ROCK SLOPE AND DITCH WIDTH DESIGN AND BLASTING FOR HIGHWAY SLOPES & EVALUATION OF USING ALUMINUM IN EMULSION FOR PRE-SPLIT LINES

Craig Boeckman

Regional Geologist

Central Region Materials

ROCK SLOPE AND DITCH WIDTH DESIGN AND BLASTING FOR HIGHWAY SLOPES

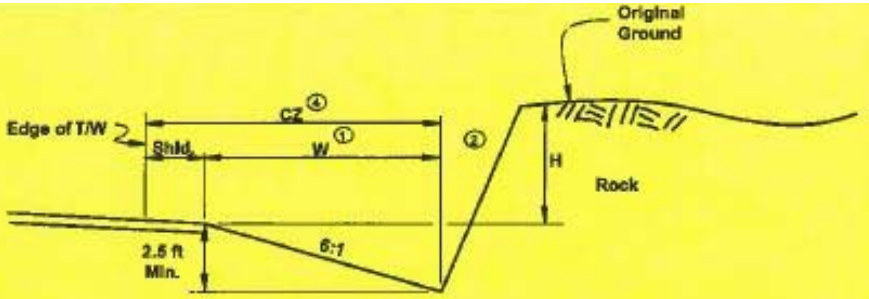
AK HIGHWAY PRECONSTRUCTION MANUAL

"Vee Ditch"

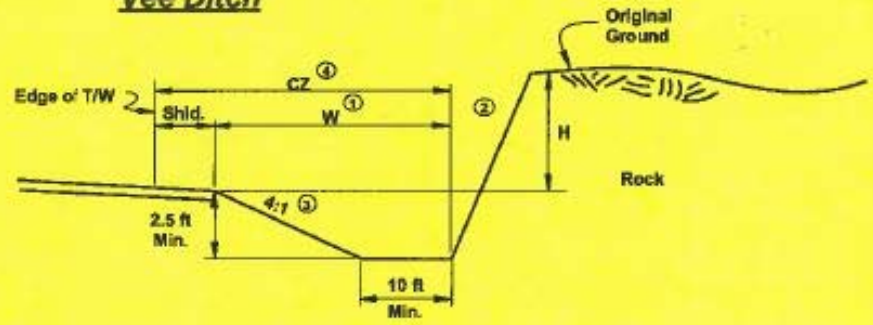
Not typically used for our rock cuts.

But it is the Standard Based on the ODOT Slope Design Guide.

"Flat Bottom Ditch" Is typically used for our rock cuts.



Vee Ditch



Flat Bottom Ditch

Rock Slope	H (ft)	W (ft)
Near Vertical to 0.50:1	0-20 20-30 30-60*	CZ - Shld. 16 19

(1) The greater value shall govern – CZ or (W+Shld.).

(2) Rock slope: As per geotechnical recommendations.

(3) If a slope steeper than 4:1 is used then barrier may be warranted. (See 1133.5). The width of slopes steeper than 4:1 shall not be included in the CZ dimension (See 1130.2.5).

(4) CZ = Clear Zone (See 1130.2).

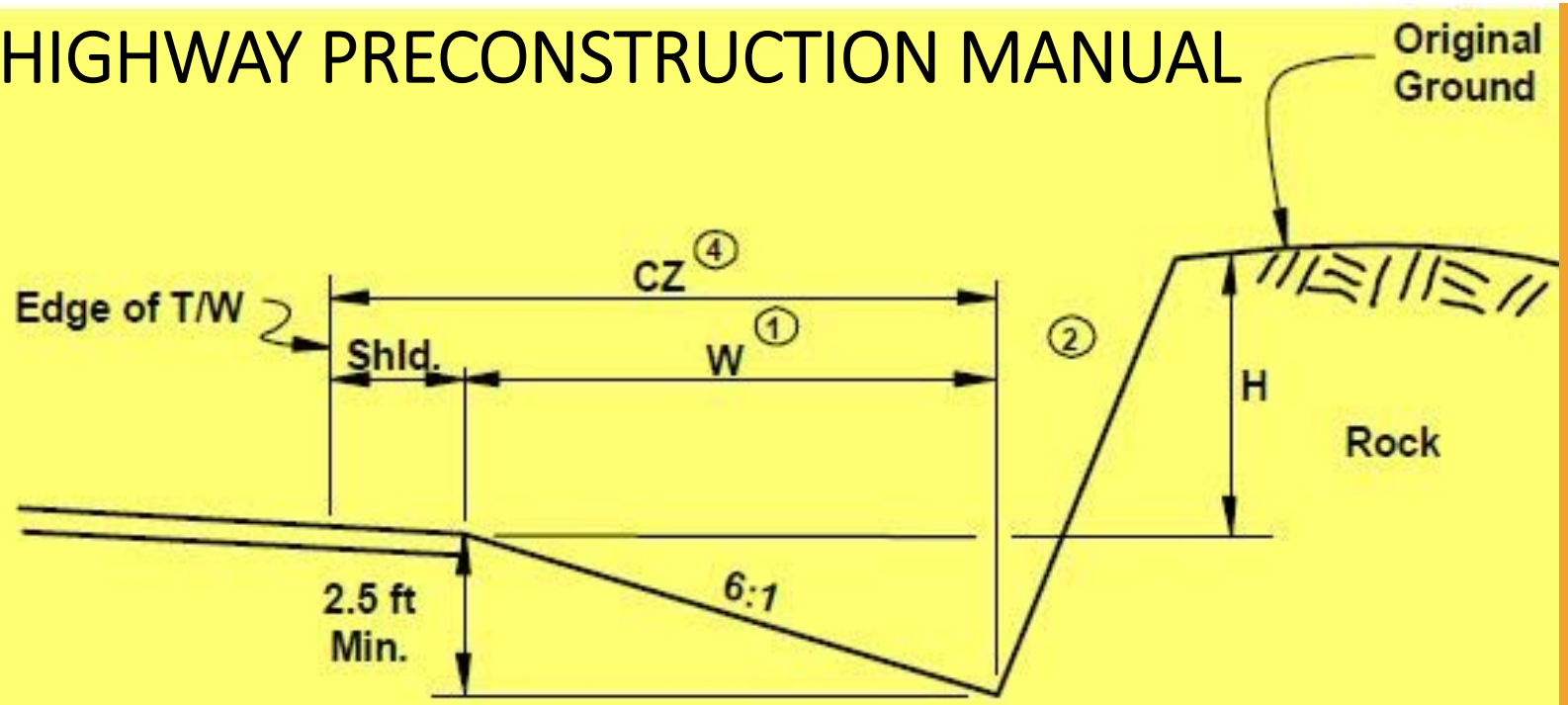
* 1. Refer cuts over 60' to regional or state geotechnical engineer for roadside ditch design.

2. For cuts over 20' in height and 1/2 mile in length it may be desirable to request design from regional or state geotechnical engineer to insure cost effectiveness.

ROCK CATCHMENT DITCH WIDTH

Recommended Sections for All ADTs

AK HIGHWAY PRECONSTRUCTION MANUAL



Rock Slope	H (ft)	W (ft)
Near Vertical to 0.50:1	0-20 20-30 30-60*	CZ - Shld. 16 19

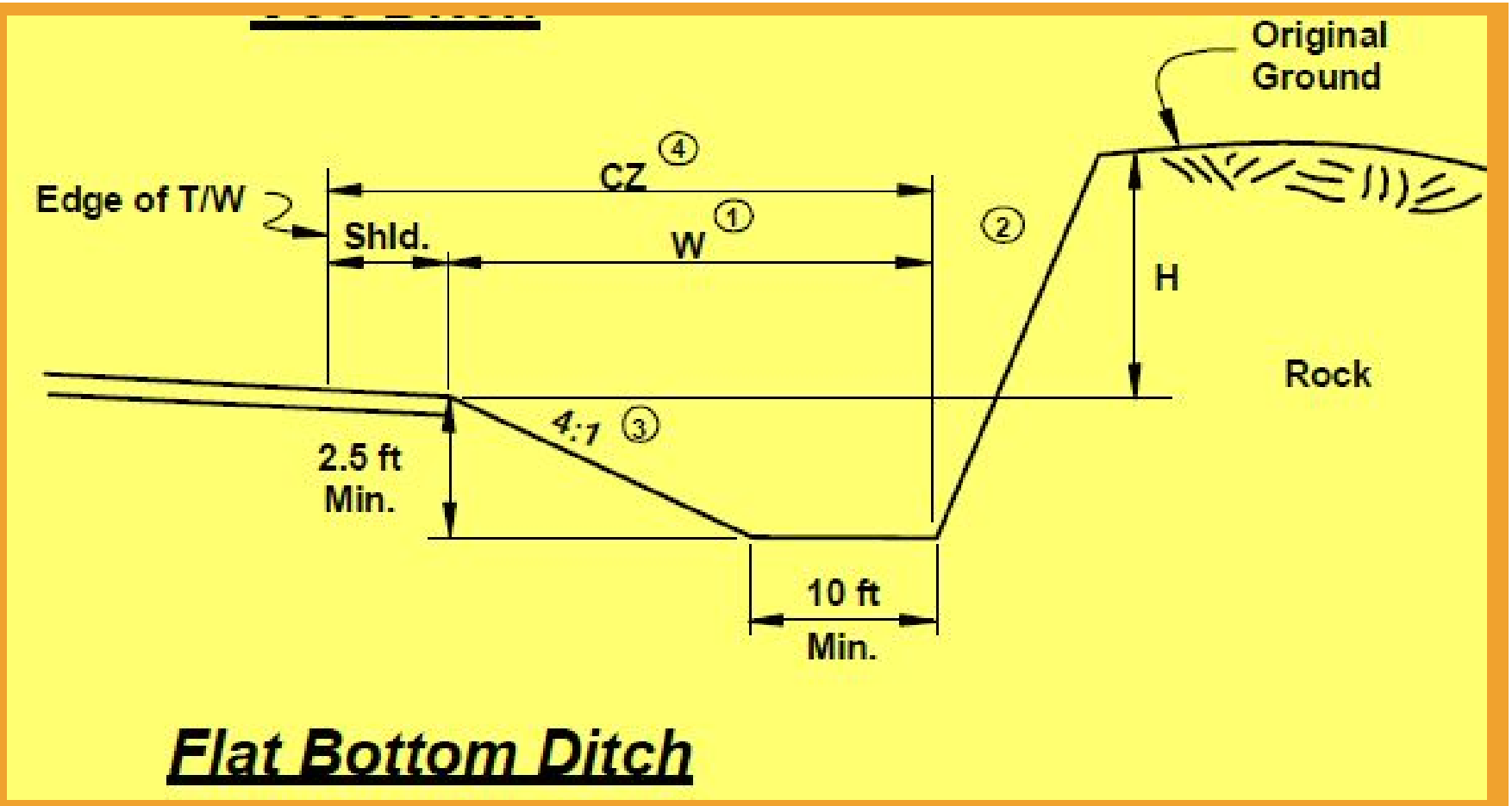
① The greater value shall govern -- CZ or (W+Shld.).

② Rock slope: As per geotechnical recommendations.

③ If a slope steeper than 4:1 is used then barrier may be warranted. (See 1130.5). The width of slopes steeper than 4:1 shall not be included in the CZ dimension (See 1130.2.5).

④ CZ = Clear Zone (See 1130.2).

* 1. Refer cuts over 60‘ to regional or state geotechnical engineer for roadside ditch design.



Flat Bottom Ditch

AK HIGHWAY PRECONSTRUCTION MANUAL

W = Depends on slope height.

Cuts > 60 ft (refer to the regional geotech engineer for roadside ditch design).

CR MATERIALS ROCK SLOPE & DITCH WIDTH EVALUATION METHODS:

1) Historical performance of the rock cuts in the area of the proposed project (M&O knowledge and observations, problem areas, bedrock types, thickness of overburden).

2) Oregon DOT&PF “Rockfall Catchment Area Design Guide”, Pierson, L., Gullixson, C.F., Chassie, R. G., November 2001.

3) Rock fall simulation software such as RocFall (RocScience®) and Colorado Rockfall Simulation Program (CRSP®).

ODOT ROCKFALL CATCHMENT AREA DESIGN GUIDE

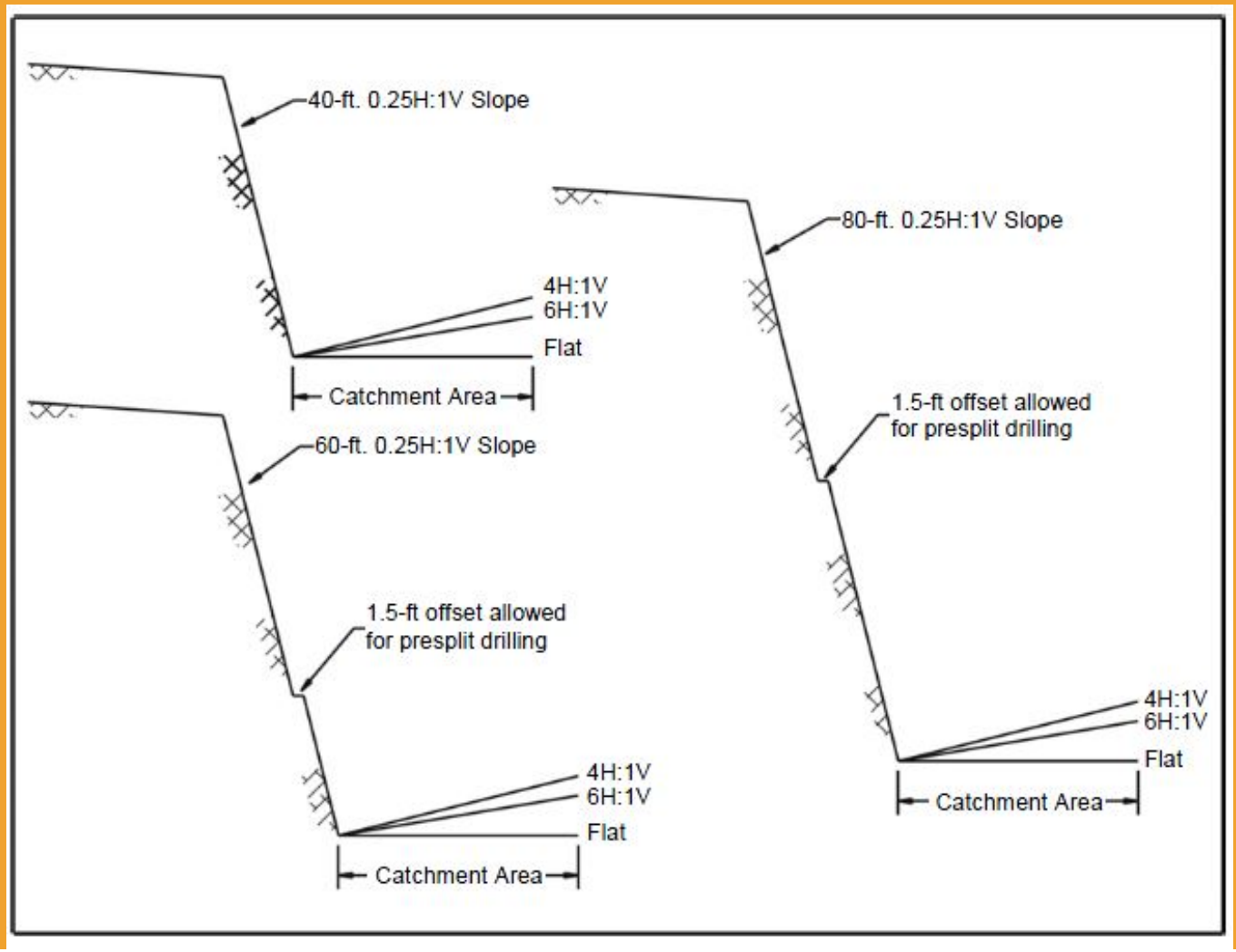
1) TESTED SLOPE HEIGHTS OF 4O, 50, 60, 70, and 80 FEET.
2) Ditch Configuration was; a) Flat Bottom, b) V-Shaped with a 6:1 fore-slope, and c) V-Shaped with a 4:1 fore-slope.

750 rocks rolled per Configuration.

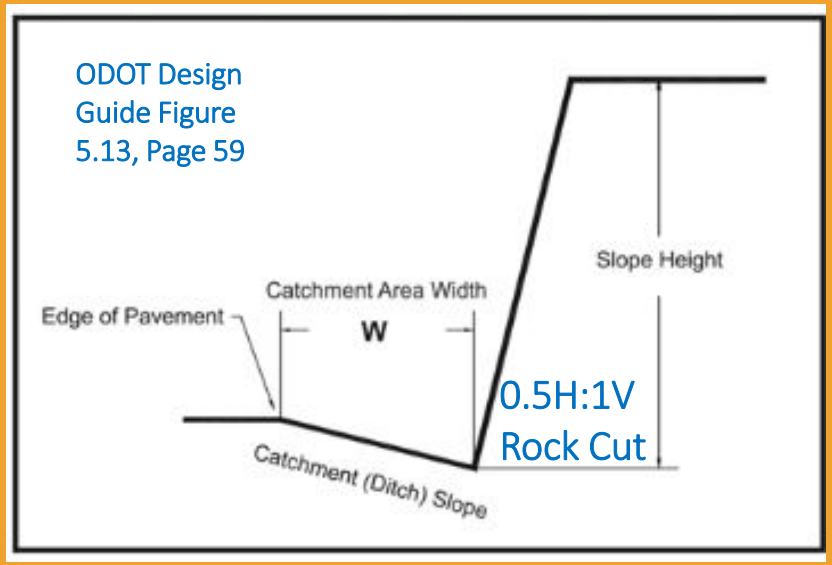
Sizes included 1 ft, 2 ft, & 3 ft diameter.

More than 11,250 Rocks rolled for the study.

ODOT Design Guide Nov 2001



ODOT ROCKFALL CATCHMENT AREA DESIGN GUIDE



The Typical Rock Cut and Ditch in the ODOT Design Guide is different from our Precon Manual by:

1) They use only V-Shaped Ditches.

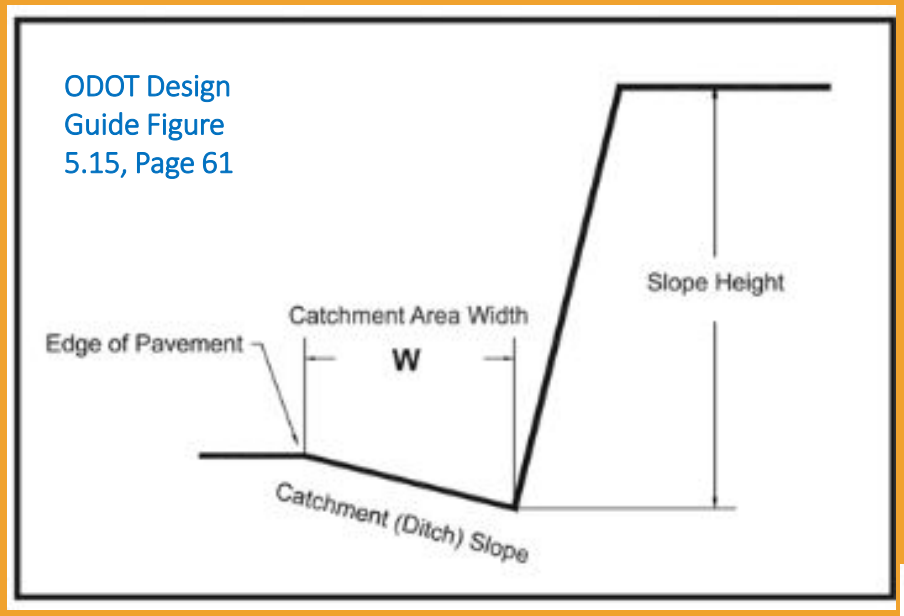
The Ditch width (W) in the Precon Manual indicates a 19 ft ditch for a 60 ft slope.

In the ODOT Design Guide a 60 ft rock cut with a 0.5H:1V slope correlates to only 85% retention.

0.5H:1V Rock Cut — Quick Reference - 60-Ft Slope Catchment Area Width - **W**

Percent Rockfall Retained	Impact	Catchment Area Slope		
		4H:1V	6H:1V	Flat
	W (ft)	**W** (ft)	**W** (ft)	**W** (ft)
50%	6	10	12	22
75%	9	13	16	30
80%	10	14	18	32
85%	10	15	19	36
90%	11	17	21	41
95%	13	19	24	51
99%	15	22	32	66

ODOT ROCKFALL CATCHMENT AREA DESIGN GUIDE



An example:

For a rock cut of 80 ft at a 0.5H:1V slope.

Using our Typical ditch configuration of a 10ft Flat Bottom Ditch with a 4:1 Foreslope. This correlates to a 6H:1V Catchment Area Slope.

Many states use at least 90% retention, some may use a 95% retention. Depends on:

Results of rock fall simulation,

Traffic volumes,

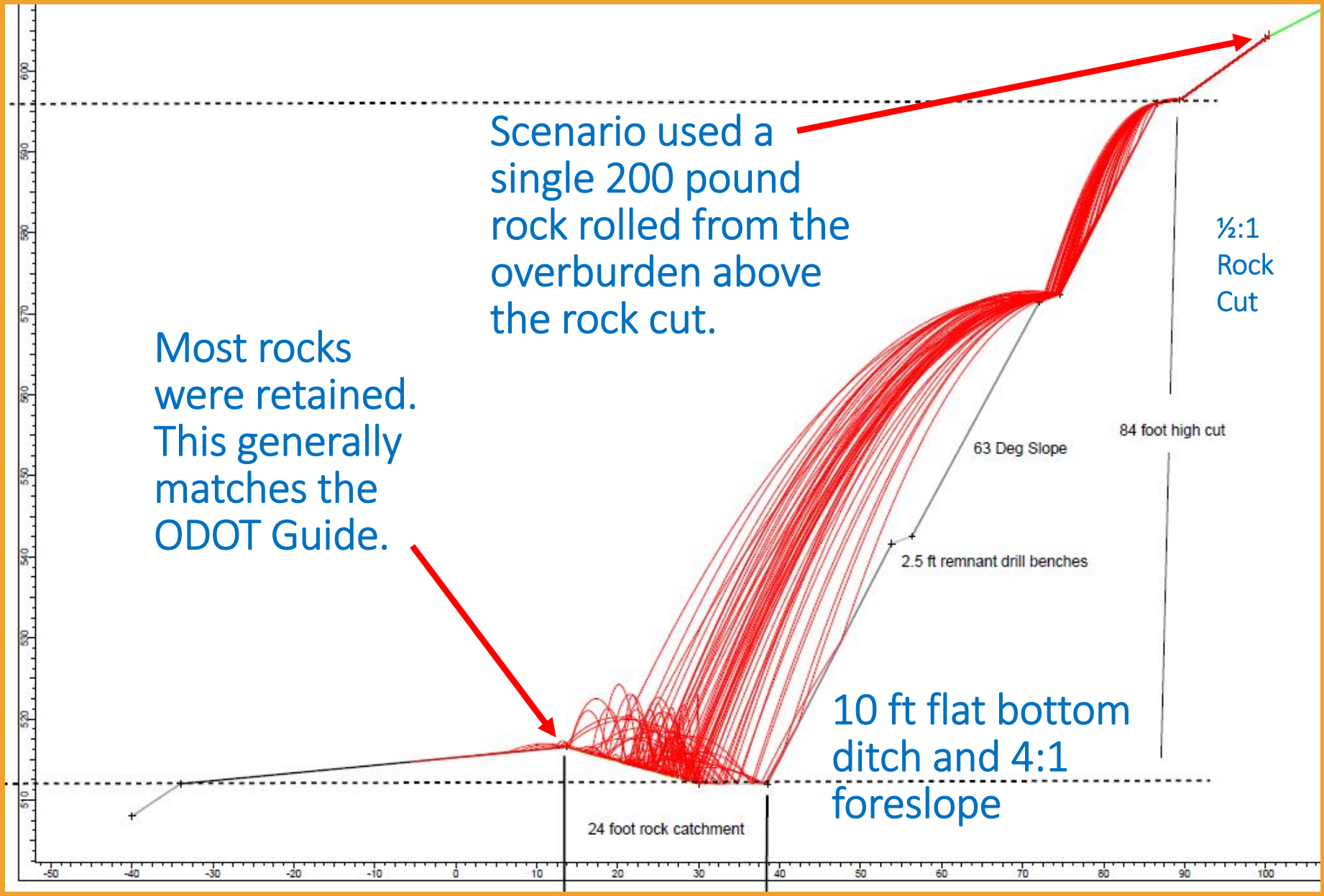
Bedrock Type (expected size and angularity of rocks).

½:1 Rock Cut

Quick Reference - 80-Ft Slope
Catchment Area Width - **W**

Percent Rockfall Retained	Impact	Catchment Area Slope		
		4H:1V	6H:1V	Flat
	W (ft)	**W** (ft)	**W** (ft)	**W** (ft)
50%	7	10	13	23
75%	10	14	17	32
80%	11	16	19	34
85%	12	17	20	38
90%	13	19	23	42
95%	15	22	26	53
99%	19	27	34	68

ROCFALL® SIMULATION SOFTWARE



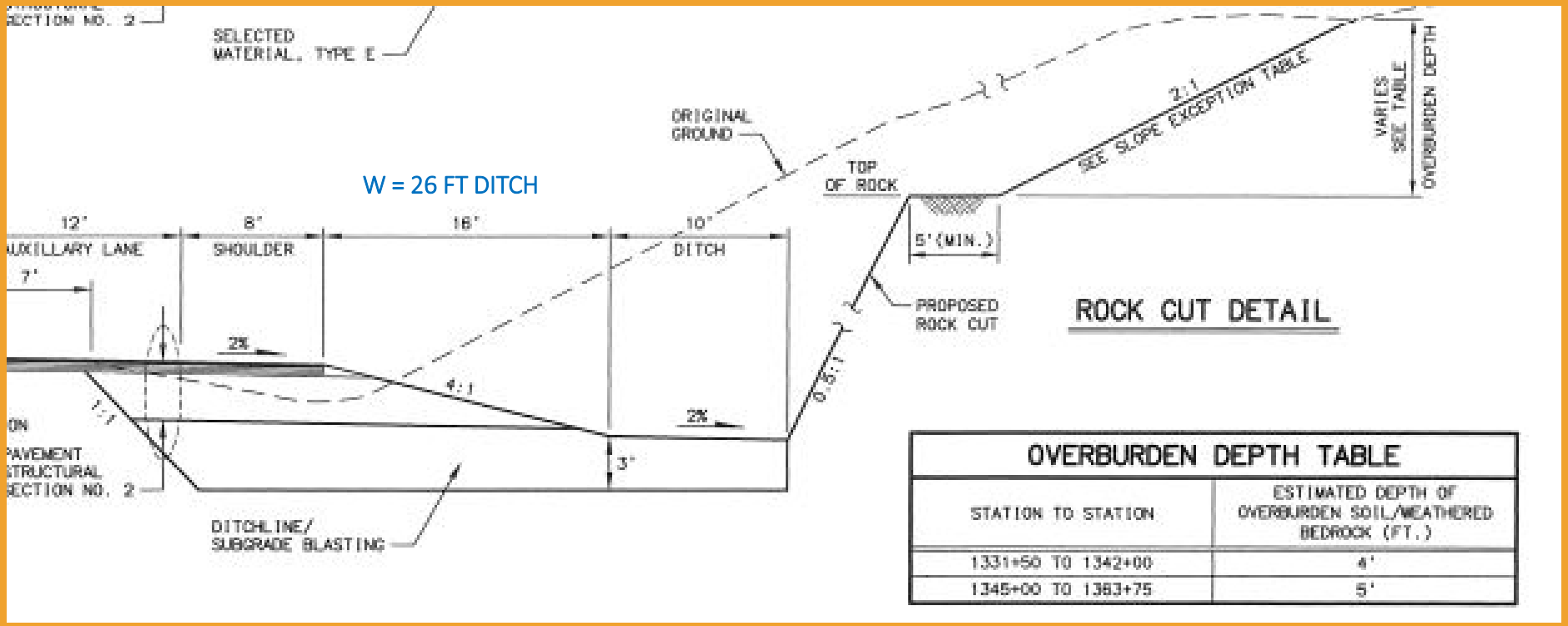
Glenn Hwy MP 109 Caribou Creek.

After designing the rock cut and ditch width we hopefully don't wind up here.

EVALUATION OF USING ALUMINUM IN EMULSION FOR PRE-SPLIT LINES

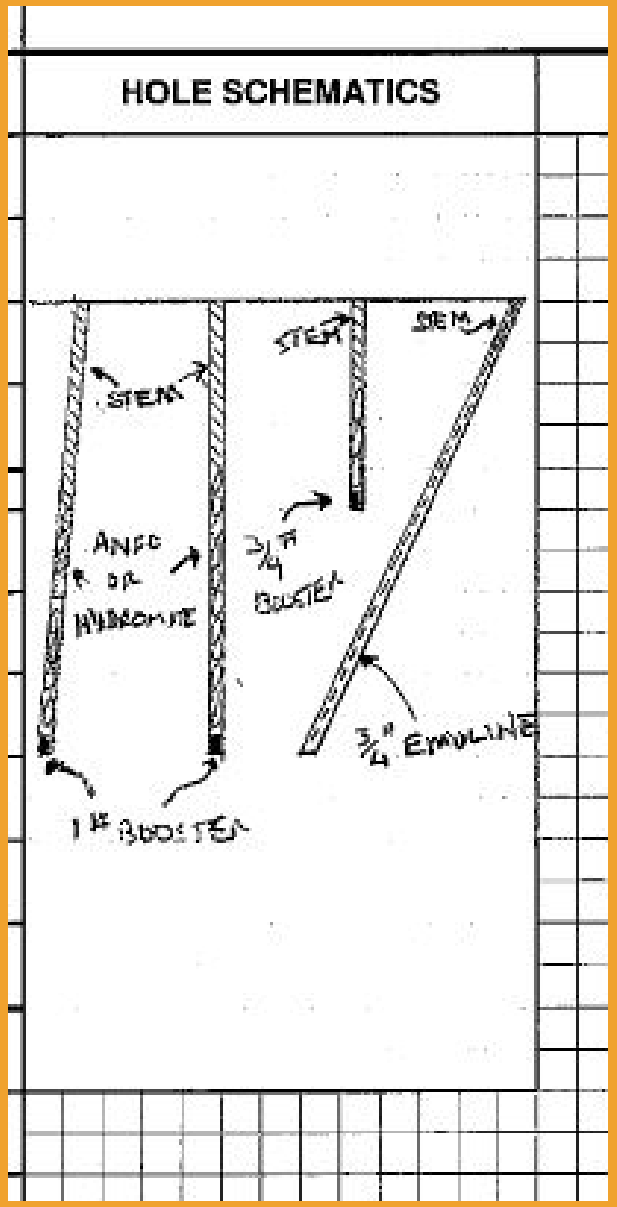
TYPICAL SECTION FOR ROCK CUT

SEW HWY MP 99-100

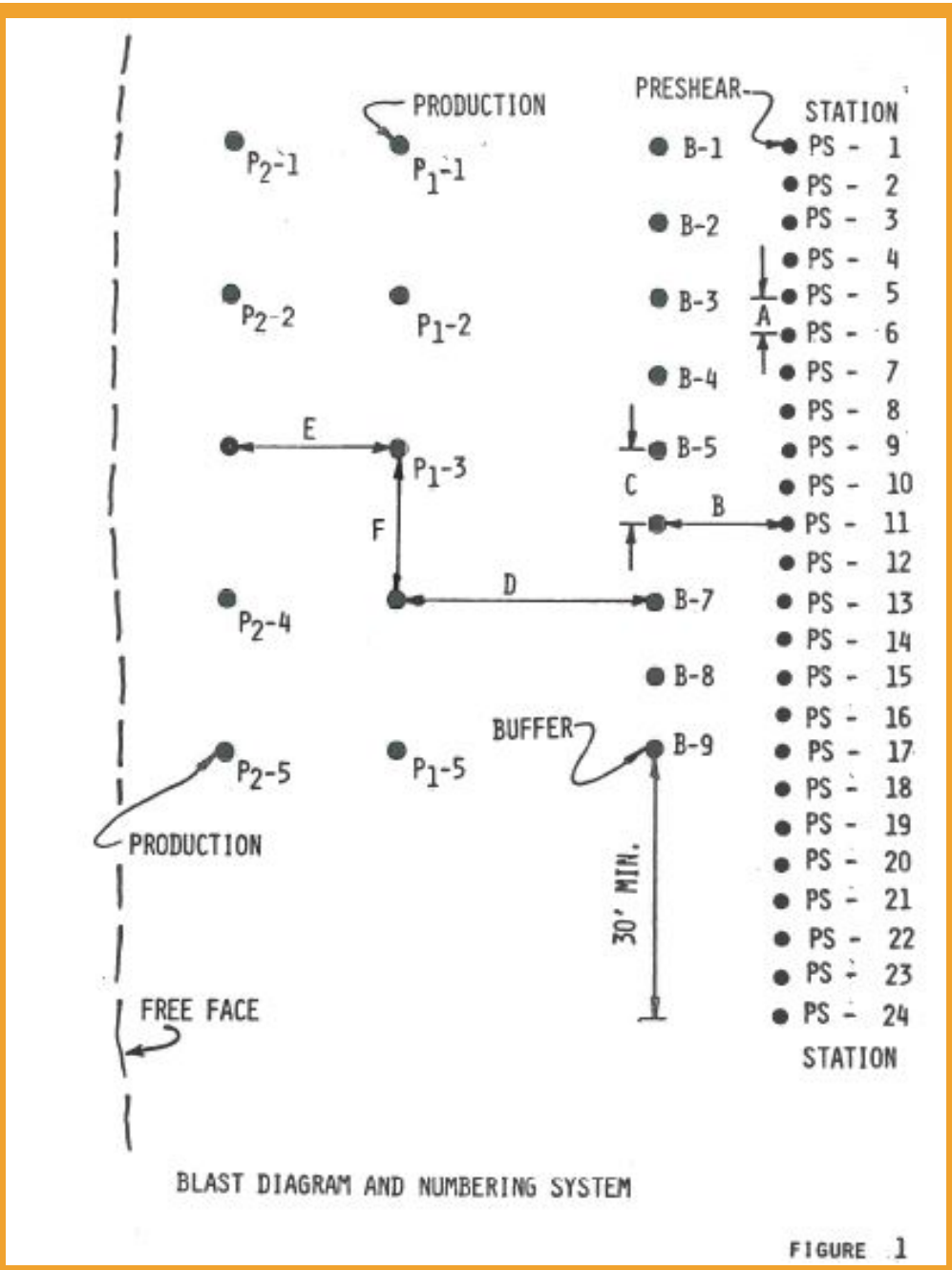


OVERBURDEN DEPTH TABLE	
STATION TO STATION	ESTIMATED DEPTH OF OVERBURDEN SOIL/WEATHERED BEDROCK (FT.)
1331+50 TO 1342+00	4'
1345+00 TO 1383+75	5'

BLASTING PLAN



Part of Granite Blasting Plan:
Sew Hwy MP 99-100

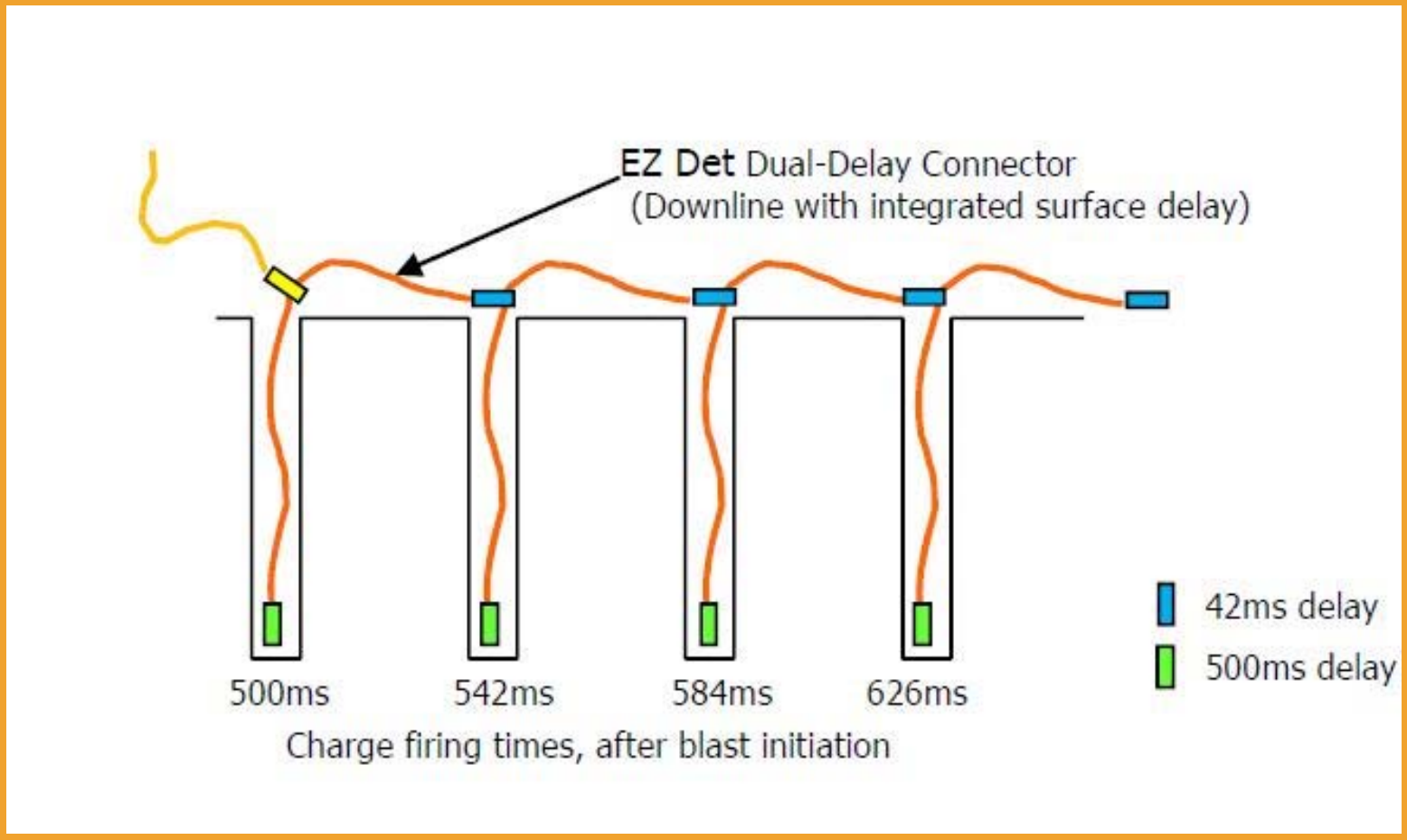


Blasting Plan Schematic:
Rock Blasting Manual, Konya 1985

DRILL FOR PRE-SPLIT


2015/ 7/24

LOADING PRE-SPLIT



Line fires left to right. Long in-hole delays ensure that the much shorter surface delays have time to fire before the ground starts moving.

First is the shock wave, then the gas phase is what actually moves the rock.

SHOT 6 SEWARD HWY MP 99-100

SHOT 6 SEWARD HWY MP 99-100

SHOT 6 SEWARD HWY MP 99-100

Use 2 video cameras, at both ends of the shot

SHOT 6 SEWARD HWY MP 99-100

SHOT 6 SEWARD HWY MP 99-100

COMPLETED ROCK CUT: SEWARD HWY MP 99-100

COMPLETED ROCK CUT: SEWARD HWY MP 99-100

COMPLETED ROCK CUT: SEWARD HWY MP 99-100

COMPLETED ROCK CUT: HICKS CREEK THROUGH-CUT

COMPLETED ROCK CUT: HICKS CREEK THROUGH-CUT

COMPLETED ROCK CUT: STERLING HIGHWAY MP 37-45

COMPLETED ROCK CUT: STERLING HIGHWAY MP 37-45

COMPLETED ROCK CUT: BIRD PARKING LOT

COMPLETED ROCK CUT: BIRD PARKING LOT

COMPLETED ROCK CUT: BIRD PARKING LOT

WHY IS THERE PERSISTENT STAINING AT THE PRE-SHEAR LINE FOR SITES:

- STERLING HWY MP 37-45
- HICKS CREEK THROUGH-CUT
- BIRD PARKING LOT

&

WHY IS THE SAME PERSISTENT STAINING ABSENT AT SEWARD HWY MP 99-100 PROJECT?

BLASTING PLAN REVIEW

STERLING HWY MP 37-45 (1999):

- Used Dyno-Split C® - 7/8” continuous emulsion.
- 0-10% Aluminum.

BIRD PARKING LOT (2003):

- Used Iresplit D® - 7/8” continuous emulsion.
- 0-6% Aluminum

HICKS CREEK THROUGH-CUT (2007):

- Used Dynosplit E® - 7/8” contiuous emulsion.
- 0-5% Aluminum

SEWARD HWY MP 99-100 (2015):

- Used Emuline® - 3/4” continuous emulsion.
- No Aluminum

WHY ALUMINUM?

Aluminum has been used in explosives for a while. It has several benefits:

- Improves rock fragmentation and displacement and reduces the amount of explosives required (1).
- Improves overall efficiency (2). Especially when trying to counteract the presence of water in the blast holes.
- It increases the energy of the explosive(2).
- Increases the explosive temperature(2).
- Increases the intensity of the shock wave(2).

References:

1) Blaster's Handbook 175th Edition©. 1977.
2) Dambov R., Nikolic M., Dambov, I., Cacarov V., June 2013

CONCLUSIONS – AESTHETIC CONCERNS:

- Pre-Shear blasting is an essential part of blasting safe slopes next to highway systems.
- Avoid allowing aluminum in the emulsion for the pre-split line if you don't want stained half casts. However natural minerals in the rock can also cause staining, although less persistent.
- FHWA is trying to make rock faces look more natural by blasting a few feet from the designed back wall and trying to rip the rock to the designed back wall (I'm not sure about this).
- Non-benched slopes is the standard design method for highway slopes. But benching can be done if a wide enough ditch is designed at the base of the slope to ensure rock fall doesn't reach the road (adds cost to rock excavation).
- Other efforts are being done to provide more natural looking slopes such as anchored wire mesh contoured to fit the slope, making it less visible (during rock fall mitigation work).

QUESTIONS ?