APPENDIX 19

Price Field Office
Hydrologic Modification Standards for Roads

I. Surface Water Channel Crossing Criteria:

(1) Crossings which require a CWA-404 or GP-40 channel alteration permit, as determined by the Utah Division of Water Rights, are to be engineered if they are part of a federal Right of Way permit application.

(2) Channel crossings requiring culverts with individual or cumulative diameters of 30 inches or greater are to be engineered, and sized to the 25 year, 6 hour event at a minimum.

A. The commonly used sizing equations for culverts or other flow conveyances might not be reliable if there are no local precipitation stations from which to obtain accurate values. Isohyets are generated from available data. Often, the isohyet values given for remote areas have large errors associated with them. In such cases, run-off and stream flows should be obtained from hydrographs if available, measured directly if possible, or estimated based on channel dimension measurements.

(3) Wherever possible, roads should be aligned perpendicular to channels at crossings.

(4) Crossings on perennial channels which require structures or channel modification, including bank disturbance, are to be engineered. Crossings on intermittent and ephemeral channels may require engineering on a case by case basis.

(5) Culverts should connect a channel at existing points on both sides of the road. Realignment of channels is strongly discouraged. If realignment is the only option, engineering shall be done to ensure channel parameters are preserved as described in I. (6) A, B, and C.

(6) Engineered designs will ensure that crossings do not cause changes to the existing channel parameters as follows:

A. Cross Sectional Dimensions: Changes to the cross sectional dimensions of a channel destabilize streams. An altered channel often undergoes a series of undesirable changes before restabilizing. Significant widening and downcutting can occur, followed by the formation of a new channel within the widened area. This process results in significant soil loss, degrading water quality. Local ground water levels are often lowered, which can cause changes in vegetation.

1. width, as measured at bankfull level: Factors which influence width are:

a. flow velocity: Velocity of flow exiting the crossing must equal velocity of flow entering the crossing. Where culverts are used, a 'V' shaped flow guide (i.e., wing walls) should be installed at the inlet. At the outlet, a 'U' shaped guide should be used to return flow to the original width, depth, and velocity. Also see criteria I. (6) A. 1. d. and I. (6) A. 2. b.

b. flow magnitude: Avoid changes in flow magnitude within the channel. Where a flood plain is present, flows from the flood plain must not be converged with channel flow. Each flood plain must be reestablished at the crossing outlet, with flow discharged at the same velocity, width, and depth as found immediately upstream of the inlet. Where culverts are used, the flood plains should have individually sized culverts, and each must be properly placed. Combination culvert/low-water crossings may be used, allowing flood level flows to go over the road. The same principles apply, differences in flow velocity on the flood plains must be considered in crossing designs. See I. (6) A. 2. a. and I. (6) A. 2. b.

c. size and type of transported sediment: Avoid creating changes in sediment load via use of erosion controls during construction and by replacing vegetation as soon after construction as possible.

d. bed and bank materials: Introduced bed and/or bank materials should have a friction coefficient similar to that of the natural channel, except where specifically designed to adjust flow velocity, and must be installed so as to withstand high flows and floods without dislodging.

2. depth, as measured from thalwag to bankfull level: The practice of installing culverts at a slope less than the natural channel bed slope to adjust flow velocity should be discontinued if changes to channel depth are to be avoided. This would also serve to reduce head at the inlet which can occur from the flow velocity change caused by the difference in culvert slope and bed slope.

a. Culverts should generally be installed with approximately ten percent of the diameter below the channel bed, provided rock or concrete aprons are included at the inlet and outlet, each flush with the original bed surface. Unless the bed is armored, both the inlet and the outlet must be installed at the existing bed level. Exceptions to this may be prescribed to reverse a preexisting downcutting problem without incurring additional costs.

b. Adjust flow velocity using an energy dissipating rock apron at the outlet.

B. Stream Channel Patterns:

1. radius of curvature: The following equation gives a relationship for the radius of curvature of meander bends to meander length and sinuosity.

$$R = L_m K^{-1.5} \div 13(K-1)^{0.5}$$

where: R = radius of curvature
L_m = meander length
K = sinuosity

and: $K = L_c \div L_v$; which may be approximated by $m_v \div m_c$

where: L_c = channel length
L_v = valley length
m_v = valley slope
m_c = channel slope

This relationship shows that parameters of a realignment can be made to mimic natural pattern geometry by adjusting channel slope and length within the realignment reach. It is necessary to design channel pattern changes (realignments) using the correct radius of curvature to avoid causing repercussions to the cross sectional dimensions. However, realignments should be made only if there are no alternatives. See I. (6) C. 1.

a. In cases where a channel must be realigned, the radius of curvature of the new alignment must equal the radius of curvature of the natural meander of the channel.

2. <u>width/variable width, as a function of depth:</u>

a. Width at bankfull of the new reach must equal width at bankfull of the original reach.

b. Banks must be contoured with the same slope as the original banks.

C. <u>Stream Channel Profile</u>:

1. <u>slope of the channel bed:</u> The bed slope is the single most sensitive physical parameter of a channel. When the bed slope changes, most or all other parameters of the pattern and cross sectional dimensions will change.

a. If possible, choose a crossing location low on the watershed, where the ground is relatively flat. See criteria I. (6) A. 2. a. and I. (6) A. 2. b.

2. <u>pool-riffle ratio:</u> At higher elevations in a watershed, the bed slope is generally greater and the channel is usually straighter (lower sinuosity). To compensate for low sinuosity, step pools and riffles develop at more frequent intervals. Pools occur where the bed slope is flatter, and riffles occur where the slope increases. Also, water seeps into the ground at pools, and discharges from the ground into the channel at riffles. If structures are built on riffles, water seepage could cause extensive damage and present potential safety risks.

a. Cross channels at pools, not at riffles.
b. Where roads must cross at riffles, in-seepage of water must be addressed in the design.

II. <u>Road Drainage Criteria:</u> Roads which run perpendicular to hill slopes act as berms, capturing sheet flow from runoff and snowmelt and converting it into channel flow along the road. This diverts water from areas immediately downslope of the road, which can cause undesirable changes in vegetation. Ditches which are typically built along roads to transport this channelized runoff are often discharged at the nearest existing wash, stream channel or low point on the terrain. Where this discharge occurs at a channel crossing (usually the downstream side of the crossing) severe erosion frequently results. Channels are significantly widened below such crossings, appearing “blown out”. See Criteria 1. (6) A. 1. b. Also, road ditches often create severe erosion gullies by headcutting back from the wash. Where roads run parallel to channels, ditched runoff is often discharged or “turned-out” toward the channel at low points along the road. This frequently results in erosive headcuts forming from the channel to the road. This erosion degrades water quality, can destabilize the receiving channel, often erodes the road surface, and can block access along a channel. The type of damage described can be minimized or prevented with little additional cost incurred.

(1) Road drainage flow should not be converged with existing channel flow.

(2) Ditch turnouts should be made along the road at locations where terrain is fairly level along the road, and which slopes gently away from the road.

(3) Turnouts should be equipped with gravel or rock aprons at each outlet. The apron should:

A. expand outward away from the outlet for a distance sufficient to disperse channel flow from the ditch back into sheet flow

B. reduce flow velocity enough to prevent rill formation.

(4) Turnouts should be placed as needed to avoid transfering water from one drainage basin or subbasin to another, and to effect as complete a return to the original flow regime as practical. Spacing criteria as specified in the Class III road standards used by the PFO are the minimum standard.

III. <u>Miscellaneous Construction Phase Criteria:</u>

(1) For activities which disturb one (1) or more acres, a Storm Water Pollution Prevention Plan (SWPPP) must be submitted to the Utah Department of Environmental Quality.

(2) The Best Management Practices (BMP’s) set forth in the Utah Nonpoint Source Management Plan for Hydrologic Modifications, Appendix B., page 3 should be implemented

as applicable.

(3) In the event construction can't be completed prior to winter closures, measures to prevent erosion from upcoming spring snowmelt should be taken as follows:

A. Loose earth and debris must be removed from drainages, and flood plains.

B. Earth and debris should not be stockpiled on drainage banks.

C. Road drainages should be checked to ensure there are none with uncontrolled outlets.

1. Be sure all ditch drainages have an outlet to prevent ponding.

2. If necessary, build temporary sediment ponds to capture runoff from unreclaimed areas.

3. Re-route ditches as needed to avoid channeling water through loosened soil.