Manzana Creek Watershed Anthropogenic Sediment Reduction Assessment, Aquatic Protection and Road Restoration Planning Project, Los Padres National Forest

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COVER PHOTO: View of the Manzana Creek watershed looking northeast from Zaca Ridge.

1. PROJECT SUMMARY

The study area for *Manzana Creek Watershed Anthropogenic Sediment Reduction Assessment, Aquatic Protection and Road Restoration Planning Project* is the approximately 56.37 mi^2 Manzana Creek watershed located within Los Padres National Forest (LPNF). With the exception of a few small private inholdings making up less than <2%, the project area is entirely owned and managed by the United States Forest Service (USFS) and located approximately 12 mi northeast of the town of Los Olivos in Santa Barbara County, California (Map 1).

The Manzana Creek watershed is an important Southern California Steelhead (*O. mykiss*) "refugia" tributary sub-watershed to the undammed Sisquoc River that is located in a highly fire-prone region of Southern California. Fires, like floods, are stochastic events that can significantly influence the quality and quantity of aquatic habitat. Increased sediment supply and channel aggradation can be expected in the years immediately following fires. Impacts are only exacerbated and contribute to the degradation of existing aquatic habitat when followed by moderate to intense winter storms and/or flooding events. With the increase in runoff rates and patterns, reduced soil infiltration rates, and possible fire damage to existing drainage features that frequently are present post fire, poorly maintained and/or designed road systems are even more vulnerable to failure and/or accelerated erosion for many years following a fire.

In order to protect existing aquatic habitat and provide Manzana Creek a better chance to recover and build resiliency against future disturbance(s), Central Coast Salmon Enhancement (CCSE) secured a Wildfires Restoration Grant through the National Fish and Wildlife Foundation (NFWF) for this project. In 2018, CCSE contracted with Pacific Watershed Associates (PWA) to: 1) identify controllable sources of anthropogenic road/trail related fine and coarse sediment sources and ongoing or potential sediment delivery sites; 2) quantify the potential sediment production volumes per site; 3) prioritize the sites treatment immediacy or urgency for corrective measures; and 4) develop treatment recommendations to prevent the identified future erosion and sediment delivery by sites from occurring; and 5) develop a forward looking prioritized plan of action for protecting and improving aquatic habitat in the Manzana Creek watershed.

To affect long-term regional education, members from the California Conservation Corps (CCC), AmeriCorps Watershed Stewards Project (WSP), and NOAA Veterans gained hands on experience and training as they assisted PWA staff conducting field inventory within selected portions of the project area. Using field inventories and data analysis, a total of 295 sites along approximately 51 mi of roads and trails were identified as having the potential to deliver sediment to streams within the project area. Of these 295 sites, PWA recommends 260 sites (88%) be treated for erosion control and erosion prevention: 42 (16%) were recommended for treatment with a high immediacy; 92 (35%) were classified as having a moderate treatment immediacy, and 126 (49%) received a low treatment immediacy or urgency/probability of needing preventative corrective actions.

PWA estimates that treating all the sites will prevent a total of approximately 24,450 yd^3 of sediment from being eroded and delivered to streams in the Manzana Creek watershed. In addition to individual, problematic erosion sites, field crews measured approximately 23.7 mi of road/trail surfaces, cutbanks, and/or ditches (representing nearly 44% of the total inventoried mileage) currently draining runoff and sediment directly to stream channels, either directly or via gullies. Of these 23.7 mi of *hydrologically* connected segments, we recommend treating 22.05 mi to diminish surface runoff and delivery of fine sediment to the adjacent stream channels: PWA estimates that this will prevent approximately 10,820 yd^3 (44%) of the total sediment delivery estimate from being delivered into stream channels during the next decade alone, if hydrologic connectivity is not drastically reduced by implementing recommended treatments.

Of the total future sediment delivery estimate of 24,450 yd^3 from identified sediment sources, approximately 19 mi of inventoried native surface roads are estimated to account for 14,580 yd^3 or nearly 60% of the total sediment delivery volume, and are therefore the most beneficial to treat of the 3 road and trail classes purely from the perspective of cost effective benefits to protect water quality and existing high value aquatic habitat present in Manzana Creek. Paved roads account for approximately 7 mi and are estimated to produce 7,770 yd^3 (<32%) of future sediment delivery volume, and the approximately 25 mi of trail width routes are predicted to account for only 2,100 yd^3 (<9%) of the total man-caused future sediment delivery volume.

In addition to presenting the sediment source assessment results by road/trail type and treatment immediacy, each point source sediment delivery site has been classified by the sediment input mechanism to the stream system (i.e. stream crossing, ditch relief culvert, road surface, landslide, or bank erosion site) along with the associated hydrologically connected reaches draining to the site. Each site has received a suite of recommended actions to prevent the estimated site erosion volume from occurring. Recommendations include corrective and preventative actions such as replacing damaged, worn out or undersized stream crossing and ditch relief culverts; adding downspouts/rock slope protection (RSP) to prevent fillslope and hillslope erosion and gully formation; installing trash racks to reduce culvert plugging potential; excavating failing fillslopes; and disconnecting hydrologically connected road/trail approaches by installing additional drainage features and improving road/trail shape.

This prioritized plan of action for cost-effective preventative erosion prevention and erosion control typically would include developing a cost-estimate to implement all the recommended erosion control measures that have resulted from this “forward-looking” sediment source assessment. However, some uncertainty is still present in costing out LPNF approved corrective measures. As a result, PWA has developed a sample plan for NFWF and LPNF to consider as a pilot project intended to demonstrate the utility of this assessment methodology for implementing site and road drainage improvement treatments.

The proposed pilot project recommends implementing erosion control and sediment prevention measures at 34 identified sediment source sites along approximately 8.7 mi of the native surfaced McKinley Mountain Road ascending through the headwaters of Fish Creek to the ridge along the wilderness boundary. Of the 260 sites and 20.05 mi of hydrologically connected road and trail recommended for treatment, this pilot project would treat 17 stream crossings, 17 road surface sites and disconnect 3.9 mi of road. Implementation under some form of a USFS National Environmental Protection Agency (NEPA) road maintenance exemption would control and prevent 4,875 yds^3 of future anthropogenic erosion and sediment delivery to the Fish Creek and Manzana Creek watershed over the next decade alone, and eliminate nearly 20% of the total assessment predicted future sediment delivery for less than a $500,000 investment.

The expected benefit of completing the treatments recommended in this report lies in the reduction of controllable sources of anthropogenic erosion and long-term sediment delivery to the Manzana Creek watershed where important refugia aquatic habitat is present for the endangered southern steelhead in the Central Coast ESU fire-prone areas of Santa Barbara County, California. With this prioritized plan of action, entities interested in the sustainability of the watershed, preservation of aquatic habitat, and increased watershed resiliency to the pending climatic variability can advance efforts to obtain funding and implement elements of the plan.

2. CERTIFICATION AND LIMITATIONS

This report of findings for the project entitled *Manzana Creek Watershed Anthropogenic Sediment Reduction Assessment, Aquatic Protection and Road Restoration Planning Project, Los Padres National Forest* was prepared under the direction of a licensed professional geologist at Pacific Watershed Associates, Inc. (PWA), and all information herein is based on data and information collected by PWA staff. Sediment-source inventory and analysis for the project, as well as erosion control treatment prescriptions, were similarly conducted by or under the responsible charge of a California licensed professional geologist at PWA.

The interpretations and conclusions presented in this report are based on a study of inherently limited scope. Observations are qualitative, or semi-quantitative, and confined to surface expressions of limited extent and artificial exposures of subsurface materials. Interpretations of problematic geologic and geomorphic features (such as unstable hillslopes) and erosion processes are based on the information available at the time of the study and on the nature and distribution of existing features.

The recommendations included in this report are professional opinions derived in accordance with current standards of professional practice and are valid as of the submittal date. No other warranty, expressed or implied, is made. PWA is not responsible for changes in the conditions of the property with the passage of time, whether due to natural processes or to the works of man or changing conditions on adjacent areas. Furthermore, to ensure proper applicability to existing conditions, the information and recommendations contained in this report shall be reevaluated after a period of no more than 3 years, and it is the responsibility of the landowner to ensure that no recommendations are inappropriately applied to conditions on the property that have changed since the recommendations were developed. Finally, PWA is not responsible for changes in applicable or appropriate standards beyond our control, such as those arising from changes in legislation or the broadening of knowledge, which may invalidate any of our findings.

Certified by:
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3. INTRODUCTION

One of the most important watershed management elements of long-term restoration and maintenance of both water quality and fish habitat is the reduction of future impacts from upland erosion and sediment delivery. Sediment delivery to stream channels from roads and road networks has been extensively documented and is recognized as a significant impediment to the health of salmonid habitat (Furniss et al., 1991; Higgins et al., 1992; Harr and Nichols, 1993; Flosi et al., 2010; NMFS, 2000, 2001). Unlike many watershed improvement and restoration activities, erosion prevention through "storm-proofing" rural, ranch, and forest roads provides immediate benefits to the streams and aquatic habitat of a watershed (Weaver and Hagans, 1999; Weaver et al., 2006, 2015). It measurably diminishes the impact of road related erosion on the biological productivity of the watershed's streams and allows future storm runoff to cleanse the streams of accumulated coarse and fine sediment, rather than allowing continued sediment delivery from managed areas.

The Manzana Creek watershed is an important Southern California Steelhead (*O. mykiss*) tributary to the undammed Sisquoc River. LPNF and Zaca/Piru Fires Restoration Conservation Strategy documents also identify and prioritize this watershed for protecting and improving habitat for Threatened Southwestern Pond Turtle and Red-Legged Frog (NMFS, 2012).

To identify and address anthropogenic sources of sediment delivery problems in the Manzana Creek watershed, CCSE contracted PWA to assess anthropogenic sources of erosion and sediment delivery within LPNF (Maps 1, 2). PWA staff completed an assessment of approximately 51 mi of maintained, seasonal, and abandoned roads and trails on the property in 2018-2019. Specifically, the purpose of the project was to: (1) identify and quantify current and potential sites of man caused road/trail related erosion and sediment delivery; and (2) develop a prioritized plan for long-term erosion control and erosion prevention, including treatment specifications, material needs, and estimated implementation time for heavy equipment and labor.

In this report, we provide results of the field assessment and data analysis, and a detailed plan of action for implementing erosion control and erosion prevention treatments to reduce road related erosion in the project area. All treatment prescriptions follow guidelines described in the *Handbook for Forest, Ranch and Rural Roads* (Weaver, et al., 2015), as well as *Parts IX* and *X* of the California Department of Fish and Game *Salmonid Stream Habitat Restoration Manual* (Taylor and Love, 2004; Weaver et al., 2006).

For an overview of terminology and techniques used in road related erosion assessments, see Appendix A. Assessment data are summarized in Tables 1-4, Map 2, and Appendix B. Construction and installation instructions for the recommended erosion control and erosion prevention treatments are provided in Table 5 and Appendixes B and C. Representative photographs are included in Appendix D.

4. FIELD DESCRIPTION OF THE ASSESSMENT AREA

4.1 Location and Travel Directions to the Field Area

The Manzana Creek Watershed assessment area is located in the Southern Coast Mountain Range within central Santa Barbara County, and is within the Los Padres National Forest (LPNF). The project area is located approximately 12 mi northeast of the town of Los Olivos (Map 1). The area is accessed from the north by taking Highway 154 exit towards Lake Cachuma off US Highway 101. Follow Highway 154 approximately 8.5 mi past Los Olivos to a roundabout and turn east onto Armour Ranch Road. Travel approximately 1.6 mi and turn left onto Happy Canyon Road. Continue on Happy Canyon Road until arriving at Cachuma Saddle parking lot at the southern watershed boundary of Manzana Creek (approximately 14 mi). Project areas can be accessed from this location. Sunset Valley Road takes you north to mainstem Manzana Creek, Davy Brown and Nira Campgrounds; Figueroa Mountain Road travels northwest to access the southwestern project area; and McKinley Mountain Road travels along the southeastern watershed boundary of the project area.

4.2 Climate and Terrain

The climate of the southern coastal range in California is characterized by hot, dry summers, and cool winters with periods of high intensity rainfall and occasional snowfall at higher elevations above 4,000 ft. Mean annual precipitation is approximately 26.5", based on climatic observations of the Prism Climate Group[1]. Most rainfall occurs between November and April. As snowfall in the watershed is seldom more than a few inches, large, flashy, flood events are associated with intense periods of rainfall and not rain-on-snow events.

The range of elevation, climatic conditions and relatively high rainfall amounts in the watershed support forests of Pine, Douglas Fir, and Coast Live Oak at higher elevations, and large stands of chaparral. Perennial flow in Manzana Creek also helps support a large riparian forest dominated by California Sycamore and Coast Live Oak, which cover large areas of the valley floor. South-facing slopes are far drier and more exposed and are commonly occupied by coastal sage scrub and annual grassland communities. Interspersed throughout this diverse landscape, there are small stands of Juniper, Bay Laurel, and California Hollyleaf Cherry, which stand out among the lower-growing chaparral and scrubland plant communities. On many of the steeper, south-facing slopes, large populations of Chaparral yucca stand out among the poorly vegetated, rocky surface.

Elevations in the project area range from 1,100 ft at the confluence of Manzana Creek and the Sisquoc River to approximately 6,500 ft in the mountainous areas along the eastern watershed boundary. Roads and trails in the project area traverse a range of elevations from ridgetops to the inner gorges of streams, including the mainstem of Manzana Creek. The extensive construction of roads for historical mining operations in this area of steep terrain, erodible geologic substrate, and high rainfall (including occasional intense winter storms) has resulted in high rates of erosion and sediment delivery from road networks to stream channels. The lower tributaries within the basin alternately traverse inner gorges with steep, unstable slopes and high rates of

[1] Rainfall data acquired from: http://www.prism.oregonstate.edu/explorer/

erosion, and low gradient areas that facilitate sediment deposition and accumulation. Whereas salmonid populations have evolved and flourished with the natural processes of rainfall and erosion in the area, the impact of anthropogenically induced erosion from resource management and road construction has resulted in accelerated sediment delivery to streams and a degradation of salmonid habitat in this important watershed.

4.3 Geology

The project area is located along the southern portion of the Coast Range Geomorphic Province (CGS, 2002). The Coast Ranges lie between the Pacific Ocean and the California Central Valley, extending from the Transverse Ranges in the vicinity of Point Conception to the California-Oregon border. The San Andreas Fault, a major strike-slip plate boundary fault, is a dominant structural feature of the Coast Ranges, extending along the western part of the province as far north as Cape Mendocino (CGS, 1977). The ranges and valleys of the province trend northwest, subparallel to the San Andreas fault. The Northwest trending structures and bands of lithologies are characteristic of the Coast Range. These ranges merge with the east-west trending Transverse Ranges to the east (USDA, 2003).

Predominate lithologies in the watershed include folded Cretaceous and Tertiary aged sedimentary sequences of layered sandstone, conglomerates, siltstones, and shale units. There is a band of Franciscan Formation rocks that includes serpentine near the southern boundary of the watershed. Faults and folds largely control the drainage patterns in the watershed (USDA, 2003).

The erosion potential of a geologic unit will vary based on local conditions, including hillslope gradients, depth to bedrock, degree of fracturing, presence and orientation of slip planes, soil erodibility, and volume of streamflow, surface runoff or groundwater throughflow. Erosion and mass wasting are prevalent in the project area because of the sheared and incompetent bedrock materials of the Coastal Belt Franciscan Complex, as well as the poorly cemented and weakly cohesive conglomerates, siltstones, and shale units. In general, the erodibility of geologic units in the project area greatly increases when vegetation is removed, either through natural processes like landsliding, fire, and flooding or anthropogenic processes like road construction. Road treatment strategies when dealing with erosion prone zones include minimizing excavation cuts, using additional rock armor, minimizing concentration of hillslope runoff or spring flow, and dispersing road surface runoff as frequently as possible.

Potential seismic hazards in the project area include strong ground shaking and slope instability. There are three mapped Quaternary age fault zones within close proximity (< 5 mi) to the project area (Dibblee, 1994). The Little Pine fault zone lies to the south and southwest; the East Huasna fault zone to the north and northwest; and Big Pine fault zone to the south and southeast (Bryant, 2017). The close proximity of mapped Quaternary fault zones may contribute to a higher likelihood that the project area will be subjected to strong ground shaking and associated slope failures.

4.4 Manzana Creek Watershed Road, Trail, and Fuel Break network

The focus of assessment within the project area includes a network of anthropogenically constructed roads, trails, and fuel breaks. PWA staff identified and categorized each designation based on construction techniques, surfacing, and existing conditions (maintenance). Map 2 identifies the approximately 51 mi of roads and trails inventoried in the project area.

Roads are constructed with heavy equipment and can generally be described as having a width (cut and/or fill) of approximately 8-25 ft and were originally built to support land use access and mining operations during the first half of the 20th century. Roads are either paved or unpaved and some alignments maintained during subsequent decades by the United States Forest Service (USFS), while others lacked recent evidence of maintenance, and still others completely abandoned.

Maintained roads show evidence of recent maintenance (e.g. brushing, culvert cleaning, grading, etc.). Maintained, year-round use roads in the Manzana Creek project area are either native surface or paved with formal drainage structures at most crossings. Although road drainage has been improved along previously upgraded reaches, many untreated permanent roads are insufficiently drained, with infrequent ditch relief culverts and minimal road shaping to improve drainage. In addition, along many of these maintained road segments, PWA observed that excessively long inboard ditches are currently draining directly into stream crossings and hydrologically connected ditch relief culverts or outboard drains, resulting in delivery of fine sediment from road runoff, ditch incision, and cutbank ravel directly into the stream network.

Abandoned roads show no evidence of recent maintenance and are usually overgrown to varying degrees. Along many of these abandoned road segments, PWA observed problems typical of outdated land use management practices, including excessive road surface erosion as a result of long segments of insloped road with no formal drainage features, plugged undersized culverts, blown out fill and culvert crossings, stream diversion gullying, and bank erosion where roads were built in or near stream channels.

Trails are considered to be originally constructed with an overall width of less than 6 ft. However, segments of the substantial trail network used for recreation within the project area have been established on previously abandoned roads, thereby adding complexity to the delineation of roads and trails for assessment. Although the trails themselves very seldom exhibit substantial erosion and sediment delivery problems, the abandoned roads on which some trails have been established were very frequently noted to be experiencing substantial erosion from poor drainage design, stream diversions, or bank erosion that was never addressed when the roads were abandoned.

Designated and mapped fuel breaks have been constructed primarily along ridgetops to aid in firefighting. While many exhibit past rilling and gullying due to poor or failed waterbarring practices, or as a result of uncontrolled OHV activities, none of the observed fuel breaks exhibited any erosion that resulted in sediment delivery to nearby streams.

5. FIELD TECHNIQUES AND DATA COLLECTION

This project consists of three distinct elements: (1) review of available historical aerial imagery to identify road/trail networks; (2) a complete field inventory of all current and potential road/trail related sediment delivery sources along approximately 51 mi of road/trail; and (3) the development of a prioritized plan of action for cost-effective erosion control and erosion prevention treatments at inventoried locations in the watershed. All project elements were completed under the direction of a PWA licensed professional geologist.

For the first phase of the project, PWA staff reviewed available historical digital imagery to identify possible road, trail and fuel break construction within Manzana Creek watershed. Staff reviewed historical aerial photographs for the years 1933, 1937, 1954, and 1977 (UCSB); digital imagery dated 1994, 2002-2006, 2009-2011, 2013-2015, and 2017-2018 (Google Earth Pro); and 2016 National Agricultural Imagery Program (NAIP) digital imagery (CaSIL, 2016). Locations of possible roads, trails, and fuel breaks observed during review were spatially digitized and the information was then transferred to a base map using ArcMap.

To facilitate the field inventory, potential locations of roads, trails and fuel breaks identified during office review were combined with additional data layers to produce rectified composite base maps. These maps were used to document the locations of inventoried sites, and to ground truth the location and configuration of mapped road/trail segments in the field. Any roads/trails that were not identified during the office review but were located in the field were also mapped and included in the field inventory. The GIS road/trail layer was then modified based on ground truthing and used in the development of the final project maps.

For the second phase of the project, PWA conducted a field inventory along selected road/trail segments and assessed all road/trail related erosion sites showing evidence of sediment delivery to the stream system. Because the purpose of the inventory was to quantify the potential magnitude of impacts of road/trail related erosion on fish-bearing streams, we excluded any site or road/trail reach showing evidence for erosion (past, current, or potential) that did not also show evidence for current or potential sediment delivery to a stream. Fuel breaks were primarily located high in the watershed along drainage divides, so no sites of sediment delivery were identified on any fuel breaks within the project area.

Inventoried sites for this assessment primarily consist of stream crossings, potential and existing landslides related to the road system, gullies below ditch relief culverts, and various discharge points (e.g., roadside gullies and saddles/low spots in the road with or without gully formation) for uncontrolled road surface and/or inboard ditch runoff.[2] For each site identified as a potential sediment source, PWA staff plotted its location on a GIS-generated geo-referenced digital pdf map uploaded to a tablet using Avenza with aerial photograph or hillshade base. In addition, staff recorded a series of field observations including: (1) detailed site description; (2) nature and magnitude of existing and potential erosion problems; (3) likelihood of erosion or slope failure; (4) future chronic and episodic sediment delivery; (5) plug potential and diversion potential at all culverted stream crossings; and (6) treatments needed for prevention or elimination of future erosion and/or sediment delivery. The data collected for each site also includes an evaluation of

[2] Detailed definitions of sediment delivery sites are provided as Supplemental Information found in Appendix A.

treatment immediacy based on the potential or likelihood of future erosion, sediment delivery from the site to a stream channel, and the level of urgency for addressing erosion problems at that location[3].

For each existing or possible problem site in the project area, PWA field staff evaluated the potential for erosion and sediment delivery, and collected field measurements (width, depth, and length of the potential erosion area) to derive erosion and sediment delivery volumes (if applicable). For most stream crossings, PWA field crews used tape and clinometer surveys to develop longitudinal profiles and cross sections of the site. These data were used to calculate road fill crossing and potential sediment delivery volumes with the STREAM computer program. This proprietary software, developed by PWA, provides accurate and reproducible estimates of: (1) the potential volume of *episodic* erosion at a stream crossing, whether over time or during any possible catastrophic, storm-generated washout; (2) excavation volumes associated with culvert installation, replacement, or decommissioning at stream crossings; and (3) backfill volumes associated with culvert installation or replacement.

In addition, field crews measured the lengths of *hydrologically* connected[4] road/trail to derive estimates for *chronic* sediment delivery. The road/trail bed, ditch, and cutbank of hydrologically connected reaches were inspected and assigned a low to high rating of chronic surface lowering and cutbank retreat. Chronic surface lowering (and cutbank retreat) rates range from 0 to 0.3ft[5] based on the level of usage, types of surfacing materials, soil competency, vegetative cover, and observed evidence of active surface erosion (Weaver, et al, 2006). Chronic sediment production from hydrologically connected road/trail reaches was calculated on a decadal basis, using the following empirical formula, an industry standard: (measured length) x (average measured width, including cutbanks and ditches) x (the assigned average lowering of the road/trail and ditch/cutbank retreat per decade).

All stream crossing culverts were analyzed to determine if they are sized to convey the 100-year peak storm flow[6] including expected sediment and organic debris in transport. PWA staff calculated the necessary culvert sizes using either (1) the Rational Method (Dunne and Leopold, 1978), for drainage areas less than 80 acres; or (2) the empirical equations of the USGS Magnitude and Frequency Method (USGS, 2012) for drainage areas equal to or larger than 80 acres. These culvert sizing calculations were used for stream crossings where the field-estimated bankfull channel dimensions were greater than approximately 3 ft by 1 ft in cross sectional area[7].

In the final phase of the project, PWA personnel analyzed the inventory results to develop cost-effective erosion control and erosion prevention prescriptions, for a prioritized plan of action for the project area. Using field observations, data analyses, and information about realistic needs for

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[3] *Treatment immediacy* is further described in Appendix A.
[4] *Hydrologically connected* describes sites/road/trail from which eroding sediment is delivered to stream channels.
[5] Chronic road surface lowering/cutbank retreat rates are as follows: H=0.3, HM=0.25, M=0.2, ML=0.15, L=0.1, and N/A= 0
[6] 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.
[7] For stream channels with cross sectional areas of 3 ft^2 or smaller, PWA follows the recommendations outlined in the California Department Fish and Wildlife *Salmonid Stream Habitat Restoration Manual* and defaults to a minimum culvert size of 24”.

future use, PWA staff assigned a treatment designation of either "upgrade" or "decommission" for each treatment site[8]. These designations are intended to provide the landowner with prescriptions for storm-proofing treatment sites and hydrologically connected road/trail segments and are PWA's best recommendations for the most efficient and cost-effective methods to accomplish this goal.

6. ASSESSMENT RESULTS

The purpose of the field assessment was to identify and quantify all locations that are currently eroding and delivering sediment to streams in the project area or show a potential to do so in the future. We did not inventory any on-going or potential erosion sites identified in the field that did not also show evidence for sediment delivery to a stream. Although such sites may impact road/trail maintenance, they do not represent a threat to water quality or fish habitat, and therefore were not applicable to this project. Should USFS wish to address these sites of non-sediment delivery on their properties, we recommend applying the same corrective measures described in this erosion control plan to the non-delivery erosion sites.

6.1 Review of Historical Aerial Photographs

PWA staff was able to identify abandoned road alignments, roads/trails that had not been identified or officially mapped, and segments of trail that are on abandoned road alignments. Using available aerial photographs of the Manzana Creek watershed from 1937 to 1977, ArcGIS Georeferencing tools, and Google Earth Pro, PWA was able to overlay historical images on modern satellite imagery with a spatial reference and successfully map roads that were not previously identified. Although a precise timeline of road construction was not determined, the precise locations of legacy abandoned mining roads allowed PWA staff to conduct field evaluation and assessment of current and potential locations of erosion and sediment delivery.

6.2 Road and Trail Characterization

Map 2 identifies the approximately 51 mi of roads and trails inventoried in the project area including approximately 7 mi of paved road, 19 mi of native road, and 25 mi of trail. As noted above, many "trails" occupy abandoned mine roads and therefore share characteristics of both road and trail, but these routes haven't been used as roads for at least 60 years. Below is a brief discussion providing general characteristics observed within each category.

Paved Roads

Sunset Valley Road (Forest Service Route 8N09) is the only paved road entirely within the scope of the project area and the Manzana Creek watershed (Map 2). The only other paved road within the scope of the project is *Figueroa Mountain Road* which traverses the southwestern watershed divide and most of it drains to the west and outside of the Manzana Creek watershed in many

[8] An overview of road upgrading and decommissioning is provided in Appendix A.

locations (Map 2). *Sunset Valley Road* extends down from Cachuma Saddle at the southern watershed divide to Nira Campground on the southwestern bank of Manzana Creek.

The road varies in width between 15 ft and 20 ft and has an average width of approximately 18 ft. The slope of the road varies, as it traverses from the ridges at the southern edge of the watershed to the base of the Manzana Creek valley. Road grades range from 5%-25%. Some of the steepest sections of road are located along the inner gorge of Davy Brown canyon leading to the confluence with Manzana Creek. Slopes here range from 15%-25%. The entire road surface has been paved using chip seal and is severely degraded in many locations. The section of road leading down to Davy Brown and Nira Campgrounds from the east have a significant number of large potholes and cracks. The road alignment is generally flat to insloped with generally tall cutbank heights that are in many locations experiencing very high ravel rates that have plugged much of the inboard ditch. The current absence of inboard ditch due to the high ravel rates has resulted in many ditch relief culverts not receiving road runoff as designed. Consequently, many excessively long sections of hydrologically connected roadbed are delivering cutbank derived fine grained sediments directly to nearby watercourses that are bisected by the road.

Native Surface Roads

There are 5 native surface (dirt) roads within the watershed that were assessed as part of this project. *Catway Jeep Trail* (Forest Service Route 29W02), *McKinley Mountain Road* (Forest Service Route 8N08), *Figueroa Lookout Road* (Forest Service Road 8N16), *Zaca Ridge Road* (Forest Service Route 8N02), and *East Pinery Road* (Forest Service Route 8N32) are seasonally used roads located in the southern half of the watershed (Map 2).

East Pinery Road is a low gradient native surfaced road that is predominantly constructed on a ridge top. There were no stream related sediment delivery sites identified on East Pinery Road. The main issues related to sediment delivery occurring on this road alignment are excessively long sections of hydrologically connected road surface discharging on the hillslope below the road. The discharge of the concentrated road surface runoff has caused large gullies to form on the hillslope which are actively conveying road related fine sediment to the Manzana Creek watershed.

Zaca Ridge Road extends northwest and has numerous segments that traverse and drain outside the Manzana Creek watershed and includes only 1 identified sediment source site.

McKinley Mountain Road (Forest Service Road 8N08) is a relatively long native surface road that extends eastward from Cachuma Saddle along the southern watershed divide. This road has multiple steep, rocky segments that should not be driven on without high clearance and 4-wheel drive. Large segments of this road are outside of the watershed, a total of 34 sites were identified along segments of road within the watershed. The majority of the identified sites were road surface problems resulting from long segments of hydrologically connected road and inboard ditch discharging to McCarthy-style outboard down drains. Many of these drains are actively being undermined due to excessive volumes of road derived, concentrated runoff being discharged onto the outboard fillslope and adjacent hillslopes below the road.

Catway Jeep Trail extends from *Zaca Ridge Road* down to *Sunset Valley Road* just downslope from Davy Brown Campground. The conditions of the road shaping and drainage infrastructure is similar to *McKinley Mountain Road* except for the road currently is overgrown and is not drivable with a 4 wheel drive vehicle. This road has numerous McCarthy-style outboard berm down drains along its alignment that are actively gullying and eroding the hillslope below the road. The active erosion is causing many of the down drains to fail and undermine the road prism and discharging excessive volumes of road derived sediment to the watershed stream system. Existing road drainage structures are too sparsely spaced and largely ineffective due to a lack of maintenance.

Trail System

The primary trail system assessed includes all of *Davy Brown Trail*, *Willow Spring Trail*, *Willow Spur Trail*, *Munch Canyon Trail*, *White Rock Connector Trail*, *White Rock Trail*, and *Sunset Valley Trail* (Map 2). These trails are located in the southern half of the watershed on the north-facing slopes of Figueroa Mountain. The higher elevation segments of these trails meander through coniferous forest and oak woodland, while the lower elevations trails traverse through chamise and scrub oak chaparral. There are multiple large sandstone and serpentine outcroppings across the face of the mountain, and these trails traverse these features in numerous places. Elsewhere, trails pass over clay, shale, and sand-rich formations that are more susceptible to erosion. In higher elevation areas where the trails traverse steeper slopes over convex hillslopes, erosion and estimated sediment delivery volumes are higher. However, site density in the higher elevation areas was also lower overall, as the density of stream crossings decreased with distance from the lower elevation, higher order stream channels.

Segments of the *Davy Brown*, *Willow Spring*, *Willow Spur*, and *Sunset Valley* trails where they follow higher order streams in the base of canyons do not appear to have been constructed on legacy mining road prisms. These valley floor trails have a more typical 4 ft wide foot prism/path and many of the stream crossing sites are natural fords, where no fill materials have been placed into the channel. Most of these crossings are stable with very low predicted erosion and future sediment delivery volumes.

White Rock Trail, *Munch Canyon*, and *White Rock Connector* extend into the lower elevation hills dominated by chaparral and were constructed on legacy abandoned mining road alignments. Although formally classified as trails, there are sites that PWA categorized as “road” sites since they exhibit characteristics of bulldozer constructed roads with larger fill prisms. Concentrated runoff captured on abandoned road surfaces identified as sites on these trail segments have greater erosion and potential sediment delivery volumes than other sites on typical trail widths cut into the native hillslopes.

Manzana Creek Trail extends east and west from Nira campground and follows the meanders of Manzana Creek in San Rafael Wilderness area. This trail is largely flat and fluctuates between 1 ft and 3 ft in width. The trail bed is sandy for much of its length. Site density was high on this trail, as numerous steep, lower order streams extend down from the slopes of the mountains to meet Manzana Creek. However, many of the sites on this trail are large ford crossings over the mainstem Manzana Creek with little to no potential for future erosion and estimated sediment delivery volumes of <5 yd^3. There were several sites identified as “road” since sections of the trail was established on an historical mining road.

Lost Valley Trail occupies a historical mining roadbed in San Rafael Wilderness connecting Manzana Creek Trail with the Hurricane Deck Trail. Inventoried sections revealed problems consistent with those observed on similar abandoned historic mining roads observed throughout the state. Uncontrolled surface runoff along hydrologically connected road lengths and stream diversions have contributed to washed out crossings and significant past erosion. Much of the remaining drainage infrastructure is no longer functioning or ineffective; existing culverts are plugged, buried, or no longer conveying stream flow. If left untreated, there is still potential for future erosion and sediment delivery but correcting these future sediment delivery problems is difficult solely with hand labor.

6.3 Summary of Field Data and Analyses

PWA field crews identified a total of 295 sites and 23.69 mi of hydrologically connected road surfaces with the potential to deliver sediment to streams in the assessment area (Map 2, Table 1, Appendix B). We recommend that 260 of these sites and 22.05 mi of the connected road segments be treated for erosion control and erosion prevention.

Table 1. Inventory results for all sediment delivery sites and hydrologically connected road/trail segments, *Manzana Creek Watershed Anthropogenic Sediment Reduction Assessment, Aquatic Protection and Road Restoration Planning Project, Los Padres National Forest.*

Sources of sediment delivery	Sediment delivery sites [a]		Hydrologically connected Roads/trails adjacent to sites		Total length of roads/trails surveyed for project (mi)[b]
	Inventoried (#)	Recommended for treatment (#)	Inventoried (mi)	Recommended for treatment (mi)	
Stream crossings	226	191	15.06	13.41	-
Landslides	8	8	0.22	0.22	-
Road surface	51	51	8.08	8.08	-
Bank erosion	8	8	0.16	0.16	-
Ditch relief culverts	2	2	0.18	0.18	-
Total	**295**	**260**	**23.69**	**22.05**	**51.40**

[a] Of the 295 sources of sediment delivery, 35 stream crossings (17 on trails, 16 on native surface roads and 2 on paved roads) are not recommended for treatment.
[b] Determined using GIS.

Field data show that treating the 260 sites will prevent the future episodic, storm driven delivery of approximately 13,630 yd^3 of sediment to streams in the Manzana Creek watershed, and that treating the 22.05 mi of connected road/trail segments could prevent delivery of approximately 10,820 yd^3 of chronic fine sediment during the next decade alone (Table 2). Of the 24,450 yd^3 of total estimated sediment delivery for the sites and road reaches recommended for treatment, approximately 56% is anticipated from *episodic* erosion and 44% from *chronic* erosion[9]. Of the approximately 51 mi of road and trail assessed, 43% is *hydrologically* connected to the stream

[9] Refer to Appendix A for complete definitions for *chronic* and *episodic* erosion and sources of sediment delivery.

system, which is a moderately high length of road compared to other sediment source assessments PWA has conducted in similar geologic settings in the coast ranges.

The 48 sites recommended for treatment on the 7 mi of assessed paved roads are estimated to contribute approximately 48% of sediment delivery from all episodic sources but less than 12% of all chronic sources (Table 2). The large potential sediment delivery volumes expected from site specific sources on paved roads is due to the number of stream crossings (n=38) and large fills having the potential to fail and deliver sediment directly to the stream system. Sediment delivery volumes expected from chronic erosion on paved roads is expected to be low since only ditch incision and continued retreat of the tall cutbanks is considered in the calculation.

The 87 sites recommended for treatment on the 19 mi of assessed unpaved road account for approximately 42% of total episodic and 81% of the total chronic sediment delivery volumes (Table 2). The large potential chronic sediment delivery volume is expected as nearly 50% of all native surfaced roads are hydrologically connected. The 125 sites recommended for treatment identified on the 25 mi of trail accounted for less than 10% of all episodic and 7% of chronic sediment delivery volumes. The lower sediment delivery volumes are expected since trails are narrow with smaller fill volumes.

Table 2. Estimated future sediment delivery for sites and hydrologically connected road/trail segments recommended for treatment, *Comprehensive Manzana Creek Watershed Anthropogenic Sediment Reduction Assessment, Aquatic Protection and Road Restoration Planning Project.*

Sources of sediment delivery	**Estimated future sediment delivery (yd^3)**				
	Paved Road	**Native Road**	**Trails**	**Roads + Trails**	**Percent of total**
1. Episodic sediment delivery from road/trail related erosion sites (indeterminate time period)					
Stream crossings	6,290	3,370	870	**10,530**	**77%**
Landslides	150	0	150	**300**	**2%**
Road surface	40	2,430	60	**2,530**	**19%**
Bank erosion	10	0	240	**250**	**2%**
Ditch relief culverts	20	0	0	**20**	**<1%**
Total episodic sediment delivery	**6,510**	**5,800**	**1,320**	**13,630**	**100%**
2. Chronic sediment delivery from road/trail surface erosion (estimated for a 10 yr period)[a]					
Total chronic sediment delivery	**1,260**	**8,780**	**780**	**10,820**	**-**
Total estimated future sediment delivery for the project area	**7,770**	**14,580**	**2,100**	**24,450**	**-**

[a] Sediment delivery for rocked and native surface road/trail is calculated for a 10 yr period. It assumes a combined width for the road, ditch, and cutbank contributing area, and a road surface lowering and cutbank retreat of 0.1-0.3 ft/decade over 1 decade based on field analyses by PWA staff. For paved roads, only ditch incision and cutbank retreat is considered in the calculation.

PWA recommends treating 191 of the 226 stream crossings assessed in the Manzana Creek watershed (Table 1). Inventoried stream crossing sites include 44 crossings with culverts, 93 fill (unculverted) crossings, 11 armored fills, and 78 fords. We project that approximately 10,530 yd^3 of future road related sediment delivery will originate from the 191 stream crossings if they are left untreated, which is approximately 77% of total future episodic sediment delivery from sites recommended for treatment in the project area (Table 2).

Of all inventoried sites in the Manzana Creek watershed, problematic stream crossings make up the majority at 77%. Of the 226, staff identified 35 stream crossings on roads and trails that have drainage structures not sufficiently designed for the 100-year peak storm discharge. Furthermore, 84 have the potential to divert in the future and 35 streams are currently diverted. Of the 44 existing culverts at stream crossings, 39 have a moderate or high potential to become plugged by sediment and debris (Table 3).

Table 3. Erosion problems at all inventoried stream crossings, *Manzana Creek Watershed Anthropogenic Sediment Reduction Assessment, Aquatic Protection and Road Restoration Planning Project, Los Padres National Forest*.

Stream crossing problem	# Inventoried				Percent of total[a]
	Paved Roads	Native Roads	Trails	Roads + Trails	
Stream crossings with diversion potential	27	22	35	84	**37%**
Stream crossings currently diverted	7	9	19	35	**16%**
Crossings with culverts likely to plug[b]	27	11	1	39	**89%**
Crossings with culverts that are currently undersized[c]	20	14	1	35	**80%**

[a]From Table 1, total stream crossings inventoried, n = 226. Total culverted crossings inventoried, n=44)
[b]Culvert plug potential is moderate to high.
[c]Culverts in stream channels larger than 3 ft x 1 ft that are too small to convey the calculated 100-year peak storm flow.

Discharge points for road surface drainage represents approximately 17% of all sites identified in the assessment (Table 1). These 51 sites are locations along poorly drained road/trail segments where accumulated concentrated flow from road surface/ditch/cutbank erosion exits the road commonly at breaks in the berm along the outside of the road or at McCarthy-style outboard berm down drains to be delivered to a stream via hillslope gullies (Map 2). The accumulation and subsequent discharge of large quantities of road surface runoff frequently results in the erosion of a length of native hillside or fillslope between the road and the downslope receiving stream channel. All 51 discharge points identified in the Manzana Creek assessment area were recommended for treatment. Estimated site-specific future sediment delivery from these sites totals 2,530 yd^3 (Table 2).

Field crews identified a total of 8 road-related fillslope landslides that require treatment (Map 2; Table 1). The total estimated sediment delivery from landslides is approximately 305 yd^3 if they are left untreated, which is approximately 3% of the total future episodic sediment delivery from recommended treatment sites in the project area (Table 2).

A bank erosion site is the result of stream erosion at the base of a road fill, as compared to a landslide site that includes other kinds of hillslope mechanisms. PWA recommends treatment for all 8 inventoried bank erosion sites to prevent approximately 255 yd^3 of future sediment from delivering to the watershed (Tables 1, 2; Map 2).

Ditch relief culverts were inventoried if they showed the potential to deliver future, site-specific erosion, or were currently functioning as conduits for delivery of road/ditch/cutbank surface sediments associated with the adjacent hydrologically connected road length. PWA inventoried a total of 2 ditch relief culverts, both are recommended for treatment (Map 2; Table 1). Ditch relief culverts represent <1% of all treatment sites, with a projected potential sediment delivery of 18 yd^3 (Table 2). This implies that most of the gullies below ditch relief culverts are mature and stable, yet they still serve as efficient conducts for road sediment delivery.

7. EROSION CONTROL AND SEDIMENT REDUCTION PLAN

7.1 Identification and Prioritization of Treatments by Road/Trail Class

As part of this project, a total of 295 sites were assessed and evaluated by PWA staff; 260 inventoried sites were recommended for erosion control and erosion prevention measures. Of the sites that we recommend for treatment, we designate 42 with priority ratings of high or high-moderate (Map 2, Table 4). We project that, if left untreated, these 42 sites and their hydrologically connected road reaches could deliver approximately 3,065 yd^3 of sediment from episodic erosion and 3,645 yd^3 of sediment from chronic erosion to streams in the Manzana Creek watershed. This accounts for approximately 27% of all projected sediment delivery from the sites recommended for treatment in the assessment area. Of this total future sediment delivery from high immediacy sites, 90% is associated with roads.

We assign moderate or moderate-low priorities to 92 sites. This represents approximately 5,805 yd^3 (episodic) and 3,195 yd^3 (chronic), or 37% of all potential sediment delivery from the sites and the associated hydrologically connected road reaches recommended for treatment. Of this total future sediment delivery from moderate immediacy sites, 92% is associated with roads.

Finally, we assign a low priority to 126 sites. We estimate that implementing erosion control and erosion prevention for these sites and hydrologically connected road reaches could prevent approximately 4,770 yd^3 (episodic) and 3,975 yd^3 (chronic) of sediment delivery to area streams, which is about 36% of the total for all recommended treatments. Of this total future sediment delivery from low immediacy sites, 92% is associated with roads.

Table 4. Evaluation of treatment immediacy for sediment delivery sites and hydrologically connected road/trail segments recommended for treatment, *Manzana Creek Watershed Anthropogenic Sediment Reduction Assessment, Aquatic Protection and Road Restoration Planning Project, Los Padres National Forest.*

Treatment immediacy	Number of treatment sites				Hydrologically connected road/trail length (mi)[a]	Estimated future sediment delivery from inventoried erosion sites[b]		Estimated future sediment delivery from road/trail, ditch, and cutbank surfaces[c]	
	Paved Road	Native Road	Trail	Roads + Trails		(yd^3)	%	(yd^3)	%
High	5	19	18	42	5.09	3,060	22%	3,640	34%
Moderate	24	31	37	92	7.51	5,800	43%	3,200	29%
Low	19	37	70	126	9.46	4,770	35%	3,980	37%
Total	**48 sites**	**87 sites**	**125 sites**	**260 sites**	**22.05**	**13,630**	**100%**	**10,820**	**100%**

[a]*Road/trail length* refers to hydrologically connected road/trail reaches adjacent to recommended treatment sites.
[b]Episodic sediment delivery for road/trail related sites (indeterminate time period).
[c]Chronic sediment delivery from adjacent hydrologically connected road/trail, ditches, and cutbanks (estimated for a 10 yr period).

In addition to site specific problems, the absence of adequate drainage along the network of road/trail in this area of steep terrain, combined with erodible geologic substrate, and occasional intense winter storms leads to chronic erosion and sediment delivery to stream channels. The uncontrolled surface drainage along approximately 44% of all identified roads and trails offer an opportunity to implement a strategy to reduce sediment delivery and achieve sediment savings by hydrologically disconnected surfaces to streams. PWA considers implementing road surface treatments a high priority. Since these treatments can be implemented through a maintenance plan without the need for additional permitting, improving road/trail surface drainage to reduce hydrologic connectivity and future chronic erosion can prevent potential future delivery of 10,820 yd^3 of sediment to Manzana Creek watershed in the next decade alone.

The 35 inventoried sites that were not recommended for treatment include stream crossings that include: (1) sites already scheduled for treatment by another NFWF grant to improve fish passage; (2) washed out crossings with no remaining fill or future erosion potential where the adjacent lengths of hydrologically connected road surface have been minimized; (3) ford crossings where the adjacent lengths of hydrologically connected road surface have been minimized; and/or (4) locations where disturbance associated with treatment was determined to be more detrimental to water quality and fish habitat than leaving the site untreated. Although these 35 sites have the potential to deliver a total of approximately 505 yd^3 of sediment to stream channels through both episodic and chronic surface erosion, field data show that the risk of sediment delivery from these sites is relatively low.

7.2 Treatments

Recommended treatments can be categorized as "site-specific" or "road/trail drainage" to address episodic and chronic sources of erosion and prevent future sediment delivery. Table 5 summarizes the recommended treatments for both categories. Refer to Appendix B for more complete treatment prescriptions for each sediment source site and hydrologically connected road/trail. In addition, Appendix C includes schematic diagrams of construction and installation techniques to be implemented at most sites[10].

<u>Site-specific treatments</u>

Stream crossings comprise approximately 77% of all identified sites. Recommended site specific treatments are primarily intended to reduce the risk of catastrophic failure and sediment delivery resulting from episodic events such as stream crossing fill erosion i.e. crossing washouts, fillslope failures as a result of mass wasting (landsliding) or stream diversion.

Recommended site specific treatments for stream crossings include: (1) constructing critical dips on the down-road hinge line to prevent diversions at streams with diversion potential; (2) replacing undersized or poorly installed culverts; (3) installing new culverts at currently un-culverted fill crossings; (4) installing trash racks or flared inlets at culverted crossings to reduce the risk of plugging; (5) constructing armored fill or rocked ford crossings; (6) decommissioning stream crossings by excavating and removing all the crossing fill and restoring the historic channel alignment, width, and sideslope configuration; (7) installing rock armor to stabilize stream crossing fillslopes, ditches, and headcuts; and (8) implementing miscellaneous site-specific treatments such as clearing out culvert debris and repairing a separated downspout (Table 5).

<u>Road/trail drainage treatments</u>

Road/trail drainage treatments address erosion and prevent future sediment delivery at road surface delivery sites, ditch relief culverts, landslides and along hydrologically connected road/trail reaches. Recommended road/trail surface treatments in the project area include: (1) road surface drainage structures such as installing rolling dips, ditch relief culverts, cross road drains, and/or sediment basins; (2) road shaping using techniques such as outsloping or insloping the road surface; and (3) "other" miscellaneous treatments such as rerouting sections of trail, applying road rock, or resurfacing treatment locations with rock/pavement. These treatment recommendations include both proposed upgrading and road decommissioning of inventoried road segments (Table 5).

[10] Detailed treatment recommendations for engineered bridges and/or fish passage features are NOT included in the erosion control sediment reduction treatment package as a result of this assessment.

Table 5. Summary of recommended erosion control and erosion prevention treatment types, *Manzana Creek Watershed Anthropogenic Sediment Reduction Assessment, Aquatic Protection and Road Restoration Planning Project, Los Padres National Forest*.

Treatment type			No.	Comments
Site specific treatments		Culvert (install)	9	Install a culvert at an un-culverted fill.
		Culvert (replace)	17	Replace an undersized, poorly installed, or worn out culvert.
		Culvert (clean/clear)	3	Remove sediment or debris from the culvert.
		Trash rack	11	Install at culvert inlets to prevent plugging.
		Armored fill or rocked ford (wet) crossing	91	Install armored fill or rocked ford crossings.
		Critical dip	10	Install to prevent stream diversions at culverted crossings.
		Overflow culvert	11	Install to prevent stream diversions at deep fill culverted crossings.
		Culvert downspout	5	Install to prevent erosion at culvert outlets.
		Miscellaneous treatments	9	Miscellaneous treatments at site-specific locations.
Road/Trail surface treatments	Drainage Structures	Ditch relief culvert (install)	35	Install new ditch relief culverts to improve surface drainage.
		Ditch relief culvert downspout	11	Install to prevent erosion at ditch relief culvert outlets.
		Rolling dip	606	Install to improve surface drainage.
		Cross-road drain	1	Install to hydrologically disconnect a decommissioned road/trail segment.
		Sediment basin	6	Install to trap and retain fine sediment from surface drainage.
	Shaping treatments	Outslope and remove ditch	40,371 ft	Adjacent to site locations, outslope and remove ditch for a total of 40,371 ft to improve surface drainage.
		Inslope	250 ft	Adjacent to site locations, inslope and retain ditch for a total of 250 ft to improve surface drainage.
		In Place Outslope	1,755 ft	Adjacent to site locations, in place outslope 1,755 ft to improve surface draining.
		Berm (remove)	2,123 ft	Adjacent to site locations, remove a total of 2,123 ft of berm to improve surface drainage.
		Clean or cut ditch	10,257 ft	Adjacent to site locations, clean or cut ditch for a total of 10,257 ft.
	Other	Reroute	4,650 ft	Reroute trail for 4,650 ft to reduce impact to adjacent stream
		Road rock (for road surfaces)	TBD	Apply rock as recommended and/or at treatment locations along roads intended for year round use.
		Paving (for road surfaces)	TBD	Replace pavement at and/or adjacent to treated sites along roads intended to remain paved for year round use.

7.3 Heavy Equipment, Labor, and Material Requirements

Equipment, labor and material needs for erosion control treatments in the assessment area are detailed in the project database. Most treatments require the use of heavy equipment for road and trail construction, e.g., excavator, bulldozer, and water truck. Hand labor is required at road sites needing new culverts, or for applying seed and mulch to ground disturbed during construction. In addition, based on requirements that implementing treatments in the San Rafael Wilderness precludes mechanized equipment, the use of additional kinetic equipment or gas powered wheelbarrows, mules, etc. may be required unless an exemption is granted.

Equipment and labor needs are reported as time, in hours, to treat all sites and road/trail segments. Estimates only include the time needed for the actual treatment work, and do not include additional construction activities such as opening roads/trails, staging materials at work sites, traveling between sites, final grading, repaving, or spreading road rock, straw, and mulch.

7.4 Future Implementation Planning

PWA understands that it is not feasible to implement all recommended treatments at one time under one large scope project. Typically, sediment source investigations along 50 mi of road/trail result in as many as 5 to 8 different construction phases and/or contracts if all the recommended site treatments are intended to be implemented. Therefore, we recommend USFS staff review the draft data results and recommended prioritized treatments included in this report prior to moving forward with developing specific treatment package(s) with estimated costs to implement a subset of the erosion control and sediment reduction plan as funding becomes available.

Most of the treatments listed in this plan are not complex or difficult for contractors with road upgrading and decommissioning experience in steep forestland settings, and are assumed reasonable if work is performed by experienced operators using modern heavy equipment.

In addition to heavy equipment, labor and material needs, additional estimated time and expense will be required for natural resource (biological, archeological and paleontological) surveys required for NEPA and/or CEQA environmental compliance; state, and federal permitting costs; variable administration; contracting expenses; and pre/post-project surveying and monitoring.

7.5 Sample Treatment Plan for McKinley Mountain Road

PWA presents the following treatment plan for McKinley Mountain Road including a detailed cost estimate for NFWF and LPNF as an example near shovel-ready aquatic protection pilot project based on the results of the Project's assessment. The following section outlines a subset of the erosion control and sediment reduction plan based on PWA's recommendations to implement site and road drainage improvement treatments along an approximately 8.7 mi section of the native surfaced McKinley Mountain Road (Map 2).

Recommendations in this sample treatment plan include treating 34 sediment source sites (17 stream crossings and 17 road surface discharge points) and 3.9 mi of hydrologically connected road. Implementing this pilot project would control and prevent 4,875 yds^3 of future anthropogenic erosion and sediment delivery to the Fish Creek and Manzana Creek watershed over the next decade alone, and eliminate nearly 20% of the total assessment predicted future sediment delivery.

Table 6 provides a summary of recommended erosion control and erosion prevention treatment types for the sample plan. Appendix B includes details for treating Sites 65 through 98 and hydrologically connected adjacent road reaches (Map 2). Appendix C provides typical construction drawings for recommended treatments and Table 7 provides estimated costs for equipment, labor, materials and PWA construction management to implement the sample project.

Table 6. Summary of recommended erosion control and erosion prevention treatment types for McKinley Mountain Road, *Manzana Creek Watershed Anthropogenic Sediment Reduction Assessment, Aquatic Protection and Road Restoration Planning Project, Los Padres National Forest*.

Treatment type		No.	Comments
Site specific treatments	Culvert (install)	1	Install a culvert at an unculverted fill (Site #86).
	Culvert (replace)	1	Replace an undersized, poorly installed, or worn out culvert at Site #96.
	Trash rack	1	Install at culvert inlets to prevent plugging (Site #86).
	Armored fill or rocked ford (wet) crossing	15	Install armored fill or rocked ford crossings (Site # 65-71, 73-75, 87, 89, 90, 95, 97) using approximately 275 yd^3 of 0.5-3’ diameter mixed riprap.
	Critical dip	2	Install to prevent stream diversions at culverted crossings (Site #86, 96).
	Miscellaneous treatments	7	Apply approximately 75 yd^3 of 0.5’-3’ diameter mixed riprap to stabilize fillslopes, headcuts, and/or to be used as energy dissipation at 7 treatment locations (Site # 74, 78, 80, 86, 88, 90, 96).
Road surface treatments	Rolling dip	123	Install to improve surface drainage.
	Outslope and remove ditch	20,095 ft	Adjacent to site locations, outslope and remove ditch for a total of approximately 20,095 ft to improve surface drainage.
	Berm (remove)	95 ft	Adjacent to site locations, remove a total of 95 ft of berm to improve surface drainage (Site #66, 74).
	Road rock (for road surfaces)	1,600 ft^2	At three treatment locations (Site # 67, 68, 71) apply 1.5” minus road rock along 1,600 ft^2 of road surface as recommended in the comment on treatment. *If road is intended to be used as a year round road, additional road rock will be required.*

PWA has summarized the likely permits required to implement the recommended treatments included in this sample pilot plan to meet regulatory agency compliance based on jurisdiction. Since this project is federal property managed by USFS, some permitting exemptions may be available. PWA assumes that this pilot project may be exempt from NEPA. However, if this project is not exempt, or specific environmental studies, inventories, and/or surveys are required, additional fees will be incurred to comply as directed by regulatory agencies during the permit application review and prior to implementation. Estimated fees or costs associated with conducting any resource studies and/or preparing permit applications are not included in Table 7.

California Department of Fish and Wildlife (CDFW) – This project will require a Lake or Streambed Alteration Agreement (LSAA) to implement treatments at the 17 stream crossing sites. Estimated permit fees are based on overall project costs according to the fee schedule[11].

Central Coast Regional Water Quality Control Board (CCRWQCB) – This project requires a 401 Water Quality Certification to implement treatments at the 17 stream crossing sites. Fees are based on the dredge/fill fee calculator for fill and excavation discharges. In addition, there are annual fees due until project meets or exceeds success criteria (commonly 5 years).

United States Army Corps of Engineers (USACE) – This project will require submission of a 404 application to implement treatments at the 17 stream crossing sites. However, there will not be any associated application fee and no additional or unique documents will be required.

Table 7. Estimated equipment times and costs to implement erosion control and erosion prevention treatments for McKinley Mountain Road, *Manzana Creek Watershed Anthropogenic Sediment Reduction Assessment, Aquatic Protection and Road Restoration Planning Project, Los Padres National Forest*.

Cost category[a]		**Cost rate[b] ($/hr)**	**Estimated Project Times (hr)[c]**			**Total estimated costs[d] ($)**
			Treatment	**Logistics**	**Total**	
Move in, move out[e]	Excavator	160	10	N/A	10	1,600
	Dozer	160	10	N/A	10	1,600
	Loader	160	10	N/A	10	1,600
	Water truck	175	10	N/A	10	1,750
	Dump truck	175	10	N/A	10	1,750
	Truck/trailer	150	10	N/A	10	1,500
Heavy equipment for site-specific treatments[f]	Excavator	225	101	30	131	29,475
	Dozer	200	50	15	65	13,000
	Water truck	175	100	30	130	22,750
	Dump truck	175	40	12	52	9,100
	Truck/trailer	150	80	24	104	15,600
Heavy equipment for road drainage treatments[g]	Excavator	225	125	38	163	36,675
	Dozer	200	257	77	334	66,800
	Loader	200	50	15	65	13,000
	Dump truck	175	40	12	52	9,100
	Water truck	175	257	77	334	58,450
Construction Staff	Laborers[h]	85	145	44	189	16,065
	Foreman[i]	125	185	56	241	30,125
Rock costs *(15 yd^3 of 1.5" minus road rock and 350 yd^3 of 0.5'-3' mixed diameter riprap, and delivery)* [j]						*63,610*
Culvert materials costs *(70' of 30", 50' of 48", couplers, and delivery)* [k]						*14,470*
Mulch and seed materials costs *(treat ~ 0.4 acres of disturbed ground)*						*1,160*
PWA *(includes project management, coordination, pre-construction layout, preparation of final construction design plans, onsite supervision, and pre-/post- construction documentation, monitoring and reporting)* [l]						*85,000*
Estimated sediment savings		**4,875 yd^3**	**Total Estimated Project Costs**			**494,180**

[11] CDFW's fee schedule effective 2018 (https://nrm.dfg.ca.gov/FileHandler.ashx?DocumentID=153001&inline).

Table 7 footnotes
[a] Costs excluded from the list are for (1) tools and miscellaneous materials; (2) variable administration and contracting expenses; (3) resource evaluations required for regulatory compliance; and (4) all fees associated with preparing required permits and permit application fees.
[b] Heavy equipment and labor costs as needed to complete recommended treatments. This estimate is based on expected prevailing wage rates and include operator/labor, fuel, and equipment rental rates from qualified private contractors and are subject to change and based on bid process.
[c] Estimated project times to complete recommended treatments, logistics (30%) are included for time to travel in between sites and onsite meetings to review treatments.
[d] All costs are subject to change.
[e] Assumes 5 hrs each way for mobilization of all equipment and all work is completed in 1 construction season.
[f] Time to complete site specific treatments as summarized in Table 6.
[g] Time to complete road drainage treatments as summarized in Table 6.
[h] Includes labor time to apply erosion control materials post construction.
[i] Includes heavy equipment contractor foreman to coordinate construction and act as a liaison between PWA and LPNF.
[j] Estimated cost of rock (with delivery) from Gene's Oil and Tool and Bee Rock (2019) and are subject to change.
[k] Estimated cost of culvert (with delivery) from Pacific Corrugated Pipe (2019) and are subject to change.
[l] Construction management services includes oversight of project to ensure project is implemented as recommended by PWA staff. Estimate is a ballpark and a more detailed cost estimate will be provided upon request.

8. CONCLUSIONS

Results from the *Manzana Creek Watershed Anthropogenic Sediment Reduction Assessment, Aquatic Protection and Road Restoration Planning Project* provide USFS and LPNF with an inventory of existing road/trail conditions and specific locations where ongoing and future anthropogenic erosion will result in sediment delivery to streams in the Manzana Creek watershed. Field crews (PWA and supporting CCC, WSP, and NOAA members) conducted inventory along approximately 51 mi of selected road and trail within the project area.

Classification of the total assessed mileage include 25 mi of trail, 7 mi of paved road and 19 mi of native surfaced road. A total of 295 sediment source sites were identified with 23.7 mi (43%) of adjacent hydrologically connected road/trail. Using field inventories and data analysis, PWA recommends treating 260 sites and 22.05 mi of hydrologically connected road and trail. Implementing recommended treatments will prevent approximately 24,450 yd^3 of sediment from entering streams within project area.

Of the total estimated sediment delivery volumes, approximately 10,820 yd^3 (56%) is anticipated from *episodic* erosion at site specific locations and 13,630 yd^3 (44%) from *chronic* erosion along hydrologically connected reaches. Native surface roads account for 14,580 yd^3 or nearly 60% of the total sediment delivery volume, and are therefore the most beneficial to treat of the 3 road and trail classes purely from the perspective of treatment cost effective benefit to protect water quality and the existing high value aquatic habitat present in Manzana Creek. Paved roads are estimated to produce 7,770 yd^3 (<32%) of the future sediment delivery volume, and the trail routes are predicted to account for only 2,100 yd^3 (<9%) of the total man-caused future sediment delivery volume.

A fundamental result of this assessment is a prioritized plan of action for cost-effective erosion and sediment control through the treatment of 260 sediment delivery sites and 22.05 mi of hydrologically connected road/trail resulting in a sediment savings of approximately 24,450 yd^3.

Since available resources may limit executing all recommended treatments included in this report, we propose USFS seek initial funds to implement the sample treatment plan provided for a portion of McKinley Mountain Road. Implementation of this pilot project will allow LPNF to showcase benefits of these cost-effective treatments resulting in reduced future road maintenance needs, improved water quality and aquatic habitat by preventing approximately 4,875 yd^3 of sediment from being eroded and delivered into streams in the Manzana Creek watershed.

When implemented and employed in combination with protective land use practices, the treatment prescriptions outlined in this report may be expected to significantly contribute to the long-term protection and improvement of water quality and salmonid habitat in the Manzana Creek watershed.

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Appendix A

Terminology and techniques used in road related erosion assessments

Manzana Creek Watershed Anthropogenic Sediment Reduction Assessment, Aquatic Protection and Road Restoration Planning Project Los Padres National Forest, Santa Barbara, California

1 TERMINOLOGY AND TECHNIQUES USED IN ROAD RELATED EROSION ASSESSMENTS

1.1 Sources of Road Related Erosion

Sources for erosion and sediment delivery in the assessment area are divided into two categories: (1) sediment from specific treatment features, and (2) sediment from the surfaces of road segments of varying lengths—and their associated cutbanks and inboard ditches—that are hydrologically connected1 to streams.

Feature-specific erosion is termed *episodic*, as it is projected to occur over an indeterminate time frame, usually from months to decades as typically triggered by some event (usually intense or significant rainfall or peak flows in a stream). Some features may show evidence for imminent failure, erosion, and sediment delivery, such as unstable road cuts or fills on steep hillslopes. Other features may show the potential for erosion and sediment delivery, but will not activate until a threshold is reached based on a combination of factors at the feature (for example, type of geologic substrate, type and density of vegetative cover; size of channel, steepness of terrain, intensity and duration of rainfall, peak flows, etc.).

In contrast to feature-specific episodic erosion, erosion from road surfaces is termed *chronic* because it occurs on an on-going basis, every time there is surface runoff, and is primarily dependent on the level of road usage, the erodibility of the ditch or road surface, and the steepness of the road. PWA estimates chronic erosion for a 10-year period, based on empirical calculations for fine sediment generation from hydrologically connected road surfaces and associated cutbanks and ditches. The amount of fine sediment delivered to stream channels from eroding road surfaces can be substantial when evaluated on timescales similar to those applied to episodic erosion features (mulit-decades), and in some watersheds may represent the greater detriment to water quality and fish habitat.

1.1.1 Feature-specific erosion sources

<u>Stream crossings</u>

A *stream crossing* is a ford or drainage structure on a road (such as a culvert or bridge) installed across a stream or watercourse (USDA Forest Service, 2000). When they erode, sediment delivery from stream crossings is always assumed to be 100%, because any sediment eroded is delivered directly to the stream. Once eroded sediment is delivered to a stream, the grain size of the sediment and the size of the stream affects the rate of sediment movement down the channel. Regardless, any eroded sediment delivered to small ephemeral streams in upland areas will eventually be transported to downstream larger fish-bearing stream channels.

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 logs or debris buried in the fill intended to convey streamflow

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

(i.e., *Humboldt log crossings*), (5) crossings with a potential for stream diversion, and (6) crossings that have currently diverted streams.

An unculverted *fill crossing* is a stream crossing without a culvert to carry the flow through the road prism. At such features, stream flow either crosses the road surface and flows over and back down the outside fillslope, or is diverted down the road via the road surface or inboard ditch. Most fill crossings are located at small Class II or III streams that only have flow during larger runoff events. *Armored fill crossings* and *ford crossings* are similarly designed to be functional, unculverted stream crossings. A properly constructed armored fill crossing contains fill in the stream crossing that is protected from erosion by the use of rock armor. It is based on a feature-specific design, using a mix of riprap-sized rock to minimize or prevent erosion during flood events while allowing the stream to flow across the surface of the road prism (Weaver et al., 2015). A ford crossing may use rock armor to stabilize the roadway where it crosses the stream, but the road is built essentially on the naturally armored stream bed, and fill is not used.

Humboldt log crossings were typically constructed during historic logging activities from logs or woody debris, usually dumped into or laid parallel to flow, which are then covered with fill. Humboldt crossings are susceptible to plugging, collapse, gullying, and washout when the woody debris rots or peak flows erode the poorly built crossing during storm events (Weaver et al., 2006). Older Humboldt log crossing structures beneath more recently installed culverts are often found in rural northern California road networks. Their existence often shows up only when sink holes develop in the road surface.

Significant erosion may occur at stream crossings when culverts are too small for the peak flow and storm flows exceed culvert capacity, or when culverts become plugged by sediment and debris. In these instances, flood runoff will pond behind the road prism and eventually spill across the roadbed causing erosion of the stream crossing fill and development of a partial or complete *washout crossing*. The larger the stream crossing fill, and the larger the stream discharge, the greater the volume of erosion and sediment delivery that will occur when flood flows overtop the crossing. Washout crossings will remain highly problematic as the stream erodes down through the erodible road fill and the banks of the developing gully continue to erode back to a natural grade.

Even more significant erosion can occur at a stream crossing that exhibits a *diversion potential*, which means that flow is diverted down the road, either on the roadbed or in the ditch, instead of spilling over the fill and back into the same stream channel. In this case, the adjacent roadbed, hillslope, and/or stream channel that receives the diverted stream flow may become deeply gullied or destabilized. As road and hillslope gullies enlarge over time, they will deliver increasingly greater quantities of sediment to downslope stream channels (Hagans et al., 1986), and streamflow diverted onto steep, unstable hillslopes may trigger large landslides or debris flows.

To be considered adequately sized, culverts at stream crossings must have the capacity to convey a 100-year peak storm flow,[2] including sediment and organic debris in transport (Weaver et al., 2006). In areas where large, floating debris may also be a problem, trash racks and trash barriers should be installed slightly upstream from culvert inlets to screen out the larger woody debris 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 stream crossing fill to prevent plugging. Improper, low-gradient culvert installations were once common because they required shorter lengths of pipe to convey flow through the road, and were therefore used to minimize construction costs. However, in the long run these cost-cutting measures often prove detrimental to erosion control and road maintenance costs because the low gradient culvert is more likely to plug with sediment and debris, and at its outlet it discharges stream flow onto steep, unconsolidated road fill rather than into the pre-existing stream channel below the road fill, resulting in pronounced erosion of the outboard, downstream fill face.

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 collect road and cutbank runoff and disperse it to the downslope hillside at frequent intervals along the road. They limit the quantity of water available in the ditch so that it cannot cause erosion in the ditch or at the outlet of the culvert. It is sometimes necessary to install downspouts or rock armor at DRC outlets to further disperse energy and prevent erosion.

Landslides

Unstable road cutbanks and fillslopes with the potential to fail during periods of high 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 active and potential road-related landslides observed in the field, but only inventories those that exhibit a potential to fail and 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) cutslope debris slides, (4) hillslope debris slides, and (5) 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 on steep hillslopes. Typically, the most cost-effective preventive treatment for unstable or potentially unstable fillslopes is the excavation and removal of unstable fill material and redepositing it in a stable, designated spoil disposal site (preferably nearby) where it cannot fail or erode and enter a watercourse. Conversely, large, deep-seated landslides are often technically infeasible or not cost-effective to treat.

2 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.

<u>Additional feature-specific sediment sources</u>

Other, less frequent sources of sediment delivery include: (1) discharge points for road surface, cutbank, and ditch erosion (e.g., the outlets of rolling dips, waterbars or lead-out ditches); (2) point source springs or multiple, closely spaced springs feeding a ditch; (3) features of bank erosion at or near a stream crossing or where the road has been built within or immediately next to a small watercourse; (4) active or beheaded headwall swales; (5) channel scour at or near stream crossings; and (6) non-road related upslope gullying caused by past logging, including eroding skid trail stream crossings, skid trail stream diversions or concentrated surface runoff from skid trail systems.

Unpaved road surfaces, and their associated cutbanks and inboard ditches, are often major sources for erosion and delivery of fine sediment to stream channels. Road surface, cutbank, and ditch erosion is termed "chronic" because it occurs throughout the year, any time there is significant surface runoff, and may include one or more of the following processes: (1) mechanical pulverizing and wearing down of road surfaces by vehicular traffic, and the use of unpaved roads during wet weather and wet soil conditions; (2) erosion of unpaved road surfaces by rainsplash and runoff during periods of wet weather; (3) erosion of poorly drained road surfaces characterized by steep grades, deep vehicle treads, outside berms or throughcut road sections that prevent surface drainage; (4) erosion of inboard ditches by road surface and cutbank runoff and emergent spring flow during wet weather periods; (5) active erosion within recently graded or maintained (bare) ditches, and (6) 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. The most common discharge points include: (1) stream crossings, where road surfaces and ditch runoff exits the road alignment and directly enters the stream; (2) ditch relief culverts where runoff leaves the road close enough to a stream to allow storm flow to enter the watercourse or where the culvert discharges runoff into a gully that connects to a downslope stream channel; (3) road surface drainage structures, including rolling dips, waterbars, berm breaks, lead-out ditches and natural low spots in the road alignment that drain runoff and eroded sediment from the road surface, down the fillslope and into a nearby watercourse.

Point source springs refer to features where spring flow is entering the roadbed and causing erosion. Flow from multiple springs may become concentrated along a road or ditch with inadequate drainage structures, creating roadside gullies or fillslope failures. *Swales* are channel-like depressions that only carry minor flow during periods of extreme rainfall. *Bank erosion* features refer to locations of streambank erosion caused or exacerbated by emplacement of a nearby road or stream crossing. *Non-road related upslope gullies* form upslope of the road (often on logged areas) and discharge runoff and eroded sediment onto the road during storm events.

1.1.2 Evaluation of hydrologically connected road segments

During our road erosion assessments, PWA measures the lengths of hydrologically connected road segments adjacent to sediment delivery features, such as on one or both approaches to stream crossings, ditch relief culverts, or other discharge points, to derive an estimate for total potential sediment delivery from all connected road surfaces and ditches in the project area. In addition, because the adjacent hydrologically connected road segments contribute to the overall erosion and sediment delivery problem at a feature, PWA considers the treatment feature and adjacent road segments as a unit when estimating future sediment delivery and developing treatment prescriptions for that location. Thus, for example, prescriptions for a culverted stream crossing would include the necessary treatments to upgrade the culvert for the 100-year peak flow, as well as those drainage treatments on one or both road approaches that are needed to reduce and minimize road surface and ditch runoff that drains to the watercourse.

1.2 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, 1999; Weaver et al., 2006, 2015). 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[3]. 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 reduce or prevent future sediment delivery to the local stream system. A well-designed storm-proofed road includes specific characteristics (see table, next page), all proven to contribute to long-term improvement and preservation of watershed hydrology and aquatic habitat.

1.2.1 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 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 may also include adding road rock or riprap as needed to fortify roads and stream crossings.

<u>Installing rolling dips</u>

Rolling dips are installed on low- to moderate-gradient hydrologically connected[4] road segments to disperse surface runoff and discharge it onto the native hillslope below the road. Rolling dips extend from the inboard edge to the outboard edge of a road, and are constructed at intervals as needed to disperse surface runoff and control erosion (typically 100, 150, or 200 ft). They are

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

effective in reducing year-round ("chronic") erosion and sediment delivery from road surfaces, and are designed to be easily drivable and not impede vehicular traffic.

Characteristics of storm-proofed roads (Weaver et al., 2006).

Storm-proofed stream crossings • All stream crossings have a drainage structure designed for the 100-year peak storm flow (with sediment and debris in transport). • 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.

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 road edge), or crowning (creating a high point somewhere near the center axis of the road so that it slopes equally inward and outward). Like rolling dips, road shaping is used to quickly drain surface runoff off the road surface and direct it to the inside ditch or to the outside road shoulder. Road shaping keep water from standing on, or flowing down, the road bed, thereby reducing roadbed saturation, surface deterioration and surface erosion.

Installing ditch relief culverts

A ditch relief culvert is a drainage structure (usually an 18 inch diameter pipe) installed across a road prism to move water and sediment from the inboard ditch to the base of the outside road fill so that it can be dispersed on the native hillslope beneath the road. Ditch relief culverts are used to drain ditch flow on roads that are insloped or crowned, that have springs and seeps draining to the ditch, or that are too steep for rolling dips or outsloping.

Excavating unstable fills and fillslopes

The fillslope, the sloping part of the road fill located between the outboard edge of the road prism and the natural hillslope below, may fail or show signs of instability and potential failure. As a preventative measure, before failure occurs, fillslope materials that shows signs of instability (cracks, scarps, or hummocky topography) or that are perched on steep slopes above a stream can be excavated and hauled or pushed to a stable spoil deposal site where they no longer threaten water quality. This is often the most cost-effective treatment for unstable road fills on forest roads.

Upgrading stream crossings

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

Techniques for upgrading small stream crossings include:

- *Installing or replacing culverts.* A culvert capable of passing the 100-year storm flow, including expected sediment and debris in transport, 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 feature. Backfill material, free of woody debris, is compacted in 0.5-1.0 ft thick lifts until at least 1/3 of the diameter of the culvert has been covered, and then backfilled over the top of the pipe to the final road tread elevation. At features where fillslopes are steeper than 2:1, or where eddying currents might erode fill on either side of the inlet, rock armor is applied to the fillslope 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 not feasible. The roadbed is heavily rocked, and a keyway in the outboard fillslope is excavated and backfilled with interlocking rock armor of sufficient size to resist transport by stream flow (Weaver at al., 2015). Armored fill crossings are constructed with a dip in the axis of the crossing to prevent diversion of the stream flow during the design flood event, and focus the flow over the axial part of the fill that is most densely armored.
- *Installing secondary drainage structures.* A variety of secondary structures may be used to increase the function of small stream crossings by preventing culvert plugging, decreasing backwater flooding, and controlling erosion. Where a culvert has been improperly installed too high in the fill, a *downspout* may be added to its outlet to carry stream flow to the base of the fill and into the natural stream channel, 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 slightly upstream of the culvert inlet will trap large debris and reduce the potential for culvert plugging. To prevent stream diversion should the culvert become plugged or its capacity exceeded, a *critical dip* (essentially a rolling dip constructed in line with the stream channel) may be installed to ensure that stream flow will be directed across the road and back into the natural channel rather than diverted down the road or ditch. Finally, an *overflow culvert* may be a necessary addition higher in the fill at a culverted crossing where, because of site conditions, plugging or capacity exceedence of the primary culvert is anticipated.

1.2.2 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 it fails, or the road crosses unstable terrain and the entire road prism must be removed. But typically, most of the road to be decommissioned (outside of stream crossings and unstable road fills) usually requires simpler, permanent improvements to surface drainage, such as surface decompaction (road ripping), additional 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 and others, 1987, 2006; Harr and Nichols, 1993; Weaver et al., 2015).

<u>Road ripping or decompaction</u>

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 enhances revegetation of formerly compacted roadbeds.

<u>Installing cross-road drain</u>

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 to accomplish the same objectives.

<u>In-place stream crossing excavation (IPRX)</u>

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 and enter the stream. In some cases, this may necessarily be as far as several hundred feet 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 excavated back to slopes a typically stable 2:1 slope gradient, and mulched and seeded for erosion control.

<u>Exported stream crossing excavation (ERX)</u>

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.

<u>In-place outsloping (IPOS)</u>

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 and/or against the corresponding, adjacent cutbank within several hundred feet of the site. As a further decommissioning measure, the spoil material placed against the cutbank helps block unwanted access to the decommissioned road.

<u>Export outsloping (EOS)</u>

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 adjacent 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.

1.3 Determining Treatment Immediacy and Cost-Effectiveness

Identifying *treatment immediacy* is an integral part of an assessment used to prioritize features prior to implementation. Treatment immediacy is a professional evaluation of how important it is to quickly perform erosion control or erosion prevention work. It is defined as “high,” "moderate," or "low," and represents the urgency of treating the feature before it erodes or fails. An evaluation of treatment immediacy is based on the following criteria: (1) *erosion potential*, or whether there is a low, moderate, or high likelihood for future erosion at a feature; (2) *sediment delivery*, which is an estimate of the sediment volume projected to be eroded from a feature and delivered to a nearby stream; and (3) the value or sensitivity of downstream resources being protected. Generally, features that are likely to erode or fail in a normal winter, and are expected to deliver significant quantities of sediment to a stream channel, are rated as having high treatment immediacy.

The *erosion potential* of a feature is a professional evaluation of the likelihood that erosion will occur during a future storm, based on local site conditions and field observations. It is a subjective probability estimate, expressed as "low," "moderate," or "high," and not an estimate of how much erosion is likely to occur. The volume of sediment projected to erode and reach stream channels is described by *sediment delivery*, which plays a significant role in determining the treatment immediacy for a feature. The larger the volume of potential future sediment delivery to a stream, the more important it becomes to closely evaluate the need for treatment.

From this assessment, treatment immediacy and *cost-effectiveness* may be analyzed, along with the client's transportation needs, to prioritize treatment features or locations for implementation. *Cost-effectiveness* is not only a necessary consideration for environmental protection and restoration projects for which funding may be limited, but is also an accepted and well-documented tool for prioritizing potential treatment features in an area (Weaver and Sonnevil, 1984; Weaver and Hagans, 1999; Weaver et al., 2006). A quantitative estimate for cost-effectiveness is determined by dividing the cost of accessing and treating a feature by the volume of sediment prevented from being delivered to local stream channels. The resulting value, or *sediment savings*, provides a comparison of cost-effectiveness among features, and an average for the entire project area. For example, if the cost to develop access and treat an eroding stream crossing is projected to be \$5000, and the treatment will potentially prevent 500 yd^3 of sediment from reaching the stream channel, the predicted cost-effectiveness for that feature would be \$5000/500yd^3, or \$10/yd^3.

PWA further evaluates cost-effectiveness for an entire assessment area by organizing features into logistical groups based on similar requirements for heavy equipment and materials, and addressing these as a unit to minimize expenses. Furthermore, although features and road segments with the lowest immediacy ratings are placed last on the list for treatment, it is sometimes possible to treat these features once the project is underway, as opportunities to cost-effectively treat low-immediacy features often arise when heavy equipment is already located nearby to perform maintenance or restoration at higher-immediacy features.

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Appendix B

Field observations and treatment recommendations for road/trail related sites

Manzana Creek Watershed Anthropogenic Sediment Reduction Assessment, Aquatic Protection and Road Restoration Planning Project Los Padres National Forest, Santa Barbara, California

List of Commonly Used Acronyms and Abbreviations

TOP	Upstream extent of excavation	**LWD**	Large woody debris
BOT	Downstream extent of excavation	**OBD**	Outboard down drain
BOF	Base of fill	**OG**	Old growth
CMP	Corrugated metal pipe (i.e. culvert)	**yd^3**	Cubic yards
DRC	Ditch relief culvert	**ft**	Linear feet
TR	Trash rack	**RR**	Road rock
IPOS	Inplace outslope	**AR**	Rock armor
EPOS	Export outslope	**XRD**	Cross-road drain
TI	Treatment immediacy	**PB**	Pull berm
H	High	**CGS**	Grade control structure
HM	High-moderate	**LS**	Landslide
M	Moderate	**SC**	Stream crossing
ML	Moderate low	**BE**	Bank erosion
L	Low	**RS**	Road surface
IBF	Inboard edge of fill	**IBR**	Inboard edge of road
OBF	Outboard edge of fill	**OBR**	Outboard edge of road
Left/Right	As looking downroad or downstream		

Table B1. Field observations and treatment recommendations for road related sites, *Manzana Creek Watershed Anthropogenic Sediment Reduction Assessment, Aquatic Protection and Road Restoration Planning Project, Los Padres National Forest*, *Santa Barbara County, CA*

Site #	Road Name	TI	Problem	Total estimated future sediment delivery (yd^3)	Hydrologically connected road length (ft)		Comment on Problem	Comment on treatment
					Left	Right		
1	Davy Brown Trail	L	SC	20	400	0	A headwall swale combines with concentrated road runoff at an at origin Class III stream. The left trail approach is hydrologically connected with a gully running down the center of the trail.	1) Install an armored fill, establish a broad dip through the crossing to convey flow, excavate a keyway 10' wide at the top x 4' wide at the base x 10' long x 1' deep and armor with 3 yd^3 of 0.5'-1' diameter rock armor. 2) Install 3 rolling dips for 400' up the left road approach.
2	Davy Brown Trail	L	SC	4	90	0	A small near origin headwall swale is conveyed down the right road for 90'. The diverted stream flow captured on the trail is actively gullying the trail 60' down the right road. A historic natural channel is located 10' downstream from the crossing, but flows bypass this stream and go 100% down the right road. Additional road run off contributed to the trail erosion from the 90' of left road.	1) Install an armored fill, establish a broad dip through the crossing to convey flow, excavate a keyway 10’ wide at the top x 4’ wide at the base x 12’ long x 1’ deep, and install 5 yd^3 of 0.5’-1.5’ diameter rock armor to the keyway. 2) Install 1 rolling dip up the left road approach.
3	Davy Brown Trail	ML	SC	13	45	300	A Class III stream crossing on Davy Brown Trail. Dead, downed trees on the outboard road of this fill crossing are likely reducing the active erosion at this site. There are 2 large trees upstream on the right bank that should not have to be removed. The split tree on the outboard fill slope may have to be removed if an armored fill is to be installed.	1) Install an armored fill, establish a broad dip through the crossing to convey flow, excavate a keyway 12’ wide at the top x 4’ wide at the base x 8’ long x 2’ deep, and install 5 yd^3 of 0.5’-1.5’ diameter rock armor to the keyway. 2) Install 2 rolling dips up the right road approach.

Table B1. Field observations and treatment recommendations for road related sites, *Manzana Creek Watershed Anthropogenic Sediment Reduction Assessment, Aquatic Protection and Road Restoration Planning Project*, *Los Padres National Forest*, *Santa Barbara County, CA*

Site #	Road Name	TI	Problem	Total estimated future sediment delivery (yd^3)	Hydrologically connected road length (ft)		Comment on Problem	Comment on treatment
					Left	Right		
4	Davy Brown Trail	L	SC	10	0	84	A Class III stream crossing on an inner gorge trail with shallow fill. There is currently minimal erosion and both upstream and downstream channels have bare shale exposed. The dip of the stratigraphic bedding is near vertical and the channel is parallel with the bed plane, and the stream follows the attitude of the beds. The trail is outsloped both left and right of the crossing, but there is diversion potential on the left. Bedrock will inhibit excavation.	1) Install an armored fill, establish a broad dip through the crossing to convey flow, excavate a keyway 8’ wide at the top x 4’ wide at the base x 8’ long x 1.5’ deep, and install 3 yd^3 of 0.5’-1’ diameter rock armor to the keyway. 2) Install 1 rolling dip up the right road approach.
5	Davy Brown Trail	L	SC	27	250	50	A Class II bedrock stream crosses an inner gorge section of Davy Brown Trail. The area is dominated by steep, shale cutbanks which continually deposit bedload into the stream. Water is currently flowing at this crossing. There is aggraded sediment on the left hinge of the crossing that will likely mobilize. The center of the channel on the right hinge of the crossing is down to bedrock. The stream runs perpendicular to the attitude of the shale.	1) Excavate aggraded sediment on the left hinge of the crossing (1 yd^3). 2) Install 1 rolling dip on the left road approach. 3) Rock the left road approach with 1 yd^3 of 1’ diameter rock.
6	Davy Brown Trail	L	SC	13	100	525	A ford crossing on a Class II stream at the confluence with Class I Davy Brown. The trail crosses the Class II along the bank of Davy Brown. Erosion is minimal but some fine sediment could be transported during high flows.	1) Rock the left and right road approaches of the channel using 0.5'-1’ diameter rock armor for 20' x 3' on the right road, and 20' x 3' on the left road. 2) Install 1 rolling dip up the left road approach. 3) Install 3 rolling dips up the right road approach.

Table B1. Field observations and treatment recommendations for road related sites, *Manzana Creek Watershed Anthropogenic Sediment Reduction Assessment, Aquatic Protection and Road Restoration Planning Project*, *Los Padres National Forest*, *Santa Barbara County, CA*

Site #	Road Name	TI	Problem	Total estimated future sediment delivery (yd^3)	Hydrologically connected road length (ft)		Comment on Problem	Comment on treatment
					Left	Right		
7	Davy Brown Trail	ML	SC	12	0	1000	A ford crossing on a Class II stream 25' from Class I Davy Brown, is down to channel grade. There is a good amount of 1' diameter rocks in the stream that can be used locally for treatment. The stream is relatively well defined but is does have diversion potential down the left road at high flows. The long right road approach is a small outslope trail that does not deliver a significant amount of flow to this site.	1) Pull back the left and right side slopes to 2:1, and establish a 4' wide channel bottom (1 yd^3). 2) Install 1 yd^3 of 0.5'-1' diameter rock armor to the ford crossing (locally sourced). 3) Install 8 rolling dips up the right road approach.
8	Davy Brown Trail	L	SC	50	160	54	A Class II stream is conveyed across the road via a ford. Both the left and right roads deliver to this crossing. A large wedge of aggraded bedload is trapped upstream of the crossing and extends approximately 100' upstream before a defined channel is visible. This crossing is at the confluence of the Class II stream and Davy Brown Creek. Treatment should include rock for both the left and right road approach. The left road approach of site #9 will be attributed to this site. The channel is at a stable grade through the crossing and matches Davy Brown Creek's grade, but there are several small headcuts in the aggraded bedload upstream of site #8.	1) Define a 4' wide channel bottom through the crossing with 2:1 side slopes. 2) Rock the left and right road approaches for 20' and 3' wide with 0.5'-1.0' diameter rock armor to prevent transport and erosion during high flows. (5 yd^3)
9	Davy Brown Trail	L	SC	3	0	115	Davy Brown Trail crosses Davy Brown Creek (Class I) at this ford crossing. This crossing is located at a 4 trail junction. This middle watershed reach of Davy Brown has a high gravel and cobble content, as opposed to the bedrock dominated upper watershed. There is a very high concentration of resident trout in this creek. This ford crossing is stable with little to no future erosion. Site #8 is a Class II stream crossing that delivers directly to Davy Brown Creek at this ford crossing.	1) Install 1 rolling dip up the right road approach (Munch Canyon Trail).

Table B1. Field observations and treatment recommendations for road related sites, *Manzana Creek Watershed Anthropogenic Sediment Reduction Assessment, Aquatic Protection and Road Restoration Planning Project*, *Los Padres National Forest*, *Santa Barbara County, CA*

Site #	Road Name	TI	Problem	Total estimated future sediment delivery (yd³)	Hydrologically connected road length (ft)		Comment on Problem	Comment on treatment
					Left	Right		
10	Davy Brown Trail	L	SC	7	40	150	A ford crossing on mainstem Davy Brown Creek. The right road approach becomes submerged during high flows and is actively eroding during those events. The right road approach is delivering to the stream for 150', and the left road for 40'. The crossing itself is relatively stable with very minor erosion and natural channel grade/ dimensions.	1) Pull back the right bank above the inboard road to 1:1 (1 yd³). 2) Move the right road 10' upslope for 50'. 3) Rock the left and right road approaches for 20' up the left road and 30' up the right road, using 0.5’-1.0’ diameter rock armor (sourced locally). 4) Pull back the left and right approaches to 2:1. 5) Install 1 rolling dip on the right road approach.
11	Davy Brown Trail	L	SC	4	405	30	Davy Brown Trail crosses Class I Davy Brown Creek at this ford crossing. The left road approach is a combination of the Willow Spur Trail and a short portion of the Davy Brown Trail. The left approach to the stream crossing is short and steep.	1) Install 2 rolling dips up the left road approach on the Willow Spur Trail.
12	Davy Brown Trail	L	SC	71	0	25	A small fill crossing on a Class III stream. The channel upstream of the crossing is well defined until it reaches a dense patch of poison oak and piled woody debris. It becomes heavily aggraded here, and is currently avulsing through the aggraded material upstream of the crossing. Below the crossing, a gully has formed but tapers out before Davy Brown Creek (gully is 30' x 3' x 2'). The gully is actively eroding in several locations.	1) Excavate a 3' wide channel bottom, upstream of the crossing, for 60' with 2:1 side slopes. (54 yd³) 2) Lay back the gully downstream of the crossing for 30' (30' long x 1.5' deep x 3' wide). (10 yd³) 3) Install an armored fill, establish a broad dip through the crossing and excavate a keyway 6' wide at the top x 4' wide at the base x 8' long x 1.5' deep, and install 3 yd³ of 1’ diameter minus rock armor to the keyway. 4) Spoil locally to the right of the stream on the flat area near the homestead.

Table B1. Field observations and treatment recommendations for road related sites, *Manzana Creek Watershed Anthropogenic Sediment Reduction Assessment, Aquatic Protection and Road Restoration Planning Project*, *Los Padres National Forest*, *Santa Barbara County, CA*

Site #	Road Name	TI	Problem	Total estimated future sediment delivery (yd^3)	Hydrologically connected road length (ft)		Comment on Problem	Comment on treatment
					Left	Right		
13	Davy Brown Trail	L	SC	5	20	80	A very steep bouldery Class III stream delivers to nearby Class I Davy Brown Creek. An armored fill has been constructed at this crossing but should be bolstered with an additional 1 yd^3 of local rock armor.	1) Bolster the current armored fill crossing with an additional 1 yd^3 of 1.0' diameter minus rock armor. Rock at the site can be used. 2) Install 1 rolling dip up the right road approach.
14	Davy Brown Trail	L	SC	17	80	20	A flashy Class III stream passes over this shallow fill crossing via a small armored fill. Erosion is minimal, but the armored fill lacks a keyway. Additional rock will ensure long term stability. The channel is comprised of large serpentine boulders that are very eroded out from the banks upstream.	1) Add 3 yd^3 of 0.5'-2' diameter rock armor to the base of the existing armored fill; key in the armor 1.5' at the BOT. Source the rock locally. 2) Install 1 rolling dip up the left road approach.
15	Davy Brown Trail	L	SC	5	200	15	A steep, bouldery Class III stream crossing on the Davy Brown Trail. The crossing is rocked with minimal erosion. The left and right outboard fill faces are actively eroding when the Class I Davy Brown is at high stage. Rock found at the site can be used to armor these fill faces. The crossing is approximately 30' upstream of the confluence.	1) Armor the outboard fill face on the left road approach 10' from the center of the profile (8' wide x 2' high x 2' deep) with 1 yd^3 of the 0.5'-1.5' diameter locally sourced rock. 2) Armor the outboard fill face on the right road approach (8' long x 4' wide x 2' deep) with 2 yd^3 of 0.5'-1.5' diameter locally sourced rock. 3) Install 1 rolling dip up the left road approach.
16	East Pinery Road	L	RS	905	600	2323	Road surface discharge point located at a low point on East Pinery Road. The right road drains from the gate at the entrance at Sunset Valley Road (2323'). There is a gully on the right road 850' long x 2' wide x 1.0' deep. The road bed is wide and highly erodible.	1) Install 3 rolling dips up the left road. 2) Install 10 rolling dips up the right road.

Table B1. Field observations and treatment recommendations for road related sites, *Manzana Creek Watershed Anthropogenic Sediment Reduction Assessment, Aquatic Protection and Road Restoration Planning Project, Los Padres National Forest, Santa Barbara County, CA*

Site #	Road Name	TI	Problem	Total estimated future sediment delivery (yd^3)	Hydrologically connected road length (ft)		Comment on Problem	Comment on treatment
					Left	Right		
17	Munch Canyon Trail	ML	SC	18	0	150	A small trail dives down the axis of a Class III stream channel. The trail is completely washed out for approximately 150'. The trail continues passed the washed out section towards Davy Brown Trail and Creek. The channel appears to be flashy with rounded cobbles and boulders dominating the substrate. The stream has diverted down the left road in the past. The majority of the instream road has washed out and the stream is relatively stable but there is remaining diversion potential at the downstream extent of the site.	1) Excavate the left bank for 75' to 2:1. 2) Store spoils along the remaining road against the left bank to prevent diversion along the left road approach.
18	Munch Canyon Trail	L	SC	2	0	50	A small fill crossing on a Class III stream on Munch Canyon connector. The left and right road approaches are outsloped and approximately 1.5' wide. Erosion is minimal at the site. A small armored fill could be installed to storm proof the trail crossing.	1) Install an armored fill, establish a broad dip through the crossing and excavate a keyway 6' wide at the top x 3' wide at the base x 6' long x 2' deep, and armor the keyway with 2 yd^3 of 0.5'-1.5' diameter rock armor.
19	Munch Canyon Trail	L	SC	5	0	200	A small Class III fill crossing on Munch Canyon Connector Trail. There is some diversion potential down the left road approach. The stream is very low energy with no active erosion through the crossing.	1) Install a rolling dip on the left hinge of the crossing to eliminate diversion potential.

Table B1. Field observations and treatment recommendations for road related sites, *Manzana Creek Watershed Anthropogenic Sediment Reduction Assessment, Aquatic Protection and Road Restoration Planning Project*, *Los Padres National Forest*, *Santa Barbara County, CA*

Site #	Road Name	TI	Problem	Total estimated future sediment delivery (yd^3)	Hydrologically connected road length (ft)		Comment on Problem	Comment on treatment
					Left	Right		
20	Willow Spur Trail	L	SC	5	206	0	A Class III stream crosses Willow Spur Trail with no formal drainage structure. Active erosion is minimal. Some stream flow diverts down the right road. Davy Brown Creek is approximately 50' downstream of the crossing. The crossing is a good site for armored fill installation. The trail is small and partially outsloped with minimal active erosion.	1) Install an armored fill, establish a broad dip through the crossing to convey flow, excavate a keyway 12' wide at the top x 6' wide at the base x 14' long x 2' deep and install 10 yd^3 of 0.5'-1.5' diameter rock armor to the keyway. 2) Build up the right hinge of the crossing to construct the dip for the armored fill. 3) Rock the road through the crossing with 60 ft2 of road rock. 4) Install 2 rolling dips up the left road approach.
21	Willow Spur Trail	L	SC	1	10	0	A small, steep Class III stream has partially washed out this trail's ford crossing. The trail is narrow with very little connected trail. The crossing is almost back to channel grade, with little future erosion, but the crossing could be hazardous to bikers/unstable walkers now that the trail has washed out. An armored fill should be installed to restore the trail. There is near source bedrock upstream.	1) Install an armored fill, establish a broad dip through the crossing to convey flow, excavate a keyway 5' wide at the top x 3' wide at the base x 19' long x 2' deep, and install 6 yd^3 of 0.5'-1.5' diameter rock armor to the keyway.
22	Willow Springs Trail	-	SC	16	50	600	A ford crossing on a Class III stream just downstream of the Willow Spur intersection. There is no active erosion at the crossing and no future erosion. The right trail approach is steep, small and very outsloped.	No treatment recommendation.

Table B1. Field observations and treatment recommendations for road related sites, *Manzana Creek Watershed Anthropogenic Sediment Reduction Assessment, Aquatic Protection and Road Restoration Planning Project, Los Padres National Forest*, *Santa Barbara County, CA*

Site #	Road Name	TI	Problem	Total estimated future sediment delivery (yd^3)	Hydrologically connected road length (ft)		Comment on Problem	Comment on treatment
					Left	Right		
23	Willow Springs Trail	L	SC	8	650	20	A Class III fill crossing on Willow Springs Trail. There is an old stream alignment approximately 25' to the left that does not look occupied. This old channel alignment is a ford crossing and does not require treatment. The left road approach does not need treatment at this site.	1) Install an armored fill, establish a broad dip through the crossing to convey flow, excavate a keyway 8' wide at the top x 4' wide at the base x 8' long x 2' deep and install 4 yd^3 of 0.5'-1.5' diameter rock armor to the keyway. 2) Install 4 rolling dips up the left road approach.
24	Willow Spur Trail	L	SC	6	0	360	A Class III stream crosses this trail at an oblique angle. The stream flows over in place bedrock on the outboard edge of the road and falls 3' below the trail to the stream below. Shallow bedrock is exposed in the channel upstream and downstream. This channel appears to be a past channel defined by the larger stream at site 25, but it still conveys flow. The crossing is stable with little to no active erosion.	1) Rock the road through the crossing. 2) Install 2 rolling dips up the right road approach.
25	Willow Springs Trail	-	SC	1	20	10	A flashy Class III stream crossing. The trail crosses the stream via a ford. The channel is full of woody debris and flow appears to be minimal. There is very minimal active erosion at the site.	No treatment recommendation.
26	Willow Springs Trail	L	SC	9	325	19	A ford crossing on a Class III stream crossing. There is exposed bedrock on the outboard road. The right bank is very steep and well vegetated, the left trail approach is connected but has very little active erosion. The exposed bedrock on the outboard fill slope could make the keyway excavation difficult.	1) Install an armored fill, establish a broad dip through the crossing to convey flow, excavate a keyway 8' wide at the top x 4' wide at the base x 10' long x 2' deep and install 5 yd^3 of 0.5'-1.5' diameter rock armor to the keyway. 2) Pull back the sediment on the left bank above the crossing (3 yd^3). 3) Install 3 rolling dips up the left road approach.

Table B1. Field observations and treatment recommendations for road related sites, *Manzana Creek Watershed Anthropogenic Sediment Reduction Assessment, Aquatic Protection and Road Restoration Planning Project, Los Padres National Forest, Santa Barbara County, CA*

Site #	Road Name	TI	Problem	Total estimated future sediment delivery (yd^3)	Hydrologically connected road length (ft)		Comment on Problem	Comment on treatment
					Left	Right		
27	Willow Springs Trail	M	BE	30	0	0	A section of Willow Spur trail is being actively undercut by bank erosion on the Right bank of a Class III stream below the trail. There are vertical banks upstream of the trail as well. The bank will continue to erode and deliver as it is along an outside bend in the stream.	1) Lay back the right bank of the stream for 60' wide x 8' long x 2' deep (35 yd^3) to 1:1 2) Reroute the trail to the right of the bank erosion for 50'. 3) Store spoils locally and use to prevent trail drainage from discharging onto the excavated slope.
28	Willow Springs Trail	L	SC	13	23	410	A ford crossing on a Class III stream on Willow Spur Trail. The outboard road of the crossing consists of 3' poorly cemented sandstone boulders. Downstream of these boulders, the left bank is over steepened and should be pulled back. The right road approach is not delivering any sediment to this site.	1) Pull back the left bank 2:1 downstream of the crossing, downstream of the boulders. 2) Spoil locally on the trail surface. 3) Install 4 rolling dips up the right road approach.
29	Willow Springs Trail	L	SC	22	1500	0	An active Class II stream flows over bedrock falls. The trail crosses the head of the break in slope before the falls. Some flow is diverting to the right for approximately 20'. There is a confluence with a Class II stream just below the crossing. There is a series of bedrock steps upstream of the crossing, and there is potential erosion along the stored sediment on the right hinge.	1) Construct a critical dip on the right hinge to prevent diversion. 2) Install 10 rolling dips up the left road.

Table B1. Field observations and treatment recommendations for road related sites, *Manzana Creek Watershed Anthropogenic Sediment Reduction Assessment, Aquatic Protection and Road Restoration Planning Project*, *Los Padres National Forest*, *Santa Barbara County, CA*

Site #	Road Name	TI	Problem	Total estimated future sediment delivery (yd^3)	Hydrologically connected road length (ft)		Comment on Problem	Comment on treatment
					Left	Right		
30	Willow Springs Road	-	SC	4	34	128	A ford crossing on a bedrock Class III stream. This crossing is approximately 25' from the confluence with a large Class I Davy Brown stream. Site #29 is approximately 75 upstream. There is near sourced bedrock on the left approach, but some fractured sediment falls into the creek before getting washed into Davy Brown Creek. This crossing is down to bedrock and will not have any future erosion. The future erosion at this site comes from the left bank downstream of the crossing. With the near source bedrock present, trail realignment is likely to be ineffective.	No treatment recommendation.
31	Willow Springs Trail	L	SC	2	62	0	A small Class III stream is conveyed through this crossing via a dip in the trail. There is shallow bedrock exposed along the right bank downstream of the crossing. The trail is small and there is minimal active erosion at this site.	1) Install an armored Fill. Establish a broad dip. Excavate a keyway 6' wide x 5' wide x 10' long x 2' deep. Armor the keyway using 5 yd^3 of 0.5'-1.0' diameter rock armor. 2) Relocate the left trail approach 5' upstream to avoid the steep slope. 3) Clear woody debris upstream of the crossing for 30'. 4) Spoil locally for trail reroute or for decommissioning of original approaches.
32	Davy Brown Trail	ML	RS	17	530	0	Mainstem Davy Brown Creek overtops its banks during high flow events and diverts a portion of its flow down a side channel that rushes down Davy Brown Trail for 175'. Eventually it delivers back to the main channel. The diversion channel is armored with large, dense boulders and small amounts of loose soil that will continue to erode away.	1) Construct a berm above the right bank of Class I Davy Brown 40' long x 10' wide at the base x 5' wide at the top x 5' deep. Place the berm such that it deflects flows from the side channel back towards mainstem Davy Brown creek. 2) Source material locally or from nearby sites as necessary.

Table B1. Field observations and treatment recommendations for road related sites, *Manzana Creek Watershed Anthropogenic Sediment Reduction Assessment, Aquatic Protection and Road Restoration Planning Project*, *Los Padres National Forest*, *Santa Barbara County, CA*

Site #	Road Name	TI	Problem	Total estimated future sediment delivery (yd^3)	Hydrologically connected road length (ft)		Comment on Problem	Comment on treatment
					Left	Right		
33	Davy Brown Trail	L	SC	9	60	0	Davy Brown Trail borders this bouldery Class III stream for 95' before reaching a rocky ford crossing. Both upstream and downstream channel reaches have large cobble, boulders, and near-source bedrock. This site does not require treatment.	No treatment recommendation.
34	Davy Brown Trail	L	SC	3	66	146	A ford crossing on Mainstem Davy Brown creek. The ford is stable. The main source of sediment delivery will be the connected trail reaches. There are large boulders being actively cemented in place by mineral rich water. There is large woody debris on the right downstream of the crossing.	1) Install 3 rolling dips on the right trail approach. 2) Install 2 rolling dips on the left trail approach.
35	Davy Brown Trail	M	SC	17	0	750	A Class III stream channel was redirected when the Davy Brown Trail was constructed. This section of trail is through-cut with a constructed berm on the outboard edge of the trail, forcing the creek to divert down the left road, around a very large boulder, and eventually back into Davy Brown Creek. This historical channel alignment is located in line with the channel upstream of the crossing and should be reestablished to prevent erosion and delivery of fine sediment to the creek.	1) Excavate a 5' wide x 2' deep channel with 2:1 side slopes for 80' from the outboard edge of the trail to Davy brown creek to convey flows downstream from the armored fill. 2) Install an armored fill, establish a broad dip, excavate a keyway 10' wide x 5' wide x 20' long x 2' deep. 3) Armor the keyway using 12 yd^3 of 0.5'-1.0' diameter rock armor. 4) Install 6 rolling dips up the right road.

Table B1. Field observations and treatment recommendations for road related sites, *Manzana Creek Watershed Anthropogenic Sediment Reduction Assessment, Aquatic Protection and Road Restoration Planning Project*, *Los Padres National Forest*, *Santa Barbara County, CA*

Site #	Road Name	TI	Problem	Total estimated future sediment delivery (yd^3)	Hydrologically connected road length (ft)		Comment on Problem	Comment on treatment
					Left	Right		
36	Davy Brown Campground	M	SC	26	297	0	A small Class III stream is conveyed across this partially paved road via an armored fill. The road has been capped with road base to establish a tight dip through the road. Class III stream flow emerges from the ditch relief culvert outflow from Figueroa Canyon road upslope. The stream is diverting to the right road for 100'. There is a considerable volume of sediment in transport below the road that delivers to Class I Davy Brown. The sediment through the crossing was likely deposited via stream transport from upstream erosion processes.	1) Cut the pavement 6' wide across the road in preparation for culvert installation. 2) Excavate from TOP to BOT and define a 4' wide channel bottom above the road with 2:1 banks. Trench vertically through the road. 3) Install a new 24" diameter x 30' long corrugated metal pipe at the base of fill. 4) Place slurry around the pipe 5) Backfill the trench with native fill and then cap with base aggregate to prepare for repaving 6) Repave the road at disturbed area of crossing. Spoil locally to the left and right in flat areas of the campground. 7) Rebuild the inboard edge of fill at 38 degrees and rock the lower 3/4 of the fillslope with 2 yd^3 of 0.5'-1.0' diameter rock armor. 8) Install an energy dissipation structure at the pipe outlet using 1 yd^3 of 0.5'-1.5' diameter rock armor.

Table B1. Field observations and treatment recommendations for road related sites, *Manzana Creek Watershed Anthropogenic Sediment Reduction Assessment, Aquatic Protection and Road Restoration Planning Project, Los Padres National Forest*, *Santa Barbara County, CA*

Site #	Road Name	TI	Problem	Total estimated future sediment delivery (yd³)	Hydrologically connected road length (ft)		Comment on Problem	Comment on treatment
					Left	Right		
37	8N09	M	SC	283	20	85	A Class III stream was historically conveyed through a double landing via an 24" corrugated metal pipe. This pipe's outlet/interior is plugged, forcing the stream to overtop. This stream flow, combined with overland flow from the surrounding hillside and landings, has created a gully through the double landing (2.5' wide x 1' deep x 180' long) and delivers to site #38 at the main paved road. This stream is also forming a headcut on the cutbank above site #38. The stream channel upstream of the inlet has a high concentration of natural cement.	1) Decommission the double landing crossing. 2) Remove the plugged corrugated metal pipe and excavate from TOP to BOT, establish a 6' wide channel bottom with 2:1 banks. 3) Store spoils locally on the landings on either side of this site.
38	8N09	HM	SC	66	0	1000	A 24" aluminum culvert conveys a flashy Class III stream through this crossing. There is a 3.5' cement headwall at the culvert inlet. There are two roads that drain to, and past this site. There is no critical dip on the paved surface. The stream crossing immediately up stream is a plugged, failing, dysfunctional culvert with lots of plugged sediment. Cachuma Ridge Road is dirt and Figueroa Road is paved; both deliver to this site. There is bedrock exposed below the culvert outlet and in the channel downstream of the site. The culvert is likely undersized for flows and debris.	1) Cut pavement 8' wide across the road in preparation of culvert replacement. Trench vertically and remove existing culvert. Install a 48" diameter x 50’ long corrugated metal pipe at the base of fill. Place slurry around pipe and backfill with native fill. Cap with base aggregate to prepare for repaving. 2) Repave the road at the disturbed crossing area. 3) Install a 3 post trash rack (or rock grate) at the culvert inlet to prevent plugging. 4) Armor the lower 1/4 of the outboard fill slope with 3 yd^3 of 0.5'-1.5’ diameter rock armor.

Table B1. Field observations and treatment recommendations for road related sites, *Manzana Creek Watershed Anthropogenic Sediment Reduction Assessment, Aquatic Protection and Road Restoration Planning Project, Los Padres National Forest, Santa Barbara County, CA*

Site #	Road Name	TI	Problem	Total estimated future sediment delivery (yd^3)	Hydrologically connected road length (ft)		Comment on Problem	Comment on treatment
					Left	Right		
39	8N09	M	SC	38	0	210	A Class III stream is diverted down the inboard ditch of the paved 8N09 for several hundred feet. Upon upgrade, this ditch could be kept and rocked, to act as an overflow to the culvert. The right road approach is slightly outsloped with no inboard ditch. This stream seems to have low energy, there is low erosion at the inboard ditch where the stream is unnaturally directed 90 degrees to the left.	1) Cut the pavement 6' wide across the road in preparation for culvert installation 2) Trench vertically and install a new culvert. 3) Install a new 24" diameter x 60' long corrugated metal pipe at the base of fill. 4) Place slurry around the pipe. 5) Backfill the trench with native material and cap with base aggregate to prepare for repaving. 6) Install an 18" diameter x 30' long overflow pipe with a 30' downspout on the left hinge of the crossing. 7) Backfill around the overflow pipe with native fill and cap the trench with base aggregate to prepare for repaving. 8) Repave the road at the disturbed areas of the crossing.

Table B1. Field observations and treatment recommendations for road related sites, *Manzana Creek Watershed Anthropogenic Sediment Reduction Assessment, Aquatic Protection and Road Restoration Planning Project*, *Los Padres National Forest*, *Santa Barbara County, CA*

Site #	Road Name	TI	Problem	Total estimated future sediment delivery (yd^3)	Hydrologically connected road length (ft)		Comment on Problem	Comment on treatment
					Left	Right		
40	8N09	L	SC	48	450	0	A Class III creek is conveyed through this crossing via a 30" aluminum corrugated metal pipe with concrete vertical headwalls. The inlet is partially plugged and there is stored sediment in the culvert. The outlet is 20% plugged due to high sediment transport in this stream. There is a diverted stream from site #39 ~450' up the left road that diverts to this crossing just downstream of the outlet. The ditch is transporting considerable sediment. The culvert is functional. A critical overflow culvert would help this crossing function in a high flow event if the culvert plugs.	1) Cut pavement prior to installation of culverts. Trench vertically and install new 48" diameter x 30' long corrugated metal pipe at the base of fill. Place slurry around pipe and backfill trench with native fill. Cap with base aggregate to prepare for repaving. 2) Repave the road at the disturbed areas at crossing. 3) Install a 18" x 60' ditch relief culvert up the left road approach. Repave the disturbed area. 4) Install a galvanized single post trash rack above the inlet to prevent plugging. 5) Armor the lower 1/4 of the outboard fillslope using 2 yd^3 or 1'-2' diameter rock armor.
41	8N09	HM	BE	11	0	0	A section of the right bank of Fish Creek along road 8N09 is being actively eroded by bank erosion processes. The eroding area is located along the outside bend of the 5-6' wide stream. The erosion will continue to undermine the bank and eventually the paved road as well if not treated. There is a large Mule Phat shrub that is constricting the flow at the bank erosion site and is likely contributing to the flows preferential path into the bank.	1) Excavate a keyway 40' wide x 2' deep x 6' long along the eroding bank. Ensure 2-3' of keyway extends below channel bed grade. 2) Armor the keyway and lower 1/2 of the fill slope using 36 yd^3 of 1-3' diameter rock armor. 3) Lay back the upper half of the fill slope to 1.5:1 for 45'. 4) Spoil locally.

Table B1. Field observations and treatment recommendations for road related sites, *Manzana Creek Watershed Anthropogenic Sediment Reduction Assessment, Aquatic Protection and Road Restoration Planning Project*, *Los Padres National Forest*, *Santa Barbara County, CA*

Site #	**Road Name**	**TI**	**Problem**	**Total estimated future sediment delivery (yd^3)**	**Hydrologically connected road length (ft)**		**Comment on Problem**	**Comment on treatment**
					Left	**Right**		
42	8N09	L	SC	53	270	30	A well-defined Class III stream crossing is conveyed under the paved 8N09 road via a 30" corrugated metal pipe with a cement wing-wall at the inlet. The inlet is approximately 30% plugged with sticks and aggraded sediment. The top of the inlet is slightly crushed. There is a 2' drop below the outlet with a small headcut. There is aggraded sediment below the outlet. The left road approach is flat with no inboard ditch. There is a parking area/ turn out to the left with a berm built up on the left bank. There is a slight low spot just left of the inlet that will pool up if the stream overtops.	1) Cut pavement prior to installation of culvert. Trench vertically and install a new 60" diameter x 60' long corrugated metal pipe set at the base of fill. Place slurry around pipe and backfill with native material. Cap with base aggregate to prepare for repaving. 2) Install a critical dip on the left hinge of the crossing to prevent diversion. 3) Repave the road at the disturbed area of the crossing. 4) Excavate a 6' wide x 2' deep x 40' long channel with 2:1 side slopes from the TOP to the inboard edge of the road to convey flows to the new pipe. 5) Install a metal grate above the inlet to prevent plugging.
43	8N09	L	RS	25	428	135	An outboard down drain made of corrugated sheet metal conveys road runoff and fine sediment to a streamside area. The majority of the sediment is fanning out, but a portion is delivering to the downstream channel reach. The drainage feature is functional. A sediment basin with regular maintenance would prevent sediment delivery. There is another outboard down drain approximately 100' up the right road approach with the same erosion below the outlet.	1) Install a sediment basin 8' x 6' x 2' with 2:1 banks. 2) Store spoils locally away from the stream. 3) Re orient the rock along the outboard drain 100' up the right road approach. 4) Install 5 yd^3 of 0.5'-2.5' diameter rock armor at the meander apex to prevent bank erosion and headcut associated with outboard down drain.

Table B1. Field observations and treatment recommendations for road related sites, *Manzana Creek Watershed Anthropogenic Sediment Reduction Assessment, Aquatic Protection and Road Restoration Planning Project*, *Los Padres National Forest*, *Santa Barbara County, CA*

Site #	Road Name	TI	Problem	Total estimated future sediment delivery (yd^3)	Hydrologically connected road length (ft)		Comment on Problem	Comment on treatment
					Left	Right		
44	8N09	ML	SC	11	52	0	A small near origin stream diverts 390' down the right road to Site #45. Stream flow has eroded a small Class III channel upstream of the road. The crossing is located on a large fan deposit. The road is paved with no inboard ditch. There is a small swale across the road.	1) Cut the pavement 6' wide prior to installation of culverts. Install a new 24" diameter x 40' long corrugated metal pipe at the base of fill. Place slurry around the pipe and backfill with native fill. Cap with base aggregate in preparation for repaving. 2) Trench vertically and install an 18" x 30' overflow culvert on the right hinge of the crossing. Backfill with native material and cap with base aggregate to prepare for repaving. 3) Repave the road at the disturbed areas of the crossing. 4) Define a 3' wide channel with 2:1 side slopes for 25' upstream of the TOP. 5) Install an energy dissipation structure at the outlet using 1 yd^3 of 0.5’-1.5’ diameter rock armor.

Table B1. Field observations and treatment recommendations for road related sites, *Manzana Creek Watershed Anthropogenic Sediment Reduction Assessment, Aquatic Protection and Road Restoration Planning Project*, *Los Padres National Forest*, *Santa Barbara County, CA*

Site #	Road Name	TI	Problem	Total estimated future sediment delivery (yd^3)	Hydrologically connected road length (ft)		Comment on Problem	Comment on treatment
					Left	Right		
45	8N09	ML	SC	25	0	150	A Class III stream is conveyed under the paved road via an 18" corrugated metal pipe with a concrete wall around the inlet. The right road approach is slightly insloped and has no inboard ditch. The pipe is set high in the fill and there is aggrading sediment inside the outlet. A gully has formed downstream of the outlet. The left road is lower than the crossing and will serve as the critical dip at this site.	1) Cut pavement prior to installation of new culvert. Trench vertically and install a new 30" diameter x 50' long corrugated metal pipe at the base of fill. Place slurry around the pipe and backfill with native fill. Cap with base aggregate to prepare for repaving. 2. Repave the road at the disturbed area of the crossing. 2) Install an energy dissipation structure at the pipe outlet using 1 yd^3 of 0.5’-1.5' diameter rock armor. 3) Armor the outboard fill slope using 4 yd^3 of 0.5’-2.5' diameter rock armor. 4) Lay back the banks downstream of the outlet to 2:1.

Table B1. Field observations and treatment recommendations for road related sites, *Manzana Creek Watershed Anthropogenic Sediment Reduction Assessment, Aquatic Protection and Road Restoration Planning Project*, *Los Padres National Forest*, *Santa Barbara County, CA*

Site #	Road Name	TI	Problem	Total estimated future sediment delivery (yd^3)	Hydrologically connected road length (ft)		Comment on Problem	Comment on treatment
					Left	Right		
46	8N09	ML	SC	165	505	0	An 18" corrugated metal pipe conveys concentrated road runoff and Class III stream flow through this crossing. The inlet is 40% plugged with concrete and fine sediment. The paved road is conveying cutbank ravel to the crossing. The crossing fill does not appear to be overtopped during storm events and the pipe is functioning. The inboard edge of fill is a vertical concrete wall.	1) Cut the pavement prior to installation of culverts. Trench vertically and replace the existing pipe with a new 24" diameter x 70' long corrugated metal pipe placed at the base fill. Align the new pipe 10' to the left of several large oak trees. Place slurry around the pipe and backfill with native fill. Cap with base aggregate to prepare for repaving. 2) Trench vertically and Install an 18" diameter x 30' long overflow culvert on the right hinge of the crossing. Backfill with native fill and cap with base aggregate. 3) Repave the road at the disturbed areas of the crossing. 3) Install a single post galvanized trash rack above the inlet. 4) Install an energy dissipation structure below the outlet using 3 yd^3 of 0.5’-1.5' diameter rock armor. 5) Armor the lower 1/4 of the outboard fill slope with 8 yd^3 of 1-2.5' diameter rock armor. 6) Pull back the left outboard fill for 65' wide x 25' long x 2.5' deep. 7) Use loader to move spoils to flat area 1000' up the left road.

Table B1. Field observations and treatment recommendations for road related sites, *Manzana Creek Watershed Anthropogenic Sediment Reduction Assessment, Aquatic Protection and Road Restoration Planning Project*, *Los Padres National Forest*, *Santa Barbara County, CA*

Site #	Road Name	TI	Problem	Total estimated future sediment delivery (yd^3)	Hydrologically connected road length (ft)		Comment on Problem	Comment on treatment
					Left	Right		
47	8N09	M	SC	119	129	0	A Class III stream is conveyed under the road via an 18" diameter corrugated metal pipe. The pipe has been set very high in the fill. There is a 4.5' drop from the outlet into the outboard fill slope with a 3' headcut forming on the surface. The upstream area is very steep with a relatively small drainage area. The left road is insloped and drains to this culvert as well. The crossing delivers to Fish creek 20' below the culvert outlet. The outboard fill is steep.	1) Excavate sediment upstream of the inlet and clean the inlet. 2) Install an 18" x 20' long downspout on the outlet of the existing pipe. Use a 35 degree elbow to join the pipe. 3) Construct a berm on the outboard edge of the road 10' long x 2' wide x 1' deep to prevent road runoff from eroding the outboard fill face. 4) Backfill the headcut under the outlet with 1 yd^3 of 0.5’-1.5' diameter rock armor.
49	8N09	ML	RS	23	310	0	A swale and road runoff are conveyed off the road via an outboard down drain, made from a 1/2 round 18" aluminum pipe. The downspout outlets short of the base of fill with subsequent past erosion. Future erosion remains as downstream material continues to be undermined. The dip is functional, and drain should extend to the downstream base of fill.	1) Remove the existing 1/2 round downspout. 2) Install a new 30" x 40' downspout with an asphalt berm to prevent overtopping and convey flow into the new outboard downdrain. 3) Construct an asphalt or concrete berm 10' wide x 2' tall x 1' wide at the inlet.

Table B1. Field observations and treatment recommendations for road related sites, *Manzana Creek Watershed Anthropogenic Sediment Reduction Assessment, Aquatic Protection and Road Restoration Planning Project*, *Los Padres National Forest*, *Santa Barbara County, CA*

Site #	Road Name	TI	Problem	Total estimated future sediment delivery (yd^3)	Hydrologically connected road length (ft)		Comment on Problem	Comment on treatment
					Left	Right		
50	8N09	L	SC	79	0	780	Class I Fish Creek is conveyed under the 8N09 road via a flat bottomed oval corrugated metal pipe (170" wide x 110" high). There is a large cement wingwall that extends 15' upstream of the inlet and 13' downstream of the outlet. There is a 3' drop below the downstream wingwall. The site is not listed as a fish barrier. The right road approach is insloped and conveys a large amount of road runoff to an outboard down drain to the right of the crossing. An inline sediment basin should be dug in the inboard ditch on the right road approach, just before the outboard down-drain to reduce sediment delivery to this Class I stream.	1) Excavate an in-line sediment basin on the inboard ditch on the right road approach just upstream of the outboard down drain (25' long x 6' wide x 2' deep in the center). Maintain sediment basin regularly. 2) Spoil on the landing to the right of the stream, adjacent to the bridge. 3) Cut pavement prior to installation of all ditch relief culverts. Trench vertically and install 2 new ditch relief culverts. Install an 18" x 30' ditch relief culvert up the right road approach with a 25 degree elbow and a 20' downspout at the springy turn out on the road (370' up the right road). Install a 24" x 30' ditch relief culvert with a 20' downspout attached with a 25 degree elbow, 600' up the right road approach. Place slurry around pipes and backfill trenches with native fill. Cap with base aggregate to prepare for repaving. 4) Repave the road at the disturbed areas. 6) Install 1 yd^3 of 0.5'-1.5' diameter rock armor for energy dissipation downstream of the 3' drop below the outlet. 7) Install 2 yd^3 of 0.5'-1.5' diameter rock armor below the ditch relief culverts for energy dissipation.

Table B1. Field observations and treatment recommendations for road related sites, *Manzana Creek Watershed Anthropogenic Sediment Reduction Assessment, Aquatic Protection and Road Restoration Planning Project, Los Padres National Forest, Santa Barbara County, CA*

Site #	Road Name	TI	Problem	Total estimated future sediment delivery (yd^3)	Hydrologically connected road length (ft)		Comment on Problem	Comment on treatment
					Left	Right		
51	8N09	ML	SC	30	41	0	An uncontrolled stream crossing on a Class III stream. The stream flow cascades over thinly bedded shale onto the inboard road area. The stream flow diverts 450' down the left road approach. There is a flat area below the road that the new channel alignment should be defined through. Diverted flow from this site delivers to site #52, 450' down the left road approach.	1) Cut pavement prior to installation of culvert. Trench vertically and install a new 48" x 50' long corrugated metal pipe at the base of fill. Place slurry around pipe and backfill trench with native fill. Import fill to rebuild the road to accommodate the new culvert size. Cap with base aggregate to prepare for repaving. 2) Repave the road at the disturbed area of the crossing. 2) Armor the lower 1/4 of the outboard fillslope with 16 yd^3 of 0.5'-1.5' diameter rock armor. 3) Install 2 yd^3 of 0.5'-1.5' diameter rock armor at the outlet for energy dissipation. 4) Spoil locally and fill the left inboard ditch.

Table B1. Field observations and treatment recommendations for road related sites, *Manzana Creek Watershed Anthropogenic Sediment Reduction Assessment, Aquatic Protection and Road Restoration Planning Project*, *Los Padres National Forest*, *Santa Barbara County, CA*

Site #	Road Name	TI	Problem	Total estimated future sediment delivery (yd^3)	Hydrologically connected road length (ft)		Comment on Problem	Comment on treatment
					Left	Right		
52	8N09	ML	SC	118	450	307	A Class III stream is conveyed through this crossing via a 24" corrugated metal pipe placed near the base of fill. The outlet is 2' above the base of fill, and flow outlets onto stable bedrock. The stream delivers directly to a Class II stream just below the crossing. The left and right inboard ditches deliver to the crossing. The diverted stream from Site #51 up the right road delivers to this site. Remediation of the diversion should reduce the flows from the inboard ditches to this site. The outboard edge of fill is steep but stable.	1) Cut the pavement prior to installation of culvert. Trench vertically and install a new 48" diameter x 60' long corrugated metal pipe at the base of fill. Place slurry around the pipe and backfill with native fill. Cap with base aggregate to prepare for repaving. 2) Repave the road at the disturbed area of the crossing 2) Install a single post galvanized trash rack above the inlet. 3) Install an energy dissipation structure at the outlet using 2 yd^3 of 0.5’-1.5' diameter rock armor. 4) Trench vertically and install 2 ditch relief culverts. Install an 18" x 60' ditch relief culvert up the left road. Install an 18" x 60' ditch relief culvert up the right road. Place slurry around the pipe and backfill using native fill. Cap with base aggregate to prepare for repaving 6) Repave the road at the disturbed areas.

Table B1. Field observations and treatment recommendations for road related sites, *Manzana Creek Watershed Anthropogenic Sediment Reduction Assessment, Aquatic Protection and Road Restoration Planning Project, Los Padres National Forest*, *Santa Barbara County, CA*

Site #	**Road Name**	**TI**	**Problem**	**Total estimated future sediment delivery (yd^3)**	**Hydrologically connected road length (ft)**		**Comment on Problem**	**Comment on treatment**
					Left	**Right**		
53	8N09	L	SC	610	147	55	A class III stream is conveyed under the paved road via an 18" corrugated metal pipe with a cement wall at the inlet. There is a downspout attached to this pipe with a 45 degree elbow that has become buried below the elbow. The outlet is still passing flows, and there is shallow bedrock downstream of the outlet and minimal erosion is occurring. If the pipe is properly sized, the current pipe does not need to be replaced.	1) Cut pavement prior to installation of culvert. Trench vertically and replace the existing corrugated metal pipe with a new 30" diameter x 90' long corrugated metal pipe at the base of fill. Place slurry around the pipe and backfill with native fill. Cap with base aggregate to prepare for repaving. 2) Repave the road at the disturbed area of the crossing. 3) Install a 30" diameter x 20' long downspout on the outlet of the culvert to convey flows to the base of fill. 4) Install an energy dissipation structure at the base of fill using 2 yd^3 of 0.5’-1.0' diameter rock armor. 5) Armor the outboard fill face using 30 yd^3 of 1-2.5' diameter rock armor. 6) Cut a ditch for 147' up the left road.
53.1	8N09	L	SC	245	150	0	A small Class III stream is conveyed through this crossing via an 18" diameter corrugated metal pipe. There is a concrete wall around the inlet, and the left inboard ditch delivers to the inlet of the corrugated metal pipe. The outboard edge of fill is long and steep. The site delivers to Fish creek downstream. The outlet is buried in talus 50' downslope from the outboard edge of the road. There is no active erosion at the BOT.	1. Install a rock grate 10' upstream of the inlet.

Table B1. Field observations and treatment recommendations for road related sites, *Manzana Creek Watershed Anthropogenic Sediment Reduction Assessment, Aquatic Protection and Road Restoration Planning Project*, *Los Padres National Forest*, *Santa Barbara County, CA*

Site #	Road Name	TI	Problem	Total estimated future sediment delivery (yd^3)	Hydrologically connected road length (ft)		Comment on Problem	Comment on treatment
					Left	Right		
54	8N09	ML	SC	787	560	362	Two Class III streams converge at the inlet of this 24" corrugated metal pipe. There is a 4' plunge onto bedrock at the outlet. The area around the outlet is also cemented with natural mineral cement. There is a large landing on the inboard fillslope. The corrugated metal pipe outlets at the base of fill. The site is stable with minor erosion and sediment delivery from the long left and right road reaches. Inboard fillslope is armored 100% with 0.5'-1' diameter rock armor.	1) Install a galvanized single post trash rack at the inlet of the culvert. 2) Trench vertically and install 3 ditch relief culverts. Install 2 18" diameter x 60' long ditch relief culverts up the left road approach. Install 1 18" diameter x 60' long ditch relief culvert on the right road approach. Place slurry around the pipe and backfill with native fill. Cap with base aggregate to prepare for repaving. 5) Install 2 (8' x 12' x 2.5') sediment basins on each inboard ditch, left and right.
55	8N09	M	DRC	18	220	0	A 100% plugged ditch relief culvert on the paved 8N09 road. The left road approach is insloped, but the inboard ditch has been filled by eroding cutbank material, rendering it useless. There is a road surface discharge point on the outboard edge of the road 25' to the left of the crossing.	1) Clean and cut the ditch for 220' up the left road approach. 2) Install a rock grate above the culvert inlet to prevent plugging.

Table B1. Field observations and treatment recommendations for road related sites, *Manzana Creek Watershed Anthropogenic Sediment Reduction Assessment, Aquatic Protection and Road Restoration Planning Project*, *Los Padres National Forest*, *Santa Barbara County, CA*

Site #	Road Name	TI	Problem	Total estimated future sediment delivery (yd³)	Hydrologically connected road length (ft)		Comment on Problem	Comment on treatment
					Left	Right		
56	8N09	ML	SC	150	1000	0	A Class III stream is conveyed under the road via an 18" corrugated metal pipe with a cement wall around the inlet. Combined road runoff from 1000' of left road flows to this site. The ditch up the left road needs to be cut and cleaned. There is also a very steep mountainside upstream that is delivering substantial amounts of rock to a fan upstream o the crossing.	1) Clear the sediment fan and rockslide (approximately 100 yd³) upstream of the crossing, 2) Cut the pavement prior to installation of all new culverts. Trench vertically and replace the existing pipe at the crossing with a new 24" diameter x 50' long corrugated metal pipe at the base of fill. Place slurry around the pipe and backfill with native fill. 3) Trench vertically and Install an 18" diameter x 30' long overflow culvert on the right hinge of the crossing. Backfill with native fill and cap with base aggregate. 4) Repave the road at the disturbed areas of the crossing. 5) Install a rock grate 15' upstream of the inlet. 6) Clean and cut the ditch for 1000' up the left road.
57	8N09	ML	RS	48	305	0	An outboard down drain conveys flow and sediment down the outboard fill slope via a corrugated steel half square chute. The drain conveys sediment to the base of fill and a 3' wide x 1.5' deep gully delivers to a Class III stream 75' downstream of the base of fill. There is sediment on the road and at the inlet of the drain. The drain inlet is plugged. Most of the road drainage bypasses this shallow, broad dip.	1) Clean the inlet of the outboard down drain and remove the brush that is plugging the inlet.

Table B1. Field observations and treatment recommendations for road related sites, *Manzana Creek Watershed Anthropogenic Sediment Reduction Assessment, Aquatic Protection and Road Restoration Planning Project, Los Padres National Forest, Santa Barbara County, CA*

Site #	**Road Name**	**TI**	**Problem**	**Total estimated future sediment delivery (yd^3)**	**Hydrologically connected road length (ft)**		**Comment on Problem**	**Comment on treatment**
					Left	**Right**		
58	8N09	ML	SC	165	807	0	A Class III stream is conveyed through this crossing via a 36" corrugated metal pipe. There is a 3' plunge at the outlet. The outboard fillslope has failed along the right hinge in the past. Road drainage is actively bypassing this crossing. The upstream area is a large avulsing sediment fan with a very wide diffuse channel. The upstream reach should be defined and cleared.	1) Cut pavement prior to installation of culvert. Trench vertically and install a new 42" diameter x 50' long corrugated metal pipe set at the base of fill. New culvert. Place slurry around pipe and backfill trench with native material. Cap with base aggregate to prepare for repaving. 2) Repave the road at the disturbed areas of the crossing. 3) Cut pavement prior to installation of all ditch relief culverts. Trench vertically and 3 new ditch relief culverts. Install 3 18" diameter x 60' long ditch relief culverts up the left road approach. 4) Repave the road at the disturbed areas. 5) Clean and define a 6' wide x 2' deep x 75' long channel with 2:1 banks upstream of the top. 6) Construct a long, 50' berm along the right hinge upstream of the inlet to contain flow (50' long x 8' wide x 3' tall) (use excavated channel material). 7) Install 5 yd^3 of 0.5'-1.5’ diameter rock armor below the outlet for energy dissipation 8) Armor the lower 3/4 of the outboard fillslope using 8 yd^3 of 1-2' diameter rock armor. 9) Clean the inboard ditch for 800' up the left road.

Table B1. Field observations and treatment recommendations for road related sites, *Manzana Creek Watershed Anthropogenic Sediment Reduction Assessment, Aquatic Protection and Road Restoration Planning Project*, *Los Padres National Forest*, *Santa Barbara County, CA*

Site #	Road Name	TI	Problem	Total estimated future sediment delivery (yd^3)	Hydrologically connected road length (ft)		Comment on Problem	Comment on treatment
					Left	Right		
59	8N09	M	DRC	64	735	0	An 18" ditch relief culvert conveys road runoff from the left road approach and flow from 3 swales on the hillslope above. The swale flow is directed into the inboard ditch and down to the ditch relied culvert. The ditch relief culvert has a half-round downspout installed but the inlet is plugged. Cutbank erosion has caused the left roads inboard ditch to fill and has started to encroach on the road surface.	1) Clean/cut the inboard ditch for 735' up the left road approach. 2) Clean the inlet of the ditch relief culvert. Routine cleaning may be necessary at this site.

Table B1. Field observations and treatment recommendations for road related sites, *Manzana Creek Watershed Anthropogenic Sediment Reduction Assessment, Aquatic Protection and Road Restoration Planning Project, Los Padres National Forest, Santa Barbara County, CA*

Site #	Road Name	TI	Problem	Total estimated future sediment delivery (yd^3)	Hydrologically connected road length (ft)		Comment on Problem	Comment on treatment
					Left	Right		
60	8N09	M	SC	113	320	0	A Class III stream is conveyed through this crossing via a 36" diameter corrugated metal pipe. There is a cracked cement wall around the inlet. The channel upstream of the crossing is flat and wide due to aggraded sediment being trapped above the fill prism. The left road delivers sediment via the inboard ditch, although there is minimal active erosion. The corrugated metal pipe is functional but may be undersized. The outlet is partially plugged with sediment.	1) Cut the pavement prior to installation of all pipes. Trench vertically and replace the existing pipe with a new 54" diameter x 40' long corrugated metal pipe set at the base of fill. Place slurry around the pipe and backfill with native material. Cap the trench with base aggregate to prepare for repaving. 2) Trench vertically and install a 30" diameter x 30' long overflow culvert on the right hinge of the crossing. Place slurry around the pipe and backfill the trench with native material. Cap the trench with base aggregate to prepare for repaving. 3) Cut the pavement prior to installation of all ditch relief culverts. Trench vertically and install 6 18" diameter x 30' long ditch relief culverts up the left road. Place slurry around the pipe and backfill with native material. Cap the trenches with base aggregate to prepare for repaving. 4) Define a 4' wide channel with 2:1 banks for 75' upstream of the inlet. 5) Install a sediment basin on the left inboard ditch approach to the crossing 12' long x 8' wide x 3' deep. 6) Armor the lower 1/4 of the outboard fill slope using 4 yd^3 of 0.5’-2.5' diameter rock armor. 8) Repave the road at the disturbed areas of the crossing.

Table B1. Field observations and treatment recommendations for road related sites, *Manzana Creek Watershed Anthropogenic Sediment Reduction Assessment, Aquatic Protection and Road Restoration Planning Project*, *Los Padres National Forest*, *Santa Barbara County, CA*

Site #	Road Name	TI	Problem	Total estimated future sediment delivery (yd^3)	Hydrologically connected road length (ft)		Comment on Problem	Comment on treatment
					Left	Right		
61	8N09	L	SC	15	1600	0	A Class III stream in an alluvial valley is conveyed under the paved road via a 24" diameter corrugated metal pipe. The culvert is in a low gradient, very low power environment and has plugged. There are no signs of active erosion as a result of this culvert plugging.	1) Clean the inlet and outlet of the culvert.
62	8N09	L	SC	3	1100	0	A Class III stream in an alluvial valley setting. There stream flows onto the paved road at grade and flows down the right road. The majority of the stream evacuates the road approximately 125' down the right road with no active erosion. The site is stable and not an erosion issue.	1) Install a broad dip on the right road 125' down, at the exit point to prevent diversion past the stream channel. 2) Repave the disturbed road surfaces.
63	8N09	L	SC	36	830	0	A Class III stream crossing with no formal drainage structure. The flow gets trapped on the road and flows down the right road before outletting over the outboard edge of fill. This discharge point can be cleaned and used as an overflow drainage site.	1) Excavate a 4' wide channel with 2:1 side slopes for 50' from the TOP to the inboard edge of the road. 2) Cut the pavement prior to installation of culverts. Trench vertically and install a new 24" diameter x 50' long corrugated metal pipe set at the base of fill. Place slurry around the pipe and backfill with native material. Cap the trench with base aggregate to prepare for repaving. 3) Spoil locally up the left road. 4) Ensure that the elevated road bed at the crossing acts as a critical dip. Berm the inboard edge of the right road to contain flows and prevent diversion. 5) Clean the discharge point 95' down the right road to utilize for overflow drainage.

Table B1. Field observations and treatment recommendations for road related sites, *Manzana Creek Watershed Anthropogenic Sediment Reduction Assessment, Aquatic Protection and Road Restoration Planning Project*, *Los Padres National Forest*, *Santa Barbara County, CA*

Site #	Road Name	TI	Problem	Total estimated future sediment delivery (yd^3)	Hydrologically connected road length (ft)		Comment on Problem	Comment on treatment
					Left	Right		
64	8N09	L	SC	1	160	0	A small Class III stream flows onto an alluvial fan at the right edge of the valley. Flow dissipates before crossing a paved road. The majority of flow diverts down the right road with no active erosion. The stream diverts 160' down the right road.	1) Excavate a 3' wide channel with 2:1 side slopes for 90' from the TOP to the inboard edge of the road. 2) Cut pavement prior to installation of culvert. Trench vertically and install new 24" diameter x 50’ long corrugated metal pipe at the base of fill. Place slurry around pipe and backfill trench with native fill. Cap with base aggregate to prepare for repaving. 3) Berm the inboard edge and raise the left hinge of the crossing to ensure flows are not able to divert down the left road in the event of a culvert plugging.

Table B1. Field observations and treatment recommendations for road related sites, *Manzana Creek Watershed Anthropogenic Sediment Reduction Assessment, Aquatic Protection and Road Restoration Planning Project, Los Padres National Forest, Santa Barbara County, CA*

Site #	Road Name	TI	Problem	Total estimated future sediment delivery (yd^3)	Hydrologically connected road length (ft)		Comment on Problem	Comment on treatment
					Left	Right		
64.1	8N09	M	SC	519	800	0	A near origin Class III stream is conveyed down an inboard ditch for 60' and under the road via a 24" corrugated metal pipe. The culvert inlet has sediment accumulating at the inlet but is not yet plugged. The outlet however has been buried and was not able to be found. On the outboard fill slope, a spring cistern is actively flowing and delivering to Davy Brown. There are no obvious flow paths or points of diversion downstream of this buried culvert, but the area is heavily vegetated.	1) Define an inboard ditch for 60' from the TOP to the inlet. 2) Cut pavement prior to installation of the culvert. Trench vertically and install the new 30" diameter x 120' long corrugated metal pipe at the base of fill. Place slurry around pipe and backfill trench with native fill. Cap with base aggregate to prepare for repaving. 3) Trench vertically and install overflow culvert on the right hinge of the crossing 18" diameter x 40' long. Backfill the trench with native fill and cap with base aggregate to prepare for repaving. 4) Add 1 yd^3 of 0.5'-1.5' diameter rock armor at the outlet of the overflow culvert. 5) Endhaul the spoils to Cachuma Saddle and spoil on the landing. 6) Re pave the disturbed road area.
65	8N08	L	SC	54	132	180	A near origin Class III stream flows across the road at a rocky fill crossing. Flows appear to be minimal and erosion is minimal as well. There is minor rilling on the left and right road approaches, and the road approach from the drainage divide right of Site 65 could use local treatments despite being disconnected from this site. This length of road has some gullying and erosion that outsloping and rolling dips would correct.	1) Install an armored fill. Establish a broad dip, Excavate a keyway (12' wide x 6' wide x 14' long x 2' deep) 2) Armor the keyway using 6 yd^3 of 0.5'-1.0' diameter rock armor. 3) Outslope road and fill ditch for 132' up the left road. 4) Outslope road and fill ditch for 180' up the right road. 5) Install 1 rolling dip on the left road. 6) Install 1 rolling dip on the right road.

Table B1. Field observations and treatment recommendations for road related sites, *Manzana Creek Watershed Anthropogenic Sediment Reduction Assessment, Aquatic Protection and Road Restoration Planning Project, Los Padres National Forest*, *Santa Barbara County, CA*

Site #	Road Name	TI	Problem	Total estimated future sediment delivery (yd^3)	Hydrologically connected road length (ft)		Comment on Problem	Comment on treatment
					Left	Right		
66	8N08	L	SC	33	92	60	A fill crossing on a near origin Class III stream located in the upper reaches of the watershed. The outboard fill slope is loose and uncompacted and is highly erodible. The left and right road approaches have numerous rills and are contributing to the erosion at the site. The left road has a small berm along the outboard edge of the road for 20' leading away from the crossing.	1) Install an armored fill. Establish a broad dip, excavate a keyway (12' wide x 6' wide x 25' long x 2' deep). 2) Armor the keyway using 15 yd^3 of 0.5’-1.5' diameter rock. 3) Outslope road and fill ditch for 60' up the right road. 4) Outslope road and fill ditch for 90' up the left road. 5) Remove the berm on the left road, excavate 6 yds (4' x 2' x 20')
67	8N08	L	SC	180	30	930	A flashy, avulsing Class III stream crosses the road in 2 places after bifurcating upstream. A large fan has built up 150' upstream of the crossing, causing the channel to aggrade and avulse across the fan. Both channels pour onto the road and combine at the outboard edge of the road before reentering the natural channel downstream. Equipment access to the upstream channel reach is feasible, and redefining the channel is a good option for limiting problems at this site. Due to substantial debris and aggradation, an armored fill may be a better option at this site. Shallow bedrock may also inhibit excavation.	1) Redefine the channel upstream of the crossing for 150' to convey flow down the left channel and into the crossing. Establish a 3' wide channel with 2:1 side slopes where feasible. 2) Install an armored fill. Establish a broad dip. Excavate a keyway (25' wide x 15' wide x 28' long x 2.5' deep). 3) Armor the keyway using 52 yd^3 of 0.5’-2.5' diameter rock armor. 4) Install 7 rolling dips on the right road approach. 5) Outslope road and fill ditch for 930' up the right road. 6) Rock the road through the crossing (15' wide x 40' long, or 20' on either side of the crossing axis).

Table B1. Field observations and treatment recommendations for road related sites, *Manzana Creek Watershed Anthropogenic Sediment Reduction Assessment, Aquatic Protection and Road Restoration Planning Project, Los Padres National Forest, Santa Barbara County, CA*

Site #	Road Name	TI	Problem	Total estimated future sediment delivery (yd^3)	Hydrologically connected road length (ft)		Comment on Problem	Comment on treatment
					Left	Right		
68	8N08	M	SC	74	0	520	A Class III stream channel has been diverted from its natural alignment as a result of road construction and a lack of formal drainage structure. The existing ford crossing is not functioning, and flows are diverting down the left road for 90' before reentering the natural channel. A gully 90' long x 3' wide x 1' deep has formed on the road bed of the left road. Road surface runoff has also carved a small gully on the right road 94' long x 2' wide x 0.5' deep. The road itself is only 1-2 feet above the natural channel and should be built up slightly along the left hinge to prevent future diversion. A seasonal ford crossing may be most suitable at this site as there is no room (too shallow of a fill) to install an armored fill or a pipe.	1) Excavate from Top to Bot and reestablish a natural channel shape and alignment through the crossing. 2) Install a ford crossing. Establish a broad dip through the channel and armor the left and right approaches using 11 yd^3 of 0.25-0.5' diameter rock armor. 3) Rock the left and right approaches for 25' on each side to prevent road-derived sediment from being transported into the ford crossing. 4) Outslope road and fill ditch for 520' up the right road. 5) Install 4 rolling dips up the right road. 6) Spoil locally on the left road approach to ensure there is no diversion potential.
69	8N08	L	SC	80	50	900	A near origin Class III stream is conveyed over a small fill crossing with minimal erosion. There is no active erosion, but a small armored fill would prevent future gully and sediment delivery in the event that erosion of the fill does begin at this site in the future.	1) Install an armored fill. Establish a broad dip, excavate a keyway (8' wide x 4' wide x 20' long x 2' deep). 2) Armor the keyway using 7 yd^3 of 0.5'-1.5' diameter rock armor. 3) Install 7 rolling dips on the right road. 4) outslope road and fill the ditch for 900' up the right road. 5) Outslope the road and fill the ditch for 50 up left road. 6) Remove the small fan at the inboard edge of the road (+5 yd^3 of excavation).

Table B1. Field observations and treatment recommendations for road related sites, *Manzana Creek Watershed Anthropogenic Sediment Reduction Assessment, Aquatic Protection and Road Restoration Planning Project*, *Los Padres National Forest*, *Santa Barbara County, CA*

Site #	Road Name	TI	Problem	Total estimated future sediment delivery (yd^3)	Hydrologically connected road length (ft)		Comment on Problem	Comment on treatment
					Left	Right		
70	8N08	L	SC	81	360	100	A Class III stream is conveyed across the road via an armored fill. The crossing has been rocked through the road and there is little active erosion on the outboard edge of fill. The armor on the outboard edge of fill is lacking smaller rock that would otherwise fill interstitial spaces in the armor. The current armored fill lacks the necessary u-shape as well. The upstream and downstream channels are rocky and offer enough local material to rebuild this armored fill appropriately. The left road is very steep and is actively eroding by way of rilling.	1) Install an armored fill. Establish a broad dip, Excavate a keyway (23' long x 18' wide x 8' wide x 2' deep). 2) Armor the keyway using 7 yd^3 of 0.5’-1.5' diameter rock armor. Utilize 15 yd^3 of existing rock to make total of 22 yd^3. 3) Outslope road and fill ditch for 360' up the left road. 4) Install 2 rolling dips up the left road.
71	8N08	L	SC	49	160	0	A fill crossing at a steep, boulder Class III stream. Erosion is minimal and the channel below the road is stable with numerous large 18"-24" diameter boulders and oak trees.	1) Install an armored fill. Establish a broad dip, excavate a keyway (14' wide x 6' wide x 12' long x 2' deep). 2) Armor the keyway using 9 yd^3 of 0.5’-1.5' diameter rock armor. 3) Outslope road and fill ditch for 160' up the left road. 4) Install 1 rolling dip up the left road.
72	8N08	L	RS	150	0	950	A long stretch of road leading down to a saddle along the Manzana Creek watershed boundary is actively eroding a 240' gully that has eroded into the road bed and delivers to a small headwater tributary north of the road.	1) Outslope road and remove ditch for 950' up the right road. 2) Install 7 rolling dips up the right road.

Table B1. Field observations and treatment recommendations for road related sites, *Manzana Creek Watershed Anthropogenic Sediment Reduction Assessment, Aquatic Protection and Road Restoration Planning Project, Los Padres National Forest*, *Santa Barbara County, CA*

Site #	Road Name	TI	Problem	Total estimated future sediment delivery (yd^3)	Hydrologically connected road length (ft)		Comment on Problem	Comment on treatment
					Left	Right		
73	8N08	L	SC	54	60	200	A near origin Class III stream with several small headcuts below the outboard edge of the road crosses over the road bed at this fill crossing. The headcuts are small but could undermine the road if they migrate and enlarge. The creek is very small and steep, and there is no room at the inboard edge of the road for a pipe inlet. An armored fill would be an effective and simple upgrade option at this site.	1) Install an armored fill. Establish a broad dip, excavate a keyway (10' wide x 6' wide x 24' long x 2' deep). 2) Armor the keyway using 14 yd^3 of 0.5’-1.5' diameter rock armor. 3) Outslope road and fill ditch for 200' up the right road. 4) Outslope road and fill ditch for 60' up the left road. 5) Install one rolling dip on the right road approach.
74	8N08	L	SC	75	550	70	A near origin Class III stream at a fill crossing with no formal drainage structure. There is a small drainage area upstream of this crossing that is entirely visible from the road. A small headcut has formed at the inboard edge of the road and a small gully has formed along the outboard edge of fill. A small armored fill would prevent further erosion of the fill crossing. The right road approach is insloped through a sharp turn. The first 70' of the right road leading away from the crossing should be outsloped to prevent future deliver from the road surface. The left road has a berm along the outboard edge of the road (1' x 2' x 75').	1) Install an armored fill, Excavate a keyway (15' long x 10' wide x 5' wide x 2' deep). 2) Armor the keyway using 8 yd^3 of 0.5’-1.5' diameter rock armor. 3) Outslope road and fill ditch for 180' up the right road. 4) Outslope road and fill ditch for 550' up the left road. 5) Install 2 rolling dips up the left road. 6) Install 1 rolling dip up the right road. 7) Remove the berm along the right road (75' x 2' x 1'), 6 yd^3 excavation.

Table B1. Field observations and treatment recommendations for road related sites, *Manzana Creek Watershed Anthropogenic Sediment Reduction Assessment, Aquatic Protection and Road Restoration Planning Project*, *Los Padres National Forest*, *Santa Barbara County, CA*

Site #	Road Name	TI	Problem	Total estimated future sediment delivery (yd^3)	Hydrologically connected road length (ft)		Comment on Problem	Comment on treatment
					Left	Right		
75	8N08	L	SC	130	0	625	A near origin Class III bedrock stream has no formal drainage structure through this fill crossing. Flows currently divert down the left road, creating a gully 120' long x 1' wide x 0.5' deep. The stream channel runs along a contact with near source bedrock. The heavily cemented sandstone along the right bank will not be easily excavated.	1) Install an armored fill. Establish a broad dip, excavate a keyway (23' long x 12' wide x 6' wide x 2' deep). 2) Armor the keyway using 16 yd^3 of 0.5'-1.5' diameter rock armor. 3) Outslope road and fill ditch for 625' up the right road. 4) Excavate the small pile of accumulated scree material from upstream. 5) Install 3 rolling dips up the right road.
76	8N08	L	RS	64	30	800	An outboard down drain at a swale along the road. A large rill extends down the right road for 165' and could develop into a gully if the outboard down drain fails to maintain the current grade. Rolling dips and outsloping will greatly improve the right road.	1) Outslope road and remove ditch for 800' up the right road. 2) Install 1 rolling dip at the swale and outboard down drain and 1 rolling dip 160' up the right road at another swale. 3) Install 3 more rolling dips up the right road beyond the swale.
77	8N08	L	RS	26	0	140	An outboard down drain directs 140' of road related runoff over the outboard edge of fill. The right road has a large rill on the road bed. The outlet of the outboard down drain has been placed 3' above the gully below, which has caused a 2' headcut to form due to plunging flows from the outlet. The gully associated with this headcut then delivers to the headwaters of East Fork Fish creek.	1) Outslope road and remove ditch for 140' up the right road. 2) Install 1 rolling dip at the site and 1 additional rolling dip up the right road.

Table B1. Field observations and treatment recommendations for road related sites, *Manzana Creek Watershed Anthropogenic Sediment Reduction Assessment, Aquatic Protection and Road Restoration Planning Project*, *Los Padres National Forest*, *Santa Barbara County, CA*

Site #	Road Name	TI	Problem	Total estimated future sediment delivery (yd^3)	Hydrologically connected road length (ft)		Comment on Problem	Comment on treatment
					Left	Right		
78	8N08	L	RS	270	1900	0	A long rill extends 1500' down the left road to an outboard down drain. A berm contains concentrated road runoff and forces it down this length of road. There is minor erosion at the drop below the outlet of the outboard down drain that could be prevented and treated with some rock armor. Road upgrades would also negate the need for this outboard down drain.	1) Install 14 rolling dips on the left road. 2) Install 1 yd^3 of 0.5'-1.0' diameter rock armor at the outlet of the outboard down drain. 3) Outslope road and remove ditch for 1900' up the left road.
79	8N08	L	RS	42	300	0	An outboard down drain that drains 300' of left road. The drain is partially plugged with sediment. The left road approach does not properly drain due to the berm on the outboard edge of the road. The headwaters if Fish Creek are 600' downstream below the road. There is no rilling occurring on the left road.	1) Outslope road and remove ditch for 300' up the left road. 2) Install 2 rolling dips up the left road. 3) Remove the failing outboard down drain.
80	8N08	L	RS	88	410	0	An outboard down drain is causing erosion of the hillslope below the road. A rill has also developed on the road surface (1' x 0.5' x 380') down the left road to the outboard down drain. The road is insloped and bermed along the outboard edge of the road.	1) Install 2 yd^3 of 0.5'-1.0' diameter rock armor at the outlet of the outboard down drain to serve as energy dissipation. 2) Outslope road and remove ditch for 410' up the left road. 3) Install 2 rolling dips up the left road.
81	8N08	L	RS	55	479	0	An outboard down drain with 479' of connected, insloped left road. The left road lacks proper drainage and shaping and there is a berm on the outboard edge that prevents any flow from leaving the road surface. The outboard down drain appears to plug often and delivers to a Class III 250' downslope of the road. There is light rilling occurring on the left road.	1) Outslope road and remove ditch for 479' up the left road. 2) Install 4 rolling dips up the left road and 1 at the site. 3) Remove the outboard down drain.

Table B1. Field observations and treatment recommendations for road related sites, *Manzana Creek Watershed Anthropogenic Sediment Reduction Assessment, Aquatic Protection and Road Restoration Planning Project*, *Los Padres National Forest*, *Santa Barbara County, CA*

Site #	Road Name	TI	Problem	Total estimated future sediment delivery (yd^3)	Hydrologically connected road length (ft)		Comment on Problem	Comment on treatment
					Left	Right		
82	8N08	L	RS	53	415	0	A long stretch of road that has an outboard berm and infrequent drainage. An outboard down drain relieves road runoff from 415' of left road that is actively eroding where flows exit the road along the outboard edge of fill. A 1x1' gully has formed below the outlet of the drain and extends into dense brush below the road. Out sloping and rolling dips will negate the need for this outboard down drain.	1) Outslope road and remove ditch for 415' up the left road. 2) Install 2 rolling dips on the left road. 3) Reshape the outboard edge of fill where erosion is occurring and remove the outboard down drain.
83	8N08	L	RS	60	290	0	An outboard down drain that drains 290' of left road has plugged and is now being flanked by road runoff on the left side of the drain. A headcut has formed on the outboard edge of the road that will likely migrate into the road surface and up the left road if left untreated. The left road is bermed and light rilling is occurring. The site delivers to the headwaters of a Class III stream.	1) Outslope road and remove ditch for 290' up the left road. 2) Install 1 rolling dip up the left road and 1 rolling dip at the site.
84	8N08	L	RS	173	0	1300	An outboard down drain collects road runoff from 1300' of right road. A 1x1' x 30' gully has formed below the outlet and disappears into dense brush below the road. Rilling is occurring on most of the 1300' of right road.	1) Outslope road and remove ditch for 1300' up the right road. 2) Install 8 rolling dips up the right road.
85	8N08	L	RS	99	0	795	An outboard down drain evacuates 795' of concentrated road runoff over the outboard edge of fill. Light rilling is occurring along the right road. The outboard down drain delivers to a Class III stream 450' downstream. A small rolling dip was placed at this outboard down drain and is effectively cutting off the road drainage beyond this site.	1) Outslope road and remove ditch for 795' up the right road. 2) Install 5 rolling dips up the right road.

Table B1. Field observations and treatment recommendations for road related sites, *Manzana Creek Watershed Anthropogenic Sediment Reduction Assessment, Aquatic Protection and Road Restoration Planning Project*, *Los Padres National Forest*, *Santa Barbara County, CA*

Site #	Road Name	TI	Problem	Total estimated future sediment delivery (yd^3)	Hydrologically connected road length (ft)		Comment on Problem	Comment on treatment
					Left	Right		
86	8N08	L	SC	643	0	440	A Class III stream at a fill crossing. The stream has deposited a large fan of sediment upstream of the road, which extends 92' upslope to the natural, defined, channel. There is no observable erosion at this site, but substantial fill and no formal drainage structure leave this site vulnerable to potentially severe erosion. Two large pine trees may need to be removed to excavate a channel and install a culvert at this site. The inlet can be set at the inboard edge of road instead of at the head of the alluvial fan to retain the trees. However, this will require that a stable channel be excavated through the fan from the inlet at the inboard edge of the road to the head of the alluvial fan deposit.	1) Excavate from Top to BOT and install a new 30" x 70' long corrugated metal pipe at the base of fill. 2) Armor the lower 3/4 of the outboard fill slope using 56 yd^3 of 1'-3' diameter rock armor. 3) Install 1 yd^3 of 0.5'-1.0' diameter rock armor at the outlet to serve as energy dissipation. 4) Install a single post galvanized trash rack at the inlet. 5) Install a critical dip on the left hinge. 6) Outslope road and fill ditch for 440' up the right road. 7) Install 3 rolling dips on the right road. 8) End haul excess spoils to the landing adjacent to Cachuma Saddle to be used for decommissioning of the landing.

Table B1. Field observations and treatment recommendations for road related sites, *Manzana Creek Watershed Anthropogenic Sediment Reduction Assessment, Aquatic Protection and Road Restoration Planning Project, Los Padres National Forest*, *Santa Barbara County, CA*

Site #	Road Name	TI	Problem	Total estimated future sediment delivery (yd^3)	Hydrologically connected road length (ft)		Comment on Problem	Comment on treatment
					Left	Right		
87	8N08	M	SC	291	40	760	A Class III stream crossing with no formal drainage structure. Upstream of the crossing, for 75', the stream channel has been filled in with aggraded sediment. The stream's flow now meanders through the alluvial fan and crosses the road on the left hinge where a rill is developing into a gully. There is a completely buried outboard down drain on the outboard edge of fill. Flows have flanked this burred down drain and eroded a small gully down the outboard edge of fill down to bedrock.	1) Excavate from TOP to the inboard edge of the road and establish a 3' wide x 2' deep channel with 2:1 side slopes where feasible. (77' long x 2' deep x 15' wide average; plus 85 yd^3 for excavation). 2) Install an armored fill. Establish a broad dip, excavate a keyway (18' long x 18' wide x 8' wide x 2' deep). Armor the keyway using 17 yd^3 of 0.5’-1.5' diameter rock armor. 3) Outslope road and fill ditch for 760' up the right road. 4) Install 4 rolling dips up the right road.
88	8N08	L	RS	86	0	590	An outboard down drain conveys 590' of concentrated road runoff from the right road. The drain has failed due to erosion at the outlet which has migrated up and undermined the structure. The drain is now suspended above the gully that has formed by rebar pins that are holding it in place. The gully (3' x 1' x 270' extends from the outboard edge of the road down to the headwaters of Fish creek. There is significant fractured bedrock in the gully, but it appears to be continuing to adjust its banks.	1) Outslope road and remove ditch for 590' up the right road. 2) Install 4 rolling dips up the right road. 3) Buttress the eroding outboard edge of fill using 4 yd^3 of 0.5’-1.5' diameter rock armor. 4) Remove the outboard down drain.

Table B1. Field observations and treatment recommendations for road related sites, *Manzana Creek Watershed Anthropogenic Sediment Reduction Assessment, Aquatic Protection and Road Restoration Planning Project*, *Los Padres National Forest*, *Santa Barbara County, CA*

Site #	Road Name	TI	Problem	Total estimated future sediment delivery (yd^3)	Hydrologically connected road length (ft)		Comment on Problem	Comment on treatment
					Left	Right		
89	8N08	M	SC	84	30	250	A fill crossing on a Class III stream. An outboard down drain was installed on the outboard edge of fill but has been undermined by the stream and is no longer functioning. A headcut has apparently migrated up to the outboard down drain from below the road fill and caused the fill to erode out from underneath the drain itself. The stream channel upstream of the crossing, as well as the cutbank, are down to bed rock and excavation production rates will be fairly low at this site.	1) Install an armored fill. Establish a broad dip, excavate a keyway (25' long x 10' wide x 4' wide x 2' deep). Armor the keyway with 13 yd^3 of 0.5’-1.5' diameter rock armor. 2) Outslope road and fill ditch for 250' up the right road. 3) Install 2 rolling dips up the right road.
90	8N08	L	SC	143	0	335	A Class III stream at a shallow fill crossing. The creek flows across the road and over the outboard edge of fill, where it flanks a large bedrock knob. Flows are currently running around the right edge of the rock outcrop, which appears to be growing in size due to substantial and rapid accumulation of cementitious mineral deposits. There is evidence of diversion 10' to the left of the crossing where an old and stabilized gully exists. There is active erosion where flows are cutting around the rock. Diversion is still possible to the left, and shallow bedrock in addition to the outcrop will considerably limit excavation for a pipe installation. An armored fill will work here, but it will have to be large and be built in a relatively complex shape in order to adequately convey flows around the flank of the bedrock outcrop.	1) Install an armored fill. Establish a broad dip, excavate a keyway (23' wide x 11' wide x 35' long -2.5' deep) around the left flank of the bedrock outcrop. Armor the keyway using 55 yd^3 of 0.5’-3' diameter rock armor. 2) Install 2 yd^3 of 0.5’-1.5' diameter rock armor at the base of the armored fill to serve as energy dissipation (bedrock will limit keyway toe excavation). 3) Outslope road and remove ditch for 335' up the right road. 4) Install 2 rolling dips on the right road approach
91	8N08	M	RS	149	0	960	An outboard down drain empties 960' of right road that lacks proper shaping and drainage features. An outboard down drain has created a gully below its half-round downspout with steep eroding slopes. This flow delivers to the headwaters of Fish Creek 280' downslope.	1) Outslope road and remove ditch for 960' up the right road. 2) Install 9 rolling dips up the right road.

Table B1. Field observations and treatment recommendations for road related sites, *Manzana Creek Watershed Anthropogenic Sediment Reduction Assessment, Aquatic Protection and Road Restoration Planning Project*, *Los Padres National Forest*, *Santa Barbara County, CA*

Site #	Road Name	TI	Problem	Total estimated future sediment delivery (yd^3)	Hydrologically connected road length (ft)		Comment on Problem	Comment on treatment
					Left	Right		
92	8N08	L	RS	129	930	60	An outboard down drain that has been flanked by flows. A gully has formed on the outboard edge of fill (1' x 0.5' x 50') that is enlarging and moving into the road bed.	1) Outslope road and remove ditch for 930' up the left road. 2) Install 4 rolling dips on the left road.
93	8N08	L	RS	107	0	610	An outboard down drain that drains 610' of right road has been undercut and is no longer functioning. There is a small headcut under the inlet of the drain that may migrate headward, cause the drain to fail, and undermine the road.	1) Outslope road and remove ditch for 610' up the right road. 2) Install 2 rolling dips up the right road.
94	8N08	L	RS	228	0	1060	1040' of road runoff empties over the outboard fillslope and has eroded a gully 5' wide x 2' wide x 3' deep x 40' long, which has extended into the road as a 1x1' gully for 70'. This gully will likely continue its headward migration up the right road over time.	1) Outslope road and remove ditch for 1060' up the right road. 2) Install 5 rolling dips on the right road. 3) Pull back the gully scarp along the outboard edge of fill 8' x 3' x 1'
95	8N08	L	SC	735	0	215	A stream valley has been filled in by sediment from bank erosion that has deposited above the road. There is very little evidence of bed and bank definition upstream of the crossing, but a small developing flow path is present across the road. The flow may be going subsurface due to the large volume of alluvial material that is actively depositing upstream of the road at the crossing. The stream valley will continue to see heavy aggradation, and a culvert inlet would likely plug at this site if installed. An armored fill may provide a better long-term solution	1) Excavate from TOP to the inboard edge of the road and define a 4' wide x 3' deep channel with 2:1 side slopes where feasible. 2) Lower the road through the axis of the crossing by 1'. 3) Install an armored fill. Establish a broad dip through crossing the convey flow, excavate a keyway (27' long x 12' wide x 4' wide x 2' deep) and armor the keyway with 16 yd^3 of 0.5'-1.5' diameter rock armor. 4) Outslope road and fill ditch for 215' up the right road. 5) Install 1 rolling dip up the right road.

Table B1. Field observations and treatment recommendations for road related sites, *Manzana Creek Watershed Anthropogenic Sediment Reduction Assessment, Aquatic Protection and Road Restoration Planning Project*, *Los Padres National Forest*, *Santa Barbara County, CA*

Site #	Road Name	TI	Problem	Total estimated future sediment delivery (yd^3)	Hydrologically connected road length (ft)		Comment on Problem	Comment on treatment
					Left	Right		
96	8N08	L	SC	118	0	280	A culverted crossing on a sizable Class III stream. The pipe is set near the base of fill, and the outlet has become plugged from rock and soil that has collapsed from the outboard edge of fill onto the pipe outlet. There is an aggraded sediment wedge upstream of the inlet indicating that the inlet may have been placed higher than the base of fill.	1) Excavate from TOP to BOT and install a 48" x 50' long corrugated metal pipe at the base of fill. 2) Armor the lower 1/4 of the outboard fill face using 5 yd^3 of 1-3' diameter rock armor. 3) Install 2 yd^3 of 0.5’-1.5' diameter rock armor at the outlet of the new pipe to serve as energy dissipation. 4) Outslope road and remove ditch for 280' up the right road. 5) Install 1 rolling dip up the right road. 6) Install a critical dip on the left hinge of the crossing.

Table B1. Field observations and treatment recommendations for road related sites, *Manzana Creek Watershed Anthropogenic Sediment Reduction Assessment, Aquatic Protection and Road Restoration Planning Project*, *Los Padres National Forest*, *Santa Barbara County, CA*

Site #	Road Name	TI	Problem	Total estimated future sediment delivery (yd^3)	Hydrologically connected road length (ft)		Comment on Problem	Comment on treatment
					Left	Right		
97	8N08	M	SC	119	45	60	Two Class III streams converge at the head of an alluvial fan and cross the road at a low point, where an outboard down drain is located. Below the outboard down drain there is an old headcut and gully that delivers to Fish Creek. The gully is down to bedrock but the headcut will continue to migrate up the outboard edge of fill and undercut the outboard down drain. Upon rebuild, move the axis of the stream 15' to the right and pull back the outboard edge of the road. The stream channel should also be defined through the alluvial fan.	1) Pull back the berm along the outboard edge of road (10' wide x 25' long x 2' deep) (19 yd^3). 2) Lower the road through the axis of the crossing by 1'. 3) Excavate a channel from TOP 1 and TOP 2 to the inboard edge of the road with a 4' wide channel bottom and 2:1 side slopes where feasible. 4) Install an armored fill. Establish a broad dip through the crossing to convey flow, excavate a keyway (25' long x 16' wide x 6' wide x 2' deep) and armor the keyway with 20 yd^3 of 0.5’-1.5' diameter rock armor. 5) Pull back the banks 2:1 below the outboard down drain.
98	8N08	L	RS	151	0	910	An outboard down drain has been placed low on the outboard fillslope, causing a gully to form on the road. The gully is currently 2' wide x 1' deep x 10' long, tapering down to a 1x1' gully for 60' as it continues down slope to a Class III stream below the road.	1) Outslope the road and remove ditch for 910' up the right road. 2) Install 4 rolling dips up the right road. 3) Remove the outboard down drain and grade the outboard fill slope to a flat surface to prevent further failure.

Table B1. Field observations and treatment recommendations for road related sites, *Manzana Creek Watershed Anthropogenic Sediment Reduction Assessment, Aquatic Protection and Road Restoration Planning Project*, *Los Padres National Forest*, *Santa Barbara County, CA*

Site #	Road Name	TI	Problem	Total estimated future sediment delivery (yd^3)	Hydrologically connected road length (ft)		Comment on Problem	Comment on treatment
					Left	Right		
99	Zaca Ridge	L	RS	258	880	0	An outboard down drain evacuates 880' of concentrated road runoff over the outboard fill slope and into a headwall swale of a tributary to Manzana Creek. A large gully has formed below the outlet (3' wide x 6' wide x 5' deep x 200' long) but extends out of sight down the densely vegetated slope. A Class III stream is visible on imagery approximately 700' downslope of the road, and this large gully likely delivers to this headwater stream. A rill has developed on the left road and extends 260' up the road.	1) Outslope road and remove ditch for 880' up the left road. 2) Install 4 rolling dips up the left road. 3) Pull back the gully scarp at the outboard edge of the road 8' x 4' x 1' to prevent further erosion after treatment.
100	Sunset Valley Trail	-	SC	16	340	12	Davy Brown Trail crosses this Active Class I stream as a ford crossing. There is cementitious mineral deposition occurring throughout the crossing, which appears to be very similar to concrete. This material is locking the bedload in place and effectively armoring the crossing. There are also 2.5-3' diameter boulders in the stream channel below the trail as well. There is an old steel water tank located on the right trail approach at the upstream extent of Davy Brown campground. Fish (salmonids) were observed at this site as well.	No treatment recommendation.
101	Davy Brown Trail	H	SC	19	65	700	An Arizona style ford crossing on Davy Brown creek. The crossing has been constructed by the installation of an 18" thick concrete apron that spans the channel. The stream gradient is artificially controlled by a series of check dams over 100' upstream. The existing concrete apron is stable but needs downstream grade control to remain stable. The right road includes Davy Brown campground and the left road includes the trail to the gate located 30' away from the channel. This structure is a fish barrier.	No site specific treatment recommendation as it will be treated by third party. However, based on final approved deigns, disconnect campground road and site drainage by third contributing to the site as much as possible.

Table B1. Field observations and treatment recommendations for road related sites, *Manzana Creek Watershed Anthropogenic Sediment Reduction Assessment, Aquatic Protection and Road Restoration Planning Project, Los Padres National Forest, Santa Barbara County, CA*

Site #	Road Name	TI	Problem	Total estimated future sediment delivery (yd^3)	Hydrologically connected road length (ft)		Comment on Problem	Comment on treatment
					Left	Right		
102	Davy Brown Trail	HM	BE	156	0	0	A broad reach of the stream is bifurcated below the channel at this location. The channel debris and vegetation have directed the majority of the flow along the right channel which has eroded a 20' section of trail. There is a large boulder exposed above the remaining trail fill. The trail traverses the right bank of the Class II for approximately 40' before leaving the riparian area. The future erosion at this site will occur as the remaining trail segment fails by bank erosion into the Class II stream. The right channel appears to have been cemented in the past, but only remnants remain. The bifurcation should be fixed, and a new channel should be defined.	1) Reroute the trail above the right bank for 200'.
103	Davy Brown Trail	L	SC	1	0	12	A small near-origin Class III stream flows down a fan upslope of the trail. The trail crosses along the left flank of the fan deposit with no observable fill prism. The stream has flowed along the right flank of the fan in the past, but there is no active erosion outside of the path. The stream fans out onto bedrock with no discernable channel definition above the right bank of Class III stream below the trail.	1) Install a 20' wide rolling dip with a broad axis at least 10' wide through the trail at the site of the alluvial fan to capture flow from the fan, 2) Rock the trail through the dip using 2.5 yd^3 of 0.5' - rock armor.
104	Davy Brown Trail	M	BE	15	20	0	BE along a streamside reach of the Davy Brown Trail. A debris jam within the creek has forced flows into the right bank where the trail is located. The trail is narrow here and likely to fail due to the natural processes of the stream. There is a small (< 1 yd^3) road surface discharge point 50' down the right road.	1) Reroute 300' of the trail 30-40' upslope on the right to prevent further erosion of the trail.

Table B1. Field observations and treatment recommendations for road related sites, *Manzana Creek Watershed Anthropogenic Sediment Reduction Assessment, Aquatic Protection and Road Restoration Planning Project*, *Los Padres National Forest*, *Santa Barbara County, CA*

Site #	Road Name	TI	Problem	Total estimated future sediment delivery (yd³)	Hydrologically connected road length (ft)		Comment on Problem	Comment on treatment
					Left	Right		
105	Davy Brown Trail	-	SC	5	0	13	A ford crossing through a broad, flashy, Class II section of Davy Brown creek. There is a concrete-like cementation of the instream substrate through the entire channel reach for hundreds of feet. There is a stable rocky cascade at the downstream extent of the crossing. Active erosion is occurring on the right bank upstream of the crossing on the native hillslope. There is minor erosion of the outboard fill on the right trail approach, with a total past erosion of approximately 1 yd³.	No treatment recommendation.
106	Davy Brown Trail	HM	BE	31	35	0	A section of actively eroding outboard fill just above a Class II stream (Davy Brown creek). Stream flow appears to be very flashy. The trail can be rerouted upslope to prevent future erosion and delivery via the trail bed.	1) Reroute the trail 50' feet upslope for 100'. 2) Define a 4' wide foot path with a 5% outslope. 3) Lay back the bank failure scarp to 2:1 for 90' wide x 12' long x 1.25' deep. 4) Store spoils locally to left and right to enhance drainage and prevent future erosion.
107	Davy Brown Trail	M	SC	94	0	0	A Small Class III stream exists a 5' drop from boulders onto a sediment fan above the trail. Some flow is splitting off and flowing over the left side of the fan, while the majority is flowing down the center of the fan and across the trail. The trail is 17' upslope from Mainstem Davy Brown Creek.	1) Capture the channel at the TOP and direct into the preferred channel alignment in the center of the fan. 2) Install an armored fill. Establish a broad dip. Excavate a keyway 6' wide x 4' wide 8' long x 2' deep. 3) Armor the keyway using 3 yd³ of 0.5'-1.0' diameter rock armor. Spoil locally.

Table B1. Field observations and treatment recommendations for road related sites, *Manzana Creek Watershed Anthropogenic Sediment Reduction Assessment, Aquatic Protection and Road Restoration Planning Project*, *Los Padres National Forest*, *Santa Barbara County, CA*

Site #	Road Name	TI	Problem	Total estimated future sediment delivery (yd^3)	Hydrologically connected road length (ft)		Comment on Problem	Comment on treatment
					Left	Right		
108	Davy Brown Trail	L	SC	9	42	0	A ford crossing through Class I Davy Brown. The crossing is stable and rocky with minimal road-based sediment delivery. During high flows the stream occupies a bench along the right bank and flows are split below the crossing. There is a small lobe of sediment with potential future delivery on the road approach. BE extends to a bedrock pool 90' upstream of the ford crossing. There were several trout observed in the pool, some of which were up to 8". 6 other fish were observed to be 3-8" long.	1) Lay back the outboard fill on the right road approach for 100' and reestablish a 3' wide trail 10' upslope. Excavation volume will be $14yd^3$.
109	Davy Brown Trail	L	SC	2	260	71	A very small near-origin Class III stream with little to no active erosion through the crossing. The trail runs through the crossing with a small fill prism in the channel. Stream flow fans out below the crossing and does not deliver sediment at this time. The outboard edge of fill vegetated with grasses and vetch. There is no erosion occurring.	1) Install an armored fill. Establish a broad dip. Excavate a keyway 12' wide x 6' wide x 8' long x 2' deep. 2) Armor the keyway using 6 yd^3 of 0.5'-1.0' diameter rock armor. 3) Install 2 rolling dips up the left road.
110	Davy Brown Trail	-	SC	1	115	25	A stable ford crossing on Davy Brown Trail over Class I Davy Brown creek. The only potential for delivery is coming from the left road approach.	No treatment recommendation.
111	Davy Brown Trail	L	SC	3	0	400	A small near-origin Class III stream flows across the trail with no formal drainage structure. There is very minimal active erosion at this site. The stream flow is partially diverted down the left road for 30' before it delivers to Class I Davy Brown. The fill is very rocky and local rock can be used for the armored fill proposed in treatment.	1) Install an armored fill. Establish a broad dip. Excavate a keyway 10' wide x 5' wide x 10' long x 2' deep. 2) Armor the keyway using 6 yd^3 of 0.5'-1.5' diameter rock armor. 3) Install 3 rolling dips up the right road.
112	Sunset Valley Road	L	BE	3	0	0	A past fill slope failure along the steep outboard fill slope above Davy Brown creek. Slope is natural, but steep and the road is near full bench at this location. A small scarp remains to fails.	1) Pull back remaining scarp 27' wide x 5' long x 0.5' deep (3 yd^3). 2) Spoil on turnout 20' up the left road approach.

Table B1. Field observations and treatment recommendations for road related sites, *Manzana Creek Watershed Anthropogenic Sediment Reduction Assessment, Aquatic Protection and Road Restoration Planning Project, Los Padres National Forest, Santa Barbara County, CA*

Site #	Road Name	TI	Problem	Total estimated future sediment delivery (yd^3)	Hydrologically connected road length (ft)		Comment on Problem	Comment on treatment
					Left	Right		
113	8N09	M	SC	738	720	0	A very steep, rocky Class III stream, and inboard ditch flow are conveyed under the road via a 24" corrugated metal pipe with a 60' full round downspout attached. The downspout has a 2'-3' drop onto bedrock and is approximately 45' from Class I Davy Brown Creek. The left road inboard ditch is filled due to the erosive cutbank above. Maintenance may be required to keep the ditch clear.	1) Clean and cut the inboard ditch for 720' up the left road approach. 2) Cut pavement prior to installation of ditch relief culverts. Trench vertically and install a new 18" x 40' long ditch relief culvert up the left road. Place slurry around pipe and backfill trench with native fill. Cap with base aggregate to prepare for repaving. 3) Add a 24" x 40' full round downspout to the current downspout at the crossing. The pipe will need to be lowered to laborers with equipment.
114	8N09	L	SC	330	250	0	A culverted crossing on paved Sunset Valley Road. The natural hillslope angle is steep (40% +) and the pipe has been placed high and short in the fill with a 40' downspout that has been partially buried by scree. There is minimal erosion below the outlet despite the 100' of open swale between the outlet and Davy Brown creek. The concrete inlet wall has been cracked, and scree is building in the channel upstream of the inlet. Plug potential is high, but the culvert appears to be functioning property.	1) Replace the concrete wall at the inlet with 2yd^3 of 0.5’-1.0' diameter rock armor. 2) Cut pavement prior to installation of ditch relief culverts. Trench vertically and install a new 18" x 40' long ditch relief culvert with an 80' downspout, 125' up the left road. Place slurry around pipe and backfill trench with native fill. Cap with base aggregate to prepare for repaving. 3) Clean/cut the ditch along the inboard edge of the left road for 250'. 4) Re pave the disturbed road area.

Table B1. Field observations and treatment recommendations for road related sites, *Manzana Creek Watershed Anthropogenic Sediment Reduction Assessment*, *Aquatic Protection and Road Restoration Planning Project*, *Los Padres National Forest*, *Santa Barbara County, CA*

Site #	Road Name	TI	Problem	Total estimated future sediment delivery (yd^3)	Hydrologically connected road length (ft)		Comment on Problem	Comment on treatment
					Left	Right		
115	8N09	M	SC	567	740	0	A steep Class III stream and inboard ditch runoff are conveyed under the road via an 18" corrugated metal pipe with a 33' downspout that has an 8' drop at the outlet, creating erosion below. The stream then flows through Davy Brown campground and down to Davy Brown Creek	1) Clean and cut the ditch for 740' up the left road approach. 2) Cut pavement prior to installation of ditch relief culverts. Trench vertically and install a new 18" x 40' long ditch relief culvert with a 40' long downspout, up the left road. Place slurry around pipe and backfill trench with native fill. Cap with base aggregate to prepare for repaving. 3) Install 2 yd^3 of 0.5'-1.5' diameter rock armor below the main culvert outlet as energy dissipation.
116	Sunset Valley Road	L	RS	79	0	800	An outboard down drain has been placed low in the inboard ditch, causing the upstream ditch to adjust to the drain grade. As a result, a small gully has formed in the upstream ditch. A secondary gully has formed on the downstream end of the drain where the outlet has a 3' drop. This will likely migrate headward and cause the drain to fail. Future erosion will be from combined headward migration of both gully headcuts. A rocked swale would be a better long term solution at this site.	1) Remove the outboard down drain and define a 90' long swale (1' deep x 2' wide x 90' long) (7 yd^3). 2) Armor the swale/ditch from the current outlet for 90' up the right road inboard ditch using 15 yd^3 of 0.5'-1' diameter rock armor. 3) Clean/cut the ditch for 430' up the right road approach.

Table B1. Field observations and treatment recommendations for road related sites, *Manzana Creek Watershed Anthropogenic Sediment Reduction Assessment, Aquatic Protection and Road Restoration Planning Project*, *Los Padres National Forest*, *Santa Barbara County, CA*

Site #	Road Name	TI	Problem	Total estimated future sediment delivery (yd³)	Hydrologically connected road length (ft)		Comment on Problem	Comment on treatment
					Left	Right		
117	8N09	L	SC	47	320	0	An 18" corrugated metal pipe conveys a very small Class III stream under the road. The stream meanders through a grassy swale. There is a minor 1' headcut above the culvert inlet. Rock has been placed below the outlet for energy dispersion but should have additional armor added. The pipe is set at a low gradient but seems to convey flow and sediment. The downstream stream has large rocks (2') that are causing some stair stepping within the channel. They lack smaller rocks to fill the interspatial area and are being flanked. The banks are over steepened and should be laid back. The upstream swale/valley is a good spot for a sediment basin (24' long x 16' wide).	1) Install a sediment basin above the TOP, 24' wide x 16' long with 2:1 slopes (14 yd³). 2) Install 2 yd³ of 0.5'-1.5’ diameter rock from the sediment basin to the inlet. 3) Install 1 yd³ of 0.5'-1.5’ diameter rock armor to the outlet for energy dispersion. 4) Establish a 3' wide channel bottom, 60' long with 2:1 side slopes from the outlet to the BOT (160 yd³). 5) Take spoils to site 118 for road building.

Table B1. Field observations and treatment recommendations for road related sites, *Manzana Creek Watershed Anthropogenic Sediment Reduction Assessment, Aquatic Protection and Road Restoration Planning Project, Los Padres National Forest, Santa Barbara County, CA*

Site #	Road Name	TI	Problem	Total estimated future sediment delivery (yd^3)	Hydrologically connected road length (ft)		Comment on Problem	Comment on treatment
					Left	Right		
118	Sunset Valley Road	L	SC	47	450	110	A culverted crossing on a Class II stream. The pipe is old, rusted out and possibly undersized. Flows from concentrated road runoff along the dirt road to the left of the crossing, pond on the paved road before breaching the berm above the culvert and eroding the outboard fill slope. The banks above the culvert are vertical and raw. The road through the crossing axis could be lifted 0.5' on rebuild to prevent ponding/sediment delivery from road	1) Cut pavement prior to installation of culvert. Trench vertical and install new 84" x 50' long corrugated metal pipe at the base of fill. Place slurry around pipe and backfill trench with native fill. Cap with base aggregate to prepare for repaving. 2) Raise the road 5' upon rebuild and breach the berm to the left of the crossing to prevent ponding and erosion of the outboard fill slope. 3) Outslope the road and fill the ditch on the dirt road to the left of the crossing for 330'. 4) Install 3 rolling dips on the dirt road to the left of the crossing. 5) Layback the upstream banks to 2:1 for 30'. 6) Armor the inboard fill slope and outboard fill slope around the inlet and outlet with 10 yd^3 of 0.5'-1.5' diameter rock armor. 7) Repave the disturbed road.

Table B1. Field observations and treatment recommendations for road related sites, *Manzana Creek Watershed Anthropogenic Sediment Reduction Assessment, Aquatic Protection and Road Restoration Planning Project*, *Los Padres National Forest*, *Santa Barbara County, CA*

Site #	Road Name	TI	Problem	Total estimated future sediment delivery (yd³)	Hydrologically connected road length (ft)		Comment on Problem	Comment on treatment
					Left	Right		
119	8N09	H	SC	91	0	590	A Class III stream is conveyed under the road via an 18" diameter corrugated metal pipe. The pipe has plugged and is now being flanked by the stream. The inboard fillslope has begun to erode collapse. This erosion will continue and compromise the road. Flow may now be traveling under the pipe and in the fill around the pipe since it has plugged. Tree roots in the fill are slowing the erosion but will not prevent eventual failure. The pipe is not properly aligned and has started to erode the right bank downstream. The pipe will be realigned upon rebuild.	1) Cut pavement prior to installation of all culverts. Trench vertically and install new 48" diameter x 60’ long corrugated metal pipe 8' to the left of the current alignment and set at the base of fill. Place slurry around pipe and backfill trench with native material. Cap with base aggregate to prepare for repaving. 2) Trench vertically and install a 24" diameter x 40’ long overflow culvert on the left hinge of the crossing. Backfill the trench with native fill and cap with base aggregate to prepare for repaving. 3) Repave the road at the disturbed areas of the crossing. 3) Armor the inboard fillslope using 2 yd^3 of 0.5’-1.5' diameter rock armor. 4) Install 1 yd^3 of 0.5’-1.5' diameter rock armor below the outlet along the right bank for energy dissipation. 5) Remove large woody debris from the upstream channel.

Table B1. Field observations and treatment recommendations for road related sites, *Manzana Creek Watershed Anthropogenic Sediment Reduction Assessment, Aquatic Protection and Road Restoration Planning Project*, *Los Padres National Forest*, *Santa Barbara County, CA*

Site #	Road Name	TI	Problem	Total estimated future sediment delivery (yd^3)	Hydrologically connected road length (ft)		Comment on Problem	Comment on treatment
					Left	Right		
120	Sunset Valley Road	L	SC	56	0	150	A culverted crossing at a small near origin Class III stream with a 24" aluminum culvert. There is a nick point 5' upstream of the inlet that is actively eroding. Future headward migration could generate more sediment that could deliver to nearby Class I Davy Brown Creek.	1) Install a 1 yd^3 grade control structure at the headcut 5' upstream of the inlet and armor with 0.5'-1’ diameter rock armor. 2) Trench vertically and install an 18" diameter x 40’ long overflow culvert on the left hinge of the crossing. Backfill the trench with native fill and cap with base aggregate to prepare for repaving. 3) Install 1 yd^3 of 0.5’-1.0’ diameter rock armor below the outlet as energy dissipation.

121	8N09	L	SC	626	0	510	An 18" corrugated metal pipe with an armored inboard fill slope conveys flow from a Class III stream, an adjacent swale, and road runoff under the road to Davy Brown Creek (Class I). The pipe is undersized and is 50% plugged. The culvert outlet is low in the fill and outlets onto shallow bedrock 15' from the confluence with Davy Brown creek. Armor installation at the outlet will require labor due to the long fill slope.	1) Cut pavement prior to installation of culvert. Trench vertically and install new 30" diameter x 90’ long corrugated metal pipe at the base of fill. Place slurry around pipe and backfill trench with native fill. Cap with base aggregate to prepare for repaving. 2) Trench vertically and install an 18" diameter x 40’ long overflow culvert on the left hinge of the crossing. Backfill the trench with native fill and cap with base aggregate to prepare for repaving. 3) Define a 2' channel with 2:1 side slopes for 45' from the inlet to the right of the crossing to capture swale flow from upstream. 4) Install a rocked keyway at the right ditch outlet using 7 yd^3 of 0.5'-1.0' diameter rock armor. 5) Cut pavement prior to installation of ditch relief culverts. Trench vertically and install a new 18" x 60' long ditch relief culvert, 220' up the left road and attach a 40' long downspout to the ditch relief culvert with a 10 degree elbow. Place slurry around pipe and backfill trench with native fill. Cap with base aggregate to prepare for repaving. 6) Construct an outboard berm for 180' on the right road. 7) Armor the lower 3/4 of the outboard fillslope using 14yd^3 of 0.5'-1.5' diameter rock armor.

Table B1. Field observations and treatment recommendations for road related sites, *Manzana Creek Watershed Anthropogenic Sediment Reduction Assessment, Aquatic Protection and Road Restoration Planning Project*, *Los Padres National Forest*, *Santa Barbara County, CA*

Site #	Road Name	TI	Problem	Total estimated future sediment delivery (yd^3)	Hydrologically connected road length (ft)		Comment on Problem	Comment on treatment
					Left	Right		
122	Sunset Valley Road	L	SC	235	0	610	A culverted crossing on a steep Class III stream along a steep hillslope above Davy Brown Creek. The culvert is functioning but should be cleared. The upstream reach is a steep bedrock channel. Scree from road runoff and cutbank erosion is plugging the CMP. There is no erosion below the downspout, which outlets 20' from Davy Brown Creek. There is a rip rap wall along the base of fill, right of the crossing from a past project.	1) Clean the culvert inlet and cut the ditch up the right road approach for 610'. 2) Cut pavement prior to installation of ditch relief culverts. Trench vertically and install a new 18" x 40' long ditch relief culvert, 110' up the right road. Place slurry around pipe and backfill trench with native fill. Cap with base aggregate to prepare for repaving. 3) Trench vertically and install an 18" diameter x 40’ long overflow culvert on the left hinge of the crossing. Install an 18" diameter x 50’ long downspout on the overflow culvert. Backfill the trench with native fill and cap with base aggregate to prepare for repaving. 4) Install 1 yd^3 of rock armor at the main culvert outlet for energy dissipation using 0.5'-1’ diameter rock armor. 5) Repave the road surface.

Table B1. Field observations and treatment recommendations for road related sites, *Manzana Creek Watershed Anthropogenic Sediment Reduction Assessment, Aquatic Protection and Road Restoration Planning Project*, *Los Padres National Forest*, *Santa Barbara County, CA*

Site #	Road Name	TI	Problem	Total estimated future sediment delivery (yd³)	Hydrologically connected road length (ft)		Comment on Problem	Comment on treatment
					Left	Right		
123	8N09	L	SC	442	130	1050	An 18" corrugated metal pipe with a cement inlet wall conveys Class III stream and inboard ditch flow under the road. The pipe inlet and outlet are open, and the pipe is set near the base of fill. There is also an energy dissipation structure below the outlet. The pipe may be undersized and there is some erosion occurring on either side of the small cement wall at the inlet.	1) Cut pavement prior to installation of culvert. Trench vertically and install new 24" diameter x 70’ long corrugated metal pipe at the base of fill. Place slurry around pipe and backfill trench with native fill. Cap with base aggregate to prepare for repaving. 2) Armor the inboard fillslope using 1 yd³ of 0.5’-1.0' diameter rock armor. 3) Install a sediment basin on the right hinge 8' wide x 8' long x 2' deep (5 yd³). 4) Clean and cut the ditch up the right road for 1050'. 5) Clean and cut the ditch for 130' up the left road. 6) Cut pavement prior to installation of ditch relief culverts. Trench vertically and install two new 18" x 30' long ditch relief culverts, up the right road. Place slurry around pipe and backfill trench with native fill. Cap with base aggregate to prepare for repaving. 7) Rock the inboard ditch for 20' up the left and right approaches using 7 yd³ of 0.5’-1.0' diameter rock. 8) Armor the outboard fill face using 20 yd³ of 1-2' diameter rock armor.

Table B1. Field observations and treatment recommendations for road related sites, *Manzana Creek Watershed Anthropogenic Sediment Reduction Assessment, Aquatic Protection and Road Restoration Planning Project*, *Los Padres National Forest*, *Santa Barbara County, CA*

Site #	Road Name	TI	Problem	Total estimated future sediment delivery (yd^3)	Hydrologically connected road length (ft)		Comment on Problem	Comment on treatment
					Left	Right		
124	Sunset Valley Road	L	SC	197	320	0	A culverted crossing at a steep Class III stream. There is no erosion but plugging has occurred due to scree from the cutbanks. The culvert outlet dumps flow onto stable bedrock and flow is conveyed onto a flat floodplain bench 20' from Davy Brown Creek.	1) Clean out the culvert inlet. 2) Cut a ditch for 320' up the left road approach. 3) Cut pavement prior to installation of ditch relief culverts. Trench vertically and install a new 18" x 50 long ditch relief culvert with a 50' long downspout, up the left road. Place slurry around pipe and backfill trench with native fill. Cap with base aggregate to prepare for repaving. 4) Install 1 yd^3 of 0.5'-1’ diameter rock armor at the culvert outlet as energy dissipation. 5) Pull back the outboard fill slope 25' wide x 18' long x 1' deep (17yd^3). 6) Construct a new berm along the outboard road 5' wide x 1' wide x 40' long (8yd^3).
125	Sunset Valley Road	-	SC	9	420	63	This ford crossing has been identified as a fish crossing barrier by CDFW and has been slated for treatments. The concrete pad through this Arizona Ford crossing is stable but there are several small drops below the outboard road that have potential to move headward, cause failure of the concrete pad and continue to pose a barrier to salmonids. There is a subtle, but functional rolling dip on the left road, but the right road approach has little formal drainage structure for 420' and there is sediment in transport along the inboard road.	No treatment recommendation. This site is being treated by a third party.

Table B1. Field observations and treatment recommendations for road related sites, *Manzana Creek Watershed Anthropogenic Sediment Reduction Assessment, Aquatic Protection and Road Restoration Planning Project*, *Los Padres National Forest*, *Santa Barbara County, CA*

Site #	Road Name	TI	Problem	Total estimated future sediment delivery (yd^3)	Hydrologically connected road length (ft)		Comment on Problem	Comment on treatment
					Left	Right		
126	Sunset Valley Road	ML	SC	240	0	337	An at origin Class III stream is conveyed through an 18" corrugated metal pipe with a 10' downspout. There is a scarp from a past failure on the outboard fill slope to the left of the crossing. A perched lobe of failed material has come to rest on the outboard fill slope just below the outlet. The berm along the outboard fill slope has been breached in several locations and road runoff has caused several small failures along the left road. The culvert inlet is partially plugged with sediment, but the interior and outlet are open. Cutbank sluff is actively being transported to the crossing on the inboard road of the right road approach.	1) Add an 18" diameter x 40' long full round downspout to the culvert outlet. 2) Clean/cut the ditch for 337' up the right road approach. 3) Cut the pavement prior to the installation of ditch relief culverts. Trench vertically and install 1 18" diameter x 40' long ditch relief culvert 180' up the right road approach at a small swale. Place slurry around the pipe and backfill with native material. Can the trench with base aggregate and prepare for repaving. 4) Repave the road at the disturbed area. 5) Pull back the outboard fill slope for 340' (340' x 3' x 1') 6) Pave a new berm (340' x 1') along the outboard fill slope from the swale up the right road approach, down to the end of site, 165' down the left road approach. 7) Clean the culvert inlet. 8) Spoil in the flat area, 200' north of Davy Brown Campground along the main road.

Table B1. Field observations and treatment recommendations for road related sites, *Manzana Creek Watershed Anthropogenic Sediment Reduction Assessment, Aquatic Protection and Road Restoration Planning Project, Los Padres National Forest*, *Santa Barbara County, CA*

Site #	Road Name	TI	Problem	Total estimated future sediment delivery (yd^3)	Hydrologically connected road length (ft)		Comment on Problem	Comment on treatment
					Left	Right		
127	8N09	HM	LS	180	0	832	A section of the outboard fill slope/hillslope has failed directly into Davy Brown Creek at the base of the hillslope below the road. The road bench appears to be a full cut bench or nearly full bench. The failing material is a cobble dominated conglomerate with rounded cobbles. The two past failures with a 16 yd^3 block of native hillslope material remaining in center of overall feature. There is a small swale above the right hinge of the site with stored spoils at the base of the inboard fill slope. The majority of the road draining currently bypasses this site. Road drainage should not be directed to this area.	1) Excavate perched material along the crown scarp along the outboard fill slope 125' wide x 10' long x 1.5' deep (70 yd^3). 2) Store spoils down the right road approach. 3) Cut pavement prior to installation of all ditch relief culverts. Trench vertically and install 4 ditch relief culverts. Install 3 18" diameter x 20' long ditch relief culverts, and 2 18" diameter x 40' long downspouts (1 per ditch relief culvert), up the right road approach. Install 1 additional 18" diameter x 20' long ditch relief culvert at the swale on the right hinge of the site and attach an 18" diameter x 40' long downspout with a 20 degree elbow. Place slurry around pipes and backfill trenches with native fill. Cap with base aggregate to prepare for repaving. 4) Clean the cutbank through the turn and outboard fill slope slide area.

Table B1. Field observations and treatment recommendations for road related sites, *Manzana Creek Watershed Anthropogenic Sediment Reduction Assessment, Aquatic Protection and Road Restoration Planning Project*, *Los Padres National Forest*, *Santa Barbara County, CA*

Site #	Road Name	TI	Problem	Total estimated future sediment delivery (yd^3)	Hydrologically connected road length (ft)		Comment on Problem	Comment on treatment
					Left	Right		
128	Sunset Valley Road	L	LS	47	0	180	A failure along the outboard fill slope of Sunset Valley Road. The shallow fill has failed down to conglomerate 6' below the road on the outboard fill slope. Material from the failure comes to rest on the small floodplain terrace at the base of the hillslope and could be transported into the stream during high flows. There is evidence of high flows overtopping the banks and occupying the floodplain terrace. The road is at risk of failure for 40' through the failure and could be buttressed with a steep, rocked outboard fill slope stretch.	1) Pull back the outboard fill slope (120' x 8' x 1.5') (160 yd^3). 2) Armor the outboard fill slope from the road down the slope for 18' (120' wide x 18' long x 2' deep) with 160 yd^3 of 1'-3' diameter rock armor. 3) Clean and cut the ditch for 180' up the right road and install a ditch relief culvert 10' down the left road from the scarp at a rocky swale. 4) Cut pavement prior to installation of ditch relief culvert. Trench vertically and install new 18" diameter x 40' long ditch relief culvert. Attach an 18" diameter x 50' long downspout to the ditch relief culvert. Place slurry around pipe and backfill trench with native fill. Cap with base aggregate to prepare for repaving. 5) Repave the road at the disturbed area.
129	8N09	M	LS	82	0	0	A past hillslope outboard fill slope failure with remaining future erosion. The remaining failure will deliver to the flood plane along the left bank of Davy Brown Creek. There is stored sediment visible below the past failure. There is a cobble dominated conglomerate exposed in the native hillslope above and below the road. Future erosion volumes will potentially deliver to Class I Davy Brown Creek at the base of slope.	1) Excavate perched fill (70' wide x 6' long x 1.5' deep) (23 yd^3). 2) Excavate perched material on the left edge of the outboard fill slope (15' wide x 20' long x 2' deep) (22 yd^3). 3) Clean the inboard ditch/ cutbank to maintain drainage through the site.

Table B1. Field observations and treatment recommendations for road related sites, *Manzana Creek Watershed Anthropogenic Sediment Reduction Assessment, Aquatic Protection and Road Restoration Planning Project*, *Los Padres National Forest*, *Santa Barbara County, CA*

Site #	Road Name	TI	Problem	Total estimated future sediment delivery (yd^3)	Hydrologically connected road length (ft)		Comment on Problem	Comment on treatment
					Left	Right		
130	Sunset Valley Road	-	SC	361	404	550	Class I Davy Brown Creek crosses an Arizona Ford Crossing at this site. Both the left and right road approaches deliver to this crossing, as does 30' of Manzana Creek. During high flows, the creek bifurcates and plunges off the right hinge of the crossing. This crossing likely presents a barrier to anadromous fish and has been identified by CDFW and prescribed treatments for passage. The concrete apron has been set high and caused aggradation of small, bedload for approximately 100' upstream. A 50' x 150' parking lot conveys runoff and sediment to crossing via the right road approach.	No treatment recommendation. This site is being treated by a third party.

Table B1. Field observations and treatment recommendations for road related sites, *Manzana Creek Watershed Anthropogenic Sediment Reduction Assessment, Aquatic Protection and Road Restoration Planning Project, Los Padres National Forest, Santa Barbara County, CA*

Site #	Road Name	TI	Problem	Total estimated future sediment delivery (yd^3)	Hydrologically connected road length (ft)		Comment on Problem	Comment on treatment
					Left	Right		
131	8N09	ML	RS	49	64	551	A steel outboard down drain conveys concentrated road run off down the outboard fill slope. The drain conveys road outflow but outlets about 5' short of the base of fill. There are stakes below the outlet which may have previously supported an additional length of drain to convey flow past the base of fill. The drain is plugged with rock at the outlet and the seal at the paved road is failing. Active erosion is minimal but will likely increase due to plugged outlet and paved seal failure. This drain delivers sediment and flow to the left bank of Manzana Creek below the road.	1) Install a new outboard down drain with an 18" x 40' corrugated metal pipe. 2) Add a T-outlet to disperse energy at the outlet. 3) Construct a berm with concrete/asphalt at the outboard fill slope to convey road runoff to the new 18" down drain. 4) Cut pavement prior to installation of all ditch relief culverts. Trench vertically and install new 24" diameter x 30' long ditch relief culvert. Attach a 24" diameter x 40' long downspout to the ditch relief culvert using a 20 degree elbow. Place slurry around pipe and backfill trench with native fill. Cap with base aggregate to prepare for repaving. 5) Repave the road at the disturbed area. 6) Install 1 yd^3 of 0.5'-1.5' diameter rock armor below the outlet of the ditch relief culvert for energy dissipation.

Table B1. Field observations and treatment recommendations for road related sites, *Manzana Creek Watershed Anthropogenic Sediment Reduction Assessment, Aquatic Protection and Road Restoration Planning Project, Los Padres National Forest, Santa Barbara County, CA*

Site #	Road Name	TI	Problem	Total estimated future sediment delivery (yd^3)	Hydrologically connected road length (ft)		Comment on Problem	Comment on treatment
					Left	Right		
132	8N09	M	SC	105	418	0	A Class III stream flows out of a confined stream valley onto an alluvial fan above 8N09 road at the entrance to Nira campground. The stream is currently diverted to the right and fans out into the parking area at Nira campground. Approximately 100' down the right road. There is a bench directly below the paved road which the channel will have to be defined through in order to convey flows to Manzana Creek.	1) Cut pavement prior to installation of culvert. Trench vertically and install a new 24" diameter x 50' long corrugated metal pipe at the base of fill. Place slurry around the pipe and backfill with native material. Cap the trench with base aggregate to prepare for repaving. 2) Repave the road at the disturbed area of the crossing. 3) Define a 4' wide channel bottom with 2:1 side slopes through the lower road prism to convey stream flow to Manzana Creek and prevent erosion. 4) Cut the pavement prior to installation of ditch relief culvert. Trench vertically and install an 18" diameter x 30' long ditch relief culvert up the left road with an 18" diameter x 40' long downspout and elbow. Place slurry around the pipe and backfill with native material. Cap the trench with base aggregate to prepare for repaving. 5) Repave the disturbed area.

Table B1. Field observations and treatment recommendations for road related sites, *Manzana Creek Watershed Anthropogenic Sediment Reduction Assessment, Aquatic Protection and Road Restoration Planning Project, Los Padres National Forest*, *Santa Barbara County, CA*

Site #	Road Name	TI	Problem	Total estimated future sediment delivery (yd³)	Hydrologically connected road length (ft)		Comment on Problem	Comment on treatment
					Left	Right		
133	Private Road	HM	SC	835	13	3090	A flashy, seasonal Class II stream is conveyed through this crossing via 2, 12" diameter cement culverts. The majority of the flow bypasses the inlets and avulses to a channel along the left hinge of the crossing. The two channels combine approximately 10' downstream. These two culverts are drastically undersized and appear to overtop on a regular basis. The road has been recently graded but gullies are present from the right road.	1) Excavate from TOP to BOT and install a new 84" x 50' long corrugated metal pipe at the base of fill. 2) Armor the lower half the inboard fillslope with 5 yd^3 of 0.5'-1.5' diameter rock armor. 3) Install a critical dip on the left hinge of the crossing. 4) Outslope and fill all ditches up the right road approach for 3,063' and up the left road approach for 13'. 5) Install 16 rolling dips up the right road approach. 6) Install a rocked keyway at a rolling dip up the right road at the active spring crossing (3 yd^3 of 0.5'-1.5’ diameter rock armor). 7) Install a single post galvanized trash rack.
134	Catway	H	RS	1132	5353	0	A long 5353' section of bermed native surfaced road evacuates the road prism via a rolling dip this location. Unmanaged road drainage up the left road has resulted in multiple 1x1' gullies throughout the length of the road. A gully has also formed down the outboard edge of fill adjacent to a non-functioning outboard down drain. This 3 x 2.5' gully delivers to a Class III stream in the base of the valley 475' downslope.	1) Outslope road, remove ditch, and pull berm for 1953' up the left road. 2) Install 12 rolling dips up the left road.

Table B1. Field observations and treatment recommendations for road related sites, *Manzana Creek Watershed Anthropogenic Sediment Reduction Assessment, Aquatic Protection and Road Restoration Planning Project*, *Los Padres National Forest*, *Santa Barbara County, CA*

Site #	Road Name	TI	Problem	Total estimated future sediment delivery (yd^3)	Hydrologically connected road length (ft)		Comment on Problem	Comment on treatment
					Left	Right		
135	Catway	M	RS	74	274	0	A confined segment of road conveys flows off the outboard edge of fill adjacent to a remnant down drain that is no longer functioning. A 2' x 1' x 275' gully is actively eroding from the outboard edge of fill down to the Class III stream at the bottom of the valley. There is a moderately functional rolling dip at this location that is forcing flows off the road.	1) Install 2 rolling dips on the left road approach. 2) Outslope road and remove ditch for 274' up the left road.
136	Catway	L	RS	94	0	272	An inboard ditch's flow is conveyed to a lead out and into a long gully that extends several hundred feet down to a Class III stream. The roadbed has a 2'x 0.5' developing gully that extends 272' up the right road. Fine sediment is in active transport through the lead out and into the gully. The gully below the road is 285' long and leads to a class III stream.	1) Outslope road and remove ditch for 272' up the right road. 2) Install 1 rolling dip up the right road.
137	Catway	M	RS	264	0	970	A section of confined road drainage on a dirt road is conveyed off the road surface via a rolling dip. Concentrated runoff is actively gullying 900' down to the headwaters of a Class III stream. There is some bedrock exposed downslope of the dysfunctional outboard down drain.	1) Outslope road and remove ditch for 970' up the right road. 2) Install 6 rolling dips up the right road.
138	Catway	H	SC	313	1495	0	A near origin Class III is conveyed over the road bed at this fill crossing. Flow from the swale has eroded a gully downstream of the crossing and the gully bifurcates at the outboard edge of the road. One headcut is actively moving up the left road, and the other is actively moving headward through the axis of the stream.	1) Install an armored fill. Lower the road through the axis of the crossing by 2.5' to establish a broad dip. Excavate a keyway (20' wide x 7' wide x 20' long x 2' deep). Armor the keyway using 20 yd^3 of 0.5'-1.5' diameter rock armor. 2) Outslope road and remove ditch for 1500' up the left road. 3) Install 8 rolling dip up the left road.

Table B1. Field observations and treatment recommendations for road related sites, *Manzana Creek Watershed Anthropogenic Sediment Reduction Assessment, Aquatic Protection and Road Restoration Planning Project*, *Los Padres National Forest*, *Santa Barbara County, CA*

Site #	Road Name	TI	Problem	Total estimated future sediment delivery (yd^3)	Hydrologically connected road length (ft)		Comment on Problem	Comment on treatment
					Left	Right		
139	Catway	HM	SC	138	174	43	A series of small gullies and concentrated road runoff combine to form the headwaters of this Class III stream. Flow is actively eroding this uncontrolled fill crossing with a 5' headcut at the outboard edge of fill. There is a rolling dip up the right road that is preventing diversion. Multiple small gullies upslope spill off the road and combine to form this drainage gully.	1) Install an armored fill. Establish a broad dip. Excavate a keyway (25' long x 22' wide x 9' wide x 2' deep). Armor the keyway using 28 yd^3 of 0.5’-2.5' diameter rock armor. 2) Outslope road and fill ditch for 175' up the left road.
140	Catway	HM	RS	77	0	262	262' of road empties over the outboard edge of fill at a breach in the outboard berm. A 3 x 2' gully has eroded into the hillslope and fill material below the road. The gully reaches a stable material 50' below the road, but sediment is still being transported to the creek approximately 300' downslope.	1) Outslope road and remove ditch for 262' up the right road. 2) Install 2 rolling dips up the right road.
141	Catway	M	RS	244	1149	0	Confined road runoff outlets the road via a small rolling dip. There is a dysfunctional down drain that is now bypassed by flows. Flow has eroded a 2 x 1 gully 410' down to a Class III stream. The hillslope below the road is steep and prone to erosion.	1) Outslope road and remove ditch for 1149' up the left road. 2) Install 8 rolling dips up the left road.
142	Catway	M	RS	149	651	0	A berm breach and very poorly defined rolling dip convey 651' of road runoff over the outboard edge of fill. Two 1x1' gullies leave the road at this location. There is a Class III stream 250' below the road.	1) Outslope road and remove ditch for 551' up the left road. 2) Install 4 rolling dips on the left road.
143	Catway	L	RS	311	1217	0	A long segment of confined road drainage on a native surfaced road is being actively conveyed via a small rolling dip. There is a metal outboard down drain that us functional. However, it is not preventing erosion. A small gully is enlarging along the left road approach. There is a gully that delivers to a Class III stream below the road as well.	1) Outslope road and remove ditch for 1217' up the left road. 2) Install 9 rolling dips up the left road.

Table B1. Field observations and treatment recommendations for road related sites, *Manzana Creek Watershed Anthropogenic Sediment Reduction Assessment, Aquatic Protection and Road Restoration Planning Project*, *Los Padres National Forest*, *Santa Barbara County, CA*

Site #	Road Name	TI	Problem	Total estimated future sediment delivery (yd^3)	Hydrologically connected road length (ft)		Comment on Problem	Comment on treatment
					Left	Right		
143.1	Catway	M	RS	155	735	0	A breach in the berm conveys 735' of left road over the outboard edge of the road and down to a Class III stream 280' below the road. There is significant gullying occurring on the left road leading to this road surface discharge point, but most of the erosion is still smaller than 1x1' at present. A partially failed outboard down drain is holding grade at the outboard edge of fill but will likely fail completely soon and cause the gully to migrate up into the left road.	1) Outslope road and remove ditch for 735' up the left road. 2) Install 6 rolling dips up the left road.
144	Catway	M	RS	307	1505	0	An outboard down drain delivers flow to the headwaters of a Class III stream from 1505' of left road. A shallow swale above the road also contributes flow to this site. The outboard down drain itself has partially failed, and a small gully has developed along the outboard edge of the road.	1) Outslope road and remove ditch for 1505' up the left road. 2) Install 10 rolling dips up the left road.
145	Catway	HM	RS	732	0	2791	A long segment of confined native surfaced road conveys concentrated road runoff to this site. A sizable gully has formed along the outboard edge of fill and the hillslope below the road. This flow and associated sediment travel down the axis of the swale to the road and then travel 300' below the road surface discharge location. The 2.5 x 4' gully is migrating headward into the road bed and will continue to erode and deliver sediment is left untreated.	1) Outslope road and remove ditch for 2791' up the right road. 2) Install 19 rolling dips up the right road.

Table B1. Field observations and treatment recommendations for road related sites, *Manzana Creek Watershed Anthropogenic Sediment Reduction Assessment, Aquatic Protection and Road Restoration Planning Project*, *Los Padres National Forest*, *Santa Barbara County, CA*

Site #	Road Name	TI	Problem	Total estimated future sediment delivery (yd^3)	Hydrologically connected road length (ft)		Comment on Problem	Comment on treatment
					Left	Right		
146	Catway	M	RS	144	641	0	A long section of confined road drainage is conveying sediment and road runoff to the headwall of a Class III stream. Some road drainage bypasses this discharge point and continues down the road. The road crosses through the headwall of a Class III stream. The road drainage should eb fixed. There is also some bank erosion on the right bank of the Class III stream below the road just downstream of the discharge point.	1) Outslope road and remove ditch for 641' up the right road. 2) Install 5 rolling dips up the right road. 3) Define a 4' wide channel bottom for 75' from swale in flat to the existing defined channel. (75' x 5' x 3', plus 42 yd^3 of excavation). 4) Use spoils to build up an outsloped road through the shallow through cut road to the newly defined channel.
147	Catway	HM	RS	56	175	0	A gully from the road above site 146 delivers flows and sediment to this site from the cutbank. Additional road runoff bypasses site 146 and delivers to this site via a 1x1' gully that extends 175' down the left road and empties over the outboard edge of fill into 2x1' gully that extends 90' down to a Class III stream.	1) Outslope road and remove ditch for 175' up the left road. 2) Install 1 rolling dip up the left road.
148	Catway	M	SC	37	104	14	A Class III stream is conveyed across the road via a steel culvert that conveys flow down the outboard fill slope. A half-round pipe outlets 10' shy of the BOT with minimal erosion. There is a small past failure on the left outboard edge of fill and a gully on the left road that delivers a small volume of sediment to the crossing.	1) Excavate from TOP to BOT and install a new 24" diameter x 50' long corrugated metal pipe at the base of fill. 2) Pull back the outboard edge of fill to prevent failure. 3) Construct a critical dip on the right hinge. 4) Outslope road and fill ditch for 104' up the left road. 5) Armor the outboard fill slope using 12 yd^3 of 1-2' diameter rock armor.

Table B1. Field observations and treatment recommendations for road related sites, *Manzana Creek Watershed Anthropogenic Sediment Reduction Assessment, Aquatic Protection and Road Restoration Planning Project*, *Los Padres National Forest*, *Santa Barbara County, CA*

Site #	Road Name	TI	Problem	Total estimated future sediment delivery (yd^3)	Hydrologically connected road length (ft)		Comment on Problem	Comment on treatment
					Left	Right		
149	Catway	H	SC	107	305	0	A steep Class III stream is conveyed over this partially washed out fill crossing. There is a relic channel in the axis of the crossing. The road has partially washed out, and there is a 2x1 gully above and below the road that extends out of sight above the road in dense chaparral.	1) Install an armored fill. Establish a broad dip, excavate a keyway (26' wide x 8' wide x 29' long x 2' deep). Armor the keyway using 34 yd^3 of 1-2.5' diameter rock armor. 2) Outslope road and fill ditch for 305' up the left road. 3) Install 1 rolling dips up the left road.
150	Catway	HM	SC	65	0	298	Stream flow and road runoff from site 149 up the right road deliver to this uncontrolled stream crossing. There is a dip through the crossing that conveys flow off the road. The combined flows have eroded a gully into the downstream channel 3' wide by 5' deep x 28' long. The downstream gully appears to have reached a stable grade.	1) Install an armored fill. Establish a broad dip, excavate a keyway (20' wide x 8' wide x 23' long x 2' deep). Armor the keyway using 25 yd^3 of 0.5’-2' diameter rock armor. 2) Outslope road and fill ditch for 298' up the right road. 3) Install 1 rolling dips up the right road.
151	Catway	HM	RS	37	0	138	A breach in the berm conveys flow from 138' of right road and a small gully that runs from the outboard edge of the road to the breach from the road above. A gully has developed along the outboard edge of the road and the headcut in the gully is actively advancing headward into the road.	1) Outslope road and remove ditch for 138' up the right road. 2) Install 1 rolling dip on the right road.

Table B1. Field observations and treatment recommendations for road related sites, *Manzana Creek Watershed Anthropogenic Sediment Reduction Assessment, Aquatic Protection and Road Restoration Planning Project*, *Los Padres National Forest*, *Santa Barbara County, CA*

Site #	Road Name	TI	Problem	Total estimated future sediment delivery (yd^3)	Hydrologically connected road length (ft)		Comment on Problem	Comment on treatment
					Left	Right		
152	Catway	HM	SC	42	0	161	A Class III stream flows onto the road and diverts down the left road for 32' before reaching site 153. The combined streams gully through the outboard edge of fill. There is an old slump block below the road that creates a low gradient depositional area in this otherwise steep terrain. The critical dip at site 153 will function for both crossings.	1) Excavate from TOP to BOT and install a new 30" diameter x 40' long corrugated metal pipe set at the base of fill. 2) Outslope road and fill ditch for 161' up the right road. 3) Install 1 rolling dip on the right road approach. 4) Armor the lower 3/4 of the outboard fill slope using 7 yd^3 of 0.5’-2' diameter rock armor.
153	Catway	M	SC	27	0	30	A Class III stream is conveyed across the road at this fill crossing with a failed outboard down drain. The road is very rocky and the existing gully below the road has poor definition due to the presence of numerous 6-12" cobbles and small boulders. There is diversion potential on the left road. Flows from site 152 are currently delivered to this crossing as well. Upstream of this site is site 146 on the road above.	1) Install an armored fill. Establish a broad dip, excavate a keyway (20' wide x 8' wide x 20' long x 2' deep). Armor the keyway using 21 yd^3 of 1-2' diameter rock armor. 2) Ensure the critical dip will maintain flows from this site and from site 152. 3) Outslope road and remove ditch for 30' up the right road approach.
154	Sunset Valley Trail	ML	SC	0	47	0	A small Class III stream is conveyed through the trail via a fill crossing. The fill crossing is dipped with very minor surface erosion of exposed soils through crossing. The upstream channel reach is full of woody debris and duff.	1) Install an armored fill, establish a broad dip through the crossing to convey flow, align the center of the channel 4' to the right, excavate a keyway 10’ wide at the top x 6’ wide at the base x 10’ long x 2’ deep, and install 6 yd^3 of 0.5’-1’ diameter rock armor to the keyway.
155	Sunset Valley Trail	-	SC	1	52	190	A trail ford crossing on upper Fish Creek. The channel is loaded with large 1' cobbles that have been locked in place by cementation. Both approaches are rocky and stable. This site requires no treatment.	No treatment recommendation.

Table B1. Field observations and treatment recommendations for road related sites, *Manzana Creek Watershed Anthropogenic Sediment Reduction Assessment, Aquatic Protection and Road Restoration Planning Project*, *Los Padres National Forest*, *Santa Barbara County, CA*

Site #	Road Name	TI	Problem	Total estimated future sediment delivery (yd^3)	Hydrologically connected road length (ft) Left	Hydrologically connected road length (ft) Right	Comment on Problem	Comment on treatment
250	Manzana Creek Trail	L	SC	4	100	260	A ford crossing on mainstem Manzana Creek. The trail crosses two defined flow paths within the active channel. The left channel is dry and probably only occupied during high flow events. The right channel is larger and at a lower grade than the left channel. Water is flowing through the right channel. Both channels are comprised of 12-24" boulders and there is a large bar built up between the two that is vegetated. Debris from storm events is caught in branches and vegetation up to 7' above the bottom of the channel. Both left and right approaches are very loose, sandy trails with intermixed cobbles and gravel. There is minimal evidence of erosion on either approach, but sand is actively being transported into the channel from both approaches. A small swale delivers to the crossing via the left road approach and is located approximately 100; from the crossing.	1) Install 2 rolling dips on the left road approach. Install 1 rolling dip at the swale on the left road. 2) Install 3 rolling dips on the right road approach.
251	Manzana Creek Trail	ML	SC	15	300	0	A partially washed out stream crossing with a 24" corrugated metal pipe exposed on the fill. This culvert crossing appears to have been built during an era when mining roads were constructed in the watershed. There is exposed bedrock at the base of the pipe, and the upstream channel is entirely comprised of bedrock. The stream has plugged the pipe at the inlet and outlet, and now diverts 175' down the right road to Manzana Creek. Delivery is questionable due to the lack of erosion, but the potential for erosion remains high within the hinges of the crossing,	1) Remove the existing corrugated metal pipe and transport off site. 2) Install an armored fill. Establish a broad dip. Excavate keyway 15' wide x 8' wide x 7' long x 2' deep. 3) Armor the keyway using 10 yd^3 of 0.5'-1.0' diameter rock armor. 4) Excavate a channel from the outboard edge of the road to the BOT, 97' long. Establish a 3' wide channel bottom with 2:1 side slopes to convey flow to Manzana Creek. 5) Install 5 rolling dips on the left road.

Table B1. Field observations and treatment recommendations for road related sites, *Manzana Creek Watershed Anthropogenic Sediment Reduction Assessment, Aquatic Protection and Road Restoration Planning Project*, *Los Padres National Forest*, *Santa Barbara County, CA*

Site #	Road Name	TI	Problem	Total estimated future sediment delivery (yd^3)	Hydrologically connected road length (ft)		Comment on Problem	Comment on treatment
					Left	Right		
252	Manzana Creek Trail	HM	SC	132	69	46	A ford crossing on a large Class III stream. The trail is largely stable, but the crossing has been established on an old mining road network. A 92' section of fill perched on the left bank is failing and is now near vertical. Two 30" diameter corrugated metal pipes are buried under the right road approach, providing evidence to suggest that this former fill prism was blown out in a storm event and the stream has since assumed an alignment to the left of the old culverts. The failing road along the upper left section of the site should be treated, but the crossing itself is stable and presents no risk of erosion.	1) Excavate the oversteepened left bank upstream of the crossing for 92' and slope back to 1.5:1 (92' x 19' x 2') = 130 yd^3. 2) Store spoils locally to the right of the excavation area along the inboard edge of the road. 3) Define a broad cross road drain on the road to convey swale flow away from the road surface and the unstable slope.
253	Manzana Creek Trail	L	RS	9	350	280	A long alignment of road through a flat floodplain terrace along Manzana Creek. A Class III stream is the back of the floodplain is delivering flow and sediment to the floodplain and the road. Sediment fans out across the floodplain. Erosion is minimal at this site, but the road does not properly drain.	1) Install 3 rolling dips to the right of the stream on the right road. 2) Install 2 rolling dips to the left of the stream on the left road.
254	Manzana Creek Trail	M	SC	6	48	0	A mostly washed out fill crossing on a Class III stream. This small, flashy stream has partially washed out this small foot path on a segment of the trail that has officially been decommissioned. The trail has been rerouted upslope and this crossing should be adequately decommissioned to prevent further erosion and delivery to Manzana Creek.	1) Decommission the stream crossing. Excavate from TOP to BOT and establish a 4' wide channel bottom with 2:1 side slopes where feasible. 2) Store spoils to the right of the crossing on the decommissioned trail.
255	Manzana Creek Trail	H	LS	85	0	0	An active road fill failure along the right bank of Manzana Creek. The trail runs parallel to the channel, and the creek has eroded away most of the fill, leaving a small portion of the fill prism remaining. This segment of the trail has been officially abandoned, but there is remaining material that will fail into the stream if left untreated.	1) Pull back the remaining vertical scarp from left to right to 1.5:1 (55' x 5' x 15') = 153 yd^3 2) Spoil locally to the left in the large flat adjacent to site 256 and utilize for local trail treatments.

Table B1. Field observations and treatment recommendations for road related sites, *Manzana Creek Watershed Anthropogenic Sediment Reduction Assessment, Aquatic Protection and Road Restoration Planning Project*, *Los Padres National Forest*, *Santa Barbara County, CA*

Site #	Road Name	TI	Problem	Total estimated future sediment delivery (yd^3)	Hydrologically connected road length (ft)		Comment on Problem	Comment on treatment
					Left	Right		
256	Manzana Creek Trail	L	SC	2	16	180	A partially washed out armored fill crossing on a Class III stream. Rock has been poorly placed along the outboard edge of fill and is not maintaining the trail fill prism. The channel upstream of the crossing is choked with dead brush and other vegetation.	1) Install an armored fill. Maintain the existing dip through the crossing. Excavate a keyway 13' wide x 8' wide x 7' long x 2' deep. 2) Armor the keyway using 6 yd^3 of 0.5'-1.0' diameter rock armor. 2. Install 2 rolling dips up the right road.
257	Manzana Creek Trail	L	SC	0	30	0	A low gradient overflow side channel on Manzana Creek on which a ford crossing has been established. There is no crossing structure in the channel, but there is potential for delivery of fine sediment generated by foot traffic in the channel. Both the left and right approaches are connected but are very flat.	1) Rock the trail through the crossing for 3' x 64' using 3 yd^3 of 0.5' - rock armor.
258	Manzana Creek Trail	L	SC	10	115	12	A fill crossing on a Class III stream. The crossing is adequately dipped to convey flow across the trail, and the channel is low gradient. There is some active bank erosion occurring up the left trail due to a large length of connected trail. There is a 1 foot headcut below the crossing. The right stream bank is oversteepened downstream of the crossing for 20'.	1) Lay back the left stream bank for 24' to 2:1 upstream of the crossing. Store spoils to the left and right. 2) Install an armored fill. Establish a broad dip, Excavate a keyway 13' wide x 7' wide x 8' long x 2' deep. 3) Armor the keyway using 6 yd^3 of 0.5'-1.5' diameter rock armor. 4) Lay back the right stream bank for 20' to 2:1. Store spoils to the left and right.

Table B1. Field observations and treatment recommendations for road related sites, *Manzana Creek Watershed Anthropogenic Sediment Reduction Assessment, Aquatic Protection and Road Restoration Planning Project, Los Padres National Forest, Santa Barbara County, CA*

Site #	Road Name	TI	Problem	Total estimated future sediment delivery (yd^3)	Hydrologically connected road length (ft)		Comment on Problem	Comment on treatment
					Left	Right		
259	Manzana Creek Trail	L	SC	16	246	0	A fill crossing on a Class III stream. The stream diverts down the right road for several hundred feet before leaving the trail and fanning out on a flat grass-covered bench above Manzana Creek. There are multiple small gullies down the road where flows have scoured out the trail material, and these have potential to enlarge considerably. There is no evidence of an historical channel alignment, but there is a suitable location to direct the stream over the trail and down to Manzana Creek before the diversion.	1) Excavate a channel from the TOP to the inboard edge of the trail 3' wide at the base with 2:1 side slopes for a total length of 178' 2) Install an armored fill. Establish a broad dip. Excavate a keyway 28' long x 12' wide x 7' wide x 2' deep. 3) Armor the keyway using 16 yd^3 of 0.5'-1.0' diameter rock armor. 4) Install a critical dip on the right hinge of the crossing to prevent further diversion 5) Install 3 rolling dips on the left trail approach 6) Rock the crossing using 1 yd^3 of 0.5' - rock armor for 3' x 10'.
260	Manzana Creek Trail	L	SC	62	0	56	A ford crossing on the alluvial fan of a very small Class III stream. Diffuse flow is conveyed through the crossing via a dip in the road. There are rocks stacked along the inboard edge of the trail, and there is no erosion at the crossing.	1) Install an armored fill. Establish a broad dip by lowering the trail 1' through the crossing. Excavate a keyway 12' wide x 7' wide x 9' long x 2' deep. 2) Armor the keyway using 7 yd^3 of 0.5'-1.0' diameter rock armor.
261	Manzana Creek Trail	ML	SC	9	0	186	A fill crossing on a Class III stream. Sediment has aggraded upstream of the crossing due to the fill prism trapping bedload and sediment in transport. There are several small headcuts downstream of the crossing that, if able to migrate headward into the trail bed, will cause the trail to fail and the sediment upstream to be delivered.	1) Install an armored fill. Establish a broad dip. Excavate a keyway 10' long x 9' wide x 3' wide 1' deep. 2) Armor the keyway using 2.5 yd^3 of 0.5'-1' diameter rock armor. 3) Install 2 rolling dips up the right road approach

Table B1. Field observations and treatment recommendations for road related sites, *Manzana Creek Watershed Anthropogenic Sediment Reduction Assessment, Aquatic Protection and Road Restoration Planning Project*, *Los Padres National Forest*, *Santa Barbara County, CA*

Site #	Road Name	TI	Problem	Total estimated future sediment delivery (yd^3)	Hydrologically connected road length (ft)		Comment on Problem	Comment on treatment
					Left	Right		
262	Manzana Creek Trail	L	SC	6	0	165	A ford crossing on a Class III stream. The channel throughout the crossing is controlled by bedrock, which brings the stream to the trail crossing via several cascades. The stream diffuses downstream onto a low gradient floodplain terrace. The right road appears to actively erode during storm events due to sheet flow from the channel.	1) Build up the critical dip on the left hinge of the crossing by importing 2 yd^3 from a nearby site with excess spoils 2) Outslope the road and remove ditch for 165' up the right road approach. 3) Install 1 rolling dip up the right road.
263	Manzana Creek Trail	L	SC	16	350	11	A ford crossing on a large and very flashy Class III stream. There are debris deposits in the near vertical stream banks and the stream appears to torrent during large storm events. There appears only to be minor sediment delivery from the road approaches. There is also evidence of an historical channel alignment 350' up the left road.	1) Outslope road and remove ditch for 15' up the right road. 2) Install 4 rolling dips on the left road approach.
263.1	Manzana Creek Trail	M	LS	50	0	0	A section of makeshift retaining wall is buttressing a 230' long section of trail above Manzana Creek. The hillslope is and highly erodible. The entire slope is raveling at a high rate, and the trail is perched directly above Manzana Creek. Fill is actively failing through the gaps in the retaining wall (PSP airstrip planks). The trail should be rerouted upslope.	1) Reroute the trail upslope 600' to avoid the unstable, raveling hillslope.
265	Manzana Creek Trail	L	SC	21	0	300	A ford crossing at a small Class III stream with a sizable alluvial fan at the base of a steep hillslope. The trail crosses the alluvial fan, and there is very little evidence of an established flow path on the fan. The stream is low power and there is minimal erosion. There is some potential for diversion, but little potential for delivery as the alluvial fan terminates on a large, flat floodplain terrace 50' from Manzana Creek.	1) Install 3 rolling dips on the right road approach. Install 1 rolling dip at the axis of the crossing to prevent diversion.

Table B1. Field observations and treatment recommendations for road related sites, *Manzana Creek Watershed Anthropogenic Sediment Reduction Assessment, Aquatic Protection and Road Restoration Planning Project*, *Los Padres National Forest*, *Santa Barbara County, CA*

Site #	Road Name	TI	Problem	Total estimated future sediment delivery (yd^3)	Hydrologically connected road length (ft)		Comment on Problem	Comment on treatment
					Left	Right		
266	Manzana Creek Trail	L	SC	16	26	106	An armored fill crossing on a Class III stream. The rock is being undermined along the right hinge of the crossing. Flows from the stream disperse onto a floodplain downstream of the crossing. The stream is low power, and erosion is not currently significant. However, further loss of stability along the outboard edge of fill could cause erosion to increase.	1) Install an armored fill. Establish a broad dip. Excavate a keyway 11' wide x 9' wide x 12' long x 2' deep. 2) Armor the keyway using 5 yd^3 of 0.5'-1.0' diameter rock armor. 3) Outslope the right trail approach for 30'. 4) Install 1 rolling dip up the right road approach.
267	Manzana Creek Trail	HM	SC	15	220	150	A fill crossing on a Class III stream. The left and right roads are hydrologically connected. Cutbank slough and road surface runoff deliver sediment to this crossing. There is a small amount of poorly placed armor along outboard edge of fill at this site, but it is not functioning. The stream is beginning to erode through the fill along the outboard edge of the trail and deliver sediment to Manzana Creek 30' downstream.	1) Install an armored fill. Establish a broad dip. Excavate a keyway 8' long x 12' wide x 5' wide x 2' deep. 2) Armor the keyway using 7 yd^3 of 0.5'-1.0' diameter rock armor. 3) Install 5 rolling dips up the left road approach.
268	Manzana Creek Trail	M	RS	36	220	0	Concentrated Road runoff has created a 54' x 5' x 4' gully down a steep hillslope above Manzana Creek. The majority of erosion at this site has ceased, but there is future erosion remaining in the oversteepened banks along either side of the gully. This site will be dangerous to treat with hand tools, but the cause of the erosion can be treated with the installation of rolling dips on the left road approach.	1) Install 3 rolling dips up the left road approach. 2) Lay back the upper 1/3 of the oversteepened gully banks to 1.5:1 or to stable native material. 3) Store Spoils locally on left and right approached and utilize for local trail treatments.

Table B1. Field observations and treatment recommendations for road related sites, *Manzana Creek Watershed Anthropogenic Sediment Reduction Assessment, Aquatic Protection and Road Restoration Planning Project*, *Los Padres National Forest*, *Santa Barbara County, CA*

Site #	**Road Name**	**TI**	**Problem**	**Total estimated future sediment delivery (yd^3)**	**Hydrologically connected road length (ft)**		**Comment on Problem**	**Comment on treatment**
					Left	**Right**		
269	6/27	HM	SC	26	89	190	A fill crossing on Class III stream with no formal drainage structure. The fill prism is partially washed out along the outboard edge of the fill. There is a small gully upstream of the crossing that appears to be actively eroding. Both left and right roads deliver to the crossing.	1) Install an armored fill. Establish a broad dip. Excavate a keyway 12' long x 11' wide x 5' wide x 2' deep. 2) Armor the keyway using 4yd^3 of 0.5'-1.0' diameter rock armor. 3) Install 1 rolling dip up the right road approach.
270	Manzana Creek Trail	L	SC	11	200	12	A fill crossing on a near origin Class III stream. There is minor erosion on the outboard fill slope. This stream is low power and erosion within the crossing is minimal. 200' of left trail is connected to the site. The cutbanks are highly erodible.	1) Install an armored fill. Establish a broad dip. Excavate a keyway 9' wide x 4' wide x 9' long x 2' deep. 2) Armor the keyway using 5 yd^3 of 0.4-1.0' diameter rock armor. 3) Install 2 rolling dips up the left road.
271	Manzana Creek Trail	L	SC	20	0	360	A near origin Class III stream crosses the road via a fill crossing with no formal drainage structure. Flow is actively eroding through the trail fill prism and will continue to do so if left untreated.	1) Install an armored fill. Establish a broad dip. Excavate a keyway 10' wide x 5' wide x 8' long x 2' deep. 2) Armor the keyway using 5 yd^3 of 0.5'-1.0' diameter rock armor. 3) Install 3 rolling dips up the right road.
272	Manzana Creek Trail	L	SC	3	0	270	Multiple ford crossings at the confluence of a large Class III stream and Manzana Creek. The right road approach leads down into the channel of the Class III, runs along the bottom of the channel and onto a large alluvial fan and then dips down into Manzana Creek for several hundred feet before exiting on the left bank. The trail crosses two large, bouldery channels within Manzana Creek. Erosion of the trail approaches on either side of this crossing is minimal, and there is no crossing structure within the channel.	1) Install 3 rolling dips up the right road approach.

Table B1. Field observations and treatment recommendations for road related sites, *Manzana Creek Watershed Anthropogenic Sediment Reduction Assessment, Aquatic Protection and Road Restoration Planning Project*, *Los Padres National Forest*, *Santa Barbara County, CA*

Site #	Road Name	TI	Problem	Total estimated future sediment delivery (yd^3)	Hydrologically connected road length (ft)		Comment on Problem	Comment on treatment
					Left	Right		
272.1	Manzana Creek Trail	L	SC	0	50	22	A ford crossing on a very small Class III stream. There is a small amount of rock armor placed along the outboard fill slope. Erosion is minimal, but there is a shallow fill prism through the crossing that could potentially erode.	1) Establish a stable ford crossing. Establish a broad dip and rock the trail through the crossing for 3' x 8'.
273	Manzana Creek Trail	-	SC	6	118	57	A ford crossing on a very wide and flashy Class II stream. The channel is dominated by cobbles and small boulders. There is a confluence with another large Class II stream 50' downstream from this site. The crossing is stable with little evidence of erosion associated with the trail approaches or the crossing.	No treatment recommendation.
274	Manzana Creek Trail	L	SC	2	11	10	A washed out fill crossing on a Class III stream. There is future erosion remaining on the oversteepened banks immediately upstream of the crossing. There is minimal active erosion at the crossing, and the crossing will function as a ford crossing.	1) Lay back the oversteepened banks above the crossing to 2:1 for 6'. 2) Spoil locally to the left and right. 3) Establish a broad dip through the crossing, lower the crossing by 0.5' to establish a ford crossing.
275	Manzana Creek Trail	L	SC	9	300	0	A ford crossing on a Class III stream. There is low erosion potential at this site, but there is aggraded sediment in the channel upstream of the crossing.	1) Install 1 rolling dip at the crossing 2) Install 4 rolling dips up the left road.
276	Manzana Creek Trail	L	LS	7	0	0	An outboard fill failure delivered directly to a Class III stream approximately 43' above the road. There is remaining future delivery in the scarp at the upper edge of the slide.	1v Lay back the scarp of the landslide to 1:1 or less (7yd^3 of excavation).

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Site #	Road Name	TI	Problem	Total estimated future sediment delivery (yd^3)	Hydrologically connected road length (ft)		Comment on Problem	Comment on treatment
					Left	Right		
277	Manzana Creek Trail	L	SC	3	69	42	A fill crossing on a Class III stream. There is a 2' headcut downstream of the base of fill, and a smaller headcut upstream of the crossing. Both trail approaches are hydrologically connected to the crossing.	1) Install an armored fill. Establish a broad dip. Excavate a keyway 11' wide x 5' wide x 8' long x 2' deep. 2v Armor the keyway using 5 yd^3 of 0.5'-1.0' diameter rock armor. 3) Install 1 rolling dip on the left trail approach.
278	Manzana Creek Trail	L	SC	5	0	100	A small fill crossing on a Class III stream with no formal drainage structure. There are several large (4' diameter boulders) located on the outboard edge of fill. There is minimal erosion at the crossing, and 12-24" rock has been placed along the base of fill downstream of the crossing to support the fill. The stream appears to be low power as there is no channel definition upstream of the crossing.	1) Install an armored fill. Establish a broad dip. Excavate a keyway 15' long x 14' wide x 8' wide x 2' deep. 2) Armor the keyway using 13 yd^3 of 0.5'-1.0' diameter rock armor. 3) Install 1 rolling dip up the right road.
279	Manzana Creek Trail	M	SC	3	22	10	A fill crossing with no formal drainage structure on a Class III stream. The stream, which is low power, is conveyed over the shallow fill prism with minimal resulting erosion. There is substantial woody debris in the channel upstream of the crossing. Existing armor at the site is being flanked by flows.	1) Install an armored fill. Establish a broad dip. Excavate a keyway 11' wide x 5' wide x 7' long x 2' deep. 2) Armor the keyway using 5 yd^3 of 0.5'-1.0' diameter rock armor.
280	Manzana Creek Trail	L	SC	4	0	0	A fill crossing on a Class III stream. The stream has diverted down the right trail and exists onto the floodplain down the trail. There is no defined channel above the crossing.	1) Install an armored fill. Establish a broad dip. Excavate a keyway 14' wide x 5' wide x 16' long x 2' deep. 2) Armor the keyway using 12 yd^3 of 0.5'-1.0' diameter rock armor. 3) Excavate a channel 14' long x 3' wide x 1' deep with 2:1 side slopes from the TOP to the inboard edge of the road to convey flows to the armored fill.

Table B1. Field observations and treatment recommendations for road related sites, *Manzana Creek Watershed Anthropogenic Sediment Reduction Assessment, Aquatic Protection and Road Restoration Planning Project*, *Los Padres National Forest*, *Santa Barbara County, CA*

Site #	**Road Name**	**TI**	**Problem**	**Total estimated future sediment delivery (yd^3)**	**Hydrologically connected road length (ft)**		**Comment on Problem**	**Comment on treatment**
					Left	**Right**		
281	Manzana Creek Trail	L	SC	5	192	0	A fill crossing on a low-power Class III stream. A 6' diameter boulder is buttressing the fill to the left of the channel downstream of the crossing. The channel is very rocky and is dominated by 12"-24" cobbles and boulders. There is very little evidence of erosion potential, but the left road is connected and does have the potential to deliver fine sediment to the channel.	1) Install an armored fill. Establish a broad dip. Excavate a keyway 7' wide x 4' wide x 8' long x 2' deep. 2) Armor the keyway using 4 yd^3 of 0.5’-1.0' diameter rock armor. 3) Establish 2 rolling dips up the left trail approach.
282	Manzana Creek Trail	L	SC	3	33	0	A fill crossing on a headwall swale that delivers to a Class III stream downslope of the road. Channel morphology becomes defined 25’ downstream of the road. There is substantial woody debris downstream of the crossing, and a large 5' diameter boulder in the axis of the channel above the BOT. There is a past fill slope failure on the left road approach that is currently buttressed by a pressure treated lumber structure. This will continue to fail down the slope but will not deliver.	1) Install an armored fill. Establish a broad dip to convey flows through the crossing. Excavate a keyway 10' wide x 5' wide x 7' long x 1.5' deep. 2) Armor the keyway using 3yd^3 of 0.5’-1.0’ diameter rock armor. 3) Install 1 rolling dip 15' to the left of the past fill failure to prevent further concentrated road runoff from eroding the fill.
283	Manzana Creek Trail	L	SC	3	140	0	A fill crossing on a headwall swale. The left and right approaches are hydrologically connected to the site. There is minimal erosion upstream of the crossing. There is a wooden retaining wall to the right that supports a loosely compacted fill prism. This material could be delivered to the crossing, and to Manzana Creek 50' downstream of the crossing.	1) Define a broad dip through the axis of the channel to minimize erosion potential of the trail approaches. 2) Rock the trail through the crossing for 3' x 12' using 1 yd^3 of 0.5' - rock armor 3) Install a critical dip on the right hinge of the crossing to prevent potential diversion. 4) Install 2 rolling dips on the left road.

Table B1. Field observations and treatment recommendations for road related sites, *Manzana Creek Watershed Anthropogenic Sediment Reduction Assessment, Aquatic Protection and Road Restoration Planning Project*, *Los Padres National Forest*, *Santa Barbara County, CA*

Site #	Road Name	TI	Problem	Total estimated future sediment delivery (yd^3)	Hydrologically connected road length (ft)		Comment on Problem	Comment on treatment
					Left	Right		
284	Manzana Creek Trail	H	SC	7	290	15	A fill crossing on a Class III stream. The left and right roads are hydrologically connected. Flows have eroded the outboard edge of fill, and a headcut is actively eroding the fill prism. The upstream channel has cut down to stable bedrock and is therefore unlikely to erode.	1) Install an armored fill. Establish a broad dip. Excavate a keyway 14' wide x 8' wide x 15' long x 2' deep. 2) Armor the keyway using 13 yd^3 of 0.5’-10' diameter rock armor. 3) Install 3 rolling dips up the left road approach.
285	Manzana Creek Trail	L	SC	5	62	20	A fill crossing on a Class III stream. A slide deposit from a past hillslope failure on the left bank 20' upstream the inboard edge of the road has come to rest along the left bank of the stream. The fill prism is very small, and is comprised mostly of rock, making erosion potential and delivery negligible. Both road approaches, however, are connected and could potentially deliver sediment to the crossing.	1) Install an armored fil. Establish a broad dip. Excavate a keyway 9' wide x 5' wide 4' long x 2' deep. 2) Armor the keyway using 2 yd^3 of 0.5’-1.0' diameter rock armor. 3) Define a 4' wide channel with 2:1 side slopes from the TOP to the inboard edge of the road for 21'. 4) Install 1 rolling dip up the left road approach.
286	Manzana Creek Trail	HM	SC	14	120	244	A fill crossing on a Class III stream. Both the left and right road approaches are hydrologically connected. There is a small fill failure along the left hinge of the crossing just downslope from the outboard edge of the road. The bottom of the channel is dominated by large, 12"-24" cobble and boulders.	1) Install an armored fill. Establish a broad dip. Excavate a keyway 13' long x 14' wide x 6' wide x 2' deep. 2) Armor the keyway using 10 yd^3 of 0.5’-1.0' diameter rock armor. 3) Install 2 rolling dips up the right road approach. 4) Install 1 dip up the left road approach.

Table B1. Field observations and treatment recommendations for road related sites, *Manzana Creek Watershed Anthropogenic Sediment Reduction Assessment, Aquatic Protection and Road Restoration Planning Project*, *Los Padres National Forest*, *Santa Barbara County, CA*

Site #	Road Name	TI	Problem	Total estimated future sediment delivery (yd^3)	Hydrologically connected road length (ft)		Comment on Problem	Comment on treatment
					Left	Right		
287	Manzana Creek Trail	L	SC	1	6	0	A fill crossing on a near origin Class III stream. There is an existing rolling dip 20' up the left road approach. The right road is lower than the crossing for 30' and does have some potential to allow the stream to divert. There is only minor erosion on the outboard edge of fill. The stream is small and evidently low power.	1) Install an armored fill. Establish a broad dip to convey flow through the crossing. Excavate a keyway 10' wide x 4' wide x 10' long x 1.5' deep. 2) Armor the keyway using 4 yd^3 of 0.5’-1.0' diameter rock armor. 3) Install 1 rolling dip 20' up the left road approach.
288	Manzana Creek Trail	M	SC	2	44	20	A large Class III stream on which a ford crossing has been established. The channel is comprised of 12"-24" boulders atop a bedrock channel base. There is virtually no erosion potential at this site. Both the left and right approaches are short and end at natural bedrock rolling dips. The shallow trail bed through the crossing is made of gravel and larger cobbles.	1) Increase the armor along the outboard edge of the trail at this crossing. Utilize onsite 1-1.5' diameter rock. Establish a 6" deep keyway at the base of the rock armor to ensure stability as much as feasible (keyway will need to excavate into bedrock). 2) Rock the trail through the crossing using 1 yd^3 of 0.5'- rock armor for 3' x 15'.
289	Manzana Creek Trail	M	SC	10	15	108	A class III stream is conveyed through this fill crossing with no formal drainage structure. There is a poorly constructed armored fill at this site that does not have a keyway. The channel upstream of the crossing is comprised of bedrock. The channel downstream of the crossing is mostly fill, and it is eroding along the left bank.	1) Install an armored fill. Establish a broad dip. Excavate a keyway 11' wide x 6' wide x 5' long x 2' deep. 2) Armor the keyway using 3 yd^3 of 0.5’-1.0' diameter rock armor. 3) Buttress the failing streambank to the left of the crossing using 2 yd^3 of 0.5’-1.5' diameter rock armor. 4) Define a 4' wide channel below the armored fill for 10' with 2:1 side slopes. 5) Define a 4' wide channel with 2:1 side slopes from the TOP to the IBR for 20'.

Table B1. Field observations and treatment recommendations for road related sites, *Manzana Creek Watershed Anthropogenic Sediment Reduction Assessment, Aquatic Protection and Road Restoration Planning Project, Los Padres National Forest, Santa Barbara County, CA*

Site #	Road Name	TI	Problem	Total estimated future sediment delivery (yd³)	Hydrologically connected road length (ft)		Comment on Problem	Comment on treatment
					Left	Right		
289.1	Manzana Creek Trail	L	LS	7	0	0	A section of perched hillslope and trail fill material on a steep slope directly above a Class III stream. There are past fill failures that have resulted in perched material below the trail. The slide material would deposit on a flat floodplain bench above the left bank of the stream. This section of trail should be rerouted to prevent further failure and eventual possible delivery. There is a small amount of road drainage outletting onto the buttressed fill along the right edge of the trail at this site.	1) Reroute the trail upslope for 200' to avoid the oversteepened trail area.
290	Manzana Creek Trail	M	SC	7	41	233	A fill crossing on a small Class III stream. The left and right roads are hydrologically connected. A rock wall has been constructed along the outboard edge of fill, and flows are flanking this wall and causing minor erosion. There is potential for the fill crossing to fail if water continues to cut into the fill and cause headward migration of the small headcut that exists now.	1) Excavate a 3' wide channel with 2:1 side slopes for 11' from the TOP to the inboard edge of the road. 2) Install an armored fill. Establish a broad dip. Excavate a keyway 12" wide x 6' wide x 12' long x 2' deep 3) Armor the keyway using 8 yd^3 of 0.5'-1.0' diameter rock armor. 4) Install 2 rolling dips up the right road. 5) Spoil locally on the left road.
291	Manzana Creek Trail	L	SC	1	12	15	A small armored fill crossing on a Class III stream. The armored fill is functioning, but the armor is undersized, and the structure has not been properly built. There is a side channel to the left that should be redirected to the armored fill. Both road approaches are hydrologically connected. The bedload in transport consists of large cobbles and boulders.	1) Install an armored fill. Establish a broad dip. Excavate keyway 12' wide x 10' wide x 8' long x 2' deep. 2) Armor the keyway using 7 yd^3 of 0.5'-1.0' diameter rock armor. Source rock locally from the site. 3) Convey the left side channel into the armored fill. 4) Install 1 rolling dip on the left road approach.

Table B1. Field observations and treatment recommendations for road related sites, *Manzana Creek Watershed Anthropogenic Sediment Reduction Assessment, Aquatic Protection and Road Restoration Planning Project*, *Los Padres National Forest*, *Santa Barbara County, CA*

Site #	Road Name	TI	Problem	Total estimated future sediment delivery (yd^3)	Hydrologically connected road length (ft)		Comment on Problem	Comment on treatment
					Left	Right		
292	Manzana Creek Trail	HM	RS	67	0	550	A road surface discharge point along Manzana Creek Trail and Manzana Creek. There is some erosion along the side of the road, and slash has been placed along the outboard edge of fill above the channel. There is potential for the outboard edge of fill to fail and for a gully to form in the trail bed.	1) Install 8 rolling dips up the right road.
293	Manzana Creek Trail	ML	SC	7	420	216	There is a ford crossing on mainstem Manzana Creek. The channel is very wide with no erosion occurring within the crossing or on the approaches. Localized road treatments would help reduce potential for road-related runoff delivery to this site.	1) Install 3 rolling dips on the left road approach. 2) Install 1 rolling dip on the right road approach.
294	Manzana Creek Trail	-	SC	3	35	15	A ford crossing through a sizable seasonal Class II stream. There is less than 1 yd^3 of fill within the crossing on the approaches. The stream bed load is comprised of cobbles and small boulders less than 18" in diameter. There is a downed oak tree 12' downstream of the crossing that spans the channel. The area is very flashy, and the streams appear to torrent in response to rain events. The stream banks are near vertical with cobbles and boulders exposed.	No treatment recommendation.
295	Manzana Creek Trail	M	RS	41	1050	0	Combined concentrated road surface runoff and hillside runoff is being conveyed down the trail and scouring a 2' x 1' gully to Manzana Creek. Concentrated road runoff delivers from Potrero trail as well.	1) Install 2 rolling dips up the left road approach on Manzana Creek Trail and 6 rolling dips up Potrero trail. 2) Rock the left road approach for 40' to harden the trail bed and prevent erosion.

Table B1. Field observations and treatment recommendations for road related sites, *Manzana Creek Watershed Anthropogenic Sediment Reduction Assessment, Aquatic Protection and Road Restoration Planning Project*, *Los Padres National Forest*, *Santa Barbara County, CA*

Site #	Road Name	TI	Problem	Total estimated future sediment delivery (yd^3)	Hydrologically connected road length (ft)		Comment on Problem	Comment on treatment
					Left	Right		
296	Manzana Creek Trail	L	SC	1	0	200	Manzana Creek Trail dips down into the active channel of Manzana Creek at Site 295 and runs in the channel in a downstream direction for 100' before exiting the channel on the right bank again. There is no constructed trail system inside the channel, and therefore no potential for erosion. This crossing should be decommissioned that the trail rerouted over the small rocky hill above the right bank of the stream.	1) Reroute the trail from Site 295 up and around the hillslope above the right bank of Manzana Creek for 500'.
297	Manzana Creek Trail	L	SC	3	80	60	A ford crossing on Manzana Creek. There is no erosion within the crossing as it has no constructed form inside the channel. However, the right approach is steep and muddy due to emergent groundwater within the stream bank. The left approach has been established on a sandy point bar, and erosion is negligible as a result. The left approach is also shielded from high velocity flows by a large bedrock outcrop located immediately upstream of the crossing along the left bank.	1) Armor the right trail approach to the stream crossing for 12' x 3' using 2 yd^3 of 0.5'-1.5' diameter rock armor. Ensure trail armoring is suitable for pedestrian and equestrian traffic.
298	Manzana Creek Trail	L	SC	7	83	96	A ford crossing on a class 1 stream. Both trail approaches are hydrologically connected. The left approach is steep with substantial fine sediment perched on the trail. There is no crossing structure in the channel, and therefore no potential for erosion within the channel itself. The stream is dominated by large cobbles and boulders, and there is a large bedrock wall along the right side of the stream.	1) Armor the left trail approach for 3' x 26' using 5 yd^3 of 0.5’-1.5' diameter rock armor. Key rock structure 1' at the base of the bank in Manzana Creek.

Table B1. Field observations and treatment recommendations for road related sites, *Manzana Creek Watershed Anthropogenic Sediment Reduction Assessment, Aquatic Protection and Road Restoration Planning Project, Los Padres National Forest, Santa Barbara County, CA*

Site #	Road Name	TI	Problem	Total estimated future sediment delivery (yd^3)	Hydrologically connected road length (ft)		Comment on Problem	Comment on treatment
					Left	Right		
299	Manzana Creek Trail	L	SC	7	0	0	A ford crossing over a poorly defined Class III stream on an alluvial fan. The trail crosses over the alluvial fan of this stream, which is located atop a tall bank of Manzana Creek. The stream diverts down the right trail and into Manzana Creek at Site 300, which is a ford crossing through Manzana Creek. Flows from this small stream are actively eroding a gully into the trail approach to Site 300. There is a flat, vegetated floodplain to the right of the crossing where flows could be safely redirected.	1) Excavate a 3' wide channel with 2:1 banks from the TOP to the floodplain to the right of the site for 95'. Ensure flows are captured and directed to floodplain to prevent diversion. 2) Spoil locally along the left bank of the cut ditch to prevent overtopping and diversion.
300	Manzana Creek Trail	L	SC	6	75	51	A ford crossing on Class I Manzana Creek. Both trail approaches are hydrologically connected. There is no potential for erosion within the crossing. Bedload within the channel is dominated by large cobble and boulders. There is a large fallen tree upstream of the crossing. The right bank upstream of the crossing is eroding and vertical, with exposed cobble and boulders in the bank from an historical channel. The right approach is actively being eroded by flows from a small Class III stream located 90' up the right trail approach and should be reshaped and armored to prevent further erosion.	1) Armor the right trail approach for 4' x 25' using 6yd^3 of 0.5’-1.5' diameter rock armor. Key in the base of the trail armor 1' deep to ensure that is not undermined by flows in Manzana Creek.

Table B1. Field observations and treatment recommendations for road related sites, *Manzana Creek Watershed Anthropogenic Sediment Reduction Assessment, Aquatic Protection and Road Restoration Planning Project, Los Padres National Forest, Santa Barbara County, CA*

Site #	Road Name	TI	Problem	Total estimated future sediment delivery (yd^3)	Hydrologically connected road length (ft)		Comment on Problem	Comment on treatment
					Left	Right		
301	Manzana Creek Trail	-	SC	2	23	32	A ford crossing on Manzana Creek. The channel splits at the crossing, and a large vegetated gravel bar has been built up the center of the active channel. There are two large channels on either side of the gravel bar. The trail enters the crossing via the left trail approach just upstream of the gravel bar, leads up onto the gravel bar, runs parallel with the channel alignment for 100', dips back down into the right channel of the creek, and then finally exists Manzana Creek on the left right bank approximately 120' downstream of the left approach. Trail definition is minimal throughout the crossing, and there is little potential for erosion.	No treatment recommendation.
302	Sunset Valley Trail	L	SC	3	20	370	A ford crossing on a very low energy Class III stream. A short left road approach and a long hydrologically connected right road. The channel bed and banks are not very well defined. There is some aggraded sediment about 20’ upstream of the crossing probably caused by vegetation within the stream.	1) Install 4 rolling dips up the right road approach.
303	Sunset Valley Trail	-	SC	0	60	25	A ford crossing on a Class III stream. The stream is low powered with little to no fill, and low potential for erosion and sediment delivery. The channel is full of duff and woody debris.	No treatment recommendation.
304	Sunset Valley Trail	-	SC	1	25	158	A ford crossing on a low energy Class III stream. The channel is poorly defined. There is very low erosion potential due to the lack of fill in the crossing. The left road approach is minimal while the right road approach is a longer hydrologically connected segment. High concentration of woody debris in the channel and in the hinges of the crossing.	No treatment recommendation.

Table B1. Field observations and treatment recommendations for road related sites, *Manzana Creek Watershed Anthropogenic Sediment Reduction Assessment, Aquatic Protection and Road Restoration Planning Project*, *Los Padres National Forest*, *Santa Barbara County, CA*

Site #	Road Name	TI	Problem	Total estimated future sediment delivery (yd^3)	Hydrologically connected road length (ft)		Comment on Problem	Comment on treatment
					Left	Right		
305	Munch Canyon Trail	HM	SC	8	150	0	A ford crossing on a Class III stream that diverts down the right road approach. The channel substrate has medium sized rocks and gravel. A gully has formed in the road surface of the right road approach for 60' before turning downslope to rejoin the stream channel.	1) Excavate a 4' wide channel bottom from TOP to BOT with 2:1 side slopes. 2) Install a critical dip on the right hinge of the crossing to insure there will be no future diversion. 3) Install 1 rolling dips up the left road approach.
306	Munch Canyon Trail	HM	SC	2	110	70	A ford crossing on a Class III stream. There is moderate erosion occurring immediately above and below the crossing. There is a headcut on the outboard fillslope, approximately 10' below the crossing. Without treatment, the headcut will continue its upslope migration and cause future erosion.	1) Install an Armored Fill, establish a broad dip through the crossing to convey flow. Excavate a keyway (14' wide at the top x 8' wide at the base x 16' long x 2' deep) and install 13 yd^3 of 0.5'-1.0' diameter rock armor. 2) Install 1 rolling dip up the right road approach.
307	Munch Canyon Trail	M	SC	14	50	0	A ford crossing on a Class III stream. The stream is currently diverted down the right road approach for 150'. The right road is flat with a lot of gravel present; however, some gullies are forming. There is no evidence of the historic channel alignment through the crossing. A headcut is present upstream of the crossing. This site will continue to divert down the right road if left un treated.	1) Excavate a channel from TOP to BOT and establish a 3' wide channel bottom with 2:1 side slopes. 2) Install a grade control structure at the headcut, 5' upstream of the inboard road. Remove the large root of the oak tree prior to installing the grade control structure.

Table B1. Field observations and treatment recommendations for road related sites, *Manzana Creek Watershed Anthropogenic Sediment Reduction Assessment, Aquatic Protection and Road Restoration Planning Project*, *Los Padres National Forest*, *Santa Barbara County, CA*

Site #	Road Name	TI	Problem	Total estimated future sediment delivery (yd³)	Hydrologically connected road length (ft) Left	Hydrologically connected road length (ft) Right	Comment on Problem	Comment on treatment
308	Munch Canyon Trail	M	SC	14	640	10	A ford crossing on a Class III, possibly Class II stream. Several 0.5' to 2' diameter rocks are being transported by the stream. There is one large 3' boulder in the middle of the stream. Cementitious mineral deposits are found throughout the stream. This crossing has a long, hydrologically connected left road approach that is actively eroding the left road approach. The channel is bifurcated roughly 50' upstream at a large 10' diameter boulder. This side channel is only occupied during high flows when the stream overtops its right bank. This side channel does not have a formal drainage structure across the road and diverts down the right road approach.	1) Armor the left trail approach to the crossing using 1 yd^3 of 0.5'-1.0' diameter rock armor. Excavate a keyway at the base of the bank. 2) Excavate a 3' wide channel bottom with 2:1 sideslopes from the inboard road at the bifurcated channel to the main channel (30' long x 4' wide x 2' deep) (9 yd^3). 3) Install 7 rolling dips up the left road approach.
309	Munch Canyon Trail	ML	SC	23	0	80	A Fill crossing on a Class III stream, connected to site #310 which it diverts to. There is past diversion down the left road approach. Brush and debris are present in the stream crossing. There is near source bedrock with 12" to 36" diameter rocks in the crossing. There is a 3' headcut 15' below the outboard road that can migrate upstream if not treated.	1) Decommission the crossing. Excavate from TOP to BOT and establish an 8' wide channel bottom with 2:1 side slopes. 2) In place outslope the right road approach for 50'. 3) In place outslope the left road approach for 550' down to site #308. 4) Spoil locally. 5) Reroute the trail at site #308 to the landing above site #343.
310	Munch Canyon Trail	ML	RS		0	250	A former diversion gully along the old Mining Road on Munch Canyon trail. The diversion has cut through the cutbank, which is made of serpentine. There is no evidence of a stream above the road, although it appears the diversion originated from the road located several hundred feet above the trail. There appears to be water running down the trail still, although it doesn't appear to be the same volume as it may have been in the past.	1) Install 1 rolling dip at the crossing to convey minor flows over the trail. 2) In place outslope the right road for 200'.

Table B1. Field observations and treatment recommendations for road related sites, *Manzana Creek Watershed Anthropogenic Sediment Reduction Assessment, Aquatic Protection and Road Restoration Planning Project, Los Padres National Forest, Santa Barbara County, CA*

Site #	Road Name	TI	Problem	Total estimated future sediment delivery (yd^3)	Hydrologically connected road length (ft)		Comment on Problem	Comment on treatment
					Left	Right		
311	White Rock Trail	M	SC	43	1750	40	A Fill crossing on a low powered Class III stream. There is a headcut on the outboard fillslope. The left road approach is long and hydrologically connected. There are a couple failures due to the road surface runoff. The channel is full of duff through the crossing with exposed tree roots.	1) Install an armored fill, establish a broad dip through the crossing to convey flow. Excavate a keyway (10' wide x 6' wide x 12' long x 2' deep) and install 7 yd^3 of 0.5'-1.5' diameter rock armor. 2) Install 18 rolling dips up the left road approach.
312	White Rock Trail	L	SC	3	100	0	A fill crossing through a Class III stream. The 100' long hydrologically connected left road and no hydrologically right road. Aggraded sediment immediately above the crossing. No visible erosion of the fill at the crossing. The road was likely an old mining road.	1) Install an armored fill, establish a broad dip through the crossing to convey flow, excavate a keyway (12' wide at the top x 5' wide at the bottom x 10' long x1.5' deep) and install 5 yd^3 of 0.5'-1.0' diameter rock armor. 2) Install 1 rolling dip up the left road approach.
313	White Rock Trail	HM	SC	48	0	1200	A fill crossing on a small Class III stream diverts down the left road approach for 15' to site #314. There is a large boulder on the outboard road that will be immovable if this site is treated. There is minimal erosion on the left road approach despite the diversion, but the outboard road at the site #314 is actively eroding due to both streams (313 & 314) flowing into the channel at #314.	1) Install an armored fill, establish a broad dip through the crossing to convey flow. Excavate a keyway (10' wide at the top x 6' wide at the base x 12' long x 2' deep) and install 7 yd^3 of 0.5'-1.0' diameter rock armor. 2) Install 12 rolling dips up the right road approach.

Table B1. Field observations and treatment recommendations for road related sites, *Manzana Creek Watershed Anthropogenic Sediment Reduction Assessment, Aquatic Protection and Road Restoration Planning Project*, *Los Padres National Forest*, *Santa Barbara County, CA*

Site #	Road Name	TI	Problem	Total estimated future sediment delivery (yd^3)	Hydrologically connected road length (ft)		Comment on Problem	Comment on treatment
					Left	Right		
314	White Rock Trail	HM	SC	3	45	15	A fill crossing on a Class III stream. This site is close to site #313, which diverts down the right road approach into this crossing. A 2' headcut is located on the outboard road and will migrate upstream and erode the trail. Slash has been placed on the headcut but does not reduce active erosion. There is a second headcut about 10' downstream from the first one.	1) Install an armored fill, establish a broad dip through the crossing to convey flow, excavate a keyway (10' wide at the top x 6' wide at the base x 15' long x 2' deep) and install 9 yd^3 of 0.5'-1.5' diameter rock armor. 2) Install 1 yd^3 of 0.5'-1.5' diameter rock armor approximately 10' below the BOT at the second headcut.
315	White Rock Trail	L	SC	14	0	830	A fill crossing on a Class III stream. The stream is currently diverted 5' up the left road then reenters the main channel, causing erosion on the left road. 2' diameter rocks have been placed below the crossing. There are 2' headcuts 30' and 40' downstream of the crossing. Some aggraded material has accumulated upstream, but most of it has already washed out.	1) Install an armored fill, establish a broad dip through the crossing to convey flow, excavate a keyway (12' wide at the top x 7' wide at the base x 10' long x 2' deep) and install 7 yd^3 of 0.5'-1.5' diameter rock armor. 2) Install two grade control structures on the headcuts downstream of the crossing, using 1 yd^3 of 0.5'-1.0' diameter rock armor at each headcut. 3) Install 7 rolling dips up the right road approach.
316	White Rock Trail	M	SC	5	5	300	A fill crossing on a Class III stream. A headcut is located at the outboard road and will migrate upstream and erode the trail. There is a 6" wide pine tree in the crossing which will have to be removed as well as the nearby sage. The right road is steep and 300' long. There is a steep reverse grade on the left hinge of the crossing that is preventing diversion.	1) Install an armored fill, establish a broad dip through the crossing to convey flow, excavate a keyway (8' wide at the top x 6' wide at the base x 10' long x 2' deep) and install 5 yd^3 of 0.5'-1.5' diameter rock armor. 2) Install 5 rolling dips up the right road approach.

Table B1. Field observations and treatment recommendations for road related sites, *Manzana Creek Watershed Anthropogenic Sediment Reduction Assessment, Aquatic Protection and Road Restoration Planning Project, Los Padres National Forest, Santa Barbara County, CA*

Site #	Road Name	TI	Problem	Total estimated future sediment delivery (yd^3)	Hydrologically connected road length (ft)		Comment on Problem	Comment on treatment
					Left	Right		
317	White Rock Trail	ML	SC	17	600	450	A fill crossing on a Class III stream. 5' downstream there is a root causing a cascade and sudden drop. Channel is slowly forming a headcut under the root and has potential to continue traveling upstream. The cascade is causing a 2.5' deep pool to form naturally. The stream is 3' wide x 1' deep and is at grade. The left upstream bank is steep, leading up to the outboard fillslope of the road prism.	1) Install 6 rolling dips up the left road approach. 2) Install 5 rolling dips up the right road approach.
318	White Rock Trail	HM	SC	22	350	0	A very small Class III stream and combined road runoff have eroded a gully into the outboard fillslope at this fill crossing. The gully has largely stabilized but does extend down to a larger Class III stream approximately 50' downslope. The channel upstream is very small and poorly defined.	1) Install an armored fill, establish a broad dip through the crossing to convey flow, excavate a keyway (12' wide at the top x 6' wide at the base x 12' long x 2' deep) and install 8 yd^3 of 0.5'-1.5' diameter rock armor. 2) Excavate a 3' wide channel bottom with 2:1 Side slopes for 25' upstream of the crossing to convey flow to the crossing. 3) Install 3 rolling dips up the left road approach.
319	White Rock Trail	M	RS	11	150	0	Road surface discharge point is delivering 150' of left road approach, road bed erosion is occurring with multiple rills forming on the trail.	1) Install 2 rolling dips up the left road approach.
320	White Rock Trail	L	SC	36	900	15	A fill crossing through a Class III stream that diverts for 10' down the right road approach at the crossing, then reenters the main channel, causing minor erosion at the crossing. Before the road was built, the original channel went straight at this point. A large amount of brush has been stacked up downstream of the crossing.	1) Install an armored fill, establish a broad dip through the crossing to convey flow, excavate a keyway (13' wide at the top x 8' wide at the base x 14' long x 2' deep) and install 11 yd^3 of 0.5'-1.5' diameter rock armor. 2) Install 9 rolling dips up the left road approach.

Table B1. Field observations and treatment recommendations for road related sites, *Manzana Creek Watershed Anthropogenic Sediment Reduction Assessment, Aquatic Protection and Road Restoration Planning Project*, *Los Padres National Forest*, *Santa Barbara County, CA*

Site #	Road Name	TI	Problem	Total estimated future sediment delivery (yd^3)	Hydrologically connected road length (ft)		Comment on Problem	Comment on treatment
					Left	Right		
321	White Rock Trail	HM	LS	7	130	15	A past road fill failure on the White Rock Trail. Road drainage at this low point has caused a failure of the outboard fillslope. This failure delivers to a stream 60' downslope. 2 small 1' headcuts are present and should be armored to prevent headward migration.	1) Install 2 rolling dips up the left road approach. 2) Install 2 yd^3 of 0.5'-1.5' diameter rock armor to the headcuts on the outboard fillslope.
322	White Rock Trail	M	SC	4	200	10	A fill crossing on a Class III stream across White Rock trail. There is a 2' headcut on the outboard fillslope.	1) Install an armored fill, establish a broad dip through the crossing to convey flow, excavate a keyway (8' wide at the top x 6' wide at the base x 10' long x 2' deep) and install 5 yd^3 of 0.5'-1.5' diameter rock armor. 2) Install 2 rolling dips up the left road approach.
323	White Rock Trail	HM	SC	9	250	20	A Ford crossing on a large Class III stream. There is minimal erosion or potential for erosion within the crossing. There is an 18' wide bank failure 10' up the right road approach that should be pulled back.	1) Rock the left and right road approaches using 3 yd^3 of 0.5' diameter rock armor. 2) Pull back the fillslope failure to 1:1 or greater where feasible. 3) Spoil locally on the left and right road approaches.
324	White Rock Trail	M	SC	5	0	225	A fill crossing with a Class III stream across White Rock Trail. There is a headcut at the outboard road, which if left untreated, will migrate upstream and erode. There is no left road approach and the right road approach is steady with minimal lowering. There is a high amount of brush in the crossing.	1) Install an armored fill, establish a broad dip through the crossing to convey flow, excavate a keyway (8' wide at the top x 6' wide at the base x 20' long x 2' deep) and install 10 yd^3 of 0.5'-1.5' diameter rock armor. 2) Install 2 rolling dips up the right road approach.

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Site #	Road Name	TI	Problem	Total estimated future sediment delivery (yd^3)	Hydrologically connected road length (ft)		Comment on Problem	Comment on treatment
					Left	Right		
325	White Rock Trail	M	SC	7	175	0	A fill crossing on a low powered Class III stream. The upstream channel is filled with duff. There is a 2' head cut on the outboard fillslope that will migrate headward into the trail prism.	1) Install an armored fill, establish a broad dip through the crossing to convey flow, excavate a keyway (10' wide at the top x 6' wide at the base x 10' long x 2' deep) and install 6 yd^3 of 0.5'-1.5' diameter rock armor. 2) Install 2 rolling dips up the left road approach.
326	White Rock Trail	L	SC	21	250	0	A large washed out fill crossing through a Class III stream that has become a ford crossing. There is 250' of hydrologically connected left road with no connected right road approach. A 1' head cut at the outboard fillslope is actively migrating towards the crossing. This crossing was likely a fill crossing in the past but has completely washed out into a ford crossing. There is a large serpentine outcropping 100' down the right road.	1) Establish a ford crossing. Excavate a 3' wide channel bottom with 2:1 side slopes from TOP to BOT. 2) Rock the trail through the crossing for 6' wide x 13' long using 2yd^3 of 0.5’ diameter rock armor. Excavate a 2' deep keyway on the outboard road before placing the rock to prevent failure. 3) Install 2 rolling dips up the left road approach.
326.1	White Rock Trail	L	BE	33	575	0	A streamside section of White Rock Trail is at risk of failing due to bank erosion into the adjacent Class III stream. Approximately 2 yd^3 of perched trail fill will likely fall into the stream if untreated. There is potential to reroute the trail up the hillside on the right bank. The eroding bank should be pulled back to prevent future erosion.	1) Reroute the trail for 300' up the right hillside. Start the reroute 100' up the left road approach. 2) Pull back the eroding right bank and failing trail bed to 1:1 or less 30'. 3) Spoil locally
327	White Rock Trail	L	SC	3	50	50	A ford crossing on a large Class III (possible Class II) stream. There is a confluence of two Class III streams roughly 100' upstream. Large rocks (~9") are located in the crossing. The right bank of the stream is a steep 4' drop from the trail.	1) Install 9 rolling dips up the right road approach.

Table B1. Field observations and treatment recommendations for road related sites, *Manzana Creek Watershed Anthropogenic Sediment Reduction Assessment, Aquatic Protection and Road Restoration Planning Project*, *Los Padres National Forest*, *Santa Barbara County, CA*

Site #	Road Name	TI	Problem	Total estimated future sediment delivery (yd^3)	Hydrologically connected road length (ft)		Comment on Problem	Comment on treatment
					Left	Right		
328	White Rock Trail	-	SC	2	50	75	A ford crossing on a Class II stream with high seasonal flows. There are large cobbles ranging from 0.5'-2' in the crossing. There is no future erosion through the crossing due to the lack of fill. The channel is at grade through the crossing.	No treatment recommendation.
329	White Rock Trail	M	SC	2	10	10	There is a small fill crossing on a Class III stream across White Rock Trail. There are large gravels, roughly 5" in diameter throughout the crossing. The left bank upstream for 5' is loose. There is a 1'-2' headcut about 12' down from the crossing. The confluence with a larger stream is approximately 25' downstream.	1) Install an armored fill, establish a broad dip through the crossing to convey flow, excavate a keyway (9' wide at the top x 5' wide at the base x 15' long x 2' deep) and install 8 yd^3 of 0.5'-1.5' diameter rock armor.
330	White Rock Trail	-	SC	5	18	620	A ford crossing through a Class II stream. The crossing is stable with no potential future erosion. The road is approaches are stable with minimal sediment delivery. There are 0.5'-2' diameter rocks throughout the cussing. No treatment is recommended.	No treatment recommendation.
331	White Rock Trail	HM	BE	8	220	0	A large, seasonal Class III stream has eroded the left bank and will undermine the trail bed approximately 20' up the left road approach if left untreated. The crossing itself is stable and requires no treatment (large, rocky ford crossing)	1) Pull back the left stream bank at the failure to 2:1 (5 yd^3 excavation). 2) Spoil locally. 3) Reroute the trail for 50' up the bank. 4) Install 2 rolling dips up the left road approach.
332	White Rock Trail	-	SC	2	20	50	A ford crossing on a Class II stream. Exposed bedrock is present through the crossing and upstream. The channel is at grade with no future erosion. The left road approach follows the bedrock out of the channel and skirts along the steep hillslope on a very narrow trail.	No treatment recommendation.

Table B1. Field observations and treatment recommendations for road related sites, *Manzana Creek Watershed Anthropogenic Sediment Reduction Assessment, Aquatic Protection and Road Restoration Planning Project*, *Los Padres National Forest*, *Santa Barbara County, CA*

Site #	Road Name	TI	Problem	Total estimated future sediment delivery (yd^3)	Hydrologically connected road length (ft)		Comment on Problem	Comment on treatment
					Left	Right		
333	White Rock Trail	M	SC	3	75	80	A ford crossing on a Class II stream across White Rock Trail. One large 2' boulder is located on the outboard road. There is near source bedrock upstream and downstream of the crossing which reduces the potential for erosion. Crossing is full of small to large rocks (9"). The stream is at grade and does not have high erosion potential.	1) Add 1 yd^3 of 0.5'-1.5' of rock armor to the right bank, directly downstream from the crossing to the right of the large 2' boulder.
334	White Rock Trail	-	SC	2	200	80	A ford crossing on a Class II stream. The crossing is stable with no potential for future erosion. Both road approaches are stable with minimal sediment delivery. There is a large amount of aggraded sediment in and upstream of the crossing. No treatment recommended.	No treatment recommendation.
335	White Rock Connector	M	SC	31	15	1800	There is a fill crossing on a low powered Class III stream on White Rock Connector Trail. There is a lot of woody debris in the stream along with 2" trees growing in the stream. There is a headcut on the outboard fillslope, supported by tree roots. Right road is 1,800' long and hydrologically connected. The headcut will migrate upstream and cause erosion.	1) Excavate from TOP to BOT, establish a 4' wide channel bottom with 2:1 sideslopes. 2) Install an armored fill, establish a broad dip through the crossing to convey flow, excavate a keyway (12' wide at the top x 6' wide at the base x 10' long x 2' deep) and install 7 yd^3 of 0.5'-1.5' diameter rock armor. 3) Install 18 rolling dips up the right road approach. 4) Spoil on the left road approach.

Table B1. Field observations and treatment recommendations for road related sites, *Manzana Creek Watershed Anthropogenic Sediment Reduction Assessment, Aquatic Protection and Road Restoration Planning Project*, *Los Padres National Forest*, *Santa Barbara County, CA*

Site #	Road Name	TI	Problem	Total estimated future sediment delivery (yd^3)	Hydrologically connected road length (ft)		Comment on Problem	Comment on treatment
					Left	Right		
336	White Rock Connector	L	SC	10	0	900	A ford crossing through a Class III stream. The streambed is mostly exposed bedrock and is covered in duff. The right road approach has a 41% grade and is hydrologically connected. There is diversion potential down the left road approach from the crossing due to poor channel definition. There is a 3' drop 30' downstream over bedrock and cementitious mineral deposits, which is stable and not likely to migrate headward.	1) Install 1 large rolling dip on the left road adjacent to the bedrock drop, approximately 15' from the stream crossing. 2) Install 1 rolling dip 40' up the right road approach. 3) Install 1 rolling dip 140' up the right road approach.
337	White Rock Connector	M	SC	53	20	200	A fill crossing on a low powered Class III stream. About 15' downstream there is a drop off where the stream cascades 15' down onto the large boulders in a Class III stream. Up the left road approach, there is another low powered Class III stream crossing. There is lots of duff through the crossing. The drop off is down the steep left bank of a large Class III stream at a turn in the stream. The water is eroding the outside bank of this turn at high flows. This bank could be supported by bedrock or large boulders. If this is the case, the future erosion calculations should be reduced.	1) Install 2 rolling dips up the right road approach.

Table B1. Field observations and treatment recommendations for road related sites, *Manzana Creek Watershed Anthropogenic Sediment Reduction Assessment, Aquatic Protection and Road Restoration Planning Project*, *Los Padres National Forest*, *Santa Barbara County, CA*

Site #	Road Name	TI	Problem	Total estimated future sediment delivery (yd^3)	Hydrologically connected road length (ft)		Comment on Problem	Comment on treatment
					Left	Right		
338	White Rock Connector	M	SC	32	0	20	A fill crossing on a steep Class III stream. A headcut is migrating up from the Class II channel below and is currently eroding the outboard road. There is a headcut 20' upstream of the crossing at the bottom of a wedge of aggraded sediment, just under an 18" diameter fallen tree. The large Class II stream below the trail is heavily incised which probably caused the headcut below the crossing to form.	1) Install an armored fill, establish a broad dip through the crossing to convey flow, excavate a keyway (12' wide at the top x 8' wide at the base x 18' long x 2' deep) and install 14 yd^3 of 0.5'-1.5' diameter rock armor. 2) Lower the road an additional 1' through the crossing to reduce diversion potential. 3) Excavate the aggraded material above the crossing from the TOP to Cross Section 2 and establish a 3' wide channel with 2:1 side slopes for 15'.
339	White Rock Connector	M	SC	31	220	0	A ford crossing on a Class III stream in an aggraded alluvial stream valley. The aggraded sediment has pinched the stream and filled in its historic alignment. The stream is now diverted down the right trail and has causes a large gully downstream. The historic channel alignment is heavily vegetated and will require clearing (+2 hrs.). The natural channel alignment should be re-occupied, and the trail rerouted approximately 6' upslope for approximately 100'. The gully should be filled and the current trail outsloped.	1) Excavate from TOP to BOT and establish a 6' wide channel bottom with 2:1 side slopes. 2) Reroute the trail approximately 6' upslope for 100'. 3) Outslope the road and fill the ditch for 75' down the right road approach. 4) Install 2 rolling dips up the left road approach. 5) Establish a ford crossing across the new stream alignment.

Table B1. Field observations and treatment recommendations for road related sites, *Manzana Creek Watershed Anthropogenic Sediment Reduction Assessment, Aquatic Protection and Road Restoration Planning Project*, *Los Padres National Forest*, *Santa Barbara County, CA*

Site #	Road Name	TI	Problem	Total estimated future sediment delivery (yd^3)	Hydrologically connected road length (ft)		Comment on Problem	Comment on treatment
					Left	Right		
340	White Rock Connector	M	SC	24	80	120	A ford crossing on a large Class II stream. The upstream channel is heavily aggraded but 10' downstream of the crossing there is a bedrock drop of 4' that holds grade. Both the left and right road approaches are hydrologically connected but neither is lowering. There is a lobe of soil on the right bank that could erode into the channel and allow a headcut to migrate into the crossing.	1) Excavate the lobe of soil on the right bank of the stream below the BOT and lay back the banks to 2:1 (6 yd^3). 2) Install a grade control structure using 2 yd^3 of 0.5'-1.5' diameter rock armor. 3) Armor the trail through the crossing using 2 yd^3 of 0.5'-1.5' diameter rock armor. Excavate a 2' deep keyway through the crossing to ensure that the headcut below the outboard road does not migrate upslope into the crossing. 4) Retain the 8" diameter live oak on the right bank downstream of the crossing.
341	White Rock Connector	ML	SC	3	0	100	A small fill crossing on a Class III stream. There are cementitious mineral deposits from the TOP to the inboard road. Woody debris and small 2" trees are downstream of the crossing. The right road approach is steep and hydrologically connected. There is aggraded sediment on the left bank.	1) Install an armored fill, establish a broad dip through the crossing to convey flow, excavate a keyway (8' wide at the top x 4' wide at the base x 10' long x 2' deep) and install 4 yd^3 of 0.5'-1.5' diameter rock armor. 2) Layback the left bank downstream of the crossing 2:1 (3 yd^3). 3) Install 1 rolling dip up the right road approach.
342	White Rock Connector	-	SC	5	115	290	A ford crossing on a Class III stream. The stream is densely vegetated up and down from the crossing. Two hydrologically connected road approaches. There is a 3' drop over bedrock 10' downstream of the crossing that is stable and unlikely to migrate headward. Road approaches are stable and deliver minimal sediment. Large boulders litter the stream up and downstream from the crossing.	No treatment recommendation.

Table B1. Field observations and treatment recommendations for road related sites, *Manzana Creek Watershed Anthropogenic Sediment Reduction Assessment, Aquatic Protection and Road Restoration Planning Project, Los Padres National Forest, Santa Barbara County, CA*

Site #	Road Name	TI	Problem	Total estimated future sediment delivery (yd^3)	Hydrologically connected road length (ft) Left	Hydrologically connected road length (ft) Right	Comment on Problem	Comment on treatment
343	Munch Canyon Trail	H	SC	81	200	0	A fill crossing on a rocky, steep Class III stream. Stream flow and road runoff combine at this site and divert down the inboard edge of the road. The diversion has created 2 large gullies through 2 road prisms before delivering to a Class II stream. The road downstream is washed out and will be decommissioned.	1) Decommission the crossing, excavate a channel from TOP to BOT and establish a 4' wide channel bottom and lay back the sideslopes 2:1. 2) Spoil locally to decommission the road.
344	Munch Canyon Trail	H	RS	1105	955	0	420' of hydrologically connected old mining road delivers concentrated road runoff to the outboard fillslope on a road above a switch back. Flows have eroded large gullies through both of the road prisms and caused a massive hillslope failure of approximately 500 yd^3 between the road prisms. The now nearly 700' gully delivers directly to a flowing Class II stream below the lower road. The lower, rawer gully is actively incising headward through the road and up the road bed towards the massive failure site. This road is highly unstable and should be decommissioned from site #209 to #243. The trail can be rerouted up a stream valley at site #209 to the landing above site #243 where it can be connected. The site can and should be treated with heavy equipment.	1) Inplace outslope 955' of the left road approach up to the old mining road, above the landing, including the mining road. 2) Pull back the scarp of the large fill failure 154' wide x 15' deep (103 yd^3). 3) Pull back the scarp of the gully through the lower road (60 yd^3).
501	Lost Valley Trail	L	SC	11	420	75	An undersized 18" corrugated metal pipe was placed in the crossing, which has now almost completely blown out. The crossing was on the former mining road, which is now being maintained as a ford crossing for Lost Valley Trail. The pipe is half buried in the left bank, which is mostly stable. The stream also appears to have reestablished a stable gradient and width. There is a small lobe of future erosion on the left bank that could be easily removed.	1) Pull back the left stream bank for 35' wide x 8' long x 1.5' deep (19 yd^3 excavation). 2) Install 3 rolling dips up the left road.

Table B1. Field observations and treatment recommendations for road related sites, *Manzana Creek Watershed Anthropogenic Sediment Reduction Assessment, Aquatic Protection and Road Restoration Planning Project*, *Los Padres National Forest*, *Santa Barbara County, CA*

Site #	Road Name	TI	Problem	Total estimated future sediment delivery (yd^3)	Hydrologically connected road length (ft)		Comment on Problem	Comment on treatment
					Left	Right		
502	Lost Valley Trail	M	SC	7	45	0	A fill crossing on Lost Valley Trail. The stream has diverted down the right road for 28' and reenters the historical channel 48' below the road. There is an historical channel just below the road that is not occupied by flows anymore. The trail is built on the old mining road through this crossing, which is low gradient.	1) Install an armored fill. Establish a broad dip. Excavate a keyway 10' long x 8' wide x 6' wide x 1' deep. Armor the keyway with 3 yd^3 of 0.5'-1.5' diameter rock armor. 2) Spoil locally to the left of the crossing.
503	Lost Valley Trail	-	SC	2	10	30	A large ford crossing on mainstem Lost Valley Creek. This crossing may have been a former corrugated metal pipe crossing, but no evidence of the crossing or fill material remains. No treatment is needed.	No treatment recommendation.
504	Lost Valley Trail	-	SC	1	55	15	A large ford crossing on Mainstem Lost Valley Creek. There is no formal crossing structure, nor any erosion visible through the crossing.	No treatment recommendation.
505	Lost Valley Trail	-	SC	3	30	175	A 100% washed out culverted crossing resulting in a large ford crossing on Lost Valley Creek. There is no erosion potential and approaches are stable.	No treatment recommendation.
506	Lost Valley Trail	M	RS	102	450	0	A section of Lost Valley Trail that has been constructed at the top of a bank along the outside bend of Lost Valley Creek. The bank is vertical and failing, and the trail is at the edge of the failure and will soon be undermined. The trail can be relocated to the alluvial terrace above the creek for 250 and safely rerouted. The right road approach delivering a very small amount of runoff to the bank as well.	1) Pull back the eroding bank to 1:1 where feasible for 65' wide x 11' long x 3' deep (95 yd^3 of excavation). 2) Reroute the trail upslope for 250' 3) Install 4 rolling dips up the right road approach.

Table B1. Field observations and treatment recommendations for road related sites, *Manzana Creek Watershed Anthropogenic Sediment Reduction Assessment, Aquatic Protection and Road Restoration Planning Project, Los Padres National Forest*, *Santa Barbara County, CA*

Site #	Road Name	TI	Problem	Total estimated future sediment delivery (yd^3)	Hydrologically connected road length (ft)		Comment on Problem	Comment on treatment
					Left	Right		
507	Lost Valley Trail	HM	SC	61	0	170	A fill crossing on a Class III stream at the base of a large alluvial fan. The stream has diverted down the left road for 115', where it gullies through the fill just above Lost Valley Creek. An older diversion gully exists 45' down the left road from the current diversion gully. The road is heavily insloped. Several hundred feet up the right road are two small, but flashy Class III streams that should be treated via installation of rocked rolling dips.	1) Excavate from Top to BOT and establish a stable ford crossing. 2) Pull back the left and right approaches to 3:1 to allow for foot traffic. 3) Install 2 rocked rolling dips up the right road approach at the two flashy Class III streams. Rock each dip for 10' x 6' through the troughs. 4) Spoil locally on the left road.
508	Lost Valley Trail	M	SC	11	10	35	A 100% washed out corrugated metal pipe crossing on the historical mining road that has been replaced by a small armored ford crossing to support to the trail. The armored fill has been dipped out to prevent diversion but lacks an adequate keyway and proper armor construction. The downstream banks are very steep and still have erosion potential. The old pipe from the crossing is still in the channel below.	1) Install an armored fill. Establish a broad dip. Excavate a keyway 12' long x 8' wide x 5' wide x 1.5' deep. Armor the keyway using 5 yd^3 0.5’-1.5' diameter rock armor. 2) Pull back the left bank of the stream below the crossing for 1" wide x 11' long x 1' deep (4 yd^3 of excavation).
509	Lost Valley Trail	H	SC	7	0	17	A large, mostly washed out fill crossing on a flashy Class III stream. The channel is comprised of large boulders and cobble, and a gully is actively eroding from the Class III stream above the crossing to the outboard edge of the road. Approximately 30' of rusted 18" diameter corrugated metal pipe is exposed in the gully.	1) Install an armored fill. Establish a broad dip. Excavate a keyway 8' long x 10' wide x 5' wide 2' deep. Armor the keyway with 6 yd^3 of 0.5’-1.5' diameter rock armor. 2) Remove the exposed corrugated metal pipe from the downstream extent of the crossing. 3) Pull back the gully slopes to 1:1 for 30'.

Table B1. Field observations and treatment recommendations for road related sites, *Manzana Creek Watershed Anthropogenic Sediment Reduction Assessment, Aquatic Protection and Road Restoration Planning Project*, *Los Padres National Forest*, *Santa Barbara County, CA*

Site #	Road Name	TI	Problem	Total estimated future sediment delivery (yd^3)	Hydrologically connected road length (ft)		Comment on Problem	Comment on treatment
					Left	Right		
510	Lost Valley Trail	H	SC	313	50	1900	A corrugated metal pipe crossing on a sizable Class III stream immediately upstream of the confluence with the east fork of Lost Valley Creek. The former road prism is mostly blown out, a large gully has been carved into the fill, and the pipe is exposed in the eroding material upstream of what was likely the inboard edge of the road. The inlet is buried beneath a large wedge of sediment that has aggraded upstream of the road prism, effectively turning the crossing into a fill crossing. There is exposed bedrock below several large headcuts near the BOT, and these are actively eroding headward into the trail and sediment wedge upstream. The channel bottom is bedrock from the BOT to the confluence with Lost Valley Creek. Treatment of this site with hand crews would negate a full decommissioning, and therefore an armored fill is likely the best alternative for treatment. Getting heavy equipment to this site will be impossible without rebuilding a road and over 20 stream crossings from Nira Camp (~3 miles away by trail).	1) Install an armored fill. Establish a broad dip, Reshape the new outboard edge of the trail to 1.5:1 where feasible. Excavate a keyway 25' long x 18' wide x 12" wide x 2.5' deep. Armor the keyway with 42 yd^3 of 0.5’-2.5' diameter rock armor. 2) Install 10 rolling dips up the right road approach.
511	Lost Valley Trail	-	SC	3	220	0	A large ford Crossing on Lost Valley Trail that was likely once a culvert crossing. The crossing is 100% washed out and there is no erosion potential.	No treatment recommendation.
512	Lost Valley Trail	-	SC	5	90	100	A large washed out crossing on Lost Valley Creek. The crossing is now a stable ford, and both road approaches are stable and well-vegetated.	No treatment recommendation.
513	Lost Valley Trail	-	SC	3	320	90	A washed out crossing on Lost Valley Trail. There is no fill material left, both approaches are stable and vegetated.	No treatment recommendation.

Table B1. Field observations and treatment recommendations for road related sites, *Manzana Creek Watershed Anthropogenic Sediment Reduction Assessment, Aquatic Protection and Road Restoration Planning Project*, *Los Padres National Forest*, *Santa Barbara County, CA*

Site #	Road Name	TI	Problem	Total estimated future sediment delivery (yd^3)	Hydrologically connected road length (ft)		Comment on Problem	Comment on treatment
					Left	Right		
514	Lost Valley Trail	-	SC	2	20	370	A 100% washed out crossing on Lost Valley Trail that is now a ford crossing. There is no erosion potential remaining. The channel is down to bedrock and the approaches are stable.	No treatment recommendation.
515	Lost Valley Trail	-	SC	2	205	125	A large ford crossing that was once a crossing on the old mining road but has since been completely washed out. The approaches are stable and there is no potential for erosion within the crossing.	No treatment recommendation.
516	Lost Valley Trail	-	SC	11	95	180	A 100% washed out crossing on the former mining road that is now a stable ford crossing on the trail. There is no potential for erosion.	No treatment recommendation.
517	Lost Valley Trail	-	SC	2	110	60	The downstream-most ford crossing on the East Branch of Lost Valley Creek. The former mining road crossing is gone, and the trail now crosses the creek via a stable ford with no future erosion potential.	No treatment recommendation.
518	Lost Valley Trail	-	SC	4	130	195	The upstream-most ford crossing on Mainstem Lost Valley Creek. The trail leaves this valley and begins to go up the East Branch of the creek after this site. There is no potential erosion at this site.	No treatment recommendation.
519	Lost Valley Trail	-	SC	4	80	106	A ford crossing on the Mainstem of Lost Valley Creek. The crossing appears to be a trail crossing only, whereas many of the other fords were once crossings on the old mining road. This ford is 100% stable and there is no erosion potential.	No treatment recommendation.
520	Lost Valley Trail	-	SC	5	120	125	A large ford crossing on mainstem Lost Valley Creek. The trail is not on the historical mining road alignment and is stable. The mining road stays on the right bank of the stream, while the trail leaves the mining road prism and crosses to the left bank at this site.	No treatment recommendation.

Table B1. Field observations and treatment recommendations for road related sites, *Manzana Creek Watershed Anthropogenic Sediment Reduction Assessment, Aquatic Protection and Road Restoration Planning Project, Los Padres National Forest*, *Santa Barbara County, CA*

Site #	Road Name	TI	Problem	Total estimated future sediment delivery (yd^3)	Hydrologically connected road length (ft)		Comment on Problem	Comment on treatment
					Left	Right		
521	Lost Valley Trail	L	SC	9	220	170	A 100% washed out crossing on the former mining road that is now serving as a ford crossing for the trail. The crossing itself is completely stable, but there is road surface runoff being delivered to the stream via the right road. This flow appears to emanate mostly from a small swale 390' up the right road. A rocked rolling dip would adequately solve this issue.	1) Install 1 rocked rolling dip 390' up the right road approach at the swale. 2) Rock the trail through the dip for 10' wide x 15' long by 8" deep.
522	Lost Valley Trail	-	SC	15	80	300	A ford crossing on mainstem Lost Valley Creek. The crossing is stable, and approaches are as well.	No treatment recommendation.
523	Lost Valley Trail	M	SC	349	200	315	A long, undersized 12" diameter corrugated metal pipe was placed very low in the fill at this former mining road crossing that Lost Valley Trail has been established on. The pipe inlet has been buried and the site now functions as a large fill crossing. The road is very wide at this site, with a large wedge of aggraded sediment upstream of the road prism. It is possible that this site was used as a landing in the past. The natural stream channel is exposed 100' upstream from the inboard edge of the road. There are two relatively small head cuts on the outboard edge of the fill, but there is no evidence of a defined flow path at this site.	1) Excavate a 4' wide x 90' long x 2' deep channel with 2:1 side slopes from the TOP to the OBR (48 yd^3 of excavation) to convey stream flow through the crossing. 2) Install an armored fill. Establish a broad dip, excavate a keyway 30' long x 12' wide x 8' wide x 2' deep. Armor the keyway using 22 yd^3 of 0.5’-1.5' diameter rock armor. 3) Install 2 rolling dips up the right road approach. 4) Source rock for the armored fill locally large cutbank failures 5) Spoil locally to the left and right. 6) Remove the woody debris from the aggraded area above the crossing (2 hours of excavation).

Table B1. Field observations and treatment recommendations for road related sites, *Manzana Creek Watershed Anthropogenic Sediment Reduction Assessment, Aquatic Protection and Road Restoration Planning Project*, *Los Padres National Forest*, *Santa Barbara County, CA*

Site #	Road Name	TI	Problem	Total estimated future sediment delivery (yd^3)	Hydrologically connected road length (ft)		Comment on Problem	Comment on treatment
					Left	Right		
524	Lost Valley Trail	L	RS	60	340	110	340' of hydrologically connected left road delivers to the left hinge of this headwall swale. There is an old gully that formed in the past along the outboard edge of the road but is now stable and vegetated. The road is flat and still may transport sediment and road runoff. There is another swale 255' up the left road that could be treated with a rocked rolling dip.	1) Install 3 rolling dips up the left road. Install 1 rolling dip at the swale 255' up the left road and rock the trail through the dip for 4' wide x 12' long.
525	Lost Valley Trail	ML	SC	125	215	68	An old, plugged corrugated metal pipe crossing on a Class III stream that has become 100% plugged and partially buried. The crossing is now functioning as a fill crossing, and the inlet and upstream channel are buried beneath a large wedge of aggraded sediment. Approximately 40% of the crossing has been washed out since this former mining road was converted into a trail. Site 526 70' up the right road appears to have diverted to this site in the past and likely caused the outboard fill to fail to the right of the crossing. The failure has since stabilized and is vegetated, but approximately 3 yd^3 of perched material remains above the failure.	1) Excavate a 4' wide x 145' long x 2' deep channel with 2:1 side slopes from the TOP to the IBR. Spoil to the left and right of the crossing. 2) Install an armored fill. Establish a broad dip. Excavate a keyway 17' long x 10' wide x 6' wide x 2' deep. Armor the keyway with 10 yd^3 of 0.5'-1.5' diameter rock armor. 3) Pull back the perched fill material remaining above the failure on the right hinge of the crossing for 8' wide x 4' long x 2' deep (3 yd^3).
526	Lost Valley Trail	M	SC	26	0	160	A small, mostly washed out fill crossing on a Class III stream. The former mining road is mostly washed out with a small section of the road remaining. The right bank and right road approach is near vertical and will eventually fail. The cutbank above the right road has also failed and has narrowed the trail bed and surface runoff appears to be contributing to the right bank failure.	1) Install an armored fill. Establish a broad dip. Excavate a keyway 14' long x 12' wide x 6' wide x 1.5' deep. Armor the keyway using 7 yd^3 of 0.5'-1.5' diameter rock armor. 2) Pull back the right outboard edge for 20' wide x 4' long x 1' deep. 3) Install 2 rolling dips on the right road.

Table B1. Field observations and treatment recommendations for road related sites, *Manzana Creek Watershed Anthropogenic Sediment Reduction Assessment, Aquatic Protection and Road Restoration Planning Project, Los Padres National Forest, Santa Barbara County, CA*

Site #	Road Name	TI	Problem	Total estimated future sediment delivery (yd³)	Hydrologically connected road length (ft)		Comment on Problem	Comment on treatment
					Left	Right		
527	Lost Valley Trail	HM	SC	34	0	0	A partially washed out fill crossing on Lost Valley Trail. The historically wide road has failed on the outboard edge and there is now a small 2' trail that is still functioning but at risk of failure as well. The trail should be moved in 8' to allow for the outboard fillslope to be stabilized. There is exposed bedrock at the TOP and BOT of the site within the axis of the stream as well, indicating that most of the fill is gone.	1) Move the trail in 8' through the crossing. 2) Reshape the outboard edge of the trail to 1.5:1 where feasible. 3) Install an armored fill. Establish a broad dip. Excavate a keyway 20' long x 10' wide x 8' wide x 2' deep. Armor the keyway with 13 yd³ of 0.5'-1.5' diameter rock armor.
528	Lost Valley Trail	M	SC	42	530	0	A small fill crossing on Lost Valley trail over a small Class III stream. The outboard edge of the fill is actively eroding and the stream shoots straight down to Lost Valley Creek below the trail. The cutbanks are made of large angular sandstone outcrops. There is a small diversion gully down the right road 20' from the crossing.	1) Install an armored fill. Establish a broad dip. Excavate a keyway 10' long x 7' wide x 5' wide x 1.5' deep. Armor the keyway with 3 yd³ of 0.5'-1.5' diameter rock armor. 2) Install 4 rolling dips up the left road approach.
529	Lost Valley Trail	HM	SC	4	10	10	An old corrugated metal pipe crossing is 100% plugged with the inlet buried. The lower half of the pipe is exposed downstream and the crossing is functioning as a fill crossing. Both the left and right hinges have been built up to prevent diversion. A plywood retaining wall has been placed on the outboard fillslope in the axis of the stream to buttress the fill, but water is carving around it and it will soon fail. It appears that the stream at this site did once divert down the right road as well.	1) Install an armored fill. Establish a broad dip. Excavate a keyway 16' long x 12' wide x 8' wide x 2' deep. Armor the keyway with 12 yd³ of 0.5'-1.5' diameter rock armor.

Table B1. Field observations and treatment recommendations for road related sites, *Manzana Creek Watershed Anthropogenic Sediment Reduction Assessment, Aquatic Protection and Road Restoration Planning Project*, *Los Padres National Forest*, *Santa Barbara County, CA*

Site #	Road Name	TI	Problem	Total estimated future sediment delivery (yd³)	Hydrologically connected road length (ft)		Comment on Problem	Comment on treatment
					Left	Right		
530	Lost Valley Trail	L	SC	37	800	0	A small fill crossing on a Class III stream. There is no formal drainage structure at this site and a small headcut has formed on the outboard edge of the fill. There is 800' of hydrologically connected left road, which is delivering sediment to the crossing.	1) Install an armored fill. Establish a broad dip. Excavate a keyway 6' long x 6' wide x 4' wide x 1.5' deep. Armor the keyway using 2 yd^3 of 0.5’-1.0’ diameter rock armor. 2) Install 7 rolling dips up the left road.
531	Lost Valley Trail	M	RS	187	0	770	770' of hydrologically connected road delivers to a Class III stream on a large alluvial terrace 500' upslope of Manzana Creek. The former mining road is comprised of sand and silt with intermixed gravels. A 1' x 1' gully has carved through the road bed in a through-cut section. The road goes in and out of several other through-cut sections over the 770' of total connected road.	1) Inslope the road and keep the ditch for 100' up the right road beginning at the crossing. 2) Relocate the trail to the outboard edge of the road to prevent foot traffic from eroding the barren slope of the former road bed for 100' beginning at the crossing. 3) Outslope the road and fill the ditch for 75' beginning at the end of the insloping treatment. 4) Install 4 rolling dips up the right road beginning at the end of the outsloping treatments 175' up the right road.
532	Lost Valley Trail	ML	SC	35	350	15	A small fill crossing on a Class III stream on Lost Valley Trail. There is a small headcut on the outboard edge of fill and erosion on the trail bed from road surface runoff. The left road approach delivers a considerable amount of road runoff to this site. If equipment is utilized to treat this site, the left road should be outsloped.	1) Establish a ford crossing. Excavate a 4' wide channel from TOP to BOT with 2:1 side slopes. Armor the trail through the ford for 10' long x 8' wide x 8" deep using 3 yd^3 of 0.5’-1.0 diameter rock armor. 2) Install 1 Type III rolling dip up the left road approach and breach the berm for 15'. Install this rolling dip at the top of the left road. 3) Install 3 Type I rolling dips up the left road.

Table B1. Field observations and treatment recommendations for road related sites, *Manzana Creek Watershed Anthropogenic Sediment Reduction Assessment, Aquatic Protection and Road Restoration Planning Project*, *Los Padres National Forest*, *Santa Barbara County, CA*

Site #	Road Name	TI	Problem	Total estimated future sediment delivery (yd^3)	Hydrologically connected road length (ft)		Comment on Problem	Comment on treatment
					Left	Right		
533	Lost Valley Trail	M	SC	127	330	0	A former corrugated metal pipe crossing on a Class III stream. The inlet is buried under a large sediment fan that has been trapped behind the inboard edge of the road and built up over time. The stream is diverting down the right road for 20, where it is scouring a gully through the outboard edge of the fill. A second diversion gully that is no longer being actively eroded exists 50' further down the road. The outlet of the CMP is hanging above a large outcrop of uplifted sandstone beds.	1) Excavate a channel 72' long x 2' deep x 4' wide with 2:1 side slopes from the TOP to the outboard edge of the road to convey stream flow to the crossing. 2) Install an armored fill. Establish a broad dip. Excavate a keyway 12' wide x 7' wide x 22' long x 1.5' deep. Armor the keyway with 11 yd^3 o.5-1.5' diameter rock armor. 3) Pull back the scarp of the diversion gully for 20' wide x 5' deep x 2' deep. 4) Lower the trail through the crossing by 3' to establish a critical dip and prevent diversion. 5) Install 3 rolling dips up the left road approach.
534	Lost Valley Trail	L	SC	27	180	15	A fill crossing on a low-power, near-origin Class III stream. There is a small headcut on the outboard edge of the fill, but there is very little drainage area and little erosion. 180' of left road also contributes flow to the stream, but erosion is relatively minor and there are no visible signs of rilling or gullying.	1) Install an armored fill. Establish a broad dip. Excavate a keyway 11' long x 8' wide x 5' wide x 1.5' deep. Armor the keyway 4 yd^3 of 0.5'-1.0' diameter rock armor. 2) Install 1 Type III rolling dip up the left road and breach the berm for 15' through the trough of the dip.
535	Lost Valley Trail	L	SC	42	100	0	A small but springy swale delivers to a Class II stream below this fill crossing via a diversion that goes 100' down the left road approach. A 1' x 2' x 80' gully has carved down to bedrock at the outlet of the diversion. An historical channel alignment exists just over the outboard edge of the road from the swale upstream.	1) Install an armored fill. Establish a broad dip. Excavate a keyway 12' long x 12' wide x 4' wide x 1.5' deep. Armor the keyway with 5 yd^3 of 0.5’-1.5' diameter rock armor. 2) Ensure that a broad critical dip is built along the left hinge of the crossing to prevent future diversion.

Table B1. Field observations and treatment recommendations for road related sites, *Manzana Creek Watershed Anthropogenic Sediment Reduction Assessment, Aquatic Protection and Road Restoration Planning Project, Los Padres National Forest*, *Santa Barbara County, CA*

Site #	Road Name	TI	Problem	Total estimated future sediment delivery (yd^3)	Hydrologically connected road length (ft)		Comment on Problem	Comment on treatment
					Left	Right		
536	Lost Valley Trail	ML	RS	40	830	0	A long section of hydrologically connected road that varies in shape from insloped to through-cut to outslope as it extends downslope and runs adjacent to a Class III stream where multiple road surface discharge points are. The Road is in poor condition and has obviously eroded extensively since it was last used for vehicles.	1) Install rilling dips up the left road approach. 2) Inslope the left road for 150' up from the discharge point, and clean and cut the ditch for 150' as well.
537	Lost Valley Trail	L	SC	13	180	0	A corrugated metal pipe crossing on a Class III stream. Two 2x1 streams converge upstream of the 12" diameter pipe and pass under the trail and former mining road prism. The outlet is half plugged, and the inlet is nearly half plugged with fine sediment as well. Most of the sediment is emanating from the road surface discharge at Site 536. The stream also appears to overtop the inboard edge of the road and flow across to the downstream extent of the crossing. The left road is hydrologically connected, but the road runoff is mostly bypassing the site.	1) Excavate TOP to BOT and remove the existing, undersized pipe. 2) Establish a stable ford crossing. Excavate a 4' wide channel from TOP to BOT and shape the banks back to 3:1 to allow for foot traffic. 3) Rock the trail through the crossing for 4' wide x 12' long. 4) Install 2 rolling dips up the left road approach.
538	Lost Valley Trail	M	RS	36	370	0	370' of hydrologically connected left road and ditch deliver to a Class III stream at a switch back on the trail. This is the last site on Lost Valley trail before the intersection with Manzana Creek Trail. There are two sizable gullies that have eroded through the former mining road prism just above the trail intersection. The sediment fans from these gullies are clearly visible in the side channel of Manzana Creek below the road prism.	1) Install 3 rolling dips up the left road approach.
538.1	Lost Valley Trail	N/A	SC	2	50	65	A class III stream crosses through a campground site and fans out onto this alluvial valley where the stream footprint is almost lost. The trail crosses this alluvial valley without any issues.	No treatment recommendation.

Table B1. Field observations and treatment recommendations for road related sites, *Manzana Creek Watershed Anthropogenic Sediment Reduction Assessment, Aquatic Protection and Road Restoration Planning Project*, *Los Padres National Forest*, *Santa Barbara County, CA*

Site #	Road Name	TI	Problem	Total estimated future sediment delivery (yd^3)	Hydrologically connected road length (ft)		Comment on Problem	Comment on treatment
					Left	Right		
538.2	Lost Valley Trail	N/A	SC	0	20	15	A Class III stream crosses a section of Lost Valley Trail that runs through an undeveloped campsite. The stream crossing does not have any formal drainage structure and is relatively stable in its current condition.	No treatment recommendation.

Appendix C

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

Manzana Creek Watershed Anthropogenic Sediment Reduction Assessment, Aquatic Protection and Road Restoration Planning Project Los Padres National Forest, Santa Barbara, California

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
17	Typical construction of road decompaction and cross road drain installation
18	Typical rock grade control structure installation
19a	Standard (Type 1) rolling dip construction
19b	Type 2 rolling dip construction for through-cut or thick berm road reaches
19c	Type 3 rolling dip construction for steep slope road reaches
20	Typical ford crossing installation
21	Typical design for de-watering streams

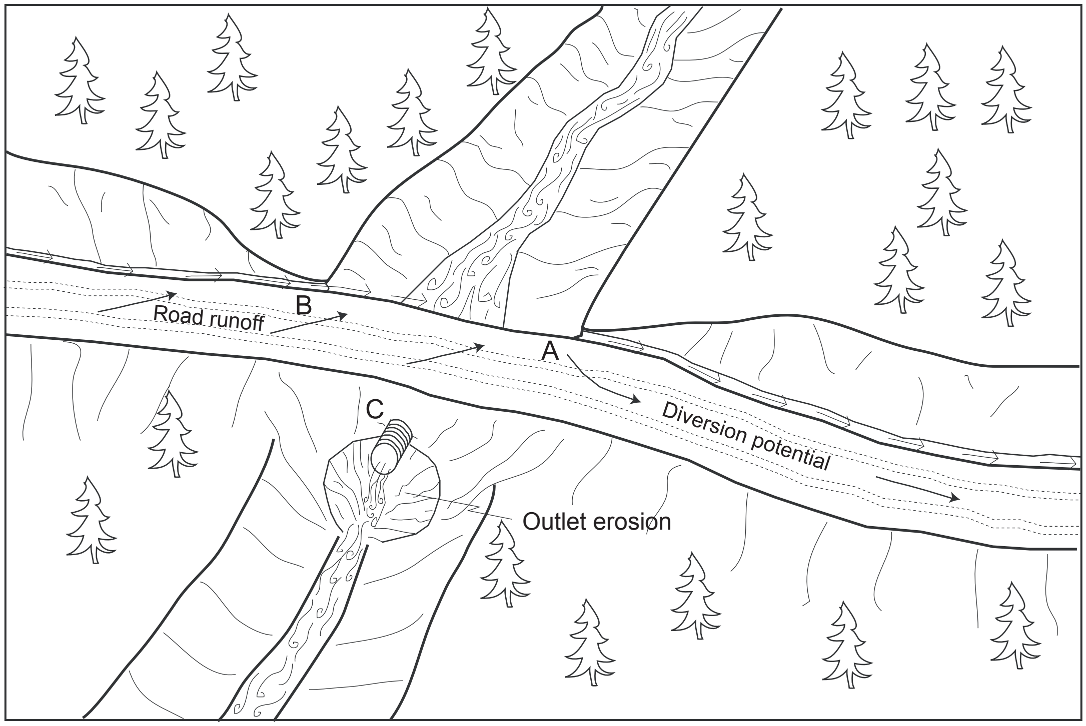
Typical Problems and Applied Treatments for a Non-fish Bearing Upgraded Stream Crossing

Problem condition (before)

A - Diversion potential

B - Road surface and ditch drain to stream

C - Undersized culvert high in fill with outlet erosion

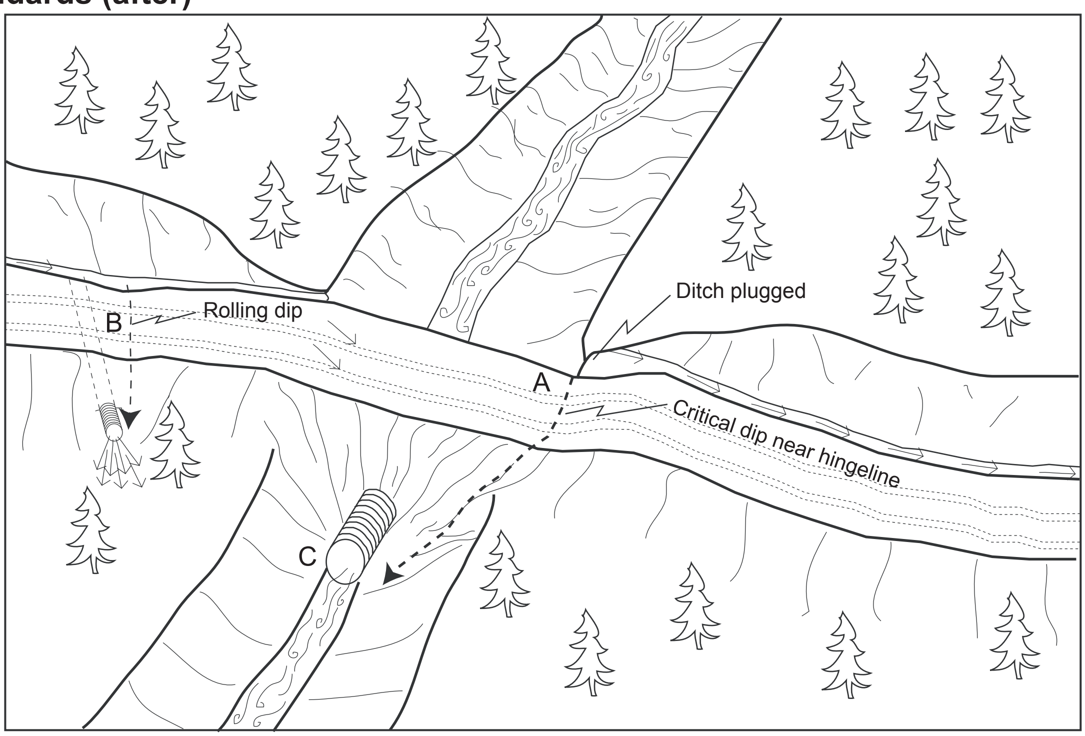


Treatment standards (after)

A - No diversion potential with critical dip installed near hingeline

B - Road surface and ditch disconnected from stream by rolling dip and ditch relief culvert

C - 100-year culvert set at base of fill



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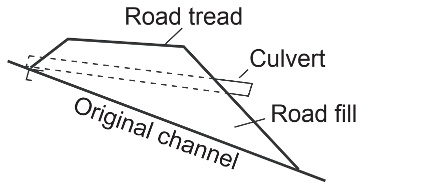
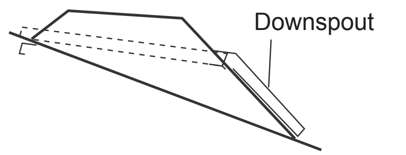
Typical Design of a Non-fish Bearing Culverted Stream Crossing

Existing



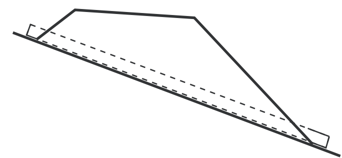
1. Culvert not placed at channel grade.
2. culvert does not extend past base of fill.

Upgraded



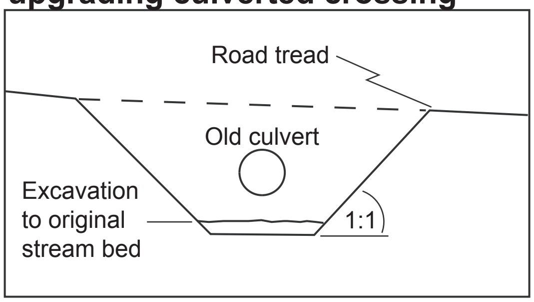
1. Culvert not placed at channel grade.
2. Downspout added to extend outlet past road fill.

Upgraded (preferred)

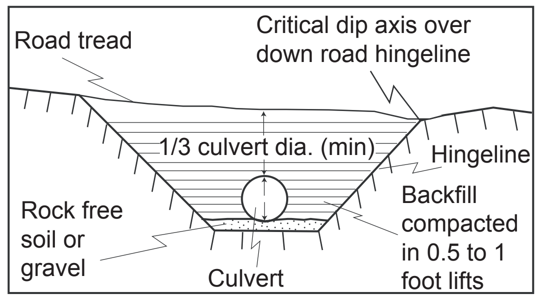


1. Culvert placed at channel grade.
2. Culvert inlet and outlet rest on, or partially in, the originial streambed.

Excavation in preparation for upgrading culverted crossing



Upgraded stream crossing culvert installation



Note:
Road upgrading tasks typically include upgrading stream crossings by installing larger culverts and inlet protection (trash barriers) to prevent plugging. Culvert sizing for the 100-year peak storm flow should be determined by both field observation and calulations using a procedure such as the Rational Formula.

Stream crossing culvert Installation

1. Culverts shall be aligned with natural stream channels to ensure proper function, and prevent bank erosion and plugging by debris.
2. Culverts shall be placed at the base of the fill and the grade of the original streambed, or downspouted past the base of the fill.
3. Culverts shall be set slightly below the original stream grade so that the water drops several inches as it enters the pipe.
5. To allow for sagging after burial, a camber shall be between 1.5 to 3 incher per 10 feet culvert pipe length.
6. Backfill material shall be free of rocks, limbs or other debris that could dent or puncture the pipe or allow water to seep around pipe.
7. First one end then the other end of the culvert shall be covered and secured. The center is covered last.
8. Backfill material shall be tamped and compacted throughout the entire process:
   - Base and side wall material will be compacted before the pipe is placed in its bed.
   - Backfill compacting will be done in 0.5 - 1 foot lifts until 1/3 of the diameter of the culvert has been covered. A gas powered tamper can be used for this work.
9. Inlets and outlets shall be armored with rock or mulched and seeded with grass as needed.
10. Trash protectors shall be installed just upstream from the culvert where there is a hazard of floating debris plugging the culvert.
11. Layers of fill will be pushed over the crossing until the final designed road grade is achieved, at a minimum of 1/3 to 1/2 the culvert diameter.

Erosion control measures for culvert replacement

Both mechanical and vegetative measures will be employed to minimize accelerated erosion from stream crossing and ditch relief culvert upgrading. Erosion control measures implemented will be evaluated on a site by site basis. Erosion control measures include but are not limited to:

1. Minimizing soil exposure by limiting excavation areas and heavy equipment distrubance.
2. Installing filter windrows of slash at the base of the road fill to minimize the movement of eroded soil to downslope areas and stream channels.
3. Retaining rooted trees and shrubs at the base of the fill as “anchor” for the fill and filter windrows.
4. Bare slopes created by construction operations will be protected until vegetation can stabilize the surface. Surface erosion on exposed cuts and fills will be minimized by mulching, seeding, planting, compacting, armoring, and/or benching prior to the first rains.
5. Excess or unusable soil will be stored in long term spoil disposal locations that are not limited by factors such as excessive moisture, steep slopes greater than 10%, archeology potential, or proximity to a watercourse.
6. On running streams, water will be pumped or diverted past the crossing and into the downstream channel during the construction process.
7. Straw bales and/or silt fencing will be employed where necessary to control runoff within the construction zone.

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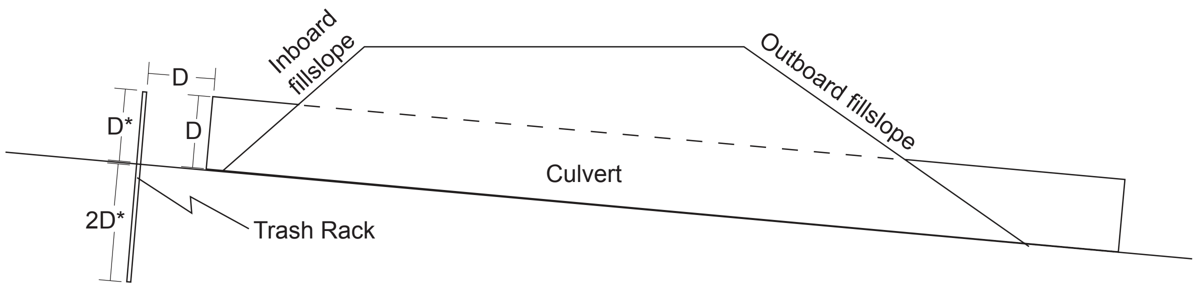
Typical Design of a Single-post Culvert Inlet Trash Rack

Cross section view



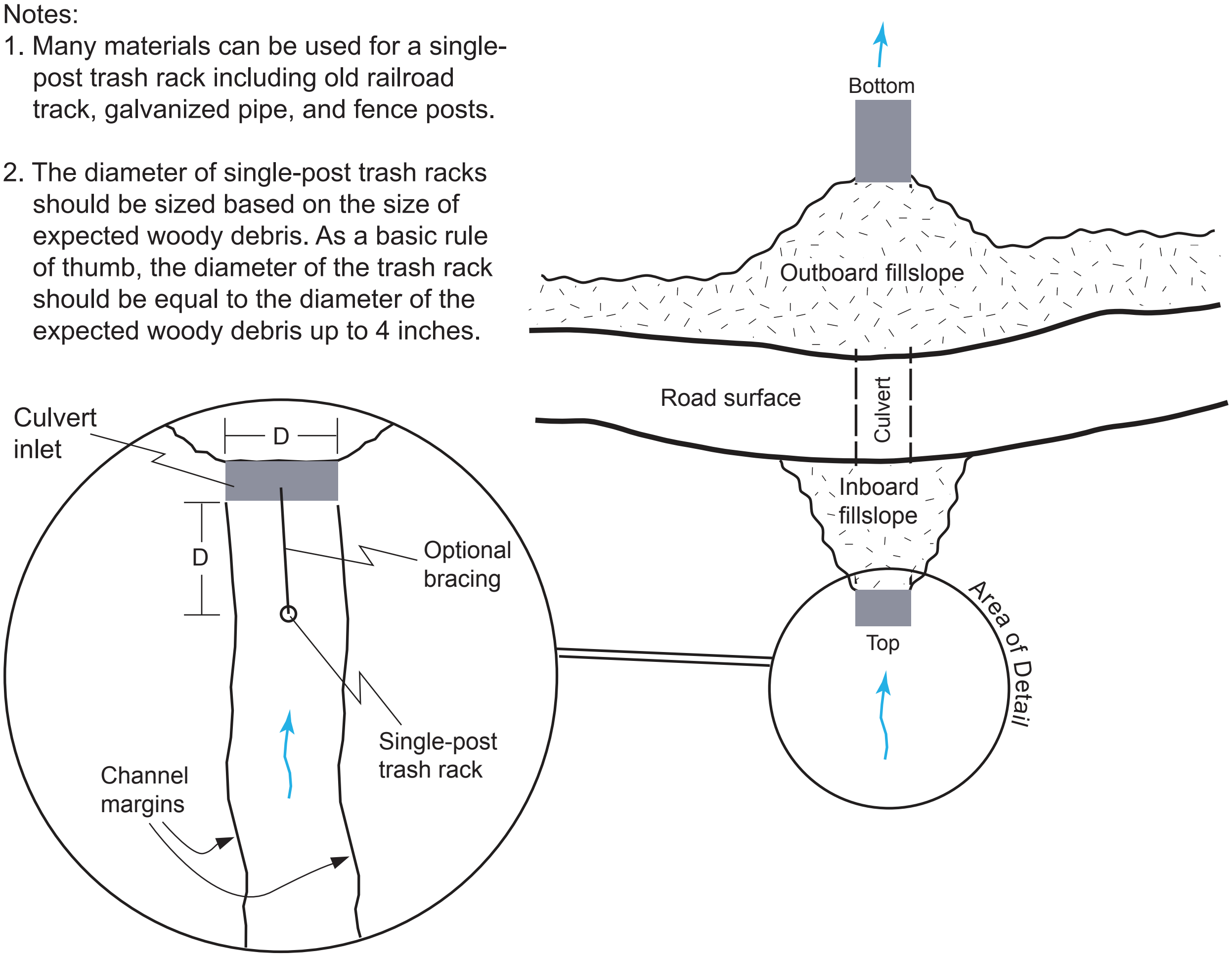
D - Culvert diameter
D* - If the culvert is designed for the 100-year peak storm flow, the trash rack height above the streambed should equal D.
If the culvert is undersized, then the trash rack needs to be extended vertically above the streambed to match or exceed the expected headwall height.

Plan view

Notes:

1. Many materials can be used for a single-post trash rack including old railroad track, galvanized pipe, and fence posts.

2. The diameter of single-post trash racks should be sized based on the size of expected woody debris. As a basic rule of thumb, the diameter of the trash rack should be equal to the diameter of the expected woody debris up to 4 inches.



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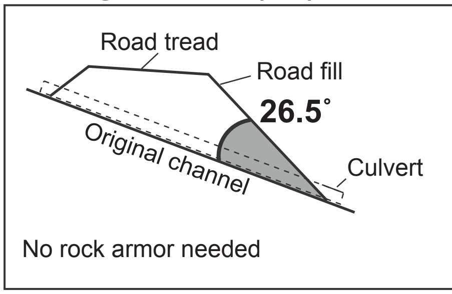
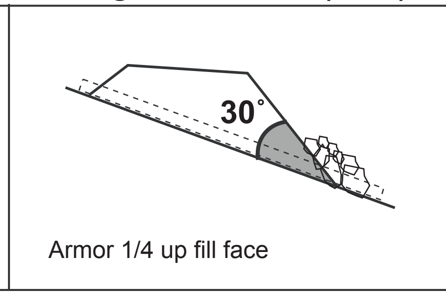
Typical Design of Stream Crossing Fill Armor

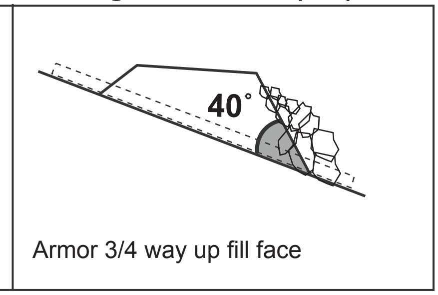
Fill angles ≤26.5° (2:1)



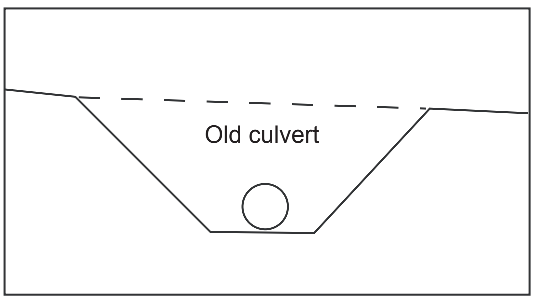
Fill angles 26.5° - 35° (1.5:1)



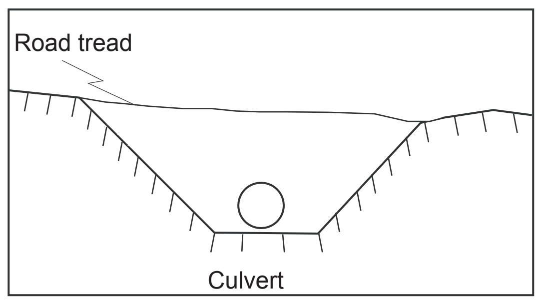
Fill angles 35° - 45° (1:1)



Fill angles 26.5° - 35° (1.5:1)



Fill angles 35° - 45° (1:1)



Note:
Road upgrading tasks typically include upgrading stream crossings by installing larger culverts and inlet protection (trash barriers) to prevent plugging. Culvert sizing for the 100-year peak storm flow should be determined by both field observation and calculations using a procedure such as the Rational Formula.

Stream crossing culvert Installation

1. Culverts shall be aligned with natural stream channels to ensure proper function, and prevent bank erosion and plugging by debris.
2. Culverts shall be placed at the base of the fill and the grade of the original streambed or downspouted past the base of the fill.
3. Culverts shall be set slightly below the original stream grade so that the water drops several inches as it enters the pipe.
5. To allow for sagging after burial, a camber shall be between 1.5 to 3 incher per 10 feet culvert pipe length.
6. Backfill material shall be free of rocks, limbs or other debris that could dent or puncture the pipe or allow water to seep around pipe.
7. First one end and then the other end of the culvert shall be covered and secured. The center is covered last.
8. Backfill material shall be tamped and compacted throughout the entire process:
   - Base and side wall material will be compacted before the pipe is placed in its bed.
   - Backfill compacting will be done in 0.5 - 1 foot lifts until 1/3 of the diameter of the culvert has been covered. A gas powered tamper can be used for this work.
9. Inlets and outlets shall be armored with rock or mulched and seeded with grass as needed.
10. Trash protectors shall be installed just upstream from the culvert where there is a hazard of floating debris plugging the culvert.
11. Layers of fill will be pushed over the crossing until the final designed road grade is achieved, at a minimum of 1/3 to 1/2 the culvert diameter.

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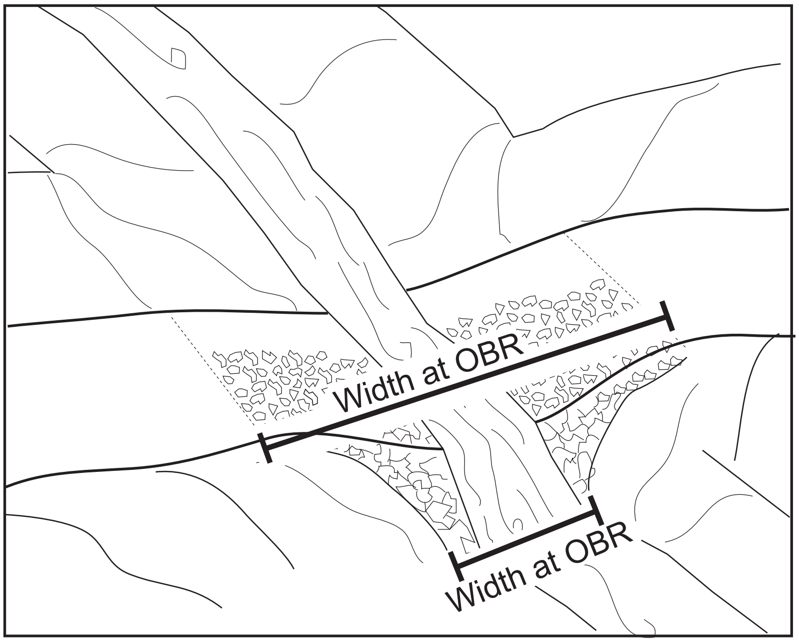
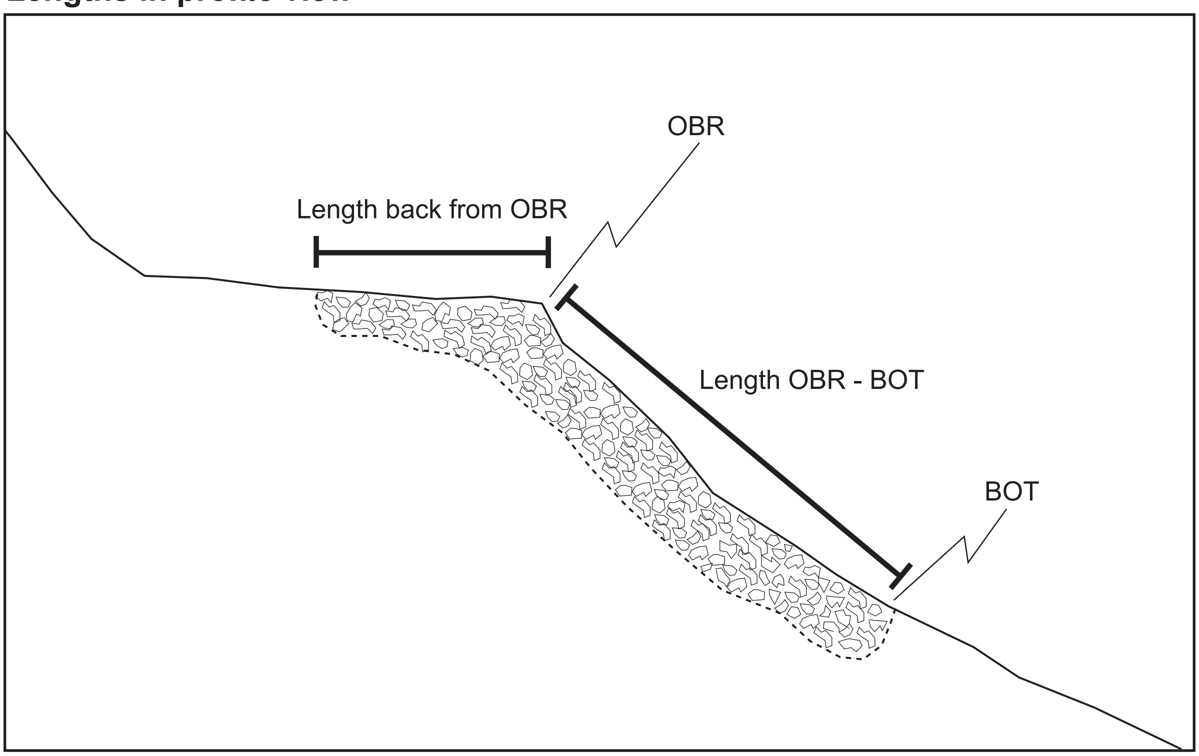
Typical Dimensions Refered to for Armored Fill Crossings

Widths in oblique view



OBR - Outboard edge of road

Lengths in profile view



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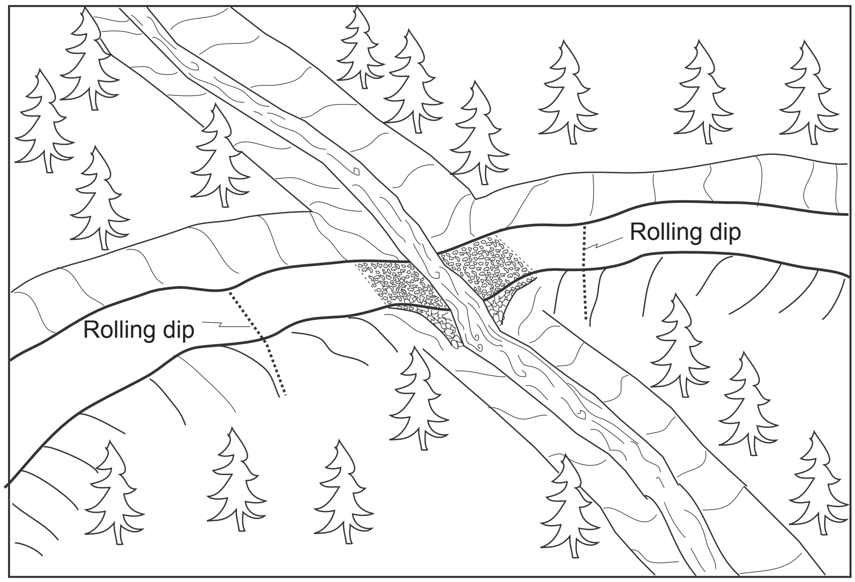
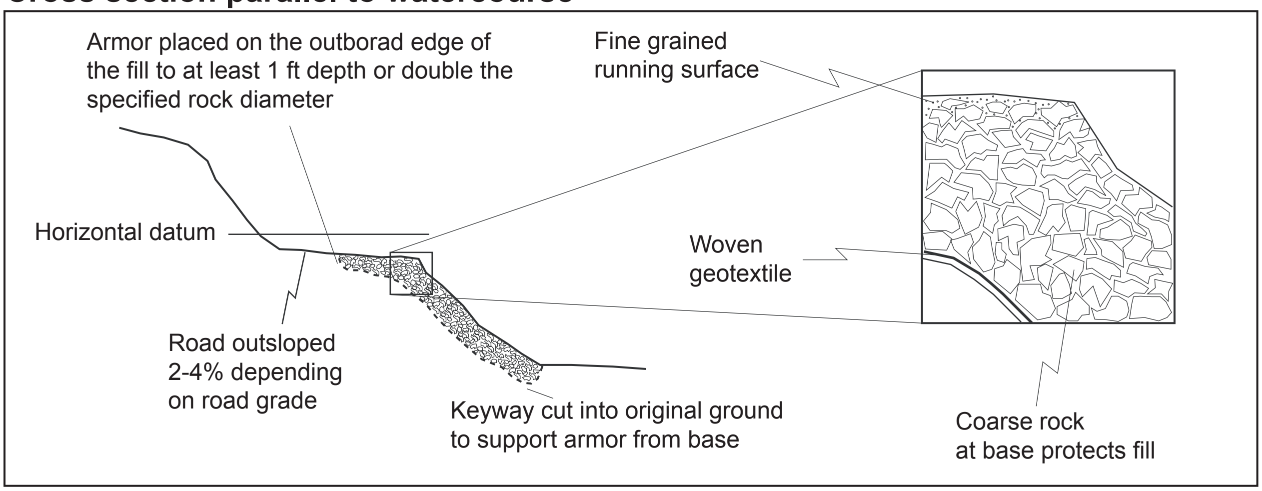
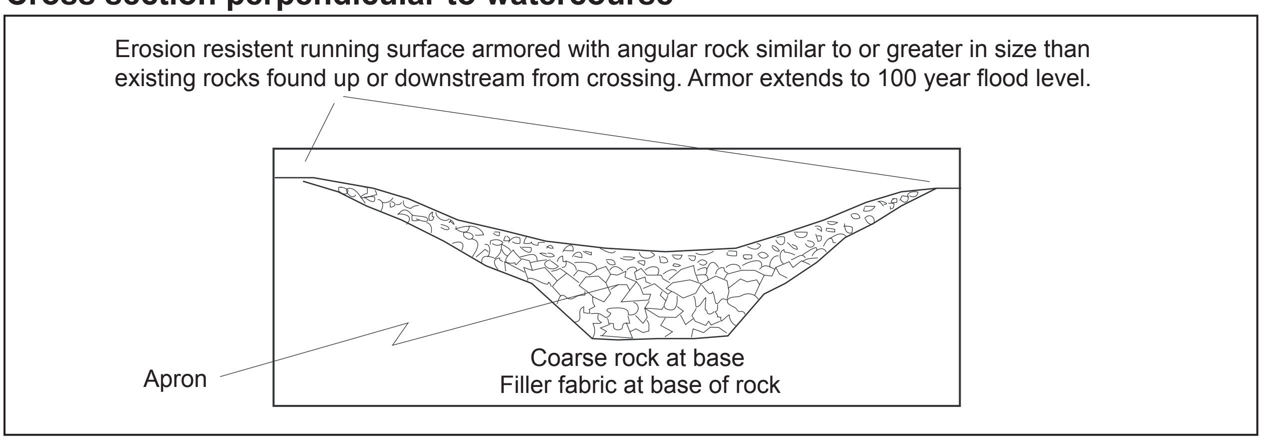
Typical Armored Fill Crossing Installation



Cross section parallel to watercourse



Cross section perpendicular to watercourse



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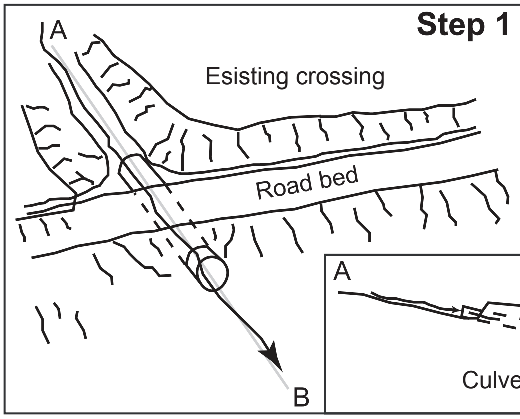
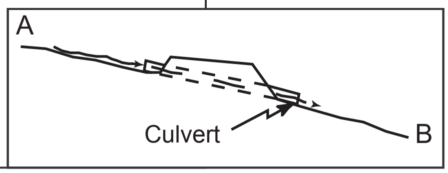
Ten Steps for Constructing a Typical Armored Fill Stream Crossing

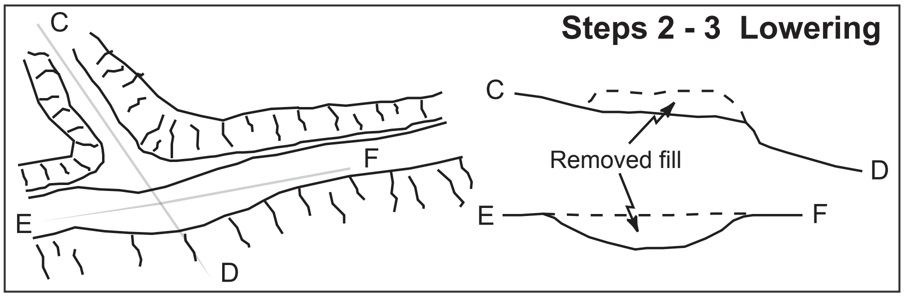




1. The two most important points are:

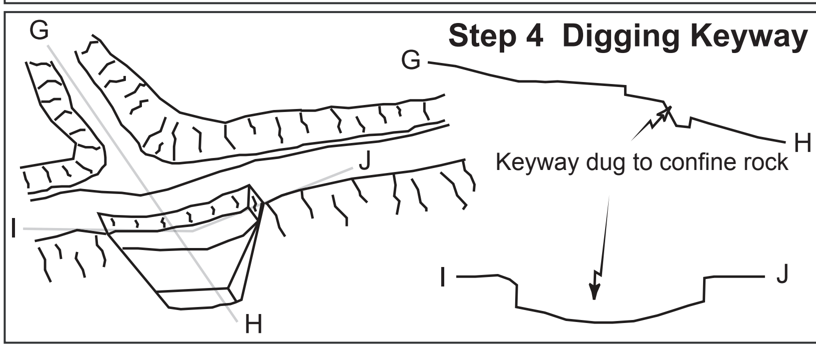
A) **The rock must be placed in a "U" shape across the channel to confine flow within the armored area.** (Flow around the rock armor will gully the remaining fill. Proper shape of surrounding road fill and good rock placement will reduce the likelihood of crossing failure).

B) **The largest rocks must be used to buttress the rest of the armor in two locations:** (i) The base of the armored fill where the fill meets natural channel. (This will butress the armor placed on the outboard fill face and reduce the likelihood of it washing downslope). (ii) The break in slope from the road tread to the outer fill face. (This will butress the fill placed on the outer road tread and will determine the "base level" of the creek as it crosses the road surface).



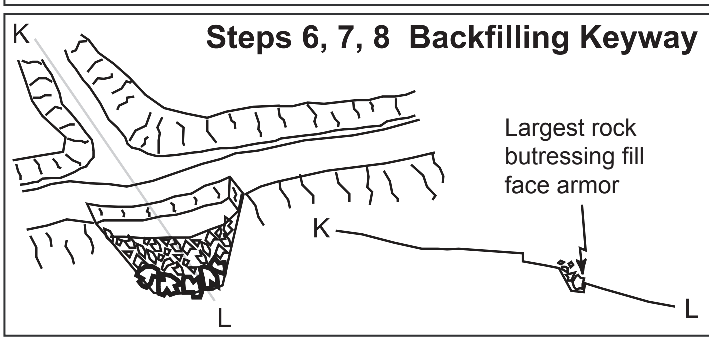
2. Remove any existing drainage structures including culverts and Humboldt logs.

3. Construct a dip centered at the crossing that is large enough to accomodate the 100-year peak storm flow and prevent diversion (C-D, E-F).



4. Dig a keyway (to place rock in) that extends from the outer 1/3 of the road tread down the outboard road fill to the point where outbaord fill meets natural channel (up to 3 feet into the channel bed depending on site specifics) (G-H, I-J).

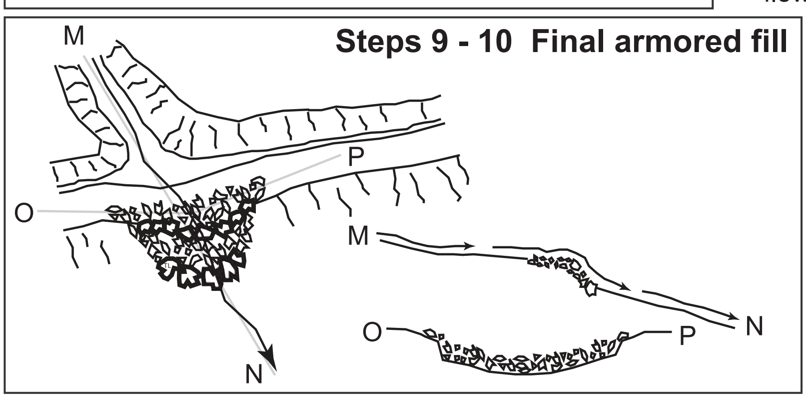
5. Install geofabric (optional) within keyway to support rock in wet areas and to prevent winnowing of the crossing at low flows.



6. Put aside the largest rock armoring to create 2 buttresses in the next step.

7. Create a buttress using the largest rock (as described in the site treatments specifications) at the base of fill. (This should have a "U" shape to it and will define the outlet of the armored fill.)

8. Backfill the fill face with remaining rock armor making sure the final armored area has "U" shape that will accomodate the largest expected flow (K-L).



9. Install a second buttress at the break in slope between the outboard road and the outboard fill face. (This should define the base level of the stream and determine how deep the stream will backfill after construction). (M-N)

10. Back fill the rest of the keyway with the unsorted rock armor making sure the final armored area has a "U" shape that will accommodate the largest expected flow (O-P).

Typical Drawing #7

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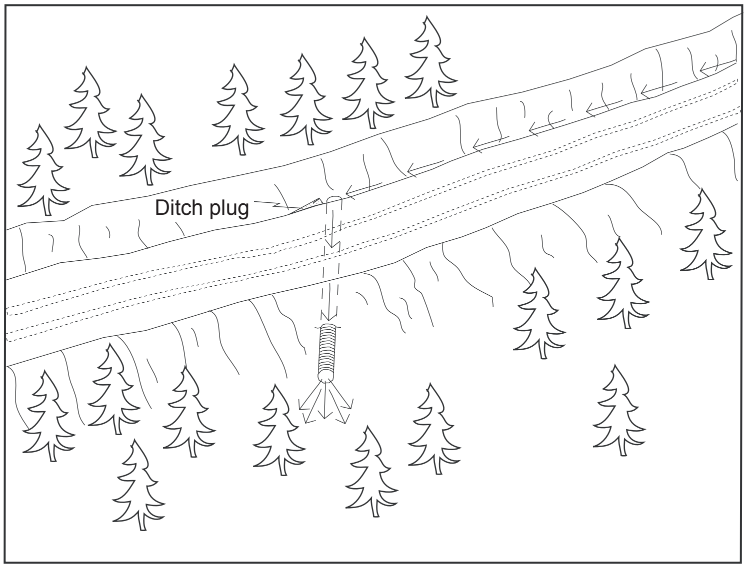
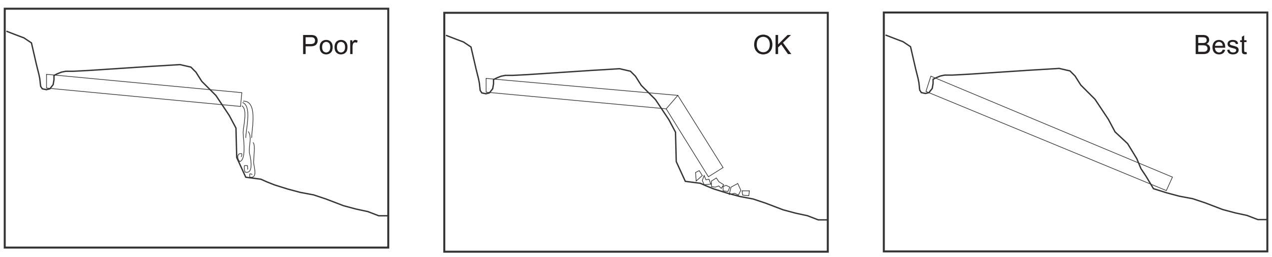
Typical Ditch Relief Culvert Installation





Ditch relief culvert installation

1) The same basic steps followed for stream crossing installation shall be employed.
2) Culverts shall be installed at a 30 degree angle to the ditch to lessen the chance of inlet erosion and plugging.
3) Culverts shall be seated on the natural slope or at a minimum depth of 5 feet at the outside edge of the road, whichever is less.
4) At a minimum, culverts shall be installed at a slope of 2 to 4 percent steeper than the approaching ditch grade, or at least 5 inches every 10 feet.
5) Backfill shall be compacted from the bed to a depth of 1 foot or 1/3 of the culvert diameter, which ever is greater, over the top of the culvert.
6) Culvert outlets shall extend beyond the base of the road fill (or a flume downspout will be used). 7Culverts will be seated on the natural slope or at a depth of 5 feet at the outside edge of the road, whichever is less.

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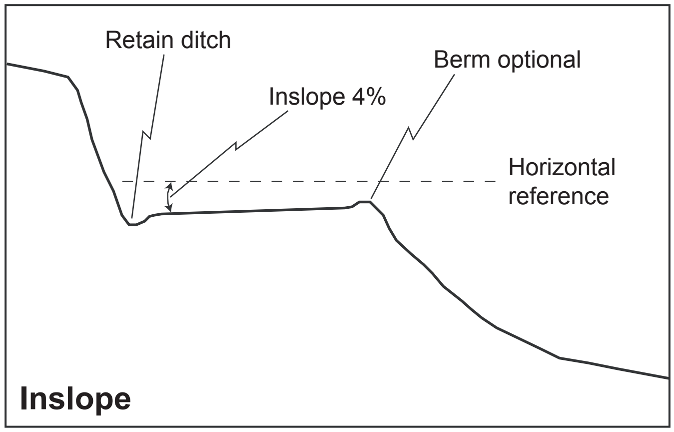
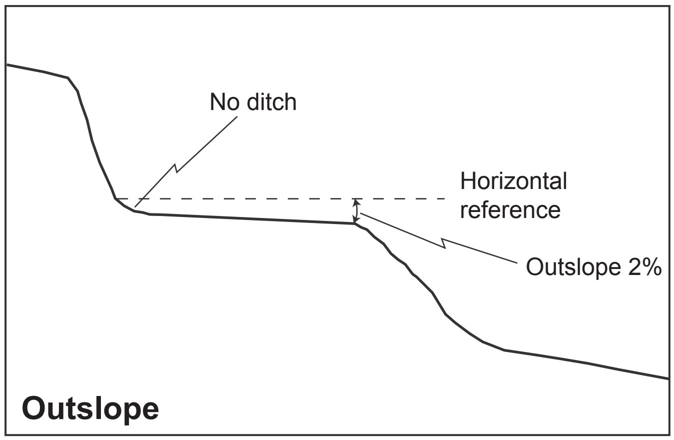
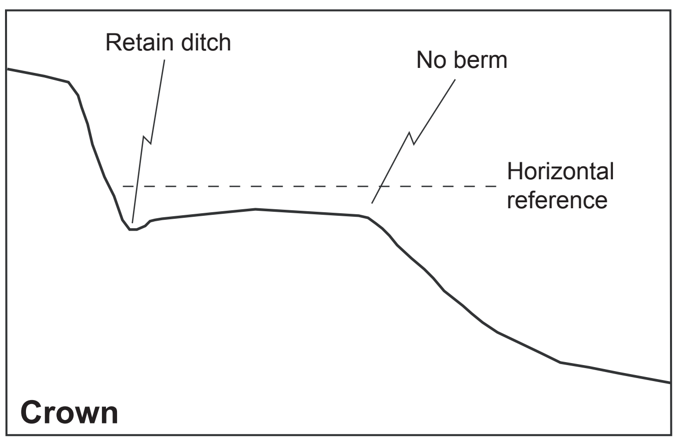
Typical Designs for Using Road Shape to Control Road Runoff







Outsloping Pitch for Roads Up to 8% Grade		
Road grade	**Unsurfaced roads**	**Surfaced roads**
4% or less	3/8" per foot	1/2" per foot
5%	1/2" per foot	5/8" per foot
6%	5/8" per foot	3/4" per foot
7%	3/4" per foot	7/8" per foot
8% or more	1" per foot	1 1/4" per foot

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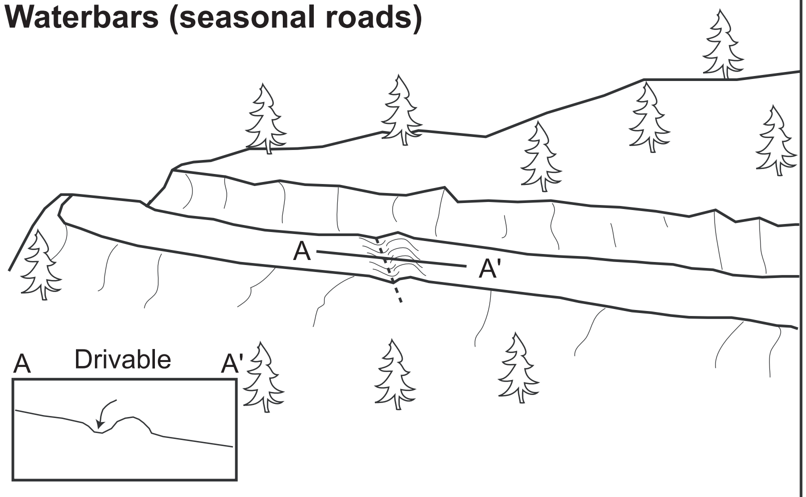
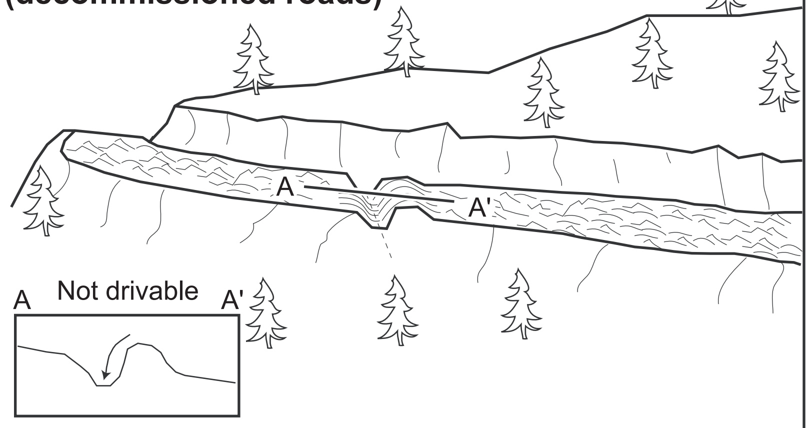
Typical Methods for Dispersing Road Surface Runoff with Waterbars, Cross-road Drains, and Rolling Dips

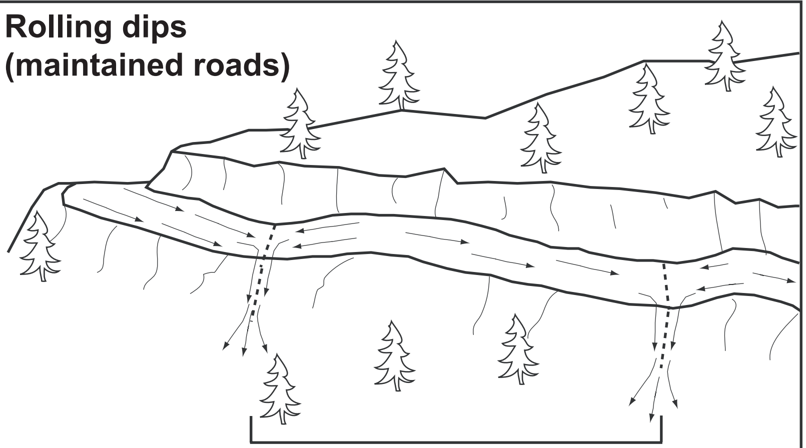
Waterbars (seasonal roads)



Cross-road drain and decompaction (decommissioned roads)



Rolling dips (maintained roads)



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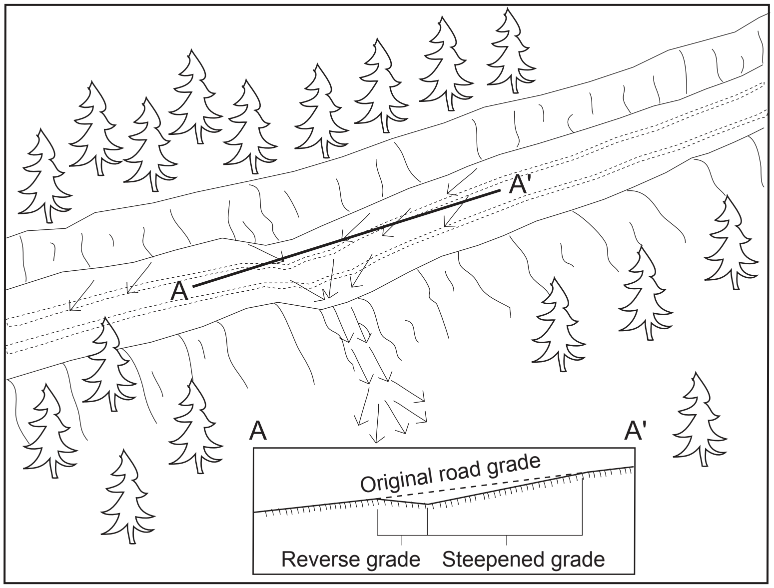
Typical Road Surface Drainage by Rolling Dips



Rolling dip installation:

1. Rolling dips will be installed in the roadbed as needed to drain the road surface.
2. Rolling dips will be sloped either into the ditch or to the outside of the road edge as required to properly drain the road.
3. Rolling dips are usually built at 30 to 45 degree angles to the road alignment with cross road grade of at least 1% greater than the grade of the road.
4. Excavation for the dips will be done with a medium-size bulldozer or similar equipment.
5. Excavation of the dips will begin 50 to 100 feet up road from where the axis of the dip is planned as per guidelines established in the rolling dip dimensions table.
6. Material will be progressively excavated from the roadbed, steepening the grade unitl the axis is reached.
7. The depth of the dip will be determined by the grade of the road (see table below).
8. On the down road side of the rolling dip axis, a grade change will be installed to prevent the runoff from continuing down the road (see figure above).
9. The rise in the reverse grade will be carried for about 10 to 20 feet and then return to the original slope.
10. The transition from axis to bottom, through rising grade to falling grade, will be in a road distance of at least 15 to 30 feet.

Table of rolling dip dimensions by road grade

Road grade %	**Upslope approach distance** (from up road start to trough) ft	**Reverse grade distance** (from trough to crest) ft	**Depth at trough outlet** (below average road grade) ft	**Depth at trough inlet** (below average road grade) ft
<6	55	15 - 20	0.9	0.3
8	65	15 - 20	1.0	0.2
10	75	15 - 20	1.1	0.01
12	85	20 - 25	1.2	0.01
>12	100	20 - 25	1.3	0.01

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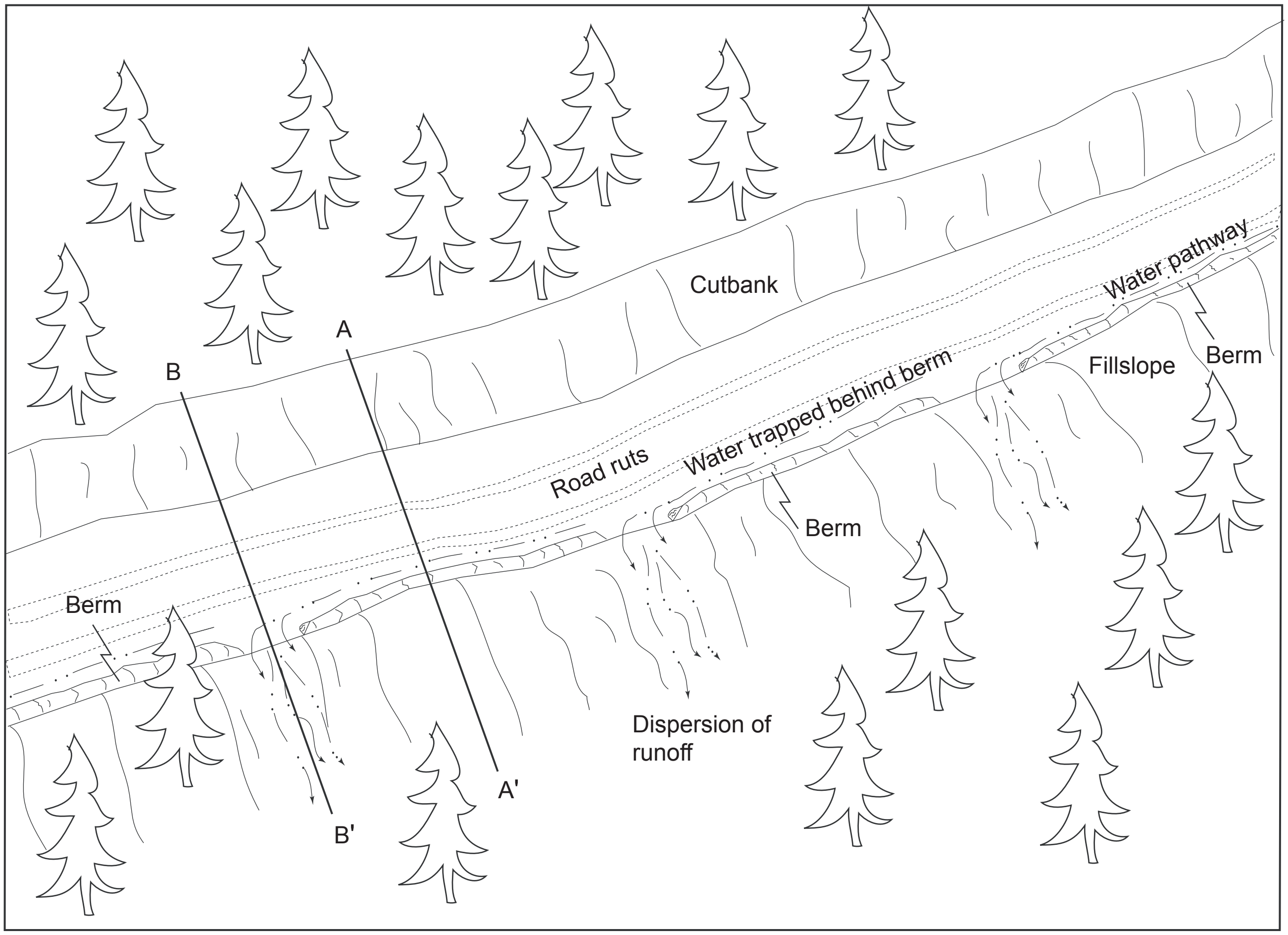
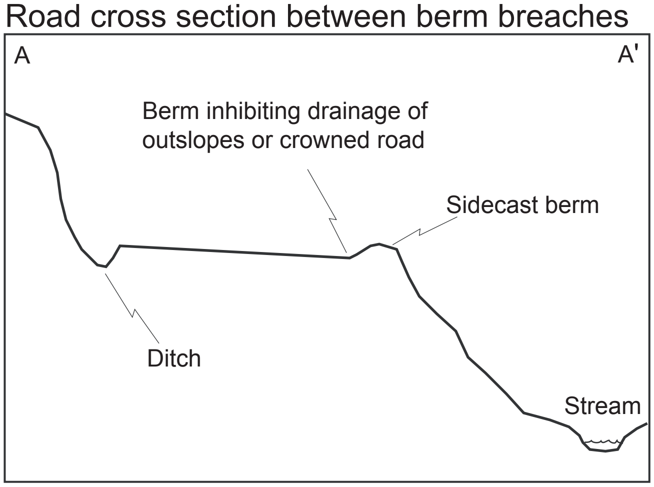
Typical Sidecast or Excavation Methods for Removing Outboard Berms on a Maintained Road

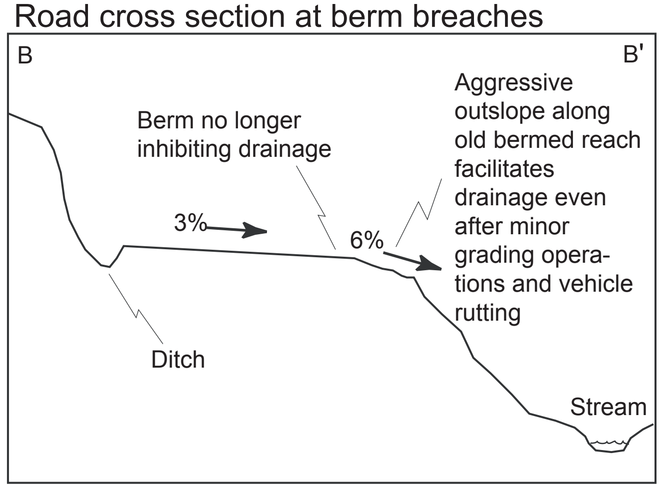
1. On gentle road segments berms can be removed continuously (see B-B').
2. On steep road segments, where safety is a concern, the berm can be frequently breached (see A-A' & B-B') Berm breaches should be spaced every 30 to 100 feet to provide adequate drainage of the road system while maintaining a semi-continuous berm for vehicle safety.



Road cross section between berm breaches



Road cross section at berm breaches



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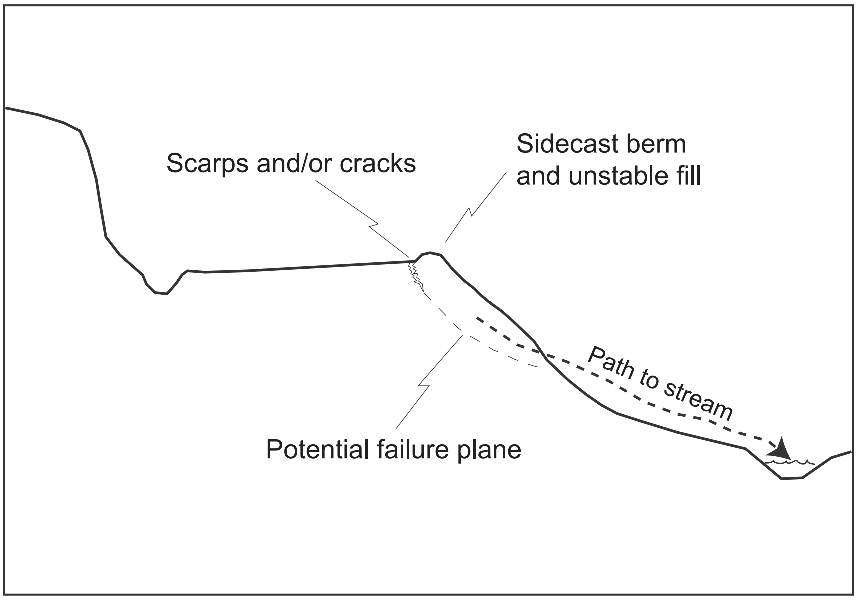
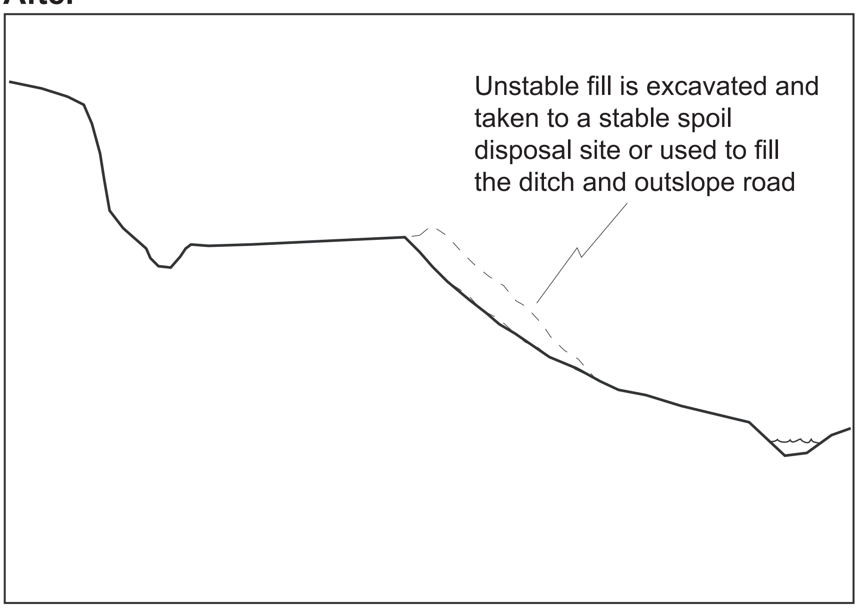
Typical Excavation of Unstable Fillslope on an Upgraded Road

Before



After



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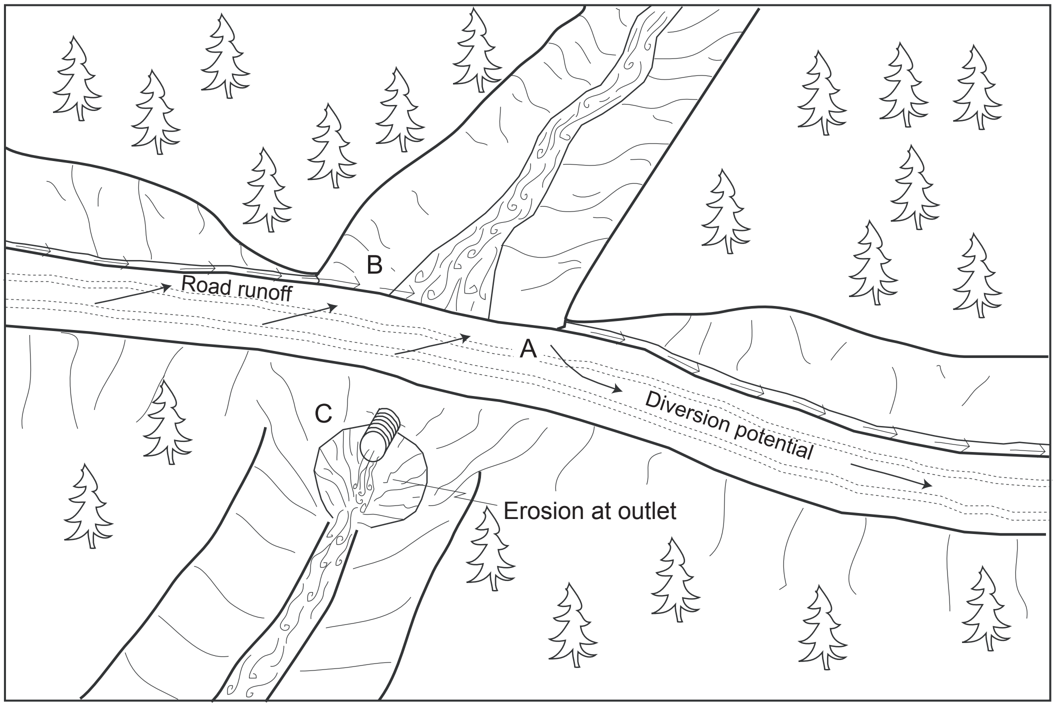
Typical Problems and Applied Treatments for a Decommissioned Stream Crossing

Problem condition (before)

A - Diversion potential

B - Road surface and ditch drain to stream

C - Undersized culvert high in fill with outlet erosion

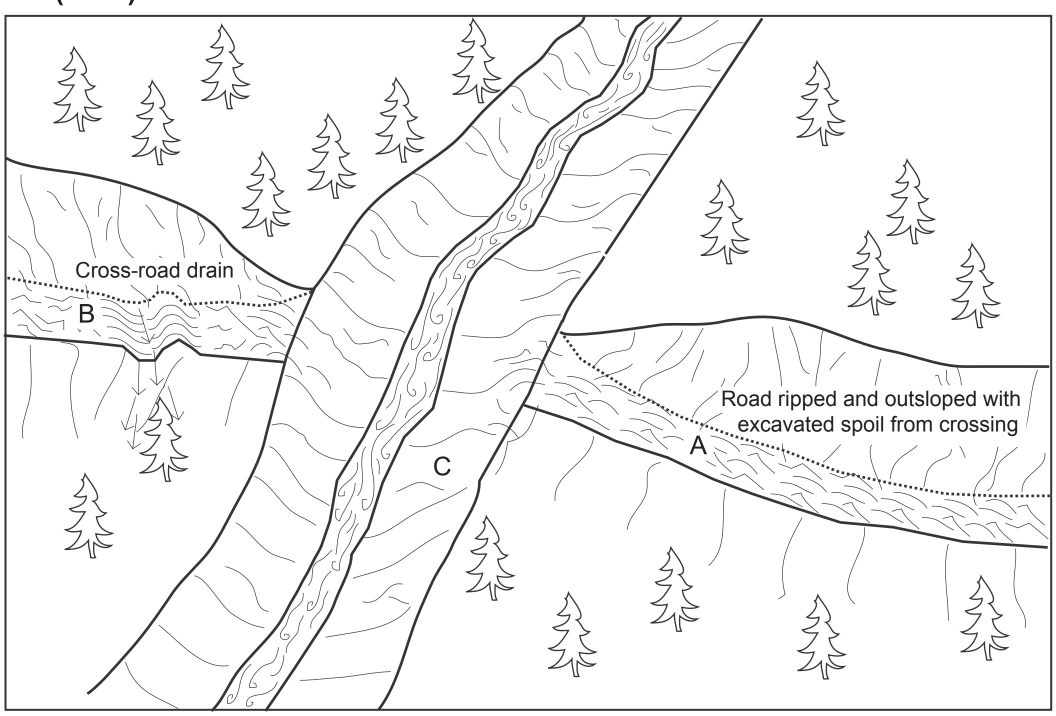


Treatment standards (after)

A - Diversion prevented by road surface ripping and outsloping using exca-vated spoils

B - Road surface and ditch disconnected from stream by road surface decompaction and cross-road drains

C - Stream crossing fill completely excavated



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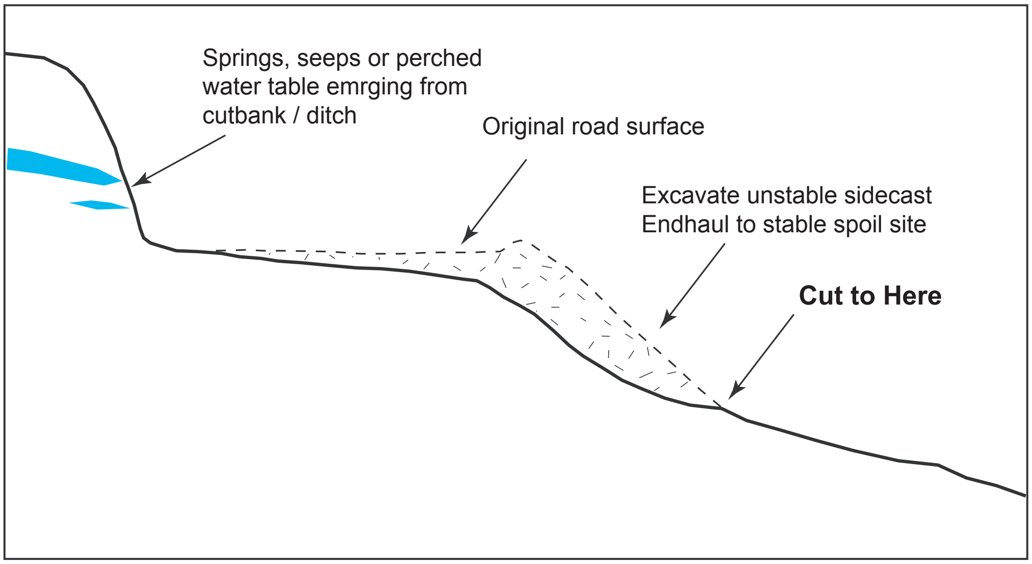
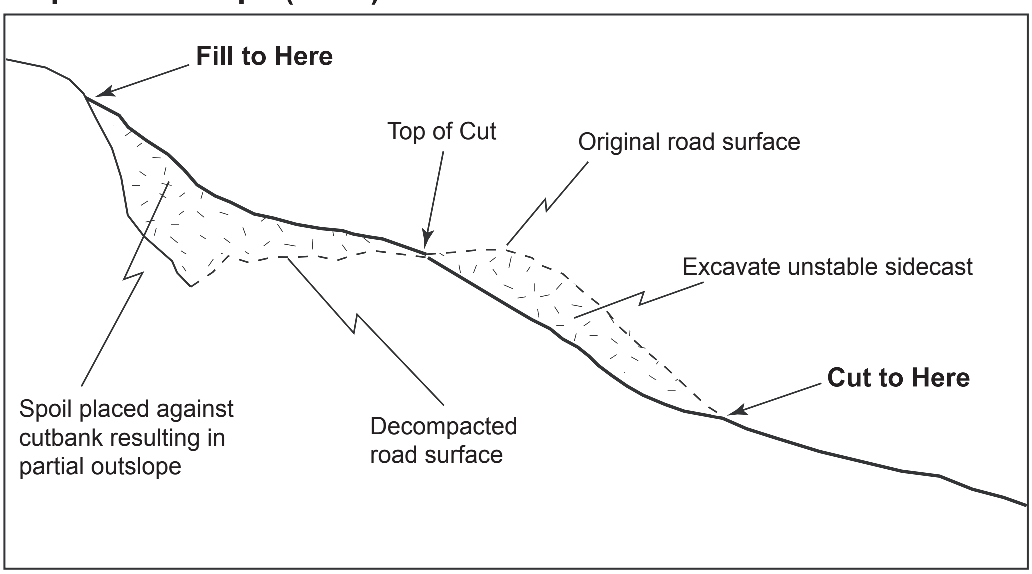
Typical Design for Road Decommisioning Treatments Employing Export and In-Place Outsloping Techniques

Export outslope (EPOS)



In-place outslope (IPOS)



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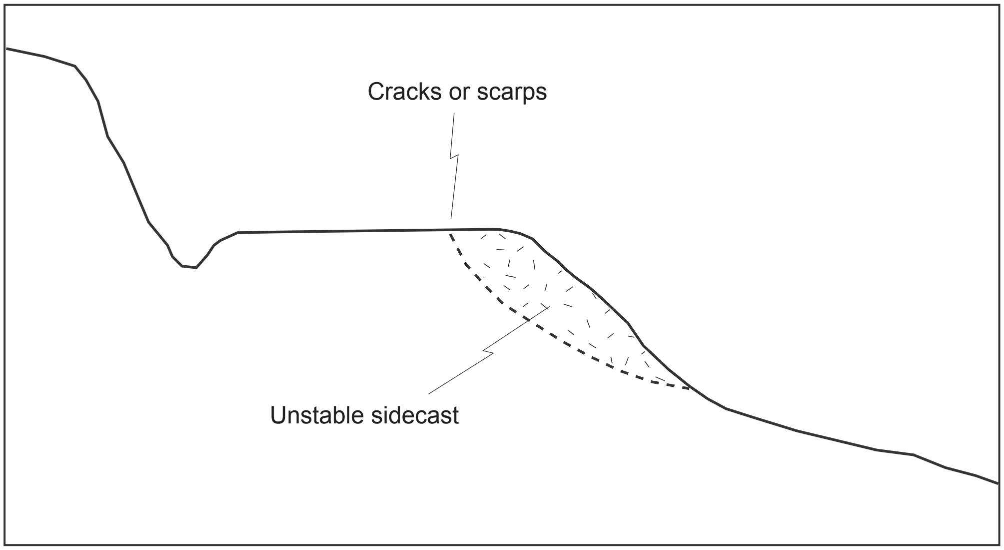
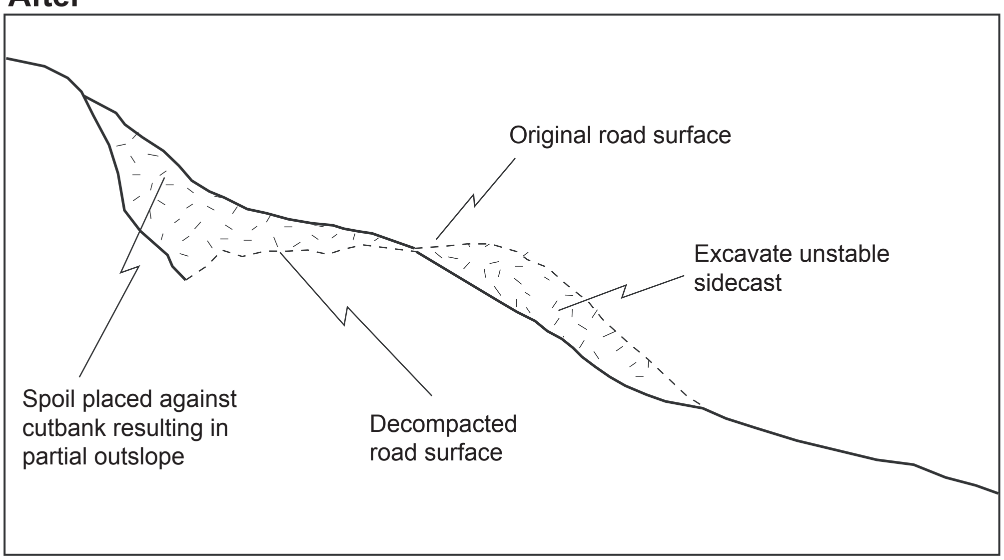
Typical Excavation of Unstable Fillslope on a Decommissioned Road

Before



After



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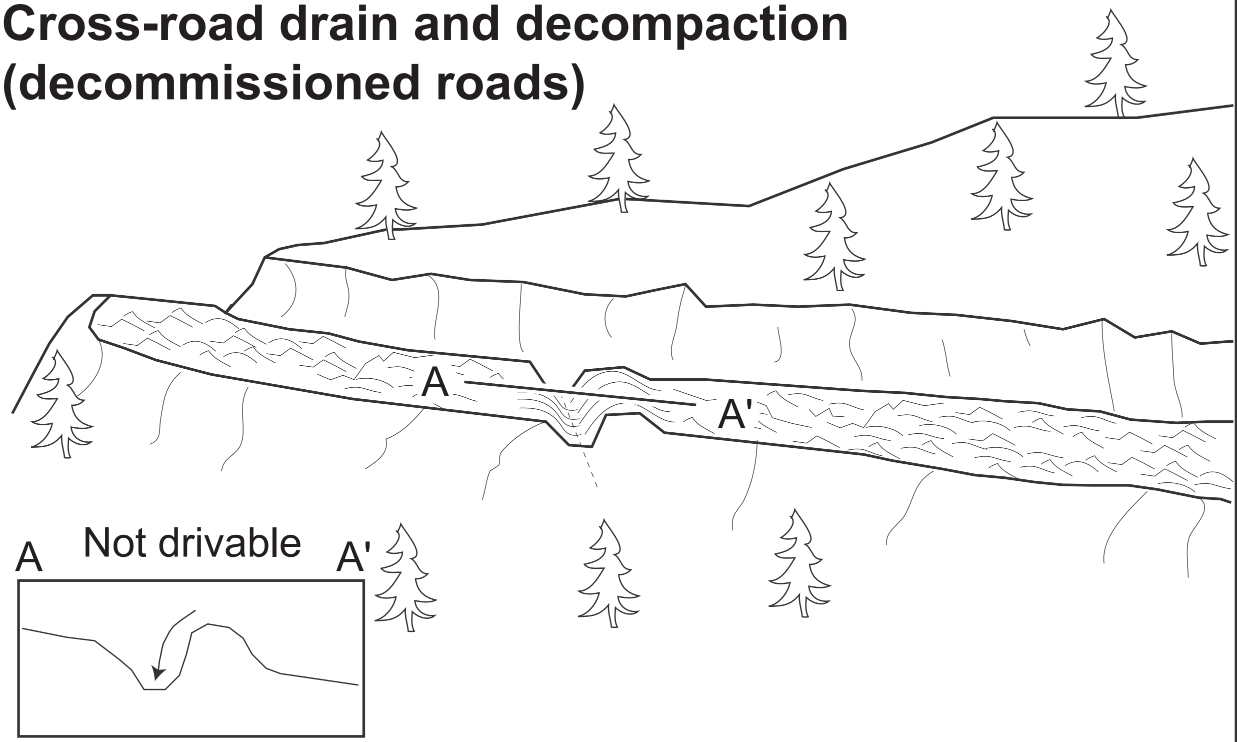
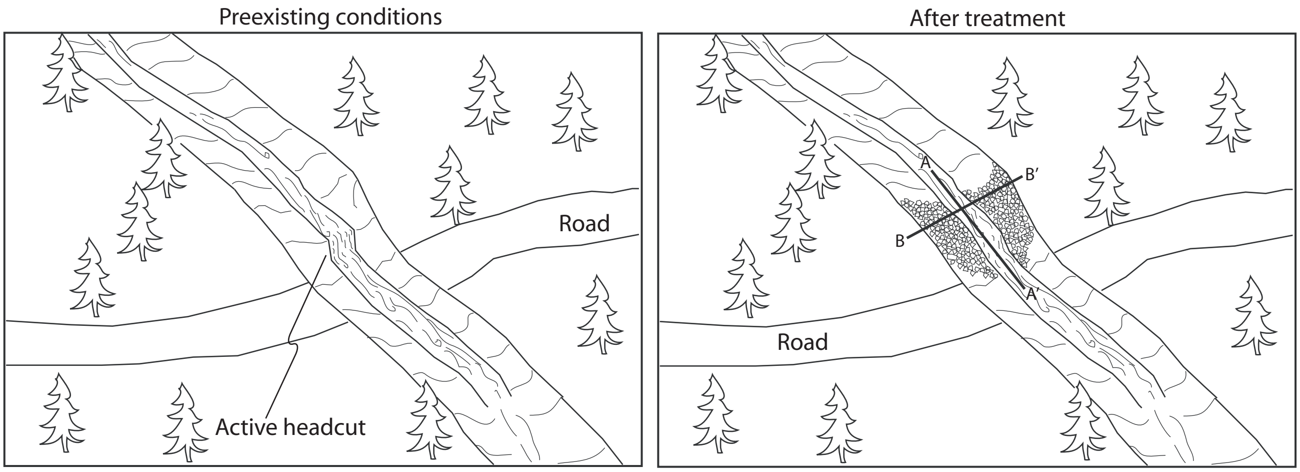
Cross-road drain and decompaction (decommissioned roads)



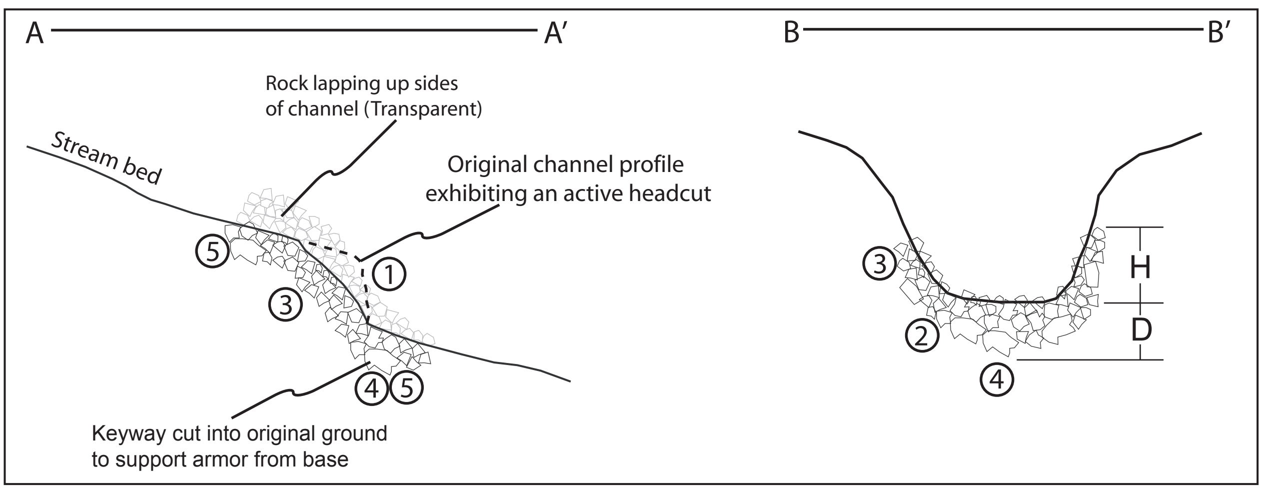
Cross road drain construction will ensure gullies, springs, road runoff and other concentrated flow will no longer collect over long lengths of road causing gully erosion and sediment delivery to streams. Cross road drains will be constructed at approximately 75 ft spacing intervals and these cross road drains will direct road surface runoff off the road onto stable hillslope locations.

Ripping the road surface 16 to 24 inches deep will increase road surface infiltration rates, decompact the road surface, and prevent concentrated runoff. Road ripping will also pulverize the compacted road surface or hardpan and allow for vegetation to establish and recover naturally.

Typical Rock Grade Control Structure Installation at man-made headcuts/knickpoints in a non-fish bearing stream channel



Cross section parallel and perpendicular to watercourse



Notes

The main objective is to create a structure that will not be flanked, undercut, or eroded by the stream.

The critical elements of a successful grade control structure are:

1) Excavating the headcut to a gentler channel gradient over a distance of stream (See road log for details)
2) rock selection- rock should be selected that is resistant to transport during design flows, and has a bell shaped distribution of sizes with the median diameter equivalent to the D50 particle size of the stream at the site of installation (See road log for range of rock diameters).
3) The rock must be placed in a “U” shape that will contain the 100 yr. return interval stream flow, won’t constrict the channel cross sectional area, and be flush with the streambed and not deflect flow.
4) The rock must be imbedded into the channel at least two rock diameters in thickness.
5) The largest rock should be used at the base and top of the grade control structure to buttress the other rock

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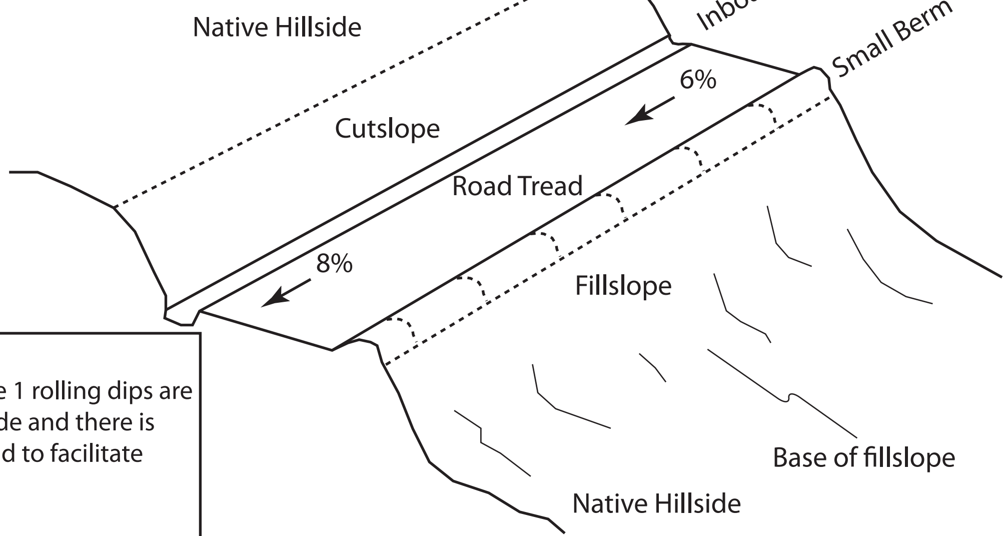
Standard (Type 1) Rolling Dip Construction

Existing Conditions



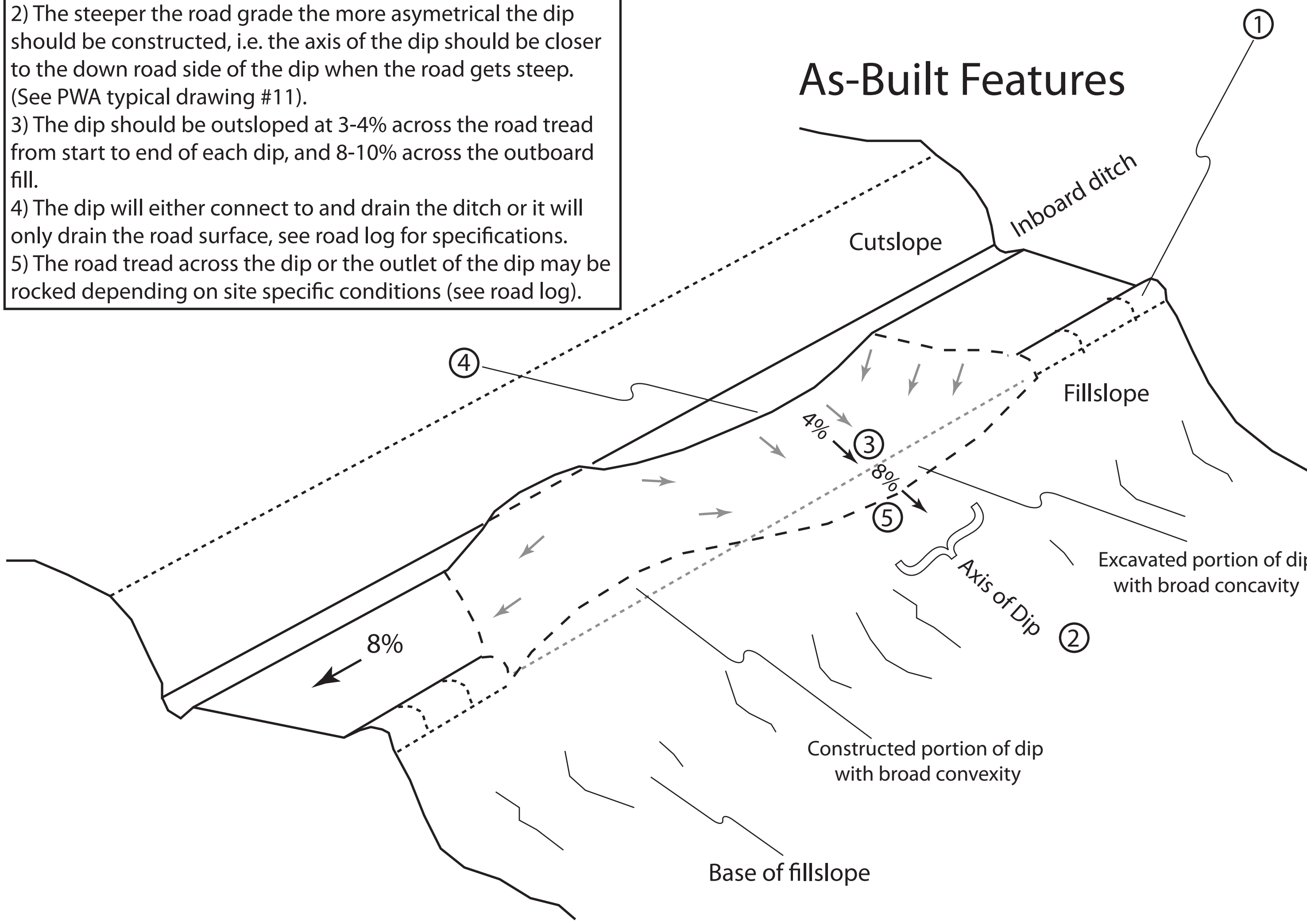
Notes

Rolling dip type 1 existing conditions: Type 1 rolling dips are utilized when roads are less than 12-14% grade and there is proximal outfall adjacent to the outboard road to facilitate road drainage.

Design Notes:

1) The berm should be removed for the entire length of the dip.
2) The steeper the road grade the more asymetrical the dip should be constructed, i.e. the axis of the dip should be closer to the down road side of the dip when the road gets steep. (See PWA typical drawing #11).
3) The dip should be outsloped at 3-4% across the road tread from start to end of each dip, and 8-10% across the outboard fill.
4) The dip will either connect to and drain the ditch or it will only drain the road surface, see road log for specifications.
5) The road tread across the dip or the outlet of the dip may be rocked depending on site specific conditions (see road log).

As-Built Features



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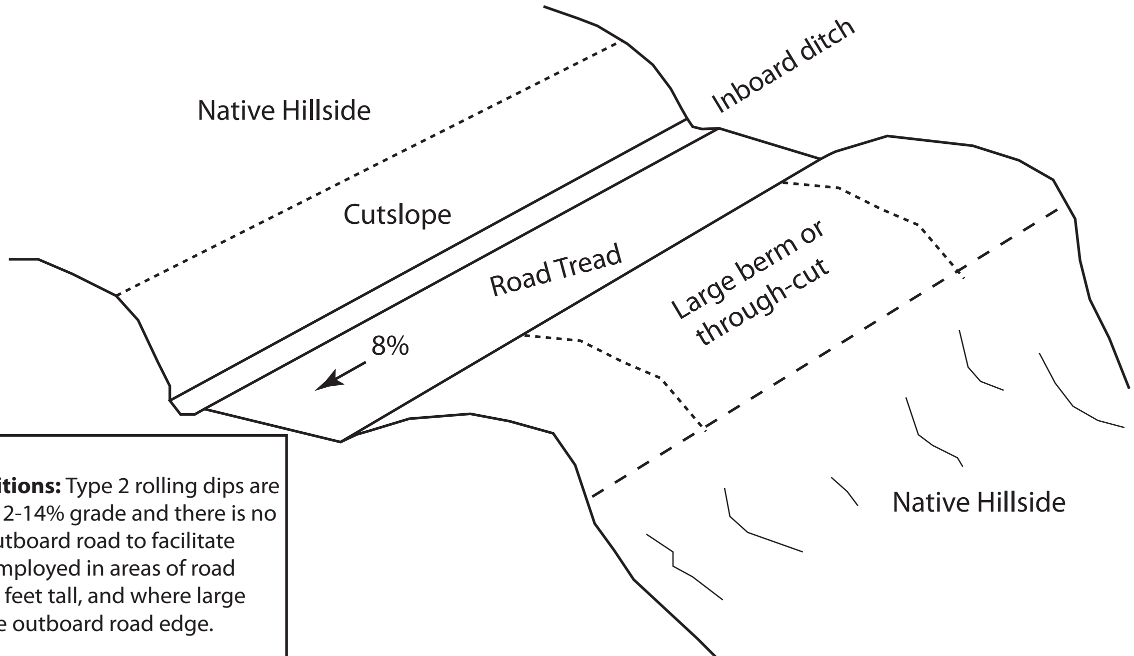
PWA Typical Drawing #19a

Type 2 Rolling Dip Construction

(Through-cut or thick berm road reaches)



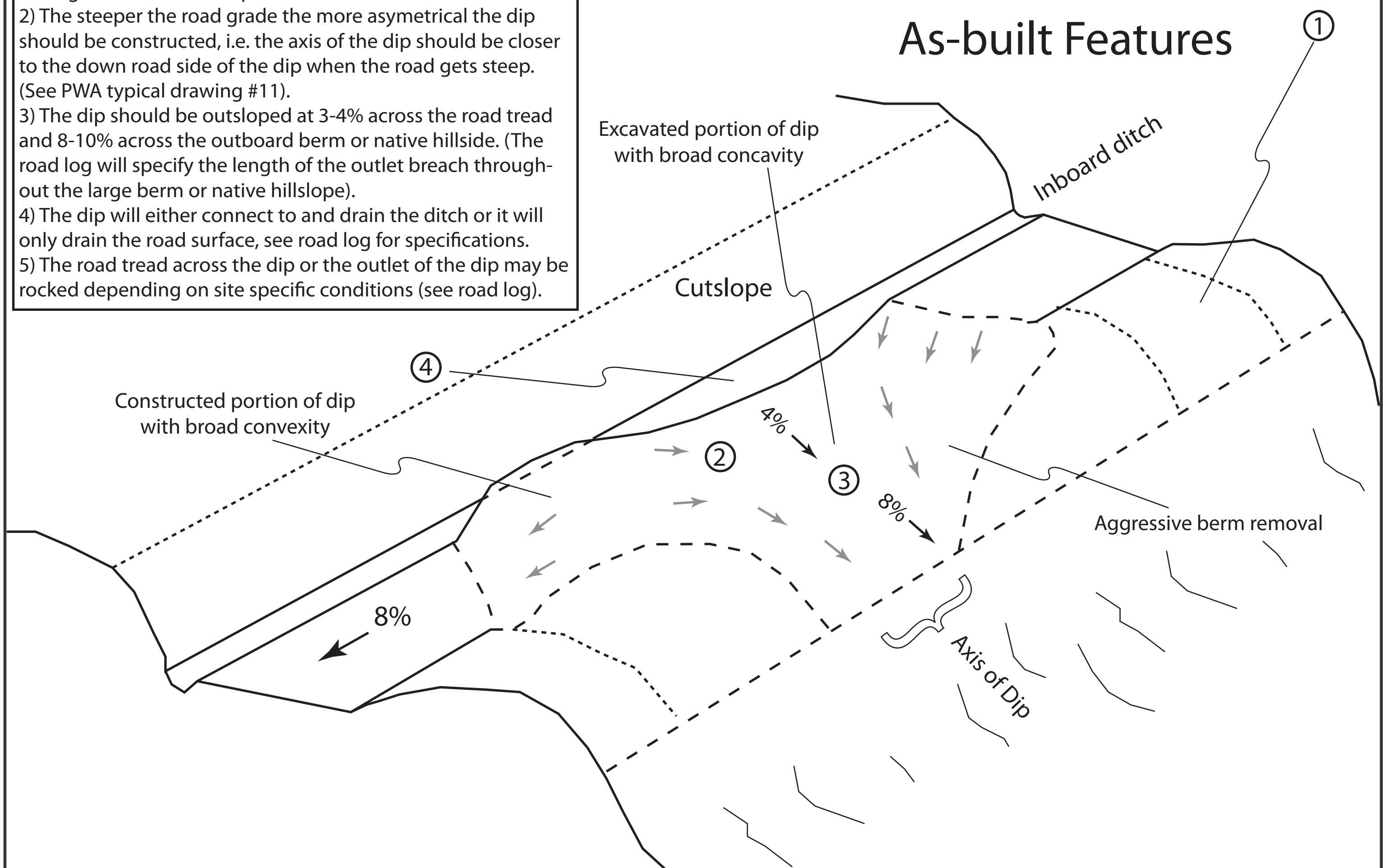
Notes

Rolling dip type 2 existing conditions: Type 2 rolling dips are utilized when roads are less than 12-14% grade and there is no proximal outfall adjacent to the outboard road to facilitate road drainage. These should be employed in areas of road through-cuts generally less than 3 feet tall, and where large wide and/or tall berms exist on the outboard road edge.

Design Notes:

1) The berm or native hillside should be removed for the entire length of the excavated portion of the dip, or, at a minimuim through the axis of the dip.
2) The steeper the road grade the more asymetrical the dip should be constructed, i.e. the axis of the dip should be closer to the down road side of the dip when the road gets steep. (See PWA typical drawing #11).
3) The dip should be outsloped at 3-4% across the road tread and 8-10% across the outboard berm or native hillside. (The road log will specify the length of the outlet breach throughout the large berm or native hillslope).
4) The dip will either connect to and drain the ditch or it will only drain the road surface, see road log for specifications.
5) The road tread across the dip or the outlet of the dip may be rocked depending on site specific conditions (see road log).

As-built Features



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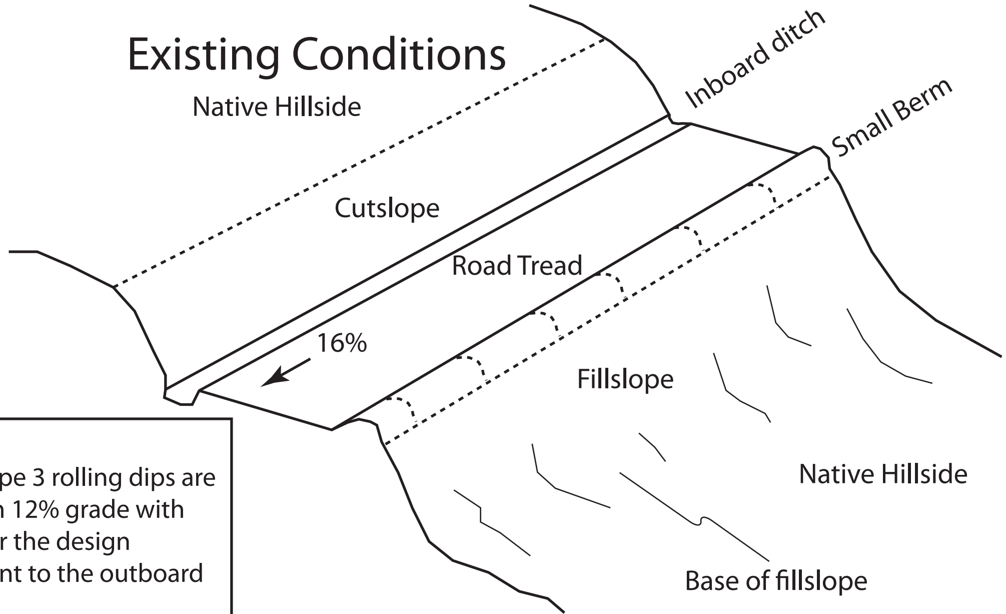
PWA Typical Drawing #19b

Type 3 Rolling Dip Construction
(steep slope outslope)

Existing Conditions

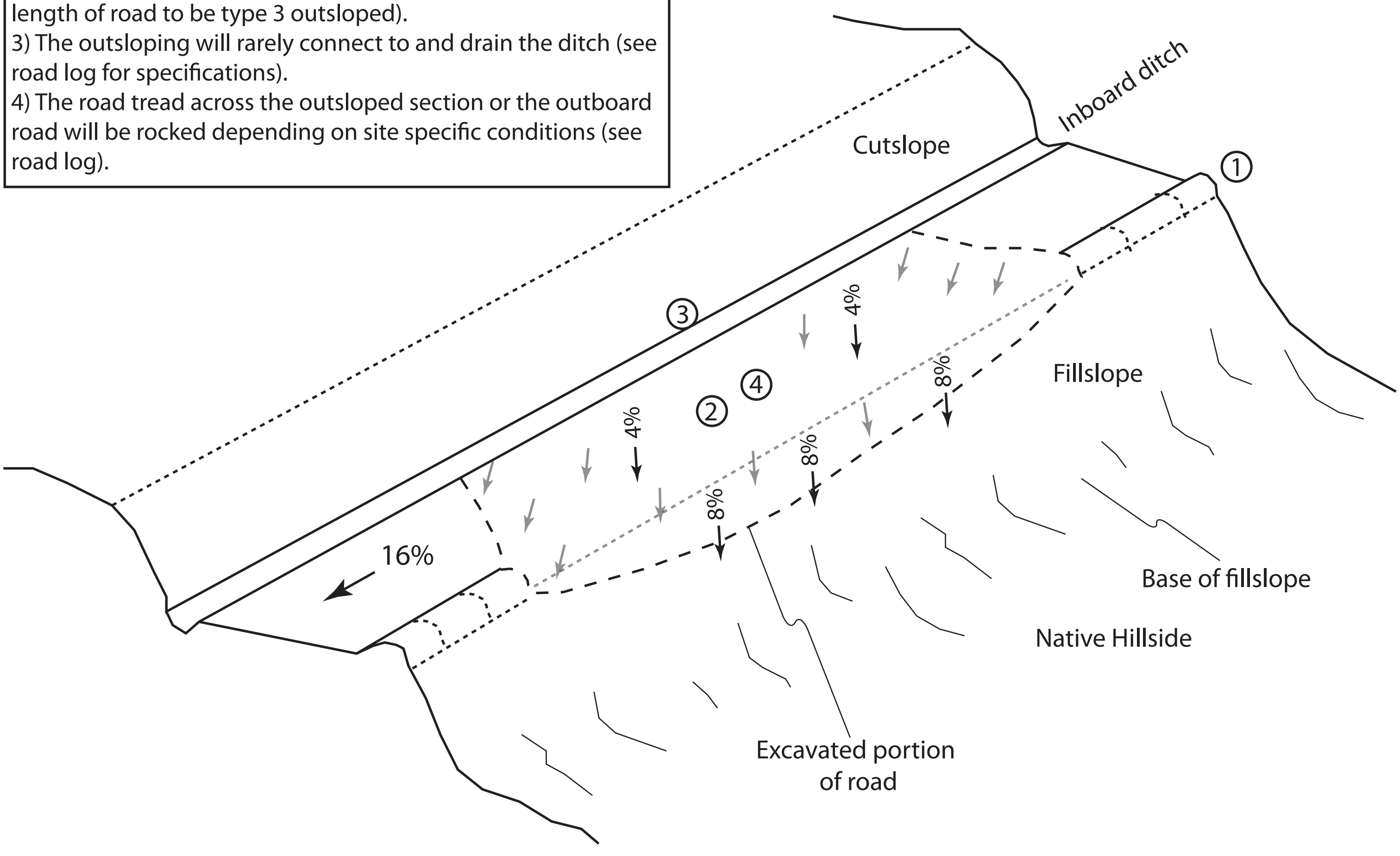


Notes

Rolling dip type 3 existing conditions: Type 3 rolling dips are utilized when roads grades are steeper than 12% grade with little opportunity to create reverse grade for the design vehicle, and there is proximal outfall adjacent to the outboard road to facilitate road drainage.

Design Notes:

1) The berm should be removed for the entire length of the outsloped section.
2) The dip should be outsloped at 2-4% across the road tread and 4-8% across the outboard fill. (The road log will specify the length of road to be type 3 outsloped).
3) The outsloping will rarely connect to and drain the ditch (see road log for specifications).
4) The road tread across the outsloped section or the outboard road will be rocked depending on site specific conditions (see road log).



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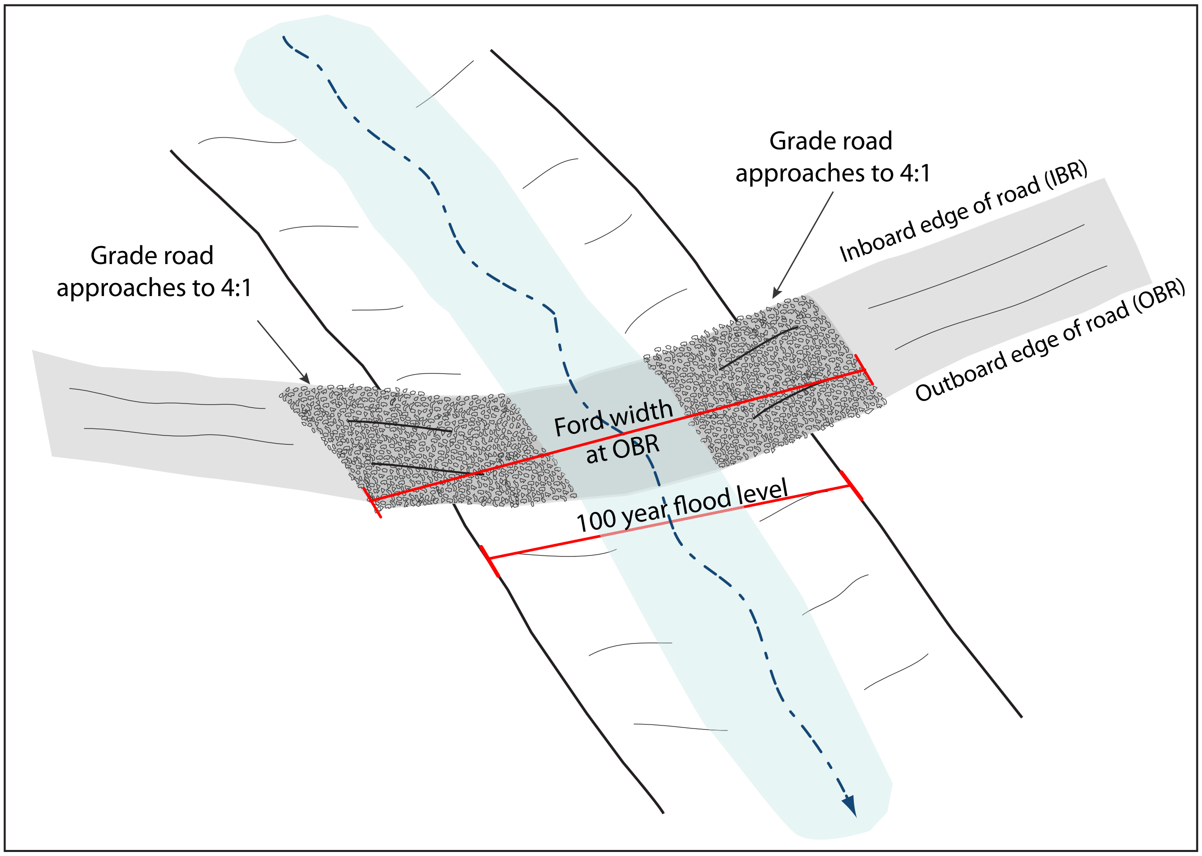
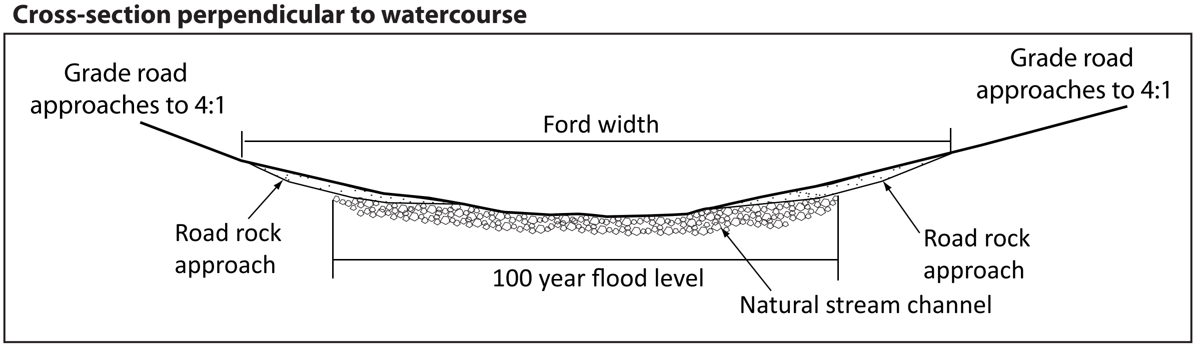
PWA Typical Drawing #19c

Typical Ford Crossing Installation

Oblique view



Cross-section perpendicular to watercourse



<u>Steps for ford crossing construction:</u>

1. Remove any existing structures (culverts, logs, large boulders, etc.)
2. Remove all road fill as you dip through the crossing to reach natural stream channel.
3. Establish a "U" shape across the channel at the width specified in the road logs.
4. Grade road approaches to specified slope angle (e.g., 4:1). Approaches may or may not be rocked; follow specifications in the road logs.

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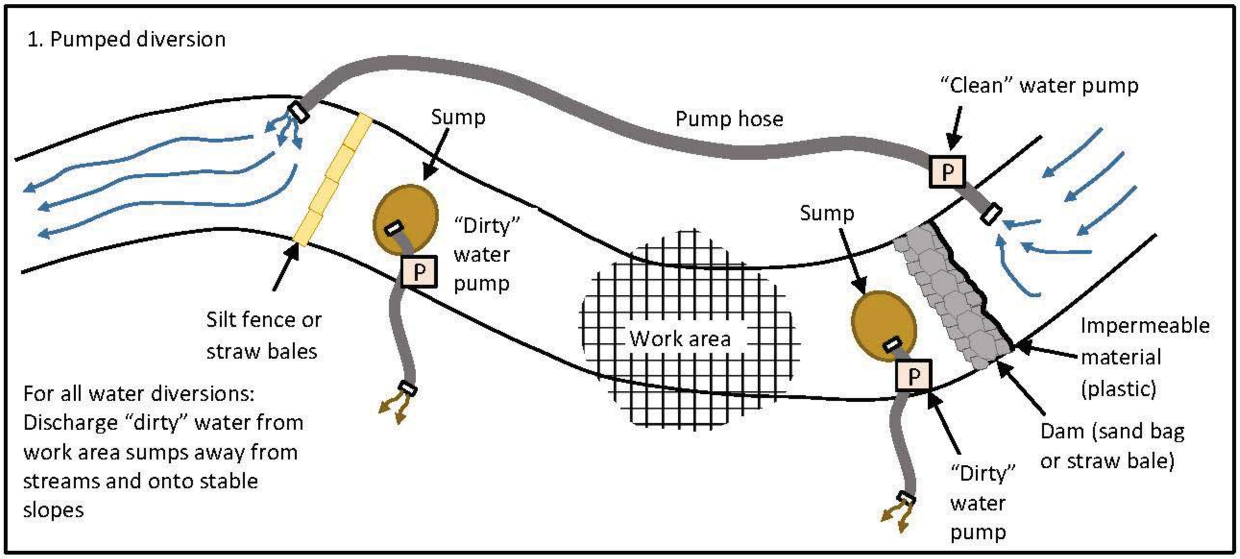
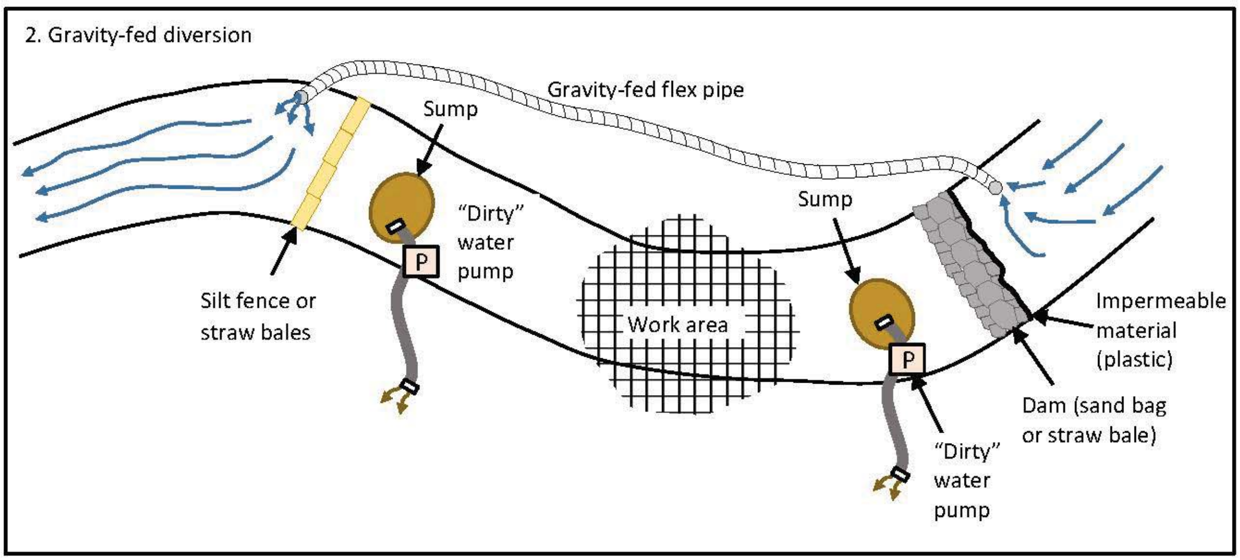
Typical Design for De-watering Streams





Stream crossing de-watering

Prior to working in and around the active stream channel, proper stream dewatering and avoidance of increasing downstream turbidity should be employed. Stream flows will be isolated upstream of the work area using cofferdams and transported downstream / around the work site through either a pumped diversion (Type 1) or by gravity diversion (Type 2) to keep the stream "live" (flowing) below the work area. An additional dam will be installed downstream of the work areas to capture any subsurface flow that might travel through the construction area. Any "dirty" water will be collected at this location and pumped away from the site where it can infiltrate into the ground without the potential to delivery to the stream and/or be used to wet fill being deposited in the spoil disposal areas.

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Appendix D

Representative photos of selected sites

Manzana Creek Watershed Anthropogenic Sediment Reduction Assessment, Aquatic Protection and Road Restoration Planning Project
Los Padres National Forest, Santa Barbara, California

Table D1. Representative Project Site Photographs, *Manzana Creek Watershed Anthropogenic Sediment Reduction Assessment, Aquatic Protection and Road Restoration Planning Project*, *Los Padres National Forest*, Santa Barbara County, CA

Photo #	Site #	Photo date	Road name	Photo description (frame view)	Photo location (standing)	Facing
1	138	6/11/2018	Catway Jeep Trail	View of a near-origin Class III stream at a fill crossing. The stream has eroded a gully through the fill prism and is actively advancing headward towards the inboard edge of the road.	Standing on the outboard edge of the fill looking towards the inboard edge of the road and the gully.	South-West
2	145	6/11/2018	Catway Jeep Trail	View of a gully along the outboard edge of the road that has been caused by concentrated road runoff and poor road design. The gully enlarges beyond the outboard edge of fill and is actively eroding into the road prism.	Standing in the center of the road prism looking downslope to where the gully exits the road.	North-West
3	150	6/11/2018	Catway Jeep Trail	View of a Class III stream crossing below a switchback in the road. The stream has gullied into the fill and natural hillslope above the road and has carved a second gully below the road.	Standing on the outboard edge of the fill looking towards the inboard edge of the road and the gully.	North-East
4	91	6/11/2018	McKinley Ridge	View of a McCarthy style drain on McKinley Ridge road. Erosion below the outlet of the drain has caused headcut that has eroded the fill from beneath the drain and caused it to fail. A headcut is now actively eroding into the road prism from beneath the drain's inlet.	Standing at the outboard edge of the road looking downslope over the outboard edge at the failed McCarthy drain.	North-West
5	94	6/11/2018	McKinley Ridge	View of a McCarthy style drain on McKinley Ridge road. Erosion below the outlet of the drain has caused headcut that has eroded the fill from beneath the drain and caused it to fail. A headcut is now actively eroding into the road prism from beneath the drain's inlet.	Standing at the outboard edge of the road looking down at the failed McCarthy drain and eroding fill.	West

Table D1. Representative Project Site Photographs, *Manzana Creek Watershed Anthropogenic Sediment Reduction Assessment, Aquatic Protection and Road Restoration Planning Project, Los Padres National Forest*, Santa Barbara County, CA

Photo #	Site #	Photo date	Road name	Photo description (frame view)	Photo location (standing)	Facing
6	16	6/11/2018	East Pinery Ridge Road	View of a long segment of road that has several small gullies eroding into its road bed due to concentrated road runoff that has been trapped on the road surface for hundreds of feet. The gullies combine into a larger gully shortly before exiting the road prism and enlarging further as it carves into the outboard edge of fill.	Standing mid road below the confluence of the two gullies.	South-East
7	344	9/6/2018	Munch Canyon	View of the large diversion gully traveling down the inboard edge of the road and crossing the road. The upper extent of the large outboard fillslope gully is seen in the center frame.	Standing on the outboard edge of the road, above the large diversion gully that travels down the outboard fillslope.	South
8	344	9/6/2018	Munch Canyon	View of the large diversion gully downcutting through the road prism before exiting the road prism and eroding the outboard fillslope.	Standing on the outboard edge of the road, below the large gully that travels down the outboard fillslope.	North

Photo 1

Photo 2

Photo 3

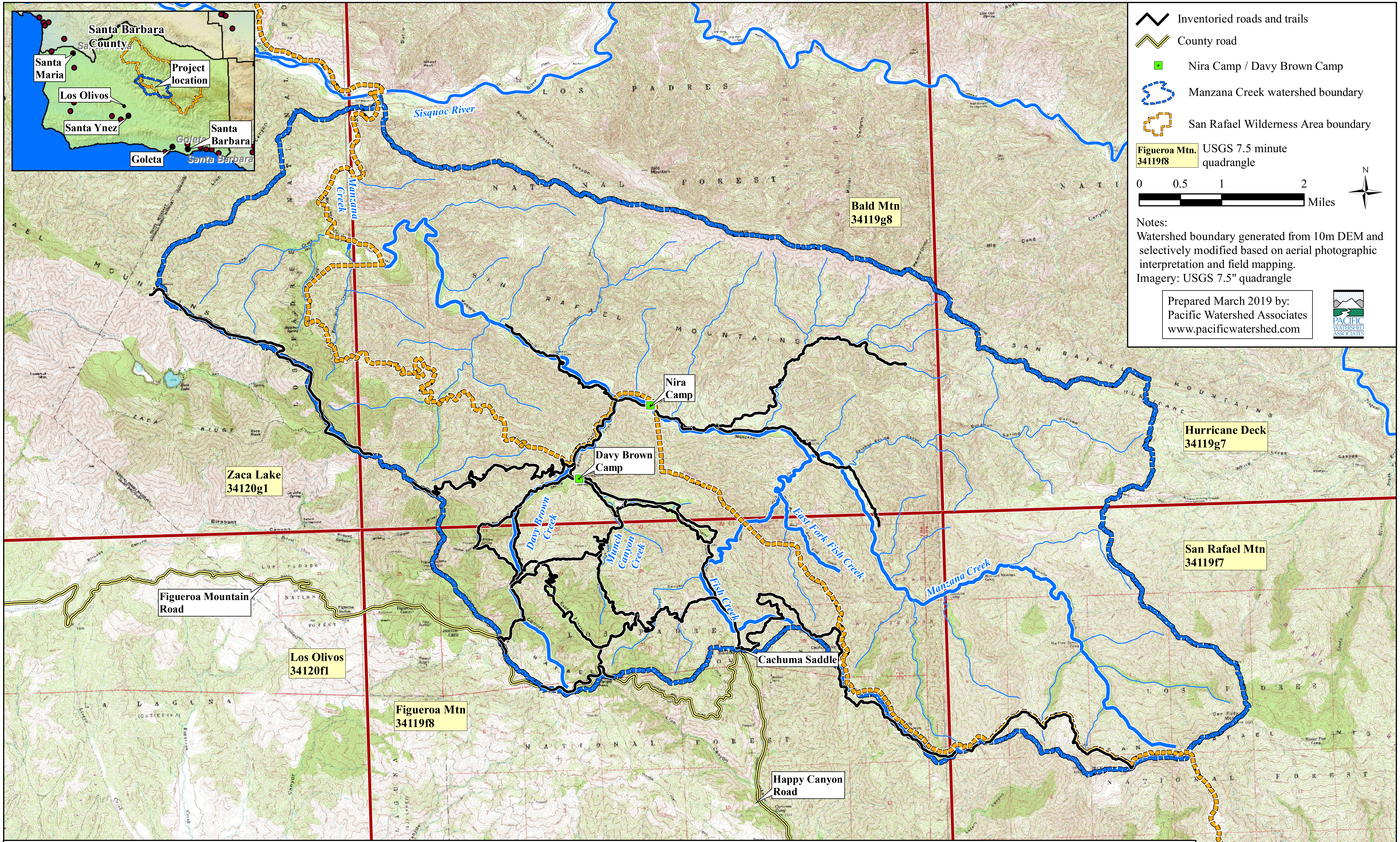
Photo 4

Photo 5

Photo 6

Photo 7

Photo 8



Map 1. Location map for the Manzana Creek Sediment Reduction Assessment, Aquatic Protection, and Road Restoration Planning Project, Los Padres National Forest, Santa Barbara County, California.

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Map 2. Inventoried roads, trails, and sediment delivery sites for the Manzana Creek Sediment Reduction Assessment, Aquatic Protection, and Road Restoration Planning Project, Los Padres National Forest, Santa Barbara County, California.

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