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Integrated hydrologic modeling to inform risk assessment for large-scale mining and salmon in Bristol Bay headwaters

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2010 TNC Alaska Resolution:

- Based on our assessment of the risks and state of current, proven mining technology, large scale mining in these critical watersheds at this time presents an inappropriate risk to the salmon systems of the region

- The Conservancy recommends that mining and other activities not be allowed that:
  - Destroy or impair habitat such that sustained abundance is placed at risk
  - Require water withdrawals that exceed ecological flow needs for fish
  - Require active management in perpetuity to avoid contamination
  - Result in acid mine drainage that cannot be eliminated by proven methods at comparable sites and scale

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Presentation Outline:

- What is an integrated hydrologic model?
- How did this help us understand risks associated with a preliminary Pebble mine design in 2012?
- Review preliminary details from 2017 Pebble Mine application for Clean Water Act wetland permits

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PLOS ONE

RESEARCH ARTICLE

Hydrologic Alterations from Climate Change Inform Assessment of Ecological Risk to Pacific Salmon in Bristol Bay, Alaska

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What is an Integrated Hydrologic Model?

- Spatially explicit estimate of atmosphere-surface water-groundwater interactions
- Water moves among reservoirs according to local physics: water balance is internal
- Provides a physically based background for ecological risk assessment

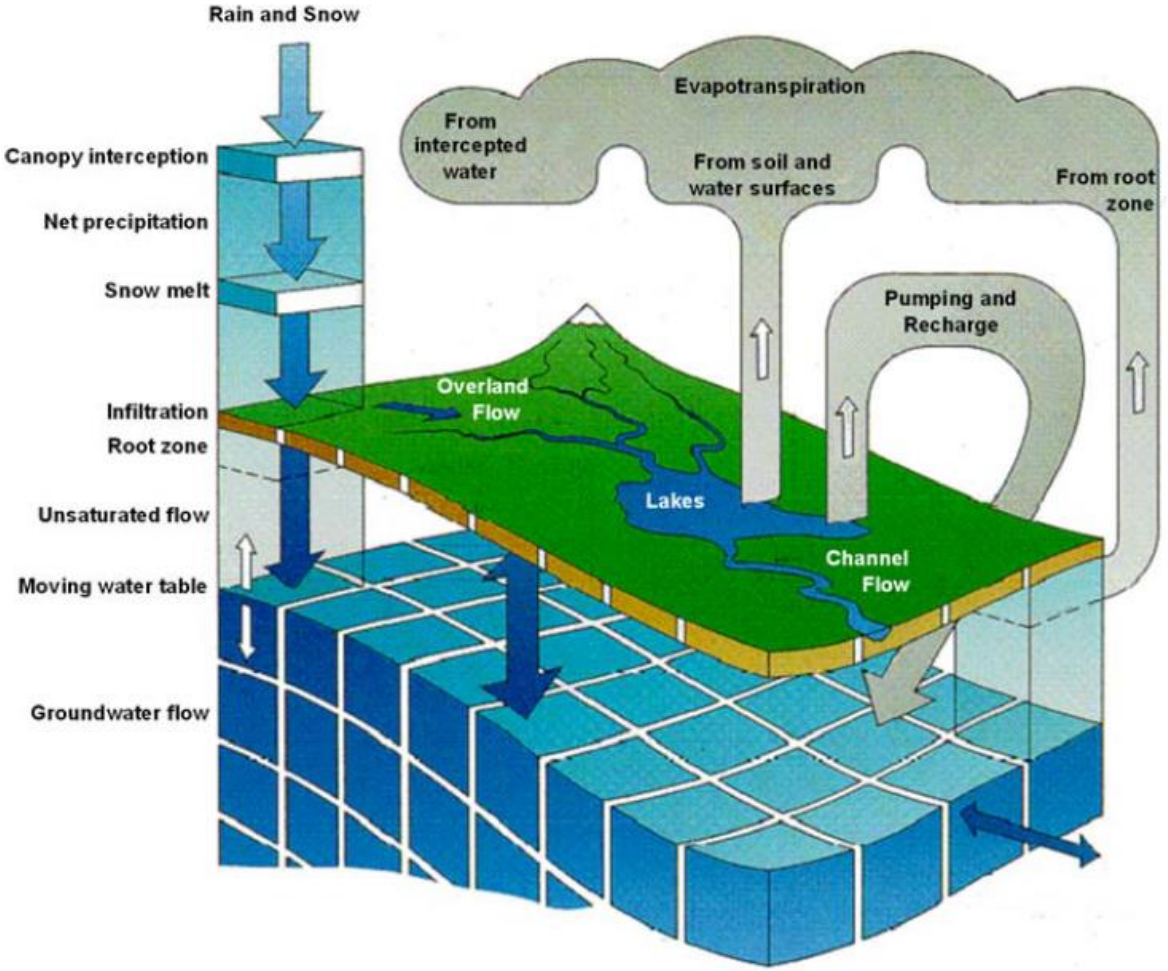
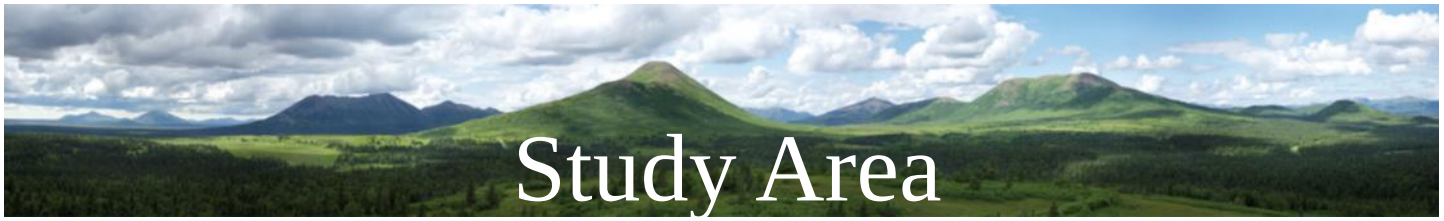


Figure 10.1 Hydrologic processes simulated by MIKE SHE.

Graham and Butts, 2005



Study Area

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Location Map

Study Area

Alaska

Area of Detail

Bristol Bay, Alaska

Nondalton
Koliganek
Newhalen
Iliamna
Pedro Bay
Lake Iliamna
New Stuyahok
Ekwok
Kokhanok
Aleknagik
Igiugig
Togiak
Levelock
Dillingham
Manokotak
Clark's Point
Portage Creek
Ekuk
South Naknek
Naknek
King Salmon
Bristol Bay
Egegik

Model Components

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Model Input:

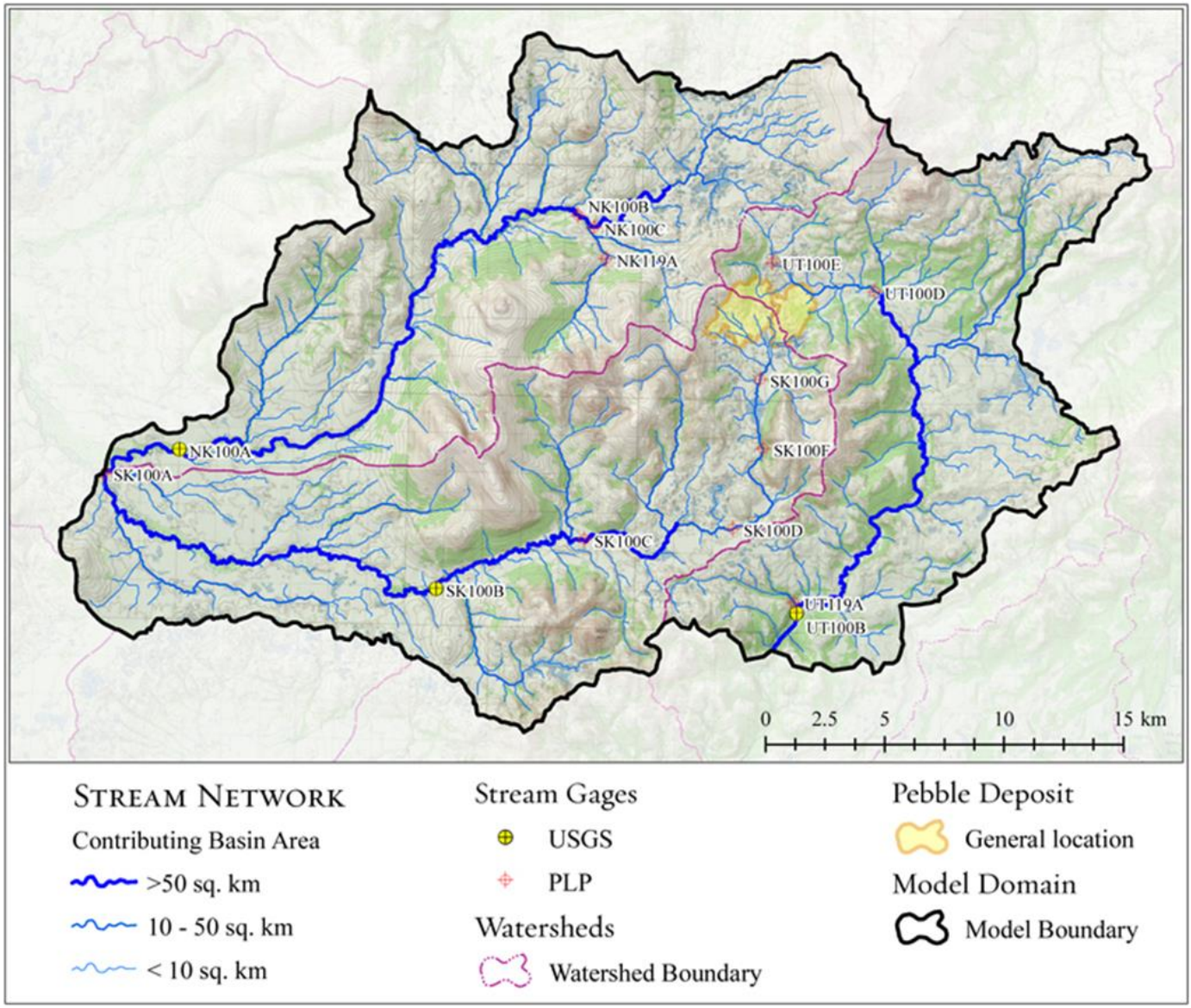
- Precipitation
- Temperature

Model Parameters:

- Lakes and streams
- Vegetation
- Soils / wetlands
- Geology
- Aquifer geometry
- Hydraulic conductivity

Calibration:

- Stream flow gage stations



Model Calibration

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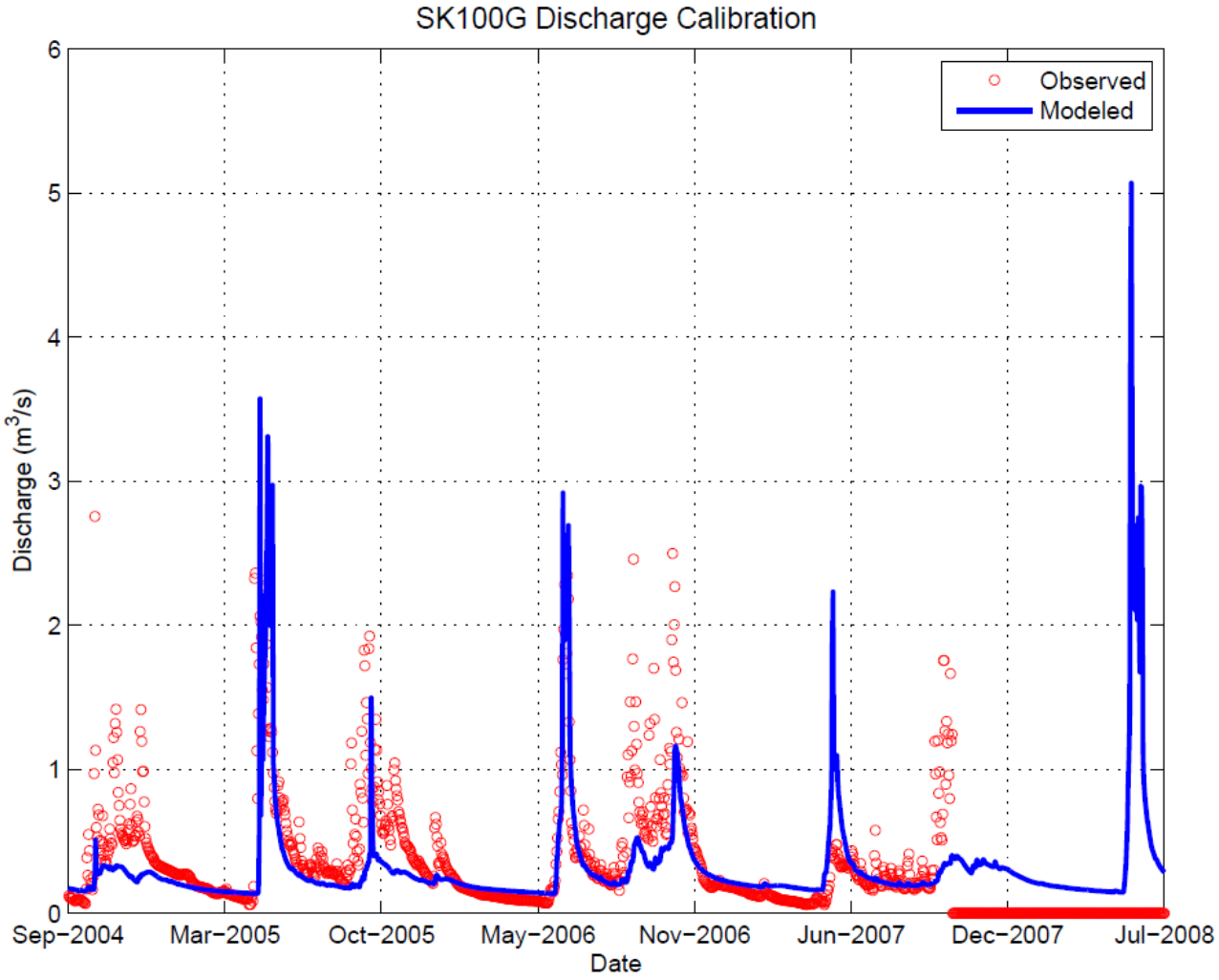
Streamflow Calibration: Upper South Fork Koktuli



A Preliminary Mine Plan

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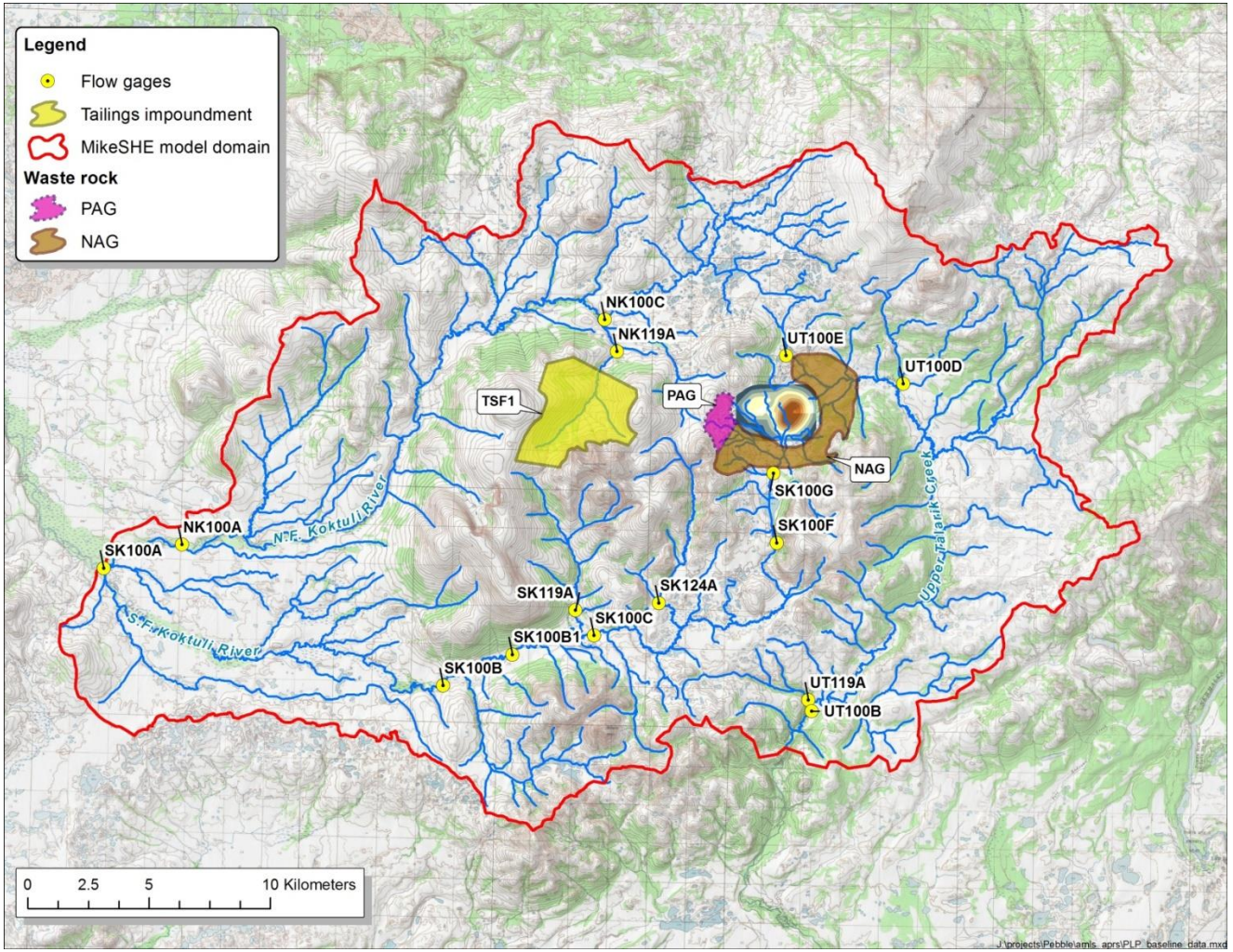
Northern Dynasty Preliminary Mine Plan: 25-year Scenario

Mine Facilities:

- Open Pit
- Waste Rock
- Tailings Storage Facility
- ~5 billion tons of material



From: Ghaffari et al. 2011. Preliminary Assessment of the Pebble Project, Southwest Alaska. Prepared for Northern Dynasty Minerals Ltd. by Wardrop (A Tetra Tech Company), Vancouver, BC. February 15.

Water Management System

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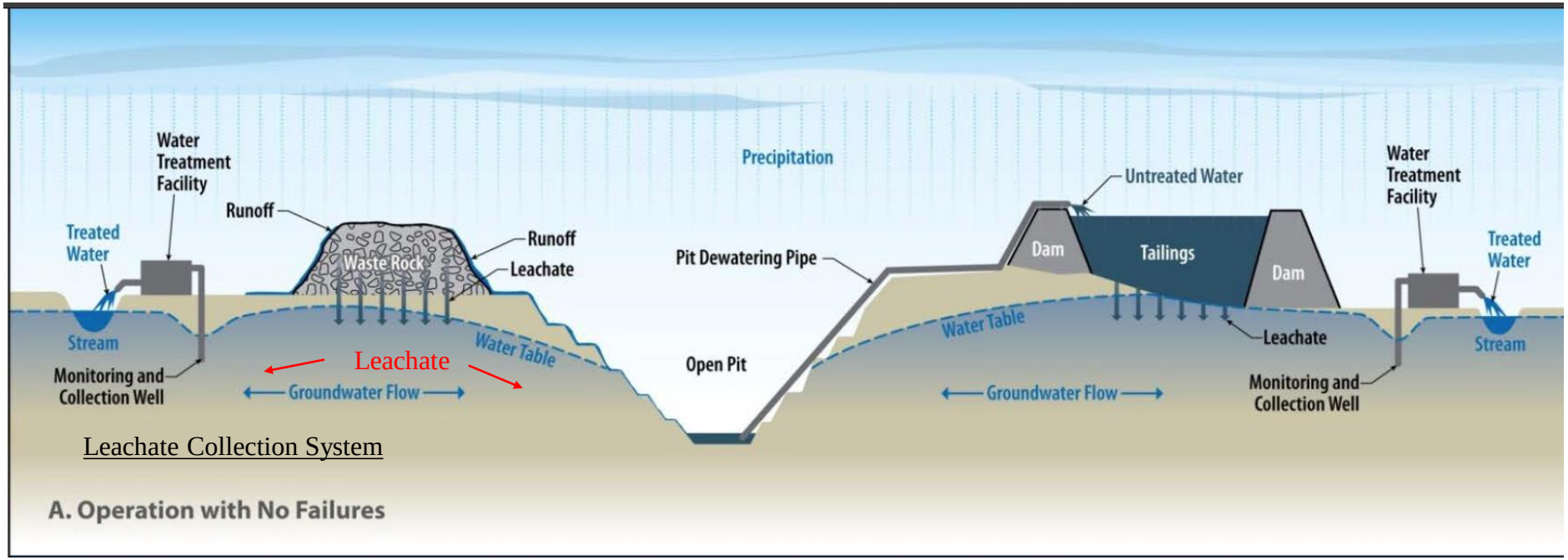

- Water Management Systems:
  - Open pit collection system
  - Tailings storage facility collection system
  - Waste rock leachate collection system
- Transfer water for use, treatment, and release back into the environment

Results: Downstream Water Quality 1

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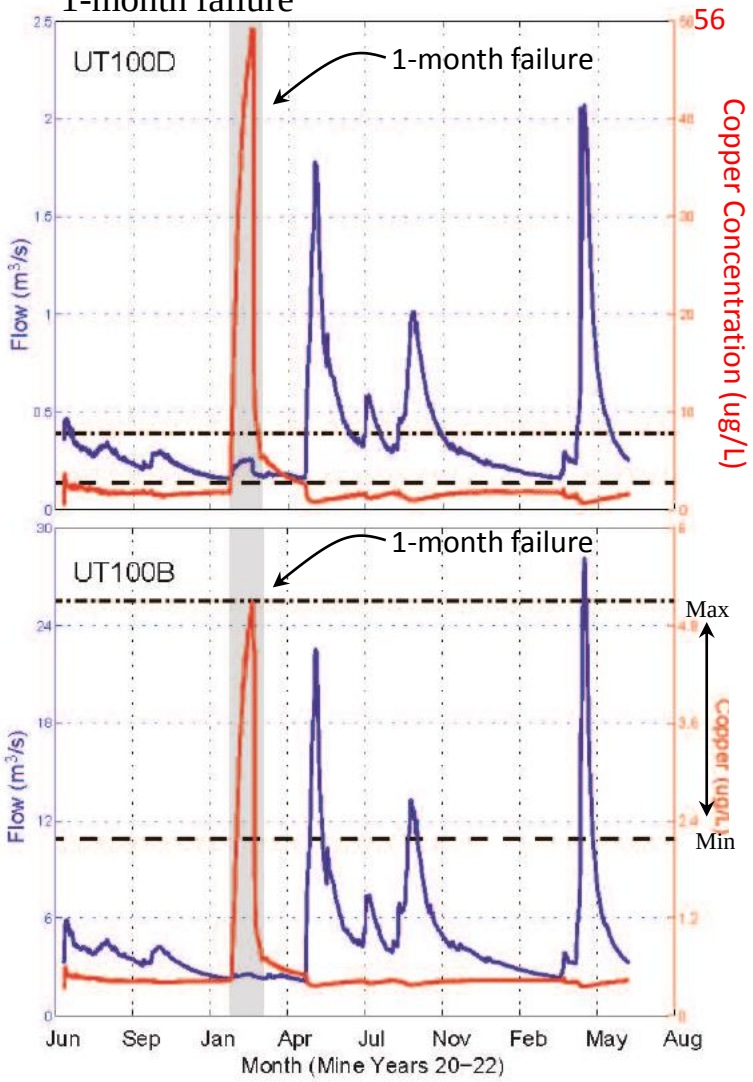
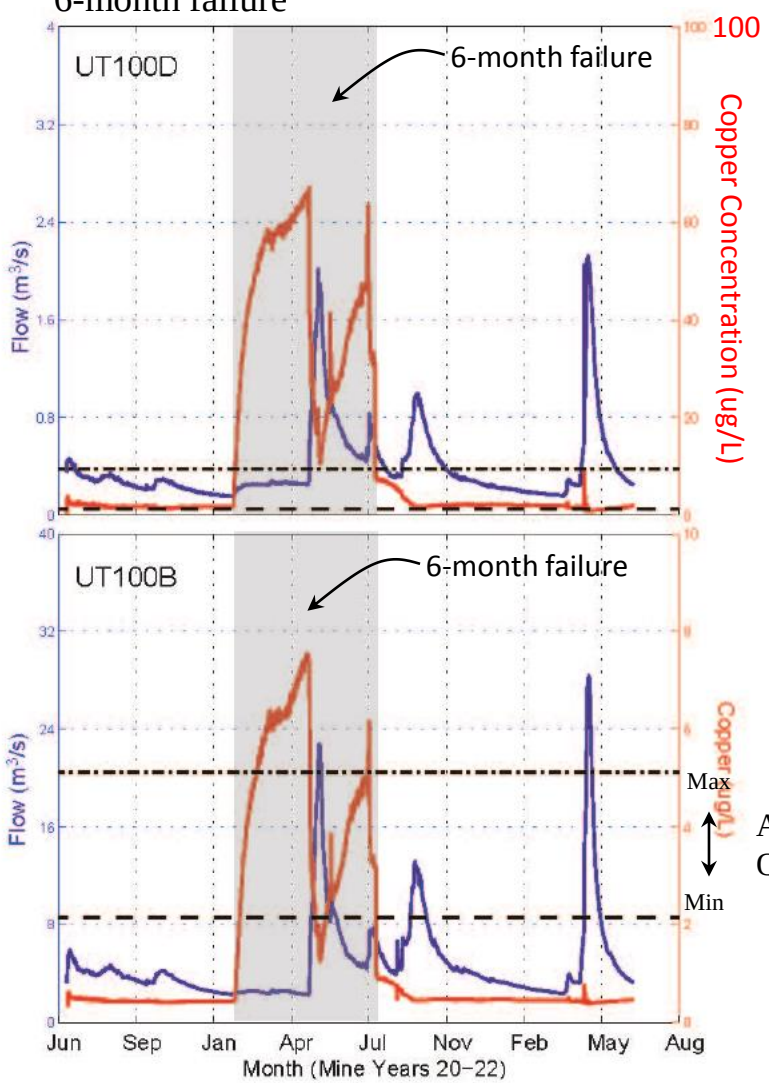
Scenario 1: Short-term failure of leachate collection system

1-month failure



6-month failure



Acute Water Quality Criteria

Results: Downstream Water Quality 2

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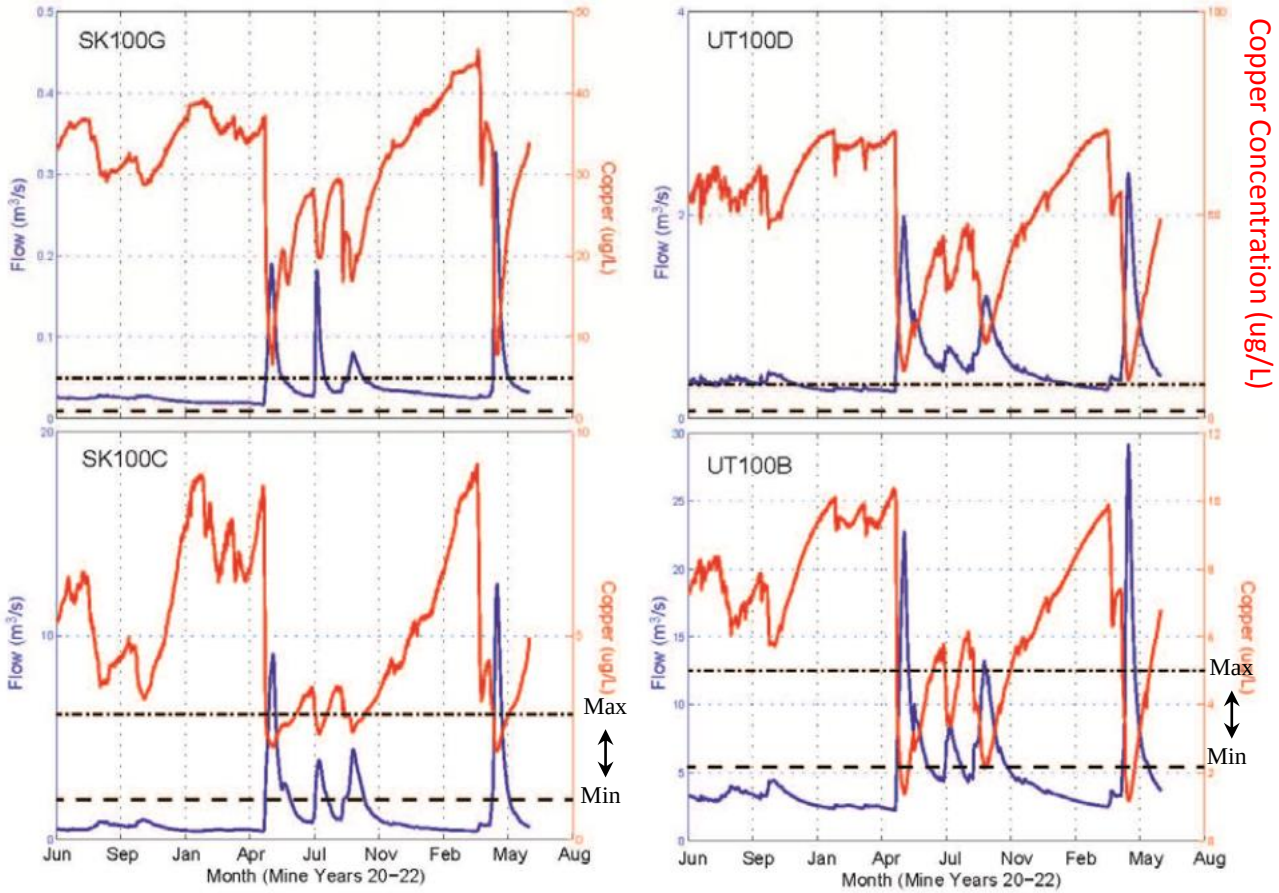
Water Quality Scenario 2:
No Leachate Collection from Waste Rock (long-term failure)

South Fork Koktuli | Upper Talarik

Upstream

Downstream



Acute Water Quality Criteria

Conclusions:

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- Meeting water quality standards for this preliminary design was dependent upon continual functioning of active leachate collection and water treatment systems.

- Even 1-month failure of leachate collection resulted in exceedance of acute (i.e., lethal) water quality standards for copper throughout much of the model domain.

- The ability to design and test the effects of mining scenarios like this one requires access to advanced hydrologic modeling tools.

Next Steps: We are currently evaluating the feasibility and seeking funding to use this model to analyze the 2017 Pebble Mine permit application

2017 Pebble Mine Application

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In December 2017, Pebble Partnership applied to the Army Corp of Engineers for wetland fill permits under the Sec. 404 of Clean Water Act

Design Summary:

- 20-year mine operating life
- 1.2 billion tons of material mined
  - 1.1 billion tons in Tailings Storage Facility
  - 330 million tongs in low grade ore facility
- 83 mile transportation corridor
  - Includes 18 mile lake crossing
- 188 mile gas pipeline from Kenai Peninsula

Design Considerations

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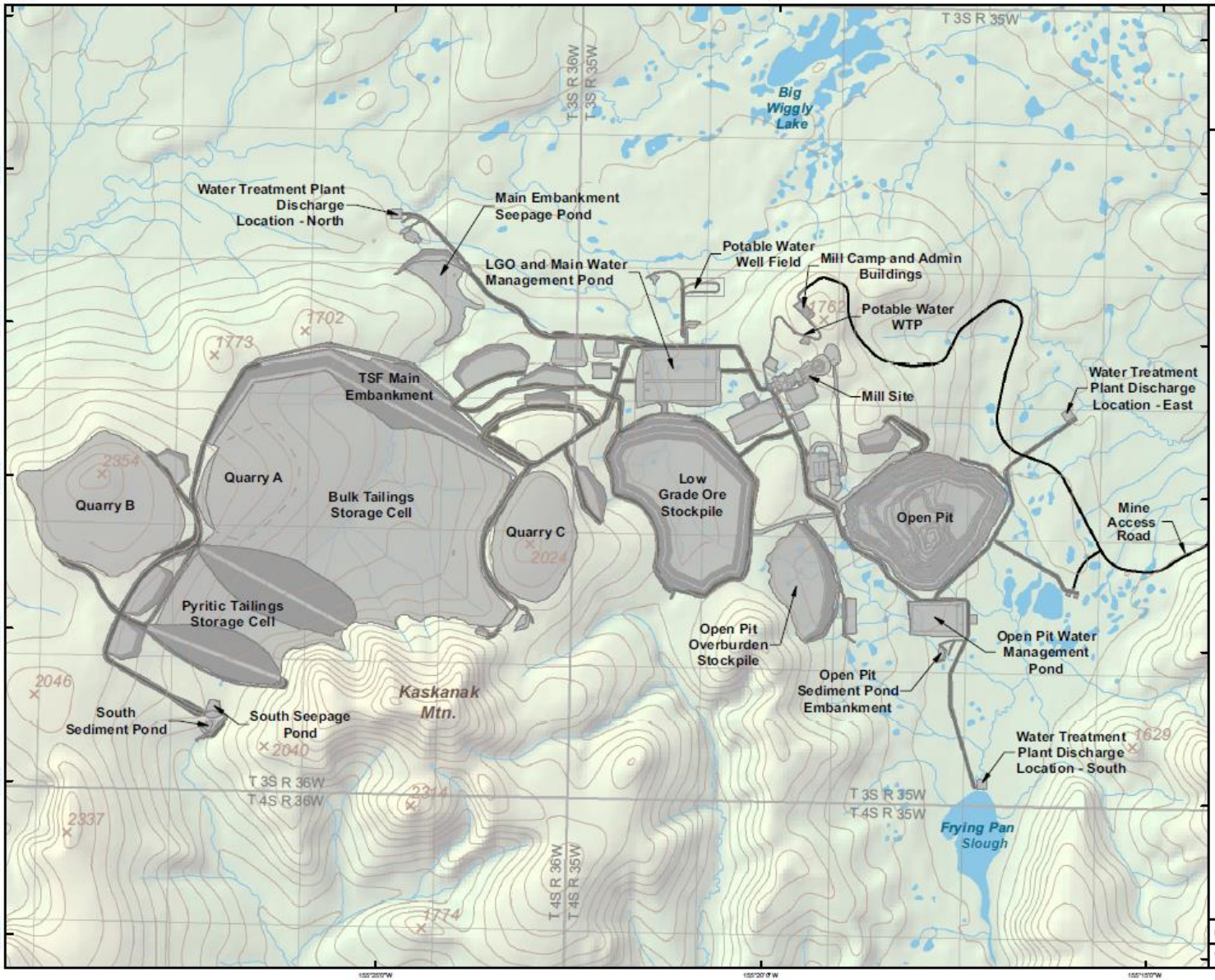
- Limited to mining the near-surface portion of the Pebble Deposit
  - This proposal only utilizes 1.2 billion of the estimated 12 billion tons in the Pebble Deposit.
- Layout consolidates most infrastructure in the North Fork Koktuli watershed, seeks to avoid Upper Talarik
- No secondary recovery of gold from pyritic tailings using cyanide leaching
- Segregation of bulk from pyritic (acid-generating) tailings to facilitate physical closure of bulk tailings
- Low-grade ore stockpile will be lined for storage of potentially acid generating (PAG) waste rock



THE pebble PARTNERSHIP

FIGURE 1-4

Mine Site Map

- Mine Site Footprint
- Mine Site Access Road
- 50' Contour (Existing)
- Township Boundary
- Section Boundary

0 0.5 1 1.5 Miles

N

Scale 1:46,000

Alaska State Plane Zone 5 (units feet)
1983 North American Datum

File: PLP_PD_1_4_MineSite.mxd	Date: 12/19/2017
Version: 1	Author: HDR

2017 Water Management Diagram

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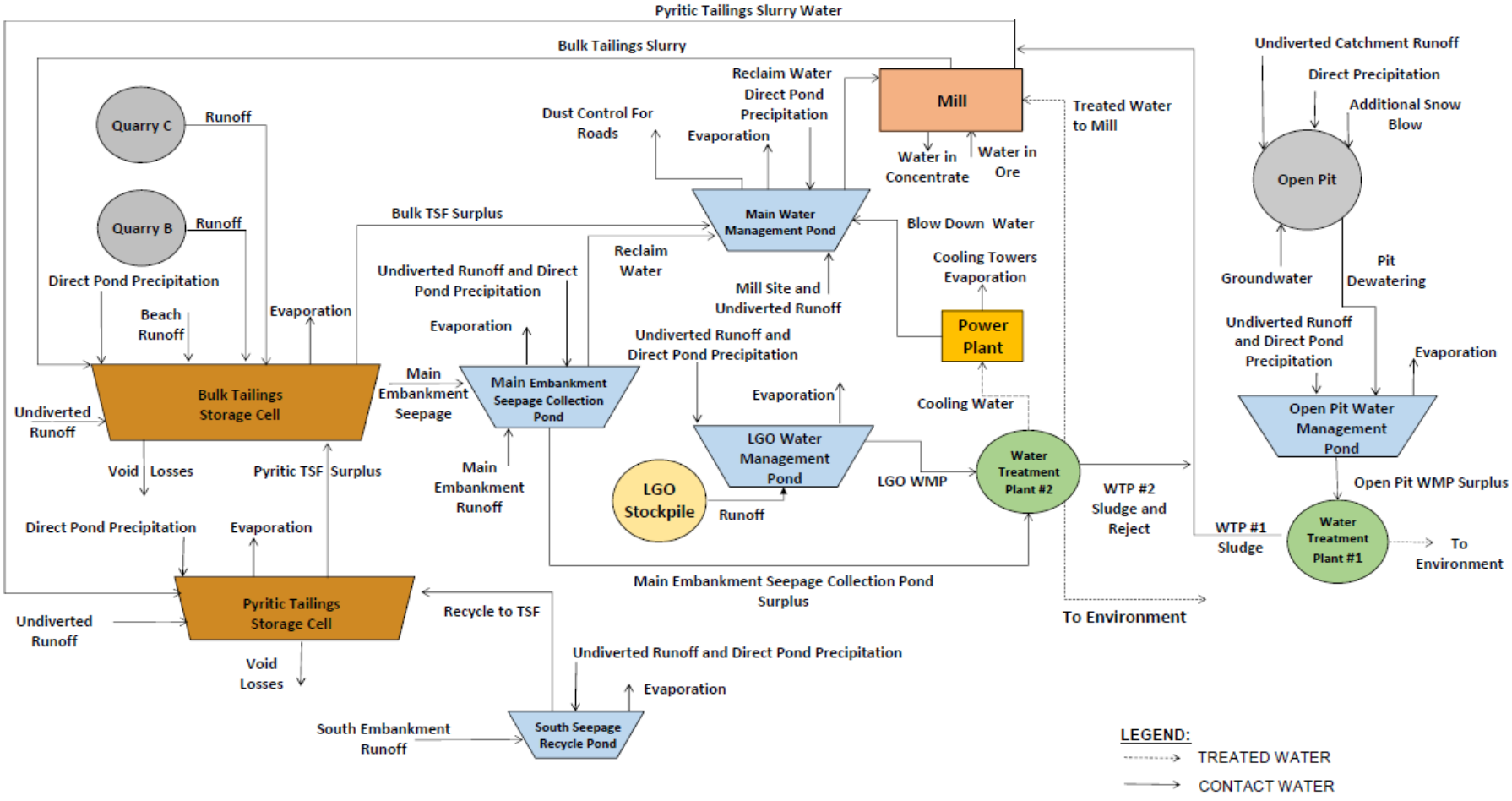

Post-Closure Water Management

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- Dewatering will stop and the open pit will begin to flood
- Pyritic tailings will remain sub-aqueous to prevent oxidation and acid generation
  - Seepage water from the embankment will be collected and either treated or directed into the pit
- Physical reclamation will contour to facilitate surface runoff to be collected for treatment or directed into the pit
- Surface water in the pit lake is expected to be acidic with high metal concentrations
  - Once the pit water level reaches a level ~50’ below groundwater, water will be pumped, treated and discharged into the environment
- Water treatment during this phase will use the existing Water Treatment Plants as necessary.
  - The reclamation and closure bond package will include provisions for periodic replacement of water treatment facilities and ongoing operation and monitoring costs over the long-term post-closure period.

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Thanks!