Appendix A

Summary of measurable project metrics

Demonstrating Road Improvements in the Napa River Basin:
Implemented Road Treatments to Reduce Erosion in the
Carneros Creek and Sulphur Creek Subwatersheds, Napa County, California

Table A1. Summary of measurable project metrics, Demonstrating Road Improvements in the Napa River Basin, Napa County, California.

Project construction start/end dates	Carneros: 08/19/2010-10/21/2010 Sulphur: 08/12/2009-11/09/2009
Sediment savings (yd^3)	4,045
Total road miles treated	5.17
Total road miles upgraded	5.13
Total road miles decommissioned	0.04
Total stream crossings treated	42
Total stream crossings upgraded	40
Total stream crossings decommissioned	2
Total landslides treated	1
Total ditch relief culverts treated	3
Total sites treated	46
Total sites upgraded	44
Total sites decommissioned	2

Appendix B

Road logs of as-built treatments in the Carneros Creek subwatershed

Demonstrating Road Improvements in the Napa River Basin:
Implemented Road Treatments to Reduce Erosion in the
Carneros Creek and Sulphur Creek Subwatersheds,
Napa County, California

Landowner	Table #	Road name
Saintsbury	B1	723 Road (upgraded; 1 decommissioned stream crossing)
	B2	Electric Avenue (upgraded)
	B3	Hammer Road (upgraded)
	B4	George Road (decommissioned)
	B5	Reservoir High Road (upgraded)
Artesa	B6	Chardonnay Road (upgraded)
	B7	Lower Chardonnay Road (upgraded)
Hudsonia	B8	Buckeye Lane (upgraded)

Table B1. 723 Road (upgraded; Saintsbury property): road log of as-built treatments. Demonstrating Road Improvements in the Napa River Basin, Napa County, California.

Abbreviations: BOT = downstream end of excavation; CD = critical dip; CMP = corrugated metal pipe (culvert); DRC = ditch relief culvert; EOS= end of survey; IBR = inboard edge of road; KD = keep or cut ditch;; OBR = outboard edge of road; OSR-FD = outslope road and fill ditch; RD = rolling dip; RR = rock road; SOS = start of survey; TOP = upstream end of excavation; XRD = cross-road drain.

Distance on road (mi)	PWA site#	Road treatment	Site description / treatments implemented	Materials used
0.000			Start survey at gate at property boundary.	
0.009		RD	Rolling dip was installed to drain road surface and cut bank to divert flow from pond above back into natural channel and off road surface.	
0.093		RD	Rolling dip was installed to drain road.	
0.110	173		Culverted stream crossing. No treatment.	
0.180	174		Culvert draining diverted stream. Difficult site; water line and outlet infrastructure in roadway. No treatment at site.	
0.192		CD	Just above intersection with "Inner George Road"; 75' below site at natural swale. A critical dip was installed.	
0.200			Site was not inventoried in original assessment. Equipment crews constructed a rocked ditch across road and down outboard fillslope of site# 180 to drain swale.	5 yd^3 8" rock
0.210	180	CD	Originally a culverted, partially washed out, stream crossing. See typical drawing for construction details. 1. Crossing was excavated from TOP to BOT flags within natural channel line and down to natural channel bottom. 2. A 42" x 90' long culvert was installed at base of fill and in the axis of the natural channel. 3. Small berm was left along outboard road to protect fill face from eroding during the first winter. 4. Road was rebuild with dip through crossing to minimize diversion potential. 5. 9 yd^3 of rock armor was installed at base of outboard fill slope around culvert outlet. 6. 1 yd^3 of rock armor was installed around inlet to buttress unstable fill.	42" x 90' CMP, 4 couplers 10 yd^3 1-2' rock
0.218			Intersection with Reservoir Road.	
0.229	181		Originally a small fill stream crossing. An armored fill crossing was installed using 10 yd^3 of 1'-2' rock. See typical drawing for construction details.	10 yd^3 1-2' rock
0.251	182		Culverted stream crossing. No treatment at site.	
0.267	183		Ditch relief culvert. 1. Culvert inlet was cleaned. 2. 5 yd^3 of 1'-2' rock armor was installed below outlet.	5 yd^3 1-2' rock

Table B1—cont. 723 Road (upgraded/decommissioned; Saintsbury property): road log of as-built treatments. Demonstrating Road Improvements in the Napa River Basin, Napa County, California.

Abbreviations: BOT = downstream end of excavation; CD = critical dip; CMP = corrugated metal pipe (culvert); DRC = ditch relief culvert; EOS= end of survey; IBR = inboard edge of road; KD = keep or cut ditch;; OBR = outboard edge of road; OSR-FD = outslope road and fill ditch; RD = rolling dip; RR = rock road; SOS = start of survey; TOP = upstream end of excavation; XRD = cross-road drain.

Distance on road (mi)	PWA site#	Road treatment	Site description / treatments implemented	Materials used
0.296		RD	Rolling dip was installed to drain road.	
0.350	184		Culverted stream crossing. 1. Crossing was excavated from TOP to BOT flags within natural channel line and down to natural channel bottom. 2. A 24" x 40' long culvert was installed at base of fill and in the axis of the natural channel. 3. A small berm was left along outboard road to protect fill face from eroding during the first winter.	24" x 40' CMP, 1 couplers
0.428		Start OSR-FD	Fence post on OBR, vertical PVC pipe at IBR; no real road fill/cut prism beyond this point. Began outslope road and fill ditch. Road was outsloped by removing any outboard berm, lowering the outboard side of the road and using material to raise the inboard side. Any inboard ditch was filled.	
0.480		RD	Rolling dip was installed to drain road.	
0.561		RD End OSR-FD	1. Rolling dip was installed to drain road. 2. Road outsloping /fill ditch ended at this point.	
0.690	188	CD	Previously washed out stream crossing to the right of the road. Spur road to 'Hammer' road. See typical drawing for construction details. 1. Crossing was excavated from TOP to BOT flags within natural channel line and down to natural channel bottom. 2. A 48" x 50' long culvert was installed at base of fill and in the axis of the natural channel. 3. A small berm was left along outboard road to protect fill face from eroding during the first winter. 4. Road was dipped through crossing to prevent diversion potential.	48" x 50'. CMP, 2 couplers
0.722	189		Two non-functioning CMP's connecting old ponds. No sediment delivery problems. Culverts were removed.	
0.764	190		Site was a culverted stream crossing with a partially plugged 24" culvert. 1. Crossing was excavated from TOP to BOT with an 8' wide channel width and down to base of fill for decommissioning. 2. Side slopes were laid back to natural channel slopes. 3. Spoil was endhauled up road to large flat past site# 188.	

Table B1—cont. 723 Road (upgraded/decommissioned; Saintsbury property): road log of as-built treatments. Demonstrating Road Improvements in the Napa River Basin, Napa County, California.

Abbreviations: BOT = downstream end of excavation; CD = critical dip; CMP = corrugated metal pipe (culvert); DRC = ditch relief culvert; EOS= end of survey; IBR = inboard edge of road; KD = keep or cut ditch;; OBR = outboard edge of road; OSR-FD = outslope road and fill ditch; RD = rolling dip; RR = rock road; SOS = start of survey; TOP = upstream end of excavation; XRD = cross-road drain.

Distance on road (mi)	PWA site#	Road treatment	Site description / treatments implemented	Materials used
0.789	500	CD	Originally a culverted stream crossing that had a failing outboard fill and exposing a white PVC pipe near confluence with Scott Creek. See typical drawing for construction details. 1. Stream crossing was excavated from TOP to BOT with an 8' channel width. 2. A 48" x 50' long culvert was set in at channel grade and at base of fill. 3. Fill slopes were rebuilt to a 2:1 angle and giving road bed a 14' width. 4. Road dipped through crossing to prevent diversion potential. 5. Spoils were stockpiled locally.	48" x 50' CMP, 2 couplers
		EOS	End of survey at site# 500	

Table B2. Electric Ave (upgraded; Saintsbury property): road log of as-built treatments. Demonstrating Road Improvements in the Napa River Basin, Napa County, California.

Abbreviations: BOT = downstream end of excavation; CD = critical dip; CMP = corrugated metal pipe (culvert); DRC = ditch relief culvert; EOS= end of survey; IBR = inboard edge of road; KD = keep or cut ditch;; OBR = outboard edge of road; OSR-FD = outslope road and fill ditch; RD = rolling dip; RR = rock road; SOS = start of survey; TOP = upstream end of excavation; XRD = cross-road drain.

Distance on road (mi)	PWA site#	Road treatment	Site description / treatments implemented	Materials used
0.000		SOS	Start survey at fence; pond to the right. Road has many natural drainage breaks.	
0.023		RD	Rolling dip was installed to drain road.	
0.046		RD	Rolling dip was installed to drain road.	
0.069		RD	Rolling dip was installed to drain road.	
0.126		RD	Rolling dip was installed to drain road surface and cut bank.	
0.143	193		Originally a culverted stream crossing. An armored fill crossing was constructed using 10 yd^3 of 1'-2' rock. See typical drawing for construction details.	10 yd^3 1-2' rock
0.161		RD	Rolling dip was installed to drain road.	
0.408			Fence with wooden posts. No gate.	
0.518	196	CD	Culverted stream crossing in grassland. A critical dip was constructed to reduce diversion potential.	
0.601	197		Originally an eroding fill stream crossing. An armored fill crossing was constructed using 10 yd^3 of 1'-2' rock. See typical drawing for construction details.	30 yd^3 1-2' rock
0.746		EOS	End of Survey at gate and site# 192. Cleaned inlet of culvert at fallen oak tree.	

Table B3. Hammer Road (upgraded; Saintsbury property): road log of as-built treatments. Demonstrating Road Improvements in the Napa River Basin, Napa County, California.

Abbreviations: BOT = downstream end of excavation; CD = critical dip; CMP = corrugated metal pipe (culvert); DRC = ditch relief culvert; EOS= end of survey; IBR = inboard edge of road; KD = keep or cut ditch;; OBR = outboard edge of road; OSR-FD = outslope road and fill ditch; RD = rolling dip; RR = rock road; SOS = start of survey; TOP = upstream end of excavation; XRD = cross-road drain.

Distance on road (mi)	PWA site#	Road treatment	Site description / treatments implemented	Materials used
0.000		Start OSR-FD	Start survey at saddle on ridge top in grassland setting. Roadbed was outsloped with a 4% graded from cutbank to outboard road. Any inboard ditch was removed	
0.018		RD	Rolling dip was installed to drain road.	
0.038		End OSR-FD	Ended outsloping road and fill ditch activities at site# 188	
0.040	188	EOS	End survey at site# 188.	

Table B4. George Road (decommissioned; Saintsbury property): road log of as-built treatments. Demonstrating Road Improvements in the Napa River Basin, Napa County, California.

Abbreviations: BOT = downstream end of excavation; CD = critical dip; CMP = corrugated metal pipe (culvert); DRC = ditch relief culvert; EOS= end of survey; IBR = inboard edge of road; KD = keep or cut ditch;; OBR = outboard edge of road; OSR-FD = outslope road and fill ditch; RD = rolling dip; RR = rock road; SOS = start of survey; TOP = upstream end of excavation; XRD = cross-road drain.

Distance on road (mi)	PWA site#	Road treatment	Site description / treatments implemented	Materials used
0.000		SOS	Start survey at intersection with 723 Road near site #180. Start to rip road with dozer to decompact surface.	
0.015		XRD	A cross road drain was constructed on lower hinge line of swale.	
0.047	199		Excavate 40 yd^3 at base of landslide; stockpile spoil locally along roadbed. Site was not treated due to the reasoning that more site disturbance would be required than what would be mitigated by the sediment savings of the treatment. Slide deposit looked stable and didn't fall under the High/High Moderate treatment immediacy criteria.	
0.129		XRD	A cross road drain was constructed.	
0.209	200		Previously a culverted stream crossing. 1. Crossing was excavated from TOP to BOT with an 8' wide channel width and down to base of fill for decommissioning. 2. Side slopes were lay back to natural channel slopes. 3. Spoil were stockpiled locally.	
0.209		EOS	End of survey at site 200. End rip road surface.	

Table B5. Reservoir High Road (upgraded; Saintsbury property): road log of as-built treatments. Demonstrating Road Improvements in the Napa River Basin, Napa County, California.

Abbreviations: BOT = downstream end of excavation; CD = critical dip; CMP = corrugated metal pipe (culvert); DRC = ditch relief culvert; EOS= end of survey; IBR = inboard edge of road; KD = keep or cut ditch;; OBR = outboard edge of road; OSR-FD = outslope road and fill ditch; RD = rolling dip; RR = rock road; SOS = start of survey; TOP = upstream end of excavation; XRD = cross-road drain.

Distance on road (mi)	PWA site#	Road treatment	Site description / treatments implemented	Materials used
	177	SOS	Washed out stream crossing on property boundary. No treatment.	
0.000		RD	Rolling dip was installed to drain road.	
0.022		Start OSR-FD	Roadbed was outsloped with a 4% graded from cutbank to outboard road. Any inboard ditch was removed	
0.034		RD	Rolling dip was installed to drain road.	
0.055		RD	Rolling dip was installed to drain road.	
0.067		End OSR-FD EOS	Ended outsloping road/fill ditch activities at intersection with 723 Road. End of survey at intersection with 723 Road.	

Table B6. Chardonnay Road (upgraded; Artesa property): road log of as-built treatments. Demonstrating Road Improvements in the Napa River Basin, Napa County, California.

Abbreviations: BOT = downstream end of excavation; CD = critical dip; CMP = corrugated metal pipe (culvert); DRC = ditch relief culvert; EOS= end of survey; IBR = inboard edge of road; KD = keep or cut ditch;; OBR = outboard edge of road; OSR-FD = outslope road and fill ditch; RD = rolling dip; RR = rock road; SOS = start of survey; TOP = upstream end of excavation; XRD = cross-road drain.

Distance on road (mi)	PWA site#	Road treatment	Site description / treatments implemented	Materials used
0.000	218	SOS	Start survey at road intersection on top of dam. Remove water bars along road length.	
0.050		RD	Rolling dip installed to drain road. Road was re-rocked.	15 yd^3 1.5” minus road rock
0.091		RD	Rolling dip installed to drain road. Road was re-rocked.	15 yd^3 1.5” minus road rock
0.127		Rd	Rolling dip installed to drain road. Road was re-rocked.	15 yd^3 1.5” minus road rock
0.164	217		No treatment at site; road dipped at right hinge line.	
0.234		RD	Rolling dip installed to drain road. Road was re-rocked.	15 yd^3 1.5” minus road rock
0.423		EOS	End of survey at locked gate on Henry Road.	

Table B7. Lower Chardonnay Road (upgraded; Artesa property): road log of as-built treatments. Demonstrating Road Improvements in the Napa River Basin, Napa County, California.

Abbreviations: BOT = downstream end of excavation; CD = critical dip; CMP = corrugated metal pipe (culvert); DRC = ditch relief culvert; EOS= end of survey; IBR = inboard edge of road; KD = keep or cut ditch;; OBR = outboard edge of road; OSR-FD = outslope road and fill ditch; RD = rolling dip; RR = rock road; SOS = start of survey; TOP = upstream end of excavation; XRD = cross-road drain.

Distance on road (mi)	PWA site#	Road treatment	Site description / treatments implemented	Materials used
0.000			At drainage divide	
0.037		RD	Rolling dip installed to drain road. Road was re-rocked.	
0.073		RD	Rolling dip installed to drain road. Road was re-rocked.	
0.114	1000	RD	Rolling dip installed to drain road. Road was re-rocked.	
0.114		EOS	End survey at rolling dip.	

Table B8. Buckeye Lane (upgraded; Hudsonia property): road log of as-built treatments. Demonstrating Road Improvements in the Napa River Basin, Napa County, California.

Abbreviations: BOT = downstream end of excavation; CD = critical dip; CMP = corrugated metal pipe (culvert); DRC = ditch relief culvert; EOS= end of survey; IBR = inboard edge of road; KD = keep or cut ditch;; OBR = outboard edge of road; OSR-FD = outslope road and fill ditch; RD = rolling dip; RR = rock road; SOS = start of survey; TOP = upstream end of excavation; XRD = cross-road drain.

Distance on road (mi)	PWA site#	Road treatment	Site description / treatments implemented	Materials used
0.000		SOS	Drainage divide where pavement begins. Steep (20%) road grade.	
0.091			Pavement ends. Entire road from this point on has been recently rocked, with rock bumps installed as speed control and/or road drainage features. Bumps are installed 90° angle to road length and could be installed at a more oblique angle to provide for better drainage.	
0.101	202	CD	Culverted stream crossing. 1. Critical dip was installed along right hingeline on rock section of road to provide for protection from potential stream diversion. 2. Road surface was re-rocked.	10 yd^3 1.5” minus road rock
0.122	203	CD	Culverted stream crossing. 1. Critical dip was installed along left hingeline crossing to provide for protection from potential stream diversion. 2. Road surface was re-rocked.	10 yd^3 1.5” minus road rock
0.158	204		No treatment at site. Ditch relief culvert with a drop inlet.	
0.184			Seven foot tall metal gate with no lock.	
0.205	205		No treatment at site. Stream crossing with 24” culvert.	
0.299	206		No treatment at site. Ditch relief culvert with drop inlet.	
0.368	207		No treatment at site. Ditch relief culvert with drop inlet.	

Table B8—cont. Buckeye Lane (upgraded; Hudsonia property): road log of as-built treatments. Demonstrating Road Improvements in the Napa River Basin, Napa County, California.

Abbreviations: BOT = downstream end of excavation; CD = critical dip; CMP = corrugated metal pipe (culvert); DRC = ditch relief culvert; EOS= end of survey; IBR = inboard edge of road; KD = keep or cut ditch;; OBR = outboard edge of road; OSR-FD = outslope road and fill ditch; RD = rolling dip; RR = rock road; SOS = start of survey; TOP = upstream end of excavation; XRD = cross-road drain.

Distance on road (mi)	PWA site#	Road treatment	Site description / treatments implemented	Materials used
0.493		RD	Rolling dip installed to drain road. Road was re-rocked.	15 yd^3 1.5” minus road rock
0.508	208		No treatment at site. Bridge crossing.	
0.523		RD	Rolling dip installed to drain road. Road was re-rocked.	15 yd^3 1.5” minus road rock.
0.785		EOS	End of survey at main gate. Gate has combination lock.	

Appendix C

Road logs of as-built treatments in the Sulphur Creek subwatershed

Demonstrating Road Improvements in the Napa River Basin:
Implemented Road Treatments to Reduce Erosion in the
Carneros Creek and Sulphur Creek Subwatersheds, Napa County, California

Landowner	Table #	Road name
Learned-Perry	C1	Cabin Road (upgraded)
	C2	Ridge/Cabin Tie Road (upgraded)
	C3	Ridge Road (upgraded)
Cain	C4	Cabin Road (upgraded)
	C5	Cabin SP1 Road (upgraded)
	C6	Danger Road (upgraded)
	C7	Diversion Road (not treated)
	C8	P-1 Road (upgraded)
	C9	Ridge Top Road (upgraded)
	C10	Vine Road (upgraded)
Marston	C11	Danger Spur 1 Road (upgraded):
	C12	Danger Road (upgraded):
	C13	Marston Loop Road (upgraded):
	C14	N.A. Younger Lane (upgrade):
Hoffman	C15	Sulphur Spring SP1 Road (upgraded)
	C16	Sulphur Spring SP2 Road (not treated)

Table C1. Cabin Road (upgraded; Learned-Perry property): road log of as-built treatments. Demonstrating Road Improvements in the Napa River Basin, Napa County, California.

Abbreviations: BOT, downstream end of excavation; CD = critical dip; CMP = corrugated metal pipe (culvert); DRC = ditch relief culvert; EOS= end of survey; IBR, inboard edge of road; KD = keep or cut ditch;; OBR, outboard edge of road; OSR-FD = outslope road and fill ditch; RD = rolling dip; RR = rock road; SOS = start of survey; TOP, upstream end of excavation; XRD = cross-road drain.

Distance on road (mi)	PWA site#	Road treatment	Site description / treatments implemented	Materials used
1.470		SOS	Start survey at the Cain/Learned-Perry property line and locked gate (combo = 1871). See Cain as-built road logs for first 1.470 miles of Cabin Road.	
	64.1		Culverted stream crossing: Trash rack installed above inlet.	1 trash rack
		Start RR	Begin newly placed road rock. Landowner paid for additional material to rock from gate to cabin completely.	Project purchased 181 yd^3 of 1.5" minus road rock
1.481		RD	Rolling dip installed to drain road.	
1.511	67	RD	Rolling dip installed to drain road.	
1.559		CD	Critical dip installed to prevent stream diversion down road.	
1.561	68		Culverted stream crossing: Large woody debris removed from inlet area.	
1.562	69		Culverted stream crossing: No treatment proposed.	
1.581		RD	Rolling dip installed to drain road.	
1.606	70		Culverted stream crossing: No treatment proposed.	
1.662	71		Culverted stream crossing: No treatment proposed.	
1.669	72		Culverted stream crossing: No treatment proposed.	
1.709	73	CD	Culverted stream crossing: Critical dip installed on left hinge of stream crossing.	
1.727		RD	Rolling dip installed to drain road.	
1.753	74	CD	Culverted stream crossing: Critical dip installed on left hinge of stream crossing and large woody debris removed from inlet area.	
1.787	75	RD	Ditch relief culvert: Rolling dip installed to drain road.	
1.794	76		Culverted stream crossing: No treatment proposed at site	
		Start KD	Ditch constructed along inboard road.	
1.800		RD	Rolling dip installed to drain road.	
1.805			Proposed ditch relief culvert not installed	
1.860		End KD	End construction of new ditch.	
1.863	77		Culverted stream crossing: No treatment proposed.	
1.902	78		Culverted stream crossing: No treatment proposed but landowner recently installed an 18" x 20' culvert.	
		End RR	End newly placed road rock	
1.925	79	CD	Culverted stream crossing: Critical dip installed on left hinge of stream crossing.	

Table C1—cont. Cabin Road (upgraded; Learned-Perry property): road log of as-built treatments. Demonstrating Road Improvements in the Napa River Basin, Napa County, California.

Abbreviations: BOT, downstream end of excavation; CD = critical dip; CMP = corrugated metal pipe (culvert); DRC = ditch relief culvert; EOS= end of survey; IBR, inboard edge of road; KD = keep or cut ditch;; OBR, outboard edge of road; OSR-FD = outslope road and fill ditch; RD = rolling dip; RR = rock road; SOS = start of survey; TOP, upstream end of excavation; XRD = cross-road drain.

Distance on road (mi)	PWA site#	Road treatment	Site description / treatments implemented	Materials used
1.951	77.1	RD	Rolling dip installed to drain road.	
1.971			Intersection with 'Ridge Cabin Tie Road'.	
2.019		RD	Rolling dip installed to drain road.	
2.048	78.1		Culverted stream crossing: No treatment proposed.	
2.055	79.1		Culverted stream crossing: No treatment proposed.	
2.074	80		Culverted stream crossing: No treatment proposed.	
2.082	81		Culverted stream crossing: No treatment proposed.	
2.091		RD	Rolling dip installed to drain road.	
2.139	82	CD	Culverted stream crossing: Critical dip installed on left hinge of stream crossing.	
2.153	84		Culverted stream crossing: No treatment proposed.	
2.168		RD	Rolling dip installed to drain road.	
2.261	85	CD	Culverted stream crossing: Critical dip installed on left hinge of stream crossing.	
2.280	86	CD	Culverted stream crossing: Critical dip installed on left hinge of stream crossing.	
2.322	87		Culverted stream crossing: No treatment proposed.	
2.362	88	CD	Culverted stream crossing: Critical dip installed on left hinge of stream crossing.	
2.419	89	RD	Rolling dip installed to drain road.	
2.439	90	CD	Culverted stream crossing: Critical dip installed on left hinge of stream crossing.	
2.462		RD	Rolling dip installed to drain road.	
2.541		RD	Rolling dip installed to drain road.	
2.594	91		Culverted stream crossing: No treatment proposed.	
2.612	92		Culverted stream crossing: No treatment proposed.	
2.626		RD	Rolling dip installed to drain road.	
2.660		RD	Rolling dip installed to drain road.	
2.680		EOS	End survey at drainage break.	

Table C2. Ridge/Cabin Tie Road (upgraded; Learned-Perry property): road log of as-built treatments. Demonstrating Road Improvements in the Napa River Basin, Napa County, California.

Abbreviations: BOT, downstream end of excavation; CD = critical dip; CMP = corrugated metal pipe (culvert); DRC = ditch relief culvert; EOS= end of survey; IBR, inboard edge of road; KD = keep or cut ditch;; OBR, outboard edge of road; OSR-FD = outslope road and fill ditch; RD = rolling dip; RR = rock road; SOS = start of survey; TOP, upstream end of excavation; XRD = cross-road drain.

Distance on road (mi)	PWA site#	Road treatment	Site description / treatments implemented	Materials used
0.000		SOS	Start survey at intersection with Cabin Road.	
0.021	93	RD	Rolling dip installed to drain road.	
0.059		RD	Rolling dip installed to drain road.	
0.094		RD	Rolling dip installed to drain road.	
0.130		RD	Rolling dip installed to drain road.	
0.132		EOS	End of survey at Ridge Road.	

Table C3. Ridge Road (upgraded; Learned-Perry property): road log of as-built treatments. Demonstrating Road Improvements in the Napa River Basin, Napa County, California.

Abbreviations: BOT, downstream end of excavation; CD = critical dip; CMP = corrugated metal pipe (culvert); DRC = ditch relief culvert; EOS= end of survey; IBR, inboard edge of road; KD = keep or cut ditch;; OBR, outboard edge of road; OSR-FD = outslope road and fill ditch; RD = rolling dip; RR = rock road; SOS = start of survey; TOP, upstream end of excavation; XRD = cross-road drain.

Distance on road (mi)	PWA site#	Road treatment	Site description / treatments implemented	Materials used
0.000		SOS	Start survey at drainage break within Mark West Creek at top of 650’ road contribution to Sulphur Creek.	
0.035		RD	Rolling dip installed to drain road.	
0.062		RD	Rolling dip installed to drain road.	
0.085		RD	Rolling dip installed to drain road.	
0.109		RD	Rolling dip installed to drain road.	
0.141		RD	Rolling dip installed to drain road.	
0.168		RD	Rolling dip installed to drain road.	
0.176			Past outboard road failure: No treatments proposed.	
0.255		RD	Rolling dip installed to drain road.	
0.306	1006	RD	Rolling dip installed to drain road.	
0.333		EOS	End of survey, intersection with spur tie road.	

Table C4. Cabin Road (upgraded; Cain property): road log of as-built treatments. Demonstrating Road Improvements in the Napa River Basin, Napa County, California.

Abbreviations: BOT, downstream end of excavation; CD = critical dip; CMP = corrugated metal pipe (culvert); DRC = ditch relief culvert; EOS= end of survey; IBR, inboard edge of road; KD = keep or cut ditch;; OBR, outboard edge of road; OSR-FD = outslope road and fill ditch; RD = rolling dip; RR = rock road; SOS = start of survey; TOP, upstream end of excavation; XRD = cross-road drain.

Distance on road (mi)	PWA site#	Road treatment	Site description / treatments implemented	Materials used
0.000		SOS	Begin survey at major drainage break near ridge top along paved road section.	
0.443	98		Culverted stream crossing: Trash rack installed above inlet.	1 trash rack
0.459			Pavement ends and metal building is to right.	
0.489			Intersection with Diversion Road.	
0.618			Driveway to left to old barn.	
0.711			Intersection with Ridge Road.	
0.722	52.1		Culverted stream crossing: No treatment proposed.	
0.774		RD	Rolling dip installed to drain road. Road is re-rocked.	20 yd^3 1.5" minus road rock
0.807		RD	Rolling dip installed to drain road. Road is re-rocked.	20 yd^3 1.5" minus road rock
0.822	53.1		Culverted stream crossing: No treatment proposed.	
0.830		CD	Critical dip installed on right hinge of stream crossing (#53.1). Road was re-rocked.	20 yd^3 1.5" minus road rock
0.861		RD	Rolling dip installed to drain road. Road was re-rocked.	20 yd^3 1.5" minus road rock
0.880	54.1		Culverted stream crossing: Replaced with a 24" x 70' long CMP at base of fill in natural channel alignment, armored outboard fillslope with at least 25 $yds^3$of 1'-2' riprap, and installed a trash rack above inlet. Road was re-rocked.	24" x 70' CMP, 3 couplers, 1 trash rack, 25 yd^3 1'-2' riprap, 20 yd^3 1.5" minus road rock
0.883		CD	Critical dip installed on right hinge of stream crossing (#54.1).	20 yd^3 1.5" minus road rock
0.923		RD	Rolling dip installed to drain road. Road was re-rocked.	20 yd^3 1.5" minus road rock
0.973	55.1	CD	Culverted stream crossing: Replaced with a 24" x 50' long CMP at base of fill in natural channel alignment with a trash rack installed above inlet and critical dip installed on right hinge of new crossing. Road was re-rocked.	24" x 50' CMP, 2 couplers, 1 trash rack, 5 yd^3 1'-2' riprap, 20 yd^3 1.5" minus road rock
0.994	56.1		Culverted stream crossing: No treatment proposed.	
1.000			Intersection with P-1 Road to the left.	
1.041	58.1		Culverted stream crossing: Proposed critical dip not installed per landowner request.	
1.102	60.1		Outboard fill failure: No proposed treatment.	

Table C4—cont. Cabin Road (upgraded; Cain property): road log of as-built treatments. Demonstrating Road Improvements in the Napa River Basin, Napa County, California.

Abbreviations: BOT, downstream end of excavation; CD = critical dip; CMP = corrugated metal pipe (culvert); DRC = ditch relief culvert; EOS= end of survey; IBR, inboard edge of road; KD = keep or cut ditch;; OBR, outboard edge of road; OSR-FD = outslope road and fill ditch; RD = rolling dip; RR = rock road; SOS = start of survey; TOP, upstream end of excavation; XRD = cross-road drain.

Distance on road (mi)	PWA site#	Road treatment	Site description / treatments implemented	Materials used
			Intersection with Vine Road.	
1.116		RD	Rolling dip installed to drain road. Road was re-rocked.	20 yd^3 1.5" minus road rock
1.144		RD	Rolling dip installed to drain road. Road is re-rocked.	20 yd^3 1.5" minus road rock
1.188	61.1		Culverted stream crossing: No treatment proposed.	
1.203		RD	Rolling dip installed to drain road. Road is re-rocked.	20 yd^3 1.5" minus road rock
1.218			Chain link gate with no lock.	
1.332			Intersection with road that goes around left side of reservoir.	
1.351		RD	Rolling dip installed to drain road. Road is re-rocked.	20 yd^3 1.5" minus road rock
1.365	62.1		Culverted stream crossing: No treatment proposed.	
1.462		EOS	End survey at the Cain/Learned-Perry property line and locked gate (combo = 1871). See Learned-Perry as-built road logs for additional work competed on the Cabin Road.	

Table C5. Cabin SP1 Road (upgraded; Cain property): road log of as-built treatments. Demonstrating Road Improvements in the Napa River Basin, Napa County, California.

Abbreviations: BOT, downstream end of excavation; CD = critical dip; CMP = corrugated metal pipe (culvert); DRC = ditch relief culvert; EOS= end of survey; IBR, inboard edge of road; KD = keep or cut ditch;; OBR, outboard edge of road; OSR-FD = outslope road and fill ditch; RD = rolling dip; RR = rock road; SOS = start of survey; TOP, upstream end of excavation; XRD = cross-road drain.

Distance on road (mi)	PWA site#	Road treatment	Site description / treatments implemented	Materials used
0.000		SOS	Start survey at intersection with Cabin Road.	
0.009		RD	Rolling dip installed to drain road and road re-rocked.	10 yd^3 of 1.5' minus road rock
0.046		RD	Rolling dip installed to drain road and road re-rocked.	10 yd^3 of 1.5' minus road rock
0.077		RD	Rolling dip installed to drain road and road re-rocked.	10 yd^3 of 1.5' minus road rock

Table C5—cont. Cabin SP1 Road (upgraded; Cain property): road log of as-built treatments. Demonstrating Road Improvements in the Napa River Basin, Napa County, California.

Abbreviations: BOT, downstream end of excavation; CD = critical dip; CMP = corrugated metal pipe (culvert); DRC = ditch relief culvert; EOS= end of survey; IBR, inboard edge of road; KD = keep or cut ditch;; OBR, outboard edge of road; OSR-FD = outslope road and fill ditch; RD = rolling dip; RR = rock road; SOS = start of survey; TOP, upstream end of excavation; XRD = cross-road drain.

Distance on road (mi)	PWA site#	Road treatment	Site description / treatments implemented	Materials used
0.103		RD	Rolling dip installed to drain road and road re-rocked.	10 yd^3 of 1.5' minus road rock
0.121	99		Culverted stream crossing: Replaced with a 30" x 40' long CMP at base of fill in natural channel alignment with a flared inlet added and a trash rack installed above inlet. Road is re-rocked.	30" x 40' CMP; 1 coupler; 30" flared inlet, 1 trash rack, 15 yd^3 of 1.5' minus road rock
0.128	1009	CD	Culverted stream crossing: Replaced with a 24" x 40' long CMP at base of fill in natural channel alignment with a trash rack installed above inlet, inboard fillslope and top of swale armored with 20 $yds^3$of 1'-2' riprap, and critical dip installed on right hinge of new crossing. Road is re-rocked.	24" x 40' CMP; 1 coupler, 1 trash rack, 20 yd^3 1'-2' riprap, 15 yd^3 1.5" minus road rock
0.236		EOS		

Table C6. Danger Road (upgraded; Cain property): road log of as-built treatments. Demonstrating Road Improvements in the Napa River Basin, Napa County, California.

Abbreviations: BOT, downstream end of excavation; CD = critical dip; CMP = corrugated metal pipe (culvert); DRC = ditch relief culvert; EOS= end of survey; IBR, inboard edge of road; KD = keep or cut ditch;; OBR, outboard edge of road; OSR-FD = outslope road and fill ditch; RD = rolling dip; RR = rock road; SOS = start of survey; TOP, upstream end of excavation; XRD = cross-road drain.

Distance on road (mi)	PWA site#	Road treatment	Site description / treatments implemented	Materials used
0.000		SOS	Start survey at intersection with Cabin Road.	
0.261		RD	Rolling dip installed to drain road.	
0.351		RD	Rolling dip installed to drain road.	
0.391		RD	Rolling dip installed to drain road.	
0.420	159		Culverted stream crossing: Replaced with a 48" x 60' long CMP at base of fill with a trash rack installed above inlet, inboard and outboard fillslopes and top of excavation are armored with 65 yds^3 of 1'-3' mixed riprap.	48" x 60' CMP, 2 couplers, 1 trash rack, 65 yds^3 1'-3' mixed riprap
0.434		RD	Rolling dip installed to drain road.	
0.475		RD	Rolling dip installed to drain road above gate on Cain property.	
0.475		EOS	Locked gate at Cain/Marston property line (combo = 1945). Road work continues; see Marston as-built road logs.	

Table C7. Diversion Road (upgraded; Cain property): road log of as-built treatments. Demonstrating Road Improvements in the Napa River Basin, Napa County, California.

Abbreviations: BOT, downstream end of excavation; CD = critical dip; CMP = corrugated metal pipe (culvert); DRC = ditch relief culvert; EOS= end of survey; IBR, inboard edge of road; KD = keep or cut ditch;; OBR, outboard edge of road; OSR-FD = outslope road and fill ditch; RD = rolling dip; RR = rock road; SOS = start of survey; TOP, upstream end of excavation; XRD = cross-road drain.

Distance on road (mi)	PWA site#	Road treatment	Site description / treatments implemented	Materials used
0.000		SOS	Start survey at intersection with Cabin Road next to barn	
0.139	95		Culverted stream crossing: No treatment proposed.	
0.142			Intersection with road to the right.	
0.190	96		Culverted stream crossing: No treatment proposed.	
0.201			Proposed rolling dip not installed.	
0.212	97		Culverted stream crossing: No treatment proposed.	
0.212		EOS	End survey at site #97.	

Table C8. P-1 Road (upgraded; Cain property): road log of as-built treatments. Demonstrating Road Improvements in the Napa River Basin, Napa County, California.

Abbreviations: BOT, downstream end of excavation; CD = critical dip; CMP = corrugated metal pipe (culvert); DRC = ditch relief culvert; EOS= end of survey; IBR, inboard edge of road; KD = keep or cut ditch;; OBR, outboard edge of road; OSR-FD = outslope road and fill ditch; RD = rolling dip; RR = rock road; SOS = start of survey; TOP, upstream end of excavation; XRD = cross-road drain.

Distance on road (mi)	PWA site#	Road treatment	Site description / treatments implemented	Materials used
0.000		SOS	Start survey at intersection with Cabin Road.	
0.032	57.1	CD	Culverted stream crossing: Critical dip installed on right hinge of stream crossing.	
		EOS	End survey and treatments at stream crossing (#57.1)	

Table C9. Ridge Top Road (upgraded; Cain property): road log of as-built treatments. Demonstrating Road Improvements in the Napa River Basin, Napa County, California.

Abbreviations: BOT, downstream end of excavation; CD = critical dip; CMP = corrugated metal pipe (culvert); DRC = ditch relief culvert; EOS= end of survey; IBR, inboard edge of road; KD = keep or cut ditch;; OBR, outboard edge of road; OSR-FD = outslope road and fill ditch; RD = rolling dip; RR = rock road; SOS = start of survey; TOP, upstream end of excavation; XRD = cross-road drain.

Distance on road (mi)	PWA site#	Road treatment	Site description / treatments implemented	Materials used
0.000		SOS	Start survey at DRC near ridge top.	
		Start OSR-FD	Road outsloped with no ditch to drain road.	

Table C9—cont. Ridge Top Road (upgraded; Cain property): road log of as-built treatments. Demonstrating Road Improvements in the Napa River Basin, Napa County, California.

Abbreviations: BOT, downstream end of excavation; CD = critical dip; CMP = corrugated metal pipe (culvert); DRC = ditch relief culvert; EOS= end of survey; IBR, inboard edge of road; KD = keep or cut ditch;; OBR, outboard edge of road; OSR-FD = outslope road and fill ditch; RD = rolling dip; RR = rock road; SOS = start of survey; TOP, upstream end of excavation; XRD = cross-road drain.

Distance on road (mi)	PWA site#	Road treatment	Site description / treatments implemented	Materials used
		Start RR	Road re-rocked from this location to turn in road near the intersection with Cabin Road.	154 yd^3 1.5" minus road rock
0.028		RD	Rolling dip installed to drain road.	
0.055		RD	Rolling dip installed to drain road.	
0.089		RD	Rolling dip installed to drain road.	
0.154		RD	Rolling dip installed to drain road.	
0.212		RD	Rolling dip installed to drain road.	
0.230		End OSR-FD	End outsloped road with no ditch and new rock.	
		End RR	End re-rocked road.	
0.267		EOS	End of Survey at intersection with Cabin Road.	

Table C10. Vine Road (upgraded; Cain property): road log of as-built treatments. Demonstrating Road Improvements in the Napa River Basin, Napa County, California.

Abbreviations: BOT, downstream end of excavation; CD = critical dip; CMP = corrugated metal pipe (culvert); DRC = ditch relief culvert; EOS= end of survey; IBR, inboard edge of road; KD = keep or cut ditch;; OBR, outboard edge of road; OSR-FD = outslope road and fill ditch; RD = rolling dip; RR = rock road; SOS = start of survey; TOP, upstream end of excavation; XRD = cross-road drain.

Distance on road (mi)	PWA site#	Road treatment	Site description / treatments implemented	Materials used
0.000		SOS	Start survey at intersection with Cabin Road near metal gate.	
	59.1		Culverted stream crossing: No treatment proposed.	
0.032		RD	Rolling dip installed to drain road.	15 yds^3 1.5" minus road rock
0.056		RD	Rolling dip installed to drain road.	15 yds^3 1.5" minus road rock
0.154		RD	Rolling dip installed to drain road.	15 yds^3 1.5" minus road rock
		EOS	End survey at rolling dip just past turn in road in somewhat flat area	

Table C11. Danger Spur 1 Road (upgraded; Marston property): road log of as-built treatments. Demonstrating Road Improvements in the Napa River Basin, Napa County, California.

Abbreviations: BOT, downstream end of excavation; CD = critical dip; CMP = corrugated metal pipe (culvert); DRC = ditch relief culvert; EOS= end of survey; IBR, inboard edge of road; KD = keep or cut ditch;; OBR, outboard edge of road; OSR-FD = outslope road and fill ditch; RD = rolling dip; RR = rock road; SOS = start of survey; TOP, upstream end of excavation; XRD = cross-road drain.

Distance on road (mi)	PWA site#	Road treatment	Site description / treatments implemented	Materials used
0.000		SOS	Start survey at intersection with Danger Road on the Marston property.	
0.000		Start OSR-FD	Start outsloped road.	
0.028		RD	Rolling dip installed to drain road.	
0.056		RD	Rolling dip installed to drain road.	
0.125		End OSR-FD	End outsloped road.	
	157		Fill stream crossing: Armored fill crossing installed using nearly 2 yd^3 0.5'-1.5' riprap.	2 yd^3 0.5'-1.5' riprap
		EOS	End survey at new armored fill crossing.	

Table C12. Danger Road (upgraded; Marston property): road log of as-built treatments. Demonstrating Road Improvements in the Napa River Basin, Napa County, California.

Abbreviations: BOT, downstream end of excavation; CD = critical dip; CMP = corrugated metal pipe (culvert); DRC = ditch relief culvert; EOS= end of survey; IBR, inboard edge of road; KD = keep or cut ditch;; OBR, outboard edge of road; OSR-FD = outslope road and fill ditch; RD = rolling dip; RR = rock road; SOS = start of survey; TOP, upstream end of excavation; XRD = cross-road drain.

Distance on road (mi)	PWA site#	Road treatment	Site description / treatments implemented	Materials used
0.000		SOS	Start survey just past locked gate (combo = 1945) at Cain/Marston property line and intersection with Danger Road. See Cain as-built road logs for treatments above gate.	
0.489		Start RB	Begin removed outboard berm section.	
0.578	158	RD	Rolling dip installed to drain road.	
0.586			Intersection with Danger Spur 1 Road.	
0.630	156	CD	Culverted stream crossing: 1 yd^3 of 0.5'-1' local riprap placed on outboard fillslope and critical dip installed on right hinge of stream crossing.	1 yd^3 0.5'-1' local riprap
		End RB	End berm removal	
0.746			Water tanks on left, stay to the right.	
1.034			Quarry and intersection, treatments continue to the left.	
1.250	476	DRC	Ditch relief culvert: Replaced with an 18" x 30' long CMP.	18" x 30' CMP, 1 coupler
1.266		EOS	End survey at intersection with Spring Road at locked gate (combo = 1945).	

Table C13. Marston Loop Road (upgraded; Marston property): road log of as-built treatments. Demonstrating Road Improvements in the Napa River Basin, Napa County, California.

Abbreviations: BOT, downstream end of excavation; CD = critical dip; CMP = corrugated metal pipe (culvert); DRC = ditch relief culvert; EOS= end of survey; IBR, inboard edge of road; KD = keep or cut ditch;; OBR, outboard edge of road; OSR-FD = outslope road and fill ditch; RD = rolling dip; RR = rock road; SOS = start of survey; TOP, upstream end of excavation; XRD = cross-road drain.

Distance on road (mi)	PWA site#	Road treatment	Site description / treatments implemented	Materials used
0.000		SOS	Start survey at 3600 front gate of property (combo= 1945 or 3375). Road is paved.	
0.011			End of pavement.	
0.092			Intersection (to left) to get to workshop.	
0.332		Start RR	Start new rocked road section at cattle guard.	334 yd^3 1.5" minus road rock
0.370	2001		Landslide: Perched fill removed and bare soil areas seeded and straw mulched.	
0.380		Start RB	Start removed berm section.	
		DRC	Ditch relief culvert installed to drain ditch.	18" x 40' CMP. 1 coupler
		RD	Rolling dip installed to drain road.	
0.434		End RB	End removed berm section.	
0.439	152	CD	Culverted stream crossing: Replaced with a 24" x 70' long CMP at base of fill in natural channel alignment a critical dip installed on right hinge of new crossing.	24" x 70' CMP, 3 couplers, 8 yd^3 1'-2' riprap
		Start OSR-FD	Start outsloped road section with no ditch or berm.	
0.462		RD	Rolling dip installed to drain road.	
0.490		End OSR-FD	End outsloped road at intersection to right.	
0.498	153		Ditch relief culvert: No proposed treatment at site.	
0.498		RD	Rolling dip installed to drain road.	
0.502		Start CR	Start crowned road surface.	
0.508		DRC	Ditch relief culvert installed to drain ditch.	18" x 40' CMP. 1 coupler
0.547		DRC	Ditch relief culvert installed to drain ditch.	18" x 40' CMP. 1 coupler
0.581	154	DRC	Ditch relief culvert installed to drain ditch.	18" x 40' CMP. 1 coupler
0.661	155	CD	Culverted stream crossing: Critical dip installed on right hinge of stream crossing.	
0.707		DRC	Ditch relief culvert installed to drain ditch.	18" x 40' CMP. 1 coupler
0.719		End CR	End crowned road surface.	
		End RR	End new road rock	
		EOS	End survey at paved road on main driveway. Road length from site# 155 to intersection is associated with site# 1008.	

Table C14. N.A. Younger Lane (upgraded; Marston property): road log of as-built treatments. Demonstrating Road Improvements in the Napa River Basin, Napa County, California.

Abbreviations: BOT, downstream end of excavation; CD = critical dip; CMP = corrugated metal pipe (culvert); DRC = ditch relief culvert; EOS= end of survey; IBR, inboard edge of road; KD = keep or cut ditch;; OBR, outboard edge of road; OSR-FD = outslope road and fill ditch; RD = rolling dip; RR = rock road; SOS = start of survey; TOP, upstream end of excavation; XRD = cross-road drain.

Distance on road (mi)	PWA site#	Road treatment	Site description / treatments implemented	Materials used
0.000		SOS	Start survey at intersection of N.A. Younger Lane and Springs Road.	
0.031		RD	Rolling dip installed to drain road.	
0.060		RD	Rolling dip installed to drain road.	
0.084		RD	Rolling dip installed to drain road.	
0.116		RD	Rolling dip installed to drain road.	
0.145		RD	Rolling dip installed to drain road.	
0.174		RD	Rolling dip installed to drain road.	
0.185			Unlocked gate.	
0.216		RD	Rolling dip installed to drain road.	
0.247		RD	Rolling dip installed to drain road.	
0.265	151		Culverted stream crossing: Replaced with a 24” x 40’ long CMP at base of fill in natural channel alignment, a trash rack is installed above inlet, and road is re-rocked through crossing.	24” x 40’ CMP, 1 coupler, 1 trash rack, 20 yd^3 1.5” minus road rock
0.272		EOS	End of survey at intersection with Marston Loop Road.	

Table C15. Sulphur Spring SP1 Road (upgraded; Hoffman property): road log of as-built treatments. Demonstrating Road Improvements in the Napa River Basin, Napa County, California.

Abbreviations: BOT, downstream end of excavation; CD = critical dip; CMP = corrugated metal pipe (culvert); DRC = ditch relief culvert; EOS= end of survey; IBR, inboard edge of road; KD = keep or cut ditch;; OBR, outboard edge of road; OSR-FD = outslope road and fill ditch; RD = rolling dip; RR = rock road; SOS = start of survey; TOP, upstream end of excavation; XRD = cross-road drain.

Distance on road (mi)	PWA site#	Road treatment	Site description / treatments implemented	Materials used
0.000		SOS	Start survey in grassy opening above satellite dish.	
		RD	Rolling dip installed to drain road.	
0.020		RD	Rolling dip installed to drain road.	
0.041		Start OSR-FD	Road outsloped with no ditch.	
0.060		End OSR-FD	End outsloped road section.	
	131	CD	Culverted stream crossing: The culvert is replaced with a new 24” x 50’ plastic culvert and a critical dip installed on right hinge.	24” x 50’ plastic culvert, 1 coupler

Table C15—cont. Sulphur Spring SP1 Road (upgraded; Marston property): road log of as-built treatments. Demonstrating Road Improvements in the Napa River Basin, Napa County, California.

Abbreviations: BOT, downstream end of excavation; CD = critical dip; CMP = corrugated metal pipe (culvert); DRC = ditch relief culvert; EOS= end of survey; IBR, inboard edge of road; KD = keep or cut ditch;; OBR, outboard edge of road; OSR-FD = outslope road and fill ditch; RD = rolling dip; RR = rock road; SOS = start of survey; TOP, upstream end of excavation; XRD = cross-road drain.

Distance on road (mi)	PWA site#	Road treatment	Site description / treatments implemented	Materials used
0.068			Large water tanks on inboard road.	
0.087	132	CD	Culverted stream crossing: The culvert is replaced with a new 18" x 30' plastic culvert and a critical dip is installed on right hinge.	18" x 30' plastic culvert, 1 coupler.
0.101	133	CD	Culverted stream crossing: The culvert is replaced with a new 42" x 29" x 50' long oval culvert and a critical dip installed on right hinge. Trash rack is installed above inlet and local riprap used to armor new fillslopes.	42" x 29" x 50' oval CMP, 2 couplers, 1 trash rack, local riprap
0.137	134	RD	Rolling dip installed to drain road.	
0.162			Houses	
0.205		BB	Intersection with driveway up to workshop where gully developed down hillside and onto road surface: Berm built along left sideslope of Class III stream approximately 200' up hillside.	
0.220	2000		Culverted stream crossing: Crews attached a flared inlet to existing concrete culvert. Proposed critical dip was not installed.	21" flared inlet
		EOS	End of survey at beginning of pavement.	

Table C16. Sulphur Spring SP2 Road (upgraded; Hoffman property): road log of as-built treatments**.** Demonstrating Road Improvements in the Napa River Basin, Napa County, California.

Abbreviations: BOT, downstream end of excavation; CD = critical dip; CMP = corrugated metal pipe (culvert); DRC = ditch relief culvert; EOS= end of survey; IBR, inboard edge of road; KD = keep or cut ditch;; OBR, outboard edge of road; OSR-FD = outslope road and fill ditch; RD = rolling dip; RR = rock road; SOS = start of survey; TOP, upstream end of excavation; XRD = cross-road drain.

Distance on road (mi)	PWA site#	Road treatment	Site description / treatments implemented	Materials used
0.000		SOS	Start survey at break in slope.	
0.007	175		Small fill crossing: No proposed treatment at site; functioning armored fill crossing.	
0.018			Proposed rolling dip, not installed	
0.040	174		Culverted stream crossing: Proposed armored fill crossing not installed.	
0.073			Intersection with foot path; steps down to Hoffman Institute.	
0.088			Low point in outsloped road: Proposed rolling dip, not installed.	
0.128		EOS	End of survey at gate, pavement begins.	

Appendix D

Selected photos of treatment sites before and after implementation

Demonstrating Road Improvements in the Napa River Basin:
Implemented Road Treatments to Reduce Erosion in the
Carneros Creek and Sulphur Creek Subwatersheds
Napa County, California

Photo 1a, b	Saintsbury property, site #180
Photo 2a, b	Saintsbury property, site #197
Photo 3a, b	Saintsbury property, site #200
Photo 4a, b	Artesa property, site #217
Photo 5a, b	Cain property, site #54.1
Photo 6a, b	Cain property, site #55.1
Photo 7a, b	Cain property, site #99
Photo 8a, b	Marston property, site #2001
Photo 9a, b	Hoffman property, site #133

Photo 1a. Saintsbury property, stream crossing site #180, before implementation. View from the left bank, looking towards the culvert inlet and road surface.

Photo 1b. Saintsbury property, site #180, same view as above, after implementation. A new 42 in. x 90 ft culvert has been installed at the base of fill

Photo 2a. Saintsbury property, stream crossing site #197, before implementation. View from the right bank, looking up-channel towards the outboard road.

Photo 2b. Saintsbury property, site #197, same view as above, after implementation. An armored fill crossing has been constructed, and channel banks excavated back to stable angles and mulched.

Photo 3a. Saintsbury property, stream crossing site #200, before decommissioning. View from the left bank, looking up-channel towards the outlet of the culvert and outboard road area.

Photo 3b. Saintsbury property, site #200, same view as above, after implementation. The culvert has been removed, the channel excavated to natural grade, and channel banks sloped and mulched.

Photo 4a. Artesa property, site #217, before implementation. View from intersection with gravel road below dam, looking down road with creek flowing from right to left through center frame.

Photo 4b. Artesa property, site #217, same view as above, after implementation. A rolling dip has been constructed to disperse road drainage and reduce the amount of concentrated runoff reaching the stream.

Photo 5a. Cain property, stream crossing site #54.1, before implementation. View from the left hillside, looking towards the culvert inlet and road surface.

Photo 5b. Cain property, site #54.1, same view as above, after implementation. A new 24 in. x 70 ft culvert has been installed at the base of fill and a trash rack placed upstream from the inlet. Also the road surface has been re-rocked.

Photo 6a. Cain property, stream crossing site #55.1, before implementation. View from 35 ft above road, looking downstream at inlet area and road surface.

Photo 6b. Cain property, site #55.1, same view as above, after implementation. A new culvert and trash rack have been installed, and the road surface has been re-rocked.

Photo 7a. Cain property, stream crossing site #99, before implementation. View from the hillslope above the crossing, looking downstream towards inlet area and the road surface.

Photo 7b. Cain property, site #99, same view as above, after implementation. A new culvert with a flared inlet has been installed, as well as a trash rack. The inlet area has been armored with riprap, bare soil areas have been seeded and mulched, and the road has been re-rocked.

Photo 8a. Marston property, site #2001, before implementation. View from left, looking towards oversteepened and perched road fill material.

Photo 8b Marston property, site #2001, same view as above, after implementation. Oversteepened and perched material has been removed. Bare soils have been seeded and mulched with straw.

Photo 9a. Hoffman property, stream crossin site #133, before implementation. View from right cutbank, looking downstream towards road surface and stream crossing.

Photo 9b Hoffman property, site #133, same view as above, after implementation. A new, properly sized oval culvert has been installed at the base of fill in alignment with the natural channel. A trash rack was installed above the inlet.

Appendix E

Terminology and techniques used in road related erosion control and erosion prevention projects

1. Sources of road related erosion
2. Overview of storm-proofing roads

1 SOURCES OF ROAD RELATED EROSION

Sources for erosion and sediment delivery are divided into two categories: (1) sediment from specific treatment sites, and (2) sediment from the surfaces of road segments of varying lengths—and their associated cutbanks and inboard ditches—that are hydrologically connected[1] to streams.

Site-specific erosion is termed *episodic* because it is projected to occur during storm events that may occur over an indeterminate time. Some sites, such as unstable fillslope landslides on steep hillslopes, may show evidence for imminent failure, erosion, and sediment delivery. But typically, individual sites can only be evaluated in terms of their likelihood to fail during the next severe storm or runoff event, with plans designed to prevent erosion and sediment delivery as a result of that eventuality.

In contrast to site-specific episodic erosion, erosion from road surfaces is termed *chronic* because it occurs on an on-going basis, during every rainfall event that results in surface runoff. Chronic road surface erosion is primarily dependent on the level of road usage, the erodibility of the road surface, the steepness of the road, and the amount of surface runoff that is collected, concentrated, and discharged from the road. PWA provides estimates of chronic erosion and sediment delivery for a 10-year period, based on empirical calculations for fine sediment generation from hydrologically connected road surfaces and associated bare cutbanks and ditches (Weaver et al., 2006). The amount of fine sediment delivered to stream channels from these eroding road surfaces can be substantial over time, and in many watersheds may represent the greater detriment to fish habitat and the aquatic ecosystem.

1.1 Site-Specific Erosion Sources

1.1.1 Stream crossings

A stream crossing is the location where a road crosses a stream channel (Weaver and Hagans, 1994). Drainage structures used in stream crossings include bridges, fords, armored fills, culverts, and a variety of temporary crossing structures. When they erode, sediment delivery from stream crossings is always assumed to be 100%, because any sediment eroded from the crossing site is delivered directly to the stream (Furniss et al., 1997; Weaver et al., 2006). The size of the stream affects the rate of sediment mobilization and movement, but any sediment delivered to small ephemeral streams will eventually be transported to downstream fish-bearing stream channels. Because of this, it is important to identify all stream crossings and evaluate the potential for erosion and sediment delivery from the site.

Common features of stream crossings that lead to erosion problems include (1) fill crossings without culverts, (2) crossings with undersized culverts, (3) crossings with culverts susceptible to being plugged, (4) crossings with culvert outlet erosion, (5) crossings with logs or debris buried

[1] *Hydrologically connected* describes sites or road segments from which eroding sediment is delivered to stream channels (Furniss et al., 2000).

in the fill intended to convey streamflow (i.e., *Humboldt crossings*), (5) crossings with a potential for stream diversion, and (6) crossings that have currently diverted streams.

A *fill crossing* is a stream crossing without a culvert or other drainage structure to carry the flow through the road prism. At such sites, stream flow either crosses the road and flows over the fillslope, or is diverted down the road via the inboard ditch. Most fill crossings are located at small Class II or III streams[2] that only have flow during larger runoff events. *Armored fill crossings* and *ford crossings* are designed to be functional, unculverted stream crossings. A properly constructed armored fill crossing is based on a site-specific design, using a mix of riprap-sized rock to minimize erosion while allowing the stream to flow across the road prism (Weaver et al., 2006). A ford crossing may use rock armor to stabilize the roadway, but the road is built essentially on the natural streambed and fill is not used.

Humboldt crossings are constructed from logs or woody debris, usually laid parallel to flow, which are then covered with fill. Humboldt crossings are susceptible to plugging, gullying, and washout during storm flows (Weaver et al., 2006). Older Humboldt log crossing structures beneath more recently installed culverts are often found in rural northern California road networks.

Large volumes of erosion may occur at stream crossings when culverts are too small for the drainage area and storm flows exceed culvert capacity, or when culverts become plugged by sediment and debris. In these instances, flood runoff will spill across the road, allowing erosion of the stream crossing fill and development of a *washout crossing*. Washout crossings will remain highly problematic as the streambed and banks continue to erode and adjust to a stable grade.

Serious erosion problems may also occur where a stream crossing has a *diversion potential*. Stream diversions occur at stream crossings that are unculverted, or have culverts that plug during a flood event, allowing water to spill out onto the road surface or into the ditch, and flow down the road and onto adjacent hillslopes or into nearby stream channels. When this occurs, the roadbed, hillslope, and/or stream channel that receives the diverted flow may become deeply gullied or destabilized. Road and hillslope gullies can develop and enlarge quickly and deliver large quantities of sediment to stream channels (Hagans et al., 1986; Furniss et al., 1997). Streamflow that is diverted onto steep or unstable slopes may also trigger hillslope landslides and large debris flows.

To be considered adequately sized, culverts at stream crossings must have the capacity to convey a 100-year peak storm flow[3] with sediment and organic debris in transport (USDA Forest Service, 2000; Weaver et al., 2006). In areas where large woody debris may lodge against the culvert, trash racks should be installed slightly upstream from culvert inlets as an additional precaution against plugging. Substandard stream crossing culverts include those that are not large enough to convey a 100-year flow, or are installed at too low of a gradient through the

[2] In general, Class I streams are waterways containing viable or restorable fish habitat, or are the source of domestic water supplies. Class II streams are those that support non-fish aquatic species. Class III streams are defined as channels with a defined bed and banks and showing evidence of sediment transport. Class IV streams are man-made watercourses.
[3] The *100-year peak storm flow* for a location is the discharge that has a 1% probability of occurring at that location during any given year.

stream crossing fill. Installing a culvert at a shallower grade than the natural upstream channel will cause sediment and debris to be deposited at and immediately upstream of the culvert inlet, which promotes plugging and decreases the culvert's capacity to carry streamflow. The outdated practice of installing culverts at insufficiently low gradients was once employed as a cost-cutting measure, because it requires a shorter length of pipe to convey flow through the road. In the long run, however, this practice often proves detrimental to erosion control and maintenance efforts because it allows the culvert to discharge water onto unconsolidated road fill rather than into the preexisting stream channel, resulting in pronounced erosion of the outboard, downstream fill face.

1.1.2 Landslides

Landslides with the potential to fail during periods of intense and prolonged rainfall events are identified in the field by tension cracks, scarps showing vertical displacement, corrective regrowth on trees (i.e., pistol butt trees) and perched, hummocky fill indicating surface instability. As a standard practice, PWA maps all existing and potential landslides observed in the field, but only inventories those that are associated with roads and show a potential to deliver sediment to a watercourse. Types of landslides in a road related erosion assessment typically include (1) road fill failures, (2) landing fill failures, (3) hillslope debris slides, and (4) deep-seated, slow landslides. The majority of treatable landslides in an assessment area are often the result of failure of unstable fill and sidecast material from earlier road construction. Preemptive excavation of small, current or potential landslides is an effective technique for erosion control, achieved by removing the unstable material and redepositing it in a stable, designated location either at or near the treatment site. Conversely, large, deep-seated landslides are usually found to be technically infeasible to treat.

1.1.3 Ditch relief culverts

A *ditch relief culvert* (DRC) is a plastic, metal, or concrete pipe installed beneath the road surface to convey flow from an inside road ditch to an area beyond the outer edge of the road fill. When properly spaced, DRCs limit the quantity of water available to cause erosion at any single location, allowing flow to disperse and reducing the likelihood of gullies forming at their outlets. It is sometimes necessary to install downspouts or rock armor at DRC outlets to further dissipate energy and prevent erosion.

1.1.4 Discharge points for road surface, cutbank, and ditch erosion.

Unpaved road surfaces, and their associated cutbanks and inboard ditches, are major sources for erosion and delivery of fine sediment to stream channels. For paved roads, ditches, cutbanks, and unpaved turnouts may still represent active sediment sources. Road surface, cutbank, and ditch erosion is termed "chronic" because it occurs throughout the year, and may include one or more of the following processes: (1) mechanical pulverizing and wearing down of road surfaces by vehicular traffic; (2) erosion of unpaved road surfaces by rainsplash and runoff during periods of wet weather; (3) erosion of inboard ditches by runoff during wet weather; and (4) erosion of cutbanks by dry ravel, rainfall, slope failures, and brushing/grading practices. *Discharge points for road surface, cutbank, and ditch erosion* are locations where sediment-laden flow from poorly drained road/cutbank/ditch segments exits the roadway to be delivered into the stream system. Discharge points are often in the form of roadside gullies or waterbars, but on some low

gradient or streamside roads may simply be low spots where concentrated flow exits the road and is delivered directly to a stream without gully formation.

1.1.5 Additional site-specific sediment sources

Additional, less frequent sources of sediment delivery that may be found in an assessment area include:

Point source springs. Point source springs refer to sites where spring flow is entering the roadbed and causing erosion. Flow from multiple springs may become concentrated along a road with inadequate drainage structures, creating roadside gullies or fillslope failures.

Sites of bank erosion. Bank erosion sites refer to locations of streambank erosion caused or exacerbated by emplacement of a nearby road.

Swales. Swales are channel-like depressions that only carry minor flow during periods of extreme rainfall.

Channel scour. Channel scour refers to the widening or deepening of stream channels as a result of increased flow levels.

Non-road related upslope gullies. These are sites of focused runoff that form upslope from a roadway, and may exacerbate erosion at the roadway or contribute sediment to the system during high discharge.

1.2 Evaluation of Hydrologically Connected Road Segments

PWA measures the lengths of hydrologically connected road segments adjacent to sediment delivery sites, such as on either side of a stream crossing, ditch relief culvert, or discharge point, to derive an estimate for total potential sediment delivery from connected road surfaces in the project area. In addition, because the adjacent hydrologically connected road segments contribute to the overall erosion and sediment delivery problem at a site, PWA considers the treatment site and adjacent road segments as a unit when estimating future sediment delivery and developing treatment prescriptions for that location.

2 OVERVIEW OF STORM-PROOFING ROADS (ROAD UPGRADING AND DECOMMISSIONING)

Forest and rural roads may be storm-proofed by one of two methods: upgrading or decommissioning (Weaver and Hagans, 1994, 1999; Weaver et al., 2006). Upgraded roads are kept open, and are inspected and maintained. Their drainage facilities and fills are designed or treated to accommodate the 100-year peak storm flow. Conversely, properly decommissioned roads are closed and no longer require maintenance. Whether through upgrading or decommissioning, the goal of storm-proofing is to make the road as "hydrologically invisible" as possible, that is, to minimize the hydrologic effects of the road and to reduce or prevent future sediment delivery to the local stream system. A well-designed storm-proofed road includes specific characteristics (Table 1), all proven to contribute to long-term improvement and protection of watershed hydrology and aquatic habitat.

2.1 Road upgrading

Road upgrading involves a variety of treatments used to make a road more resilient to large storms and flood flows. The most important of these include upgrading stream crossings (especially culvert upsizing to accommodate the 100-year peak storm flow and debris in transport, and treatments to correct or prevent stream diversion); removing unstable sidecast and fill materials from steep slopes; and applying road drainage techniques (e.g., installing ditch relief culverts, removing berms, constructing rolling dips, insloping or outsloping the road) to improve dispersion of surface runoff. Road upgrading often also includes adding road rock or riprap as needed to fortify roads and crossings. The treatments are fully described by Weaver et al. (2006).

2.1.1 Installing rolling dips

Rolling dips are installed on low- to moderate-gradient, hydrologically connected roads to disperse surface runoff and discharge it onto the native hillslope below the road. Rolling dips may extend from the inboard edge to the outboard edge of a road prism, or just on the roadbed, and are constructed at intervals as needed to control erosion (typically 100, 150, or 200 ft). They are effective in reducing year-round ("chronic") sediment delivery from road surfaces, and are designed to be easily drivable and not impede vehicular traffic.

2.1.2 Road shaping

Road shaping changes the existing geometry or orientation of the road surface, and is accomplished through insloping (sloping the road toward the cutbank), outsloping (sloping the road toward the outside edge), or crowning (creating a high point near the center axis of the road so that it slopes both inward and outward). Like rolling dips, road shaping is used to prevent uncontrolled delivery of road surface runoff by dispersing it into the inside ditch or onto the hillslope below the road. This is also effective in preventing the formation of gullies at the edge of the road, and localized slope instability below the road. Road shaping is almost always used in concert with rolling dips to disperse surface runoff.

Table 1. Characteristics of storm-proofed roads (*from* Weaver et al., 2006).

Storm-proofed stream crossings • All stream crossings have a drainage structure designed for the 100-year peak storm flow (with debris). • Stream crossings have no diversion potential (functional critical dips are in place). • Stream crossing inlets have low plug potential (trash barriers installed). • Stream crossing outlets are protected from erosion (extended beyond the base of fill; dissipated with rock armor). • Culvert inlet, outlet, and bottom are open and in sound condition. • Undersized culverts in deep fills (greater than backhoe reach) have emergency overflow culvert. • Bridges have stable, non-eroding abutments and do not significantly restrict 100-year flood flow. • Fills are stable (unstable fills are removed or stabilized). • Road surfaces and ditches are "hydrologically disconnected" from streams and stream crossing culverts. • Class I stream crossings meet CDFG and NMFS fish passage criteria (Taylor and Love, 2003).
Storm-proofed fills • Unstable and potentially unstable road and landing fills are excavated or structurally stabilized. • Excavated spoil is placed in locations where it will not enter a stream. • Excavated spoil is placed where it will not cause a slope failure or landslide.
Road surface drainage • Road surfaces and ditches are "hydrologically disconnected" from streams and stream crossing culverts. • Ditches are drained frequently by functional rolling dips or ditch relief culverts. • Outflow from ditch relief culverts does not discharge to streams. • Gullies (including those below ditch relief culverts) are dewatered to the extent possible. • Ditches do not discharge (through culverts or rolling dips) onto active or potential landslides. • Decommissioned roads have permanent drainage and do not rely on ditches. • Fine sediment contributions from roads, cutbanks, and ditches are minimized by utilizing seasonal closures and implementing a variety of surface drainage techniques including berm removal, road surface shaping (outsloping, insloping, or crowning), road surface decompaction, and installing rolling dips, ditch relief culverts, waterbars, and/or cross-road drains to disperse road surface runoff and reduce or eliminate sediment delivery to the stream.

2.1.3 Installing ditch relief culverts

A ditch relief culvert is a drainage structure (usually an 18 in. pipe) installed across a road prism to move water and sediment from the inboard ditch so that it can be dispersed on native hillslope downslope from the road. Ditch relief culverts are used to drain ditch flow on roads that are too steep for rolling dips or outsloping, as well as at sites with excessive flow from springs or seepage from cutbanks.

2.1.4 Excavating unstable fillslope

The fillslope, the sloping part of the road between its outboard edge and the natural ground surface below, may fail or show signs of potential failure. As a preventative measure, unstable fillslope sediment is excavated and relocated (endhauled or pushed) to a permanent, stable spoil disposal site.

2.1.5 Upgrading stream crossings

Techniques used to remediate road related erosion at a stream crossing are dependent on the size of the stream channel, and specific physical characteristics at the crossing site. Class I and large stream crossings may require a bridge, or, if their banks are small or low gradient, a ford crossing may be suitable, particularly if seasonal use is anticipated. A common approach to upgrading moderate-sized crossings of Class II and III streams is to construct a culverted fill crossing capable of withstanding the 100-year flood flow. Techniques for upgrading small and moderate-size stream crossings include:

Installing or replacing culverts. A culvert capable of withstanding the 100-year peak storm flow is installed or replaced in the fill crossing. Culverts on non fish-bearing streams are placed at the base of fill, in line and on grade with the natural stream channel upstream and downstream of the crossing site. Backfill material, free of woody debris, is compacted in 0.5-1.0 ft thick lifts until 1/3 of the diameter of the culvert has been covered. At sites where fillslopes are steeper than 2:1, or where eddying currents might erode fill on either side of the inlet, rock armor is applied as needed.

Installing an armored fill. Armored fills are installed on smaller stream crossings with relatively small fill volume, but where debris torrents are common, channel gradients are steep, or inspection and maintenance of a culverted crossing is impossible or unlikely to occur. The roadbed is heavily rocked and a keyway at the base of the outboard fillslope is excavated and backfilled with interlocking rock armor of sufficient size to resist transport by stream flow. Armored fill crossings are constructed with a dip in the axis of the crossing to prevent diversion of the stream flow, and focus the flow over the part of the fill that is most densely armored.

Installing secondary structures. A variety of secondary structures may be used to increase the function of small stream crossings by allowing uninterrupted stream flow, decreasing plugging, and controlling erosion. Where a culvert has been improperly installed too high in the fill, a *downspout* may be added to its outlet to release the flow close to the ground surface, rather than letting it cascade from the height of the culvert. *Rock armor* may be used to buttress steep fillslopes, as well as to prevent erosion of inboard or outboard fillslopes by eddying currents. A *trash rack* placed in the channel above a culvert inlet will trap debris and reduce plugging. To prevent stream diversion should the culvert become plugged or its capacity exceeded, a *critical dip* (essentially a rolling dip constructed on the down-road hingeline of the fill) may be installed to ensure that stream flow will be directed across the road and back into the natural channel. Finally, an *overflow culvert* may be a necessary addition at a culverted crossing where, because of site conditions, plugging or capacity exceedence of the primary culvert is anticipated.

2.2 Road decommissioning

In essence, decommissioning is "reverse road construction," although complete topographic obliteration of the roadbed is not usually required to achieve cost-effective erosion prevention. In most cases, serious erosion problems are confined to a few, isolated locations along a road (perhaps 10% to 20% of the full road network to be decommissioned) where stream crossings need to be excavated, unstable sidecast on the downslope side of a road or landing needs to be removed before failure, or the road crosses unstable terrain and the entire road prism must be removed. But typically, lengths of road beyond the extent of individual treatment sites usually require simpler, permanent improvements to surface drainage, such as surface decompaction, additional cross-road drains, and/or partial outsloping. As with road upgrading, the heavy equipment techniques used in road decommissioning have been extensively field tested and are widely accepted (Weaver and Sonnevil, 1984; Weaver et al., 1987, 2006; Harr and Nichols, 1993; Pacific Watershed Associates, 1994).

2.2.1 Road ripping or decompaction

Road ripping is a technique in which the surface of a road or landing is disaggregated or "decompacted" to a depth of at least 18 in. using mechanical rippers. This action reduces or eliminates surface runoff and usually enhances revegetation.

2.2.2 Installing cross-road drains

Cross-road drains (also called "deep waterbars") are large ditches or trenches excavated across a road or landing surface to provide drainage and prevent runoff from traveling along, or pooling on, the former road bed. They are typically installed at 50, 75, 100 or 200 ft intervals, or as necessary at springs and seeps. In some locations (e.g., streamside zones), partial outsloping may be used instead of cross-road drain construction.

2.2.3 In-place stream crossing excavation (IPRX)

IPRX is a decommissioning treatment used for roads or landings that are built across stream channels. The fill (including the culvert or Humboldt log crossing) is completely excavated and the original streambed and side slopes are exhumed. Excavated spoil is stored at nearby, stable locations where it will not erode. In some cases, this may necessarily be as far as several hundred feet, or more, from the crossing. An IPRX typically involves more than simply removing a culvert, as the underlying and adjacent fill material must also be removed and stabilized. As a final measure, the sides of the channel may be cut back to slopes of 2:1, and mulched and seeded for erosion control.

2.2.4 Exported stream crossing excavation (ERX)

ERX is a decommissioning treatment in which stream crossing fill material is excavated and the spoil is hauled off-site for storage (the act of moving spoil material off-site is called "endhauling"). This procedure is necessary when large, stable storage areas are not available at or near the excavation site. It is most efficient to use dump trucks to endhaul the spoil material.

2.2.5 In-place outsloping (IPOS)

IPOS (also called "pulling the sidecast") calls for excavation of unstable or potentially unstable sidecast material along the outside edge of a road prism or landing, and placement of the spoil on the roadbed against the corresponding, adjacent cutbank or within several hundred feet of the site. As a further decommissioning measure, the spoil material is placed against the cutbank to block vehicular access to the road.

2.2.6 Export outsloping (EOS)

EOS is a technique comparable to IPOS, except that spoil material is moved off-site to a permanent, stable storage location. EOS is required when it is not possible to place spoil material against the cutbank, e.g., where the road prism is narrow or where there are springs along the cutbank. EOS usually requires dump trucks to endhaul the spoil material. This technique is used for both decommissioning and upgrading roads, but as the roadbed is partially or completely removed, EOS is more commonly used for decommissioning.

References for Appendix D

Furniss, M., Flanagan, S., and McFadin, B., 2000, Hydrologically-connected roads: An indicator of the influence of roads on chronic sedimentation, surface water hydrology and exposure to toxic chemicals: Fort Collins, CO, USDA Forest Service, Rocky Mountain Research Station, Stream Systems Technology Center, Stream Notes, July, 2000, p. 5-7

Hagans, D.K., Weaver, W.E., and Madej, M.A., 1986, Long-term on-site and off-site effects of logging and erosion in the Redwood Creek Basin, Northern California, *in* Papers presented at the American Geophysical Union meeting on cumulative effects (December 1985): New York, NY, National Council for Air and Stream Improvement Technical Bulletin, no. 490, p. 38-66. Available from: http://www.krisweb.com/biblio/gen_ncasi_hagans_etal_1986_roadsed.pdf

Harr, R.D., and Nichols, R.A. 1993, Stabilizing forest roads to help restore fish habitats: A northwest Washington example: Fisheries, v. 18, no. 4, p. 18-22. Available from: http://afs.allenpress.com/perlserv/?request=get-abstract&doi=10.1577%2F1548-8446(1993)018%3C0018%3ASFRTHR%3E2.0.CO%3B2

USDA Forest Service, 2000, Water/road interaction field guide: San Dimas, CA, San Dimas Technology and Development Center, 68 p. Available from: http://www.fs.fed.us/eng/pubs/pdf/00771803.pdf

Weaver, W.E., and Hagans, D.K., 1994, Handbook for forest and ranch roads: a guide for planning, designing, constructing, reconstructing, maintaining and closing wildland roads: Ukiah, CA, Mendocino County Resource Conservation District, 198 p. Available from: http://www.mcrcd.org/publications/

Weaver, W.E, and Hagans, D.K., 1999, Storm-proofing forest roads, *in* Sessions, J., and Chung, W., eds., Proceedings of the International Mountain Logging and 10th Pacific Northwest Skyline Symposium, Corvallis, Oregon, April 1999: Oregon State University, Forest Engineering Department, p 230-245. Available from: http://www.iufro.org/science/divisions/division-3/30000/30600/publications/

Weaver, W.E., and Sonnevil, R.A., 1984, Relative cost-effectiveness of erosion control for forest

land rehabilitation, Redwood National Park, *in* Conference on Erosion Control, Man and Nature, XV, Denver, CO., February 23-24, 1984, Proceedings: Denver, CO, International Erosion Control Association, p. 83-115.

Weaver, W.E., Hagans, D.K., and Madej, M.A., 1987, Managing forest roads to control cumulative erosion and sedimentation effects, *in* Callaham, R.Z., and DeVries, J.J., eds., California Watershed Management Conference, November 18-20, 1986, Proceedings: Berkeley, CA, University of California, Wildland Resources Center, Report 11, p. 119-124. Available from: http://danr.ucop.edu/wrc/pubs.html

Weaver, W.E., Hagans, D.K., Weppner, E., 2006, Part X: Upslope erosion inventory and sediment control guidance, *in* Flosi, G., Downie, S., et al., eds., California salmonid stream habitat restoration manual, 3d. ed.: Sacramento, CA, California Department of Fish and Game, 207 p. Available from: https://nrmsecure.dfg.ca.gov/FileHandler.ashx?DocumentID=3596

Appendix F

Typical drawings (schematic diagrams) showing components of erosion control and erosion prevention treatments and techniques for construction.

No.	Drawing title
1	Typical problems and applied treatments for a non-fish bearing upgraded stream crossing
2	Typical design of a non-fish bearing culverted stream crossing
3	Typical design of a single-post culvert inlet trash rack
4	Typical design for armoring fillslopes
5	General armored fill dimensions
6	Typical armored fill crossing installation
7	Ten steps for constructing a typical armored fill crossing
8	Typical ditch relief culvert installation
9	Typical designs for using road shape to control road runoff (using insloping, outsloping, and crowning)
10	Typical methods for dispersing road surface runoff with waterbars, cross-road drains, and rolling dips
11	Typical road surface drainage by rolling dips
12	Typical sidecast or excavation methods for removing outboard berms on a maintained road
13	Typical excavation of unstable fillslope on an upgraded road
14	Typical problems and applied treatments for a decommissioned stream crossing
15	Typical design for road decommissioning treatments employing export and in-place outsloping techniques
16	Typical excavation of unstable fillslope on a decommissioned road