Overview: Bonding Requirements for Major Mine Projects

Senate Judiciary Committee Hearing

March 2, 2012

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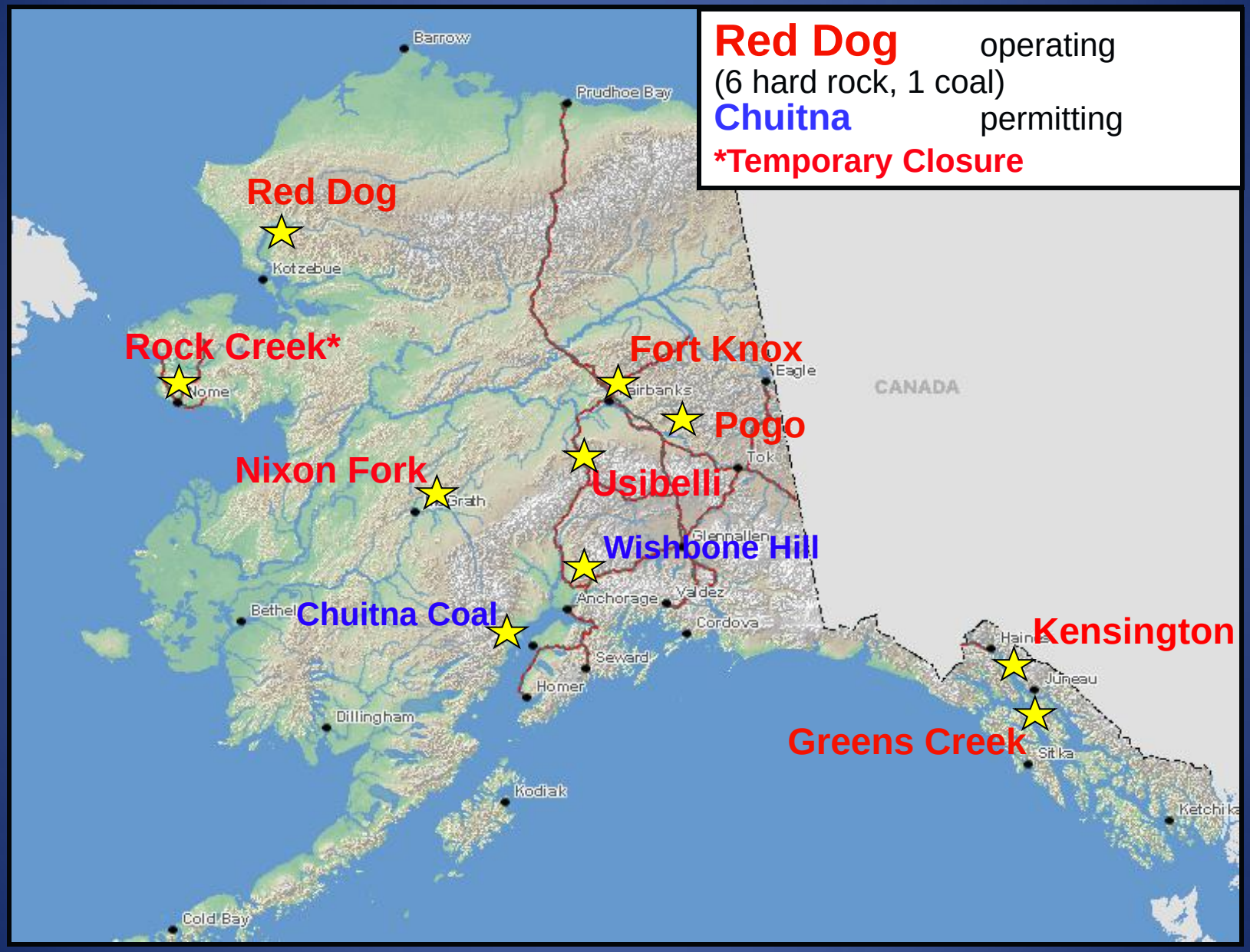
Alaska Department of Natural Resources

Office of Project Management and Permitting

Large mining projects in Alaska



A Brief(!) Mine Permitting Primer

No Single Permit to Mine: there are many permits & authorizations

STATE

- Plan of Operations (DNR)
- Reclamation and Bonding (DNR)
- Waste Management Permits and Bonding (ADEC)
- CWA Section 402 APDES Water Discharge Permit
- Certification of ACOE Permits (ADEC)
- Sewage Treatment System Approval (ADEC)
- Air Quality Permits (ADEC)
- Fish Habitat and Fishway Permits (ADF&G)
- Water Rights (DNR)
- Right of Way/Access (DNR/DOT)
- Tidelands Leases (DNR)
- Dam Safety Certification (DNR)
- Cultural Resource Protection (DNR)
- Monitoring Plan (Surface/Groundwater/Wildlife) (DNR/DEC)

FEDERAL

- US EPA Air Quality Permit review
- US EPA Safe Drinking Water Act (UIC Permit)
- US ACOE Section 404 Dredge and Fill Permit
- US ACOE Section 10 Rivers and Harbors Act
- US ACOE Section 106 Historical and Cultural Resources Protection
- NMFS Threatened and Endangered Species Act Consultation
- NMFS Marine Mammal Protection Act
- NMFS Essential Fish Habitat
- NMFS Fish and Wildlife Coordination Act
- USFWS Threatened and Endangered Species Act Consultation
- USFWS Bald Eagle Protection Act Clearance
- USFWS Migratory Bird Protection
- USFWS Fish and Wildlife Coordination Act

(These are only some of the authorizations required)

State Agencies

(LARGE MINE PERMITTING TEAM)

- Dept of Natural Resources
  --Lead State agency for coordination: AS 27.05.010(b)
- Dept of Environmental Conservation
- Dept of Fish and Game
- Dept of Health & Social Services
- Dept of Law
- Dept of Transportation & Public Facilities
- Dept of Commerce, Community and Economic Development

Federal Agencies

- US Environmental Protection Agency
- US Army Corps of Engineers
- US Fish and Wildlife Service
- National Marine Fisheries Service

Federal Land Managers

- Bureau of Land Management
- US Forest Service
- National Park Service
- US Fish and Wildlife Service

State Large Mine Permitting Team

- Coordinates review of applications and numerous State permit requirements
- Reviews, analyzes, and evaluates complex technical documents for adequacy and soundness
- Benefits from multi-disciplinary expertise of team of experienced professionals (geologists, hydrologists, mining/civil/environmental engineers, biologists, environmental scientists)
- If the Team does not have the expertise, it can hire additional experts.
- Team members conduct mine inspections and evaluate permit updates during operations.
- The Team is involved from pre-permitting to post-closure.

National Environmental Policy Act (NEPA) Process for an Environmental Impact Statement

A means for considering and evaluating alternatives

Not a permit

- Triggered by major federal action (Notice of Intent)
- Contents:
  - proposed project, purpose & need, and project alternatives (must include No Action alternative)
  - description of the affected environment
  - analysis of environmental consequences of proposed project and alternatives
- Designation of Lead Federal Agency & selection of 3rd party contractor to mange the EIS
- Multiple Public Notice and Comment Requirements
- State participates as a Cooperating Agency and works to dovetail its permitting processes with the EIS timetable and public notice requirements

Baseline Studies

- Surface Water Quality & Quantity
- Groundwater Quality & Quantity
- Aquatic Life (Includes Marine & Freshwater Fish, Invertebrates, etc.)
- Wildlife
- Wetlands
- Socioeconomics
- Subsistence
- Traditional Ecological Knowledge
- Cultural Resources
- Air Quality
- Meteorology
- Health Impact Assessment
- Visual Resources
- Noise

State and federal agencies consult in advance with project applicants to help ensure the right information is collected

Monitoring Plans & Environmental Audits

- Air Qual, Water Qual, Fish & Wildlife are monitored according to approved plan
- Environmental Audits on 5 year schedule tied to re-crafting & reissuance of permits
- All environmental systems audited
- Audits evaluate Agencies as well as operations
- Audits by 3rd party experts
- Financial Assurances revisited and recalculated based on Audit results

Summary

- Many permits required, many state/federal agencies involved
- Experienced agency professionals involved in permitting and regulation
- Third-party experts utilized if agencies don't have the expertise
- Comprehensive analysis of potential environmental, socioeconomic, and health impacts for each project
- Air, Water, Fish & Wildlife Monitoring required
- Financial assurances are required and regularly updated

Financial Assurances
i.e., Bonding

Underlying Philosophy

- At no time is the financial assurance to be less than the amount required by the State to complete reclamation
- The bond amount can be increased any time the mine is shown to have inadequate financial assurance.

Authorities

- Reclamation Bonding is required in Alaska (AS 27.19) for mining projects
  - State reclamation standards apply to state, federal, municipal, and private lands and waters subject to mining
  - The bond is based on a Reclamation Plan that must be approved by the DNR prior to mining (AS 27.19.030)
  - DEC has separate bonding requirements that can be included with the DNR into a single bond.

Reclamation Standard (AS 29.19.020)

"A mining operation shall be conducted in a manner that prevents unnecessary and undue degradation of land and water resources, and the mining operation shall be reclaimed as contemporaneously as practicable with the mining operation to leave the site in a **stable condition**."

Reclamation Performance Standards (11 AAC 97.200-240)

- Return waterborne soil erosion to pre-mining levels in one year.
- Achieve revegetation, where feasible, in five years without reseeding or fertilizer
- Topsoil is to be salvaged, stockpiled and protected for later use in reclamation
- Surface contours are to be made conducive to natural revegetation
- Site shall be reclaimed such that it retains sufficient moisture for natural revegetation
- **Stream channels disturbed need to be reestablished in a stable condition or location**
- Pit and quarry walls and subsidence features need to be made stable.
- Buildings and structures are to be removed unless authorized to stay.
- Scrap iron, equipment, tools, piping, hardware, chemicals, fuels, waste, and general construction debris are to be removed or properly disposed.
- Facilities associated with heap leach facilities are to be reclaimed.
- Underground openings are to be sealed after closure.
- "A miner shall reclaim a mined area that has potential to generate acid rock drainage (acid mine drainage) in a manner that prevents the generation of acid rock drainage or prevents the offsite discharge of acid rock drainage."

Reclamation Plan General Elements

11 AAC 97.310

- Property descriptions and maps
- Description of mining plan and schedule
- Reclamation measures for treatment of:
  - Topsoil and revegetation
  - Tailings ponds, reservoirs, dumps, pits, etc.
  - Stream replacement
  - Roads, airstrips, and access
  - Buildings

Bonding Statute (AS 27.19.040)

- Bond amount not to exceed an amount reasonably necessary to ensure performance of the reclamation plan
- DNR Commissioner shall establish the bond amount
- A cooperative management agreement with the Federal agencies (land manager) or another State agency is allowed

DEC Statute AS46.03.100(f) for Waste Management and Disposal

- Financial assurance required for closure and monitoring:
  - Of a solid waste facility with chemical treatment of ores (tailings and rock dumps)
  - Of a facility with potential to generate or generates Acid Rock Drainage

Bond Calculation Elements

- Calculation needs to agree with Reclamation and Closure Plan and include inflation.
- Rental Equipment to be used at current rates – quotes required
- Labor with burden at little Davis-Bacon rates
- Mob-Demob estimated for the site (not % of directs)
- Salvage value of buildings and equipment cannot be utilized
- Includes water treatment and post closure monitoring
- Indirect costs include: engineering redesign, contingency, contractor profit, agency administration costs, etc.

Updates to the Financial Assurance Package

- At least every 5 years when permits are renewed
- After an environmental audit
- Upon significant mine design changes that would affect the bond calculation
- Major changes in prices of fuel or consumables
- Anytime it is believed that the project is under-bonded

Bonding Instruments – Large Mines
(11 AAC 97.4)

- Performance Bond to be placed with DNR
  - Corporate Surety Bond
  - Personal Bond accompanied by:
    - Letter of Credit
    - Certificate of Deposit
    - Deposit of cash
    - Deposit of gold bullion (25% greater than bond am't)
  - General Performance Bond
  - Payments to the Mine Reclamation Trust Fund (AS 37.14.800)
- Interest earned may stay with the bond

Financial assurances are based on a detailed engineering analysis

Teck-Pogo Inc.
teckcominco

Reclamation & Closure Plan Update

Table F.1: Demolition Hourly Labor Wage Rages

Description		General Demolition Crew	Mechanical Crew	Heavy Equipment Operator	Electrical Crew	Foreman	Laborer
Base Hourly Rate - straight time		$26.55	$26.04	$27.77	$30.83	$30.55	$23.43
Overtime for 50 hour week	10.0%	$2.66	$2.60	$2.78	$3.08	$3.06	$2.34
Adjusted Hourly Base Rate		$29.21	$28.64	$30.55	$33.91	$33.61	$25.77
Social Security, Medicaid, Unemployment, Liability, and Workers Comp Insurance	21.7%	$6.34	$6.22	$6.63	$7.36	$7.29	$5.59
Total Direct						40.90	$31.37
Labor Indirec						$4.87	$3.74
Benefits - per						$8.24	$6.32
Field Overhe						$3.00	$3.00
Small Tools A						$8.00	$8.00
Camp and/or						24.11	$21.06
Total Indirec							
Total Hourly						65.01	$52.42

Teck-Pogo Inc.
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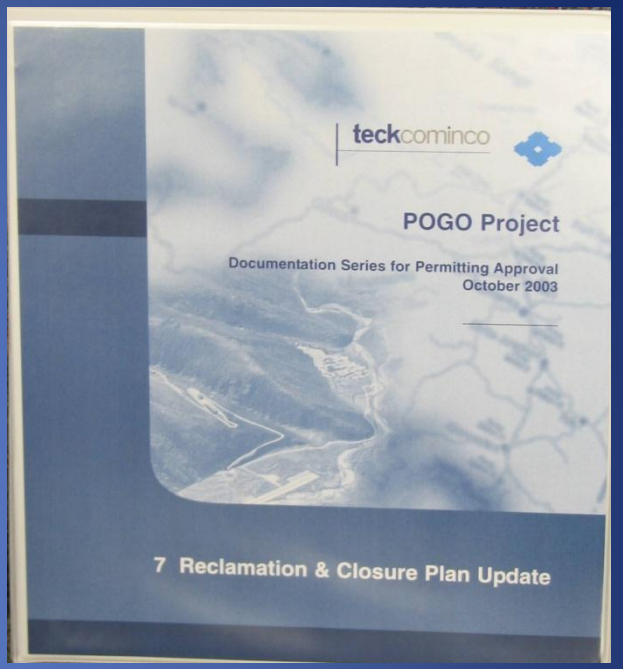
Reclamation & Closure Plan Update

Table F.2: Hourly Equipment Rates ($)

Equipment	Equipment Lease Rate	Maintenance & Fuel	Support & Transport	Total
Excavator 330	31.00	52.00	16.60	100.00
Excavator 375L	48.00	89.00	27.40	164.00
Excavator 235	31.00	52.00	16.60	100.00
Dozer D10R	73.00			
Dozer D8R	42.00			
D6R Dozer	30.00			
Grader 16G	34.00			
Water Truck	20.00			
Tamrock Drill	48.00			
Shotcrete Machine	20.00			
Picker Truck	30.00			
Re-seeding	15.00			
Shear on 375L	65.00			
FE Loader 950	30.00			
FE Loader 980G	45.00			
FE Loader 992C	62.00			
Dump Truck 14Cy	25.00			
Self Load Flat Bed	50.00			
Low Bed Truck	35.00			
Dump Truck 17cy	31.00			
Crane Truck 20T	45.00			
Crane Truck 50T	70.00			
Track Skidder 528	50.00			



amec

POGO: RECLAMATION COST ESTIMATE (SEPTEMBER 2003)

Project Number: U419F
Currency: USD 4Q2002

Description	Qty	Unit	Unit Direct Hr	Total Direct Hr	TotalDirect Lab Cost	Unit Mat	Total Mat Cost	Unit Sub	Total Sub Cost	Unit Equip	Total Equip Cost	Total Cost
Phase I: Post-Construction				4,988	287,345		13,213		26,400		156,977	483,935
Phase II: Reclamation Concurrent with Mining												
A-07 WELLS				115	6,294		1,200		0		0	7,494
A-09 GRAVEL PADS				363	21,312		900		0		25,013	47,224
A-12 ROCK PILES				2,928	165,891		0		0		197,786	363,677
A-13 LINERS UNDER ROCK PILES				629	35,340		0		0		41,040	76,381
A-14 PADS UNDER ROCK PILES				340	19,996		870		0		23,860	44,726
A-15 EXPLOSIVES STORAGE				406	23,515		0		0		10,904	34,418
R-01 SURFACE BOREHOLES				2,000	114,060		50,000		0		31,260	195,320
S-00 WATER QUALITY ASSURANCE				0	0		0		10,000		0	10,000
Phase II: Reclamation Concurrent with Mining				6,781	386,408		52,970		10,000		329,862	779,241

Financial Assurances for Alaska Mines

Audited & recalculated every 5 years
or when significant changes occur

Operation	***Total Bond ($ Millions)*** *29Feb2012*
Greens Creek Mine	$30.5
Red Dog Mine	$304.5
Fort Knox (& True North) Mine	$37.6
Usibelli Coal Mine & Exploration	$11.6
Kensington Project	$7.4
Rock Creek Mine	$6.8
Pogo Mine	$49.2
Nixon Fork Mine	$3.5
TOTAL	$451.1

Alaska Dept. of Fish & Game specific roles/authorities

Title 16 Permits

Fishway & Fish Habitat

Issued by ADFG

Div. of Habitat

- AS 16.05.841: Fishway Act

For activities within or across a stream used by fish that could represent an impediment to the efficient passage of fish. e.g., culverts; water withdrawals; stream realignments or diversion; dams; low-water crossings; and construction, placement, deposition, or removal of any material or structure below **ordinary high water**

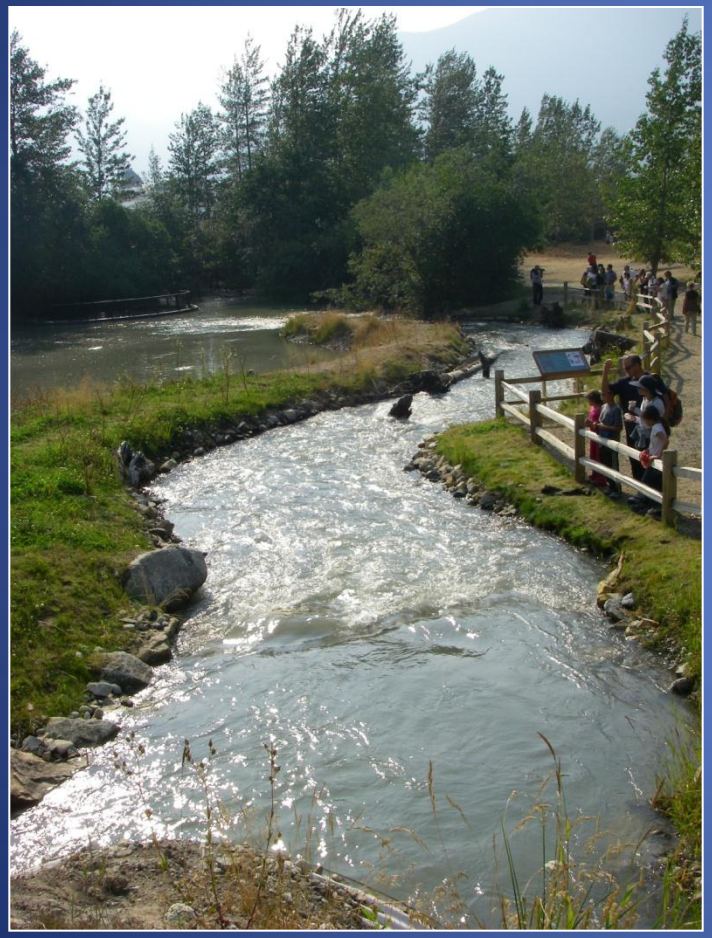
- AS 16.05.871: Anadromous Fish Act

All activities within or across a specified anadromous waterbody and all instream activities affecting a specified anadromous waterbody require approval from the OHMP, including construction; road crossings; gravel removal; mining; water withdrawals; the use of vehicles or equipment in the waterway; stream realignment or diversion; bank stabilization; blasting; and the placement, excavation, deposition, or removal of any material.

ADF&G Project Permitting

- Activities associated with large project development that would typically require permits from the ADF&G include:
  - Fish Habitat Permits for:
    - Construction of fish barriers (i.e., dams);
    - Flow reduction;
    - Bridges, culverts, buried pipelines, etc.;
    - Water withdrawal and intake structures;
    - Stream re-alignment; and
    - Instream mitigation projects.
  - Fish Resource Permits from the Sport Fish and Commercial Fish Divisions associated with project monitoring.

Avoid - Minimize - Mitigate



- Examples of mitigation projects that may be appropriate for large projects include:
  - Construction of wetland complexes;
  - Fish habitat improvement projects
  - Riparian planting of native species;
  - Clean-up of old abandoned sites in the area; and
  - Bank stabilization.

Coal Specific Requirements

per Alaska Surface Coal Mining Control and Reclamation Act (ASCMCRA)
AS 27.21 & 11 AAC 90

Fish and Wildlife Protection Plan

11 AAC 90.081

- (a) Each application must include a plan to prevent or minimize disturbance and adverse impacts on fish, wildlife, and related environmental values in accordance with 11 AAC 90.423, including impact control measures, management techniques, and monitoring methods to protect, enhance, or mitigate the following, if they can reasonably be expected to be affected by the proposed activities:
  - (2) important species, as determined by the commissioner, including fish and game of economic, recreational, or subsistence importance; eagles, migratory birds, other animals protected by state or federal law, and their habitats; and
  - (3) habitats of unusually high value for fish or wildlife.

- (b) Except as provided in (c) of this section, the plan must include protective measures to be used during the active mining phase of the operation, and enhancement measures to be used during the reclamation and postmining phases of the operation to develop aquatic and terrestrial habitats.

Coal Regulatory Program consults with ADF&G Habitat to accomplish the above

Reclamation Bonding

- The ASCMCRA requires under 11 AAC 90.201 - 213 that, as a prerequisite for obtaining a coal mining permit, a person must post a reclamation bond to ensure that the regulatory authority will have funds to reclaim the site if the permittee fails to complete the reclamation plan approved in the permit.
- Reclamation performance bonds are posted to cover all operations during the term of the permit. Prior to permit issuance, the permittee must post a bond to cover one of the following areas:
    - The entire permit area;
    - The initial area of land to be affected under a cumulative bond schedule; or
    - The initial area of land to be affected under an incremental bond schedule.

Bond Amount

- Minimum bond amount based on regulatory authority's independent analysis of the amount that would be necessary for a third party to complete the reclamation plan in the event of bond forfeiture.
- The bond amount generally reflects reclamation costs at the projected point of maximum reclamation liability (usually the point of maximum disturbance) within the permit area or an initial increment of that area.
- Bond updated prior to additional disturbance or when cost of reclamation increases

Bond Release

- When all reclamation requirements of the approved permit and regulatory program have been met, the regulatory authority may release the reclamation bond.
- Permittee may apply for release of the bond on all or part of the permit or increment as reclamation is completed. (Encourages concurrent reclamation)
- Regulations recognize three discrete phases of reclamation for purposes of bond release.
  - Phase I – Backfilling, grading, and drainage control (60% of total bond)
  - Phase II – Replacement of topsoil and the establishment of vegetation (~30% of total bond)
  - Phase III – Completion of all surface coal mining and reclamation activities

End of Presentation

Questions?

Coal Regulatory Program
Additional Informational Slides

Additional Coal Regulatory Info

- One of the purposes of the Alaska Surface Coal Mining and Control Act (AS 27.21) is to assure that reclamation of land on which surface coal mining takes place is accomplished as contemporaneously as practicable with the surface coal mining activity, and to assure that the rights of surface landowners and other persons with an interest in the land are protected.
- Alaska Statute 27.21.160 requires that, prior to permit issuance, the applicant file a performance bond, sufficient to cover the cost of reclamation in accordance with the approved reclamation plan.

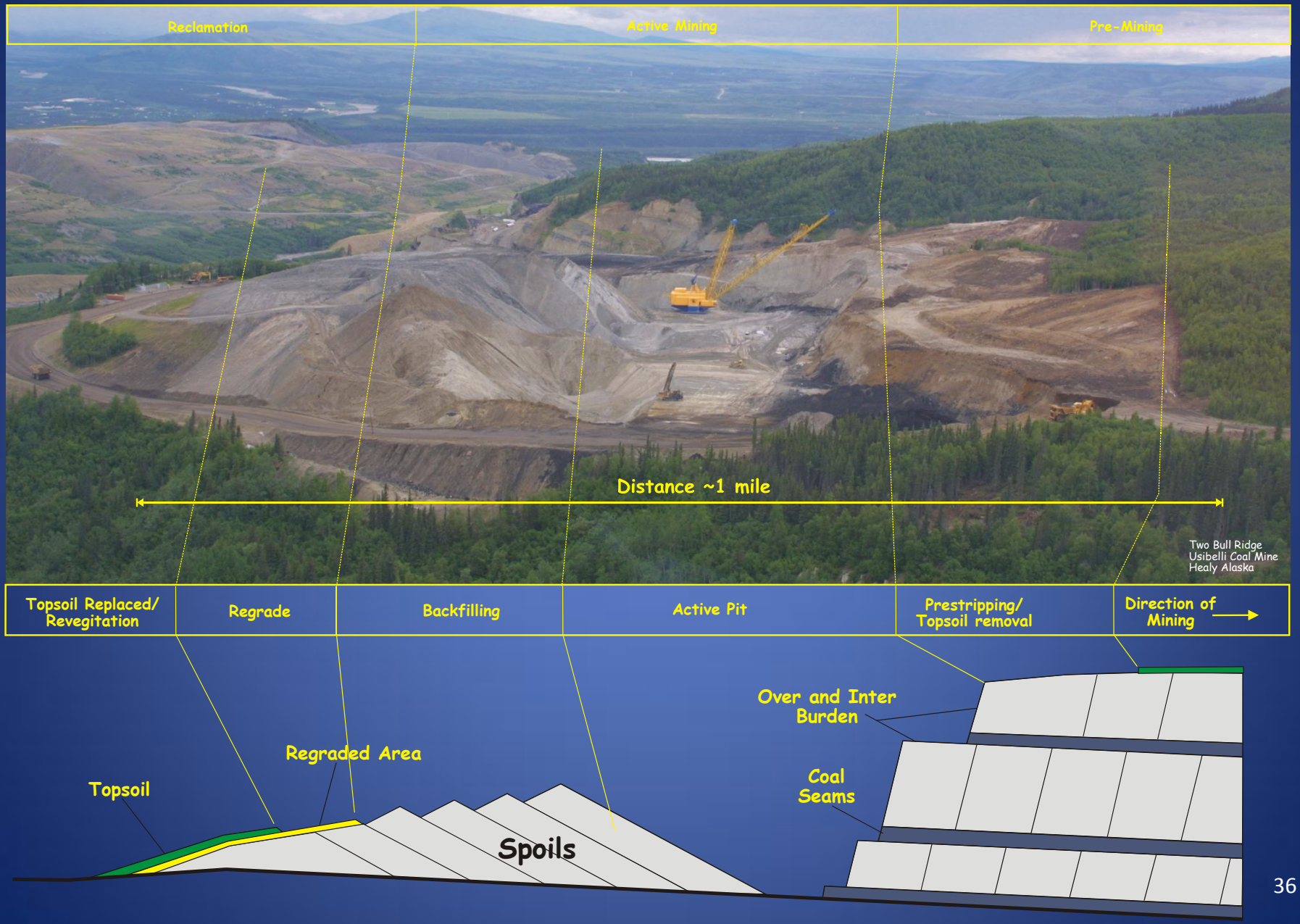
Additional Coal Regulatory Info (Cont.)

- 11 AAC 90.083. RECLAMATION PLAN GENERAL REQUIREMENTS. (a) Each application must contain a plan for reclamation of the proposed permit area showing how the applicant will comply with 11 AAC 90.301 - 11 AAC 90.501. The plan must include, at a minimum, all information required under 11 AAC 90.083 - 11 AAC 90.101.

Additional Coal Regulatory Info (Cont.)

- The reclamation plan must contain a detailed description of the intended post mining land use, including how the proposed post mining land use will be achieved.
- The description must be accompanied by comments concerning the proposed use by the legal or equitable owner of record of the surface of the proposed permit area and state and local government agencies which would have to initiate, implement, approve, or authorize the proposed land use following reclamation.

Reclamation Practices



First steps: Environmental resource Information (baseline Studies)

- Hydrology and geology
  - (11 AAC 90.043-045)
- Ground water information
  - (11 AAC 90.047)
- Surface water information
  - (11 AAC 90.049)
- Alternative water supply information
  - (11 AAC 90.051)

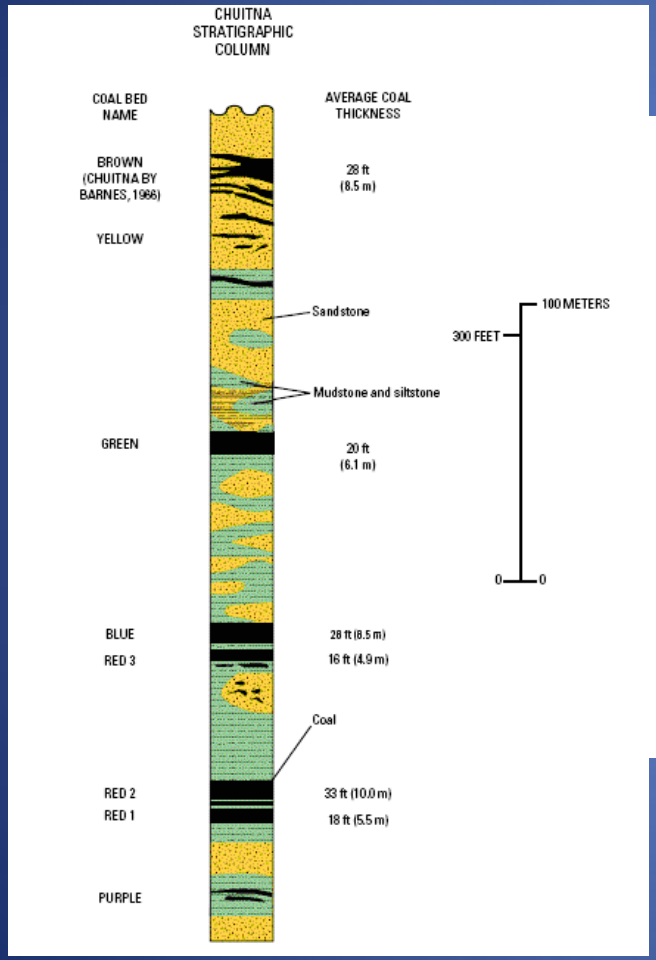
11 AAC 90.043. HYDROLOGY AND GEOLOGY

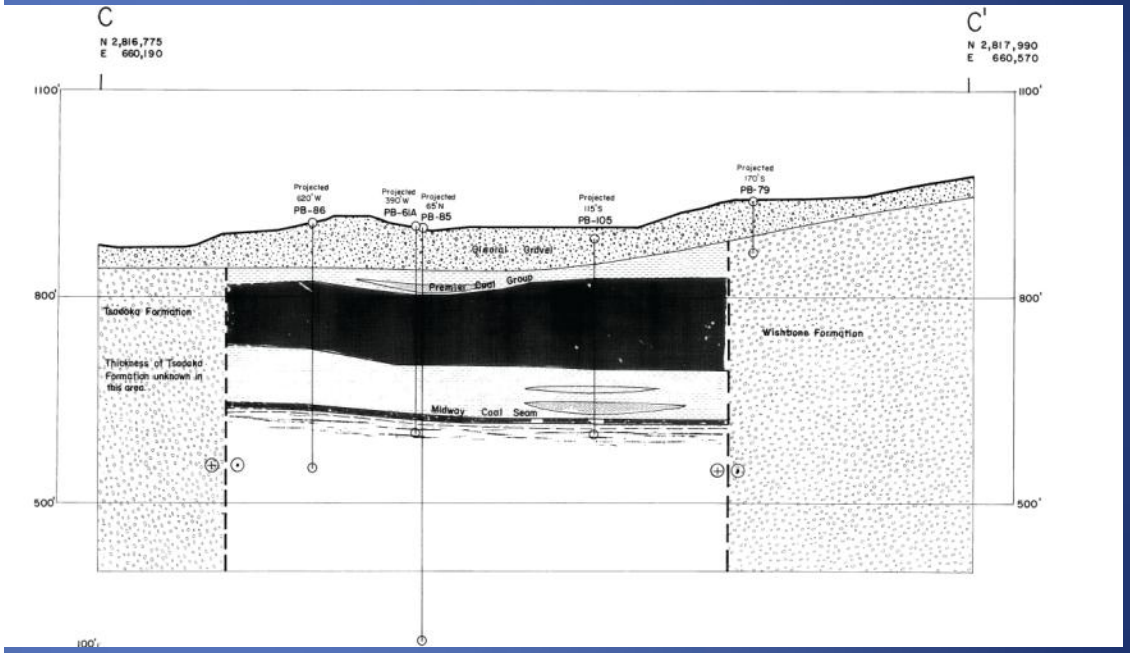
(a) Each application must describe the geology, hydrology, and water quality and quantity of all land within the permit area, adjacent area, and the general area. The description must include information on the characteristics of all surface and ground water within the general area and any other water that will flow into or receive discharge of water from the general area.

(b) All water quality analyses performed to meet the requirements of this section, 11 AAC 90.047, or 11 AAC 90.049 [,] must be conducted according to the methodology in *Standard Methods for the Examination of Water and Wastewater, 21st edition,* adopted by reference in 11 AAC 90.001(c), or the methodology in 40 C.F.R. Part 136 and 40 C.F.R. Part 434, adopted by reference in 11 AAC 90.001(b).

(c) Information on hydrology, water quality and quantity, and geology related to hydrology of the area outside the proposed permit area and within the general area will be provided by the commissioner to the extent that the data are available from an appropriate federal or state agency. The permit will not be approved without this information unless the commissioner determines that the information is not necessary to determine the impact the proposed operation will have on environmental and other resources within the permit area and general area.

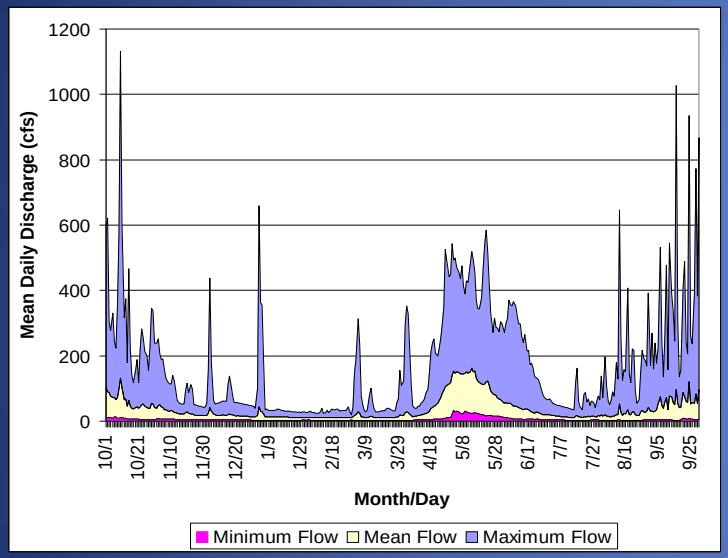
Geology

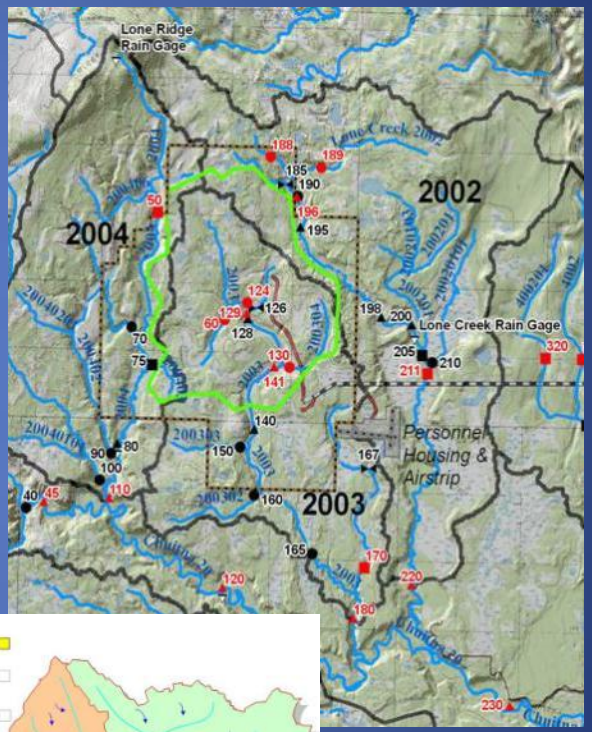

CHUITNA
STRATIGRAPHIC
COLUMN
COAL BED
NAME
AVERAGE COAL
THICKNESS
BROWN
(CHUITNA BY
BARNES, 1966)
28 ft
(8.5 m)
YELLOW
Sandstone
Mudstone and siltstone
100 METERS
300 FEET
0
0
GREEN
20 ft
(6.1 m)
BLUE
28 ft (8.5 m)
RED 3
16 ft (4.9 m)
Coal
RED 2
33 ft (10.0 m)
RED 1
18 ft (5.5 m)
PURPLE

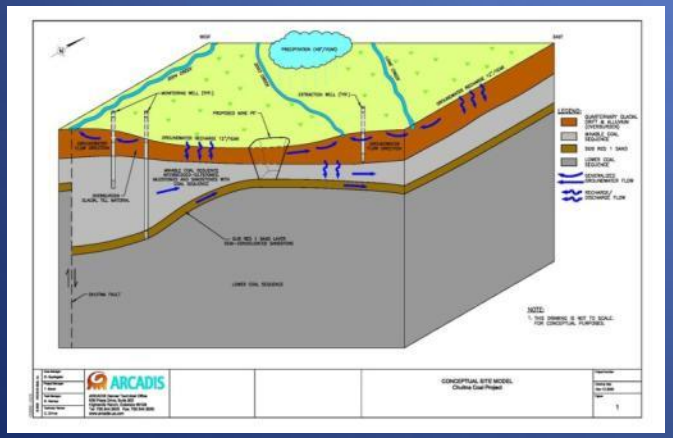

C
N 2,816,775
E 660,190
C'
N 2,817,990
E 660,570
1100'
800'
500'
Projected
620' W
PB-86
Projected
390' W
PB-6IA
Projected
65' N
PB-85
Projected
115' S
PB-105
Projected
170' S
PB-79
Glacial Gravel
Premier Coal Group
Tsadaka Formation
Thickness of Tsadaka
Formation unknown in
this area
Wishbone Formation
Midway Coal Seam

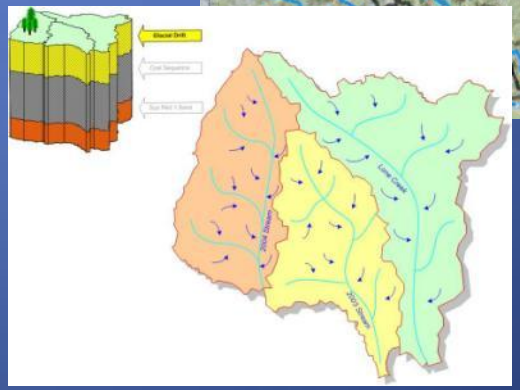
Surface & Groundwater Hydrology and Hydrogeology

Daily Flow Variation at Station 180 – 2003 Creek









Water Quality

		Station 141 on 2003 Creek									
	TSS	Hardness	Al - T	Cu - T	Cu - D	Fe - T	Fe - D	Mn - T	Mn - D	Zn - T	Zn - D
Date	mg/L	mg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
Aug-06	10	20	180	1	< 1	1,420	860	90	100	6	6
Feb-07	< 5	40	50	< 1	< 1	3,170	1,520	270	210	< 5	< 5
May-07	23	20	530	< 1	< 1	3,590	1,670	170	100	8	< 5
Jul-07	< 5	30	50	< 1	< 1	3,350	1,740	230	210	< 5	< 5
Oct-07	< 5	10	100	< 1	< 1	1,280	870	70	< 10	< 5	< 5
Feb-08	< 5	30	60	< 1	< 1	2,910	1,450	220	220	< 5	< 5
May-08	11	< 10	130	< 1	< 1	480	250	80	70	< 5	< 5
Aug-08	< 5	20	60	< 1	< 1	3,090	970	350	340	< 5	< 5
Sep-08	8	< 10	140	1	< 1	930	610	40	< 10	< 5	< 5

First steps: Environmental resource Information (Cont.)

- Climatological information
  - (11 AAC 90.053)
- Vegetation information
  - (11 AAC 90.055)
- Fish and wildlife information
  - (11 AAC 90.057)
- Soil resources information
  - (11 AAC 90.059)
- Land use information
  - (11 AAC 90.061)

Climatological
(Local and Regional Weather Data)

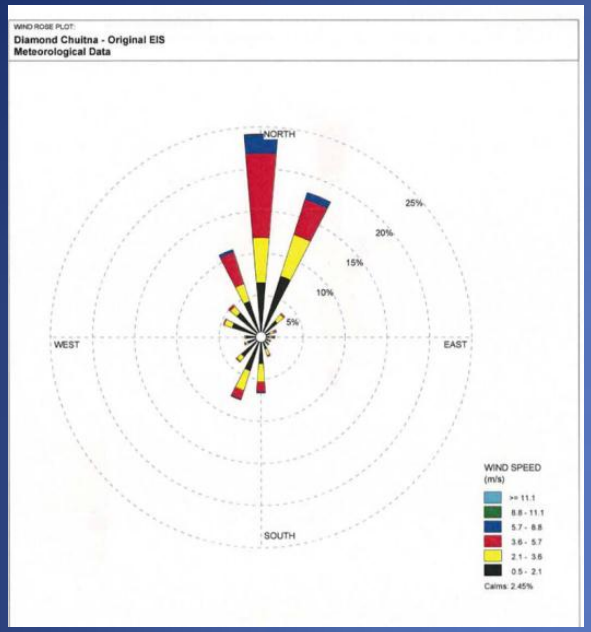
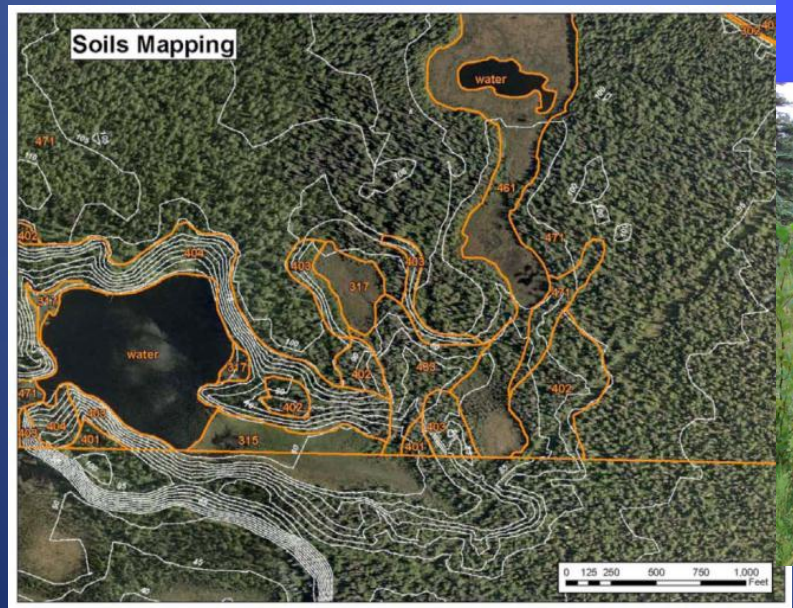


Table 5.2c **AVERAGE SNOW DEPTH AND SNOW WATER EQUIVALENT FIRST OF MONTH MEASUREMENTS (INCHES)**

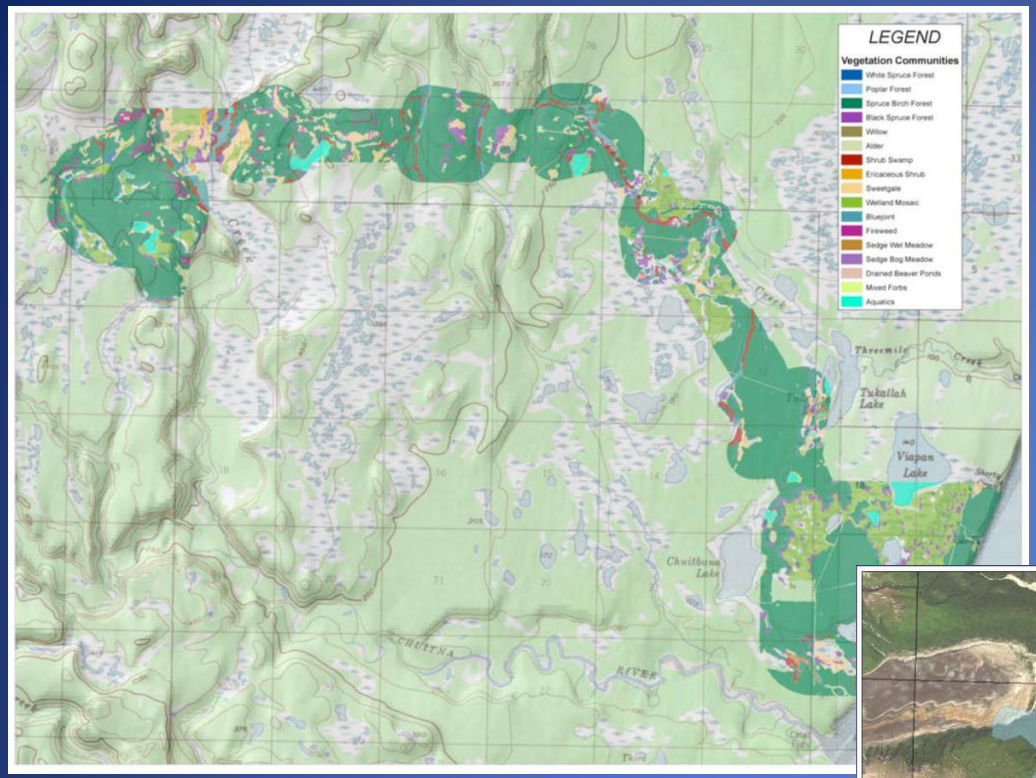
Station	POR	February		March		April		May	
		depth	swe	depth	Swe	depth	swe	depth	swe
Chuitna Plateau	1982-2005	62.0	21.2	69.0	24.7	71.0	28.2	70.0	29.4
	# years in avg	11	11	23	23	23	23	9	9
Congahbuna Lake	1982- 2005	30.0	7.7	34.0	9.3	37.0	11.2	25.0	8.5
	# years in avg	14	14	23	23	24	24	11	11
Lone Ridge	1983-2005	68.0	23.3	80.0	28.9	84.0	31.6	64.0	34.9
	# years in avg	6	6	21	21	20	20	6	6
Granite Point	1982-2004	20.0	5.4	20.0	5.2	17.0	5.3	4.0	1.4
	# years in avg	11	11	22	22	23	23	6	7
Heartbreak Hill	1983-1987	45.0	11.5	53.0	14.7	50.0	16.1	37.0	14.1
	# years in avg	4	4	4	4	4	4	4	4
Hunt Creek	1983-1987	49.0	13.5	56.0	16.4	54.0	17.7	46.0	17.6
	# years in avg	4	4	4	4	4	4	3	3
Lone Creek	1983-1987	34.0	8.2	42.0	10.6	39.0	11.6	33.0	12.8
	# years in avg	4	4	4	4	4	4	3	3
Capps Plateau	1982-1987	68.0	33.3	93.0	39.7	46.0	38.4	57.0	48.6
	# years in avg	6	6	6	6	7	7	6	6

Soils

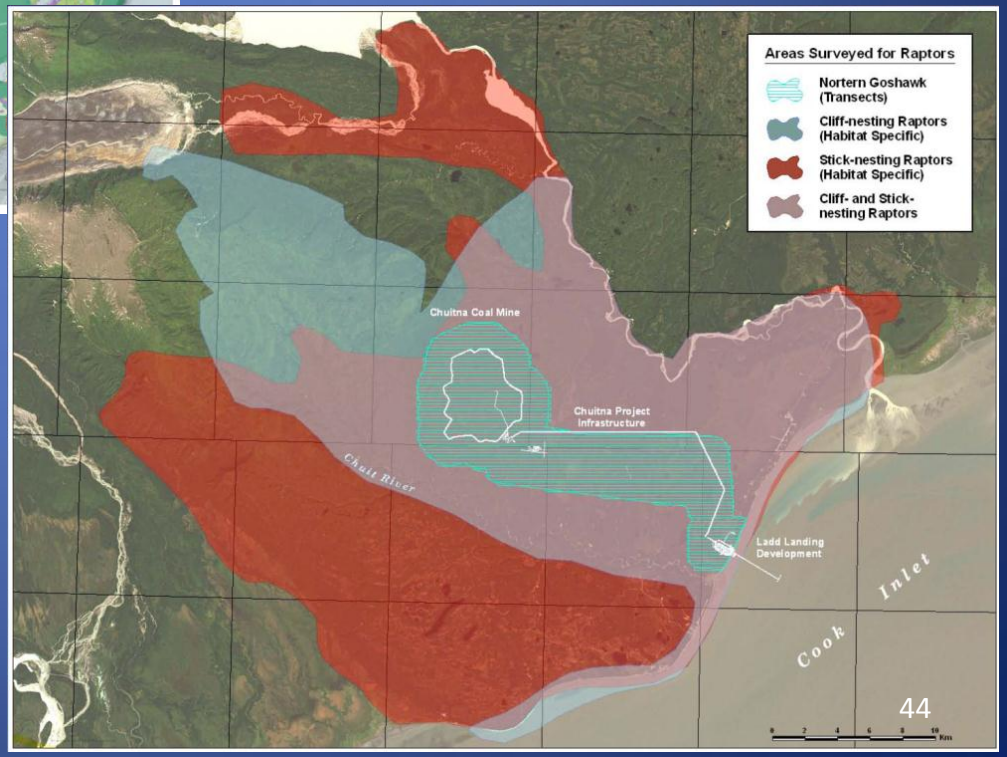


Wetland Organic Soils, MU 310
Chichantna Muck

Vegetation& Wetlands



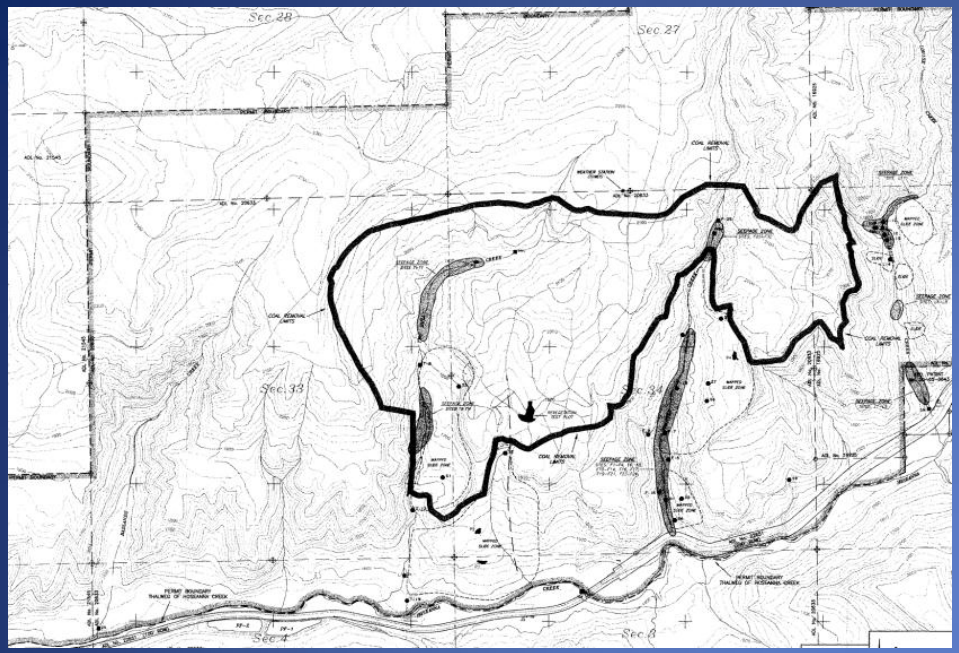
Fish & Wildlife

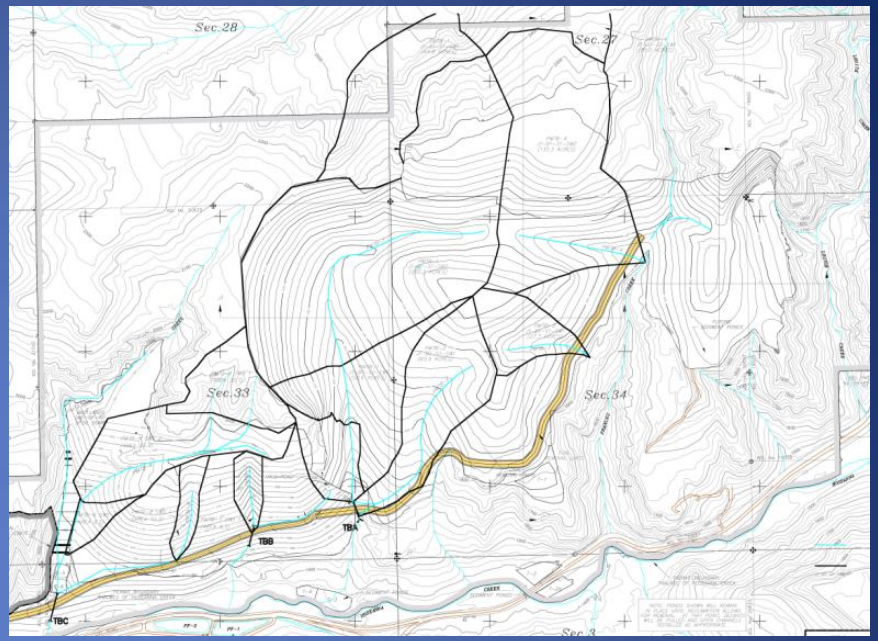


Pre- & Post- Mining Topography Approximate Original Contour (AOC)

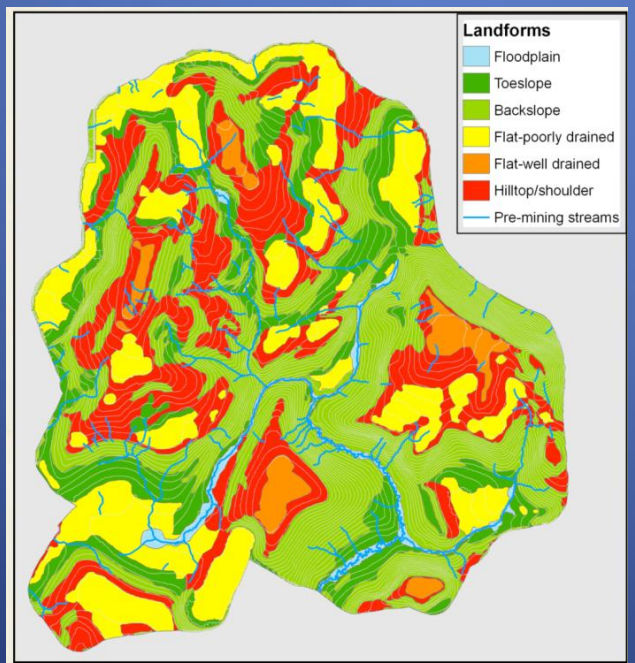
- Means that surface configuration achieved by backfilling and grading of the mined area so that the reclaimed area, including any terracing or access roads, closely resembles the general surface configuration of the land before mining and blends into and complements the drainage pattern of the surrounding terrain in accordance with the performance standards of this chapter.

Pre- & Post- Mining Topography





Post-mining vegetation

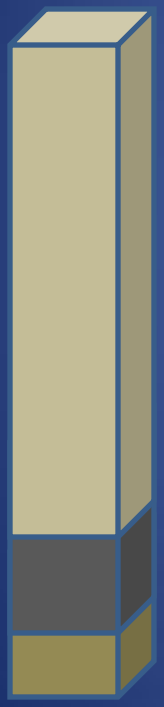


Landform	Slope Range (%)	Actively Reclaimed Communities	Communities That Will Establish Naturally	Postmine Topo (%)
Hilltop and shoulder	0-25	Mixed forest	Alder scrub Bluejoint meadow Fireweed meadow	23
Backslope	7-25	Mixed forest	Alder scrub Bluejoint meadow Fireweed meadow	37
Drainage	0-25	Shrub swamp in shallower, less sloping drainages. Forest in more incised, steeper drain ages.	Bluejoint meadow Alder	**
Toeslope	0-7	Shrub swamp Low scrub	Bluejoint meadow Wet mixed forests may develop	15
Flat, well - drained	0-3	Mixed forest	Alder scrub Bluejoint meadow Fireweed meadow	3
Flat, poorly drained	0-3	Low scrub Sedge meadow Vegetated pond	Shrub swamp Bluejoint meadow	20
Depression	0-3	Sedge meadow Vegetated pond	Shrub swamp Bluejoint mead ow	**
Floodplain	0-3	Shrub swamp Sedge meadow	Bluejoint meadow	2

** Drainages a nd depressions are part of meso scale topography created during backfilling and grading; they are not mapped on the post -mining topography.

Swell Factor

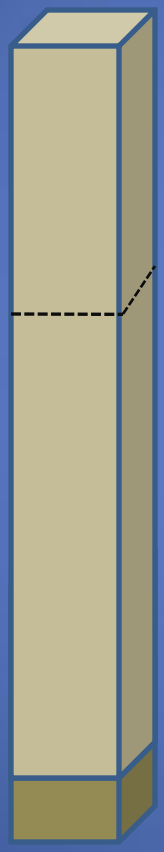
60% initial swell volume
25% final swell Volume



4 cuyd Sandstone
(12'X3'X3')

1 cuyd Coal
(3'X3'X3')

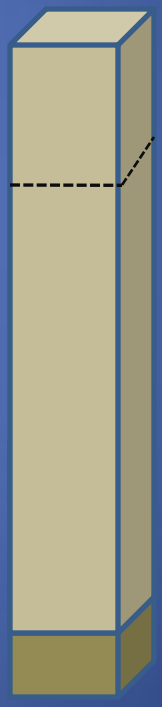
Undisturbed



1.4 cuyd add. volume
(4.2'X3'X3')

Total volume
of 6.4 cuyd of
loose sandstone

Initial Swell Volume

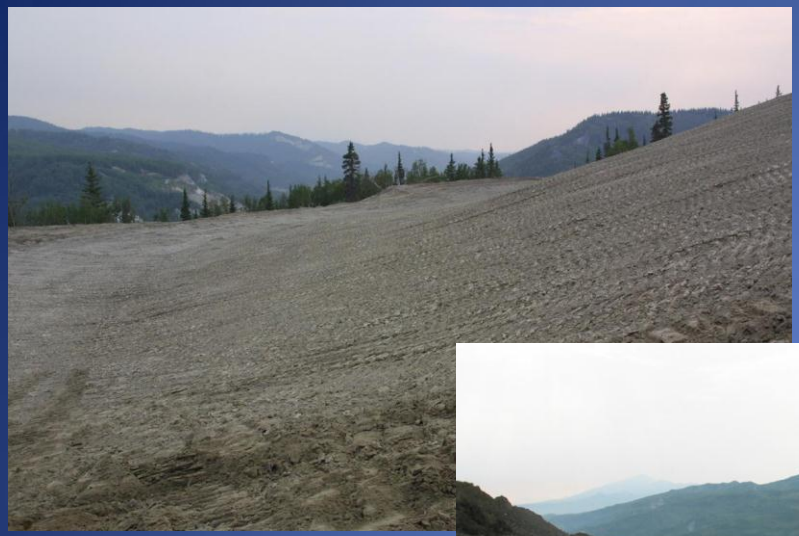


1 cuyd add.
volume

Total volume
of 5 cuyd of
loose
sandstone

Final Swell Volume

Backfilling and Regrading



Topsoil Placement

Seeding