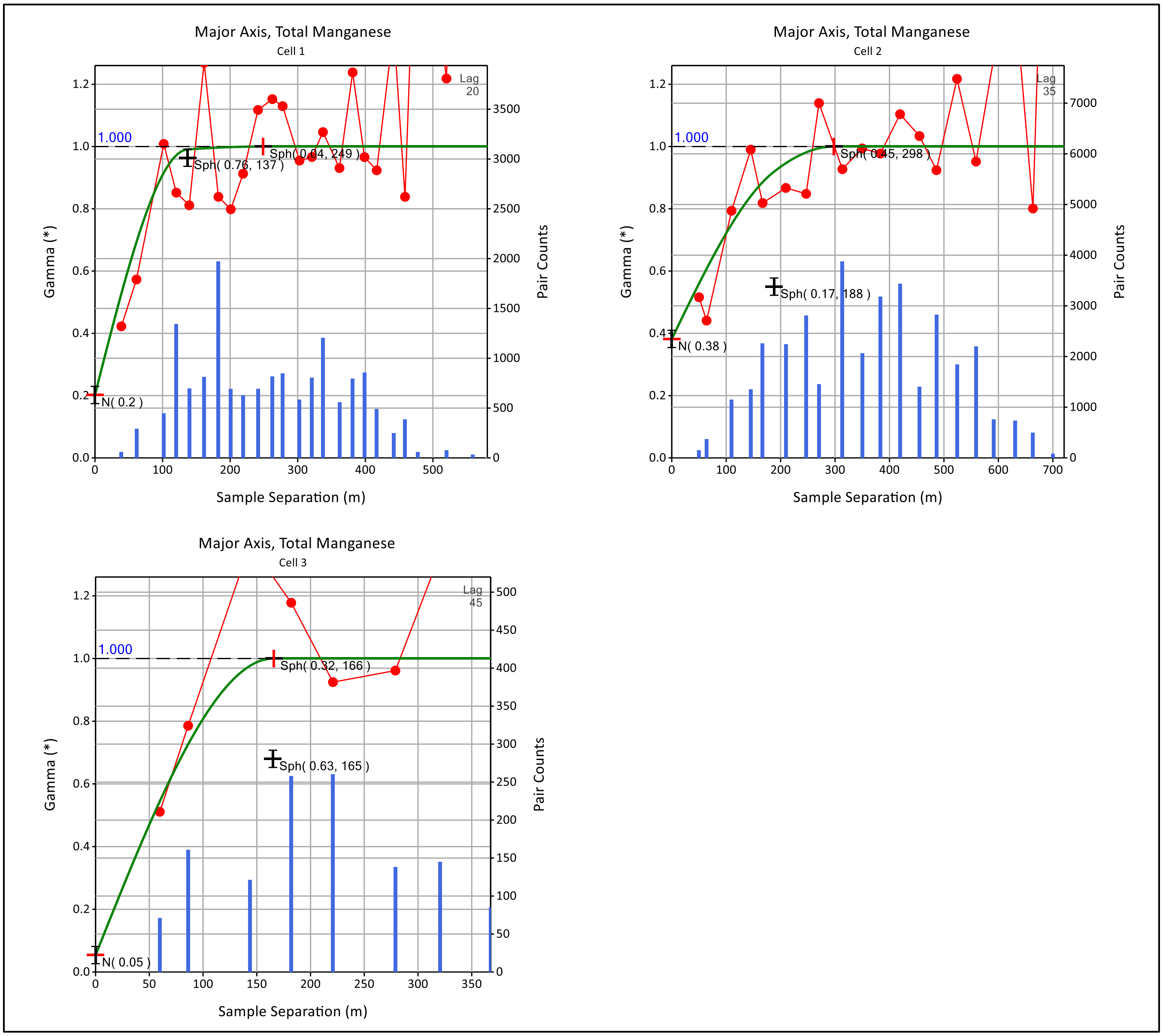
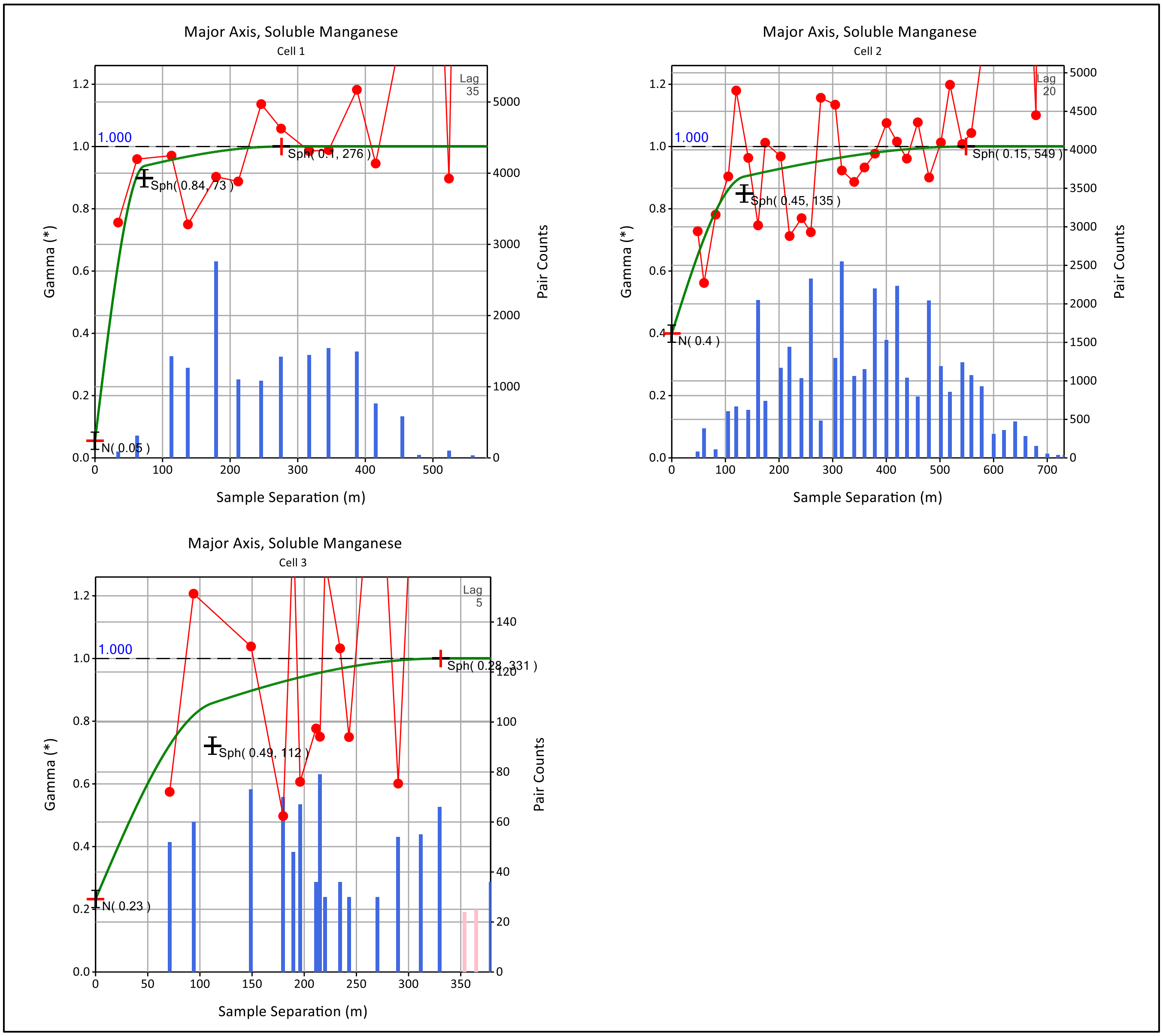


**Figure 14-6: Major Axis Variograms for Soluble Manganese, Normal Scores, by Cell**




## 14.5.4 Search Parameters

Interpolation searches were performed using inverse distance squared (to third exponent) for manganese grades, nearest neighbour for particle size indicators, and the spheroid model in Leapfrog® for supporting geochemical values. These methods were selected to minimize bias within the local search neighbourhood. All searches were performed with major and semi-major axes orientation on the horizontal plane, and the minor axis on vertical.

### 14.5.5 Block Size Determination

A sub-block model was used to determine volumes of the Chvaletice tailings deposits, allowing for higher resolution with smaller block sizes around the perimeter slopes of the model. Parent block size for the model was determined based on drillhole spacing and de-clustered mean analysis. Using the de-clustering cell size optimization utility in GEOVIA GEMS™, it was determined that a 50 m cell size was the optimal size (Figure 14-7). The model was established using a parent cell size of 50 m by 50 m by 4 m, and minimum sub-cell size of 12.5 m by 12.5 m by 4 m.

Table 14-5 lists the de-clustered mean values for total and soluble manganese concentrations. The sub-block model was established with overall model dimension as listed in Table 14-6.

**Figure 14-7: De-clustered Mean Versus Cell Size**

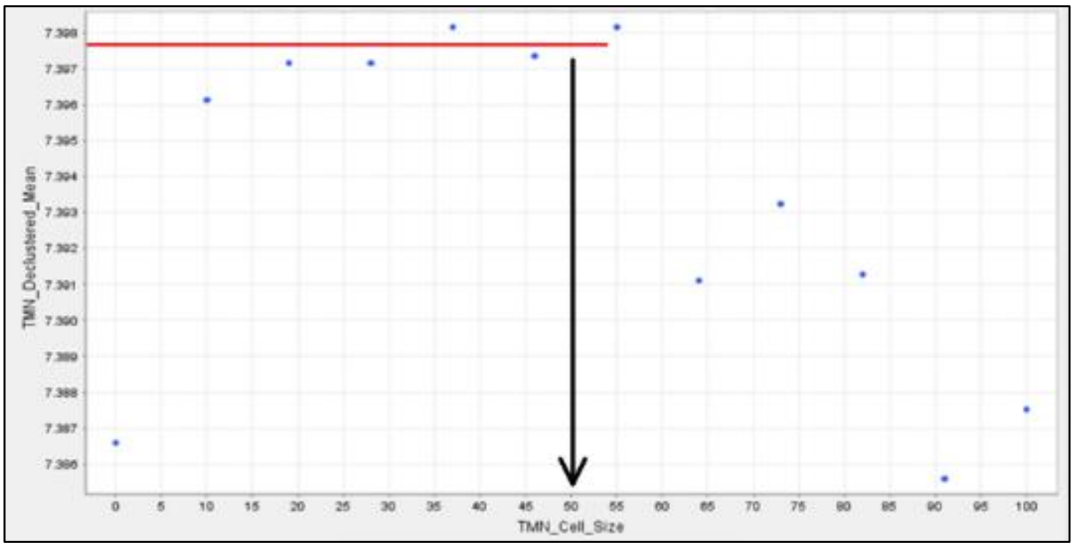


**Table 14-5: Block Size Determination De-clustered Manganese Concentrations**

| Dataset | Value | Count | Mean | De-clustered Mean |
|---|---|---|---|---|
| T1 | tMn | 564 | 7.86 | 8.01 |
| | sMn | - | 6.40 | 6.40 |
| T2 | tMn | 681 | 6.85 | 6.62 |
| | sMn | - | 5.44 | 5.19 |
| T3 | tMn | 211 | 7.43 | 7.42 |
| | sMn | - | 5.65 | 5.63 |

**Table 14-6: Block Model Dimensions (S-JTSK Coordinate System)**

| Model | Origin_X | Origin_Y | Origin_Z | Size_X | Size_Y | Size_Z | Blocks_X | Blocks_Y | Blocks_Z |
|---|---|---|---|---|---|---|---|---|---|
| Parent | -671,600 | -1,058,750 | 240 | 50 | 50 | 4 | 27 | 28 | 23 |
| Sub-block | - | - | - | 12.5 | 12.5 | 4 | - | - | - |

### 14.5.6 Bulk Density Estimation

Mineralogy, grain size, and the method used for deposition of historically processed material as a slurry into the tailings deposits has a significant influence on the final in situ dry bulk density of the tailings material. Water content, particle size gradations, mineral density composition, and degree of compaction from overlying material all contribute to grain settlement and packing. Recovery of the tailings material from the Sonic drill core tube was conducted to minimize the disturbance of in situ material conditions. In practice, controlled core recovery is nearly impossible for saturated tailings and very challenging in under saturated material. Slumping and plasticity of the material caused some variability in the estimated core recoveries.

Core recovery values were collected during field logging along with the moisture and mass measurements collected from laboratory sample processing were used as the basis for calculating in situ bulk density for the tailings material.

Idealized core volumes for the one metre sub-samples were factored for core volume recovery and then back calculated to the full 2 m core run volume before being factored again by 0.25 to represent the volumes of 25% split assay samples that were sent to SGS.

All samples were weighed as wet samples on receipt at the lab, then again following split extraction for the PSA-LD samples. They were then dried at 105°C until no additional moisture loss was measured. In situ dry bulk density was calculated based on the wet mass of the assay sample received at SGS prior to extraction of the PSA-LD sample split, and then was factored to account for moisture loss during the PSA-LD sample preparation and from drying the final sample to estimate the dry mass of the assay sample as received. This dry mass was then factored over the sample volume estimated to have been received at the lab, using the following formula:

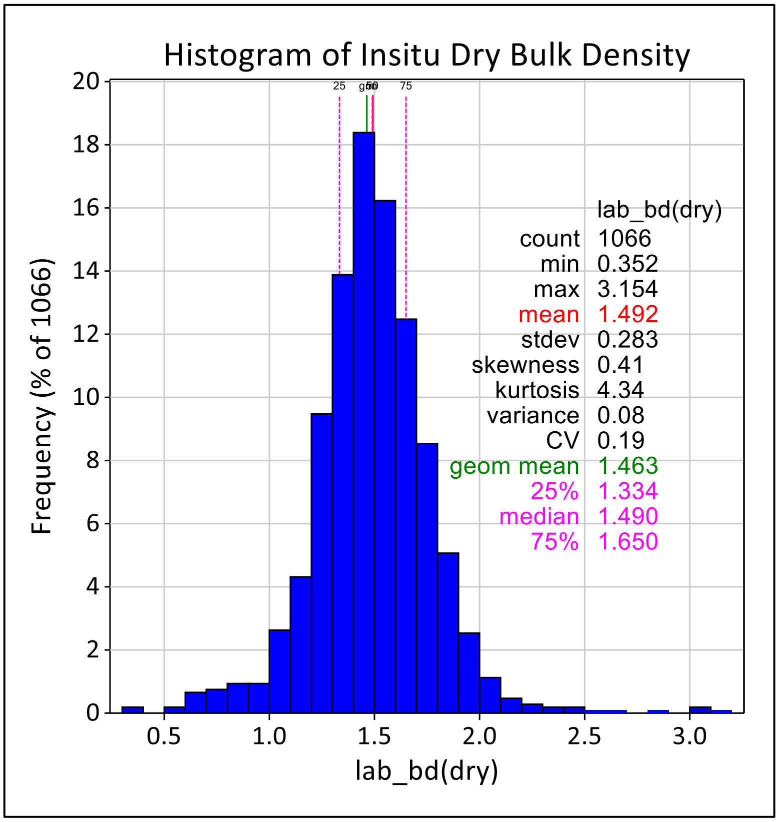
$$Insitu\ Dry\ bulk\ density = \frac{(Wet\ mass\ of\ sample\ as\ received) - (Mass\ of\ Total\ Moisture\ Content)}{Assay\ sample\ volume, measured\ in\ field}$$



TETRA TECH

In situ dry bulk density values for individual samples, as calculated from field and laboratory data, range between 0.35 and 3.154 t/m$^3$, with 95 percent probability interval of 0.87 to 2.01 t/m$^3$, and average of 1.49 t/m$^3$ ±0.017 t/m$^3$ (95% CI) as depicted in the frequency distribution shown in Figure 14-8. Immeasurable moisture loss in the field and visual estimation of core recovery, in addition to mineralology and grainsize, influences the wide range of in situ dry bulk density. The in situ dry bulk density values were composited to 2 m and included as variables in the final model interpolation. This result in spatially unique values applied to the block model.

**Figure 14-8: Frequency Distribution of Calculated In Situ Dry Bulk Density, Represented On Raw Sample Intervals**



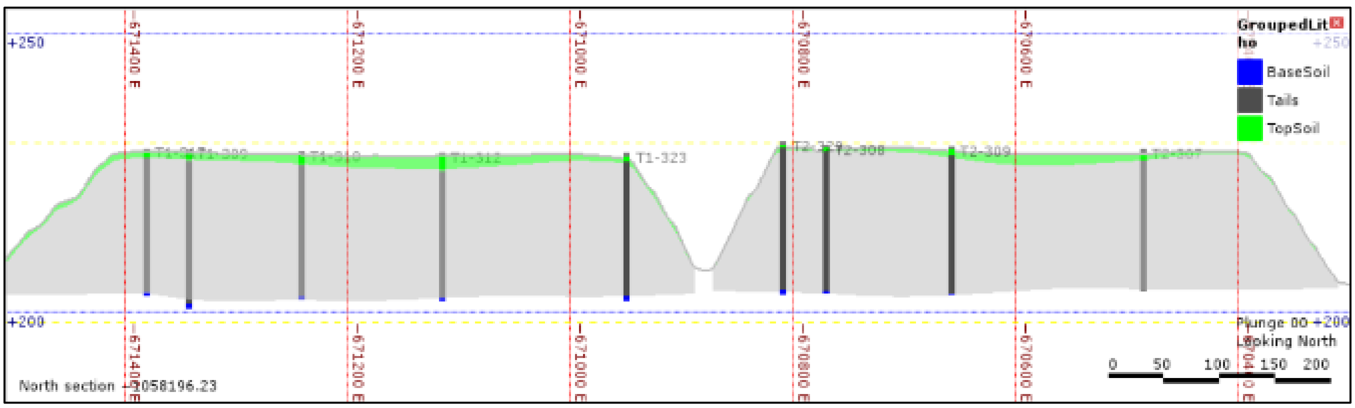

## 14.6 Volume Estimations

Volume estimates for the cells were developed using the topographic DEM to constrain upper surfaces and deposit perimeters, and logged drill hole data were used to constrain the lower boundary of tailings with original ground soils. A simplified lithological model was developed for each cell to identify topsoil, tailings and subsoil. The volume of material defined as tailings was then used to confine all numerical models and estimates reported for each cell under the MREs. Table 14-7 lists the volume estimates for tailings material contained in each cell and Figure 14-9 shows a typical section through Cells #1 and #2 with the three simplified lithologies identified.

**Table 14-7: List of Estimated Volume of Tailings within Each Cell, Constrained by Topography**

| Cell | Surface Area | Topsoil Volume ($m^3$) | Tails Volume ($m^3$) |
|---|---|---|---|
| #1 | 326,400 | 284,870 | 6,720,300 |
| #2 | 393,200 | 365,820 | 8,035,200 |
| #3 | 313,200 | 167,030 | 3,035,900 |
| **Total** | **1,032,800** | **817,720** | **17,791,400** |

**Figure 14-9: Typical Section Looking North Through Cells #1 and #2 Showing the Simplified Lithology and Tailings Volume Used for Deposit Modelling (5x Vertical Exaggeration)**




## 14.7 Geological Interpretation for Model

The mineralization found in tailings at the CMP was deposited by manmade processes following grinding and flotation processes of black pyritic shale and is therefore not characteristic of a traditional bedrock hosted manganese deposit. The material can be physically characterized as a compacted soil, with varying degrees of particle sizes from clay to coarse sand. Mineralogy has been quantified by limited XRD analyses, with resulting manganese bearing mineral phases identified as rhodochrosite (and other manganese-bearing carbonates), spessartine (and other manganese-silicates); quartz was the main gangue mineral, and pyrite was the main sulphide mineral.

Deposition of tailings materials was episodic over the life of the historical mining operations. The material was deposited from processed materials with mixed particle sizes suspended in slurry. The deposits are characterized by the broad lateral (i.e., horizontal to sub-horizontal) extent of particle segregation as the slurry flooded the tailings facility. Thin beds of sediment would have been deposited and flowed laterally outwards with a particle gradation from coarse to fine away from the point of discharge. It is interpreted that grain size and moisture content may have more similarity with materials in a vertical sense and have more variability in a horizontal sense. It has been demonstrated by metallurgical testwork that a weak relationship exists with increasing manganese grade and with increasing particle size. However, variogram assessment has indicated that the best spatial continuity, in a statistical sense, occurs laterally within the horizontal plane. All searches for block model interpolation were undertaken relative the horizontal plane using a relatively flat elliptical search.

Local beds, or lenses, of oxidized tailings material were observed in core logging to exist along the upper, or outermost surfaces, and infrequently at depth within the deposit, with thicknesses typically ranging at less than 0.5 m. These zones are due to oxidized pyrite and other sulphide minerals contained in under saturated tailings that were exposed to air for long durations, representing periods of hiatus or where local beaching occurred within the tailings at a distance to the point of deposition. These zones have not been modelled in detail and are considered to be insignificant in the broader sense of the deposit. For the purpose of the MRE, all tailings materials are considered to be primary, or unoxidized, materials.

A deposit model was developed using Seequent Leapfrog® Geo v.4.4.2 to represent the volume of tailings within each facility, and to further subdivide the tailings into domains representing ranges in elemental concentration, particle size and in situ dry bulk density.

Each cell was first segmented into lithology volumes for topsoil, tailings and subsoil, based on descriptions in the field logs. The tailings unit for each cell was applied as an external shell to constrain the grade, particle size, moisture and bulk density models.

The particle size model was based on data from the laser diffraction particle size analysis. The grain size distribution was simplified to percentages of clay, silt, sand, and gravel using both European and North American soil classification standards. Additionally, the data was simplified to single value indices to characterize the distribution. Particle diameters measured for each decile of the distribution characterizes how the particles are statistically distributed throughout the deposit, where D50 represents the particle size of the 50$^{th}$ percentile (or median value), and D80 represents the particle diameter at the 80$^{th}$ percentile. Alternatively, the distribution was also characterized by the percent of the sample which passes a defined screen mesh, such as P75 which describes the percentage of the sample which passes nominal screen size of 75 µm (i.e., 200 mesh). Table 14-8 lists the average value for these indices as modelled, by cell.

The moisture model was based on moisture data measured by SGS labs from mass measurements on receipt of the sample and after drying, after applying a correction for mass loss from the PSA-LD sample split.

**Table 14-8: List of Average Values for Modelled Variables Compared, Listed by Cell**

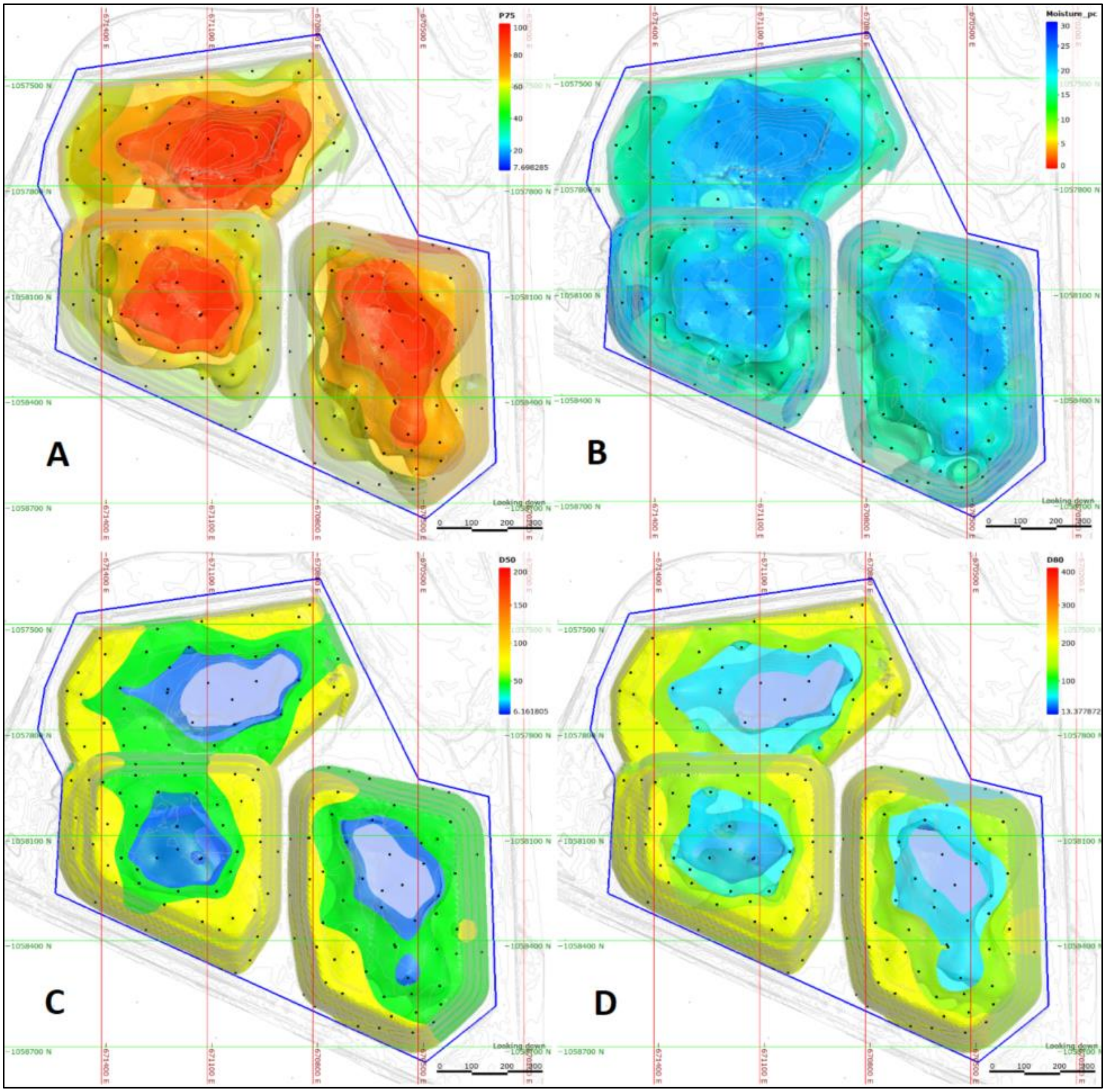
| Cell | Particle Size | | | | Moisture (%) |
|---|---|---|---|---|---|
| | D50 (µm) | D80 (µm) | D90 (µm) | P75 (%) | |
| T1 | 64.14 | 152.90 | 219.01 | 66.48 | 21.20 |
| T2 | 49.46 | 125.38 | 185.02 | 71.29 | 21.46 |
| T3 | 66.96 | 157.08 | 230.42 | 67.48 | 20.68 |

An additional 18 elemental concentrations were interpolated into the block model to help inform metallurgical studies and mine planning exercise (Table 14-9). These elements are not included as part of the Mineral Resource statement.

### Table 14-9: Additional Elements Interpolated into Block Model

| Element | Method |
|---|---|
| As | 4-Acid AAS |
| Ca | 4-Acid AAS |
| Cd | 4-Acid AAS |
| Co | 4-Acid AAS |
| Cu | 4-Acid AAS |
| Fe | 4-Acid AAS |
| Hg | 4-Acid AAS |
| K | 4-Acid AAS |
| Mg | 4-Acid AAS |
| Na | 4-Acid AAS |
| Ni | 4-Acid AAS |
| P | 4-Acid AAS |
| Pb | 4-Acid AAS |
| Se | 4-Acid AAS |
| Zn | 4-Acid AAS |
| P | XRF |
| C | LECO |
| S | LECO |

**Figure 14-10: Plan Views of Geological Model Volumes**




Notes:

- A – P75 grain size indices
- B – moisture
- C – D80 grain size indices
- D – D50 grain size indices

## 14.8 Manganese Break-Even Grade

Market studies are ongoing as EMN evaluates production of high-purity, selenium-free, 99.9% EMM and/or HPMSM product.

Based on preliminary on-site and off-site operating cost estimates and metal recovery estimates, the breakeven grade is estimated to be 3.20% tMn. All the costs and recoveries are based on preliminary estimates and may not be representative of the actual project costs and parameters. Assumptions for this grade calculation include:

- A 99.7% EMM metal price of US$2.00/kg or US$0.91/lb (Shanghai Metals Market, December 2018); the commodity price is expected to be higher for 99.9% manganese EMM
- A pre-concentration operating cost of US$5.22/t feed
- A leaching and refining operating cost estimate of US$173.00/t concentrate
- A 63% recovery for magnetic separation derived from the average total manganese recovery of 87.7% on the average head grade, 71% recovery for leaching and refining
- It is assumed that mining selectivity will not be applied due to inherent difficulty of grade control and selective mining for this deposit type.

The deposit is being considered as a bulk tonnage opportunity and it is assumed that selective mining will not be applied. All tailings material will be sent to the process plant on a diluted basis as a re-pulped slurry, and no cut-off grade can reasonably be applied to the deposit (i.e., no mining waste will be generated). The case for economic extraction relies on the net value of resources being sent to the plant to be positive; the average feed grades must be greater than the breakeven grade (cost equivalent) of 3.20% tMn. The estimated breakeven cut-off grade falls below the grades of most of the blocks (excluding 10,000 t which has grades lower than 3.20% tMn).

## 14.9 Mineral Resource Estimate

The MRE was calculated using Seequent Leapfrog® Geo Edge using Phase 1 and Phase 2 drilling results for the total and soluble manganese grades and bulk density values. The 2 m composited data were interpolated into a sub-block model and reported on a block tonnage weighted basis.

Table 14-10 lists the MRE for in situ tailings material at the CMP. This estimate is effective as of December 8, 2018. This estimate adheres to guidelines set forth by NI 43-101 and the CIM Best Practices.

### Table 14-10: Mineral Resource Estimate for the Chvaletice Manganese Project, Effective December 8, 2018

| Cell | Class | Volume ('000 $m^3$) | Tonnage (kt) | In Situ Dry Bulk Density ($t/m^3$) | tMn (%) | sMn (%) |
|---|---|---|---|---|---|---|
| #1 | Measured | 6,577 | 10,029 | 1.52 | 7.95 | 6.49 |
| | Indicated | 160 | 236 | 1.47 | 8.35 | 6.67 |
| #2 | Measured | 7,990 | 12,201 | 1.53 | 6.79 | 5.42 |
| | Indicated | 123 | 189 | 1.55 | 7.22 | 5.30 |
| #3 | Measured | 2,942 | 4,265 | 1.45 | 7.35 | 5.63 |
| | Indicated | 27 | 39 | 1.45 | 7.90 | 5.89 |
| **Total** | **Measured** | **17,509** | **26,496** | **1.51** | **7.32** | **5.86** |
| | **Indicated** | **309** | **464** | **1.50** | **7.85** | **6.05** |
| **Combined** | **M&I** | **17,818** | **26,960** | **1.51** | **7.33** | **5.86** |

Notes:

- Estimated in accordance with the CIM Definition Standards on Mineral Resources and Mineral Reserves adopted by CIM council, as amended, which are materially identical to the Joint Ore Reserves Committee Australasian Code for Reporting of Exploration Results, Mineral Resources and Ore Reserves 2012 Edition (JORC Code).
- The Chvaletice Mineral Resource has a reasonable prospect for eventual economic extraction. Mineral Resources do not have demonstrated economic viability, and no Mineral Reserves have been defined for the CMP.
- Indicated Resources have lower confidence that Measured Resources. A breakeven grade of 3.20% tMn has been estimated for the Chvaletice deposit based on preliminary pre-concentration operating costs of US$5.22/t feed, leaching and refining operating cost estimates of US$173.00/t concentrate, 63% recovery for magnetic separation derived from the average total manganese recovery of 87.7% on the average head grade, 71% recovery for leaching and refining, and a metal price of US$2.00/kg for 99.7% EMM (Shanghai Metals Market, Dec 2018). The commodity price for high-purity, 99.9% EMM is expected to be higher.
- A cut-off grade has not been applied to the block model. The estimated breakeven cut-off grade falls below the grade of most of the blocks (excluding 10,000 t which have grades less than 3.20% tMn). It is assumed that material segregation will not be possible during mining due to inherent difficulty of grade control and selective mining for this deposit type.
- Grade capping has not been applied.
- Numbers may not add exactly due to rounding.

Figure 14-11 shows a plan view of the block model for Cells #1, #2 and #3 and definition of sections A-A' and B-B'. Figure 14-12 shows vertical cross sections along these lines for soluble manganese block values and for P75 block values.

**Figure 14-11: Plan View of Block Model Showing Section Lines and Soluble Manganese Grade Distribution at Surface**

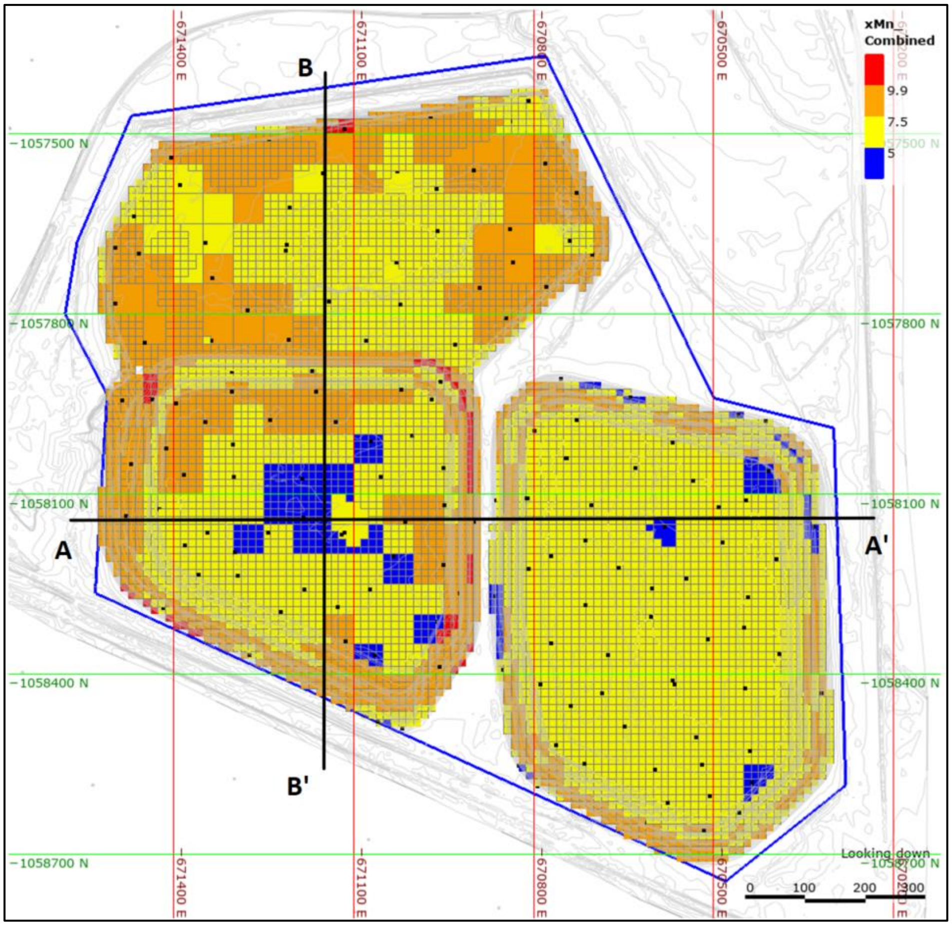
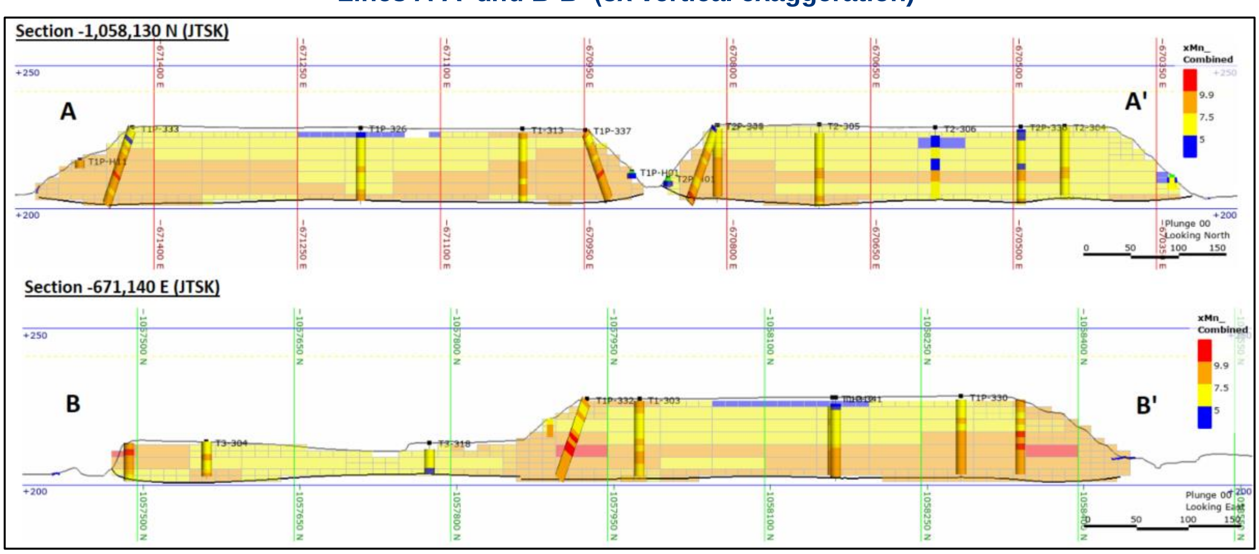



**Figure 14-12: Vertical Cross-Section View Showing Total Mn Block Values Along Lines A-A' and B-B' (3x vertical exaggeration)**






TETRA TECH

## 14.10 Classification

Mineral Resource classification was performed in reference to CIM Best Practices. No set standard exists for classification of resources for tailings deposits.

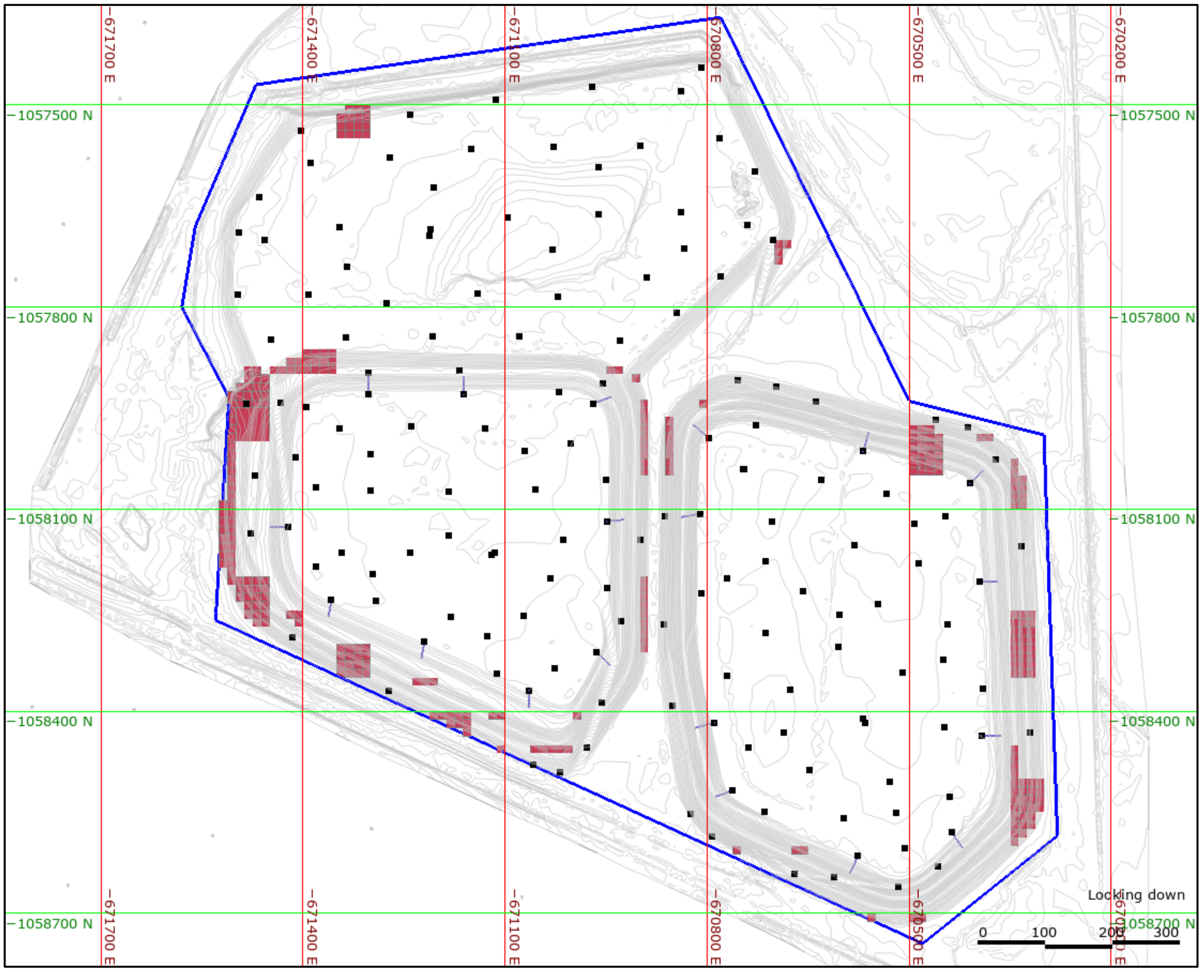
In accordance with CIM Definitions Standards (2014) the QP is of the opinion that the CMP is a reasonable prospect for eventual economic extraction on the basis of:

- Extensive drill investigation and geochemical assaying of representative samples collected from the Chvaletice tailings storage facility has confirmed the material has continuous and anomalous concentration of manganese throughout the tailings material contained above the original ground surface and below a topsoil reclamation cap
- The net average Measured (7.32%) and Indicated (7.85%) total manganese grades reported for the MRE are greater than the breakeven grade of 3.20% manganese, and only 10,000 tonnes of tailings material have grade less than the breakeven grade of 3.20% manganese (Section 14.6)
- The tailings deposits are located above ground surface, with immediately accessible transportation infrastructure and are located in proximity to industrially zoned land that is suitable for process plant development
- Further engineering and financial assessments will be conducted to validate the economic viability of the CMP.

Measured Mineral Resources are those materials with evidence derived from detailed and reliable exploration, sampling and testing which is sufficient to confirm geological and grade or quality continuity between points of observation. The materials comprising Measured Mineral Resources have quantity, grade or quality, densities, shape, and physical characteristics that are estimated with confidence sufficient to allow the application of modifying factors to support detailed mine planning and final evaluation of the economic viability of the deposit. Confidence ranges for Measured Resources were evaluated using the total manganese variograms and by variance sensitivities of the closest sample and average distance of samples for each cell within the block model. Blocks have been classified as Measured where total manganese grades have been based on a minimum of five samples within a maximum average distance of 100 m and with closest sample within a maximum of 75 m. The majority of the model blocks have been classified as Measured.

Indicated Mineral Resources are those materials where evidence is derived from adequately detailed and reliable exploration, sampling and testing and is sufficient to assume geological and grade or quality continuity between points of observation. Distribution and concentration of manganese concentrations have been reasonably defined for the majority of the deposits by drilling spaced at approximately 100 metre spacing confirming trends with three-dimensional continuity and allowing for modelling of grade distribution in conjunction with numerous other chemical and physical parameters. Indicated Resources have a lower confidence than Measured Resources. Those blocks within the established bounds of the tailings deposits that did not meet the criteria established for Measured Mineral Resources have been classified as Indicated. Presence of tailings material in these locations is very probable however given the distances to supporting samples the grade has been estimated with lower confidence than Measured Resources. Figure 14-13 depicts the model blocks which have been classified as Indicated Mineral Resources, representing approximately 2% of the overall resource tonnage.

**Figure 14-13: Plan View Showing Extent of Indicated Resource Blocks (Red); Measured Blocks are not Shown (All Remaining Blocks)**




## 14.11 Grade Tonnage Curves

As means of a reference to tonnage sensitivity and distribution of manganese grade, Figure 14-14 shows the grade-tonnage curve. The grade-tonnage tabulation includes all blocks contained within the model and have not been segmented based on Mineral Resource classification.

**Figure 14-14: Grade-tonnage Curve for the Chvaletice Manganese Project, Total Manganese**

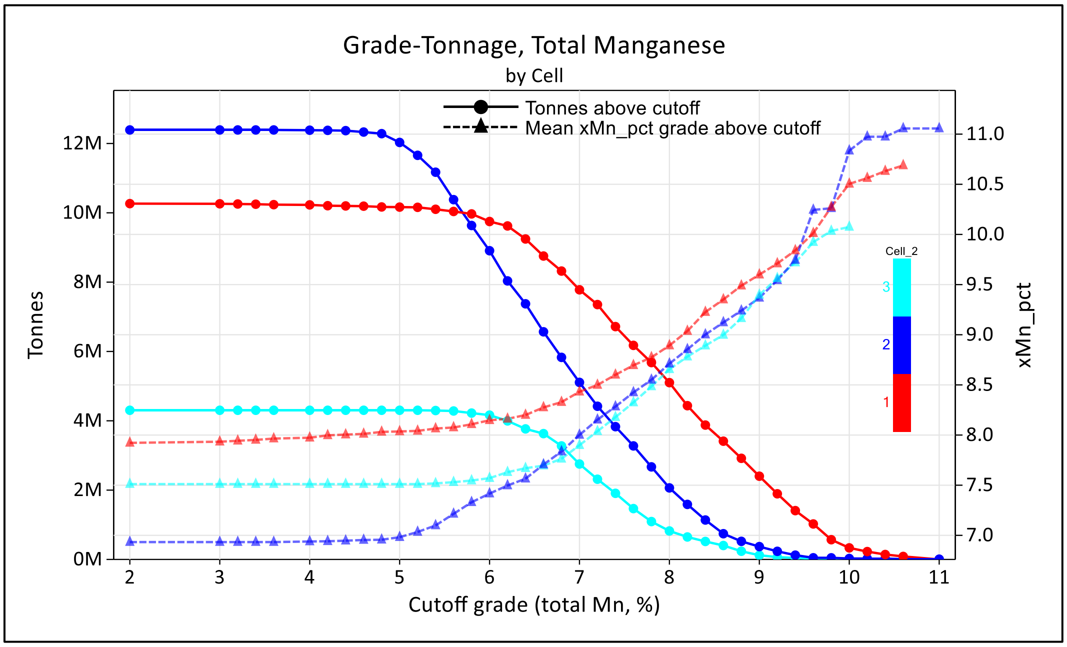
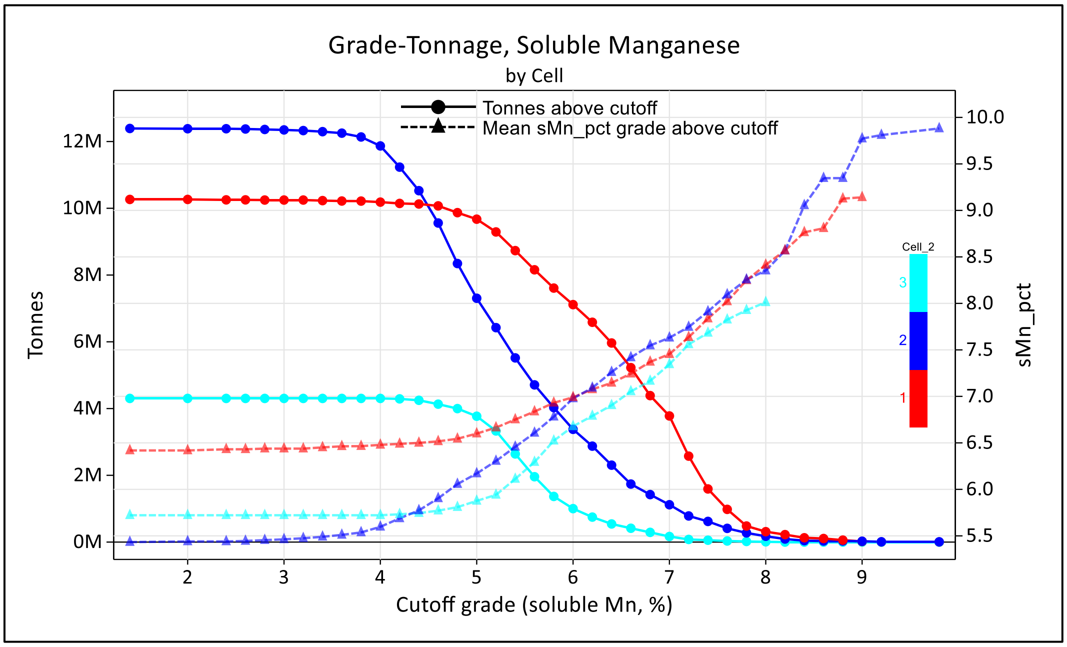



**Figure 14-15: Grade-tonnage Curve for the Chvaletice Manganese Project, Soluble Manganese**






TETRA TECH

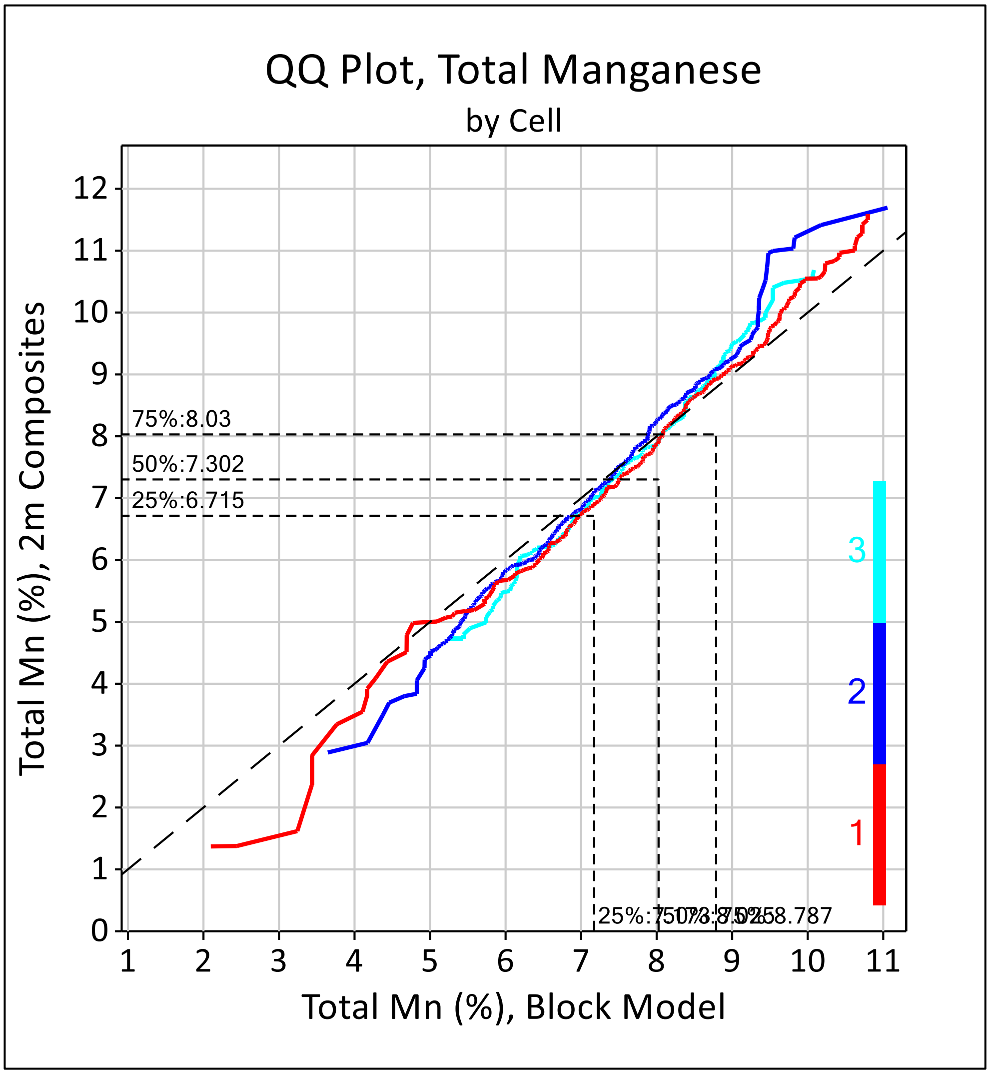
## 14.12 Model Validation

Model validation was conducted by visual inspection, and various geostatistical comparisons.

A visual inspection of the modelled variables along vertical cross sections comparing raw values, composite values and block values was conducted. No visual concerns were observed, and the interpolated models fit the drillhole sample data well.

A quantile-quantile (QQ) assessment is used as a visual check to compare shape of two dataset distributions. Figure 14-16 shows a QQ plot by cell where quantiles of the composite total manganese values are compared with the block total manganese values. It is observed that excellent correlation exists for data in the middle two quantiles, with slight deviation in the higher an lower grade ranges due to minor smoothing of data in the block model.

**Figure 14-16: Quantile-Quantile Plot for 2 m Composites and Block Model Values of Total Manganese**

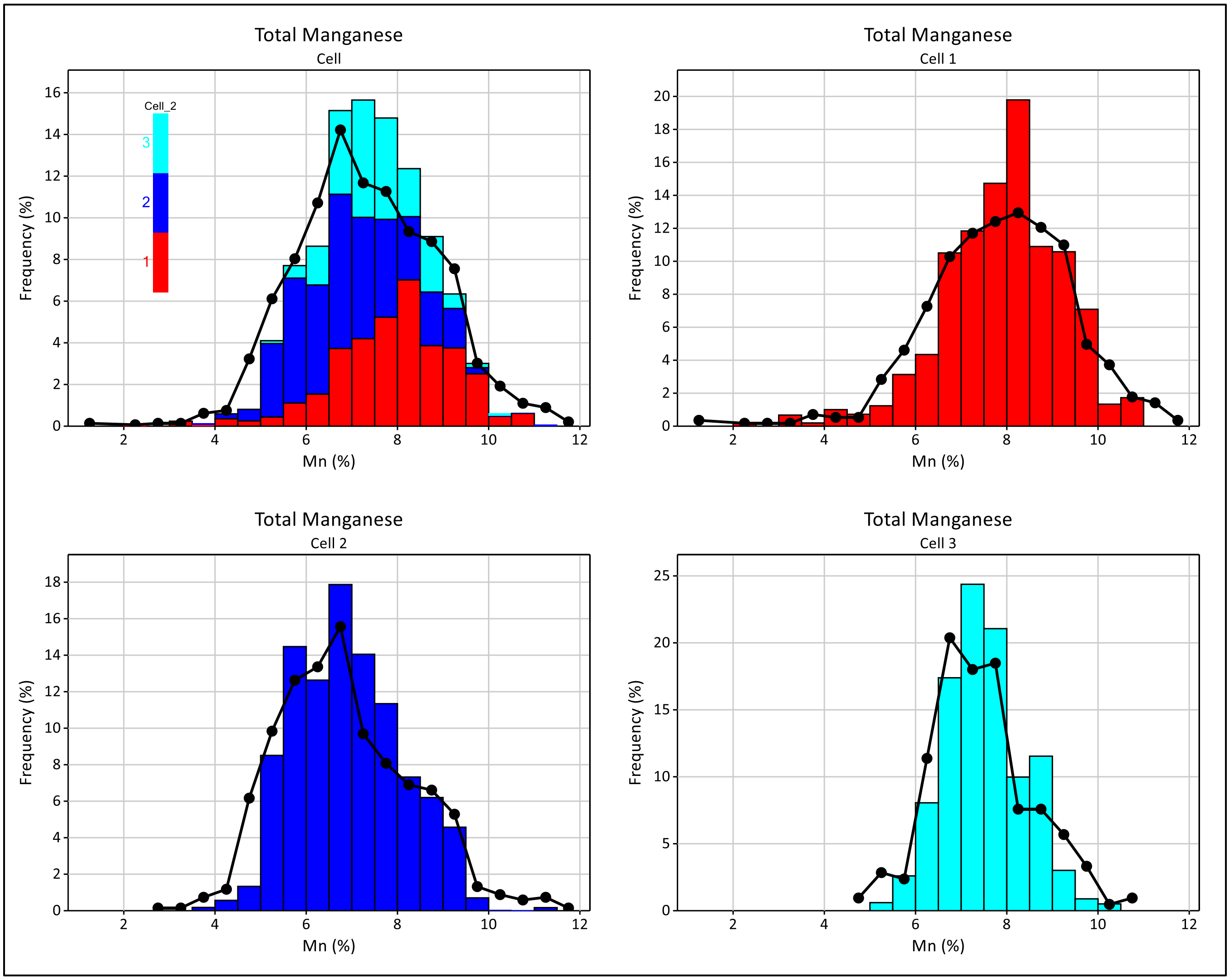





TETRA TECH

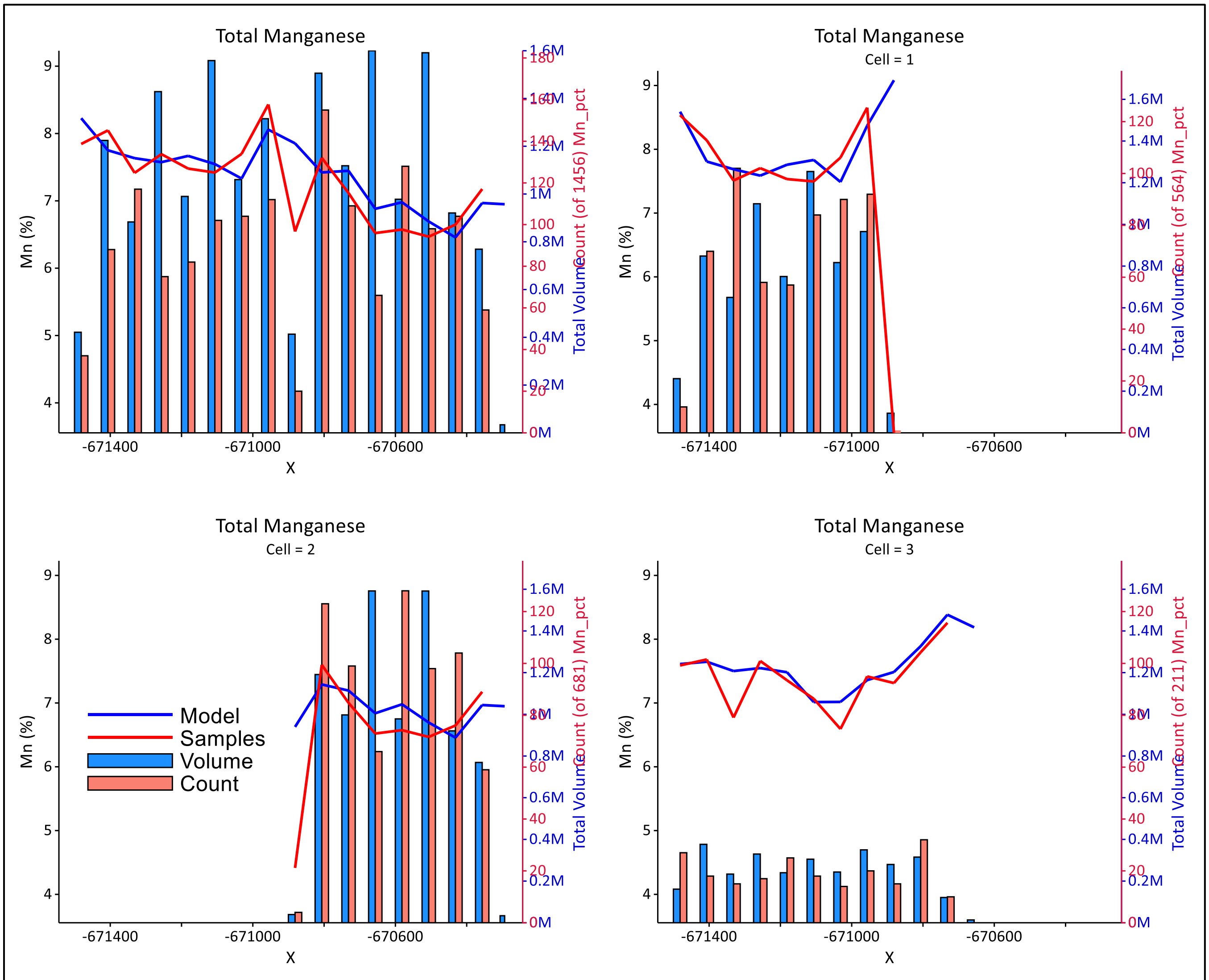
Comparison of histogram distribution between the input 2 m composite data and the block model output is also used as a visual check to compare the data distributions, to verify that a bias has not been introduced during the interpolation procedure. Figure 14-17 shows excellent correlation exists between the datasets, where overall shape and tails have been preserved.

**Figure 14-17: Histogram Comparison for 2 m Composites and Block Model Values of Total Manganese**




A swath plot analysis was completed on the both the entire dataset and individual cell datasets. The analysis enables spatial verification for reasonable congruence of original assay data to the interpolated values along the three principal axes of the model. Figure 14-18 shows swath plots along the X-axis, Figure 14-19 along the Y-axis, and Figure 14-20 along the Z-axis. The analysis results indicate good correlation of the modelled blocks and no major bias has been introduced to the model during the interpolation process.

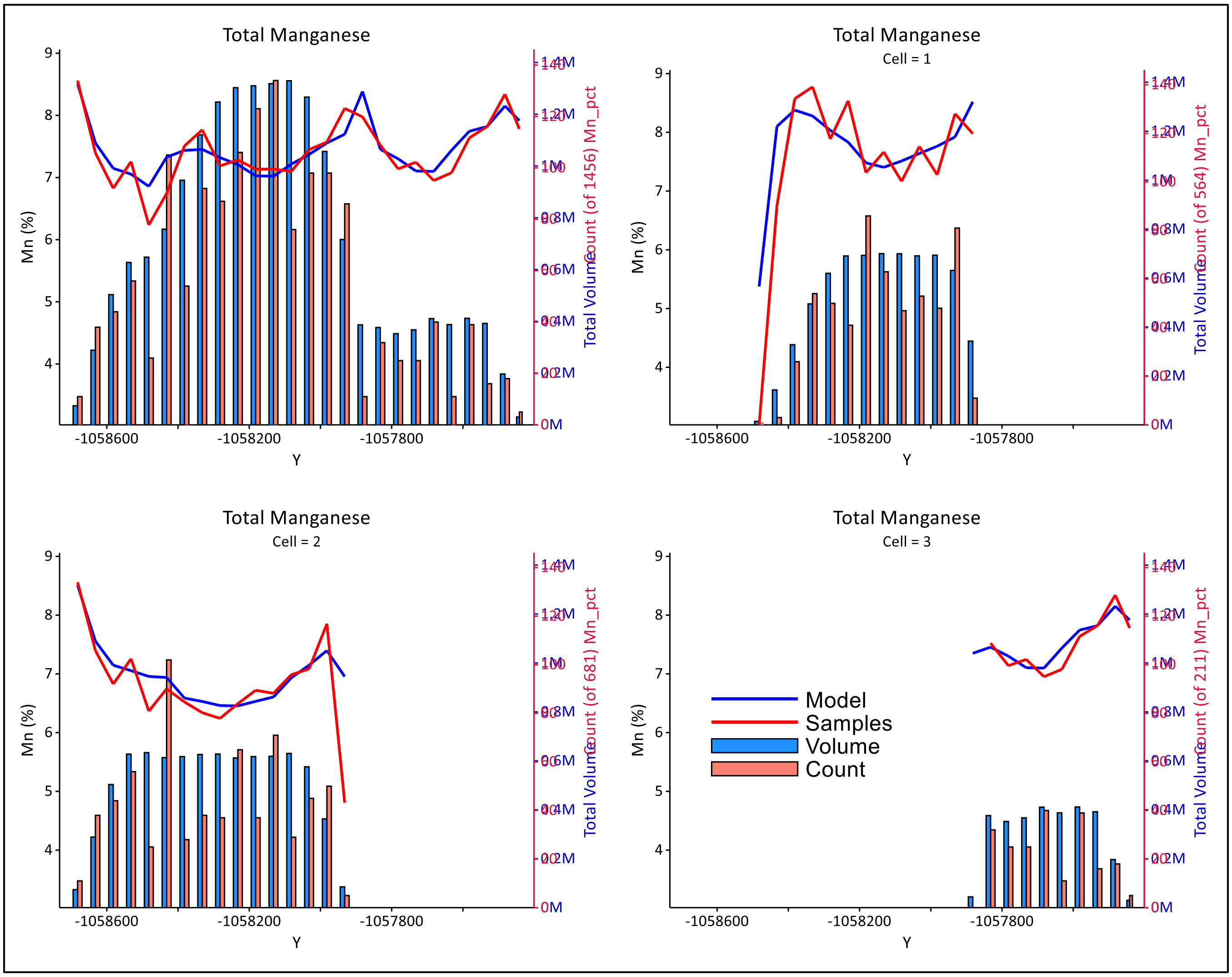
## Figure 14-18: Swath Plots Along X-Aixs, Total Manganese Values Shown





TETRA TECH

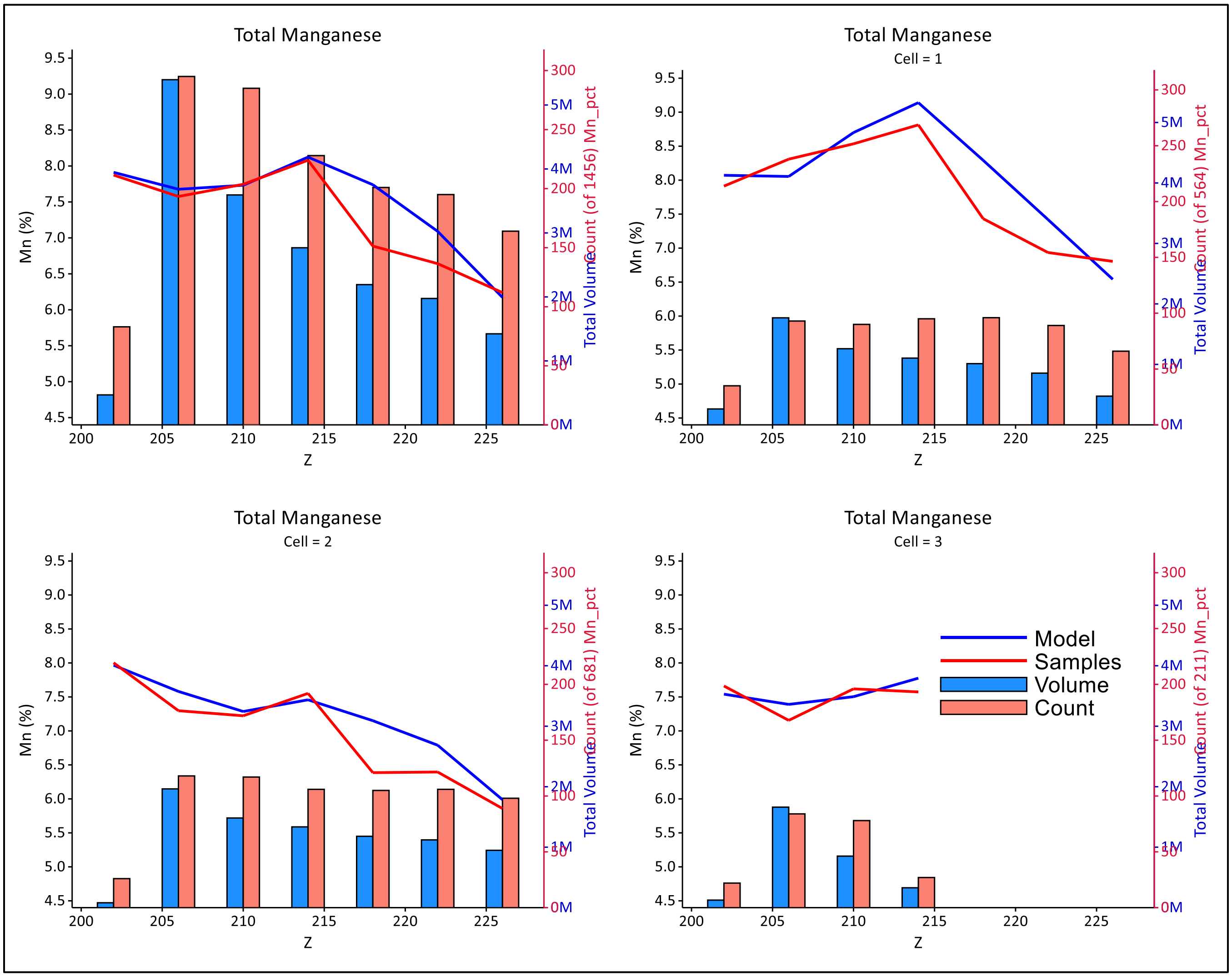
## Figure 14-19: Swath Plots Along Y-Axis, Total Manganese Values Shown






TETRA TECH

**Figure 14-20: Swath Plots Along Z-Axis, Total Manganese Values Shown**




The QP has conducted various forms of model validation and believes the model is a fair and reasonable representation of the sampling data collected from on-site investigations completed to date.

# 15.0 ENVIRONMENTAL STUDIES, PERMITTING, AND SOCIAL OR COMMUNITY IMPACT

The area covered by the Chvaletice tailings has been significantly impacted by past mining and other heavy industrial activities. Czech law exempts land owners and developers from impacts prior to 1989, when communism ended in then Czechoslovakia. Mining activity at Chvaletice predates 1975.

Environmental baseline studies have been in progress since the summer of 2016. These studies include collection of flora, fauna, hydrological, hydrogeological, climatic, air quality, land-use and socio-economic data.

In September 2017, GET (author: Ing. Mario Petru) produced a report resulting from an environmental baseline study titled *Chvaletice – Trnávka Tailing Pond Project* for Mangan (Petru 2017). The purpose of GET's study was to document the characteristics of the CMP's location according to land registrars and land use plans for the municipalities of both Chvaletice and Trnávka. Environmental interests that are significant are included in the report, such as landscape ecological stability, protected areas and trees, landscape elements, and areas or sites with historical, cultural, archaeological or geological significance. Climate, air, water, soil, geological and natural resources, fauna, flora and ecosystems, landscape and population of the area are environmental characteristics outlined in the report. The baseline study provides an overall assessment of the environment in the area of interest, Chvaletice and Trnávka.

On March 23, 2017, Tebodin Czech Republic, s.r.o. (author: Martin Vavron), provided a report titled *Localization Services for Scoping Study (Czech Republic)* (Vavron 2017) for EMN that identified local requirements and permits required for the CMP. The study reports on the local operating and construction costs, such as reagent and logistic costs, operation consumables, duties and taxes, bulk construction material rates, labour surveys and the supply of electrical energy (tariff structure and quality) for the CMP. Local regulatory requirements discuss the permitting process and Czech environmental regulations, standards and best practices for an environmental monitoring and management plan (EMMP), including waste water, waste and tailings storage, air, noise and other environmental regulations. A time schedule for the process of an environmental impact assessment (EIA), environmental permits and building permits was provided, which suggests that permitting could take approximately 16 months from the time an EIA report and permit application is filed.

EMN has initiated pro-active and regular consultation with community stakeholders, which are expected to intensify as the CMP evaluation and planning advances. Mangan opened a Project Information Center in November 2017 in the Town of Chvaletice's Municipal Culture House to provide residents with opportunities to learn about the CMP and to provide feedback and suggestions to Mangan.

Due to the location of the CMP on the shore of the Labe River, there is potential for environmental sensitivities related to runoff and potential impacts to local groundwater. Currently, EMN has knowledge of impacted groundwater due to the historical industrial activity in the area and is being monitored by groundwater wells.

Planning and preparation of EMN's environmental assessment application has been initiated, with the objective of filing a Project Description/Notification early in 2019. The Project Description/Notification will include a description of:

- Manganese production process
- Project footprint
- Results of baseline and other studies conducted to date
- Health, safety and environmental management plans
- Impact mitigation and avoidance plan/measures
- Socio-economic impacts
- Preliminary reclamation plan/objectives.

These will be made available to local communities, residents and organizations, as well as to regulators, during a public comment and consultation period. Input and comments received, as well as any requirements for changes or additional studies will serve to form the basis of an Environmental Impact Assessment application, which MCS currently intends to file later in 2019.

# 16.0 ADJACENT PROPERTIES

Adjacent to the Chvaletice manganese deposit (tailings deposit) is a coal-fired power station and a pre-cast concrete plant, with an infrastructure of highways and railways running through the center of these properties.

Additionally, two small granite bedrock crush quarries are located to the south of the power plant.

# 17.0 OTHER RELEVANT DATA AND INFORMATION

There is no other relevant data or information pertaining to the Property.

# 18.0 INTERPRETATIONS AND CONCLUSIONS

## 18.1 Mineralogy and Mineral Resources

The CMP is located in the Pardubice region of the Czech Republic approximately 89 km east of Prague by road. A long history of mining has occurred in the area, with continued industrial activity from the 820 MW coal-fired power generation plant now located on the former mill site that produced the CMP tailings.

The CMP tailings deposits are located within easy access to road, rail and river for transportation of goods, and a plentiful workforce that resides in numerous local communities. The deposits were constructed above ground using dried and compacted manganiferous tailings as the perimeter dams to hold the slurries which were deposited from the historical pyrite flotation plant.

Recent delineation drilling completed by EMN in 2017 and 2018 has resulted in the completion of 160 drillholes, totaling 3,188.8 m, spaced at approximately 100 m throughout each of Cell #1, #2 and #3, and which have allowed for continuous sampling through the full vertical profile of the tailings material. A resultant 1,484 samples have been sent for analysis of geochemistry, particle size analysis, specific gravity and in situ bulk density measurements, and original pore moisture content determination. Elevated concentrations of manganese have been confirmed within the materials forming the outer perimeter embankments by 2018 drilling investigation and sampling. The full drilling database make for a comprehensive and robust foundation for high-confidence Mineral Resource estimation.

Sample digestion using aqua regia has been used as a proxy for the soluble manganese mineral components of the materials, however, actual solubility may vary relative to the solvents and processes determined from the metallurgical testwork. Total manganese concentrations have been determined using lithium borate fusion and XRF analysis, which has provided consistent results between drill programs and between labs. Elevated concentration of manganese has been measured in all samples collected from the tailings material with laboratory reported ranges for total manganese between 1.16 to 12.32% Mn, and soluble manganese between 0.66 to 10.50% Mn, with an average of 79% of the total manganese measured to be soluble, occurring predominantly as the manganese carbonate minerals rhodochrosite and kutnohorite. The manganese concentrations were well-distributed throughout each cell, however, a slight decrease in average grade is observed towards the center of each cell. The upper portion of Cell #2 shows a consistently slightly lower concentration of manganese compared to the lower portion of the cell. A similar, but less pronounced, trend is observed for Cell #1. This may reflect changes to mining or processing methods, increased dilution or removal of materials with less manganese during the historical pyrite mining activities.

Preliminary inspection of the grain size distribution analysis indicates that the dominant particle size is silt-sized. Overall, approximately 6.2% of the material is clay-sized (less than 2 µm), approximately 56.6% of the material is silt-sized (greater than 2 µm, less than 63 µm), 37.2% is sand-sized (greater than 63 µm, less than 2 mm) and less than 1% is gravel-sized (greater than 2 mm) based on the European ISO TS 17892-4 standard. A general trend in all three cells is observed whereby particle size grades from coarse to fine towards the center of each cell. This is evidently related to particle size sorting in a playa-like environment, due to the hydraulic placement of the tailings material from spigots located on the periphery of the tailings piles and direction of flow towards the center of the piles, where decantation of liquid overflow took place at the center of each pile.

Moisture content measured from each sample ranges from approximately 1.2 to 39.3% and averaging 21.1% overall. As with particle size distributions, moisture shows a strong zonation towards the center of each cell where the material is observed to be saturated with above average moisture contents. This is attributed to the moisture retention capacity and low permeability of the fine silt and clay-sized materials predominant around the center of each cell.

In situ dry bulk density has been calculated for each sample based on estimated core recovery volumes in the field and measured sample mass and moisture content in the laboratory. The in situ dry bulk density variable is considered critical for the accurate estimation of total tonnages with the deposit. Immeasurable moisture loss in the field and visual estimation of core recovery influences the range of in situ dry bulk density. The calculated values ranged from 0.35 to 3.15 $t/m^3$, with 95 percent probability interval of 0.87 to 2.01 $t/m^3$, and average of 1.49 $t/m^3$ ±0.017 $t/m^3$ (95% chlorine). The in situ dry bulk density is a function of the composite mineral densities in addition to the degree of compaction in the tailings.

Quality assurance procedures were prepared by EMN and Tetra Tech and implemented by EMN during the site investigation. Implementation was verified by QP James Barr, P.Geo., during two separate two-day site visits to the Property (2017 and 2018). Quality control was undertaken by the QP following receipt of the laboratory data. The MRE was prepared and validated by the QP using guidelines set forth by NI 43-101 and the CIM Best Practices resulting in Inferred and Indicated MREs for each of the cells. The QP is satisfied that integrity of samples has been preserved during handling, preparation and analysis and believes that the resulting mineral resource model to accurately represents the in situ material.

## 18.2 Mineral Processing and Metallurgical Testing

The process mineralogical study verified the previous findings, indicating that manganese mainly occurs in the form of manganese carbonates, including rhodochrosite and kutnohorite, both of which are soluble in dilute acid. The manganese carbonates account for approximately 80% of the total manganese. The second main manganese mineral group, approximately 19% of the manganese, is in the form of manganese silicate minerals, which are refractory to acid dissolution. The main gangue minerals are quartz, feldspar, sericite/muscovite, pyrite, apatite, and others. Pyrite is the primary sulfide mineral present in the samples tested. Particle sizing of the samples tested varies substantially within the tailings storage piles, ranging from 43 to 97% passing 74 µm, averaging 74% passing 74 µm. It appears that the particle size of the material located at the edge of the tailings storage pile is coarser than the material at the center of the pile.

The test results show that the mineral materials of economic interest respond well to high-intensity magnetic separation. Manganese recovery to the magnetic concentrate varies from 76.7 to 94.3% tMn, averaging 87.7% tMn. On average, the magnetic separation can improve the feed manganese content from 7.2% tMn (the MB composite) to approximately 14% tMn, ranging from 12.0 to 15.4% tMn.

On average, sulfuric acid leaching can extract approximately 75% of the manganese from the magnetic separation concentrate, ranging from 71.9 to 82.8% tMn. When considering the downstream iron/phorsphorus removal treatment, the optimized leach conditions were determined as leach temperature at approximately 90ºC, with a leach retention time of 5 to 6 hours and 0.42 acid to 1.0 feed ratio.

The test results show that with the purification treatments, the impurity contents in the pregnant solution can be reduced to the levels meeting the requirements for high purity EMM production using a selenium-free process.

Three semi-continuous HPEMM pilot plant runs were conducted on the MB composite, high-grade composite (Composite P1) and low-grade composite (Composite P2) using the conditions developed from the batch tests. With further optimized test conditions (Pilot Plant Runs 2 and 3), a higher than 63% average current efficiency was achieved. According to the assay data by CRIMM, it is anticipated that the impurity contents of the HPEMM products should be lower than the criteria required by potential users of HPEMM.

A preliminary HPMSM generation test program confirmed that high purity manganese sulfate monohydrate can be produced from the Chvaletice resource. The best quality HPMSM powder was produced from the HPEMM flakes generated during the CMP HPEMM pilot plant runs. The target specifications were not achieved during the CMP testwork program when using CMP magnetic separation concentrate (without electrowinning) or purchased EMM flakes produced using a selenium-addition procedure.

The dewatering test results show that the thickening and filtration rates of the leach residue and the magnetic tailings are expected to be similar to the materials produced by other EMM producers.

# 19.0 RECOMMENDATIONS

## 19.1 Mineral Resources

The 2018 drilling program that was completed during the summer of 2018, was designed to compliment the 2017 drilling investigation. Sampling in 2018 was conducted from infill and twin hole drilling, and from drilling in areas that had not previously been tested. The program was designed in order to increase confidence in the geological data for use in mineral resource estimation. The combined 2017 and 2018 database has assessed both the vertical and lateral variation of physical and chemical characteristics of the tailings deposits and has resulted in a high-confidence MRE. No further geochemical drilling or sampling related to Mineral Resource delineation is recommended at this time.

In situ dry bulk density values have been calculated based on core volume recoveries that were estimated in the field, and sample mass and moisture volumes that were measured in the laboratory. The calculated bulk density is comparable in both the 2017 and 2018 drill investigations, however, different approaches to estimating core recovery has led to some local differences in this value. A well-supported sample distribution has been modelled for in situ dry bulk density and developed for the project which can be used to estimate average values with error margins or can be maintained as a variable model throughout the deposit. Sample volume is a critically sensitive variable for this calculation and care must continue to be taken in the field to obtain accurate volume estimates for any future samples being evaluated for in situ bulk density.

The block model has been constructed to include concentrations of several elements for use in generating a geo-metallurgical model. EMN may wish to consider applying metallurgical recovery and NSR values to the block model to further evaluate the performance of the mineral extraction process in the next iteration of the CMP tailings extraction plan. The block model has been developed to support mine planning studies. It is recommended that the CMP advance to PEA-level study.

As part of the PEA and potential future engineering studies, EMN may wish to consider trial mining using an excavator to sample specific blocks for reconciliation of grades reported in the block model, and to generate samples for further metallurgical testwork, as required. During this trial mining program, EMN may wish to consider an assessment of laboratory analytical procedures suitable for operational QA/QC and grade control procedures.

Preliminary characterization for potential acid generation and metal leaching has been conducted by EMN and Tetra Tech. The results have indicated variable results of the potential of the existing tailings material to generate acid. It is recommended that a full characterization program be undertaken to evaluate the potential for net acid generation and the kinetic reaction dynamics by humidity cells of both the head (i.e. current tailings material) and tail (i.e. future tailings product) materials. The assessment should include metal leaching analysis of the existing tailings for interim excavation and the future tailings product for future reclamation planning. A budget for this work is presented in Table 19-1.

Further work totaling approximately US$100,000 is recommended for mineralogical studies to characterize potential acid generation and metal leaching of the tailings material, and for technical consulting services related to further assessment of the multi parameter mineral resource model for use by mining, metallurgical or environmental disciplines. The estimated program budget is inclusive of sample collection, analyses, and professional services and is segmented by task in Table 19-1.

**Table 19-1: Recommended Budget for Mineralogical Studies**

| Task | Unit Rate* (US$) | Number of Units | Estimated Cost (US$) |
|---|---|---|---|
| An ARD-ML program including initial static characterization and kinetic cells testing | $500 (static)<br>$6,000 kinetic | 24 samples<br>9 samples | 65,000 |
| Technical services, consulting and revision to the geology/block model in support of mining, metallurgical and environmental disciplines | - | - | 35,000 |
| **Estimated Total** | **-** | **-** | **100,000** |

Notes: *Unit rates are considered to be inclusive of equipment, contractors, consumables, analysis, shipping, consulting, project management and travel expenses, and are estimated based on actual expenses previously incurred by EMN.

## 19.2 Mineral Processing and Metallurgical Testing

Further metallurgical testing is recommended to better define metallurgical performance, optimize processing conditions and generate design-related data using the samples produced from 2017 and 2018 drilling programs. The testwork should include process and magnetic separation waste material characterization. Further pilot plant programs are anticipated to be conducted using the drill core samples generated from the 2018 drilling program. The sample products, as requested by potential customers, are expected to be generated from the pilot plant testing.

The recommended test program should focus on:

- Equipment sizing and type optimization
- Flowsheet optimization
- Product flexibility and optimization
- Waste material characterisations and reuse
- Variability verification tests using the samples produced from the 2018 drilling program
- Electrowinning testing using full size cathodes
- EMM plate passivation tests
- Solid-liquid separation additional confirmation tests
- Impurity impact and purification tests, especially Mg control optimization tests
- Ammonia recovery tests
- Product sample generation for the potential users (may include a demonstration plant.)
- HPEMM and HPMSM product analysis.
- Ammonium sulphate by-product production testwork.
- Additional HPMSM crystallization tests (and additional deep purification tests)

The testwork should include bench scale tests, large scale verification tests, and pilot plant runs to simulate industrial operations.

A total of US$930,000 has been estimated for the further testing program, excluding sample generation and shipment costs and the rental and manufacture costs for the pilot plant test equipment (Table 19-2).

**Table 19-2: Recommended Budget for Metallurgical Testwork**

| Item | Estimated Cost (US$) |
|---|---|
| Mineralogy | 20,000 |
| Bench Scale Beneficiation Tests, including variability tests | 50,000 |
| Leaching Investigation, including variability tests | 50,000 |
| Solution Purification | 70,000 |
| EMM Electro-Winning | 50,000 |
| HPMSM Crystallization Tests | 50,000 |
| HPEMM Passivation Tests | 20,000 |
| S/L Separation and Residue Washing | 30,000 |
| Pilot-scale Beneficiation Testing | 150,000 |
| Pilot-scale Metallurgical Testing | 350,000 |
| Tailings/Residue Characterization testing | 50,000 |
| Product Analysis | 40,000 |
| **Total** | **930,000** |

# 20.0 REFERENCES

ALS Canada Ltd, 30th Dec 2014, COA_VA14199511_116227-28883357

ALS Canada Ltd, 13th Jan 2015, COA_VA15005481_117190-28980198

ALS China, Oct 2018, Data Assay Report (GZ18063000)

ALS China, Nov 2018, Data Assay Report (GZ18223290)

AMEC Foster Wheeler (2016). Chvaletice EMM Project, Chvaletice, Czech Republic, Process Development Report. September 15th, 2016.

Bateria Slany – Various reports from 1986 to 1989, a Czech state battery producer's resource, metallurgical, environmental, engineering and economic studies of Chvaletice manganese tailings.

Changsha Research Institute of Mining and Metallurgy Co., Ltd. (2017), 27th May 2017, Exploratory Magnetic Separation Test Work Report

Changsha Research Institute of Mining and Metallurgy Co., Ltd., (2018), Dec 2018, Compilation of EMI Chvaletice Manganese Project (CMP) Test-Work Reports

CINF Engineering Co., Ltd., Aug 2017, Scoping Study Report_Chvaletice EMM Project

Cullen, et al. (2013). Mineral Resource Estimate Technical Report for the Plymouth Mn-Fe Deposit Woodstock Property New Brunswick, Canada. Prepared for Buchans Minerals Corporation and Centrerock Mining Limited. May 6, 2013.

Czech Hydrometereological Institute, http://portal.chmi.cz/

Ministry of Environment of the Czech Republic, 2018, document reference number MZP/2018/550/387-Hd, ZN/MZP/2018/54, dated April 17, 2018.

Daniel Smutek, 2016; Chvaletice. Sulphur and Manganese Through Quarrying. Nature and Regional Protection Agency of Czech Republic (multi-stakeholder project for Iron Mountains Geopark with participation of European Union)

Dept. Earth and Ocean Sciences, UBC, 8th Jan 2015, Quantitative Phase Analysis of 2 Powder Samples Using the Rietveld Method and X-Ray Powder Diffraction Data

GET (2015), Legislative Aspects Related to The Granting of a Permit for the Mining and treatment of Manganese Ore, Chvaletice – Tailing Ponds 1, 2 (3104804), Řečany – Tailing Pond 3 (3243700), prepared for Navigator Management Ltd. April 2015,

Global ARD Testing Services Inc. 19th Dec 2015, Certificate of Analysis; Project # 1523

Global ARD Testing Services Inc. 25th Jan 2016, Certificate of Analysis; Project # 1523

Kemetco Research Inc., Jan 2015 to Feb 2015, Data Report KT1-5, Project #: I00301

Kemetco Research Inc., Feb 2016, Data Report – Mg Removal Using Fluoride, Project #: Eu Mn J0201

Kemetco Research Inc., Feb 2016, Data Report – Mg Removal Using Hydroxide, Project #: Eu Mn J0201

Met-Solve Laboratories Inc., 2nd Mar 2016, MS1656 Euro Manganese, Project #: MS1656

Met-Solve (2016), project MS1656 Euro Manganese prepared for Marco Romero, President and CEO, Euro Manganese Inc., March 2nd, 2016.

Novotny J. and Husak F. (1972). Borehold slude sedimentation grain size sorting (pg. 4/6 of Chvaletice P054730_en document)

Petru, M. (2015). The Environmental and Social Conditions in the Territory Conflicts of Interest in Regard to Environmental Protection Interim Report (translated from Czech). GET s.r.o. April 2015.

Petru, M. (2017). Chvaletice – Trnavka Tailing Pond, Environmental Baseline Study, for Mangan Chvaletice sro Published by GET September 2017.

Price, William, A, 2009. MEND Report 1.20.1. CANMET Mining and Mineral Sciences Laboratory, Prediction Manual for Drainage Chemistry from Sulphidic Geologic Materials.

PRK Partners, 2017, PRK Partners to Cannacord Genuity Corp,, confidential letter, subject: Legal Opinion on matters related to Euro Manganese Inc., dated April 27, 2018, Prague.

Process Mineralogical Consulting Ltd., 15th Dec 15 2015, Mineralogical Note

Process Mineralogical Consulting Ltd., 27th Jan 2016, Mineralogical Note

SGS Canada Inc., 6th Oct 2017, An Investigation into Acid Leaching and Mineralogical Characterization on Samples from the Chvaletice manganese deposit (draft report), Project 16204-001

Tetra Tech (2018). Technical Report on Mineral Resource Estimation for the Chvaletice Manganese Project, Chvaletice, Czech Republic. Document No. 704-MIN-VMIN-03117-REP-R0007-00. June 21, 2018.

Vavron, M. (2017). Localization Services for Scoping Study (Czech Republic). Prepared for Euro Manganese Inc. Published by Tebodin Czech Republic, s.r.o. March 23, 2017.

# APPENDIX A CERTIFICATES OF QUALIFIED PERSONS

## James Barr, P.Geo.

**I, James Barr, P.Geo. of Kelowna, British Columbia, do hereby certify:**

- I am Senior Geologist and Team Lead with Tetra Tech Canada Inc. with a business address at Suite 150 - 1715 Dickson Avenue, Kelowna, BC, V1Y 9G6.
- This certificate applies to the technical report entitled "Technical Report and Mineral Resource Estimate for the Chvaletice Manganese Project Chvaletice, Czech Republic" with effective date of December 8th, 2018 (the "Technical Report").
- I graduated from the University of Waterloo in 2003 with a B.Sc. (Honours) in Environmental Science, Earth Science and Chemistry. I am a registered Professional Geoscientist with Engineers and Geoscientists of British Columbia (#35150). Since 2003 I have worked as an exploration and resource geologist for numerous precious metal, base metal, and industrial commodity projects in Canada, Africa and Mexico. Since 2008, I have prepared, reviewed and audited mineral resource estimates, including projects for reprocessing of heap leach facilities, waste dumps and tailings deposits which are relevant to the content of this Technical Report.
- I am a "Qualified Person" for purposes of National Instrument 43-101 (the "Instrument").
- I visited the Property that is the subject of the Technical Report from July 1st through to July 3rd, 2017 and July 30th through to July 31st, 2018.
- I am independent of Euro Manganese Inc., as defined by Section 1.5 of the Instrument.
- Previous to this report, I was a co-author of the Technical Report prepared for Mangan Chvaletice sro. entitled "Technical Report on Mineral Resource Estimation for the Chvaletice Manganese Project Chvaletice, Czech Republic" with effective date of April 27, 2018.
- I am responsible for Sections 1.0 (except 1.4) through 12.0, 14.0 through 17.0, 18.1, 19.1, and 20.0 of this Technical Report.
- I confirm that I have read NI 43-101 and Form 43-101F1, and the Technical Report has been prepared in accordance with them.
- To the best of my knowledge, information, and belief, as of the date of this certificate the Technical Report contains all scientific and technical information that is required to be disclosed to make the Technical Report not misleading.

Signed and dated this 28th day of January 2019, in Kelowna, British Columbia.

*"original signed and sealed by"*
*James Barr, P.Geo*

James Barr, P.Geo.
Senior Geologist and Team Lead - Geology
Tetra Tech Canada Inc.

## Jianhui (John) Huang, Ph.D., P.Eng.

**I, Jianhui (John) Huang, Ph.D., P.Eng., of Vancouver, British Columbia, do hereby certify:**

- I am a Senior Metallurgist with Tetra Tech Canada Inc. with a business address at Suite 1000, 10th Fl., 885 Dunsmuir St., Vancouver, BC, V6B 1N5.
- This certificate applies to the technical report entitled "Technical Report and Mineral Resource Estimate for the Chvaletice Manganese Project Chvaletice, Czech Republic" with effective date of December 8th, 2018 (the "Technical Report").
- I am a graduate of North-East University, China (B.Eng., 1982), Beijing General Research Institute for Non-ferrous Metals, China (M.Eng., 1988), and Birmingham University, United Kingdom (Ph.D., 2000). I am a member in good standing of the Association of Professional Engineers and Geoscientists of British Columbia (#30898). My relevant experience includes over 30 years involvement in mineral processing for base metal ores, gold and silver ores, rare metal ores, and industrial minerals. I am a "Qualified Person" for purposes of National Instrument 43-101 (the "Instrument").
- I visited the Property that is the subject of the Technical Report on February 5, 2018 and the testing labs during January 2017 and December 2018.
- I am responsible for Sections Section 1.4, 13.0, 18.2, 19.2, and 20.0 of the Technical Report.
- I am independent of Euro Manganese Inc. as defined by Section 1.5 of the Instrument.
- I have been involved with technical reviews of the process flowsheet developed by CINF Engineering Co., Ltd and the test work conducted by Changsha Research Institute for Mining and Metallurgy Co., Ltd. Also, previous to this report, I was a co-author of the Technical Report prepared for Mangan Chvaletice s.r.o. entitled "Technical Report on Mineral Resource Estimation for the Chvaletice Manganese Project Chvaletice, Czech Republic" with effective date of April 27, 2018 (released June 21, 2018).
- I confirm that I have read NI 43-101 and Form 43-101F1, and the Technical Report has been prepared in accordance with them.
- To the best of my knowledge, information, and belief, as of the date of this certificate the Technical Report contains all scientific and technical information that is required to be disclosed to make the Technical Report not misleading.

Signed and dated this 28th day of January 2019, at Vancouver, British Columbia.

*"original signed and sealed by"*
*Jianhui (John) Huang, Ph.D., P.Eng.*

Jianhui (John) Huang, Ph.D., P.Eng.
Senior Metallurgist
Tetra Tech Canada Inc.



TETRA TECH