

APPENDIX A: SPECIAL PUBLIC NOTICE COMMENT PERIOD SUMMARY



Memorandum

Date: March 9, 2026

To: Jonathan Hegna, U.S. Army Corps of Engineers

From: Bill Craig, AECOM

Subject: Donlin Gold Project Supplemental EIS – Special Public Notice Comment Period Summary

The U.S. Army Corps of Engineers (Corps) published a special public notice on January 26, 2026, to inform the public of the intent to prepare a supplemental environmental impact statement (SEIS) for the Donlin Gold Mine Project. The purpose of the SEIS is limited to evaluating the potential environmental consequences of a larger hypothetical tailings release scenario to meet the requirement of the U.S. District Court (District of Alaska) remand in *Orutsararmiut Native Council, et al. vs. U.S. Army Corps of Engineers, et al.* The special public notice process provided interested parties with information related to the supplemental analysis and requested public comments on the preparation of the SEIS and the analysis of a larger tailings spill (or range of spill scenarios).

The special public notice period for the Donlin Gold Project SEIS began on January 26, 2026, and expired on February 24, 2026. The Corps received a total of 14 submissions during the special public notice comment period. Below is a summary of the comments that were received that were relevant to analysis of a larger tailings spill (or range of spill scenarios):

- Comments included suggestions for consultations in all of the communities that could be affected by a larger tailings spill, including requests for the Corps and the Bureau of Land Management to provide technical assistance and Yup'ik or Cup'ik translators.
- Various commenters, including tribes, requested that the Corps and the Bureau of Land Management model scenarios for 5 percent, 20 percent, 50 percent, and 90 percent releases of the full capacity of the tailings storage facility.
- The U.S. Fish and Wildlife Service recommended a spill scenario to model 20 percent of the total wet tailings storage facility volume, to be modeled in 5-year increments for at least 30 years, conducted for high flow conditions in Crooked Creek and the Kuskokwim River, and include a 50-year or 100-year flood event, incorporating the Scenarios Network for Alaska and Arctic Planning climate projections for the region.
- Commenters requested that the SEIS fully and transparently quantify impacts to fish and wildlife harvests, access to traditional gathering areas, and intergenerational transfer of cultural practices from a larger tailings spill that has the potential to affect fish, wildlife, water quality, and aquatic resources that are essential to tribal subsistence practices.
- The Bethel Native Corporation passed a resolution that requested the Corps determine the average of the 25 largest tailings failures since 2000 (as a percentage of each tailings storage facilities capacity) and analyze a spill of that percentage in the SEIS.
- The State of Alaska indicated that the SEIS process would be a vital opportunity to reassess potential environmental and socioeconomic impacts associated with a larger tailings release scenario than previously evaluated. The State recommended that the Corps maintain a continued and disciplined focus on the narrow scope of review

identified in the Court Order, consistent with the National Environmental Policy Act and the limited nature of the remand. The State also stated that the Corps should avoid any conflation of the SEIS analysis with Alaska's separate dam safety certification process. With regards to spill scenario modeling, the State recommended that the SEIS should provide transparent documentation of modeling assumptions, potential failure modes, spill volumes, and uncertainties. The State also recommended evaluating in the SEIS a full range of hydrological and geotechnical scenarios relevant to large-scale tailings containment structures. The State further recommended ensuring inclusive public involvement and meaningful engagement with Alaska Native communities, local governments, and stakeholders in the Yukon-Kuskokwim region, recognizing the importance of traditional ecological knowledge and community perspectives in the environmental review processes. Several commenters raised concerns that are outside the scope of this court-ordered remand for an SEIS. These submissions included comments that asked to delay or stop the SEIS process pending completion of feasibility studies or reconsideration of the overall mine proposal; requests to incorporate new information related to general water quality, erosion, and other operational impacts; and requests to correct perceived deficiencies in the 2018 Final EIS, including analyses of human health, fish, air quality, and water quality. Commenters also requested evaluation of additional project alternatives and reconsideration of the design and engineering of the tailings storage facility. These comments pertained to the broader project design, feasibility, and environmental analyses previously completed, rather than the limited purpose of this SEIS. Table 1 below lists the comment submissions that the Corps received during the special public notice comment period.

Table 1: Special Public Notice Comment Submissions

Name	Organization	Type of Submitter
Ana Hoffman	Bethel Native Corporation	Tribe
Ashlynn Simeon	Hamilton Tribal Council	Tribe
Plaintiff Tribes	Orutsararmiut Native Council, Chevak Traditional Council, Native Village of Eek, Organized Village of Kwethluk, Native Village of Kwigillingok, Tuluksak Native Community	Tribes
Ashlynn Simeon	Mother Kuskokwim Tribal Coalition of the Yukon-Kuskokwim Region	Tribe
Jorjena Barringer ¹	U.S. Department of Interior, Bureau of Land Management	Federal Agency
James Hyun ²	State of Alaska	State Government
Jennifer Spegon	U.S. Fish and Wildlife Service	Federal Agency
Theogene Mbabaliye	U.S. Environmental Protection Agency	Federal Agency
Grant Fairbanks	---	Individual
Timothy Schuerch	Calista Corporation	Native Corporation
Gloria Simeon	---	Individual
Abigail Lamont	Pitka's Point Traditional Council	Tribe

Name	Organization	Type of Submitter
Mother Kuskokwim Tribal Coalition – 145 individual signatures	Mother Kuskokwim Tribal Coalition of the Yukon-Kuskokwim Region	Tribe
Sarah Saunders	Earthjustice (on behalf of Orutsarmiut Native Council, Chevak Traditional Council, Native Village of Eek, Organized Village of Kwethluk, Native Village of Kwigillingok, Tuluksak Native Community)	NGO (on behalf of tribes)

Notes:

NGO = non-governmental organization

1 This comment was a request to be added to the mailing list.

2 The State of Alaska submitted duplicate comments through the project email address and the project website.

APPENDIX B: DONLIN GOLD PROJECT, 2025 TSF MAIN DAM BREACH ASSESSMENT



Donlin Gold Project 2025 TSF Main Dam Breach Assessment

Prepared by BGC Engineering Alaska Inc. for:



May 29, 2026

Project 0011603

Document ER-0011603-0229



May 29, 2026

Project 0011603
Document PM-0011603.0229

Donlin Gold LLC
2525 C Street, Suite 450
Anchorage, Alaska 99503

Attention: Allison B. Rumsey
on behalf of Donlin Gold LLC

2025 TSF Main Dam Breach Assessment – Rev 4

Please find the above-referenced report attached for your records. We appreciate the opportunity to collaborate with you on this challenging and interesting project.

Should you have any questions, please do not hesitate to contact the undersigned.

Yours sincerely,

BGC Engineering Alaska Inc.
per:

A handwritten signature in black ink, appearing to read 'H. Weatherly', with a stylized flourish at the end.

Hamish Weatherly, M.Sc. P.Geo.
Principal Hydrologist

EXECUTIVE SUMMARY

This assessment evaluates hypothetical breach scenarios for the Tailings Storage Facility (TSF) Main Dam at the proposed Donlin Gold open-pit mine in southwestern Alaska. The study was commissioned following a U.S. District Court ruling that required analysis of tailings releases larger than the previously modeled 0.5% of TSF capacity, in line with empirical evidence suggesting releases from dam failures can be greater than 20%.

The scope of work included:

- Establish credible failure scenarios and release volumes.
- Model dam breach hydrographs and downstream flood routing using HEC-HMS and HEC-RAS.
- Assess inundation extents and tailings deposition for a range of breach scenarios.

The TSF Main Dam is a fully lined, rockfill embankment designed to meet stringent stability standards under static and seismic conditions. At closure, the TSF will contain ~567.6 million short tons of tailings, with a total storage volume of 334,300 acre-ft (412.4 Mm³).

Failure Scenarios & Release Volumes

- Empirical methods and regulatory reviews suggest tailings releases from dam failures typically range from 5% to 38% of stored volume.
- Four breach scenarios were modeled: 0.5%, 5.4%, 13.3%, and 24.6% of total tailings volume, plus pond water.
- The most plausible “credible failure mode” is a catastrophic piping failure, initiated by poor construction QA/QC and liner defects.

Flood Wave Modeling & Inundation

- Breach hydrographs show peak outflows ranging from 197,000 cfs (5,580 m³/s) (0.5% scenario) to 2,047,000 cfs (58,000 m³/s) (24.6% scenario), with peak flows occurring within 10 to 41 minutes of breach initiation.
- Inundation modeling indicates Crooked Creek would experience significant flooding in larger release scenarios, with maximum water depths of up to 28 ft (8.5 m) at the Village of Crooked Creek.
- Downstream communities (Chuathbaluk, Aniak, Kalskag) would see elevated river levels, but flooding is expected to remain confined to the channel, limiting overbank impacts.

Tailings Deposition & Transport

- A significant portion of the tailings are modelled as being deposited in Crooked Creek (64% to 100% for the four scenarios evaluated); the remainder is transported to the Kuskokwim River and ultimately to the Bering Sea.
- The fine-grained tailings are expected to be mobilized in suspension and gradually transported downstream over time.

Limitations

- The scenarios modeled are hypothetical and represent extreme, highly unlikely conditions.
- The study does not assess breach probability, population at risk, or detailed downstream consequences.
- Modeling is based on current best practices but is subject to uncertainties in physical processes and empirical methods.

Conclusion

This assessment provides a comprehensive analysis of potential TSF Main Dam breach scenarios at Donlin Gold, supporting regulatory compliance and emergency planning. The findings highlight the importance of robust dam design, construction quality, and ongoing monitoring to minimize risk.

TABLE OF REVISIONS

Date	Revision	Remarks
October 24, 2025	0	Report submission
December 18, 2025	1	Resubmittal to include geotechnical appendix
January 5, 2026	2	Minor revisions
February 24, 2026	3	Update to Table 6-5
May 29, 2026	4	Changes to Limitations section and minor edits

LIMITATIONS

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¹ References in these Limitations to the “document” include the document to which these Limitations are attached, any content contained in this document, and any content referenced in this document but located in one of BGC’s proprietary software applications (e.g., Cambio).

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1.0 INTRODUCTION

1.1 Background

Donlin Gold LLC (Donlin Gold) is currently planning to develop the Donlin Gold Project (Project), a proposed open pit gold mine, in southwestern Alaska. BGC Engineering Alaska Inc. (BGC) has carried out technical studies for the Project since 2004, including geotechnical, hydrogeological, and hydrological assessments in support of Feasibility Studies (FS), the most recent FS being the 2011 Feasibility Study Update, as well as studies to support an Environmental Impact Statement (EIS), federal permitting, and state permitting. That work has included a feasibility-level design of the proposed Tailings Storage Facility (TSF) (BGC, July 22, 2011).

In the Final Environmental Impact Statement (FEIS) for the Project (US Army Corps of Engineers, 2018), the effects of a partial failure of the TSF Main Dam were evaluated by BGC (June 1, 2015). Both releases of water and tailings were considered, constituting approximately 0.5% of the maximum TSF capacity. The 0.5% estimate was determined during an early-stage Failure Mode and Effects Analysis (FMEA) workshop for the Project (SRK Consulting, 2015). The Orutsararmuit Native Council (ONC) challenged the FEIS in U.S. District Court; specifically, ONC argued that a larger tailings release should have been evaluated. On September 30, 2024, Judge Sharon Gleason² ruled in favour of the plaintiff, specifically saying that the “Corps violated NEPA by failing to consider a tailings spill larger than 0.5% of the TSF’s total volume and by declining to assess a catastrophic tailings spill based solely on its low probability of occurrence.” She further cited “a 2011 presentation summarized previous studies and found that on average, tailings released due to dam breaks ranged from 20-40% of total tailings volume” and a “2010 report on tailings dam failures indicated that upon breakage, the released tailings generally amount to about one-fifth of those contained within the facilities”. In response to the Judge’s decision, Donlin Gold prepared a scope of work dated December 9, 2024, and requested that BGC identify and model a larger tailings release scenario.

1.2 Scope of Work

As per BGC’s proposal dated December 14, 2024, the scope of work included the following:

- Establish a recommended tailings and water release volume(s) to be modelled, including supporting rationale
- Identify a credible failure model scenario for the release volume(s)
- Develop a dam breach hydrograph(s) for the identified tailings release scenario(s) using HEC-HMS
- Route the dam breach hydrograph(s) downstream using a two-dimensional (2D) hydraulic model.

² Decision and Order. Case No. 3:23-cv-00071-SLG, Orutsararmuit Native Council, et al. v. U.S. Army Corps of Engineers, et al.

The scope of work was authorized by Donlin Gold under purchase order number 4501070369 dated December 31, 2024.

1.3 Limitations

The dam breach and inundation analyses completed by BGC here-in were based on hypothetical modes of failure under extreme and highly unlikely conditions. As a result, the results of the analyses presented herein in no way reflect upon the structural integrity or safety of the proposed TSF Main Dam, as this study does not fully account for the design safety measures, management practices, or regulatory requirements implemented to prevent a breach from occurring. Rather, it was assumed that a hypothetical failure of the dam could occur, so that the area of impact could be estimated.

This report only addresses the potential inundation extent in the event of a hypothetical breach of the TSF Main Dam larger than 0.5% of its total containment volume. This study does not attempt to quantify the probability of a dam breach by the selected scenarios or any other mechanism. Furthermore, this study does not include an assessment of the population at risk or detailed evaluation of downstream consequences in terms of loss of life, environmental, cultural or economic values.

The applied methodology adopted by BGC followed the current state of practice for tailings dam breach analyses, as documented in recent publications prepared by the Canadian Dam Association (CDA, 2021) and the International Commission on Large Dams (ICOLD, 2022). These analyses inherently acknowledge the limitations in precisely modeling the impacts of a dam breach, largely due to the evolving nature of the science and the incomplete understanding of some physical processes represented in current models.

2.0 PHYSICAL SETTING

2.1 Project Location

The Project is located approximately 277 air miles (445 km) west of Anchorage and 145 air miles (235 km) northeast of Bethel. The Project would be an open-pit, hard rock gold mine. The gold resource is hosted in intrusive and sedimentary rock in two main areas, Lewis and ACMA, with 80% found in intrusive rock. The proven and probable reserves total 556.5 million short tons (st). Donlin Gold anticipates that the mill would have an average production rate of 59,000 st/d.

This project would require approximately 3 to 4 years to construct facilities and ramp up production. Using conventional “truck and shovel” operations and bulk and selective mining methods on a 24-hour-per-day, 365-day-per-year basis, Donlin Gold anticipates an active mine life of approximately 27.5 years.

The proposed Donlin Gold project would require the development of the Lewis and ACMA pits and the construction of mining facilities; milling facilities; tailings, waste rock, and overburden storage facilities; an upriver port and lower river port; a natural gas pipeline; and supporting infrastructure. The open pit and waste rock storage facility would be constructed in the American Creek watershed, which is a 6.9 sq.mi. (17.9 km²) tributary of Crooked Creek (Drawing 01). The TSF would be in the Anaconda Creek Valley to the immediate south. Anaconda Creek is a 7.7 sq.mi. (20 km²) tributary of Crooked Creek. Both tributaries flow from east to west and discharge into Crooked Creek, which has a watershed area of approximately 100 sq.mi. (259 km²) in the vicinity of the proposed mine facilities.

Crooked Creek is a 330 sq.mi. (855 km²) tributary of the Kuskokwim River and generally flows from north to south-southeast. The creek is characterized by a meandering channel planform (severe to tortuous in the valley bottom). In the vicinity of the proposed mine, Crooked Creek has a bankfull width of approximately 50 ft (15 m) and the valley width is on the order of 600 ft (180 m) to 1150 ft (350 m). In lower reaches, the average bankfull width increases to about 100 ft (30 m).

Approximately 13.5 miles (22 km) downstream of the TSF Main Dam, Crooked Creek discharges into the Kuskokwim River. Here the upstream watershed area of the Kuskokwim River is 31,100 sq.mi (80,610 km²). The Village of Crooked Creek, with a population of 90 people³, is located at this junction with buildings located on the floodplain of Crooked Creek and the north bank of the Kuskokwim River. The Kuskokwim River is confined on either bank at this location and has a bankfull width of 1300 ft to 1800 ft (400 m to 550 m).

The Kuskokwim River has a low sinuosity, meandering planform downstream of Crooked Creek with occasional channel splits around islands. The river is generally confined by valley slopes on either bank for about 30 miles (48 km) below the confluence as it flows to the southwest.

³ Based on 2020 census data ([Alaska Native Village Statistical Areas - 2020 Census - Data as of January 1, 2020](#)). All populations quoted in this report are based on 2020 census data.

Beyond this point, the river turns to the west and becomes increasingly less confined as it approaches the coastal plains. With this loss in confinement, the river adopts a moderately sinuous meandering planform within a 5.5-mile-wide (8.9 km) floodplain. The river also adopts a more complex morphology with numerous active and abandoned side channels, and a main channel that is predominantly confined to the north end of the wide floodplain. Communities in this lower wider reach include:

- Chuathbaluk (population 104) at mile 71 (km 115)
- Aniak (population 510) at mile 81 (km 130)
- Upper Kalskag (population 212) at mile 114 (km 183)
- Lower Kalskag (population 278) at mile 116 (km 187)⁴.

2.2 TSF Design

The tailings and process affected water will be stored in a fully geomembrane-lined valley impoundment located south of the proposed open pit in the Anaconda Creek watershed. The first (starter) TSF Main Dam construction campaign prior to mine start-up comprises a 198 ft (60 m) high embankment, which will be raised in the downstream direction in seven construction campaigns starting in the first year of operations. Dam raises are planned for approximately every four years thereafter throughout the remaining mine life. The final (ultimate) dam height is 471 ft (144 m). The total catchment area reporting to the TSF Main Dam will be 5.9 sq.mi. (15.3 km²).

During construction, the TSF Main Dam footprint at Donlin would be excavated to expose bedrock, with the embankment constructed using rockfill, engineered filter zones, and a prepared underlayer for the geomembrane (BGC, July 22, 2011). The TSF Main Dam will be constructed of compacted rockfill⁵ and will be lined on its upstream face with 60 mil (0.06 inch thick) single-sided textured (down) linear low-density polyethylene (LLDPE) liner as the low-permeability barrier to seepage. Liner bedding and filter/transition layers will separate the liner from the rockfill. The liner will be underlain by a 3 ft (1 m) thick bedding layer, two 10 ft (3 m) thick filter zones, and a 20 ft (6 m) thick transition rockfill zone. The upstream face of the dam will be benched at each raise with local slopes of 2H:1V. The downstream slope of the dam will be 1.7H:1V. The dam has been designed at a feasibility-level to meet or exceed the most stringent State of Alaska and industry standards for stability under both static and seismic conditions⁶. A cross-section of the proposed dam at its ultimate height is provided in Figure 2-1.

A network of rockfill underdrains designed to convey the baseflow through the Anaconda Creek valley will be placed beneath the liner system along the channel bed of Anaconda Creek and significant tributaries. The underdrain will be comprised of coarse processed rockfill with a mean

⁴ River mile and river km are the downstream channel distance from the TSF Main Dam.

⁵ The grain size distribution of the rockfill will be 0.8 in to 39.4 in with a D₅₀ of 7.9 in (BGC, July 22, 2011). The D₅₀ is the median size that splits the distribution with half above and half below this diameter.

⁶ It is further noted that BGC was retained by Donlin Gold in September 2025 to produce a detailed design package for the TSF Main Dam and other proposed dams for the Project.

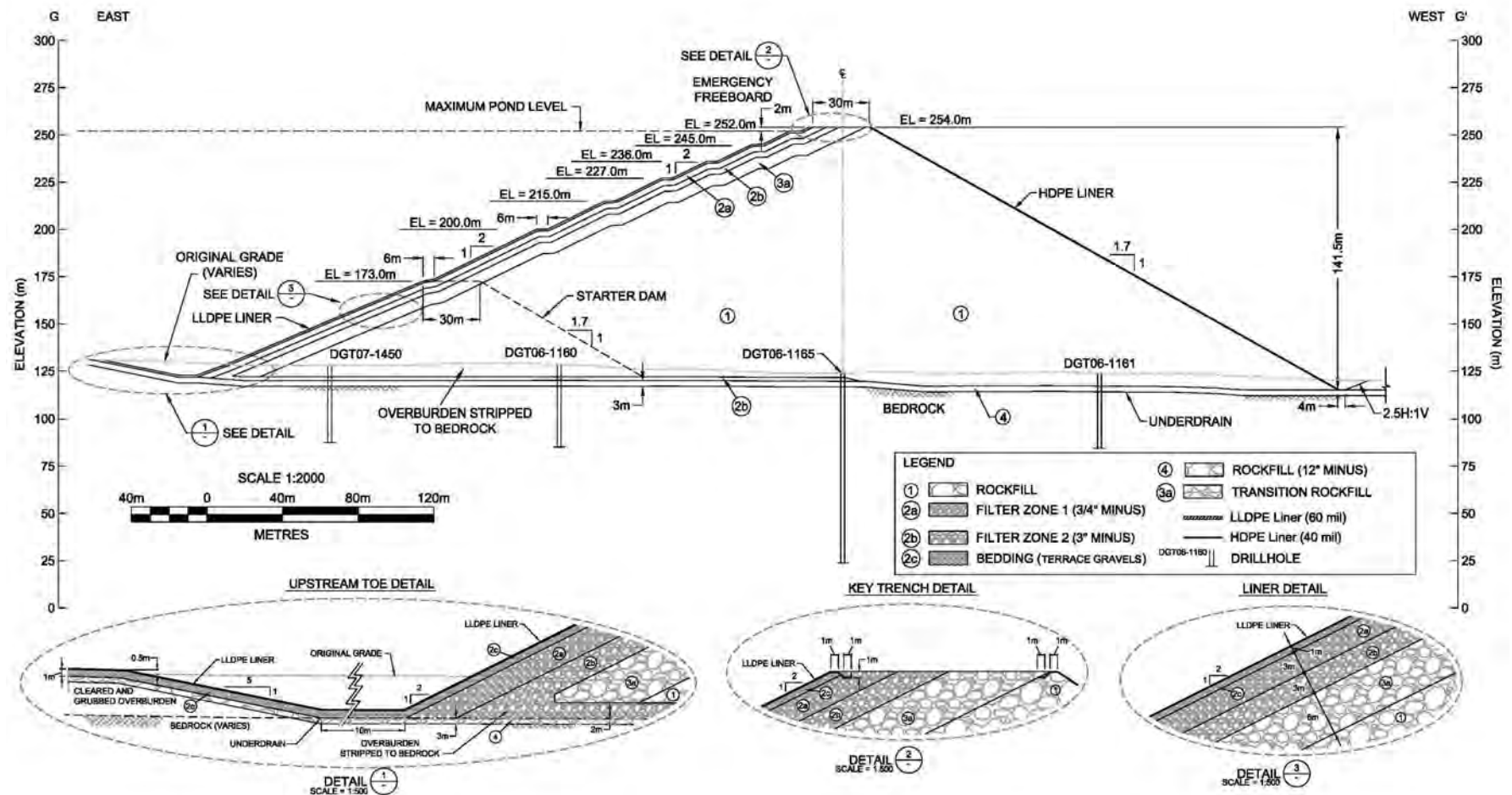
diameter of 1.0 ft (0.3 m) and wrapped in geofabric. The underdrain will be approximately 10 ft (3 m) deep along the valley bottom, with an invert width of 3 ft (1 m), a maximum width of approximately 33 ft (10 m) at the top and side slopes of 1.5H:1V.

The TSF will have an ultimate capacity of 356,714 acre-ft (440 Mm³), corresponding to an ultimate impoundment surface area of 3.7 sq.mi. (9.5 km²) (BGC, July 22, 2011). At the end of operations, the TSF will contain 567.6 million short tons of tailings⁷, occupying a volume of 334,300 acre-ft (412.4 Mm³). With an estimated average porosity of 54%, the tailings volume will include 153,800 acre-ft (189.7 Mm³) of solids and 180,500 acre-ft (222.7 Mm³) of interstitial water.

The tailings will be partially covered by a supernatant pond during operations. The proposed tailings deposition plan is to create a tailings beach around the entire TSF, pushing the operating pond toward the center of the facility. BGC (July 22, 2011) computed the annual tailings volumes, maximum flood elevations, dam crest elevations, and corresponding minimum beach widths for each dam construction raise; minimum beach widths ranged from 330 ft (100 m) to 1,970 ft (600 m) under average operating conditions. Water balance modelling indicates a 50th percentile pond volume of 9,760 acre-ft (12.0 Mm³) by the end of operations (BGC, October 25, 2016). During the closure phase, the operating pond will be pumped to the open pit to facilitate dry closure of the TSF.

Several years before the end of operations, tailings deposition will be modified to direct the operating pond toward the southeast corner of the TSF. This will be done in anticipation of the post closure period, when the tailings cover runoff will be diverted to Crevice Creek through the closure spillway. Closure of the TSF is expected to take approximately five years. Water remaining in the impoundment at closure will be pumped to the ACMA pit through the reclaim pipeline. The TSF cover will include rockfill overlain by colluvium/terrace gravel overlain by a peat/mineral mix that will act as a growth medium for cover system vegetation. Surface runoff on the cover will be directed to a lined pond in the southeast corner of the reclaimed TSF. The downstream faces of the tailings dam will be flattened to 3H:1V at closure before the placement of the colluvium and organic cover material.

⁷ This value accounts for 2% reagent addition to the processed ore.



2.3 Tailings Properties

2.3.1 Tailings Characteristics

The tailings are classified as low plastic silt, typically consisting of 5% sand, 80% silt, and 15% clay and have an average specific gravity of 2.72 (BGC, July 22, 2011). The average tailings dry density is estimated to range from 69.9 pcf (1.12 t/m³) at the end of the first year of operations to 78.0 pcf (1.25 t/m³) at the end of mine life and reach a terminal density of 81.2 pcf (1.30 t/m³). At a dry density of 78.0 pcf (1.25 t/m³), the deposited tailings will have an approximate solids concentration of 70% by weight (46% by volume) at the end of operations.

2.3.2 Tailings Rheology

The rheological characteristics of the deposited tailings (i.e., yield stress⁸ and plastic viscosity⁹) depend on the solids content, type of tailings material, age and consolidation, saturation, and other factors. Samples with a volumetric concentration (C_v) less than about 20% can be considered Newtonian with relatively low yield stress and viscosity, while samples with C_v greater than about 20% display increasingly non-Newtonian characteristics (CDA, 2021).

The tailings yield stress and viscosity at various solids concentrations are plotted on Figure 2-2 and Figure 2-3 from rheological testing of gold tailings from various sites around the world. Generally, more yield stress data than viscosity data are available in the literature. The rheological data were obtained from the following sources:

- Selected tailings samples as reported by Zengeni (2016)
- Tailings samples from the LaRonde Mine and Louvicort Mine in Québec, Canada as reported by Saebimoghaddam (2005)
- A gold tailings sample reported by Gawu and Fourie (2004)
- Tailings from the Bulyanhulu Mine in Tanzania as reported by Henriquez and Simms (2009)
- Tailings sample for the Eskay Creek Revitalization Project in northwest British Columbia, Canada (Knight Piésold, July 9, 2024)
- Two gold mine sites in British Columbia, Canada where BGC is the engineer of record and rheological testing of the tailings has been conducted (yield stress only).

These samples were selected for comparison as they all have similar grain size distributions as the Donlin tailings grind.

Maximum yield stress and viscosity values used by BGC for modelling the various dam breach scenarios in this study are listed in Table 2-1. Considering the high solids content, the breach outflows and the flood wave propagation were modelled as non-Newtonian flows. Not all the dam breach scenarios modelled herein include a C_v value of 46% due to dilution from the

⁸ Yield stress is the amount of stress a material can withstand before it begins to deform permanently, or plastically.

⁹ Plastic viscosity is a non-Newtonian fluid property representing a fluid's resistance to flow once a certain yield stress is exceeded, indicating the friction between particles and the liquid phase.

supernatant pond. For these scenarios, unique yield stress and viscosity values were selected as discussed further in Section 3.4. The yield stress and viscosity values selected for the Donlin TSF are shown on Figure 2-2 and Figure 2-3. The selected values follow general best fit lines through the datasets, although a lower limit yield stress value of 300 Pa was selected for a C_v value of 46% for conservatism (higher yield stress values have lower transport mobility).

Table 2-1 Maximum yield stress and viscosity values adopted for Donlin tailings mobilized in a breach.

C_v (%)	C_w (%)	Yield Stress (Pa)	Viscosity (Pa s)
46	70	300	0.33

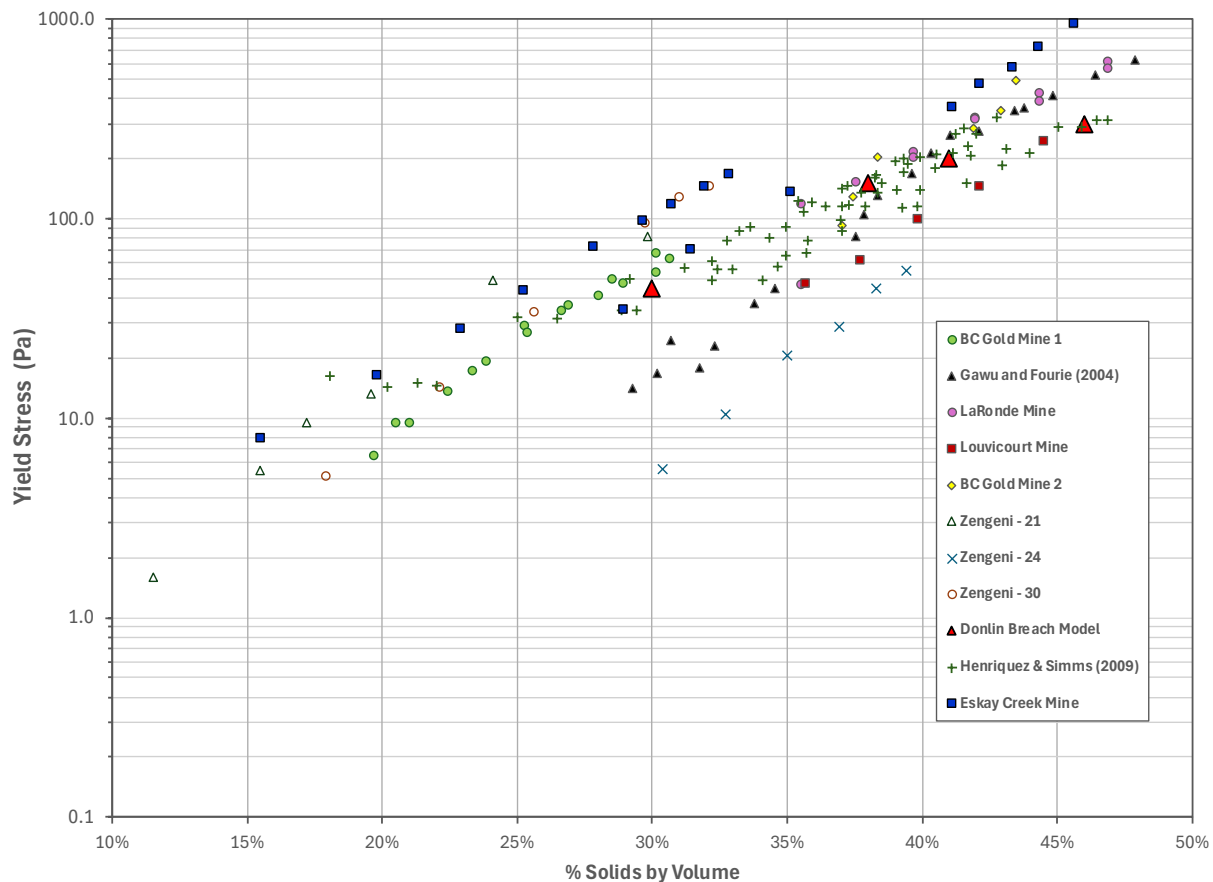


Figure 2-2 Yield stress data for Donlin tailings plotted with literature data.

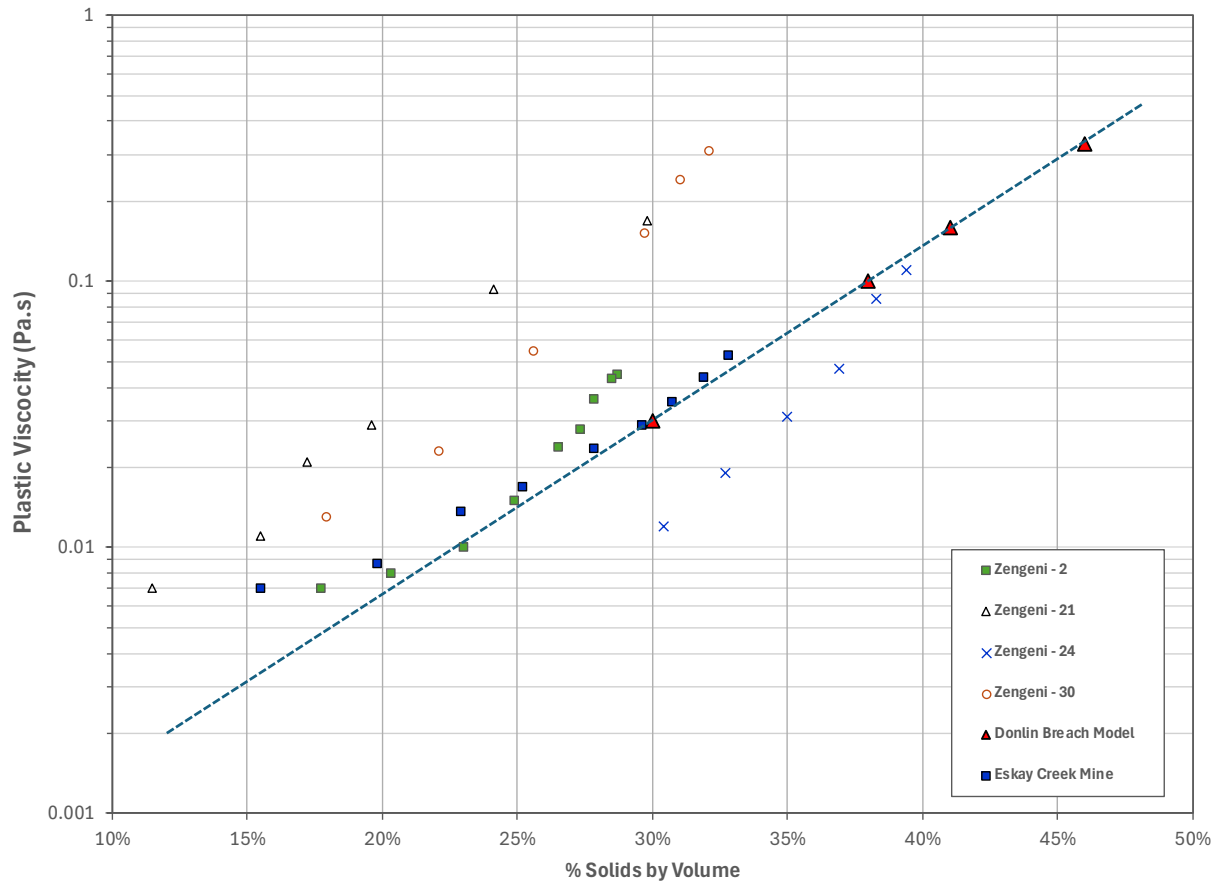


Figure 2-3 Plastic viscosity data for Donlin tailings plotted with literature data.

2.3.3 Liquefaction

Static liquefaction has been reported as a contributing factor to recent tailings releases at Mount Polley (Independent Expert Engineering Investigation and Review Panel, 2015), Fundão (Morgenstern et al., 2016), and Brumadinho (Robertson et al., 2019). Static liquefaction of a dam or tailings deposit refers to the process whereby a contractive granular material, saturated to a level of more than 80%, loses its strength in response to an applied static stress.

Liquefaction occurs only in saturated soils, so the depth to groundwater (either free or perched) influences liquefaction susceptibility (Kramer, 1996). Liquefaction susceptibility decreases with increasing groundwater depths. Loose fills, such as those placed without compaction (e.g., hydraulic fill dams and mine tailings piles), are very likely to be susceptible to liquefaction.

Liquefaction occurs when the structure of a loose, saturated soil (or tailings) breaks down due to some rapidly applied loading, such as placement of materials during dam construction or tailings deposition, or rapid cyclic loading such as earthquakes or blasting.

The tailings for the Project are expected to be liquefiable as they will be fine-grained, saturated, and loose (i.e., low settled dry density). The TSF Main Dam is designed as a zoned, coarse-grained rockfill embankment with internal drains and filters and founded on bedrock (Figure

2-1). The dam embankment materials will be compacted to a dense and unsaturated state and hence will not be liquefiable.

2.4 Hydrology

Both Crooked Creek and the Kuskokwim River are gaged by the US Geological Survey (USGS).

A USGS gaging station was installed in July 2007 on Crooked Creek near the creek mouth at the village of Crooked Creek (#15304010, 61°53'24", 158°09'16", 174 ft [53.0 m] elevation).

Donlin is currently funding the maintenance and operation of this station by the USGS. Figure 2-4 plots daily average streamflow data at the Crooked Creek gage for the period July 2007 to December 2024. A watershed area of 330 sq.mi. (855 km²) reports to this gage.

The Kuskokwim River is also gaged by the USGS immediately upstream of the Crooked Creek confluence (#15304000) 61°52'10", 158°06'41", 159 ft [48.5 m] elevation). This gage has been in operation since 1951 and has an upstream watershed area of 31,100 sq.mi. (80,610 km²), which is approximately 100x larger than the Crooked Creek watershed. Figure 2-5 plots daily average streamflow data at the Kuskokwim River gage for the period 1993 to 2024.

Both hydrographs display a freshet peak in May during the annual spring melt. After the spring peaks, flows are maintained by rainfall at a moderately high level (about half those of the spring peak) through the summer and early fall.

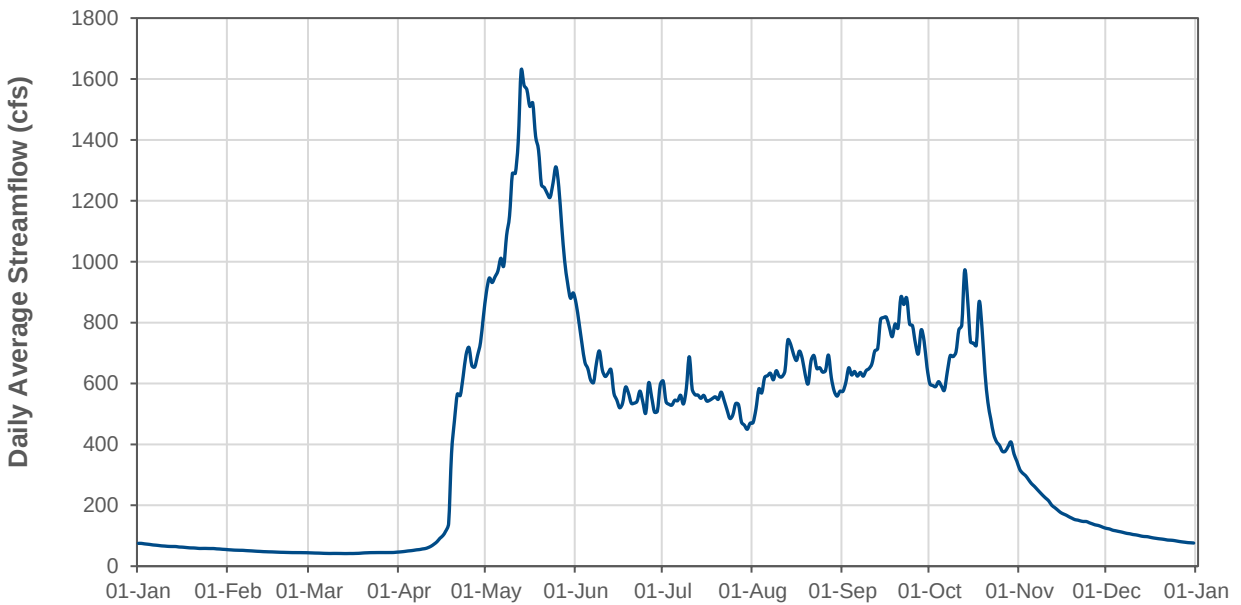


Figure 2-4 Daily average flow at USGS Crooked Creek (#15304010) gage for the period 2007-2024.

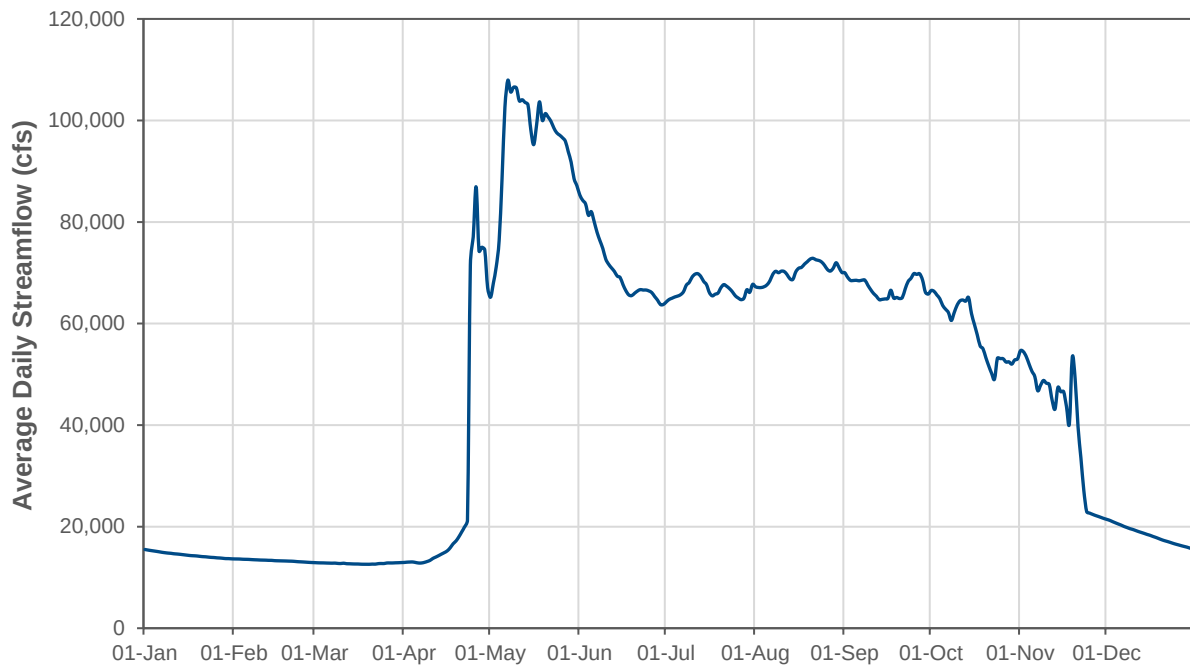


Figure 2-5 Daily average flow at USGS Kuskokwim River (#15304000) gage for the period 1993-2024.

3.0 CREDIBLE DAM FAILURE SCENARIO

In the following sections, a “credible failure mode” refers to failure mechanisms that are technically feasible given the materials present in the facility and its foundation, the properties of those materials, the configuration of the facility, drainage conditions and surface water control at the tailings facility, throughout the life cycle under static and transient loading conditions the facility may be subject to over that life cycle (ICMM, 2021). In short, a “credible failure mode” refers solely to the possible mechanism by which a release could theoretically occur and not to the likelihood or probability. A “credible failure mode” may be extremely unlikely.

3.1 ADNR Guidelines

The ADNR (2017) guidelines recommend that the following two hydrologic conditions be considered when conducting a dam breach analysis:

1. “Flood stage” – assumes the dam fails with the reservoir and spillway discharge at maximum capacity or overtopping, and flooding is occurring based on the 100-year flood or on some percentage of the probable maximum flood (PMF) or another technically justifiable value such as the inflow design flood (IDF).
2. “Sunny day” – assumes that the dam fails with the reservoir level, inflow, and discharge at normal operating levels.

The ADNR Guidelines further note that for embankment dams, such as proposed at Donlin, modes to consider are a breach caused by overtopping or a piping failure. Overtopping can occur as a result of:

- Increased water levels in the impoundment reaching the dam crest
- An earthquake-induced deformation or settlement of the dam crest towards the pond.

The former is more likely to occur under “Flood stage”, while an earthquake-induced deformation could occur under “Flood stage” or “Sunny day” conditions (although Sunny day conditions are more likely considering that flooding conditions generally only occur for a limited number of days during most years).

Piping can occur regardless of the elevation of the water in the impoundment, although such a scenario is typically assumed to occur when the pond is at its normal operating condition, consistent with a “Sunny day” failure.

3.2 Failure Mode and Effects Analysis

On December 2 and 3, 2014, an early-stage Failure Mode and Effects Analysis (FMEA) workshop for the Project was held in Vancouver, BC, Canada. The overall objective of the FMEA workshop was to identify and evaluate all significant risks associated with the TSF Main Dam and the Snow Gulch Reservoir Dam with a view to identifying and addressing risks in the current and future design stages for the two structures. Results of the FMEA workshop are documented in an SRK report dated March 2015. Table 3-1 summarizes the “credible failure modes” of the TSF Main Dam that were identified in the workshop.

Table 3-1 Credible TSF Main Dam breach scenarios identified in the 2014 early-stage FMEA workshop (after SRK, March 2015). The rows highlighted in yellow were modelled by BGC (June 1, 2015) as part of the FEIS for the Donlin Gold Project.

#	Scenario	Full or Partial Breach	Consequence Severity	Likelihood	Risk Rating
1	Downstream failure of dam due to material variability results in partial breach and loss of material (1620 acre-ft / 2 Mm ³) that reaches Crooked Creek.	Partial	Major	Unlikely	Moderately High
2	Poor QA/QC during construction of filter/liner materials results in a leak and ultimately a piping failure and a catastrophic breach.	Full	Critical	Very Unlikely	Moderately High
4	Liner rupture directly above the underdrain leads to sinkhole and outflow of tailings through underdrain.	Partial	Critical ¹	Unlikely	Moderately High
11	Spillway blockage by ice and snow leads to overtopping and breach of the dam.	Full	Critical	Very Unlikely	Moderately High
20	Rupture of the liner leads to piping of native materials into the underdrain and release of tailings and formation of a sinkhole over time ² .	Partial	Moderate	Very Unlikely	Low
24	Mass wasting failure at the abutment (landslide) occurs following construction results in catastrophic failure of the dam.	Full	Critical	Very Unlikely	Moderately High
37	Deep-seated failure of the dam foundation due to undiscovered conditions leads to catastrophic failure of the dam.	Full	Critical	Very Unlikely	Moderately High

Notes:

1. For this scenario, the SRK (March 2015) report notes that a loss of 20% of tailings would be enough to lead to critical consequences.
2. This scenario is slightly different than scenario 4 in that the liner rupture is not directly above the underdrain, so this requires piping through alluvial soils.

3.3 FEIS

As a follow-up to the FMEA workshop and as part of the FEIS for the Project, BGC was requested to evaluate the effects of a partial tailings release. Specifically, BGC (June 1, 2015) modeled an unplanned release of up to 1,620 acre-ft (2 Mm³) (0.5% of the total volume) of tailings and process-affected water from the TSF from a partial breach of the dam due to:

- Piping
- A liner rupture leading to a sinkhole and outflow of tailings through the underdrain.

These two failure modes reflect scenarios #1 and #4 from the FMEA (0.5% of workshop (i.e., highlighted rows in Table 3-1). Four scenarios were modelled by BGC, as summarized in Table 3-2.

Table 3-2 Scenarios modelled by BGC (June 1, 2015).

Scenario	Description
1	Partial piping breach under normal operating conditions, 1,620 acre-ft (2 Mm ³) of tailings released
2	Partial piping breach under normal operating conditions, 1,620 acre-ft (2 Mm ³) of pond water released
3	Liner rupture leading to underdrain flow, 1,620 acre-ft (2 Mm ³) of tailings released
4	Liner rupture leading to underdrain flow, 1,620 acre-ft (2 Mm ³) of pond water released

All four scenarios were considered to occur under “Sunny day¹⁰” hydrologic conditions.

3.4 Selected Dam Breach Scenario

Scenarios #1, #4, and #20 from the FMEA workshop represent partial breaches of the TSF, rather than a full breach of the dam. “Credible dam failure” scenarios identified in the FMEA workshop not modelled by BGC in 2015 include:

- Scenario #2 – piping failure leading to a catastrophic breach of the dam
- Scenario #11 – spillway at the end operations blocked by snow and ice, leading to overtopping and breach of the dam
- Scenario #24 – a landslide occurs at the abutment resulting in catastrophic failure of the dam
- Scenario #27 – deep-seated failure of the dam foundation due to undiscovered conditions leads to catastrophic failure of the dam.

Each of the above-listed failure modes were given a “Moderately High” risk rating. For this update, a catastrophic piping failure of the TSF Main Dam was considered the most plausible “credible failure mode”.

The potential root cause of a piping failure at Donlin is poor QA/QC during construction (including dam raises), combined with a seepage flow starting due to a liner defect near the

¹⁰ Also referred to as a “Fair weather” hydrologic condition (CDA, 2021).

upper elevation of the dam slope and ponded water against the upstream lined dam face. This seepage could lead to retrogressive slumping from the downstream toe, then settlement of the dam crest, and overtopping.

The hypothetical tailings releases were modelled under the following conditions:

- “Sunny day” hydrologic conditions
- An ultimate dam height of 471 ft (144 m)
- A tailings volume of 334,300 acre-ft (412.4 Mm³) consisting of 153,800 acre-ft (189.7 Mm³) of solids and 180,500 acre-ft (222.7 Mm³) of interstitial water
- A supernatant pond volume of 9,760 acre-ft (12.0 Mm³), which is the 50th percentile pond volume at the end of operations (BGC, October 25, 2016) and represents normal operating conditions.

These conditions represent a conservative scenario as the hypothetical tailings release is assumed to occur at the end of operations with a full buildout of the TSF. The probability of a hypothetical tailings release will decrease significantly in closure as the operating pond is removed, the downstream faces of the tailings dam are flattened to 3H:1V, and the tailings consolidate over time.

4.0 TAILINGS RELEASE VOLUME

Having established that an overtopping failure (initiated by piping) of the TSF Main Dam will be modelled at the end of operations, the next task is to identify the total tailings release volume to be modelled and provide supporting rationale for the selected volume. The following sections provide that commentary.

4.1 Discharge Mechanisms

The flow behaviour of a tailings dam breach outflow differs from that of water and will impact the total volume of tailings and water released. Historical events indicate that in most cases, not all stored tailings were released during a breach (e.g., Rico et al., 2008). The breach outflow from a TSF is generally conceptualized as two processes that can occur individually, simultaneously, or sequentially (CDA, 2021), as described below and illustrated in Figure 4-1.

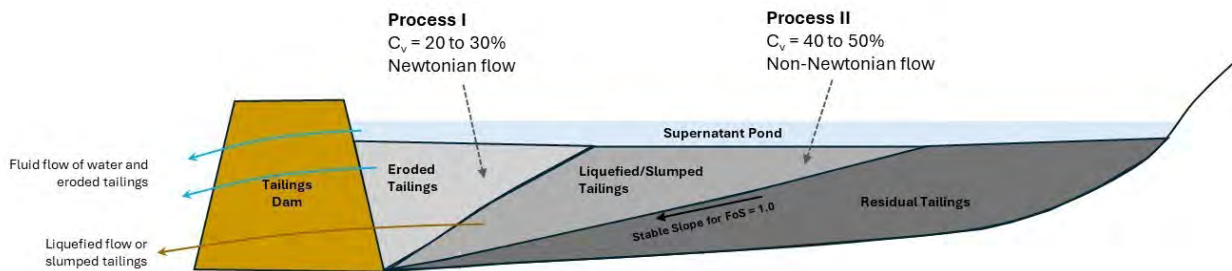


Figure 4-1 Schematic of mobilized volumes in a tailings release (modified from CDA Workshop on Tailings Dam Breach Analysis, 2023 CDA Conference).

Process I – Initial Flood Wave

Process I involves the discharge of supernatant pond water, which causes erosion of the tailings and downcutting through the dam materials. Depending on the location of the supernatant pond within the TSF, this process may occur at the onset of the failure driving the breaching process, or the pond release may occur after the dam has failed due to some other trigger causing discharge of the tailings mass (or portion thereof) first (CDA, 2021)

In general, the sediment/solids concentration in water floods rarely exceeds 20%-30% by volume, or approximately 40%-50% by weight (O'Brien, 1986; García et al., 2008). Therefore, the outflow volume from Process I is typically estimated by assuming that the pond volume mixes with eroded tailings up to a maximum 30% volumetric concentration (CDA, 2021).

Process II – Flow of Liquefied or Slumped Tailings

Process II represents the discharge of flowable tailings due to tailings liquefaction or progressive slumping of unsupported tailings.

During Process I, the discharged pond water causes erosion of the tailings and downcutting through the dam. Lateral unloading starts to develop as Process I continues, initiating tailings liquefaction/slumping and mobilization until a stable backscarp angle is established (Factor of Safety, FoS = 1.0). This process cannot be modelled as water (i.e., Newtonian flow), as the

yield stress and viscosity of liquefied tailings results in non-Newtonian fluid behaviour (CDA, 2021). Modelling non-Newtonian sediment laden fluids requires knowledge of the rheology (i.e., yield stress and viscosity).

Some of the mobilized tailings would be carried downstream in Process I with the initial flood wave, while some of the tailings would discharge as part of Process II. Process I breach outflows have a relatively low solids content and are highly erosive. In contrast, Process II runouts have a high solids content and typically result in limited erosion. Therefore, Process I outflows are generally the dominant process that erodes the dam material (Adria, Martin, & McDougall, 2023).

4.2 Empirical Methods

Several empirical methods have been developed by researchers to estimate potential tailings release volumes. Some of those methods are discussed below.

Rico, Benito, and Diez-Herrero (2008)

One of the first empirical methods to estimate tailings volume release was developed by Rico, Benito, and Diez-Herrero (2008), who analyzed 29 tailings releases around the world. Rico et al. plotted tailings release volume (V_F , in $10^6 \times \text{m}^3$ or Mm^3) versus tailings storage volume (V_T , in Mm^3) for 21 of the releases and arrived at the following best-fit regression equation:

$$V_F = 0.354 \cdot V_T^{1.01} \quad [\text{Eq. 4-1}]$$

These results are also shown visually in Figure 4-2. Rico et al.'s (2008) equation shows that on average, approximately one-third of the tailings volume is released during dam failures. Figure 4-2 includes an envelope curve ($V_F = V_T$), which represents the maximum tailings volume that could be released in an extreme situation in which the entire storage volume is emptied following the dam break. Rico et al.'s relation appears to be somewhat biased in that it includes data from four water retention dams, where almost the entire storage volume was released (Figure 4-2).

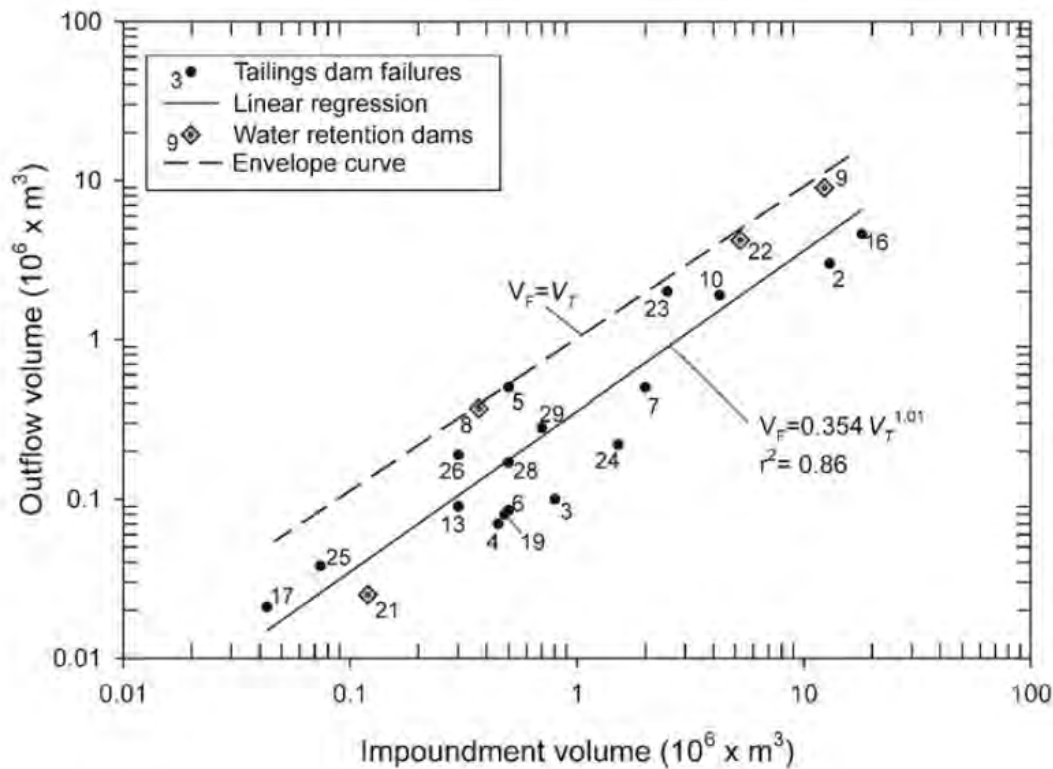


Figure 4-2 Tailings outflow volume (V_F) versus the volume stored at the dam (V_T) at the time of the dam failure (from Rico et al., 2008).

[Larrauri and Lall \(2018\)](#)

Larrauri and Lall (2018) adopted the same dataset of Rico et al. (2008) but extended it with an additional seven cases. The final regression equation using the updated dataset (28 cases) is (Figure 4-3):

$$V_F = 0.332 \cdot V_T^{0.95} \quad [\text{Eq. 4-2}]$$

[Piciullo et al. \(2022\)](#)

Piciullo et al. (2022) further extended the dataset of Rico et al. and Larrauri and Lall by evaluating a total of 71 cases. The resulting regression equation is provided in Equation 4-3 and shown in Figure 4-3.

$$V_F = 0.214 \cdot V_T^{0.77} \quad [\text{Eq. 4-3}]$$

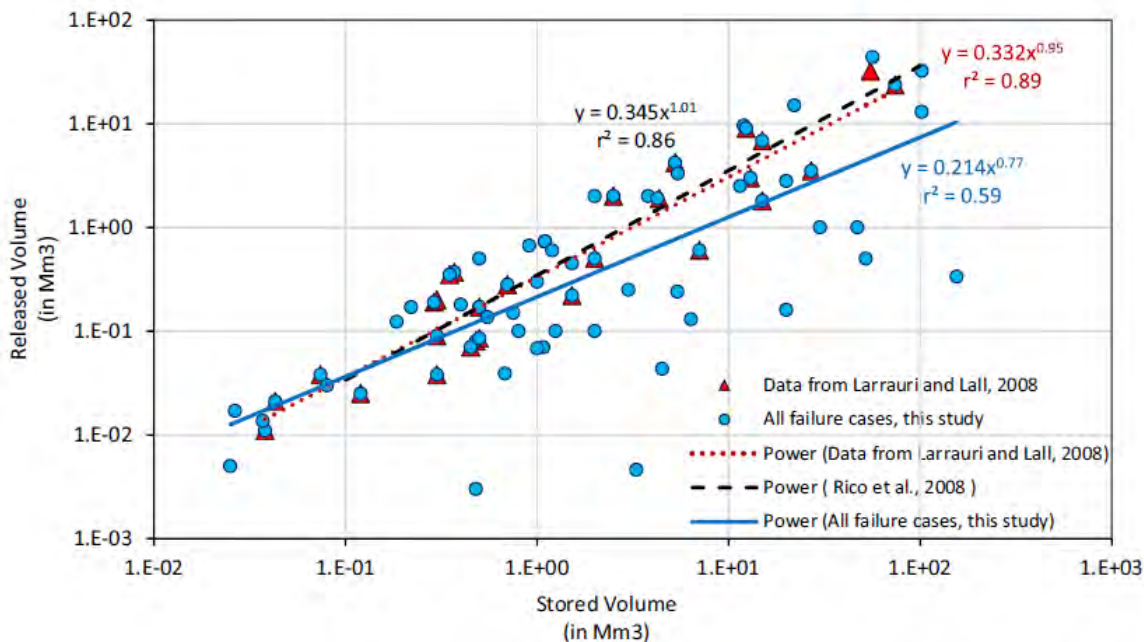


Figure 4-3 Correlation between released and stored volumes of TSFs: comparison between Rico et al. (2008), 21 cases, Larrauri and Lall (2018), 28 cases, and Piciullo et al. (2022), 71 cases (from Piciullo et al., 2022).

The Piciullo et al. (2022) dataset includes a greater scatter of cases, particularly where the released tailings volume is significantly lower than the storage volume. As a result, the coefficient of determination¹¹ (r^2) is much lower for the Piciullo et al. equation ($r^2 = 0.59$) compared to Rico et al. ($r^2 = 0.86$) and Larrauri and Lall ($r^2 = 0.89$). The finding that a larger dataset on tailings releases led to a weaker correlation between stored and released volumes implied to Piciullo et al. that the stored volume (V_T) cannot be considered as the only parameter describing the released volume (V_R). The authors found that dam height (H) was also a factor. A multi-linear regression was completed on the log-transformed values expressing released and stored tailings volumes in cubic meter (m^3) and height (H) in meter (m), resulting in the following equation ($r^2 = 0.75$):

$$V_R = 10^{0.330} \cdot H^{0.994} \cdot V_T^{0.611} \quad [\text{Eq. 4-4}]$$

Post-Failure Tailings Slope

For facilities with a pond and liquefiable tailings, like the Donlin TSF, the estimated total outflow volume of tailings during a dam failure has two components: water and eroded tailings (Process I) and mobilized tailings through liquefaction (Process II) (Figure 4-1).

The outflow volume from Process I is typically estimated by assuming that the pond volume mixes with eroded tailings up to a maximum 30% volumetric concentration. The outflow volume from Process II is then estimated by assuming an average post-failure slope (CDA, 2021).

¹¹ A measure of the proportion of the variance explained by the model, with $r^2 = 1$ representing a perfect correlation between observed and modelled values.

Reviews of historic tailings releases by Lucia et al. (1981) and Blight and Fourie (2003) indicate that the post-failure tailings slope typically varies between 2° and 5° (3.5% to 9% grade), depending on the type and properties of the stored tailings. This range of values can be used as a guide to assume a reasonable limit of the final backscarp of the TSF, which is then used to draw a cone of depression to estimate the total tailings release volume (CDA, 2021).

As a first step, BGC evaluated whether the assumed supernatant pond volume of 9,760 acre-ft (12.0 Mm³) would be sufficient to erode the TSF Main Dam to the base during the breach process. An approach developed by Adria et al. (2023) was used for this calculation. First, the volume of the dam that could be eroded is calculated using Equation 4-5 with a breach side slope of 1H:1V, a bottom breach width of 0 m, and the geometry of the dam in question (i.e., crest width, upstream dam slope, and downstream dam slope). The calculation is performed at regular breach depth intervals, moving downwards from the crest elevation until natural ground is reached.

$$V_M = B_B + H_B^2 \cdot (W_C Z_B + H_B Z_B (Z_U + Z_D)/3) \quad [\text{Eq. 4-5}]$$

where: V_M = the volume of eroded dam volume (m³), B_B = bottom breach width (m), H_B = breach height (m), W_C = crest width of dam (m); Z_D is the slope for the downstream face of the dam (1V:xH); Z_U is the slope for the upstream face of the dam (1V:xH); and Z_B is the slope for the breach sides (1V:xH).

Second, the eroded dam volume is calculated using Equation 4-6 for the same intervals using the outflow volume and varying the breach height.

$$V_{ED} = 1.26 \cdot H_W^{1.803} V_{Out}^{0.338} \quad [\text{Eq. 4-6}]$$

where: V_{ED} is the volume of the eroded dam material (m³), H_w is the height of water above the breach (m), and V_{Out} is the volume of breach outflow (m³) that typically includes the supernatant pond and the eroded tailings material (solids + interstitial water) (i.e., Process I outflow).

Equation 4-6 is based on a regression analysis between observed eroded dam volumes and Process I breach outflow volumes.

Third, the two eroded dam volume curves are plotted and the breach height where the two curves intersect represents the ultimate breach height. If the curves do not cross, it indicates that the breach could progress down to natural ground.

BGC applied Equations 4-5 and 4-6 to the TSF Main Dam with the following assumptions:

- A breach height of 459 ft (140 m), which is the approximate height of the tailings and pond under 50th percentile conditions.
- The pond outflow entrains tailings material with an overall 30% volumetric solids concentration. Based on an assumed initial pond volume of 9,760 acre-ft (12.0 Mm³) and a tailings porosity of 54%, V_{Out} is then estimated at 27,970 acre-ft (34.5 Mm³).

The resulting two curves are shown on Figure 4-4. The two curves intersect at an approximate height of 75 ft (23 m), which represents the ultimate height above natural ground at the toe of the dam. In other words, the breach is not predicted to erode to the toe of the dam.

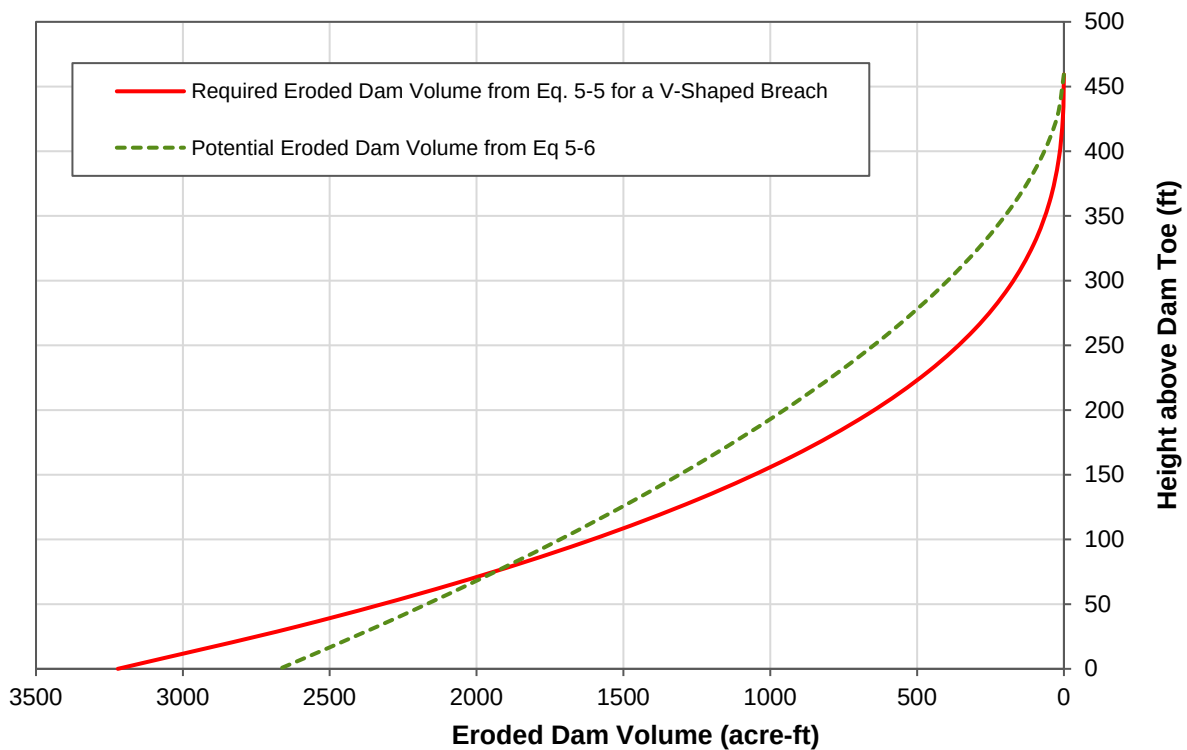


Figure 4-4 Comparison of the calculated eroded dam volume against the dam volume that would need to be eroded to reach a breach height of 459 ft (140 m) with a V-shape breach.

To estimate the potential volume of tailings solids released at the Donlin TSF, an average post-failure surface of 3° (5.2%) from a height of 75 ft (23 m) above the upstream toe of the dam was assumed and projected back from the hypothetical breach location. This angle represents a typical post-failure slope (Blight & Fourie, 2003). Based on this adopted failure angle, BGC generated a post-failure surface from the end-of-mine life projected tailings surfaces using the GIS software GlobalMapper (Blue Marble Geographics). The calculated release volume using this method is 120,440 acre-ft (148.5 Mm³) for a 3° post-failure slope.

Comparison of Empirical Methods

Table 4-1 provides a comparison of the empirical methods discussed above. The 50th percentile pond volume at the end of operations, 9,760 acre-ft (12.0 Mm³), would be added to these release volumes for dam breach modelling.

Table 4-1 Tailings release volume estimates using various empirical methods.

Method	Tailings Storage Volume (acre ft)	Release Volume (acre ft) ⁵	Release Percentage
Piciullo et al. (2022) – single regression ¹	334,300	17,910	5.4%
Piciullo et al. (2022) – multiple regression ²	334,300	44,350	13.3%
Larrauri and Lall (2018) ³	334,300	82,140	24.6%
3° backscarp angle (75 ft above the upstream dam toe)	334,300	120,440	36%
Rico et al. (2008) ⁴	334,300	125,780	38%

Note:

1. 71 cases with linear regression of release volume versus storage volume.
2. 71 cases with multiple regression of release volume versus storage volume and dam height.
3. 28 cases with linear regression of release volume versus storage volume.
4. 21 cases with linear regression of release volume versus storage volume.
5. 50th percentile pond volumes at the end of operations would be added to these release volumes for dam breach modelling.

4.3 Lynker

Lynker (April 11, 2024) was retained by the Mother Kuskokwim Tribal Coalition to conduct a dam breach analysis for the Donlin TSF. Lynker developed a set of scenarios around three different release volumes ranging from a small breach to a catastrophic liquefaction and mobilization of nearly all the tailings. These breach volume scenarios were calculated using a release of 5%, 50%, and 90% of the total storage volume of the TSF. The Lynker analysis did not evaluate the risk of occurrence of a dam breach.

Lynker (April 11, 2024) acknowledged that the 90% release scenario was historically anomalous; however, they argued that the 90% breach scenario provided context for a catastrophic, total liquefaction scenario as a theoretical upper envelope for use in emergency response planning with specific reference to the 2019 catastrophic failure of Dam B-1 at the Córrego do Feijão mine in Brazil (Robertson et al., 2019).

Robertson et al. (2019) described, “the failure [of the Córrego do Feijão dam] was the result of flow (static) liquefaction within the materials of the dam.” As discussed in Section 2.3.3, the Donlin TSF Main Dam embankment will be constructed of compacted rockfill that is not liquefiable. Hence, the Córrego do Feijão TSF tailings release is considered a very poor analogy for the proposed conditions of the TSF Main Dam.

4.4 Other Environmental Reviews for Mine

Recent National Environmental Policy Act (NEPA) and related environmental reviews in North America for other mining projects include:

- The Kensington Mine Supplemental Environmental Impact Statement (SEIS) (Tongass National Forest, 2021).
- The withdrawn Resolution Mine Final EIS (FEIS) (Tonto National Forest, 2021).

- The discussion of a catastrophic tailings release by the USACE in the Pebble Mine FEIS and EPA's final Clean Water Act Section 404(c) veto.

Kensington SEIS

The Kensington SEIS evaluated the impacts of a proposed life of mine extension of the underground Kensington gold mine in southeast Alaska. The SEIS assessed several TSF alternatives and used the empirical relation of Larrauri and Lall (2018) to provide an estimate of the release volumes under each action alternative.

Resolution Mine FEIS

Resolution Copper has proposed developing an underground copper mine on National Forest System land near the town of Superior in Pinal County, Arizona, approximately 60 miles (100 km) east of Phoenix. Five alternatives for the deposition of 810,700 acre-ft (1,000 Mm³) of tailings were evaluated for the FEIS. A simplified breach analysis was conducted for each alternative and to assess tailings release volumes, the empirical relation of Larrauri and Lall (2018) was selected. The Tonto Forest Service recognized the following limitations to the empirical method:

- The largest facility in the Larrauri and Lall dataset is 60,000 acre-ft (74 Mm³) compared with 810,700 acre-ft (1,000 Mm³) for the planned Resolution Copper facility. The extrapolation goes well beyond the bounds of the original dataset and represents an uncertainty since larger facilities may or may not react like smaller facilities.
- Specific embankment construction methods are not factored into the empirical equations. Of the 35 facilities included in the Larrauri and Lall empirical relation, 24 used an upstream construction method, one used modified centerline, and none used centerline (Bowker, 2019). It was recognized that the Resolution Copper TSF would have a fundamentally different type of embankment than most of the previous failures, with two alternatives using a modified-centerline embankment and two using a centerline embankment.
- The Larrauri and Lall dataset extends as far back as 1965 and many of the documented failures may have been designed to lower factors of safety or higher acceptable levels of risk than currently used.
- The empirical estimates are based solely on facility volume and do not account for operational methodologies, topography, or actual failure mode.

While recognizing these limitations, the Tonto Forest Service selected the Larrauri and Lall empirical method as the most reasonable method to inform the NEPA process and assess differences between alternatives. The level of current design and site-specific information was considered sufficient to use the empirical method, and the downstream effects reflected the real-world conditions experienced during other failures.

Pebble Mine FEIS

The Alaska District of the USACE (July 2020) examined the potential environmental impacts of the proposed Pebble Mine, which would mine a copper-gold-molybdenum porphyry deposit

located in southwest Alaska (approximately 200 miles [320 km] southwest of Anchorage). Tailings produced from the mine were proposed to be stored in two facilities: a bulk TSF and a pyritic TSF.

The bulk TSF would have two embankments: the main embankment (545 feet [166 m] high) and the south embankment (300 feet [91 m] high). The bulk TSF would provide storage capacity for 1.1 billion short tons of bulk tailings. The main embankment of the bulk TSF would be built with earthfill and rockfill material and would not be lined. The pyritic TSF would be fully lined and would store approximately 155 million tons of pyritic tailings, up to 93 million tons of PAG waste rock, and an operating supernatant pond that would fully cover the tailings. There would be three embankments, north, east, and south, that would be zoned rockfill and earthfill structures constructed with the downstream method on a foundation of bedrock. These embankments would form a “ring” embankment around three sides of the TSF, and would have maximum heights of 335, 225, and 215 feet (102 m, 69 m, and 66 m).

The Pebble Mine FEIS included a 2014 EPA report that modelled hypothetical tailings releases. Modelling was conducted for overtopping and piping failures of a 300 ft (90 m) high and 685 ft (210 m) high tailings dam, assuming a range of dam failure durations and the release of 20% of the total tailings storage volume¹².

4.5 Documented Dam Failures

BGC also evaluated whether any documented TSF dam failure is analogous to the Donlin TSF Main Dam based on size, site conditions, and design, and could therefore be used to estimate a more likely release volume. As described in Appendix A, BGC did not identify any such failure, based on a review of 20 well-documented case studies of TSF dam failures where the root cause(s) of the failures was described. Specifically, in the past 25 years with improved dam design practices, governance, and regulation, there has been no documented failure of a tailings dam constructed as is proposed for the Donlin Gold TSF Main Dam – a rockfill embankment with a geomembrane liner that is founded on bedrock of high shear resistance and raised using the downstream construction raise method. Thus, there is no basis for concluding that one partial tailings release size is more likely to occur than another.

4.6 Tailings Release Volume Scenarios

In summary, the previous sections have highlighted that:

- Empirical equations/methods indicate tailings release volumes that range between 5% and 38% of the total storage volume.
- Previous EISs have used the empirical relation of Larrauri and Lall (2018) to provide an estimate of the release volume for action alternatives.

Each of the methods acknowledges that predicting the release volume for a specific tailings facility is highly variable due to site- and facility-specific consideration. Therefore, it was

¹² The rationale behind the 20% tailings release volume is not provided in the 2014 EPA report but this value does fall within the range of empirical values presented in Section 5.1.

determined that a range of hypothetical volumes should be modeled for the current study, including 0.5% (as per the original FEIS value, 5.4%), 13.3%, and 24.6%. This approach recognizes that Larrauri and Lall was effectively an update to the previous work by Rico.

Echoing the Resolution Mine FEIS, the reader should recognize that:

- The largest facility in the Larrauri and Lall dataset is 60,000 acre-ft (74 Mm³) compared with 356,714 acre-ft (440 Mm³) for the proposed TSF Main Dam.
- Specific embankment construction methods are not factored into the empirical equations. Of the 35 facilities included in the Larrauri and Lall empirical relation, 24 used an upstream construction raise method and one used modified centerline (Bowker, 2019). The Donlin TSF would have a fundamentally different type of embankment than most of the previous failures, with a downstream construction raise method and a rockfill core that have been shown to reduce the risk of catastrophic release.

The dam breach scenarios modelled, including release volumes and adopted rheological parameters, are summarized in Table 4-2. The rheological parameters vary between the modelled scenarios, reflecting the varying volumetric sediment concentration. Selected yield stress and plastic viscosity values are based on interpolation of the plotted values in Figure 2-2 and Figure 2-3.

Table 4-2 TSF Main Dam breach scenarios including release volume and rheological parameters.

% tailings release	Tailings Release Volume ¹ (acre ft)	Pond Volume (acre ft)	Total Release Volume (acre ft)	C _v (%)	Yield Stress (Pa)	Plastic Viscosity (Pa s)
24.6	82,140	9,730	91,870	41%	200	0.16
13.3	44,350	9,730	54,080	38%	150	0.10
5.4	17,910	9,730	27,640	30%	45	0.03
0.5	1,670	0	1,670	46%	300	0.33

Note:

1. Volume includes tailings solid and void water with an assumed sediment concentration volume (C_v) of 46%.

5.0 DAM BREACH HYDROGRAPH

5.1 Introduction

The breach hydrograph was developed using the dam break module in HEC-HMS (version 4.12) (US Army Corps of Engineers [USACE], 2022). HEC-HMS is recommended by Alaska Dam Safety for quantitative dam failure analysis (ADNR, 2017). The HEC-HMS breach module allows for simulation of breach formation under overtopping and piping failure conditions. The data requirements of the HEC-HMS dam break module are:

- Initial water level
- Breach bottom elevation
- Left and right slope angles (H:V)
- Breach bottom width
- Breach formation time
- A volume-elevation curve above the post-failure surface in the TSF.

The primary output from the breach analysis is a breach outflow hydrograph.

Development of a dam breach is influenced by several factors, including the dam construction type, materials, and geometry, the materials impounded by the dam, the shape of the storage basin, and downstream topography (Canadian Dam Association (CDA), 2021). The combination of breach parameters defines the peak discharge and the shape of the outflow hydrograph, which influence the estimated consequences in conjunction with downstream routing and inundation mapping.

There are various guidelines that provide a recommended range of values for various dam breach parameters, including the Federal Energy Regulatory Commission (FERC, 2015), USACE (2007), and ADNR (2017), as summarized in Table 5-1.

Table 5-1 Recommended range of breach parameters for dams.

Parameter	FERC ¹ (2015)	USACE ¹ (2007)	ADNR ² (2017)
Average breach width	1 to 5 times the height of the dam	0.5 to 5 times the height of the dam	1 to 5 times the height of the dam
Breach side slope	0.25H:1V to 1H:1V	0H:1V to 1H:1V	0.25H:1V to 1H:1V
Breach formation time	0.1 to 1 hour	0.1 to 1 hour	0.1 to 1 hour

Notes:

1. Tabulated values are for engineered water retaining dams.
2. Tabulated values are for engineered rockfill dams.

To arrive at values for the average breach width and breach formation time, a number of empirical equations have been developed including those by von Thun and Gillette (1990),

Froehlich (2008), and Xu and Zhang¹³ (2009). Applying these empirical equations to the hypothetical release volumes from the TSF Main Dam:

- The breach formation time ranges between 0.6 and 1.6 hours with an average of 1.1 hours
- The average breach width ranges between 560 ft and 1160 ft (170 m and 355 m) with an average of 860 ft (260 m), which is approximately two times the dam height.

For the HEC-HMS modelling, the following dam breach parameters were used:

- A breach formation time of 1 hour, which is at the upper end of the recommended ranges provided in Table 5-1. A shorter breach formation time is not recommended as Walder and O'Connor (1997) and Xu and Zhang (2009) reviewed the mean erosion rate for past water retaining dam failures and showed that erosion rates were generally in the range of 30 to 300 ft/h. At a height of 471 ft (144 m) and using the upper range of past erosion rates (i.e., 300 ft/h), the breach formation time of the TSF Main Dam would exceed 1 h.
- Breach side slopes of 1H:1V as recommended by Froehlich (2008) for overtopping failures
- For simplicity, a bottom breach width of 410 ft¹⁴ (125 m) was used for all scenarios, as calculated using the parameters above.
- The bottom elevation of the breach was adjusted for each scenario.
- All scenarios were modelled as an initial piping failure leading to overtopping, except the 0.5% tailings release scenario, which was modelled as a piping failure as it does not assume release of the 9,760 acre-ft (12.0 Mm³) operating pond.

Although accurately representing breach geometry is important, a modelling study by Ghahramani et al. (2022) determined that the volume of tailings released is the primary factor influencing predictions of downstream impacts, rather than breach geometry itself.

5.2 Results

The parameters used to generate the dam breach hydrographs and a summary of the hydrographs for the four scenarios is shown in Table 5-2. The breach hydrographs are presented in Figure 5-1. As expected, the peak outflow varies significantly with the volume of the release. The peak outflow for the 0.5% release volume scenario occurs at 10 minutes, with a flow rate of 197,000 cfs (5,580 m³/s), after which it decreases rapidly and ceases. In contrast, the 5.4%, 13.3%, and 24.6% release volume scenarios reach their peak outflow between 30 and 40 minutes following breach initiation, with flow rates ranging from 647,000 cfs (18,300 m³/s) to 2,047,000 cfs (58,000 m³/s). For these larger release volumes, the outflow is completed after approximately 65 to 70 minutes.

¹³ The Xu and Zhang (2009) empirical equations for breach development were not considered per the recommendation of the USBR (2014).

¹⁴ Which equates to an average breach width of 880 ft (270 m).

Table 5-2 Breach parameters used to generate the breach hydrograph and summary of the breach hydrograph.

Parameter	Release Volume Scenario (Percentage of Storage Volume)			
	0.5%	5.4%	13.3%	24.6%
Dam Breach Parameters				
Top Elevation (ft)	824	824	824	824
Bottom Breach Elevation (ft)	525	492	492	459
Bottom Breach Width (ft)	410	410	410	410
Side Slopes (xH:1V)	1	1	1	1
Breach Formation Time (hrs)	1	1	1	1
Breach Mechanism	Piping	Piping ²	Piping ²	Piping ²
Piping Elevation (ft)	541	N/A	N/A	N/A
Summary of Breach Dam Hydrographs				
Peak Outflow (cfs)	197,000	647,000	1,190,000	2,047,000
Time of Peak Outflow (h:mm) ¹	1:11	1:30	1:36	1:41
Release Volume (acre-ft)	1,671	27,640	54,080	91,870

Note:

1. Where the breach initiates at 1:00 h.
2. Piping failure leading to retrogressive failure at the dam toe, followed by slumping of the dam crest and overtopping.

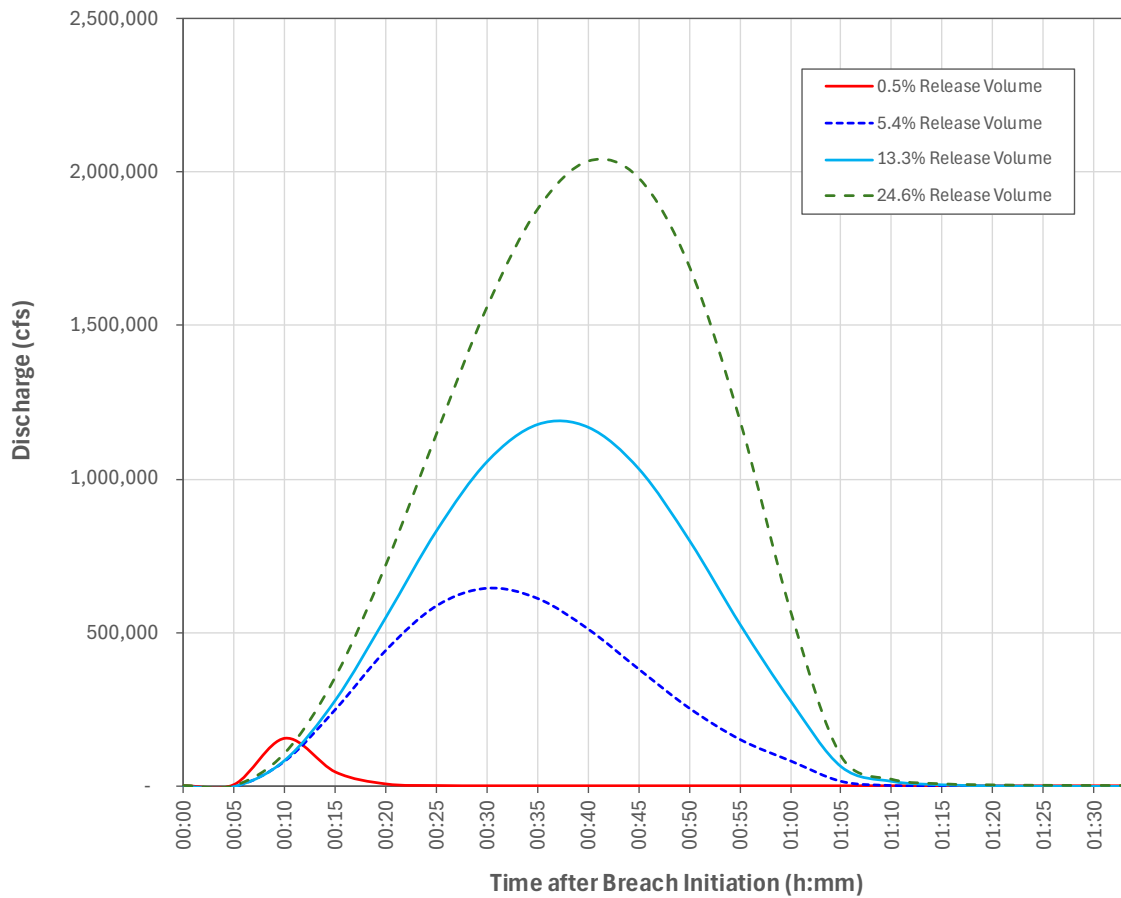


Figure 5-1 Dam breach hydrographs for the four breach scenarios.

6.0 DAM BREACH FLOOD WAVE ROUTING AND INUNDATION MODELLING

6.1 Hydraulic Model

Inundation modelling involves using a hydraulic model to route the breach hydrographs downstream of the TSF Main Dam. Two-dimensional flood wave routing of the dam breach scenarios was conducted using the HEC-RAS software package (Version 6.6) developed by the US Army Corps of Engineers. Full momentum Saint-Venant equations were used to solve for unsteady flows associated with the breaches.

The flood waves generated by a breach of the Donlin TSF are considered non-Newtonian as they move down Crooked Creek. For all four scenarios, the volume of tailings released is significantly greater than the creek's flow, and the influence of the creek's flow on the properties of the tailings is regarded as negligible. However, once these flood waves discharge into the Kuskokwim River, it is expected that flows into the river will mix and dilute the tailings, thereby restoring Newtonian fluid behavior.

To capture both the non-Newtonian and Newtonian flow regimes, two hydraulic models were developed. This is because HEC-RAS is not capable of simulating non-Newtonian and Newtonian fluids concurrently due to its computational framework, which is designed for single rheological behavior per simulation run. As such, one model was configured to simulate the non-Newtonian flows along Crooked Creek using the rheological parameters provided in Table 4-2, while the other model was set up for Newtonian flow conditions along the Kuskokwim River.

Model Domain

The model domain sets the geographical boundaries of the hydraulic model. The model domain for the non-Newtonian model included:

- Anaconda Creek downstream of the TSF Main Dam to the confluence with Crooked Creek
- Crooked Creek from several miles upstream of the Anaconda Creek confluence and downstream to the junction with Kuskokwim River
- Approximately 4 miles (6.5 km) of the Kuskokwim River upstream and downstream from the confluence with Crooked Creek.

The model domain for the Newtonian model:

- the Kuskokwim River from about 10 miles (16 km) upstream of the confluence with Crooked Creek to downstream of the Village of Lower Kalskag (an approximate length of 120 miles [190 km]).

The model domains included the floodplains of Crooked Creek and the Kuskokwim River to ensure the full extent of overbank flows was captured. The full model domain is shown in Figure 6-1.

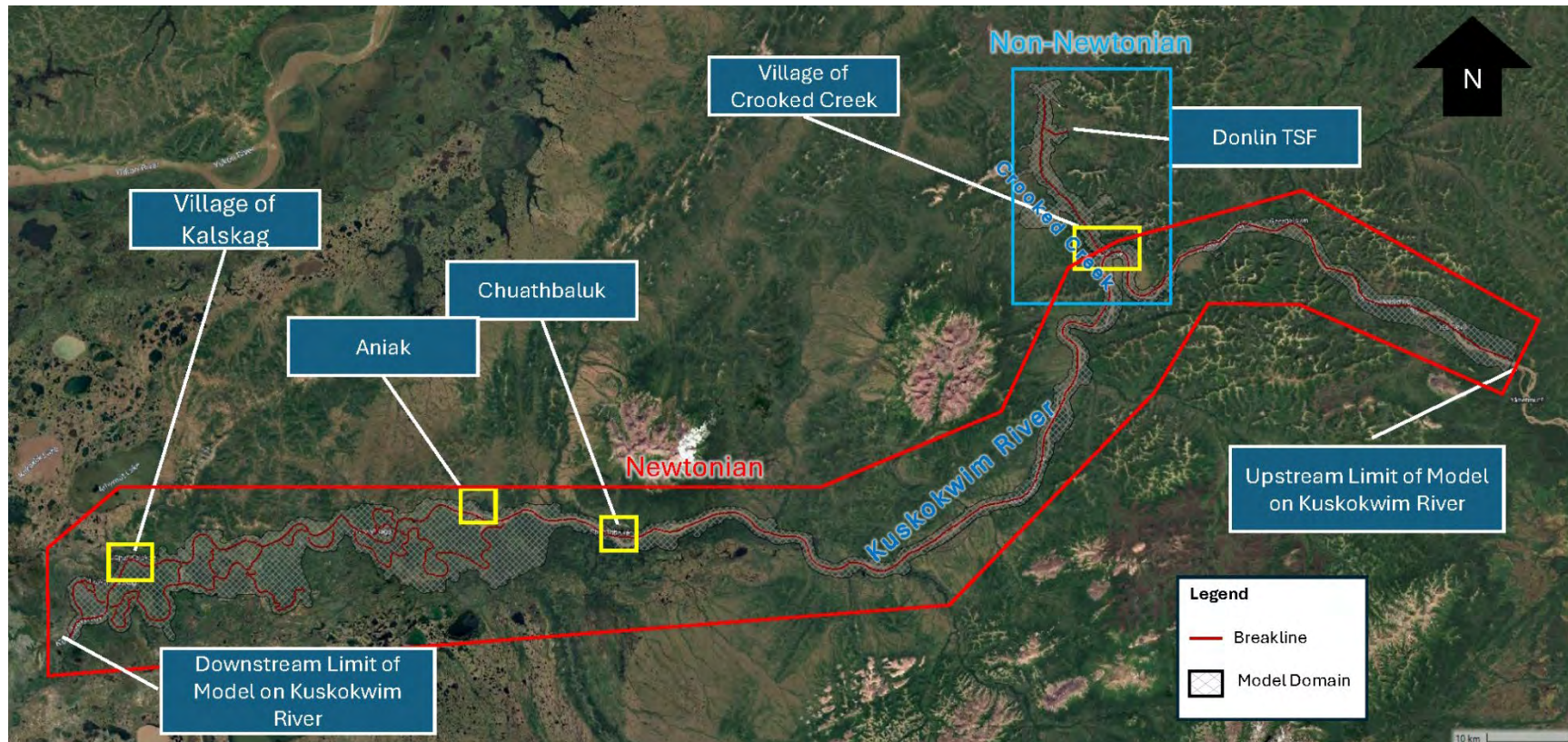


Figure 6-1 The model domain used to simulate the flood wave routing and inundation.

CDA (2021) guidelines note that modelling of the downstream flooding should extend to the point where the incremental flow effects of a failure would no longer represent a threat to life, properties and the environment, or where sufficient warning time would exist. For Sunny day scenarios, FEMA (2013) recommends the study extend until the flows decrease to be within the river channel (i.e., within a 2-year flood that is typically considered to be a bankfull flood), or until a large water body, such as a lake, reservoir, or an ocean is intercepted. Both the CDA and FEMA recommended model domain conditions were met on review of the dam breach results.

Topography and Bathymetry

In this study, the model's topography was developed utilizing the 16-foot (5-meter) Digital Elevation Model (DEM) data for Alaska, obtained from the U.S. Geological Survey's National Map 3D Elevation Program¹⁵ (USGS, 2022). This bare-earth DEM was generated through interferometric synthetic aperture radar techniques.

The DEM excludes elevations beneath water surfaces. Data regarding bathymetric elevations was unavailable for Anaconda Creek, Crooked Creek, and the Kuskokwim River. For Anaconda and Crooked creeks, the absence of bathymetric data is considered to have a negligible impact and was not considered. This is because the magnitude of the breach flood waves is much greater than the capacity of these two watercourses. For the Kuskokwim River, however, the absence of detailed bathymetric information required an adjustment to the model's discharge input. This adjustment was necessary to ensure that the modeled water surface elevations accurately reflected observed conditions. Details regarding the adjustment are discussed in the Hydrologic Inflow Boundary Conditions section.

Mesh Development

HEC-RAS 2D uses a numerical mesh or grid to discretize the area of interest into a series of discrete areas (i.e., computational cells) that are considerably smaller than the area of interest. The concept is that as computational cell sizes approach infinitesimal dimensions, they can precisely represent the hydraulic processes that drive flooding. However, using infinitesimally small cells would require infinitely large computing resources. As such, the objective of mesh development is to use the coarsest mesh possible to reduce model runtime, while preserving the desired level of accuracy in the hydraulic results.

Within HEC-RAS, a 2D mesh is generated based on:

- The model domain (the outer extents of the model).
- Refinement areas to define sub-domains where the mesh properties (e.g., mesh resolution) are adjusted.
- Breaklines to align the mesh with terrain features which influence the flow such as dikes, ditches, terraces, and embankments. HEC-RAS 2D provides options to adjust the mesh resolution along breaklines.

¹⁵ Horizontal datum = North American Datum of 1983 (NAD83); Vertical datum = North American Vertical Datum of 1988 (NAVD88).

From these inputs, HEC-RAS 2D generates the mesh consisting of interconnected grid cells with computational points at the cell centroids and along the faces of the cells (i.e., along the cell sides).

The non-Newtonian model used a base mesh resolution of 82 ft (25 m) whereas the Newtonian model used a base resolution of 164 ft (50 m). The coarser resolution for the Newtonian model was selected to reduce model runtime, as the broader, more uniform flow in the Kuskokwim River allows for less spatial detail without significantly compromising model accuracy. Both models incorporated breaklines along the centerlines of the main watercourses and major secondary channels to ensure that mesh elements are aligned with the direction of water flow, thereby improving the representation of hydraulic gradients and flow paths. A summary of the mesh properties is provided in Table 6-1.

Table 6-1 HEC-RAS mesh properties.

Property	Non Newtonian Model (Crooked Creek)	Newtonian Model (Kuskokwim River)
Number of Mesh Cells	136,793	352,400
Average Mesh Face Length (ft)	89	154
Average Cell Size (sq.ft)	7,780	23,530

Hydrologic Inflows and Boundary Conditions

The breach scenarios considered in this report are assumed to occur under Sunny day conditions. Relative to the magnitude of the dam breach hydrographs (i.e., Figure 5-1), average flows in Crooked Creek are minimal (Figure 2-4) and would not impact model results. Therefore, background flows in Crooked Creek were not modelled for any of the breach scenarios.

In contrast, discharges in the Kuskokwim River are significant through most of the year as discussed in Section 2.4. The water elevation of the Kuskokwim River at gage #15304000 on the date of DEM acquisition was 140 ft (42.6 m), which represents a streamflow of 34,330 cfs (965 m³/s). However, the water elevation at the gage in the DEM is 2 ft (0.7 m) lower at 137 ft (41.8 m). This implies that the wetted portion of the Kuskokwim River in the DEM has been hydro-flattened (i.e., the DEM-creator has gone through and imposed a water surface over the river, which is common practice).

Using published stage-discharge curves for the Kuskokwim River gage (USGS, 2025), an elevation of 137 ft (41.8 m) is equivalent to a streamflow of 32,100 cfs (910 m³/s). While a Sunny day breach scenario could occur at any time of the year, BGC elected to model average flow conditions during the summer, which roughly represents median conditions between the freshet peak and winter low flows. Average flow in the June to September period at the Kuskokwim gage is 68,900 cfs (1950 m³/s). Therefore, a steady state inflow of 36,700 cfs (1040 m³/s) was used as an inflow boundary condition to the model at the upstream model domain boundary of the Kuskokwim River.

The approach of adjusting the discharge to account for the lack of bathymetry in the DEM is a simplification and the river channel is depicted as much shallower than it is. This artificially reduced channel depth increases the frictional resistance within the model, since water encounters more contact with the channel bed and banks. As a result, the flood wave travels more slowly (i.e., the flood wave speed decreases) and experiences greater attenuation – meaning the wave loses energy and dissipates more rapidly as it moves downstream.

A summary of the boundary conditions used in the two models is presented in Table 6-2. The non-Newtonian model used a single boundary condition at the Donlin TSF dam to inject the breach hydrographs for the four scenarios. The flood wave hydrographs for each scenario were extracted from the non-Newtonian model along a cross-section at the confluence with the Kuskokwim River. Flows in the Kuskokwim River were omitted from the non-Newtonian model.

The Newtonian model incorporated an upstream inflow boundary condition to simulate river flows of 68,900 cfs (1950 m³/s). An initial simulation was conducted to achieve steady-state flow conditions within the river, which subsequently served as the starting point for further analysis. The flood wave extracted from the non-Newtonian model at the confluence of Crooked Creek and the Kuskokwim River was applied as an inflow boundary condition. A normal flow boundary condition was designated at the downstream limit to facilitate the exit of the flood wave from the model domain.

Table 6-2 Boundary conditions used in the models.

Location	Type	Description
Non-Newtonian Model (Crooked Creek)		
Donlin TSF (Anaconda Creek)	Inflow Boundary Condition	Dam breach hydrograph for specific scenario.
Newtonian Model (Kuskokwim River)		
Kuskokwim River Inlet	Inflow Boundary Condition	Steady state inflow of 36,700 cfs (1040 m ³ /s) to simulate a flow of 68,900 cfs (1950 m ³ /s).
Confluence with Crooked Creek	Inflow Boundary Condition	Flood wave hydrograph extracted from the non-Newtonian model at Crooked Creek upstream of the confluence with the Kuskokwim River.
Kuskokwim River Outlet	Normal Flow Boundary Condition	Normal depth outflow with a friction slope of 0.0005

Roughness Parameters

HEC-RAS 2D uses the Manning's roughness coefficient (Manning's n) to represent hydraulic flow resistance. A Manning's n value of 0.06 was selected for the floodplains and a value of 0.035 was chosen for the watercourses. These values were selected based on standard guidelines and field observations, as recommended by Chow (1959) and the HEC-RAS User Manual.

6.2 Results

6.2.1 Flood Inundation

Breach inundation maps for the four scenarios are shown in Drawing sets A (24.6% tailings release scenario), B (13.3% tailings release volume scenario), C (5.4% tailings release volume scenario), and D (0.5% tailings release volume scenario) and illustrate the maximum flooding extents. The extents of the modelled inundation areas are summarized in Table 6-3.

Table 6-3 Summary of modelled inundation areas.

Tailings Release Scenario	Drawing Set Number	Crooked Creek Inundation Area (acres)	Kuskokwim River Inundation Area (acres) ¹
24.6	A	5,580	6,250
13.3	B	4,930	2,910
5.4	C	4,390	3,100
0.5	D	340	-

Note:

1. Expressed as the area flooded outside the extent of the Kuskokwim River for the baseflow conditions.

Summaries of the peak flows, flood arrival times and the peak arrival times for the four communities within the study area are presented in Table 6-4 for the 24.6%, 13.3% and 5.4% tailings release scenarios. The flood wave produced by the 0.5% tailings release scenario does not reach any of the communities or the Kuskokwim River. The hydrographs produced by the dam breach flood wave at the communities of Chuathbaluk (mile 71, km 115), Aniak (mile 81, km 130), and Upper/Lower Kalskag (mile 114, km 183) are shown in Figure 6-2 to Figure 6-5. Channel profiles showing the maximum water surface elevations (above the base DEM level) at the four communities are shown in Figure 6-6 to Figure 6-9.

Specific results for the four communities are summarized as follows:

Village of Crooked Creek

The flood wave arrives at Crooked Creek between 1 hour and 45 minutes (24.6% release scenario) and 2 hours and 20 minutes (5.4% release scenario) after breach initiation. Peak water elevations occur about 20 minutes later. The maximum water depth ranges from 28 ft (8.5 m) for the 24.6% tailings release volume scenario to 17 ft (5.2 m) for the 5.4% scenario (Figure 6-6). Flooding of portions of the community occurs for three tailings release scenarios.

Native Village of Chuathbaluk

The flood wave arrives at the river reach near Chuathbaluk in 13 hours and 45 minutes (24.6% release scenario) to 16 hours and 25 minutes (5.4% release scenario), with peak water elevations occurring between 25 and 27 hours after breach initiation. The maximum water depth above baseflow is between 2 ft (0.6 m) for the 24.6% scenario and 1 ft (0.3 m) for the 5.4%

scenario (Figure 6-7). The water levels are expected to remain confined to the river channel, limiting overbank impacts.

Village of Aniak

The river reach near Aniak experiences a flood wave arrival time between 16 hours and 30 minutes (24.6% release scenario) to 19 hours and 20 minutes (5.4% release scenario), and peak water elevations occur between 31 and 33 hours post-breach. The maximum water depth above baseflow is between 1.5 ft (0.5 m) for the 24.6% scenario and 0.9 ft (0.3 m) for the 13.3% scenario (Figure 6-8). The water levels are expected to remain confined to the river channel, limiting overbank impacts.

Village of Kalskag

At Upper/Lower Kalskag, the flood wave on the river arrives between 37 hours (24.6% release scenario) and 45 hours (5.4% release scenario) after the breach, with peak water elevations occurring between 58 and 60 hours. The maximum water depth above baseflow ranges from 1.2 ft (0.4 m) for the 24.6% scenario to 0.7 ft (0.2 m) for the 13.3% scenario (Figure 6-9). The water levels are expected to remain confined to the river channel, limiting overbank impacts.

Table 6-4 Modelled front arrival times, peak arrival time and peak flow. The 0.5% tailings release scenario flood wave does not reach the populated communities.

Location	Tailings Release Scenario		
	24.6%	13.3%	5.4%
	Front Arrival Time (h:mm)		
Crooked Creek	1:45	2:10	2:20
Chuathbaluk	13:45	16:05	16:25
Aniak	16:30	19:00	19:20
Kalskag	37:10	45:00	44:30
	Peak Arrival Time (h:mm)		
Crooked Creek	2:05	2:30	2:45
Chuathbaluk	25:05	27:00	26:10
Aniak	31:10	32:20	33:00
Kalskag	58:40	60:20	60:00
	Peak Flow (cfs) and Incremental Peak Flow (cfs)¹		
Crooked Creek ²	Peak: 416,300	Peak: 170,060	Peak: 129,750
Chuathbaluk	Peak: 88,630 Incremental: 19,730	Peak: 78,280 Incremental: 9,380	Peak: 79,130 Incremental: 10,230
Aniak	Peak 76,370 Incremental: 7,470	Peak 69,380 Incremental: 480	Peak: 69,970 Incremental: 1,070
Kalskag ³	Peak: 64,300 Incremental: 6,660	Peak: 60,780 Incremental: 3,140	Peak: 61,090 Incremental: 3,450

Notes:

1. The incremental peak flow is the difference between the modelled peak flow and the base flow in the Kuskokwim River.
2. Peak flows for the community of Crooked Creek are upstream of the confluence with the Kuskokwim River along Crooked Creek.
3. The base flow at Kalskag is reduced compared to other sites due to a segment of the flow being conveyed through a side channel.

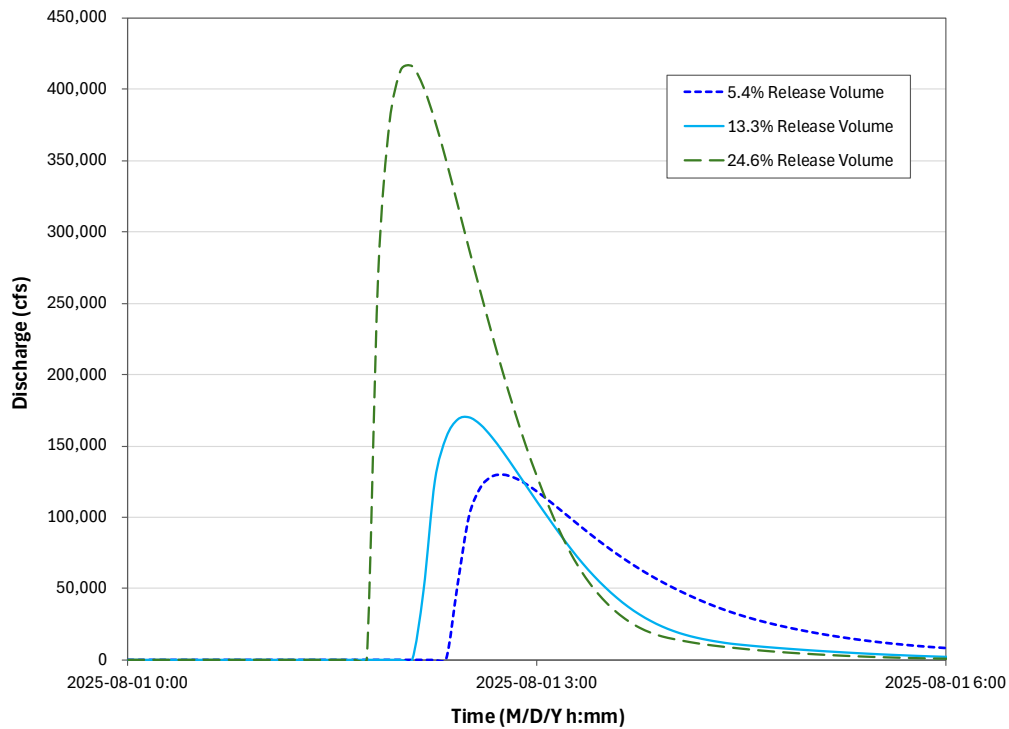


Figure 6-2 Crooked Creek hydrograph of the flood wave at the Village of Crooked Creek (cross-section C).

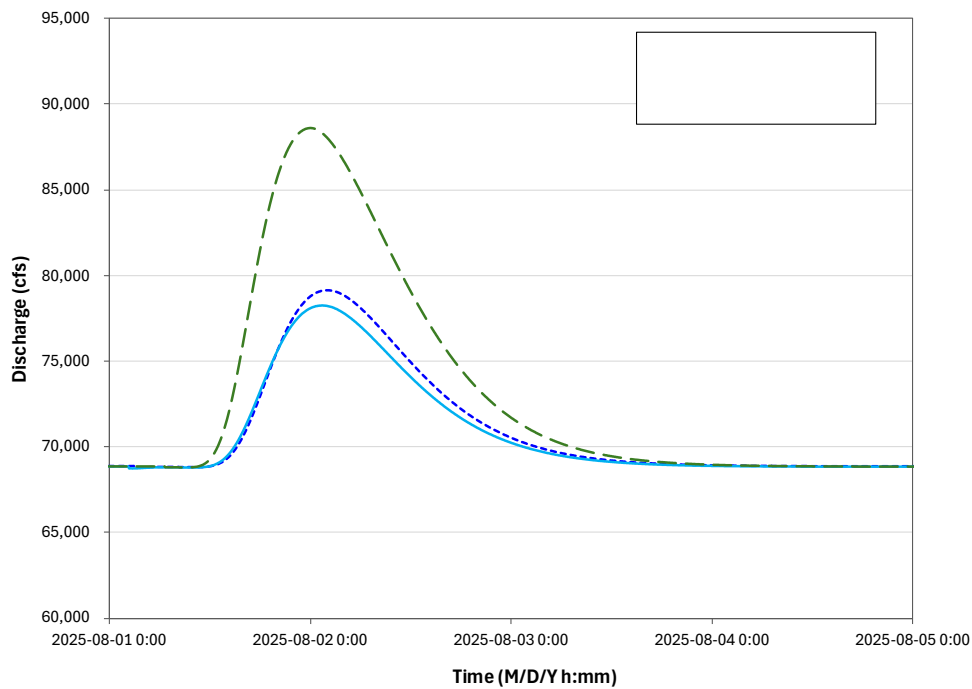


Figure 6-3 Kuskokwim River hydrograph of the flood wave at the Native Village of Chuathbaluk (cross-section H).

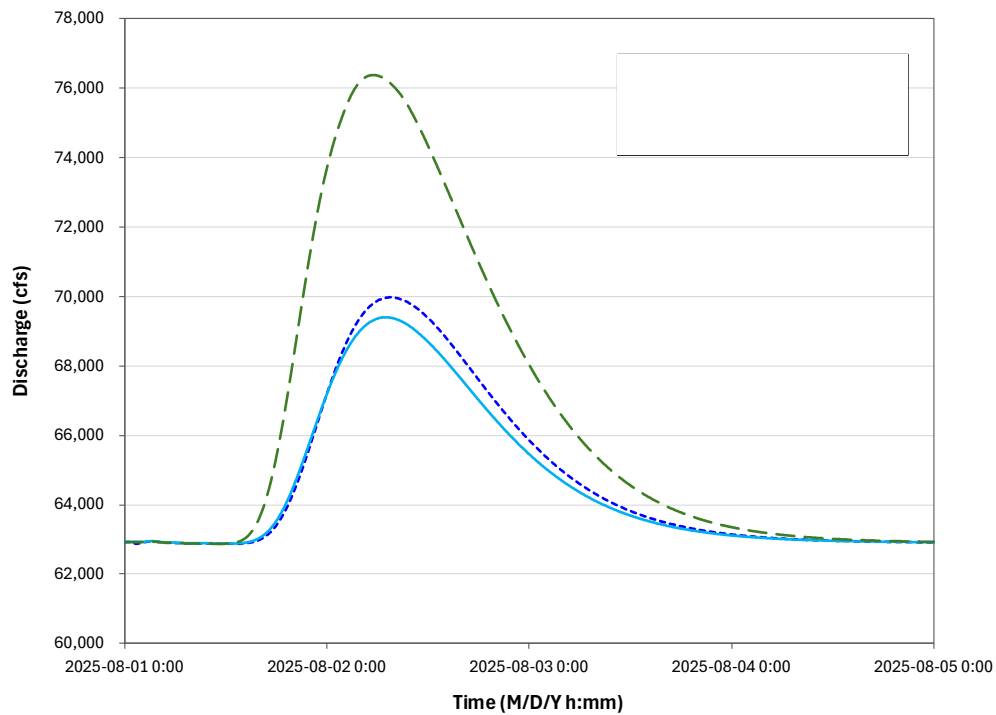


Figure 6-4 Kuskokwim River hydrograph of the flood wave at the Village of Aniak (cross-section I).

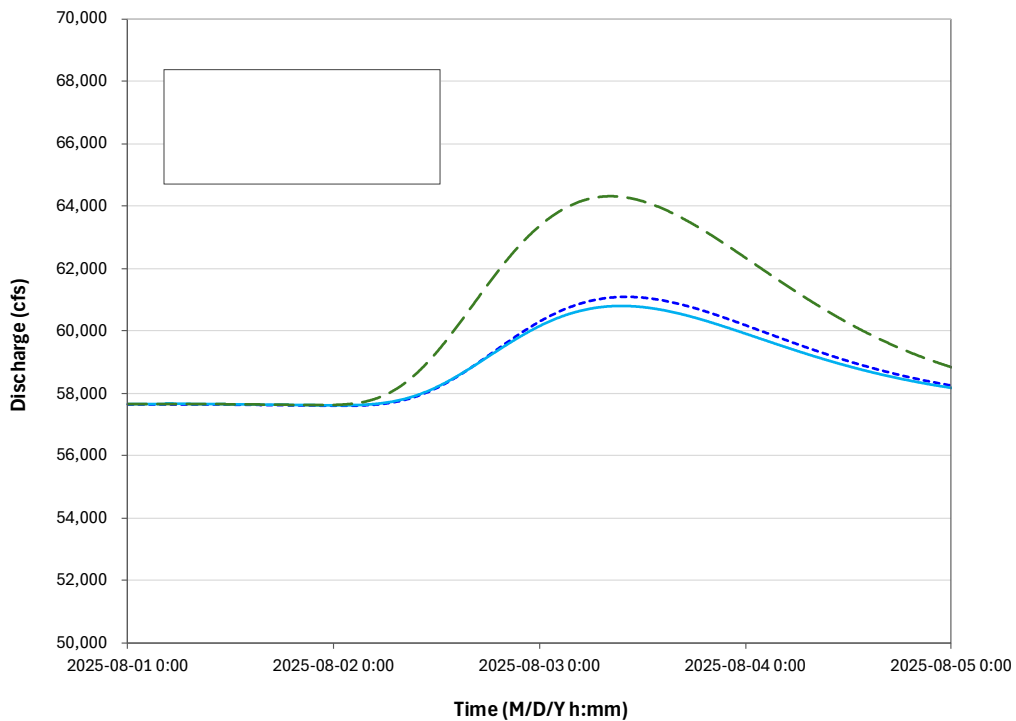


Figure 6-5 Kuskokwim River hydrograph of the flood wave at the Village of Kalskag (cross-section K).

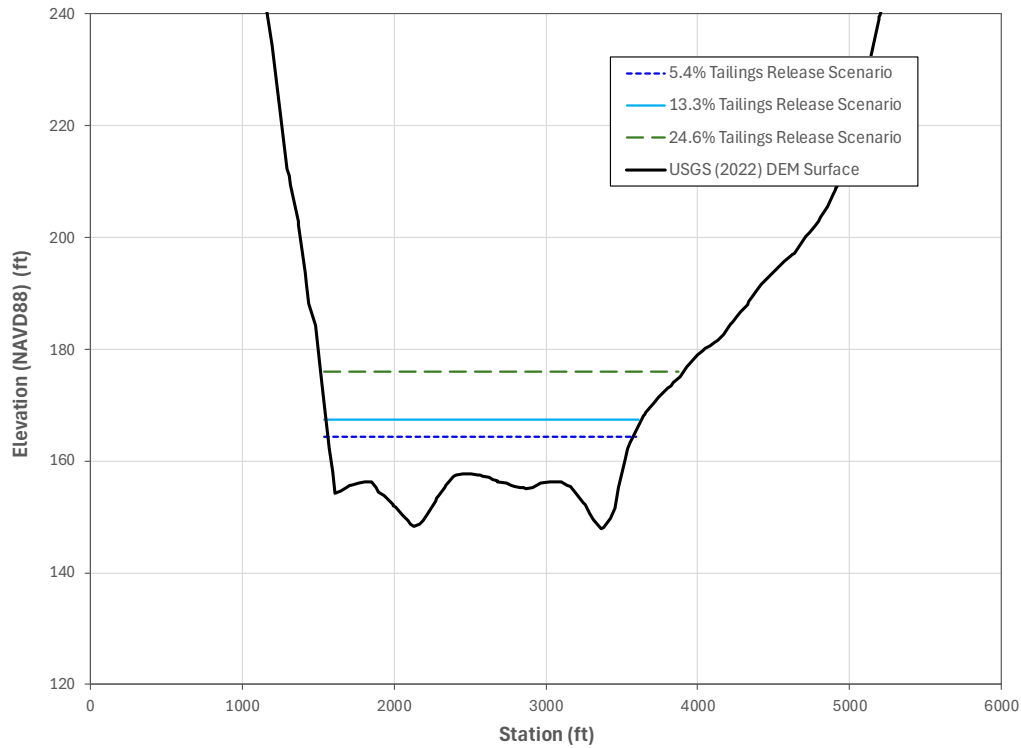


Figure 6-6 Maximum water surface elevation at the Village of Crooked Creek (cross-section C).

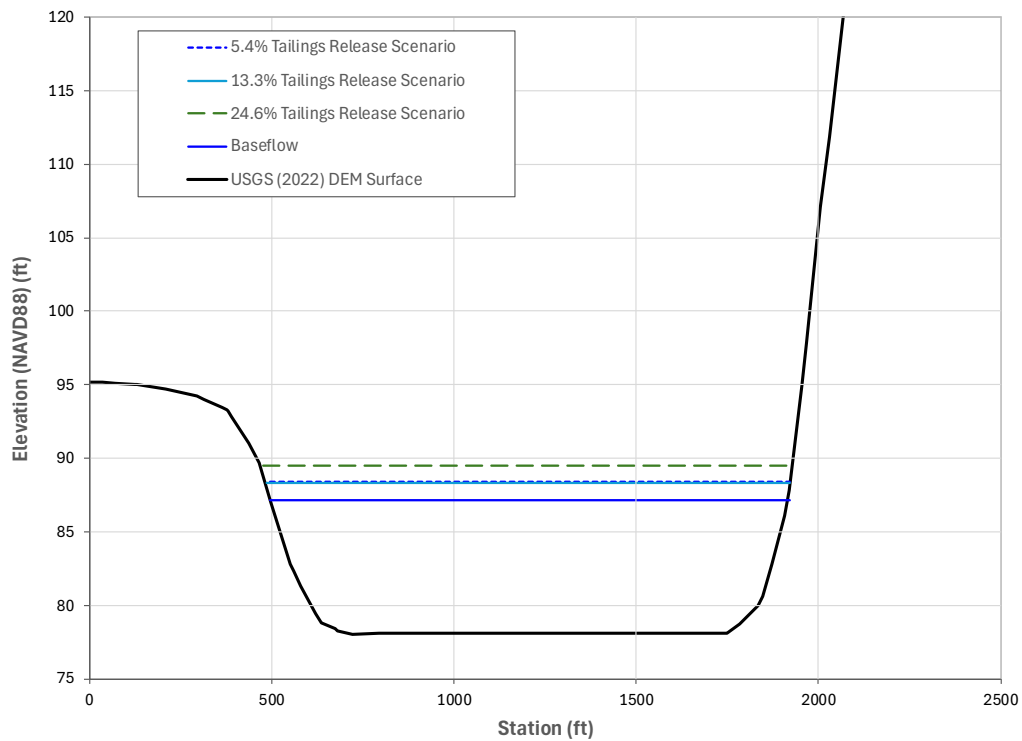


Figure 6-7 Maximum water surface elevation at the Native Village of Chuathbaluk (cross-section H).

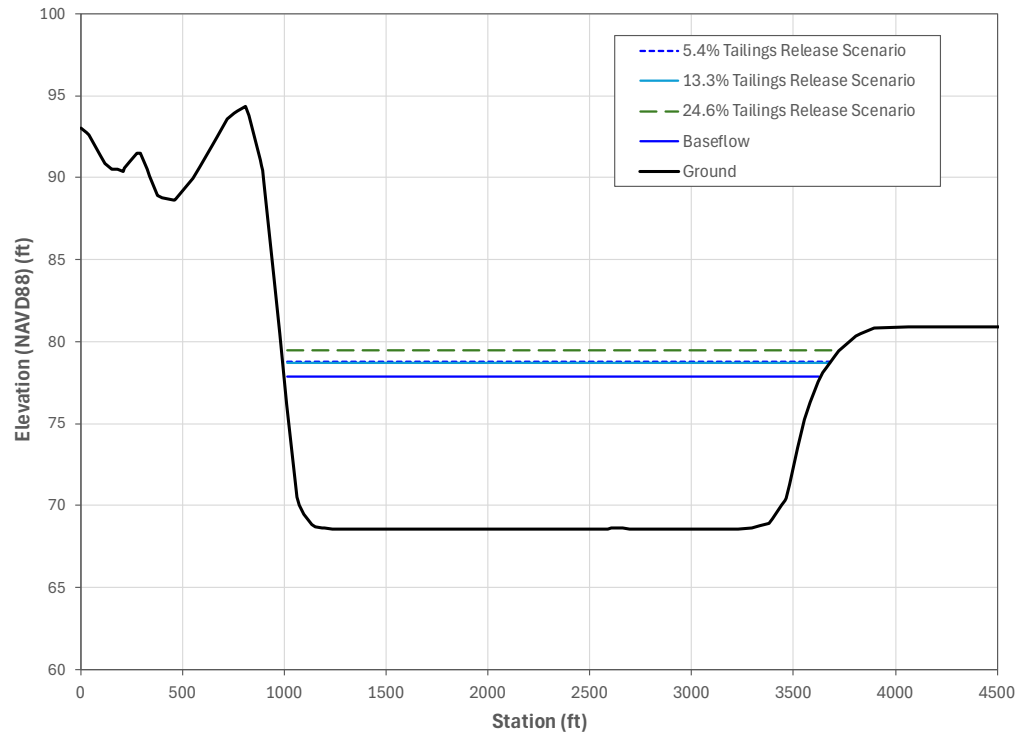


Figure 6-8 Maximum water surface elevation at the Village of Aniak (cross-section I).

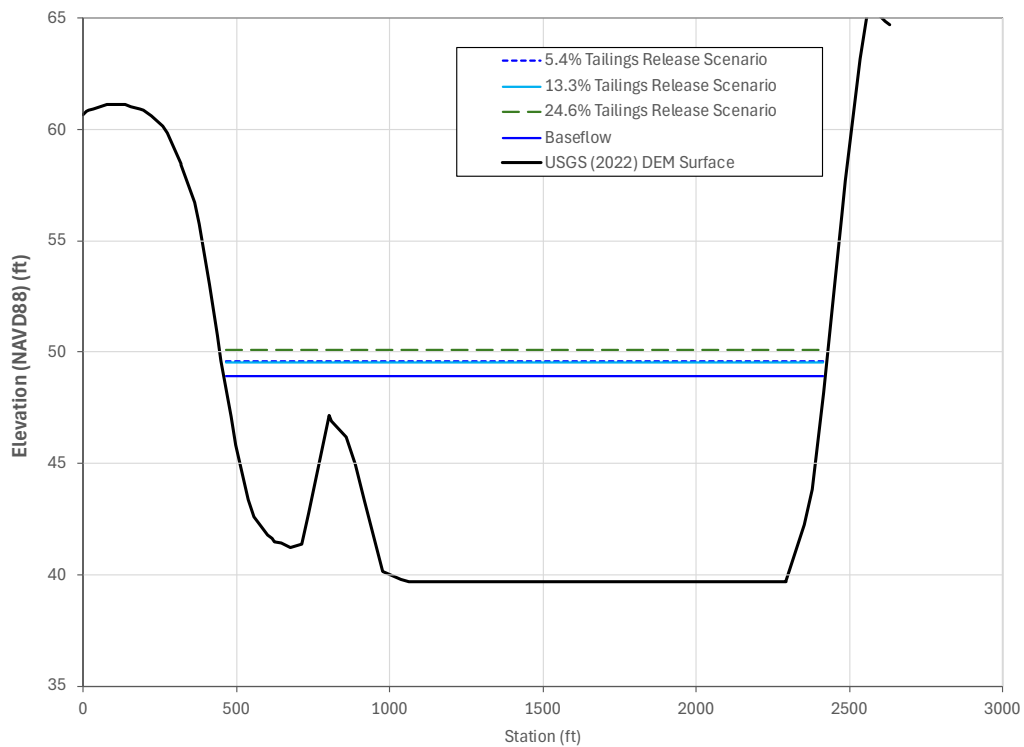


Figure 6-9 Maximum water surface elevation at the Village of Kalskag (cross-section K).

6.2.2 Tailings Deposition in Crooked Creek

Assessment of the tailings deposition along Crooked Creek was made by extracting the flow depth from the non-Newtonian model at the final time step of the model after the flood wave had stopped.

A summary of the tailings deposition in Crooked Creek and the discharge into the Kuskokwim River is provided in Table 6-5 and Figure 6-10. As expected, the deposition of tailings in Crooked Creek and their discharge into the Kuskokwim River both increase with the volume of tailings released. However, the percentage of total tailings deposited in Crooked Creek and discharged into the Kuskokwim River varies. This variation is due to the relationship between the magnitude of the release and the corresponding rheology. For example, larger releases may alter the flow characteristics of the tailings, affecting how much is retained in Crooked Creek versus transported to the Kuskokwim River. This is especially true for the 5.4% release volume, which exhibits the lowest yield stress and plastic viscosity among the four scenarios. Consequently, a proportionally reduced volume of tailings is deposited into Crooked Creek, while a correspondingly greater proportion is discharged into the Kuskokwim River.

It is expected that, over time, the tailings deposited in Crooked Creek will be transported to the Kuskokwim River due to ongoing streamflow erosion and surficial erosion (erosion occurring at the ground surface) from rainfall and snowmelt.

Table 6-5 Summary of tailings deposition in Crooked Creek and discharged to Kuskokwim River.

Tailings Release Scenario (%)	Volume of Tailings Released (acre ft)	Tailings Deposition in Crooked Creek (acre ft)	Deposition in Crooked Creek (%) ¹	Discharged to Kuskokwim River (acre ft) ²
24.6	82,140	61,464	75%	30,406
13.3	44,350	40,780	92%	13,300
5.4	17,910	11,495	64%	16,145
0.5	1,670	1,670	100%	0

Notes:

1. Expressed as a percentage of the volume of tailings released and not the total release volume including the pond.
2. Includes both tailings and pond water (except for the 0.5% release volume scenario).
3. Expressed as a percentage of the total release volume.

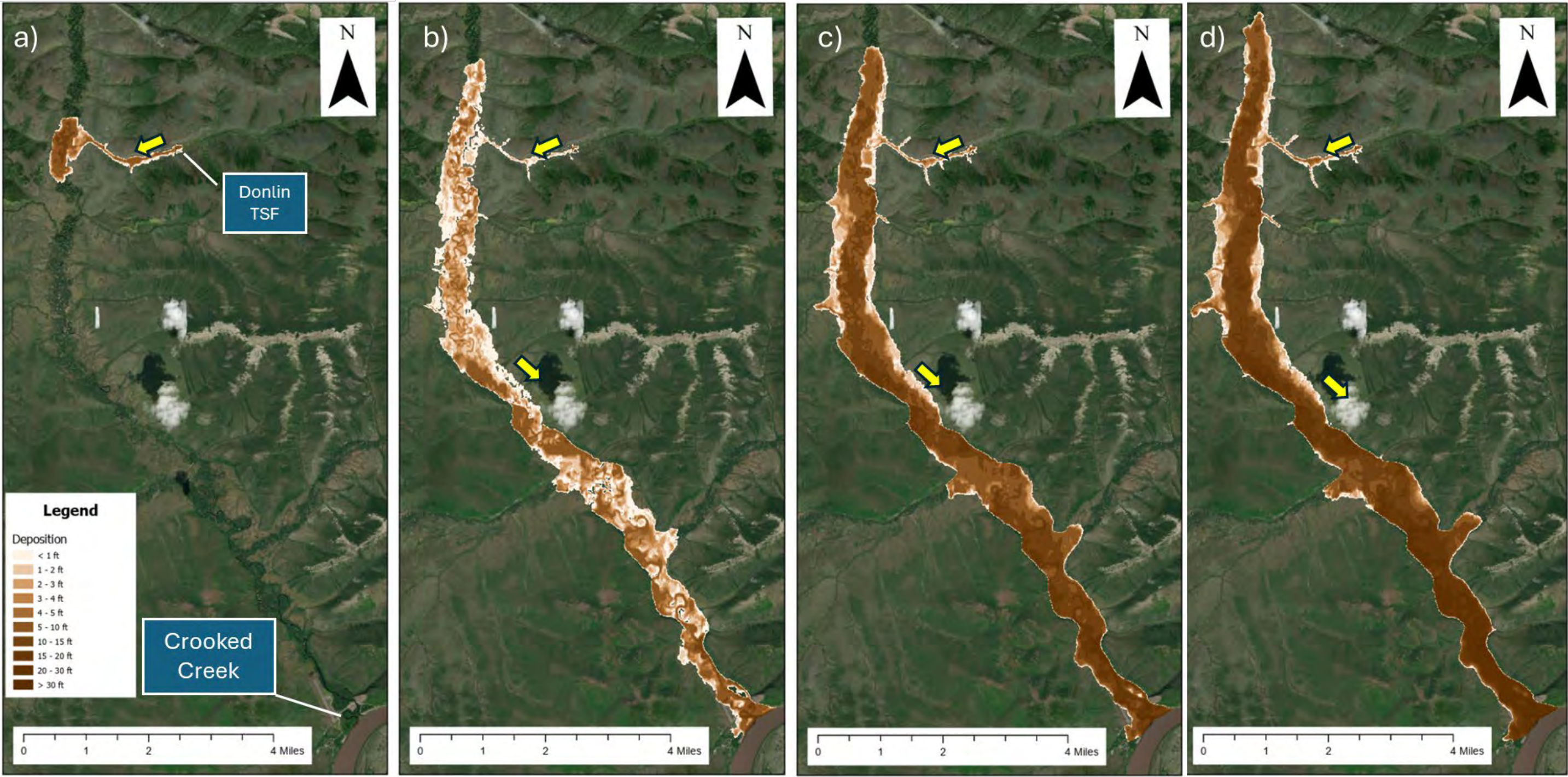


Figure 6-10 Crooked Creek tailings deposition for the a) 0.5% release volume, b) 5.4% release volume, c) 13.3% release volume and d) 24.6% release volume. The yellow arrow represents the flow direction.

A majority (>80-90%) of the tailings not deposited in Crooked Creek is expected to be transported in suspension by the Kuskokwim River due to its fine-grained nature (mostly silts and clays), ultimately reaching the mouth of the river at the Bering Sea. Silts and clays are easily transported in suspension due to their low settling velocity. Whether the tailings get transported during the initial flood wave or re-entrained over several seasons would be dependent on flows in the Kuskokwim River. The Samarco Fundão tailings release provides an example of this outcome. The dam collapsed on November 5, 2015, releasing approximately 35,430 acre-ft (43.7 Mm³) of tailings into the Río Doce (Morgenstern et al., 2016). On November 22, fine tailings particles in suspension reached the Atlantic Ocean, a distance of 415 miles (668 km) (Nascimento et al., 2022) (Figure 6-11).



Figure 6-11 Google Earth image of Fundão tailings transported in suspension by the Río Doce and deposited in the Atlantic Ocean.

The remaining suspended sediment (<10-20%) will likely be deposited where the flood wave inundates side channels of the Kuskokwim River, where channel velocities are expected to be much lower than in the main channel.

7.0 CLOSURE

We trust the above satisfies your requirements. This scope of work was completed by Hamish Weatherly, M.Sc., and Patrick Grover, Ph.D., of BGC. Should you have any questions or comments, please do not hesitate to contact us.

Yours sincerely,

BGC Engineering Alaska Inc.
per:



Hamish Weatherly, M.Sc., PG
Principal Hydrologist

Reviewed by:

Jack Seto, M.Sc., PE
Principal Geotechnical Engineer

State of Alaska, BGC Engineering Alaska Inc. AECC1558

JTCS/PG/gc/mm

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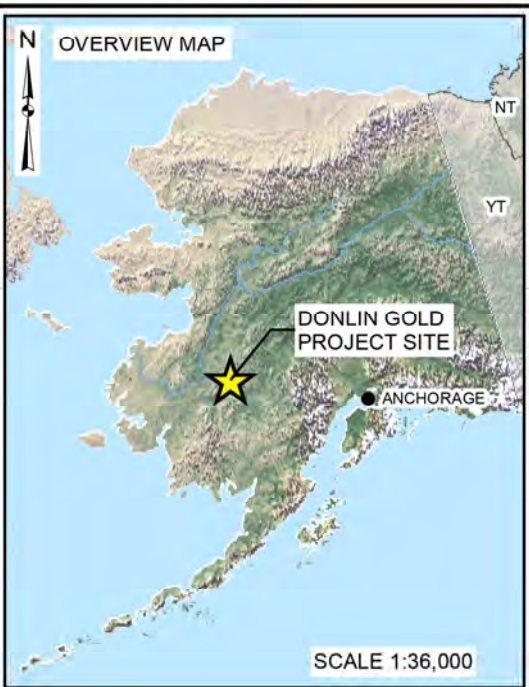
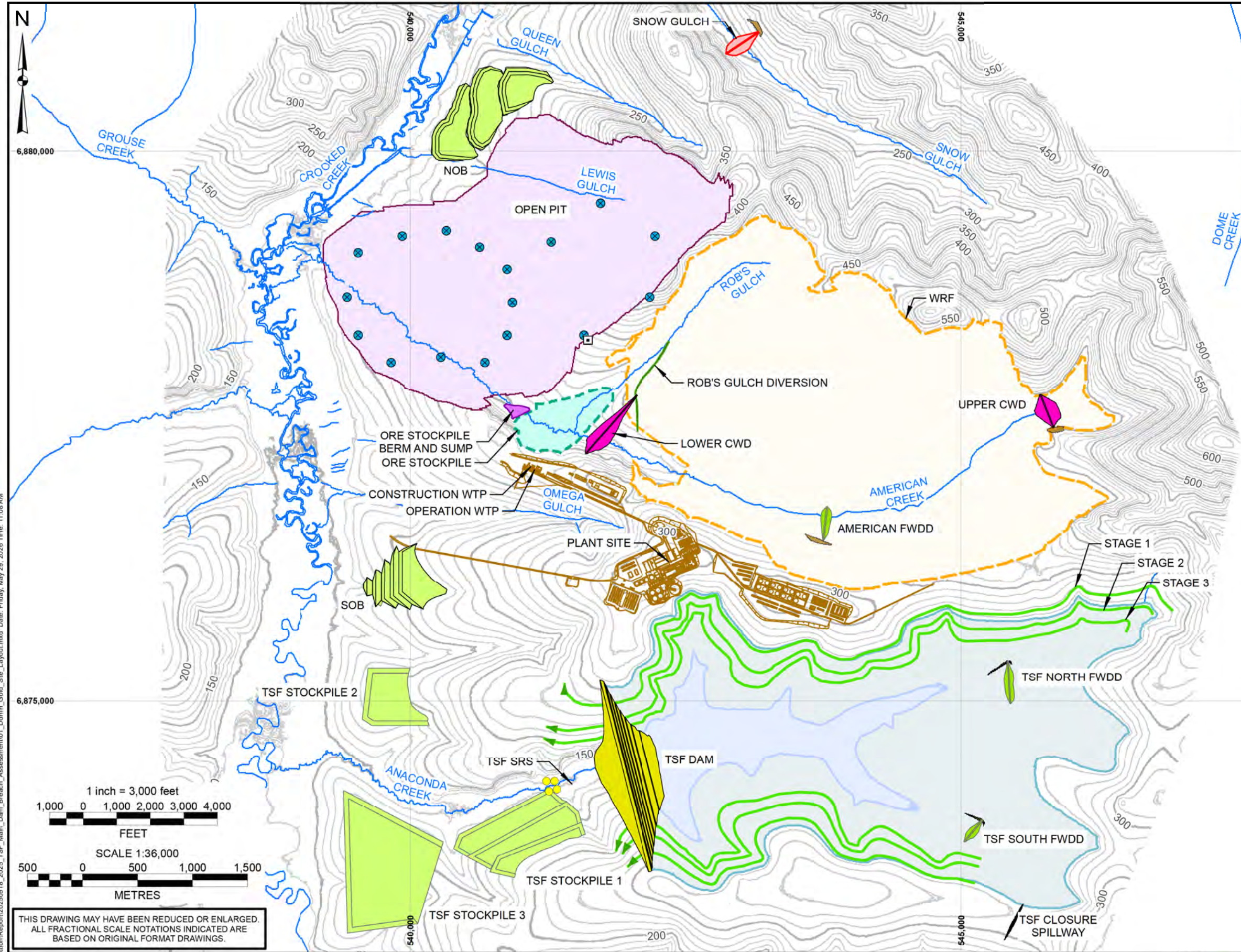
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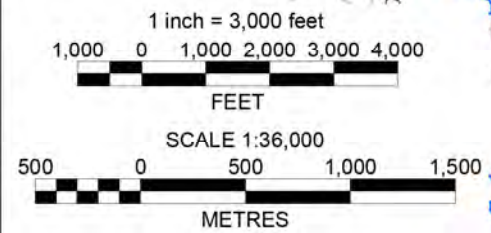
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DRAWINGS





- LEGEND
- SEEPAGE MONITORING / RECYCLE WELL
 - SUMP
 - PERIMETER DEWATERING WELL
 - PLANT SITE
 - DIVERSION CHANNEL
 - ROB'S GULCH DIVERSION
 - TSF DAM (ULTIMATE)
 - FRESH WATER DIVERSION DAM (FWDD)
 - CONTACT WATER DAM (CWD)
 - FRESH WATER DAM
 - SPILLWAY
 - OVERBURDEN STOCKPILE
 - ORE STOCKPILE BERM AND
 - WASTE ROCK FACILITY (WRF)
 - ULTIMATE PIT CREST
 - ORE STOCKPILE
 - STARTER TAILINGS IMPOUNDMENT (171 m)
 - ULTIMATE TAILINGS IMPOUNDMENT (253 m)



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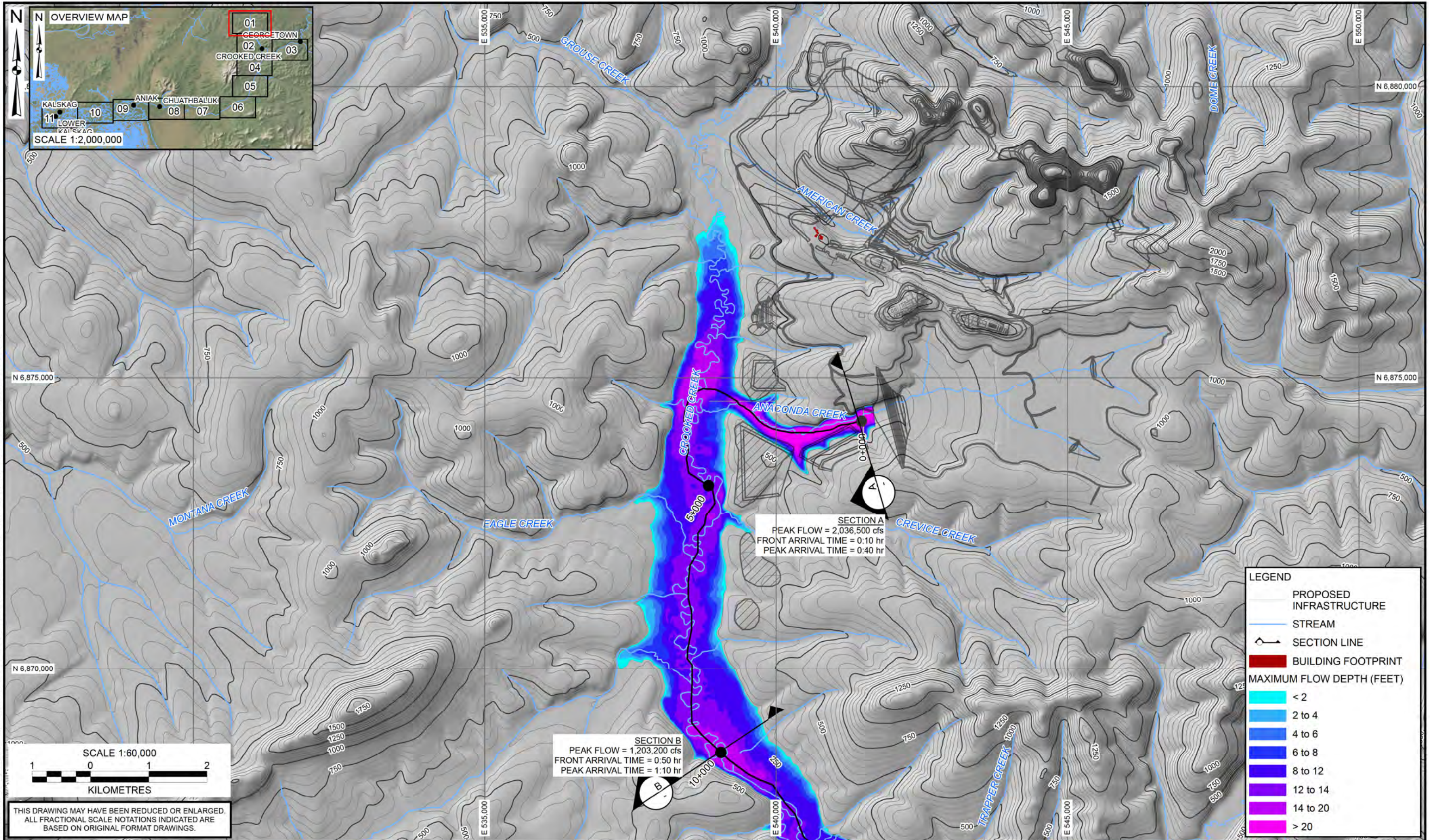
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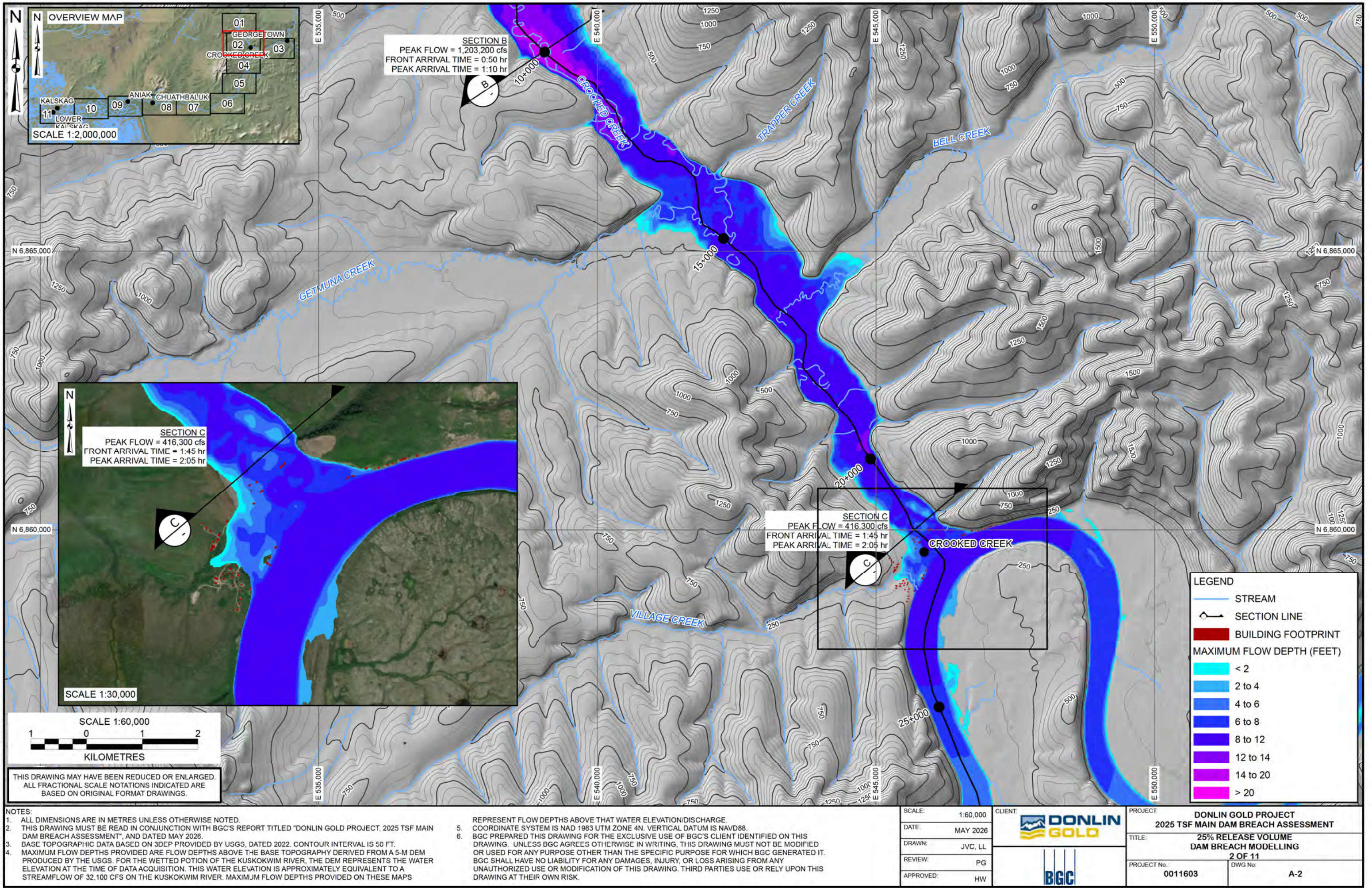
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TITLE: DONLIN GOLD SITE LAYOUT	
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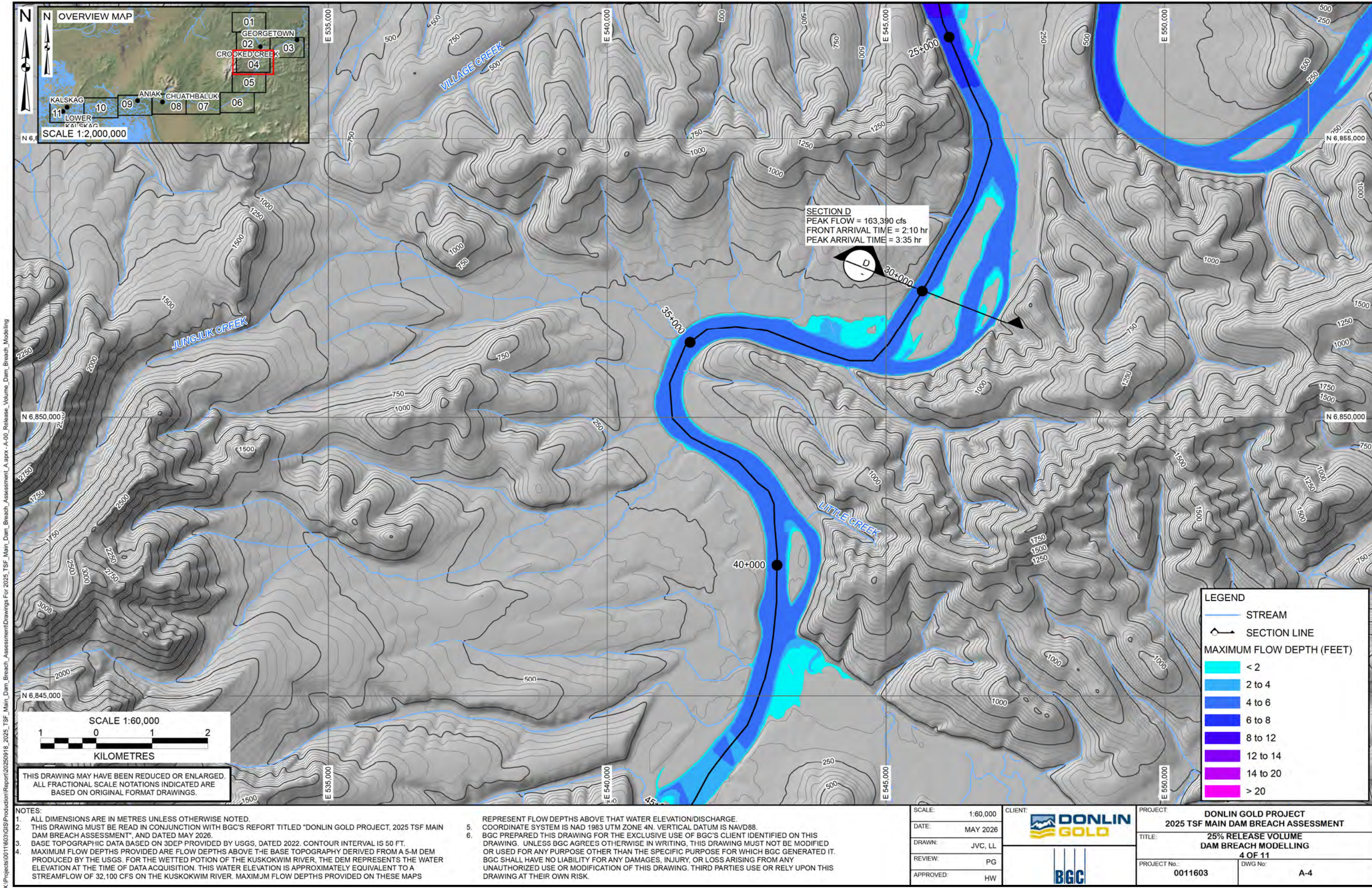
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		REVIEW: PG		1 OF 11
BGC		APPROVED: HW		PROJECT No.: 0011603
				DWG No: A-1

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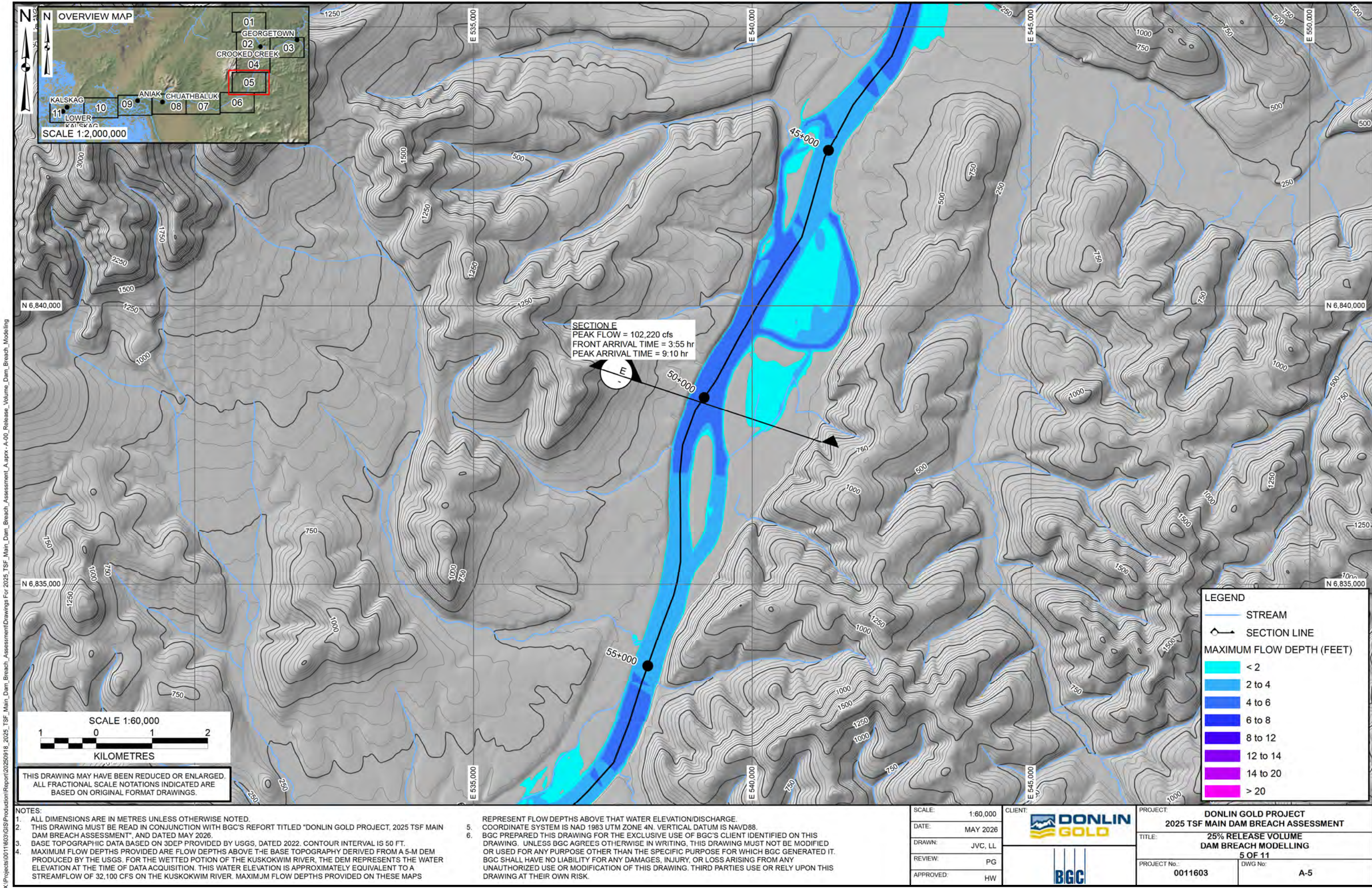
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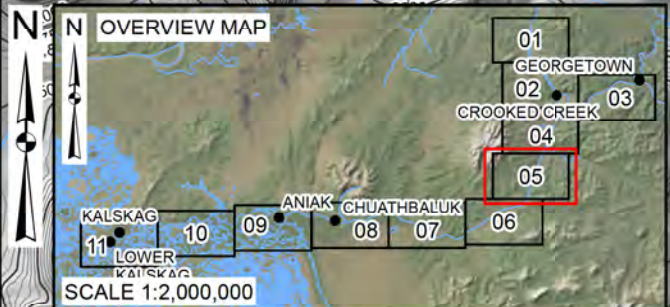
DONLIN GOLD

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TITLE:	25% RELEASE VOLUME DAM BREACH MODELLING 4 OF 11	
PROJECT No.:	0011603	DWG No: A-4

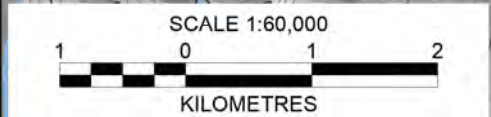


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SECTION E
PEAK FLOW = 102,220 cfs
FRONT ARRIVAL TIME = 3:55 hr
PEAK ARRIVAL TIME = 9:10 hr

LEGEND	
	STREAM
	SECTION LINE
MAXIMUM FLOW DEPTH (FEET)	
	< 2
	2 to 4
	4 to 6
	6 to 8
	8 to 12
	12 to 14
	14 to 20
	> 20



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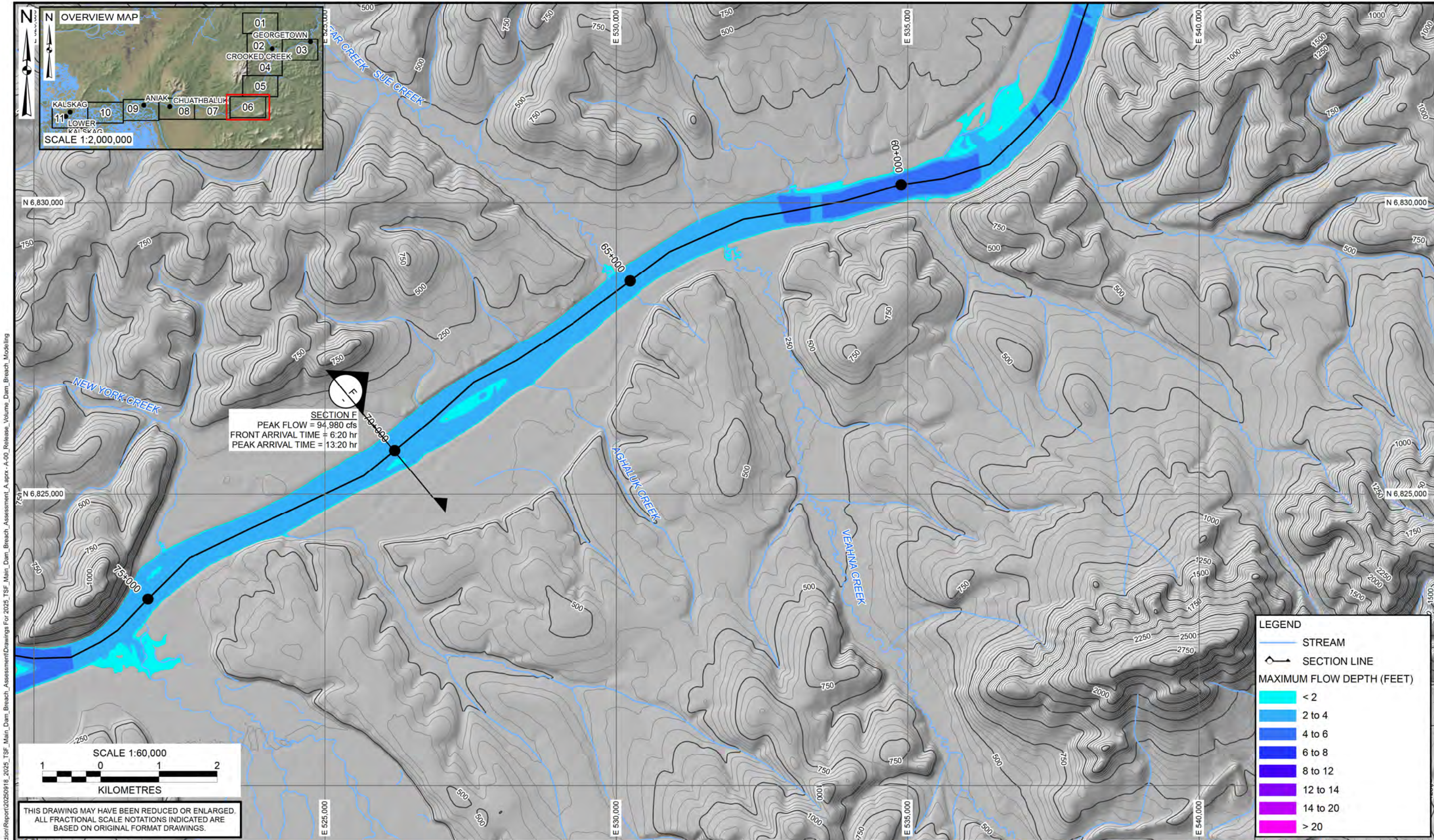
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APPROVED:	HW

CLIENT:

PROJECT: DONLIN GOLD PROJECT 2025 TSF MAIN DAM BREACH ASSESSMENT	
TITLE: 25% RELEASE VOLUME DAM BREACH MODELLING 5 OF 11	
PROJECT No.: 0011603	DWG No: A-5



X:\Projects\0011603\GIS\Production\Drawings\For 2025 TSF Main Dam Breach Assessment_A appx - A-00 Release_Volume Dam Breach Modelling

NOTES:

1. ALL DIMENSIONS ARE IN METRES UNLESS OTHERWISE NOTED.
2. THIS DRAWING MUST BE READ IN CONJUNCTION WITH BGC'S REPORT TITLED "DONLIN GOLD PROJECT, 2025 TSF MAIN DAM BREACH ASSESSMENT", AND DATED MAY 2026.
3. BASE TOPOGRAPHIC DATA BASED ON 3DEP PROVIDED BY USGS, DATED 2022. CONTOUR INTERVAL IS 50 FT.
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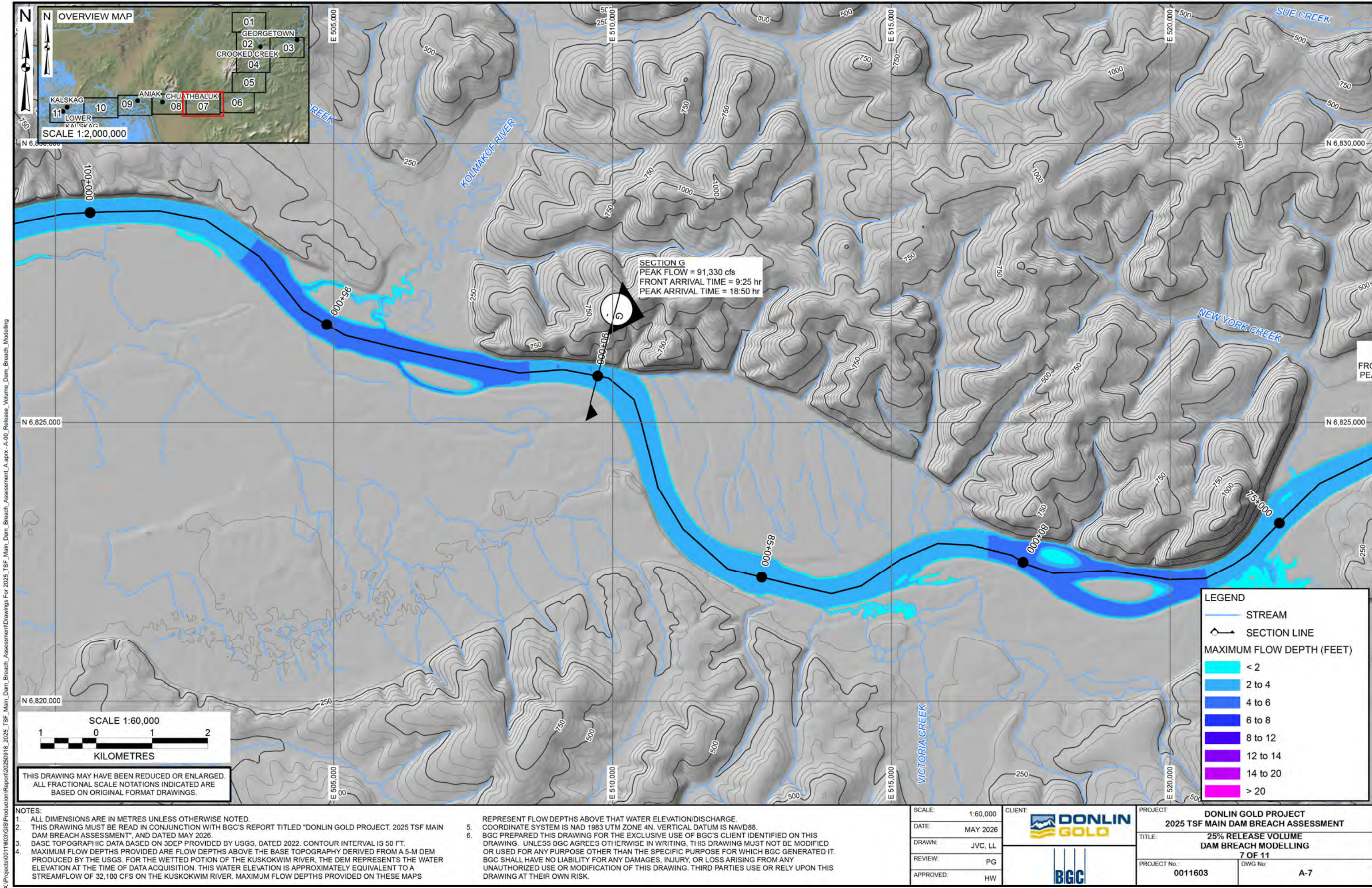
REPRESENT FLOW DEPTHS ABOVE THAT WATER ELEVATION/DISCHARGE.

COORDINATE SYSTEM IS NAD 1983 UTM ZONE 4N. VERTICAL DATUM IS NAVD88.

5. BGC PREPARED THIS DRAWING FOR THE EXCLUSIVE USE OF BGC'S CLIENT IDENTIFIED ON THIS DRAWING. UNLESS BGC AGREES OTHERWISE IN WRITING, THIS DRAWING MUST NOT BE MODIFIED OR USED FOR ANY PURPOSE OTHER THAN THE SPECIFIC PURPOSE FOR WHICH BGC GENERATED IT. BGC SHALL HAVE NO LIABILITY FOR ANY DAMAGES, INJURY, OR LOSS ARISING FROM ANY UNAUTHORIZED USE OR MODIFICATION OF THIS DRAWING. THIRD PARTIES USE OR RELY UPON THIS DRAWING AT THEIR OWN RISK.
- 6.

SCALE:	1:60,000
DATE:	MAY 2026
DRAWN:	JVC, LL
REVIEW:	PG
APPROVED:	HW

CLIENT: DONLIN GOLD	
PROJECT: DONLIN GOLD PROJECT	
2025 TSF MAIN DAM BREACH ASSESSMENT	
TITLE: 25% RELEASE VOLUME	
DAM BREACH MODELLING	
6 OF 11	
PROJECT No.: 0011603	DWG No.: A-6



X:\Projects\0011603\GIS\Production\Drawings\For 2025 TSF Main Dam Breach Assessment_A.aprx - A-00_Release_Volume_Dam_Breach_Modelling

NOTES:

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REPRESENT FLOW DEPTHS ABOVE THAT WATER ELEVATION/DISCHARGE.

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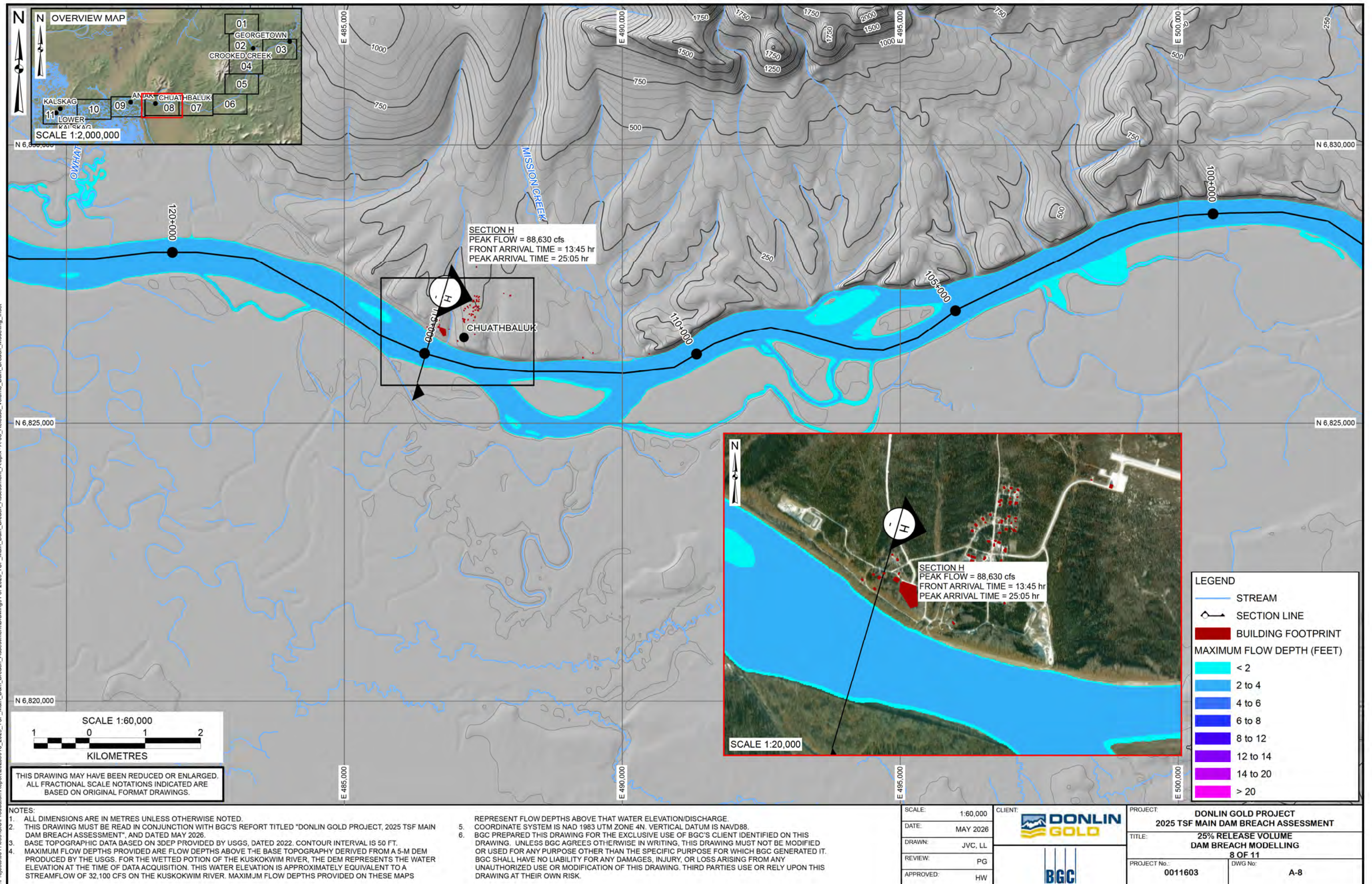
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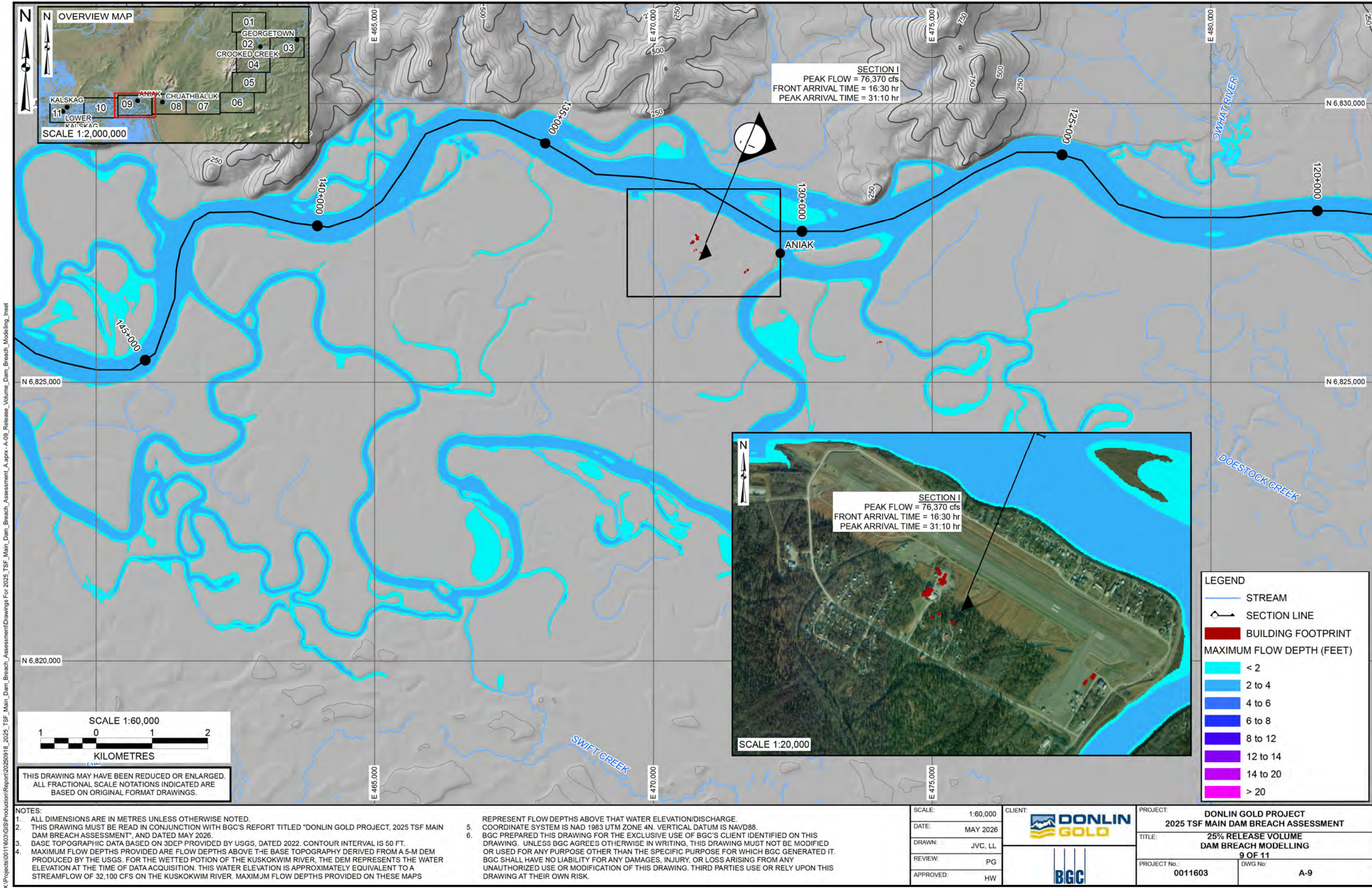
SCALE:	1:60,000
DATE:	MAY 2026
DRAWN:	JVC, LL
REVIEW:	PG
APPROVED:	HW

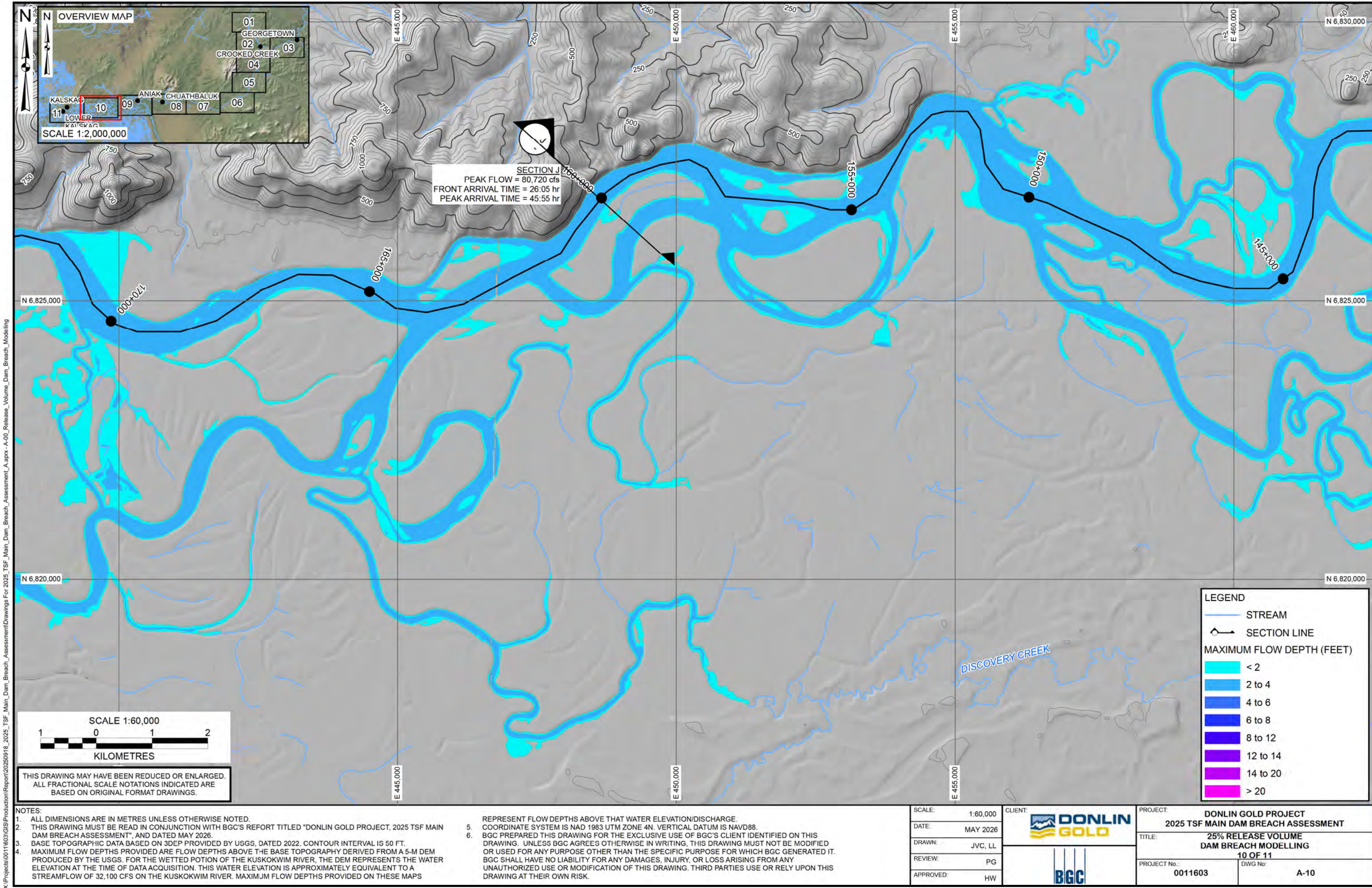
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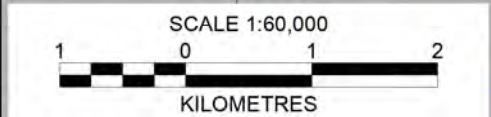

PROJECT:	DONLIN GOLD PROJECT 2025 TSF MAIN DAM BREACH ASSESSMENT	
TITLE:	25% RELEASE VOLUME DAM BREACH MODELLING 7 OF 11	
PROJECT No.:	0011603	DWG No: A-7







SECTION J
PEAK FLOW = 80,720 cfs
FRONT ARRIVAL TIME = 26:05 hr
PEAK ARRIVAL TIME = 45:55 hr



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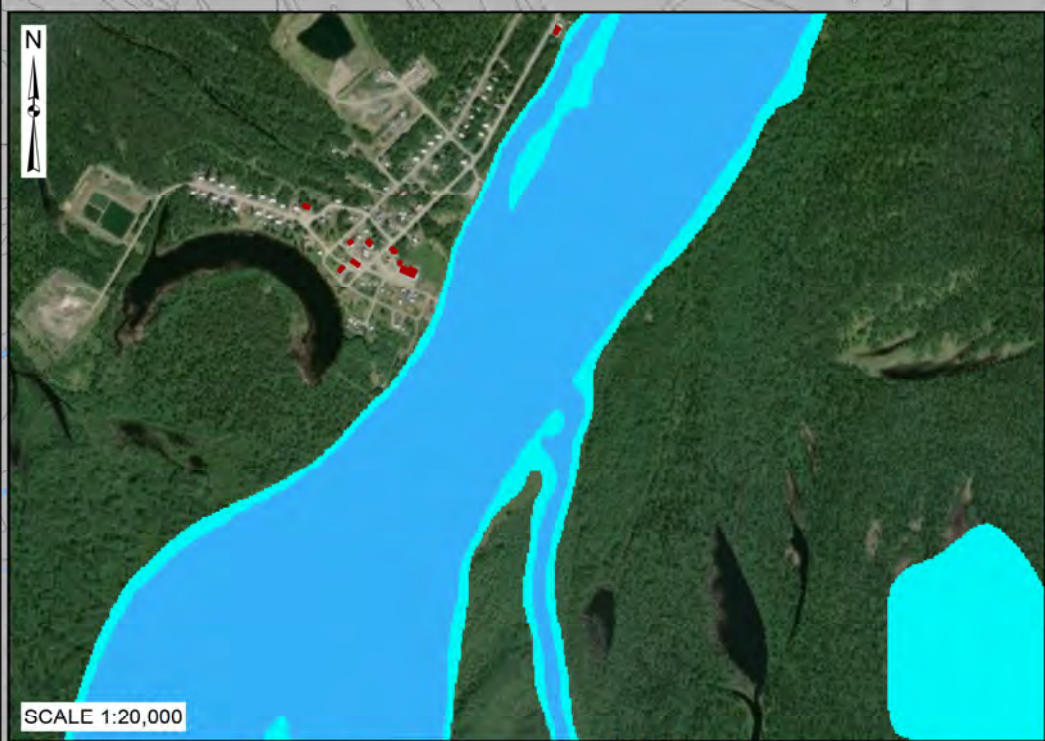
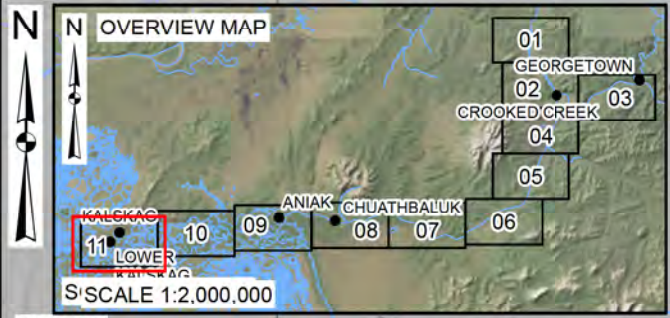
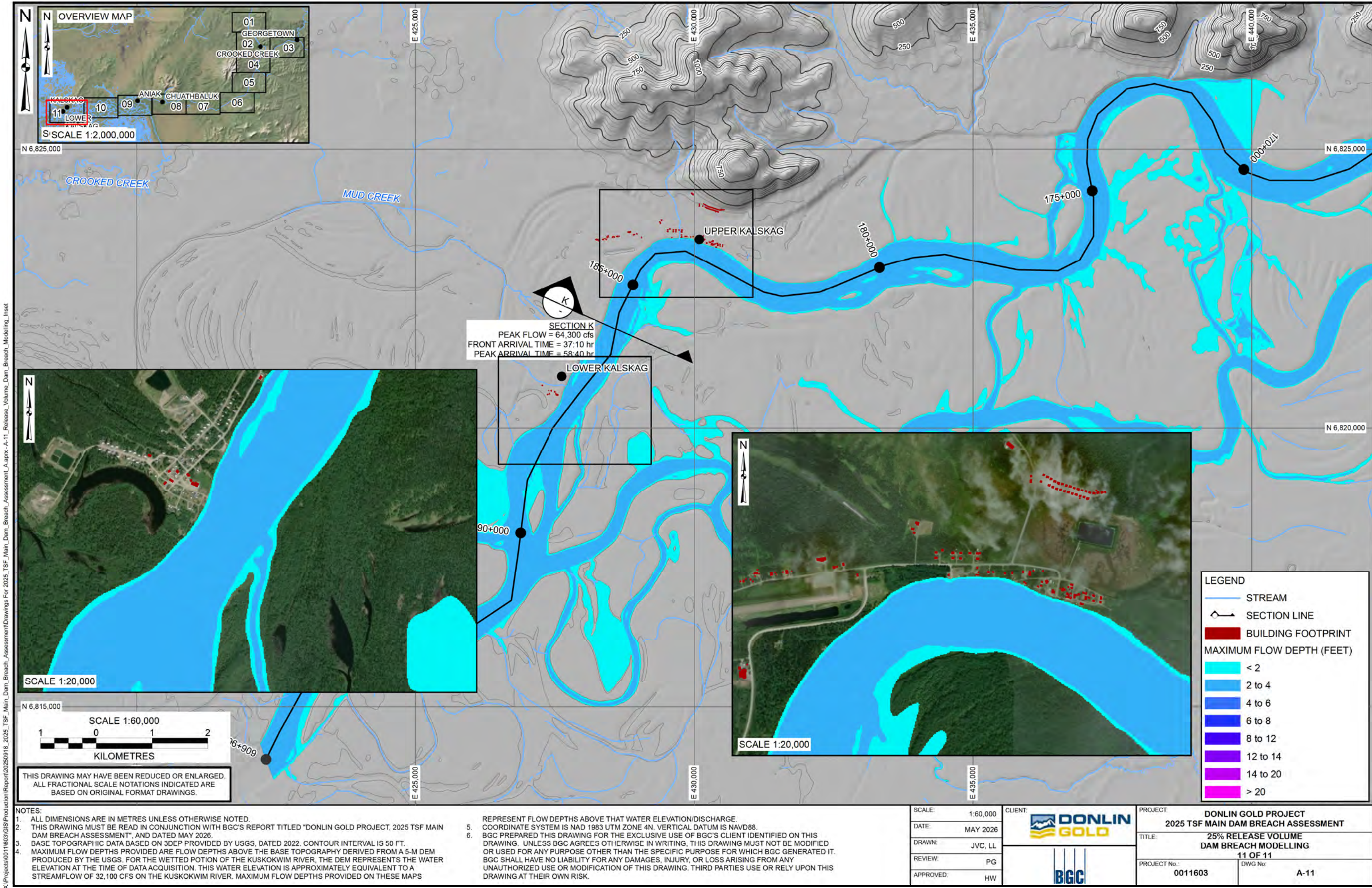
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COORDINATE SYSTEM IS NAD 1983 UTM ZONE 4N. VERTICAL DATUM IS NAVD88.

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SCALE:	1:60,000
DATE:	MAY 2026
DRAWN:	JVC, LL
REVIEW:	PG
APPROVED:	HW

CLIENT:

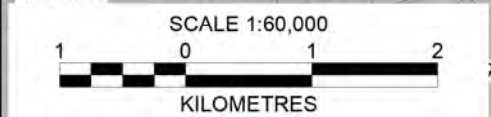
PROJECT:	DONLIN GOLD PROJECT 2025 TSF MAIN DAM BREACH ASSESSMENT	
TITLE:	25% RELEASE VOLUME DAM BREACH MODELLING 10 OF 11	
PROJECT No.:	0011603	DWG No: A-10



SECTION K
PEAK FLOW = 64,300 cfs
FRONT ARRIVAL TIME = 37:10 hr
PEAK ARRIVAL TIME = 58:40 hr



LEGEND	
	STREAM
	SECTION LINE
	BUILDING FOOTPRINT
MAXIMUM FLOW DEPTH (FEET)	
	< 2
	2 to 4
	4 to 6
	6 to 8
	8 to 12
	12 to 14
	14 to 20
	> 20



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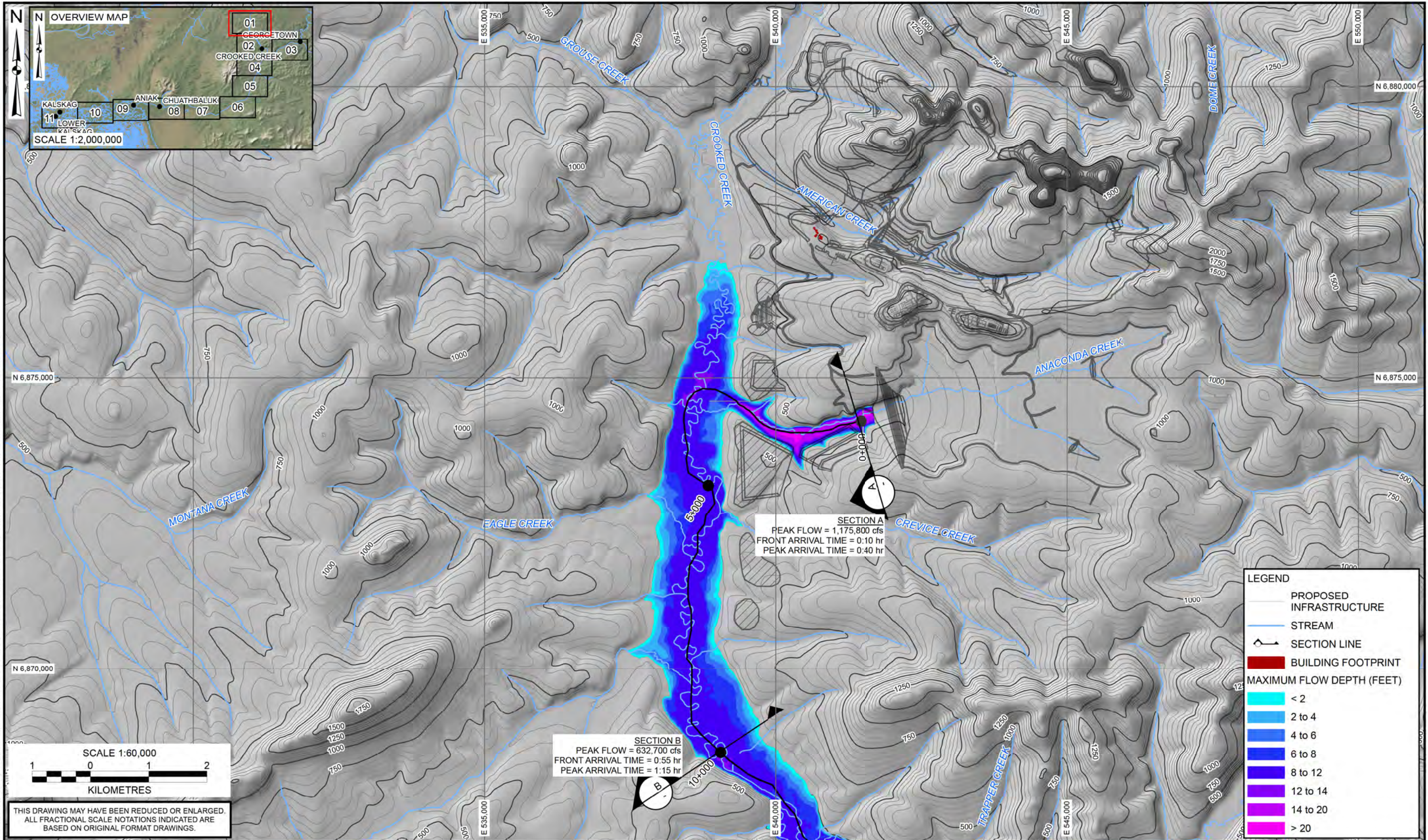
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SCALE:	1:60,000
DATE:	MAY 2026
DRAWN:	JVC, LL
REVIEW:	PG
APPROVED:	HW

CLIENT:

PROJECT: DONLIN GOLD PROJECT 2025 TSF MAIN DAM BREACH ASSESSMENT	
TITLE: 25% RELEASE VOLUME DAM BREACH MODELLING 11 OF 11	
PROJECT No.: 0011603	DWG No: A-11

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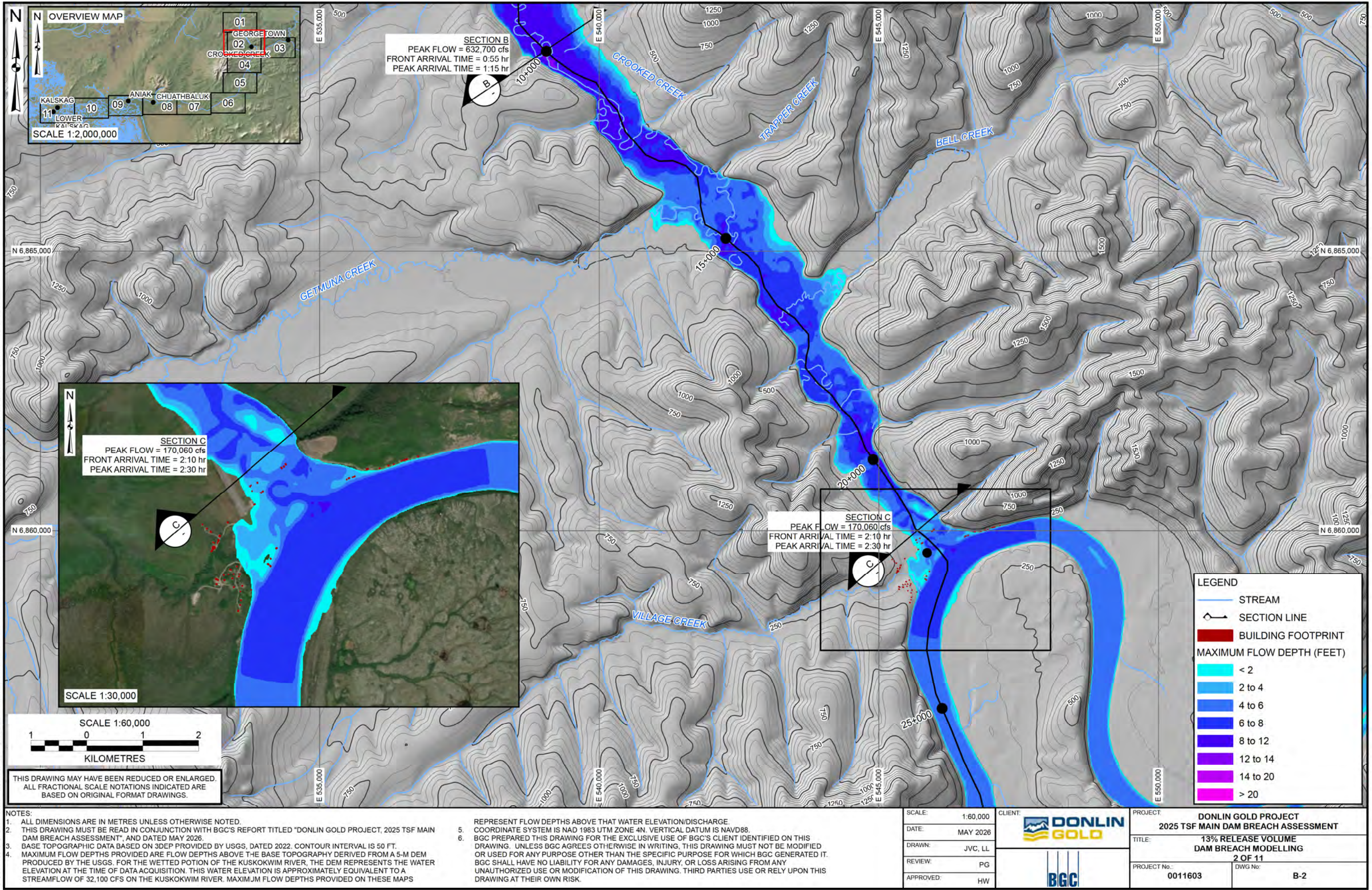
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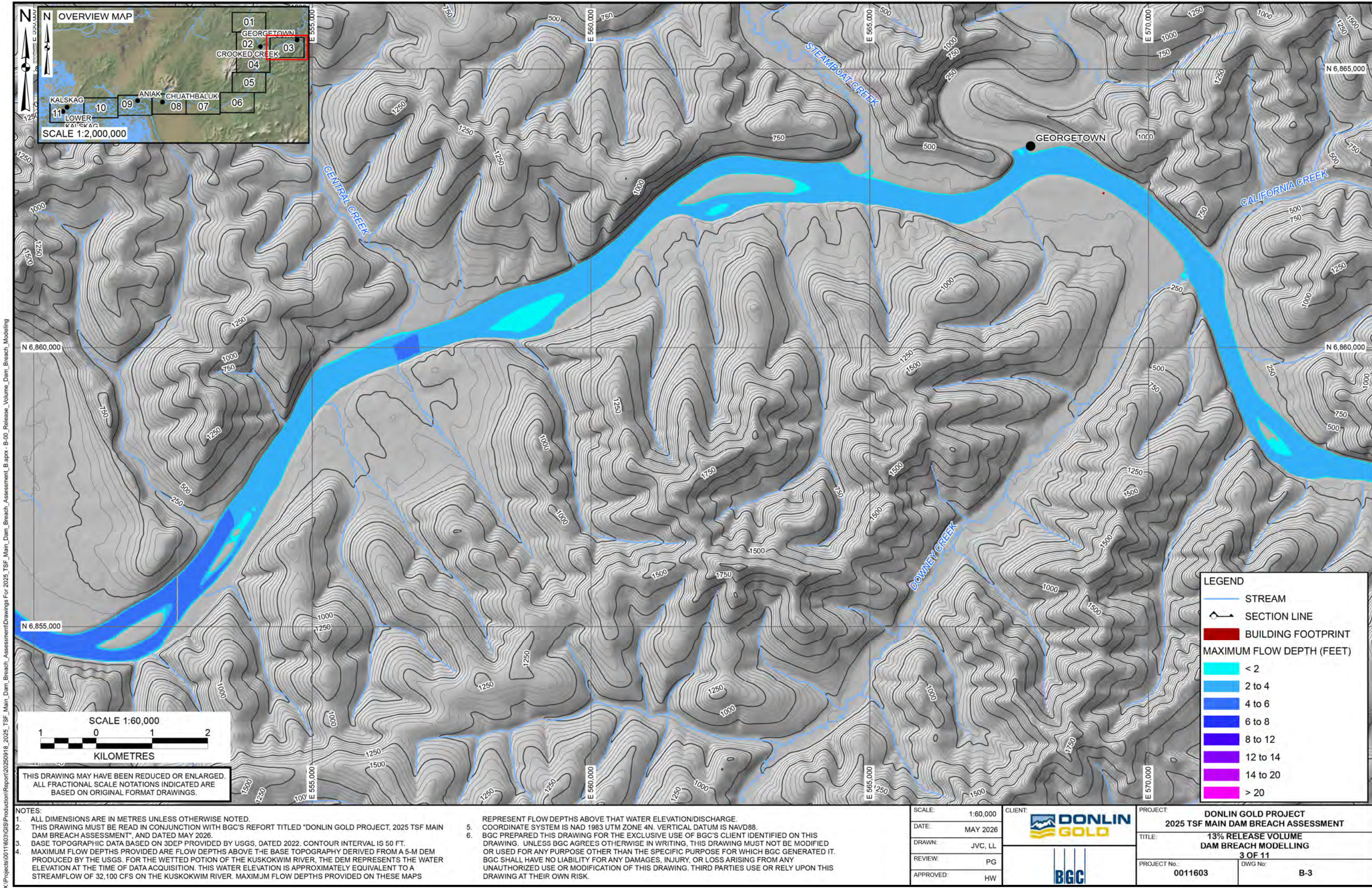
SCALE: 1:60,000
DATE: MAY 2026
DRAWN: JVC, LL
REVIEW: PG
APPROVED: HW



PROJECT: DONLIN GOLD PROJECT
2025 TSF MAIN DAM BREACH ASSESSMENT
TITLE: 13% RELEASE VOLUME
DAM BREACH MODELLING
1 OF 11
PROJECT No.: 0011603
DWG No: B-1

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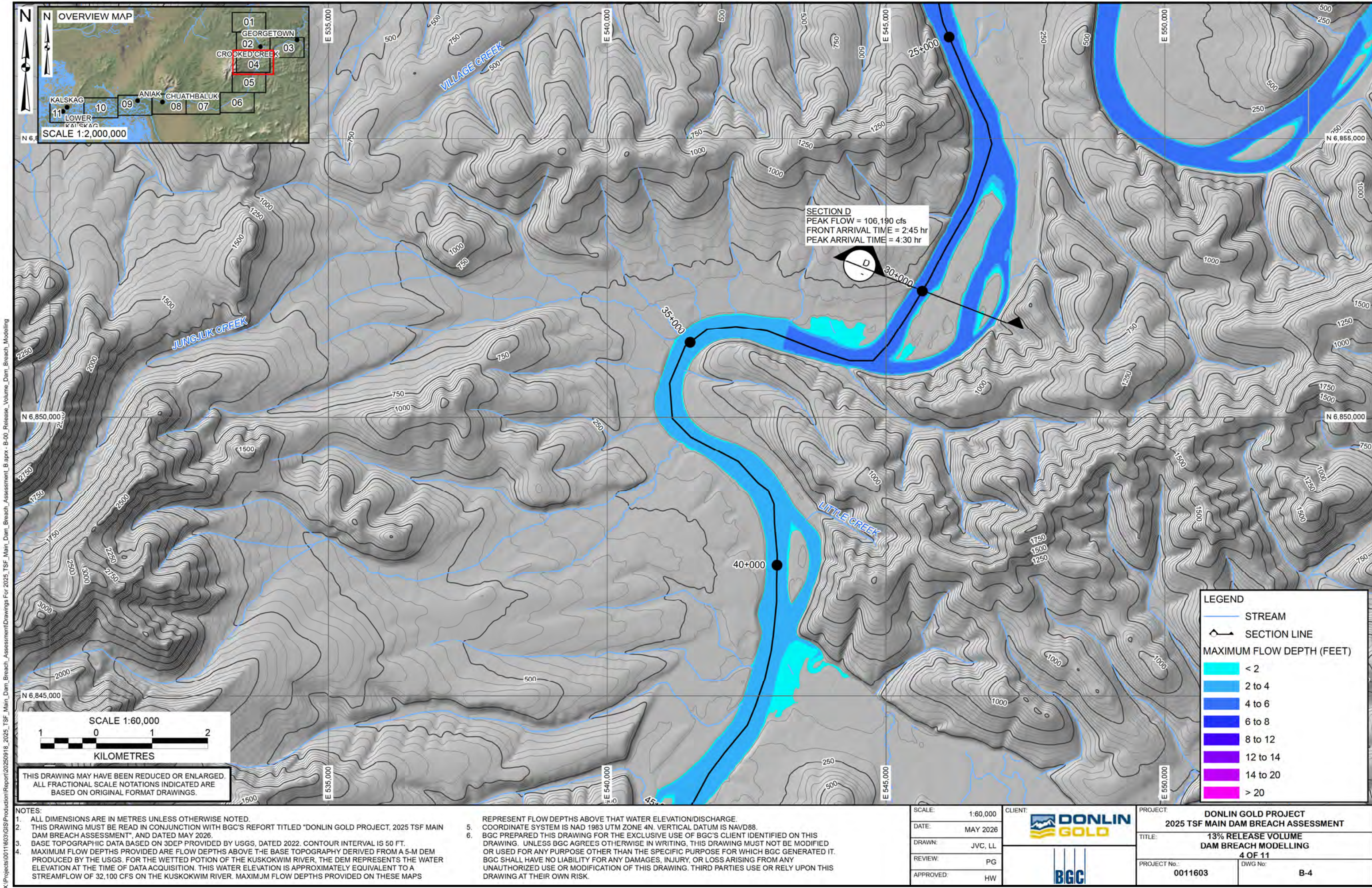
SCALE:	1:60,000
DATE:	MAY 2026
DRAWN:	JVC, LL
REVIEW:	PG
APPROVED:	HW

CLIENT:

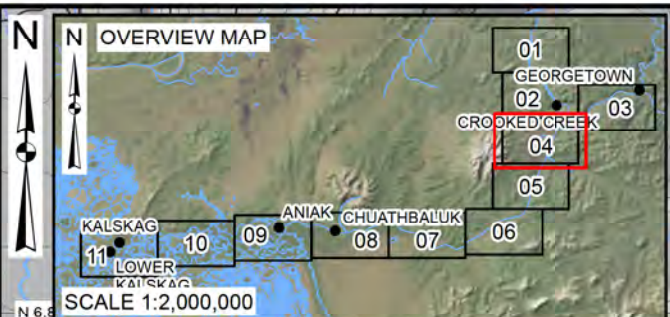
DONLIN GOLD

BGC

PROJECT:	DONLIN GOLD PROJECT 2025 TSF MAIN DAM BREACH ASSESSMENT	
TITLE:	13% RELEASE VOLUME DAM BREACH MODELLING 3 OF 11	
PROJECT No.:	0011603	DWG No: B-3



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SECTION D
PEAK FLOW = 106,190 cfs
FRONT ARRIVAL TIME = 2.45 hr
PEAK ARRIVAL TIME = 4.30 hr

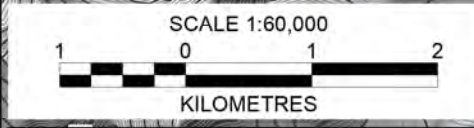
LEGEND

— STREAM

— SECTION LINE

MAXIMUM FLOW DEPTH (FEET)

< 2
2 to 4
4 to 6
6 to 8
8 to 12
12 to 14
14 to 20
> 20



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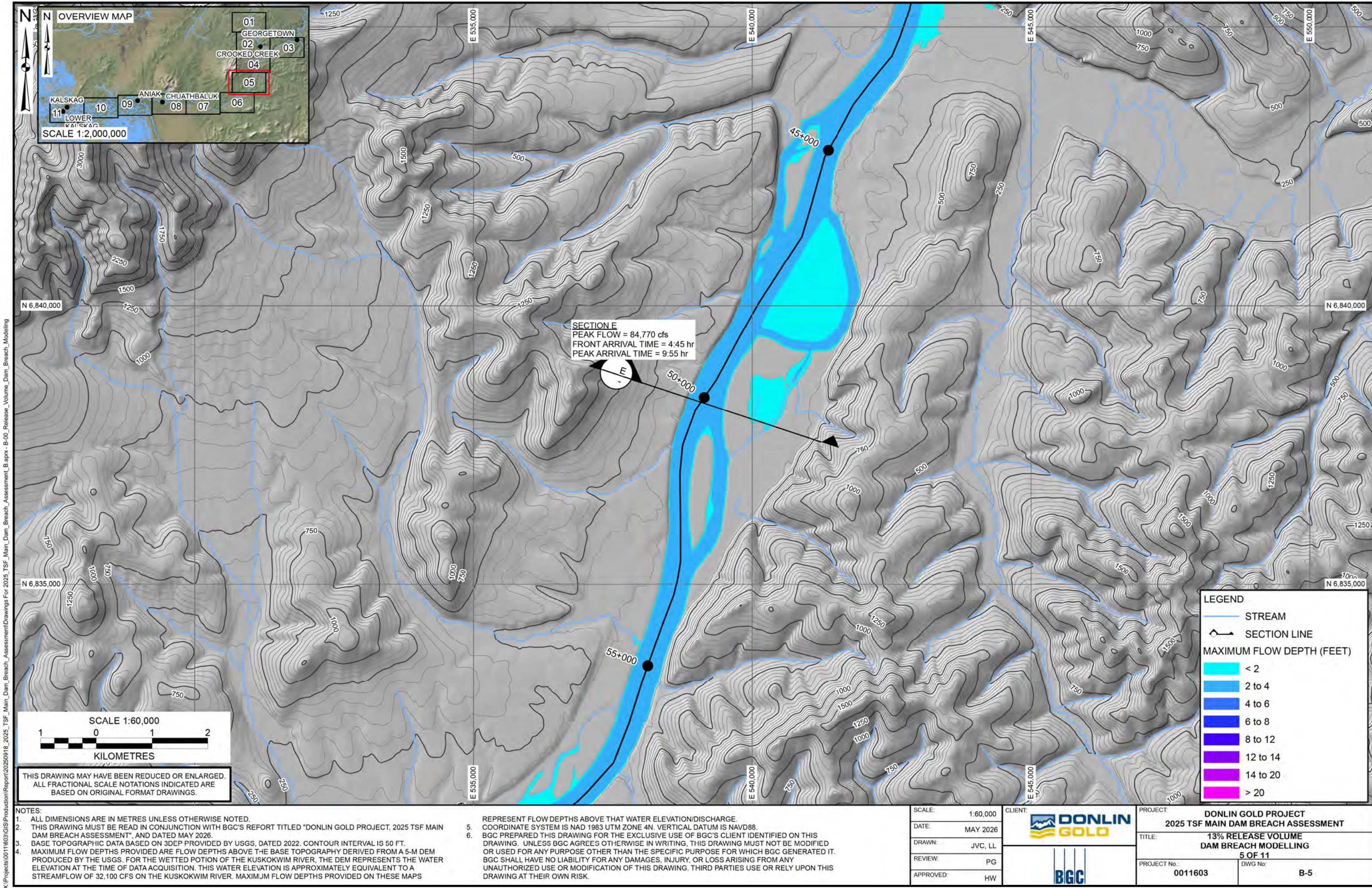
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SCALE:	1:60,000
DATE:	MAY 2026
DRAWN:	JVC, LL
REVIEW:	PG
APPROVED:	HW

CLIENT:

PROJECT:	DONLIN GOLD PROJECT 2025 TSF MAIN DAM BREACH ASSESSMENT
TITLE:	13% RELEASE VOLUME DAM BREACH MODELLING 4 OF 11
PROJECT No.:	0011603
DWG No.:	B-4



X:\Projects\0011603\GIS\Production\Drawings\For 2025 TSF Main Dam Breach Assessment_B.aprx - B-00_Release_Volume_Dam_Breach_Modeling

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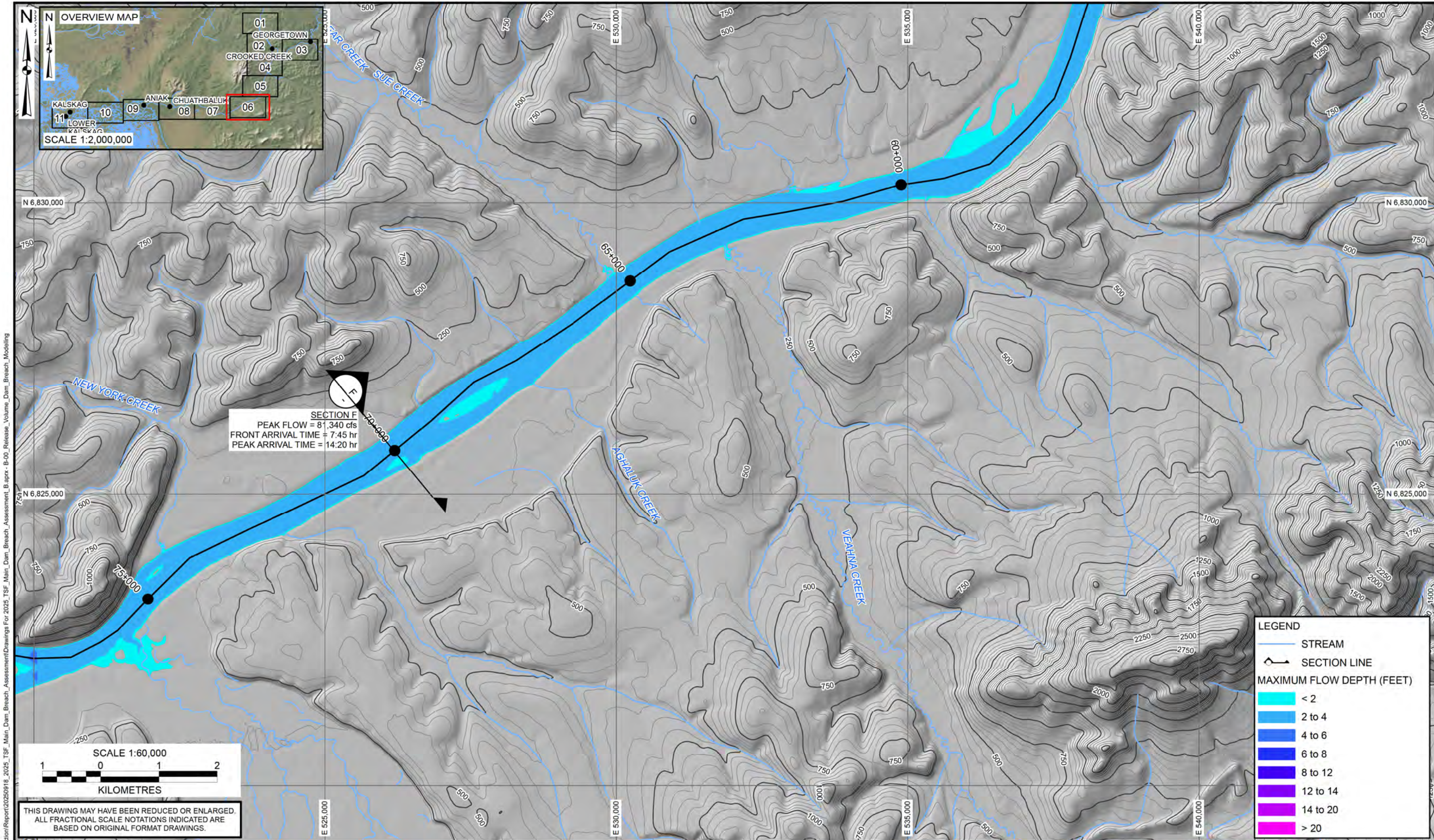
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SCALE:	1:60,000
DATE:	MAY 2026
DRAWN:	JVC, LL
REVIEW:	PG
APPROVED:	HW

CLIENT:




PROJECT:	DONLIN GOLD PROJECT 2025 TSF MAIN DAM BREACH ASSESSMENT	
TITLE:	13% RELEASE VOLUME DAM BREACH MODELLING 5 OF 11	
PROJECT No.:	0011603	DWG No: B-5



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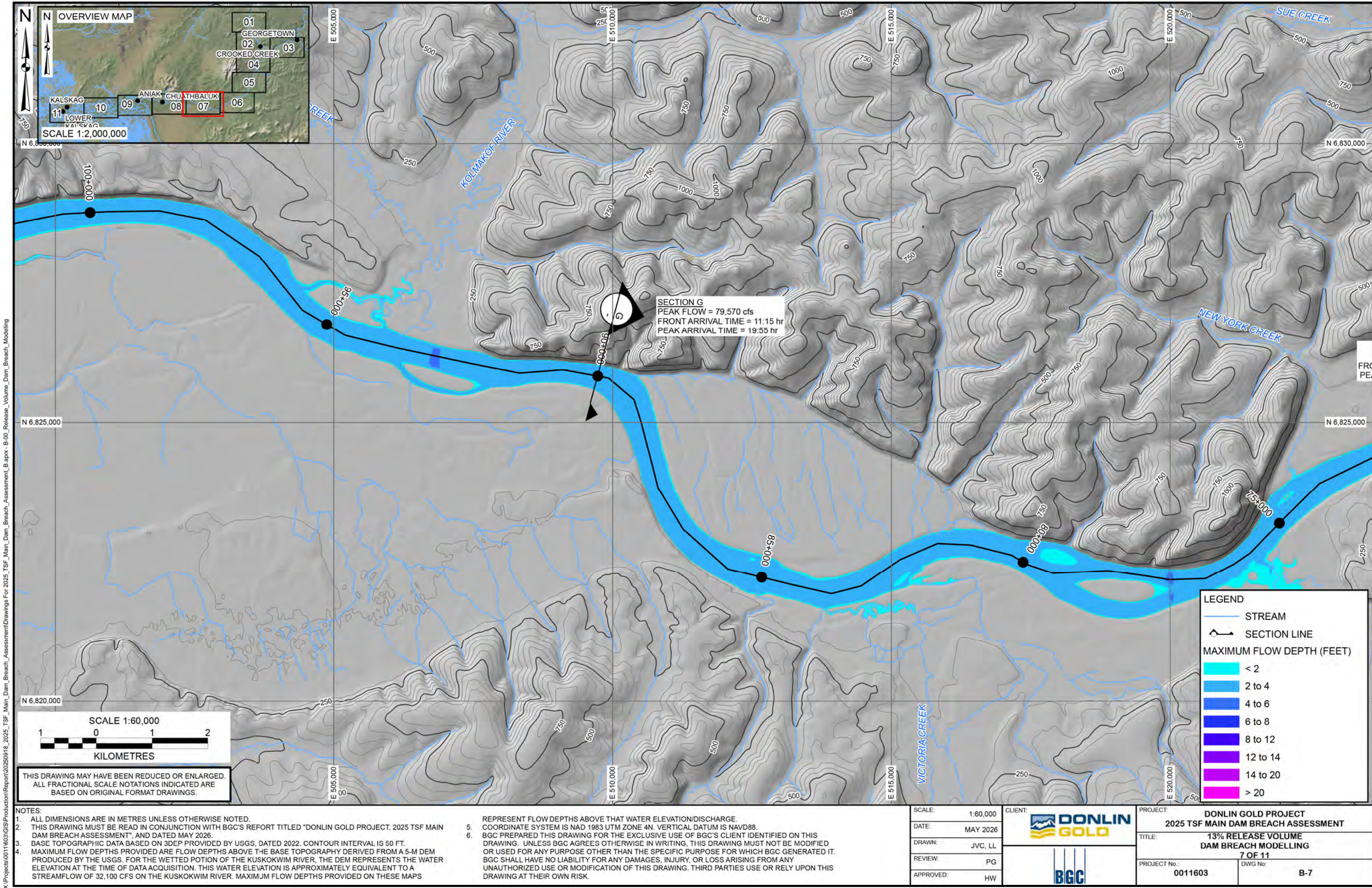
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SCALE:	1:60,000
DATE:	MAY 2026
DRAWN:	JVC, LL
REVIEW:	PG
APPROVED:	HW

CLIENT:

PROJECT: DONLIN GOLD PROJECT 2025 TSF MAIN DAM BREACH ASSESSMENT	
TITLE: 13% RELEASE VOLUME DAM BREACH MODELLING 6 OF 11	
PROJECT No.: 0011603	DWG No: B-6



X:\Projects\0011603\GIS\Production\Drawings\For 2025 TSF Main Dam Breach Assessment\B appx - B-00_Release_Volume_Dam_Breach_Modelling

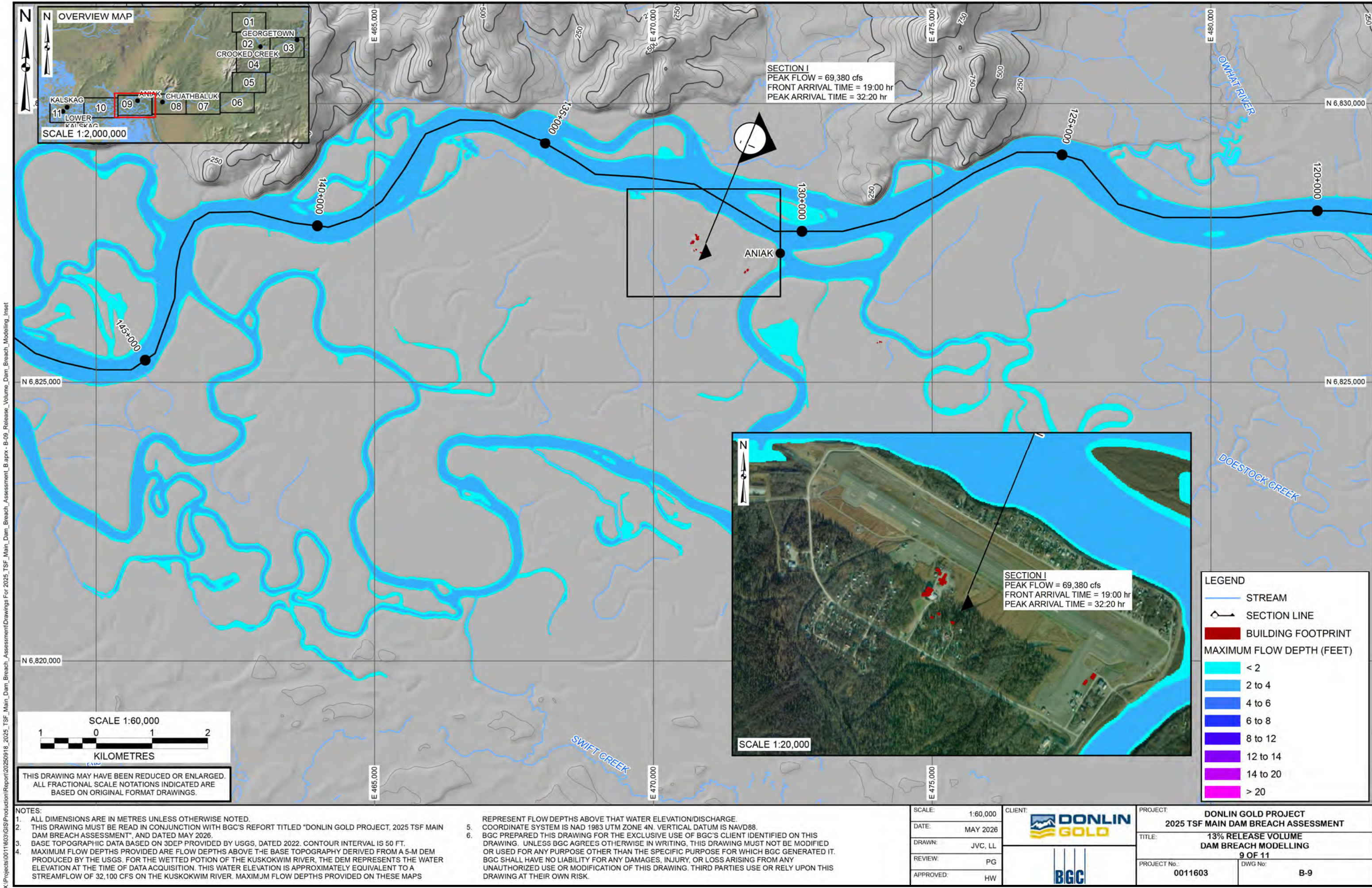
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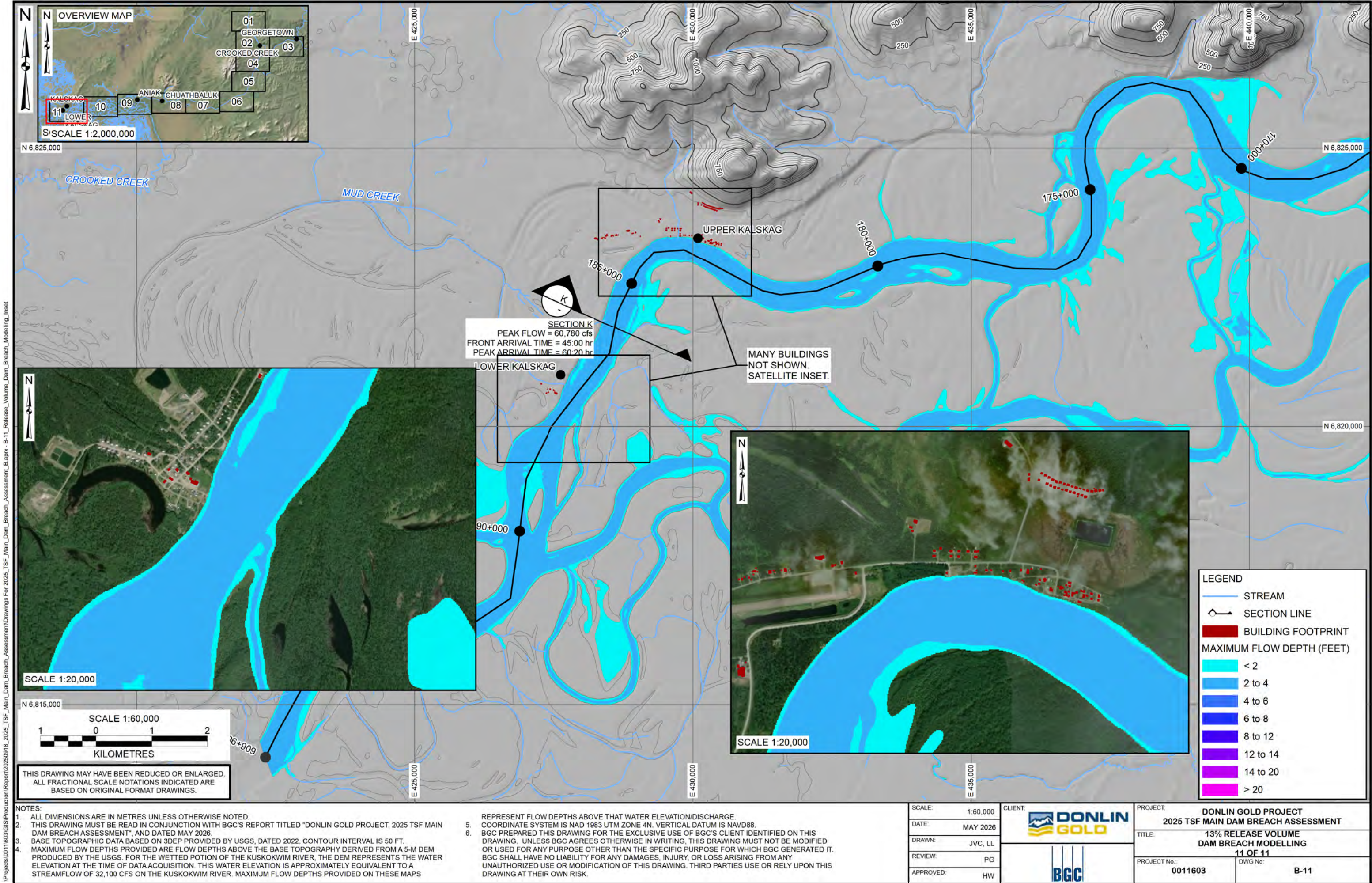
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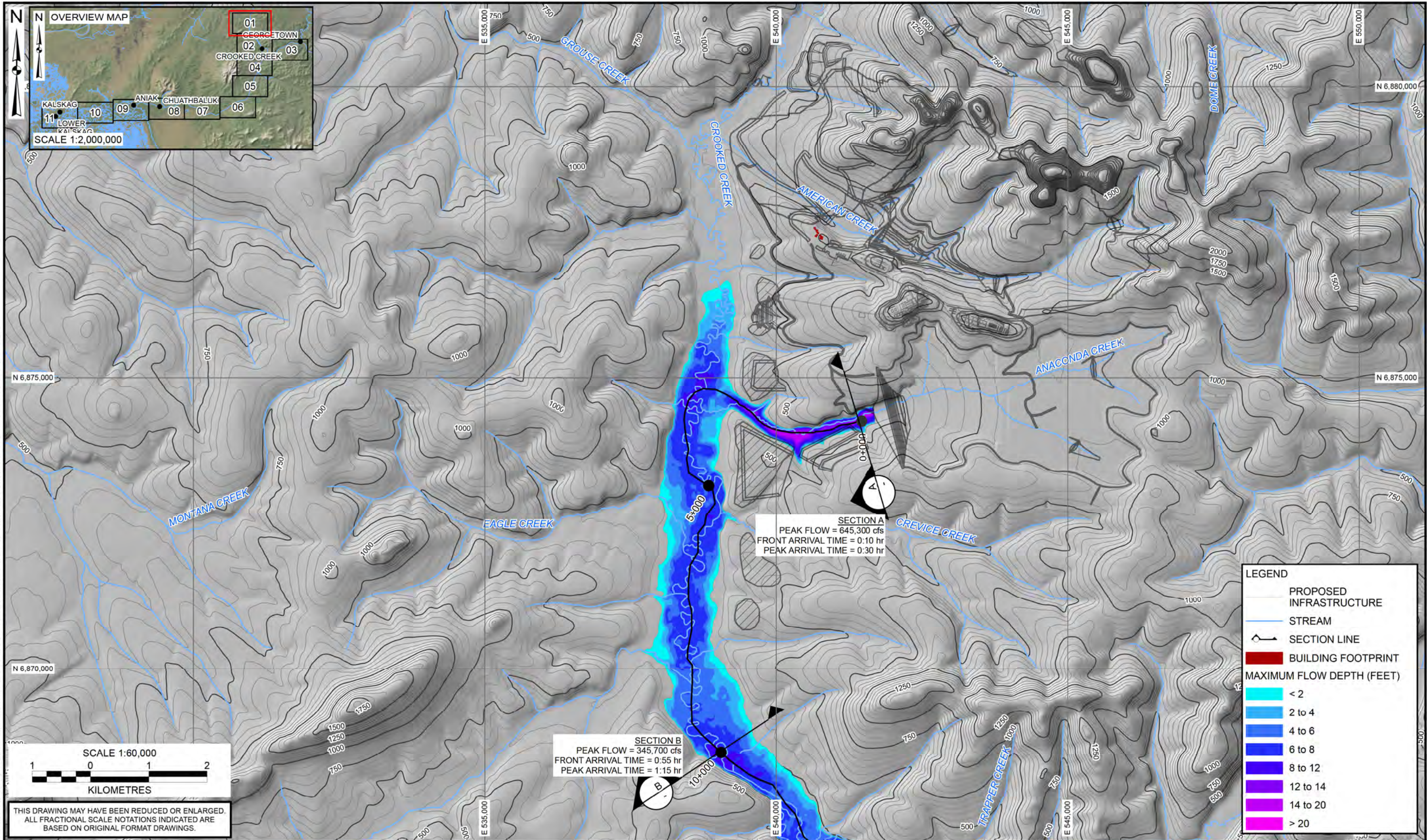
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2025 TSF MAIN DAM BREACH ASSESSMENT
TITLE: **13% RELEASE VOLUME**
DAM BREACH MODELLING
7 OF 11
PROJECT No.: **0011603**
DWG No: **B-7**





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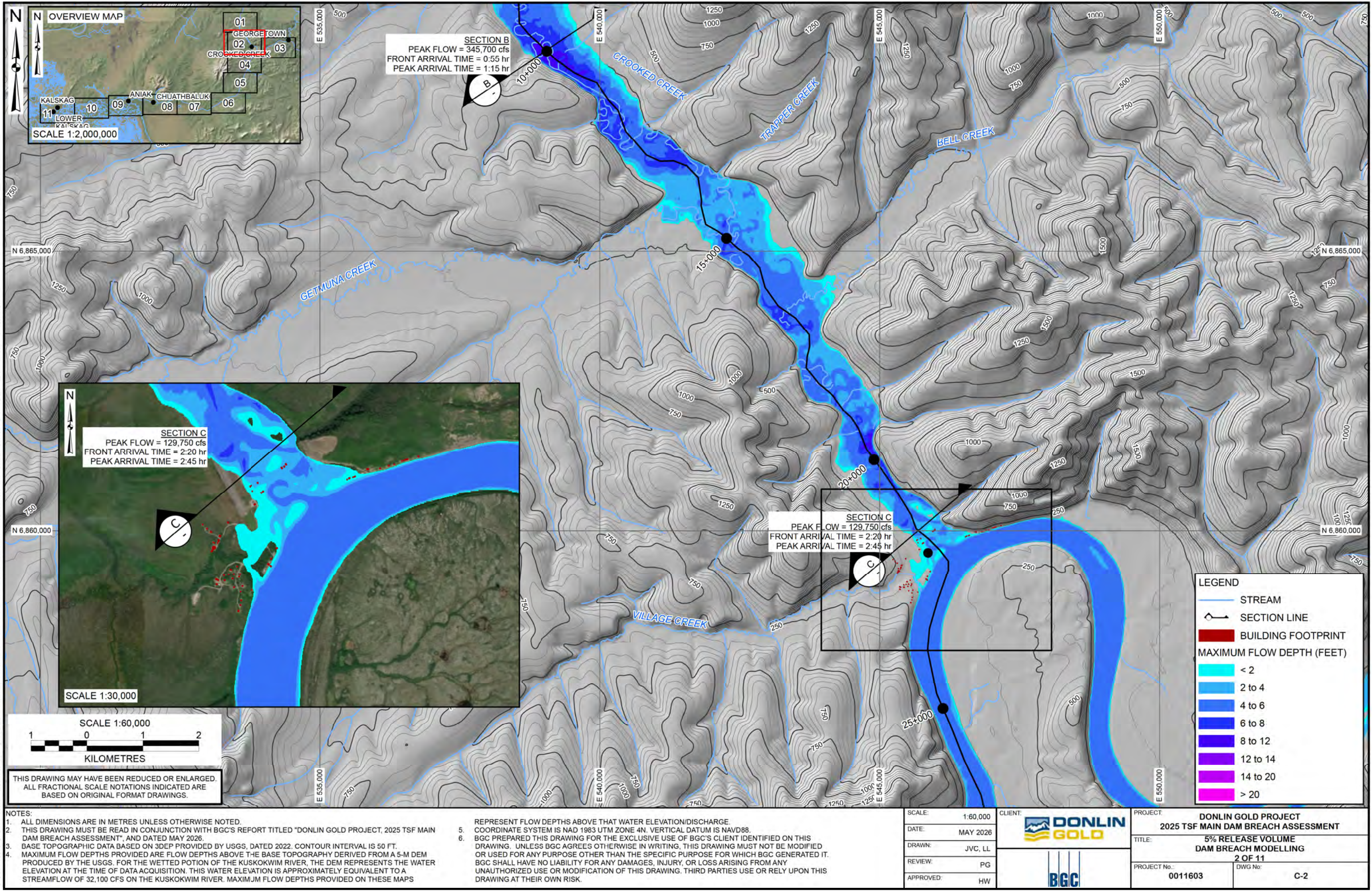
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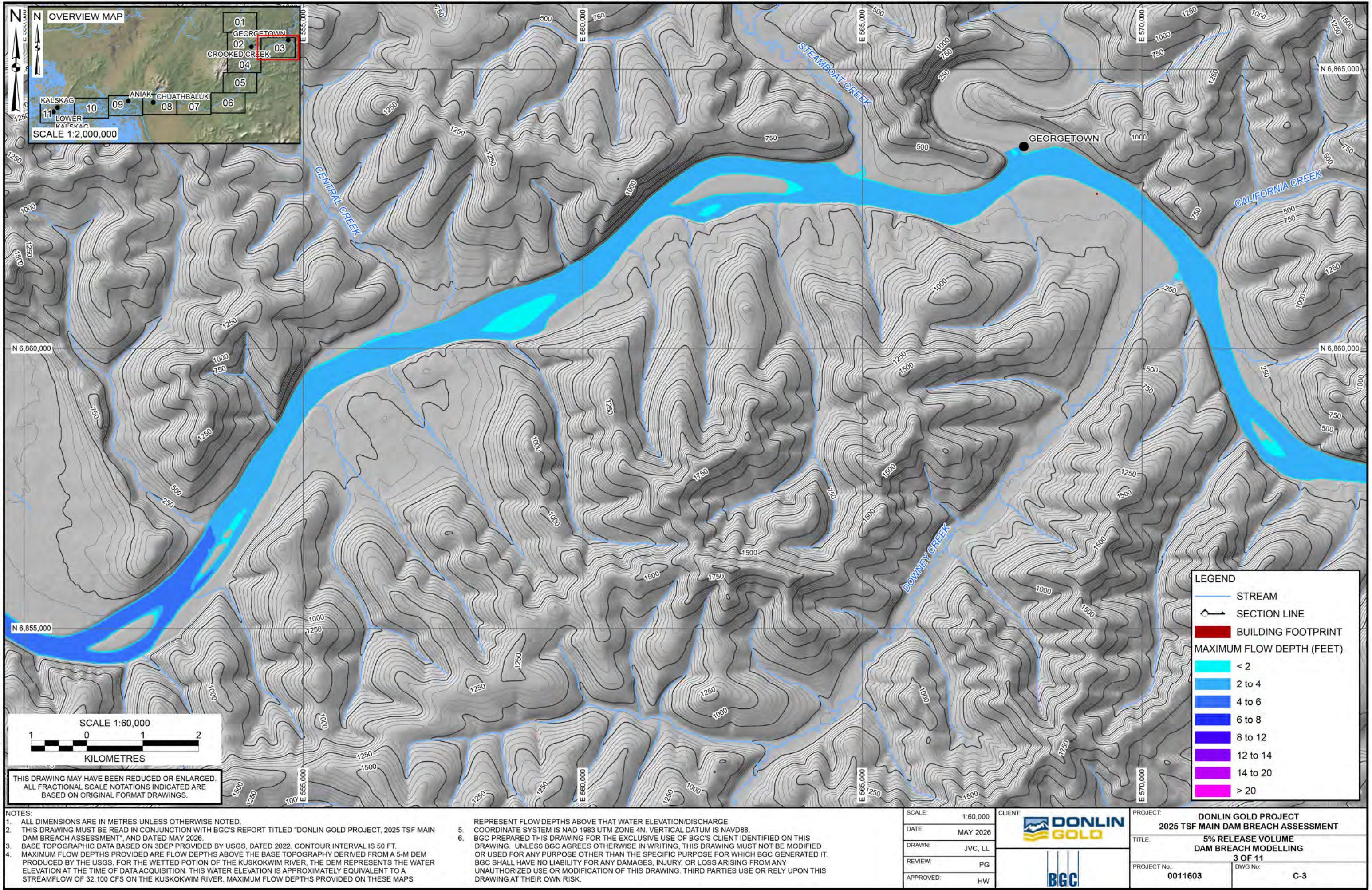
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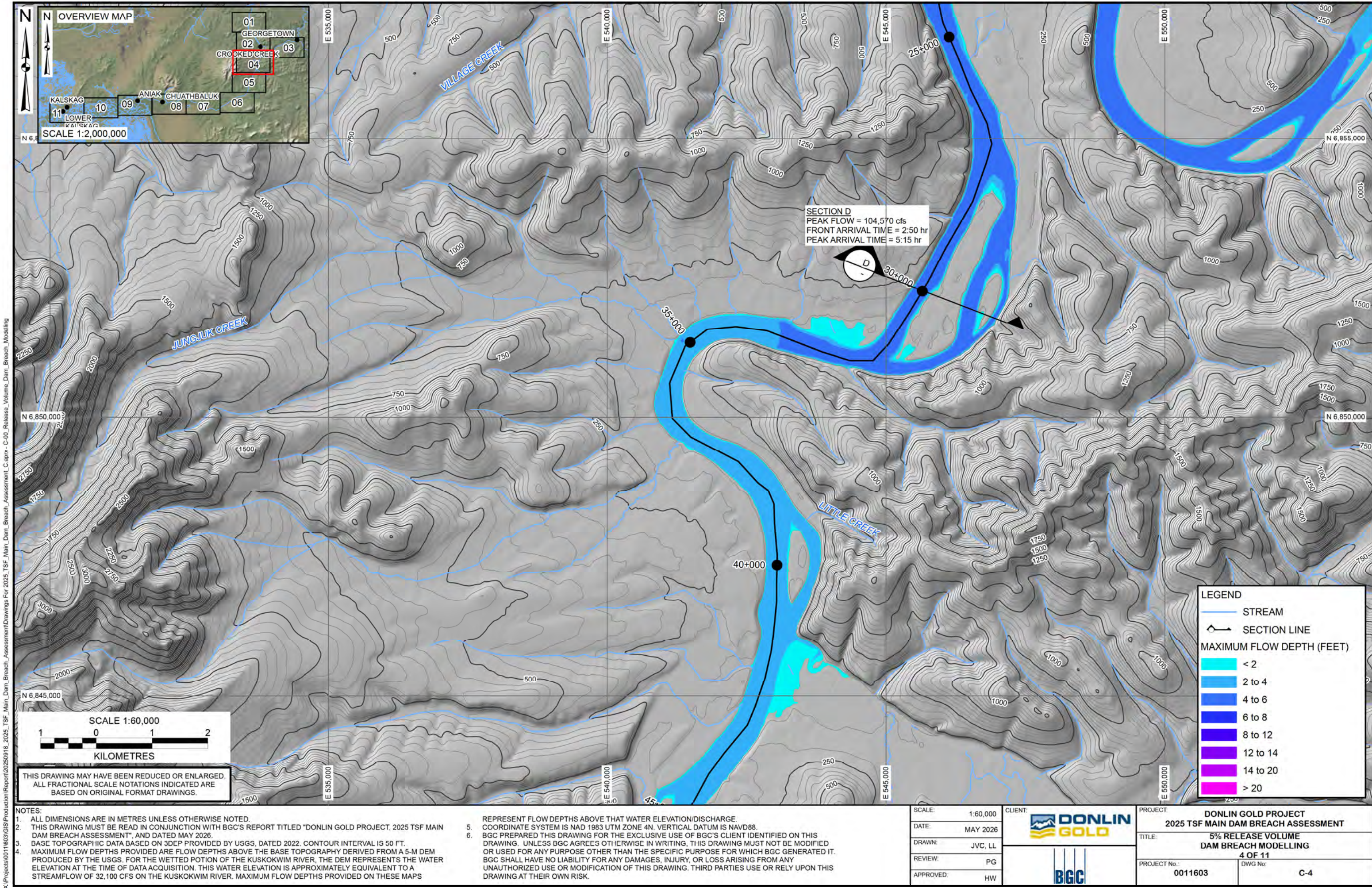
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PROJECT No.:	0011603	DWG No:
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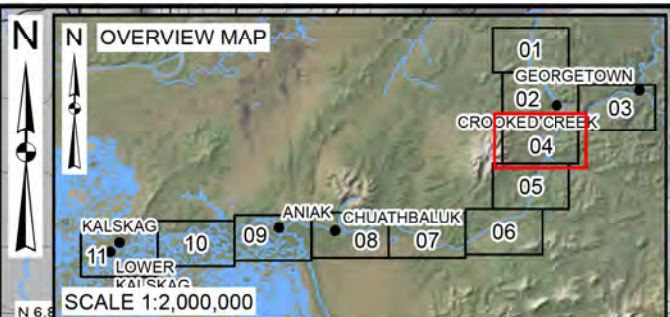


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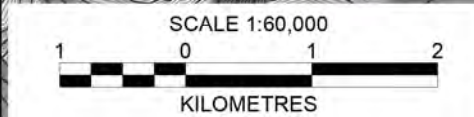


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FRONT ARRIVAL TIME = 2:50 hr
PEAK ARRIVAL TIME = 5:15 hr

LEGEND	
	STREAM
	SECTION LINE
MAXIMUM FLOW DEPTH (FEET)	
	< 2
	2 to 4
	4 to 6
	6 to 8
	8 to 12
	12 to 14
	14 to 20
	> 20



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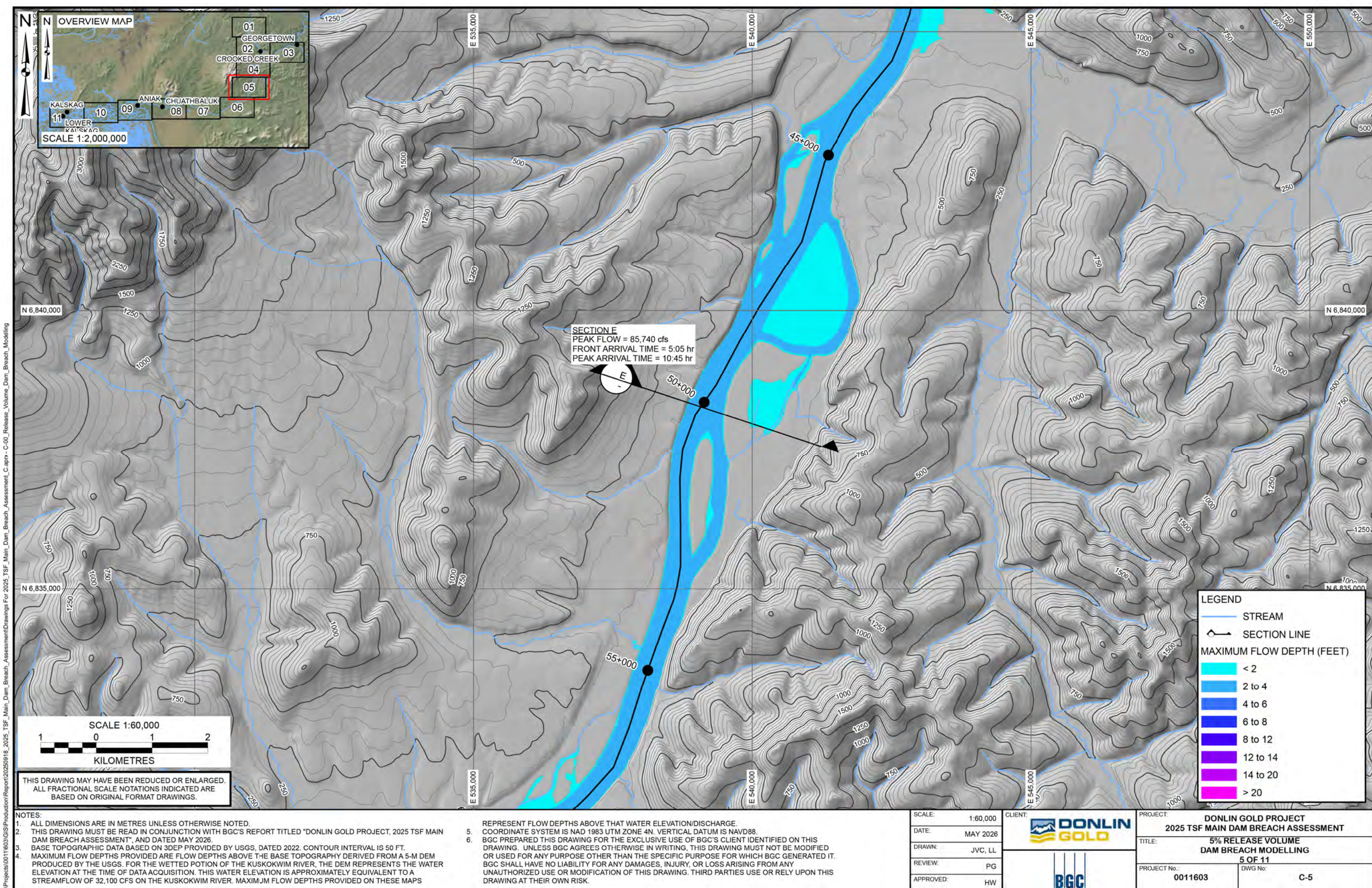
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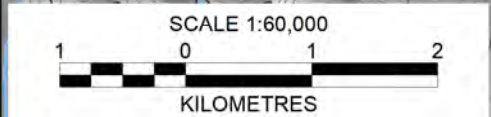
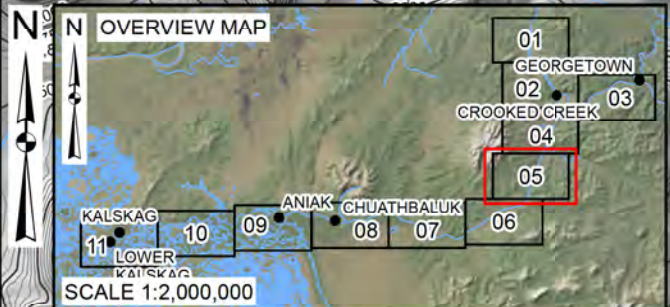
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PROJECT No.:	0011603	DWG No: C-4



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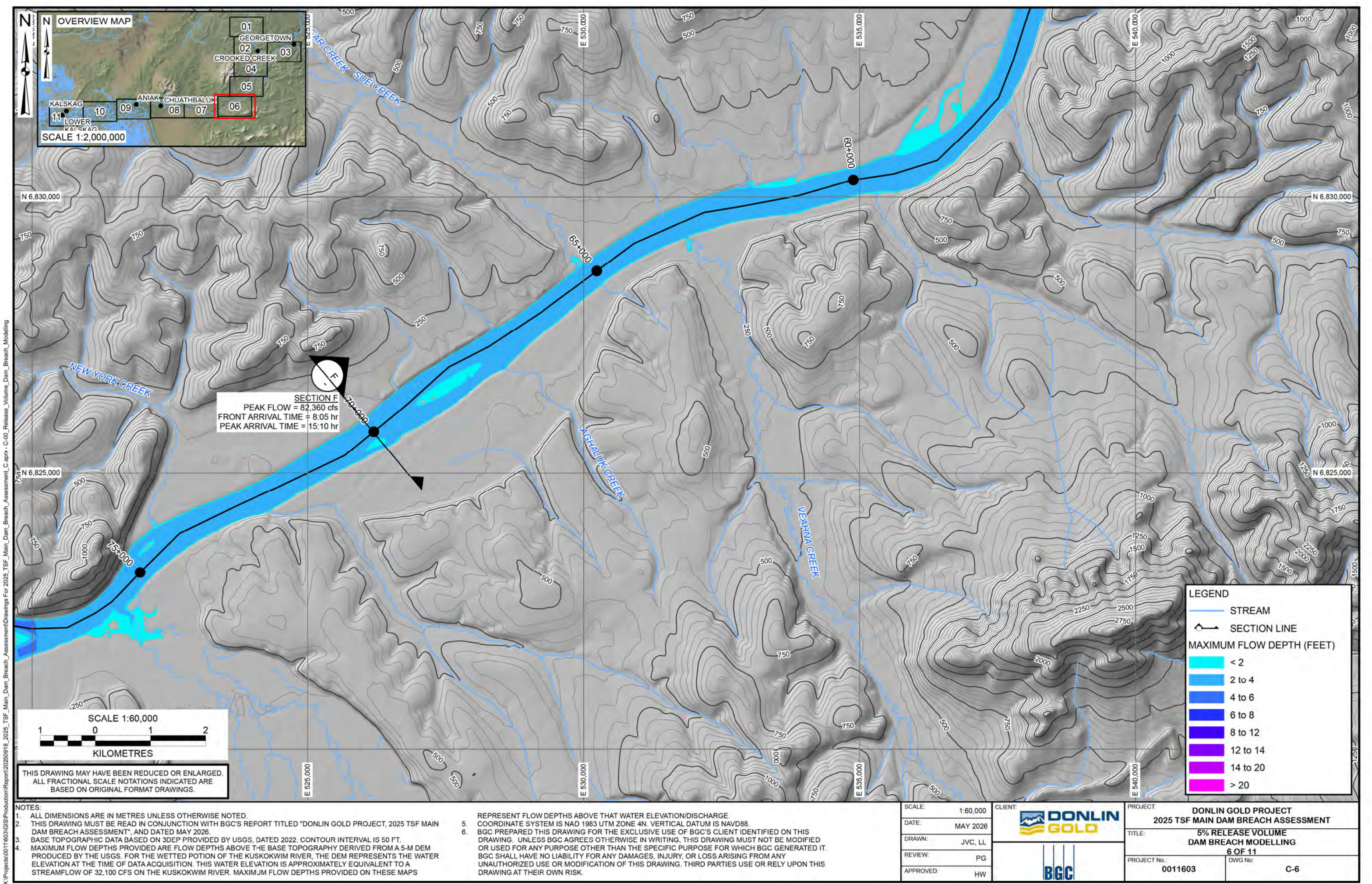
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SECTION F
PEAK FLOW = 82,360 cfs
FRONT ARRIVAL TIME = 8:05 hr
PEAK ARRIVAL TIME = 15:10 hr

LEGEND

— STREAM

— SECTION LINE

MAXIMUM FLOW DEPTH (FEET)

< 2
2 to 4
4 to 6
6 to 8
8 to 12
12 to 14
14 to 20
> 20

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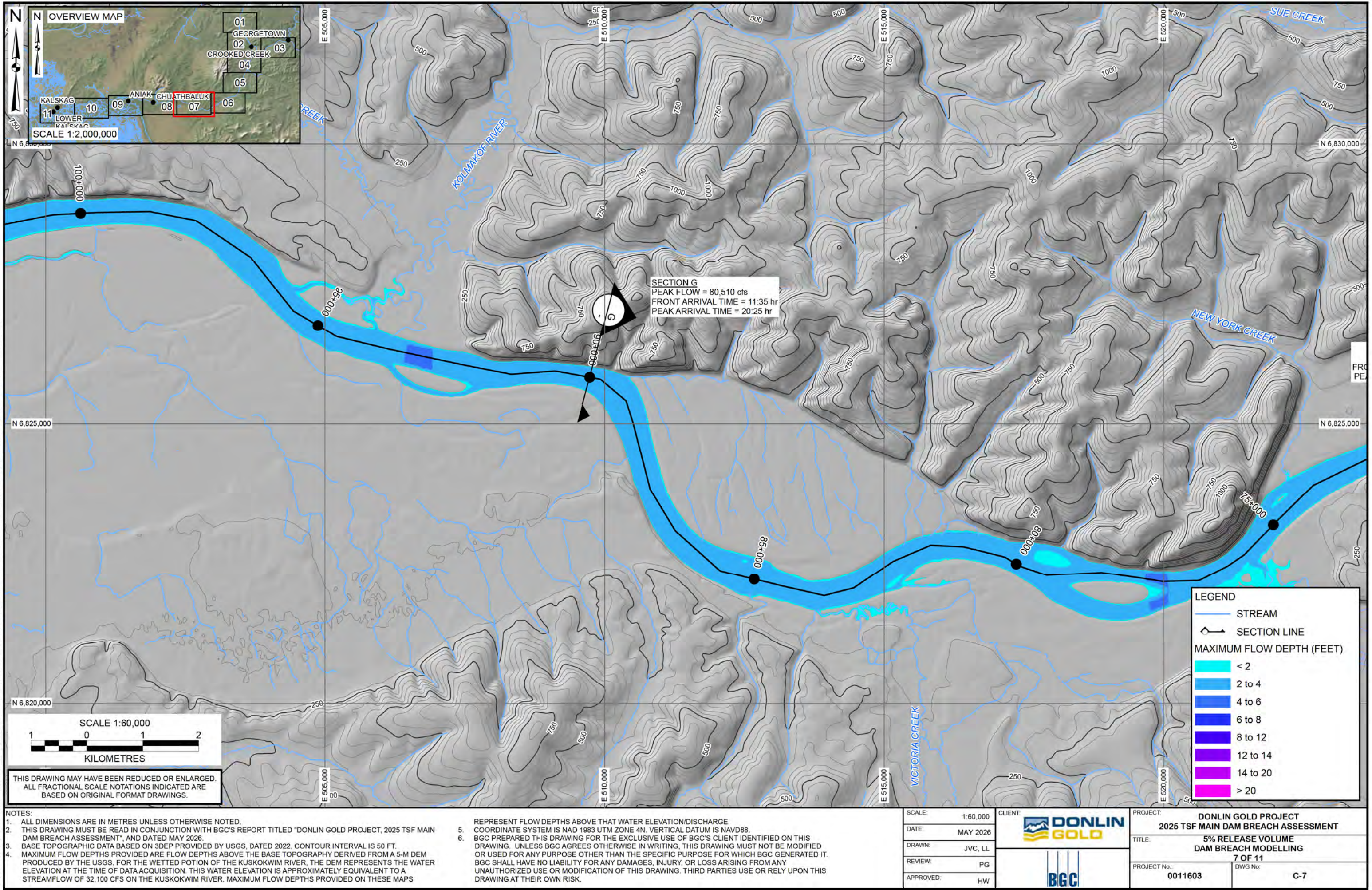
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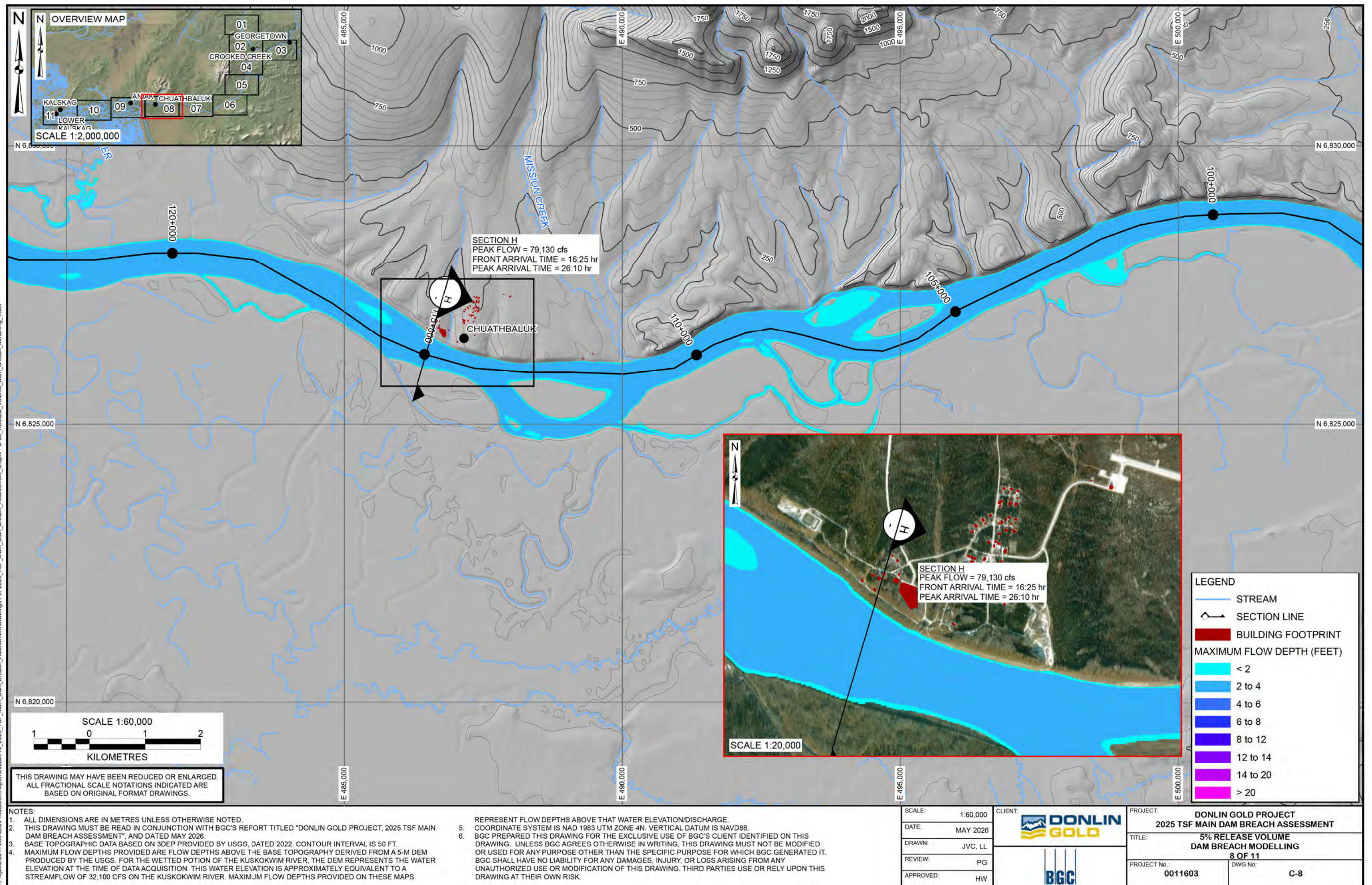
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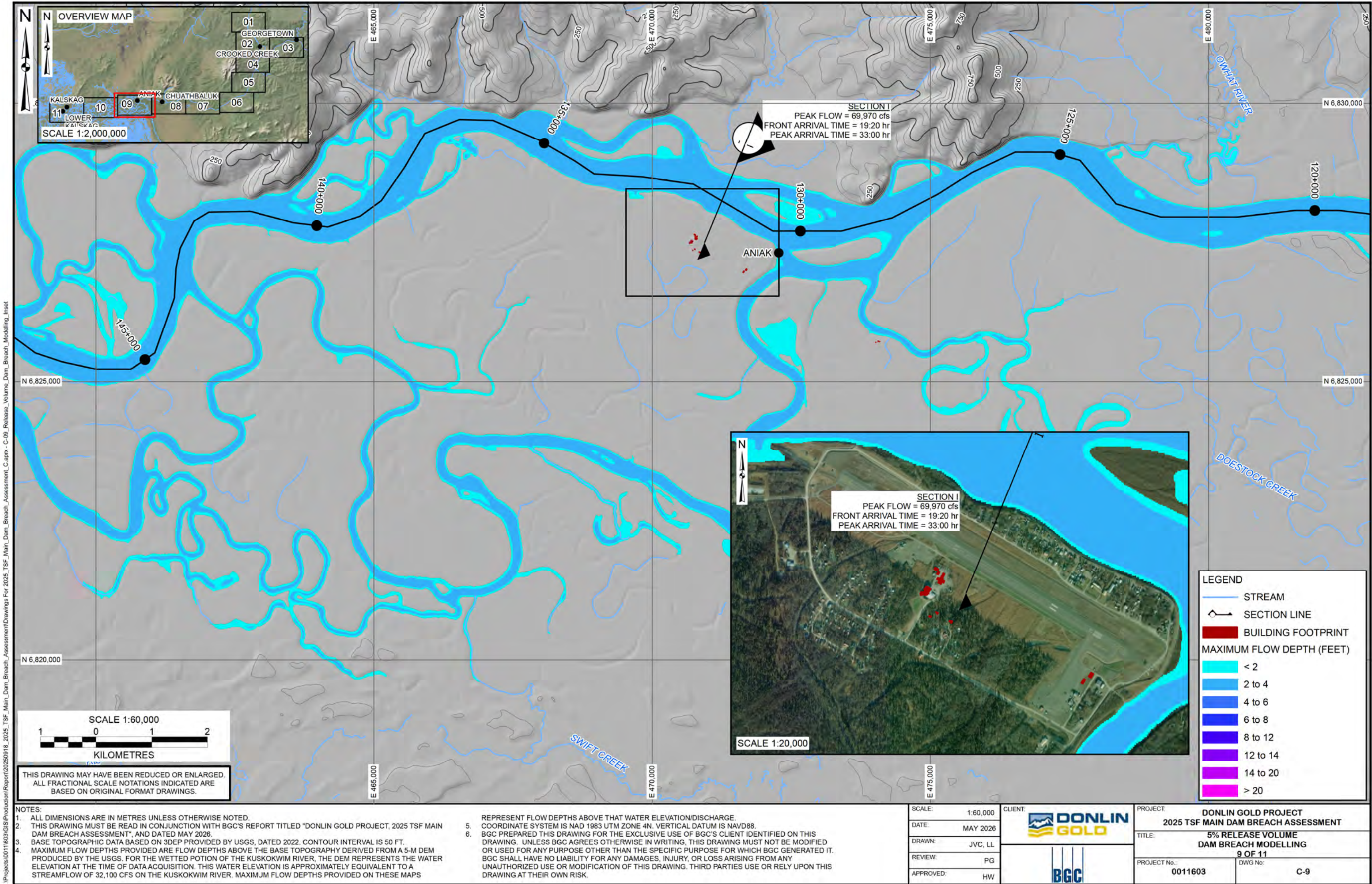
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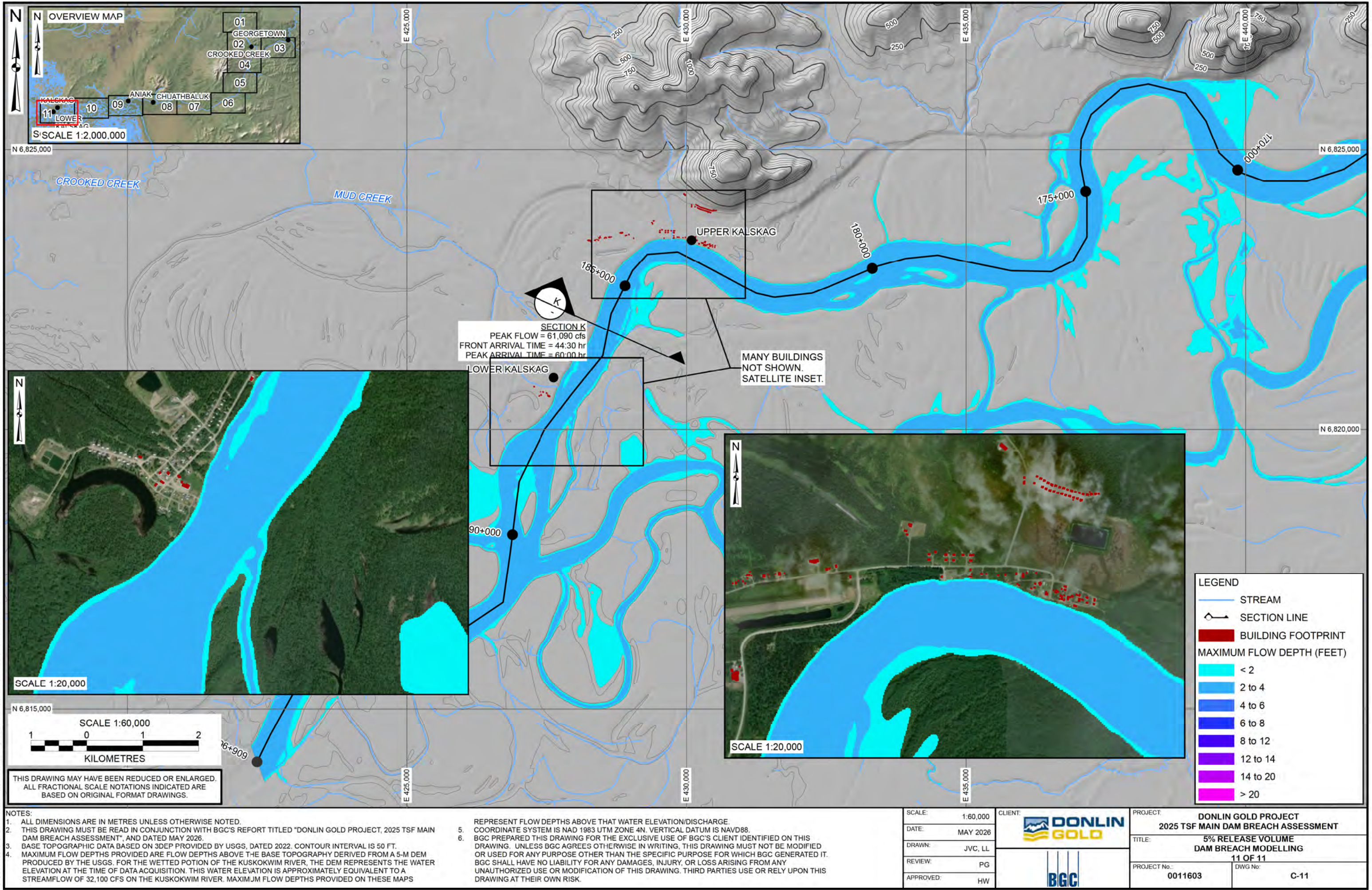
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APPENDIX A

GLOBAL REVIEW OF TAILINGS DAM FAILURES





Appendix A – Global Review of Tailings Dam Failures

Implications for the Donlin Gold Tailings Storage Facility Design

Prepared by BGC Engineering Alaska Inc. for:



January 5, 2026

Project 0011603

Document 0011603-01B

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EXECUTIVE SUMMARY

The Donlin Gold Project is a proposed open-pit, hard rock gold mine located in west-central Alaska with a proposed 27 year mine life at an average of 59,000 short tons (53,500 tonnes) per day. Slurry tailings are proposed to be contained within a fully geomembrane-lined tailings storage facility (TSF) impoundment within the Anaconda Creek valley. The tailings will be retained by a zoned rockfill dam embankment (TSF Main Dam) that is initially 198 ft (60 m) high and raised in the downstream direction over the life of mine up to an ultimate height of approximately 471 ft (144 m). Non-contact water diversion channels will be constructed around the perimeter of the TSF to limit the amount of non-contact water runoff within the TSF catchment that would require management. At the end of operations, the TSF will store approximately 334,300 acre-ft (412 Mm³) of tailings and a dry cover (comprising rockfill, soil, and vegetation) will be constructed.

The Donlin Gold TSF Main Dam has been designed with the following key design features to mitigate against credible failure modes:

- The TSF design has been informed by extensive site characterization that has been carried out over a period of two decades.
- The dam embankment will be founded directly on bedrock, which provides a high level of foundation support, including under seismic loading.
- The dam is configured as a zoned rockfill embankment with a geomembrane liner covering the upstream face that extends across the foundation of the TSF impoundment.
- The dam embankment incorporates bedding, filter (2), and transition rockfill layers to protect the embankment against internal erosion from dam seepage.
- The dam will be raised in the downstream direction during the life of mine.
- A network of underdrains below the geomembrane liner within the TSF impoundment will convey groundwater and possible liner leakage across the base of the TSF Main Dam to a seepage recovery system that is located downstream of the dam, from where the water will be managed.
- The TSF has been permitted to allow for treatment and discharge of excess water, which will reduce the risk of overtopping.

A literature review of historical recorded tailings dam failures was completed to evaluate the resilience of the Donlin Gold TSF design. A review of the most comprehensive, publicly-available TSF failure database, CSP², which includes recorded tailings dam failures from between 1915 and April 2025, indicated that the three most frequently reported causes of tailings dam failures are: 1) crest overtopping, 2) static failure, and 3) seismic-induced failure. The review also showed that downstream construction raised dams, as proposed for the Donlin Gold TSF, have failed at less than half the rate as upstream-raised dams that are typically founded on previously-deposited tailings materials.

In recorded history, there has been a total of 94 TSF failures in the United States (USA) where released tailings have been reported, the first in 1940 and the most recent in 2018. These 94 tailings dams were distinctly different from the Donlin Gold TSF design. Of these, ten were

reported as raised with the downstream construction method. Of these ten failures, none were waste rock (rockfill) dams and the most recent occurred in 1989. There has been only one recorded failure of a tailings dam that was constructed of waste rock in the USA, the 1972 Buffalo Creek upstream-raised coal TSF.

A total of twenty well-documented tailings dam failures were further reviewed to assess whether their failure modes were applicable to the Donlin Gold TSF. The dam failures were attributed to: liquefaction of tailings that served as foundation materials for upstream construction raises; inadequate dam foundation characterization; weak soil foundations; high precipitation environments; poor dam filter design; and inadequate water management and design. As noted above, such conditions either do not apply to the Donlin Gold TSF or the Donlin Gold TSF has been designed to mitigate against such failure modes.

In conclusion, from the data reviewed, there has been no documented failure of a TSF constructed as is proposed for the Donlin Gold TSF (i.e., a rockfill embankment that is founded on bedrock of high shear resistance and raised using the downstream construction raise method).

In 2026, the Donlin Gold TSF will be designed at a detailed level to meet or exceed State of Alaska and industry standards (e.g., Global Tailings Review, 2020; ICMM, 2021; ICOLD, 2025) for stability under both static and seismic loading conditions. Risk-informed decision-making, continuous performance monitoring, independent review (i.e., from Independent Tailings Review Boards or Dam Safety Reviews), and a commitment to the highest standard of tailings facility stewardship are embedded within the facility's governance plan.

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A-1 INTRODUCTION

Donlin Gold LLC (Donlin Gold) is currently planning to develop the Donlin Gold Project, a proposed open pit gold mine, in southwestern Alaska. BGC Engineering Alaska Inc. (BGC) has carried out technical studies for the Donlin Gold Project since 2004, including geotechnical, hydrogeological, and hydrological assessments in support of Feasibility Studies (FS), the most recent FS being the 2011 Feasibility Study Update. That work has included a feasibility level design of the proposed Tailings Storage Facility (TSF) (BGC, July 22, 2011). BGC also completed studies to support an Environmental Impact Statement (EIS), federal permitting, and state permitting. In 2026, BGC will be preparing the detailed design of the TSF.

A-1.1 Background

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A-1.2 Objectives

The objectives of this report are to:

1. Summarize recent research and documented failures of TSF Dams, highlighting the failure modes, key lessons learned.
2. Identify trends in the current state of practice.
3. Contextualize the Donlin Gold TSF design within the broader landscape of global tailings management, referencing relevant standards and case studies of TSF failures.
4. Describe the root causes of well-documented, historical TSF failures and assess the applicability of such failure modes occurring at the Donlin Gold TSF based on project-specific design features, risk mitigation measures, and planned governance.

A-2 TECHNICAL BACKGROUND

This section describes basic concepts of tailings dam design with attention to starter dams and dam raise construction methods. Discussion is also provided on how tailings dams can fail (i.e., failure modes).

A-2.1 Tailings Dam Raise Construction Methods

Tailings are the waste material left over in mining operations after the valuable component has been removed through processing of a host rock. TSFs must be designed to safely operate

under a variety of conditions and retain tailings and water during mine operations and post closure.

Tailings impoundment dams are commonly constructed in stages through the life of the mine, with fill materials added incrementally (i.e., “raised”) as additional storage capacity is required. This sequenced methodology is different than a water storage reservoir which is often constructed to its final height before operation begins. The phased nature of tailings dams makes it possible to adapt to operational changes or issues encountered during the life of the mine.

Successive tailings dam raises are constructed using several types of materials, including soil borrow, processed aggregate, tailings, or quarried bedrock in a conventional zoned configuration (Vick, 1990). Typically, in the mining industry, there are three basic types of tailings dam embankment design, as illustrated in Figure A-1.

- a. Upstream construction
- b. Downstream construction
- c. Centerline construction

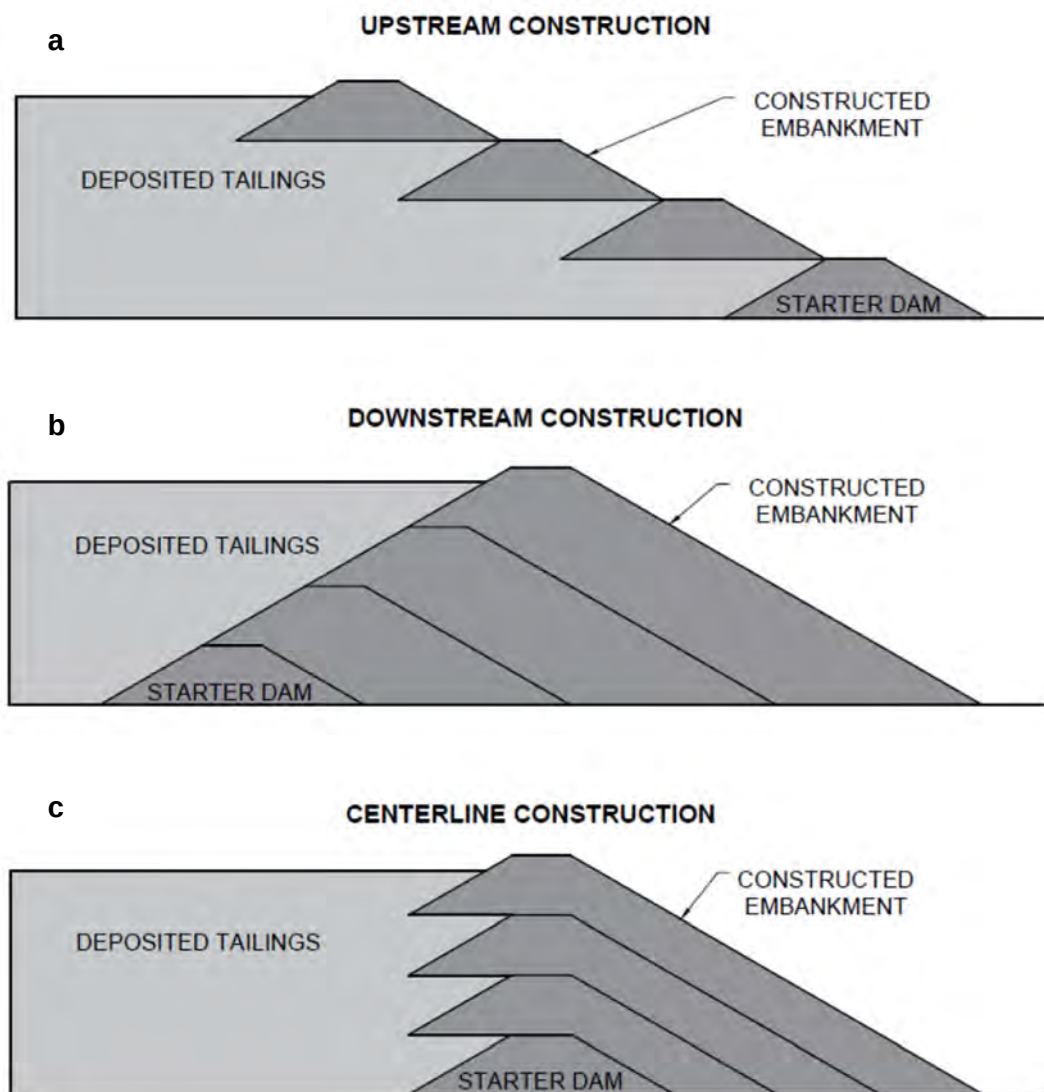


Figure A-1 Tailings dam raise construction methods (modified from Vick, 1990).

In upstream constructed dams, previously deposited tailings become the foundation for future embankment raises (Vick, 1990). As a result, the stability of an upstream constructed dam is dependant on the strength of the tailings in the upstream support zone. Stark et al. (2022) reported that “many of the upstream tailings dam failures that occurred before 2000 are related to loose sands and weak slimes that were entrapped in the downstream area of the dam”.

Centerline constructed dams are partially founded on previously deposited tailings, albeit less compared to upstream dams. In contrast to upstream and centerline dams, a downstream dam is not founded on previously-deposited tailings, and its stability is not dependant on the strength of tailings.

The pros, cons, and typical use cases of each construction method are summarized in Table A-1.

Table A-1 Summary of pros, cons, and typical use case of tailings dam construction methods.

Method	Pros	Cons	Typical Use Case
Upstream	• Least expensive • Construction schedule can be shorter than other options	• High risk in seismic/wet climates • Requires high degree of oversight in design, construction and operations (e.g., managing pond levels)	• Arid regions • Low output mines • Limited area available for dam construction
Centerline	• More resilient than upstream • Moderate cost	• Requires more dam fill material than upstream • Moderate construction complexity	• Medium to large mines • Moderate precipitation/seismic areas
Downstream	• Most resilient • Suitable for high rainfall/seismic areas	• Most expensive due to larger volume of dam fill materials required • Large footprint	• Large-scale mine operations • Sufficient area available for downstream raise construction • High precipitation/seismic areas

A-2.2 Tailings Dam Failure Modes

The International Commission on Large Dams (ICOLD) (2001) categorized tailings dam failures into nine failure modes, as summarized in Table A-2 and illustrated in Figure A-2.

Table A-2 Tailings dam failure modes (ICOLD, 2001).

Failure Mode	Definition	See Figure A-2
Slope Instability (SI)	Failure of the embankment under its own weight or under loading, when the shear strength is exceeded by stresses (e.g., from tailings load, porewater pressure, surcharge during construction). Includes static (flow) liquefaction ² of the embankment material.	a
Seismic Instability / Earthquake (EQ)	Induced or accelerated by seismic shaking (earthquakes). This may mobilize cyclic (seismic) liquefaction in saturated zones, reduce shear strength, generate excess pore pressures, or trigger slope slides, flow slides, or other instability.	b
Seepage and Internal Erosion (SE)	Progressive removal of soil particles due to the flow of water through the embankment body or foundation. This may begin as fine particle movement, form channels or “pipes,” and can ultimately lead to a breach	c
Weak Foundation Conditions (FN)	Weakness, deformation, or collapse of the foundation or interface between dam and foundation (e.g., settlement, bearing failure, subsidence, deformation under load, static liquefaction). This can compromise the dam’s stability or lead to excessive deformation or cracking.	d
Overtopping (OT)	Water or tailings slurry flows over the crest of the dam, beyond its freeboard or spillway capacity, eroding the crest and downstream slope until breach occurs. Often triggered by extreme rainfall, unexpected inflows, or insufficient spillway capacity.	e
Collapse of Structural Elements (ST)	Failures arising from defects, design flaws, construction errors, material deficiencies or deterioration of structural components (e.g., embankment materials, filter/ drain components, liners, interface elements).	f
External Erosion / Erosion by Nearby Waterways (ER)	Erosion of the dam from its exposed surfaces by wave action, rainfall runoff, wind, or external hydraulic flows.	g
Mine Subsidence (MS)	Collapse or deformation of underlying mine workings (underground voids) which causes settlement or deformation of foundation and the overlying tailings dam structure.	h
Unknown (U)	Cases where the failure documentation is insufficient or ambiguous.	N/A

² Liquefaction, as defined by the United Nations Office for Disaster Risk Reduction, refers to the loss of strength experienced in loosely packed, saturated or close to saturated sediments at or near the ground surface that lose their strength in response to strong ground shaking (e.g., from an earthquake, transit of machinery, or blasting), or due to the development of excess pore water pressures resulting from a change in head or confining pressures. Liquefaction is not one of the ICOLD dam failure modes but can be triggered by some of the causes (e.g., overtopping; erosion of the dam toe; increase in the water table due to high rainfall, groundwater inflow, or inadequate drainage), or trigger events such as slope instability, seismic instability, and foundation failures.

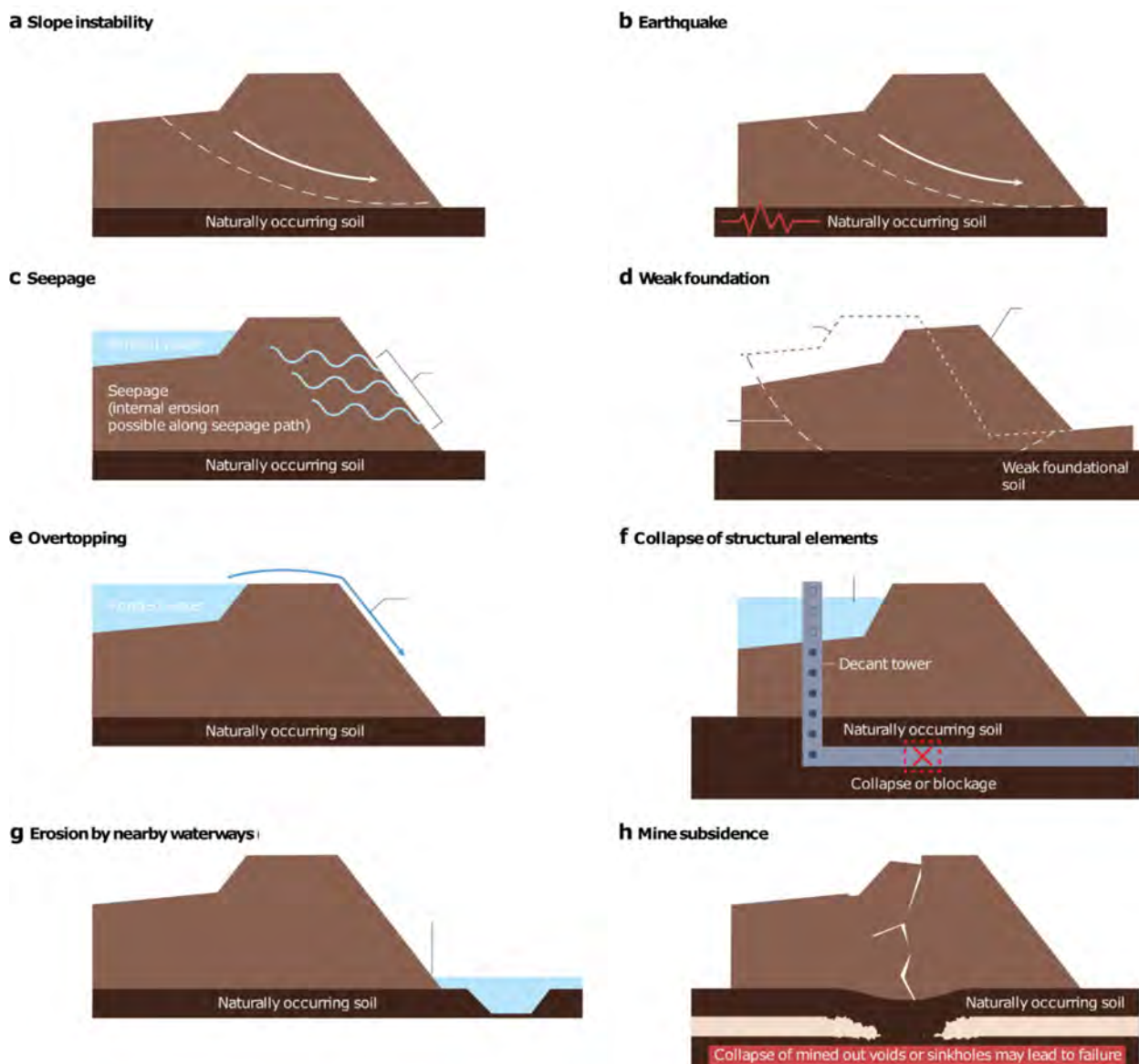


Figure A-2 ICOLD tailings dam failure modes (from Hudson-Edwards et al., 2024).

A-3 DONLIN GOLD TSF DESIGN

A-3.1 TSF Description

The tailings and process-affected water will be stored in a fully geomembrane-lined valley impoundment located south of the proposed open pit in the Anaconda Creek watershed. The TSF Starter Dam construction campaign prior to mine start-up comprises a 198 ft (60 m) high embankment, which will be raised in the downstream direction as noted, starting in the first year of operations. Dam raises are planned periodically thereafter throughout the remaining mine life. The final (ultimate) dam height is approximately 471 ft (144 m).

During construction, the Donlin TSF Main Dam footprint will be excavated to expose bedrock. The dam embankment will be constructed using rockfill, filter, and bedding layers (BGC,

December 2012). Figure A-3 shows a cross-section of the dam at its ultimate height). The upstream face of the dam will be benched at each raise with local slopes of 2H:1V. The downstream slope of the dam will be 1.7H:1V.

The hydrology, hydraulics, stability, seismic, and seepage design criteria applicable to the tailings dam have been designed to meet or exceed those recommended by the Alaska Department of Natural Resources (DNR) dam safety regulatory guidelines (ADNR, July 2017). The design of appurtenant structures has been designed based on procedures from agencies such as the U.S. Bureau of Reclamation, U.S. Army Corps of Engineers, Federal Emergency Management Administration, ICOLD, and the Canadian Dam Association (CDA). In 2026, the detailed design of the TSF will also consider Global Tailings Review (2020), ICMM (2021), and ICOLD (2025).

The Donlin tailings material is considered liquefiable and brittle, due to its expected saturated, fine-grained, and loose state. However, because the TSF Main Dam is designed to be raised in the downstream direction (see Figure A-2b), and founded directly on bedrock (which is not liquefiable or brittle), the dam does not rely on the strength of the tailings for structural integrity, as would be the case for both upstream (Figure A-2a) and centerline (Figure A-2c) dams.

At the end of operations, the TSF will contain 567.6 million short tons of tailings, occupying a volume of approximately 334,300 acre-ft (412 Mm³).

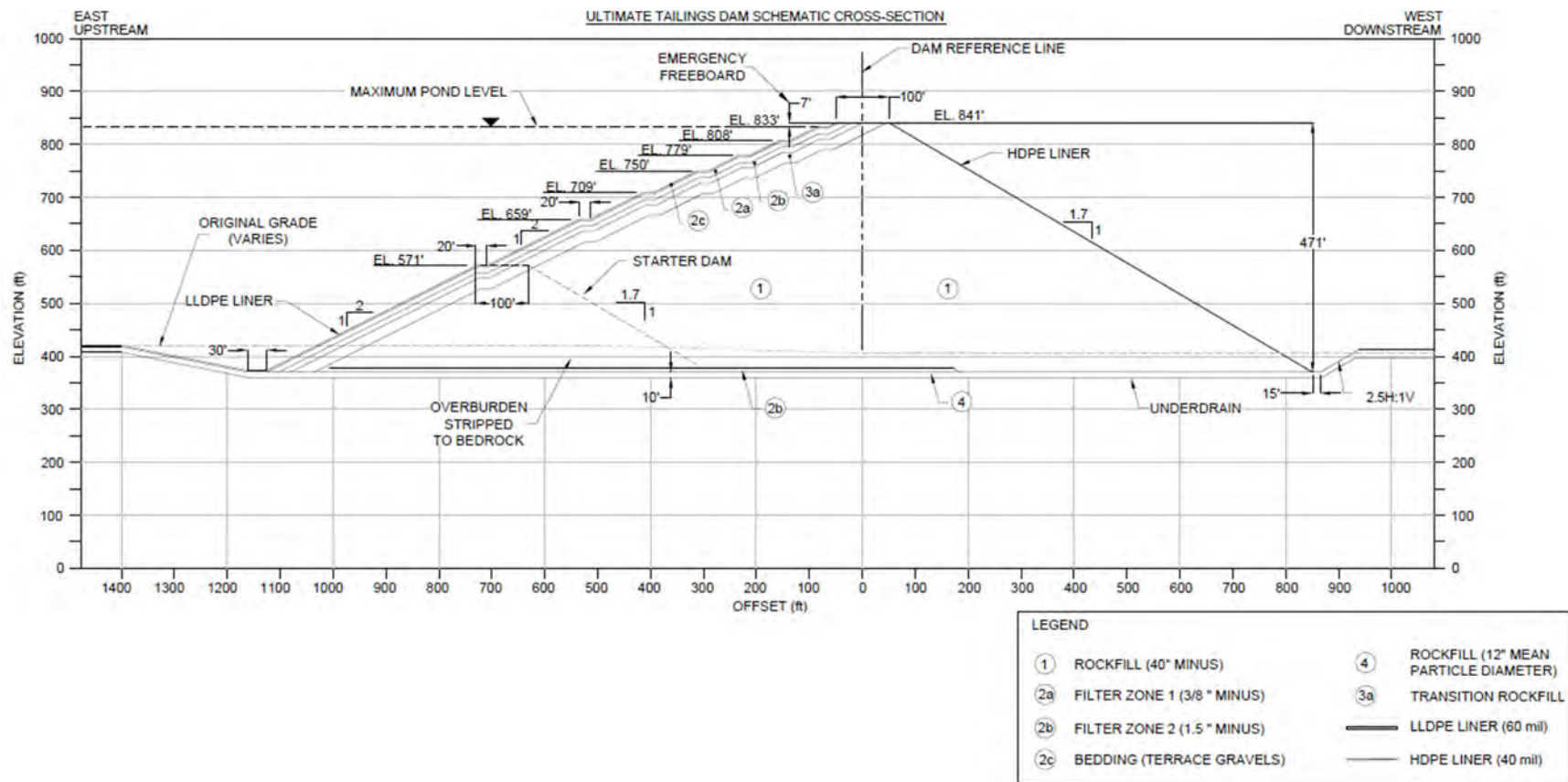


Figure A-3 Ultimate TSF Main Dam schematic cross-section (from BGC, December 2012).

The Donlin Gold TSF will be closed and rehabilitated with a dry closure design. Dry closure means the tailings are consolidated until it gains sufficient strength to be capped with rockfill and soil, and then graded and vegetated to form a stable landform. Several years before the end of operations, the Donlin Gold tailings deposition will be modified to direct the operating pond toward the southeast corner of the TSF (see Figure A-4). This will be done in anticipation of the post closure period, when the tailings cover runoff will be diverted to Crevice Creek through a closure spillway. Water remaining in the impoundment at closure will be pumped to the ACMA pit through the reclaim pipeline. The downstream faces of the TSF Main Dam will be flattened to 3H:1V at closure and revegetated.

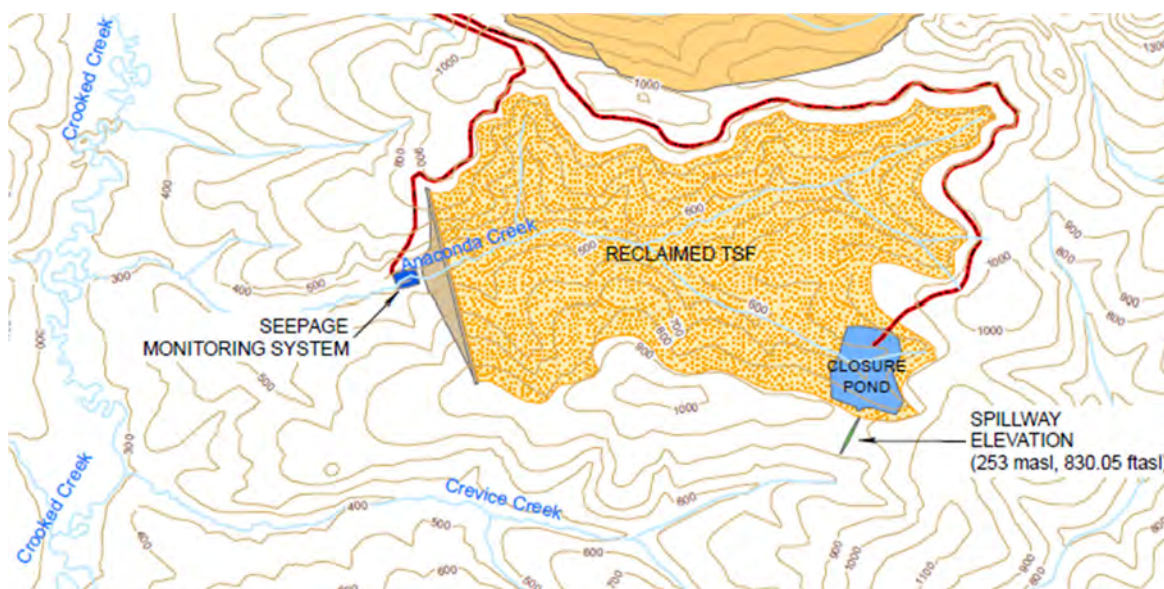


Figure A-4 Schematic of reclaimed TSF at closure (not to scale) (from SRK, February 2017).

A-3.2 Key Design Features

Table A-3 lists the key features that have been incorporated to provide a robust design for the Donlin Gold TSF.

Table A-3 Donlin Gold TSF key design features.

Design Element	Commentary
Foundation Preparation	The TSF Main Dam foundation will be excavated to remove all soil and highly-weathered bedrock so that the dam embankment is founded on bedrock. Under this condition, the dam embankment foundation is not liquefiable, and foundation materials that are considered unsuitable (e.g., wet, soft, and susceptible to deformations in the thawed state) will be removed. The sound foundation, which has been confirmed in boreholes drilled up to approximately 500 ft (150 m) below the existing ground surface within the dam footprint, minimizes embankment deformations, reduces the potential for collapse, and enhances embankment stability.
Downstream Rockfill Shell	Embankment will be entirely constructed of durable rockfill sourced from quarry or select mine rock. Rockfill will be placed and compacted in lifts to a dense state. The embankment will be raised using the downstream raise construction method.

Design Element	Commentary
Dam Embankment Zone Fills	The dam embankment includes layers of bedding material (Terrace Gravels), two filter materials (1 and 2), transition rockfill, and rockfill (see Figure A-3 - 1) to be protected against internal erosion, and to provide drainage, in the event of dam seepage.
Geomembrane Liner	The upstream face of the embankment is covered with a geomembrane liner, which acts as a low-permeability barrier to seepage. The tailings will also be a low-permeability medium, particularly as it consolidates and densifies.
Underdrain	A rockfill underdrain network will be constructed beneath the geomembrane liner within the lined impoundment and at the full width at the base of the TSF Main Dam. The underdrain serves to convey groundwater and potential leakage through the geomembrane liner across the base of the embankment. This will lower the phreatic level within the embankment and increase the embankment stability.
Seismic Design	For the final detailed design, the seismic stability of embankment will be evaluated based on the results of the site-specific seismic hazard assessment and designed for the maximum credible earthquake (MCE) or 10,000 year return period event.
Flood Management	The TSF will be sized to store the 24-hour probable maximum precipitation plus 200-year snowmelt and considering climate change projections. Non-contact water diversion channels will be constructed around the perimeter of the TSF to divert non-contact runoff from the Anaconda Creek catchment away from the TSF and reduce the volume of water flowing into the TSF and requiring management. The TSF Main Dam will have a minimum freeboard (i.e., vertical distance from the maximum water surface to the lowest point of the dam crest) such that TSF pond water will not overtop the dam due to wave action, even under elevated pond levels or under extreme wind conditions. The TSF is permitted for treatment and discharge of excess water.
Tailings Deposition Plan	The tailings will be partially covered by a supernatant pond during operations. The proposed tailings deposition plan is to create a tailings beach around the entire TSF perimeter, pushing the operating pond toward the center of the facility and away from the upstream face of the TSF Dam.
Seepage Recovery System	A seepage recovery system, comprised of a containment pond and pumping wells, will be installed downstream of the TSF Main Dam to collect groundwater baseflows and possible leakage from the lined TSF impoundment. It is intended to prevent TSF seepage from being discharged to the environment. The collected waters will be pumped back, re-used or treated and discharged.
Instrumentation and Monitoring	Instrumentation will be installed for performance monitoring. Instruments such as vibrating wire piezometers, survey prisms, and slope inclinometers will be installed in the Starter Dam. Additional instruments will be installed with each dam raise and to replace damaged instruments, if applicable. In addition, monitoring wells will be installed downstream of the seepage recovery system from which groundwater samples will be collected for water quality testing.
Closure	During the closure phase, the operating pond will be pumped to the open pit to facilitate dry closure of the TSF. To produce a dry facility post-closure, the tailings cover runoff will be diverted to Crevice Creek through the closure spillway. The TSF cover will act as a growth medium for cover system vegetation. The downstream face of the TSF Main Dam will be flattened to 3H:1V and revegetated as is planned for the tailings surface.

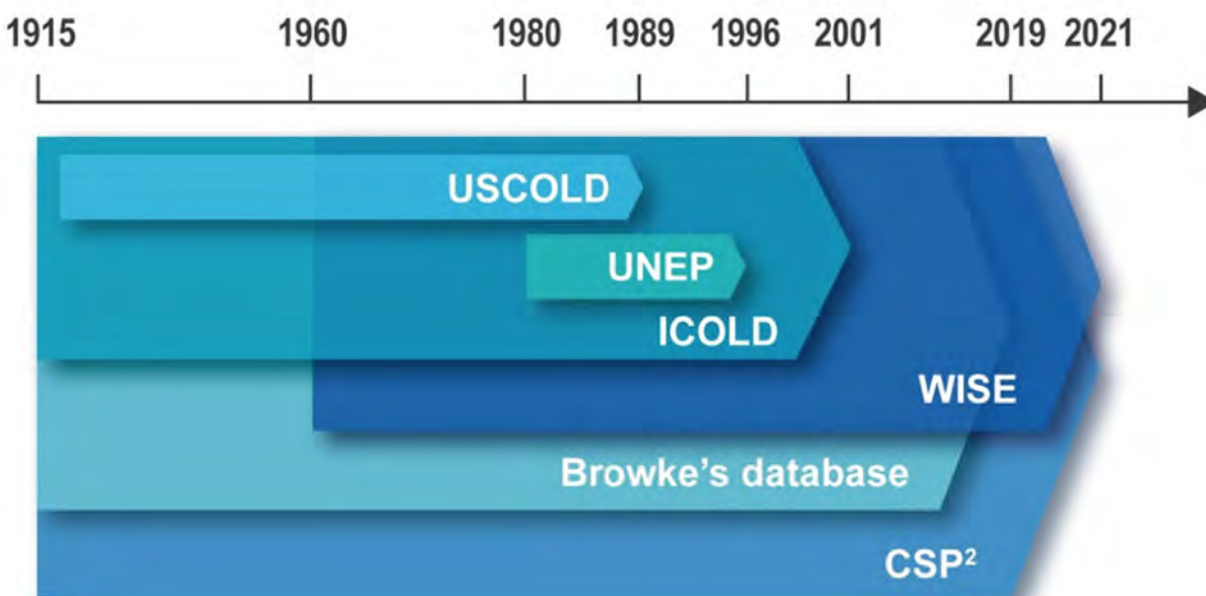
A-4 TSF FAILURE DATABASE AND LITERATURE REVIEW

A-4.1 Literature Review

A literature review has been conducted to identify statistical trends in historical TSF failures. This research is summarized in the following sub-sections.

A-4.1.1 TSF Failure Databases

Tailings dam failure databases widely referenced in the literature (e.g., ICOLD, WISE, World Mining Failures, CSP²) vary in available dam attributes, and have regional, temporal, and magnitude bias. The CSP² tailings dam failure database was used in this study, as it is objectively the most temporally complete, as illustrated in Figure A-5. It has extensive information about the dam attributes that make it suitable for statistical analysis and is considered the most detailed and technically robust failure database publicly available online (Piciullo et al., 2022).



Note: USCOLD = U.S Committee on Large Dams; UNEP = United Nations Environment Programme; ICOLD = International Commission on Large Dams; WISE = World Information Service on Energy; CSP² = Center for Science in Public Participation

Figure A-5 Timeline of tailings dam failure databases (from Piciullo et al., 2022, licensed under the CC BY 4.0).

A-4.1.2 TSF Databases

There are two commonly referenced TSF databases:

- The Global Tailings Portal is a free and publicly available database of over 1,800 tailings dams disclosed by over 100 mining companies worldwide. It is built and hosted by GRID Adrenal in collaboration with the Church of England Pensions Board (Coe) and the Swedish National Pension Funds' Council on Ethics (SNP) and is supported by the

United Nations Environment Programme (UNEP). While accurate and detailed, it is statistically incomplete.

- The Global TSF Registry, led by ICOLD Committee L (Tailings Dams and Waste Lagoons), in partnership with CoE and UNEP, built on the Global Tailings Portal work, and commenced an initiative in 2022 to develop a singular, worldwide geo-census of TSFs. It is currently the most comprehensive tailings dam database available, with over 24,000 TSFs and 44,000 tailings dams verified, as of May 2024, but it is still likely incomplete (Rana et al., 2024).

A-4.1.3 TSF Failure Statistics

Piciullo et al. (2022) reported on a number of TSF failure statistical trends based on 257 dam failures that were considered “Type 1”, defined within the CSP² TSF failure database as “a failure in the dam itself involving an unplanned release of tailings”. BGC reviewed the CSP² database to assess whether the statistical findings reported in Piciullo et al. (2022) remained valid based on more recent TSF failures. Of 399 records in the database from 1915 to present day, a total of 345³ Type 1 failures were found, an increase of 88 failures from the 257 failures reported by Piciullo et al. (2022). The additional failures include a wide range of dates of failure, geographic locations, and causes. Of these additional 88 failures, 24 occurred after Piciullo et al. published in 2022. Attachment 1 lists the 345 recorded Type 1 failures. For clarity, the statistics and descriptions provided below for TSF failures refer to only Type 1 failures.

The proportions of the number of tailings dam failures reported by Piciullo et al. (2022) by cause, dam construction raise method and TSF activity status are illustrated in Figure A-6. These statistics were recalculated by BGC with the additional 88 failures, and were found to be similar to those reported in Piciullo et al. (2022). (i.e., within 6%). Thus, the TSF failure statistics reported by Piciullo et al. (2022) and shown in Figure A-6 are still considered statistically representative.

³ The 54 database records that were filtered out of this study are events that did not result in an unplanned release of tailings.

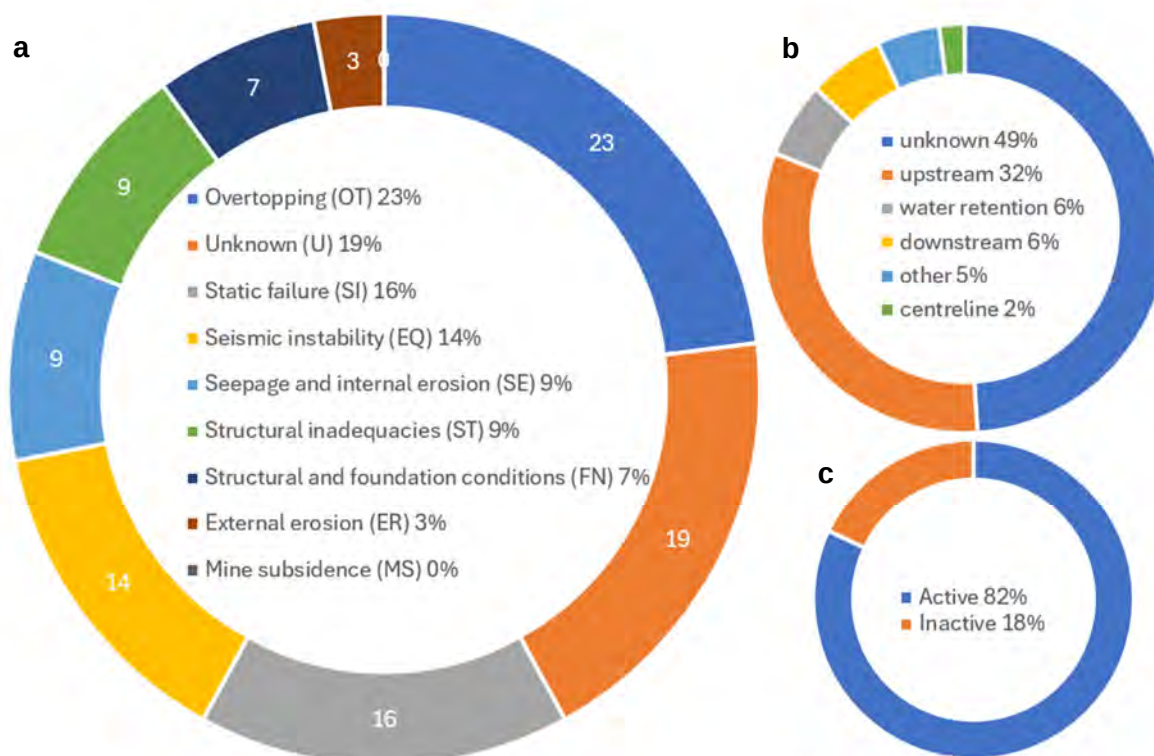


Figure A-6 Proportion of reported tailings dam failures by: a. cause, b. construction raise method, and c. activity status (after Piciullo et al., 2022).

These statistics reveal the following:

- Excluding the unknown cases, overtopping, static failure, and seismic instability are the three most frequently reported causes of failure, accounting for approximately 65% of the reported causes.
- For almost half (49%) of all reported TSF failures, the dam raise construction method was unknown. Where the dam raise construction method has been identified (i.e., excluding the unknown cases), failures of upstream-raised dams have occurred more than five times as often as downstream-raised dams.
- There have been over four times the number of failures in active facilities, defined as facilities where tailings are being deposited and/or construction of the dam is ongoing, compared to inactive facilities.

The CSP² database was further sorted by dam fill type. Of those where the dam fill type was known and reported, only 5% of failures were rockfill (as proposed for Donlin Gold TSF) or waste rock fill dams.

A-4.1.3.1 TSF Failures by Decade

As shown in Figure A-7, the recorded number of Type 1 worldwide tailings dam failures per decade has remained relatively constant since the 1960's (CSP², 2025). As the number of

tailings dams has been rapidly increasing, the failure rates of tailings dams are in fact decreasing (Stark et al., 2022).

The CSP² database does not provide much details on when the tailings dams were constructed, particularly for those dams constructed prior to the year 2000. Thus, it is difficult to assess how evolving regulations, governance, and design standards may have influenced TSF failure rates over time.

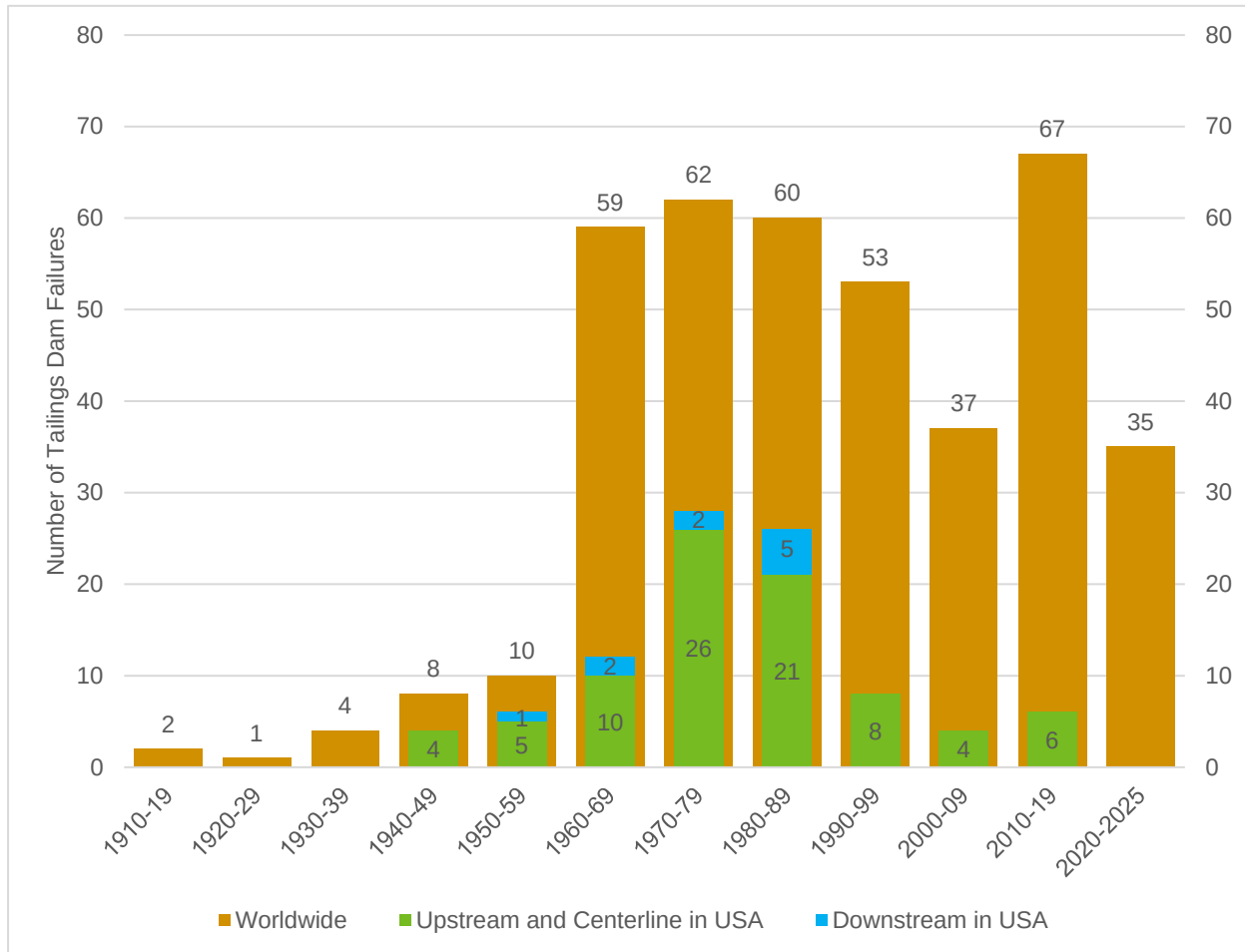


Figure A-7 Number of Type 1 tailings dam failures recorded per decade, worldwide and in the USA, by construction method (CSP², 2025).

A-4.1.3.2 TSF Failure Rates by Geography

The proportion of tailings dam failures is simultaneously decreasing in the developed world (e.g., United States [USA], Canada, United Kingdom) and increasing in the developing world (e.g., Brazil, China, Chile), as economic development and regulatory standards continue to influence failure rates (Lyu et al., 2019). Historically, failure rates in the USA peaked during the rapid development of the 1970s and 1980s, when many dams were constructed in a short time with relatively less governance. Following increased stringency in regulation and adoption of

better practices in the 1990s, TSF failure rates in the USA decreased (Azam & Li, 2010; Davies et al., 2000).

A similar pattern is now observed in developing countries that are experiencing recent economic growth that often outpaces regulatory oversight (Lyu et al., 2019). Geographic bias in the available databases is affected by the lack of transparency in reporting. This shifting distribution of failures also reflects the increasing stringency of regulatory bodies and improvements in engineering best practice in developed regions, as discussed further in Section A-4.1.4.

A-4.1.3.3 TSF Failure Rates by Dam Raise Construction Method

Of all tailings dams constructed, it is estimated that approximately half are raised using the upstream construction method (Section A-2.1), which was the dominant construction method in the 20th century (Rana et al., 2024). An overwhelming amount of peer-reviewed technical research has consistently shown that active upstream dams show the highest incidence of stability concerns, even in high governance settings (e.g., reported by Davies and Martin, 2000; Morgenstern, 2020; Halabi et al., 2022; Piciullo et al., 2022).

This research shows that upstream dams are inherently less stable, due to their reliance on being supported on previously-placed tailings for dam stability (see Figure A-1a). While upstream dams can be constructed safely, they require more careful technical design, operations, and construction oversight. Downstream construction has become the most popular method since 2010, owing to its increased stability (Hudson-Edwards et al., 2024).

Figure A-8 shows the TSF failure rates by dam type, for both worldwide and in the USA (Stark et al., 2022). Failure rates for upstream, centerline, and downstream dam types have decreased worldwide since 2000 (see Figure A-8a). In the USA, TSF failure rates for upstream/centerline/downstream dam types were comparatively higher than worldwide prior to 2000 (see Figure A-8b). As discussed in Section A-4.1.3.2, this trend is attributed to the historical lack of transparency outside of the USA in reporting TSF failures. Since 2000, TSF failure rates for upstream/centerline/downstream dam types in the USA have been much lower than worldwide. The last recorded failure of a downstream raised tailings dam in the USA was 1989 (Stark et al., 2022; CSP², 2025).

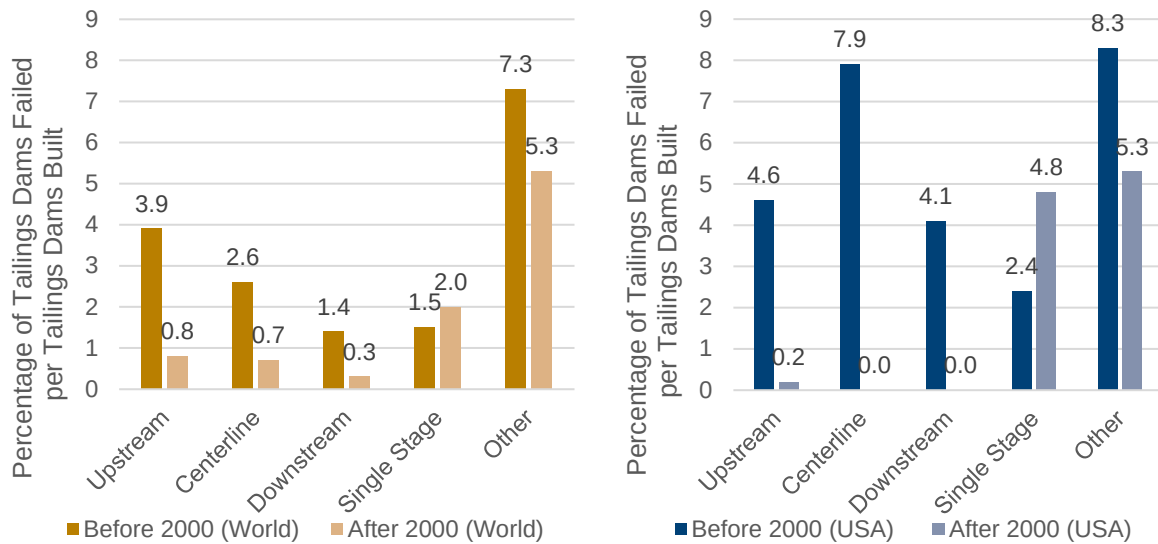


Figure A-8 Percentage of tailings dam failed according to dam type worldwide (from Stark, 2022; data from GRID Adrenal and CSP²).

Of the 94 tailings dam failures in the USA recorded in the CSP2 database (spanning the period of 1940 to 2018), ten were reported to be downstream constructed dams. Eight of the ten failures were for earth fill dams and two were for dams constructed of mine waste; none were reported for rockfill dams as is proposed for the Donlin TSF Main Dam. In fact, only one of the 94 recorded tailings dam failures in the USA was noted to be constructed of waste rock (rockfill), the 1972 Buffalo Creek coal mine TSF that failed due to overtopping and was an upstream constructed dam (see Table 1-1 in Attachment 1 for further details).

A-4.1.3.4 TSF Failure Rates by Dam Height

Tall tailings dams are found to fail at a lower rate, as shown in Figure A-9 (Stark et al., 2022). This figure shows lower dam failure rates with increasing dam height, which is attributed to additional design, analysis, instrumentation, monitoring, inspection, and external peer review for high tailings dams (Stark et al., 2022). The Donlin Gold TSF Main Dam is designed with an ultimate height of 471 ft (144 m), in the dam height class (i.e., greater than 100 m) associated with the lowest historical failure rate.

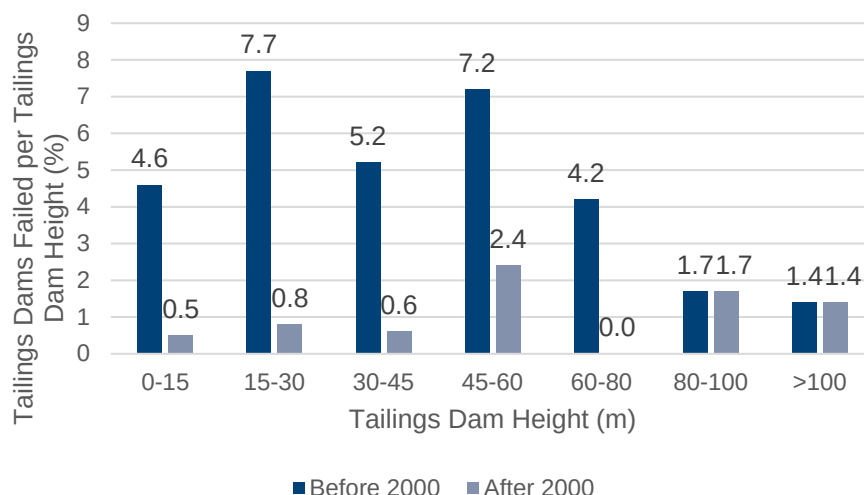


Figure A-9 Failure rate of tailings dam by dam height (from Stark, 2022; data from GRID Adrenal and CSP²).

A-4.1.3.5 TSF Failure Rates in High Seismic Hazard Zones

Approximately 13% of TSFs globally are located in high or very high seismic hazard zones, and failure rates “systematically rise as seismic hazard increases” (Hudson-Edwards et al., 2024). That said, not all high-seismic regions have reported TSF failures. North America and Oceania (i.e., Indonesia/Papua New Guinea/New Zealand) have largely avoided quake-induced TSF failures, owing to quality earthquake engineering (Hudson-Edwards et al., 2024). Notably, the massive 2010 Chile (M8.8) and 2011 Japan (M9.0) earthquakes resulted in no known tailings dam breaches, reflecting improved design for seismic loads in recent decades (Hudson-Edwards et al., 2024). The Donlin Gold TSF will be designed to withstand seismic loads that have been determined based on a site-specific seismic hazard assessment.

A-4.1.4 State of Practice, Governance, and Risk Management in TSF Design

The development of internationally unified and adopted standard management guidelines has been primarily driven by major TSF failures and their devastating consequences over the past decade (e.g., Global Tailings Review, 2020; ICMM, 2021). Standard practice in TSF design has an increased emphasis on the level of practice and the level of governance.

The level of practice is defined by how well failure modes are characterized and controlled through monitoring, design, and operational procedures. A facility with a high level of practice is thoroughly characterized, has robust procedures, and implements additional controls in response to new information (Russell et al., 2025).

The level of governance is the extent to which governance systems, policies, and accountabilities are established and implemented for dam safety (Russell et al., 2025).

Governance recommendations in standard management guidelines include the following types of activities (Global Tailings Review, 2020):

- Appointment of responsible persons and accountable executives and efficient communication channels among them.
- Independent Tailings Review Board (ITRB) and Dam Safety Reviews (DSRs).
- Regular inspections and risk assessments.
- Timely action on review recommendations.
- Planning and budgeting for closure and post-closure activities.

The impacts of improved practice and governance of TSFs are challenging to quantify but are estimated to reduce the probability of failure by one order of magnitude each (i.e., two orders of magnitude combined) (Russell et al., 2025).

In the USA, tailings dam failures peaked during the 1970s and 1980s, a period when mine production expanded rapidly and many facilities were constructed in short timeframes using design approaches that were less mature than modern practice (Azam & Li, 2010; U.S. EPA, 1994). There were seven major tailings dam failures in the USA between 1965 and 1985, including the upstream constructed 1972 Buffalo Creek failure that resulted in 125 fatalities. These failures resulted in additional national regulations on tailings dam safety in the USA (Ellingwood et al., 1993). The dramatic reduction in failure rates after 1990 is linked to several important shifts in regulation, engineering practice, and governance.

Key regulatory reforms, including the 1977 Surface Mining Control and Reclamation Act (SMCRA), the 1976 Resource Conservation and Recovery Act (RCRA), and the expansion of state-level dam safety programs. In Alaska, the DNR dam safety guidelines have further increased regulatory scrutiny and formalized independent geotechnical review for large tailings facilities (DNR, July 2017). These introduced clearer permitting processes, enhanced inspection authority, and evolving stability criteria for mining impoundments in the USA and Alaska. The industry has adopted more rigorous geotechnical dam design methods, including improved seepage control, filter and drain design, better understanding of liquefaction, more conservative factors of safety, and increased use of downstream and centerline construction raise methods rather than upstream methods (Davies & Martin, 2000). Governance improvements also played a major role, including requirements for independent technical review, clearer definition of engineer-of-record (EoR) responsibilities, formalized operations, maintenance, and surveillance (OMS) programs, and the incorporation of failure case histories into design practice (ICOLD, 2001; Blight, 2010; Global Tailings Review, 2020). Together, these changes produced a change in dam safety culture and contributed to the sustained decline in tailings dam failures across the USA since the early 1980s, as evidenced by the statistics in Figure A-7.

A-4.2 TSF Failure Case Studies

A literature review was conducted to identify case studies where the root cause(s) of historical TSF dam failures were documented by independent technical experts. As discussed in Section A-4.1.1, a total of 345 failures listed in the CSP² database resulted in the release of tailings. From this list of 345 failures, 20 described the root cause(s) of the TSF failures in independent technical review reports or technical journal papers through assessment of field investigations, laboratory testing, and engineering analyses.

The 20 TSF failure case studies span the period of 1965 to 2023 (Figure A-10). Of the 20 failures, nine and eleven failures occurred prior to and following the year 2000, respectively, reflecting both historical and modern conditions.



Figure A-10 Timeline of the selected TSF failure case studies.

The selected case studies have detailed dam attributes in the CSP² database, as reproduced in Attachment 2, Table 2-1. Descriptions of the failure event and the root cause, as determined by the independent technical experts, are provided in Table 2-2.

The 20 case studies have release volumes estimated to range from 85,000 m³ to 43,700,000 m³, or approximately 1% to 100% (median = 26%) of the TSF storage volume.

A-4.3 Case Studies Comparison to Donlin Gold TSF

The selected TSF failure case studies were reviewed to assess whether the failure mode(s) could apply to the proposed Donlin Gold TSF summarized in Table A-4. Table A-4 also describes the key features that have been incorporated in the Donlin TSF dam design to mitigate against the failure mode(s).

Table A-4 Comparison of TSF case studies failure modes and their likelihood for the Donlin Gold TSF.

TSF Failure	Root Cause(s)	How the Root Cause is Addressed in the Donlin Gold TSF design
El Corazón	Rupture in geomembrane, which was the exclusive reliance for containment; lack of engineered filters or drainage systems. (Emerman, 2023)	Engineered filters beneath the liner and an underdrain have been included in dam design to protect against internal erosion and provide drainage. Over time, low permeable tailings will be deposited directly against the geomembrane.
Jagersfontein	Static liquefaction of tailings in upstream construction with previously deposited tailings in the foundation. Undrained strengths were not considered (University of Pretoria and University of the Witwatersrand, 2024)	Dam is proposed to be constructed using downstream raise methods. Dam will be founded on bedrock foundation, which has been investigated to more than 50 m.
Brumadinho	Static liquefaction of tailings in upstream construction. Tailings were loose, saturated, and brittle. (Robertson et al., 2019)	Dam is proposed to be constructed using downstream raise methods. Dam will be founded on bedrock.

TSF Failure	Root Cause(s)	How the Root Cause is Addressed in the Donlin Gold TSF design
Cadia	Deformation of a weak, brittle foundation layer (volcanic rock, weathered to a residual soil) beneath the embankment, static liquefaction of tailings in upstream construction. (Jeffries et al., 2019)	Dam is proposed to be constructed using downstream raise methods. No weak layers have been identified within the foundation strata near the TSF Main Dam area (see point 1, below).
Fundao (Samarco)	Static liquefaction of loose sand underlain by slimes in upstream construction. (Morgenstern et al., 2016)	Dam is proposed to be constructed using downstream raise methods. Dam will be founded on bedrock.
Mount Polley	Glaciolacustrine layer with low shear resistance in the Dam Foundation not identified in site characterization. Chronic excess water and insufficient freeboard. Dam was not designed for undrained strengths. (Independent Expert Engineering investigation and Review Panel, 2015)	No weak layers have been identified within the foundation strata near the TSF Main Dam area (see point 1, below). Dam is designed with adequate freeboard and water management (diversion channels, underdrain, operational plan, permitted discharge) (see point 2, below).
Ajka	Dam was constructed of fly ash and slag. Dam was not constructed as specified. A lack of seepage control in dam design led to buildup in hydraulic pressures and internal erosion in dam. (Banvolgyi, 2018)	Dam embankment will be constructed of rockfill with the upstream face covered with a geomembrane liner, which acts as a low-permeability barrier to seepage from the TSF impoundment. Engineered filters and an underdrain have been included in dam design to protect against internal erosion and provide drainage.
Karamken	High permeability dam materials, chronic leakage and frost susceptible soils in embankment foundation. (Glotov et al., 2018)	Dam will be founded on bedrock (i.e., all soil and highly weathered bedrock that could be considered frost susceptible will be removed). The upstream face of the embankment is covered with a geomembrane liner, which acts as a low-permeability barrier to seepage.
Partizansk (Dalenergo)	TSF was overfilled with tailings and water for the size of the dam and a lack of drainage and monitoring infrastructure. (Robinson, 2004)	Dam is designed with adequate freeboard and water management (diversion channels, underdrain, operational plan, permitted discharge) (see point 2, below). Furthermore, the dam will be instrumented and monitored during operations.
Aitik	Poor filter design and drainage, causing external erosion. (Goransson et al., 2000)	Filter compatible design will prevent internal erosion. Underdrain will maintain low phreatic surface within the dam embankment. Dam is designed with adequate freeboard.
Baia Mare	Inadequate freeboard and drainage caused internal erosion (piping), paired with lack of monitoring and maintenance. (Baia Mara Task Force, 2000)	Dam is designed with adequate freeboard and water management (diversion channels, underdrain, operational plan, permitted discharge) (see point 2, below).
Los Frailes	Weak clay layers in foundation, led to large deformation and loss of freeboard, exacerbated by lack of monitoring. (Williams, 2021)	No weak layers have been identified within the foundation strata near the TSF Main Dam area (see point 1, below).

TSF Failure	Root Cause(s)	How the Root Cause is Addressed in the Donlin Gold TSF design
Omai (Cambior)	Filter incompatibility causing internal erosion (piping). (DRT, 1996)	Engineered filters and an underdrain have been included in dam design to protect against internal erosion and provide drainage.
Merriespruit (Harmony)	Insufficient freeboard, as designed, combined with poor surface water management. (Blight, 1998)	Dam is designed with adequate freeboard and water management (diversion channels, underdrain, operational plan, permitted discharge) (see point 2, below).
Tapo Canyon	Cyclic liquefaction of tailings in upstream construction. (Harder and Stewart, 2006)	Dam is proposed to be constructed using downstream raise methods. Dam foundation will be founded on bedrock.
Stava	Upstream construction on geological unsuitable site; block in decant pipe without redundancy. (Berti et al, 1988)	Dam is proposed to be constructed using downstream raise methods. Dam will be founded on bedrock. No decant pipe is required for drainage in the Donlin Gold TSF.
Churchrock	Differential settlement in foundation soils, and dispersive embankment soils when exposed to low pH uranium tailings. (Nelson & Kane, 1980)	Dam will be founded on bedrock. Differential foundation settlement shown to be negligible in analysis.
Bafokeng	Internal erosion caused by high phreatic surface, combined with static liquefaction of tailings in upstream construction. (Blight, 1998)	Dam is proposed to be constructed using downstream raise methods. Dam will be founded on bedrock.
El Cobre Old Dam	Cyclic liquefaction of tailings in upstream construction. (Williams, 2021)	Dam is proposed to be constructed using downstream raise methods. Dam will be founded on bedrock.
Cerro Negro No. (3 of 5)	Cyclic liquefaction of tailings in upstream construction. (Dobry and Alvarez, 1967)	Dam is proposed to be constructed using downstream raise methods. Dam will be founded on bedrock.

Of the 20 failure case studies reviewed, eight were attributed to liquefaction of tailings materials for upstream construction raises. This failure mode is extremely unlikely to occur at the Donlin Gold TSF because of the proposed downstream construction raise method and because the dam will be founded on bedrock.

Five case studies have failure modes that have been considered for the Donlin Gold TSF. These include the following two root causes that have been specifically considered and mitigated against through the Donlin Gold TSF's design stages:

1. Poor site characterization was found to be the root cause of the Mount Polley and Los Frailes failures. In both cases, weak clay layers in the soil foundation were not properly characterized in site investigation. Within the Donlin TSF Main Dam ultimate footprint, a total of 51 overburden boreholes, 25 diamond drillholes (i.e., with cored rock) and 43 test pits have been completed. Field and laboratory testing of the soil and rock have been completed, as have geophysical surveys. The adequacy of the site investigations completed will be assessed by the Alaska DNR as part of dam safety permitting. As previously discussed, all soil and highly weathered bedrock are proposed to be removed from the dam foundation.

2. Poor water management and inadequate freeboard were found to be the root causes of the Baia Mara, Partizansk (Dalenergo), Mount Polley, and Merriespruit failures. In these cases, they were designed with inadequate freeboard due to poor understanding of the water balance of the facility (i.e., management and control of all water inflows, outflows, unpredictable fluctuations such as storms) or were simply over-filled with water and tailings for the size of the dams. That is, these failures were predictable events, caused by inadequate design, and could have been prevented with a data-informed water balance and/or following industry-standard practices for tailings and water management. The Donlin Gold TSF is designed for extreme precipitation and snowmelt events, and accounts for climate change. A site-specific climate analysis has been completed for the Donlin Gold Project to inform the climate hydrology inputs used in design. Donlin Gold is also permitted to treat and discharge excess water at the project site, including water from the TSF. Commensurate with best practices, continuous monitoring, review, and assessments of the water balance and available freeboard will be carried out throughout operations and closure to maintain adequate freeboard and mitigate against the potential of overtopping of the TSF Main Dam.

Of the 20 case studies described above, construction began prior to 1999 in 18 cases. As discussed in Section A-4.1.4, the state of practice and scrutiny of regulation and governance have improved markedly since then. While ITRBs have recently become common practice at all stages of tailings dam design, construction, operations and closure, ITRBs were notably not found to be established at the time of failure, in public record, for all 20 case studies. Improved governance alone could have mitigated against the failure modes studied. An ITRB was established for the Donlin Gold Project between 2007 and 2015 and restarted with new board members in 2024. Finally, during the dam permitting review, the Alaska DNR, Dam Safety and Construction Unit, will retain outside experts to review the TSF and dam design.

The Donlin Gold TSF design is governed by risk-informed decision-making and independent review. When constructed, the performance of the TSF will be continuously monitored. The design and proposed operations approach align with the GISTM and ICMM guidelines. The governance structure and adherence to international standards reflect the sector's progression towards safer and more resilient tailings management.

A-5 CLOSURE

We trust the above satisfies your requirements. Should you have any questions or comments, please do not hesitate to contact us.

Yours sincerely,

BGC Engineering Alaska Inc.
per:



Jack Seto, M.Sc., P.E.
Principal Geotechnical Engineer

A handwritten signature in blue ink, appearing to read "Christy Rouault", followed by a stylized star symbol.

Christy Rouault, M.Sc., P.Eng. (Canada)
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Principal Geotechnical Engineer

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JTCS/EC/gc/js

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ATTACHMENT 1

CSP² TAILINGS DAM FAILURES

RECORDS



Table 1-1 Tailings dam failure records from the CSP² database.

Tailings Dam Failure	Country ²	Ore Type	Dam Type ³	Dam Fill ⁴	Dam Height (m)	Storage (m³)	Type Key ⁵	Type Cause ⁶	Incident Date	Release Volume (m³)	Runout (km)	Deaths
Andavilque, Llallagua, Potosí, Bolivia (Corporación Minera de Bolivia - Comibol)	Bolivia	Sn				~21 million tons	B	ER	16-Mar-25		5	2
Chambishi, Sino Metals (China Nonferrous Metal Mining Corp), Zambia	Zambia	Cu					A	SE	18-Feb-25	80,000	100	
Iduapriem mine, Beposa TSF (AngloGold Ashanti Iduapriem Limited), Tarkwa, Western Region, Ghana	Ghana	Au					A		17-Feb-25	80,000	1.7	
Seikmu Village Tract, Hpakant, Kachin state, Myanmar	Myanmar	Jade			3		A	ST	13-Jan-25			12
Las Cenizas mine (Grupo Minero Las Cenizas S.A.), Cabildo, Chinchorro, Peñablanca, Valparaíso region, Chile	Chile	Cu					A	SE	13-Jun-24			
Siana in Surigao del Norte, Philippines (TVI Resource Development Philippines Inc/Greenstone Resources Corporation)	Philippines	Au					B		11-May-24		0.3	
El Corazón mine (Agroindustrial El Corazón S.A), Imbabura, Ecuador	Ecuador	Au	DS		5	55,000	A	SE	4-Nov-23			
Williamson Mine, Mwadui Lohumbo, Kishapu District, Shinyanga Province, Tanzania (Petra Diamonds-75% and the Government of Tanzania-25%)	Tanzania	Diamonds	Modified CL	Sand	26	25,760,000	A	SI	7-Nov-22	12,800,000	7.5	
Jagersfontein, South Africa (De Beers, a unit of Anglo American)	South Africa	Diamonds	US			22,000,000	A	ST	11-Sep-22	6,000,000	63	3
Agua Dulce, Potosí, Bolivia (Federación Departamental de Cooperativas Mineras de Potosí (Fedecomín))	Bolivia	Ag, Zn					A		23-Jul-22			
Shanxi Daoer Aluminum Co, Wenquan Township Jiaokou County, Shanxi Province, China	China	Al					A	ST	27-Mar-22	224,000		
QMM Mandena Mine (QIT Madagascar Minerals / Rio Tinto)	Madagascar	Ti					A	OT	17-Feb-22			
Thelkoloï, in Odisha, India (JSW Bhushan Power and Steel Limited)	India	Fe					A		20-Jan-22			
MMK Chrome smelter, (MMK - Metallurgy Industry Trade and Port Management Inc), Toroslar district of Mersin, Turkey	Turkey	Cr					A		12-Jan-22			
Pau Branco mine, Quadrilátero Ferrífero region, Brazil (Vallourec)	Brazil	Fe					A	OT	8-Jan-22			
Zululand Anthracite Colliery (ZAC) coal mine, KwaZulu-Natal, South Africa	South Africa	Coal					A	ST	24-Dec-21	1,500		
San Antonio de María mine, Ananea Puno Minería, La Rinconada, Ananea district, Peru	Peru	Au					A	OT	26-Nov-21			
Nesko Madencilik AŞ (Yıldızlar Holdings) Şebinkarahisar district, Giresun Province, Turkey	Turkey	Cu, Pb, Zn					A	SI	18-Nov-21	> 4,500	5	
Rio Panusco SA de CV, municipality of Concordia, Sinaloa State, Mexico	Mexico	Ag Cu Pb Zn					B	OT	13-Oct-21			
Catoca Mine, Angola (Angolan state diamond company Endiama-41% and Russia's Alrosa-41%)	Angola	Diamonds					A	OT?	15-Jul-21		100	12
Aurizona mine, Maranhão, Brazil (Equinox Gold)	Brazil	Au					A	OT	25-Mar-21			
Rongxing Investment Limited, Chambishi, Zambia	Zambia	Cu					A	ST	15-Oct-20		0.2	
Sasa Tailings Storage Facility 4, central Macedonia (Central Asia Metals)	North Macedonia	Pb, Zn, Ag					A		14-Sep-20			
Ponce Enríquez, Azuay Province, Equador (Austro Gold)	Equador	Au					A	ST	2-Jul-20	50		
San José de Los Manzanos, Canelas, Durango, Mexico (Exportaciones de Minerales de Topia SA - EMITSA)	Mexico	Pb, Zn					A	OT	1-May-20	6,000	5	
Sasan Ultra Mega Power Project, Harrahva in Singrauli district of Madhya Pradesh, India (Reliance Company)	India	Ash					A		10-Apr-20		7.7	6
Yichun Luming Mining, Heilongjiang Province, China (China Railway Resources Group)	China	Mo	US				A	ST	28-Mar-20	2,530,000	208	
Nossa Senhora do Livramento, Mato Grosso, Brazil (VM Mineração e Construção, Cuiabá)	Brazil	Au			15	580,000	A		1-Oct-19		2	
Cobriza mine, San Pedro de Coris district, Churcampa province, Huancavelica region, Peru (Doe Run Perú S.R.L)	Peru	Cu	US				A		10-Jul-19	67,488	375	
Muri, Jharkhand, India (Hindalco Industries Limited)	India	Al					B	ST	9-Apr-19		0.2	
Machadinho d'Oeste, Oriente Novo, Rondônia, Brazil (Metalmig Mineração Indústria e Comércio S/A)	Brazil	Sn					B		29-Mar-19			
Brumadinho, Mina Córrego do Feijão, Minas Gerais, Brazil (Vale)	Brazil	Fe	US	T	87	12,000,000	B	SI	25-Jan-19	9,570,000	600	270
Duke Energy, L.V. Sutton Power Station, Wilmington, North Carolina.	United States	Ash				2,100,000	B	OT	20-Sep-18			
Duke Energy, HF Lee Power Plant, Goldsboro, North Carolina	United States	Ash				875,000	B	OT	20-Sep-18	2,000		
Cieneguita mine, Urique municipality, Chihuahua, Mexico (Minera Rio Tinto and Pan American Goldfields)	Mexico	Au Ag	US				A	SI	4-Jun-18	439,000	26	5
Hector Mine Pit Pond, MN, USA	United States	Fe			17	185,000	B	OT	24-Apr-18	123,000		
Cadia, New South Wales (Newcrest Mining)	Australia	Cu Au	DS / US	MW	94		A	FN	9-Mar-18	1,330,000	0.5	
Huancapetí, Recuay province, Áncash region, Peru (Compañía Minera Lincuna SA, Grupo Picasso)	Peru	Au, Cu					A	U	3-Mar-18	80,000		
Barcarena, Pará, Brazil , Alunorte (Hydro Alu Norte/Norsk Hydro ASA)	Brazil	Al					A	OT	17-Feb-18			
Hernic PGM Project, South Africa (Jubilee Metals Group)	South Africa	Cr		MW	39	4,875,000	A	U	29-Dec-17			
Kokoya mine, Liberia (MNG Gold-Liberia)	Liberia	Au					A	ST	23-Sep-17	11,356		
Vedanta Aluminium Limited Smelter Ash Pond, Jharsuguda, India	India	Al					A	U	28-Aug-17	2,625,000		
Mishor Rotem, Israel (Rotem Amfert Negev Ltd.,Israel Chemicals (ICL))	Israel	P	US		60		A	SI	30-Jun-17	100,000	20	
La Zarza, Huelva, Andalusia, Spain (Ormonde Mining Plc)	Spain	Cu					B	OT	17-May-17	270,000	53	
Husab, Namibia (Swakop Uranium (Taurus Minerals))	Namibia	U					A	OT	May-17			
Highland Valley Copper, British Columbia, Canada (Teck Resources)	Canada	Cu		Sand	140		A	ER	8-Apr-17	850	0	
Tonglvshan Mine, Hubei Province, China (China Daye Ltd.)	China	Cu Au Ag Fe					A		12-Mar-17	200,000	0.5	2
Antamok, Baguio, Philippines (Philex)	Philippines	Au					B	ST	28-Oct-16	50,000		
Duke Energy Coal Ash, Goldsboro, North Carolina	United States	Coal				415,000	B	OT	1-Oct-16			
Luoyang, Dahegou Village, Henan Province, China (Luoyang Xiangjiang Wanji Aluminium Co., Ltd.)	China	Al	US	MW	45	2,000,000	A	SI	8-Aug-16	2,000,000	2	
Kazzinc Mining & Metallurgical Company (Glencore) - Concentrator TSF, Ridder (once called Leninogorsk), Kazakhstan	Kazakhstan	Pb Zn					A	ST	22-May-16		~100	
Fundao-Santarem (Germano), Minas Gerais, Brazil (Samarco = Vale & BHP)	Brazil	Fe	US	MW	110	56,400,000	A	ST	5-Nov-15	43,700,000	668	19
Herculano Iron Mine, Itabirite, Minas Gerais, Brazil	Brazil	Fe			61.5	4,500,000	A	U	10-Sep-14			3
Buenavista del Cobre mine, Cananea, Sonora, Mexico (Grupo Mexico)	Mexico	Cu					A	SI	7-Aug-14	40,000		
Imperial Metals, Mt Polley, British Columbia, Canada	Canada	Cu Au	Modified CL	MW	40	74,000,000	A	FN	4-Aug-14	23,600,000	7	

Tailings Dam Failure	Country ²	Ore Type	Dam Type ³	Dam Fill ⁴	Dam Height (m)	Storage (m³)	Type Key ⁵	Type Cause ⁶	Incident Date	Release Volume (m³)	Runout (km)	Deaths
Stolice mine, Northwestern Serbia (Farmakom MB)	Serbia	Sb				1,200,000 tonnes	B	OT	7-Jul-14	100,000		
Queensland Nickel, Yabulu Refnery, Townsville, Australia	Australia	NI					A	OT	13-Apr-14	80,000		
Monte Neme (Leitosa S.A.), Coruña, Galicia, Spain	Spain	W, Sn					B		10-Feb-14	24,000		
Dan River Steam Station, North Carolina (Duke Energy)	United States	Coal			12	155,000,000	A	ST	2-Feb-14	334,000		
Obed Mountain Coal Mine Alberta, Canada	Canada	Coal					B	U	31-Oct-13	670,000	180	
Coalmont Energy Corporation, Basin Coal Mine	Canada	Coal					A	OT	24-Aug-13	30	30	
Casa Berardi Mine, La Sarre, Abitibi region, Quebec (Hecla Mining Company)	Canada	Au					B	OT	May-13	57,000		
El Herrero mine, Otáez, Barrancas province, Durango state, Mexico (Grupo Minero Bacís, Durango)	Mexico	Au Ag						OT	20-Jan-13	300,000	130	4
Gullbridge Mine, Newfoundland, Canada	Canada	Cu	DS	E	7	800,000	B	SI	17-Dec-12	100,000	0.5	
Sotkamo, Kainuu Province, Finland (Talvivaara)	Finland	Ni Cu Zn U			25	5,400,000	A	SE	4-Nov-12	240,000		
Padcal No 3, Benquet Philippines (Philex)	Philippines	Au Cu				102,000,000	A	OT	2-Aug-12	13,000,000		
Hudson Bay (HB) Mine, Salmo, British Columbia (Regional District of Central Kootenay & Teck)	Canada	Pb Zn			25	1,800,000	B	SE	11-Jul-12			
Johson Gold Mining Corporation at Baranggay Bangong-Bayan	Philippines	Au					A	ER	13-Apr-12			
Mineracao Serra Grande Tailings Dam, State of Goias, Brazil (Anglo Ashanti)	Brazil	Au	CL				A	OT	1-Jan-12	900		
Mianyang City, Songpan County, Sichuan Province, China	China	Mn					A	OT	21-Jul-11	10,000		
Ray Mine, Hayden, AZ, USA (Asarco)	United States	Cu					A	ST	5-May-11	3,600		
Bloom Lake, Newfoundland, Canada (Cleveland Cliffs)	Canada	Fe					A	U	May-11	200,000		
Kayakari, Japan	Japan	Au Ag	US		36	400,000		EQ	11-Mar-11	41,000		2
Ajka Alumina Plant, Kolontár, Hungary (MAL Magyar Aluminum)	Hungary	Al	DS	Compacte d Fly Ash	22	30,000,000	A	SE	4-Oct-10	1,000,000		10
Zijin Mining, Xinyi Yinyan Tin Mine, Guangdong Province, China	China	Sn					A	OT	21-Sep-10			22
Huancavelica, Peru, Unidad Minera Caudalosa Chica	Peru	Ag Cu Pb Zn			10		A	SE	25-Jun-10	100,000	110	
Las Palmas, Penciahue, VII Region, Maule, Chile (COMINOR)	Chile		DS	CST	15	220,000	B	EQ	27-Feb-10	170,000	0.5	4
Veta del Agua Tranque No. 5, Nogales, V Region, Valparaíso, Chile	Chile	Cu	US	CST	16	80,000	B	EQ	27-Feb-10	30,000	0.1	
Tranque Adosado Planta Alhué, Alhué, Region Metropolitana, Chile	Chile		DS		15		A	EQ	27-Feb-10			
Tranque Planta Chacón, Cachapoal, VI Region, Rancagua, Chile	Chile						B	EQ	27-Feb-10			
Tranque Adosado Planta Alhué, Alhué, Region Metropolitana, Chile (Florida Mining)	Chile		US				B	EQ	27-Feb-10			
Karamken, Magadan Region, Russia (cyanide-leach processing facility of gold mines in the region)	Russia	Au			27	4,600,000	B	ST	29-Aug-09	1,200,000		2
Huayuan County, Xiangxi Autonomous Prefecture, Hunan Province, China	China	Mn					A	U	14-May-09	50,000		3
Kingston fossil plant, Harriman, Tennessee, USA (TVA)	United States	Coal	US				A	U	22-Dec-08	4,100,000	4.1	
Taoshi, Linfen City, Xiangfen county, Shanxi province, China (Tahsan Mining Co.)	China	Fe	US	WR	50.7	290,000	A	SI	8-Sep-08	190,000	2.5	277
Shiqiaozi, Haicheng, Liaoning, China (Dingyang Mining Co Ltd, subsidiary of Xiyang Corp)	China	Fe			10	150,000		SE	25-Nov-07			10
Bernburg, Germany (Solvay)	Germany	Limestone	US		22		A	SI	Feb-07	150,000		
Glebe Mines, Cavendish Mill, UK	United Kingdom	F	US	E			B	OT	22-Jan-07	20,000		
Mineracao Rio Pomba Cataguases, Mirai, Minas Gerais, Brazil, Mineração (Industrias Quimicas Cataguases)	Brazil	Al			35	3,800,000	A	OT	10-Jan-07	2,000,000		
Fonte Santa ,Freixia De Espado a Cinta, Potugal	Portugal	?	DS	E	25		B	OT	27-Nov-06	231,600	2.5	
Miliang, Zhen'an County, Shangluo, Shaanxi Province, China	China	Au					A	ST	30-Apr-06		5	17
Mineracao Rio Pomba Cataguases, Mirai, Minas Gerais, Brazil, Mineração (Industrias Quimicas Cataguases)	Brazil	Al					A	U	Mar-06	400,000		
Lafayette Mining Polymetallic, Rapu Rapu Island, Albay, Philippines	Philippines	Au					A	OT	Oct-05			
Tailings Dam, USA	United States	Cu	US	E	43	500,000	A	SE	26-May-05	170,000	25	
Bangs Lake, Jackson County, Mississippi, USA (Mississippi Phosphates Corp)	United States	P					A	ST	14-Apr-05	64,350		
Partizansk, Primorski Krai, Russia (Dalenergo)	Russia	Coal	Ring			20,000,000	A	U	22-May-04	160,000		
Malvésí, Aude, France (Comurhex, Cogéma/Areva)	France	U					A	U	20-Mar-04	30,000	0.7	
Cerro Negro, Petorca Province, Quinta region, Chile (Cia Minera Cerro Negro), (5 of 5)	Chile	Cu	US	T			A	EQ	3-Oct-03	80,000	20	
Sasa Mine, Macedonia	North Macedonia	Pb Zn	US			2,000,000	A	ST	30-Aug-03	100,000	12	
Mineracao Rio Pomba Cataguases, Mirai, Minas Gerais, Brazil, Mineração (Industrias Quimicas Cataguases)	Brazil	Al					A	U	2003	1,200,000		
El Cobre, Chile - El Soldado (Exxon)	Chile	Cu	US	T			B	OT	8-Nov-02	4,500		
El Cobre, Chile, 2, 3, 4, 5 (Exxon)	Chile	Cu	US	T			B	OT	22-Sep-02	8,000		
San Marcelino Zambales, Philippines, Bayarong dam (Benguet Corp-Dizon Copper-Silver Mines Inc)	Philippines	Cu Au				47,000,000	B	OT	11-Sep-02	1,000,000		
San Marcelino Zambales, Philippines, Camalca dam (Benguet Corp-Dizon Copper-Silver Mines)	Philippines	Cu Au					B	OT	27-Aug-02			
Sebastião das Águas Claras, Nova Lima district, Minas Gerais, Brazil	Brazil	Fe					A	U	22-Jun-01		8	2
Nandan Tin mine, Dachang, Guangxi Province, China	China	Sn	US				A	U	18-Oct-00			28
Inez, Martin County, Kentucky, USA (Massey Energy subsidiary Martin Co. Coal Corp)	United States	Coal				7,500,000	A	FN	11-Oct-00	1,068,500	120	
Aitik mine, near Gällivare, Sweden (Boliden Ltd)	Sweden	Cu	DS	MW & E	15	15,000,000	A	ER	8-Sep-00	1,800,000	5.2	
Borsa, Romania (Remin S.A - govt)	Romania	Pb Zn					A	OT	10-Mar-00	20,000		
Baia Mare, Romania (Aurul S.A.,Esmeralda Exploration)	Romania	Au	DS then US	T	7	800,000	A	ST	30-Jan-00	100,000	100	
Toledo City, Philippines (Atlas Con Mining Corp)	Philippines	Cu					B	ST	9-Aug-99	5,700,000		
Red Mountain, BC	Canada	Au Ag	Jumbo				A	SE	5-Jun-99	10,000		
Huelva, Spain (Fertiberia, Foret)	Spain	P					A	OT	31-Dec-98	50,000		
Zamboanga Del Norte, Sibutad Gold Project (Philex Mining Corp)	Philippines	Au					A	OT	27-Jun-98			
Los Frailes, near Seville, Spain (Boliden Ltd.)	Spain	Pb Zn	DS	WR	27	15,000,000	A	FN	25-Apr-98	6,800,000	41	
Zamboanga Del Norte, Sibutad Gold Project (Philex Mining Corp)	Philippines	Au					A	OT	6-Nov-97			

Tailings Dam Failure	Country ²	Ore Type	Dam Type ³	Dam Fill ⁴	Dam Height (m)	Storage (m³)	Type Key ⁵	Type Cause ⁶	Incident Date	Release Volume (m³)	Runout (km)	Deaths
Pinto Valley, Arizona, USA (BHP Copper)	United States	Cu	US				B	SI	22-Oct-97	230,000		
Tranque Antiguo Planta La Cocinera, IV Region, Vallenar, Chile	Chile		US/CL		30		A	EQ	14-Oct-97	60,000	0.15	
Algarrobo, IV Region, Vallenar, Chile	Chile	Fe	US		18		A	EQ	14-Oct-97			
Algarrobo, IV Region, Vallenar, Chile	Chile	Fe	US		20		A	EQ	14-Oct-97			
Maitén, IV Region, Vallenar, Chile	Chile		US		15		A	EQ	14-Oct-97			
Amatista, Peru	Peru		US				B	EQ	12-Nov-96	600,000		
Caravelí, Peru	Peru						B	EQ	12-Nov-96			
El Porco, Bolivia (Comsur-62%, Rio Tinto-33%)	Bolivia	Pb Zn					A	U	29-Aug-96	166,000	300	
Majdanpek, Serbia, Šaški Potok tailings dam, (RTB Copper Mines)	Serbia	Cu							9-May-96	350,000		
Sgurigrad, Bulgaria	Bulgaria	Pb Zn	US	T	45	1,520,000	A	SI	01-May-96	220,000	6	
Marcopper, Marinduque Island, Philippines (2 of 2) (Placer Dome and President Marcos)	Philippines	Cu	Open Pit			15,000,000	B	ST	24-Mar-96	1,600,000	26	
Laisvall (Boliden), Sweden	Sweden	Pb,Zn, Ag	Unk	tailings & moraine	40	20,000,000	A	ER	1996	0		
Negros Occidental, Bulawan Mine Sipalay River, Philippines (Philex Mining Corp)	Philippines	Au					A	U	8-Dec-95			
Golden Cross, Waitekauri Valley, New Zealand (Coeur d'Alène Mines)	New Zealand	Au		R	25-30	3,000,000	A	FN	Dec-95			
Surigao del Norte Placer, Philippines (2 of 3) (Manila Mining Corp)	Philippines	Au	WR	E	17		B	FN	2-Sep-95	50,000		12
Omai Mine, Tailings dam No 1, 2, Guyana (Cambior)	Guyana	Au	WR	R	44	5,250,000	A	ER	19-Aug-95	4,200,000	80	
Middle Arm, Launceston, Tasmania	Australia	Au	CL	E	4	25,000	A	OT	25-Jun-95	5,000		
Hopewell Mine, Hillsborough County, Florida, USA (IMC-Agrico)	United States	P					A	U	19-Nov-94	1,900,000		
Payne Creek Mine, Polk County, Florida, USA (IMC-Agrico)	United States	P					A	U	2-Oct-94	6,800,000		
Merriespruit, near Virginia, South Africa (Harmony) - No 4A Tailings Complex	South Africa	Au	US paddock	T	31	7,040,000	B	OT	22-Feb-94	600,000	4	17
Minera Sera Grande: Crixas, Goias, Brazil	Brazil	Au	DS then US	CST	41	2,250,000	A	SI	Feb-94	0		
Tapo Canyon, Northridge, California	United States	Aggregate	US	T	24		B	EQ	17-Jan-94	135,000	0.2	
Fort Meade, Florida, Cargill phosphate (3 of 3)	United States	P					A	U	Jan-94	76,000		
Longjiaoshan, Daye Iron Ore mine, Hubei	China	Fe	US				A	U	Jan-94			31
Magma Copper Company Pinto Valley Division Pinto Valley Operations, Arizona	United States	Cu					A	OT	Jan/Feb-93	90,000		
Marcopper, Marinduque Island, Mogpog Philippines(12/6) (1 of 2) (Placer Dome-President Marcos)	Philippines	Cu					A	U	6-Dec-93			2
TD 7, Chingola, Zambia	Zambia	Cu	US	T&E	5		A	OT	1-Aug-93	42		
Itogon-Suyoc, Baguio gold district, Luzon, Philippines (Benguet Corp)	Philippines	Au Ag					A	OT	26-Jun-93			
Saaiplaas, South Africa, failure on south ring dyke (22Mar93)	South Africa	Au	US	CST	28		A	SI	22-Mar-93	100		
Saaiplaas, South Africa, 2 failures on west ring dyke (18-19Mar93)	South Africa	Au	US	CST	28		A	SI	18-Mar-93	100		
Ray Complex, Pinal County, Arizona, AB-BA Impoundment	United States	Cu	US		46		A	OT	9-Jan-93	216,000	18	
Marsa, Peru (Marsa Mining Corp)	Peru	Au					A	OT	1993			6
Kojkovac, Montenegro	Montenegro	Pb Zn	WR	E		3,500,000	B	ER	Nov-92	-		
Maritsa Istok 1, Bulgaria	Bulgaria	Coal		Ash	15	52,000,000	A	ER	1-Mar-92	500,000		
Tubu, Benguet, No.2 Tailings Pond, Luzon, Philippines - Padcal (Philex)	Philippines	Cu				102,000,000	A	FN	2-Jan-92	32,243,000		
Ajka Alumina Plant, Kolontár, Hungary	Hungary	Al	DS	Compacte d Fly Ash	25	4,500,000	A	ST	3-Nov-91	43,200		
Sullivan Mine, Kimberley, BC, Canada (Cominco, Inc)	Canada	Pb Zn	US		21		A	SI	23-Aug-91	75,000		
Magma Mine Tailings Dam #3	Philippines	Cu	US				A	SI	4-Jan-91	8,000		
Brewer Gold Mine Jefferson South Carolina	United States	Au					A	U	1-Nov-90	41,640	80	
Matachewan Mines, Kirtland Lake, Ontario	Canada	Pb					A	U	17-Oct-90	190,000	168	
Soda Lake, California, USA	United States	Na	US	E	3		B	EQ	17-Oct-89			
Stancil, Maryland, USA	United States	Sand	US	E	9	74,000	A	SI	25-Aug-89	38,000	0.1	
Silver King, Idaho, USA	United States	Ag Pb	DS	E	9	37,000	B	OT	5-Aug-89	100		
Southern Clay, Tennessee, USA	United States	Clay	WR	E	5		A	SE	09-Jul-89	300		
Little Bay Mine (Atlantic Coast Copper Co), Little Bay, Newfoundland and Labrador, Canada	Canada	Cu				1,250,000	B		1989	500,000		
Big Four, Florida, USA	United States	P	CL	E			B	FN	1989			
Thompson Creek, Idaho, USA (Cyprus)	United States	Mo	CL	CST	146	27,000,000	B	SE	1989			
Unidentified, Hernando, County, Florida, USA #2	United States	Limestone	US	E	12	3,300,000	A	OT	Sep-88	4,600		
Jinduicheng, Shaanxi Province., China	China	Mo	US		40		A	OT	30-Apr-88	700,000		20
Consolidated Coal No.1, Tennessee, USA,	United States	Coal	DS	MW	85	1,000,000	B	ST	19-Jan-88	250,000		
Riverview, Hillsborough County, Florida (Gardiner/Cargill)	United States	P					A	ER	1988	246		
Unidentified, Hernando, County, Florida, USA #1	United States	Limestone	DS	E	12		B	FN	1988			
Surigao Del Norte Placer, Philippines (1 of 3) (Manila Mining Corp)	Philippines	Au					A	U	9-Jul-87			
Montcoal No.7, Raleigh County, West Virginia, USA	United States	Coal					A	U	8-Apr-87	87,000	80	
Bekovsky, Western Siberia	Siberia	Coal	US	Argillite, aleurolite	53	52,000,000	A	SI	25-Mar-87	0		
Xishimen, China	China	Fe	US	T	31		A	SI	21-Mar-87	2,230		
Marianna Mine #58, PA	United States	Coal	US	E	37	300,000	A	SI	19-Nov-86			
Mankayan District, Luzon, Phillippines, No.3 Tailings Pond (Benguet Corp subsidiary Lepanto Con Mining Co)	Philippines	Cu Au		E			A	ST	17-Oct-86	100,000		
Pico de Sao Luis, Gerais, Brazil	Brazil	Fe		T	20		A	ER	2-Oct-86			
Story's Creek, Tasmania	Australia	Sn	Valley side		17	30,000	B	OT	16-May-86	100		
Rossarden, Tasmania	Australia	Sn	WR	E	7.5	200,000	B	OT	16-May-86			

Tailings Dam Failure	Country ²	Ore Type	Dam Type ³	Dam Fill ⁴	Dam Height (m)	Storage (m³)	Type Key ⁵	Type Cause ⁶	Incident Date	Release Volume (m³)	Runout (km)	Deaths
Itabirito, Minas Gerais, Brazil (Itaminos Comercio de Minerios)	Brazil	Fe	Gravity	Masonry	30		A	ST	May-86	100,000	12	7
Mineral King, BC, Canada	Canada	Pb Zn	CL	CST	6	Small	B	OT	20-Mar-86			
Huangmeishan, China	China	Fe					A	SE	1986			19
Spring Creek Plant, Borger, Texas, USA	United States	Sand			5	30,000	A	OT	1986			
Bonsal, North Carolina, USA	United States	Sand	WR	E	6	38,000	A	OT	17-Aug-86	11,000	0.8	
Niujiaolong tailings pond, China	China	Cu	US	T	40	1,100,000	A	OT	25-Aug-85	730,000	4.2	
Stava, North Italy, Prestavel Mine (Prealpi Mineraria)	Italy	F	US	CST	29.5	400,000	A	SI	19-Jul-85	180,000	4.2	269
La Belle, Pennsylvania, USA	United States	Coal	DS	MW	79	1,230,000	B	FN	17-Jul-85			
Cerro Negro No. (4 of 5)	Argentina	Cu	US	CST	40	2,000,000	A	EQ	3-Mar-85	500,000	8	
Veta de Agua No. 1, Chile	Chile	Cu	US	T	24	700,000	A	EQ	3-Mar-85	280,000	5	
Marga, Chile - El Teniente (Codelco)	Chile	Cu					B	OT	1985			
Niujiaolong, Hunan (Shizhuyuan Non-ferrous Metals Co.)	China	P	US		40	1,100,000	A	U	1985	731,000	4.2	49
Olinghouse, Nevada, USA	United States	Au	WR	E	5	120,000	A	SE	1985	25,000	1.5	
El Cobre No. 4 - El Soldado (Exxon)	Cuba	Cu	DS	CST	50		A	EQ	1985			
Texasgulf 4B Pond, Beaufort, Co., North Carolina, USA	United States	P	WR	T	8	12,300,000	B	SI	Apr-84			
Mirolubovka, Southern Ukraine	Ukraine	Fe	US	E&T	32	80,000,000	A	SI	15-Jan-84	0		
Battle Mt. Gold, Nevada,	United States	Au	DS	E	8	1,540,000	A	SI	1984			
Virginia Vermiculite, Louisa County, Virginia, USA	United States	Vermiculite	WR	E	9		A	ST	1984			
Vallenar 1 and 2	Chile	Cu					B	OT	1983			
Sipalay, Philippines, No.3 Tailings Pond (Maricalum Mining Corp)	Philippines	Cu		MW		22,000,000	A	FN	8-Nov-82	15,000,000		
Royster, Florida, USA	United States	Gypsum	US	T	21		A	FN	1982			
Ages, Harlan County, Kentucky, USA	United States	Coal					A	U	18-Dec-81	96,000	163	1
Dixie Mine, Colorado, USA	United States	Au					B	U	Apr-81			
Balka Chuficheva, Russia	Russia	Fe	US	CST	25	27,000,000	A	SI	20-Jan-81	3,500,000	1.3	
Texasgulf No. 1 Pond, Beaufort Co., North Carolina, USA	United States	P	WR	E		24,700,000	B	SI	1981			
Veta de Aqua A	Mexico	Cu					A	EQ	1981			
Veta de Aqua B	Mexico	Cu					A	EQ	1981			
Tyrone, New Mexico (Phelps Dodge)	United States	Cu	US	CST	66	2,500,000	A	SE	13-Oct-80	2,000,000	8	
Sweeney Tailings Dam, Longmont, Colorado, USA	United States	Sand			7		A	SE	May-80			
Marga, Sewell, VI Region, Rancagua, Chile - El Teniente (Codelco)	Chile	Cu					B	OT	Jun-05			
Arena, Sewell, VI Region, Rancagua, Chile - El Teniente (Codelco)	Chile	Cu					B	OT	Jun-05			
San Nicolas, Peru	Peru						B	ST	1980			
Kyanite Mining, Virginia, USA	United States	Kyanite			11	430,000	B	OT	1980			
Churchill Copper, BC	Canada	Cu					A	SE	1-Dec-79	37,854		
Churchrock, New Mexico, United Nuclear	United States	U	CL	E	11	370,000	A	FN	16-Jul-79	370,000	110	
Unidentified, British Columbia, Canada	Canada	?					A	FN	1979	40,000		
Suncor E-W Dike, Alberta, Canada	Canada	Oil Sands	WR	MW	30		B	SI	1979			
Arcturus, Zimbabwe	Zimbabwe	Au	US	T	25	680,000	A	OT	31-Jan-78	39,000	0.3	1
Mochikoshi No. 2, Japan (2 of 2)	Japan	Au	US	T	19	480,000	A	EQ	15-Jan-78	3,000	0.24	
Norosawa, Japan	Japan	Au	DS		24	225,000	B	EQ	15-Jan-78			
Mochikoshi No. 1, Japan (1 of 2)	Japan	Au	US	T	28	480,000	A	EQ	14-Jan-78	80,000	8	1
Hirayama, Japan	Japan	Au	DS		9	87,000	B	EQ	1978			
Syncrude, Alberta, Canada	Canada	Oil Sands	CL	T			B	FN	1978			
Madison, Missouri, USA	United States	Pb	WR	E	11		A	OT	28-Feb-77			
Grants, Milan, New Mexico, USA mill site (Homestake Mining)	United States	U	US	T	21		A	ST	1-Feb-77	30,000		
Western Nuclear, Jeffrey City, Wyoming, USA #2	United States	U					A	SI	1977	8,700		
Pit No. 2, Western	United States	REE	US	T	9		A	SI	1977			
Kerr-McGee, Churchrock, New Mexico, USA	United States	U	WR	E	9		A	FN	Apr-76			
Zlevoto No. 4, Yugoslavia	Yugoslavia	Pb Zn	US	T	25	1,000,000	A	SI	1-Mar-76	300,000		
Dashihe, China	China	Fe	US		37		A	EQ	1976			
Unidentified, Idaho, USA	United States	P	DS	E	34		B	SI	1976			
Cadet No. 2, Montana,	United States	Barite	CL	E	21		A	SI	Sep-75			
Silverton, Colorado, USA	United States	Au Ag					A	U	Jun-75	72,500		
Madjarevo, Bulgaria	Bulgaria	Pb Zn	US	T	40	3,000,000	A	ST	Apr-75	250,000	20	
Carr Fork, Utah, USA (Anaconda)	United States	Cu Au			10		A	ST	Feb-75			
Heath Steele main dam, Brunswick, Canada (American Metals)	Canada	Pb Zn	WR	R,E	30		A	FN	1975			
Mike Horse, Montana, USA (Asarco)	United States	Pb Zn	US	T	18	750,000	B	OT	1975	150,000	24	
Dresser No. 4, Montana,	United States	Barite	CL	E	15		A	FN	1975			
Keystone Mine, Crested Butte, Colorado, USA	United States	Mo					B	U	1975			
Bafokeng, South Africa	South Africa	Pt	US	T	20	13,000,000	A	SE	11-Nov-74	3,000,000	45	12
Golden Gilpin Mine, Colorado, USA	United States	Au			12		B	U	Nov-74			
Deneen Mica Yancey County, North Carolina, USA	United States	Mica	US	CST	18	300,000	A	SI	1-Jun-74	38,000	0.03	
Majdanpek, Serbia, Valja Fundata tailings dam, (RTB Copper Mines)	Serbia	Cu					A	ST	21-Jan-74	7,000,000		
Silver King, Idaho, USA	United States	Ag	DS	E	9	37,000	A	OT	16-Jan-74	13,600		

Tailings Dam Failure	Country ²	Ore Type	Dam Type ³	Dam Fill ⁴	Dam Height (m)	Storage (m³)	Type Key ⁵	Type Cause ⁶	Incident Date	Release Volume (m³)	Runout (km)	Deaths
Galena Mine, Idaho, USA (ASARCO) (2 of 2)	United States	Ag Pb	US	MW	9		A	OT	15-Jan-74	3,800	0.61	
Berrien, France	France	Ag Pb	US	R	9		A	SE	1974			
GCOS, Alberta, Canada	Canada	Oil Sands	US	T	61		A	SI	1974			
Unidentified, Mississippi, USA #2	United States	Gypsum	US	T	20		A	FN	1974			
Unidentified, Canaca, Mexico	Mexico	Cu	US	T	46		A	OT	1974			
Ray Mine, Arizona, USA #2 (Kennecott)	United States	Cu	US	T	52		A	SI	5-Feb-73			
(unidentified), Southwestern USA	United States	Cu	US	E	43	500,000	A	SI	1973	170,000	25	
Earth Resources, N M,	United States	Cu	US	T	21		A	OT	1973			
Ray Mine, Arizona, USA	United States	Cu	US	T	52		A	SI	2-Dec-72			
Brunita Mine, Caragena, Spain (SMM Penaroya)	Spain	Zn, Pb, Cu	US	MW	25	1,080,000	A	OT	20-Oct-72	70,000		1
Buffalo Creek, West Virginia, USA (Pittson Coal Co.)	United States	Coal	US	WR	16	500,000	A	OT	26-Feb-72	500,000	64.4	125
Galena Mine, Idaho, USA (ASARCO) (1 of 2)	United States	Ag Pb	US	E	14		A	ER	1972			
Fort Meade, Florida (Cities Service)	United States	P	CL	E	15	12,340,000	A	U	3-Dec-71	9,000,000	120	
Certej gold mine, Romania	Romania	Au Ag	US		25		A	SI	30-Oct-71	300,000		89
Chungar, Peru	Peru						A	EQ	19-Mar-71			yes
Pinchi Lake, BC, Canada	Canada	Hg	WR	E	13		A	ER	1971			
Ticapampa, Peru	Peru				20		B	EQ	1971			3
Atacocha, Peru (Compañía Minera Atacocha)	Peru	Cu, Pb, Zn					B	St	1971			
Quiruvilca mine, Almirvica tailings dam, Peru (2 of 2)	Peru	Cu Ag Pb Zn			40		A	EQ	1971			
Western Nuclear, Jeffrey City, Wyoming, USA	United States	U					A	ST	1971			
Mufulira, Zambia (Roan Consolidated Mines)	Zambia	Cu			50	1,000,000	A	MS	Sep-70	68,000		89
Maggie Pye, United Kingdom	United Kingdom	Clay	US	T	18		A	SI	Jan-70	15,000	0.035	
Park, United Kingdom	United Kingdom	Clay	WR	T	3		A	OT	1970			
Portworthy, United Kingdom	United Kingdom	Clay	DS	R	15		A	ST	1970			
Unidentified, Mississippi, USA	United States	Gypsum	US	T	15		A	OT	1970			
Williamsport Washer, Maury County, Tennessee, USA	United States	P			21		A	U	1970			
Phoenix Copper, BC	Canada	Cu	US				A	SE	12-Sep-69	11,356		
Bilbao, Spain	Spain	Fe					A	SI	1969	115,000	0.035	1
Buenaventura, Peru	Peru						B	EQ	1969			
Monsanto Dike 15, TN,	United States	P	DS	E	43	1,230,000	A	SE	1969			
Stoney Middleton, UK	United Kingdom	?					A	SI	8-Feb-68			
Yauli-Yacu, Peru	Peru		US		80		B	EQ	1969			
Hokkaido, Japan	Japan	Pb Zn	US	T	12	300,000	A	EQ	1968	90,000	0.15	
Agrico Chemical, Florida, USA	United States	P					A	U	1968			
Climax, Grand Junction, CO, USA - Mill (Climax Molybdenum Co)	United States	U					A	U	2-Jul-67	12,000		
Fort Meade, Florida (Mobil Chemical)	United States	P					A	U	Mar-67	2,000,000		
Iwiny Tailings Dam, Poland	Poland	Cu	US	E		16,000,000	A	MS	1967	4,600,000	15	18
Unidentified, United Kingdom	United Kingdom	Coal	DS		20		A	SI	1967			
Unidentified, United Kingdom #2	United Kingdom	Coal	DS	MW	14		A	SI	1967			
Unidentified, United Kingdom #3	United Kingdom	Sand	DS	E	30		A	SE	1967			
Mir mine, Sgurigrad, Bulgaria	Bulgaria	Pb Zn	US	T	45	1,520,000	A	OT	May-66	450,000	8	488
Williamthorpe, UK #2	United Kingdom	Coal					A	FN	24-Mar-66			
Gypsum Tailings Dam (Texas, USA)	United States	Gypsum	US	T	16	6,360,000	A	SE	1966	130,000	0.3	
Williamthorpe, UK #1	United Kingdom	Coal		MW			A	OT	1966			
Derbyshire, United Kingdom	United Kingdom	Coal	DS		8		B	FN	1966	30,000	0.1	
Tymawr, United Kindom #2	United Kingdom	Coal			12		A	OT	29-Mar-65		0.7	
La Patagua New Dam, Chile (La Patagua - private)	Chile	Cu	US	T	15	100,000	A	EQ	28-Mar-65	35,000	5	
Los Maquis No. 3	Chile	Cu	US		15	43,000	A	EQ	28-Mar-65	21,000	5	
Hierro Viejo, Chile	Chile	Cu	US	T	5		A	EQ	28-Mar-65	800	1	
Ramayana No. 1, Chile	Chile	Cu	US	T	5		A	EQ	28-Mar-65	150		
Cerro Blanco de Polpaico, Chile	Chile	Limestone	WR	R	9		A	EQ	28-Mar-65			
El Cerrado, Chile	Chile	Cu	US	T	25		B	EQ	28-Mar-65			
Los Maquis No. 1	Chile	Cu	US	T	15	30,000	B	EQ	28-Mar-65	20,000		
Sauce No. 1, Chile	Chile	Cu	US	T	6		A	EQ	28-Mar-65			
Sauce No. 2, Chile	Chile	Cu	US	T	5		B	EQ	28-Mar-65			
Sauce No. 3, Chile	Chile	Cu	US		5		B	EQ	28-Mar-65			
Sauce No. 4, Chile	Chile	Cu	US	T	5		B	EQ	28-Mar-65			
Cerro Negro No. (3 of 5)	Argentina	Cu	US	T	20	500,000	A	EQ	28-Mar-65	85,000	5	
Cerro Negro No. (2 of 5)	Argentina	Cu	US	T	46		B	EQ	28-Mar-65			
Cerro Negro No. (1 of 5)	Argentina	Cu	US	T	46		B	EQ	28-Mar-65			
El Cobre Old Dam	Cuba	Cu	US	T	35	4,250,000	A	EQ	28-Mar-65	1,900,000	12	200
El Cobre New Dam	Cuba	Cu	DS	CST	19	350,000	A	EQ	28-Mar-65	350,000	12	
Bellavista, Chile	Chile	Cu	US	T	20	450,000	A	EQ	28-Mar-65	70,000	0.8	
El Cobre Small Dam - El Soldado (Penarroya)	Cuba	Cu	US	T	26	985,000	B	EQ	28-Mar-65			

Tailings Dam Failure	Country ²	Ore Type	Dam Type ³	Dam Fill ⁴	Dam Height (m)	Storage (m³)	Type Key ⁵	Type Cause ⁶	Incident Date	Release Volume (m³)	Runout (km)	Deaths
American Cyanamid, Florida #2	United States	P					A	U	1965			
N'yukka Creek, USSR	USSR	?	WR	E	12		A	FN	1965			
Unidentified, Idaho, USA	United States	P	DS	E	18		A	SI	1965			
Alcoa, Texas, USA	United States	Al			19	4,500,000	A	U	1-Oct-64			
Castano Viejo Mine, San Juan, Argentina	Argentina	Cu Ag Pb Zn	Wood	T	9	26,500	A	SE	1964	17,000	2.2	3
El Descargador, Cartagena-La Unión, Murcia province, Spain (Belleza Group)	Spain	Pb, Zn, Ag						SI	14-Oct-63	66,000		
Louisville, USA	United States	Carbide			31	910,000	A	SE	1963	667,000	0.1	
Huogudu, Yunnan Tin Group Co., Yunnan	China	Sn	US		19	5,420,000	A	U	26-Sep-62	3,300,000	4.5	171
Mines Development, Edgemont, South Dakota, USA	United States	U					A	U	11-Jun-62	100	40	
American Cyanamid, Florida	United States	Gypsum					A	U	1962	11,356,230		
Quiruvilca mine, Almivirca tailings dam, Peru (1 of 2)	Peru	Cu Ag Pb Zn			40		A	EQ	1962			
Union Carbide, Maybell, Colorado, USA	United States	U					A	U	6-Dec-61	280		
Tymawr, United Kingdon #1	United Kingdom	Coal					A	OT	Dec-61		0.7	
Jupille, Belgium	Belgium	Coal			46	550,000	A	SE	1961	136,000	0.6	11
La Luciana, Reocín (Santander), Cantabria, Spain	Spain		US	T	24	1,250,000	A	SI	17-Aug-60	100,000	0.5	18
San Finx (Industrias Gallegas S.A.), Lousame, La Coruña, Galicia, Spain	Spain	W, Sn			10		B	ST	1960			
Union Carbide, Green River, Utah, USA	United States	U					A	OT	19-Aug-59	8,400		
Mailuu-Suu #7 tailings dam (Kyrgyzstan)	Krygyzstan	U				1,200,000	A	EQ	16-Apr-58	600,000	40	2
Milpo, Peru	Peru				60		B	EQ	1956			yes
Grootvlei, South Africa	South Africa	Au	US	T			A	SI	1956			
Unidentified, Peace River, Florida, USA 3/52	United States	P	WR	E	8		A	SI	Mar-52			
Unidentified, Alfaria River, Florida, USA 2/52	United States	P	WR	E	8		A	SI	Feb-52			
Casapulca, Peru (Centromin)	Peru	Cu Ag Pb Zn	US		60		B	EQ	1952			yes
Unidentified, Peace River, Florida, USA 9/51	United States	P	WR	MW	6		A	SE	Sep-51			
Unidentified, Peace River, Florida 7/51	United States	P	WR	MW	30		A	SE	Jul-51			
Unidentified, Peace River, Florida, USA 2/51	United States	P	DS	E			A	SE	Feb-51			
Sullivan Mine, Kimberley, BC, Canada	Canada	Pb Zn	US	T			A	SI	1948	1,100,000		
Castle Dome, Arizona, USA	United States	Cu	US	T			A	SE	29-Sep-47	150,000	0.1	
Hollinger, Canada	Canada	Au	US	T	15		A	FN	1944			
Kennecott, Utah, USA	United States	Cu	US	T			A	FN	1942			
Captains Flat Dump 3, Australia	Australia	Cu		T			A	U	1942	40,000		
Kennecott, Garfield, Utah, USA	United States	Cu	US	T			A	SI	1941			
St. Joe Lead, Flat Missouri, USA	United States	Pb	US	T	15		A	OT	1940			
Captains Flat Dump 6A, Australia	Australia	Cu	US	T			A	SI	1939			
Abercyon, UK	United Kingdom	Coal			37		A	SI	1939	164,000	0.6	
Los Cedros, Tlalpujahua, Michoacán, México	Mexico	Au Ag	US	T	35	11,480,000	B	ST	27-May-37	2,500,000	11	300
Simmer and Jack, South Africa	South Africa	Au	US	T			A	SI	1937			2
Barahona, Chile	Chile	Cu	US	CST	61	20,000,000	A	EQ	10-Jan-28	2,800,000		54
Unidentified, South Africa	South Africa	Au					A	U	1917			
Agua Dulce, Sewell, VI Region, Rancagua, Chile	Chile	Cu			61		A	OT	15-Jun-15	180,000		

- Notes:
1. Data from CSP² (2025), unless stated otherwise.
 2. Country has been extracted from the record title.
 3. Dam-Type Key: US = Upstream, DS = Downstream, CL = Centerline, WR = Water retention, NR = Not reported.
 4. Type Key: A = Active dam failure, B = Inactive dam failure.
 5. Dam fill Material Key: T = Tailings, CST = Cycloned sand, MW = Mine waste, E = Earthfill, R = Rockfill.
 6. Type Cause Key: SI = Slope Instability; EQ = Seismic Instability / Earthquake; SE = Seepage and Internal Erosion; FN = Weak Foundation; OT = Overtopping; ST = Collapse of Structural Elements; ER = External Erosion / Eros8ioin by Nearby Waterways; U = Unknown

ATTACHMENT 2

TSF FAILURE CASE STUDIES



Table 2-1 Select failure case histories details¹.

TSF	Date (dd-mm-yy)	Country	Dam Raise Method	Dam Height (m)	Storage Volume (m³)	Dam Fill Material	Release (m³)	Release as % of Storage Volume	Runout (km)	Deaths	Cause ²
El Corazón	4-Nov-23	Ecuador	Downstream	5	55,000	Unknown	Unknown	Unknown	Unknown	Unknown	SE
Jagersfontein	11-Sep-22	South Africa	Upstream	30 ⁽⁴⁾	22,000,000	Tailings ⁽⁴⁾	6,000,000	27%	63	3	ST
Brumadinho	25-Jan-19	Brazil	Upstream	87	12,000,000	Tailings	9,570,000	80%	600	270	SI
Cadia	9-Mar-18	Australia	Downstream / Upstream	94	180,000,000 ³	Mine Waste	1,330,000	1%	0.5	Unknown	FN
Fundao (Samarco)	5-Nov-15	Brazil	Upstream	110	56,400,000	Mine Waste	43,700,000	77%	668	19	ST
Mt Polley	4-Aug-14	Canada	Modified Centerline	40	74,000,000	Mine Waste	23,600,000	32%	7	Unknown	FN
Ajka	4-Oct-10	Hungary	Downstream	22	30,000,000	Compacted Fly Ash	1,000,000	3%	Unknown	10	SE
Karamken	29-Aug-09	Russia	Single Stage	27	4,600,000	Unknown	1,200,000	26%	Unknown	2	ST
Partizansk (Dalenergo)	22-May-04	Russia	Ring		20,000,000	Unknown	160,000	1%	Unknown	Unknown	U
Aitik	8-Sep-00	Sweden	Downstream	15	15,000,000	Mine Waste & Earthfill	1,800,000	12%	5.2	Unknown	ER
Baia Mare	30-Jan-00	Romania	Downstream then Upstream	7	800,000	Tailings	100,000	13%	100	Unknown	ST
Los Frailes	25-Apr-98	Spain	Downstream	27	15,000,000	Waste Rock	6,800,000	45%	41	Unknown	FN
Omai (Cambior)	19-Aug-95	Guyana	Single Stage	44	5,250,000	Rockfill	4,200,000	80%	80	Unknown	ER
Merriespruit (Harmony)	22-Feb-94	South Africa	Upstream paddock	31	7,040,000	Tailings	600,000	9%	4	17	OT
Tapo Canyon	17-Jan-94	USA	Upstream	24	Unknown	Tailings	135,000	Unknown	0.2	Unknown	EQ
Stava	19-Jul-85	Italy	Upstream	29.5	400,000	Coarse Sand Tailings	180,000	45%	4.2	269	SI
Churchrock	16-Jul-79	USA	Centerline	11	370,000	Earthfill	370,000	100%	110	Unknown	FN
Bafokeng	11-Nov-74	South Africa	Upstream	20	13,000,000	Tailings	3,000,000	23%	45	12	SE
El Cobre Old Dam	28-Mar-65	Chile	Upstream	35	4,250,000	Tailings	1,900,000	45%	12	200	EQ
Cerro Negro No. (3 of 5)	28-Mar-65	Chile	Upstream	20	500,000	Tailings	85,000	17%	5	Unknown	EQ

Notes:

1.

Data from CSP² (2025) unless otherwise noted.

2.

Cause Key: SI = Slope Instability; EQ = Seismic Instability / Earthquake; SE = Seepage and Internal Erosion; FN = Weak Foundation; OT = Overtopping; ST = Collapse of Structural Elements; ER = External Erosion / Erosion by Nearby Waterways; U = Unknown

3.

Data from Newmont Corporation's tailings inventory, accessed October 24, 2025: https://s24.q4cdn.com/382246808/files/doc_downloads/2025/08/Newmont-Tailings-Disclosures-2025.pdf

4.

Data from University of Pretoria and University of Witwatersrand, accessed on December 3, 2025: <https://www.dws.gov.za/DSO/Documents/Jagersfontein%20Final%20Report.pdf>

Table 2-2 Select TSF failure case histories; description and cause.

TSF Failure	Description	Root Cause(s)	Reference
El Corazón	The failure occurred in a dam constructed less than 15 m from a creek, violating local regulations requiring a 30 m buffer from streams. The incident was first noticed as muddy, cyanide-laden water seeping from the face of the embankment, with a measured total cyanide concentration over 600 times the Ecuadorian limit. The release caused visible discoloration in downstream rivers and raised concerns about ecological and livestock impacts. Notably, the dam had reportedly been leaking since its construction in 2020, but the failure became apparent only when the seepage began to entrain solids.	The failure was caused by a tear in the geomembrane liner, which allowed water to escape into the embankment and initiate internal erosion (piping). This was fundamentally due to improper design: the dam relied solely on the geomembrane for containment, had excessively steep slopes, lacked engineered drainage and filter systems, and did not destroy cyanide before deposition, making it vulnerable to failure if the liner was compromised.	Emerman, 2023
Jagersfontein	A large section of the dam wall, constructed with tailings material and the upstream dam raise method, collapsed suddenly static liquefaction, releasing millions of cubic meters of liquefied tailings that inundated the downstream community, destroying homes, infrastructure, and causing fatalities and injuries. The failure resulted in extensive environmental and social impacts.	The failure was primarily due to elevated pore water pressures within the tailings mass, coupled with insufficient freeboard and ponding on the TSF surface. This reduced shear strength to undrained strengths, which were not considered in design, and triggered static liquefaction in the upstream constructed portion of the dam. The lack of internal drainage, oversteepening of slopes to angle of repose, absence of buttressing, and reliance on tailings as structural material and in the foundation compounded the risk. . Reports indicated visible seepage, cracks, and instability in the dam wall, but these warning signs were not adequately addressed.	University of Pretoria and University of Witwatersrand, 2024
Brumadinho	The failure was a slope failure, causing the dam to collapse without warning, approximately three years after tailings disposal was terminated. It initiated at the dam crest and propagated down to just above the Starter Dam through weak layers of fine tailings in the dam body, eventually reaching their critical length, resulting in rapid collapse of the entire dam. The dam's crest dropped, the toe region bulged outward, and the dam's surface broke apart. About 75% of the stored volume was released in less than five minutes, resulting in a destructive mudflow downstream.	The root cause was flow (static) liquefaction within marginally stable, iron-rich tailings that were loose, saturated, and brittle due to particle bonding. Contributing factors included an over-steep upstream slope, a setback that placed upper dam raises over weaker fine tailings, persistently high water levels from inadequate internal drainage, and intense wet season rainfall that reduced suction and shear strength in the unsaturated zone. The immediate trigger was a combination of ongoing internal creep and strength reduction from rainfall, culminating in a sudden and complete loss of strength and rapid liquefaction of the tailings.	Robertson et al., 2019
Cadia	The embankment failed, causing a large section of the embankment to slump outward and release tailings. The failure occurred in two phases: first, a slow and progressive movement developed over several months in the foundation, and then a rapid collapse occurred after evacuation, resulting in a loss of containment but no injuries.	The failure was primarily due to an unidentified weak, brittle foundation layer (volcanic rock, weathered to a residual soil) beneath the embankment, which deformed under the weight of the dam. This foundation deformation triggered static liquefaction of the loose, saturated tailings, causing a sudden loss of strength and rapid collapse. Construction activities and foundation weakness were the main drivers; small earthquakes the day before were found not to be a significant factor.	Jeffries et al., 2019
Fundao (Samarco)	The failure was an abrupt development of static liquefaction of loose, saturated sand tailings that were underlain by soft, compressible slimes. The embankment catastrophically failed, initiating at the left abutment and abruptly transforming from a solid to fluid state. The breach released approximately 32 million cubic meters as a high velocity flowslide of tailings, which overtopped a downstream dam and devastated the town of Bento Rodrigues, resulting in significant loss of life and environmental damage.	The cause of the failure was static liquefaction of loose, saturated sand tailings that were underlain by soft, compressible slimes. The trigger was lateral extrusion of these slimes under the embankment as it was raised, which reduced horizontal confinement in the overlying sand tailings and caused them to contract and liquefy. This condition was created by a combination of design changes following a 2009 piping incident, unplanned slimes deposition near the dam crest, and a setback in the dam alignment that placed the embankment over slimes. Small earthquakes on the day of failure likely accelerated the process.	Morgenstern et al., 2016
Mt Polley	The breach released millions of cubic meters of water and tailings suddenly and without warning, causing extensive downstream environmental damage. The failure was rapid, with no identified precursors, and was characterized by the outward displacement and rotation of the embankment due to foundation failure. The breach occurred when the loading imposed by the dam exceeded the capacity of the underlying foundation materials, resulting in a shear failure along a weak layer of glaciolacustrine clay about 8–10 m below the original ground surface.	The root cause of the failure was the undrained shear failure of a continuous layer of glaciolacustrine clay beneath the embankment, triggered when the embankment loading exceeded the clay's shear strength, resulting in sudden collapse. This layer, which was not detected or properly characterized during site investigations and design, became normally consolidated under the load of the dam, making it susceptible to contractive, strain-weakening behavior and undrained failure. The design did not account for this critical foundation condition. Contributing factors included the use of an oversteepened downstream slope (1.3H:1V) and incremental dam raising without adequate long-term planning or buttressing.	Independent Expert Engineering investigation and Review Panel, 2015

TSF Failure	Description	Root Cause(s)	Reference
Ajka	The embankment was constructed in stages using hydraulically placed fly ash and bottom slag from a nearby coal-fired power plant, forming a low-quality, concrete-like material. The red mud was deposited as a slurry, forming a basin-shaped deposit with a significant water depth at its centre. Over time, the structure was weakened by chemical weathering from the highly alkaline red mud, and the geometry of the reservoir (with steep slopes and variable water levels) further compromised stability. Ultimately, hydraulic pressures and internal erosion led to a sudden breach and devastating downstream impacts.	The use of marginal construction materials (fly ash and slag), inadequate compaction and quality control, and a lack of proper seepage control or internal drainage.	Banvolgyi, 2018
Karamken	The tailings dam was constructed in permafrost terrain, and after closure of operations in 1994, the facility was left unattended. 15 years later, the dam failed catastrophically, releasing saturated slurry tailings that destroyed part of the nearby village, caused fatalities, and severely contaminated the Khasyn River ecosystem.	The dam’s permeable embankment and inadequate clay content, together with a spillway channel constructed over unstable permafrost, led to chronic leakage and structural weakness. After the facility was abandoned in 1994, critical components such as steel linings and the emergency spillway were removed or looted, further increasing vulnerability. Seasonal thawing of the permafrost base, intense rainfall, and the use of heavy machinery on the dam crest saturated and destabilized the structure, ultimately causing collapse. Once breached, the clay-rich tailings liquefied and mobilized rapidly.	Glotov et al., 2018
Partizansk (Dalenergo)	A ring dike-type coal ash dam at a coal-fired electric power station breached open, approximately 50 meters wide. The failure released coal ash into a drainage canal, which then flowed into a tributary of the Partizanskaya River and ultimately reached Nahodka Bay. The dam, constructed solely from coal ash and located on the river floodplain, was overfilled, with ash reaching within 50 cm of the crest and leaving almost no freeboard for water accumulation. The spill covered the drainage canal and floodplain, and monitoring data showed elevated concentrations of metals and other contaminants in surface waters downstream of the site.	The root cause was chronic overfilling of the impoundment, which left insufficient freeboard to safely accommodate precipitation or additional ash. The dam was constructed entirely from coal ash without engineered monitoring systems such as piezometers or groundwater stability controls, and lacked any drainage or emergency management infrastructure except for a makeshift system installed after the breach. The absence of routine monitoring, maintenance, and structural oversight allowed water levels to rise dangerously close to the crest, ultimately leading to internal erosion and structural instability. The dam’s floodplain location further increased vulnerability to high water events, and the lack of contingency planning or alternative disposal sites compounded the risk.	Robinson, 2004
Aitik	Heavy rain triggered a failure of the dam extension near the decant tower and discharge culvert, likely due to leakage or collapse of the culvert, which rapidly escalated and resulted in a breach about 120 m wide. This initial failure was followed by the collapse of the upstream capture dam, allowing a large volume of water to flow from the tailings pond into the clarification pond and subsequently into downstream rivers, though the two-step failure helped reduce the overall flood impact, causing a temporary rise in suspended solids but no significant long-term effects.	High pore pressure due to poor filter drainage, leading to erosion/sliding in support fill, and leakage/collapse of discharge culvert, possibly due to poor joint sealing, lack of reinforcement, or gravel foundation.	Goransson et al., 2000
Baia Mare	The tailings dam failed when excessive water from heavy rainfall and rapid snowmelt caused the pond to overtop and erode the dam crest. The overtopping led to a breach in the dam wall, allowing cyanide-laden tailings and process water to escape rapidly into the downstream river system. The spill entered the river system, contaminating the Somes, Tisza, and Danube rivers, and caused extensive ecological damage, including massive fish kills and disruption of drinking water supplies for millions of people across Romania, Hungary, and Serbia.	The dam failed due to overtopping and erosion of the dam crest, triggered by excessive water accumulation from heavy rainfall and rapid snowmelt. The dam’s design lacked adequate freeboard and drainage capacity, and the foundation materials were not sufficiently engineered to resist seepage and piping. These deficiencies, without proper monitoring and maintenance, allowed water to erode the dam structure, ultimately leading to a breach and uncontrolled release.	Baia Mara Task Force, 2000
Los Frailes	The tailings dam catastrophically breached suddenly, releasing acidic tailings and contaminated water into the Agrio and Guadiamar rivers and rapidly inundating downstream areas. The failure resulted in extensive environmental damage, including the flooding of farmland and protected wetlands, and threatened the Doñana National Park.	The root cause was foundation instability due to progressive raising of the dam, which increased the load on underlying weak clay layers, eventually exceeding their pre-consolidation pressure losing an order of magnitude of stiffness. This led to large deformations, loss of freeboard, and ultimately overtopping and breach of the dam. The failure was exacerbated by inadequate geotechnical investigation and design for the foundation conditions, as well as insufficient monitoring and risk management during dam operation and raising.	Williams, 2021
Omai (Cambior)	The integrity of the dam’s sloping core was compromised, allowing water to escape rapidly through the dam and into the Omai and Essequibo Rivers, without a physical breach of the dam embankment. The event was first noticed when water was observed flowing at the toe of the dam, followed by the appearance of longitudinal cracks on the crest and large flows issuing from both ends of the dam. The impoundment water level dropped by 12 meters within 60 hours, with most of the cyanide-bearing process water reaching the river system through an uncontrolled release, while the majority of tailings solids remained in the impoundment.	The failure was caused by internal erosion (piping) through the dam, initiated by two critical defects: (1) filter incompatibility between the filter sand and the adjacent rockfill, and (2) internal erosion and piping around the diversion conduit. The filter sand was not adequately protected by a properly graded transition zone, allowing it to wash into the coarse rockfill and leave the overlying saprolite core unsupported. This led to the formation of cavities and cracks in the core, which eventually connected to the reservoir, enabling water to flow through the dam. Simultaneously, poor compaction and lack of filter protection around the diversion conduit allowed concentrated seepage and further internal erosion. These mechanisms acted independently but ultimately converged, resulting in a sudden loss of core integrity and rapid release of water.	DRT, 1996

TSF Failure	Description	Root Cause(s)	Reference
Merriespruit (Harmony)	The failure was a sudden and large collapse of the dam wall, followed by a high-velocity flow of liquefied tailings into the downstream area. The tailings were released rapidly and flowed into the nearby town of Merriespruit, causing extensive property damage and loss of life.	The failure was caused by overtopping of the dam following intense rainfall, which eroded the crest and downstream slope. The dam's design and construction were inadequate for extreme rainfall events, with insufficient freeboard and poor surface water management. The eroded embankment lost stability, and the saturated tailings liquefied, resulting in a flow failure and breach.	Blight, 1998
Tapo Canyon	The tailings dam failed suddenly during a M6.7 earthquake, 18 km from the site. The event resulted in a 60-meter-wide breach of the dam, with sections of the embankment displaced up to 90 meters downstream. Liquefied tailings flowed through the breach, travelling hundreds of meters down the natural drainage channel. Although the failure occurred in a largely undeveloped area and caused no deaths or injuries, it led to significant economic losses for the dam owners and a downstream water treatment facility.	The dam failed due to earthquake-induced liquefaction of saturated, contractive tailings and possibly embankment materials during the 1994 Northridge earthquake (M6.7, 18 km from site). Strong ground shaking generated cyclic shear stresses that exceeded the undrained shear strength of the tailings, causing a rapid loss of effective stress and triggering flow failure. The embankment and impounded tailings were susceptible to liquefaction due to their loose, saturated state and contractive behavior, which was a result of site-specific depositional and construction practices. The resulting flow slide breached the dam, allowing liquefied tailings to escape downstream.	Harder and Stewart, 2006
Stava	Two tailings dams collapsed in rapid succession: The upper dam failed first, overwhelming the lower dam, and releasing tailings at high velocity. The resulting mudflow destroyed the village of Stava and continued downstream, causing fatalities and massive destruction.	The root cause was a combination of poor geotechnical design, inadequate construction practices, and a lack of proper monitoring and maintenance. The dams were built using the upstream method on a geologically unsuitable site, with tailings deposited in thin layers that created high pore pressures and low stability margins. Over time, the upper dam became critically unstable due to the accumulation of water and tailings, exacerbated by a blocked decant pipe that prevented proper drainage. This led to a rapid increase in pore pressure and static (flow) liquefaction of the tailings, triggering the collapse of the upper dam, which in turn overwhelmed the lower dam. The absence of rigorous safety checks, effective control of pore pressures, and regulatory oversight allowed these deficiencies to persist.	Berti et al, 1988
Churchrock	The dam was constructed on deep deposits of clayey, silty sand, some of which were highly collapsible upon wetting. Over time, settlement of up to a metre was observed along the embankment, leading to the formation of longitudinal and transverse cracks. The dam was not lined, allowing seepage into the foundation soils, and borrow for embankment fill was excavated just upstream, further increasing seepage and wetting of the foundation. As the impoundment was filled, the freeboard was reduced, and the tailings solution came into direct contact with the embankment, eliminating the protective sand beach that was intended to prevent internal erosion. Ultimately, cracks within the embankment became filled with tailings solution, causing internal erosion that caused the tailings dam to fail, releasing a large volume of uranium mill tailings solution and solids into the downstream environment.	The cause of the breach was a combination of differential settlement, cracking, and internal erosion (piping) within the embankment, exacerbated by the dispersivity of the embankment soils when exposed to the low pH of the tailings solution. The collapse of the foundation soils due to wetting led to instability, particularly at the downstream toe, where an initial shear failure likely occurred. This failure then progressed upstream through internal erosion and further slope failures.	Nelson & Kane, 1980
Bafokeng	The failure initiated as a leak in the dam wall, which rapidly enlarged into a breach about 130 m wide, releasing a massive flow slide of tailings that traveled up to 45 km downstream. Liquefied tailings slurry flowed through the breach, engulfing a vertical mine shaft and flooding the Kwa-Leragane River valley. The flood destroyed surface structures and fatally trapped underground workers.	Ultimately, the dam breached due to a combination of internal erosion and localized liquefaction within the dam wall, triggered by heavy rainfall that led to excessive water accumulation on the dam. The dam's construction featured horizontal layering of sandy and clayey tailings, which resulted in high horizontal permeability and allowed the phreatic surface to rise, saturating sections of the wall. During emergency operations, a front-end loader was used on the saturated wall, potentially causing localized liquefaction or densification of the tailings. Additionally, vibrations or failure of a temporary penstock shaft near the breach may have further destabilized the structure. Poor operational practices contributed, including maintaining an excessively large pool, lack of piezometric monitoring, and inadequate geotechnical oversight.	Blight, 1998
El Cobre Old Dam	The dam catastrophically failed following a magnitude 7.4 earthquake. The failure involved rapid liquefaction of the tailings, resulting in the sudden collapse of the dam and a destructive flow that inundated the town of El Cobre. The dam's collapse was abrupt, with the liquefied tailings travelling rapidly downstream and causing extensive loss of life and property. This failure highlighted the dangers of upstream construction in seismically active regions and led to significant changes in Chilean tailings dam design.	The root cause was seismic-induced liquefaction of loose, saturated tailings within an upstream-constructed dam. The dam was built with steep slopes and on materials susceptible to liquefaction, making it highly vulnerable to earthquake loading. The intense seismic shaking triggered a rapid loss of shear strength in the tailings, leading to flow liquefaction and the dam's collapse.	Williams, 2021

TSF Failure	Description	Root Cause(s)	Reference
Cerro Negro No. (3 of 5)	One of the four dams at the site failed during the 1968 M7 earthquake, approximately 38 km from site. It was the only active tailings facility at the time. The earthquake induced rapid liquefaction of the fine tailings in the dam's core, which was observed as waves forming on the surface shortly after the seismic event. This liquefied material eroded the small dike at the border of the dam, quickly widening the breach and allowing tailings to flow up to 5 km downstream. The other dams at Cerro Negro, which were all inactive, suffered only minor fractures and slides, highlighting the increased vulnerability of saturated, unconsolidated, recently deposited tailings during seismic loading.	The root cause was the presence of a saturated, unconsolidated tailings core that was highly susceptible to earthquake-induced liquefaction, due to a lack of compaction in the dam's shell and the absence of adequate drainage. The seismic shaking rapidly reduced the shear strength of the tailings, causing the core to behave as a fluid and exert pressure on the dam's embankment., and leading to erosion and breach of the dam.	Dobry and Alvarez, 1967



Donlin Gold Project TSF Main Dam Breach Assessment – Additional Runs

Prepared by BGC Engineering Alaska Inc. for:



May 29, 2026

Project 0011603

Document ER-0011603-0242-2



May 29, 2026

Project 0011603
Document ER-0011603.0242-1

Donlin Gold LLC
725 E. Fireweed Lane, Suite 200
Anchorage, Alaska 99503

Attention: Enric Fernandez, Permitting and Environmental Manager

TSF Main Dam Breach Assessment – Additional Runs – Rev 2

Please find the above-referenced report attached for your records. We appreciate the opportunity to collaborate with you on this challenging and interesting project.

Should you have any questions, please do not hesitate to contact the undersigned.

Yours sincerely,

BGC Engineering Alaska Inc.
per:

A handwritten signature in black ink, appearing to read 'H. Weatherly', with a stylized, cursive script.

Hamish Weatherly, M.Sc. P.Geo.
Principal Hydrologist

TABLE OF REVISIONS

Date	Revision	Remarks
May 8, 2026	0	Final report submitted.
May 14, 2026	1	Correction made to drawings to reflect US standard rather than metric units.
May 29, 2026	2	Changes to Limitations section and minor edits.

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1.0 INTRODUCTION

1.1 Background

Donlin Gold LLC (Donlin Gold) is currently planning to develop the Donlin Gold Project (Project), a proposed open pit gold mine, in southwestern Alaska. BGC Engineering Alaska Inc. (BGC) has carried out technical studies for the Project since 2004, including geotechnical, hydrogeological, and hydrological assessments in support of Feasibility Studies (FS), the most recent FS being the 2011 Feasibility Study Update, as well as studies to support an Environmental Impact Statement (EIS), federal permitting, and state permitting. That work has included a feasibility-level design of the proposed Tailings Storage Facility (TSF) (BGC, July 22, 2011).

In the Final Environmental Impact Statement (FEIS) for the Project (US Army Corps of Engineers [USACE], 2018), the effects of a partial failure of the TSF Main Dam were evaluated by BGC (June 1, 2015). Both releases of water and tailings were considered, constituting approximately 0.5% of the maximum TSF capacity. The 0.5% estimate was determined during an early-stage Failure Mode and Effects Analysis (FMEA) workshop for the Project (SRK Consulting, 2015). The Orutsararmuit Native Council (ONC) challenged the FEIS in U.S. District Court; specifically, ONC argued that a larger tailings release should have been evaluated. On September 30, 2024, Judge Sharon Gleason² ruled in favour of the plaintiff, specifically saying that the “Corps violated NEPA by failing to consider a tailings spill larger than 0.5% of the TSF’s total volume and by declining to assess a catastrophic tailings spill based solely on its low probability of occurrence.” She further cited “a 2011 presentation summarized previous studies and found that on average, tailings released due to dam breaks ranged from 20-40% of total tailings volume” and a “2010 report on tailings dam failures indicated that upon breakage, the released tailings generally amount to about one-fifth of those contained within the facilities”.

In response to the Judge’s decision, Donlin Gold requested that BGC identify and model a larger tailings release scenario. BGC ultimately modelled four breach scenarios under Sunny day conditions: 0.5%, 5.4%, 13.3%, and 24.6% releases of total tailings volume, plus pond water. Results of that analysis are documented in BGC, February 24, 2026, which is herein referred to as the Main Report. The Main Report should be referenced for a detailed description of the methodologies employed and background information.

This report documents additional dam breach model runs requested by the USACE and their subcontractor AECOM.

² Decision and Order. Case No. 3:23-cv-00071-SLG, Orutsararmuit Native Council, et al. v. U.S. Army Corps of Engineers, et al.

1.2 Scope of Work

In e-mails dated April 24 and April 29, 2026, the USACE and their subcontractor AECOM requested that BGC model the following additional breach scenarios:

1. Re-run the 5.4% and 13.3% release volume scenarios using a breach time of 0.6 hours.
2. Run an additional breach scenario with a release volume of 27%, also with a breach time of 0.6 hours.
3. Route the breach hydrographs (5.4%, 13.3%, and 27%) downstream in Crooked Creek using the non-Newtonian HEC-RAS model developed as part of the Main Report.
4. Finalize a bathymetric surface along the Kuskokwim River using Sentinel satellite imagery. Transpose that bathymetry into the numerical mesh for the Kuskokwim River Newtonian HEC-RAS model.
5. Take the non-Newtonian breach hydrographs (5.4%, 13.3%, and 27%) at the mouth of Crooked Creek and apply them as Newtonian inflow hydrographs into the Kuskokwim River Newtonian HEC-RAS models for Sunny day (5.4%, 13.3%, and 27%) and Flood stage (27%) conditions.
6. Use simple calculations of diffusion theory to show how the volumetric concentrations of the mixed flows would change along the river, with emphasis on the downstream villages of Chuathbaluk, Aniak and Kalskag, to confirm/justify the Newtonian flow approach down the Kuskokwim River.

The scope of work was authorized by Donlin Gold under purchase order number 4501070369 dated December 31, 2024.

1.3 Limitations

The dam breach and inundation analyses completed by BGC here-in were based on hypothetical modes of failure under extreme and highly unlikely conditions. As a result, the results of the analyses presented herein in no way reflect upon the structural integrity or safety of the proposed TSF Main Dam, as this study does not fully account for the design safety measures, management practices, or regulatory requirements implemented to prevent a breach from occurring. Rather, it was assumed that a hypothetical failure of the dam could occur, so that the area of impact could be estimated.

This report only addresses the potential inundation extent in the event of a hypothetical breach of the TSF Main Dam. This study does not attempt to quantify the probability of a dam breach by the selected scenarios or any other mechanism. Furthermore, this study does not include an assessment of the population at risk or detailed evaluation of downstream consequences in terms of loss of life, environmental, cultural or economic values.

The applied methodology adopted by BGC followed the current state of practice for tailings dam breach analyses, as documented in recent publications prepared by the Canadian Dam Association (CDA, 2021) and the International Commission on Large Dams (ICOLD, 2022). These analyses inherently acknowledge the limitations in precisely modeling the impacts of a dam breach, largely due to the evolving nature of the science and the incomplete understanding of some physical processes represented in current models.

2.0 TAILINGS DAM BREACH

2.1 Tailings Release Volume Scenarios

Consistent with the Main Report, the assumed failure mechanism is an overtopping failure (initiated by piping) of the TSF Main Dam occurring at the end of operations. The updated dam breach scenarios modelled, including release volumes and adopted rheological parameters, are summarized in Table 2-1. The rheological parameters vary between the modelled scenarios, reflecting the varying volumetric sediment concentration. Selected yield stress and plastic viscosity values are based on interpolation of the plotted values in Figure 2-2 and Figure 2-3 of the Main Report.

Table 2-1 TSF Main Dam breach scenarios including release volume and rheological parameters.

% Tailings Release	Tailings Release Volume ¹ (acre ft)	Pond Volume (acre ft)	Total Release Volume (acre ft)	C _v (%)	Yield Stress (Pa)	Plastic Viscosity (Pa s)
27	100,000	9,730	109,730	42%	220	0.16
13.3	44,350	9,730	54,080	38%	150	0.10
5.4	17,910	9,730	27,640	30%	45	0.03

Note:

1. Volume includes tailings solid and void water with an assumed sediment volumetric concentration (C_v) of 46%.

The values reported in Table 2-1 for the 5.4% and 13.3% tailings release scenarios are consistent with those in the Main Report. The 27% release volume scenario is slightly larger than the 24.6% value used in the Main Report. The 24.6% release volume was based on the empirical relation of Larrauri and Lall (2018). The USACE and AECOM requested that a release volume of 27% also be modelled to reflect the average % release volume of the dam failure cases in the Larrauri and Lall (2018) dataset.

2.2 Dam Breach Hydrographs

In the Main Report, the breach hydrographs were developed using the dam break module in HEC-HMS (version 4.12) (USACE, 2022). HEC-HMS is recommended by Alaska Dam Safety for quantitative dam failure analysis (ADNR, 2017). The following dam breach parameters were used in the Main Report:

- A breach formation time of 1 hour
- Breach side slopes of 1H:1V
- A bottom breach width of 410 ft³ (125 m)
- All scenarios were modelled as an initial piping failure leading to overtopping.

³ Which equates to an average breach width of 880 ft (270 m).

In a teleconference meeting on April 13, 2026, AECOM and the Corps requested that BGC conduct a sensitivity analysis on the adopted dam breach parameters listed above. The sensitivity scenarios listed in Table 2-2 were subsequently modelled by BGC for the 27% release volume scenario. The modelled range in breach width and formation time reflect the upper and lower limits noted in the Main Report. The resulting dam breach hydrographs are provided in Figure 2-1.

Table 2-2 Dam breach parameters for sensitivity analysis of 27% release volume scenario.

Variable	Scenario							
	1	2	3	4	5	6	7	8
Bottom Width (ft)	410	410	410	410	410	410	260	620
Breach time (hr)	1	1	0.6	0.6	1.6	1.6	1	1
Progression shape ¹	linear	sine	linear	sine	linear	sine	linear	linear

Note:

1. Unlike linear growth, the sine wave method causes the breach to grow rapidly in the early-to-mid stages of development and more slowly as it approaches its maximum size.

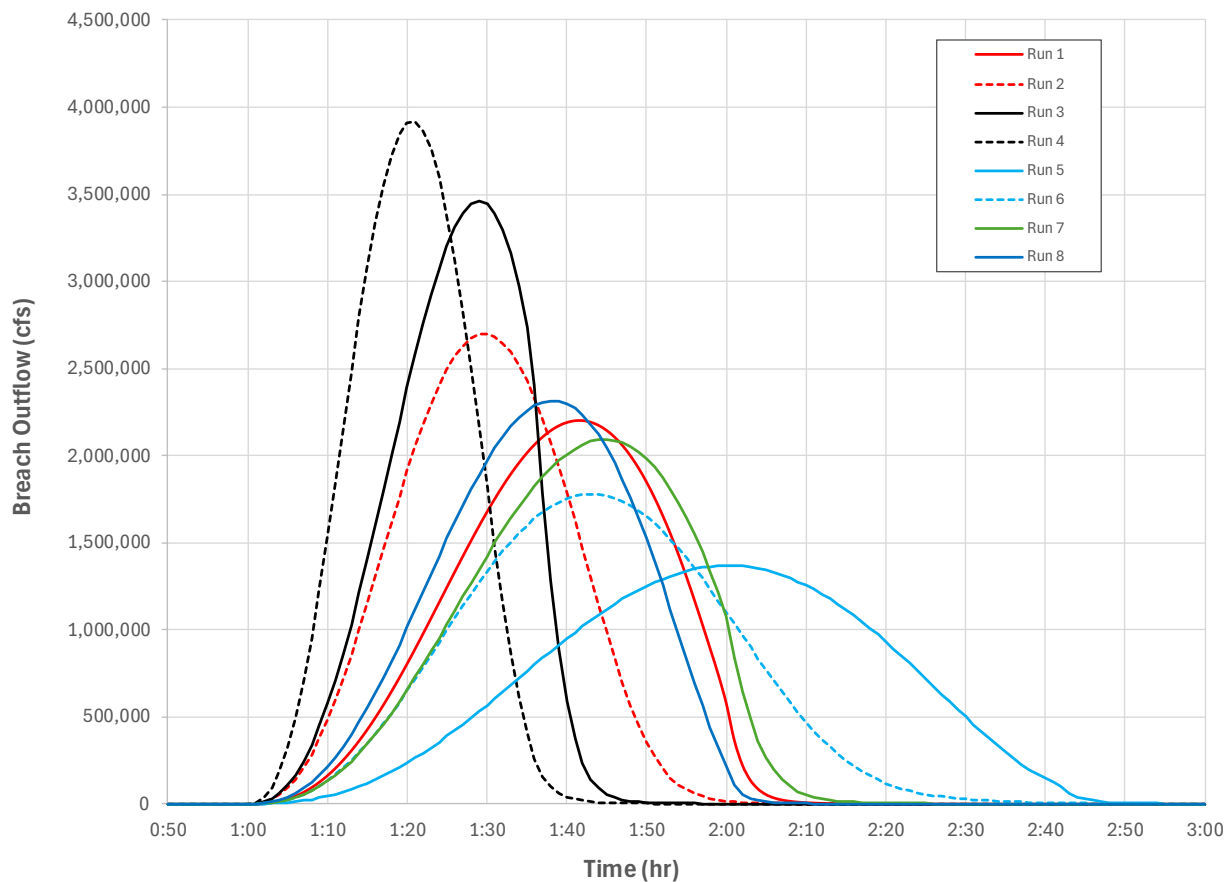


Figure 2-1 Sensitivity dam breach hydrographs for the 27% release volume scenario.

The sensitivity results of Figure 2-1 were presented to the Corps and AECOM during a teleconference meeting on April 22, 2026. On review of the results, the Corps and AECOM requested that for the release scenarios listed in Table 2-1, BGC use the following breach parameters:

- A breach formation time of 0.6 hour
- Breach side slopes of 1H:1V
- A bottom breach width of 410 ft (125 m)
- Linear growth of the breach.

The parameters used to generate the dam breach hydrographs and a summary of the hydrographs for the four scenarios are shown in Table 2-3. The resulting dam breach hydrographs for the three scenarios are provided in Figure 2-2.

Table 2-3 Breach parameters used to generate the breach hydrograph and summary of the breach hydrograph.

Parameter	Release Volume Scenario (Percentage of Storage Volume)		
	5.4%	13.3%	27%
Dam Breach Parameters			
Top Elevation (ft)	824	824	824
Bottom Breach Elevation (ft)	459	459	459
Bottom Breach Width (ft)	410	410	410
Side Slopes (xH:1V)	1	1	1
Breach Formation Time (hrs)	0.6	0.6	0.6
Breach Mechanism	Piping ²	Piping ²	Piping ²
Summary of Breach Dam Hydrographs			
Peak Outflow (cfs)	1,032,000	1,884,000	3,462,000
Time of Peak Outflow (h:mm) ¹	1:20	1:25	1:29
Release Volume (acre-ft)	27,640	54,080	109,730

Note:

1. Where the breach initiates at 1:00 h.
2. Piping failure leading to retrogressive failure at the dam toe, followed by slumping of the dam crest and overtopping.

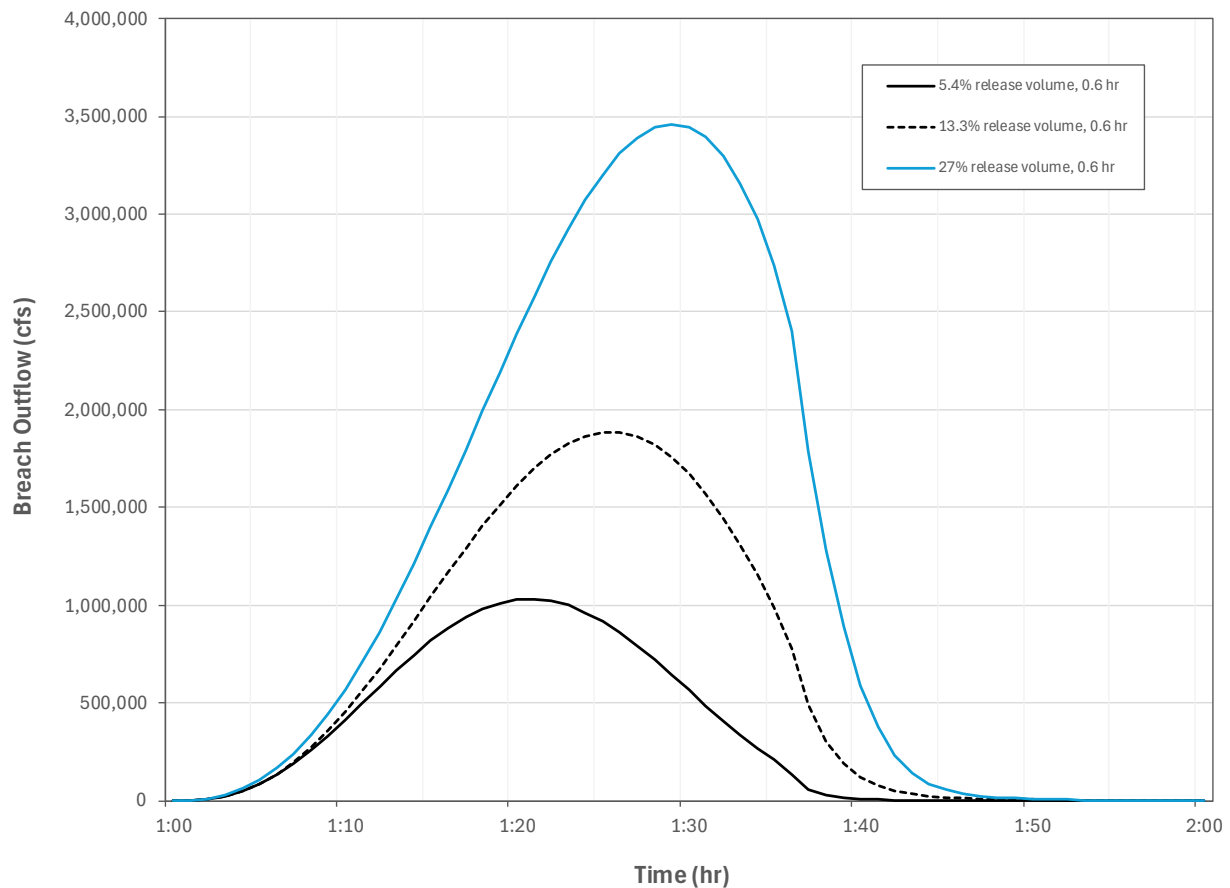


Figure 2-2 Dam breach hydrographs for the 5.4%, 13.3%, and 27% release volume scenarios with a breach development time of 0.6 hours and a bottom breach width of 410 ft (125 m).

Figure 2-3 shows how the dam breach hydrographs for the 5.4% and 13.3% release volume scenarios using a breach development time of 0.6 hours compare to those used in the Main Report (breach development time = 1 hr). The updated hydrographs are seen to peak earlier and at a higher magnitude, although the release volumes are the same.

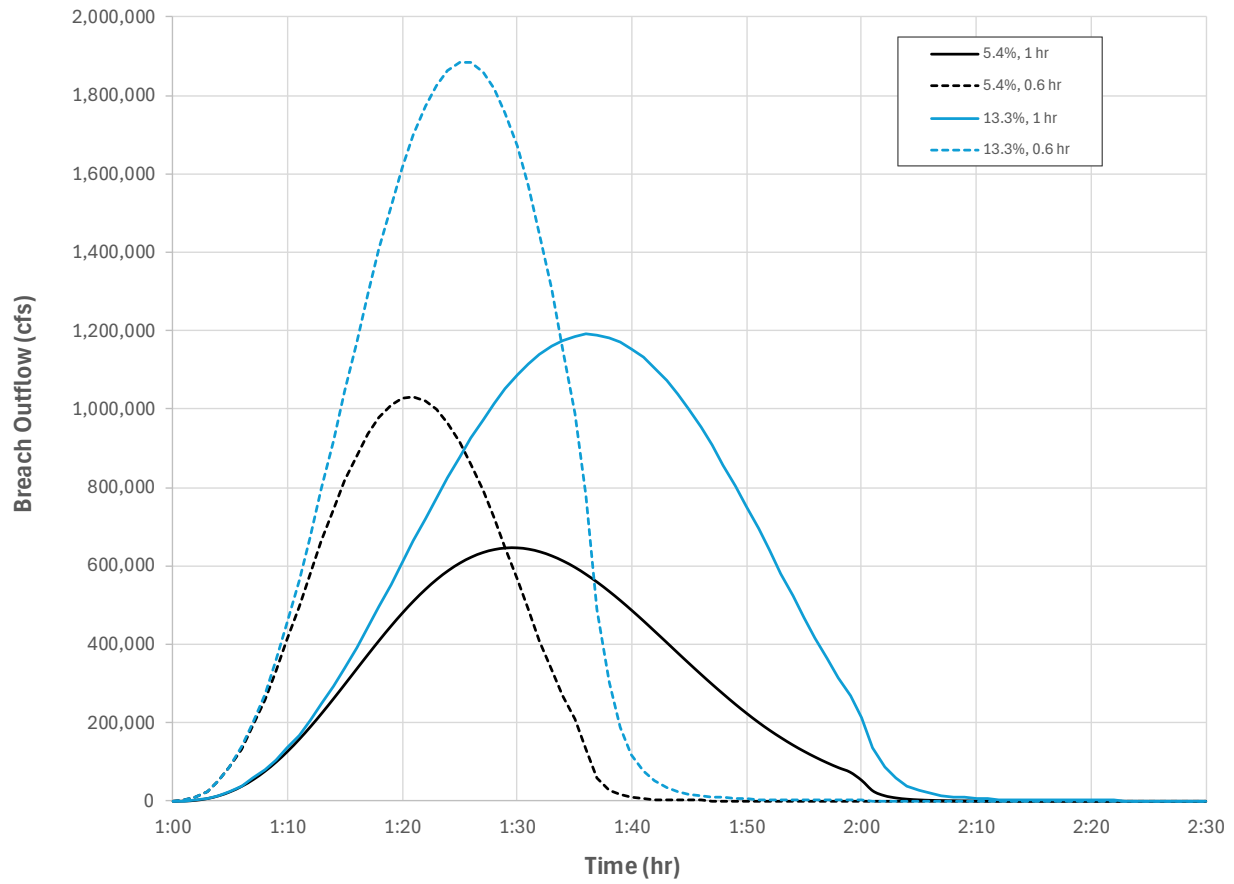


Figure 2-3 Dam breach hydrographs for the 5.4% and 13.3% release volume scenarios with breach development times of 0.6 hours (this report) and 1 hr (the Main Report).

3.0 DAM BREACH FLOOD WAVE ROUTING AND INUNDATION MODELLING

3.1 Hydraulic Model

Two-dimensional flood wave routing of the dam breach scenarios was conducted using the HEC-RAS software package (Version 6.6) developed by the USACE. Full momentum Saint-Venant equations were used to solve for unsteady flows associated with the breaches. Changes incorporated into the HEC-RAS model for this report are documented in the following sections.

Flow Regime

The flood waves generated by a breach of the Donlin TSF are considered non-Newtonian as they move down Crooked Creek. For the breach scenarios considered in the Main Report and this report, the volume of tailings released is significantly greater than the creek's flow, and the influence of the creek's flow on the properties of the tailings is regarded as negligible. However, once these flood waves discharge into the Kuskokwim River, BGC (February 24, 2026) assumed that the flows into the river would mix and dilute the tailings, thereby restoring Newtonian fluid behavior.

To capture both the non-Newtonian and Newtonian flow regimes, two hydraulic models were developed as part of the Main Report. This division was necessary as HEC-RAS cannot simulate non-Newtonian and Newtonian fluids concurrently due to its computational framework, which is designed for single rheological behavior (i.e., constant sediment concentration and constant rheological parameters) per simulation run (see [Multi-Phase Modeling \(Mixing Clear Water and Mud/Debris\)](#)). As such, one model was configured to simulate the non-Newtonian flows along Crooked Creek, while the other model was set up for Newtonian flow conditions along the Kuskokwim River. The flood wave extracted from the non-Newtonian model at the confluence of Crooked Creek and the Kuskokwim River was applied as an inflow boundary condition to the Newtonian model.

Assuming a Newtonian fluid likely underestimates flow depth and inundation near the confluence (mile 14), as higher concentrations increase the flow resistance. However, the closest village downstream of the confluence is Chuathbaluk (mile 71). By the time the floodwave arrives near this community, assuming a non-Newtonian flow regime would likely result in a less conservative estimation of flow depth.

Results of that mixing process are discussed in Sections 3.2.1 and 3.2.4.

Model Domain

The model domain sets the geographical boundaries of the hydraulic model. The Crooked Creek domain for the non-Newtonian model included:

- Anaconda Creek downstream of the TSF Main Dam to the confluence with Crooked Creek
- Crooked Creek from several miles upstream of the Anaconda Creek confluence and downstream to the junction with Kuskokwim River

- Approximately 4 miles (6.5 km) of the Kuskokwim River upstream and downstream from the confluence with Crooked Creek.

The Kuskokwim River domain for the Newtonian model included:

- the Kuskokwim River from about 10 miles (16 km) upstream of the confluence with Crooked Creek to downstream of the Village of Lower Kalskag (an approximate length of 120 miles [190 km]).

The model domains included the floodplains of Crooked Creek and the Kuskokwim River to ensure the full extent of overbank flows was captured. The full model domain is shown in Figure 3-1.

Topography and Bathymetry

The model's base topography was developed utilizing the 16-foot (5-m) Digital Elevation Model (DEM) data for Alaska, obtained from the U.S. Geological Survey's National Map 3D Elevation Program⁴ (USGS, 2022). This bare-earth DEM was generated through interferometric synthetic aperture radar techniques. However, the DEM excludes elevations beneath water surfaces.

For Anaconda and Crooked creeks, the absence of bathymetric data was considered to have a negligible impact and was not considered (BGC, February 24, 2026). This is because the magnitude of the breach flood waves is much greater than the capacity of these two watercourses.

For the Kuskokwim River, however, the absence of detailed bathymetric information required an adjustment to the model's discharge input. This adjustment was necessary to ensure that the modeled water surface elevations accurately reflected observed conditions. The DEM water elevation of the Kuskokwim River at gage #15304000 on the date of the DEM acquisition was 137 ft (41.8 m). Using published stage-discharge curves for the Kuskokwim River gage (USGS, 2025), an elevation of 137 ft (41.8 m) is equivalent to a streamflow of 32,100 cfs (910 m³/s). Therefore, in the Main Report, a steady state inflow of 36,700 cfs (1040 m³/s) was used as an inflow boundary condition to the model. In other words, 32,100 cfs (910 m³/s) of streamflow was not modelled.

⁴ Horizontal datum = North American Datum of 1983 (NAD83); Vertical datum = North American Vertical Datum of 1988 (NAVD88).

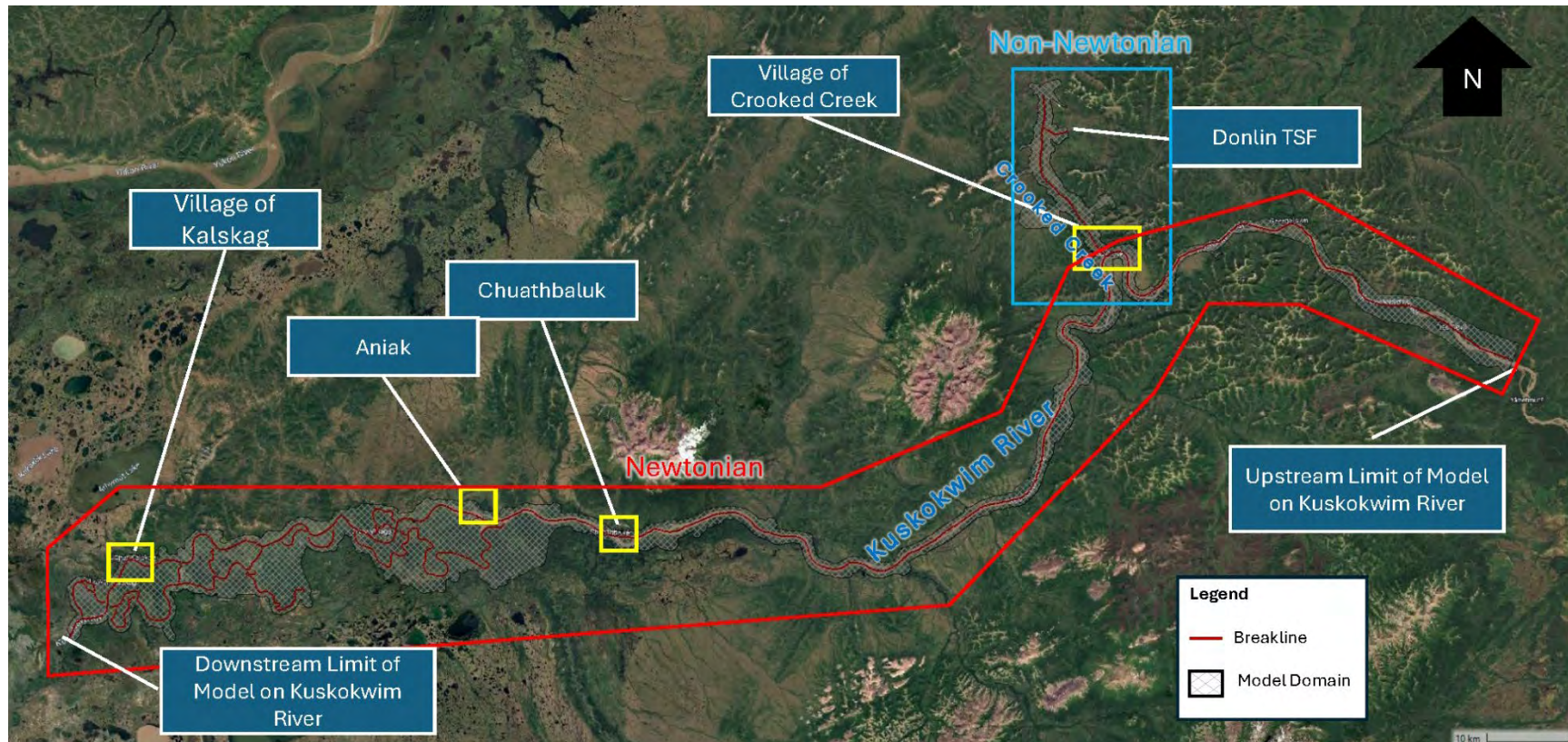


Figure 3-1 The model domain used to simulate the flood wave routing and inundation.

As part of the updated model runs, the Corps and AECOM requested that BGC burn a channel into the DEM such that it broadly reflects the shape of the Kuskokwim River mainstem channel. To approximate the channel dimensions, BGC was guided by bathymetric surveys of the Kuskokwim River conducted by AKS Engineering & Forestry, LLC. (August 2022) and Terrasond (March 15, 2023) in 2022. These surveys were completed at the request of Donlin Gold to investigate barge navigation at shallow areas (i.e., pinch points) along the river. The available bathymetry data is shown in Figure 3-2.

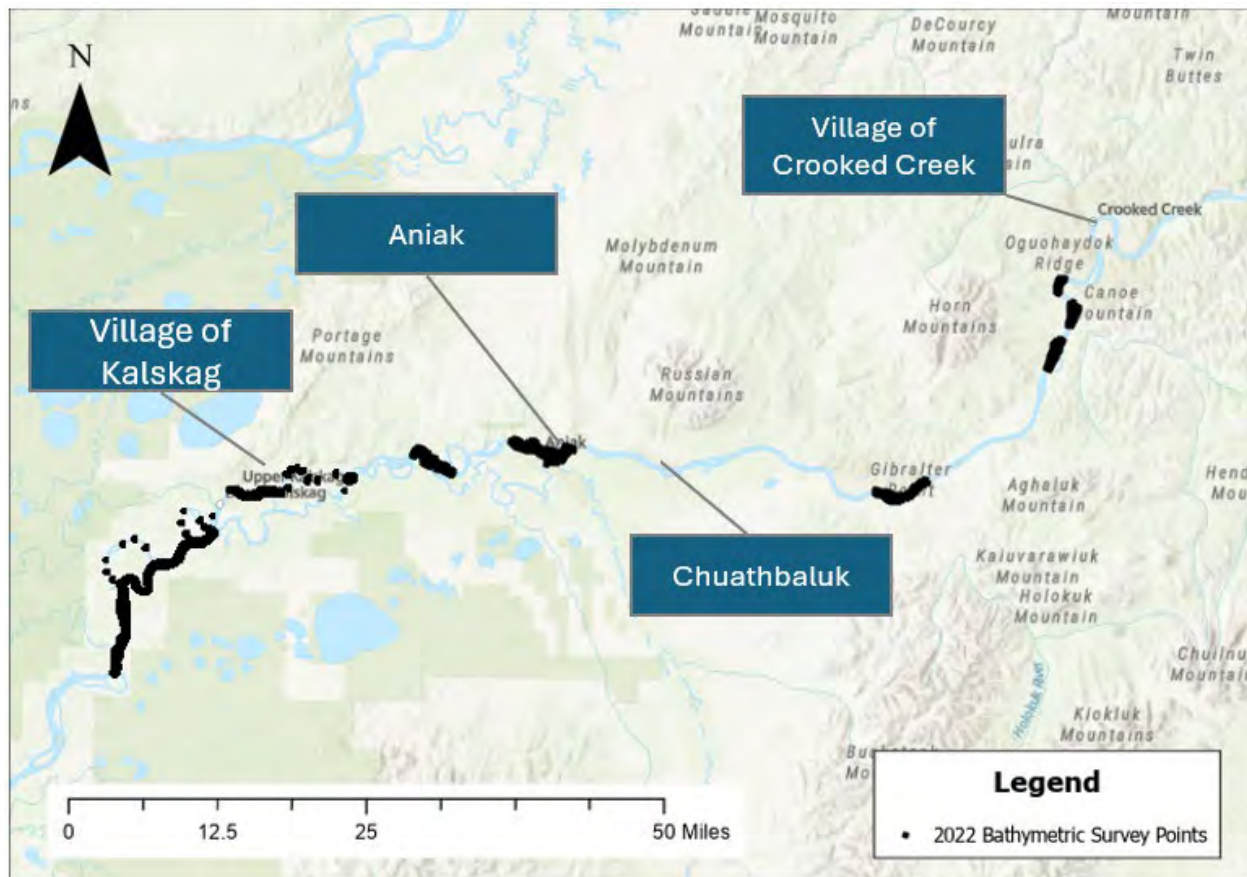


Figure 3-2 Available 2022 bathymetric data in the study reach.

The channel bathymetry for the Kuskokwim River was established using satellite-derived methods. An XGBoost machine learning model was implemented, with inputs comprising pixel values from 12 Sentinel-2 satellite bands collected at survey measurement locations and trained against river depth data. This methodology was selected for its efficiency in producing reliable channel bathymetry across extensive distances. Two Sentinel-2 scenes were utilized: one representing the upper section of the Kuskokwim River and another for the lower section. The upper segment was calibrated with the Terrasond (March 15, 2023) survey data, while the lower segment used the data from AKS Engineering & Forestry, LLC. (August 2022). Model performance for the upper section yielded a training R^2 of 0.76 and a root mean square error (RMSE) of 3.0 feet (0.9 m) Figure 3-3). In comparison, the lower section exhibited a training R^2

of 0.58 and RMSE of 4.3 feet (1.3 m) (Figure 3-4). Reduced accuracy in the lower section is attributed to several factors: (1) greater river depth downstream exceeding light penetration limits (~8 m), and (2) absence of recorded water surface elevation during the survey, necessitating estimation from the HEC-RAS model based on comparable flow conditions. Consequently, the model for the lower section is inclined to underestimate river depth, resulting in conservative predictions.

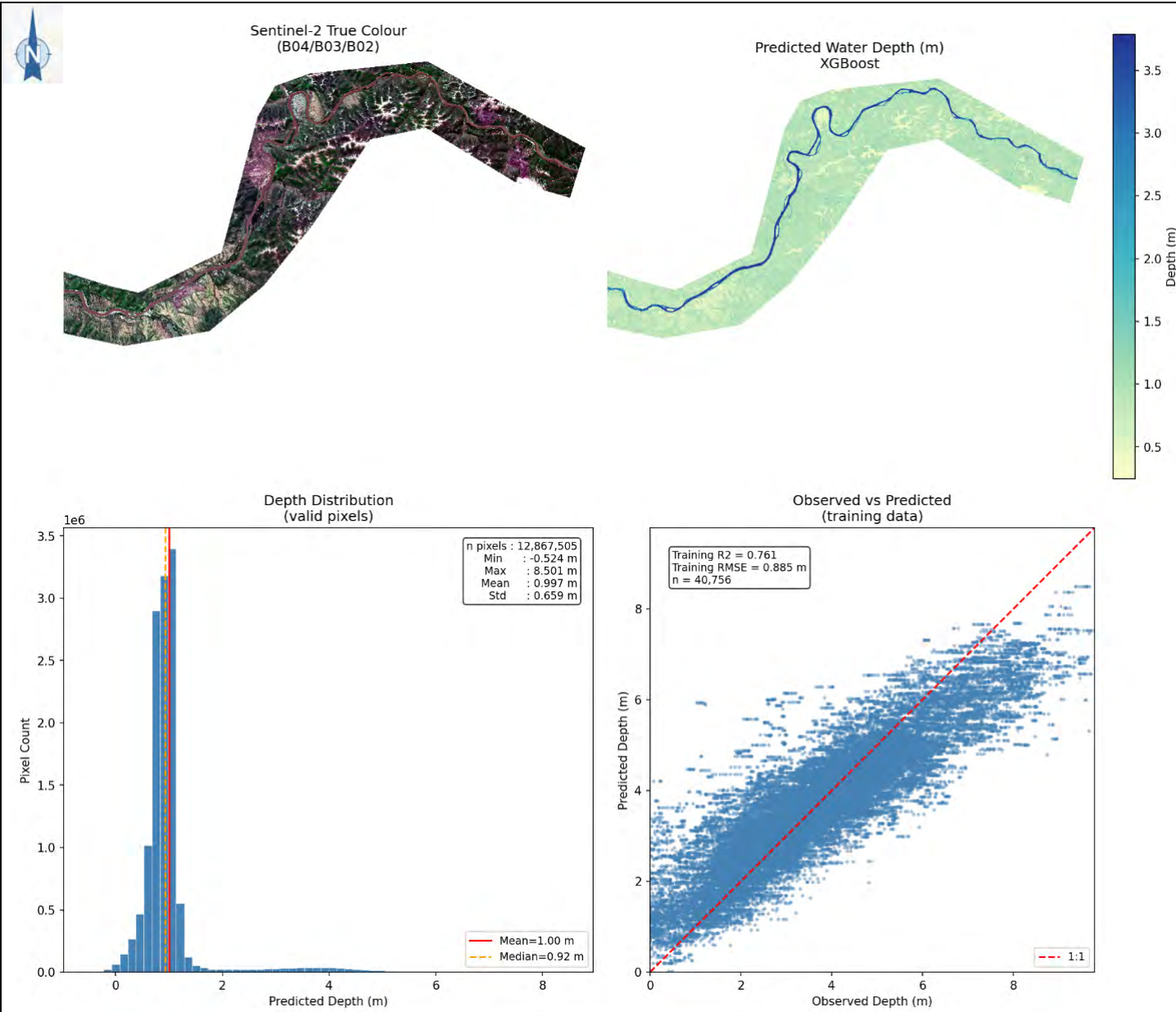


Figure 3-3 Satellite-derived bathymetry model performance and diagnostics for the upper section of the Kuskokwim.

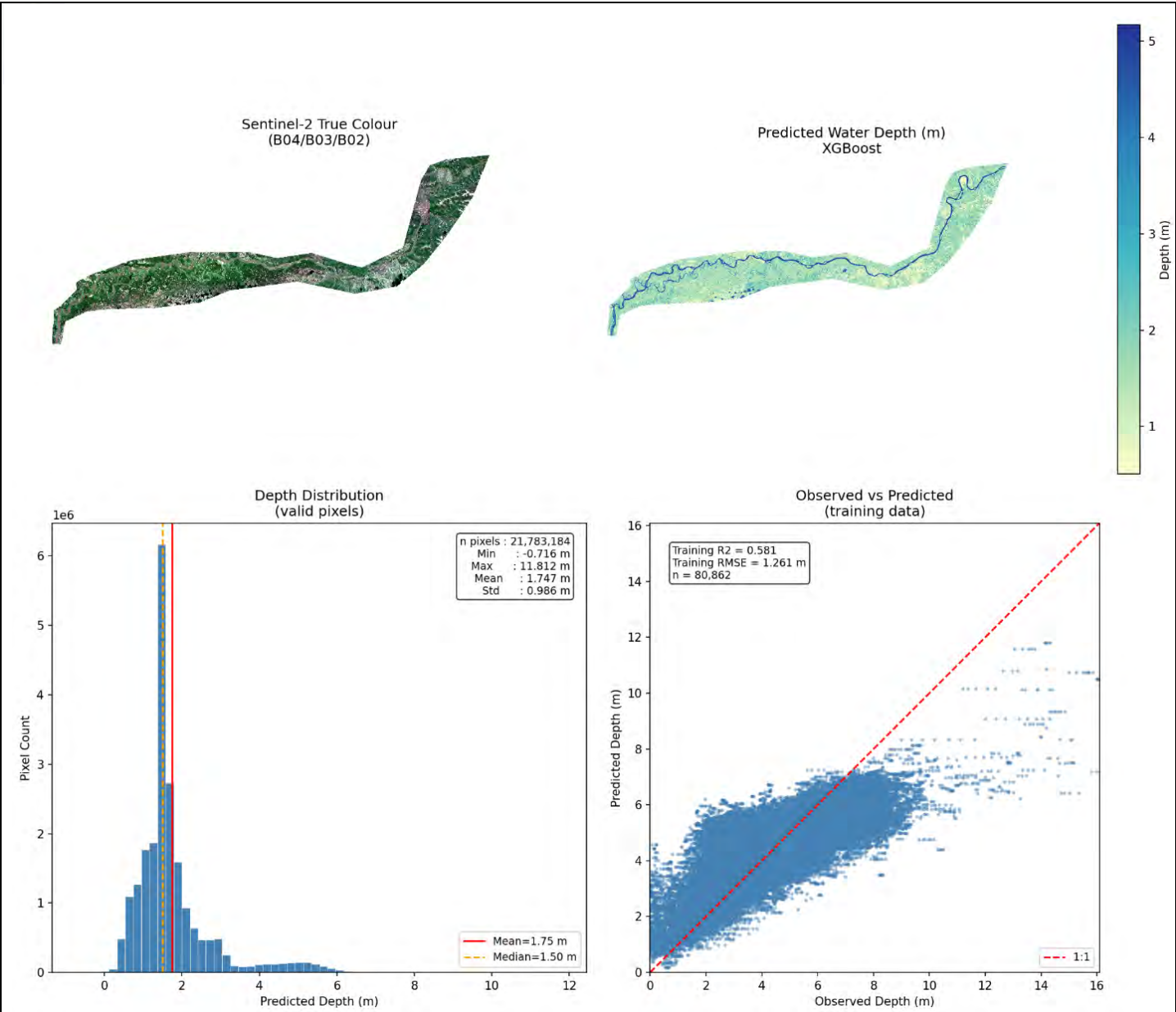


Figure 3-4 Satellite-derived bathymetry model performance and diagnostics for the lower section of the Kuskokwim River.

Figure 3-5 shows an example of the Kuskokwim River at Aniak with and without the satellite-derived bathymetry.

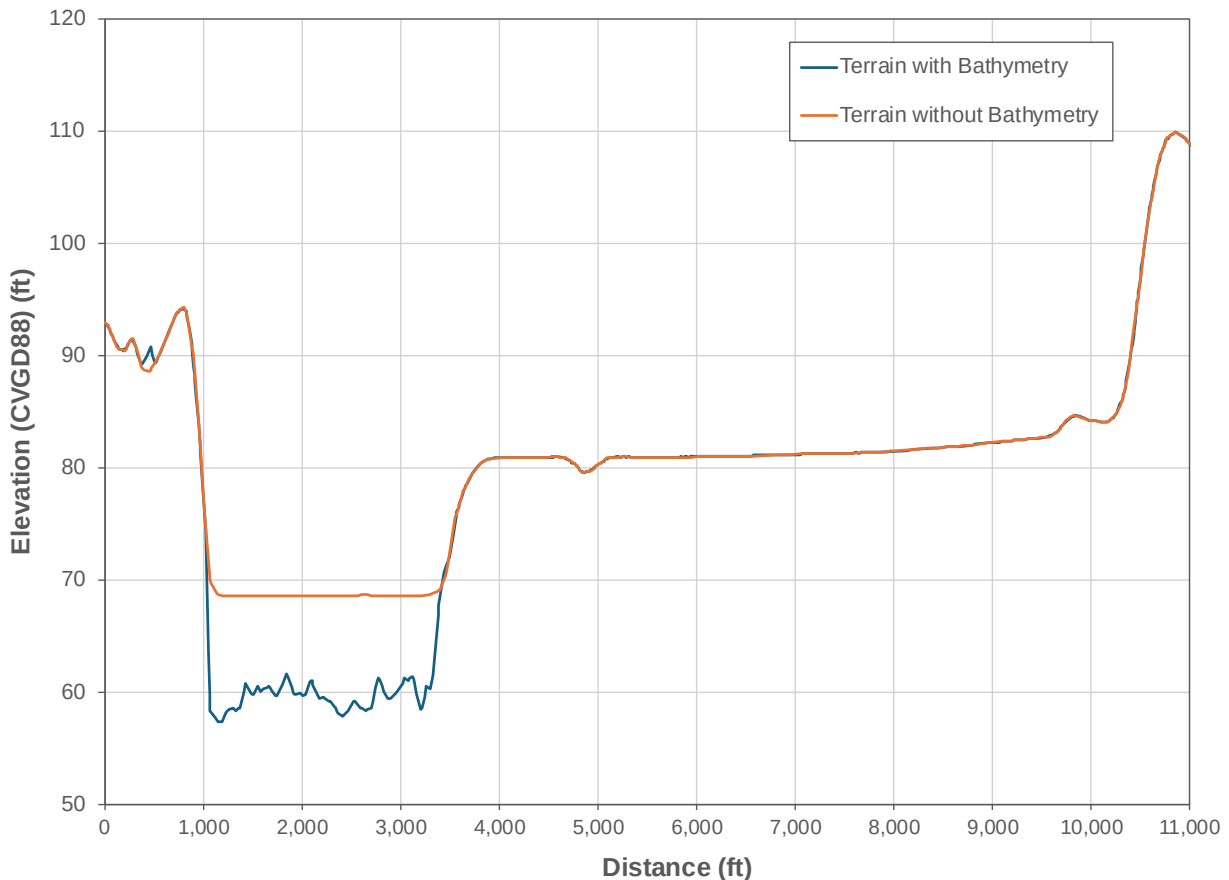


Figure 3-5 Comparison of the cross-section at Aniak before and after the satellite-derived bathymetry has been incorporated into the terrain. View is looking downstream at approximately 50 times vertical exaggeration.

Hydrologic Inflows

For this updated analysis, BGC was requested to model the 5.4%, 13.3%, and 27% release volumes under Sunny day conditions and the 27% release volume under Flood stage conditions.

Relative to the magnitude of the dam breach hydrographs (i.e., Figure 2-2), average flows in Crooked Creek are minimal (on the order of 600 to 1600 cfs, see Figure 2-4 of the Main Report) and would not impact model results for the Sunny day scenarios. The same is true for Flood stage conditions. Using regional regression equations developed by Curran et al. (2016), the Q_{100} of Crooked Creek at its mouth⁵ is estimated at 7,840 cfs (222 m³/s). Therefore, background flows in Crooked Creek were not modelled for any of the breach scenarios.

⁵ Drainage area = 330 sq. mi. (855 km²).

In contrast, discharges in the Kuskokwim River are significant through most of the year. For Sunny day conditions, BGC previously used the average flow in the June to September period to represent Sunny day flow conditions. This flow was estimated at 68,900 cfs (1,950 m³/s) based on streamflow data from the USGS gage located on the Kuskokwim River immediately upstream of the Crooked Creek confluence (#15304000). This gage has been in operation since 1951 and has an upstream watershed area of 31,100 sq.mi. (80,610 km²), which is approximately 100x larger than the Crooked Creek watershed. For Flood stage conditions, BGC estimated the Q₁₀₀ for this gage at 319,300 cfs (9,040 m³/s) using the USGS PeakFQ on-line software (<https://rconnect.usgs.gov/peakfq/>).

Boundary Conditions

A summary of the boundary conditions used in the models is presented in Table 3-1. The Crooked Creek non-Newtonian model used a single boundary condition at the Donlin TSF dam to inject the breach hydrographs for the breach scenarios. The bulked flood wave hydrographs for each scenario (with sediment) were extracted from the non-Newtonian model along a cross-section at the confluence with the Kuskokwim River.

The Newtonian model for the Kuskokwim River incorporated an upstream inflow boundary condition to simulate river flows of 68,900 cfs (1,950 m³/s) [Sunny day] and 319,300 cfs (9,040 m³/s) [Flood stage]. An initial simulation was conducted to achieve steady-state flow conditions within the river for Sunny day and Flood stage scenarios, which subsequently served as the starting point for further analysis. The flood wave hydrograph extracted from the non-Newtonian model at the confluence of Crooked Creek and the Kuskokwim River was then applied as Newtonian inflow boundary condition. A normal flow boundary condition was designated at the downstream limit to facilitate the exit of the flood wave from the model domain.

Table 3-1 Boundary conditions used in the updated models.

Location	Type	Description
Non-Newtonian Model (Crooked Creek)		
Donlin TSF (Anaconda Creek)	Inflow Boundary Condition	Dam breach hydrograph for specific scenario.
Newtonian Model (Kuskokwim River)		
Kuskokwim River Inlet	Inflow Boundary Condition	Steady state inflow of 68,900 cfs (1,950 m ³ /s) for the Sunny day scenarios. Steady state inflow of 319,300 cfs (9,040 m ³ /s) for the Flood stage scenario.
Confluence with Crooked Creek	Inflow Boundary Condition	Flood wave hydrograph extracted from the non-Newtonian model at Crooked Creek upstream of the confluence with the Kuskokwim River.
Kuskokwim River Outlet	Normal Flow Boundary Condition	Normal depth outflow with a friction slope of 0.0005

3.2 Results

3.2.1 Flow Mixing

Figure 3-6 shows the mixing of the modelled Crooked Creek breach hydrographs (as routed to the creek mouth) with the Kuskokwim River baseflows for the four breach scenarios considered herein. That is:

- updated 5.4% release volume for Sunny day conditions
- updated 13.3% release volume for Sunny day conditions
- 27% release volume for Sunny day conditions
- 27% release volume for Flood stage conditions.

Information displayed on Figure 3-6 includes:

- The combined stream discharge of the two flows as a function of time.
- The combined Cv as a function of time.
- The average Cv for a 2-hour period, which represents the bulk of the breach hydrograph.
- Upper (Cv = 30%) and lower (Cv = 20%) limits that define the boundary between non-Newtonian and Newtonian flows. The CDA (2021) defines this boundary as between 20 and 30%, while the USACE (n.d.) notes that sediment laden fluids with volumetric concentrations of up to 30% can be considered a Newtonian fluid.

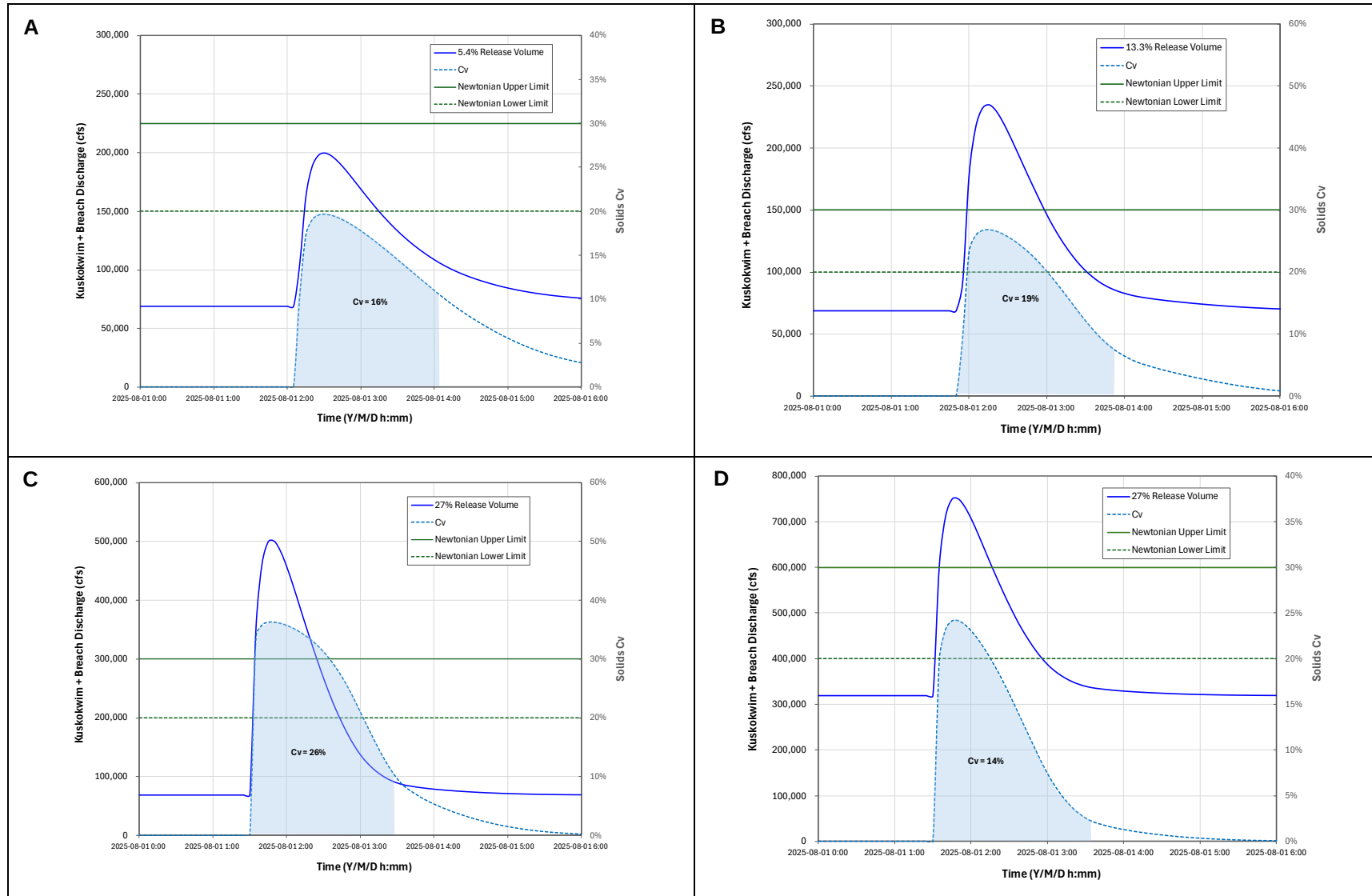


Figure 3-6 Mixed flow hydrographs for Crooked Creek at its mouth with Kuskokwim River baseflows. A) 5.4% release scenario, Sunny day conditions. B) 13.3% release scenario, Sunny day conditions. C) 27% release scenario, Sunny day conditions. D) 27% release scenario, Flood stage conditions.

Volumetric sediment concentrations for the mixed flows at the confluence are summarized in Table 3-2. Based on these results, it would be appropriate to consider the 5.4% Sunny day, 13.3% Sunny day, and 27% Flood stage scenarios as Newtonian fluids after mixing with the Kuskokwim River flows. The 27% Sunny day scenario would be transitional between a non-Newtonian and Newtonian flow.

Table 3-2 Maximum and average volumetric sediment concentrations for the mixed flows at the Crooked Creek – Kuskokwim River confluence.

Breach Scenario	Max Cv (%)	Average Cv (%)
5.4%, Sunny day	20	16
13.3% Sunny day	27	19
27% Sunny day	36	26
27% Flood stage	24	14

3.2.2 Flood Inundation

Breach inundation maps for the four scenarios are shown in Drawing sets A (5.4% tailings release scenario, Sunny day), B (13.3% tailings release scenario, Sunny day), C (27% tailings release volume scenario, Sunny day), and D (27% tailings release volume scenario, Flood stage). A fifth drawing set, E, is provided for the Q_{100} flood conditions in the Kuskokwim River only. The extents of the modelled inundation areas are summarized in Table 3-3. It is stressed that the Q_{100} results for the Kuskokwim River do not represent floodplain maps and should not be used as such, given that BGC has inferred the river bathymetry from satellite data. For the purposes of this report, the variable of interest is the incremental increase in flood depth over baseflow conditions as the breach flood wave progresses downstream.

Table 3-3 Summary of modelled inundation areas.

Tailings Release Scenario	Flood Induced	Drawing Set Number	Crooked Creek Inundation Area (acres)	Kuskokwim River Inundation Area (acres)
5.4%	Sunny Day	A	4,507	937 ¹
13.3%	Sunny Day	B	5,110	1,460 ¹
27%	Sunny Day	C	5,902	2,421 ¹
27%	Flood Stage	D	5,902	4,574 ¹
-	Q_{100}	E	n/a	159,898

Note:

- Expressed as the area flooded outside the extent of the Kuskokwim River for the baseflow conditions.

Summaries of the peak flows, flood arrival times and the peak arrival times for the four communities within the study area are presented in Table 3-4 for the four tailings release

scenarios. The hydrographs produced by the dam breach flood wave at the communities of Crooked Creek (mile 14, km 22), Chuathbaluk (mile 71, km 115), Aniak (mile 81, km 130), and Upper/Lower Kalskag (mile 114, km 183) are shown in Figure 3-7 to Figure 3-11. Figure 3-7 includes the routed breach hydrographs from the Main Report for comparison.

Channel profiles showing the maximum water surface elevations at the four communities are shown in Figure 3-12 to Figure 3-15.

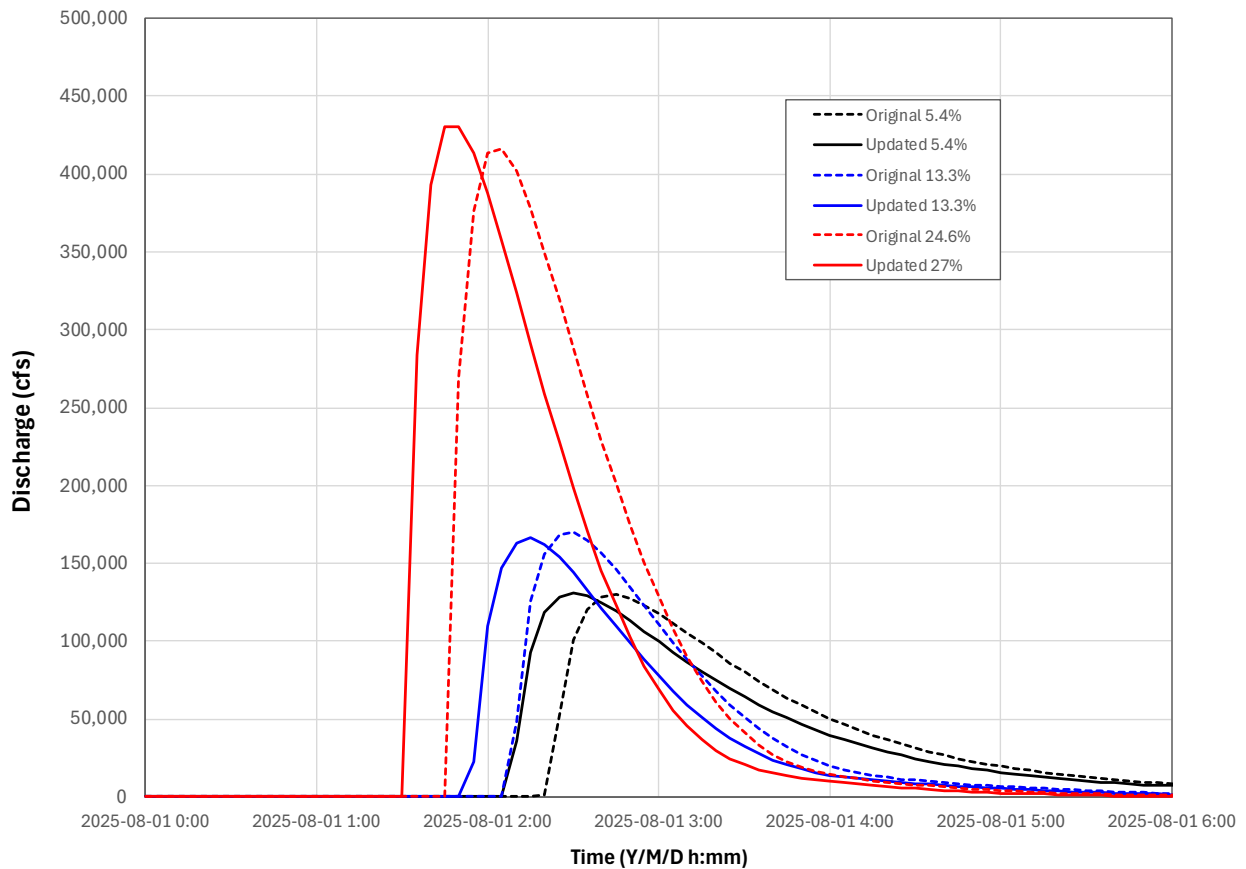


Figure 3-7 Crooked Creek hydrograph of the flood wave at the Village of Crooked Creek (cross-section C).

Table 3-4 Modelled front arrival times, peak arrival time and peak flow.

Location	Tailings Release Scenario			
	Sunny day	Sunny day	Sunny day	Flood stage
	5.4%	13.3%	27%	27%
	Front Arrival Time (h:mm)			
Crooked Creek	2:10	1:55	1:30	
Chuathbaluk	11:20	10:55	9:30	6:45
Aniak	18:40	18:45	14:40	10:00
Kalskag	25:30	25:25	22:10	25:10
	Peak Arrival Time (h:mm)			
Crooked Creek	2:30	2:15	1:50	
Chuathbaluk	20:25	19:05	18:50	17:00
Aniak	23:35	23:45	22:25	19:55
Kalskag	40:45	40:30	41:10	39:30
	Peak Flow (cfs), Incremental Peak Flow (cfs) ¹ , and Incremental Increase in Flow Depth (ft) ²			
Crooked Creek ³				
Peak	130,600	166,080	430,730	
Chuathbaluk				
Peak	80,600	79,400	91,930	340,160
Incremental Peak	11,700	10,500	23,030	6,160
Incremental Depth	1.1	1.0	2.1	0.7
Aniak ⁴				
Peak	72,900	72,100	81,120	213,210
Incremental Peak	7,900	7,100	16,120	6,300
Incremental Depth	1.0	0.9	1.8	0.3
Kalskag ⁴				
Peak	53,200	52,800	57,140	176,670
Incremental Peak	4,000	3,600	7,940	2,580
Incremental Depth	0.6	0.6	1.1	0.2

Notes:

1. The incremental peak flow is the difference between the modelled peak flow and the base flow in the Kuskokwim River.
2. The incremental increase in flow depth is the difference between the modelled peak flow depth and the base flow depth in the Kuskokwim River.
3. Peak flows for the community of Crooked Creek are upstream of the confluence with the Kuskokwim River along Crooked Creek.
4. The base flows at Aniak and Kalskag is reduced compared to other sites due to a segment of the flow being conveyed through a side channel.

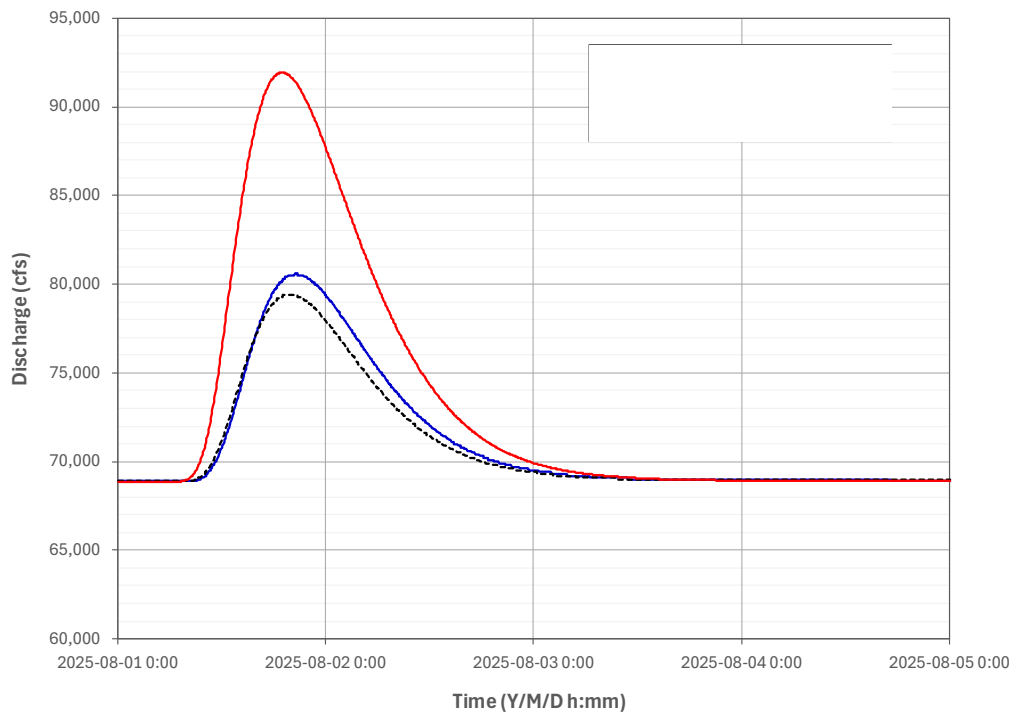


Figure 3-8 Kuskokwim River hydrograph of the flood wave at the Native Village of Chuathbaluk (cross-section H).

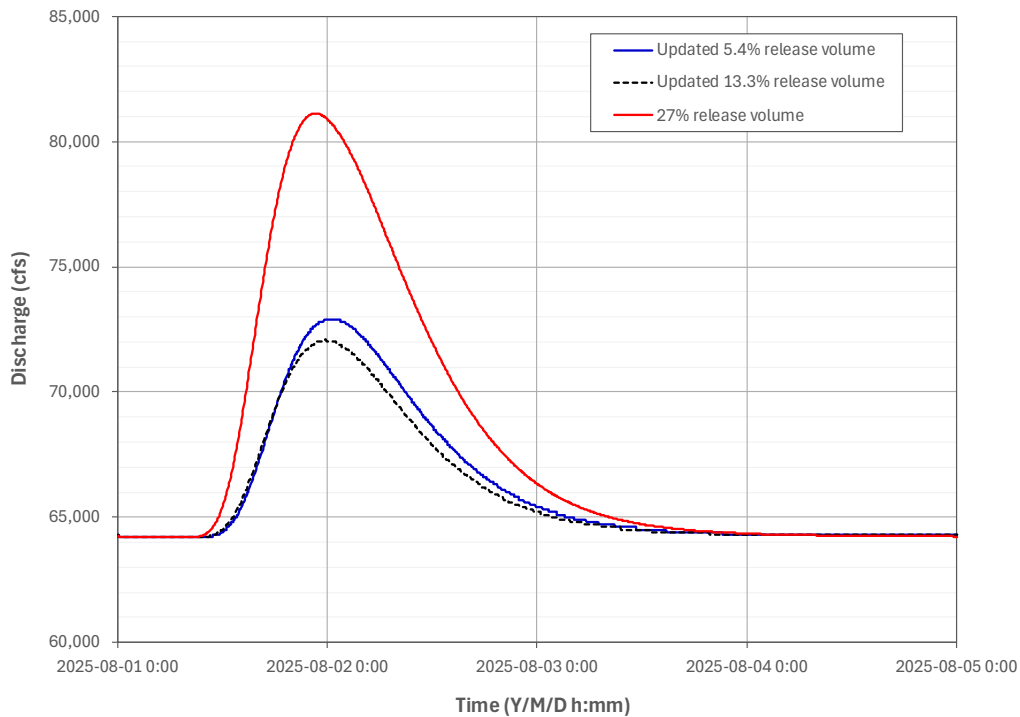


Figure 3-9 Kuskokwim River hydrograph of the flood wave at the Village of Aniak (cross-section I).

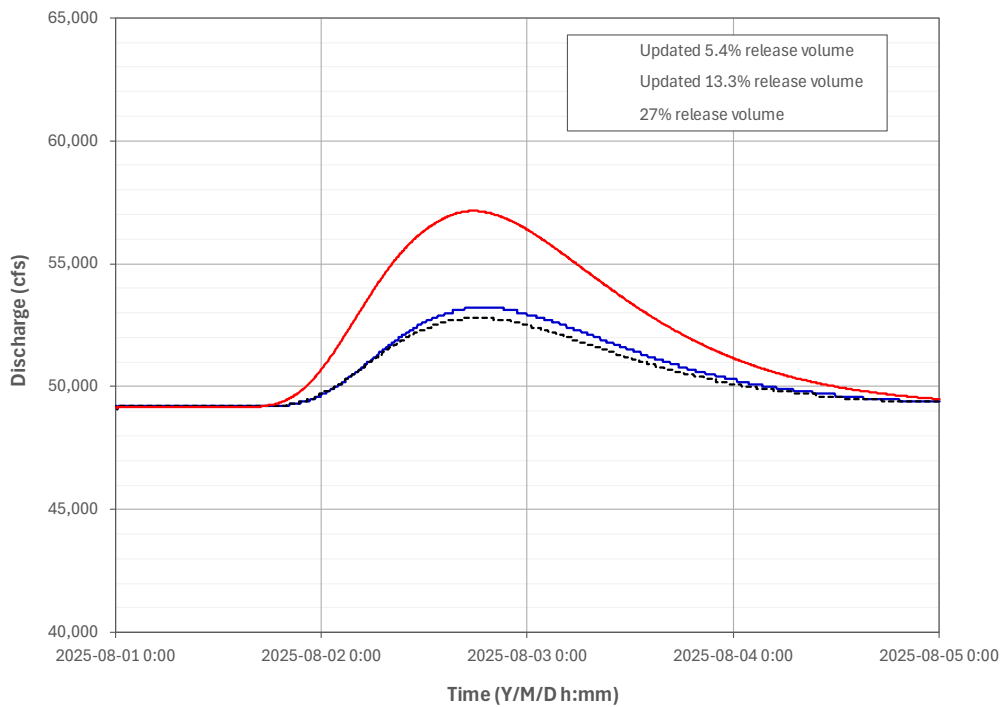


Figure 3-10 Kuskokwim River hydrograph of the flood wave at the Village of Kalskag (cross-section K).

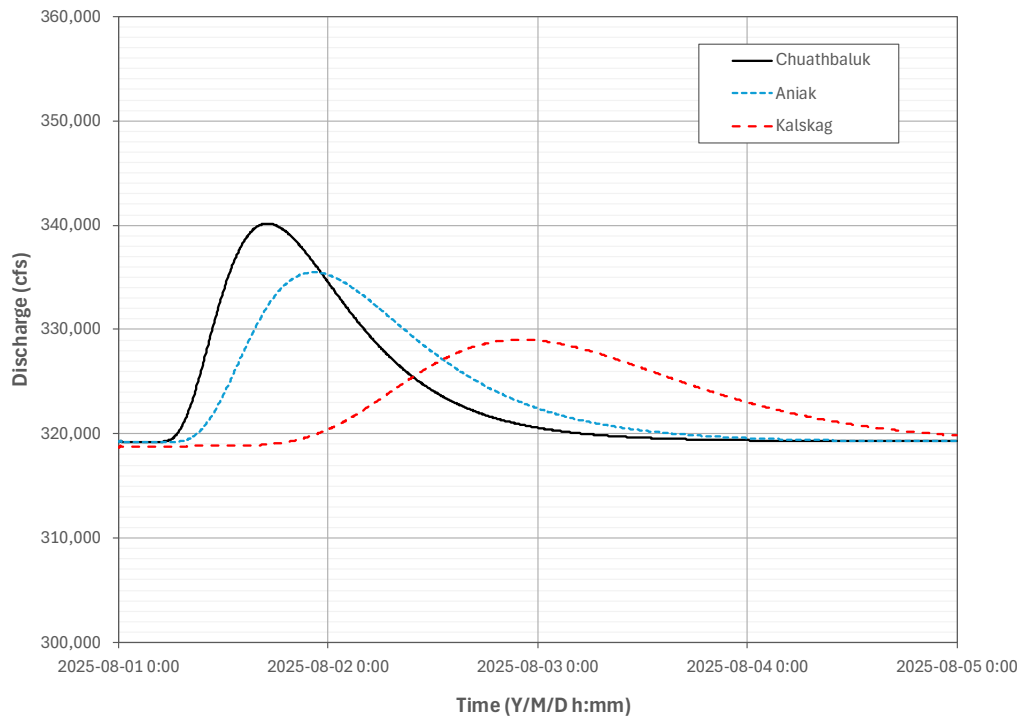


Figure 3-11 Kuskokwim River hydrograph of the 27% release volume Flood stage flood waves at Chuathbaluk (cross-section H), Aniak (cross-section I), and Kalskag (cross-section K).

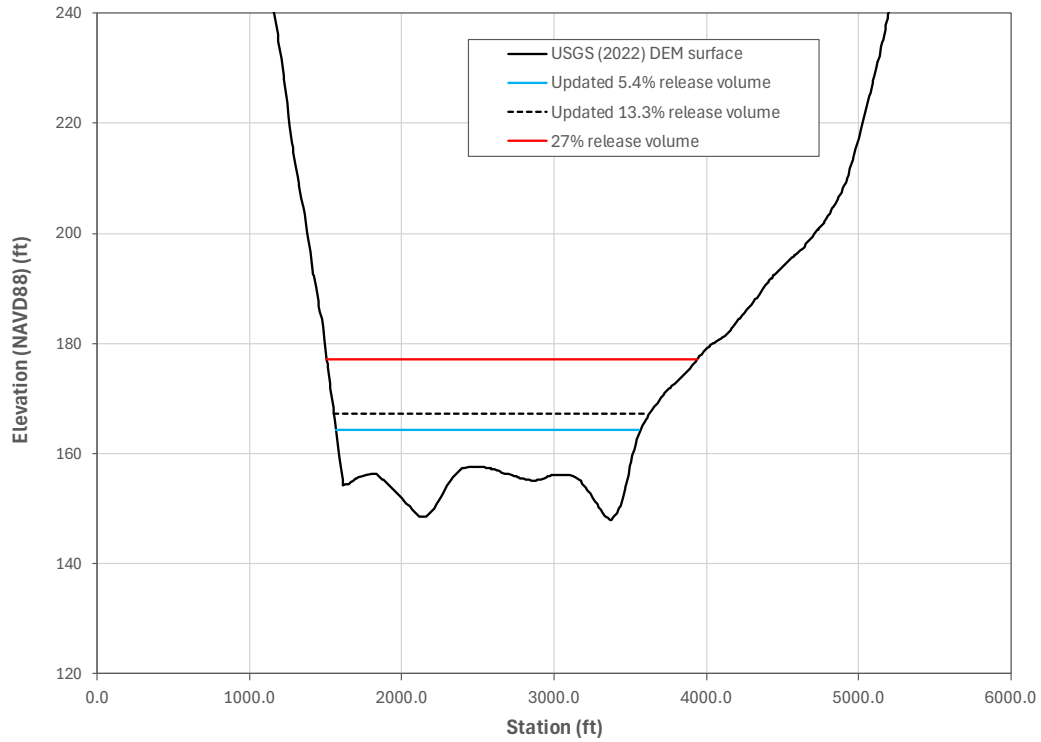


Figure 3-12 Maximum water surface elevation at the Village of Crooked Creek (cross-section C) – downstream view.

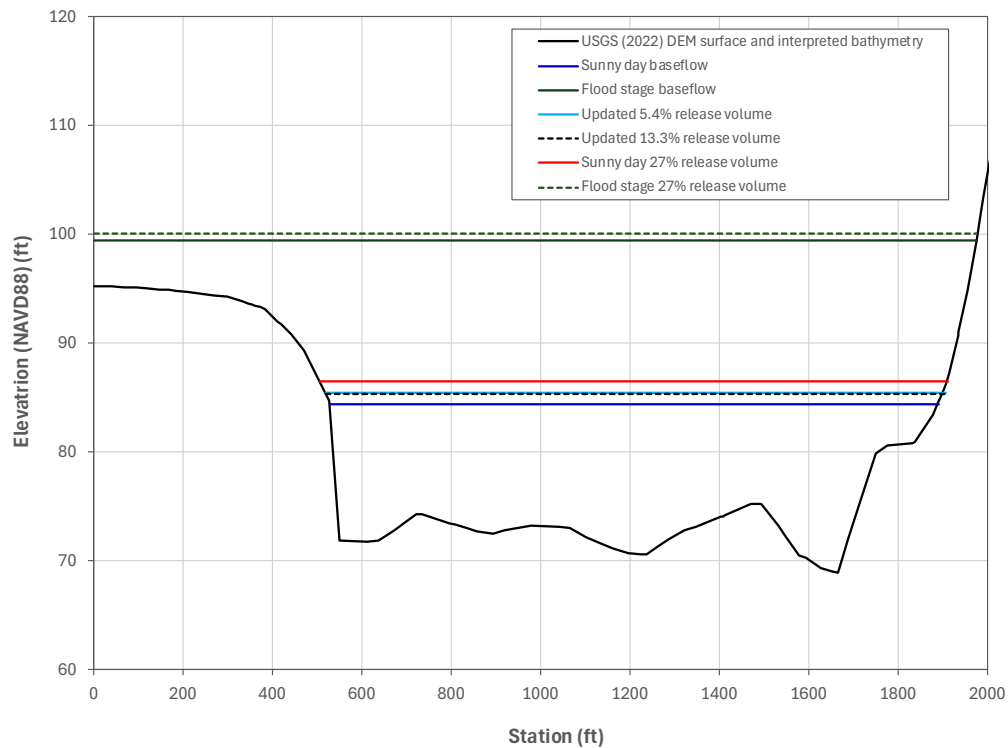


Figure 3-13 Maximum water surface elevation at the Native Village of Chuathbaluk (cross-section H) – downstream view.

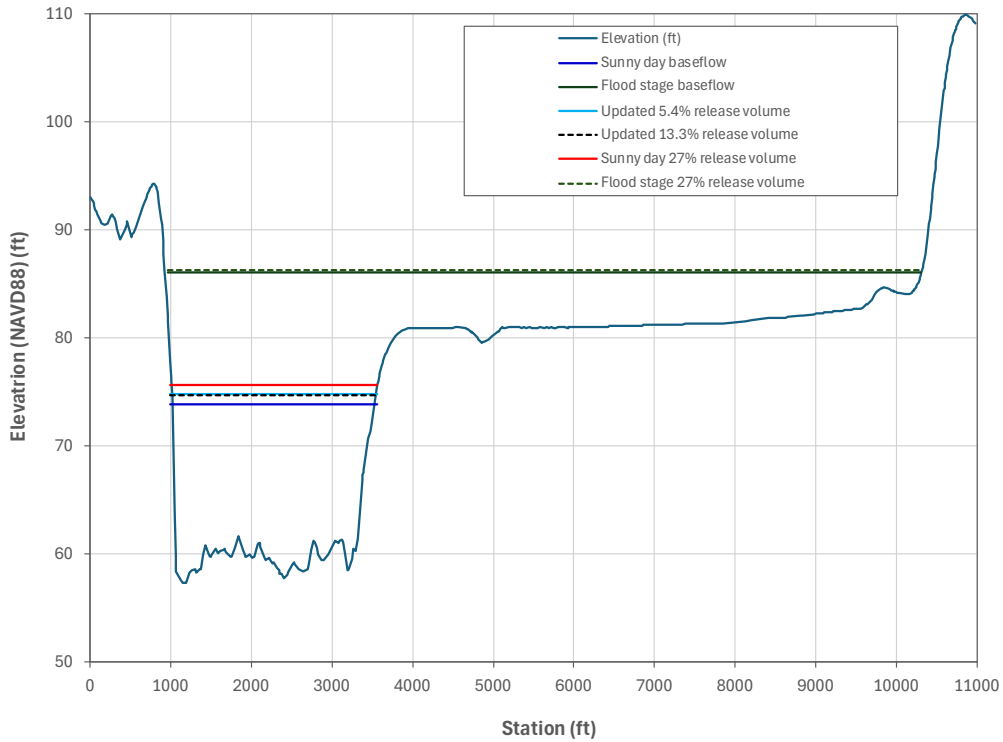


Figure 3-14 Maximum water surface elevation at the Village of Aniak (cross-section I) – downstream view.

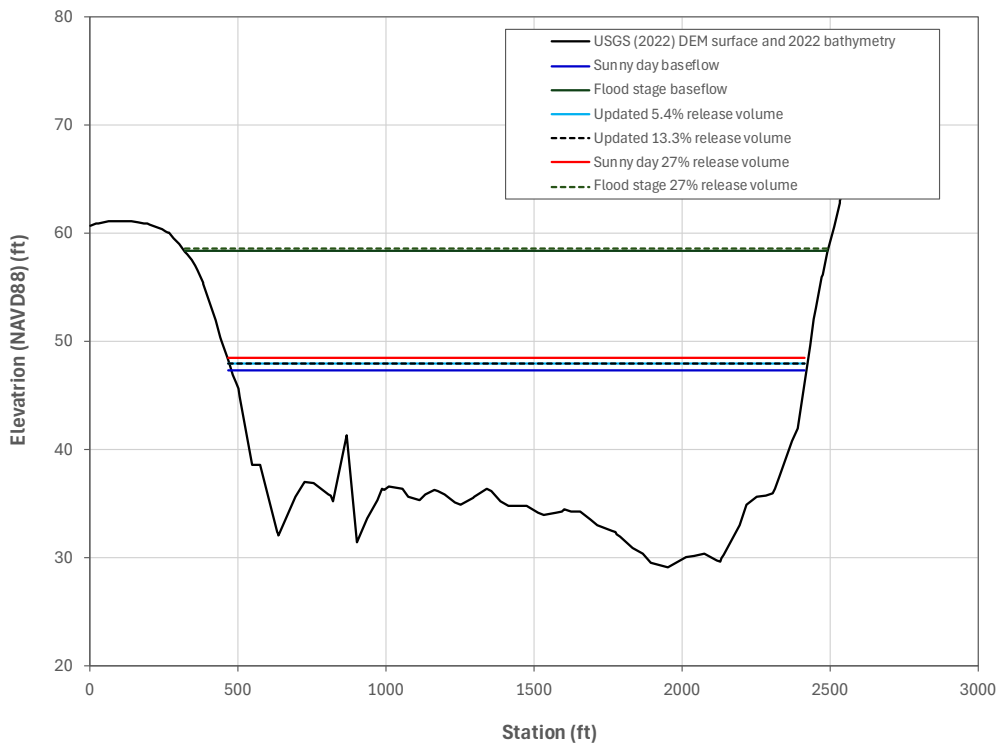


Figure 3-15 Maximum water surface elevation at the Village of Kalskag (cross-section K) – downstream view.

Specific results for the four communities are summarized as follows:

Village of Crooked Creek

The flood wave arrives at Crooked Creek between 1 hour and 30 minutes (27% release scenario) and 2 hours and 30 minutes (5.4% release scenario) after breach initiation. Peak water elevations occur about 20 minutes later. The maximum water depth ranges from 29.2 ft (11.8 m) for the 27% tailings release volume scenario to 16.4 ft (6.7 m) for the 5.4% scenario (Figure 3-12). Flooding of portions of the community occurs for three tailings release scenarios.

Native Village of Chuathbaluk

The flood wave arrives at the river reach near Chuathbaluk in 6 hours and 45 minutes (27% Flood stage release scenario) to 11 hours and 20 minutes (5.4% release scenario), with peak water elevations occurring between 17 and 20 hours after breach initiation. The maximum water depth above baseflow is between 2.1 ft (0.6 m) for the 27% Sunny day scenario and 0.7 ft (0.2 m) for the 27% Flood stage scenario (Figure 3-13). There is no flooding of the community under baseflow or breach conditions.

Village of Aniak

The river reach near Aniak experiences a flood wave arrival time between 10 hours (27% Flood stage release scenario) to 18 hours and 45 minutes (13.4% release scenario), and peak water elevations occur between 20 and 24 hours post-breach. The maximum water depth above baseflow is between 1.8 ft (0.6 m) for the 27% Sunny day scenario and 0.3 ft (0.1 m) for the 27% Flood stage scenario (Figure 3-14). There is some flooding of buildings in Aniak for the Flood stage scenario under baseflow (i.e., Q_{100}) (Drawing E-9) and breach conditions (Drawing D-9).

Village of Kalskag

At Upper/Lower Kalskag, the flood wave on the river arrives between 22 hours (27% Sunny day release scenario) and 25 hours (5.4% release scenario) after the breach, with peak water elevations occurring between 40 and 41 hours. The maximum water depth above baseflow is between 1.8 ft (0.6 m) for the 27% Sunny day scenario and 0.3 ft (0.1 m) for the 27% Flood stage scenario (Figure 3-15). There is some flooding of buildings in Upper/Lower Kalskag for the Flood stage scenario under baseflow (i.e., Q_{100}) (Drawing E-11) and breach conditions (Drawing D-11).

3.2.3 Tailings Deposition in Crooked Creek

Assessment of the tailings deposition along Crooked Creek was made by extracting the flow volume left behind in the floodplain from the non-Newtonian model at the final time step of the model after the flood wave had stopped. A summary of the tailings deposition in Crooked Creek and the discharge into the Kuskokwim River is provided in Table 3-5 and Figure 3-16.

Table 3-5 Summary of tailings deposition in Crooked Creek and discharged to Kuskokwim River.

Tailings Release Scenario (%)	Volume of Tailings Released (acre ft)	Tailings Deposition in Crooked Creek (acre ft)	Deposition in Crooked Creek (%) ¹	Discharged to Kuskokwim River (acre ft) ²
5.4	17,910	11,877	66%	15,763
13.3	44,350	41,558	93%	12,702
27	100,000	69,588	70%	40,142

Notes:

1. Expressed as a percentage of the volume of tailings released and not the total release volume including the pond.
2. Includes both tailings and pond water.

3.2.4 Sediment Advection and Dispersion

Downstream of the confluence, sediment concentration was treated as an advected and diffused scalar. As the sediment-laden breach flow mixes with the much larger receiving discharge of the Kuskokwim River, volumetric concentrations are expected to decrease rapidly. Once concentrations fall below approximately 20-30%, flow behaviour is expected to transition to Newtonian, and non-Newtonian rheological effects are no longer controlling.

This section presents results of a one-dimensional (1D) advection-dispersion analysis simulating the downstream transport of tailings solids following the dam breach. The breached slurry mixes with Kuskokwim River baseflow at the confluence and is routed downstream under advection and longitudinal dispersion. Each of the four breach scenarios were evaluated.

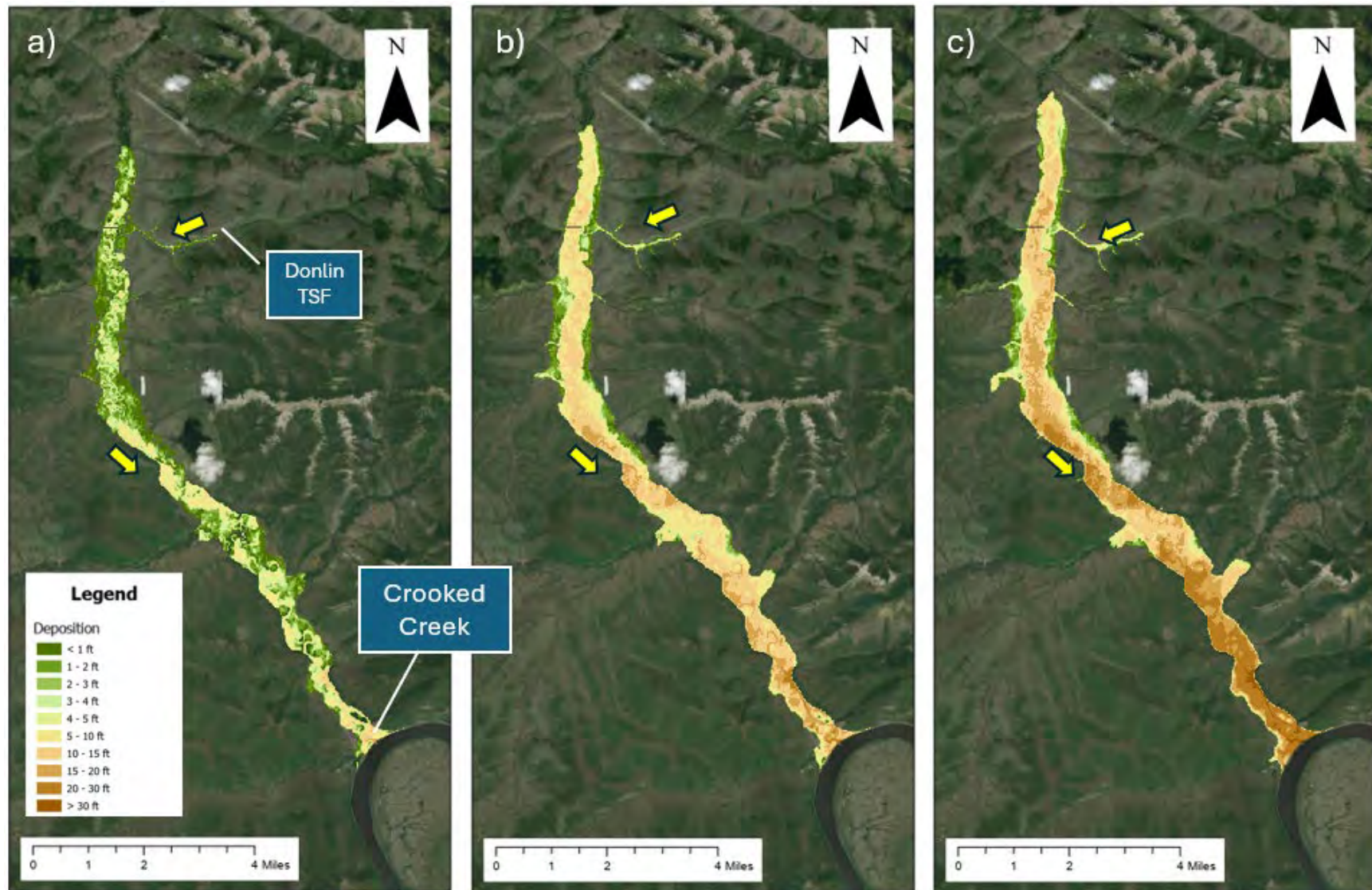
3.2.4.1 Model Description

Source Concentration at the Confluence

At each time step the breach hydrograph provides the breach discharge Q_b (m³/s), the solids volume fraction C_v , and the Kuskokwim River baseflow Q_{base} (m³/s). Assuming complete instantaneous mixing at the confluence, a volumetric mass balance gives the tailings concentration entering the river:

$$C_{src}(t) = \frac{Q_b(t) C_v(t)}{Q_b(t) + Q_{base}(t)}$$

where C_{src} is the time-varying concentration at the source. When the breach hydrograph is complete ($Q_b = 0$) this equation evaluates to zero and only clean baseflow occupies the channel.



River Velocity from Total Discharge

The plume is advected at the reach-averaged velocity $u(t)$, derived from the total discharge and the time-varying cross-section area:

$$u(t) = \frac{Q_{total}(t)}{A_{eff}(Q_{total}(t))}, Q_{total}(t) = Q_b(t) + Q_{base}(t)$$

The effective cross-section area $A_{eff}(Q(t))$ is described by a quadratic stage-discharge rating curve calibrated to the Kuskokwim River downstream of Crooked Creek:

$$A(Q) = aQ^2 + bQ + c$$

Because the parabola is downward opening ($a < 0$), it reaches a maximum at the vertex discharge $Q^* = -b / (2a)$. For $Q > Q^*$ the area is clamped at A^* to prevent physically unrealistic velocity reduction at high breach flows:

$$A_{eff}(Q) = \min(A(Q), A^*), Q^* = -\frac{b}{2a}$$

The rating curve coefficients used in all scenarios are defined in Table 3-6.

Table 3-6 Rating curve parameters considered for the model.

Variable	metric	US standard
a	$-4.856 \times 10^{-5} \text{ m}^{-1}$	$-1.593 \times 10^{-4} \text{ ft}^{-1}$
b	0.8157	
c	412.8 m^2	$4,443 \text{ ft}^2$
Q^* (vertex discharge)	$\approx 8,400 \text{ m}^3/\text{s}$	$\approx 296,600 \text{ cfs}$
A^* (vertex area)	$\approx 3,838 \text{ m}^2$	$\approx 41,310 \text{ ft}^2$

1D Advection-Dispersion Transport

Tailings concentration $C(x, t)$ along the reach evolves under the 1D advection-dispersion equation (ADE):

$$\frac{\partial C}{\partial t} + u(t) \frac{\partial C}{\partial x} = D_L \frac{\partial^2 C}{\partial x^2}$$

where x is distance downstream (m), t is time (s), and D_L is the longitudinal dispersion coefficient (m^2/s). The upstream boundary condition is $C(0, t) = C_{src}(t)$ and a zero-gradient (Neumann) condition is applied at the downstream end.

The longitudinal dispersion coefficient is calculated using Fischer et al.'s (1979) formula:

$$D_L = 0.011 \frac{u^2 W^2}{hu^*}$$

where u is the mean river velocity, W is the river width, h is the mean river depth and u^* is the shear velocity (m/s). The shear velocity is calculated as $u^* = \sqrt{ghS}$, in which, g is the gravitational acceleration and S is the energy gradient.

The equation is discretized explicitly using first-order upwind differences for advection and second-order central differences for diffusion:

$$C_i^{n+1} = C_i^n + \Delta t \left[-u^n \frac{C_i^n - C_{i-1}^n}{\Delta x} + D_L \frac{C_{i+1}^n - 2C_i^n + C_{i-1}^n}{\Delta x^2} \right]$$

Numerical Stability and Adaptive Sub-stepping

Stability of the explicit scheme requires the Courant (Cr) and diffusion (Di) numbers to satisfy:

$$Cr = \frac{u \Delta t}{\Delta x} \leq 1, Di = D_L \frac{\Delta t}{\Delta x^2} \leq 0.5$$

Because breach-peak velocities can reach several metres per second, the configured outer time step Δt would violate the Courant condition at peak flow. The solver therefore selects the number of internal sub-steps $n_{sub} = \lceil \frac{\Delta t}{\Delta_{sub}} \rceil$ needed to satisfy both criteria with conservative targets ($Cr \leq 0.80$, $Di \leq 0.40$) and advances the concentration field through n_{sub} sub-steps per outer hydrograph step. The outer step cadence governs hydrograph forcing while the inner step is a purely numerical device used for stability.

Post-Breach Tail Period

After the hydrograph ends the simulation continues for a user-specified tail duration. During this period the breach is closed ($Q_b = 0$, $C_v = 0$) and the Kuskokwim River carries only baseflow, allowing the existing plume to continue travelling downstream and dispersing without new source material. All four scenarios are simulated for a total of 32 hours from the start of the breach. Table 3-7 describes the numerical parameters common to the four scenarios.

Table 3-7 Model parameters.

Parameter	metric	US standard
Domain length	500 km	310 miles
Grid spacing (Δx)	50 m	164 ft
Outer time step (Δt)	2.5 min	
Longitudinal dispersion (D_L)	3,875 m ² /s	41,710 ft ² /s
Total simulation duration	32 h	
Output time interval	10 min	
Output distance interval	50 m	164 ft
Courant number target	0.80	
Diffusion number target	0.40	

3.2.4.2 Assumptions

- Complete instantaneous mixing is assumed at the Crooked Creek confluence. Near-field mixing dynamics and lateral concentration gradients are not resolved.
- Kuskokwim River sediment concentrations are assumed to be negligible.
- The channel cross-section area is treated as a function of total discharge only (via the rating curve) and is spatially uniform along the entire reach. Local channel geometry variations are not captured.
- Solid settling, deposition, and resuspension are not modelled. The analysis represents a conservative, soluble-tracer upper bound on downstream concentrations.
- The longitudinal dispersion coefficient $D_L = 41,710 \text{ ft}^2/\text{s}$ ($3,875 \text{ m}^2/\text{s}$) is a Fischer-style estimate for the Kuskokwim River and has not been field-calibrated. The sensitivity of results to this parameter was assessed by adjusting this value by +/- 50%. Similar results were obtained in the vicinity of the downstream communities.
- The first-order upwind advection scheme introduces numerical diffusion proportional to $u \Delta x / 2$. With $\Delta x = 164 \text{ ft}$ (50 m) and $D_L = 41,710 \text{ ft}^2/\text{s}$ ($3,875 \text{ m}^2/\text{s}$), the numerical diffusivity is small relative to physical dispersion for all scenarios but will smooth sharp concentration fronts.
- The rating curve was extrapolated to breach-peak discharges well above the calibration range. The vertex clamping prevents physically unrealistic velocities but introduces uncertainty in peak-flow hydraulics.

3.2.4.3 Scenarios and Results

Table 3-8 and Figure 3-17 summarize the four breach scenarios for which the advection-dispersion analysis was completed. Peak source concentration is the maximum tailings volumetric concentration at the Crooked Creek confluence after mixing with Kuskokwim baseflow.

Table 3-8 Simulated scenarios.

Scenario	Breach C_v	Kuskokwim River Flow (cfs)	Peak Breach Flow (cfs)	Peak Mixed C_v
5.4% Release, Sunny day	0.30	68,900	130,600	19.6%
13.3% Release, Sunny day	0.38	68,900	166,080	26.9%
27% Release, Sunny day	0.42	68,900	430,730	36.2%
27% Release, Flood stage	0.42	319,300	430,730	24.1%

Results of the analysis are presented in Figure 3-18. These results show that the tailings plumes rapidly disperse. The closest downstream community is Chuathbaluk, which is about 57 miles (91 km) downstream of the Crooked Creek confluence. Figure 3-18 indicates maximum sediment concentrations of less than about 5% at this community for all four scenarios, indicating that the assumption of Newtonian fluid down the Kuskokwim River after the confluence is reasonable.

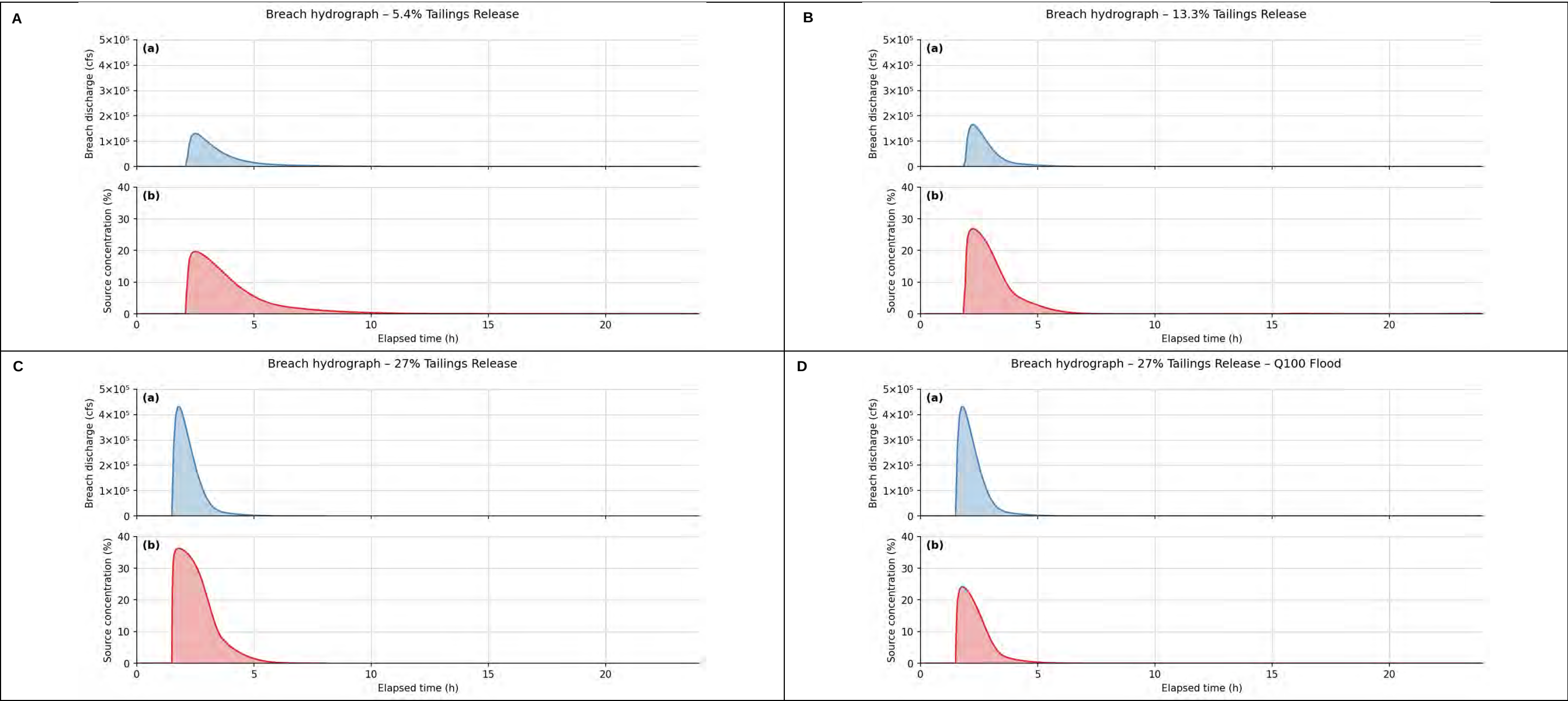


Figure 3-17 Tailings release: (a) breach discharge and (b) source concentration at the Crooked Creek confluence for: A) 5.4% release volume, Sunny day, B) 13.3% release volume, Sunny day, C) 27% release volume, Sunny day, and D). 27% release volume, Flood stage.

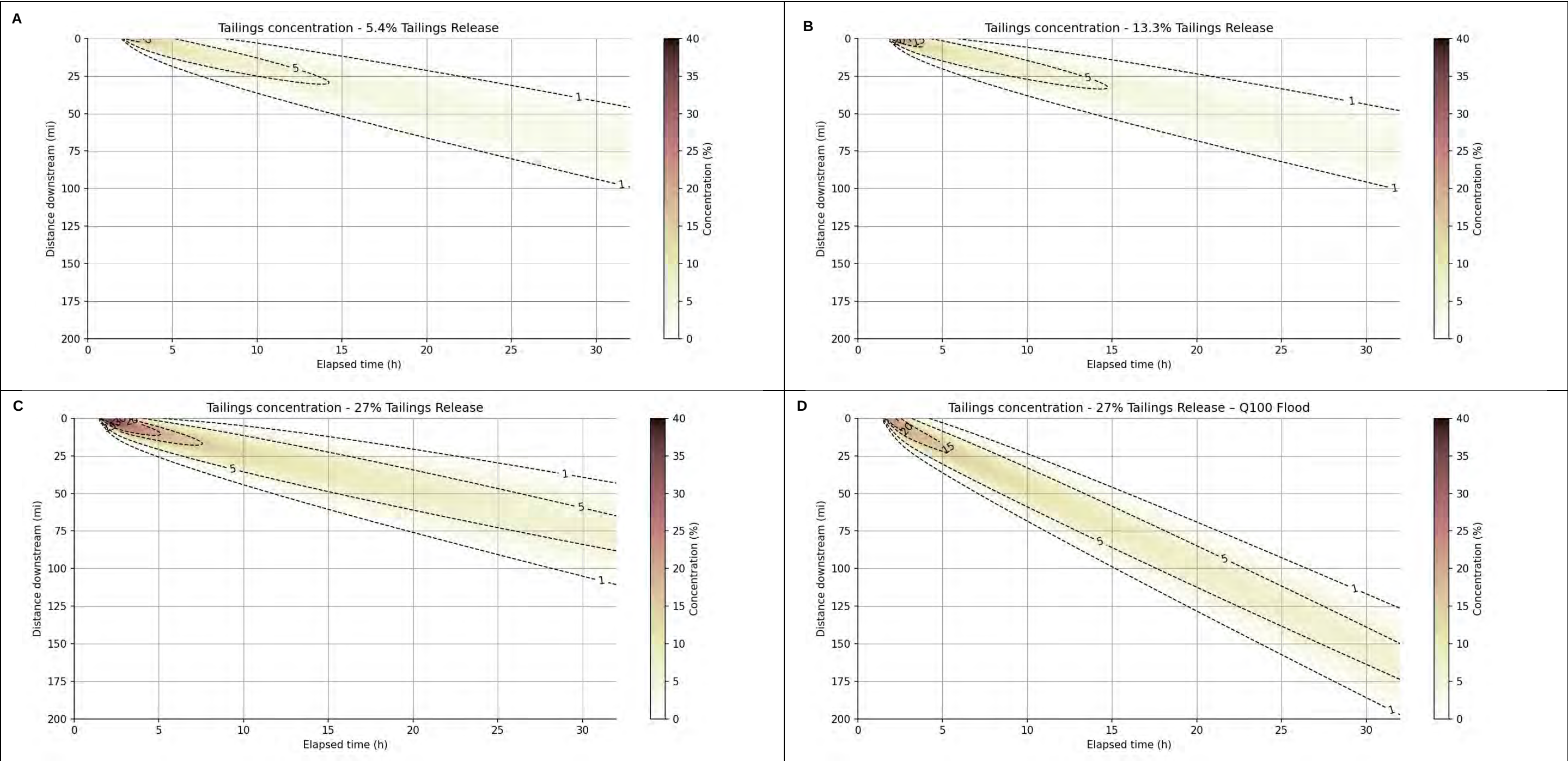


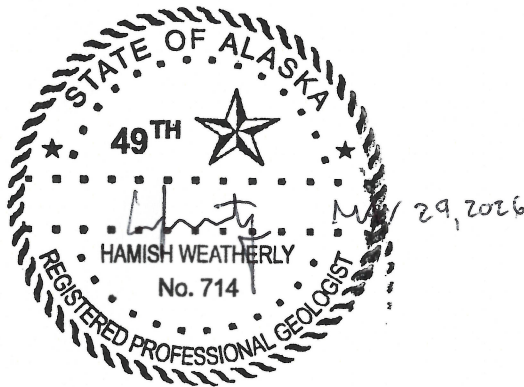
Figure 3-18 Tailings concentration field over time and distance for: A) 5.4% release volume, Sunny day, B) 13.3% release volume, Sunny day, C) 27% release volume, Sunny day, and D). 27% release volume, Flood stage. Dashed contours mark selected concentration levels (%).

4.0 CLOSURE

We trust the above satisfies your requirements. This scope of work was completed by Hamish Weatherly, M.Sc., Patrick Grover, Ph.D., and Caio Stringari, Ph.D., of BGC. Should you have any questions or comments, please do not hesitate to contact us.

Yours sincerely,

BGC Engineering Alaska Inc.
per:



Hamish Weatherly, M.Sc., PG
Principal Hydrologist

Reviewed by:

Jack Seto, M.Sc., PE
Principal Geotechnical Engineer

State of Alaska, BGC Engineering Alaska Inc. AECC1558

JTCS/PG/gc/mm

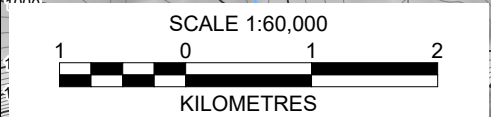
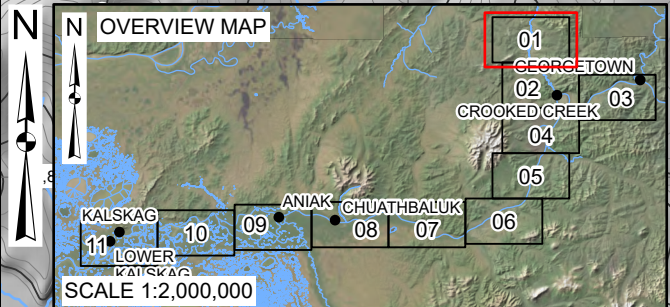
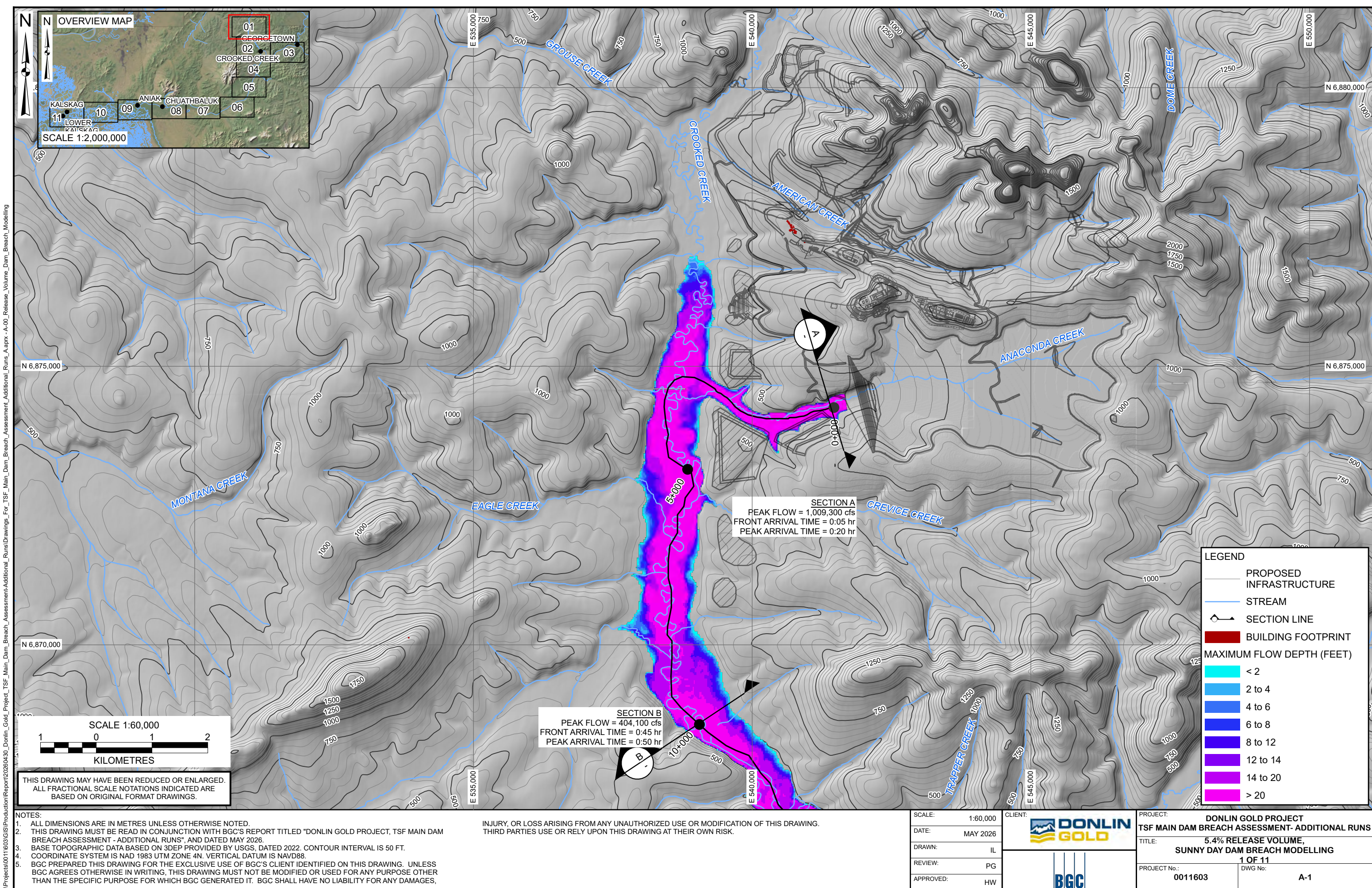
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DRAWINGS





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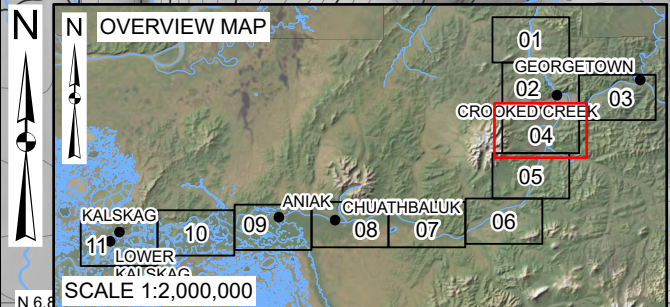
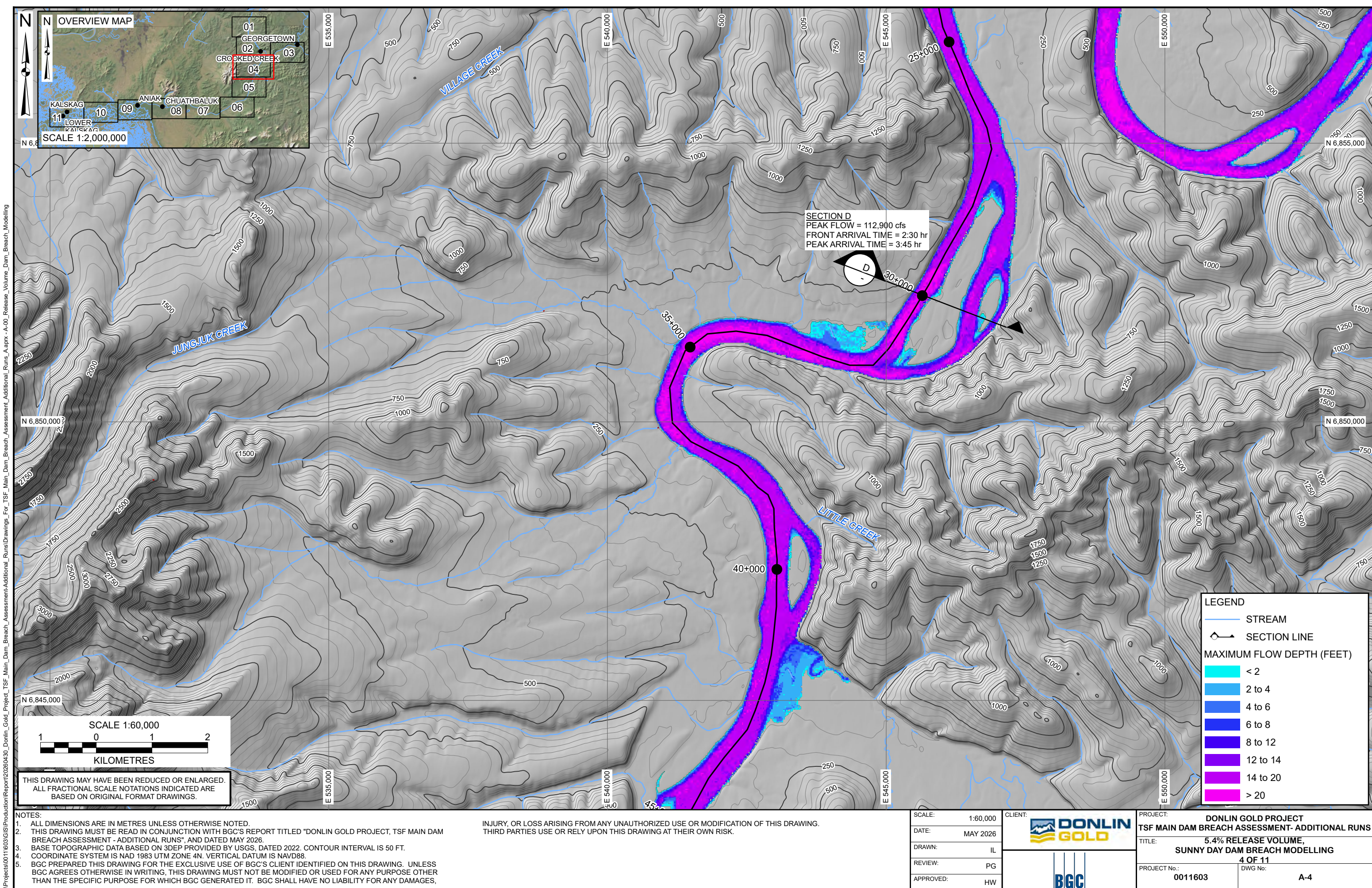
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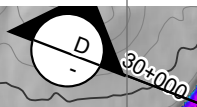
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REVIEW:	PG
APPROVED:	HW

CLIENT:

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TITLE:	5.4% RELEASE VOLUME, SUNNY DAY DAM BREACH MODELLING 1 OF 11
PROJECT No.:	0011603
DWG No:	A-1



SECTION D
PEAK FLOW = 112,900 cfs
FRONT ARRIVAL TIME = 2:30 hr
PEAK ARRIVAL TIME = 3:45 hr



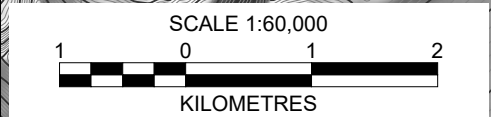
LEGEND

— STREAM

— SECTION LINE

MAXIMUM FLOW DEPTH (FEET)

< 2
2 to 4
4 to 6
6 to 8
8 to 12
12 to 14
14 to 20
> 20



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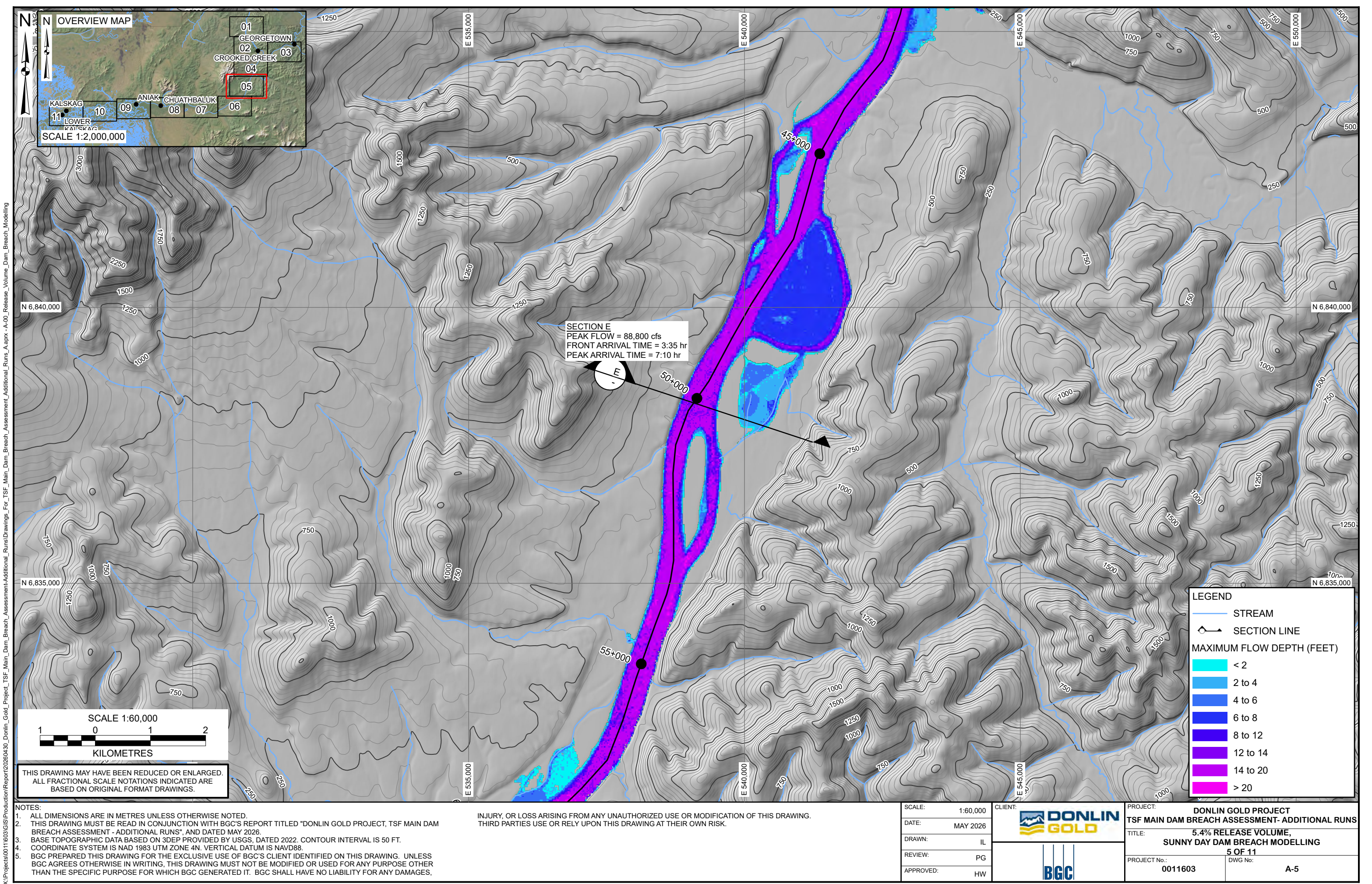
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SCALE:	1:60,000
DATE:	MAY 2026
DRAWN:	IL
REVIEW:	PG
APPROVED:	HW

CLIENT:

PROJECT:	DONLIN GOLD PROJECT TSF MAIN DAM BREACH ASSESSMENT- ADDITIONAL RUNS	
TITLE:	5.4% RELEASE VOLUME, SUNNY DAY DAM BREACH MODELLING	
PROJECT No.:	0011603	DWG No: A-4
		4 OF 11



SECTION E
PEAK FLOW = 88,800 cfs
FRONT ARRIVAL TIME = 3:35 hr
PEAK ARRIVAL TIME = 7:10 hr

LEGEND

—

 STREAM

—

 SECTION LINE

MAXIMUM FLOW DEPTH (FEET)

< 2

2 to 4

4 to 6

6 to 8

8 to 12

12 to 14

14 to 20

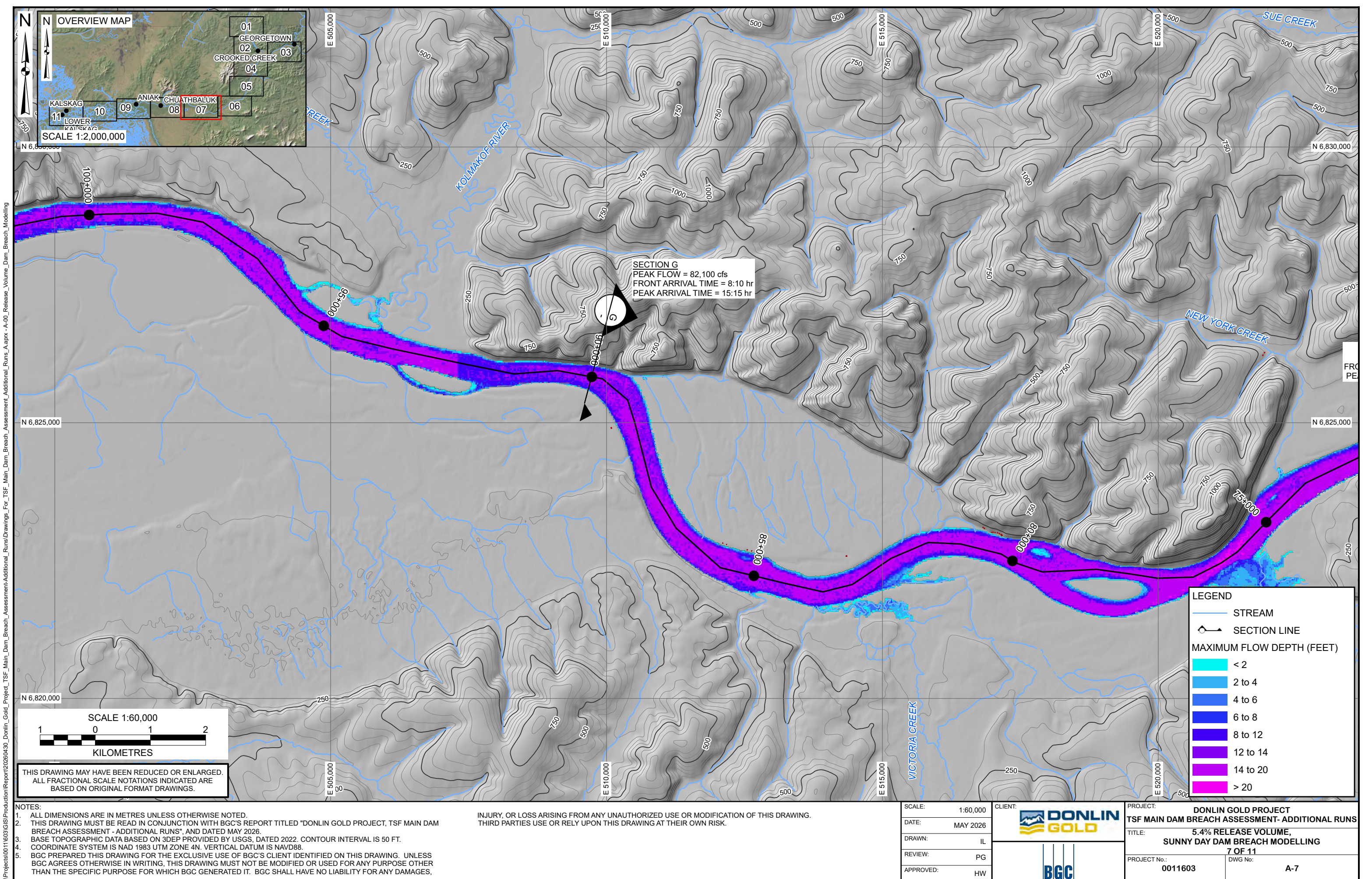
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SCALE: 1:60,000
DATE: MAY 2026
DRAWN: IL
REVIEW: PG
APPROVED: HW

CLIENT:

PROJECT: DONLIN GOLD PROJECT
TSF MAIN DAM BREACH ASSESSMENT- ADDITIONAL RUNS
5.4% RELEASE VOLUME,
SUNNY DAY DAM BREACH MODELLING
5 OF 11
PROJECT No.: 0011603
DWG No: A-5



SECTION G
PEAK FLOW = 82,100 cfs
FRONT ARRIVAL TIME = 8:10 hr
PEAK ARRIVAL TIME = 15:15 hr

LEGEND

—

STREAM

↔

SECTION LINE

MAXIMUM FLOW DEPTH (FEET)

< 2

2 to 4

4 to 6

6 to 8

8 to 12

12 to 14

14 to 20

> 20

NOTES:

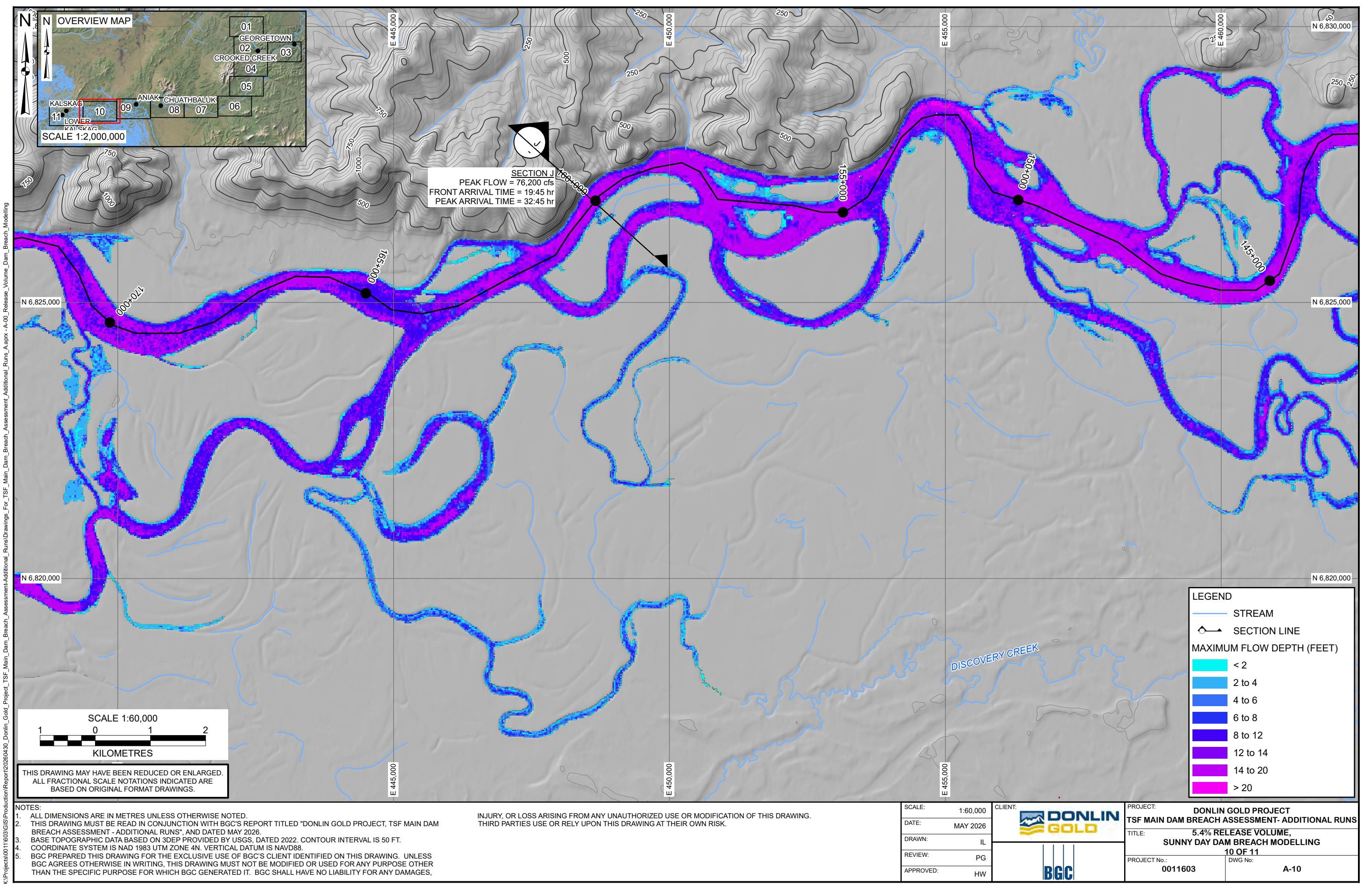
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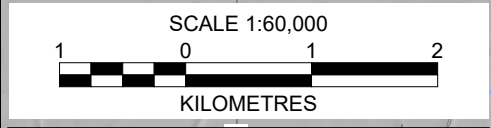
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DATE:	MAY 2026
DRAWN:	IL
REVIEW:	PG
APPROVED:	HW

CLIENT:

PROJECT:	DONLIN GOLD PROJECT	
	TSF MAIN DAM BREACH ASSESSMENT- ADDITIONAL RUNS	
TITLE:	5.4% RELEASE VOLUME, SUNNY DAY DAM BREACH MODELLING	
	7 OF 11	
PROJECT No.:	0011603	DWG No: A-7



SECTION J
PEAK FLOW = 76,200 cfs
FRONT ARRIVAL TIME = 19:45 hr
PEAK ARRIVAL TIME = 32:45 hr



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LEGEND

— STREAM

— SECTION LINE

MAXIMUM FLOW DEPTH (FEET)

< 2

2 to 4

4 to 6

6 to 8

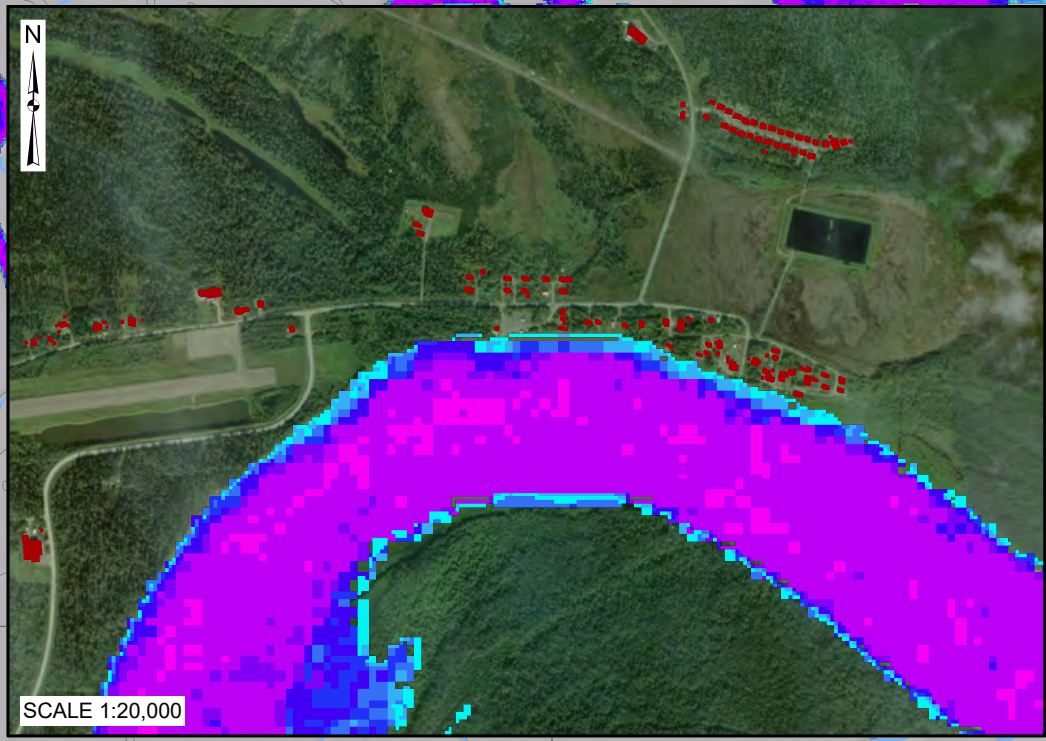
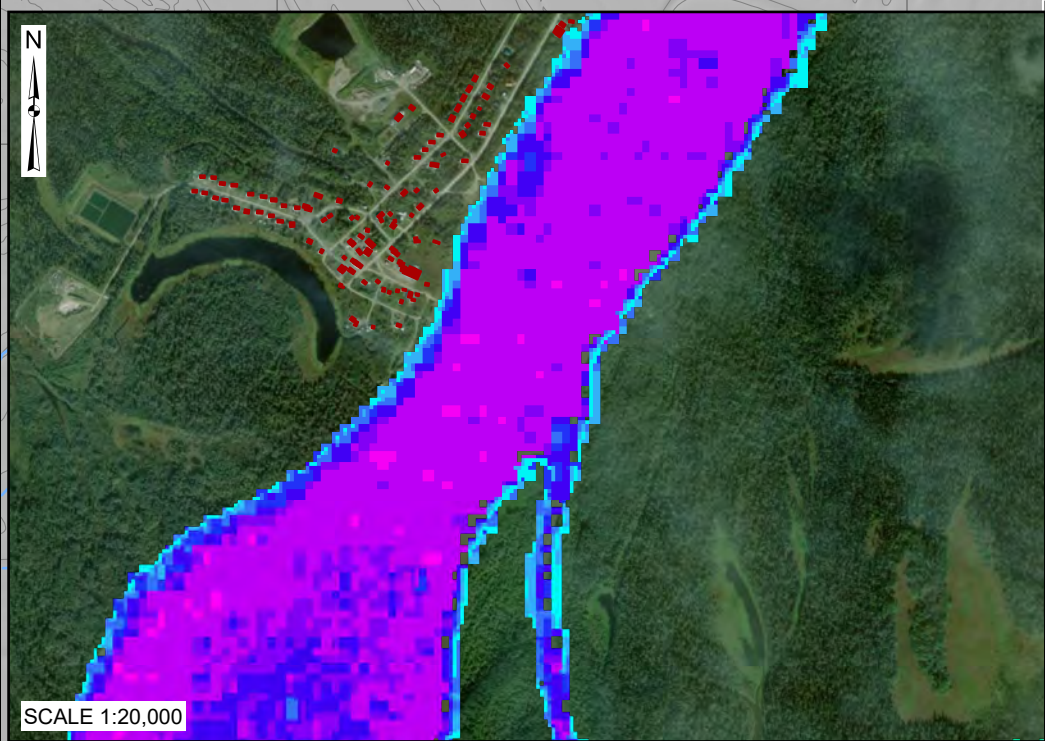
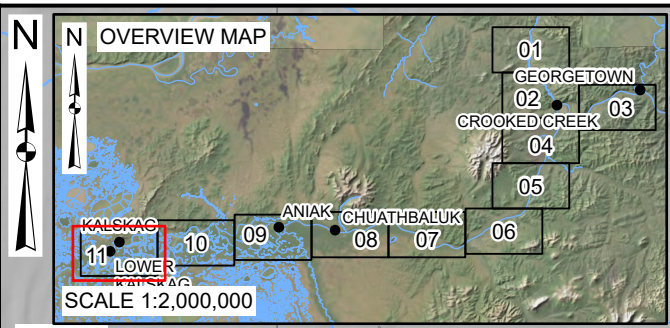
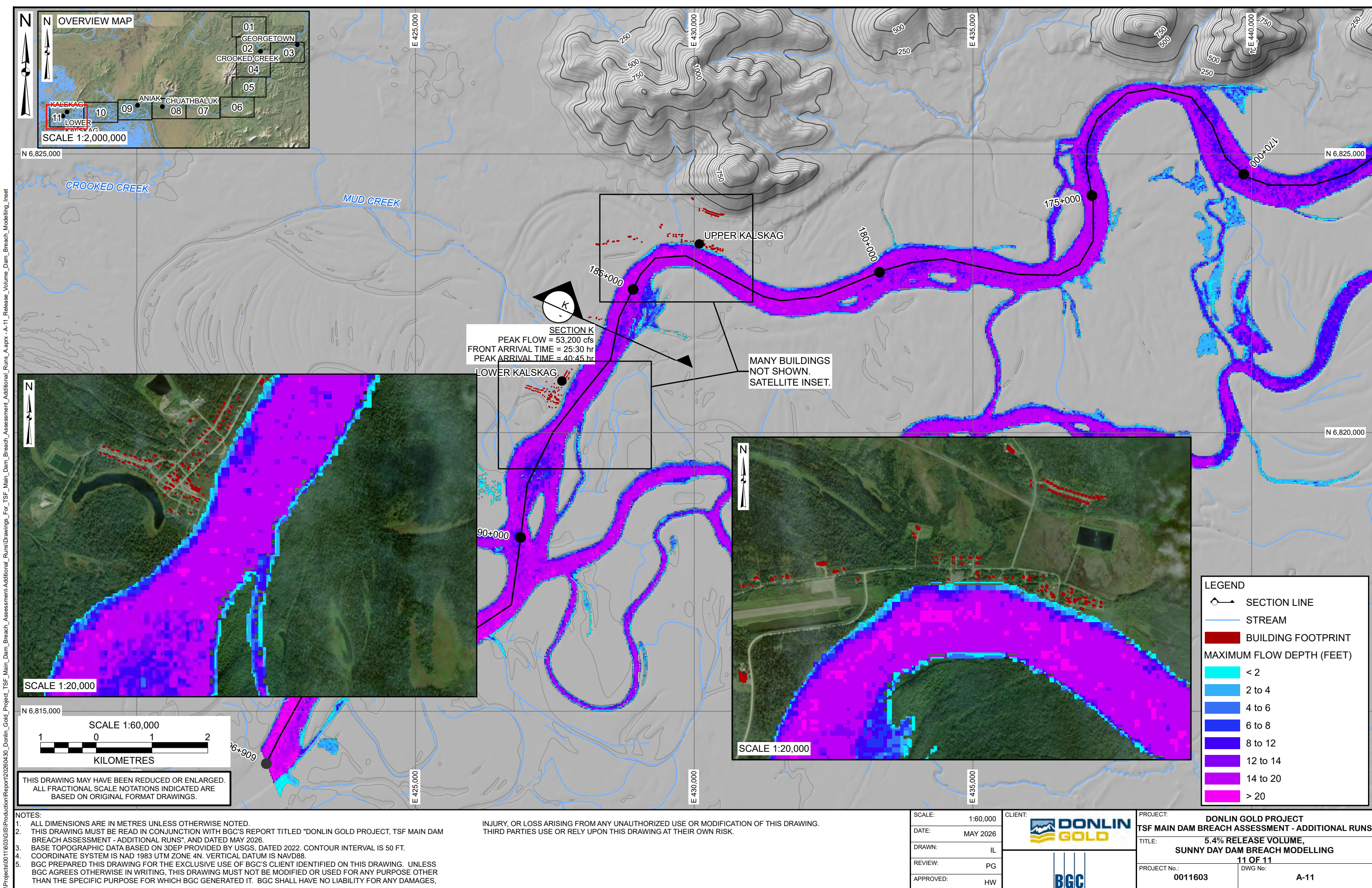
8 to 12

12 to 14

14 to 20

> 20

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		DATE:	MAY 2026		
		DRAWN:	IL		
		REVIEW:	PG		
		APPROVED:	HW		

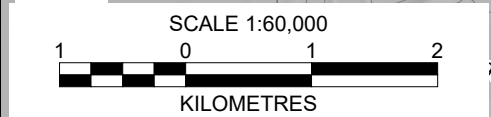


SECTION K
PEAK FLOW = 53,200 cfs
FRONT ARRIVAL TIME = 25:30 hr
PEAK ARRIVAL TIME = 40:45 hr

MANY BUILDINGS
NOT SHOWN.
SATELLITE INSET.

LEGEND

- SECTION LINE
- STREAM
- BUILDING FOOTPRINT
- MAXIMUM FLOW DEPTH (FEET)
- < 2
- 2 to 4
- 4 to 6
- 6 to 8
- 8 to 12
- 12 to 14
- 14 to 20
- > 20



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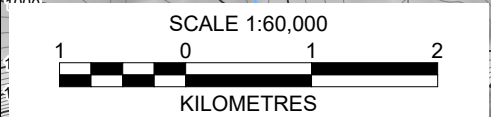
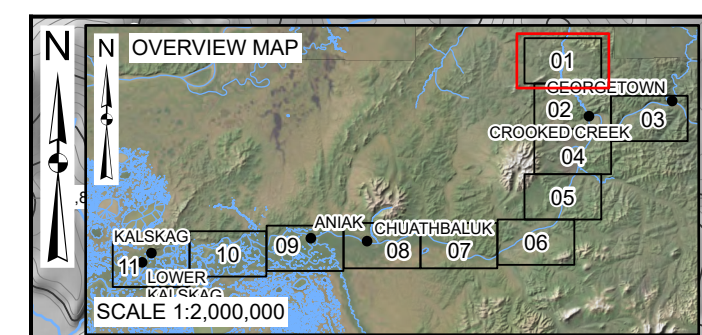
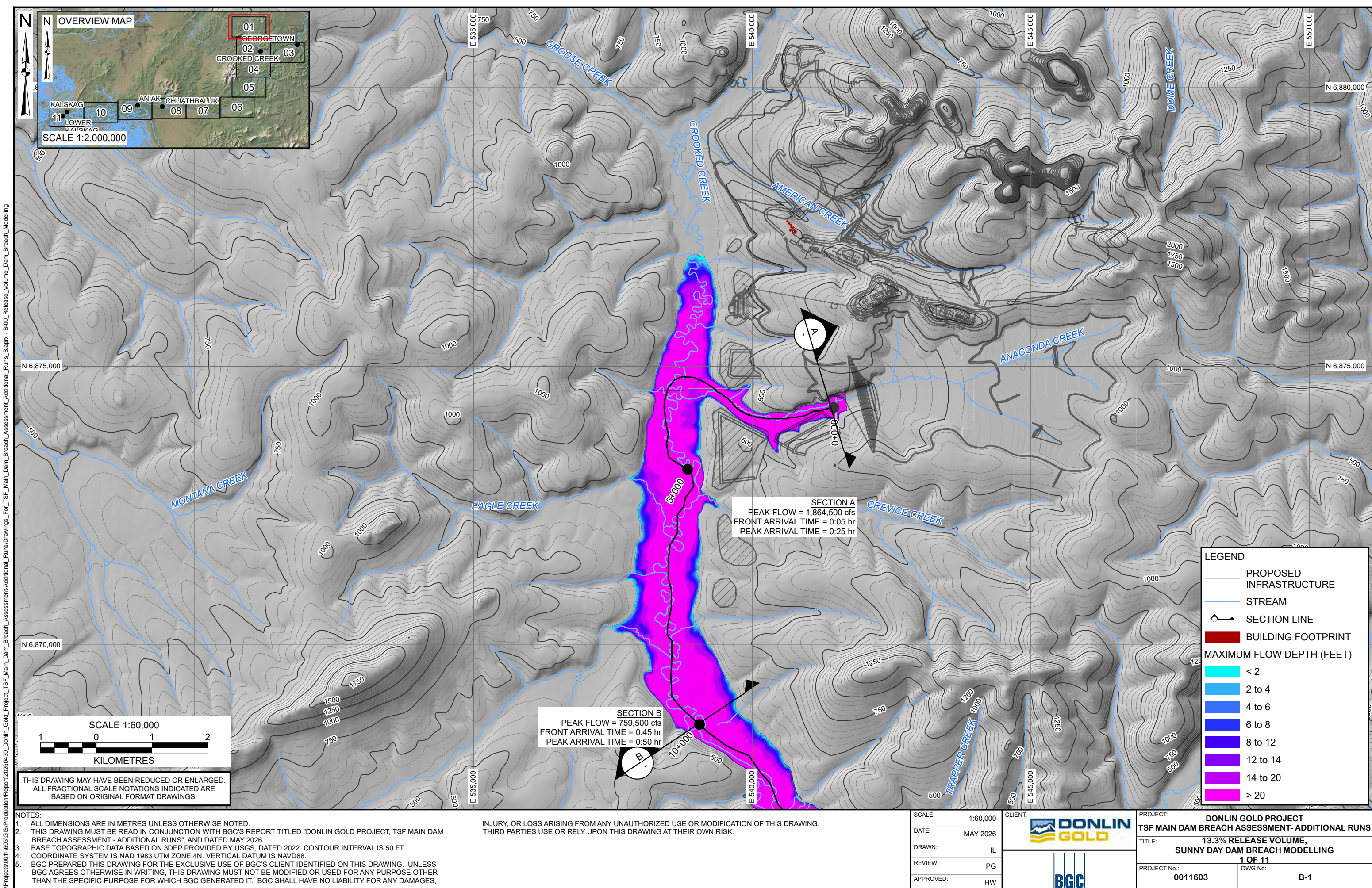
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SCALE:	1:60,000
DATE:	MAY 2026
DRAWN:	IL
REVIEW:	PG
APPROVED:	HW

CLIENT:

PROJECT:	DONLIN GOLD PROJECT	
	TSF MAIN DAM BREACH ASSESSMENT - ADDITIONAL RUNS	
TITLE:	5.4% RELEASE VOLUME, SUNNY DAY DAM BREACH MODELLING	
	11 OF 11	
PROJECT No.:	0011603	DWG No.: A-11



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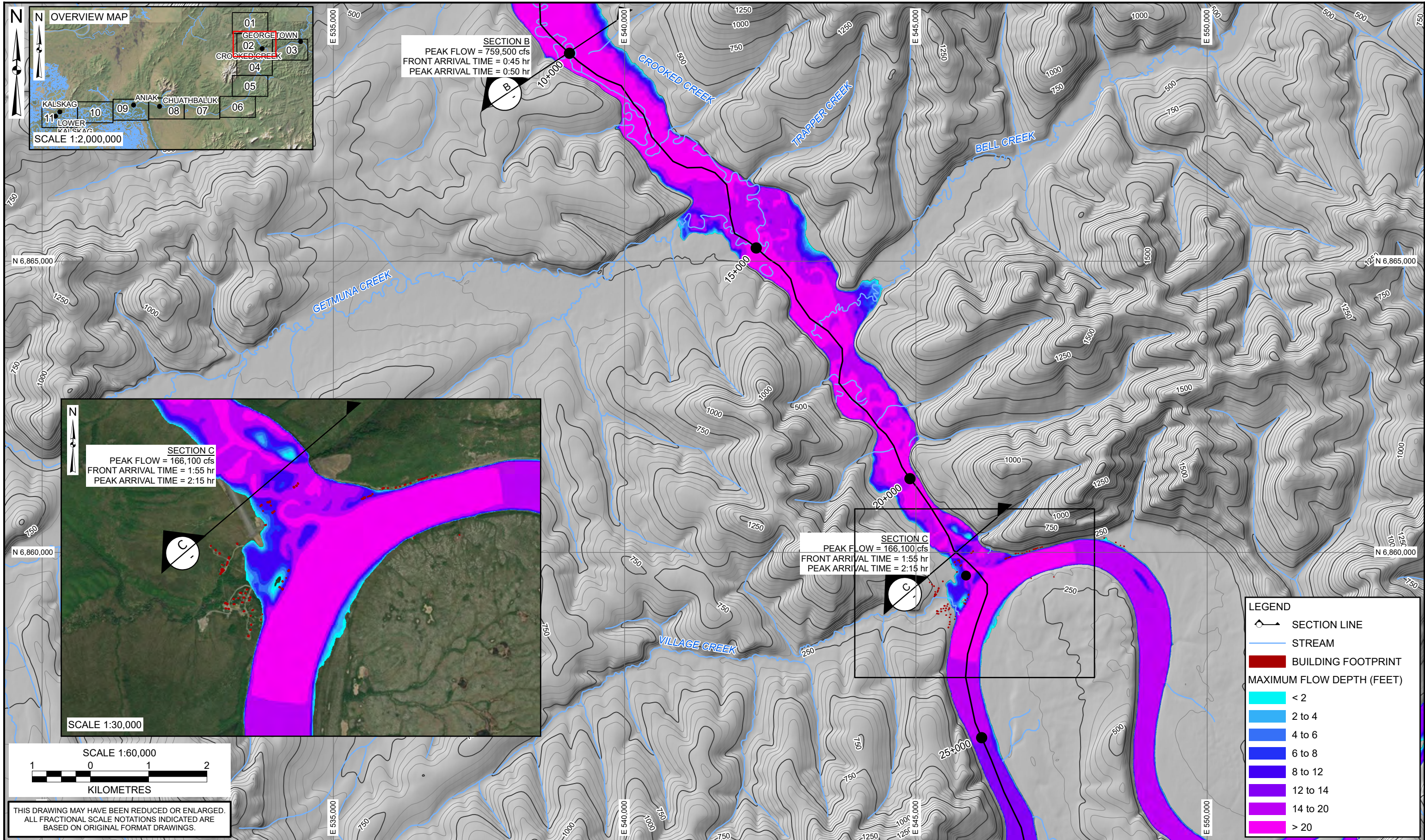
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SCALE:	1:60,000
DATE:	MAY 2026
DRAWN:	IL
REVIEW:	PG
APPROVED:	HW

CLIENT:

PROJECT:	DONLIN GOLD PROJECT TSF MAIN DAM BREACH ASSESSMENT- ADDITIONAL RUNS
TITLE:	13.3% RELEASE VOLUME, SUNNY DAY DAM BREACH MODELLING 1 OF 11
PROJECT No.:	0011603
DWG No.:	B-1

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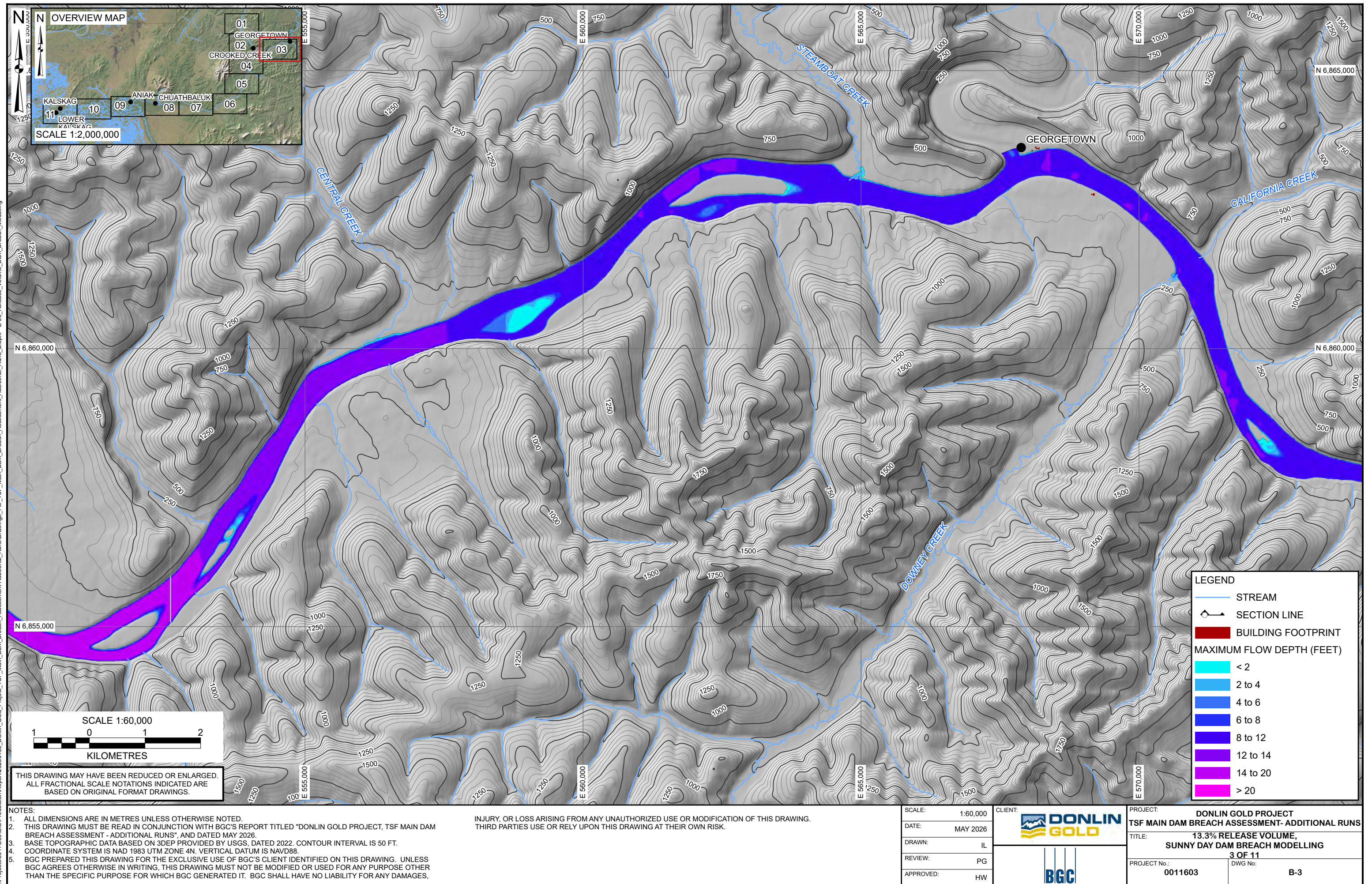
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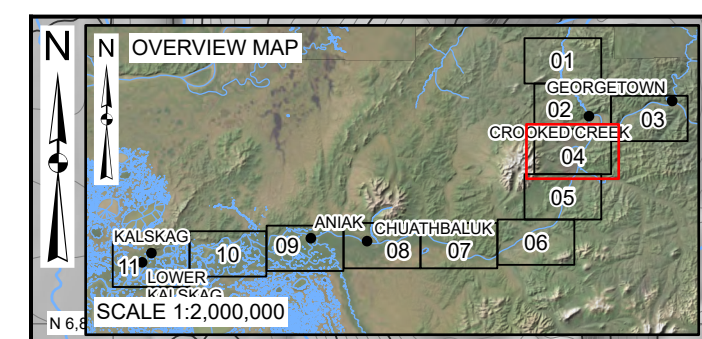
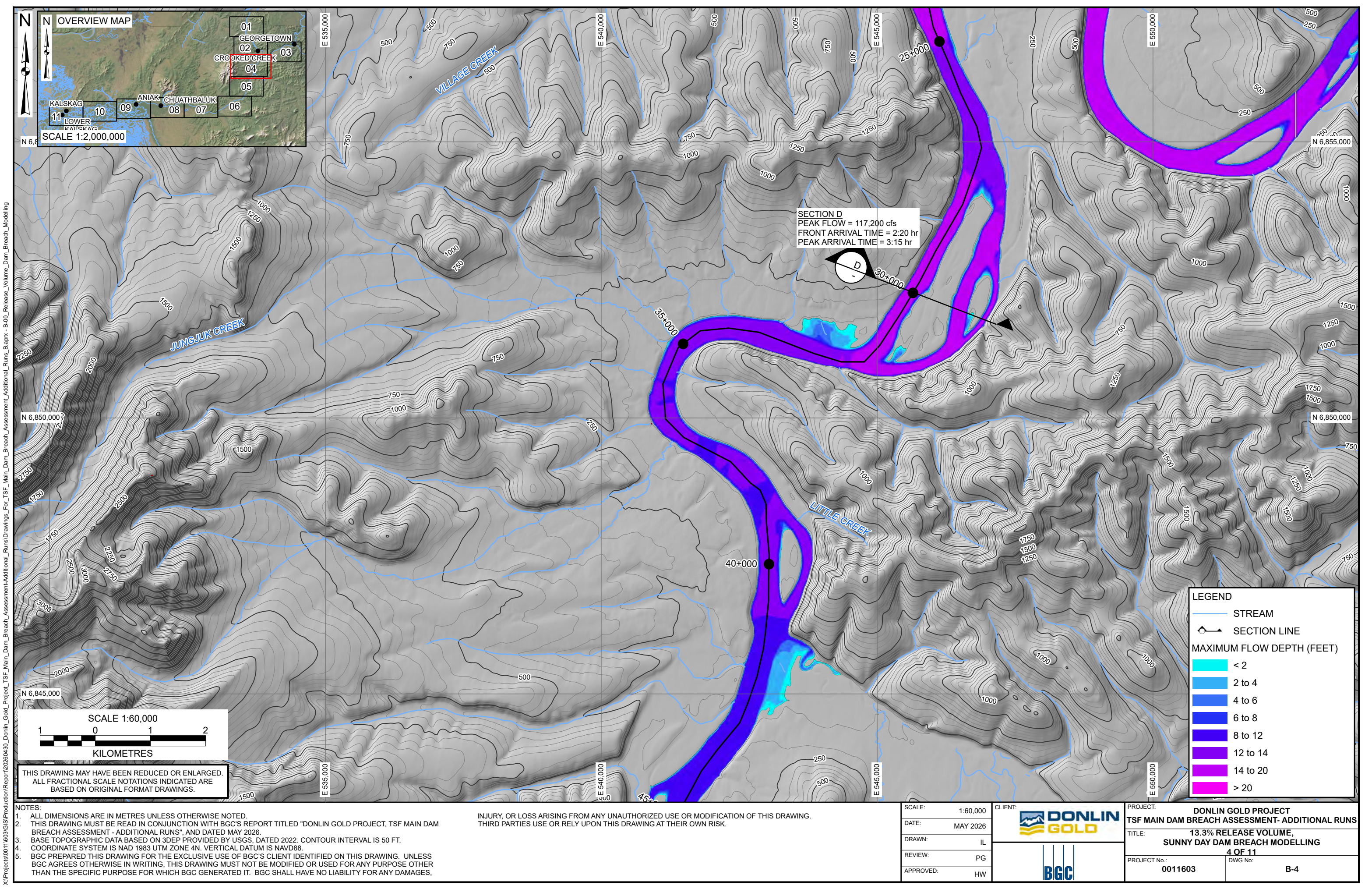
CLIENT:

DONLIN GOLD

BGC

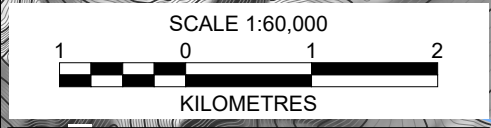
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TITLE:	13.3% RELEASE VOLUME SUNNY DAY DAM BREACH MODELLING, 2 OF 11	
PROJECT No.:	0011603	DWG No.: B-2





SECTION D
PEAK FLOW = 117,200 cfs
FRONT ARRIVAL TIME = 2:20 hr
PEAK ARRIVAL TIME = 3:15 hr

LEGEND	
	STREAM
	SECTION LINE
MAXIMUM FLOW DEPTH (FEET)	
	< 2
	2 to 4
	4 to 6
	6 to 8
	8 to 12
	12 to 14
	14 to 20
	> 20



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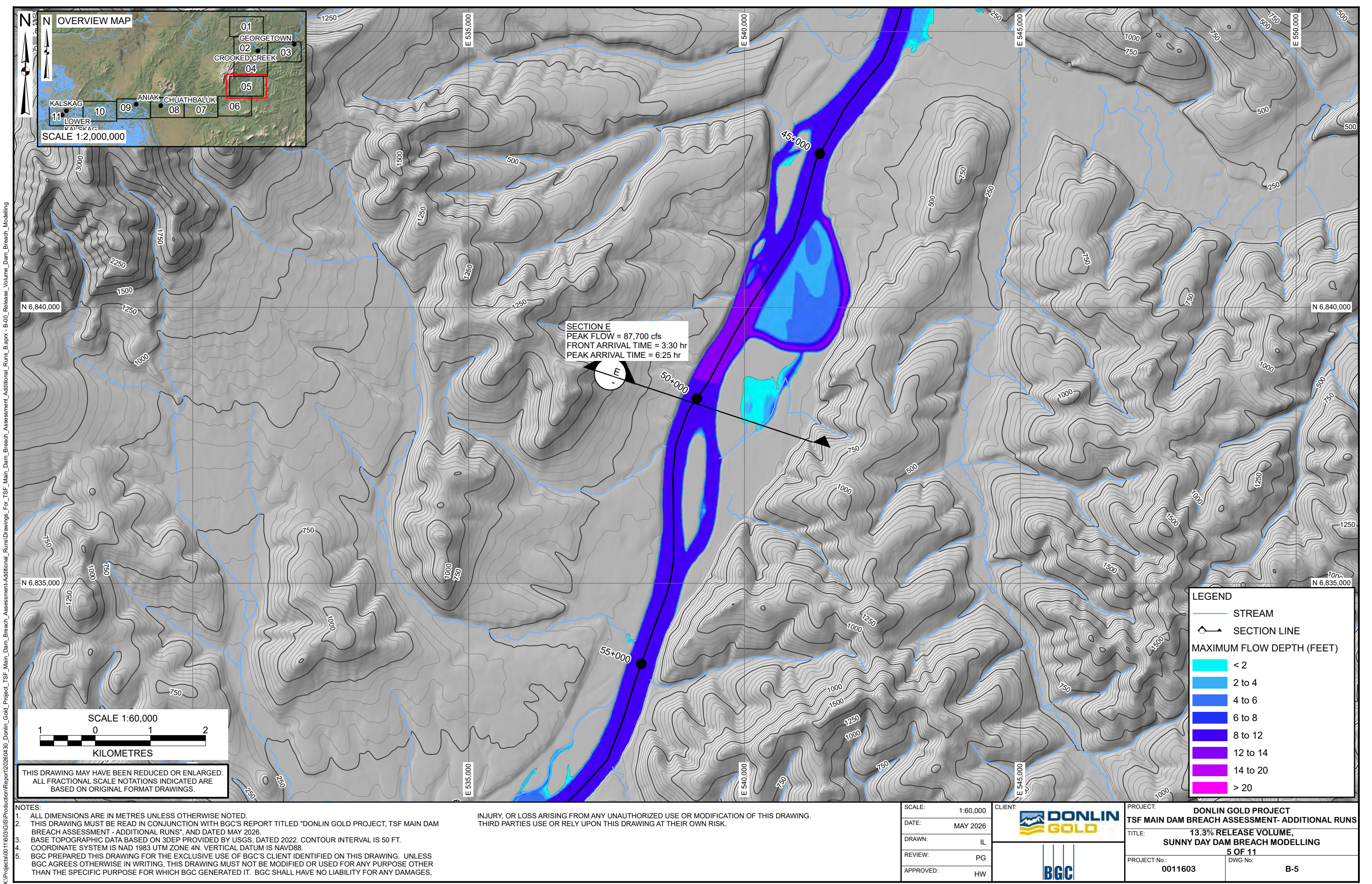
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SCALE:	1:60,000
DATE:	MAY 2026
DRAWN:	IL
REVIEW:	PG
APPROVED:	HW

CLIENT:

PROJECT:	DONLIN GOLD PROJECT TSF MAIN DAM BREACH ASSESSMENT- ADDITIONAL RUNS	
TITLE:	13.3% RELEASE VOLUME, SUNNY DAY DAM BREACH MODELLING	
PROJECT No.:	0011603	DWG No.: B-4
		4 OF 11



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5. BGC PREPARED THIS DRAWING FOR THE EXCLUSIVE USE OF BGC'S CLIENT IDENTIFIED ON THIS DRAWING. UNLESS BGC AGREES OTHERWISE IN WRITING, THIS DRAWING MUST NOT BE MODIFIED OR USED FOR ANY PURPOSE OTHER THAN THE SPECIFIC PURPOSE FOR WHICH BGC GENERATED IT. BGC SHALL HAVE NO LIABILITY FOR ANY DAMAGES,

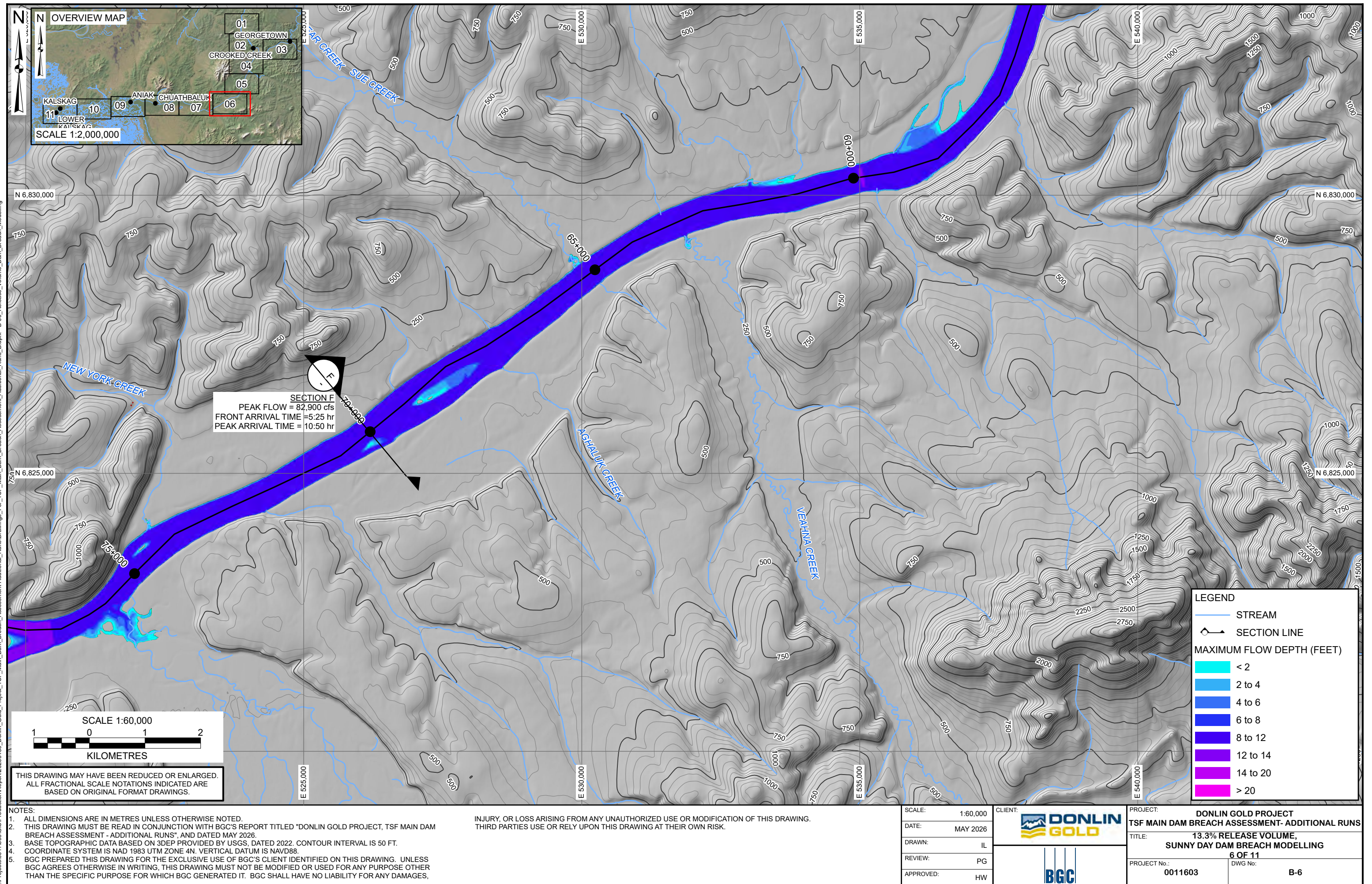
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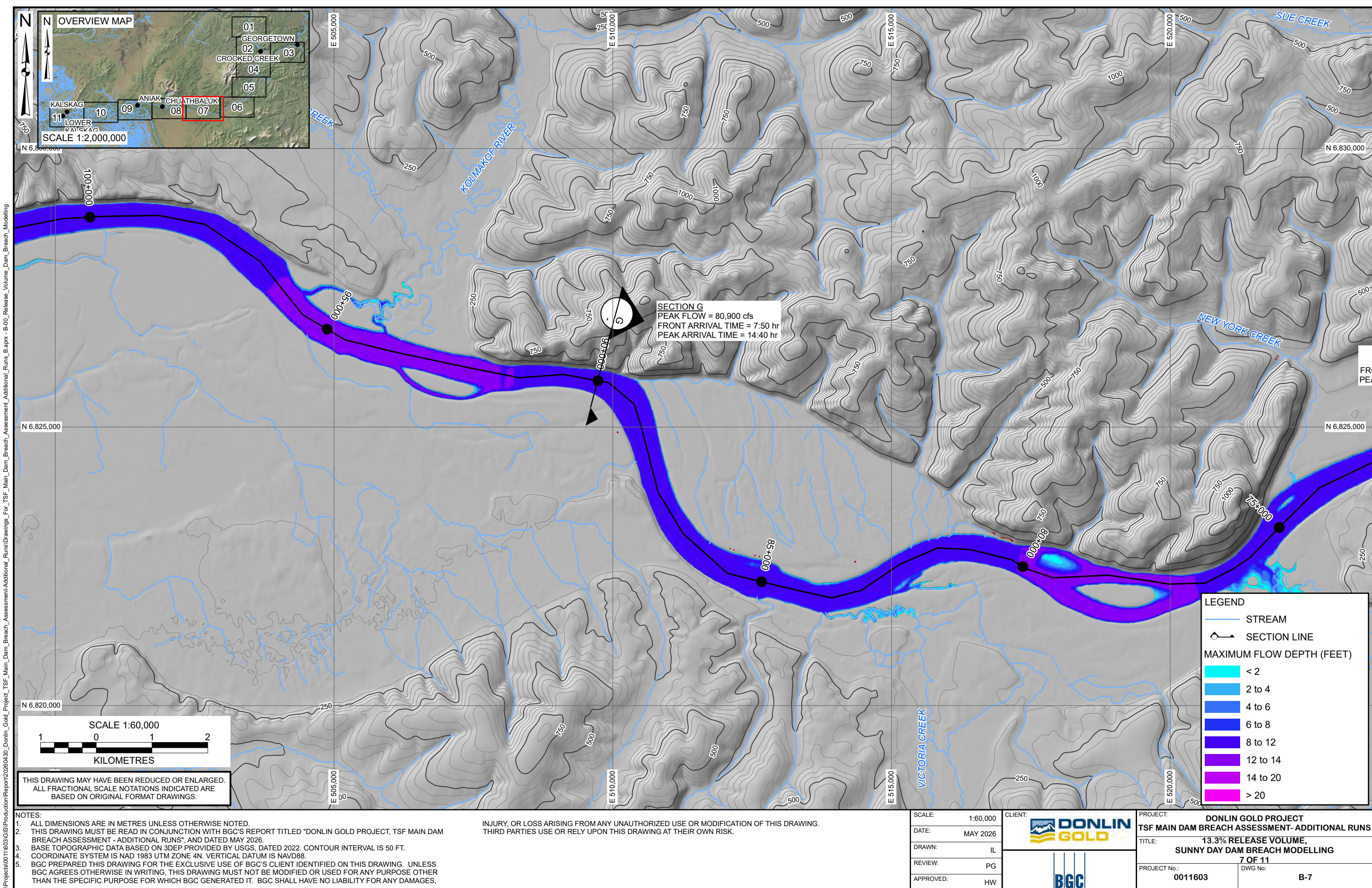
SCALE:	1:60,000
DATE:	MAY 2026
DRAWN:	IL
REVIEW:	PG
APPROVED:	HW

CLIENT:




PROJECT:	DONLIN GOLD PROJECT TSF MAIN DAM BREACH ASSESSMENT- ADDITIONAL RUNS
TITLE:	13.3% RELEASE VOLUME, SUNNY DAY DAM BREACH MODELLING 5 OF 11
PROJECT No.:	0011603
DWG No.:	B-5





SECTION G
PEAK FLOW = 80,900 cfs
FRONT ARRIVAL TIME = 7:50 hr
PEAK ARRIVAL TIME = 14:40 hr

LEGEND

—

STREAM

↔

SECTION LINE

MAXIMUM FLOW DEPTH (FEET)

< 2

2 to 4

4 to 6

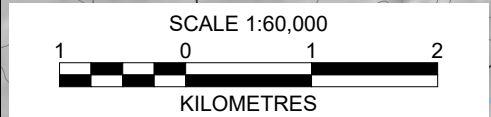
6 to 8

8 to 12

12 to 14

14 to 20

> 20



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ALL FRACTIONAL SCALE NOTATIONS INDICATED ARE
BASED ON ORIGINAL FORMAT DRAWINGS.

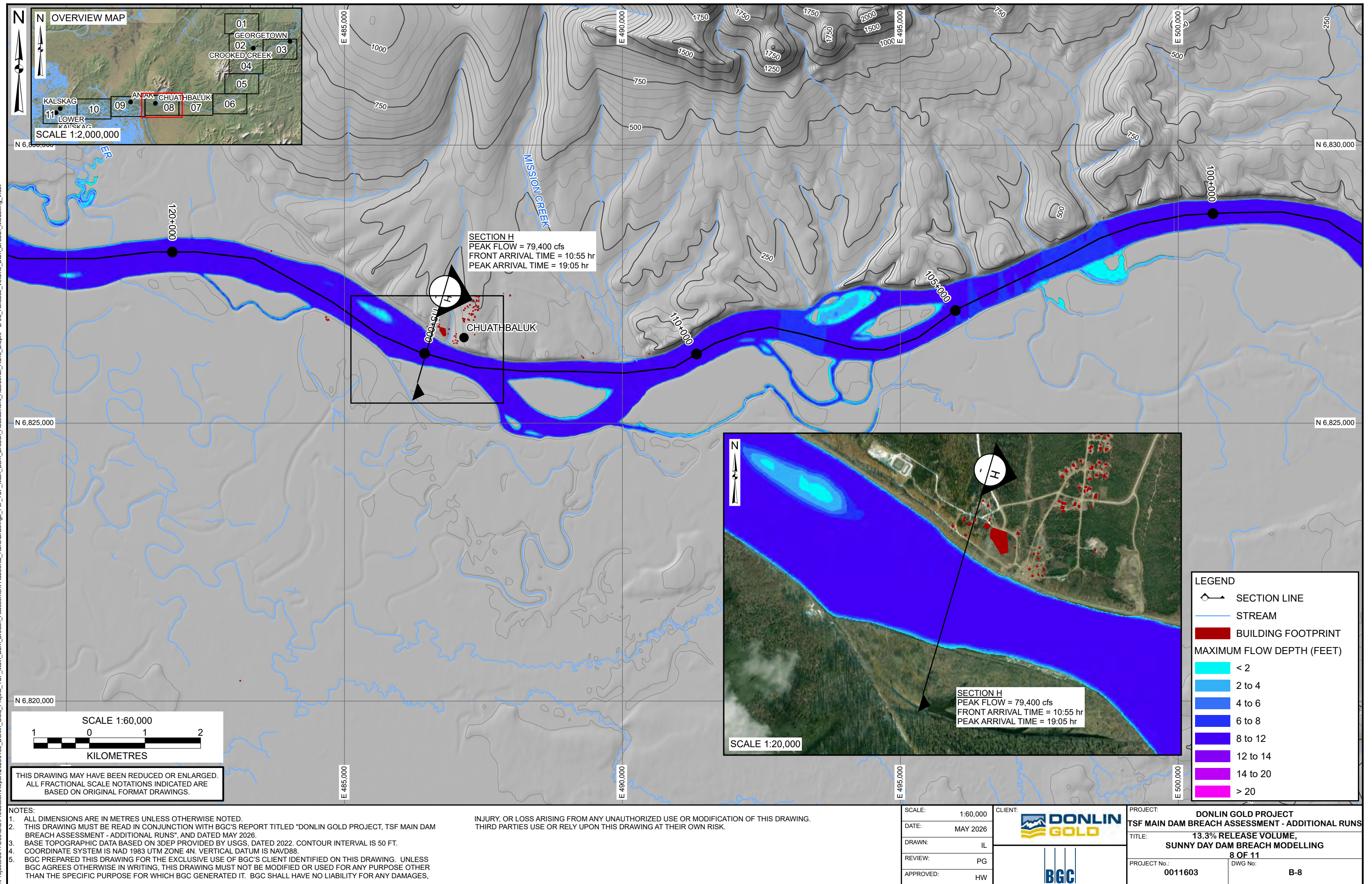
- NOTES:
1. ALL DIMENSIONS ARE IN METRES UNLESS OTHERWISE NOTED.
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 3. BASE TOPOGRAPHIC DATA BASED ON 3DEP PROVIDED BY USGS, DATED 2022. CONTOUR INTERVAL IS 50 FT.
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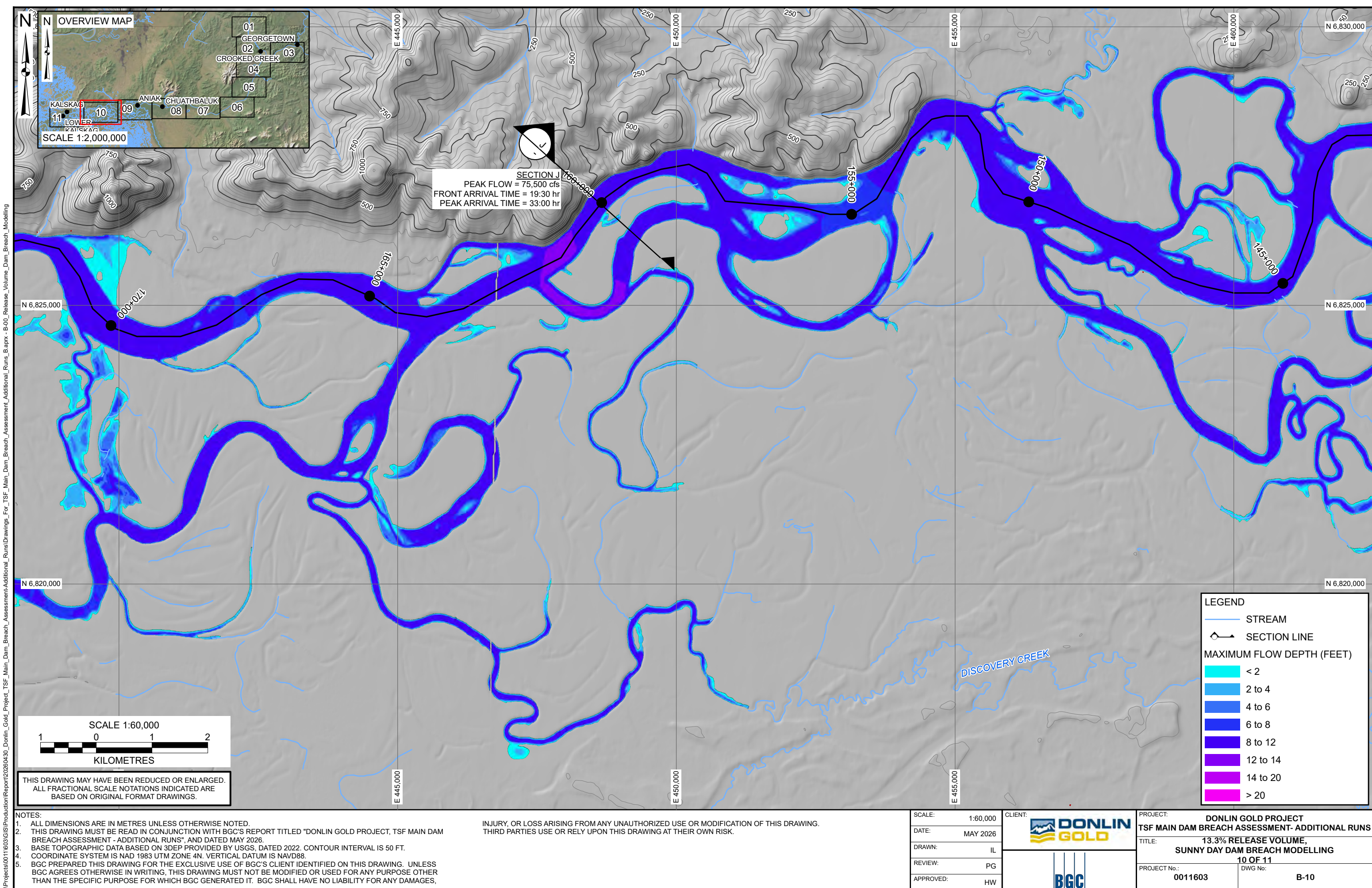
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SCALE:	1:60,000
DATE:	MAY 2026
DRAWN:	IL
REVIEW:	PG
APPROVED:	HW

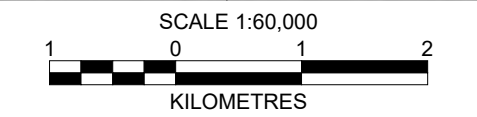
CLIENT:

PROJECT:	DONLIN GOLD PROJECT TSF MAIN DAM BREACH ASSESSMENT- ADDITIONAL RUNS	
TITLE:	13.3% RELEASE VOLUME, SUNNY DAY DAM BREACH MODELLING	
PROJECT No.:	0011603	DWG No: B-7





SECTION J
PEAK FLOW = 75,500 cfs
FRONT ARRIVAL TIME = 19:30 hr
PEAK ARRIVAL TIME = 33:00 hr



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LEGEND

—

STREAM

—

SECTION LINE

MAXIMUM FLOW DEPTH (FEET)

< 2

2 to 4

4 to 6

6 to 8

8 to 12

12 to 14

14 to 20

> 20

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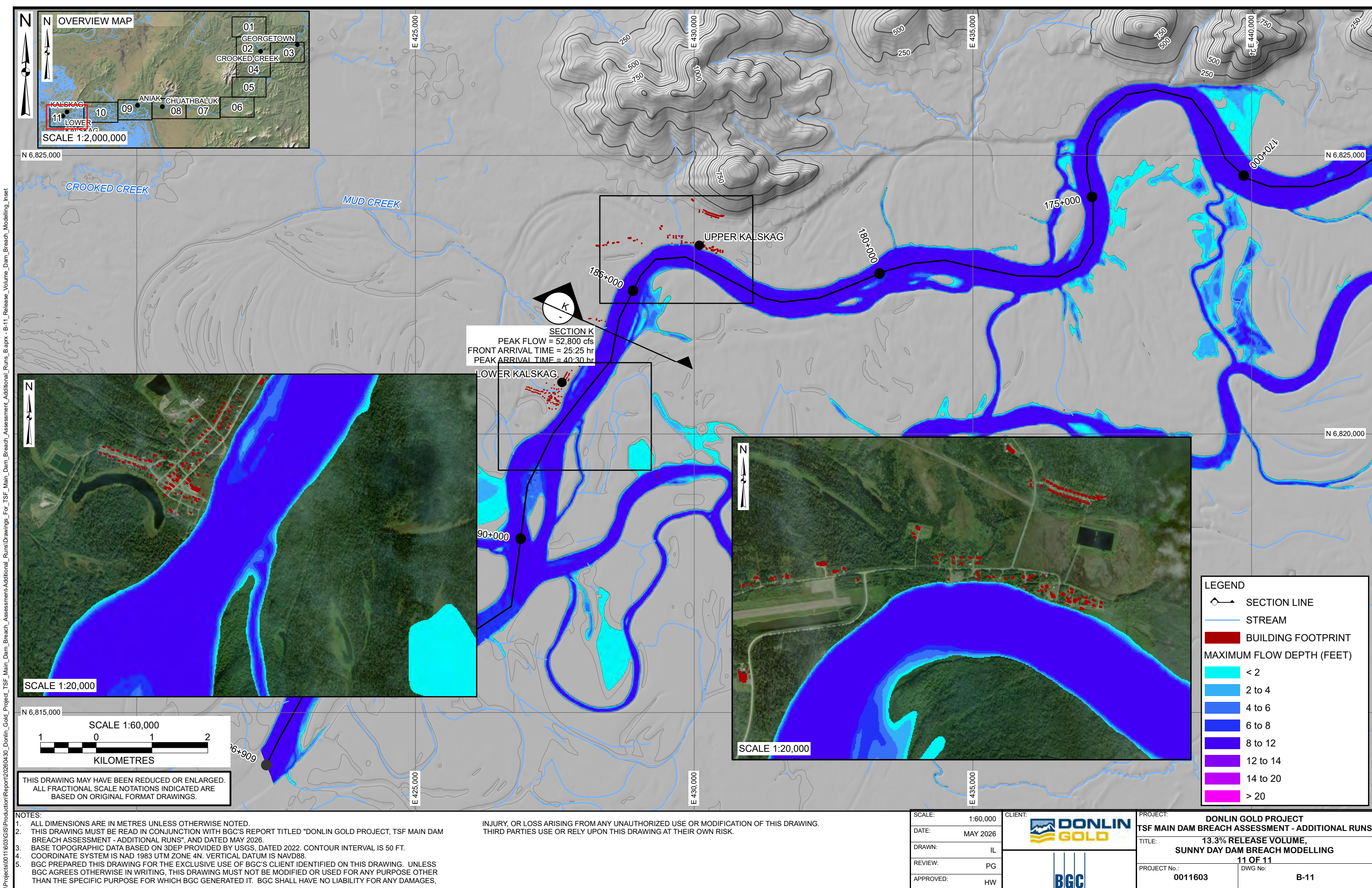
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SCALE:	1:60,000
DATE:	MAY 2026
DRAWN:	IL
REVIEW:	PG
APPROVED:	HW

CLIENT:



PROJECT:	DONLIN GOLD PROJECT	
	TSF MAIN DAM BREACH ASSESSMENT- ADDITIONAL RUNS	
TITLE:	13.3% RELEASE VOLUME, SUNNY DAY DAM BREACH MODELLING	
	10 OF 11	
PROJECT No.:	0011603	DWG No: B-10



SECTION K
PEAK FLOW = 52,800 cfs
FRONT ARRIVAL TIME = 25:25 hr
PEAK ARRIVAL TIME = 40:30 hr



LEGEND

- SECTION LINE
- STREAM
- BUILDING FOOTPRINT
- MAXIMUM FLOW DEPTH (FEET)
- < 2
- 2 to 4
- 4 to 6
- 6 to 8
- 8 to 12
- 12 to 14
- 14 to 20
- > 20

NOTES:

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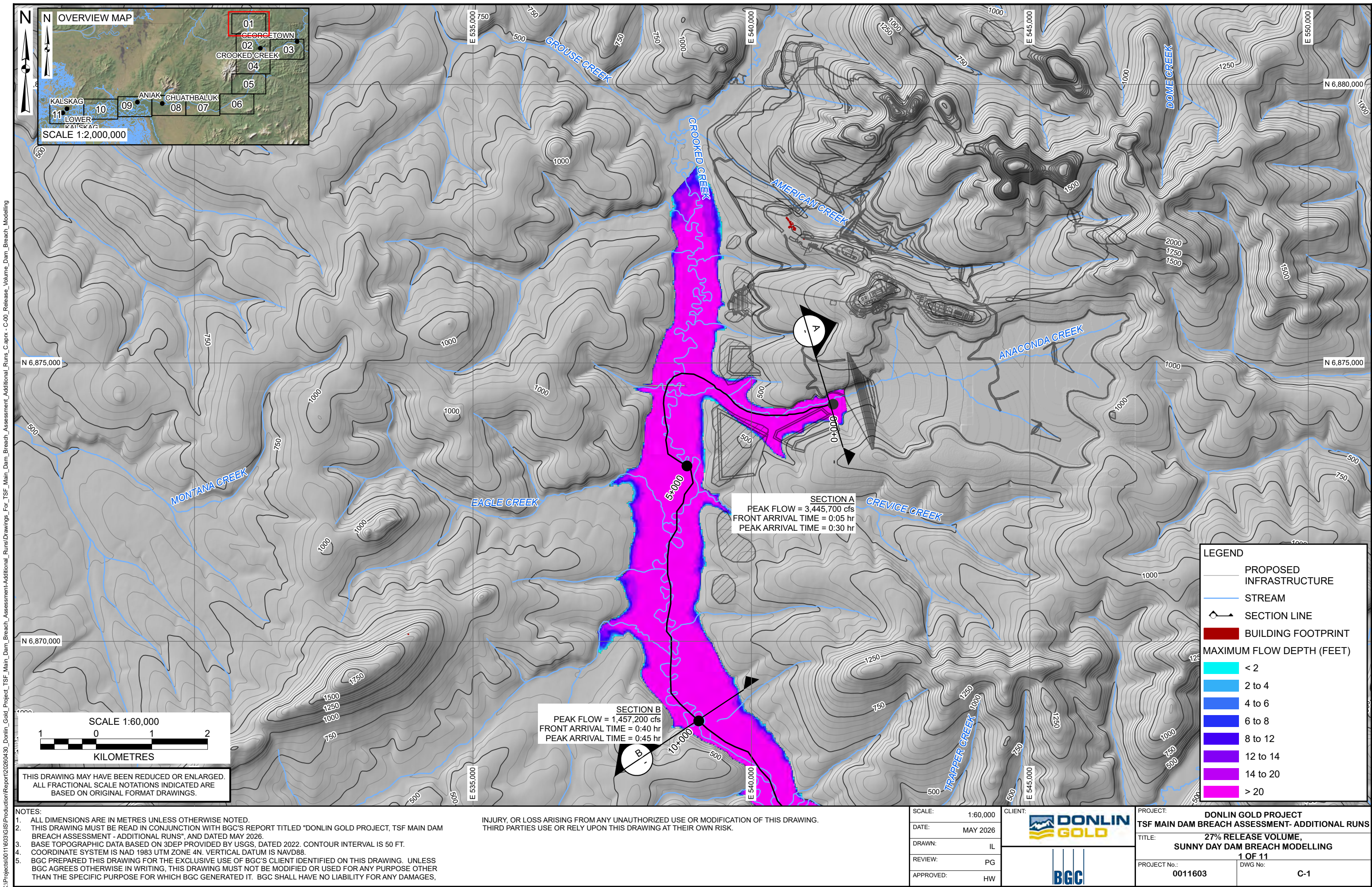
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DRAWN:	IL
REVIEW:	PG
APPROVED:	HW

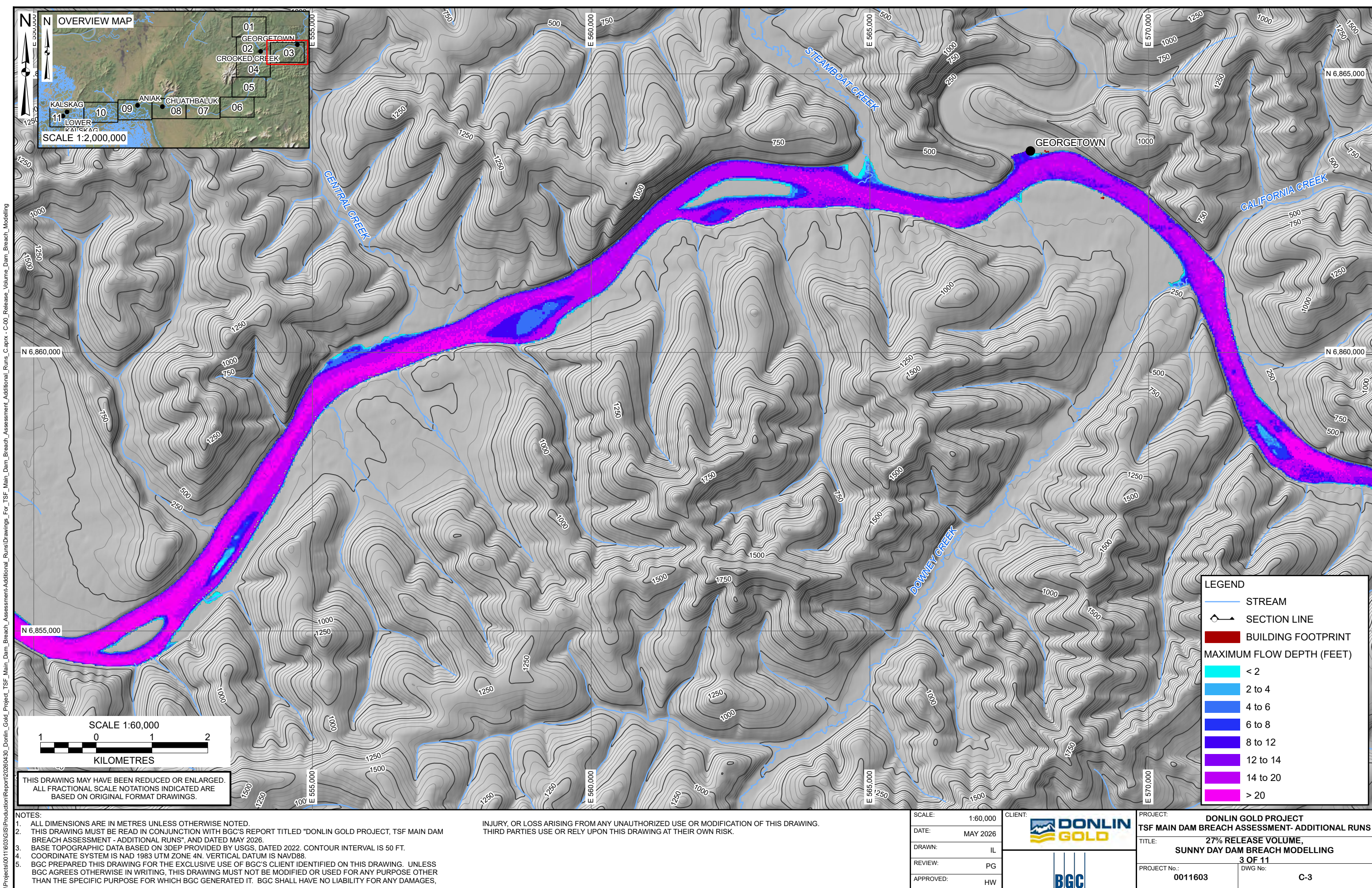
CLIENT:

DONLIN GOLD

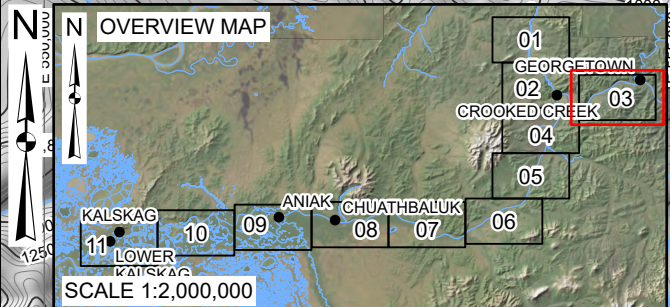
BGC

PROJECT:	DONLIN GOLD PROJECT
TITLE:	TSF MAIN DAM BREACH ASSESSMENT - ADDITIONAL RUNS
PROJECT No.:	0011603
DWG No.:	B-11





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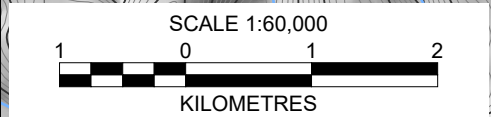


N 6,860,000

N 6,855,000

N 6,865,000

N 6,860,000



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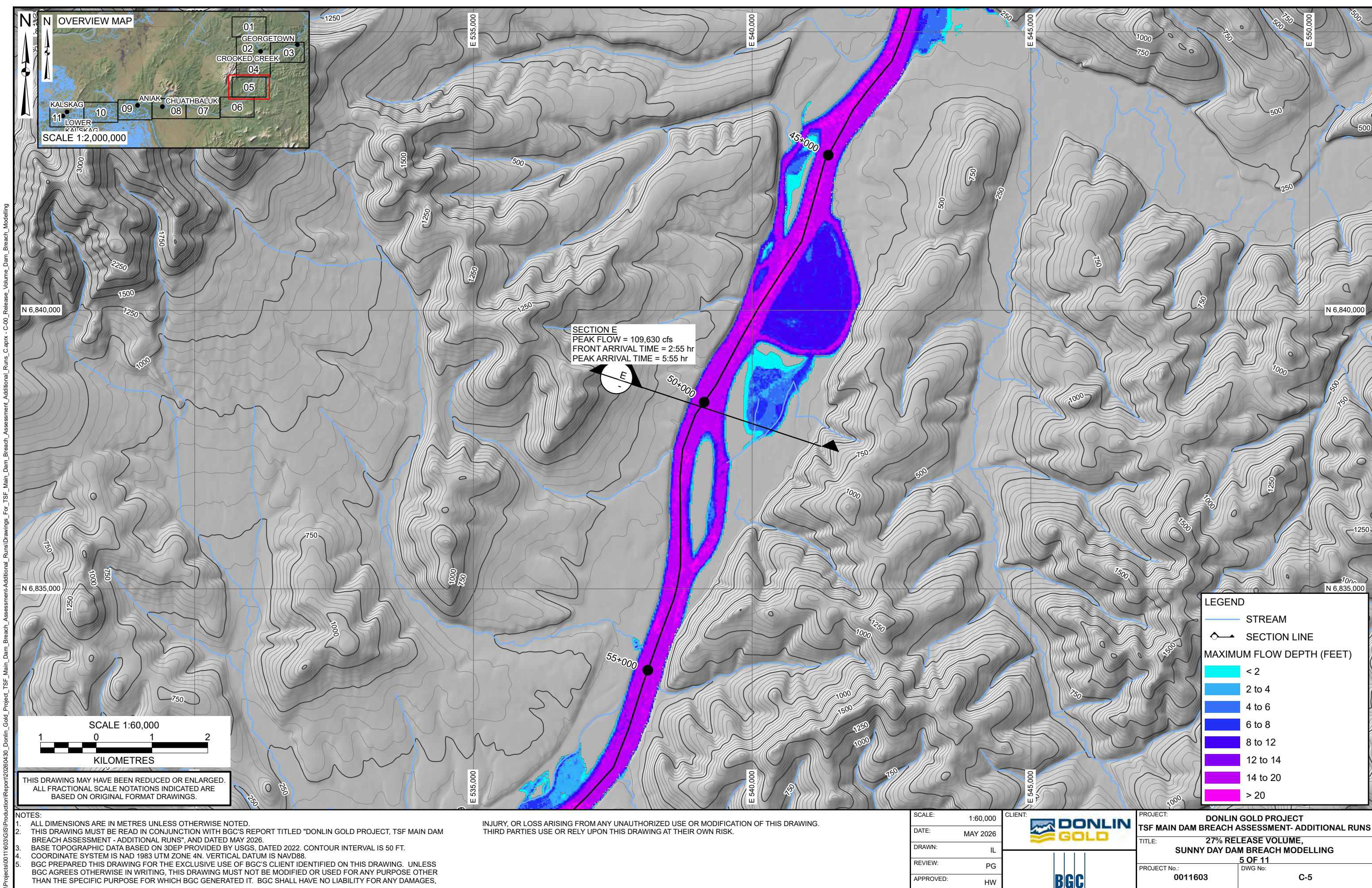
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SCALE:	1:60,000
DATE:	MAY 2026
DRAWN:	IL
REVIEW:	PG
APPROVED:	HW

CLIENT:



PROJECT:	DONLIN GOLD PROJECT TSF MAIN DAM BREACH ASSESSMENT- ADDITIONAL RUNS	
TITLE:	27% RELEASE VOLUME, SUNNY DAY DAM BREACH MODELLING	
PROJECT No.:	0011603	DWG No: C-3



SECTION E
PEAK FLOW = 109,630 cfs
FRONT ARRIVAL TIME = 2:55 hr
PEAK ARRIVAL TIME = 5:55 hr

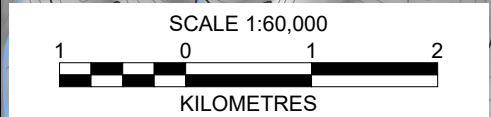
LEGEND

— STREAM

— SECTION LINE

MAXIMUM FLOW DEPTH (FEET)

< 2
2 to 4
4 to 6
6 to 8
8 to 12
12 to 14
14 to 20
> 20



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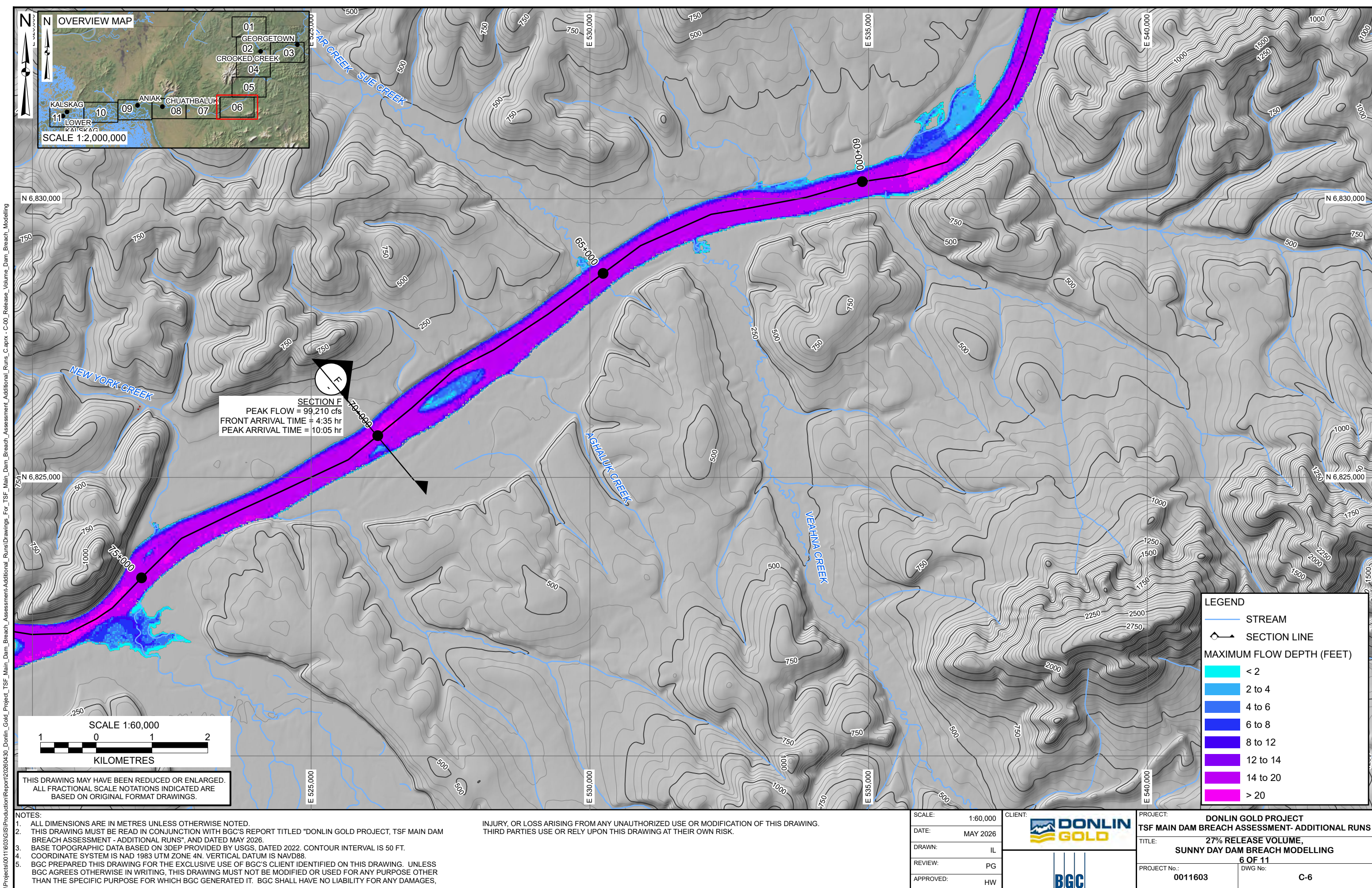
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SCALE:	1:60,000
DATE:	MAY 2026
DRAWN:	IL
REVIEW:	PG
APPROVED:	HW

CLIENT:

PROJECT:	DONLIN GOLD PROJECT TSF MAIN DAM BREACH ASSESSMENT- ADDITIONAL RUNS	
TITLE:	27% RELEASE VOLUME, SUNNY DAY DAM BREACH MODELLING	
PROJECT No.:	0011603	DWG No: C-5
		5 OF 11

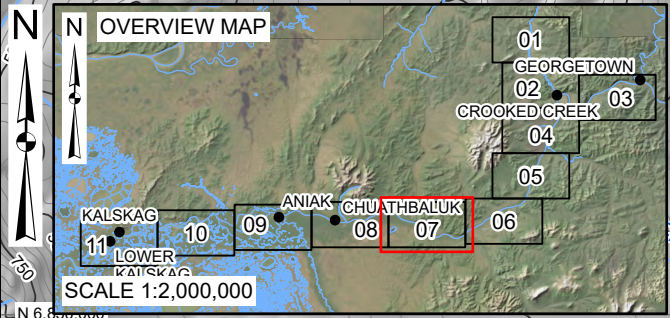
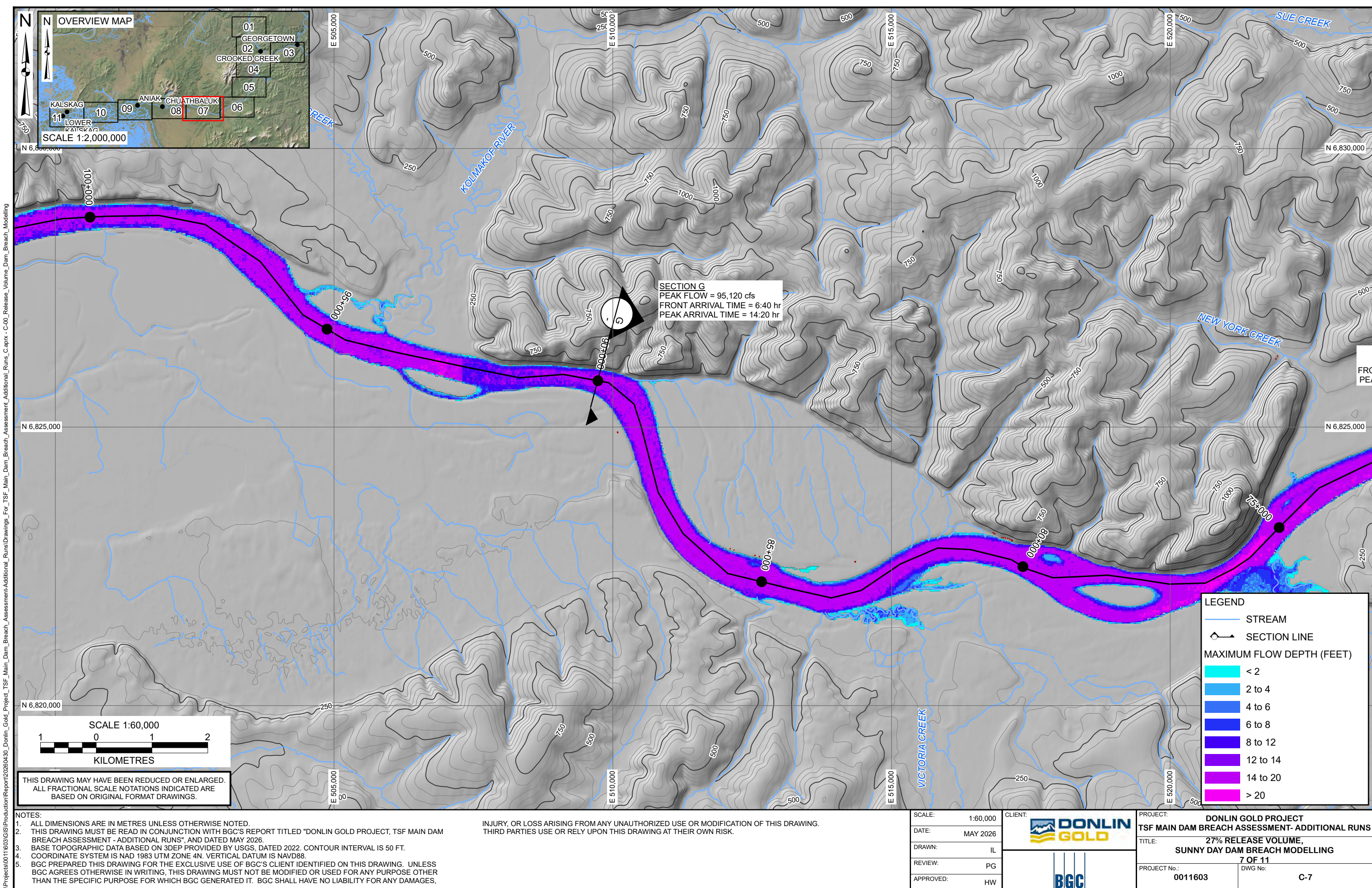


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SCALE:	1:60,000	CLIENT:		PROJECT:		DONLIN GOLD PROJECT	
DATE:	MAY 2026			TSF MAIN DAM BREACH ASSESSMENT- ADDITIONAL RUNS			
DRAWN:	IL			TITLE:	27% RELEASE VOLUME, SUNNY DAY DAM BREACH MODELLING 6 OF 11		
REVIEW:	PG			PROJECT No.:	0011603	DWG No:	C-6
APPROVED:	HW						



SECTION G
PEAK FLOW = 95,120 cfs
FRONT ARRIVAL TIME = 6:40 hr
PEAK ARRIVAL TIME = 14:20 hr

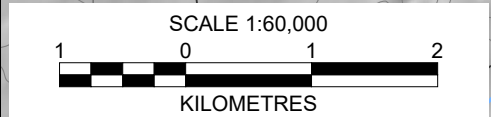
LEGEND

— STREAM

— SECTION LINE

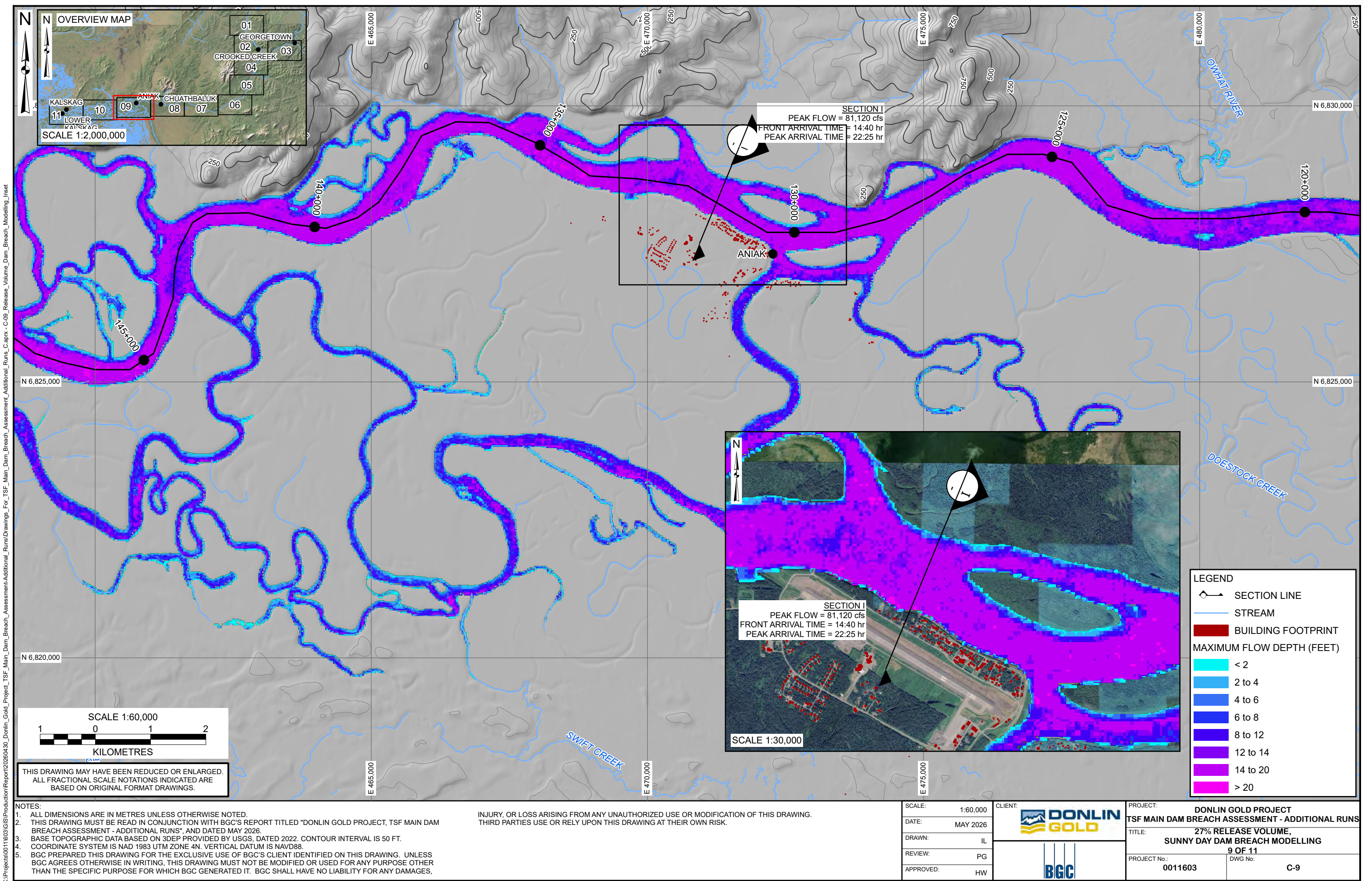
MAXIMUM FLOW DEPTH (FEET)

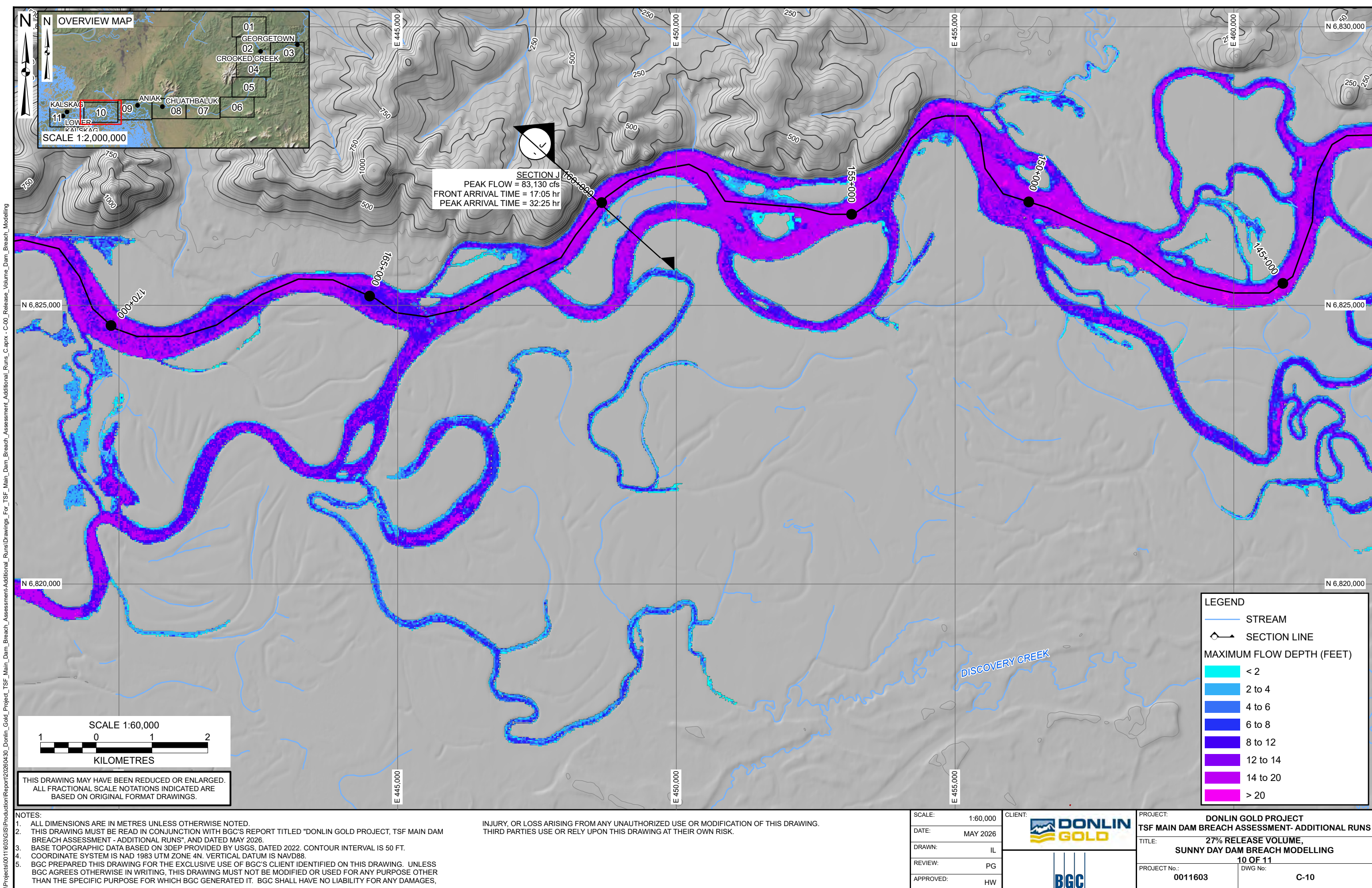
< 2
2 to 4
4 to 6
6 to 8
8 to 12
12 to 14
14 to 20
> 20



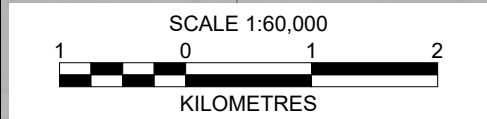
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	SCALE:	1:60,000		
	DATE:	MAY 2026		
	DRAWN:	IL		
	REVIEW:	PG		
	APPROVED:	HW		





SECTION J
PEAK FLOW = 83,130 cfs
FRONT ARRIVAL TIME = 17:05 hr
PEAK ARRIVAL TIME = 32:25 hr



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LEGEND

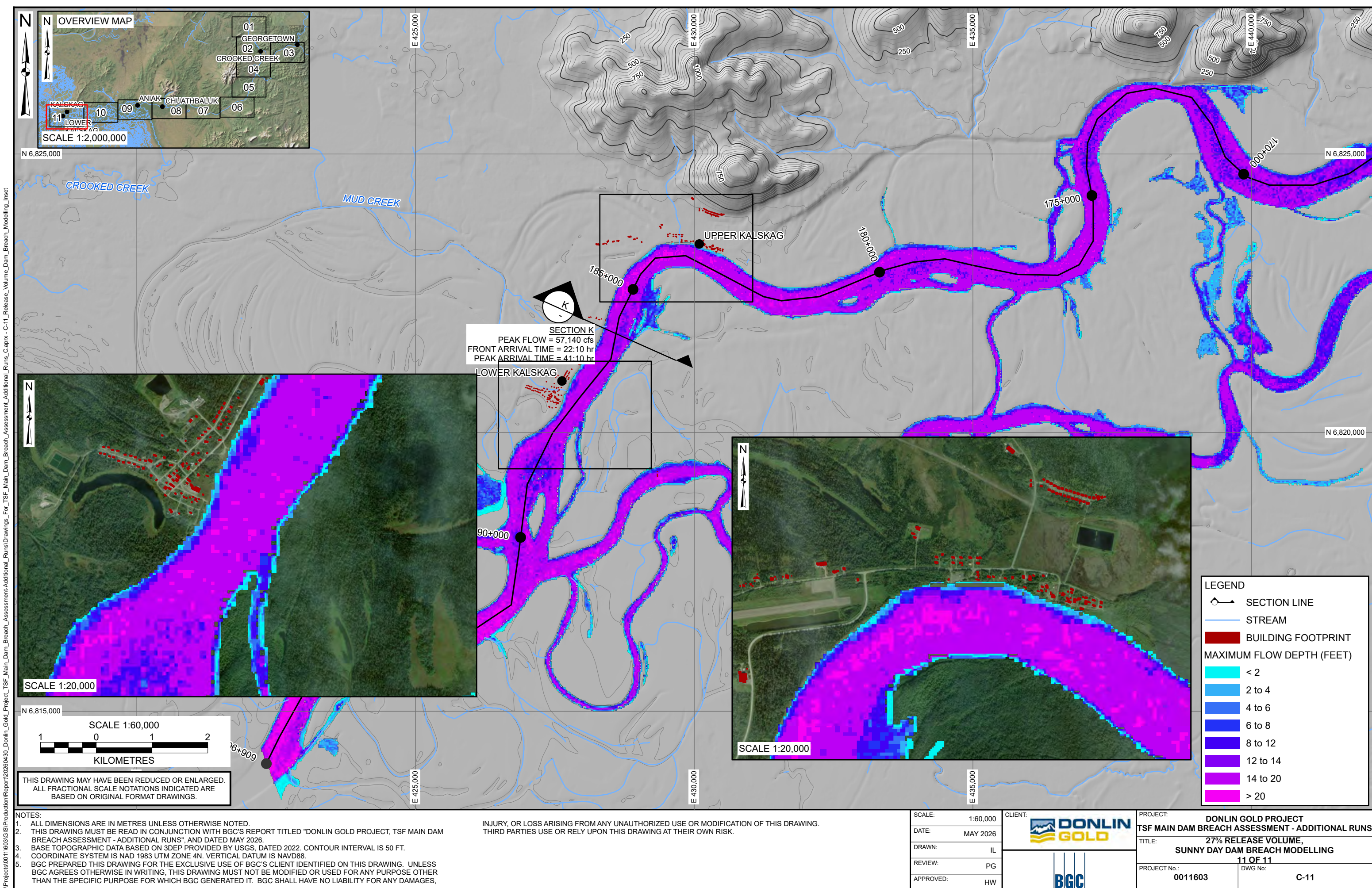
— STREAM

— SECTION LINE

MAXIMUM FLOW DEPTH (FEET)

< 2
2 to 4
4 to 6
6 to 8
8 to 12
12 to 14
14 to 20
> 20

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		DATE: MAY 2026		
		DRAWN: IL		
		REVIEW: PG		
		APPROVED: HW		



SECTION K
PEAK FLOW = 57,140 cfs
FRONT ARRIVAL TIME = 22:10 hr
PEAK ARRIVAL TIME = 41:10 hr

SCALE 1:20,000

SCALE 1:20,000

SCALE 1:60,000



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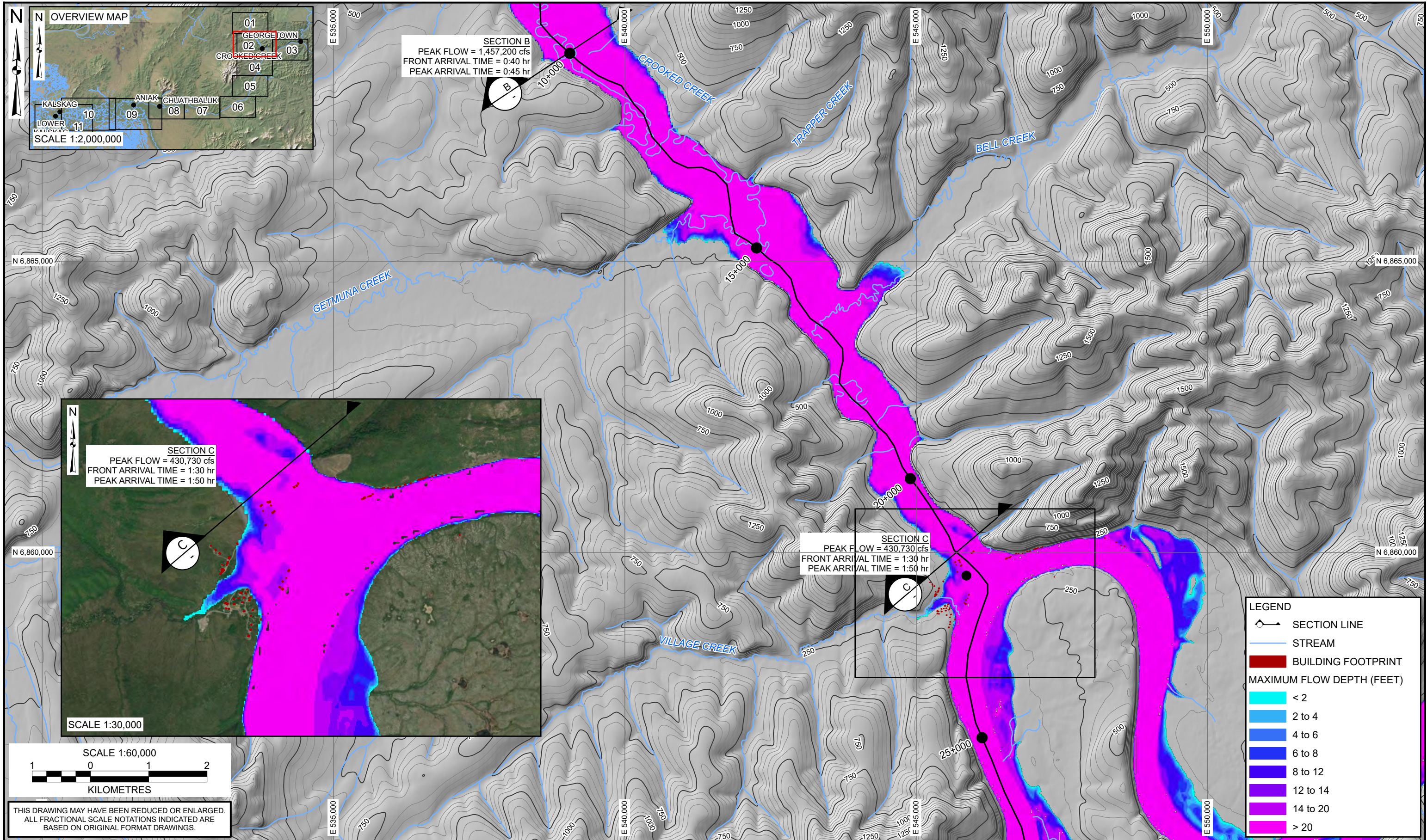
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DATE:	MAY 2026
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REVIEW:	PG
APPROVED:	HW

CLIENT:

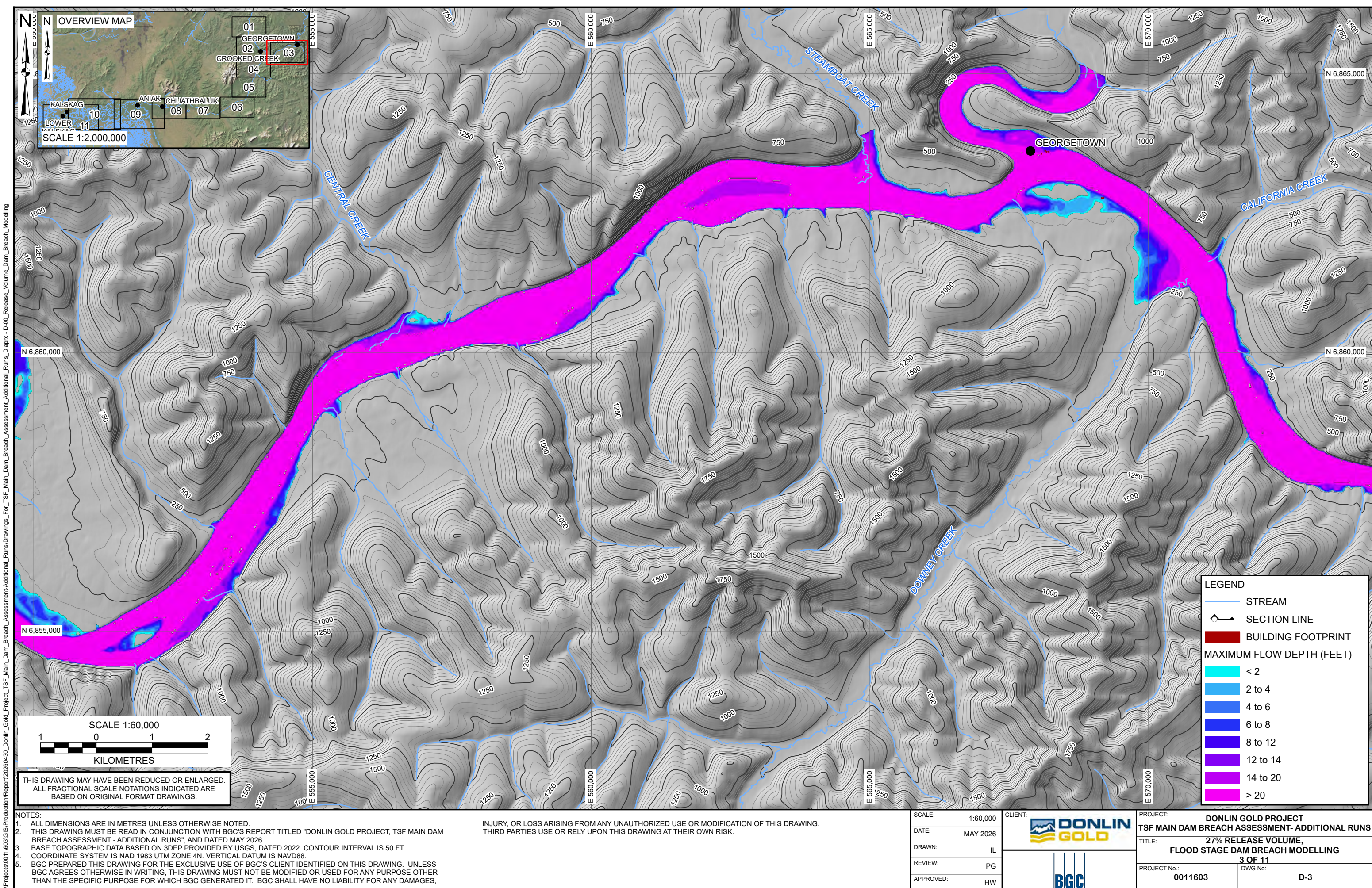


PROJECT:	DONLIN GOLD PROJECT TSF MAIN DAM BREACH ASSESSMENT - ADDITIONAL RUNS	
TITLE:	27% RELEASE VOLUME, SUNNY DAY DAM BREACH MODELLING	
PROJECT No.:	0011603	DWG No.: C-11

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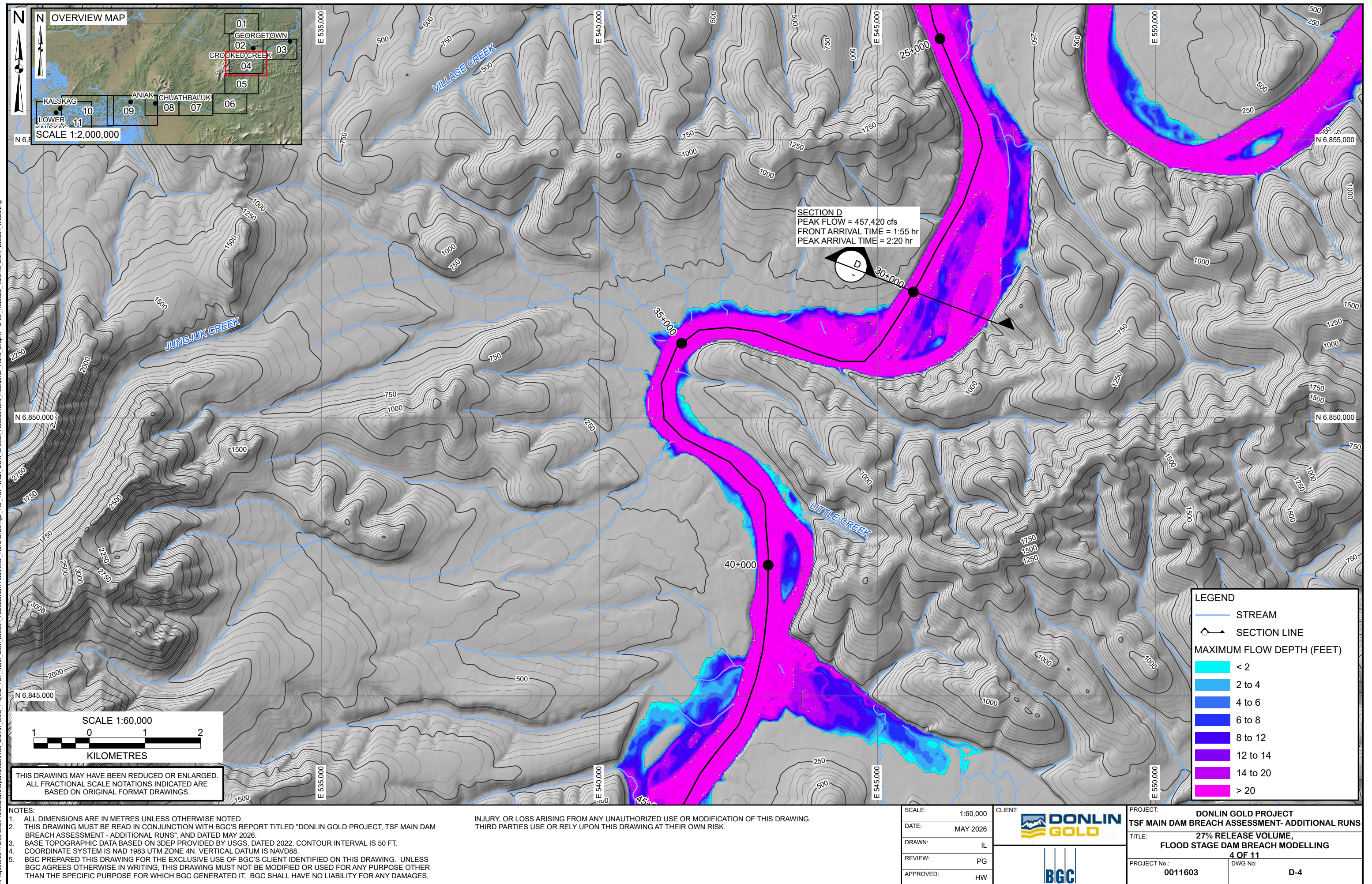


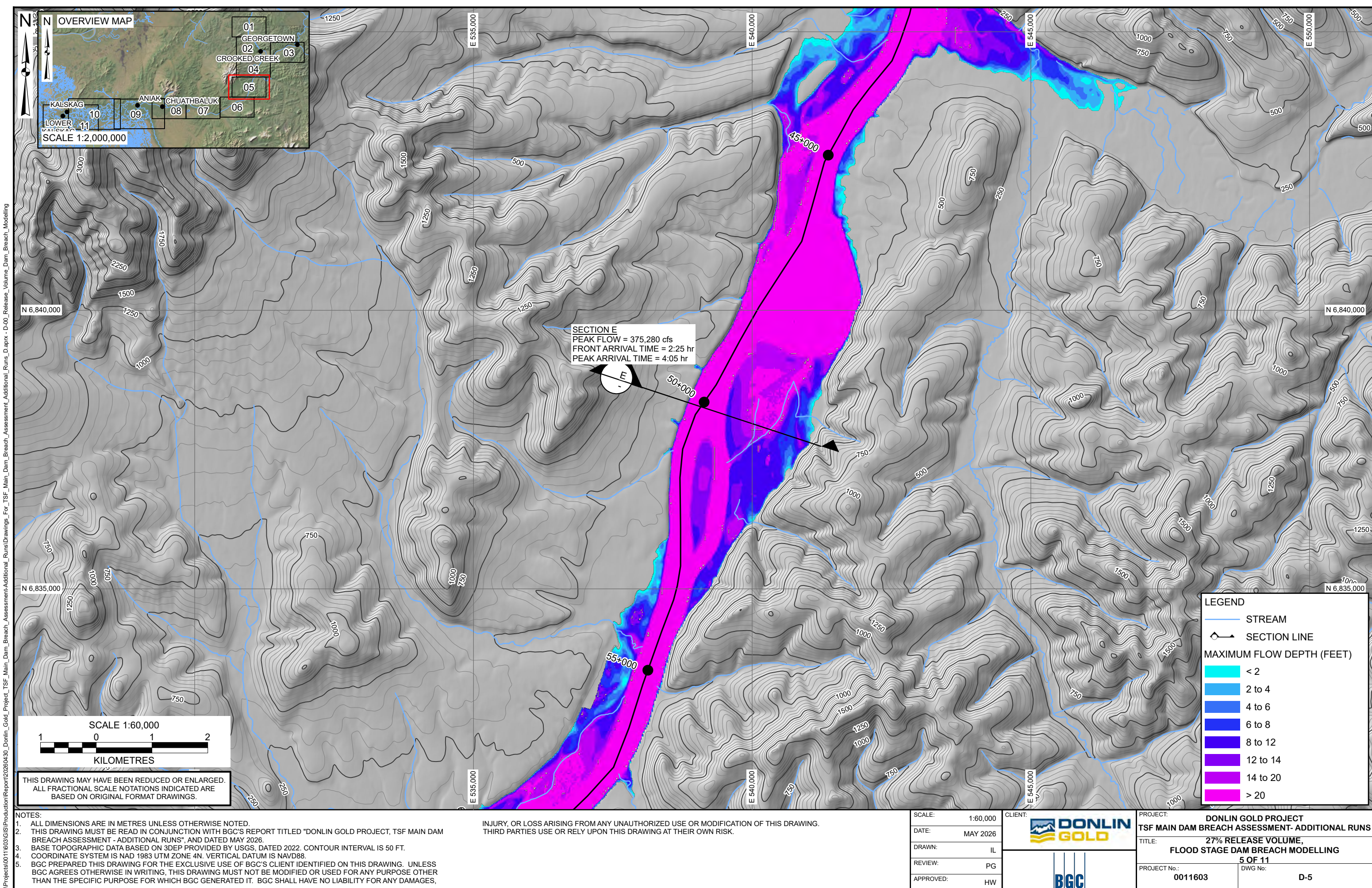
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SCALE:	1:60,000	CLIENT:	 
DATE:	MAY 2026	PROJECT:	
DRAWN:	IL	TSF MAIN DAM BREACH ASSESSMENT- ADDITIONAL RUNS	
REVIEW:	PG	TITLE:	
APPROVED:	HW	27% RELEASE VOLUME, FLOOD STAGE DAM BREACH MODELLING	
		3 OF 11	
		PROJECT No.:	
		0011603	
		DWG No:	
		D-3	





SECTION E
PEAK FLOW = 375,280 cfs
FRONT ARRIVAL TIME = 2:25 hr
PEAK ARRIVAL TIME = 4:05 hr

LEGEND

—

STREAM

—

SECTION LINE

MAXIMUM FLOW DEPTH (FEET)

< 2

2 to 4

4 to 6

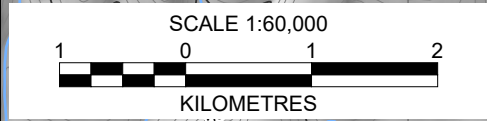
6 to 8

8 to 12

12 to 14

14 to 20

> 20



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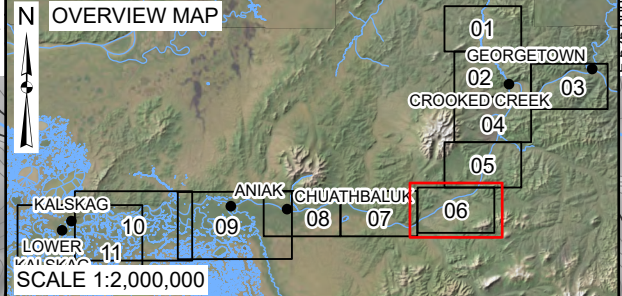
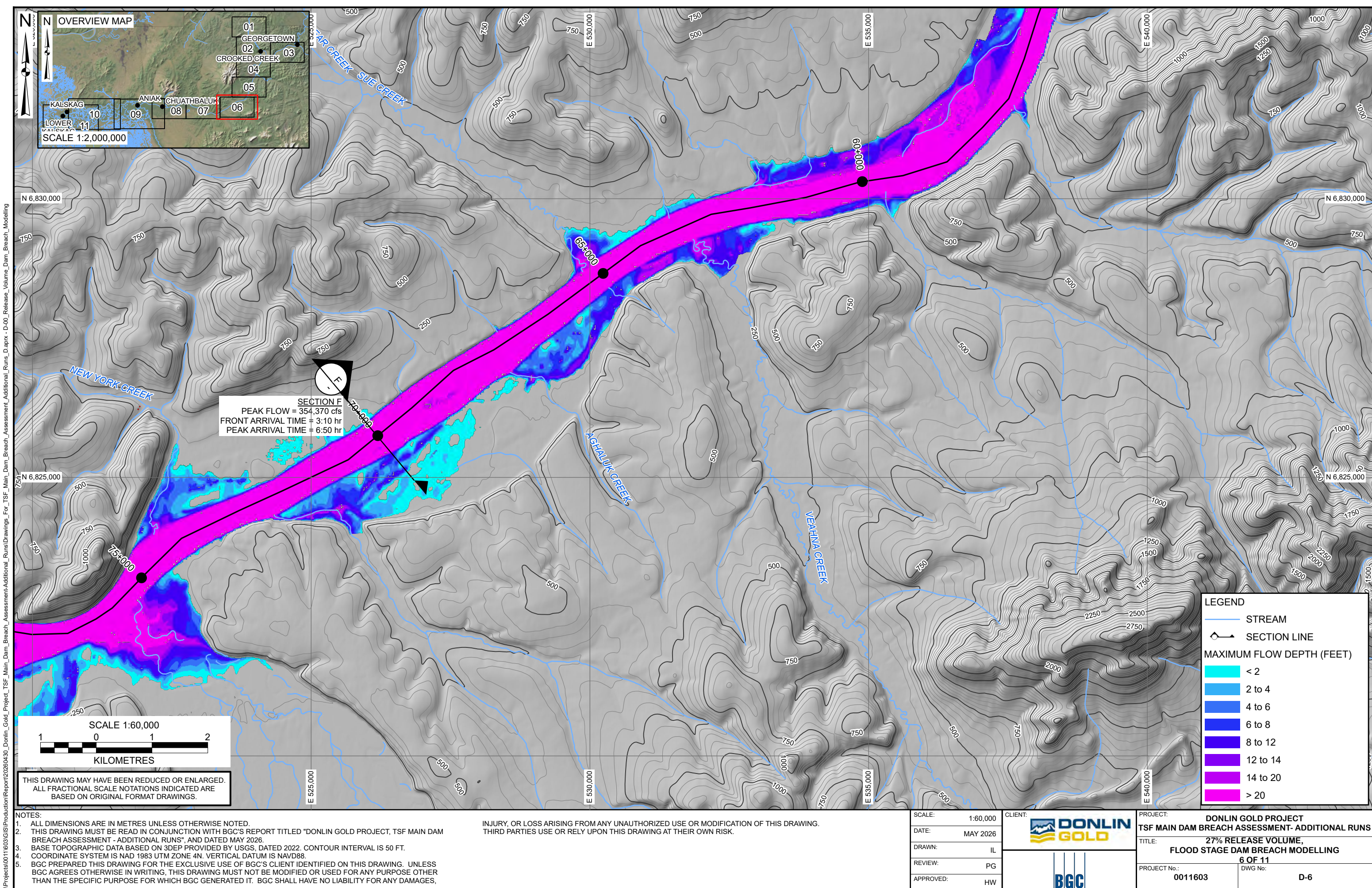
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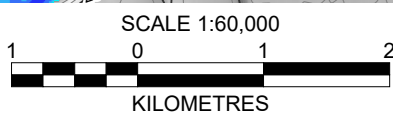
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DATE:	MAY 2026
DRAWN:	IL
REVIEW:	PG
APPROVED:	HW

CLIENT:

PROJECT:	DONLIN GOLD PROJECT TSF MAIN DAM BREACH ASSESSMENT- ADDITIONAL RUNS	
TITLE:	27% RELEASE VOLUME, FLOOD STAGE DAM BREACH MODELLING	
PROJECT No.:	0011603	DWG No: D-5



SECTION F
PEAK FLOW = 354,370 cfs
FRONT ARRIVAL TIME = 3:10 hr
PEAK ARRIVAL TIME = 6:50 hr



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LEGEND

—

STREAM

—

SECTION LINE

MAXIMUM FLOW DEPTH (FEET)

< 2

2 to 4

4 to 6

6 to 8

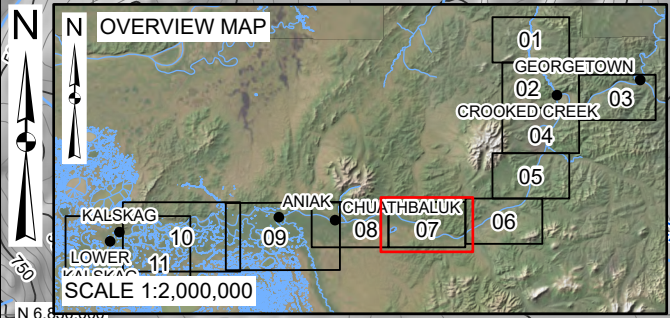
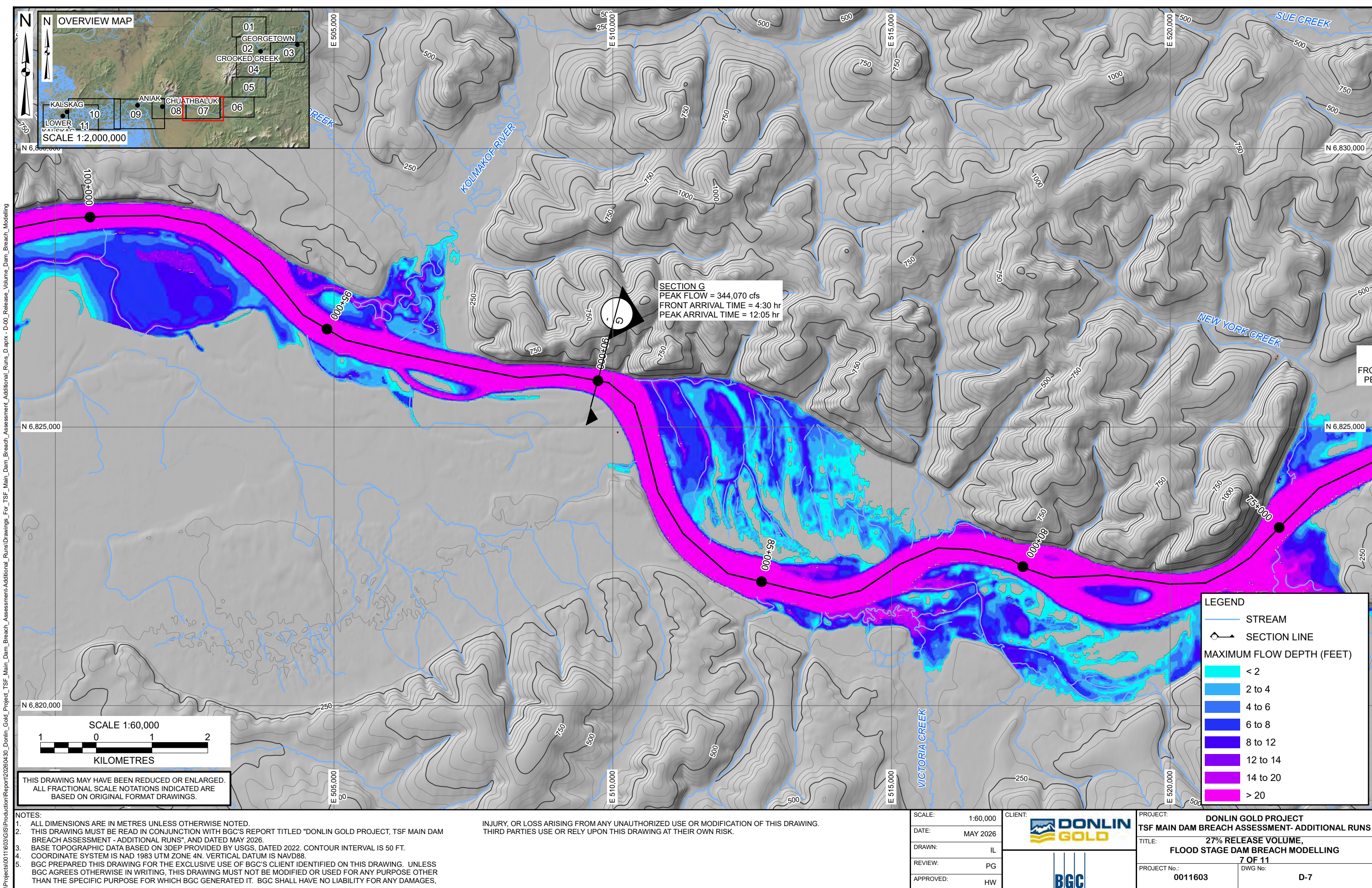
8 to 12

12 to 14

14 to 20

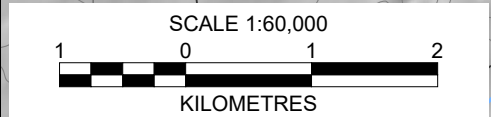
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	SCALE:	1:60,000		
	DATE:	MAY 2026		
	DRAWN:	IL		
	REVIEW:	PG		
	APPROVED:	HW		



SECTION G
PEAK FLOW = 344,070 cfs
FRONT ARRIVAL TIME = 4:30 hr
PEAK ARRIVAL TIME = 12:05 hr

LEGEND	
	STREAM
	SECTION LINE
MAXIMUM FLOW DEPTH (FEET)	
	< 2
	2 to 4
	4 to 6
	6 to 8
	8 to 12
	12 to 14
	14 to 20
	> 20



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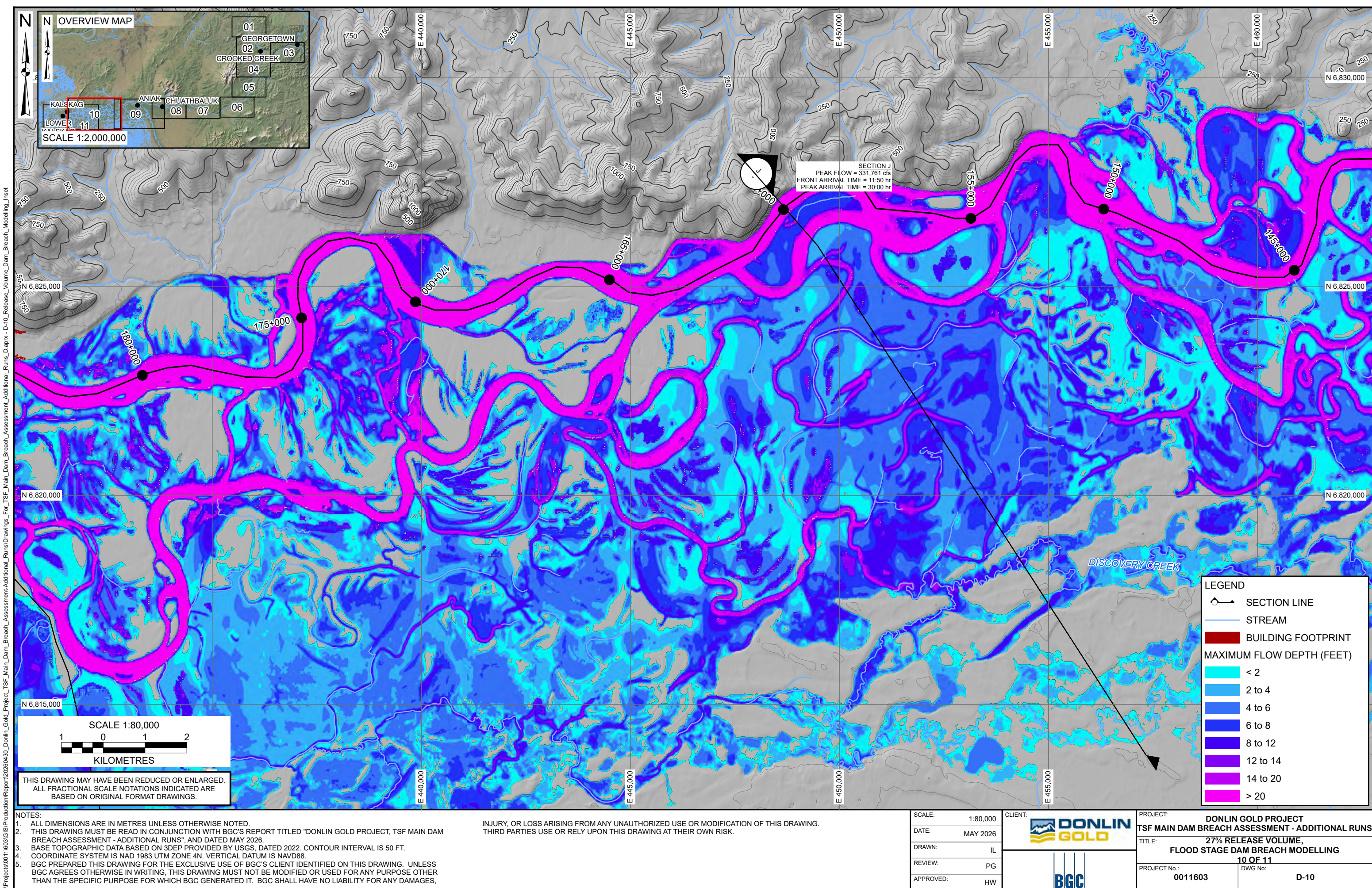
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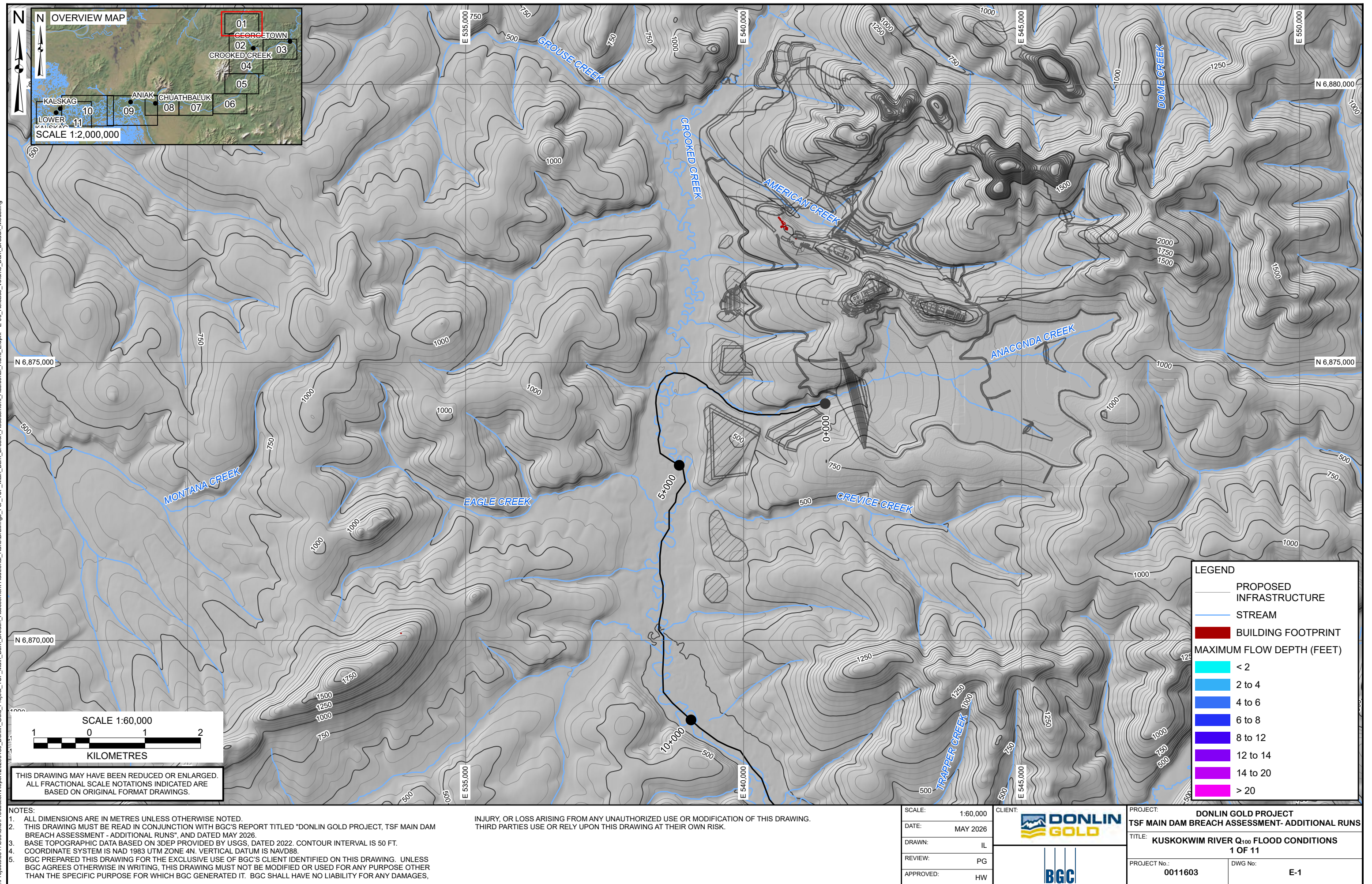
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REVIEW: PG
APPROVED: HW

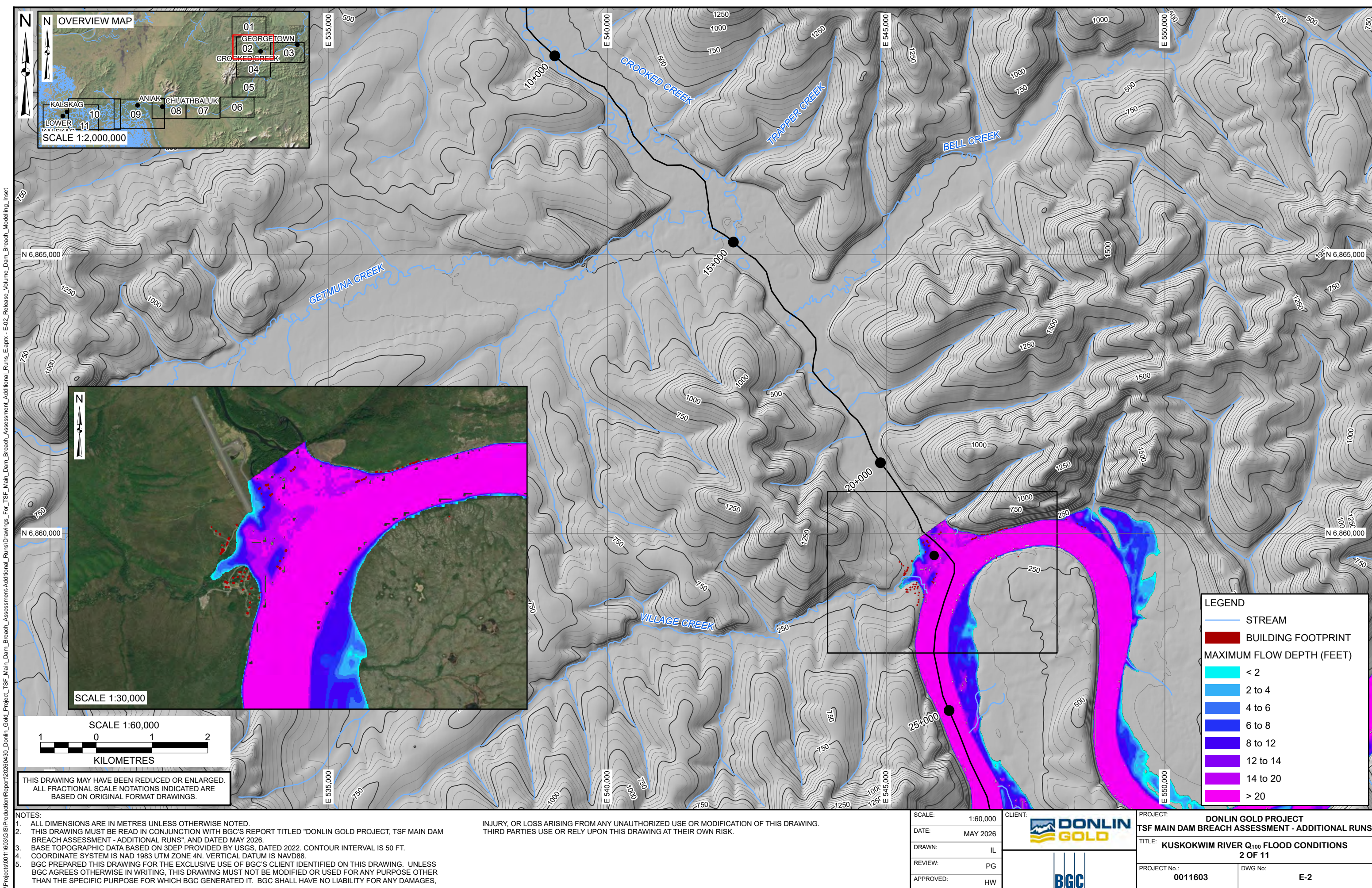
DONLIN
GOLD

BGC

PROJECT: DONLIN GOLD PROJECT
TSF MAIN DAM BREACH ASSESSMENT- ADDITIONAL RUNS
TITLE: 27% RELEASE VOLUME,
FLOOD STAGE DAM BREACH MODELLING
7 OF 11
PROJECT No.: 0011603
DWG No.: D-7





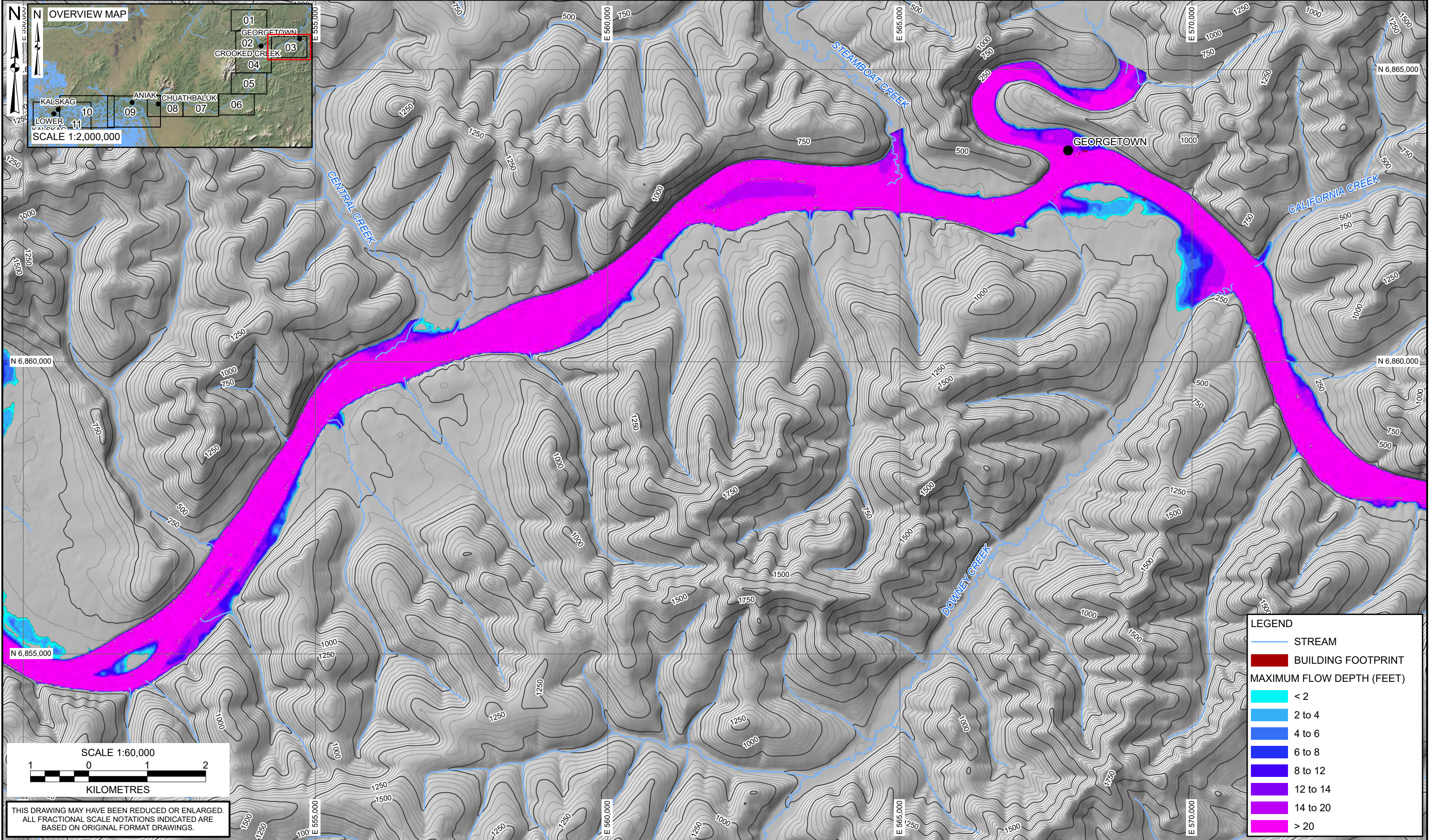


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DATE:	MAY 2026			
DRAWN:	IL			
REVIEW:	PG			
APPROVED:	HW	PROJECT:	DONLIN GOLD PROJECT TSF MAIN DAM BREACH ASSESSMENT - ADDITIONAL RUNS	
		TITLE:	KUSKOKWIM RIVER Q ₁₀₀ FLOOD CONDITIONS 2 OF 11	
		PROJECT No.:	0011603	DWG No.: E-2



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DATE:	MAY 2026
DRAWN:	IL
REVIEW:	PG
APPROVED:	HW

CLIENT:

PROJECT:

DONLIN GOLD PROJECT

TSF MAIN DAM BREACH ASSESSMENT- ADDITIONAL RUNS

TITLE:

KUSKOKWIM RIVER Q₁₀₀ FLOOD CONDITIONS

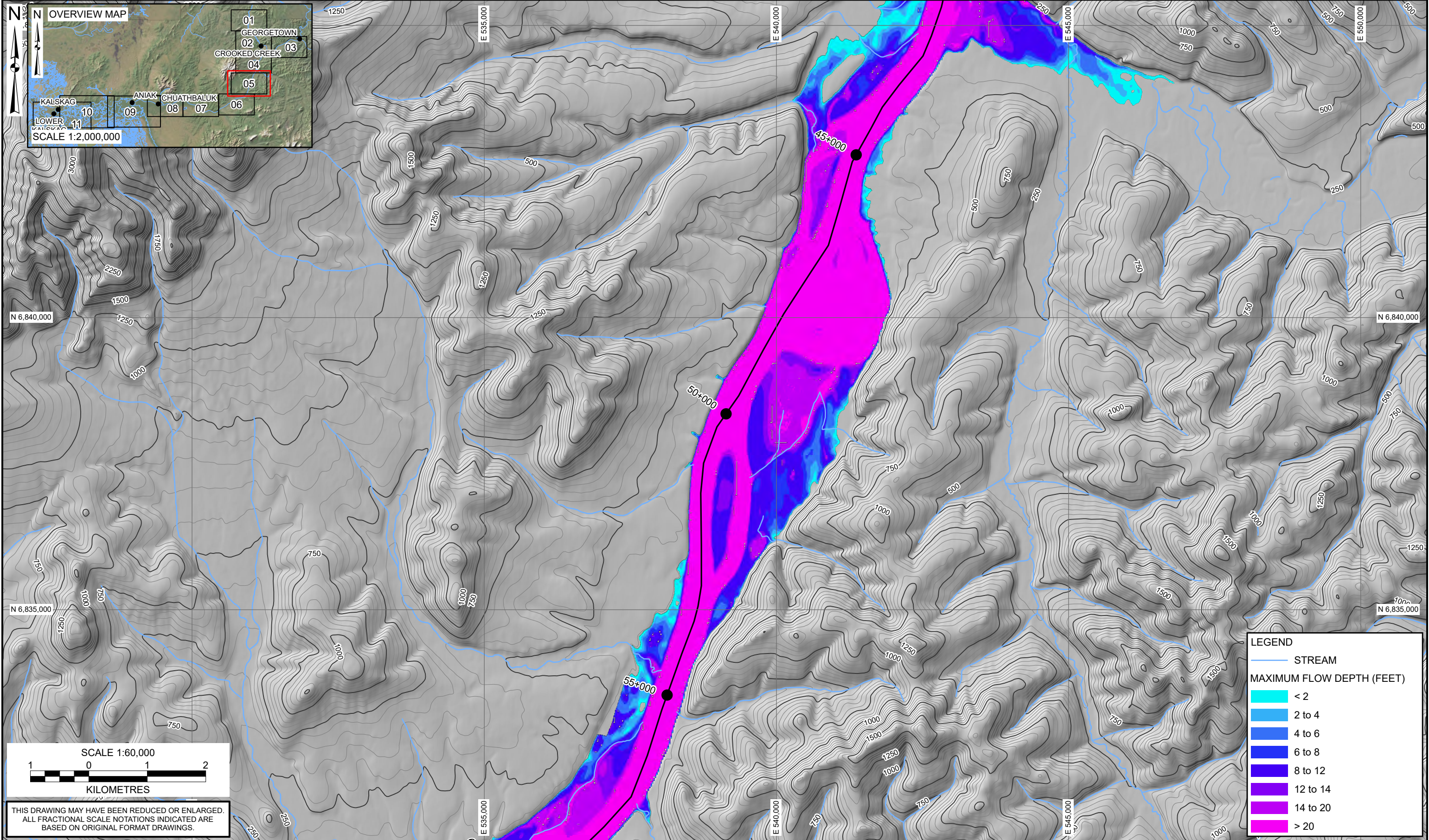
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PROJECT No.:

0011603

DWG No:

E-3

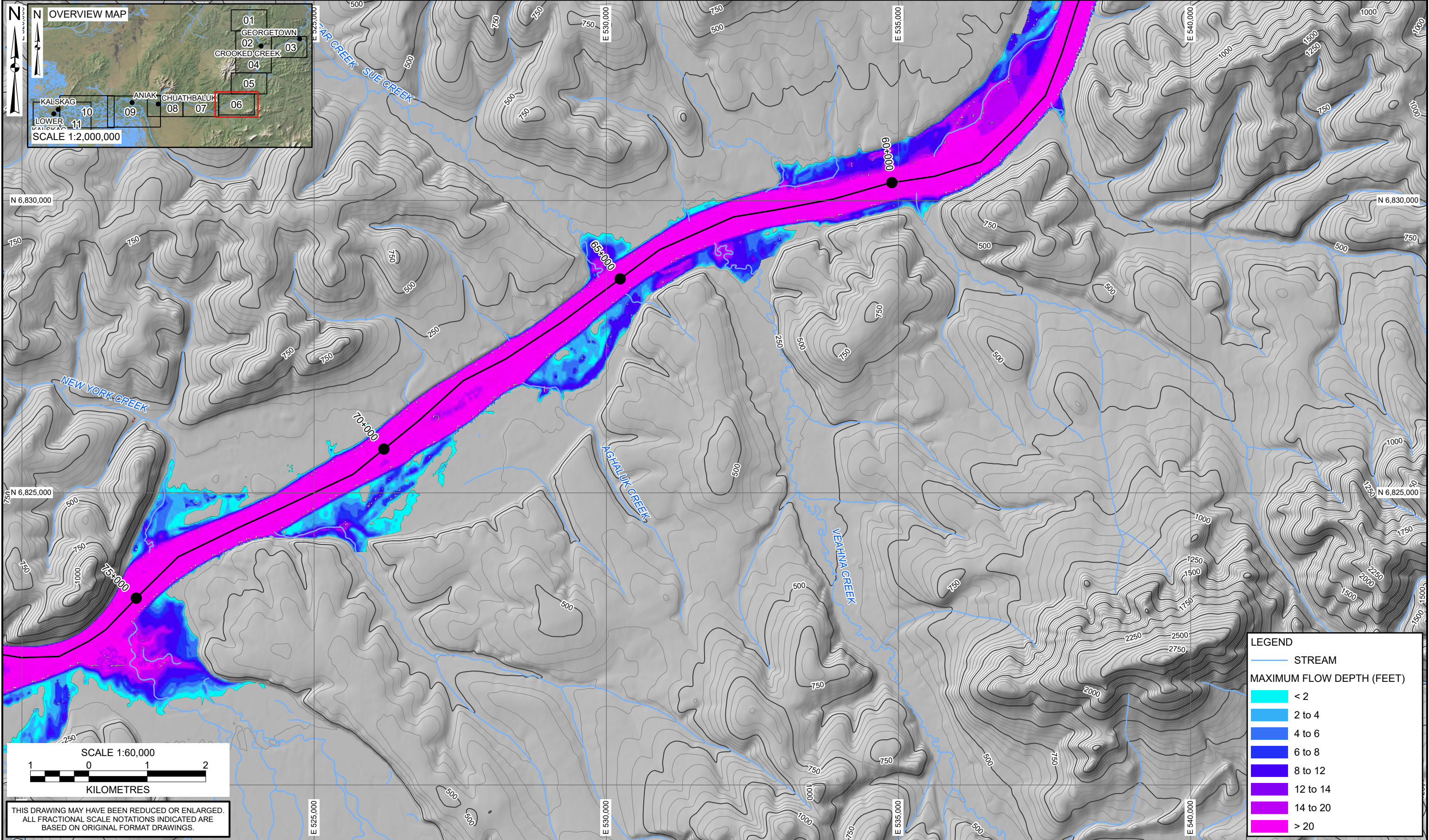


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DATE:	MAY 2026		TITLE: KUSKOKWIM RIVER Q₁₀₀ FLOOD CONDITIONS 5 OF 11	
DRAWN:	IL		PROJECT No.:	DWG No:
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APPROVED:	HW			

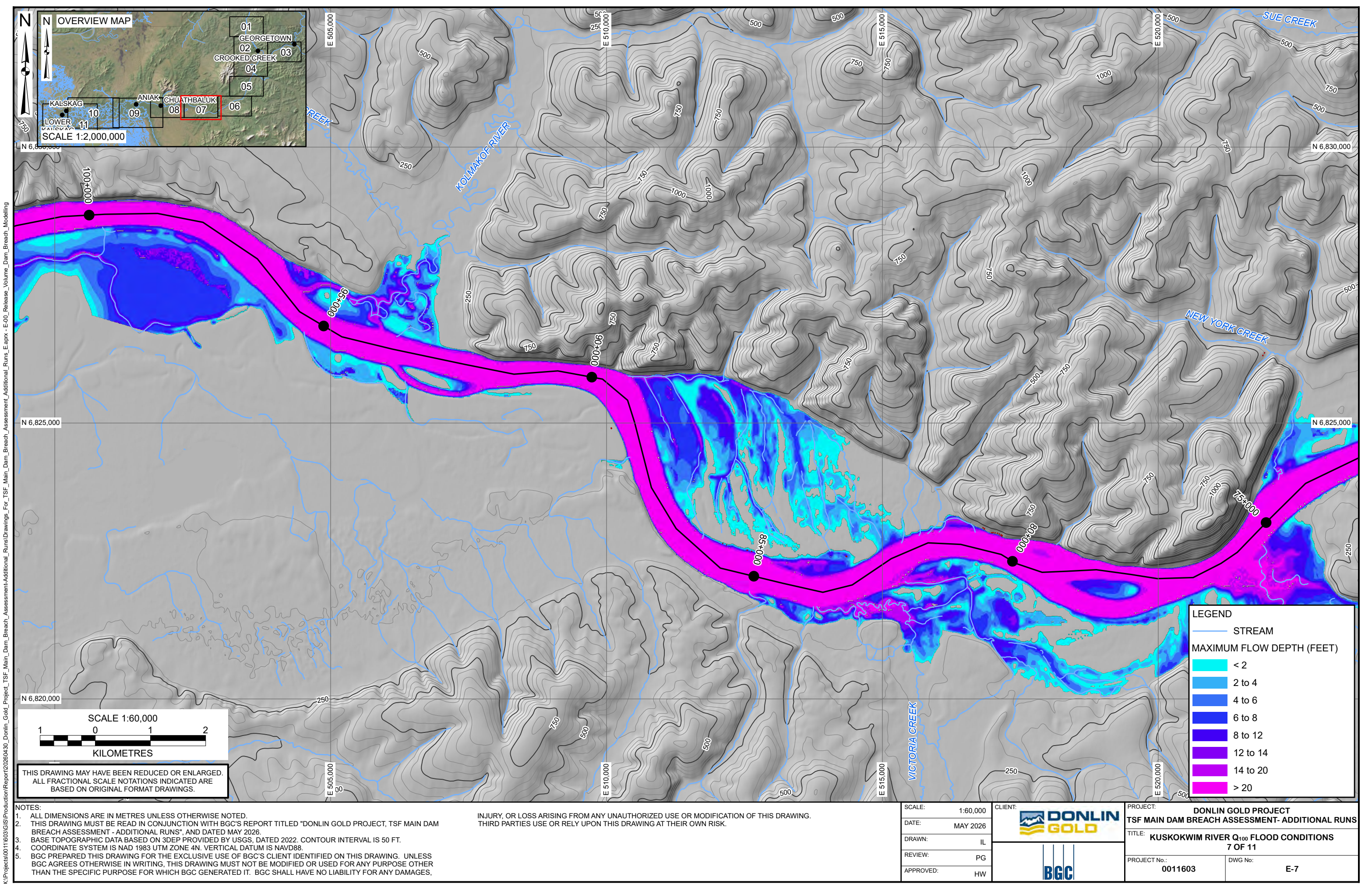


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DATE:	MAY 2026		TITLE: KUSKOKWIM RIVER Q₁₀₀ FLOOD CONDITIONS 6 OF 11	
DRAWN:	IL		PROJECT No.:	DWG No:
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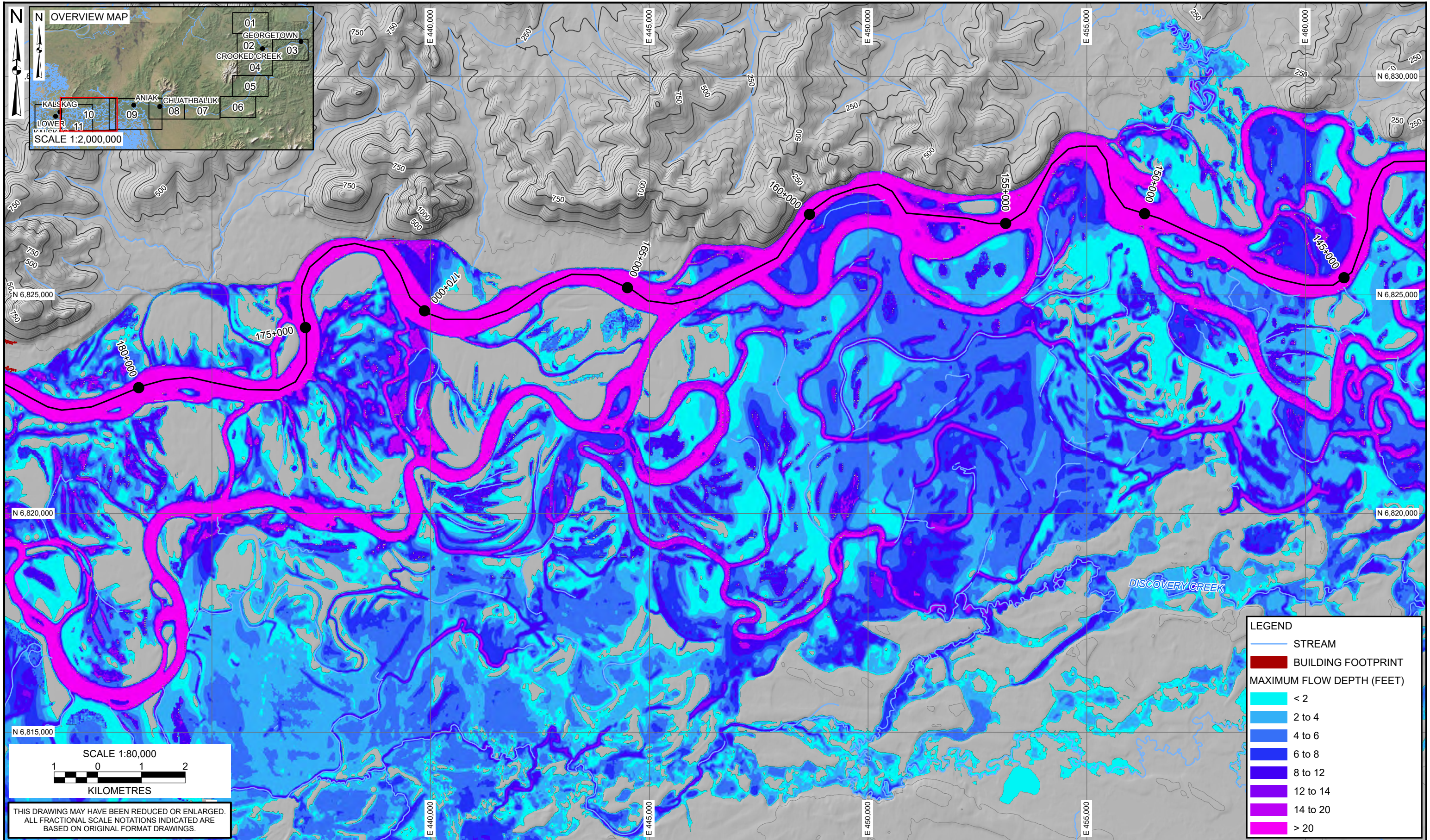
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DRAWN:	IL
REVIEW:	PG
APPROVED:	HW

CLIENT:




PROJECT: DONLIN GOLD PROJECT TSF MAIN DAM BREACH ASSESSMENT- ADDITIONAL RUNS	
TITLE: KUSKOKWIM RIVER Q ₁₀₀ FLOOD CONDITIONS 7 OF 11	
PROJECT No.: 0011603	DWG No: E-7

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APPENDIX C: ANILCA SECTION 810 EVALUATION

APPENDIX C

ANILCA SECTION 810 ANALYSIS OF SUBSISTENCE IMPACTS

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1. INTRODUCTION

The 2018 Donlin Gold Project Final Environmental Impact Statement (2018 FEIS) analyzed a Donlin Gold, LLC (Donlin Gold) proposal to develop an open pit gold mine in southwest Alaska, 10 miles north of the village of Crooked Creek located on the Kuskokwim River. The proposed Donlin Gold Project (Project) would build mining and ore processing facilities at the mine site, transportation facilities, and a 315-mile buried natural gas pipeline from Cook Inlet to the mine site to support electrical generation.

The 2018 FEIS analysis included an evaluation of the potential impacts of a hypothetical failure of the tailings storage facility (TSF) Main Dam. The hypothetical failure considered a partial dam breach which released approximately 0.5 percent of the facility's total capacity. In June 2025, the U.S. District Court (Alaska) issued an order remanding the 2018 FEIS to the U.S. Army Corps of Engineers (Corps) and Bureau of Land Management (BLM) to supplement the 2018 FEIS with the evaluation of larger tailings spills without vacating the Corps' and BLM's authorizations for the Project. The Corps published a special public notice to prepare a supplemental EIS (SEIS) on January 26, 2026. BLM has updated this Alaska National Interest Lands Conservation Act (ANILCA) Section 810 analysis following the 2025 court ruling to include findings from the larger tailings dam spill scenarios analyzed in the SEIS. This ANILCA Section 810 analysis replaces the 2018 analysis, Appendix N of the 2018 FEIS, and as such includes a comprehensive analysis of all alternatives therein, including additional analyses within the SEIS.

This analysis of subsistence impacts for the Donlin Gold Project is based on information included in the 2018 FEIS and SEIS. The Corps is the lead agency for the 2018 FEIS and SEIS, and the BLM is a cooperating agency. Donlin Gold submitted applications to the BLM in July 2012 and January 2013 for a right-of-way (ROW) grant to construct, operate, maintain, and close a 97-mile portion of pipeline and associated fiber optic cable which crosses BLM-managed land. As a whole, the pipeline and associated infrastructure consist of a 315-mile, 14-inch diameter, buried natural gas pipeline and associated buried fiber optic cable from the west side of Cook Inlet to the mine site in the Kuskokwim River watershed.

Section 810(a) of ANILCA, 16 USC § 3120(a), requires that an evaluation of subsistence uses and needs should be completed for any Federal determination to "withdraw, reserve, lease, or otherwise permit the use, occupancy or disposition of public lands." Due to the project requiring a ROW grant from the BLM for the natural gas pipeline's proposed crossing of Federally managed lands, an evaluation of potential impacts to subsistence under ANILCA § 810(a) must be completed for the 2018 FEIS and SEIS.

The proposed 315-mile pipeline ROW would traverse approximately 97 miles of BLM land north and west of the Alaska Range in the Kuskokwim River valley, in discontinuous segments

from about Milepost (MP) 168 to MP 310 of the proposed pipeline ROW. This represents about 30.8 percent of the total ROW length, with State of Alaska lands constituting about 65.5 percent, and ANCSA Corporation lands (Calista Corporation, The Kuskokwim Corporation [TKC], and Cook Inlet Region, Inc. [CIRI]) constituting 3.7 percent.

The pipeline is part of the energy supply infrastructure for the proposed open pit gold mine located approximately 10 miles north of the village of Crooked Creek. In addition to the pipeline and the mine site, the Project will include transportation infrastructure for barge transportation on the Kuskokwim River. This infrastructure will include an expansion of the existing port at Bethel and the development of a new port at Jungjuk Creek on the Kuskokwim River near the mine site. Ocean barges traveling to Bethel and river barges from Bethel to the mine's proposed port site would carry freight and diesel fuel approximately 190 miles up the Kuskokwim River, through the Yukon Delta National Wildlife Refuge (YDNWR). The U.S. Fish and Wildlife Service (FWS) has designated authority for Federal fisheries management on the Kuskokwim River. The YDNWR Manager is the in-season manager for Federal subsistence fisheries on Federally managed waters of the Kuskokwim River, pursuant to the delegation of authority from the Federal Subsistence Board.

Six alternatives were analyzed in the 2018 FEIS, which considered the impacts of the entire project including the mine site, transportation corridor, pipeline, and associated infrastructure. Two of the six alternatives analyzed in the 2018 FEIS involve variations of the pipeline component of the project, and alternatives included an analysis of a partial tailings dam release. The Evaluation and Findings sections of this analysis contain summaries of each alternative. Detailed descriptions of the alternatives can be found in Chapter 2 of the 2018 FEIS.

This 810 Analysis will address all alternatives and all associated impacts. This includes mine construction and operations, road transportation, and mining waste remediation aspects of the project.

This analysis uses information presented in the 2018 FEIS and SEIS to evaluate the potential impacts to subsistence pursuant to ANILCA § 810. Citations in this document reference studies which are also incorporated in the 2018 FEIS and SEIS. Only information provided in the 2018 FEIS and SEIS have been considered in this analysis of subsistence impacts. A joint record of decision between the Corps and the BLM was issued in August 2018, and it selected Alternative 2 from the 2018 FEIS, Donlin Gold's proposed action. The SEIS analyzes the resulting social, economic, physical, chemical, and biological impacts of a larger tailings spill scenarios on the affected areas under Alternative 2. Neither additional alternatives nor other impacts will be evaluated. The BLM will use the SEIS analysis for its ANILCA Section 810 review and assess if changes to the existing ROW are needed.

Chapter 1 of the 2018 FEIS and SEIS describe the purpose and need/scope for the proposed action, along with the regulatory and permitting authorities of the lead and cooperating agencies.

Chapter 2 of the 2018 FEIS provides a detailed overview of the proposed action and six alternatives, including major components at the mine site, transportation infrastructure, and pipeline. Due to the limited scope of the SEIS, Chapter 2 of the SEIS describes the tailings management and additional spill scenarios analyzed in the SEIS. Chapter 3 of the 2018 FEIS describes the affected environment, analysis area, and analyzes the potential direct and indirect environmental consequences of the proposed action and alternatives. Chapter 4 of the 2018 FEIS describes cumulative effects. The SEIS includes analyses of the additional spill scenarios, supplementing Chapters 3 and 4 of the 2018 FEIS. This 810 analysis uses the information in the 2018 FEIS and SEIS and presents the BLM findings of the effects of the proposed Donlin Gold Project to subsistence uses and resources.

1.1. Subsistence Evaluation Factors

Section 810(a) of ANILCA, 16 USC § 3120(a), requires that an evaluation of subsistence uses and needs should be completed for any Federal determination to “withdraw, reserve, lease, or otherwise permit the use, occupancy or disposition of public lands.” As such, an evaluation of potential impacts to subsistence under ANILCA § 810(a) must be completed for the 2018 FEIS and SEIS because the project requires a BLM ROW grant for the natural gas pipeline’s proposed crossing of Federally managed lands. ANILCA requires that this evaluation include findings on three specific issues:

1. The effect of use, occupancy, or disposition on subsistence uses and needs;
2. The availability of other lands for the purposes sought to be achieved; and,
3. Other alternatives that would reduce or eliminate the use, occupancy, or disposition of public lands needed for subsistence purposes (16 USC § 3120(a)).

The evaluation and findings required by ANILCA § 810 are set out for each of the six alternatives considered in the 2018 FEIS and the additional spill scenarios considered in the SEIS.

1.2. Determinations

Pursuant to ANILCA § 810, a finding that the proposed action may significantly restrict subsistence uses imposes additional requirements, including provisions for notices to the State of Alaska and appropriate regional and local subsistence committees, a hearing in the vicinity of the area involved, and the making of the following determinations, as required by ANILCA § 810(a)(3) prior to approving the proposed land use:

- Such a significant restriction of subsistence uses is necessary, consistent with sound management principles for the utilization of the public lands;

- The proposed activity will involve the minimal amount of public lands necessary to accomplish the purpose of the use, occupancy, or other disposition; and,
- Reasonable steps will be taken to minimize adverse effects upon subsistence uses and resources resulting from such actions.

If there is no positive finding (i.e. no significant restrictions to subsistence uses are expected to occur), then the determinations are not required.

To determine if a significant restriction of subsistence uses and needs may result from any one of the alternatives discussed in the 2018 FEIS and additional spill scenarios discussed in the SEIS, including their cumulative effects, the following factors in particular are considered:

- **Abundance:** The reduction in the availability of subsistence resources caused by a decline in the population or abundance of harvestable resources. This may include fish, wildlife, edible plants, house logs, firewood or drinking water, for example. Forces that might cause a reduction in abundance include adverse impacts on habitat, direct impacts on the resource, increased harvest, and increased competition from non-subsistence users.
- **Availability:** Reductions in the availability of resources used for subsistence purposes caused by alteration of their distribution, migration patterns, or location, and
- **Access:** Limitations on access to subsistence resources, including from increased competition for the resources, including physical and legal barriers.

This analysis begins with evaluations and findings for the No Action Alternative and for each of the six action alternatives discussed in Chapter 2, Section 2.3 of the 2018 FEIS and Section 2.1 of the SEIS. The cumulative case is evaluated in Chapter 4, Section 4.2 of the 2018 FEIS, and the affected environment and environmental consequences analysis is contained in Chapter 3 of the 2018 FEIS, including Section 3.2 for Soils, Section 3.6 for Groundwater Hydrology, Section 3.12 for Wildlife, Section 3.13 for Fish and Aquatic Resources, Section 3.19 for Environmental Justice, Section 3.21 for Subsistence, and Section 3.22 for Human Health. In the SEIS, the changes in the affected environment for salmon are discussed in Chapter 3, and the environmental consequences of the larger tailings dam releases are analyzed in Chapter 4, including Section 4.2 for Soils, Section 4.6 for Groundwater Hydrology, Section 4.12 for Wildlife, Section 4.13 for Fish and Aquatic Resources, Section 4.18.2 for Subsistence Economy, and Section 4.20 for Human Health. The information contained in the 2018 FEIS and SEIS is the data used in this analysis.

1.3. Findings

The Section 810 Evaluation concludes with a distinct finding that the proposed action and alternatives either may or will not significantly restrict subsistence uses for identified subsistence communities or groups.

A finding of “may significantly restrict” requires either 1) that the process be stopped for the action and the action prohibited; or 2) that the agency proceed to the notice and hearings step described below. A finding of “no significant restriction” concludes the Section 810 process.

A proposed action and/or alternatives are considered to significantly restrict subsistence uses if, after consideration of any stipulations or protection measures included as a part of each alternative, that action or alternative can be expected to result in a substantial reduction in the opportunity to continue subsistence uses of renewable resources. Substantial reductions in the opportunity to continue subsistence uses generally are caused by large reductions in the abundance, or a major redistribution of resources; extensive interference with access; or, major increases in the use of those resources by non-subsistence users. A proposed action and/or alternatives may be found to “not create a significant restriction,” but it may be appropriate for the analyst to identify and attempt to mitigate localized, individual restrictions created by an action.

The Findings are stated as either:

- This evaluation concludes that the action will not result in a significant reduction in subsistence uses; or
- This evaluation concludes that the action may result in a significant restriction to subsistence uses for the communities of _____ due to (specify causes).

The first Finding, above, is frequently referred to as a “Negative Finding” in that no significant restrictions are expected to occur. Likewise, the second Finding is commonly referred to as a “Positive Finding,” in that significant restriction may be expected to occur.

In some cases, individual alternatives will fall below the “may significantly restrict” threshold, and only the cumulative case exceeds the threshold. Note that the cumulative effects analysis is not, in and of itself, a proposed action. Instead, the purpose of the cumulative effects analysis is to determine the effects of the proposed action and alternatives together with other past, present, and reasonably foreseeable future actions. In this way, a finding of “may significantly restrict” subsistence uses in the cumulative case is, in effect, a Positive Finding, even though the finding is only noted under the cumulative case. A Positive Finding in the cumulative case triggers the Notice, Hearing, and Determination requirements of ANILCA § 810(a).

2. EVALUATION AND FINDINGS FOR ALTERNATIVES

The ANILCA § 810 evaluations and findings focus on potential impacts to the subsistence resources themselves, as well as access to resources, and economic and cultural issues that relate to subsistence use. The following evaluations are based on information relating to the environmental and subsistence consequences of the No Action Alternative and Alternatives 2,

3A, 3B, 4, 5A and 6A, as outlined in the environmental analysis as presented in Chapter 3 and the cumulative case as presented in Chapter 4 of the 2018 FEIS.

Detailed descriptions of the alternatives are in Chapter 2 of the 2018 FEIS and detailed descriptions of the spill scenarios are in Chapter 2 of the SEIS. These descriptions include the proposed mine site, transportation facilities, and pipelines, including construction, operational, and closure phases. The analysis for each alternative below includes a short summary of the alternatives description and impact analyses described in detail in the 2018 FEIS and the SEIS.

2.1. Evaluation and Findings for Alternative 1 – No Action Alternative

Alternative Summary: Alternative 1 of the Donlin Gold EIS is the No Action Alternative. Selection of this alternative would result in continued current management of BLM lands under the Southwest Management Framework Plan (1981) and the Ring of Fire Resource Management Plan (2008). Under the No Action Alternative, the mine site, transportation infrastructure, and natural gas pipeline would not be built and project-related impacts (both positive and negative) would not occur. The evaluations and findings presented here conclude that the impacts to subsistence as a result of this alternative would be nonexistent.

(See Section 2.1.4 of this analysis for Findings of Alternative 1.)

2.1.1. Alternative 1 – Evaluation and the Effect of Use, Occupancy, or Disposition on Subsistence Uses and Needs

Under the No Action Alternative, there would be no reduction in the abundance of harvestable resources used for subsistence purposes. There would be no adverse impacts on wildlife habitats, direct impacts on subsistence resources, or increased harvest and increased competition from non-subsistence users. There would be no reduction in the availability of subsistence resources caused by an alteration in their distribution, migration, or location. There would be no limitation on the access of subsistence users to harvestable resources, including physical and legal barriers.

The evaluations and findings presented here conclude that the impacts to subsistence as a result of this alternative would be nonexistent.

2.1.2. Alternative 1 – Evaluation of the Availability of Other Lands

Under the No Action Alternative, the mine, transportation infrastructure, and natural gas pipeline would not be built. Therefore, there would be no need to evaluate other lands for the natural gas pipeline.

2.1.3. Alternative 1 – Evaluation of Other Alternatives that Would Reduce or Eliminate the Use, Occupancy, or Disposition of Public Lands Needed for Subsistence Purposes

Under the No Action Alternative, the mine, transportation infrastructure, and natural gas pipeline would not be built. Therefore, there would be no need to evaluate other ways to accommodate the proposed action.

2.1.4. Alternative 1 – Summary of Findings

The evaluations and findings presented here conclude that the No Action Alternative impacts to subsistence would be nonexistent. The impacts to subsistence resources and access discussed above would be minimal, as the mine, transportation infrastructure, and natural gas pipeline would not be built. Project-related impacts would not occur under the No Action Alternative. This finding applies to the entire project area, involving the villages of Tuntutuliak, Napakiak, Napaskiak, Oscarville, Bethel, Kwethluk, Akiakchak, Akiak, Tuluksak, Kalskag, Upper and Lower Kalskag, Aniak, Chuathbaluk, Napaimute, Crooked Creek, Georgetown, Red Devil, Sleetmute, Stony River, McGrath, Nikolai, Tyonek, and Skwentna.

2.2. Evaluation and Findings for Alternative 2 – Donlin Gold Proposed Action

Alternative Summary: Donlin Gold's Proposed Action would establish an open-pit, hard rock gold mine in southwestern Alaska, 10 miles north of the village of Crooked Creek, on land leased from the Calista Corporation. The Kuskokwim Corporation (TKC) has granted surface use rights to Donlin Gold. Donlin Gold also has legal control of approximately 13 acres in the Snow Gulch area per a lease agreement with Lyman Resources in Alaska, Inc. The proposed project would require 3 to 4 years to construct, followed by an active mine life of approximately 27 years. After the end of the Operations Phase, the mine site facilities, port facilities, and the pipeline would be closed and reclaimed as permit conditions require.

The three main project components include (detailed descriptions are included in Chapter 2 of the 2018 FEIS):

- **Mine Site** – This component would include two open pits (that would merge into one), ore processing facilities, Waste Rock Facility (WRF), TSF, water treatment plants, facilities to house the workforce, equipment to transport ore from the open pit to the processing plant, hydrologic control features (freshwater diversion dams, contact water dams, and a freshwater reservoir), and a power plant (Figure ES-2). The Mine Site would occupy a total area of approximately 14 square miles (9,000 acres). Figure 2.3-1 in the 2018 FEIS presents a general layout of the proposed Mine Site.
- **Transportation Corridor** – Alternative 2 would include shipping cargo from marine terminals in Seattle and Vancouver via ocean barges up the Kuskokwim River to a cargo

terminal in Bethel. At Bethel, cargo would be transferred from ocean barges to river barges for towing up the Kuskokwim River to the upriver Angyaruaq (Jungjuk) Port site. Cargo would be transported by truck from the port to the Mine Site. This includes a 30-mile access road, a 5,000-foot dedicated airstrip, and up to an estimated 116 round trip river barges per season for the life of the mine. Additionally, improvements to the Bethel Yard Dock and are expected to be proposed for construction and operations by an independent party, and as such are not part of Donlin Gold's Proposed Action. Because those improvements are expected to occur only as the Donlin Gold Proposed Action moves forward, these improvements were considered and evaluated as a connected action in the 2018 FEIS and this analysis of subsistence impacts pursuant to the National Environmental Policy Act (40 CFR 1508.25). Connected Actions associated with the Bethel Yard Dock include the Bethel Cargo Terminal and Bethel Fuel Terminal and Tank Farm.

- **Natural Gas Pipeline** – This component would include a 316-mile, 14-inch, buried steel natural gas pipeline to support power generation at the mine site, built from Cook Inlet to the mine site. Elements of the pipeline include the ROW corridor, fiber optic cable, above ground facilities, compressor station, and temporary work areas outside of ROW including winter access routes, borrow material sites, and airstrips.

(See Section 2.2.4 of this analysis for Findings of Alternative 2.)

2.2.1. Alternative 2 – Evaluation and the Effect of Use, Occupancy, or Disposition on Subsistence Uses and Needs

Introduction: Section 3.21 of the 2018 FEIS details the direct and indirect effects of Alternative 2 on subsistence resource abundance and availability, access, competition, and socio-cultural effects (job, incomes, and shift work). Section 4.18 of the SEIS details the direct and indirect effects of the spill scenarios on subsistence resource abundance and availability, access, competition, and socio-cultural effects (job, incomes, and shift work). The assessment of effects on subsistence practices from changes in resource abundance and availability draws on the analysis of biological effects provided in Section 3.12, Wildlife, and Section 3.13, Fish and Aquatic Resources, of the 2018 FEIS and Section 4.12, Wildlife, and Section 3.13, Fish and Aquatic Resources, of the SEIS. The analysis of impacts to access focuses on disturbance and displacement from traditional subsistence use areas based on spatial and seasonal overlaps between project activities and subsistence use areas for the affected communities. The analysis of restrictions due to competition examines the potential for the proposed project to introduce new users of fish and wildlife resources in the area of the proposed action.

2.2.1.1. Mine Site

Summary: The mine site's impacts on subsistence would be most pronounced for communities closest to the mine, including Georgetown and Crooked Creek, and on BLM lands north and east

of Crooked Creek and north of the proposed Jungjuk Port site (Figure 3.15-1C, Generalized Land Status 2018 FEIS). The primary impacts to subsistence resources from general mine activities would include fugitive dust, risks to migratory waterfowl, and the decrease of salmon production in the Crooked Creek watershed. More detailed evaluations of impacts to subsistence uses and resources from the mine site are described below.

2.2.1.1.1. Fugitive Dust from Mine Activities

Federal lands adjacent to the mine would potentially be contaminated with dust emissions containing various particulate materials from ore processing and road maintenance. Existing soils and rock at the mine site naturally contain concentrations of mercury, arsenic and antimony (Section 3.2 2018 FEIS, Table 3.2-4). Fugitive dust would be generated by processes such as drilling and blasting in the pit, waste rock and ore handling, road traffic, and wind erosion of exposed surfaces such as ore stockpiles and tailings beaches. Fugitive dust generated during Mine Site construction and operations could potentially result in elevated concentrations of metals in soils surrounding the Mine Site over time through dust deposition. The dust particulates would reflect the minerals in the source material. Soil quality could be affected by fugitive dust settling on soil, or gaseous mercury emissions that wash out of the atmosphere as wet or dry deposition. Gaseous mercury could be emitted from the mill facility, waste rock, and tailings pond water (Section 3.2.3.2.4 2018 FEIS). Table 3.2-4 in the soils section of the 2018 FEIS estimates arsenic levels in soils from fugitive dust after mine closure could exceed Alaska Department of Environmental Conservation cleanup levels. Figure 3.2-10 of the 2018 FEIS shows the estimated fugitive dust deposition that would extend onto BLM lands south and east of the mine site.

The effects of fugitive dust on wildlife are described in Section 3.12.2.5.2 of the 2018 FEIS. The 2018 FEIS states that wildlife could be exposed to metals in dust during the construction and operations phases. Exposure could be through direct inhalation of dust or incidental ingestion of soil or food items. During the closure phase, wildlife may be affected by the presence of deposited mine site fugitive dust emissions in the soil.

Metals released from the soil due to the project's ground disturbing activities may affect wildlife. Table 3.12-4 in the 2018 FEIS shows that existing soil at the mine site contains concentrations of arsenic and mercury exceeding their respective Lowest Observed Effect Concentrations (LOECs) for protection of terrestrial plants, soil invertebrates, birds and mammals (LANL 2015), and that estimated soil concentrations of antimony, arsenic and mercury will increase by mine closure from fugitive dust. Arsenic and mercury levels at mine closure would exceed LOECs at mine closure (Table 3.12-4 2018 FEIS).

The 2018 FEIS concludes that ground disturbing activities at the mine site would increase the risk of contaminated airborne dust inhalation and the spread of dust to soil, water, and vegetation in the area, which in turn could slow growth or cause changes in plant communities in the area (Section 3.12.2.5.2 & Section 3.10.3.2.3 2018 FEIS).

The 2018 FEIS further concludes that the potential impacts from fugitive dust from the mine and associated roads could affect the abundance and availability of fish and wildlife, and slow growth patterns or change overall plant communities for subsistence resources on BLM lands near the villages of Crooked Creek and Georgetown during mining construction and operations for approximately 30 years (Figure 3.2-10 2018 FEIS). This impact would be the result of dust with exposed metals produced at the Mine Site (consisting mostly of waste rock and ore) which has the potential of getting into soils and plants which may then be consumed by fish and wildlife. Estimated annual average concentrations of mercury due to the Project stack and fugitive dust sources near Crooked Creek and Georgetown are shown in Figure 3.8-5 and Figure 3.8-6 of the 2018 FEIS.

Based on the subsistence use data and maps for Crooked Creek and central Kuskokwim subregion communities (Figure 3.21-16 and Figure 3.21-63 2018 FEIS) it does not appear that the BLM lands in proximity to the mine site are utilized for subsistence search and harvest areas. As such, fugitive dust would not result in significant impacts to subsistence uses on Federally managed public lands and resources.

2.2.1.1.2. Impacts to Migrating Waterfowl

Per the 2018 FEIS and SEIS, migratory birds may be at risk of injury or mortality from the tailings storage facility and contact water dam during operations during spring migration and from landing on the open water of the pit lake after mine closure. Migrating birds, particularly waterfowl and shorebirds, could be attracted to water associated with the mine, especially when surrounding wetlands are frozen. Migrating water birds may be at risk from ingestion of toxic water, food or sediments at the water storage features of the mine. Waterfowl (ducks, geese, and swans) and their eggs are important traditional subsistence species harvested in both spring and fall in upper Kuskokwim River communities (Section 3.21 2018 FEIS).

Potential impacts from the pit lake to migrating waterfowl may affect birds migrating to breeding areas on Federal lands within the Yukon-Delta National Wildlife Refuge and BLM lands in the Innoko bottoms (Spragens 2016), both of which are an important subsistence resource for villages along the Kuskokwim River and villages in the Innoko bottoms area (Section 3.21 2018 FEIS).

During the 2013 scoping meetings for the Donlin Gold Project Draft EIS, some parties expressed concern regarding the potential for migratory waterfowl to absorb contaminants from the Donlin Gold Project water containment facilities, including the contact water dam ponds, the tailings storage facility, and the pit lake. The potential impact of contamination of waterfowl from mine site water containment facilities is discussed and analyzed in Section 3.12, Wildlife. A summary of the Ecological Risk Assessment (ERA) is presented in the 2018 FEIS in Section 3.21, Subsistence. The ERA was prepared to analyze potential risk of wildlife exposure to toxic compounds and metals in the pit lake, but did not specifically focus on waterfowl.

Concern was also expressed during scoping meetings that the new areas of standing water associated with mine site facilities may attract waterfowl, or that waterfowl may be attracted to areas of open water during migration. The ERA analysis, as well as the analysis potential impacts of contaminants on wildlife in Section 3.13, Wildlife, included a number of assumptions inherent in the risk assessment, including:

- Use of whole rock concentration data from boreholes to estimate future sediment concentrations;
- Overestimates of receptor exposure durations (assuming full year exposure, although some species migrate during winter months and the pit lake is expected to be frozen for up to seven months per year);
- Poor wildlife and bird habitat being the only habitat available adjacent to the pit lake and other water containment facilities, offering limited or no food sources, and unfavorable conditions for bathing or wading;
- Adjacency of other suitable, more productive natural water bodies in the vicinity of the pit lake;
- Low likelihood of large-scale flocks being attracted to these waters, as waterfowl populations do not typically fly over the mine site (incidences of attraction are associated with unpredictable, unusual, or anomalous weather or migration patterns);
- Conservative assumptions regarding dietary fractions of pit lake items; and,
- Assumption of 100 percent bioavailability of ingested sediments and food.

If a permit is issued, the Preferred Alternative in the 2018 FEIS will include the appropriate Best Management Practices (BMPs) that the project proponent would be required to follow. These BMPs include requirements for an avian protection and a wildlife protection plan during Construction and Operations for the project. Further wildlife protection mitigation measures were considered to prevent wildlife access to the mine site water containment facilities (see 2018 FEIS Chapter 5, Impact Avoidance, Minimization, and Mitigation). If permitted, Donlin Gold would undertake adaptive management actions should pit lake water quality fail to meet standards during monitoring. The project design incorporates many levels of regulating water quality to address potential issues (Chapter 2 2018 FEIS and Section 4.22, SEIS Table 4.22-1).

Due to BMPs, mitigation measures and adaptive management actions described above, impacts to waterfowl would not result in significant impacts to subsistence uses.

2.2.1.1.3. Impacts to Salmon from Reduced Flow in Crooked Creek

Pit dewatering during development and operation of the mine would reduce water flow in the lower reaches of perennial streams in the vicinity of the mine pit as compared to pre-mining conditions. This is due to reduction of groundwater discharge to streams, induced leakage from streams to the pit dewatering system, and the re-routing of water from American and Anaconda Creeks for use in mining operations (Section 3.6 2018 FEIS). Stream losses to groundwater are expected to occur mostly along a 2- to-3 mile stretch of Crooked Creek and its tributaries in closest proximity to the pit. The greatest reduction in streamflow due to losses to groundwater would be during winter months (December through March) because streamflow is naturally lower during those months and because under natural conditions during those months, most streamflow is the result of groundwater discharge to the creeks. In addition, the water treatment plant that would return water to Crooked Creek during summer months would not normally operate during the winter (Section 3.6 2018 FEIS).

During mine development, the waste rock facility and construction of the open mining pits would substantially reduce flow in American Creek. Under low flow conditions, Crooked Creek streamflow at the confluence of American Creek is expected to be reduced by approximately one-third (28 percent through 33 percent) from December to March during year 20 of mine development, when the greatest groundwater impacts to streamflow from development would be anticipated. During average flow conditions, for comparison, it is expected flow reductions would range from 19 to 23 percent during those months. Annual average streamflow reduction is expected to be 17 percent under average flow conditions and 22 percent under low flow conditions (Section 3.6 2018 FEIS).

Streamflow reductions were also evaluated considering a scenario with high hydraulic conductivity (high K) values in the groundwater flow model. Under this scenario at the confluence of American Creek, 46 to 67 percent of wintertime flow in Crooked Creek is expected to be lost under normal (50 percentile) flow conditions; while 69 to 100 percent of the wintertime streamflow is expected to be lost under low-flow conditions at Year 20. Average annual streamflow reduction of Crooked Creek at American Creek under the high hydraulic conductivity scenarios is expected to be 31 percent under average conditions and 46 percent under low flow conditions (Section 3.6 2018 FEIS).

Under these predicted scenarios of reduced wintertime flow rates, Crooked Creek water levels may be too low for spawning salmon, and egg survival in spawning gravels may be limited or eliminated completely by low water and freezing conditions (Section 3.13.3.2.1 2018 FEIS). These conditions would continue during mining (30 years) and after mine closure as the pit lake fills (50 years) and as pit water is pumped and treated in perpetuity to prevent ground water and surface water contamination. Salmon may be nearly or completely extirpated from Crooked Creek by hydrological changes from mine development, operation, and closure.

Potential impacts to salmon in Crooked Creek would affect the abundance and availability of fish for subsistence in the Kuskokwim River within the Yukon Delta National Wildlife Refuge. However, based upon the size of the Crooked Creek drainage, Chinook, coho, chum, pink, and sockeye salmon production that would be lost to mine activity is believed to be relatively small compared to the total Kuskokwim drainage's salmon production (Section 3.13.2.3.2 2018 FEIS). Remaining salmon resources in the Kuskokwim River drainage could be relied upon to address any lost subsistence opportunities caused by reductions in Crooked Creek's productivity. Since the 2018 EIS, western Alaska has continued to experience a significant decline in both Chinook (*Oncorhynchus tshawytscha*) and chum (*Oncorhynchus keta*) salmon populations. Low marine survival appears to be a primary driver, particularly during years of anomalously warm ocean temperatures. In particular, chum salmon populations have been depressed for the last 6 years. In 2025, chum salmon returns underperformed compared to the previous two seasons and remained well beneath historical harvest and escapement levels. Final passage estimates at the Kuskokwim River sonar recorded 159,622 chum salmon, compared to pre-collapse baselines of 556,000 in 2018 and 385,000 in 2019 (Federal Subsistence Board 2026). In response to these declines in Chinook and chum salmon, state and Federal fishery management agencies have implemented a range of conservation measures, including restrictions or closures of subsistence, commercial, and sport fisheries to protect returning adults, reduced bycatch limits in Federally managed fisheries, and enhanced monitoring and research efforts. These current or future Federal closures could limit access to these alternative resources for subsistence users.

2.2.1.2. Transportation Infrastructure

Summary: Transportation activities (barging of cargo and fuel) and infrastructure (the construction of a port at Angyaruaq (Jungjuk) on the Kuskokwim River) would impact the abundance and distribution of fish resources on the Kuskokwim River and interfere with subsistence access to the river, as described below. Barging will affect all villages on the river from Crooked Creek to the mouth of the Kuskokwim River. These villages include Bethel, Napaiak, Napaskiak, Oscarville, Kwethluk, Akiakchak, Akiak, Tuluksak, Upper and Lower Kalskag, Aniak, Chuathbaluk, Napaimute, and Crooked Creek. Impacts from barging include displacement of subsistence fishing activities by barges and tugs, disruption or reduced access to subsistence fishing activities and sites (set nets, fish wheels, processing rafts, etc.) along the river. Subsistence fish resources (salmon and resident fish species populations) may also be negatively affected by the magnitude and intensity of barge traffic proposed in Alternative 2. Effects to fish may increase when river water levels are low, as barge rafts will need to be uncoupled and barges towed individually or in pairs, or lighter barge loads per trip would be required to navigate to the Jungjuk port. This would require additional barge round trips on the river and increase impacts to subsistence fishers on the Kuskokwim River and to subsistence fish resources.

2.2.1.2.1. Barging Impacts to Fish and Birds

The potential impacts of industrial barge traffic on the Kuskokwim River to fish from displacement and stranding, propeller wash, bed scour and fish injury and mortality are described in Section 3.13, Fish and Aquatic Resources, of the 2018 FEIS.

The Kuskokwim River shipping season of 110 days is assumed to occur from June 1st to October 1st, allowing for two weeks of downtime to allow for occasional low flows. Between Bethel and Angyaruaq (Jungjuk) Port, available draft on the river is limited by the depth of water in the shallower sections of the river (Section 2.3.2.2.1 of the 2018 FEIS). Based on interviews with Kuskokwim River barge operators, currently there are approximately 68 round trip freight and fuel barge tows per year serving the villages upriver of Bethel (Section 3.23.1.3 of the 2018 FEIS). Alternative 2 proposes 89 additional round trip river barges per year during project construction and 116 round trip river barges per year during mine operations (Section 2.3.2.2.1 of the 2018 FEIS) which would result in almost a 200% increase in barge traffic along the Kuskokwim River.

The trips would likely impact spawning adult fish, eggs in spawning redds, and juvenile fish by disturbing, or causing their direct injury or mortality, potential displacement or stranding, and from river bed scour and siltation. The proposed increase in barging activity would potentially impact salmon, broad and humpback whitefish, sheefish, and rainbow smelt, all subsistence species important to villages on the Kuskokwim River (Section 3.13 of the 2018 FEIS).

Impacts to fish from river barges have been documented on other river systems and are discussed in Section 3.13, Fish and Aquatic Resources, of the 2018 FEIS. Propellers of tugs used to push river barges produce hydraulic forces that thrust through the water column and to the river bottom, causing displacement and mortality of adult fish, eggs, larvae and other aquatic life (Gutreuter et al. 2003, Killgore et al. 2005, Holland 1986). Fish displacement and stranding by passing barges have been documented on large river systems in Europe (Kucera-Hirzinger et al. 2009) and on the Columbia River in the U.S. (Pearson et al. 2006, Ackerman 2002).

Subsistence users on the Kuskokwim River harvest five species of Pacific salmon using drift gillnetting, set gillnetting, fish wheels, and hook and line methods of harvest (Section 3.21.5.5 2018 FEIS). Season openings for salmon fishing (i.e. the time period that a specific type of fishing, such as subsistence, commercial or recreational fishing activities may occur) are limited, especially for Chinook salmon, due to low escapement numbers and conservation concerns. Barge traffic may disrupt the movement and distribution of migrating salmon and access to the river by subsistence fishers, and interfere with subsistence users' fish wheels, set nets, and drift nets. Barge traffic may displace or swamp smaller fishing boats, dislodge or break fish wheels, or cause nets to detach from their anchors and float away. These disturbances could cause subsistence users to miss the salmon season open dates or reduce their harvests because nets

would be disturbed or have to be removed often as barges pass up and down the river during season open dates.

Spring waterfowl hunting takes place on the Kuskokwim River by subsistence users when the river breaks up, particularly for black scoters (*Melanitta americana*). Barge traffic may disturb and disperse migrating birds and reduce access by subsistence users hunting on the river from boats.

In summary, potential impacts from the increase in barging on the Kuskokwim River may cause extensive interference with access to the river for subsistence users along the river due to the increase in barging traffic during the short subsistence season open dates for fisheries. The barging impacts may also cause large reductions in the abundance and availability of fish resources important to subsistence users on the Kuskokwim River within the Yukon Delta National Wildlife Refuge. Therefore, this evaluation concludes that Alternative 2 may result in a significant restriction to subsistence uses for the communities of Bethel, Tuntutuliak Napakiak, Napaskiak, Oscarville, Kwethluk, Akiachak, Akiak, Tuluksak, Upper and Lower Kalskag, Aniak, Chuathbaluk, Napaimute, and Crooked Creek due to a substantial reduction in the opportunity to continue uses of subsistence resources on the Kuskokwim River. Barging on the Kuskokwim River during construction and operation of the mine may cause extensive interference with access to the Kuskokwim River by subsistence users from villages along the river. It may cause a major redistribution of salmon, rainbow smelt, and whitefish, which are important subsistence resources for those villages.

2.2.1.3. Natural Gas Pipeline

Summary: The effects to subsistence from construction and operation of the natural gas pipeline would affect the Cook Inlet villages of Tyonek, and Skwentna and the upper Kuskokwim villages of Nikolai, McGrath, and Takotna. The pipeline ROW intersects with the subsistence search and harvest areas of these villages, as shown in Section 3.21 of the 2018 FEIS. It may also affect the distribution and abundance of upland birds, moose, caribou and black bear sought by subsistence users in these villages. The increased access along the pipeline ROW may cause a major increase in use of these resources by non-subsistence users.

During construction, the effects of clearing the ROW, including trenching, drilling and the presence of machinery, pipeline transport, workers, and infrastructure on and along the pipeline ROW, would cause a redistribution of moose, caribou, black bear, and furbearers. It would negatively affect access to subsistence use areas and availability of subsistence resources. The effects would be temporary (3-4 years) and would not result in a significant restriction to these subsistence resources. However, during mine operations (27 years) the cleared ROW corridor would allow for increased access to subsistence resources by non-local residents using aircraft into the Farewell Airstrip. This could cause a major increase in competition for those subsistence resources along and adjacent to the pipeline ROW by non-subsistence users. Villages that may

be adversely affected by increased access to and competition in the area include McGrath, Nikolai, and Takotna.

2.2.1.3.1. Impacts from Increased Access along the Gas Pipeline Right-of-Way

Under Alternative 2, the 315-mile long pipeline ROW crosses approximately 97 miles of BLM land north and west of the Alaska Range in the Kuskokwim River valley, in discontinuous segments of the proposed pipeline ROW from about Milepost (MP) 168 to MP 310. This represents about 30.8 percent of the total ROW length, with State of Alaska lands constituting about 65.5 percent, and ANCSA corporation lands (Calista Corporation, The Kuskokwim Corporation [TKC], and Cook Inlet Region, Inc. [CIRI]) constituting 3.7 percent.

During construction, 14,100 acres of wildlife habitat would be cleared along the entire length of the pipeline, with approximately 4,329 acres cleared on BLM lands. Construction activities and noise would affect the availability of subsistence resources beyond the pipeline corridor during the estimated 3 to 4 year construction period (Section 3.21.6.3.3 2018 FEIS). Access through the active construction area would be limited during construction activities. During mine operations (estimated 27 years), the buried pipeline ROW would not be fenced and would be brushed every 10 years to provide for visual monitoring (Chapter 2 2018 FEIS).

The pipeline corridor may affect subsistence activities and may increase access to Federal lands by non-subsistence users such as sport hunters and fishers, and recreational users such as snow machine riders taking advantage of a newly established corridor into an undeveloped portion of rural Alaska. The newly cleared ROW corridor access may provide increased access north and west of the Alaska Range for fly-in sport hunters and trappers who are currently utilizing the Farewell Airstrip and may therefore affect the abundance and availability of moose, caribou, black bear and furbearers, which are important subsistence resource for the villages of McGrath, Takotna and Nikolai (Figure 3.21-69 2018 FEIS).

Increased activity and access from the Farewell Airstrip and along the nearby gas pipeline right-of way may cause major increases in the disturbance and use of moose, caribou, black bear and furbearer subsistence resources by recreational sport hunters and commercial outfitters. These are important subsistence resources for the villages of McGrath, Takotna, and Nikolai. This evaluation concludes that Alternative 2 may result in a significant restriction to subsistence use for the communities of McGrath, Takotna and Nikolai due to a substantial increase in competition for subsistence resources along the natural gas pipeline at the Farewell Airstrip.

2.2.1.3.2. Impacts to Sheefish & White Fish Spawning Areas

Sheefish are an important subsistence fish on the Kuskokwim River, and are harvested in the lower river (Fall et al. 2007) and upper river (Krauthoefer et al. 2007, Brown et al. 2012) in spring. Sheefish provide a source of fresh fish prior to salmon runs. Residents of Telida also harvest sheefish in August and September at the mouth of Highpower Creek, within the

Kuskokwim River watershed (Williams et al. 2005). Sheefish spawn in very few locations in the Kuskokwim River watershed. Sheefish have been described in only four areas, including the Big River, the Middle Fork Kuskokwim River, at the confluence of East Fork and the Tonzana River, and lower Highpower Creek (Stuby 2012). Sheefish are migratory and make long movements related to feeding, spawning and overwintering. They generally spawn in the upper portions of the Kuskokwim watershed in the fall and overwinter in the lower river (Stuby 2012).

Broad whitefish and humpback whitefish are also important to the regional subsistence economy of the Kuskokwim River watershed. These fish make up greater than half of the non-salmon fish harvest (Coffing 1991, Krauthoefer et al. 2007). Broad and humpback whitefish spawn in a limited number of locations in the Kuskokwim watershed. Both species migrate upstream to spawn in October and move downstream to overwinter in the lower river and exhibit fidelity to feeding and spawning areas (Harper et al. 2012). Spawning areas for both species are in the middle reaches of the Big River (Harper et al. 2012).

Under Alternative 2, the ROW for the proposed Donlin gas pipeline crosses the upper reaches of the Big River and Middle Fork Kuskokwim River, about 30 miles upstream of where sheefish, broad whitefish, and humpback whitefish spawn. Open-cut crossings of these tributaries are proposed in winter (Chapter 2 2018 FEIS). Open-cut crossings involve excavation of the trench across the river using excavators operated from the riverbank and within the stream channel to dig the trench to lay the pipe. Potential impacts to anadromous and resident fish would involve sediment loads generated from trenching operations moving downriver, adversely affecting sheefish, humpback whitefish, and broad whitefish eggs incubating in gravels on spawning grounds (Section 3.13.3.2.3 2018 FEIS). It would potentially impact known spawning areas on the Big River and Middle Fork Kuskokwim River, which are classified as Essential Fish Habitat under the Magnuson-Stevens Act. Impacts to these spawning areas would have consequences for the entire Kuskokwim watershed, as spawning areas for these whitefish species are limited and produce fish that travel throughout the watershed and are an important subsistence resource.

Potential impacts from the natural gas pipeline ROW may affect the abundance and availability of sheefish and whitefish on the Big River and Middle Fork of the Kuskokwim River on nearby BLM lands. These fish are an important subsistence resource for the villages of McGrath, Takotna, and Nikolai, as well as villages on the Kuskokwim River within the Yukon Delta National Wildlife Refuge. However, with the incorporation of BMPs per the 2018 FEIS and due to the short duration of trenching activities, these impacts are not expected to result in a significant restriction to subsistence resources.

2.2.1.4. Spill Scenarios

Summary: Under Alternative 2, spills of hazardous materials necessary for the mining operation such as fuel and cyanide would have the potential to impact subsistence species and subsistence harvest patterns, depending on the amount and location of the spill. Section 3.24, Spill Risk, in

the 2018 FEIS identifies hazardous materials, describes existing response capacities, and reviews probabilities of spills of various sizes. The fate and behavior of spilled materials is outlined, followed by a set of nine specific spill scenarios to be analyzed in detail. For this Section 810 analysis, nine spill scenarios used in the 2018 FEIS and larger tailings spills used in the SEIS are outlined with an analysis of potential impacts to subsistence resources and uses. Spill scenarios are considered to have a low probability of occurring; however, such scenarios would have a high consequence to subsistence resources if they occurred.

Under Alternative 2 the following spills scenarios and impacts are identified:

2018 FEIS Scenario 1: Ocean Barge Rupture at Sea

In this scenario, approximately 735,000 gallons of diesel would be released from a grounding south of the Kuskokwim River mouth. Of this volume, approximately half of the spilled gallons (367,500) would reach the shore. This spill could have the potential to affect hundreds of miles of shoreline and could affect near shore subsistence activities. This spill scenario would impact subsistence resources and use on Federal lands within the Yukon Delta National Wildlife Refuge. The magnitude and duration of the impact would depend on the location and volume of the spill, season of the year, and clean up and emergency response time. Indirect effects of the spill would include contamination of marine and coastal subsistence resources and would be more impacting if the spill occurred during salmon runs. The effect of this spill scenario would have major impacts to fish subsistence resources on the Kuskokwim River.

2018 FEIS Scenario 2: River Barge Release

The spill scenario indicates that up to 37,817 gallons would be released from a breach of the double hull and two compartments in the fuel barge. Timely response and clean up might recover half of this amount (approximately 18,908 gallons). The spill impact would affect fish and water birds in the Kuskokwim River, including Chinook salmon and migratory birds. The effect of this spill scenario would have major impacts to subsistence resources on the Kuskokwim River.

2018 FEIS Scenario 3: Tank Farm Release

Storage of diesel fuel would occur in tank farms located in Dutch Harbor, Bethel, Angyaruaq (Jungjuk) Port, and at the mine site. Secondary containment structures are generally engineered to hold 110 percent of the volume of the largest tank. The spill scenario for this material estimates that the entire tank contents are released but contained within the secondary containment structure. The effect of this spill to subsistence resources would depend on the location and volume of the spill, season of the year, the length of time the spill was in secondary containment and clean up and emergency response time.

2018 FEIS Scenario 4: Tanker Truck Release

Tanker truck spills would occur at the Jungjuk Port during transfer operations from barges to port storage tanks, from storage tanks to tanker trucks, or on the port road to the mine. The spill scenario is for loss of up to 13,500 gallons, with recovery dependent on whether tundra or water

bodies are affected. The effect of this spill to subsistence resources would depend on the proximity to wetlands and waterways, season of the year, and clean up and emergency response time; but the effects could be major if it contaminates wetlands or reaches the Kuskokwim River.

2018 FEIS Scenario 7: Cyanide Release

If cyanide came into contact with water, both aquatic and terrestrial mammals could be adversely affected. Cyanide reacts readily in the environment and degrades or forms complexes and salts of varying stabilities. It is toxic at very low concentrations to all living organisms. The effect of a cyanide spill on subsistence resources would depend on the volume of cyanide and location of the spill, but it could have major effects on freshwater and marine environments.

2018 FEIS Scenario 8: Mercury Release

If elemental mercury is spilled, some of it would be emitted as gaseous mercury that could be highly toxic to animals. If spilled mercury escapes cleanup efforts, it would be subject to natural methylation processes and would add incrementally to the mercury levels in the ground and air, thus increasing the chronic exposure of aquatic biota and fish. Mercury persists in the environment, and bio-accumulates within food webs, potentially increasing exposure to fish-eating animals. The effect of wind born dust from trucks on the port road, or release of mercury vapor during ore processing, could have effects on fish, terrestrial wildlife, and vegetation.

2018 FEIS Scenario 9:

Partial Tailings Dam Failure (0.5 Percent of Contents)

The partial tailings dam failure of 0.5 percent of the tailings dam storage capacity analyzed in the 2018 FEIS would release contaminated tailings and water into Crooked Creek and the Kuskokwim River. The impacts to subsistence resources and uses would include reduced access for local subsistence users and contaminated water resources important for terrestrial wildlife and fish, including salmon and resident fish populations. A tailings dam failure could not be cleaned up easily and quickly, its effects would continue long-term, and the failure would affect subsistence fish resources in communities downriver from the mine. This scenario would have major impacts to subsistence resources for the entire Kuskokwim River watershed.

SEIS Larger Tailings Dam Failures (5.4 to 27 Percent of Contents)

Under each dam spill scenario analyzed in the SEIS (i.e., 5.4 percent, 13.3 percent, or 27 percent of the tailings dam storage capacity), the magnitude and duration of impacts would increase compared to the partial tailings dam failure analyzed in the 2018 FEIS. Further, the level of impact to subsistence resources would vary depending on proximity to the dam and the volume of material released by any failure. Water quality downstream of the tailings dam would be impacted by increased metals for years to decades under the 5.4 and 13.3 percent scenarios; however, metal contamination could last for over a century under the 27 percent scenario. Vegetation regrowth could be unachievable in some locations under the 5.4 and 13.3 percent scenarios and in many locations under the 27 percent scenario. Fish and wildlife habitat could

take years to recover under the 5.4 and the 13.3 percent scenarios and decades under the 27 percent scenario, causing a larger time period of displacement (availability) of subsistence wildlife species. There would be acute injury and mortality to fish extended to the lower reaches of Cooked Creek under the 5.4 and 13.3 percent scenarios, but there could be chronic effects, lasting an indeterminable number of years, to fish in Cooked Creek and the Kuskokwim River at large, likely resulting in a generationally lower abundance of resources for many communities. These scenarios would have major long-term impacts to subsistence resources for communities throughout the Kuskokwim River watershed.

2.2.2. Alternative 2 – Evaluation of the Availability of Other Lands

The proposed Donlin Gold Project extends from the west side of Cook Inlet through the natural gas pipeline ROW to the mine site located 10 miles north of the village of Cooked Creek. Transportation infrastructure includes the mine access road and upriver barge landing at Angyaruaq (Jungjuk) Port and the connected action involving improvements to the Bethel Yard Dock, Bethel Fuel Storage, and Dutch Harbor Fuel Storage facilities. Large segments of the proposed project are outside of BLM lands. The mine site and the transportation infrastructure would not be located on Federal land. As noted above, the BLM-managed portion of the pipeline ROW is located in discontinuous segments from about Milepost (MP) 168 to MP 310 of the proposed pipeline ROW, amounting to about 30.7 percent of the total ROW length (Figure 3.15-1B 2018 FEIS).

Barges transporting fuel and cargo from Bethel on the Kuskokwim River pass through Federal lands within the Yukon Delta National Wildlife Refuge, although the bed of the river itself is under state ownership. The Kuskokwim River cannot be avoided if barging is used for transportation during construction and operation of the mine.

As described in the 2018 FEIS, the proposed pipeline ROW in the preferred alternative was designed and engineered to optimize many environmental and economic considerations. The most direct routes are the most economic, if environmental hazards, such as permafrost and hazardous slope conditions, are to be avoided. Ridgelines were used where possible to minimize wetlands impacts. The ROW configuration was designed to minimize overlap and proximity with the Iditarod National Historic Trail and to avoid Alaska Native allotments. From MP 169 to MP 204, the proposed ROW partially overlaps with six townships of Federal lands with some non-Federally managed lands within five miles away (Figure 3.15-1B 2018 FEIS). From MP 220 to MP 235, and from MP 255 to MP 310, the proposed pipeline corridor crosses large contiguous blocks of BLM lands, which would virtually preclude alternative routes to avoid BLM lands. It is unlikely that alternative non-Federal lands can feasibly substitute for the proposed ROW segments on BLM lands due to geography and the need for proper engineering design.

McGrath, Nikolai, and Takotna have documented subsistence use areas for large mammals and berries in the vicinity of MP 175, west of Windy Fork, within BLM lands of the ROW (see

Figure 3.21-60 and Figure 3.21-62 2018 FEIS). These three communities have documented use areas for large mammal harvest in the vicinity of MP 150 of the pipeline ROW, near Farewell, but this is outside of BLM lands.

Crooked Creek residents have documented subsistence use areas for moose in the George River basin where the pipeline ROW crosses the East Fork George River and the George River (approximately MP 280–295) (Figure 3.21-16 2018 FEIS).

2.2.3. Alternative 2 – Evaluation of Other Alternatives that Would Reduce or Eliminate the Use, Occupancy, or Disposition of Public Lands Needed for Subsistence Purposes

Alternatives that would reduce or eliminate the use of public lands needed for subsistence purposes include Alternative 1 (No Action). Section 2.4 in the 2018 FEIS, Alternatives Considered but Eliminated from Detailed Analysis, discusses other alternatives that were considered, but eliminated from analysis due to economic or technological disadvantages, or because they did not meet the purpose of the proposed action to produce the gold resource discovered on Calista Corporation and TKC lands at the Donlin Gold site.

2.2.4. Alternative 2 – Summary of Findings

The following section presents a summary of the findings for Alternative 2, where the finding is that the activity may cause a significant restriction to subsistence uses. Findings of no significant restriction are not listed here.

2.2.4.1. Barging on Kuskokwim River

As outlined in Section 2.2.1.2 of this analysis, Alternative 2 may result in a significant restriction to subsistence uses for the communities of Bethel, Tuntutuliak Napakiak, Napaskiak, Oscarville, Kwethluk, Akiachak, Akiak, Tuluksak, Upper and Lower Kalskag, Aniak, Chuathbaluk, Napaimute, and Crooked Creek due to a substantial reduction in the opportunity to continue uses of subsistence resources on the Kuskokwim River. Barging on the Kuskokwim River during construction and operation of the mine may cause extensive interference with access to the Kuskokwim River by subsistence users from villages along the river. It may cause a major redistribution of salmon, rainbow smelt, and whitefish, which are important subsistence resources for those villages.

2.2.4.2. Pipeline Right-of-way Access by Non-Subsistence Users

As outlined in the analysis in Section 2.2.1.3, Alternative 2 may result in a significant restriction to subsistence use for the communities of McGrath, Takotna and Nikolai due to a substantial increase in competition for subsistence resources along the natural gas pipeline at the Farewell Airstrip. Increased activity and access at the Farewell Airstrip and along the nearby gas pipeline right-of way may cause major increases in the disturbance and use of moose, caribou, black bear

and furbearer subsistence resources by recreational sport hunters and commercial outfitters. These are important subsistence resources for the villages of McGrath, Takotna, and Nikolai.

2.2.4.3. TSF Spill Scenarios

As outlined in Section 2.2.1.4, TSF spill scenarios under Alternative 2 may result in a significant restriction to subsistence use. A tailings dam failure of any size would impact subsistence resources of fish and wildlife to communities downstream of the spill.

2.3. Evaluation and Findings for Alternative 3A – Reduced Diesel Barging: LNG Powered Haul Trucks

Alternative Summary: Alternative 3A would use liquefied natural gas (LNG) instead of diesel to power the large (+300-ton payload) trucks that would move waste rock and ore from the open pits. These large trucks would account for approximately 75 percent of the total annual diesel consumption under Alternative 2. This alternative does not propose using LNG for the trucks hauling cargo and fuel on the mine access road from the Angyaruaq (Jungjuk) port. During operations, Alternative 3A would reduce the barging of diesel fuel on the river compared to Alternative 2. Other than increased throughput, the natural gas pipeline component would be the same as Alternative 2.

The primary differences between this alternative and Alternative 2 are the addition of the LNG plant and storage tanks near the mine site processing plant, reduced consumption of diesel, reduced barge trips, reduced on-site diesel storage, and increased natural gas consumption. At present, LNG-powered haul trucks are not commercially available. However, the technology to use natural gas products (such as LNG or compressed natural gas) in other industrial applications is proven and equipment manufacturers, such as Caterpillar, are actively developing dual fuel (diesel and natural gas) options for the mining industry. Caterpillar expects that equipment such as haul trucks will be commercially available and proven suitable for arctic conditions before mining equipment would be procured. If that did not occur, this alternative would not be feasible.

(See Section 2.3.4 of this analysis for Findings of Alternative 3A.)

2.3.1. Alternative 3A – Evaluation and the Effect of Use, Occupancy, or Disposition on Subsistence Uses and Needs

Introduction: Evaluation and the Effect of Use, Occupancy, or Disposition on Subsistence Uses and Needs for Alternative 3A are largely similar to those analyzed for Alternative 2 in Section 2.2 above. Effects on subsistence uses from changes in subsistence resources and access to subsistence resources in the vicinity of the mine site and along the pipeline route would be the same as in Alternative 2, since there would be no change in the mine or pipeline route associated with Alternative 3A. Competition for resources and socio-cultural impacts to subsistence practices would be the same as Alternative 2. The areas where Alternative 3A impacts are different than Alternative 2 are analyzed below.

2.3.1.1. Transportation Infrastructure

Alternative 3A proposes a reduction in river barge traffic by about one-third as compared to Alternative 2. This reduction would translate into larger time intervals between barges which would reduce the potential effects on riverine habitat and subsistence resources, and potential barge interference with subsistence fishing gear, fish camps, and boat access along the river.

Under Alternative 2, total barge round trips would be 116 per year (232 one-way trips). This includes 58 cargo round trips and 58 diesel fuel round trips. Under Alternative 3A, total annual barge round trips would be reduced to 77, representing 154 one-way trips. This includes 19 diesel fuel barge round trips and 58 cargo barge round trips (Table 2.3-8 2018 FEIS).

Subsistence resources and access to the river would be affected by barge traffic under Alternative 3A, but to a lesser degree than Alternative 2 (reduced by 78 total one-way trips) (Table 2.3-34 2018 FEIS). Riverine habitats and fish resources would still be affected by barge traffic and reductions in abundance and major redistribution of fish resources important to subsistence may occur. Barges under Alternative 3A would cause extensive interference with boat access by subsistence users on the Kuskokwim River.

2.3.1.2. Spill Scenarios

Under Alternative 3A, spill impacts to subsistence are the same as those found in Alternative 2, except that a new scenario on release of LNG is relevant.

Scenario 6: Liquefied Natural Gas (LNG) Release

LNG spills could be small (pinhole leaks from the storage tanks or spills while fueling the LNG-fueled trucks) or large (LNG-fueled truck accident or unlikely rupture of LNG plant storage tank with release of up to 55,000 gallons of LNG). If released, LNG would transition back to a gaseous phase. If a large amount of LNG is spilled on water within a short period of time, the relatively warmer temperature of the water would cause the LNG to rapidly transition to its gaseous phase. The impacts to subsistence from an LNG release would depend on the location, magnitude, and duration of the spill.

2.3.2. Alternative 3A – Evaluation of the Availability of Other Lands

Alternative 3A would make no change in the ROW alignment, so the evaluation of alternative lands would be the same as Alternative 2, Section 2.2.2.

2.3.3. Alternative 3A – Evaluation of Other Alternatives that Would Reduce or Eliminate the Use, Occupancy, or Disposition of Public Lands Needed for Subsistence Purposes

Alternative 3A would make no change in the ROW alignment, so the evaluation of other alternatives that would reduce or eliminate the use, occupancy, or disposition of public lands needed for subsistence purposes would be the same as Alternative 2, Section 2.2.3.

2.3.4. Alternative 3A – Summary of Findings

The following section presents a summary of the findings for Alternative 3A, where the finding is that the activity may cause a significant restriction to subsistence uses. Findings of no significant restriction are not listed here.

2.3.4.1. Barging on Kuskokwim River

For the transportation infrastructure component, the number of barge trips in Alternative 3A would be reduced compared to Alternative 2. However, the number of trips is still an increase compared to the current number of barge trips, would impact subsistence fish resources and use of the river, and may result in the significant restriction to subsistence uses for Kuskokwim River communities outlined in Alternative 2.

This evaluation concludes that Alternative 3A may result in a significant restriction to subsistence uses for the communities of Bethel, Tuntutuliak, Napakiak, Napaskiak, Oscarville, Kwethluk, Akiachak, Akiak, Tuluksak, Upper and Lower Kalskag, Aniak, Chuathbaluk, Napaimute and Crooked Creek due to a substantial reduction in the opportunity to continue harvest of subsistence resources on the Kuskokwim River. As described for Alternative 2, barging on the Kuskokwim River during construction and operations of the mine would cause extensive interference with access to the Kuskokwim River by subsistence users from villages along the river, would cause a large reduction in abundance, and would cause a major redistribution of salmon, rainbow smelt, and whitefish which are important subsistence resources for those villages.

2.3.4.2. Pipeline Right-of-way Access by Non-Subsistence Users

Impacts to subsistence from the gas pipeline ROW for Alternative 3A would be the same as for Alternative 2. As with Alternative 2, this evaluation concludes that Alternative 3A may result in a significant restriction to subsistence use for the communities of McGrath, Takotna, and Nikolai due to a substantial increase in competition for subsistence resources along the natural gas pipeline at the Farewell Airstrip. Increased activity and access from the Farewell Airstrip and along the nearby gas pipeline right-of-way may cause major increases in the disturbance and use of moose, caribou, black bear and furbearer subsistence resources by recreational sport hunters

and commercial outfitters. These are important subsistence resources for the villages of McGrath, Takotna and Nikolai.

2.4. Evaluation and Findings for Alternative 3B – Reduced Diesel Barging: Diesel Pipeline

Alternative Summary: Under Alternative 3B, an 18-inch diameter diesel pipeline would be constructed from Cook Inlet to the mine site to reduce diesel barging on the Kuskokwim River. A natural gas pipeline would not be constructed; natural gas would not be used in Alternative 3B. Diesel from the pipeline would be used to fuel the mine’s power generation facilities, mobile vehicle fleet, and equipment (Section 2.2.4 2018 FEIS).

The diesel pipeline would be buried and located in the same corridor proposed for the natural gas pipeline under Alternative 2, with an additional 19-mile segment between Tyonek and the start of the proposed corridor for the natural gas line, for a total of 334 miles. This additional segment would cross the Beluga River using Horizontal Directional Drilling. Alternative 3B would require improvements to the existing Tyonek North Foreland Barge Facility and transportation of diesel fuel in Cook Inlet. It would also require a robust leak detection system and pre-positioned response infrastructure and equipment along the pipeline route. Alternative 3B would also eliminate the barging of diesel fuel after construction (Section 2.3.4 2018 FEIS)

The primary differences between this alternative and Alternative 2 are the replacement of the natural gas pipeline with a diesel fuel pipeline, reduced barge trips due to elimination of diesel barging, increased consumption of diesel, and no natural gas consumption. In addition, some of the construction infrastructure would be required to remain through operations to provide for a reasonable diesel spill response capability. This would necessitate maintaining some of the construction facilities and most of the airstrips in a usable condition throughout the operating life of the pipeline (Section 2.3.4.3 2018 FEIS). Modifications may be required to some of the proposed airstrips to make them suitable for multi-season (as opposed to just winter) use and additional Hercules C- 130 capable airstrips and staging areas would be required (Table 2.3-37 2018 FEIS). The airstrips required for spill response capacities include the nine new airstrips proposed as facilities to support construction in Alternative 2 (Table 2.3-28 2018 FEIS), plus three additional Donlin Gold proposed airstrips: Puntilla Airstrip, Tatlawiksuk Airstrip, and George River Airstrip.

(See Section 2.4.4 of this analysis for Findings of Alternative 3B.)

2.4.1. Alternative 3B – Evaluation and the Effect of Use, Occupancy, or Disposition on Subsistence Uses and Needs

Introduction: Evaluation and the Effect of Use, Occupancy, or Disposition on Subsistence Uses and Needs for Alternative 3B are largely similar to those analyzed for Alternative 2 in Section 2.2 above. Effects on subsistence uses from changes in subsistence resources and access to

subsistence resources in the vicinity of the mine site would be the same as in Alternative 2, since there would be no change in the mine associated with Alternative 3B. Socio-cultural impacts to subsistence practices would be the same as Alternative 2. The areas where Alternative 3B impacts are different than Alternative 2 are analyzed below.

2.4.1.1. Transportation Infrastructure

Alternative 3B would reduce the number of barge trips as compared to Alternative 2, but would still involve 58 total round trips, which may result in significant reduction in subsistence uses for communities on the Kuskokwim River as outlined in Alternative 2. In addition, diesel fuel spills from the pipeline in Alternative 3B would likely affect subsistence fish resources on BLM lands along the pipeline ROW, the extent of which would depend on the volume of fuel spilled, season of year, and proximity of the spill to watersheds. Diesel tanker traffic in Alternative 3B would increase the potential for fuel spills in Cook Inlet and collisions with marine mammals, which would affect subsistence resources for the village of Tyonek.

2.4.1.2. Diesel Pipeline

Alternative 3B analyzed the impacts of the nine airstrips described under Alternative 2, plus three additional proposed airstrips at Puntilla, Tatalwiksuk, and George River. Under this alternative, all 12 airstrips would remain open for diesel spill response capabilities, as compared to Alternative 2 which would reclaim any newly constructed airstrips associated with pipeline construction. Gravel roads would remain in place along the ROW for spill response (Section 2.3.4.3 2018 FEIS). The potential increase in access by hunters from outside the area using those airstrips and gravel roads would likely cause increased competition impacts as compared to Alternative 2. Access by non-subsistence users resulting in increased competition for resources would occur along the pipeline corridor and would affect subsistence users from villages along the ROW, including Tyonek, Skwentna, Red Devil, Stony River, and Sleetmute along with the upper Kuskokwim villages of Nikolai, McGrath, and Takotna.

2.4.1.3. Spill Scenarios

Under Alternative 3B, the likelihood of 2018 FEIS Spill Scenarios 2 through 4 (river barge, tank farm, and tanker truck releases) occurring would be reduced due to decreased barge activity, but impacts would be of the same type and intensity as those discussed under Alternative 2. The 2018 FEIS Scenarios 7 and 8 (cyanide and mercury releases) would have the same impacts on subsistence as described for Alternative 2. Rupture of an ocean-going barge in Cook Inlet and a diesel pipeline release are new scenarios associated with this alternative.

2018 FEIS Scenario 1: Ocean Barge Rupture at Sea (Cook Inlet)

During the operations and closure phases, diesel fuel would be delivered by ocean-going vessels to a fuel dock at Tyonek or Port MacKenzie, resulting in an increased spill risk from ocean barge rupture in Cook Inlet. Diesel fuel spills could occur if a tanker ran aground or was otherwise

compromised; however, only one or two barge compartments would be expected to fail. In the event of such an occurrence, the direct impacts would be as described in Scenario 1 above under Alternative 2 and would depend on the size of the spill, wind and weather, the extent of dispersion, cleanup response time, and time of year. If a spill occurred during the summer, it would impact salmon runs in Cook Inlet. Fuel spills in Cook Inlet would also impact Cook Inlet Belugas. The effect of this spill scenario would have major impacts to subsistence resources in Cook Inlet.

2018 FEIS Scenario 5: Diesel Pipeline Release

Spills from the proposed pipeline, associated pump stations, valves, or pigging facilities could occur during project operation. A spill on land may have less impact than a spill in water, depending on the location, since spills in water could potentially have a wider footprint and affect various fish species that are important subsistence resources for many communities. If the spill reached a river at a pipeline crossing, the effects of the spill would be much like a river barge spill. The pipeline crosses several streams that are habitat for spawning salmon and some resident fish species. Underground pipeline leaks may go undetected and contaminate water resources over long periods of time. The spill scenario was for a major rupture and a large volume of diesel spilled, namely 422,000 gallons or more. A spill of this scale could result in major impacts to water bodies, wetlands and vegetation, birds, fisheries, and marine mammals affecting subsistence resources and uses.

2.4.2. Alternative 3B – Evaluation of the Availability of Other Lands

Alternative 3B would make no change in the ROW alignment, so the evaluation of alternative lands would be the same as Alternative 2, Section 2.2.2.

2.4.3. Alternative 3B – Evaluation of Other Alternatives that Would Reduce or Eliminate the Use, Occupancy, or Disposition of Public Lands Needed for Subsistence Purposes

Alternative 3B would make no change in the ROW alignment, so the evaluation of other alternatives that would reduce or eliminate the use, occupancy, or disposition of public lands needed for subsistence purposes would be the same as Alternative 2, Section 2.2.3.

2.4.4. Alternative 3B – Summary of Findings

The following section presents a summary of the findings for Alternative 3B, where the finding is that the activity may cause a significant restriction to subsistence uses. Findings of no significant restriction are not listed here.

2.4.4.1. Barging on Kuskokwim River

For the transportation infrastructure component, the decreased number of barge trips in Alternative 3B would reduce impacts compared to Alternative 2; however, the frequency of cargo barge trips may still impact subsistence fishing and use of the river and may result in significant restrictions to subsistence uses for Kuskokwim River communities outlined in Alternative 2.

This evaluation concludes that Alternative 3B may result in significant restrictions to subsistence uses for the communities of Bethel, Tuntutuliak, Napakiak, Napaskiak, Oscarville, Kwethluk, Akiachak, Akiak, Tuluksak, Upper and Lower Kalskag, Aniak, Chuathbaluk, Napaimute and Crooked Creek due to a substantial reduction in the opportunity to continue uses of subsistence resources on the Kuskokwim River. Barging on the Kuskokwim River during construction and operations of the mine would cause extensive interference with access to the Kuskokwim River by subsistence users from villages along the river, and would cause a major redistribution of salmon, rainbow smelt, and whitefish, which are important subsistence resources for those villages.

2.4.4.2. Pipeline Right-of-way Access by Non-Subsistence Users

This alternative analyzed the impacts of the nine airstrips described under Alternative 2, plus three additional proposed airstrips at Puntilla, Tatalwiksuk, and George River. Under that alternative, all 12 airstrips would remain open for diesel spill response capabilities (rather than being closed after construction as under Alternative 2). Gravel roads would remain in place along the ROW for spill response (Section 2.3.4.3 2018 FEIS). The potential increase in access by hunters from outside the area using those airstrips and gravel roads would likely cause increased competition impacts compared to Alternative 2. Access by non-subsistence users resulting in increased competition for resources would occur along the pipeline corridor and would affect subsistence users from villages along the ROW, including McGrath, Takotna, Nikolai, Tyonek, Skwentna, Red Devil, Stony River, and Sleetmute.

Therefore, this evaluation concludes that Alternative 3B may result in a significant restriction to subsistence resources for the communities of McGrath, Takotna, Nikolai, Tyonek, Skwentna, Red Devil and Sleetmute due to a substantial increase in competition for subsistence resources along the diesel pipeline and at the 12 airstrips that would remain open for spill response. Increased access at the 12 Airstrips and along the diesel pipeline right-of way would cause a major increase in the use of moose, caribou, black bear and furbearer subsistence resources by non-subsistence users. These are important subsistence resources for the villages of McGrath, Takotna, Nikolai, Tyonek, Skwentna, Red Devil, Stony River, and Sleetmute.

2.5. Evaluation and Findings for Alternative 4 – Birch Tree Crossing Port

Alternative Summary: Alternative 4 would move the upriver port site from Angyaruaq (Jungjuk) (under Alternative 2) to Birch Tree Crossing, located about 124 river miles upriver from Bethel.

This would reduce the barging distance for freight and diesel out of Bethel bound for the mine site. The same volume of cargo and diesel fuel would be transported by barge as in Alternative 2. A 76-mile, all-season gravel access road would link this port site to the Donlin Gold Project mine site.

The mine site portion for Alternative 4 would be the same as Alternative 2.

The natural gas pipeline under Alternative 4 would be the same as Alternative 2.

There would be no other substantive changes to other project components as described for Alternative 2.

(See Section 2.5.4 of this analysis for Findings of Alternative 4.)

2.5.1. Alternative 4 – Evaluation and the Effect of Use, Occupancy, or Disposition on Subsistence Uses and Needs

Impacts to subsistence from the mine site, pipeline, and transportation infrastructure components for Alternative 4 would be the same as those analyzed for Alternative 2 in Section 2.2 above. Effects on subsistence uses from changes in subsistence resources and access to subsistence resources in the vicinity of the mine site and along the pipeline route would be the same as in Alternative 2, since there would be no change in the mine or pipeline route associated with Alternative 4. Competition for resources and socio-cultural impacts to subsistence practices would be the same as Alternative 2. The areas where Alternative 4 impacts are different than Alternative 2 are analyzed below.

2.5.1.1. Transportation Infrastructure

The barging distance on the Kuskokwim River would be less than for Alternative 2, but river villages down river from Aniak would still experience the same level of barge traffic as in Alternative 2.

The road from the Birch Tree Crossing site would cross the Owhat River watershed, which is an important area for subsistence activities by residents from Aniak, Chuathbaluk, and Napaimute (Figure 3.21-20 2018 FEIS). Access to subsistence resources would likely be reduced during road operations because hunting and trapping could be prohibited in the immediate vicinity of the road. The port site would be partially reclaimed at the end of Mine Site operation. Sheet piles would be removed and the area around the barge landing would be recontoured. A barge landing and the full access road would be maintained for delivery of WTP reagents, equipment, fuel, and supplies, as well as to provide access to the project site for long-term monitoring and operating the pit lake water treatment plant (Section 2.3.5.2 2018 FEIS). The Birch Tree Crossing port site would also displace set net and drift net fishing locations opposite the downstream mouth of Aniak Slough.

2.5.1.2. Spill Scenarios

Under this alternative, the likelihood of Scenario 2 (river barge release) occurring would be reduced due to reduced barging distances; however, the impacts would be of the same types as those discussed under Alternative 2. Impacts under Scenarios 1, 3, 4, 7, and 8 (ocean barge, tank farm, tanker truck, cyanide, and mercury releases) for Alternative 4 would be the same as those discussed under Alternative 2. The risk of fuel spills from tanker trucks in Alternative 4 is increased compared to Alternative 2, due to the longer road from the river to the mine.

2.5.2. Alternative 4 – Evaluation of the Availability of Other Lands

Alternative 4 would make no change in the ROW alignment, so the evaluation of alternative lands would be the same as Alternative 2, Section 2.2.2.

2.5.3. Alternative 4 – Evaluation of Other Alternatives that Would Reduce or Eliminate the Use, Occupancy, or Disposition of Public Lands Needed for Subsistence Purposes

Alternative 4 would make no change in the ROW alignment, so the evaluation of other alternatives that would reduce or eliminate the use, occupancy, or disposition of public lands needed for subsistence purposes would be the same as Alternative 2, Section 2.2.3.

2.5.4. Alternative 4 – Summary of Findings

The following section presents a summary of the findings for Alternative 4, where the finding is that the activity may cause a significant restriction to subsistence uses. Findings of no significant restriction are not listed here.

2.5.4.1. Barging on Kuskokwim River

Impacts to subsistence for the transportation infrastructure are the same as for Alternative 2, but would impact fewer villages on the Kuskokwim River because of the shorter distance to the Birch Tree Crossing port site. Barge traffic would not travel as far to the Birch Tree Crossing port site, but Alternative 4 may result in impacts to the availability and abundance of subsistence on BLM lands south of the access road from the port to the mine, affecting the villages of Aniak, Chuathbaluk, and Napiamute.

This evaluation concludes that Alternative 4 may result in a significant restriction to subsistence uses for the communities of Bethel, Tuntutuliak, Napakiak, Napaskiak, Oscarville, Kwethluk, Akiachak, Akiak, Tuluksak, Upper and Lower Kalskag, Aniak, and Chuathbaluk due to a substantial reduction in the opportunity to continue uses of subsistence resources on the Kuskokwim River. Barging on the Kuskokwim River during construction and operations of the mine would cause extensive interference with access to the Kuskokwim River by subsistence

users from villages along the river, and would cause a major redistribution of salmon, rainbow smelt, and whitefish, which are important subsistence resources for those villages.

2.5.4.2. Pipeline Right-of-way Access by Non-Subsistence Users

This evaluation also concludes that Alternative 4 may result in a significant restriction to subsistence uses for the communities of McGrath, Takotna and Nikolai due to a substantial increase in competition for subsistence resources along the natural gas pipeline at the Farewell Airstrip. Increased activity and access from the Farewell Airstrip and along the nearby gas pipeline ROW would cause major increases in the disturbance and use of moose, caribou, black bear and furbearer subsistence resources by recreational sport hunters and commercial outfitters. These are important subsistence resources for the villages of McGrath, Takotna and Nikolai.

2.6. Evaluation and Findings for Alternative 5A – Dry Stack Tailings

Alternative Summary: Alternative 5A incorporates an alternate tailings method, using the dry stack tailings (DST) method instead of the subaqueous tailings method that would be used under Alternative 2. This alternative would use filter-presses and vacuum-filters to increase the solid content to more than 80 percent. This alternative was suggested during scoping to avoid the potential for releases from the tailings dam proposed under Alternative 2.

The dry stack TSF and operating pond would be located in the Anaconda Creek Valley in the same general location as under Alternative 2.

This alternative includes two options:

- Unlined Option: The dry stack TSF would not be lined with a Linear Low-Density Polyethylene (LLDPE) liner.
- Lined Option: The dry stack tailings would be underlain by a pumped overdrain layer throughout the footprint, with an impermeable LLDPE liner below.

The tailings would be spread and compacted in lifts, creating a “dry stack” that would be approximately 412 feet high and extend a maximum length of 1.6 miles from the upper dam crest. The ultimate combined operating pond and dry stack footprint would be 2,463 acres. During Closure, the tailings would be covered with soil, an LLDPE cover, and vegetated.

The transportation corridor under Alternative 5A would be the same as Alternative 2.

The natural gas pipeline under Alternative 5A would be the same as Alternative 2.

(See Section 2.6.4 in this analysis for Findings of Alternative 5A)

2.6.1. Alternative 5A – Evaluation and the Effect of Use, Occupancy, or Disposition on Subsistence Uses and Needs

Impacts to subsistence from the mine site and pipeline components for Alternative 5A would be the same as those analyzed for Alternative 2 in Section 2.2 above. Effects on subsistence uses from changes in subsistence resources and access to subsistence resources in the vicinity of the mine site and along the pipeline route would be the same as in Alternative 2, since there would be no change in the mine or pipeline route associated with Alternative 5A. Competition for resources and socio-cultural impacts to subsistence practices would be the same as Alternative 2. The areas where Alternative 5A impacts are different than Alternative 2 are analyzed below.

2.6.1.1. Transportation Infrastructure

Alternative 5A would require seven additional diesel fuel barge trips per year as compared to Alternative 2, for a total of 123 round trip barge trips annually (Section 2.3.6.2 2018 FEIS). This barge traffic increase would increase the potential for diesel fuel spills on the river, further impact subsistence resources, and further restrict subsistence access to the Kuskokwim River. See Alternative 2 impacts in Section 2.2.1.2 for detailed analysis of impacts.

2.6.1.2. Spill Scenarios

Direct and indirect impacts of Alternative 5A under 2018 FEIS Scenarios 1 through 4, and 7 and 8 (ocean or river barge, tank farm, tanker truck, cyanide, and mercury releases) would be the same as those discussed under Alternative 2. The impacts of 2018 FEIS Scenario 9 (tailings dam failure) would be less than Alternative 2, because dry stacking the tailings would reduce the potential of tailings dam failure.

2.6.2. Alternative 5A – Evaluation of the Availability of Other Lands

Alternative 5A would make no change in the ROW alignment, so the evaluation of alternative lands would be the same as Alternative 2, Section 2.2.2.

2.6.3. Alternative 5A – Evaluation of Other Alternatives that Would Reduce or Eliminate the Use, Occupancy, or Disposition of Public Lands Needed for Subsistence Purposes

Alternatives that would reduce or eliminate the use of public lands needed for subsistence purposes include Alternative 1 (No Action). Section 2.4, Alternatives Considered but Eliminated from Detailed Analysis, discusses other alternatives that were considered, but eliminated from detailed analysis due to economic or technological disadvantages, or because they did not meet the purpose of the proposed action to produce the gold resource discovered on Calista Corporation and TKC lands at the Donlin Gold site.

2.6.4. Alternative 5A – Summary of Findings

The following section presents a summary of the findings for Alternative 5A, where the finding is that the activity may cause a significant restriction to subsistence uses. Findings of no significant restriction are not listed here.

2.6.4.1. Barging on Kuskokwim River

With the increase in impacts from barge traffic in Alternative 5A as compared to Alternative 2, Alternative 5A may result in a significant restriction to subsistence uses for the communities of Bethel, Tuntutuliak, Napakiak, Napaskiak, Oscarville, Kwethluk, Akiachak, Akiak, Tuluksak, Upper and Lower Kalskag, Aniak, Chuathbaluk, Napaimute, and Crooked Creek due to a substantial reduction in the opportunity to continue the harvest of subsistence resources on the Kuskokwim River. Barging on the Kuskokwim River during construction and operations of the mine would cause extensive interference with access to the Kuskokwim River by subsistence users from villages along the river, and would cause a major redistribution of salmon, rainbow smelt, and whitefish, which are important subsistence resources for those villages.

2.6.4.2. Pipeline Right-of-way Access by Non-Subsistence Users

This evaluation also concludes that Alternative 5A may result in a significant restriction to subsistence uses for the communities of McGrath, Takotna and Nikolai due to a substantial increase in competition for subsistence resources along the natural gas pipeline at the Farewell Airstrip. Increased access at the Farewell Airstrip and along the nearby gas pipeline right-of way would cause major increases in the use of moose, caribou, black bear and furbearer subsistence resources by non-subsistence users. These are important subsistence resources for the villages of McGrath, Takotna and Nikolai.

2.7. Evaluation and Findings for Alternative 6A – Modified Natural Gas Pipeline Alignment: Dalzell Gorge Route

Alternative Summary: Alternative 6A, Dalzell Gorge Route, would realign the natural gas pipeline between MP 106.5 to 152.7, a distance of 46.2 miles, or 14.6 percent of the Alternative 2 pipeline alignment. The pipeline ROW under Alternative 6A would be slightly shorter, at 313 miles, compared to 316 miles for Alternative 2. In the affected segment, the Alternative 6A alignment would be to the west of the proposed action and would traverse Dalzell Gorge. No Federal lands are involved in this proposed segment of the pipeline alignment.

While less land overall would be impacted, Alternative 6A, Dalzell Gorge Route, would require 4.1 miles of additional access roads overall, and 11 material sites involving 391 acres of disturbance. New gravel airstrips would be constructed at Pass Creek and Tatina. Fourteen potential water sources have been identified for construction of the segment of pipeline in this alternative. The Dalzell Gorge Route would cross Happy River and the South Fork of the Kuskokwim River using HDD.

The mine site facilities under Alternative 6A would be the same as Alternative 2. The transportation corridor under Alternative 6A would be the same as Alternative 2.

(See Section 2.7.4 of this analysis for Findings of Alternative 6A.)

2.7.1. Alternative 6A – Evaluation and the Effect of Use, Occupancy, or Disposition on Subsistence Uses and Needs

Impacts to subsistence from the mine site and transportation infrastructure components for Alternative 6A would be the same as those analyzed for Alternative 2 in Section 2.2 above. Effects on subsistence uses from changes in subsistence resources and access to subsistence resources in the vicinity of the mine site and transportation infrastructure would be the same as in Alternative 2, since there would be no change in the mine or barging associated with Alternative 6. Socio-cultural impacts to subsistence practices would be the same as Alternative 2. The areas where Alternative 6A impacts are different than Alternative 2 are analyzed below.

2.7.1.1. Natural Gas Pipeline

The pipeline ROW for Alternative 6A would be three miles shorter than in Alternative 2, potentially reducing impacts to subsistence resources by creating less ground and vegetation disturbance along the ROW. Two additional airstrips would be constructed at Pass Creek and Tatina for construction of this portion of the pipeline (Section 2.3.7.3 2018 FEIS). These airstrips would likely increase access to hunters from outside of the area and increase competition for subsistence resources such as moose. In the affected segment, the Alternative 6A alignment would be to the west of the proposed action and would traverse Dalzell Gorge. No Federal lands are involved in this proposed segment of the pipeline alignment.

2.7.1.2. Spill Scenarios

Direct and indirect impacts of Alternative 6A under 2018 FEIS Scenarios 1 through 4, and 7 through 9 (ocean or river barge, tank farm, tanker truck, cyanide, mercury releases, and tailings dam failure) would be the same as those discussed under Alternative 2.

2.7.2. Alternative 6A – Evaluation of the Availability of Other Lands

Alternative 6A would make no change in the ROW alignment as it crosses Federally managed public lands, so the evaluation of alternative lands would be the same as Alternative 2, Section 2.2.2.

2.7.3. Alternative 6A – Evaluation of Other Alternatives that Would Reduce or Eliminate the Use, Occupancy, or Disposition of Public Lands Needed for Subsistence Purposes

Alternative 6A would make no change in the ROW alignment as it crosses Federally managed public lands, so the evaluation of other alternatives that would reduce or eliminate the use, occupancy, or disposition of public lands needed for subsistence purposes would be the same as Alternative 2, Section 2.2.3.

2.7.4. Alternative 6A – Summary of Findings

As Alternative 6A does not change any of the project components on Federally managed public lands or resources, impacts to subsistence from the mine site, transportation infrastructure, and pipeline components of Alternative 6A would be the same as for Alternative 2.

2.8. Evaluation and Findings for the Cumulative Case

Cumulative Case Summary: The cumulative case evaluates the impact of the proposed action (Alternative 2) in conjunction with past, present, and reasonably foreseeable future actions in the 2018 FEIS Analysis Area. Reasonably foreseeable actions are summarized in Table 4.2-1 of the 2018 FEIS.

The past and present actions that have influenced subsistence are incorporated into the current baseline conditions described in Section 3.21.5: Community Harvest Patterns. Federal and State regulations with a complex history govern subsistence uses and resources in the region, as described in Section 3.21.3, Subsistence, Regulatory Environment. Changes in subsistence resource abundance and availability, particularly the decline of moose in Game Management Unit 19 and the decline of Kuskokwim River Chinook stocks, have also influenced current harvest practices. Sociocultural changes have and will likely continue to influence subsistence production, as described in Section 3.21.6.1.3, Subsistence, Potential Socio-cultural Impacts. However, subsistence uses continue in communities and associated traditional use areas throughout the 2018 FEIS Analysis Area, providing continuity in social organization, identity, and cultural beliefs. The geographic area of consideration for cumulative effects on subsistence practices extends widely across the 2018 FEIS Analysis Area and includes:

- Habitat and migratory range for subsistence resources such as caribou herd ranges, salmon migratory ranges, and migratory waterfowl ranges.
- The traditional subsistence use areas for communities potentially affected by the project. These areas can be quite extensive, from hundreds to thousands of square miles, as noted in Table 3.21-27, and displayed in maps throughout Section 3.21.5, Community Harvest Patterns in the 2018 FEIS. The reasonably foreseeable future actions relevant to impacts to subsistence resources include:

- Oil and gas exploration and development in Cook Inlet, particularly projects affecting the northwest portion of Cook Inlet.
- Mineral exploration and mining.
- Commercial Fishing, including fisheries in the Bering Sea with a bycatch of Western Alaska-bound salmon, and intercept fisheries that take Western Alaska-bound salmon.
- Tourism, recreation, sport hunting and fishing, particularly if recreational and guided sport hunting and recreational fishing were to increase in the Kuskokwim River basin.

These reasonably foreseeable future actions would likely induce little change to subsistence resource abundance and availability, access to subsistence resources, competition for subsistence resources, or sociocultural effects on subsistence uses. However, factors contributing to a further decline in Kuskokwim River Chinook stocks represent an adverse impact that may result in a significant restriction in subsistence uses of Chinook and other salmon species in the Kuskokwim River, caused by a large reduction in the abundance and a major redistribution of subsistence salmon resources.

(See Section 2.8.4 of this analysis for Findings of the Cumulative Case.)

2.8.1. Cumulative Case – Evaluation and the Effect of Use, Occupancy, or Disposition on Subsistence Uses and Needs

With the implementation of Alternative 2, there would be direct and indirect impacts to subsistence practices and a contribution to cumulative effects on subsistence resources and practices. Portions of the proposed action, if implemented in conjunction with past, present, and future actions, may result in significant restrictions to subsistence resources consistent with the Summary of Findings for the Cumulative Case (Section 2.8.4).

The cumulative effects for Alternatives 3A and 3B would be similar to Alternative 2. However, these alternatives would have a lower volume of barge traffic on the Kuskokwim River over the life of the project and a reduced potential for impacts to riverine habitat, subsistence resources, and subsistence activities associated with the river. Alternative 3B would contribute to cumulative effects to subsistence resources and practices.

The cumulative effects for Alternatives 4, 5A, and 6A would be similar to Alternative 2, and contribute to cumulative effects to subsistence resources, uses, and needs.

Past, ongoing, and reasonably foreseeable future actions were identified in the Project Area (see Section 4.2). These include past mining operations as well as mineral exploration and other small-scale placer mining activities; oil and gas exploration and development activities near Cook Inlet; ground-disturbing activities near communities and tributaries, including gravel extraction; seasonal barging to serve villages along the Kuskokwim River; ongoing subsistence

and commercial fishing activities and other boating-related traffic along the main river channel; community water supply development; waste disposal; fuel spills; and new roads and airport improvements. Such past and ongoing activities, combined with natural events, have contributed in variable ways to adverse effects on anadromous and resident fish populations and aquatic habitat by altering flow regimes and drainage patterns; diminishing water quality from riverbank erosion, turbidity, and sedimentation; and degrading the extent of productive habitat conditions. In addition, the run size and escapement of certain stocks of salmon (particularly king and chum salmon in Crooked Creek) and, to a certain extent, other anadromous and resident fish populations, have diminished in recent years due to a range of factors that are not fully understood by resource managers or the scientific community. The various components of the proposed project (Alternative 2) may result in an incremental increase of impacts of variable intensities that would contribute to the cumulative effects on fish and aquatic resources in the drainages within the Project Area during all three project phases. The cumulative effects on fish and aquatic resources of the proposed project in combination with those of other past, ongoing, and reasonably foreseeable future projects, are expected to increase over the life of the project.

The effects of predicted climate impacts may increase in later project years due to warming temperatures and altered precipitation patterns and thus could exacerbate identified cumulative effects. Shifts in fish populations may occur due to subsequent habitat and precipitation or temperature changes, affecting subsistence resources as well. As noted in the SEIS, the TSF will be designed to account for climate change projections; a changing climate would not increase probability of a tailings release.

The geographic area of consideration for cumulative effects on wildlife extends widely across the EIS Analysis Area and includes habitat and migratory range for mammal and bird populations that use the area where direct and indirect impacts of the project would occur. Past, ongoing, and Reasonably Foreseeable Future Actions were identified in the Project Area, including small-scale placer mining and other ground-disturbing activities and access for recreation and subsistence activities (Section 4.2 2018 FEIS). These actions have removed or modified some wildlife habitat and cause behavioral disturbance of terrestrial mammals and birds in some adjacent areas. The ongoing or future similar activities would likely induce minimal overall changes to available bird and terrestrial mammal habitats, or use of them, when considering the availability of similar habitat in the region. The existing harvest levels for large mammals, particularly moose, tend to maintain the population near the limit of sustainable harvest. The project activities combined with existing activities and human presence in the vicinity may cause some species of wildlife or birds to avoid areas in which project activities or human presence occurs. However, many species would be expected to habituate to noise, human presence, and other activities. Changes would be expected to be incremental on a regional scale. Climate impacts over time may result in changes in habitat, such as an increase in woody vegetation, as well as changes in fire regime with potentially greater fire extent or severity. Shifts in wildlife populations may occur due to subsequent habitat changes (changes in food, forage, or

shelter, for example), large-scale biome shifts, and precipitation or temperature trend changes. Past, ongoing, and reasonably foreseeable future actions were identified in the Project Area including commercial fishing, shipping/barging of fuel and supplies, and other marine traffic (Section 4.2 2018 FEIS). These actions have provided a level of activity that could adversely affect marine mammals through risk of vessel strikes, behavioral disturbance, and potential fuel spills. In addition, there has been some subsistence hunting of marine mammals in the area. Under Alternative 2, the main types of impact for marine mammals would be behavioral disturbance or risk of injury or mortality from barges or during in-water construction at the ports. The slow speed of the barges would be expected to reduce impacts. Populations of marine mammals are limited in the river where the port construction would occur, reducing impacts. Overall, the combined impact on wildlife from the proposed project and past, present, and future actions is expected to be geographically or temporality limited within a large area. While the individual impact of the proposed project is measurable, the cumulative effect is still considered to be limited, given the limited area of disturbance over the region.

2.8.2. Cumulative Case – Evaluation of the Availability of Other Lands

The cumulative case would make no change in the ROW alignment, so the evaluation of alternative lands would be the same as Alternative 2, Section 2.2.2.

2.8.3. Cumulative Case – Evaluation of Other Alternatives that Would Reduce or Eliminate the Use, Occupancy, or Disposition of Public Lands Needed for Subsistence Purposes

Alternatives that would reduce or eliminate the use of public lands needed for subsistence purposes include Alternative 1 (No Action). Section 2.4, Alternatives Considered but Eliminated from Detailed Analysis, discusses other alternatives that were considered, but eliminated from detailed analysis due to economic or technological disadvantages, or because they did not meet the purpose of the proposed action to produce the gold resource discovered on Calista Corporation and TKC lands at the Donlin Gold Project site.

2.8.4. Cumulative Case – Summary of Findings

The cumulative case for the proposed Donlin Gold Project may result in significant restriction to subsistence uses for the communities of Bethel, Tuntutuliak, Napakiak, Napaskiak, Oscarville, Kwethluk, Akiachak, Akiak, Tuluksak, Upper and Lower Kalskag, Aniak, Chuathbaluk, Napaimute, and Crooked Creek on the Kuskokwim River due to large reductions in the abundance of Chinook salmon and a major redistribution of salmon resources on the Kuskokwim River.

3. NOTICE AND HEARINGS

A finding that the proposed action may significantly restrict subsistence uses imposes additional requirements, including provisions for notices to the State of Alaska and appropriate regional and local subsistence committees, as well as a hearing in the vicinity of the area involved.

ANILCA § 810(a) provides that no “withdrawal, reservations, lease, permit, or other use, occupancy or disposition of the public lands which would significantly restrict subsistence uses shall be effected” until the Federal agency gives the required notice and holds a hearing in accordance with ANILCA § 810(a)(1) and (2).

3.1. 2016 Draft EIS ANILCA 810 Locations and Dates

In the draft 810 analysis, published with the 2016 Draft EIS as Appendix N, the BLM made a preliminary finding that all alternatives and the cumulative case presented in the Draft EIS met the “may significantly restrict” threshold. As a result, public hearings were held in the potentially affected communities in conjunction with the Draft EIS public meetings.

Notice of the Draft EIS meetings was posted on the Army Corps of Engineers website and the BLM ePlanning website. In conjunction with the Draft EIS meetings, BLM held ANILCA § 810(a) Subsistence public hearings on the following dates and locations:

Aniak	January 20, 2016
Crooked Creek	January 21, 2016
Anchorage	January 28, 2016
Bethel	February 1, 2016
Quinhagak	February 16, 2016
Akiak	February 17, 2016
Nunapitchuk	March 17, 2016
Tyonek	March 25, 2016
McGrath	March 26, 2016
Lower Kalskag	April 5, 2016
Holy Cross	April 6, 2016
Chuathbaluk	April 11, 2016

3.2. 2026 Draft Supplemental EIS ANILCA 810 Locations and Dates

In the draft 810 analysis, published with the 2026 Draft Supplemental EIS as Appendix C, the BLM made a preliminary finding that, with the additional TSF spill scenarios presented in the Draft Supplemental EIS, all alternatives and the cumulative case continue to meet the “may significantly restrict” threshold. As a result, public hearings were held in the potentially affected communities in conjunction with the Draft Supplemental EIS public meetings.

Notice of the Draft Supplemental EIS meetings were posted on the Army Corps of Engineers website and the BLM ePlanning website, in addition to the Corps' Special Public Notice of Availability. In conjunction with the Draft Supplemental EIS meetings, BLM will hold ANILCA § 810(a) Subsistence public hearings on the following dates and locations:

Bethel	October 14, 2026
Crooked Creek	October 15, 2026
Aniak	October 16, 2026

Notices for public hearings will be posted on the following websites:

- Army Corps of Engineers: <https://www.poa.usace.army.mil>
- BLM ePlanning website: <https://eplanning.blm.gov/Project-Home/?id=47cc0084-a7f2-f011-8406-001dd802fdea>
- Donlin Gold project website: <https://www.donlingoldseis.com>

4. 2018 FEIS SUBSISTENCE DETERMINATIONS UNDER ANILCA § 810(A)(3)(A), (B), AND (C)

The following determinations were made at the conclusion of the 2018 FEIS and ANILCA Section 810 evaluations. Section 5 will be developed at the conclusion of the 2027 SEIS and ANILCA Section 810 evaluations.

ANILCA § 810(a) provides that no “withdrawal, reservation, lease, permit, or other use, occupancy or disposition of the public lands which would significantly restrict subsistence uses shall be effected” until the Federal agency gives the required notice and holds a hearing in accordance with ANILCA § 810(a)(1) and (2), and makes the three determinations required by ANILCA § 810(a)(3)(A), (B), and (C). The three determinations that must be made are: 1) That such a significant restriction of subsistence use is necessary, consistent with sound management principles for the utilization of the public lands; 2) That the proposed activity will involve the minimal amount of public lands necessary to accomplish the purposes of such use, occupancy, or other such disposition; and 3) That reasonable steps will be taken to minimize adverse impacts to subsistence uses and resources resulting from such actions [16 U.S.C. § 3120(a)(3)(A), (B), and (C)].

Through feedback provided during the scoping meetings, the BLM, as part of the Draft EIS, made a preliminary determination that Alternatives 2, 3A, 3B, 4, 5A and 6A may significantly restrict subsistence uses for the communities of Tyonek, Skwentna, McGrath, Nikolai and Takotna, Bethel, Tuntutuliak, Napakiak, Napaskiak, Oscarville, Kwethluk, Akiachak, Akiak, Tuluksak, Upper and Lower Kalskag, Aniak, Chuathbaluk, Napaimute Red Devil, Sleetmute, Stony River, and Crooked Creek.

The BLM also made a preliminary determination that the cumulative case may significantly restrict subsistence uses for the communities of Bethel, Tuntutuliak, Napakiak, Napaskiak, Oscarville, Kwethluk, Akiachak, Akiak, Tuluksak, Upper and Lower Kalskag, Aniak, Chuathbaluk, Napaimute and Crooked Creek.

Therefore, the BLM undertook the notice and hearing procedures required by ANILCA § 810 (a)(1) and (2) in conjunction with release of the Donlin Gold Project Draft EIS in order to solicit public comment from the potentially affected communities of Aniak, Crooked Creek, Bethel, Quniagak, Akiak, Nunapitchuk, Tyonek, McGrath, Lower Kalskag, Holy Cross, and Chuathbaluk, as well as from all subsistence users. A public meeting and 810 hearing was also held in Anchorage. The dates of the meetings held are listed in section 3 above.

4.1. Significant Restriction of Subsistence Use is Necessary, Consistent with Sound Management Principles for the Utilization of Public Lands

The BLM authorizes ROWs to fulfill its responsibilities under the authority of Section 28 of the Mineral Leasing Act of 1920, as amended. Donlin Gold filed a ROW application with the BLM for the proposed project across Federal lands. The BLM is responsible for providing a ROW across Federal lands for the proposed natural gas pipeline, while providing protections for specific habitat, resources and uses. Therefore, the BLM finds that issuance of a ROW for this action would be necessary and consistent with sound principles for the utilization of public lands.

4.2. The Proposed Activity Will Involve the Minimum Amount of Public Lands Necessary to Accomplish the Purposes of Such Use, Occupancy or Other Disposition

The BLM has determined that Alternative 2 involves the minimum amount of public lands necessary to accomplish the purpose of the proposed activity, which is to grant a ROW for a natural gas pipeline for the project. The pipeline would be necessary to supply energy to operate the proposed Donlin Gold Mine. An alternative that varied the pipeline route (Dalzell Gorge route Alt 6A), and the no action alternative were also analyzed. All other alternatives (3A-LNG trucks, 3B-Diesel pipeline, 4-BirchTree Crossing Port, 5A-Dry Stacking of Tailings) would not change the proposed pipeline route, nor the need for a ROW across Federal public lands.

Alternatives that would reduce or eliminate the use of public lands needed for subsistence purposes include Alternative 1 (No Action). Section 2.4 in the 2018 FEIS, Alternatives Considered but Eliminated from Detailed Analysis, discusses other alternatives that were considered that involve less Federal public lands, but were eliminated from analysis due to economic or technological disadvantages, lack of feasibility, or because they did not meet the purpose of the proposed action to produce the gold resource discovered on Calista Corporation and TKC lands at the Donlin Gold site.

4.3. Reasonable Steps will be taken to Minimize Adverse Impacts upon Subsistence Uses and Resources Resulting from Such Actions

The following design features, best management practices, agency mitigation, monitoring, and adaptive management opportunities are discussed in Chapter 5 of the 2018 FEIS. These proposed measures are designed to protect various subsistence resources and their habitat and to reduce negative impacts from the proposed Donlin Gold mine. Given these steps, the BLM has determined that the proposed action includes all reasonable steps to minimize adverse impacts on subsistence uses and resources.

4.3.1. All Components

A12 – Where practicable, construction and maintenance schedules would seek to minimize impacts on subsistence hunting and fishing, with the understanding that some construction activities must also take advantage of seasonal and environmental conditions.

A13 – Donlin Gold would implement a “no hunting/fishing policy” for employees at work sites to minimize competition from employees for local resources.

A14 – The project design includes the development and implementation of a Construction Communications Plan to inform the public and commercial operators of construction activities.

A19 – The project design includes shift work schedules to maximize opportunities for employees to remain active in subsistence harvest efforts during Construction and Operations Phases.

A23 – Surfaces would be progressively reclaimed throughout operation. Sediment controls would include site grading and capping of erodible material, revegetation, and re-routing of surface runoff to reestablish natural conditions.

4.3.2. Mine Site

M2 – At the tailings storage facility (TSF) dry beach, the project design includes installing silt fences, removing snow from active placement areas only, and using polymer suppressant to minimize dust.

M11 – Numerous locations and combinations of locations were analyzed for TSF and WRF layouts during the alternatives development process. These are summarized in Appendix C. The layout of major mine facilities was designed to minimize wetland impacts and limit effects on water quality to the American and Anaconda Creek watersheds. The 404(b)(1) analysis will document the steps taken to minimize wetlands impacts.

M13 – Water management planning at the mine site would assist in controlling the flow of groundwater at the pit and other major facilities (WRF, TSF), as well as controlling the potential effects of groundwater flow on water quality downgradient of the mine. This would be

accomplished through design elements such as dewatering wells, collection of groundwater infiltration through and around the TSF at the SRS pond, and lake level maintenance following closure. A variety of groundwater monitoring activities would also be planned. M13 broadly covers design features of the water management plan, with details available in Chapter 2, Alternatives. Chapter 3 sections provide design and impact analysis pertaining to individual resources.

M14 – During the Operations Phase, concurrent reclamation activities (e.g., certain tiers and areas within the WRF) would be conducted immediately after construction and stabilization and whenever practicable in disturbed areas no longer required for active mining.

M21 – The mine plan incorporates the concept of design for closure. This incorporates methods for safe and efficient closure of the mine as an integral part of the planned mine design and operations. Implementing design for closure can have the effect of minimizing disturbance and the re-handling of materials.

4.3.3. *Transportation*

T1 – Ocean and river fuel barges would be double-hulled and have multiple isolated compartments for transporting fuel to reduce the risk of a spill.

T3 – The barge operations system was designed to avoid the need for dredging the navigation channel in the river.

T6 – Donlin would implement barge guidelines for operating at certain river flow rates, and conduct ongoing surveys of the Kuskokwim River navigation channel to identify locations that should be avoided to minimize effects on bed scour and the potential for barge groundings. As part of the proposed operation, equipment will be available to free or unload/lighten barges in the event of groundings. The equipment will be available as part of ongoing operations; it will not all be dedicated standby equipment.

T9 – The project design includes a communication program to keep local communities informed of the schedules and current status of barge traffic, as well as to minimize displacement of subsistence fishing by barges (see Appendix W for Donlin Gold's Barge Communication Plan). Donlin Gold would consult with people experienced with navigation on the Kuskokwim River to incorporate local knowledge as the company designs its barging operations and guidelines.

T10 – To reduce impacts on existing river traffic and potential for groundings and accidents, Donlin would establish navigational aids and develop procedures for queuing in narrow channels. Donlin Gold vessels would use state-of-the-art navigation and communication equipment.

T14 – River pilots would be used for all tug and barge traffic between the mouth of the Kuskokwim River and Bethel (see Appendix W for Donlin Gold's Barge Communication Plan).

4.3.4. Pipeline

P3 – The project design includes a natural gas pipeline to decrease the amount of barging needed to transport diesel fuel. The design decision to use a natural gas pipeline instead of barging 110 Mgal of diesel per year was developed in response to community concern about barge traffic levels.

P7 – Appropriate notices, warning signs, and flagging would be used to promote public safety. Barricades may also be used around dangerous areas such as open trenches during construction.

P12 – The project design includes routing of the pipeline and siting of the related compressor station along an existing corridor in Susitna Flats State Game Refuge to minimize impacts.

P16 – Donlin Gold will coordinate with and help educate people who want to travel in the area during the pipeline construction period through its Public Outreach Plan to either allow controlled access through or within construction zones or provide alternate access.

4.3.5. Best Management Practices

- Designing and installing culverts and bridges on transportation routes for fish passage;
- Implementation of Stormwater Pollution Prevention Plans (SWPPPs) and/or Erosion and Sediment Control Plans (ESCPs), and use of industry standard BMPs for sediment and erosion control;
- Development and maintenance of ODPCPs, SPCC Plans, and FRPs;
- Use of BMPs, such as watering and use of dust suppressants, to control fugitive dust;
- Preparation and implementation of a Stabilization, Rehabilitation, and Reclamation Plan (SRRP);
- Compliance with Alaska Department of Natural Resources (ADNR) Dam Safety requirements through certificates of approval to construct and operate dams to include preparation of Emergency Action Plans and completion of a Failure Modes Effects Analysis (FMEA);
- Appropriate bonding/financial assurance required by ADNR and BLM;
- Compliance with ADNR Temporary Water Use Authorization conditions for water withdrawal, such as screening requirements to avoid fish entrainment or injury, establishing water withdrawal rates and volumes, and as appropriate timing of water withdrawal to avoid fish migration, spawning, and incubating eggs;

- Monitoring of water withdrawals to ensure permitted limits are not exceeded;
- Preparation of a Wildlife Avoidance and Human Encounter/Interaction Plan;
- Verification that project vessels are equipped with proper emergency towing equipment in accordance with 18 AAC 75.027(f);
- Development of Blasting Plans;
- Development of Invasive Species Prevention and Management Plans (ISPMPs) and application of industry-standard BMPs relating to nonnative invasive species (NNIS) prevention and management;
- Compliance with Section 106 Programmatic Agreement (PA) and Cultural Resources Management Plan (CRMP), including adequate survey prior to ground-breaking activities and protocol for inadvertent discovery of cultural resources;
- Verifying pipeline integrity with visual and other non-destructive inspections of welds, hydrostatic testing, use of in-line inspection tools, and aerial inspections; and,
- Use of cathodic protection (specific method to be determined in final design) for corrosion protection of the steel pipeline.

4.3.6. *Agency mitigation*

Mit 12 – Where practicable and in compliance with FAA and safety requirements, establish recommended minimum flight altitudes (>1,500 feet is recommended to minimize impacts to Dall sheep and other wildlife when these animals are present in the vicinity of the work).

Mit 15 – Install signs that clearly distinguish trails from the pipeline ROW at points where the pipeline crosses trails to guide trail users to stay on the trail and off the pipeline ROW where the two are not co-located. As practicable, revegetate, or otherwise block access to, a narrow strip of the pipeline ROW where it crosses the trail to help steer and keep trail users on the trail, and to reduce the visual effect of the pipeline ROW crossing.

Apply measures to further restrict public access to the ROW to reduce indirect effects.

Close the pipeline ROW to Off Highway Vehicle (OHV) and snowmachine use, where appropriate and based on land ownership, to minimize increased recreational access.

Mit 18 – Donlin Gold should consult with the Alaska Department of Fish and Game and local subsistence users for current information and traditional knowledge to identify locations and times when subsistence activities occur, and to the extent practicable, minimize impacts to these activities. The Donlin Advisory Technical Review and Oversight Committee (DATROC) may serve to facilitate consultation, as appropriate.

Mit 19 – Maintain communication throughout all project phases with subsistence users concerning perception of ecological risk or potential exposure of waterfowl or fish to contamination. A communication method is important to address concerns and perceptions about contamination. The communication may include monitoring and testing of bird carcasses and fish, if appropriate. Biological monitoring may include fish tissue, feathers, and animal hair to detect any changes in contaminant concentrations. DATROC may serve to facilitate communication, as appropriate.

Mit 26 – Develop a Subsistence Plan and Report that would incorporate BMPs for the mine operations to maintain or improve subsistence activities and avoid potential conflicts. The plan may be developed with input from the local subsistence users, and may be organized through efforts from DATROC.

The plan may include monitoring of mine activities to ensure that subsistence resources are adequately protected throughout the active mine life and Post-Closure. The plan may also include an adaptive management framework where certain monitoring activities may no longer be needed, but additional monitoring may be required based on the results of previous years' activities.

Implement a two-way communications strategy to keep local communities informed of the schedules and current status of barge traffic, and keep Donlin Gold informed of the location and timing of commercial and subsistence fishing activities. The communication plan should include Bethel, due to the volume of traffic moving through Bethel Port. (Donlin Gold's Barge Communication Plan is available in Appendix W).

Mit 36 – Where appropriate, employ seasonal timing restrictions on blasting, as stipulated by resource agencies, to reduce noise related effects of blasting during sensitive subsistence hunting activities (e.g., fall moose hunting).

Mit 82 – Include speed limits in barge guidelines proposed as a design feature and identify periods of limited or suspended barging, to the extent practicable. Limit barging or restricted timing of barges during key commercial or subsistence fishing periods and in critical habitat areas (Cook Inlet and Kuskokwim Bay) to avoid periods of concentrated animal activity. Suspend barging during the smelt spawn (May) until the spawn is over.

4.3.7. Monitoring and adaptive management being considered by the project proponent

Mon 2 – Develop adaptive management plan(s) in conjunction with local communities. Involve residents when determining parameters and performance standards, as appropriate.

Mon 41 – Monitor and test bird carcasses and fish, if and where appropriate, as part of a communication strategy to address perceived risk throughout the project. Designate a point of contact for monitoring and testing procedures.

Mon 44 – Monitoring to evaluate the relationship between vessel speeds and wave heights of representative barge tows in potential hotspot areas during the first years of construction would help determine what barge operational measures are needed (if any) to minimize or avoid risks relative to the displacement and/or stranding of small out migrant salmon and other young-of-year fishes, as well as commercial and subsistence fishing.

5. 2027 SEIS SUBSISTENCE DETERMINATIONS UNDER ANILCA § 810(A)(3)(A), (B), AND (C)

This section will contain the determinations made at the conclusion of the 2027 SEIS and ANILCA Section 810 evaluations.

6. LITERATURE CITED

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