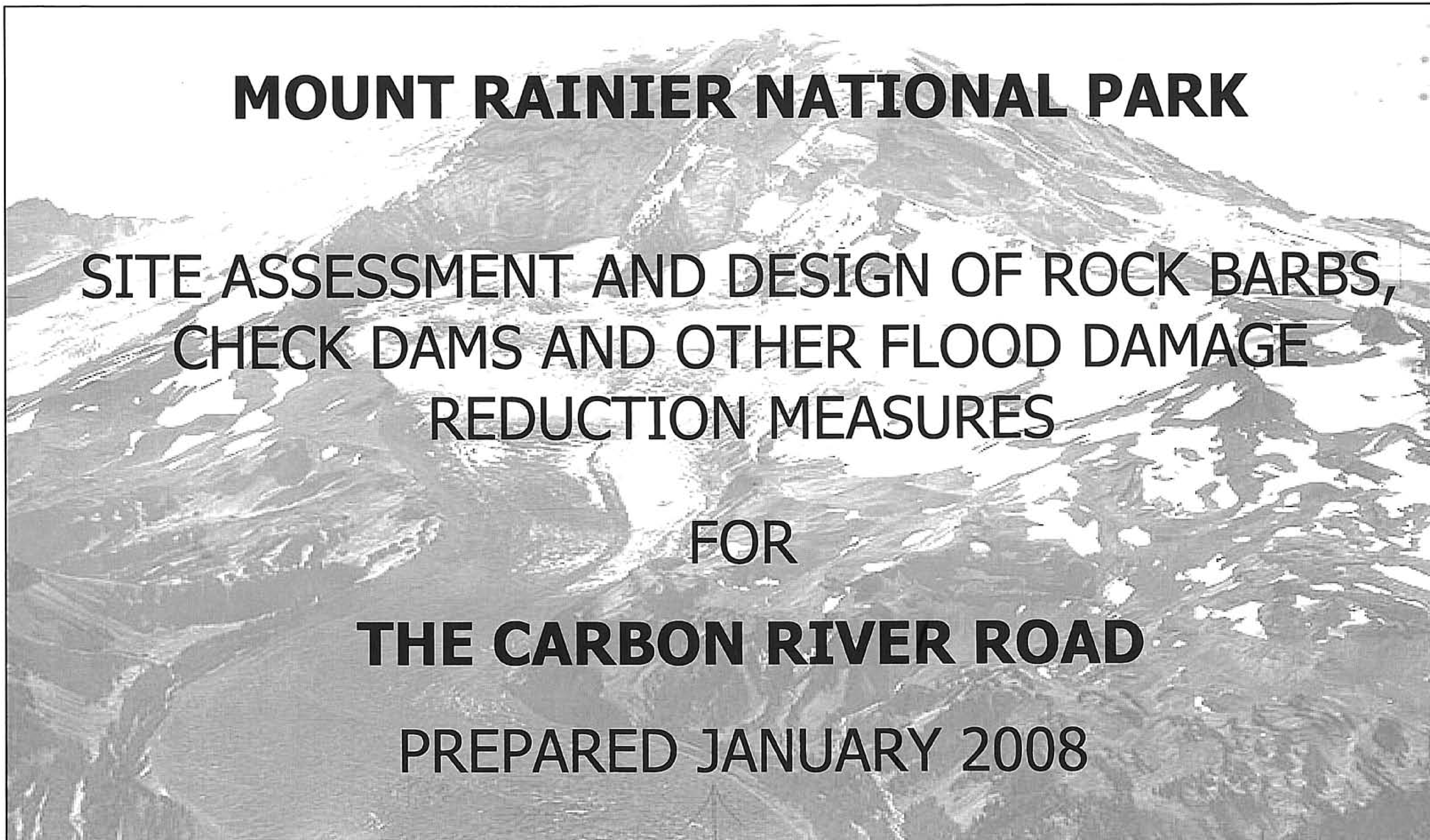
Appendix 3: Geomax: Site Assessment and Design of Rock Barbs, Check Dams and Other Flood Damage Reduction Measures for Carbon River Road (January 2008) (detached)

This detachment is available on the park's website located at http://www.nps.gov/mora and on the Planning, Environment and Public Comment (PEPC) website located at http://parkplanning.nps.gov/mora.



MOUNT RAINIER NATIONAL PARK

SITE ASSESSMENT AND DESIGN OF ROCK BARBS, CHECK DAMS AND OTHER FLOOD DAMAGE REDUCTION MEASURES

FOR

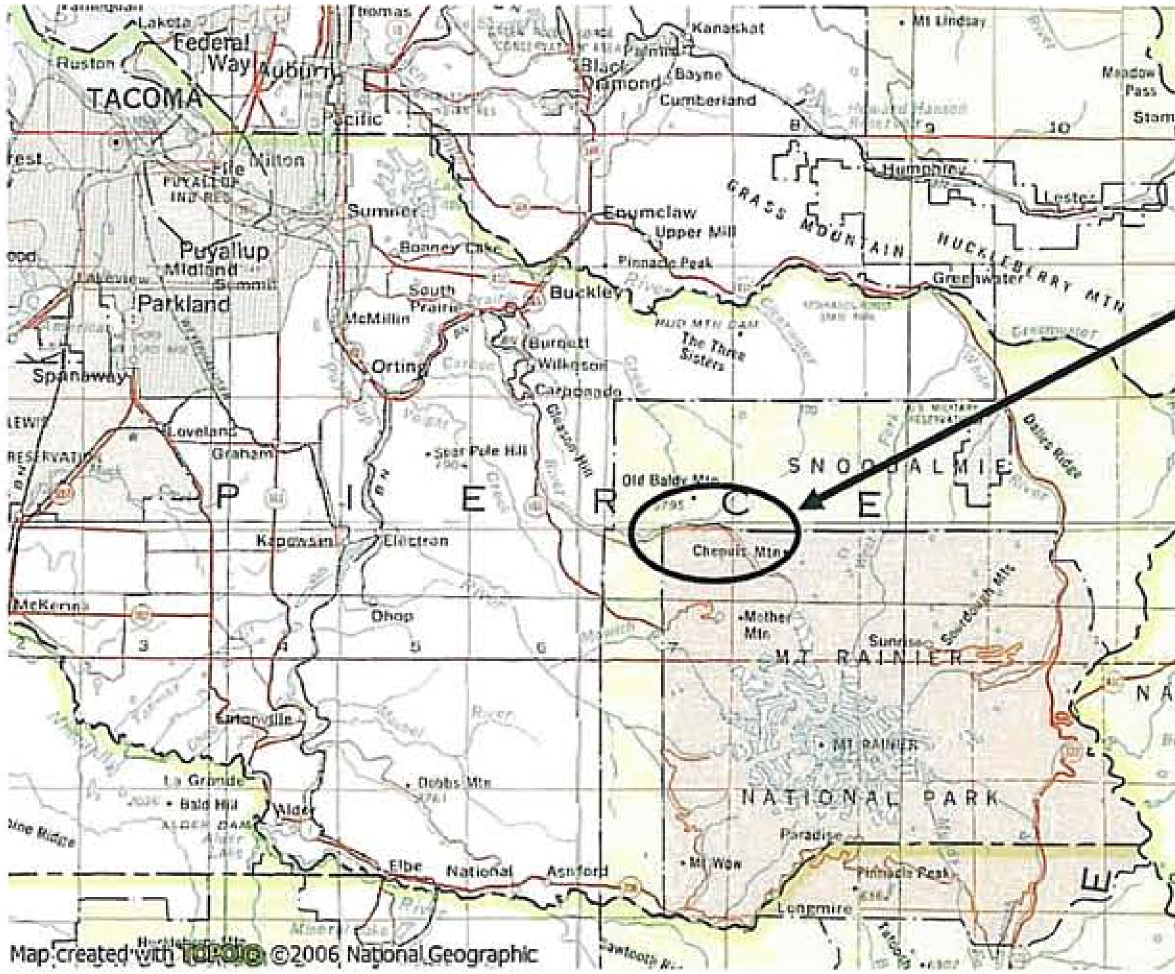
THE CARBON RIVER ROAD

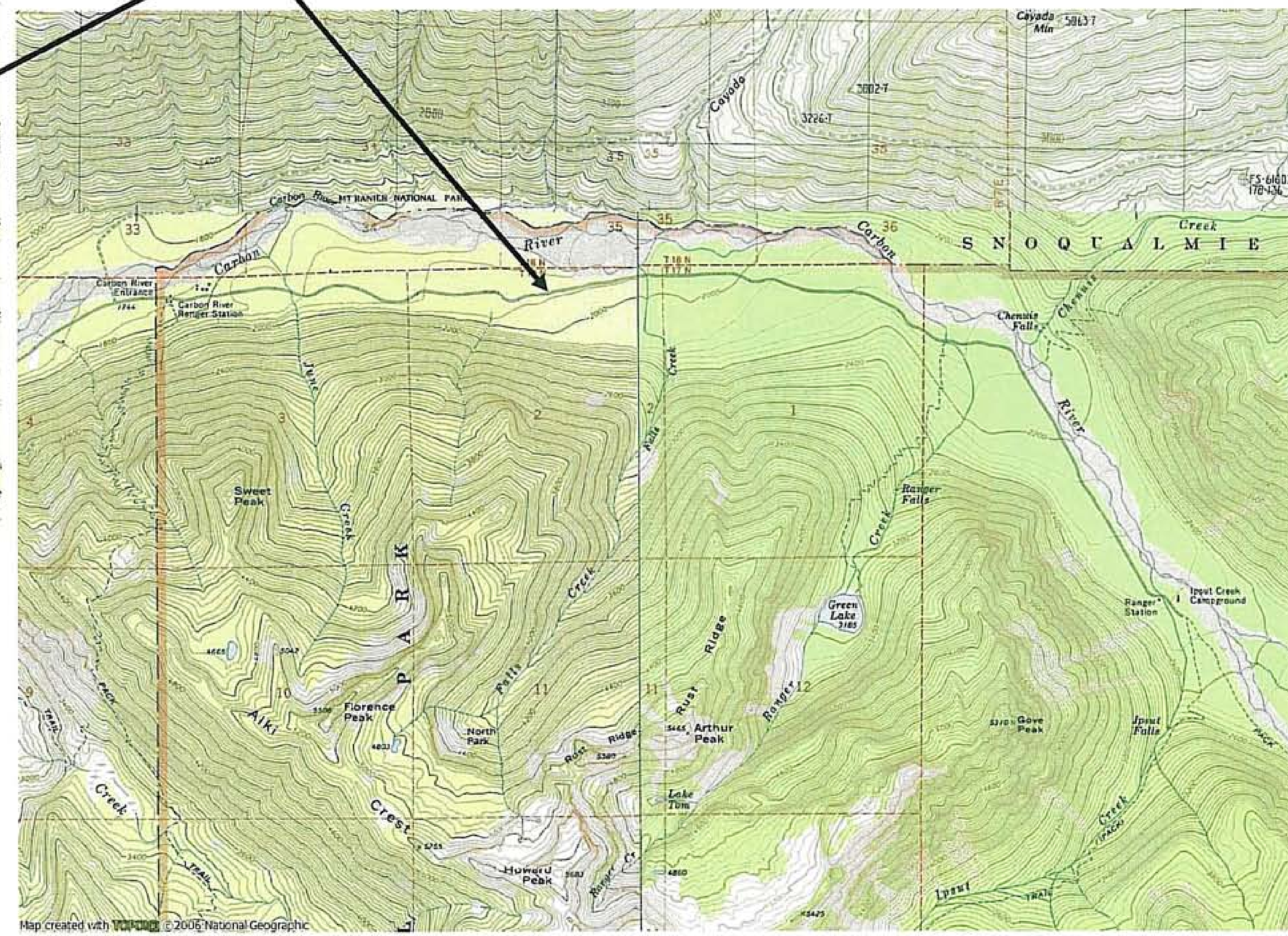
PREPARED JANUARY 2008

30% DESIGN- CARBON RIVER ROAD FLOOD DAMAGE REDUCTION MEASURES			By Geomax (Geomorphology, Geomechanics, Geodesign)	Drawing Status: 30% Design	
Date: January 30, 2008	Drawn By: Allan S. Potter, P.E.	Checked by: D&M Reichmuth	For Mt. Rainier National Park	Sheet No. 1	Of 84

LOCATION MAP- CARBON RIVER ROAD, NORTHWEST ENTRANCE OF MOUNT RAINIER NATIONAL PARK

CARBON RIVER ROAD





30% DESIGN- CARBON RIVER ROAD FLOOD DAMAGE REDUCTION MEASURES			By Geomax	Drawing Status: 30% Design	
Date: January 30, 2008	Drawn By: Allan S. Potter, P.E.	Checked by: D&M Reichmuth	For Mt. Rainier National Park	Sheet No. 2	Of 84

GENERAL NOTES

1. This Carbon River Road site assessment/construction plan is submitted in response to Order No. P9455070095, dated September 14, 2007. The purpose is to provide river stabilization and flood damage reduction techniques that could be used to improve the Carbon River Road in the event a decision is made to re-open a road corridor.

2. All work shall be performed in accordance with these drawings and related specifications for construction of ROCK GRADE CONTROL STRUCTURES.

3. Construction access and haul routes will be identified prior to start of work. Do not deviate from approved routes without prior approval.

4. The final orientation and grades of all rock structures will be established in the field at the time of construction. Locations may be adjusted to minimize damage to existing vegetation, make adjustments for as-found conditions, or to improve the function of the design.

5. As a result of potential adjustments described in NOTE 4 above and the general difficulty in obtaining accurate survey measurements in an active river, the final quantity of large rock to be placed may be greater than or less than the estimated quantities shown in the plans.

6. The Ordinary High Water Line is not shown on the drawings.

7. Future Maintenance of Rock Structures- The project involves construction of in-stream structures utilizing natural rock and/or wood materials placed in a manner that minimizes disturbance to the watercourse. While GEOMAX has a long track record of successfully designing similar projects, it is recognized that the stabilization structures will be subject to the forces of nature and may require maintenance or repair in the future, particularly after the first major flood. The Carbon River is a high energy environment moving tremendous quantities of bedload. The river is capable of rapid erosion or deposition, and can make drastic and sudden course changes. While Geomax has numerous rock structures that are still functional after 10-30 years, on the Carbon River it is expected that minor reconstruction will be necessary after every major flood. Also, these structures are not designed to survive a major debris flow.

8. Future Road Maintenance- The Carbon River floodplain is a difficult environment for a road. The riverbed has the highest build-up rate of any river in the park (one foot every decade). Regardless of what structural measures are taken to reduce damage; damage will still occur, particularly to areas where the river bed is near the height of the road. It was acknowledged after construction in 1924 that the road was situated in harms way, as it immediately suffered major flood damage and the civil engineer was fired (from Windshield Wilderness, by David Luter, published 2006).

9. In these specifications, the term "Engineer" refers to a representative of Geomax, P.C.

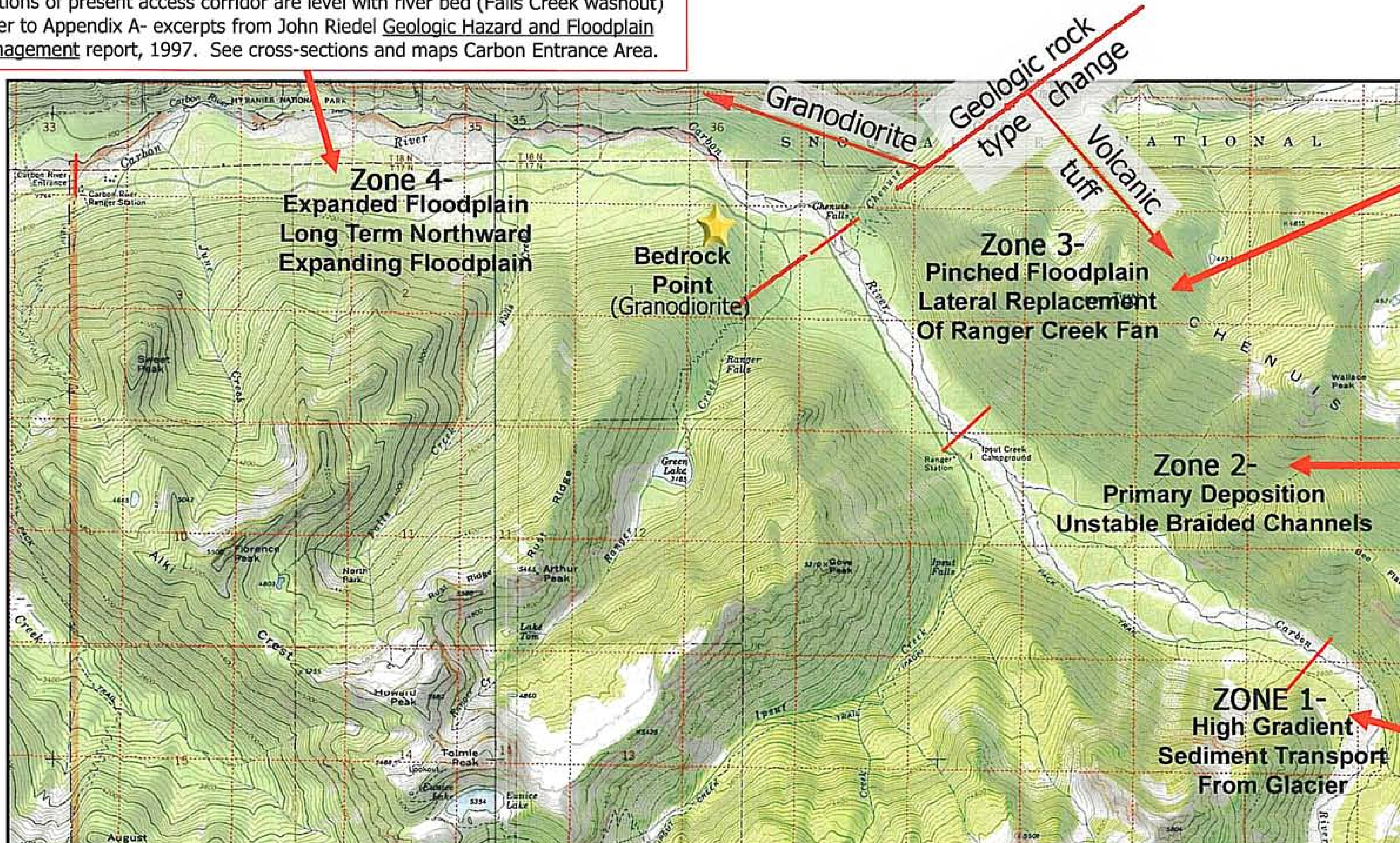
10. Geomax advises bypassing the Carbon River Fairfax Bridge for haul trucks delivering materials.

TABLE OF CONTENTS

- Floodplain widens
- Flow perpendicular to mountain
- Mountain uplift may cause river to trend to north side of valley
- Terraces (and alluvial fans) of fine grained soil on south side of river experience lateral replacement
- Sections of present access corridor are level with river bed (Falls Creek washout)
- Refer to Appendix A- excerpts from John Riedel Geologic Hazard and Floodplain Management report, 1997. See cross-sections and maps Carbon Entrance Area.

CARBON RIVER BEHAVIOR AND GEOMORPHIC ZONES

In order to understand the root causes of the Carbon River Road problems, it is important to review the underlying condition and behavior of the river system.



Geomorphic Zones

Carbon River In Mount Rainier National Park

Half Mile Square Grid Shown In Dashed Red

- Floodplain narrows
- Radial flow away from mountain (uplift steepens gradient)
- Lateral replacement along west bank (Big Bite is an example)
- End of Case III debris flow inundation zone

- Major depositional area
- Unstable braided channels
- Ipsut Creek lower than main river
- Refer to Appendix A- excerpts from John Riedel Geologic Hazard and Floodplain Management report, 1997. See cross-sections and maps.

- Narrow valley
- Steep gradient
- Effective sediment transport
- Subject to large scale debris flows

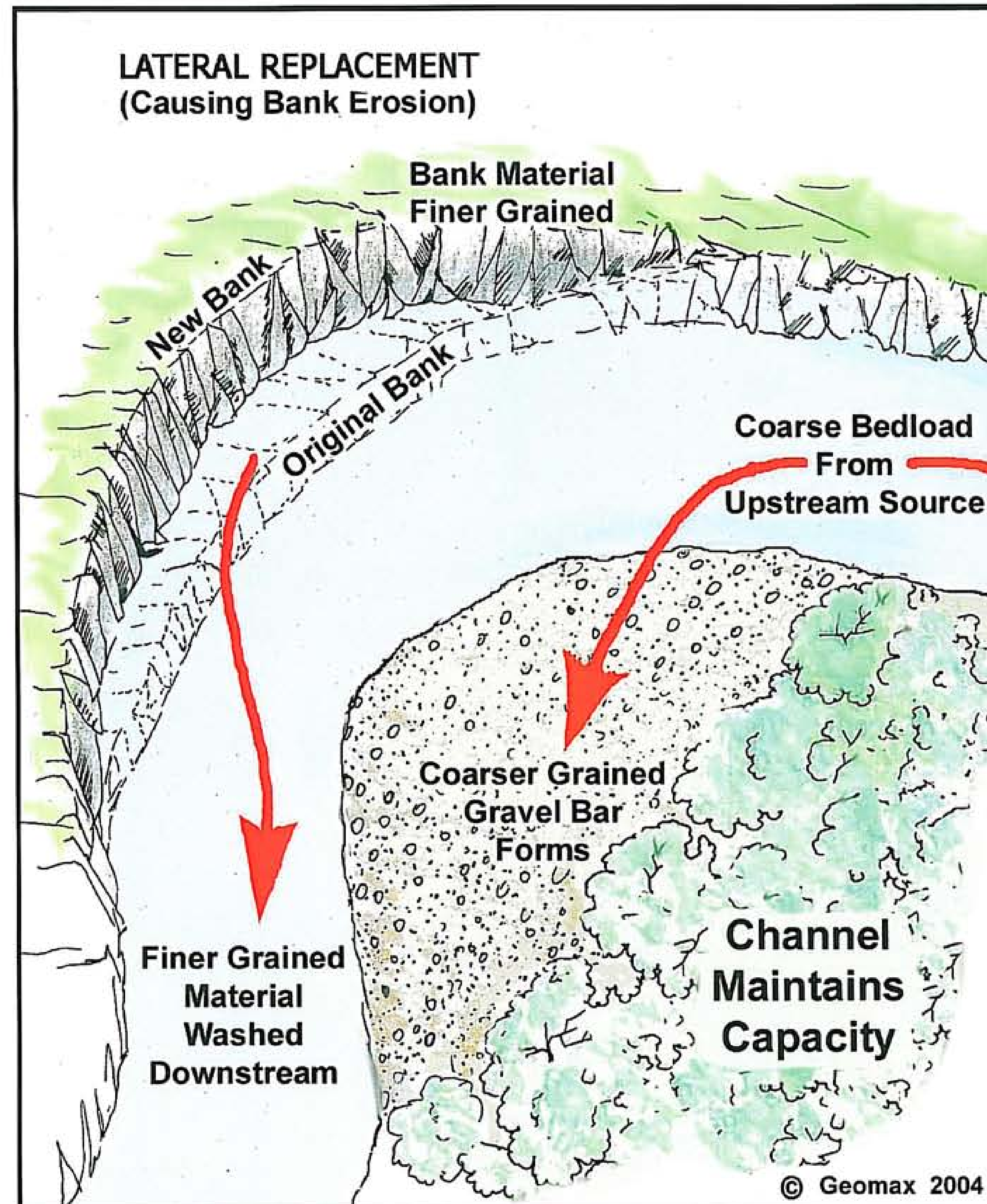
Note: The concept of "Lateral Replacement" is explained on the next page

Note: The Carbon River has been subdivided into zones that have different characteristics and behavior. Because it is often necessary to apply a different analysis and design in each zone, project planning must recognize the location of the boundaries.

30% DESIGN- CARBON RIVER ROAD FLOOD DAMAGE REDUCTION MEASURES			By Geomax (Geomorphology, Geomechanics, Geodesign)	Drawing Status: 30% Design	
Date: January 30, 2008	Drawn By: Allan S. Potter, P.E.	Checked by: D&M Reichmuth	For Mt. Rainier National Park	Sheet No. 5	Of 84

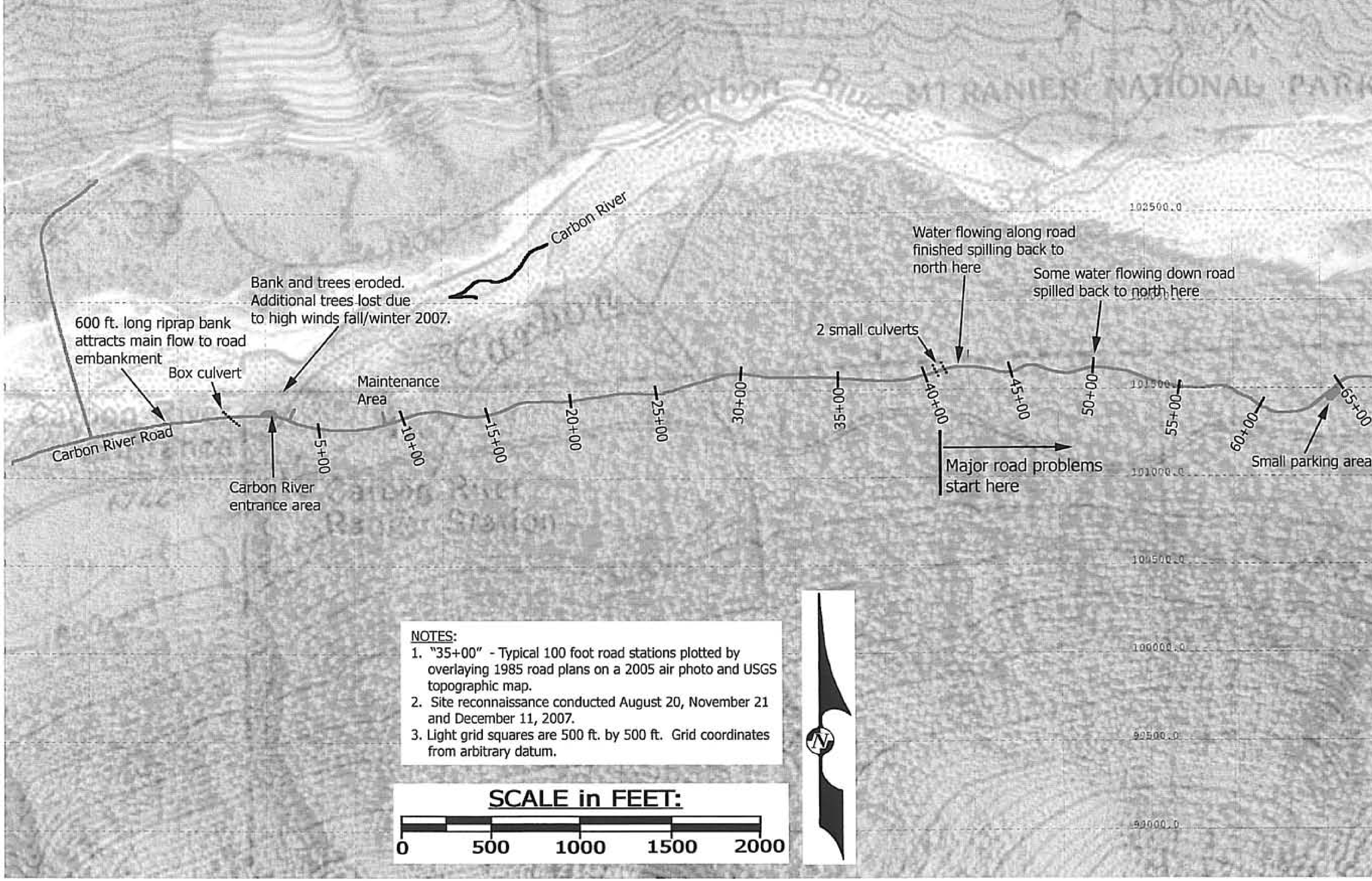
HOW LATERAL REPLACEMENT WORKS

Occasionally, a river that carries a coarse bedload will pass through an area that contains finer, easily eroded formations or significantly finer sedimentary deposits. When this occurs, a process called lateral replacement can take place. The finer material is eroded and flushed downstream, and the coarser gravel is deposited on the floodplain. The channel size (conveyance area) is maintained during the replacement process. Often, a higher volume of finer material is eroded than coarser material deposited. This is possible because it is much easier for the stream to transport the finer material that was eroded than to transport the coarser bedload that it originally carried.



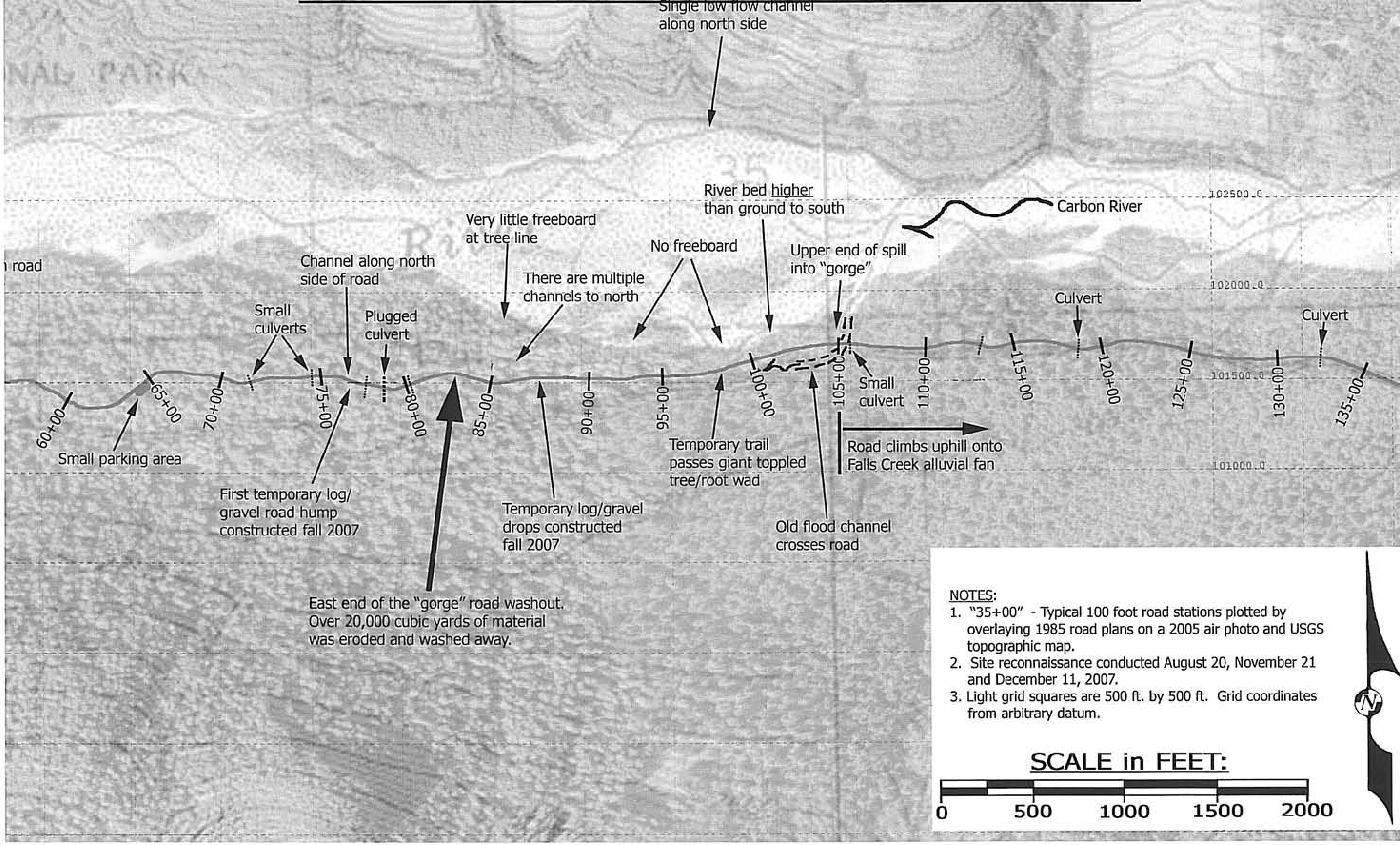
30% DESIGN- CARBON RIVER ROAD FLOOD DAMAGE REDUCTION MEASURES			By Geomax	Drawing Status: 30% Design	
Date: January 30, 2008	Drawn By: Allan S. Potter, P.E.	Checked by: D&M Reichmuth	For Mt. Rainier National Park	Sheet No. 6	Of 84

ASSESSMENT OF EXISTING CONDITIONS- SHEET 1



30% DESIGN- CARBON RIVER ROAD FLOOD DAMAGE REDUCTION MEASURES			By Geomax GEOMORPHOLOGY, GEOMECHANICS, GEODESIGN	Drawing Status: 30% Design	
Date: January 30, 2008	Drawn By: Allan S. Potter, P.E.	Checked by: D&M Reichmuth	For Mt. Rainier National Park	Sheet No. 7	Of 84

ASSESSMENT OF EXISTING CONDITIONS- SHEET 2



NOTES:

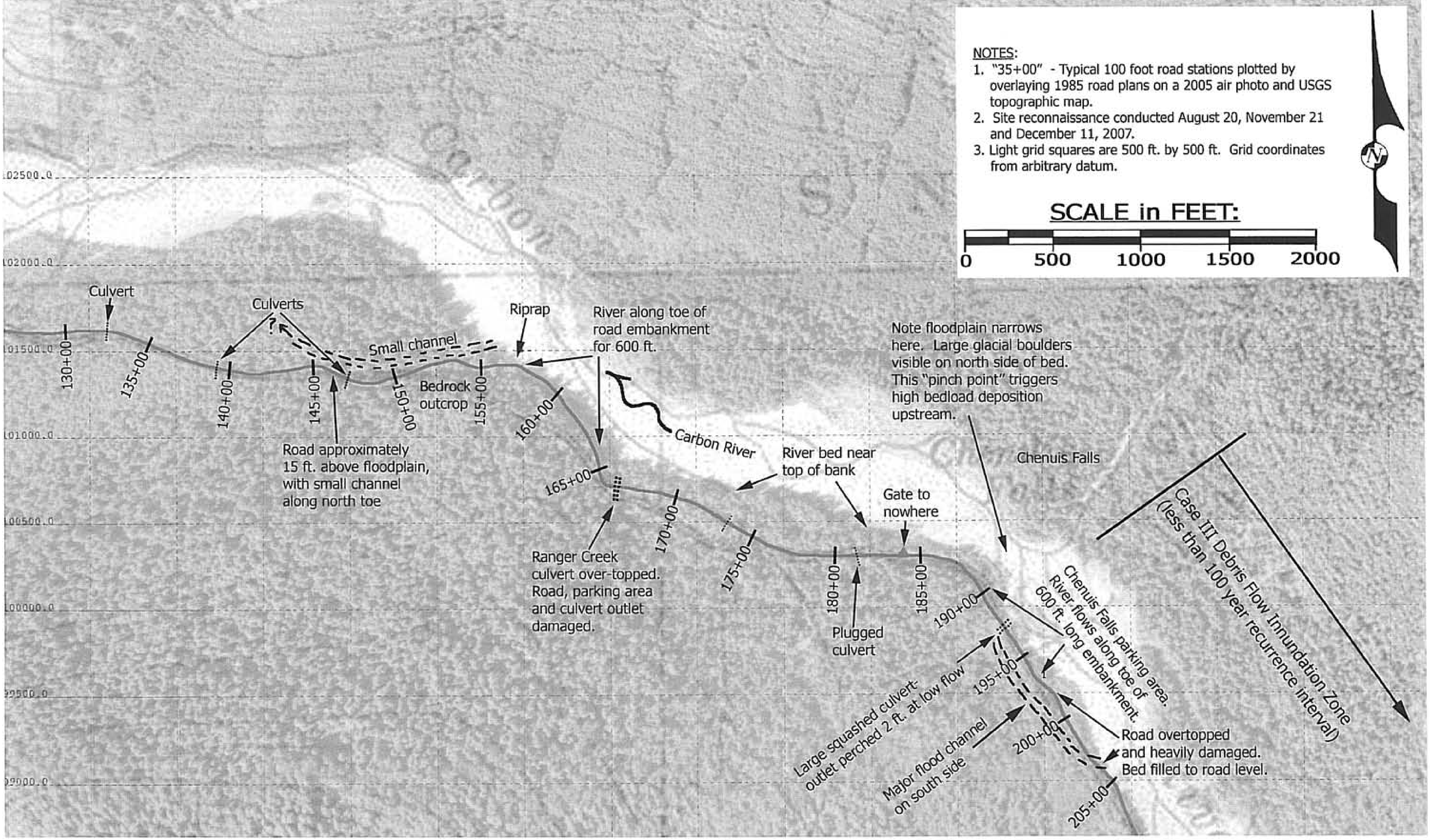
1. "35+00" - Typical 100 foot road stations plotted by overlaying 1985 road plans on a 2005 air photo and USGS topographic map.
2. Site reconnaissance conducted August 20, November 21 and December 11, 2007.
3. Light grid squares are 500 ft. by 500 ft. Grid coordinates from arbitrary datum.

SCALE in FEET:

0 500 1000 1500 2000

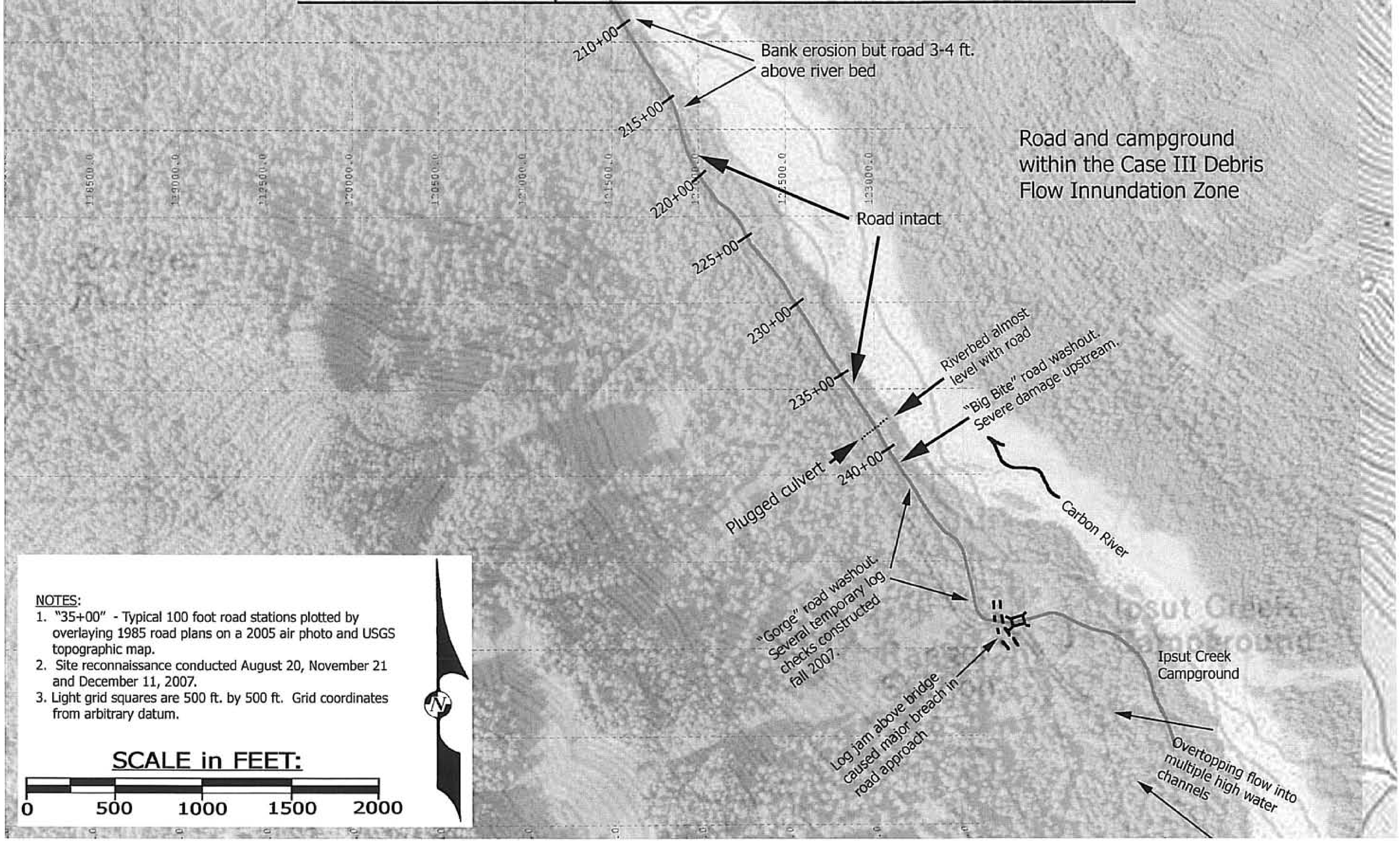
30% DESIGN- CARBON RIVER ROAD FLOOD DAMAGE REDUCTION MEASURES			By Geomax	Drawing Status: 30% Design	
Date: January 30, 2008	Drawn By: Allan S. Potter, P.E.	Checked by: D&M Reichmuth	For Mt. Rainier National Park	Sheet No. 8	Of 84

ASSESSMENT OF EXISTING CONDITIONS- SHEET 3



30% DESIGN- CARBON RIVER ROAD FLOOD DAMAGE REDUCTION MEASURES			By Geomax GEOMORPHOLOGY, GEOMECHANICS, GEODESIGN	Drawing Status: 30% Design	
Date: January 30, 2008	Drawn By: Allan S. Potter, P.E.	Checked by: D&M Reichmuth	For Mt. Rainier National Park	Sheet No. 9	Of 84

ASSESSMENT OF EXISTING CONDITIONS- SHEET 4

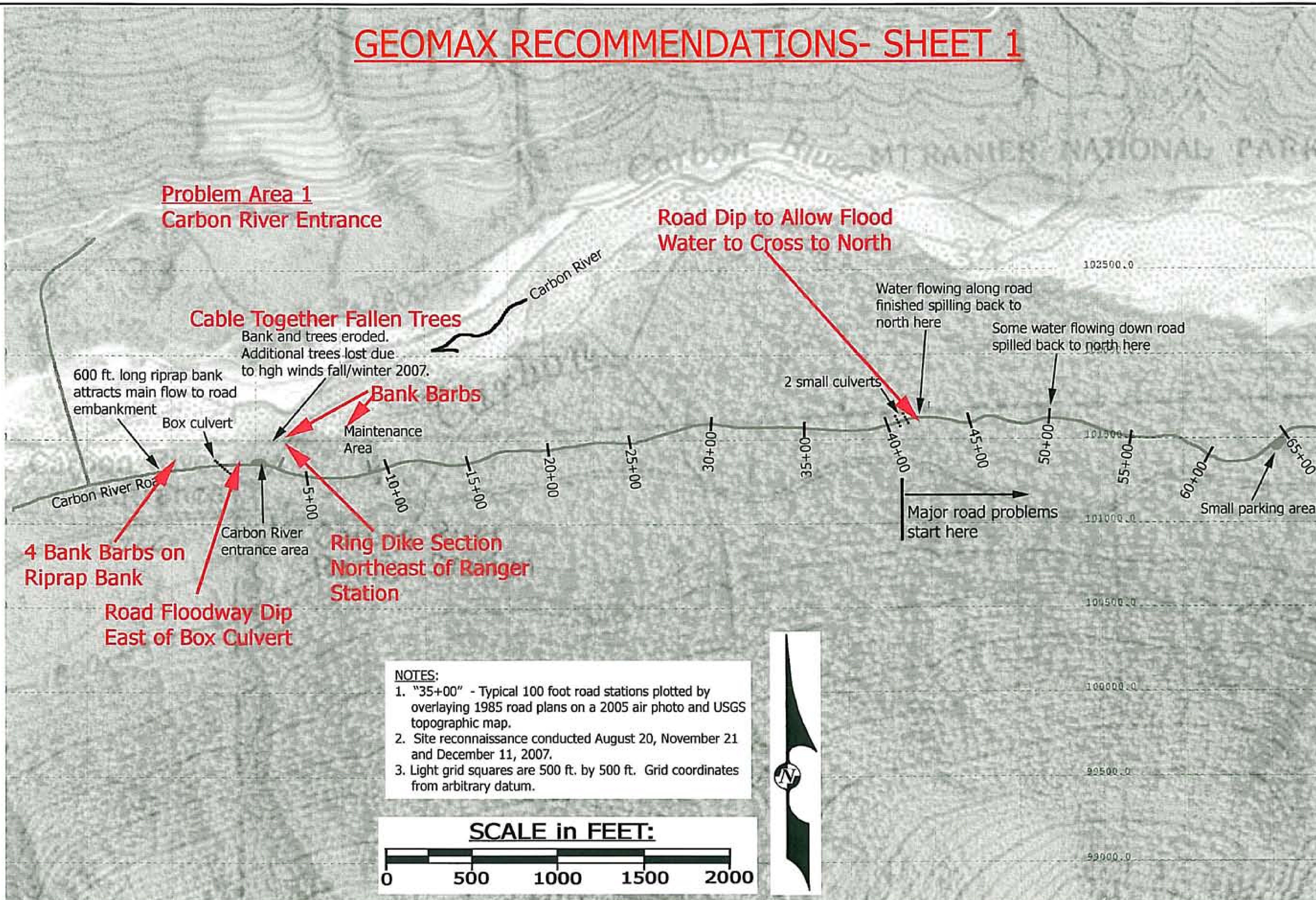


NOTES:
1. "35+00" - Typical 100 foot road stations plotted by overlaying 1985 road plans on a 2005 air photo and USGS topographic map.
2. Site reconnaissance conducted August 20, November 21 and December 11, 2007.
3. Light grid squares are 500 ft. by 500 ft. Grid coordinates from arbitrary datum.

SCALE in FEET:

0 500 1000 1500 2000

30% DESIGN- CARBON RIVER ROAD FLOOD DAMAGE REDUCTION MEASURES			By Geomax	Drawing Status: 30% Design
Date: January 30, 2008	Drawn By: Allan S. Potter, P.E.	Checked by: D&M Reichmuth	For Mt. Rainier National Park	Sheet No. 10 Of 84

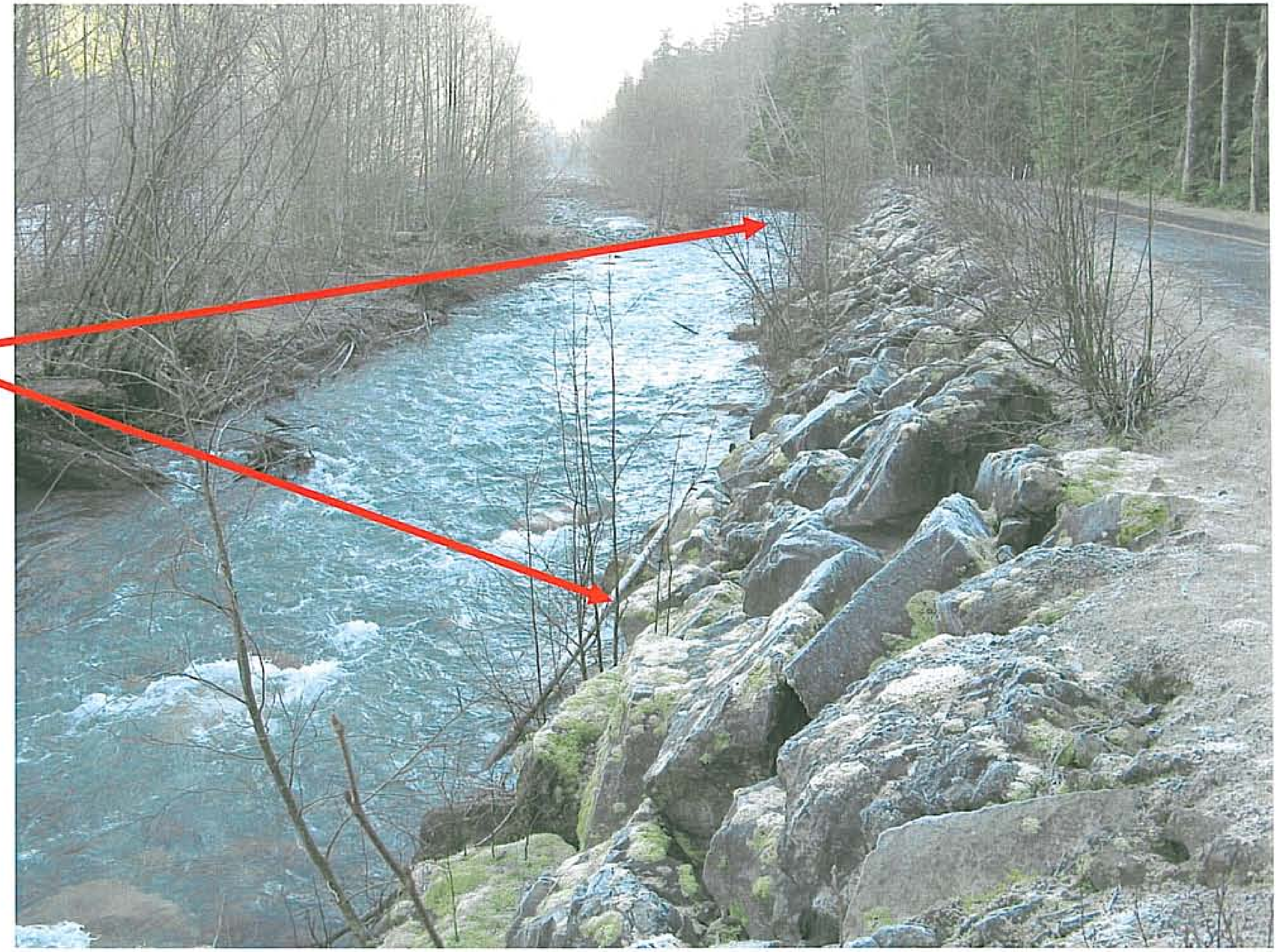


30% DESIGN- CARBON RIVER ROAD FLOOD DAMAGE REDUCTION MEASURES			By Geomax GEOMORPHOLOGY, GEOMECHANICS, GEODESIGN	Drawing Status: 30% Design	
Date: January 30, 2008	Drawn By: Allan S. Potter, P.E.	Checked by: D&M Reichmuth	For Mt. Rainier National Park	Sheet No. 11	Of 84

Road Bank at Carbon Entrance

Construct 4 bank barbs spaced 200 feet part to re-direct high velocity flow away from rip-rap bank. This should also shift the low flow channel to the north over time. See the next page for a diagram on the effects of rip rap. These structures will also work in conjunction with two bank barbs upstream to redirect concentrated flow away from the eroding banks near the ranger station.

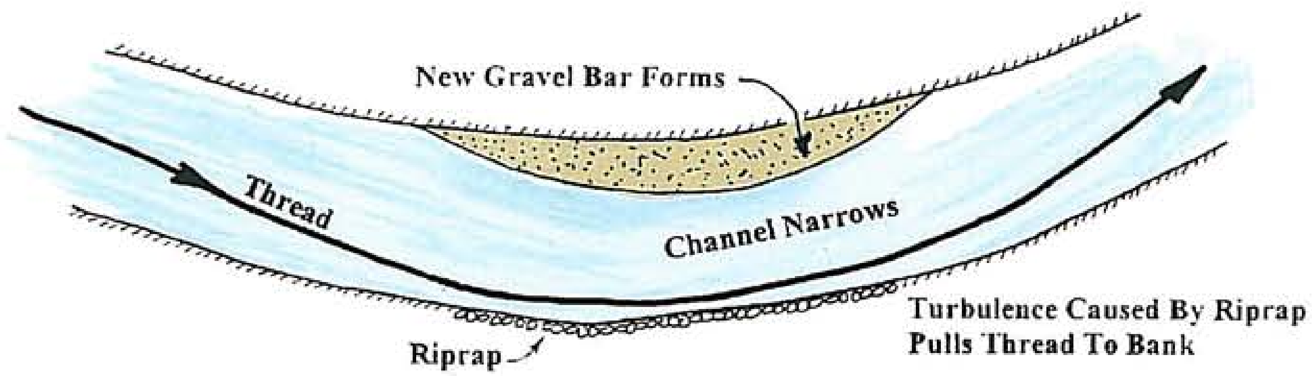
See typical details.



30% DESIGN- CARBON RIVER ROAD FLOOD DAMAGE REDUCTION MEASURES			By Geomax	Drawing Status: 30% Design	
Date: January 30, 2008	Drawn By: Allan S. Potter, P.E.	Checked by: D&M Reichmuth	For Mt. Rainier National Park	Sheet No. 12	Of 84

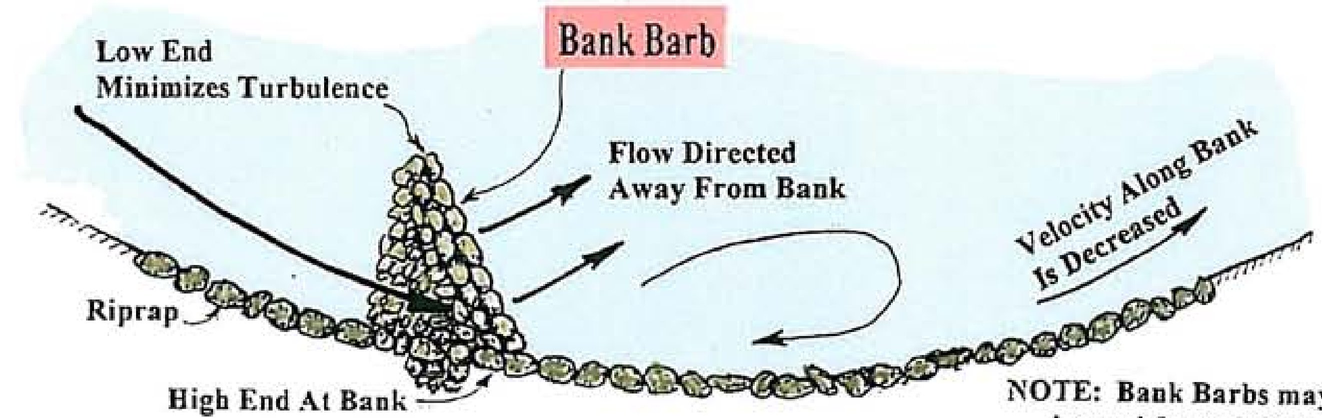
HOW BANK BARBS REDUCE SCOUR ALONG A RIPRAP BANK

TYPICAL RIPRAP BEHAVIOR



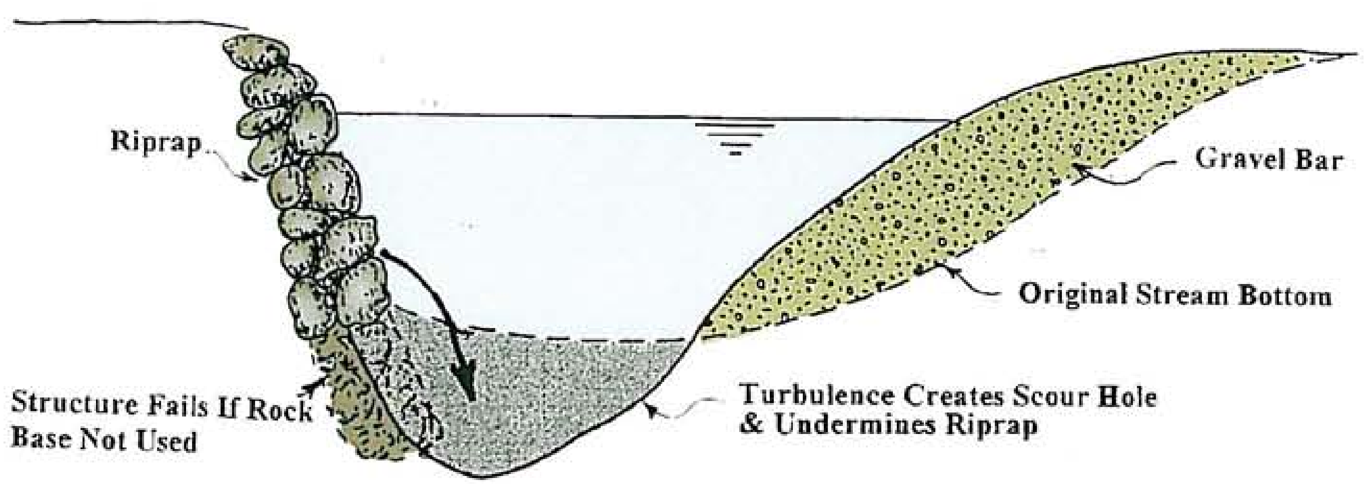
IMPACT ON THREAD

WITH THE ADDITION OF A BANK BARB



NOTE: Bank Barbs may be used for stabilizing banks without riprap.

IMPROVED CONFIGURATION



CROSS SECTION

30% DESIGN- CARBON RIVER ROAD FLOOD DAMAGE REDUCTION MEASURES			By Geomax	Drawing Status: 30% Design	
Date: January 30, 2008	Drawn By: Allan S. Potter, P.E.	Checked by: D&M Reichmuth	For Mt. Rainier National Park	Sheet No. 13	Of 84

Carbon River Entrance Area

A Geomax survey indicates that the Carbon Ranger Station foundation is 5 feet above the average elevation of the adjacent gravel/cobble bar. It is however, threatened by channel migration and loss of protective trees. See Appendix A for 1997 cross-sections and discussion of this area.

Construct a bank barb north of this location, with an elevated keyway extending to the high ground adjacent to the restroom facilities. In addition, construct a 2-3 foot high dike section 100 feet long, curving around the buildings upstream. Tie into end of remaining dike. If the bank loss cannot be prevented, the buildings may eventually have to be relocated.

30% DESIGN- CARBON RIVER ROAD FLOOD DAMAGE REDUCTION MEASURES			By Geomax	Drawing Status: 30% Design	
Date: January 30, 2008	Drawn By: Allan S. Potter, P.E.	Checked by: D&M Reichmuth	For Mt. Rainier National Park	Sheet No. 14	Of 84

River Bank Near Main Entrance

Low lying areas of the Carbon River are experiencing accelerated loss of old growth trees due to saturated ground conditions and repeated high winds. Rangers indicated that there were three high wind events in the fall/early winter of 2007 that toppled a significant number of trees in the Carbon Entrance area alone. When trees along the bank are lost, the bank stability is also lost.

As a management policy, Geomax recommends that toppled trees be used for bank protection by turning the stalks parallel to the bank and anchoring them with cable to either other trees or buried deadmen at 90 degrees. Root balls can be cut off if necessary to be able to position the trees.

See typical detail.

Carbon River Entrance Area, North of Buildings

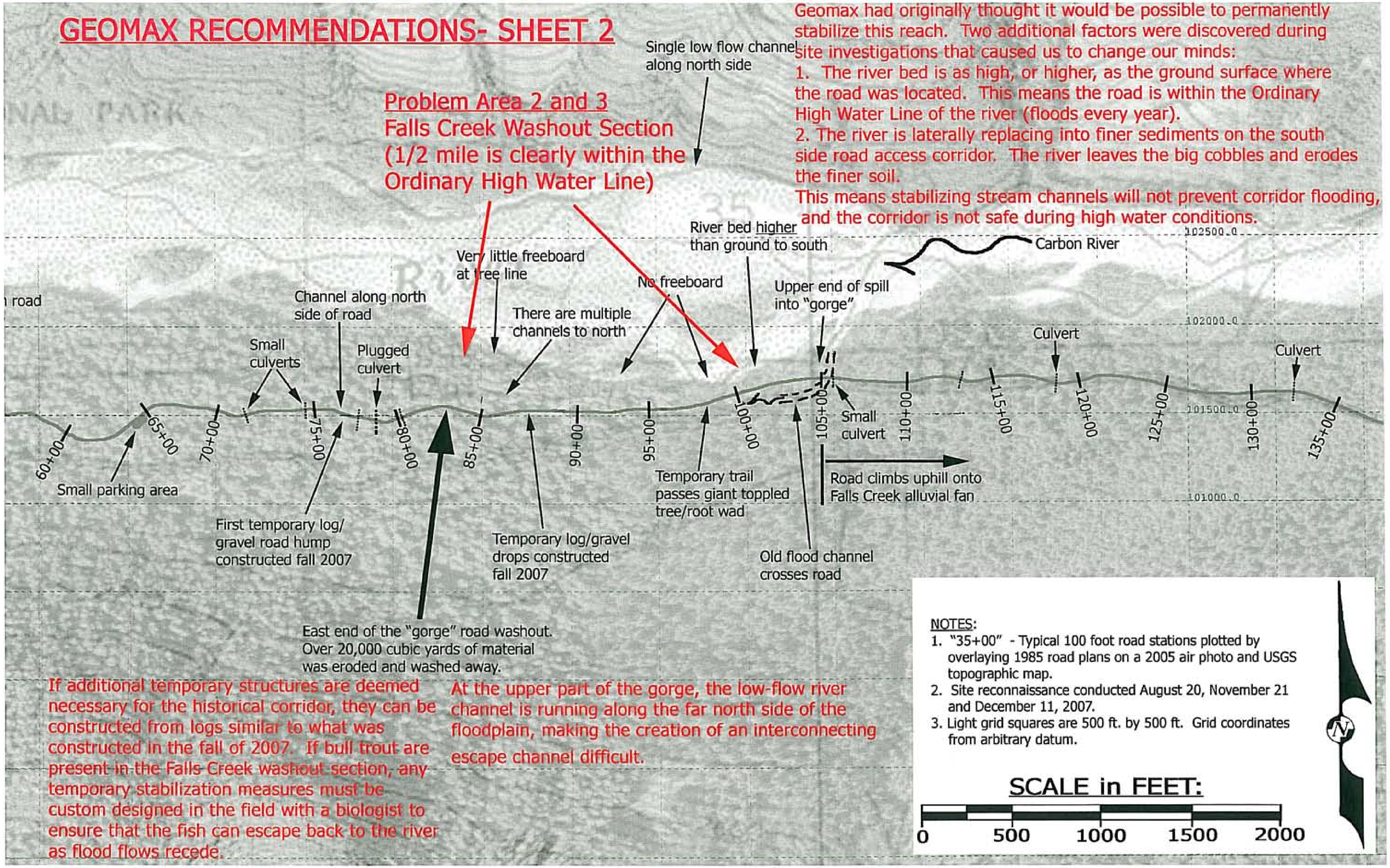
Cable trees together to create logjam from fallen trees north of buildings

30% DESIGN- CARBON RIVER ROAD FLOOD DAMAGE REDUCTION MEASURES			By Geomax	Drawing Status: 30% Design	
Date: January 30, 2008	Drawn By: Allan S. Potter, P.E.	Checked by: D&M Reichmuth	For Mt. Rainier National Park	Sheet No. 16	Of 84

Station 42+00

Construct 30 foot long road dip here, east of existing culverts

30% DESIGN- CARBON RIVER ROAD FLOOD DAMAGE REDUCTION MEASURES			By Geomax GEOMORPHOLOGY, GEOMECHANICS, GEODESIGN	Drawing Status: 30% Design	
Date: January 30, 2008	Drawn By: Allan S. Potter, P.E.	Checked by: D&M Reichmuth	For Mt. Rainier National Park	Sheet No. 17	Of 84



30% DESIGN- CARBON RIVER ROAD FLOOD DAMAGE REDUCTION MEASURES			By Geomax	Drawing Status: 30% Design	
Date: January 30, 2008	Drawn By: Allan S. Potter, P.E.	Checked by: D&M Reichmuth	For Mt. Rainier National Park	Sheet No. 18	Of 84

Station 77+00- First Temporary Log Trail Hump Fall 2007

30% DESIGN- CARBON RIVER ROAD FLOOD DAMAGE REDUCTION MEASURES			By Geomax GEOMORPHOLOGY, GEOMECHANICS, GEODESIGN	Drawing Status: 30% Design	
Date: January 30, 2008	Drawn By: Allan S. Potter, P.E.	Checked by: D&M Reichmuth	For Mt. Rainier National Park	Sheet No. 19	Of 84

Station 83+00- Temporary Log Check Structure Fall 2007

30% DESIGN- CARBON RIVER ROAD FLOOD DAMAGE REDUCTION MEASURES			By Geomax GEOMORPHOLOGY, GEOHYDRAULICS, GEODESIGN	Drawing Status: 30% Design	
Date: January 30, 2008	Drawn By: Allan S. Potter, P.E.	Checked by: D&M Reichmuth	For Mt. Rainier National Park	Sheet No. 20	Of 84

Station 86+00- Second High Water Channel "Gorge" to the North

30% DESIGN- CARBON RIVER ROAD FLOOD DAMAGE REDUCTION MEASURES			By Geomax (GEOMORPHOLOGY, GEOMECHANICS, GEODESIGN)	Drawing Status: 30% Design	
Date: January 30, 2008	Drawn By: Allan S. Potter, P.E.	Checked by: D&M Reichmuth	For Mt. Rainier National Park	Sheet No. 21	Of 84

Station 88+00- Two Temporary Log Check Structures Fall 2007

30% DESIGN- CARBON RIVER ROAD FLOOD DAMAGE REDUCTION MEASURES			By Geomax	Drawing Status: 30% Design	
Date: January 30, 2008	Drawn By: Allan S. Potter, P.E.	Checked by: D&M Reichmuth	For Mt. Rainier National Park	Sheet No. 22	Of 84

Lateral Replacement in Falls Creek Washout

Note coarse gravel and cobble on left (north) side of photos and fine grained soils on the right (south) side

Previous Road Location

30% DESIGN- CARBON RIVER ROAD FLOOD DAMAGE REDUCTION MEASURES			By Geomax	Drawing Status: 30% Design	
Date: January 30, 2008	Drawn By: Allan S. Potter, P.E.	Checked by: D&M Reichmuth	For Mt. Rainier National Park	Sheet No. 23	Of 84

Station 98+00

Station 102+00

Previous Road Location

If additional temporary structures are deemed necessary, use existing downed trees to construct checks similar to those constructed in the fall of 2007. Any temporary structures must be custom designed in the field, with the assistance of a fish biologist, to ensure that bull trout can escape back to the river.

30% DESIGN- CARBON RIVER ROAD FLOOD DAMAGE REDUCTION MEASURES			By Geomax	Drawing Status: 30% Design	
Date: January 30, 2008	Drawn By: Allan S. Potter, P.E.	Checked by: D&M Reichmuth	For Mt. Rainier National Park	Sheet No. 24	Of 84

Station 105+00- Upper End of Falls Creek Washout

Place temporary log checks in gulley if a method can be found to allow bull trout to escape

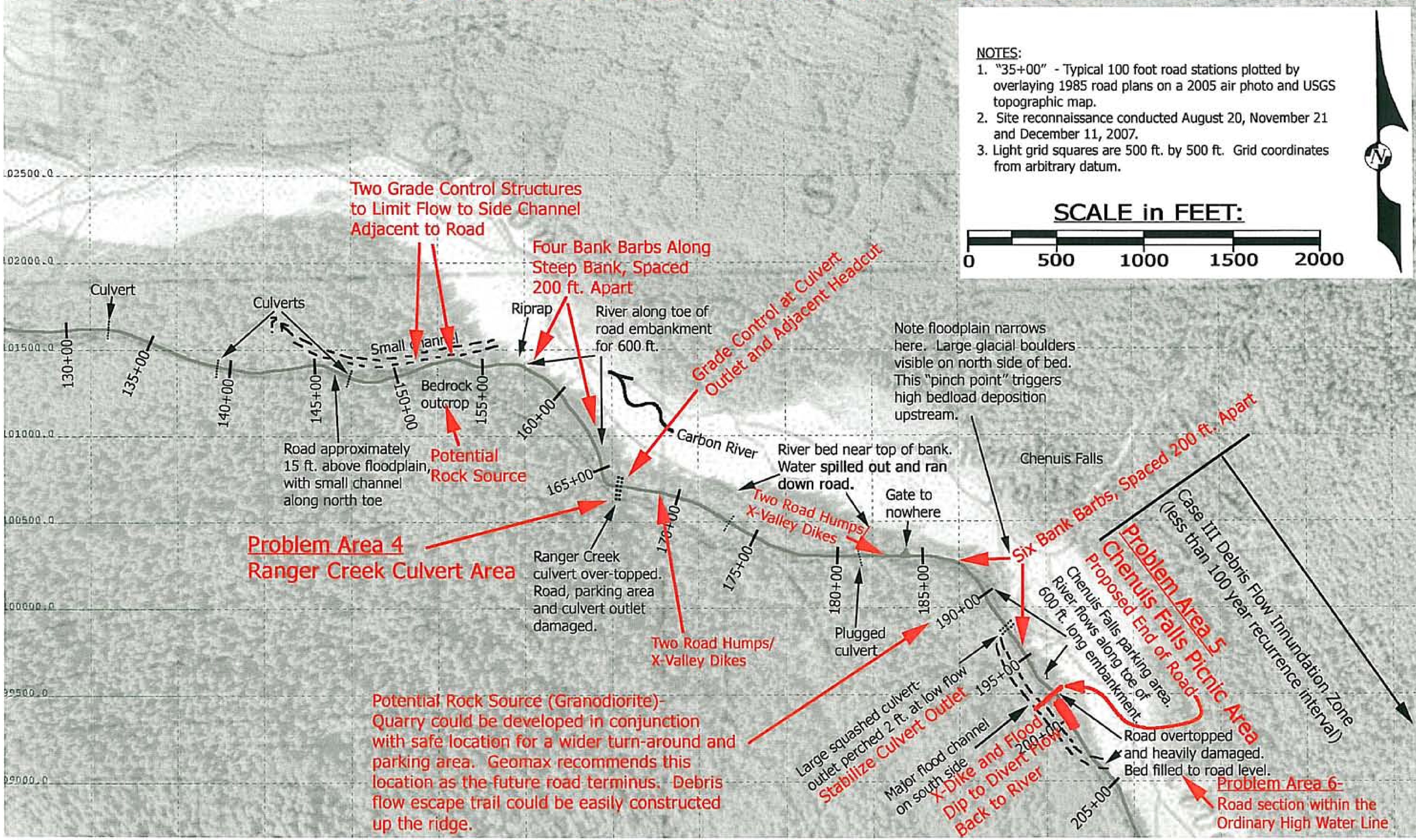
30% DESIGN- CARBON RIVER ROAD FLOOD DAMAGE REDUCTION MEASURES			By Geomax	Drawing Status: 30% Design	
Date: January 30, 2008	Drawn By: Allan S. Potter, P.E.	Checked by: D&M Reichmuth	For Mt. Rainier National Park	Sheet No. 25	Of 84

North of Station 98+00, Looking at South River Bank

Note that river bed is almost level with the top of the bank on the south side.

30% DESIGN- CARBON RIVER ROAD FLOOD DAMAGE REDUCTION MEASURES			By Geomax GEOMORPHOLOGY, GEOMECHANICS, GEODESIGN	Drawing Status: 30% Design	
Date: January 30, 2008	Drawn By: Allan S. Potter, P.E.	Checked by: D&M Reichmuth	For Mt. Rainier National Park	Sheet No. 26	Of 84

GEOMAX RECOMMENDATIONS- SHEET 3



30% DESIGN- CARBON RIVER ROAD FLOOD DAMAGE REDUCTION MEASURES			By Geomax GEOMORPHOLOGY, GEOMECHANICS, GEODESIGN	Drawing Status: 30% Design	
Date: January 30, 2008	Drawn By: Allan S. Potter, P.E.	Checked by: D&M Reichmuth	For Mt. Rainier National Park	Sheet No. 27	Of 84

Station 152+00

Outcrop of Granodiorite rock that would make a good quarry source for structural rock

30% DESIGN- CARBON RIVER ROAD FLOOD DAMAGE REDUCTION MEASURES			By Geomax GEOMORPHOLOGY, GEOMECHANICS, GEODESIGN	Drawing Status: 30% Design	
Date: January 30, 2008	Drawn By: Allan S. Potter, P.E.	Checked by: D&M Reichmuth	For Mt. Rainier National Park	Sheet No. 28	Of 84

Station 154+00- Flood Channel Next to Road

Construct two grade control structures to limit flow to channel adjacent to road

Photo taken from road, looking north

30% DESIGN- CARBON RIVER ROAD FLOOD DAMAGE REDUCTION MEASURES			By Geomax	Drawing Status: 30% Design	
Date: January 30, 2008	Drawn By: Allan S. Potter, P.E.	Checked by: D&M Reichmuth	For Mt. Rainier National Park	Sheet No. 29	Of 84

Station 157+00- Begin Riprap Bank

Construct the first in a series of four bank barbs 50 ft. east of here. Bank barbs continue to east, spaced 200 ft. apart.

30% DESIGN- CARBON RIVER ROAD FLOOD DAMAGE REDUCTION MEASURES			By Geomax GEOMORPHOLOGY, GEOMECHANICS, GEODESIGN	Drawing Status: 30% Design	
Date: January 30, 2008	Drawn By: Allan S. Potter, P.E.	Checked by: D&M Reichmuth	For Mt. Rainier National Park	Sheet No. 30	Of 84

Station 157+00 to 163+00- Road Fill with Steep Bank

Construct four bank barbs to redirect flow away from toe of bank

30% DESIGN- CARBON RIVER ROAD FLOOD DAMAGE REDUCTION MEASURES			By Geomax GEOMORPHOLOGY, GEOMECHANICS, GEOGESIGN	Drawing Status: 30% Design	
Date: January 30, 2008	Drawn By: Allan S. Potter, P.E.	Checked by: D&M Reichmuth	For Mt. Rainier National Park	Sheet No. 31	Of 84

Station 167+00- Ranger Creek Culvert Looking East

Construct two road humps to east to prevent over bank flood flows from concentrating in the road corridor

Construct dip to east to allow flood water to cross road instead of over-topping and breaching road fill if culvert plugs

Construct grade control to protect culvert outlet and check headcut from water that flowed along road from the east

Build trash rack on culvert inlet

30% DESIGN- CARBON RIVER ROAD FLOOD DAMAGE REDUCTION MEASURES			By Geomax GEOMORPHOLOGY, GEOMECHANICS, GEODESIGN	Drawing Status: 30% Design	
Date: January 30, 2008	Drawn By: Allan S. Potter, P.E.	Checked by: D&M Reichmuth	For Mt. Rainier National Park	Sheet No. 32	Of 84

Station 167+00- Ranger Creek Culvert Looking North

Construct grade control at culvert outlet

30% DESIGN- CARBON RIVER ROAD FLOOD DAMAGE REDUCTION MEASURES			By Geomax GEOMORPHOLOGY, GEOMECHANICS, GEODESIGN	Drawing Status: 30% Design	
Date: January 30, 2008	Drawn By: Allan S. Potter, P.E.	Checked by: D&M Reichmuth	For Mt. Rainier National Park	Sheet No. 33	Of 84

Station 173+00, Slightly East

Construct easternmost road hump/cross dike in Ranger Creek section here. Prevent over-bank flows from concentrating and flowing down road corridor. This section may be within the Ordinary High Water Line of the river.

30% DESIGN- CARBON RIVER ROAD FLOOD DAMAGE REDUCTION MEASURES			By Geomax	Drawing Status: 30% Design	
Date: January 30, 2008	Drawn By: Allan S. Potter, P.E.	Checked by: D&M Reichmuth	For Mt. Rainier National Park	Sheet No. 34	Of 84

Station 173+00, from River Bed Looking South at Bank Line

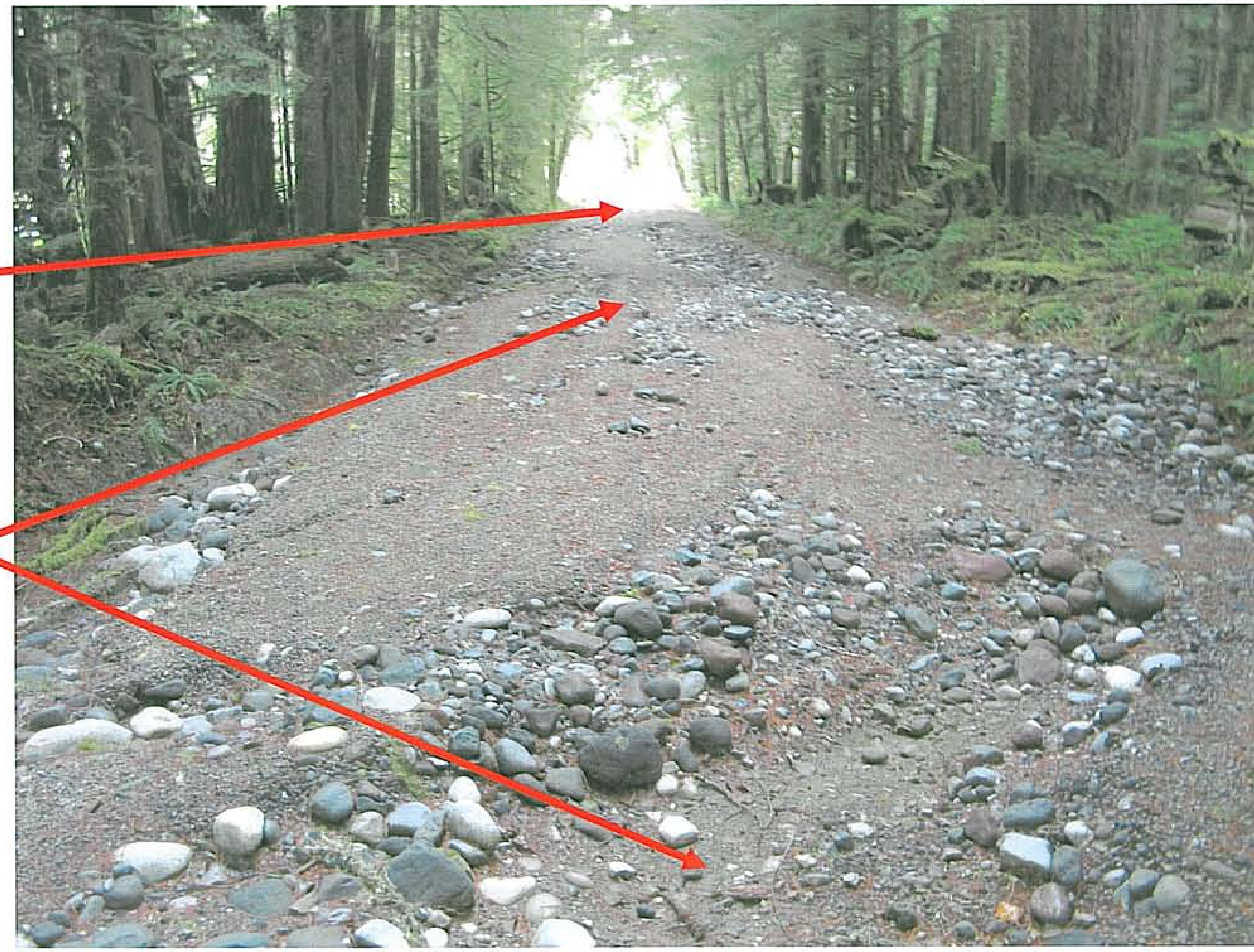
Note that river bed is near the top of the bank on the south side.

30% DESIGN- CARBON RIVER ROAD FLOOD DAMAGE REDUCTION MEASURES			By Geomax GEOMORPHOLOGY, GEOMECHANICS, GEODESIGN	Drawing Status: 30% Design	
Date: January 30, 2008	Drawn By: Allan S. Potter, P.E.	Checked by: D&M Reichmuth	For Mt. Rainier National Park	Sheet No. 35	Of 84

Station 181+50, Looking East

Water spills out here and flows down the road corridor, towards the bottom of the photo. This section of road is within the Ordinary High Water Line of the river.

Construct two road hump/x-valley dikes to prevent flood overflow from concentrating in the road corridor.



30% DESIGN- CARBON RIVER ROAD FLOOD DAMAGE REDUCTION MEASURES			By Geomax GEOMORPHOLOGY, GEOMECHANICS, GEODESIGN	Drawing Status: 30% Design	
Date: January 30, 2008	Drawn By: Allan S. Potter, P.E.	Checked by: D&M Reichmuth	For Mt. Rainier National Park	Sheet No. 36	Of 84

Station 181+50

Close-up of the location where flood water spills out, shown in the previous photo.

30% DESIGN- CARBON RIVER ROAD FLOOD DAMAGE REDUCTION MEASURES			By Geomax (GEOMORPHOLOGY, GEOMECHANICS, GEODESIGN)	Drawing Status: 30% Design	
Date: January 30, 2008	Drawn By: Allan S. Potter, P.E.	Checked by: D&M Reichmuth	For Mt. Rainier National Park	Sheet No. 37	Of 84

Station 186+00

Construct a series of six bank barbs beginning here, spaced 200 ft. apart. The barbs continue east, and re-direct high velocity flow away from the toe of the bank.

30% DESIGN- CARBON RIVER ROAD FLOOD DAMAGE REDUCTION MEASURES			By Geomax GEOMORPHOLOGY, GEOMECHANICS, GEODESIGN	Drawing Status: 30% Design	
Date: January 30, 2008	Drawn By: Allan S. Potter, P.E.	Checked by: D&M Reichmuth	For Mt. Rainier National Park	Sheet No. 38	Of 84

Station 187+50

First section of Chenuis Falls Parking Area

30% DESIGN- CARBON RIVER ROAD FLOOD DAMAGE REDUCTION MEASURES			By Geomax	Drawing Status: 30% Design	
Date: January 30, 2008	Drawn By: Allan S. Potter, P.E.	Checked by: D&M Reichmuth	For Mt. Rainier National Park	Sheet No. 39	Of 84

Station 190+00, Looking North

Glacial boulders on north side of river bed, across from Chenuis Falls picnic area. The floodplain is narrowed here, which triggers increased deposition immediately upstream.

30% DESIGN- CARBON RIVER ROAD FLOOD DAMAGE REDUCTION MEASURES			By Geomax (GEOMORPHOLOGY, GEOMECHANICS, GEODESIGN)	Drawing Status: 30% Design	
Date: January 30, 2008	Drawn By: Allan S. Potter, P.E.	Checked by: D&M Reichmuth	For Mt. Rainier National Park	Sheet No. 40	Of 84

Station 192+50- Chenuis Falls Parking Area

Construct bank barbs to redirect high velocity flow away from the toe of the bank

30% DESIGN- CARBON RIVER ROAD FLOOD DAMAGE REDUCTION MEASURES			By Geomax GEOMORPHOLOGY, GEOMECHANICS, GEODESIGN	Drawing Status: 30% Design	
Date: January 30, 2008	Drawn By: Allan S. Potter, P.E.	Checked by: D&M Reichmuth	For Mt. Rainier National Park	Sheet No. 41	Of 84

Station 192+50- Chenuis Falls Parking Area, Looking East

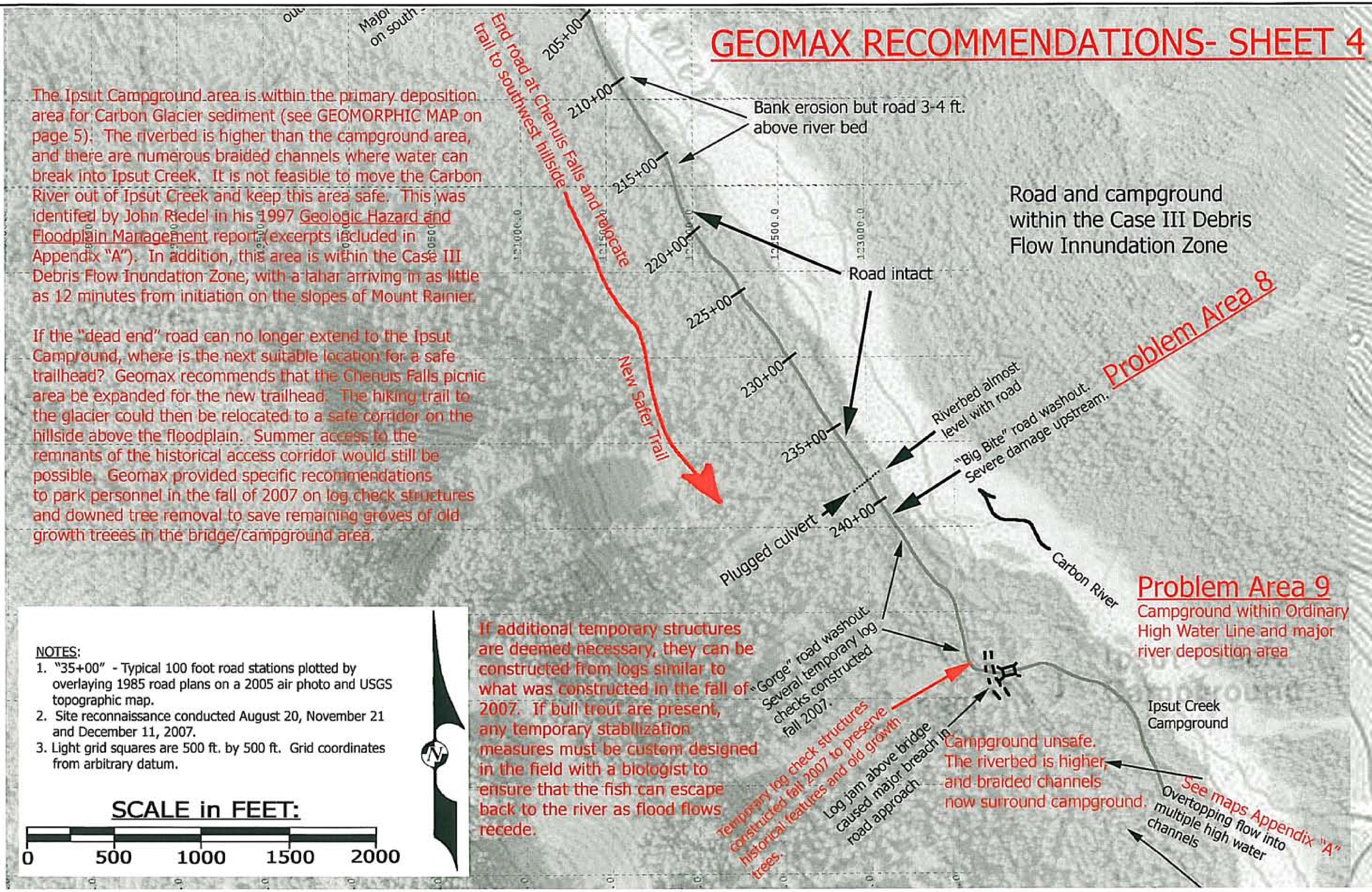
Geomax recommends terminating road at east end of Chenuis Falls Parking area. Road beyond this point is not sustainable, and is within the Case III Debris Flow Inundation Zone.

30% DESIGN- CARBON RIVER ROAD FLOOD DAMAGE REDUCTION MEASURES			By Geomax GEOMORPHOLOGY, GEOMECHANICS, GEODESIGN	Drawing Status: 30% Design	
Date: January 30, 2008	Drawn By: Allan S. Potter, P.E.	Checked by: D&M Reichmuth	For Mt. Rainier National Park	Sheet No. 42	Of 84

Station 197+00- Channel on South Side of Road, Looking East

Construct a cross-valley dike across this channel, and a floodway dip to the east to direct flood water back to river. Water presently spills out upstream, crosses the road, and flows down this channel to the culvert at the Chenuis Falls parking area.

30% DESIGN- CARBON RIVER ROAD FLOOD DAMAGE REDUCTION MEASURES			By Geomax	Drawing Status: 30% Design	
Date: January 30, 2008	Drawn By: Allan S. Potter, P.E.	Checked by: D&M Reichmuth	For Mt. Rainier National Park	Sheet No. 43	Of 84



30% DESIGN- CARBON RIVER ROAD FLOOD DAMAGE REDUCTION MEASURES			By Geomax	Drawing Status: 30% Design	
Date: January 30, 2008	Drawn By: Allan S. Potter, P.E.	Checked by: D&M Reichmuth	For Mt. Rainier National Park	Sheet No. 44	Of 84

Station 204+00, Looking Southeast

The riverbed is near the level of the road. The flow to the northwest for several hundred feet is within the Ordinary High Water Line of the river.

30% DESIGN- CARBON RIVER ROAD FLOOD DAMAGE REDUCTION MEASURES			By Geomax GEOMORPHOLOGY, GEOMECHANICS, GEODESIGN	Drawing Status: 30% Design	
Date: January 30, 2008	Drawn By: Allan S. Potter, P.E.	Checked by: D&M Reichmuth	For Mt. Rainier National Park	Sheet No. 45	Of 84

Station 204+00, Looking Northwest

Road Corridor

Looking downstream from the location of the previous photo. Water spills out and flows down the road corridor. The road is now a gravel/cobble deposition area within the Ordinary High Water Line of the river.

30% DESIGN- CARBON RIVER ROAD FLOOD DAMAGE REDUCTION MEASURES			By Geomax GEOMORPHOLOGY, GEOMECHANICS, GEODESIGN	Drawing Status: 30% Design	
Date: January 30, 2008	Drawn By: Allan S. Potter, P.E.	Checked by: D&M Reichmuth	For Mt. Rainier National Park	Sheet No. 46	Of 84

Station 240+50- "Big Bite" Washout

Another example of lateral replacement, where the river erodes fine roadbed soil, and leaves behind coarse river bedload.

30% DESIGN- CARBON RIVER ROAD FLOOD DAMAGE REDUCTION MEASURES			By Geomax	Drawing Status: 30% Design	
Date: January 30, 2008	Drawn By: Allan S. Potter, P.E.	Checked by: D&M Reichmuth	For Mt. Rainier National Park	Sheet No. 47	Of 84

Ipsut Washout Section

Road washout west of Ipsut Campground

30% DESIGN- CARBON RIVER ROAD FLOOD DAMAGE REDUCTION MEASURES			By Geomax GEOMORPHOLOGY, GEOMECHANICS, GEODESIGN	Drawing Status: 30% Design	
Date: January 30, 2008	Drawn By: Allan S. Potter, P.E.	Checked by: D&M Reichmuth	For Mt. Rainier National Park	Sheet No. 48	Of 84

Ipsut Campground Bridge Plugged and Road Breached

Bridge

Road breached after log jam formed above bridge opening and water spilled over road.

30% DESIGN- CARBON RIVER ROAD FLOOD DAMAGE REDUCTION MEASURES			By Geomax	Drawing Status: 30% Design	
Date: January 30, 2008	Drawn By: Allan S. Potter, P.E.	Checked by: D&M Reichmuth	For Mt. Rainier National Park	Sheet No. 49	Of 84

Log Jam Above Ipsut Bridge

30% DESIGN- CARBON RIVER ROAD FLOOD DAMAGE REDUCTION MEASURES			By Geomax GEOMORPHOLOGY, GEOMECHANICS, GEODESIGN	Drawing Status: 30% Design	
Date: January 30, 2008	Drawn By: Allan S. Potter, P.E.	Checked by: D&M Reichmuth	For Mt. Rainier National Park	Sheet No. 50	Of 84

Geomax Recommendation Fall 2007-
4 to 6 large downed trees need to be removed to possibly save historical old growth trees in vicinity of Ipsut Ranger Cabin location

30% DESIGN- CARBON RIVER ROAD FLOOD DAMAGE REDUCTION MEASURES			By Geomax	Drawing Status: 30% Design	
Date: January 30, 2008	Drawn By: Allan S. Potter, P.E.	Checked by: D&M Reichmuth	For Mt. Rainier National Park	Sheet No. 51	Of 84

Rock Structure Summary Table

Structure Location- Road Station	Structure Type	Purpose	Structure Height (or Thickness)	Rock Volume/ LF Strucutre (minus voids)	Structure Length	Rock Volume	Extended Keyway Length	Keyway Volume @ 1 CY/LF (minus voids)	Total Rock Quantity at 10% Voids		Remarks
			Feet	Cu. Yds.	Feet	Cy. Yds.	Feet	Cu. Yds.	Cu. Yds.	Tons	
Carbon Entrance	Bank Barb	Redirect Flow from riprap bank				150.0		0.0	150	300	
Carbon Entrance	Bank Barb	Redirect Flow from riprap bank				150.0		0.0	150	300	
Carbon Entrance	Bank Barb	Redirect Flow from riprap bank				150.0		0.0	150	300	
Carbon Entrance	Bank Barb	Redirect Flow from riprap bank				150.0		0.0	150	300	
Carbon Entrance	Culvet Trash Rack	Protect culvert inlet				0.0		0.0	0	0	Culvert Trash Crack
Carbon Entrance	Road Flood Dip	Flood overflow for June Creek culvert	2.0	1.5	50	75.0		0.0	75	150	
Carbon Entrance	Bank Barb	Redirect flow from bank near buildings				150.0	75	75.0	225	450	
Carbon Entrance	Ring Dike Section	Protect entrance buildings	2.5	1.2	100	120.0		0.0	120	240	
Station 42+00	Road Flood Dip	Allow flood waters to cross road	1.5	1.0	50	50.0		0.0	50	100	
152+00	Rock Grade Control	Limit flow to side channel	2.5	1.2	50	60.0		0.0	60	120	
154+00	Rock Grade Control	Limit flow to side channel	2.5	1.2	50	60.0		0.0	60	120	
157+50	Bank Barb	Redirect flow from riprap bank				150.0		0.0	150	300	
159+50	Bank Barb	Redirect flow from riprap bank				150.0		0.0	150	300	
161+50	Bank Barb	Redirect flow from riprap bank				150.0		0.0	150	300	
163+50	Bank Barb	Redirect flow from riprap bank				150.0		0.0	150	300	
166+00	Grade control	Stabilize culvert outlet	2.5	1.2	80	96.0		0.0	96	192	
166+00	Culvert Trash Rack					0.0		0.0	0	0	Culvert trash rack
166+50	Grade Control(2 small structures)	Check head cut east of culvert outlet	2.5	1.0	60	60.0		0.0	60	120	
166+50 to 167+00	Road Flood Dip	Flood overflow for June Creek culvert				0.0		0.0	0	0	
168+00	Road Hump/X-Valley Dike	Block water flow along road	2.0	1.0	60	60.0		0.0	60	120	Allow 50 CY to build hump in road grade
170+00	Road Hump/X-Valley Dike	Block water flow along road	2.0	1.0	60	60.0		0.0	60	120	Allow 50 CY to build hump in road grade
182+00	Road Hump/X-Valley Dike	Block water flow along road	2.0	1.0	70	70.0		0.0	70	140	Allow 50 CY to build hump in road grade
184+00	Road Hump/X-Valley Dike	Block water flow along road	2.0	1.0	125	125.0		0.0	125	250	Allow 50 CY to build hump in road grade
186+00	Bank Barb	Redirect flow from riprap bank				150.0	50	50.0	200	400	
188+00	Bank Barb	Redirect flow from riprap bank				150.0	50	50.0	200	400	
190+00	Bank Barb	Redirect flow from riprap bank				150.0		0.0	150	300	
192+00	Bank Barb	Redirect flow from riprap bank				150.0		0.0	150	300	
194+00	Bank Barb	Redirect flow from riprap bank				150.0		0.0	150	300	
196+00	Bank Barb	Redirect flow from riprap bank				150.0		0.0	150	300	
192+50	Grade Control Culvert Outlet	Protect outlet from being undercut				20.0		0.0	20	40	
192+50	Culvert Trash Rack					0.0		0.0	0	0	Culvert trash rack
198+00	X-Valley Dike	Protect proposed end of road	3.0	2.0	100	200.0		0.0	200	400	
199+00	Flood Dip	Return flow from south channel to river	2.0	1.0	50	50.0		0.0	50	100	
TOTAL QUANTITIES:						3356 CY		175 CY	**3531 CY**	**7062 Tons**	

30% DESIGN- CARBON RIVER ROAD FLOOD DAMAGE REDUCTION MEASURES			By Geomax (GEOMORPHOLOGY, GEOMECHANICS, GEODESIGN)	Drawing Status: 30% Design	
Date: January 30, 2008	Drawn By: Allan S. Potter, P.E.	Checked by: D&M Reichmuth	For Mt. Rainier National Park	Sheet No. 52	Of 84

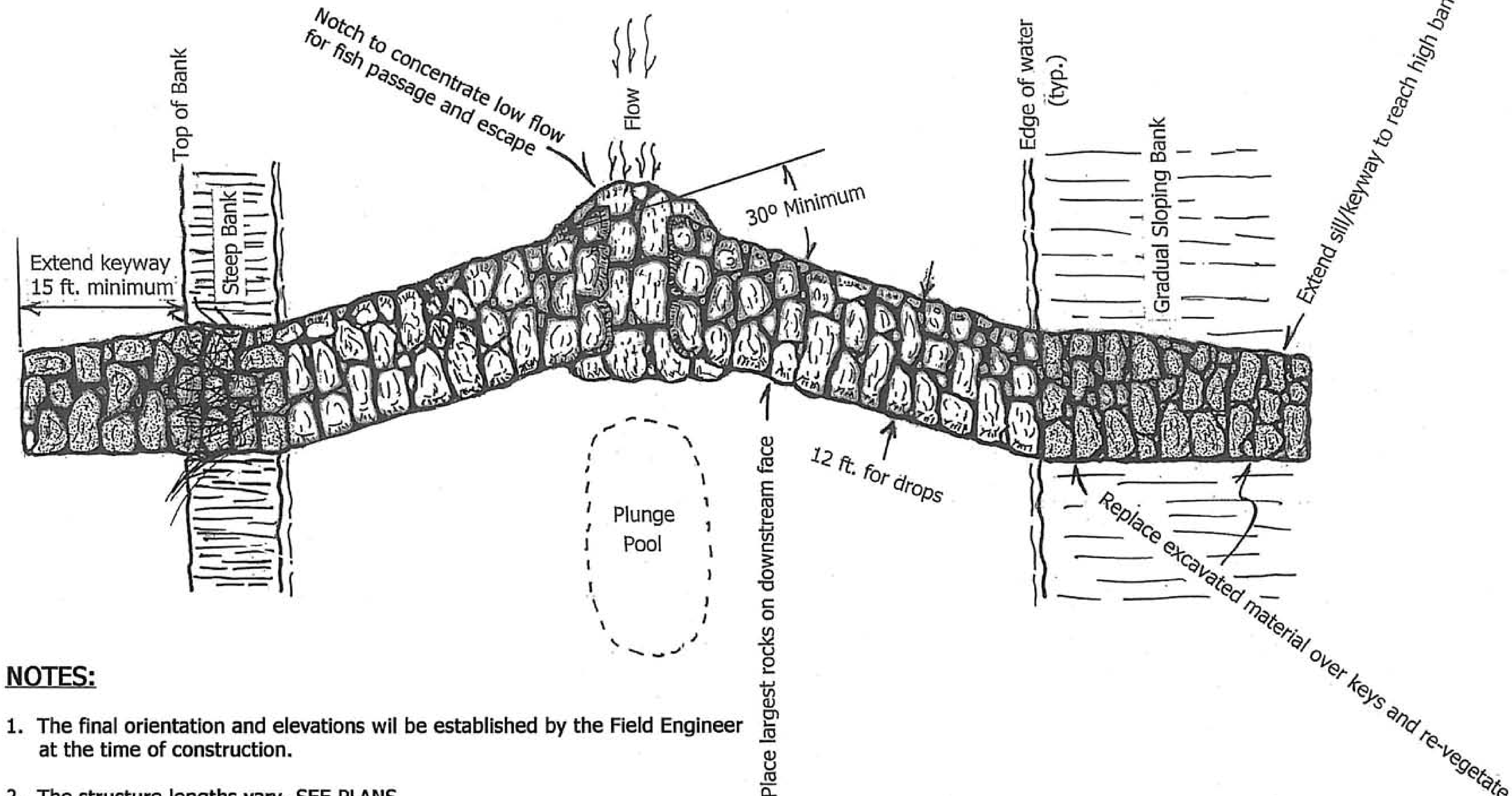
TYPICAL STRUCTURE DETAILS

- Side channel rock grade control structure
- Rock-cored road hump/cross valley dike
- Bank barb
- Roadway flood dip
- Culvert inlet trash rack
- Tree stalk erosion check structure
- Bank stabilization using fallen trees

TYPICAL SIDE CHANNEL ROCK GRADE CONTROL STRUCTURE- PLAN VIEW

Use Rock Gradation "A"

NOT TO SCALE



NOTES:

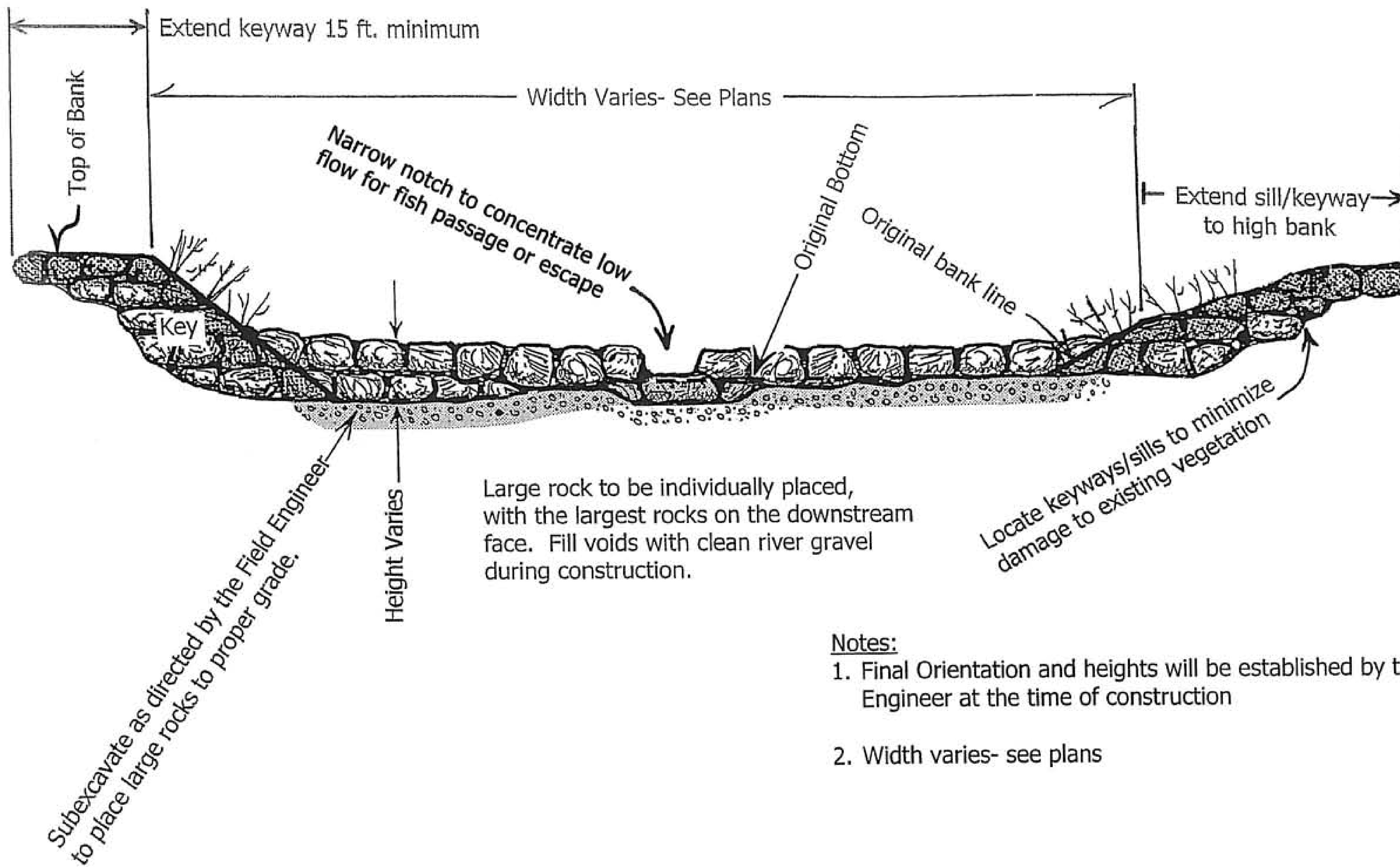
1. The final orientation and elevations wil be established by the Field Engineer at the time of construction.
2. The structure lengths vary- SEE PLANS

30% DESIGN- CARBON RIVER ROAD FLOOD DAMAGE REDUCTION MEASURES			By Geomax	Drawing Status: 30% Design	
Date: January 30, 2008	Drawn By: Allan S. Potter, P.E.	Checked by: D&M Reichmuth	For Mt. Rainier National Park	Sheet No. 54	Of 84

TYPICAL SIDE CHANNEL GRADE CONTROL STRUCTURE CROSS-SECTION

Rock Gradation "A"

NO SCALE



Large rock to be individually placed, with the largest rocks on the downstream face. Fill voids with clean river gravel during construction.

Notes:

1. Final Orientation and heights will be established by the Field Engineer at the time of construction
2. Width varies- see plans

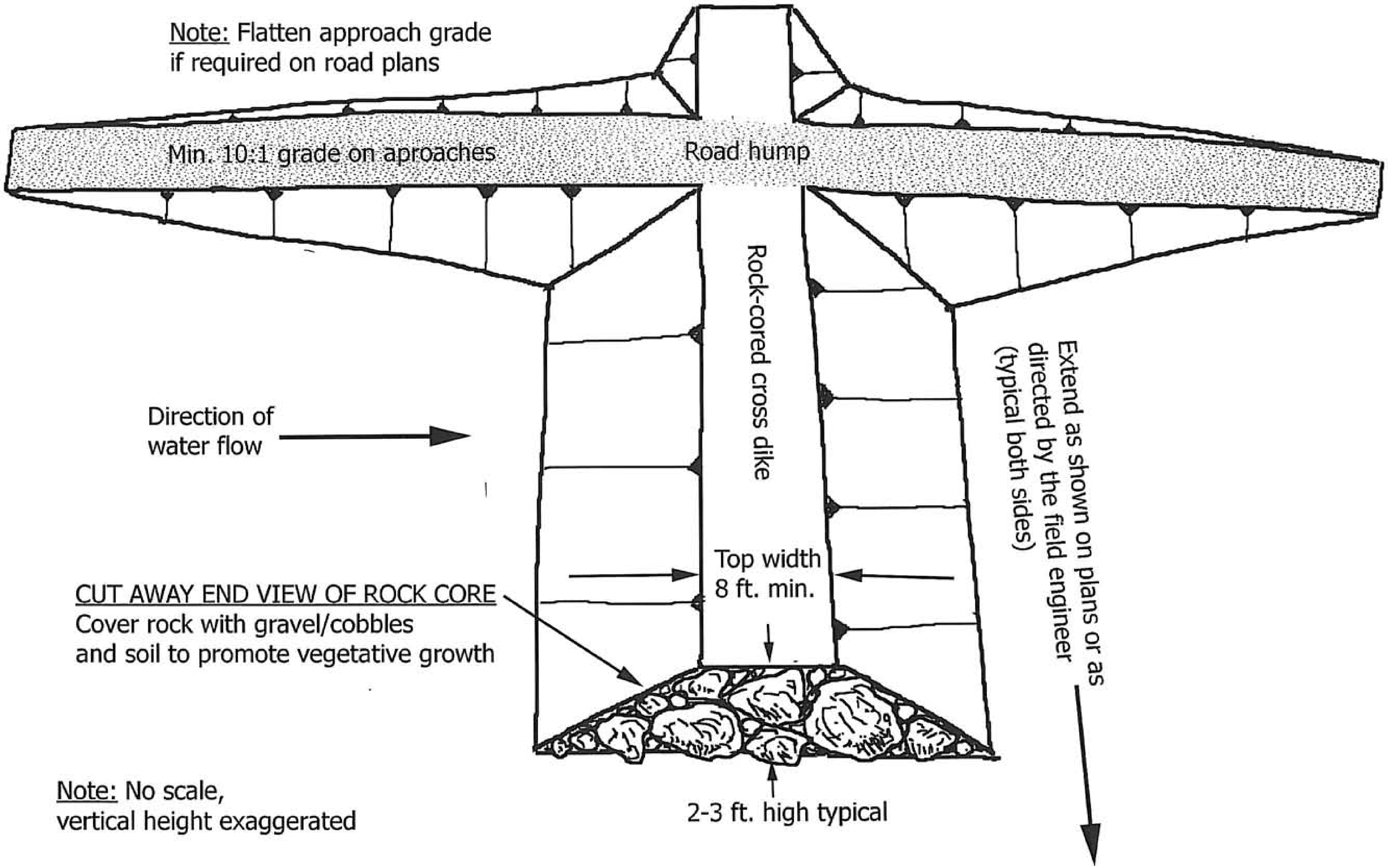
30% DESIGN- CARBON RIVER ROAD FLOOD DAMAGE REDUCTION MEASURES			By Geomax	Drawing Status: 30% Design	
Date: January 30, 2008	Drawn By: Allan S. Potter, P.E.	Checked by: D&M Reichmuth	For Mt. Rainier National Park	Sheet No. 55	Of 84

PHOTO OF SIMILAR GRADE CONTROL STRUCTURE (IN AN ACTIVE CHANNEL)

Toppenish Creek- White Swan, Washington

30% DESIGN- CARBON RIVER ROAD FLOOD DAMAGE REDUCTION MEASURES			By Geomax GEOMORPHOLOGY, GEOMECHANICS, GEODESIGN	Drawing Status: 30% Design	
Date: January 30, 2008	Drawn By: Allan S. Potter, P.E.	Checked by: D&M Reichmuth	For Mt. Rainier National Park	Sheet No. 56	Of 84

TYPICAL ROCK-CORED ROAD HUMP/CROSS VALLEY DIKE- Use Rock Gradation "B"



30% DESIGN- CARBON RIVER ROAD FLOOD DAMAGE REDUCTION MEASURES			By Geomax	Drawing Status: 30% Design	
Date: January 30, 2008	Drawn By: Allan S. Potter, P.E.	Checked by: D&M Reichmuth	For Mt. Rainier National Park	Sheet No. 57	Of 84

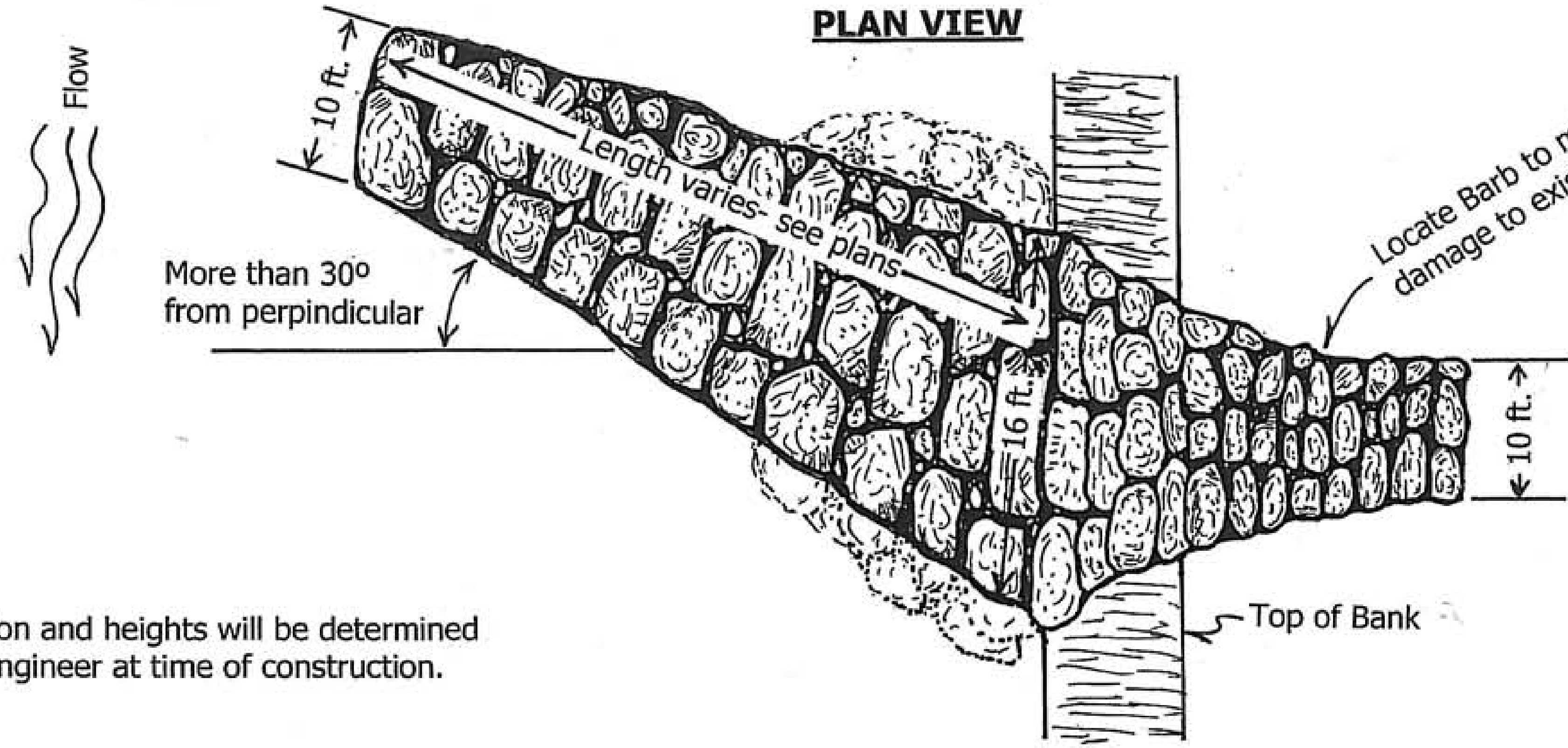
PHOTO OF SIMILAR ROAD HUMP/CROSS VALLEY DIKE

Toppenish Creek- White Swan, Washington

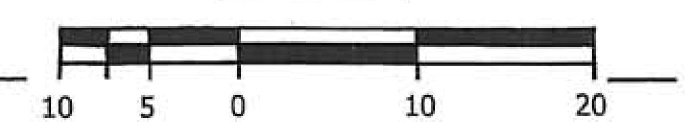
30% DESIGN- CARBON RIVER ROAD FLOOD DAMAGE REDUCTION MEASURES			By Geomax	Drawing Status: 30% Design	
Date: January 30, 2008	Drawn By: Allan S. Potter, P.E.	Checked by: D&M Reichmuth	For Mt. Rainier National Park	Sheet No. 58	Of 84

TYPICAL ROCK BANK BARB (use Rock Gradation "A")

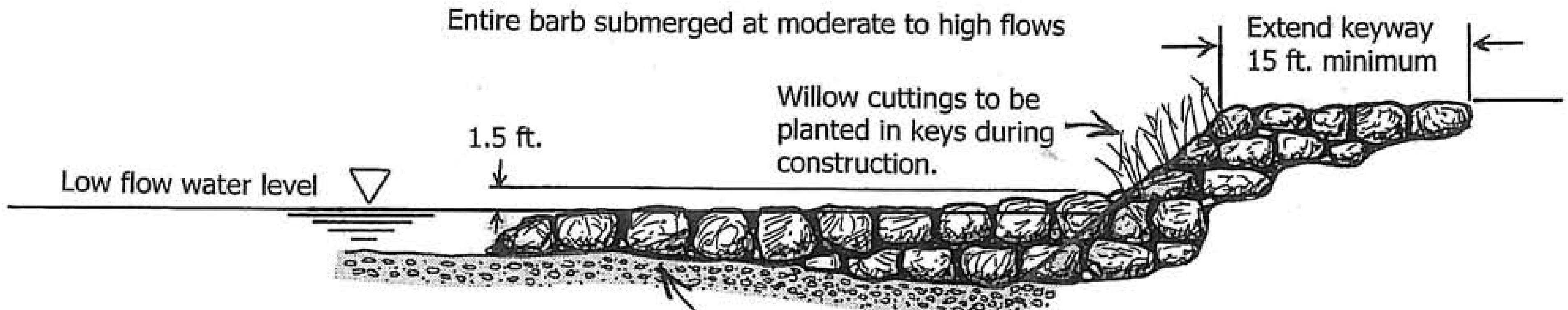
PLAN VIEW



Note:
Final orientation and heights will be determined by the Field Engineer at time of construction.



CROSS SECTION-LOOKING UPSTREAM



See Technical Specifications for additional instructions

Large rock to be individually placed, with the largest rocks on the downstream face. Fill voids with clean river gravel during construction.

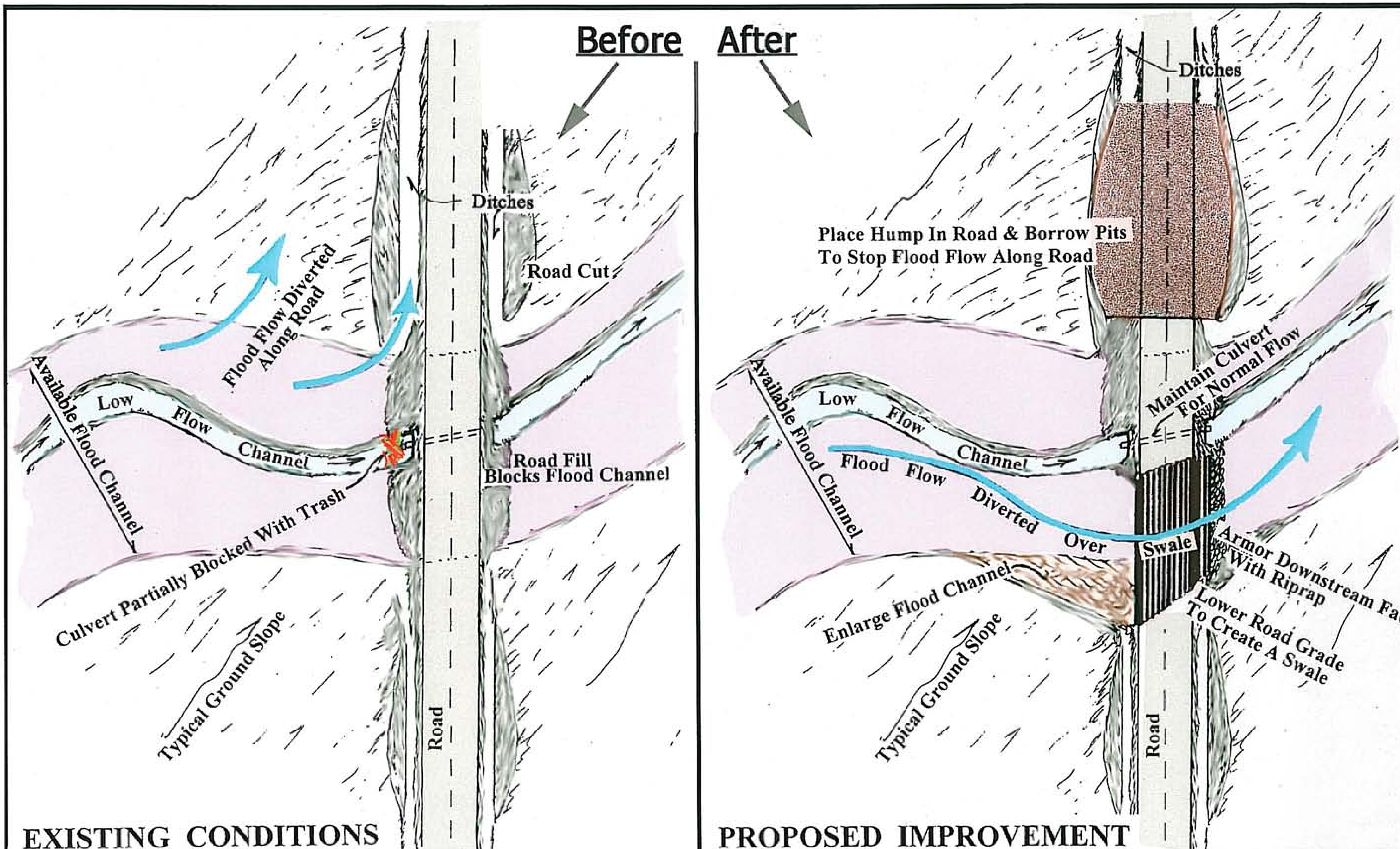
30% DESIGN- CARBON RIVER ROAD FLOOD DAMAGE REDUCTION MEASURES			By Geomax	Drawing Status: 30% Design	
Date: January 30, 2008	Drawn By: Allan S. Potter, P.E.	Checked by: D&M Reichmuth	For Mt. Rainier National Park	Sheet No. 59	Of 84

PHOTO OF SIMILAR ROCK BANK BARB

Teanaway River- Cle Elum, Washington

30% DESIGN- CARBON RIVER ROAD FLOOD DAMAGE REDUCTION MEASURES			By Geomax GEOMORPHOLOGY, GEOMECHANICS, GEODESIGN	Drawing Status: 30% Design	
Date: January 30, 2008	Drawn By: Allan S. Potter, P.E.	Checked by: D&M Reichmuth	For Mt. Rainier National Park	Sheet No. 60	Of 84

TYPICAL ROADWAY FLOOD DIP- Rock Gradation "B"



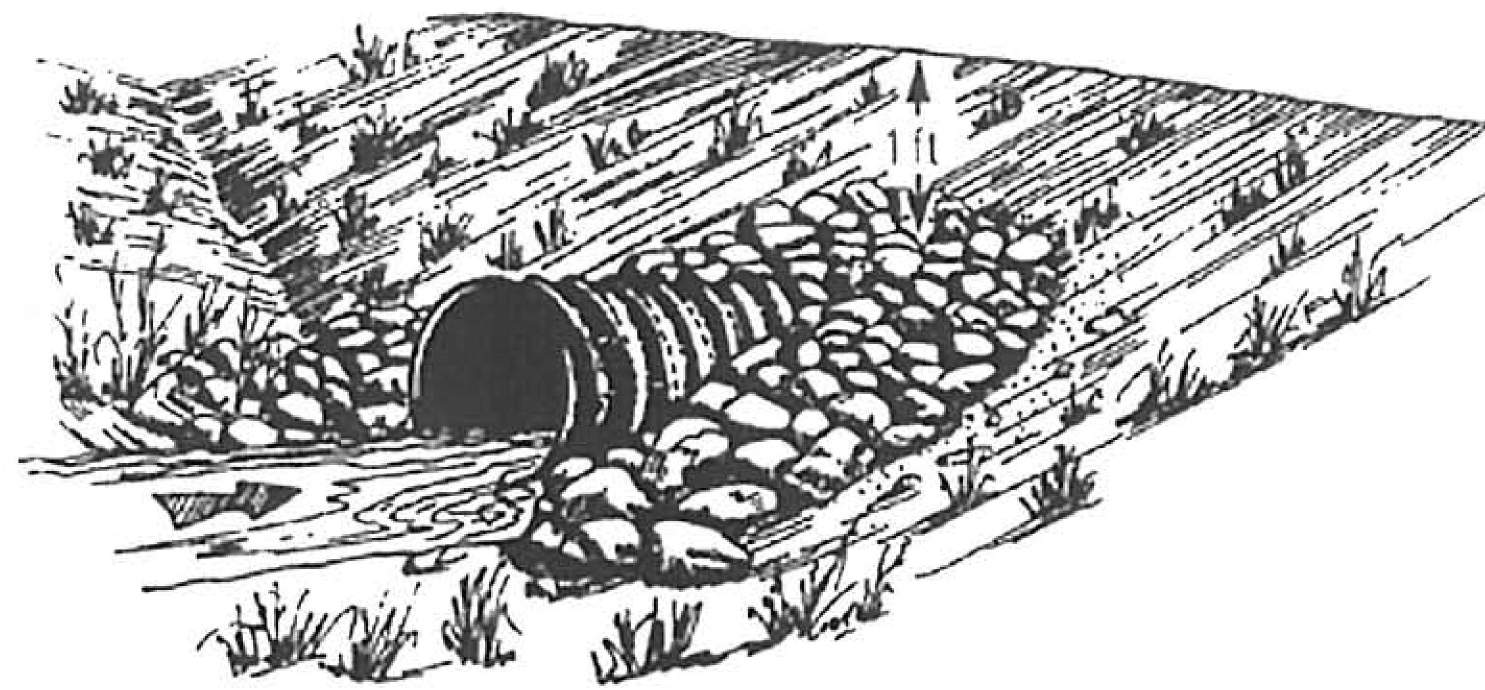
30% DESIGN- CARBON RIVER ROAD FLOOD DAMAGE REDUCTION MEASURES			By Geomax	Drawing Status: 30% Design	
Date: January 30, 2008	Drawn By: Allan S. Potter, P.E.	Checked by: D&M Reichmuth	For Mt. Rainier National Park	Sheet No. 61	Of 84

PHOTO OF SIMILAR ROADWAY FLOOD DIP

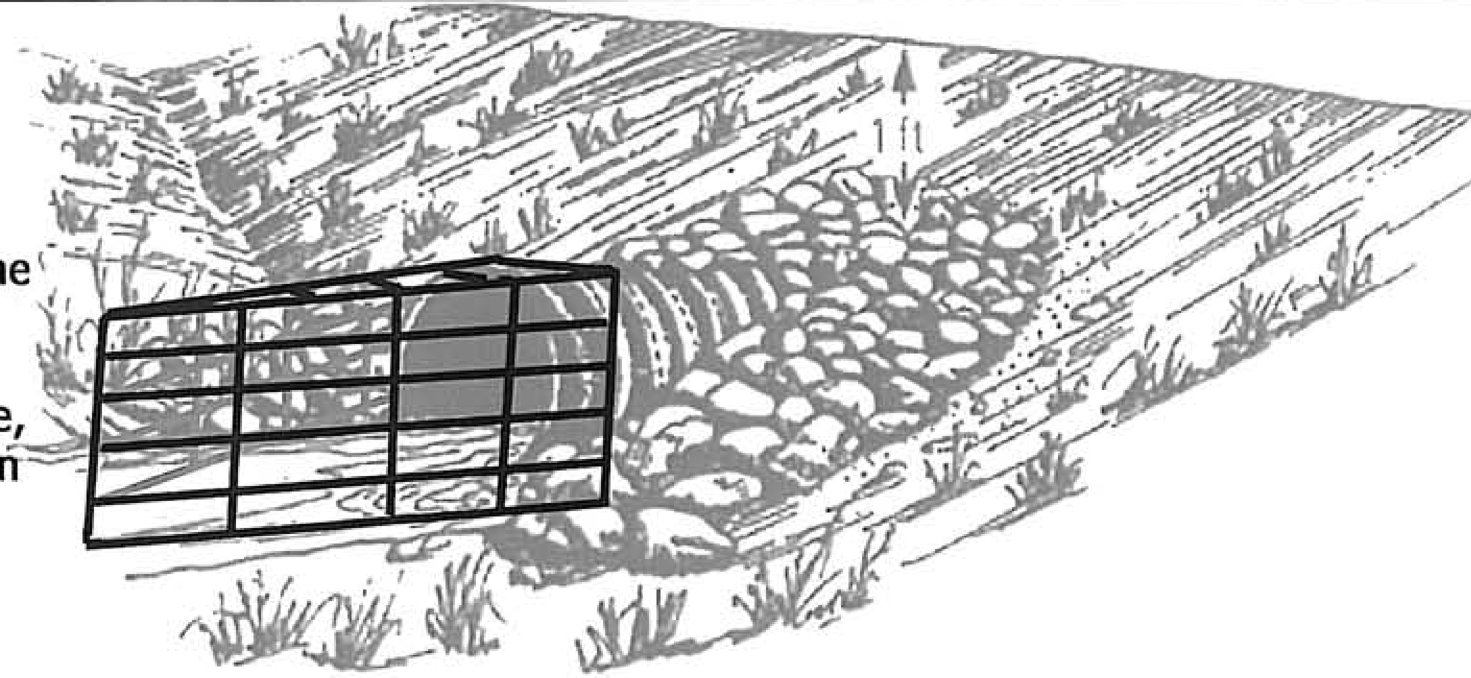
30% DESIGN- CARBON RIVER ROAD FLOOD DAMAGE REDUCTION MEASURES			By Geomax	Drawing Status: 30% Design	
Date: January 30, 2008	Drawn By: Allan S. Potter, P.E.	Checked by: D&M Reichmuth	For Mt. Rainier National Park	Sheet No. 62	Of 84

TYPICAL CULVERT INLET TRASH RACK

WITHOUT TRASHRACK-
Debris can quickly span and plug culvert inlet



WITH WEDGE-SHAPED TRASH RACK ADDED-
Some debris pushed to the sides by the force of the water. If a jam develops on the front of the wedge, some water can still strain through and reach the culvert inlet.



30% DESIGN- CARBON RIVER ROAD FLOOD DAMAGE REDUCTION MEASURES			By Geomax	Drawing Status: 30% Design	
Date: January 30, 2008	Drawn By: Allan S. Potter, P.E.	Checked by: D&M Reichmuth	For Mt. Rainier National Park	Sheet No. 63	Of 84

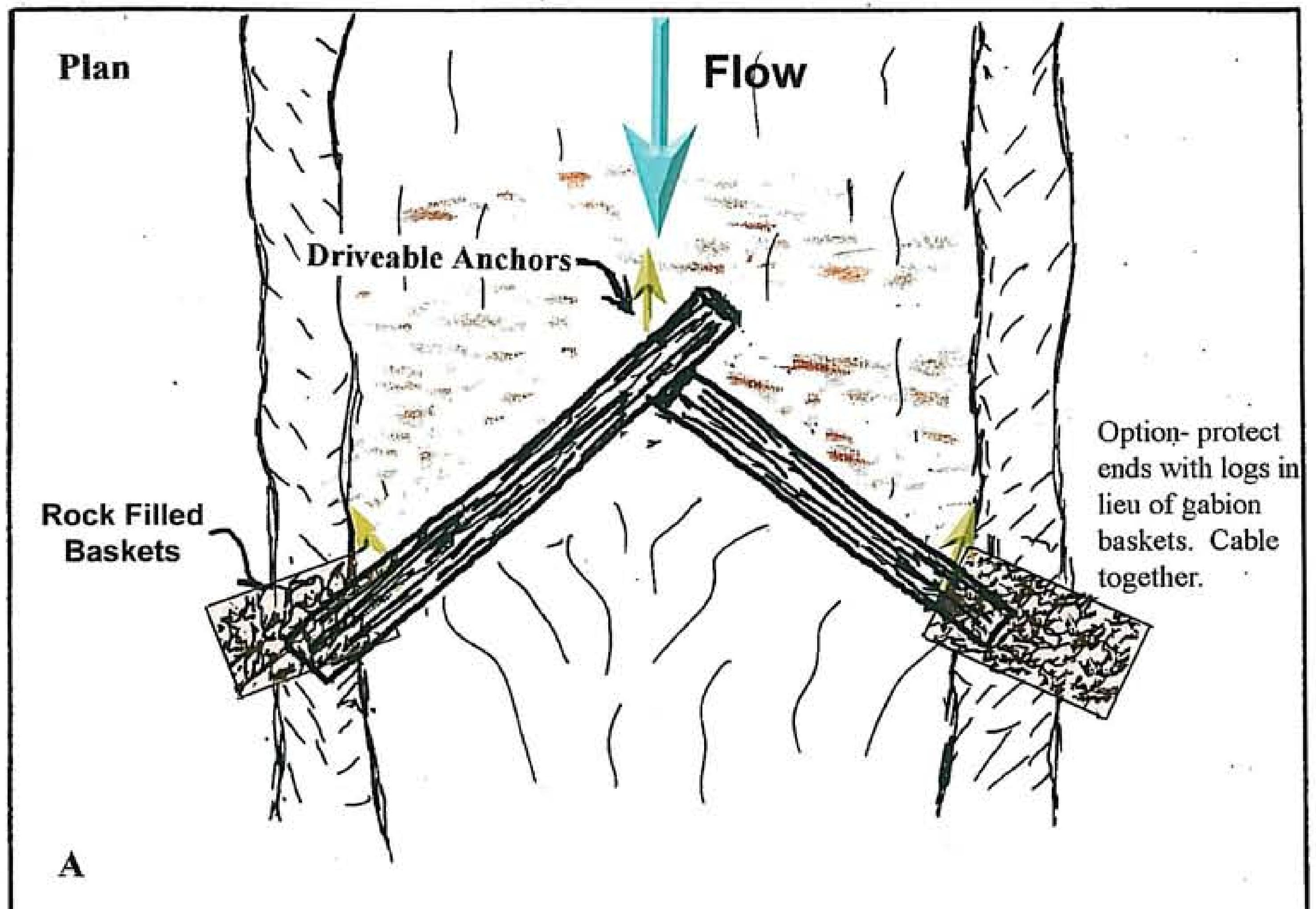
PHOTO OF SIMILAR TRASH RACK CONSTRUCTED BY WSDOT OR FOREST SERVICE

Located south of Randall, WA

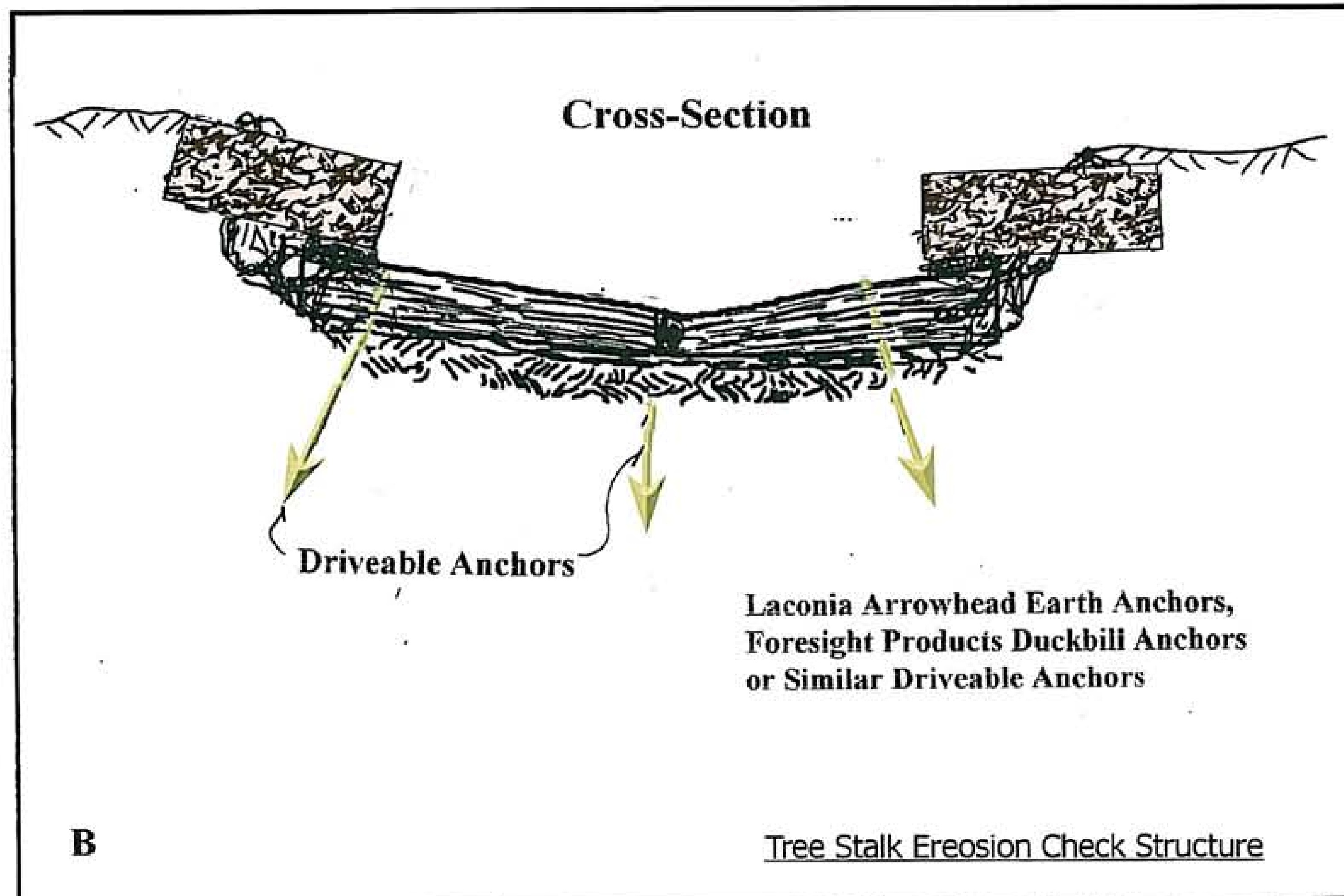
30% DESIGN- CARBON RIVER ROAD FLOOD DAMAGE REDUCTION MEASURES			By Geomax GEOMORPHOLOGY, GEOMECHANICS, GEODESIGN	Drawing Status: 30% Design	
Date: January 30, 2008	Drawn By: Allan S. Potter, P.E.	Checked by: D&M Reichmuth	For Mt. Rainier National Park	Sheet No. 64	Of 84

TYPICAL TREE STALK EROSION CHECK STRUCTURE

TOP VIEW



CROSS SECTION

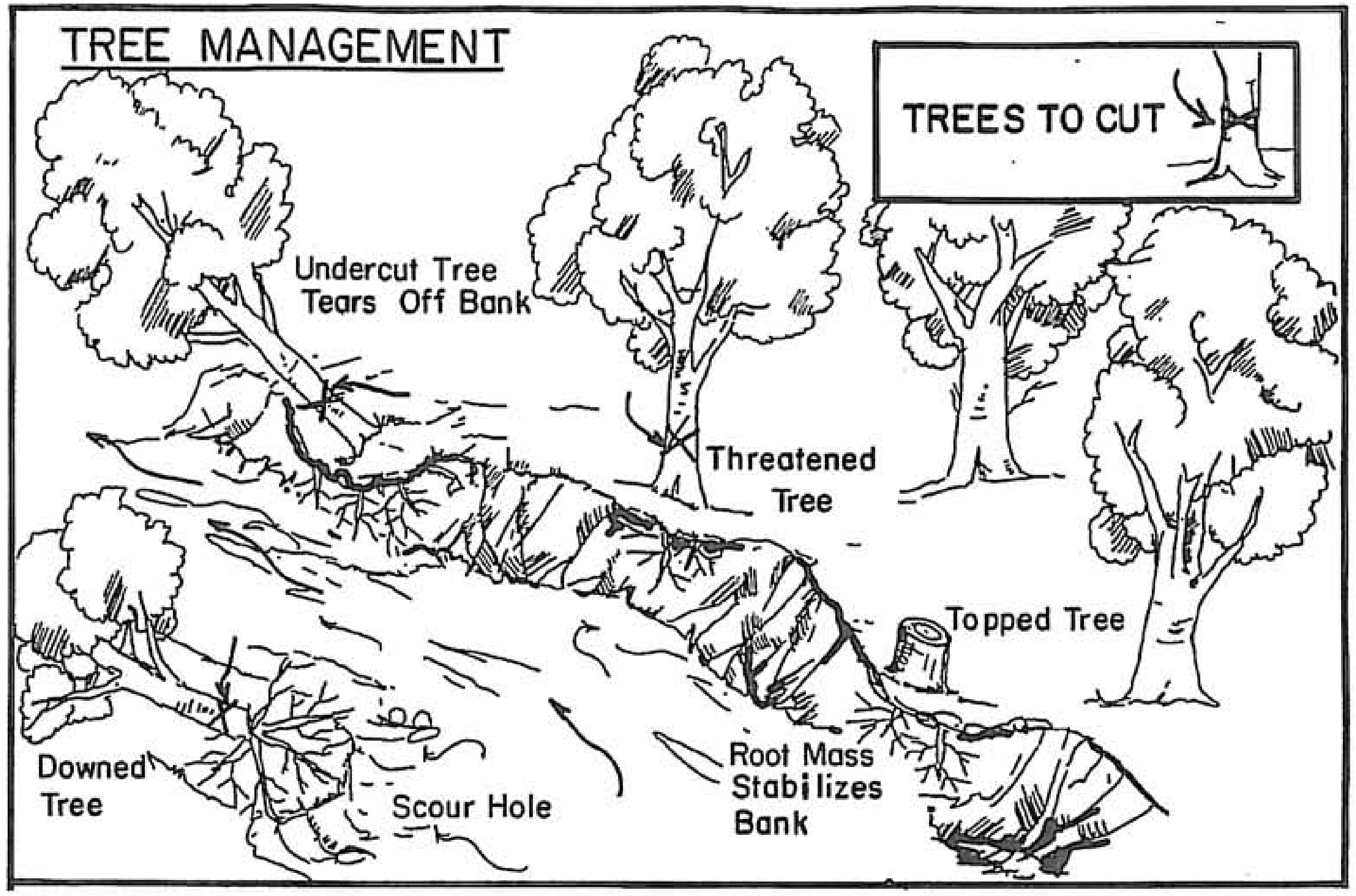


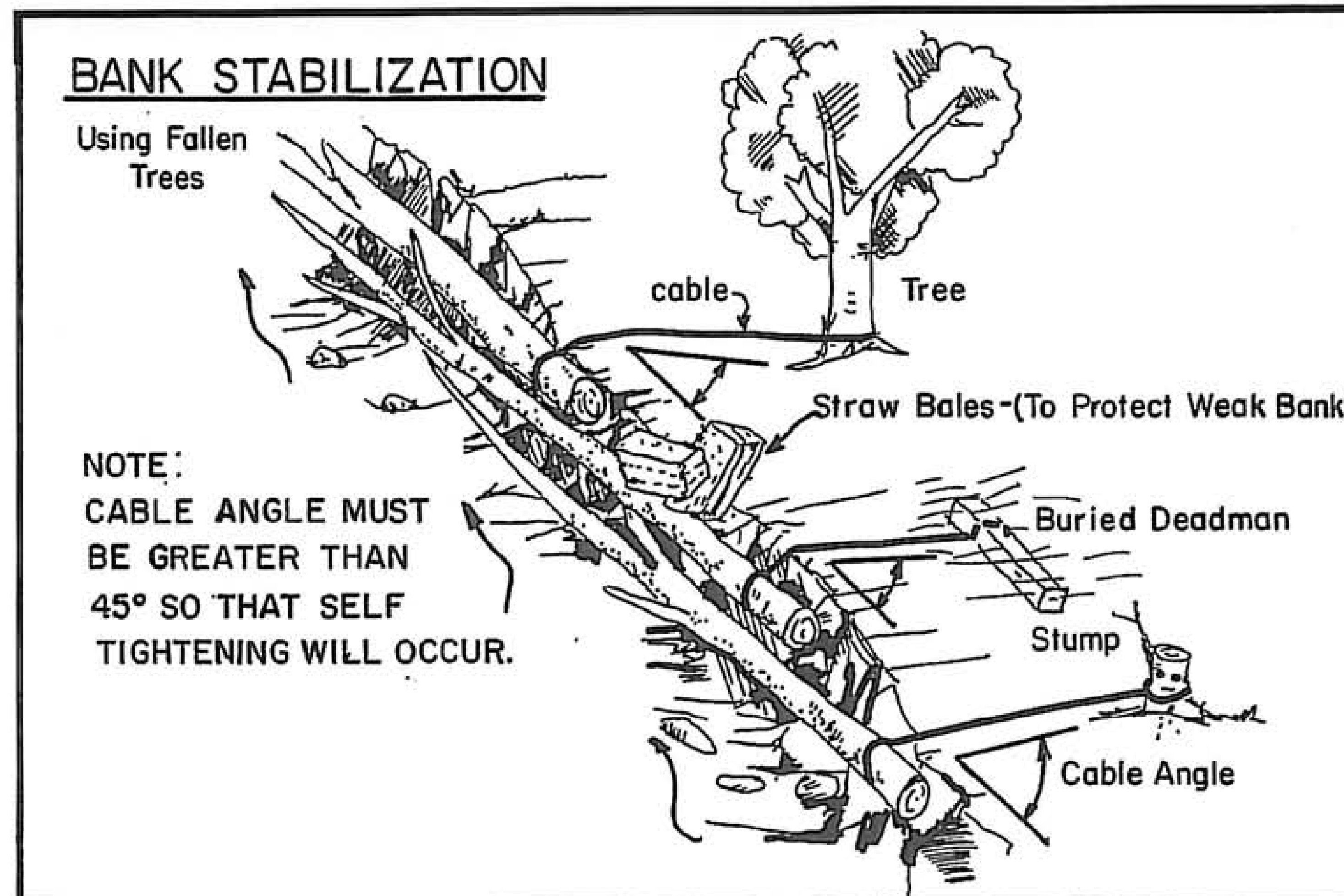
30% DESIGN- CARBON RIVER ROAD FLOOD DAMAGE REDUCTION MEASURES			By Geomax	Drawing Status: 30% Design	
Date: January 30, 2008	Drawn By: Allan S. Potter, P.E.	Checked by: D&M Reichmuth	For Mt. Rainier National Park	Sheet No. 65	Of 84

PHOTO OF CARBON RIVER TREE STALK EROSION CHECK STRUCTURE FALL 2007

<table>
<tr><td colspan="3">30% DESIGN- CARBON RIVER ROAD
FLOOD DAMAGE REDUCTION MEASURES</td><td>By Geomax
GEOMORPHOLOGY, GEOMECHANICS, GEODESIGN</td><td colspan="2">Drawing Status:
30% Design</td></tr>
<tr><td>Date:
January 30, 2008</td><td>Drawn By:
Allan S. Potter, P.E.</td><td>Checked by:
D&M Reichmuth</td><td>For
Mt. Rainier National Park</td><td>Sheet No.
66</td><td>Of
84</td></tr>
</table>

BANK STABILIZATION USING FALLEN TREES





30% DESIGN- CARBON RIVER ROAD FLOOD DAMAGE REDUCTION MEASURES			By Geomax	Drawing Status: 30% Design	
Date: January 30, 2008	Drawn By: Allan S. Potter, P.E.	Checked by: D&M Reichmuth	For Mt. Rainier National Park	Sheet No. 67	Of 84

CONSTRUCTION SPECIFICATIONS FOR ROCK STRUCTURES

PART 1 -- **GENERAL**

1.1 THE REQUIREMENT

A. The CONTRACTOR shall construct all rock structures shown on the drawings in accordance with these specifications.

B. Provide equipment and operator meeting the requirements of this specification. Coordinate with the ENGINEER for the installation of the rock structures.

1.2 REFERENCES

A. Following documents and others referenced therein form part of the Specification to extent designated in this Section.

American Society for Testing and Materials (ASTM)

C 127 Test Method for Apparent Specific Gravity

C 535 Test Method for Abrasion

American Association of State Highway Transportation Officials (AASHTO)

AASHTO 103 Test Method for Freeze Thaw Loss

PART 2 -- **PRODUCTS**

2.1 MATERIALS - STRUCTURAL ROCK

A. Rock for structures shall be sound and durable against disintegration under conditions encountered during transportation, placement and operation. Rock shall be hard, tenacious and otherwise of a suitable quality to ensure permanency. Rock showing signs of deterioration, cracks, entrapped air or other defects shall not be used. Rocks shall be angular, and without slabby pieces (i.e. each piece having a longest dimension not greater than three times its' shortest dimension).

1. Two different gradations of structural rock will be used on the project, Gradation "A" and Gradation "B". The plans and details will identify which gradation shall be used for each structure. The requirements of the two different gradations for structural rock are shown in the following tables. The approximate weight assumes a rectangular shape with average dimensions as shown in each table. A unit weight of 160#/ft.^{3} was used to calculate the approximate minimum rock weight for each size range.

ROCK GRADATION "A"

% Larger Than Given Size by Weight	Average Rock Dimension (Feet)	Approximate Minimum Rock Weight(Pounds)
0	5	18,000
30	4	10,000
70	3	4,200
80	2	1,300
100	1	160

ROCK GRADATION "B"

% Larger Than Given Size by Weight	Average Rock Dimension (Feet)	Approximate Minimum Rock Weight(Pounds)
0	3.5	7,000
30	3	4,200
60	2	1,300
100	1	160

Note: the Average Rock Dimension is defined as the average of the height, length and width, measured in perpendicular directions. The largest dimension shall not be more than three (3) times the smallest dimension.

2. Concrete masonry, concrete pavement or other concrete products may not be used for structural rock.

3. **Test Requirements** - rocks shall conform to the following requirements:

   a. Apparent Specific Gravity- minimum 2.6 per ASTM C-127

   b. Maximum Percent Abrasion- 45% per ASTM C-535

   c. Freeze-thaw loss- maximum 10 percent after 12 cycles per AASHTO 103 Procedure A

2.2 MISCELLANEOUS FILLER ROCK

A. Voids in the rock structures shall be filled, as directed by the ENGINEER, with clean gravel and cobbles.

PART 3 - EXECUTION

2.3 COORDINATION AND SAFETY REQUIREMENTS

A. Construction of the grade control structures requires close coordination with the ENGINEER, who will provide continuous technical input during rock placement activities.

B. The CONTRACTOR is solely responsible for maintaining safe working conditions near the equipment and for the safe operation of the equipment. If at any time the CONTRACTOR or his operator feels that instructions given by the ENGINEER or his representative would create a potentially unsafe working condition or would jeopardize the equipment, the ENGINEER or his representative must be immediately notified of the problem. The ENGINEER will then work with the CONTRACTOR to find an acceptable alternative method to complete the task.

C. The CONTRACTOR is solely responsible for complying with all applicable Federal and State safety regulations.

D. The CONTRACTOR shall assume full financial and legal responsibility for any damage caused by his machinery including, but not limited to, the following:

1. Any equipment becoming stuck due to unstable ground or operator error

2. Any equipment which tips over due to unstable ground or operator error

3. Any environmental damage due to fuel, hydraulic, lubricant or coolant leaks

4. Any damage to existing culverts, bridges, paved roadways, irrigation structures or other property caused during rock delivery or construction.

2.4 ENVIRONMENTAL PROTECTION REQUIREMENTS

A. The CONTRACTOR shall comply with all applicable Federal, State and local laws and regulations, as well as the provisions of the government permits applicable to this project.

B. The CONTRACTOR shall provide environmental protective measures and procedures to prevent and control pollution, limit habitat disruption, and correct environmental damage that occurs during construction.

2.5 MINIMUM EQUIPMENT REQUIREMENTS

A. Because time is of the essence, all equipment utilized on this project, whether on-site or off-site (i.e. trucks, quarry processing equipment, etc.) shall be fully functional and capable of performing the necessary operations in an efficient and timely manner.

B. Sufficient equipment shall be available at each critical job component (i.e. quarry operations, material hauling, in-stream placement, etc.) to ensure that time delays are kept to an absolute minimum. If excessive delays are encountered, the GEOMAX engineer shall have sufficient grounds to either require additional equipment be added to eliminate the bottleneck or stop hourly payments for the equipment that is idled.

C. Service, maintenance and repairs shall be current and in accordance with the manufactures' recommendations for all equipment both on-site and off-site used on the project. Equipment components (bucket teeth, tracks, hoses, etc.) showing excessive wear shall be immediately repaired or the entire machine be replaced. Equipment showing excessive wear is sufficient grounds for the GEOMAX engineer to require repair or replacement of that machine.

D. Manufacturer's original safety equipment shall be operational, including control systems, mirrors, windshield washers/wipers, and anti-vandalism access protection (locking access doors, panels, fluid filler caps, battery box cover, etc.) on all machines used on the job. Safety equipment deficiencies are sufficient grounds for the GEOMAX engineer to require repair or replacement of that machine.

E. All equipment working in or near the water shall be free from leaks of fuel, hydraulic fluid, and oil. The hydraulic systems shall utilize a biodegradable, non-toxic, "fish friendly" hydraulic fluid, meeting the toxicity requirements of the Environmental Protection agency and the US Fish and Wildlife Service. All equipment shall be cleaned with high pressure water/steam prior to delivery to remove all surface oil, grease, dirt and plant matter. Proper cleaning is especially critical, to prevent the spread of seeds of noxious and/or non-native vegetation into the riparian corridor.

F. All equipment to be used on the job shall be made available for inspection by Geomax personnel (or a designated representative) prior to start of work to ensure initial compliance with the hereinabove stated specifications.

2.6 PLACEMENT EQUIPMENT AND OPERATOR

A. The CONTRACTOR shall provide a minimum of one hydraulic excavator with an opposable hydraulic thumb suitable for placement of individual rocks. The excavator(s) shall weigh a minimum of 85,000 pounds. The operator(s) must be skilled at picking large, individual rocks and placing them in the structures.

B. The ENGINEER may reject an excavator or operator at any time if any of the requirements of this specification are not met. The CONTRACTOR shall then promptly replace the equipment and/or operator without additional charge.

2.7 CONSTRUCTION OF ROCK STRUCTURES

A. The required stream grade control structures are shown on the plans. The final location, orientation and height will be determined in the field by the ENGINEER.

B. The approximate sequence for constructing each type of rock structure is included in the SEQUENCE OF CONSTRUCTION FOR ROCK STRUCTURES below.

C. Each stone shall be individually set in place at essentially its final position using the excavator aided by its opposable thumb. At the Engineer's direction, some of the stones shall be picked up and repositioned. Stream bed excavation shall only be large enough to accommodate each rock and maintain surface grade. Excavated material and water shall be sprinkled over the structure to form an interlocking network with the placed stones. Excess material shall be gently deposited upstream of the structure or wasted as directed by the ENGINEER. Rocks shall normally be oriented such that the flattest side is located on the bottom and the rock is most stable. The largest available stones usually are placed along the downstream face of the structure. Adjacent stones shall be set in contact with each other such that the voids between the stones are as small as the character of the stone will permit. Drops shall slope downward from the water's edge to an in-stream low point or notch as directed by the ENGINEER.

D. It should be anticipated that some re-handling of the stones after initial placement may be required to achieve correct slopes, grades, elevations, position, and water surface profile.

E. Under no circumstances shall any structure be left in a half finished state overnight unless approved by the ENGINEER.

F. Moving stones within the stream by drifting or rolling down the bank normally will not be permitted. Stones shall not be dropped from a height of greater than one foot while building structures.

SEQUENCE OF CONSTRUCTION FOR ROCK STRUCTURES

Sequence for DROP STRUCTURES on side channels

a) Excavate the first keyway in the bank nearest the rock stockpile.

b) Place rock along the specified alignment, proceeding out from the key. Subexcavate as directed by the Engineer to place large rocks to desired line and grade.

c) Excavate keyway in the far bank.

d) Complete the installation by dressing up the key areas and upper banks.

e) Extend keyways as directed to reach a stable end point. Extended keyways are normally constructed by placing the rock on top of the ground with minimal excavation, but may be constructed flush with the ground if directed by the field engineer. In that case construct in accordance with sequence for SILLS.

Sequence for SILLS

a) Sills shall be constructed in a similar manner as drop structures, except that the top elevation of the finished structure follows the existing ground or stream bed surface or else is placed approximately level underground.

b) Clear vegetation from the sill location. Clearing of vegetation shall be limited to areas that are absolutely necessary for construction of the project.

c) Excavate the trench to the line, depth and grade specified or as directed by the Engineer.

d) Place rocks in the trench. Adjust rocks to minimize the spaces between the rocks. Fill void spaces between rocks with excavated material.

e) Dispose of excavated material as directed by the Engineer.

Sequence for BANK BARBS

a) Excavate for the keyway near the river's edge. Place structural rock and willow cuttings in the key and backfill voids with finer material that will promote vegetative growth.

b) Place rock along the specified barb alignment, proceeding out from the key. Move the excavator onto the top of the barb and continue to place large rocks to desired line and grade.

c) Complete the installation by dressing up the key area and upper bank.

Sequence for ROAD FLOODWAY DIPS, and ROAD HUMPS/CROSS VALLEY DIKES

f) Place the rock to the specified grade, excavating as required to meet the design elevations.

g) Continue placing the rock on the specified alignment, with the largest rock seated on the downstream edge.

h) Cover the rock with gravel, cobbles and soil (outside of the road prism). Smooth and blend with the surrounding ground. Dress side slopes to grade shown on drawings.

APPENDIX "A"

Excerpts from 1997 report

GEOLOGIC HAZARD AND FLOODPLAIN MANAGEMENT

By National Park Service geologist John Riedel

GEOLOGIC HAZARD
and FLOODPLAIN MANAGEMENT

Mount Rainier General Management Plan
August 1997

Jon L. Riedel
National Park Service Geologist

regulatory floodplains. As a result, detailed floodplain studies were undertaken at Longmire, Carbon Entrance and Ipsut Campground. A US Geological Survey floodplain study (Nelson, 1986) was used for floodplain management at Sunshine Point Campground.

Table 1. Application of the Floodplain Management Guideline (NPS, 1993) using preliminary floodplain assessments at developed sites in Mount Rainier National Park.

Excepted Actions	Outside Regulatory Floodplain	Inside Regulatory Floodplain*
Kautz Creek	White River Entrance/Housing	Longmire Complex
Falls Creek Picnic Area	Ohanapecosh Housing	Carbon Entrance Housing
Nahunta Falls Picnic Area	Tahoma Woods Housing	Ipsut Campground Housing
Narada Falls Overlook	Sunrise	
Box Canyon Picnic Area	Paradise	
Box Canyon Overlook	Coug. Rock Camp Tender House	
Stevens C Ent/G Patriarchs	White R. Camp Tender House	
Chinook Pass Picnic Area	Nisqually Entrance Housing	
Camp Muir	Mowich Lake Campground	
Camp Schurman	Sunshine Point CG	

* following preliminary floodplain assessment (these sites were later studied in detail).

Detailed floodplain studies included site surveys and construction of hydraulic models to assess flood hazards and conditions, and to map floodplain boundaries. The surveys also provided valuable information on floodplain topography that was very useful for geologic hazard management at these sites.

Typical floodplain mapping techniques use hydraulic models that assume the bed and banks of the stream are stationary. Most larger stream channels at Mount Rainier are unstable, as generally indicated by their braided channel pattern and eroding banks. In valleys throughout the park, deposition of glacial sediments by floods and debris flows is the primary cause of stream channel instability. Channel deposition rates on three rivers were investigated to determine how unstable these stream beds are, and ultimately to determine how long typical floodplain studies are accurate.

On the White River in the early 1960's, Fahnestock (1963) measured stream deposition in a reach 1.5 miles (2.4 km) below the Emmons Glacier. He found a net deposition of 1.08 ft (33 cm) in 2 years. The bed of Tahoma Creek between river mile three and six (km 4.8 - 9.7) deposited an average of 6.6 ft (201 cm) in 6 years, following increased glacier outburst activity from South Tahoma Glacier (Walder and Driedger, 1994).

Table 3. Range in approximate arrival times for debris flows from the summit of Mount Rainier to 23 development sites. Note that flows initiated below the summit could arrive earlier than the times given. Debris flow velocities taken from Pierson (Personal Communication, 1995).

Site	Distance (mi (km))	Arrival (minutes)
White River Entrance	11.1 (17.9)	14-38
Sunrise Visitor Center	10.9 (17.6)	N/A
White River Campground	6.8 (11.0)	6-21
Carbon Entrance	14.3 (23.0)	20-53
Falls Creek Picnic Area	12.4(20.0)	17-44
Ipsut Campground	9.9 (16.0)	12-34
Mowich Lake Campground	8.0 (12.8)	N/A
Tahoma Woods	24.7 (39.7)	51-106
Nisqually Entrance	14.7 (23.6)	22-55
Sunshine Point Campground	14.3 (23.0)	21-53
Kautz Creek	9.3 (14.9)	11-30
Longmire	8.7 (14.0)	10-28
Cougar Rock Campground	7.0 (11.3)	6-22
Nahunta Falls Picnic Area	4.7(7.6)	4-14
Paradise Visitor Center	5.3 (8.5)	N/A
Narada Falls Overlook	5.3(8.5)	N/A
Box Canyon Picnic Area	8.5(13.7)	10-28
Box Canyon Overlook	8.3(13.3)	9-25
Stevens Canyon Ent/Grove of Patriarchs	10.4(16.8)*	13-36
Ohanapecosh	12.4 (20)*	17-44
Chinook Pass Picnic Area	11.4(18.3)	N/A
Camp Schurman	2.6(1.6)	1-4
Camp Muir	2.5(1.6)	1-4

*Distance from Little Tahoma Peak.
N/A sites on ridges unlikely to be inundated by debris flow

by Crandell and Hoblitt (1986) and Hoblitt and others (1995). Maps for tephra fallout hazard by Hoblitt and others (1995) are not detailed enough to distinguish between park sites. This is due to the fact that Mount Rainier is within tephra fallout zones from several other Cascade Range

PART III-A. Results of the Risk Analysis

The results of the risk analysis are presented below. Sources for map information are listed with each component of the risk equation. Table 4 provides the matrix used to calculate individual scores. Table 5 is a ranking of hazard scores by site, while Table 6 presents the rank of site risk scores.

$$\text{Hazard} = (a) \times (b) \times (c) \times (d) \times (e)$$

(a) Debris flows inundation level and frequency. Sources: Scott and others (1992), and Scott and Vallance (1995). If a site is in case III inundation zone, it is also in the other debris flow hazard zones.

SCORE	INDICATOR	SITE
1	OUTSIDE DEBRIS FLOWS ZONE	Mowich Lake Campground Sunrise Visitor Center Paradise Visitor Center Narada Falls Overlook Chinook Pass Picnic Area
2	MAXIMUM DEBRIS FLOWS ZONE (10,000 year recurrence interval)	None
4	CASE I INUNDATION ZONE (500-1,000 year interval) probably not associated with precursor volcanic activity	Tahoma Woods Nahunta Falls Picnic Area Camps Muir and Schurman
8	CASE II INUNDATION ZONE (100-500 year recurrence interval, but closer to 100 year) probably associated with precursor volcanic activity	White River Entrance Carbon Entrance Ohanapecosh Sunshine Point Campground Nisqually Entrance Falls Creek Picnic Area Stevens C. Ent/Grove of Patriarchs
16	CASE III INUNDATION ZONE (<100 year recurrence interval)	White River Campground Ipsut Campground Cougar Rock Campground Longmire Kautz Creek Box Canyon Picnic Area Box Canyon Overlook

(b) Pyroclastic flow hazard. Source: Hoblitt and others, (1995).

SCORE	INDICATOR	SITE
1	OUTSIDE THE PYROCLASTIC ZONE	Carbon Entrance White River Entrance Ohanapecosh Mowich Lake Campground Tahoma Woods Sunshine Point Campground Nisqually Entrance Falls Creek Picnic Area Chinook Pass Picnic Area Stevens C. Ent/Grove of Patriarchs
4	WITHIN THE PYROCLASTIC FLOW ZONE	Ipsut Campground Longmire White River Campground Paradise Visitor Center Cougar Rock Campground Sunrise Visitor Center Kautz Creek Camp Muir Camp Schurman Narada Falls Overlook Nahunta Falls Picnic Area Box Canyon Picnic Area Box Canyon Overlook

(c) Regions downstream of hydrothermally altered rock. Source: Zimbelman (1997, personal communication).

SCORE	INDICATOR	SITE
1	NOT DOWNSTREAM FROM AREAS OF HYDROTHERMALLY ALTERED ROCK	All others (15 sites)
4	DOWNSTREAM FROM AREAS OF HYDROTHERMALLY ALTERED ROCK	White River Campground White River Entrance Tahoma Woods Nisqually Entrance Sunshine Point Campground Camp Schurman Box Canyon Picnic Area Box Canyon Overlook

Management Action: No further management action necessary.

B. Geologic Hazard Management

This site is the most hazardous in the park by a large margin. Its hazard score of 1024 was twice that of the next most hazardous site, Camp Schurman (Table 5). It is located in a case III inundation zone for debris flows, which are believed to occur at least once every 100 years (Hoblitt and others, 1995). High hazard rating also stems from three factors. First, the site is located very close to the volcano. Second the campground rests on a terrace only 35 ft (3.2m) above the White River. The terrace itself is formed by a debris flow deposits believed to be 500-2,000 years old (Crandell, 1971). Third, and most important, is the presence of a large mass of fractured, hydrothermally altered rock on Little Tahoma Peak, which is perched just above the campground (Sisson, 1995; Zimbelman, 1995). These rocks are known to be the source of a 1963 debris avalanche that stopped only 2,000ft (600m) short of the camp after it had already traveled 4.3 miles (7km). Non-volcanic hazards such as rock falls and snow avalanches are not a concern at this site, which is protected by a ridge on the side of Burroughs Mountain.

High hazard and large overnight occupation make this the highest risk site in the park, despite relatively low value of infrastructure versus sites such as Longmire and Ohanapecosh (Table 6).

CARBON RIVER VALLEY

4. Carbon River Entrance and Housing.

A. Floodplain Management.

Action Class: The entrance facility is an excepted action dependent upon its location next to the road. The ranger station, housing and administrative areas are class one actions.

Regulatory Floodplain: For the housing and administrative area the regulatory floodplain is the 100 year floodplain.

Floodplain Assessment: The NPS performed a preliminary floodplain assessment in 1994 that suggested both sites were within the 100 year floodplain. A detailed floodplain study was undertaken during 1995-96 to provide a more detailed floodplain assessment.

Flood discharge was estimated by two procedures. Regional regression equations gave one estimate (Cummans and others, 1975), while watershed area ratio reduction from the USGS gage at Carbondale gave another (Table 7). The area reduction ratio method was ultimately used for flood discharge in the hydraulic model because it provided a slightly more conservative estimate.

High hydraulic roughness estimates used were based on regional work by the USGS that indicates roughness is high on densely vegetated overbank areas (Arcement and Schneider, 1987, Prych, 1988, and Jarret and Trieste, 1987). Hydraulic roughness was estimated for this study using a procedure originally developed by Cowan (1956), modified by Aldridge and Garrett (1973) and further modified by Arcement and Schneider (1987). Base roughness values were determined using Barnes (1967).

Flow regime was not modeled at supercritical. Recent research by the USGS suggest that supercritical flow does not occur in natural channels of high gradient (>.002) streams (Jarret, 1985). According to Jarret's research, energy dissipated by the mobility of the bed and banks of the river keeps flow in a subcritical regime.

A summary of the hydraulic model output for the entrance area is given in Table 8. Depths of flow for the three floods modeled range from 4-6 ft (1-1.8m), while flood velocities are approximately 8 feet/second (2.4m/sec). These high velocities provide abundant energy for the river to erode its banks, as is illustrated by stream bank erosion at both developed sites.

The hydraulic model results indicate that all of the facilities are presently outside their regulatory floodplains (Figures 7 and 8). Historic flooding at the entrance station has been observed, however. The channel of June Creek has shifted to the west since publication of the USGS 7.5 minute map in 1971, and is believed to be the source of flood waters at the entrance.

Table 7. Discharge estimates for flood events on the Carbon River.

	AT FAIRFAX (50,496 acres)	AT ENTRANCE (34,718 acres)		AT IPSUT (13,216 acres)	
(in cfs)	GAGE #12094000	% of gage	regression	% of gage	regression
Q 25	4,060	2,680	2,321	934	1,418
Q 50	10,700	7,062	5,637	2,461	3,531
Q 100	12,200	8,052	6,418	2,806	4,042
Q 500					

Table 8. Summary of hydraulic data from HEC2 model for the Carbon River at the entrance and housing area, cross section 9 (see fig. 8 for cross section location). See Appendix C for additional cross sections.

Recurrence Interval (years)	Discharge (Q) (cfs)	Water Surface Elevation (CWSEL) (ft asl)	Depth (ft)	Channel Velocity (VCH) (fs)
25	2680	2596.53	4.03	7.74
50	7062	2598.55	6.05	7.53
100	8052	2598.73	6.23	7.90

Carbon River Cross Sections Near Entrance Station

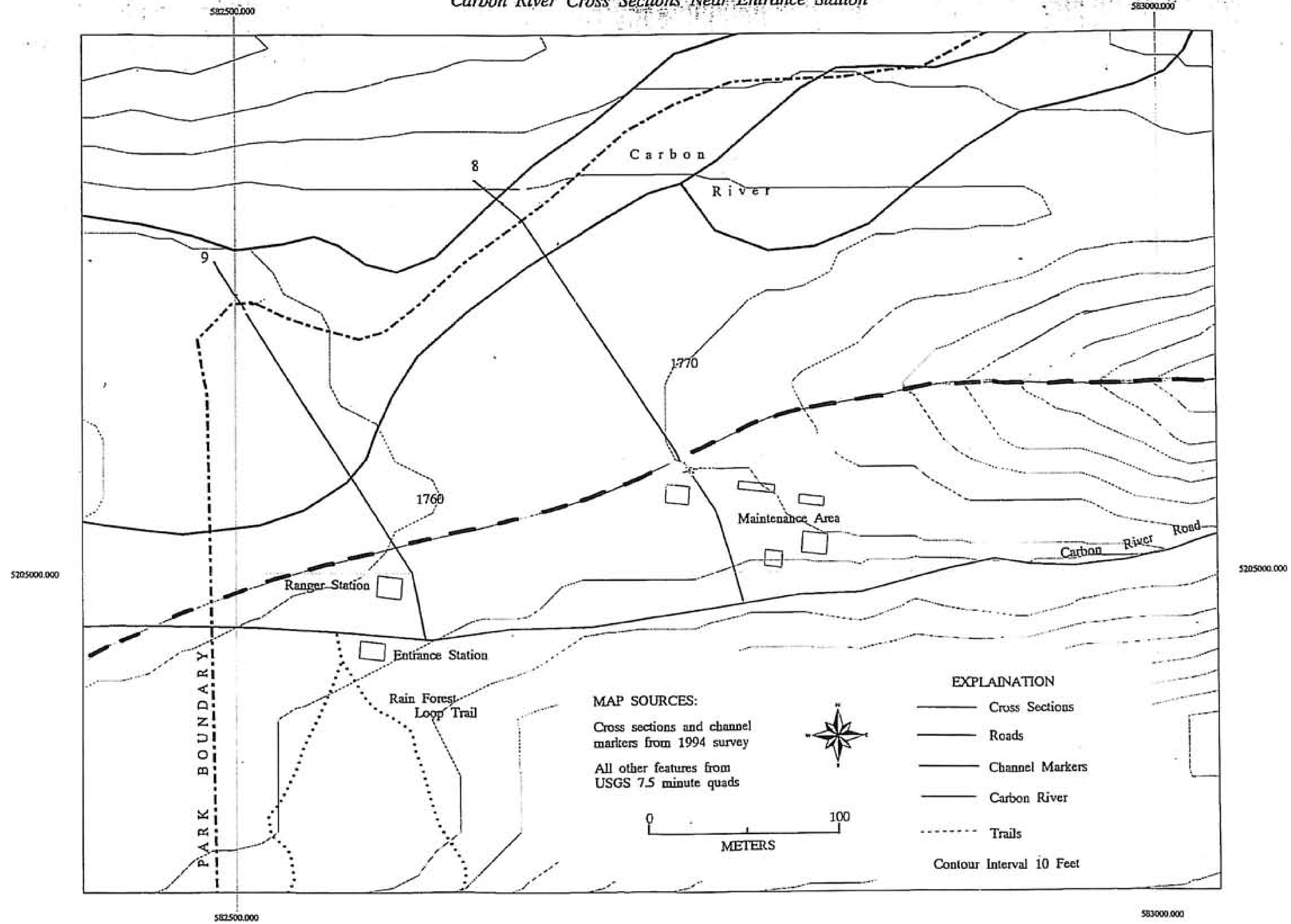


Figure 8. Floodplain map for the Carbon River near the Carbon River Entrance Station. Approximate floodplain boundary shown by dashed line.

30% DESIGN- CARBON RIVER ROAD FLOOD DAMAGE REDUCTION MEASURES			By Geomax	Drawing Status: 30% Design	
Date: January 30, 2008	Drawn By: Allan S. Potter, P.E.	Checked by: D&M Reichmuth	For Mt. Rainier National Park	Sheet No. 78	Of 84

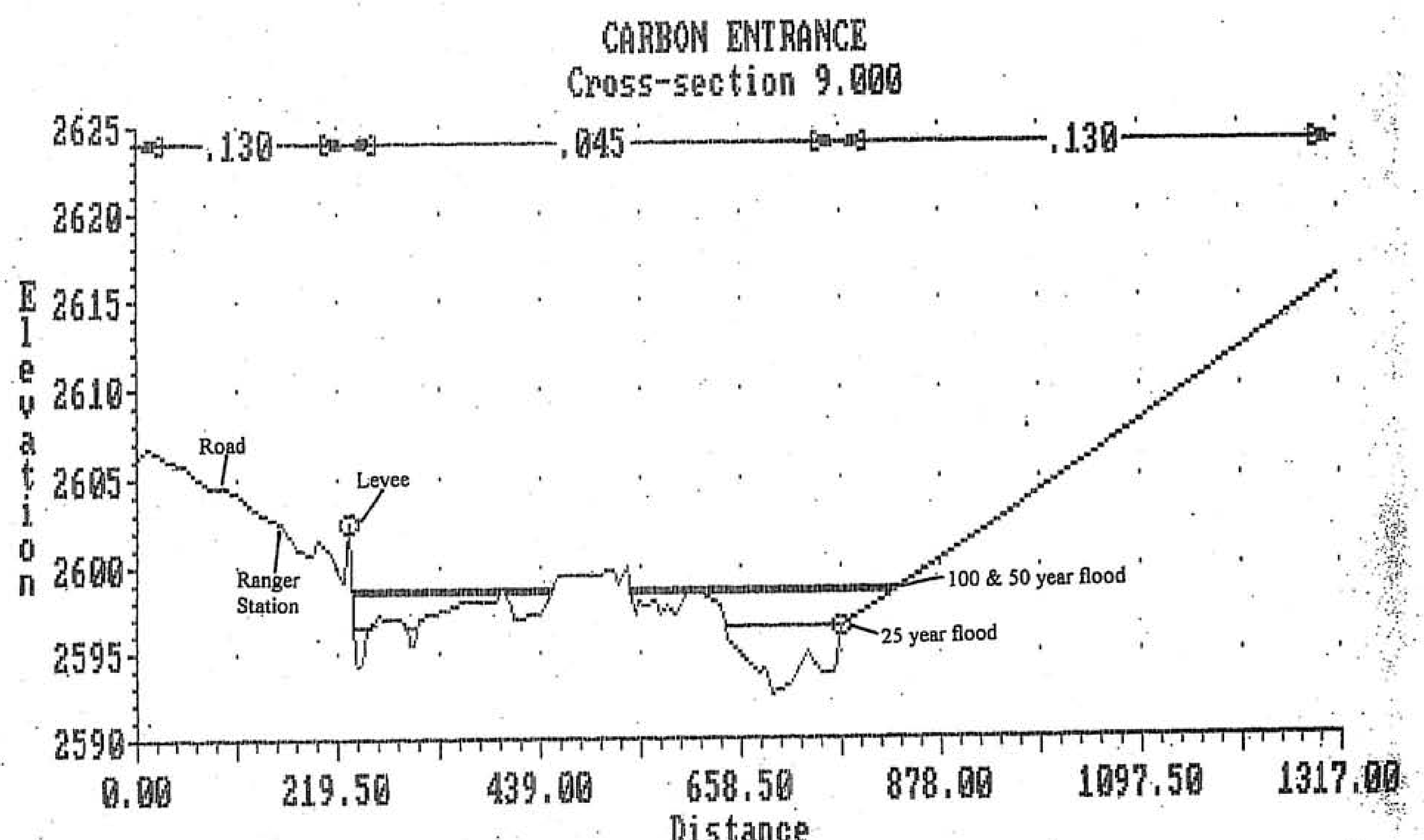


Figure 7. Floodplain cross section at Carbon River Entrance from floodplain model HEC2. View looking downstream.

30% DESIGN- CARBON RIVER ROAD FLOOD DAMAGE REDUCTION MEASURES			By Geomax	Drawing Status: 30% Design	
Date: January 30, 2008	Drawn By: Allan S. Potter, P.E.	Checked by: D&M Reichmuth	For Mt. Rainier National Park	Sheet No. 79	Of 84

The presence of floodplain soils and an apparent absence of volcanic tephra at this site suggests that larger floods might have occasionally inundated this site in the not-so-distant past. Further, channel changes expected over the next few decades could threaten these facilities by bank erosion.

Management Action: The site is outside its regulatory floodplain of the Carbon River. Flooding at the entrance is caused by June Creek. Flooding involves less than 2ft (.6m) of standing water and very low velocities. No further management action is necessary for either the entrance or housing site at this time. Continued bank erosion, however, will threaten portions of these sites in the near future.

B. Geologic Hazard Management

The Carbon Entrance facilities are located on a low terrace adjacent to the Carbon River floodplain. The site is mapped in a case II inundation zone with a recurrence interval of 100-500 years (Hoblitt and others, 1995). The hazard score for this site is relatively low at eight (Table 5), while risk ranked 17th out of 23 sites examined (Table 6). Risk is low due to low vulnerability and low value of infrastructure at this site.

Non-volcanic geologic hazards are presently not a concern at the Carbon Entrance. Its location in the middle of the floodplain limits the potential for hazard associated with valley walls such as snow avalanches, landslides and rock falls.

5. Falls Creek Picnic Area.

A. Floodplain Management.

Action Class: Picnic areas and associated sanitary facilities are excepted actions in the floodplain management guideline.

Regulatory Floodplain: N\A

Floodplain Assessment: Falls Creek Picnic Area rests on the left bank floodplain of the Carbon River. Damage from the February 1996 flood to the road downstream of this site was severe. Future flood damage should be expected since the road lies at a low elevation relative to the currently active river channel.

Management Action: No further management action necessary at this time.

B. Geologic Hazard Management.

This site ranked low in hazard relative to the other sites with a score of eight (Table 5). Risk was 19th of 23 sites due to low hazard and site value. Non-volcanic geologic hazards are presently

not a concern at Falls Creek picnic area. Its location in the middle of the floodplain limits the potential for hazards associated with valley walls such as snow avalanches, landslides and rock falls.

6. Ipsut Campground.

A. Floodplain Management

Action Class: Campgrounds and associated sanitary facilities are excepted actions in the floodplain management guideline. Walk-in sites in this campground, however, were determined to be in a high flood hazard area, making certain management steps required if these sites are to remain open.

Regulatory Floodplain: N/A

Floodplain Assessment: A detailed floodplain study was undertaken after a preliminary floodplain assessment in 1994 determined the site was in a high flood hazard area adjacent to the floodplain of the Carbon River. Methods for flood discharge and hydraulic roughness estimation and for hydraulic modeling followed those at Carbon Entrance.

Seven cross sections were surveyed on the Carbon River floodplain in fall 1994. Floodplain geometry data from the survey was combined with hydraulic roughness and discharge estimates to construct a step-backwater hydraulic model of the site. The many channels that form the large braided channel network in this area shift constantly. Numerous modern and old flood channels crisscross the floodplain (Figure 9). Flood flow through them is shallow, but rapid. Depths of flow for the 50 and 100 year floods in the main channel are only 3.5 ft (1m), but velocities are estimated at 8 ft/second (2.4m/sec; Table 9).

Surveyed cross sections shown in Figures 10 and 11 illustrate that parts of the campground, walk in sites and entrance road occupy very low parts of the floodplain. The majority of the campground rests on a low terrace, 5-6 ft (1.5-1.8m) above the modern channel. The walk in sites are isolated by swift water in a side-channel during even smaller flood events. High flood hazard occurs at discharges of 1,000 cfs or greater.

Hydraulic model output indicates that most of the camp is outside the existing100 year floodplain (Figures 10 and 11). However, the unstable nature of braided channels and the fact that parts of the campground are at lower elevations than the active channel suggest that the 100 year floodplain boundaries from the model may not be accurate for very long. Therefore, the 100 year floodplain boundary lines are conservatively drawn to include the low-elevation flood channels on the southwest end of the valley (Figure 12). This places the campground within the 100 year floodplain.

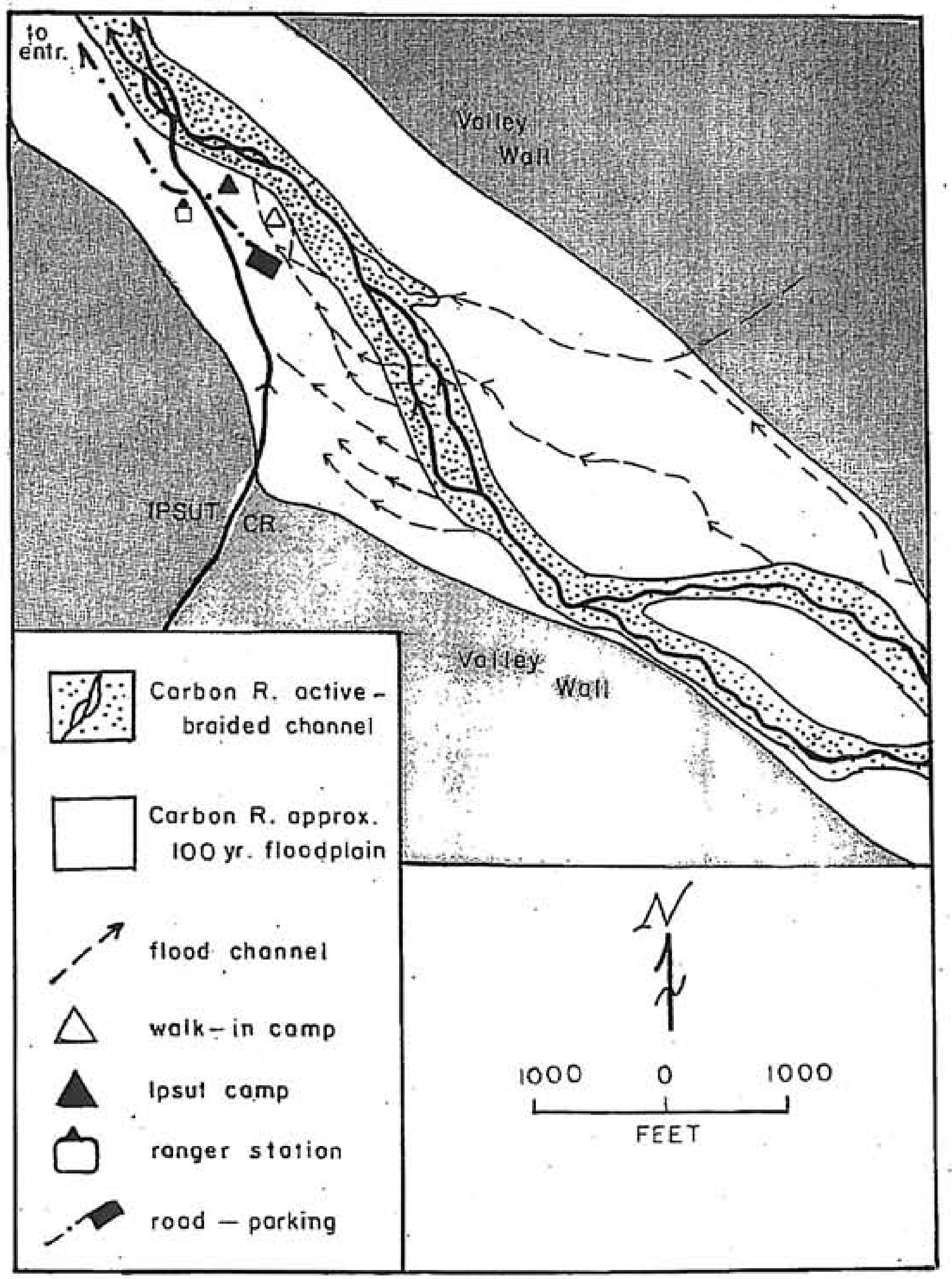


Figure 9. Preliminary 100 year floodplain map and hydrologic features at Ipsut Campground.

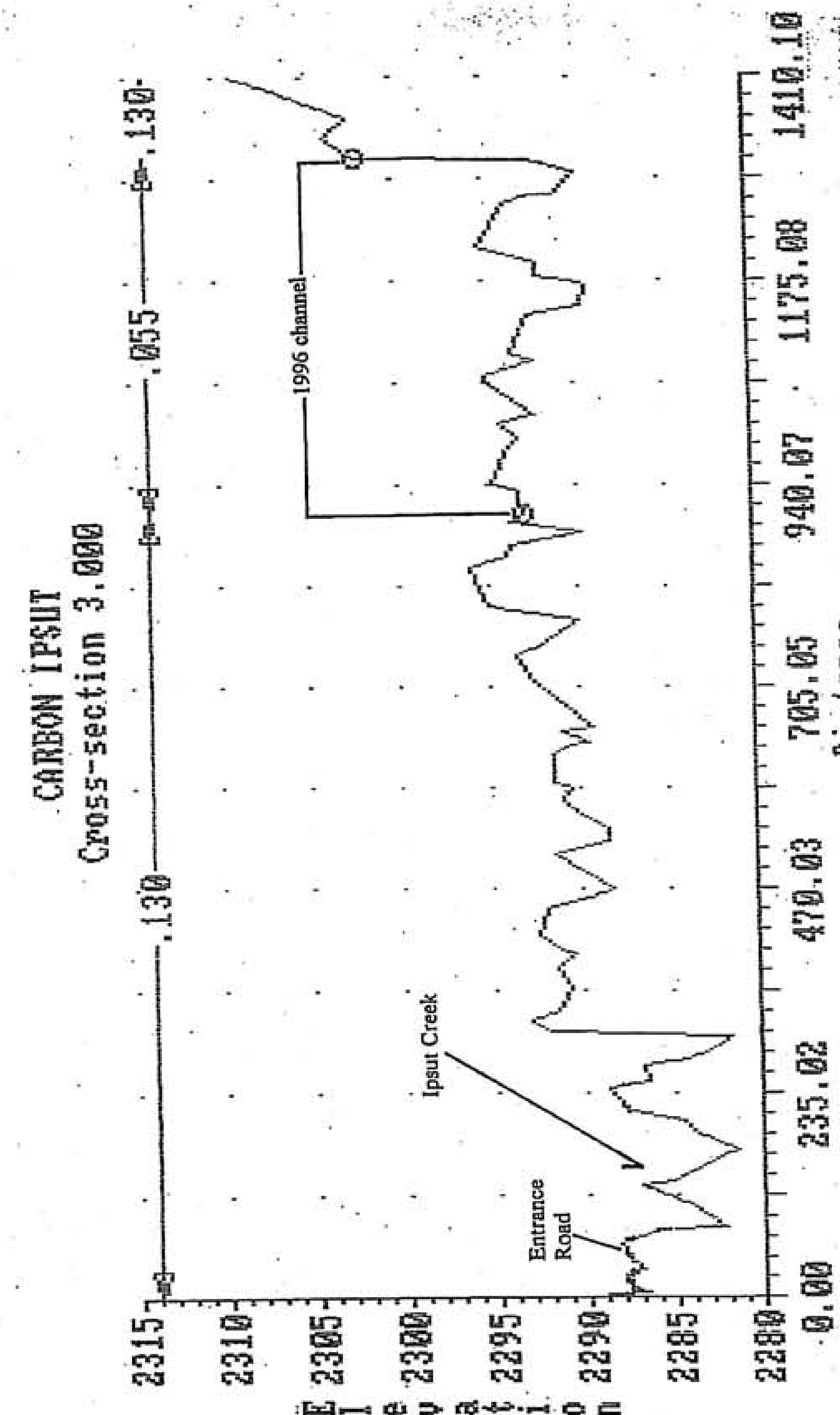


Figure 10. Floodplain cross section at Ipsut Campground from floodplain model HEC2. Cross section #3, see Figure12 for location. View looking downstream.

30% DESIGN- CARBON RIVER ROAD FLOOD DAMAGE REDUCTION MEASURES			By Geomax	Drawing Status: 30% Design	
Date: January 30, 2008	Drawn By: Allan S. Potter, P.E.	Checked by: D&M Reichmuth	For Mt. Rainier National Park	Sheet No. 81	Of 84

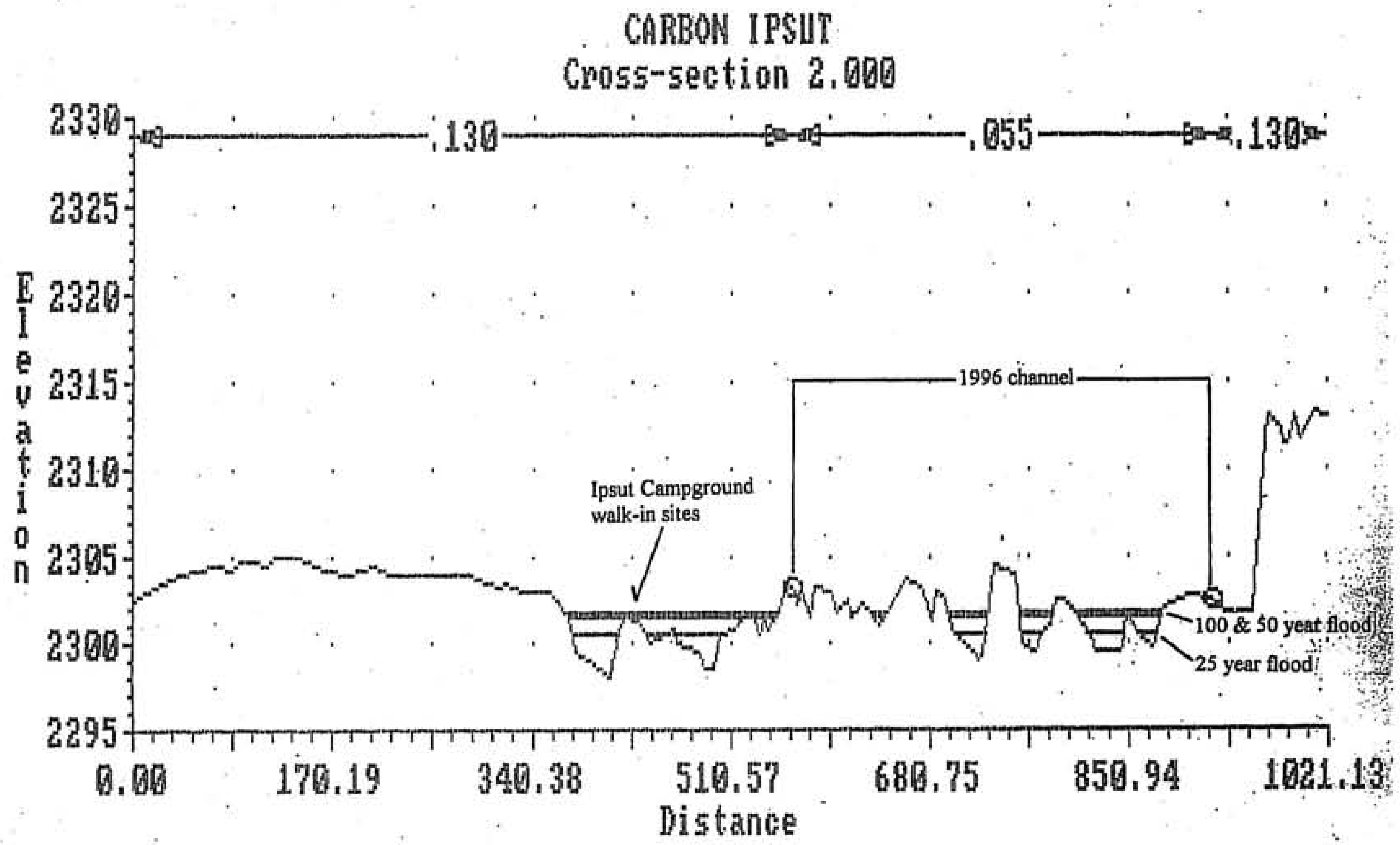


Figure 11. Floodplain cross section at Ipsut Campground from floodplain model HEC2. Cross section #2, see Figure12 for location. View looking downstream.

30% DESIGN- CARBON RIVER ROAD FLOOD DAMAGE REDUCTION MEASURES			By Geomax	Drawing Status: 30% Design	
Date: January 30, 2008	Drawn By: Allan S. Potter, P.E.	Checked by: D&M Reichmuth	For Mt. Rainier National Park	Sheet No. 82	Of 84

Carbon River Cross Sections Near Ipsut Creek Campground

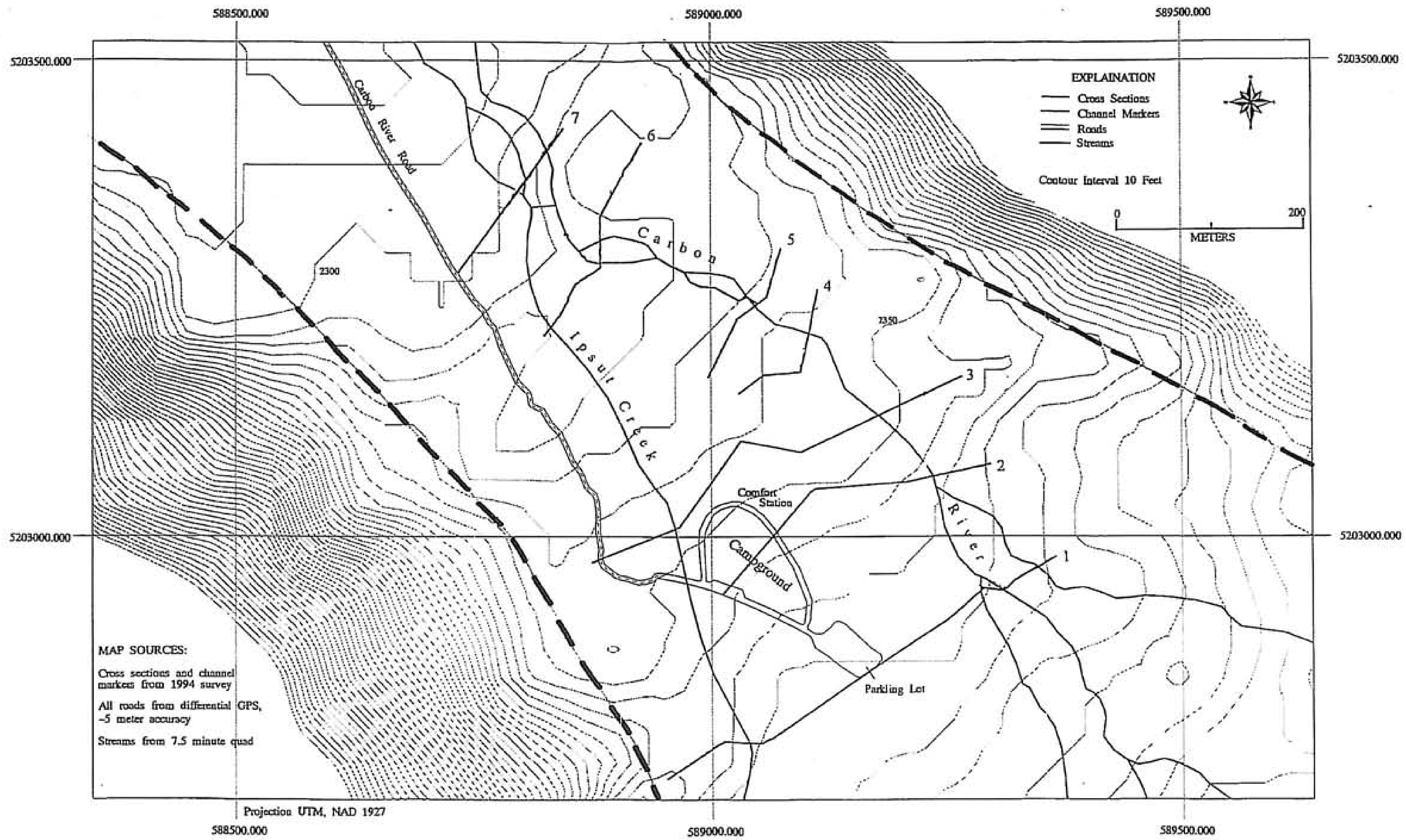


Figure 12. Floodplain map for the Carbon River near Ipsut Campground. Approximate floodplain boundary shown by dashed line.

30% DESIGN- CARBON RIVER ROAD FLOOD DAMAGE REDUCTION MEASURES			By Geomax GEOMORPHOLOGY, GEOMECHANICS, GEODESIGN	Drawing Status: 30% Design	
Date: January 30, 2008	Drawn By: Allan S. Potter, P.E.	Checked by: D&M Reichmuth	For Mt. Rainier National Park	Sheet No. 83	Of 84

Over the next few decades it is anticipated that continued deposition in the modern channel and upstream channel alignment will cause the Carbon River to shift to the south, isolating and claiming all or parts of the campground, and causing considerable damage to roads, trails and other facilities.

Table 9. Summary of hydraulic data from HEC2 model for the Carbon River at Ipsut Campground, cross section 2. See Appendix C for additional cross sections.

Recurrence Interval (years)	Discharge (Q) (cfs)	Water Surface Elevation (CWSEL) (ft asl)	Depth (ft)	Channel Velocity (VCH) (fs)
25	934	2300.53	2.43	6.9
50	2461	2302.53	3.43	7.7
100	2806	2301.63	3.53	8.1

Management Action: Since parts of the walk-in campgrounds are in a hazardous area, floodplain information should be made available to camp users. Further, the walk in sites located between the river and a flood channel should be closed or relocated. Consideration should also be given to closing the camp in late fall and early winter during the rain-on-snow flood period. If the walk-in sites are to remain at this campground, a contingency evacuation plan, approved by the regional safety officer, must be submitted.

B. Geologic Hazard Management.

This site is located on a low terrace less than six feet (1.8m) above the floodplain of the Carbon River in a case III debris flow inundation zone (recurrence interval of less than 100 years; Hoblitt and others, 1995). Hazard score for this site was low considering its proximity to the volcano and its valley bottom location (Table 5). The facts that the Carbon River watershed heads in more recent, less hydrothermally altered rocks than other valleys is the primary reason that hazard score wasn't higher (Zimbelman, 1995). Risk score ranked ninth highest in the park, which is surprising considering the low value of this site (Table 6). The high risk score at this site is due to its close proximity to the volcano and Carbon River channel. Non-volcanic geologic hazards are presently not a concern at this site. This site's location in the middle of the floodplain limits potential for hazards associated with valley walls such as snow avalanches, landslides and rock falls.

7. Mowich Lake Campground.

A. Floodplain Management.

Action Class: Campgrounds and associated sanitary facilities are excepted actions in the floodplain management guideline.

Regulatory Floodplain: N\A

Road segments discussed below are shown on Figure 20. Analysis focuses on debris flow hazards identified and described by Crandell (1971), Scott and others (1992), Hoblitt and others (1995), and Zimbelman (1995). Non-volcanic geologic hazards such as rock falls, snow avalanches and other mass movements are identified in this study and by Crandell (1967). Geographic Information System maps for debris flow inundation levels, slopes in excess of 35 degrees, and roads were used to assist in the identification of hazardous areas along the roads. Color aerial photographs and geologic maps were used to identify snow avalanche and other nonvolcanic hazards along the road corridor.

White River Road from State Route 410 to White River Campground (Figure 20-A). At its eastern end, this road begins on a valley wall some 480 ft (146m) above the White River. The valley wall and stream channel near the entrance are currently stable. After crossing, Deadwood Creek, the road enters a case I debris flow inundation zone (recurrence interval 500-1,000 years). The road stays within this zone until it drops on to the debris cone of Shaw Creek, where it enters the case III inundation area for debris flows. Bridges over Fryingpan Creek and the White River on the upper segment of this road owuld be particularly hazardous locaitons during a debris flow. Stopping of traffic anywhere above White River Entrance is not advised in an evacuation, since most of the road lies at a low elevation on or near the floodplain of White River. Snow avalanches and occasional rock falls are a potential geologic hazard on the segment of road above the bridge over White River.

Sunrise Road (Figure 20-B). At its junction with the White River road, this route is in a case III debris flow inundation area. As the road climbs out of the debris flow hazard zones, it traverses steep valley walls that are covered with thick glacial deposits. In several locations on the lower switchback, road-cut slopes on the uphill side and fill placed on the downhill side of the road are unstable. These areas produce occasional rock falls and sliding and slumping of small masses glacial till. Many of these failures are expanding, and could cause temporary closure of the road. Once the road turns west, the upper segment is generally free of the slope instability problems that plague the lower part of the road. Rock falls and other non-volcanic hazards are minimal on the upper road.

Carbon River Road (Figure 20-C). The Carbon River Road enters Mount Rainier National Park on a low terrace along the floodplain of the Carbon River. This position places the road in a case two debris flow inundation zone (recurrence interval 500-1,000 years). Near the mouth of Ranger Creek, the road enters a case III debris flow inundation zone, and stays within it until the road end at Ipsut Campground. Portions of the road near Falls Creek are prone to flood damage, and the road is currently closed due to damage from a 1996 flood. Rock falls, snow avalanches and other non-volcanic geologic hazards are not a concern along the Carbon River road within the park.

Mowich Lake Road (Figure 20-D). This road traverses a divide between the Puyallup and Carbon Rivers, and within the park is completely outside any debris flow or pyroclastic hazard zones. At an elevation of 4480 ft (1366m), near a sharp turn to the south, the road crosses a talus