MEDFORD REGIONAL WATER RECLAMATION FACILITY OUTFALL ASSESSMENT STUDY

For the Rogue Fly Fishers & Federation of Fly Fishers

Assessment & Report completed by
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BACKGROUND & STUDY OBJECTIVES

The Medford Regional Water Reclamation Facility is the waste-water treatment plant for the Rogue River Valley covering Medford, Central Point, Jacksonville, Phoenix, Talent, Eagle Point, and some unincorporated areas in Jackson County. Treated effluent is discharged from an outfall pipe located close to the south side of the Rogue River channel at river mile 130.5. Detailed effluent quality limits are defined in Medford's current NPDES discharge permit signed by DEQ on December 13, 2011 (copy of permit online at:

http://www.deq.state.or.us/wq/trading/docs/MedfordNpdesPermit.pdf)

Besides setting chemical limits on the effluent, NPDES permits also define a mixing zone for the discharge. A mixing zone allows an area of effluent mixing within the receiving stream where water quality may exceed some State and Federal standards to allow time for initial mixing and dilution. Once outside the mixing zone, however, the receiving stream must meet all applicable water-quality standards. The basic requirements of mixing zones are defined in Oregon Administrative Rule (OAR) 340-041-0053 part of which is copied below:

Mixing Zones

(b) A point source for which the mixing zone is established may not cause or significantly contribute to any of the following conditions outside the boundary of the mixing zone:

(A) Materials in concentrations that will cause chronic (sublethal) toxicity. Chronic toxicity is measured as the concentration that causes long-term sublethal effects, such as significantly impaired growth or reproduction in aquatic organisms, during a testing period based on test species life cycle. Procedures and end points will be specified by the Department in wastewater discharge permits;

(B) Exceedances of any other water quality standards under normal annual low flow conditions.

(For the complete text of OAR 340-041-0053 see Appendix A.)

Medford's NPDES permit defines the mixing zone for the sewage outfall as:

> *The allowable mixing zone is that portion of the Rogue River contained within a band extending out 100 feet from the south bank of the river and extending from a point 10 feet upstream of the outfall to a point 300 feet downstream from the outfall. The Zone of Immediate Dilution (ZID) is defined as that portion of the allowable mixing zone that is with 2 feet upstream to 30 feet downstream of the point of discharge.*

Outside of this defined mixing zone all water-quality standards applicable to the Rogue River must be met and all listed beneficial uses supported. The beneficial uses for the Rogue River are listed in Table 271A in Appendix A. The beneficial use of particular

concern for this study is "fish and aquatic life." Several water-quality standards, such as dissolved oxygen, temperature, and pH, are set to protect fish and aquatic life. An inherent challenge when assessing these parameters, however, is that they vary seasonally, daily, and even hourly, depending on weather and flow conditions. Thus it can be difficult to sample at the specific time when water quality is impacted and violations occur. Biocriteria, however, is a water-quality standard based on an assessment of specific aquatic communities, which thereby directly determines if aquatic life is being protected. The biocriteria standard, as defined in Oregon's OARs along with its related definitions, is listed below.

340-041-0011

Biocriteria

Waters of the State must be of sufficient quality to support aquatic species without detrimental changes in the resident biological communities.

Stat. Auth.: ORS 468.020, 468B.030, 468B.035 & 468B.048
Stats. Implemented: ORS 468B.030, 468B.035 & 468B.048
Hist.: DEQ 14-1991, f. & cert. ef. 8-13-91; Renumbered from 340-041-0027 by DEQ 17-2003, f. & cert. ef. 12-9-03

(76) "Without Detrimental Changes in the Resident Biological Community" means no loss of ecological integrity when compared to natural conditions at an appropriate reference site or region.

(19) "Ecological Integrity" means the summation of chemical, physical, and biological integrity capable of supporting and maintaining a balanced, integrated, adaptive community of organisms having a species composition, diversity, and functional organization comparable to that of the natural habitat of the region.

(5) "Appropriate Reference Site or Region" means a site on the same water body or within the same basin or ecoregion that has similar habitat conditions and represents the water quality and biological community attainable within the areas of concern.

(6) "Aquatic Species" means plants or animals that live at least part of their life cycle in waters of the state.

Therefore, the purpose of this study is to collect samples of aquatic macroinvertebrates and attached benthic algae (periphyton), upstream and downstream of the defined mixing zone of Medford's outfall, to determine if there are nuisance growths or detrimental changes to these resident biological communities, and thus document whether or not the current discharge violates water-quality standards.

METHODS

Field samples for algae and macroinvertebrates were collected on October 10 & 11, 2012. There had been no measurable rain in the region for over eight weeks prior to sampling. Stream flows were stable and had reached the annual low flow, with the flow measured at the Raygold USGS stream gaging station near Central Point (5 miles downstream of Medford's outfall) of 1410 cubic feet per second (cfs). Maximum daily water temperatures measured at the Raygold station on October 10 & 11, were 9.8 and 9.6 degrees C (49.6 & 49.2^0 F), respectively. The maximum summer temperature in 2012 recorded at this station was 18.9 degrees C (66^0 F), on August 19th.

SAMPLE SITES

Three sites were selected for sampling, one upstream of the outfall and two downstream (Figure 1). Each site consisted of a single riffle with a gravel/cobble substrate and depths ranging from approximately a few inches to two feet deep.

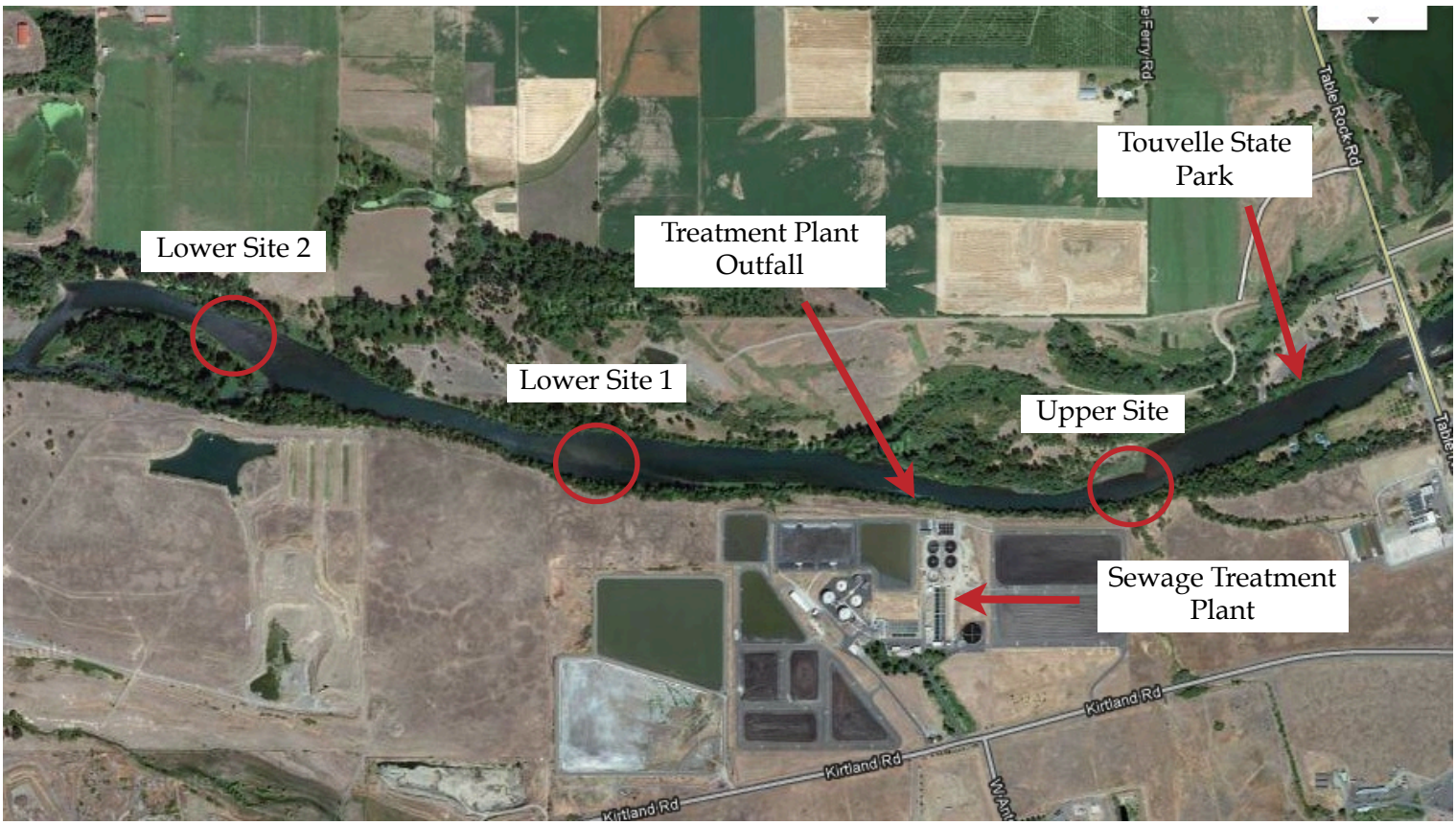
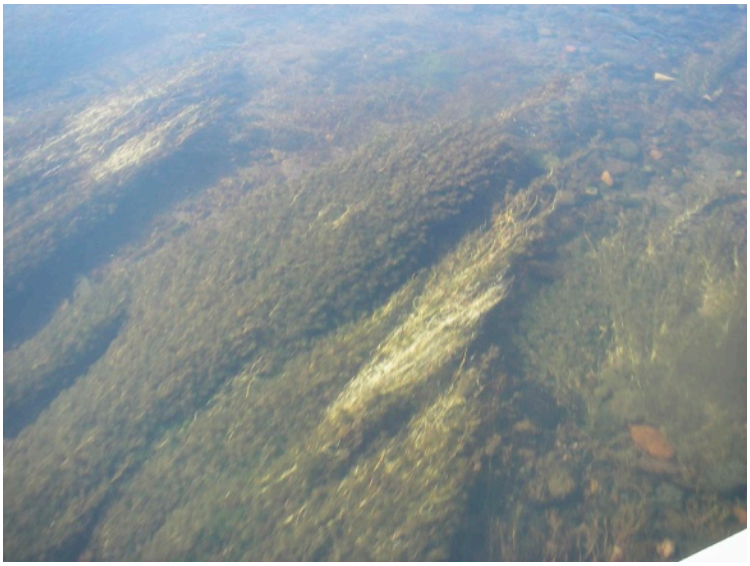


Figure 1. Sample site locations above and below the Medford waste-water outfall.

Upper Site - The upper site (US1) is a broad riffle located 0.2 mile downstream from the boat ramp at Touvelle State Park and 0.3 mile above the outfall.

Lower Site 1 - Lower Site 1 (LS1), the first sample site below the outfall, was located on the south side of the river channel 0.4 mile below the outfall discharge point, well below the 300 foot lower boundary of the effluent's mixing zone. This was the first riffle habitat suitable to sample below the outfall. The substrate of large gravel and cobble was similar to the upstream site. Dense growths of periphyton and some attached macrophytes occurred on the substrate throughout the riffle at this site.

Lower Site 2 - Lower Site 2 (LS2) was located on the south side of the river channel one mile below the outfall discharge point. Substrate and flow conditions were similar to the upper sample site. Periphyton and macrophyte growth, while not as prevalent as at LS1, was still visibly heavier than at the upper site.



FIELD SAMPLING METHODS

Algae - Algal samples were collected following the methods described by US Geologic Survey (USGS) for periphyton sampling (Carpenter 2003). Periphyton specifically refers to plants, fungi, and/or bacteria attached to the surfaces of rocks or other plants (Hynes 1972). The algal component of periphyton, or epilithic algae, consists primarily of diatoms plus some bluegreen algae and filamentous green algae.

One algal sample was collected at each sample site, except for site LS1 where a second duplicate sample also was collected. For each sample 15 representative rocks were randomly selected by choosing 15 pairs of random numbers from a random numbers table. The first number of each pair identified the percent distance up from the bottom of the riffle and the second number identified the percent distance across the riffle from the closest bank.

Each selected rock was photographed (Appendix B), then all material from a measured area on the surface of each rock was removed by first isolating the sample area with the end of a plastic pipe (scribe) (Figure 2). First, the area outside of the scribe was scraped with a knife to remove all the material, then the area inside the scribe was scraped and washed into a plastic bucket. After washing the area from all 15 rocks into the bucket, the algal slurry was placed into a labeled sample bottle and set in a cooler with ice. Later the same day, the total volume of material from each sample was measured in a graduated cylinder and then homogenized in an electric blender. A measured subsample was removed from the blender and preserved in a sample bottle with buffered formalin. These samples were sent to Aquatic Analysts for species identification, and to calculate cell density and biovolume.

Figure 2. Plastic pipe end used to define algal sampling area.

Macroinvertebrates - Aquatic macroinvertebrates were collected following the methods prescribed by the Oregon Department of Environmental Quality (DEQ 2009) and the Pacific Northwest Aquatic Monitoring Partnership (PNAMP 2008). Two complete macroinvertebrate samples were collected at each site so within site sample differences could be compared to between-site differences.

Individual macroinvertebrate samples were collected using a D-frame aquatic net with a 500-micron mesh collection bag (Figure 3). A complete sample consisted of eight, one-square foot, individual samples. Each one-square foot sample was randomly selected within the riffle by using a pair of random numbers from a random numbers table. After locating the sample spot, the D-frame net was placed firmly on the stream bottom and the invertebrates were dislodged from a one-square foot area upstream of the net by scrubbing all rocks larger than a golf ball with a soft vegetable brush. After these rocks were cleaned the area was disturbed by hand to a depth of approximately two to four centimeters. The material in the net (debris plus invertebrates) was placed in a bucket until all eight samples were collected and composited in the bucket. The bucket's contents were then placed in a labeled sample bottle and preserved with 90% ethanol.

The six invertebrate samples were delivered to Aquatic Biological Associates where each sample had a minimum of 500 invertebrates randomly sorted from the sample debris, identified to genus or the lowest practical level according to DEQ protocol, and each taxon counted.

Figure 3. Collecting macroinvertebrate sample with D-frame kick net.

RESULTS & DISCUSSION

GENERAL OBSERVATIONS

Figures 4 & 5 show the effluent plume flowing downstream along the south side of the river channel. The length of the plume with floating foam was visible downstream beyond the 300-foot mixing zone size defined in Medford's NPDES permit. Part of the OARs for mixing zones (340-041-0053) (see Appendix A) states:

(a) A point source for which the mixing zone is established may not cause or significantly contribute to any of the following:

(C) Floating debris, oil, scum, or other materials that cause nuisance conditions;

The plume observed during this study violates the above requirement. Besides the visual plume and surface foam, a distinct odor from the effluent was detectable over a half mile downstream from the discharge point.

Figure 4 & 5. The effluent plume extending downstream hundreds of feet below the outfall.

In addition, dense growths of attached plants and algae were observed at both sample sites below the outfall (Figures 6 & 7), but not at the upstream sample site (Figure 8). At LS1 the algal growth formed a dense mat covering the gravel/cobble substrate. Such excessive algal growth can alter macroinvertebrate diversity and abundance by covering rock surfaces and thus altering habitat, and impact water quality by causing large diel swings in dissolved oxygen and pH levels (Dodds 2002).

Figure 6. Algal mat on rocks in riffle at LS1.

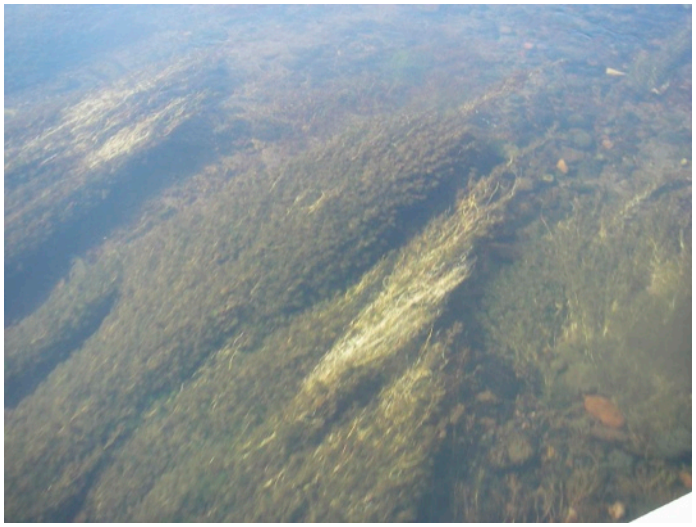


Figure 7. *Potamageton* mat on rocks in riffle at LS2.

Figure 8. Rocks in riffle at US1 without algal mats.

ALGAE

A total of 44 periphyton algae taxa were identified from the three sites and four samples collected (Appendix C). Of these, 42 were diatom species and two were blue-green algae. The species diversity at individual sites ranged from 28 species at LS2, to 25 species at US1, to 24 at LS1 and LS1 QA (Table 1).

While there was considerable overlap in species found between the three sites, some distinctions were apparent. Foremost was the dominance of the blue-green algae *Oscillatoria limnetica*, at US1 where it contributed 38.4 percent of total biovolume, compared to 4.8, 0.9, and 1.9 at LS1, LS1 QA, and LS2, respectively. *O. limnetica* is a mat-forming blue-green algae that can become established in low-nutrient streams, in part, because of its ability to generate energy heterotrophically (personal comm., Kurt Carpenter, USGS). It might also indicate higher grazing influence by invertebrates as other more nutritious diatoms are kept in check. *Nostoc* sp., a nitrogen-fixing blue-green algae, while not collected in the periphyton samples, was observed on the surface of rocks at the upper site but not the lower two sites (see rock photos Appendix B), indicating higher nutrient levels below the outfall. In addition, two of the dominant diatom species at LS1, *Nitzschia frustulum* and *Nitzschia dissipata*, are eutrophic-adapted taxa, also indicating increased nutrient levels at the lower site.

Table 1. Summary of Periphyton Algae Conditions

SITES	TOTAL TAXA	DOMINANT 3 TAXA	TOTAL CELL DENSITY # cells/cm^2	TOTAL BIOVOLUME um^3/cm^2
Upper Site (US1)	25	Oscillatoria limnetica Cymbella affinis Synedra ulna	517,677	208,446,248
Lower Site 1 (LS1)	24	Synedra ulna Diatoma vulgare Nitzschia frustulum	6,529,509	2,873,469,430
Lower Site 1 QA (LS1 QA)	24	Nitzschia frustulum Synedra ulna Nitzschia dissipata	7,477,968	2,448,594,004
Lower Site 2 (LS2)	28	Synedra ulna Epithemia turgida Oscillatoria limosa	3,578,640	2,031,248,711

Another important indicator of water quality is the overall amount of algae growing on rock surfaces. For periphyton samples this can be expressed as a cell density (number of algal cells/cm^2) and biovolume (cubic microns of algae/cm^2). Large differences were observed in these indicators between the upper site and two lower sites (Table 1 & Figures 9 - 10). Compared to US1, algal density (# cells/cm^2) was 12.6 to 14.4 times higher at LS1, and 6.9 times higher at LS2. Similarly total biovolume (um^3/cm^2) of periphyton increased more than ten fold at the lower sites compared to the upper site. These data further confirm the visual differences observed in plant growth upstream versus downstream from the outfall.

Increases in the density and volume of algae growing on stream substrates can result from increases in light, temperature, and/or nutrients (Hynes 1972). Given the similar directional orientation of the three sites sampled (Figure 1), differences in light levels between sites would be minimal. The effluent discharge is the only source between the upper site and two lower sites that could produce the large increase in algal abundance, both cell density and biovolume. The measured increases in algal abundance can also negatively affect dissolved oxygen and pH levels, and thus impact other aquatic life (Dodds 2002).

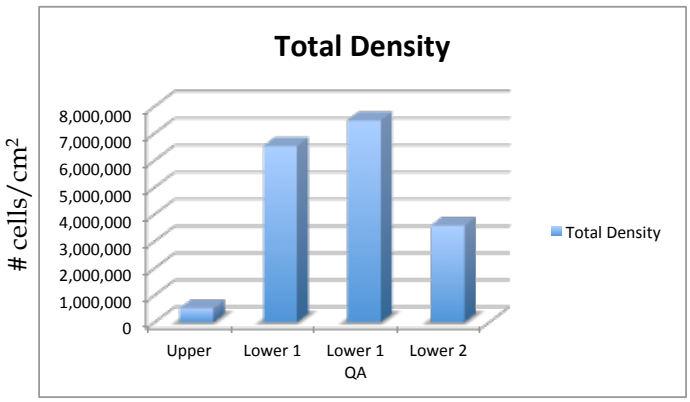


Figure 9. Total algal cell density measured at the three study sites.

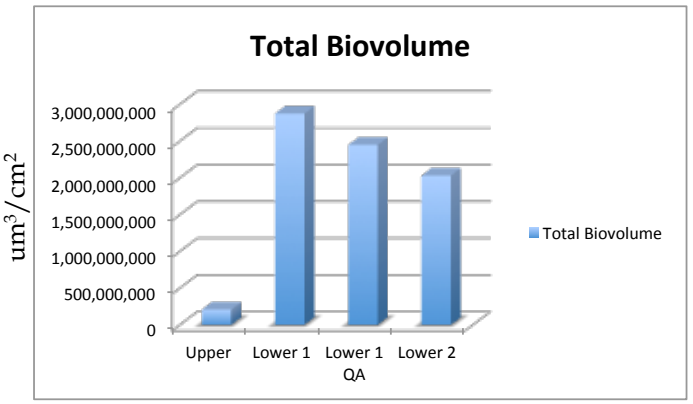


Figure 10. Total algal biovolume measured at the three study sites.

The shift in dominant taxa to eutrophic adapted species, plus the large increase in cell density and biovolume, at both sites below the outfall, indicate high nutrient levels in the effluent.

MACROINVERTEBRATES

Changes in the macroinvertebrate community due to changes in water quality and/or habitat are typically exhibited by changes in abundance, overall diversity, and by changes in the abundance or presence/absence of individual species. Specific community attributes are referred to as metrics (Karr & Chu 1999). Table 2 lists the results of eight metrics for each sample site. Since two samples (QA = the second, or Quality Assurance sample) were collected at each of the three sample sites, it is possible to test if differences between sites are statistically significant or within the range of sampling plus natural variability. The Tukey Comparison of Means test was used to determine the significance level of differences between sites (Appendix D). The probability that the results observed between two sites are similar is expressed as the "p-value" (Elliott 1971). A p-value of 0.01, for example, says there is only a 1% chance of the observed result occurring if no real difference exists. A p-value of 0.05 or less is considered to be significant, 0.01 or less highly significant, and 0.001 or less very highly significant. Based on this analysis, differences between US1 and LS1 were highly significant for all eight metrics. Differences between US1 and LS2 were significant for all metrics except two, total taxa richness and % Oligochaeta (Table 2).

Table 2. Summary of Aquatic Macroinvertebrate Metrics

Macro Invert Metrics	Upper Site (US1)	Upper Site QA (US1 QA)	Lower Site 1 (LS1)	Lower Site 1 QA (LS1 QA)	Lower Site 2 (LS2)	Lower Site 2 QA (LS2 QA)	*Sig. Dif. between Upper-Lower
Total Abundance	21,550	22,153	4852	4440	9297	5289	0.003 0.02
EPT Abundance	7871	9080	242	294	1743	1141	0.001 0.002
Total Taxa Richness	46	42	32	32	37	38	0.01 0.06
EPT Taxa Richness	23	21	9	7	14	14	0.002 0.01
% Sensitive EPT Taxa	26	31.7	4.4	6.2	15.6	18.3	0.006 0.04
% Intolerant Taxa	29.6	35.3	3.3	5.5	16.5	18.5	0.004 0.02
% Oligochaeta	5.4	8.2	24.3	26.1	12.3	12.2	0.002 0.06
% Non-Insect Taxa	11.6	16.4	56.3	60.2	29	28.1	0.001 0.02

* Upper # = p-value between US1 and LS1
Lower # = p-value between US1 and LS2

Abundance - Abundance was calculated as the number of invertebrates per square meter, and is represented by two metrics: Total Abundance and EPT Abundance. Total abundance dropped over 400% between US1 and LS1, and over 200% between US1 and LS2 (Figure 11). Based on the Tukey test, this drop in abundance is highly significant.

EPT abundance refers to the abundance of mayflies (**E**phemeroptera), stoneflies (**P**lecoptera), and caddisflies (**T**richoptera). Species within these three orders are particularly sensitive to changes in water quality and habitat conditions, and decline in abundance when environmental conditions decline. The drop in abundance of these sensitive species was even more significant than total abundance with declines of over 3,000% from US1 to LS1 and more than a 500% drop from US1 to LS2 (Figure 12).

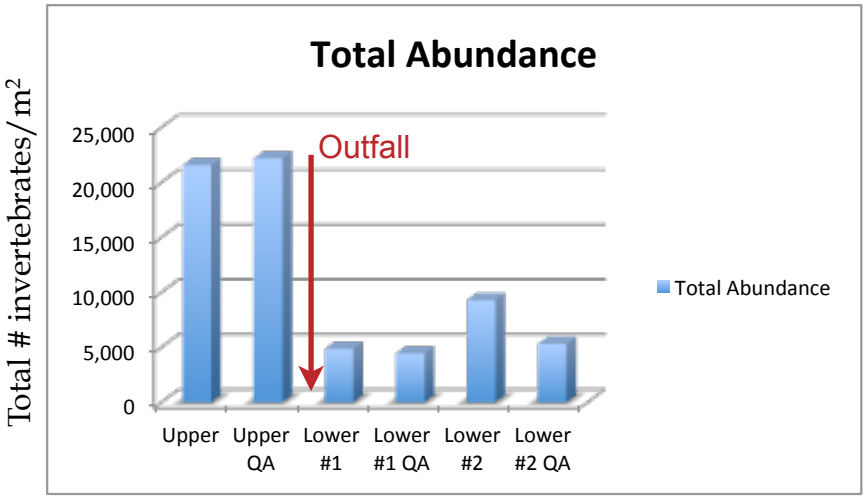


Figure 11. Total abundance of macroinvertebrates for samples above and below the outfall.

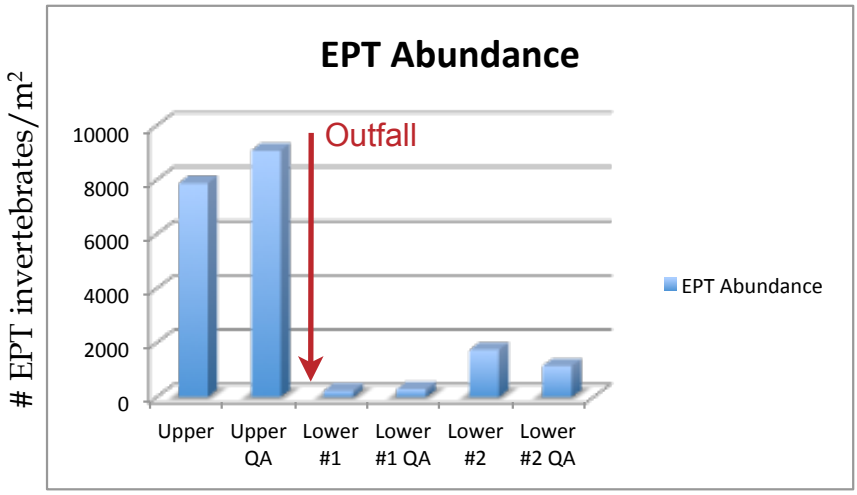


Figure 12. Abundance of mayfly, stonefly, and caddisfly taxa (EPT) for samples above and below the outfall.

Diversity - Species diversity is a common attribute used to characterize the health of biological communities, with lower diversity indicating more stress or disturbance in the system (Karr & Chu 1999). For this study, two metrics are shown that describe macroinvertebrate diversity: total taxa richness and EPT taxa richness. Total taxa richness is simply the total number of invertebrate species identified to the lowest practical level at each site (see Appendix E for complete taxa list). This metric dropped significantly from US1 to LS1 with a decline of an average of 44 taxa at US1 to 32 taxa at LS1 (Figure 13). Some recovery was seen further downstream at LS2, where mean total taxa declined from 44 at US1 to 37.5 at LS2.

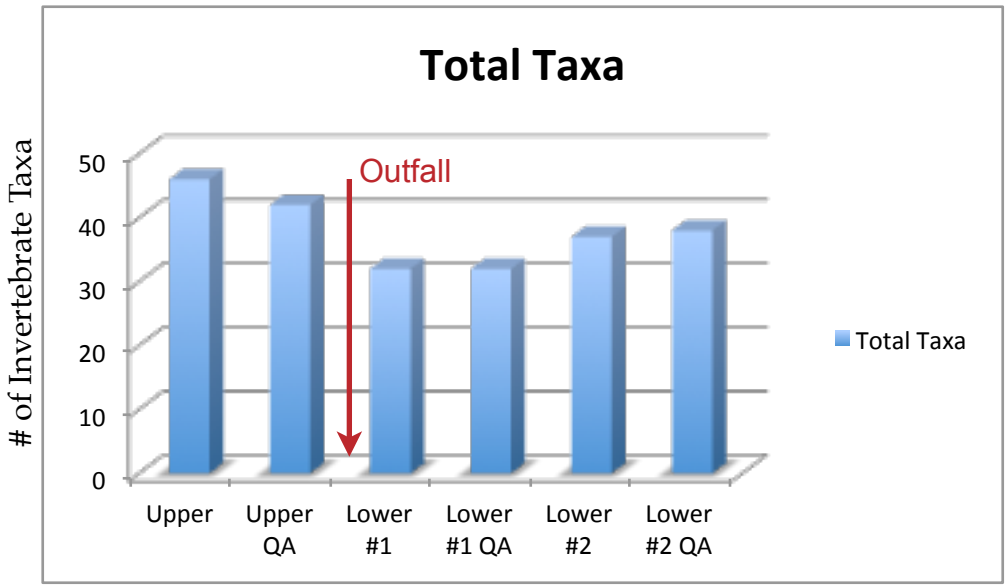


Figure 13. Total number of macroinvertebrate taxa above and below the outfall.

Because total taxa includes species that are both sensitive and tolerant to poor water quality, a metric more sensitive to declining water quality and habitat conditions is EPT Taxa Richness. This metric is based on the species diversity of just mayflies, stoneflies, and caddisflies, insect orders dominated by species that require high water quality and habitat conditions, and therefore, lower EPT taxa richness indicates declines in water quality and/or habitat (Ward 1992).

Figure 14 shows the changes in EPT taxa richness from the upper site to the lower sites. A significant drop in EPT taxa was observed below the outfall, especially between sites US1 and LS1 were mean EPT taxa dropped from 22 to 8. Again some recovery of EPT taxa was seen at LS2, where 14 EPT taxa were identified. Compared to US1, the drop in EPT taxa at both LS1 and LS2 is highly significant (Table 2).

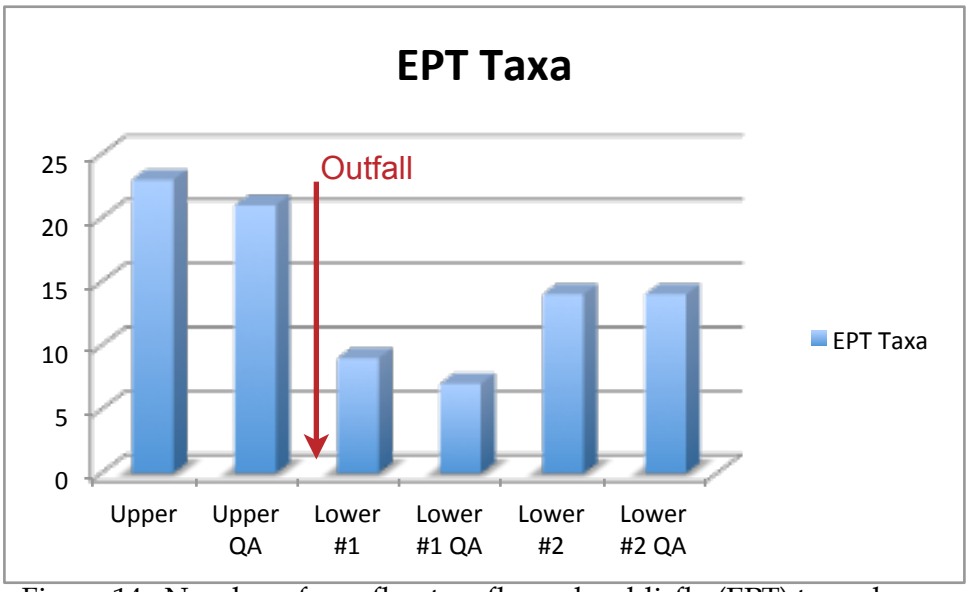


Figure 14. Number of mayfly, stonefly, and caddisfly (EPT) taxa above and below the outfall.

Changes in Species Composition - Besides changes in abundance and diversity, changes in species composition also indicate if environmental conditions are changing for the better or worse. For example, a decline in the percent of sensitive species or an increase in the percent of tolerant species indicates a drop in water quality and/or habitat. Four metrics were calculated to assess changes in species composition: % Sensitive EPT, % Intolerant Taxa, % Oligochaeta, and % Non-Insect Taxa.

Percent sensitive EPT and % intolerant taxa are metrics sensitive to water quality and habitat condition, and decline as conditions decline. Results for both of these metrics showed a significant drop below the outfall, with the largest drops occurring at LS1 compared to US1 (Figures 15 & 16). For both metrics the changes were highly significant with % sensitive EPT taxa dropping from a mean of 28.9 at US1, to 5.3 and 17 at LS1 and LS2, respectively. The change in % intolerant taxa was even greater with mean values dropping from 32.5 at US1 to 4.4 at LS1 and to 17. 5 at LS2.

The other two species composition metrics, % Oligochaeta and % non-insect taxa, increase as environmental conditions decline. Oligochaetes are a common group of aquatic worms that can tolerate low levels of dissolved oxygen as well as other water quality stressors. One family, the Tubificidae, are commonly called *sludge worms* for their common abundance in organically polluted waters (Thorp & Covich 2001). The % non-insect taxa includes snails, clams, and crustaceans, in addition to aquatic worms. Non-

insect taxa are generally more tolerant of poor water quality, and increase in abundance as more sensitive insect taxa decline.

Both % Oligochaeta and % non-insect taxa, showed significant increases at the sites below the outfall compared to the site upstream (Figures 17 & 18). Given that Oligochaetes make up a large part of the non-insect taxa, it's not surprising that these two metrics have similar results. The increase in these metrics at LS1 compared to US1 were highly significant, and indicate declines in water quality. Some recovery was observed at LS2, but the increases were still significant compared to US1 (Table 2).

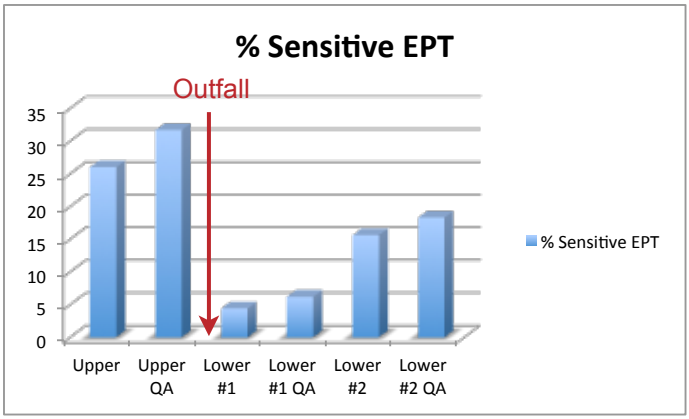


Figure 15. Relative percent of total abundance by mayflies, stoneflies, and caddisflies (EPT).

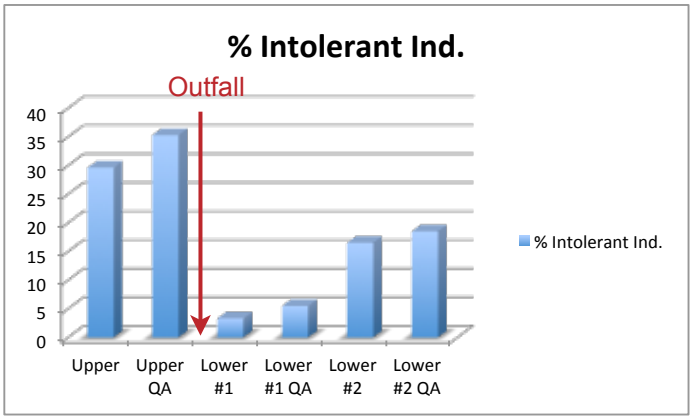


Figure 16. Relative percent of total abundance by taxa intolerant of poor water quality and habitat conditions.

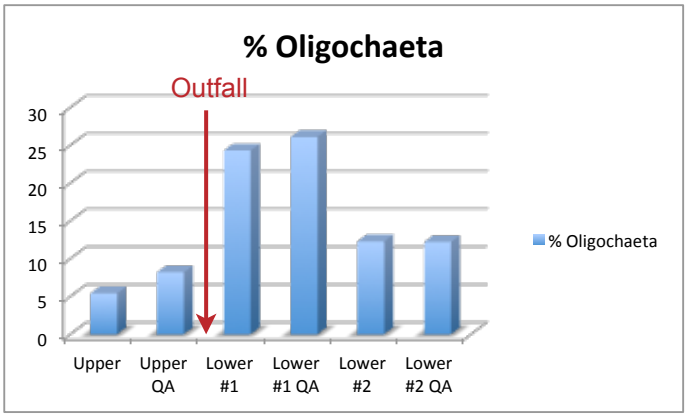


Figure 17. Relative percent of total abundance by Oligochaeta for each sample.

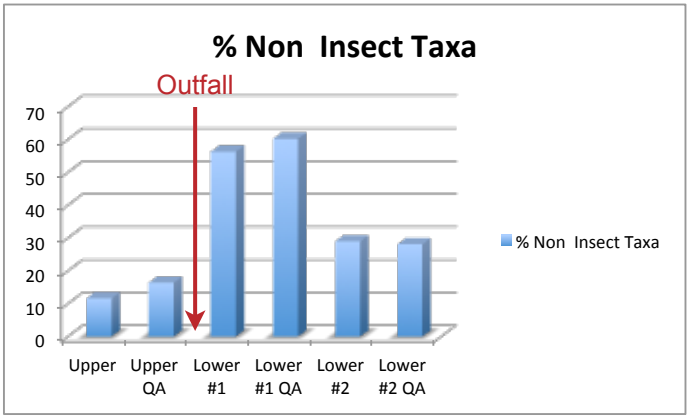


Figure 18. Relative percent of total abundance by non-insect taxa.

The presence or absence of specific macroinvertebrate taxa is another useful indicator of changes in water quality. For example, most species of Plecoptera (stoneflies) are sensitive to organic enrichment and drops in dissolved oxygen as well as other water quality and habitat parameters (Surdick & Gaufin 1978). In addition several species of stoneflies have long-lived nymphal stages (>2 years), and thus need adequate water quality over extended periods of time.

In this study a total of nine stonefly taxa were collected at US1 (Appendix E). Of these nine taxa only one was collected at LS1 (a single specimen of *Claassenia sabulosa*). Four of the nine stonefly taxa were collected at LS2. This loss of stonefly taxa at the lower sites is another strong indicator of water quality impairment.

Other sensitive taxa collected at US1 but absent at LS1 included the mayflies (Ephemeroptera) *Ephemerella excrucians*, *Rhithrogena* sp., and *Paraleptophlebia* sp., plus the caddisflies (Trichoptera) *Glossosoma* sp. and *Rhyacophila* sp.

CONCLUSION

The objective of this study was to determine if the effluent from Medford's waste-water treatment plant caused detrimental changes in the resident biological community below its defined mixing zone, and thus violate Oregon's biocriteria standard and its NPDES permit. Two biological communities were assessed, periphyton algae and aquatic macroinvertebrates at three sties, one upstream 0.3 mile from the outfall and two downstream (0.4 and 1.0 mile below the outfall). All three sites had similar habitat.

Results for both periphyton and aquatic macroinvertebrates showed clear and significant declines in all metrics used to assess biological condition, at both sample sites below the outfall compared to the site just above the outfall.

The algal community increased over ten fold in both cell density and biovolume at the downstream sites, with the largest increases observed at the site closest to the outfall. The only source for such large periphyton increases is the waste-water effluent and associated changes in water quality, most likely increases in nutrient levels.

All eight metrics used to assess aquatic macroinvertebrates declined significantly at the sites below the outfall compared to the upstream site. The changes in the macroinvertebrate community indicate a decline in water quality at the downstream sites, most likely due water quality impacts from the effluent and the effect of excessive algal growth. Excessive amounts of algae can cause large diel swings in dissolved oxygen and pH, then when the algae dies off, its decomposition by bacteria can cause significant drops in oxygen levels. In addition the thick carpet of algae on the substrate alters the habitat quality for many macroinvertebrate species. Water quality and habitat impacts are reflected by the changes in species composition and the large drop in macroinvertebrate abundance below the outfall. Such a large drop in macroinvertebrate abundance might also indicate toxic levels of ammonia occurring below the outfall.

Given the consistent and significant changes observed in composition, diversity, and abundance for both biological communities, this study confirms that the Medford waste water discharge violated the biocriteria standard and its NPDES permit, which do not allow any detrimental changes to the biotic community below the edge of the prescribed mixing zone (300 feet downstream and 100 feet out from south bank). The impacts were most pronounced at the first downstream site (LS1) located 0.4 mile below the outfall. The second downstream site (LS2), located a mile below the outfall, showed some recovery in biological condition, but significant impacts to the biota were still measured.

Finally, while not assessed by this study, the section of river throughout the study reach is widely used for spawning by chinook salmon. Given the impacts observed to periphyton and macroinvertebrates, and the sensitivity of developing salmon eggs to changes in dissolved oxygen and other water quality parameters, the possibility that salmon egg survival is being impacted at sites below the outfall is a legitimate concern.

ACKNOWLEDGEMENTS

This study was supported through grants from The International Federation of Fly Fishers, The Oregon Council of the International Federation of Fly Fishers, Rogue Fly Fishers, Southern Oregon Fly Fishers, and Klamath Country Fly Casters. Also thanks to John MacDiarmid for his oversight throughout the project and invaluable help in the field, Clint Brumitt for his help with fieldwork and photography, and to Ian Waite and Kurt Carpenter for their critical review and technical assistance.

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APPENDICES

Appendix A – Applicable OARs

340-041-0011

Biocriteria

Waters of the State must be of sufficient quality to support aquatic species without detrimental changes in the resident biological communities.

Stat. Auth.: ORS 468.020, 468B.030, 468B.035 & 468B.048
Stats. Implemented: ORS 468B.030, 468B.035 & 468B.048
Hist.: DEQ 14-1991, f. & cert. ef. 8-13-91; Renumbered from 340-041-0027 by DEQ 17-2003, f. & cert. ef. 12-9-03

340-041-0053

Mixing Zones

(1) The Department may allow a designated portion of a receiving water to serve as a zone of dilution for wastewaters and receiving waters to mix thoroughly and this zone will be defined as a mixing zone;

(2) The Department may suspend all or part of the water quality standards, or set less restrictive standards in the defined mixing zone, provided that the following conditions are met:

(a) A point source for which the mixing zone is established may not cause or significantly contribute to any of the following:

(A) Materials in concentrations that will cause acute toxicity to aquatic life as measured by a Department approved bioassay method. Acute toxicity is lethal to aquatic life as measured by a significant difference in lethal concentration between the control and 100 percent effluent in an acute bioassay test. Lethality in 100 percent effluent may be allowed due to ammonia and chlorine only when it is demonstrated on a case-by-case basis that immediate dilution of the effluent within the mixing zone reduces toxicity below lethal concentrations. The Department may on a case-by-case basis establish a zone of immediate dilution if appropriate for other parameters;

(B) Materials that will settle to form objectionable deposits;

(C) Floating debris, oil, scum, or other materials that cause nuisance conditions; and

(D) Substances in concentrations that produce deleterious amounts of fungal or bacterial growths.

(b) A point source for which the mixing zone is established may not cause or significantly contribute to any of the following conditions outside the boundary of the mixing zone:

(A) Materials in concentrations that will cause chronic (sublethal) toxicity. Chronic toxicity is measured as the concentration that causes long-term sublethal effects, such as significantly

impaired growth or reproduction in aquatic organisms, during a testing period based on test species life cycle. Procedures and end points will be specified by the Department in wastewater discharge permits;

(B) Exceedances of any other water quality standards under normal annual low flow conditions.

(c) The limits of the mixing zone must be described in the wastewater discharge permit. In determining the location, surface area, and volume of a mixing zone area, the Department may use appropriate mixing zone guidelines to assess the biological, physical, and chemical character of receiving waters, effluent, and the most appropriate placement of the outfall, to protect instream water quality, public health, and other beneficial uses. Based on receiving water and effluent characteristics, the Department will define a mixing zone in the immediate area of a wastewater discharge to:

(A) Be as small as feasible;

(B) Avoid overlap with any other mixing zones to the extent possible and be less than the total stream width as necessary to allow passage of fish and other aquatic organisms;

(C) Minimize adverse effects on the indigenous biological community, especially when species are present that warrant special protection for their economic importance, tribal significance, ecological uniqueness, or other similar reasons determined by the Department and does not block the free passage of aquatic life;

(D) Not threaten public health;

(E) Minimize adverse effects on other designated beneficial uses outside the mixing zone.

(d) Temperature Thermal Plume Limitations. Temperature mixing zones and effluent limits authorized under 340-041-0028(12)(b) will be established to prevent or minimize the following adverse effects to salmonids inside the mixing zone:

(A) Impairment of an active salmonid spawning area where spawning redds are located or likely to be located. This adverse effect is prevented or minimized by limiting potential fish exposure to temperatures of 13 degrees Celsius (55.4 Fahrenheit) or more for salmon and steelhead, and 9 degrees Celsius (48 degrees Fahrenheit) or more for bull trout;

(B) Acute impairment or instantaneous lethality is prevented or minimized by limiting potential fish exposure to temperatures of 32.0 degrees Celsius (89.6 degrees Fahrenheit) or more to less than 2 seconds);

(C) Thermal shock caused by a sudden increase in water temperature is prevented or minimized by limiting potential fish exposure to temperatures of 25.0 degrees Celsius (77.0 degrees Fahrenheit) or more to less than 5 percent of the cross section of 100 percent of the 7Q10 low flow of the water body; the Department may develop additional exposure timing restrictions to prevent thermal shock; and

(D) Unless the ambient temperature is 21.0 degrees of greater, migration blockage is prevented or minimized by limiting potential fish exposure to temperatures of 21.0 degrees Celsius (69.8 degrees Fahrenheit) or more to less than 25 percent of the cross section of 100 percent of the 7Q10 low flow of the water body.

(e) The Department may request the applicant of a permitted discharge for which a mixing zone is required, to submit all information necessary to define a mixing zone, such as:

(A) Type of operation to be conducted;

(B) Characteristics of effluent flow rates and composition;

(C) Characteristics of low flows of receiving waters;

(D) Description of potential environmental effects;

(E) Proposed design for outfall structures.

(f) The Department may, as necessary, require mixing zone monitoring studies and/or bioassays to be conducted to evaluate water quality or biological status within and outside the mixing zone boundary;

(g) The Department may change mixing zone limits or require the relocation of an outfall, if it determines that the water quality within the mixing zone adversely affects any existing beneficial uses in the receiving waters.

Stat. Auth.: ORS 468.020, 468B.030, 468B.035 & 468B.048
Stats. Implemented: ORS 468B.030, 468B.035 & 468B.048
Hist.: DEQ 17-2003, f. & cert. ef. 12-9-03; DEQ 1-2007, f. & cert. ef. 3-14-07; DEQ 2-2007, f. & cert. ef. 3-15-07

340-041-0275

Water Quality Standards and Policies for this Basin

(1) pH (hydrogen ion concentration). pH values may not fall outside the following ranges:

(a) Marine waters: 7.0-8.5;

(b) Estuarine and fresh waters (except Cascade lakes): 6.5-8.5;

(c) Cascade lakes above 3,000 feet altitude: pH values may not fall outside the range of 6.0 to 8.5.

(2) Total Dissolved Solids. Guide concentrations listed below may not be exceeded unless otherwise specifically authorized by DEQ upon such conditions as it may deem necessary to carry out the general intent of this plan and to protect the beneficial uses set forth in OAR 340-04l-0271: 500.0 mg/l.

(3) Minimum Design Criteria for Treatment and Control of Sewage Wastes:

(a) During periods of low stream flows (approximately May 1 to October 31): Treatment resulting in monthly average effluent concentrations not to exceed 10 mg/l of BOD and 10 mg/l of SS or equivalent control;

(b) During the period of high stream flows (approximately November 1 to April 30): A minimum of secondary treatment or equivalent control and unless otherwise specifically authorized by the Department, operation of all waste treatment and control facilities at maximum practicable efficiency and effectiveness so as to minimize waste discharges to public waters.

Stat. Auth.: ORS 468.020, 468B.030, 468B.035 & 468B.048
Stats. Implemented: ORS 468B.030, 468B.035 & 468B.048
Hist.: DEQ 17-2003, f. & cert. ef. 12-9-03

Basin-Specific Criteria (Rogue)

340-041-0271

Beneficial Uses to Be Protected in the Rogue Basin

(1) Water quality in the Rogue Basin (see Figure 1) must be managed to protect the designated beneficial uses shown in Table 271A (November 2003).

(2) Designated fish uses to be protected in the Rogue Basin are shown in Figures 271A (November 2003) and 271B (August 2005).

[ED. NOTE: Tables referenced are available from the agency.]

Stat. Auth.: ORS 468.020, 468B.030, 468B.035 & 468B.048
Stats. Implemented: ORS 468B.030, 468B.035 & 468B.048
Hist.: DEQ 17-2003, f. & cert. ef. 12-9-03; DEQ 2-2007, f. & cert. ef. 3-15-07

Table 271A

Designated Beneficial Uses Rogue Basin (340-41-0271)

Beneficial Uses	**Rogue River Estuary & Adjacent Marine Waters**	**Rogue River Main Stem from Estuary to Lost Creek Dam**	**Rogue River Main Stem above Lost Dam & Tributaries**	**Bear Creek Main Stem**	**All Other Tributaries to Rogue River & Bear Creek**
Public Domestic Water Supply[1]		X	X	*	X
Private Domestic Water Supply[1]		X	X		X
Industrial Water Supply	X	X	X	X	X
Irrigation		X	X	X	X
Livestock Watering		X	X	X	X
Fish & Aquatic Life[2]	X	X	X	X	X
Wildlife & Hunting	X	X	X	X	X
Fishing	X	X	X	X	X
Boating	X	X	X	X	X
Water Contact Recreation	X	X	X	X	X
Aesthetic Quality	X	X	X	X	X
Hydro Power			X		X
Commercial Navigation & Transportation	X	X			
1 With adequate pretreatment (filtration & disinfection) and natural quality to meet drinking water standards					
2 See also Figures 271A and 271B for fish use designations for this basin.					
* Designation for this use is presently under study					

Table produced November, 2003

Appendix B - Rock Sample Photos

Algal rock photos Upper Site (US1):















Algal rock photos Lower Site 1 (LS1)









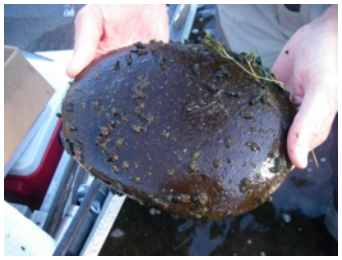


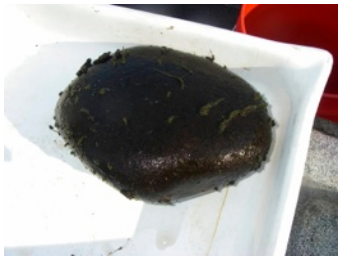




Algal rock photos Lower Site 2 (LS2)















Appendix C - Algal Taxa Occurrence

Note: "*" indicates presence of species at that site.

	Species	Upper Site		Lower Site 1		Lower Site 1 QA		Lower Site 2		Group
			Biovolume Percent		Biovolume Percent		Biovolume Percent		Biovolume Percent	
1	Achnanthes exigua							*	0.1	diatom
2	Achnanthes lanceolata			*	0.4	*	0.5	*	0.2	diatom
3	Achnanthes minutissima	*	0.9	*	0.1	*	0.3	*	0.5	diatom
4	Amphora perpusilla	*	0.7							diatom
5	Cocconeis placentula	*	5.9	*	2.3	*	4.5	*	4.0	diatom
6	Cymbella affinis	*	10.0	*	6.7	*	5.0			diatom
7	Cymbella minuta	*	2.6	*	0.9	*	2.1	*	0.5	diatom
8	Cymbella sinuata			*	0.7			*	0.2	diatom
9	Cymbella tumida			*	3.1					diatom
10	Diatoma vulgare	*	5.6	*	19.7	*	10.7	*	7.3	diatom
11	Epithemia sorex							*	1.4	diatom
12	Epithemia turgida							*	15.9	diatom
13	Fragilaria construens venter							*	0.6	diatom
14	Fragilaria pinnata							*	0.2	diatom
15	Fragilaria vaucheria	*	0.4			*	1.2	*	0.4	diatom
16	Gomphoneis herculeana					*	7.5			diatom
17	Gomphonema angustatum	*	0.8	*	2.7	*	1.8	*	1.3	diatom
18	Gomphonema sp.	*	0.3							diatom
19	Gomphonema olivaceum			*	0.3					diatom
20	Gomphonema subclavatum	*	1.7	*	0.7	*	2.5	*	1.5	diatom
21	Gomphonema tenellum	*	0.3							diatom
22	Gomphonema ventricosum			*	2.1	*	2.4			diatom
23	Hannaea arcus					*	2.4			diatom
24	Melosira varians	*	7.7	*	4.0			*	11.4	diatom
25	Navicula cascadensis							*	0.1	diatom

	Species	Upper Site		Lower Site 1		Lower Site 1 QA		Lower Site 2		Group
			Biovolume Percent		Biovolume Percent		Biovolume Percent		Biovolume Percent	
26	Navicula cryptocephala	*	0.8	*	0.5	*	0.8	*	0.5	diatom
27	Navicula cryptocephala veneta	*	1.9	*	0.4	*	0.5	*	0.9	diatom
28	Navicula decussis							*	0.2	diatom
29	Navicula minuscula	*	0.1			*	0.1	*	0.1	diatom
30	Navicula viridula							*	0.6	diatom
31	Nitzschia amphibia	*	0.7	*	0.7	*	0.5			diatom
32	Nitzschia communis			*	1.1	*	0.2	*	0.1	diatom
33	Nitzschia dissipata	*	1.5	*	7.7	*	16.1	*	2.0	diatom
34	Nitzschia frustulum	*	7.0	*	15.6	*	20.9	*	9.5	diatom
35	Nitzschia innominata			*	0.1					diatom
36	Nitzschia linearis	*	2.2							diatom
37	Nitzschia palea	*	0.5							diatom
38	Nitzschia paleacea	*	0.4	*	0.2	*	0.3			diatom
39	Oscillatoria limnetica	*	38.4	*	4.8	*	0.9	*	1.9	bluegreen
40	Oscillatoria limosa							*	13.9	bluegreen
41	Rhoicosphenia curvata	*	0.5	*	0.7	*	1.8	*	2.1	diatom
42	Stephanodiscus astraea minutula					*	0.5			diatom
43	Synedra mazamaensis	*	0.7							diatom
44	Synedra ulna	*	8.5	*	24.5	*	16.7	*	22.4	diatom
	Total Taxa	**25**		**24**		**24**		**28**		

Appendix D - Tukey Comparison of Means Test Results for Macroinvertebrate Metrics

> H_aov <- aov(Total.Abundance ~ SITE, data=Hafele2)

> summary(H_aov)

	Df	Sum Sq	Mean Sq	F value	Pr(>F)
SITE	2	343323841	171661920	62.056	0.003626 **
Residuals	3	8298708	2766236		

Signif. codes: 0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

> H_Tuk <- TukeyHSD(H_aov, "SITE")

Tukey multiple comparisons of means

95% family-wise confidence level

Fit: aov(formula = Total.Abundance ~ SITE, data = Hafele2)

$SITE	diff	lwr	upr	p adj
Lower #2-Lower #1	2647.0	-4303.121	9597.121	0.3738838
Upper-Lower #1	17205.5	10255.37	24155.621	0.0039653
Upper-Lower #2	14558.5	7608.37	21508.621	0.0064375

~~~~~~

> EPT_aov <- aov(EPT.Richness ~ SITE, data=Hafele2)

> summary(EPT_aov)

	Df	Sum Sq	Mean Sq	F value	Pr(>F)
SITE	2	197.33	98.667	74	0.0028 **
Residuals	3	4.00	1.333		

Signif. codes: 0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

> EPT_Tuk <- TukeyHSD(EPT_aov, "SITE")

Tukey multiple comparisons of means
~~~~~~

95% family-wise confidence level

Fit: aov(formula = EPT.Richness ~ SITE, data = Hafele2)

$SITE	diff	lwr	upr	p adj
Lower #2-Lower #1	6	1.17478	10.82522	0.0280101
Upper-Lower #1	14	9.17478	18.82522	0.0024993
Upper-Lower #2	8	3.17478	12.82522	0.0125787

~~~~~~

> S_EPT_aov <- aov(X..Sensitive.EPT ~ SITE, data=Hafele2)

> summary(S_EPT_aov)

	Df	Sum Sq	Mean Sq	F value	Pr(>F)
SITE	2	557.21	278.603	39.205	0.007074 **
Residuals	3	21.32	7.106		

Signif. codes: 0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

> S_EPT_Tuk <- TukeyHSD(S_EPT_aov, "SITE")

Tukey multiple comparisons of means

95% family-wise confidence level

Fit: aov(formula = X..Sensitive.EPT ~ SITE, data = Hafele2)

$SITE	diff	lwr	upr	p adj
Lower #2-Lower #1	11.7	0.5753632	22.85464	0.0438472
Upper-Lower #1	23.6	12.4653632	34.74464	0.0062265
Upper-Lower #2	11.9	0.7503632	23.02964	0.0421707

~~~~~~

> Intol_aov <- aov(X..Intolerant.Ind. ~ SITE, data=Hafele2)

> summary(Intol_aov)

	Df	Sum Sq	Mean Sq	F value	Pr(>F)
SITE	2	789.61	394.81	56.938	0.004112 **

Residuals 3 20.80 6.93

Signif. codes: 0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

> Intol_Tuk <- TukeyHSD(Intol_aov, "SITE")

Tukey multiple comparisons of means

95% family-wise confidence level

Fit: aov(formula = X..Intolerant.Ind. ~ SITE, data = Hafele2)

$SITE	diff	lwr	upr	p adj
Lower #2-Lower #1	13.12	2.116	24.123	0.0313865
Upper-Lower #1	28.08	17.076	39.083	0.0036301
Upper-Lower #2	14.96	3.956	25.963	0.0219291

~~~~~~

> Oligo_aov <- aov(X..Oligochaeta ~ SITE, data=Hafele2)

> summary(Oligo_aov)

	Df	Sum Sq	Mean Sq	F value	Pr(>F)
SITE	2	357.31	178.655	96.657	0.001889 **

Residuals 3 5.55 1.848

Signif. codes: 0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

> Oligo_Tuk <- TukeyHSD(Oligo_aov, "SITE")

Tukey multiple comparisons of means

95% family-wise confidence level

Fit: aov(formula = X..Oligochaeta ~ SITE, data = Hafele2)

$SITE	diff	lwr	upr	p adj
Lower #2-Lower #1	-12.95	-18.63	-7.268	0.0050398
Upper-Lower #1	-18.40	-24.08	-12.718	0.0018196
Upper-Lower #2	-5.45	-11.13	0.231	0.0556454

~~~~~~

```
> Nonins_aov <- aov(X..Non..Insect.Inv. ~ SITE, data=Hafele2)
> summary(Nonins_aov)
            Df   Sum Sq    Mean Sq   F value   Pr(>F)
SITE        2    2034.57   1017.29   156.26    0.0009271 ***
Residuals   3    19.53     6.51
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
> Nonins_Tuk <- TukeyHSD(Nonins_aov, "SITE")
  Tukey multiple comparisons of means
    95% family-wise confidence level
Fit: aov(formula = X..Non..Insect.Inv. ~ SITE, data = Hafele2)
$SITE                 diff     lwr      upr       p adj
Lower #2-Lower #1    -29.70   -40.36   -19.038    0.0028132
Upper-Lower #1       -44.25   -54.91   -33.588    0.0009110
Upper-Lower #2       -14.55   -25.21    -3.888    0.0217027
```

~~~~~~`

```
> EPTAbun_aov <- aov(EPT.Abundance ~ SITE, data=Hafele2)
> summary(EPTAbun_aov)
            Df   Sum Sq     Mean Sq    F value   Pr(>F)
SITE        2    78807636   39403818   129.42    0.001226 **
Residuals   3    913395     304465
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
> EPTAbun_Tuk <- TukeyHSD(EPTAbun_aov, "SITE")
  Tukey multiple comparisons of means
    95% family-wise confidence level
Fit: aov(formula = EPT.Abundance ~ SITE, data = Hafele2)
```
~~~~~~

$SITE	diff	lwr	upr	p adj
Lower #2-Lower #1	1174.0	-1131.772	3479.772	0.2312398
Upper-Lower #1	8207.5	5901.728	10513.272	0.0013917
Upper-Lower #2	7033.5	4727.728	9339.272	0.0021620

~~~~~~

> Total_aov <- aov(Total.Taxa ~ SITE, data=Hafele2)

> summary(Total_aov)

	Df	Sum Sq	Mean Sq	F value	Pr(>F)
SITE	2	144.33	72.167	25.471	0.01312 *
Residuals	3	8.50	2.833		

Signif. codes: 0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

> Total_Tuk <- TukeyHSD(Total_aov, "SITE")

Tukey multiple comparisons of means

95% family-wise confidence level

Fit: aov(formula = Total.Taxa ~ SITE, data = Hafele2)

$SITE	diff	lwr	upr	p adj
Lower #2-Lower #1	5.5	-1.5339062	12.53391	0.0923123
Upper-Lower #1	12.0	4.9660938	19.03391	0.0115984
Upper-Lower #2				
~~~~~~

Appendix E - Macroinvertebrate Species-Abundance Table

Abundances converted to a standard full sample (if subsampled) and one square meter basis.

	Rogue River Lower #1 2012-10-10 Main	Rogue River Lower #1 2012-10-10 QA	Rogue River Lower #2 2012-10-10 Main	Rogue River Lower #2 2012-10-10 QA	Rogue River Upper 2012-10-11 Main	Rogue River Upper 2012-10-11 QA
Taxon	Abundance	Abundance	Abundance	Abundance	Abundance	Abundance
Turbellaria	1069	1120	1081	595	242	525
Nemata	20	30	16	20	81	81
Oligochaeta	1180	1160	1146	646	1170	1816
Helobdella stagnalis	20					
Fluminicola	10	20				
Physa	202	141	194	10		
Helisoma		10				
Juga		20		1		
Pisidium	40	10				
Crangonyx	40				40	
Acari	151	161	258	212	968	1210
Acentrella insignificans	10		48	40	81	81
Baetis tricaudatus	20	20	226	30	242	444
Drunella grandis/ spinifera	10		81	212	40	81
Ephemerella excrusians			258		2461	2703
Ephemerella tibialis				10		40
Epeorus	10		145	50	363	242
Rhithrogena					404	444
Paraleptophlebia					40	81
Sweltsa			32	10	81	40
Zapada cinctipes				10	81	40
Calineuria californica			16		40	
Claassenia sabulosa		1		10	121	282
Perlodidae					121	40
Isoperla					121	202
Skwala					121	121

Pteronarcys californica					1	1
Pteronarcys princeps			16			
Sialis		10				
Amiocentrus aspilus	40	20	16		81	
Brachycentrus occidentalis	30	91	533	545	1049	1654
Glossosoma				20	121	323
Glossosoma				10	40	40
Cheumatopsyche						40
Hydropsyche			16	101	1816	1412
Hydroptila					81	
Lepidostoma	20	20	16			
Lepidostoma (Neodinarthrum)	50	101	323	81	323	686
Lepidostoma (Neodinarthrum)		10				
Ceraclea	50	30		10		
Dicosmoecus gilvipes			16	1	1	
Rhyacophila coloradensis group					40	81
Narpus concolor		20		40		
Optioservus		10		10	81	202
Optioservus	171	262	533	494	1210	1574
Zaitzevia			16	10	121	40
Zaitzevia			16	30	807	726
Ceratopogoninae			16			
Hemerodromia	10		65	10	121	121
Simulium	10		113	10	40	
Simulium			16	10		
Antocha			16	10	807	525
Antocha					81	
Chironomidae	121	212	646	262	726	282
Cardiocladius			16			
Cricotopus	182	71	581	262	1574	888
Cricotopus bicinctus group	40	50				
Cricotopus nostocicola					807	847
Cricotopus trifascia group	141	61	258	121	40	
Cryptochironomus		10				
Diamesa					40	161
Eukiefferiella brehmi group						121

Eukiefferiella claripennis group	30	20	145	81	686	888
Eukiefferiella devonica group	10	10	339	81	242	282
Eukiefferiella pseudomontana group	10					
Micropsectra			65	50	81	81
Microtendipes pedellus group	20	10	16			
Orthocladius	393	272	662	282	40	161
Orthocladius complex	101	272	145	333	1896	1775
Polypedilum	595	151	1081	484	1614	605
Potthastia gaedii group				10	81	40
Synorthocladius	40	20	97	20	40	40
Thienemanniella			16	40		81
Thienemannimyia complex		10		10	40	