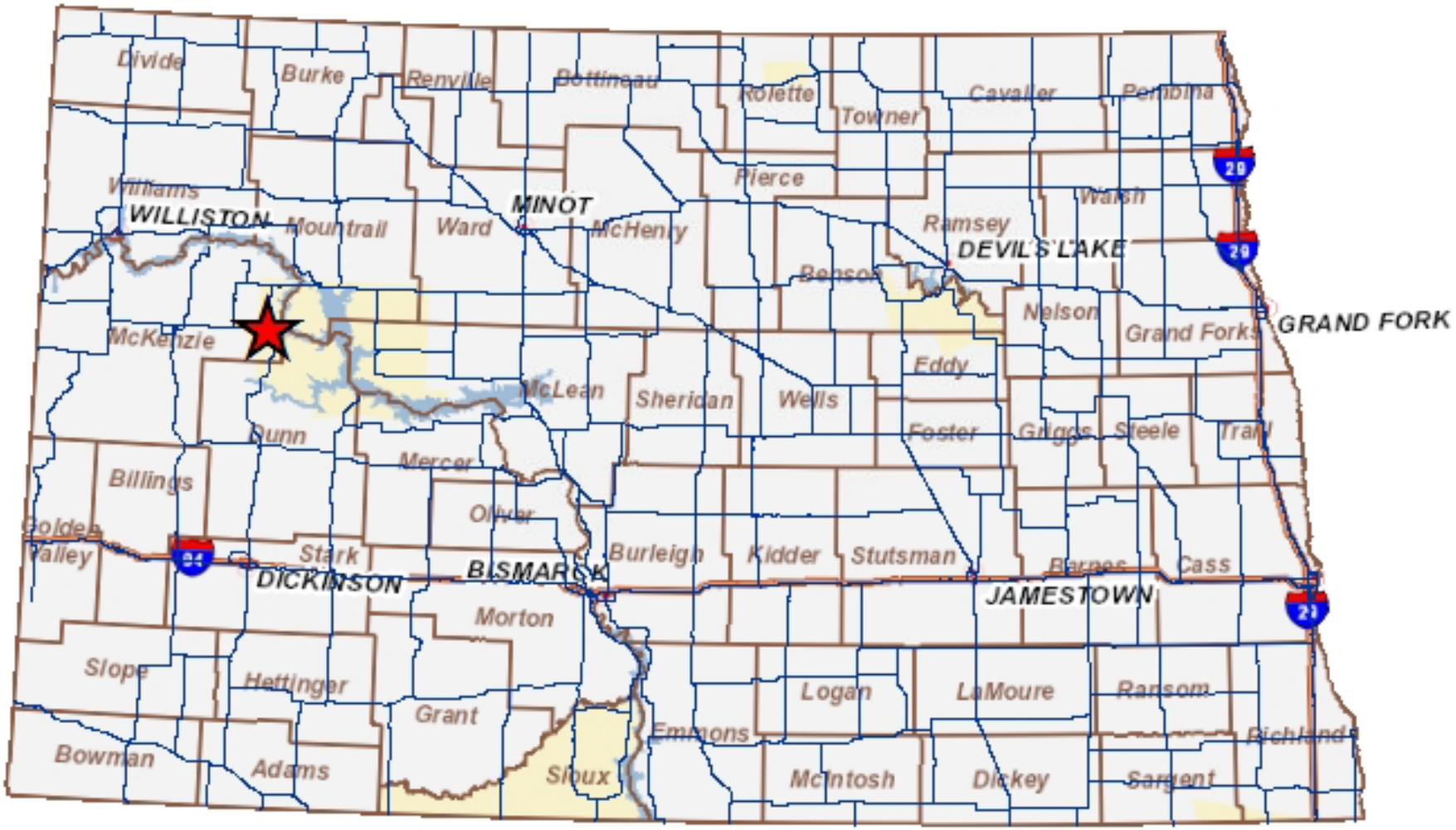
# Highway 73 Landslide
# Bear Den Creek

**Matt Kurle, P.E – NDDOT**

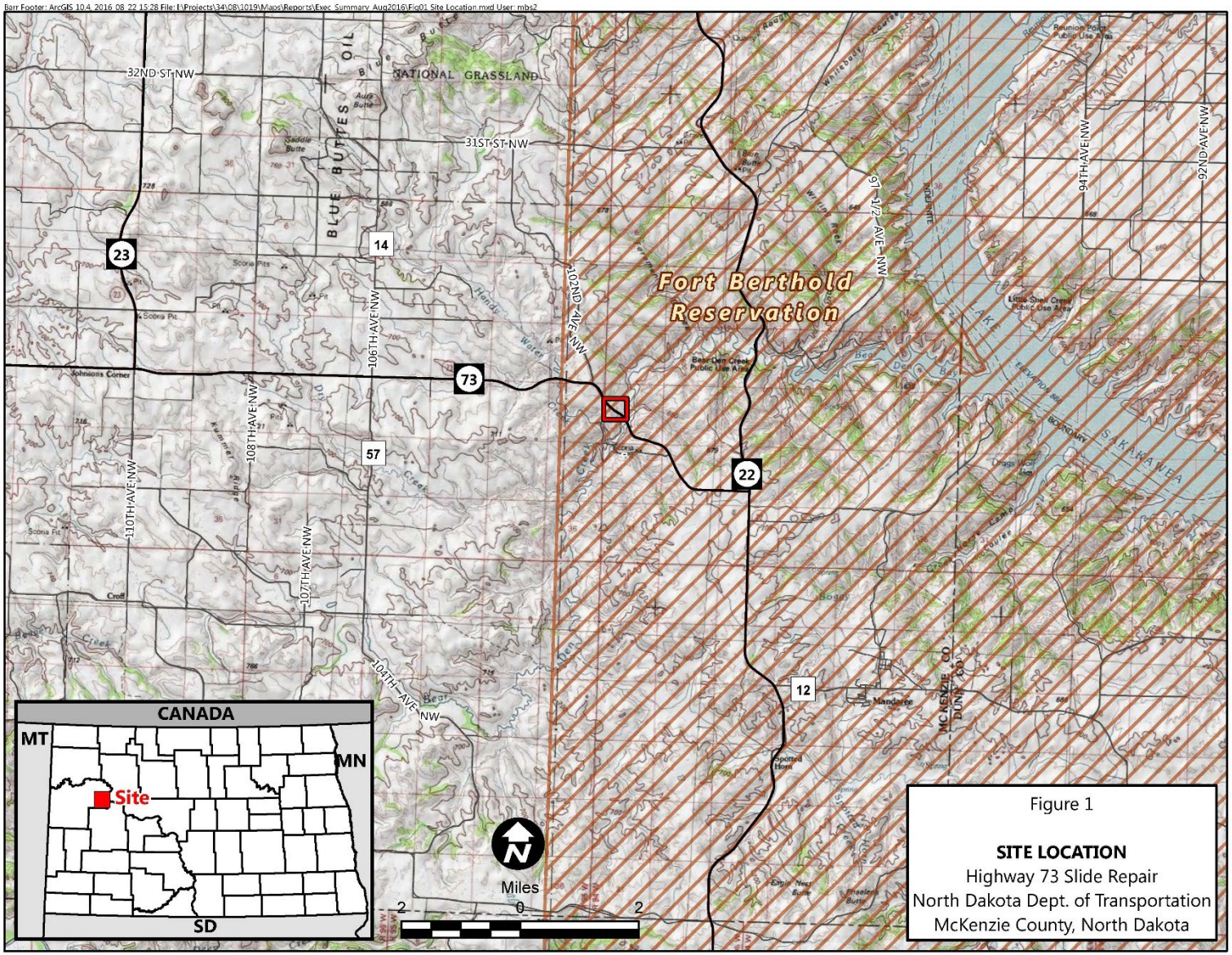
**Aaron T. Grosser, D.GE, P.E. – Barr Engineering Co.**

**Gregory R. Fischer, Ph.D., D.GE, P.E. – Shannon & Wilson, Inc.**

# Highway 73


Divide
Burke
Renville
Bottineau
Rolette
Towner
Cavalier
Pembina
Williams
WILLISTON
Mountrail
Ward
MINOT
McHenry
Pierce
Ramsey
Walsh
DEVILS LAKE
Benson
Nelson
Grand Forks
GRAND FORK
McKenzie
Eddy
McLean
Sheridan
Wells
Foster
Griggs
Steele
Trail
Dunn
Mercer
Billings
Oliver
Golden Valley
Stark
DICKINSON
BISMARCK
Burleigh
Kidder
Stutsman
Barnes
Cass
JAMESTOWN
Morton
Slope
Hettinger
Grant
Logan
LaMoure
Ransom
Emmons
Richland
Bowman
Adams
Sioux
McIntosh
Dickey
Sargent

# Highway 73


32ND ST NW
31ST ST NW
BLUE BUTTES
NATIONAL GRASSLAND
Fort Berthold Reservation
23
14
73
57
22
12
106TH AVE NW
108TH AVE NW
110TH AVE NW
107TH AVE NW
104TH AVE NW
102ND AVE NW
91ST 1/2 AVE NW
94TH AVE NW
92ND AVE NW
Johnsons Corner
Scoria Pit
Mandaree
CANADA
MT
MN
SD
Site
N
Miles
0
2
2
Figure 1
SITE LOCATION
Highway 73 Slide Repair
North Dakota Dept. of Transportation
McKenzie County, North Dakota

# Highway 73
# 2010 Imagery

# May 11, 2011

# May 17, 2011

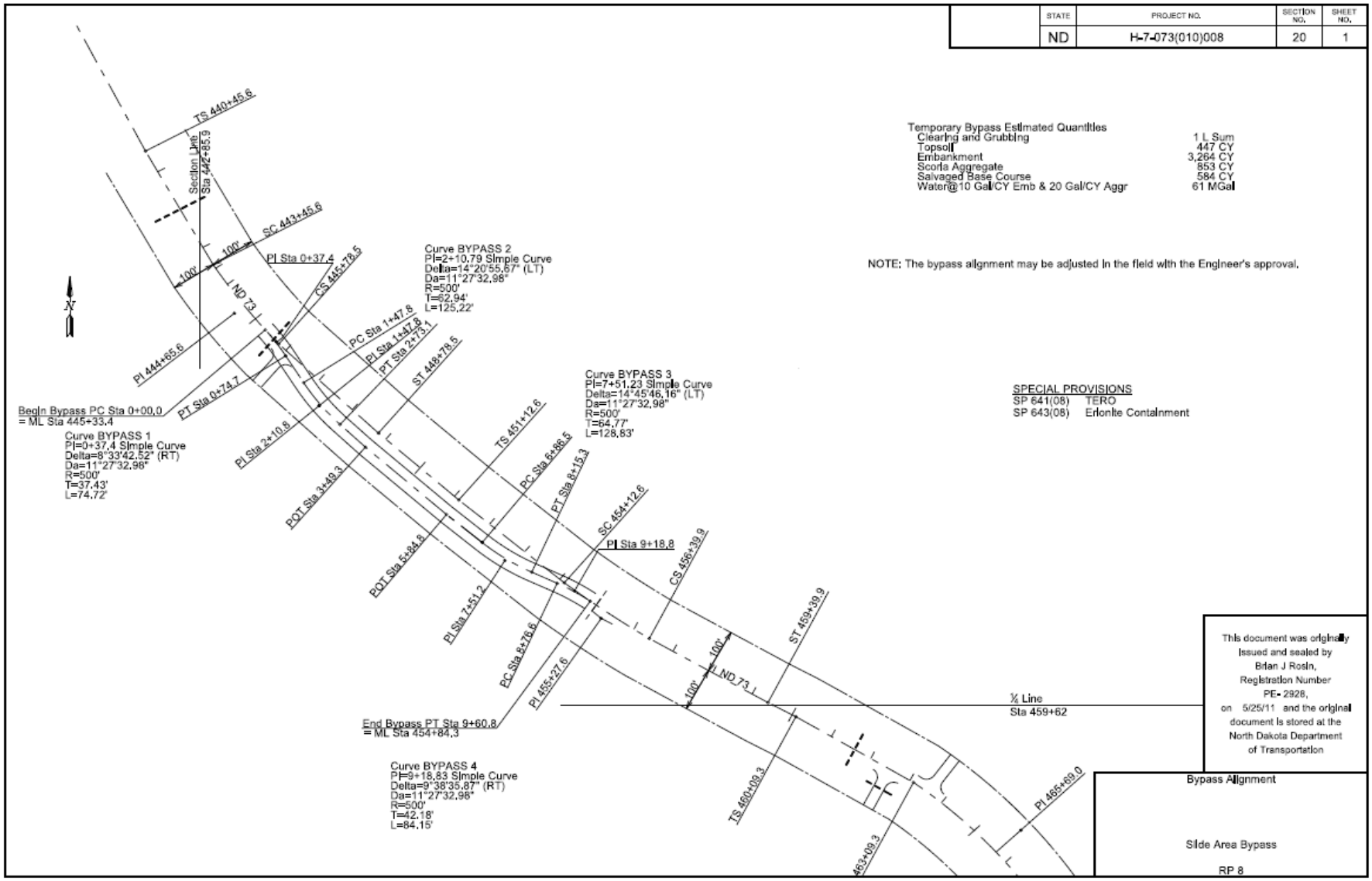
# May 23, 2011

# June 2011

## Emergency Declaration

Phase 1 – Emergency Bypass
Cost Estimate - $184,900
Actual Cost - $218,650 – Lump Sum Bid

# Phase 1 – Emergency Bypass



# Phase 1 – Emergency Bypass

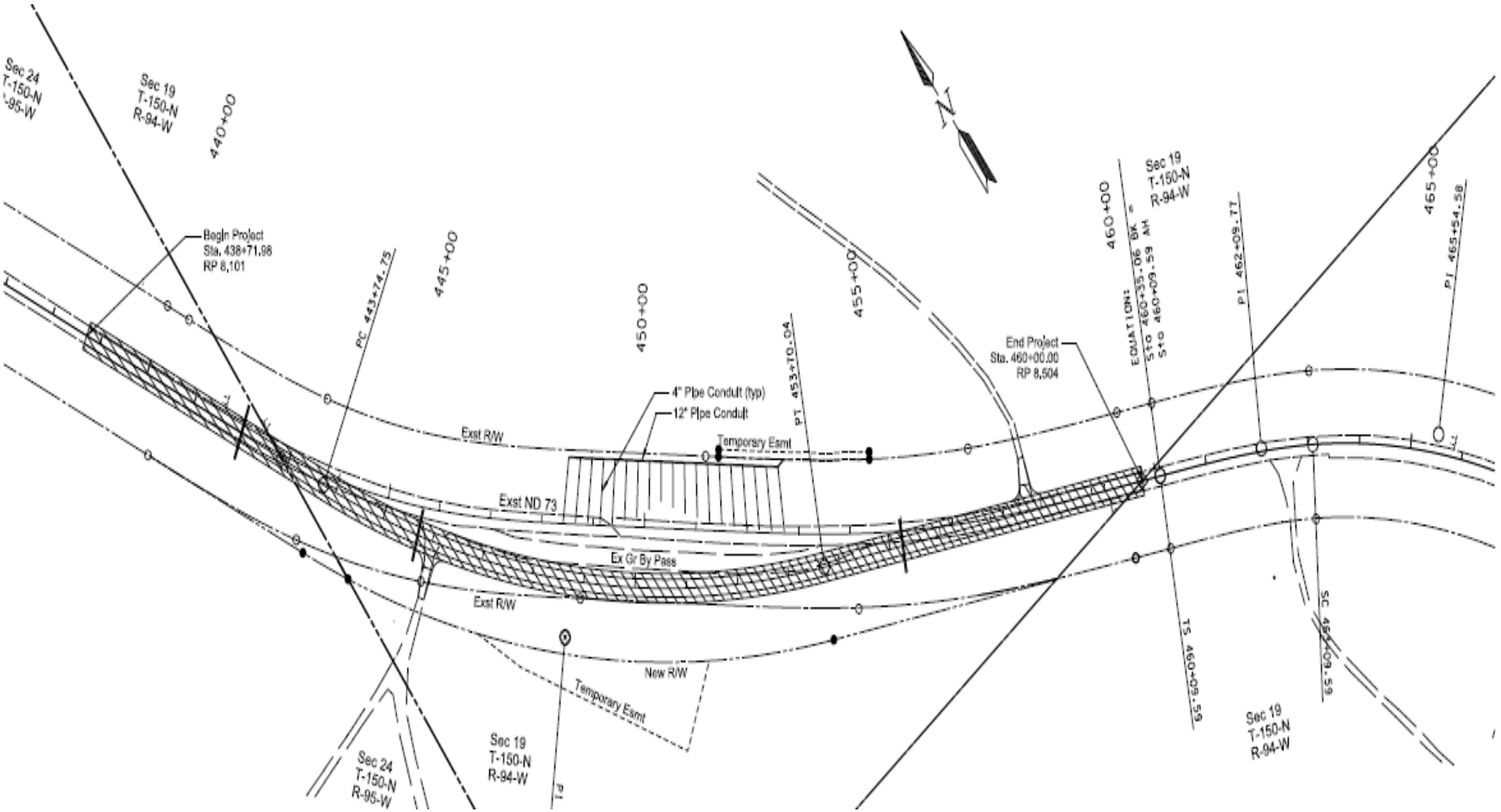
Project Started June 30, 2011
Project Completed September 9,2011

# Phase 2
# Roadway Realignment/Slide Stabilization

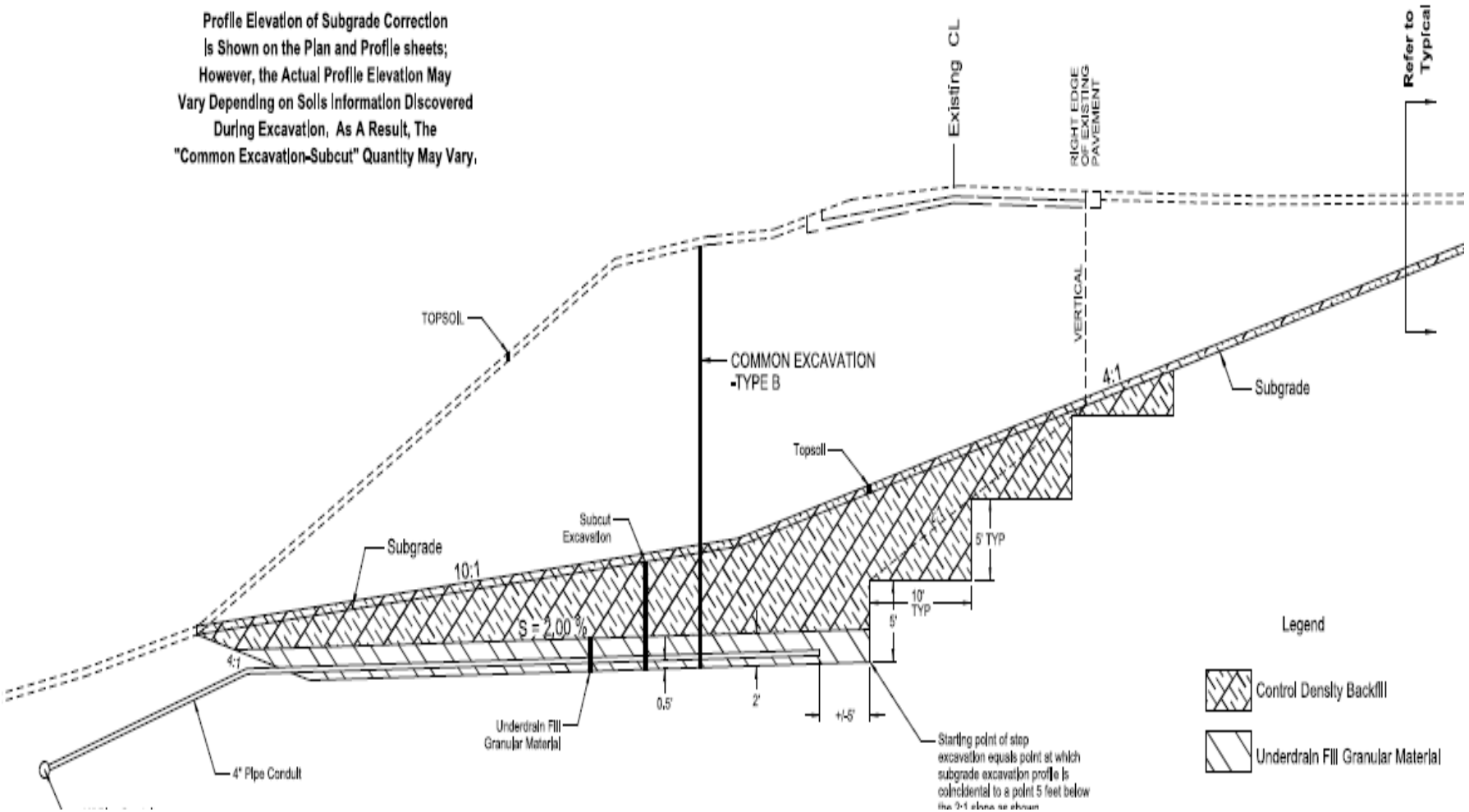
Project: SER-7-073(009)124 PCN:19321
Final Cost: $1,850,000
Project Dates:

- Stability Recommendation: 11/18/2011 (Consultant)
- Plans Complete: 3/26/2012
- Bid Opening: 5/04/2012
- Construction Completed: Summer/Fall 2012

# Phase 2
# Roadway Realignment/Slide Stabilization



# Phase 2
# Roadway Realignment/Slide Stabilization



# Phase 2
# Roadway Realignment/Slide Stabilization

# Highway 73 RP 8 Spring 2013

Picture Taken 5/21/13

# Highway 73 RP 8 Summer 2013

# Highway 73 RP 8 Summer 2013

# Highway 73 RP 8 March 2014

# July 2014

## Emergency Declaration - Continuation

- Something Bigger is going on here
- Pay for Contractor Patching – $18,650
- Allow Time for Larger Geotechnical Investigation

# February 2015

## Emergency Declaration - Continuation

- FHWA Meeting to Discuss Options
- Split Project into 2 Phases
  - 1.)Phase 1 – Maintenance
    Drainage Improvements
    Estimated Cost - $415,000
  - 2.) Phase 2 – Permanent Realignment
    Estimated Cost - $15,000,000
- Two-phase approach signed off by FHWA in March 2015

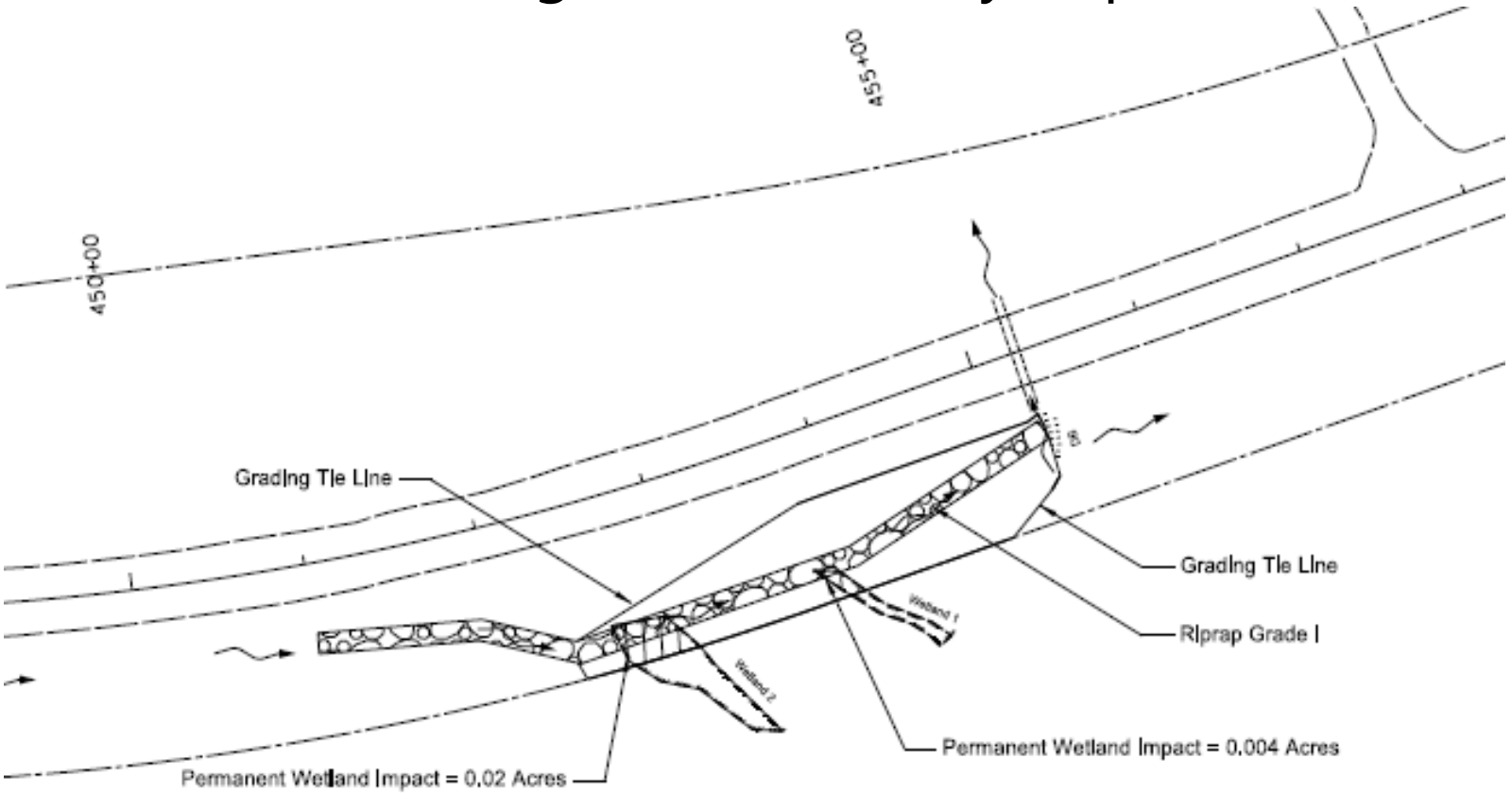
# March 2015

## Phase 1 – Drainage and Roadway Improvements

- NDDOT Developed Plans to Remove Free Standing Water and Restore Roadway Profile
- Plans Completed July 2015
- Project Bid September 2015
- Project Completed November 2015
- Total Cost for Project - $352,000

# Phase 1 Plan

## Phase 1 – Drainage and Roadway Improvements



# Phase 1 Construction

## Phase 1 – Drainage and Roadway Improvements

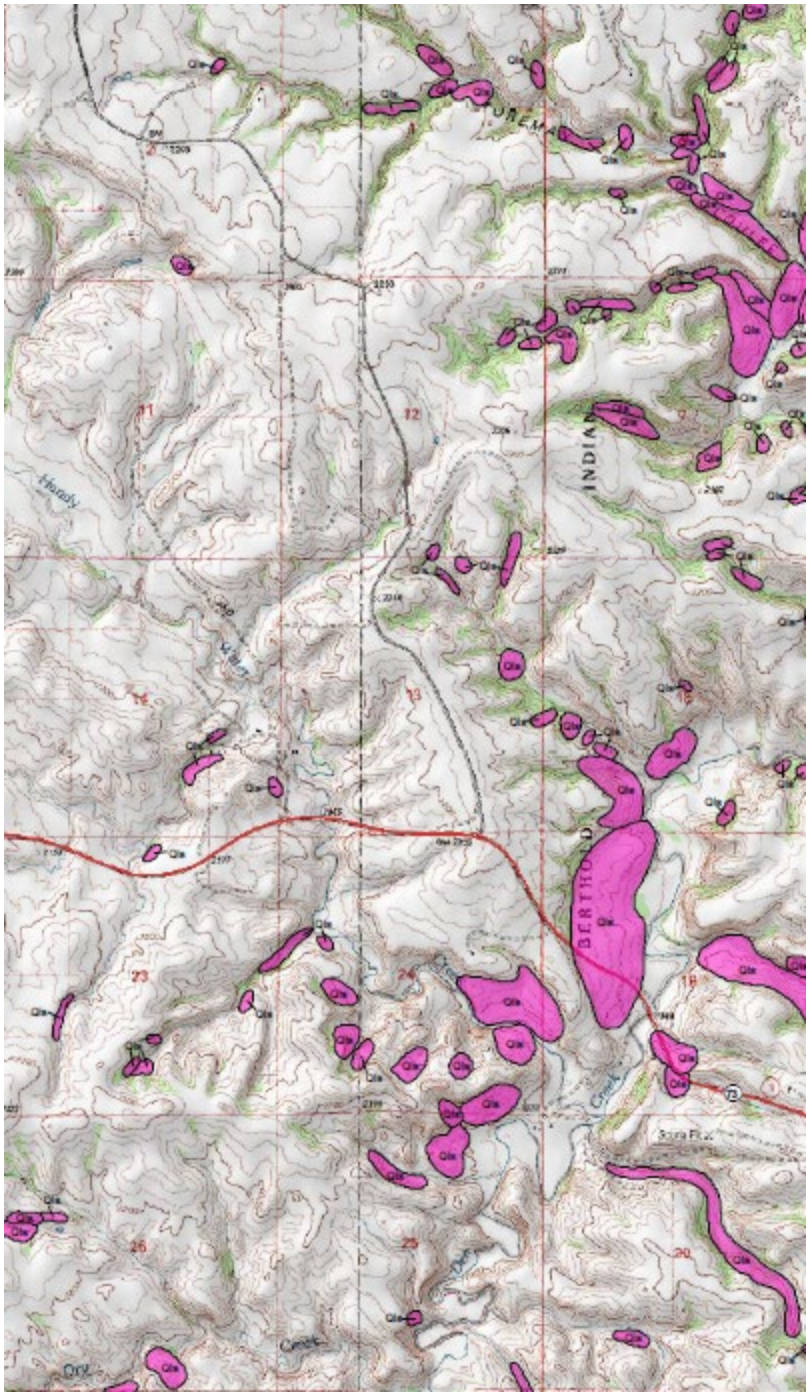
# Phase 1 Completed

## Phase 1 – Drainage and Roadway Improvements

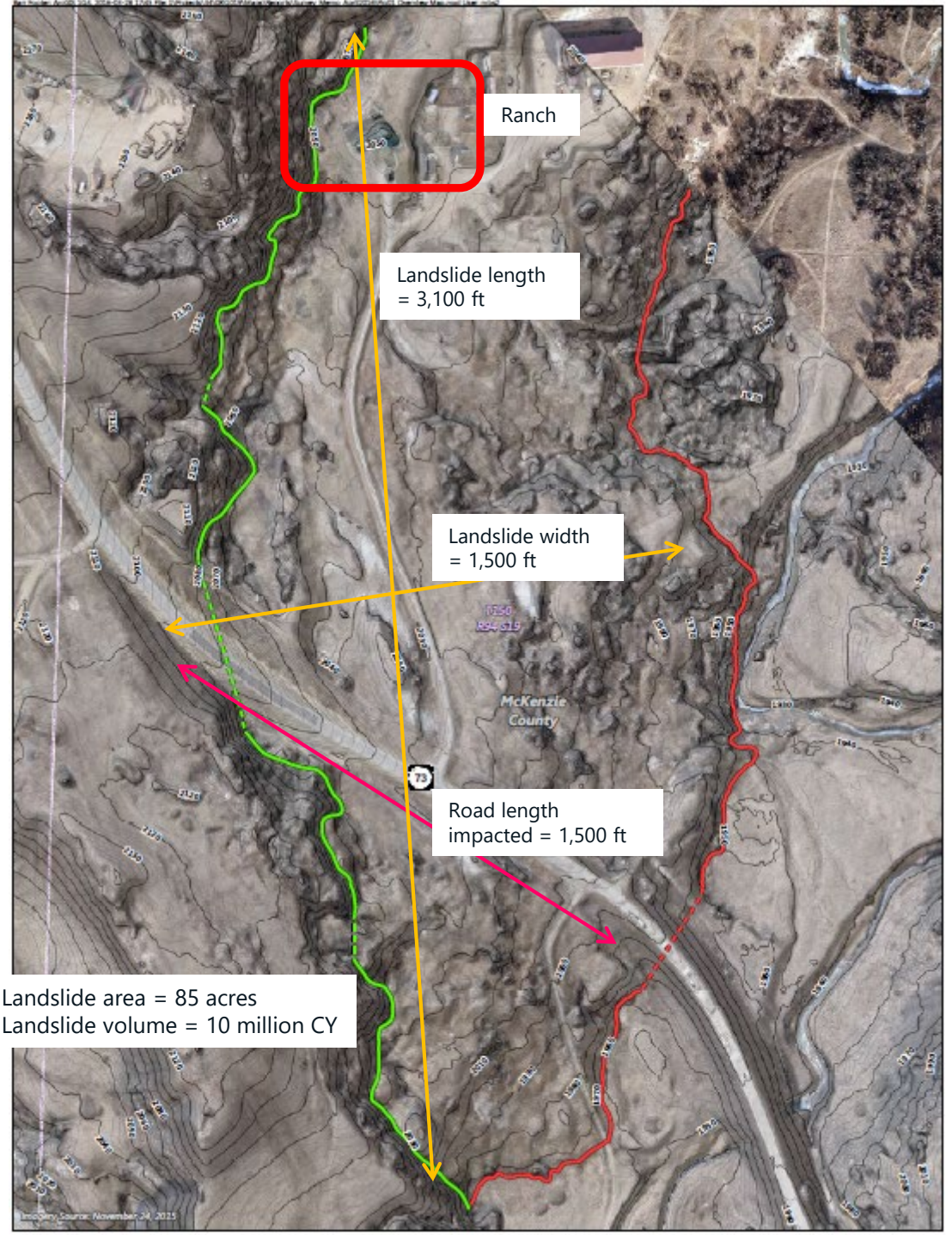
# This Project – Barr & SRF

- Phase I: Scoping (to define scope of work in Phase II)
- Phase II: Geotechnical Investigation and Recommendation (characterize problem and select recommended alternative)
- Phase III: Environmental Documentation and Preliminary Engineering (of recommended alternative)
- Phase IV: Plans & Specs
- Phase V: EOR – Construction

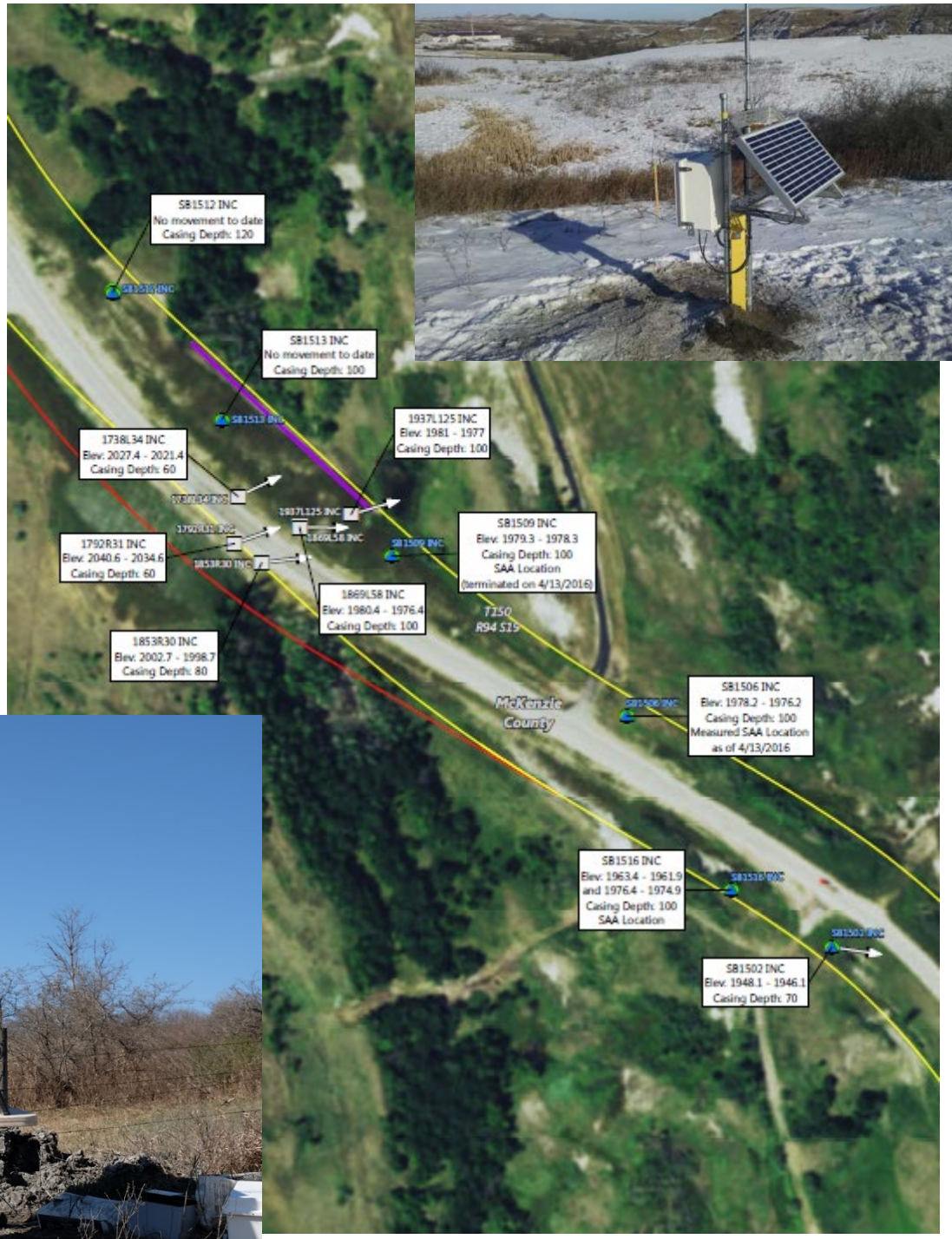
North Dakota Geological Survey—areas of landslides



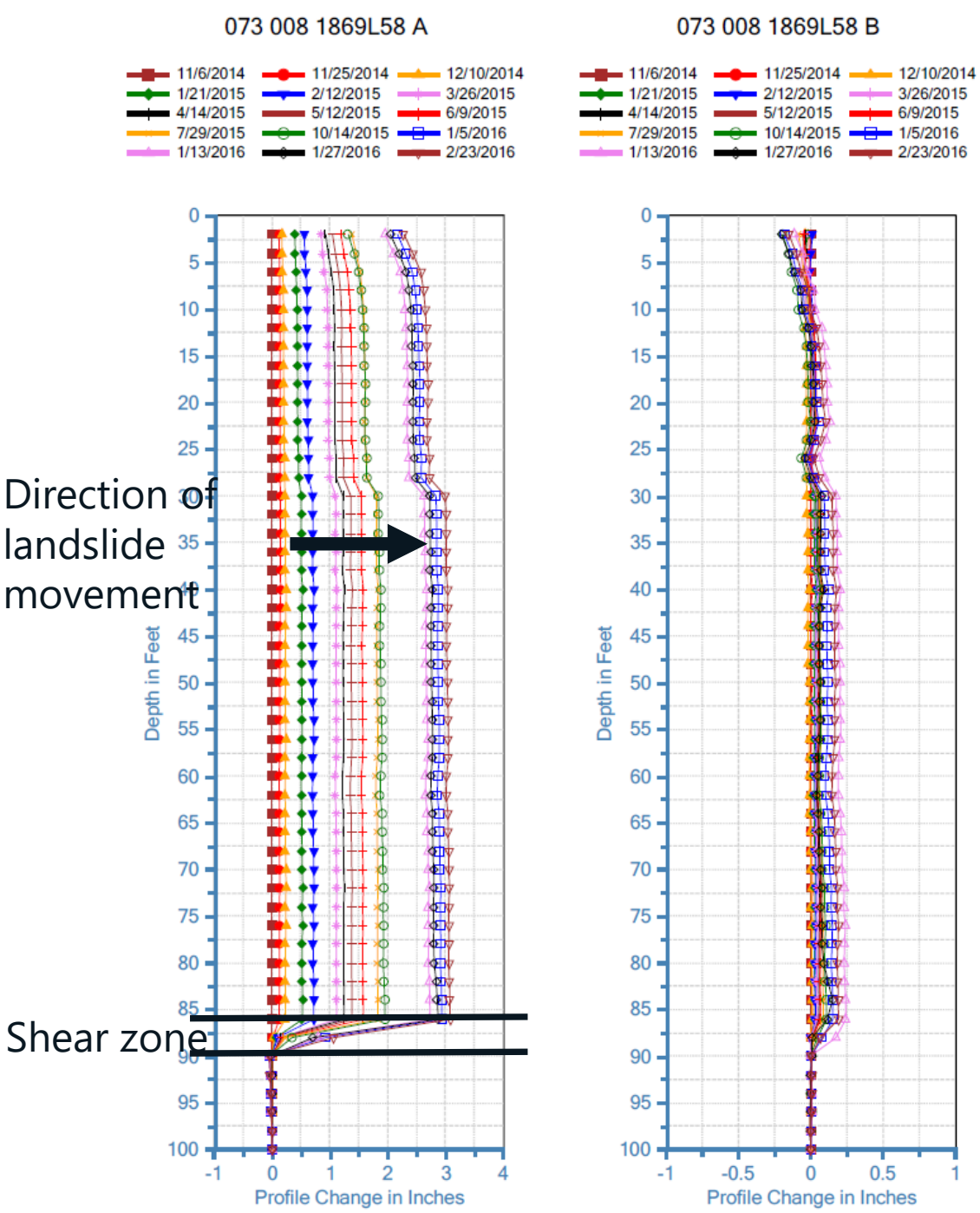
# Landslide Characteristics



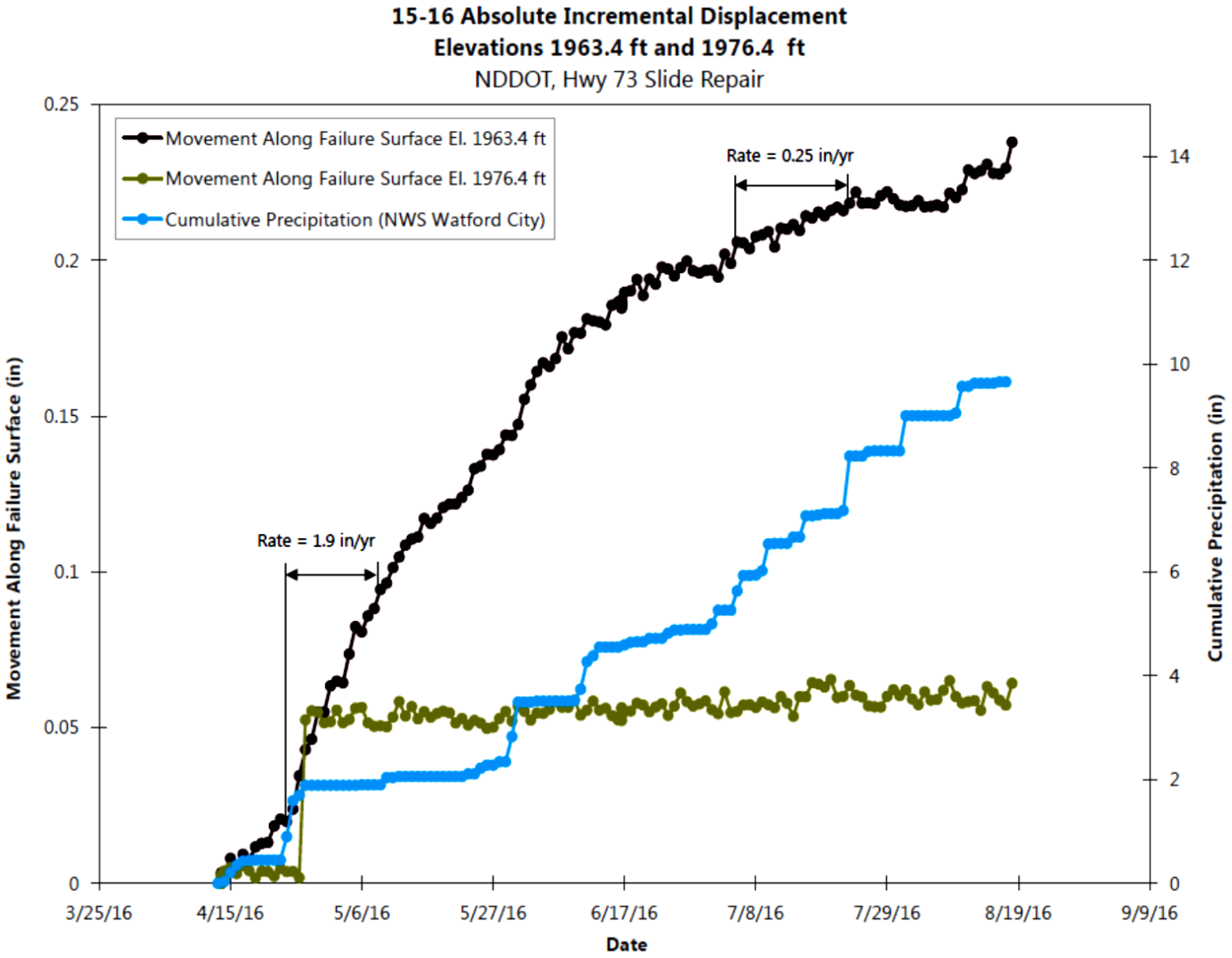
# Landslide Monitoring – “electric garden hose”



# Deformation Measurements



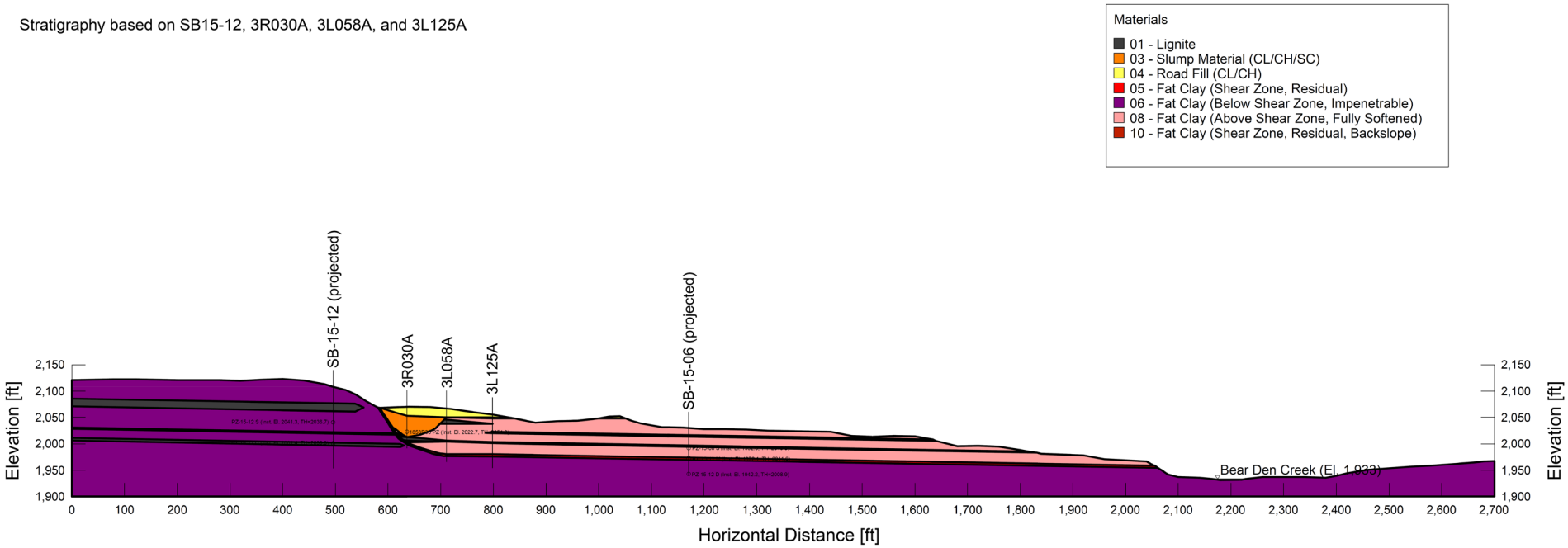
# Deformation Measurements (near real-time basis)



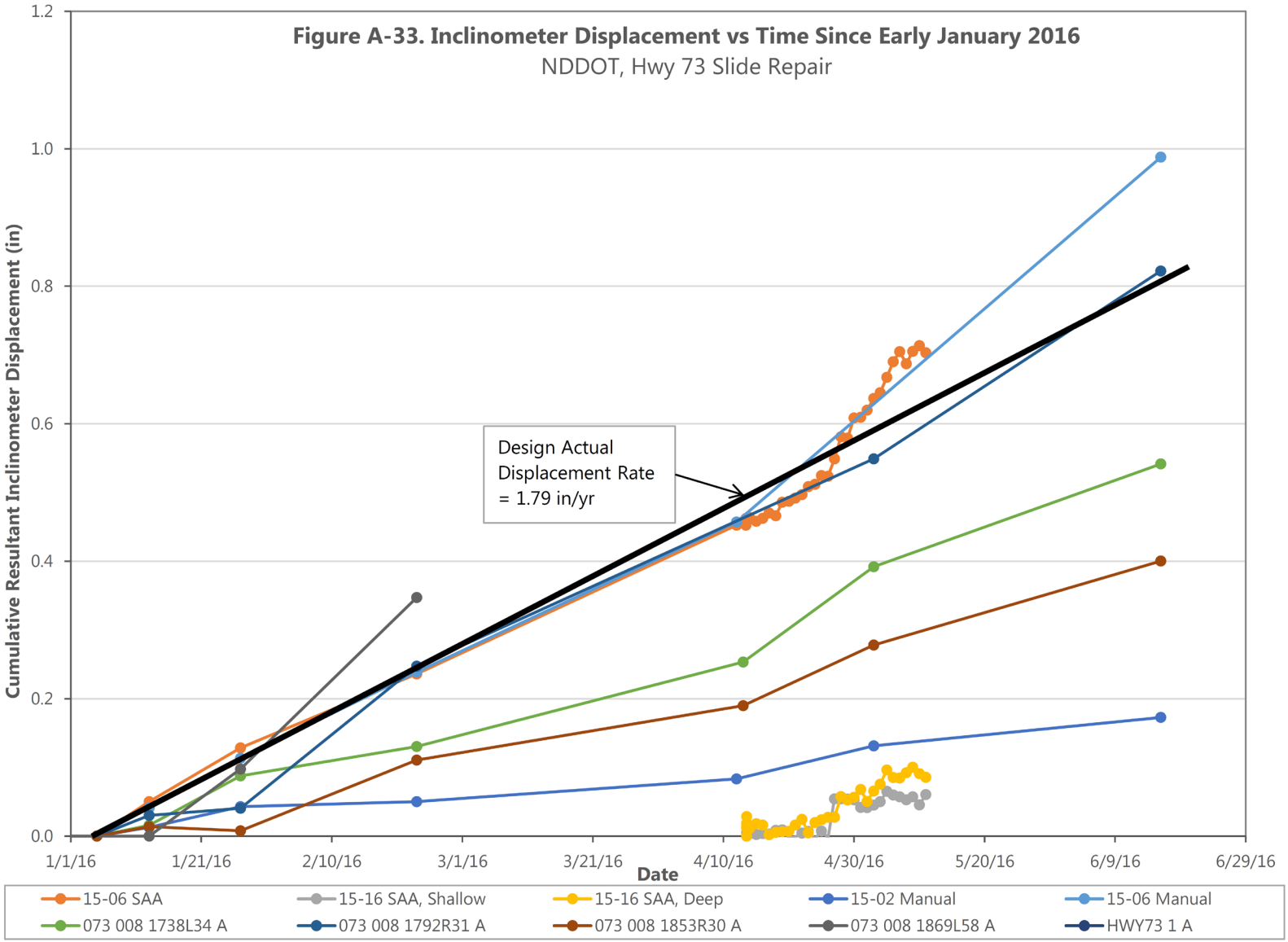
# Geotechnical Modeling – existing conditions

- Seepage calibration with GeoStudio to match observed porewater pressures
- Slope stability and deformation calibration with finite difference modeling to match ongoing deformation
- Parameters calibrated were consistent with laboratory testing results, but also reflected scale of area analyzed, including variations of geo-materials

# Cross Section for Geotechnical Modeling



# Deformation Modeling Calibration



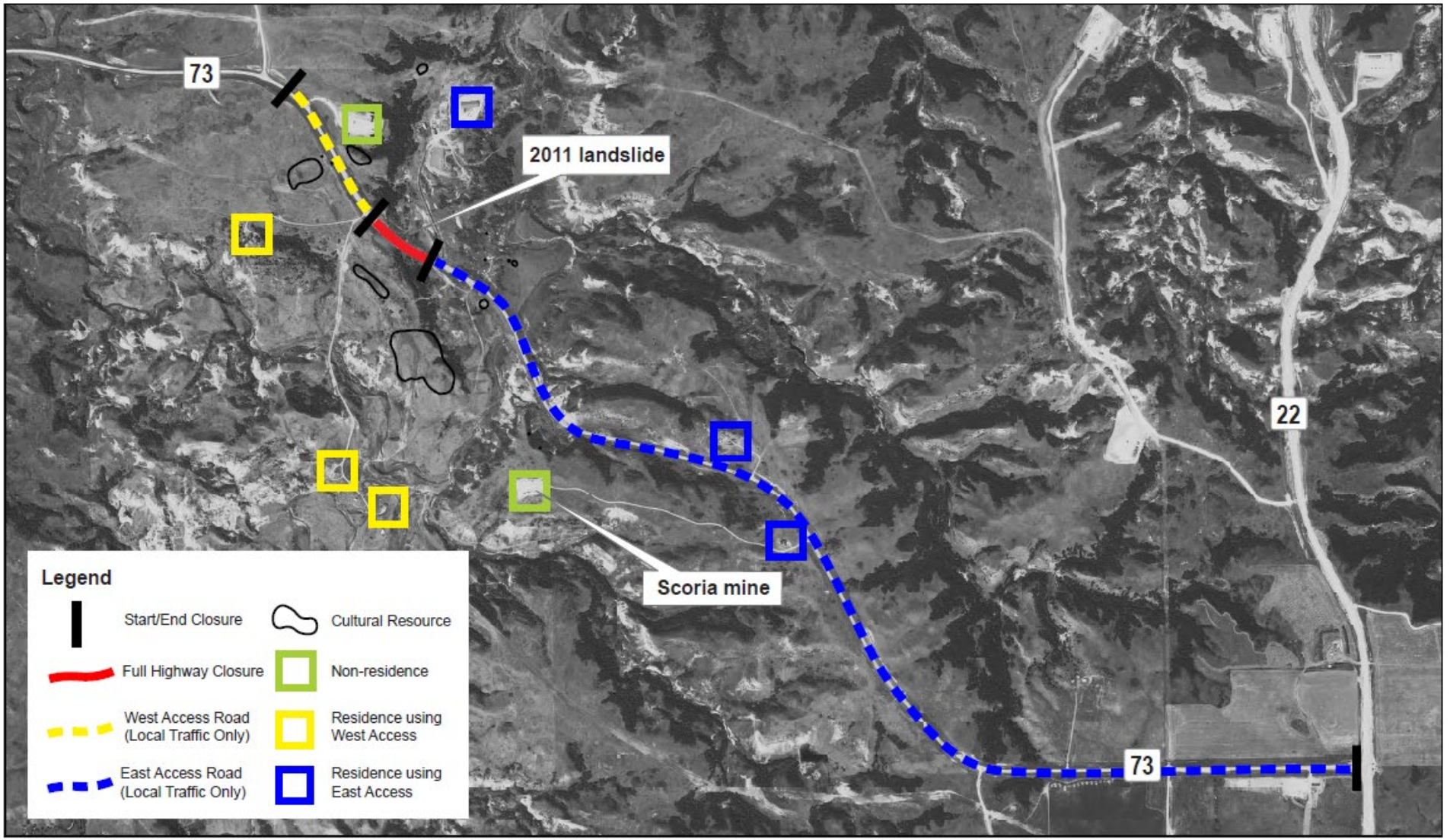
# Three Alternatives

- Do nothing
- Highway realignment
- Repairs within current alignment of highway

# Do Nothing

- Effects
  - reduced speed
  - ongoing maintenance, potentially including temporary shutdown
  - permanent shutdown
- Does NOT meet the purpose of the project

# Restricted Access to Properties




SRF Consulting Group, Inc.

Figure A - Highway 73 Closure Scenario

0 0.25 0.5 1 Miles

N

# Long Detours under a Closure Scenario

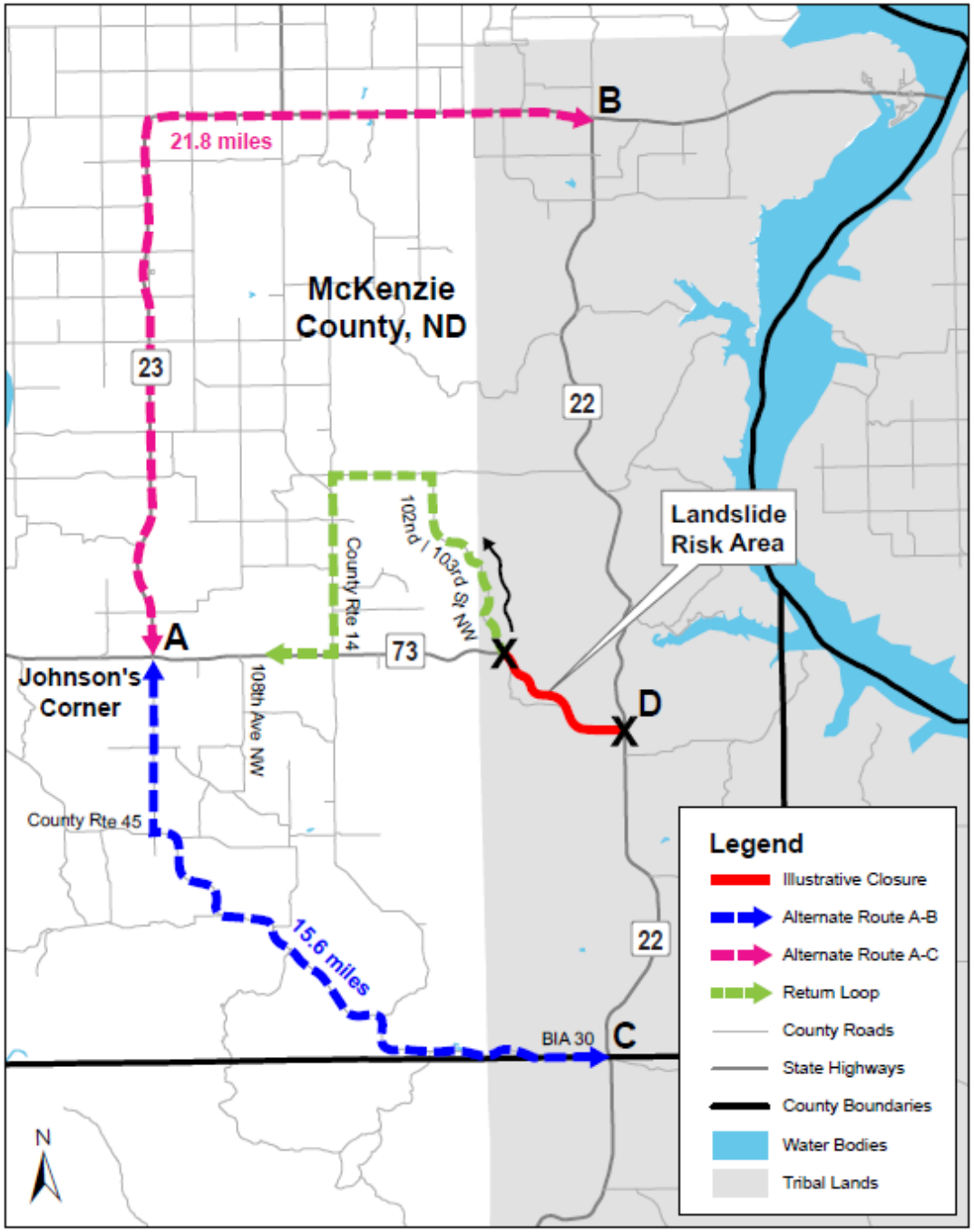
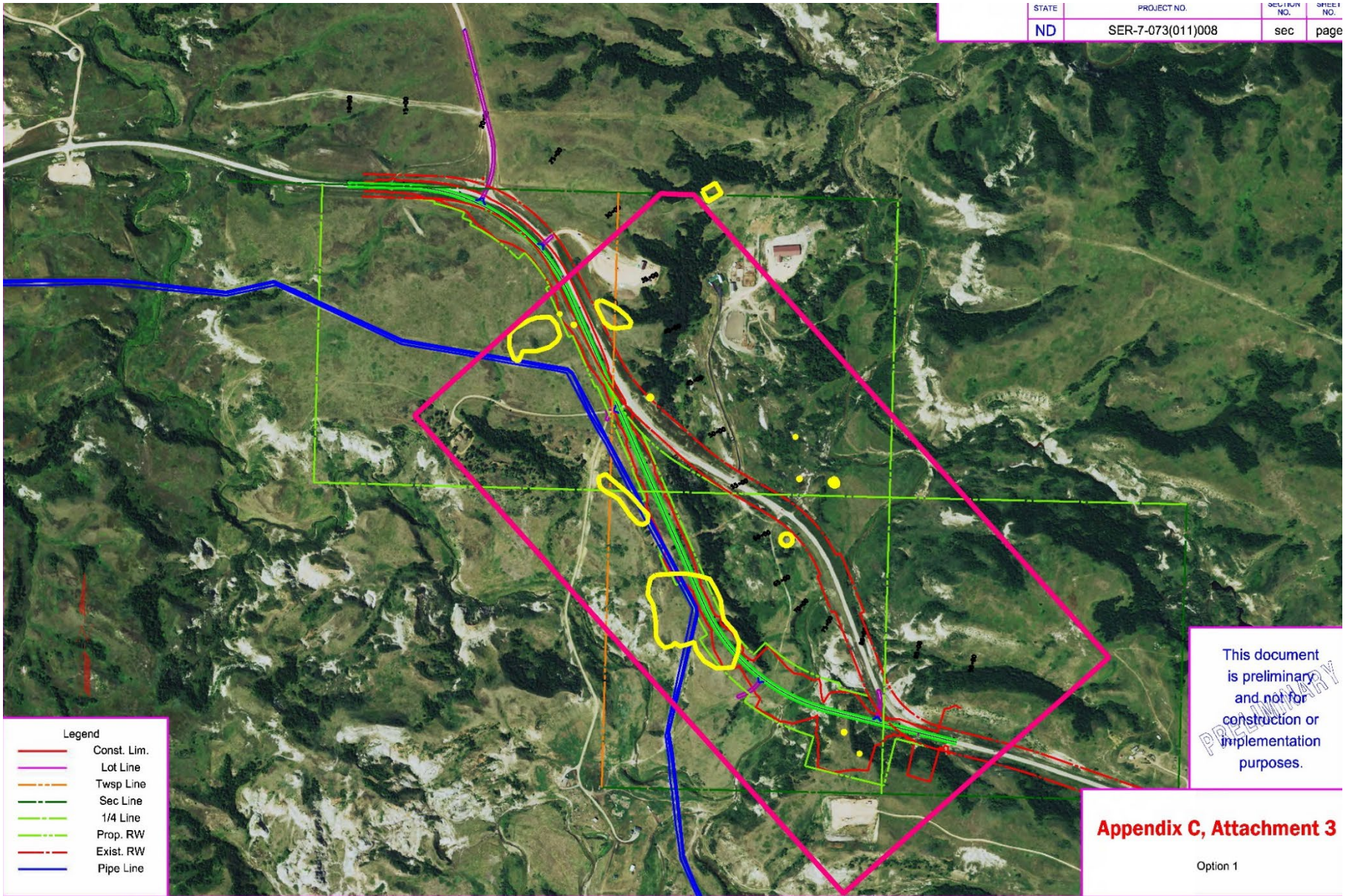
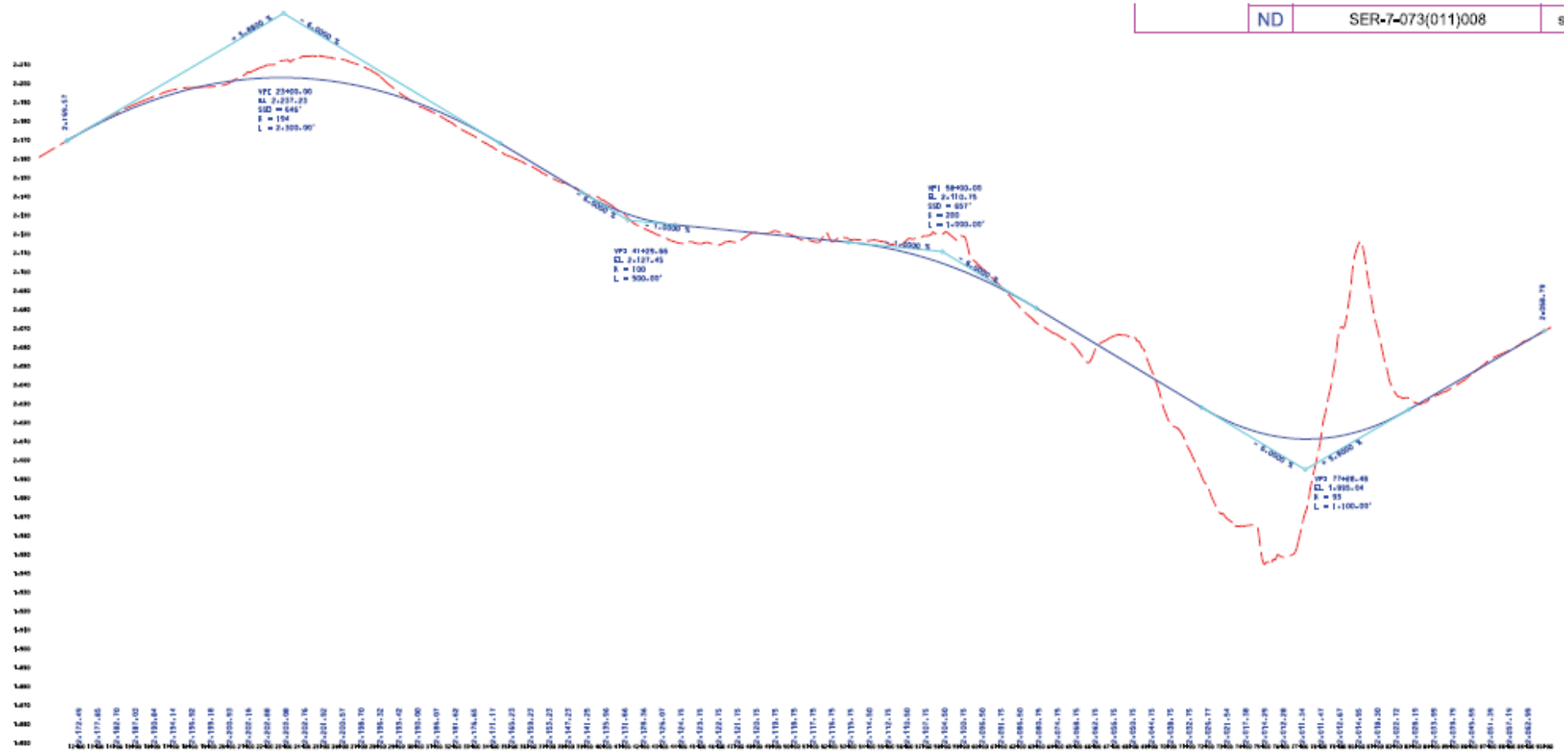



Figure B - Highway 73 Closure Scenario

# Highway Realignment



# Highway Realignment Profile

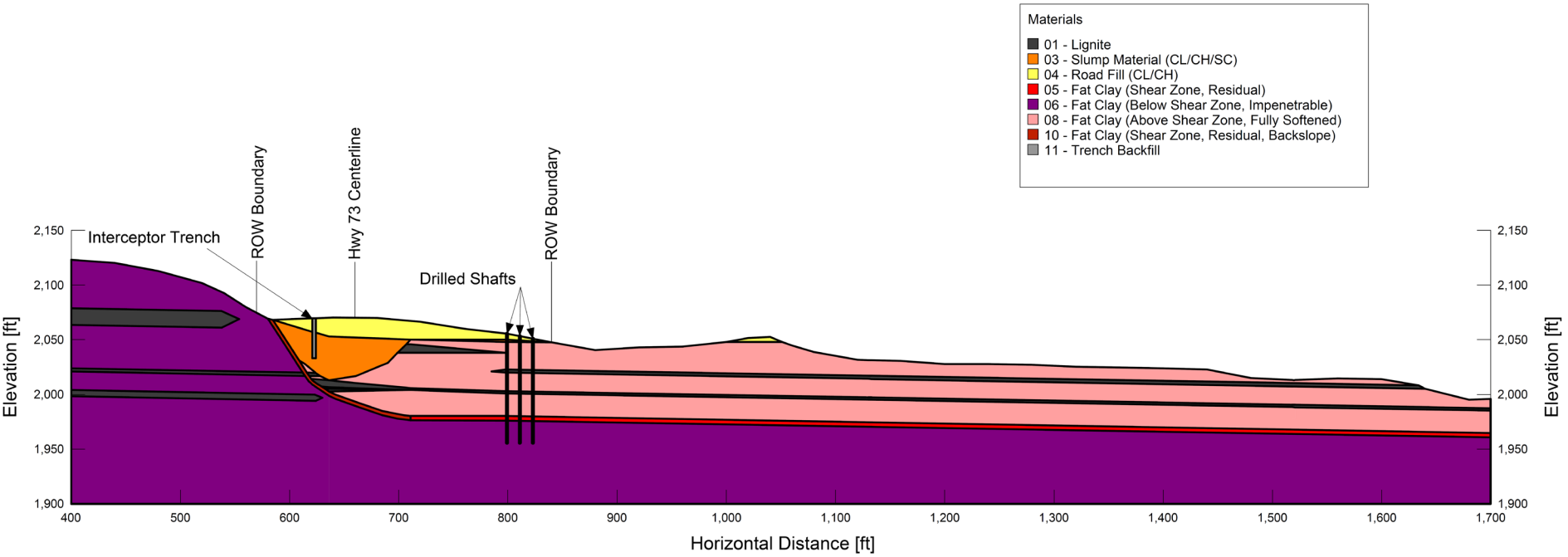


# Recommended Alternative

- One interceptor trench within ROW + two-three rows of drilled shafts
- Cost in the order of $13.5M - $18.5M (scoping level accuracy)
- Overall timeline through Phase IV: Plans & Specs on the order of 9 months

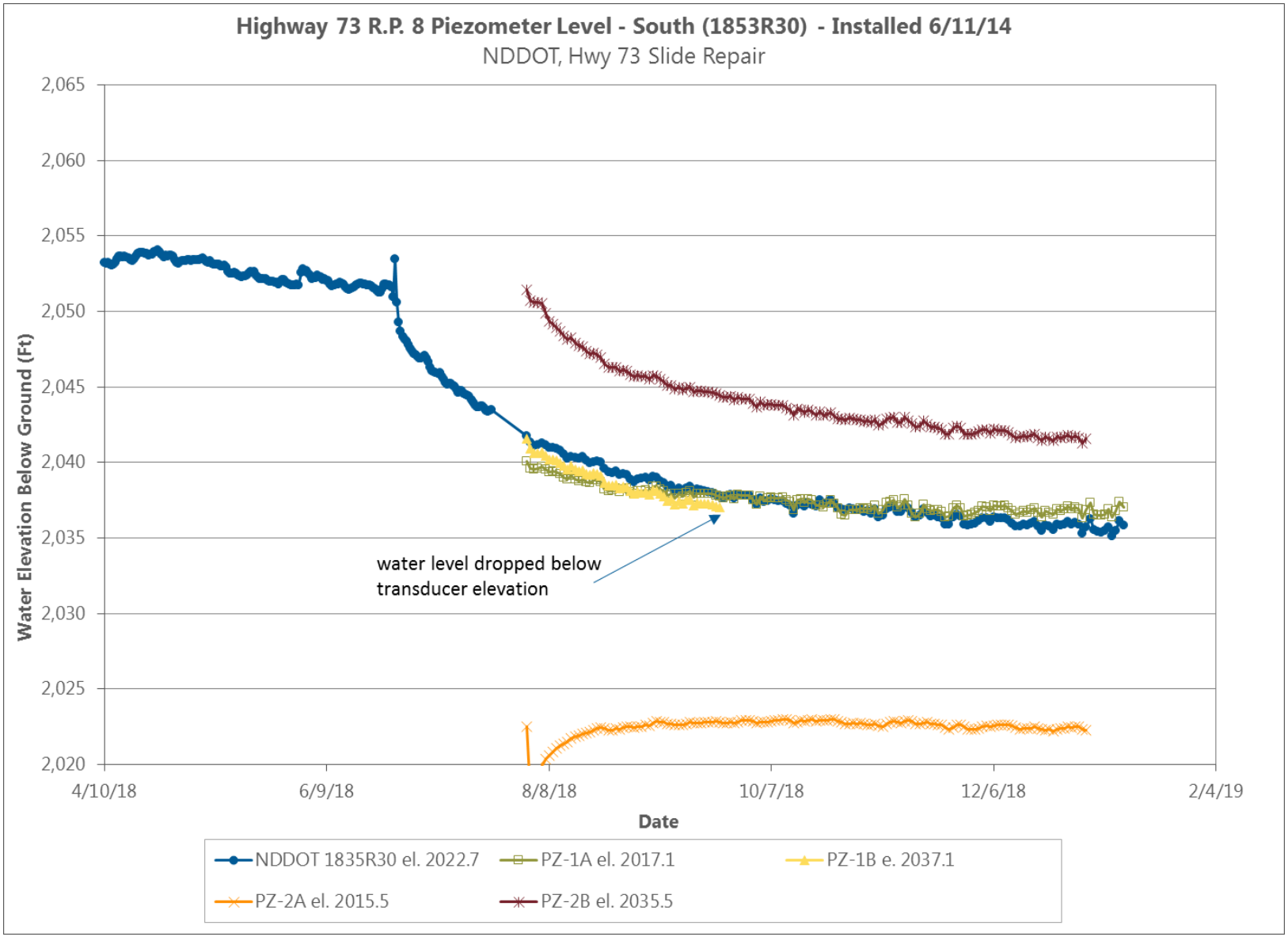
# Plan View of Interceptor Trench and Rows of Drilled Shafts

# Maintain Current Alignment

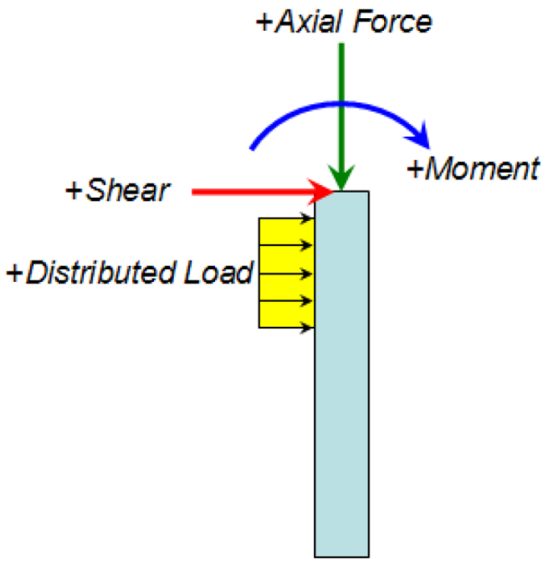


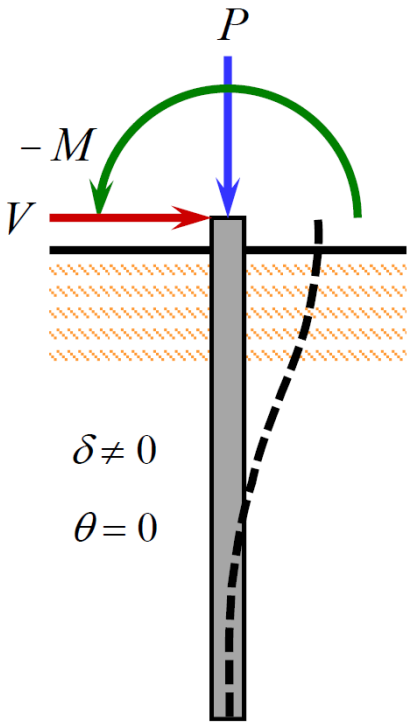
# Interceptor trench

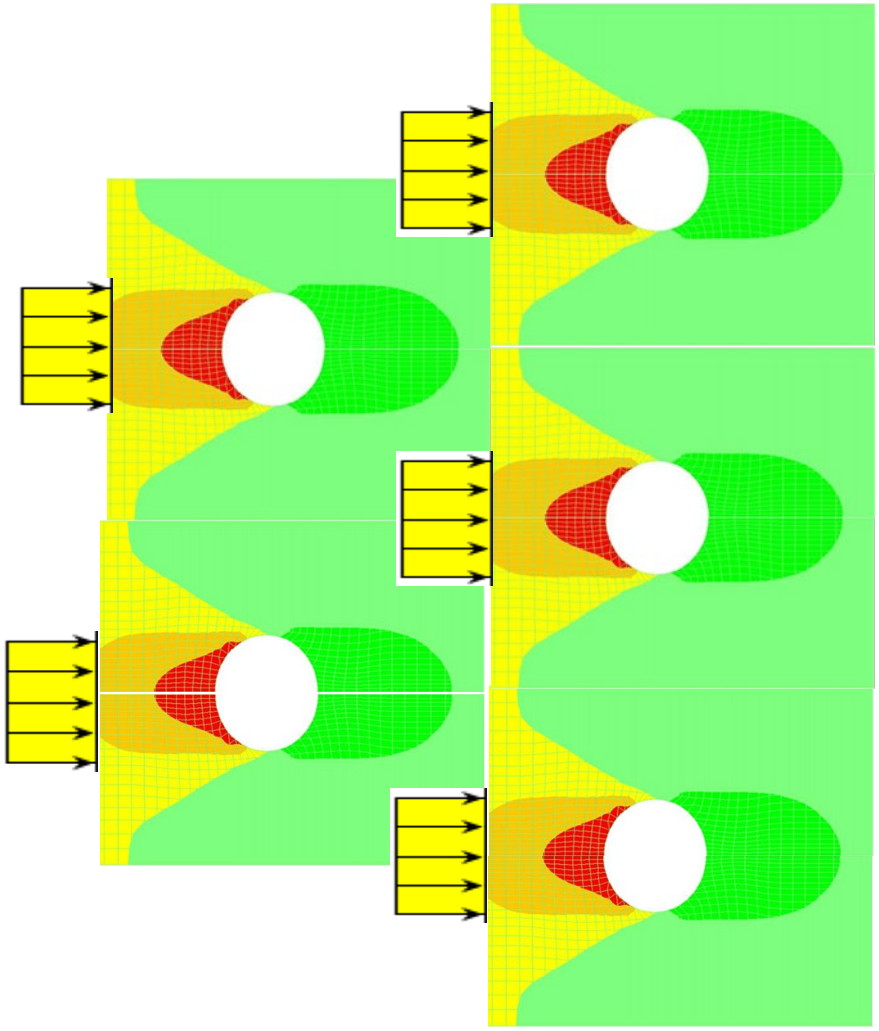
# Groundwater Control



# Drilled Shaft Design Concept

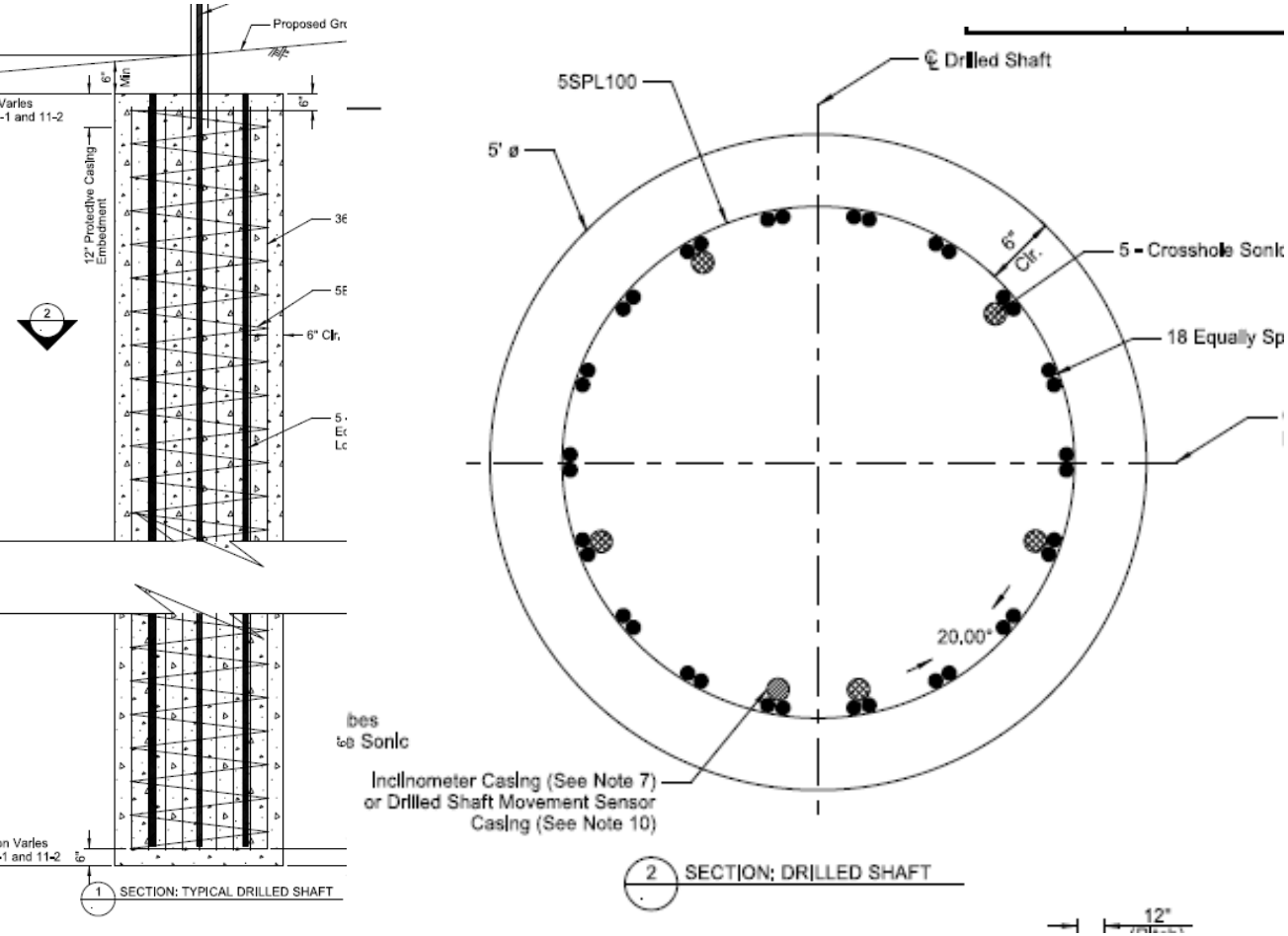


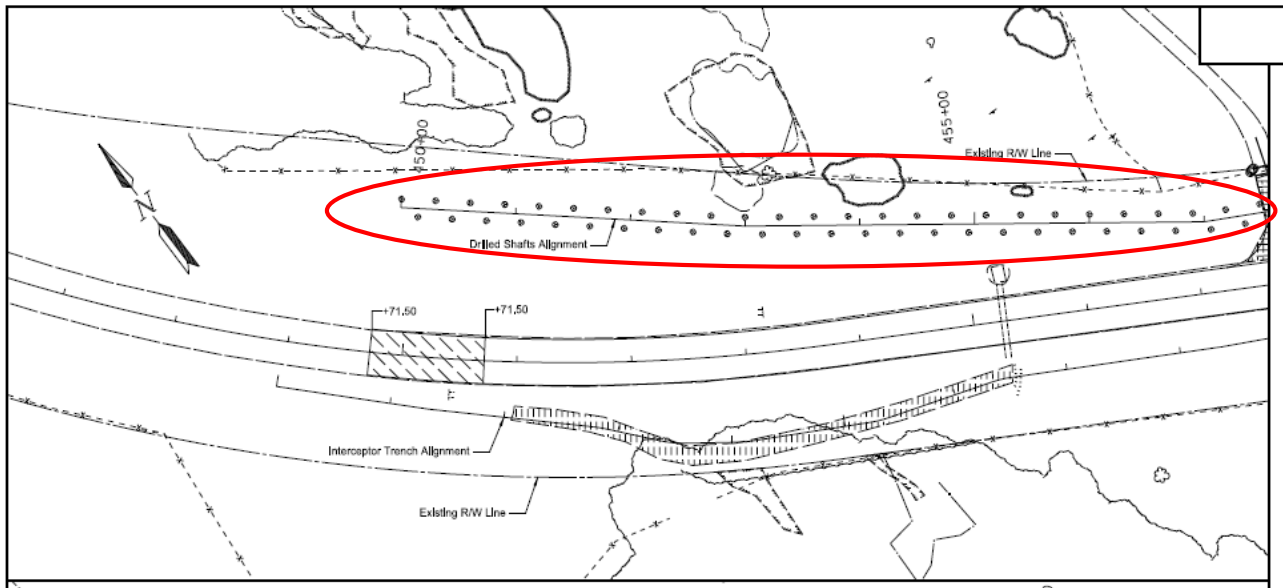
Plan View Loading Configuration

# Drilled Shaft Details from Bid Documents




- 5-foot-diameter drilled shafts
- 2% steel by area
- total length based on depth to failure surface, minimum 20 feet of shaft below failure
- A larger diameter shaft would exceed moment capacity as designed

# Repair Layout




| STATE | PROJECT NO. | SECTION NO. | SHEET NO. |
|---|---|---|---|
| ND | SER-7-073(011)008 | 40 | 1 |

| | | | | |
|---|---|---|---|---|
| 202 | 0169 | Removal of End Section - All Types & Sizes | | |
| | | 462+61 - 68' RT | 2 | EA |
| 202 | 0174 | Removal of Pipe - All Types & Sizes | | |
| | | 462+61 - 68' RT | 63 | LF |
| 202 | 0132 | Removal of Bituminous Surfacing | | |
| | | 457+77 LT | 248 | SY |
| 411 | 0105 | Milling Pavement Surface | | |
| | | 449+71,5 to 450+71,5 | 445 | SY |
| | | 462+87.13 to 463+87.13 | 311 | SY |
| 708 | 8100 | Remove Riprap | | |
| | | 450+96 to 455+29 | 508 | CY |

Removal of Bituminous Surfacing

Milling Pavement Surface

Remove Riprap

Saw Cut

This document was originally issued and sealed by Jonathan P. Morgenroth Registration Number PE- 6872, on 08/15/17 and the original document is stored at the North Dakota Department of Transportation

Removals

ND Hwy 73
Landslide Repair

447+00 to 467+00 R2

# Construction

- Contract Highlights
- Trench Drain Installation
  - Trench Installation Procedures
  - Challenges
  - Techniques to Address Challenges
- Drilled Shaft Installation
  - Typical Construction
  - Challenges
  - Techniques to Address Challenges
  - Inspection and Testing
  - Remediation

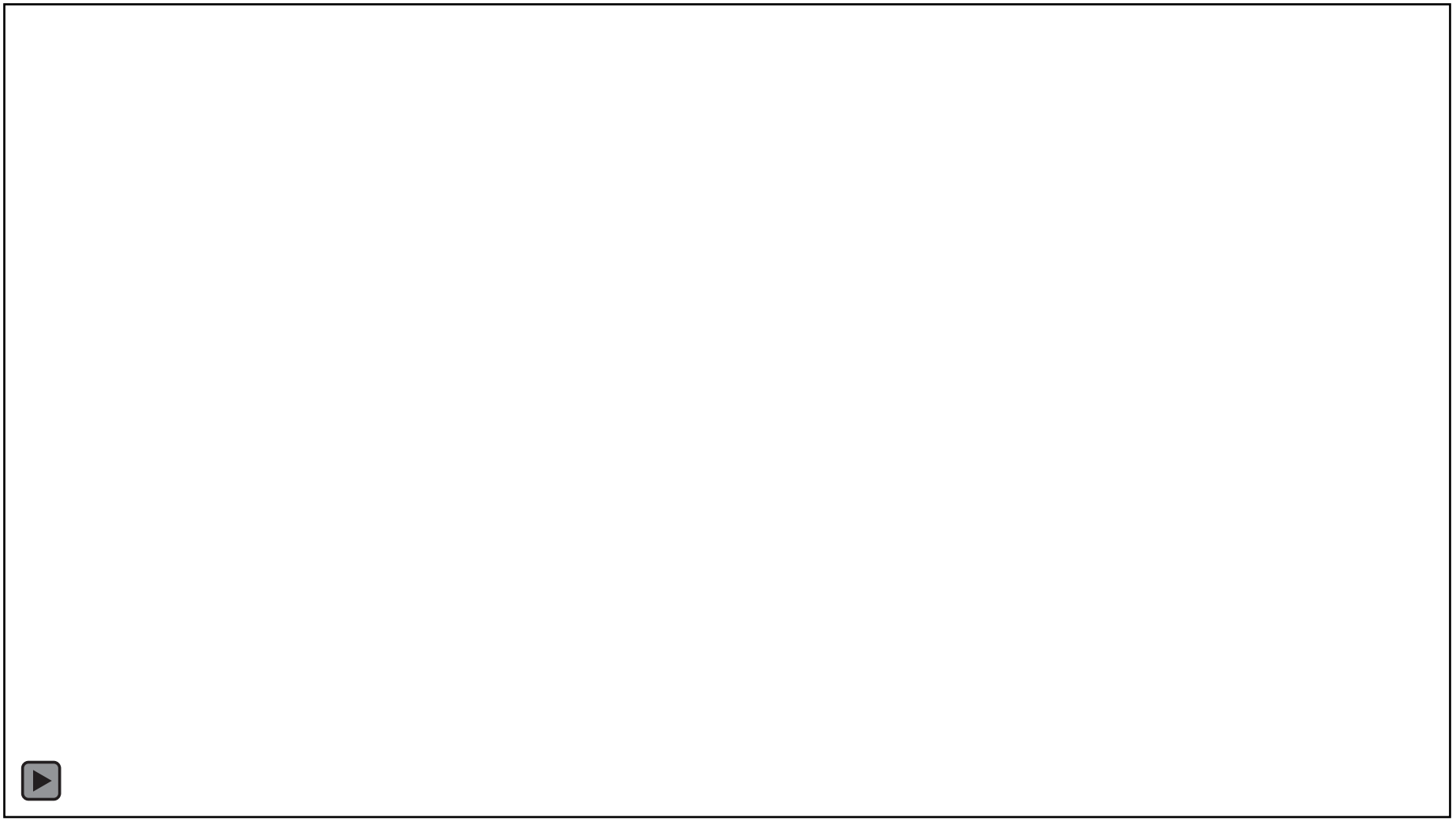
# Contract Highlights

- Engineer's Cost Estimate ($13,705,449)
- Seven Submitted Bids
- Bid Range from $9,329,039 to $14,827,210
- Awarded to Veit Construction
- Schedule
  - Trench Drain Required First
  - Followed by Drilled Shafts
  - Followed by Repaving

# Trench Drain

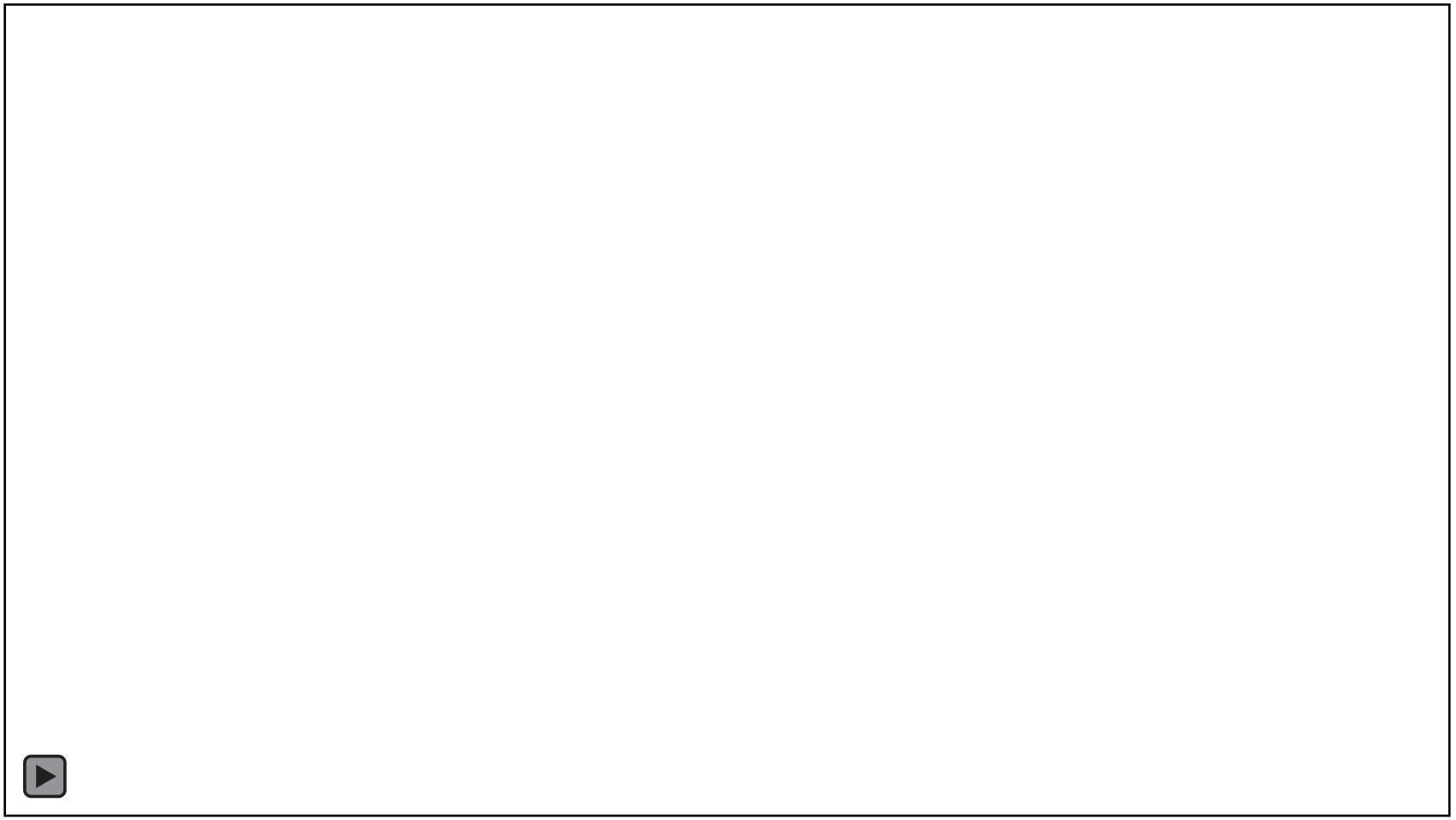
# Trenching Operations

# Encountering Groundwater



# Water Flow During Installation

# Water Flow Post Installation



# Challenges

- Specialty Sub Schedule
- Pulling Trencher Uphill

# Pulling Trencher Uphill

# Drilled Shafts

# Drilling Shafts

# Tying Reinforcement Cage

# Picking up the Reinforcement Cage

# Setting the Reinforcement Cage

# Setting up to Place Concrete

# Placing Concrete via Free Fall

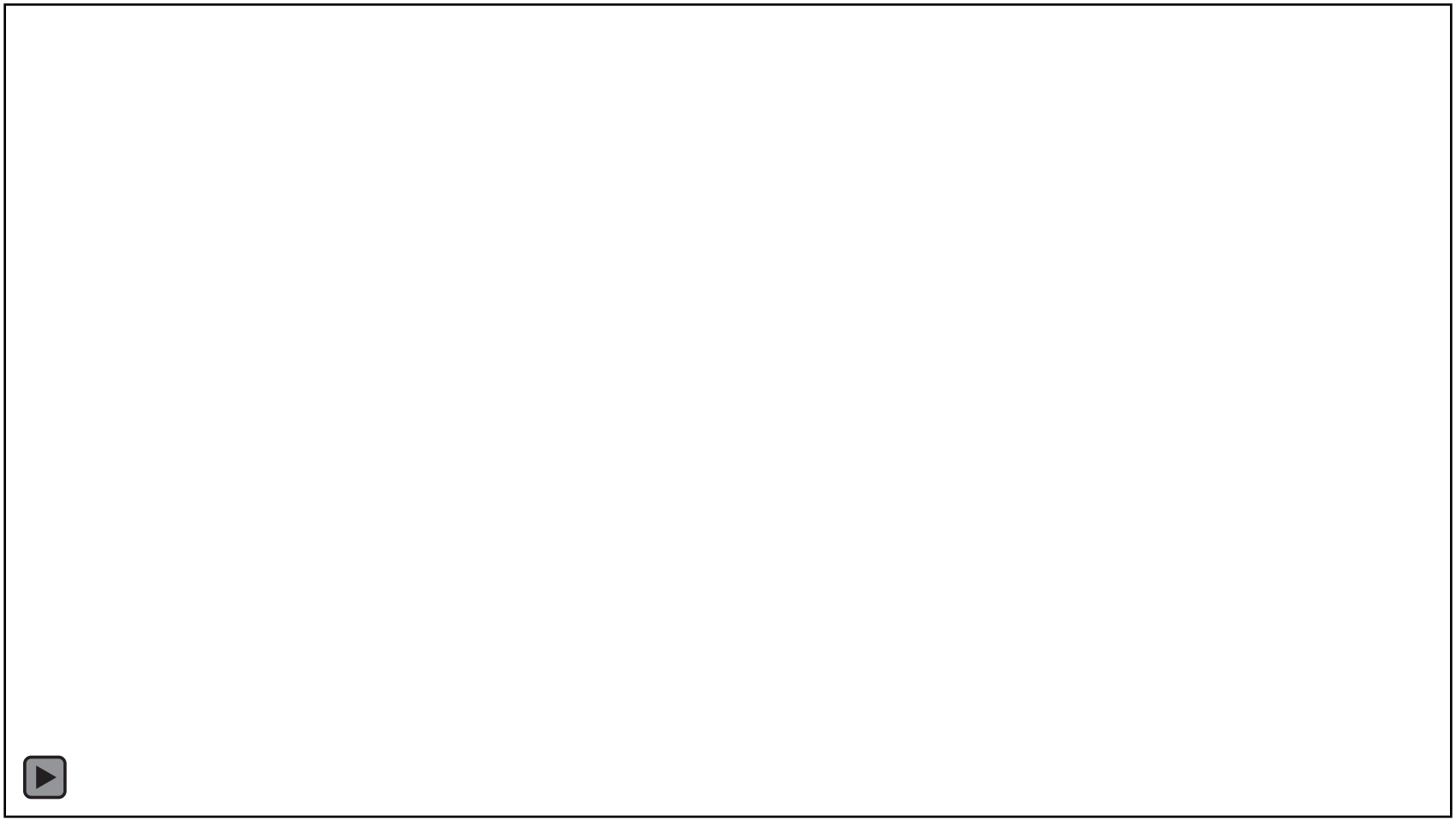
# Completed Drilled Shaft

# First Challenge – Groundwater and Caving Soil

# Cuttings Below Groundwater

# Caving without Groundwater

# Caving in Presence of Groundwater



# Addressing Caving and Groundwater by Casing

- Typically first method used to address caving
- May or may not seal-off groundwater
- If groundwater not sealed off then tremie pours required

# Typical Casing Used

# Clean-out Bucket

# Water Trapped Behind Casing

# Pump and Bail Water and Contaminated Concrete

# Casing, Often Stuck

# Telescoping Casing

- Means to extend casing deeper
- Results in larger diameter temporary casing, which may alter requirements for reinforcement

# Telescoping Casing

# Polymer Slurry

- Reduces or eliminates need for casing by providing viscous fluid in hole that supports excavation
- Specialized equipment and field technicians
- Messy

# Mixing up the Slurry

# Slurry Tent with Ground Defrosters

# Drilling with Polymer Slurry

# Slurry Testing

# Drilling Bucket

# Second Challenge – Placing Concrete Underwater

# Pump Truck and Tremie Pipe

# Pump Truck and Tremie Pipe

# Pumping out Slurry and Measuring Tremie Embedment

# Pulling Casing with Slurry

# Third Challenge – Cold Weather Construction

# Dealing with the Cold

# Hi-Low Thermometer to Measure Temperatures under Concrete Blanket

# Importance of Inspection

# Instrumentation

# SHANNON & WILSON, INC.

## DRILLED SHAFT INSTALLATION LOG

JOB NAME: ND-73 Landslide Repair
JOB NUMBER: 23-1-01674-002
CONTRACTOR: Veit & Company, Inc
OBSERVED BY: ALL
REVIEWED BY: GRF

SHAFT NO.: A30
DATE EXCAVATION STARTED: 7/19/2018 16:58 PM
DATE SHAFT FINISHED: 7/20/2018 13:45 PM
SPECIAL ITEMS: None
WEATHER: Partly Cloudy, 60's to 80's

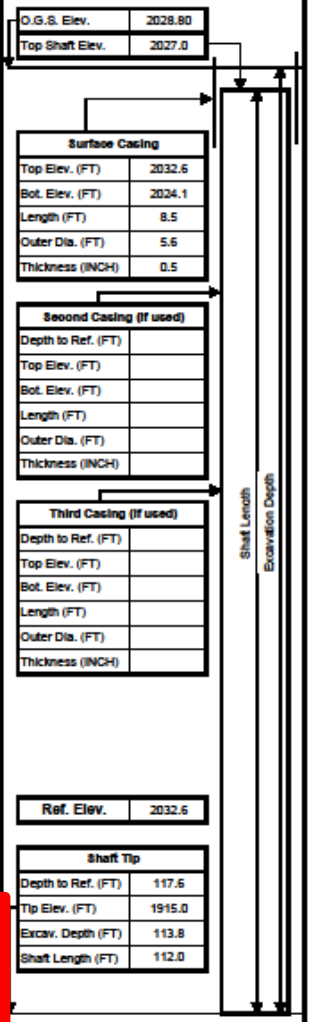
### DESIGN AND AS-BUILT SUMMARY

| | | DESIGN | AS-BUILT |
|---|---|---|---|
| LOCATION | STATION | 8+85 | 8+85 |
| | OFFSET FROM DESIGN CL (FT) | 7.5 | 7.5 |
| | O.G.S. ELEVATION (FT) | N/A | 2028.8 |
| SHAFT DIMENSIONS | SHAFT DIA. (FT) | 5.0 | 5.0 |
| | TOP SHAFT ELEV. (FT) | 2027.0 | 2027.0 |
| | TOP SOCKET ELEV. (FT) | N/A | N/A |
| | TIP ELEVATION (FT) | 1915.0 | 1915.0 |
| | SOCKET LENGTH (FT) | N/A | N/A |
| | SHAFT LENGTH (FT) | 112.0 | 112.0 |
| | PLUMBNESS | <2% | <2% |
| | GROUNDWATER ELEV. (FT) | N/A | N/A |
| REINFORCEMENT | VERT. REBAR SIZE | 11 | 11 |
| | VERT. REBAR LENGTH (FT) | 111.0 | 111 |
| | VERT. REBAR QTY. | 36 | 36 |
| | REBAR PROJECTION (FT) | N/A | N/A |
| | PROJ. REBAR ELEV. (FT) | N/A | N/A |
| | MAX. UNREINF. BOTTOM (FT) | 0.5 | 0.5 |
| | HORIZ. REBAR SIZE | 5 | 5 |
| | HORIZ. REBAR SPACING (FT) | Spiral | Spiral |
| | SPIRAL PITCH (INCH), (IF USED) | 7 | 7 |
| DRILLING FLUID | TYPE OF SLURRY (IF USED) | None | |
| | TEST NO. | 1 | 2 |
| | TIME SAMPLED | | |
| | DEPTH SLURRY SAMPLED | | |
| | DENSITY | | |
| | pH | | |
| | VISCOSITY | | |
| | SAND CONTENT | | |
| CONCRETE PLACEMENT | CONDITION OF BASE | Clay, Cleaned | |
| | WATER INFLOW QTY. (GAL/MIN) | 1 | |
| | WATER INFLOW DEPTH (FT) | 108 | |
| | CONC. PLACEMENT METHOD | Wet Tremie/Freefall | |
| | TIME CONC. START | 15:04 | |
| | TIME CONC. END | 17:30 | |
| | THEORETICAL VOL. (C.Y.) | 81.5 | |
| | ACTUAL VOL. (C.Y.) | 83 | |
| | TOP CONC. VIBRATED (FT) | 5 | |

REMARKS: (e.g., drilling equipment, communication, out of roundness, change in cage elevation, CSL tubes, etc.):

Drill Rig: CZM EK 160
Difficulty placing concrete with tremie pipe. Removed Tremie pipe about 60 feet below the top of drilled shaft and placed via freefall until the top of shaft. See FAR for more details.

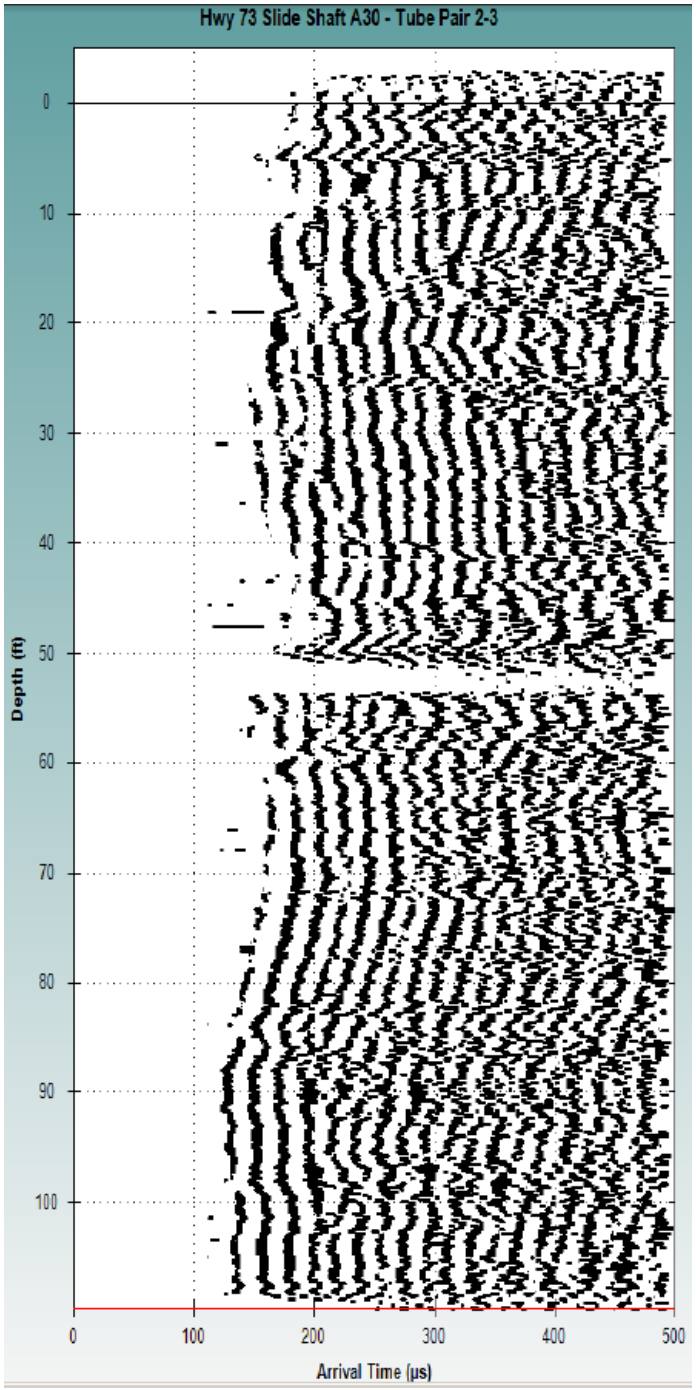
### AS-BUILT SHAFT PROFILE



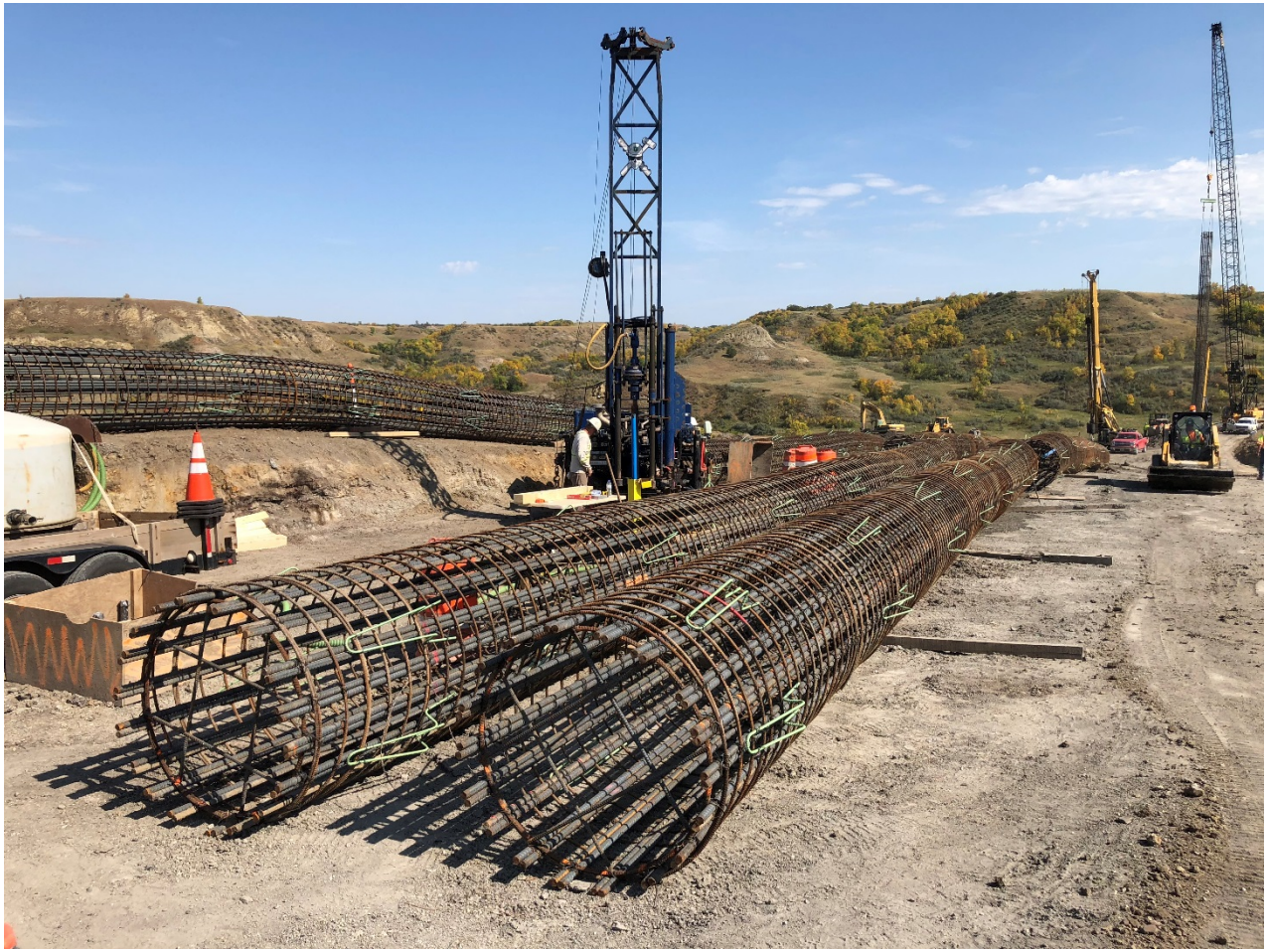

### SOIL PROFILE

| Depth (BGS) | Soil Description Summary |
|---|---|
| 0 | Brown, moist, Sandy Clay, blocky |
| 14 | Blue-gray, moist, Sandy Clay, massive |
| 24 | Boulder encountered, switched to core barrel to keep shaft plumb |
| 44 | 6-inch lignite seam, carrying small amount of water |
| 75 | Sandstone encountered, switch to core barrel to keep shaft plumb |
| 90 | Black, moist, Lignite. Alternate between core barrel and auger to keep shaft plumb and advance excavation |
| 98 | Blue-gray, moist, Sandy Clay, massive |
| 108 | Black, moist, Lignite. Able to auger through |
| 113 | Gray, moist, Sandy Clay<br>Bottom of Excavation at 113.8 |

SHAFT: A30 SHEET 1 OF 1



# Coring Shaft for Defect



# Core Recovery at Defect

# Conclusions

- Drilled shafts relatively new to NDDOT
- Special provisions written and used on two (soon to be three) projects
- Requires specialty contractors
- Requires inspection
- Testing can be used to verify integrity
- Drilled shafts should be considered as another tool in your foundation option box

Questions?
SHANNON&WILSON, INC.