Rock Management & ARD Mitigation at a Northern Minnesota Highway Realignment

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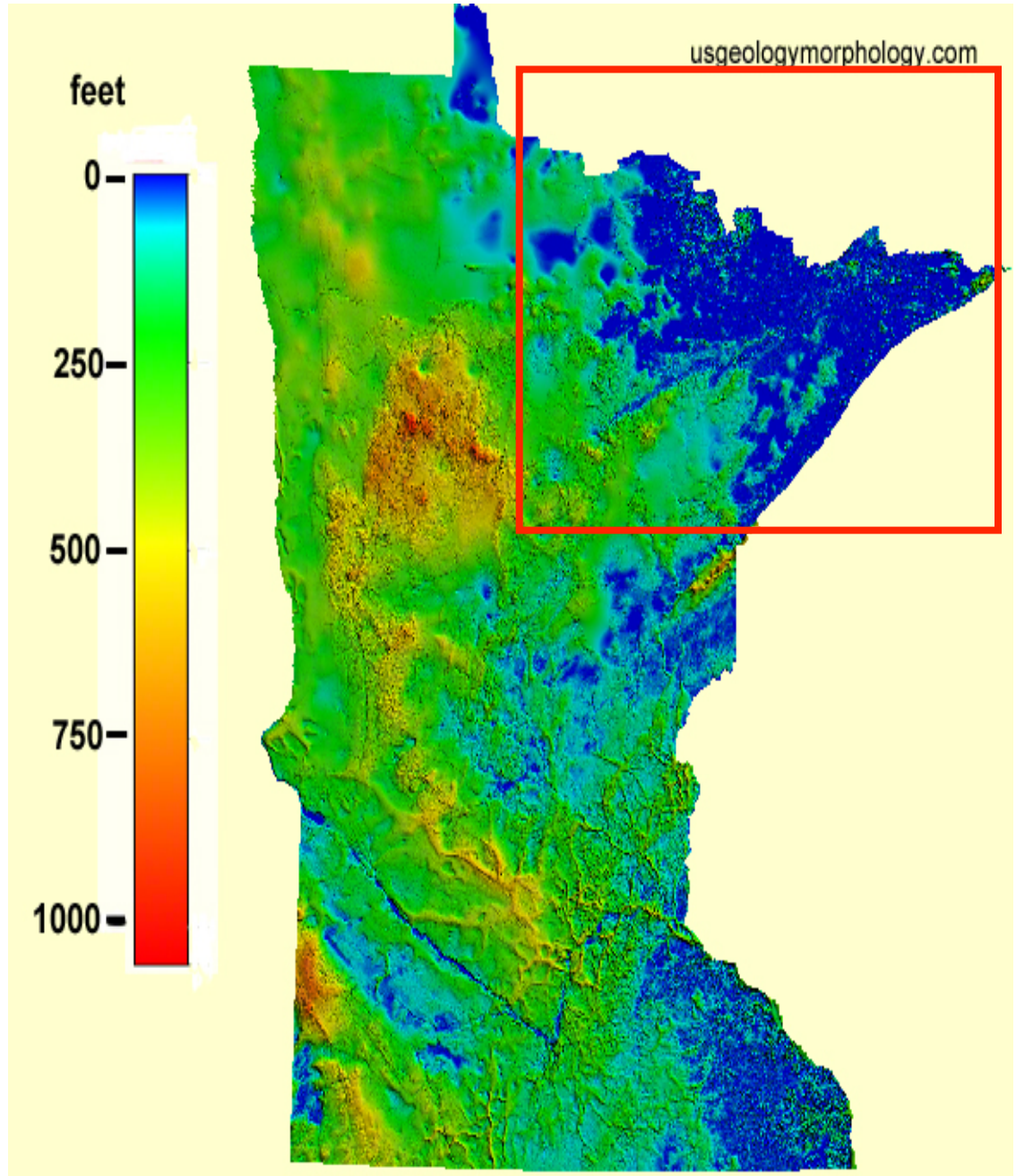
BARR

GOLDER

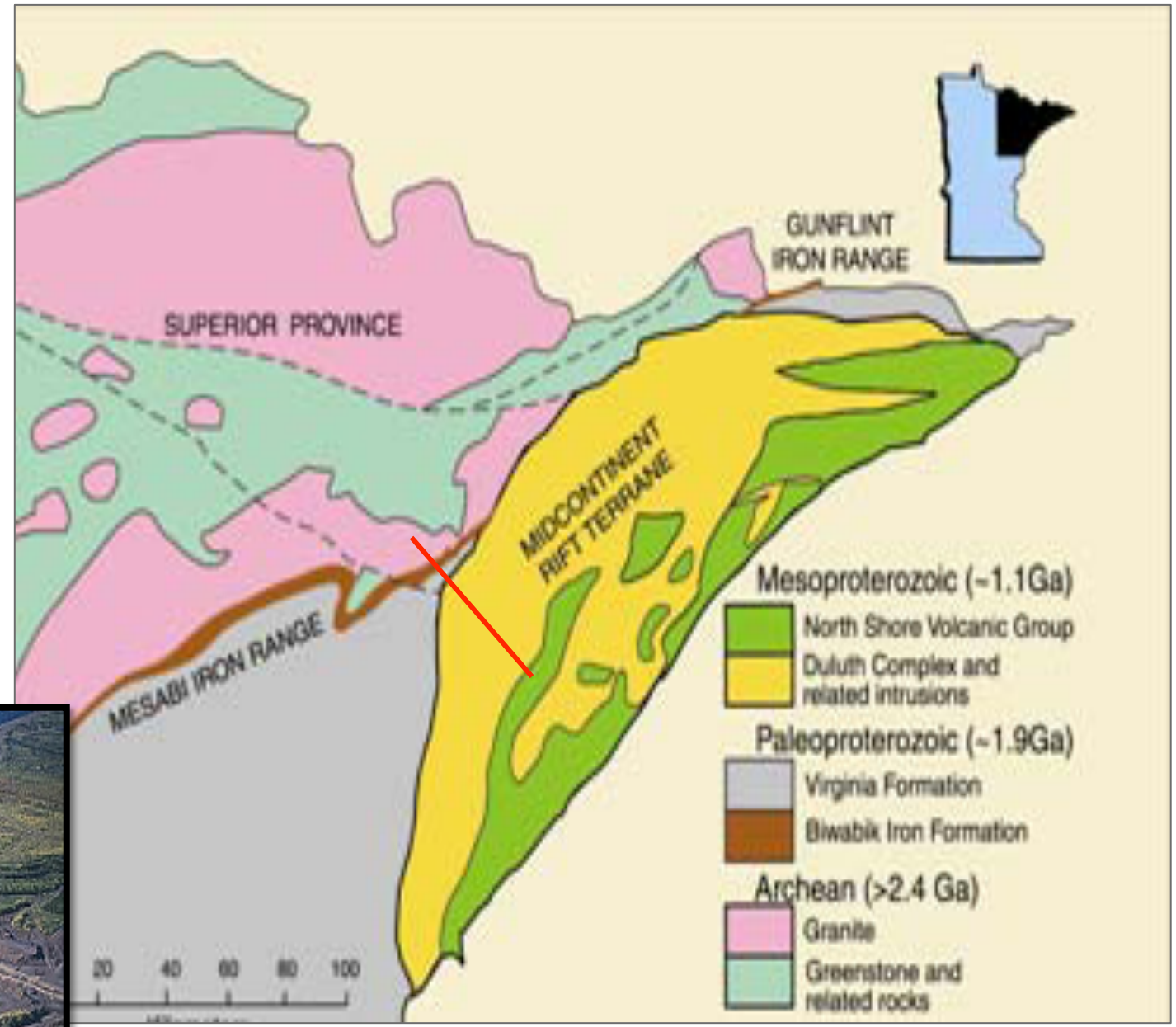
DEPARTMENT OF TRANSPORTATION

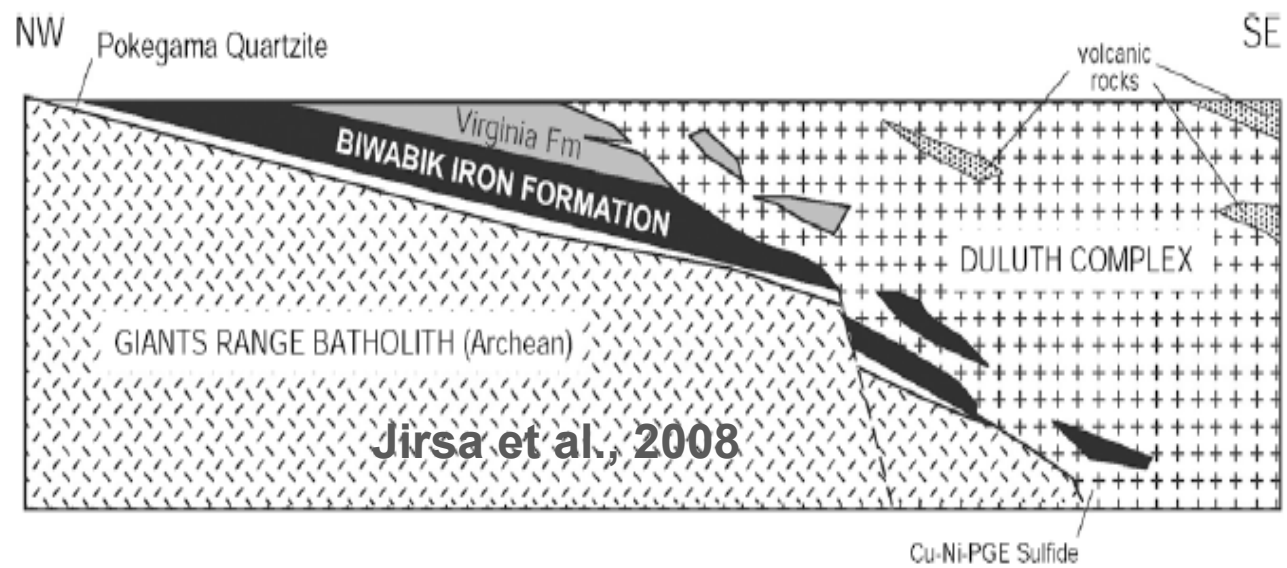
Geography/Orientation



Depth to bedrock. Data: Minnesota Geological Survey.
Data processed with dlgv32 Pro, courtesy of the U.S. Geological Survey.

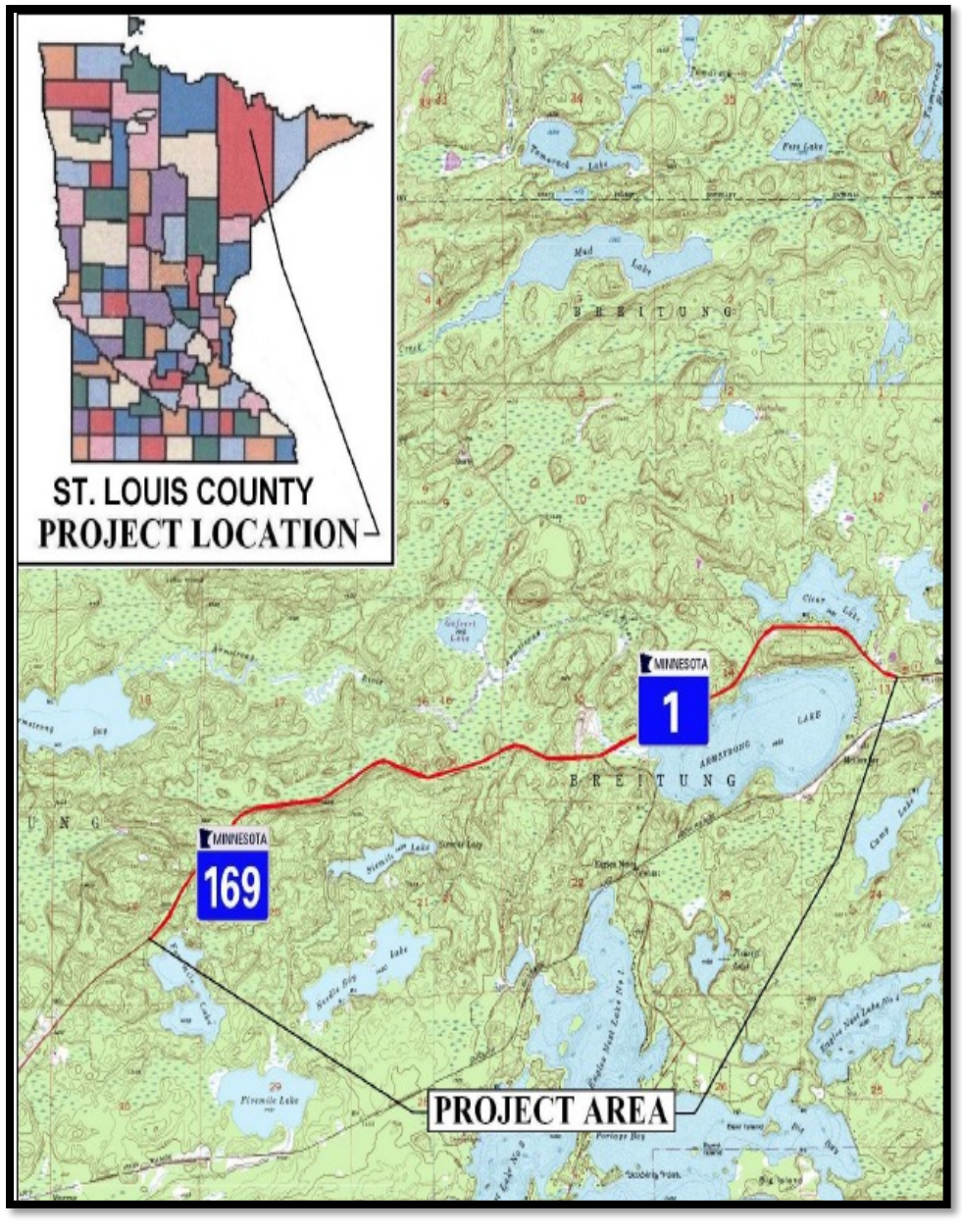
Geology and Mining





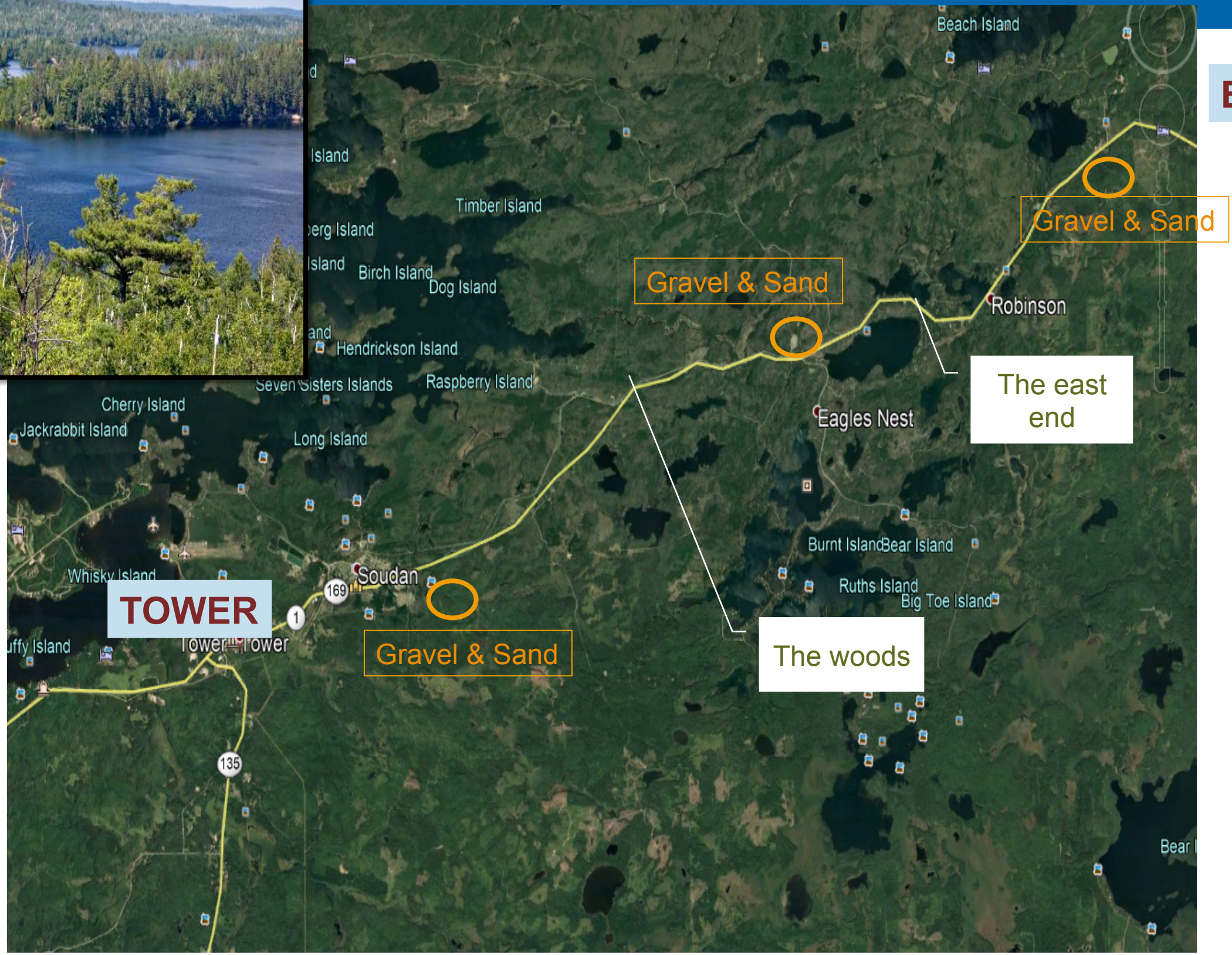
Jirsa et al., 2008

General Outline



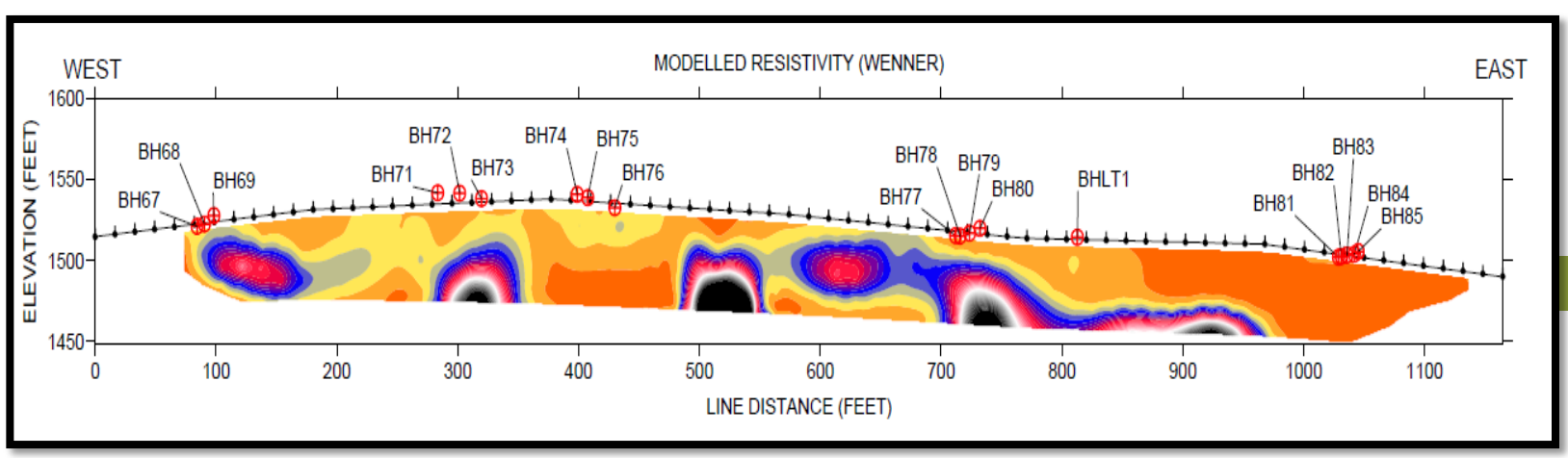
- Characterization and planning phase
- Mitigation Plan development/acceptance
  - Characterization, planning
  - Design challenges
  - Technical basis for mitigation
- Implementation
  - Amendment materials
  - Screening process/lime addition/membrane application
  - Field challenges
- Water quality monitoring and results

ghway 169/Eagles Nest Project

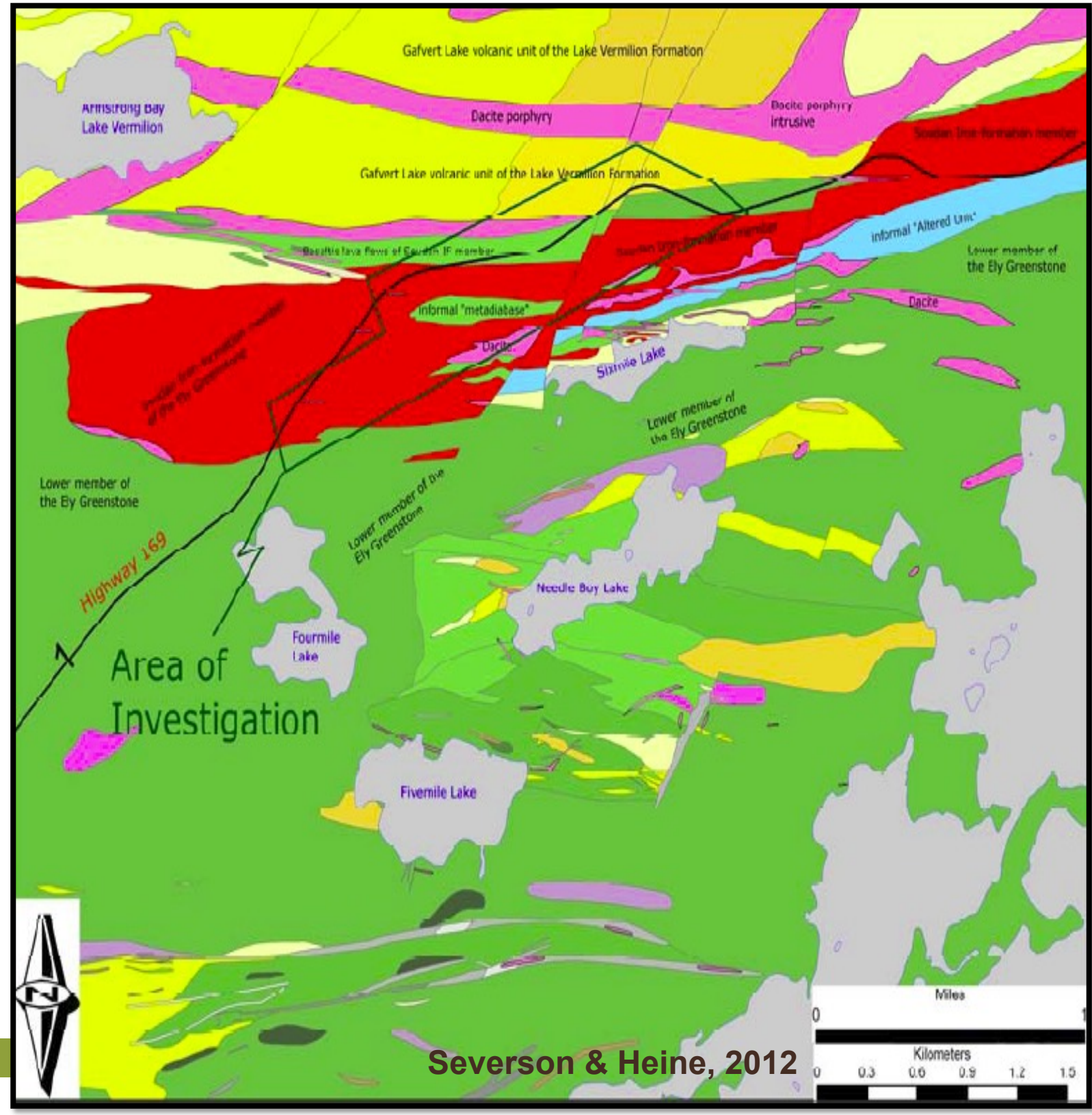


Investigation/ Characterization

- Over 5,500 feet of core drilling in 200 boreholes
- ~ 900 assays
- ~ 8,000 feet of electrical resistivity/IP geophysics
- ~6 years of study and $1M+ in investigative expenses
- Consulted MN DNR and other US DOTs
- Formation of Technical Working Group and Environmental Advisory Team



Site Geology



Severson & Heine, 2012

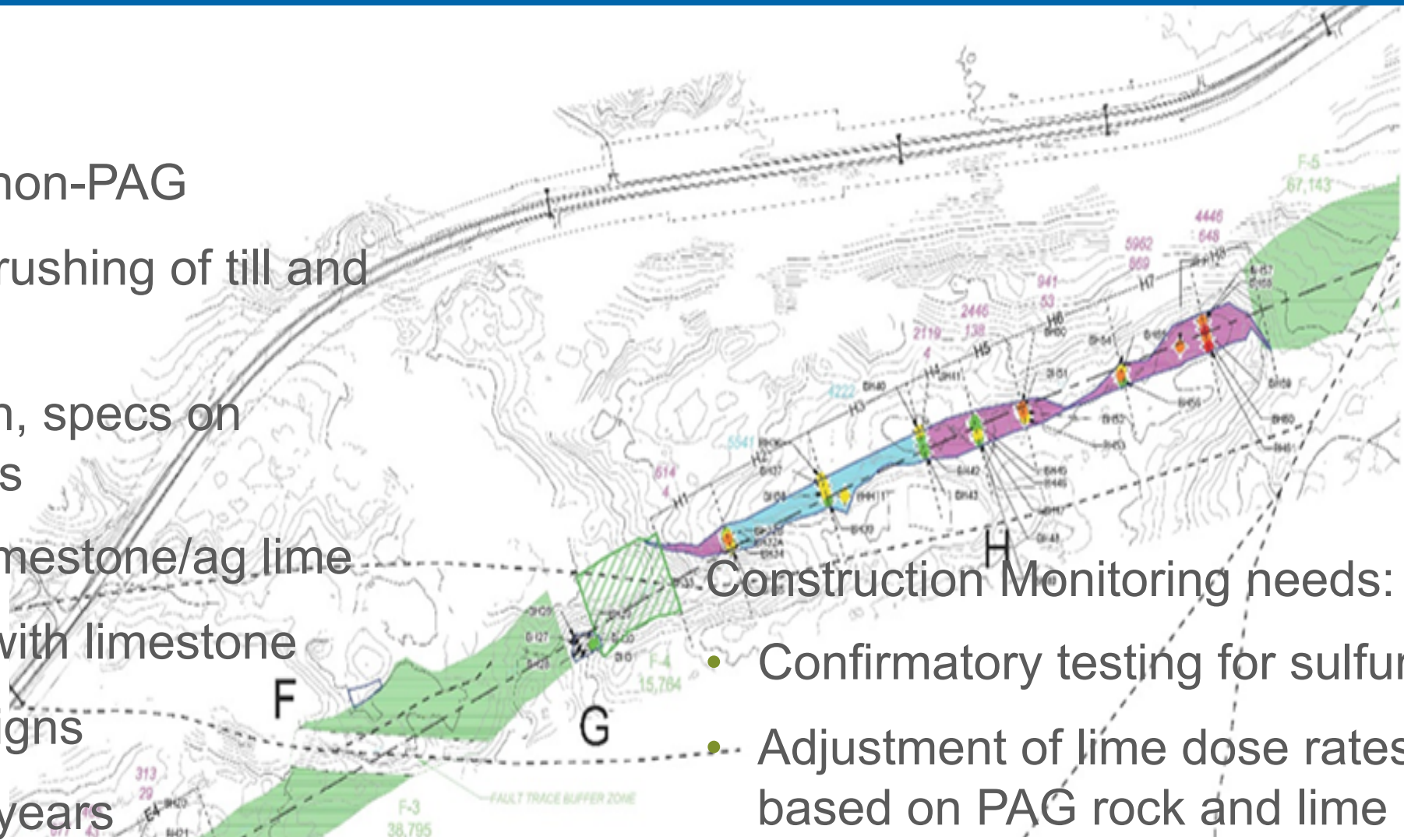
Mitigation Plan

- Acid-base accounting
  - total sulfur and carbon; speciated forms of sulfur
  - neutralization potential
- Identified a design criterion for PAG rock: NPR< 3
- Determined a preliminary lime demand for the project

PAG Rock Mitigation Plan

Plan Protocols:

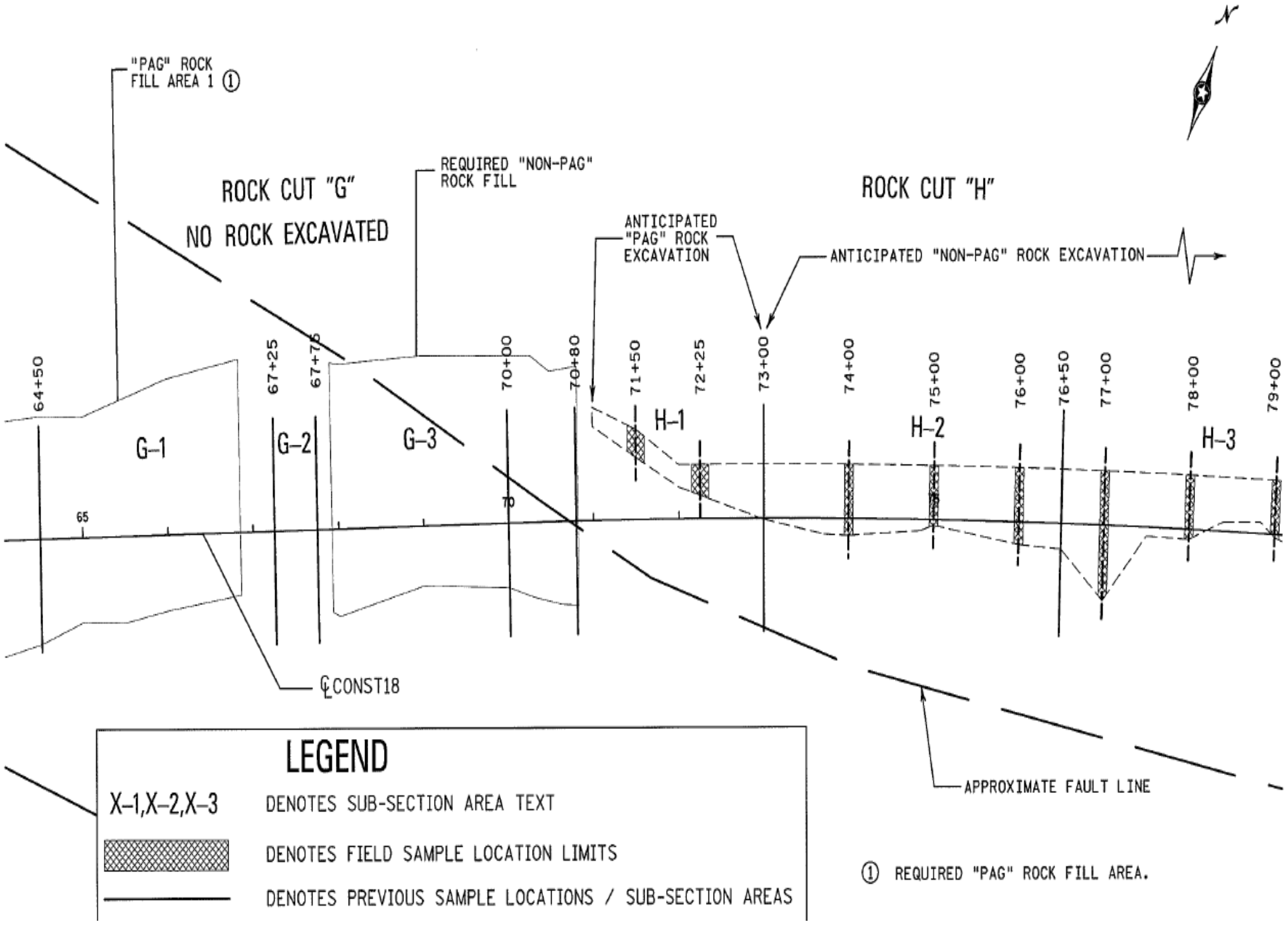
- Designated PAG/non-PAG
- Placed limits on crushing of till and overburden
- Consolidation plan, specs on neutralizing agents
  - dosing rates limestone/ag lime
  - lining ditches with limestone
  - repository designs
- monitoring for 10 years



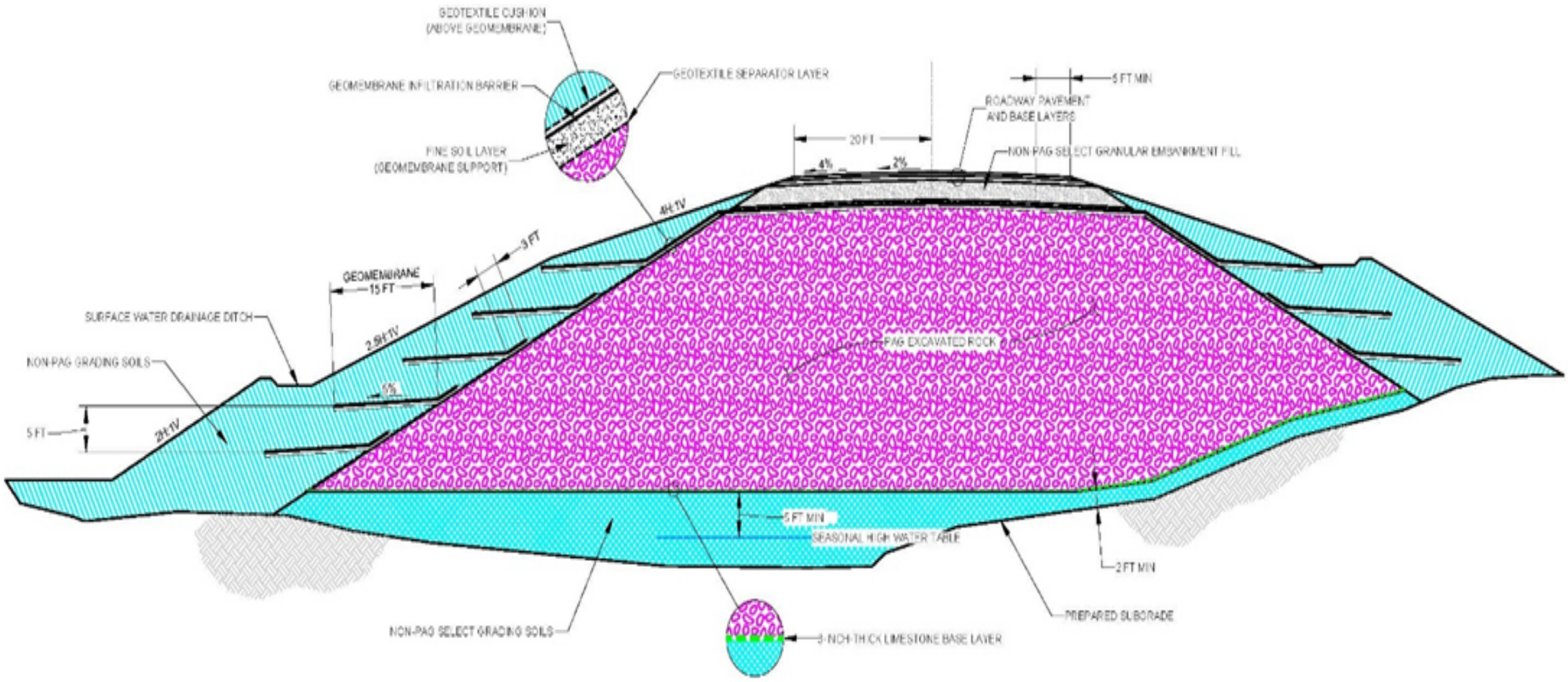
Construction Monitoring needs:

- Confirmatory testing for sulfur
- Adjustment of lime dose rates based on PAG rock and lime characteristics
- Screening aggregate sources

Plans: Pre-blast Testing; Planning for PAG Fill



Design of Typical Repository



CLIENT: MINNESOTA DEPARTMENT OF TRANSPORTATION		PROJECT: HIGHWAY 169 REALIGNMENT ARD MITIGATION PLAN	
CONSULTANT: Golder Associates	YYYY-MM-DD: 2018-08-30	TITLE: TYPICAL FILL SECTION	
	DESIGNED: FSS		
	PREPARED: FSS		
	REVIEWED: TK		
	APPROVED: RV		
PROJECT NO: 1543068	PHASE: 002	REV: 0	FIGURE: 8

Lime Mitigation/Dosing

- NPR ≥ 3 is repository design criterion
- AP and NP were pre-determined to provide estimate of augmentation of NP required to achieve NPR = 3
- NP from rock and added lime:

$$NP_{mitigation} = (3 \cdot AP_{revised}) - NP_{rock}$$

Contractor provided instruction on amendment rates

Dosing Rates

Rock Cut and Section Details				Results of Field			Limestone					Ag Lime				
Rock Cut	Rock Cut Section	STA to STA	Pre-construction Rock Cut Section Volume Estimate	Field Verified Rock Cut Section Volume	Revised Limestone Requirement (based on new %S and/or rock volume)	Truck Count Estimate	Total Corrected mass	Total corrected volume	Application Rate	Section Totals	Section Totals	Total Corrected mass	Total corrected volume	Application Rate	SectioIn Totals	Section Totals
Q	Q1	357+00-359+00	16	30	0	2	0.0	0.0	0.0	34.6	18.4	0.0	0.0	0.0	44.5	41.9
	Q2	359+00-36100	1,617	1,112	0	62	0.0	0.0	0.0			0.0	0.0	0.0		
	Q3	361+00-362+00	1,157	838	0	47	0.0	0.0	0.0			0.0	0.0	0.0		
	Q4	362+00-365+00	4,786	7,189	41	399	19.9	10.6	0.03			25.6	24.1	0.06		
	Q5	365+72-368+00	7,151	5,011	28	278	13.9	7.4	0.03			17.8	16.8	0.1		
	Q6	368+00-370+50	72	711	2	39	0.8	0.44	0.011			1.1	1.0	0.025		
R	R1	374+00-375+50	538	648	0	36	0.0	0.0	0.0	0.5	0.2	0.0	0.0	0.0	0.6	0.6
	R2	375+50-379+00	2,888	1,411	1	78	0.5	0.2	0.0031			0.6	0.6	0.0071		
	R3	379+00-382+50	0	0	0	-	0.0	0.0	#VALUE!			0.0	0.0	#VALUE!		
	R4	382+50-385+00	689	850	0	47	0.0	0.0	0.0			0.0	0.0	0.0		
	R5	385+00-386+00	299	13	0	1	0.0	0.0	0.0			0.0	0.0	0.0		
	R6	386+00-388+00	0	0	0	-	0.0	0.0	#VALUE!			0.0	0.0	#VALUE!		
		390+28.96-														

- Real-time adjustments based on
  - New confirmatory sulfur values
  - Lime quality, moisture, CCE
  - Estimated capacity of the trucks and of backhoe bucket

Mitigation Plan finalized & accepted in 2016

Groundbreaking May, 2017

Blasting the highs

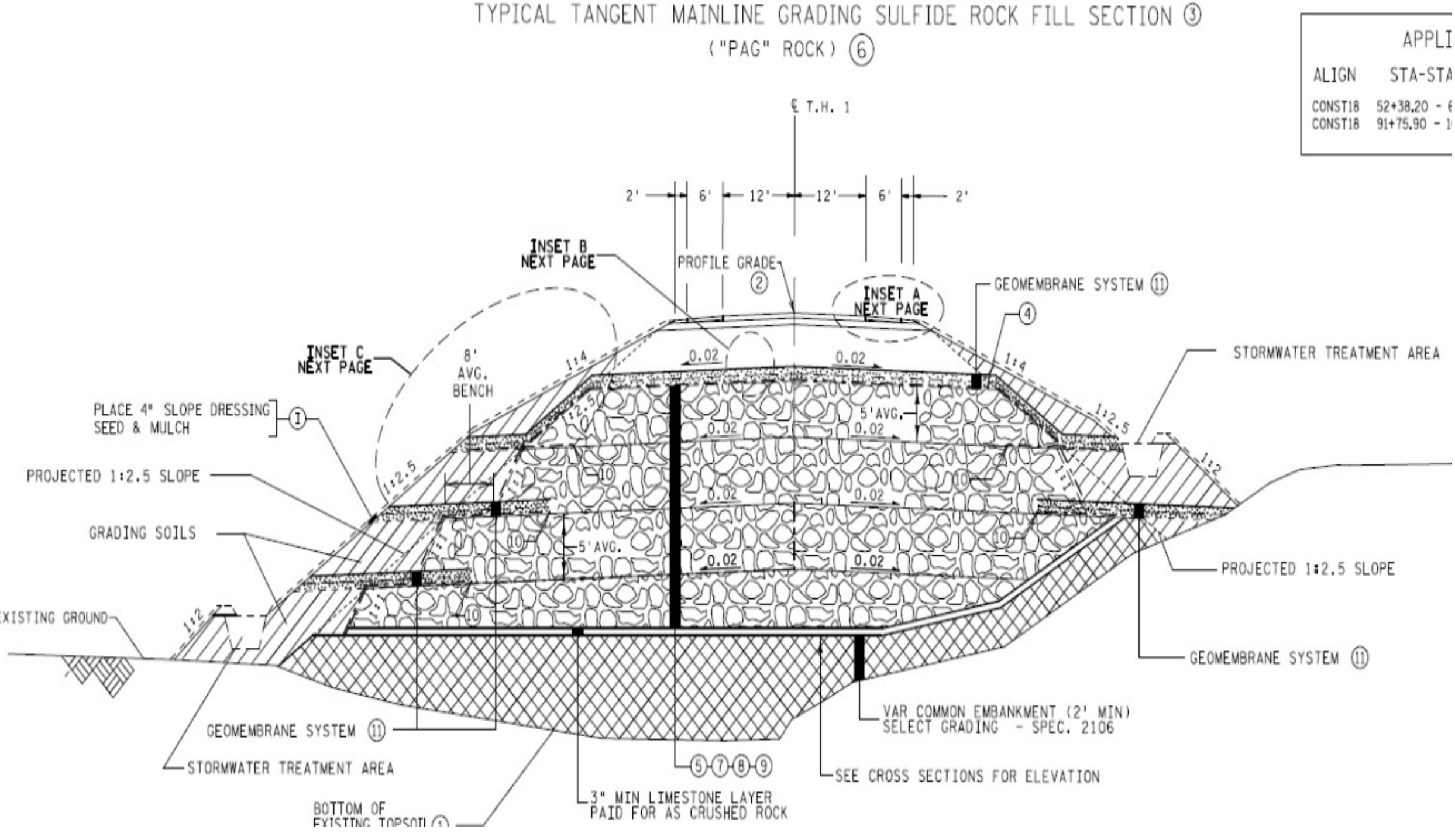
Filling the lows

- primary PAG fill area, prior to grading

- rock-cored highway

~20m high PAG rock landfill

plans: PAG fill/repository

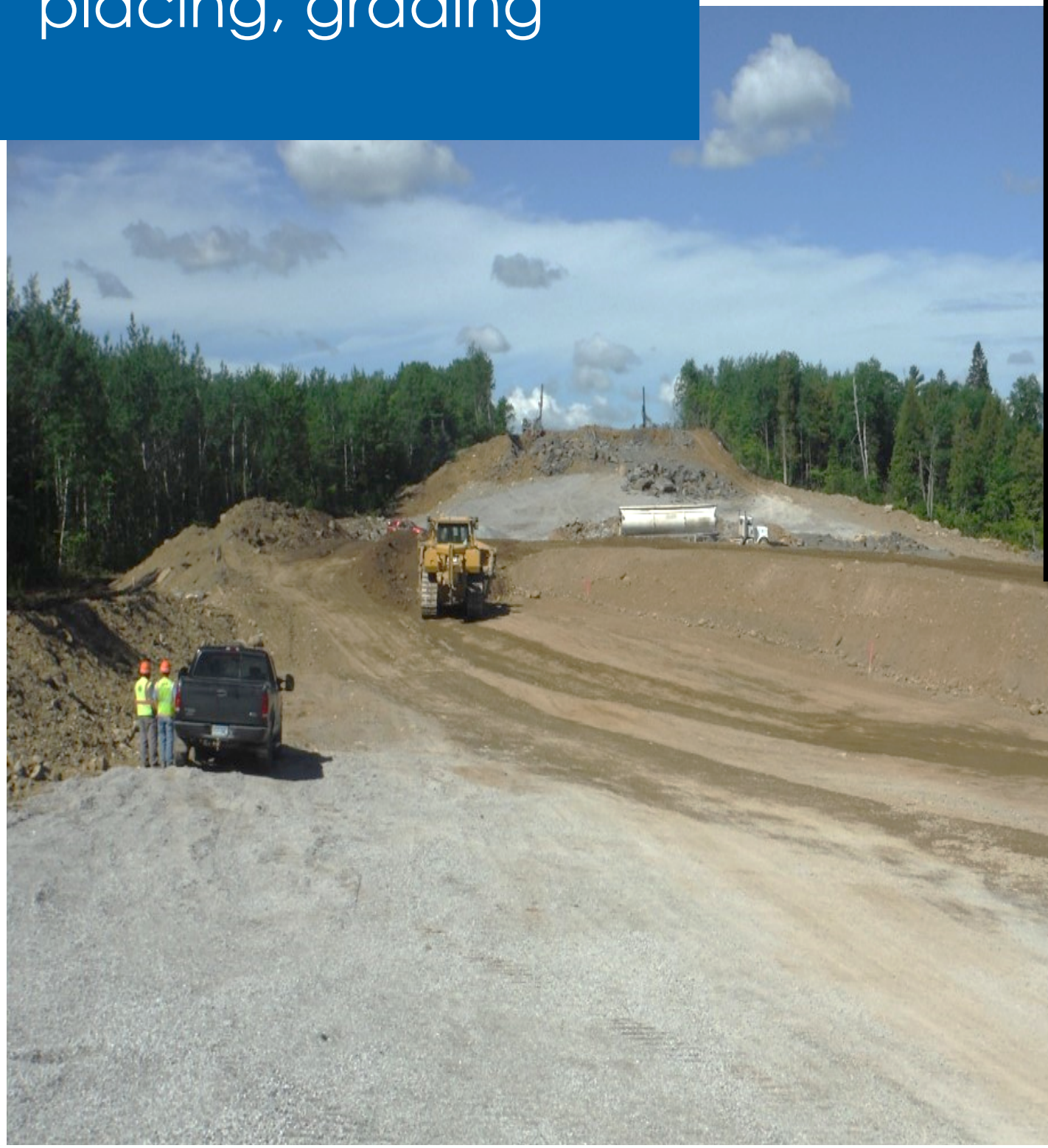


NP Amendment Materials

Material	Limestone	Agricultural Lime
Source	Michigan dolomitic limestone via neighboring site	Pulp mill lime mud
Processing	Crushed on site to meet spec	Stored under plastic on site
PSD	<1”	100% passing 60 mesh
Moisture Content	--	20%
CCE	102%	100.4

- Besides TNP and Can, ag lime is source of Na, Mg, Cl

Hauling, dosing, placing, grading



Building successive benches

Lots of equipment
- 20 side dumps
- 14 articulators
- 3 dozers
- 2 rollers
- 1 backhoe

Fast, intense pace, in restricted work area

Ideal blending

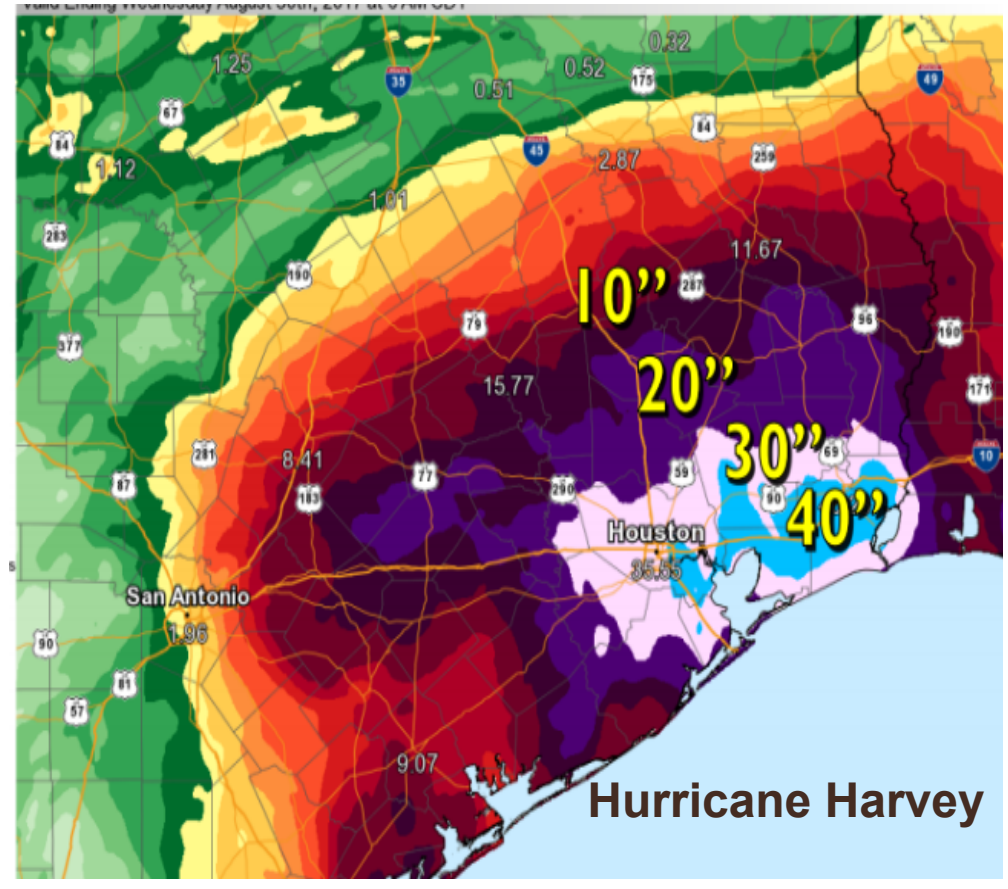
Fabrics and covers

Plan versus execution

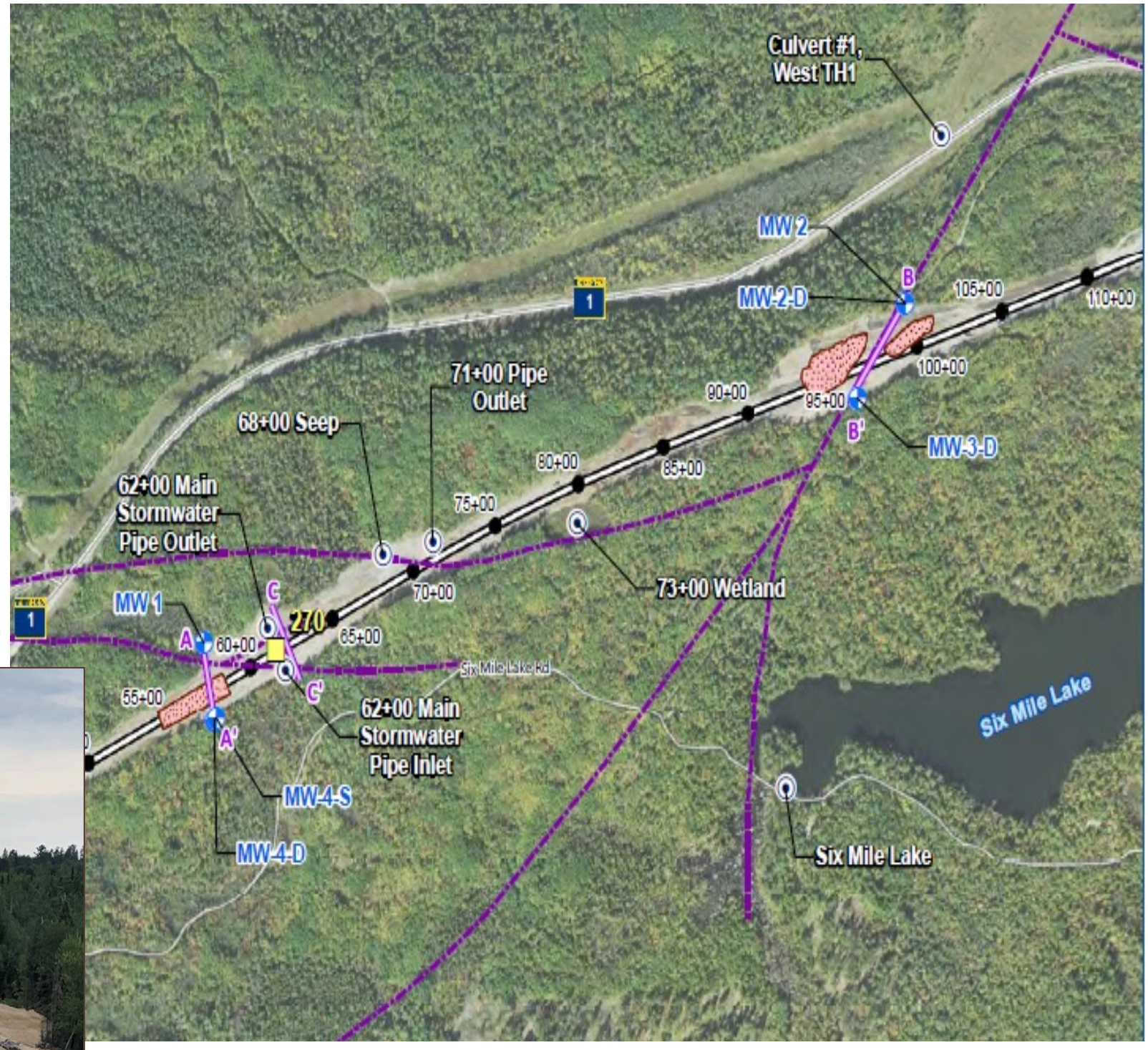
- TAT conflicted w/ construction schedule
  - Confirmatory testing became another pre-construction investigation
- Blending impractical at low dose rates
  - Combined blending and layering
- Examination of saturated hydric soils
  - Reactive secondary sulfides
  - field leach test, odor after HCl

project challenges

- Rain
  - 500mm
- Hurricane
- Snow



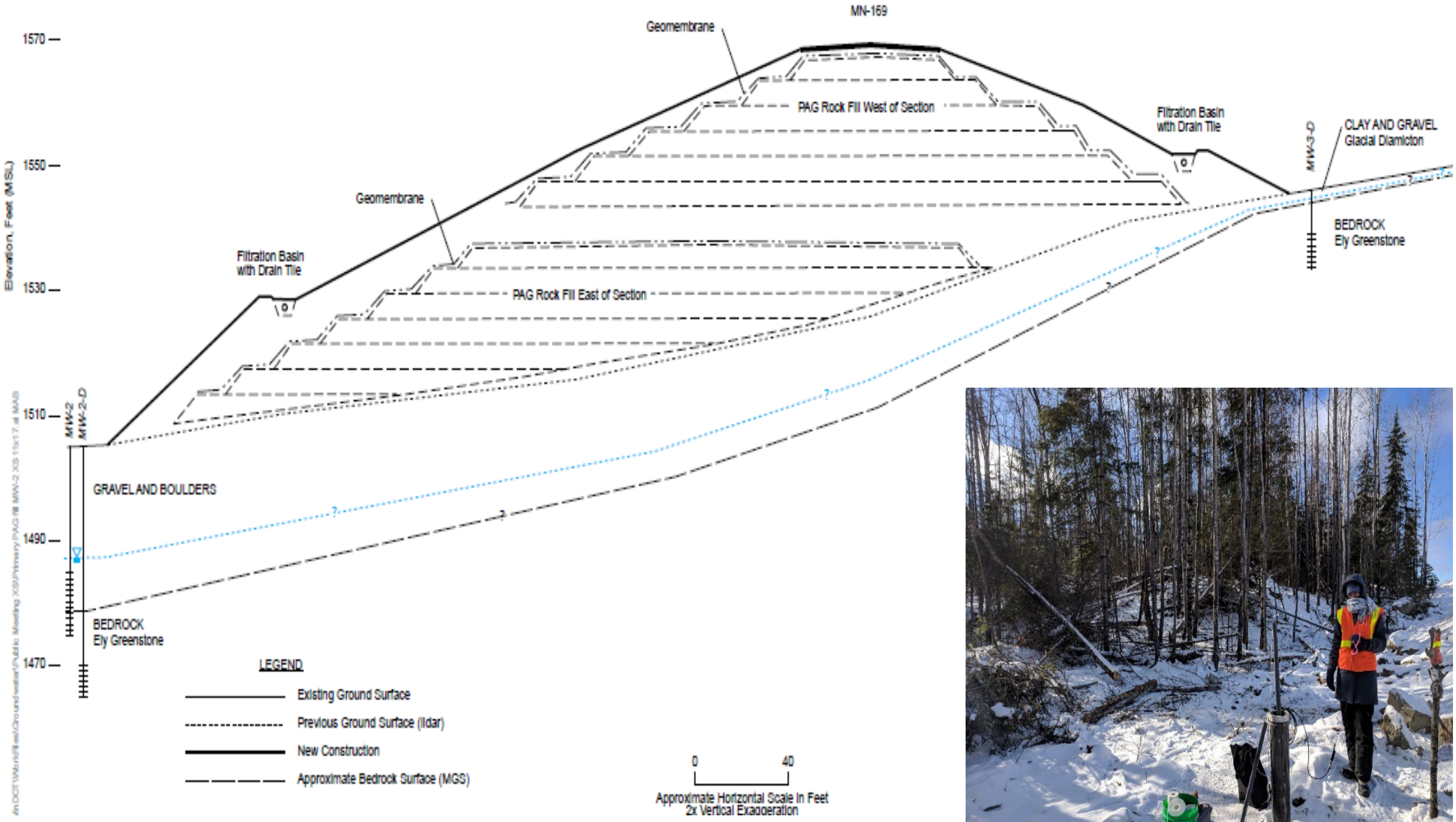
As-Built Project Configuration & Monitoring Network



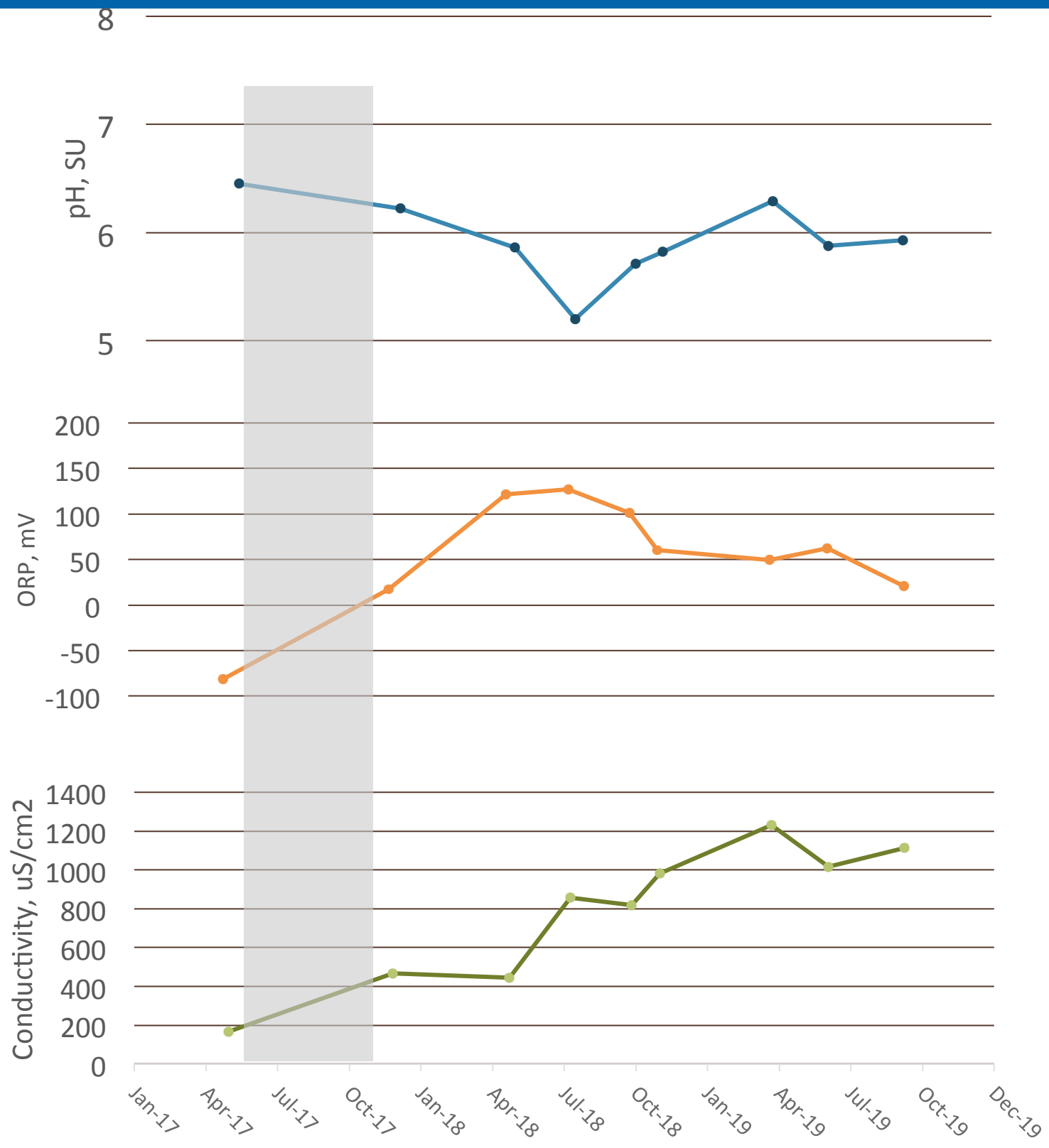
As-built PAG repository characteristics

	Primary PAG rock fill (F-5)	Secondary PAG rock fill (F-3)
Approximate volume of mixed PAG rock and lime amendment material contained	54,900 yd^3 PAG rock; 3,000 yd^3 lime amendment[1]	9,100 yd^3 PAG rock; 200 yd^3 lime amendment
Location	Sta. 91+75 to 103+00	Sta. 55+00 to 58+00
Approximate dimensions	35 ft. (max thickness) by 780 (max length); Two isolated fills, on either side of a fault	20 ft. (max thickness) by 405 (max length); entirely west of the fault
Initial PAG placement	May 26, 2017	September 20, 2017
Final geomembrane cover placement	November 2, 2017	November 3, 2017
Groundwater monitoring network	MW-2, MW-2-D, MW-3-D	MW-1, MW-4-S, MW-4-D

Primary PAG Fill Section



Drain-down water quality response



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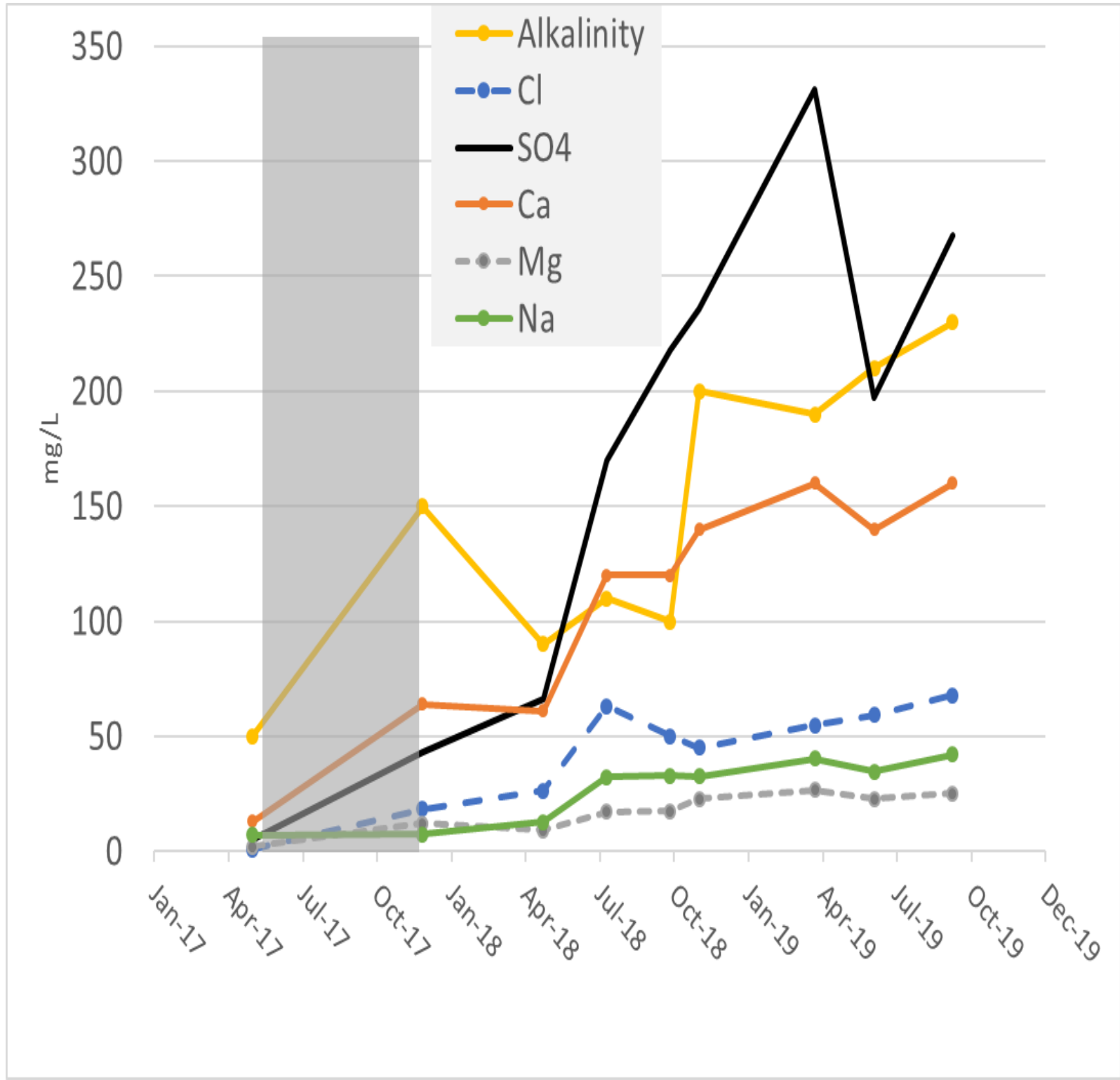
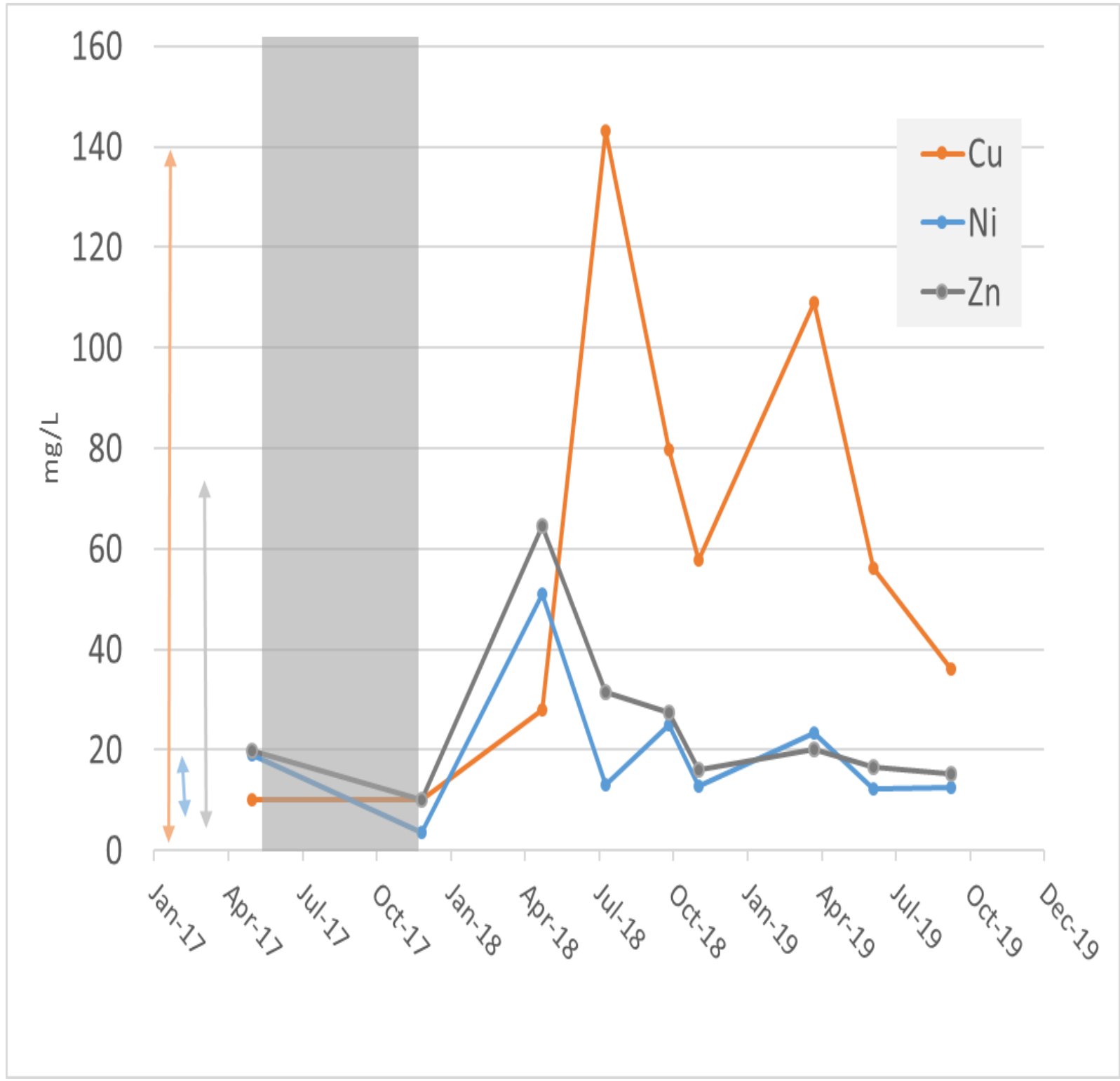


Trace metals – drain-down response



Summary

- Broad stakeholder group/ many agencies (Health, Natural Resources, Pollution Control, DOT)
  - drove detailed investigation, enhanced mitigation, and public engagement
- Applied mining best practices to prevent and mitigate ARD
  - Drain-down effect apparent, monitoring ongoing
- Project earned awards from the Office of Environmental Services, and from the Association of General Contractors
  - Serves as basis for new formalized MnDOT ARD guidance

Questions?