NORWEST
CORPORATION

Suite 1830, 1066 W. Hastings Street
Vancouver, BC V6E 3X2
Tel: (604) 602-8992
www.norwestcorp.com

January 5, 2015

Project #: 341-8

Wolverine Coal Partnership
Wolverine Mine
PO Box 2140
Tumbler Ridge, BC V0C 2W0

Attention: **Nathan Scarbrough**
Senior Mine Engineer, Walter Energy, Inc.

Dear Nathan:

Subject: **Wolverine Tailings Facility – 2014 Dam Breach Inundation Study**

1. INTRODUCTION

Wolverine Coal Partnership (WCP) has requested that Norwest Corporation (Norwest) provide an update to the dam breach inundation study presented in the 2005 and 2007 permit reports (Norwest 2005, 2007). Since the 2007 permit report was issued, the Canadian Dam Association (CDA) guidelines have been updated with revised seismic design criteria. The scope of this study is to update the dam breach assessment and review the CDA dam classification for the tailings facility, which is currently classified as 'high'. This information is also required for emergency response planning and for submission to the BC Ministry of Energy and Mines.

2. IMPOUNDMENT CONFIGURATION

The Wolverine Tailings Facility is located at the Walter Energy Wolverine Mine near Tumbler Ridge, British Columbia, as shown on Figure 1. The tailings facility is comprised of a 1.4km long compacted fill dam that impounds slurry tailings deposited from spigot points along the dam crest line. Tailings are piped from the adjacent Wolverine process plant with clarified water recycled back from the impoundment. The tailings facility is classified as having 'high' downstream consequences in the event of a dam breach event. This rating is due to the close proximity of the re-aligned Wolverine Forest Service Road, BC Rail line and a natural gas pipeline operated by Shell Canada. These facilities are situated along and within 50m of the downstream eastern toe of the dam structure. The dam is comprised of an initial earth fill starter dyke completed in 2006, followed by continued downstream raises of Coarse Coal Reject (CCR) material until April 2012 to the design height of about 20m. Overburden exists beneath the dam footprint to a considerable depth (over 130m) and includes a thick compressible lower clay deposit.

The geometry of the tailings facility has several elements that reduce the severity of a breach during operation to levels that are much lower than most other dams. These elements include:

- Low dam height (20m).
- Wide dam crest (30m).
- Wide tailings beach (minimum 100m from the upstream crest, 1% slope).
- Freeboard (minimum 2m).
- Small reservoir (3m maximum depth, 25 ha pond area, pond volume of approximately 120,000m^3).
- Downstream constructed dam.

The mine was shut down during May 2014 and the tailings facility was put under care and maintenance. The facility has not been used to deposit tailings or to reclaim water since that time. As a result, the tailings facility currently has a freeboard of about 7m.

3. DAM BREACH INUNDATION STUDY

3.1. Review of Potential Failure Modes

Norwest have reviewed the potential tailings dam failure modes which includes the most recent seismic criteria for mining dams (CDA, 2014). In addition, Norwest have been conducting annual inspections since construction (2006) and more recently, quarterly monitoring data reviews (since 2012). Monitoring data confirms slow ductile movements in the compressible lower clay foundation unit due to ongoing consolidation of the clay. The movements are resulting in very minor vertical and lateral displacements with current rates in under 0.1m per year for both. The slow ductile movement rates have also recently reduced since material was last placed during the 2011/2012 construction season. This movement is not considered a failure mode, rather a response to undrained loading from the dam fill and is within expected limits.

The most credible potential failure mode leading to downstream impacts was considered to be:

- **Deformation and settlement of the dam structure during a seismic event.** Seismic deformations along a potential slip surface were estimated to be less than 5m, as defined by the critical yield acceleration pseudo-static stability approach.

The calculated failure surface in this case is a rotational slip that begins in the tailings beach area, runs through the lower clay foundation unit and exits beyond the downstream toe of the dam. Slip surfaces failing through the dam fill have higher factors of safety, and therefore much less seismic deformation (if any). Since the dam fill itself is unlikely to be intercepted, this suggests the dam crest line integrity remains intact and a widespread loss of freeboard is not expected. This is the potential failure mode that will be used for the dam breach and inundation analysis.

A number of other failure modes were evaluated but were considered less likely scenarios for development of the inundation zone. These include:

- **Cracking of the dam from settlement (or differential settlement) of the fill materials.** The tailings dam has not been raised since the ultimate height was reached for most of the dam in 2012 and there are no plans to raise beyond the permit elevation of 852m. There have also been no signs of cracking or distress in the dam fill since that time.
- **Liquefaction of the foundation.** There is a thin potentially liquefiable foundation layer beneath the dam which was identified during the site investigation. A stability analysis was conducted that confirmed the factor of safety was high (even under conservative assumptions) and the failure plane is at least 12m below the ground surface.
- **Overtopping of the reservoir.** Calculations presented during the original permit report (Norwest, 2005) show the increase in pond elevation due to the inflow design flood (currently the 1 in 1,000 year event) plus wave effects are in the order of 1.1m. This is 0.9m less than the 2m design freeboard. As part of the 2014 annual inspection, WCP have been advised to review the design flood event to meet current CDA guidelines. The revised design flood volume according to the new CDA guidelines is expected to result in a modest pond elevation increase (likely much less than 0.9m), given the small catchment size which is essentially just the tailings area. It should also be noted that the freeboard of the tailings facility is currently over 7m since the mine is idle and no water is being pumped to the facility. Upon resumption of operations, it will take several years before the minimum design 2m freeboard is reached based on the as-built dam configuration. At closure, a spillway will be established that removes the pond and the potential for overtopping. The combination of the cover soil on the tailings and the underdrain will keep the tailings largely unsaturated near the dam crest.
- **Piping failure.** Piezometers in the near surface boulder gravel foundation unit indicate the water level in the dam is at ground surface. Visual inspections and water quality testing also indicate that there is no tailings pond seepage entering the downstream toe ditch. These observations confirm that a piping failure is not a concern due to the lack of seepage which is needed to induce fines migration.
- **Excessive surface water erosion of dam fill.** The downstream slope of the tailings dam has largely been re-sloped for reclamation (as noted in the last annual inspection). Vegetation has already begun to develop in lower portions of the dam. The dam slope has proved to be reasonably robust during the mine life and there are no immediate concerns with excessive erosion.

3.2. Tailings Runout Modelling

A tailings runout analysis has been conducted to determine the inundation extent should a there be a loss of contents from the tailings facility. It is postulated that a seismic or static slump event creates a condition leading to a partial loss of water and tailings. A local drop in freeboard then causes a flow of saturated (beach) tailings and water to erode a channel through the dam. Tailings that pass through the eroded channel beyond the dam would then spill into a fan at the toe of the dam. The geometry of such a failure was estimated using the following steps:

- A slump of 5m is created along the potential failure slip surface generated from a seismic event. The failure slip surface extends from the tailings beach into the lower clay foundation and exits beyond the downstream toe.
- The slump causes a liquefaction flow of tailings material with an inverted cone shape and a 10% side slope angle. This is a conservative assumption as the deeper (older) tailings will have aged and become less susceptible to a liquefaction flowslide.
- Eventually the tailings pond is intercepted and causes a release of the supernatant pond water (impact of released pond water is addressed Section 3.3).
- The resulting volume (tailings and eroded dam fill) flows out forming a 1% slope radiating out from the apex of the fan. Beach slopes in the impoundment have been measured to be in the order of 1% based on survey data.
- This fan interacts with the natural topography (including the railway embankment, the dam toe, and the floodplain).
- The limit of this fan defines the inundation distance from the toe of the dam. Figure 2 illustrates the extent of the inundation area for a failure through an arbitrary point along the dam.
- Several locations on the dam were examined, the inundation distance plotted for each, allowing the delineation of a potential inundation zone when the tailings elevation is at the ultimate height. The inundation zone will be smaller if the impoundment has not yet reached the design tailings capacity. The inundation zone for a tailings flowslide is presented on Figure 3.

Using this methodology, the following conclusions were reached:

- The maximum volume of tailings lost is 85,000 m^3 (plus there is an additional 14,000 m^3 of dam material).
- It is anticipated that the tailings flow will spill onto the Wolverine floodplain, but it will not reach the river.
- The plant site is positioned on higher ground in the south and any release of water or tailings will naturally flow towards lower ground to the north.
- The railway embankment captures a portion of the flow, but the remainder spills into the Wolverine River flood plain.

- The potential inundation zone extends about 400m north of the dam toe at the north end of the facility and 300 metres south of the south end of the facility.
- The potential inundation zone would be covered by a tailings thickness of less than 4m between the dam and the railway, and less than 2m thick on the Wolverine flood plain.

3.3. Hydraulic Modelling

3.3.1. Dam Breach Analysis

A dam breach analysis was performed to determine the consequences of dam failure in accordance with the Canadian Dam Association Dam Safety guidelines (CDA, 2014). Technical Note 1 (WDOE, 2007 provides a useful reference for dam breach analysis and presents a comprehensive set of equations to estimate dam breach dimensions, time for breach development, and peak discharge. The WDOE website (http://www.ecy.wa.gov/programs/wr/dams/GuidanceDocs_ne.html) also provides several template spreadsheets that can be used to perform the dam breach calculations described in Technical Note 1. The Break-1 spreadsheet (Walther, 2007) was used to estimate the dam breach dimensions, time for breach development, and peak discharge for a breach of the dam. A seismic induced failure with water at the maximum design (ultimate) elevation of 850m was modeled as the failure scenario for this assessment. The Break-1 spreadsheet results for the failure and the CDA guidelines for mining dams (CDA, 2014) were used to assess the consequences of failure of the tailings dam.

Geotechnical modeling of a seismic induced failure suggests slumping of the dam results in a tailings flow before water is released from the pond, primarily due to the presence of the tailings beach. The tailings slump occurs within the beach area and does not intercept the pond area. However, the slump backscarp of approximately 5m may result in a flow that further erodes the tailings beach at a slope of 10% towards the pond. The tailings flow is assumed to have a 10% slope through the tailings beach with a 1% runout slope. For the failure analysis using Break-1, the 10% slope through the tailings beach was used as the model input for the downstream slope, and the in-place tailings slope of 1% was used as the model input for the upstream slope. There is no dam crest width in this scenario.

For the failure analysis using Break-1, the maximum volume of water (120,000m^3) under normal operating conditions was assumed available to erode the breach opening. This is the volume of water stored in the pond between the elevation of the pond bottom (847m) and the maximum water elevation in the impoundment (850m).

The dam breach scenarios both result in erosion of tailings material, which is a cohesionless material. The input parameters for a cohesionless material result in a greater amount of material eroded, a larger breach width, and higher peak flows.

Two methods are presented in Technical Note 1 and in Break-1 to estimate the dam breach peak discharge. Norwest has selected the Modified Weir Discharge method as more representative for the Wolverine case. This method calculates the volume of dam material eroded and then calculates the breach geometry and dimensions. The Modified Weir Discharge method considers the erosion resistance of the dam material when calculating the eroded material volume and allows the user to select cohesionless or erosion resistant input parameters. The modified weir equation is then used to estimate the dam breach peak discharge based on the water depth and breach dimensions. The other method, Froehlich method, uses the Froehlich equation, an empirical equation that estimates the dam breach peak discharge directly from the volume of water in the reservoir and the height of the water behind the dam. The Froehlich approach does not directly calculate the breach dimensions, therefore the Break-1 spreadsheet was used to reverse-calculate the minimum breach widths. The Froehlich approach also does not consider the dam materials or the dam geometry.

The Break-1 failure results for the tailings dam are summarized in Table 1. The modified weir equation indicates a dam breach peak discharge of 14.5m^3/s.

Table 1
Break-1 Failure Results for Wolverine Tailings Pond

Pond Dimensions	Break-1 Methods	Breach Peak Discharge (m^3/s)	Average Breach Width (m)	Breach Width / Max Dam Height[1]
Depth = 3m Volume =120,000m^3	Modified Weir Discharge	14.5	1.6	0.6

[1]Typical Range 0.5 to 3.0

The Washington DOE guidance indicates that the selection of the preferred method be based on professional judgment (Walther, 2007). The Colorado Guidelines for Dam Breach Analysis compares multiple dam breach methods, including the Froehlich and Modified Weir methods, and recommends the Modified Weir Method for cohesionless earthen embankments with this height and storage capacity (State of Colorado, 2010). Seismic induced failure causes dam failure and tailings flows prior to the release of water resulting in a scenario best suited to a method that calculates the breach geometry and then the peak flow, such as the Modified Weir Method.

3.3.2. Flood Inundation Analysis and Hazard Evaluation

Failure as a result of a seismic or static slump of the tailings dam would likely result in a localized breach leading to a loss of tailings from the impoundment. Most of the tailings will be contained with the inundation zone shown on Figure 3. As a result of the dam breach and liquefied tailings flow, 120,000 m^3 of water would be released into the Wolverine River floodplain with a peak rate estimated to be 14.5m^3/s. Although most of the tailings solids would settle out of the water within the inundation zone, some suspended fines would inevitably flow into the Wolverine River, resulting in temporary high sediment loads and turbidity in the water. The Wolverine River is at least 300m from the downstream toe of the tailings dam, and there is expected to be insignificant flood attenuation in this reach.

The area of the Wolverine River drainage just above the project area is approximately 350 km^2, which results in a Mean Annual Flood (MAF) of 67m^3/s (KWL, 2004a). The 10-year peak flood on the Wolverine River was estimated using BC Provincial government report entitled "Streamflow in the Omineca-Peace Region" (Ministry of Environment Land and Parks, 2000). The Omineca-Peace Region is divided into six sub-zones, each comprising streams that exhibit reasonably homogenous hydrological behaviour. Wolverine River lies within the sub-zone known as the South Interior. Using the peak flow equation show below, the 10-year flood the Wolverine River drainage above Mast Creek is estimated at 207m^3/s.

$$Q_{10} = 1.4\ A^{0.853}$$

where A is the drainage area (km^2)

The peak breach flow from a seismic or static induced slump at the tailings pond would therefore result in a flow about 22% of the MAF and about 7% of the 10-year peak flood in the Wolverine River. It is expected that the breach peak flow is unlikely to pose significant risk to the public or downstream bridge structures. Should the dam breach occur during the MAF, flows would increase from about 67m^3/s to 82m^3/s. This would represent approximately 40% of the 10-year peak flood value.

3.4. Dam Classification

The tailings facility is classified as having 'High' downstream consequences in the event of a dam breach event which was due to the close proximity of the re-aligned Wolverine Forest Service Road, BC Rail line and a natural gas pipeline. The revised fine tailings inundation area is a larger area than reported in the 2007 permit report (Norwest, 2007), however there are no stakeholders or population within the revised inundation area. Hydraulic modelling indicates the peak flow as a result of a dam breach is well below the calculated 10-year flood for the Wolverine River. This flood event would likely cause a negligible increase in the river level but does not appear to pose a significant risk to stakeholders further downstream. To that end, the CDA tailings dam classification remains unchanged at 'High' as the consequences of a breach remain essentially the same as previously determined.

4. SUMMARY REMARKS

Norwest have completed a dam breach assessment for the Wolverine tailings facility. Potential failure modes have been reviewed for plausibility to assist with determination of the fine tailings inundation zone. A breach due to a seismic slump was considered to result in the most severe tailings inundation zone which is presented in Figure 3.

Peak discharge arising from a breach in the tailings facility has been estimated at 14.5m^3/s. The calculated flows suggest that there will be moderate impact to the Wolverine River. Most of the tailings solids would settle out of the water within the inundation zone (Figure 3), although some suspended fines would inevitably be carried into the Wolverine River resulting in a period of high sediment loads and turbidity. Dam classification has also been evaluated and as a result there is no recommended change to the current classification.

5. CLOSURE

The purpose of this letter is to provide WCP with a Dam Breach Assessment. As mutual protection to WCP, the public, and ourselves, this letter, figures and data are submitted for exclusive use by WCP. We specifically disclaim any responsibility for losses or damages incurred through the use of our work for a purpose other than as described in the letter. Our letter should not be reproduced in whole or in part without our express written permission, other than as required in relation to regulatory submission.

Analyses and results contained herein were prepared by Greg Lewsley, P.Eng. and Paul Kos, P.Eng. with Sean Ennis P.Eng. as senior reviewer.

Yours sincerely,

NORWEST CORPORATION

Paul Kos, P. Eng.
Senior Geological Engineer

PROFESSIONAL PROVINCE OF G. LEWSLEY # 35357 BRITISH COLUMBIA ENGINEER

Greg Lewsley, P.Eng.
Geotechnical Engineer

Jan 5, 2015

Sean Ennis, P.Eng.
Vice President, Mining

PROFESSIONAL PROVINCE OF O.S. ENNIS BRITISH COLUMBIA ENGINEER

JAN 5/15

Enclosures:

Figure 1	Site Location Plan
Figure 2	Example Tailings Flow
Figure 3	Tailings Flowslide Inundation Area

REFERENCES

Canadian Dam Association (2014). Application of Dam Safety Guidelines to Mining Dams. October 2014.

Kerr Wood Leidal (2004a). Wolverine Coal Project: Peak Flow Estimates. Technical Memorandum. 360-025. March 4, 2014.

Kerr Wood Leidal (2004b). Wolverine Coal Project: Wolverine River Flood Plain Modelling. Technical Memorandum. 360-025. March 24, 2014.

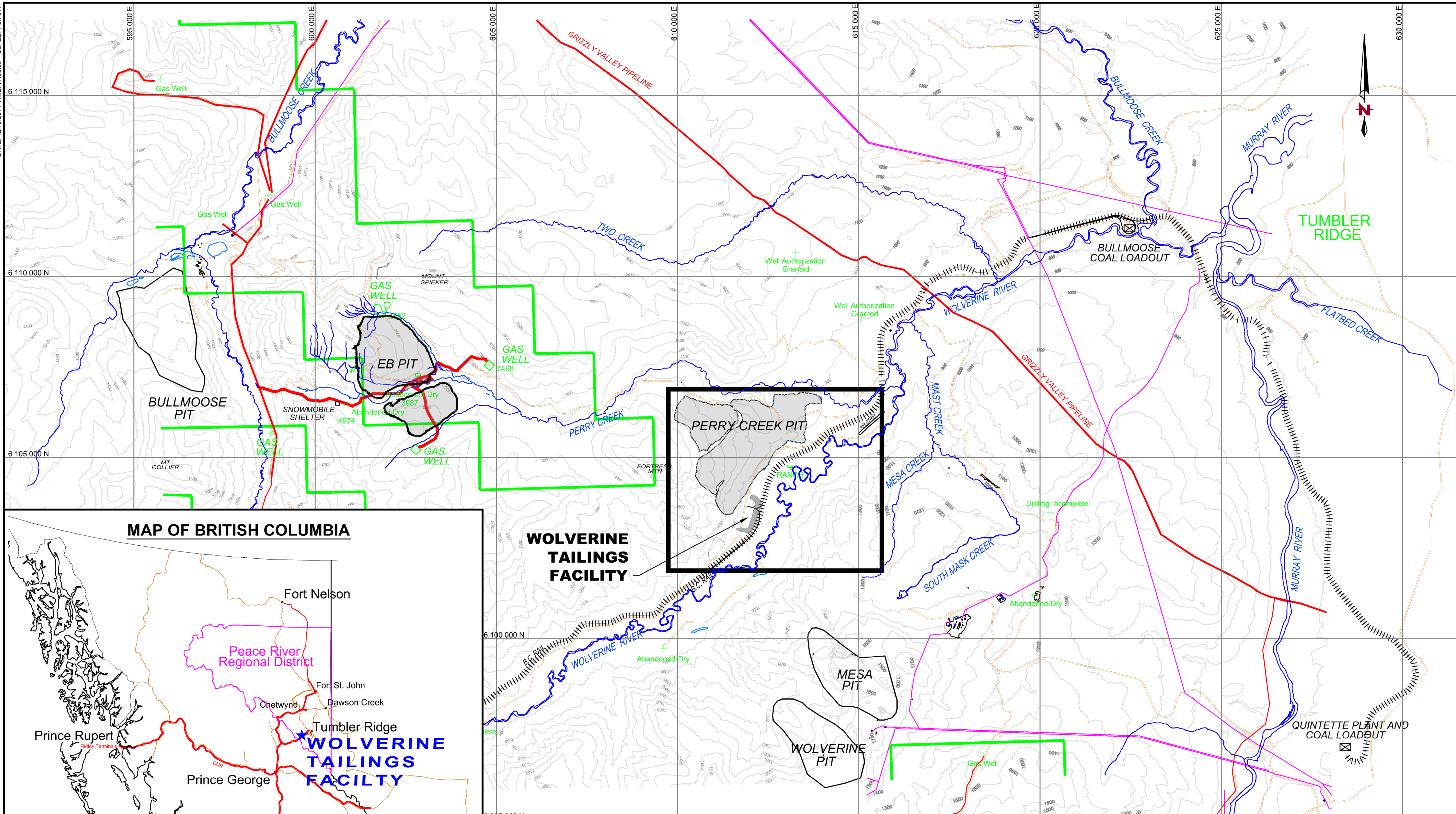
Norwest Corporation (2014). Wolverine Mine 2014 Tailings Facility Annual Inspection. Report prepared for Wolverine Coal Partnership. November 2014.

Norwest Corporation (2007). Mine Permit Amendment: Tailings and CCR Management Plan. Report prepared for Walter Energy (Western Canadian Coal). April 2007

Norwest Corporation (2005). Permit Level Geotechnical Designs for the Tailings Facility and Coarse Coal Reject Pile. Report prepared for Walter Energy (Western Canadian Coal). January 2005.

Walther, Martin. (2007). Appropriate Technology: Simplified Dam Failure Analysis Using Spreadsheet Computations. Instruction for Spreadsheets. Washington State Department of Ecology (WDOE). http://www.ecy.wa.gov/programs/wr/dams/GuidanceDocs_ne.html. October 31, 2007.

Washington State Department of Ecology (WDOE). October 2007. Dam Safety Guidelines. Technical Note 1: Dam Break Inundation Analysis and Downstream Hazard Classification. 92-55E. Water Resources Program Publications.



DATE: 12/19/2014 TIME: 17:05:00 SCALE: 1:8.7041

FILENAME: I:\PROJECTDATA\WOLVERINE_C_341\341-8_2014 GEOTECH\DISC\DRAFTING\FIG.1.1_SITE_LOCATION_PLAN.DWG
XREF FILE(S): WalterEnergy
IMAGE FILE(S):

LEGEND

- RAIL
- ROAD
- CREEK
- POWERLINES
- PIPELINE
- DRILLED OIL/GAS WELL
- OIL AND GAS FIELD BOUNDARIES

1000m 0 1000 2000 3000 4000 5000m

SCALE 1:100,000

SCALE INDICATED IS BASED ON A 11"x17" FORMAT PRINT

REV.	DATE	DESCRIPTION	DWN	DSG	CHK	APR
0	2014-12-17	ISSUED FOR DAM BREACH INUNDATION STUDY	GL	GL	GL	SE

WALTER ENERGY.

WOLVERINE COAL PARTNERSHIP

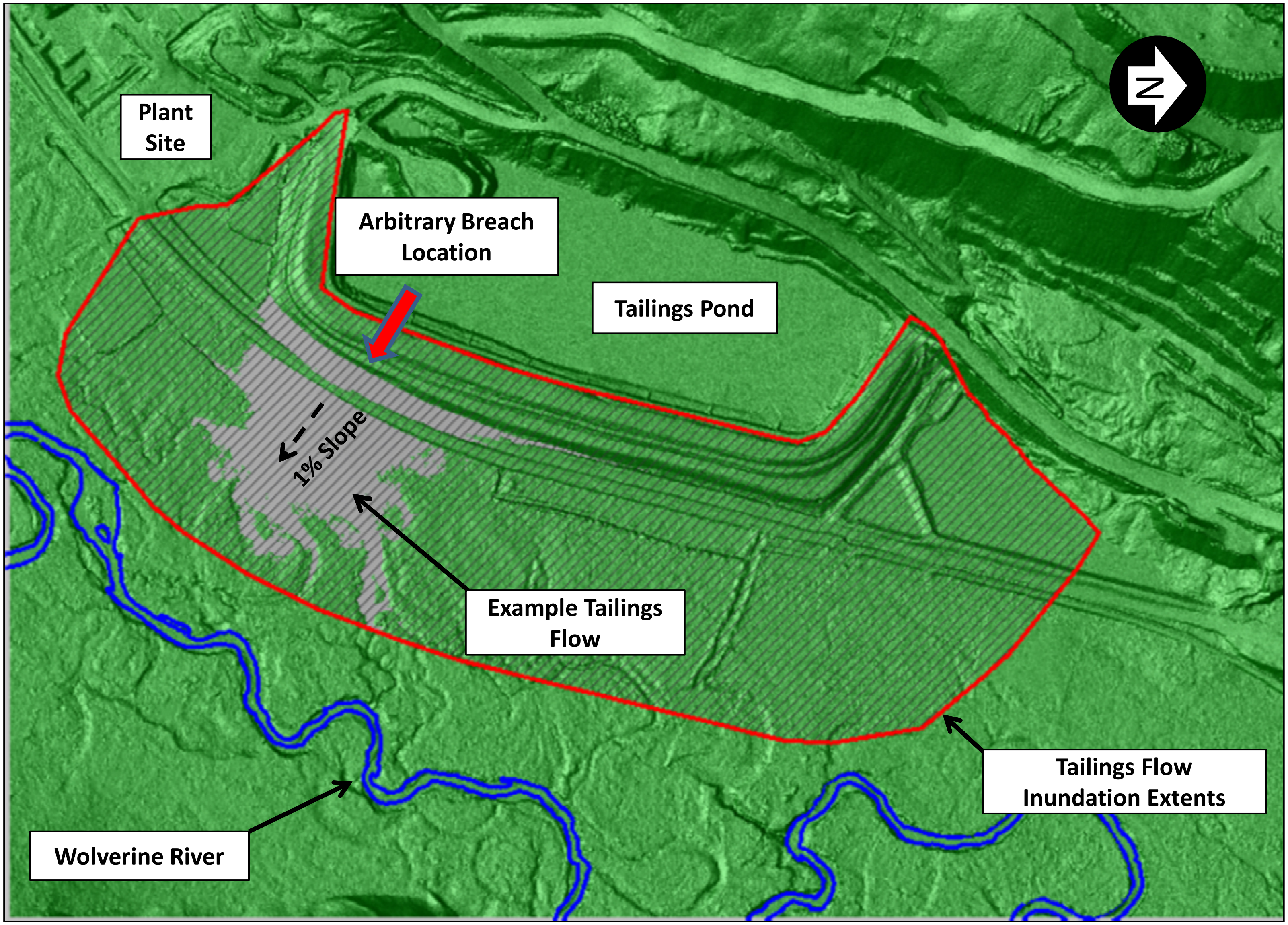
WOLVERINE PROJECT

SCALE:	1:100000
DATE:	2014-12-17
CO-ORD. SYS.:	UTM -NAD83-10
DRW'N BY:	GL
DSG'N BY:	GL
REV'D BY:	GL
APP'D BY:	SE

WOLVERINE TAILINGS FACILITY
SITE LOCATION MAP

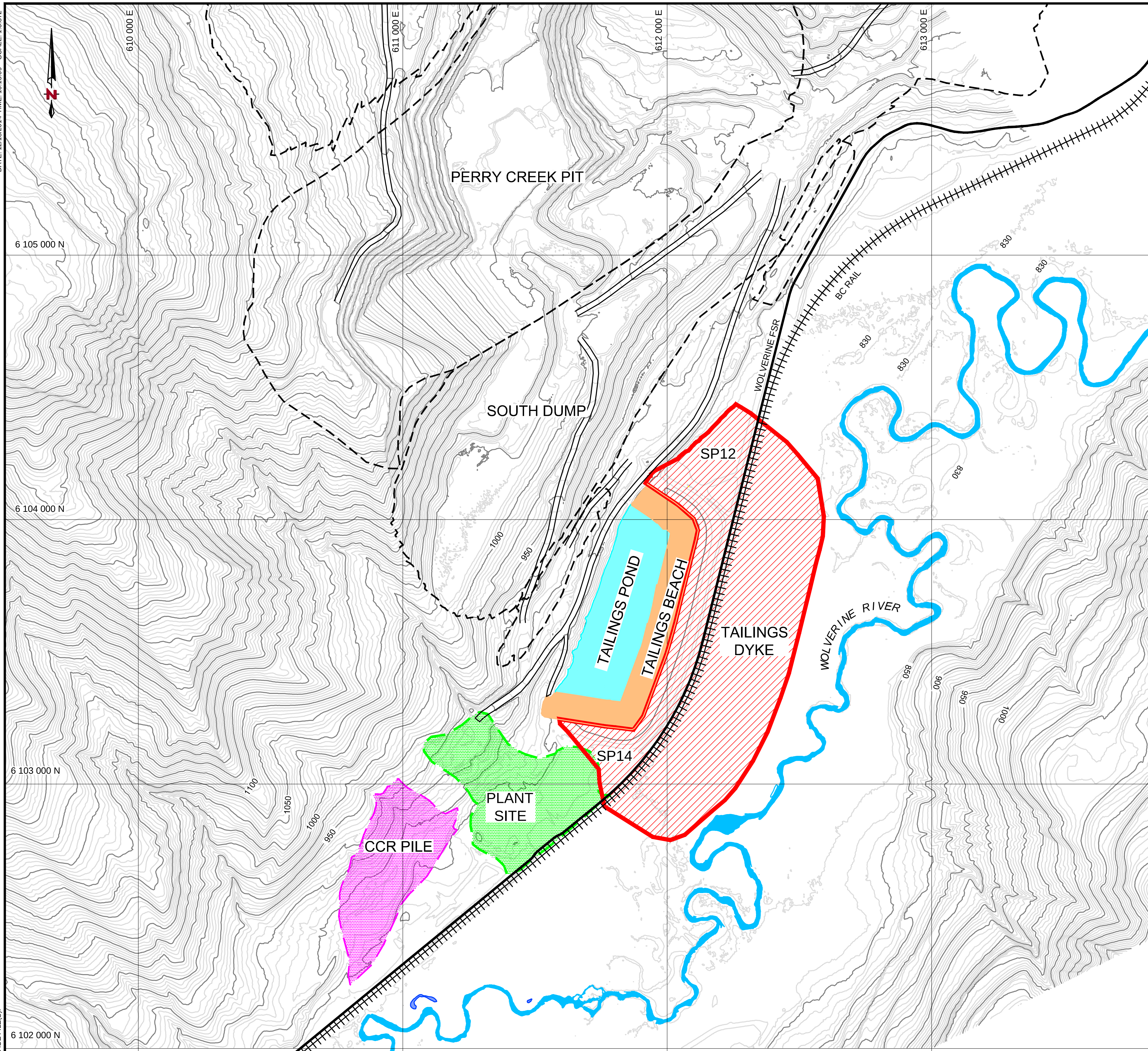
NORWEST

PROJECT NO.:	FIG. NO.:	REV.:
341-8	1	0



Notes:
1. The breach location is an arbitrary point selected to illustrate the geometry of a tailings flow out of the tailings facility.

WALTER ENERGY	WALTER ENERGY		
	WOLVERINE MINE		
TAILINGS FACILITY DAM BREACH STUDY EXAMPLE TAILINGS FLOW			
NORWEST	341-8	FIGURE 2	REV. 1



LEGEND:

PUBLIC ACCESS ROADS

MINE HAUL ROADS

DUMP/PIT OUTLINE

RAILWAY

POTENTIAL INNUNDATION AREA
(DUE TO FINE COAL TAILINGS FLOWSLIDE)

NOTES:

1. TOPOGRAPHY BASED ON 2013 LIDAR DATA PROVIDED BY WOLVERINE COAL PARTNERSHIP.
2. CONTOURS ARE SHOWN IN 5m INTERVALS.

0 100 200 300 400 500 1000m

SCALE 1:15,000

REV.	DATE	DESCRIPTION	DWN	DSG	CHK	APR
0	2014-12-18	ISSUED FOR DAM BREACH INUNDATION STUDY	VJG	GL	GL	SE

WALTER ENERGY.

WOLVERINE COAL PARTNERSHIP

WOLVERINE PROJECT

SCALE:	AS SHOWN
DATE:	2014-12-17
CO-ORD. SYS.:	UTM NAD83-10
DRW'N BY:	VJG
DSG'N BY:	GL
REV'D BY:	GL
APP'D BY:	SE

TAILINGS FACILITY
TAILINGS FLOWSLIDE INUNDATION AREA

NORWEST

PROJECT NO.: 341-8 | FIG. NO.: 3 | REV.: 0

DATE: 12/18/2014 TIME: 16:15:09 SCALE: 1:3,872

FILENAME: I:\PROJECTDATA\WOLVERINE_C_341\341-8_2014 GEOTECH\DISC\DRAFTING\DAM BREACH STUDY\FIGURE 3 INNUDATION AREA.DWG
XREF FILE(S): XREF1
IMAGE FILE(S):