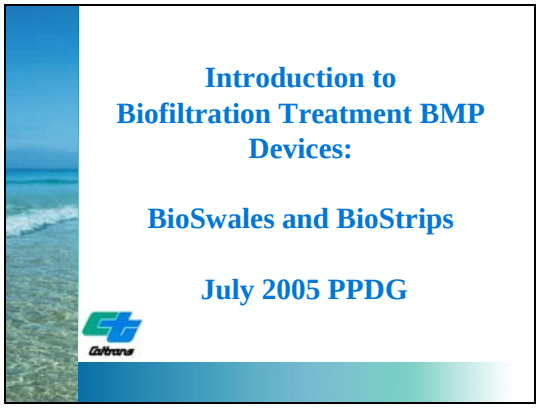
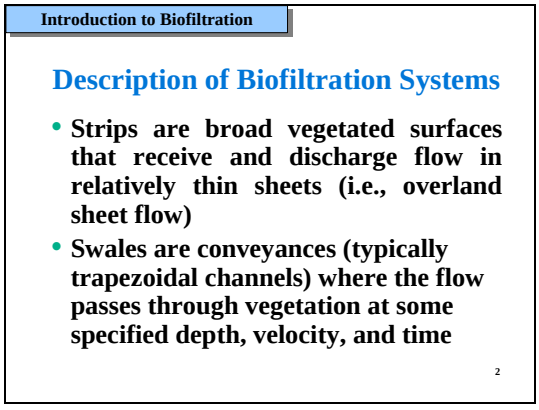


Slide 1: This module will present the Caltrans-approved Treatment BMP Biofiltration Swales and Strips. These have been on the approved as Caltrans Treatment BMPs for several years, but a criteria was added to the July 2005 PPDG regarding BioSwales. In addition to the information presented today, Appendix B of the PPDG (Project Planning and Design Guide) has a 6-page section on the Biofiltration Systems.

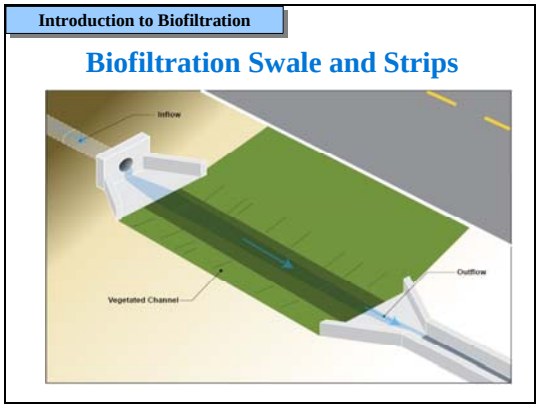


Slide 2: Treatment Biofiltration strips ("BioStrips") are broad vegetative surfaces that receive and discharge flow in relatively thin sheets (i.e., overland sheet flow). Usually depth and velocity calculations are not needed to establish that BioStrips are effective, but refer to the soon to be revised PPDG for any new criteria that may be issued.

Treatment Biofiltration Swales ("Bioswales") are vegetated swales designed as concentrated flow conveyances, typically trapezoidal channels; they will carry storm water runoff designed from the more frequent rainfall events, which we will describe in an upcoming slide as a Water Quality Flow event. We will see also shortly that there are criteria for depth of flow, velocity of flow, and travel time for a vegetated swale to be considered as a Treatment BMP Bioswale.

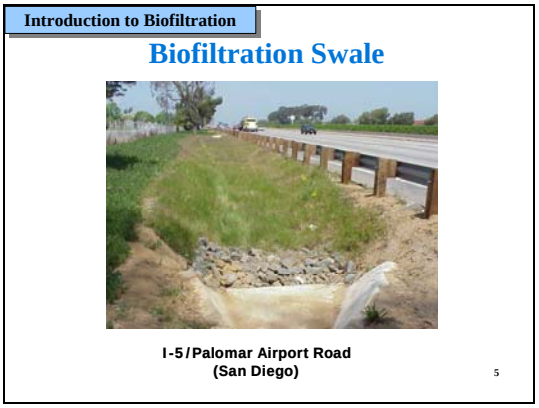
If the same conveyance is used to drain the roadway under the larger, "HDM design events", the peak flow and depth under those conditions will be much greater than for the WQF event, and guidelines in HDM Chapters 800 through 890 must be applied.

The same equation can be used to determine depth and velocity of flow, given the width, side slope ratio of the channel, and flow Q into the channel, and that is by using Manning's Equation. However, as we will shown during the Workshop Example for Bioswales, the frictional forces for the lower flow (the WQF) are much higher than for the larger events, and a different "Manning's n value" is used for BioSwales, whereas the value used according to HDM Chapter 800 for larger flows in vegetated channels (0.24 vs. 0.05).

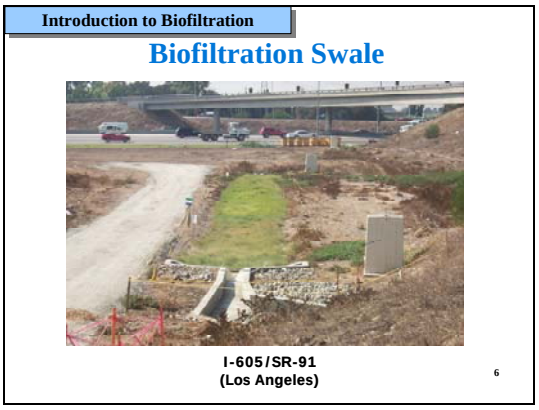


Slide 3: This is a schematic showing both a BioSwale (darker strip with the large arrow in the center of the slide, which carries concentrated flow from the pipe and collects flow from the adjacent BioStrips (which carries shallow sheet flow from the impervious surface [the roadway]).

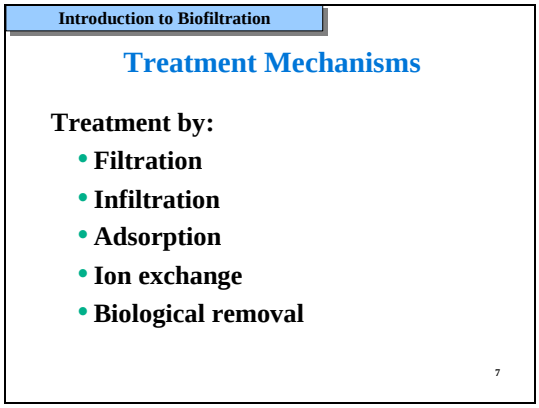
Slide 4: This is a Biofiltration Strip located in Los Angeles. Runoff from the freeway sheet flows into the Biostrip. Note the concrete collector ditch on the downstream end; this was constructed for monitoring purposes only and would not be part of a typical design. Vegetation in the BioStrips and BioSwales at this time is limited to grasses and sorbs.



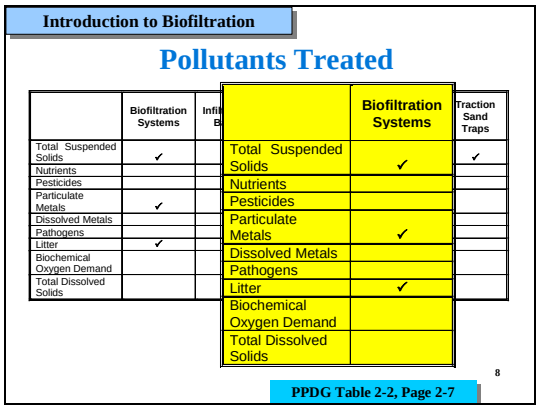
Slide 5: This is a photograph of a trapezoidal BioSwale in San Diego. The vegetation used was salt grass.



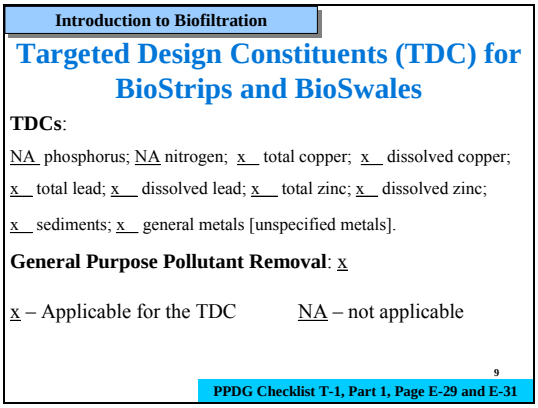
Slide 6: This is a photograph of another trapezoidal BioSwale, this one in Los Angeles. This one was constructed in a similar manner as the one in San Diego. Runoff from a pipe was intercepted and conveyed through a concrete channel (for monitoring purposes) and distributed into the BioSwale. The runoff was sampled upstream and downstream of the BioSwale, and treatment measured.



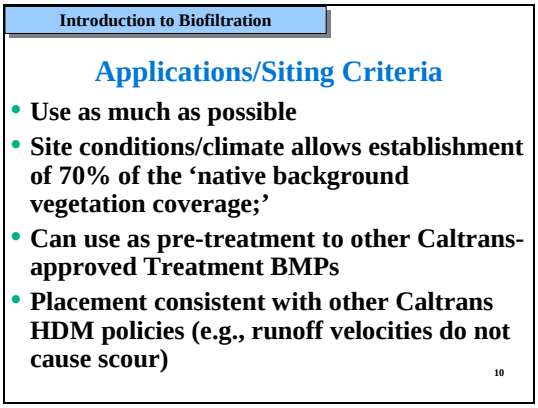
Slide 7: Both BioSwales and BioStrips treat storm water by filtration, infiltration, adsorption, ion exchange, and biological removal. Additionally, biofiltration vegetation lessens raindrop impact, thereby minimizing erosion within the vegetated area. Use of biofiltration systems also reduces the overall impervious area of the project.



Slide 8: This table shows the target pollutants that BioSwales and BioStrips are effective in removing. They include totals suspended solids, particulate metals, and litter. Although litter may be trapped in the bioswales and BioStrips, litter removal is not a primary function of biofiltration. Biofiltration systems are included in the TDC process for these constituents (Questions 9, 10, 11, 12, 13, 14, 15, 16 for specific pollutants, and 17 for "general pollutants"), as we will see in the next slide.



Slide 9: This table shows the TDC listed pollutants that BioSwales and BioStrips are effective in removing. They include Total Suspended Solids (TSS), certain particulate and dissolved metals, and litter. Although litter may be trapped in the BioSwales and BioStrips, litter removal is usually not a primary function of biofiltration. Biofiltration systems are included in the TDC process for these constituents (Questions 9, 10, 11, 12, 13, 14, 15, 16, and 17 for General Pollutants).



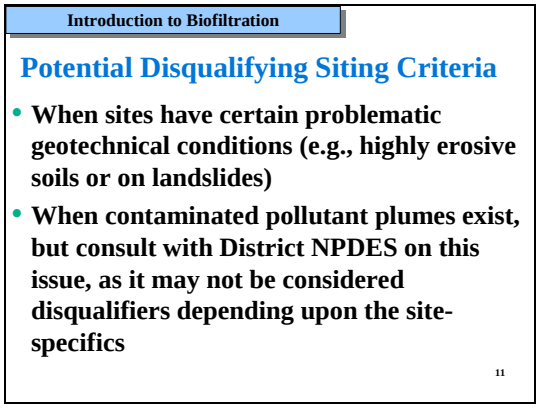
Slide 10:

•Use as much as possible: BioSwales and BioStrips are intended to treat runoff from impervious tributary areas. BioSwales and BioStrips should be considered to the extent practicable where site conditions and climate allow vegetation establishment, and where flow velocities do not cause scour.

•Site conditions/climate allows establishment of 70% of the 'native background vegetation coverage': this language is from the SWMP, and refers to a uniform vegetative cover, which provides about 70% of the native background vegetative coverage. Turf grass is the preferred vegetation. Can use as pre-treatment to other Caltrans-approved Treatment BMPs

•Placement consistent with other Caltrans HDM policies (e.g., runoff velocities do not cause scour): BioSwales and BioStrips should be designed such that they are consistent with other Caltrans policies (e.g., Highway Design Manual Chapters 800 to 890), especially is used to convey "HDM events."

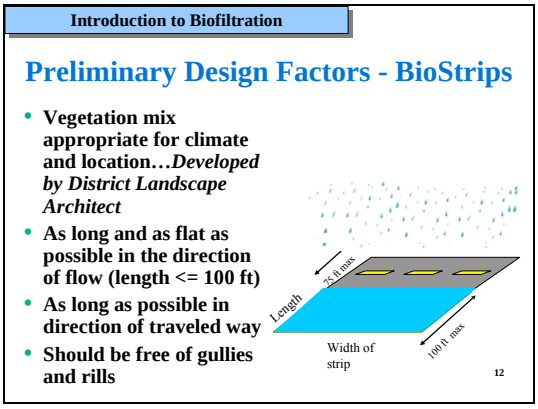
One other item: Biofiltration systems will provide better treatment when infiltration is allowed to occur in the soils supporting the vegetation; there may be situations when replacing the upper 6 inches of existing soil with coarser, more permeable soils, would greatly benefit not only plant establishment but also treatment.



Slide 11: BioSwales and BioStrips may not be allowed in these situations.

•When sites have certain problematic geotechnical conditions (e.g., highly erosive soils or on landslides): for example, proposing a BioSwale to cross the head scarp of an active landslide is not advised.

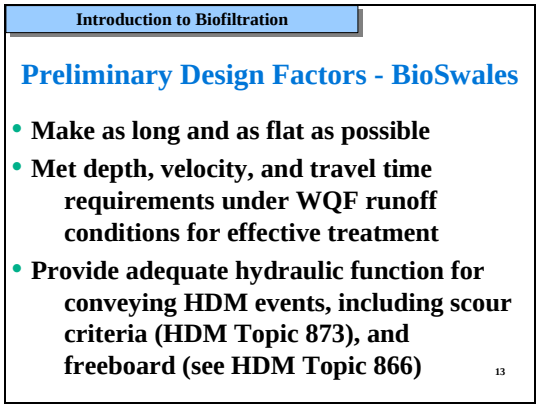
•When contaminated pollutant plumes exist, but consult with District NPDES on this issue, as it may not be considered disqualifiers depending upon the site-specifics.



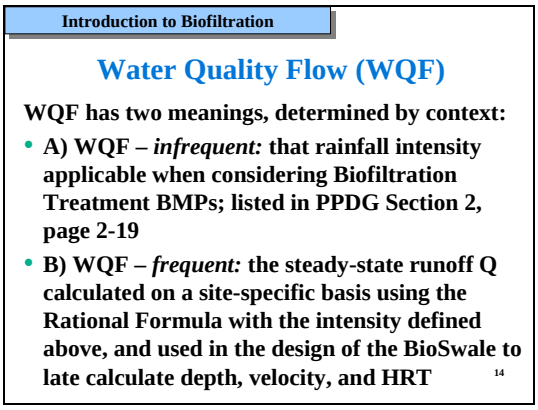
Slide 12: BioStrips should be designed such that they provide maximum treatment by designing them as long as possible (in the direction of flow), as flat as the site will allow, and free of gullies and rills. There is no minimum length or maximum slope at this time, but these are being considered and consult with the next revision of the PPDG. The maximum width (in the direction of flow) should not exceed 30 m for unpaved sections (see HDM Topic 816.6). Vegetation mix must be appropriate for the climate and location; this is developed by the District Landscape Architect.

Usually BioStrips do not involve calculations for depth or velocities, but often the length of the tributary area (cross section of the roadway on this slide) contributing runoff to the biofiltration strip from an impervious area is recommended as no greater than 75 feet unless some estimate of made of the flow depth as it leaves the roadway,

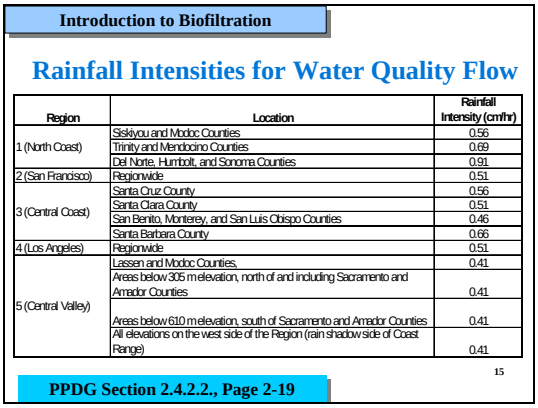
with a goal of less than one inch under Water Quality Flow conditions being suggested.



Slide 13:
As described, BioSwales may be designed for the "HDM Design Storm" this is done in accordance with Highway Design Manual; each type of roadway will have a recommended rainfall event recurrence interval that can be used to later establish the rainfall intensity that must be carried (the intensity will be used in the "Rational Formula" that will be shown in an upcoming slide); in this case, BioSwales should be designed such that they provide adequate hydraulic function for conveying the HDM storm event while meeting scour criteria.
To be considered as a Treatment BMP, a BioSwale must meet depth, velocity, and travel time, and these will be shown shortly.
A width of 1.2 m (4.0 ft) for a BioSwale is preferred so it can be maintained with a front-end loader, but verify proposed dimensions with District Maintenance staff.
The Water Quality Flow (WQF) is the parameter used for design of the BioSwales, and this event has a much lower intensity than the HDM design storm. We will shortly present show two slides that present the WQF intensities throughout the state.



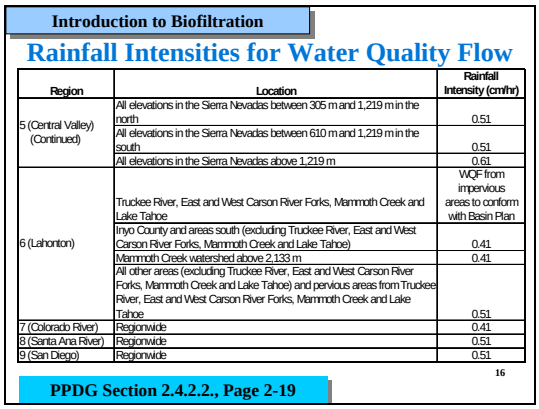
Slide 14: WQF has two meanings, determined by context:
A) WQF – infrequent: that rainfall intensity applicable when considering Biofiltration Treatment BMPs; listed in PPDG Section 2, page 2-19
B) WQF – frequent: the steady-state runoff Q calculated on a site-specific basis using the Rational Formula with the intensity defined above, and used in the design of the BioSwale to late calculate depth, velocity, and HRT
As I just described, BioSwales are designed for high flow routing and scour protection "Design Storm"; this is done in accordance with Highway Design Manual.



Slide 15: Rainfall intensities associated with WQFs were negotiated with the

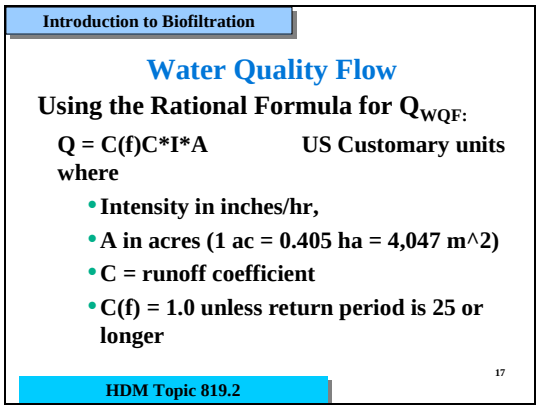
State Water Resources Control Board and the Region Water Quality Control Boards and are summarized here. The listed values of rainfall intensity would be used with the Rational Formula (Q = CiA) to generate runoff from areas that would discharge flow to a filtration treatment device.

Note that the intensity values given are subject to change, and consult the latest version of the PPDG for these values.

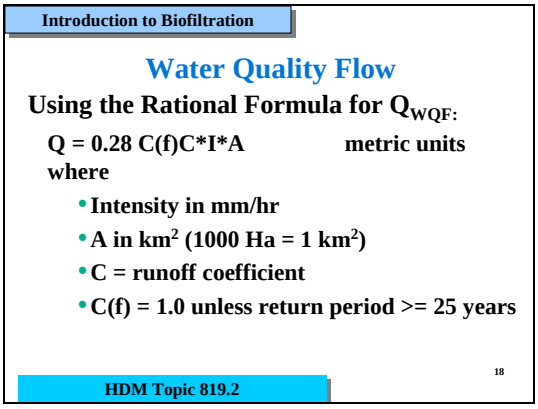


Region	Location	Rainfall Intensity (cm/hr)
5 (Central Valley) (Continued)	All elevations in the Sierra Nevadas between 305 m and 1,219 m in the north	0.51
	All elevations in the Sierra Nevadas between 610 m and 1,219 m in the south	0.51
	All elevations in the Sierra Nevadas above 1,219 m	0.61
6 (Lahonton)	Truckee River, East and West Carson River Forks, Mammoth Creek and Lake Tahoe	WQF from impervious areas to conform with Basin Plan
	Inyo County and areas south (excluding Truckee River, East and West Carson River Forks, Mammoth Creek and Lake Tahoe)	0.41
	Mammoth Creek watershed above 2,133 m	0.41
	All other areas (excluding Truckee River, East and West Carson River Forks, Mammoth Creek and Lake Tahoe) and pervious areas from Truckee River, East and West Carson River Forks, Mammoth Creek and Lake Tahoe	0.51
7 (Colorado River)	Regionwide	0.41
8 (Santa Ana River)	Regionwide	0.51
9 (San Diego)	Regionwide	0.51

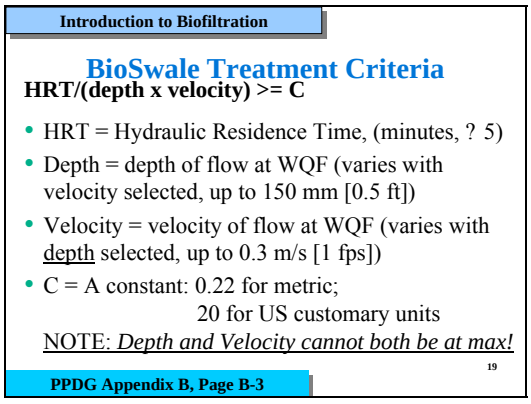
Slide 16: This slide is a continuation of the previous slide, showing WQF intensities.



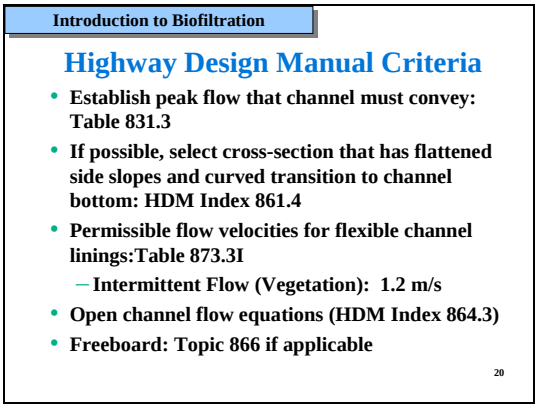
Slide 17: The Water Quality Flow (WQF) is the primary design criteria used for design of BioSwales, and this rainfall intensity defines a fairly frequent event, on the order of a 2-yr return interval. Prior to verifying that depth, velocity, and travel time criteria are met, it will be necessary to calculate the flow into the BioSwale from its tributary area, and to do that we will use the Rational Formula, shown here in US Customary units.



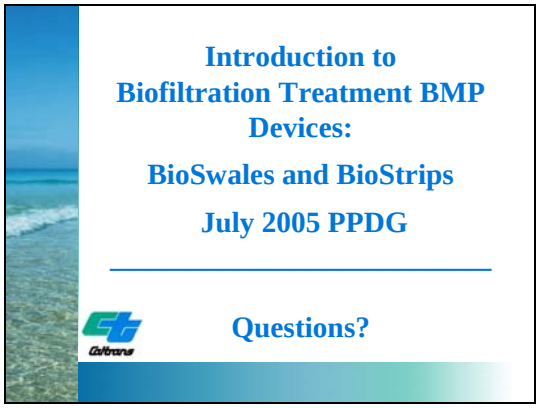
Slide 18: This is the Rational Formula for metric units.



Slide 19: This is Equation 1 from the PPDG Appendix B:
HRT/(depth x velocity) ≥ C
Where HRT = Hydraulic Residence Time (minutes, ≥ 5);
Depth = depth of flow at WQF (varies with velocity selected, up to 150 mm [0.5 ft]);
Velocity = velocity of flow at WQF (varies with depth selected, up to 0.3 m/s [1 fps]); and
C = A constant: 0.22 for metric; 20 for US customary units
This equation defines an interrelationship between depth and velocity that must be met for a swale to be considered as a Treatment BMP BioSwale under the WQV rainfall intensity.
Note: The units must be as shown to use the constant value shown on the slide. An upcoming revision to the PPDG is expected to change the units for this equation, making them dimensionally balance and changing the constant accordingly, but calculations performed using either equation will still be correct as long as the correct dimensions are used.



Slide 20: Applicable Caltrans Highway Design Manual Chapters 800 - 890 Criteria include:
•Establishing the peak flow that the channel must convey (HDM Index 821.3, Table 831.3)
•Selecting a cross-section that has flattened side slopes and curved transition to channel bottom (HDM Index 861.4)
•Evaluating permissible flow velocities for flexible channel linings (Table 873.3I), inermittent flow with vegetation: 1.2 m/s (4.0 ft/s)
·Open channel flow equations (HDM Index 864.3), including Manning's Equation.
·The HDM also references FHWA HEC 15 for permissible velocities.
The reader should refer to HDM Topics 866 for Freeboard: "When the possibility of damage is slight or non-existent, or where the type of facility is minor, freeboard need not be provided."



Slide 21: This module presented the Caltrans-approved Treatment BMP Biofiltration Swales and Strips. In addition to the information presented today, Appendix B of the PPDG (Project Planning and Design Guide) has a 6-page section on the Biofiltration Systems. The District NPDES Design Coordinator or the HQ Design Office of Storm Water Management can be contacted if you have additional questions.