Chapter 4 Drainage

4-1 General

Managing water on the right of way requires a drainage system that effectively responds to the immediate environment. A typical highway drainage system includes conveyances of all types: gutters, drains, ditches, culverts, storm sewers, and other miscellaneous drainage structures.

The system is designed and constructed to collect, treat, and remove storm water from the highway right of way. It must be properly maintained to:

- Permit the maximum use of the roadway.
- Prevent damage to the highway structure.
- Protect natural resources.
- Protect abutting property from physical damage.
- Comply with applicable storm water management permits.

Drainage facilities should be maintained as nearly as possible to the condition and at the capacity for which they were originally designed and constructed. The entire drainage system should be generally inspected at least twice a year or otherwise based on specific environmental permit requirements, past experience, and professional judgement. Deficiencies should be corrected when they are discovered. Additional inspections may be required during heavy storms and periods of high runoff in order to determine the effectiveness of the system. High water marks should be observed and recorded as well as conditions that threaten damage to the drainage facility or the highway. Maintenance personnel must be continually alert to assure that all natural water course channels crossing the right of way remain open. WSDOT policy regarding accommodation of Storm water Runoff onto Right of Way is outlined in Policy Statement Number P 2032 dated February 10, 2012. This policy clarifies the departments responsibility for establishing and maintaining storm water management systems for its highways and other facilities that adequately manage the volumes and quality of storm water according to standards contained within the *Highway Runoff Manual* M 31-16.

4-2 Drainage From Abutting Properties

Storm water is the only effluent allowed to be discharged upon the highway right of way. RCW 47.44 allows persons and entities who have been issued utility franchises or permits to encroach on or cross highway right of way to install and maintain the item for which the permit was granted.

Population growth, urban sprawl, and numerous new regulations restrict how maintenance crews can maintain surface and subsurface drainage systems. Regulations that may affect drainage maintenance include:

- Endangered Species Act
- Federal Clean Water Act – National Pollutant Discharge Elimination System (NPDES)
- Storm Water Management
- Wetlands Preservation
- WDFW Hydraulic Rules
- Growth Management Act
- Shoreline Management Act
- Irrigation Limitations

It is important that the Washington State Department of Transportation (WSDOT) not allow abutting property owners to discharge water onto the highway right of way without obtaining a permit. Property owners may obtain permits by applying at the WSDOT area or region office. Drainage design engineers and maintenance staff review potential drainage impacts from the abutting property to the highway right of way. The property owner may be required to mitigate water quality and/or quantity impacts to obtain a permit.

Maintenance personnel who routinely patrol a roadway section must be trained in the basic knowledge of what types of direct drainage and sheet flow from abutting property may require a permit. These include new:

- Commercial developments such as shopping centers
- Subdivisions
- Industrial development
- Automobile wrecking yards
- Dairy and other intensive farming activities.

Maintenance personnel should report land use changes they observe to their supervisor. The supervisor will forward this information to the appropriate reviewer.

4-3 Ditches and Gutters

Open ditches should be routinely checked and maintained as close as possible to the line, grade, depth, and cross section to which they were constructed. Vegetation in ditches often helps prevent erosion and treats storm water. Remove vegetation only when flow is blocked or excess sediments have accumulated. Remove vegetation using "best management practices" that minimize erosion and sediment escape to water bodies.

Excessive erosion of drainage ditches must be controlled or repaired. Ditch linings of loose or grouted rock and concrete or other energy dissipation methods can control erosion. However, these linings need be checked frequently and repaired as necessary.

Keep ditches and gutters free of litter and debris. Repair cracks and breaks as necessary.

Be especially careful when chemicals are used for brush and grass control in open ditches. Herbicides must be carefully controlled so as not to contaminate water or to transfer and concentrate chemicals in adjacent areas where environmental damage may result. Always follow product application instructions.

Be alert for diversion ditches on top of cut slopes that prevent slope erosion by intercepting surface drainage. Diversion ditches must be maintained to retain their diversion shape and capability.

Surplus material that results from ditch cleaning can often be used for widening. Material placed into the adjacent portions of the highway or disposal areas must not obstruct or impair other roadside drainage areas. Do relocate material that may cause sedimentation problems into water bodies. Take care to avoid causing erosion problems or loose unstable fills. Do not use non-porous materials such as clay. They can become unstable when wet and trap water in the existing fill. If there is doubt about using such surplus material, contact the Region Soils Engineer for assistance and consult with your Region Maintenance Environmental Coordinator.

Do not blade ditch cleanings across roadway surfaces. Dirt and debris remaining on the pavement after ditch cleaning operations must be swept from the pavement.

Avoid undercutting the roadway back slope or in slope. Undercutting weakens the slope and will cause damaging slip-outs and other forms of slope erosion.

4-4 Rockfall Ditches and Slope Benches

Keep rock fall ditches and slope benches clean. Large amounts of slough or rock fall and other slide material that effectively block the ditch or bench should be removed as soon as possible.

4-5 Dry Wells

Dry wells accommodate the drainage flow in certain areas where:

- Natural outfalls for a drainage system were not available.
- Their use reduces the need for or size of downstream facilities.

These dry wells should be inspected periodically. Replace the drain rock if storm water no longer percolates into the soil. Within NPDES permit coverage areas, dry wells must be inspected annually and maintained to the applicable standards found in the *Highway Runoff Manual* M 31-16. Inspection frequencies may be revised in accordance with NPDES permit provisions. Inspection and maintenance work completed on dry wells within NPDES permit coverage areas must be documented in the Highway Activity Tracking System (HATS) to meet annual reporting requirements.

4-6 Culverts

A culvert is a closed conduit under a roadway or embankment used to maintain flow from a natural channel or drainage ditch. A culvert should convey flow without causing damaging backwater, excessive flow constriction, or excessive outlet velocities.

WSDOT's highway culvert inventory is managed in HATS. WSDOT is responsible for maintaining culverts that cross under state owned highways and culverts under county road approaches. Culverts under approaches to city streets that are designated as part of the highway system are the responsibility of the city under RCW 47.24.020 and as clarified under the current City State Guidelines. Culverts under privately owned roads are the responsibility of the private property owner per the provision of access connection permits referenced within WAC 468-51—080 (3).

As a general guideline, culverts should be inspected twice a year, once before the fall/winter storms and once after the rainy season has ended to ensure they are clean and in good operating condition. Culverts may be inspected more or less than this frequency based on the past history of the particular culvert.

A routine culvert inspection form is found in HATS and shall be used to document certain deficiencies that necessitate culvert cleaning and repair. A level 1 inspection form is found in HATS and shall be used to rate the condition of the culvert feature as well as document certain deficiencies identified during the inspection that require further action including cleaning, repair, and notification to region hydraulic program to perform a level 2 inspection. A level 1 inspection is expected to be performed at least once every 5 years or as resources allow. If conditions change significantly then Level 1 inspections may occur more frequently.

Changes in the upstream watershed due to logging, land development activities, farming practices, forest fires, etc., may increase water runoff, sedimentation, and debris. With these conditions more frequent inspections, particularly after periods of high runoff, are necessary to enable maintenance personnel to take corrective measures if damage has occurred. During storms and floods, critical areas need to be inspected and the culvert inlets kept clear. For these inspections that are in response to storms and floods the routine inspection form may be used.

Badly worn or broken culverts should be repaired, replaced, or rehabilitated to minimize the possibility of damage to the roadbed by water saturating the fill material. Depending on the scope of this work, it may be completed by state workforces in the Maintenance Program or by contractors under the funding and management of the Preservation Program. All culvert repair work conducted within the Maintenance Program shall be documented in HATS.

Culverts with 50 percent or more constriction should be flushed or otherwise cleaned to restore the culvert's original capacity. (Follow any applicable permit provisions and use BMPs to minimize adverse impacts to water quality or fish when doing this work). Some of the larger culverts in flowing streams are designed for construction below the stream bed, to accommodate fish life. In these cases, the culvert should also be cleared of obstructions that may be detrimental to the passage of fish. All culvert cleaning work conducted shall be documented in HATS.

Culverts should be checked for scour around the inlet and outlet. Scoured areas should be repaired with rip-rap or some other protection if necessary. In some cases, standing water is desirable at the inlet end of the culvert to settle out sediment. Vegetation at culvert ends can be controlled by residual herbicides or mechanical means.

Controlled burning of vegetation at culvert ends is a feasible alternative at some locations. Whatever method of vegetation control utilized needs to be accompanied by erosion and sediment control features/practices.

Pavement markings that show the location of culverts should be renewed annually. These markings are critical for quickly locating culverts for both emergency and routine maintenance. Pavement markings of more permanent materials, such as thermoplastics, are encouraged.

4-7 Automatic Pumps

Automatic pumps, sumps, and pipes at underpass structures or draining depressed sections of highway must be kept in good operating condition at all times. Each installation must be inspected on a routine basis, at least once per week. Inspections should include the electrical, ventilation, greasing and drainage systems.

4-8 Under Drains

Under drains are often constructed in the subgrade to intercept subsurface water from springs and seepage water from the surface or percolating from below. Control of this water is essential to ensure the stability of the subgrade upon which the highway is constructed.

Inspect under drains on the same schedule as culverts. Keep their outlets open and clean. Choked under drains can be cleaned by high pressure flushing with water or flexible sewer rods. In cases where roots effectively block the drainage, the use of herbicides may be needed. Whatever method of cleaning is used, consideration for erosion and sediment control is needed.

4-9 Horizontal Drains

Horizontal drains (HDs) are effective devices in some locations for draining water from hillsides to help maintain slope stability. They are generally plastic pipes that have been engineered and constructed into hillsides. When drilling into the hillside during initial installation, a steel casing is used but once the plastic drainpipe is placed in the hillside, the steel casing is pulled out, leaving the final HD in place. The HD is typically 37 mm (1.5 inches) in diameter and can reach several hundred feet or more back into the hillside. Inspection and maintenance for HDs is recommended at an annual frequency, and is optimally completed with guidance from a person experienced with the installation or maintenance of such drains. Over time, HDs can become clogged by silt, minerals, and biological matter or sheared off due to ground movement. This would result in reduced flows and unfavorable increases in the groundwater level and, therefore, would increase the risk of renewed slide activity. The following guidance should be used for the inspection and cleaning of horizontal drains. Documenting the maintenance operation and results achieved at the time of cleaning will provide accurate and usable records for engineering evaluation and long-term asset management.

4-9.1 *Horizontal Drain Outlet*

The HD should protrude from the finished slope. The discharge end of the HD pipe is open to allow water to flow out. However, in the event a collection piping system or manifold is installed, a cap is attached to the end of the HD pipe to access the pipe for cleanout. The collection pipes should be attached in a manner that does not conflict with future maintenance operations. Ideally, the HD should be photographed and its location, length of each pipe, and other details of the HD should be documented in an as-built as part of the construction documentation. This information should be provided by the Construction Office to the Area Maintenance Office who will be maintaining the HDs. The Chief Engineering Geologist in the Geotechnical Office may be helpful in acquiring an as-built for the HD. If a detailed as-built is not completed during construction, the location of the HD outlet should be documented with GPS coordinates when it is initially maintained. A sketch map may be helpful for ongoing inspection and maintenance activities. Access and maintenance needs should be communicated to HD designers in the Geotechnical Office and/or in the Region Design Office during the design process so these issues can be given full consideration during project development.

4-9.2 *Location Marking*

Since the HD outlets can become obscured over time with vegetation or other hillside debris, their location should be marked in the field so they can be easily found for routine inspection and maintenance. A short, green stripe should be painted perpendicular to the travel lane at the edge of pavement to mark the location of the HD outlet. If the painted mark becomes worn over time, it should be re-painted as part of the routine HD inspection. A short piece of surveyor's tape or ribbon can also be tied around the HD outlet to make it more visible on the hillside. A carsonite marker may also be placed at the HD outlet for this purpose.

4-9.3 Inspection and Cleaning

Inspection should preferably be done by a person familiar with the design, installation, or maintenance of HDs. Flows from each HD should be measured prior to cleaning. This can be done by timing the volume discharged into a five gallon bucket and reported as gallons per minute (gpm). A numbering system or some type of identification scheme for the drains should be established and recorded in HATS so inspection and cleaning operation can be documented against each specific drain. The cleaning procedure should be done only after initial flows are measured and recorded for all HDs. Adjacent drain flows can be affected during the flushing operation. Inspections and cleaning of HDs should be documented in HATS. The feature activity type in HATS that should be selected for this is "Horizontal Drains". During the inspection, any field marking that has worn away or is missing should be noted for refreshing or replacement. Items such as any blockage or damage to the HD outlet, if the HD outlet is becoming obscured from view should be documented. The amount of water draining from the HD should also be identified in the HATS record. Once the cleaning is complete and a sufficient amount of time has lapsed to ensure that all cleaning or surging waters have drained from the HD, flows should be measured again and recorded. Some removal of vegetation may be required to allow for completion of an HD inspection.

4-9.4 Cleaning Equipment

Vactor trucks or trailer-mounted vactor units are commonly used to provide an adequate water supply and pressure for HD cleaning. Vactor units may need to be modified for HD cleaning. These units usually come with hoses on a hydraulically-controlled feed spool system. This hose may need to be replaced with smaller diameter hose to clean the smaller diameter HD pipe that is typically 37-mm (1.5-in) diameter. The hose will need to be several hundred feet in length and be equipped with proper swivel connections to allow for maximum rotation. Pressure washer pumps can also be configured and used for HD cleaning if vactor units are not available.

4-9.5 Nozzle and Hose

Nozzles have been developed for pipeline cleaning which are self-feeding. Nozzles are designed with four main components: (1) size of hose attachment, (2) gallons per minute (gpm) delivered, (3) maximum pressure rating (psi), and (4) physical design (shape) of the nozzle. Hoses are limited to certain gpm and psi ratings. A high strength, very lightweight, thermal plastic hose is usually used.

A hose for cleaning long horizontal drain pipes should allow for at least 12 gpm of flow. Head loss is greater in a smaller diameter hose, therefore making it much less effective at advancing into the pipe at greater depths. The hose should be rated for at least 5,000 psi working pressure. Nozzle designs vary greatly. Markings may be made on the hose at 25-foot intervals to assist in the HD cleaning procedure described below. Such markings would have to be refreshed periodically as they become worn from repeated HD cleanings. Having two or three nozzle types to adapt to actual field conditions is recommended. At least two nozzles should be available for use that have one central front jet and six rear radial jets which are angled back at about 15 degrees. The radial jets help

to feed the hose into the drain pipe, as well as provide flushing of the drain slots in the horizontal drain pipe. The nozzle outside diameter should not be more than 27 mm (1.1 in). The design of the nozzle should be matched to the hose to gain maximum pull by the self-advancing nozzle. The selection of nozzles should be done by a nozzle supplier who can match the pump and delivery system with the hose selected for optimal design. The length of the nozzle is not critical, but a compact overall design is recommended.

4-9.6 *Cleaning Sequence*

Pressure should be limited to 2,000 psi at the nozzle. The flow should be maximized to speed up the cleaning process. A minimum of 12 gpm should be used. Cal-Trans prepared a report "Effectiveness of Horizontal Drains" (Report No. FHWA/CA/TL-80/16) which states that "best performance can be expected when pressures are maintained between 1,600 and 2,000 psi and when the water volume is 30 gpm or more." The general sequence for cleaning drains is very simple unless obstructions are encountered. After any protective caps have been removed, advance the nozzle with enough pressure to maintain a slow, steady feed rate. Drains should be cleaned in a slow, steady manner so that permanent damage to the drains may be avoided. The hose should never be advanced at a very fast speed directly to the end of the drain. The nozzle and hose should be inserted about 8 m (25 ft) and then removed at a slow, steady rate of about 0.3 to 1.0 m/sec (1 to 3 ft/sec). After the first 8 m (25 ft) and slow removal, the nozzle should be advanced to 15 m (50 ft) and then removed at the recommended rate. This process should be continued by adding about 8 m (25 ft) each time and noting the amount of debris and sediment each time. Once the full depth of the drain has been reached, the pressure should be turned up to 1,800 to 2,000 psi and the hose slowly removed at a rate of 0.3 to 0.7 m/sec (1 to 2 ft/sec). This higher pressure cleaning is the major cleaning of the drain. If obstructions are encountered, the depth of the obstruction should be measured and recorded.

The rear jets that advance the hose act as cleaning jets when removed in a slow, steady manner.

During the entire operation of cleaning, the nozzle should not be allowed to sit at one location at high pressure as this may damage the drain pipe and scour material from outside the drain pipe. At no time should air pressure be used in the drain pipe. Also, the drain outlet must always be open during flushing to prevent the buildup of pipe pressure which could ultimately damage the HD. If a significant amount of material is removed, it is recommended to repeat this higher pressure cleaning. It is not necessary to do this more than twice. It is important that the operator knows the drain depth and makes sure to stop the nozzle 4 to 7 m (15 to 25 ft) short of the end of the drain, so that the end cap of the drain pipe may not be damaged. If the use of such high pressures results in HD damage, test with lower pressures (possibly 600 psi) to determine the highest allowable pressure which consistently does not cause damage.

4-9.7 Surging

Surging is the process of flooding or filling the HD with water, then letting it drain out in an effort to stimulate water flow in the HD. During the cleaning process, the pressurized water being sprayed through nozzles inside the drain can push through slots in the HD and compress soil particles in an outward direction from the HD. If this appears to have decreased the flow of water from the HD, a surging procedure can be used to help re-establish flow in the horizontal drains. Surging operations are performed after the jet-cleaning operation. The pump should provide about 50-gpm and 1,500 psi pressure during the surging operation. The hose diameter could be 20 to 25 mm (0.75 to 1 in). The operation is performed in several 60 second cycles. Any protective caps should be replaced after all cleaning and surging operations are completed.

4-10 Storm Sewers and Catch Basins

In many areas underground pipe systems are necessary to carry storm runoff normally handled by ditches. Storm sewers are often used in long, depressed highways or along curbed sections on city streets. Water carried by the system is generally collected through inlets, catch basins, or manholes and carried by pipe to an out fall on a natural waterway.

Clogged pipes can often be cleaned with high-pressure water jets. But, if tree roots or broken pipes are causing the clogging, more service will be required. Flexible rotary cutters will remove roots intruding into a pipe.

Broken pipes may be repaired by jacking an insert liner into the failed location. Otherwise, the failed pipe may have to be excavated and relayed to repair it. Whatever method of cleaning is selected, consideration for erosion and sediment control is needed. In no case can debris or sediment be allowed to enter a water body.

Manholes are generally used where there is a change in profile or alignment and also at strategic points in long, straight sections in order to provide access for cleaning the pipe.

Inspect and clean inlets, catch basins, and manholes using a vacuum truck or manual cleaning methods. Frequency of inspections shall follow the regional area's requirements, with exception of NPDES and TMDL coverage areas. Conduct inspections during storms to ensure that the inlet grates are not becoming clogged with water-born debris. Schedule sweeping operations to help prevent the accumulation of leaves, paper, or other clogging debris.

Within NPDES permit coverage areas, catch basins must be inspected annually and maintained to the applicable standards found in the *Highway Runoff Manual* M 31-16. Inspection frequencies may be revised in accordance with NPDES permit provisions. Inspection and maintenance work completed on catch basins within NPDES permit coverage areas must be documented in HATS to meet annual reporting requirements.

When pavement is overlaid by contract or maintenance work crews be sure that the manhole covers are flush with the finished pavement elevations.

4-11 Bank Protection

Maintenance personnel must be continually alert to conditions that may cause scour, undermining, or washout of highway embankments or structures by storms, floods, or wave action.

Highways adjacent to water courses, drainage ways, and embankments throughout the state are protected in a variety of ways against damage due to high water. These include barbs, stone rip-rap, grouted rip-rap, pile revetments, retaining walls and cribs, rock and wire mesh (gabions), and vegetation.

These features must be inspected during storms or periods of high water, as well as at least once each spring or after major high water periods, and repairs made where required. Make repairs with materials similar to those in place. If possible, take corrective measures to eliminate the direct cause of the damage.

Hydraulic Project Approval permits (Washington State Department of Fish and Wildlife) and other regulatory permits may apply to this type of work. Permits are commonly conditioned to protect fish life and habitat.

When the need for significant additional bank protection around structures or embankments is indicated, the area superintendent is to be notified immediately and a determination made as to whether or not the protection materials will be placed by maintenance or construction forces. New bank protection projects should be reviewed by hydraulic engineers to ensure that proper design and risk/safety factors are addressed.

4-12 Detention Ponds, Tanks, and other Storm water Treatment Facilities

Designers are increasingly specifying the use of detention ponds and tanks that store water runoff and release it slowly through a controlled outfall or outlet. In this way the size of downstream pipes and culverts can be reduced, erosion is mitigated, and solids that settle out can be removed. Other storm water treatment facilities, commonly referred to as Best Management Practices, or BMPs, are also increasingly being used to comply with storm water management requirements.

To function correctly the controlled outfall or outlet pipe must be free of debris. Accumulated settled materials must be removed on a schedule based on experience at each site. If oil separators are combined with these facilities, timely removal and proper disposal of oils is essential.

Within NPDES permit coverage areas, detention ponds, tanks, and other types of BMPs must be inspected annually and maintained to the applicable standards found in the *Highway Runoff Manual* M 31-16. Inspection frequencies may be revised in accordance with NPDES permit provisions. Inspection and maintenance work completed on detention ponds, tanks, and other BMPs within NPDES permit coverage areas must be documented in the Highway Activity Tracking System (HATS) to meet annual reporting requirements.

If inspection or cleaning necessitates working inside an underground detention tank, confined space procedures must be followed.