

# Reclamation & Closure Red Dog Zinc-Lead Mine Delong Mtns, Alaska

Mine Design, Operations & Closure Conference  
May 2011

Jack DiMarchi  
Large Mine Project Coordinator  
Alaska Department of Natural Resources

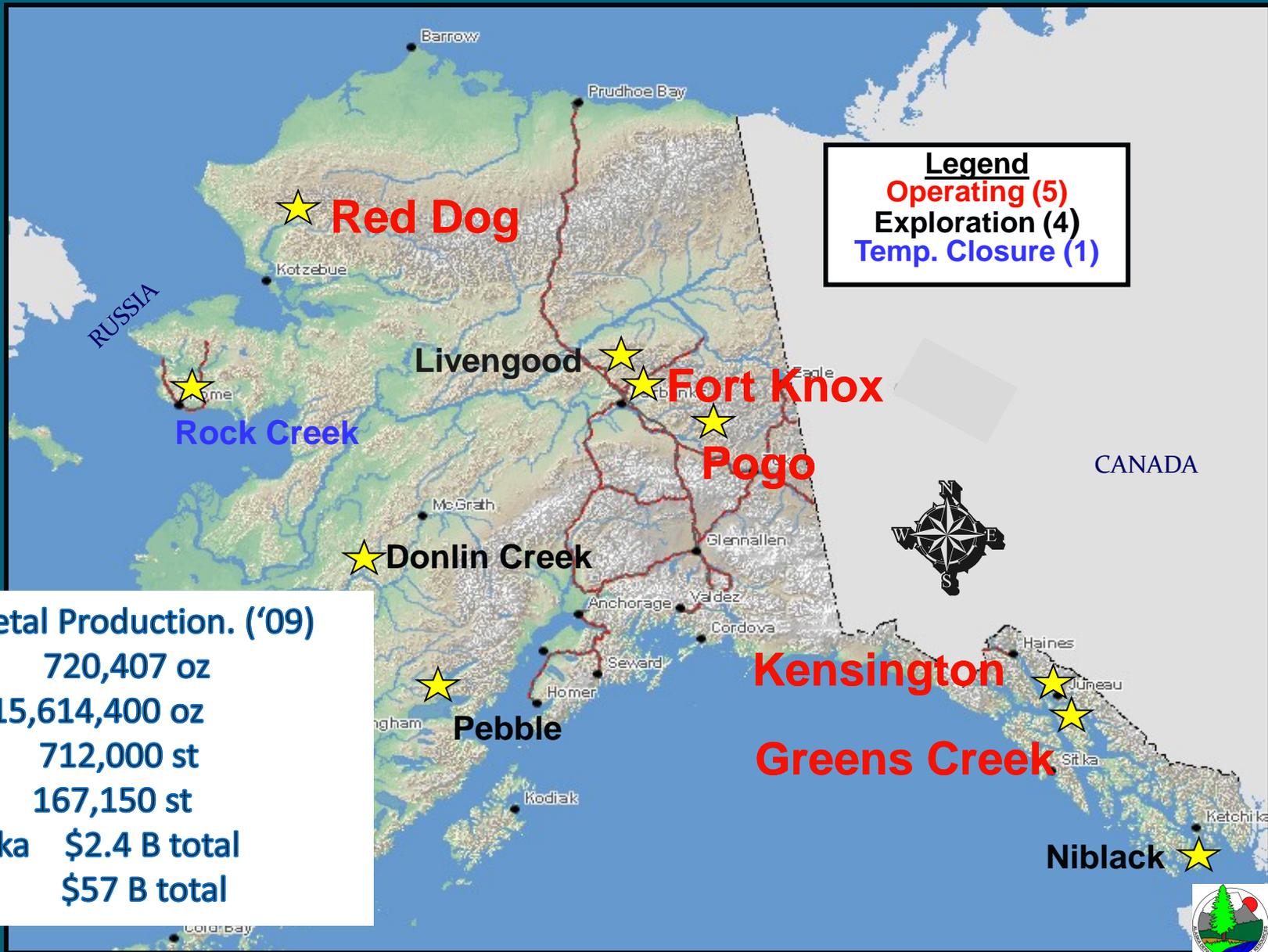


# Presentation Outline

- Alaska Mines
- Red Dog Mine
  - Overview
  - Mine Operations
  - Reclamation & Closure Plan (by Facility)
  - R & C Bonding
  - Community Engagement



# Mine Projects in Alaska



**Legend**  
 Operating (5)  
 Exploration (4)  
 Temp. Closure (1)

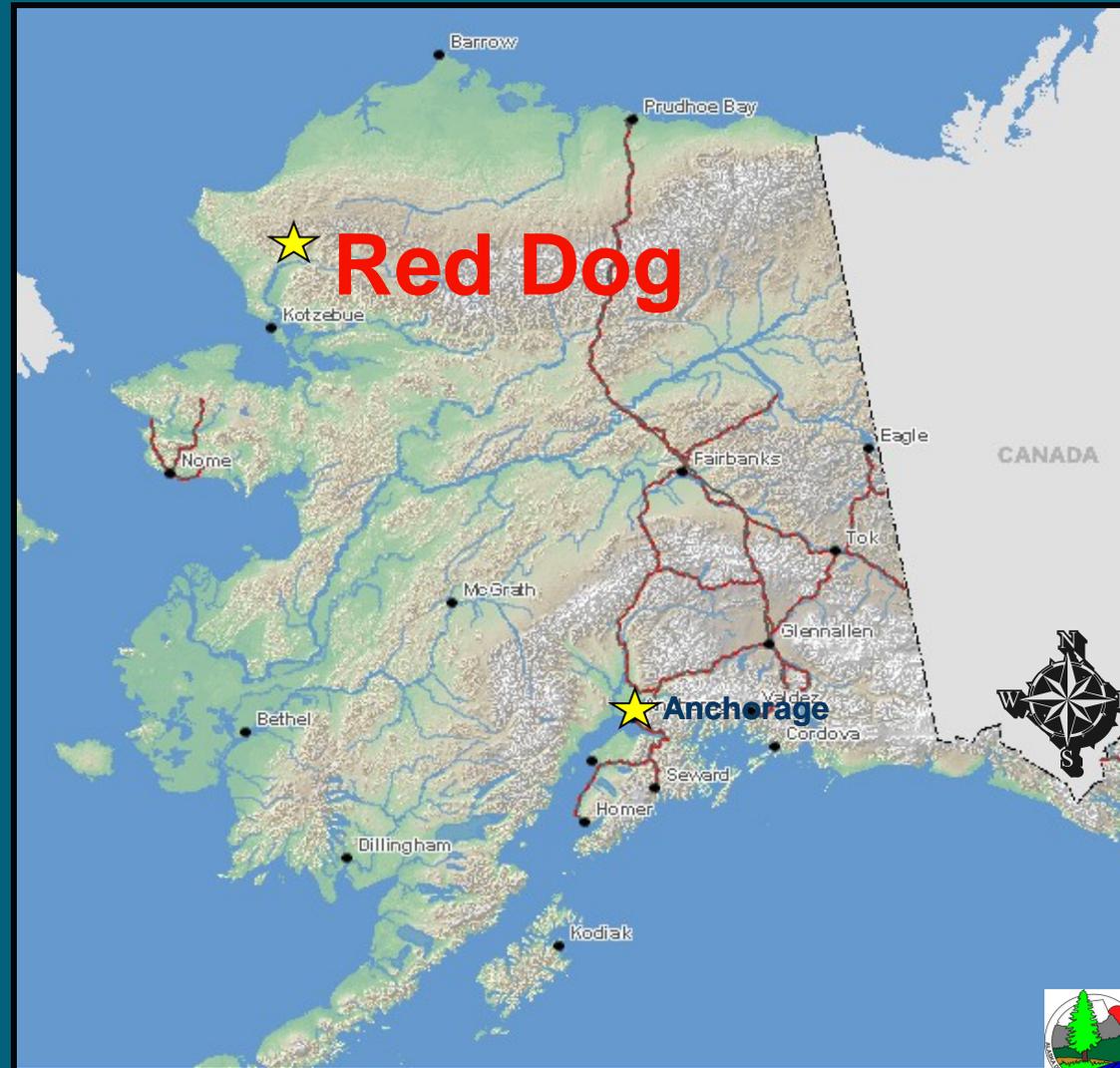
**Alaska Metal Production. ('09)**

- Au 720,407 oz
- Ag 15,614,400 oz
- Zn 712,000 st
- Pb 167,150 st
- Alaska \$2.4 B total
- U.S. \$57 B total



# Red Dog Mine

- Teck Corp. - Operator
- NANA Native Land
- DeLong Mts, Brooks Range
- 9.0 in. total prec.
  - 48 in. snow
- Hi/Low temps (average)
  - 27.8/15.3° F
- 80 mi. from Kotzebue
- 600 mi. from Anchorage
- Air/Barge access
- 450 employees
- Production began in 1989



# Red Dog Mine

- Shale-hosted MS
- LOM '89 – '31?
- Current Resource 63.4Mst  
16.2% Zn, 4.2% Pb, 3 opt Ag
- Two Open Pits
- Mill 10,000 stpd ore
- Flotation mill
- Produce 1.2M stpa con
- Produce 7.5M oz Ag
- Shipped Seasonally
- 6.6M stpa Waste rock



Concentrate ship lightering barge



Main Pit



# Reclamation & Closure

- Regulated by - DNR (R & C Plan Approval), DEC (Waste Management Permit)
- Primary objective to protect water quality, physical and chemical stability of the site
- Developed in 6-yr period with agency, operator, expert and stakeholder input
- On Native (private) property
- First AK mine to permit perpetual water treatment – increased bond requirements
- R & C Plan – recurring 5 year audit by 3<sup>rd</sup> party firm and updated
- Concurrent reclamation is required
- Post closure monitoring of reclamation performance



# Supporting Documents

What the hell?  
I can't read any  
of this!!!

- **Supporting Document B: Plans of Operations**
  - B1 Red Dog Mine Development Plan (TCAK, 2004)
  - B2 Plan of Operations for Waste Rock Management
  - B3 Plan of Operations for Tailings and Water Management
- **Supporting Document F: Reclamation and Revegetation**
  - F3 Revegetation Plan for the Red Dog Mine (ABR, Inc., 2007)
- **Supporting Document I – Red Dog Mine, Monitoring Plan**
  - Water quality monitoring – “Quality Assurance Plan – for the Red Dog Mine Water Quality Monitoring Program, NPDES AK-003865-2”.
  - Biomonitoring program as described in Methods for Aquatic Life Monitoring to Satisfy Requirements under 1998 NPDES Permit, NPDES AK-003865-2, .
  - Geochemical monitoring – “Assay Laboratory Quality Assurance SOP”
- **Supporting Document J: Cost Estimates**
  - J1: Basis of Estimate -Closure Costs [Report]
    - Excel tables available upon request, pdf's are included with the report
  - J2: Basis of Estimate -Post Closure Costs [Report]
    - Excel tables available upon request, pdf's are included with the report
  - J3: Basis of Estimate -Suspension Costs [Report]
    - Excel tables available upon request, pdf's are included with the report
- **State of Alaska Department of Revenue Memorandum – Subject: Recommended 4.3% Real Rate of Return for Red Dog Mine Funds**
- **Supporting Document A: Consultation & Property Description**
  - A1 Closure Workshops (this is provided on a cd)
  - A2 Legal Description of Property
- **Supporting Document C: Geotechnical**
  - C1 Main Waste Stockpile Stability Assessments
  - C2 Drawings from updated Geotechnical Report (URS, 2008)
  - C3 Dam History Report, Red Dog Tailings Main Dam, Future Raises to Closure (URS, 2007)
  - C4 Preliminary Conceptual Design Report, Red Dog tailings Main Dam, Future Raises to Closure (URS, 2007)
  - C5 Stability Analysis for Future Raises to Closure, Tailings Main Dam (URS, 2007)
  - C6 Seepage Analysis Report, Red Dog Tailings Main Dam, Future Raises to Closure (URS, 2007)
  - C7 Drawings from Back Dam Investigation and Design (Golder Associates, 2006)
  - C8 Preliminary Spillway Design, Red Dog Tailings Main Dam, Ultimate Closure Configuration (URS, 2008)
- **Supporting Document D: Geochemistry**
  - D1 Consolidation of Studies on Geochemical Characterization of Waste Rock and Tailings (SRK, 2003)
  - D2 Supporting Geochemical Review and Interpretation (SRK, 2005)
  - D3 Aqqaluk Geochemistry – Supplemental Testing Program (SRK, 2007)
  - D4 Lime Requirements and Predicted Geochemical Changes
- **Supporting Document E: Water Management**
  - E1 Red Dog Water and Load Balance
  - E2 Flood Frequency Update for Middle Fork Red Dog Creek (Peratrovich, Nottingham & Drage Inc., 2002)
  - E3 Red Dog Creek Rediversion Design and Criteria and Plan (TCAK, 2004)
  - E4 Assessment of Water Treatment Methods Applicable for Closure
  - E5 Assessments of Methods for Managing Post-Closure Water Treatment Sludge
- **Supporting Document F: Reclamation and Revegetation**
  - F1 Mine Area Closure Options – Summary of the Cover Studies
  - F2 Evaluation of Borrow Sources
- **Supporting Document G: Demolition**
  - Demolition Cost Estimates (Denison Environmental Services, 2004)
- **Supporting Document H: Ecological Risks**
  - Evaluation of Ecological Risk within the Ambient Air/Solid Waste Permit Boundary (Exponent, 2008)

# Operations, Reclamation & Closure

- **Current Ops and Closure Plan By Facility**
  - **Mill**
  - **Main and Aqqaluk Open pits**
  - **Tailings Storage Facility**
  - **Waste Rock Stockpiles**
  - **Water Management/Treatment**



# Mine Operations -Buildings

- Mill 10,000 stpd ore
- 3 WTP
- Accommodations
- Con Storage Building
- Gyratory crusher
- Maintenance Shop
- Admin offices
- Conveyors
- Fuel Storage
- Warehouse
- The total surface disturbance area ~225 acres



# Closure & Reclamation – Mill and Buildings

- High value components will be removed for salvage/scrap.
- The remainder will be demolished. Bulk demolition wastes will be disposed of in a landfill within waste stockpiles.
- Hazardous material will be removed and handled according to regulations specific to each material.



# Closure & Reclamation - Buildings

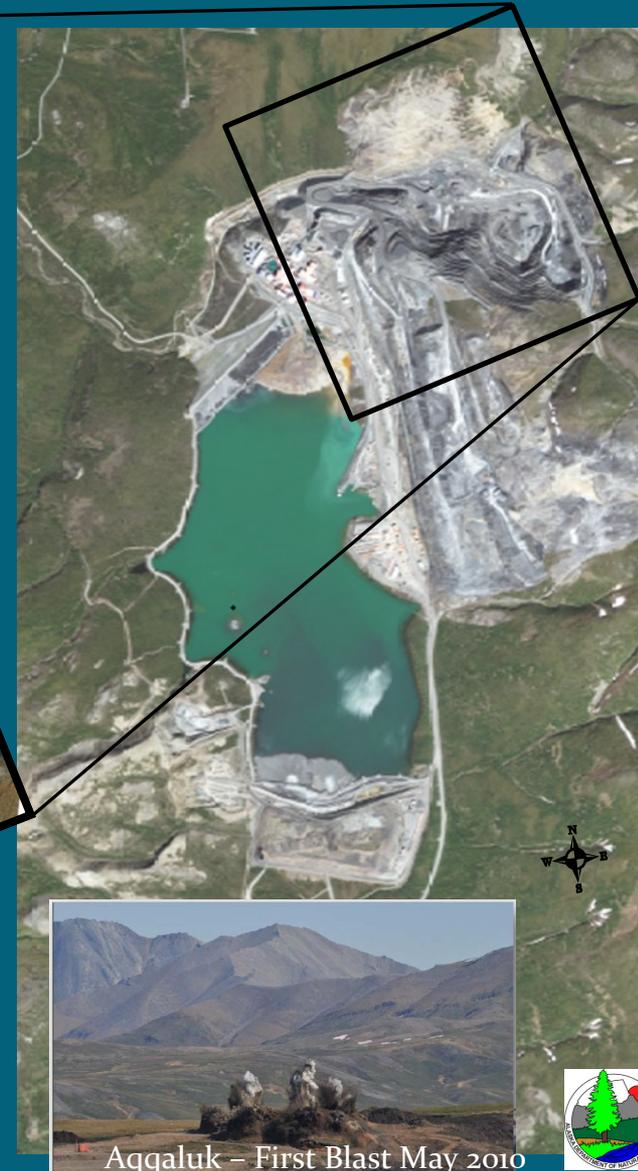
- Metal-contaminated soils below the ore processing structures be removed to the waste stockpiles.
- Areas will be regraded. Non-contaminated material will be placed as fill where necessary, then revegetated.
- Vegetated areas impacted by fugitive dust will require further monitoring and assessment before appropriate remediation plans can be developed



Gyratory Crusher

# Mine Operations – Open Pits

- Two Open Pits
  - Main ('89 –'12)
  - Aqqaluk ('12-'31)



Main Pit – View to Southwest



Aqqaluk – First Blast May 2010



# Closure & Reclamation – Open Pits

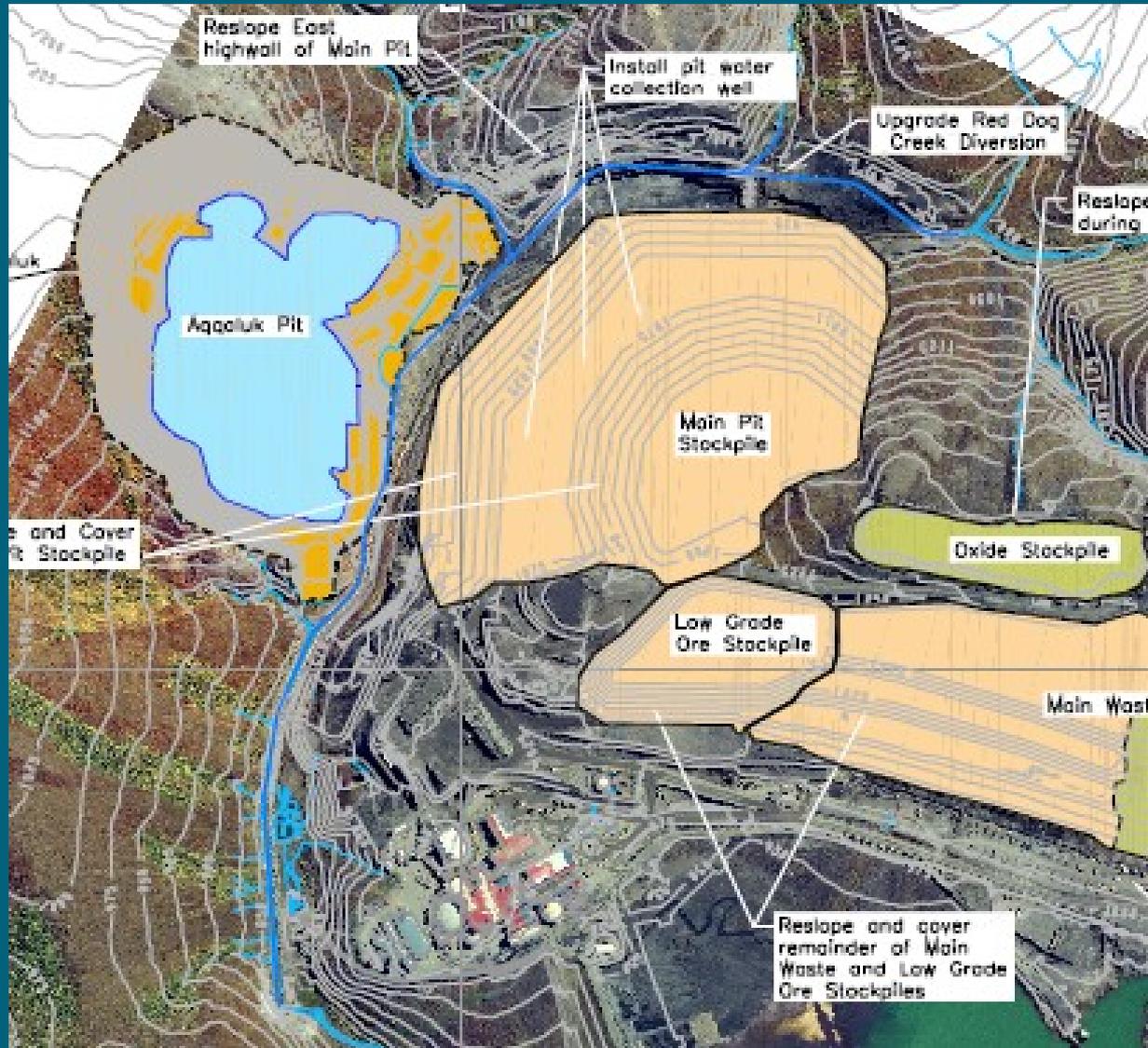
- The Main Pit will be backfilled during operations with waste from the Aqqaluk pit, except the eastern highwall will be blasted back to a 4:1 slope
- Aqqaluk Pit would used to store impacted water and water level managed.
- Wide benches will be covered, revegetated. A berm will be constructed to mark the high wall as a hazard for snow machines.



Main Pit



# Closure & Reclamation – Open Pits



# Mine Operations – Waste Rock

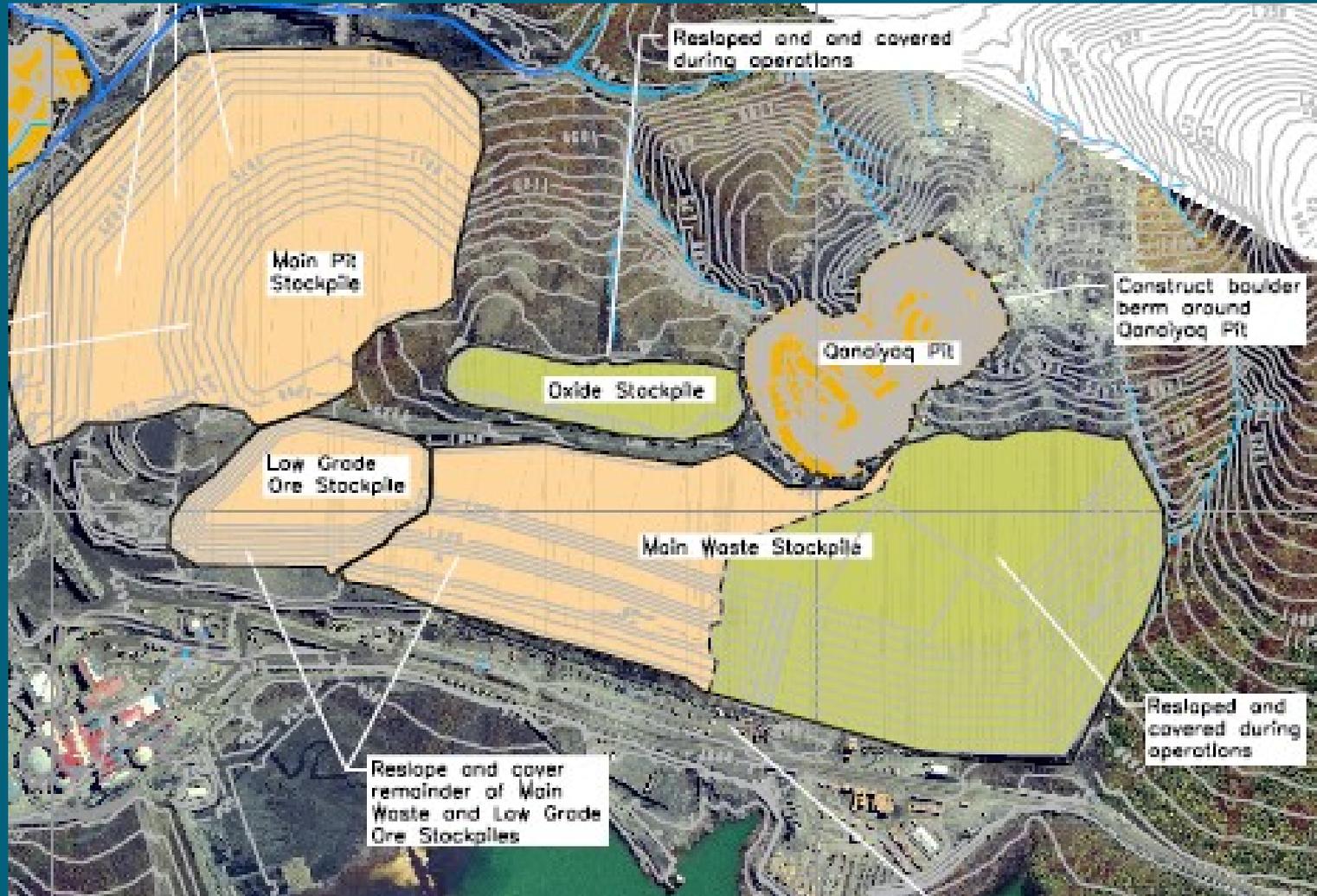
- **18,000 stpd waste (av.)**
  - 7.7Mstpa
- **Main Waste Stockpile**
  - 33M tons '09
  - Add. 29M tons by '31
- **Main Pit Stockpile (refill)**
  - 104M tons by '31
- **Total - 166M tons LOM**
- **Segregate - blast hole assays**
- **High metal content**
  - ~1-4% Zn
  - ~1-2.5%Pb, 2-7.6% Fe
- **Acid generating**
  - Low NP/AP



Main Waste Stockpile



# Closure & Reclamation – Waste Rock Stockpiles



# Closure & Reclamation – Waste Rock Stockpiles

- Waste rock stockpiles will:
  - Recontoured to 3H:1V
  - Final slopes will approximate natural landforms, incorporate swales to channel surface runoff and to minimize the need for engineered channels;
  - Receive a complex soil cover consisting of two 18-inch layers of weathered shale. The lower layer will be compacted to minimize infiltration of water and oxygen into the waste .
  - Re-vegetated with seed mix to stabilize cover while natural species propagate.



# Closure & Reclamation – Waste Rock Stockpiles

## Revegetation Species for Soil Covers

Plant Species		Planting Specifications																
<p>Native-grass cultivars</p> <table> <tr> <td>Primary List</td> <td>Secondary List</td> </tr> <tr> <td>Nortran hairgrass</td> <td>Bering hairgrass</td> </tr> <tr> <td>Tundra bluegrass</td> <td>Arctared fescue</td> </tr> <tr> <td>Alpine bluegrass</td> <td></td> </tr> <tr> <td>Spike trisetum</td> <td></td> </tr> <tr> <td>Thickspike wheatgrass</td> <td></td> </tr> <tr> <td>Polargrass</td> <td></td> </tr> <tr> <td>Bluejoint</td> <td></td> </tr> </table>		Primary List	Secondary List	Nortran hairgrass	Bering hairgrass	Tundra bluegrass	Arctared fescue	Alpine bluegrass		Spike trisetum		Thickspike wheatgrass		Polargrass		Bluejoint		<p>Seeding Rate 20 lb/acre (final mixture). Ratio of species will depend on availability, but mix may include predominantly tundra bluegrass and alpine bluegrass for drier areas and Nortran hairgrass, polargrass, and bluejoint for mesic sites.</p>
Primary List	Secondary List																	
Nortran hairgrass	Bering hairgrass																	
Tundra bluegrass	Arctared fescue																	
Alpine bluegrass																		
Spike trisetum																		
Thickspike wheatgrass																		
Polargrass																		
Bluejoint																		
<table> <tr> <td>Native forbs</td> <td>Other potential species</td> </tr> <tr> <td>Tilesy sage</td> <td>Tall fireweed</td> </tr> <tr> <td>Alpine milkvetch</td> <td>Siberian aster</td> </tr> <tr> <td>Alpine sweetvetch</td> <td>Arctic bladderpod</td> </tr> <tr> <td>Boreal sweetvetch</td> <td></td> </tr> <tr> <td>Field Oxytrope</td> <td></td> </tr> <tr> <td>Boreal yarrow</td> <td></td> </tr> </table>		Native forbs	Other potential species	Tilesy sage	Tall fireweed	Alpine milkvetch	Siberian aster	Alpine sweetvetch	Arctic bladderpod	Boreal sweetvetch		Field Oxytrope		Boreal yarrow		<p>Seeding rate 40 seeds/yd<sup>2</sup> for each species. Ratio of species will depend on availability, but mix may include alpine milkvetch, field oxytrope, Arctic bladderpod, and Siberian aster for dry areas; and tilesy sage, boreal sweetvetch, alpine sweetvetch, tall fireweed for mesic areas.</p>		
Native forbs	Other potential species																	
Tilesy sage	Tall fireweed																	
Alpine milkvetch	Siberian aster																	
Alpine sweetvetch	Arctic bladderpod																	
Boreal sweetvetch																		
Field Oxytrope																		
Boreal yarrow																		

# Closure & Reclamation – Waste Rock Stockpiles Engineered Soil Cover Studies

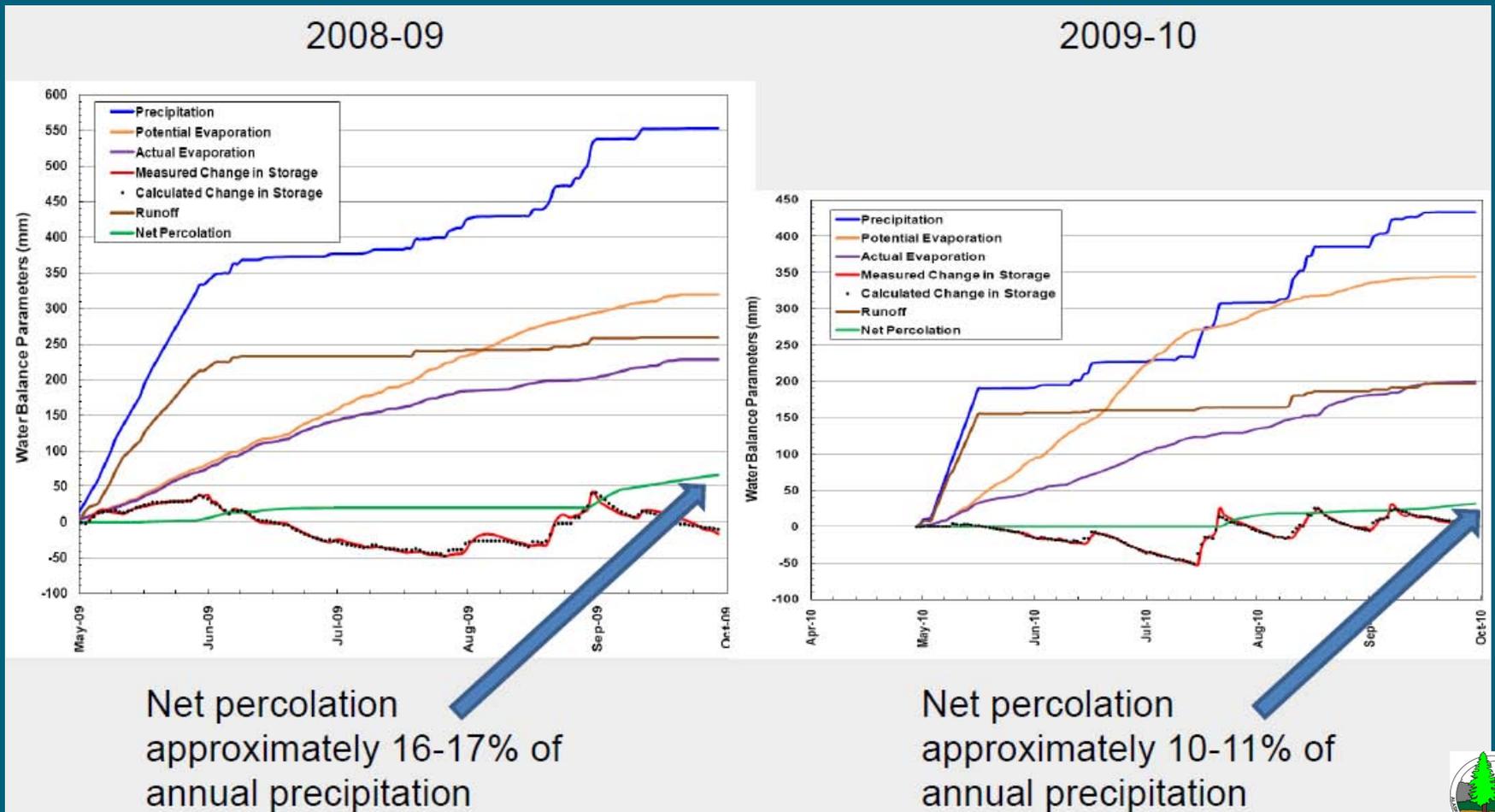
- Soil Cover Test Plots
- 20 more years to study



# Closure & Reclamation – Waste Rock Stockpiles

## Soil Cover Water Balance Fluxes

- West Station, oxide Stockpile



# Closure & Reclamation – Waste Rock Stockpiles Conceptual View

Current View of Main Waste Stockpile



Conceptual View of Re-graded and Reclaimed Main Waste Stockpile Year 2040



# Closure & Reclamation – Waste Rock Stockpiles

## Concurrent Reclamation



# Mine Operations - Tailings

- **2.4Mst tailings placed per yr.**
- **High metal content**
  - Ave. 1.6%Pb, 3.3%Zn, 8.9% Fe
- **Acid generating**
  - Low NP/AP (.005)
- **37Mst placed by '10**
- **87.1Mst by '31**
- **HDPE lined rock-fill dam**
- **Tail water pH 6-7**
- **Pump Back System**
  - ~ 800gpm



# Closure & Reclamation – Tailings

- The tailings area reclamation is based on the “Clean Pond” scenario. The primary objectives are:
  - Covering the tailings with water to restrict oxidation and acid generation (“wet closure”);
  - Managing contaminated water to keep the pond as clean as possible;
  - Ensuring long-term stability of the dams, while minimizing any seepage;



# Closure & Reclamation – Tailings Dam

- The dam will be managed for long term stability as follows:
  - Spillway constructed (in bedrock) to protect against overtopping, will pass a design flood with a flow depth of 1.4 feet; prevent overtopping
  - A 600-ft wide beach to restrict seepage rates to about 550 gpm; and
  - Seepage collection at the toe of the dam will be sent to the Aqqaluk Pit.



# Mine Operations – Water Management

- Surface runoff/waste dumps runoff/dump and pit sump
- 3 WTP
  - #1 – TSF water for mill use
  - #2 – TSF water then to Red Dog Creek
    - (up to 1.5 B gal/yr)
  - #3 Mine sump and waste rock seepage then to TSF
- Lime treatment - metal hydrox & gypsum



# Mine Operations – Water Management

## Mine Water Quality



# Closure & Reclamation – Water Management

- Perpetual seasonal water treatment and discharge but transition to post-closure levels (1.42Bgpa)
- Impacted water directed to Aqqaluk pit
  - (waste rock and dam seepage, surface runoff and precip, main pit wells)
- May include new WTP construction or mods to existing
- WTP 1 becomes available (no mill reclaim from TSF)
- Treatment will require 7.3M tons CaO/yr
- Sludge (after drying) - 69,000 yd<sup>3</sup> per year
- Annual WT costs of \$5.8M



WTP#2 clarifier



# Monitoring during Mining Operations

- **Biomonitoring – water quality, fish, aquatic invertebrates, periphyton**
- **Permafrost and sub-permafrost groundwater monitoring**
- **Mine water management – water balance, load balance**
- **Waste rock management – quantities, geochemistry, placement**
- **Tailings management – quantities, geochemistry**
- **Inert solid wastes – quantities**
- **Reclamation – disturbance, soil properties, reclaimed areas – soil properties, survival**
- **Dust**
- **Wildlife**



# Closure & Reclamation – Monitoring

- **Monitoring Post-Closure**

Post-closure monitoring has no definite endpoint. Many aspects of the existing monitoring will continue, with the possible modifications provided below:

- ***5 Years after Closure***

- Reduce dam stability monitoring, closed waste management facilities, assessment of revegetation success

- ***5 – 30 Years after Closure***

- Reduce permafrost and sub-permafrost gw monitoring, reduce vegetation, erosion monitoring

- ***Beyond 30 years after Closure***

- Further reductions? Permanent staff remains on site

# Closure & Reclamation – Financial Assurance

- Suspension Costs
- Reclamation Costs
- Annual Post-closure Costs
- NPV - Trust Fund Concept (NPV based on 8% ROR, 3.5% inflation, 0.2% mgmt fees = 4.3% ERROR)

Years <i>(after suspension of mining)</i>	Suspension <i>(site maintenance and ongoing water treatment)</i>	Closure Earthwork and other reclamation	Closure Water Treatment	Post-Closure <i>(perpetual annual water treatment)</i>	Yearly Total Cash Flows	Net Present Value <i>(at a 4.3% estimated real rate of return)</i>
1	\$13,290,000				\$13,290,000	\$305,150,000
2	\$13,290,000				\$13,290,000	
3	\$13,290,000				\$13,290,000	
4	\$13,290,000				\$13,290,000	
5	\$13,290,000				\$13,290,000	
6		\$25,900,000	\$7,850,000		\$33,750,000	
7		\$25,900,000	\$7,850,000		\$33,750,000	
8				\$10,540,000	\$255,656,279	

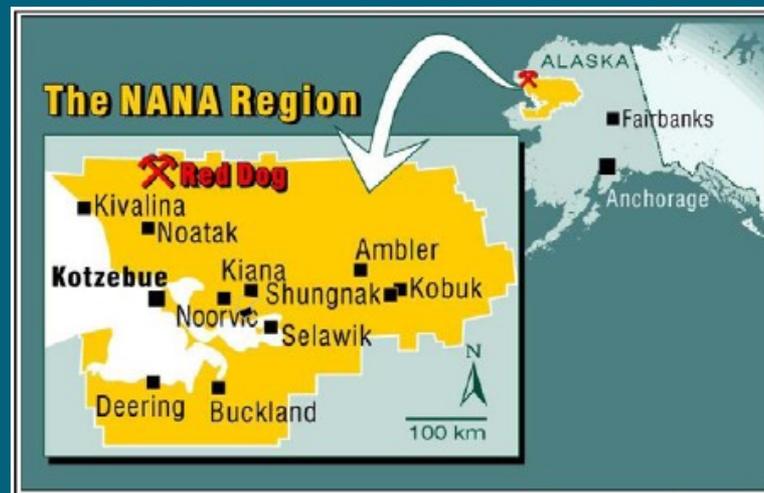


# Reclamation & Closure Plan

## Community Engagement

**NANA owns the Red Dog mineral deposit and the lands surrounding it. NANA is one the largest of 13 Alaska Native regional corporations created under the Alaska Native Claims Settlement Act (ANSCA) by the United States Congress in 1971.**

**Reclamation & Closure at Red Dog is very much a local issue with direct impact on the Native landowners that will depend on continued use of the area for subsistence long after the mine closes.**



# Reclamation & Closure Plan

## Community Engagement

- 50 plus meetings over 5 years –throughout the NANA region,
  - Annual and Community meetings, workshops in '04, '05, '06 ;
- Subsistence Committee, key NANA Staff, and key NANA board members toured reclaimed mines in Canada in 2007.
- Costs for the comprehensive community engagement were fully funded by company. Community input was important to the development of a sound plan.
- Four Processes
  - Analysis – '04 to '07 – identify all reasonable options, R&D, converge on viable options;
  - Information Sharing – '05 to '07 - reports on options, DVD, multiple meetings, calls, and presentations;
  - Feedback and Evaluation –'06 to '07 – 3 sets of multi-stakeholder workshops, DVD with questionnaire, community meetings, Subsistence Committee tour of reclaimed mines in Canada;
  - Approvals – '07 to '09
    - Review, revision of closure plan within NANA and Teck, approval by NANA Board and Red Dog Management Committee; then
    - Review, revision, and approval with State; development and approval of cost estimate; Public meetings, comment period for State Approvals.

# THANKYOU

