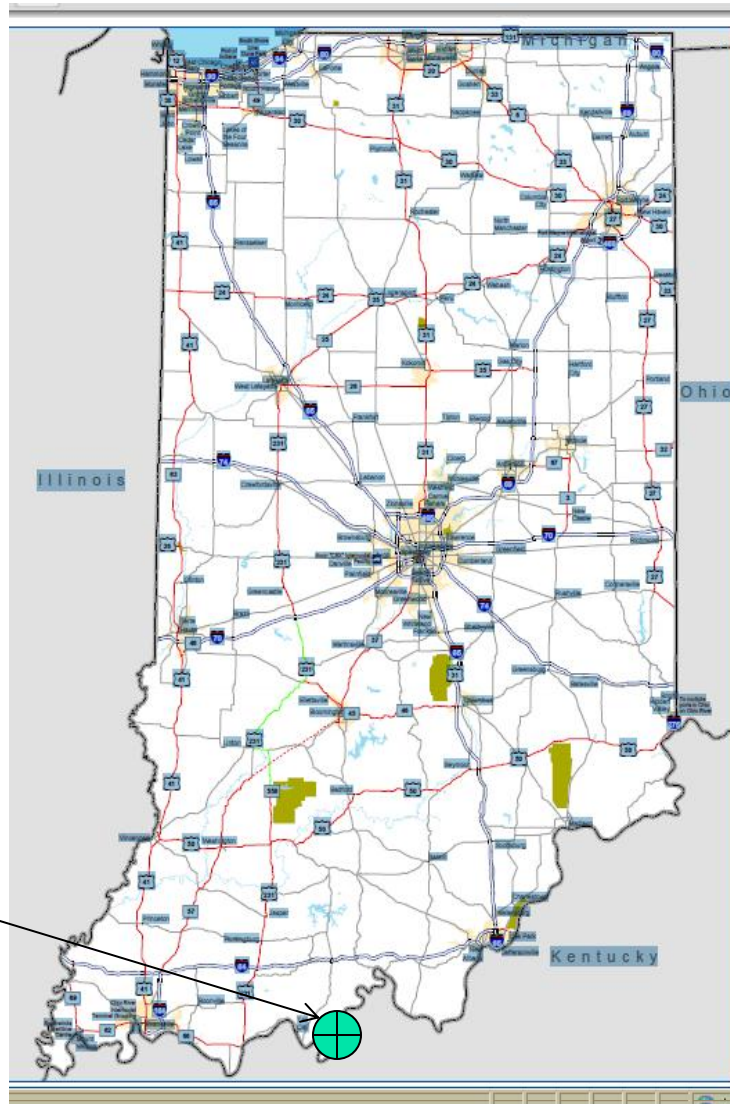


Case History

S.R. 237 in Perry County, IN



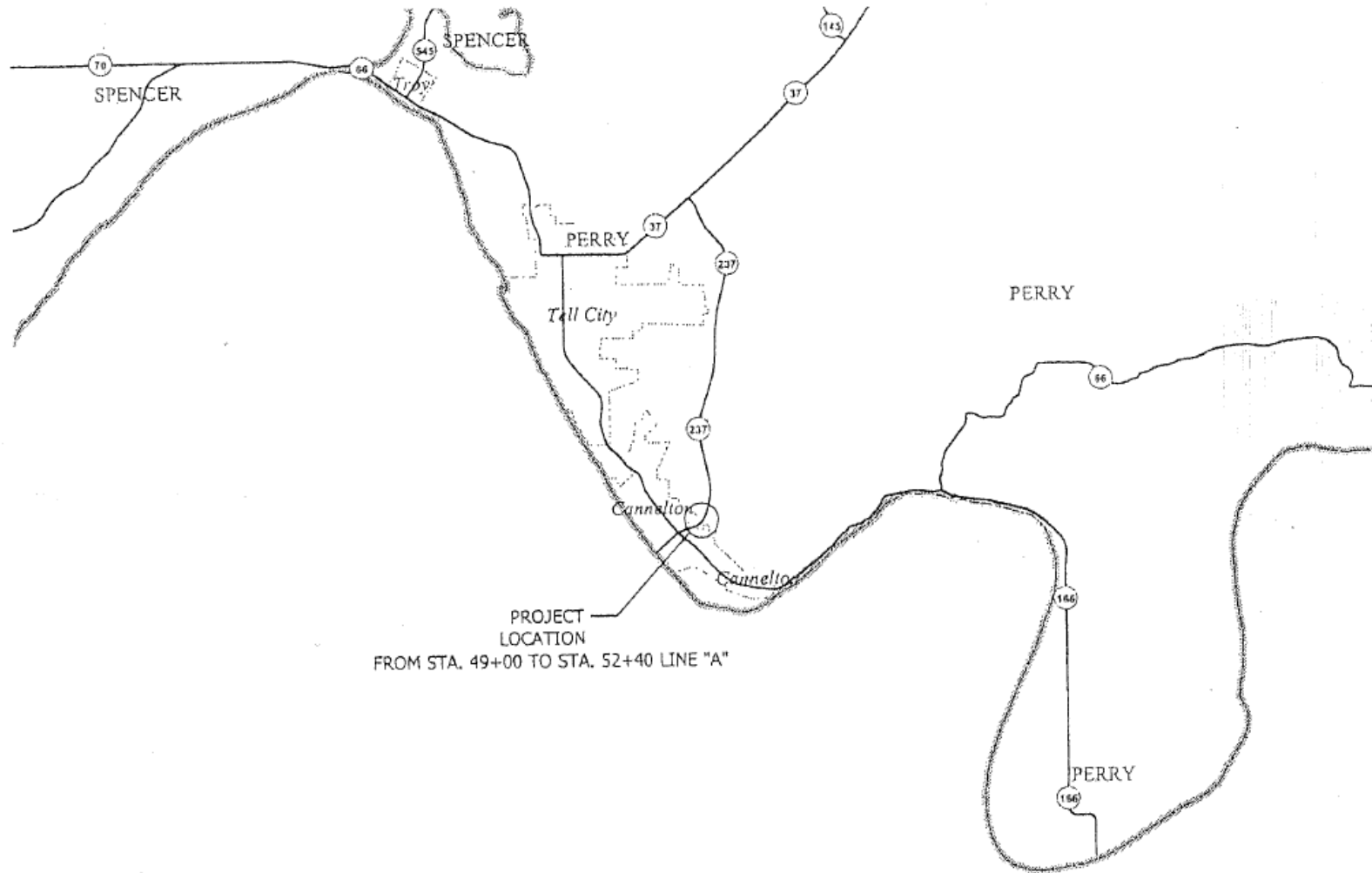
Indiana Road Map



Project location



General Site Plan



Aerial View of the Site



Original Roadway Construction

- S.R. 237 was originally built in 2003. This particular slope is approximately one-half mile long and was designed to be 2:1 and up to 112 feet high.



Geotechnical Challenges

- High embankment fills
- Slopes designed as steep as 2:1, placed on sloping natural ground
- Variations in rock surface elevations
- Fills consist of soils, shale and sandstone
- Environmental constraints



Slope after original construction.



First Slope Failure

- In May 2010 during heavy rain, the slope moved.
- The road edge and guardrail experienced vertical displacement.
- Northbound driving lane closed.



First Slope Failure



First Slope Failure

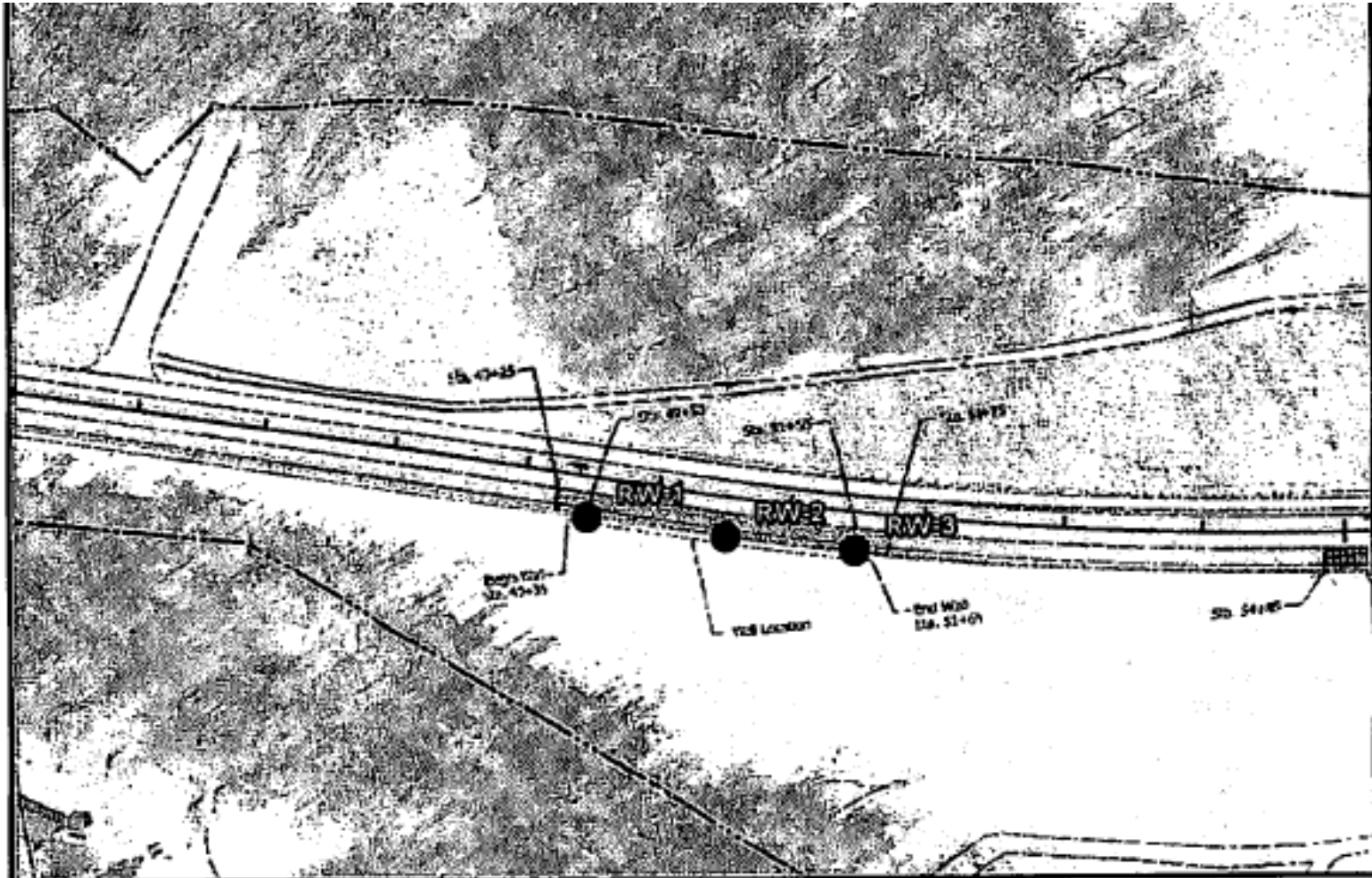


First Slide

- **Possible causes for the first slide:**
 - Actual slope measured steeper than 2:1 with the height of 112 feet, combined with the type of fill used (co-mingled soil and shale) was unstable.
 - Possible inadequate benching.
 - Water pouring from slope (excessive groundwater).
 - Heavy rainfall in spring.



First Slide



Boring location plan for the first slide.

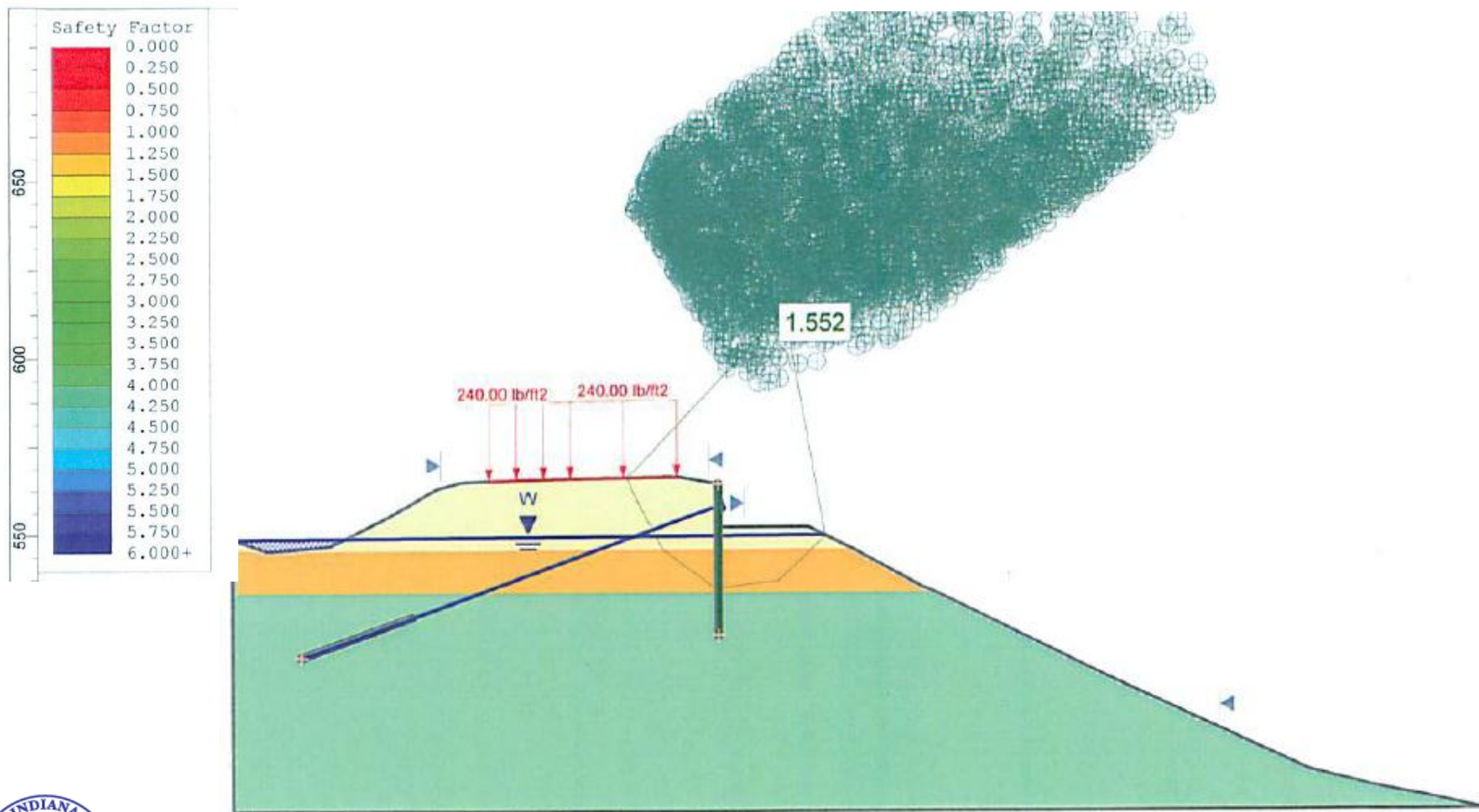
First Slide Correction in 2010

- A soil nail wall with a design-build contract requiring a seven year warranty.
- Extend outlet drainage pipe to the toe of the east slope.
- The contractor proposed a new H-pile encased in concrete wall with tiebacks and a shotcrete facing after the bid which was accepted by INDOT.



First Slide Correction in 2010

Contractor's Design



After First Correction

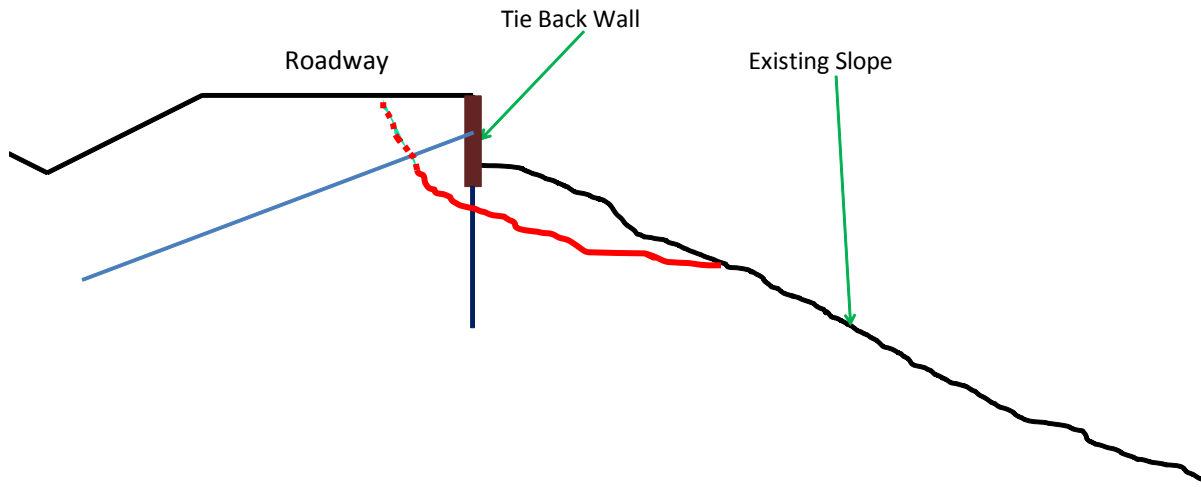


Second Slope Failure

- In April 2012 during heavy rain, the slope in front of the wall moved. It gradually dropped vertically approximately 12 feet due to new failure.



Second Slope Failure



Second Slope Failure



Second Slope Failure



Second Slope Failure

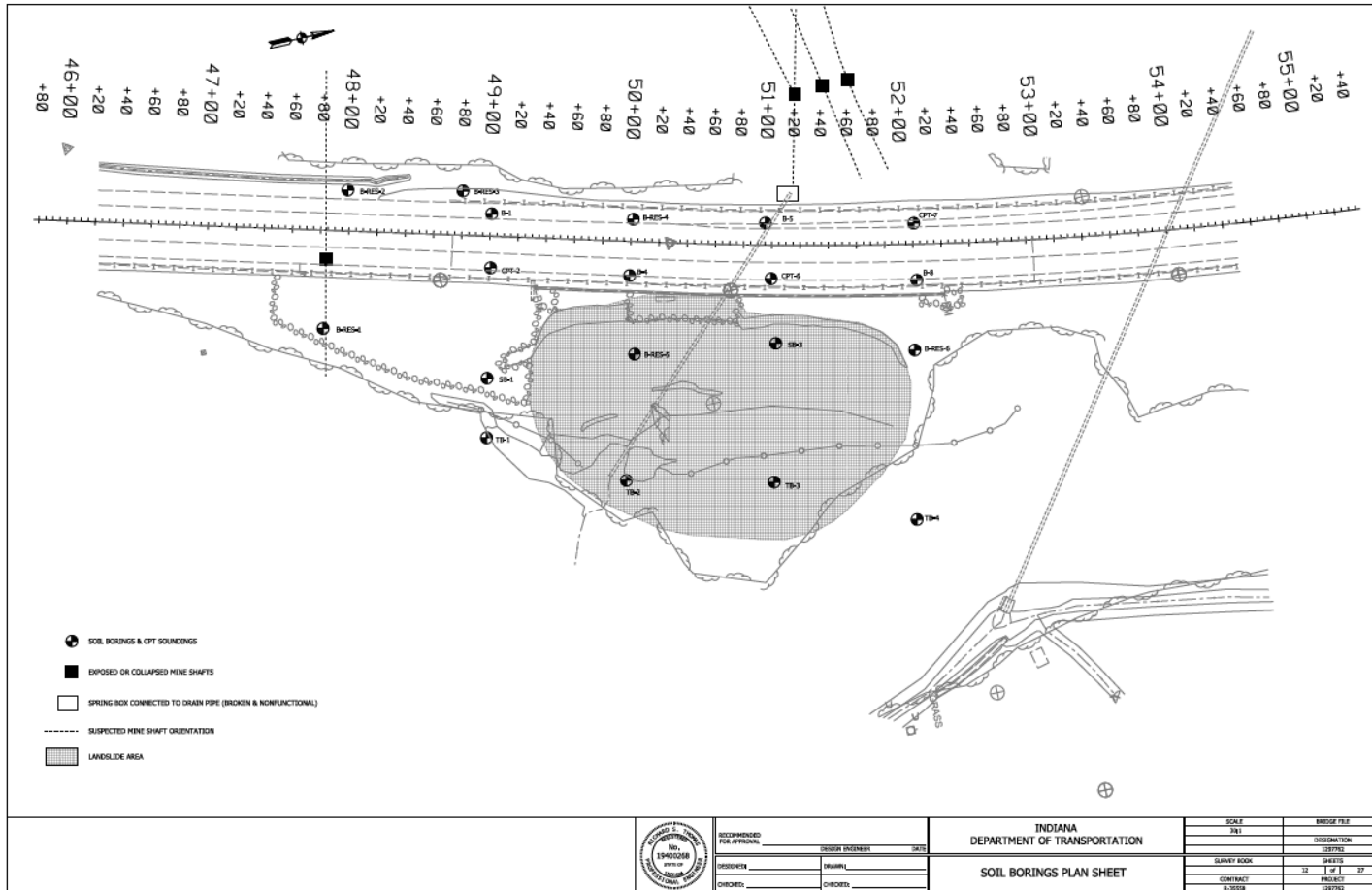


Second Slide

- **Possible causes for the second slide:**
 - Surface slide triggered by heavy rainfall.
 - Failure of outlet pipe of spring box which was buried underneath the roadway.
 - Insufficient investigation after the first slide. Borings were only 40 feet deep.



Second Slide



Boring location plan for the second slide.



Design for Second Slide

■ Phase-1 Design

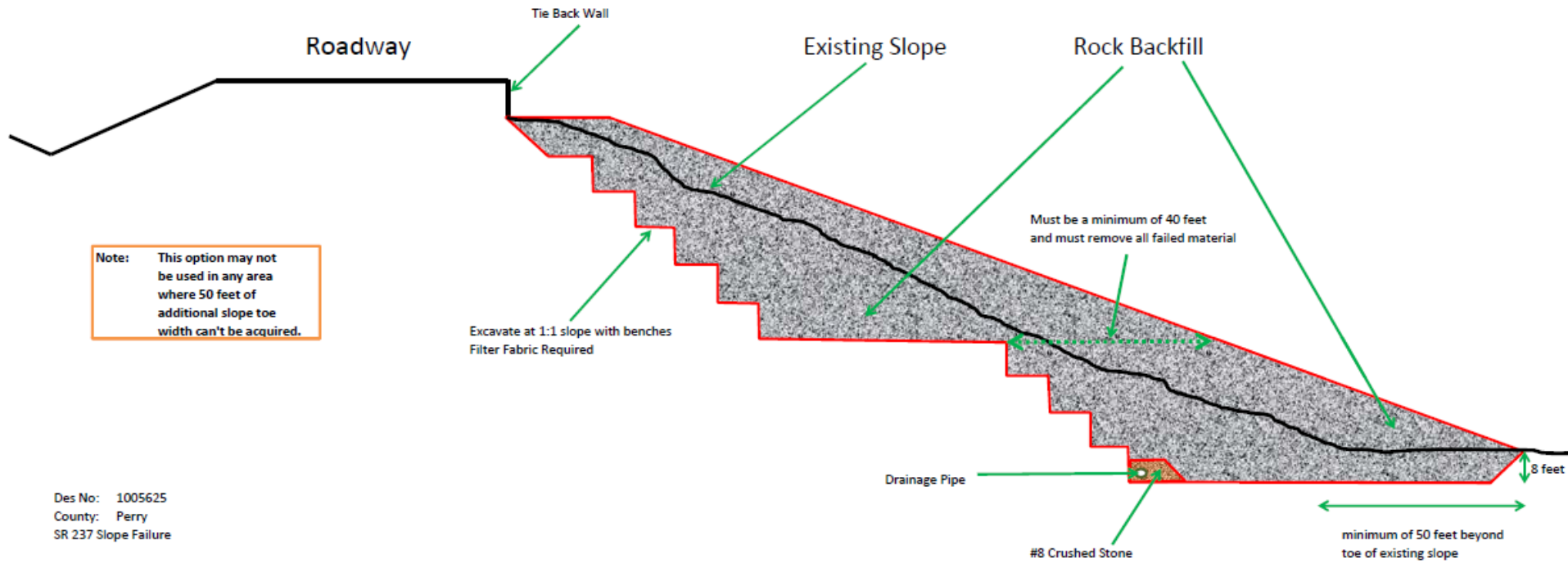
- Drainage correction: includes spring box repair & horizontal drains

■ Phase-2 Design

- Rock backfill (chosen)
- Three tier soil nail walls



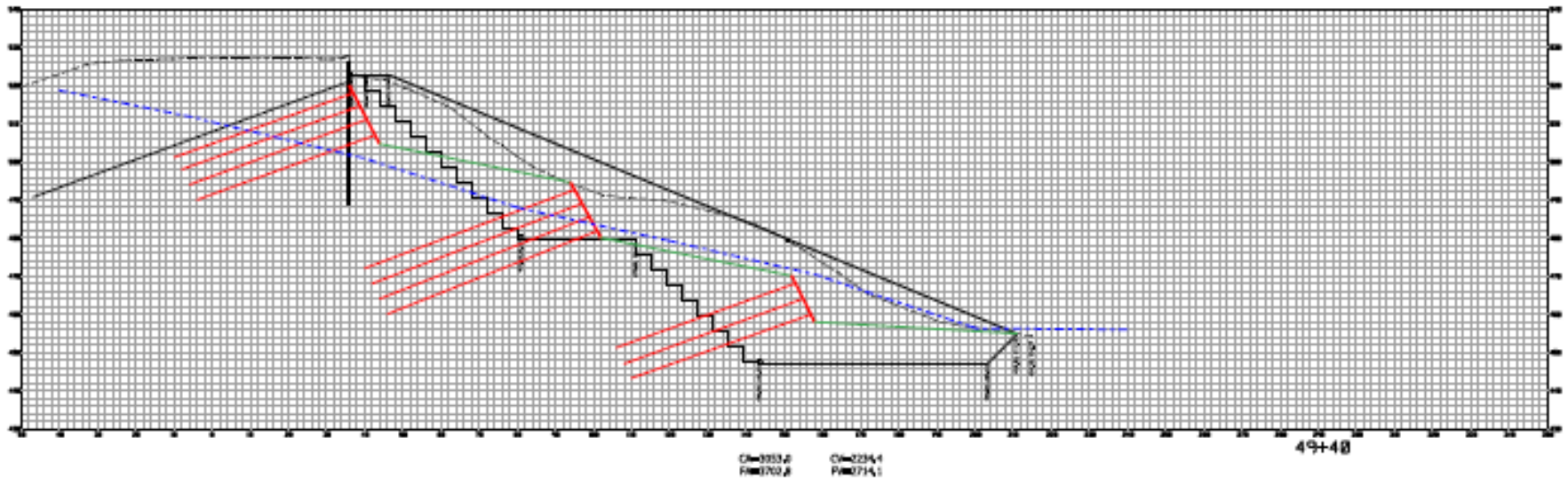
Correction Using Rock Backfill



Des No: 1005625
County: Perry
SR 237 Slope Failure



Correction Using Three Tier Wall



Problems With Rock Backfill

- Slide aggravated further after letting in March 2013 due to heavy rains.
- Massive amount of water seeped out of the slope.
- The rock backfill was not viable option anymore because it would require the 1:1 temporary slope.
- Potential destabilization of existing soldier pile wall.



Problems With Rock Backfill

Another Surprise:

- During exploratory excavation for the spring box repair, coal mine shafts were uncovered.



Mine Shaft Discovery



Mine Shaft Discovery



Mine Shaft Discovery

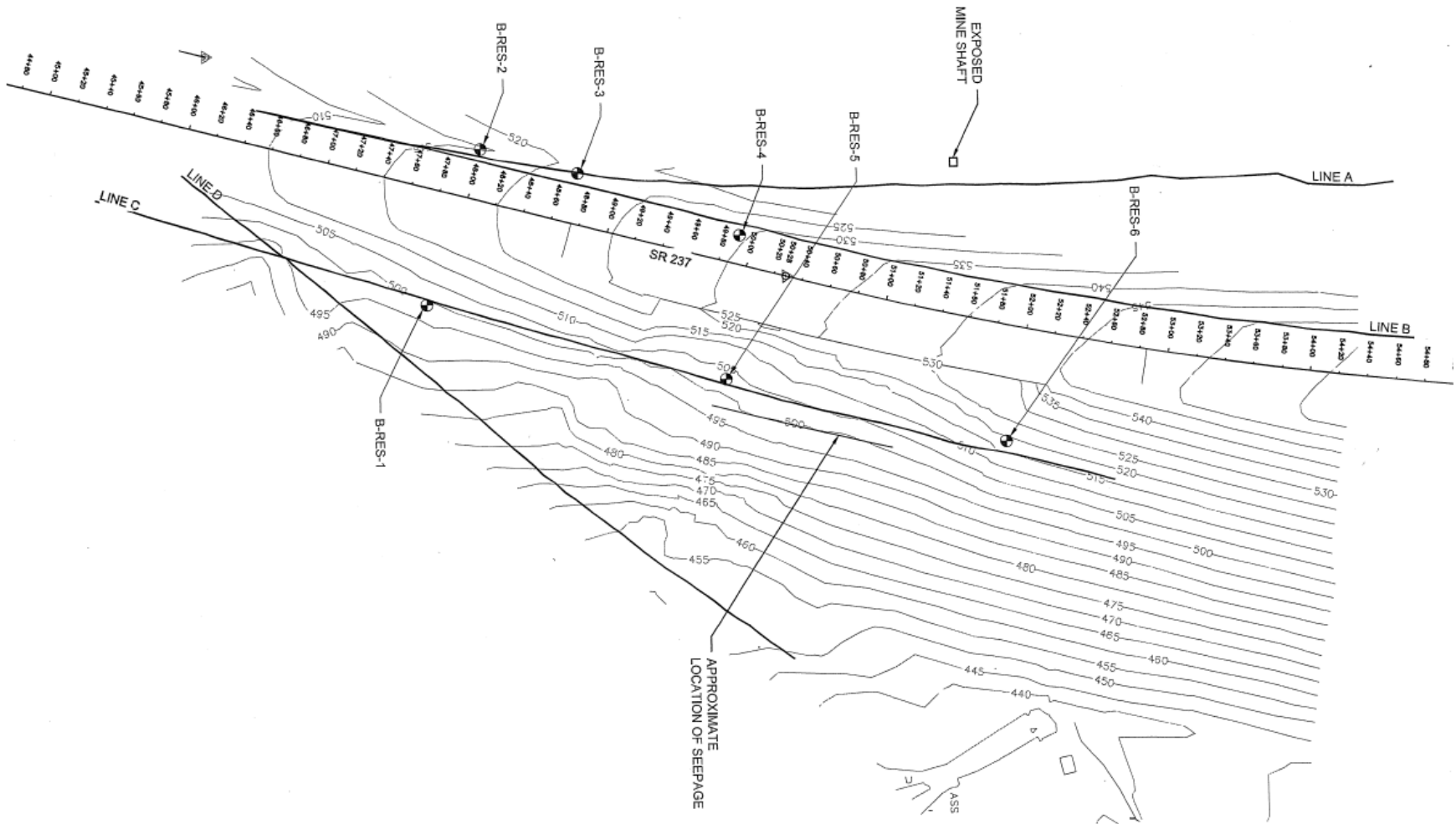


More Investigation

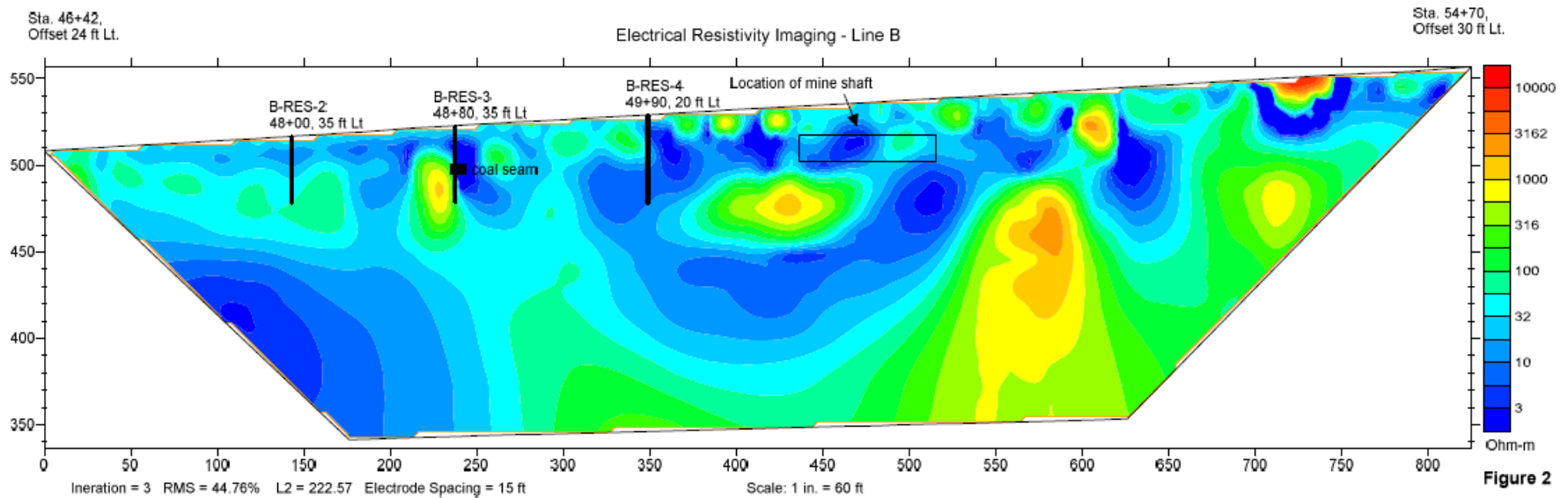
- Resistivity study done to search for mines.



Map of Resistivity Lines



Resistivity Study Results



More Investigation

- Resistivity study done to search for mines.
- More borings to verify the locations of suspected mines under the roadway as per geophysical study (resistivity testing).
- Borings reveal several collapsed mine shafts under roadway.



Revised Solution

- **Phase-1 Design**

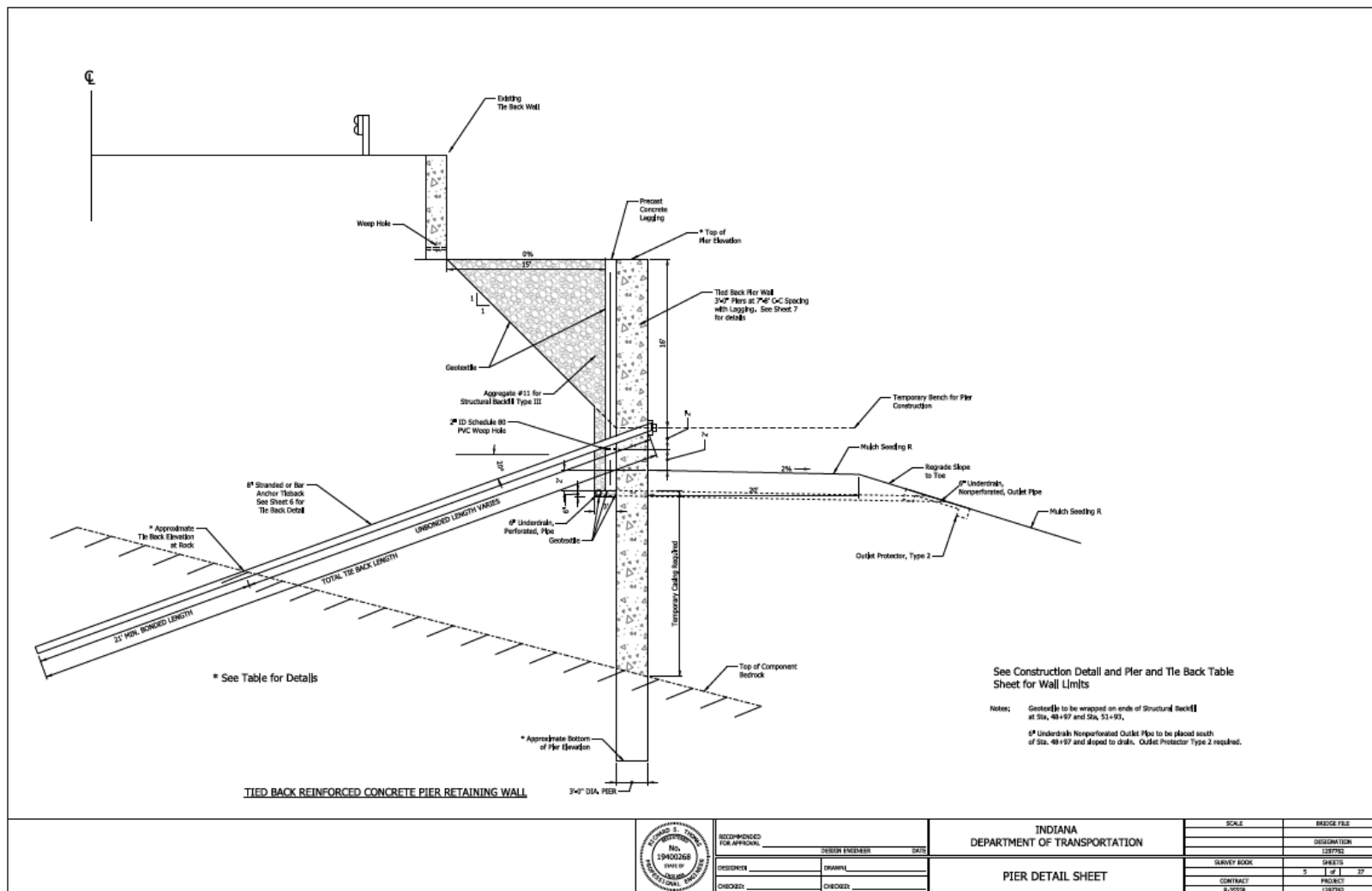
- Drainage correction
 - Mine shaft interceptor drain
 - Grout the mine shafts

- **Phase-2 Design**

- Drilled pier (3 ft. dia.) with tieback socket into rock



Design Cross Section



RECOMMENDED FOR APPROVAL	DESIGN ENGINEER	DATE
DESIGNER	DRAWN	
CHECKED	CHECKED	

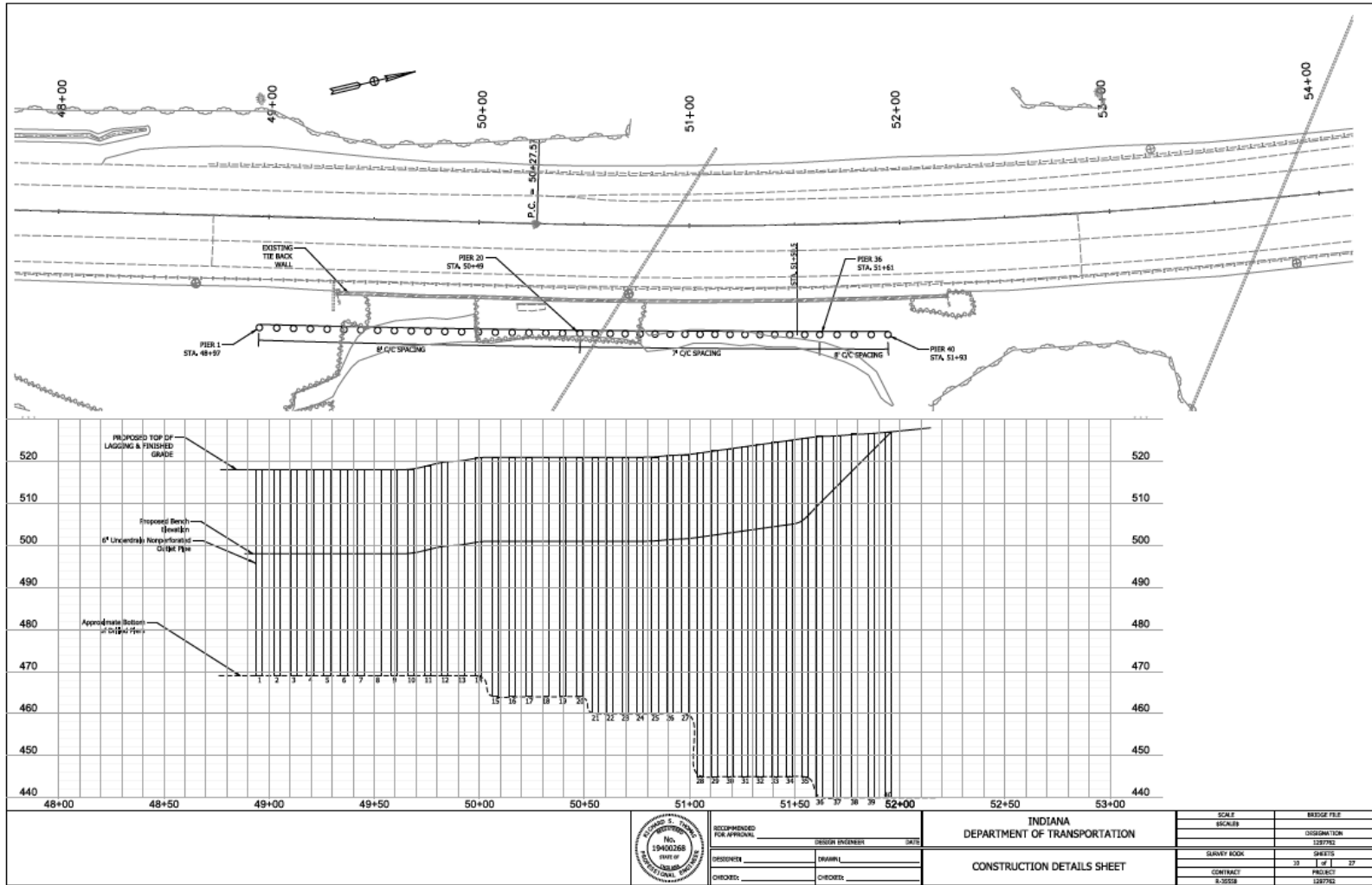
INDIANA
DEPARTMENT OF TRANSPORTATION

PIER DETAIL SHEET

SCALE	BRIDGE FILE
	DISCUSSION
	128792
SURVEY BOOK	SHEETS
	5 OF 37
CONTRACT	PROJECT
8-3558	128792



Drilled Shafts and Drain Layout



WPLS



RECOMMENDED FOR APPROVAL: _____ DESIGN ENGINEER (SEIT)
 DESIGNED BY: _____ DRAWN BY: _____
 CHECKED BY: _____

INDIANA DEPARTMENT OF TRANSPORTATION
 CONSTRUCTION DETAILS SHEET

SCALE	BRIDGE FILE
SCALE	DESIGNATION
SURVEY BOOK	SHEETS
CONTRACT	PROJECT
8-3552B	12776



Drainage Correction



Grouting to Fill Mine Shafts



Constructability Concerns

- The new drilled pier wall was originally proposed to be 15 feet from the existing wall.
- The construction of new drilled pier wall affecting the integrity of existing soldier pile wall.



Additional Changes to the Design

- Move the proposed drilled pier wall 40 ft away from existing soldier pile wall (25 ft further) to provide safe excavation for inside lagging and backfill.
- Change temporary casing to a permanent casing for drilled piers due to possible co-mingled fill material.
- Provide casing for tieback un-bonded length to avoid major loss of grout due to unclassified fill material.



Acknowledgments

- H.C. Nutting Company
- Alt & Witzig Engineering, Inc.
- Earth Explorations, Inc.
- INDOT Office of Geotechnical Services
- INDOT Office Of Design Vincennes District
- Ragle, Inc.
- Berkel & Company Contractors, Inc.
- Lutgring Brothers, Inc.



Acknowledgments

- Athar Khan
- Jonathan Paauwe
- Mir Zaheer
- Jean Hiadari



Questions?

