17.0 Stormwater Impact Assessment

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Chapter Summary

As part of a biological assessment, WSDOT assesses the environmental effects of stormwater and the construction of stormwater best management practices (BMPs) on the project site. This chapter provides background information on stormwater management as it relates to highway projects (Section 17.1), guidance to determine and quantify these effects (Section 17.2), and a list of online resources (Section 17.3).

- This chapter first provides an overview of the WSDOT *Highway Runoff Manual* but does not address the selection of BMPs that are incorporated into the project plans (Section 17.1.1). The selection process is outlined in the WSDOT *Highway Runoff Manual.*

- The chapter also summarizes the BMP types identified in the WSDOT *Highway Runoff Manual* so that biologists who are writing BAs can be more familiar with stormwater treatment facilities (Section 17.1.2). BMPs for runoff treatment are described in Section 17.1.2.3, and BMPs for stormwater flow control are described in Section 17.1.2.4. This section also describes the importance of maintenance of BMPs to ensure they function properly (Section 17.1.2.1) and also design flows and volumes (Section 17.1.2.2).

- Instructions are then given for completing a stormwater analysis in a stepwise fashion (Section 17.2), including:

    - Step 1: Obtaining the Endangered Species Act Stormwater Design Checklist (Section 17.2.1)

    - Step 2: Incorporating information about the selected BMPs into the project description (Section 17.2.2)

    - Step 3: Defining the action area for a project (Section 17.2.3)

    - Step 4: Determining species use and presence of critical habitat within the action area (Section 17.2.4)

    - Step 5: Describing existing environmental conditions (Section 17.2.5)

    - Step 6: Determining the extent of stormwater related effects to species and critical habitat – separate protocols for analyzing flow impacts and for analyzing water quality impacts in Eastern

(Section 17.2.6.1) and Western Washington (Section 17.2.6.2) are described

- Step 7: Examining site-specific conditions that may affect stormwater-related effects but that are not reflected in modeling results (Section 17.2.7)
- Step 8: Double-checking the action area to ensure it incorporates all anticipated physical, biological, chemical effects (Section 17.2.8)
- Step 9: Pulling it all together: completing a comprehensive exposure-response analysis for listed species and critical habiat (Section 17.2.9)
- Step 10: Finally, guidance is provided to quantify stormwater-related effects and make effect determinations in accordance with Section 7 of the ESA (Section 17.2.10)

- Online resources for stormwater are provided in Section 17.3.

17.1 Background Information on Stormwater Management for Highway Projects

Projects that construct new impervious surface may affect the quantity and quality of runoff originating from within the project area for the following reasons:

1. Impervious surface prevents rainwater from infiltrating, can reduce groundwater recharge, and affect base flows of nearby surface water.
2. Conversion of pervious surfaces (e.g., vegetated areas) to impervious surface can result in increased surface runoff. Changes to the pattern or rate of surface runoff may increase peak flows in receiving waters.
3. The presence of impervious surface provides a platform that collects settled air pollutants, contaminants from vehicles and road maintenance activities, and sediment from the surrounding environment. These pollutants are mobile and become a part of the runoff that moves through the watershed.

WSDOT incorporates stormwater BMPs into the project design to manage the quality and quantity of runoff. Stormwater BMPs are designed to reduce pollution and attenuate peak flows and volumes associated with stormwater runoff. Some temporary BMPs are used only during the construction phase of a project. Permanent BMPs are used to control and treat runoff generated by continued operation of the highway, park-and-ride lot, rest area, ferry holding area, or other transportation project site. Properly designed, constructed and maintained stormwater BMPs can provide important benefits. However, stormwater BMPs do not eliminate all stormwater impacts. Projects that construct new impervious surface need to address the potential short- and long-term effects on species and habitat listed or designated under the Endangered Species Act (ESA).

Project biologists must evaluate all of the short- and long-term stormwater effects associated with a project. These effects include:

- Changes in flows (peak, base, duration)
  - Direct effects associated with changes in flow or local hydrology
  - Indirect effects associated with changes in flow or local hydrology
- Changes in pollutant loads and concentrations
  - Direct effects associated with changes in pollutant loads and concentrations
  - Indirect effects associated with changes in pollutant loads and concentrations
- Temporary impacts that occur during the construction of stormwater BMPs and conveyance facilities
  - Direct effects associated with installation or construction of stormwater treatment elements (BMPs, conveyance, ditches, outfalls, etc.)
- Permanent impacts from the physical presence of stormwater treatment elements (BMPs, conveyance, ditches, outfalls, etc.).
  - Indirect effects associated with installation or construction of stormwater treatment elements (BMPs, conveyance, ditches, outfalls, etc.).

17.1.1 Summary of WSDOT *Highway Runoff Manual*

The WSDOT *Highway Runoff Manual* provides uniform technical guidance and establishes minimum requirements for avoiding and mitigating water resource impacts associated with the development of state-owned and operated transportation infrastructure systems, and for reducing water resource impacts associated with redevelopment of those facilities.

The *Highway Runoff Manual* is used by project stormwater engineers and designers as guidance to evaluate site conditions, to help characterize the stormwater treatment needs for proposed projects and to identify and appropriately size BMPs to provide adequate treatment and flow control for stormwater runoff.

The *Highway Runoff Manual* meets the level of stormwater management established by the Washington Department of Ecology to achieve compliance with federal and state water quality regulations. These regulations require stormwater treatment systems to be properly designed, constructed, maintained, and operated to achieve the following goals:

- Prevent pollution of state waters, protect water quality, and comply with state water quality standards

- Satisfy state requirements for all known, available, and reasonable methods of prevention, control, and treatment (AKART) of wastes prior to discharge to waters of the state

- Satisfy the federal technology-based treatment requirements under 40 CFR 125.3

- Prevent further water quality impairment resulting from new stormwater discharges and make reasonable progress in addressing existing sources of water quality impairment.

The *Highway Runoff Manual* reflects the best available science in stormwater management to ensure that WSDOT projects protect environmental functions and values. WSDOT considers this manual to include all known, available, and reasonable methods of prevention, control, and treatment for stormwater runoff discharges, consistent with state and federal law.

To uphold federal and state wetland regulations, WSDOT strives to maintain the extent, quality and existing hydrology of wetlands to which its stormwater facilities discharge. WSDOT attempts to avoid discharges to wetlands that provide habitat for listed species. However, some wetlands are dependent upon the inputs from roadway runoff to maintain their hydrologic characteristics so stormwater-related flows to these systems are maintained.

Projects that design, construct and maintain stormwater BMPs in a manner consistent with the *Highway Runoff Manual* are considered by the Department of Ecology to have satisfied the above requirements. However, as projects undertake the ESA consultation process, additional treatment and analysis may be required in order to adequately assess, minimize or avoid impacts to listed species.

A summary of BMP types in the *Highway Runoff Manual* is provided in the section below. This information is provided so that biologists will better understand the information they are provided by project engineers.

17.1.2 Summary of WSDOT *Highway Runoff Manual* Stormwater BMPs

This section provides background information to biologists who are writing BAs to familiarize them with stormwater management concepts. The section describes the design flows and volumes (Section 17.1.2.2), and also the function and effectiveness of the BMPs included in the *Highway Runoff Manual*. There are a total of 16 BMPs for runoff treatment (water quality – Section 17.1.2.3) and 9 BMPs for flow control (water quantity – Section 17.1.2.4) in the *Highway Runoff Manual*. The experimental and low-preference BMPs described herein may be used in unusual situations with project-specific approval. For further information on stormwater BMPs, the *Highway Runoff Manual* (or other documents referenced in the following sections) should be consulted. This manual can be found at: <http://www.wsdot.wa.gov/Environment/WaterQuality/default.htm>.

17.1.2.1 Maintenance of BMPs

The effectiveness of runoff treatment and flow control BMPs is highly dependent on adequate and frequent maintenance. Lack of maintenance can result in excessive sediment buildup in ponds, which can reduce storage volume; die-off of vegetation in vegetated BMPs, leading to reduced pollutant uptake and filtration; and clogging of outlets and orifices, affecting hydraulic function. BMP effectiveness claims and assumptions are only applicable to maintained facilities Maintenance standards for WSDOT BMPs are described in the *Highway Runoff Manual*. For ESA-related consultations, it is assumed that stormwater BMPs and conveyance and discharge structures will be maintained as described in the *Highway Runoff Manual.*

17.1.2.2 BMP Design Flows and Volumes

Runoff treatment BMPs are designed using runoff volume (wet pool facilities) or discharge rates. Flow control BMPs are designed based on peak discharge rates and durations. In western Washington, wet pool runoff treatment BMPs (e.g., wet ponds, stormwater treatment wetlands) are designed with a wet pool volume that is equal to or greater than the runoff volume from 91^{st} percentile, 24-hour storm event. In eastern Washington, wet pool BMPs are designed with a wet pool volume that is equal to the runoff volume from a 6-month, long duration storm event. In western Washington, discharge-based runoff treatment BMPs (e.g., biofiltration swales, media filters) located upstream of detention facilities (if present) are designed to treat the flow rate at or below which 91 percent of the annual runoff volume will be treated. In eastern Washington, discharge-based runoff treatment BMPs upstream of detention facilities (if present) are designed to treat the peak runoff discharge from a 6-month, short duration storm event. If discharge-based runoff treatment BMPs are located downstream of a detention facility in either western or eastern Washington, they are designed to treat the 2-year release rate from the facility.

Flow control BMPs are designed to meet the following criteria:

- In western Washington, stormwater discharges must match developed discharge durations to predeveloped durations for the range of predeveloped discharge rates from 50 percent of the 2-year peak flow up to the full 50-year peak flow.

- In eastern Washington, limit the peak release rate of the postdeveloped 2-year runoff volume to 50 percent of the predeveloped 2-year peak and maintain the predeveloped 25-year peak runoff rate.

BMPs can be configured as **on-line** BMPs, in which all runoff is conveyed through the facility, or as **off-line** facilities, in which flows exceeding the design discharge rate bypass the BMP. All volume-based (wet pool) runoff treatment BMPs and flow control BMPs are designed as on-line facilities. Discharge-based runoff treatment BMPs can be designed as off-line or on-line facilities. However, on-line discharge-based runoff treatment BMPs in western Washington will be larger so that they can meet the 91 percent runoff volume treatment goal. This is because on-line discharge-based BMPs do not effectively treat runoff when flows exceed the design flow. Off-line BMPs do treat the design flow as excess flows bypass the facility.

17.1.2.3 BMPs for Runoff Treatment

Runoff treatment BMPs are organized into four runoff treatment targets:

- **Basic Treatment** BMPs are designed to effectively remove suspended solids from stormwater (80 percent removal) through physical treatment processes (sedimentation/settling, filtration). The basic treatment target applies to most projects that generate and discharge stormwater runoff to surface waters.

- **Enhanced Treatment** BMPs are designed to remove dissolved metals from stormwater through enhanced treatment mechanisms (chemical and biological processes). Enhanced treatment BMPs also remove suspended solids from stormwater as or more effectively than basic treatment BMPs. The enhanced treatment target applies to runoff from higher-traffic roadways in some cases.

- **Oil Control** BMPs are designed to remove non-polar petroleum products from stormwater through flotation and trapping. The oil control treatment target applies to runoff generated in high-use intersections, rest areas, and maintenance facilities statewide; and in higher-traffic roadways in eastern Washington.

- **Phosphorus Control** BMPs are designed to remove phosphorus from stormwater (50 percent removal) through enhanced sedimentation, as well as chemical and biological processes. The phosphorus control treatment target applies to runoff generated in areas that discharge to phosphorus-sensitive surface water bodies.

Multiple treatment targets may apply to individual TDAs and to different TDAs within a project.

The following runoff BMP types are described in the subsections below:

- Infiltration BMPs
- Dispersion BMPs
- Biofiltration BMPs
- Wet Pool BMPs
- Media Filtration BMPs
- Oil Control BMPs.

Infiltration BMPs

Infiltration is the discharge of stormwater to shallow groundwater through porous soils, and infiltration BMPs treat stormwater through filtration and chemical soil processes (adsorption and ion exchange). The *Highway Runoff Manual* includes the following four infiltration BMPs:

- Bioinfiltration pond (eastern Washington only)
- Infiltration pond
- Infiltration trench
- Infiltration vault.

Along with dispersion (described in the section below), infiltration is a preferred method of treatment, offering the highest level of pollutant removal. In order to use infiltration for runoff treatment, native soils must meet (or be amended to meet) specific permeability and chemical criteria. In addition to treatment, infiltration BMPs provide effective flow control by reducing the volume and peak surface water discharge rates. Another important advantage to using infiltration is that it recharges the ground water, thereby helping to maintain summertime base flows in streams and reducing stream temperature naturally. These are important factors in maintaining a healthy habitat for instream biota.

Infiltration facilities must be preceded by a presettling basin to remove most of the sediment particles that would otherwise reduce the infiltrative capacity of the soil. Infiltration strategies intended to meet runoff treatment goals may be challenging for many project locations in western Washington due to strict soil and water table requirements. Eastern Washington generally offers more opportunities for the use of infiltration BMPs.

Bioinfiltration ponds are vegetated ponds that store and infiltrate stormwater while also removing pollutants through vegetative uptake. This BMP, developed and used more commonly in eastern Washington, functions as both a biofiltration BMP and an infiltration BMP and can meet basic, enhanced and oil control treatment targets. Bioinfiltration ponds can only be applied in eastern Washington, and because of limitations on ponding depth they require a large footprint to meet flow control requirements.

Infiltration ponds are open-water facilities that store and infiltrate stormwater vertically through the base. Implementation of infiltration ponds can be challenging due to their large space requirements. Because treated runoff is removed from the surface water system, specific treatment targets are not applicable to this BMP.

Infiltration trenches (also called infiltration galleries) are gravel-filled trenches designed to store and infiltrate stormwater. They commonly include perforated pipe for conveyance of stormwater throughout the trench. Limitations of infiltration trenches are similar to those of infiltration basins, but they can be configured to more easily fit into constrained sites and linear roadway corridors. Below-ground infiltration BMPs such as infiltration trenches may also be subject to underground injection control (UIC) rules.

Infiltration vaults are below-ground storage facilities (tanks, concrete vaults) with perforations or open bases, allowing stormwater to infiltrate. Limitations of infiltration vaults are similar to those of infiltration basins, but they can fit more constrained sites – even located beneath pavement. An additional challenge for infiltration vaults is the maintenance access challenges that below-ground facilities pose – potentially requiring confined-space entry by maintenance personnel. Like infiltration trenches, infiltration vaults may be subject to underground injection control (UIC) rules.

Dispersion BMPs

Dispersion BMPs treat stormwater by vegetative and soil filtration and shallow infiltration of sheet flow discharge. The two dispersion BMPs included in the *Highway Runoff Manual* are:

- Natural dispersion
- Engineered dispersion.

Natural dispersion is sheet flow discharge of runoff into a preserved, naturally vegetated area. It is perhaps the single most effective way of mitigating the effects of highway runoff in nonurban areas. Natural dispersion can meet the basic and enhanced treatment targets by making use of the pollutant-removal capacity of the existing naturally vegetated area. The naturally vegetated area must have topography, soil, and vegetation characteristics that provide for the removal of pollutants.

Natural dispersion has several notable benefits: it can be very cost-effective, it maintains and preserves the natural functions, and it reduces the possibility of further impacts on the natural areas adjacent to constructed treatment facilities. In most cases this method not only meets the requirements for runoff treatment but also provides flow control. However, if channelized drainage features are near the runoff areas requiring treatment, then engineered dispersion or other types of engineered solutions may be more appropriate.

Despite the benefits described above, natural dispersion requires a substantial area of land adjacent to the runoff source area. This area must be protected from future development with a conservation easement or other measure. Because of this, applicability of this BMP is very limited for roadway/highway projects.

Engineered dispersion is sheet flow dispersion of concentrated stormwater (using flow spreaders). This BMP uses the same removal processes as natural dispersion, and can also meet basic and enhanced treatment targets. For engineered dispersion, a manmade conveyance system directs concentrated runoff to the dispersion area (via storm sewer pipe or ditch, for example). The concentrated flow is dispersed at the end of the conveyance system to mimic sheet-flow into the dispersion area. Engineered dispersion techniques coupled with compost-amended soils and additional vegetation enhance the modified area. These upgrades help to ensure that the dispersion area has the capacity and ability to infiltrate surface runoff.

The limitations described under natural dispersion above also apply to engineered dispersion.

Biofiltration BMPs

Biofiltration BMPs treat stormwater through vegetative and soil filtration and uptake. The *Highway Runoff Manual* includes the following five biofiltration BMPs:

- Vegetated filter strip – basic, narrow, and compost-amended
- Biofiltration swale
- Wet biofiltration swale
- Continuous inflow biofiltration swale
- Media filter drain (previously called ecology embankment).

Vegetated filter strips are gradually sloping areas adjacent to the roadway that treat runoff by maintaining sheet flow, reducing runoff velocities, filtering out sediment and other pollutants, and providing some infiltration into underlying soils. The flow can then be intercepted by a ditch or other conveyance system and routed to a flow control BMP or outfall. Vegetated filter strips can the meet basic treatment target, and are well suited for linear roadway projects where sheet flow can be maintained from the roadway surface (no curbs, gutters, or channelized drainage at the edge of pavement). In addition to the basic vegetated filter strip, there are two modifications to the vegetated filter strip BMP: the narrow area vegetated filter strip, and the compost-amended vegetated filter strip.

The **narrow-area vegetated filter strip** is similar to the basic vegetated filter strip, but is simpler to design. This BMP is limited to impervious flow paths of 30 feet or less, and also meets the basic treatment target.

The **compost-amended vegetated filter strip** (CAVFS) is an enhanced version of the basic vegetated filter strip. By incorporating compost amendment and subsurface gravel courses, CAVFS can meet basic, enhanced, phosphorus control, and oil control treatment targets.

Biofiltration swales are relatively wide (compared to conveyance ditches) vegetated channels that treat runoff by filtering concentrated flow through grassy vegetation with a shallow flow depth. The swale functions by slowing runoff velocities, filtering out sediment and other pollutants, and providing some infiltration into underlying soils. Biofiltration swales can meet the basic treatment target.

Biofiltration swales can also be integrated into the stormwater conveyance system, as they are typically designed as on-line BMPs (no bypass of flows exceeding design discharge). Existing roadside ditches may be good candidates for upgrading to biofiltration swales. Biofiltration swales are not recommended for use in arid climates. In semi-arid climates, drought-tolerant grasses should be specified.

The **wet biofiltration swale** is a variation of a basic biofiltration swale that is applicable where the longitudinal slope is slight, the water table is high, or continuous low base flow tends to cause saturated soil conditions. The wet biofiltration swale typically uses different vegetation that is suitable for saturated conditions, and meets the basic treatment target.

The **continuous inflow biofiltration swale** is another variation of the biofiltration swale that is applicable where water enters a channel continuously along the side slope rather than being concentrated at the upstream end. This BMP also meets the basic treatment target.

The **media filter drain** (previously called ecology embankment) is a BMP that incorporates a treatment train of pollutant removal mechanisms immediately adjacent to a raised roadway and meets the basic, enhanced, and phosphorus control treatment targets. Unconcentrated runoff enters the media filter drain through a narrow grass strip, and is filtered through a shallow subsurface media consisting of mineral aggregate, dolomite, gypsum, and perlite. The media filter drain also provides infiltration through the base of the media gallery, but is not approved for use as a flow control BMP. The media filter drain integrates soil amendments in the grass strip, providing significant pollution reduction and flow attenuation. Its application is limited to raised highways located in relatively flat terrain. This BMP can often be constructed with little or no additional right-of-way, making it a cost-effective solution to managing highway runoff.

Wet Pool BMPs

Wet pool BMPs treat runoff by reducing velocities and settling particulate material. Vegetated portions of wet pool BMPs also treat runoff with vegetative and soil filtration and uptake. The *Highway Runoff Manual* includes the following four BMPs:

- Wet pond
- Combined wet/detention pond
- Constructed stormwater treatment wetland
- Combined stormwater treatment wetland/detention pond.

In addition to the BMPs included in the *Highway Runoff Manual*, underground **wet vaults** are sometimes used for runoff treatment when site area constraints do not allow for a large surface pond facility. Wet vaults are the least preferred method of runoff treatment, and are not included in the *Highway Runoff Manual*.

A **wet pond** is a constructed basin containing a permanent pool of water throughout the wet season. Wet ponds function primarily by settling suspended solids, and can meet the basic treatment target. Wet ponds can also be sized larger to meet the phosphorus control treatment target. Biological action of plants and bacteria provides some additional treatment. Wet ponds are usually more effective and efficient when constructed using multiple cells (i.e., a series of individual smaller basins), where coarser sediments become trapped in the first cell, or forebay.

Because the function of a wet pond depends upon maintaining a permanent pool of water to provide treatment, wet ponds are generally not recommended for use in arid or semi-arid climates. Cold-climate applications can be problematic, and additional modifications must be considered. The spring snowmelt may have a high pollutant load and produce a larger runoff volume to be treated. In addition, cold winters may cause freezing of the permanent pool or freezing at inlets and outlets. High runoff salt concentrations resulting from road salting may affect pond vegetation, and sediment loads from road sanding may quickly reduce pond capacity.

Wet ponds can be configured to provide flow control by adding **detention** volume (live storage) above the permanent wet pool. This is called a **combined wet/detention pond**.

Constructed stormwater treatment wetlands are similar to wet ponds, but are configured to include shallower zones with substantial vegetation for enhanced filtration and uptake. This BMP can meet basic and enhanced treatment targets Sediment and associated pollutants are removed in the first cell of the system via settling. The processes of settling, biofiltration, biodegradation, and bioaccumulation provide additional treatment in the subsequent cell or cells. In general, constructed stormwater treatment wetlands could be incorporated into drainage designs wherever water can be collected and conveyed to a maintainable artificial basin.

Constructed stormwater treatment wetlands offer a suitable alternative to wet ponds or biofiltration swales and can also provide treatment for dissolved metals. The landscape context for stormwater wetland placement must be appropriate for creation of an artificial wetland (i.e., ground water, soils, and surrounding vegetation). Natural wetlands cannot be used for stormwater treatment purposes.

Very few constructed stormwater wetlands exist in Washington state. However, constructed stormwater wetlands can be a preferred stormwater management option over other surface treatment and flow control facilities. In general, this option is a more aesthetically appealing alternative to ponds.

Constructed stormwater treatment wetlands can be configured to provide flow control by adding **detention** volume (live storage) above the permanent wet pool. This is called a **combined stormwater treatment wetland/detention pond**.

Media Filtration BMPs

Media filtration BMPs treat stormwater through physical filtration (straining) of particulates when using inert media, as well as chemical processes (e.g., adsorption, ion exchange) when media are reactive. The *Highway Runoff Manual* does not include any media filtration BMPs. However, some media filtration BMPs that can be used with approval from the regional WSDOT Hydraulics Office and Maintenance Supervisor include:

- Sand filter basin
- Linear sand filter
- Sand filter vault
- Proprietary canister filters.

Media filtration BMPs capture and temporarily store stormwater runoff and then slowly filter it through a bed of granular media such as sand, organic matter, perlite, soil, or combinations of organic and inorganic materials. In this process, stormwater passes through the filter medium, and particulate materials either accumulate on the surface of the medium (which strains surficial solids) or are removed by deep-bed filtration. Silica sands are relatively inert materials for sorption and ion exchange. However, sands that contain significant quantities of calcitic lime, iron, magnesium, or humic materials can remove soluble contaminants such as heavy metals or pesticides through precipitation, sorption, or ion exchange. For more information on media filtration BMPs, see the *Stormwater Management Manual for Western Washington* (Ecology 2005).

The **sand filter basin** is a pond-type open water facility where water is stored and travels vertically through the media filter in the bed of the basin. Sand filter basins require a substantial amount of area, and like all media filtration BMPs require intensive maintenance. In general, surface sand filters are not recommended where high sediment loads are expected, because sediments readily clog the filter. Sodding the surface of the filter bed can reduce clogging to some degree. This treatment method is not reliable in cold climates because water is unable to penetrate the filter bed if it becomes frozen.

The **linear sand filter** is a below-ground sand filter configuration that can be installed at the edge of impervious areas, and can fit more constrained sites than the sand filter basin.

The **sand filter vault** is a below-ground facility incorporating a settling chamber and a filtration bed. While the underground configuration allows for application in more constrained sites than the above-ground sand filter basin, the already intensive maintenance requirements are more challenging due to access constraints.

Proprietary **canister filters** (including the CONTECH StormFilter and the CONTECH MFS) are vault-style facilities that provide filtration of stormwater through replaceable cartridge cylinders filled with filter media. These BMPs can configured as above-ground or below-ground vaults, and the media can be designed for specific treatment needs.

Media filtration BMPs are <u>not</u> included in the *Highway Runoff Manual*.

Oil Control BMPs

BMPs that have the primary function of removing oil from stormwater include the following:

- Oil containment boom
- Baffle-type oil/water separator
- Coalescing plate separator
- Catch basin inserts.

Of these BMPs, only the oil containment boom is included in the *Highway Runoff Manual*. The baffle-type oil/water separator and the coalescing plate separator are not included in the *Highway Runoff Manual* because of maintenance challenges associated with them. The following other BMPs can perform the oil control function in addition to meeting other runoff treatment functions:

- Bioinfiltration pond (eastern Washington only; see Infiltration BMPs section above)
- Compost-amended vegetated filter strip (see Biofiltration BMPs section above).

Oil containment booms contain sorptive material that captures oil and grease at the molecular level. These booms are applied to open water stormwater treatment BMPs including wet ponds, and capture floating petroleum product. An oil control BMP should be placed as close to the source as possible but protected from sediment. Sorptive oil containment booms can be placed on top of the water in sediment control devices and can be used in ponds and vaults.

Baffle-type oil/water separators and **coalescing plate separators** are below-ground vault facilities that collect oil and grease by trapping the floating material. These BMPs are configured as below-ground vault-type facilities, are expensive to maintain, and usually pose safety hazards for maintenance workers who must work in confined spaces or out in roadway traffic. Moreover, it is difficult to verify whether these BMPs are working effectively. Baffle oil/water separators and coalescing plate devices should be installed downstream of primary sediment control devices and can be used at pond outlets. For more information on these oil control BMPs, see the *Stormwater Management Manual for Western Washington* (Ecology 2005).

Catch basin inserts with sorptive media are appropriate only for the very lowest sediment yield areas because they can easily plug and cause roadway flooding. Catch basin inserts must be maintained (inspected and replaced) frequently to effectively remove pollutants from stormwater.

Runoff Treatment Trains

Runoff treatment is often achieved using a series of BMPs rather than a single facility. However, the *Highway Runoff Manual* does not recognize treatment trains as a viable approach to meeting enhanced or phosphorus control treatment targets without project-specific approval.

Treatment trains often involve a basic treatment BMP such as wet pool or biofiltration followed by a media filtration BMP. This provides settling of the coarser solid material in stormwater before additional removal of finer material can be achieved. By removing solids prior to filtration the rate at which the media filter clogs can be reduced, extending the maintenance cycle of the facility.

17.1.2.4 BMPs for Stormwater Flow Control

Stormwater flow control BMPs are designed to control the flow rate or the volume of runoff leaving a developed site. The primary flow control mechanisms are dispersion, infiltration, and detention. Increased peak flows and increased durations of sustained high flows can cause downstream damage due to flooding, erosion, and scour, as well as degradation of water quality and instream habitat through channel and stream bank erosion. The following provides an overview of the most commonly used flow control BMPs for highway application.

Infiltration BMPs

Infiltration BMPs reduce the volume of runoff discharged to surface waters from a site. If surface discharge is not completely eliminated, infiltration BMPs can reduce the flow rates and the durations of sustained high flows. The *Highway Runoff Manual* includes the following 6 infiltration BMPs for flow control:

- Bioinfiltration pond (eastern Washington only)
- Infiltration pond
- Infiltration trench
- Infiltration vault
- Drywell
- Permeable pavement systems.

Bioinfiltration ponds, **infiltration ponds**, **infiltration trenches**, and **infiltration vaults** are described in section 17.1.2.3 BMPs for Stormwater Runoff Treatment. **Bioinfiltration ponds** are restricted to eastern Washington, and may not be able to fully meet flow control criteria.

Drywells, which function similar to infiltration trenches, are subsurface concrete structures that convey stormwater runoff into the soil matrix. Drywells can be used to meet flow control requirements, but do not provide runoff treatment. Uncontaminated or properly treated stormwater must be discharged to drywells in accordance with the Ecology Underground Injection Control (UIC) program.

Permeable pavement systems are alternative paving materials that allow infiltration of rainfall directly to the pavement base. Permeable pavement types include permeable concrete, permeable asphalt, and paver systems. Permeable pavement cannot be used alone to meet flow control criteria, but can reduce the size of downstream BMPs.

Dispersion BMPs

Dispersion BMPs control flows through shallow infiltration, which reduces the volume of surface runoff. Sheet flow in the dispersion area increases the runoff travel time, decreasing flow rates. The *Highway Runoff Manual* includes the following two dispersion BMPs for flow control:

- Natural dispersion
- Engineered dispersion.

Natural dispersion and engineered dispersion are described in Section 17.1.2.3, BMPs for Stormwater Runoff Treatment.

Detention BMPs

Detention BMPs control flows by storing runoff and releasing it at reduced rates. The three detention BMPs included in the *Highway Runoff Manual* are the following:

- Detention pond
- Detention vault
- Detention tank.

Detention ponds are open-water basins that store runoff and release it at reduced rates. These BMPs can be configured as a dry pond to control flow only, or it can be combined with a wet pond or constructed stormwater treatment wetland to also provide runoff treatment within the same footprint. These combined facilities, called combined wet/detention ponds and combined stormwater wetland/detention ponds, are described in Section 17.1.2.3, BMPs for Stormwater Runoff Treatment. Detention ponds generally require a substantial area of land.

Detention vaults and **detention tanks** are below-ground storage facilities that are commonly used for projects that have limited space and thus cannot accommodate a pond. Although vaults and tanks require minimal right-of-way, they are difficult to maintain due to poor accessibility and effort required for visual inspection. Typically, the increased construction and maintenance expenses quickly offset any initial cost benefits derived from smaller right-of-way purchases. Consequently, underground detention is the least preferred method of flow control.

17.2 Stepping through a Stormwater Analysis

The project biologist should integrate the discussion about stormwater and the stormwater BMPs into the various sections of the BA, including project description, existing environmental conditions, action area, effects analysis, and effect determinations. Other sections of the BA such as the species and critical habitat section contain relevant information that will be incorporated into the stormwater analysis. The species and critical habitat section provides information on the presence and timing of various life stages of species within the action area that will be used to help to identify the potential for exposure, and limit the stormwater modeling to those months when each of the species may be present. Some species and lifestages exhibit distinct seasonality whereas others may be present year-round. It is important to note that stormwater discharges generally cause long-term effects to receiving waterbody conditions. Discharges may be episodic in nature, but occur in perpetuity. The analysis of effects must take these persistent indirect effects into account in order to understand long-term project effects on habitat, habitat forming-processes and the functionality of habitat characteristics or existing environmental conditions. The potential exposure(s) of individual fish to these discharges over time hinges upon the life history strategy and timing of various life stages of species within the action area.

The following sections describe the appropriate documentation of stormwater elements and impacts within the BA and step through the process of evaluating stormwater and stormwater BMP effects on species and habitat for eastern and western Washington. Nine steps are outlined below for completing a stormwater analysis:

- Step 1: Obtain the Endangered Species Act Stormwater Design Checklist (Section 17.2.1)
- Step 2: Incorporate information about the selected BMPs into the project description (Section 17.2.2)
- Step 3: Define the action area for a project (Section 17.2.3)
- Step 4: Determine species use and presence of critical habitat within the action area (Section 17.2.4)
- Step 5: Describe existing environmental conditions (Section 17.2.5)
- Step 6: Determine the extent of stormwater related effects to species and critical habitat – separate protocols for analyzing flow impacts and for analyzing water quality impacts in Eastern (Section 17.2.6.1) and Western Washington (Section 17.2.6.2) are described
- Step 7: Examine site-specific conditions that may affect stormwater-related effects but that are not reflected in modeling results (Section 17.2.7)
- Step 8: Re-evaluate the action area to ensure it incorporates all anticipated physical, biological, chemical effects (Section 17.2.8)
- Step 9: Pull it all together: complete a comprehensive exposure-response analysis for listed species and critical habitat (Section 17.2.9)
- Step 10: Quantify stormwater-related effects and make effect determinations in accordance with Section 7 of the ESA (Section 17.2.10).

17.2.1 Step 1: Obtain the Endangered Species Act Stormwater Design Checklist and Review Project Plans

The project biologist describes stormwater management plans in the BA based on the information presented by the project engineer in the ESA stormwater design checklist and project plans. The project biologist should request the project engineer to fill out this checklist. Checklist templates (one for western Washington and one for eastern Washington) are available, along with other stormwater-related guidance, on WSDOT's Biological Assessment website at: <http://www.wsdot.wa.gov/Environment/Biology/BA/default.htm#Stormwater>.

The checklist breaks down the analysis of stormwater elements and impacts into areas draining to specific outfalls or into "threshold discharge areas" or TDAs. The *Highway Runoff Manual* defines TDAs as follows: *An on-site area draining to a single natural discharge location or* *multiple natural discharge locations that combine within 1/4 mile downstream (as determined by the shortest flow path).*

Project plans may also be useful in determining locations of proposed BMPs and outfalls. These locations must be known in order to assess environmental impacts of the BMPs themselves, and in order to accurately describe the proposed conveyance system how its configuration influences the potential for exposure. The project biologist should be prepared to ask for additional information during or before site visits, because the location of the displaced habitat must be identified in the field.

The completed checklist should not be attached to the BA; rather, the information summarized in the checklist should be incorporated into the appropriate sections of the BA.

17.2.2 Step 2: Incorporate Stormwater Information into the Project Description

17.2.2.1 Describe Proposed Changes to Impervious Surface

For each TDA, the project description should clearly convey how the project plans to change the existing configuration of impervious surface within the action area. For projects with numerous TDAs (i.e., more than 10 TDAs), information should be compiled and presented by waterbody or subwatershed.

Following is a list of information that should be included in the project description in the BA. The bulk of this information will be provided to the biologist via the ESA stormwater design checklist.

- Existing impervious surface area (acres) and treatment
  - Acreage receiving runoff treatment (basic; enhanced)
  - Acreage receiving no runoff treatment
  - Acreage receiving flow control prior to discharge
  - Acreage that infiltrates
  - Acreage receiving no flow control prior to discharge
- New impervious surface area (acres) and treatment
  - Total area of impervious surface draining into each proposed BMP (acres), outfall, and/or TDA.
  - Acreage that will receive runoff treatment (basic; enhanced)

    - Acreage that will receive no runoff treatment
    - Acreage that will receive flow control prior to discharge
    - Acreage that infiltrates
    - Acreage that will receive no flow control prior to discharge
- Impervious surface area to be removed (acres) as a result of the proposed project, and anticipated final condition of the areas where it will be removed
    - If a project will remove a large quantity of impervious surface in one or more TDAs, this should be clearly described in the BA and these changes should be quantified.
    - It may be appropriate to summarize "net new" impervious surface for these projects.
      Net New Impervious = Existing Impervious Area + New Impervious Area – Removed Impervious Area
- Existing impervious surface area that will be retrofitted as a result of the proposed project
    - Existing acreage retrofitted for runoff treatment
    - Existing acreage retrofitted for flow control
- Identify the receiving water(s) for flow or runoff from each BMP/outfall and/or TDA.

The project description should also identify and describe all project-related changes or improvements to arterial or surface streets, frontage roads, and facilities.

17.2.2.2 Describe Proposed Stormwater BMPs

Linear projects such as highways often span several drainage basins or watersheds. As a result, different methods of stormwater treatment may be proposed for new impervious surfaces in different basins. The project engineer will likely refer to these different drainage areas as threshold discharge areas, and will summarize each TDA in the ESA stormwater design checklist prepared for the project. The project engineer will identify an appropriate BMP(s) for each TDA as necessary.

The project description should first fully describe existing runoff treatment and flow control BMPs. Name and describe the existing BMPs and indicate where they are located. The general information on BMPs provided earlier (Section 17.1.2) may inform this description. F or projects using unconventional or experimental stormwater designs, BAs should clearly describe the proposed designs and how they will manage water quality or flow control. Also describe the existing stormwater conveyance system (i.e., is it an open or closed system). When describing the conveyance system, clearly describe the distance to and/or conveyance channel characteristics from discharge points or outfalls to receiving waterbodies. Most of this information is supplied to the project biologist through the ESA stormwater design checklist. In summary:

- Describe the existing runoff treatment and flow control
- Describe the existing BMPs and their locations
- Describe the existing conveyance system and discharge points or outfalls.

Next the project biologist should describe the proposed runoff treatment and flow control BMPs. If BMPs already exist at a project site and will not be altered or retrofitted in any way, this should be disclosed. Similarly, if removal, alteration, discontinuation or retrofitting of existing BMPs is proposed, this must be clearly explained in the project description. For new stormwater elements (BMPs, conveyance, outfalls, etc.), name and describe the proposed element and indicate where are they located, whether they are temporary or permanent, and how they are to be constructed (e.g., heavy equipment, or installed below the surface). For those stormwater elements that will partially or completely infiltrate runoff, the project engineer should provide the project biologist with justification for the anticipated level of infiltration to include in the project description of the BA. This justification must be included in the BA and should properly account for and address all of the following conditions:

- Seasonal variations in precipitation intensity and soil moisture
- Permeability of embankment fill and native soils
- Seasonal variations in depth to groundwater
- Vegetation present to provide evapotranspiration.

At the time of publication of this document, the hydrologic performance of media filter drains (previously called ecology embankments) and compost-amended vegetated filter strips have been assessed, and the following conclusions can be made:

- Performance monitoring that has been conducted on media filter drains located on SR 167 and SR 18 has demonstrated a 62 percent reduction of runoff volume over a wet-season extended monitoring period. This reduction in flow volume can be attributed to two processes: evapotranspiration of water in the near-surface soils and infiltration of water into the surrounding subsoils. Both of these processes can be expected to occur at sites where media filter drains are constructed in accordance with the siting and design criteria presented in the *Highway Runoff Manual*. Thus, it is reasonable to credit this amount of runoff flow volume reduction in the pollutant loading calculations for any WSDOT project that proposes to use media filter drains, as long as the project design team has verified that the site-specific conditions are suitable for their use.

- The prevailing soil and groundwater conditions at the media filter drain sites monitored along SR 18 and SR 167 would not typically be associated with stormwater facilities designed to infiltrate substantial volumes of runoff. The fact that the media filter drains at SR 18 and SR 167 are collectively proving to infiltrate and evapotranspire 62 percent of the tributary highway runoff volume during larger storm events in the wet season is a testament to what can be accomplished when runoff flows are not concentrated along the highway shoulder.

- Performance monitoring that has been conducted on two compost-amended vegetated filter strips located along I-5 has demonstrated average runoff volume reductions of between 93 and 97 percent (Herrera 2007b). However, data from this study have also shown that infiltration performance may decrease when high precipitation depth and/or intensities contribute to saturated conditions within the filter strips. In general, infiltration performance is maximized when storm precipitation depths are below 0.3 to 0.4 inches. After this threshold, runoff volumes from filter strips will generally increase as a function of precipitation depth.

Monitoring data can provide the justification for assumed infiltration / water loss for other BMPs as well. The infiltration performance of these and other BMPs is being continually studied, and additional information may exist.

The project description should also include an explanation that the stormwater treatment is consistent with the *Highway Runoff Manual*, as represented by the project engineer in the ESA stormwater design checklist.

The project description should describe all stormwater elements (BMPs, conveyance, outfalls, etc.), construction activities associated with them, and related impact minimization measures. Examples include the excavation to install underground pipe that directs runoff from the roadway, construction of a swale that directs runoff from the roadway to the point of discharge, installation of a new outfall or discharge site, installation of riprap at the outlet pipe, or upgrades of an existing detention pond.

The project biologist should also accurately describe the proposed stormwater conveyance system (i.e., is it an open or closed system). When describing the conveyance system, provide the distance to and/or conveyance channel characteristics from discharge points or outfalls to receiving waterbodies. The project designer, via the ESA stormwater design checklist, will provide the biologist with this information.

The project description should characterize any flow control or runoff treatment exemptions the project qualifies for, in accordance with the *Highway Runoff Manual* and as presented in the ESA stormwater design checklist. If the project designer indicates that proposed stormwater BMPs will drain to any of the following waterbodies: **Puget Sound; Columbia River; and Lakes Sammamish, Silver, Union, Washington and Whatcom**, the biologist may not need to evaluate potential project effects to flow conditions or hydrology in the BA, because these are waterbodies considered that are considered flow exempt by USFWS and some of them are also considered flow exempt by NOAA.

- USFWS considers all the waterbodies listed above as flow exempt
- NOAA only considers Puget Sound, the Columbia River, and Lake Washington flow exempt.

If the discharge is to an HRM exempt waterbody but not on the USFWS or NOAA list above, the project biologist should work with project designers and hydrologists to provide rationale as to why the flow effects are minor or work with project designers to analyze or model anticipated project effects on flow in the analysis of effects section of the BA. In summary:

- Describe the proposed runoff treatment and flow control
- Describe the proposed stormwater elements and their locations
- Justify incidental infiltration rates chosen for each proposed BMP or other stormwater element
    - Justification should be based on soil infiltration rates and abilities, presence or absence of a lining in the BMP or stormwater element, depth to ground water table, slope, and vegetation.
    - Justification should properly account for and address seasonal variation and conditions in excess of the "design storm."
- Describe construction sequence, activities, and impact minimization measures for installing proposed stormwater elements
- Describe the proposed conveyance system and points of discharge (or outfalls) to receiving waterbodies
- Determine if runoff will discharge to waterbodies that are considered exempt (by the Services) from flow control requirements. If discharge is to a waterbody requiring flow control, coordinate with project designers to

generate description of proposed flow control and assess effects to hydrology and flow conditions.

17.2.2.3 Quantify and Describe Habitat Impacts from Construction

The installation of several project elements, including stormwater components may require clearing of existing vegetation, in-water work to install an outfall, placement of rock to inhibit erosion or scour at the outfall location, alteration of the landscape or topography, or temporary disturbance to habitat while equipment is placed underground.

For each project element, of which stormwater management is one, it is important to quantify the extent of anticipated impacts, indicate whether the habitat displacement will be temporary or permanent, and provide enough detail to support later discussions of how the impacts may affect listed species and habitat. Quantifying project impacts is discussed in detail in the ACTION AREA section (8.0) of this manual. The project description should quantify anticipated impacts on habitat in terms of:

- Approximate habitat area affected by the activity
- Location of impacts relative to sensitive habitats or species
- Habitat and/or vegetation type
- Terrain and how topography might enhance or inhibit potential project impacts extending to sensitive habitats or species.

17.2.3 Step 3: Define the Action Area for the Proposed Project: Describe the Project's Stormwater Related Effects

The action area represents the geographic extent of anticipated physical, biological and chemical effects stemming from the proposed project. The direct and indirect effects from proposed stormwater elements constitute one component of this larger action area defined for the project in its entirety. The geographic extent of water quality effects and changes in flow or hydrology would define the stormwater-related component of the action area. Procedures for determining the extent of changes in flow or hydrology are described in the *Analyzing Effects on Flow and Duration* subsections of 17.2.6.1 (eastern Washington) and 17.2.6.2 (western Washington). In these same sections, the protocols for analyzing water quality effects are focused specifically on defining stormwater effects on listed species or proposed or designated critical habitat NOT on defining the geographic extent of water quality effects. <u>In other words, the water quality protocols do not predict the full extent of project-related effects on water quality relative to existing or existing conditions</u>. In order to estimate the full extent of water quality impacts to help delineate the action area, the biologist will need to work with project stormwater engineers and hydrologists to estimate the full extent of short- and long-term project-related water quality effects to the environment (turbidity, pollutant loading, pollutant concentrations, etc.). This area may be larger than the area identified in the water quality analysis described in subsections of 17.2.6.1 (eastern Washington) and 17.2.6.2 (western Washington). And depending upon site specific conditions may in some instances be larger than the area identified in the water quality analysis eastern Washington.

17.2.4 Step 4: Determine Species Use and Presence of Critical Habitat within the Action Area and in the Vicinity of Each TDA Discharge Point or Outfall

Within the action area, and in the vicinity of the discharge location(s) or outfall(s) associated with each TDA, the biologist should determine the potential use and presence of species, the presence of suitable habitat for various life stages, critical habitat, and the related primary constituent elements. The biologist should identify the timing of various life stages to determine what months are of interest (a key input in the western Washington HI-RUN model) for the stormwater analysis for each species and to determine what the potential for exposure to stormwater discharge from project BMPs. Ultimately this information, coupled with information from steps 4, 5, and 6 will help the biologist to assess whether, how and where listed species or their habitat may be exposed to the project's stormwater-related effects. Step 9 (Section 17.2.9) describes the synthesis of this information as part of the exposure-response analysis.

17.2.5 Step 5: Describe Water Quality Indicators and Relevant Habitat Characteristics in the Existing Environmental Conditions

Existing environmental conditions in the project's receiving waters may influence the type of analysis that will be required. Stormwater effects are generally more pronounced in small receiving water bodies, and/or in water bodies that already exhibit signs of impairment. BAs must characterize the conditions that prevail in any water bodies (including wetlands) to which stormwater will be discharged.

Conditions within receiving waterbodies should be clearly described in the existing environmental conditions section. The NOAA and USFWS matrices of Pathways and Indicators (NOAA 1996, USFWS 1998) provide useful frameworks for completing this task. For projects with potential water quality impacts, existing or existing conditions for temperature, sediment/turbidity, and chemical contamination/nutrients should be established. A summary of these criteria is provided in the tables below (Tables 17-1 and 17-2).

For projects with potential impacts to habitat (i.e., effects from BMP construction or alteration of flows) it is important to include information on the existing or existing conditions of the habitat types or characteristics within the action area, including stream type and aquatic habitat features, descriptions of substrate conditions, flow conditions (seasonal or perennial), and riparian habitat. In addition, the biologist should describe the suitability of habitat within the action area for a given species and life stage. All of this information helps the biologist to gauge whether there is potential for listed species to be exposed to stormwater impacts, and if there is exposure, what possible responses can be anticipated. If critical habitat is addressed in the BA, describe the primary constituent elements that currently exist within the action area and their condition.

Table 17-1. Water quality indicators identified in the NOAA Fisheries matrix of pathways and indicators.

	Indicators [a]	Properly Functioning	At Risk	Not Properly Functioning
Water Quality	Temperature	50–57ºF [b]	57-60º (spawning) 57-64º (migration &rearing) [c]	> 60º (spawning) > 64º (migration & rearing) [c]
	Sediment/turbidity	<12% fines (<0.85 mm) in gravel [d], turbidity low	12-17% (west-side), [d] 12-20% (east-side), [c] turbidity moderate	>17% (west-side), [d] >20% (east side) [c]fines at surface or depth in spawning habitat [c], turbidity high
	Chemical contamination and nutrients	Low levels of chemical contamination from agricultural, industrial and other sources, no excess nutrients, no Clean Water Act 303(d) designated reaches	Moderate levels of chemical contamination from agricultural, industrial and other sources, some excess nutrients, one Clean Water Act 303(d) designated reach. [e]	High levels of chemical contamination from agricultural, industrial and other sources, high levels of excess nutrients, more than one Clean Water Act 303(d) designated reach. [e]

[a] The ranges of criteria presented here are not absolute; they may be adjusted for unique watersheds.
[b] Bjornn, T.C. and D.W. Reiser, 1991. Habitat Requirements of Salmonids in Streams. American Fisheries Society Special Publication 19:83-138. Meehan, W.R., ed.
[c] Biological Opinion on Land and Resource Management Plans for the: Boise, Challis, Nez Perce, Payette, Salmon, Sawtooth, Umatilla, and Wallowa-Whitman National Forests. March 1, 1995.
[d] Washington Timber/Fish Wildlife Cooperative Monitoring Evaluation and Research Committee, 1993. Watershed Analysis Manual (Version 2.0). Washington Department of Natural Resources.
[e] A Federal Agency Guide for Pilot Watershed Analysis (Version 1.2), 1994.

Table 17-2. Water quality indicators identified in the USFWS matrix of pathways and indicators.

Diagnostic or Pathway	Indicators	Functioning Appropriately	Functioning at Risk	Functioning at Unacceptable Risk
Water Quality	Temperature	7-day average maximum temperature in a reach during these life history stages: [b, c] Incubation 2 – 5ºC Rearing 4 – 12ºC Spawning 4 – 9ºC Also, temperatures do not exceed 15ºC in areas used by adults during migration (no thermal barriers).	7-day average maximum temperature in a reach during the following life history stages: [b, c] Incubation <2ºC or 6ºC Rearing <4ºC or 13 - 15ºC Spawning <4ºC or 10ºC Also, temperatures in areas used by adults during migration sometimes exceeds 15ºC.	7-day average maximum temperature in a reach during the following life history stages: [b, c] Incubation <1ºC or >6ºC Rearing >15ºC Spawning <4ºC or > 10ºC also temperatures in areas used by adults during migration regularly exceed 15ºC (thermal barriers present).
	Sediment (in areas of spawning & incubation; address rearing areas under *substrate embeddedness*)	Similar to Chinook salmon, [b] for example: <12% fines (<0.85 mm) in gravel, [d] ≤20% surface fines ≤6 mm. [e, f]	Similar to Chinook salmon: [b] e.g., 12-17% fines (<0.85mm) in gravel, [d] e.g., 12-20% surface fines. [g]	Similar to Chinook salmon [b]: e.g., >17% fines (<0.85mm) in gravel;[d] e.g., >20% fines at surface or depth in spawning habitat. [g]
	Chemical contamination & nutrients	Low levels of chemical contamination from agricultural, industrial, and other sources; no excess nutrients; no Clean Water Act 303(d) designated reaches. [h]	Moderate levels of chemical contamination from agricultural, industrial and other sources, some excess nutrients, one Clean Water Act 303(d) designated reach. [h]	High levels of chemical contamination from agricultural, industrial and other sources, high levels of excess nutrients, more than one Clean Water Act 303(d) designated reach. [h]

[a] The values of criteria presented here are not absolute; they may be adjusted for local watersheds given supportive documentation.
[b] Rieman, B.E. and J.D. McIntyre. 1993. Demographic and habitat requirements for conservation of bull trout. USDA Forest Service, Intermountain Research Station, Boise, ID.
[c] Buchanan, D.V. and S.V. Gregory. 1997. Development of water temperature standards to protect and restore habitat for bull trout and other cold water species in Oregon. In W.C. Mackay, M.K. Brewin, and M. Monita, eds. Friends of the Bull Trout Conference Proceedings. P8.
[d] Washington Timber/Fish Wildlife Cooperative Monitoring Evaluation and Research Committee, 1993. Watershed Analysis Manual (Version 2.0). Washington Department of Natural Resources.
[e] Overton, C.K., J.D. McIntyre, R. Armstrong, S.L. Whitewell, and K.A. Duncan. 1995. User's guide to fish habitat: descriptions that represent natural conditions in the Salmon River Basin, Idaho. U.S. Department of Agriculture, Forest Service, Intermountain Research Station, Gen Tech. Rep. INT-GTR-322.
[f] Overton, C.K., S.P. Wollrab, B.C. Roberts, and M.A. Radko. 1997. R1/R4 (Northern/Intermountain regions) Fish and Fish Habitat Standard Inventory Procedures Handbook. U.S. Department of Agriculture, Forest Service, Intermountain Research Station, Gen Tech. Rep. INT-GTR-346.
[g] Biological Opinion on Land and Resource Management Plans for the: Boise, Challis, Nez Perce, Payette, Salmon, Sawtooth, Umatilla, and Wallowa-Whitman National Forests. March 1, 1995.
[h] A Federal Agency Guide for Pilot Watershed Analysis (Version 1.2), 1994.

Again, this information helps the biologist to gauge whether there is potential for critical habitat to be exposed and what possible responses could be anticipated. If it exists, representative site-specific information should be used.

Providing a thorough description of existing conditions in the BA will help better explain what changes might take place and better support the effects analysis and effect determinations.

A summary of information that should be included is provided in the list below:

1. Describe existing habitat conditions within the action area paying particular attention to those habitat features and receiving water characteristics that may be affected by the proposed project. For aquatic species describe existing conditions as described in the NOAA or USFWS Matrices of Pathways and Indicators.

    - For those indicators that will be potentially affected by the proposed project, include a detailed description in addition to the summary matrix within the text of the BA.

    - For those projects addressing stormwater impacts, be sure to address the water quality criteria summarized in the tables above.

    - For those indicators that will not be affected by the project, provide a summary of their condition in the matrix with a brief textual summary, and include your more detailed write-up of the indicator in an appendix of the BA.

2. Describe condition of the habitat relative to the species' habitat needs. Describe suitability for each species and lifestages that may occur within the action area. For example, is it suitable rearing or spawning habitat? Is the habitat FMO (foraging, migratory or overwintering habitat) for bull trout? By establishing clearly what habitat types are present within the action area and whether or not they are suitable for various life stages, the biologist can more clearly define the scope of their effects analysis for each species.

3. For critical habitat, evaluate the existing condition for each of the defined Primary Constituent Elements that occur within the project action area.

4. When/where a dilution model is required (see Section 17.2.6.1 for eastern Washington protocol and Section 17.2.6.2 for western Washington protocol), gather additional information on the receiving waterbodies' characteristics. The biologist will likely need to request support from the project hydrologist in gathering this information:

- ◻ Channel geometry (e.g., stream depth, stream velocity, channel width, slope, or Mannings Roughness)
- ◻ Water chemistry (e.g., hardness, representative background concentrations for each water quality parameter of interest. Currently the following stormwater pollutants are being analyzed: Total Suspended Solids, dissolved and total copper, dissolved and total zinc).
- ◻ Water quality (i.e., temperature, other potential pollutants such as pesticides, dissolved oxygen, etc).

If there is no data available, you will not be able to document the existing conditions in the receiving body. In this case, it may be possible to find existing data for a comparable system. Check with the WSDOT Stormwater and Watersheds Program Manager (Dick Gersib) before using data from a comparable system. In addition, WSDOT liaisons at NMFS and USFWS should be consulted to ensure there is mutual agreement regarding the surrogate system that is chosen for analysis.

When selecting data sources, strive to utilize data that has been quality controlled. Potential information sources include:

- MGSFlood Hydrologic Model for precipitation data
- Department of Ecology (DOE) 303(d) list
- Department of Ecology Environmental Information Management (EIM) system for water quality data: <http://apps.ecy.wa.gov/eimreporting/Search.asp>
- The Limiting Factors Analysis by Washington State Conservation Commission
- Local agencies
- USGS Annual Washington State Data Report for water year 2005: <http://wa.water.usgs.gov/data>
- Additional water quality information may be available from the Environmental Protection Agency and the United States Geological Survey.

The last section of this chapter provides a list of on-line resources that provide existing information on existing receiving water conditions including, water quality, flow, and if it is an exempt waterbody.

17.2.6 Step 6: Determine the Extent of Effects Associated with Stormwater and Stormwater BMPs

This section provides guidance for analyzing stormwater effects for eastern (Section 17.2.6.1) and western Washington (Section 17.2.6.2). The guidance provided for analyzing effects on flow and duration can be used both for the delineation of the action area, as well as for an assessment of direct and indirect project effects upon listed species and critical habitat. The protocols outlined for analyzing stormwater quality are more focused in that they provide guidance specifically for assessing direct and indirect project water quality effects upon listed species and critical habitat and not for describing the full geographic extent of project-related water quality effects.

Projects that will not have stormwater effects on listed species or proposed or designated critical habitat due to location, absence of the species and habitats, or a project type that does not have new impervious surface and does not alter flow conditions (e.g., bridge seismic retrofit, ACP overlay, guardrail installation, a project area that is located a great distance from surface water, a project that can infiltrate all runoff due to highly permeable soils, etc.) need not complete a detailed stormwater analysis. These projects are expected to include a brief stormwater discussion as part of the project description and to document project effects (or lack thereof) on listed species along with supporting rationale in the effects analysis section of the BA.

Stormwater BMPs reduce impacts resulting from the development of pollution-generating impervious surface. Although BMPs reduce the effects of impervious surface, they do not completely eliminate the effects to either flow (base, peak or duration) or water quality for many projects.

For those projects that could expose and potentially affect listed species or proposed or designated critical habitat documentation and analysis is required. A BA's stormwater analysis consists of two parts:

1. An analysis of the effects of <u>changes in flow</u>
2. An analysis of the effects of <u>changes in water quality</u>.

While the flow analysis protocols are similar for projects in eastern and western Washington, two distinct procedures have been developed for analyzing the water quality aspects of stormwater effects in eastern Washington and western Washington. A step by step description of how to implement the two components of a BA stormwater analysis for eastern and western Washington is outlined in the subsections below.

17.2.6.1 Eastern Washington Stormwater Analytical Process

Analyzing Effects on Flow Conditions and Local Hydrology

Changes in flow conditions and local hydrology can result in direct and indirect effects to species and critical habitats including: Changes to channel characteristics (pool/riffle/run configuration;

bank stability; etc.) due to scour, substrate impacts due to fines introduced via bank destabilization or scour depositional areas, introduction of excess fines and related effects to substrate conditions or the food base, direct effects to active redds, eggs, or emerging fry resulting from scour and/or deposition, indirect effects to temperature associated with reduced base flows.

To analyze potential effects on peak flow rates, the rational method or single event hydrograph methods (Soil Conservation Service [SCS] or Santa Barbara Unit Hydrograph [SBUH]) can be used. To provide a detailed quantitative analysis of potential project effects on flow durations, a continuous hydrologic simulation model would be needed but no such model is available for use in eastern Washington and therefore a surrogate analysis method using a single event hydrograph method should be employed. The *Highway Runoff Manual* provides flow control design guidance for eastern Washington for use with a unit hydrograph model that approximates the peak flow reduction needed to prevent an increase in the durations of channel-forming peak flows. This guidance can be used as a surrogate threshold to determine if proposed flow control measures are adequate to prevent this impact.

This analysis is completed by qualified WSDOT or consultant staff as determined by the WSDOT project manager. The project biologist will need to coordinate with the WSDOT project manager to ensure that they receive results from this analysis for inclusion in the biological assessment.

Once the project biologist has received the results of the analysis described above, they should work with the hydrologist or modeler to describe the following:

- What changes to flows are anticipated (base, peak)?
- How do anticipated flows compare to, and how will they affect existing conditions?
- How may changes in flow potentially affect habitat characteristics, and conditions in the project's receiving waterbodies?
- Will altered flows or local hydrology affect habitat for listed species (or habitat forming processes) in a manner that impairs function, reduces suitability, or otherwise disrupts normal behavior (feeding, moving, sheltering, etc.)?

The BA must evaluate the effects associated with the proposed flow control measures over time, including describing the expected performance standards (at and below the design storm event) and known limitations of the proposed flow control measures if storm events exceed or greatly exceed the design storm event). For stormwater runoff that runs through an infiltration BMP, water will only be discharged into receiving water when the rainfall event exceeds the capacity of the BMP. Some BMPs discharge at their designed discharge storm events.

A project will minimize its effects on flow if it can fully disperse or infiltrate all runoff from new impervious area, without discharging this runoff either directly or indirectly through a conveyance system to surface waters. Most of the projects occurring in eastern Washington are expected to use infiltration or dispersion for flow control. Very few projects will require a detailed flow analysis.

The NMFS and USFWS consider there will be no effect to flow of the receiving waters, for projects discharging to the Columbia River. NOAA considers there will be no effect to flow only when water is not transferred from contributing watersheds with ESA or EFH resources. Discharges to any HRM exempt waterbody (except the Columbia River) requires providing in the BA either the rationale as to why there is no effect on flow or a detailed description of anticipated project impacts to flow. Use the Exempt Surface Waters List (see Online Resources in Section 17.3) to determine if effects will be discountable.

The biologist must evaluate whether the anticipated changes to habitat will have any effect on the suitability of habitat or the quality and/or functionality of any primary constituent elements of critical habitat. Factors to consider that may reduce habitat quality or functionality include:

- Changes to channel characteristics (pool/riffle/run configuration; bank stability; etc.) due to scour
- Substrate impacts due to fines introduced via bank destabilization or scour depositional areas
- Introduction of excess fines and related effects to substrate conditions or the food base.
- Direct effects to active redds, eggs, or emerging fry resulting from scour and/or deposition
- Indirect effects to temperature associated with reduced base flows.

The impacts to habitat resulting in direct or indirect effects to the listed species or critical habitat will influence the stormwater-related effect determination(s) for the project. The project biologist must also determine whether specific life-stages could be exposed to the effects generated by altered flows. If exposure could occur, determining the anticipated response of affected fish will also help to inform the stormwater-related effect determination.

Analyzing Effects on Water Quality

Stormwater runoff from roads conveys pollutants, sometimes at concentrations that are toxic to fish (Spence et al. 1996). The main pollutants of concern are heavy metals from vehicle sources (EPA 1980). Additionally PAHs from urbanized areas (Van Metre et al. 2000; Kayhanian et al. 2003) can have long-term deleterious effects on salmonids (Peterson et al. 2003). Finally, roads can also deliver pesticides to surface waters (Kayhanian et al. 2003). The relative success of removing pollutants from stormwater runoff depends upon the treatment technology used, and maintenance of treatment facilities. Studies indicate variability among different treatment applications (Schueler 1987; Hayes et al. 1996; Young et al. 1996).

Stormwater-delivered pollutants can affect the physiological or behavioral performance of salmonids in ways that reduce growth, migratory success, reproduction, and cause death. Water quality degradation can contribute to a reduction of growth and immune system function that reduce growth and subsequent ocean survival. The likelihood and extent of effects on fish from the discharge of roadway pollutants to surface waters can vary spatially and temporally. Effects are influenced by background water quality conditions, life stage of the fish, duration of exposure, concentration and relative toxicity of the pollutants, and concurrent discharges and/or background levels of other contaminants.

Currently stormwater assessments in biological assessments focus upon total suspended solids and total and dissolved copper and zinc. The potential effects associated with each of these is summarized below.

Sediment introduced into streams can degrade spawning and incubation habitat, and negatively affect primary and secondary productivity. This may disrupt feeding and territorial behavior through short-term exposure to turbid water. Research indicates that chronic exposure can cause physiological stress responses that can increase maintenance energy and reduce feeding and growth (Lloyd et al. 1987; Servizi and Martens 1991).

Quantifying turbidity levels and their effects on listed fish is complicated by several factors. First, turbidity from an activity will typically decrease as distance from the activity increases. How quickly turbidity levels attenuate is dependent upon the quantity of materials in suspension (e.g., mass or volume), the particle size of suspended sediments, the amount and velocity of receiving water (dilution factor), and the physical and chemical properties of the sediments. Second, the impact of turbidity on fish is not only related to the turbidity levels, but also the particle size of the suspended sediments. Also, the lifestage of the fish at exposure, and water temperature bear on the effects that fish will experience.

Effects of suspended sediment, either as turbidity or suspended solids, on fish are well documented (Bash et al. 2001). Suspended sediments can affect fish behavior and physiology and result in stress and reduced survival. Temperature acts synergistically to increase the effect of suspended sediment. The severity of effect of suspended sediment increases as a function of the sediment concentration and exposure time, or dose (Newcombe and Jensen 1996; Bash et al. 2001). Suspended sediments can cause sublethal effects such as elevated blood sugars and cough rates (Servizi and Martens 1991), physiological stress, and reduced growth rates. Elevated turbidity levels can reduce the ability of salmonids to detect prey, cause gill damage (Sigler et al. 1984; Lloyd et al. 1987; Bash et al. 2001), and cause juvenile steelhead to leave rearing areas (Sigler et al. 1984). Additionally, studies indicate that short-term pulses of suspended sediment influence territorial, gill-flaring, and feeding behavior of salmon under laboratory conditions (Berg and Northcote 1985). Also, a potentially positive reported effect is providing refuge and cover from predation, though this circumstance is considered to be limited. Salmonids have evolved in systems that periodically experience short-term pulses (days to weeks) of high suspended sediment loads, often associated with flood events, and are adapted to such high pulse exposures. Adult and larger juvenile salmonids appear to be little affected by the high concentrations of suspended sediments that occur during storm and snowmelt runoff episodes (Bjornn and Reiser 1991).

Fine sediment can also affect food for juvenile salmonids. Embedded gravel and cobble reduce access to microhabitats (Brusven and Prather 1974), entombing and suffocating benthic organisms. When fine sediment is deposited on gravel and cobble, benthic species diversity and densities have been documented to drop significantly (Cordone and Pennoyer 1960; Herbert et al. 1961; Bullard, Jr. 1965; Reed and Elliot 1972; Nuttall and Bilby 1973; Bjornn et al. 1974; Cederholm et al. 1978).

There are three known physiological pathways of metal exposure and uptake within salmonids: (1) gill surfaces can uptake metal ions which are then rapidly delivered to biological proteins (Niyogi et al. 2004); (2) olfaction (sense of smell) receptor neurons (Baldwin et al. 2003), and; (3) dietary uptake. Of these three pathways, the mechanism of dietary uptake of metals is least understood. For dissolved metals, the most direct pathway to aquatic organisms is through the gills (Kerwin and Nelson 2000).

Relative toxicity of metals can be altered by hardness, water temperature, pH, suspended solids, and presence of other metals. Water hardness affects the bio-available fraction of metals from gill surfaces; as hardness increases; metals are less bio-available, and therefore less toxic (Kerwin and Nelson 2000; Hansen et al. 2002b; Niyogi et al. 2004). However, Baldwin et al. (2003) did not find any influence of water hardness on the inhibiting effect of copper on salmon olfactory functions. Olfactory inhibition can decrease the ability of salmon to recognize and avoid predators and navigate back to natal streams for spawning, resulting in reduced spawning success, and increased predation (Baldwin et al. 2003).

The annual loadings of water quality contaminants from untreated or poorly treated road stormwater runoff can result in sublethal effects that occur sooner and/or more often relative to existing conditions. Exposure to metal mixtures may result in sublethal effects that reduce growth or immune system functions that could persist after Chinook leave their natal streams. Arkoosh et al. (1998) determined that alteration in disease resistance was sustained even after Chinook were removed from the source of pollutants for two months (and kept in hatcheries), and concluded that immune alteration in early life stages may persist into early ocean residency of Chinook.

Most published literature concerns the acute toxicity of most metals on an individual basis, though in aquatic receiving bodies most metals typically exist in mixtures, and are known to interact with each other (Niyogi et al. 2004). These mixtures interacting at gill (and olfaction) mediums likely result in adverse effects, and the physiological consequence of metal mixtures is a continuing area of study (Niyogi et al. 2004). However, individual metal concentrations, and some mixture concentrations and combinations have been tested with a variety of *Oncorhynchus* (i.e., Chinook, coho, and rainbow trout), and *Salvelinus* (bull and brook trout) species. Tested endpoints range from lethal to sublethal effects, which include reduced growth, fecundity, avoidance, reduced stamina, and neurophysiological and histological effects on the olfactory system. For example, mixtures containing copper and zinc were found to have greater than additive toxicity to a wide variety of aquatic organisms including freshwater fish (Eisler 1998), and other metal mixtures also yielded greater than additive toxic effects at low dissolved metal concentrations (Playle 2004).

The steps for completing a water quality analysis in eastern Washington are depicted in Figure 17.1 below.

In order to answer the first question, "Can the proposed stormwater system be designed to prevent surface water discharges?" the biologist must work with the project hydrologist and stormwater engineer to fully describe the treatment strategy and anticipated discharges from the proposed project.

The second question states, "Is project so far from receiving water that runoff will effectively infiltrate before reaching it?" This may be the case in unlined channel conveyances that have adequate soils, surface area, and contact time to allow for complete infiltration before surface water discharge. Answering yes to this question will require a discussion of the following items in the BA for justification:

- Type of conveyance – Conveyance must be an unlined open channel or ditch, not a pipe or lined conveyance ditch. Describe the general configuration.
- Distance to receiving water – This will affect the contact time and the capacity of the channel base to infiltrate runoff.
- Other inputs – Does the unlined open channel or ditch collect and/or convey substantial flow from off-site areas?
- Infiltratability of soil – Soils at the unlined open channel or ditch must have relatively high infiltration rate (Hydrologic Type A or B).
- Depth to groundwater – Seasonal high groundwater table must not meet the unlined open channel or ditch base or be shallow. As a guideline, separation between seasonal high groundwater and the unlined open channel flow line should be 5 feet or greater for acceptable infiltration (criteria for infiltration BMPs – see Section 5-4.2.1 of the *Highway Runoff Manual* for more information).
- Observations of existing flow conditions – Document any observations of flow during a storm event or evidence of flow conditions in the unlined open channel or ditch during conditions that could potentially deliver stormwater to receiving waters (e.g., excessive snow melt during seasonally high groundwater period). If surface discharge of runoff to the receiving water is evident, answer "no" to the question.

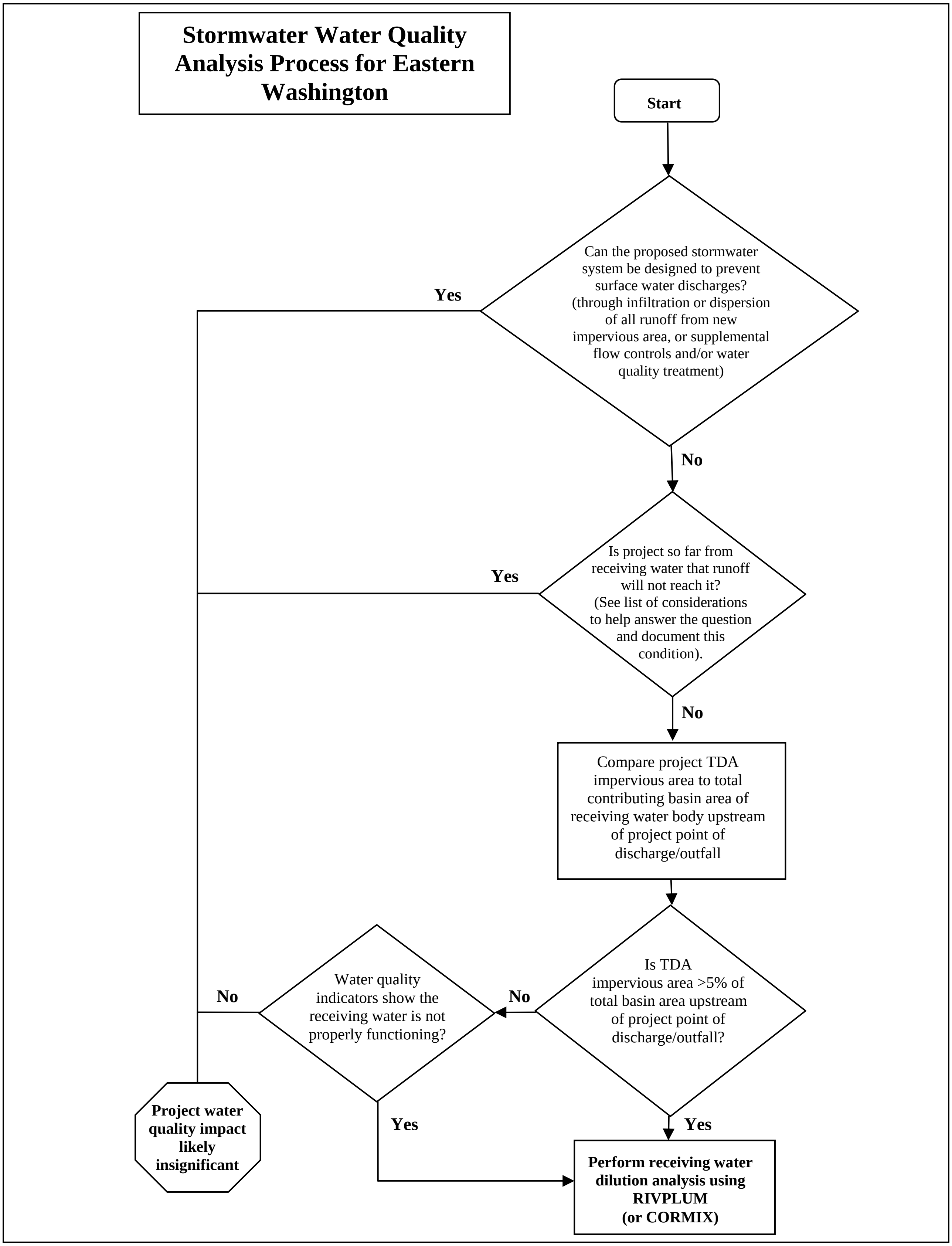

Figure 17.1. Stormwater water quality analysis process for Eastern Washington.

The project biologist, hydrologist and stormwater engineer would need to work together to ensure this information was included in the BA.

The third question states, "Is TDA impervious area > 5% of the total basin area upstream of the project point of discharge/outfall?"

To perform the land-area based dilution analysis, the contributing impervious area for the project is compared to the total contributing basin area for the receiving water upstream of the project discharge. This analysis may be based on a TDA or project wide drainage basin approach depending on the length of the project, and the number and location of the receiving waterbodies. If the project drainage basin represents 5 percent or less of the total upstream basin area, it is assumed that the receiving water will have sufficient dilution capacity to mitigate potential impacts from the project **if** background water quality conditions are not degraded.

The following steps outline how the land-area based dilution analysis is completed:

1. Using the project's ESA stormwater checklist, determine the project's TDA impervious area or the projects total impervious area.

2. To determine if the project drainage basin is greater than 5 percent of the total basin area (contributing drainage area upstream of project discharge point in receiving water), the total basin area can be delineated using the on-line GIS-based tool StreamStats, developed by USGS: <http://water.usgs.gov/osw/streamstats/Washington.html>.

3. If the TDA or project area represents:

    - ◻ MORE than 5 percent of the receiving water drainage basin, then a receiving water dilution analysis using RIVPLUM for streams and rivers or CORMIX for lakes must be completed. Contact the Fish and Wildlife Program at WSDOT Headquarters for assistance in determining the annual load numbers for the calculations.

    - ◻ LESS than 5 percent of the receiving water drainage basin, then an analysis of the water quality conditions in the receiving waterbody must be completed. Water quality conditions in the receiving water are described by the water quality indicators in the NOAA or USFWS Pathways and Indicators Matrices.

        i. If the water quality indicators show the receiving water is *not properly functioning*, then a receiving water dilution analysis using RIVPLUM for streams and rivers or CORMIX for lakes must be completed.

ii. If the water quality indicators show the receiving water is *at risk* or *properly functioning*, then a water quality impacts are likely to be insignificant.

17.2.6.2 Western Washington Analytical Process

Analyzing Effects on Flow Conditions and Local Hydrology

Changes in flow conditions and local hydrology can result in direct and indirect effects to species and critical habitats including: Changes to channel characteristics (pool/riffle/run configuration; bank stability; etc.) due to scour, substrate impacts due to fines introduced via bank destabilization or scour depositional areas, introduction of excess fines and related effects to substrate conditions or the food base, direct effects to active redds, eggs, or emerging fry resulting from scour and/or deposition, indirect effects to temperature associated with reduced base flows.

To analyze potential project effects on flow and duration, a continuous simulation model can be used. MGSFlood is the primary continuous simulation model for use with WSDOT projects in western Washington, and is used to design flow control and runoff treatment BMPs. Other continuous simulation models that can be used to analyze flow and durations include the Western Washington Hydrology Model (WWHM) and King County Runoff Time Series (KCRTS).

This analysis is completed by qualified WSDOT or consultant staff as determined by the WSDOT project manager. The project biologist will need to coordinate with the WSDOT project manager to ensure that they receive results from this analysis for inclusion in the biological assessment.

Once the project biologist has received the results of the analysis described above, they should work with the hydrologist or modeler to describe the following:

- What changes to flows are anticipated (base, peak, duration)?
- How do anticipated flows compare to, and how will they affect existing conditions?
- How may changes in flow potentially affect habitat characteristics, and conditions in the project's receiving waterbodies?
- Will altered flows or local hydrology affect habitat for listed species (or habitat forming processes) in a manner that impairs function, reduces suitability, or otherwise disrupts normal behavior (feeding, moving, sheltering, etc.)?
- Will altered flows or local hydrology affect habitat conditions in a way that measurably affects the suitability and function of habitat for the listed species?

The BA must evaluate the effects associated with the proposed flow control measures over time, including describing the expected performance standards (at and below the design storm event) and known limitations of the proposed flow control measures if storm events exceed or greatly exceed the design storm event). For stormwater runoff that runs through an infiltration BMP, water will only be discharged into receiving water when the rainfall event exceeds the capacity of the BMP. Some BMPs discharge at their designed discharge storm events.

A project will minimize its effects on flow if it can fully disperse or infiltrate all runoff from new impervious area, without discharging this runoff either directly or indirectly through a conveyance system to surface waters.

The USFWS consider there will be no effect to flow of the receiving waters, for projects discharging to the following western Washington waterbodies: Puget Sound; Columbia River; and Lakes Sammamish, Silver, Union, Washington, and Whatcom. NOAA considers there will be no effect to flow to flow of the receiving waters, for projects discharging to the following western Washington waterbodies: Puget Sound, Columbia River, and Lake Washington, and only when water is not transferred from contributing watersheds with ESA or EFH resources. Discharges to any HRM exempt waterbody not on the USFWS and/or NOAA list requires providing in the BA either the rationale as to why there is no effect on flow or a detailed description of anticipated project impacts to flow. Use the Exempt Surface Waters List (see ON-LINE RESOURCES in Section 17.5) to determine if effects will be discountable.

The biologist must evaluate whether the anticipated changes to habitat will have any effect on the suitability of habitat or the quality and/or functionality of any primary constituent elements of critical habitat. Factors to consider that may reduce habitat quality or functionality include:

- Changes to channel characteristics (pool/riffle/run configuration; bank stability; etc.) due to scour
- Substrate impacts due to fines introduced via bank destabilization or scour depositional areas
    - Introduction of excess fines and related effects to substrate conditions or the food base
- Direct effects to active redds, eggs, or emerging fry resulting from scour and/or deposition
- Indirect effects to temperature associated with reduced base flows.

The impacts to habitat resulting in direct or indirect effects to the listed species or critical habitat will also influence the stormwater-related effect determination(s) for the project. The project biologist must also determine whether specific life-stages could be exposed to the effects generated by altered flows. If exposure could occur, determining the anticipated response of affected fish will also help to inform the stormwater-related effect determination.

Analyzing Effects on Water Quality

Stormwater runoff from roads conveys pollutants, sometimes at concentrations that are toxic to fish (Spence et al. 1996). The main pollutants of concern are heavy metals from vehicle sources (EPA 1980). Additionally PAHs from urbanized areas (Van Metre et al. 2000; Kayhanian et al. 2003) can have long-term deleterious effects on salmonids (Peterson et al. 2003). Finally, roads can also deliver pesticides to surface waters (Kayhanian et al. 2003). The relative success of removing pollutants from stormwater runoff depends upon the treatment technology used, and maintenance of treatment facilities. Studies indicate variability among different treatment applications (Schueler 1987; Hayes et al. 1996; Young et al. 1996).

Stormwater-delivered pollutants can affect the physiological or behavioral performance of salmonids in ways that reduce growth, migratory success, reproduction, and cause death. Water-quality degradation can contribute to a reduction of growth and immune system function that reduce growth and subsequent ocean survival. The likelihood and extent of effects on fish from the discharge of roadway pollutants to surface waters can vary spatially and temporally. Effects are influenced by background water quality conditions, life stage of the fish, duration of exposure, concentration and relative toxicity of the pollutants, and concurrent discharges and/or background levels of other contaminants.

Currently, stormwater assessments in biological assessments focus on total suspended solids and total and dissolved copper and zinc. The potential effects associated with these pollutants are summarized below.

Sediment introduced into streams can degrade spawning and incubation habitat, and negatively affect primary and secondary productivity. This may disrupt feeding and territorial behavior through short-term exposure to turbid water. Research indicates that chronic exposure can cause physiological stress responses that can increase maintenance energy and reduce feeding and growth (Lloyd et al. 1987; Servizi and Martens 1991).

Quantifying turbidity levels and their effects on listed fish is complicated by several factors. First, turbidity from an activity will typically decrease as distance from the activity increases. How quickly turbidity levels attenuate is dependent upon the quantity of materials in suspension (e.g., mass or volume), the particle size of suspended sediments, the amount and velocity of ambient water (dilution factor), and the physical and chemical properties of the sediments. Second, the impact of turbidity on fish is not only related to the turbidity levels, but also the particle size of the suspended sediments. Also, the lifestage of the fish at exposure, and water temperature bear on the effects that fish will experience.

Effects of suspended sediment, either as turbidity or suspended solids, on fish are well documented (Bash et al. 2001). Suspended sediments can affect fish behavior and physiology and result in stress and reduced survival. Temperature acts synergistically to increase the effect of suspended sediment. The severity of effect of suspended sediment increases as a function of the sediment concentration and exposure time, or dose (Newcombe and Jensen 1996; Bash et al. 2001). Suspended sediments can cause sublethal effects such as elevated blood sugars and cough rates (Servizi and Martens 1991), physiological stress, and reduced growth rates. Elevated turbidity levels can reduce the ability of salmonids to detect prey, cause gill damage (Sigler et al. 1984; Lloyd et al. 1987; Bash et al. 2001), and cause juvenile steelhead to leave rearing areas (Sigler et al. 1984). Additionally, studies indicate that short-term pulses of suspended sediment influence territorial, gill-flaring, and feeding behavior of salmon under laboratory conditions (Berg and Northcote 1985). Also, a potentially positive reported effect is providing refuge and cover from predation, though this circumstance is considered to be limited. Salmonids have evolved in systems that periodically experience short-term pulses (days to weeks) of high suspended sediment loads, often associated with flood events, and are adapted to such high pulse exposures. Adult and larger juvenile salmonids appear to be little affected by the high concentrations of suspended sediments that occur during storm and snowmelt runoff episodes (Bjornn and Reiser 1991).

Fine sediment can also affect food for juvenile salmonids. Embedded gravel and cobble reduce access to microhabitats (Brusven and Prather 1974), entombing and suffocating benthic organisms. When fine sediment is deposited on gravel and cobble, benthic species diversity and densities have been documented to drop significantly (Cordone and Pennoyer 1960; Herbert et al. 1961; Bullard, Jr. 1965; Reed and Elliot 1972; Nuttall and Bilby 1973; Bjornn et al. 1974; Cederholm et al. 1978).

There are three known physiological pathways of metal exposure and uptake within salmonids: (1) gill surfaces can uptake metal ions which are then rapidly delivered to biological proteins (Niyogi et al. 2004); (2) olfaction (sense of smell) receptor neurons (Baldwin et al. 2003); and (3) dietary uptake. Of these three pathways, the mechanism of dietary uptake of metals is least understood. For dissolved metals, the most direct pathway to aquatic organisms is through the gills (Kerwin and Nelson 2000).

Relative toxicity of metals can be altered by hardness, water temperature, pH, suspended solids, and presence of other metals. Water hardness affects the bio-available fraction of metals from gill surfaces; as hardness increases; metals are less bio-available, and therefore less toxic (Kerwin and Nelson 2000; Hansen et al. 2002b; Niyogi et al. 2004). However, Baldwin et al. (2003) did not find any influence of water hardness on the inhibiting effect of copper on salmon olfactory functions. Olfactory inhibition can decrease the ability of salmon to recognize and avoid predators and navigate back to natal streams for spawning, resulting in reduced spawning success, and increased predation (Baldwin et al. 2003).

Exposure to metal mixtures may result in sublethal effects that reduce growth or immune system functions that could persist after fish leave their natal streams. Arkoosh et al. (1998) determined that alteration in disease resistance was sustained even after Chinook were removed from the source of pollutants for 2 months (and kept in hatcheries), and concluded that immune alteration in early life stages may persist into early ocean residency of Chinook.

Most published literature concerns the acute toxicity of most metals on an individual basis, though in aquatic receiving bodies most metals typically exist in mixtures, and are known to interact with each other (Niyogi et al. 2004). These mixtures interacting at gill (and olfaction) mediums likely result in adverse effects, and the physiological consequence of metal mixtures is a continuing area of study (Niyogi et al. 2004). However, individual metal concentrations, and some mixture concentrations and combinations have been tested with a variety of *Oncorhynchus* (i.e., Chinook, coho and rainbow trout), and *Salvelinus* (bull and brook trout) species. Tested endpoints range from lethal to sublethal effects, which include reduced growth, fecundity, avoidance, reduced stamina and neurophysiological and histological effects on the olfactory system. For example, mixtures containing copper and zinc were found to have greater than additive toxicity to a wide variety of aquatic organisms including freshwater fish (Eisler 1998), and other metal mixtures also yielded greater than additive toxic effects at low dissolved metal concentrations (Playle 2004).

In western Washington, a model has been developed for analyzing water quality impacts; the *Highway Runoff Dilution and Loading Model* (HI-RUN). The model provides a risk-based tool for evaluating exposure and potential effects on listed species. All BAs must include a rationale explaining if and how this analytical tool has been used, and a reference to the version/date of the model used in preparation of the BA. HI-RUN model can be used to conduct two primary analyses using separate subroutines:

1. End-of-pipe loading subroutine – Evaluation of existingexisting and proposed pollutant loading values from a specific TDA, or the entire project area. Evaluation of existingexisting and proposed pollutant concentrations at specific outfall discharge locations is also provided as output from this routine.

2. Receiving water dilution subroutine – Evaluation of existingexisting and proposed pollutant concentrations at specific outfall discharge locations after mixing within the associated receiving water.

The procedure for analyzing potential water quality effects (western Washington) requires an examination of the anticipated dissolved zinc loadings at end-of-pipe. As mentioned in the existing environmental conditions section above, the existing environmental conditions (i.e., conditions within the receiving waterbody) may influence what analytical steps and model outputs are required for a given project. If existing conditions in the action area are "properly functioning" or "functioning at acceptable levels of risk" and if the end-of-pipe loading subroutine indicates the project will likely decrease annual pollutant loadings, it <u>may be unnecessary to run or provide outputs from the HI-RUN dilution subroutine</u>.

The HI-RUN Users Guide provides detailed step-by-step guidance to this procedure, but a brief summary is included here so that biologists can use this distilled guidance to begin their stormwater analysis and refer to the Users Guide only if additional information or clarification is needed.

The first step in using HI-RUN to evaluate water quality effects is to run the end-of-pipe loading subroutine to assess the potential of the proposed project to increase the delivery of pollutant loads to the receiving water when compared to the existing condition. Model outputs from this subroutine provide estimates of pollutant loadings and a set of probabilities that may be used to assess whether the project is likely to increase or decrease annual pollutant loadings in each TDA (or receiving waterbody). Once this step has been completed, Figure 17-2 below, outlines the process for determining whether the HI-RUN dilution subroutine is required. Once the outputs HI-RUN end-of-pipe loading subroutine are available, the biologist completes the following steps:

- The biologist reviews the results of the end-of-pipe loading subroutine (comparison of dissolved zinc [DZn], in particular the probability statistics [P(exceed)] for loading, to thresholds displayed in Figure 17-1) to determine the need for a detailed mixing zone analysis in the receiving water (HI-RUN receiving water dilution subroutine).
    - If the P(exceed) value for loading is greater than the 0.45 threshold, outputs from the HI-RUN receiving water dilution subroutine are required.
    - If the P(exceed) value obtained from the end-of-pipe loading subroutine for DZn is less than or equal to the 0.45 threshold value identified above, a second P(exceed) threshold value of 0.35 is examined.
    - If the P(exceed) value for loading is greater than the 0.35 threshold, an alternate, less rigorous “land-area based” dilution analysis must be performed.
        - To perform the land-area based dilution analysis, the contributing impervious area for the project is compared to the total contributing basin area for the receiving water upstream of the project discharge.
            - If the project drainage basin represents 5 percent or less of the total upstream basin area, it is assumed that the receiving water will have sufficient dilution capacity to mitigate potential impacts from the project **if** background water quality conditions are not degraded. To determine if the project drainage basin is greater than 5 percent of the total basin area (contributing drainage area upstream of project discharge point in receiving water), the total basin area can be delineated using the on-line GIS-based tool StreamStats, developed by USGS: <http://water.usgs.gov/osw/streamstats/index.html>.
            - Analyses using the receiving water dilution subroutine would still be required if the water quality indicators show the receiving water is functioning *at risk* or *not properly functioning*. Water quality conditions in the receiving water are described by the water quality indicators in the NOAA or USFWS Pathways and Indicators Matrices.

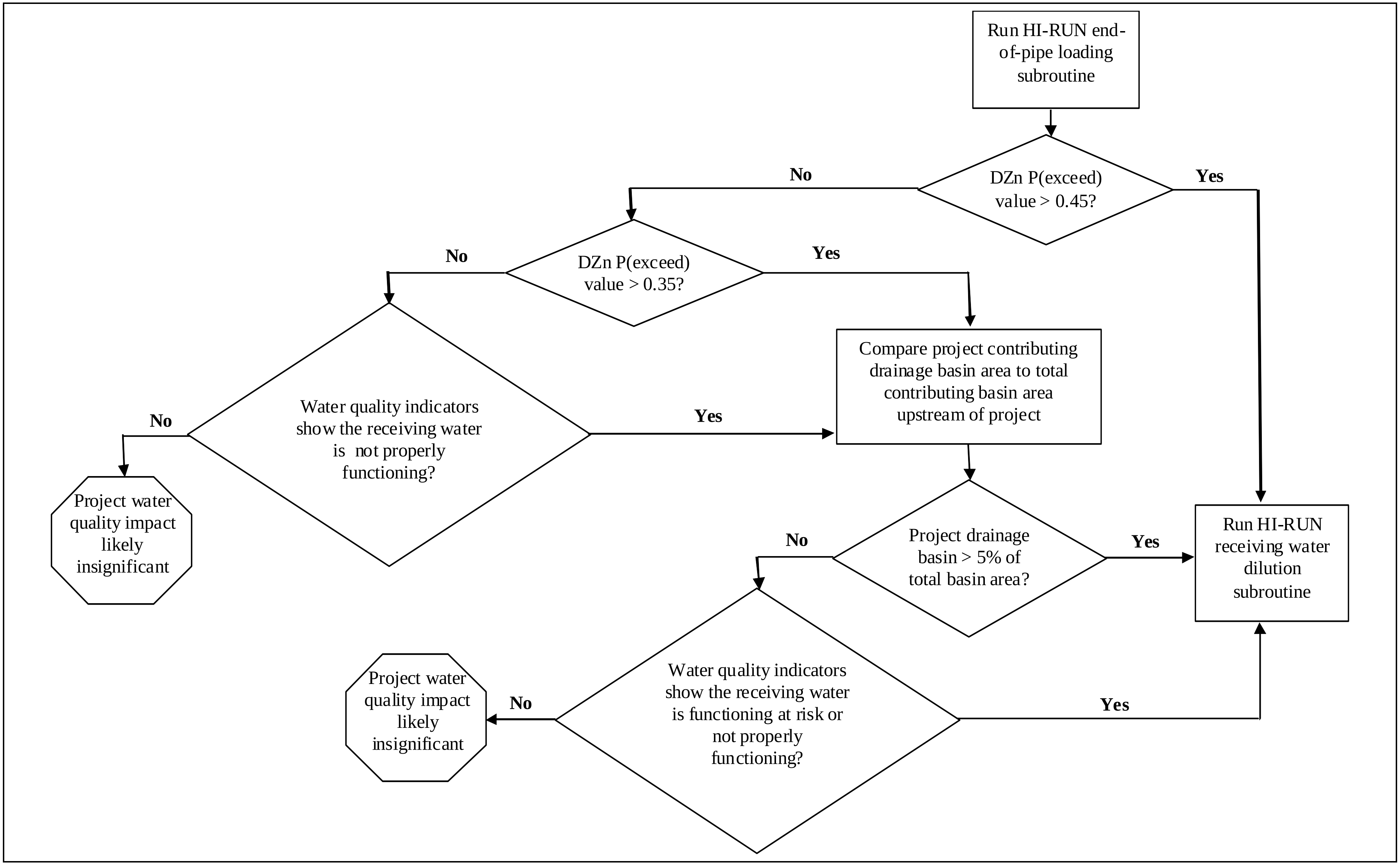

Figure 17-2. HI-RUN model stormwater analysis decision tree: Western Washington.

- ◻ If the P(exceed) value for loading is less than or equal to the 0.35 threshold, the background water quality conditions of the receiving waterbody must be examined.

  – If the water quality criteria are *not properly functioning*, then the alternate, "land-area based" dilution analysis must be performed as described above.

  – If the water quality criteria are *at risk* or *properly functioning*, then the project-related water quality impacts are likely insignificant and the biologist would need to document why this is the case (see Step 4 above for how to document).

The annual loadings of water quality contaminants from untreated or treated road stormwater runoff can result in sublethal effects to fish. Projects that can demonstrate that they will reliably achieve a reduction of pollutant loadings (for all pollutants of interest and in all or most TDAs) should use this information in a discussion in the BA on the general adequacy of the proposed stormwater design. For projects that cannot demonstrate that they will reliably achieve a reduction of pollutant loadings (for all pollutants of interest and in all or most TDAs), additional steps must be taken to assess exposure and potential effects to listed species and their habitat.

If HI-RUN Receiving Water Dilution Subroutine modeling predicts exposure above the established biological thresholds for zinc and copper could occur, or that there is an increase in the area of potential exposure when comparing existing versus proposed conditions, the biologist must then evaluate whether site-specific conditions could potentially mitigate or reduce these estimated impacts (i.e., does runoff flow directly to treatment BMPs or is there flow over vegetated or permeable surfaces prior to reaching the BMP, are there unlined conveyance elements or ditches that could result in additional infiltration, etc.). This may be a qualitative or quantitative analysis that accompanies modeling results. Factors to consider in this analysis are summarized in Step 7 below.

In order to assess impacts to species and critical habitat, the project biologist should work with the project engineer or water quality modeler to describe the following:

- When project related changes to water quality are anticipated

- How anticipated changes to water quality compare to and affect existing conditions

- How changes to water quality will potentially affect habitat suitability and species.

The project biologist must determine whether listed species (individuals) and specific life-stages are potentially present (temporally or spatially) and could be exposed to the water quality effects of the proposed project. If exposure could occur, determining the geographic extent and timing of this exposure will help the biologist determine the anticipated response of affected fish. The biologist must also evaluate whether the anticipated changes to water quality will have any short- or long-term effect on the suitability of habitat or the quality or functioning of any primary constituent elements.

Two case studies are presented below, based upon the case studies contained in the HI-RUN Users Guide, to demonstrate use of the HI-RUN model in the stormwater quality effects analysis process and how to interpret model results for analyzing stormwater effects on species and critical habitat. Case Study #1 involves using the end-of-pipe loading subroutine, but not the receiving water dilution subroutine. Case Study #2 involves the use of both routines. The case studies below differ from what is presented in the User's Guide in that they provide additional detail regarding how model outputs are interpreted.

Case Study #1. Completing the End-of-Pipe Loading Subroutine

The hypothetical project evaluated in Case Study #1 has the following characteristics:

- Existing roadway area: 10 acres
- Existing treatment: none
- Proposed roadway area: 12 acres (2 additional acres)
- Proposed treatment: biofiltration swale (sized for 2 acres) and media filter drain (previously referred to as ecology embankments) sized for 4 additional acres (retrofit)
- Outfall: All runoff in the TDA discharges through a single outfall (only one subbasin)
- Incidental infiltration: Due to sufficient separation between the base of the media filter drain and the seasonal high water table elevation, it is determined that the facility will achieve approximately 60 percent infiltration on an annual runoff volume basis. The biofiltration swale is not expected to have substantial incidental infiltration.
- Detention: Detention is not planned for this TDA because the receiving water is exempt from flow control requirements.

ESA-listed fish species present in the project receiving water include Puget Sound Chinook salmon and Puget Sound steelhead. The example focuses on evaluating the potential water quality effects of highway runoff on rearing steelhead in the month of February. However, the determination of which months to run the model for must be based on the potential presence of both steelhead and Chinook in the action area. If they are expected to be present year round, then the model should be run for all 12 months. If the action area is rearing habitat for both species, and they are not expected to be present during July, August, and September due to low or no flow conditions and temperature, then the model would only need to be run for the other nine months. Complete documentation for why only 9 months was analyzed must be included in the document.

The model inputs for Case Study #1 are described in detail in the HI-RUN Users Guide, and the resulting output for the End-of-Pipe Loading Subroutine for Case Study #1 appears in Figure 17-3 below.

Highway Runoff Dilution and Loading model (HI-RUN) Version 1.0 091908

End of Pipe Loading Subroutine Report

This model is for stormwater analysis associated with biological assessments, and is not a design tool.

Date/Time of Run: 9/19/08 15:25
Outfall ID: SR 13, MP 12.2, TDA 3
Rain Gauge: Puget East 40

Baseline Conditions
No Treatment
0% Infiltration - 10 acres

Proposed Conditions
No Treatment
0% Infiltration - 6 acres
Basic Treatment
0% Infiltration - 2 acres
Enhanced Treatment
60% Infiltration - 4 acres

Load Analysis

	Dissolved Copper Load (lb/yr)		Dissolved Zinc Load (lb/yr)	
	Baseline	Proposed	Baseline	Proposed
Max	8.75	5.6	126	30
75th Percentile	0.464	0.36	3.77	2.7
Median	0.268	0.24	2	1.6
25th Percentile	0.154	0.16	1.05	1
Min	0.005	0.031	0.033	0.18
P (exceed)		0.463		0.438

Concentration Analysis

Subbasin 1	Dissolved Copper Conc (mg/L)		Dissolved Zinc Conc (mg/L)	
	Baseline	Proposed	Baseline	Proposed
Max	0.061	0.062	0.929	0.74
75th Percentile	0.006	0.005	0.05	0.039
Median	0.004	0.004	0.027	0.024
25th Percentile	0.002	0.003	0.014	0.016
Min	0	0.001	0.001	0.004
P (exceed)		0.51		0.476

Figure 17-3. End-of-pipe loading subroutine results – Case Study #1.

The P(exceed) value for dissolved zinc loading is used to determine what level of analysis (if any) is needed of water quality effects in the receiving water. Based upon the thresholds for dissolved zinc described in the flow chart (Figure 17-2), the resulting P(exceed) value (0.44) is less than the upper threshold value of 0.45, but greater than the lower threshold value of 0.35. Therefore, a simplified dilution analysis must be conducted as a next step.

The model output should be provided in an appendix to the BA. But the results from the model output should be summarized within the BA. For a biologist, the P(exceed) values for all of the pollutants evaluated can be used in the BA to describe the general effect of the project on annual loads relative to existing conditions. In this case, the loads for dissolved zinc occurring post project are higher than existing loads 44 percent of the time and lower than existing conditions 56 percent of the time, indicating there is a slight improvement in water quality conditions resulting from the proposed project on dissolved zinc. The loads for dissolved copper occurring post project are higher than existing loads 46 percent of the time and lower than existing conditions 54 percent of the time, indicating there is a slight improvement in water quality conditions resulting from the proposed project. The results for the annual load analysis for all five pollutants of concern (TSS, total and dissolved copper and zinc) can be included in a summary table in the BA. Table 17-3 provides a generalized format summarizing these data. Note this table presents purely hypothetical data and does not directly incorporate results from Case Study #1. The actual model output/report should be placed in an appendix.

Table 17-3. Example table format for summarizing results from annual pollutant load analysis from the HI-RUN end-of-pipe subroutine.

Parameter	Median Existing Load (lbs/year)	Median Proposed Load (lbs/year)	P(exceed) Value
TSS	4,513	2927	0.39
TCu	1.16	0.81	0.38
DCu	0.268	0.230	0.46
TZn	7.03	4.80	0.38
DZn	1.99	1.60	0.44

The results provided in the highlighted column indicate the following:

- 39 percent of the time, total suspended solids associated with the proposed condition exceed the existing condition (end-of-pipe). This indicates the proposed project will generally result in improved conditions.
- 38 percent of the time, total copper levels associated with the proposed condition exceed the existing condition (end-of-pipe). This indicates the proposed project will generally result in improved conditions.
- 46 percent of the time, dissolved copper levels associated with the proposed condition exceed the existing condition (end-of-pipe). This

indicates the proposed project may result in improved conditions. Completing a dilution analysis, if this analytical step is triggered by the P(exceed) values for dissolved zinc exceeding HI-RUN thresholds, would help to determine the extent of potential improvements.

- 38 percent of the time, total zinc levels associated with the proposed condition exceed the existing condition (end-of-pipe). This indicates the proposed project will generally result in improved conditions.

- 44 percent of the time, dissolved zinc levels associated with the proposed condition exceed the existing condition (end-of-pipe). Note that the resulting P(exceed) value (0.44) is less than the upper threshold value of 0.45, but greater than the lower threshold value of 0.35. Therefore, a simplified dilution analysis must be conducted as a next step.

In addition, the biologist might use the other summary statistics provided to describe the effect of the proposed project on existing or existing conditions. The maximum values provide a worst-case load estimate for comparing the existing and proposed conditions. Similarly, the median values provide the most likely load estimate for comparing the proposed and existing conditions. The percentile values provide an indication of the overall distribution of the loading estimates. For example, the 75^{th} percentile value represents the load estimate at which 75 percent of the values will be lower and 25 percent will be higher. These statistics can help the biologist describe the relative risk associated with impacts resulting from the proposed project. In this case study, the proposed project will reduce the load of both dissolved copper and dissolved zinc in all cases except the 25^{th} percentile for dissolved copper and the minimum for both dissolved copper and dissolved zinc indicating that there is a very low risk that the project will increase annual loads for both dissolved copper and zinc.

In addition, the end of pipe loading routine provides end-of-pipe concentrations summary statistics and concentrations for various durations of storm/discharge. The end-of-pipe concentrations do not accurately reflect the conditions fish would be exposed to within the receiving waterbody. As a result, concentration output from the end-of-pipe loading subroutine should be used to describe the quality of stormwater discharged to the receiving waterbody not to support any detailed discussions regarding effects of stormwater to species or habitat within the receiving waterbody itself.

Case Study #1 then completes a simplified dilution analysis that indicates that the impervious surface area within this project TDA is less than 5 percent of the receiving water drainage basin. This outcome requires the project biologist to revisit the water quality criteria to determine if the water quality indicators are functioning at risk or not properly functioning (see Figure 17-2). In this case, the receiving water existing or existing conditions are properly functioning, and there is no additional stormwater dilution modeling required.

The biologist should summarize and discuss the results of the stormwater analysis in the "Analysis of Effects" section as follows:

- Describe project-generated differences in the pre- and post-project loading; compare loading estimates (Table 17-3 provides a generalized format for presenting these results)

- Describe the location of the outfall(s)/ point(s) of discharge with reference to habitat suitability, species occurrence, and potential for exposure.

- Report the results of the simplified dilution analysis by including the results of the watershed analysis. Include information like the size of the watershed in relation to the size of the TDA, and any information about the watershed (e.g., the amount of impervious surface) that may be available and relevant to discussion of water quality in the watershed. Include a discussion of the water quality existing indicators. Stormwater effects are generally more pronounced in small receiving waterbodies and/or in watersheds that already exhibit signs of impairment.

- Discuss the potential for exposure of listed fish to stormwater discharge. Include information on the lifestage that may be exposed. If there is a potential for exposure, include a general discussion on potential responses (of species or lifestage) to increased or decreased pollutant loads.

The fate of stormwater constituents in the receiving water will vary based on their chemistry and the chemistry of the receiving water. Some chemicals may bind tightly to sediment and eventually settle into the substrate. Only fish species and habitat components that are closely associated with the substrate during periods of stability or those that are present during events that resuspend sediments are likely to be exposed through absorption or ingestion. Depending on the environmental and biological fate of the stormwater constituent, exposure to other species may occur through food web interactions.

Some stormwater constituents may remain in the water column and be more available to species that use the site. Depending on the species length of time at the site and their life stage, they may be exposed through absorption and ingestion. Again, depending on the environmental and biological fate of the chemical of concern, exposure to other species may occur through food web interactions.

Though the HI-RUN model does not include cadmium, lead, chromium and PAHs, these are other pollutants that can potentially affect fish. Lead levels in stormwater runoff have declined to extremely low levels following the removal of lead from gasoline.

Typical effects of cadmium toxicity to freshwater organisms include spinal deformities, inhibited respiration, immune response, temporary immobility, decreased growth, inhibited reproduction, decreased survival, and population alterations (Sorensen 1991; Brent and Herricks 1998; Sanchez-Dardon et al. 1999). The 120-hour LC50 for cadmium in juvenile bull trout in a mixture was 0.83 µg/L (Hansen et al. 2002a). Cicmanec and Jackson (2001) reviewed sub-lethal tests conducted with rainbow and brown trout. The No Observed Effect Concentrations (NOECs) ranged from 3.4 µg/L to 9.3 µg/L. These studies indicate that measurable impacts to growth, survival, reproduction, and/or metabolism may occur to Chinook, steelhead, and bull trout in the action area from stormwater effluent containing cadmium.

Sensitivity to chromium varies widely, even among closely related species (Eisler 1986). Effects of chromium toxicity to freshwater organisms include reduced growth and disease resistance, behavioral modifications, disrupted feeding, cell damage in the gills, osmoregulatory upset in outmigrating smolts, and reduced reproduction and survival in freshwater fish (Anestis and Neufeld 1986; Eisler 1986). Stevens and Chapman (1984) reported an Lowest Observed Effect Concentration (LOEC) for rainbow trout of 157 µg/L chromium +3 (hardness equals 25 mg/L). These studies indicate that measurable impacts to growth, survival, reproduction, and/or metabolism may occur to Chinook, steelhead, and bull trout in the action area from stormwater effluent containing chromium.

PAHs from urbanized areas (Van Metre et al. 2000; Kayhanian et al. 2003) can have long-term deleterious effects on salmonids (Peterson et al. 2003). Arkoosh et al. (1991) found that juvenile Chinook salmon that migrated through the Duwamish River estuary, which is contaminated with PCBs and PAHs, and heavily influenced by an urban landscape, bioacccumulated the pollutants, and showed signs of suppressed immune responses compared to uncontaminated fish. Juvenile Chinook in the Duwamish estuary showed suppressed immune function, reduced survival, and impaired growth (Varanasi et al. 1993). In laboratory experiments, juvenile Chinook exposed to a PCB mixture and a *N. salmincola* infection had greater immune damage than fish exposed to either stressor alone (Jacobson et al. 2003).

WSDOT is currently not analyzing for these other pollutants in their stormwater runoff. The five pollutants of concern (TSS, total and dissolved zinc and copper) are serving as indicators of pollutant loads for all stormwater pollutants and for evaluating removal efficiencies of the stormwater treatment BMPs until new information becomes available.

<u>Case Study #2. Completing the Dilution Subroutine</u>

The hypothetical project evaluated in Case Study #2 has the following characteristics:

- Existing roadway area: 24.8 acres
- Existing treatment: biofiltration swale (sized for 4.3 acres)
- Proposed roadway area: 31.1 acres (6.3 additional acres)
- Proposed treatment: media filter drain (previously referred to as ecology embankments) sized for 6.3 new acres. Existing biofiltration swale remains (sized for 4.3 acres).
- Outfall: All runoff in the TDA discharges through a single outfall (only one subbasin).
- Incidental infiltration: Due to sufficient separation between the base of the media filter drain and the seasonal high water table elevation, it is

determined that the facility will achieve approximately 60 percent infiltration on an annual runoff volume basis. The biofiltration swale is not expected to have substantial incidental infiltration.

- Detention: Detention is planned for this TDA to meet the *Highway Runoff Manual* flow control requirements.

- ESA-listed fish species present in the project receiving water includes Puget Sound Chinook salmon. An analysis will be performed to evaluate the potential water quality effects of highway runoff on rearing Chinook salmon in the months of August and September. If rearing Chinook are expected to be present during other months, those months should also be incuded in the analysis.

- Background water quality data from a site upstream of the project outfall is available from a previous watershed assessment effort. The median values for DCu and DZn are 0.002 and 0.003 mg/L, respectively.

- Receiving water quality indicators are properly functioning.

The model inputs for Case Study #2 are described in detail in the HI-RUN Users Guide, and the resulting output for the End-of-Pipe Loading Subroutine for Case Study #2 appears in Figure 17-4 below.

The P(exceed) value for dissolved zinc loading is 0.518. The resulting P(exceed) value (0.518) is greater than the 0.45 threshold depicted on Figure 17-2. Therefore, a detailed dilution analysis using the receiving water dilution subroutine must be conducted as a next step.

The model output should be provided in an appendix to the BA. But the results from the model output should be summarized within the BA. The P(exceed) values and additional summary statistics would be used by the biologist in the BA as described in Case Study #1 to generally describe the difference between the post-project and existing conditions with regard to water quality. This discussion would be followed by a more rigorous description of project-related effects generated from the HI-RUN Receiving Water Dilution Subroutine results.

The inputs for the HI-RUN Receiving Water Dilution Subroutine, are provided for Case Study #2 in the HI-RUN Users Guide. The outputs generated by the model for the existing or existing condition (Figure 17-5) and for the proposed condition (Figure 17-6), indicate that the biological threshold for zinc would be exceeded until 19 feet below the outfall in both existing and proposed conditions.

The distance downstream (19 feet) calculated for the proposed condition defines the area within which ESA-listed aquatic species could be exposed to pollutant concentrations sufficient to cause adverse sub-lethal effects. This information would then be considered by the author of the biological assessment when making a stormwater-related effect determination. However, it must be stressed that this output is intended to provide a general assessment of the risk for pollutant

Highway Runoff Dilution and Loading model (HI-RUN) Version 1.0 091908

End of Pipe Loading Subroutine Report

This model is for stormwater analysis associated with biological assessments, and is not a design tool.

Date/Time of Run: 9/19/08 15:58
Outfall ID: SR 13, MP 15.5, TDA 1
Rain Gauge: Montesano

Baseline Conditions
No Treatment
0% Infiltration - 20.5 acres
Basic Treatment
0% Infiltration - 4.3 acres

Proposed Conditions
No Treatment
0% Infiltration - 20.5 acres
Basic Treatment
0% Infiltration - 4.3 acres
Enhanced Treatment
60% Infiltration - 6.3 acres

Load Analysis

	Dissolved Copper Load (lb/yr)		Dissolved Zinc Load (lb/yr)	
	Baseline	Proposed	Baseline	Proposed
Max	27	28	354	254
75th Percentile	2.02	2.1	15.7	16
Median	1.21	1.3	8.45	9.1
25th Percentile	0.745	0.8	4.87	5.3
Min	0.042	0.054	0.022	0.19
P (exceed)		0.53		0.518

Concentration Analysis

Subbasin 1	Dissolved Copper Conc (mg/L)		Dissolved Zinc Conc (mg/L)	
	Baseline	Proposed	Baseline	Proposed
Max	0.068	0.081	0.922	0.658
75th Percentile	0.006	0.006	0.046	0.044
Median	0.004	0.004	0.026	0.026
25th Percentile	0.002	0.002	0.015	0.016
Min	0	0.001	0.001	0.003
P (exceed)		0.512		0.504

Figure 17-4. End-of-pipe loading subroutine results – Case Study #2.

Highway Runoff Dilution and Loading model (HI-RUN) Version 1.0 091908

Recieving Water Dilution Subroutine Report - Subbasin 1

This model is for stormwater analysis associated with biological assessments, and is not a design tool.

Date/Time of Run:	9/19/08 16:20
Outfall ID:	SR 13, MP 15.5, TDA 1
Rain Gauge:	Montesano
Description:	

Baseline Condition
No Treatment
0% Infiltration - 4.3 acres
0% Infiltration - 20.5 acres

Proposed Condition
No Treatment
0% Infiltration - 20.5 acres
Basic Treatment
0% Infiltration - 0 acres with detention
0% Infiltration - 4.3 acres
Enhanced Treatment
60% Infiltration - 6.3 acres with detention

Distance Downstream from Discharge = 19 feet

Dissolved Copper - August - Probability of Occurrence

Baseline Conditions (Discharge Duration (hrs))

Conc.		0 - 3	3 - 6	6 - 12	12 - 24	24 - 48	48 - 96	96 - 192	>192
> 0.004	0.006	0	0.001	0.002	0.002	0.001	0	0	0
0.002 - 0.004	0.994	0.036	0.161	0.312	0.295	0.145	0.039	0.006	0
0 - 0.002	0	0	0	0	0	0	0	0	0
		0.036	0.162	0.313	0.297	0.146	0.039	0.006	0

Proposed Conditions (Discharge Duration (hrs))

Conc.		0 - 3	3 - 6	6 - 12	12 - 24	24 - 48	48 - 96	96 - 192	>192
> 0.004	0.005	0	0	0	0	0.001	0.001	0.001	0.001
0.002 - 0.004	0.993	0	0.001	0.013	0.066	0.177	0.279	0.262	0.195
0 - 0.002	0	0	0	0	0	0	0	0	0
		0	0.001	0.014	0.066	0.178	0.28	0.264	0.196

Dissolved Copper - September - Probability of Occurrence

Baseline Conditions (Discharge Duration (hrs))

Conc.		0 - 3	3 - 6	6 - 12	12 - 24	24 - 48	48 - 96	96 - 192	>192
> 0.004	0.01	0	0.002	0.003	0.003	0.001	0	0	0
0.002 - 0.004	0.989	0.047	0.182	0.315	0.276	0.131	0.033	0.005	0
0 - 0.002	0	0	0	0	0	0	0	0	0
		0.048	0.184	0.318	0.279	0.133	0.033	0.005	0

Proposed Conditions (Discharge Duration (hrs))

Conc.		0 - 3	3 - 6	6 - 12	12 - 24	24 - 48	48 - 96	96 - 192	>192
> 0.004	0.01	0	0	0	0.001	0.002	0.003	0.002	0.001
0.002 - 0.004	0.989	0	0.002	0.017	0.084	0.21	0.296	0.24	0.14
0 - 0.002	0	0	0	0	0	0	0	0	0
		0	0.002	0.017	0.084	0.212	0.299	0.242	0.141

Dissolved Zinc - August - Probability of Occurrence

Baseline Conditions (Discharge Duration (hrs))

Conc.		0 - 3	3 - 6	6 - 12	12 - 24	24 - 48	48 - 96	96 - 192	>192
> 0.0086	0.026	0.001	0.004	0.008	0.008	0.004	0.001	0	0
0.003 - 0.0086	0.974	0.035	0.16	0.301	0.293	0.142	0.038	0.005	0
0 - 0.003	0	0	0	0	0	0	0	0	0
		0.036	0.164	0.309	0.301	0.145	0.039	0.005	0

Proposed Conditions (Discharge Duration (hrs))

Conc.		0 - 3	3 - 6	6 - 12	12 - 24	24 - 48	48 - 96	96 - 192	>192
> 0.0086	0.024	0	0	0	0.002	0.004	0.007	0.006	0.005
0.003 - 0.0086	0.974	0	0.001	0.014	0.063	0.173	0.274	0.256	0.193
0 - 0.003	0	0	0	0	0	0	0	0	0
		0	0.001	0.014	0.065	0.177	0.281	0.262	0.198

Dissolved Zinc - September - Probability of Occurrence

Baseline Conditions (Discharge Duration (hrs))

Conc.		0 - 3	3 - 6	6 - 12	12 - 24	24 - 48	48 - 96	96 - 192	>192
> 0.0086	0.047	0.002	0.009	0.015	0.013	0.006	0.002	0	0
0.003 - 0.0086	0.953	0.045	0.174	0.302	0.268	0.127	0.033	0.004	0
0 - 0.003	0	0	0	0	0	0	0	0	0
		0.047	0.182	0.317	0.282	0.133	0.034	0.004	0

Proposed Conditions (Discharge Duration (hrs))

Conc.		0 - 3	3 - 6	6 - 12	12 - 24	24 - 48	48 - 96	96 - 192	>192
> 0.0086	0.046	0	0	0.001	0.004	0.01	0.014	0.011	0.007
0.003 - 0.0086	0.952	0	0.002	0.017	0.079	0.201	0.285	0.231	0.136
0 - 0.003	0	0	0	0	0	0	0	0	0
		0	0.002	0.018	0.083	0.211	0.299	0.243	0.142

Figure 17-5. Receiving water dilution subroutine results – final iteration evaluating existing or existing conditions in Case Study #2.

Highway Runoff Dilution and Loading model (HI-RUN) Version 1.0 091908

Recieving Water Dilution Subroutine Report - Subbasin 1

This model is for stormwater analysis associated with biological assessments, and is not a design tool.

Date/Time of Run: 9/19/08 16:20
Outfall ID: SR 13, MP 15.5, TDA 1
Rain Gauge: Montesano
Description:

Distance Downstream from Discharge = 19 feet

Baseline Condition
No Treatment
0% Infiltration - 4.3 acres
0% Infiltration - 20.5 acres

Proposed Condition
No Treatment
0% Infiltration - 20.5 acres
Basic Treatment
0% Infiltration - 0 acres with detention
0% Infiltration - 4.3 acres
Enhanced Treatment
60% Infiltration - 6.3 acres with detention

Dissolved Copper - August - Probability of Occurrence

Baseline Conditions

Conc. (		0 - 3	3 - 6	6 - 12	12 - 24	24 - 48	48 - 96	96 - 192	>192
> 0.004	0.006	0	0.001	0.002	0.002	0.001	0	0	0
0.002 - 0.004	0.994	0.036	0.161	0.312	0.295	0.145	0.039	0.006	0
0 - 0.002	0	0	0	0	0	0	0	0	0
		0.036	0.162	0.313	0.297	0.146	0.039	0.006	0

Proposed Conditions

Conc. (		0 - 3	3 - 6	6 - 12	12 - 24	24 - 48	48 - 96	96 - 192	>192
> 0.004	0.005	0	0	0	0	0.001	0.001	0.001	0.001
0.002 - 0.004	0.993	0	0.001	0.013	0.066	0.177	0.279	0.262	0.195
0 - 0.002	0	0	0	0	0	0	0	0	0
		0	0.001	0.014	0.066	0.178	0.28	0.264	0.196

Discharge Duration (hrs)

Dissolved Copper - September - Probability of Occurrence

Baseline Conditions

Conc. (		0 - 3	3 - 6	6 - 12	12 - 24	24 - 48	48 - 96	96 - 192	>192
> 0.004	0.01	0	0.002	0.003	0.003	0.001	0	0	0
0.002 - 0.004	0.989	0.047	0.182	0.315	0.276	0.131	0.033	0.005	0
0 - 0.002	0	0	0	0	0	0	0	0	0
		0.048	0.184	0.318	0.279	0.133	0.033	0.005	0

Proposed Conditions

Conc. (		0 - 3	3 - 6	6 - 12	12 - 24	24 - 48	48 - 96	96 - 192	>192
> 0.004	0.01	0	0	0	0.001	0.002	0.003	0.002	0.001
0.002 - 0.004	0.989	0	0.002	0.017	0.084	0.21	0.296	0.24	0.14
0 - 0.002	0	0	0	0	0	0	0	0	0
		0	0.002	0.017	0.084	0.212	0.299	0.242	0.141

Discharge Duration (hrs)

Dissolved Zinc - August - Probability of Occurrence

Baseline Conditions

Conc. (		0 - 3	3 - 6	6 - 12	12 - 24	24 - 48	48 - 96	96 - 192	>192
> 0.0086	0.026	0.001	0.004	0.008	0.008	0.004	0.001	0	0
0.003 - 0.0086	0.974	0.035	0.16	0.301	0.293	0.142	0.038	0.005	0
0 - 0.003	0	0	0	0	0	0	0	0	0
		0.036	0.164	0.309	0.301	0.145	0.039	0.005	0

Proposed Conditions

Conc. (		0 - 3	3 - 6	6 - 12	12 - 24	24 - 48	48 - 96	96 - 192	>192
> 0.0086	0.024	0	0	0	0.002	0.004	0.007	0.006	0.005
0.003 - 0.0086	0.974	0	0.001	0.014	0.063	0.173	0.274	0.256	0.193
0 - 0.003	0	0	0	0	0	0	0	0	0
		0	0.001	0.014	0.065	0.177	0.281	0.262	0.198

Discharge Duration (hrs)

Dissolved Zinc - September - Probability of Occurrence

Baseline Conditions

Conc. (		0 - 3	3 - 6	6 - 12	12 - 24	24 - 48	48 - 96	96 - 192	>192
> 0.0086	0.047	0.002	0.009	0.015	0.013	0.006	0.002	0	0
0.003 - 0.0086	0.953	0.045	0.174	0.302	0.268	0.127	0.033	0.004	0
0 - 0.003	0	0	0	0	0	0	0	0	0
		0.047	0.182	0.317	0.282	0.133	0.034	0.004	0

Proposed Conditions

Conc. (		0 - 3	3 - 6	6 - 12	12 - 24	24 - 48	48 - 96	96 - 192	>192
> 0.0086	0.046	0	0	0.001	0.004	0.01	0.014	0.011	0.007
0.003 - 0.0086	0.952	0	0.002	0.017	0.079	0.201	0.285	0.231	0.136
0 - 0.003	0	0	0	0	0	0	0	0	0
		0	0.002	0.018	0.083	0.211	0.299	0.243	0.142

Discharge Duration (hrs)

Figure 17-6. Receiving water dilution subroutine results – final iteration evaluating proposed conditions in Case Study #2.

exposure for ESA-listed species from highway runoff. Other potential stormwater effects (e.g., loading impacts and flow-related effects) are identified in the HI-RUN end-of-pipe loading subroutine and in the procedure outlined above for analyzing effects on flow conditions and local hydrology, respectively.

Where this assessment indicates a potential risk exists, a more detailed assessment (quantitative or qualitative) of the project should be performed to determine whether there are mitigating factors that are not reflected in the output of the HI-RUN model (see Step 7 below). Step 7 below summarizes factors that would be considered when completing this assessment. In general this assessment would examine potential site characteristics not addressed in the HI-RUN model that influence water quality or flow impacts (i.e., open conveyance, distance from outfall to receiving waterbody), quality and suitability of habitat within the receiving waterbody for various lifestages of species, and anticipated timing of discharges relative to the anticipated use and timing of species in the receiving waterbody.

The HI-RUN model automatically calculates the adverse sub-lethal effect thresholds for dissolved zinc and copper, based upon the background concentrations of these metals in the receiving waterbody. The dissolved copper and dissolved zinc existing concentrations and concentrations resulting in the post-project condition are presented relative to the adverse sub-lethal effect thresholds, above which, adverse sub-lethal effects may occur:

- The current adverse sub-lethal effect threshold for DZn is 5.6 µg/L over background zinc concentrations between 3.0 µg/L and 13 µg/L (Sprague 1968).

- The HI-RUN model currently calibrates to the receiving water's actual background concentration regardless of whether it falls within the range provided by the threshold described above. Model outputs will automatically calculate a 0.0056 mg/L (5.6 microgram/liter) increase in DZn over the receiving water's background concentration.

- The adverse sub-lethal effect threshold for DCu is 2.0 µg/L over background levels of 3.0 µg/L or less (Sandahl et al. 2007).

- The HI-RUN model currently calibrates to the receiving water's actual background concentration regardless of whether it falls below a background of 3.0 µg/L or less. Model outputs will automatically calculate a 0.002 mg/L (2.0 microgram/liter) increase in DCu over the receiving water's background concentration

- 1 mg/L (milligram per liter) = 1,000 µg/L (micrograms per liter). To convert model outputs from mg/l to µg/L, move the decimal place three places to the right.

The summary output for both conditions is provided below.

The model output should be provided in an appendix to the BA. But the results from the model output should be summarized within the BA. Table 17-4 provides a generalized format summarizing these data for each individual parameter. Note this table presents purely hypothetical data and does not directly incorporate results from Case Study #2. Values in this table represent distances downstream from the outfall (in feet) where receiving water concentrations will exceed the applicable threshold for biological effects with a 5 percent probability. Separate values are presented for the proposed and existing conditions, respectively.

Table 17-4. Example table format for summarizing results from dilution analyses performed using the HI-RUN dilution subroutine.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	MAX
Species A	7/6	5/4	4/3	8/7							7/6	8/7	8/7
Species B			4/3	8/7	9/7	10/9							10/9
Species C	7/6	5/4	4/3	8/7	9/7	10/9	8/7	5/4	6/5	5/4	7/6	8/7	10/9
Species D	7/6	5/4	4/3	8/7							7/6	8/7	8/7

Existing condition/proposed condition

In the model output, the left-hand column for both existing and proposed conditions is highlighted in green. This column depicts the probability of concentrations falling within the following ranges:

- The bottom row: Zero to the background (established by the biologist and/or project hydrologist based upon available existing water quality data)
- The middle row: Background to the biological threshold (for dissolved copper or zinc)
- The top row: Above the biological threshold (for dissolved copper or zinc).

By providing summary data for pollutant concentrations in this way, the model allows the biologist to effectively describe the potential for biological thresholds to be exceeded between the established point of interest downstream of the project and the discharge point or outfall. For example, based upon the output for existing conditions provided above, concentrations of dissolved copper in a given runoff event during the month of August have a 0.6 percent probability of exceeding the biological threshold and a 1 percent probability in September. Similarly, for dissolved zinc, there is a 2.6 percent probability that concentrations will exceed the biological threshold during a runoff event in the month of August and a 4.7 percent probability in September. For the proposed condition, there is a 0.5 percent probability that concentrations of dissolved copper will exceed the biological threshold during a runoff event in the month of August and a 1 percent probability in September. Similarly, for dissolved zinc, there is a 2.4 percent probability that concentrations will exceed the biological threshold during a runoff event in the month of August and a 4.6 percent probability in September.

The model outputs also describe the potential for different ranges of discharge durations (the cells along the bottom of the output tables highlighted in green) occurring in a given month (taking into account the proposed BMPs and how they affect discharge within the TDA). The biologist can use this information to help describe likelihood that a discharge event of a given duration will occur. The biologist can also examine the probability of certain concentration ranges occurring during discharge events of specific duration. This helps to describe how long fish may be exposed.

The biologist should summarize and discuss the results of the stormwater analysis in the "Analysis of Effects" section as follows:

- Describe project-generated differences in the pre- and post-project loading; compare loading estimates

- Analyze the location of the outfall/discharge point and the modeled zone of effect (distance downstream to the point of interest) relative to habitat suitability, species occurrence, and timing of the species relative to when and where stormwater discharges are anticipated to evaluate the potential for exposure

- If there is potential for exposure, the biologist would include general discussions on the anticipated timing and duration of exposure, on the potential response of species or critical habitat to increased or decreased pollutant loads, and on toxicity related to the anticipated pollutant concentrations.

The toxicity of the stormwater constituents is species-specific and effects may be visible at various levels of biological organization (i.e., on a molecular, cellular, tissue, or whole-organism level). Often, research has not been conducted on ESA-listed species and results must be extrapolated based on physiological and environmental similarities. Laboratory studies are useful due to the ability to control for multiple variables, thus providing the ability to determine cause-and-effect relationships.

However, the laboratory studies have not been verified with field studies. Currently there is limited peer reviewed science on the effects of pollutants of concern on listed species in the natural environment. The focus of the BA analysis will be on the changes the project is having on the existing conditions and on the potential for exposure for listed species to concentrations exceeding the established biological thresholds.

17.2.7 Step 7: Examine Site-Specific Conditions that May Lessen or Magnify Stormwater Effects

In some cases, site-specific conditions may help to lessen or may magnify the predicted effects. Qualitative or quantitative factors to consider and that may influence potential stormwater impacts include:

- Soils that support infiltration: Soils that support infiltration will reduce the amount of stormwater that reaches the receiving waterbody. Soil information can be accessed at the following websites: <http://remotesens.css.wsu.edu/washingtonsoil/> and <http://www.or.nrcs.usda.gov/pnw_soil/wa_reports.html>.

- Outfall configuration: Is it a single pipe? Does it end in a diffuser or flow spreader that could increase dilution (and therefore decrease pollutant concentrations) within the receiving waterbody?

- Runoff conveyance characteristics: Is it a closed system with no opportunity for evapo- transportation or infiltration, or does runoff flow through a broad/unlined/open channel?

- Distance from the outfall to a receiving waterbody: If the outlet does not end directly at a riprap pad within the OHWL of the receiving waterbody, then there is the opportunity for dispersion and infiltration of flows. The longer the distance from the receiving waterbody, the greater the opportunity for dispersion, evaporation, infiltration and even additional treatment through the interaction of the stormwater with soils and vegetation. This factor may be considerably less important under “wet season” conditions when soils are saturated.

- Characteristics of the receiving waterbody: Is it an ephemeral channel? Is the point of discharge within a wetland or riparian buffer? Is the wetland reliant upon stormwater discharges to maintain its hydrology? Is it an emergent wetland that will provide additional treatment and mixing prior to discharging to the receiving water body? Is the wetland and/or receiving waterbody used by fish for habitat? All of these considerations will influence potential effects and exposure.

- Does the outfall or project discharge to a dynamic fast moving receiving water body or to a slower moving receiving waterbody? If the outfall or project discharge is to a slow moving or tidally influenced waterbody, a different mixing model (i.e., CORMIX) will need to be used to determine the potential for exposure to stormwater concentrations in exceedance of biological effect thresholds. Describe the temporal and spatial effects this condition could have on potential exposure.

All of these factors working individually or together can influence the amount and quality of the stormwater prior to it entering the receiving water.

Similarly, site-specific factors related to habitat and species in the receiving water need to be reconsidered in light of this additional information in order to accurately assess and describe anticipated exposures. The significance of these site-specific factors, is that they potentially affect:

- Quality and suitability of habitat within the receiving waterbody for various lifestages of species resulting from project-related impacts to water quality, flow, or local hydrology
- Anticipated timing of discharges relative to the anticipated use and timing of species in the receiving waterbody
- Potential exposure(s) and anticipated response(s) of fish to stormwater concentrations in exceedance of biological effect thresholds.

17.2.8 Step 8: Revisit Action Area Extent to Reflect Effects from Stormwater BMP Construction and Stormwater Runoff.

The project biologist will not be able to complete this step until after stormwater effects have been identified and their physical, chemical and biological effects assessed. It is important to remember from the outset that stormwater is only one component used in defining the action area. The project biologist will need to iteratively revisit how the action area has been defined as the anticipated effects associated with various project elements are more fully understood or more accurately estimated.

17.2.9 Step 9: Assess Potential Exposure and Response of Species and Critical Habitat

The biologist must evaluate all of the direct and indirect effects resulting from the proposed stormwater management and designs when providing rationale in support of stormwater-related effect determinations for listed species and critical habitat. This requires the biologist fully integrate all of the preceding steps into a coherent analysis and discussion. The biologist must consider all of the stormwater effects and risks for exposure identified in Step 6 (Section 17.2.6) and modified in Step 7 (Section 17.2.7), taking into consideration the biology of the species and habitat (Step 4 – Section 17.2.4), within the context of existing conditions identified in Step 5 (Section 17.2.5).

- The project may result in insignificant, incremental or significant effects, and may persistently or episodically affect pollutant loads, pollutant concentrations, flow and/or local hydrology. The biologist must consider all of these short- and long-term effects.

- The biologist must assess whether, how, and where listed species or their habitat may be exposed (temporally and spatially) to these direct and indirect effects and how they affect conditions in the receiving waters over time.

- The biologist must describe how listed species (individuals) or their habitat will respond to exposure:

  - Will individuals experience significant disruption to their normal behaviors (feeding, moving, or sheltering) or essential behaviors (spawning, egg incubation, etc.)?

  - Will habitat conditions be altered in a way(s) that measurably affect suitability and function for the listed species)?

- The biologist must evaluate whether anticipated project-related effects to existing conditions within the receiving waterbody will influence the potential for exposure, and the projected responses of listed species and their habitat.

17.2.10 Step 10: Factor Stormwater Impacts into Effect Determinations

The BA provides a single effect determination for each listed species, which take into account the effects of the entire project including stormwater discharges and new and modified stormwater elements. As a preliminary step in reaching that determination, the project biologist focuses on assessing just the stormwater effects (i.e., changes to the pattern or rate of runoff, peak flows, flow durations, and base flow, as well as changes in pollutant loads and pollutant concentrations) and makes an effect determination for each species or habitat related to anticipated stormwater effects. However, these stormwater-specific effect determinations are then considered in conjunction with all of the effect determinations generated for other project elements (e.g., noise, in-water work, indirect effects, etc.) to arrive at a single overall effect determination for each species addressed in the BA.

17.2.10.1 Effect Determinations for Listed Species and Designated Critical Habitat

Determination of No-Effect Based on No Exposure

If listed habitat and species utilization areas do not temporally or spatially overlap with the areas that will be affected by changes in stormwater pollutant loading, water quality, flow, local hydrology or areas that lie within the BMP or conveyance system footprint (including the outfall), then the species and habitat will not be exposed. Projects that result in no net increase of pollutants to the receiving water and have no effect on flow and local hydrology in the receiving water will have no stormwater impacts on listed species or habitat. If species or habitat is not exposed to the stormwater discharges or new or modified BMPs and related infrastructure, a *no-effect* determination is warranted for this element of the project. Remember that the overall effect determination for each species is based on effects of the entire project, not just the stormwater discharges and stormwater and infrastructure.

Determination of May Affect, Not Likely to Adversely Affect

Where the effects of the stormwater discharges and proposed stormwater designs (i.e., BMPs, conveyance, points-of-discharge) on a listed species or habitat are judged to be beneficial, discountable, or insignificant, a *may affect, not likely to adversely affect* determination is warranted for the stormwater element of the project. Stormwater effects that are beneficial, discountable, or insignificant will be dependent upon project conditions, receiving waterbodies, stormwater treatment levels, existing conditions, and presence of species or habitat.

A project biologist who has reached this effect determination has provided all the analysis required and has clearly outlined any stormwater effects (i.e., changes in water quality, flow and local hydrology), the footprint of the BMPs, outfall locations, conveyance system characteristics and potential for influencing project stormwater effects, and temporary and permanent effects. The project biologist has also identified the habitat availability and historical use by the species in the action area and relative to the anticipated temporal and spatial extent of stormwater effects, and has documented the extent of exposure in the effects analysis. All predicted effects have been adequately supported and identified as beneficial, discountable, or insignificant (see discussion of each of these terms below) in the effects analysis.

<u>Beneficial Effects</u>

A beneficial effect (without any adverse effects) does not qualify for a *no-effect* determination. If the proposed stormwater design will have only beneficial effects and no adverse effects on a listed species or habitat, then a *may affect, not likely to adversely affect* determination is warranted for the stormwater element of the project. For example, if a project will result in decreases in both pollutant loadings and concentrations, the project would provide a beneficial effect related to water quality.

<u>Discountable Effects</u>

If the project biologist determines that exposure to stormwater-related effects is extremely unlikely to occur, and this can be supported with best available science, then the effect is discountable. For example, effects related to changes in water quality may be discountable if the species is extremely unlikely to be present when stormwater discharges will occur (i.e., there is little chance for exposure to occur). The rationale for concluding that the effects are discountable must be explained in the effects analysis. Where the effects are discountable, *a may affect, not likely to adversely affect* determination is warranted for the stormwater element of the project.

Insignificant Effects

Perhaps exposure to the stormwater-related effects is likely, but the response of the listed species or habitat is expected to be so small that it cannot be meaningfully measured, detected, or evaluated. The project biologist could infer this if the probability of pollutant concentrations exceeding the established biological thresholds is extremely low (i.e., less than 1 percent),and/or if changes to annual pollutant loads, flows or local hydrology relative to existing conditions are negligible (i.e., predicted plume size is extremely small or discharges will be infrequent). In each of these cases, the project biologist should explain the rationale for concluding that the effects are insignificant in the effects analysis. Where the effects are insignificant, a *may affect, not likely to adversely affect* determination is warranted.

Determination of May Affect, Likely to Adversely Affect

Effects on listed species and critical habitat that are not beneficial, discountable, or insignificant warrant a *may affect, likely to adversely affect* determination for the stormwater element of the project.

Quantifying Adverse Effects on Species

If an effect is not beneficial, discountable, or insignificant, then it is an adverse effect. Adverse effects can be either direct impacts on the listed species or indirect impacts on its habitat or prey species. Stormwater impacts that result in measurable adverse effects to listed species or critical habitat may include changes to the pattern or rate of runoff, peak flows, flow durations, and base flow, as well as changes in pollutant loads and pollutant concentrations that result from projects that create significant amounts of pollution generating impervious surface and/or projects that occur in watersheds with degraded baseline or existing conditions. These assessments must be supported by pertinent existing information on the habitat elements, species life history, and number of individuals and life stages that may be affected.

Stormwater-related effects that are likely to affect an individual animal’s ability to seek shelter, forage, move freely, reproduce, or survive result in *take*. These are the endpoints used to quantify or describe the adverse effect on a species.

A project biologist who has reached this effect determination has provided all the content recommended in Section 17.2 and has clearly outlined the existing and proposed stormwater treatment and design in the project description, including temporary and permanent facilities, outfall locations, and existing and proposed conveyance. The project biologist has also identified the habitat availability and historical use by the species, and has described the relevant water quality indicators and habitat characteristics in the existing environmental conditions, and has documented the spatial and temporal extent of exposure of the stormwater and proposed stormwater discharges and BMPs in the effects analysis. All predicted impacts on an individual animal’s ability to survive, reproduce, move freely, forage, or seek shelter are supported with best available science and are addressed in the effects analysis.

17.2.10.2 Effect Determinations for Proposed Species or Proposed Critical Habitats

Jeopardy Determination

If an adverse effect is significant enough (i.e., if an entire subpopulation will be adversely affected), then the proposed action may jeopardize the continued existence of the species. A jeopardy determination applies only to species that are *proposed* for listing under the ESA. For a negative jeopardy determination, the BA includes the statement "The project is not likely to jeopardize the continued existence of the species."

A project biologist who believes that a project might jeopardize a proposed species should consult the WSDOT Environmental Office.

Adverse Modification Determination

An adverse effect is considered an *adverse modification* if it destroys the conservation role of the critical habitat for a species. An adverse modification determination applies to proposed or designated critical habitat units. For a negative adverse modification determination, the BA includes the statement "The project is not likely to adversely modify the critical habitat unit."

It is possible for a project to have an adverse effect on any or all of the primary constituent elements yet not reach the level of an adverse modification to the critical habitat unit. A project biologist who believes that a project might adversely modify a critical habitat unit should consult the WSDOT Environmental Office.

17.3 On-line Resources for Stormwater

17.3.1 WSDOT Resources

WSDOT *Highway Runoff Manual* <http://www.wsdot.wa.gov/Environment/WaterQuality/Runoff/HighwayRunoffManual>.

Exempt Surface Waters List (table 3-5 in the WSDOT *Highway Runoff Manual*) <http://www.wsdot.wa.gov/fasc/EngineeringPublications/Manuals/HighwayRunoffManual.pdf>.

WSDOT NPDES Progress Reports <http://www.wsdot.wa.gov/Environment/WaterQuality/default.htm#reports>.

17.3.2 Existing Soil/Water Quality and Stream Flow Information

Washington Ecology – River and Stream Water Quality Monitoring <http://www.ecy.wa.gov/programs/eap/fw_riv/rv_main.html>.

Washington Ecology – Environmental Information Management <http://www.ecy.wa.gov/eim/>

Snohomish County – Surface Water On-line Data
<http://198.238.192.103/spw_swhydro/wq-search.asp>.

USGS National Water Quality Assessment Program – Data Warehouse
<http://infotrek.er.usgs.gov/traverse/f?p=NAWQA:HOME:7497878595394337582>.

Washington State's Water Quality Assessment
<http://www.ecy.wa.gov/programs/wq/303d/2002/2002-index.html>.

Department of Ecology 303d List
< http://www.ecy.wa.gov/programs/wq/303d/index.html>.

Limiting Factors Analysis by Washington State Conservation Commission
< http://salmon.scc.wa.gov/>.

Background Soil Metals Concentrations for Washington State
Publication #94-115
<http://www.ecy.wa.gov/pubs/94115.pdf>.

17.3.3 Water Quality Standards

U.S. EPA Water Quality Standards
<http://www.epa.gov/waterscience/standards/>.

State Water Quality Standards
<http://www.ecy.wa.gov/programs/wq/swqs/new-rule.html>.

17.3.4 Current Research

WSDOT – Current Stormwater Research
<http://www.wsdot.wa.gov/environment/stormwater/default.htm>.

USGS National Water Quality Assessment Program
<http://water.usgs.gov/nawqa/>.

USGS National Highway Runoff
Water-Quality Data and Methodology Synthesis
<http://ma.water.usgs.gov/fhwa/biblio/default.htm>.

Washington Ecology – Whole Effluent Toxicity (WET) Testing
<http://www.epa.gov/waterscience/standards/>.

Northwest Fisheries Science Center
<http://www.nwfsc.noaa.gov/publications/displayinclude.cfm?incfile=journalarticlein_press.inc>.

Society of Environmental Toxicology and Chemistry (SETAC) < http://www.setac.org/>.

Aquatic Toxicology journals – no specific on-line ability

Also see references provided in the HI-RUN Users Guide available on the WSDOT Environmental Website.