US Army Corps
of Engineers
Huntington District

Rock Cut-Slope Design and Construction

Auxiliary Spillway and Relocation of SR 3051 & 302 Dewey Lake, KY

Michael Nield - Geologist

Four Main Topics of Discussion

1. Project Description
2. Site Geology
3. Rock Cut-Slope Design
4. Construction Challenges

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Auxiliary Spillway – Dewey Dam, K
Project Descripti

ocated in Eastern Kentucky

am completed in 1949

olled earth embankment
am with a tunnel type outlet
orks in the left abutment.

Hydrologic Deficiencies at Dewey Dam

Dam Safety Assurance Program identified deficiencies with the existing spillway during predicted floods, resulting in a high risk of dam failure with catastrophic consequences downstream.

Correction:

- **Raise the Dam crest (future work)**
- **Raise crest of Brandy Keg Dike (this contract)**
- **Restrict flows to the Existing Spillway (this contract)**
- **Construct 129' wide Auxiliary Spillway (this contract)**
- **Relocate State Routes 302 and 3051 (this contract)**

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Auxiliary Spillway – Dewey Dam, K
Project Descripti

Project Features Impacted by Hydrologic Deficiencies

Existing Spillway

xisting spillway was not designed to withstand predicted flows.

onstructed horizontal restrictors, which reduced the spillway idth from 60 feet to 43 feet.

ock excavation by mechanical (non-explosive) methods.

Brandy Keg Dike

Raised Brandy Keg Dike approximately 3 feet.

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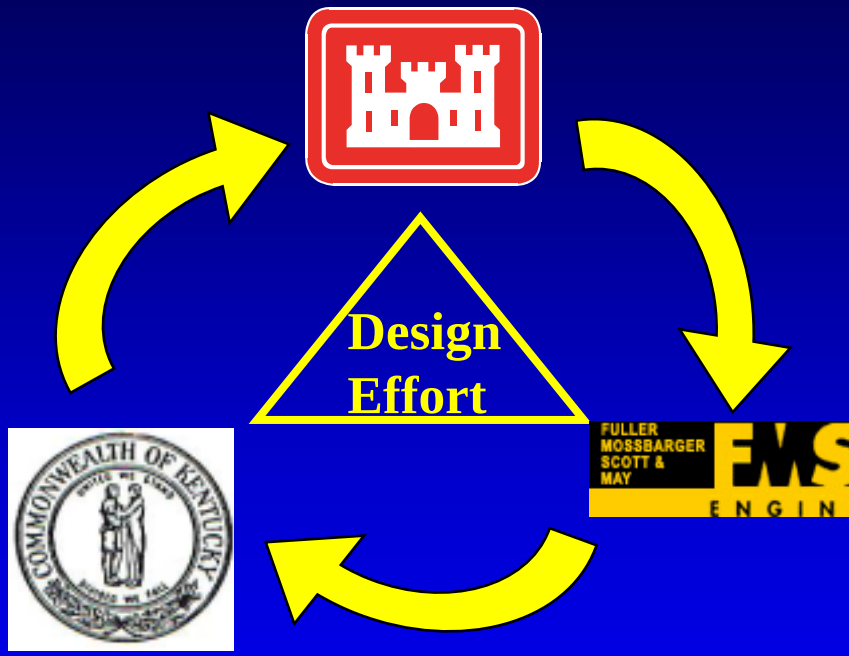
Auxiliary Spillway – Dewey Dam, K
Project Descripti

Relocation of State Route 302



State Route 302 was relocated as a result of the construction for the Auxiliary Spillway.

Design was performed by Fuller Mossbarger Scott & May Engineers with close cooperation by the Kentucky Department of Transportation and the Corps of Engineers.

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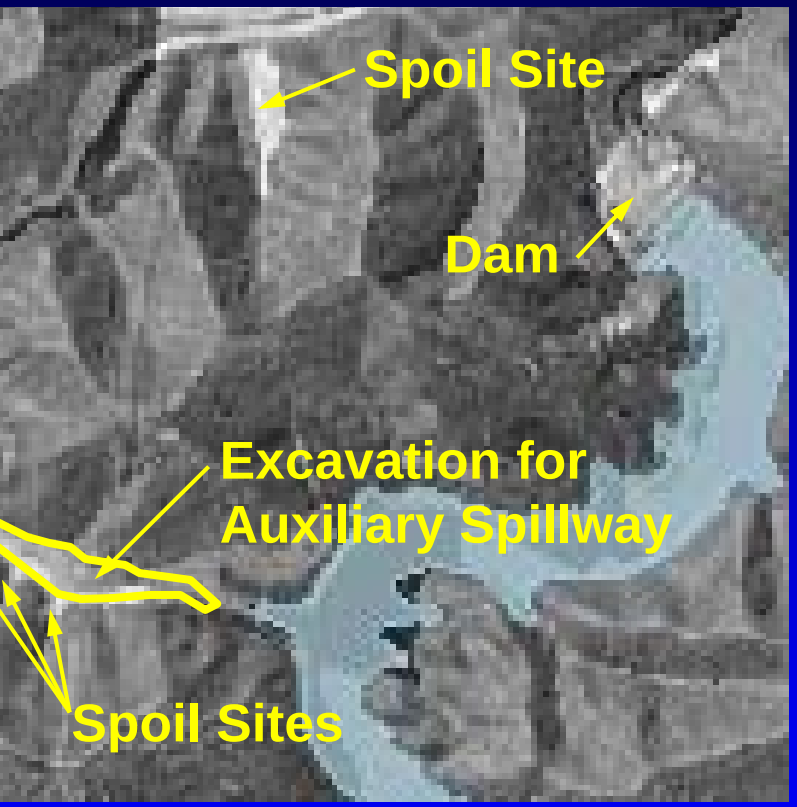
Auxiliary Spillway



Constructed a 129-foot wide Auxiliary Spillway through bedroc

Relocate State Route 3051 and a portion of State Route 302.

SUBJECT OF THIS PRESENTATION

Four Main Topics of Discussion

1. Project Description
2. Site Geology
3. Rock Cut-Slope Design
4. Construction Challenges

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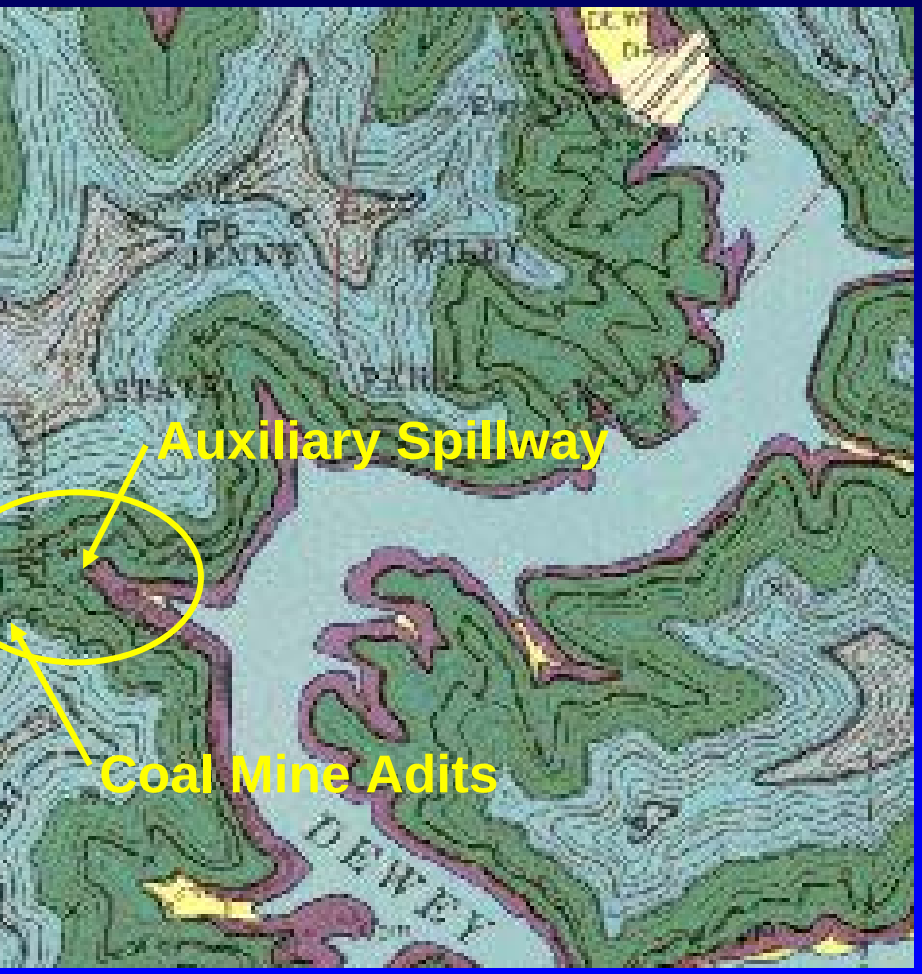
Auxiliary Spillway – Dewey Dam, I
Site Geolo

Existing and Field Data

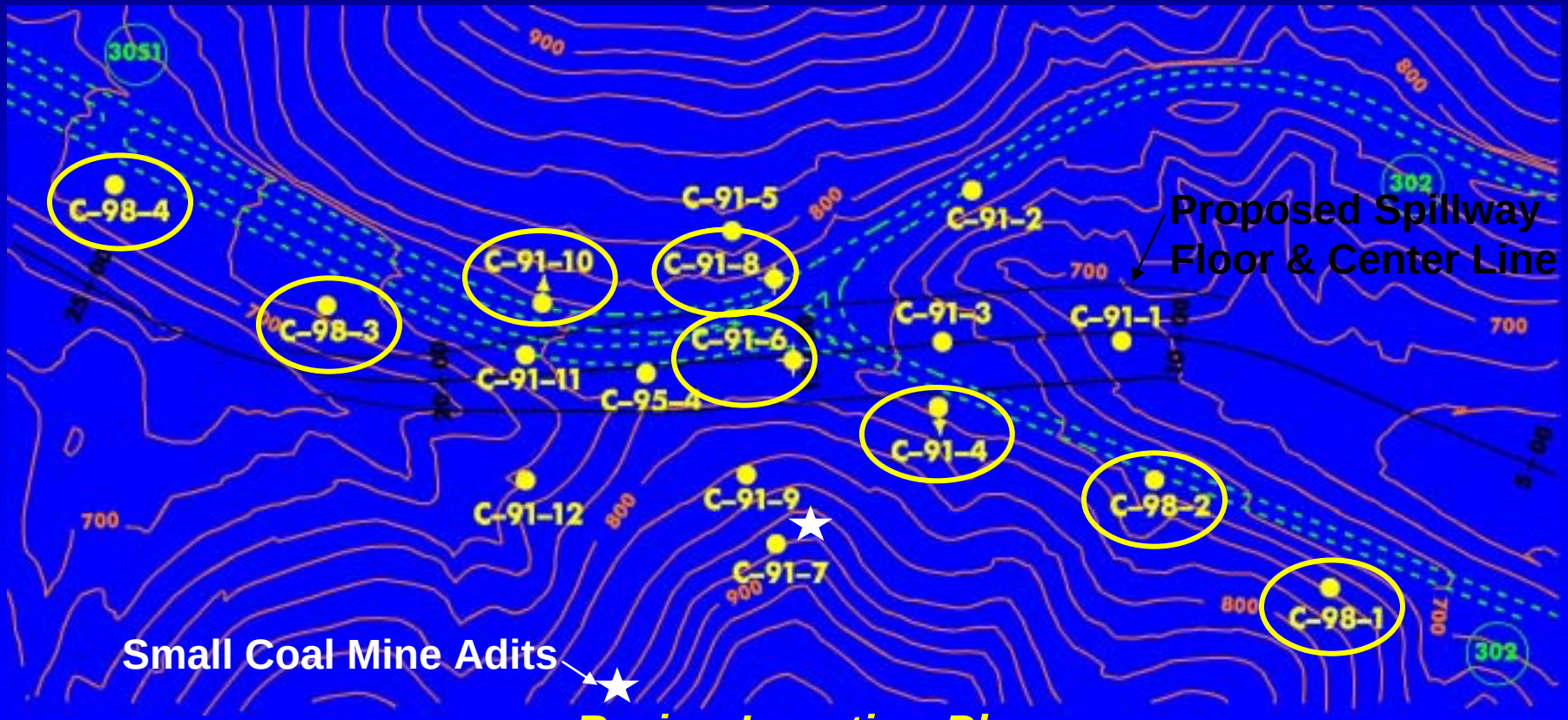


Geologic Quadrangle Map

Joint Measurements from Outcrop

Exploratory Drilling

- **Total of 17 Borings (15 2-inch diameter borings)**
- **2 Angled Borings to Obtain Discontinuity Orientations**
- **2 4-inch Diameter Core Borings, Pressure Tested at Sill Location**
- **4 Borings for Highway Relocation**



Boring Location Plan

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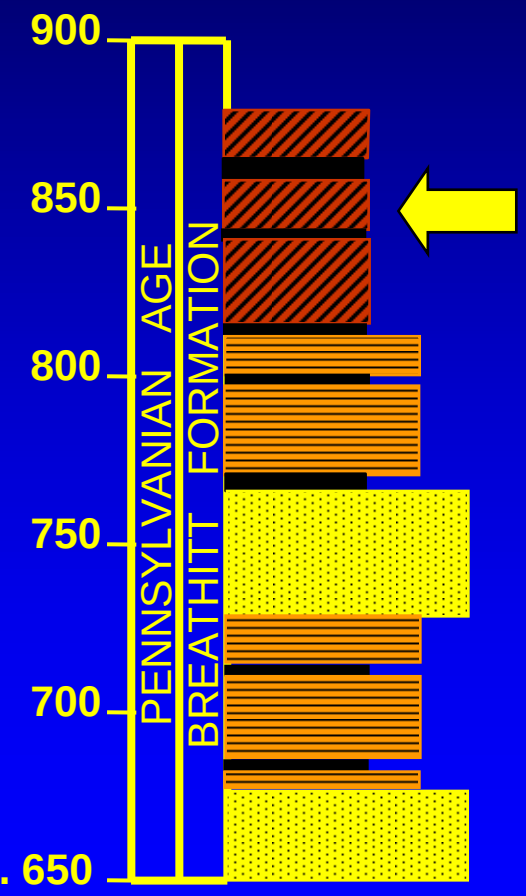
Auxiliary Spillway – Dewey Dam, K
Site Geolo

Lithology



Geologic Column

WEATHERED SHALE AND CLAYSTONE: reddish brown to dark gray, soft, clayey, occasionally broken or weathered.

Low percentage of core recovery (30 -90).

Low RQD (30 – 75).

Core Sampl

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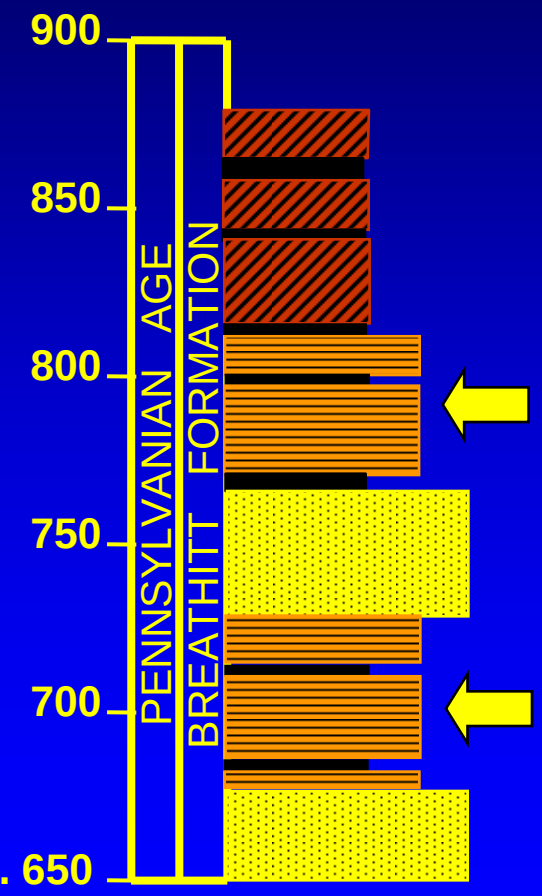
Auxiliary Spillway – Dewey Dam, K
Site Geolo

Lithology



SHALE with interbedded siltstone: gray to dark gray, soft to moderately hard.

High percentage of core recovery (90–100).

Medium range RQD (65 – 85)

Geologic Column

Core Sampl

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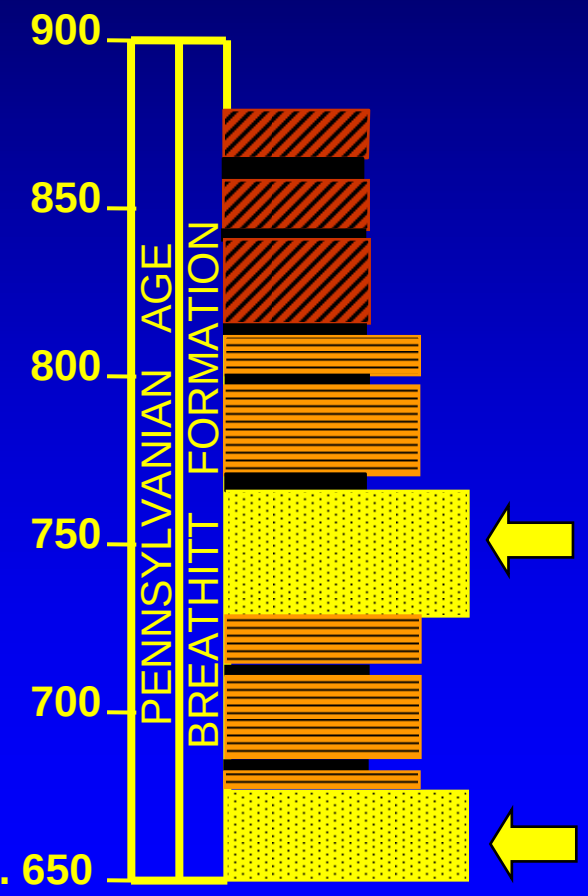
Auxiliary Spillway – Dewey Dam, K
Site Geolo

Lithology



Geologic Column

SANDSTONE: light gray, moderately hard, fine to medium grained, micaceous.

High percentage of core recovery (95 –100).

Good RQD (95 - 100)

Core Sampl

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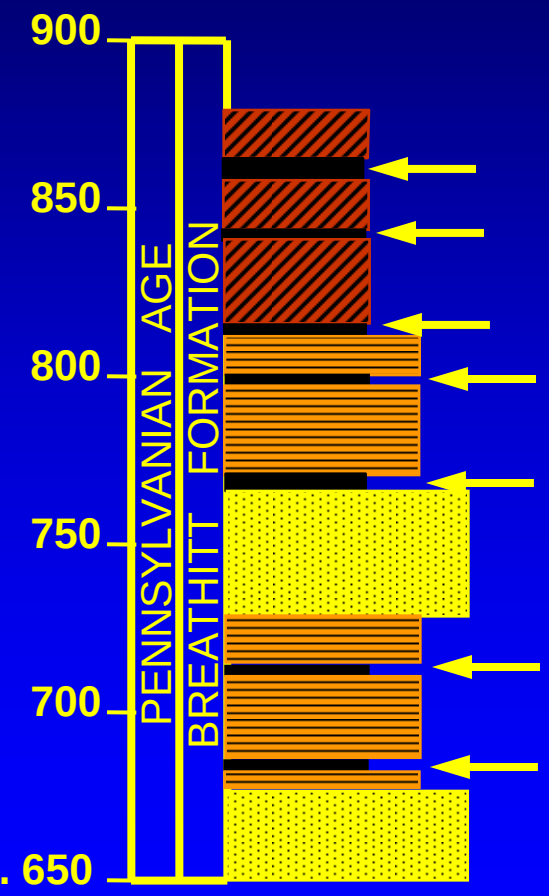
Auxiliary Spillway – Dewey Dam, K
Site Geolo

Lithology



COAL SEAMS: black, moderately hard, slightly to severely broken.

0.8' to 2.7' thick.

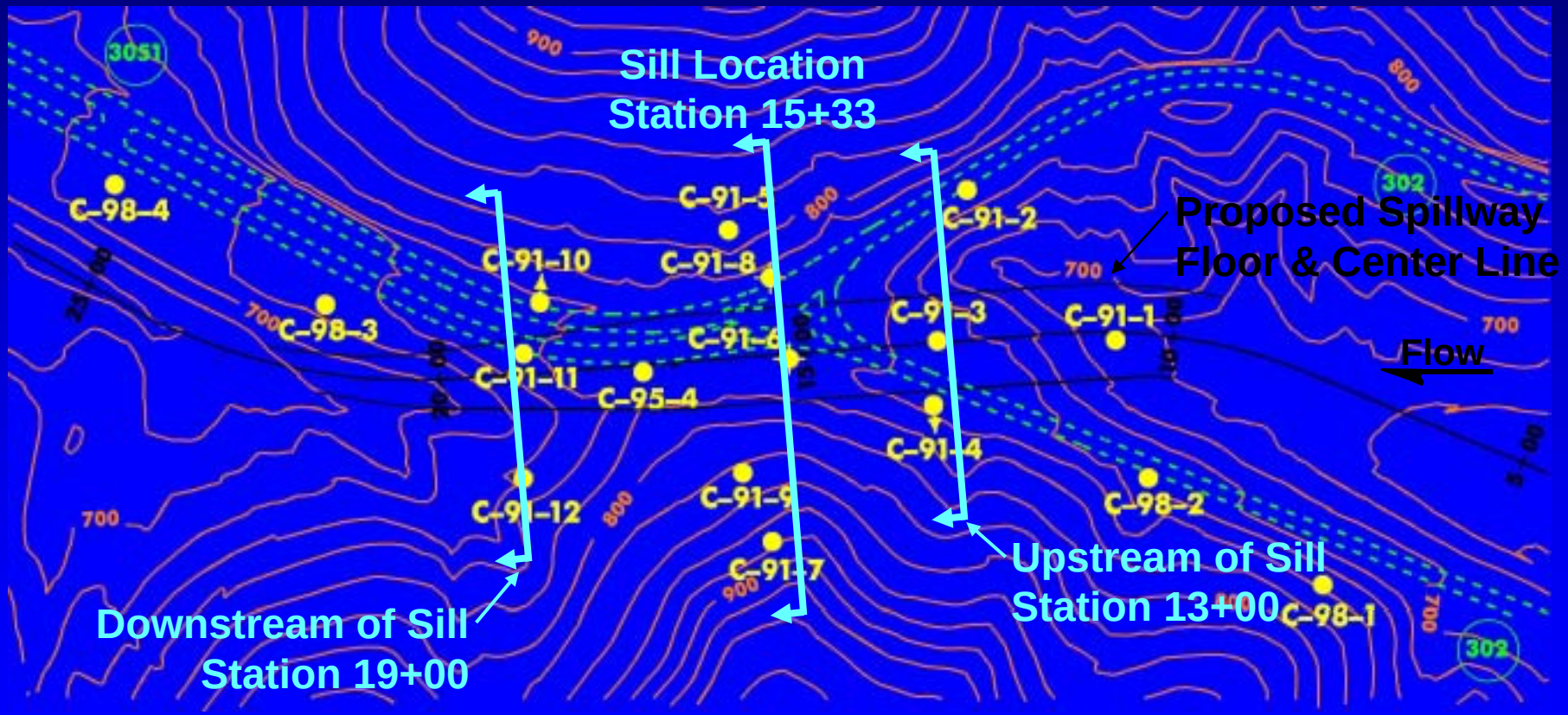
Core loss common.

Poor RQD

Geologic Column

Core Sampl

Geologic Cross Sections



Geologic Cross Section Location Plan

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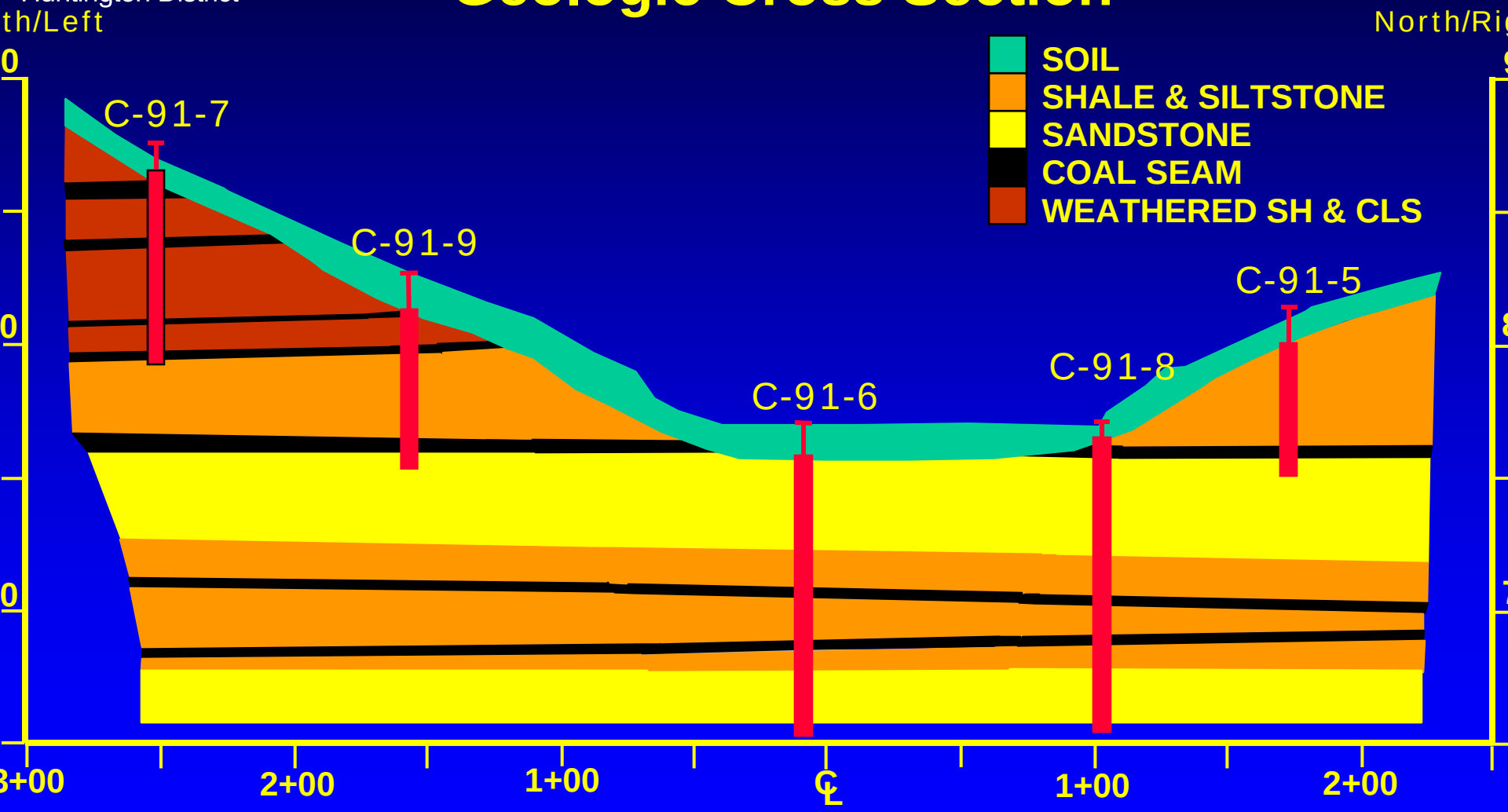
Auxiliary Spillway – Dewey Dam, K
Site Geolo

Geologic Cross Section



Station 15+33 – Spillway Crest

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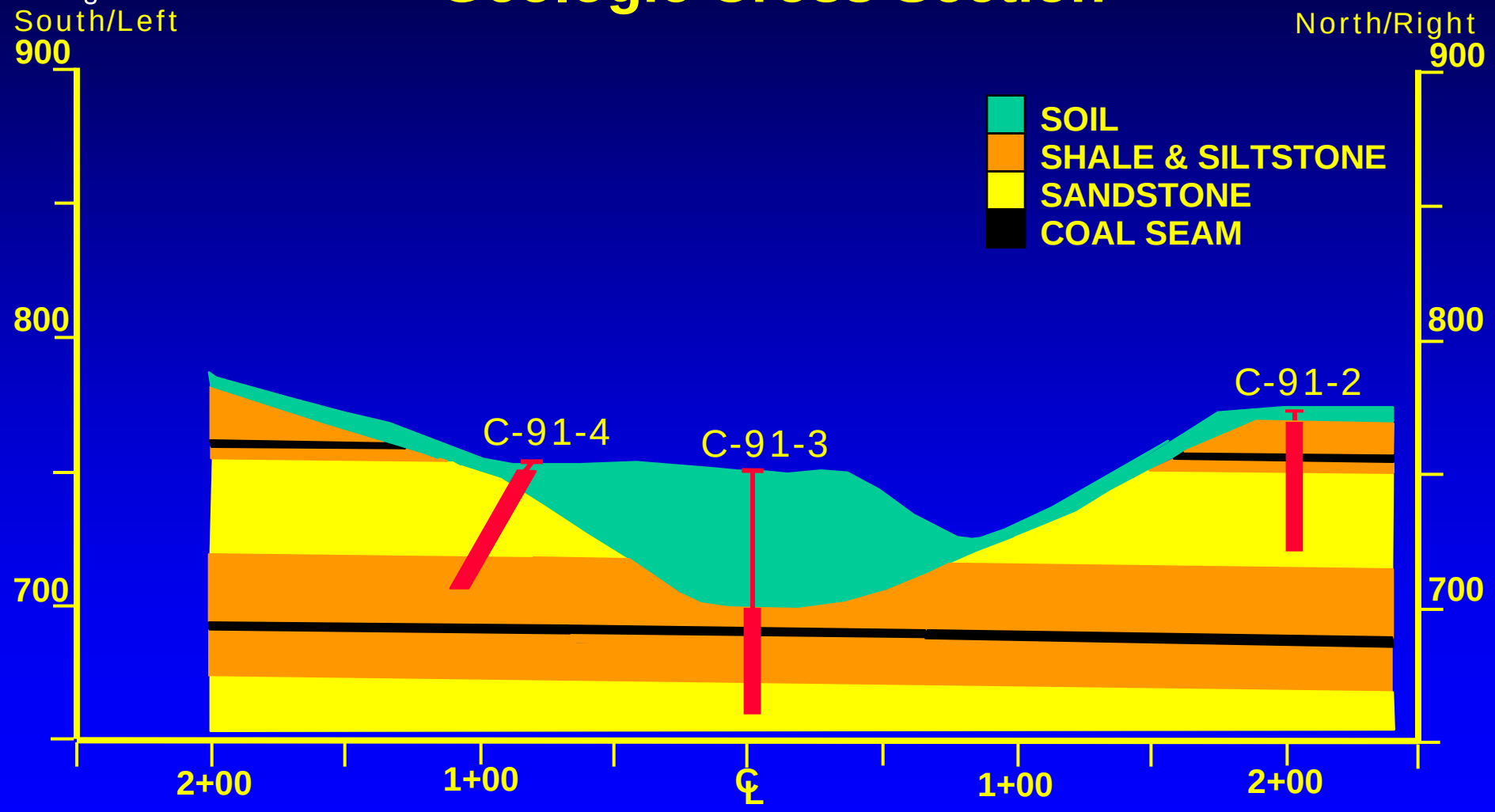
Auxiliary Spillway – Dewey Dam, K
Site Geolo

Geologic Cross Section



Station 13+00 (Upstream of Sill)

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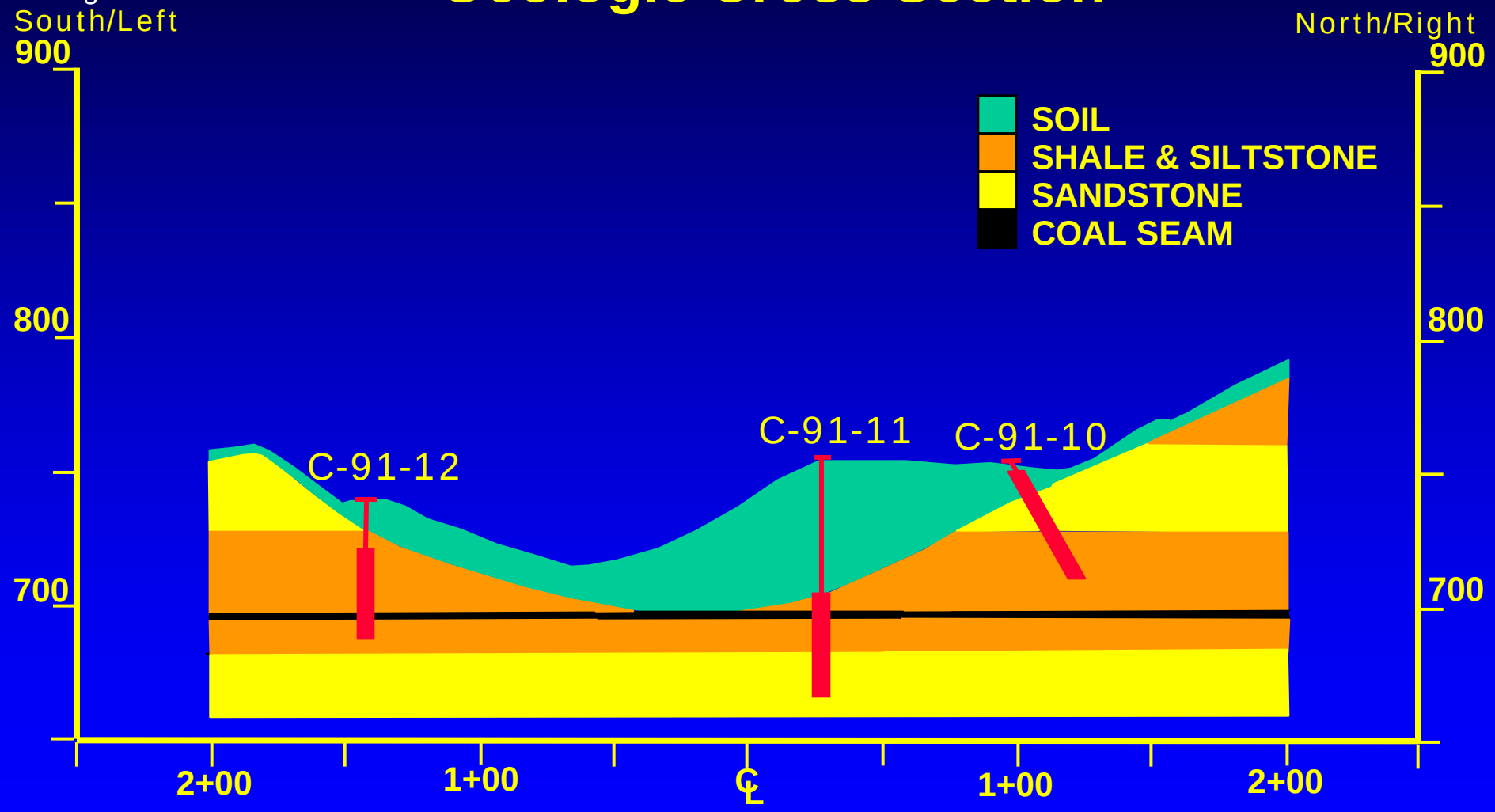
Auxiliary Spillway – Dewey Dam, K
Site Geolo

Geologic Cross Section



Geologic Section - Station 19+00 (Downstream of Sill)

Four Main Topics of Discussion

1. Project Description
2. Site Geology
3. Rock Cut-Slope Design
4. Construction Challenges

Rock Cut Slope Design Topics

1. Bench and Slope Design
2. Wedge/Block Analysis
3. Rock Fall Analysis
4. Spillway Sill Design

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Auxiliary Spillway – Dewey Dam, K
Rock Cut Slope Desi

Bench and Slope Design

elatively flat-lying sedimentary rock, with interbedded lithologie
hat have varying resistance to weathering and high angled joints

he cut slope design needs to minimize the effects of differential
eathering to reduce wedge/block failures and rock fall hazards.

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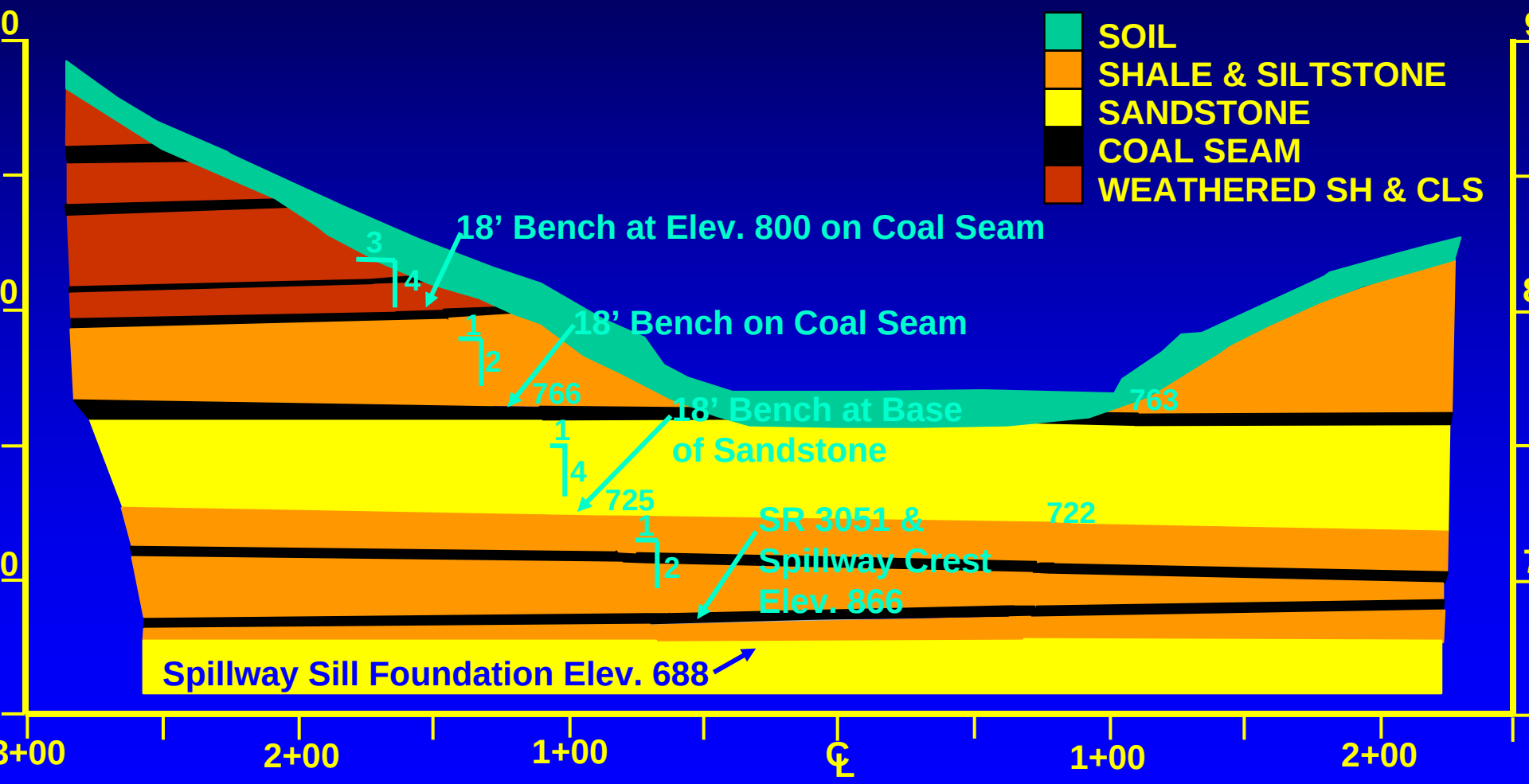
Auxiliary Spillway – Dewey Dam, K
Rock Cut Slope Desi

Bench and Slope Design



Geologic Section - Station 15+33 – Spillway Crest

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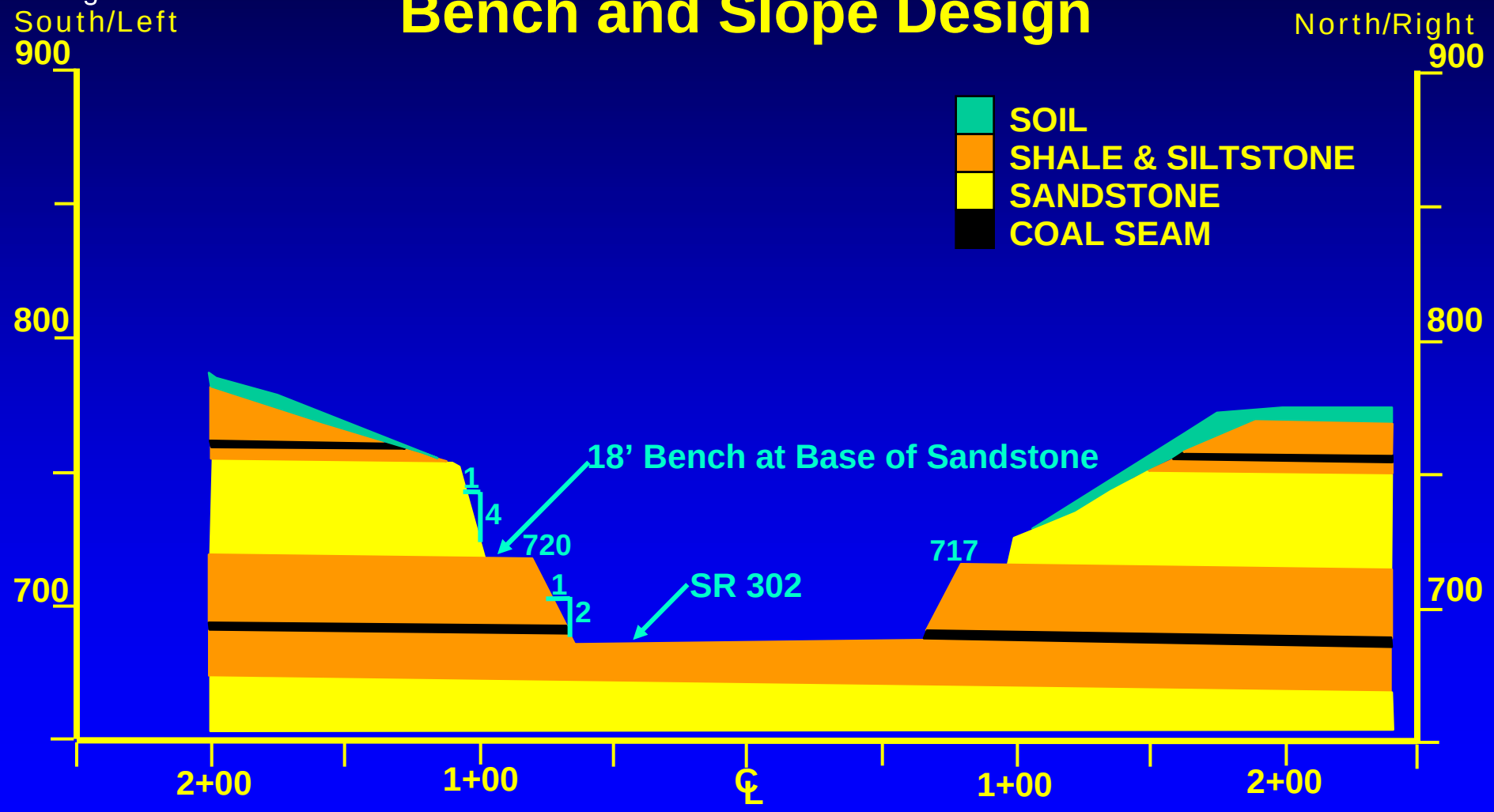
Auxiliary Spillway – Dewey Dam, K
Rock Cut Slope Desi

Bench and Slope Design



Geologic Section - Station 13+00 (Upstream of Sill)

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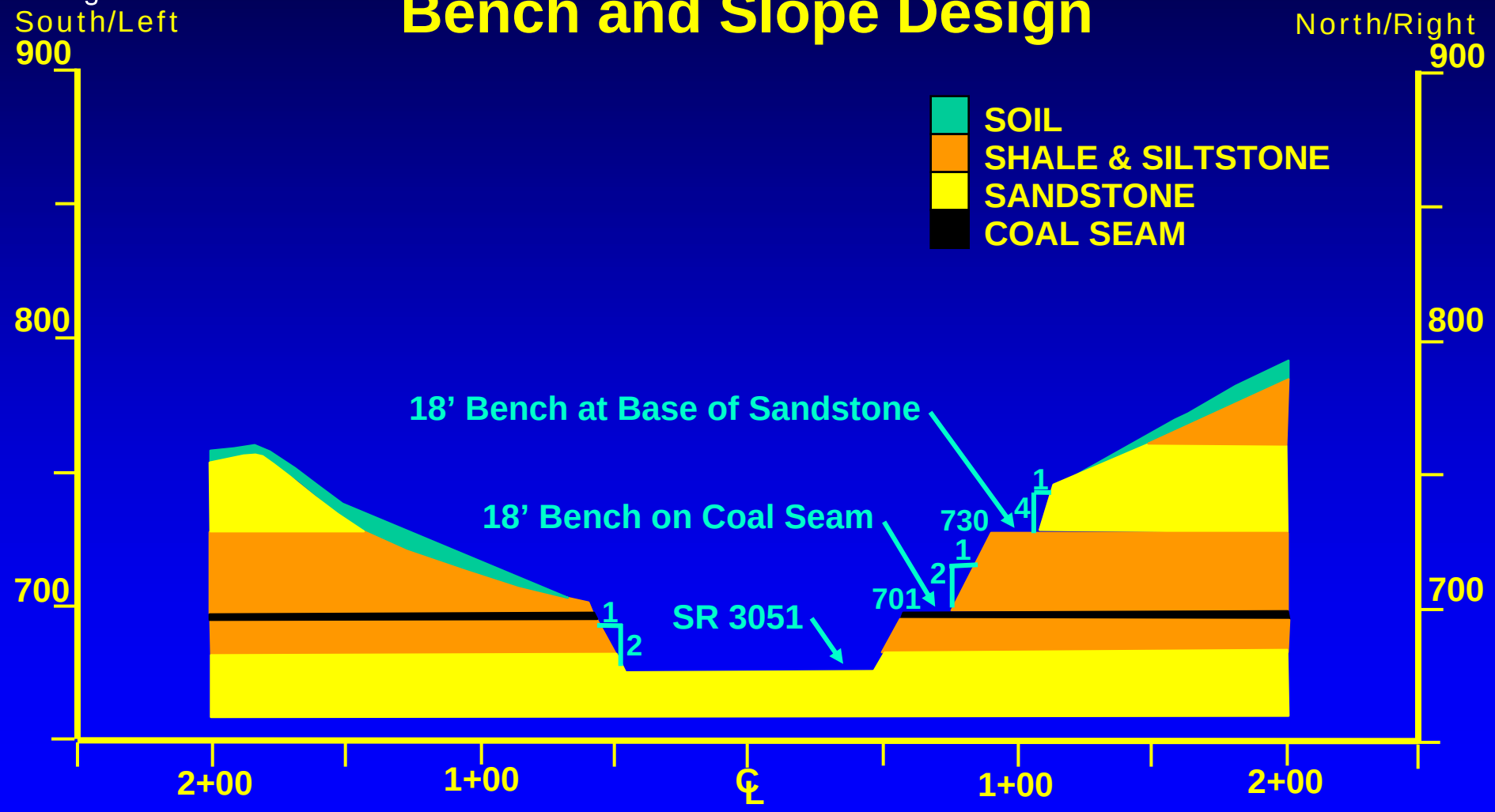
Auxiliary Spillway – Dewey Dam, K
Rock Cut Slope Desi

Bench and Slope Design



Geologic Section - Station 19+00 (Downstream of Sill)

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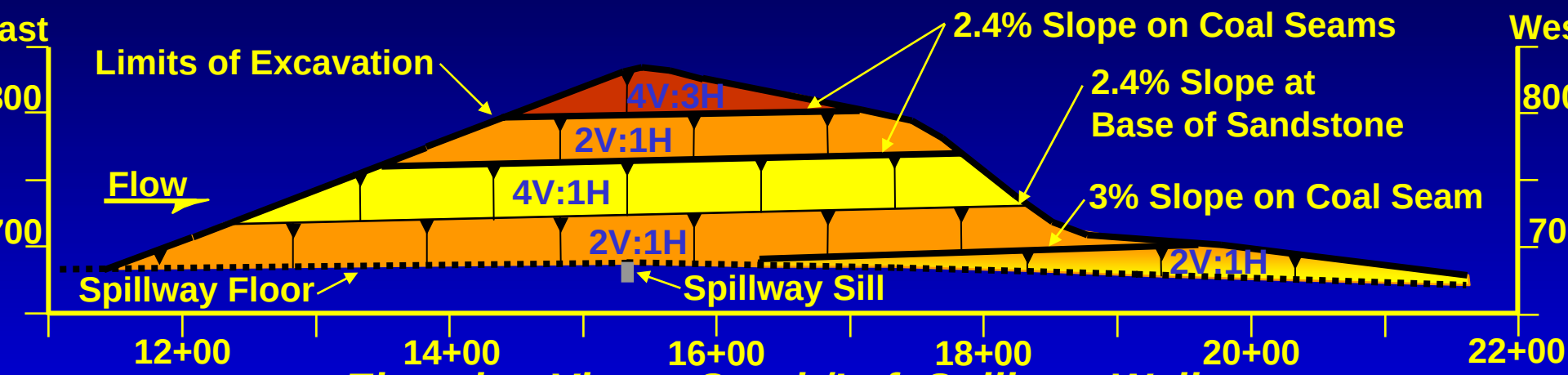
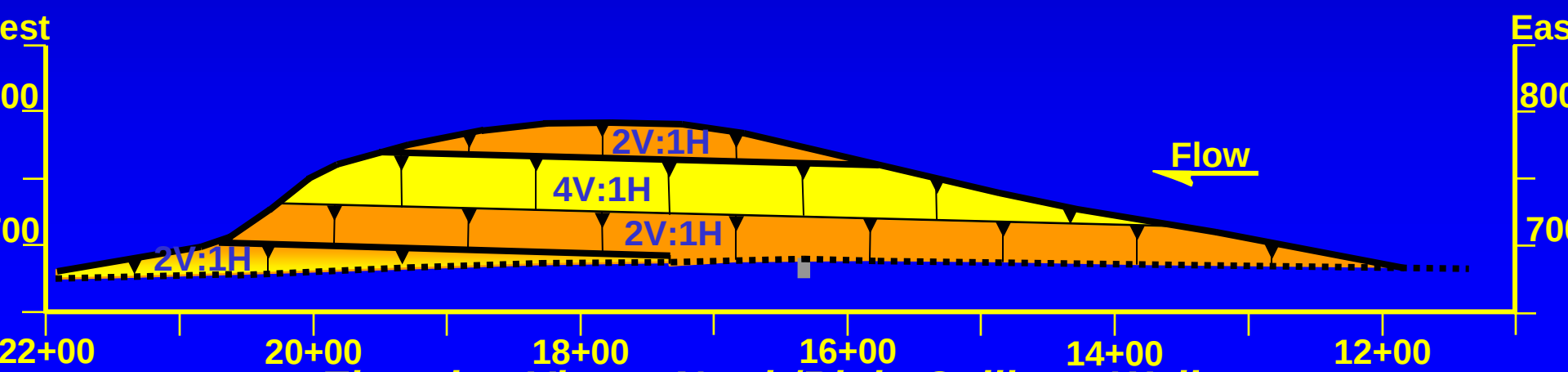
Auxiliary Spillway – Dewey Dam, K
Rock Cut Slope Desi

Bench and Slope Design



Elevation View – South/Left Spillway Wall



Elevation View – North/Right Spillway Wall

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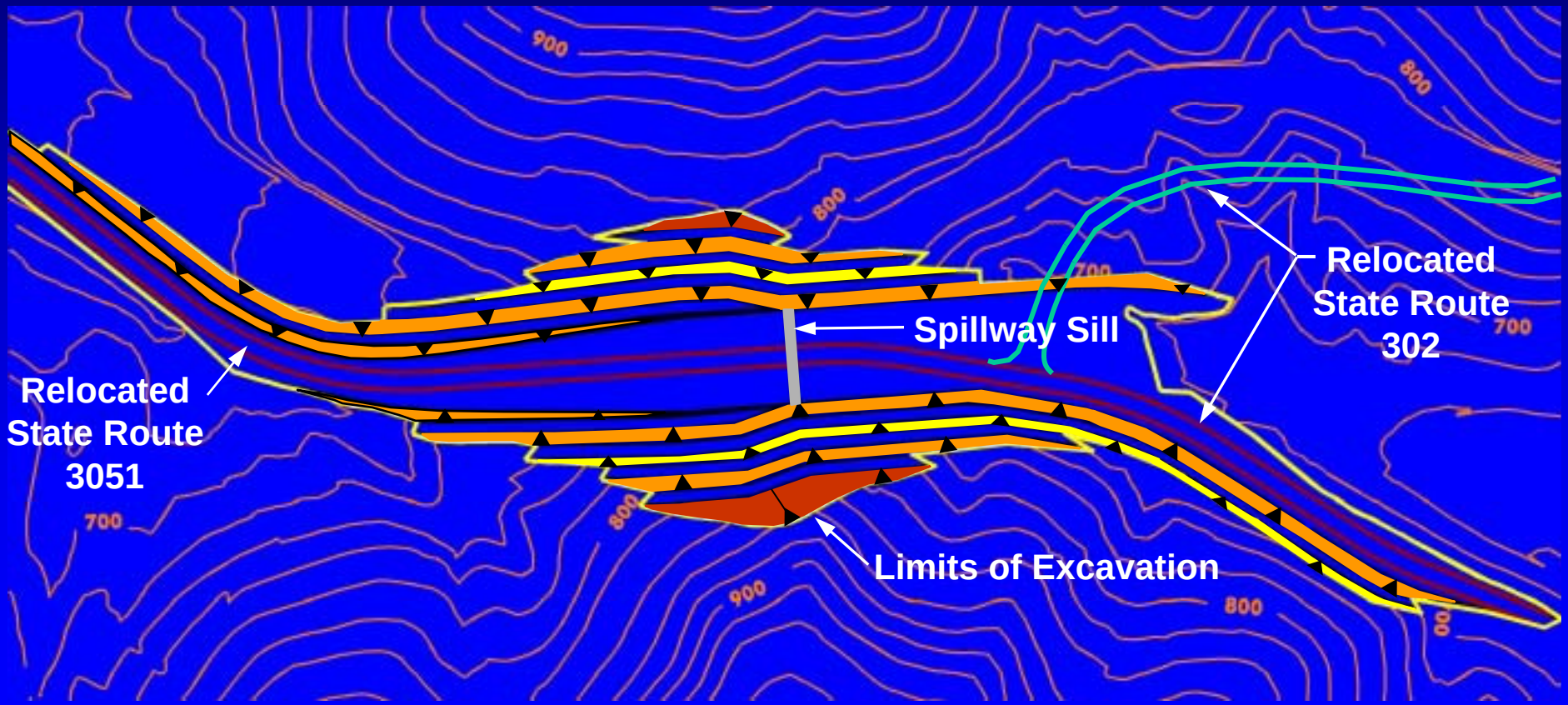
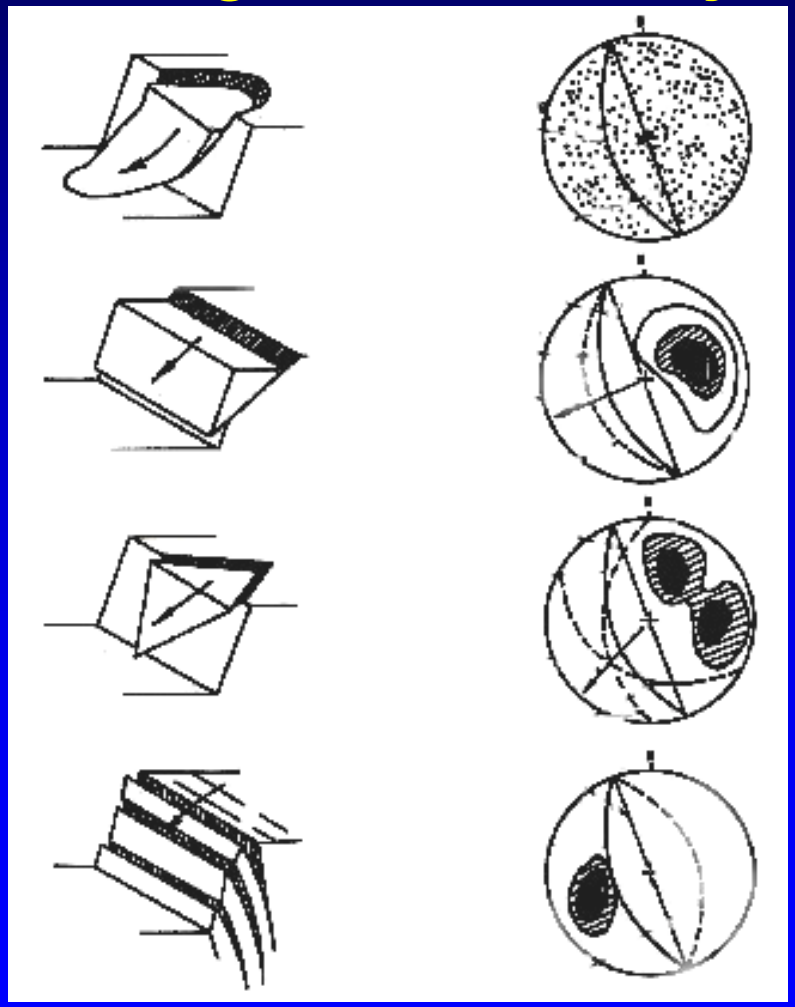
Auxiliary Spillway – Dewey Dam, K
Rock Cut Slope Desi

Bench and Slope Design



Plan View

Wedge/Block Analysis - Four Main Failure Modes



Circular Failure – soil-like failure, unlikely to occur at this project, will not be discussed at this time.

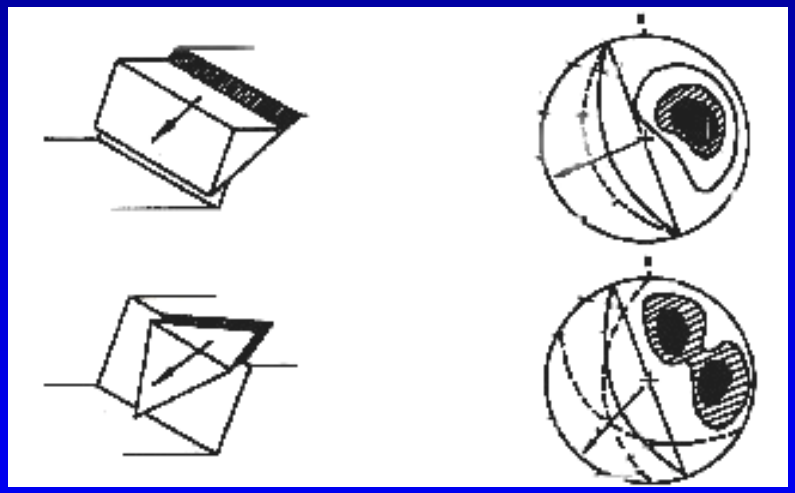
Planar Failure – common with joints that are parallel to cut-slope some failures may be blast induced

Wedge Failure – could be detrimental, large volume of rock.

Toppling Failure – similar results as planar failure, unlikely to occur at this project, will not be discussed at this time.

n Hoek, E. and Bray, J.W. "Rock Slope Engineering" 1981.

Wedge/Block Analysis - Four Main Failure Modes



Planar Failure – common with joints that are parallel to cut-slope some failures may be blast induced

Wedge Failure – could be detrimental, large volume of rock.

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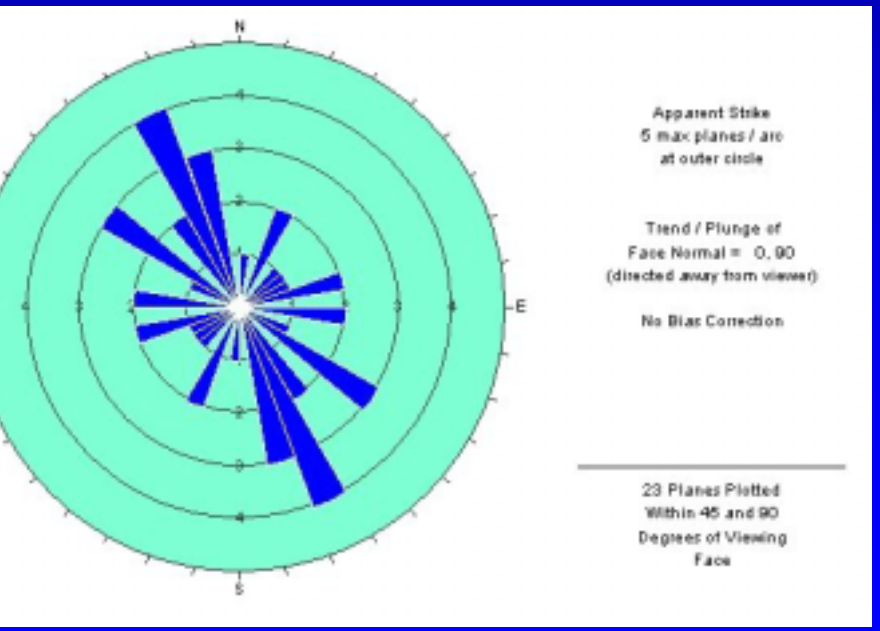
Auxiliary Spillway – Dewey Dam, K
Rock Cut Slope Desi

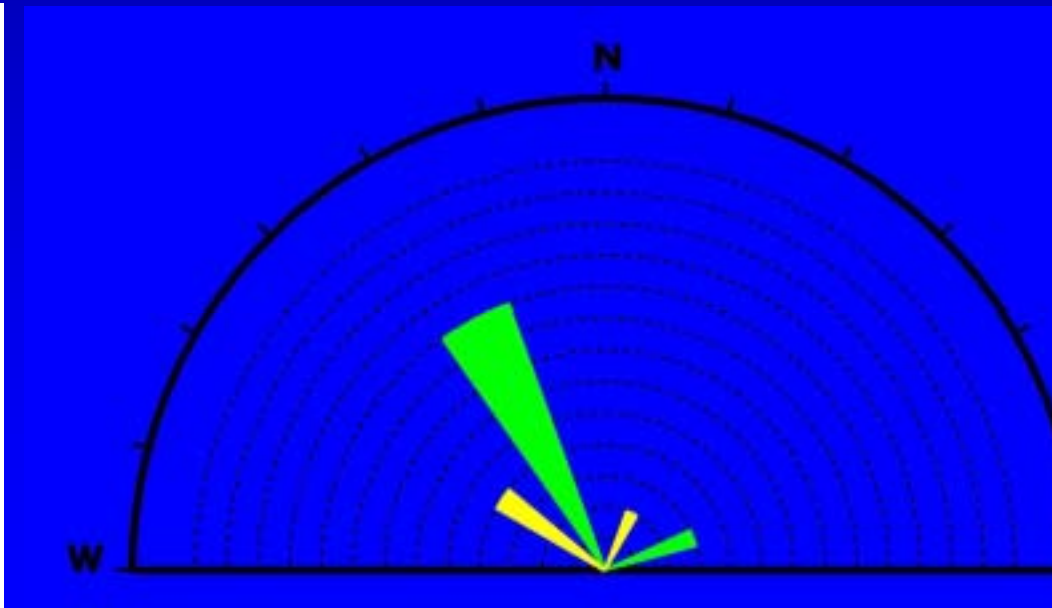
Wedge/Block Analysis – Joint Analysis

nt measurements obtained from outcrops and angled exploratory ings.

ical joint surface has a planar shape with smooth texture, occasiona stained or slightly open.



Joint Rosette



Simplified Joint Rosette

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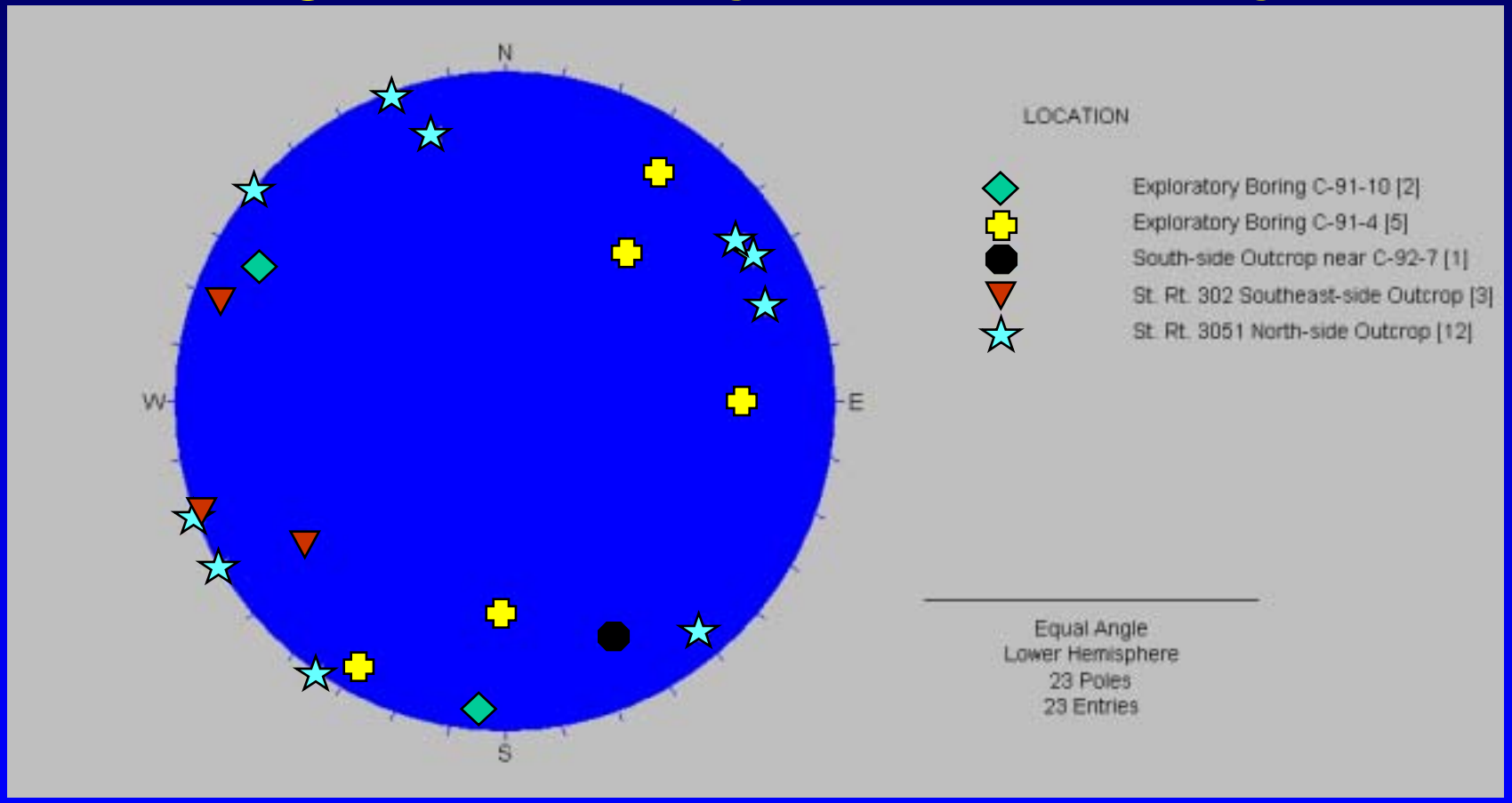
Auxiliary Spillway – Dewey Dam, K
Rock Cut Slope Desi

Wedge/Block Analysis – Joint Analysis



Stereographic Projection of Joint Measurements – Pole Plot

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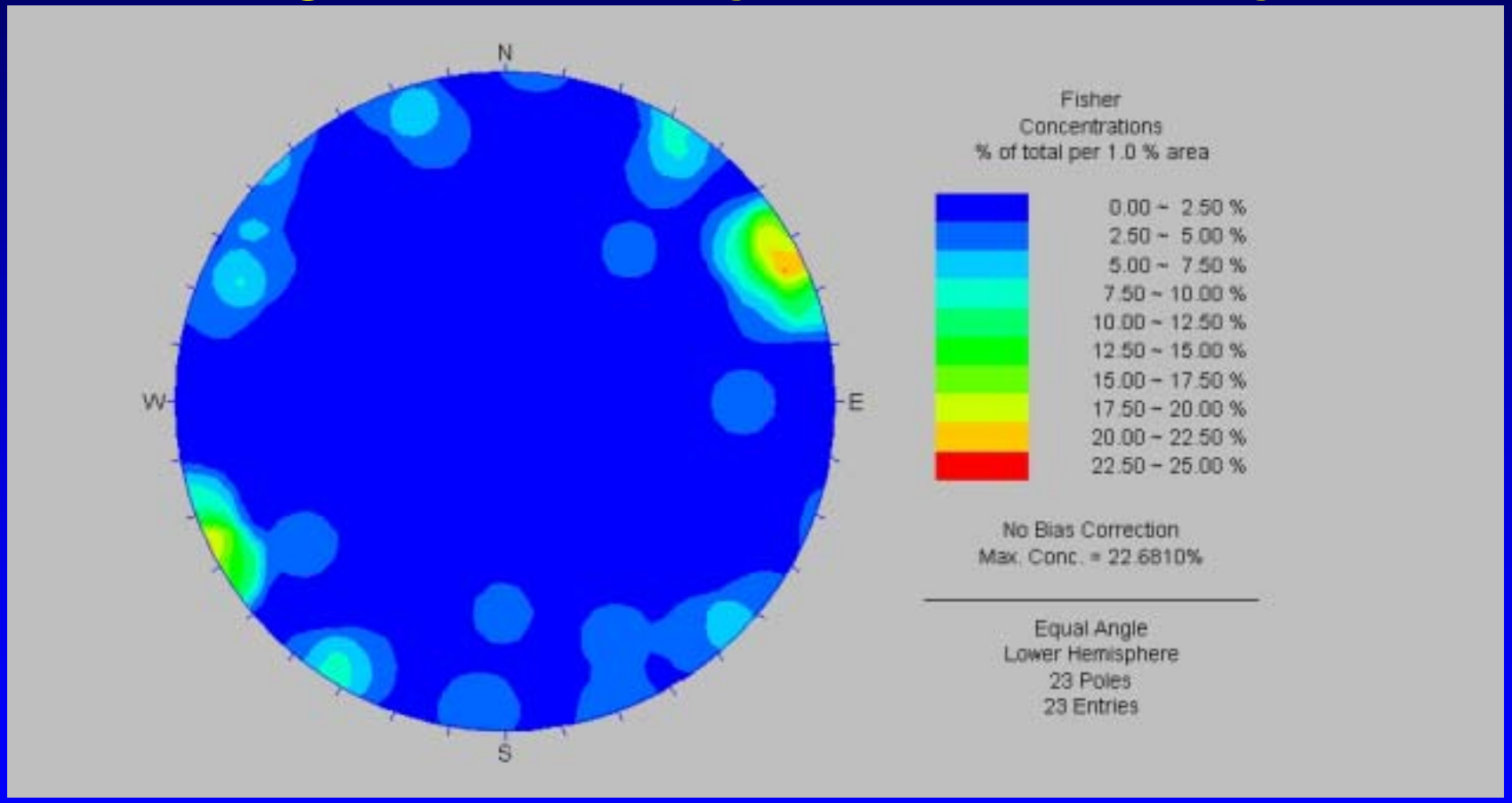
Auxiliary Spillway – Dewey Dam, K
Rock Cut Slope Desi

Wedge/Block Analysis – Joint Analysis



Stereographic Projection of Joint Measurements – Contoured Plot of Poles

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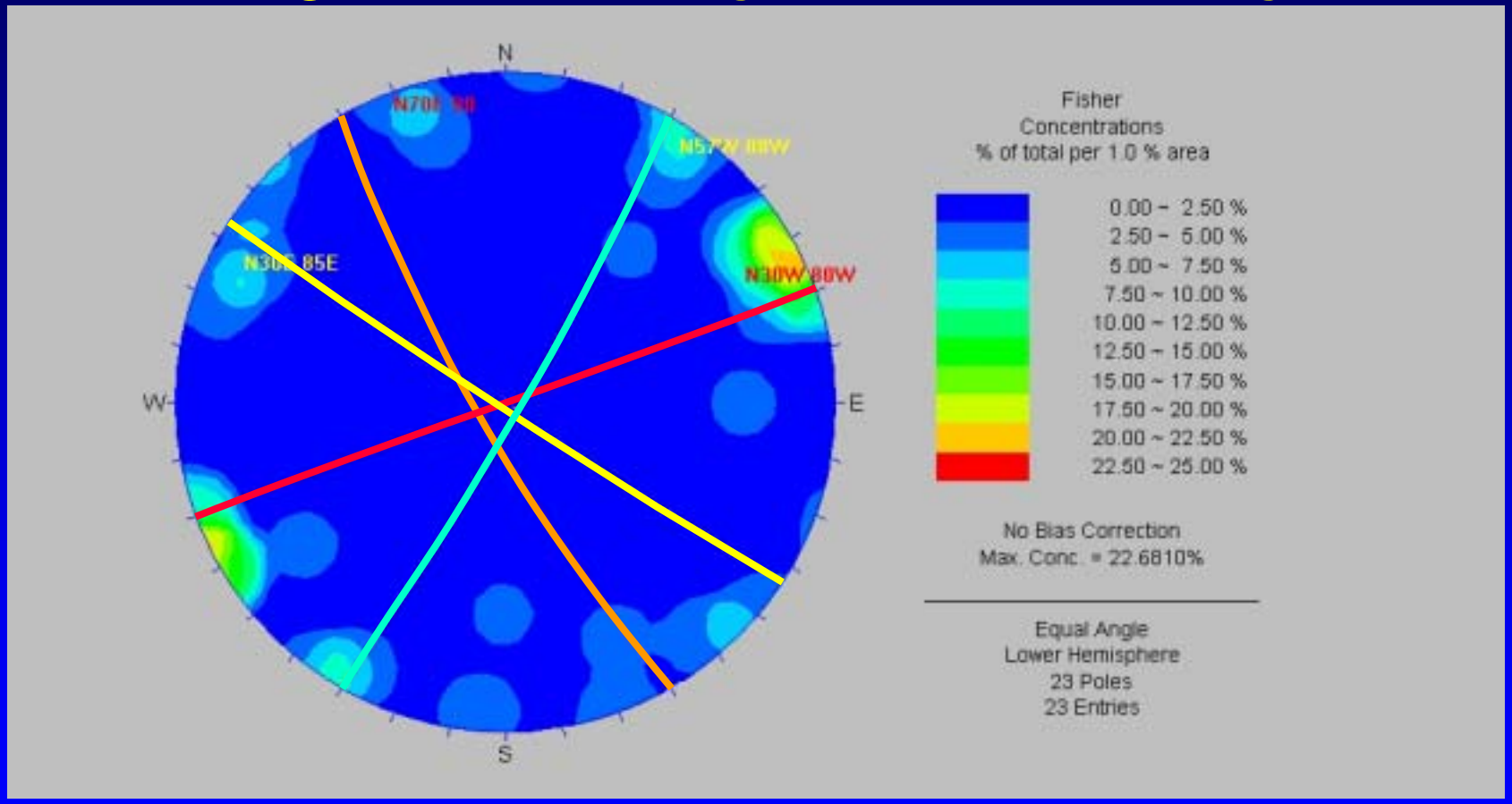
Auxiliary Spillway – Dewey Dam, K
Rock Cut Slope Desig

Wedge/Block Analysis – Joint Analysis



reographic Projection of Joint Measurements – Planes Representing Joint S

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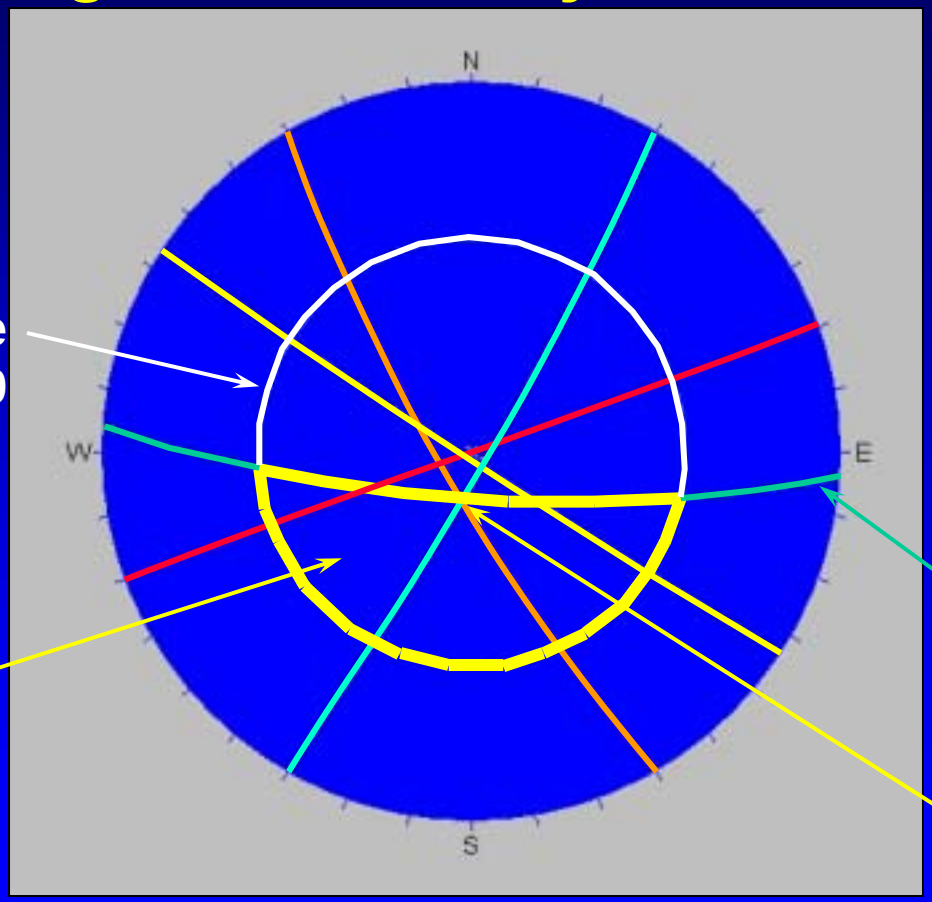
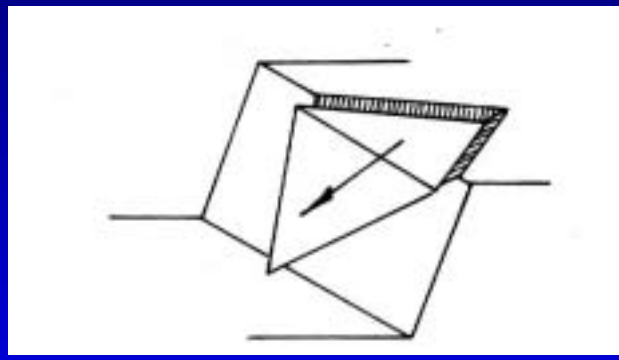
Rock Cut Slope Desi

Wedge/Block Analysis – Wedge Failure Analysis

Sandstone
Angle = 30

Wedge
ling Zone





1/4:1 Slope – North Wall

Joint Intersection

Stereographic Projection of Planes used for Wedge Analysis

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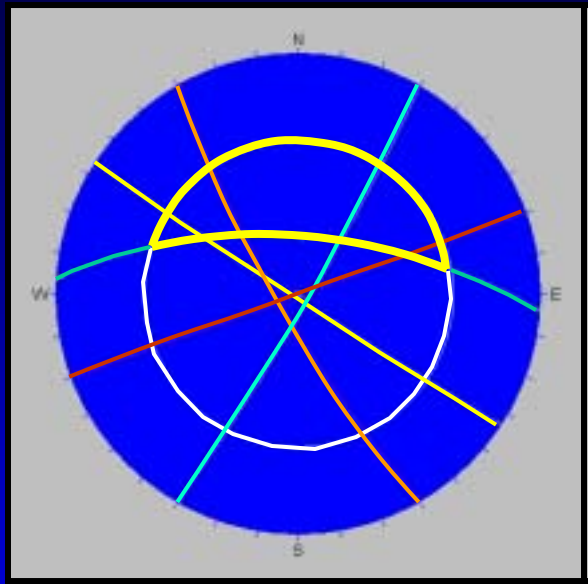
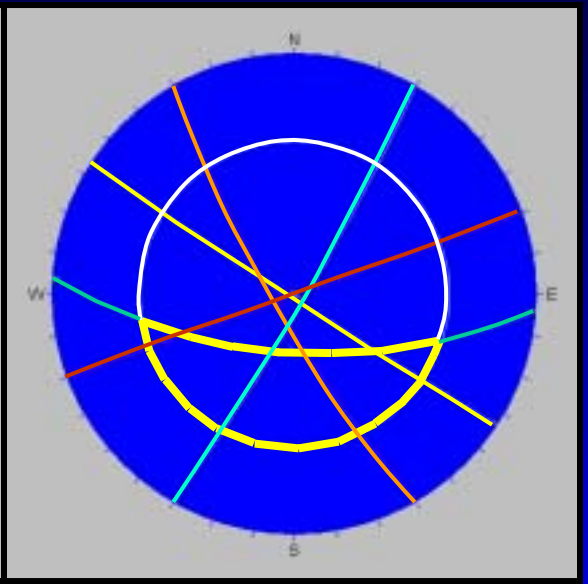
Auxiliary Spillway – Dewey Dam, K
Rock Cut Slope Desig

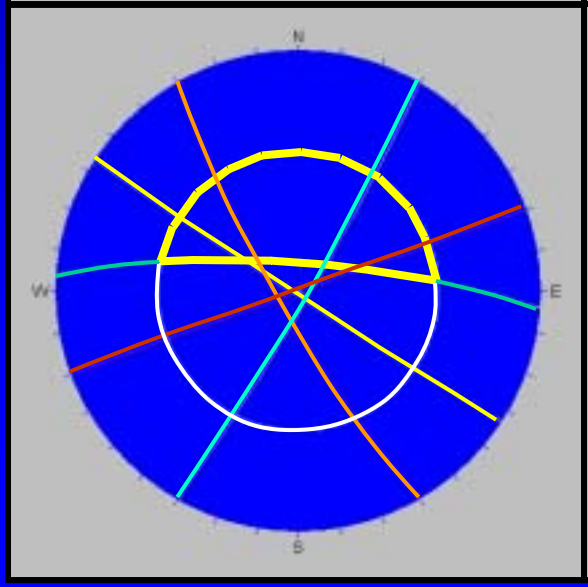
Wedge Analysis 1/2:1 Slope South Wall Shale

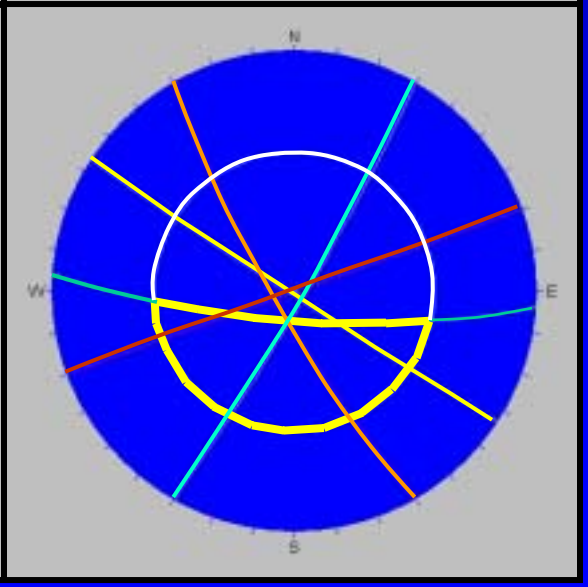




Wedge Analysis 1/2:1 Slope North Wall Shale

Wedge Analysis 1/4:1 Slope South Wall Sandstone





Wedge Analysis 1/4:1 Slope North Wall Sandstone

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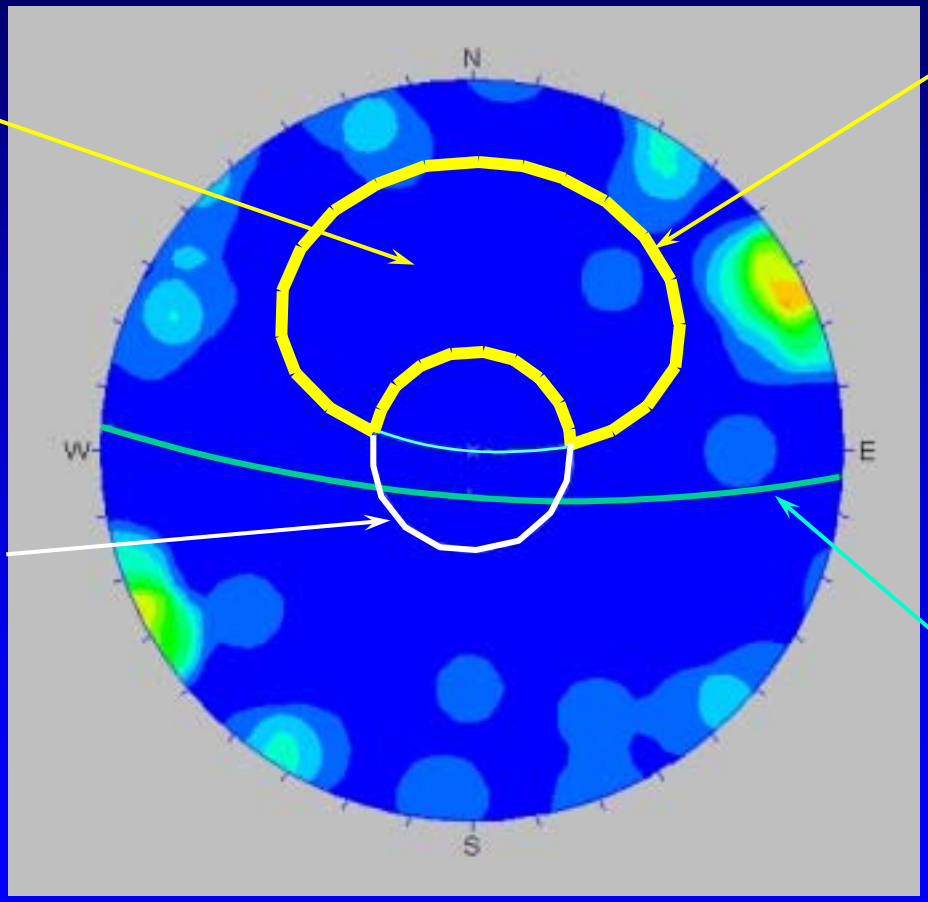
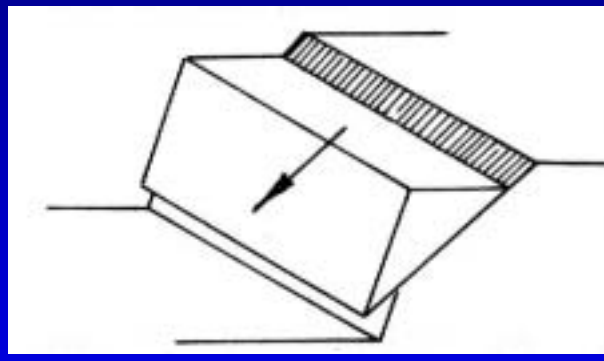
Auxiliary Spillway – Dewey Dam, K
Rock Cut Slope Desi

Wedge/Block Analysis – Planar Failure

Planar
ding Zone

Daylight Envelope





andstone
ngle = 30

1/4:1 Slope – North Wall

Stereographic Projection of Poles used for Planar Analysis

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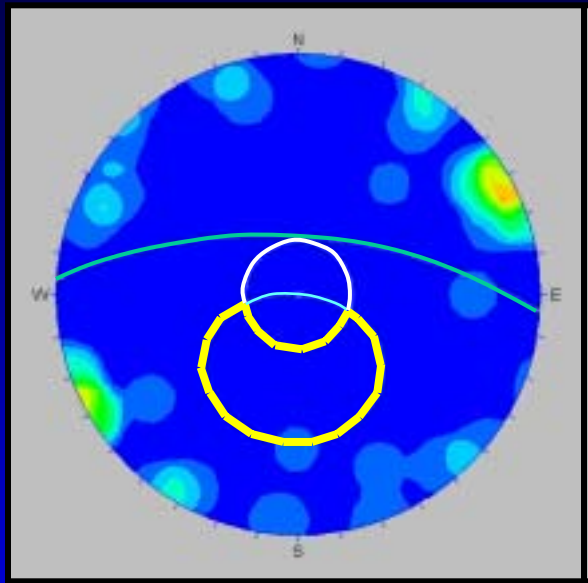
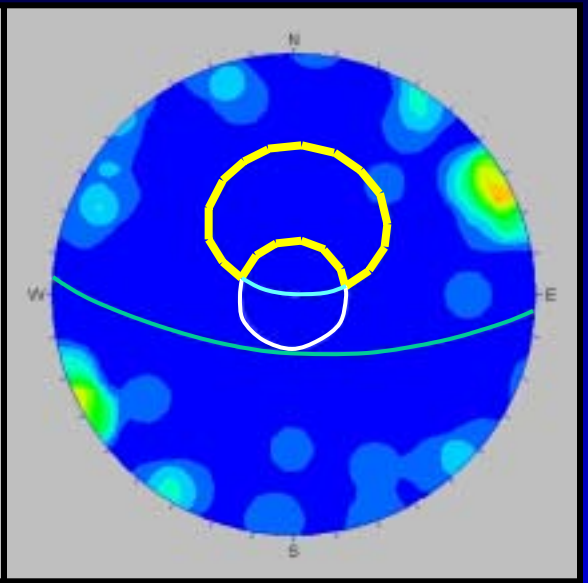
Auxiliary Spillway – Dewey Dam, K
Rock Cut Slope Desig

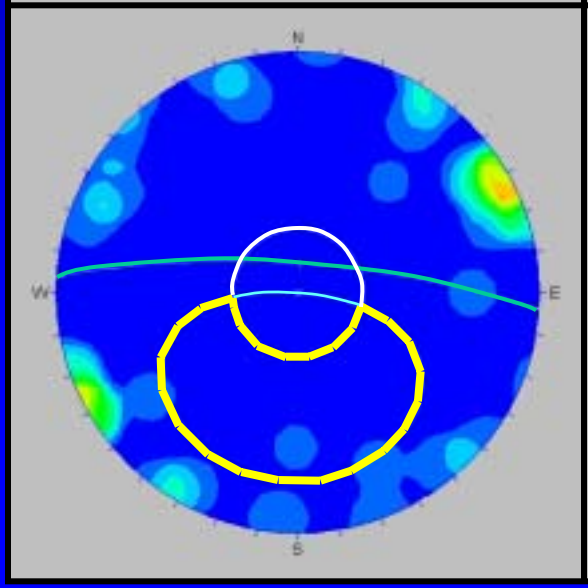
Planar Analysis 1/2:1 Slope South Wall Shale

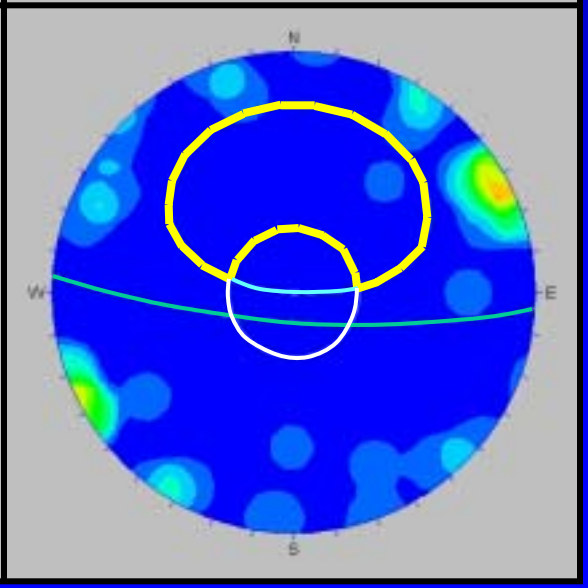




Planar Analysis 1/2:1 Slope North Wall Shale

Planar Analysis 1/4:1 Slope South Wall Sandstone





Planar Analysis 1/4:1 Slope North Wall Sandstone

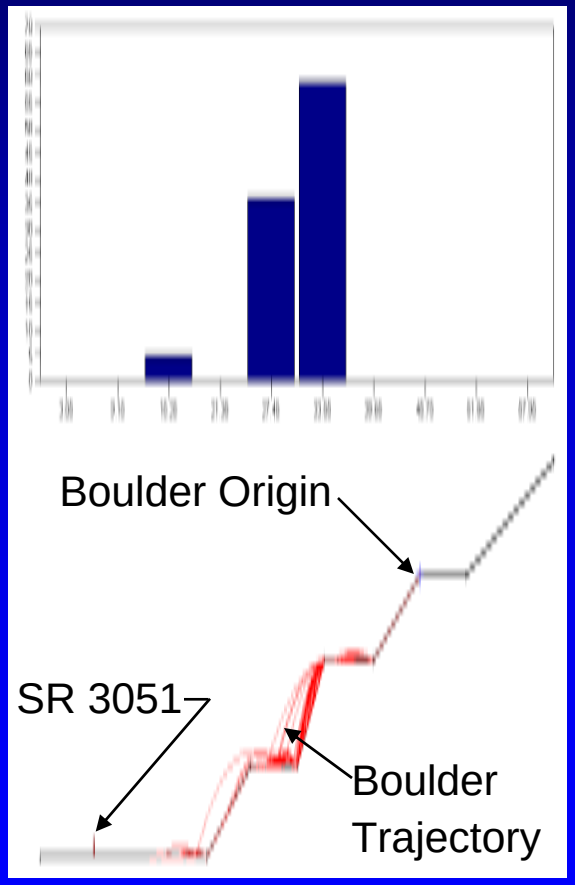
Rock Fall Analysis – Input Parameters

Values are subjective, derived from published tables.

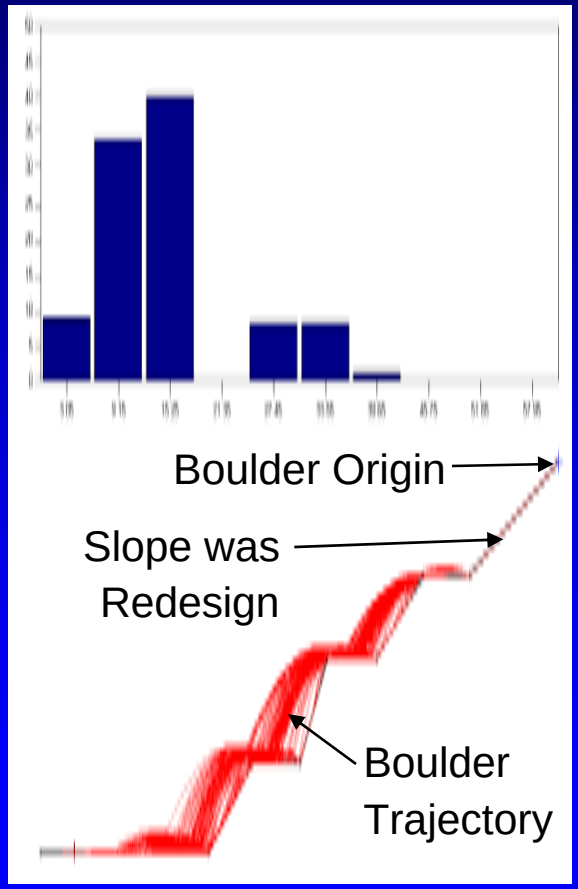
Computer programs included Colorado Rockfall Simulation and RocFall.

SURFACE AND MATERIALS	Coefficient of Normal Restitution		Coefficient of Tangential Restitution		Friction Angle (Phi angle)	
	mean	std. dev.	mean	std. dev.	mean	std. dev.
ALL BENCHES	0.35	0.02	0.85	0.02	25	5
SLOPES IN SANDSTONE	0.37	0.05	0.87	0.05	25	5
SLOPES IN SHALE/SILTSTONE	0.37	0.05	0.87	0.05	30	5

Rock Fall Analysis

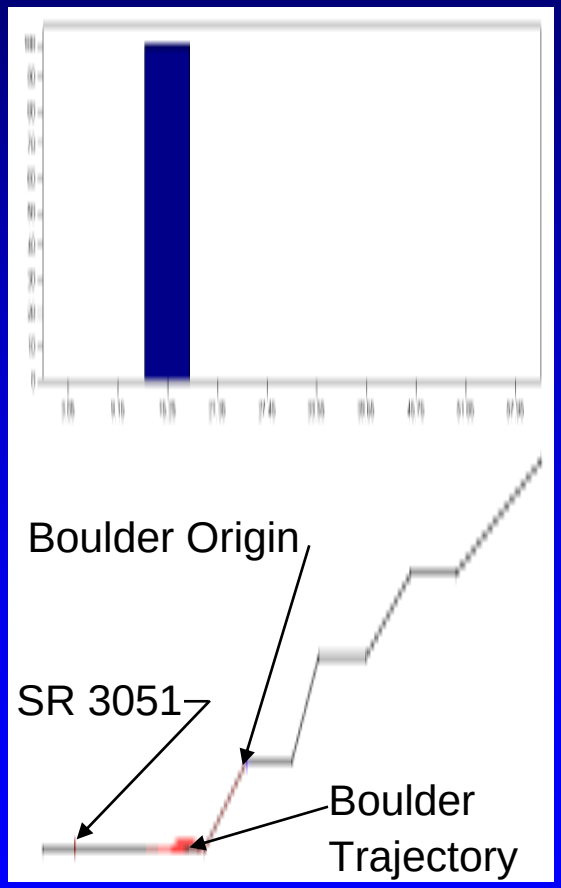


Boulder Origin at Bench Elev. 800

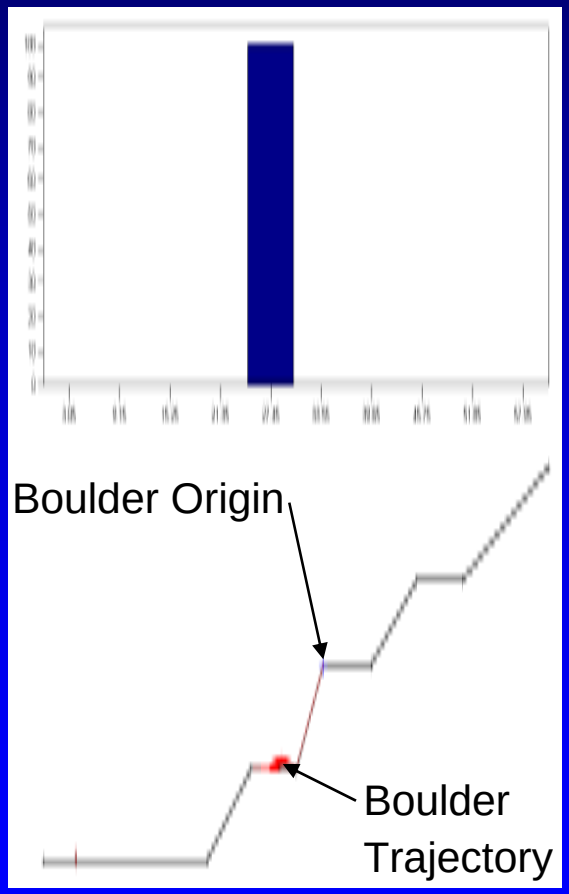


Boulder Origin at Top of Cut Slope

Rock Fall Analysis



Boulder Origin at Bench Elev. 725



Boulder Origin at Bench Elev. 766

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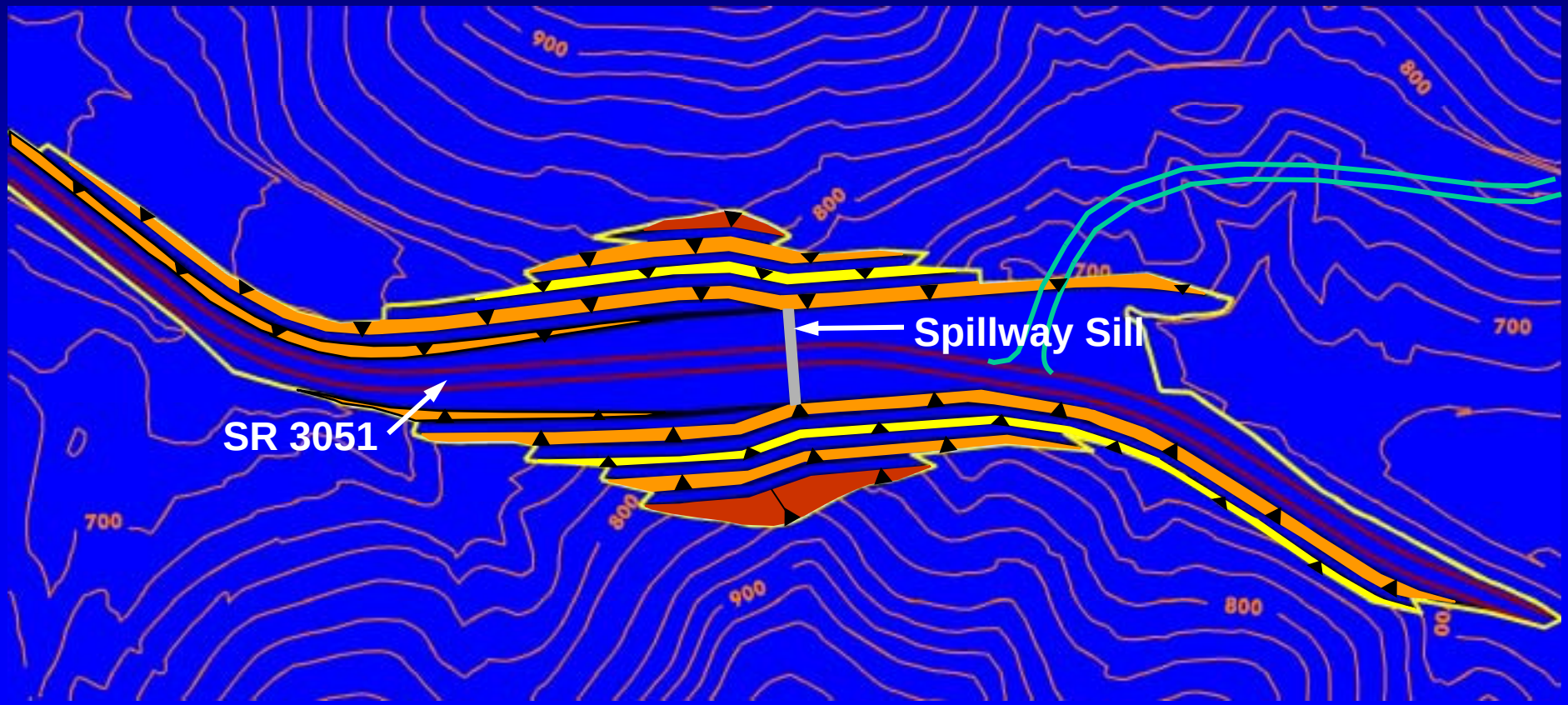
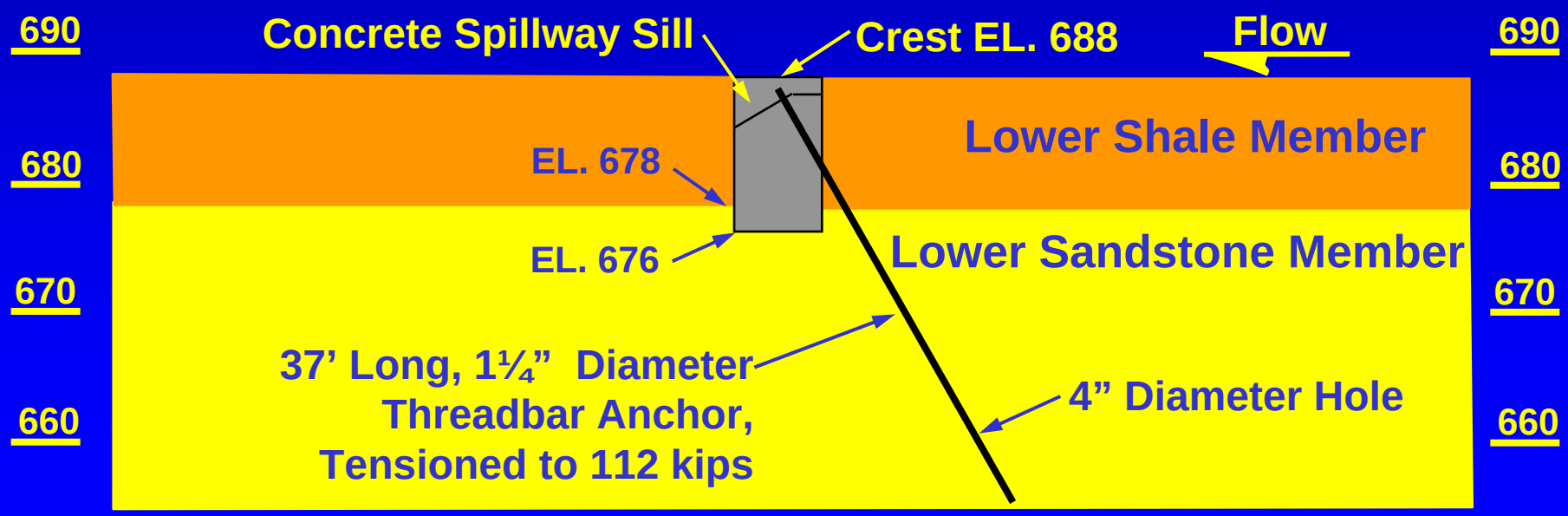
Spillway Sill Design



Plan View

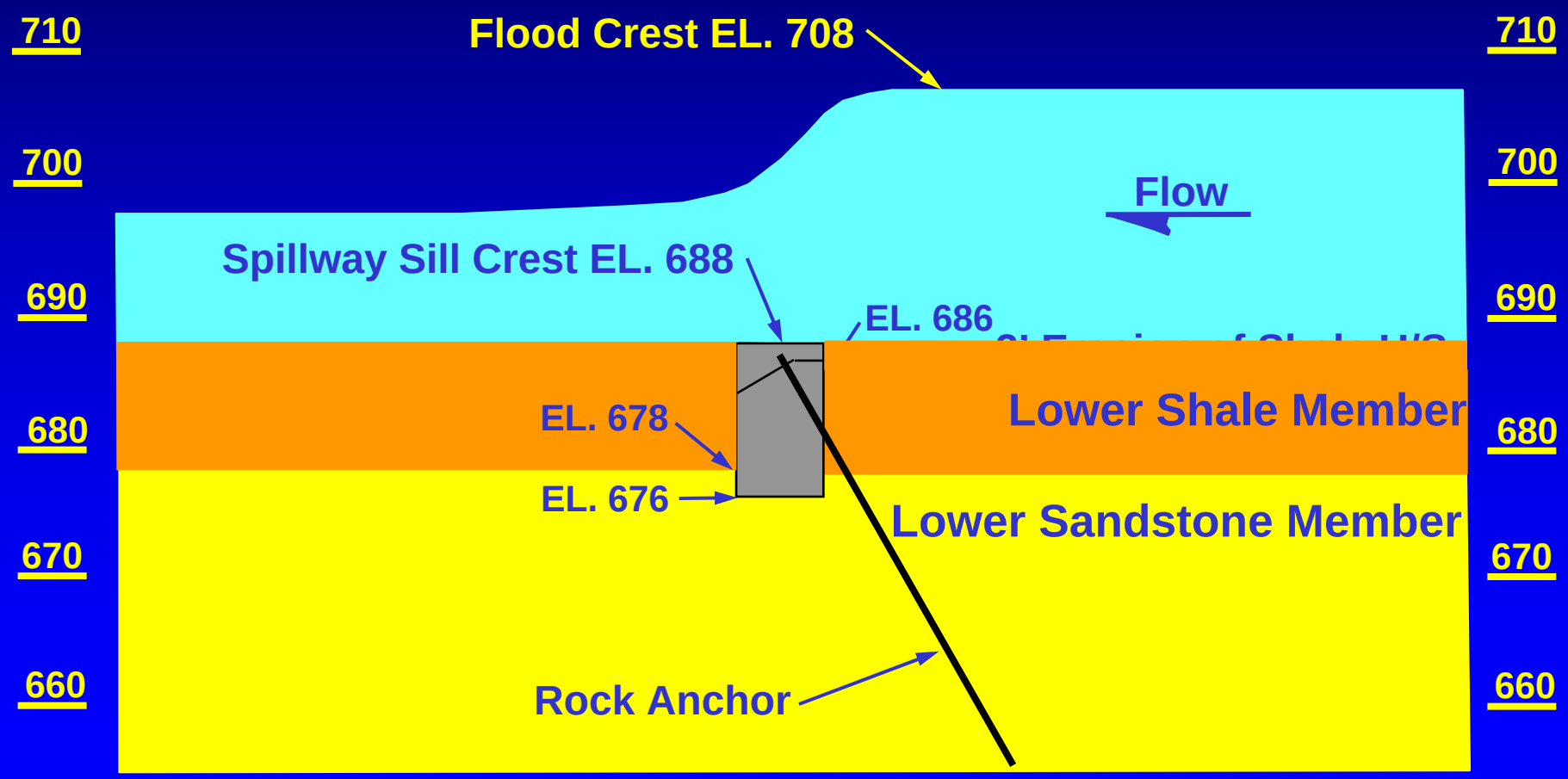
Spillway Sill – Bedrock Parameters

LITHOLOGIC MEMBER	Sliding Friction Strength phi	Sliding Friction Strength c	Cross Bed Shear Strength phi	Cross Bed Shear Strength c	Anchor Bond Strength	Unit Weight	Allowable Bearing Pressure
	degree	psi	degree	psi	psi	pcf	psi
LOWER SHALE	25	0	30	10	65	160	90
LOWER SANDSTONE	25	15	50	175	95	150	320



Cross Section – Spillway Sill – Normal Condition

Spillway Sill Design – Headcut Erosion



Cross Section – Spillway Sill – Flood Condition

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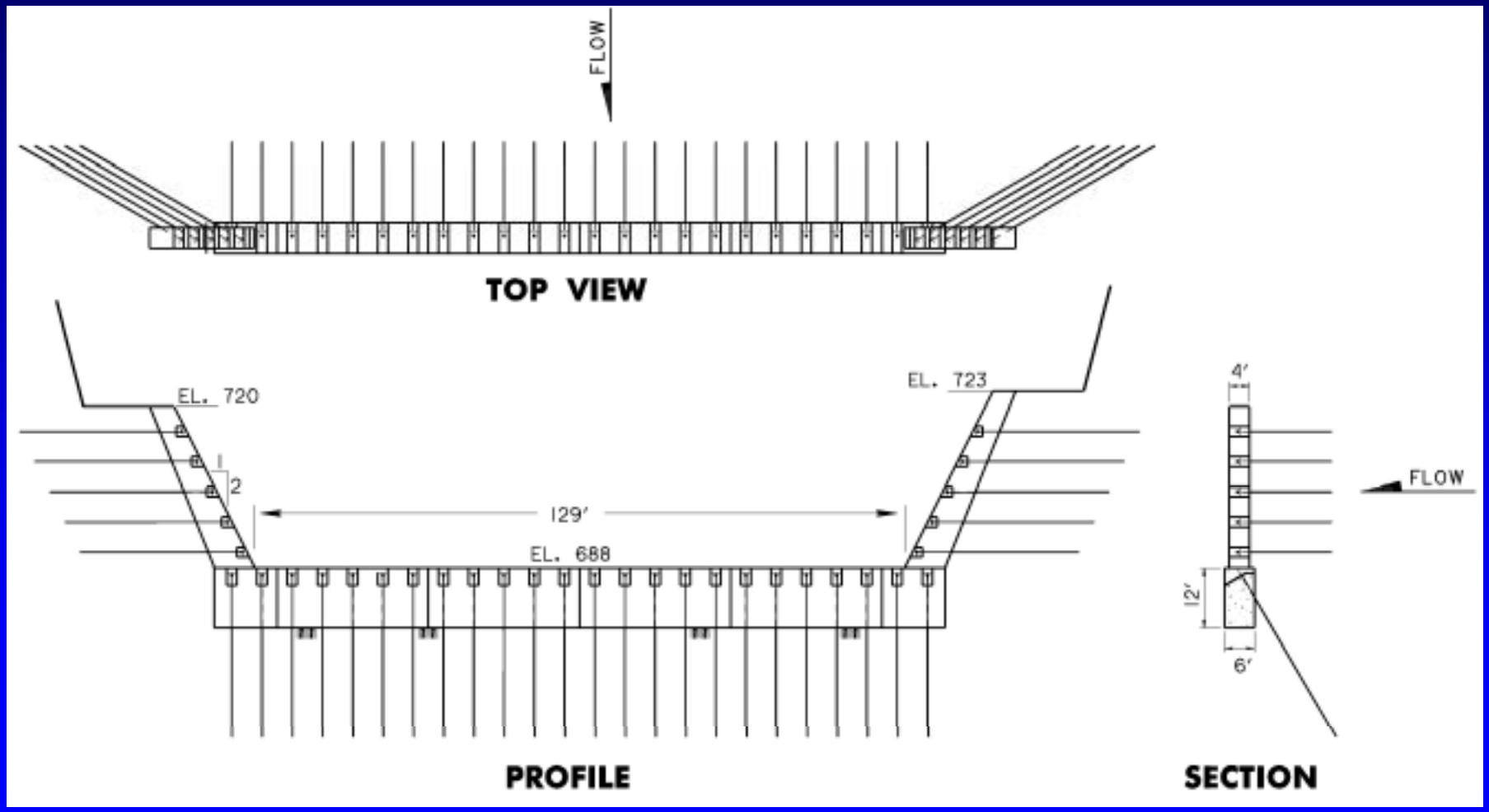
Auxiliary Spillway – Dewey Dam, K
Rock Cut Slope Desi

Spillway Sill Design



Four Main Topics of Discussion

1. Project Description
2. Site Geology
3. Rock Cut-Slope Design
4. Construction Challenges

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Auxiliary Spillway – Dewey Dam, K
Construction Challeng

Construction Contract

- **PRIME CONTRACTOR:**
  Tab Construction Co. of Canton, Ohio
- **DRILLING AND BLASTING SUBCONTRACTOR:**
  Hilltop Energy Inc. of Mineral City, Ohio
- **CONSTRUCTION DURATION:**
  Approximately Two Years from August 2000 to September 2002.
- **FINAL EXCAVATION QUANTITIES:**
  Rock Excavation: 677,000 cubic yards
  Structural (Rock/Concrete) Excavation: 1,000 cubic yards
  Common (Soil) Excavation: 306,000 cubic yards
- **FINAL CONSTRUCTION CONTRACT COST:**
  $12.8 Million Dollars

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Modifying Rock-Cut Slopes

Removal of Slip-Prone Soil

Initial Rock Cut

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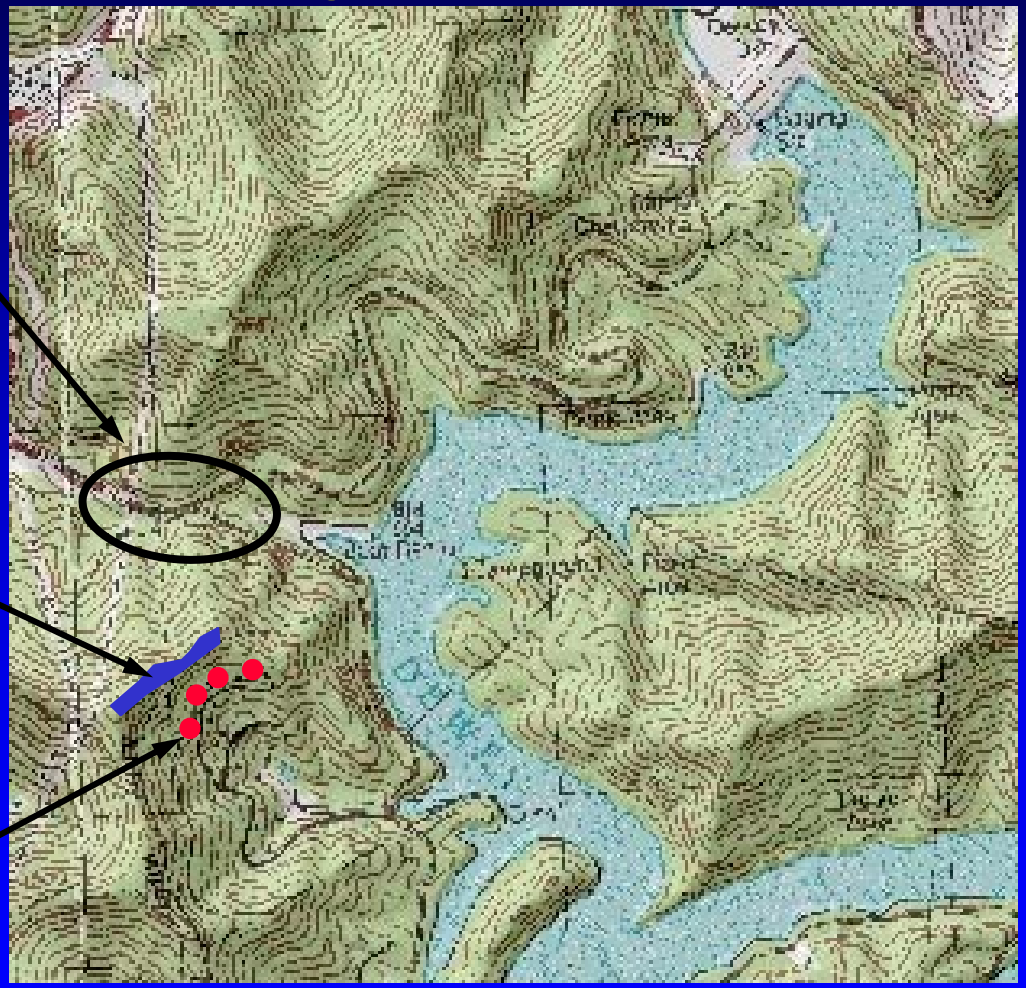
Auxiliary Spillway – Dewey Dam, K
Construction Challeng

Blasting Vibration Control

Blasting for uxiliary Spillway SR 3051 & 302

Perched Boulders

Homes



Location of Homes

Blasting Within 790 Feet of Boulders and 1,000 Feet From Homes

Restricted Peak Particle Velocity to 1.5 in/sec at 200 Feet From Blast

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Auxiliary Spillway – Dewey Dam, K
Construction Challeng

Blasting Vibration Control

Large Boulders Located on Ridge Line and Perched Above Homes

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Auxiliary Spillway – Dewey Dam, K
Construction Challeng

Drilling And Blasting

Pre-Split Drilling
18" to 30" Center to Center

Loading Production Shot

Drilling And Blasting

Production Blast

Production Blast

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Construction Challeng

Excavation and Spoil Sites

Rock Excavation

Spoil Sites

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Construction Challeng

Maintaining Traffic and Utilities During Excavation

View of South/Left Spillway Wall

Spillway Sill

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Auxiliary Spillway – Dewey Dam, K
Construction Challeng

Spillway Sill

Over Excavation of Spillway Sidewalls

Modifications to Correct for Future Erosion of Shale

Final Product

South/Left Spillway Wall as Viewed from Upstream

North/Right Spillway Wall as Viewed from Upstream

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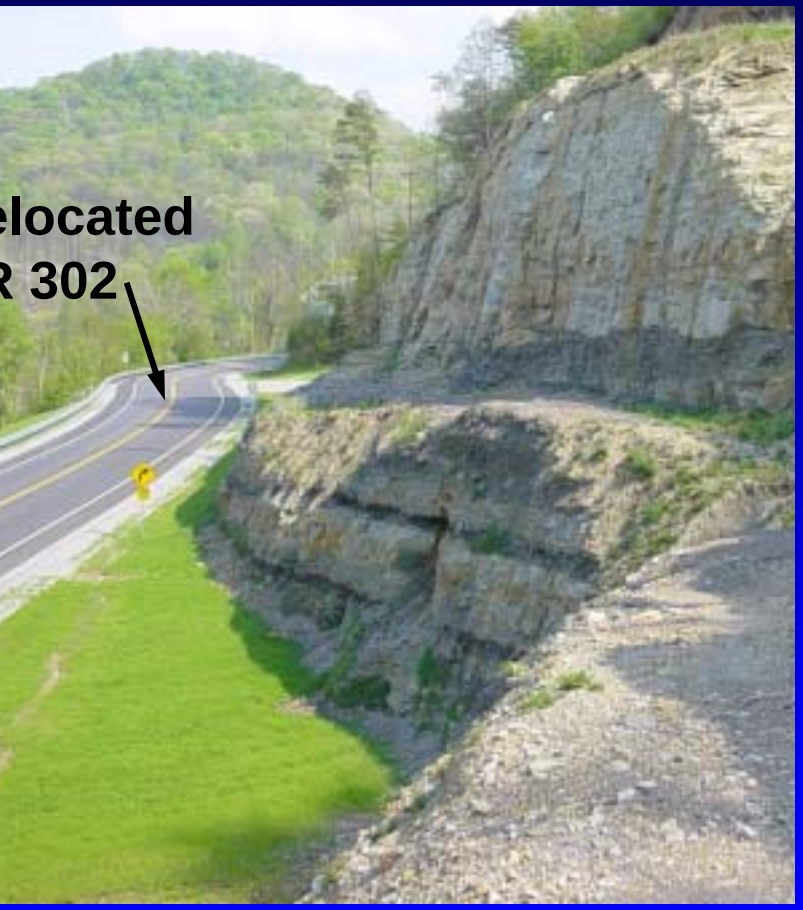
Auxiliary Spillway – Dewey Dam, K
Construction Challeng

Final Product



Upstream of Spillway Route 302 Transition

Auxiliary Spillway Viewed from Downstream

Questions & Discussion

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