



Engineering Geology

Bridge Engineering & Infrastructure MANAGEMENT



ROCKFALL MITIGATION: ANALYSIS, DESIGN & IMPLEMENTATION ON NJ HIGHWAYS

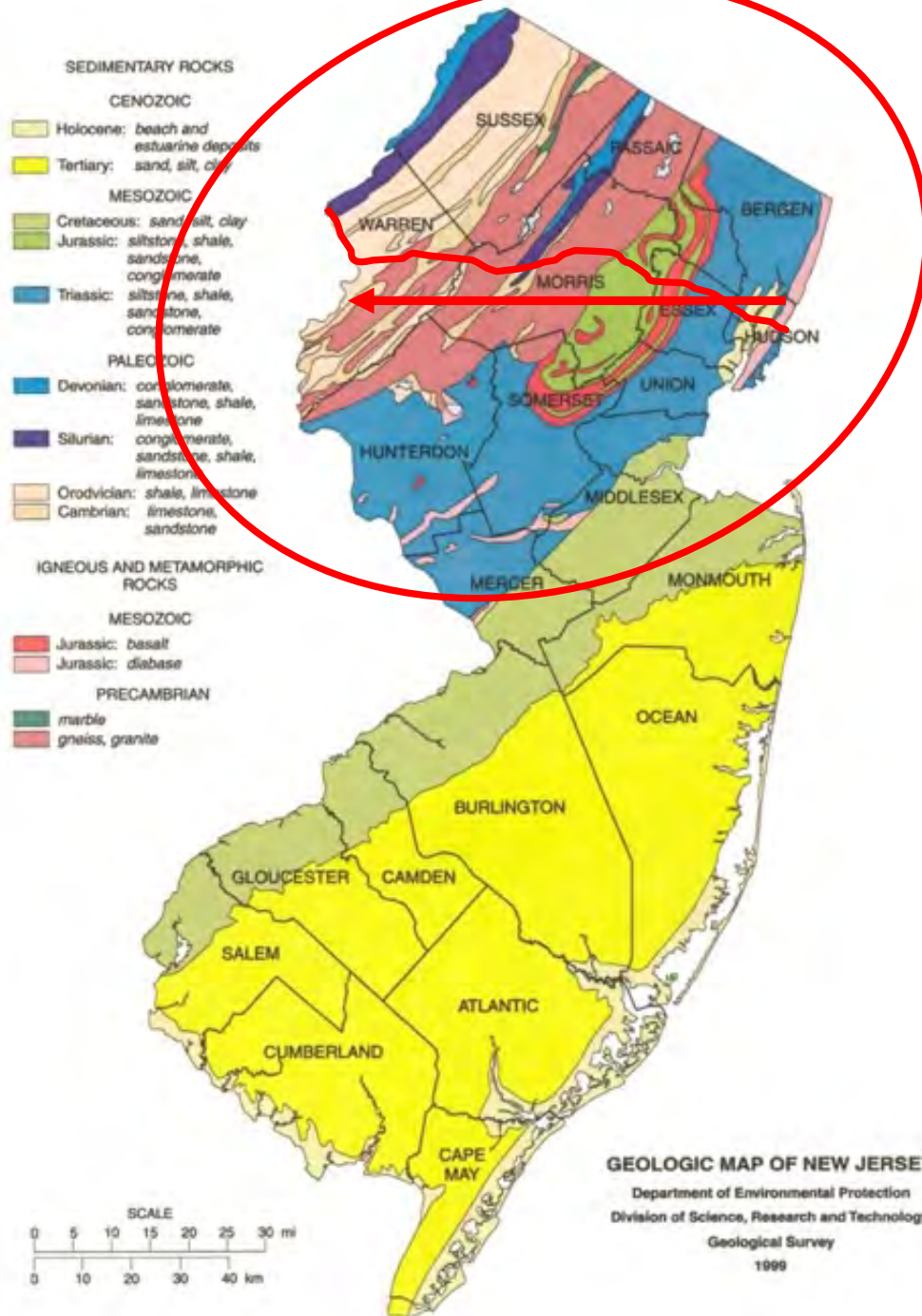


NEW JERSEY + ROCK





NEW JERSEY GEOLOGY 101





















































May 21, 2010



May 22, 2010





CONTRIBUTING FACTORS TO HIGHWAY ROCKFALL HAZARDS

- **GEOLOGY & GEOMETRY**
 - ROCK TYPE & CHARACTERISTICS
 - ROCK CUT SLOPE GEOMETRY
 - DISCONTINUITIES
(JOINTS, FRACTURES)
 - ROADWAY GEOMETRY
- **GROUNDWATER**
 - HYDROSTATIC PRESSURE
 - ICEJACKING
- **EROSIONAL**
 - CLIMATIC
 - CHEMICAL
 - ROOT JACKING
- **CONSTRUCTION TECHNIQUES**











ROCKFALL HAZARD MANAGEMENT SYSTEM





ROCKFALL HAZARD MANAGEMENT SYSTEM (RHMS)

- **440+ STATE & INTERSTATE HIGHWAY ROCK CUT SLOPES**
- **IDENTIFY & MONITOR ROCKFALL HAZARDS TO TRAVELING PUBLIC**
- **ROCKFALL MITIGATION PROJECT PRIORITIZATION & DEVELOPMENT**





ROCKFALL HAZARD RATING SYSTEM (RHRS)

- **DEVELOPED LATE 1980'S BY FHWA & IMPLEMENTED 1993**
- **PROACTIVE VS REACTIVE**
- **CHARACTERIZE, EVALUATE & NUMERICALLY RANK HAZARDS**
- **~ 60% OF STATE DOT'S**





RHRS

- **GEOLOGY PARAMETERS**
 - **ROCK TYPE & STRUCTURE**
 - **EROSIONAL FEATURES**
 - **DISCONTINUITIES**
 - **ROCK FRICTION**
 - **WATER**
 - **SLOPE HEIGHT**
 - **BLOCK SIZE**
 - **CATCH AREA**
 - **ROCKFALL HISTORY**
- **ROADWAY PARAMETERS**
 - **ROADWAY WIDTH**
 - **SIGHT DISTANCE**
 - **TRAFFIC DATA**
 - **SPEED LIMIT**
- **EXPONENTIAL SCORING**



ROCKFALL HAZARD MANAGEMENT SYSTEM 2018 UPDATE 3

Rockfall Hazard Management System - Complete Inventory



^ one ranking established for several adjacent cuts
 * based upon RHRS Detailed Rating Score; 'A' & 'B' cuts only
 ** For programming use; only considers 'A' cuts not in CD/PE/FD
 *** Recently mitigated; Rating (Prelim/Detailed) requires revision

RHRS Rating Ranking*	Non-Programmed Ranking **	Route	MP	Prelim. Rating	Detailed Rating	Notes/Comments
--		46 WB	1.4 R	C	688	Mitigation Construction Completed 2015
1^		80 WB	1.3 R	A	660	In Preliminary Design 2012
n/a		80 WB	0.5 R	A	636	Outside NJDOT jurisdiction
1^		80 WB	1.15 R	A	630	In Preliminary Design 2012
2		78 EB	10.3 R	A	592	Group 2014-1: PE/FD Assignment #1 (UPC # 153380)
3		29 NB	27.78 R	A	576	Group 2014-1: PE/FD Assignment #2 (UPC # 158020)
4		287 SB/RAMP D	53.0 R	B	573	
5		287 SB	55.6 R	B	555	
6		78 WB	10.3 R	A	515	Group 2014-1: PE/FD Assignment #1 (UPC # 153380)
1^		80 WB	1.4 R	A	512	In Preliminary Design for remediation 2012
7		287 SB	67.4 R	B	507	Catch full of debris-9/2008, mesh and fence intact
8		23 NB	18.8 R	A	503	In Concept Development Group 2016-1
9		15 NB	19.0 R	A	503	In Concept Development Group 2015-1
10		15 SB	5.2 R	A	494	In Concept Development Group 2015-1
11		80 EB	41.0 R	B	488	In Concept Development Group 2015-1
12		29 NB	17.8 R	A	485	In Concept Development Group 2015-1





ROCKFALL MITIGATION PROGRAM



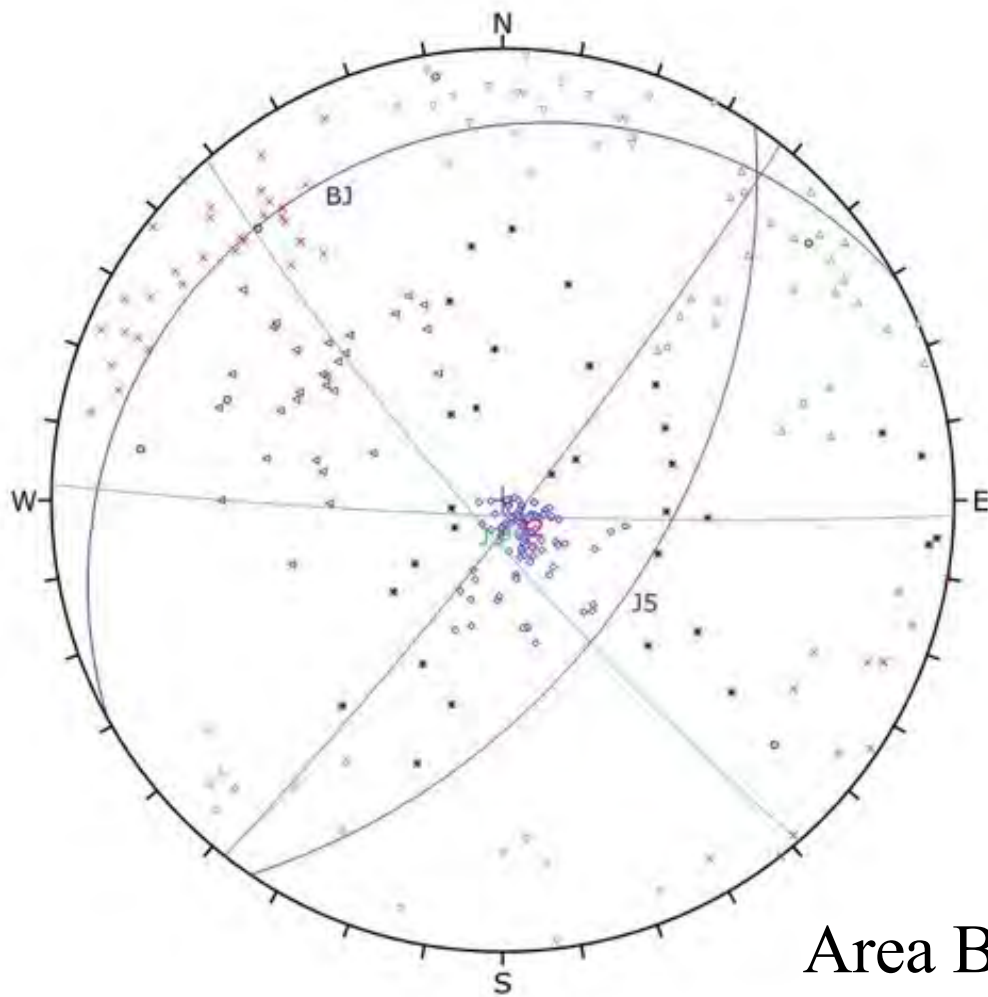


ROCKFALL MITIGATION PROGRAM

- **CONCEPT DEVELOPMENT**
 - GEOLOGICAL FIELD MAPPING
 - KINEMATIC ANALYSIS
 - ROCKFALL MODELLING
 - SELECTION OF MITIGATION MEASURES
- **PRELIMINARY/FINAL DESIGN**
 - MITIGATION DESIGN
 - CONSTRUCTION CONSIDERATIONS
- **CONSTRUCTION**







Symbol	FEATURE	Quantity
◇	B1	91
×	J2	46
△	J3	36
▽	J4	27
○	J5	29
◊	S2	6
■	U	31

	Color	Dip	Dip Direction	Label
Mean Set Planes				
1m		12	331	B1
2m		85	128	J2
3m		82	229	J3
4m		86	182	J4
5m		52	124	J5

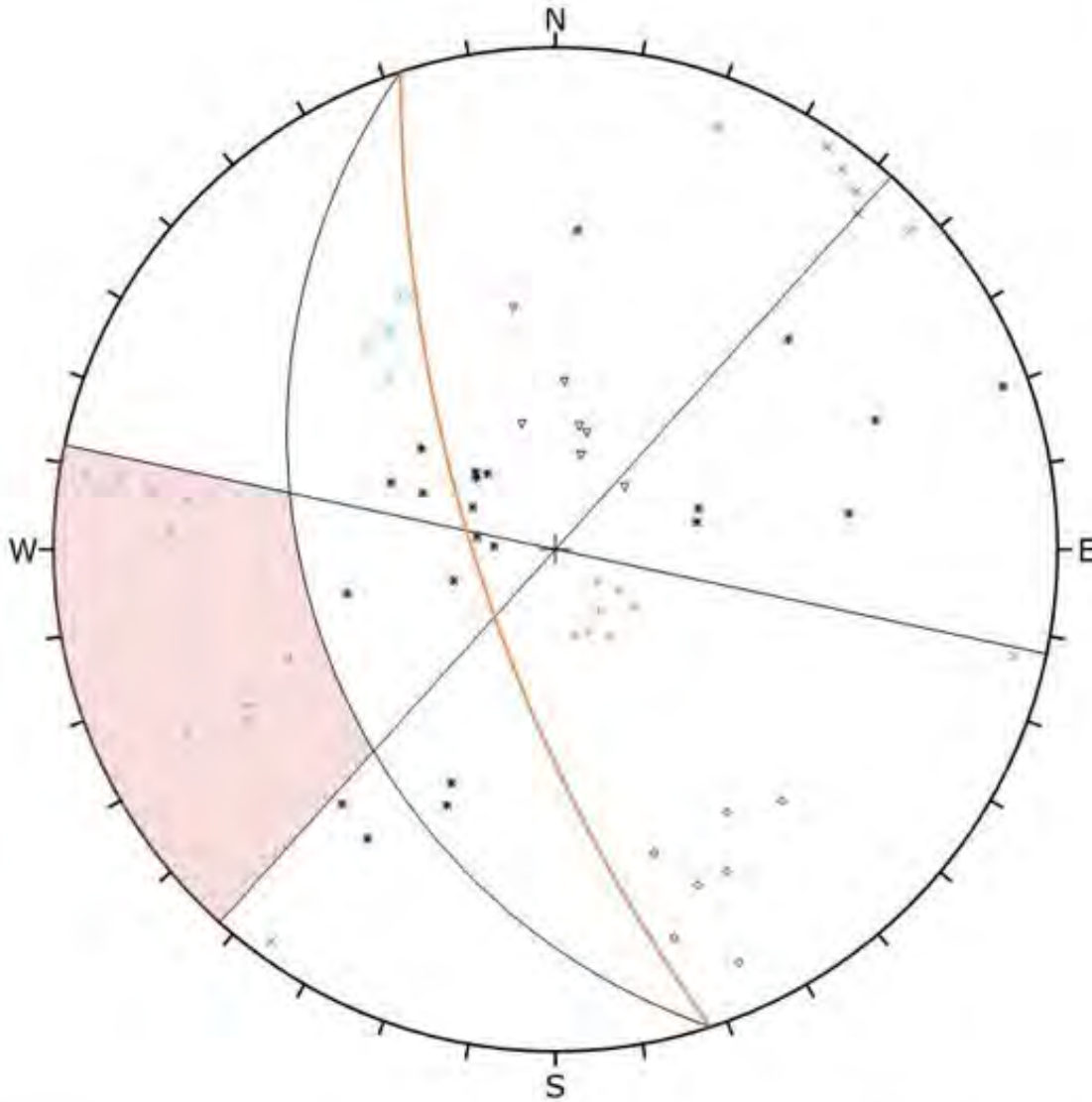
Plot Mode	Pole Vectors
Vector Count	269 (269 Entries)
Hemisphere	Lower
Projection	Equal Angle

Area B: Field Investigation



Project			
Analysis Description	All Area B Joint Set Data		
Drawn By	ABG	Company	
Date		File Name	Area B all data.dips7






Symbol	MEAN SET	Quantity
○	31	7
×	32	7
△	33	7
◊	34	7
◊	35	7
◊	36	6
◊	37	4
■	U	22

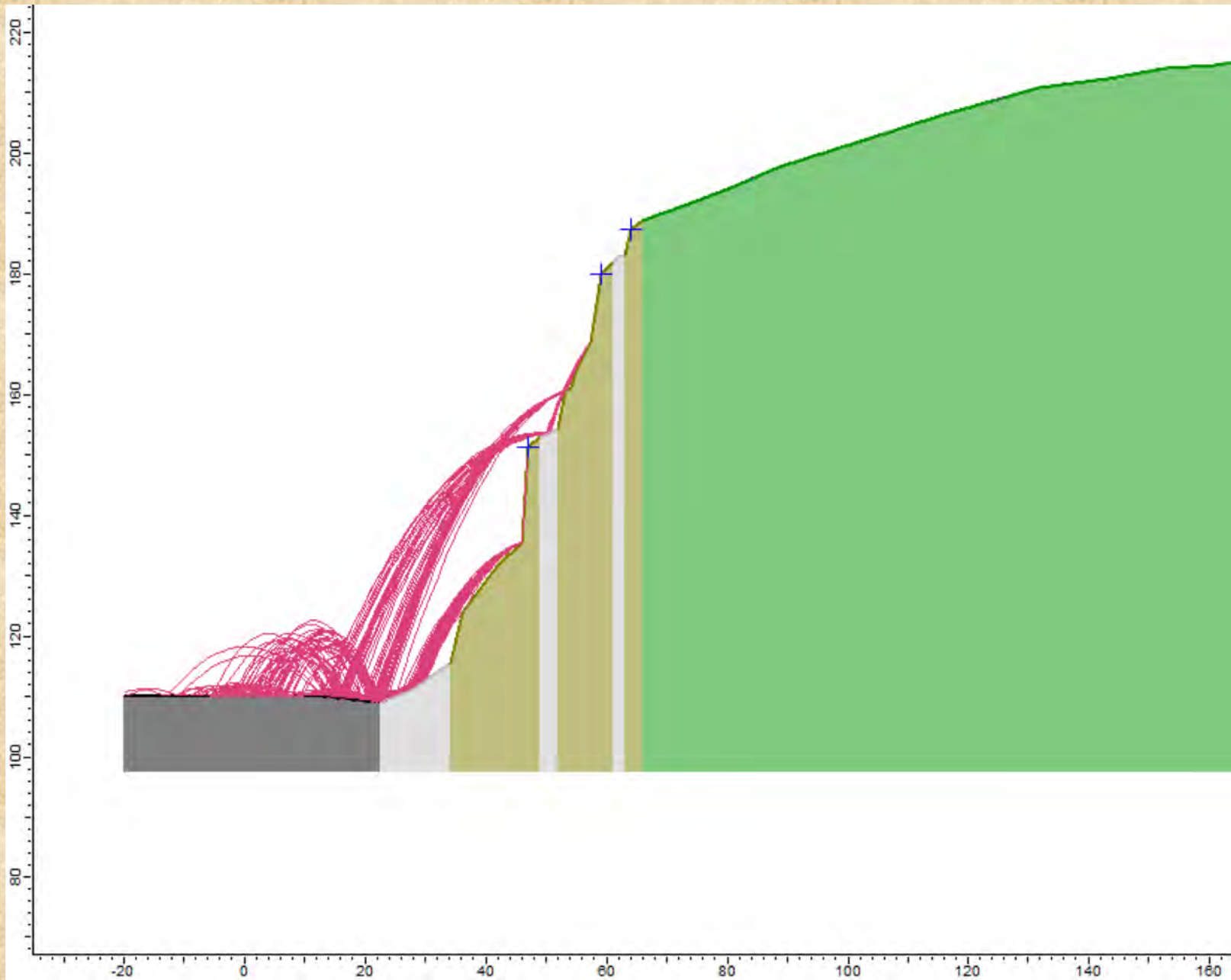
Kinematic Analysis		Flexural Toppling		
Slope Dip		72		
Slope Dip Direction		252		
Friction Angle		35°		
Lateral Limits		30°		
		Critical	Total	%
Flexural Toppling (All)		10	67	14.93%
Flexural Toppling (Set 3: 33)		6	7	85.71%
Flexural Toppling (Set 7: 37)		4	4	100.00%

Plot Mode	Pole Vectors
Vector Count	67 (67 Entries)
Hemisphere	Lower
Projection	Equal Angle

Area A: Kinematics

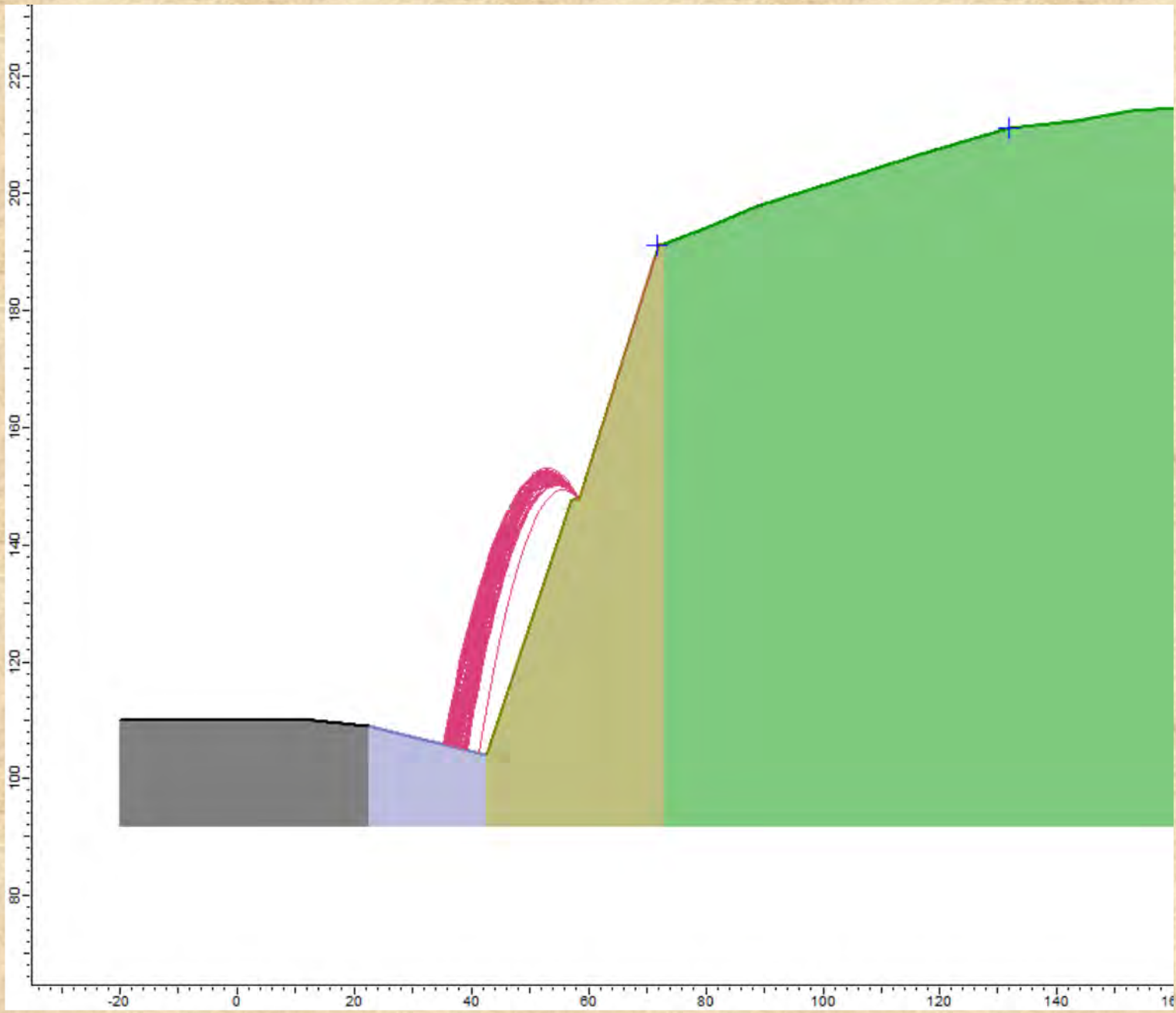
	Project	Kinematic Analysis, Toppling, 3V:1H cut slope, north end (of Jurassic)	
	Analysis Description	Kinematic Analysis, Toppling, 3V:1H cut slope, north end (of Jurassic)	
	Drawn By	ABG	Company
	Date		File Name





ROCKFALL MODELLING





Rockfall Modelling





ROCKFALL MITIGATION APPROACHES

- REMOVAL
- STABILIZATION
- PROTECTION





- **REMOVAL/EXCAVATION**
- **SCALING**









- **REMOVAL/EXCAVATION**
 - **SCALING**
 - **BLASTING**





ROUTE I-80 ROXBURY TWP





ROUTE I-80 ROXBURY TWP









- **STABILIZATION**
 - **SHOTCRETE**
 - **BUTTRESSES**
 - **ROCK BOLTS/DOWELS**
 - **PINNED MESH**
 - **DRAINAGE**











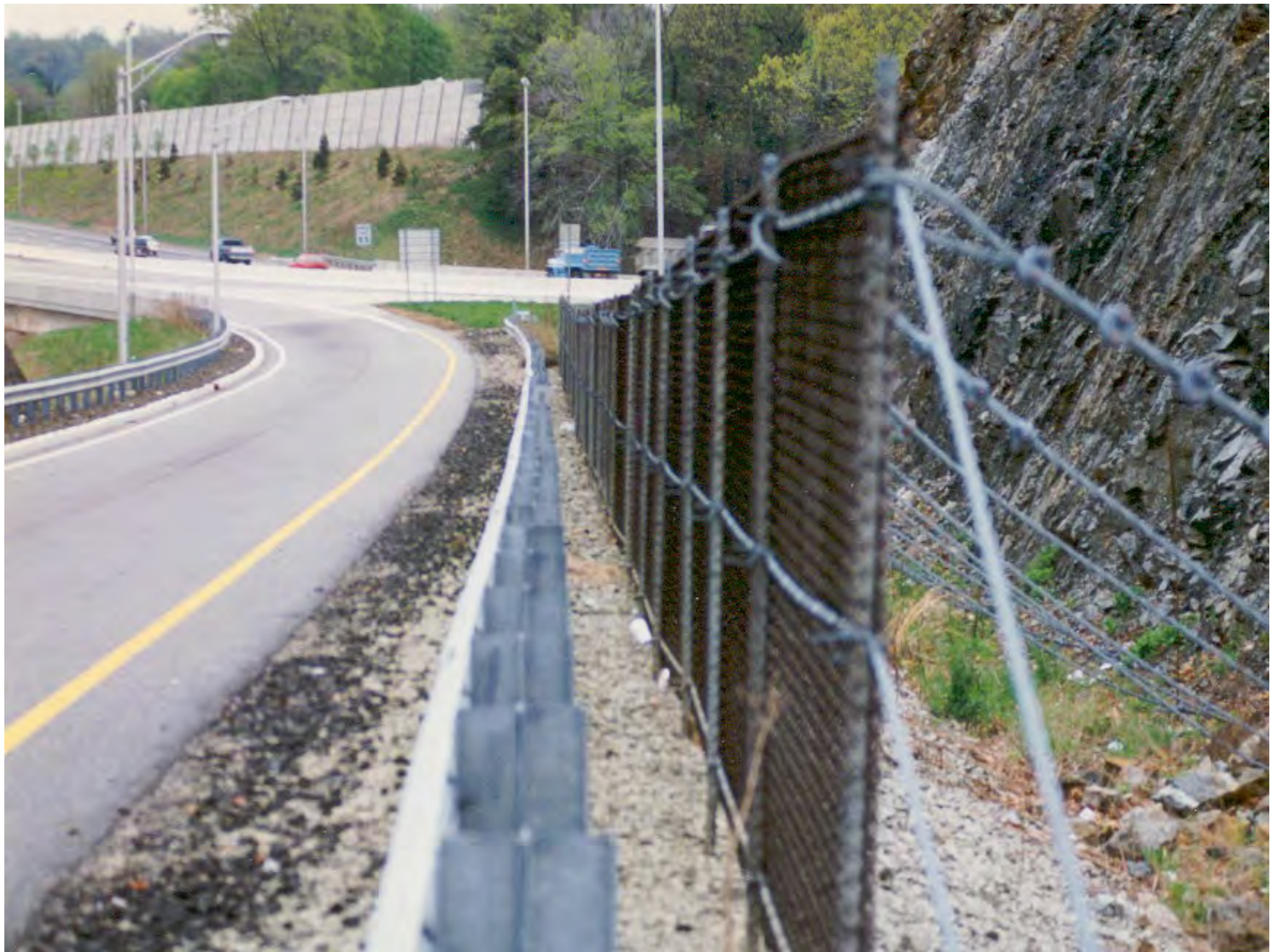


- **PROTECTION**

- **CATCHMENT**
- **BARRIERS/FENCES**
- **ROCK MESH DRAPES**













RECENTLY COMPLETED PROJECTS

RT. 46 MP 1.4-2.4 KNOWLTON

RT. 5 EDGEWATER/FORT LEE

RT. 80 MP 21.9 ALLAMUCHY

RT. 80 MP 15

FRELINGHUYSEN/ALLAMUCHY

RT. 80 ROCKFALL MITIGATION

ROXBURY

RT. 10 MP 22.2 W. ORANGE

RT. 46 & 80 WARREN/MORRIS CO.

RT. 78 MP 44.75 BERKELEY HEIGHTS







ROUTE 46 MP 1.4-2.4WB KNOWLTON TWP





ROUTE 5 EDGEWATER/FORT LEE





ROUTE 5 EDGEWATER/FORT LEE





CURRENT PROJECTS

RT. 80 HARDWICK/KNOWLTON

RT. 78 BETHLEHEM

RT. 29 KINGWOOD

RT. 29 LAMBERTVILLE

RT. 22 PHILLIPSBURG

RT. 80 DENVILLE

RT. 206 ANDOVER

RT. 280 W. ORANGE

RT. 23&94 HARDYSTON

RT. 15 JEFFERSON

RT. 23 WEST MILFORD





ROUTE I-80 DELAWARE WATER GAP





**ROUTE I-80
DELAWARE WATER GAP**





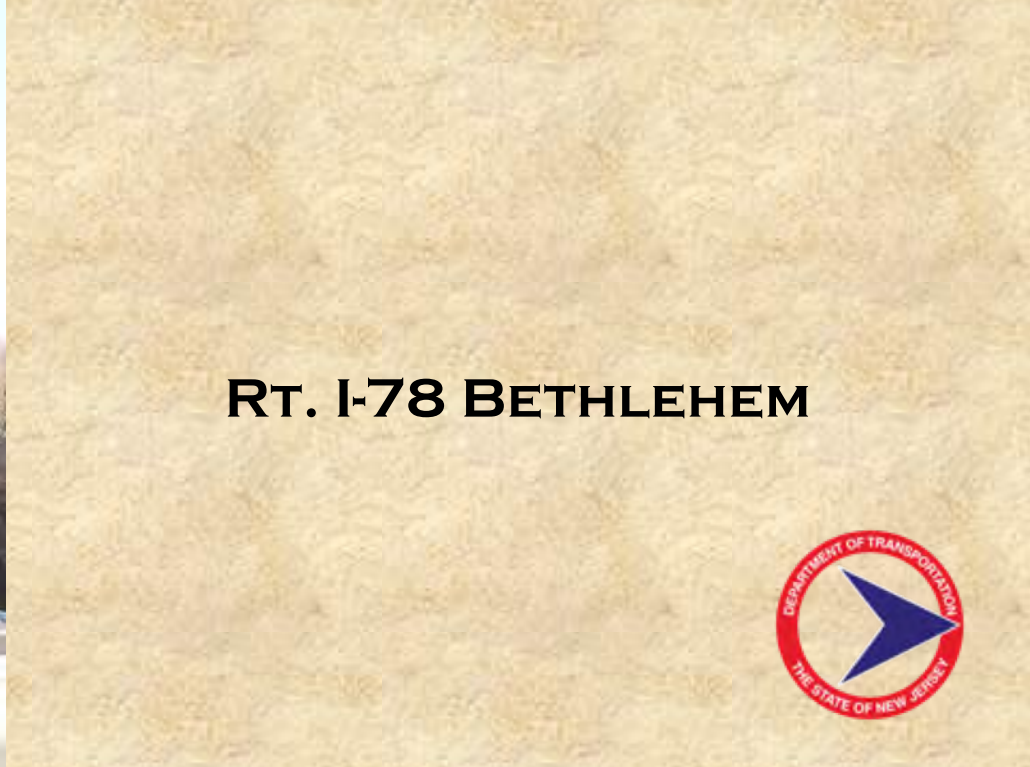
**ROUTE I-80
DELAWARE WATER GAP**





RT. I-78 BETHLEHEM





RT. I-78 BETHLEHEM





RT. I-78 BETHLEHEM





ROUTE 29 KINGWOOD TWP









ROUTE 29 KINGWOOD TWP



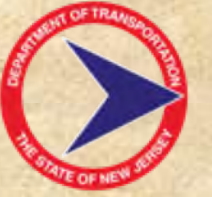
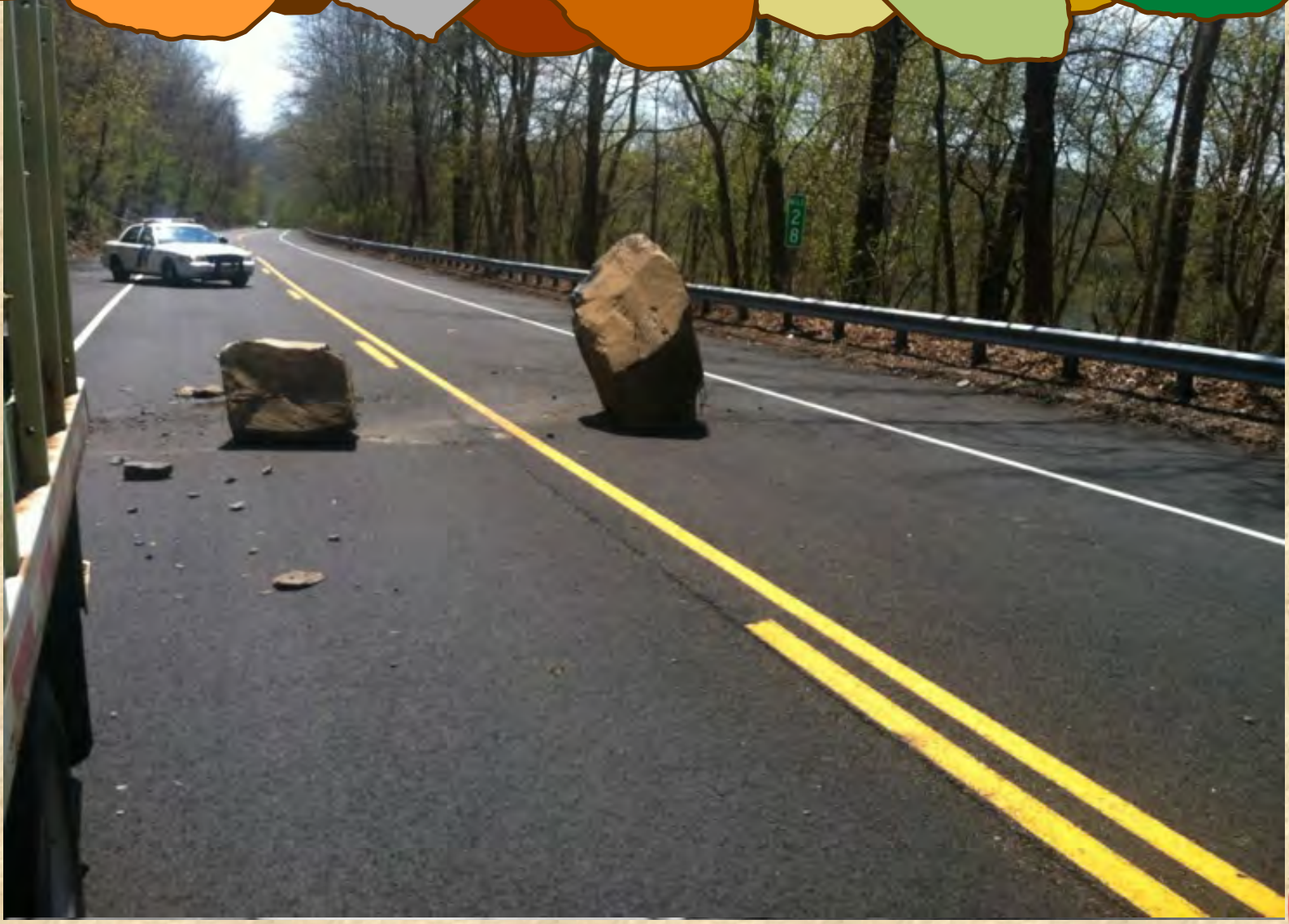




**IN
CONCLUSION...**











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