2006

Evaluation of Washington's Industrial Stormwater General Permit

Prepared by:
EnviroVision and Herrera Environmental Consultants

November 2006

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Prepared for:

Washington Department of Ecology
Contract no. C0600124

In response to:

Engrossed Substitute Senate Bill 6415, and identified in RCW 90.48.555
Notes: Report to legislature--2004 c 225

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Executive Summary

In 2004, Washington State Department of Ecology was directed to submit a report to the Washington State Legislature on methods to improve the effectiveness of Industrial Stormwater General NPDES permit requirements. This study and report was prepared in partial fulfillment of the legislative directive.

By design, the focus of this study has been on the monitoring requirements and permit targets. However, these only serve as evaluation tools. The overall goals of the ISWGP permit and NPDES permit program should be the effective integration of these tools into a larger process for improving site conditions and reducing pollutant inputs to receiving waters. The recommendations developed in this study are aimed at achieving these goals and ultimately providing better water quality protection.

The following technical tasks associated with the ISWGP were identified for study:

- Research and summarize the approach to NPDES permit monitoring requirements used by other States;
- Analyze existing data collected under the industrial NPDES permit programs in Washington State;
- Provide recommendations to improve the visual assessments required by the permit;
- Provide monitoring recommendations to improve compliance determinations under the permits;
- Evaluate the impacts of monitoring recommendations; and
- Evaluate the use of numeric effluent limits in the industrial permit.

Key Findings

- The extensive database provided by Ecology for analysis in this study was comprised of data compiled from over 1,000 industrial stormwater permittees in the State of Washington. The central tendency, range, and variability of data from individual parameters generally matched what has been found elsewhere. No specific recommendations were identified for a parameter unless there were nearly 400 data points or more to support it; the more frequently measured parameters had over 2,500 to 4,500 data points. These large numbers of data points would greatly reduce potential influences from outliers or errors.

- The monitoring data exhibits a right-skewed distribution pattern due to the presence of numerous high-end values. As is typical for stormwater data, there is a high degree of variability relative to what is observed in the data from other types of pollutant monitoring

(e.g., wastewater influent). Given the high variability of the data, a large number of observations will generally be required in any hypothesis testing in order to detect significant patterns.

All of the parameters examined, except ammonia, were measured at levels that exceeded the benchmark and action levels. However, there was a large range in terms of the frequency and magnitude of the exceedances exhibited for each of the parameters with zinc identified as the greatest concern. Median values for almost all of the parameters were below the applicable benchmark which suggests that the permit targets are generally being met when assessed relative to the central tendency of the data from all of the reporting facilities.

Under the existing permit monitoring requirements, a direct determination of an individual facilities compliance with water quality standards cannot be made because detailed discharge and receiving water information are necessary to conduct such an evaluation.

A high percentage of samples exceeded the water quality criteria when dilution factors of 0 (i.e., end of pipe) and 10:1 were assumed. The percentage of exceedance for all parameters dropped to less than 35 percent with a dilution factor of 25:1, and less than 15 percent with a dilution factor of 50:1. When the actual benchmark concentrations were assumed for the stormwater discharge and then evaluated relative to representative receiving water conditions, the typical dilution that would be required to meet acute water quality criteria ranged from <1:1 for lead to 17:1 for copper. Similarly, the typical dilution that would be required to meet chronic water quality criteria ranged from <2:1 for zinc to 76:1 for lead. This indicates that the existing benchmarks, if attained, are fairly protective of water quality under most discharge scenarios.

There were significant differences in median pollutant concentrations measured between the various industrial categories. However, there was no meaningful or consistent pattern to the observed differences.

The possibility of establishing numeric effluent limits for this permit, as is the case with individual stormwater permits, was also reviewed. It was determined that the data needed to develop numeric limits are not currently available and could not be confidently applied against the large range of facility sizes, types, and locations represented by this general permit.

Recommendations

Moderate changes are recommended to the required water quality monitoring and reporting to simplify and streamline efforts and improve the quality and quantity of stormwater data. This should also improve tracking of corrective actions and their effectiveness and improve feedback to permittees about what works. These changes include:

Increasing the number of required monitoring events from four to five and focusing the monitoring on the period of highest concern.

Reducing written reports to twice annually.

Establishing monitoring and reporting requirements that make a clear distinction between the period of assessment and the period of corrective action.

Defining new qualifying conditions for storm events that will make it easier for permittees to collect the required samples while still providing adequate data for assessing site conditions.

Identifying a more meaningful set of monitoring parameters for assessing both BMP performance and potential receiving water impacts.

The most controversial of the recommended changes to the permit are those associated with the permit targets (i.e., benchmarks and action levels) and response requirements for exceedances of permit targets. These include;

Recommending new permit targets for all of the parameters evaluated. The new targets are realistic, technology-based benchmarks that are derived based on regional monitoring data. The new permit targets are lower than the existing permit targets and effectively restrict the acceptable range of pollutant concentrations that industry must strive to meet.

Defining more stringent response requirements to elevated pollutant concentrations with a more practical timeline for assessing the effectiveness of implemented actions before moving into the next response level. Continued improvements in discharge quality must occur until the benchmark can be attained.

Recommendations are also presented to improve the effectiveness of routine visual site inspections by providing a more detailed site checklist and implementing a training program for industrial site inspectors.

Last, recommendations for improving NPDES program management are presented. These include;

Implementing a supplemental monitoring program to address technical issues that cannot be effectively addressed through permittee monitoring and to serve as an auditing function to verify the adequacy of the permittee monitoring program.

Improving the database management system to allow easier assessment of permit compliance, enhance identification of high risk sites, improve evaluation of BMP effectiveness and overall program performance.

Improving feedback and reporting associated with the permit by requiring better tracking of site activities by permittees and formalizing constructive feedback between Ecology and the permittees with regard to program operations and key research findings.

There are no significant cost differences to permittees for implementation of these recommendations, but there are cost implications to Ecology. Both the Supplemental Monitoring program and Visual Inspection Training Program represent activities that are not currently funded.

Overall, the package of recommendations reflect an adaptive management approach that is more streamlined, more practical to apply, and more scientifically defensible. At the same time, these recommendations will produce an ISWGP that better protects State water quality.

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Section 1: Study Framework

The primary purpose of this study was to evaluate data collected through the current Industrial Stormwater General Permit (ISWGP) and to use this information to evaluate monitoring requirements and permit targets that are identified in the current permit. The need for this evaluation was driven by Ecology's stated intention during development of the 2002 ISWGP and by legislative action taken as a result of litigation associated with the permit.

With over 1,000 industrial facilities discharging into the waters of the state, it is challenging to implement a permit program that is general enough to cover a wide range of facilities while still being restrictive enough to protect surface waters. The program has undergone several revisions and reviews since 1992, when Ecology issued the first Baseline Stormwater General Permit for Industrial and Construction Activities.

Prior to 2000, permit compliance was determined primarily through visual assessments. Ecology revised the permit in 2002 to include monitoring requirements and issued it under the name Industrial Stormwater General Permit. Monitoring efforts were required to "provide tangible evidence of Permittees' performance and the overall effectiveness of the permit" (Ecology 2002). It was Ecology's stated intent that the data collected be used to better target the monitoring requirements:

> "Ecology will evaluate the monitoring requirements at the next reissue of this permit. The data will be used to better target monitoring requirements and could result in increasing or decreasing monitoring, adding or subtracting parameters, and adding or removing monitoring requirements for industrial groups" (Ecology 2002).

The Industrial Stormwater General Permit was appealed to the Pollution Control Hearings Board. A total of eleven separate appeal issues were identified by the Board (Ecology 2004). Although most of the appeals reached settlement or were ruled on by the Board, three appeal issues were unresolved. To address these issues, a bill (ESSB 6415) was introduced to the Washington State Legislature (Legislature) and eventually signed into law in March 2004 (RCW 90.48.555). As a result of these permit revisions, appellant groups dropped their on-going permit appeals, the permit modifications incorporated into the Industrial Stormwater General permit were implemented, and Ecology was directed to submit a report to the Legislature on methods to improve the effectiveness of NPDES permit monitoring requirements. The study and report presented here were prepared in partial fulfillment of the legislative directive. This report represents the first major effort to evaluate stormwater data actually obtained by Washington permittees in order to provide recommendations for improving the overall effectiveness of the permit program.

The following technical tasks associated with the ISWGP were identified for study:

Research and summarize the approach to NPDES permit monitoring requirements used by other States;

Analyze existing data collected under the industrial NPDES permit programs in Washington State;

Provide recommendations to improve the visual assessments required by the permit;

Provide monitoring recommendations to improve compliance determinations under the permit;

Evaluate the impacts of the permit monitoring recommendations; and

Evaluate the use of numeric effluent limits in the industrial permit.

Early in the process, a technical advisory committee (Committee) was formed to review the results of the research and data analysis and to discuss recommendations developed by the consultant team. This information was presented to the Committee through a series of formal presentations and written products. It was also presented to Ecology management staff and inspectors. Two reports "Evaluation of Monitoring Data from General NPDES Permits for Industrial and Construction Stormwater" and "Visual Inspection of Stormwater BMPs" were submitted as review drafts to the Committee and the final versions are included as Appendix I and II to this document. A technical memorandum titled "Draft Recommendations for Modifications to the Monitoring Strategy for the Industrial Stormwater General NPDES Permit" was also presented for review. This technical memorandum was not finalized. Instead, review comments were used to develop this document. (The draft technical memorandum has not been included with this report to avoid future confusion as to the final recommendations developed.) This process allowed separate review and refinement of the individual technical pieces prior to release of this more comprehensive report. Because much of the supporting information related to the data analysis and BMP inspection guidance is provided in the appendices, only the key findings are summarized in the main body of this report.

Comments from Committee members and Ecology staff were carefully considered in developing the recommendations presented here and, in fact, resulted in significant modifications or refinements to this document. However, the findings and recommendations included in this report are ultimately those of the consultant team; they have not been formally reviewed or approved by Ecology or other stakeholders. It was the intent of Ecology to aid development of the work without overly influencing the outcome. Therefore, specific policy or regulatory ramifications have not been evaluated.

The report is divided into seven sections. Section 1 (presented here) introduces the framework for the project. Section 2 is an overview of ISWGP programs around the nation. Section 3 is a summary of the results of the analysis of Washington States ISWGP data. Section 4 specifically describes the development of permit targets because this was a key issue of the study. Section 5 describes the series of recommendations associated with different aspects of permittee monitoring. Section 6 describes recommendations applicable to management of the ISWGP permit package. And finally, Section 7 provides the study summary and conclusions.

Section 2: Overview of ISWGP Program & Requirements

Summary of Washington State's Program

In 1992, Ecology issued the first Stormwater General Permit that included industrial and construction activities. Three years later (1995), the general permit was divided into two separate permits for industry and construction. Because a permit cycle is five years, Ecology reissued the general permit in October of 2000, to expire in 2005. However, Ecology's intent was to review the reissued permit and to revise and replace it before 2003.

In 2002, Ecology proposed revoking the existing industrial general permit and replacing it with a revised permit that included an expiration date of 2007. One of the significant revisions included the requirement for stormwater monitoring.

The revised permit was appealed to the Pollution Control Hearings Board by both business and environmental groups. Legislation was eventually introduced in early 2004 as an attempt to resolve the ongoing appeal. Engrossed Substitute Senate Bill 6415 was signed into law by Governor Locke in March 2004. All groups dropped their appeal, and permit modifications proceeded (Ecology, August 2004). The Industrial General Permit was modified in 2004 with an effective date of January 14, 2005.

In Washington, the first stormwater monitoring period associated with the general permit began in the second quarter of 2003. Previously, permit compliance was determined solely by onsite field visits (Ecology 2002). With sampling and reporting requirements, Ecology was intending to obtain "tangible evidence of Permittees' performance and the overall effectiveness of the permit" (Ecology 2002).

Quarterly monitoring and sampling of stormwater is required at all facilities that discharge to surface water. The objective of sampling is to "capture stormwater with the greatest exposure to significant sources of pollution" (Ecology, December 2004). To meet this objective, there were a number of qualifying conditions used to define an appropriate storm event for monitoring, including a minimum dry period before the storm (24-hours), a minimum storm size (0.1" over 24 hours), and a requirement to collect samples within the first hour of discharge. Results from monitoring must be reported to Ecology each quarter using a discharge monitoring report (DMR) form.

The key parameters that must be monitored by all facilities include; turbidity, pH, total zinc, and oil and grease. Additional parameters (i.e., total copper and total lead) must be included if total zinc concentrations are high. There are also additional monitoring parameters that are applicable for specific industry sectors. For example, industries identified as the timber product industry, paper, and allied products must also monitor for biochemical oxygen demand (5-day) (BOD_5).

There are two unique aspects of Washington's ISWGP. One is the establishment of two permit targets; 1) a benchmark and 2) an action level, for each parameter. The other is a three-tiered system of response to exceedances of the permit targets. Responses are tied to whether the benchmark(s) or the action level is exceeded. These unique aspects of Washington's ISWGP are a product of legislation passed in 2004 and reflect an adaptive management approach to the permit. Benchmarks and action levels are used as indicators to gauge the level of concern and associated response. The three triggers and corresponding response levels are summarized below:

Level one trigger – occurs if any of the results are above the benchmark

Level 1 Response – site inspection within two weeks of receipt of sampling results. Inspection results and remedial actions taken should be summarized and placed with the Stormwater Pollution Prevention Plan (SWPPP) and reported to Ecology.

Level two trigger – occurs if any two of the previous four sampling results for a parameter are above the action level.

Level 2 Response – the source(s) of contamination should be promptly identified. All available options of source control should be investigated and then implemented. A report should be submitted to Ecology.

Level three trigger – occurs if any four samples are above the action levels.

Level 3 Response – same as Level 2 Response plus required installment of additional stormwater treatment (according to Ecology's 2004 Fact Sheet Addendum).

Comparison of ISWGP Requirements

Setting Permit Benchmarks

EPA's Benchmarks

The concept of "benchmarks" was introduced with the publication of EPA's Multi-Sector General Permit (MSGP) in September of 1995. As described in the permit, benchmarks are target concentrations set for most of the pollutants found in stormwater discharged from a facility. Pollutant concentrations above the benchmark would signal a "level of concern" indicating that the stormwater discharge could potentially impair, or contribute to impairment of water quality or affect human health from the ingestion of water or fish (FRN 1995). If stormwater discharges are below a benchmark, EPA determined that the facility had "little potential for water quality concern" (FRN 1995).

Benchmarks were not designed to be effluent limits, but were intended to serve as indicators (FRN 1995). According to EPA, benchmarks are "merely levels which EPA has used to determine if a stormwater discharge from any given facility merits further monitoring to insure that the facility has been successful in implementing a storm water pollution prevention plan" (FRN 1995). If a benchmark was exceeded, facility operators would be expected to review their operations and improve their Best Management Practices (BMPs).

Although EPA's intention for using benchmarks as indicators seems clear, there has been confusion in their practical application and they are sometimes viewed or treated as effluent limits. A basis for this confusion can be attributed to EPA's approach in initially setting benchmarks. EPA used a combination of water quality criteria (from the 1986 "Gold Book"), wastewater treatment standards, and stormwater discharge limits. For heavy metals, which represent the bulk of the parameters listed, most benchmarks were based on the acute fresh water ambient water quality criteria. If these criteria were not available, the lowest observed effect level (LOEL) was used.

The benchmarks for conventional pollutants were derived from a wider variety of sources. As noted above, the benchmarks for BOD_5 and pH are based upon the secondary wastewater treatment regulations. The benchmark for oil and grease was set based upon the "stormwater effluent limitation guideline" for petroleum refining facilities, and the benchmark for total suspended solids (TSS) is derived from the median concentration of the National Urban Runoff Program database (FRN 1995).

The turbidity benchmark was originally established to be consistent with many state numeric water quality criteria. The value of 5 NTU above background was agreed to in negotiations for the 1998 modification to the 1995 MSGP (FRN 1995). However, because the benchmark required a permittee to monitor both the discharge and the receiving stream, EPA has proposed changing the turbidity benchmark to an end-of-pipe limit of 50 NTU in the 2006 proposed reissuance of the MSGP (EPA 2006). This value was derived from a combination of sources including data presented in the *Stormwater Effects Handbook* (Burton and Pitt 2001), water quality standards from the state of Idaho, and a review of existing DMR data (EPA 2006).

In most cases, benchmarks have not changed significantly since 1995. Even though EPA is currently in the process of revising their MSGP, proposed new benchmarks have changed only slightly. Table 2-1 identifies those benchmark values that have changed as well as the source of the proposed 2006 values.

Table 2-1. EPA benchmarks and their origins. (All units in mg/L except where noted.)

Pollutant	MSGP Benchmarks			Origin of Proposed 2006 Benchmarks[1]
	1995	2000	2006 Proposed	
Conventional Pollutants				
Ammonia	19	19	19	Acute Aquatic Life Criteria 2002
Biochemical Oxygen Demand (BOD_5)	30	30	30	Secondary Treatment Regulations (40 CFR 133)
Chemical Oxygen Demand	120	120	120	Factor of 4 times BOD_5 concentration
Total Suspended Solids	100	100	100	National Urban Runoff Program median concentration
Oil and grease	15	15	15	Median concentration of Storm Water Effluent Limitation Guideline (40 CFR Part 419)

Pollutant	MSGP Benchmarks			Origin of Proposed 2006 Benchmarks[1]
	1995	2000	2006 Proposed	
Turbidity (NTU)	N/A	5 NTU above	50	See explanation in text.
Nitrate+Nitrite Nitrogen	0.68	0.68	0.68	National Urban Runoff Program median concentration
Total Phosphorus	2.0	2.0	2.0	North Carolina stormwater benchmark
pH (s.u.)	6.0–9.0	6.0–9.0	6.0–9.0	Secondary Treatment Regulations (40 CFR 133)
Heavy Metals				
Aluminum, Total	0.75	0.75	0.75	Acute Aquatic Life Criteria 2002
Antimony, Total	0.636	0.636	0.64	Updated to WQ criteria – Human health for consumption
Arsenic, Total	0.16854	0.16854	0.15	Chronic aquatic life Criteria 2002
Beryllium, Total	0.13	0.13	0.13	WQ Criteria-LOEL Acute
Cadmium, Total*	0.0159	0.0159	0.0021	Acute Aquatic Life Criteria 2002
Chromium, Total*	N/A	N/A	1.8	Acute Aquatic Life Criteria 2002
Copper, Total*	0.0636	0.0636	0.014	Acute Aquatic Life Criteria 2002
Iron, Total	1.0	1.0	1.0	Acute Aquatic Life Criteria 2002
Lead, Total*	0.0816	0.0816	0.082	Acute Aquatic Life Criteria 2002
Magnesium, Total	N/A	0.0636	0.064	Min. level based on a MDL times a factor of 3.18
Mercury, Total	0.0024	0.0024	0.0014	Acute Aquatic Life Criteria 2002
Nickel, Total*	1.417	1.417	0.47	Acute Aquatic Life Criteria 2002
Selenium, Total	0.2385	0.2385	0.005	Chronic Aquatic Life Criteria 2002
Silver, Total*	0.0318	0.0318	0.0038	Acute Aquatic Life Criteria 2002
Zinc, Total*	0.065	0.117	0.12	Acute Aquatic Life Criteria 2002

*Dependent on water hardness. Value listed here is based on a hardness of 100 mg/L.

1 - Source of Table: Federal Register Notice 1995 and EPA Proposed MSGP 2006.

In order to develop benchmarks for specific industries, EPA collected sampling data for each industry sector or sub-sector. Where the median concentration of a parameter was higher than the benchmark, EPA took the next step of comparing the pollutant to potential materials on-site that could be exposed, or activities that may generate these pollutants. If a source could be identified, then the permit includes that parameter for analytical monitoring for that industry sector. If no source could be identified, analytical monitoring was not required (FRN 1995).

In 2006, a new requirement is being proposed by EPA which would require dischargers to select additional site-specific analytical parameters for monitoring based upon the types of materials that are both exposed to, and can be mobilized by, contact with stormwater (EPA 2006).

Washington State's Benchmarks

Benchmarks were first proposed in Washington State as part of the revisions to the October 4, 2000 industrial stormwater general permit. Previously, permit compliance was determined solely by inspections conducted by Ecology staff. The 2000 permit revision required collection of stormwater data, with the intention of obtaining 'tangible evidence' of how well a facility was operating and managing its stormwater. In addition, information obtained from stormwater analyses could be provided to the public (Ecology 2002).

Ecology's intention in setting benchmarks was similar to EPA's; they were to be used as indicators of the level of risk of violating water quality standards. Specifically:

> "Benchmark values are not water quality criteria or effluent limits but they are intended to identify discharges that are at low risk of violating water quality standards. Discharges that do not exceed the benchmark values are not likely to violate water quality standards. Discharges that do exceed one or more benchmark values represent a higher risk of violating water quality standards" (Ecology 2002).

Ecology adopted the same benchmark values as EPA's October 2000 MSGP for industrial activities for heavy metals, oil and grease, pH, ammonia, phosphorus, and BOD and most of the industry specific parameters. The benchmark value for turbidity (25 NTU) was based on field observations by Ecology staff (Ecology 2002). It is important to note that EPA's benchmark value for total metals was based on an assumed water hardness of 100 mg/L, a value much higher than what is generally found in Washington waterways. Therefore, the appropriateness of these values for protecting Washington State waters has been an ongoing issue of debate.

As described previously, a second value called an "action level", was introduced to the permit in 2004 in response to a legislative mandate to enforce an adaptive management approach into the permit. Action levels, similar to benchmarks, were intended to be indicator values. For the heavy metals (copper, lead, and zinc) action levels were calculated as the benchmark value plus one standard deviation (as derived from California's highway runoff program data (Ecology, August 2004). For the remaining parameters, action levels were set at twice the benchmark value (Ecology, August 2004). Action levels and benchmarks (in this report they are collectively referred to as "permit targets") are used to identify the degree of response needed, as described previously.

Comparison of Benchmarks in Other States

In order to further understand the basis for Washington's permitting requirements and to compare between programs, permitting requirements in other states were investigated. Initially, States selected for review included Oregon and California because their programs were considered most similar to Washington. Other state programs assessed were chosen in order to provide a broader overview of the different approaches to permit implementation. In total, 15 state NPDES programs were reviewed during this information gathering exercise.

In general, most States have adopted the benchmarks established by EPA, although often with minor modifications. Twelve of fifteen states reviewed (Arizona, California, Colorado, Montana, Utah, Washington, Wisconsin, Virginia, Georgia, New Jersey, Maryland, and Delaware) are using

EPA's benchmarks. Vermont, which is in the process of developing their permit program also plans to use the EPA benchmarks. There were two states that did not use the EPA benchmarks; Oregon and Connecticut. Oregon set benchmark values that were mostly higher than EPA. For example, EPA's total zinc benchmark is 0.117 mg/L and Oregon's is 0.6 mg/L (Table 2-1). Oregon's benchmarks were developed in 1997 and are based upon existing stormwater data or existing water quality standards. Benchmarks for copper, lead, and zinc were developed using acute standards and a dilution of 5 (to account for higher receiving stream flows found during storm events) (ODEQ 2006).

Connecticut used stormwater data reported under their general permit from 1992 – 1997 to establish benchmark values. In addition, they established separate values for industrial sites that were operational prior to October 1, 1997 compared to those sites operational after this date. For older facilities (prior to 1997), benchmark values were based upon the 80th percentile of the cumulative relative frequency graphs developed from the dataset. For newer facilities, benchmark values were based upon the median value (50th percentile) (CTDEQ 2003). For example, for facilities built prior to 1997, the total zinc benchmark is 0.5 mg/L. For facilities built post-1997, the total zinc benchmark is 0.2 mg/L. In some cases, Connecticut's benchmarks are lower than EPA benchmarks, and in other cases they are higher. Table 2-2 provides a summary of the different benchmark values established by some of the States to illustrate the range of differences. The table does not contain all the key parameters that are monitored by each state, only those that coincide with the key parameters monitored in Washington.

Table 2-2. Benchmarks for selected States.

Parameter	EPA	WA	OR	CA	CT (pre-1997)	CT (post 1997)
Total Copper (mg/L)	0.0636	0.0636	0.1	0.0636	0.100	0.06
Total Lead (mg/L)	0.0816	0.0816	0.4	0.0816	0.05	0.03
Total Zinc (mg/L)	0.117	0.117	0.6	0.117	0.5	0.2
Oil & Grease (mg/L)	15	15	10	15	5	2.5
pH (SU)	6-9	6-9	5.5-9	6-9	-	-
Turbidity (NTU)	50*	25	<10%	-	-	-
TSS (mg/L)	100*	-	130	100	100	30

*Proposed for 2006.

Other Permit Requirements

The following paragraphs provide a brief summary of how some of the key elements of the industrial stormwater permits (i.e. parameters monitored, frequency, and reduction allowances) differ between States. This is not meant to be a comprehensive overview but only to provide some basic background into various regulatory approaches to NPDES permit programs.

Basic Parameters monitored

EPA's core suite of parameters required for every industrial site includes total lead, total copper, total zinc, oil and grease, and pH. In the 2006 permit update, EPA is proposing to add total suspended solids and turbidity. Some states have adopted EPA's parameters while others incorporated various modifications. Virginia uses the same suite as EPA but also includes total organic carbon and nitrogen (VA SWCB 2004). Oregon uses the same parameters as EPA plus total suspended solids. Connecticut requires sampling for nine parameters (Table 2-3 below) as well as an aquatic toxicity test. Washington requires sampling for total zinc, oil and grease, pH, and turbidity. Permittees in California must sample for total suspended solids, oil and grease (or total organic carbon), specific conductance, and pH. In addition, during 2008-2009, all California permittees are required to complete a one-time supplementary sampling analysis for additional parameters (i.e., common metals, chemical oxygen demand, and semi volatile organic compounds). California intends to use the information collected to further refine their monitoring requirements (SWRCB 2005).

Table 2-3. Required monitoring parameters.

State	Copper	Lead	Zinc	Oil & Grease	pH	Turbidity	TSS	COD	TP	TKN	Nitrate	Aquatic Toxicity
EPA	√	√	√	√	√	√	√*					
WA			√	√	√	√						
OR	√	√	√	√	√	√	√					
CA				√	√		√					
CT	√	√	√	√			√	√	√	√	√	√

*Proposed for 2006

Monitoring Frequency

The frequency at which permittees are required to collect samples of their discharges is highly variable. EPA suggests quarterly monitoring which has been adopted by some states such as Washington. Oregon previously required bi-annual monitoring, but is revising their permit to increase sampling to four times a year; two samples prior to December 31st (with a minimum time interval of 14 days between sample collection) and two samples after January 1st. The monitoring period is from July 1st to June 30th, which would allow for opportunities to collect a sample during a summer storm event (ODEQ 2006). California requires monitoring of the first and second storms of the wet season (October – May) (SWRCB 2005). Connecticut and Virginia require annual (one time) monitoring, as will Vermont. Maryland does not require monitoring (Gertler 2006). According to one study, monitoring frequency varies across the U.S. from 4 to 70 times per permit cycle (Alongi 2006).

Reductions in Sampling

Some states allow for reductions in sampling when results are consistently below benchmark values. EPA, in their new permit, will issue a waiver for the remainder of the permit term if an average of four sampling events does not exceed the benchmark (EPA 2006). Virginia issues a waiver to suspend sampling if the analytical results are below benchmark values for two consecutive years. Connecticut allows for sampling suspension if results are below benchmarks for two years. However, sampling then resumes after two years. Connecticut also has a special provision for facilities that have fewer than 25 employees. For these facilities, sampling may be suspended after the first year if that year's results do not exceed the levels listed (CTDEQ 2003). In Washington and Oregon, if a facility's results are less than the benchmark values for eight consecutive quarters, then sampling may be suspended for the remainder of the permit term. California appears to be the only state that does not allow for monitoring waivers (SWRCB 2005).

Responses to Benchmark Exceedances

The required response to an exceedance of permit targets also varies widely between States. Most states require some sort of response if analytical results are above benchmark values. EPA's proposed permit revisions would require permittees to review their Stormwater Pollution Prevention Plan (SWPPP) and document the results of the review if the annual average of four quarterly monitoring results exceeds a benchmark. Documentation of action and/or inaction based upon the SWPPP review must be kept on-site. Although the practice has been to review and revise the SWPPP if necessary, the trend is toward changing the plan, not simply reviewing it (EPA 2006).

Other states sometimes require that BMPs are assessed to determine why an exceedance occurred and corrective actions must then be put in place. In Oregon's proposed new permit, if stormwater samples exceed any benchmark value, the permittee must investigate the cause of the elevated pollutant level(s), review the Stormwater Pollution Control Plan (SWPCP; Oregon's equivalent to the SWPPP) and develop an Action Plan which is an addendum to the SWPCP. The Action Plan must be submitted to the Department of Environmental Quality for approval. In addition, if at the end of the fourth year of coverage, the geometric mean of the last four samples collected exceeds the benchmark(s), the permittee will be required to obtain an individual permit (ODEQ 2006). In California, if one or more benchmarks are exceeded, then permittees must revise SWPPP's and BMP's in a short period of time and must also sample the next two consecutive qualified storm events (SWRCB 2005). As described previously, Washington appears to be the only state that has a tiered system to increase the response(s) to exceedances.

Inspection and Enforcement

As with other aspects of the industrial stormwater permit program, there was a wide variation in how often facilities are inspected and the frequency of enforcement actions. Many States follow the EPA guidelines requiring annual inspections; others rely heavily on more frequent inspections. The State of Virginia has a well-defined and extensive inspection program. Inspectors in the seven regions inspect all major and minor facilities. Major facilities are inspected twice a year and minor facilities are inspected once every five years (Tuxford 2006). In the phone survey conducted for this evaluation, States often reported an overall low rate of compliance by permittees with developing a SWPPP, monitoring, and documenting corrective actions. However, some of the people interviewed also commented that level of compliance with documentation and reporting was less critical than having a process in place that leads to corrective actions on site.

Section 3: Analysis of Washington's Existing ISWGP Data

One of the initial tasks related to this project was an analysis of existing data that have been collected through the current industrial stormwater general permit. The primary goal of this analysis was to evaluate the utility of these data for gauging permit compliance and understanding the level of water quality protection that is occurring. In keeping with this overall goal, the specific objectives of this analysis were as follows:

Describe general distribution of the data including central tendency, variation, and presence or absence of outliers.

Compare data to applicable benchmarks and action levels from the general permits.

Compare data and existing benchmarks to applicable state water quality criteria based on representative receiving water conditions and dilution factors.

Compare data across industrial categories to determine if there are significant differences in pollutant concentrations.

The results from this analysis were summarized previously in a draft data report that was submitted to Ecology and the project's Advisory Committee for review. Following receipt of comments on the draft, the data report was subsequently finalized and is presented in Appendix I of this document. Because this analysis provides the basis for many of the recommendations that are presented in subsequent sections of this document, the major conclusions from the data report are summarized in this section. This section provides an initial summary of the quantity and quality of data that were used in this analysis. It then summarizes the results for the each of the analysis objectives identified above under the following subsection headings: Data Distribution, Comparisons to Applicable Benchmarks and Action Levels, Comparisons to Hypothetical Water Quality Criteria, and Comparisons Among Industrial Categories. Finally, the findings from the analysis are summarized at the end the section. However, the reader should refer to the full data report in Appendix I for more detailed information on the data sources, methods, results, and conclusions derived from this analysis.

Data Quantity and Quality

The industrial stormwater data for this analysis were compiled by Ecology from Discharge Monitoring Reports (DMRs) that were submitted by permittees pursuant to the monitoring and reporting requirements of the current industrial stormwater general permit. These data were initially entered into a database system that is maintained at Ecology and then exported to a Microsoft Excel spreadsheet for subsequent analysis. This spreadsheet included data from NPDES sampling that was conducted during the second, third, and fourth quarters of 2003 and all four quarters of 2004 and 2005. These data were obtained from a total of 808 permitted facilities with

758 located in Western Washington, 45 in Eastern Washington, and 8 unclassified because no address information was provided in the database.

Overall, the data set contained 21,486 values for a total of 22 different parameters. The number of values available for specific monitoring parameters can be divided into high, intermediate, and low categories depending on their associated monitoring requirements as identified in the NPDES permit. For example, turbidity, pH, total zinc, and oil and grease have the highest number of values because all facilities are required by the NPDES permit to conduct sampling for these parameters. As shown in Table 3-1, the total number of values for the 22 parameters ranges from 2,651 to 4,479.

Table 3-1. Total number of available data values by monitoring parameter identified in the general NPDES industrial stormwater permit.

Parameter	Total Number of Values
Turbidity	4479
pH	4442
Zinc, Total	4264
Oil & Grease	2651
Copper, Total	1177
Lead, Total	1034
BOD, 5 day, 20 deg. C	1105
Phosphorus, Total	410
Nitrogen, Nitrite + Nitrate, Total	397
Solids, Total Suspended	146
Nitrogen, Ammonia, Total	70
Oxygen, Dissolved	51
Benzoic Acid	46
Phenol	46
P-Cresol (4-Methylphenol)	44
Alpha-Terpineol	40
Coliform, Fecal	18
Mercury, Total	7
Nitrogen, Nitrate, Total	7
Chromium, Total	4
Cadmium, Total	2
Total Dissolved Gas	1

While monitoring for turbidity, pH, total zinc, and oil and grease are required for all permittees, the NPDES permit requires routine sampling for total copper, total lead, biochemical oxygen demand (BOD), ammonia nitrogen, nitrate + nitrite nitrogen, and total phosphorus only for specific industrial sectors. Because of these less stringent sampling requirements, less data are available for these six parameters. Therefore, they are classified as intermediate with regard to the number of data values available. As shown in Table 3-1, the total number of values in this category ranges from 70 to 1,177. The remaining 12 parameters in Table 3-1 are classified as low with regard to the number of data values that are available. The total number of values in this category ranges from 1 to 146.

Furthermore, there are no specific benchmark or action levels identified in the NPDES permit for these parameters.

Data quality was assessed based on a review of outliers, missing data, and data qualifiers that were present in the database obtained from Ecology. In total, there were 22,794 entries in the database with no value reported for various reasons. The most frequently cited reason (72 percent of the time) for not reporting a value was "No Qualifying Storm Event". Additional analyses showed that this qualifier was observed with much greater frequency during sampling events conducted during summer periods (April – Sept.). Approximately 13 percent of the unreported values were listed as below the detection limit. However, no detection limit was provided. Three additional qualifiers within the database (i.e., Not Reported, Value Not Submitted, and DMR Not Submitted) were cited 12 percent of the time for unreported values. The other frequently cited qualifiers for unreported data include: consistent attainment, equipment failure, incorrect analysis, laboratory error, lost sample, no discharge, and other.

There is some concern that the quality of the industrial stormwater data may be compromised due to the presence of these unreported values and other numerous reporting and data entry errors in the database. However, this analysis proceeded under the assumption that there were a sufficient number of values available for parameters in the high and intermediate data quantity categories to accurately evaluate their characteristics (e.g., central tendency, variation, skew), despite the possible influence of these errors. The validity of this assumption was generally supported based on comparisons of the results from this analysis to those from other studies of industrial stormwater data. These comparisons showed there were similar patterns in the data for specific parameters across all the different studies. This is further described in the Data Distribution section below and in Appendix I.

Data Distribution

The analysis of the existing industrial stormwater data indicated that most of the monitoring parameters exhibit a distinctly right-skewed distribution due to the presence of numerous outliers in the upper end of the data range. This distribution is commonly observed in water quality data that are collected during storm sampling due to the influence of sporadic, high flow events that are associated with higher pollutant concentrations (Helsel and Hirsch 1992). Furthermore, the maximum concentrations for several of the parameters (e.g., total zinc, total copper, nitrate + nitrite nitrogen, and total phosphorus) appeared to be extreme outliers that may indicate that the associated values were incorrectly entered in the DMR or database. However, these values were left in the database for subsequent analysis pending more a detailed quality assurance review by Ecology.

The analysis also indicated that the data for many of the parameters exhibit a very high degree of variability. For example, the coefficients of variation calculated from these data ranged from 0.12 for pH to 7.06 for total zinc. The high degree of variability in these data is generally consistent with the findings from other studies of data compiled data from industrial stormwater general permits.

For example, Strenstrom and Lee (2005) reported coefficients of variation ranging from 0.2 to 17 for data from a suite of 16 monitoring parameters that were compiled through industrial stormwater general permits in the following jurisdictions: Los Angeles County, CA; Sacramento County, CA; and the state of Connecticut. To provide some frame of reference for interpreting these results, these same authors also examined influent data from large, west coast wastewater and water treatment plants and found the coefficients of variation for all parameters to be less than 0.5.

Comparisons to Applicable Benchmarks and Action Levels

In order to assess compliance with Washington's industrial stormwater general permit (Table 3-2), the existing data for turbidity, pH, total zinc, oil and grease, total copper, total lead, BOD, ammonia nitrogen, nitrite + nitrate nitrogen, and total phosphorus were compared to applicable benchmarks and action levels identified in Table 2-5. These comparisons showed that all of the parameters except ammonia were measured at levels that exceeded the benchmarks and action levels. However, there was a large range in terms of the frequency and magnitude of the exceedances exhibited for each of the parameters. Therefore, each parameter was classified as being of high, moderate, or low concern based on the frequency of these exceedances. Specifically, total zinc was identified as the only parameter of high concern because over 50 percent of the associated samples exceeded the applicable benchmark and 21 percent exceeded the action level. Turbidity, total copper, BOD, and nitrate + nitrite nitrogen were identified as being of moderate concern because between 20 and 50 percent of the samples exceeded the benchmark. Finally, pH, oil and grease, total lead, total phosphorus, and ammonia nitrogen were classified as being of low concern because less than 20 percent of the collected samples exceeded the applicable benchmark.

Table 3-2. Benchmark values and action levels identified in the industrial stormwater general permit.

Parameter	Benchmark	Action Level
Zinc, Total (µg/L)	117	372
Copper, Total (µg/L)	63.6	149
Lead, Total (µg/L)	81.6	159
Turbidity (NTU)	25	50
pH	range 6-9	range 5-10
Oil & Grease (mg/L)	15	30
BOD, 5 day, 20 C (mg/L)	30, 140[a]	60
Nitrogen, Ammonia, Total (mg/L)	10[a], 21.8	38
Nitrogen, Nitrite + Nitrate, Total (mg/L)	0.68	1.36
Phosphorus, Total (mg/L)	2	4

mg/L: milligrams/liter.
µg/L: microgram/liter.
NTU: nephelometric turbidity unit.
[a] The 140 mg/L benchmark for BOD and 10 mg/L benchmark for ammonia nitrogen are associated with non-hazardous waste landfills listed in the industrial category 05-Landfills.

It should also be noted that the median values for almost all of the parameters were below the applicable benchmark. The only exception was zinc which had a median value (139 g/L) that was slightly higher than the applicable benchmark of 117 g/L. These results suggest that the state's industrial stormwater permit targets are generally being met when assessed relative to the central tendency of the data from all of the reporting facilities.

Comparisons to Water Quality Criteria

The task to determine whether dischargers covered under a general permit are in compliance with surface water quality standards presents significant challenges. Compliance with these standards requires an assessment of both numeric and narrative criteria. The narrative criteria include such prohibitions as: no toxic substances in toxic amounts, no resulting increase of pollutant concentrations above background (the anti-degradation policy), or the loss of a beneficial use. Compliance with narrative criteria requires site-specific studies of the discharge and its physical, chemical, and biological impacts to receiving waters. Therefore, an assessment of narrative criteria cannot be practicably performed using a large state-wide dataset. Even the assessment of compliance with numeric criteria is a complex undertaking. In order to perform this assessment, all of the following site-specific information is also required:

Effluent pollutant concentration

Effluent discharge rate

Receiving water background pollutant concentration

Receiving water discharge rate

Receiving water hardness concentration (for metals only)

Appropriate translator values (for metals only).

Only one of these (i.e., effluent pollutant concentration) is measured as a requirement of the industrial stormwater general permit. A series of assumptions about representative receiving water conditions was necessary to evaluate whether hypothetical water quality criteria (for both acute and chronic effects) would be exceeded given the actual effluent pollutant concentrations and a range of dilution factors. These representative receiving water conditions were developed for both eastern and western Washington, based on queries of Ecology's Environmental Information Management (EIM) database and values from the literature. Separate analyses were then performed to evaluate hypothetical water quality criteria for the following four parameters: total zinc, total copper, total lead, and turbidity. In each case, the percentage of samples exceeding the hypothetical water quality criteria was calculated. More detailed descriptions of the assumptions and methodology used in this analysis are provided in Appendix I.

The results of this analysis indicated that a high percentage of samples exceeded the water quality criteria when dilution factors of 0 and 10 were assumed. Total copper was of particular concern given that over 90 percent of the samples in both eastern and western Washington exceeded the acute and chronic criteria with a dilution factor of 0. (A dilution factor of 0 is equivalent to the concentration at the "end of pipe".) Total zinc and turbidity were identified as being of moderate concern with between 40 and 90 percent of the samples in both eastern and western Washington exceeding the associated criteria with a dilution factor of 0. Finally, lead was identified as being of lower concern with less than 40 percent of the samples exceeding the acute criterion in both eastern and western Washington with a dilution factor of 0. However, it should be noted that a high percentage of samples (> 90 percent) still exceeded the chronic criterion for lead with a dilution factor of 0. The percentage of exceedance for all parameters dropped to less than 35 percent with a dilution factor of 25, and to less than 15 percent with a dilution factor of 50.

Based on these results, it can be concluded that discharges of industrial stormwater may be contributing to exceedances of the water quality criteria when little or no dilution is available in the receiving water. However, the number of exceedances drops substantially when relatively moderate levels of dilution are available.

A relatively wide range of dilution factors was used in this analysis (i.e., 0, 10, 25, and 50) in order to determine the minimum required dilution necessary to meet water quality criteria. However, the actual dilution factor required to meet water quality criteria can also be calculated for each parameter given its associated benchmark and assumed receiving water conditions. For reference, these required dilution factors are presented in Table 3-3.

Table 3-3. Dilution factors required to meet water quality criteria assuming effluent concentrations that are equal to the benchmarks specified in the industrial stormwater general permit.

		Zinc [b]		Copper [c]		Lead [d]	
	Turbidity [a]	Acute	Chronic	Acute	Chronic	Acute	Chronic
Western Washington							
Worst-Case	4.7	5.1	5.8	33	56	4.0	190
Typical	4.2	3.4	3.8	17	23	2.7	76
Best-Case	3.0	2.4	2.6	10	14	1.8	48
Eastern Washington							
Worst-Case	4.7	6.0	8.5	12	18	1.9	75
Typical	4.2	1.4	1.6	5.7	8.4	0.9	25
Best-Case	3.0	0.9	1.0	3.0	4.5	0.6	15

[a] Required dilution factors assuming the benchmark for turbidity from the general NPDES permit for industrial stormwater (25 NTU).
[b] Required dilution factors assuming the benchmark for zinc from the general NPDES permit for industrial stormwater (117 µg/L).
[c] Required dilution factors assuming the benchmark for copper from the general NPDES permit for industrial stormwater (63.8 µg/L).
[d] Required dilution factors assuming the benchmark for lead from the general NPDES permit for industrial stormwater (81.6 µg/L).

Comparison Among Industrial Categories

A statistical analysis was performed on the existing industrial stormwater data to determine whether there were significant differences in median concentrations across the industrial categories identified in Table 3-4. The specific goal of this analysis was to evaluate whether certain industrial categories should be considered under a different general permit because their effluent water quality is inherently different. To ensure that sufficient data were available to accurately describe the data distribution for each parameter, only those industrial categories with at least 25 samples were included in these analyses.

Table 3-4. Industrial facility categories used in the analysis of existing data from the industrial stormwater general permit.

Category	Number of Facilities
01 - Facilities with effluent limitations	1
02 - Manufacturing	233
03 - Mineral, metal, oil, and gas	4
04 - Hazardous waste treatment, or disposal facilities	0
05 - Landfills	20
06 - Recycling facilities	64
07 - Steam electric plants	2
08 - Transportation facilities	205
09 - Treatment works	12
10 - Construction sites > 5 acres	1
11 - Light industrial activity	238
12 - Significant contributor	1
NC - No category specified	27

Results from this analysis indicated there were significant differences in median concentrations among industrial categories for nine of the ten parameters evaluated. However, there was no meaningful pattern to the differences. That is, no industrial categories were identified as having high or low concentrations across all the parameters or within a particular category of parameters (e.g., metals).

It should be noted that the industrial categories are groupings of different types of facilities at a very broad level. For example, the following industrial sectors are all grouped under the Manufacturing (02) industrial category: Lumber and Wood Products (24--), Chemical and Allied Products (26--), and Primary Metals Industries (33--). Therefore, it is possible that more meaningful results could be obtained if additional comparisons were made at the industrial sector level. However, due to the large number of industrial sectors that are represented in the compiled data and the associated inconsistencies in the amount of available data, it was not practical to collectively analyze the industrial sectors using the conventional statistics that were applied in the comparisons of the broader industrial categories. As additional data are compiled through future monitoring under the permit, the utility of analyzing data at the industrial sector level should be revisited.

Key Findings

The data exhibit a distinctly right-skewed distribution pattern due to the presence of numerous high-end values. There is also a high degree of variability relative to what is observed in the data from other types of pollutant monitoring (e.g., wastewater influent). These attributes are a typical characteristic of stormwater data and have implications for the methodologies that are employed in their interpretation and analysis (Helsel and Hirsch 1992). Specifically, measures of central tendency and spread must be minimally influenced by extreme observations. Furthermore, non-parametric data analysis techniques should be used in all hypothesis testing to account for the non-normal distribution of the data. Finally, given the high variability of the data, a large number of observations will be required in any hypothesis testing in order to detect any statistically significant patterns.

All of the parameters except ammonia were measured at levels that exceeded the benchmark and action levels. However, there was a large range in terms of the frequency and magnitude of the exceedances exhibited for each of the parameters with zinc identified as the greatest concern. Median values for almost all the parameters were below the applicable benchmark which suggests that the permit targets are generally being met when assessed relative to the central tendency of the data from all of the reporting facilities.

The results from this analysis indicated that a high percentage of samples exceeded the water quality criteria when dilution factors of 0 and 10 were assumed. The percentage of exceedance for all parameters dropped to less than 35 percent with a dilution factor of 25, and less than 15 percent with a dilution factor of 50. When the actual benchmark concentrations were assumed for the stormwater discharge and then assessed in relation to representative receiving water conditions, the typical dilution factors that would be required to meet acute water quality criteria ranged from 0.9 for lead to 17 to copper. Similarly, the typical dilution factors that would be required to meet chronic water quality criteria ranged from 1.6 for zinc to 76 for lead. This indicates that the existing benchmarks, if attained, are fairly protective for zinc, less protective but reasonable under most scenarios for copper, very protective for lead in terms of acute concentrations, but not protective if the discharge represented a chronic condition.

There were significant differences in median concentrations among industrial categories. However, there was no meaningful or consistent pattern to these differences.

Section 4: Establishing Permit Targets

A key aspect of the monitoring and reporting strategy is establishing the permit targets (i.e., effluent limits, benchmarks, and action levels). Because the development of new permit targets is the most complex and controversial of the series of recommendations presented, and because other recommendations, (in particular the recommendations detailing responses to excursions), are dependent upon where the permit targets are established, this section provides background detail concerning the permit target recommendations.

In general, Federal and State regulations require that NPDES permits contain effluent limits that are either water quality based or technology based. Water quality based effluent limits are based on compliance with State water quality standards. Technology based effluent limits are based on treatment technologies that are available for specific pollutants. The more stringent of these two limits must be chosen to establish the permit limit for each parameter of concern. Exceedances of effluent limits constitute a violation of the permit and may lead to regulatory enforcement actions.

As described in Section 2, benchmarks and actions levels are often used in lieu of numeric effluent limits by the EPA and some states (including Washington) to serve as "indicators" of a potential to cause a water quality violation. As stormwater pollutant concentrations increase in magnitude above a benchmark, there is an increasing probability that water quality standards will be violated. Unlike effluent limits, stormwater pollutant concentrations that exceed a benchmark or action level do not constitute a violation of the permit; rather, they trigger a mandatory response by the permittee. However, it is considered a permit violation if the permittee does not take the required actions that are triggered by an exceedance of the permit target.

The relevance of Washington's existing benchmarks and action levels has been an issue of debate. Most of Washington's benchmarks were adopted from EPA's 2000 general permit. As described in Section 2, EPA has used several different approaches to establish these benchmarks and is currently in the process of revising them. In Washington, the most commonly expressed concern with regard to benchmarks is related to the adoption of EPA's benchmarks for heavy metals. These benchmarks were established to be protective of aquatic life; hence, they are based on water quality criteria. Unfortunately, the underlying assumption for water hardness (i.e., 100 mg/L as $CaCO_3$) that EPA used to establish the water quality criteria is not applicable to Washington State waters where water hardness tends to be much lower (Appendix I). Consequently, the metals benchmarks are considered to be too high; they would effectively allow higher stormwater toxicity in Washington than in other areas having higher water hardness values. Benchmarks for other parameters were derived by EPA using a variety of resources and references. With the addition of action levels to the permit, a further mix of sources and rationales is introduced to the process of setting permit effluent targets. This lack of consistency in setting benchmarks and action levels makes it difficult to defend their suitability for either protecting aquatic life or evaluating the performance of stormwater water BMPs.

The variable approach previously used to set benchmarks and action levels for the existing permit was reasonable, given the lack of industrial stormwater data available at the time. However, now that there are data available it is appropriate that the permit targets be reviewed against these new data. In fact, it was Ecology's intention that the monitoring data collected be used to inform changes for the next permit cycle (Ecology 2002).

As part of this study, the feasibility of establishing both water quality and technology based effluent limits and/or benchmarks for specific parameters was evaluated. The overriding goals in evaluating these different options were to develop permit targets that; 1) appropriately reflect the large variation and skewed distribution of stormwater data, 2) were defensible or there was a clear rationale for their use, 3) could be consistently applied to all parameters, and 4) were practicable to apply and were attainable by permittees. The section below discusses the technical issues that are currently impeding the development of numeric effluent limits. The section that follows then presents a recommended approach for establishing new benchmark and actions levels that take into consideration the goals identified above.

Evaluation of Numeric Effluent Limits

As described above, numeric effluent limits can be water quality or technology based. Water quality based effluent limits must be established if there is a "reasonable potential" for the discharge to cause or contribute to a violation of water quality standards. To make this determination, a reasonable potential analysis is performed to consider: 1) what levels of pollution a discharger has released in the past, 2) background concentrations of the pollutants in question, 3) the amount of dilution available, and 4) any other pertinent factors. Once this analysis is performed, effluent limits may be established to prevent violations of State water quality standards. These effluent limits can be based on an individual waste load allocation (WLA) or on a WLA developed during a basin-wide total maximum daily loading (TMDL) study.

Establishment of water quality based numeric limits for specific pollutants was considered during the initial phases of this project. However, the development of numeric effluent limits following the process described above requires access to detailed, site-specific information in order to perform the reasonable potential analysis. Furthermore, this information must be collected on multiple occasions to adequately characterize the discharge and to allow for the development of scientifically and legally defensible effluent limits. As discussed in Section 3, the existing data that were compiled through the ISWGP are insufficient for evaluating compliance with State water quality standards because they do not include any information on receiving water characteristics and effluent discharge rates. Therefore, they are also generally unsuitable for use in establishing effluent limits. Clearly, it would be a vast and expensive undertaking to collect these data for all 1,169 active ISWGP permittees. This process could be streamlined by organizing facilities by receiving water body or receiving water size to assign mixing zones; however, this would still leave a large variation in discharge quality and quantity conditions that would make it difficult to establish meaningful numeric limits.

This issue of development of water quality based numeric effluent limits for general permits was addressed during development of Ecology's Boatyard Permit. The following text, excerpted from the fact sheet for the Boatyard Permit (Ecology 2006), summarizes this issue:

> "The USEPA and Ecology have determined that it is generally not possible to conduct a reasonable potential analysis for each facility covered under a general permit in the same manner as for an individual facility and still retain the benefits of a general permit. However, EPA and Ecology are mandated to protect water quality when authorizing discharges…. To resolve this conflict, EPA derived the concept of "benchmarks" in general permits. Benchmark values are not water quality standards and are not permit limits. They are indicator values. Ecology considers values at or below benchmark as unlikely to cause a water quality violation."

The analysis conducted as part of this study also examined the feasibility of establishing technology based effluent limits. As described above, technology based effluent limits are based on available treatment technologies for specific pollutants and are established by regulation or developed on a case-by-case basis (40 CFR 125.3, and Chapter 173-220 WAC). As specified in the Clean Water Act, Best Conventional Technology (BCT) and Best Available Technology Economically Achievable (BAT) are the minimum treatment performance standards for industrial wastewater discharges including stormwater runoff. BCT applies only to conventional pollutants (e.g., TSS, BOD, pH, and fecal coliform bacteria). BAT applies to toxics and non-conventional pollutants. In the 2006 proposed reissuance of the MSGP, EPA (2005) has acknowledged that best management practices (BMPs) meet the mandated BCT and BAT treatment levels for stormwater pollutants.

The analysis presented in Section 3 identified several factors that complicate the process of establishing technology based effluent limits for BMPs that are used to treat industrial stormwater. Most notably, the analysis showed there is a high degree of variability in the data that makes it difficult to establish definitive performance targets for these BMPs across the broad range of facilities that are covered under a general permit. There were also no clear patterns in the data that would allow BMP performance targets to be derived for specific types of industrial categories or facility types.

Other researchers (Ashby 2005, Currier et al. 2006) have identified a number of other potential issues that make establishment of technology based effluent limits for industrial stormwater BMPs problematic. The primary issue raised by these researchers was the lack of a reliable database to describe current emissions by industry types or categories, and a general lack of information on the performance of existing BMPs. The current industrial permits have not produced an emissions database for most industrial categories because of inconsistencies in monitoring or compliance with monitoring requirements.

In summary, the data needed to develop water quality or technology based numeric effluent limits are currently not available and could not be confidently applied against the large range of facility sizes, types, and locations represented in the general permit. The section that follows presents an alternative approach for establishing permit targets that utilizes benchmark and action levels as opposed to numeric limits.

Evaluation of Technology-based Targets

Due to the many complex issues surrounding the establishment of numeric effluent limits, the development of technology based targets, such as the benchmark and action levels currently used, was the primary focus of this evaluation. More specifically, the existing data compiled through ISWGP over the period from 2003-2005 were analyzed and then used to established broad performance goals for stormwater pollutants. A number of methods for setting these goals were evaluated using examples from other States and from other permits within Washington. Based upon this evaluation, a Simple Percentile Method based on individual facility median pollutant values was selected as the recommended protocol for establishing permit targets. To apply this method, the median and 75th percentiles of facility median values were calculated from the existing ISWGP data to represent the benchmark and action level values for specific pollutants. (Note: the median pollutant value is equivalent to the 50th percentile of the available tabulated ISWGP data.)

This method meets all of the criteria identified above for improving the permit targets. For example, unlike the existing benchmarks that were derived using a variety of methodologies (Section 2), there is clear and consistent rationale for deriving benchmark and action levels using the Simple Percentile Method. Because the benchmark and action levels are tied to the existing data that were compiled through the ISWGP, they will more accurately reflect BMP performance for the types of facilities that are covered under the permit and considering the region's prevailing climatic conditions. This method will also facilitate implementation of an adaptive management approach for establishing benchmarks. For example, with each permit revision cycle the data can be reanalyzed using this approach to determine if lower benchmarks and/or action levels are warranted in response to improvements in BMP design. This method can also be consistently applied to all parameters as long as there is sufficient data available.

Use of the median and 75th percentile values in establishing the benchmark and action levels is both easy to defend and explain. Continuing to include both a benchmark and an action level, as adopted during development of the existing permit, is a way of accounting for the natural variability in stormwater data. It also acknowledges that the goal of monitoring is to measure performance against indicator values (i.e., permit targets) as a means of assessing a specific facility's operations against expected performance. In practice, this approach assumes that those facilities with stormwater pollutant concentrations below the median are likely better performers with regard to appropriate BMP selection and proper implementation/maintenance. Using the median value as a benchmark thus indicates there is a baseline performance target that half of the permittees have managed to attain. When pollutant concentrations for a facility are between the median and 75th percentiles, the permittee will recognize that some improvement in BMP performance is called for in order to meet the baseline performance target. Similarly, facilities with pollutant concentrations above the 75th percentiles are clearly in the poor performance range and some corrective actions are required.

Finally, the Simple Percentile Method takes into account the high variability and skewed distribution of stormwater data. In calculating the benchmark and action levels, the median stormwater pollutant concentration for each facility is calculated first to remove some of the overall variance from the data and provide some characterization of individual facility performance. The median value is used in lieu of the mean in this step of the analysis because it is less sensitive to the outliers in a skewed data distribution; thus, it will provide a better measure of the data's central tendency (Helsel and Hirch 1992). This idea is carried forward in the analysis by basing the benchmark and action levels on the median and 75th percentiles, respectively. As with the median, the 75th percentile value is also not strongly influenced by the outliers in a skewed data distribution.

In the following section on recommendations, the proposed permit targets developed using the Simple Percentile Method are presented along with results from a risk assessment associated with their adoption.

Section 5: Recommended Changes to Permittee Monitoring

Stormwater Discharge Monitoring

This section describes a series of recommendations related to stormwater discharge monitoring by permittees, including changes to many aspects of Ecology's NPDES permit monitoring program. The specific recommendations address the following: monitoring and reporting timing and frequency; qualifying storm conditions; parameters measured; permit targets; and required responses to excursions above permit targets. Recommendations for each of these aspects of permittee monitoring are described below along with the rationale for recommended changes and a discussion of relevant issues of concern.

Monitoring and Reporting Recommendations

Sample Collection and Reporting Frequency

Current Permit:

The current Industrial Stormwater General Permit requires quarterly monitoring and reporting. A Discharge Monitoring Report (DMR) must be submitted to Ecology within 45 days following the end of a quarter. This is a common approach to this type of NPDES permit monitoring. The individual sample is evaluated on a quarterly basis against the benchmark and action level, and then compared to the previous results in order to determine the necessary level of response required.

Recommended Change:

1. Revise the monitoring and reporting schedule to correlate to a "site assessment" period and a "corrective actions" period.
2. Focus monitoring on the period that encompasses the season of highest precipitation: September through March.
3. Require stormwater monitoring to occur a minimum of five times in this period.
4. Reduce written reports to twice annually; the first report, similar to a DMR, would be submitted at the end of the winter site assessment period and the second would be submitted in early fall to report on scheduled corrective actions that have been put into place.

The "Site Assessment report", which would act as a DMR, would be due in April following the September through March "site assessment" period. The report would include the results of the individual sampling events as well as the median value for each parameter calculated from the five sampling events. The median value would be compared to the permit targets (i.e., benchmarks and action levels) and used to determine whether follow-up action is required. If corrective actions are needed, (as defined by the median value and response level), the permittee would be required to identify potential corrective actions and to provide a schedule for their implementation as part of the site assessment report. Permittees would have until September or October of that same year to implement the corrective actions identified. In October, the "Actions and implementation" report would be submitted to Ecology. The purpose of this report would be to confirm that the planned corrective actions have been put into place, and to clearly state that the monitoring results for the next season will reflect "corrected conditions". Permittees could begin the next season's monitoring as soon as they have submitted their "Actions and Implementation" report.

Rationale:
This approach has a number of important advantages. First, it promotes better evaluation of site conditions by both permittees and inspectors. Five data points viewed together will provide a much better assessment of overall site discharge characteristics than individual data points spread out over a long period of time. Because compliance with permit targets will be assessed relative to the central tendency of the data as opposed to data points from individual samples, this approach also recognizes the highly variable nature of stormwater data and the inherent uncertainty in their interpretation. In the 2006 reissuance of the NPDES Stormwater Multi-Sector General Permit for Industrial Activities, the U.S. EPA (2006) also acknowledged the high variability of stormwater data and advocated a similar approach by requiring compliance decisions based on the average of four samples. Use of the median value is proposed in lieu of the average due to the statistical considerations that were described previously in Section 2. Specifically, the analysis of existing industrial stormwater data indicated that most of the monitoring parameters exhibit a distinctly right-skewed distribution. The median value is generally less sensitive to outliers than the mean and is thus a better measure of the data's central tendency (Helsel and Hirch 1992). It should be stressed that the use of median value in compliance determinations does not preclude a permittee from taking more immediate steps to improve site conditions based on the results from individual samples. It would still be in their best interests to do so.

Another benefit of this approach is that it makes a clear distinction between the period of assessment and the period of action(s). The separation of data into annual groupings that represent an increased level of corrective action(s) will be valuable for both evaluating the effectiveness of BMPs and assessing the extent to which site conditions improve over time. This approach will impose a more responsive process for identifying and scheduling corrective actions. Specifically, submission of the actions and implementation report will provide a "paper trail" for tracking water quality improvements for specific types of BMPs. This information could then provide feedback for identifying the most effective BMPs for specific applications with the overall goal of improving the program's long-term effectiveness. Finally, a system of bi-annual reporting has the indirect advantage of reducing reporting requirements and making data entry more efficient.

While quarterly monitoring has the advantage of tradition and the perception that more frequent reporting is more protective, it does not lend itself to a practical schedule of assessment and actions. As noted in Section 2, it also is the largest factor contributing to unreported values and a less robust database for characterizing industrial stormwater quality. The difficulty in capturing a storm event during the two summer period quarters appears to be the most frequent cause of failure to collect a sample.

The increase from four monitoring events (reported quarterly) to five events in the period of highest precipitation will result in more characteristic data while also allowing a direct and simple determination of the median value.

Issues:
A key concern around less frequent reporting appears to be related to the desire for permittees to make corrective adjustments as soon as the data indicates a need, rather than on what is perceived as an annual basis. Less frequent reporting may also be viewed as reducing accountability to the public and as removing the publics' ability to review the data on a more frequent basis.

The recommended change in reporting frequency does not negate a permittee's ability to make corrective adjustments during the site assessment period. Clearly, if the first sample results are above the permit targets it behooves the permittee to immediately implement controls in order to keep the annual median within an acceptable limit. However, from a practical viewpoint, the winter period may not be the most opportune time to implement large scale changes (e.g., rerouting of stormwater, installation of control facilities, re-surfacing metal roofs). While the public would not have access to the full data set (via Ecology's database) until March, they could request through Ecology a copy of the SWPPP with the current individual monitoring event data at any time.

There was also a concern that individual data points would be lost by using the median value. However, this concern can be addressed by requiring that all the individual data values be included in the Site Assessment Report (or DMR) in addition to the median value.

Another concern with this approach is that it may allow permittees to discharge poor quality stormwater for a longer period than under the existing permit; i.e., the entire winter rather than one quarter. However, under the existing permit, a more rapid to elevated pollutant concentrations would only be realized when high pollutant concentrations were measured in the first quarter of the winter season and then controlled before the second quarter. It is just as likely that high pollutant concentrations would not be measured until the second winter quarter or later, since high pollutant concentrations are correlated to storm event characteristics that are equally prevalent throughout the winter. In those cases, the recommended approach would result in a determination of response and move to corrective actions earlier than the quarterly approach. In practice, the efficiency of either approach in evaluating compliance with permit targets will vary greatly depending upon the frequency and magnitude of exceedances at an individual facility.

Another concern with this revised approach is that by focusing only on the winter period, there will be no data for late summer when stream flows are lowest, creating adverse conditions in the receiving water. Late summer or early fall storms that occur after long periods of dry weather can also represent a "seasonal first-flush" condition when pollutant concentrations can be highest due to the longer period of pollutant accumulation between storms. This is a valid concern, but it is also difficult to target and adequately characterize late summer conditions via a routine quarterly monitoring approach (i.e., the existing strategy). These events are very difficult to capture even in well focused efforts. In fact, the summer and fall quarters are not well represented in the existing monitoring data and the explanation typically provided for a failure to collect a sample is "non-qualifying storm". An accurate assessment of impacts during the low flow period and inputs associated with the seasonal first-flush are more appropriately addressed through a study specifically designed to address these questions. This type of study is identified as an important objective to be addressed in the Supplemental Monitoring Program outlined in Section 5 of this report.

The requirement of an additional storm event (a minimum of 5 instead of a maximum of 4) was added as a result of review comments received on the draft Technical Memorandum and therefore there has been no opportunity for advisory members to comment.

Qualifying Monitoring Conditions

Current Permit:
The current permit requires at least a 24-hour dry period before the targeted storm event, and that the storm event size is at least 0.1" of rain in 24 hours or reaches an intensity equal to 0.1" in 24 hours. It also stipulates that samples be collected within the first hour of discharge, although the permittee does not need to sample outside of regular business hours or in unsafe conditions. The current permit does allow for the use of "best efforts" to achieve storm event collection criteria and allows permittees to submit results even if one or more of the sampling criteria are not met.

Recommended Change:

1. Retain the 24-hour dry period requirement.
2. Remove the storm event size target.
3. Extend the sample collection period from 1 hour to within the first 12 hours of discharge.

Rationale:
The storm event size requirement (0.1" min) is inconsequential; any storm that results in discharge from the site should be appropriate for sampling. The emphasis on monitoring during the first hour of a storm event stems from evidence from other parts of the nation that there is a "first-flush" at the beginning of a storm event when pollutant concentrations are highest. While this may be the case when there is a long antecedent dry period before a storm event and/or there is a distinct storm front at the onset of the storm, it generally has not been found to be a consistent runoff characteristic in Western Washington. It can also be very difficult to meet the current criterion; it essentially means that all storms that begin outside regular working hours will not qualify and that an almost immediate response is needed for a storm event. Even if this criterion could consistently be met, it would not necessarily reflect the period of highest pollutant concentrations. Many site characteristics (site size, configuration, impervious surface, available stormwater detention, etc.) greatly affect the speed with which stormwater reaches the discharge point. This, in combination with the various storm event attributes (storm size, rain intensity, changes in intensity during the storm, duration of the storm, etc.) further confounds any prediction of the period when pollutant concentrations are likely to peak.

Although the qualifying storm event conditions in the existing permit are somewhat typical for stormwater monitoring, they also can hinder the collection of samples. As previously described, the majority of the explanations for why samples were not collected during a given quarter were due to non-qualifying storm events. One of the largest deterrents to collecting a sample, when there is a qualifying storm event, is trying to capture the first hour of discharge. This eliminates all storms that begin during non-work hours and also reduces flexibility around sample collection. The existing approach sets limits to sampling that are difficult to achieve in the hopes of capturing a worst case condition. It also provides permittees with an easy explanation for not obtaining the required samples. The recommended change will give permittees more flexibility and should result in more complete data sets. The data collected will represent the general discharge condition as opposed to worst case.

Issues:

This approach removes any perception of trying to monitor worst case conditions and places the emphasis on maximizing the number of samples collected to more fully characterize the discharge. However, as detailed above, it is unlikely that worst case conditions were actually being monitored due to the many confounding factors that influence pollutant concentrations in stormwater runoff. Instead, these qualifying conditions were likely to be limiting the number of events monitored and therefore decreasing the amount of site characterization data available.

Parameters Measured

Current Permit:

Under the current permit, total zinc, turbidity, pH, and oil and grease are the key parameters that must be measured during each storm event. If the total zinc concentration exceeds the benchmark, then total lead and total copper must be measured in subsequent samples. There are 16 other water quality parameters listed in the permit, but these are associated with additional monitoring requirements for specific industrial groups.

Recommended Change:

1. Eliminate oil and grease and pH monitoring requirements from this permit.
2. Add monitoring requirements for total lead and total copper for each storm event.
3. Include dissolved metal (for zinc, copper, and lead) analysis as Level 3 Response requirements.
4. Replace turbidity requirement with total suspended solids (TSS).
5. Replace BOD requirement (applicable for select industries) with COD.

Rationale:

There is little evidence that oil and grease and pH are a concern in industrial stormwater discharges. As described in the data analysis report (Appendix I), only relatively small number of samples (< 15 percent) exceeded the applicable benchmark for pH. Likewise, only 7 percent of the samples for oil and grease exceeded the benchmark. Furthermore, oil and grease concentrations in the majority of samples were below applicable detection limits. The reason there are few excursions of the oil and grease benchmark is more likely related to how and when the samples are collected, rather than providing evidence of well controlled site conditions. Oil and grease problems are more appropriately addressed by visual assessments; by the time the laboratory results are available, the event causing the problem will likely have ended.

Copper has become a focus of Endangered Species Act (ESA) related concerns around stormwater and the existing data do indicate there are frequent exceedances for this parameter. Results from the data analysis (Appendix I) also indicate that lead concentrations may be a concern at a chronic toxicity level. Given these concerns, inclusion of these parameters in routine monitoring is prudent. Direct analysis of dissolved metals has also been added to the Level 3 Response requirements to allow a more thorough assessment of potential receiving water impacts.

Two other significant changes to the permit targets are recommended that are not based on evaluation of the existing data but rather on practical considerations. These are exchanging turbidity for TSS and exchanging COD for BOD.

According to Ecology's Fact sheet for the existing permit (Ecology 2002), turbidity was initially selected instead of TSS because there is an associated water quality standard for this parameter. However, turbidity as a water quality evaluation tool has limitations. This is reflected in the State water quality standards; rather than a single numeric limit such as exists for other parameters, the turbidity criterion is dependent upon background concentrations. This makes it difficult to apply to direct measurements of a discharge. It is also reflected in the range of turbidity benchmarks used in permits in Washington State and elsewhere. Another important shortcoming is that turbidity is not a conservative element and is not based on a mass of pollutants (i.e., milligrams in a liter of water) and therefore cannot be used to calculate a pollutant load. This is why TSS is a more pragmatic and useful measurement and why it is used in TMDL studies. The most important benefit in terms of the industrial stormwater permit is that TSS provides a much better reflection of BMP performance. Specifically, most stormwater BMPs provide treatment via settling and/or filtration. Therefore, monitoring stormwater discharges for TSS will yield information that is directly relevant to performance given these treatment mechanisms. In contrast, turbidity can be related to the presence of colloidal solids that may not be affected by these standard treatment mechanisms. There is little difference in cost between the two measurements. In addition, TSS would typically be analyzed by a qualified lab (rather than as a field measurement), reducing concerns of possible bias in reporting.

The change from BOD to COD affects only a few industry groups. The existing BOD monitoring requirement is derived from wastewater treatment plant regulations and represents the short-term (5-day) oxygen demand of the water. However, BOD can underestimate the actual oxygen demand in contaminated waters due to toxicity (i.e., inhibition of the test microorganisms), and can underestimate the actual oxygen demand from chemical substances such as reduced iron in anoxic water. In contrast, COD better represents the long-term oxygen demand of the water, but can overestimate the actual oxygen demand in waters because some chemicals are oxidized that would not be under normal conditions. COD is slightly more expensive but it requires only a small sample volume which will reduce shipping costs. One important advantage is that it has a long holding time (28 days for COD versus 2 days for BOD) which will make it much easier for permittees to submit samples that meet the required testing protocols.

No recommendations were considered for the 14 remaining water quality parameters that are required for measurement by specific industrial groups. These should be evaluated when more monitoring data are available.

Overall, more complete data sets for heavy metals will improve the ability to characterize discharge and potential impacts for these parameters that are of greatest concern, while TSS and COD are more closely linked to site conditions and BMP performance.

These recommendations will not result in any additional analytical expenses because the elimination of oil and grease monitoring will offset the added cost for these two metals. There are only slight differences in cost for turbidity and TSS analysis and between BOD and COD analysis. In addition, collection and reporting will be simplified because requirements will not change between quarters. (Currently, total copper and total lead are added to the parameter list if zinc concentrations exceed the benchmark.)

Issues:
One concern with this parameter list is that dissolved metals (zinc, copper, and lead) should be analyzed in all samples instead of, or in addition to, total metal concentrations. This suggestion was made because the dissolved forms are more toxic and directly regulated pursuant to State water quality standards. The question of what percentage of the total metal concentration can be assumed to be in the dissolved form is also an issue of dispute. The primary problem with analysis of dissolved metals is that samples must either be field filtered, which requires special equipment and care (field contamination issues for zinc are especially high), or they must be filtered at the lab within 24-hours of collection which can be difficult to achieve. Therefore, it was considered more appropriate to collect information on dissolved metals through the supplemental monitoring program and by including them in the analyses that are required for the Level 3 Response when more experienced professionals would be collecting the samples.

Another concern is that the oil and grease monitoring requirement should not be eliminated. The fact that reported concentrations were consistently low could be interpreted as providing positive evidence of site conditions.

The recommendation to switch to TSS and COD from turbidity and BOD was made as a result of comments received on intermediate review Memos and additional research into these parameters. These recommendations, therefore, have not been reviewed by others. It is possible some reviewers will prefer that turbidity is retained due to its ease of measurement and the fact that there is a water quality standard associated with this parameter.

Revisions to the Permit Targets

Current Permit:

There was no consistently applied method used to establish benchmark and action levels in the current permit that can be described and easily compared to the recommended method. They are, however, largely based on values used by EPA and which many other States have adopted. A detailed discussion of the origination and use of benchmarks and action levels in Washington is included in Section 2.

Recommended Change:

1. Use the Simple Percentile Method to establish benchmarks and action levels for those parameters that have an adequate database. (A detailed discussion of the rationales for adopting the Simple Percentile Method is provided in Section 4.) To apply this method, the 50^{th} and 75^{th} percentiles were calculated from data that were collected in 2003-2005 through the general NPDES industrial stormwater permit. The benchmark and action level values (Table 4-1) represent the median and 75^{th} percentiles, respectively.
2. Adopt TSS benchmark and action threshold of 18 and 49 mg/L, respectively.
3. Adopt a COD benchmark and action threshold of 17.1 and 41.9 mg/L, respectively.

As shown in Table 5-1, adoption of the new benchmarks developed by using the recommended Simple Percentile Method would result in decreases in all of the existing benchmarks except zinc, which would increase slightly. The action levels would decrease for all parameters. Effectively, these changes would result in narrowing the range of acceptable performance. Although some of these reductions are notable, it is important to remember that they were developed based on existing data. This means that they should represent attainable targets, albeit targets that will require some effort to consistently achieve.

Table 5-1. Comparison of benchmarks and actions levels.

	Existing Permit Targets		Recommended Permit Targets	
Parameter	Benchmark	Action Level	Benchmark	Action Level
Total Zinc (µg/L)	117	372	142	280
Total Copper (µg/L)	63.6	149	23.8	42.6
Total Lead (µg/L)	81.6	159	17.3	40.0
Turbidity (NTU)	25	50	NA	NA
TSS (mg/L)	NA	NA	18	49
BOD_5 (mg/L)	30, 140[a]	60	NA	NA
COD (mg/L)	NA	NA	17.1	41.9
Nitrite + Nitrate N (mg/L)	0.68	1.36	0.49	0.86
Total Phosphorus (mg/L)	2	4	0.2	0.6

[a] The 140 mg/L benchmark for BOD is for non-hazardous waste landfills.
BOD: Biochemical oxygen demand (5 day)
COD: Chemical Oxygen demand
C: Celsius
mg/L: milligrams/liter
µg/L: microgram/liter
NTU: nephelometric turbidity unit

Because the existing Washington State NPDES monitoring data are used to establish the permit targets, this is considered a technology-based method. As described in Section 4, establishing the benchmarks based on median values from the existing data indicates there are realistic performance targets for each pollutant that at least one-half of the permittees have managed to attain. Similarly, facilities with pollutant concentrations above the action level are clearly in need of corrective action because at least two-thirds of the permittees have managed to attain better performance. For their part, the permittees can easily comprehend the process used to derive these targets.

Rationale:
This approach establishes benchmarks and action levels that were all derived from the same source and that are attainable. The approach is technology-based and represents an adaptive management approach to setting permit targets. A key advantage to this method is that it is easy to explain and the rationale is defensible. It sets a simple system in place for future revisions to the targets. As technology changes and BMP performance improves, the targets can be revised accordingly.

This approach accommodates the high variability in the data by allowing a cushion between the benchmark and action levels where industries have an incentive to improve operations and progress toward the new benchmark, but are not overly encumbered by the process.

The COD permit targets were developed from the existing ISWGP data for BOD_5. BOD_5 represents 70 percent of the total biochemical oxygen demand based on the theoretical demand curve at Day 5. Thus, BOD_5 should be 70 percent of the COD for typical waters.

The TSS targets were developed from the database as well. However, because few industries need to monitor TSS, the amount of available data is small (<150 samples) and does not represent a wide range of facilities or conditions. The fact that the range between the benchmark and action level encompasses the new benchmark set by the State of Connecticut that is based on their industrial monitoring data, provides some additional support for these recommendations. However, EPA is proposing a TSS benchmark that is much higher (e.g., 100 mg/L) in their MSGP, that is based on the median value from untreated urban stormwater runoff. Given the small amount of available data for deriving these target values and the large difference between the EPA targets, the TSS permit targets should be re-evaluated when more monitoring data are available.

Issues:
An important issue related to the establishment of technology-based permit targets is how protective they are of water quality. As described in Section 3, assessing compliance with numeric criteria is a complex undertaking that requires site-specific information. Furthermore, Section 4 recognizes that a formal analysis of reasonable potential is not possible with the data that are currently available.

In order to make some generalized assessment of the permit targets and their implications for water quality, a risk assessment was performed using Monte Carlo simulations to determine the probability of exceeding numeric water quality criteria in western and eastern Washington. This risk assessment focused solely on copper, lead, and zinc because these are primary parameters of concern and there are relevant water quality criteria for each metal. To perform the risk assessment, the Monte Carlo simulations used simple dilution models and representative receiving water data to generate the following model inputs: background pollutant concentrations, background water hardness, and background total suspended solids (for determining metal translator values). A detailed description of the approach used for this risk assessment is provided in Appendix III. The output of the risk assessment is an estimate of the probability that numeric water quality criteria will be exceeded given different amounts of available dilution.

Table 5-2. Results from Monte Carlo Risk Assessment of proposed benchmark and action levels.

Dilution Factor	Copper Benchmark (23.8 µg/L)				Copper Action Level (42.6 µg/L)			
	Western WA		Eastern WA		Western WA		Eastern WA	
	Acute	Chronic	Acute	Chronic	Acute	Chronic	Acute	Chronic
1	88.8	95.7	35.4	55.2	98.3	99.4	68.3	84.5
2	57.1	76.5	13.0	23.6	85.1	94.6	37.3	55.2
5	17.0	29.7	4.9	8.6	41.6	62.6	9.5	19.0
10	5.9	12.0	2.5	4.3	16.5	28.8	5.3	8.5
25	2.8	5.3	2.7	4.0	3.1	8.5	2.0	3.9
50	3.3	5.0	2.1	3.6	3.6	6.6	2.9	4.4

Dilution Factor	Lead Benchmark (17.3 µg/L)				Lead Action Level (40 µg/L)			
	Western WA		Eastern WA		Western WA		Eastern WA	
	Acute	Chronic	Acute	Chronic	Acute	Chronic	Acute	Chronic
1	0.1	97.1	0.0	62.3	2.0	100.0	0.3	90.6
2	0.0	79.3	0.0	27.7	0.1	99.1	0.0	72.1
5	0.0	39.7	0.0	11.9	0.0	79.3	0.1	30.4
10	0.0	18.7	0.0	8.2	0.0	44.3	0.0	14.6
25	0.0	9.6	0.0	6.4	0.1	17.5	0.1	7.6
50	0.0	9.5	0.0	5.0	0.0	11.7	0.0	4.4

Dilution Factor	Zinc Benchmark (142 µg/L)				Zinc Action Level (280 µg/L)			
	Western WA		Eastern WA		Western WA		Eastern WA	
	Acute	Chronic	Acute	Chronic	Acute	Chronic	Acute	Chronic
1	74.5	80.1	23.6	27.3	97.6	98.3	60.1	65.3
2	28.8	35.6	12.0	14.0	77.5	84.2	31.8	37.2
5	2.6	3.1	7.4	8.2	20.2	24.4	13.0	15.2
10	1.4	1.7	8.4	9.1	3.0	4.2	9.2	9.6
25	1.1	1.6	8.4	9.1	1.3	1.9	9.7	10.6
50	0.6	0.8	8.6	8.9	1.1	1.2	7.7	8.2

Values presented in the table indicate the percent probability that the water quality criterion will be exceeded for the specified dilution factor and effluent pollutant concentration equal to the benchmark or action level.

Table 5-2 contains a summary of the results from the risk assessment. Because each parameter may have a different level of acceptable risk depending on its toxicity, prevalence, and other factors, it becomes a regulatory or policy issue to determine whether the permit targets represent a balanced approach between setting realistic, technology-based permit targets and providing adequate water quality protection. For the sake of allowing some comparative assessment of the proposed benchmarks in relation to water quality risk, it was assumed that a 10 percent probability of exceeding the applicable numeric criteria would be considered acceptably low by most people. Using 10 percent probability as a guide, then;

> Zinc would reach an acceptable risk for meeting acute criteria (<10 percent probability) in both Western and Eastern Washington at dilutions of as low as 5:1 and chronic criteria at dilutions of about 10:1.
> Copper would reach an acceptable risk in Western and Eastern Washington for both acute and chronic criteria at dilutions as low as 10:1.
> Lead would require no dilution to meet acute criteria in Western and Eastern Washington . The eastern side of the State would require a 5:1 dilution to meet chronic criteria but the western side of the State would require dilutions as high as 50:1.

(Note: The appropriateness of applying chronic criteria to stormwater data is controversial. Some people argue that stormwater discharges are sporadic and therefore do not represent a chronic condition. Others argue that at least in western Washington there are long periods of stormwater runoff that meet the definition (24-hour duration) of a chronic condition.)

A second issue identified is that changing permit targets will result in confusion due to the perceived difficulties in trying to implement this type of revision. However, continued use of the existing targets has no clear regulatory advantage. These targets were appropriate at the onset of the permit and most were defensible because of their general, nationwide use. The existing permit targets are not specific to Washington State conditions (particularly water hardness) and would be difficult to justify for continued use given the available performance based monitoring data.

Revisions to Response Requirements

Current permit:
There are three levels of response identified in the current permit. A Level 1 Response is defined for any individual quarterly sample that is above the benchmark or action level. If multiple samples are above the action level, a Level 2 or 3 Response may be required. A Level 2 Response is required if two out of four consecutive samples are above the action level; a Level 3 Response is required if any four samples are above the action level. This response system results in most facilities with problem concentrations implementing a Level 1 Response for the first year or more until enough samples are collected to make a determination of Level 2 or 3 Response needs.

The current Level 1 Response defines practical steps to address water quality concerns by: evaluating possible sources; identifying source and operational control methods; evaluating the need for changes to the stormwater pollution prevention plan (SWPPP); and summarizing results and any remedial actions in the quarterly discharge monitoring report (DMR).

The current Level 2 Response is similar to Level 1 except it requires that permittees investigate all options for source and operational controls and stormwater treatment BMPs, and requires that source and operational BMPs identified are implemented. It also requires preparation of a Source Control Report within 6 months that outlines actions taken, planned, or scheduled for controlling pollutant sources.

The Level 3 Response is similar to Level 2 except that the emphasis is placed on implementing stormwater treatment BMPs rather than just source and operational control BMPs. The Level 3 Source Control Report is due within 12 months of initiating a Level 3 Response. The Level 3 Response does allow permittees to request a waiver from employing stormwater treatment BMPs and outlines a process for obtaining the waiver.

It is inferred by the overall approach in the existing permit that permittees could remain at a Level 1, 2, or 3 Response for the life of the permit. It is the action level rather than the benchmark that is the actual initiator of control efforts in terms of requiring a higher level of response.

Recommended Change:

1. Retain three levels of response with the level of response dictated by each permittee's attainment of target concentrations (similar to the existing program).
2. Eliminate monitoring for the rest of the permit, if the median value is at or below the benchmark through two monitoring seasons. (This incentive is essentially the same as exists in the current permit).
3. Change the response criteria, as summarized in Table 5-3. If the annual median pollutant value is above the benchmark, a Level 1, 2, or 3 Response would be required according to the following:

   Level 1: Required if annual median value (for any key parameter) is above the benchmark or action level in any one year or it if remains above the benchmark but below the action level in any two consecutive years.

   Level 2: Required if annual median value (for any key parameter) is between the benchmark and action level for three consecutive years or above the action level for two consecutive years.

   Level 3: Required if annual median value (for any key parameter) is between the benchmark and action level for more than four consecutive years and if no additional improvements can be identified, or if the annual median value is above the action level for three consecutive years.

Table 5-3. Decision chart for determining appropriate response level.

		Less than BM	Less than BM	Between BM and AL	Greater than AL
Current Year Median Value is →		Less than BM	Less than BM	Between BM and AL	Greater than AL
Previous Year Median Value is →		Less than BM	Greater than BM	Less than or greater than BM	Less than or greater than BM
Year in Permit Cycle	**1**	C	C	1	1
	2	E	C	1	2
	3	E	C	2	2
	4	E	C	2	3
	5	E	C	2	3

BM = Benchmark AL = Action Level E = End monitoring for remainder of the permit
C = Continue monitoring but no response action is required
1 – Follow Level 1 Response requirements
2 – Follow Level 2 Response requirements (if no additional improvements are identified, move to Level 3)
3 - Follow Level 3 Response requirements

4. Adopt the following modifications to the response requirements:

   Level 1 Response requirements:

   Identify potential sources of stormwater pollutants in the discharge and list these in the spring data assessment report.
   Identify source and operational control options to reduce pollutant contaminant levels and list these in the spring data assessment report.
   Evaluate whether additional monitoring site(s) are necessary to better delineate pollutant sources and describe these in the spring data assessment report.
   Select and implement control options with a high likelihood of reducing pollutant levels. Briefly describe those implemented in the fall "Actions and implementation" report.
   Summarize findings, decisions, and actions in fall actions and implementation report. Clearly describe all reduction options that have been implemented and make appropriate changes to SWPPP to reflect findings.

Level 2 Response requirements:

Develop a source-tracking program and describe this in the spring data assessment report. (The source tracking program should include a minimum of two additional monitoring sites; more sites may be required for complex facilities.)

Implement source-tracking program during the subsequent monitoring period.

Develop a Source Control Plan based on results from source-tracking program. This plan must include a prioritized list of possible pollutant reduction options for each source identified and should include source, operational, and stormwater treatment BMPs. The plan should also include a schedule for implementation of high priority options. Submit the Source Control Plan with the spring data assessment report.

Implement selected control options.

Summarize findings, decisions, and actions in the fall actions and implementation report. Clearly describe all reduction options that have been implemented.

Level 3 Response requirements:

Perform a more thorough evaluation of site discharge and receiving water impacts by a trained professional. This will include direct measurements of discharge flow, some measurement or estimate of receiving water flows, additional analysis for dissolved metals and any other constituents identified as a concern in the discharge, and an estimate of dilution required to meet water quality standards. This evaluation will require three monitoring events during winter and three during late summer or the low flow period for the receiving water.

Prepare a summary report for submittal with the next data assessment report. Ecology will use this information along with the detailed information developed by the permittee during Level 1 and 2 to determine the next step which could be a requirement for an individual permit with numeric effluent limits.

Rationale:

This approach puts more emphasis on attaining benchmark concentrations rather than action levels. It provides ample time and incentive for permittees to evaluate site conditions and implement controls, yet sets a clear timeline for required actions. All facilities that exceed either target (benchmark or action level) begin at a Level 1 Response, because the most practical initial steps (Level 1 Response) are the same. This approach also acknowledges that once a Level 2 Response is required, it will take at least two full years before the benefits of implemented control options can be expected because of the time required for adequate source tracking and source prioritization. Facilities that are able to demonstrate continued improvement either in actual pollutant concentrations or implementation of meaningful corrective actions may continue at a Level 2 Response as long as the annual median value is not above the action level. This promotes improvements, positive reinforcement of efforts, and incentives to implement BMPs. While there are some differences between the Level 1 and 2 Responses for the existing and recommended approach, the Level 3 Response is clearly more demanding.

Issues:

One issue raised regarding the recommended changes to response requirements is that permittees are allowed to continue to pollute for too long. It is difficult to evaluate whether the time it takes a specific permittee to reach a Level 2 or 3 Response is longer with this approach than with the existing permit. This would depend on the frequency and magnitude of exceedances of the permit targets. The recommendations presented here were developed to reflect a practical timeline that allows a reasonable period to assess the effectiveness of implemented actions before moving into the next level of solutions. Unlike the existing permit, all permittees with exceedances of either permit target begin at a Level 1 Response. However, the recommended Level 1 Response is more detailed than under the existing permit and reflects the logical first steps that a permittee must take to identify and control a problem. It is very possible that a pollutant could be brought under control during Level 1. Another significant but practical change is the acknowledgement that to fully execute a Level 2 Response will take two years because of the extra time required to implement a source tracking program. In summary, the recommended approach uses the Levels of Response as steps that build upon each other, which is also reflected in the response timeline. Additionally, all three of the Response Levels are more rigorous than what is described in the existing permit.

A second issue raised is that the Level 3 Response is too rigorous and is equivalent to a "reasonable potential to exceed water quality standards" that is currently required during development of an individual permit. A permittee could spend needless time and money acquiring data that may not be used to support an application for an individual permit. The intent of the Level 3 Response monitoring is to provide the initial data required to evaluate the degree of concern associated with the specific discharge. It does not meet the data needs required to complete a reasonable potential analysis. However, the data would still be of value for that analysis. A permittee could negotiate with Ecology if they believed an individual permit was a likely scenario and wished to move directly to compiling the information required for a reasonable potential analysis.

Visual Monitoring

The current NPDES general permit for industrial facilities requires visual monitoring of stormwater pollution sources and BMPs, with the intent being to provide feedback to confirm BMP effectiveness or the need for modified or additional BMPs to control pollutants onsite. This permit requirement is essential for effective permit compliance. Changes in the permit requirements for visual monitoring, including the required inspection frequency, are not warranted. However, other changes recommended include amending the guidance for conducting visual monitoring, revising visual inspection checklists, and implementing a training program for site inspectors. This section describes the current permit, recommended changes, reasons for these recommendations, and potential issues. Appendix II contains suggested guidance information for assisting permittees in filling out visual monitoring checklists, along with example checklists for stormwater facility inventories and routine site inspections.

Current Permit:

Under the current permit, visual inspections are required at least quarterly. The purpose of these inspections is to assess whether the controls identified in the SWPPP to reduce pollutants in stormwater are implemented and adequate. Results from the inspections are to be filed along with the permittees' SWPPP. The person conducting inspections at industrial sites is not required to be certified or trained. Ecology has provided a visual inspection form that permittees can use.

Recommended Change:

1. Amend Ecology's guidance for conducting visual monitoring by adopting a more detailed visual inspection checklist such as provided in Appendix II
2. Implement a training program to support the Visual Assessment portion of the NPDES program

Rationale:

In general, there is little assistance and direction provided for permittees on completing visual inspections, resulting in confusion and inaction. The existing Ecology guidance describing how to conduct a visual site inspection is limited. By amending the guidance, more effective visual monitoring would be promoted, and therefore more effective stormwater pollution control could be achieved on many industrial sites.

In addition, an expanded visual checklist would ensure that all potential sources of pollutants are noted and no significant issues are being overlooked. The visual checklist should be used by inspectors during routine (and required) site inspections. The expanded visual inspection checklist contained in Appendix II was created based on the language in the existing industrial stormwater general permit.

In developing the recommended expanded checklist, a comparison was made to checklists from other jurisdictions to determine how they conduct visual BMP inspections at industrial sites. As a result of this search, it was concluded that the checklist should include both common structural stormwater BMPs and good housekeeping measures. A thorough visual inspection checklist should contain detailed, yet understandable questions while the accompanying written guidance should provide clarification regarding the questions asked. Although long checklists often provide useful detail, it is unlikely that inspectors will use them because of the time it would take to fill them out. Therefore, the recommended checklist contains much more information than the existing inspection form that Ecology offers while also maintaining simplicity so that it will be readily useable by permittees.

While the expanded guidance document and inspection checklists will enable inspectors to do a more thorough job of inspecting industrial sites, there remains a need for improved awareness of industrial stormwater pollution sources and control methods. Often the site inspector is a site foreman, engineer, or safety officer who may have limited knowledge of stormwater pollution prevention. With no training and the limited guidance currently available, it is possible for inspectors to overlook problems onsite that may be contributing to stormwater pollution. Similar to the program required for NPDES general construction permittees, a training program for industrial site inspectors should be implemented to raise the awareness and skill of industrial site personnel who conduct inspections.

Issues:
The primary issue identified by Ecology site inspectors was related to the length of the initial checklist developed. Additional time would be needed to perform routine site inspections (with the initial checklist) and it was unlikely that site personnel would complete it. In response, two checklists were created. One checklist describes relatively permanent site features and activities and the second checklist would be for routine inspections of conditions that are subject to change as a result of activities occurring on the site. The checklist for the permanent site features would be used to document an inventory of the stormwater facilities and onsite activities affecting stormwater quality. The second checklist, for routine inspections, is shorter and thus would be used to assess BMP performance, ongoing sources of pollution, and additional BMP needs to satisfy the industrial general permit requirements for regular inspections.

The two revised checklists and the accompanying guidance document are the appendices of Appendix II.

Section 6: Recommended Changes to Permit Program Management

Supplemental Monitoring Program

Through the process of developing recommendations for changes to the Industrial Stormwater General Permit, it became clear that an additional program was needed. A supplemental monitoring program would serve two key purposes; it would be used to address technical issues that cannot be effectively addressed through permittee monitoring and it could serve as an auditing function to further verify the adequacy of the permittee monitoring program.

Some of the primary technical issues that have been identified that would benefit from a focused study designed specifically to address them include;

- More direct evaluation of compliance with water quality standards
- Development of discharge appropriate translator values for predicting dissolved metal concentrations
- Assessment of special conditions such as summer low flow impacts and seasonal first flush
- Development of rainfall/runoff relationships for different size facilities
- Audit and feedback on monitoring and reporting adequacy
- Collect data to assess the feasibility of developing actual water quality or performance based effluent limits for specific categories of facilities.

The first step to evaluating compliance with water quality standards has been taken in this study by providing probability based risk assessments based on representative receiving water conditions. However, direct monitoring and evaluation of the results would provide a much better assessment of this risk based on actual receiving water conditions and representative facilities. The monitoring program could be focused on different discharge scenarios, such as smaller rivers with multiple dischargers, or even large river systems with concentrated stormwater discharge activity. The purpose would be to identify those scenarios having the highest risk. The information gathered from this program would be valuable for supporting decisions for future revisions to this general permit.

Another issue related to evaluation of compliance with water quality standards is the "translator value" used for determining that portion of a total metal that is in the dissolved form (and therefore more toxic). Federal guidelines (40 CFR 122.45) also require that all permit effluent limitations, standards, or prohibitions for a metal be expressed in terms of "total recoverable metal". However, acute water quality standards for metals in WAC 173-201A are generally expressed in terms of dissolved metals. Therefore, a metals translator value is required to convert the effluent total recoverable metal concentration to an estimate of the dissolved metal concentration that would be present in the receiving water. Specifically, the translator value is that fraction of total recoverable metal in the receiving water that is dissolved (EPA 1996). These translator values can be determined empirically based on site-specific monitoring data, or published values may be utilized. There is a wide range in these values depending on their specific method of calculation. As described in the data analysis report (Appendix I), the assumed translator value is a significant factor in predicting the potential for State water quality standard exceedances, at least in Western Washington. A sensitivity analysis using a translator value that represented typical measurements (i.e., the 50th percentile) as compared to the 95th percentile, indicated there was a nearly 25 percent decrease in the predicted exceedances. This emphasizes that this issue will continue to be a source of debate until actual data are used to better quantify the value. The study developed to assess translator values should reflect different pollutant sources (e.g., parking lots versus roofs) and different treatment systems (e.g., treatment ponds versus composted filter strips) as well as other variables that might effect the translator values.

Other specific scenarios that could be more adequately addressed through short term, focused monitoring are summer low flow conditions and a seasonal first flush response. As highlighted earlier in this report, there is debate regarding pollutant loadings from these events.

The second purpose of a supplemental monitoring program is to provide a training and audit function. Although there are many benefits to having permittees monitor their sites, there will always likely be a perception that the data collected is not of the highest quality and/or may be biased. If the permittee monitoring program was augmented by audit style monitoring using outside professionals, these concerns could be addressed. For example, this might include an assessment of 1 percent of facilities (approximately 10 each year). The assessment effort could also serve as a training program for permittees, similar to the construction site inspection program currently used by WSDOT.

This monitoring program would not need to be expensive, although the program would need to be supported by an additional funding source. The key technical questions that have been identified during evaluation of the current general permit could be addressed as part of the audit monitoring program and through a series of focused studies carried out over the lifespan of the permit.

Database Management

Monitoring data collected by the permittees must be managed by Ecology in an organized database that allows for timely review and analysis. The primary purpose of this database is to maintain a central archive for the monitoring results that can be used to determine compliance, establish appropriate corrective action levels, and evaluate the overall performance of the program at improving water quality in the long-term. To provide for flexible use of collected monitoring data, the database must include: individual sample results for each parameter: calculated median values; the applicable action level (i.e., 1, 2, or 3), if any, in affect at the time of sample collection; and a general description of the BMPs that were implemented during each wet weather site assessment period. Quality assurance flags (estimated or rejected values as reported by the permittees and/or laboratory) should be included, as well as an automated quality assurance warning system. This system would flag data that are outside a range of reasonable values for any given parameter (e.g., pH values greater than 14), allowing Ecology to review the data and determine if there are problems with data entry, measurement units, or analytical methods.

The data collected would allow Ecology to conduct the following analyses/evaluations of collected data:

- Track permit compliance, monitoring compliance, and determine the necessary action levels for individual permittees.
- Evaluate water quality of sites grouped by BMP type and provide updates to permittees with regard to the BMPs that proving most effective.
- Evaluate trends in effluent quality over time and evaluate performance of individual facilities.
- Identify high risk sites.
- Determine if revised benchmark levels and action levels are warranted in response to improvements in BMP design.
- Evaluate the overall effectiveness of the permit program.

Feedback and Reporting

Finally, recommendations have also been developed with regard to how information obtained through the permit is handled and utilized. This is related to both information maintained by permittees and information maintained by Ecology.

Although the existing permit requires that permittees modify their SWPPs when actions are taken on their site, the language should be strengthened and clarified. Permittees should be required to maintain traceable records of problems, actions taken, and results. From these records it should be possible to track the progression and chronology of activities on the site. The annual reporting program described in Section 4 would enhance the development of a traceable record.

Another recommendation made by the advisory committee was that Ecology provide constructive feedback to permittees on program operations and especially on BMP performance. The recent study of zinc sources provides an excellent example. The results from this study should be summarized in a fact sheet and distributed to all permittees. Ecology could go even further by developing a list of alternative (zinc free) products or after-market fixes (e.g., roof sealants or paints) that are appropriate for use on existing facilities or products.

Section 7: Summary and Conclusions

By design, the focus of this study has been on the monitoring requirements and permit targets. However, these only serve as evaluation tools. The overall goals of the ISWGP permit and NPDES permit program should be the effective integration of these tools into a larger process for improving site conditions and reducing pollutant inputs to receiving waters. The recommendations developed in this study are aimed at achieving these goals and ultimately providing better water quality protection.

Benefits to Water Quality

Lower Permit Targets: The proposed revisions to the ISWGP would establish realistic, technology-based permit targets that are based on regional monitoring data. While the benchmarks are generally slightly lower than those in the current permit, the action levels are substantially lower; narrowing the acceptable range of pollutant concentrations that industry must strive to meet. Continued improvements in discharge quality must occur until the benchmark(s) can be attained.

Establishes a Clear Link Between Actions and Results: Through reorganization of the monitoring and reporting, a clear distinction is made between the period of assessment and the period of corrective action. These practical steps more directly tie the results to a continuum of appropriate action; *site assessment* *corrective actions* *site assessment* *corrective actions.* The recommendations developed from the study will allow the reporting of results to reflect these ongoing steps (rather than simply documenting individual data points) and will greatly improve the evaluation of both BMPs and permit program effectiveness.

More Rigorous Response Requirements: The required responses to excursions above permit targets, as proposed here, are clearer and more rigorous. For example, the Level 1 and 2 responses include a new requirement that corrective actions be specifically documented in an annual Actions and Implementation Report. In addition, the Level 2 response requires implementation of a source-tracking program and submission of a follow-up Source Control Plan. Finally, the Level 3 response requires implementation of a more thorough evaluation of site discharge and receiving water impacts by a trained professional.

Improved Data Collection: The proposed revisions to the ISWGP would increase the number of required sampling events from four to five. In addition, data collection requirements for the three primary metals of concern (i.e., copper, lead, and zinc) would increase; this increase would affect measurements of both total and dissolved metals. (Dissolved metals would be measured through Level 3 monitoring and through the Supplemental Monitoring Program). This will improve the database for these metals and ultimately lead to a better understanding of their potential contribution to receiving water contamination. The Supplemental Monitoring

Program could also be used to directly address concerns regarding seasonal low flow and first flush conditions that cannot be effectively evaluated through permittee monitoring. Lastly, the resulting data will reflect parameters that are more meaningful for assessing BMP performance and more useful for interpreting water quality impacts.

More Effective Visual Monitoring: Proposed improvements to the visual monitoring program include a more detailed checklist for site inspections and training requirements for inspectors. These measures should increase the overall effectiveness of the program and provide tangible benefits for water quality. (Since WSDOT implemented a construction site inspection training program, their site audits have shown significant improvements in all of the BMP performance measures they evaluate [WSDOT 2003, WSDOT 2004, WSDOT 2005]).

Benefits to Ecology

All of the water quality protection benefits will benefit Ecology and their mission to protect State water quality. However, there are additional policy or program benefits that will be derived from the proposed recommendations that are also important. These include:

Defensible Permit Targets: The proposed changes to the ISWGP would establish a methodology for defining technology-based permit targets (the Simple Percentile Method) that can be consistently applied across all parameters. This method is easy to explain and adequately accounts for the natural variability and skewed distribution typically observed in stormwater monitoring data. Because the permit targets are tied to existing regional data, they will more accurately reflect BMP performance for those types of facilities that are covered under the permit.

Adaptive Approach: The proposed changes to ISWGP would establish monitoring and reporting requirements that make a clear distinction between the period of assessment and the period of corrective action. These changes will, in turn, provide a means for tracking water quality improvements through the use of different types of BMPs. This information can then be used to develop a feedback loop between Ecology and the permittees for identifying the most effective BMPs for specific applications with the overall goal of improving water quality over the long-term.

Improved Program Management: Improvements in NPDES program management will accrue through more efficient data management and through more frequent communication with permittees regarding program operations and key research findings.

Supplemental Monitoring: The implementation of a Supplemental Monitoring program can be used to address critical technical issues associated with the permit and improve Ecology's decision making processes with regard to future changes to the NPDES program.

Benefits to Permittees

This series of recommendations will benefit permittees in the following ways:

Increased Flexibility for Sample Collection: Proposed changes to the ISWGP would remove the existing storm event size target and extend the sample collection period from 1 hour to within the first 12 hours of discharge. In addition, quarterly sampling would no longer be required; rather, sampling would be conducted over the season of highest precipitation: September through March. These recommended changes will give permittees more flexibility in meeting their monitoring requirements and lead to more complete data sets.

Streamlined Reporting Requirements: Proposed changes to the ISWGP would reduce the reporting frequency over the current requirement for quarterly DMR submission. Specifically, written reports would only be required twice annually; the first report, similar to a DMR, would be submitted at the end of the winter site assessment period (e.g., in April or May), and the second would be submitted in early fall to report on the progress of scheduled corrective actions.

More Meaningful Parameter List: Proposed changes to the ISWGP would require TSS monitoring in lieu of turbidity, and COD monitoring in lieu of BOD. Monitoring stormwater discharges for TSS will yield information that is directly relevant to the performance of most stormwater BMPs and provide more useful data for use in TMDL studies. COD will better represent the long-term oxygen demand of the stormwater discharge, and has a less stringent sample holding time requirements than does BOD. Monitoring requirements for oil and grease and pH would be eliminated entirely because existing data indicate that these parameters are not a substantial water quality concern. However, the proposed changes to the ISWGP would increase monitoring requirements for lead and copper because these parameters are identified as a concern.

Practical Timeline: Although the requirements to respond to a permit target exceedance are more rigorous, the timeline for assessing the effectiveness of implemented actions before moving into the next response level is more practical and realistic.

Training Program: The recommendation that Ecology develop a training program for visual assessments will improve site inspections, making them a more effective evaluation tool.

Formal Feedback Loop: Requiring Ecology to periodically review results and report back to permittees with information on BMP and program effectiveness and research findings will accelerate implementation of the most effective BMPs and ultimately reduce the amount of resources expended on selecting and implementing BMPs.

Cost Implications

There are no significant cost differences to permittees for implementation of these recommendations, but there are cost implications to Ecology. Both the Supplemental Monitoring program and the Visual Inspection training program represent activities that are not currently funded by the department.

Overall, the program will be more streamlined, reflect an adaptive approach, better protect water quality and yet be more practical to apply.

References

Alongi, Neil. "Technology: How Does Oregon Compare?" Presentation at 2006 Stormwater Conference. Environmental Law Education Center, Portland, OR. April 28, 2006.

Ashby, Karen. 2005. Personal communication (letter to Debbie Irvin, Clerk to the Board, Executive Office, State Water Resources Control Board, Sacramento, California, regarding recommendations for the revisions of the industrial general permit, water quality order 97-03-DWQ). Chair, California Stormwater Quality Association, Menlo Park, California. February 18, 2005.

Burton, G. Allen and Robert E. Pitt. Stormwater Effects Handbook. Boca Raton, Florida: Lewis Publishers, 2002.

California State Water Resources Control Board (SWRCB). Draft 2005 Industrial Activities Stormwater General Permit. 2005.

Connecticut Department of Environmental Protection (CTDEQ). General Permit for the Discharge of Stormwater Associated with Industrial Activity. July 2003.

Crosier, Anne. Personal Communication. Virginia Department of Environmental Quality. Storm Water Enforcement Manager. February 8, 2006.

Currier, B., Minton, G., Pitt, R., Roesner, L.A., Schiff, K., Stenstrom, M., Strassler, E., and Strecker, E. 2006. Stormwater Panel Recommendations to the California State Water Resources Control Board: The Feasibility of Numeric Effluent Limits Applicable to Discharges of Storm Water Associated with Municipal, Industrial and Construction Activities. June 19, 2006.

Federal Register Notice (FRN). September 29, 1995. (Volume 60 Number 189)

Federal Register Notice. October 30, 2000. (Volume 65 Number 210)

Federal Register Notice. December 1, 2005. (Volume 70 Number 230)

Gertler, Ed. Personal Communication. Maryland State Department of Environmental Quality. February 2, 2006.

Helsel, D. R. and R. M. Hirsch. Statistical Methods in Water Resources. Studies in Environmental Science 49. Elsevier Publications, New York, New York. 1992.

Oregon Department of Environmental Quality (ODEQ). NPDES General Permits 1200-A, 1200-Z and 1200-COLS Renewal Evaluation Report. Memorandum. Attachment G. August 10, 2006.

Oregon Department of Environmental Quality. NPDES General Permit 1200-Z. Attachment A.2.a. Effective July 1, 2007.

Revised Code of Washington (RCW). 90.48.555 Construction and industrial storm water general permits – Effluent Limitations. 2004.

Stenstrom, M. K. and H. Lee. Industrial Storm Water Monitoring Program – Existing Statewide Permit Utility and Proposed Modifications. Final Report. University of California, Civil and Environmental Engineering Department, Los Angeles, California. 2005.

Tuxford, Burton. Personal Communication. Virginia Department of Environmental Quality. Stormwater Permitting Program. February 3, 2006.

U.S. Environmental Protection Agency (EPA). May 1986. Quality Criteria for Water ("Gold Book"). EPA 440/5-86-001. Office of Water Regulations and Standards.

U.S. EPA. June 1996. The metals translator: guidance for calculating a total recoverable permit limit from a dissolved criterion. EPA 823-B-96-007. U.S. Environmental Protection Agency. Office of Water.

U.S. EPA. 2006. Fact Sheet for 2006 Proposed Reissuance of National Pollutant Discharge System (NPDES) Stormwater Multi-Sector General Permit for Industrial Activities.

Virginia State Water Control Board (VA SWCB). Fact Sheet. Reissuance of a General VPDES Permit. February 2004.

Washington Administrative Code (WAC). Chapter 173-201A. Water Quality Standards for Surface Waters of the State of Washington.

Washington Administrative Code. Chapter 173-220. National Pollutant Discharge Elimination System Permit Program.

Washington State Department of Ecology (Ecology). Fact Sheet for Industrial Stormwater General Permit. 2002.

Washington State Department of Ecology. Fact Sheet Addendum for the Modification of the Industrial Stormwater General Permit. August 2004.

Washington State Department of Ecology. The Industrial Stormwater General Permit. Modified December 1, 2004.

Washington State Department of Ecology. Fact Sheet for Boatyard Permit. 2006.

Washington State Department of Ecology Website. http://www.ecy.wa.gov

Washington State Department of Transportation (WSDOT). NPDES Annual Progress Reports. Cedar-Green, Island-Snohomish, and South Puget Sound Water Quality Management Areas. National

Pollutant Discharge Elimination System MS4 Permits WASM10001, WASM20001, and WASM30001. 2003, 2004, 2005.

Washington State Legislature. Engrossed Substitute Senate Bill 6415 (ESSB 6415). Concerning Stormwater General Permits. March 31, 2004.

40 CFR 122.44. 2003. Establishing limitations, standards, and other permit conditions (applicable to State NPDES programs, see § 123.25). Code of Federal Regulations.

40 CFR 122.45. 2005. EPA Administered Permit Programs: The National Pollutant Discharge Elimination System. Code of Federal Regulations.

40 CFR 125.3. 2005. Criteria and Standards for the National Pollutant Discharge Elimination System. Code of Federal Regulations.

Appendix I

DATA ANALYSIS REPORT

Evaluation of Monitoring Data from General NPDES Permits for Industrial and Construction Stormwater

Prepared for

Washington State Department of Ecology

and

EnviroVision

October 2006

HERRERA ENVIRONMENTAL CONSULTANTS

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DATA ANALYSIS REPORT

Evaluation of Monitoring Data from General NPDES Permits for Industrial and Construction Stormwater

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Introduction

The Washington State Department of Ecology (Ecology) is currently implementing a study to evaluate monitoring and reporting requirements identified in the state's existing general National Point Discharge Elimination System (NPDES) permits for industrial and construction stormwater. This study is required pursuant to Engrossed Substitute Senate Bill (ESSB) 6415 that was passed by the state legislature on March 9, 2004. The ultimate goal of this study is to develop improved monitoring requirements for these permits to determine the effectiveness of stormwater best management practices and to ascertain compliance with state water quality standards.

One of the initial tasks related to this study was a compilation, review, and analysis of existing data that have been collected through the general NPDES permits for industrial and construction stormwater. The primary goal of this analysis is to evaluate the utility of these data for gauging permit compliance and understanding the level of water quality protection that is occurring. This report was prepared by Herrera Environmental Consultants (Herrera) to summarize the results from this analysis. In keeping with the overall goal of this study, the specific objectives of this report are as follows:

- Describe the general distribution of industrial and construction stormwater data including central tendency, variation, and presence or absence of outliers.

- Compare existing industrial stormwater data across industrial categories to determine if there are significant differences in pollutant concentrations.

- Compare industrial and construction stormwater data to applicable benchmarks and action levels established by the general permits.

- Compare industrial and construction stormwater data to hypothetical state water quality criterion that are derived based on representative receiving water conditions and dilution factors. (Note that compliance with actual state water quality standards cannot be assessed using data compiled through the general NPDES permits for industrial and construction stormwater. To predict compliance with standards would require additional site-specific data, receiving water data, and assessment of narrative standards and other policies.)

This report begins with a description of the data sources that were used in this analysis. The specific data analysis methods that were used to meet the study objectives identified above are then described in detail. The results from these analyses are then presented with supporting tabular and graphical data summaries provided as necessary. Finally, these results are discussed in relation to the primary goal of the study with major conclusions from this analysis summarized in the final section of the report.

Data Sources

The specific sources for data that were analyzed within this report are summarized under separate subsections below for industrial and construction stormwater, respectively. Included are descriptions of how the data were compiled and the associated temporal and geographic coverage. The total quantity of data that was compiled from each source is also described along with any known quality assurance issues.

Industrial Stormwater

Data Source

Industrial stormwater data were compiled by Ecology from Discharged Monitoring Reports (DMRs) that were submitted by permittees pursuant to the monitoring and reporting requirements of the general NPDES industrial stormwater permit. These data were initially entered into a database system that is maintained at Ecology's headquarter office in Olympia and then exported to a Microsoft Excel® spreadsheet for subsequent analysis by Herrera. This spreadsheet included data from NPDES sampling that was conducted the second, third, and fourth quarters of 2003 and all four quarters of 2004 and 2005. These data were obtained from a total of 808 permitted facilities with 758 located in Western Washington, 45 in Eastern Washington, and 8 unclassified because no address information was provided in the database.

For subsequent analyses of the industrial stormwater data, these 808 facilities were subdivided into one of 11 general industrial categories that are defined in the NPDES permit and Code of Federal Regulations [40 CFR 122.26(b)(14)]. The associated category names were simplified to the descriptions used by the U.S. EPA to define categories of stormwater discharges (U.S. EPA, 2006). A twelfth category identified as "Significant Contributor (12)" was present in the dataset from Ecology, but not defined in the NPDES permit or Code of Federal Regulations. Finally, a thirteenth category, "No Category Specified", was added because several facilities within the dataset could not be classified within any of the other 12 categories. The names of all 13 categories and number of facilities that fall into each of these categories are provided in Table 1. These data indicate that the number of facilities in each category ranges from 0 to 238. However, 83 percent of the facilities were concentrated in just three categories: Manufacturing (02), Transportation Facilities (08), and Light Industrial Activity (11). Out of the remaining facilities, 15 percent were concentrated in the following four categories: Landfills (05), Recycling Facilities (06), Treatment Works (09), and No Category Specified. In general, the analyses performed in this report generally focused on the data from these seven categories.

The facilities were further subdivided into industrial sectors based on the first two digits of their Standard Industrial Classification (SIC) codes. SIC Codes are assigned in the permitting process based on the primary activities performed at a facility. Categorization at this level allows for a more detailed evaluation of the types of facilities that are represented in the database. For this analysis, 35 industrial sectors were identified based on SIC codes that were present in the database. These 35 industrial sectors were generally derived from the 30 sectors of industrial activity that are defined in the Federal Register (Vol. 65, No. 210). However, some variation from the categories in the Federal Register exist due to the exclusion of some SIC codes entirely (e.g., Agricultural Services [07], Forestry [08]) and the combination of multiple SIC codes in a single sector (e.g., Sector Y includes Rubber and Miscellaneous Plastic Products [30] and Miscellaneous Manufacturing Industries [39]). The names of all 35 industrial sectors and number of facilities that fall into each of these sectors are provided in Table 2. These data show the number of facilities in each industrial sector ranges from 1 to 127, with an average of 22 facilities present in each industrial sector across all 35 categories. In general, the analyses performed in this report were not conducted at this level due to the low data volume within each industrial sector.

Table 1. Total number of facilities by industrial category.

Category	Number of Facilities
01 - Facilities with effluent limitations	1
02 - Manufacturing	233
03 - Mineral, metal, oil, and gas	4
04 - Hazardous waste treatment, or disposal facilities	0
05 - Landfills	20
06 - Recycling facilities	64
07 - Steam electric plants	2
08 - Transportation facilities	205
09 - Treatment works	12
10 - Construction sites > 5 acres	1
11 - Light industrial activity	238
12 - Significant contributor	1
NC - No category specified	27

Data Quantity

Overall, the data set obtained for industrial stormwater contained 21,486 values for a total of 22 different parameters. The number of values available for specific monitoring parameters can be divided into high, intermediate, and low categories depending on their associated monitoring requirements as identified in the NPDES permit. For example, turbidity, pH, total zinc, and oil & grease have the highest number of values because all facilities are required by the NPDES permit to conduct sampling for these parameters. As shown in Table 3, the total number of values for these parameters ranges from 2,651 to 4,479.

Table 2. Total number of facilities by industrial sector.

SIC Code	Sector	Number of Facilities
07--	Agricultural Services	1
08--	Forestry	1
10--	Metal Mining	1
12--	Coal Mining	1
17--	Construction Special Trade Contractors	3
20--	Food and Kindred Products	40
22--	Textile Mill Products	3
24--	Lumber and Wood Products	127
25--	Furniture and Fixtures	3
26--	Paper and Allied Products	14
27--	Printing, Publishing and Allied Industries	2
28--	Chemicals and Allied Products	40
29--	Petroleum and Coal Products	6
30--	Rubber and Miscellaneous Plastic Products	37
31--	Leather and Leather Products	1
32--	Stone, Clay and Glass Products	23
33--	Primary Metals Industries	13
34--	Fabricated Metal Products	62
35--	Industrial & Commercial Machinery and Computer Equipment	28
36--	Electronic and Other Electrical Equipment	7
37--	Transportation Equipment	33
38--	Measuring, Analyzing, and Controlling Instruments; Photographic; Optical Goods	1
39--	Miscellaneous Manufacturing Industries	6
40--	Railroad Transportation	11
41--	Local and Interurban Passenger Transportation	23
42--	Motor Freight Transportation and Warehousing	108
44--	Water Transportation	30
45--	Transportation by Air	21
47--	Transportation Services	2
49--	Electric, Gas, and Sanitary Services	42
50--	Wholesale Trade-Durable Goods	63
51--	Wholesale Trade Non-Durable Goods	23
52--	Building Materials, Hardware, Garden Supply, & Mobile Home Dealers	2
82--	Educational Services	1
95--	Environmental Quality Programs	2
	Total	**781**

Table 3. Total number of available data values by monitoring parameter identified in the general NPDES industrial stormwater permit.

Parameter	Total Number of Values
Turbidity	4479
pH	4442
Zinc, Total	4264
Oil & Grease	2651
Copper, Total	1177
Lead, Total	1034
BOD, 5 day, 20 deg. C	1105
Phosphorus, Total	410
Nitrogen, Nitrite + Nitrate, Total	397
Solids, Total Suspended	146
Nitrogen, Ammonia, Total	70
Oxygen, Dissolved	51
Benzoic Acid	46
Phenol	46
P-Cresol (4-Methylphenol)	44
Alpha-Terpineol	40
Coliform, Fecal	18
Mercury, Total	7
Nitrogen, Nitrate, Total	7
Chromium, Total	4
Cadmium, Total	2
Total Dissolved Gas	1

Unlike the four parameters noted above, the NPDES permit only requires routine sampling for total copper, total lead, biochemical oxygen demand (BOD), ammonia nitrogen, nitrate + nitrite nitrogen, and total phosphorus for specific industrial sectors. For example, monitoring for total copper and total lead is only required at facilities that fall into one of the following five industry sectors: Primary Metals, Metal Mining, Automobile Salvage, Scrap Recycling, or Metals Fabricating. Additionally, sampling for these parameters is required if data from a particular facility indicates the benchmark for total zinc has been exceeded for two consecutive quarters. Because of these less stringent sampling requirements, these six parameters are classified as intermediate with regard to the number of data values that are available. As shown in Table 3, the total number of values in this category ranges from 70 to 1,177.

The remaining 12 parameters in Table 3 are classified as low with regard to the number of data values that are available. The total number of values in this category ranges from 1 to 146. Furthermore, there are no specific benchmark or action levels identified in the NPDES permit for these parameters. Due to these considerations, subsequent analyses presented in this report focused on parameters in the high to intermediate data quantity categories. These ten parameters (i.e., turbidity, pH, total zinc, oil & grease, total copper, total lead, BOD, ammonia nitrogen, nitrate + nitrite nitrogen, and total phosphorus) are hereafter referred to as the "primary analysis parameters" within this report.

As noted above, data analyses presented within this report will examine trends in the industrial stormwater data across 13 industrial categories (see Table 1). The number of values that are available within each of these categories is shown in Table 4 for each of the primary analysis parameters. Similarly, the number of values that are available within each of the 35 industrial sectors is shown in Table 5 for these same parameters.

Table 4. Total number of data values for primary analysis parameters by industrial category.

	Number of Values per Parameter						
Industrial Category	Turbidity	pH	Zinc	Oil & Grease	Copper	Lead	BOD
01 - Facilities with effluent limitations	8	8	8	0	4	2	0
02 - Manufacturing	1327	1323	1233	722	280	230	743
03 - Mineral, metal, oil, and gas	24	24	23	23	1	1	0
04 - Hazardous waste treatment, or disposal facilities	0	0	0	0	0	0	0
05 - Landfills	135	135	120	75	22	21	64
06 - Recycling facilities	295	294	288	196	196	178	0
07 - Steam electric plants	3	3	3	1	0	0	0
08 - Transportation facilities	1010	988	959	557	196	169	8
09 - Treatment works	77	77	76	55	18	18	0
10 - Construction sites > 5 acres	6	6	6	6	0	0	0
11 - Light industrial activity	1450	1445	1412	950	440	396	275
12 - Significant contributor	7	7	4	0	0	0	0
NC - No category specified	137	132	132	66	20	19	15
Total	4479	4442	4264	2651	1177	1034	1105

Data Quality

The data quality for industrial stormwater was assessed based on a review of outliers, missing data, and data qualifiers that were present in the database that was obtained from Ecology. In total, there were 22,794 entries in the database with no value reported for various reasons. Three parameters (e.g., arsenic, chlorine, and guthion) had no results reported. There were also 181 facilities in the database that did not report any values. The primary reasons cited for not reporting values are summarized in Figure 1 based on the qualifiers present in the database. These data show that "No Qualifying Storm Event" was cited most frequently (72 percent of the time) for unreported values. Approximately 13 percent of the unreported values were listed as below detection limit; however, no detection limit was provided. Three additional qualifiers within the database (i.e., Not Reported, Value Not Submitted, and DMR Not Submitted) were cited 12 percent of the time for unreported values (these categories are collectively grouped under the "Not Reported" heading in Figure 1). The other frequently cited qualifiers for unreported data include: consistent attainment, equipment failure, incorrect analysis, laboratory error, lost sample, no discharge, and other.

Table 5. Total number of data values for primary analysis parameters by industrial category.

SIC Code	Category	Number of Values per Parameter						
		Turbidity	pH	Zinc, Total	Oil & Grease	Copper, Total	Lead, Total	BOD
07--	Agricultural Services	5	5	5	5			
08--	Forestry	7	7	4				
10--	Metal Mining	1	1	1	1	1	1	
12--	Coal Mining	9	9	9	9			
17--	Construction Special Trade Contractors	19	19	19	5	12	11	
20--	Food and Kindred Products	268	265	269	213	58	55	221
22--	Textile Mill Products	18	18	18	11	10	9	
24--	Lumber and Wood Products	799	784	734	382	83	67	615
25--	Furniture and Fixtures	14	14	12	9			
26--	Paper and Allied Products	77	80	79	69	8	8	20
27--	Printing, Publishing and Allied Industries	10	10	10				
28--	Chemicals and Allied Products	226	226	221	156	49	43	159
29--	Petroleum and Coal Products	27	27	23	18			
30--	Rubber and Miscellaneous Plastic Products	207	206	202	129	43	33	
31--	Leather and Leather Products	4	4	4	4			
32--	Stone, Clay and Glass Products	109	111	100	51	12	4	
33--	Primary Metals Industries	75	76	76	54	65	48	
34--	Fabricated Metal Products	307	302	291	192	215	192	
35--	Industrial & Commercial Machinery & Computer Equip.	86	91	79	36		1	
36--	Electronic and Other Electrical Equipment	63	65	65	53	10	8	
37--	Transportation Equipment	343	344	329	197	132	122	
38--	Measuring, Analyzing, and Controlling Instruments; Photographic; Optical Goods	8	8	8	8			
39--	Miscellaneous Manufacturing Industries	24	24	24	11	3	4	
40--	Railroad Transportation	54	54	50	26	10	8	
41--	Local and Interurban Passenger Transportation	101	100	101	54	13	9	
42--	Motor Freight Transportation & Warehousing	529	526	502	302	127	111	6
44--	Water Transportation	151	151	145	92	30	27	
45--	Transportation by Air	154	137	146	74	15	15	
47--	Transportation Services	4	4	4	3			2
49--	Electric, Gas, and Sanitary Services	250	250	224	153	37	36	64
50--	Wholesale Trade-Durable Goods	289	289	276	191	204	186	
51--	Wholesale Trade Non-Durable Goods	89	88	88	67	16	13	3
52--	Building Materials, Hardware, Garden Supply, & Mobile Home Dealers	2	2	1	1			
82--	Educational Services	1	1	1				
95--	Environmental Quality Programs	12	12	12	9	4	4	
	Total	4342	4310	4132	2585	1157	1015	1090

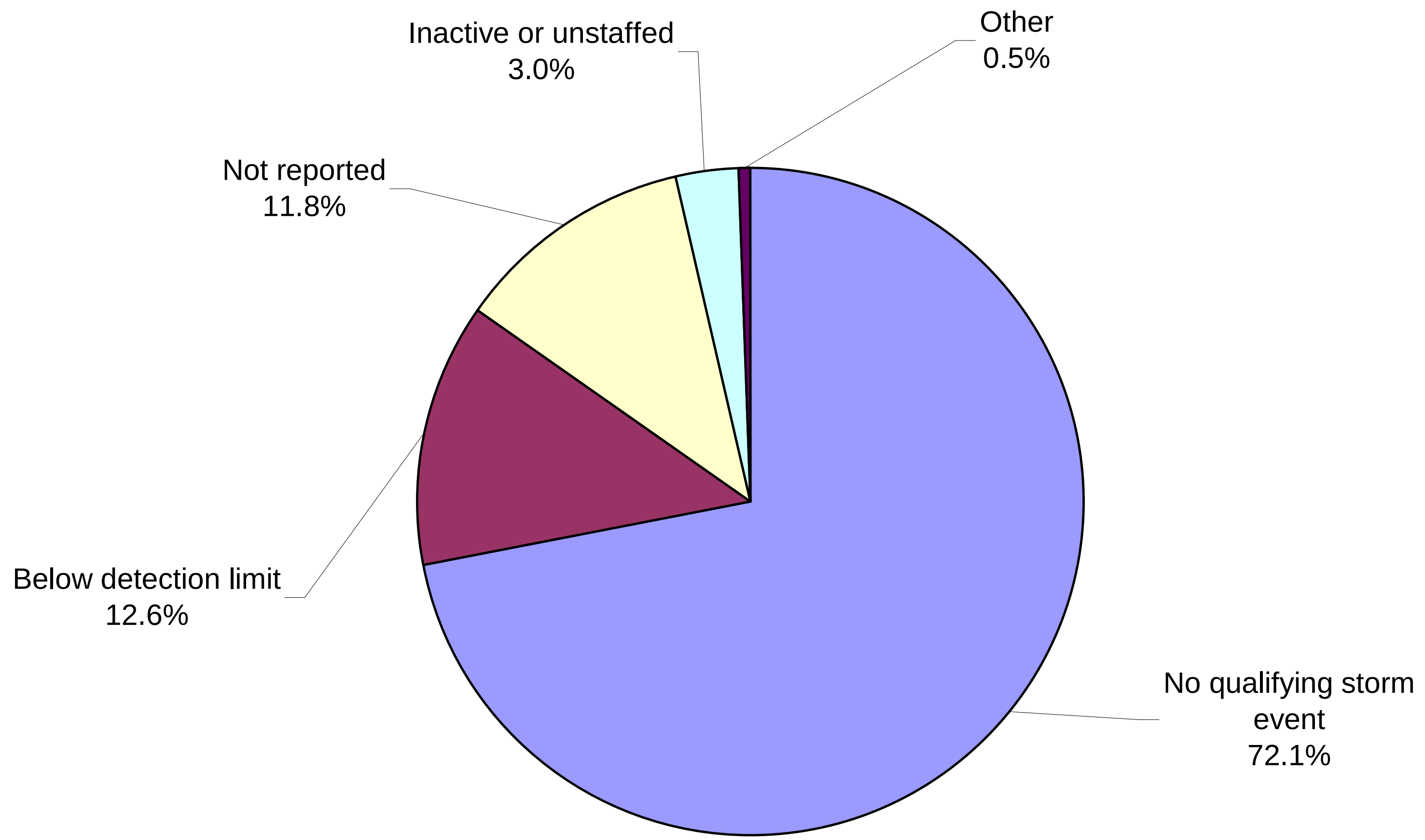


Figure 1. Distribution of unreported values for industrial stormwater by database qualifier.

The reported and unreported values were also summarized for each quarter to determine if the time of year made a difference in the reporting frequency (Table 6). The number entries in the database with the "No Qualifying Storm Event" qualifier was also tallied on a quarterly basis to determine if a lack of rainfall during dry seasons was a primary influence on reporting frequency. These data show there are not substantial differences between the total number of values reported for each quarter; however, the first quarter of 2003 was not included in this dataset, thus the number of values in this quarter only represent two years of sampling instead of three years for the 2nd, 3rd, and 4th quarters. Although the number of values reported on a quarterly basis did not vary greatly, the values not reported and the no qualifying storm event categories do appear to be substantially higher in the 2nd and 3rd quarters. This suggests that reporting frequency was lower during the summer period (April – Sept.) primarily due to a lack of qualifying storm events.

Table 6. Breakdown of reported values, unreported values, and no qualifying storm event values by quarter of the year.

	1st Quarter	2nd Quarter	3rd Quarter	4th Quarter
Values reported	5533	5880	4634	5439
Values not reported	4362	8343	7885	4424
No qualifying storm event	*2159*	*5831*	*6200*	*2238*

Construction Stormwater

Data Source

In general, sources for construction stormwater data are extremely limited due to a lack of monitoring and reporting requirements prior to the issuance of the revised general NPDES construction stormwater permit in November 2005. Construction stormwater data that are analyzed within this report were obtained from an Ecology (2005) study that was implemented over two winter wet seasons in 2003/04 and 2004/05. The primary objective of this study was to obtain representative data to characterize the quality of stormwater discharged from construction sites. To meet this objective, a "snap-shot" survey of construction sites was conducted to measure turbidity, transparency, and total suspended solids (TSS) in their associated runoff. In addition to the collection of these data, monitoring personnel also documented site conditions during the surveys including site size, stage of construction, and the types of best management practices (BMPs) that were in use.

In order to conduct this survey, a list of 183 eligible construction sites in four counties within Western Washington (i.e., King, Snohomish, Pierce, and Thurston) was developed using Ecology's Water Quality Permit Life Cycle System (WPLCS) database. Site visits were then conducted at these construction sites and samples were collected if stormwater was observed discharging off-site. In summary, a total of 44 unique sites were sampled in connection with this effort. Out of the remaining 139 sites from the WPLCS database, eight could not be located, 13 had already completed construction, 15 had not yet started construction, and 103 had no discharge at the time of the site visit.

As noted above, Ecology monitoring personnel documented the conditions at each of 44 sampling sites. Based on this information, 36 percent of the sites were described as large (i.e., > 20 acres), 48 percent as medium (i.e., between 5 and 20 acres), 14 percent as small (i.e., < 5 acres), and 2 percent unclassified due to a lack of data. All 44 sites also had at least one of the following BMPs: storm drain protection, stormwater pond or basin, and disturbed soil protection (e.g., mulch, plastic, vegetation, or erosion control blankets). Finally, the Ecology monitoring personnel indicated that six of the sites discharged directly to receiving waters, all of which were small streams with widths of 2 to 5 feet. The remainder of the sites either allowed the stormwater water to infiltrate into the ground or discharged it to a municipal stormwater collection system.

Data Quantity

A total of 47, 49, and 50 values were obtained for transparency, turbidity, and TSS, respectively from sampling conducted at the 44 sites identified above. (Note that multiple samples were collected from several of the 44 sites.) These numbers are consistent with Ecology's goal of collecting at least 45 samples that was established at the study's onset.

Data Quality

The primary data quality issues for construction stormwater are the limited geographic and temporal coverage of the sampling. For example, sampling for this study was limited to a relatively small number of sites spread throughout four counties in Western Washington. Furthermore, the monitoring only spanned two winter seasons, both of which were drier than normal (Ecology 2005). Finally, the total number of values obtained from this study is relatively small. Therefore, definitive conclusions regarding construction stormwater quality cannot be inferred based on these data.

Data Analysis Methods

Analysis methods for the industrial and construction stormwater data are described in the following sections. The presentation of this information is organized under separate subsections for each of the data analysis goals identified in the introduction to this report.

Data Distribution

Tabular and graphical summaries were generated to show the distribution of the compiled industrial and construction stormwater data including: central tendency, variation or spread, skewness, and presence or absence of outliers. The tabular summaries specifically present the following summary statistics for each monitoring parameter:

- Sample size (total number of values)
- Mean
- Median
- Minimum
- 10^{th} Percentile
- 90^{th} Percentile
- Maximum
- Standard deviation
- Coefficient of variance (CV).

Graphical data summaries consisting of "box and whisker" plots were generated to present the following information: the 10^{th} and 90^{th} percentiles of the data as the lower and upper whiskers, respectively; the 25^{th} and 75^{th} percentiles of the data as the lower and upper boundaries of the box, respectively; and the median as the point in the box.

For the industrial stormwater data, the tabular and graphical summaries were generated for the ten primary analysis parameters identified previously. These summaries were organized to facilitate comparisons of the data across the 13 industrial categories (see Table 1). Additional tabular summaries with a subset of the summary statistics identified above were also generated to facilitate comparisons of the data across the 35 industrial sectors (see Table 2). However, these latter summaries are not presented or discussed within the main body of this report; rather, they are presented in Appendix A for reference only.

Only tabular data summaries were prepared for the construction stormwater data. These summaries present the statistics identified above for the transparency, turbidity, and TSS data that were compiled from Ecology (2005).

Comparison among Industrial Categories

Statistical analyses were performed on the data from the ten primary analysis parameters to determine whether there were significant differences in median concentrations across the industrial categories. To ensure that sufficient data were available to accurately describe the data distribution for each parameter, only those industrial categories with at least 25 samples were included in these analyses. In cases where more than two industrial categories had adequate numbers of samples, these statistical comparisons were made using a Kruskal Wallis test (Helsel and Hirch 1992). If the KruskalWallis test indicated that significant differences in median concentrations existed between one or more of the industrial categories, a follow-up nonparametric multiple range test (Zar 1984) was performed on the data to determine which specific categories were different from the others. In cases where only two industrial categories had adequate numbers of samples, the statistical comparisons were made using a Mann Whitney U test. For all tests, statistical significance was evaluated at an alpha level (α) of 0.05.

Comparison to NPDES Permit Benchmarks and Action Levels

In order to assess compliance with the general NPDES industrial stormwater permit, the compiled industrial stormwater data for turbidity, pH, total zinc, oil & grease, total copper, total lead, BOD, ammonia nitrogen, nitrite + nitrate nitrogen, and total phosphorus were compared to applicable benchmarks and action levels identified in Table 7. Similarly, the compiled construction stormwater data for turbidity were compared to the applicable benchmark (i.e., 50 nephelometric turbidity units [NTU]) and action level (i.e., 250 NTU) from the general NPDES construction stormwater permit. Based on these comparisons, the percentage of samples exceeding the benchmark and action levels was calculated. For the industrial stormwater data, these percentages were calculated for each individual industrial category in Table 1, Western Washington, Eastern Washington, and the entire state of Washington.

Table 7. Benchmark values and action levels identified in the general NPDES industrial stormwater permit.

Parameter	Benchmark	Action Level
BOD, 5 day, 20° C (mg/L)	30, 140[a]	60
Copper (μg/L)	63.6	149
Lead (μg/L)	81.6	159
Nitrogen, Ammonia, Total (mg/L)	10[a], 21.8	38
Nitrogen, Nitrite + Nitrate, Total (mg/L)	0.68	1.36
Oil & Grease (mg/L)	15	30
pH	range 6-9	range 5-10
Phosphorus, Total (mg/L)	2	4
Turbidity (NTU)	25	50
Zinc, Total (μg/L)	117	372

mg/L: milligrams/liter.
μg/L: microgram/liter.
NTU: nephelometric turbidity unit.
[a] The 140 mg/L benchmark for BOD and 10 mg/L benchmark for ammonia nitrogen are associated with non-hazardous waste landfills listed in the industrial category 05-Landfills.

Comparison to Hypothetical Water Quality Criteria

The task to determine whether dischargers covered under a general permit are in compliance with the surface water quality standards presents significant challenges. Compliance with Washington's water quality standards requires assessment of the discharger's compliance with the numeric criteria and narrative standards and policies. These physical and chemical criteria have been determined by the U.S. Environmental Protection Agency to be protective of aquatic life, human health, and sediment quality. They are periodically revised to incorporate the best available science. In the case of an individual discharger, Ecology conducts a reasonable potential analysis that compares pollutant concentrations in the discharge with the physical and chemical properties of the receiving water to determine compliance with the numeric criteria.

Water quality standards take into account potential dilution, ratio of dissolved to total metals, water effects ratios, and background concentration. These are site specific parameters. The calculations used for this study take into account only dilution and dissolved to total metals ratio.

The narrative standards and policies portion of the water quality standards are more difficult to quantify. They include such prohibitions as: no toxic substances in toxic amounts, no resulting increase of pollutant concentrations above background (the antidegradation policy), or the loss of a beneficial use. Compliance with narrative standards and policies require conducting site-specific studies of the discharge and its physical, chemical, and biological impacts to receiving water. Assessing compliance with the narrative standards and policies portion of the water quality standards is beyond the scope of the programmatic approach used in this report.

In order to determine if the designated uses of a water body, as defined in WAC 173-201A, are adequately maintained through the general NPDES industrial stormwater permit, the compiled industrial stormwater data for turbidity, total zinc, total copper, and total lead were compared to hypothetical water quality criteria based on a set of representative receiving water conditions and dilution factors. A similar approach was applied to the compiled construction stormwater data for turbidity to determine if the designated uses of a water body are adequately maintained through the general NPDES construction stormwater permit. Based on these comparisons, the percentage of samples that would potentially exceed the water quality criteria was calculated using all the compiled data for each parameter and only those data that did not exceed the benchmark. For the industrial stormwater data, these percentages were also calculated for each individual industrial category identified in Table 1.

To assess the sensitivity of these analyses, these percentages were calculated using three separate sets of representative receiving water conditions to represent typical, worst case, and best case scenarios for the potential to exceed water quality standards. For example, all the conditions (e.g., receiving water background pollutant concentration and hardness) selected under the worst case scenario would make it more likely that the water quality criteria would be exceeded for any given parameter.

The specific steps that were used to compare sample concentrations to the water quality criteria are as follows:

1. Typical, worst case, and best case background concentrations for each parameter were generated for western and eastern Washington, respectively, based on queries of Ecology's Environmental Information Management System (EIM) database (Ecology, 2006). More specifically, the EIM database was queried to obtain data from river systems in each region of the state for the targeted parameters (i.e., turbidity, total zinc, total copper, and total lead). The typical scenario for total zinc, total copper, and total lead was developed using the mean value from the dataset for each parameter. The worst case scenario used the 75th percentile, and the best case the 25th percentile. The typical scenario for turbidity was developed using the mean value from the dataset, the worst case scenario used the 25th percentile, and the best case the 75th percentile. These concentrations are presented in Table 8.

Table 8. Representative theoretical background concentrations of pollutants for receiving water conditions in western and eastern Washington.

	Dissolved Copper µg/L	Dissolved Lead µg/L	Dissolved Zinc µg/L	Turbidity NTU
Western Washington				
Worst-Case	1.5	0.24	5.0	1.7
Typical	0.77	0.047	1.8	3.8
Best-Case	0.46	0.021	1.0	10
Eastern Washington				
Worst-Case	1.18	0.3	33	1.4
Typical	0.71	0.088	3.3	3.8
Best-Case	0.49	0.023	1.0	10

Data source: Queries of Environmental Information Management system; Ecology (2006).
µg/L: microgram/liter.
NTU: nephelometric turbidity unit.

2. Using the sample concentrations from the compiled industrial and construction stormwater, a theoretical receiving water concentration at the facility's point of discharge was calculated using the typical, worst case, and best case background concentrations from Step 1, and assumed dilution factors within the receiving water of 0, 10, 25, and 50 for the facility's stormwater discharge. The following equation was used to make these calculations for the 2.5, 5, and 10 dilution factors:

$$C_r = (1/F_d \times C_f) + ([1 - 1/F_d] \times C_b)$$

where:

C_r = receiving water concentration at facility point of discharge
F_d = dilution factor

C_f = stormwater sample concentration from facility
C_b = receiving water background concentration.

3. Theoretical receiving water concentrations computed for total zinc, total copper, and total lead from Step 2 were converted to dissolved concentrations to facilitate comparisons to the water quality criteria which are based on the dissolved forms of these metals. These conversions were made using "translator values" that were derived from guidance presented by Pelletier (1996). Because these translator values vary depending on the TSS concentration in the receiving water, the EIM database was again queried to obtain typical, worst case, and best case concentrations for this parameter in eastern and western Washington, respectively. The typical scenario was developed using the mean value from each dataset, the worst case scenario used the 25^{th} percentile, and the best case the 75^{th} percentile. These TSS concentrations and the associated translator values are presented in Table 9.

Table 9. Assumed total suspended solids concentrations and associated translator values for converting total metal concentrations to dissolved concentrations for receiving waters in western and eastern Washington.

	Assumed TSS Concentrations [a] (mg/L)	Copper Translator	Lead Translator	Zinc Translator
Western Washington				
Worst-Case	2	1	0.466	1
Typical	5	1	0.466	1
Best-Case	14	0.931	0.466	0.973
Eastern Washington				
Worst-Case	3	1	0.466	1
Typical	7	1	0.466	1
Best-Case	23	0.786	0.466	0.868

[a] Data source: Queries of Environmental Information Management system; Ecology (2006).

4. Theoretical receiving water concentrations from Step 2 (turbidity only) and Step 3 (dissolved zinc, dissolved copper, and dissolved lead) were compared to hypothetical water quality criteria. Because state water quality standards for zinc, copper, and lead vary with the hardness of the receiving water, the EIM database was again queried to obtain typical, worst case, and best case concentrations for this parameter in eastern and western Washington, respectively. The typical scenario was developed using the mean value from each dataset, the worst case scenario used the 25^{th} percentile, and the best case the 75^{th} percentile. These hardness concentrations were used to determine the water quality criteria which are

presented in Table 10. The state water quality standard for turbidity requires that stormwater related increases in the receiving water not exceed background turbidity by 5 NTU. To assess compliance with the hypothetical water quality criterion in this analysis, the theoretical receiving water turbidity levels from Step 2 were compared to the background turbidity levels presented in Table 8. If more than a 5 NTU increase was observed, it was assumed that the water quality criterion for turbidity was exceeded.

Table 10. Hypothetical acute and chronic water quality criteria for metals in receiving waters of western and eastern Washington.

	Assumed Hardness [a] (mg/L as $CaCO_3$)	Dissolved Copper		Dissolved Lead		Dissolved Zinc	
		Acute	Chronic	Acute	Chronic	Acute	Chronic
		µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
Western Washington							
Worst-Case	18	3.4	2.6	9.6	0.37	27	24
Typical	25	4.6	3.5	14	0.54	35	32
Best-Case	36	6.5	4.7	21	0.81	48	44
Eastern Washington							
Worst-Case	35	6.3	4.6	20	0.79	47	43
Typical	68	12	8.2	42	1.6	83	75
Best-Case	100	17	11	65	2.5	114	105

[a] Hardness used to compute water quality criteria for copper, lead, and zinc. Data source: Queries of Environmental Information Management system; Ecology (2006).
mg/L: milligrams/liter.
µg/L: microgram/liter.

5. For each parameter, the percentage of samples exceeding the water quality criteria was calculated based on all the compiled data and only those data that did not exceed the benchmark. For the industrial stormwater data, these percentages were calculated for each individual industrial category identified in Table 1. These results were then compiled in summary tables.

Data Analysis Results

Data analysis results from the compiled monitoring data are presented herein. These results are organized under separate subsections for industrial and construction stormwater data.

Industrial Stormwater

Data analysis results for industrial stormwater are summarized below under separate sections for each of the primary analysis parameters. For each parameter, the results are presented in relation to the study objectives that were identified in the introduction to this report. Specifically, separate subsections present results for the each of the following analyses as described in the previous section: data distribution, comparison among industrial categories, comparison to NPDES permit benchmarks and action levels, and comparison to state water quality standards (if applicable).

Turbidity

Data Distribution

Tabular and graphical data summaries for turbidity levels are provided in Table 11 and Figure 2, respectively, by individual industrial category and for all categories combined. Tabular data summaries for turbidity are also provided in Appendix A by industrial sector; however, these data are presented for reference only and are not discussed herein. Turbidity had the largest quantity of data of all the parameters with 4,479 values across all the industrial categories. The mean and median values from these data were 66 and 15 NTU, respectively; and the coefficient of variation was 4.1. The asymmetrical shape of the box plots presented in Figure 2 indicate that the turbidity data have a right-skewed distribution due to the presence of numerous outliers in the upper end of the data range. Across all industrial categories, the 90^{th} percentile and maximum values for the data were 120 and 9,700 NTU, respectively.

Comparison Among Industrial Categories

Sufficient amounts of data (i.e., n > 25) for statistical comparisons of turbidity levels were only available in the following seven industrial categories (Table 11). Results from these analyses (i.e., Kruskal Wallis test and follow-up multiple range test) indicate the data can generally be differentiated into two groups with low and high median turbidity levels, respectively (Table 12). Specifically, median levels for the Treatment Works (09), Landfills (05), No Category Specified, and Light Industrial Activity (11) categories were significantly lower than those for the remaining three categories: Transportation Facilities (08), Recycling Facilities (06), and Manufacturing (02).

Table 11. Summary statistics for turbidity levels measured in industrial stormwater by industry category.

Industry Category	n	Mean (NTU)	Median (NTU)	Minimum (NTU)	10th Percentile (NTU)	90th Percentile (NTU)	Maximum (NTU)	Std. Dev. (NTU)	Coefficient of Variation	Exceedance of Benchmark [a]	Exceedance of Action Level [b]
01 - Facilities with effluent limitations	8	6.7	5.0	1.9	1.9	14	14	4.9	0.73	0%	0%
02 - Manufacturing	1,327	93	20	0.16	3.1	180	9,700	356	3.84	45%	27%
03 - Mineral, metal, oil, and gas	24	8.3	3.2	0.43	1.1	22	52	12	1.51	8%	4%
05 - Landfills	135	15	7.9	0.48	1.4	37	165	21	1.44	16%	4%
06 - Recycling facilities	295	58	19	0.0	3.3	156	710	104	1.80	42%	27%
07 - Steam electric plants	3	9	10	3.7	3.7	12	12	4.4	0.50	0%	0%
08 - Transportation facilities	1,010	81	17	0	2.7	142	5,380	319	3.94	40%	24%
09 - Treatment works	77	13	5.7	0.4	1.0	28	100	18	1.39	10%	8%
10 - Construction sites > 5 acres	6	42	19	4.5	4.5	173	173	65	1.55	50%	17%
11 - Light industrial activity	1,450	45	12	0.05	2.1	77	5,490	189	4.17	31%	16%
12 - Significant contributor	7	31	2.5	1.5	1.5	149	149	56	1.80	29%	29%
No category specified	137	38	8.4	0.7	2.7	72	1,190	118	3.13	24%	15%
All categories	4,479	66	15	0	2.4	120	9,700	272	4.10	37%	21%

[a] Benchmark for turbidity is 25 NTU.
[b] Action level for turbidity is 50 NTU.
Std. Dev.: Standard Deviation.

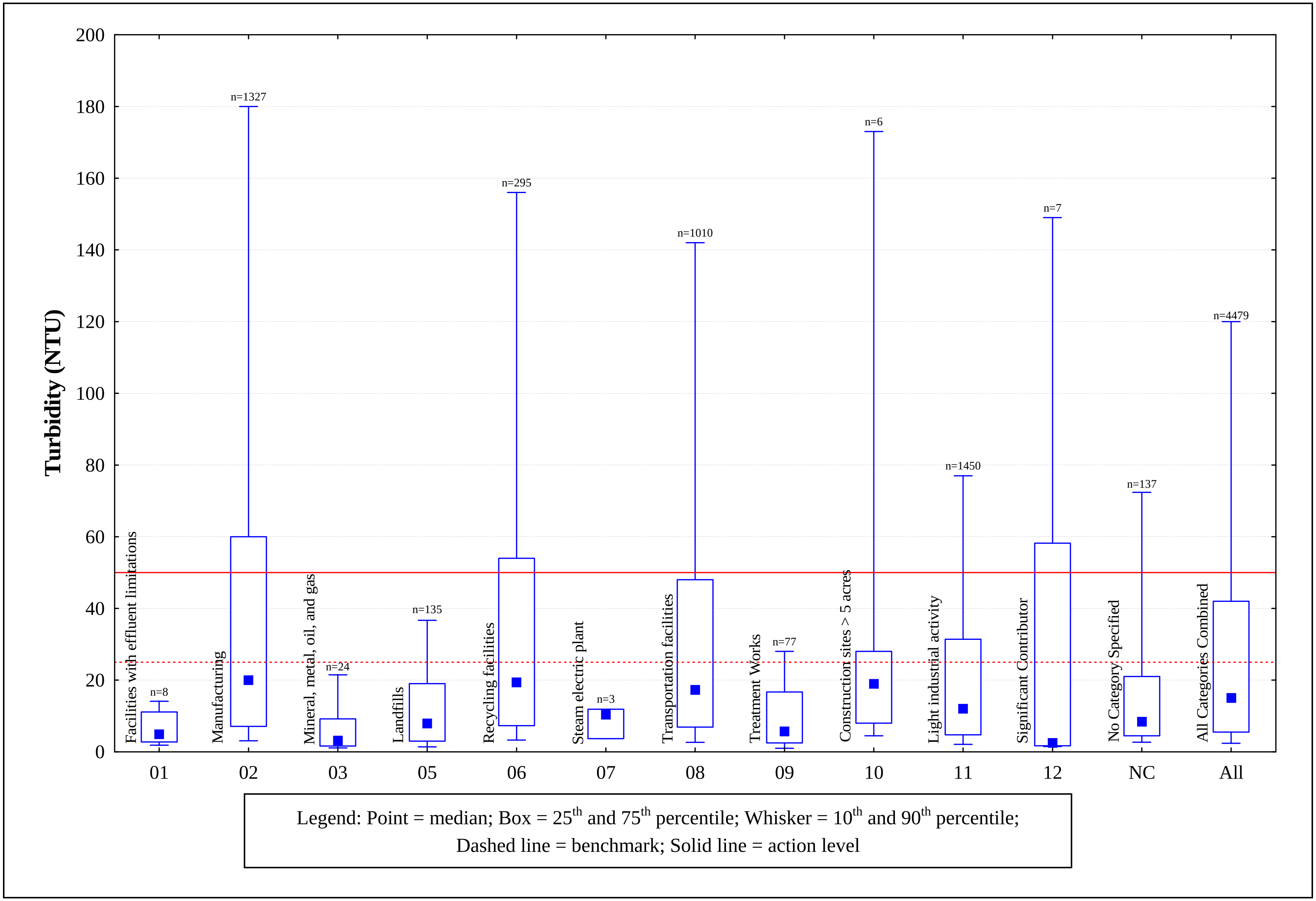


Figure 2. Turbidity levels measured in industrial stormwater by industrial category.

Table 12. Comparison of median concentrations for industrial stormwater pollutants across industrial sectors.

Parameter	p-value [a]	Industrial Category						
		Low Mean Rank						High Mean Rank
Turbidity	**< 0.0001**	09	05	NC	11	08	06	02
pH	**< 0.0001**	11	NC	02	09	08	06	05
Total Zinc	**< 0.0001**	05	09	06	02	08	NC	11
Oil and Grease	**< 0.0001**	09	11	02	NC	05	08	06
Total Copper	0.4909	02		06		08		11
Total Lead	**< 0.0001**	11		02		08		06
BOD	**< 0.0001**	05			02			11

[a] Values in bold indicate significant differences exist between industrial categories based on a Kruskal Wallis test (α = 0.05).
[b] Industrial categories connected by a single unbroken line are not significantly different based on a nonparametric multiple range test.

Comparison to NPDES Permit Benchmarks and Action Levels

Analyses performed across all 13 industrial categories showed that 37 and 21 percent of the samples had turbidity values that exceeded the applicable benchmark (25 NTU) and action level (50 NTU), respectively (Table 11). Considering only the seven industrial categories in Table 11 with a relatively large number of samples (i.e., n > 25), the benchmark and action level for turbidity were exceeded in at least 40 and 24 percent of the samples, respectively, in the following three industrial categories: Manufacturing (02), Recycling Facilities (06), and Transportation Facilities (08). The benchmark and action level for turbidity were exceeded in fewer than 31 and 16 percent of the samples, respectively, for the remaining four industrial categories: Landfills (05), Treatment Works (09), Light Industrial Activity (11), and No Category Specified.

Comparison to Hypothetical Water Quality Criteria

Results from the comparisons of sample concentrations to the hypothetical water quality criterion for turbidity are summarized in Table 13 for western Washington, eastern Washington, and the entire state. The results are subdivided within this table to show the percentage of samples exceeding the applicable criterion based on all collected samples versus only those samples with concentrations below the benchmark. The presentation of these results is also organized under separate subsections below based on these divisions of the data. Finally, Appendix B (Tables B-1 and B-2) provides a more detailed data summary with comparisons by industrial category for samples collected in eastern and western Washington.

All Collected Samples

Analyses of the compiled data showed high percentages of samples exceeding the hypothetical water quality criterion for turbidity with dilution factors of 0 and 10; however, these percentages declined considerably with dilution factors of 25 and higher (Table 13). For example, across the entire state of Washington and all 13 industrial categories, the percentages of samples that exceeded the criterion were 64 and 20 percent given the "typical" receiving water conditions described previously and dilution factors of 0 and 10, respectively. Given the same receiving water conditions and dilution factors of 25 and 50, these percentages dropped to 9 and 5 percent, respectively.

Table 13. Percentage of turbidity samples exceeding the state water quality criterion given hypothetical receiving water conditions for eastern and western Washington and dilution factors of 0, 10, 25, and 50.

	n	Exceedance of Criterion (%)[a]			
		0 DF	10 DF	25 DF	50 DF
All Samples					
Western Washington	4280	64 (49-70)	20 (18-21)	9 (9)	5 (5)
Eastern Washington	184	80 (65-87)	27 (25-30)	17 (15-17)	8 (8)
All Washington	4464	65 (50-71)	21 (18-21)	10 (9-10)	5 (5)
Samples with Values ≤ Benchmark					
Western Washington	2740	44 (21-54)	0 (0)	0 (0)	0 (0)
Eastern Washington	85	56 (25-72)	0 (0)	0 (0)	0 (0)
All Washington	2825	44 (21-54)	0 (0)	0 (0)	0 (0)

[a] Values represent the percentage of sample exceeding the water quality criterion based on representative receiving water conditions for the typical scenario (value not in parentheses) and the best and worst case scenarios (values in parentheses).
DF: Dilution factor.

Analyses of spatial patterns in the data indicated the percentage of samples exceeding the water quality standard for turbidity was somewhat higher in eastern Washington relative to western Washington (Table 13). For example, 80 to 27 percent of the samples in eastern Washington exceeded the criterion with the typical receiving water conditions and dilution factors of 0 and 10, respectively. With the same receiving water conditions and dilution factors, only 64 to 20 percent of the samples, respectively, exceeded the criterion in western Washington.

The analyses also showed there were substantial differences in the percentages of samples exceeding the water quality criterion for turbidity between industrial categories when lower dilution factors (e.g., 0 and 10) were assumed. For example, when comparing only those industrial categories in Table B-1 with a relatively large sample size (i.e., n > 25), the percentage of samples in western Washington that exceeded the criterion ranged from 39 percent for Treatment Works (09) to 72 percent for Manufacturing (02), assuming the typical receiving water conditions and a dilution factor of 0. Similarly, the percentage of samples in eastern Washington that exceeded the criterion (Table B-1) ranged from 76 percent for Manufacturing (02) to 84 percent for Transportation Facilities (08) assuming the same receiving water conditions and dilution factor. When higher dilution factors (e.g., > 10) were assumed for both eastern and western Washington, the percentages of samples exceeding the water quality criterion were similarly low (<25 percent) across all categories.

Samples with Concentrations Below the Benchmark

In contrast to the results above, analyses performed on the subset of samples with concentrations below the benchmark showed that the hypothetical water quality criterion for turbidity was only exceeded when a dilution factor of 0 was assumed. More specifically, across the entire state of Washington and all 13 industrial categories, the percentage of samples that exceeded the criterion was 44 percent given the "typical" receiving water conditions and a dilution factor of 0 (Table 13). This percentage dropped to 0 assuming the same receiving water conditions and a dilution factor of 10 or higher.

pH

Data Distribution

Tabular and graphical data summaries for pH for individual industrial categories and for all categories combined are provided in Table 14 and Figure 3, respectively. Tabular data summaries by industrial sector for pH are also provided in Appendix A. Based on all 4,442 pH values present in the database, the mean and median levels for this parameter were 7.1 and 6.7, respectively, across all of the industrial categories; and the coefficient of variation was 0.12. The mean pH value from this study was generally similar to those reported from other studies. For example, Stenstrom and Lee (2005) reported mean pH values of 7.01 and 7.16 from monitoring data compiled from general NPDES industrial stormwater permits in Los Angeles County, CA and Sacramento County, CA, respectively. The same authors reported a slightly lower mean pH value (6.32) for the state of Connecticut. Coefficients of variation for pH in these same studies ranged from 0.17 to 0.95.

The box plots presented in Figure 3 indicate that the distribution of the data complied for this analysis is relatively symmetrical around the median. The 90^{th} percentile and maximum values for the pH data were 7.6 and 11.6, respectively. (Note that five outliers were eliminated from the dataset prior to this analysis because they exceeded the acceptable range for pH [i.e., 0-14]).

Comparison Among Industrial Categories

Sufficient amounts of data (i.e., n > 25) for statistical comparisons of pH levels were only available in seven industrial categories (Table 14). Results from these analyses (Table 12) indicate that Light Industrial Activity (11) had a lower median concentration relative to Transportation Facilities (08), Landfills (05), and Recycling Facilities (06). Median turbidity levels in all other remaining industrial categories (Manufacturing (02), Treatment Works (09),

Table 14. Summary statistics for pH levels measured in industrial stormwater by industry category.

Industrial Category	n	Mean	Median	Minimum	10th Percentile	90th Percentile	Maximum	Std. Dev.	Coefficient of Variation	Exceedance of Benchmark [a]	Exceedance of Action Level [b]
01 - Facilities with effluent limitations	8	6.3	6.0	6.0	6.0	7.0	7.0	0.46	0.07	0%	0%
02 - Manufacturing	1,323	6.6	6.7	2.0	5.5	7.7	11.6	0.97	0.15	18%	3%
03 - Mineral, metal, oil, and gas	24	7.4	7.3	6.4	6.9	8.0	8.0	0.44	0.06	0%	0%
05 - Landfills	135	6.9	6.9	5.0	6.1	7.5	8.3	0.58	0.08	6%	1%
06 - Recycling facilities	294	6.8	7.0	2.2	6.0	7.6	10.0	0.77	0.11	8%	1%
07 - Steam electric plants	3	7.0	7.0	6.9	6.9	7.0	7.0	0.06	0.01	0%	0%
08 - Transportation facilities	988	6.7	6.7	2.2	6.0	7.5	10.6	0.75	0.11	12%	1%
09 - Treatment works	77	6.8	6.8	5.4	6.0	7.4	7.9	0.53	0.08	8%	0%
10 - Construction sites > 5 acres	6	6.3	6.0	5.4	5.4	7.8	7.8	0.88	0.14	50%	0%
11 - Light industrial activity	1,445	6.6	6.6	1.0	5.6	7.4	10.0	0.78	0.12	16%	2%
12 - Significant contributor	7	5.8	6.0	5.0	5.0	6.5	6.5	0.49	0.08	43%	0%
No category specified	132	6.5	6.6	4.4	5.5	7.5	8.2	0.73	0.11	14%	1%
All categories	4,442	7.1	6.7	1.0	5.5	7.6	11.6	0.83	0.12	14%	2%

[a] Benchmark for pH is <6 or >9.
[b] Action level for pH is <5 or >10.
Std. Dev.: Standard Deviation.

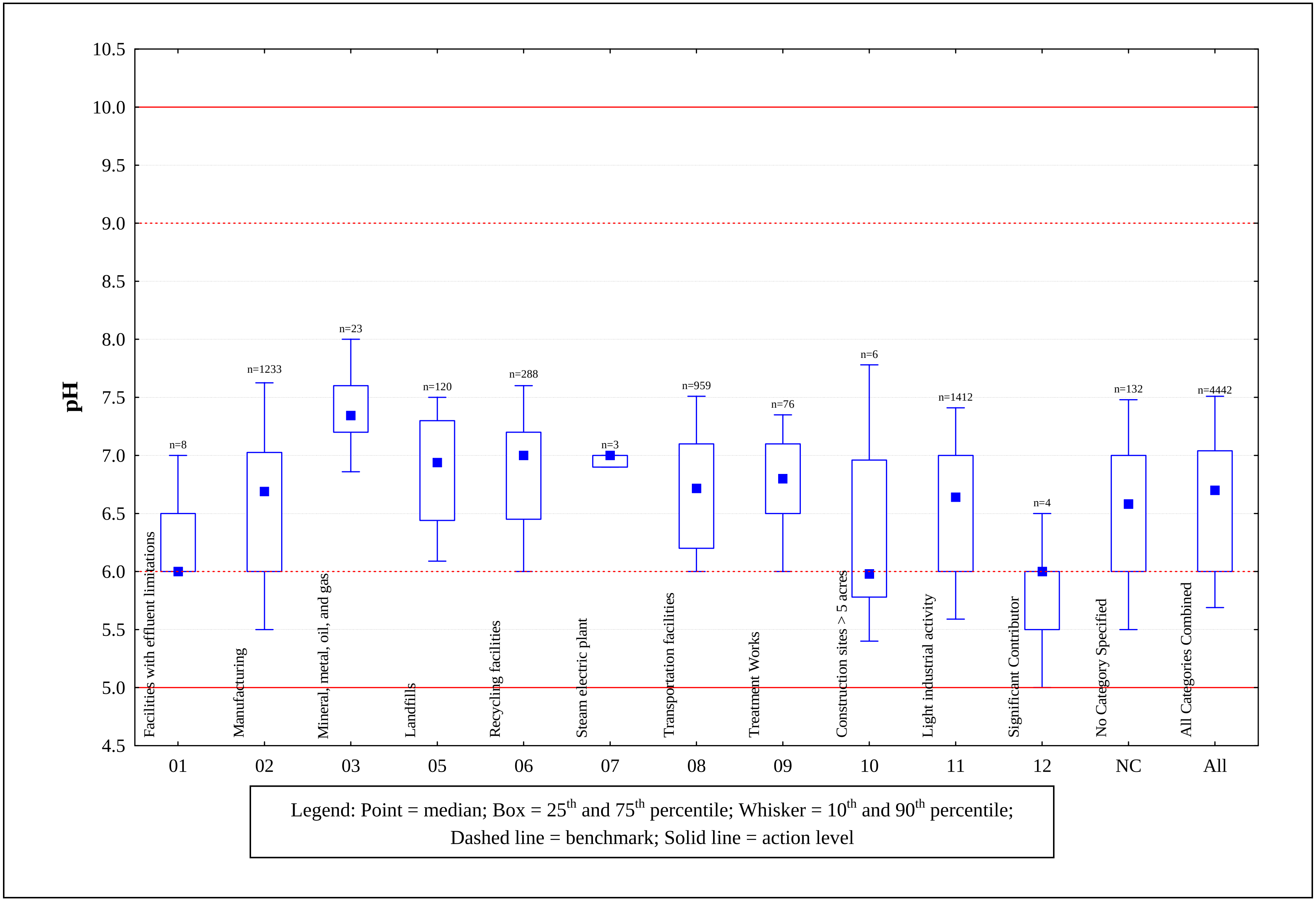


Figure 3. Levels of pH measured in industrial stormwater by industrial category.

and No Category Specified) were intermediate between these two groups and were generally not differentiated in the statistical analysis.

Comparison to NPDES Permit Benchmarks and Action Levels

As shown in Table 14, analyses performed across all 13 industrial categories showed that only 14 and 2 percent of the samples exceeded the applicable benchmark (pH <6 or pH >9) and action level (pH <5 or pH >10), respectively. Considering only the seven industrial categories in Table 14 with a relatively large number of samples (i.e., n > 25), Manufacturing (02) had the highest percentage of samples exceeding the benchmark and action level at 18 and 3 percent, respectively.

Total Zinc

Data Distribution

Tabular and graphical data summaries for total zinc concentrations are provided in Table 15 and Figure 4, respectively, by individual industrial category and for all categories combined. Tabular data summaries for total zinc are also provided in Appendix A by industrial sector. Based on all 4,264 total zinc values that were present in the database, the mean and median concentrations for this parameter were 469 and 139 micrograms per liter (μg/L), respectively, across all the industrial categories; and the coefficient of variation was 7.1. The mean value from this study was generally low relative to the mean value from other studies. For example, Stenstrom and Lee (2005) reported mean values ranging from 510 to 4,960 μg/L for total zinc based on data that were compiled through general NPDES industrial stormwater permits in the following jurisdictions: Los Angeles County, CA; Sacramento County, CA; and the State of Connecticut. The coefficients of variation for total zinc from this same dataset ranged from 7.59 to 13.85.

The asymmetrical shape of the box plots presented in Figure 4 indicate that the total zinc concentrations compiled for this analysis have a right-skewed distribution due to the presence of numerous outliers in the upper end of the data range. Across all industrial categories, the 90^{th} percentile value for the data was 692 μg/L. The maximum (130,000 μg/L) represents an extreme outlier that may indicate the associated value was incorrectly entered in the DMR or database.

Comparison Among Industrial Categories

Sufficient amounts of data (i.e., n > 25) for statistical comparisons of total zinc concentrations were only available in seven industrial categories (Table 15). Results from these analyses (Table 12) indicate the data can be differentiated into two groups with low and high median total zinc concentrations, respectively. Specifically, median concentrations for the Landfills (05) and Treatment Works (09) categories were significantly lower than those for the remaining five categories: Manufacturing (02), Recycling Facilities (06), Transportation Facilities (08), Light Industrial Activity (11), and No Category Specified.

Table 15. Summary statistics for total zinc concentrations measured in industrial stormwater by industry category.

Industrial Category	n	Mean (µg/L)	Median (µg/L)	Minimum (µg/L)	10th Percentile (µg/L)	90th Percentile (µg/L)	Maximum (µg/L)	Std. Dev. (µg/L)	Coefficient of Variation	Exceedance of Benchmark [a]	Exceedance of Action Level [b]
01 - Facilities with effluent limitations	8	1639	1600	520	520	3110	3,110	779	0.48	100%	100%
02 - Manufacturing	1,233	321	140	0.02	19.0	722	8,110	653	2.03	55%	22%
03 - Mineral, metal, oil, and gas	23	80.2	30.0	2.00	9.00	220	650	147	1.83	17%	4%
05 - Landfills	120	158	35.0	0.002	6.00	347	4,400	457	2.89	18%	8%
06 - Recycling facilities	288	308	119	2.00	24.0	730	6,410	580	1.88	50%	23%
07 - Steam electric plants	3	41.6	34.0	17.8	17.8	73.0	73	28.4	0.68	0%	0%
08 - Transportation facilities	959	318	146	0.136	25.1	604	16,200	810	2.54	57%	20%
09 - Treatment works	76	122	43.6	1.00	12.0	300	1,140	199	1.63	29%	7%
10 - Construction sites > 5 acres	6	796	368	180	180	2600	2,600	931	1.17	100%	50%
11 - Light industrial activity	1,412	774	150	0.00	32.6	750	130,000	5645	7.29	58%	23%
12 - Significant contributor	4	16.3	9.00	0.021	0.021	47.0	47.0	21.2	1.30	0%	0%
No category specified	132	533	149.5	0.255	20.0	881	18,200	1790	3.36	58%	28%
All categories	4,264	469	139	0	20.4	692	130,000	3317	7.06	55%	21%

[a] Benchmark for zinc is 117 µg/L.
[b] Action level for copper is 372 µg/L.
Std. Dev.: Standard Deviation.
µg/L: microgram/liter.

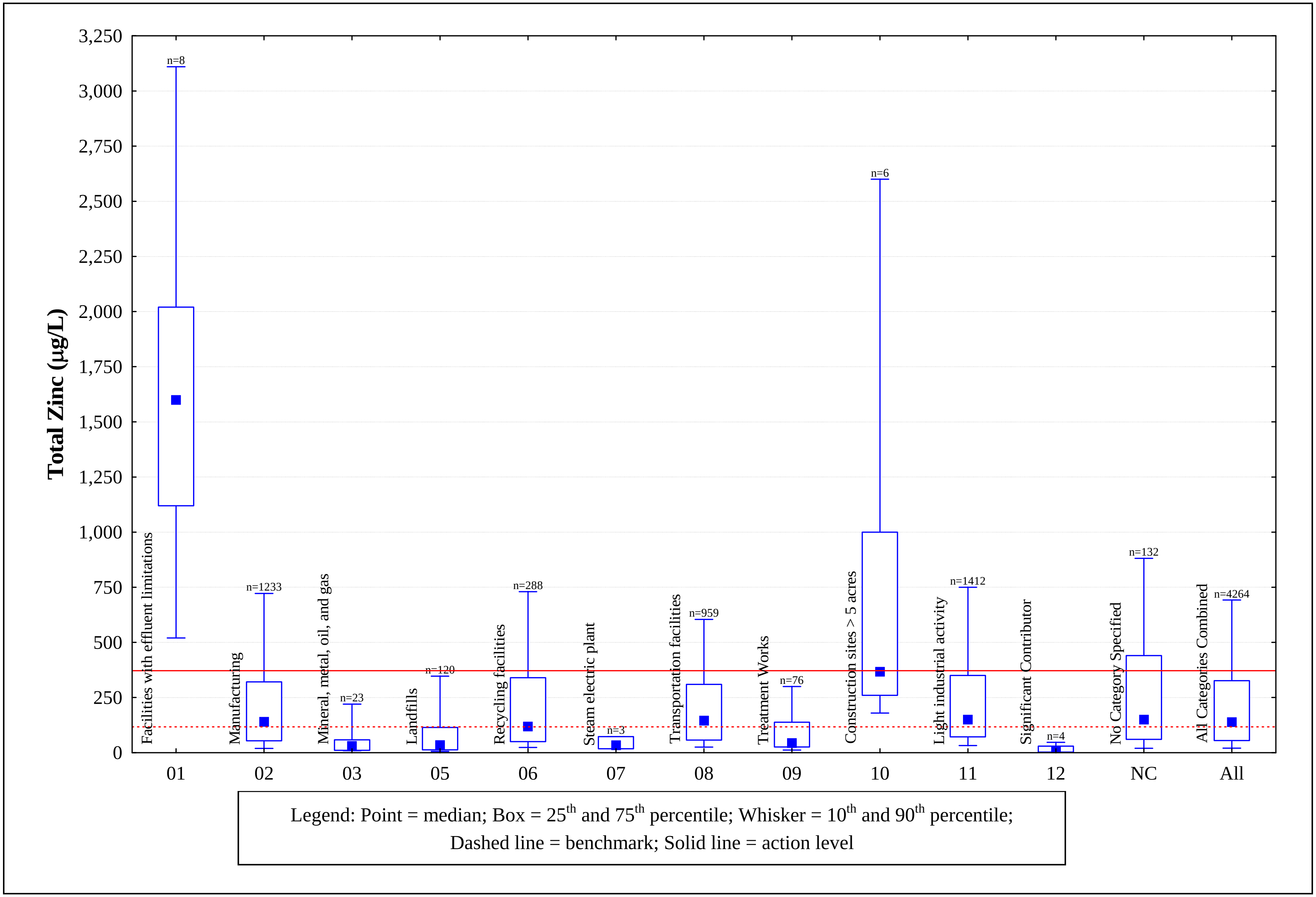


Figure 4. Total zinc concentrations measured in industrial stormwater by industrial category.

Comparison to NPDES Permit Benchmarks and Action Levels

As shown in Table 15, analyses performed across all 13 industrial categories showed that 55 and 21 percent of the samples had total zinc concentrations that exceeded the applicable benchmark (117 μg/L) and action level (372 μg/L), respectively. Considering only the seven industrial categories in Table 15 with a relatively large number of samples (i.e., n > 25), the benchmark and action level for total zinc were exceeded in at least 50 and 20 percent of the samples, respectively, in the following five industrial categories: Manufacturing (02), Recycling Facilities (06), Transportation Facilities (08), Light Industrial Activity (11), and No Category Specified. The benchmark and action level for total zinc were exceeded in fewer than 30 and 8 percent of the samples, respectively, for the remaining two industrial categories: Landfills (05) and Treatment Works (09).

Comparison to Hypothetical Water Quality Criteria

Results from the comparisons of sample concentrations to the hypothetical water quality criterion for dissolved zinc are summarized in Table 16 for western Washington, eastern Washington, and the entire state. The results are subdivided within this table to show the percentage of samples exceeding the applicable criterion based on all collected samples versus only those samples with concentrations below the benchmark. The presentation of these results is also organized under separate subsections below based on these divisions of the data. Finally, Appendix B (Tables B-3 and B-4) provides a more detailed data summary with comparisons by industrial category for samples collected in eastern and western Washington.

All Collected Samples

Similar to the results presented above for turbidity, analyses of the compiled data showed high percentages of samples exceeding the hypothetical water quality criterion for dissolved zinc with dilution factors of 0 and 10; however, these percentages declined considerably with dilution factors of 25 and higher (Table 16). For example, across the entire state of Washington and all 13 industrial categories, the percentages of samples that exceeded the criterion were 83 and 24 percent given the typical receiving water conditions and dilution factors of 0 and 10, respectively. Given the same receiving water conditions and dilution factors of 25 and 50, these percentages dropped to 7 and 3 percent, respectively. Nearly identical results were obtained from comparisons of the data to the chronic criterion for dissolved zinc (see Table 16).

Analyses of spatial patterns in the data indicated the percentage of samples exceeding the water quality criterion for dissolved zinc was only slightly higher in western Washington relative to eastern Washington (Table 16). For example, 84 to 24 percent of the samples in western Washington exceeded the criterion with the typical receiving water conditions and dilution factors of 0 and 10, respectively. With the same receiving water conditions and dilution factors, 70 to 10 percent of the samples, respectively, exceeded the criterion in eastern Washington. A similar pattern was observed in the data when comparisons were made to the chronic criterion for dissolved zinc (see Table 16).

Table 16. Percentage of total zinc samples exceeding state water quality criteria given hypothetical receiving water conditions for eastern and western Washington and dilution factors of 0, 10, 25, and 50.

		Exceedance of Acute Criterion (%) [a]				Exceedance of Chronic Criterion (%) [a]			
	n	0 DF	10 DF	25 DF	50 DF	0 DF	10 DF	25 DF	50 DF
All Samples									
Western Washington	4066	84 (79-88)	24 (16-35)	7 (5-14)	3 (2-6)	85 (80-88)	26 (17-39)	9 (6-16)	4 (2-6)
Eastern Washington	183	70 (58-83)	10 (4-50)	3 (1-25)	1 (1-12)	75 (60-85)	13 (5-58)	3 (1-33)	1 (1-16)
All Washington	4249	83 (78-88)	24 (15-36)	7 (5-14)	3 (2-6)	85 (79-88)	26 (17-40)	8 (5-16)	4 (2-7)
Samples with Values ≤ Benchmark									
Western Washington	1847	65 (54-73)	0 (0)	0 (0)	0 (0)	67 (57-75)	0 (0)	0 (0)	0 (0)
Eastern Washington	70	23 (0-54)	0 (0)	0 (0)	0 (0)	34 (0-60)	0 (0)	0 (0)	0 (0)
All Washington	1917	63 (52-72)	0 (0)	0 (0)	0 (0)	66 (55-74)	0 (0)	0 (0)	0 (0)

[a] Values represent the percentage of sample exceeding the water quality criteria based on representative receiving water conditions for the typical scenario (value not in parentheses) and the best and worst case scenarios (values in parentheses).
DF: Dilution factor.

In comparisons made between the seven industrial categories in western Washington with a relatively large sample size (i.e., n > 25), the percentage of samples that exceeded the acute criterion for dissolved zinc ranged from 56 percent for Treatment Works (09) to 89 percent for Light Industrial Activity (11), assuming the typical receiving water conditions and a dilution factor of 0 (see Table B-3). Similarly, for the three industrial categories in eastern Washington with a large sample size, the percentage of samples that exceeded the criterion ranged from 47 percent for Transportation Facilities (08) to 87 percent for Manufacturing (02), assuming the same receiving water conditions and dilution factor. When higher dilution factors (e.g., > 10) were assumed for both eastern and western Washington, the percentages of samples exceeding the criterion were similarly low (< 25 percent) across all categories. Nearly identical results were obtained from comparisons of the data to the chronic criterion for dissolved zinc (see Table B-3).

Samples with Concentrations Below the Benchmark

Analyses performed on the subset of samples with concentrations below the benchmark showed that the acute and chronic water quality criteria for dissolved zinc were only exceeded when a dilution factor of 0 was assumed. For example, across the entire state of Washington and all 13 industrial categories, the percentage of samples that exceeded the acute criterion was 63 percent given the typical receiving water conditions and a dilution factor of 0 (Table 16). This percentage dropped to 0 assuming the same receiving water conditions and a dilution factor of 10 or higher. Nearly identical results were obtained from comparisons of the data to the chronic criterion for dissolved zinc.

Oil and Grease

Data Distribution

Tabular and graphical data summaries for oil and grease concentrations are provided in Table 17 and Figure 5, respectively, for each industrial category and for all of the categories combined. Tabular data summaries for oil and grease are also provided in Appendix A by industrial sector. Based on all 2,651 oil and grease values that were present in the database, the mean and median concentrations for this parameter were 7.6 and 5.0 milligram per liter (mg/L), respectively, across all the industrial categories; and the coefficient of variation was 3.3. For comparison, Stenstrom and Lee (2005) reported mean values ranging from 5.66 to 11.26 mg/L for oil and grease based on data that were compiled through general NPDES industrial stormwater permits in the following jurisdictions: Los Angeles County, CA; Sacramento County, CA; and the State of Connecticut. The coefficients of variation for total zinc from this dataset ranged from 1.61 to 14.57. The box plots presented in Figure 5 indicate that the oil and grease data frequently have a left-skewed distribution that is most likely related to large numbers of non detect values that are present in the database. Across all industrial categories, the 90^{th} percentile and maximum values for oil and grease were 12 and 914 mg/L, respectively.

Comparison Among Industrial Categories

Sufficient amounts of data (i.e., n > 25) for statistical comparisons of oil and grease concentrations were only available in seven industrial categories (Table 17). Results from these analyses (Table 12) indicate the data can be differentiated into two groups with low and high median oil and grease concentrations, respectively. Specifically, median concentrations for the Treatment Works (09), Light Industrial Activity (11), and Manufacturing (02) categories were significantly lower than those for Recycling Facilities (06) and Transportation Facilities (08). The remaining two categories (No Category Specified and Landfills [05]) had median concentrations that were intermediate between these two groups and were generally not differentiated from the others in the statistical analysis.

Comparison to NPDES Permit Benchmarks and Action Levels

Analyses performed across all of the industrial categories showed that only 7 and 3 percent of the samples exceeded the applicable benchmark (15 mg/L) and action level (30 mg/L), respectively for oil and grease (Table 17). Considering only the seven industrial categories in Table 17 with a relatively large number of samples (i.e., n > 25), Recycling Facilities (06) had the highest percentage of samples exceeding the benchmark and action level at 16 and 7 percent, respectively.

Table 17. Summary statistics for oil & grease concentrations measured in industrial stormwater by industry category.

Industrial Category	n	Mean (µg/L)	Median (µg/L)	Minimum (µg/L)	10th Percentile (µg/L)	90th Percentile (µg/L)	Maximum (µg/L)	Std. Dev. (µg/L)	Coefficient of Variation	Exceedance of Benchmark [a]	Exceedance of Action Level [b]
02 - Manufacturing	722	6.3	5.0	0.0	1.0	11	120	8.9	1.4	6%	2%
03 - Mineral, metal, oil, and gas	23	3.7	5.0	1.0	1.0	6.0	8.0	2.2	0.6	0%	0%
05 - Landfills	75	19.6	5.0	1.0	2.0	6.0	914	107	5.5	4%	3%
06 - Recycling facilities	196	12.2	5.0	0.8	1.0	22	232	27	2.2	16%	7%
07 - Steam electric plants	1	5.0	5.0	5.0	--	--	5.0	--	--	0%	0%
08 - Transportation facilities	557	9.4	5.0	0	1.9	12	561	31	3.3	9%	4%
09 - Treatment works	55	5.1	2.5	1.0	1.0	5.4	82	12	2.4	5%	4%
10 - Construction sites > 5 acres	6	12.7	5.0	2.8	2.8	41	41	15	1.2	33%	17%
11 - Light industrial activity	950	5.9	5.0	0.0	1.0	10	151	9.7	1.6	5%	2%
No category specified	66	7.1	5.0	1.3	2.0	14	47	9.7	1.4	8%	6%
All categories	2,651	7.6	5.0	0	1.0	12	914	25	3.3	7%	3%

[a] Benchmark for oil & grease is 15 mg/L.
[b] Action level for oil & grease is 30 mg/L.
Std. Dev.: Standard Deviation.

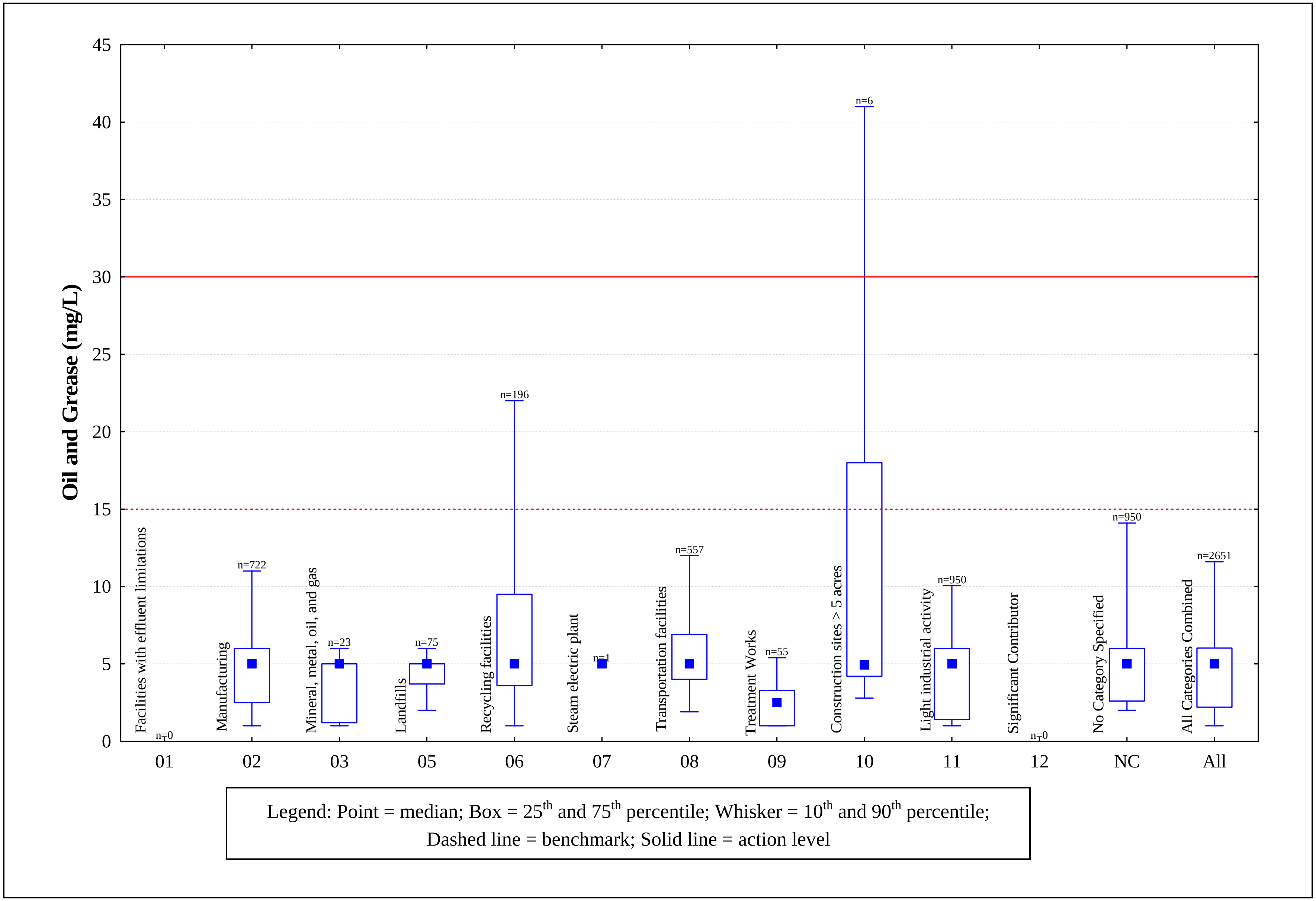


Figure 5. Oil and grease concentrations measured in industrial stormwater by industrial category.

Total Copper

Data Distribution

Tabular and graphical data summaries for total copper concentrations are presented in Table 18 and Figure 6, respectively, by individual industrial category and for all categories combined. Tabular data summaries for total copper are also provided in Appendix A for each industrial sector. Based on the 1,177 total copper values that were present in the database, the mean and median concentrations for this parameter were 73.1 and 22.2 µg/L, respectively, across all the industrial categories; and the coefficient of variation was 5.6. For comparison, Stenstrom and Lee (2005) reported mean values ranging from 130 to 1,010 µg/L for total copper based on data that were compiled through general NPDES industrial stormwater permits in the following jurisdictions: Los Angeles County, CA; Sacramento County, CA; and the State of Connecticut. The coefficients of variation for total copper from this same dataset ranged from 2.31 to 16.50.

The box plots presented in Figure 6 indicate the total copper concentrations compiled for this analysis have a right-skewed distribution due to the presence of numerous outliers in the upper end of the data range. Across all industrial categories, the 90th percentile value for the data was 104 µg/L. The maximum (11,000 µg/L) represents an extreme outlier that may indicate that the associated value was incorrectly entered in the DMR or database.

Comparison Among Industrial Categories

Sufficient amounts of data (i.e., n > 25) for statistical comparisons of total copper concentrations were only available in four industrial categories (Table 18). Results from these analyses (Table 12) indicate there were no significant differences in median total copper concentrations between these categories: Manufacturing (02), Recycling Facilities (06), Transportation Facilities (08), and Light Industrial Activity (11).

Comparison to NPDES Permit Benchmarks and Action Levels

As shown in Table 18, analyses performed across all 13 industrial categories showed that 21 and 6 percent of the samples had total copper concentrations that exceeded the applicable benchmark (63.6 µg/L) and action level (149 µg/L), respectively. Considering only the four industrial categories in Table 18 with a relatively large number of samples (i.e., n > 25), the benchmark was exceeded in 15 to 20 percent of the samples while the action level was exceeded in 5 to 10 percent.

Comparison to Hypothetical Water Quality Criteria

Results from the comparisons of sample concentrations to hypothetical water quality criteria for dissolved copper are summarized in Table 19 for western Washington, eastern Washington, and the entire state. The results are subdivided within this table to show the percentage of samples exceeding the criteria based on all collected samples versus only those samples with concentrations below the benchmark. The presentation of these results is also organized under

Table 18. Summary statistics for total copper concentrations measured in industrial stormwater by industry category.

Industrial Category	n	Mean (µg/L)	Median (µg/L)	Minimum (µg/L)	10th Percentile (µg/L)	90th Percentile (µg/L)	Maximum (µg/L)	Std. Dev. (µg/L)	Coefficient of Variation	Exceedance of Benchmark [a]	Exceedance of Action Level [b]
01 - Facilities with effluent limitations	4	36	38	6.0	6	63.6	63.6	31.5	0.9	0%	0%
02 - Manufacturing	280	86	22	0.03	5	100	11000	659	7.6	21%	6%
03 - Mineral, metal, oil, and gas	1	158	158	158	--	--	158	--	--	100%	100%
05 - Landfills	22	78	14	2.1	5.9	83	1230	259	3.3	14%	5%
06 - Recycling facilities	196	117	26	2.0	6.7	160	5940	476	4.1	29%	10%
08 - Transportation facilities	196	47	28	0.04	5.9	115	496	72	1.5	28%	6%
09 - Treatment works	18	37	26	5.2	5.7	64	224	49.5	1.4	11%	6%
11 - Light industrial activity	440	48	22	0.01	7	89	1700	111	2.3	16%	5%
No category specified	20	292	10	0.01	2.2	333	4930	1098	3.8	20%	10%
All categories	1177	73.1	22.2	0.01	6	104	11000	410	5.6	21%	6%

[a] Benchmark for copper is 63.6 µg/L.
[b] Action level for copper is 149 µg/L.
Std. Dev.: Standard Deviation.

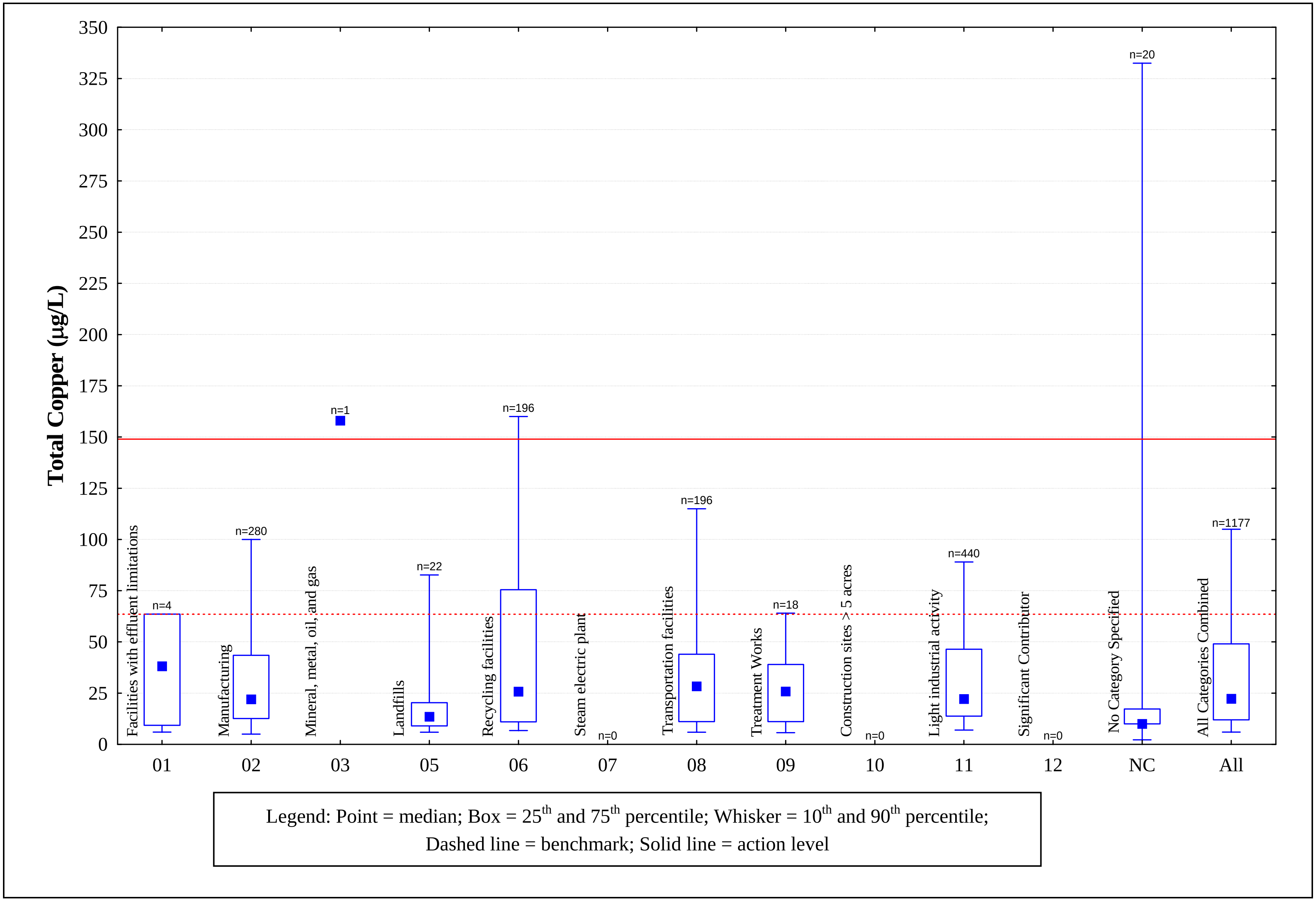


Figure 6. Total copper concentrations measured in industrial stormwater by industrial category.

separate subsections below based on these divisions of the data. Finally, Appendix B (Tables B 5 and B-6) provides a more detailed data summary with comparisons by industrial category for samples collected in eastern and western Washington.

Table 19. Percentage of total copper samples exceeding state water quality criteria given hypothetical receiving water conditions for eastern and western Washington and dilution factors of 0, 10, 25, and 50.

		Exceedance of Acute Criterion (%)[a]				Exceedance of Chronic Criterion (%)[a]			
	n	0 DF	10 DF	25 DF	50 DF	0 DF	10 DF	25 DF	50 DF
All Samples									
Western Washington	1141	95 (88-96)	31 (18-54)	12 (6-25)	5 (3-12)	96 (92-97)	44 (26-74)	17 (9-42)	7 (4-20)
Eastern Washington	36	64 (47-86)	14 (3-25)	3 (0-8)	0 (0-3)	81 (58-92)	22 (8-31)	3 (3-14)	0 (0-3)
All Washington	1177	94 (87-96)	31 (17-53)	11 (6-24)	5 (3-11)	96 (91-97)	43 (25-73)	17 (9-41)	7 (4-20)
Samples with Values ≤ Benchmark									
Western Washington	926	94 (86-96)	15 (0-43)	0 (0-8)	0 (0)	95 (90-96)	31 (9-68)	0 (0-28)	0 (0-2)
Eastern Washington	27	52 (30-81)	0 (0)	0 (0)	0 (0)	74 (44-89)	0 (0-7)	0 (0)	0 (0)
All Washington	953	93 (84-95)	15 (0-42)	0 (0-7)	0 (0)	95 (89-96)	30 (9-66)	0 (0-27)	0 (0-2)

[a] Values represent the percentage of sample exceeding the water quality criteria based on representative receiving water conditions for the typical scenario (value not in parentheses) and the best and worst case scenarios (values in parentheses).
DF: Dilution factor.

All Collected Samples

As with the parameters discussed previously, the analysis performed hereshowed high percentages of the collected samples exceeding the hypothetical water quality criterion for dissolved copper when dilution factors of 0 and 10 were applied; however, these percentages declined considerably with dilution factors of 25 and higher (see Table 19). For example, across the entire state of Washington and all 13 industrial categories, the percentages of samples that exceeded the acute criterion were 94 and 31 percent given the typical receiving water conditions and dilution factors of 0 and 10, respectively. Given the same receiving water conditions and dilution factors of 25 and 50, these percentages dropped to 11 and 5 percent, respectively. Nearly identical results were obtained from comparisons of the data to the chronic criterion for dissolved copper (Table 19).

Analyses of spatial patterns in the data indicated the percentage of samples exceeding the water quality criterion for dissolved copper was only slightly higher in western Washington relative to eastern Washington (Table 19). For example, 95 to 31 percent of the samples in western Washington exceeded the criterion with typical receiving water conditions and dilution factors of

0 and 10, respectively. With the same receiving water conditions and dilution factors, 64 to 14 percent of the samples exceeded the criterion in eastern Washington. A similar, though less pronounced pattern was observed in the data when comparisons were made to the chronic criterion for dissolved copper (see Table 19).

In comparisons that were made between the four industrial categories in western Washington with a relatively large sample size (i.e., n > 25), the percentage of samples that exceeded the acute criterion for dissolved copper (see Table B-5) ranged from 91 percent for Manufacturing (02) to 98 percent for both Recycling Facilities (06) and Light Industrial Activity (11), assuming typical receiving water conditions and a dilution factor of 0. When higher dilution factors (e.g., > 10) were assumed, the percentages of samples exceeding the criterion were similarly low (< 20 percent) across all the categories. Nearly identical results were obtained from comparisons of the data to the chronic criterion for dissolved copper (see Table B-5). However, there were insufficient data to make comparisons between the various industrial categories in eastern Washington.

Samples with Concentrations Below the Benchmark

The analysis performed here on the subset of samples with concentrations below the benchmark showed that the acute and chronic water quality criteria for dissolved copper were only exceeded when dilution factors of 0 and 10 were assumed. For example, across the entire state of Washington and all 13 industrial categories, the percentages of samples that exceeded the acute criterion were 93 and 15 percent given the typical receiving water conditions and dilution factors of 0 and 10, respectively. Given the same receiving water conditions and dilution factors of 25 and 50, these percentages dropped to 0. Nearly identical results were obtained from comparisons of the data to the chronic criterion for dissolved copper (Table 19).

Total Lead

Data Distribution

Tabular and graphical data summaries for total lead concentrations are provided in Table 20 and Figure 7, respectively, by individual industrial category and for all categories combined. Tabular data summaries for total lead are also provided in Appendix A by industrial sector. Based on the 1,034 total lead values present in the database, the mean and median concentrations for this parameter were 48 and 12 μg/L, respectively, across all the industrial categories; and the coefficient of variation was 4.0. For comparison, Stenstrom and Lee (2005) reported mean values ranging from 60 to 4,480 μg/L for total lead concentrations based on data that were compiled through general NPDES industrial stormwater permits in the following jurisdictions: Los Angeles County, CA; Sacramento County, CA; and the state of Connecticut. The coefficients of variation for total lead from this same dataset ranged from 3.82 to 14.12.

The box plots presented in Figure 7 indicate the total lead concentrations compiled for this analysis generally have a right-skewed distribution due to the presence of numerous outliers in the upper end of the data range. Across all industrial categories, the 90th percentile and maximum values for the data were 79 and 3,730 μg/L, respectively.

Table 20. Summary statistics for total lead concentrations measured in industrial stormwater by industry category

Industrial Category	n	Mean (µg/L)	Median (µg/L)	Minimum (µg/L)	10th Percentile (µg/L)	90th Percentile (µg/L)	Maximum (µg/L)	Std. Dev. (µg/L)	Coefficient of Variation	Exceedance of Benchmark [a]	Exceedance of Action Level [b]
01 - Facilities with effluent limitations	2	82	81.6	81.6	81.6	81.6	81.6	0	0	0%	0%
02 - Manufacturing	230	47	10	0.006	1.0	94.5	1,240	145	3.1	12%	4%
03 - Mineral, metal, oil, and gas	1	14	14	14	--	--	13.9	--	--	0%	0%
05 - Landfills	21	14	6	1.0	2.0	20.9	110	25	1.8	5%	0%
06 - Recycling facilities	178	107	25	0.1	2.6	170	3,730	347	3.2	21%	11%
08 - Transportation facilities	169	32	20	0.05	3.5	60.6	289	43	1.4	18%	2%
09 - Treatment works	18	9.4	7.0	0.9	1.2	24.6	30	8.4	0.9	0%	0%
11 - Light industrial activity	396	31	10	0.01	1.7	50	3,000	157	5.0	6%	3%
No category specified	19	53	10	0.007	2.0	235	576	137	2.6	11%	11%
All categories	1,034	48	12	0.006	1.7	79	3,730	190	4.0	12%	4%

[a] Benchmark for lead is 81.6 µg/L.
[b] Action level for lead is 159 µg/L.
Std. Dev.: Standard Deviation.

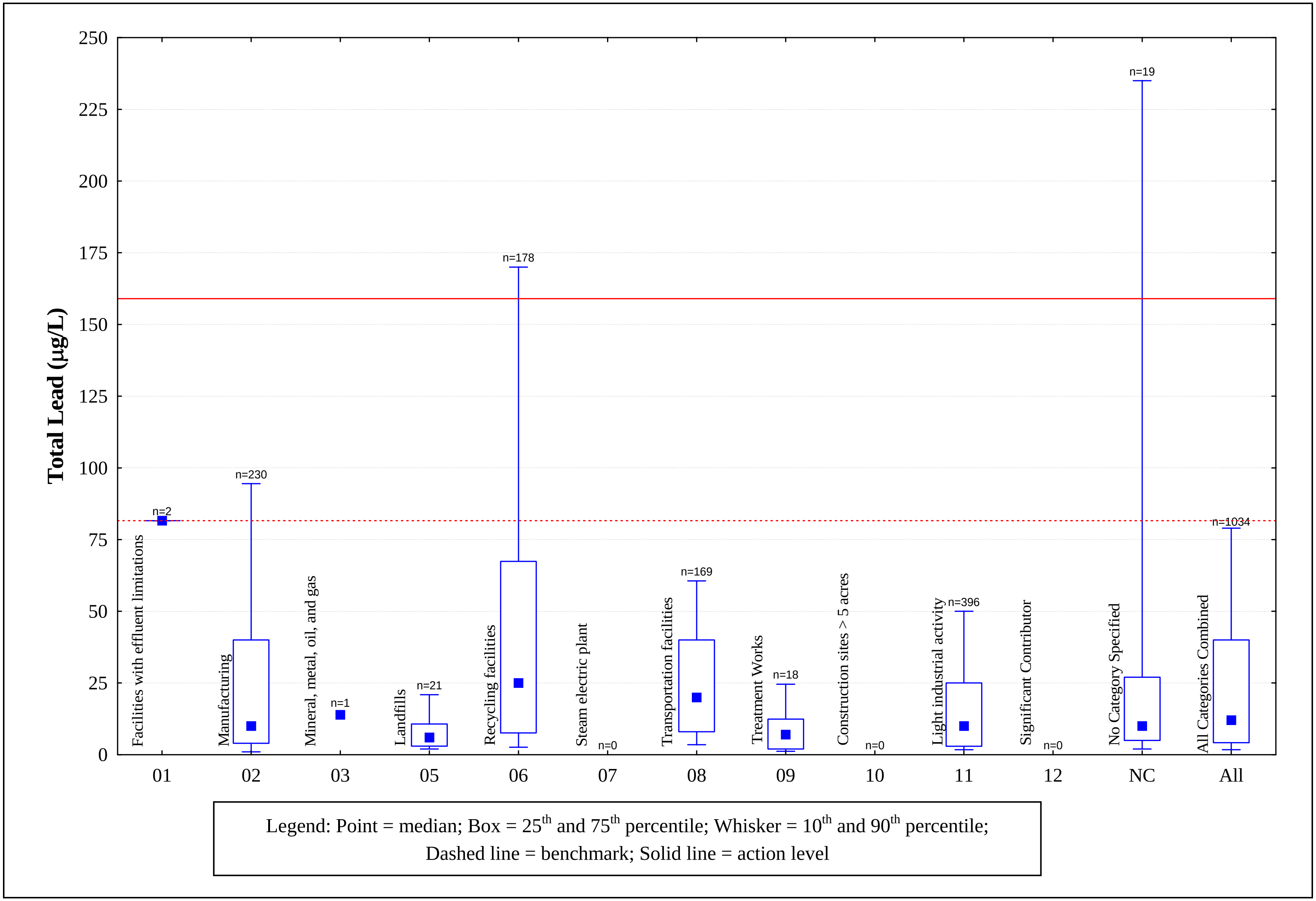


Figure 7. Total lead concentrations measured in industrial stormwater by industrial category.

Comparison Among Industrial Categories

Sufficient amounts of data (i.e., n > 25) for statistical comparisons of total lead concentrations were only available in four industrial categories (Table 20). Results from these analyses (Table 12) indicate the data can be differentiated into two groups with low and high median total lead concentrations, respectively. Specifically, median concentrations for the Light Industrial Activity (11), and Manufacturing (02) categories were significantly lower than those for Transportation Facilities (08) and Recycling Facilities (06).

Comparison to NPDES Permit Benchmarks and Action Levels

Analyses performed across all nine industrial categories reporting total lead concentrations showed that 12 and 4 percent of the samples had total lead concentrations that exceeded the applicable benchmark (81.6 μg/L) and action level (159 μg/L), respectively (Table 20). Considering only the four industrial categories in Table 20 with a relatively large number of samples (i.e., n > 25), the benchmark was exceeded in 6 to 21 percent of the samples while the action level was exceeded in 3 to 11 percent.

Comparison to Hypothetical Water Quality Criteria

Results from the comparisons of sample concentrations to hypothetical water quality criteria for dissolved lead are summarized in Table 21 for western Washington, eastern Washington, and the entire state. The results are subdivided within this table to show the percentage of samples exceeding the applicable criterion based on all collected samples versus only those samples with concentrations below the benchmark. The presentation of these results is also organized under separate subsections below based on these divisions of the data. Finally, Appendix B (Tables B-7 and B-8) provides a more detailed data summary with comparisons by industrial category for samples collected in eastern and western Washington.

All Collected Samples

Across the entire state of Washington and all 13 industrial categories, the percentages of samples that exceeded the acute criterion for dissolved lead were 31, 2, 1 and 0 percent given the typical receiving water conditions and dilution factors of 0, 10, 25, and 50, respectively. In comparison to these results, the percentages of samples exceeding the chronic criterion for dissolved lead were substantially higher. For example, across the entire state of Washington and all 13 industrial categories, the percentages of samples that exceeded the chronic criterion were 93, 51, 33, and 13 percent given the typical receiving water conditions and dilution factors of 0, 10, 25, and 50, respectively.

Analyses of spatial patterns in the data indicate that the percentage of samples exceeding the water quality criterion for dissolved lead was higher in western Washington relative to eastern Washington (Table 21). For example, 32 percent of the samples in western Washington exceeded the criterion with the typical receiving water conditions and a dilution factor of 0, whereas only 17 percent of the samples exceeded the criterion in eastern Washington given the same receiving water conditions and dilution factor. A similar pattern was observed in the data when comparisons were made to the chronic criterion for dissolved lead (see Table 21).

Table 21. Percentage of total lead samples exceeding state water quality criteria given hypothetical receiving water conditions for eastern and western Washington and dilution factors of 0, 10, 25, and 50.

		Exceedance of Acute Std. (%)[a]				Exceedance of Chronic Std. (%)[a]			
	n	0 DF	10 DF	25 DF	50 DF	0 DF	10 DF	25 DF	50 DF
All Samples									
Western Washington	999	32 (17-40)	2 (2-3)	1 (1-2)	0 (0-1)	93 (89-97)	52 (45-79)	33 (18-62)	13 (9-47)
Eastern Washington	35	17 (11-23)	0 (0)	0 (0)	0 (0)	86 (69-91)	26 (23-51)	17 (11-26)	11 (6-23)
All Washington	1034	31 (17-39)	2 (2-3)	1 (1-2)	0 (0-1)	93 (89-97)	51 (44-78)	33 (18-61)	13 (9-46)
Samples with Values ≤ Benchmark									
Western Washington	909	25 (9-34)	0 (0)	0 (0)	0 (0)	93 (88-97)	47 (40-77)	27 (10-59)	5 (0-42)
Eastern Washington	29	0 (0-7)	0 (0)	0 (0)	0 (0)	83 (62-90)	10 (7-41)	0 (0-10)	0 (0-7)
All Washington	938	24 (9-33)	0 (0)	0 (0)	0 (0)	92 (87-96)	46 (39-76)	26 (9-57)	4 (0-41)

[a] Values represent the percentage of sample exceeding the water quality criteria based on representative receiving water conditions for the typical scenario (value not in parentheses) and the best and worst case scenarios (values in parentheses).
DF: Dilution factor.

In comparisons that were made between the four industrial categories in western Washington with a relatively large sample size (i.e., n > 25), the percentage of samples that exceeded the acute criterion for dissolved lead (see Table B-7) ranged from 24 percent for Light Industrial Activity (11) to 47 percent for Recycling Facilities (06), assuming the typical receiving water conditions and a dilution factor of 0. For the same four industrial categories in Western Washington, the percentage of samples that exceeded the chronic criterion ranged from 87 percent for Manufacturing (02) to 96 percent for both Recycling Facilities (06) and Transportation Facilities (08), assuming the same receiving water conditions and dilution factor. There were insufficient data to make comparisons between industrial categories in eastern Washington.

Samples with Concentrations Below the Benchmark

Analyses performed on the subset of samples with concentrations below the benchmark showed that the acute water quality criterion for dissolved lead was only exceeded when a dilution factor of 0 was assumed. More specifically, across the entire state of Washington and all 13 industrial categories, the percentage of samples that exceeded the acute criterion was 24 percent given the typical receiving water conditions and a dilution factor of 0 (see Table 21). This percentage dropped to 0 given the same receiving water conditions and a dilution factor of 10 or higher. In comparison to these results, the percentages of samples exceeding the chronic criterion for dissolved lead were substantially higher. For example, across the entire state of Washington and all 13 industrial categories, the percentages of samples that exceeded the chronic criterion were 92, 46, 26, and 4 percent given the typical receiving water conditions and dilution factors of 0, 10, 25, and 50, respectively.

Biological Oxygen Demand

Data Distribution

Tabular and graphical data summaries for BOD are provided in Table 22 and Figure 8, respectively, by individual industrial category and for all categories combined. Tabular industrial sector summaries for BOD are also provided in Appendix A. Overall, there were 1,105 BOD values present in the database with mean and median concentrations of 37 and 10 mg/L, respectively. The coefficient of variation for these data was 1.9. The box plots presented in Figure 8 indicate the BOD concentrations generally have a right-skewed distribution due to the presence of outliers in the upper end of the data range. Across all industrial categories, the 90^{th} percentile and maximum values for the data were 101 and 639 mg/L, respectively.

Comparison Among Industrial Categories

Sufficient amounts of data (i.e., $n > 25$) for statistical comparisons of BOD concentrations were available for three of the five industrial categories reporting data (Table 22). Results from these analyses (Table 12) indicate the data can be differentiated into two groups with low and high median BOD concentrations, respectively. Specifically, the median concentration for the Landfills (05) category was significantly lower than those for Manufacturing (02) and Light Industrial Activity (11).

Comparison to NPDES Permit Benchmarks and Action Levels

Analyses performed across the five industrial categories reporting BOD values showed that 25 and 16 percent of the samples exceeded the applicable benchmark (30 mg/L, 140 mg/L for non-hazardous waste landfills) and action level (60 mg/L), respectively (Table 22). Considering only the three industrial categories in Table 22 with a relatively large number of samples (i.e., $n > 25$), the benchmark was exceeded in 13 to 27 percent of the samples while the action level was exceeded in 0 to 17 percent.

Ammonia Nitrogen

Data Distribution

Tabular and graphical data summaries for ammonia nitrogen are provided in Table 23 and Figure 9, respectively, by individual industrial category and for all categories combined. Tabular

Table 22. Summary statistics for BOD measured in industrial stormwater by industry category.

Industrial Category	n	Mean (mg/L)	Median (mg/L)	Minimum (mg/L)	10th Percentile (mg/L)	90th Percentile (mg/L)	Maximum (mg/L)	Std. Dev. (mg/L)	Coefficient of Variation	Exceedance of Benchmark [a]	Exceedance of Action Level [b]
02 - Manufacturing	743	40	11	0.5	3	111	639	77	1.9	27%	17%
05 - Landfills	64	7.0	4.5	0.2	1.0	12	39	7.8	1.1	0%	--
08 - Transportation facilities	8	13	9.5	2.0	2	33	33	11	0.9	13%	0%
11 - Light industrial activity	275	35	12	2.0	3.3	100	340	58	1.7	27%	16%
No category specified	15	17	15	3.0	3.0	26	90	21	1.2	7%	7%
All categories	1,105	37	10	0.2	3.0	101	639	70	1.9	25%	16%

[a] Benchmark for BOD is 30 mg/L with the exception of category 05 which has a benchmark of 140 mg/L.
[b] Action level for BOD is 60 mg/L.

Table 23. Summary statistics for ammonia nitrogen measured in industrial stormwater by industry category.

Industrial Category	n	Mean (mg/L)	Median (mg/L)	Minimum (mg/L)	10th Percentile (mg/L)	90th Percentile (mg/L)	Maximum (mg/L)	Std. Dev. (mg/L)	Coefficient of Variation	Exceedance of Benchmark [a]	Exceedance of Action Level [b]
05 - Landfills	66	0.27	0.08	0.005	0.01	0.64	4.8	0.64	2.4	0%	0%
11 - Light industrial activity	4	6.9	8.7	0.10	0.1	10.21	10.2	4.8	0.7	0%	0%
All categories	70	0.65	0.10	0.005	0.01	0.96	10.2	1.9	3.0	0%	0%

[a] Benchmark for ammonia nitrogen is 21.8 mg/L, except for Landfills (05) which is 10 mg/L.
[b] Action level for ammonia nitrogen is 38 mg/L.

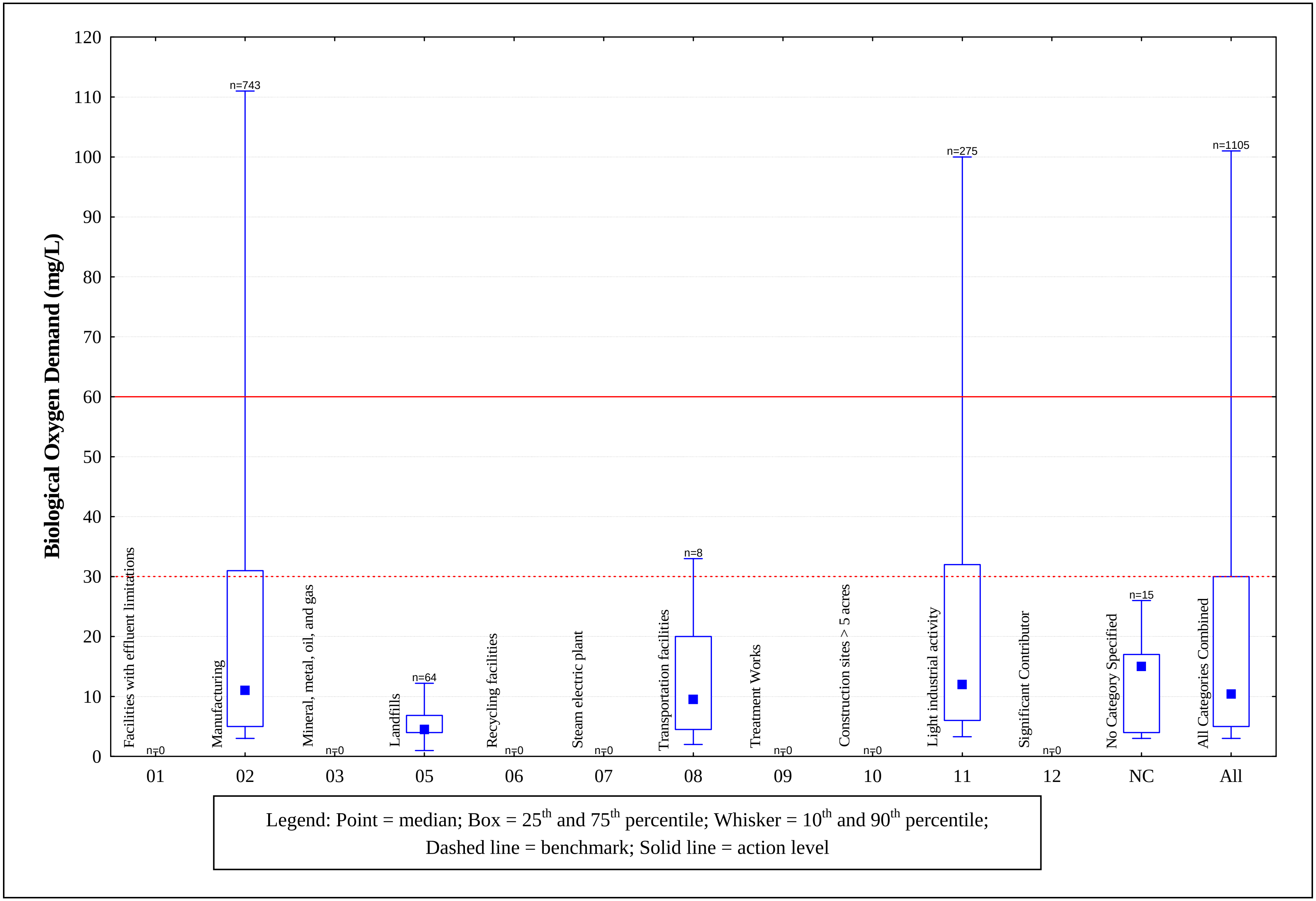
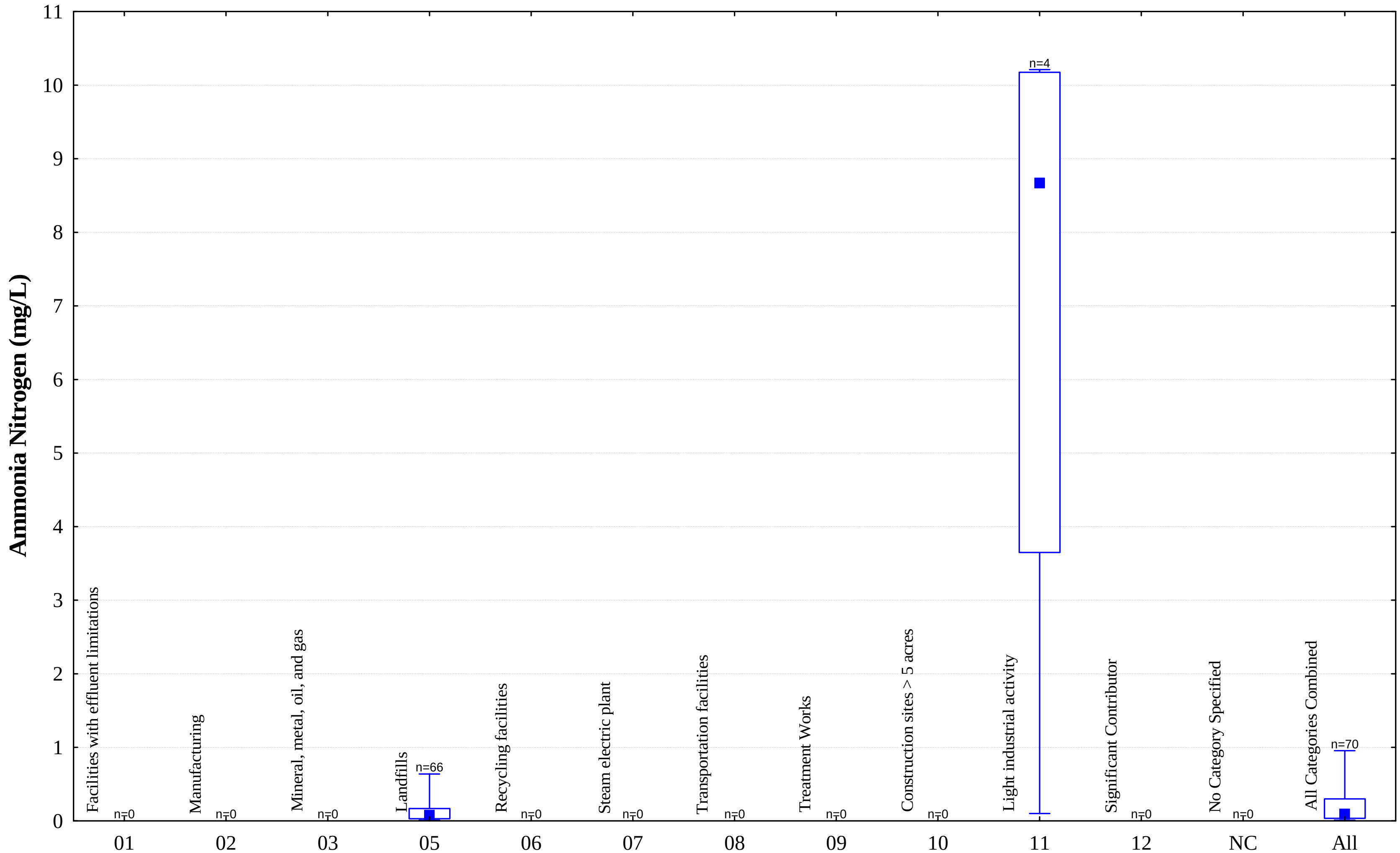


Figure 8. Biological oxygen demand concentrations measured in industrial stormwater by industrial category.



Legend: Point = median; Box = 25th and 75th percentile; Whisker = 10th and 90th percentile;
Note: The benchmark (21.8 mg/L) and action level (38 mg/L) are off scale

Figure 9. Ammonia nitrogen concentrations measured in industrial stormwater by industrial category.

summaries are also provided in Appendix A by industrial sector. Based on the 70 total ammonia nitrogen values present in the database, the mean and median concentrations for this parameter were 0.65 and 0.10 mg/L, respectively, across all the industrial categories; and the coefficient of variation was 3.0. Similarly, the 90^{th} percentile and maximum values were 0.96 and 10.2 mg/L, respectively.

Comparison Among Industrial Categories

Statistical comparisons of the median concentrations for ammonia nitrogen were not performed because there were insufficient numbers of samples.

Comparison to NPDES Permit Benchmarks and Action Levels

The applicable benchmarks (21.8 mg/L, 10 mg/L for non-hazardous waste landfills) and action level (38 mg/L) for ammonia nitrogen were not exceeded in any sample (Table 23).

Nitrate + Nitrite Nitrogen

Data Distribution

Tabular and graphical data summaries for nitrate + nitrite nitrogen are provided in Table 24 and Figure 10, respectively, by individual industrial category and for all categories combined. Tabular summaries for each industrial sector are also presented in Appendix A. Overall, there were 397 values for nitrate + nitrite nitrogen present in the database. The mean and median concentrations from these values were 2.2 and 0.5 mg/L, respectively: and the coefficient of variation was 4.0. The 90^{th} percentile value for the data was 3.1 mg/L. The maximum value (100 mg/L) represents an extreme outlier that may indicate that the associated value was incorrectly entered in the DMR or database.

Comparison Among Industrial Categories

Sufficient amounts of data (i.e., n > 25) for statistical comparisons of nitrate + nitrite nitrogen concentrations were only available for two of the industrial categories reporting nitrate + nitrite data: Manufacturing (02) and Light Industrial Activity (11). Results from these analyses (i.e., Mann Whitney U test) indicated that the median concentration for Manufacturing (02) was significantly higher than that for Light Industrial Activity (11).

Comparison to NPDES Permit Benchmarks and Action Levels

Exceedances of the applicable benchmark (0.68 mg/L) and action level (1.36 mg/L) for nitrate + nitrite occurred in 38 and 21 percent of the samples, respectively (Table 24). Considering only the two industrial categories in Table 24 with a relatively large number of samples (i.e., n > 25), the benchmark and action level were exceeded in 45 and 25 percent of the samples, respectively, for Manufacturing (02) and 34 and 20 percent of the samples, respectively, for Light Industrial Activity (11).

Table 24. Summary statistics for nitrate + nitrite nitrogen measured in industrial stormwater by industry category.

Industrial Category	n	Mean (mg/L)	Median (mg/L)	Minimum (mg/L)	10th Percentile (mg/L)	90th Percentile (mg/L)	Maximum (mg/L)	Std. Dev. (mg/L)	Coefficient of Variation	Exceedance of Benchmark [a]	Exceedance of Action Level [b]
02 - Manufacturing	142	2.5	0.6	0.01	0.18	4	83.7	9.5	3.8	45%	25%
08 - Transportation facilities	2	50	50	0.5	0.5	100	100	70	1.4	50%	50%
11 - Light industrial activity	249	1.6	0.4	0.01	0.061	2.68	61	5.3	3.3	34%	20%
No category specified	4	0.8	0.3	0.2	0.202	2.38	2.4	1.0	1.3	25%	25%
All categories	397	2.2	0.5	0.01	0.089	3.1	100	8.6	4.0	38%	21%

[a] Benchmark for nitrate + nitrite nitrogen is 0.68 mg/L.
[b] Action level for nitrate + nitrite nitrogen is 1.36 mg/L.

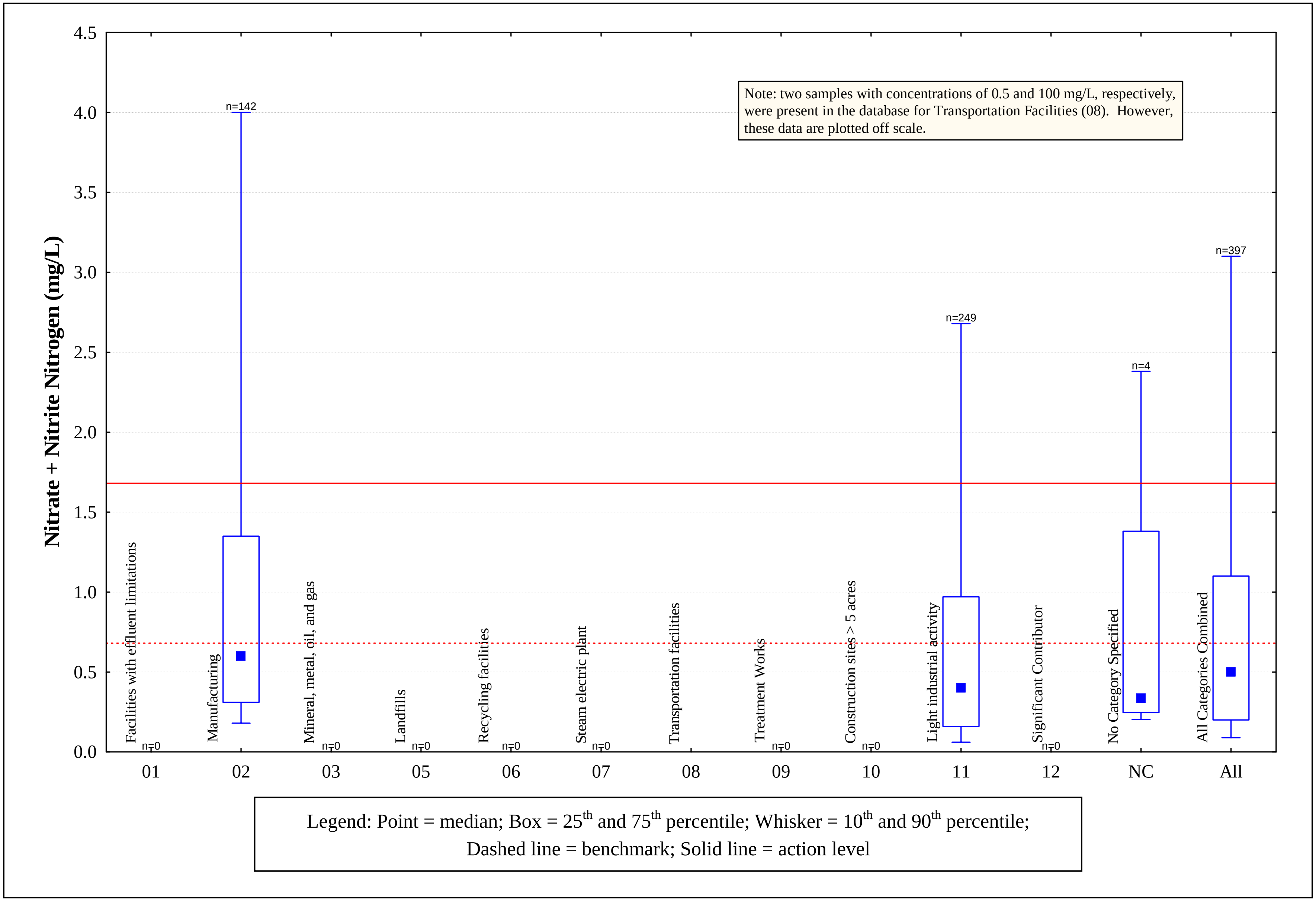


Figure 10. Nitrate + nitrite nitrogen concentrations measured in industrial stormwater by industrial category.

Total Phosphorus

Data Distribution

Tabular and graphical data summaries for total phosphorus are provided in Table 25 and Figure 11, respectively, by individual industrial category and for all categories combined. Tabular data summaries by industrial sector are also provided in Appendix A. Based on the 410 total phosphorus values in the database, the mean and median concentrations were 1.4 and 0.2 mg/L, respectively, across all five of the industrial categories reporting data; and the coefficient of variation was 5.2. For comparison, Stenstrom and Lee (2005) reported a mean value of 0.45 mg/L for total phosphorus concentrations based on data that were compiled through general NPDES industrial stormwater permits in the state of Connecticut. The coefficient of variation from the Connecticut, dataset was 4.3. The 90th percentile value for data compiled through this study was 2.5 mg/L. The maximum value (175 mg/L) represents an extreme outlier that may indicate that the associated value was incorrectly entered in the DMR or database.

Comparison Among Industrial Categories

Sufficient amounts of data (i.e., n > 25) for statistical comparisons of TP values were only available for the following two industrial categories: Manufacturing (02) and Light Industrial Activity (11). Results from these analyses indicated that the median concentration for Manufacturing (02) was significantly higher than that for Light Industrial Activity (11).

Comparison to NPDES Permit Benchmarks and Action Levels

As shown in Table 25, analyses performed for all five industrial categories reporting total phosphorus values showed that only 11 and 7 percent of the samples exceeded the applicable benchmark (2 mg/L) and action level (4 mg/L), respectively. Considering only the two industrial categories in Table 25 with a relatively large number of samples (i.e., n > 25), the benchmark and action level for TP was exceeded in 9 and 8 percent of the samples for Manufacturing (02) and 12 and 6 percent of the samples for Light Industrial Activity (11).

Construction Stormwater

Data analysis results for construction stormwater are summarized below. Specifically, separate subsections present results for each of the following analyses that are described in the Data Analysis Methods section: data distribution, comparison to NPDES permit benchmarks and action levels, and comparison to hypothetical water quality criteria (if applicable). As noted in the Data Sources section, the construction stormwater data presented herein were analyzed previously in Ecology (2005). Due to this consideration, this section only highlights the major trends from these data. For a more detailed analyses of these data, the reader should refer to the earlier Ecology report.

Table 25. Summary statistics for total phosphorus measured in industrial stormwater by industry category.

Industrial Category	n	Mean (mg/L)	Median (mg/L)	Minimum (mg/L)	10th Percentile (mg/L)	90th Percentile (mg/L)	Maximum (mg/L)	Std. Dev. (mg/L)	Coefficient of Variation	Exceedance of Benchmark [a]	Exceedance of Action Level [b]
02 - Manufacturing	135	1.8	0.13	0.004	0.05	1.3	137	12	6.7	9%	8%
06 - Recycling facilities	2	12	12	0.08	0.081	23	23	16	1.4	50%	50%
08 - Transportation facilities	2	3.2	3.2	1.2	1.2	5.1	5.1	2.8	0.9	50%	50%
11 - Light industrial activity	266	1.1	0.26	0.005	0.042	2.5	23	2.9	2.5	12%	6%
No category specified	5	0.08	0.05	0.04	0.044	0.18	0.2	0.06	0.7	0%	0%
All categories	410	1.4	0.2	0.004	0.05	2.5	137	7.3	5.2	11%	7%

[a] Benchmark for total phosphorus is 2 mg/L.
[b] Action level for total phosphorus is 4 mg/L.

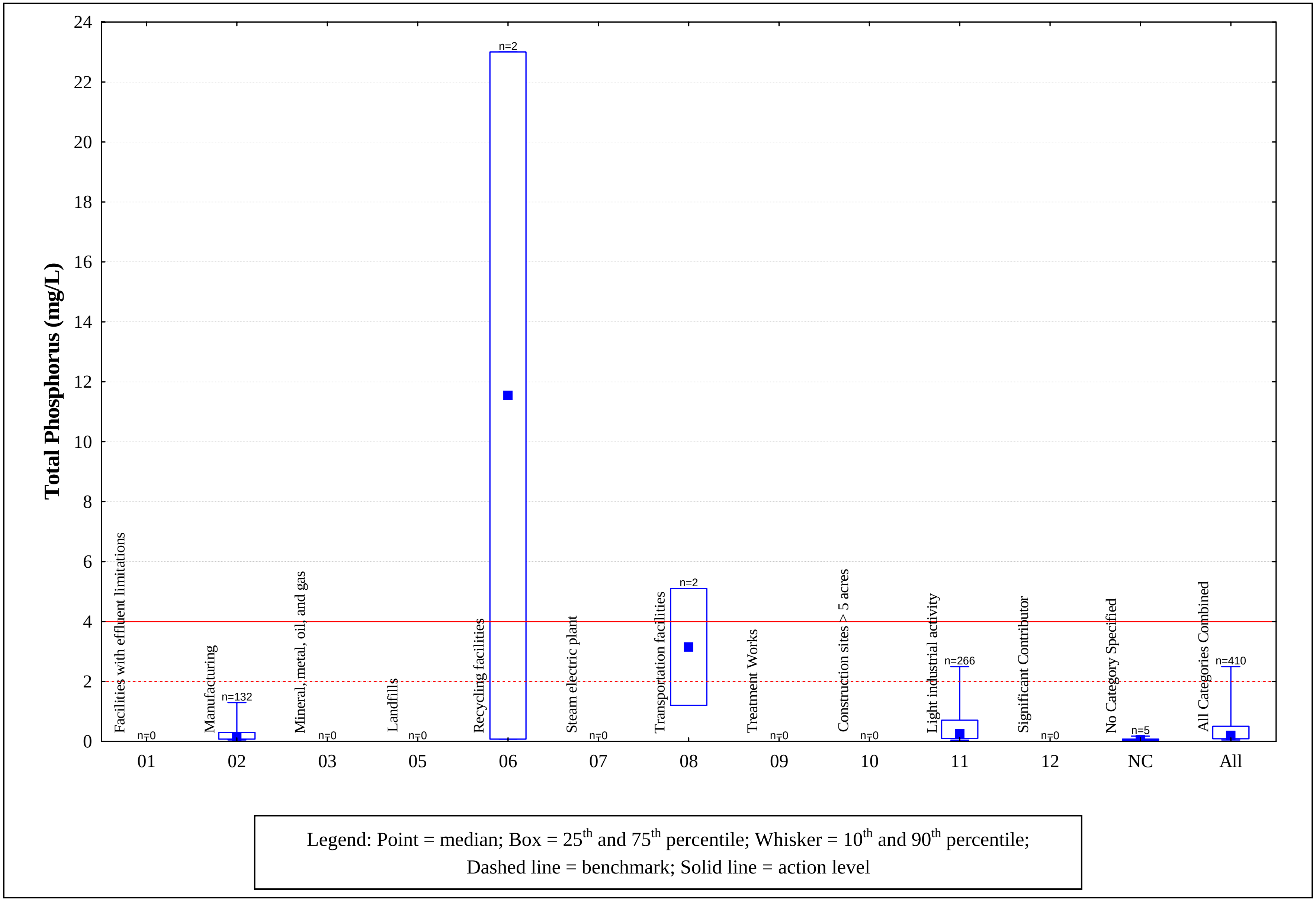


Figure 11. Total phosphorus concentrations measured in industrial stormwater by industrial category.

Data Distribution

A tabular summary for transparency, turbidity, and TSS data collected from Western Washington construction sites is provided in Table 26. In total, there were 47, 49, and 50 values for transparency, turbidity, and TSS, respectively, in the dataset. The mean and median values for transparency were 31 and 27 cm, respectively; and the coefficient of variation was 0.7. Similarly, the mean and median values for turbidity were 69 and 29 NTU, respectively; and the coefficient of variation was 1.3. Finally, the mean and median concentrations for TSS were 256 and 14 mg/L, respectively; and the coefficient of variation was 4.4.

Comparison to NPDES Permit Benchmarks and Action Levels

Turbidity was the only parameter monitored with associated benchmark values and action levels. Exceedances of the applicable benchmark (50 NTU) and action level (250 NTU) occurred in 29 and 6 percent of the samples, respectively.

Comparison to Hypothetical Water Quality Criteria

Results from the comparisons of sample concentrations to state water quality criteria for turbidity are summarized in Table 27. When all collected samples were considered in the analyses, the percentage of samples that exceeded the state water quality criterion for turbidity ranged from 86 to 6 percent given typical receiving water conditions and dilution factors of 0 and 50, respectively. Analyses performed on the subset of samples with concentrations below the benchmark showed that the water quality standard was only exceeded when a dilution factor of 0 was assumed.

Table 26. Summary statistics for transparency, turbidity, and TSS measured in stormwater from Western Washington construction sites.

Parameter	n	Mean	Median	Minimum	10th Percentile	90th Percentile	Maximum	Std. Dev.	Coefficient of Variation	Exceedance of Benchmark [a]	Exceedance of Action Level [b]
Transparency (cm)	47	31	27	0.7	4.6	60	60	22	0.7	--	--
Turbidity (NTU)	49	69	29	2.3	6.2	194	430	94	1.3	29%	6%
TSS (mg/L)	50	256	14	1.0	3.0	123	7470	1115	4.4	--	--

[a] Benchmark for turbidity is 50 NTU.
[b] Action level for turbidity is 250 NTU.

Table 27. Percentage of turbidity samples exceeding state water quality criterion at construction sites given hypothetical receiving water conditions for western Washington and dilution factors of 0, 2.5, 5, and 10.

	n	Exceedance of Criterion (%)			
		0 DF	10 DF	25 DF	50 DF
All Samples					
Western Washington	49	86 (73-90)	27 (27-29)	18 (18)	6 (6)
Samples with Values ≤ Benchmark					
Western Washington	35	80 (63-86)	0 (0)	0 (0)	0 (0)

DF: Dilution factor.
[a] Values represent the percentage of sample exceeding the water quality criterion based on representative receiving water conditions for the typical scenario (value not in parentheses) and the best and worst case scenarios (values in parentheses).

Discussion and Conclusion

This section provides a discussion of the data presented herein and summarizes major conclusions from these data relative to the study objectives that were identified in the introduction to this report. To maintain consistency with the previous section, this information is presented under separate subsections for each of the following analyses: data distribution, comparison among industrial categories, comparison to NPDES permit benchmarks and action levels, and comparison to state water quality standards.

Data Distribution

In general, the analyses presented in this report indicate that most of the industrial stormwater parameters exhibited a distinctly right-skewed distribution due to the presence of numerous outliers in the upper end of the data range. This distribution is commonly observed in water quality data that are collected during storm sampling due to the influence of sporadic, high flow events that are associated with high pollutant concentrations. Furthermore, the maximum concentrations for several of the parameters (e.g., total zinc, total copper, nitrate + nitrite nitrogen, total phosphorus) appeared to be extreme outliers that may indicate that the associated values were incorrectly entered in the DMR or database.

The results also indicate that the data for many of the industrial and construction stormwater parameters exhibit a very high degree of variability. For example, the coefficients of variation calculated from these data ranged from 0.12 for pH to 7.06 for total zinc. Similarly, the coefficients of variation calculated from the compiled construction stormwater data ranged from 0.7 for transparency to 4.4 for total suspended solids. The high degree of variability in these data is generally consistent with the findings from other studies of compiled data from general NPDES industrial stormwater permits. For example, Strenstrom and Lee (2005) reported coefficients of variation ranging from 0.2 to 17 for data from a suite of sixteen monitoring parameters that were compiled through general NPDES industrial stormwater permits in the following jurisdictions: Los Angeles County, CA; Sacramento County, CA; and the state of Connecticut.

As noted previously, the available data for the construction stormwater parameters are extremely limited in terms of the total number of samples and geographic coverage. Therefore, additional data are required for these parameters in order to draw more definitive conclusions regarding their associated distributions.

Comparisons Among Industrial Categories

Statistical analyses indicated there were significant differences in median concentrations among industrial categories for all the parameters that were evaluated, with the exception of total copper. (As noted previously, these analyses could not be performed for ammonia nitrogen because there were insufficient data.) However, even where there were significance differences between industrial categories, the overall utility of this information was limited because few meaningful patterns could be discerned in the results from the multiple range tests (see Table 12). More specifically, these tests generally showed little consistency with regard to the industrial categories that were identified as having high or low concentrations across all the parameters or within particular categories parameters (e.g., metals). The only possible exceptions to this broad generalization were observed for the following three industrial categories: Recycling Facilities (06), Treatment Works (09), and Transportation Facilities (11). Recycling Facilities (06) and Transportation Facilities (11) appeared to be differentiated from the majority of other categories due to high turbidity levels and high oil and grease concentrations, whereas Treatment Works (09) could be differentiated based on low total zinc and oil and grease concentrations.

It should be noted that the industrial categories are groupings of different types of facilities at a very broad level. For example, the following industrial sectors from Table 2 are all grouped under the Manufacturing (02) industrial category: Lumber and Wood Products (24--), Chemical and Allied Products (26--), and Primary Metals Industries (33--). Therefore, it is possible that more meaningful results could be obtained if additional comparisons were made at the industrial sector level. However, due to the large number of industrial sectors that are represented in the database and the associated inconsistencies in the amount of available data (see Tables 2 and 5), it was not practical to collectively analyze the industrial sectors using the conventional statistics that were applied in the comparisons of the industrial categories.

Comparison to NPDES Permit Benchmarks and Action Levels

With the exception of ammonia nitrogen, all of the primary monitoring parameters identified in the general NPDES permit for industrial stormwater were measured at levels that exceeded the benchmarks and action thresholds. However, there was a large range in terms of the frequency and magnitude of the exceedances exhibited for each of the parameters. Each parameter was classified as being of high, moderate, and low concern based on the frequency of these exceedances. Specifically, total zinc is identified as the only parameter of high concern because over 50 percent of the associated samples exceeded the applicable benchmark and 21 percent exceeded the action level. Turbidity, total copper, BOD, and nitrate + nitrite nitrogen are identified as being of moderate concern because between 20 and 50 percent of the samples exceeded the benchmark. Finally, pH, oil and grease, total lead, total phosphorus, and ammonia nitrogen are classified as being of low concern because less than 20 percent of the collected samples exceeded the applicable benchmark.

The results for construction stormwater also showed that the applicable benchmark for turbidity was routinely exceeded. However, due to the limited number of samples in this data set, it is difficult to make definitive conclusions regarding the level of concern that should be applied to this parameter.

Comparison to Hypothetical Water Quality Criteria

The existing data compiled through the general NPDES permit for industrial and construction stormwater cannot be used to assess compliance with state water quality standards. The following is a list of the information that would be required in order to make these determinations. Only one of these (i.e., effluent pollutant concentration) is available through the current NPDES permit database.

- Effluent pollutant concentration
- Effluent discharge rate
- Receiving water background pollutant concentration
- Receiving water discharge rate
- Receiving water hardness concentration (for metals only)
- Appropriate translator values (for metals only).

In an effort to further evaluate this question, a set of representative receiving water conditions was generated for each monitoring parameter based on queries of Ecology's EIM database and values from the literature. These representative receiving water conditions were then used to evaluate whether hypothetical water quality criteria would be exceeded given the actual effluent pollutant concentration from the permits and by assuming different dilution factors within the receiving water. However, it should be recognized that this approach seeks to make broad generalizations for processes that are driven almost entirely by site-specific conditions and interactions.

Furthermore, there are several assumptions used in this simplified approach that warrant further discussion, the first being potential correlations between input parameters. Specifically, in highly developed watersheds, background pollutant concentrations frequently show a positive correlation with discharge in the receiving water (Herrera 2001, 2004, 2005). This would tend to make it more difficult to meet water quality criteria for some parameters (e.g., metals) and more easy for other parameters (e.g., turbidity). In addition, hardness frequently shows a negative correlation with discharge due to dilution of ground water inputs to the receiving water that have naturally high mineral concentrations. This would tend to make it more difficult to meet water quality criteria for metals. These relationships were not fully captured in this approach to assessing water quality criteria, although the associated sensitivity analyses do provide some measure of the potential impact. For example, the worst case scenario used higher pollutant concentrations and lower hardness values relative to the typical scenario which, as noted above, are the conditions that would likely prevail if the correlations described above are present in the data.

Another assumption in this approach that warrants further discussion relates to the translator values that were used to estimate dissolved metal concentrations in the receiving water from total metal concentrations in the effluent. The translator values used in this analysis were taken from Pelletier (1996) and represent the 95th percentile value for the predicted dissolved metal concentration in the receiving water. Thus, they provide a conservative estimate relative to what might be expected if the translator values were predicting an average or median concentration.

To evaluate the effect of this assumption on the overall results of this analysis, the EIM database was queried to obtain data on the dissolved and total fractions of zinc from samples collected in western and eastern Washington, respectively. The average ratio of these fractions was then computed for each region (i.e., 0.362 and 0.660 for eastern and western Washington, respectively) and used in place of the values from Pelletier (1996) to predict the percentage of samples exceeding the state water quality standard based on the typical receiving water scenario and a dilution factor of 0. This analysis showed the translator values have a modest impact on the overall results for zinc. For example, the percentages of samples in western Washington that exceeded the water quality criterion for zinc were 84 and 60 percent using the Pelletier (1996) and alternative translator values, respectively. Similarly, the percentages of samples in eastern Washington that exceeded the criterion were 70 and 60 percent using the Pelletier (1996) and alternative translator values, respectively.

A relatively wide range of dilution factors was used in this analysis (i.e., 0, 10, 25, and 50) in order to determine the minimum required dilution necessary to meet water quality criteria. However, the actual dilution factor required to meet water quality criteria can also be calculated for each parameter given its associated benchmark and assumed receiving water conditions. For reference, these required dilution factors are presented in Table 28.

Table 28. Dilution factors required to meet water quality criteria assuming effluent concentrations equal the benchmarks specified in the general NPDES permit for construction and industrial stormwater.

	Turbidity [a]	Zinc [b]		Copper [c]		Lead [d]		Turbidity [e]
		Acute	Chronic	Acute	Chronic	Acute	Chronic	
Western Washington								
Worst-Case	4.7	5.1	5.8	33	56	4.0	190	9.7
Typical	4.2	3.4	3.8	17	23	2.7	76	9.2
Best-Case	3.0	2.4	2.6	10	14	1.8	48	8.0
Eastern Washington								
Worst-Case	4.7	6.0	8.5	12	18	1.9	75	--
Typical	4.2	1.4	1.6	5.7	8.4	0.9	25	--
Best-Case	3.0	0.9	1.0	3.0	4.5	0.6	15	--

[a] Required dilution factors assuming benchmark for turbidity from the general NPDES permit for industrial stormwater (25 NTU).
[b] Required dilution factors assuming benchmark for zinc from the general NPDES permit for industrial stormwater (117 μg/L).
[c] Required dilution factors assuming benchmark for copper from the general NPDES permit for industrial stormwater (63.8 μg/L).
[d] Required dilution factors assuming benchmark for lead from the general NPDES permit for industrial stormwater (81.6 μg/L).
[e] Required dilution factors assuming benchmark for turbidity from the general NPDES permit for construction stormwater (50 NTU).

The results from the analyses of the industrial stormwater data indicate that a high percentage of samples exceed the water quality criteria when dilution factors of 0 and 10 are assumed. Total copper is of particular concern given that over 90 percent of the samples in both eastern and western Washington exceeded the acute and chronic criteria with a dilution factor of 0. Total zinc and turbidity are identified as being of moderate concern with between 40 and 90 percent of the samples in both eastern and western Washington exceeding the associated criteria with a dilution factor of 0. Finally, lead is identified as being of lower concern with less than 40 percent of the samples exceeding the acute criterion in both eastern and western Washington with a dilution factor of 0. However, it should be noted that a high percentage of samples (> 90 percent) still exceeded the chronic criterion for lead with a dilution factor of 0. The percentage of exceedance for all parameters dropped to less than 35 percent with a dilution factor of 25, and less than 15 percent with a dilution factor of 50. Based on these results, it can be concluded that, when little or no dilution is available in the receiving water, discharges of industrial stormwater may be contributing to exceedances of the water quality criteria; however, the number of exceedances drops rapidly when relatively moderate levels of dilution are available.

Analyses performed on the subset of samples from industrial stormwater with concentrations below the benchmark showed that the water quality criteria were typically only exceeded when a dilution factor of 0 was assumed. The only notable exception was the chronic criterion for dissolved lead which exhibited a fairly high percentage of sample exceedances with a dilution factor of 10 in addition to a dilution factor of 0. These results suggest that water quality criteria are generally met if the benchmark values are achieved by the permittees, and a relatively small amount of dilution is assumed in the receiving water.

Analyses performed on the construction stormwater data showed similar trends to those observed for the industrial stormwater data. Specifically, a high percentage of samples exceed the water quality criterion for turbidity when dilution factors of 0 and 10 are assumed; however, the percentage of exceedance dropped off rapidly with higher dilution factors. Analyses performed on the subset of samples with concentrations below the benchmark showed that the water quality criterion was only exceeded when a dilution factor of 0 was assumed.

References

40 CFR 122.26. 1998. Storm water discharges (applicable to State NPDES programs, see 123.25). Code of Federal Regulations.

Ecology. 2005. Stormwater Quality Survey of Western Washington Construction Sites, 2003-2005. Publication No. 05-03-028. Washington State Department of Ecology, Olympia, Washington.

Ecology. 2006. Database retrieval: Water quality data from river systems for hardness, total suspended solids, turbidity, total zinc, total copper, and total lead. Environmental Information Management (EIM) system (<http://www.ecy.wa.gov/eim/index.htm>), Washington State Department of Ecology, Olympia, Washington. March 17, 2006.

Helsel, D.R. and R.M. Hirsch. 1992. Statistical Methods in Water Resources. Studies in Environmental Science 49. Elsevier Publications.

Herrera. 2001. Five-Year Project Report: City of Des Moines Water Quality Monitoring Program. Prepared for the City of Des Moines by Herrera Environmental Consultants, Inc., Seattle, Washington.

Herrera. 2004. Years 2001-2002 Water Quality Data Report: Green Duwamish Watershed Water Quality Assessment. Prepared for King County Department of Natural Resources by Herrera Environmental Consultants, Inc., Seattle, Washington.

Herrera. 2005. Year 2003 Water Quality Data Report: Green Duwamish Watershed Water Quality Assessment. Prepared for King County Department of Natural Resources by Herrera Environmental Consultants, Inc., Seattle, Washington.

Pelletier, G. 1996. Applying Metals Criteria to Water Quality-Based Discharge Limits, Empirical Models of the Dissolved Fraction of Cadmium, Copper, Lead, and Zinc. Watershed Assessments Section, Environmental Investigations and Laboratory Services Program, Washington State Department of Ecology, Olympia, Washington.

Stenstrom, M. K. and H. Lee. 2005. Industrial Storm Water Monitoring Program – Existing Statewide Permit Utility and Proposed Modifications. Final Report. University of California, Civil and Environmental Engineering Department, Los Angeles, California.

U.S. EPA. 2006. Sectors of Industrial Activity that Require Permit Coverage. Obtained February 7 from U.S. Environmental Protection Agency (U.S. EPA) website: <http://cfpub.epa.gov/npdes/stormwater/swcats.cfm>. February 7, 2006.

WAC 173-201A. 2003. Water Quality Standards for Surface Waters of the State of Washington. Washington Administrative Code. July 1, 2003.

Zar, J.H. 1984. Biostatistical Analysis. 2nd edition. Prentice Hall, Inc., Englwood Cliffs, New Jersey.

APPENDIX A

Summary Statistics for Monitoring Parameters Measured In Industrial Stormwater by Industry Sector

Table A-1. Summary statistics for turbidity levels measured in industrial stormwater by industry sector.

SIC	Sector	# of facilities	# of values	Mean (NTU)	Median (NTU)	Minimum (NTU)	Maximum (NTU)	Std. Dev. (NTU)	Coefficient of variation	Exceedance of benchmark[a]	Exceedance of action level[b]
07	Agricultural services	1	5	24	16	9.8	60	21	0.9	0%	0%
08	Forestry	1	7	31	2.5	1.5	149	56	1.8	29%	29%
10	Metal mining	1	1	52	52	52	52	--	--	100%	100%
12	Coal mining	1	9	3	2.7	1.3	10	3	0.8	0%	0%
17	Construction special trade contractors	3	19	171	27	3.9	778	240	1.4	58%	37%
20	Food and kindred products	40	268	103	22	0.1	5490	402	3.9	46%	28%
22	Textile mill products	3	12	20	12	1.7	52	18	0.9	33%	8%
23	Apparel and other finished products made from fabrics and similar material	1	6	51	44	18	85	26	0.5	83%	33%
24	Lumber and wood products	127	799	129	27	0.2	9700	452	3.5	51%	33%
25	Furniture and fixtures	3	14	25	22	4.8	91	25	1.0	29%	14%
26	Paper and allied products	14	77	21	10	0.5	190	33	1.5	21%	13%
27	Printing, publishing and allied industries	2	10	11	6.8	1.2	33	11	1.0	20%	0%
28	Chemicals and allied products	40	226	28	14	0.4	193	36	1.3	31%	16%
29	Petroleum and coal products	6	27	55	28	2.3	220	64	1.2	56%	37%
30	Rubber and miscellaneous plastic products	37	207	32	15	0.5	460	51	1.6	34%	20%
31	Leather and leather products	1	4	10	10	4.1	16	5	0.5	0%	0%
32	Stone, clay and glass products	23	109	51	16	0.3	980	116	2.3	41%	23%
33	Primary metals industries	13	75	28	12	0.5	580	72	2.6	23%	11%
34	Fabricated metal products	62	307	48	18	0.2	1150	114	2.4	39%	19%
35	Industrial & commercial machinery & computer equip.	28	86	32	14	0.05	235	52	1.6	33%	16%
36	Electronic and other electrical equipment	7	63	13	6.5	0.5	78	17	1.2	16%	5%
37	Transportation equipment	33	343	23	8.4	0.5	560	61	2.6	18%	8%
38	Measuring, analyzing, and controlling instruments; photographic, medical and optical goods; watches and clocks	1	8	6	5.2	1.5	11	3	0.6	0%	0%
39	Miscellaneous manufacturing industries	6	24	23	11	1.2	80	24	1.1	33%	17%
40	Railroad transportation	11	54	115	34	0.6	1990	292	2.5	57%	39%
41	Local and interurban passenger transportation	23	101	35	12	1.5	490	76	2.2	29%	15%
42	Motor freight transportation & warehousing	108	529	116	23	0.3	5380	423	3.7	48%	30%
44	Water transportation	30	151	39	18	0.3	343	56	1.4	39%	21%
45	Transportation by air	21	154	19	5.3	0	690	64	3.3	13%	7%
47	Transportation services	2	4	133	115	50	250	87	0.7	100%	75%
49	Electric, gas, and sanitary services	42	250	23	8.0	0.4	640	56	2.5	17%	9%
50	Wholesale trade-durable goods	63	289	57	19	0	710	103	1.8	42%	27%
51	Wholesale trade non-durable goods	23	89	29	14	0.1	676	74	2.5	28%	9%
52	Building materials, hardware, garden supply, and mobile home dealers	2	2	101	101	2.1	200	140	1.4	50%	50%
82	Educational services	1	1	4	3.8	3.8	3.8	--	--	0%	0%
95	Environmental quality programs	2	12	11	11	2.5	28	8	0.7	8%	0%
	No sector specified	26	137	38	8.4	0.7	1190	118	3.1	24%	15%

[a] Benchmark for turbidity is 25 NTU

[b] Action level for tubidity is 50 NTU

Table A-2. Summary statistics for pH levels measured in industrial stormwater by industry sector.

SIC	Sector	# of facilities	# of values	Mean	Median	Minimum	Maximum	Std. Dev.	Coefficient of variation	Exceedance of benchmark[a]	Exceedance of action level[b]
07	Agricultural services	1	5	7.7	7.8	6.5	8.4	0.71	0.09	0%	0%
08	Forestry	1	7	5.8	6.0	5.0	6.5	0.49	0.08	43%	0%
10	Metal mining	1	1	7.2	7.2	7.2	7.2	--	--	0%	0%
12	Coal mining	1	9	7.8	8.0	7.5	8.0	0.23	0.03	0%	0%
17	Construction special trade contractors	3	19	6.9	6.9	6.0	8.7	0.76	0.11	0%	0%
20	Food and kindred products	40	265	6.6	6.7	3.8	9.7	0.77	0.12	15%	3%
22	Textile mill products	3	12	6.5	6.7	5.3	7.3	0.60	0.09	17%	0%
23	Apparel and other finished products made from fabrics and similar material	1	6	6.0	6.0	6.0	6.0	0.00		0%	0%
24	Lumber and wood products	127	784	6.5	6.5	2.0	9.8	0.91	0.14	19%	3%
25	Furniture and fixtures	3	14	6.5	6.5	5.6	7.2	0.51	0.08	14%	0%
26	Paper and allied products	14	80	6.7	6.9	4.0	9.1	0.80	0.12	19%	4%
27	Printing, publishing and allied industries	2	10	6.2	6.4	5.0	7.0	0.76	0.12	20%	0%
28	Chemicals and allied products	40	226	6.7	6.8	4.3	10.7	0.92	0.14	14%	4%
29	Petroleum and coal products	6	27	6.8	7.0	5.4	7.9	0.73	0.11	19%	0%
30	Rubber and miscellaneous plastic products	37	206	6.2	6.1	4.0	8.4	0.72	0.12	23%	1%
31	Leather and leather products	1	4	7.1	7.2	6.9	7.2	0.14	0.02	0%	0%
32	Stone, clay and glass products	23	111	7.0	7.0	3.9	11.6	1.04	0.15	9%	4%
33	Primary metals industries	13	76	6.8	7.0	3.2	8.6	1.03	0.15	7%	4%
34	Fabricated metal products	62	300	6.7	6.8	2.3	9.9	0.95	0.14	15%	3%
35	Industrial & commercial machinery & computer equip.	28	91	6.7	6.7	2.6	8.5	0.86	0.13	13%	1%
36	Electronic and other electrical equipment	7	65	6.8	7.0	2.7	8.0	0.83	0.12	8%	3%
37	Transportation equipment	33	344	6.7	6.8	3.8	10.0	0.65	0.10	10%	0.3%
38	Measuring, analyzing, and controlling instruments; photographic, medical and optical goods; watches and clocks	1	8	6.6	6.5	6.0	7.0	0.42	0.06	0%	0%
39	Miscellaneous manufacturing industries	6	24	6.3	6.3	5.0	8.4	0.99	0.16	33%	0%
40	Railroad transportation	11	54	6.6	6.6	5.5	10.2	0.79	0.12	9%	2%
41	Local and interurban passenger transportation	23	100	6.6	6.6	4.8	8.5	0.69	0.10	10%	1%
42	Motor freight transportation & warehousing	108	526	6.6	6.5	1.0	9.0	0.77	0.12	12%	1%
44	Water transportation	30	151	6.9	6.9	5.0	9.8	0.74	0.11	7%	0%
45	Transportation by air	21	137	6.9	6.9	4.5	10.6	0.88	0.13	10%	2%
47	Transportation services	2	4	7.0	7.0	6.0	8.1	0.95	0.14	0%	0%
49	Electric, gas, and sanitary services	42	250	6.9	7.0	5.0	9.3	0.59	0.09	6%	0.4%
50	Wholesale trade-durable goods	63	289	6.8	6.9	2.2	10.0	0.79	0.12	8%	1%
51	Wholesale trade non-durable goods	23	88	6.5	6.5	5.0	7.6	0.61	0.09	16%	0%
52	Building materials, hardware, garden supply, and mobile home dealers	2	2	5.8	5.8	5.0	6.5	1.06	0.18	0%	0%
82	Educational services	1	1	6.6	6.6	6.6	6.6	--	--	0%	0%
95	Environmental quality programs	2	12	7.0	6.9	6.5	7.7	0.36	0.05	0%	0%
	No sector specified	26	132	6.5	6.6	4.4	8.2	0.73	0.11	14%	1%

[a] Benchmark for pH is <6 or >9

[b] Action level for pH is <5 or >10

Table A-3. Summary statistics for total zinc concentrations measured in industrial stormwater by industry sector.

SIC	Sector	# of facilities	# of values	Mean (µg/L)	Median (µg/L)	Minimum (µg/L)	Maximum (µg/L)	Std. Dev. (µg/L)	Coefficient of variation	Exceedance of benchmark[a]	Exceedance of action level[b]
07	Agricultural services	1	5	12	10	0.01	40	16	1.4	0%	0%
08	Forestry	1	4	16	9.0	0.021	47	21	1.3	0%	0%
10	Metal mining	1	1	297	297	297	297	--	--	100%	0%
12	Coal mining	1	9	42	11	2.0	220	69	1.6	11%	0%
17	Construction special trade contractors	3	19	379	392	0.98	1040	278	0.7	79%	53%
20	Food and kindred products	40	269	362	204	0.12	2882	449	1.2	69%	29%
22	Textile mill products	3	12	585	288	87	3400	912	1.6	92%	42%
23	Apparel and other finished products made from fabrics and similar material	1	6	288	225	94	561	191	0.7	83%	33%
24	Lumber and wood products	127	734	224	119	0.362	2600	312	1.4	50%	17%
25	Furniture and fixtures	3	12	144	49	10	800	230	1.6	25%	8%
26	Paper and allied products	14	79	300	90	8	7950	922	3.1	41%	16%
27	Printing, publishing and allied industries	2	10	84	77	0.149	250	69	0.8	20%	0%
28	Chemicals and allied products	40	221	328	179	0.02	8110	643	2.0	61%	27%
29	Petroleum and coal products	6	23	344	140	20.8	2600	558	1.6	57%	22%
30	Rubber and miscellaneous plastic products	37	202	318	160	5.0	2960	435	1.4	62%	22%
31	Leather and leather products	1	4	40	32	12.4	82	31	0.8	0%	0%
32	Stone, clay and glass products	23	100	920	135	0.03	39400	4497	4.9	56%	16%
33	Primary metals industries	13	76	346	100	1.0	5160	881	2.5	41%	14%
34	Fabricated metal products	62	291	2593	310	1.58	130000	11964	4.6	75%	45%
35	Industrial & commercial machinery & computer equip.	28	79	409	96	0.0	9410	1245	3.0	43%	16%
36	Electronic and other electrical equipment	7	65	289	88	5.0	3500	642	2.2	37%	14%
37	Transportation equipment	33	329	249	120	0.05	5300	496	2.0	52%	16%
38	Measuring, analyzing, and controlling instruments; photographic, medical and optical goods; watches and clocks	1	8	24	20	2.0	56	18	0.8	0%	0%
39	Miscellaneous manufacturing industries	6	24	244	169	19	1200	276	1.1	67%	17%
40	Railroad transportation	11	50	290	183	0.34	1800	339	1.2	70%	22%
41	Local and interurban passenger transportation	23	101	173	103	4.7	1210	193	1.1	46%	10%
42	Motor freight transportation & warehousing	108	502	377	162	0.14	16200	1023	2.7	62%	21%
44	Water transportation	30	145	380	244	0.7	4000	515	1.4	74%	34%
45	Transportation by air	21	146	230	50	1.56	6300	694	3.0	32%	12%
47	Transportation services	2	4	1134	283	71	3900	1848	1.6	75%	50%
49	Electric, gas, and sanitary services	42	224	138	37	0.002	4400	361	2.6	21%	7%
50	Wholesale trade-durable goods	63	276	317	120	2.0	6410	587	1.9	53%	23%
51	Wholesale trade non-durable goods	23	88	323	168	0.37	3110	500	1.5	63%	23%
52	Building materials, hardware, garden supply, and mobile home dealers	2	1	7840	7840	7840	7840	--	--	100%	100%
82	Educational services	1	1	19	19	19	19	--	--	0%	0%
95	Environmental quality programs	2	12	99	72	20	300	91	0.9	25%	0%
	No sector specified	26	132	533	150	0.255	18200	1790	3.4	58%	28%

[a] Benchmark for zinc is 117 µg/L

[b] Action level for zinc is 372 µg/L

Table A-4. Summary statistics for oil and grease concentrations measured in industrial stormwater by industry sector.

SIC	Sector	# of facilities	# of values	Mean (mg/L)	Median (mg/L)	Minimum (mg/L)	Maximum (mg/L)	Std. Dev. (mg/L)	Coefficient of variation	Exceedance of benchmark[a]	Exceedance of action level[b]
07	Agricultural services	1	5	3.6	5.0	1.0	5.0	1.9	0.5	0%	0%
10	Metal mining	1	1	1.8	1.8	1.8	1.8	--	--	0%	0%
12	Coal mining	1	9	1.3	1.0	1.0	2.0	0.4	0.3	0%	0%
17	Construction special trade contractors	3	5	5.5	6.6	2.0	7.2	2.1	0.4	0%	0%
20	Food and kindred products	40	213	8.7	5.0	1.0	151.0	14.4	1.7	12%	5%
22	Textile mill products	3	9	4.6	5.0	3.0	5.0	0.9	0.2	0%	0%
23	Apparel and other finished products made from fabrics	1	2	3.6	3.6	3.6	3.6	--	--	0%	0%
24	Lumber and wood products	127	382	7.2	5.0	0.0	120.0	10.3	1.4	8%	2%
25	Furniture and fixtures	3	9	5.5	5.3	5.0	5.9	0.3	0.1	0%	0%
26	Paper and allied products	14	69	5.1	3.7	1.0	70.0	8.4	1.7	3%	1%
28	Chemicals and allied products	40	156	4.8	4.3	0.3	26.0	4.1	0.9	3%	0%
29	Petroleum and coal products	6	18	7.8	5.0	1.0	41.0	9.1	1.2	11%	6%
30	Rubber and miscellaneous plastic products	37	129	5.0	4.0	0.0	39.1	5.5	1.1	4%	2%
31	Leather and leather products	1	4	5.6	5.4	5.4	6.0	0.3	0.1	0%	0%
32	Stone, clay and glass products	23	51	6.3	5.0	1.0	34.0	6.3	1.0	6%	4%
33	Primary metals industries	13	54	2.8	2.0	0.0	9.6	2.1	0.8	0%	0%
34	Fabricated metal products	62	192	7.1	5.0	0.0	83.3	8.3	1.2	8%	3%
35	Industrial & commercial machinery & computer equip.	28	36	12.9	5.1	0.0	106.0	20.9	1.6	19%	8%
36	Electronic and other electrical equipment	7	53	4.5	5.0	0.0	5.4	1.3	0.3	0%	0%
37	Transportation equipment	33	197	2.5	1.0	0.0	38.0	3.6	1.4	1%	1%
38	Measuring, analyzing, and controlling instruments;	1	8	1.3	1.0	1.0	2.7	0.7	0.5	0%	0%
39	Miscellaneous manufacturing industries	6	11	7.8	7.1	1.0	16.0	4.2	0.5	9%	0%
40	Railroad transportation	11	26	7.3	6.5	2.0	18.8	4.3	0.6	12%	0%
41	Local and interurban passenger transportation	23	54	14.6	5.0	1.0	223.0	37.6	2.6	13%	9%
42	Motor freight transportation & warehousing	108	302	8.6	5.0	1.0	359.0	22.0	2.6	10%	4%
44	Water transportation	30	92	12.1	5.0	0.0	561.0	57.9	4.8	4%	1%
45	Transportation by air	21	74	6.3	5.0	1.0	96.3	11.2	1.8	4%	1%
47	Transportation services	2	3	20.9	7.9	6.9	48.0	23.4	1.1	33%	0%
49	Electric, gas, and sanitary services	42	153	12.5	5.0	1.0	914.0	75.5	6.0	5%	3%
50	Wholesale trade-durable goods	63	191	12.5	5.0	0.8	232.0	27.4	2.2	17%	8%
51	Wholesale trade non-durable goods	23	67	6.8	5.0	1.0	82.0	10.3	1.5	3%	3%
52	Building materials, hardware, garden supply, and mobile	2	1	7.1	7.1	7.1	7.1	--	--	0%	0%
95	Environmental quality programs	2	9	2.6	2.5	2.5	3.0	0.2	0.1	0%	0%
	No sector specified	26	66	7.1	5.0	1.3	46.8	9.7	1.4	8%	6%

[a] Benchmark for oil & grease is 15 mg/L
[b] Action level for oil & grease is 30 mg/L

Table A-5. Summary statistics for total copper concentrations measured in industrial stormwater by industry sector.

SIC	Sector	# of facilities	# of values	Mean (μg/L)	Median (μg/L)	Minimum (μg/L)	Maximum (μg/L)	Std. Dev. (μg/L)	Coefficient of variation	Exceedance of benchmark[a]	Exceedance of action level[b]
10	Metal mining	1	1	158.0	158.0	158.0	158.0	--	--	100%	100%
17	Construction special trade contractors	3	12	106.3	99.0	7.1	222.0	82.9	0.8	67%	33%
20	Food and kindred products	40	58	47.7	20.5	0.8	734.0	98.4	2.1	17%	3%
22	Textile mill products	3	6	46.0	23.5	6.7	140.0	50.6	1.1	33%	0%
23	Apparel and other finished products made from	1	4	21.0	24.0	5.0	31.0	11.6	0.6	0%	0%
24	Lumber and wood products	127	83	35.7	21.4	0.1	600.0	68.0	1.9	17%	2%
26	Paper and allied products	14	8	50.5	25.0	20.0	140.0	45.7	0.9	25%	0%
28	Chemicals and allied products	40	49	42.3	25.9	5.0	300.0	51.7	1.2	18%	4%
30	Rubber and miscellaneous plastic products	37	43	65.3	20.0	3.6	530.0	116.0	1.8	26%	12%
32	Stone, clay and glass products	23	12	938.1	19.2	10.0	11,000.0	3,168.7	3.4	8%	8%
33	Primary metals industries	13	65	61.4	18.0	0.4	473.0	101.0	1.6	28%	12%
34	Fabricated metal products	62	215	59.9	24.0	0.0	1,700.0	144.4	2.4	21%	7%
36	Electronic and other electrical equipment	7	10	21.5	20.6	3.2	54.3	15.9	0.7	0%	0%
37	Transportation equipment	33	132	29.4	22.8	0.0	177.0	24.5	0.8	8%	1%
39	Miscellaneous manufacturing industries	6	3	7.0	7.1	4.0	10.0	3.0	0.4	0%	0%
40	Railroad transportation	11	10	67.2	22.3	5.0	490.0	149.1	2.2	10%	10%
41	Local and interurban passenger transportation	23	13	18.5	15.5	7.0	41.0	11.4	0.6	0%	0%
42	Motor freight transportation & warehousing	108	127	50.3	29.4	3.8	496.0	72.9	1.5	19%	6%
44	Water transportation	30	30	49.3	36.3	0.0	194.0	46.7	0.9	20%	7%
45	Transportation by air	21	15	39.5	7.0	5.0	150.0	52.9	1.3	27%	7%
49	Electric, gas, and sanitary services	42	37	61.9	16.7	1.0	1,230.0	201.4	3.3	14%	5%
50	Wholesale trade-durable goods	63	204	113.5	22.7	2.0	5,940.0	467.2	4.1	27%	10%
51	Wholesale trade non-durable goods	23	16	18.2	16.5	2.0	63.6	19.3	1.1	0%	0%
95	Environmental quality programs	2	4	22.8	25.0	11.0	30.0	9.1	0.4	0%	0%
	No sector specified	26	20	292.3	10.0	0.0	4,930.0	1,098.1	3.8	20%	10%

[a] Benchmark for copper is 63.6 μg/L
[b] Action level for copper is 149 μg/L

Table A-6. Summary statistics for total lead concentrations measured in industrial stormwater by industry sector.

SIC	Sector	# of facilities	# of values	Mean (μg/L)	Median (μg/L)	Minimum (μg/L)	Maximum (μg/L)	Std. Dev. (μg/L)	Coefficient of variation	Exceedance of benchmark[a]	Exceedance of action level[b]
10	Metal mining	1	1	13.9	13.9	13.9	13.9	--	--	0%	0%
17	Construction special trade contractors	3	11	29	33	1.7	70	24	0.8	0%	0%
20	Food and kindred products	40	55	20	10	0.05	200	33	1.6	4%	2%
22	Textile mill products	3	5	6.3	6	6	7.56	0.7	0.1	0%	0%
23	Apparel and other finished products made from fabrics	1	4	14	6.5	4	37	16	1.2	0%	0%
24	Lumber and wood products	127	67	20	8	0.006	332	47	2.4	3%	3%
26	Paper and allied products	14	8	34	40	1	110	36	1.1	13%	0%
28	Chemicals and allied products	40	43	65	40	2	597	130	2.0	12%	9%
30	Rubber and miscellaneous plastic products	37	33	15	7	0.08	40	15	1.0	0%	0%
32	Stone, clay and glass products	23	4	29	25	25	40	7.5	0.3	0%	0%
33	Primary metals industries	13	48	98	10	0.01	1240	278	2.9	21%	8%
34	Fabricated metal products	62	192	55	25	0.02	3000	223	4.1	11%	5%
35	Industrial & commercial machinery & computer equip.	28	1	1.7	1.7	1.7	1.7	--	--	0%	0%
36	Electronic and other electrical equipment	7	8	15	6.5	1.44	78	26	1.7	0%	0%
37	Transportation equipment	33	122	7	3.3	0.01	89.7	11	1.6	1%	0%
39	Miscellaneous manufacturing industries	6	4	3.9	4	1.8	5.7	1.8	0.5	0%	0%
40	Railroad transportation	11	8	43	40	1.5	81	22	0.5	0%	0%
41	Local and interurban passenger transportation	23	9	15	4.5	1	40	17	1.2	0%	0%
42	Motor freight transportation & warehousing	108	111	31	15	2	289	49	1.6	6%	4%
44	Water transportation	30	27	33	13	0.05	144	38	1.2	11%	0%
45	Transportation by air	21	15	37	40	25	50	7.3	0.2	0%	0%
49	Electric, gas, and sanitary services	42	36	13	7	0.9	110	19	1.5	3%	0%
50	Wholesale trade-durable goods	63	186	104	25	0.1	3730	339	3.2	22%	10%
51	Wholesale trade non-durable goods	23	13	29	20	2	81.6	28	1.0	0%	0%
95	Environmental quality programs	2	4	3.3	2	1.6	7.6	2.9	0.9	0%	0%
	No sector specified	26	19	53	10	0.007	576	137	2.6	11%	11%

[a] Benchmark for lead is 81.6 μg/L
[b] Action level for lead is 159 μg/L

Table A-7. Summary statistics for biological oxygen demand concentrations measured in industrial stormwater by industry sector.

SIC	Sector	# of facilities	# of values	Mean (mg/L)	Median (mg/L)	Minimum (mg/L)	Maximum (mg/L)	Std. Dev. (mg/L)	Coefficient of variation	Exceedance of benchmark[a]	Exceedance of action level[b]
20	Food and kindred products	40	221	35.9	13.0	2.0	340.0	58.6	1.6	29%	16%
24	Lumber and wood products	127	615	46.7	14.0	0.5	639.0	82.6	1.8	30%	21%
26	Paper and allied products	14	20	10.2	9.0	4.0	27.0	6.1	0.6	0%	0%
28	Chemicals and allied products	40	159	17.2	6.0	1.5	320.0	40.9	2.4	9%	4%
42	Motor freight transportation & warehousing	108	6	7.3	5.5	2.0	14.0	5.0	0.7	0%	0%
47	Transportation services	2	2	29.5	29.5	26.0	33.0	4.9	0.2	50%	0%
49	Electric, gas, and sanitary services	42	64	7.0	4.5	0.2	39.0	7.8	1.1	0%	--
51	Wholesale trade non-durable goods	23	3	6.8	7.0	4.0	9.3	2.7	0.4	0%	0%
	No sector specified	26	15	17.4	15.0	3.0	90.0	21.3	1.2	7%	7%

[a] Benchmark for BOD is 30 mg/L with the exception of sector 49 which has a benchmark of 140 mg/L
[b] Action level for BOD is 60 mg/L

Table A-8. Summary statistics for ammonia nitrogen concentrations measured in industrial stormwater by industry sector.

SIC	Sector	# of facilities	# of values	Mean (mg/L)	Median (mg/L)	Minimum (mg/L)	Maximum (mg/L)	Std. Dev. (mg/L)	Coefficient of variation	Exceedance of benchmark[a]	Exceedance of action level[b]
32	Stone, clay and glass products	23	3	9.2	10.1	7.2	10.2	2	0.2	0%	0%
39	Miscellaneous manufacturing industries	6	1	0.1	0.1	0.1	0.1	--	--	0%	0%
49	Electric, gas, and sanitary services	42	66	0.3	0.1	0.0	4.8	0.6	2.4	0%	0%

[a] Benchmark for ammonia nitrogen is 21.8 mg/L for all sectors except for 49 which has a benchmark of 10 mg/L

[b] Action level for ammonia nitrogen is 38 mg/L

Table A-9. Summary statistics for nitrate + nitrite nitrogen concentrations measured in industrial stormwater by industry sector.

SIC	Sector	# of facilities	# of values	Mean (mg/L)	Median (mg/L)	Minimum (mg/L)	Maximum (mg/L)	Std. Dev. (mg/L)	Coefficient of variation	Exceedance of benchmark[a]	Exceedance of action level[b]
20	Food and kindred products	40	217	1.5	0.4	0.01	61.0	4.9	3.3	34%	21%
28	Chemicals and allied products	40	174	2.5	0.6	0.01	83.7	9.2	3.7	43%	22%
47	Transportation services	2	2	50.3	50.3	0.5	100.0	70.4	1.4	50%	50%
	No sector specified	26	4	0.8	0.3	0.2	2.4	1.0	1.3	25%	25%

[a] Benchmark for nitrate + nitrite nitrogen is 0.68 mg/L
[b] Action level for nitrate + nitrite nitrogen is 1.36 mg/L

Table A-10. Summary statistics for total phosphorus concentrations measured in industrial stormwater by industry sector.

SIC	Sector	# of facilities	# of values	Mean (mg/L)	Median (mg/L)	Minimum (mg/L)	Maximum (mg/L)	Std. Dev. (mg/L)	Coefficient of variation	Exceedance of benchmark[a]	Exceedance of action level[b]
20	Food and kindred products	40	230	1	0.3	0.005	23	3.1	2.4	14%	7%
28	Chemicals and allied products	40	170	1.4	0.1	0.004	137	10.7	7.4	7%	6%
47	Transportation services	2	2	3.2	3.2	1.2	5.1	2.8	0.9	50%	50%
50	Wholesale trade-durable goods	63	2	11.5	11.5	0.081	23	16.2	1.4	50%	50%
51	Wholesale trade non-durable goods	23	1	0.1	0.1	0.12	0.12	--	--	0%	0%
	No sector specified	26	5	0.08	0.1	0.044	0.18	0.1	0.7	0%	0%

[a] Benchmark for total phosphorus is 2 mg/L
[b] Action level for total phosphorus is 4 mg/L

APPENDIX B

Percentages of Samples Exceeding State Water Quality Standards by Industrial Category Given Hypothetical Receiving Water Conditions and Varying Dilution Factors

Table B-1. Percentage of turbidity samples that potentially exceed state water quality criteria given hypothetical receiving water conditions for eastern and western Washington and dilution factors of 0, 10, 25, and 50.

		Exceedance of Std. (%)[a]			
Category	n	0 DF	10 DF	25 DF	50 DF
Western Washington					
01 - Facilities with effluent limitations	8	25 (0-38)	0 (0)	0 (0)	0 (0)
02 - Manufacturing	1286	72 (58-76)	27 (24-27)	14 (14-15)	8 (7-8)
03 - Mineral, metal, oil, and gas	23	22 (13-26)	0 (0)	0 (0)	0 (0)
05 - Landfills	135	48 (30-54)	4 (3-4)	1 (1)	0 (0)
06 - Recycling facilities	295	71 (57-76)	25 (22-27)	12 (11-12)	4 (4)
07 - Steam electric plants	3	67 (0-67)	0 (0)	0 (0)	0 (0)
08 - Transportation facilities	960	68 (53-75)	23 (21-23)	10 (10)	5 (5)
09 - Treatment works	74	39 (27-45)	8 (3-8)	0 (0)	0 (0)
10 - Construction sites > 5 acres	6	67 (50-83)	17 (17)	17 (17)	0 (0)
11 - Light industrial activity	1370	58 (42-65)	15 (13-15)	5 (4-5)	3 (2-3)
12 - Significant contributor	7	29 (29)	29 (14-29)	14 (14)	0 (0)
No category specified	113	50 (35-61)	14 (14)	5 (5)	4 (4)
All Western Washington	**4280**	**64 (49-70)**	**20 (18-21)**	**9 (9)**	**5 (5)**
Eastern Washington					
02 - Manufacturing	41	76 (68-90)	22 (22-24)	22 (20-22)	7 (7)
03 - Mineral, metal, oil, and gas	1	100 (100)	0 (0-100)	0 (0)	0 (0)
08 - Transportation facilities	50	84 (66-88)	30 (26-36)	24 (18-24)	14 (14)
09 - Treatment works	3	67 (33-67)	0 (0)	0 (0)	0 (0)
11 - Light industrial activity	80	79 (66-84)	30 (28-30)	14 (13-14)	6 (6)
No category specified	9	89 (44-100)	22 (22)	0 (0)	0 (0)
All Eastern Washington	**184**	**80 (65-87)**	**27 (25-30)**	**17 (15-17)**	**8 (8)**
All Washington	**4464**	**65 (50-71)**	**21 (18-21)**	**10 (9-10)**	**5 (5)**

[a] Values represent the percentage of sample exceeding the water quality standard based on representative receiving water conditions for the typical scenario (value not in parentheses) and the best and worst case scenarios (values in parentheses).
DF: Dilution factor.

Table B-2. Percentage of turbidity samples with levels less than the benchmark that potentially exceed state water quality criteria given hypothetical receiving water conditions for eastern and western Washington and dilution factors of 0, 10, 25, and 50.

		Exceedance of Std. (%)[a]			
Category	n	0 DF	10 DF	25 DF	50 DF
Western Washington					
01 - Facilities with effluent limitations	8	25 (0-38)	0 (0)	0 (0)	0 (0)
02 - Manufacturing	713	49 (24-57)	0 (0)	0 (0)	0 (0)
03 - Mineral, metal, oil, and gas	22	18 (9-23)	0 (0)	0 (0)	0 (0)
05 - Landfills	113	38 (17-45)	0 (0)	0 (0)	0 (0)
06 - Recycling facilities	170	49 (25-59)	0 (0)	0 (0)	0 (0)
07 - Steam electric plants	3	67 (0-67)	0 (0)	0 (0)	0 (0)
08 - Transportation facilities	584	48 (23-59)	0 (0)	0 (0)	0 (0)
09 - Treatment works	66	32 (18-38)	0 (0)	0 (0)	0 (0)
10 - Construction sites > 5 acres	3	33 (0-67)	0 (0)	0 (0)	0 (0)
11 - Light industrial activity	968	40 (19-51)	0 (0)	0 (0)	0 (0)
12 - Significant contributor	5	0 (0)	0 (0)	0 (0)	0 (0)
No category specified	85	33 (13-48)	0 (0)	0 (0)	0 (0)
All Western Washington	**2740**	**44** **(21-54)**	**0** **(0)**	**0** **(0)**	**0** **(0)**
Eastern Washington					
02 - Manufacturing	19	47 (32-79)	0 (0)	0 (0)	0 (0)
08 - Transportation facilities	20	60 (15-70)	0 (0)	0 (0)	0 (0)
09 - Treatment works	3	67 (33-67)	0 (0)	0 (0)	0 (0)
11 - Light industrial activity	38	55 (29-66)	0 (0)	0 (0)	0 (0)
No category specified	5	80 (0-100)	0 (0)	0 (0)	0 (0)
All Eastern Washington	**85**	**56** **(25-72)**	**0** **(0)**	**0** **(0)**	**0** **(0)**
All Washington	**2825**	**44** **(21-54)**	**0** **(0)**	**0** **(0)**	**0** **(0)**

[a] Values represent the percentage of sample exceeding the water quality standard based on representative receiving water conditions for the typical scenario (value not in parentheses) and the best and worst case scenarios (values in parentheses).
DF: Dilution factor.

Table B-3. Percentage of total zinc samples that potentially exceed state water quality criteria given hypothetical receiving water conditions for eastern and western Washington and dilution factors of 0, 10, 25, and 50.

		Exceedance of Acute Std. (%)[a]				Exceedance of Chronic Std. (%)[a]			
Category	n	0 DF	10 DF	25 DF	50 DF	0 DF	10 DF	25 DF	50 DF
Western Washington									
01 - Facilities with effluent limitations	8	100 (100)	100 (100)	88 (63-88)	38 (13-88)	100 (100)	100 (100)	88 (88-100)	63 (13-88)
02 - Manufacturing	1194	83 (78-86)	25 (16-36)	7 (5-14)	3 (2-6)	84 (79-87)	26 (17-40)	9 (6-16)	3 (2-6)
03 - Mineral, metal, oil, and gas	22	36 (27-50)	5 (5)	0 (0-5)	0 (0)	41 (32-50)	5 (5-14)	0 (0-5)	0 (0)
05 - Landfills	120	82 (76-91)	31 (25-38)	21 (21-24)	20 (19-21)	85 (79-94)	34 (26-41)	22 (21-25)	20 (19-21)
06 - Recycling facilities	288	84 (78-88)	26 (19-33)	8 (4-18)	2 (1-5)	85 (80-89)	27 (20-37)	9 (5-19)	3 (1-7)
07 - Steam electric plants	3	33 (33-67)	0 (0)	0 (0)	0 (0)	67 (33-67)	0 (0)	0 (0)	0 (0)
08 - Transportation facilities	909	85 (80-90)	24 (13-37)	6 (4-12)	3 (1-5)	87 (81-90)	26 (16-40)	7 (5-13)	3 (1-5)
09 - Treatment works	73	56 (45-74)	7 (5-15)	1 (0-5)	0 (0-1)	59 (48-75)	8 (5-15)	4 (1-5)	0 (0-1)
10 - Construction sites > 5 acres	6	100 (100)	50 (33-83)	33 (17-33)	17 (17)	100 (100)	67 (33-83)	33 (17-33)	17 (17-33)
11 - Light industrial activity	1331	89 (85-92)	26 (17-37)	8 (6-15)	4 (3-7)	90 (86-93)	27 (19-40)	9 (6-16)	5 (3-7)
12 - Significant contributor	4	25 (0-25)	0 (0)	0 (0)	0 (0)	25 (25)	0 (0)	0 (0)	0 (0)
No category specified	108	84 (83-87)	33 (25-44)	12 (9-22)	6 (4-9)	85 (83-87)	37 (27-47)	15 (9-24)	6 (5-10)
All Western Washington	**4066**	**84 (79-88)**	**24 (16-35)**	**7 (5-14)**	**3 (2-6)**	**85 (80-88)**	**26 (17-39)**	**9 (6-16)**	**4 (2-6)**
Eastern Washington									
02 - Manufacturing	39	87 (74-92)	8 (0-64)	0 (0-15)	0 (0-10)	90 (74-92)	10 (3-74)	0 (0-38)	0 (0-10)
03 - Mineral, metal, oil, and gas	1	100 (100)	0 (0-100)	0 (0)	0 (0)	100 (100)	0 (0-100)	0 (0-100)	0 (0)
08 - Transportation facilities	50	47 (39-71)	6 (4-29)	4 (2-14)	2 (2-8)	57 (39-73)	8 (6-39)	4 (2-14)	2 (2-12)
09 - Treatment works	3	0 (0-67)	0 (0)	0 (0)	0 (0)	33 (0-67)	0 (0)	0 (0)	0 (0)
11 - Light industrial activity	81	79 (63-86)	14 (6-57)	4 (1-35)	1 (1-16)	80 (67-90)	17 (7-62)	5 (1-41)	1 (1-22)
No category specified	9	67 (67)	11 (0-56)	0 (0-44)	0 (0-11)	67 (67)	11 (0-67)	0 (0-44)	0 (0-22)
All Eastern Washington	**183**	**70 (58-83)**	**10 (4-50)**	**3 (1-25)**	**1 (1-12)**	**75 (60-85)**	**13 (5-58)**	**3 (1-33)**	**1 (1-16)**
All Washington	**4249**	**83 (78-88)**	**24 (15-36)**	**7 (5-14)**	**3 (2-6)**	**85 (79-88)**	**26 (17-40)**	**8 (5-16)**	**4 (2-7)**

[a] Values represent the percentage of sample exceeding the water quality standard based on representative receiving water conditions for the typical scenario (value not in parentheses) and the best and worst case scenarios (values in parentheses).
DF: Dilution factor.

Table B-4. Percentage of total zinc samples with concentrations less than the benchmark that potentially exceed state water quality criteria given hypothetical receiving water conditions for eastern and western Washington and dilution factors of 0, 10, 25, and 50.

		Exceedance of Acute Std. (%)[a]				Exceedance of Chronic Std. (%)[a]			
Category	n	0 DF	10 DF	25 DF	50 DF	0 DF	10 DF	25 DF	50 DF
Western Washington									
02 - Manufacturing	547	63 (51-70)	0 (0)	0 (0)	0 (0)	65 (55-71)	0 (0)	0 (0)	0 (0)
03 - Mineral, metal, oil, and gas	19	26 (16-42)	0 (0)	0 (0)	0 (0)	32 (21-42)	0 (0)	0 (0)	0 (0)
05 - Landfills	90	33 (30-39)	0 (0)	0 (0)	0 (0)	36 (32-42)	0 (0)	0 (0)	0 (0)
06 - Recycling facilities	143	69 (57-76)	0 (0)	0 (0)	0 (0)	70 (59-78)	0 (0)	0 (0)	0 (0)
07 - Steam electric plants	3	33 (33-67)	0 (0)	0 (0)	0 (0)	67 (33-67)	0 (0)	0 (0)	0 (0)
08 - Transportation facilities	381	65 (52-75)	0 (0)	0 (0)	0 (0)	68 (55-77)	0 (0)	0 (0)	0 (0)
09 - Treatment works	51	37 (22-63)	0 (0)	0 (0)	0 (0)	41 (25-65)	0 (0)	0 (0)	0 (0)
11 - Light industrial activity	570	74 (64-82)	0 (0)	0 (0)	0 (0)	76 (67-84)	0 (0)	0 (0)	0 (0)
12 - Significant contributor	4	25 (0-25)	0 (0)	0 (0)	0 (0)	25 (25)	0 (0)	0 (0)	0 (0)
No category specified	39	56 (54-64)	0 (0)	0 (0)	0 (0)	59 (54-64)	0 (0)	0 (0)	0 (0)
All Western Washington	**1847**	**65 (54-73)**	**0 (0)**	**0 (0)**	**0 (0)**	**67 (57-75)**	**0 (0)**	**0 (0)**	**0 (0)**
Eastern Washington									
02 - Manufacturing	9	44 (0-67)	0 (0)	0 (0)	0 (0)	56 (0-67)	0 (0)	0 (0)	0 (0)
08 - Transportation facilities	30	13 (0-53)	0 (0)	0 (0)	0 (0)	30 (0-57)	0 (0)	0 (0)	0 (0)
09 - Treatment works	3	0 (0-67)	0 (0)	0 (0)	0 (0)	33 (0-67)	0 (0)	0 (0)	0 (0)
11 - Light industrial activity	25	32 (0-56)	0 (0)	0 (0)	0 (0)	36 (0-68)	0 (0)	0 (0)	0 (0)
No category specified	3	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
All Eastern Washington	**70**	**23 (0-54)**	**0 (0)**	**0 (0)**	**0 (0)**	**34 (0-60)**	**0 (0)**	**0 (0)**	**0 (0)**
All Washington	**1917**	**63 (52-72)**	**0 (0)**	**0 (0)**	**0 (0)**	**66 (55-74)**	**0 (0)**	**0 (0)**	**0 (0)**

[a] Values represent the percentage of sample exceeding the water quality standard based on representative receiving water conditions for the typical scenario (value not in parentheses) and the best and worst case scenarios (values in parentheses).
DF: Dilution factor.

Table B-5. Percentage of total copper samples that potentially exceed state water quality criteria given hypothetical receiving water conditions for eastern and western Washington and dilution factors of 0, 10, 25, and 50.

		Exceedance of Acute Std. (%)[a]				Exceedance of Chronic Std. (%)[a]			
Category	n	0 DF	10 DF	25 DF	50 DF	0 DF	10 DF	25 DF	50 DF
Western Washington									
01 - Facilities with effluent limitations	4	100 (75-100)	50 (0-50)	0 (0-50)	0 (0)	100 (100)	50 (50)	0 (0-50)	0 (0-50)
02 - Manufacturing	276	91 (84-92)	29 (18-54)	12 (6-24)	5 (3-12)	92 (88-92)	44 (24-75)	17 (8-41)	7 (4-21)
05 - Landfills	22	91 (82-95)	23 (14-23)	5 (5-23)	5 (5-9)	91 (91-95)	23 (23-59)	14 (5-23)	5 (5-18)
06 - Recycling facilities	196	98 (89-99)	41 (28-53)	18 (10-37)	7 (5-18)	99 (93-99)	49 (38-70)	28 (13-48)	12 (7-31)
08 - Transportation facilities	184	95 (88-96)	30 (15-58)	11 (5-19)	4 (2-11)	96 (91-98)	51 (21-73)	15 (9-48)	5 (3-16)
09 - Treatment works	18	100 (89-100)	22 (6-56)	6 (6-17)	6 (0-6)	100 (100)	50 (17-67)	6 (6-44)	6 (0-11)
11 - Light industrial activity	421	98 (91-99)	29 (15-55)	9 (5-24)	3 (2-9)	99 (95-99)	40 (25-78)	15 (8-38)	6 (2-17)
No category specified	20	85 (85)	20 (20)	15 (10-20)	10 (10-15)	85 (85-90)	20 (20-45)	20 (15-20)	10 (10-20)
All Western Washington	1141	**95 (88-96)**	**31 (18-54)**	**12 (6-25)**	**5 (3-12)**	**96 (92-97)**	**44 (26-74)**	**17 (9-42)**	**7 (4-20)**
Eastern Washington									
02 - Manufacturing	4	75 (25-100)	0 (0)	0 (0)	0 (0)	100 (50-100)	0 (0)	0 (0)	0 (0)
03 - Mineral, metal, oil, and gas	1	100 (100)	100 (0-100)	0 (0-100)	0 (0)	100 (100)	100 (100)	0 (0-100)	0 (0)
08 - Transportation facilities	12	58 (50-92)	25 (8-42)	8 (0-17)	0 (0-8)	75 (58-100)	42 (17-42)	8 (8-25)	0 (0-8)
11 - Light industrial activity	19	63 (47-79)	5 (0-16)	0 (0)	0 (0)	79 (58-84)	11 (0-26)	0 (0-5)	0 (0)
All Eastern Washington	36	**64 (47-86)**	**14 (3-25)**	**3 (0-8)**	**0 (0-3)**	**81 (58-92)**	**22 (8-31)**	**3 (3-14)**	**0 (0-3)**
All Washington	1177	**94 (87-96)**	**31 (17-53)**	**11 (6-24)**	**5 (3-11)**	**96 (91-97)**	**43 (25-73)**	**17 (9-41)**	**7 (4-20)**

[a] Values represent the percentage of sample exceeding the water quality standard based on representative receiving water conditions for the typical scenario (value not in parentheses) and the best and worst case scenarios (values in parentheses).
DF: Dilution factor.

Table B-6. Percentage of total zinc samples with concentrations less than the benchmark that potentially exceed state water quality criteria given hypothetical receiving water conditions for eastern and western Washington and dilution factors of 0, 10, 25, and 50.

		Exceedance of Acute Std. (%)[a]				Exceedance of Chronic Std. (%)[a]			
Category	n	0 DF	10 DF	25 DF	50 DF	0 DF	10 DF	25 DF	50 DF
Western Washington									
01 - Facilities with effluent limitations	4	100 (75-100)	50 (0-50)	0 (0-50)	0 (0)	100 (100)	50 (50)	0 (0-50)	0 (0-50)
02 - Manufacturing	222	89 (81-90)	12 (0-42)	0 (0-5)	0 (0)	90 (85-91)	31 (5-69)	0 (0-27)	0 (0-1)
05 - Landfills	19	89 (79-95)	11 (0-11)	0 (0-11)	0 (0)	89 (89-95)	11 (11-53)	0 (0-11)	0 (0-5)
06 - Recycling facilities	140	97 (85-99)	18 (0-34)	0 (0-11)	0 (0)	99 (90-99)	29 (13-59)	0 (0-28)	0 (0-4)
08 - Transportation facilities	155	94 (85-95)	17 (0-50)	0 (0-4)	0 (0)	95 (89-97)	41 (6-68)	0 (0-38)	0 (0)
09 - Treatment works	16	100 (88-100)	13 (0-50)	0 (0-6)	0 (0)	100 (100)	44 (6-63)	0 (0-38)	0 (0)
11 - Light industrial activity	354	97 (90-98)	16 (0-46)	0 (0-9)	0 (0)	98 (94-99)	29 (11-74)	0 (0-26)	0 (0-2)
No category specified	16	81 (81)	0 (0)	0 (0)	0 (0)	81 (81-88)	0 (0-31)	0 (0)	0 (0)
All Western Washington	**926**	**94 (86-96)**	**15 (0-43)**	**0 (0-8)**	**0 (0)**	**95 (90-96)**	**31 (9-68)**	**0 (0-28)**	**0 (0-2)**
Eastern Washington									
02 - Manufacturing	4	75 (25-100)	0 (0)	0 (0)	0 (0)	100 (50-100)	0 (0)	0 (0)	0 (0)
08 - Transportation facilities	7	29 (14-86)	0 (0)	0 (0)	0 (0)	57 (29-100)	0 (0)	0 (0)	0 (0)
11 - Light industrial activity	16	56 (38-75)	0 (0)	0 (0)	0 (0)	75 (50-81)	0 (0-13)	0 (0)	0 (0)
All Eastern Washington	**27**	**52 (30-81)**	**0 (0)**	**0 (0)**	**0 (0)**	**74 (44-89)**	**0 (0-7)**	**0 (0)**	**0 (0)**
All Washington	**953**	**93 (84-95)**	**15 (0-42)**	**0 (0-7)**	**0 (0)**	**95 (89-96)**	**30 (9-66)**	**0 (0-27)**	**0 (0-2)**

[a] Values represent the percentage of sample exceeding the water quality standard based on representative receiving water conditions for the typical scenario (value not in parentheses) and the best and worst case scenarios (values in parentheses).
DF: Dilution factor.

Table B-7. Percentage of total lead samples that potentially exceed state water quality criteria given hypothetical receiving water conditions for eastern and western Washington and dilution factors of 0, 10, 25, and 50.

		Exceedance of Acute Std. (%)[a]				Exceedance of Chronic Std. (%)[a]			
Category	n	0 DF	10 DF	25 DF	50 DF	0 DF	10 DF	25 DF	50 DF
Western Washington									
01 - Facilities with effluent limitations	2	100 (100)	0 (0)	0 (0)	0 (0)	100 (100)	100 (100)	100 (100)	100 (0-100)
02 - Manufacturing	226	32 (14-38)	3 (2-3)	1 (1-2)	0 (0-1)	87 (87-92)	48 (41-77)	33 (14-60)	12 (10-42)
05 - Landfills	21	10 (10-14)	0 (0)	0 (0)	0 (0)	95 (95-100)	24 (19-71)	10 (10-38)	5 (5-24)
06 - Recycling facilities	178	47 (39-53)	6 (5-8)	4 (2-4)	1 (1-2)	96 (94-99)	64 (60-87)	49 (39-75)	29 (21-63)
08 - Transportation facilities	157	39 (17-49)	0 (0-1)	0 (0)	0 (0)	96 (94-99)	66 (55-90)	43 (17-77)	11 (4-57)
09 - Treatment works	18	6 (0-11)	0 (0)	0 (0)	0 (0)	94 (83-100)	28 (17-72)	6 (0-44)	0 (0-22)
11 - Light industrial activity	378	24 (11-34)	1 (1)	0 (0-1)	0 (0)	94 (86-98)	46 (39-72)	24 (12-54)	8 (5-41)
No category specified	19	21 (11-26)	5 (5-11)	0 (0-5)	0 (0)	95 (95)	37 (32-79)	26 (11-58)	11 (11-32)
All Western Washington	**999**	**32 (17-40)**	**2 (2-3)**	**1 (1-2)**	**0 (0-1)**	**93 (89-97)**	**52 (45-79)**	**33 (18-62)**	**13 (9-47)**
Eastern Washington									
02 - Manufacturing	4	50 (50)	0 (0)	0 (0)	0 (0)	100 (75-100)	50 (50-75)	50 (50)	50 (25-50)
03 - Mineral, metal, oil, and gas	1	0 (0)	0 (0)	0 (0)	0 (0)	100 (100)	0 (0-100)	0 (0)	0 (0)
08 - Transportation facilities	12	25 (17-33)	0 (0)	0 (0)	0 (0)	92 (75-100)	33 (33-42)	25 (17-33)	17 (8-33)
11 - Light industrial activity	18	6 (0-11)	0 (0)	0 (0)	0 (0)	78 (61-83)	17 (11-50)	6 (0-17)	0 (0-11)
All Eastern Washington	**35**	**17 (11-23)**	**0 (0)**	**0 (0)**	**0 (0)**	**86 (69-91)**	**26 (23-51)**	**17 (11-26)**	**11 (6-23)**
All Washington	**1034**	**31 (17-39)**	**2 (2-3)**	**1 (1-2)**	**0 (0-1)**	**93 (89-97)**	**51 (44-78)**	**33 (18-61)**	**13 (9-46)**

DF: Dilution factor.

[a] Values represent the percentage of sample exceeding the water quality standard based on representative receiving water conditions for the typical scenario (value not in parentheses) and the best and worst case scenarios (values in parentheses).

Table B-8. Percentage of total lead samples with concentrations less than the benchmark that potentially exceed state water quality criteria given hypothetical receiving water conditions for eastern and western Washington and dilution factors of 0, 10, 25, and 50.

		Exceedance of Acute Std. (%)[a]				Exceedance of Chronic Std. (%)[a]			
Category	n	0 DF	10 DF	25 DF	50 DF	0 DF	10 DF	25 DF	50 DF
Western Washington									
01 - Facilities with effluent limitations	2	100 (100)	0 (0)	0 (0)	0 (0)	100 (100)	100 (100)	100 (100)	100 (0-100)
02 - Manufacturing	204	25 (5-31)	0 (0)	0 (0)	0 (0)	85 (85-91)	42 (35-75)	25 (5-56)	2 (5-36)
05 - Landfills	20	5 (5-10)	0 (0)	0 (0)	0 (0)	95 (95-100)	20 (15-70)	5 (5-35)	0 (0-20)
06 - Recycling facilities	140	32 (22-40)	0 (0)	0 (0)	0 (0)	95 (93-99)	54 (49-83)	35 (22-68)	9 (0-53)
08 - Transportation facilities	150	37 (13-47)	0 (0)	0 (0)	0 (0)	96 (94-99)	64 (53-90)	41 (13-76)	7 (0-55)
09 - Treatment works	18	6 (0-11)	0 (0)	0 (0)	0 (0)	94 (83-100)	28 (17-72)	6 (0-44)	0 (0-22)
11 - Light industrial activity	358	20 (6-30)	0 (0)	0 (0)	0 (0)	94 (85-98)	43 (36-70)	20 (7-52)	3 (0-38)
No category specified	17	12 (0-18)	0 (0)	0 (0)	0 (0)	94 (94)	29 (27-76)	18 (0-53)	0 (0-24)
All Western Washington	**909**	**25 (9-34)**	**0 (0)**	**0 (0)**	**0 (0)**	**93 (88-97)**	**47 (40-77)**	**27 (10-59)**	**5 (0-42)**
Eastern Washington									
02 - Manufacturing	2	0 (0)	0 (0)	0 (0)	0 (0)	100 (50-100)	0 (0-50)	0 (0)	0 (0)
03 - Mineral, metal, oil, and gas	1	0 (0)	0 (0)	0 (0)	0 (0)	100 (100)	0 (0-100)	0 (0)	0 (0)
08 - Transportation facilities	9	0 (0-11)	0 (0)	0 (0)	0 (0)	89 (67-100)	11 (11-22)	0 (0-11)	0 (0-11)
11 - Light industrial activity	17	0 (0-6)	0 (0)	0 (0)	0 (0)	76 (59-82)	12 (6-47)	0 (0-12)	0 (0-6)
All Eastern Washington	**29**	**0 (0-7)**	**0 (0)**	**0 (0)**	**0 (0)**	**83 (62-90)**	**10 (7-41)**	**0 (0-10)**	**0 (0-7)**
All Washington	**938**	**24 (9-33)**	**0 (0)**	**0 (0)**	**0 (0)**	**92 (87-96)**	**46 (39-76)**	**26 (9-57)**	**4 (0-41)**

DF: Dilution factor.

[a] Values represent the percentage of sample exceeding the water quality standard based on representative receiving water conditions for the typical scenario (value not in parentheses) and the best and worst case scenarios (values in parentheses).

Appendix II

EVALUATION OF MONITORING METHODS FOR INDUSTRIAL AND CONSTRUCTION NPDES PERMITS

Visual Inspection of Stormwater BMPs

Prepared for

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October 11, 2006

Contents

Introduction

The Washington State Department of Ecology (Ecology) is evaluating monitoring methods for National Pollutant Discharge Elimination System (NPDES) construction and industrial stormwater general permits. As part of this effort, Ecology is interested in determining if visual inspections are adequately identifying the pollution issues present on site, and if the issues being identified during inspections are reflective of water quality monitoring data.

This report has been prepared to assist Ecology in determining if modifications to visual inspection requirements and protocols for onsite best management practices (BMPs) are warranted for NPDES permittees, and to offer recommendations for improved inspections as appropriate. Ecology recently revised its construction site inspection form and has set forth requirements for a training program for construction site inspectors that will be a key component of NPDES construction permit compliance beginning in October 2006. This inspector training program will include visual examples of effective and ineffective BMP applications. It is expected that this required training will provide a strong basis for guiding inspectors to perform productive visual inspections at construction sites. Therefore, this report focuses primarily on suggestions to improve industrial site visual inspections with only a few observations and suggestions related to construction sites.

Background

All NPDES general permit holders have to prepare a Stormwater Pollution Prevention Plan (SWPPP). The purpose of a SWPPP is to outline actions that will be followed to reduce or eliminate pollutants that come in contact with precipitation and stormwater runoff on a site and therefore better protect receiving water quality. Within a SWPPP, stormwater BMPs are identified to reduce or eliminate stormwater pollutants onsite. These BMPs can be structural or nonstructural. Examples of structural BMPs include catch basin filter inserts, vegetated swales, and oil/water separators that capture stormwater pollutants before they leave the site. Examples of nonstructural BMPs include good housekeeping techniques and practices designed to prevent potential pollutants from coming in contact with precipitation and stormwater runoff, such as sweeping of loading docks and installing covers over waste material storage areas. A monitoring plan which includes water quality sampling and visual inspections is also required to be included in a SWPPP.

Periodic visual inspections are required to identify potential stormwater pollutants and determine areas where improvements are needed. A visual inspection should determine if the SWPPP has been implemented, if BMPs are working properly and are being maintained, and if there are other issues of concern for water quality protection. After completing a visual inspection, results must be summarized in an inspection report or recorded on a checklist/inspection form and filed onsite with the SWPPP to comply with the conditions of the general construction permit and general industrial stormwater permit. If the inspection indicates any problems, the report must include a summary of actions that will be taken to address the problem. Reporting any non-compliance with the permit is required.

Existing Guidance and Requirements for Visual Inspections

Construction Sites

Ecology recently produced a guidance document for monitoring at construction sites that describes how to conduct stormwater monitoring and provides limited guidance on visual inspections (Ecology 2006). This document is called "How to do Stormwater Monitoring: A Guide for Construction Sites" (Ecology publication number 06-10-020). In this document, an example site inspection checklist is provided for use by inspectors. This checklist relies upon assignment of a good, fair, or poor rating for the condition and functionality of each BMP in use on the site. There is, however, no explanation given in the guidance document on how to make these assignments; the visual inspection section of this document is vague and provides only a few examples.

Although Ecology's written guidance for visual inspections at construction sites is limited, starting in October 2006, the person conducting the visual inspections must be a Certified Erosion and Sediment Control Lead (CESCL). To become a CESCL an individual must take a certification course. It is anticipated that this course will train inspectors to conduct inspections and properly rate the condition and functionality of the onsite BMPs. Although the training required for the CESCLs will provide this background, the large numbers of courses and trainers that will be involved are an indication that more written detail in the guidance document will still be helpful in standardizing the visual inspection ratings.

Consistency in visual inspections is important not only for fairness in enforcement actions, but it also allows for analysis of the overall effectiveness of stormwater programs at the municipal, county, or state level. If the inspection reports provide enough detail, Ecology may be able to determine, for instance, that the biggest problem affecting runoff interception swales is the lack of maintenance. The lack of maintenance may allow sediment buildup and decrease swale capacity. This level of detail will become increasingly important as communities and permittees deal with waste load allocations under total maximum daily load (TMDL) regulations and begin estimating whether their actions are yielding the required reductions in pollutant loads.

Industrial Sites

The Industrial Stormwater General Permit requires visual monitoring to be conducted at all applicable industrial sites at least quarterly during storm events and at least once during the dry season (Ecology 2005). As part of visual inspections, the general permit also requires each Permittee to identify BMPs that are inadequate or pollutant sources that are not identified or poorly described in the SWPPP. When visual monitoring identifies inadequacies in the SWPPP, due to the actual discharge of or potential to discharge a significant amount of any pollutant, the SWPPP must be modified and BMPs adjusted to correct the deficiency (Ecology 2005).

Although Ecology has published a guidance document that describes how to sample stormwater at an industrial site, it provides limited guidance on how to conduct a visual site inspection at an industrial site (Ecology 2002). Ecology's Guidance Manual for Preparing/Updating a SWPPP for Industrial Facilities (Ecology 2004) describes the process of creating a SWPPP for industrial facilities, but there is little guidance on how to conduct visual site inspections. The appendix for the guidance manual contains a form (worksheet #11) that is the basis for documenting visual BMP inspections. The worksheet contains a table that consists of five columns. In the table the user is to record the date of the inspection, identify the surface or ground water body that receives stormwater discharged from the site, pollutants observed in the stormwater, and recommended action steps. No specific questions are asked, there are no examples given, and very little guidance is provided to promote effective visual inspections and associated record-keeping. The only instructions are found in the form header:

> "List of observed pollutants and descriptions of intensities of each. Include floatables, oil sheen, discoloration, turbidity, odor, etc. in the SW."

Worksheet #11 does not list structural BMPs or nonstructural BMPs, or give guidance on how to inspect them. Using this form, an inspector would have a difficult time knowing what issues to look for onsite, especially if he/she were not trained to understand runoff pollutant sources and corresponding BMP options. Currently, Ecology does not require industrial site inspectors to be certified and there are no training courses readily available for these inspectors. Industrial site inspectors are often foremen, onsite engineers, or site safety officers. They are not required to have a background in stormwater pollution prevention and may not have a clear understanding of what is contributing to stormwater pollution. The worksheet requires that the person making the observations sign a certificate that states, under the penalty of law, that the form is true, accurate, and complete. Without adequate guidance, many of the industrial site employees who conduct the inspections may be reluctant to sign this.

It would be beneficial if Ecology distributed a guidance document describing how to inspect the structural BMPs and what good housekeeping items to look for on the site while conducting a visual inspection. Examples include: how to inspect catch basins and oil/water separators to know when maintenance is required, and what general maintenance is needed on site to keep pollutants out of stormwater.

Survey of BMP Inspection Procedures

As part of the effort to create a new industrial site inspection checklist for Ecology, an extensive web search was conducted to determine how other jurisdictions conduct visual BMP inspections at industrial sites. As noted above, since Ecology has already established a relatively rigorous program for training of construction site BMP inspectors, the review was limited to industrial site inspections. Many industrial site inspection forms were found that are used by cities and state agencies across the country. The majority of these forms were intended to be used by the industrial stormwater permit holders to show compliance with their permit requirements. Forms from nine jurisdictions were selected for closer examination. These jurisdictions included:

- City of Portland, Oregon – Industrial Facility Stormwater Inspection Report (City of Portland undated).
- Sacramento County, California – Checklist Summary of Violations for Stormwater Program (Sacramento County 2004).
- EPA – NPDES Industrial Stormwater Worksheet (Industrial) (EPA 2005).
- Minnesota Pollution Control Agency – Site Inspection Form for Industrial Activities (MPCA 1999).
- City of Austin, Texas – Annual SWP3 Comprehensive Site Compliance Evaluation Inspection (City of Austin 2002).
- Wisconsin Department of Natural Resources – Annual Facility Site Compliance Inspection Report (WDNR 2005).
- City of Bellevue, Washington – Public Inspection and Maintenance Checklists (City of Bellevue 2002).
- Seattle Public Utilities Business Inspection Program Checklist (City of Bellevue 2002).
- Caltrans – Storm Water Quality Handbooks, Maintenance Staff Guide (Caltrans 2003).

A summary of the positive and negative aspects of the inspection forms reviewed were documented and compared to the existing form used in Washington State (worksheet #11 from Ecology's industrial SWPPP guidance manual). The information from these forms was used to create an expanded visual inspection checklist for industrial NPDES permit holders in the State of Washington.

Several questions were considered when reviewing each form. These questions helped to determine what should be included in the Ecology checklist. The following questions were considered:

- Is the length of the form appropriate? Is it too long or too short?
- Is it easy to use? (Is it obvious what is being asked? Are examples provided so the inspector knows what potential sources of stormwater pollutants are possible on the site?)
- If the inspector does not have a background in stormwater management will they be able complete the inspection based on the information

provided in the form? In other words, is the form simple enough for the lay person to complete?

- Are the appropriate questions being asked on the form?

- Is the form complete for most situations (i.e., are all common structural and nonstructural industrial BMPs included and described)?

- Are there items included that are not relevant in the State of Washington that should not appear in Ecology's inspection form?

- Can the information in the form be compiled and analyzed to identify trends on a regional or statewide basis?

The inspection forms from the nine jurisdictions reviewed vary greatly in length, format, and content. The length of the forms range between one and six pages and the format varies between fill-in-the-blank questions, *yes, no*, or *N/A* questions, and check boxes. The majority of the forms address nonstructural, good housekeeping techniques and many of them are very thorough in describing what the inspector should be looking for onsite concerning nonstructural BMPs. Most of the forms do not address structural BMPs, and if they are addressed there is very little information about how to inspect the structural BMPs and only a limited number of them are addressed.

In general, the forms that are longer appear to be easier to use. The long forms generally provide more guidance and ask more questions that would help an inspector identify potential stormwater issues onsite. The questions that could be answered with a *yes*, *no*, *N/A*, or check box are the easiest to understand. The fill-in-the-blank questions are often too open-ended and could be difficult for a person without a background in stormwater pollution control to answer. The best fill-in-the-blank questions are specific and include example answers so that the inspector knows what is being asked. For example, the Minnesota Pollution Control Agency's site inspection form asks if there are raw, intermediate, or final products exposed to stormwater. It then lists the following examples: log, coal, salt, sand, gravel, lumber, scrap, metal products, vehicle parts, etc. Having these examples is important because an inspector may have noticed these products onsite but may have not thought to list them. In addition, because of the wide range of products listed the question is applicable to several different types of industries.

Overall, two forms were deemed the easiest to use. These forms are also the most comprehensive of the forms reviewed in this research effort. These inspection forms were prepared by the City of Portland and Seattle Public Utilities. These forms were used as templates in creating a new checklist for Ecology's consideration.

Summary of Findings

Construction Site Visual Inspections

Ecology's guidance and training for construction site BMP inspectors should promote effective BMP inspections and maintenance. However, the value of construction site BMP inspection documentation could be improved through formalizing a joint BMP review process with Ecology inspectors and permittee inspectors. Ecology could use the joint review results to evaluate whether visual BMP inspections are being done consistently and thoroughly and to then refine the CESCL training program to further improve BMP inspections.

Industrial Site Visual Inspections

The web search described above provided background information on how various jurisdictions conduct visual inspections at industrial sites and ideas for improving Ecology's industrial BMP inspection worksheet and guidance materials. After comparing inspection materials from other jurisdictions with the identified needs for NPDES permittees in the State of Washington, five key findings were identified. Each of these findings is presented in this section.

1. For ease of use the visual inspection form should consist mainly of check boxes and yes/no questions. This format allows an inspector to quickly and easily answer the questions. Fill-in-the-blank questions are too open-ended for someone without a background in stormwater management unless there are many examples listed. Examples of potential sources of stormwater pollutants are necessary to give the inspector an idea of what to look for and what could potentially be a stormwater pollutant. The more focused and directed the questions are that are presented in the form of check boxes, the easier it will be for Ecology to discern larger trends.

2. Any questions on the visual inspection form should be specific. Many of the inspection forms that were reviewed are general and do not include specific questions. An example of a general question, from the Minnesota Pollution Control Agency's form, is:

    > *Determine if the nonstructural and structural BMPs as indicated on your plan are installed and functioning properly. Please describe corrective actions needed to repair nonfunctioning BMPs.*

    Even if the inspector had the pollution prevention plan with them, and knew what structural and nonstructural BMPs were being referred to, would they know how to determine if the BMPs are installed and functioning properly? It is better to ask detailed questions or a series of specific questions to address the potential issues associated with the individual BMPs. For example, to determine if catch basins are functioning properly or in need of repair or maintenance, Seattle Public Utilities asks the following series of questions on its inspection form:

Are catch basins present on site? Y/N
If yes how many?
Are catch basins equipped with outlet traps?
Select outlet trap type <u>*PVC elbow*</u> <u>*Metal Elbow*</u>
Has material accumulated to fill over 60% of the capacity of the CB? Y/N
Select material(s) in catch basin <u>*sediment*</u> <u>*plants*</u> <u>*trash*</u>
Is there evidence of contamination in catch basins? Y/N
Select contaminant <u>*Oil/grease*</u> <u>*Paint*</u> <u>*Solvent*</u> <u>*Sewage*</u> <u>*Unknown*</u>

This series of questions tells the inspector exactly what to look for rather than just asking if the catch basin is functioning properly.

Detailed questions make the inspection form longer but allow for a more complete inspection and easier comparisons between visual inspections, regardless of the inspector. Also, for an inspector without knowledge of stormwater management, a more detailed inspection form would be useful to help identify all potential issues on a site; when using a general form it is much easier to overlook or ignore a stormwater pollution problem.

3. The inspection form should include both structural and nonstructural BMPs. None of the inspection forms that were reviewed from other jurisdictions effectively address both types of BMPs. The majority of the inspection forms that were reviewed focus on nonstructural, good housekeeping techniques. Common structural BMPs should also be listed along with a description of the BMP and common maintenance and performance issues.

4. The majority of the forms assume more understanding of stormwater pollution than is most likely appropriate, given most industrial site inspectors have no training or background in stormwater management. For this reason it is important that the forms be easy to use and ask simple questions. The more broad or difficult the questions are to answer, the more likely the inspector will overlook a stormwater pollution issue onsite.

5. Ecology currently does not provide enough guidance, nor is training readily available, for the typical inspector to effectively inspect BMPs at an industrial site. If a training program similar to that for construction site inspectors is not implemented for industrial site inspectors in the State of Washington, then more detailed guidance needs to be provided. The industrial SWPPP guidance manual should be expanded to provide more

information on visual inspections and their importance for overall water quality protection, and to explain how to use a more detailed inspection checklist and why the issues listed in the checklist are important. Having training available for industrial site inspectors would further improve the ability of the inspectors to conduct a thorough visual inspection.

The conclusions reached as part of the industrial site BMP inspection form review were used to create a new visual inspection checklist that Ecology could provide to industrial NPDES permittees. All five of the issues noted above were considered when creating this expanded visual inspection checklist. The expanded checklist asks specific questions that are easy to understand. These questions are aimed at inspectors without formal stormwater management knowledge. The expanded checklist is comprehensive, including the most common structural and nonstructural BMPs used on industrial sites. In addition to the checklist, an accompanying guidance document was prepared to be used with the checklist as a reference. This guidance document is included as Appendix A to this report. It is recommended that this guidance document and the expanded visual inspection checklist be incorporated into Ecology's industrial SWPPP guidance manual.

The information included in the expanded visual inspection checklist was divided into two sections. The inspection of permanent, or relatively consistent, site features was separated from the onsite conditions that could change relatively frequently as a result of activities occurring on the site. The conditions that remain relatively consistent over time are included in Form B - Industrial Site Stormwater Facility Inventory (see Appendix B to this report). The conditions that could change frequently are included in Form C - Industrial Site Stormwater Inspection Checklist (see Appendix C to this report).

Prior to filling out Form C, the inspector should complete Form B. Once Form B has been completed one time it does not need to be completed again unless site operations change, the site is expanded or otherwise reconfigured in a way that alters potential sources of stormwater pollution, or there are changes in the stormwater facilities onsite. Form C should be used each time that routine site inspections are conducted to satisfy the industrial general permit requirements.

Separating the expanded checklist into two forms allows the site specific stormwater issues to be identified (using Form B, or a comparable form) prior to documenting routine inspections (using Form C, or a comparable form tailored to the site). Form B can be used to direct the contents of the routine inspection checklist (Form C). This allows the routine inspections to focus on specific site activities that may generate pollutants in runoff and the BMPs that are used to control pollutants at those locations. A shorter routine inspection checklist will likely increase the likelihood of an inspector using it.

Additional Recommendations

Some other potential changes to Ecology's visual inspection programs for both industrial and construction sites might include:

- Adjusting which visual parameters are emphasized, depending on industry type. For example, oil sheens should be emphasized for sites with many vehicles, turbidity should be emphasized for sites with exposed soils, and identification of galvanized surfaces should be emphasized for sites with a prevalence of exposed structural metal.

- Collecting visual inspection data from construction sites simultaneous to collecting water quality data. Comparison of the visual inspection data with the water quality sampling results would allow assessment of the effectiveness of the visual inspections.

- Implementing independent inspections by Ecology staff to independently rate industrial and/or construction BMP performance using the checklists provided to permittees and then compare them with the onsite inspector's ratings as a means of evaluating effectiveness and consistency of the checklists.

The expanded visual inspection checklist (Form C included in Appendix C to this report) is intended to be an example that should be tailored for a particular site. The industrial general permit covers so many different types of industries and site characteristics that it is impossible to generate a series of forms that would effectively represent all permittees' sites, such that a specific permittee could choose from a collection of inspection forms created by Ecology to pick the one that is best suited to their site. Furthermore, the types of BMPs implemented at different facilities under the same industry category might also vary. Thus, the contents of Form C focus on the different types of BMPs that may be used on a site, and this format requires less than a dozen categories on the visual inspection checklist. Individual permittees should be encouraged to tailor Forms B and C to their site, with site-specific guidance and assistance provided by Ecology personnel as needed to ensure that the resultant visual inspection documentation is as useful as possible to reduce stormwater pollution.

References

Austin, City of. 2002. Annual SWP3 Comprehensive Site Compliance Evaluation Inspection, Storm Water Pollution Prevention Plan, Austin Bergstrom International Airport. City of Austin, Texas. Obtained on May 12, 2006 from city website: <http://www.ci.austin.tx.us/austinairport/downloads/siteinspect.pdf>.

Bellevue, City of. 2002. Utilities Surface Water Maintenance Standards for Public and Private Systems. Public Inspection and Maintenance Checklists. City of Bellevue, Washington. Obtained from SCVURPPP website: <http://www.scvurppp-w2k.com/bmp_om_forms.htm>.

Caltrans. 2003. Storm Water Quality Handbooks, Maintenance Staff Guide. Publication number CTSW-RT-02-057. California Department of Transportation.

Ecology 2002. How to do Stormwater Sampling. A guide for Industrial Facilities. Washington State Department of Ecology, Olympia, Washington. Obtained on May 12, 2006 from agency website: <http://www.ecy.wa.gov/pubs/0210071.pdf>

Ecology. 2004. Guidance Manual for Preparing/Updating a SWPPP for Industrial Facilities. Washington State Department of Ecology, Olympia, Washington. Obtained on May 12, 2006 from agency website: <http://www.ecy.wa.gov/pubs/0410030.pdf>.

Ecology. 2006. How to do Stormwater Monitoring A guide for construction sites. Washington State Department of Ecology, Olympia, Washington. Obtained on May 12, 2006 from agency website: <http://www.ecy.wa.gov/biblio/0610020.html>.

Ecology. 2005. The Industrial Stormwater General Permit: A National Pollutant Discharge Elimination System and State Waste Discharge General Permit for Stormwater Discharges Associated with Industrial Activities. Washington Department of Ecology, Olympia, Washington. Obtained on September 27, 2006 from agency website: http://www.ecy.wa.gov/programs/wq/stormwater/industrial/final%20ISWGP%20Permit%20modification%20after%20comment.pdf

EPA. 2005. National Pollutant Discharge Elimination System (NPDES) Compliance Inspection Manual. Appendix P: NPDES Industrial Storm Water Investigation and Case Development Worksheet (Industrial). Environmental Protection Agency. Obtained on May 12, 2006 from agency website: <http://epa.gov/compliance/resources/publications/monitoring/inspections/npdesinspect/npdesinspectappp.pdf>.

Golding, Stephen. 2006. A Survey of Zinc Concentrations in Industrial Stormwater Runoff. Publication No. 06-03-009. Washington Department of Ecology, Olympia, Washington.

Herrera. 2006. Data Analysis Report: Evaluation of Monitoring Data from General NPDES Permits for Industrial and Construction Stormwater. Prepared for the Washington State Department of Ecology and EnviroVision Corporation by Herrera Environmental Consultants, Inc., Seattle, Washington.

King County. Undated. Oil/Water Separator Fact Sheet. King County, Washington. Obtained on May 12, 2006 from county website: <http://dnr.metrokc.gov/wlr/indwaste/OW_8.5x11.pdf>.

MPCA. 1999. Site Inspection Form, NPDES/SDS General Storm Water Permit MNG611000 for Industrial Activity. Minnesota Pollution Control Agency. Obtained on May 12, 2006 from agency website: <http://www.pca.state.mn.us/water/pubs/sw-isiteins.pdf>.

Portland, City of. Undated. Industrial Facility Stormwater Inspection Report. City of Portland, Oregon. Obtained on May 12, 2006 from city website: <http://www.portlandonline.com/shared/cfm/image.cfm?id=53790>.

Sacramento County. 2004. Checklist Summary of Violations for Stormwater Program. Sacramento County, California. Obtained on May 12, 2006 from county website: <http://www.emd.saccounty.net/WP/EMDstormwater.htm>.

SPU. 2003. SPU Business Inspection Program Checklist. Seattle Public Utilities, Seattle, Washington.

WDNR. 2005. Annual Facility Site Compliance Inspection Report. Wisconsin Department of Natural Resources. Obtained on May 12, 2006 from agency website: <http://prodwbin99.dnr.state.wi.us/org/water/wm/nps/pdf/stormwater/3400176.pdf>.

Guidance for Washington State Department of Ecology Industrial Facility Stormwater BMP Visual Inspection Checklist

The Stormwater Management Manuals for Eastern and Western Washington (Ecology 2004 and 2005) contain a list of manufacturing facilities and their associated Potential Pollutant Generating Sources. These sources may be consulted for more detailed lists of items to include as part of the visual inspection source control. The information presented below is more general in nature and is intended to support thorough documentation using the Visual Inspection Checklist.

Material Storage

The SWPPP must list exposed "significant" materials for the site. Refer to worksheet #2A of the SWPPP to determine which materials should be included. A copy of the SWPPP must be present onsite and accessible to the inspector. Additional guidance for visual inspections of material storage areas includes the following:

- For each of the materials included in worksheet #2A, check to see if the materials are contained and covered. Check to make sure that lids are secure and that containers are not deteriorating and that any other containment devices, such as curbs on the perimeter of the storage area, are functioning correctly and are not cracked or damaged. Any significant materials that are exposed to precipitation and stormwater runoff need to be addressed. The inspector needs to note any issues on the inspection checklist and explain what action will be taken to remedy the problem.

For additional information on material storage refer to the following BMPs in the Ecology stormwater manuals for eastern and western Washington (Ecology 2004 and 2005, respectively):

- BMPs for storage of liquid, food waste, or dangerous waste containers – page 2-55 (Ecology 2005) or page 8-51 (Ecology 2004),

- BMPs for storage of liquids in permanent above-ground tanks – page 2-58 (Ecology 2005) or page 8-53 (Ecology 2004),

- BMPs for storage or transfer (outside) of solid raw materials, by-products, or finished products – page 2-60 (Ecology 2005) or page 8-55 (Ecology 2004).

Spill Prevention

Spill prevention is a key element of SWPPP implementation. Effective implementation of a spill prevention plan will include the following:

- There should be a written spill prevention plan for the site and copies should be available in places where there are opportunities for a spill to occur such as loading docks or refueling areas. If copies of the spill prevention plan are not available then the inspector should note this on the inspection checklist and make sure that an appropriate person is aware of the problem.

- Employees or, at a minimum, the shift foreman or site supervisor, should all be trained in spill response in order to respond quickly to a spill. If there has not been recent training for the appropriate employees then the inspector should note this and let the appropriate person know so that training can be scheduled.

- In high risk spill areas, clean-up materials need to be available and clearly labeled as “spill kit”. If this is not the case, the inspector should note this on the inspection checklist and make sure that an appropriate person is aware of the problem.

For additional information on spill prevention refer to the following BMPs in the Ecology stormwater manuals for eastern and western Washington (Ecology 2004 and 2005, respectively):

- BMPs for spills of oil and hazardous substances – page 2-53 (Ecology 2005) or page 8-49 (Ecology 2004).

General Maintenance Practices

Good housekeeping practices for pollution prevention associated with general site maintenance are a major element of effective SWPPP implementation. Additional guidance for general site maintenance practices includes the following:

- Outdoor areas should be swept to pick up dirt, waste materials, or other pollutants that could be washed off paved areas when it rains. Sweeping should take place when dry material has been spilled or when there is noticeable build-up of material on pavement (roughly once a week).

- Outdoor areas should not be hosed down or otherwise washed into storm drains. This practice rinses pollutants from the paved surfaces into storm drains. If there is a spill it should be cleaned up according to directions described in the spill control plan. If there is a buildup of material on paved areas, it should be swept up or otherwise collected and disposed using an appropriate waste container rather than washed off the surface.

- Storm drain inlets should be inspected frequently. If water is backing up, then the inlet may be clogged and is in need of maintenance. If potentially polluting material is accumulating around the inlet it needs to be cleaned up. Accumulated material also indicates that outdoor paved areas around the storm drain need to be cleaned.

- Evidence of material spills in paved areas requires immediate attention. Pollutants should either be swept or cleaned up according to the spill control plan.

Loading Dock

Guidance for effective pollution control at loading docks includes the following:

- If there are storm drains inside or near the loading dock, there is a potential for pollutants from the loading dock to enter the stormwater system. These drains should be protected to prevent pollutants from entering them.

- Loading docks should have protective measures in place to contain any spills or pollutants and to prevent materials from being exposed to rain while they are being loaded or unloaded. Loading docks should be fully roofed to prevent any materials from being exposed to rain. In addition, there should be containment below the dock to keep spills from reaching a storm drain and containment measures in place to prevent material from spilling off the dock. If any of these items are missing the inspector should list modifications to be implemented to fully contain or cover materials being loaded/unloaded at the dock.

- Spill kits need to be located at the loading dock. If they are not, the inspector should note it on the inspection checklist and make sure that an appropriate person is aware of the deficiency.

For additional information on pollution control at loading docks refer to the following BMPs in the Ecology stormwater manuals for eastern and western Washington (Ecology 2004 and 2005, respectively):

- BMPs for loading and unloading areas for liquid or solid material – page 2-29 (Ecology 2005) or page 8-31 (Ecology 2004).

Vehicle and Heavy Equipment Storage and Maintenance

Guidance for effective pollution control for vehicle and equipment storage and maintenance includes the following:

- If there are signs of leaking oil and/or motor fluids onsite (i.e. sheen in puddle) the inspector should identify the source of the leak and notify the appropriate person so that it can be repaired. Equipment and vehicles are often sources of leaks and should be inspected for leaking motor oil or other fluids.

- If fueling and/or maintenance occur onsite, there should be measures in place to keep fuel and other pollutants from mixing with stormwater. These areas should be covered and/or curbing should be in place around the area to prevent stormwater from flowing onto the area and becoming contaminated. If these areas are exposed to precipitation and stormwater runoff the inspector should note it on the inspection checklist and list ways to modify the existing setup to prevent and minimize stormwater pollution.

For additional information on pollution source control associated with vehicle and heavy equipment storage and maintenance refer to the following BMPs in the Ecology stormwater manuals for eastern and western Washington (Ecology 2004 and 2005, respectively):

- BMPs for fueling at dedicated stations – page 2-19 (Ecology 2005) or page 8-21 (Ecology 2004),
- BMPs for maintenance and repair of vehicles and equipment – page 2-34 (Ecology 2005) or page 8-35 (Ecology 2004), and
- BMPs for parking and storage of vehicles and equipment – page 2-48 (Ecology 2005) or page 8-46 (Ecology 2004).

Vehicle and Equipment Wash Water Practices

Guidance for effective vehicle and equipment washing practices includes the following:

- Wash water from vehicle and equipment cleaning can contain a variety of pollutants including detergents, degreasing chemicals, oils, suspended solids, heavy metals, and organics. Wash areas should be covered, enclosed or contained to prevent stormwater from mixing with these pollutants. If wash areas are exposed to stormwater the inspector should note it on the inspection sheet and list ways to modify the existing setup to prevent and minimize stormwater pollution at the site.
- Cleaning additives are potential stormwater pollutants. Water containing additives should be contained so that it cannot enter storm drains or mix with stormwater.
- Wash water should be recycled or routed to the sanitary sewer (which may require additional permits) so that pollutants do not enter stormwater.

For additional information on vehicle and equipment wash water practices refer to the following BMPs in the Ecology stormwater manuals for eastern and western Washington (Ecology 2004 and 2005, respectively):

- BMPs for washing and steam cleaning vehicle/equipment/building structures – page 2-64 (Ecology 2005) or page 8-59 (Ecology 2004).

Waste Storage and Disposal Practices

Guidance for effective pollution control for waste storage and disposal includes the following:

- While inspecting the site the inspector should check for signs of solid waste in areas exposed to precipitation and stormwater runoff. Garbage or solid waste on the ground may indicate that there are not enough waste receptacles, they are not large enough, or that they are not being emptied frequently enough. If this is the case, the inspector should describe the problem and list necessary modifications for improving the situation.

- Dumpsters and trash compactors need to be covered and free of leaks. When the contents of these receptacles are exposed to rain they can contribute pollutants to stormwater. Liquid waste represents a particular challenge as it may flow into a storm drain without any rainfall. If the trash containers are not properly covered or are leaking, the inspector should describe the problem and list any modifications needed to improve the situation.

- Many industrial sites have what is commonly known as a "boneyard." The boneyard is an area containing old, spare, outdated, or other equipment that is not currently being used. The boneyard may be a source of oil, grease, hydraulic fluid, or metals in runoff. The inspector should note signs of stormwater runoff pollution in these material storage areas and list the necessary modifications for improving the situation.

Stormwater Treatment Structures

The following is basic information on structural BMP inspections and maintenance. Please consult Volume V, Section 4.6 of the Department of Ecology's *Stormwater Management Manual for Western Washington* (Ecology 2005) or *Stormwater Management Manual for Eastern Washington* (Ecology 2004) for more detailed information on design and maintenance of structural stormwater treatment systems.

Catch Basins

Catch basins are facilities such as inlets or manholes in which the bottom of the device extends below the outlet pipe. This serves as a "trap" to allow removal of coarse particulates in stormwater runoff. Many inlets also have an inverted elbow covering the outlet. Because the elbow extends below the surface of the water, floatable trash and oil is also trapped. Rigid or fabric inserts are sometimes used to enhance pollutant removal. Oil absorbent pillows may also be used in catch basins which receive large amounts of oil and grease. Visual inspection of catch basins should be conducted following the guidance presented below.

- The types of pollutants in the catch basins indicate their probable source(s). This information should be used by the inspector to determine what other measures could be implemented onsite. For example, if there is a large amount of oil and grease in the catch basin then vehicles may have been improperly serviced or there may be a leak somewhere on site that is in need of repair.

- If trash or debris is blocking more than 10 percent of the inlet to the catch basin it should be cleaned.

- If the catch basins have inserts, they need to be inspected after every storm event and the inserts replaced before they are full. When the inserts are full they become difficult to remove because they get heavy and the fabric inserts can rip when they are too heavy.

- Catch basins with sumps below the outlet pipe should be cleaned when accumulated material in the sump is 6 inches from the bottom of the outlet pipe. Some catch basins may have a permanent pool of standing water. If this is the case, use a rod to probe for the top of the accumulated sediment. Cleaning can be done manually or using a vacuum (vactor) truck.

- Catch basins with inverted elbows for their outlet should be inspected at the start of the rainy season and after large storms. If the water surface is not visible due to excessive floating debris then the catch basin should be cleaned. As a rule of thumb a typical catch basin should be cleaned every one to two years.

- Oil absorbent pillows should be replaced every one to two years or if they are observed to have broken apart or are soaked with oil. To determine if they are soaked with oil look for an oil sheen within the catch basin.

For additional information on catch basins refer to the following BMPs in the Ecology stormwater manuals for eastern and western Washington (Ecology 2004 and 2005, respectively):

- BMPs for maintenance of stormwater drainage and treatment systems – page 2-40 (Ecology 2005) or page 8-40 (Ecology 2004).

Oil/Water Separators

Oil/water separators are of three types: coalescing plate (with closely stacked, inclined plates), gravity separator (a vault with compartments that force water to move along the bottom and oil to float to the top), or vaults/pools with skimmers (devices to remove oil off the top of the water column). All three types rely on oil floating to the surface, resulting in the separation of oil and water. Visual inspection of oil/water separators should be conducted following the guidance presented below.

- The inspector should check the thickness of floating oil in the chambers. When the floating oil is an inch thick or more it needs to be removed and disposed of appropriately (typically at an offsite location).

- The inspector should check the sludge buildup using a stick long enough to reach the bottom; if there is resistance to push through to the bottom then there is a sludge buildup. When the sludge build-up on the bottom of the oil/water separator is 6 inches or greater, it needs to be serviced.

- If the oil/water separator has coalescing plates, the plates need to be cleaned before there is a build-up of silt or sediment. Sediment build-up allows oil to pass through the separators and into storm sewers. The inspector should check the amount of sediment on the plates and, if there is a buildup, make sure they will be cleaned. Cracked or damaged plates should be replaced.

- If sediment is a continuing issue in the separator, the inspector should investigate the source of sediment and determine if there are other measures that can be implemented to control its source elsewhere onsite.

Underground Treatment Vaults

Underground treatment vaults temporarily store runoff, allowing some settling and/or filtering of sediments and associated pollutants. There are many different types of treatment vaults. Examples include baffled vaults and many of the proprietary devices such as swirl concentrators and/or media filters such as compost or sand. Each vault should come with instructions for use from the manufacturer. Because there are many different vault designs, the following are general rules only, and the manufacturer's directions for cleaning and maintenance should be followed when available.

- The inspector should check the depth of sediment and debris in the vault. As a rule of thumb it is suggested that vaults be cleaned when of the depth of debris and/or sediment exceeds the depth of the sediment capture zone by more than 6 inches.

- The inspector should determine how long it has been since the filters were replaced. The filters should be replaced per the manufacturer's recommendation.

- The inlet to the vault should be checked for clogging. If the inlet is clogged it could be a sign of other issues onsite (e.g., debris improperly disposed of) that need to be addressed. The inspector should determine if other measures can be implemented onsite to control the clogging problem.

Vegetated Treatment Systems

Vegetated treatment systems use vegetation to slow and filter stormwater. Examples include swales and filter strips usually planted with a variety of grasses or other ground cover. Vegetated systems designed with shrubs or wetland plants require special care. Consult the Department of Ecology's *Stormwater Management Manual for Western Washington* or *Stormwater Management Manual for Eastern Washington* in these cases. Visual inspection of vegetated treatment systems should include the following:

- The inspector should inspect the average height of the grass. Vegetated treatment systems should be inspected twice per year for invasive species (weeds and other invasive plants that can shade out the grass, greatly reducing stormwater filtration effectiveness). Maintenance, usually mowing, is required when vegetation is greater than ten inches tall. Grass should be mowed to 3 or 4 inches in height.

- The inspector should check the vegetated system for trash and debris. Trash and debris need to be removed from the treatment system at least twice per year.

- The treatment system needs to be inspected for bare areas twice a year. If bare areas exceed 10 percent of the area the facility needs to be reseeded and/or planted to restore vegetative cover.

- Water standing in a swale for an extended period of time after a storm usually indicates that sediment deposits are blocking the flow and should be removed.

Infiltration Facilities

Infiltration facilities rely on infiltration to reduce the volume of stormwater runoff from a site. Examples include underground facilities such as dry wells and surface facilities such as infiltration ponds and trenches. Some infiltration facilities may include vegetation and are sometimes known as rain gardens. Visual inspection of infiltration facilities should be conducted following the guidance presented below.

- The inspector should check the sediment volume in the facility. Sediment needs to be removed when the sediment volume exceeds the facility’s design capacity. Refer to design plans to determine when maintenance is required.

- The inspector should check the facility for trash and debris. Trash and debris need to be removed from the treatment system at least twice per year.

- The inspector should inspect infiltration facilities for standing water 72 hours after a storm. If there is standing water the facility likely requires maintenance.

- The inspector should inspect infiltration facilities for burrows, holes, or mounds. If they are present and causing erosion or leakage, maintenance is required.

- The inspector should inspect infiltration facilities for evidence of erosion. If evidence of erosion is present, maintenance is required.

- The inspector should inspect the average plant height once a year. Maintenance is usually required for grassed areas when vegetation is greater than 12 inches tall.

- During an inspection, the inspector should check for general maintenance issues. If anything is observed it should be noted on the inspection sheet and addressed.

Treatment Ponds

Treatment ponds range from small, often concrete-lined facilities to large ponds. They can remove particulates and any associated pollutants through settling/sedimentation. Visual inspection of treatment ponds should be conducted following the guidance presented below.

- Trash and debris volume exceeding about one garbage can is considered excessive and should be removed.

- The inspector should check the sediment volume in the pond. Sediment needs to be removed when the sediment volume exceeds the facility's design capacity, usually about 10 percent of the pond depth. Refer to design plans to determine when maintenance is required. Formation of sediment deltas at the inlet to a pond is a sign that maintenance is required.

- The inspector should check the pond for trash and debris. Trash and debris volume exceeding about one garbage can is considered excessive and should be removed, immediately. Lesser amounts should be removed at least twice per year.

- The inspector should inspect treatment ponds for burrows, holes, or mounds in the surrounding berms. If they are present and causing erosion or leakage, maintenance is required.

- The inspector should inspect treatment ponds for evidence of erosion in the berms. If evidence of erosion is present, maintenance is required.

- Any invasive, poisonous, or noxious weeds should be removed as soon as possible. Trees may need to be removed if they are interfering with maintenance access.

- During an inspection, the inspector should check for general maintenance issues. If problems are observed they should be noted on the inspection form and addressed.

References

Ecology. 2004. Stormwater Management Manual for Eastern Washington. Ecology Publication 04-10-076. Washington State Department of Ecology. September 2004.

Ecology. 2005. Stormwater Management Manual for Western Washington. 5 vols. Ecology Publications 05-10-029 through 05-10-0339. Washington State Department of Ecology, Water Quality Program. February 2005.

Form B - Industrial Site Stormwater Facility Inventory

Fill out this inventory prior to conducting routine visual site inspections or after substantial changes in site operation or stormwater facilities occur. The identification of facilities and issues in this inventory are then used to direct use of the Inspection Checklist (Form C). Appendix A of this guidance or the Stormwater Pollution Prevention Plan for the site may be consulted to help fill out this inventory.

Name of the facility: ____

Facility location: ____

Mailing address: ____

Contact person: ____

Phone number: ____

Type of business: ____

SIC code number: ____

NPDES industrial stormwater permit number: ______________________________

Number of employees: ____________________

Spill Prevention

Is there a written spill prevention plan for the facility? ☐ Yes ☐ No

Is the spill plan posted in a location accessible to all employees? ☐ Yes ☐ No

Are employees trained and aware of the spill plan? ☐ Yes ☐ No

Are spill clean-up materials kept on site? ☐ Yes ☐ No

Are clean-up materials clearly labeled "SPILL KIT"? ☐ Yes ☐ No

Are spill kits located near high risk spill areas? ☐ Yes ☐ No

General Maintenance Practices

Are paved outdoor areas regularly swept? ☐ Yes ☐ No

Frequency: ☐ Daily ☐ Weekly ☐ Monthly ☐ As needed

Are paved outdoor areas washed? ☐ Yes ☐ No

Frequency: ☐ Daily ☐ Weekly ☐ Monthly ☐ As needed

Are storm drain inlets inspected, maintained, and/or cleaned? ☐ Yes ☐ No

Cleaning frequency: ☐ Weekly ☐ Monthly ☐ Quarterly ☐ As needed
Basis for determining need for cleaning: ______________________________
Method of cleaning: ______________________________

Loading Dock

Is the loading dock fully roofed? ☐ Yes ☐ No

Does the loading dock area drain to a storm drain? ☐ Yes ☐ No

Is there containment so materials and spills do not reach the storm drain? ☐ Yes ☐ No

Are spill kits are located at the dock? ☐ Yes ☐ No

List all significant materials that are loaded and unloaded at the dock (including industrial waste, byproduct, and raw, intermediate, or final products):

____
____
____
____
____
____

List modifications to loading dock operations/BMPs needed to fully contain or cover materials:

____
____
____
____

Vehicle and Heavy Equipment Storage and Maintenance

Are trucks and/or heavy equipment parked onsite? ☐ Yes ☐ No

Are there storm drain inlets in the parking area(s)? ☐ Yes ☐ No

Are vehicle/equipment repairs and maintenance completed onsite? ☐ Yes ☐ No

Are repair and maintenance areas enclosed? ☐ Yes ☐ No

Does fueling occur onsite? ☐ Yes ☐ No

Is the fueling area covered? ☐ Yes ☐ No
Are there drain inlets in the fueling area? ☐ Yes ☐ No
If yes, where do the drains discharge?

☐ Storm ☐ Sanitary ☐ Dry well ☐ Other treatment device ________________

☐ Unknown

List modifications and/or additions to vehicle storage, maintenance, and fueling operations/ BMPs needed to prevent and minimize pollution of site stormwater:

____

____

____

____

____

Vehicle and Equipment Washwater Practices

Are there drain inlets in the wash area? ☐ Yes ☐ No

If yes, where do the drains discharge?

☐ Storm ☐ Sanitary ☐ Dry well ☐ Other treatment device ________________

☐ Unknown

Is the wash area completely covered, enclosed, or contained? ☐ Yes ☐ No

Are cleaning additives used in the washwater? ☐ Yes ☐ No ☐ Unknown

If yes, what type? ____

Is the wash water recycled? ☐ Yes ☐ No

Waste Storage and Disposal Practices

Are waste receptacles available, intact, and of adequate size? ☐ Yes ☐ No

How are accumulated liquids managed?

____

____

____

____

____

Is a “boneyard” present? (The boneyard is an area containing old, spare, non-working equipment or machinery.) ☐ Yes ☐ No

Is the boneyard completely covered, enclosed, or contained? ☐ Yes ☐ No

Does the boneyard drain to a stormdrains? ☐ Yes ☐ No

List modifications to waste storage practices needed to prevent and minimize pollution of site stormwater:

____

____

____

____

____

Stormwater Treatment Structures

Catch Basins

Catch basins are facilities such as inlets or manholes in which the bottom of the structure extends below the outlet pipe. This serves as a sump or "trap" to allow removal of coarse particulates in stormwater runoff.

Are there catch basins onsite? ☐ Yes ☐ No

Are catch basins regularly cleaned or inspected? ☐ Yes ☐ No

How frequent are they inspected?

☐ Monthly ☐ Quarterly ☐ Annually ☐ As needed

How frequent are they cleaned?

☐ Monthly ☐ Quarterly ☐ Annually ☐ Unknown

Identify catch basins and type of treatment below:

Catch basin I.D. __________	☐ Inverted elbow	☐ Sump below outlet pipe	☐ Catch basin insert
Catch basin I.D. __________	☐ Inverted elbow	☐ Sump below outlet pipe	☐ Catch basin insert
Catch basin I.D. __________	☐ Inverted elbow	☐ Sump below outlet pipe	☐ Catch basin insert
Catch basin I.D. __________	☐ Inverted elbow	☐ Sump below outlet pipe	☐ Catch basin insert
Catch basin I.D. __________	☐ Inverted elbow	☐ Sump below outlet pipe	☐ Catch basin insert
Catch basin I.D. __________	☐ Inverted elbow	☐ Sump below outlet pipe	☐ Catch basin insert
Catch basin I.D. __________	☐ Inverted elbow	☐ Sump below outlet pipe	☐ Catch basin insert
Catch basin I.D. __________	☐ Inverted elbow	☐ Sump below outlet pipe	☐ Catch basin insert

Oil/Water Separators

Oil/water separators are of three types: coalescing plate (with closely stacked, inclined plates), gravity separator (a vault with compartments that force water to move along the bottom and oil to float to the top), or vaults/pools with skimmers (devices to remove oil off the top of the water column). All three types rely on oil floating to separate oil and water.

Are there oil/water separators onsite? ☐ Yes ☐ No

Underground Treatment Vaults

Underground treatment vaults temporarily store runoff, allowing some settling and/or filtering of sediments and associated pollutants. Examples include baffled vaults and many of the proprietary devices such as swirl concentrators and/or media filters such as compost or sand.

Are there underground treatment vaults onsite? ☐ Yes ☐ No

Vegetated Treatment Systems

Vegetated treatment systems use vegetation to slow and filter stormwater. Examples include swales and filter strips.

Are there vegetated treatment systems onsite? ☐ Yes ☐ No

Infiltration Facilities

Infiltration facilities rely on infiltration to reduce the volume of stormwater runoff from a site. Examples include underground facilities such as dry wells and surface facilities such as infiltration ponds. Some infiltration facilities may include vegetation and may be designed as rain gardens.

Are there infiltration basins and/or trenches on site? ☐ Yes ☐ No

Treatment Ponds

Treatment ponds range from small, often concrete-lined facilities to large ponds. They can remove particulates and any associated pollutants through settling/sedimentation.

Are there one or more treatment ponds onsite? ☐ Yes ☐ No

Form C - Industrial Site Stormwater Inspection Checklist

Use this checklist during each visual site inspection. Refer to the Stormwater Facility Inventory (Form B) to determine which sections of this checklist should be filled out. For example, if the industrial site contains only catch basins and an oil/water separator then the underground vaults and Table 1 - Vegetated treatment, infiltration, and treatment ponds, should not be filled out.

Date and time of inspection: ______________________________

Weather conditions: ______________________________

Inspector name(s): ______________________________

Inspector title(s): ______________________________

Inspector phone number(s): ______________________________

Material Storage

For each significant material listed in worksheet #2A in the Stormwater Pollution Prevention Plan (those significant materials potentially exposed to precipitation), verify the condition of the controls used to prevent pollutant contact with precipitation and runoff:

Type of Significant Material	Is Material Contained?	Is Material Covered?	Is There Evidence of Covered/Contained Material Escaping the Storage Area? If Yes, Explain	Is Further Action Required to Completely Cover or Contain Materials?
	Yes / No	Yes / No		
	Yes / No	Yes / No		
	Yes / No	Yes / No		
	Yes / No	Yes / No		
	Yes / No	Yes / No		
	Yes / No	Yes / No		
	Yes / No	Yes / No		

General Maintenance Practices

Is there evidence of pollutants, waste materials, or spilled industrial product(s) on paved areas or in storm drain inlets that should be cleaned up before the next rain event to prevent entry into surface waters? ☐ Yes ☐ No

Recommended actions:

Loading Dock

Is there evidence of pollutants, waste materials, or spilled industrial product(s) escaping the loading dock that should be cleaned up before the next rain event to prevent entry into the stormwater system? ☐ Yes ☐ No

Recommended actions:

Vehicle and Heavy Equipment Storage and Maintenance

Are there signs of leaking oil and/or motor fluids (sheen on the puddles)? ☐ Yes ☐ No

Are there non-operating vehicles parked on-site? ☐ Yes ☐ No

Recommended actions:

Waste Storage and Disposal Practices

Are garbage dumpsters and trash compactors covered and free of leaks? ☐ Yes ☐ No

Is there evidence of significant spilled materials around waste containers? ☐ Yes ☐ No

Are there oils, grease, or other substances exposed to stormwater in boneyard? ☐ Yes ☐ No

Recommended actions:

Stormwater Treatment Structures

Catch Basins

Indicate types of material trapped by catch basin:

☐ Sediment ☐ Trash ☐ Oil/grease ☐ Paint ☐ Other ____________________

How deep is the material in the catch basin from the bottom of the outlet pipe? _ Inches

Recommended actions:

Oil/Water Separators

Is the floating oil in the chambers two inches or more thick? ☐ Yes ☐ No

Is there a sludge buildup on the bottom of the separator? ☐ Yes ☐ No

(*Check sludge level by taking a stick long enough to reach the bottom; if there is resistance to push through to the bottom then there is a sludge buildup, if it is greater than 8 inches thick it should be serviced. Most oil/water separators do not remove sediments very well, so any sediment observed in the separator probably indicates excessive sediment loading to the system.*)

Is there a buildup of silt or solids on the coalescing plates? ☐ Yes ☐ No ☐ NA

Recommended actions:

Underground Treatment Vaults

Is the inlet to the vault clear of debris? ☐ Yes ☐ No

Does the vault need to be cleaned? ☐ Yes ☐ No

Assess cleaning frequency based on manufacturer's recommendations. Otherwise clean when the vault bottom is half full of sediment (measure from the bottom of the outlet pipe to the bottom of the vault).

Recommended actions:

Vegetated Treatment Systems, Infiltration Systems, and Treatment Ponds

Inspect each vegetated treatment system, infiltration basin or trench, and treatment pond facility present at the site. If you notice any of the listed maintenance issues, place an X in the corresponding box in Table 1. If there are no maintenance issues, leave the box blank. If you notice an issue that is not listed in this table, please describe it in the "other issues or comments" row of Table 1. Indicate NA when not applicable.

Table 1. Stormwater treatment facility inspection summary.

Maintenance Issue	Vegetated Treatment Systems	Infiltration Facilities	Treatment Ponds
Presence of woody plant species			
Average plant height > 4 inches			
Sediment volume exceeds capacity			
Debris or trash present (in the structure or blocking the inlet or outlet)			
Standing water 72 hours after a storm event (may result in less capacity for the next storm as well as providing mosquitoes with place to breed)			Not applicable
Burrows, holes, or mounds (may weaken berms surrounding detention facilities)			
General maintenance (inlet/outlet structural integrity, damage, erosion, graffiti, vandalism)			
Evidence of erosion (rills, gullies, or sediment deposits at toe of slope)			
Bare areas (from excess erosion or sedimentation)			
Ponding or vector problems (mosquitoes, wasps, rats, nutria, birds, and domestic pets)			

Other issues or comments? ____

____

____

Appendix III

Introduction

This appendix documents analyses that were performed to evaluate the potential for exceeding Washington's surface water quality standards given proposed revisions to the permit targets identified in the Industrial Stormwater General Permit (ISWGP). In general, compliance with water quality standards requires assessment of the discharger's compliance with the numeric criteria and narrative standards and policies.

The narrative standards and policies portion of the water quality standards are more difficult to quantify. They include such prohibitions as: no toxic substances in toxic amounts, no resulting increase of pollutant concentrations above background (the antidegradation policy), or the loss of a beneficial use. Compliance with narrative standards and policies require conducting site-specific studies of the discharge and its physical, chemical, and biological impacts to receiving water. Assessing compliance with the narrative standards and policies portion of the water quality standards is beyond the scope of this analysis.

The numeric criteria have been determined by the U.S. Environmental Protection Agency to be protective of aquatic life, human health, and sediment quality. They are periodically revised to incorporate the best available science. Water quality standards take into account potential dilution, ratio of dissolved to total metals, water effects ratios, and background concentration. These are site-specific parameters. In the case of an individual discharger, Ecology conducts a reasonable potential analysis that compares pollutant concentrations in the discharge with the physical and chemical properties of the receiving water to determine compliance with the numeric criteria.

Because this analysis must take into account the broad range of facility types and receiving waters that would be covered under the ISWGP, compliance with numeric criteria cannot be evaluated based on site-specific information. Therefore, this analysis utilized simple dilution models to evaluate the potential for exceeding the numeric criteria given the following model inputs: representative receiving water data for western and eastern Washington, representative dilution factors, and the proposed permit targets. To provide some basis for assessing uncertainty in this analysis, Monte Carlo simulation was employed in running the dilution models to determine the probability of exceeding the numeric criteria based on the receiving water conditions with the highest potential for occurrence. This risk assessment focused solely on zinc, copper, and lead since these are primary parameters of concern and there are relevant water quality criteria for each metal. A detailed description of the approach used for this risk assessment is provided in the following section. The results from this analysis are then presented in the concluding section.

Data Analysis Methods

This analysis utilized a spreadsheet dilution model with the following equation to predict theoretical receiving water concentrations for total zinc, total copper, and total lead at the facility's point of discharge assuming effluent concentrations equal to the proposed benchmark and action levels in Table 1:

$$C_r = (1/F_d \quad C_f) + ([1 - 1/F_d] \quad C_b)$$

where:

C_r = receiving water concentration at facility point of discharge
F_d = dilution factor
C_f = effluent concentration
C_b = receiving water background concentration.

Separate analyses were performed assuming representative receiving water conditions for western and eastern Washington and the following dilution factors (F_d) for the facility's effluent in the receiving water: 1, 2, 5, 10, 25, and 50. The predicted receiving water concentration after effluent discharge was subsequently compared to applicable numeric water quality criterion to determine if the proposed benchmark or action level is protective of water quality given each specified amount of dilution.

Monte Carlo simulation was incorporated into the spreadsheet model using the Crystal Ball software package in order to quantify uncertainty in the analyses that stems from the following variables:

- Receiving water background concentrations
- Translator values for estimating dissolved metals concentrations from total metals concentrations
- Hardness dependent numeric criteria for metals

The following subsections describe in more detail the procedures that were used to incorporate each of these variables into the model.

Receiving Water Background Concentrations

Representative background concentrations in the receiving water were obtained for western and eastern Washington, respectively, based on queries of Ecology's Environmental Information Management System (EIM) database (Ecology, 2006). More specifically, the EIM database was queried to obtain data from river systems in each region of the state for the targeted parameters (i.e., total zinc, total copper, and total lead). The Crystal Ball software package was then used to fit theoretical probability distributions to these data to describe their expected uncertainty. These probability distributions were used to generate input data during 1,000 iterations of the model. Model output from these iterations were subsequently evaluated to determine the probability of exceeding numeric water quality criteria given receiving water conditions with the highest potential for occurrence. Histograms derived from the actual EIM data and the theoretical probability distributions are presented in Figures 1, 2, and 3 for total zinc, total copper, and total lead, respectively.

Translator Values

Theoretical receiving water concentrations computed for total zinc, total copper, and total lead from the equation above must be converted to dissolved concentrations to facilitate comparisons to the water quality criteria which are based on the dissolved forms of these metals. These conversions were made using translator values that were derived from guidance presented by Pelletier (1996). Because these translator values vary depending on the total suspended solids concentration in the receiving water, the EIM database was again queried to obtain data for this parameter from rivers systems in eastern and western Washington, respectively. The Crystal Ball software package was then used to fit theoretical probability distributions to these data to describe their expected uncertainty. These probability distributions were used to generate input data during 1,000 iterations of the model. Model output from these iterations were subsequently evaluated to determine the probability of exceeding numeric water quality criteria given total suspended solids concentrations in the receiving water with the highest potential for occurrence. Histograms derived from the actual EIM data and the theoretical probability distributions are presented in Figure 4. Cumulative frequency plots for the translator values that were derived from these data are presented in Figures 5, 6, and 7 for total zinc, total copper, and total lead, respectively.

Hardness Dependant Numeric Criteria for Metals

Because state water quality standards for zinc, copper, and lead vary with the hardness of the receiving water, the EIM database was again queried to obtain data for this parameter from rivers systems in eastern and western Washington, respectively. The Crystal Ball software package was then used to fit theoretical probability distributions to these data to describe their expected uncertainty. These probability distributions were used to generate input data during 1,000 iterations of the model. Model output from these iterations were subsequently evaluated to determine the probability of exceeding numeric water quality criteria given total suspended solids concentrations in the receiving water with the highest potential for occurrence. Histograms derived from the actual EIM data and the theoretical probability distributions are presented in Figure 8.

Data Analysis Results

Results from the analyses described above are summarized in Table 2. These data indicate the percent probability that the water quality criterion will be exceeded for the specified dilution factor and effluent pollutant concentration equal to the benchmark or action level. A more detailed discussion of these results is provided in the main body of this report.

References

Ecology. 2006. Database retrieval: Water quality data from river systems for hardness, total suspended solids, turbidity, total zinc, total copper, and total lead. Environmental Information Management (EIM) system (<http://www.ecy.wa.gov/eim/index.htm>), Washington State Department of Ecology, Olympia, Washington. March 17, 2006.

Pelletier, G. 1996. Applying Metals Criteria to Water Quality-Based Discharge Limits, Empirical Models of the Dissolved Fraction of Cadmium, Copper, Lead, and Zinc. Watershed Assessments Section, Environmental Investigations and Laboratory Services Program, Washington State Department of Ecology, Olympia, Washington.

Table 1. Recommended permit targets for total zinc, total copper, and total lead for the Industrial Stormwater General Permit

Parameter	Recommended Permit Targets	
	Benchmark	Action Level
Total Zinc (µg/L)	142	280
Total Copper (µg/L)	23.8	42.6
Total Lead (µg/L)	17.3	40.0

µg/L: microgram/liter

Table 2. Results from Monte Carlo Risk Assessment of proposed benchmark and action levels.

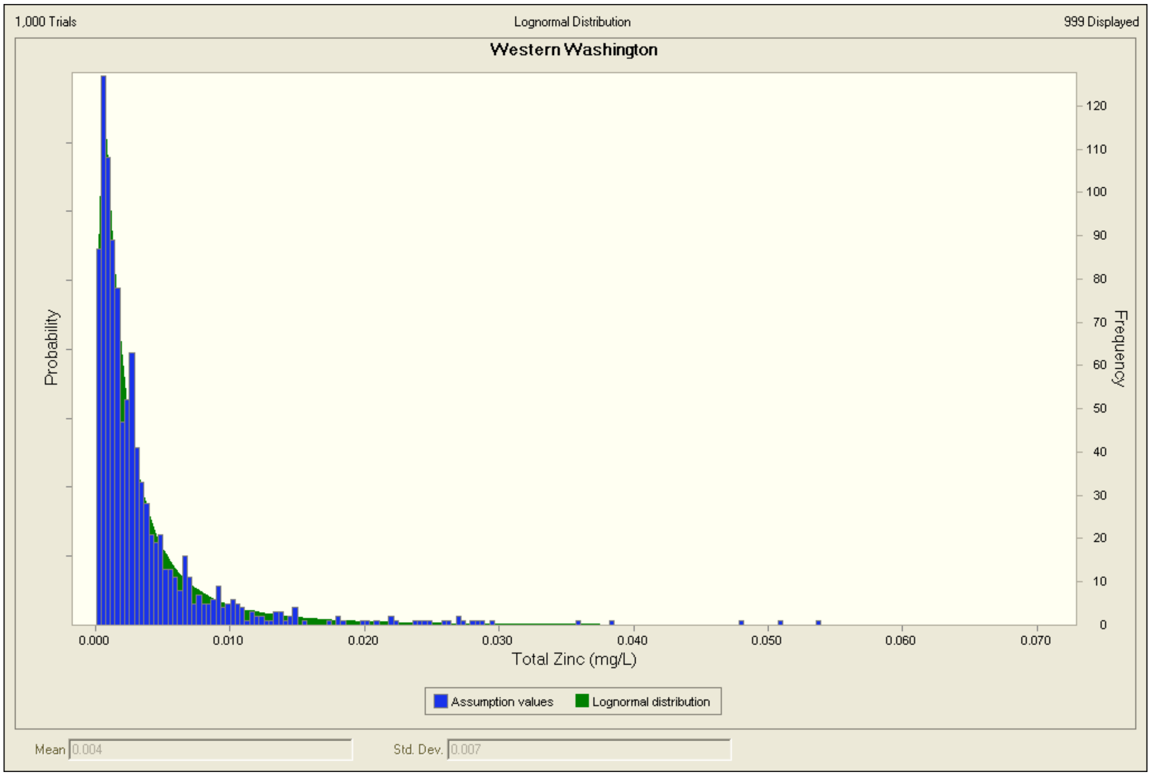
Dilution Factor	Copper Benchmark (23.8 µg/L)				Copper Action Level (42.6 µg/L)			
	Western WA		Eastern WA		Western WA		Eastern WA	
	Acute	Chronic	Acute	Chronic	Acute	Chronic	Acute	Chronic
1	88.8	95.7	35.4	55.2	98.3	99.4	68.3	84.5
2	57.1	76.5	13.0	23.6	85.1	94.6	37.3	55.2
5	17.0	29.7	4.9	8.6	41.6	62.6	9.5	19.0
10	5.9	12.0	2.5	4.3	16.5	28.8	5.3	8.5
25	2.8	5.3	2.7	4.0	3.1	8.5	2.0	3.9
50	3.3	5.0	2.1	3.6	3.6	6.6	2.9	4.4

Dilution Factor	Lead Benchmark (17.3 µg/L)				Lead Action Level (40 µg/L)			
	Western WA		Eastern WA		Western WA		Eastern WA	
	Acute	Chronic	Acute	Chronic	Acute	Chronic	Acute	Chronic
1	0.1	97.1	0.0	62.3	2.0	100.0	0.3	90.6
2	0.0	79.3	0.0	27.7	0.1	99.1	0.0	72.1
5	0.0	39.7	0.0	11.9	0.0	79.3	0.1	30.4
10	0.0	18.7	0.0	8.2	0.0	44.3	0.0	14.6
25	0.0	9.6	0.0	6.4	0.1	17.5	0.1	7.6
50	0.0	9.5	0.0	5.0	0.0	11.7	0.0	4.4

Dilution Factor	Zinc Benchmark (142 µg/L)				Zinc Action Level (280 µg/L)			
	Western WA		Eastern WA		Western WA		Eastern WA	
	Acute	Chronic	Acute	Chronic	Acute	Chronic	Acute	Chronic
1	74.5	80.1	23.6	27.3	97.6	98.3	60.1	65.3
2	28.8	35.6	12.0	14.0	77.5	84.2	31.8	37.2
5	2.6	3.1	7.4	8.2	20.2	24.4	13.0	15.2
10	1.4	1.7	8.4	9.1	3.0	4.2	9.2	9.6
25	1.1	1.6	8.4	9.1	1.3	1.9	9.7	10.6
50	0.6	0.8	8.6	8.9	1.1	1.2	7.7	8.2

Values presented in the table indicate the percent probability that the water quality criterion will be exceeded for the specified dilution factor and effluent pollutant concentration equal to the benchmark or action level.

Figure 1. Histogram and the theoretical probability distribution for total zinc data used in Monte Carlo simulations.



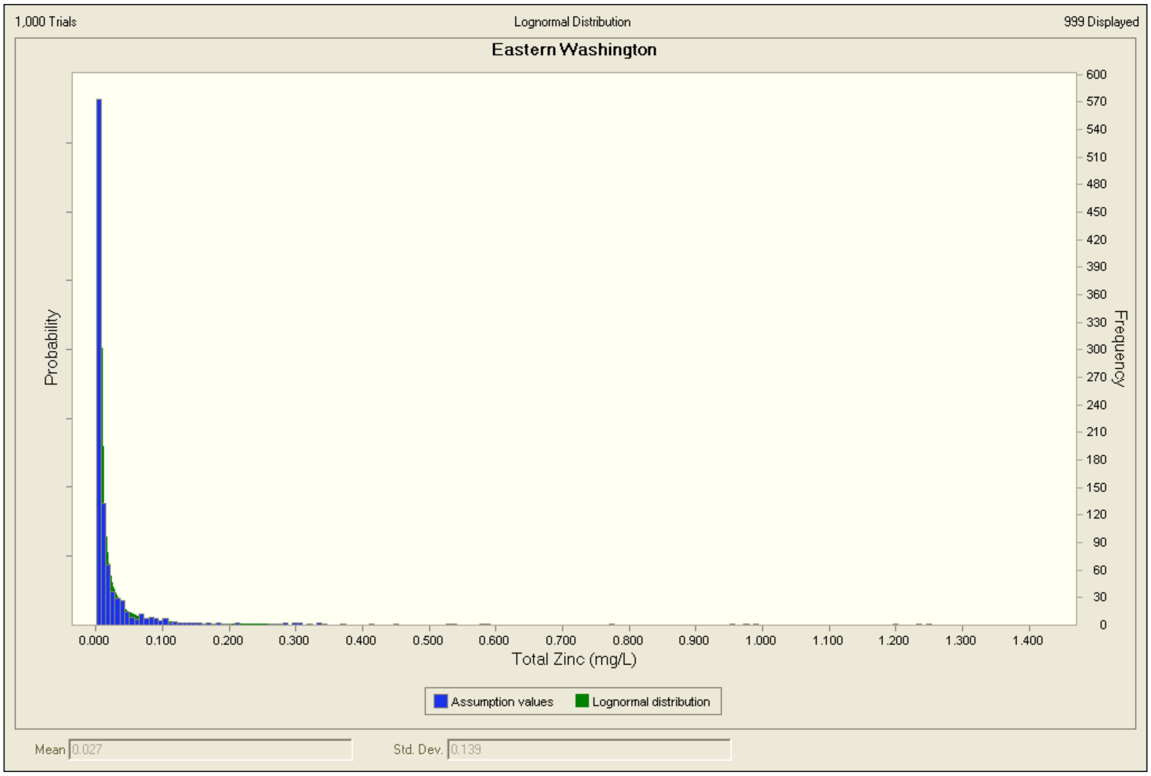
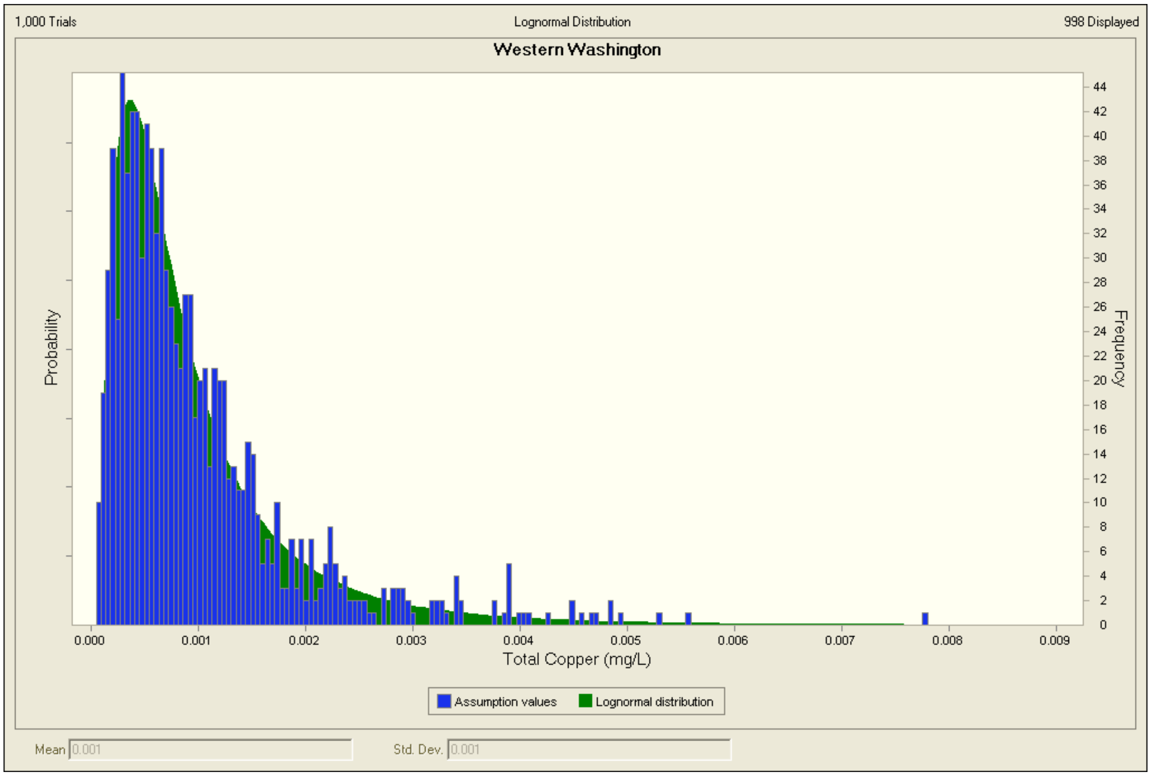


Figure 2. Histogram and the theoretical probability distribution for total copper data used in Monte Carlo simulations.



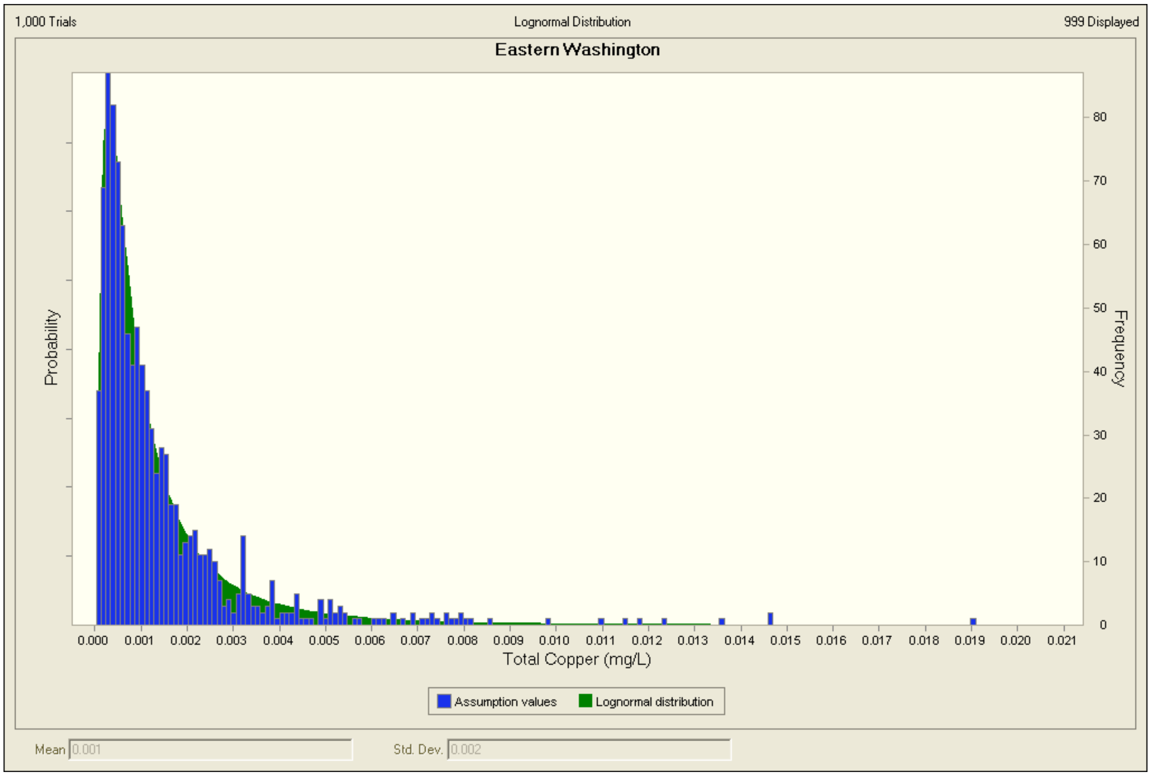
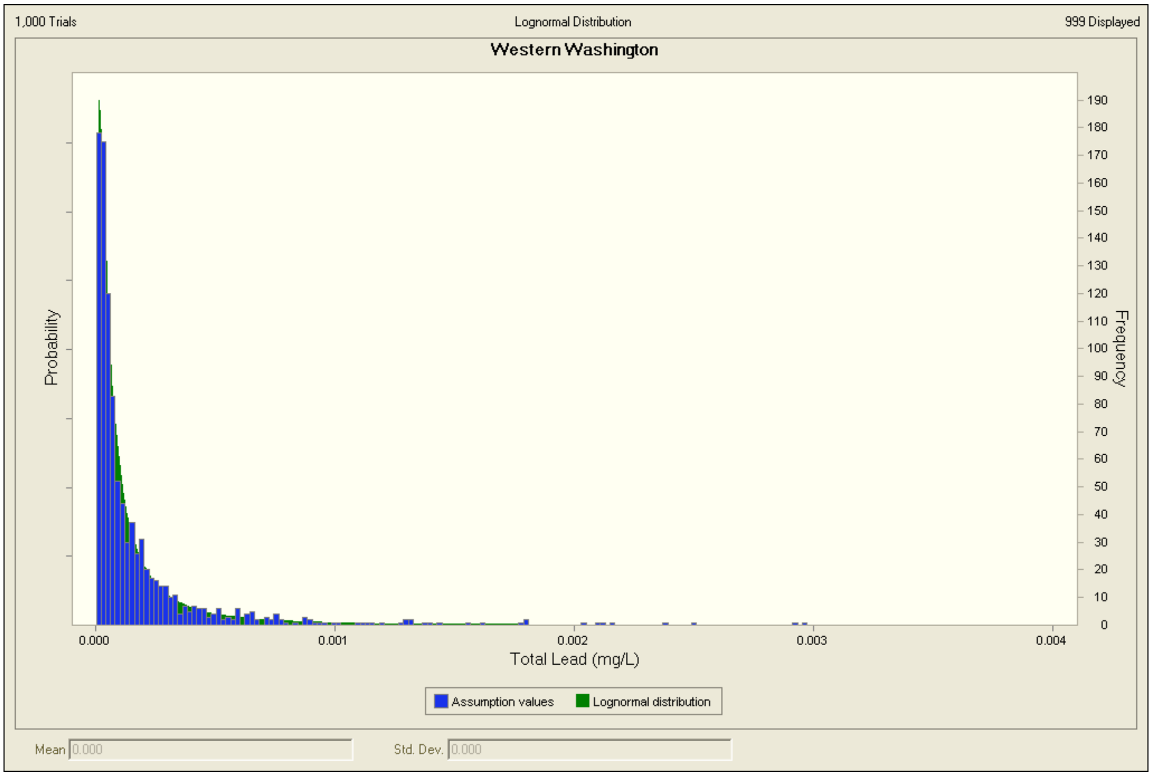


Figure 3. Histogram and the theoretical probability distribution for total lead data used in Monte Carlo simulations.



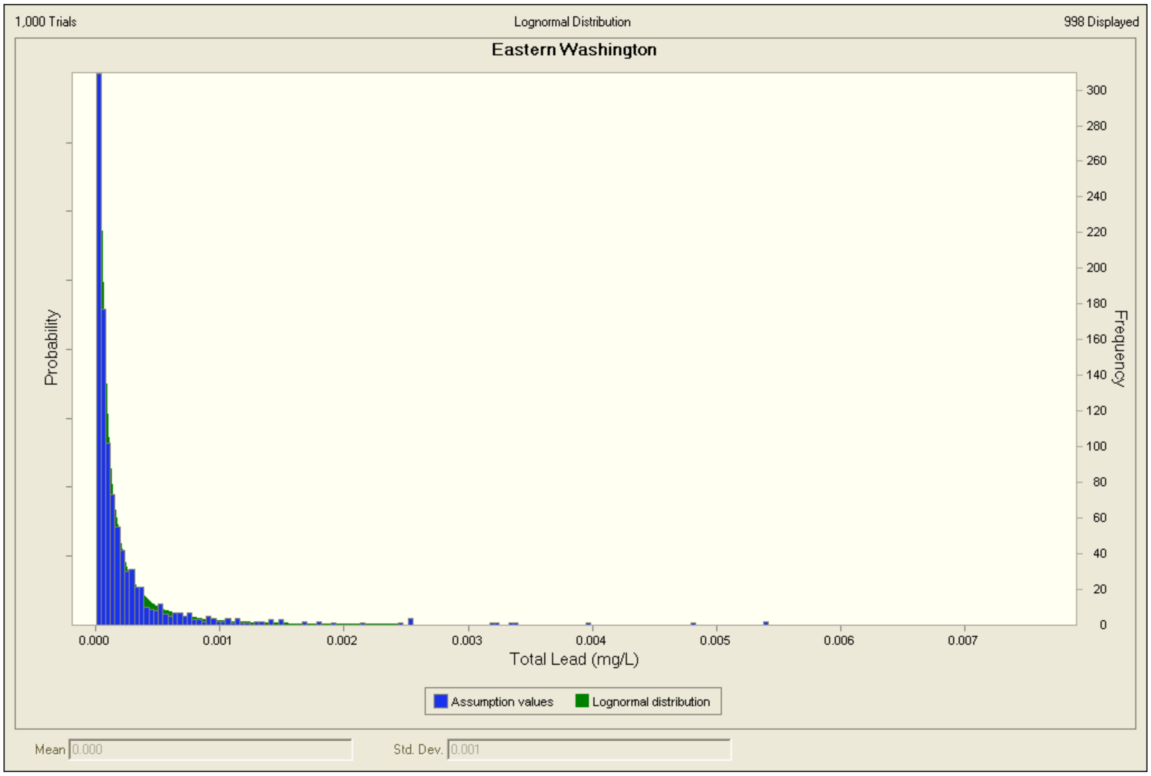
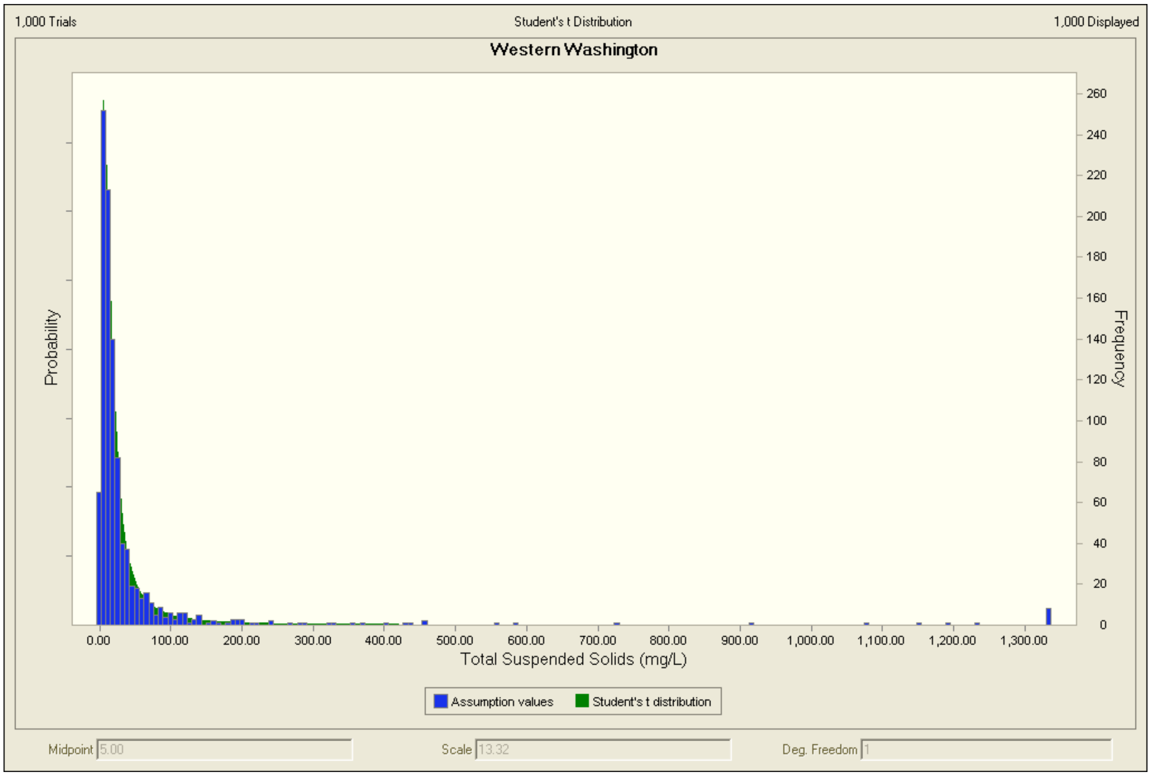


Figure 4. Histogram and the theoretical probability distribution for total suspended solids data used in Monte Carlo simulations.



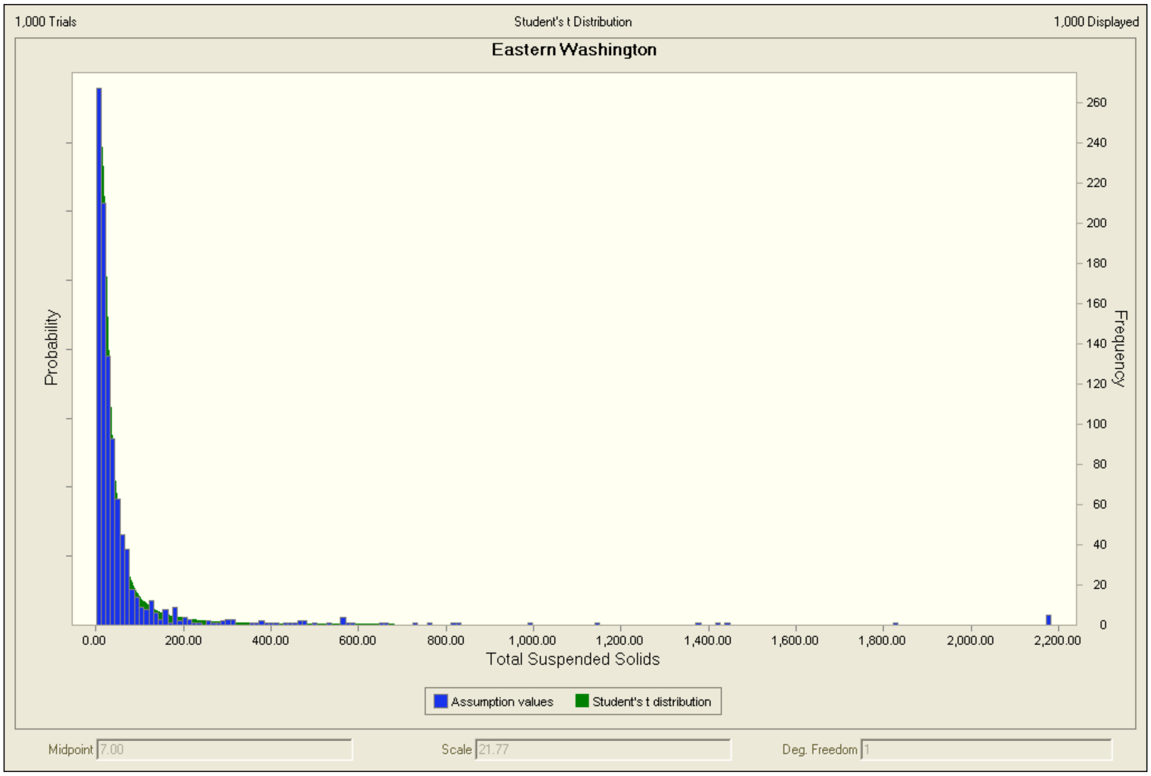
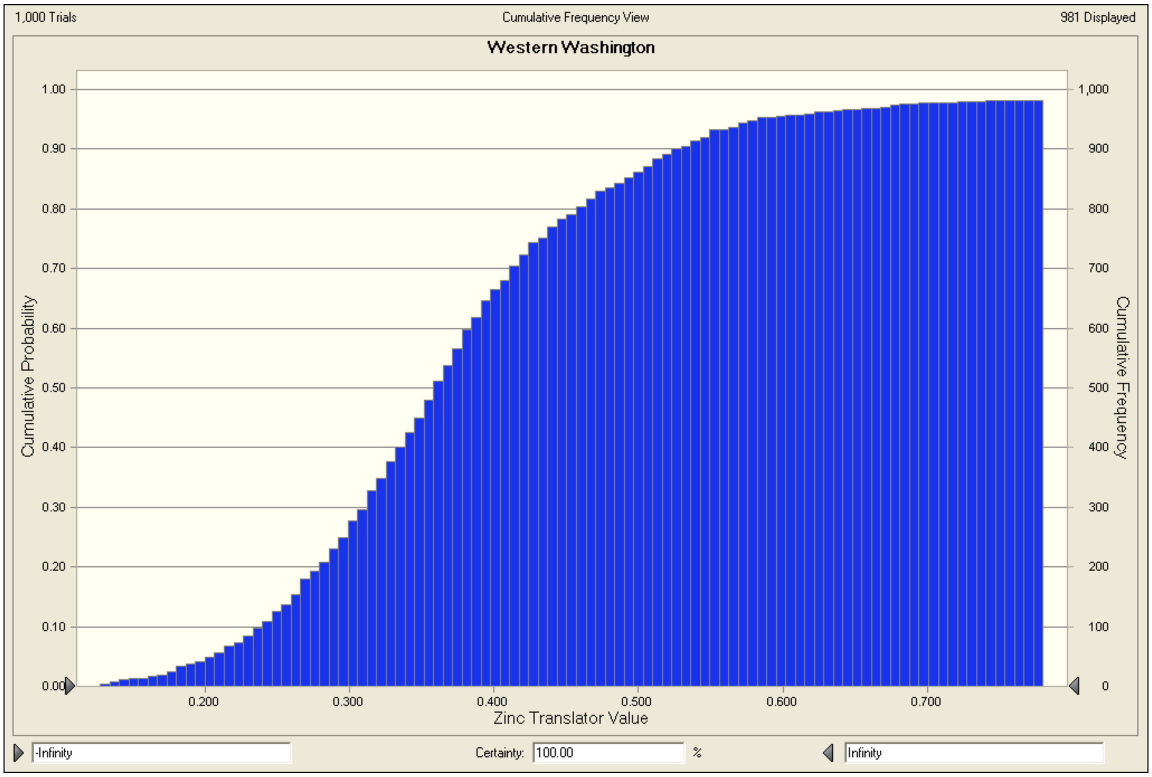


Figure 5. Cumulative frequency plot for zinc translator values used in Monte Carlo simulations.



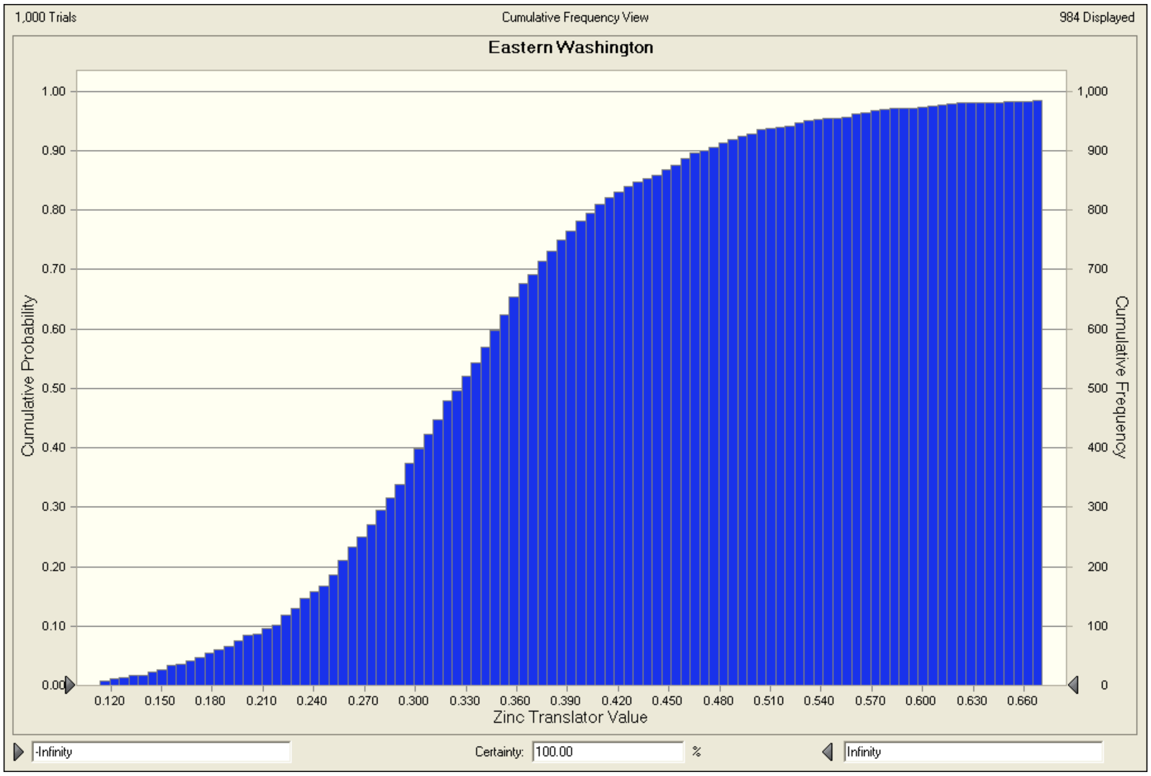
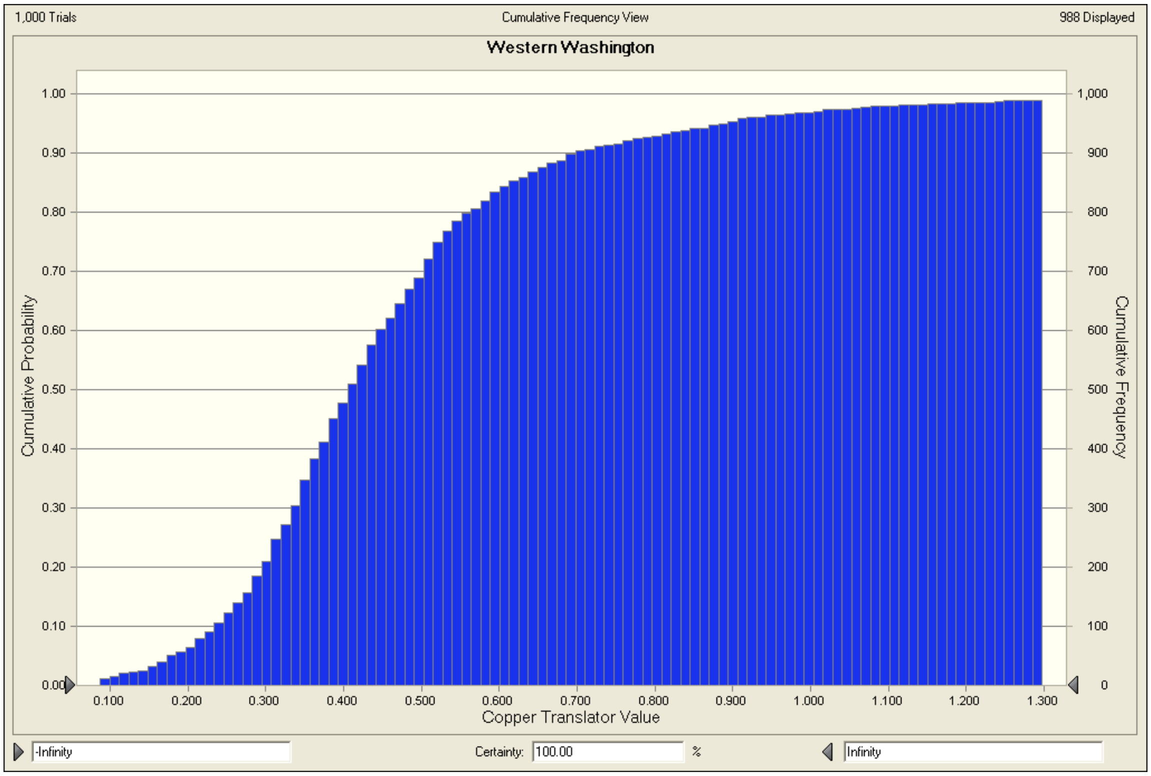


Figure 6. Cumulative frequency plot for copper translator values used in Monte Carlo simulations.



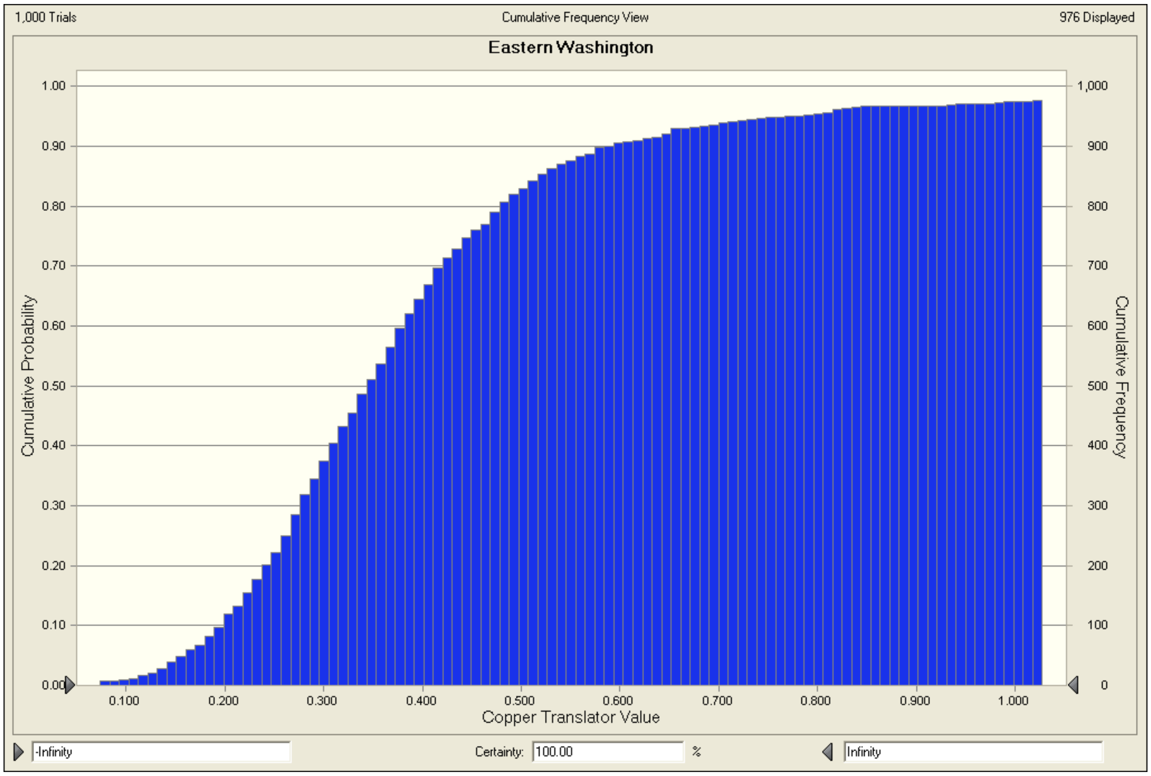
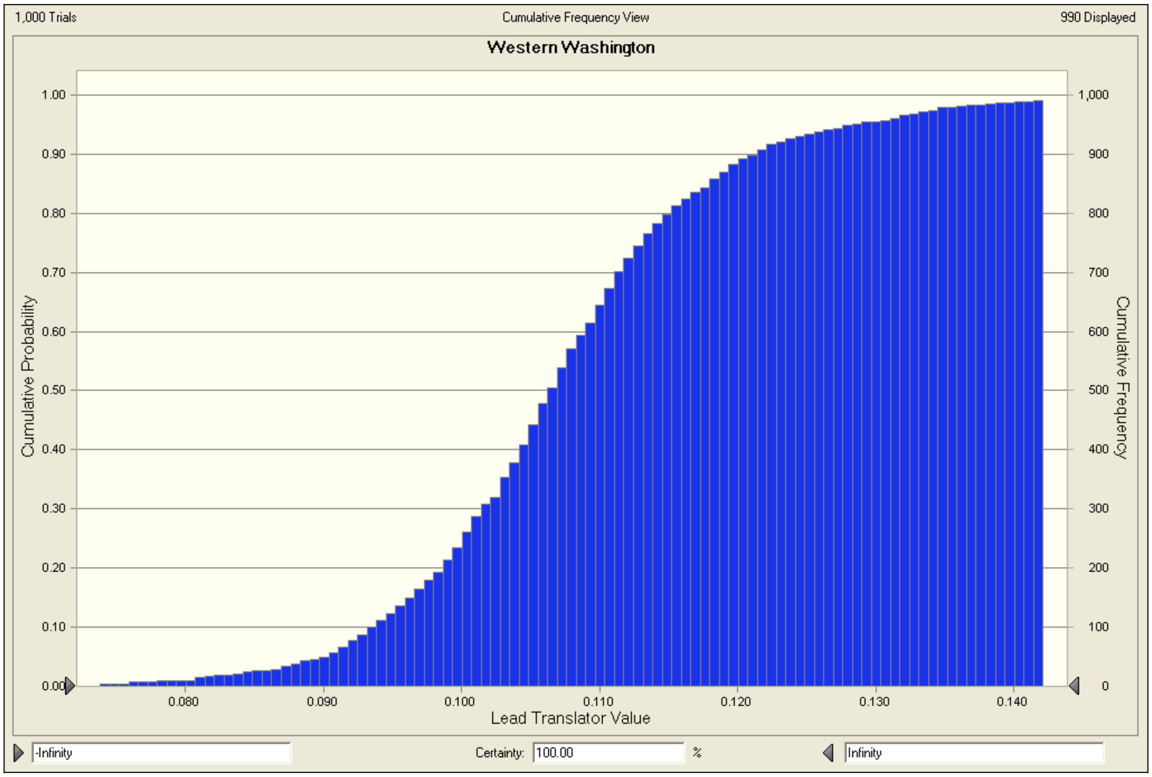


Figure 7. Cumulative frequency plot for lead translator values used in Monte Carlo simulations.



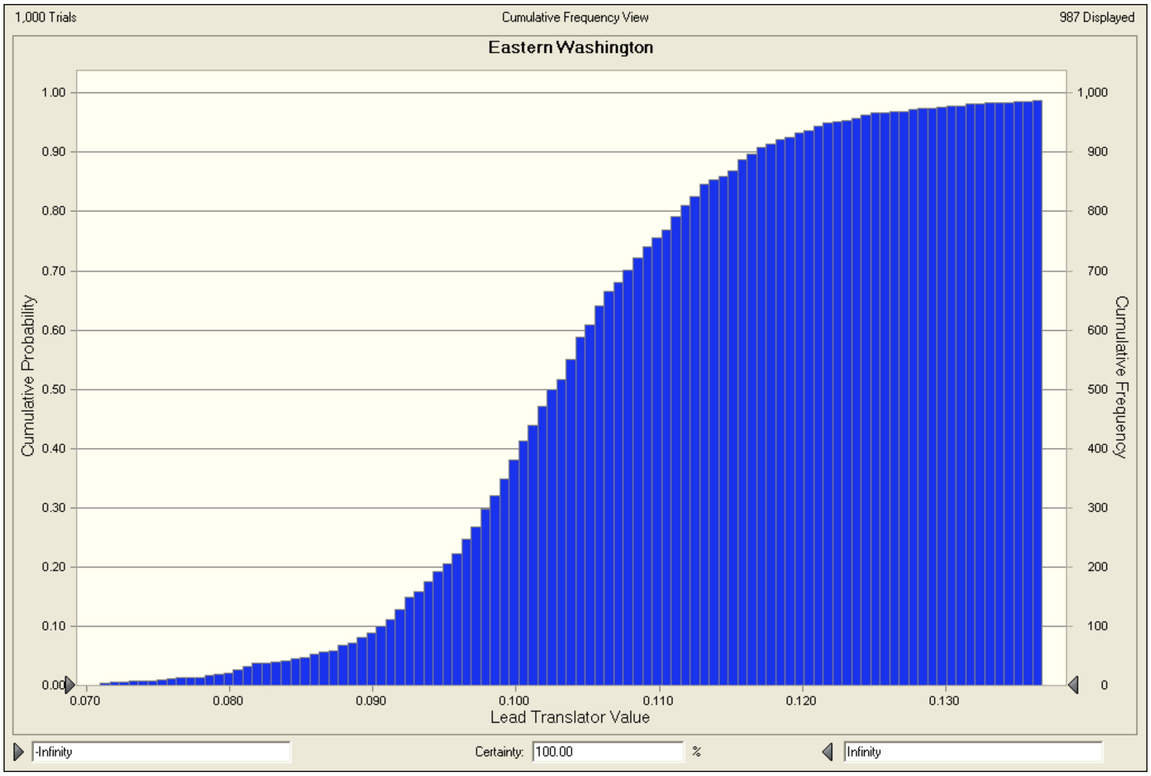


Figure 8. Histogram and the theoretical probability distribution for hardness data used in Monte Carlo simulations.