BRALORNE GOLD MINE TAILINGS STORAGE FACILITY HYDROTECHNICAL ASSESSMENT



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LIMITATIONS OF REPORT

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1.0 INTRODUCTION

1.1 General

Bralorne Gold Mines Ltd. (Bralorne) retained Tetra Tech EBA (Tetra Tech) to conduct a dam breach analysis and inundation mapping of the Tailings Storage Facility (TSF). The mine site is situated approximately 160 km north of Vancouver in the Cadwallader Creek Valley.

The Bralorne TSF is an earth–fill embankment structure constructed in 2004 to the present elevation of approximately 1054.3 m (3459 ft). The embankment is separated into north and south sections by a ridge of native material. Bralorne has proposed raising the tailings dam by 2.4 m (8 ft) to a crest elevation of 1056.7 m (3467 ft). The embankment is approximately 305 m (1000 ft) in length, and the design raised crest width is approximately 5.5 m (18 ft). The south section is currently approximately 10 m (30 feet) in height at its maximum elevation and the north section is roughly 8 m (24 feet) in height. At the current crest elevation, the storage volume is approximately 98,000 m^3. The facility does not contain a spillway, with outflow occurring through seepage and evaporation. The embankment was constructed with an upstream and downstream slope of 1.75H:1V and 2H:1V, respectively.

2.0 HYDROTECHNICAL ASSESSMENT

Design, operation, closure, and reclamation of Mine Tailings Dams and Impoundments in British Columbia is regulated by the Health, Safety and Reclamation Code for Mines in British Columbia (2008) under the Mines Act (2003), which requires that all major impoundments, water management facilities and dams be designed in accordance with the criteria provided in the Canadian Dam Association (CDA), Dam Safety Guidelines (2007).

The Canadian Dam Association (CDA) guideline for an Inflow Design Flood (IDF) ranges from 100 year flood to Probable Maximum Flood (PMF) based on the consequence classification. The following sections provide a brief description of the study watershed, a review of available climatic and hydrometric data, and a summary of the development of the design runoff volume corresponding to each classification category.

2.1 Watershed

Bralorne TSF is located approximately 7 km to the south of Gold Bridge, BC. It has a total catchment area of approximately 0.45 km2. The catchment area consists of 15% bare land, 10% pond area and 75% forested land. The elevation varies from about 990 m (3250 ft) at the TSF to 1250 m (4100 ft) along the watershed boundary. The median elevation of the Bralorne TSF catchment area is approximately 1005 m. Downstream of the embankment, Cadwallder Creek enters Hurley River in a confined canyon with a slope of 3%. Hurley River then enters a valley near Gold Bridge with a decreased slope of 1%.

A ditch along the Bralorne-Hurley Forest Service Road intercepts the catchment area into half. It is intended to act as a surface run-off diversion channel along the south side of the facility. During a major flood event, such as the 1000-year flood or above, the Bralorne-Hurley Road diversion ditch is likely to fail, allowing the upstream runoff to flow into the TSF. Therefore, it is considered in the hydrological analysis that surface water runoff from the north, south and west sides of the pond drains to the tailings facility.

2.2 Climatic and Snow Course Data

Two climate stations operated by the Meteorological Service of Canada (MSC) were considered to be representative of the climate conditions at the project site (Table 2.2a).

Table 2.2a: Regional Climate Stations

Station Name	Station No.	Elevation (m)	Period of Record	Data Type	Rainfall IDF* Curve	Distance to Site (km)
Bralorne	1080930	1015	1924-1963	Daily	No	2
Lajoie Dam	1084490	686	1963-1982	Daily	Yes	6

*Intensity – Duration – Frequency data

The rainfall intensity frequency (IDF) data obtained for the Lajoie climate station is shown in Table 2.2b. It provides intensities for various return periods. The 200-year and 1000-year 24-hour rainfall totals were obtained by extrapolation.

Table 2.2b: Rainfall Intensity Frequency Data at Regional Climate Stations

Return Period (Years)	24-Hour Rainfall Total (mm)
	Lajoie Dam
2	27.7
5	41.2
10	50.1
25	61.3
50	69.7
100	77.9
200	87.4
1000	107.9

The River Forecast Centre of the BC Ministry of Environment has a number of snow survey sites in the B.C. Middle Fraser Region. The station closest to the project site is the Bralorne Manual Snow Survey station (at an elevation of 1382 m). The information for this manual snow survey station is presented in Table 2.2c.

Table 2.2c: Regional Snow Pillow Station

Station Name	Station No.	Elevation	Period of Record	Distance to Site
Bralorne Snow Station	1C14	1382 m	1963-present	4 km

The average snow water equivalents for the period of record at the Bralorne snow survey station are summarized in Table 2.2d. The data shows that the average maximum snow water equivalent (162 mm) occurs in April. As this station is significantly higher than Bralorne TSF, the use of the snow data is conservative.

Table 2.2d: Average Snowpack Data

Month	Snow Water Equivalent (mm)
Jan	75
Feb	128
Mar	158
Apr	162
May	71

2.3 Hydrometric Data

There is no current stream flow data available within the Bralorne TSF watershed. Regional hydrometric data was obtained from the Water Survey of Canada to characterize the hydrology of the study area. The regional hydrometric stations used in this study are listed in Table 2.3a.

Table 2.3a: Regional Hydrometric Stations

Station ID	Station Name	Drainage Area (km^2)	Period of Record	Status
08ME011	Hurley River near Bralorne	368	1927-1933	Inactive
08ME027	Hurley River below Lone Goat Creek	312	1996-2010	Active
08ME028	Bridge River above Downton Lake	708	1997-2010	Inactive

2.4 Determination of Inflow Design Flood

Based on dam classification, the Inflow Design Flood (IDF) to a reservoir can range from 100-year return period to Probable Maximum Flood (PMF), which is defined as the most severe flood that may reasonably be expected to occur at a particular location. Table 2.4a provides the definitions of various consequence classifications and their corresponding design flood (CDA, 2007). As the Consequence Classification for the Bralorne TSF is to be established in this study, design floods ranging from 100-year return period to PMF are calculated in the following sections.

Table 2.4a: CDA 2007 Consequence Classification Criteria and Design Earthquake and Flood

Dam Classification from CDA 2007	Loss of Life	Economic and Social Losses	Environmental and Cultural Losses	Annual Exceedance Probability Level	
				Earthquake Design Ground Motion	Inflow Design Flood
Extreme	>100	Extreme – Critical Infrastructure or Service	Major Loss of Critical Habitat – No Restoration Possible	1/10,000	PMF
Very High	10-100	Very High –Important Infrastructure or Services	Significant Loss of Critical Habitat – Restoration Possible	1/5,000	2/3 between 1/1000 year and PMF
High	1-10	High –Infrastructure, Public Transit and Commercial	Significant Loss of Important Habitat – Restoration Possible	1/2,500	1/3 between 1/1000 year and PMF
Significant	Unspecified	Temporary and Infrequent	No Significant Loss of Habitat – Restoration Possible	1/1,000	Between 1/100 and 1/1000 year
Low	0	Low	Minimal Short Term Loss	1/500	1/100 year

2.4.1 Determination of the 100-Year and 1,000-Year Floods

Two methods were used to determine the 100-year and 1000-year floods: a rainfall-runoff approach and a regional analysis. The rainfall-runoff approach refers to the development of a hydrologic model to determine the runoff hydrograph at the site. The regional analysis involves frequency analyses of regional hydrometric data and determination of the relationship between unit peak discharge and size of drainage area. The following paragraphs further illustrate the methodology and present the results of the two approaches.

Rainfall-Runoff Approach

The rainfall intensity duration frequency data obtained from Lajoie Dam climate station was used as the basis for determining the 100-year and 1000-year 24-hour rainfall depth at Bralorne site. Since the Lajoie Dam station is at elevation 686 m, which is much lower than the median basin elevation of the Bralorne TSF watershed (1005 m), daily rainfall data from the Bralorne climate station were analyzed. The average maximum daily rainfall totals were calculated from available data at the Lajoie Dam and Bralorne stations (Table 2.4b).

Table 2.4b: Average Maximum Daily Rainfall

Station Name	Elevation (m)	Average Max Daily Rainfall (mm)	Max Daily Rainfall Ratio
Lajoie Dam	686	31.2	1.00
Bralorne	1015	45.3	1.45

A relationship between average maximum daily rainfall and elevation was developed using the above results of the analysis. The average maximum daily rainfall at the Bralorne station is about 1.45 times of that at the Lajoie Dam station. This ratio was then applied to the 24-hour rainfall total at the Lajoie Dam climate station. And the 100-year 24-hour and 1000-year 24-hour rainfall depths at Bralorne site were determined to be 113.1 mm and 156.6 mm, respectively.

Table 2.4c: Rainfall Intensity Frequency Data at Bralorne

Return Period (Years)	24-Hour Rainfall Total (mm)	
	Lajoie Dam	Bralorne
2	27.7	40.2
5	41.2	59.8
10	50.1	72.7
25	61.3	89.0
50	69.7	101.2
100	77.9	113.1
200	87.4	126.9
1000	107.9	156.6

To take into account the snowmelt occurring during a rain-on-snow event, the following equation was applied (Gray, 1970):

For heavily forested regions (60 – 100%)

$$M = (0.074 + 0.007*P)*(T_a - 32) + 0.05$$

Where

M = snowmelt (in/day);

P = precipitation (in); and

T_a = temperature (°F).

For the 100-year and 1000-year floods, the 24-hour rainfall depth and the average daily temperature from February to May were used in estimating the daily snowmelt rate. The average value of the mean daily temperature was determined to be 2.7°C at the Bralorne climate station. The average daily snowmelt during the 100-year and 1000-year rainfall events was determined to be 14.3 mm/day and 15.7 mm/day, respectively. This daily snowmelt is considered reasonable when compared to the Bralorne snow survey station data because there would be enough snow to supply the calculated snowmelt amount. The combination of the 24-hour precipitation and snowmelt amount for the 100-year and 1,000-year event are 127.2 mm and 172.2 mm, respectively.

The hydrologic model used in the runoff analysis was HEC-HMS version 4.0, developed by U.S. Army Corps of Engineers. The US Soil Conservation Service (SCS) unit hydrograph method was applied to determine the runoff hydrograph from the 24-hour rainfall combined with the average daily snowmelt rate. The SCS Type 1A distribution was selected to define the distribution of rainfall over 24 hours. The average daily snowmelt was evenly distributed and combined with the 1000-year hyetograph. In general, 75% of the Bralorne TSF catchment area consists of forested area in good condition. Soil Type B, representing soil with a well and moderate well drained infiltration rate, was chosen for the study area. Antecedent moisture condition II (average conditions) was assumed. A curve number of 66 was selected for the catchment area. Slopes, elevations and channel lengths were taken from topographic map to estimate the time of concentration for the catchment area.

Using the rainfall-runoff approach, the resultant 100-year and 1000-year peak inflows to Bralorne TSF were summarized in Table 2.4d.

Table 2.4d: Peak Flood Estimates from Hydrologic Model

Return Period (Years)	Flood Estimates at TSF (m^3/s)
100	0.7
1000	1.4

Regional Analysis

A regional hydrological analysis was carried out to establish 100-year and 1000-year flood inflows to Bralorne TSF. Flood frequency analyses were conducted for the selected regional hydrometric stations using the HYFRAN software Version 2.2. Four different frequency distributions; GEV, Gumbel, Three Parameter Lognormal and the Log Pearson Type III distributions were applied to the data. The maximum instantaneous flows were plotted against drainage area and a logarithmic regression equation was fitted for 100-yr and 1000-yr floods. The peak flow estimates were prorated to the project site, as tabulated in Table 2.4e.

Table 2.4e: Peak Flood Estimates from Regional Analysis

Return Period (Years)	Flood Estimate (m^3/s)
100	0.9
1000	1.3

100-year and 1000-year Flood

The 100-year and 1000-year peak flood estimates obtained from the hydrologic model and the regional analysis are comparable with up to 0.2 m^3/s difference. As the HEC-HMS hydrologic model was based on site specific conditions such as soil type and local climate data, it is considered the preferred method when compared to the regional analysis, which was based on stream flow data from watersheds sizing significantly greater than that of Bralorne TSF. Therefore, the 100-year and 1000-year peak inflows to Bralorne TSF were determined as 0.7 m^3/s and 1.4 m^3/s, respectively.

2.4.2 Determination of the Probable Maximum Flood

Two methods were used to calculate the Probable Maximum Flood (PMF) for the Bralorne TSF, first through the rainfall-runoff modelling approach, and second using the PMF estimator for British Columbia as described by Abrahamson (2010). For the first method, the 24-hour Probable Maximum Precipitation (PMP) was estimated using the Hershfield method described in the Rainfall Frequency Atlas for Canada (Hogg and Carr, 1985).

$$K_{M24} = 19 \times 10^{-0.000965\, X_{24}}$$

$$X_{PMP} = X_{24} + K_{M24} \times S$$

Where

K_{M24} = frequency factor for a 24-hour duration rainfall;

X_{24} = mean annual 24-hour extreme rainfall (30 mm);

X_{PMP} = PMP for a 24-hour duration (mm); and

S = standard deviation for a 24-hour duration rainfall (11 mm).

The 24-hour PMP determined by this method is 338 mm.

The hydrologic model developed in determining the 1000-year peak flood estimate was used in deriving the Probable Maximum Flood. The 24-hour PMP was distributed using SCS Type 1A rainfall distribution, and the daily snowmelt rate for combining with the 24-hour PMP was determined to be 21.9 mm/day, using the previous equation from Gray (1970). The daily snowmelt was then evenly distributed and combined with the design hyetograph. The PMF for Bralorne TSF was determined to be about 4.8 m^3/s.

The PMF estimator for British Columbia (Abrahamson, 2010) was further used as a rough check for the results of the hydrologic model. The following equation for Southern Interior Region (SE Upper Zone 12B and 15) was applied:

$$Q_{PMF} = 4.1768 \times A^{0.924}$$

Where

Q = probable maximum flood (m^3/s); and

A = area of the watershed (km^2).

The PMF determined using the PMF estimator for British Columbia is approximately 2.0 m^3/s. However, the PMF estimator is based on very few data points for small catchments and is not considered to be particularly accurate for this application. Therefore, the hydrologic model, which provides a more conservative PMF estimate, was considered to be more representative to the project site. Therefore, the PMF to Bralorne TSF is estimated to be 4.8 m^3/s.

2.4.3 Inflow Design Flood

As indicated earlier, the rainfall-runoff method is considered appropriate for developing the IDF for Bralorne TSF as it accounts for site specific conditions such as soil type and local climate data. The 1000-year flood and the PMF were determined to be 1.4 m^3/s and 4.8 m^3/s, respectively. The following equation was used in developing the IDF hydrographs for the project site (CDA, 2007):

$$Q_{IDF} = Q_{1000} + C(Q_{PMF} - Q_{1000})$$

Where:

Q_{IDF} = Inflow design flood (m^3/s);

Q_{PMF} = Probable maximum flood (m^3/s);

Q_{1000}= 1000-year flood (m^3/s);

C = Coefficient (1/3 for High consequence class, and 2/3 for Very High consequence class)

The IDF corresponding to Low, Significant, High, Very High and Extreme Consequence Classification to the Bralorne TSF are provided in Table 2.4f and Figure 2.4a.

Table 2.4f: Inflow Design Flood to the Bralorne TSF

Dam Classification from CDA 2007	Design Flood Criteria	Inflow Design Flood (m^3/s)
Extreme	PMF	4.8
Very High	2/3 between 1/1000 year and PMF	3.7
High	1/3 between 1/1000 year and PMF	2.5
Significant	Between 1/100 and 1/1000 year	0.7 – 1.4
Low	1/100 year	0.7

2.5 Flood Routing and Freeboard Determination

A hydrological model was developed to compute water levels in Bralorne TSF during a range of IDFs as listed in Table 2.4f. The following sections provide a summary of the methodology and results of the flood routing analysis.

2.5.1 Volume-Elevation Relationship

A survey of the upper portion of the reservoir and TSF dam was performed by Bralorne. DTM was extracted from the survey data and used to define the reservoir and dam geometry in the hydraulic model. The volume-area-elevation relationship for the TSF was developed and shown in Figure 2.5a. Based on this information, the Bralorne TSF has an existing capacity of 98,200 m³ (3,460,000 ft³) and surface area of 45,300 m² (488,000 ft³). According to the proposed increase by 2.4 m in the embankment elevation, the TSF would have a capacity of 224,000 m³ (7,900,000 ft³) and a surface area of 56,300 m² (606,000 ft²) at the proposed crest elevation of 1056.7 m (3467 ft), this corresponds to a storage volume increase of 125,700 m³ (4,440,000 ft³).

2.5.2 Flood Routing Results

The flood routing was performed using the HEC-HMS model, which includes a routing component for flows through reservoirs. The starting water surface elevation was assumed to be at the current crest elevation of 1054.3 m (3459 ft). For current conditions, this is a conservative assumption as the current pond level is measured to be about 1.0 m below the crest, although crest elevation varies. Yet, as more tailings will be added to the facility, the available storage for stormwater runoff will progressively decrease. At the recent tailings production rate of 27,500 tonnes/year and assumed average settled tailings dry density of 1.4 tonnes/cubic metre, the tailings solids will occupy approximately 19,600 cubic metres/year.

Assuming that the reservoir has no release structure in place, the results of the HEC-HMS flood routing during IDFs corresponding to a range of classifications are summarized in Table 2.5a. It includes the peak pond level and inflow volume, assuming 100% of direct runoff contribution from the upstream catchments. Figure 2.5b presents the results of the flood routing graphically.

Table 2.5a: Results of Flood Routing

Consequence Classification	Proposed Dam Crest Elevation (m)	Initial Pond Level* (m)	Peak Pond Level (m)	Peak Inflow Volume (1000 m³)	Peak Inflow (m³/s)	Peak Outflow (m³/s)	Available Freeboard (m)
Low	1056.7	1054.3	1054.8	23.3	0.7	0.0	1.9
Significant	1056.7	1054.3	1054.8 - 1055.1	23.3 - 38.5	0.7-1.4	0.0	1.6 - 1.9
High	1056.7	1054.3	1055.6	62.5	2.6	0.0	1.1
Very High	1056.7	1054.3	1056.0	86.9	3.7	0.0	0.7
Extreme	1056.7	1054.3	1056.5	112.1	4.8	0.0	0.2

*Initial pond level is assumed to be the current embankment crest elevation.

2.5.3 Freeboard Requirement

In accordance with the 2007 CDA Guidelines, the freeboard at all dam structures should be evaluated for normal and extreme conditions. In general, the crest level of an embankment structure should be set so that the structure is protected against the most critical of the following cases (CDA 2007):

- No overtopping by 95% of the waves caused by the most critical wind with a frequency of 1/1,000 year when the reservoir is at its maximum normal elevation,
- No overtopping by 95% of the waves caused by the most critical wind when the reservoir is at its maximum extreme level during the passage of the IDF.

At the Bralorne TSF, a low angle beach has formed adjacent to the upstream face of the embankment. Therefore, during the maximum normal elevation, no wave action is expected. During the passage of the IDF, approximately 1.7 m of water depth is expected against the upstream face of the raised embankment at current tailings beach elevation. For a "High" consequence dam, the design return period of wind speed used for calculation of freeboard during IDF is 2 years.

A wind and wave analysis was performed to determine the freeboard requirements for the Bralorne TSF embankment. A frequency analysis of hourly wind data (1990-2014) at the Gwyneth Lake climate station (ID 2005051304) was conducted. The winds blowing from the north-west, west, south-west and south were used, since these winds travel directly towards the upstream face of the dam. An extreme event analysis using the methods described by Goda (1988) was used to calculate the wind speed for various return periods from the 24-year time series data. Goda's extreme event analysis uses a partial duration or peak-over-threshold data series. The primary and secondary thresholds of 6.5 m/s and 7.8 m/s were selected. The best fit distribution for each extreme value analysis was chosen to estimate the design events. Table 2.5b shows the Goda extreme event analysis results.

Table 2.5b: Goda Extreme Event Wind Speed Analysis Results

Return Period (y)	Wind Speed (m/s)	Wind Speed (km/h)
2	8.5	30.7
1,000	39.4	142.0

Setup and wave height were calculated using the 2-year wind value. The wind tide or setup is a phenomenon in which the water level at the dam rises due to the effect of wind blowing over the water. The setup was calculated using the following equation (Smith, 1985):

$$S = FV^2/63000D$$

Where

S = Wind tide or setup in m

F = Fetch in km

V = Wind velocity in km/h

D = Average reservoir depth in m

The wave height was calculated using the following equation (Smith, 1985):

$$H_w = 0.00513V^{1.06}F_e^{0.56}$$

$$F_e = KL$$

Where

H_w = Wave height in m

F_e = effective fetch in km

L = Maximum straight unobstructed water length facing the dam in km

K = Fetch correction factor based on the relation between the average reservoir width and L

The wave run-up is the height above the mean water surface at which a crest of a wave will interact with the barrier. The water run-up is based on the design wave height. A factor of 1.37 was applied to the calculated significant wave height to obtain the design wave height, which is the average of the highest 5% waves, as recommended by the CDA for freeboard calculations. Based on the embankment slopes, the ratio of run-up to the design wave height was determined to be 2.3 (Smith, 1985).

In this case, the 'minimum freeboard' is the difference between the peak level during the IDF and the dam crest. For a "High" classification dam, the freeboard should be such that 95% of the waves do not overtop the dam during a 2-year wind under design flood conditions. The results of the freeboard requirement for wind and wave actions are summarized in Table 2.5c.

Table 2.5c: Wind Setup and Wave Run-up

Parameter	During Passage of IDF
Wind Frequency	2-yr
Wind Setup (m)	0.002
Wave Runup (m)	0.29
Total Required Freeboard for Wind and Wave Actions (m)	0.29

The freeboard requirement for the Bralorne TSF design raise scenario was summarized in Table 2.5d.

Table 2.5d: Summary of Freeboard Assessment

Parameter	Bralorne TSF Dam Design Raise Scenario
Initial Water Level (m)*	1054.3
Design Crest Elevation (m)	1056.7
IDF Water Level (m)**	1055.6
IDF Inflow Volume (m^3)**	62,500
Required Freeboard for Wave Actions (m)	0.29
Required Freeboard for IDF Inflow (m)	1.3
Available Freeboard (m)**	0.8

*Initial water level is assumed to be the current embankment crest elevation.

**Corresponds to the "High" consequence classification.

3.0 DAM BREAK ANALYSIS

The consequence classification of a dam depends on the incremental consequence of a dam breach failure, and this can be the result of overtopping, a piping failure or an earthquake. A dam break analysis, including characterization of a hypothetical dam breach, flood wave routing and inundation mapping was carried out as part of this analysis.

3.1 Breach Analysis

The characterization of the dam breach and initial flood hydrograph was conducted using the US National Weather Service Breach Erosion Model (BREACH). The BREACH model was used to evaluate breach opening, time of dam failure and the subsequent breach flow into Cadwallader Creek and Hurley River. It is estimated that approximately 224,000 m^3 (7,900,000 ft^3) of tailings were deposited in the TSF (assuming the density of in place tailing is 1.4 tonnes/m^3) at the proposed full pond level. Two breach scenarios were modelled to obtain the breach hydrograph of the TSF Dam.

- Breach Scenario 1: a "Sunny Day" event where the dam failure is triggered by earthquake or internal dam erosion (piping).
- Breach Scenario 2: an overtopping failure caused by the local 24-hr PMP storm event inflow

Both breach scenarios were assumed to behave as water, however, the flood routing was modeled using mixed flow for the TSF breach as further explained in Section 3.2. A summary of the selected dam breach parameters and results of the breach analyses are provided in Table 3.1a. The breach parameters selected were the most conservative, yet realistic values based on available information. These parameters produced the highest expected peak flow from the breach.

Table 3.1a: Dam Breach Parameters and Results

Dam Breach Parameter	Breach Scenario 1	Breach Scenario 2
Failure Mode	Piping	Overtopping
Dam Breach Elevation (m)	1056.7	1056.7
Volume of Reservoir at Breach (m^3)	224,000	224,000
Reservoir Surface Area at Breach (m^2)	56,290	56,290
Elevation of Piping Failure Commencement(m) [1]	1049	N/A
Width of Crest (m)	5.5	5.5
Length of Crest (m)	305	305
Dam Slopes (H:V)	1:1.75 (u/s) and 1:2.0 (d/s)	1:1.75 (u/s) and 2.0:1.75 (d/s)
D_{50} Grain Size (mm)	1 (inner) and 5 (outer)	1 (inner) and 5 (outer)
Porosity Ratio	0.25 (inner) and 0.30 (outer)	0.25 (inner) and 0.30 (outer)
Unit Weight (lb/ft^3)	120 (inner) and 135 (outer)	120 (inner) and 135 (outer)
Internal Friction (°)	35 (inner) and 33 (outer)	35 (inner) and 33 (outer)
Cohesive Strength (lb/ft^2)	150 (inner) and 50 (outer)	150 (inner) and 50 (outer)
Results		
Breach Formation Time (hrs)	0.09	2.4
Breach Width (m)	6.5	24.8
Peak Flow (m^3/sec)	465	688

Notes: [1] Piping Height = 0.7 * Dam Height (State of Colorado, 2010)

A sensitivity analysis of peak breach flows was conducted for a number of parameters to provide confidence for the selected values. The sensitivity of the peak flow, breach formation time and breach width were tested for a selected range of values for a specific parameter while holding all other input parameters constant. Results of the sensitivity analysis (Table 3.1b) indicate that the magnitude of the peak discharge computed by BREACH is most sensitive to the value selected for the initial piping elevation and grain size. With the lowest possible initial piping elevation of 1046.6 m, the peak outflow could be as high as 673 m^3/s.

Table 3.1b: Dam Breach Sensitivity Analysis

Parameter	Base Value	Range of Values	Range of Peak Flow (m^3/sec)	Range of Breach Time (hr)	Range of Breach Width (m)
Initial Piping Elevation (m)	1049.1	1046.6 – 1049.7	673- 399	0.14 – 0.08	8.8 – 6.0
D_{50} Grain Size (mm)	5.0	1.0 - 7.0	399 - 465	0.12 - 0.08	6.1 – 6.5
Porosity Ratio	0.3	0.1 – 0.5	433 – 489	0.12 – 0.06	6.4 – 6.7
Unit Weight (lb/ft^3)	120	120 – 135	No Change	No Change	No Change
Cohesive Strength (lb/ft^2)	104	0 - 208	No Change	No Change	No Change

Note: Sensitivity conducted for Breach Scenario 1

Of the two failure scenarios evaluated, the Sunny Day failure results in a smaller amount of peak flood compared to the PMF overtopping event. Therefore, the hydrograph resultant from the overtopping failure is selected to be the critical case that is used to prepare the inundation mapping.

3.2 Flood Wave Routing

As summarized in Section 3.1, a large volume of the TSF outflow is composed of tailings. Flows composed of a mixture of water and sediment (tailings) exhibit different fluid properties than pure water flows. Water/tailings mixtures are nonhomogeneous, non-Newtonian, transient flood events whose fluid properties change as it flows downstream.

To account for non-Newtonian flows, flood modelling was conducted using FLO-2D, a 2-dimensional model that has the ability to simulate mudflows. Publicly available digital TRIM data were used to create topographic point data. Approximately 20 km^2 area was obtained which cover Cadwallader Creek and the Hurley River Valley down to Gold Bridge with a total channel length of approximately 10 km. The TRIM data does not include any stream channel bathymetry and the contour interval was not detailed enough to identify stream banks and channels. No edits were made to this data used in the flood routing model. As such, the flood routing analysis assumes that streams are already flowing at a level corresponding to the date the topographic data was collected in 2007 and the breach outflows are computed as flow on top of the topographic surface. The potential impact of this assumption is that if a dam failure occurs during a large flood event in the Hurley River, dam breach flood levels may be higher than those modelled.

The downstream channel roughness coefficient (Manning's n) was estimated to be 0.04 for the channel, 0.07 for the open fields along the river valley and 0.12 for the forested area. Overtopping inflow hydrograph from the BREACH analysis (Figure 3.2a) was entered downstream of the TSF. Flood routing analyses were conducted to determine the extent of the inundation to the downstream area.

The water/tailings mixture (mud flood) has fluid properties different from pure water for unit weight, dynamic viscosity and initial shear stress. These parameters are required to evaluate Non-Newtonian fluid properties which impact hydraulic parameters calculated such as flow depth, flow velocity and time to peak. It is expected that flows with a high viscosity such as mudflows will result in slower velocities, greater depths and slower time to peak than a pure water flood. The following empirical relationships were used to compute viscosity and shear stress (FLO-2D Guidelines):

$$\eta = 0.00172 e^{29.5 C_v} \quad (Pa)$$

$$\tau = 0.000602 e^{33.1 C_v} \ (Pa - \text{sec})$$

$$C_v = volume\ of\ sediment \div (volume\ of\ water\ plus\ sediment)$$

As shown, the viscosity and yield stress are functions of the volumetric sediment concentration C_v (percent concentration by volume of solids). Table 3.2a summarizes the water/tailings mixture properties stored in the TSF assuming fully mixed conditions.

Table 3.2a: Mudflow Properties

Parameters	Scenario – Overtopping Failure
Tailings Specific Gravity	2.8
Tailings Sediment Concentration[1]	0.50
Volume of Tailings (m^3)	224,000
Volume of Water (m^3) [2]	112,000
Mud Flood Sediment Concentration	0.33
Viscosity of Mud Flood (Pa-sec)	29.1
Shear Stress of Mud Flood (Pa)	33.4

[1] Estimated using tailings specific gravity and average dry density

[2] Volume of PMF inflow

3.3 Inundation Mapping

Inundation map was created for the TSF overtopping failure scenario to illustrate maximum water depth and time to maximum flooding depth (warning time).

Figures 3.3a-e illustrates the maximum flood depth caused by overtopping of the TSF during the passage of PMF. The tailings/water mixture flows eastwards into Cadwallader Creek. The majority of the flow joins the Hurley River and travels northwards for about 7.0 km before reaching the Bridge River. There is also a portion flow going southwards up Cadwallader Creek but does not reach the historical mining community of Bralorne. Generally, the extent of inundation is confined to the valley of the Hurley River. The flood slightly spreads out at the Bridge River. The Town of Gold Bridge, however, is situated above the maximum flood level and remained outside of the inundation zone. Figures 3.3f-j illustrates that it takes the flood wave about 2.5 hours to reach the maximum depth in the Hurley River and about 5.5 hours to reach the Bridge River by Gold Bridge.

It should also be noted that the results summarized above show the effects of the overland flood routing of the dam breach. It is expected that these results will vary depending on the magnitude of the Hurley River flow at the time of the dam break. As the mud flow progresses downstream, impacts diminish.

4.0 REVIEW OF CONSEQUENCE CLASSIFICATION

The 2007 CDA Dam Safety Review Guidelines provide consequence classification criteria as well as suggested design flood and earthquake levels as shown in the previous section (Table 2.4a).

A review of the TSF Dam classification was conducted as per the CDA 2007 Dam Safety Guideline criteria:

- Loss of life.
- Environmental impacts and cultural values.
- Infrastructure and economics.

In order to review the Consequence classification of the TSF, the dam breach inundation mapping (Figure 3.3a-e) was used to identify the magnitude of each criterion.

Loss of Life

There are many factors which affect the severity of the loss of life consequence such as depth of flow, velocities and advance warning time within the inundated area.

As shown in the inundation mapping (Figures 3.3 a-e), there are no access roads or infrastructure in the inundation area immediately downstream of the TSF. The presence of workers below the dam is temporary and infrequent. Downstream of Cadwallader Creek and along the Hurley River, no establishment was identified within the inundation area using Google Earth imagery. Both the community of Bralorne and the Town of Gold Bridge are outside the flood inundation area. Based on the criteria levels for loss of life, the consequence classification rating would be "Significant".

Environmental Impacts and Cultural Values

The mud flood caused by a TSF breach will inundate and leave tailings deposited along Cadwallader Creek, the Hurley River and the Bridge River. Based on the natural resource information database of British Columbia (iMap BC), all these streams are fish bearing water bodies that provide habitat for fisheries such as the Rainbow Trout, Whitefish, and Kokanee. Environmental losses could potentially occur due to habitat degradation (infilling of spawning habitats, loss of food supply, etc.) and chemical toxicity to fish and their invertebrate prey. Tailings that get into the substrate can take a long time to wash out, and can cause significant mortalities to invertebrates or result in changes to the invertebrate (and fish) communities. Based on this, the environmental impact is determined to be "High" and likely restorable in the long term. It should be noted that, the environmental consequence classification rating was made without a detailed environmental impact assessment. It may be reviewed and revised, if necessary, with input from qualified environmental professionals.

As the historical community of Bralorne and the Town of Gold Bridge are both outside the inundation area, minimal impact on the culture values is expected.

Infrastructure and Economics

As detailed in Figure 3.3b-e, the mud flow would travel along the Hurley River valley and risk the integrity of the Bralorne Road Bridge. It is anticipated that there would be "Significant" economic loss to remediate the infrastructure.

Summary

Based on the three criteria measures described above, it was recommended that the consequence of the Bralorne TSF Dam be "High".

5.0 CONCLUSIONS

The conclusions reached during this hydrotechnical engineering investigation of the proposed raised embankment of the Bralorne Mine TSF dam are:

- Based on the results of the dam break analysis and inundation mapping, a breach of the raised embankment under conditions of a Probable Maximum Flood would result in a mud flow that would travel down Cadwallader Creek and the Hurley River and enter the Bridge River. The tailings outflow will not cause incremental flooding to the community of Bralorne and the Town of Gold Bridge.

- The consequence classification rating of the Bralorne Mine TSF is determined as "High" due to the expected environmental impact associated with a potential breach.

- The Inflow Design Flood (IDF) corresponding to the “High” consequence classification is 1/3 between 1/1000 year and Probable Maximum Flood (PMF). Results of the hydrological analysis indicate a runoff volume of 62,500 m^3 into the TSF during an IDF event.
- In accordance with the 2007 CDA Guidelines, the freeboard at the TSF was estimated for normal and extreme conditions. Under the normal condition, no wave action is expected due to the presence of a low angle beach against the upstream face of the TSF embankment. During the IDF (maximum extreme pond level) and when a shallow tailings beach is not present adjacent to the embankment, a freeboard of 0.29 m in addition to the storm storage is required to protect the embankment against the 2-year wind set-up and wave run-up.

6.0 RECOMMENDATIONS

The current tailings storage capacity is of concern and efforts to address this have been initiated by Bralorne. It is recommended that the proposed embankment raise be constructed at earliest opportunity to create adequate capacity for tailings, process water, and design storm event storage.

7.0 CLOSURE

We trust this report meets your present requirements. If you have any questions or comments, please contact the undersigned.

Respectfully submitted,
Tetra Tech EBA Inc.

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11-21-2014

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Nov.21/2014

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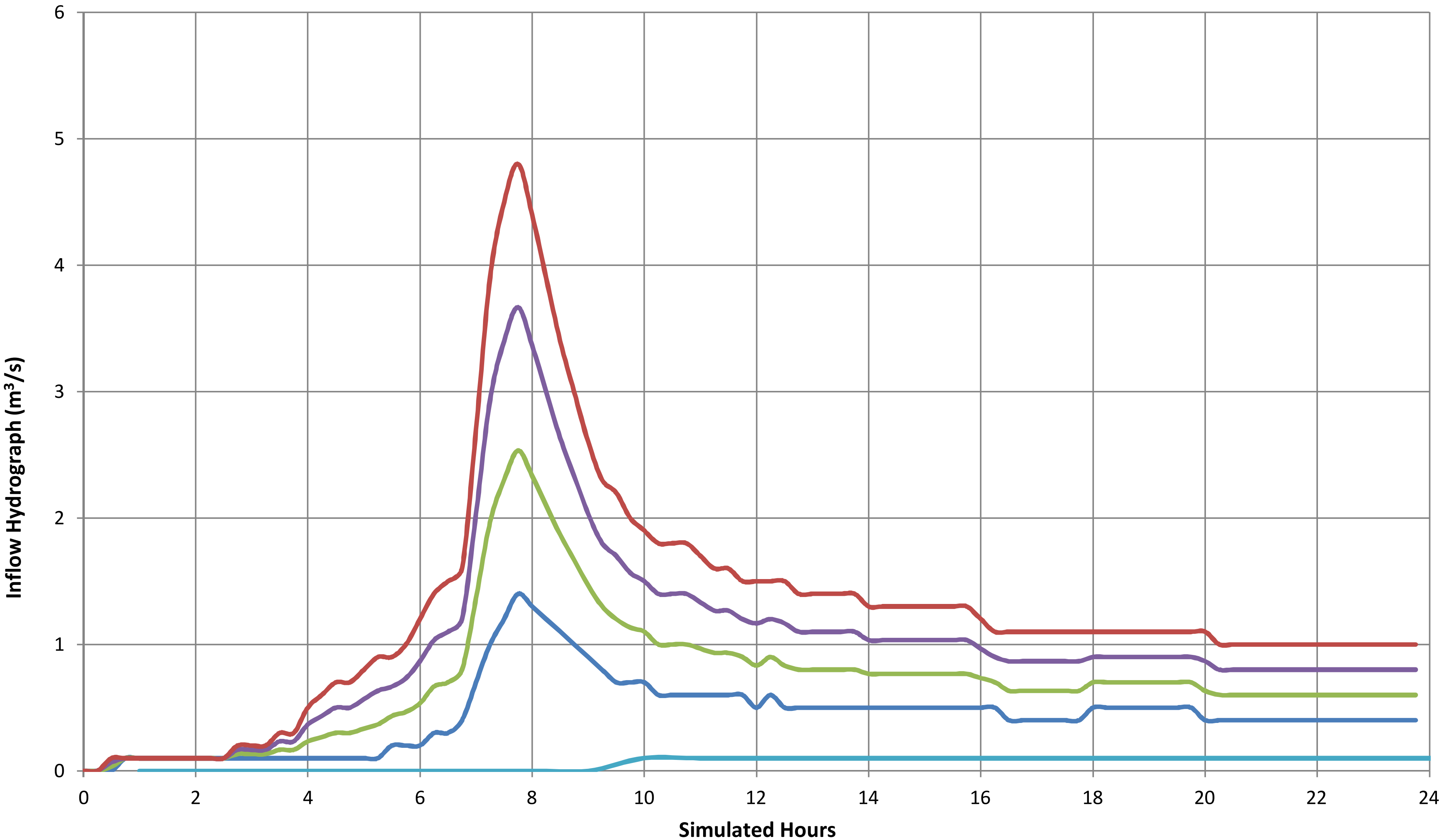
FIGURES



NOTES

- 100- yr (Low)
- 1000-yr
- 1/3 Between 1000-yr and PMF (High)
- 2/3 Between 1000-yr and PMF (Very High)
- PMF (Extreme)

STATUS
ISSUED FOR USE

CLIENT

BRALORNE GOLD MINES LTD.

TETRA TECH

BRALORNE TAILINGS STORAGE FACILITY HYDROTECHNICAL ASSESSMENT

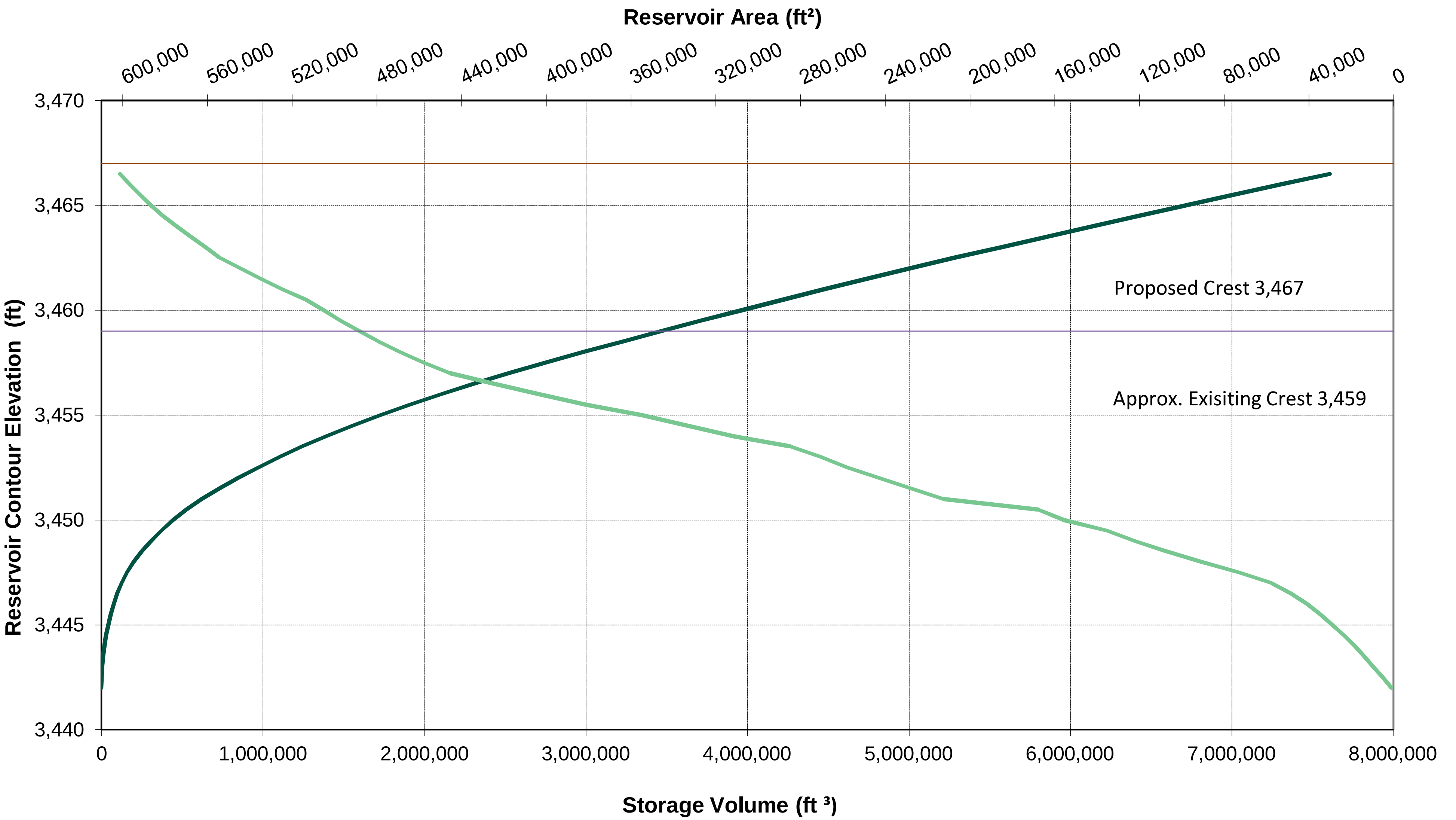
Bralorne TSF Inflow Hydrograph

PROJECT NO.	DWN	CKD	APVD	REV
V15103090	EL	AGC	AGC	0

OFFICE: EBA-VANC

DATE: October 2014

Figure 2.4a



NOTES

Storage Volume
Reservoir Size
Crest
Existing

STATUS
ISSUED FOR USE

CLIENT
BRALORNE GOLD MINES LTD.

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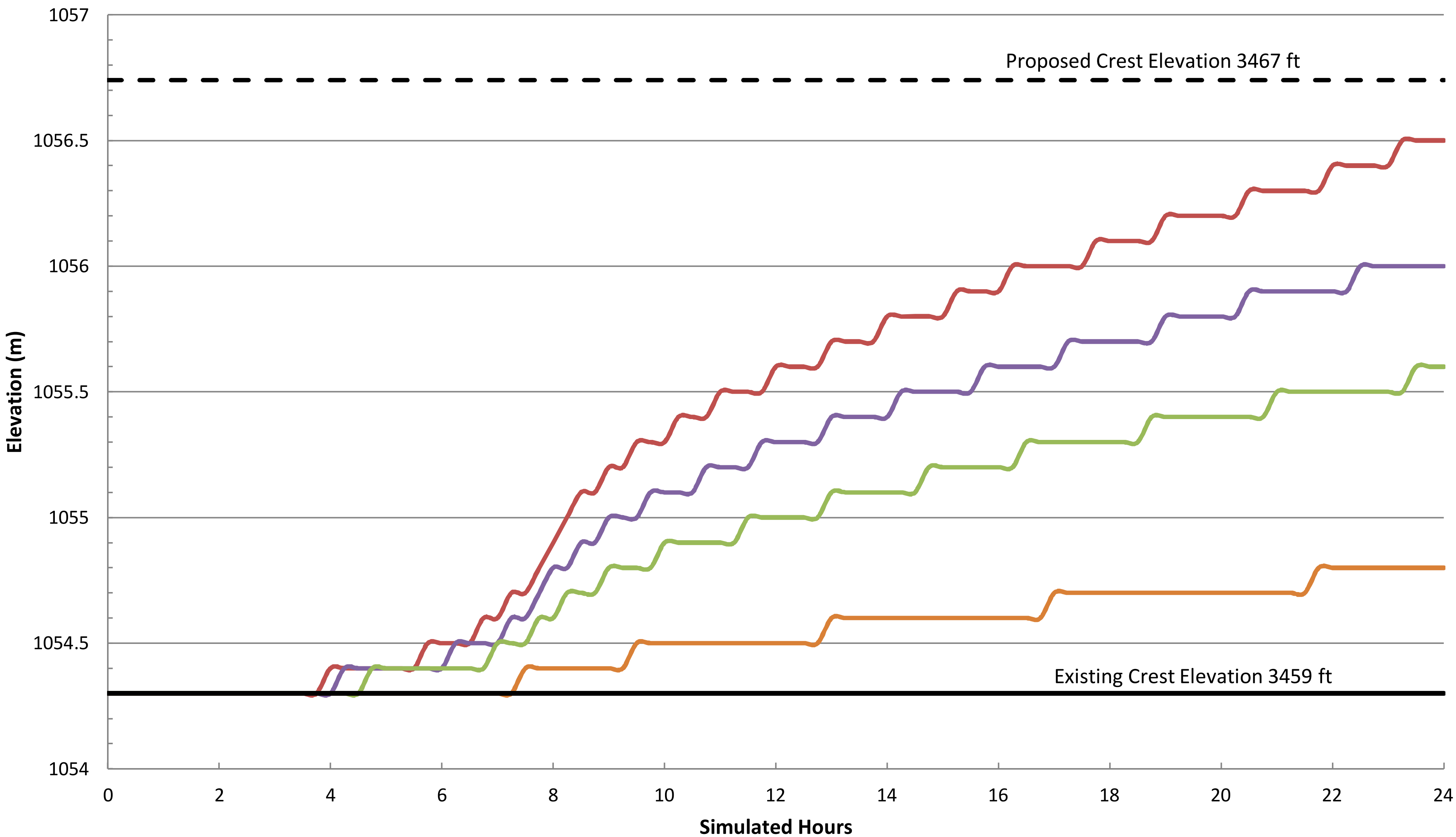
BRALORNE TAILINGS STORAGE FACILITY HYDROTECHNICAL ASSESSMENT

Bralorne TSF Storage Curve
Volume - Area - Elevation

PROJECT NO.	DWN	CKD	APVD	REV
V15103090	RH	EL	CJ	0

OFFICE: EBA-VANC
DATE: October 2014

Figure 2.5a



NOTES

Lake Level (Extreme)
Lake Level (Very High)
Lake Leve (High)
Lake Level (Low)
Proposed Dam Crest Elevation
Existing Dam Crest Elevation

STATUS
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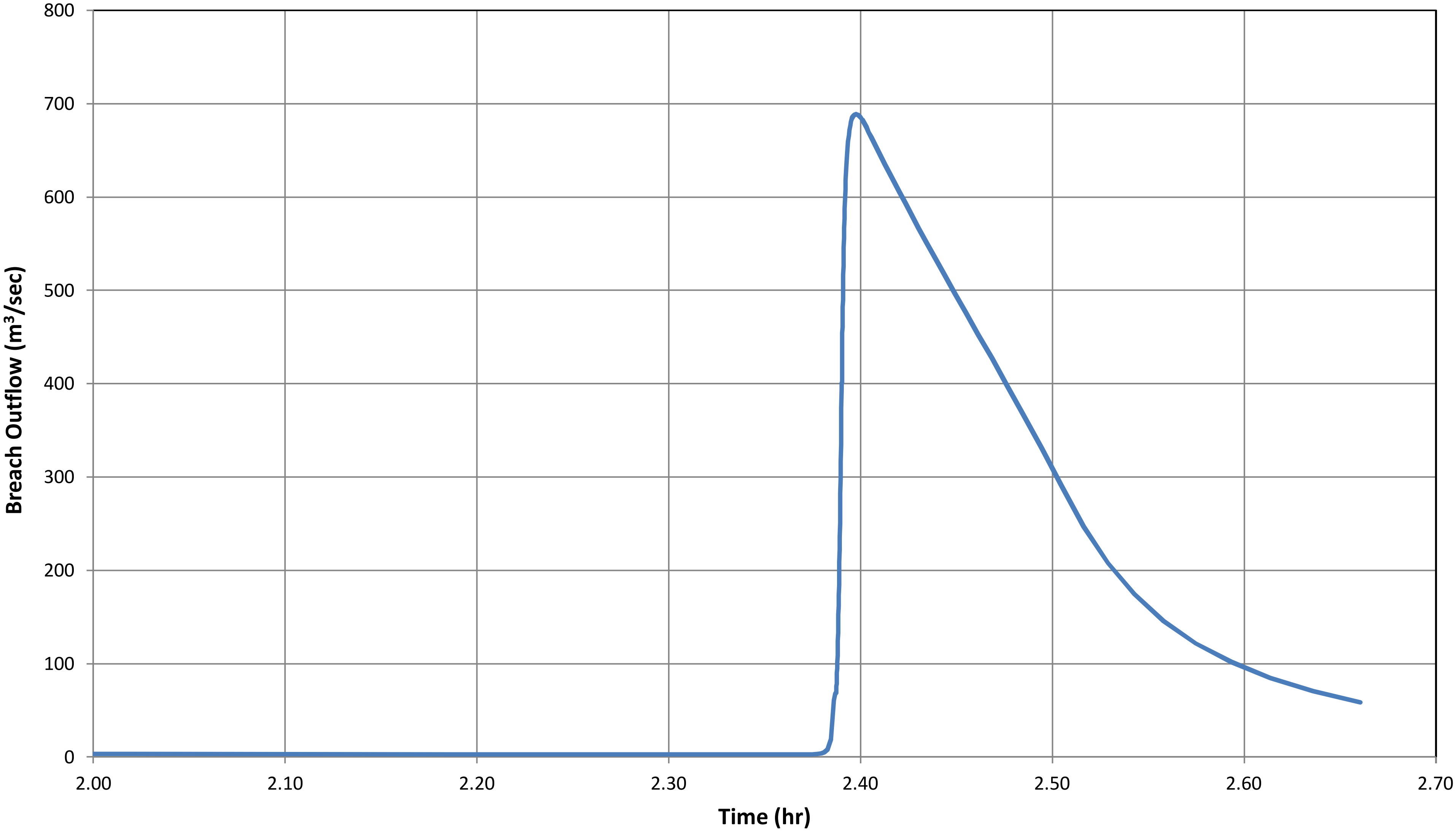
BRALORNE TAILINGS STORAGE FACILITY HYDROTECHNICAL ASSESSMENT

Bralorne TSF Flood Routing Reservior Levels

PROJECT NO.	DWN	CKD	APVD	REV
V15103090	RH	EL	CJ	0

OFFICE	DATE
EBA-VANC	October 2014

Figure 2.5a



NOTES

Overtopping Failure - with PMF Inflow

STATUS
ISSUED FOR USE

CLIEN

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BRALORNE TAILINGS STORAGE FACILITY HYDROTECHNICAL ASSESSMENT

Bralorne TSF Overtopping Failure Inflow Hydrograph

PROJECT NO.	DWN	CKD	APVD	REV
V15103090	EL	AGC	AGC	0

OFFICE	DATE
EBA-VANC	October 2014

Figure 3.2a

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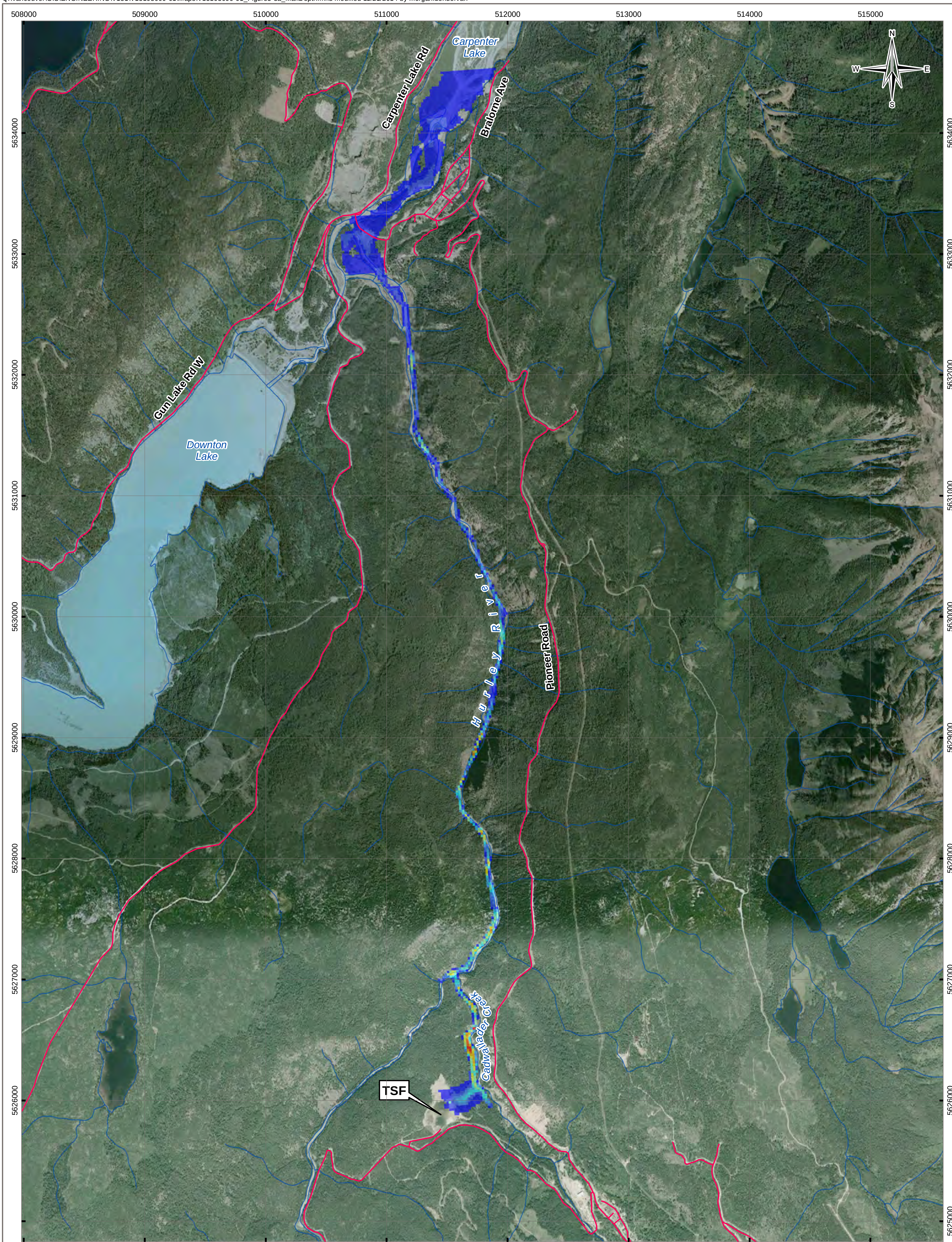

LEGEND

- Road
- Waterbody/Watercourse

Maximum Flood Depth (m)

- 12.8 - 13.6
- 11.8 - 12.7
- 10.8 - 11.7
- 9.8 - 10.7
- 8.9 - 9.7
- 7.9 - 8.8
- 6.9 - 7.8
- 5.9 - 6.8
- 5.0 - 5.8
- 4.0 - 4.9
- 3.0 - 3.9
- 2.0 - 2.9
- 1.1 - 1.9
- 0.0 - 1.0

NOTES

1. TSF overtopping failure caused by the local 24-hr PMP storm inflow.
2. Base Data Source: Imagery from Google; Province of BC (2013) CanVec 1:50,000

STATUS
ISSUED FOR USE

BRALORNE TAILINGS STORAGE FACILITY HYDROTECHNICAL ASSESSMENT

Dam Break Inundation Mapping Maximum Flood Depth - Overview

PROJECTION: UTM Zone 10
DATUM: NAD83
CLIENT: **Bralorne Gold Mines Ltd.**

Scale: 1:30,000
500 250 0 500
Metres

TETRA TECH EBA

FILE NO.: V15103090-01_Figure3-3a_MaxDepth.mxd

PROJECT NO.	DWN	CKD	APVD	REV
V15103090-01	MEZ	SL	EL	0

OFFICE: Tt EBA-VANC
DATE: November 21, 2014

Figure 3.3a

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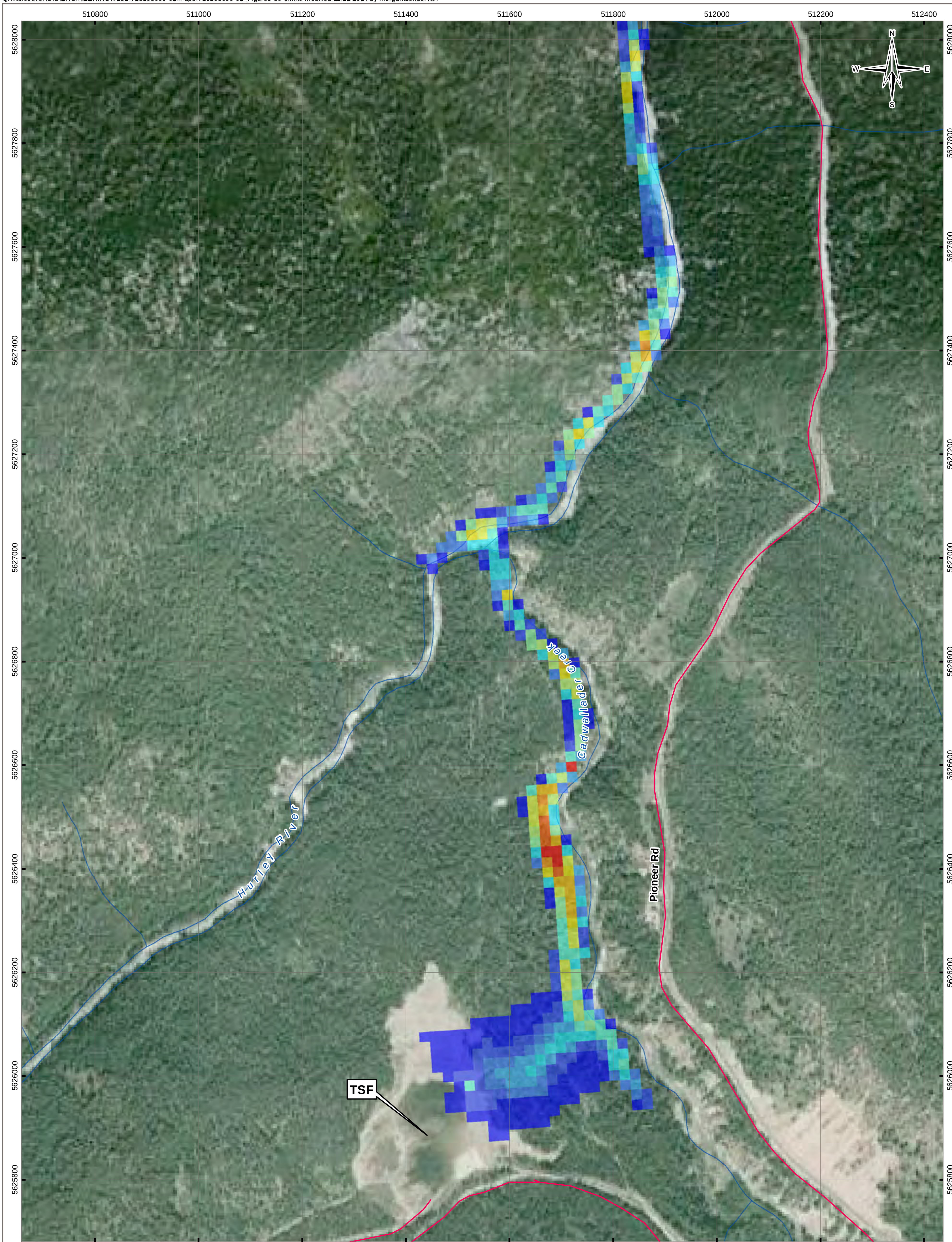
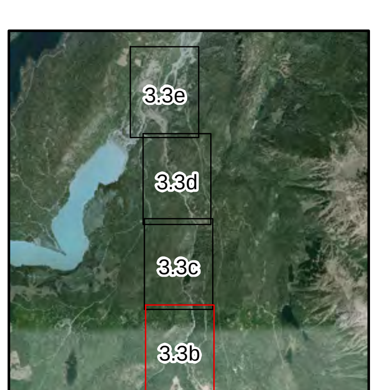


LEGEND

- Road
- Waterbody/Watercourse

Maximum Flood Depth (m)

- 12.8 - 13.6
- 11.8 - 12.7
- 10.8 - 11.7
- 9.8 - 10.7
- 8.9 - 9.7
- 7.9 - 8.8
- 6.9 - 7.8
- 5.9 - 6.8
- 5.0 - 5.8
- 4.0 - 4.9
- 3.0 - 3.9
- 2.0 - 2.9
- 1.1 - 1.9
- 0.0 - 1.0



NOTES

1. TSF overtopping failure caused by the local 24-hr PMP storm inflow.
2. Base Data Source: Imagery from Google; Province of BC (2013) CanVec 1:50,000

STATUS
ISSUED FOR USE

BRALORNE TAILINGS STORAGE FACILITY HYDROTECHNICAL ASSESSMENT

Dam Break Inundation Mapping
Maximum Flood Depth Map 1

PROJECTION: UTM Zone 10
DATUM: NAD83

Scale: 1:7,000
100 50 0 100
Metres

CLIENT: **Bralorne Gold Mines Ltd.**

TETRA TECH EBA

FILE NO.: V15103090-01_Figure3-3b-e.mxd

PROJECT NO.	DWN	CKD	APVD	REV
V15103090-01	MEZ	SL	EL	0

OFFICE: Tt EBA-VANC
DATE: November 21, 2014

Figure 3.3b

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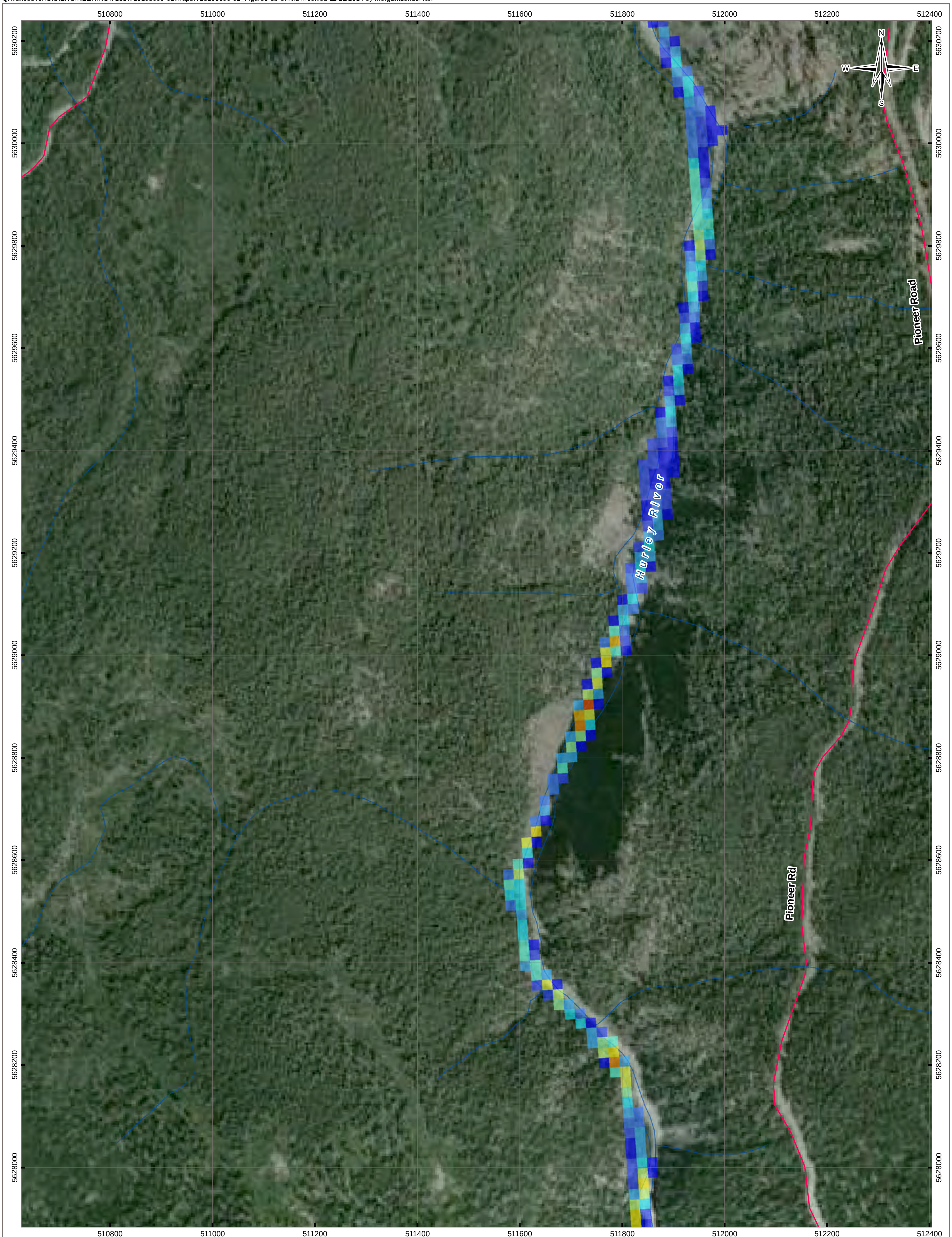


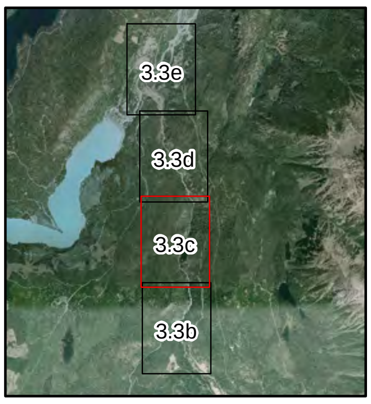
LEGEND

Road

Waterbody/Watercourse

Maximum Flood Depth (m)

- 12.8 - 13.6
- 11.8 - 12.7
- 10.8 - 11.7
- 9.8 - 10.7
- 8.9 - 9.7
- 7.9 - 8.8
- 6.9 - 7.8
- 5.9 - 6.8
- 5.0 - 5.8
- 4.0 - 4.9
- 3.0 - 3.9
- 2.0 - 2.9
- 1.1 - 1.9
- 0.0 - 1.0



NOTES

1. TSF overtopping failure caused by the local 24-hr PMP storm inflow.
2. Base Data Source: Imagery from Google; Province of BC (2013) CanVec 1:50,000

STATUS
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BRALORNE TAILINGS STORAGE FACILITY HYDROTECHNICAL ASSESSMENT

Dam Break Inundation Mapping
Maximum Flood Depth Map 2

PROJECTION	DATUM	CLIENT
UTM Zone 10	NAD83	Bralorne Gold Mines Ltd.

Scale: 1:7,000
100 50 0 100
Metres

FILE NO.
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TETRA TECH EBA

PROJECT NO.	DWN	CKD	APVD	REV
V15103090-01	MEZ	SL	EL	0

OFFICE	DATE
Tt EBA-VANC	November 21, 2014

Figure 3.3c

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LEGEND

- Road
- Waterbody/Watercourse

Maximum Flood Depth (m)

- 12.8 - 13.6
- 11.8 - 12.7
- 10.8 - 11.7
- 9.8 - 10.7
- 8.9 - 9.7
- 7.9 - 8.8
- 6.9 - 7.8
- 5.9 - 6.8
- 5.0 - 5.8
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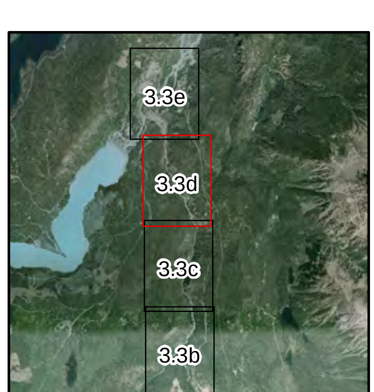
- 1.1 - 1.9
- 0.0 - 1.0



NOTES

1. TSF overtopping failure caused by the local 24-hr PMP storm inflow.
2. Base Data Source: Imagery from Google; Province of BC (2013) CanVec 1:50,000

STATUS
ISSUED FOR USE

BRALORNE TAILINGS STORAGE FACILITY HYDROTECHNICAL ASSESSMENT

Dam Break Inundation Mapping Maximum Flood Depth Map 3

PROJECTION	DATUM	CLIENT
UTM Zone 10	NAD83	Bralorne Gold Mines Ltd.

Scale: 1:7,000

100 50 0 100

Metres

FILE NO.
V15103090-01_Figure3-3b-e.mxd

TETRA TECH EBA

PROJECT NO.	DWN	CKD	APVD	REV
V15103090-01	MEZ	SL	EL	0

OFFICE	DATE
Tt EBA-VANC	November 21, 2014

Figure 3.3d

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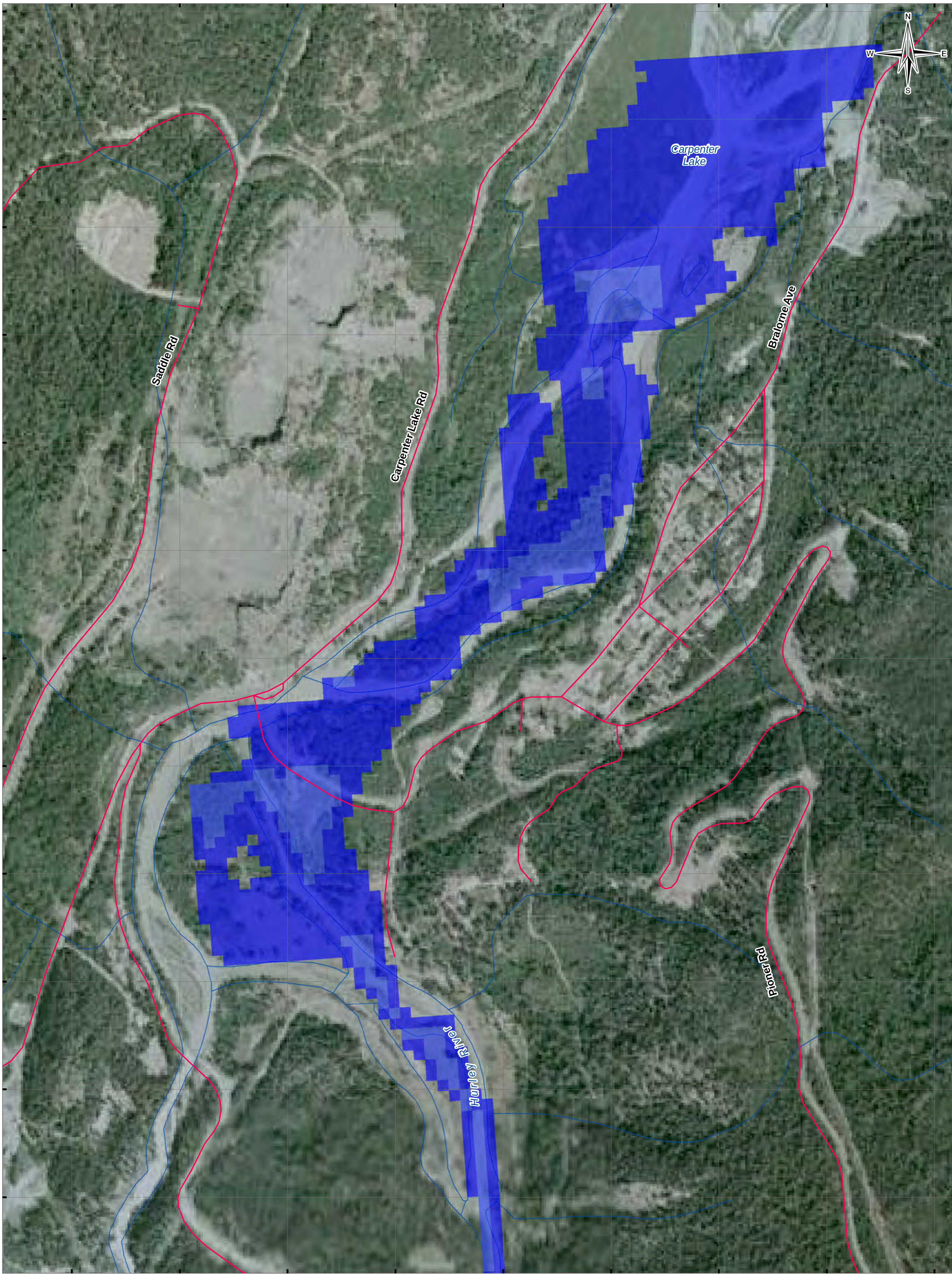
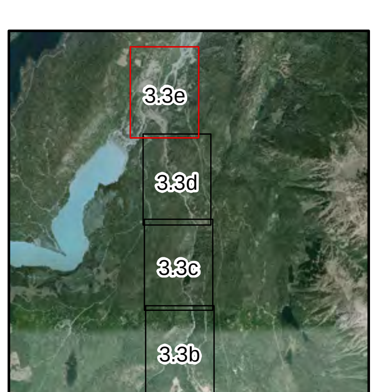


LEGEND

- Road
- Waterbody/Watercourse

Maximum Flood Depth (m)

- 12.8 - 13.6
- 11.8 - 12.7
- 10.8 - 11.7
- 9.8 - 10.7
- 8.9 - 9.7
- 7.9 - 8.8
- 6.9 - 7.8
- 5.9 - 6.8
- 5.0 - 5.8
- 4.0 - 4.9
- 3.0 - 3.9
- 2.0 - 2.9
- 1.1 - 1.9
- 0.0 - 1.0



NOTES

1. TSF overtopping failure caused by the local 24-hr PMP storm inflow.
2. Base Data Source:
   Imagery from Google; Province of BC (2013)
   CanVec 1:50,000

STATUS
ISSUED FOR USE

BRALORNE TAILINGS STORAGE FACILITY HYDROTECHNICAL ASSESSMENT

Dam Break Inundation Mapping
Maximum Flood Depth Map 4

PROJECTION	DATUM	CLIENT
UTM Zone 10	NAD83	Bralorne Gold Mines Ltd.

Scale: 1:7,000

100 50 0 100

Metres

TETRA TECH EBA

FILE NO.
V15103090-01_Figure3-3b-e.mxd

PROJECT NO.	DWN	CKD	APVD	REV
V15103090-01	MEZ	SL	EL	0

OFFICE	DATE
Tt EBA-VANC	November 21, 2014

Figure 3.3e

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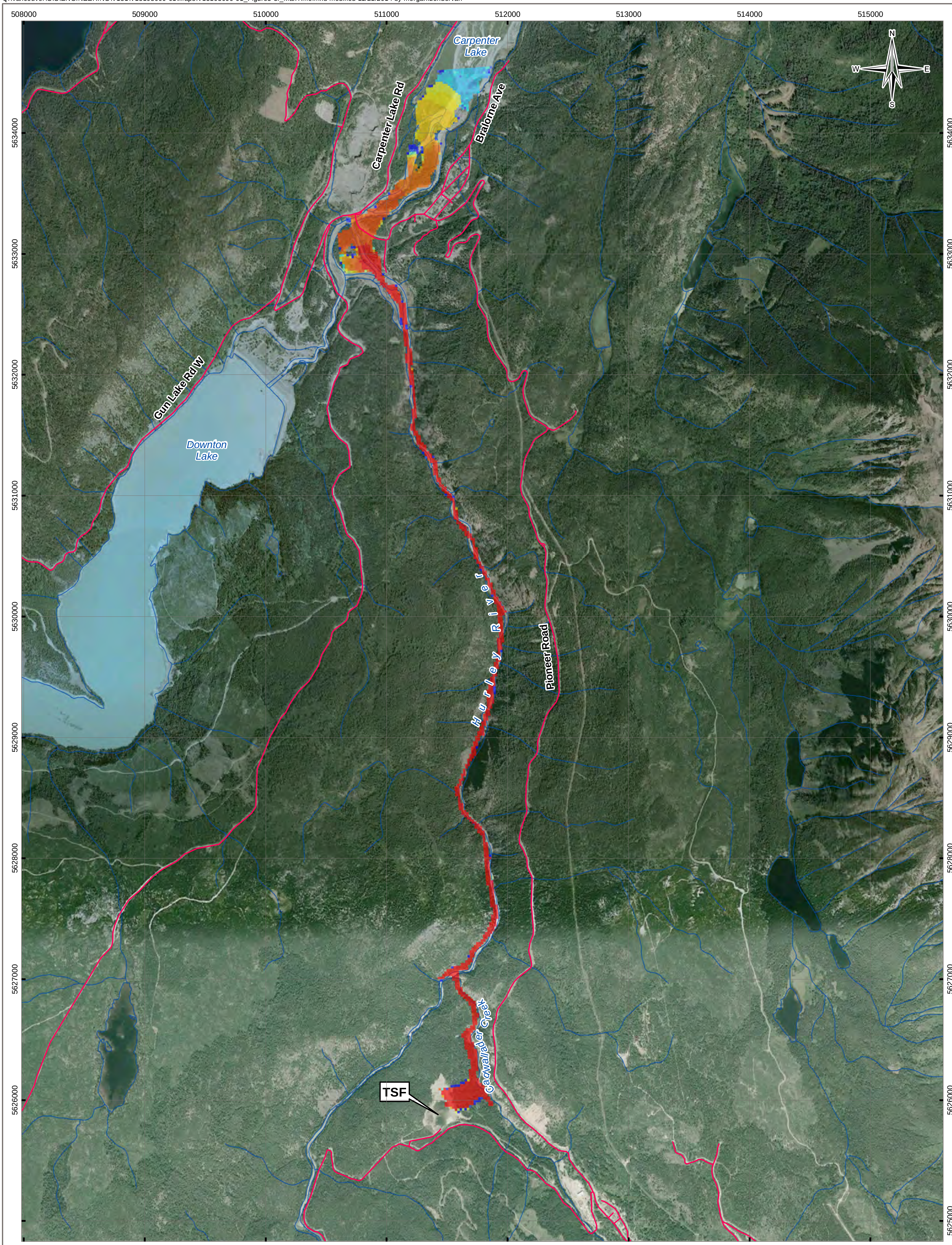


LEGEND

- Road
- Waterbody/Watercourse

Time to Maximum Depth (hours)

- 2.4 - 7.1
- 7.2 - 11.8
- 11.9 - 16.5
- 16.6 - 21.2
- 21.3 - 25.8
- 25.9 - 30.5
- 30.6 - 35.2
- 35.3 - 39.9
- 40.0 - 44.6
- 44.7 - 49.3
- 49.4 - 54.0
- 54.1 - 58.7
- 58.8 - 63.4
- 63.5 - 68.1
- 68.2 - 72.7
- 72.8 - 77.4
- 77.5 - 82.1
- 82.2 - 86.8
- 86.9 - 91.5
- 91.6 - 96.2

NOTES

1. TSF overtopping failure caused by the local 24-hr PMP storm inflow.
2. Base data source: Imagery from Google; Province of BC (2013) CanVec 1:50,000

STATUS
ISSUED FOR USE

BRALORNE TAILINGS STORAGE FACILITY HYDROTECHNICAL ASSESSMENT

Dam Break Inundation Mapping Time to Maximum Flood Depth - Overview

PROJECTION	DATUM	CLIENT
UTM Zone 10	NAD83	Bralorne Gold Mines Ltd.

Scale: 1:30,000

500 250 0 500

Metres

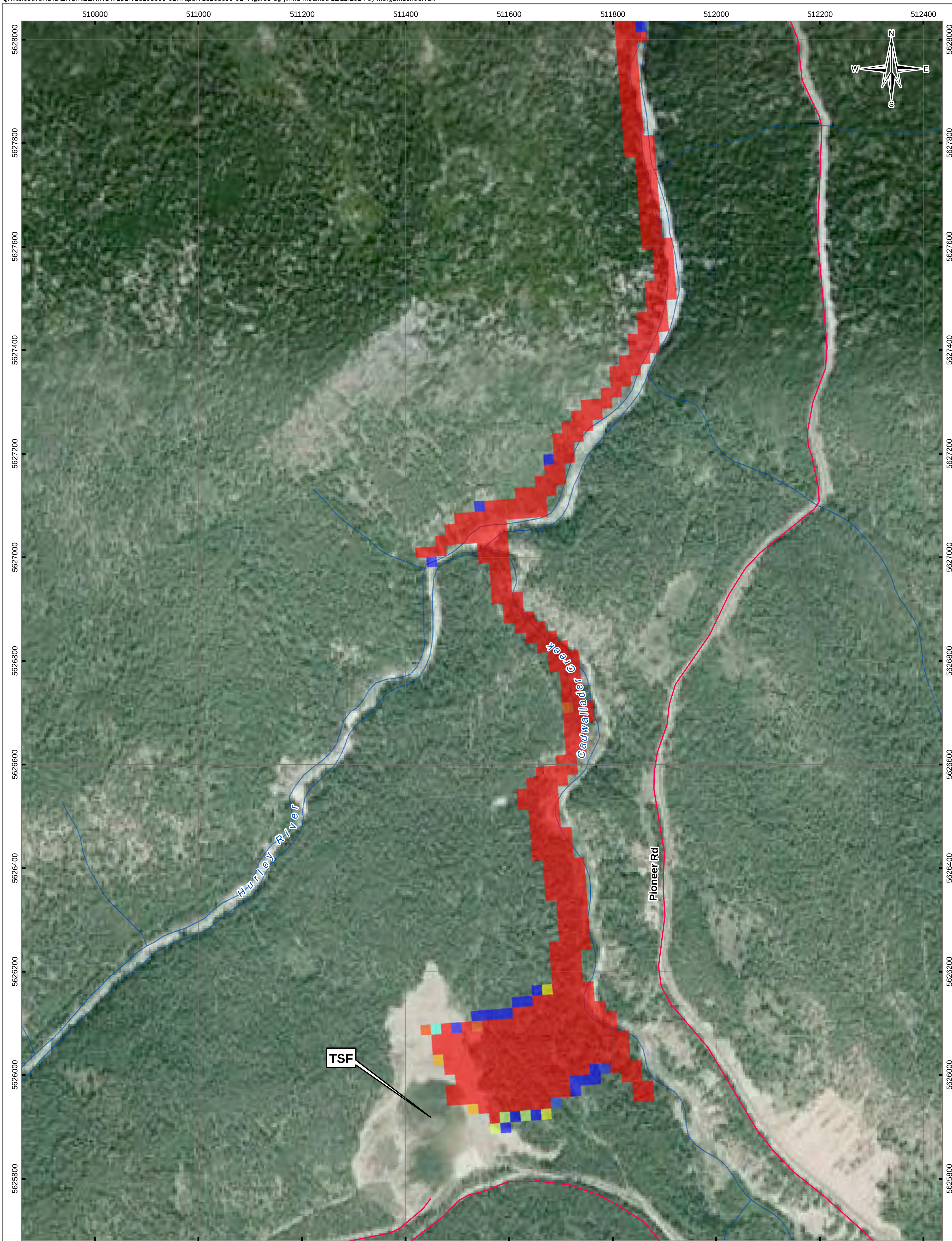
TETRA TECH EBA

FILE NO.
V15103090-01_Figure3-3f_MaxTime.mxd

PROJECT NO.	DWN	CKD	APVD	REV
V15103090-01	MEZ	SL	EL	0

OFFICE	DATE
Tt EBA-VANC	November 21, 2014

Figure 3.3f

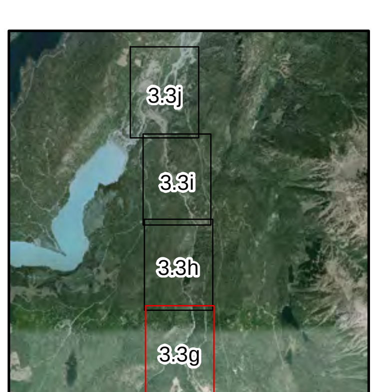


LEGEND

- Road
- Waterbody/Watercourse

Time to Maximum Depth (hours)

- 2.4 - 7.1
- 7.2 - 11.8
- 11.9 - 16.5
- 16.6 - 21.2
- 21.3 - 25.8
- 25.9 - 30.5
- 30.6 - 35.2
- 35.3 - 39.9
- 40.0 - 44.6
- 44.7 - 49.3
- 49.4 - 54.0
- 54.1 - 58.7
- 58.8 - 63.4
- 63.5 - 68.1
- 68.2 - 72.7
- 72.8 - 77.4
- 77.5 - 82.1
- 82.2 - 86.8
- 86.9 - 91.5
- 91.6 - 96.2



NOTES

1. TSF overtopping failure caused by the local 24-hr PMP storm inflow.
2. Base Data Source: Imagery from Google; Province of BC (2013) CanVec 1:50,000

STATUS
ISSUED FOR USE

BRALORNE TAILINGS STORAGE FACILITY HYDROTECHNICAL ASSESSMENT

Dam Break Inundation Mapping
Time to Maximum Flood Depth Map 1

PROJECTION	DATUM	CLIENT
UTM Zone 10	NAD83	Bralorne Gold Mines Ltd.

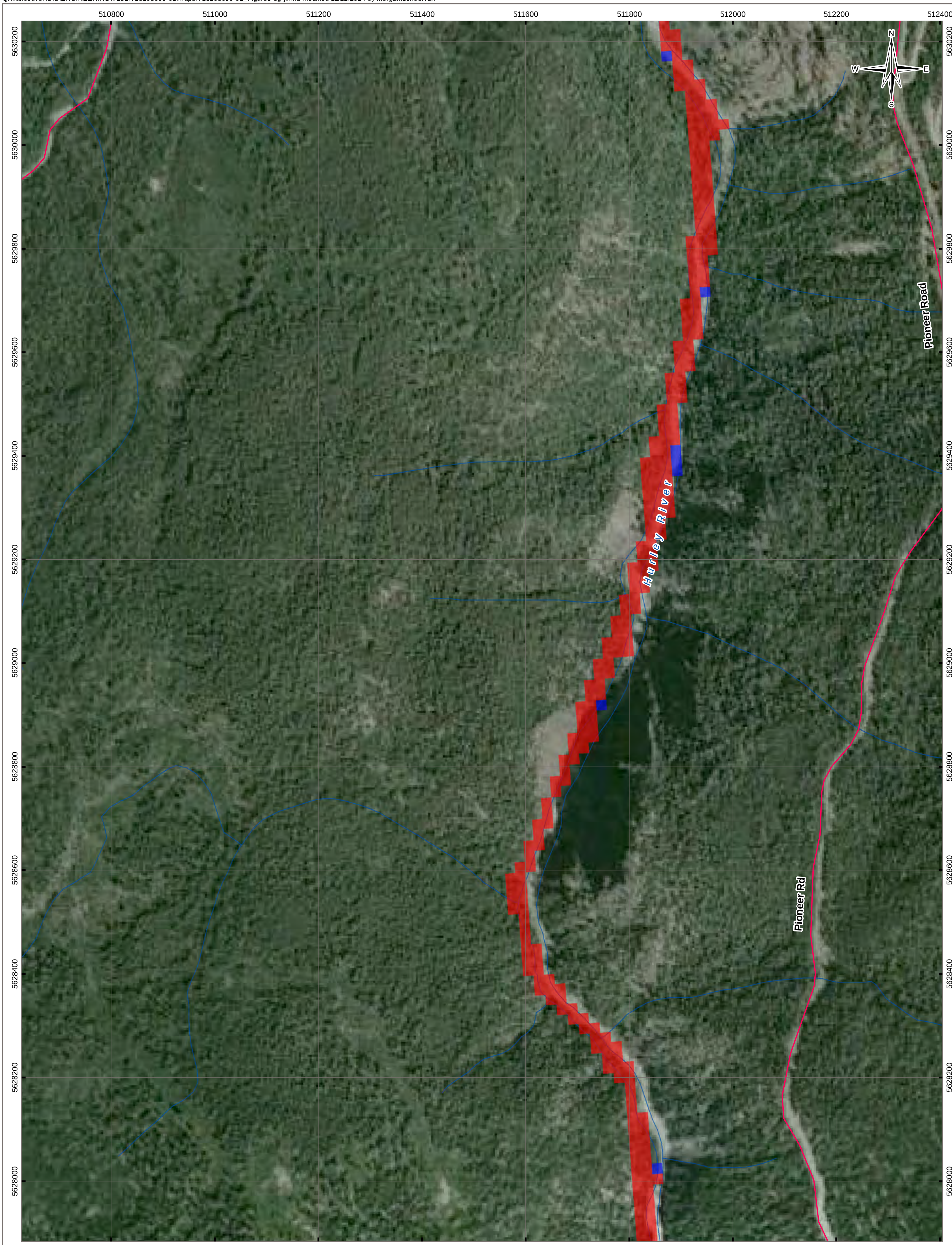
Scale: 1:7,000
100 50 0 100
Metres

TETRA TECH EBA

FILE NO.				
V15103090-01_Figure3-3g-j.mxd				
PROJECT NO.	**DWN**	**CKD**	**APVD**	**REV**
V15103090-01	MEZ	SL	EL	0
OFFICE	**DATE**			
Tt EBA-VANC	November 21, 2014			

Figure 3.3g

Q:\Vancouver\GIS\ENGINEERING\V151\V15103090-01\Maps\V15103090-01_Figure3-3g-j.mxd modified 11/21/2014 by morgan.zondervan

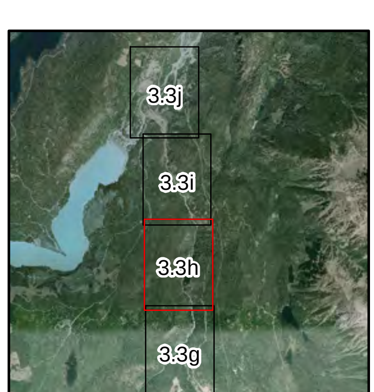


LEGEND

- Road
- Waterbody/Watercourse

Time to Maximum Depth (hours)

- 2.4 - 7.1
- 7.2 - 11.8
- 11.9 - 16.5
- 16.6 - 21.2
- 21.3 - 25.8
- 25.9 - 30.5
- 30.6 - 35.2
- 35.3 - 39.9
- 40.0 - 44.6
- 44.7 - 49.3
- 49.4 - 54.0
- 54.1 - 58.7
- 58.8 - 63.4
- 63.5 - 68.1
- 68.2 - 72.7
- 72.8 - 77.4
- 77.5 - 82.1
- 82.2 - 86.8
- 86.9 - 91.5
- 91.6 - 96.2



NOTES

1. TSF overtopping failure caused by the local 24-hr PMP storm inflow.
2. Base Data Source: Imagery from Google; Province of BC (2013) CanVec 1:50,000

STATUS
ISSUED FOR USE

BRALORNE TAILINGS STORAGE FACILITY HYDROTECHNICAL ASSESSMENT

Dam Break Inundation Mapping Time to Maximum Flood Depth Map 2

PROJECTION	DATUM	CLIENT
UTM Zone 10	NAD83	Bralorne Gold Mines Ltd.

Scale: 1:7,000

100 50 0 100

Metres

FILE NO.
V15103090-01_Figure3-3g-j.mxd

TETRA TECH EBA

PROJECT NO.	DWN	CKD	APVD	REV
V15103090-01	MEZ	SL	EL	0

OFFICE	DATE
Tt EBA-VANC	November 21, 2014

Figure 3.3h

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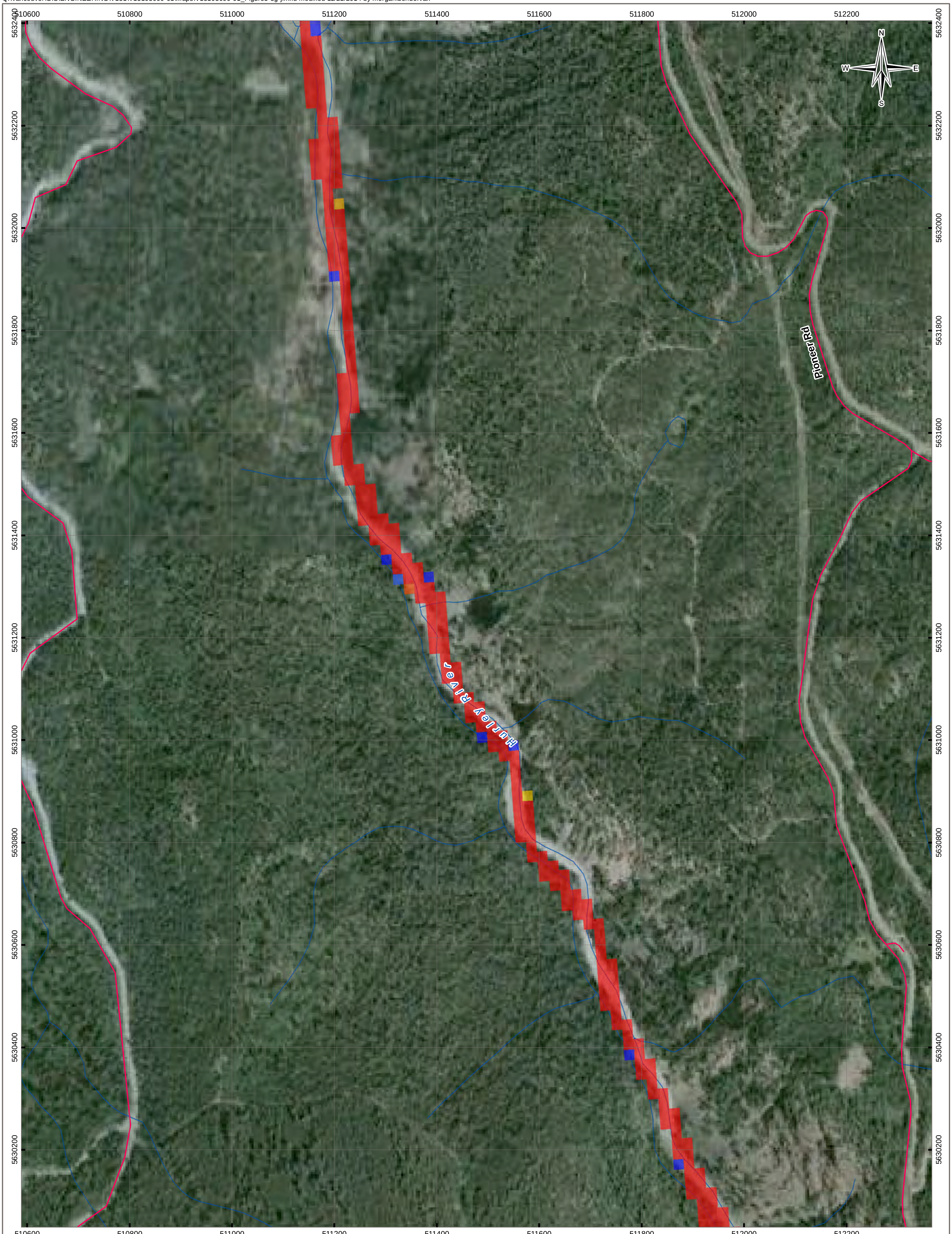


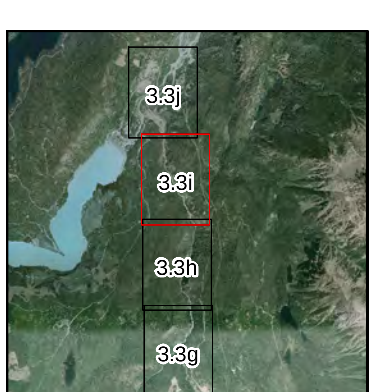
LEGEND

Road

Waterbody/Watercourse

Time to Maximum Depth (hours)

- 2.4 - 7.1
- 7.2 - 11.8
- 11.9 - 16.5
- 16.6 - 21.2
- 21.3 - 25.8
- 25.9 - 30.5
- 30.6 - 35.2
- 35.3 - 39.9
- 40.0 - 44.6
- 44.7 - 49.3
- 49.4 - 54.0
- 54.1 - 58.7
- 58.8 - 63.4
- 63.5 - 68.1
- 68.2 - 72.7
- 72.8 - 77.4
- 77.5 - 82.1
- 82.2 - 86.8
- 86.9 - 91.5
- 91.6 - 96.2



NOTES
1. TSF overtopping failure caused by the local 24-hr PMP storm inflow.
2. Base Data Source:
Imagery from Google; Province of BC (2013) CanVec 1:50,000

STATUS
ISSUED FOR USE

BRALORNE TAILINGS STORAGE FACILITY HYDROTECHNICAL ASSESSMENT

Dam Break Inundation Mapping
Time to Maximum Flood Depth Map 3

PROJECTION	DATUM	CLIENT
UTM Zone 10	NAD83	Bralorne Gold Mines Ltd.

Scale: 1:7,000
100 50 0 100
Metres

TETRA TECH EBA

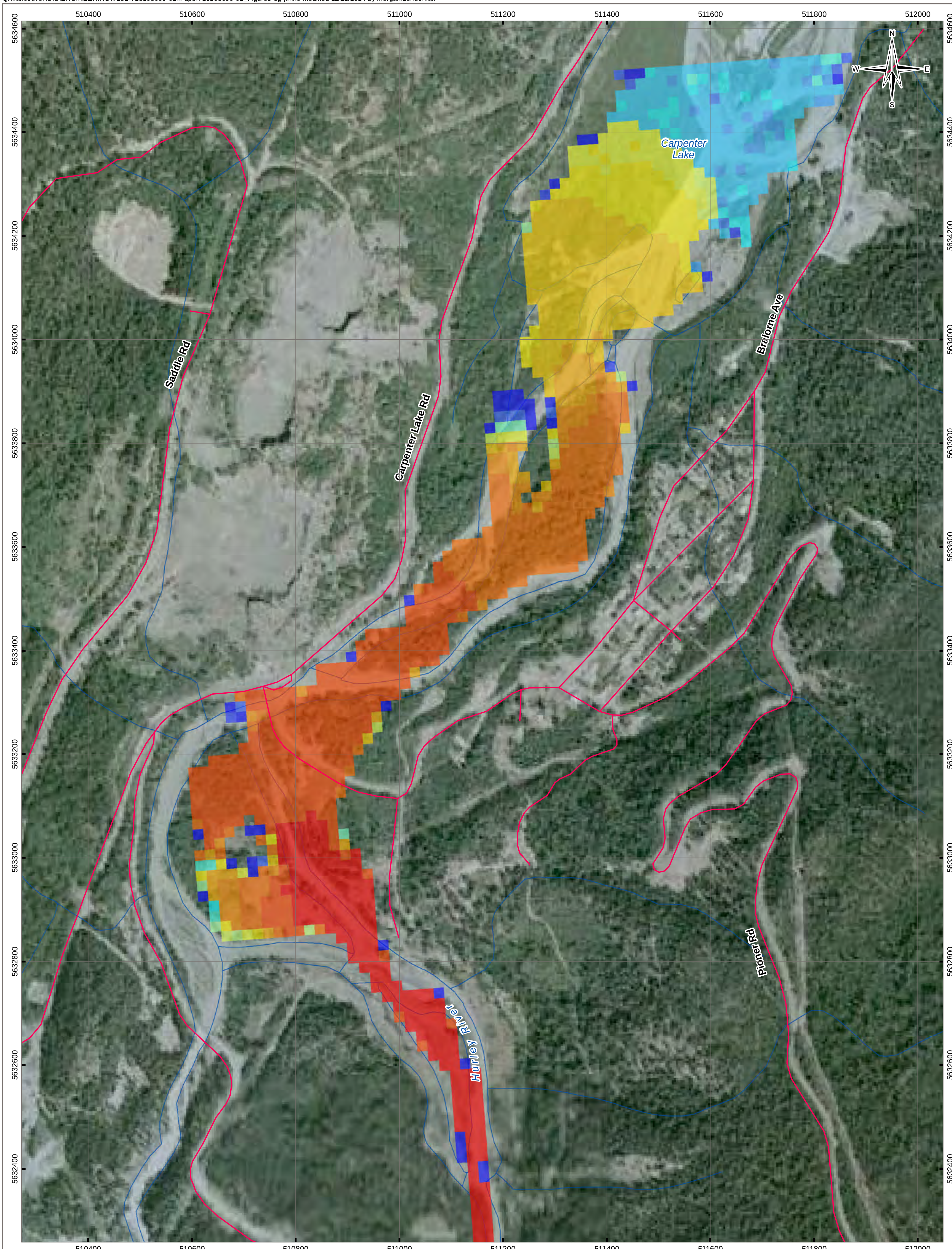
FILE NO.
V15103090-01_Figure3-3g-j.mxd

PROJECT NO.	DWN	CKD	APVD	REV
V15103090-01	MEZ	SL	EL	0

OFFICE	DATE
Tt EBA-VANC	November 21, 2014

Figure 3.3i

Q:\Vancouver\GIS\ENGINEERING\V151\V15103090-01\Maps\V15103090-01_Figure3-3g-j.mxd modified 11/21/2014 by morgan.zondervan

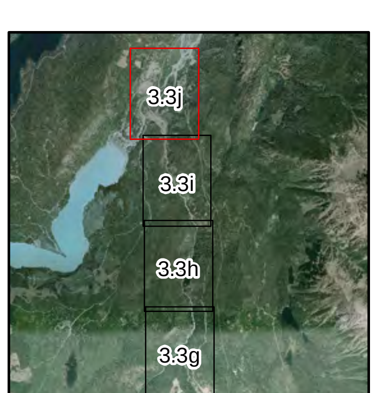


LEGEND

- Road
- Waterbody/Watercourse

Time to Maximum Depth (hours)

- 2.4 - 7.1
- 7.2 - 11.8
- 11.9 - 16.5
- 16.6 - 21.2
- 21.3 - 25.8
- 25.9 - 30.5
- 30.6 - 35.2
- 35.3 - 39.9
- 40.0 - 44.6
- 44.7 - 49.3
- 49.4 - 54.0
- 54.1 - 58.7
- 58.8 - 63.4
- 63.5 - 68.1
- 68.2 - 72.7
- 72.8 - 77.4
- 77.5 - 82.1
- 82.2 - 86.8
- 86.9 - 91.5
- 91.6 - 96.2



NOTES

1. TSF overtopping failure caused by the local 24-hr PMP storm inflow.
2. Base Data Source: Imagery from Google; Province of BC (2013) CanVec 1:50,000

STATUS
ISSUED FOR USE

BRALORNE TAILINGS STORAGE FACILITY HYDROTECHNICAL ASSESSMENT

Dam Break Inundation Mapping Time to Maximum Flood Depth Map 4

PROJECTION	DATUM	CLIENT
UTM Zone 10	NAD83	Bralorne Gold Mines Ltd.

Scale: 1:7,000
100 50 0 100
Metres

TETRA TECH EBA

FILE NO.				
V15103090-01_Figure3-3g-j.mxd				
PROJECT NO.	DWN	CKD	APVD	REV
V15103090-01	MEZ	SL	EL	0
OFFICE	DATE			
Tt EBA-VANC	November 21, 2014			

Figure 3.3j

APPENDIX A

TETRA TECH EBA'S GENERAL CONDITIONS

GENERAL CONDITIONS

DESIGN REPORT

This report incorporates and is subject to these “General Conditions”.

1.0 USE OF REPORT AND OWNERSHIP

This Design Report pertains to a specific site, a specific development, and a specific scope of work. The Design Report may include plans, drawings, profiles and other support documents that collectively constitute the Design Report. The Report and all supporting documents are intended for the sole use of Tetra Tech EBA’s Client. Tetra Tech EBA does not accept any responsibility for the accuracy of any of the data, analyses or other contents of the Design Report when it is used or relied upon by any party other than Tetra Tech EBA’s Client, unless authorized in writing by Tetra Tech EBA. Any unauthorized use of the Design Report is at the sole risk of the user.

All reports, plans, and data generated by Tetra Tech EBA during the performance of the work and other documents prepared by Tetra Tech EBA are considered its professional work product and shall remain the copyright property of Tetra Tech EBA.

2.0 ALTERNATIVE REPORT FORMAT

Where Tetra Tech EBA submits both electronic file and hard copy versions of reports, drawings and other project-related documents and deliverables (collectively termed Tetra Tech EBA’s instruments of professional service), only the signed and/or sealed versions shall be considered final and legally binding. The original signed and/or sealed version archived by Tetra Tech EBA shall be deemed to be the original for the Project.

Both electronic file and hard copy versions of Tetra Tech EBA’s instruments of professional service shall not, under any circumstances, no matter who owns or uses them, be altered by any party except Tetra Tech EBA. Tetra Tech EBA’s instruments of professional service will be used only and exactly as submitted by Tetra Tech EBA.

Electronic files submitted by Tetra Tech EBA have been prepared and submitted using specific software and hardware systems. Tetra Tech EBA makes no representation about the compatibility of these files with the Client’s current or future software and hardware systems.

3.0 ENVIRONMENTAL AND REGULATORY ISSUES

Unless so stipulated in the Design Report, Tetra Tech EBA was not retained to investigate, address or consider, and has not investigated, addressed or considered any environmental or regulatory issues associated with the project specific design.

4.0 CALCULATIONS AND DESIGNS

Tetra Tech EBA has undertaken design calculations and has prepared project specific designs in accordance with terms of reference that were previously set out in consultation with, and agreement of, Tetra Tech EBA’s client. These designs have been prepared to a standard that is consistent with industry practice. Notwithstanding, if any error or omission is detected by Tetra Tech EBA’s Client or any party that is authorized to use the Design Report, the error or omission should be immediately drawn to the attention of Tetra Tech EBA.

5.0 GEOTECHNICAL CONDITIONS

A Geotechnical Report is commonly the basis upon which the specific project design has been completed. It is incumbent upon Tetra Tech EBA’s Client, and any other authorized party, to be knowledgeable of the level of risk that has been incorporated into the project design, in consideration of the level of the geotechnical information that was reasonably acquired to facilitate completion of the design.

If a Geotechnical Report was prepared for the project by Tetra Tech EBA, it will be included in the Design Report. The Geotechnical Report contains General Conditions that should be read in conjunction with these General Conditions for the Design Report.

6.0 INFORMATION PROVIDED TO TETRA TECH EBA BY OTHERS

During the performance of the work and the preparation of the report, Tetra Tech EBA may rely on information provided by persons other than the Client. While Tetra Tech EBA endeavours to verify the accuracy of such information when instructed to do so by the Client, Tetra Tech EBA accepts no responsibility for the accuracy or the reliability of such information which may affect the report.