Unknown Foundation Testing and Emergency Repairs for the Lake Cushman Bridge

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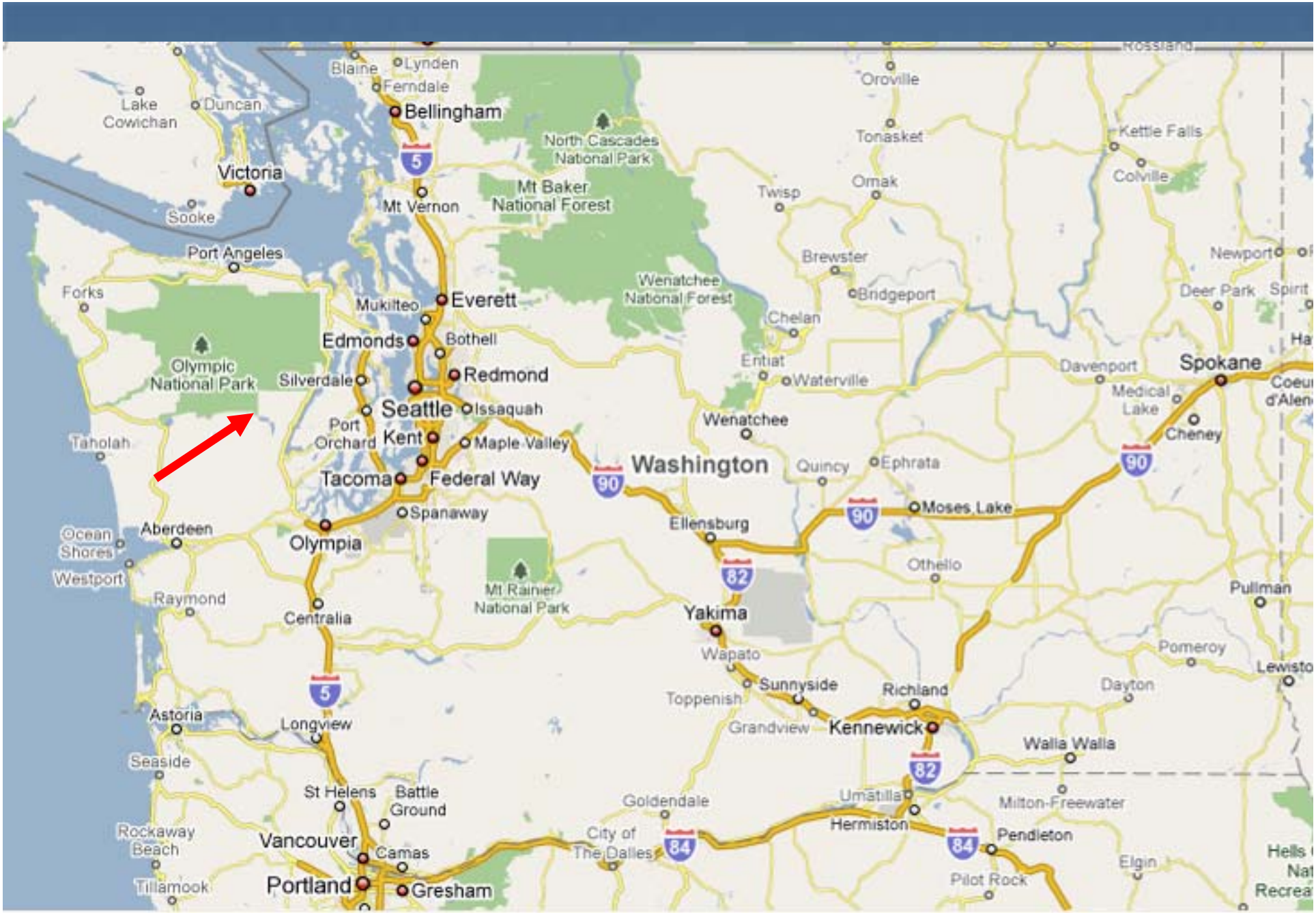
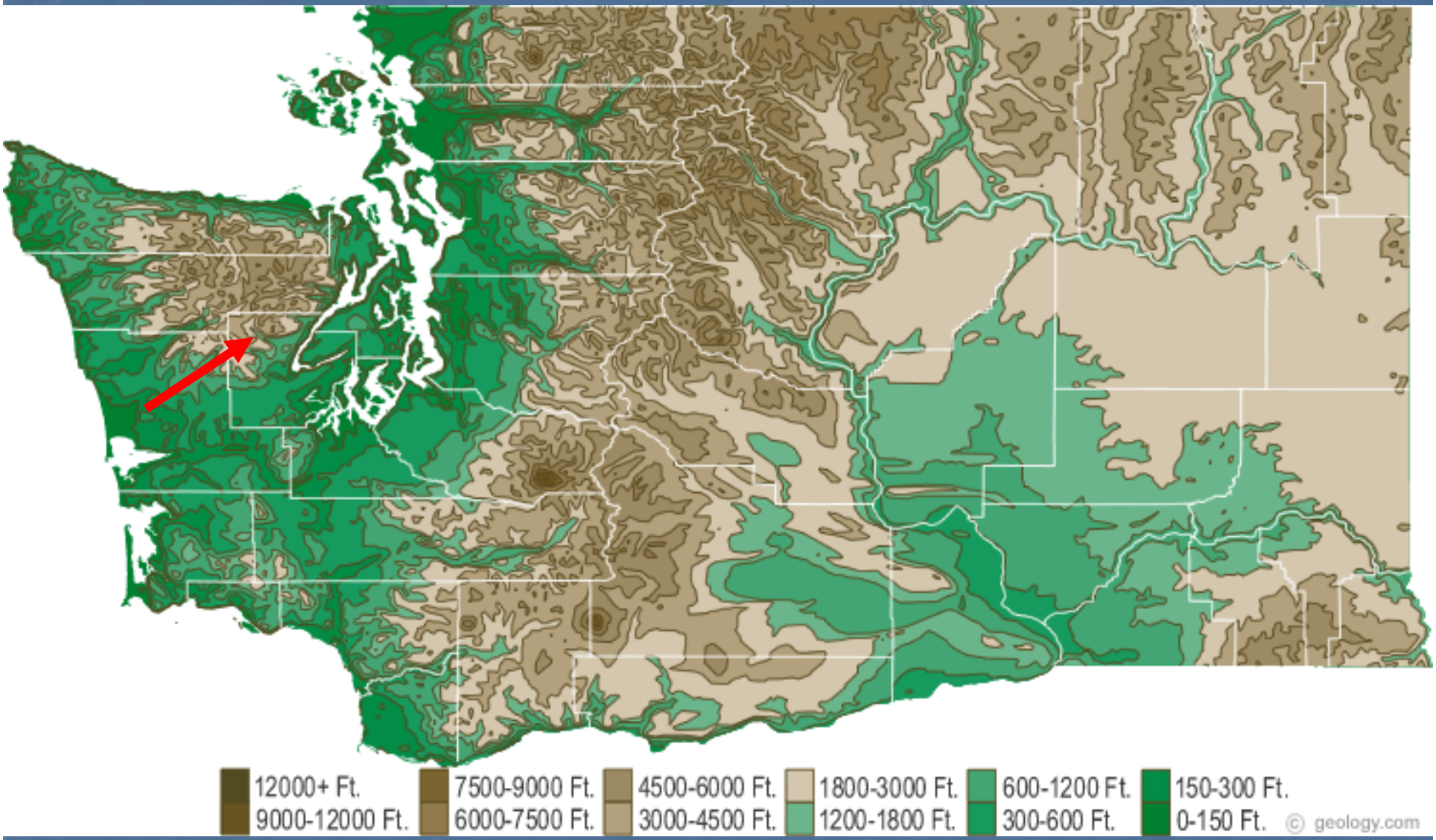
Dan Stromberg, Collins Engineers

History & Background

- Original structure designed and constructed by Bureau of Public Roads, in 1958.
- Built as part of the causeway across Lake Cushman, Olympic Peninsula, Washington State
- Lake Cushman is a reservoir built for power generation by Puget Sound Power; formed by damming the N. Fk. Skokomish River
- Bridge is on National Forest land abutting Olympic National Park


Blaine
Lynden
Ferndale
Bellingham
Lake Cowichan
Duncan
Victoria
Sooke
Port Angeles
Forks
Mt Vernon
North Cascades National Park
Mt Baker National Forest
Oroville
Tonasket
Kettle Falls
Colville
Twisp
Omak
Brewster
Bridgeport
Wenatchee National Forest
Chelan
Entiat
Waterville
Wenatchee
Mukilteo
Everett
Edmonds
Bothell
Redmond
Silverdale
Seattle
Issaquah
Port Orchard
Kent
Maple Valley
Federal Way
Tacoma
Spanaway
Olympic National Park
Taholah
Ocean Shores
Westport
Aberdeen
Olympia
Raymond
Centralia
Mt Rainier National Park
Washington
Quincy
Ephrata
Moses Lake
Ellensburg
Othello
Yakima
Wapato
Toppenish
Sunnyside
Grandview
Richland
Kennewick
Pasco
Walla Walla
Umatilla
Hermiston
Pendleton
Pilot Rock
Milton-Freewater
Goldendale
City of The Dalles
Dayton
Pomeroy
Pullman
Lewiston
Elgin
Davenport
Spokane
Medical Lake
Cheney
Coeur d'Alene
Newport
Deer Park
Spirit
Astoria
Longview
Seaside
St Helens
Battle Ground
Vancouver
Camas
Portland
Gresham
Rockaway Beach
Tillamook
5
90
82
84


12000+ Ft.
9000-12000 Ft.
7500-9000 Ft.
6000-7500 Ft.
4500-6000 Ft.
3000-4500 Ft.
1800-3000 Ft.
1200-1800 Ft.
600-1200 Ft.
300-600 Ft.
150-300 Ft.
0-150 Ft.
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Lake Cushman

Lake Cushman is a 4,010 acre (16 km²) lake on the north fork of the Skokomish River in Mason County, Washington. The lake is maintained by Cushman Dam No. 1 providing electrical power to the Tacoma Power system. Though slightly colder than out-of-state lakes, Lake Cushman's temperature is relatively normal for Washington lakes. It is fed by the Skokomish River which is a glacial runoff river.
View article on wikipedia.org

By Juha.K

Photos





More photos

Sponsored Links

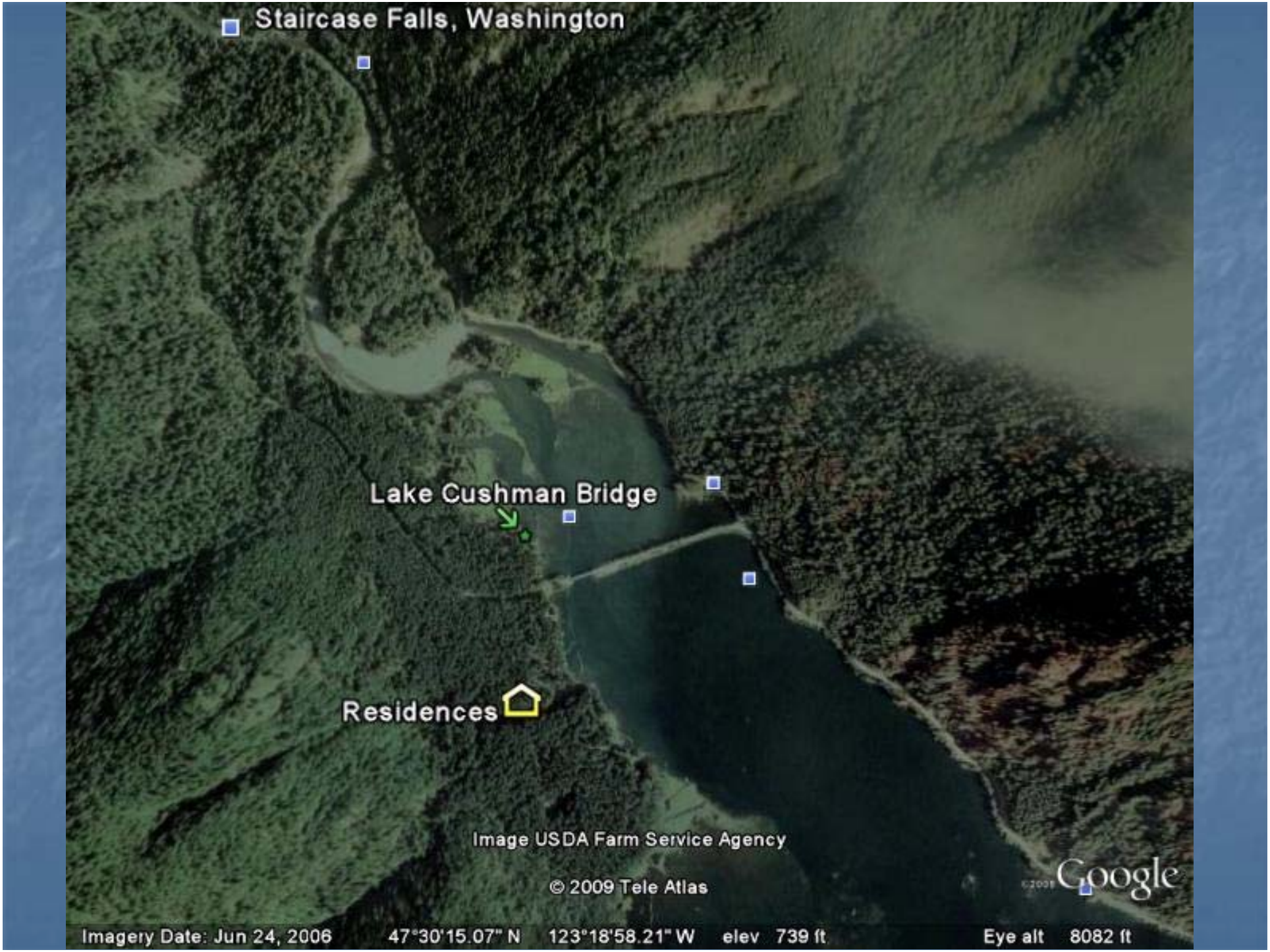
Lake Sinclair Real Estate - www.cblakesinclair.com - View All Lake Sinclair Property Lake Homes, Condos, and Town Homes

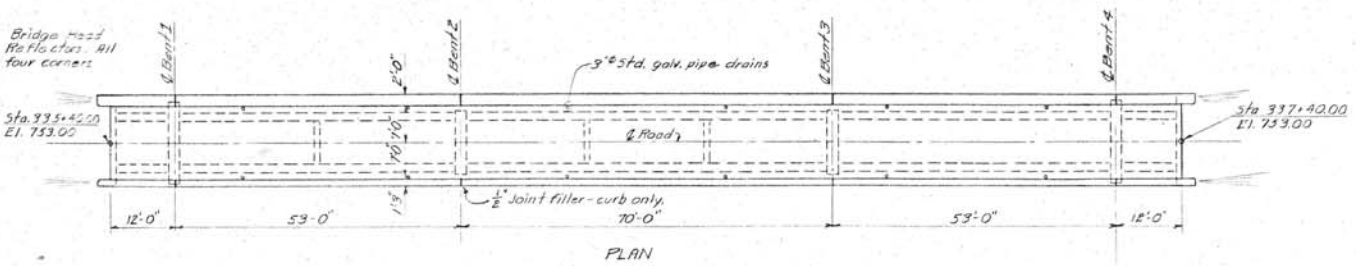
Premier Lake Homes - www.reserveatlakekeowee.com - The Reserve at Lake Keowee. Plan your visit. Packages from $145.

User-created content

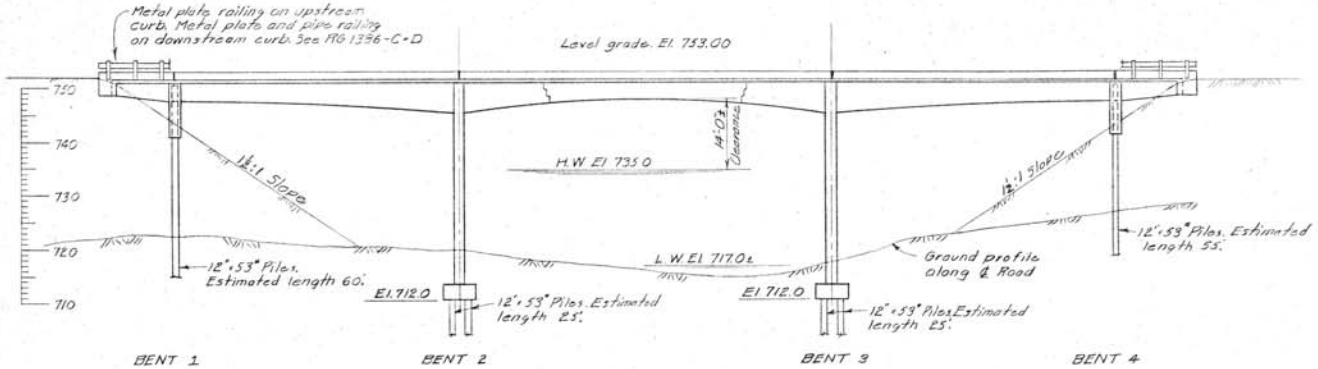
Washington Campsites (trip planning) - Lake Cushman State Park
Travels - Lake Cushman
The Pacific Northwest - Lake Cushman
Seattle Area - Lake Cushman (View)
Places - Lake Cushman


Olympic National Park
Lake Cushman Bridge
Residences
Lake Cushman Resort
Image USDA Farm Service Agency
Image © 2009 DigitalGlobe
© 2009 Tele Atlas
Imagery Date: Jun 24, 2006
47°28'31.94" N
123°17'51.40" W
elev 2341 ft
Eye alt 46458 ft

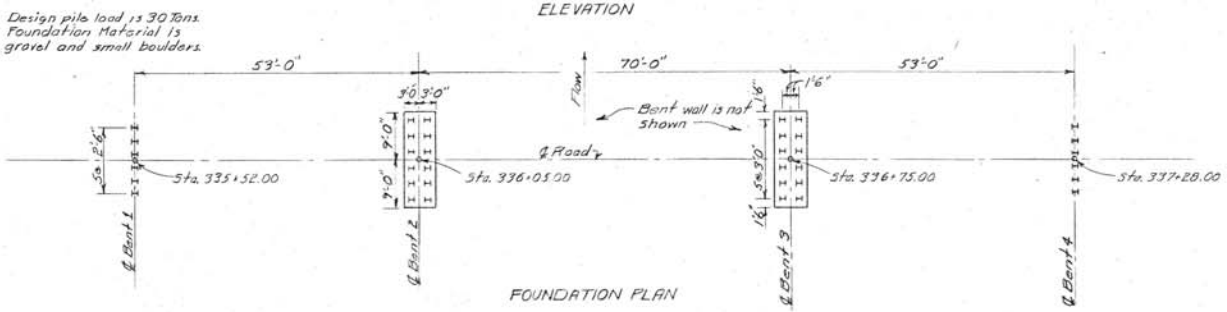

Staircase Falls, Washington
Lake Cushman Bridge
Residences
Image USDA Farm Service Agency
© 2009 Tele Atlas
Google
Imagery Date: Jun 24, 2006
47°30'15.07" N
123°18'58.21" W
elev 739 ft
Eye alt 8082 ft



PLAN



ELEVATION



FOUNDATION PLAN

GENERAL NOTES

SPECIFICATIONS: Construction, Bureau of Public Roads F.P.57. Design, A.A.S.H.O. Standard Specifications for Highway Bridges 1953.

DEAD LOAD: Concrete 150 Lbs. per cu.ft. paving allowance 25 Lbs. per sq.ft. of roadway surface.

LIVE LOAD: H30-524-44 Loading. Impact $I = \frac{50}{L+125}$ (L = span length). Maximum I = 30%.

UNIT STRESSES: f_c = 1320 p.s.i. f_s = 20,000 p.s.i. n = 10

CONCRETE: All concrete shall be Class "A". Maximum size of coarse aggregate shall be 1½". All concrete shall be mixed with Type II Portland Cement (low alkali) and with an air entraining admixture. All concrete shall be vibrated. All exposed corners shall be chamfered ¾" unless otherwise noted.

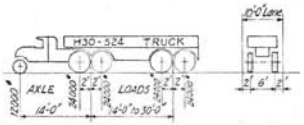
FINISHING CONCRETE: Roadway slab and curbs shall be finished according to specifications. The outside faces of the slab and curbs shall be given a "rubbed finish". All other surfaces shall be given an "ordinary finish".

REINFORCEMENT STEEL: All bars shall be deformed intermediate grade steel conforming to A.S.T.M. Specification A15-54T. All bars in the slab shall be supported on "metal chairs" or an approved type of concrete saddle. Except as shown all dimensions refer to center of bars.

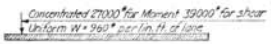
STEEL BRIDGE RAILING: All items of rail construction are included in the contract item for "Steel Bridge Railing" and include the metal plate rail, metal pipe rail and couplings, steel posts and all rail and post securing bolts, nuts, washers and shims. All items of steel rail construction shall be galvanized. The pay length for the steel bridge railing shall be measured out to out of end wings.

STRUCTURAL STEEL PILES: All piles are steel "H" bearing piles.

BRIDGE HEAD REFLECTORS: Will be furnished by the Bureau of Public Roads. Cost of installation on end wings of railing shall be included in the contract item for "Steel Bridge Railing."



H30-524 TRUCK DIAGRAM



H30-524 LANE LOADING

ESTIMATE

Structure Excavation	100 Cu.yds.
Class "A" Concrete	308 Cu.yds.
Reinforcement Steel	62,000 Lbs.
Miscellaneous Steel	5,500 Lbs.
Structural Steel Piles, Furnishing	1,300 Lin.ft.
Structural Steel Piles, Driving	36 Each
Steel Bridge Railing	410 Lin.ft.

DEPARTMENT OF COMMERCE
BUREAU OF PUBLIC ROADS — SAN FRANCISCO, CALIFORNIA

LAKE CUSHMAN BRIDGE

STATION 336+40

WASHINGTON FOREST DEVELOPMENT ROAD PROJECT

OLYMPIC 245-B

APPROVED: H. R. Cuneo
SUPERVISING BRIDGE ENGINEER

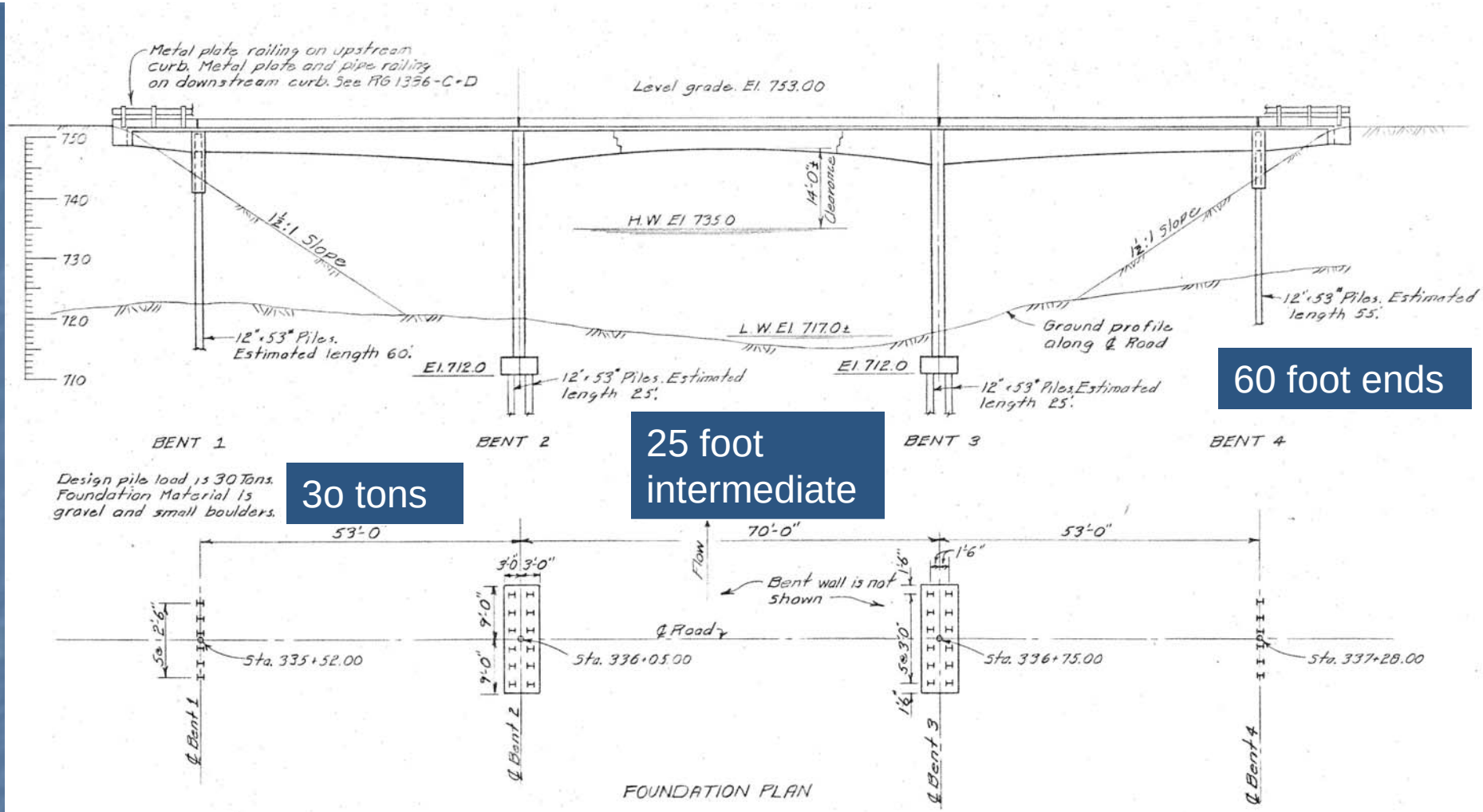
SCALE: 3/32" = 1'-0"

#2357-0.1

NOVEMBER 1957

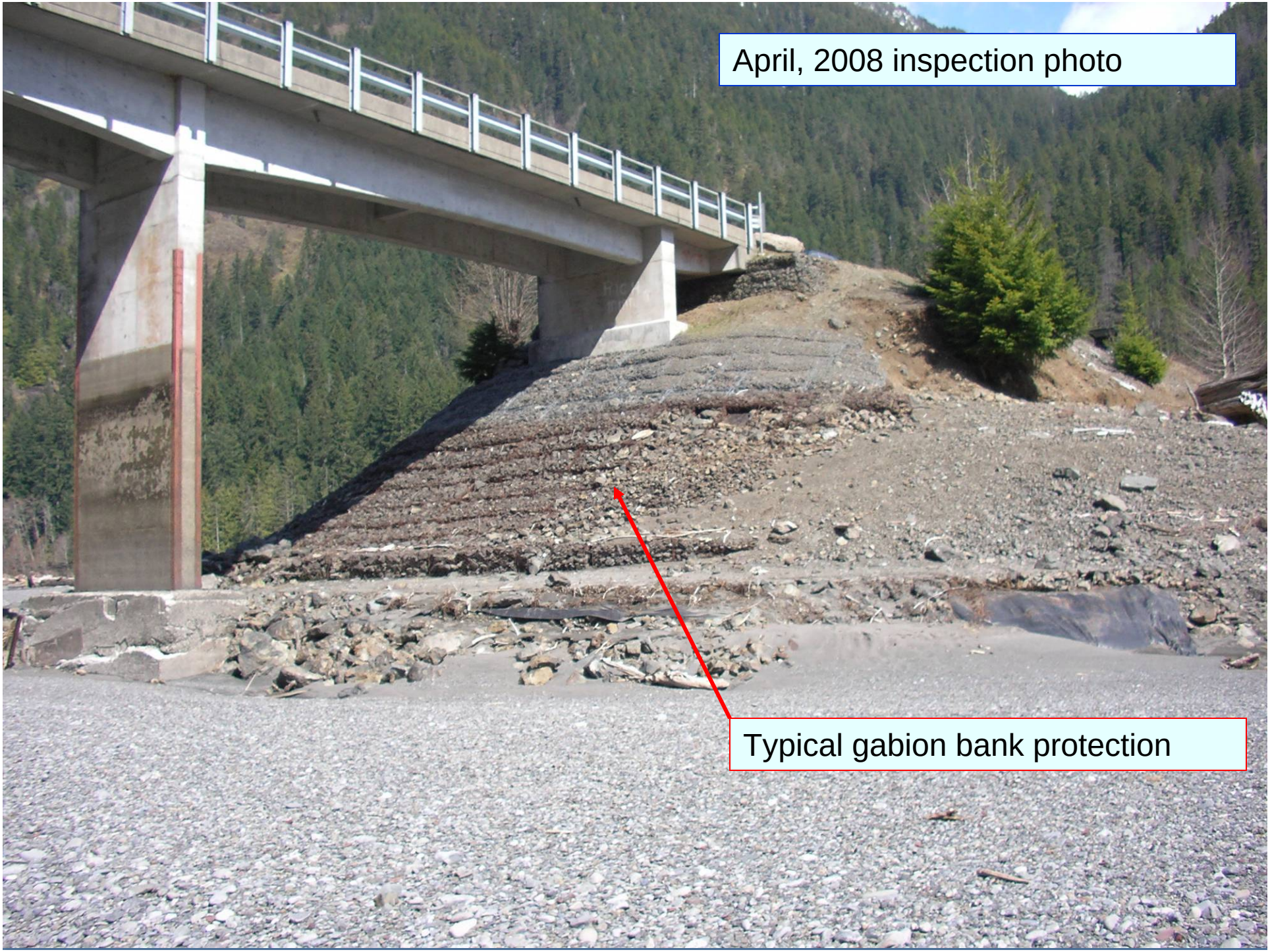
SHEET 1 OF 4 SHEETS

RG1386-A


Metal plate railing on upstream curb. Metal plate and pipe railing on downstream curb. See RG 1336-C-D
Level grade. El. 753.00
750
740
730
720
710
1½:1 Slope
H.W. El 735.0
14'-0" Clearance
1½:1 Slope
12"x53" Piles. Estimated length 60'.
L.W. El. 717.0±
Ground profile along ℄ Road
12"x53" Piles. Estimated length 55'.
El. 712.0
12"x53" Piles. Estimated length 25'.
El. 712.0
12"x53" Piles. Estimated length 25'.
BENT 1
BENT 2
BENT 3
BENT 4
60 foot ends
25 foot intermediate
3o tons
Design pile load is 30 Tons. Foundation Material is gravel and small boulders.
53'-0"
70'-0"
53'-0"
3'0" 3'-0"
Flow
1'6"
Bent wall is not shown
9'-0"
9'-0"
℄ Road
Sta. 335+52.00
Sta. 336+05.00
Sta. 336+75.00
Sta. 337+28.00
℄ Bent 1
℄ Bent 2
℄ Bent 3
℄ Bent 4
FOUNDATION PLAN


October, 2002 photo


November, 2002 inspection photo


April, 2008 inspection photo
Typical gabion bank protection

Scour Issues

- Developed from time of construction
  - Lateral Migration scour
  - Contraction scour
  - Local scour (debris)
  - Wave action
- Many attempts to study and mitigate

Historic Scour Mitigation

- 1968 – large riprap placed
- 1976 – gabion mats on lower fills and around piers (piles exposed again in 1977)
- 1981 – extensive gabion mats on fills and around piers (successful until 2007)
- Evaluated in 1981 by Hydraulic consultant
  - Encasement of piles 6 – 10 feet below existing
  - Extensive riprap and gabions
  - Recommended extensive check dam (this would mean no fishies could swim upstream!)

➔1986+ MONITORING

Underwater Inspections

- October, 2002
- March, 2006 (In conjunction with FHWA to develop an Underwater Inspection Training Video)
- Both inspections performed by Collins Engineers, Inc.

December 3, 2007

- Stream Gage 1.2 miles upstream from bridge
- Logged discharge at 20,100 cfs which exceeds a 50-year flood
- Largest flow since construction of the bridge (1934 – 27,000; 1949 – 24,200)
- Highest flows occur in Nov/Dec—after reservoir has been lowered

Re-establish Access

- Restoring access was politically charged:
  - 23 landowners with access rights (boat or road?)
  - FERC re-licensing of dam
- Forest service – land, trailhead, safety, decommissioning, fire management, administration (but maybe not?)
- Short-term vs long-term
  - Factors of safety
- Funding - ERFO

Evaluation Challenges

- No drill logs at bridge itself
- No as-builts
- Pay item for piles from original construction contract increased 144% (longer piles, more piles, driving costs?)
- Center pier vs. end pier
- No deficiencies despite previous scour and significant overloads

Evaluation Opportunities

- Baseline inspection of existing bridge (post flood damage)
- Documentation of post-construction changes to structure
- Underwater inspection
- In-place testing of existing piles to determine as-built lengths
- Drilling of site (pending)

Specialized Inspection/Evaluation through Collins Engineers, Inc.

- Underwater inspection and condition assessment of piles through diving.
- Above water inspection and condition assessment of piles through climbing and/or ladder access
- Determination of in-place pile lengths for both submerged piles and piles that are above water. (Muenow and Associates as subcontractor)
- Specialized access (high ladder) to gather as-built dimensions
- Specialized non-destructive testing to determine the location of steel components embedded in concrete.
- Assessment and reporting

Underwater inspection and condition assessment of piles through diving.

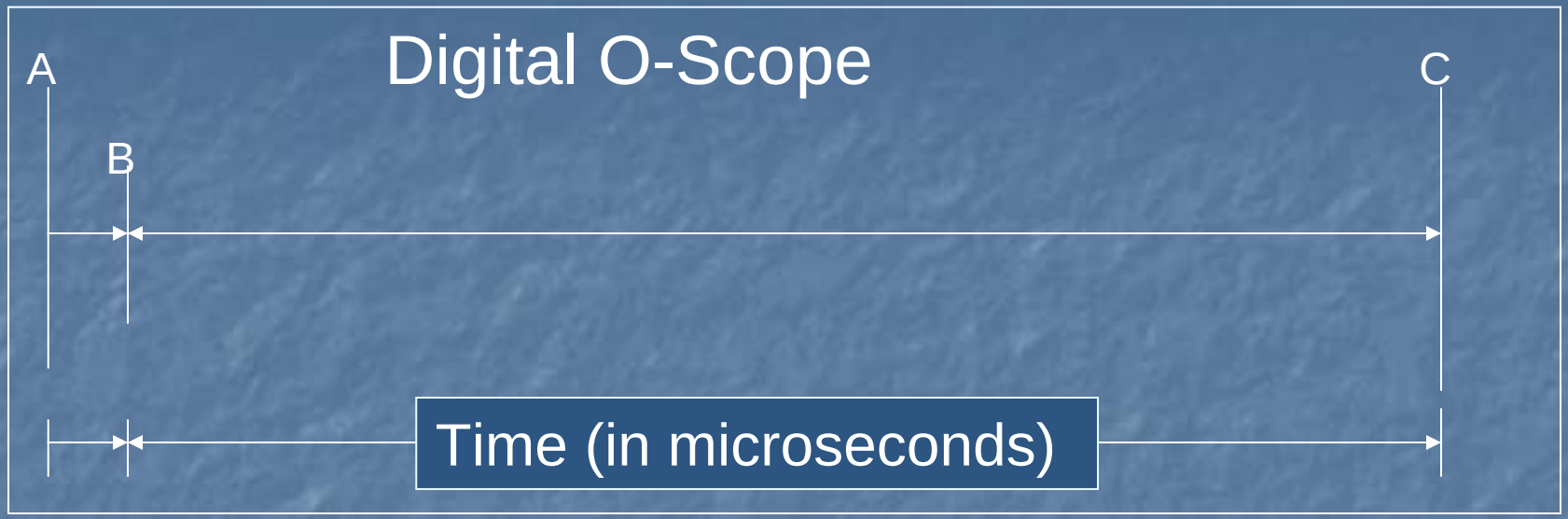
Above water inspection and condition assessment of piles through climbing and/or ladder access

Determination of in-place pile lengths for both submerged piles and piles that are above water.

In-place Pile Length Determination

- Based on sound wave theory – “Pulse Echo Test” – inducer/receiver
- Measures length of a feature until a discontinuity that exceeds 50% of the cross-sectional area is encountered
- The end of a pile would be read as a discontinuity.

MUENOW and ASSOCIATES, Inc.



Graphic of Reflected Energy on O-Scope

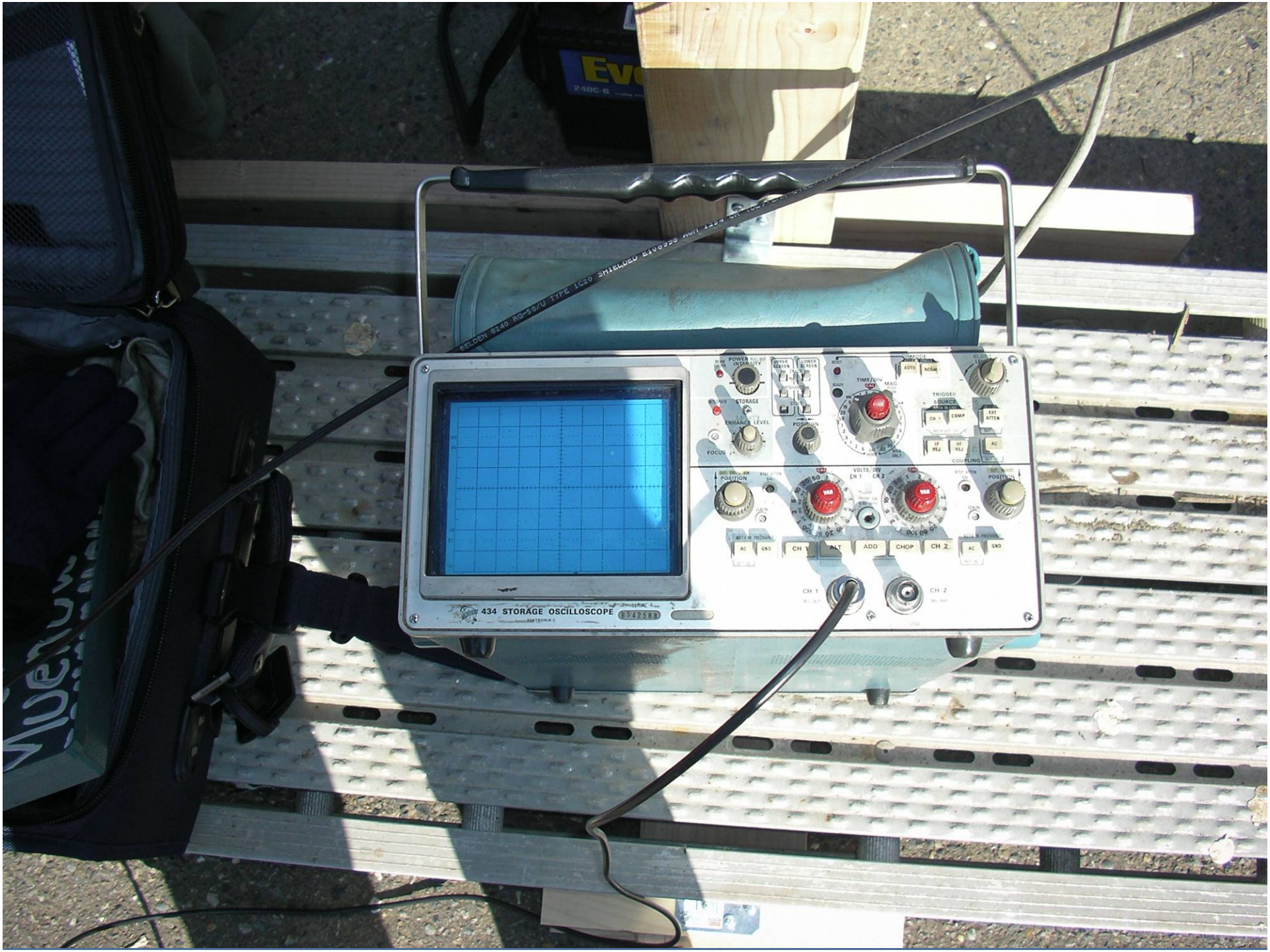
A. Initial Impact…Starts Timing Sweep

B. Reflection…Top of Pile or in cap

C. Reflection…Bottom of Pile or
Reflection from discontinuity

Length of Pile is B to C: Time/2


Long cable


434 STORAGE OSCILLOSCOPE
B542588
CH 1
ALT
ADD
CHOP
CH 2
AC
GND
TRIGGER
SOURCE
STORAGE
ENHANCE LEVEL
FOCUS
POSITION
TIME/DIV
VOLTS/DIV
COUPLING

Gather as-built dimensions and perform non-destructive testing to determine the location of steel components embedded in concrete.


PENN HI
RULZ
PENN HIGH
RULZ

Assessment and Report

- Results of pile lengths translated to structural capacity of entire bridge
- Results of modifications regarding improved overall stability/bracing from deeper caps
- Evaluation of slope stability for support of a load
- Work within small factor of safety (FS=1.4) with load restrictions (HS15) and site management

Short-term Access Solution

- “Bridge” the gap
- Used reduced factors of safety
  - (minimum criteria but checked against historic overloads and conditions)
- Mitigation/management of site
  - Control loads by gate access
  - Annual inspection
  - Post-flood inspection
  - Short-term = 5 years!


CASE

Summary

- Foundation constraints for emergency access to establish minimum design criteria (working with what you have to move ahead)
- Multiple in-depth inspection techniques
  - Value within one firm → One stop “shopping”
  - Availability of technology
- It doesn’t have to look great...it just needs to do the job SAFELY!
- A long-term solution is still in planning. All data will be used in looking at alternatives.
- Documentation, documentation, documentation!

Costs

- Inspection Contract - $24,700
- Bridge Supply and Installation
  - Supply - $93,685
  - Installation - $28,455
- Being able to get to your cabin again:
  - PRICELESS?