Tab D – Drainage Design Standards

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D.1. Definitions

D.1.A) *Average Recurrent Interval*. Average recurrent interval is defined as the average number of years, over a long period of time, in which a given flood event is equaled or exceeded in magnitude of discharge. Flood flows to be used for the design of waterways, channels and closed conduits shall have minimum average recurrence intervals as follows:

D.1.B) *Major Waterways* have a drainage area of four square miles or more and shall be designed for an average recurrence interval of 100 years. This frequency would only apply to subdivision design and not, for instance, agricultural channel design.

D.1.C) *Secondary Waterways* have a drainage area of between one and four square miles and shall be designed for an average recurrence interval of twenty-five years, except as hereinafter provided.

D.1.D) *Minor Waterways* have a drainage area of one square mile or less and shall be designed for an average recurrence interval of ten years, except as hereinafter provided.

D.1.E) *All Waterways* are, or can be, regulated by CDF&G through 1600 agreements and in some instances the National Oceanic and Atmospheric Administration (NOAA Fisheries) through Army Corps of Engineers 404 permits. Storm water conveyance facilities within fish and aquatic life bearing jurisdictional streams shall, in addition to providing for storm flow, also meet any conditions set by appropriate agencies (California Department of Fish and Game, National Oceanic and Atomistic Administration, etc.) for fish and aquatic life passage. Often these conditions require average recurrence intervals of 100 years or more.

D.2. Hydrologic Design:

In additional to the traditional hydrological analysis procedures outlined below designers must now also consider environmental effects on the watershed caused by the drainage improvements used. Filtration of runoff before discharge to a water body may be required pursuant to the standards and conditions established by the appropriate agency(ies). Exact specifications for storm water treatment facilities are beyond the scope of these road standards. All the methods used to mitigate for water quality are too numerous to be repeated in this standard, and designers are directed to the many publications concerning water quality and erosion control. Road Design is the main subject of this standard and the effects of a new road in the watershed must be carefully considered. The most important Low Impact to Hydrology (LITH) design principle road designers should keep in mind is to not cut off ANY natural swales, or drainage courses. Convey ALL natural swales across the road using critical dips or culverts with energy dissipaters so that natural drainage waters are delivered to their natural courses at non-erosive velocities. Do not use an inboard ditch to convey water from one natural course then concentrate it at the

next road drainage facility. Following this LITH principle alone will accomplish over 90% of the goal of minimizing the road's disruptive effect to the watershed.

Those waterways on which stream gauging stations have been maintained for a sufficient time and for which factors are available to convert historic streamflow into streamflow based upon projected development of the watershed shall be designed to carry the flows statistically predictable. Where stream gauging stations are not available, watershed design discharge shall be determined by the use of the rational formula:

$Q = C\ I\ A\ K$

in which:

Q = design discharge, cubic feet per second
C = runoff coefficient based upon ultimate development
I = intensity of rainfall, inches per hour
A = tributary watershed area, acres
K = K factor

D.2.A) *Time of Concentration.* Time of concentration shall be based on an initial time of seven minutes for commercial or similar areas, ten minutes for lots smaller than 1/2 acre, and fifteen minutes for lots of 1/2 acre and larger.

D.2.B) *Size of Watersheds.* Most watersheds are too large for application of the rational method in one step. In that case, the waterway shall be subdivided into reaches of reasonable length and the rational formula applied to each reach step by step, properly accumulating the parameters. The initial reach for rational method hydrology must be consistent with the initial area (not more than two acres) and concentration time chosen by the designer.

D.3. **Mean Seasonal Precipitation and "K" Factor**. Mean Seasonal Precipitation. On MENDOT STD D10, locate the approximate site in question. Pick the nearest isohyetal contour line and record the mean seasonal precipitation for the site. Calculate the factor of safety for high precipitation areas, "K", by dividing the mean seasonal precipitation by fifty. The minimum value of K shall be 1.0.

D.4**. Runoff Coefficient, "C"**

D.4.A) *Ultimate Development.* Hydraulic design shall be predicated upon ultimate development of the tributary watershed. Valley areas and gently to moderately sloping uplands, which are undeveloped at the time of design, shall be assumed to be fully developed as single and two-family residential zones (lots under 1/4 acre in size) unless a publicly proposed development, precise zoning, or the General Plan indicates a different land density or intensity. Areas of steep terrain shall be assumed to be developed fully to an intensity of use compatible with the nature of the terrain; such use may be for residential development in lots larger than 1/2 acre, unless precise existing zoning or the General Plan indicates a different density or intensity. Steep terrain is defined as terrain whose general average slope is in excess of twenty percent. Undeveloped areas whose average ground slope is between fifteen and twenty percent may be assumed as being developed into residential subdivisions with lot size of 1/4 to 1/2 acre, unless

existing development, existing zoning or the General Plan indicates a different density or intensity.

D.4.B) *Public Vegetated Areas.* Public parks, public golf courses and other publicly owned areas may be considered as vegetated to the extent that they are actually vegetated, unless publicly proposed plans show that the body having jurisdiction intends to alter the existing use of the area so as to make the surface less pervious.

D.4.C) *Other Vegetated Areas*. For other vegetated areas, runoff coefficients shall be determined by using MENDOT STD D12.

D.4.D) *Impermeable Areas*. For impermeable areas use Cp = 0.9

D.4.E) *Composite Areas*. When vegetated areas are combined impermeable areas in excess of twenty percent of the total area, use Cv curve (see MENDOT STD No. 12) to reduce Cp by the formula:

$$Ct = Cv \frac{Av}{At} + Cp \frac{Ap}{At}$$

Where:

Ap = Impermeable area (includes building roof area, paving, gravel, rock)
At = Total Area
Av = Area planted or vegetated
Cp = Coefficient of runoff of impermeable area
Ct = Coefficient adjusted for vegetated area
Cv = Coefficient of runoff for vegetated areas

D.4.F) *Heavy Soils*. All curves on MENDOT STD No. D12 represent well drained sandy loam soils native to Mendocino County. Increase C obtained from any curve by a value of twenty-five percent for areas of predominantly poorly drained clay soil.

D.5. **Rainfall Intensity, "I"**. Rainfall intensity shall be obtained from the Intensity/Duration/Frequency curves published by the California Department of Water Resources. Curves for several locations in Mendocino County are provided on MENDOT STD. No. D11.

D.6. **Submittal Requirements**

D.6.A) *Drainage Report*. For the purpose of review by the County, hydrology, hydraulic (closed conduit backwater and open channel backwater), and gutter and inlet capacity calculations will be required. The calculations must be signed and stamped by a California Registered Civil Engineer.

D.6.B) *Assumptions.* Assumptions used in preparing calculations shall be listed.

D.6.C) *Design Aids and References*. The design aids and references which were used in support of the calculations for design of drainage improvements shall be listed. Supply this office with copies of reference data. If computers are used, the input and output shall be sufficient to allow easy checking.

D.6.D) *Hydrology Maps*. Hydrology map(s) shall be provided for both on and off-site drainage areas. The maps shall be of sufficient scale and detail to show drainage areas. Drainage areas shall be numbered and outlined to facilitate checking. The area of each drainage area shall be shown on the map.

D.6.E) *Calculations*. Hydrologic and hydraulic calculations showing beginning hydraulic gradeline, energy losses at junctions, bends, structures, friction slopes, etc. shall be submitted to the engineer

D.6.F) *Hydraulic and Energy Gradeline*. In addition to the calculations, the hydraulic gradeline and the energy gradeline shall be shown for all open or closed drainage improvements except gutters.

D.6.G) *Plans*. Plan views, profiles, cross-sections and details of all drainage facilities including a typical lot grading plan shall be submitted.

D.6.H) *Inlets and Gutters*. Entrance capacity and gutter depth calculations shall be submitted for all drainage inlets.

D.6.I) *Storm water Treatment Facilities*. Filtration of runoff before discharge to a water body may be required pursuant to the standards and conditions established by the appropriate agency(ies). Exact specifications for storm water treatment facilities are beyond the scope of these road standards.

D.7. **Hydraulic Design**

D.7.A) *General:*

1) For the solution of hydraulic design problems commonly encountered, reference shall be made to generally accepted references. For those uncommon design problems not susceptible to solution by reference, the design engineer shall provide such reference, treatise, model study report, or prototype test as is necessary to confirm the hydraulic design.

2) Secondary or minor waterways out-letting into major or secondary downstream waterways shall be designed to operate against a twenty-five or ten-year flow respectively in the major or secondary downstream waterway, provided that the ground elevation along the secondary or minor system shall be above the 100-year water surface elevation in the major or secondary downstream waterway.

3) If a secondary or minor waterway is placed in a closed conduit, sufficient additional surface routes for flood flows shall be made available to carry the added flow increment up to the 100-year design discharge with no more than nuisance damage to improvements or projected improvements and with no inundation of present or future

buildings. If such surface routes cannot be made available, the secondary or minor waterway shall be designed to carry the 100-year design discharge.

4) Design depth of flow in gutters shall not exceed 0.4 foot for the ten-year flow. Roadside ditches, when allowed, shall not be used where the design flow is greater than that which could be carried in a standard gutter flowing 0.4 foot deep on the same slope as the road profile slope. Where the discharge exceeds gutter capacity, a closed conduit system shall be provided. Roadside ditches shall be designed so that the water surface of the design discharge will be at or below the outside edge of the road shoulder such that there is no flood water in the normal travel-way of the road and below adjacent ground level.

5) Discharge of drainage waters are subject to State Water Quality Control Board (SWQCB) standards, which include project, and regional discharge permits (such as NPDES) which must be adhered to. Filtration of runoff before discharge to a water body may be required pursuant to the standards and conditions established by the appropriate agency(ies). Exact specifications for storm water treatment facilities are beyond the scope of these road standards. Installation of Drainage Structures are regulated by CDF&G and in some instances the National Oceanic and Atmospheric Administration (NOAA Fisheries) through 1600 agreements and Army Corps of Engineers 404 permits respectively. CDF&G publishes "California Salmonid Stream Habitat Restoration Manual" and NOAA Fisheries publishes "Guidelines for Salmonid Passage at Stream Crossings". These and other publications are available at these and other agencies and it is the applicants responsibility to obtain such current requirements. Storm water conveyance facilities within fish and aquatic life bearing jurisdictional streams shall, in addition to providing for storm flow, also meet any conditions set by appropriate agencies (California Department of Fish and Game, National Oceanic and Atomistic Administration, etc.) for fish and aquatic life passage. Often these conditions require average recurrence intervals of 100 years or more.

D.7.B) *Manning's "n" Values:* Manning's "n" values for design shall be as follows:

1)	Plastic pipes, smooth wall	n = .010
2)	Concrete, steel troweled or smooth-form finish	n = .013
3)	Concrete pipe, precast or cast-in-place	n = .014
4)	Concrete, wood float or broomed finish, including pneumatically applied mortar	n = .017
5)	Asphaltic concrete	n = .017
6)	Corrugated metal pipe (non-spiral)	n = .024
7)	Sack concrete riprap	n = .030

8)	Grouted rock riprap	n = .030
9)	Loose rock riprap	n = .035
10)	Grassed channels:	
	a) For VR greater than 20	n = .035
	b) For VR less than 20	(From Reference)
11)	Constructed Natural Waterways	n = .050 Minimum

12) For natural channels, vegetated swales, or cases not covered above, "n" values shall be determined from generally accepted references. For materials other than stated above, "n" values may be accepted if developed and specified by the State of California and/or by an independent test performed by a reputable organization.

D.7.C) *Open Channels:* Constructed open channels and waterways shall be designed to carry the quantity of flow determined as set forth above with minimum freeboard between design water surface and the top of bank of 1.50 feet or 0.2 of the specific energy, whichever is greater. Where this minimum freeboard does not provide the necessary differential head to allow adequate gravity drainage for projected development of the tributary areas, the design water surface shall be lowered sufficiently to allow such areas to drain to the channel by gravity, except where levees are permitted. Levees are generally unacceptable; specific exception to allow levees may be granted in tidal areas or in other situations of extreme difficulty only after a specific determination by the County of Mendocino Director of Transportation that the proposed levee is the only feasible method of providing adequate flood protection.

1) For natural waterways and constructed natural waterways design flow may be allowed in an overflow area above the defined banks provided, however, the flow must be contained within a defined overflow area and freeboard provided as specified above between the water surface and adjacent ground elevation or finished grade elevation within lots or areas in which improvements are to be constructed. Less than 1.50 feet freeboard may be considered for small natural swales and creeks through open space such as parks and golf courses. In any event, freeboard shall be adequate to provide for reduced capacity due to weed growth and 100-year flow within the right-of-way.

2) For computing the required freeboard, superelevation of the water surface on curves shall be determined with references noted and the design water surface adjusted therefor. Open channels shall not be designed with a slope in the range of plus or minus twenty percent of critical slope unless added freeboard for instability waves is provided. Channels designed for supercritical flow shall have their sequent depth below top of bank.

3) Channels shall be designed taking into account the energy losses due to existing and projected road crossings or other obstructions to be placed within the channel. Energy losses for bridge piers, interior walls in multiple box culverts, or other

obstructions within the channel, shall be predicated upon the entrance obstruction width plus two feet of debris allowance on each side of each obstruction. For bridge piers or multiple box culverts, in lieu of the two feet of debris allowance on the full height of the pier or interior walls, such piers or walls may be extended upstream on a two to one downward slope to the channel invert. A debris width of two feet on each side of the downward sloping wall shall be considered for the upper quarter of the bridge or culvert depth except that the minimum height of debris shall be two feet. In lieu of debris allowance at small pipes and groups of small pipes, a flared entrance section or a debris trap must be used.

4) Bridges, culverts, and utility crossings which span major and secondary open channels and which are existing, planned or projected at the time of channel design shall have a minimum clearance from soffit to design water surface of 1.0 foot and shall cause no encroachment on the specified minimum freeboard in the upstream channel or waterway. Channels shall be designed with proper allowances for hydraulic losses for all such planned or projected future crossings to maintain clearance and freeboard as specified above. In the case that a crossing is proposed over an existing channel where the hydraulic effect of the crossing was not considered in design of the channel, minor encroachment on freeboard may be permitted provided that it can be shown that such encroachment would not adversely affect gravity drainage of adjacent tributary areas. Modification of the existing channel and special attention to the design of piers or other obstructions placed in the channel may be required to keep any encroachment on freeboard at an acceptable magnitude.

5) The water surface profile shall be computed and plotted through all crossing structures. Culverts of all types providing crossings of minor waterways shall be designed hydraulically in accordance with entrance criteria contained in Section D for minor waterway closed conduit systems.

6) Constructed natural waterways shall be excavated as required to pass the design discharge under interim and ultimate conditions of natural plant and tree growth and of other natural channel characteristics. Trees and other plants and grass shall be planted as a part of initial construction to promote and encourage ultimate natural appearance. Willows and other phreatophytes shall be planted along the low flow water line as a part of initial construction.

7) The ultimate constructed natural waterway shall satisfy the freeboard requirements in this Chapter. The constructed natural waterway may be utilized in any situation where right-of-way space can be provided and temporary unvegetated appearance can be tolerated prior to growth and generation of natural amenities.

8) The gradients for constructed open unlined channels in secondary waterways shall not exceed four percent and shall be a minimum of one percent. The gradient for lined or paved ditches shall not be less than 0.5 percent.

D.7.D) *Closed Conduit Systems*

1) Major and secondary waterways placed within a closed conduit system shall have a minimum one foot clearance between the design water surface and the soffit of the conduit. The design depth in circular conduits shall not exceed 0.80 of the diameter of the conduit for major and secondary waterways. Minor waterways placed in closed conduit systems may be designed for full conduit capacity and, if necessary, pressure flow. The hydraulic entrance condition at a closed conduit minor waterway shall be such that the ten-year discharge will have the specified freeboard in the upstream channel or waterway and that the 100-year discharge will be contained within the banks of the upstream waterway or within drainage easements. The entrance to the closed conduit minor waterway may be submerged provided that the above criteria are satisfied. At inlets and non-pressure-type manholes within a closed conduit system, a hydraulic gradeline shall be not less than one foot below the gutter or inlet surface elevation or such that free weir flow will be assured at inlets. At locations where conduits are stubbed out for future extension, the design hydraulic gradeline shall be low enough to allow proper drainage of the tributary area, with a minimum of 1.5 feet below general existing ground level. For conduits designed for supercritical flow, the energy gradeline shall not be above ground level at inlets and non-pressure- type manholes

2) Energy losses due to debris load caused by splitting flow at entrance to or within a closed conduit system shall be computed in the same manner as obstruction losses in open channels. In addition to normal friction losses, energy losses due to entrance and exit conditions, bends and transitions shall be computed and considered.

3) Velocities in conduits shall be a minimum of 2.5 feet per second to give a self-cleaning action to prevent siltation.

4) Manholes, catch basins, or drop inlets shall be provided at all junctions of pipes larger than 12 inches and at intervals not to exceed 400 feet along the conduit.

5) Closed conduits shall be aligned as close to straight as possible. Reverse curves shall not be allowed. Horizontal or vertical curves shall only be made using beveled reinforced concrete pipe, using the standard bevels provided by the pipe manufacturer.

D.7.E) *Other Applicable Standards*.

1) Discharge of drainage waters are subject to State Water Quality Control Board (SWQCB) standards, which include project, and regional discharge permits(such as NPDES) which must be adhered to. Furthermore, alterations to drainage courses both in stream and upland are regulated by the California Department of Fish & Game (CDF&G).

2) Installation of Drainage Structures are regulated by CDF&G and the National Oceanic and Atmospheric Administration (NOAA Fisheries), in some instances, through 1600

agreements and Army Corps of Engineers 404 permits respective. CDF&G publishes "California Salmonid Stream Habitat Restoration Manual" and NOAA Fisheries publishes "Guidelines for Salmonid Passage at Stream Crossings".