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Guidelines for Forest Roads and Landings

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This set of guidelines outlines the intent, procedures and general specifications for truck roads and landings to be followed by The Pacific Lumber Company (PALCO) and its contractors and employees. These provisions provide guidance and direction to supervisors, foresters, equipment operators and contractors involved in road-related activities on PALCO owned land. Many measures and procedures are in addition to those specifically provided by the Forest Practice Rules for road-related operations on forest lands managed by the Company.

Implementation of measures generally described in the PALCO Road Manual has the following general goals:

- to provide a low cost, efficient road systems for forest management activities,
- to develop stable, low impact roads,
- to eliminate (decommission) unstable, high impact, and high maintenance roads,
- to minimize impacts to fish and wildlife resources,
- to prevent impacts to beneficial water uses, and
- to minimize road system-related costs.

This manual provides practical guidance covering the fundamentals of road planning, design, construction, reconstruction, maintenance and closure. It is organized by topics, and they appear in the same general order that they are encountered in the field. The text contains general information on the intent of PALCO roading practices, as well as general specifications covering a variety of roading techniques. PALCO is committed to following the provisions outlined in this manual, and will adopt feasible mitigation measures, or equivalent alternatives, which provide protection to water quality and substantially lessen significant adverse environmental impacts associated with road-related activities.

The sections of this manual address the following issues:

Planning - the need for, and process of, transportation planning for watersheds and planning for individual roads, including road standards and route planning.

Road design - road prism and landing design, surface drainage design, and designs for wet or unstable soils.

Drainage - information on surface drainage techniques and structures, drainage design and spacing, stream crossings, bridges, culvert sizing and placement, and temporary stream crossings.

Construction - the construction process, including grubbing and clearing, grading, stream crossing and bridge installation, surfacing, erosion control and spoil disposal.

Reconstruction - the special but increasingly common activity of road reconstruction, including road relocation, road redesign, drainage structure upgrading and replacement, and erosion control.

Maintenance - road maintenance techniques and scheduling, especially in light of their potential effect on water quality in a watershed.

Closure - techniques by which roads can be temporarily closed or permanently abandoned and "erosion-proofed" to prevent subsequent soil loss and to put land back into production.

A. Importance of Proper Planning and Construction

Roads can be compatible with a healthy, well managed watershed, as long as they are well planned, properly designed, located, constructed and regularly maintained. On the other hand, poor road building and maintenance practices can cause excess runoff and damaging erosion and sedimentation. Proper planning, design and construction techniques can prevent water quality problems and significantly extend the useful life of a road while avoiding many of these environmental problems. Roads can be planned and located to avoid unstable, erodible areas and stream crossings can be built using simple, protective techniques which minimize the potential for future impacts. PALCO is committed to developing a low-maintenance, low-impact road system throughout their ownership in order to avoid both high maintenance costs and unacceptable environmental impacts.

B. Creating and Maintaining a Stable Road

The features described in this section form the building blocks of stable roads. They include: 1) the road's physical environment, 2) critical control points (locations of special concern or sensitivity), 3) legal and physical restrictions on road location, and 4) ways to keep a stable road once it's built.

1. Physical Environment

The road's physical environment influences its stability and potential impact on the environment. The three main elements affecting a watershed's sensitivity to a road include the steepness of the land (slope), bedrock and soil conditions along the alignment, and surface and subsurface drainage conditions along the route. Together, these physical factors help determine the best choice for road location in a watershed, and dictate the most suitable construction techniques.

The ***slope*** of the land is one of the most important elements that control where and how roads are built. Road building becomes more difficult and expensive as land slopes become steeper. Roads built on steep slopes are also more likely to have erosion and stability problems.

The stability and erodibility of a road is largely controlled by the underlying ***bedrock*** and soil material. Bedrock composition and soil properties can vary quickly along a road route. Each soil

and bedrock type reacts differently to road construction and road drainage. The type of bedrock can influence erodibility, slope stability and the ease of excavation, as well as road maintenance requirements and costs. Soil texture is very important in determining "erosion hazard rating."

Drainage is also a key physical element of a stable road. Water which has emerged onto the ground surface must be directed away from the site as soon as is possible. If the road must pass over a known wet area, subsurface drainage techniques will be used to drain the ground beneath the roadbed. Avoidance is the least expensive and most successful method for preventing subsurface drainage problems. There are two important rules for handling surface runoff***:*** 1) get water off the road rapidly so it cannot erode or seep into the roadbed, and 2) get water off the road often to avoid large, erosive flows from long, undrained ditches or road surfaces.

2. Control Points

The stability of a road and its impact on the environment is often determined by how the road is designed and located around physical points of control (***control points)*** in the landscape. Efforts will be made to avoid as many obstacles, like stream crossings, during road planning and field location. Obstacles to a stable road (and areas which we will generally attempt to avoid) include unstable slopes (slumps, debris slides, debris flows, and earthflows); hard rock outcrops; very steep slopes; highly erodible soils; ponds, lakes and streams; and wetlands. These features will be precisely located during reconnaissance since they constitute controls that will influence final road location.

Every effort will be made to develop agreements with adjacent landowners in order to prevent property boundaries from forcing roads to be built in unsuitable locations. Finally, trained specialists, including geologists, will be employed, as necessary, to determine the best, most feasible routes for roads, to develop mitigations and to choose alternate routes which bypass potential problem areas. It is our philosophy that employing an expert to solve a technical problem is more cost-effective and more environmentally protective than repairing a major road failure or damaging the environment.

Stream crossings are particularly vulnerable to erosion and failure and represent one of the most sensitive locations in a watershed. For this reason, the number and size of stream crossings that are constructed along new roads will be minimized. Every effort will be made to locate stream crossings where channels are least incised, across natural benches, and where sideslopes are as gentle and stable as is possible. Endhauling will be used on the approaches to stream crossings where sidecasting could otherwise result in erosion or sediment delivery to a stream channel.

3. Other Limitations on Road Construction and Location

A number of physical limitations on road location have already been discussed, including obstacles and stream crossings. Other factors may also limit when and where a road can be built.

The extremes of wet and dry in our coastal climate also limit the time of year when construction activities can safely take place. Work must be shut down ***when*** conditions begin to affect water quality. Table 1 describes the seasons and the types of road-related activities that are undertaken by PALCO throughout the year.

Table 1. General Timing of PALCO road-related activities.

Season	Planning and design	Field Layout	Construction and Reconstruction	Inspection and Maintenance	Log Hauling	Closure
Winter	+[1]	+	No	+	(rocked roads)	No
Spring	+	+	(late)	+	(late)	-
Summer	+	-	+	+	+	+
Fall	+	-	(early)	+	(early)	+

[1] ***Key to symbols: "+" = good or excellent season for this activity. "" = OK or good time to perform this work. "-" = not a very good season for this type of work. "No" = this is not a good time for construction or closure work using heavy equipment, unless there is an extended dry period. Each season has periods when work can be undertaken.***

A sufficient buffer or filter strip of undisturbed vegetation will be left between road building and road maintenance activities and nearby streams. Road surface drainage will be sent through a filtering area with enough ground cover to catch sediment coming from road runoff. Filter strips should be retained even for Class III watercourses that may not be flowing at the time of road construction or maintenance.

4. Maintaining Stable Roads

PALCO views road building as a long-term commitment of both resources (money and equipment) and personnel. If we are unable to make the needed long-term commitment to maintain a road or a road system, then the road will not be constructed, or it will be built as a temporary road with drainage structures removed after use. Any existing roads which PALCO decides to "abandon" and cease maintenance will be proactively closed (decommissioned) or made temporary (stream crossing fills excavated, permanent surface drainage installed, etc.).

A road built with drainage structures and stream crossings needs to be maintained. Periodic inspections and storm maintenance needs to be performed frequently and regularly during the first several rainy seasons as the road "settles in" and stabilizes.

C. Planning for Roads and Landings

Good planning can minimize the impact of a road on the environment and provide low-maintenance, low-cost access for land management. PALCO will conduct basin-wide transportation planning for the development of new road networks in unroaded basins and in watersheds where existing roads have been abandoned for many years, and will conduct similar planning in roaded watersheds in order to establish the best possible low impact road system for long term management. Transportation planning alternatives will be developed for each watershed, alternatives will be explored and evaluated, and the long-term road network will be systematically implemented as land management in each area is conducted.

Four basic tenants will guide PALCO road planning:

1. Minimize the number of roads constructed in watersheds through basin-wide planning.

2. Existing roads will be used wherever possible, provided their use fits into the long term transportation plan for the watershed and provided their use will cause less impact to streams than the construction of alternate routes.

3. Roads will be located and constructed to minimize disturbance to natural features and potentially unstable areas, to minimize the number and size of watercourse crossings and to minimize the effect of the road system on watercourses and aquatic resources.

4. Roads will be planned, designed and built to the minimum standard necessary to accommodate all anticipated uses and equipment, while at the same time to a sufficient standard to provide high levels of protection to water quality and aquatic and riparian habitat.

1. Road System Layout

In forest road planning, the concepts “less is best” and “avoid the worst” generally describe the most economical and environmentally sound approach to planning for road system layout, construction, reconstruction and closure (decommissioning). PALCO adheres to this philosophy. Watershed-wide road system planning and layout attempts to locate roads where they will optimally serve management activities while minimally affecting aquatic and riparian resources. PALCO road standards strive to minimize watershed impacts by striving to meet the following general goals:

- Minimize total road miles in each watershed,
- Minimize new road construction by using existing roads,
- Minimize construction of high standard permanent and seasonal roads by employing temporary roads whenever feasible,
- Minimize the number of watercourse crossings by selecting upland routes,
- Minimize cuts, fills and vegetation clearing by contouring roads across the landscape,
- Minimize road work near the WLPZ, and on unstable areas, inner gorges and steep slopes,
- Minimize road width,

- Minimize road gradient,
- Minimize the concentration of runoff on and from roads, and
- Avoid problem areas and serious obstacles, when possible.

2. Road Construction versus Reconstruction

Like many industrial forest lands in the northcoast, PALCO lands often have several generations of old railroad systems dating from the late 1800's, to roads constructed, and then abandoned, in the mid-1900's, to roads built in the last several years. Older roads were built to different, lower standards. Some of these roads are now abandoned and others are overgrown with vegetation. Often, it is not a simple decision whether or not to use an existing road rather than build an alternate alignment. The existing road may be poorly located or it may have been poorly constructed. Sometimes, it may be more expensive to upgrade the existing road than to build another.

PALCO views road reconstruction as an opportunity to improve watershed conditions and reduce long-term erosion while providing access to a previously harvested or managed area. Older, inactive or overgrown roads can be brought back into the actively maintained road system. In other instances, it is often possible to temporarily open an old road, and then to permanently close it upon completion of operations. In this way the old road can be "**erosion-proofed**" against future storm damage and then returned to forest production. Other times, an old road system may be so poorly located, or it may be so deteriorated that only small portions of it can be rebuilt without causing extensive erosion. In this case, a new road may need to be built at a more stable location.

Watershed transportation planning will be the vehicle used to determine which roads are to be reused and upgraded, which roads are to be used once and then permanently closed, and which roads are to be decommissioned without being used again.

3. Selecting Favorable Ground for New Roads

In laying out new road systems in a watershed, the most favorable ground is identified and utilized whenever possible. Over the last several years, PALCO has focused new road building efforts on ridge-tops and relatively gentle upslope areas. Construction costs, maintenance costs and environmental impacts will be minimized by sticking to such areas as ridges, saddles, natural benches and flatter natural slopes. Terrain to avoid includes hard rock areas, inner gorge slopes, steep slopes, watercourse and lake protection zones, erodible soils, wet areas and swamps, areas of unstable soils and sensitive wildlife habitat. The recognition and avoidance of unstable slopes is without doubt the most effective and cost-efficient method of managing landslide-prone terrain.

Generally, road planning efforts will strive to achieve the following objectives for PALCO lands:

- Avoiding unstable slopes or soils,
- Preventing destabilization, using special road building techniques, when potentially unstable slopes cannot be avoided,
- Stabilizing slopes which show signs of instability using special techniques developed by a trained engineer/geologist,

- Protecting downslope resources when an unstable area cannot be physically or economically avoided, prevented or stabilized.

4. Road Design

Road design is strongly influenced by both economic and environmental factors, and design largely determines subsequent construction and maintenance costs. Under-design can be environmentally disastrous, yet both road length and road width should be designed to minimum standards. Narrow roads dramatically reduce excavation and sidecast volumes, thereby reducing cutbank height and the potential for slope failure. Over-design can also be a costly mistake. Long term maintenance costs are also likely to be higher for wider roads.

Road prism: Road prisms may be designed to be ***full bench***, ***partial bench*** (part cut and part fill/sidecast) or ***full fill***. Roads constructed without endhauling are partial bench roads where spoil is used to widen the roadbed, fill depressions and fill stream channels crossed by the road. The fill is either placed and compacted, or sidecast loosely into the desired location. In the past, sidecasting was a routine road building practice employed by PALCO and other companies during road construction, but today there are many circumstances where sidecasting is no longer acceptable and alternative designs and methods are being employed.

In general, PALCO will design and construct full bench, endhauled roads on steep slopes (those over about 60%), in watercourse protection zones, or where water quality would be impacted by the failure of sidecast materials. Full bench construction requires that all the spoil be either used in filling local stream crossings and low spots in the new road, or endhauled to a stable storage site. Full bench roads are usually constructed using excavators. In general, sidecast construction techniques will be limited to low gradient slopes (<60%) or to areas where streams are located far from the road prism and there is no chance of sediment delivery to a stream channel.

Road cutbanks and fillslopes: The angle or steepness of both cut and fillslopes is very important in building stable roads. On balance, PALCO will design new cutbanks as steep as the soils and bedrock will permit, but not so steep or tall as to be unstable. Fillslopes can be built to a variety of angles depending on the properties of the material used, the amount of compaction, soil moisture and the type and density of surface vegetation. While a thin veneer of sidecast may hold on a slope steeper than 65%, a thick wedge of loose sidecast may not be stable even at a 50% slope. Some soils, such as those in the Humboldt WAA , are particularly erodible and unstable when undercut or sidecast onto moderate or steep slopes. In these critical areas, stable road fills can be built by using layered compaction methods. Although it is our intention to avoid such areas whenever possible, engineered fills that utilize reinforcing fabrics or other internal supports can be constructed in unstable areas with nearly vertical fill faces.

Road surface: ***Road surface design*** is really ***road surface drainage design.*** The Company recognizes that it is critical to properly design road surfaces to minimize erosion from the road bed, ditch, cutbank and fillslope surfaces. Insloped roads drain surface runoff to the inside of the roadbed into a ditch. Crowned roads drain water both ways from the center of the road, but an inside ditch is still required. When inside ditches are used, frequent ditch relief culverts or rolling dips will be installed to minimize ditch erosion and to prevent gullying at culvert outlets. PALCO employs a minimum 18-inch diameter pipe for ditch relief culverts.

Outsloped roads are typically less expensive to construct and less difficult and expensive to maintain than insloped roads. Where conditions permit, PALCO roads will be constructed with an outsloped surface, no ditch and no outside berms. Where fillslopes are stable, roads will be designed and constructed with minimum width and with a mild outslope (3-4%). However, on most roads, especially those with grades in excess of eight percent (8%), outsloping is often not enough to get surface flow off the road quickly, and crowned or insloped surfaces will most often be

utilized. If outsloping is used, ***rolling dips*** (broad grade-breaks) will be employed to divert surface runoff from the road. Rolling dips and a smooth, unbermed road surface are key to maintaining a well drained, outsloped road.

Rolling dips and other waterbreaks will be spaced along the road close enough together that the road surface does not gully and sediment is not eroded and delivered to a stream from the dip. It is important to use rolling dips because traffic will quickly break down and/or breach waterbars. Waterbars will generally be reserved for roads that are to have little or no winter use.

Subdrainage design techniques: Subdrainage is used to carry subsurface or emergent water away from the road. If not drained, seepage can cause severe construction and maintenance problems. Special subdrainage measures will be used if wet soils cannot be avoided, a spring develops during construction or where soils are unable to support rock surfacing needed for winter use of the road. Ditches and French drains are common methods of draining emergent, upslope ground water.

If the roadbed crosses an intermittent or perennial spring, soils beneath the road surface may need extra drainage. Gravel drainage blankets may be used to drain the water laterally to the toe of the fillslope. Filter fabrics (geotextiles) will be used to maintain separation between the native soil and the gravel in certain areas. Geotextiles will also be used at the base of the subgrade to maintain soil separation and prevent soil pumping into the rock and gravel surfacing.

Landing design and layout: Log landings built along forest roads vary tremendously in size and frequency within the property. Where streams are far from the road, maximum hillslope gradients for building small landings using sidecasting methods are usually the same as for road construction: about 60 percent. Sidecasting on steeper slopes will generally be avoided. Keyways or benches will be constructed for the development of compacted fills where landings are built on steeper slopes.

In general, landing construction will be limited to the fewest number and smallest size that are absolutely needed for yarding operations. The following terrain will generally be avoided as sites for landings: 1) unstable slopes and soils, 2) slopes steeper than 60% with no natural benches, 3) steep headwater swales and inner gorge slopes, 4) narrow ridges between steep headwater swales, 5) any steep slopes (>50%) which leads without flattening to a watercourse and 6) areas underlain by steeply dipping or highly fractured rock layers. These are sites where damaging landslides are most likely to occur. Existing landing that are located in these areas will not be enlarged. Sidecasting will be strictly minimized around the perimeter of landings and any unstable sidecast that has access to a stream channel will be excavated and removed.

D. Drainage

It is PALCO's policy that roads will be designed and constructed to cause minimal disruption of natural drainage patterns. Provisions for two elements of road drainage will be included in every project.

Road surface drainage (including drainage which originates from the cutbank, road surface and fillslope) and

Hillslope drainage (including drainage from large springs, gullies and streams which ***cross*** the road alignment).

1. Road Surface Drainage

Road surface drainage is accomplished by insloping, outsloping or crowning the roadbed. PALCO recognizes that without adequate cross-slope, the road surface will either pond water, or concentrate runoff down the roadbed and create surface erosion.

Outsloped roads: Where conditions are suitable, PALCO forest roads will be constructed as single lane, outsloped roads with minimal cut-and-fill. All-season roads built high on the hillside, or wherever the surface can be kept dry, should be outsloped. Conditions that might limit road outsloping include: 1) steep road grades, 2) winter hauling requirements, or 3) excessive runoff or spring-flow from the cutbank or road bed. To the extent feasible, rolling dips will be employed to drain surface runoff from outsloped roads. Rolling dips will be designed and constructed into new roads, and they may be built into existing roads that are being reconstructed. Waterbars and/or rolling dips will be used to drain low standard seasonal or temporary, unsurfaced roads where winter use will not occur.

Insloped and crowned roads with ditches: Insloped or crowned roads may need to be constructed where road grades are steep, where the fillslope is unstable or where outsloping would create unsafe driving conditions. Insloped roads will be built with an inside drainage ditch to collect and remove road surface runoff. Ditch relief culverts or rolling dips will be designed and installed at intervals close enough to prevent erosion of the ditch and discharge area.

Ditches which discharge into stream crossings (at culvert inlets) will be eliminated or strictly minimized. This standard will be incorporated into new road construction designs as well as road reconstruction and upgrading efforts. Likewise, efforts will be made to ensure that ditch relief culverts do not discharge into a watercourse without first flowing through an adequate filter strip. “Filtering” can be accomplished by thick downslope vegetation, gentle slopes, settling basins, or windrows of woody debris and mulch placed and secured on the slope.

Ditch relief culverts do not need to be large, since they carry flow only from the cutbank, springs and a limited length of road surface. Minimum ditch relief culvert sizes will generally be 18 inches (diameter). Smaller culverts which exhibit problems or potential problems will be replaced and upgraded as road drainage is upgraded throughout the property. In new installations, ditch relief culverts will preferably be installed at the base of the fill (rather than “shot-gunned” out of the fill) or fitted with a downspout. As road upgrading work is conducted on the property, existing ditch relief culverts causing fill erosion will either be properly replaced or fitted with downspouts or other erosion prevention structures.

2. Hillslope Drainage (stream crossings)

Streams can be crossed with bridges, culverts or fords. Culverts are the most common stream crossing structure. Bridges are best for large streams or where there is a lot of floating wood and debris in flood flows. Bridges also have less effect on fisheries than other methods. Fords work well on small to medium sized streams where there is a stable stream bottom and vehicle traffic is seasonal or light.

Stream crossings will always be designed for adequate fish passage where fish could be seasonally present, for minimum impact on water quality, and to handle peak runoff and flood waters. The type of stream crossing selected for installation (permanent or temporary; bridge, culvert or ford) will depend on a number of factors and design considerations.

PALCO recognizes the importance of proper stream crossing design to minimize the effects of forest management activities on watercourses. The following design standards will be followed on the property.

1. All stream crossings will be built with a “fail-safe” drainage design. Critical rolling dips will be installed so that stream crossings on all newly built or reconstructed roads will not have a “diversion potential” (DP).

2. During road reconstruction, high DP crossings will be corrected by constructing a broad rolling dip over or immediately down-road from the fill if feasible.

3. During road reconstruction, undersized culverts will be fitted with new, properly sized culverts, or a second overflow culvert will be installed higher in the fill as an emergency overflow pipe.

4. Debris barriers will be designed, installed and maintained upstream from culvert inlets where there is a recognized potential for culvert plugging.

5. A recognized quantitative method of peak flow determination and culvert sizing will be employed for all new or reconstructed stream crossings. The results of these determinations may be modified to fit ground observations.

E. Construction

The construction phase of a road project is when planning and design decisions are carried out on the ground. PALCO recognizes that poor execution of plans, no matter how well designed, can result in a poorly constructed road that causes serious environmental impacts. The skill and experience of supervisors and equipment operators will play a large part in determining the success of the project. A program of technical training of foresters and equipment operators is currently underway. A road engineer, with responsibilities of design and quality control, has recently been added to PALCO staff. Once plans and designs are prepared, any substantial changes in road alignment or in road or drainage design will only be made by qualified personnel.

1. Timing

Road planning, design and field reconnaissance work will be conducted at any time of year. Activities which expose large amount of bare soil, including construction, reconstruction and decommissioning, will be conducted during the time of year when the best results can be achieved with the least damage to the environment. Clearing (cutting and removal of vegetation from the right-of-way) will be performed anytime weather permits. Yarding (removing trees) and **grubbing** (removing stumps and surface organics), results in soil disturbance and will be limited

to reasonably dry soil conditions. ***Grading*** (excavating the road bench) creates large expanses of bare soil and will be performed only during dry conditions. Road construction, reconstruction and decommissioning is best performed during the spring, summer or early fall, but certain upgrading work can be performed all year long, depending on road surfacing, soil moisture and weather conditions. Minimizing the effects on the aquatic system and water quality will be of major importance in scheduling and conducting such activities.

The timing of stream crossing installation is critical to maintaining and protecting water quality. Timing is also important to fisheries in many watersheds. All non-emergency road construction activities involving the installation and removal of stream crossings will be completed before the onset of the winter period or during extended dry periods. Emergency erosion control and erosion prevention work and road maintenance activities will be performed during the winter period in order to minimize erosion and sedimentation problems as they arise.

2. Clearing and Grubbing

The road centerline will be clearly marked on the ground prior to clearing. Trees and shrubs will be left growing below the base of the proposed fillslopes, and the right-of-way will be kept to the minimum width necessary for the planned use of the road. For slopes over about 35 percent in gradient, the organic layer on the soil surface will be substantially disturbed or removed before placing or sidecasting fill on top.

Cull logs and coarse slash may be piled in a row (a "***filter windrow***") parallel to the road at the base of the proposed fill to contain eroded sediments. Filter windrows will be installed where roads are being built near a stream channel where sediment would have the opportunity to enter the stream.

3. Grading and Compaction, including Sidecasting

Sidecast construction methods will not be employed on moderate or steep slopes near stream channels where loose material could saturate and slide downslope and into the stream. Similarly, sidecast and waste material will not be placed where it could erode and be delivered to a watercourse.

Sidecast failures are usually associated with ground slopes of 65% or steeper, although springs and seeps can cause failures at much gentler slope angles. We will follow the general rule-of-thumb to minimize sidecasting on ground slopes of over 60%, and to not develop sidecast slopes exceeding 65%. Sidecasting will not be employed on slopes exceeding 50% which extend directly to a watercourse where slope failure would deliver sediment to the stream. Such full bench road construction will usually be reserved for moderate or steep slopes, or where a road approaches or parallels a stream channel that could be impacted by sidecasting.

4. Constructing on Wet Soils

The application of coarse rock surfacing is a time-tested method for solving wet road surface conditions on forest roads. Rocking allows trucking and hauling on many roads during periods of wet weather. While surfacing can double the cost of a road, the rock or gravel cover provides a stable surface that can be used to extend the operating season without damaging water quality.

PALCO uses a variety of techniques to maintain a stable road and protect water quality when constructing on wet soils or when it is anticipated that operations will be conducted on the road

during the wet winter period. Small springs and seeps will be drained using clean gravel drains and surface rocking, combined with synthetic geotextiles. Water emerging from road cutbanks can be controlled using a vertical drainage trench. Water emerging beneath the roadbed can also be controlled by installing a drainage blanket beneath the fill. A variety of other inexpensive and successful engineering methods are available, and have been used by the Company, to solve special subsurface drainage problems. PALCO employs a road engineer to assist the company in formulating solutions in these and other situations.

5. Constructing on Unstable Slopes

Our first rule of road construction and reconstruction is to stay away from unstable areas and landslides whenever possible. Alternate alignments will be developed wherever possible. PALCO realizes that where water quality would be seriously threatened by operations on unstable slopes, road construction or reconstruction projects may have to be deferred or entirely avoided. Unstable slopes that threaten water quality must be recognized and may be considered ***unsuitable*** for road building. Professional evaluations of slope stability and debris flow hazard can best be made by a trained geologist or engineering geologist. Where necessary, an experienced engineering geologist or geotechnical engineer will be consulted before designing roads on unstable slopes.

6. Constructing Stream Crossings

Common types of stream crossings include bridges, culverted fills, fords and a variety of temporary crossings. Stream crossing construction involves two discrete phases: 1) constructing the road bench approaching and leaving the crossing site, and 2) constructing the fill and installing the drainage structure. Both elements are critically important to protecting water quality.

Stream crossing approaches: Excavation of the approaching roadbed is a critical part of constructing every stream crossing. If the channel sideslopes are steep, any sidecasting on the approaches could deliver soil directly to the watercourse. Where roads are to cross stream canyons or incised channels with steep sideslopes PALCO will evaluate and locally employ full bench construction methods in order to protect water quality. Excavators are ideal machines to perform full bench construction on difficult stream crossing approaches. Crossing sites exhibiting unstable soil will be avoided wherever possible.

Bridge installation: Where topographic conditions are suitable, bridges may be the best, least damaging choice for stream crossing installations and will be considered for all larger, deeply incised Class I (fish-bearing) watercourses. There is less disturbance during installation of bridges and there is less chance they will fail during floods.

As with culverted stream crossings, the greatest potential impact to stream channels occurs during installation. Installation will minimize the use of equipment in the stream. Generally, bridges will be installed at right angles to the channel with enough clearance beneath the structure to pass flood flows and organic debris. The adjacent approaches to each bridge will be drained so that road runoff does not directly enter the watercourse. If the road climbs away from the crossing in one or both directions, the approaches will be flattened for at least 50 feet if feasible and rock surfaced.

During installation, the abutments will be prepared and placed (or constructed) on each bank to accept the bridge. Each abutment will be leveled, secured to the bank and set back from the channel edge.

Culvert installation: During road building, the construction of culverted stream crossings has the greatest potential of all activities to cause immediate sediment pollution. If culverts are not properly aligned, bedded, backfilled and covered, they will be subject to premature failure. In all cases, disturbance to the stream banks and streambed will be minimized during stream crossing construction. For added protection, flowing streams will be diverted and dewatered as much as is possible during construction to reduce erosion at the work site.

Except in unusual cases, new stream crossing culverts will be placed at the base of the fill, and at the grade of the original streambed. First, large rocks and woody debris that could damage the pipe or cause seepage will be removed from the culvert foundation. As the culvert is installed, it is aligned with the natural stream channel.

Since nearly every culvert will sag after it is buried, all culverts placed in "new fill" will be installed with a "camber" or slight hump in the bed centered under the middle of the pipe. The amount of camber should be between 1.5 to 3 inches per 10 feet of culvert pipe length. To prevent leaking, backfill material will be compacted in lifts as it is placed around and over the pipe. Fill will then be placed over the top of the culvert to a depth of at least 1 foot for 18" to 36" culverts, or a minimum of 1/3 to _ the culvert diameter for larger pipes. If the fill is very shallow, a pipe-arch or two smaller culverts may be installed. Once backfilling has been completed, the inlet and outlet of the culvert will be armored as necessary to prevent erosion. A trash protector will be installed just upstream from the inlet if there is a recognized plugging hazard from floating debris.

Every effort will be made to ensure that road runoff will be diverted off the road bed and away from new fills before it reaches the stream crossing. Every effort will be made to ensure that road surfaces and ditch systems on the approaches to stream crossings are dewatered and drained into vegetated areas below the road before reaching the crossing. In addition, if feasible, a "critical dip" (rolling dip) will be placed at the down-road side of each stream crossing fill to prevent stream diversions and to provide a "fail-safe" drainage design in the event of culvert plugging.

Temporary stream crossings: By definition, temporary stream crossings are designed to be removed. Installation of temporary crossing will be done with the minimum possible amount of disturbance to the channel bed and banks, and using the least amount of fill material possible. During installation, sidecasting will be strictly minimized. Colorful flagging, straw mulch or some other marker will be spread over the natural channel bottom before the crossing is filled so that the same, stable bed can be uncovered when the crossing is removed. Following removal, temporary stream crossing fills will be fully removed and the sites will be left in a relatively undisturbed condition that is subject to minimal erosion.

For shallow, dry channels, rock-lined dry-fords may be installed as temporary stream crossings. The road will be built to dip across the channel using as little fill as possible.

If the stream is deeply incised or flowing at the time of installation, a temporary log, log-and-culvert, culverted fill or temporary bridge will be installed. For log crossings, vegetation is first pruned from the streambed and banks. A culvert will be placed in the bed of live streams. Logs may be bundled using cables (for easy removal) and placed in the channel. When the log "fill" has been built up within 18 inches of the road grade, it is covered with a 6-inch layer of straw. Filter fabric may be used with or instead of straw on top of the logs, to keep sediment from filtering down into the stream, although straw alone usually works better. Local soil will then be placed on top for the temporary running surface.

7. Rolling dips

Rolling dips provide for low cost, low-maintenance road surface drainage and will be appropriately employed to control drainage on PALCO roads. Rolling dips are simply breaks in the grade of a road that are used to drain road surface runoff and prevent surface rilling and erosion. They are much broader and less abrupt than waterbars and, if properly constructed, can be driven over at normal driving speeds. They are most often used on outsloped roads, but can be employed on all road types. As a road becomes steeper, rolling dips should become more frequent, deeper and with a longer approach. Rolling dips can be installed during new road construction, or they can be built on existing roads to improve surface drainage.

Excavation for a rolling dip will typically begin 50 to 100 feet up-road from where the axis of the dip is planned. Material is progressively excavated from the roadbed, slightly steepening the grade, until the axis is reached. The axis of a rolling dip can be angled (up to 30) to the road alignment, but the dip may also be built essentially perpendicular to the road, making travel by loaded trucks somewhat easier. Beyond the axis, the roadbed slope should actually rise slightly, or reverse grade, to ensure that road runoff cannot continue down the road surface. The rise in grade is carried for about 10 to 20 feet before the road falls again at its original slope. Unlike a waterbar, the down-slope or reverse-grade portion of a rolling dip is generally not composed of fill. The entire drainage structure should be excavated into solid roadbed materials or native ground, and the excess spoil materials stored at a stable location where it will not erode and enter a stream crossing.

Rolling dips require very little maintenance if they are constructed properly and at an adequate spacing. They should not collect enough runoff to develop significant erosion and no eroded sediment should be delivered to a stream. The length and depth of the rolling dip should be adequate to divert road runoff but not so great as to interrupt or endanger traffic at normal speeds. Care will be taken to train grader operators and to ensure that they do not fill the depressions with soil or cut deeply into the lower part of the rising section, thereby eliminating the change-in-grade.

8. Subgrade and Surfacing

The road surface can be a significant source of fine sediment to stream channels in a managed watershed, especially where roads are actively used for log hauling. Proper road location, design, construction, drainage and surfacing can greatly reduce this sediment source. Fine sediment can be particularly damaging to fish and fish habitat.

Permanent roads that are to be used for winter and wet weather hauling will be surfaced or otherwise treated to improve trafficability and reduce erosion. Roads which receive heavy use will be inspected regularly to discover early signs of damage, such as the build up of thick dust accumulations or excess water and mud.

A stable and well drained subgrade is essential for a good road. Native material may be suitable for the road's subgrade and weak or wet subgrades will be strengthened by adding loose or crushed rock or gravel, or by spreading a geotextile fabric over the subgrade and then covering it with a layer of rock. Water passes through the synthetic fabric, but the wet soil remains below. The geotextile also gives it strength by spreading forces laterally.

Ideally, a “base course” of 2 to 3 inch diameter angular rock is usually dumped on the compacted native surface, spread to a uniform depth and then compacted. A finer “surface course” several inches in thickness is then spread over the compacted base coarse material to provide a dense, smooth running surface. In practice, a single thick layer (6 to 10 inches) of well graded rock is often spread on the road surface.

9. Erosion Control During Construction

PALCO recognizes that road construction can cause serious soil erosion and stream sediment pollution. Some erosion is the result of poor road location, design or construction, operator error and poor maintenance practices, but some clearly comes from inadequate erosion and sediment control on the construction site. PALCO has developed standard operating procedures and operator training programs to minimize unnecessary road-related erosion.

Roads and landings: Both mechanical and vegetative measures will be employed to minimize erosion from roads and landings under construction. Effective erosion prevention employs proper road location, pre-planning of cuts and fills, minimizing soil exposure, compacting fill or endhauling loose fill materials from steep slopes and stream-side areas, developing stable cut and fillslopes. To minimize erosion, road construction will typically be performed during the “dry” season, and all surface drainage structures will be constructed and in-place prior to the winter period. Erosion during road and landing construction will be minimized on PALCO projects by keeping soil disturbance to an absolute minimum, and by properly timing the period of disturbance. Erosion control measures such as rolling dips and waterbars will be used for surface drainage control, while filter windrows, straw mulch and seeding will be used to control erosion of new fillslopes.

Spoil disposal sites, borrow sites and rock pits: Erosion will also be controlled in areas where large expanses of bare soil have been created, such as spoil disposal sites, borrow sites and rock pits. Proper location, excavation and topographic development of disposal sites and rock pits are key elements to assuring controlled drainage and minimizing erosion and sediment problems. Spoil disposal areas, borrow sites and rock pits will not be located near streams where sidecast, tailings or sediment-laden runoff would impact a watercourse. Impacts will be minimized by controlling drainage and runoff.

Stream crossings: Stream crossings are where roads come into closest contact with flowing water. For this reason, it is critical that proper and sufficient erosion control measures be applied and that sediment entering the watercourse is minimized. Regardless of the measures chosen, PALCO acknowledges that any successful erosion control technique must be correctly installed and regularly maintained to be effective.

Erosion control and erosion prevention efforts will be directed to culvert inlets, culvert outlets, through-fill road surfaces, fillslopes, and inside ditches. PALCO will employ a variety of measures at these sites to ensure that erosion is Minimized. Rock armor or flared inlets, upstream trash racks and drop inlets may be prescribed to protect the culvert from plugging. Well placed outlets, flumes, downspouts and energy dissipation prevent outlet erosion. Rock surfacing, waterbars, rolling dips and/or outsloping will be used at many locations to minimize road surface erosion.

In addition to controlling road surface runoff, a fail-safe drainage design (critical dip) will be incorporated into every stream crossing where there is a potential for stream diversion. In general, they will be placed on or near the hinge line where the road fill intersects the native ground.

F. Reconstruction

PALCO views road reconstruction as an opportunity to upgrade and improve a road in one or more ways. PALCO has initiated and is conducting a programmatic effort to upgrade and "storm-proof" forest road systems within the ownership. A variety of tasks are undertaken in this effort. In general, stream crossings and unstable fill and cutslopes present the greatest challenge to road reconstruction, and the greatest opportunities for future erosion prevention and rehabilitation.

Reconstruction can be used to reopen old abandoned roads, or to upgrade and improve active roads that are not "up-to-standard." Abandoned, closed roads can be rebuilt to provide temporary access to an area, or they can be permanently upgraded to become part of the maintained road network. First, an inventory IS conducted to identify the current condition of the road in relation to the desired standard. Culverts will be upgraded to current standards, additional drainage structures will be installed. If needed, the road bed may be reshaped for improved surface drainage and unstable fills will be removed and/or stabilized.

1. Decision to Rebuild: Redesign Considerations

Decisions about reopening an abandoned road are made on-site, after having inspected the entire route and reviewing the pros and cons of redisturbing the area. Both economic and environmental considerations will be employed to decide whether or not to reconstruct a road.

Temporarily reopening a poorly built road may provide environmental benefits if rehabilitation work can reduce continuing or future erosion from the old alignment. If temporary access to an area is needed, it is often justified to remove even abundant vegetation from an old, overgrown roadbed if substantial erosion prevention projects could be completed during reconstruction or when the road is properly "put-to-bed." On the other hand, just because an old road exists in a watershed is not sufficient justification to reopen it when an alternate alignment would prove much more suitable and less damaging.

Reconstruction becomes more difficult where the road prism has been badly damaged by gully erosion, stream crossing washouts and/or by landsliding. Most washed out stream crossings are usually easy to rebuild, but where entire sections of the roadbed have been entirely lost due to past erosion or landsliding it may not be economically worth rebuilding. Future maintenance requirements can add substantially to the final cost of road reconstruction.

When reopening or upgrading an old road, improvements in the existing design will be made wherever possible, and conditions which led to past failures will be corrected so the road does not fail again. If the road is to be permanent, drainage structures will be brought up to current standards so they are not undersized for the design flood flow. Undersized culverts and drainage structures will be redesigned for the 50-year flow. Stream crossings that currently have a high potential for stream diversion will have critical dips installed if feasible, thereby eliminating the diversion potential. Humboldt log crossings will be permanently removed or replaced with properly designed bridges or culverts. As with construction, all reconstruction work will be conducted in a manner that minimizes soil disturbance.

2. Reconstruction Techniques

The most efficient equipment for road reconstruction include hydraulic excavators and bulldozers for earth moving, dump trucks for endhauling spoil, and graders for final road smoothing. PALCO

now maintains a number of each of these types of equipment that are used for road-related activities (construction, reconstruction, upgrading, maintenance, closure, etc.).

Many older forest and ranch roads on the property were built with an insloped surface and an inside ditch. In appropriate locations, these routes will be converted to low-impact, low maintenance outsloped roads with rolling dips. In other locations, ditch relief culverts, berm removal and other surface drainage improvements will be made to improve drainage and lessen erosion risk.

Washed-out stream crossings present one of the most common obstacles on our older, abandoned roads that are to be reconstructed. Usually, part or all the fill has been eroded because the culvert was either too small or plugged with debris. These crossings will be redesigned and rebuilt just as though they were new installations. If the fill was only partially eroded, the remaining fill will be excavated before a new culvert is installed. If a bridge is to be installed, all the old fill will be removed from the crossing and the banks graded or excavated back to a stable angle.

Failed road benches can also be a serious obstacle to reconstruction. Failures can involve either the outer half of the roadbed or the entire road prism. Sidecasting into the void in hopes of developing a new road bench at the same spot will often result in continued instability. Instead of sidecasting to rebuild road width, we will attempt to establish and maintain a narrow road or cut slightly into the inside bank. Where failures have removed most or all of the former road bench, road reconstruction may require an engineered solution, such as a reinforced fill or a crib wall, or rerouting. Where necessary, a qualified specialist will be used to design solutions for these difficult reconstruction sites.

If road or landing fill shows signs of pending failure and would slide into a stream, then the unstable material will be excavated and hauled to a stable storage site for disposal. Cutslope failures which block the road surface generally represent a less serious erosion problem than fillslope failures, since the road bed may store much of the failed cutbank material and prevent it from moving downslope.

3. Slash and Spoil Disposal

Reconstruction of abandoned roads often involves substantial vegetation removal from the road surface. Slash generated during this process will not be mixed in and sidecast with soil materials. Instead, it will be piled and burned, or it will be placed along the alignment separately from soil as a windrow along the outside edge of the fill. Spoil materials generated from road reconstruction (largely from cutbank failures), will be safely disposed in a stable location where it will not erode or enter a watercourse. Spoil disposal techniques and precautions are the same as for new road construction.

4. Erosion Control

Erosion prevention and erosion control can actually be improved by road reconstruction. Upgrading or removing stream crossings and removing unstable fills can greatly reduce the likelihood of sediment delivery to stream channels. Even the temporary, single reuse of an abandoned road can serve as an opportunity to perform critical erosion control and erosion prevention work when the road is permanently closed.

Erosion control during reconstruction of permanent and seasonal roads is largely the same as for new construction. Surface erosion will be minimized by keeping excavation and soil exposure to a minimum, and by retaining as much roadside vegetation as possible. The largest potential source of erosion will be at reconstructed stream crossings. Use of temporary bridges, as well as protective measures at culvert inlets, culvert outlets, road surfaces, and fillslopes will help reduce the potential for erosion on reconstructed roads.

The timing of reconstruction, especially stream crossings, can also help prevent and control unnecessary erosion. Non-emergency stream crossing reconstruction will be performed during low water conditions. Winter period road reconstruction will only be performed during dry periods. Long road sections will not be "opened" and rebuilt in the winter without performing concurrent erosion control work.

G. Maintenance

PALCO believes regular road maintenance is essential to protect the road and to prevent environmental damage. Only temporary roads that have been ***properly*** closed will no longer need continued maintenance. Road and drainage structure maintenance is a fundamentally important part of developing, managing and utilizing our wildland road system and we are firmly committed to providing necessary personnel and financial resources required to provide both preventive and emergency inspections and maintenance on all permanent and seasonal roads, regardless of their level of use.

1. Inspection and Maintenance Schedules

Roads and drainage structures will be inspected annually prior to the beginning of winter. Inspections will cover culvert inlets and outlets on stream crossings and ditch relief culverts, road surface drainage such as waterbars, outsloping and ditches, as well as road and landing fills. In addition to annual, pre-winter drainage structure inspections, crews will also inspect and perform emergency maintenance during and following winter storms.

Some drainage structures are more prone to problems than others. Based on past maintenance experience, a rating system and inspection plan will be developed for all culverts within the PALCO road network. Culverts will be entered into PALCO's GIS and coded to indicate culvert location and size.

2. Maintaining Surfaced Roads

The first rule of maintaining a stable road surface is to minimize hauling and grading during wet weather on unsurfaced roads. Serious damage to the road surface begins with loss of road drainage and excess standing water. Ruts indicate that road strength is deteriorating. A poorly maintained road surface will channel water, reduce road life and result in sediment pollution to streams.

Summer hauling can also churn and pulverize road surface material and create thick, loose layers of soil and rock powder (dust). Loose dust can then erode and flow into streams with the first fall runoff. For this reason, summer hauling will be accompanied by dust control and watering to maintain road surface stability, and by grading adequate to maintain a smooth running surface.

Excess grading is also counter-productive, creating fine material which is available for transport to ditches and streams. Road surfaces will be graded only when needed to maintain a stable,

smooth running surface and to maintain the original surface drainage. Over-grading results in unnecessary erosion and increases road surface rock wear. Steep road sections will quickly loose their running surface with frequent grading. Grading is best performed when the soil materials are slightly damp. Unplanned berms that concentrate runoff during winter rains generally will not be left along the outside edge of the road.

Over years of hauling and grading, road surfacing materials gradually break down or are inadvertently moved off the side of the road. Steep sections of road and curves experience the highest rates of wear and material loss. To resurface or restore the road bed, such roads will occasionally be ripped and refreshed with new aggregate.

Where inside ditches are used, ditch maintenance is needed to clear blockages and maintain flow capacity. Inspecting ditches during periods of high runoff will indicate which ditches need cleaning. Often, nothing more than shovel work at problem spots is required to solve ditch drainage problems. Frequent, routine mechanical grading of ditches is usually unnecessary and can cause ditch and cutbank erosion and undermine steep cutslopes. Ditches along PALCO roads will be graded only when and where necessary to maintain ditch function.

3. Maintaining Seasonal Roads

Unsurfaced seasonal roads require almost the same maintenance effort as permanent roads, but are much more sensitive to wet weather use. Road surface grading may be required after each period of intensive use in order to maintain proper surface drainage. Dust control and watering is usually necessary to prevent excessive loss of surface materials. Seasonal, unsurfaced roads can be badly damaged by even occasional use during wet periods when the roadbed is soft. PALCO will also employ temporary or seasonal road closures, where necessary, to protect the road surface, minimize erosion and reduce road maintenance costs.

4. Stream Crossing Maintenance

Stream crossing culvert inspections and maintenance will be performed prior to each winter period, and culverts will also be inspected and cleared during and after winter storms to prevent plugging. Identified problems will be corrected; delay can result in road damage and costly road repairs. The most critical component of successful culvert maintenance is to fix problems early, so that failure never occurs.

Culvert maintenance activities will include hand, shovel and chain saw work as well as mechanical (backhoe) cleaning at culvert inlets. Floatable debris, material wedged in the culvert inlet or debris barrier, and sediment deposits that threaten to plug the culvert will be cleared away. Damaged culvert ends will be straightened and re-opened. Outlets showing erosion will be armored or fitted with a downspout.

Bridges and fords may also require maintenance. Permanent fords showing erosion may need additional rock armor. Riprap and other bridge abutment protection will be repaired as soon as damage is noticed. Debris that becomes lodged in the bridge structure will be cut free and removed.

5**.** Maintaining Cuts and Fills

The key to maintaining cuts and fillslopes is to ***observe and note*** when and how changes to these features occur. Corrective measures can then be implemented. Typical cutslope problems along

PALCO roads include locally heavy ravelling, rilling, and slumping. Unless the sediment problems threaten water quality or vehicle safety, applying mulch and vegetation may be sufficient.

Instability in fillslopes and sidecast materials often shows up on the surface or edge of the road as small tension cracks and scarps. This is one sign we look for in our inventories to identify potentially unstable fill material that needs to be excavated. The outside perimeter of landings built using sidecast methods commonly show such instabilities. If the potential instability is perched above a stream channel and threatens to enter the channel, immediate treatment will be required and the project will be given the highest priority. Improving drainage and excavating unstable soils or buried materials are typical fillslope treatments which will be employed by PALCO on our forest roads.

6. Spoil Disposal

If excavations, grading and culvert basin cleaning and maintenance produces excess material, it will be stored locally or hauled to a stable site safely distant from streams. Excess spoil from maintenance activities will not be sidecast near streams or on steep slopes. Berms of excess spoil along the road shoulder will be removed or frequently breached prior to the rainy season.

H. Closure and Abandonment

There are many reasons for closing or proactively "abandoning" (decommissioning) a forest road, most of which involve either excessive maintenance costs, lack of continued need or potentially serious water quality problems. In addition to preventing erosion, roads that are properly closed no longer require continued expenditures for maintenance, until and unless they are reopened and reactivated.

Roads may be divided into three classes: permanent (all-weather and seasonal), temporary and abandoned. Permanent and seasonal roads are part of the overall road network that will be actively inspected and maintained. Drainage structures on seasonal roads will receive regular inspection and maintenance because as they are just as likely to fail as those on more actively traveled routes. Temporary roads are constructed or reconstructed for a single entry access to an area, such as for harvesting an isolated stand of timber. Temporary roads are "put-to-bed" following their use, surface drainage improved, unstable fills removed and stream crossing fills being fully excavated.

Abandoned roads are found in locations throughout the property. These old roads were once a part of the active road network but may have since become overgrown with vegetation and may no longer be driveable. Some of these may be needed for future management. Drainage structures are typically not maintained on abandoned roads. Abandoned, unmaintained roads represent potential sediment sources. We have committed ourselves to systematically inventory and proactively treat potential sources of erosion from abandoned roads on the property. This will be done by either upgrading or by closing (decommissioning). This is one element of our road armoring and erosion prevention program.

1. Techniques for Road Closure

Once an industry-wide practice, PALCO no longer considers it acceptable to abandon roads by simply closing a gate or blocking the road and letting it "return to nature," as these actions can cause serious future erosion and water quality problems. A variety of techniques have been recently developed which allow temporary roads to be used once, and then "put-to-bed" until they

are needed again. These same road closure techniques can be used to "erosion-proof" old abandoned roads.

Closing a road does not imply that every foot of the road needs intensive treatment to prevent future erosion. Rather, aggressive treatment is required only on those segments of road which have a potential to generate erosion and to yield sediment to stream channels. Segments of road which pose no risk of sediment delivery will likely be left intact and receive only minimal road drainage improvements. Implementing these road closure practices will also help minimize structural damage to expensive road networks when they are not being used. When (and if) the road is again needed to provide access to the area, it can be reconstructed with minimal effort.

All permanently closed (decommissioned) roads will be "erosion-proofed" by excavating stream crossings and removing stream crossing culverts, excavating visibly unstable road and landing fills, and treating the ditch and road surface to disperse runoff and prevent surface erosion. Bare soil areas will be planted where necessary to control erosion and sediment delivery to stream channels. The goal of road closure is to leave the road so that little or no maintenance is required for stability while the road is unused.

Typical road closure treatments that are used on PALCO property are described below.

Stream crossing excavations: All stream crossings on temporary or abandoned seasonal and permanent roads will be completely excavated ***before*** the first winter period following their installation or closure (if not, they should be capable of passing the 50-year flood flow for that channel). Existing crossings on abandoned or old temporary roads will be systematically inventoried and scheduled for treatment.

Removing a stream crossing involves excavating and removing all materials placed in the stream channel when the crossing was built. It is not enough to simply excavate and remove the culvert; the entire fill will be excavated down to the original channel bottom and the banks will be graded back to a stable angle. The channel bottom will be as wide or wider than the natural channel above or below the crossing. The approaching road segments will be outsloped or cross-road drained to prevent erosion.

Treatment of unstable areas: Any visibly unstable road or landing fill (or sidecast) that is likely to enter a Class I, II, or III watercourse will be inventoried and excavated and/or treated during road decommissioning operations. Such areas are observed to occur most often 1) around the perimeter of landings, 2) on sidecast constructed roads built on steep slopes, 3) where roads have been built on steep slopes over springs or seeps, and 4) where roads have been cut into steep headwater swales or "dips" in the hillside.

Cutbank failure materials are often completely caught and stored on the adjacent road prism. For this reason, cutbank instabilities often do not need (and will not receive) the same amount of "erosion-proofing" and stabilizing as do fillslopes and stream crossings.

Road surface runoff and other drainage structures: Roads that are to be closed (decommissioned) and unmaintained will have adequate, self-maintaining surface drainage. Inside road ditches will either be eliminated or breached with cross-road drains or rolling dips so that water is not diverted and gullies do not deliver sediment to stream channels. Outside road berms will typically be removed or frequently breached to encourage continuous drainage off the road surface.

Erosion control: Most erosion control work along closed roads will be accomplished by 1) physically excavating stream crossings, unstable fills and landing sidecast, 2) installing cross-road drains, 3) road ripping, and 4) local road outsloping. Other hand-labor erosion control and revegetation practices that may be of use include mulching, installation of energy dissipation (e.g., rock armoring and woody debris), seeding and planting.

If rock armor is needed, the channel-bottom of excavated stream crossings will be armored with well graded rock. Rock and/or woody debris can also be placed at the outlets to cross-road drains where it is necessary to control sediment delivery.

Revegetation: Vegetation is the ultimate, long-term erosion control agent. Because it takes time to grow a thick, effective cover, some physical erosion control measures (such as mulch) may be needed for the first year or two following road closure.

Seeding with grass and other fast growing species may be used to protect bare side slopes to stream channels from raindrop and rill erosion. Planting will be conducted immediately after the surface is disturbed, or as soon thereafter is necessary to maximize germination and survival. In dry climates or in soils with poor water holding capacities, broadcast seeding may yield poor results unless the seeds are covered. Mulches can increase seedling germination and establishment, as well as control erosion on dry or erodible sites.

Two basic methods for spreading seed are dry seeding and hydraulic seeding. Dry seeding and fertilizing along roads will be done with cyclone-type rotary seeders. In hydraulic seeding (hydro-seeding), a wet slurry of seed, mulch and fertilizer is typically applied from a pump truck or portable trailer to steep slopes or where ravel or erosion rates are high. PALCO will employ both methods.

Most permanently closed or decommissioned roads will also be planted with conifers to return the site to forest and timber production. Where necessary, compacted and/or rock-surfaced roads will be decompacted (scarified) to reduce surface runoff and promote seedling survival.

Guidelines for seeding method selection on PALCO roads

Site conditions	Sample situations	Seeding method
Steep (>50%) or windy slopes, high to extreme erosion hazard	steep cutbanks and fillslopes	hydraulic seeding with a sprayed or tacked mulch
Moderate (30-50%) and steep slopes, medium to high erosion hazard	moderate and steep cutbanks and fillslopes; stream crossing fills and bridge sites	hydraulic seeding or dry seeding with a mulch
Gentle and moderate slopes, medium to high erosion hazard	cutbanks, fillslopes and spoil disposal sites not near a watercourse	hydraulic seeding or dry seeding; mulch where needed
Gentle and moderate slopes, low to moderate erosion hazard	cutbanks, fillslopes and spoil disposal sites not near a watercourse	dry seeding; mulch if needed to improve revegetation

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