FINAL REPORT

Lower Deschutes River Macroinvertebrate & Periphyton Study

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SUMMARY

This report describes objectives, methods and results for a macroinvertebrate study in the Deschutes River. This study is identified by the Pelton Round Butte Project License and was conducted consistent with a study plan developed in consultation with Portland General Electric and the Pelton Round Butte Fish Committee. A baseline study was conducted in 1999-2001, prior to the implementation of selective water withdrawal. This report summarizes results of two years of post-selective water withdrawal (SWW) sampling and a comparison with pre-SWW baseline sampling.

Post-SWW sampling was conducted in October in 2013 and 2014, and April/May 2014 and April 2015. Sample sites included nine mainstem sites downstream of the Project, with seven sites coinciding with sites sampled in both years during the baseline study; two additional downstream sites (at Sandy Beach and Macks Canyon) to provide additional information further downstream of Maupin; and three upstream above-Project reference sites on each of the tributaries feeding into Lake Billy Chinook (Metolius, Middle Deschutes, and Crooked rivers), useful for identifying any long-term changes in conditions potentially independent of SWW effects. Macroinvertebrate samples were taken using a D-frame kick net with 500-micron mesh, collecting four kick samples (each approximately 2 ft^2 in area) at each site. At 8 sites, the samples were composited in accordance with ODEQ protocols; at the other 4 sites, samples were kept separate as replicates, to facilitate statistical comparisons. Periphyton samples were also collected at all sample sites, with only one composite sample (10 rocks, approximately 125 cm^2 in area total) to be taken at each site.

Sampling was also conducted at three sites located within the first 3 miles downstream of the Project that were augmented with gravel in accordance with the Lower River Gravel Study Plan, with the nearby post-SWW site at Dizney Island (RM 99) serving as the control site. At gravel augmentation sites, three replicate kick samples were taken within the deposit zone. No periphyton samples were collected at the gravel augmentation sites.

Macroinvertebrate and periphyton communities are naturally complex and dynamic, varying tremendously due to normal seasonal and annual environmental variation, periodic large-scale environmental disturbances, and simple chance. This assessment employed a spatially and temporally stratified sampling design to evaluate Project effects on the aquatic community. The evaluation considered three lines of inference: 1) longitudinal trends downstream from the Project, 2) comparisons of sites downstream and upstream of the Project, 3) comparisons of pre- vs. post-SWW samples.

The lower Deschutes River supports a tremendously productive and diverse aquatic ecosystem. Benthic macroinvertebrate numbers typically reach 10,000 or more individual organisms per square meter of substrate in productive riffle habitats. The benthic macroinvertebrate community was diverse, with most sites supporting 30 to 50 taxa. Insects generally predominated, although non-insect taxa were also abundant at certain times and places.

Seasonal differences were apparent across years between fall and spring samples. Macroinvertebrate densities in fall were almost double those of spring as large numbers of smaller, younger organisms were present. Taxa richness was generally similar, as the same taxa were generally represented in varying proportions in both seasons with minor differences among the less-abundant taxa. Annual variation in consecutive sampling years was relatively low in relation to seasonal and spatial patterns. Organism density and taxa richness were particularly consistent. Species composition was more variable.

The general distribution of the benthic macroinvertebrate community in the lower Deschutes River shows a distinct difference between the sites immediately downstream of the Project, and those sites below Shitike Creek. While high densities of organisms were documented at all sites, taxa richness was substantially lower immediately downstream from the Project than in sites farther downstream. Non-insect taxa including oligochaete worms, flatworms, and snails predominated at sample sites within 4 miles of the Project (Sites 1-3). Insects at these sites were primarily dipterans (chironomids and simuliids) versus the mayfly and caddisfly larvae prevalent in sites farther downstream. Filter feeders and omnivores were abundant immediately downstream from the Project, particularly in fall. Downstream from the immediate Project influence, the macroinvertebrate community generally varied from site to site with no obvious longitudinal pattern.

Macroinvertebrate communities in the Deschutes and Metolius rivers upstream from the Project are generally less dense but similarly diverse to downstream sites below the immediate influence of the Project. Densities in the Crooked River were substantially greater than the other two upstream sites and similar to densities documented throughout the lower river. The benthic community in upstream sites included many of the same taxa observed in lower river sites although the assemblage was distinctly different in terms of the percentage of major taxa. The Metolius site was further distinguished by the prevalence of insect taxa – non-insects did not comprise a substantial portion of the sample in any collection.

Differences in pre- and post-SWW macroinvertebrate community composition provide some evidence for implementation effects which were most apparent in the area immediately downstream from the Project. Study results did not identify large changes in the macroinvertebrate community before and after SWW implementation but seasonal changes in community composition were apparent and consistent with shifts in life cycle timing which may be explained by changing temperature patterns downstream from the Project. Most every species that was present or common before SWW implementation was also present or common after SWW implementation but changes in relative seasonal numbers were apparent. Changes were complex. Some taxa appear to have decreased while others have increased. The change in temperature as a result of the SWW operations may explain the density shifts noted for several of the key taxa of interest.

Attached benthic algae in the lower Deschutes River included a large and diverse diatom community but a few “soft” algae species generally dominated the biovolume. Taxa richness ranged from 17 to 56 diatom taxa, while soft algae included only 3 to 10 taxa depending on sample site. Seasonal and annual variation in periphyton was substantial in post-SWW samples. Periphyton densities, biovolumes, and taxa richness from the baseline study are not comparable because of differences in processing and analysis in the standardized EPA/USGS methodology used in the post-SWW study and less rigorous methods used in the baseline study. Diatom and soft algae densities were consistently greater in spring than fall, while biovolume of both was generally greater in the fall. Large differences among years were also observed in post-SWW samples particularly for soft algae.

No consistent longitudinal spatial trend was apparent for periphyton densities, biovolumes or taxa richness in post-SWW samples from lower Deschutes sites downstream from the Project. Any site differences that occurred were dwarfed by annual and seasonal variability. Periphyton biovolumes are also heavily influenced by sampling depth and proximity to shoreline. The taxa assemblage in reference sites upstream from the Project was distinctly different than the taxa present at the Lower Deschutes river sites. However, no consistent differences were documented in periphyton densities, biovolumes or taxa richness between Lower Deschutes sites and reference sites upstream from the Project.

Statistical-significant differences were identified in pre- vs. post-SWW comparisons of twelve of the 14 metrics describing spring diatom communities in seven lower Deschutes sites sampled in both periods. Changes included reductions in percentages of eutraphentic taxa,[1] low DO taxa, and siltation taxa; increases in the Pollution Tolerance Index and percent nitrogen autotroph taxa. No significant pre- vs. post- SWW differences were detected for the autecological metrics for fall sampling efforts.

Benthic macroinvertebrate densities at gravel sites were significantly higher and taxa richness was significantly lower than at the control site during fall 2013. Some of the highest oligochaete and gastropod densities of the study were documented at gravel sites in fall 2013. Densities and taxa richness were not significantly different among the sites for the other three seasonal collections. Taxa richness, modified Hilsenhoff Biotic Index (HBI) scores, and the Oregon Department of Environmental Quality (ODEQ) Impairment Index scores gradually improved at gravel sites as the study progressed. Gravel augmentation sites supported uniquely high seasonal densities of the filter-feeding polychaete *Manayunkia speciosa* (10,000 individuals/m^2) and *Urnatella gracilis* (goblet worms), small, sessile (i.e., fixed to the substrate), colonial animals that resemble cnidarian hydroids (*Hydra*).

[1] *Eutraphenic taxa favor environments with a rich supply of nutrients.*

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INTRODUCTION

In June of 2005, a new license was issued by the Federal Energy Regulatory Commission (FERC) for the Pelton Round Butte Project. Article 416 in this license requires that a macroinvertebrate and periphyton monitoring study be conducted following the implementation of selective water withdrawal (SWW) at the Round Butte Dam facility. During relicensing, a macroinvertebrate study was conducted in 1999-2001 to establish the baseline data to which comparisons could be made after the implementation of selective water withdrawal (Kvam et al. 2001, 2002). Article 416 directs that the study be repeated (i.e., two spring and two fall sampling events) once a new equilibrium has been reached, starting three years after implementation of selective water withdrawal using the same methods and locations. Selective water withdrawal was initiated in late 2009. Post-SWW sampling was conducted in October of 2013, April/May of 2014, October of 2014, and April of 2015.

Selective water withdrawal from Lake Billy Chinook was designed to provide downstream passage of juvenile salmonids and to help meet water quality standards in the lower river immediately downstream of the Project (CTWSRO & PGE 2000). Water was previously withdrawn at depth by the hydroelectric intakes in Lake Billy Chinook (Raymond et al. 1998). Resulting outflow temperatures were typically cold during spring and early summer, then warmer than pre-Project conditions during late summer and fall after the supply of deep cold water was exhausted. Discharge waters were also nutrient-rich, and relatively free of fine particulate organic matter (seston), especially during the summer and early fall when the lake water-column was stratified.

Operation of the selective water withdrawal at Round Butte Dam has restored a more natural temperature regime in the lower Deschutes River throughout the year. The SWW allows discharge of a mixture of surface and subsurface water throughout the spring, summer, and fall to better match historical temperature patterns.

Aquatic macroinvertebrates (insects, worms, snails, etc.) and periphyton (attached benthic algae) are tremendously powerful ecosystem indicators and integrators of physical environmental changes which are often complex and variable across time and space. Macroinvertebrate communities are particularly sensitive to the effects of temperature, which directly affects rates of metabolism, food ingestion and assimilation, growth and development, which greatly affect life cycle duration and generation time. Aquatic macroinvertebrates are also an important and highly productive component of the lower Deschutes River ecosystem which contributes to a popular and productive fishery for trout and steelhead.

STUDY GOALS & OBJECTIVES

The primary goal of this study is to provide a more comprehensive understanding of the ecosystem changes downstream from the Pelton Round Butte Project following the implementation of selective water withdrawal. Surface water withdrawal is intended to provide a more natural condition in the riverine ecosystem downstream. Does it do that, and what does that look like? No specific operational decisions are assumed to be predicated on results of this study, but information can be expected to inform any future considerations.

A secondary goal of this study is to determine how the benthic macroinvertebrate community has responded to gravel augmentation. Article 433 of the license for the Lower River Gravel Study identifies the need for corresponding monitoring as follows:

> *To monitor the response of the benthic macroinvertebrate community (e.g., grazers, predators, collectors) to gravel augmentation, invertebrate samples will be collected from each experimental gravel augmentation site in concert with invertebrate studies related to SWW. Collected samples will be sieved, sorted and preserved in 100% ethanol in the field for subsequent laboratory processing. Invertebrate identification and enumeration will be performed by a contract laboratory. In the laboratory, samples will be processed under a dissecting scope, and identified to the lowest practical taxonomic unit (typically genus). From these samples species composition, abundance, and diversity indices will be calculated. Upon completion of invertebrate identification, data will be analyzed using ANOVA and other appropriate statistical techniques (Underwood 1991). Analysis will center upon effectiveness monitoring of the planned gravel augmentation.*

Box 1. Study objectives.

1. **Evaluate changes in abundance and taxonomic condition of benthic invertebrates and periphyton downstream from the Pelton Round Butte Project following implementation of surface water withdrawal operations.**
2. **Monitor the response of the benthic macroinvertebrate community to gravel augmentation.**

STUDY AREA

The invertebrate study area includes the lower Deschutes River from the Reregulating Dam downstream to Mack's Canyon, approximately 24 miles upstream from the confluence of the Columbia River (Figure 1). The Reregulating Dam is located 100 miles upstream of the Columbia River. The Reregulating Dam is one of three dams comprising the Pelton Round Butte Hydroelectric Project. The uppermost dam, Round Butte, forms Lake Billy Chinook, a large and deep reservoir. Downstream of Round Butte Dam is Pelton Dam, which impounds Lake Simtustus, a narrow reservoir. The Reregulating Dam, which impounds the Reregulating Reservoir, is operated for maintaining stable flows in the lower Deschutes River downstream of the Project.

Lake Billy Chinook receives its inflow from three major tributaries, the Metolius, Deschutes, and Crooked Rivers, which form three arms to the reservoir. The Metolius River is a spring-dominated system, which provides a stable supply of cold water to the reservoir throughout the year. The Deschutes River is fed by spring flow and snowmelt, which largely drains forested lands. Flows in this river are substantially reduced by irrigation withdrawals during the spring and summer. Finally, the Crooked River originates from the Ochoco Mountains of central Oregon and flows primarily through agricultural lands. The Crooked River is heavily impacted by irrigation withdrawal and return flows in its mid and upper reaches. The irrigation return flows are responsible for relatively high nutrient concentrations in river waters during the spring and summer irrigation season. Although the Crooked River has a significant spring component, it is flashier than the upper Deschutes River and the Metolius River because of tighter soils and greater overland flow during storm events.

Water flowing from the Reregulating Dam represents the majority of the flow in the Deschutes River below the Project. Discharge is relatively stable, and typically ranges between 4,000 and 6,000 cubic feet/second (cfs) annually (CTWSRO and PGE 2000). Water quality monitoring in 1999 determined that the lower Deschutes River had moderate to high water quality. Biochemical oxygen demand and ammonia levels were below detection, and dissolved oxygen values were near or above 100 percent saturation. Low concentrations of nitrate (NO_3) appeared to limit plant growth in the lower Deschutes River (Eilers et al. 2000).

Major tributaries to the lower Deschutes River include Shitike Creek (RM 96.7), Trout Creek (RM 88.9), Warm Springs River (RM 84.7), and White River (RM 44.0). Westside streams, such as Shitike Creek, Warm Springs River, and the White River have good water quality, probably due to the large volume of Cascade Range snowmelt these systems receive. Factors influencing water quality conditions in the lower Deschutes River include treated sewage outfalls from the towns of Warm Springs and Maupin, and irrigation returns located on the east bank of the river between the Reregulating Dam and Trout Creek.

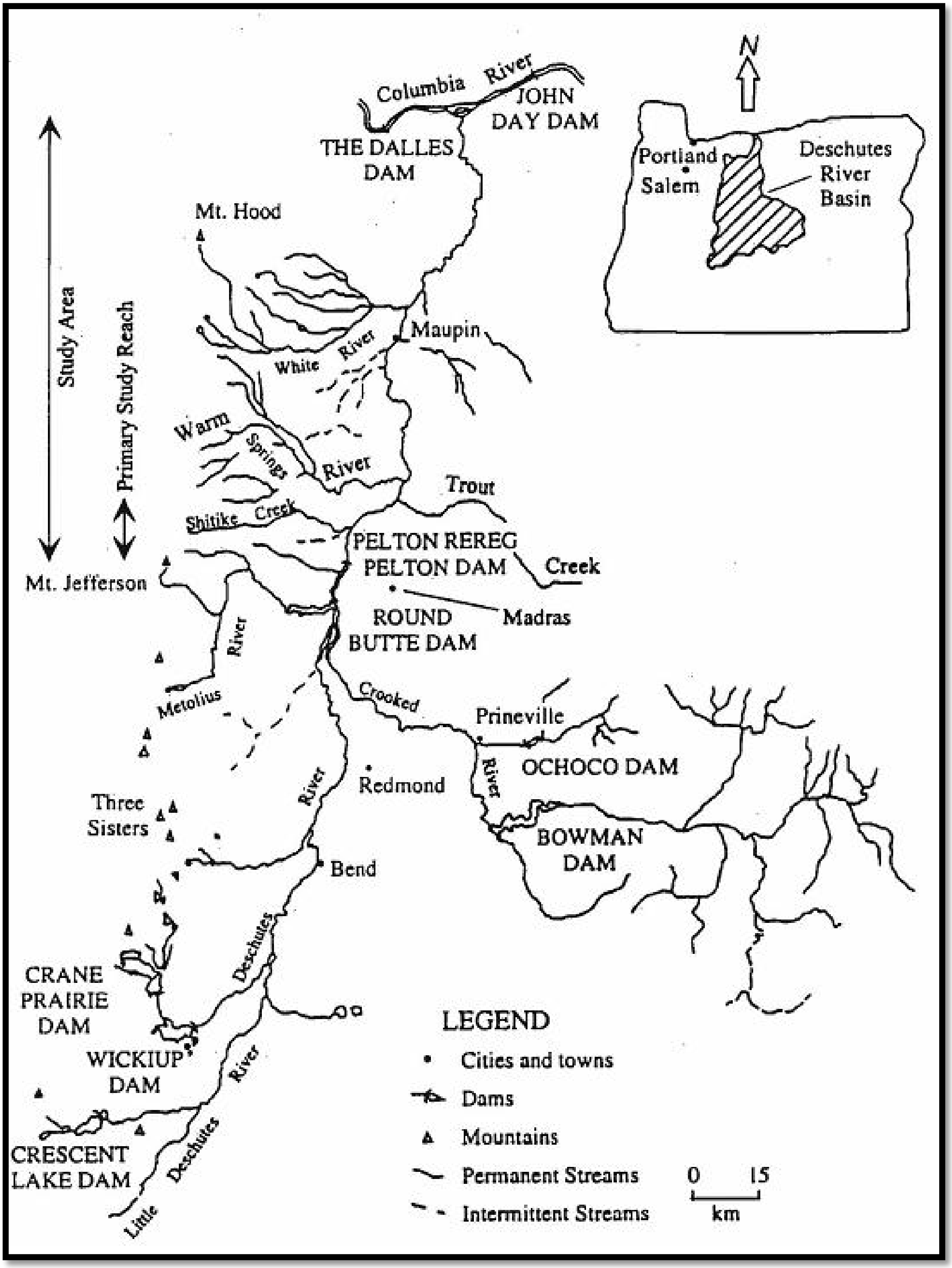

Figure 1. The Deschutes River basin (Fassnacht 1997).

METHODS

Experimental Design

This study employs a before-after experimental design. Significant differences in macroinvertebrate and periphyton characteristics between baseline and post-SWW samples stratified by season may be indicative of SWW effects. However, biological communities can also vary tremendously due to normal environmental variation, periodic large-scale environmental disturbances, and simple chance. Thus, it can be difficult or impossible to confidently attribute any observed changes to cause-and-effect. We can clearly describe differences. We cannot definitively prove they are due to SWW effects. Cause and effect can more confidently be identified when a suitable treatment-control can be identified. This is obviously difficult because there is only one Deschutes River and no comparable mainstem sampling locations exist upstream from the reservoir (only tributary sites).

While baseline and post-SWW comparisons are an essential part of the experimental design, inferences on SWW effects will also be informed by spatial patterns in the post-SWW sampling. Effects can be expected to dissipate with distance downstream as the river gradually resets itself to ambient conditions. Sample sites upstream from the reservoir might also be expected to somewhat represent conditions that are not affected by the SWW. Significant differences in macroinvertebrate and periphyton characteristics along the river continuum will also provide an indication of SWW effects. The combination of before-after and longitudinal sampling provides a strong basis for inference of SWW effects.

Gravel augmentation effects may be identified by a simple treatment-control comparison. Comparisons are made between samples from the substrate augmentation footprint and adjacent sites of similar depth and velocity. The test hypothesis is rejected when differences between treatment and control sites are significant.

TEST HYPOTHESES

H1: Macroinvertebrate and periphyton characteristics[a] are similar for comparable locations and sampling periods before and after SWW implementation.

H2: Macroinvertebrate and periphyton characteristics[a] are similar above, below and downstream from the Project.

H3: Macroinvertebrate and periphyton characteristics[a] are similar within and adjacent to gravel augmentation sites.

[a] *Characteristics include abundance, species composition, functional composition, and indicator indices.*

A temporally-stratified sampling design with limited replication is employed to distinguish SWW effects from normal variability. This design accounts for annual and seasonal variability in macroinvertebrate and periphyton characteristics. The abundance, composition, and diversity of aquatic invertebrates in rivers are highly variable on a spatial and seasonal basis. Both the baseline and post-SWW studies include seasonal strata (spring and fall) and annual replication (two years of sampling). Replicate sampling was limited in the post-SWW study, collected from four selected sample sites, for each season, and year in order to distinguish among strata and site conditions from within site variability.

Sampling and laboratory methods generally followed those established in the baseline study based on extensive consultation and guidance from PGE, governmental agencies, and nongovernmental entities involved in project licensing. Matching baseline study methods was preferred for providing comparable pre- and post-SWW data. Some refinements in sampling, laboratory, and analytical methods were also incorporated in post-SWW sampling to effectively evaluate longitudinal patterns above, below, and downstream from the Project.

Sample Sites & Numbers

Baseline Sample Sites 1999-2001

Sampling was conducted immediately downstream of the Pelton Round Butte Hydroelectric Project to identify proximate impacts of the Project on the invertebrate community, and above and below major tributaries downstream of the Project to identify the increasing influence of tributary inflows on the invertebrate community in the lower Deschutes River. Invertebrates were also collected in the three major tributaries flowing into Lake Billy Chinook; the Metolius, Deschutes, and Crooked Rivers, to establish reference conditions for macroinvertebrates within the Deschutes River study area.

Twelve invertebrate sampling sites were established for the baseline study in the lower Deschutes River between the Reregulating Dam (RM 100.0) to below the confluence of the White River (RM 44.0) (Figure 2). The greatest density of sampling sites was established in the 3.3-mile section of the river between the Reregulating Dam and Shitike Creek where Project effects were expected to be most significant. Sites were more widely dispersed upstream and downstream of major tributaries that might influence macroinvertebrates. Sites established below tributaries were placed far enough downstream to allow for horizontal mixing of tributary waters with those in the river mainstem. No site was established immediately above the confluence of the Columbia River due to the lack of suitable gravel and cobble substrates. Upstream sites above the Project were chosen to establish reference conditions for macroinvertebrates within the Deschutes study area. It was understood that these sites upstream from the reservoir would possess substantially different flow, habitat, temperature, and water quality characteristics than the lower Deschutes River.

Sites were generally characterized by gravel and cobble substrates, depths between 0.1 and 3.0 ft, and velocities between 1.0 and 3.0 ft/sec. Most sampling areas were situated adjacent to islands, since these areas of the river consistently contained the targeted range of substrate, depth, and velocity conditions. These characteristics provide optimum conditions for macroinvertebrate and periphyton production.

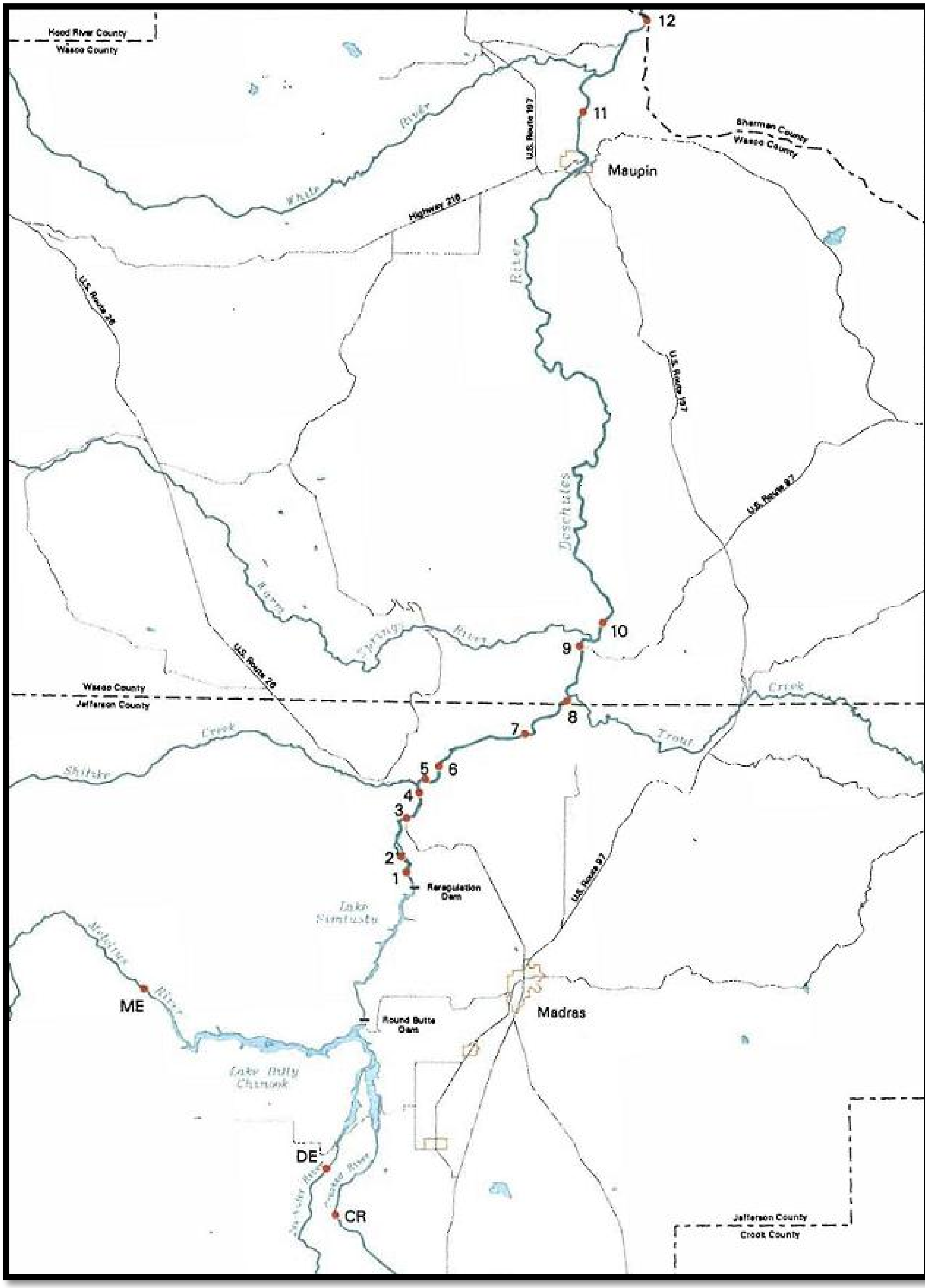

Figure 2. Location of baseline sampling sites for the lower Deschutes River macroinvertebrate and periphyton monitoring study.

Samples were collected from shallow areas at four sites downstream from the Project. The shallow areas (i.e., < 1.0 ft depth) were sampled to determine if invertebrates located in margins of the river (the "varial" zone) subjected to periodic dewatering during flow fluctuations differed in abundance and composition from those in deeper areas of the river. Only shallow sites could be sampled at Sites 5 and 7. Sites 1 and 8 included sampling in both shallow and deep areas.

To account for seasonal as well as annual variability in aquatic macroinvertebrate abundance and community structure, macroinvertebrate and periphyton samples were collected in the fall of 1999 and 2001 and in the spring of 2000 and 2001. During the first year of baseline study, samples were collected and analyzed for 14 downstream locations and 3 upstream reference sites above the Project (Table 1). A total of 16 or 17 sites were included in fall 1999 and spring 2000 sampling. Samples from all sites were analyzed. Based on Year One findings, analyses were reduced to just 7 downstream locations and 3 upstream reference sites during baseline Year Two (2001) based on results of first year sampling and guidance from the technical oversight committee. Samples were collected at all sites, but only a subset was analyzed because first-year results showed relatively little difference between adjacent sites. Four macroinvertebrate samples were collected at each site and each sample was analyzed separately. Five periphyton samples were collected at each site but samples were pooled for analysis.

Table 1. Summary of baseline sample sites analyzed by date.

Site	Depth	River Mile	Oct 1999	May 2000	May 2001	Oct 2001
1	Deep	99.9	✓	✓	✓	✓
1S	Shallow	99.9	✓	✓	✓	✓
2	Deep	99.5	✓	✓	--	--
3	Deep	99	✓	✓	✓	✓
4	Deep	97.5	✓	✓	--	--
5S	Shallow	96	✓	✓	✓	✓
6	Deep	94.5	✓	✓	--	--
7S	Shallow	90.4	✓	✓	✓	✓
8	Deep	88	✓	✓	--	--
8S	Shallow	88	✓	✓	--	--
9	Deep	85	✓	✓	✓	✓
10	Deep	84	✓	✓	✓	✓
11	Deep	48	✓	✓	--	--
12	Deep	45.5	✓	✓	--	--
ME	Deep	Metolius R.	✓	✓	✓	✓
DE	Deep	Deschutes R.	✓	✓	✓	✓
CR	Deep	Crooked R.	--	✓[a]	✓	✓
Total			**16**	**17**	**10**	**10**

[a] *The spring 2000 Crooked River sample was collected in August.*

Post-SWW Sampling 2013-2015

The post-SWW sampling is based on the sampling effort conducted during the second year of baseline studies with additional sampling of the gravel augmentation sites (Table 2). Sample sites included the 7 downstream sites where baseline analyses were completed in both years during the baseline study. Two additional downstream sites were sampled in order to provide another lower river reference site well-removed from the area of SWW effects (Figure 3). Sample Site 12 (Sandy Beach) was added – this site was sampled during the first baseline year but not in the second. A new site was also selected downstream in the vicinity of Mack's Canyon (Site 13). The three above-Project reference sites (ME, DE, and CR) located above Lake Billy Chinook were also included for identifying any long-term changes in conditions independent of SWW effects.

Table 2. Summary of post-SWW macroinvertebrate sample sites.

			River	Baseline		Macroinvertebrates		Periphyton
	Site	**Depth**	**Mile**	**Yr 1**	**Yr 2**	**Composite**	**Replicate**	**Composite**
Below Project	**1**	Deep	99.9	4	4	1	--	1
	1S	Shallow	99.9	4	4	0[b]	4	1
	2	Deep	99.5	4	--	--	--	
	3	Deep	99	4	4	0[b]	4[c]	1
	4	Deep	97.5	4	--	--	--	
	5S	Shallow	96	4	4	1	--	1
	6	Deep	94.5	4	--	--	--	
	7S	Shallow	90.4	4	4	0[b]	4	1
	8	Deep	88	4	--	--	--	
	8S	Shallow	88	4	--	--	--	
	9	Deep	85	4	4	0[b]	4	1
	10	Deep	84	4	4	1	--	1
	11	Deep	48	4	--	--	--	
	12	Deep	45.5	4	--	1	--	1
	13	Deep	23.9	--	--	1	--[d]	1
Above	**ME**	Deep	Metolius R.	4	4	1	**--**	**1**
	DE	Deep	Deschutes R.	4	4	1	**--**	**1**
	CR	Deep	Crooked R.	4[a]	4	1	**--**	**1**
	Total	***Sites***		***17[a]***	***10***	***8***	***4***	***12***
		Samples		***68[a]***	***40***	***8***	***16***	***12***

[a] Crooked River sample was not included in first sample season.

[b] Composite-equivalent estimates were derived from pooled replicate samples.

[c] Replicates also serve as control for gravel augmentation analysis.

[d] Value of replicated sampling at new sites would be limited by lack of pre-SWW baseline data for comparison.

Figure 3. Post-SWW sampling site locations for the Lower Deschutes Macroinvertebrate and Periphyton study.

For consistency with baseline results, sampling locations were replicated as closely as possible. Sampling in different habitats would introduce an undesirable confounding factor. Baseline sample locations were well documented in field records from the original sampling efforts. While the river channel is relatively stable at most sample sites, changes since 2001 resulted in different habitat conditions at several baseline sample sites. New sample locations were selected in the nearest possible proximity to the previous site in order to avoid confounding effects of sampling different habitat conditions. Further details on sampling locations can be found in Appendix I.

For macroinvertebrate collections at four sites (1s, 3, 7s, and 9), kick samples were kept separate as replicates, as in the baseline study. These sites were selected based on pre-SWW results to encompass the portion of river over which project effects were manifested and then mediated as the river resets. At the request of reviewers, kick samples at the remaining eight sites (1, 5s, 10, 12, 13, and the three reference sites) were composited into one sample, for approximate consistency with current ODEQ methodology (Table 2). Periphyton samples were also collected at all SWW effect evaluation sites, with only one composite sample to be taken at each site.

Gravel Augmentation Sites

Three sites downstream of the Project have been augmented with gravel in accordance with the Lower River Gravel Study Plan (Figure 4). Gravel augmentation sites include Jason Smiths at RM 98.9 (Site G1), Paxton's Riffle at RM 98.0 (Site G2), and Warm Springs at RM 97.5 (Site G3). Sites are in close proximity to Site 3 at Dizney Island, which serves as the control site (Figure 4).

Article 433 of the license, which prescribed the Lower River Gravel Study, did not identify a sampling design or desired precision level, but this analysis lends itself to a simple treatment-control design. Macroinvertebrate samples collected from the gravel augmentation footprint may be compared with samples from near-by areas of similar depth and velocity. Portions of gravel augmentation sites include areas that can be readily sampled for macroinvertebrates. All gravel was placed over about a two week time period. Hence, all portions of the footprint have been in the river for similar durations.

Sample sizes for macroinvertebrate samples are identified in Table 3. Three macroinvertebrate samples were collected and analyzed per gravel augmentation site. All samples were collected from within the gravel footprint. Untreated controls outside the area of gravel augmentation were from samples already being collected at a nearby site as part of the post-SWW evaluation (Site 3). The post-project gravel augmentation sites include comparable depths and velocities to post-Project sample sites. Replicates for statistical analysis are provided by the 3 sites (e.g., 3 samples on the 3 footprints for nine total sites vs. 4 replicate samples from Site 3). Each replicate kick sample consists of one, two-foot square area (consistent with the control site). No periphyton samples were collected at the gravel augmentation sites.

Figure 4. Gravel augmentation sampling site locations for the Lower Deschutes Macroinvertebrate and Periphyton study (2013-2015).

Table 3. Summary of gravel augmentation macroinvertebrate samples collected per sampling event.

Site		River Mile	Replicates
3	Control	99.0	4[a]
G 1	Treatment	98.9	3
G 2	Treatment	98	3
G 3	Treatment	97.5	3
Total (new)	***Sites***		***3***
	Samples		***9***

[a] *Controls provided by post-SWW study site.*

Annual Replication

The original study design was based on sampling for two years, pre and post-SWW, in order to accommodate annual differences in macroinvertebrate patterns that might result from normal variability in environmental patterns. Some differences were observed from site-to-site and seasonally in different years although the general pattern of increasing diversity with distance below the Project was consistent in all sample periods. The Project License also stipulated two years of post-SWW sampling. Table 4 identifies the annual sampling scheme.

Table 4. Gravel augmentation sampling schedule and sample numbers, including seasonal and annual replicates.

			Macroinvertebrates		Periphyton
Year	Season	Purpose	Composite	Replicate	Composite
1	Fall (Oct 2013)	SWW effects	8 x 1 = 8	4 x 4 = 16	12 x 1 = 12
		Gravel Aug.	0	3 x 3 = 9	0
	Spring (May 2014)	SWW effects	8 x 1 = 8	4 x 4 = 16	12 x 1 = 12
		Gravel Aug.	0	3 x 3 = 9	0
2	Fall (Oct 2014)	SWW effects	8 x 1 = 8	4 x 4 = 16	12 x 1 = 12
		Gravel Aug.	0	3 x 3 = 9	0
	Spring (May 2015)	SWW effects	8 x 1 = 8	4 x 4 = 16	12 x 1 = 12
		Gravel Aug.	0	3 x 3 = 9	0
Total			***32***	***100***	***48***

Field Sampling

Baseline Sampling

The aquatic invertebrate sampling program implemented during baseline sampling on the lower Deschutes River was designed to meet the ODEQ's Level 3 macroinvertebrate assessment protocol in 1999, which also conformed to the Environmental Protection Agency's (EPA's) revised Rapid Bioassessment Protocols (RPB) for invertebrates (Barbour et al. 1999). These macroinvertebrate protocols required a standardized and quantitative sampling approach, as well as a relatively fine level of taxonomic identification. ODEQ's Level 3 protocol provided a sensitive measure of habitat and water quality conditions in a stream, and could be used for determining general levels of disturbance, as well as spatial and temporal changes in habitat and water quality condition (Hafele and Mulvey 1998; OWEB 1999).

Four samples were collected at each study site using a D-frame kick sampler having 500-micron Nitex mesh. This was the same sampler employed by ODEQ for their biomonitoring programs and was recommended for Level 1, 2, and 3 protocols (Hafele and Mulvey 1998; OWEB 1999). All samples were collected in riffles or shallow runs possessing coarse gravel to small cobble substrates. Standard samples were collected from areas possessing water depths between 1.0 and 3.0 ft deep, and mean water column velocities between 1.0 and 3.0 ft per second. The "shallow" samples used to assess the macroinvertebrate community in the varial zone were taken from areas having water depths less than 1 ft and mean water column velocities between 1.0 and 3.0 ft per second. Sample locations were randomly selected following ODEQ's protocol, although selection was limited to areas possessing the described habitat criteria. Sampling was not conducted at a specified location until depths were determined to be suitable with a top-setting wading rod and velocities determined to be suitable with a Swoffer current meter.

Each sample was collected from an area of the stream bottom that was 1 ft wide (i.e., width of kick net) and 2 ft long (i.e., 2 ft^2). This area of the stream bottom was vigorously kicked for a period of one minute. Larger substrates were then scrubbed by hand to dislodge remaining organisms. Substrates were sampled to a depth of approximately 0.2 ft. The depth, mean water column velocity, substrate composition, and embeddedness of each sampling location were recorded in a field notebook. Water temperatures were also measured at the time of sampling.

The samples were not combined as recommended in ODEQ's invertebrate protocol (Hafele and Mulvey 1998; OWEB 1999), but rather were preserved in separate containers to allow for independent statistical analysis. The samples were also processed in the lab separately, but were statistically combined to yield results identical to those which would have been produced using ODEQ's method. The samples were labeled (location, date and time of sampling, habitat type, and sample number), and preserved with 90 percent ethanol.

In addition to macroinvertebrate sampling, periphyton (benthic algae) samples were collected from five submerged rocks at each study site following standard EPA Rapid Bioassessment Protocols (Barbour et al. 1999). Scrapings were obtained from each of the five rocks, with each scraping consisting of an area of 5 cm^2. The total area sampled at each site was therefore 125 sq-cm. These scrapings were then combined in a single container for taxonomic analysis. The samples were preserved in 3 percent formalin.

Post-SWW Sampling

Field sampling methods established in the baseline study were emulated in the post-SWW sampling. The baseline study collected 4 samples per site as per ODEQ protocol, but unlike the protocol, samples were not composited for analysis. At four sites (1s, 3, 7s, and 9), this approach was maintained, and four replicate kick samples were collected for macroinvertebrates during post-SWW sampling (Table 2), which provided replicate samples that facilitated statistical comparisons. Each replicate kick sample consisted of one, two-foot square area (consistent with the baseline). Lab analyses of these samples were based on a 300-count invertebrate subsample for each replicate sample (e.g. 4 per site).

At the request of the reviewers, composited kick samples were collected at the remaining eight sampling sites (1, 5s, 10, 12, 13, and the three reference sites) (Table 2). The composited kick sample consisted of the aggregate of four, two-foot square areas for consistency with the baseline sampling protocol.[2] Lab analyses were based on a 500-count invertebrate subsample for each site.

Sampling required approximately one week per sample season with a two-person crew. Boat or raft access was required to reach sample sites, many of which are located near islands in the river channel.

Field Procedures

Macroinvertebrate samples were collected using methods identical to those detailed above for the baseline study, with exception of compositing the four kick samples at eight of the sites. The depth, mean water column velocity, substrate composition, and embeddedness of each sampling location were recorded in a field notebook. Air and water temperatures, pH, conductivity, and dissolved oxygen (DO) were also measured *in situ* at each site during sampling. All samples were preserved with 95% ethanol/ethanol mixture.

During the fall 2013 sampling trip, it was noted that when kick sampling at several sites with higher current velocities, large amounts of sand were captured in the D-net. Such volumes of sand in the samples required multiple bottles per sample, and the excess sand prevented consistent preservation with the ethanol mixture used. In an effort to prevent incomplete preservation of samples, and to provide cleaner samples for lab processing, samples collected with excess sand and fine gravels were elutriated during all three subsequent collection trips. Such samples were placed in a 5-gallon bucket and agitated (stirred), with the lighter organic components poured off into a mesh sieve. This process was repeated until no further organic debris or organisms were seen being poured off. This elutriated component was then transferred to a sample container and preserved with ethanol. The remaining gravel was scanned for 3-5 minutes for heavier organisms that may have remained in the bucket, such as snails, clams, or those insects that build cases or attach themselves to substrates (caddis larvae). If any organisms were seen, all sand and gravel was placed in a separate container, preserved in ethanol, and labeled as the "substrate component" of that sample. If no organisms were found in the flushed sand or gravel component, it was discarded.

Periphyton samples were also taken from rocks collected within the sampling site. In the baseline study, five submerged rocks were randomly selected, and five scrapings were obtained from each of the five rocks, with each scraping consisting of an area of 5 cm^2. For the post-SWW study, an area delimiter (a section of a 1½ inch-diameter PVC pipe fitted with a neoprene collar at one end) similar to that recommended by the EPA and USGS protocols was used to

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[2] *ODEQ protocol has been changed from four, two-foot squares to eight, one-foot squares in order to reduce potential confounding effects of patchy habitat distributions. However, the Fish Committee recommended maintaining a consistent protocol to the baseline study for the post-SWW analysis.*

subsample the surface area of 10 rocks (Figure 5). The delimiter has a sampling area of 12.5 cm^2, thus resulting in a total sampled area of 125 cm^2 for the composite sample, comparable to the sampling area reported in baseline study.

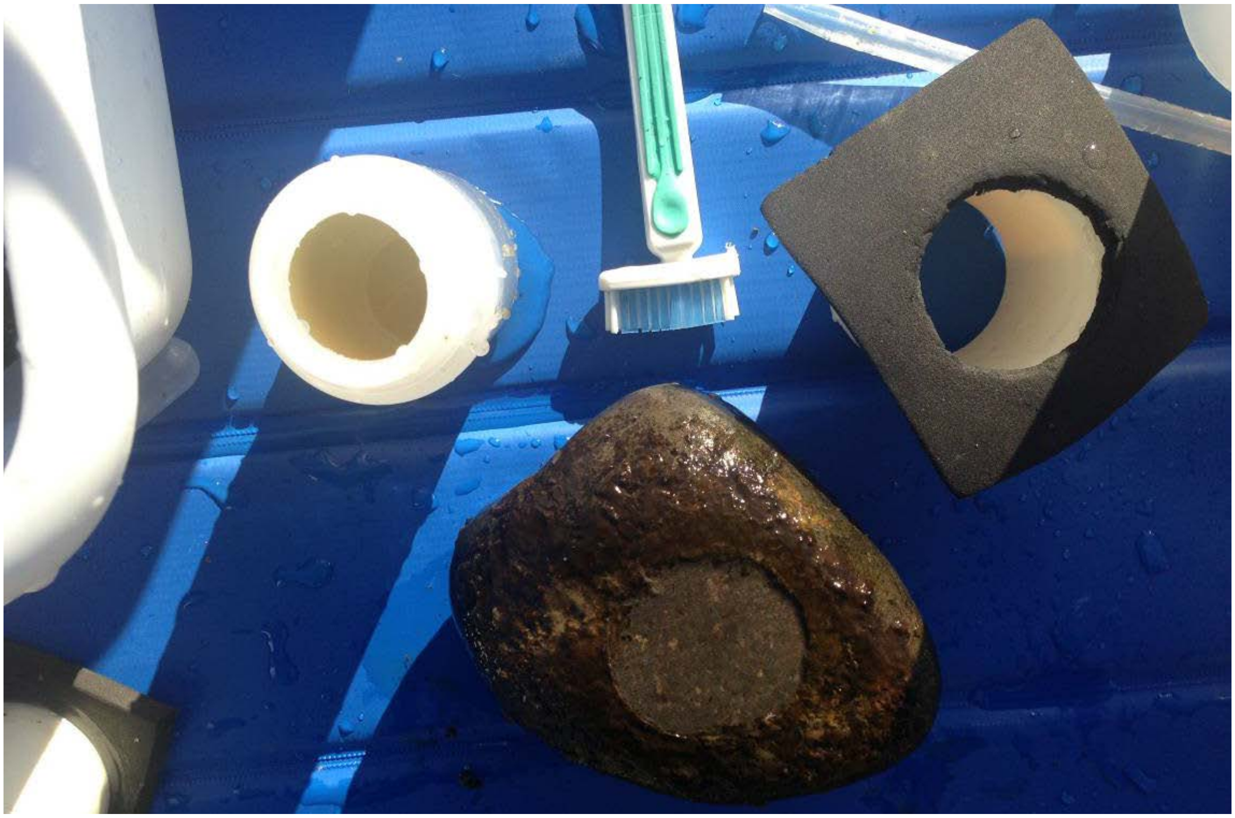


Figure 5. Area delimiter, brush and other sampling equipment used to collect periphyton from cobble substrates, with an example of a cleaned area on a cobble.

The procedure for the post-SWW collection method was as follows. The delimiter was pressed firmly on a cobble's surface to create a water-tight seal. A small amount of water was added to the enclosed area to test the seal. If no leakage occurred, a small brush was inserted into the delimiter to scrub the area. A small pipette was used to remove the disturbed periphyton/water mixture, which was added to a 125-ml sample holding bottle. More water was added, and scrubbing continued until the periphyton/water mixture was relatively clear in color. The delimiter was then removed from the rock, and the area was examined for any remaining attached algae, which were scraped off with a knife and added to the sample bottle. Once the sampling on a rock was completed, the sampled contents were added to the composite sample bottle (500-ml), and the sample was preserved using 100% formalin, to a final concentration of 3-5% formalin for the sample.

Laboratory Analysis

Baseline Analysis

Laboratory processing of the Deschutes River invertebrate samples in October 1999 and May 2000 consisted of: 1) picking and sorting the entire sample, 2) identifying taxa present and completing a voucher specimen collection, and 3) enumerating the samples according to taxonomic groups. All invertebrates in each sample were subsequently enumerated.

Statistical analysis of the 1999 and 2000 data determined that there were few significant differences between these sites and adjacent ones. Therefore, May and October 2001 invertebrate samples from only Sites 1, 1s, 3, 5s, 7s, 9, 10, and the three reference sites were processed. Samples from the remaining sites (2, 4, 6, 8, 8s, 11, and 12) were archived.

In 2001, laboratory processing involved: 1) large organic material not removed in the field was rinsed, visually inspected for invertebrates, and discarded; 2) contents from a single sample were then spread evenly over a gridded pan approximately 6 cm by 6 cm; and 3) squares within the gridded pan were randomly selected and invertebrates were removed from these squares until at least 300 organisms were encountered (Caton 1991). Total abundance of the total sample was then extrapolated based on the number of squares counted. Because subsampling can miss rare organisms (Merritt et al. 1996), the gridded pan was searched for rare taxa after subsampling. Although not as thorough as complete sample enumeration, subsampling combined with a rare taxa search was thought to provide representative estimates of taxa richness. Benthic macroinvertebrates were identified to taxonomic levels specified under ODEQ's Level 3 invertebrate protocol (Hafele and Mulvey 1998; OWEB 1999) using a zoom stereo-microscope. A taxonomic list of Oregon stream macroinvertebrates was obtained from ODEQ prior to taxonomic analysis.

The potential presence of two mollusk and three insect species considered sensitive species by the U.S. Fish and Wildlife Service (USFWS) and U.S. Forest Service (USFS) was also evaluated. These were the Columbia pebblesnail (*Fluminicola columbiana*) and the shortface lanx (*Fisherola nuttalli*). Both species were identified as present in the Deschutes River during surveys conducted in Columbia River streams in 1988 (Neitzel and Frest 1990). Three species of aquatic insects are also listed as sensitive species by the USFWS: the abbellan hydropsychid caddisfly (*Hydropsyche abella*), Cascades apatanian caddisfly (*Apatania tavala*), and the Deschutes ochrotrichian caddisfly (*Ochrotrichia phenosa*).

Laboratory processing of the Deschutes River periphyton samples involved subsampling and consisted of: I) filtering an appropriate aliquot of the sample through a 0.45 micrometer membrane filter; 2) preparation of permanent microscope slides made from a subsection of the filter; and 3) counting 100 algal units (either cells, colonies, or filaments) along a measured transect of the microscope slide with a Zeiss Standard microscope. Only those algal units that were believed to be alive at the time of collection (demonstrated by an intact chloroplast) were counted.

Post-SWW Analysis

For consistency with the baseline, laboratory sorting and analysis was designed to be similar to the baseline method documented above with minor refinements as detailed below.

Macroinvertebrates

The baseline work was based on a full sample count in Year 1 and a 300-organism subsample count in Year 2, with midges identified to subfamily. The current ODEQ protocol is based on a 500-count method, and includes midges identified to genus/species levels. The post-SWW methods employed both a 500-count subsample for composite sample analysis at eight sites and a 300-count subsample for replicate samples at the remaining four sites (Tables 2 and 5). Organisms were identified to taxonomic levels specified under ODEQ's Level 3 invertebrate protocol (Hafele and Mulvey 1998; OWEB 1999). Chironomids (midge larvae) were identified to the subfamily level, equivalent to the baseline study efforts. To ensure that taxonomy was compatible among studies, the baseline taxa list from the baseline study was provided to the current laboratory, with the request to keep as closely to those levels as possible, which the lab accommodated. Some taxonomy has changed since the baseline study (e.g., Tricorythidae to Leptohyphidae, Tubificidae to Naididae), which were made to the post-SWW taxa list along with additions of new taxa collected during the study.

The baseline study found zooplankton to be present in some samples, but these organisms are not representative of communities downstream from the dam because they are primarily entrained from the reservoirs. Thus, zooplankton are more incidental contributors to the benthic macroinvertebrate samples. If zooplankton entrainment patterns are of interest, drift samples would be a much more direct and efficient means of sampling. In the baseline analysis, zooplankton were not included in the 300-count subsample count but were counted separately. Zooplankton counts in the post-SWW analysis follow the final protocol adopted for the baseline study, in that they were not counted or included in the 300-count or 500-count subsamples. However, zooplankton were removed from the subsample, and archived for possible future needs.

Periphyton

The expert consensus on algae identification methodology has evolved since the baseline study. In the baseline study, periphyton samples were subjected to a 100-count, which included both diatoms and soft algae together. Taxonomy laboratories contacted for this study were unfamiliar with this method, and had concerns about both replicating the method and about the results being unrepresentative, due to the low count. Standard practice now involves use of EPA RBP and USGS NAWQA protocols (Barbour et al. 1999; Charles et al. 2002). These algae protocols are well-documented, and include a set 300-count of soft algae cells and 600-valve count for diatoms. Limitations of the original method may be why the baseline study identified no substantive periphyton difference among samples. We therefore adopted the standard protocols used by the USGS NAWQA program.

In the laboratory, samples were thoroughly mixed by shaking. Permanent diatom slides were prepared: subsamples were taken and treated with 70% Nitric acid (HNO3) and digested using a closed-vessel microwave digestion system (Milestone Ethos EZ), following the method developed by the Academy of Natural Sciences, Philadelphia (Charles et al. 2002). Samples were neutralized by rinses with distilled water, and subsample volumes were adjusted to obtain adequate densities. Small amounts of each sample were dried onto 22-mm square coverslips. Coverslips were mounted on slides using Naphrax diatom mount. To ensure a high quality mount for identification and to make replicates available for archives, 3 slide mounts were made from each sample. One of the replicates was selected from each sample batch for identification. A diamond scribe mark was made to define a transect line on the cover slip, and a minimum of 600 diatom valves were identified along the transect mark. A Leica DM 2500 compound microscope, Nomarski contrast, and 1000x magnification were used for identifications. Diatoms were identified to the lowest possible taxonomic level, generally species, following standard taxonomic references.

For soft-bodied (or non-diatom) algae samples, the raw periphyton sample was manually homogenized and emptied into a porcelain evaporating dish. A small, random sub-sample of algal material was pipetted onto a standard Palmer-Maloney microscope slide using a disposable pasture pipette. Visible (macroscopic) algae were also sub-sampled in proportion to their estimated abundance relative to the total volume of algal material in the sample, and added to the liquid fraction on the slide. The Palmer-Maloney cell was then covered with a 22 x 30 mm coverslip.

Soft-bodied algae were identified to species, where possible, using a Leica DM 2500 compound microscope under 200X and 400X magnification, following standard taxonomic references. Three hundred natural units of algae were counted and identified; total cells were also counted and recorded. Live diatoms were counted from a fixed volume in the Palmer-Maloney cell in order to achieve density estimates.

Data Analysis

Macroinvertebrates

Key biotic metrics included those identified in ODEQ's Level 3 protocol (Hafele and Mulvey 1998; OWEB 1999):

Abundance – The total number of individuals collected in a given sample. Density is calculated as the number of individuals per unit area (i.e., m^2). Density values could be calculated from the samples because they were obtained from a standardized sampling area (2 sq^2).

Taxa Richness – The total number of macroinvertebrate taxa present in each sample. This metric generally increases with increasing water quality and/or habitat diversity and is used as a relative measurement of the health of the benthic invertebrate community.

Mayfly, Stonefly, and Caddisfly Richness – The number of distinct taxa within the insect orders Ephemeroptera (mayflies), Plecoptera (stoneflies), and Trichoptera (caddisflies) were determined. These orders are regarded to be relatively sensitive to pollution. Following ODEQ Level 3 protocols (Hafele and Mulvey 1998; OWEB 1999), taxa richness values were calculated separately rather than jointly for mayflies, stoneflies, and caddisflies. The separate taxa richness values generally increase with increasing water quality. Consequently, this is a widely used indicator of overall stream health.

Community Composition – The relative abundance of major taxonomic groups provides information on a stream community’s structure and the relative contribution of the populations to the total fauna (Barbour et al. 1999). Eight major taxonomic groups were used to describe the community structure in our analysis: Ephemeroptera, Plecoptera, Trichoptera, Coleoptera (beetles), Chironomidae (midges), Diptera (true flies other than midges), Other Insects, and Non-insects. Composition measures of certain taxonomic groups are often used as indicators of impairment in streams. For example, Chironomid (midge) relative abundance can be used as a general indicator of organic or sediment pollution and impairment and provides a measure of invertebrate community balance (Barbour et al. 1999). Samples that have a disproportionate number of Chironomidae may indicate environmental stress, as midge larvae are often tolerant to sedimentation and nutrient enrichment.

Sensitive Taxa – This is the number of taxa in each sample that are known to be very sensitive to stream disturbance (Hafele and Mulvey 1998; OWEB 1999).

Sediment Sensitive Taxa – These are taxa in each sample that are very sensitive to inputs of fine sediment. The presence of one or more of these taxa indicates that fine sediments are probably not a major concern (Hafele and Mulvey 1998; OWEB 1999).

Modified Hilsenhoff Biotic Index – The Modified Hilsenhoff Biotic Index (MHBI) is used to portray the overall pollution tolerance of the benthic invertebrate community as a single value (Barbour et al. 1999). Tolerance values range from 1 to 10, with 1 describing very little or no tolerance to organic pollution and 10 describing very high tolerance to organic pollution. The MHBI is calculated as:

$$MHBI = \sum x_i t_i / n$$

Where x_i is number of individuals within a given taxa, t_i is the tolerance value for this taxa, and n the total number of organisms in a sample. For the MHBI, tolerance values for each invertebrate taxonomic group were the same as those used in the baseline study, based upon ODEQ's tolerance classifications (Hafele and Mulvey 1998; OWEB 1999).

Percent Tolerant Taxa – This is the percentage of all invertebrates present in a sample that are considered to be tolerant to disturbance. In contrast to metrics that describe the presence of sensitive species, tolerant species are likely to be found at all sites, including the most pristine or undisturbed sites. For comparability of post-SWW samples with baseline study results, the tolerance ratings were determined for each taxonomic group based upon ODEQ's tolerance classifications (Hafele and Mulvey 1998; OWEB 1999) used by the baseline study. Percent sediment tolerant taxa were also calculated using the same values used in the baseline study, which were based upon ODEQ's tolerance rating criteria for specific taxonomic groups.

Percent Dominant Taxon – This metric is the percent contribution of the numerically most dominant taxon to the total number of invertebrates present in a sample. A community dominated by one species may indicate high levels of nutrient enrichment (high invertebrate density levels), or the presence of toxic contaminants (low invertebrate density levels).

Functional Food Group Classification – Each aquatic invertebrate taxon was placed in one of six functional food groups, which identify the trophic status (i.e., food requirements) of a particular taxon. The functional food group categories that were employed in our analysis were: 1) grazers (or scrapers), which feed on attached algae or periphyton; 2) shredders, which feed on coarse particulate organic matter (CPOM) such as leaves; 3) collectors, which feed on fine particulate organic matter (FPOM) deposits; 4) filter feeders, which feed on FPOM within the water column; 5) predators; and 6) omnivores, which feed on a variety of materials. Invertebrate functional food groups were determined from the literature, including classifications provided for invertebrate genera by the EPA (Barbour et al. 1999). The percent of organisms belonging to each functional food group reflects the type of food base that may be determining the composition of invertebrate taxa in a river or stream. For example, a high grazer to filter feeder ratio is indicative of an aquatic ecosystem in which periphyton is the most abundant source of food for the invertebrate community (Klemm et al. 1990). In contrast, a low grazer to filter feeder ratio is indicative of an aquatic ecosystem where FPOM is the most important source of energy to the aquatic invertebrate community.

ODEQ Impairment Index – At the time of the baseline study, ODEQ recommended the use of either a multivariate or multimetric analytical procedure for the comparison of samples among sites as part of the Level 3 protocol (Hafele and Mulvey 1998; OWEB 1999). For comparability of post-SWW samples with baseline study results, ODEQ's multimetric analysis was employed to assess the relative health of the macroinvertebrate community among study sites on the lower Deschutes River. This analysis incorporates a number of the key biotic metrics identified above into an impairment score, which is used to describe overall stream condition or health. The impairment score is calculated by calculating individual scores varying from 1 to 5 for each metric and then adding these together for the total score. The higher the total score, the lower the impairment. However, ODEQ's multimetric analysis procedure was developed based on data collected from wadeable streams and the narrative criteria used ("severe," "moderate," "slight," and "no," impairment) are probably not directly applicable to a large river like the Deschutes (Hafele and Mulvey 1998; OWEB 1999).

To facilitate macroinvertebrate community comparisons between sites, pelagic crustaceans (cladocerans, copepods) that likely originated in Lake Simtustus and the Reregulating Reservoir were ignored when generating the metrics described previously. The crustaceans were recorded at sites in close proximity to the Reregulating Dam, which increased density and other metric values relative to more downstream sites.

For sites with replicate samples instead of composited samples, composite-equivalent samples were required in order to faciltate comparisons to the composite samples. To create composite-equivalent samples, the 300-count data from replicate samples at each site were pooled, effectively creating a 1,200+ count sample, from which the above metrics were calculated. While taxa richness measures were still not comparable, the rest of the metrics were less affected by pooling.

Periphyton

Periphyton density was calculated as the number of algal units per square centimeter. Average biovolume estimates of each species were obtained from microscopic measurements of each algal taxon. Periphyton taxa richness was determined by enumerating the total number of algal taxa identified in the subsample from each microscope slide.

Taxa and raw counts were entered into the processing lab's customized database software. Density calculations were performed for diatoms and non-diatom algae. Diatom density estimates are expressed as number of valves per square centimeter. Non-diatom algae density estimates are expressed as both natural counting units per square centimeter and cells per square centimeter. Biovolume calculations were also performed for diatoms and non-diatom algae. Biovolume estimates are expressed as cubic micrometers per square centimeter.

In addition, the processing laboratory calculated a number of ecological metrics commonly used for diatoms (Stevenson and Bahls 1999). These were generated for both the present study (2013-2015), as well as for sample results from the baseline study (1999-2001). Baseline data was originally presented as estimates of total numbers per square centimeter, and it was necessary to convert these values back to the original 100-cell counts, from which metrics were calculated.

Community Structure

Cosmopolitan Taxa Percent – Percent relative abundance of cosmopolitan species, i.e., taxa distributed widely in temperate regions, have a broad ecological niche, and are generally aggressive and opportunistic species that develop large populations in response to disturbance and may exclude native species (Lowe 1974).

Dominant Taxon Percent – Percent relative abundance of the dominant diatom species counted.

Shannon H (log2) – Shannon Diversity Index (Weber 1973) using log base 2 (Bahls 1992; Teply and Bahls 1995), a quantitative measure that reflects both how many different taxa there are in a dataset, how evenly distributed individuals are among those taxa. Diversity increases when both when the number of taxa and evenness increases, and is highest when all taxa are equally abundant.

Species Richness – Total number of species counted (during proportional count). Higher species richness is indicative of high biotic integrity. Decreases in species richness are thought to be caused by increased stress, due to factors such as pollution, lower nutrients, or lower light levels.

Inorganic Nutrients

Nitrogen Autotroph Taxa Percent – Percent relative abundance of nitrogen autotroph taxa that tolerate concentrations of organic N ranging from small to elevated levels (van Dam et al. 1994).

Eutraphentic Taxa Percent – Percent relative abundance of eutraphentic and hypereutraphentic diatoms, those taxa preferring highly nutrient-enriched waters (van Dam et al. 1994).

Rhopalodiales Percent – Percent relative abundance of *Epithemia* and *Rhopalodia* species, from an order of diatoms that harbor nitrogen-fixing endosymbionts (cyanobacteria). The abundance of diatoms in this group indicates likely nitrogen-limiting conditions at this site.

Metals

Abnormal Cells Percent – Percent relative abundance of cells exhibiting teratogenic effects, positively correlated to heavy metal contaminations in streams (McFarland et al. 1997).

Acidophilous Taxa Percent – Percent relative abundance of acidobiontic (< 5.5 pH) and acidophilous (5.5-7.0 pH) diatoms (van Dam et al. 1994).

Alkaliphilous Taxa Percent – Percent relative abundance of alkalibiontic (>8.5 pH) and alkaliphilous (7.0-8.5 pH) diatoms (van Dam et al. 1994).

Disturbance Taxa Percent – Percent relative abundance of *Achnanthidium minutissimum* (or its original name, *Achnanthes minutissima*) in a sample. This species is an attached diatom that is often a pioneer species in areas recently disturbed by scouring flows or toxic pollution (Stevenson and Bahls 1999).

Metals Tolerant Taxa Percent – Percent relative abundance of species known to tolerate elevated concentrations of heavy metals (Teply and Bahls 2005).

Organic Nutrients

Pollution Tolerance Index – Aggregate index based on pollution tolerance, similar to the Hilsenoff Biotic Index for macroinvertebrates (see above). Tolerance is designated by three classes: species most tolerant to pollution (1), species tolerant of pollution (2) and species sensitive to pollution (3) (Lange-Bertalot 1979; Bahls 1992), with scores ranging from 1 for most polluted to 3 for least polluted. The PTI is calculated as:

$$PTI = \sum n_i t_i / N$$

Where n_i is number of cells count for a taxa, t_i is the tolerance value for this taxa, and N the total number of cells counted.

Nitrogen Heterotroph Taxa Percent – Percent relative abundance of diatoms that are facultative heterotrophs and obligate nitrogen heterotrophs (van Dam et al. 1994).

Polysaprobous Taxa Percent – Percent relative abundance of alpha-mesosaprobous (moderately tolerant of organic pollution, with lower dissolved oxygen requirements), alphameso/polysaprobous, and polysaprobous (highly tolerant of very strong organic pollution, with extremely low dissolved oxygen requirements) diatoms, based upon the Saprobien system (van Dam et al. 1994; Stevenson and Bahls 1999).

Low DO Taxa Percent – Percent relative abundance of low (<50% saturation) to very low (10% saturation) oxygen demand diatoms (van Dam et al. 1994).

Sediment

Siltation Taxa Percent – Percent relative abundance of *Navicula* (Cavinula, Craticula, Diadesmis, Dickieia, Fallacia, Geissleria, Hippodonta, Luticola, Navicula, Placoneis, Sellophora, Proshkina, Kobayasiella and Aneumastus) plus *Nitzschia* (Nitzschia, Simonsonia and Tryblionella) plus *Surirella* (Bahls 1992; Teply and Bahls 2005). Diatoms from these genera are more mobile and are able to move to the surface if covered by silt; their abundance reflects the degree of siltation.

Motile Taxa Percent – Percent relative abundance of highly motile and moderately motile (with raphes, but not highly motile) diatom taxa (van Dam et al. 1994). This metric is similar to siltation taxa.

Statistical Analysis

This final report includes a summary of baseline and post-SWW sample results in both graphical and tabular formats (Appendices II and III). Statistical analyses have been performed where sample replication was sufficient to allow for statistical comparisons. The analyses were run on a select subset of the calculated benthic metrics.

For post-SWW sampling, analysis of variance (ANOVA) was used to test for significant differences among sampling events and/or sites, and particularly to determine if there were differences among seasons or a significant upstream-downstream trend. Prior to ANOVA testing, data were evaluated for strong violations of assumptions of normality and unequal variance. Although ANOVA is robust to moderate assumption violations, transformations or outlier removal were considered when Shapiro-Wilk's test of normality (on ANOVA residuals) was rejected with $p<0.05$. Planned linear contrasts were used after significant ANOVA results to test for seasonal differences or monotonic downstream trends. If interaction between sampling event and sites was significant, differences among sites were evaluated for each individual sampling event. These analyses were limited to the four sites sampled with replication (n=4), as sites with composited samples lacked the sample size (n=1) for comparisons.

In addition, a multivariate ordination procedure, principle components analysis (PCA), was utilized on the post-SWW taxonomic data to explain the relative contribution of different taxa to observed grouping patterns that best explain variability in the data. The goal of ordination is to preserve differences between samples, to reduce the dimensionality of the data, and to create a set of independent covariates from a set of correlated variables. The general approach is to define a new set of axes that describe the majority of the variability in the multivariate data. The first axis is a vector fitted to the direction of maximum variability in the data.

Successive axes are orthogonal (perpendicular) to the existing axes, with each additional axis explaining a smaller portion of the total variation in the data.

PCA is a data analysis tool usually used to reduce the number of variables in a data set, while retaining as much information as possible (Hintze 1998). PCA calculates an uncorrelated set of variables, referred to as factors or principal components, ordered so that the first few retain most of the variation present in the original variables (Hintze 1998). Using the statistics program MVSP (Kovach 1999), PCA was used as an exploratory method on the post-SWW data sets to observe any grouping patterns, aggregating multivariate data to highlight differences in the community assemblages.

This analysis was based on the 35 most abundant taxa, instead of utilizing the full set of taxa. Multivariate analyses are well-known to be unstable when there are more variables (taxa) than samples. It is a generally accepted practice to reduce the number of variables, especially if they outnumber the cases by 3:1 or nearly 4:1, as is seen in this study's data sets. Most recommendations are to have at least 5 times more observations than variables. In the post-SWW macroinvertebrate data set, there were 48 distinct cases (12 sites, 4 sampling trips) and 125 unique taxa as variables. For the periphyton data set, there were 48 distinct cases and 190 unique taxa as variables.

Reduction also reduced confounding effects of the large number of zero counts in rare taxa. PCA is especially sensitive to highly skewed variables, but all multivariate methods are impacted by a variable that only has a small number of non-zero observations. Limiting the analysis to the 35 most abundant taxa substantially addresses much of the concern regarding confounding effects of absences on the results of the PCA.

For benthic macroinvertebrate and periphyton data, the abundances (and biovolumes for periphyton) were summed for each taxon across all samples collected in the four sampling trips, and then the taxa were arranged from most to least. For macroinvertebrates, the top 35 taxa accounted for 96.4% of the total estimated abundances. Individually by cases, these 35 taxa accounted for over 90% (range 91.6-99.6%) of the estimate density within each case; the exception was at the Metolius site, averaging 64.7% (54.5-71.3%). Therefore, these 35 taxa were reasonably representive of the assemblage in each case. For periphyton density, we counts were limited to diatoms; the top 35 taxa accounted for 97% of the total estimated abundances of all cases. The top 25 diatom taxa were ultimately selected for the PCA analysis because the elimination of 10 taxa resulted in better amount of variability explained and more clearly showed the apparent trends in the diatom assemblage.

For benthic macroinvertebrate and periphyton data, PCA was used to create an ordination plot placing sites along a set of axes based upon the average abundance or compositions of the most prevalent taxa from each site. PCA biplots were created to show longitudinal and seasonal differences in macroinvertebrates and periphyton assemblages among the sites consistent with patterns observed in the other graphs. Taxonomic variables are represented by arrows with the direction and length of each arrow plotted to indicate the amount of influence that variable has upon the two axes. Sites were plotted in the ordination in relation to those metrics and taxonomic variables found at the site, thus similar sites would be located closer together.

For comparisons of pre- and post-SWW metrics, the composite samples and composite-equivalent samples were used to compare pre- and post- SWW average results for only those sites below the Project that were consistently sampled in both studies (Sites 1, 1S, 3, 5S, 7S, 9, and 10). Taxa richness metrics could not be used because the different subsampling efforts in the pre- vs post-SWW sampling (full sort, 500-count, 300-count, pooled 1,200-count) biases the data, making such comparisons inadvisable (Barbour and Gerritsen 1996). Comparisons were made using paired t-tests, with metric results paired by site and season (n=7). For most metrics, the pre- to post- SWW differences were not normally distributed; therefore, the data set was analyzed with the nonparametric Wilcoxon Signed-Rank test for differences in medians.

For gravel augmentation sampling, a two-way ANOVA was used to test for significant differences among the control and three augmentation sites, as well as among the four sampling events. Assumptions of normality and equal variance were also tested with each ANOVA. Multiple comparisons were also run, using either Tukey's test or the Holm-Sidak multiple comparison procedure.

RESULTS

Sampling was conducted during four collection periods from October 2013 through April 2015 at the nine sites on the lower Deschutes River starting immediately downstream of the Pelton Round Butte Hydroelectric Project and extending downstream to the Mack's Canyon campground site (Table 5). Composite samples of macroinvertebrates and periphyton were also collected at reference sites in the three major tributaries flowing into Lake Billy Chinook; the Metolius, Deschutes, and Crooked Rivers. Lastly, replicate samples were collected at three gravel augmentation sites located between River Miles 97.5 and 99.0. Details on the collection efforts, including specific GPS coordinates, number and types of samples collected, and sampling dates are given in Table 5. Further details on collection sites are given in Appendix I.

In addition to benthic samples, physical and basic water quality measurements were collected for each site visit (Tables 6 and 7) to characterize conditions at each sampling site. The data collected provides a general description for each sampling location and was intended to inform potential observations of any large, unexplained differences in the results among sites (i.e., a sample taken in an area with high fines vs. a site with lots of boulders). However, a detailed assessment of water quality patterns downstream from the project was beyond the scope of this study, and would require a study design specific to that purpose.

Samples were collected in velocities that mostly ranged from 1-3 ft/s, in substrates that were generally a cobble-gravel mixture, with varying amounts of sand. Sites 9 and 12, and the Crooked River reference site (CR) were sites with higher compositions of boulder-sized substrates, usually large basalt pieces with sharp edges. Spot-recorded water temperatures were generally around 11-14˚C, with temperatures increasing in a downstream trend, peaking usually around Sites 9 and 10. During spring periods, a decrease in temperature was seen at Sites 12 and 13, which are below the glacially-fed White River. At the reference sites, the spring-fed Metolius River exhibited the lowest temperatures (6.4-8.2˚C), and the Crooked River recorded the highest temperatures (12.5-14.4˚C). Dissolved oxygen levels were near saturation levels or higher, with lower recorded levels and saturations occurring during the fall visits at Sites 1 and 1S immediately downstream from the Project (Tables 6 and 7). Measurements for pH in the lower Deschutes River ranged from 7.91 to 9.67 during the two-year study, with lower pH readings during fall 2013 (7.91-8.44) and the highest during spring 2015 (9.21-9.67). During the two spring visits, Sites 12 and 13 recorded the lowest pH levels in comparison with the other lower Deschutes River sites upstream, possibly due to the influence of the White River as well (Tables 6 and 7). The reference sites displayed similar pH levels, ranging from 6.86 at the Metolius site (ME) in fall 2013 to 9.02 at the Crooked River site (CR) in spring 2015, with the highest pH level recorded during the spring 2015 visit.

Regarding the unusually high pH measurements taken in Spring 2015, since these are uniformly high, even in the upper reference sites, it is highly likely that the meter we used was off in its calibration. Therefore, any *in situ* measurements taken should be considered preliminary at best, and compared to official measurements taken by PGE or agencies.

Table 5. Summary of sampling locations, dates, and efforts for the October 2013 and April/May 2014 field trips for the Lower Deschutes Macroinvertebrate and Periphyton study.

Site	Latitude	Longitude	Samples	Fall 2013	Spring 2014	Fall 2014	Spring 2015
ME – Metolius River Reference near Monty Campground	44.621124°	121.475366°	Four-Kick Composite – 1 Periphyton Composite – 1	Oct 14	Apr 28	Oct 8	Apr 29
DE –Deschutes River Reference, at the USGS gage	44.498621°	121.320875°	Four-Kick Composite – 1 Periphyton Composite – 1	Oct 15	Apr 28	Oct 8	Apr 29
CR – Crooked River Reference, u/s of Opal Springs Dam	44.477621°	121.301858°	Four-Kick Composite – 1 Periphyton Composite – 1	Oct 15	Apr 29	Oct 8	Apr 29
Site 1S – Shallow, d/s Reregulating Dam	44.727809°	121.247144°	Replicate Kick Sample – 4 Periphyton Composite – 1	Oct 16	Apr 29	Oct 6	Apr 27
Site 1 – Deep, d/s Reregulating Dam	44.727809°	121.247144°	Four-Kick Composite – 1 Periphyton Composite – 1	Oct 16	Apr 30	Oct 6	Apr 27
Site 3 – Dizney Island	44.738600°	121.241970°	Replicate Kick Sample – 4 Periphyton Composite – 1	Oct 16	Apr 30	Oct 6	Apr 27
G1 – Jason Smith Gravel Aug.	44.739444°	121.242578°	Replicate Kick Sample – 3	Oct 16	Apr 30	Oct 6	Apr 27
G2 – Paxton's Riffle Gravel Aug.	44.745616°	121.228346°	Replicate Kick Sample – 3	Oct 16	Apr 30	Oct 6	Apr 27
G3 – Warm Spring Gravel Aug.	44.756711°	121.226424°	Replicate Kick Sample – 3	Oct 16	Apr 30	Oct 6	Apr 27
Site 5S – Lumber Mill Island, d/s Shitike Creek	44.764617°	121.227025°	Four-Kick Composite – 1 Periphyton Composite – 1	Oct 17	Apr 30	Oct 7	Apr 28
Site 7S – Fornication Island	44.795813°	121.127400°	Replicate Kick Sample – 4 Periphyton Composite – 1	Oct 17	May 1	Oct 7	Apr 28
Site 9 – above Warm Springs River	44.859496°	121.075256°	Replicate Kick Sample – 4 Periphyton Composite – 1	Oct 17	May 1	Oct 7	Apr 28
Site 10 – below Warm Springs River	44.866138°	121.059858°	Four-Kick Composite – 1 Periphyton Composite – 1	Oct 17	May 1	Oct 7	Apr 28
Site 12 – Sandy Beach	45.240553°	121.048945°	Four-Kick Composite – 1 Periphyton Composite – 1	Oct 18	May 1	Oct 5	Apr 26
Site 13 – Mack's Canyon	45.391698°	120.882248°	Four-Kick Composite – 1 Periphyton Composite – 1	Oct 18	May 2	Oct 5	Apr 26

Table 6. Physical and water quality measurements collected at invertebrate sampling sites in October 2013 and April/May 2014.

Parameters	Sampling Sites									Reference Sites			Gravel Augmentation Sites		
	1	1S	3	5S	7S	9	10	12	13	ME	DE	CR	G1	G2	G3
Fall 2013	10/16	10/16	10/16	10/17	10/17	10/17	10/17	10/18	10/18	10/14	10/15	10/15	10/16	10/16	10/16
Velocity (ft/s)	2.70	2.78	2.28	2.19	2.73	2.12	2.55	1.51	2.61	2.85	3.38	1.12	1.78	2.51	1.93
Depth (ft)	1.33	0.66	1.69	0.81	0.84	1.08	1.63	1.59	1.71	1.74	1.30	2.43	0.93	1.37	0.70
Boulder (%)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Cobble (%)	82.5	62.5	55.0	61.3	52.5	77.5	50.0	57.5	48.8	52.5	30.0	43.8	81.7	73.3	50.0
Gravel (%)	11.3	31.3	35.0	27.5	25.0	20.0	27.5	28.8	38.8	32.5	57.5	41.3	15.0	26.7	50.0
Sand (%)	6.3	6.3	10.0	11.3	22.5	2.5	22.5	8.8	12.5	15.0	12.5	15.0	3.3	0.0	0.0
Embeddedness (%)	17.5	11.3	20.0	25.0	26.3	18.8	55.0	42.5	27.5	21.3	16.3	40.0	3.3	1.7	1.7
Air Temperature (°C)	14.8	14.8	13.5	6.4	14.1	15.7	14.3	19	12.3	-	5.9	11.6	13.8	15.4	11.6
Water Temperature (°C)	11.5	11.5	11.8	10.7	11.3	12.3	11.9	11.7	11.7	7.3	8.8	12.5	12.2	12.3	11.8
Dissolved Oxygen (mg/L)	9.86	9.86	10.16	9.9	10.69	11.26	11.28	11.68	12.46	11.4	11.36	10.25	10.12	10.53	10.65
% Dissolved Oxygen	95.2	95.2	100.3	92.7	101.5	108.9	108.5	110.5	115.4	100.3	103.1	102.4	98.6	102.9	103.3
Specific Conductivity (µS/cm)	115.5	115.5	116.8	116.6	115.9	117.1	114	113.8	115	72	115	207.5	117.6	116.4	116.4
pH	7.91	7.91	7.93	7.96	8.16	8.4	8.36	8.36	8.44	6.86	7.72	8.29	8.19	8.35	8.4
Spring 2014	4/30	4/30	4/30	5/1	5/1	5/1	5/1	4/28	4/28	5/2	4/29	4/29	4/30	4/30	4/30
Velocity (ft/s)	3.12	2.53	1.82	1.83	3.07	1.92	2.88	2.10	3.28	2.89	2.95	1.38	1.63	2.29	2.05
Depth (ft)	1.36	0.70	1.60	0.73	0.90	1.18	1.25	1.90	1.61	2.08	1.15	0.80	1.07	1.47	0.87
Boulder (%)	0.0	3.8	0.0	0.0	0.0	2.5	0.0	0.0	0.0	0.0	0.0	2.5	0.0	0.0	0.0
Cobble (%)	75.0	35.0	37.5	47.5	40.0	75.0	30.0	53.8	58.8	26.3	10.0	75.0	73.3	40.0	50.0
Gravel (%)	20.0	47.5	40.0	27.5	31.3	20.0	40.0	31.3	31.3	36.3	50.0	8.8	11.7	43.3	36.7
Sand (%)	5.0	13.8	22.5	25.0	28.8	2.5	30.0	15.0	7.5	37.5	32.5	13.8	15.0	16.7	13.3
Embeddedness (%)	26.3	27.5	12.5	26.3	38.8	35.0	45.0	35.0	26.3	41.3	16.3	36.3	20.0	23.3	18.3
Air Temperature (°C)	12.7	12.7	23.4	12.6	28.4	24.3	22.4	18.9	22.9	21.2	12.3	18.3	27.8	21.6	18.1
Water Temperature (°C)	11.4	11.4	11.7	11.5	12.1	13.4	14.3	12.4	12.5	8.2	10.5	13.8	11.7	12.5	12.1
Dissolved Oxygen (mg/L)	12.51	12.51	13.11	12.34	12.55	12.38	11.72	11.35	11.55	11.42	11.06	10.34	13.31	13.23	13.07
% Dissolved Oxygen	118.8	118.8	127.1	118.5	123.7	124.4	120	109.5	111.3	103.9	104.9	107.8	127.3	129.7	129.1
Specific Conductivity (µS/cm)	121.6	121.6	130.4	119	124.7	117.4	109.1	111.3	110.6	69.2	113.1	190.1	124.6	127.3	125.2
pH	8.71	8.71	8.97	8.63	9.03	8.78	8.85	8.33	7.72	7.82	7.52	8.29	8.83	9.33	8.95

Table 7. Physical and water quality measurements collected at invertebrate sampling sites in October 2014 and April 2015.

Parameters	Sampling Sites									Reference Sites			Gravel Augmentation Sites		
	1	1S	3	5S	7S	9	10	12	13	ME	DE	CR	G1	G2	G3
Fall 2014	**10/6**	**10/6**	**10/6**	**10/7**	**10/7**	**10/7**	**10/7**	**10/5**	**10/5**	**10/9**	**10/8**	**10/8**	**10/6**	**10/6**	**10/6**
Velocity (ft/s)	3.24	2.70	2.96	3.00	2.79	2.16	3.58	1.66	2.83	2.72	3.25	1.46	1.49	1.97	1.89
Depth (ft)	1.28	0.68	1.35	0.79	0.79	1.38	1.31	1.43	1.33	1.68	1.38	0.70	0.80	1.33	0.82
Boulder (%)	5.0	0.0	0.0	6.25	0.0	27.5	0.0	7.5	0.0	0.0	0.0	25.0	0.0	0.0	0.0
Cobble (%)	52.5	45.0	47.5	57.5	60.0	65.0	47.5	57.5	57.5	55.0	30.0	47.5	66.7	63.3	76.7
Gravel (%)	32.5	45.0	32.5	13.75	12.5	6.25	26.25	15.0	30.0	17.5	30.0	25.0	16.7	21.7	11.7
Sand (%)	10.0	10.0	20.0	22.5	27.5	1.25	26.25	20.0	12.5	27.5	40.0	2.5	16.7	15.0	11.7
Embeddedness (%)	31.25	10.0	18.8	27.5	38.75	32.5	38.75	45.0	23.75	25.0	2.5	38.75	8.3	11.7	10.0
Air Temperature (°C)	16.4	16.4	21.6	–	–	–	–	34.4	30.9	17	14.8	21	20.9	23.4	22.3
Water Temperature (°C)	13.2	13.2	13.7	–	–	–	–	14.8	15.2	7.4	11.8	14.4	13.6	13.8	13.7
Dissolved Oxygen (mg/L)	9.2	9.2	9.9	–	–	–	–	10.8	11.7	11.9	10.7	10.2	9.83	10.29	9.95
% Dissolved Oxygen	86.5	86.5	94.5	–	–	–	–	105.2	114.9	105.5	105.6	107.7	93.5	98.1	95.1
Specific Conductivity (µS/cm)	123	123	124	–	–	–	–	124	124	66.9	111.1	192.6	123	123	124
pH	8.78	8.78	8.91	–	–	–	–	8.88	8.89	7.44	7.02	7.72	8.91	8.94	8.86
Spring 2015	**4/27**	**4/27**	**4/27**	**4/28**	**4/28**	**4/28**	**4/28**	**4/26**	**4/26**	**4/30**	**4/29**	**4/29**	**4/27**	**4/27**	**4/27**
Velocity (ft/s)	3.16	2.63	3.27	1.98	2.64	2.67	3.10	2.16	2.64	2.98	2.88	1.37	2.13	2.58	2.13
Depth (ft)	1.30	0.63	1.28	0.80	0.79	1.30	1.15	1.50	1.15	1.73	1.30	0.58	1.03	1.33	0.73
Boulder (%)	0.0	0.0	0.0	0.0	0.0	25.0	0.0	33.75	0.0	0.0	0.0	27.5	0.0	0.0	0.0
Cobble (%)	63.75	58.75	40.0	50.0	45.0	52.5	40.0	46.25	67.5	42.5	17.5	32.5	93.3	56.7	51.7
Gravel (%)	26.25	22.5	35.0	23.8	27.5	17.5	32.5	8.75	21.25	35.0	35.0	20.0	6.7	28.3	35.0
Sand (%)	10.0	18.75	25.0	26.3	27.5	5.0	27.5	11.25	11.25	22.5	42.5	20.0	0.0	15.0	16.7
Embeddedness (%)	23.75	12.5	8.75	37.5	28.75	31.25	32.5	30.0	10.0	36.25	22.5	25.0	0.0	3.3	6.7
Air Temperature (°C)	16.3	16.3	25.1	14.4	22.3	22.3	18.5	20.1	16.0	12.2	9.7	20.5	22.6	22.7	20.8
Water Temperature (°C)	11.0	11.0	11.7	11.0	11.9	13.1	14.0	12.4	13.0	6.4	11.5	14.0	11.4	12.0	12.0
Dissolved Oxygen (mg/L)	13.8	13.8	13.1	12.0	11.9	11.6	11.6	12.2	12.7	12.4	11.0	11.1	14.4	12.9	13.1
% Dissolved Oxygen	131.3	131.3	126.4	114.6	115.7	116.4	119.9	114.8	121.2	108.3	105.9	113.1	138.6	125.9	127.5
Specific Conductivity (µS/cm)	121	121	115	114	113	114	110	113	115	68	115	178	117	115	116
pH	9.58	9.58	9.67	9.51	9.47	9.48	9.42	9.22	9.21	8.54	8.64	9.02	9.64	9.67	9.62

" – " Malfunctioning water quality meter. No measurements recorded.

Benthic Macroinvertebrates

Macroinvertebrate sampling during the two-year post-SWW study revealed a highly productive benthic community in the lower Deschutes River. Full sample counts are available in Appendix II Tables 5-8. Metric summary results can be viewed in Appendix III Tables 5-8, and in Appendix IV Figures 1-8.

Density

For the post-SWW sampling, average densities at sites in the lower Deschutes River were generally higher during the fall periods compared to spring periods (Figure 6; Appendix III Tables 5-8; Appendix IV Figure 1). In fall 2013, densities ranged from 9,865 individuals/m^2 at Site 12 (Sandy Beach) to 36,072 individuals/m^2 at Site 10 (below Warm Springs River), with an overall average of 18,576 individuals/m^2. In fall 2014, densities were similar, ranging from 7,873 individuals/m^2 at Site 7s to 31,661 individuals/m^2 at Site 10, with an overall average of 16,867 individuals/m^2.

In contrast to fall densities, spring 2014 densities were generally lower, averaging 11,090 individuals/m^2 overall, and ranging from approximately 6,500 individuals/m^2 at Site 1 (downstream of the Reregulating Dam) and Site 10, to over 14,700 individuals/m^2 at Site 3 (Dizney Island) and Site 13 (Mack's Canyon) (Figure 6; Appendix III Tables 5-8; Appendix IV Figure 1). Densities in spring 2015 were comparable to the previous spring, with an overall average of 10,414 individuals/m^2, and a range of 7,106 individuals/m^2 at Site 5s (Lumber Mill Island) to 15,290 individuals/m^2 at Site 1S (shallow site downstream of the Reregulating Dam).

ANOVA was run on the four sites with replication (Sites 1S, 3, 7S, and 9). There was one extreme density observation at Site 3 in spring 2014, with more than 33,000 individuals/m^2. Because this value compromised the ANOVA assumptions, analysis was run both with and without this outlier. There were no consistent differences among sites for density ($p = 0.085$; $p = 0.078$ without outlier), but there was significant difference among sampling events ($p =0.033$; $p = 0.0042$ without outlier), with higher densities during fall sampling events compared to spring (season linear contrast $p=0.0093$; $p = 0.0006$ without outlier). Although the interaction between site and sampling event was only marginally significant with the outlier removed ($p = 0.29$; $p = 0.085$), we tested for site differences within each sampling event. The fall 2014 sampling event showed a significant difference among sites ($p = 0.003$), as well as a significant linear trend ($p=0.002$), with densities decreasing downstream.

Benthic macroinvertebrate densities were generally higher on lower Deschutes River sites in comparison to densities on two of the three the reference sites located upstream of Lake Bill Chinook. Overall, densities at Metolius River (ME) and Deschutes River (DE) reference sites ranged from 1,630 individuals/m^2 in spring 2014 to 6,671 individuals/m^2 in spring 2015 (Figure 6; Appendix III Tables 5-8; Appendix IV Figure 1). In contrast, densities at the Crooked River (CR) reference site were considerably higher, especially after the site was relocated to a more accessible location. In fall 2013, CR density was 6,621 individuals/m^2; this initial site placement was limited to pockets of substrates between large boulders in water depths exceeding 2 ft.

After the relocation of the site to an area with suitable substrates and depths, densities increased, ranging from 11,541 individuals/m^2 the following spring 2014, to 17,417 individuals/m^2 in fall 2014 (Figure 6; Appendix III Tables 5-8; Appendix IV Figure 1).

Taxa Richness

Total taxa richness measures for lower Deschutes River sites during the two-year study were similar between years and between the two seasons (Figure 7; Appendix III Tables 5-8; Appendix IV Figure 2). Throughout the two-year study, Site 1 recorded the lowest total taxa richness, ranging from 24-28 taxa, and Site 9 (above Warm Springs River) had the highest, ranging from 42-47 taxa (Figure 7; Appendix IV Figure 2). Taxa richness at the reference sites showed numbers of taxa similar to those on the lower Deschutes River, with the ME reference site displaying the highest number of taxa (38-41 taxa), and the CR reference site showing the lowest (23-32 taxa).

As seen in baseline study results, the macroinvertebrate community displayed apparent longitudinal patterns of variation. Taxa richness during both seasons showed lower numbers of taxa immediately downstream from the Project (Sites 1 and 1S), with a gradual increase in taxa numbers downstream to Site 9 (Figure 7; Appendix IV Figure 2). Taxa richness decreased slightly at Sites 10 and 12, with an increase again at Site 13 in fall sampling, but not during spring sampling (Figure 7, Appendix III Tables 5-8; Appendix IV Figure 2). For the upstream reference sites, the ME reference site was generally higher than the DE and CR sites for all visits, with the exception of fall 2014, when the DE site exceeded ME total taxa richness by 1 taxa (39 vs. 38).

Statistical analysis of the four sites with replication (Sites 1S, 3, 7S, and 9) confirmed significant differences in taxa richness among sites ($p<0.00001$), as well as a significant linear trend ($p=0.00001$), with the number of taxa increasing from upstream to downstream. Statistical analysis showed no overall difference in taxa richness values among sampling events ($p=0.098$). The results were similar for EPT taxa richness (Appendix IV Figure 3), with significant differences in EPT richness among sites ($p<0.00001$), and a significant linear trend ($p<0.00001$), with the number of taxa increasing from upstream to downstream. Statistical analysis also showed an overall difference in taxa richness values among sampling events ($p = 0.009$), and seasons ($p = 0.002$), with significantly higher EPT richness during spring.

Community Composition

Community compositions in the lower Deschutes River during the two-year post-SWW study showed substantial contributions of non-insect taxa in both the fall and spring collections; non-insect taxa consisted primarily oligochaete worms, flatworms, and snails (Figures 8 and 9). Species composition immediately downstream from the Project was also distinctly different from areas farther downstream (Figures 8 and 9). Non-insect taxa dominated the benthic community immediately downstream of the Project (70-80% in the fall, 60% in the spring). This pattern was prevalent for sites within 1.0 mile of the Re-regulation Dam (Sites 1, 1S, and 3); also of note was an increase of 20-42% Other Diptera at these sites in the spring 2015 collection, especially at Site 3, which proved to be Simuliidae (blackflies) larvae.

Seasonal differences in the lower Deschutes River included increased contributions of caddisfly larvae (Trichoptera) in the fall community as compared to the spring community. The spring community showed higher contributions of dipteran larvae (chironomids and simuliids) and mayflies (Ephemeroptera) nymphs, and lower contributions of non-insect taxa compared to the fall community.

Statistical analysis of the four sites with replication (Sites 1S, 3, 7S, and 9) confirmed significant differences in the distribution and seasonality of several major taxonomic groups. The relative abundance of non-insect taxa was significantly different among sites ($p<0.00001$), with a significant linear trend ($p=0.0007$), with the contribution of non-insects decreasing in a downstream direction. Statistical analysis showed an overall difference in the relative abundance of non-insect taxa values among sampling events ($p=0.0002$), and seasons ($p=0.0001$), with significantly higher contributions during fall sampling periods.

For the relative abundance of mayflies, statistical analysis of the four sites with replication showed significant interaction between sites and events ($p=0.004$), indicating that results were not consistent among sampling events. Tests for each event showed differences among sites ($p<0.005$) and significant linear trends ($p<0.0005$) for all events except fall 2013, with the mayfly contribution increasing downstream. Seasonal differences also varied longitudinally – with higher mayfly contribution at Sites 9 ($p=0.001$) and 7S ($p=0.02$) in the spring, but no significant differences among seasons at Sites 1S ($p=0.58$) and 3 ($p=0.08$).

Data on taxonomic groups was transformed to approximate normality by using the arcsin of the square-root of the relative abundance value. The relative abundance of caddisflies showed significant difference among sites ($p<0.0001$) and a significant linear trend ($p=0.00002$), with the caddisfly contribution increasing downstream, but no difference among events ($p=0.17$). Statistical analysis showed differences among sites in the relative abundance of chironomids, but no consistent downstream, trend was apparent. There was a significant difference in the relative abundance of chironomids among sampling events ($p<0.0001$), and seasons ($p<0.0001$), with significantly higher chironomid contributions during spring.

For the upstream reference sites, the ME reference site was comprised of 40-60% EPT taxa during both seasons, with the remainder of the community being chironomids and other dipterans, and a small amount of non-insect taxa, primarily nematodes and oligochaete worms. In contrast, the CR reference site was dominated by non-insect taxa (48-83%), higher in the spring, with smaller contributions of mayflies, caddisflies, and chironomids. Community compositions at the DE reference site consisted of 30-47% EPT taxa, 29-49% non-insect taxa, and the remainder a combination of Elmidae (riffle beetles), chironomids, and other dipterans (Figures 8 and 9, Appendix III Tables 5-8).

A principal components analysis (PCA) was run with the mean densities of the 35 most abundant taxa (Table 8) identified in the post-SWW study (representing approximately 96.4% of the total estimated density of samples collected during the study), resulting in an ordination plot with 48 cases representing each site/sampling date. The PCA biplot (Figure 10) confirms spatial relationships previously shown in the simple plots, accounting for 44.7% of the variation in the data set. The biplot shows a separation of the upper reference sites CR, DE, and ME to the left of Axis 1 away from the other sites based on an increased abundance of Tanypodinae midges, and a benthic community assemblage distinctly different than the major taxa influencing Lower Deschutes river sites. Sites located immediately downstream from the Project (Sites 1, 1S, and 3) were grouped together to the right of Axis 1, and were also distinctly different from areas farther downstream, which were grouped together at the lower side of Axis 2 (Figure 10). Case scores for sites 1, 1S, and 3 appear to be influenced by higher abundances of non-insect taxa, such as Planaridae (PLAN), Physidae (PHYS), Juga (JUGA), and *Manayunkia speciosa* (MASP). Sites downstream of Shitike Creek grouped together based on influences from a number of mayfly (*Ephemerella* spp., *Epeorus*, *Rhithrogena*, *Acentrella*) stonefly (*Hesperoperla*, *Pteronarcys*), and caddisfly taxa (*Hydropsyche, Cheumatopsyche, Protopila, Glossosoma*), as well as several riffle beetle taxa (*Optioservus, Zaitzevia*). Each grouping is also roughly divided by season, with spring samples to the left and fall samples to the right (Figure 10).

Further reducing the taxa list to the top 15 taxa resulted in a PCA biplot accounting for 53.4% of the variation in the data set, while still representing approximately 78.7% of the total estimated density of samples collected post-SWW. The biplot still shows distinct separations of the upper reference sites, sites immediately below the Project, and sites downstream of Shitike Creek, but with the more influential taxa featured (Figure 11).

Table 8. Species codes used for 35 most abundant taxa for the post-SWW study sampling, used in PCA ordination plots (Figures 10 and 11). Taxa are listed in order of abundance, top to bottom, left to right.

Species Codes for Top 35 Macroinvertebrate Taxa					
HYPS	*Hydropsyche*	***OPTI***	*Optioservus*	**EPEO**	*Epeorus*
NAID	Naididae	***ACARI***	Hydracarina	**HEPA**	*Hesperoperla pacifica*
VORT	*Vorticifex*	***LUMBR***	Lumbriculidae	***PTCA***	*Pteronarcys californica*
ORTHO	Orthocladiinae	**CHEU**	*Cheumatopsyche*	***ZAIT***	*Zaitzevia*
FLUM	*Fluminicola*	***MASP***	*Manayunkia speciosa*	***ACIN***	*Acentrella insignificans*
PLAN	Planariidae	***OLIGO***	Oligochaeta	***HEME***	*Hemerodromia*
LUMB	Lumbricidae	***HAPLO***	*Haplotaxis*	***PHYS***	*Physa/Physella*
BATR	*Baetis tricaudatus*	***NEMA***	Nematoda	**HYPT**	*Hydroptila*
EPLL	*Ephemerella*	***RHITH***	*Rhithrogena*	**TANY**	Tanytarsini
GLOS	*Glossosoma*	***PROTO***	*Protoptila*	**PETRO**	*Petrophila*
SIMU	*Simulium*	***GAMM***	*Gammarus*	**BABI**	*Baetis bicaudatus*
AMIO	*Amiocentrus*	***JUGA***	*Juga newberryi*		

Functional Feeding Groups

Corresponding functional feeding group compositions in the lower Deschutes River during the two-year post-SWW study show the fall collections were generally higher in Scrapers/Grazers (mostly snails) and filter feeding taxa (largely hydropsychid caddis larvae and blackfly larvae), whereas in the spring period, collector-gatherer taxa comprised a majority of the community (Figures 12 and 13).

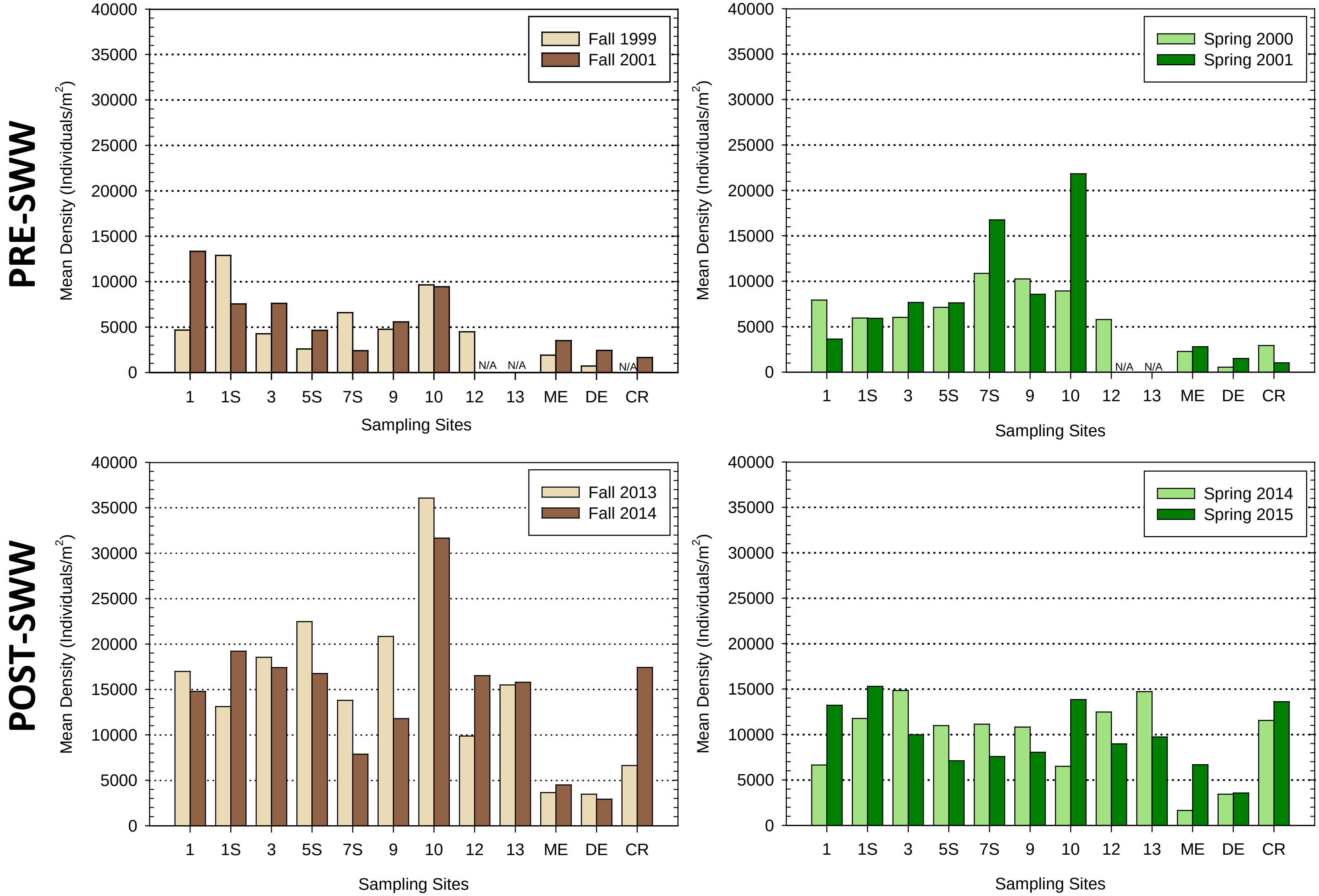


Figure 6. **Benthic invertebrate densities in the lower Deschutes River downstream from the re-regulation dam and three reference sites.**

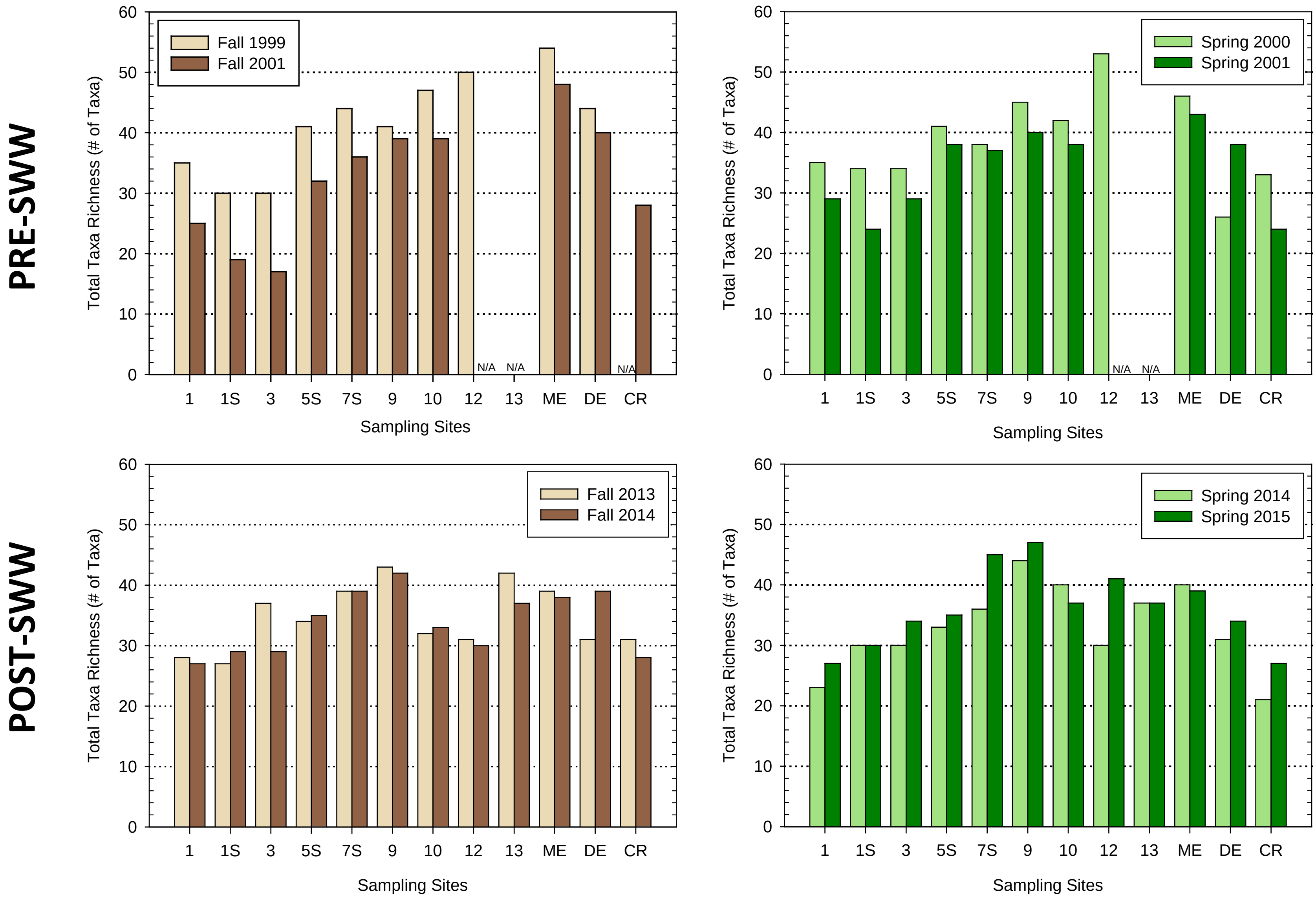


Figure 7. **Benthic macroinvertebrate total taxa richness in the lower Deschutes River downstream from the re-regulation dam and three reference sites.**

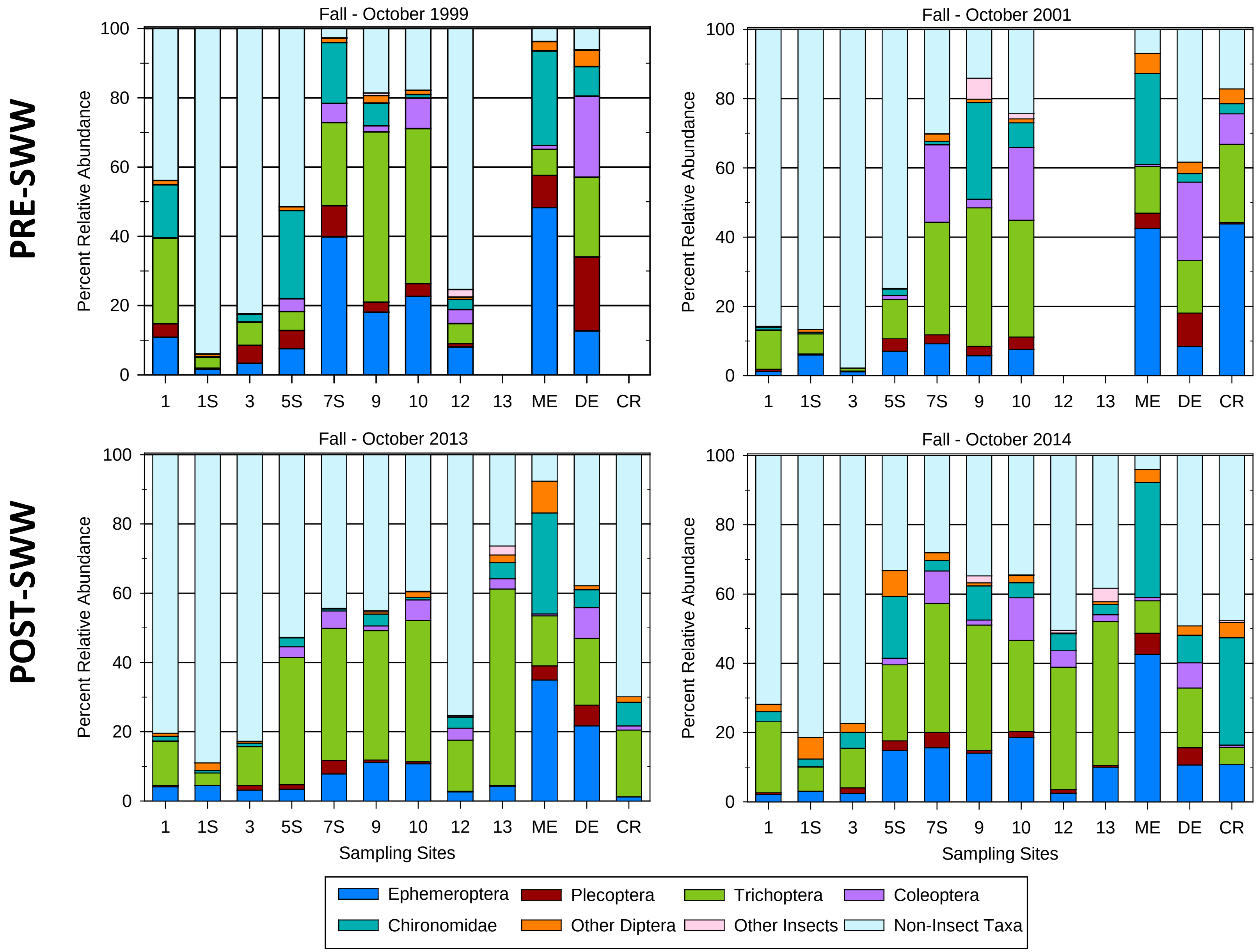


Figure 8. Benthic macroinvertebrate community composition for fall periods in the lower Deschutes River downstream from the re-regulation dam and three reference sites.

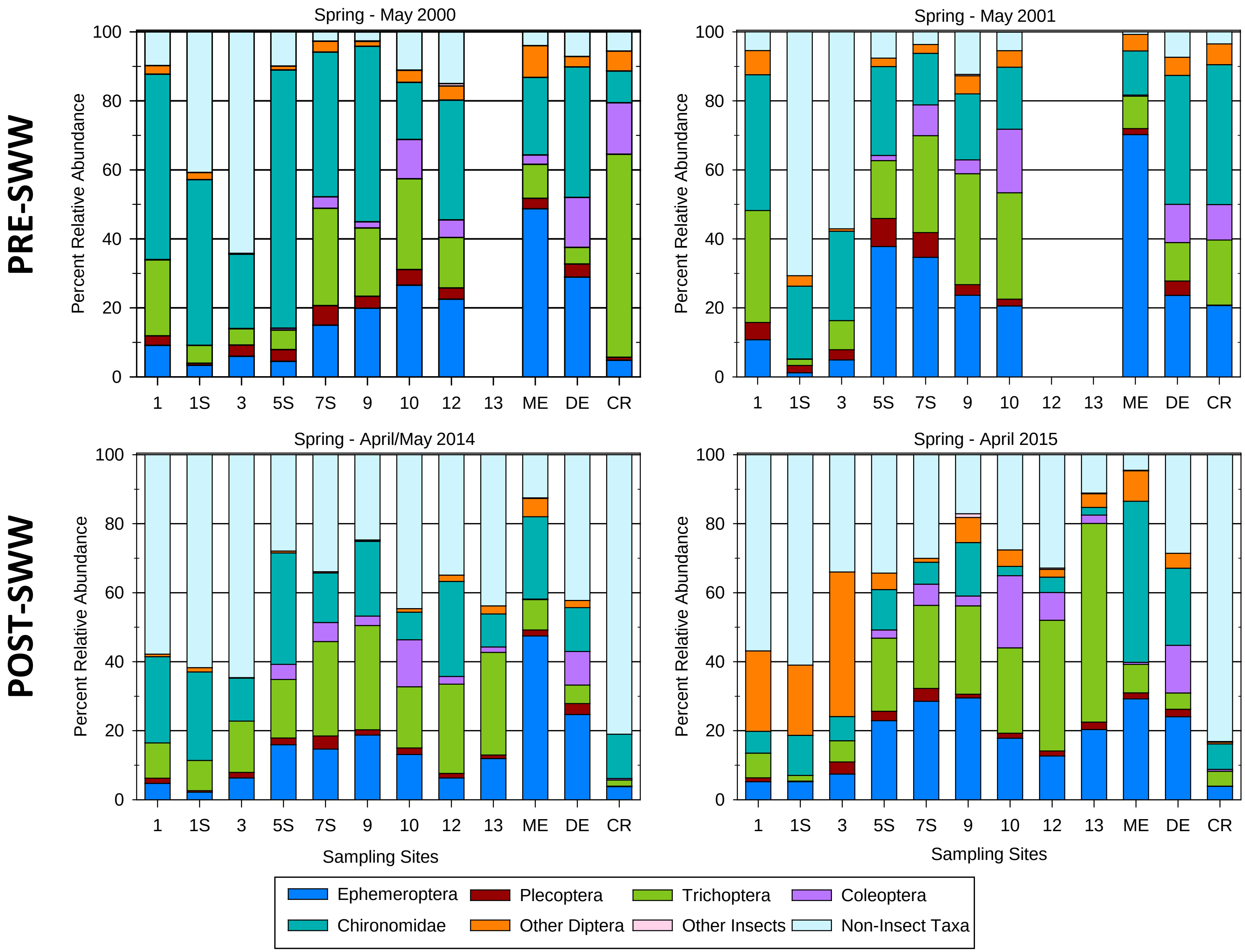


Figure 9. Benthic macroinvertebrate community composition for spring periods in the lower Deschutes River downstream from the re-regulation dam and three reference sites.

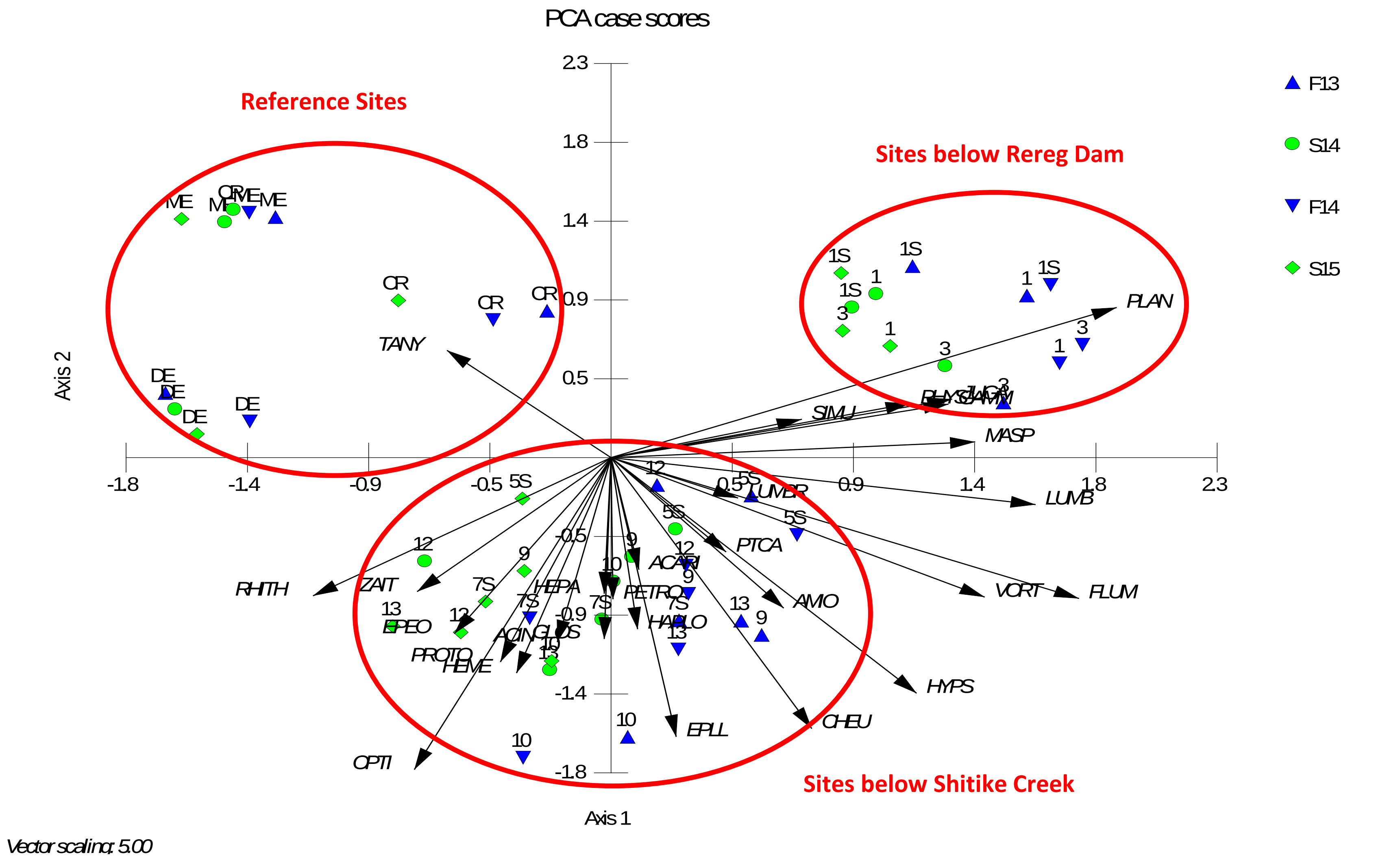


Figure 10. **Principal Components Analysis (PCA) plotting the 48 cases of each site/sampling date along gradients of mean abundances of the top 35 macroinvertebrate taxa collected in the 2-year study (Taxonomic codes are defined in Table 8). Note that longer arrows represent stronger gradients, and short arrows represent weaker gradients.**

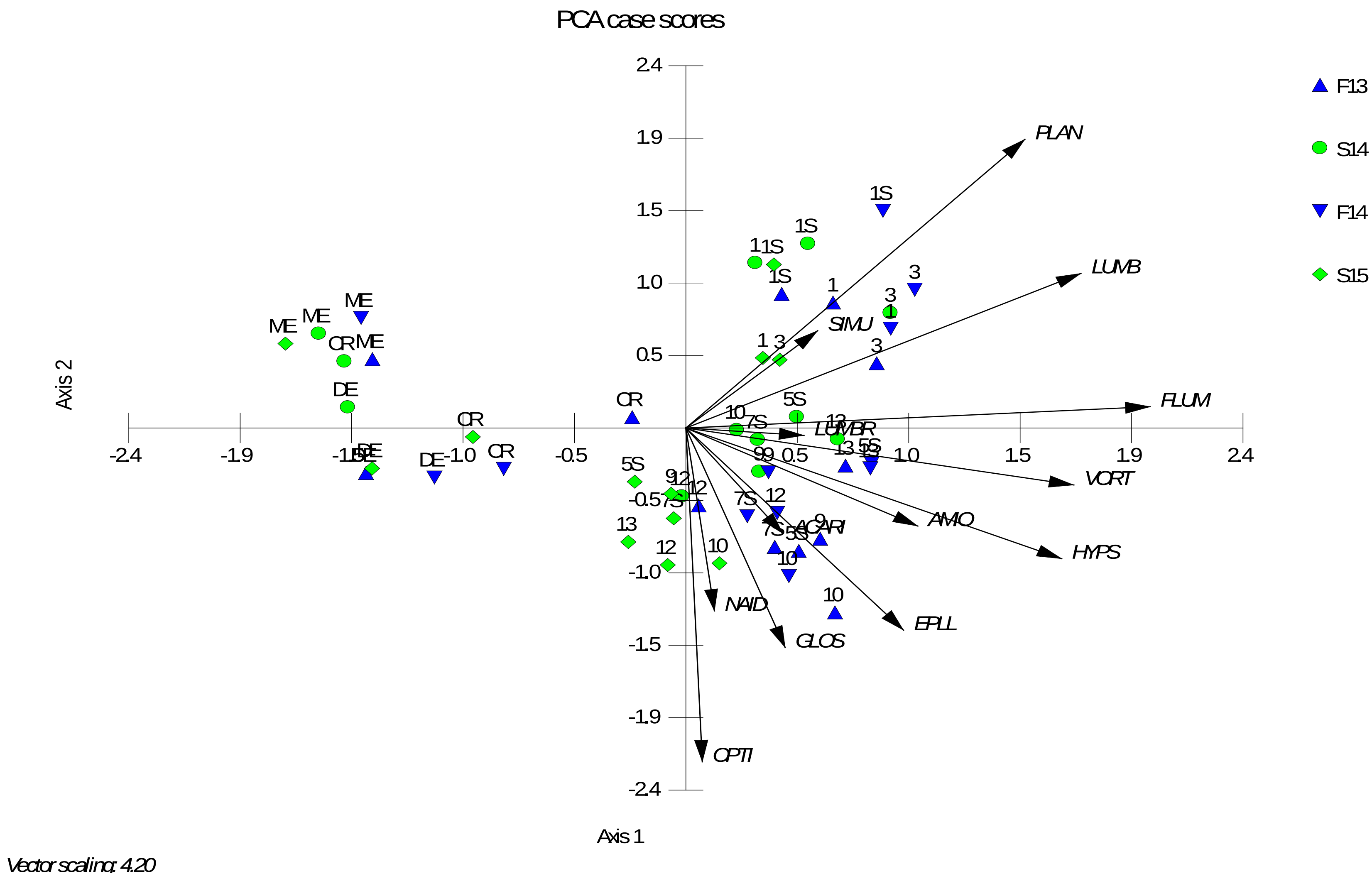


Figure 11. Principal Components Analysis (PCA) plotting the 48 cases of each site/sampling date along gradients of mean abundances of the top 15 macroinvertebrate taxa collected in the 2-year study (Taxonomic codes are defined in Table 8). Note that longer arrows represent stronger gradients, and short arrows represent weaker gradients.

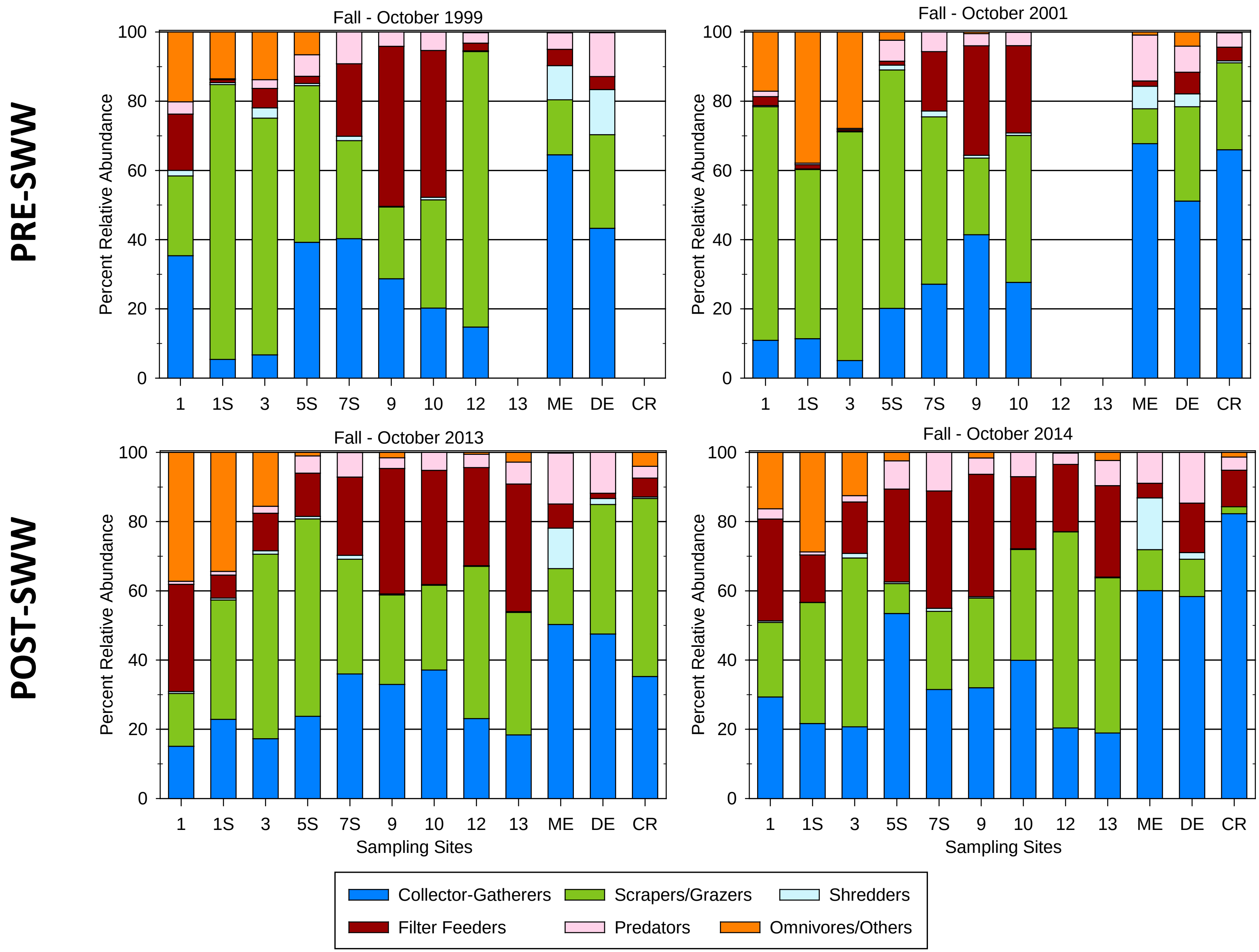


Figure 12. Benthic macroinvertebrate functional feeding groups for fall periods in the lower Deschutes River downstream from the re-regulation dam and three reference sites.

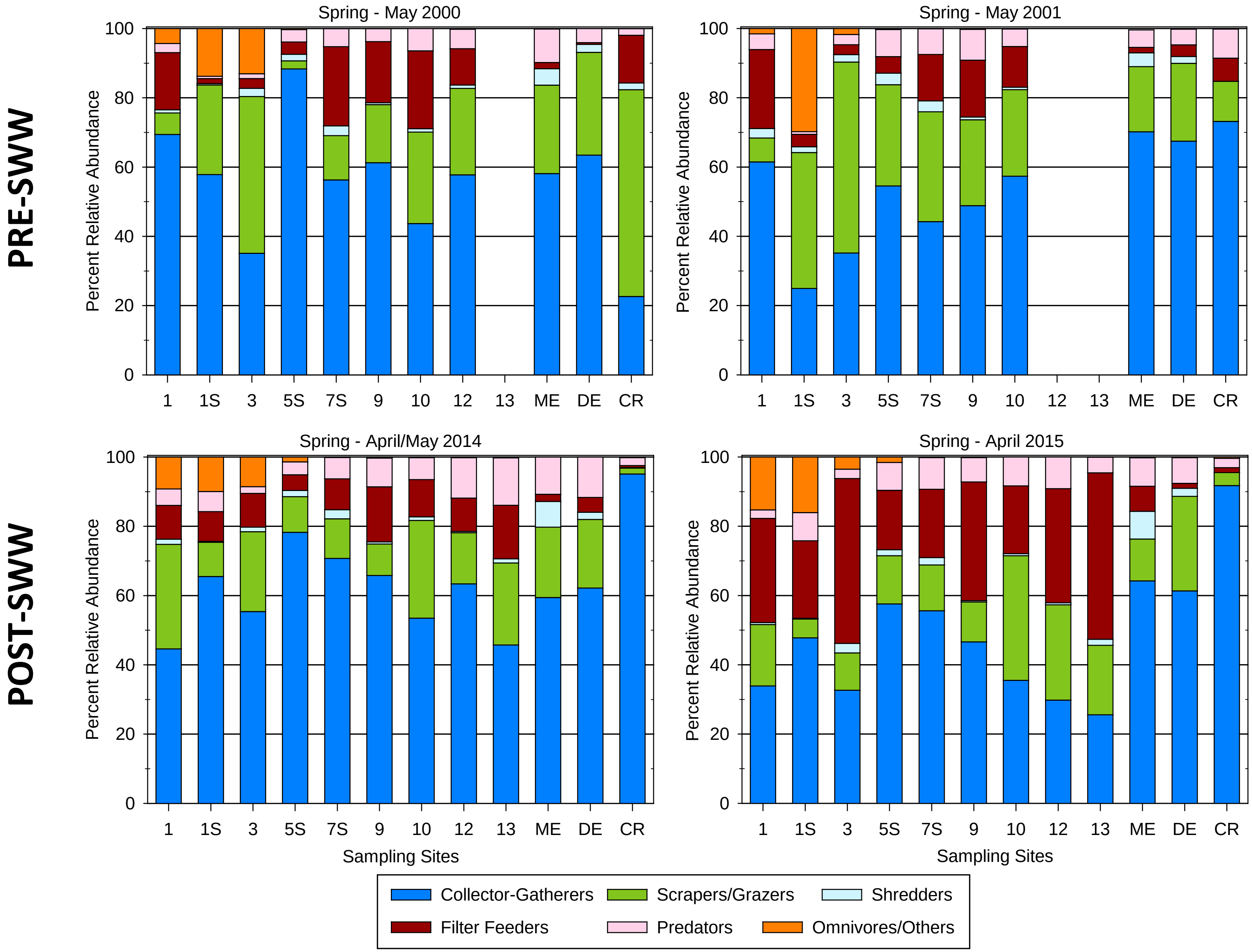


Figure 13. Benthic macroinvertebrate functional feeding groups for spring periods in the lower Deschutes River downstream from the re-regulation dam and three reference sites.

Pre-SWW vs. Post-SWW Comparisons

All sample-count and metric summary data for pre-SWW and post-SWW collections can be viewed in Appendix II and Appendix III. In addition, figures of macroinvertebrate metrics for pre-SWW and post-SWW collections, along with additional graphs of "taxa of interest," are included in Appendix IV Figures 9-23.

Statistical analysis of metric results were nonparametric paired t-tests, that compared average metric results of pre-SWW to post-SWW by season (fall and spring). Metric results from the post-SWW study (2013-2015) were compared to baseline study results from 1999-2001 looking primarily at Sites 1 through 10, which were consistently sampled in both studies. Statistical results are included in Table 9.

Density

For density, Sites 1-10 in the lower Deschutes River during the post-SWW fall collection efforts showed an overall average of 18,664 individuals/m^2 compared with an overall average of 6,846 individuals/m^2 from fall 1999 and 2001 (Figure 6), a difference that is statistically significant ($p=0.023$; Table 9) for fall density. For the spring periods, average density was 10,548 individuals/m^2 in spring 2014 and 2015, and an overall average of 9,212 individuals/m^2 in spring 2000 and 2001, a difference that is not significant. Plots of recorded densities from both studies in Figure 6 confirms that larger changes in density have taken place in the fall, and suggest a slight longitudinal shift in spring densities, with increases at sites immediately below the Project, and decreases at sites further downstream.

Differences in fall densities can be partially attributed to the increased abundances of non-insect taxa (Figures 8 and 9), specifically oligochaete worms, flatworms, and gastropods captured in benthic sampling. Oligochaete (round worm) numbers appeared to be much more abundant in post-SWW than pre-SWW samples (Figure 14). Oligochaete numbers increased at all lower Deschutes River sites. For Sites 1-10, the average increase in oligochaete density was 2,874 individuals/m^2 in fall collections (an increase of 12.7% in community composition), and 2,153 individuals/m^2 during spring collections (19.3% increase in community composition). Results in Table 9 indicate that both of these increases are significant ($p=0.022$).

Although sample sizes were not adequate to test changes in the upper reference sites, observations show that Crooked River and upper Deschutes sites both saw increases in Oligochaeta (especially at the CR site), but not the Metolius site. Because of the widespread nature of this change, we are lead to believe that the difference could be that sample preservation methods in the baseline study were not effective for these soft-bodied organisms. Lower concentrations of ethanol or alcohol do not preserve oligochaete worms effectively, leading to decay, and thus rendering enumeration and identifications difficult to impossible. The alternative, of course, is that stream conditions in the Crooked and Deschutes rivers above the Project and in the lower Deschutes River all changed significantly enough to favor a widespread increase in oligochaete densities.

Table 9. Results of statistical comparisons (paired t-test) between Pre- and Post-SWW averages of selected metrics and taxa of interest for spring and fall sampling collections for 7 sites below the Project (Sites 1, 1S, 3, 5S, 7S, 9, and 10).

	Fall				Spring			
Metrics	**Pre-SWW**	**Post-SWW**	**Difference (Pre-Post)**	**p-value**	**Pre-SWW**	**Post-SWW**	**Difference (Pre-Post)**	**p-value**
Density	6,845.7	18,664.3	-11,818.6	**0.023**	9,212.3	10,548.3	-1,336	0.44
Percent Tolerant Taxa	57.9	35.3	22.6	**0.016**	26.9	17.3	9.6	0.08
Percent Sediment Tolerant Taxa	30.6	13.4	17.2	**0.030**	11.9	4.3	7.6	**0.046**
Modified HBI	4.64	4.87	-0.23	0.220	4.14	4.76	-0.62	**0.022**
ODEQ Multimetric Index	26.3	26.7	-0.4	0.670	32.1	30	2.1	0.2
Community Composition								
Percent Mayflies	10.1	8.2	1.9	0.813	15.6	8.5	7.1	0.300
Percent Stoneflies	3.1	1.5	1.7	**0.016**	3.9	1.9	2.0	**0.016**
Percent Caddisflies	21.0	24.4	-3.4	0.578	18.8	16.9	1.8	0.938
Percent Chironomids	7.7	4.0	3.7	0.109	33.7	14.3	19.4	**0.016**
Percent Other Diptera	1.0	2.1	-1.2	0.156	2.8	7.7	-4.9	0.297
Percent Coleoptera	4.8	2.9	1.9	0.578	3.6	4.2	-0.6	0.938
Percent Non-Insects	51.7	56.8	-5.1	0.469	21.7	41.2	-19.5	**0.047**
Functional Feeding Groups								
Percent Collector-Gatherers	22.8	29.5	-6.7	0.156	52.8	53.1	-0.4	0.813
Percent Collector-Filterers	15.3	23.4	-8.1	0.078	11.6	18.5	-6.9	0.156
Percent Scrapers	47.2	31.3	15.9	**0.031**	24.8	16.5	8.3	0.297
Percent Shredders	0.9	0.6	0.4	**0.016**	1.8	1.3	0.5	**0.016**
Percent Predators	3.8	4.4	-0.6	0.156	4.4	5.9	-1.6	**0.016**
Percent Omnivores	10.0	10.8	-0.8	0.813	4.6	4.7	-0.1	0.688
Taxa of Interest								
Oligochaetes	201.6	3,076.0	-2,874.40	**0.022**	207.2	2,360.9	-2,153.7	**0.022**
Planaridae (flatworms)	669.7	1,508.4	-838.70	0.078	260.4	549.9	-289.5	**0.027**
Gastropoda	2,930.4	4,467.0	-1,536.60	0.156	904.2	981.4	-77.3	0.688
Stoneflies	178.8	238.8	-60.01	0.297	365.3	186.4	179.0	0.078
Pteronarcys	41.2	84.3	-43.06	**0.047**	148.4	114.8	33.7	0.297
Hesperoperla	104.8	137.0	-32.22	0.469	129.3	61.6	67.7	**0.047**
Hydropsychidae	993.9	3,552.9	-2,558.93	**0.022**	1,093.0	958.1	134.9	0.938
Baetis tricaudatus	197.3	564.0	-366.75	**0.025**	265.8	400.1	-134.3	0.078
Ephemerella spp.	32.4	744.3	-711.92	**0.027**	811.6	488.8	322.8	0.219
Drunella spp.	17.7	22.4	-4.68	0.813	137.4	95.2	42.2	0.219
Rhithrogena	159.6	95.1	64.50	0.219	33.9	14.2	19.7	0.150
Epeorus spp.	4.5	61.8	-57.31	**0.047**	65.2	127.4	-62.3	0.937

Flatworm (Planaridae) densities were approximately twice as large in the 2013-2015 samples as in the 1990-2001 samples (Figure 15). In all years, numbers were much higher in fall than spring but increased in both seasons. Statistical comparisons in Table 9 indicate that flatworm densities increased significantly after SWW only for spring sampling (p=0.027). Observations show that this increase occurred at the three sites within 1 mile of the Reregulating Dam (sites 1, 1S, and 3). Flatworm numbers were very low at sites farther downstream and did not substantially increase from the pre-SWW baseline. Flatworms were more numerous in the new sampling site at Mack's Canyon (site 13) than in other downstream sites but Mack's Canyon has no past data from the baseline study for comparison. It should also be noted that substantial differences in flatworm numbers were also observed between sample years in the pre-SWW baseline.

Snails (Gastropoda), like flatworms, were generally most common within the first few miles downstream of the Reregulating Dam with abundance decreasing downstream from Site 5S (Figure 16). Snails were present but not abundant in sample sites upstream from the reservoir. Numbers of snails generally increased in fall samples, with the largest increases in the lowermost sites (Sites 10 and 12). For instance, gastropod densities increased an average of 2,400 individuals/m^2 in fall collections at Sites 5S, 7S, 9, and 10 from baseline study levels in 1999 and 2001, however this increase was not significant (p=0.156; Table 9). In the spring collections, gastropod densities are generally similar among pre- and post-SWW collections, with an average increase of only 186 individuals/m^2 (Figure 16); there was no significant difference between pre- and post SWW spring gastropod densities (p=0.688, Table 9).

Taxa Richness

Taxa richness results between the various years of sampling are dependent upon how the samples were collected and the level of effort taken to subsample each sample; the more individuals that are counted and identified in the sample, the closer to the true estimate of taxa richness.

During the first year of the baseline study, samples were not subsampled. As a result, pooling the replicate sample results together accounts for every invertebrate in the combined sample, typically in excess of 3,000 individuals. In contrast, a subsample of 300 individuals from each replicate sample, as was done for the second year of the baseline study, yields an average of 1200 individuals from a combined composite sample. Collecting a sample composited in the field, and subjected to a 500-count subsample, accounts for considerably less of the sample total than the previous two methods. As a result, total taxa richness results for fall 1999 and spring 2000 are noticeably higher than taxa richness estimates for all other years, pre- and post-SWW. To make reasonable comparision among the different sampling methods, subsample counts would require significant reconstruction starting with the raw count results to be able to randomly select a new simulated 500 individual count for each sample.

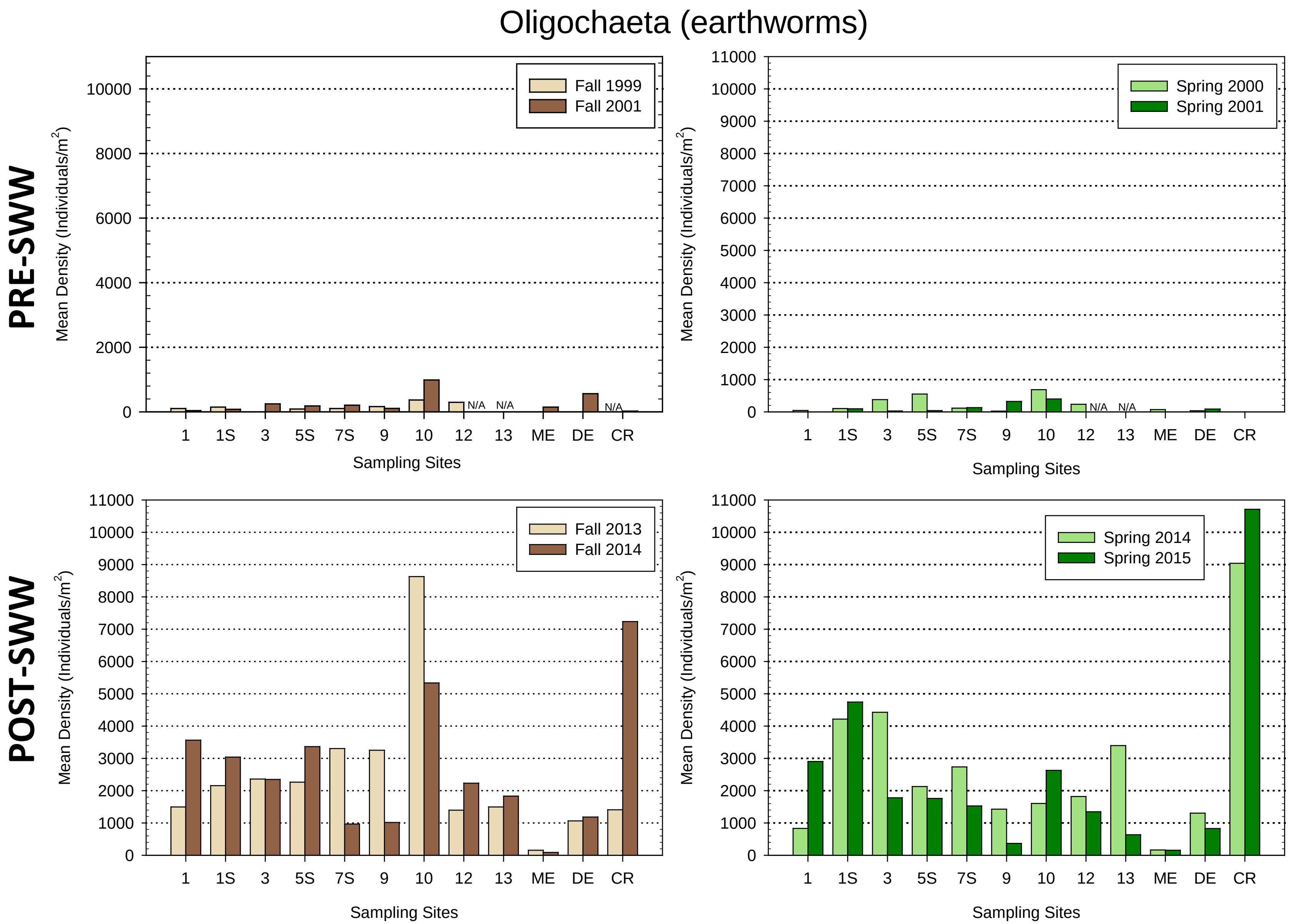


Figure 14. Oligochaete worm densities in the lower Deschutes River downstream from the re-regulation dam and three upstream reference sites.

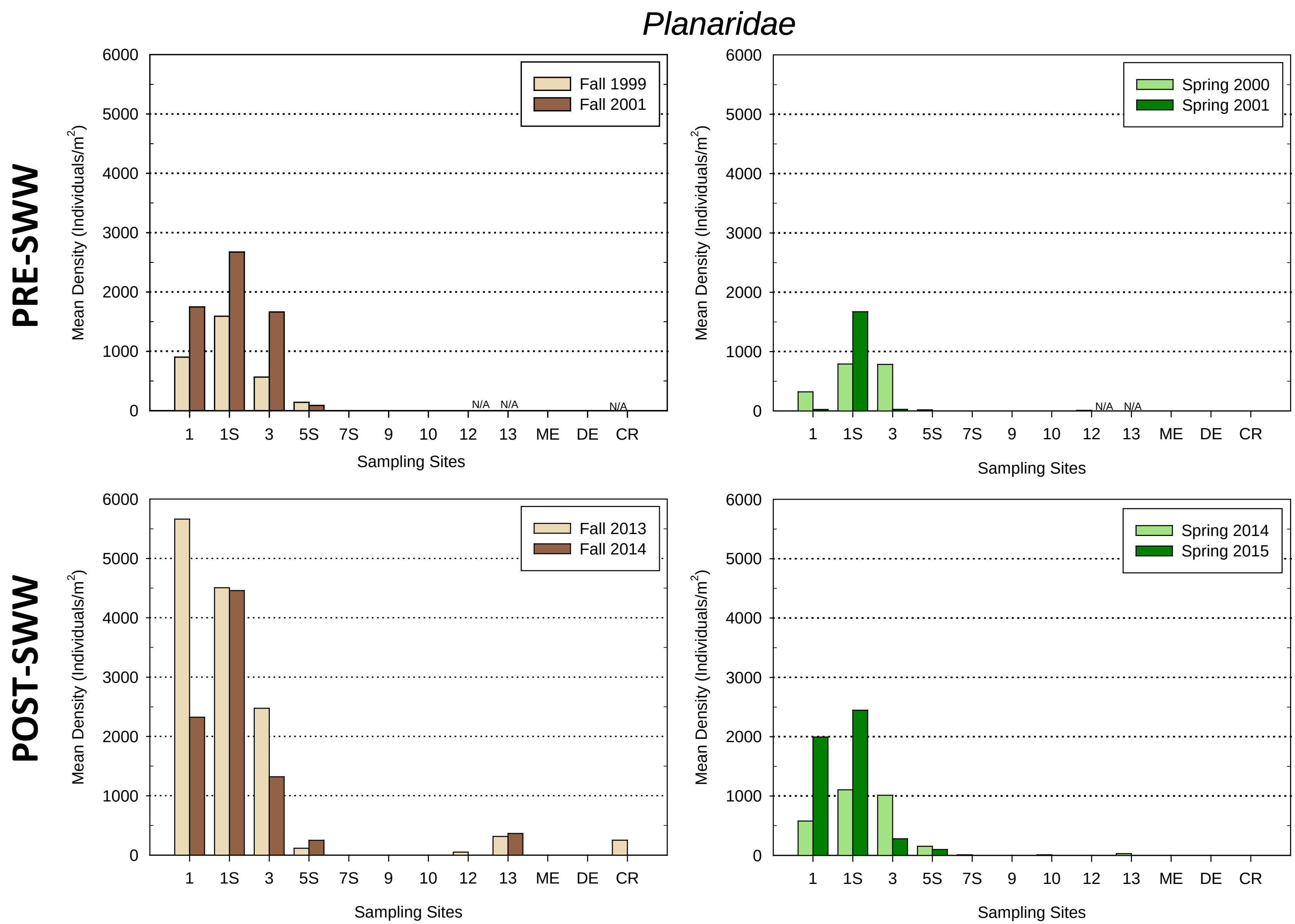


Figure 15. Planaridae flatworm densities in the lower Deschutes River downstream from the re-regulation dam and three upstream reference sites.

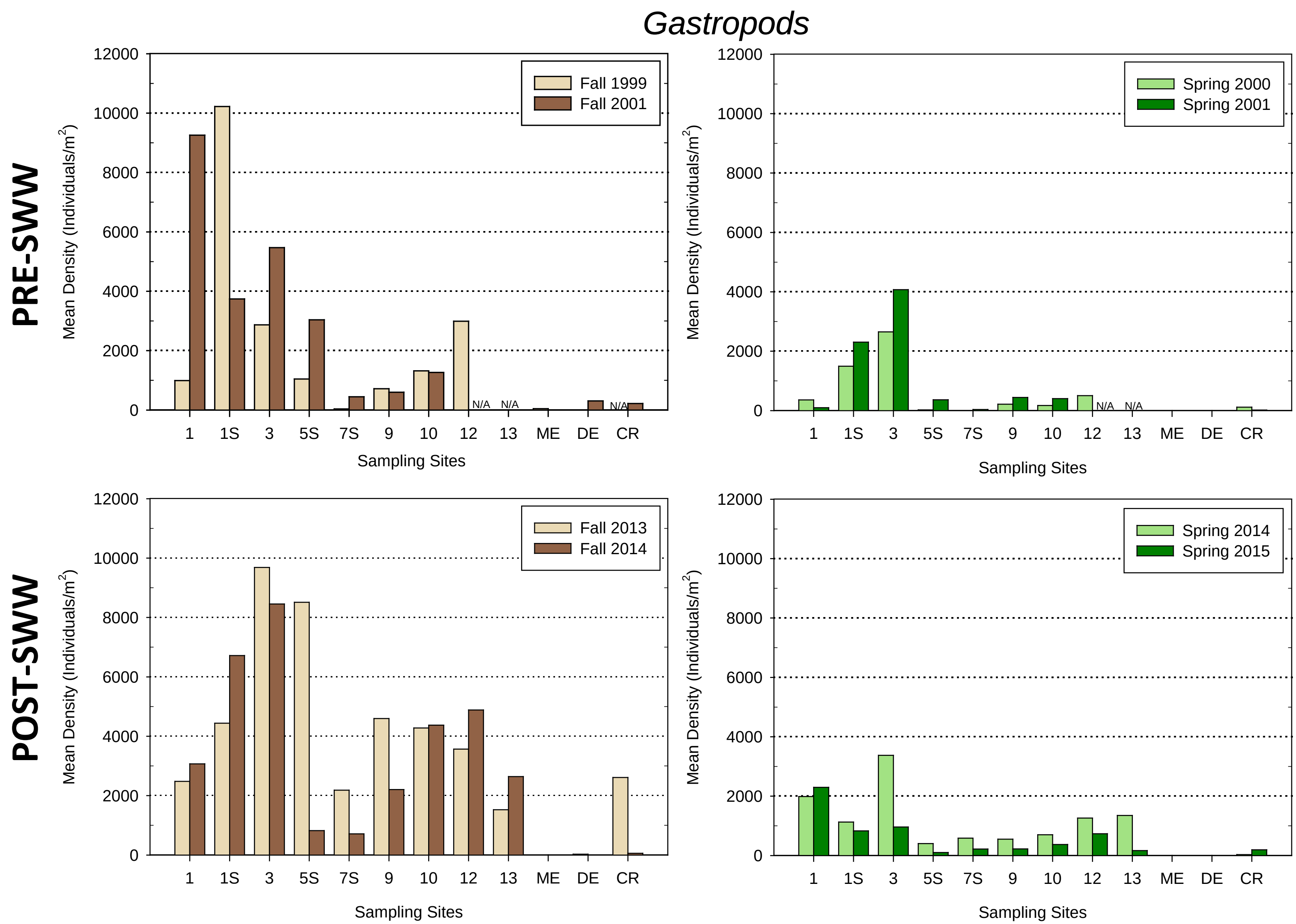


Figure 16. **Gastropod (snails and limpets) densities in the lower Deschutes River downstream from the re-regulation dam and three upstream reference sites.**

However, looking at the trends, the baseline study results for taxa richness consistently indicated lower numbers of taxa at Sites 1, 1S, and 3, within the first mile downstream of the Project, and then relatively similar taxa richness further downstream (Figure 7). Post-SWW sampling efforts in 2013-2015 similarly suggest lower taxa richness immediately below the Project (Sites 1 and 1S), but also showed a gradual increase in the number of taxa continuing downstream to Site 9. During the post-SWW fall collections, taxa richness decreased at Sites 10 and 12, but Site 13 showed a total taxa richness similar to that seen at Sites 7S and 9. In the spring, total taxa richness was similar at Sites 10, 12, and 13 (Figure 7). Total taxa richness at the upper reference sites showed similar trends between pre-SWW and post-SWW collections.

Tolerance Measures and Indices

A series of paired t-tests were conducted on a selection of tolerance metrics involving relative abundances (%) and indices of ecosystem health. Average metric results of pre-SWW to post-SWW by season (fall and spring) were compared using average results from Sites 1 through 10 (n=7), which were consistently sampled in both studies.

For the relative abundance of Tolerant Taxa, Sites 1-10 in the lower Deschutes River during the post-SWW fall collection showed an overall average of 35.3% compared with an overall average of 57.9% from fall 1999 and 2001 (Table 9; Appendix IV Figure 12), a drop of 22.6% that is statistically significant (p=0.016). For the spring periods, Percent Tolerant Taxa was 17.3% in spring 2014 and 2015, and an overall average of 26.9% in spring 2000 and 2001, a decrease of 9.6% that is marginal (p=0.08) in significance. Plots of recorded Percent Tolerant Taxa results from both studies confirm that the relative abundance of Tolerant Taxa has been reduced in post-SWW study years (Appendix IV Figure 12).

For the relative abundance of Sediment Tolerant Taxa, Sites 1-10 in the lower Deschutes River during the post-SWW fall collection showed an overall average of 13.4% compared with an overall average of 30.6% from fall 1999 and 2001 (Table 9; Appendix IV Figure 13), a drop of 17.2% that is statistically significant (p=0.030). For the spring periods, Percent Sediment Tolerant Taxa was 4.3% in spring 2014 and 2015, and an overall average of 11.9% in spring 2000 and 2001, a decrease of 7.6% that is also significant (p=0.046). Plots of recorded Percent Sediment Tolerant Taxa results from both studies confirm that the relative abundance of Sediment Tolerant Taxa has been reduced in post-SWW study years (Appendix IV Figure 13).

Indices tested include the Modified HBI and ODEQ's multimetric index (Appendix IV Figures 10-11). The Modified HBI did not differ significantly between pre- and post-SWW in the fall collection (a 0.23 point increase in post-SWW samples; p=0.22). However, for the spring periods, the Modified HBI overall average increased from 4.14 in spring 2000 and 2001 to 4.76 in spring 2014 and 2015, an increase of 0.62 that was significant (p=0.022). For the ODEQ multimetric index, scores for both seasons were not significantly different between pre- and post-SWW studies (p>0.20).

Community Composition/Functional Feeding Groups

For the relative abundance of major taxa at Sites 1-10 in the lower Deschutes River, there were no significant differences detected between pre- and post-SWW sampling in either season for percent mayflies, caddisflies, other dipterans, or Coleoptera taxa groups. For Percent Stoneflies, both post-SWW fall and spring collection efforts showed a significant (p=0.016) overall decrease of 1.7-2% compared with pre-SWW percentages (Table 9). For the spring periods, Percent Chironomids was 14.3% in spring 2014 and 2015, and an overall average of 33.7% in spring 2000 and 2001, a significant decrease of 19.4% (p=0.016). In contrast, Percent Non-insects did not differ significantly between pre- and post-SWW in the fall collection efforts (p=0.469), but did show significant difference in spring collections, increasing from an overall average of 21.7% in pre-SWW spring sampling to 41.2% in post-SWW spring sampling, an increase of 19.5% that was significant (p=0.047).

For the functional feeding groups, the overall average relative abundances between pre- and post-SWW estimates at Sites 1-10 did not differ significantly for most feeding strategies during fall or spring collections. Exceptions were scrapers (grazers), shredders, and predators. Percent Scrapers showed an overall 15.9% decrease in the fall collections from pre-SWW to post-SWW periods that was significant (p=0.031), whereas Percent Predators showed an overall small increase of 1.6% in the spring collections from pre-SWW to post-SWW periods that was also significant (p=0.016). For Percent Shredders, both post-SWW fall and spring collection efforts showed a significant (p=0.016) overall small decrease of 0.4-0.5% compared with pre-SWW percentages (Table 9).

Taxa of Interest

In addition, several EPT macroinvertebrate taxa of particular interest to salmonids were also examined for significant changes from pre- to post-SWW periods. These taxa include the Giant Salmonfly (*Pteronarcys*), Golden Stone (*Hesperoperla),* net-spinning hydropsychid caddisflies, minnow-tail mayfly (*Baetis tricaudatus*), spiny crawler mayflies *Ephemerella* spp. and *Drunella* spp., and flatheaded mayflies *Rhithrogena* and *Epeorus* spp. Graphs of the estimated densities for all study years for these taxa are featured in Appendix IV Figures 14-16 and 19-23.

Nearly all of these selected taxa showed significant pre- to post-SWW differences for the fall collection period, usually as increases in post-SWW densities for Sites 1-10 in the lower Deschutes River. *Pteronarcys*, Hydropsychidae, *Baetis tricaudatus*, *Ephemerella* spp., and *Epeorus* spp. all indicate significant (p<0.05) increases in overall densities post-SWW (Table 9). The stonefly *Hesperoperla pacifica* revealed a significant (p=0.047) decrease in post-SWW density (Appendix IV Figure 15), whereas the mayflies *Drunella* spp. and *Rhithrogena* showed no significant pre-to post-SWW differences in either season. Hydropsychidae caddisfly larvae showed the largest increase for the post-SWW fall collection efforts, with an overall average of 3,552.9 individuals/m^2 compared with an overall average of 993.9 individuals/m^2 from fall 1999 and 2001 (Appendix IV Figure 16), an increase of 2,559 individuals/m^2.

Antocha craneflies were widely distributed in 1999-2001 samples but absent in most 2013-2014 samples (Figure 17). *Antocha* were found at virtually all sample sites during springs of 2000 and 2001, generally increasing in abundance with distance downstream from the project. *Antocha* were also documented at almost all sites during fall in 1999 and 2000, albeit in much lower numbers than spring.

While widely distributed, this species was not particularly abundant in comparison with other species in any sample date or year. During baseline study years, *Antocha* comprised an overall average of just 1.1% of all organisms sampled. Percent relative abundance of these craneflies peaked at about 3-4% in the lowermost sample sites during spring of 2000 and 2001 (Figure 18). Relative abundance was somewhat higher at sample sites upstream from the reservoir during 2000-2001, reaching 5-6%. However, *Antocha* have also have disappeared from the Crooked River and Deschutes River reference sites upstream from the reservoir. Only the Metolius site shows *Antocha* numbers similar to pre-SWW levels.

These results also highlight the utility in the experimental design of the study reference sites upstream from the reservoir. While habitat conditions in these sites are not representative of those occurring in an unimpounded Deschutes River downstream from the project site, they are informative regarding the normal fluctuations in macroinvertebrate communities unaffected by the project.

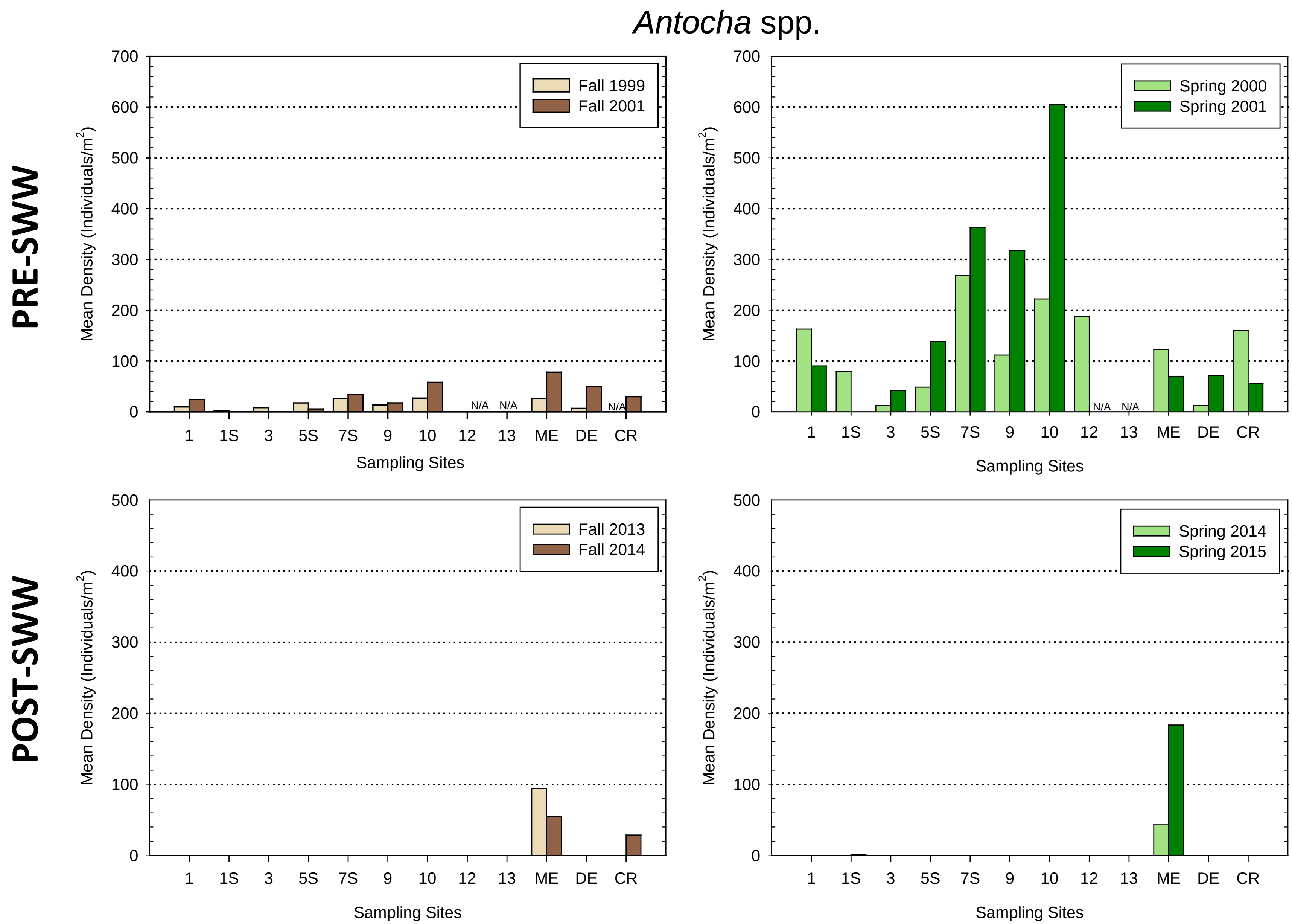


Figure 17. Antocha spp. cranefly larvae densities in the lower Deschutes River downstream from the re-regulation dam and at three upstream reference sites.

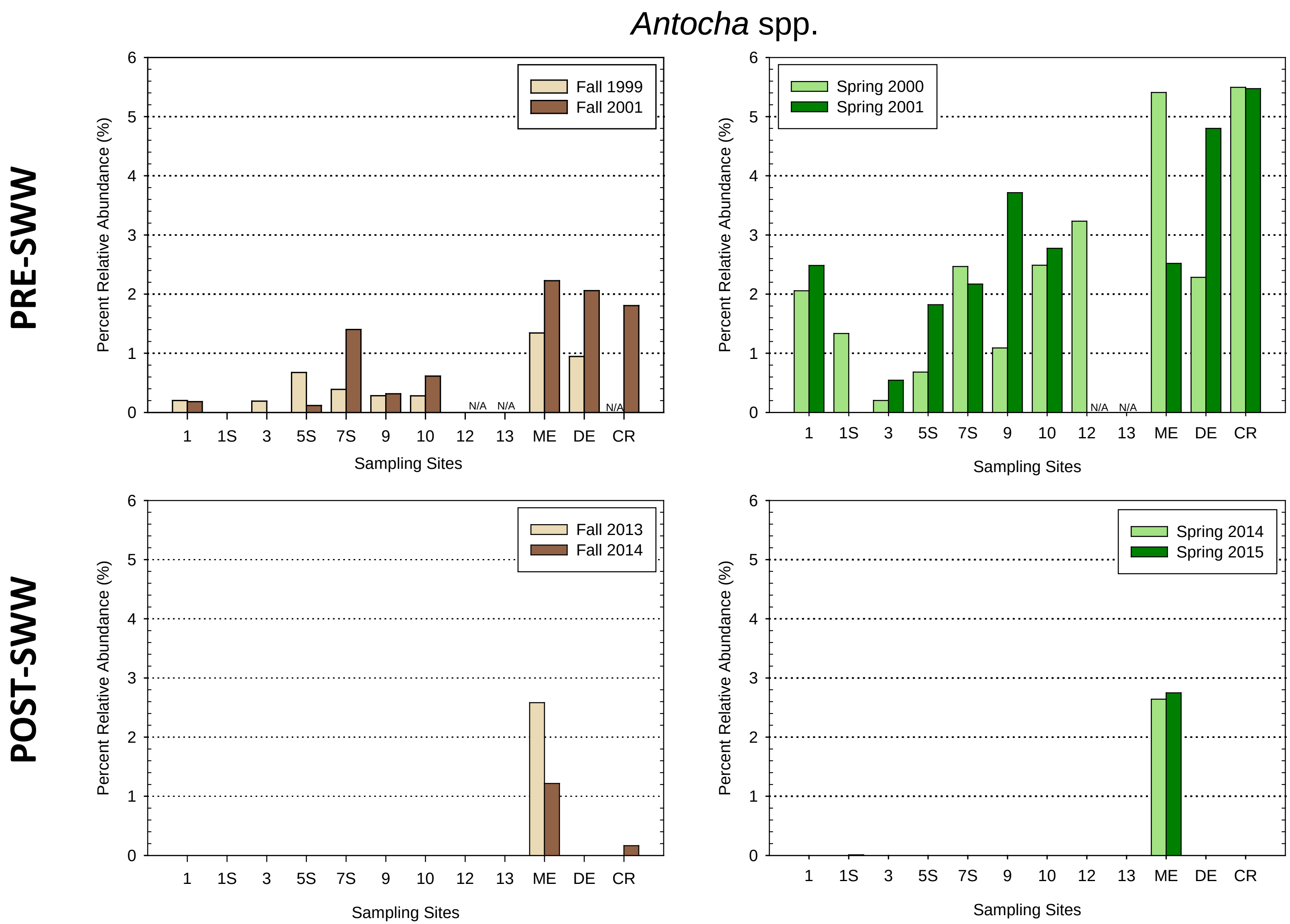


Figure 18. Antocha spp. cranefly larvae percent relative abundances in the lower Deschutes River downstream from the re-regulation dam and three upstream reference sites.

Periphyton

The use of the EPA RBP protocol for sampling and analyzing periphyton samples generated separate results for the components of periphyton: diatom results, based on a 600-valve count, and non-diatoms, or "soft" algae, based on a 300-count of natural algal cell units. Sample-count data for periphyton samples is available in Tables 1-8 in Appendix V and all metric summary data (both pre- and post-SWW) is available in Tables 1-11 in Appendix VI, along with graphs in Appendix VII Figures 1-12.

Density

Periphyton sample results for post-SWW study efforts show that periphyton densities are generally dominated by the "soft" algae component, with density estimates in some cases numbering over ten times higher than diatom densities (Figure 19). During the first year of study, soft algae contributions to periphyton density averaged 75% in fall 2013 and 55% in spring 2014. During the second year, "soft" algae contributed an average of 96% in the fall 2014 and 82% in spring 2015. Diatoms contributed the remainder.

Seasonally, diatom densities were higher in the spring collections, with overall average diatom density for the lower Deschutes River sites totaling 493,183 cells/cm^2 in fall 2013 and dropping to 97,909 cells/cm^2 in fall 2014, as compared to spring totals of 1.5 million cells/cm^2 in 2014 and 1.2 million cells/cm^2 in 2015. Peaks in diatom density of over 3 million cells/cm^2 were seen in spring 2015 at Sites 7S, DE, and CR. For "soft" algae, density estimates were far more variable between years with no discernable seasonal trends. Overall average density for the lower Deschutes River sites in fall 2013 was 1.8 million cells/cm^2 and 3.4 million cells/cm^2 in fall 2014. Overall average density for spring samples was 3.4 million cells/cm^2 in 2014, and a large increase to 12 million cells/cm^2 in 2015. This notable increase in "soft" algae densities can be seen across nearly all sites in spring 2015, except for Sites 1, 10, 12, and ME (Figure 19).

Biovolumes

As was seen with "soft algae" species representing high densities, "soft" algae in the lower Deschutes River comprised high amounts of periphyton biovolumes, commonly recording biovolumes in excess of 50 million cubic micrometers per square centimeter (µm^3/cm^2) (Figure 20). During the first year of study, diatom contributions to periphyton biovolume averaged 65% in fall 2013 and spring 2014, with soft algae contributing 35%. During the second year, "soft" algae averaged contributions increased to 85% in the fall 2014 and 76% in spring 2015, with diatoms contributions averaging 15% and 24%, respectively.

For diatoms, biovolumes ranged from 7.5 million µm^3/cm^2 at Site 5S in fall 2014, to 3.7 billion µm^3/cm^2 at Site CR in spring 2015 and were comprised of *Diatoma vulgaris* and several species of stalked diatoms. Diatom biovolumes were lower during the fall periods, when compared to the spring biovolumes. Overall average biovolumes for diatoms at the lower Deschutes River sites were 366 million µm^3/cm^2 in fall 2013 and 45.8 million µm^3/cm^2 in fall 2014, compared to spring totals of 452 million µm^3/cm^2 in 2014 and 291 million µm^3/cm^2 in 2015. Fall sampling also showed peaks of diatom biovolumes over 1 billion $\mu m^3/cm^2$ at Sites 12 and 13 in fall 2013, at Site 7S in spring 2014, and at Site CR during both spring sampling events (Figure 20).

Stalked diatoms (*Cymbella* and *Gomphoneis* spp.) were observed at several sites both below and above the reservoir during the post-SWW study in 2013-2015 (Figure 21). At most sites samples during this study, these species comprised less than 10% of the total periphyton biovolumes, although for October 2013 collections at the two lowermost sites (12 and 13) stalked diatoms accounted for a large amount of the total periphyton biovolume (Figure 21). At Site 12 (Sandy Beach), stalked diatoms contributed 38.9% to the total periphyton biovolume at that site, mostly *Cymbella mexicana* and some *Gomphoneis minuta*. At Site 13 (Macks Canyon), stalked diatoms contributed 66.8% to the total periphyton biovolume at that site, largely *Gomphoneis minuta*. In spring 2015, three sites (1S, 5S, and CR) had stalked diatom contributions at or approaching 20% of the total periphyton biovolume; interestingly, these are all sites where samples are collected at shallow depths (<1 ft). In the second year of study, stalked diatoms accounted for 20% or less of the total periphyton biovolume at all sites; the highest stalked diatom contribution in October 2014 was 11.3% of the total periphyton biovolume at Site 13 and was comprised of six different stalked diatom taxa. In spring 2015, stalked diatoms contributed 39.4% of the total periphyton biovolume at Site 7S, all *Gomphoneis* taxa (Figure 21).

For "soft" algae taxa, biovolumes ranged from 1.9 million $\mu m^3/cm^2$ at Site 10 in fall 2013, to 13.6 billion $\mu m^3/cm^2$ at Site DE in spring 2015, largely comprised of *Ulothrix zonata.* Overall average biovolumes for "soft" algae in the lower Deschutes River sites were significantly higher and more variable, averaging 143 million $\mu m^3/cm^2$ in fall 2013 and 1.6 billion $\mu m^3/cm^2$ in fall 2014, compared to spring totals of 294 million $\mu m^3/cm^2$ in 2014 and a considerably higher average biovolume of 2.2 billion $\mu m^3/cm^2$ in 2015. Fall sampling also showed peaks of soft algae biovolume of 12.5 billion $\mu m^3/cm^2$ at Site 1 and 1.9 billion $\mu m^3/cm^2$ at Site CR in fall 2014 (both mostly *Cladophora glomerata*), and peaks of 13.6 billion $\mu m^3/cm^2$ at Site DE (mostly *Cladophora glomerata*) and 6 billion $\mu m^3/cm^2$ at Site CR (mostly *Stigonema* and *Stigeoclonium*) in spring 2015 (Figure 20).

We also note that periphyton biovolumes are also heavily influenced by sampling depth and proximity to shoreline. During sampling trips, we observed thicker algal growth in very shallow shoreline areas with very low stream velocities. These conditions located along the edges of the river would produce the preferred environment for these stalked forms of diatoms (Kociolek and Spaulding 2003), as opposed to the higher velocities out in the riffle areas sampled during this study. As noted earlier, we documented contributions of *G. minuta* at Sites 1S, 5S, 7S, and CR in both seasonal periods – these sites were in water depths of less than 1 foot. Any comparisons of periphyton results between spring and fall samples collected during this study and samples collected by other studies should control for depth and velocity differences in sample sites.

Taxa Richness

For periphyton taxa richness, diatoms accounted for a majority of taxa present, compared to soft algae taxa (Figure 22). Diatom taxa richness ranged from 17 taxa at Site 7S during the fall 2013 collection to 56 taxa at the upstream reference site CR in the fall 2014 collection. “Soft” algae taxa richness ranged from 3 taxa, present at numerous sites during both years and seasons, to 10 taxa at the upstream reference site ME during the spring 2015 collection. No apparent seasonal or spatial trends in taxa richness were observed during the two-year study.

Community Composition

A principal components analysis (PCA) was run with the mean densities of the 25 most abundant diatom taxa identified in the post-SWW study (representing approximately 91.9% of the total estimated density of diatoms in samples collected during the study), so as to present an ordination plot with 48 cases representing each site/sampling date. The PCA biplot (Figure 23) reveals relationships that account for 42.9% of the variation in the data set. The biplot shows some separation of the upper reference sites CR, DE, and ME to the lower left quadrant, arcing from the left side of Axis 1 to the lower extent of Axis 2, away from the other sites based on an increased abundance of *Achnanthidium gracillimum* and *Encyonema silesiacum*, and a taxa assemblage distinctly different than the taxa present at the lower Deschutes river sites (Figure 23). Upper reference sites also loosely grouped by seasons, with fall collections grouping closer to Axis 1, and spring collections markers extending towards lower Axis 2. Lower Deschutes River sites located downstream from the Project were grouped together largely by seasons and years. Fall samples grouped together to the left of Axis 2 and above Axis 1. Fall 2014 (F14) collections were grouped closer to the origin (0, 0) whereas fall 2013 collections extended into the upper left quadrant more (Figure 23). Case scores for fall diatoms appear to be influenced by higher abundances of *Navicula cryptotenella* (Figure 23). Spring samples were a larger group that was more widely distributed to the right of Axis 2 in the biplot, with spring 2014 sampling falling below Axis 1 and spring 2015 above it. Spring 2014 samples appear to be influenced by higher densities of *Nitzchia paleacea* and *Diatoma moniliformis*, plus several additional species of *Nitzschia, Diatoma vulgaris,* and *Achnanthidium* (Figure 23). Spring 2015 samples were influenced strongly by the densities of *Stephanodiscus medius, S. minutulus, S. hantzschii,* and *Synedra mazamaensis*, along with several other taxa.

A second PCA was run with the mean biovolumes of the top 20 diatom taxa biovolume contributors identified in the post-SWW study (representing approximately 89.6% of the total estimated biovolume of diatoms in samples collected during the study), so as to present an ordination plot with 48 cases representing each site/sampling date. The PCA biplot (Figure 24) reveals relationships that account for 34.9% of the variation in the data set. Sampling sites do not show much of a separation of sites by their longitudinal positions in the biplot, with only the spring sampling events of the upper reference sites on the Metolius River (ME) and the Upper Deschutes (DE) grouping together closely along the far left of Axis 1, and the fall sampling events at Site ME separating out in the lower left quadrant. However, the biplot does still show broad separations of the sites by sampling seasons, with spring sampling events in the upper left quadrant of the biplot highly influenced by *Synedra ulna*, *Stephanodiscus medius*, and *Diatoma vulgaris* biovolumes. Fall sampling events are located more to the lower right of the biplot (Figure 24). Among the diatom taxa influencing fall samples are *Stephanodiscus niagarae, Cocconeis pediculus, Gomphoneis minuta,* and *Staurosira construens v. binodis*, along with 5-6 other taxa.

A final PCA was run with the mean biovolumes of the top 25 periphyton taxa contributors, both soft algae and diatoms, to biovolumes identified in the post-SWW study (representing approximately 94.7% of the total estimated biovolume of all periphyton in samples collected during the study), so as to present an ordination plot with 48 cases representing each site/sampling date. The PCA biplot (Figure 25) reveals relationships that account for 36.7% of the variation in the data set. Similar to the diatom biovolumes biplot, sampling sites do not show any separation of sites by their longitudinal positions in the biplot, but instead group by sampling season and event. Axis 1 expresses largely a temporal gradient, with the first year of study, fall 2013 and spring 2014, falling to the left side of Axis 1, and the second year of study tending to the right side. Axis 2 is largely a seasonal gradient with fall sampling sites largely located above Axis 1, and spring 2015 sampling instances below Axis 1. Spring 2014 sampling events are seemingly less related to Axis 2, as they fall both above and below the far left end of Axis 1. Sites with the highest biovolumes in fall 2014, Sites 1, 3, and CR (see Figure 20), were sites with high biovolumes of *Cladophora glomerata*, as indicated by the arrow extending out to the far right of the biplot (Figure 25). Periphyton taxa in the biplot are a mix of “soft” algae and diatom taxa, with each sampling event influenced by 5-6 taxa. Many of the taxa influential to Year 1 samples are diatoms, whereas many of the taxa extending to the right of the biplot indicate higher biovolumes are due to “soft” algae (Figure 25), which is also in agreement with the earlier results indicating higher biovolume contributions of diatoms in the first year, shifting to higher “soft” algae contributions to biovolumes in the second year.

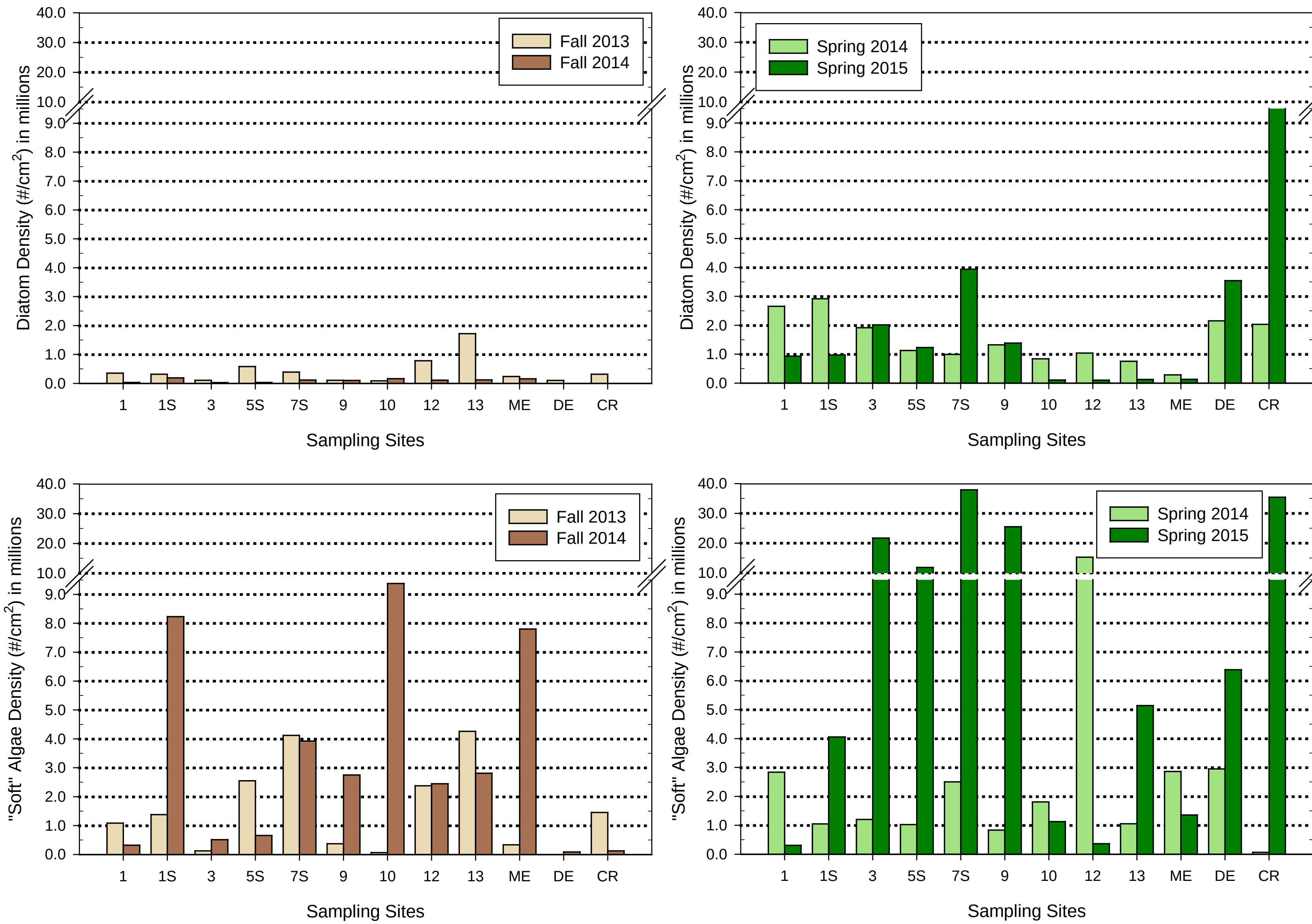


Figure 19. **Estimates of diatom and "soft" algae density from composite periphyton samples collected in the lower Deschutes River downstream from the re-regulation dam and three reference sites.**

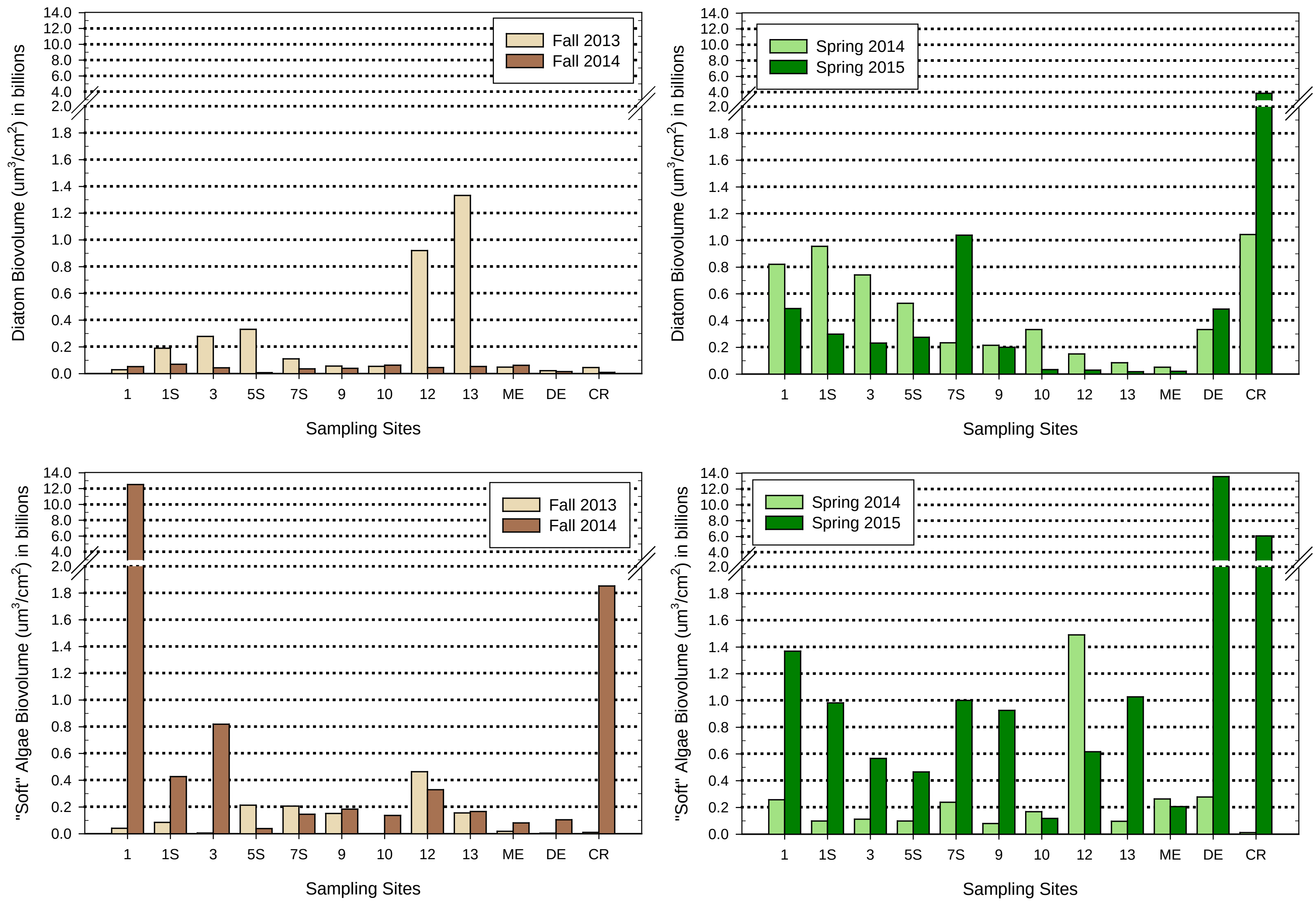


Figure 20. **Estimates of diatom and "soft" algae biovolume from composite periphyton samples collected in the lower Deschutes River downstream from the re-regulation dam and three reference sites.**

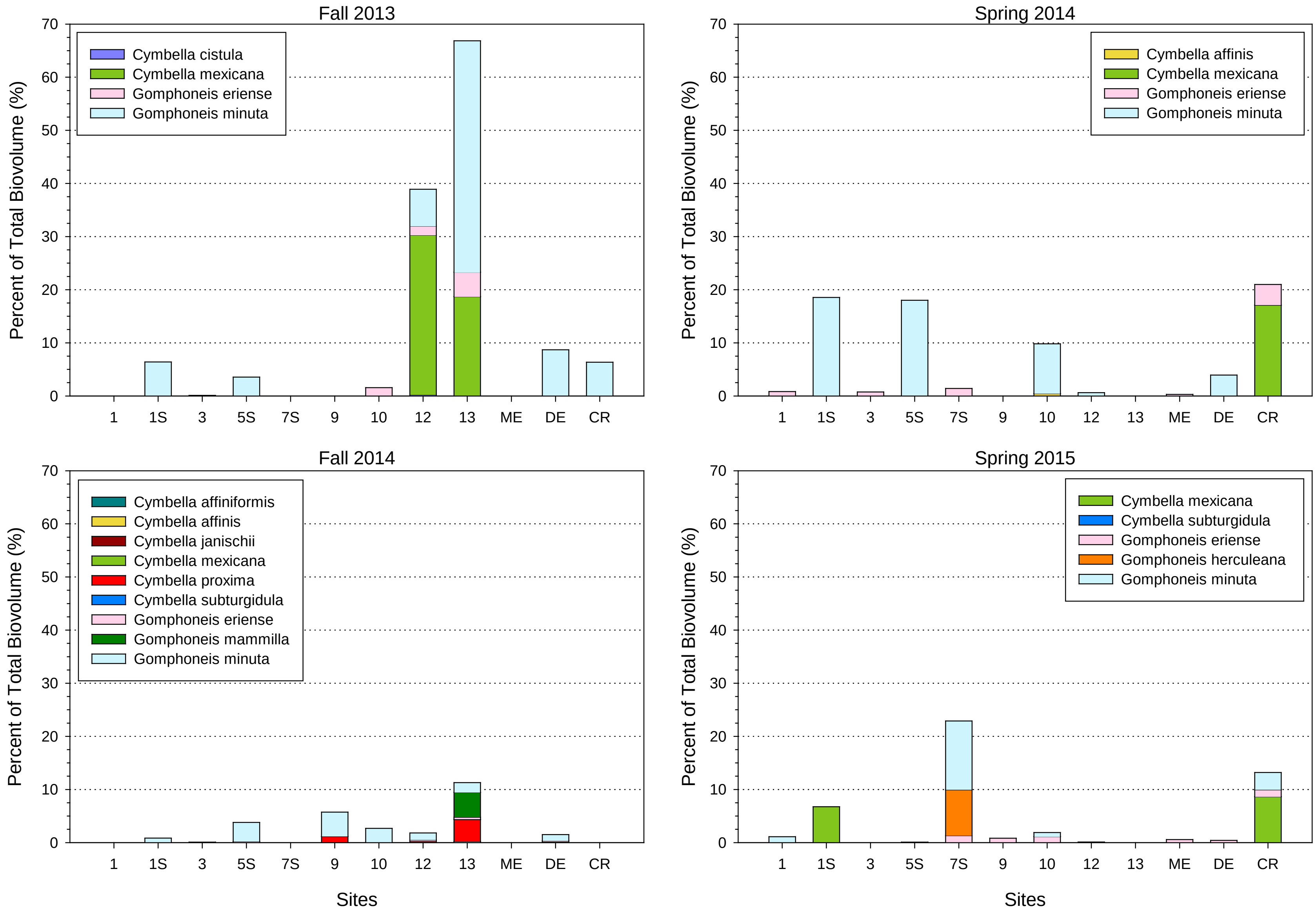


Figure 21. **Percent contributions to Total Periphyton Biovolumes for stalked diatom taxa in the genera *Cymbella* and *Gomphoneis* in the lower Deschutes River downstream from the re-regulation dam and three reference sites.**

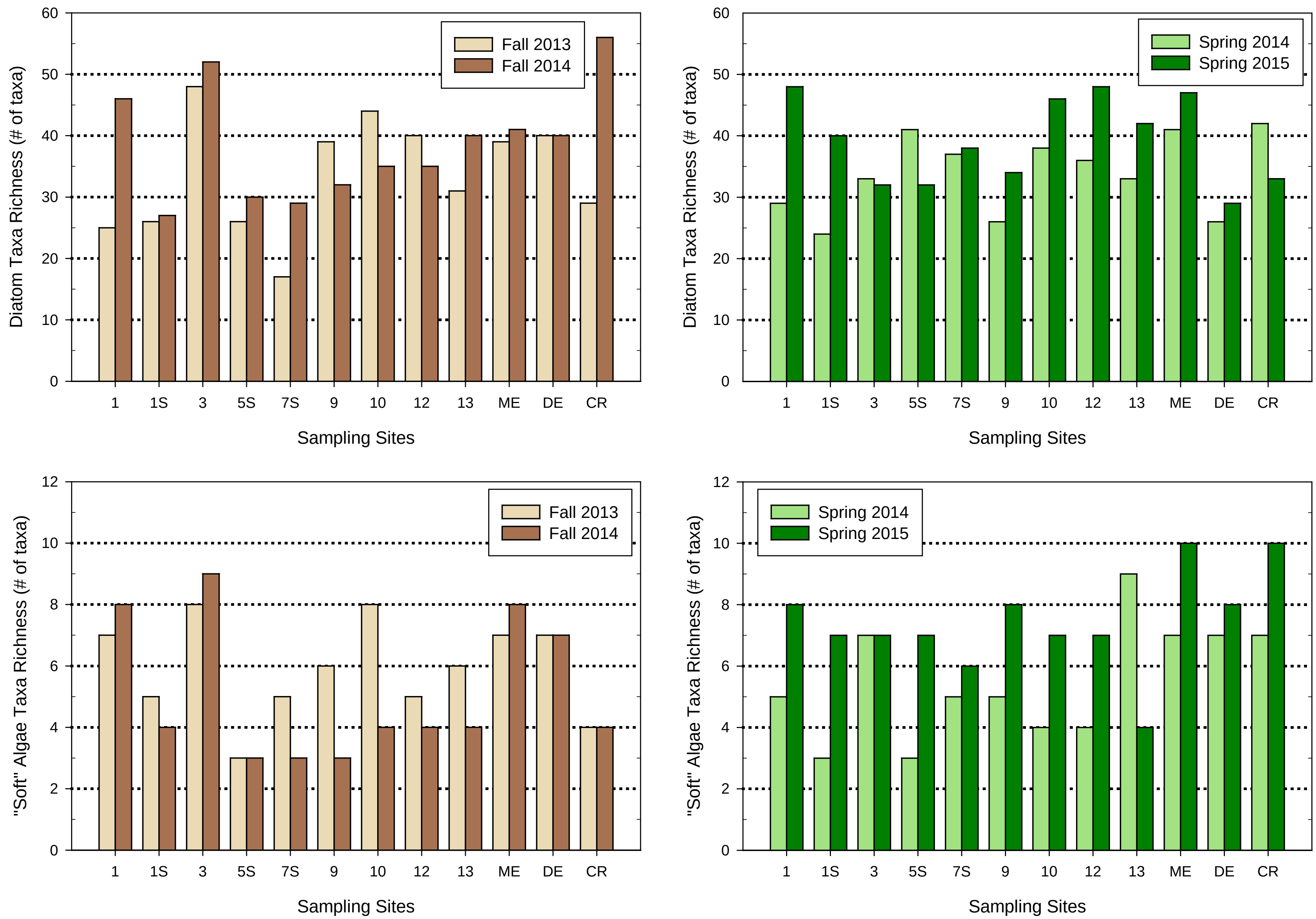


Figure 22. Estimates of diatom and "soft" algae taxa richness from composite periphyton samples collected in the lower Deschutes River downstream from the re-regulation dam and three reference sites.

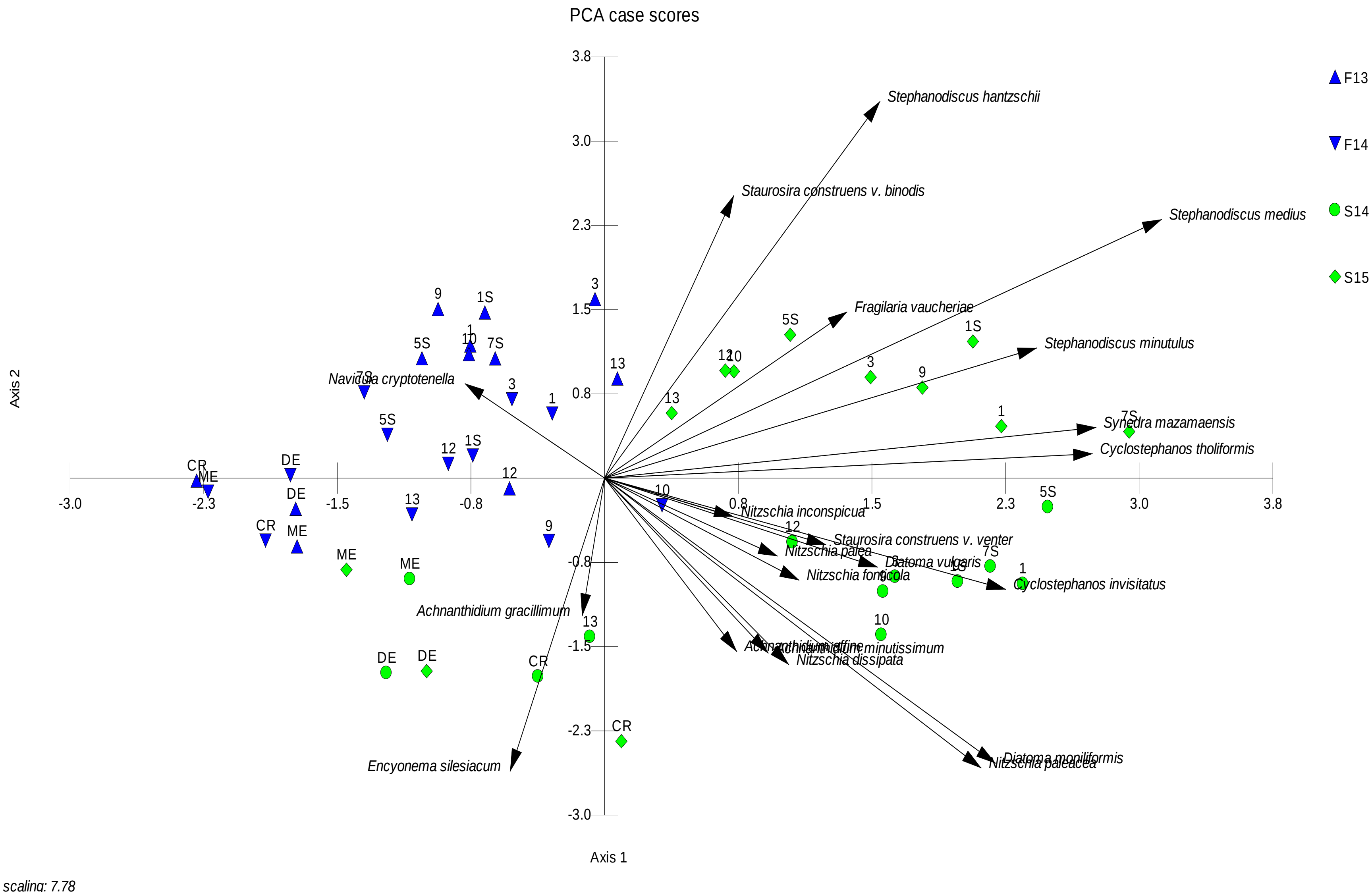


Figure 23. **Principal Components Analysis (PCA) plotting the 48 cases of each site/sampling date along gradients of mean abundances of the top 25 diatom taxa collected in the 2-year study. Note that longer arrows represent stronger gradients, and short arrows represent weaker gradients.**

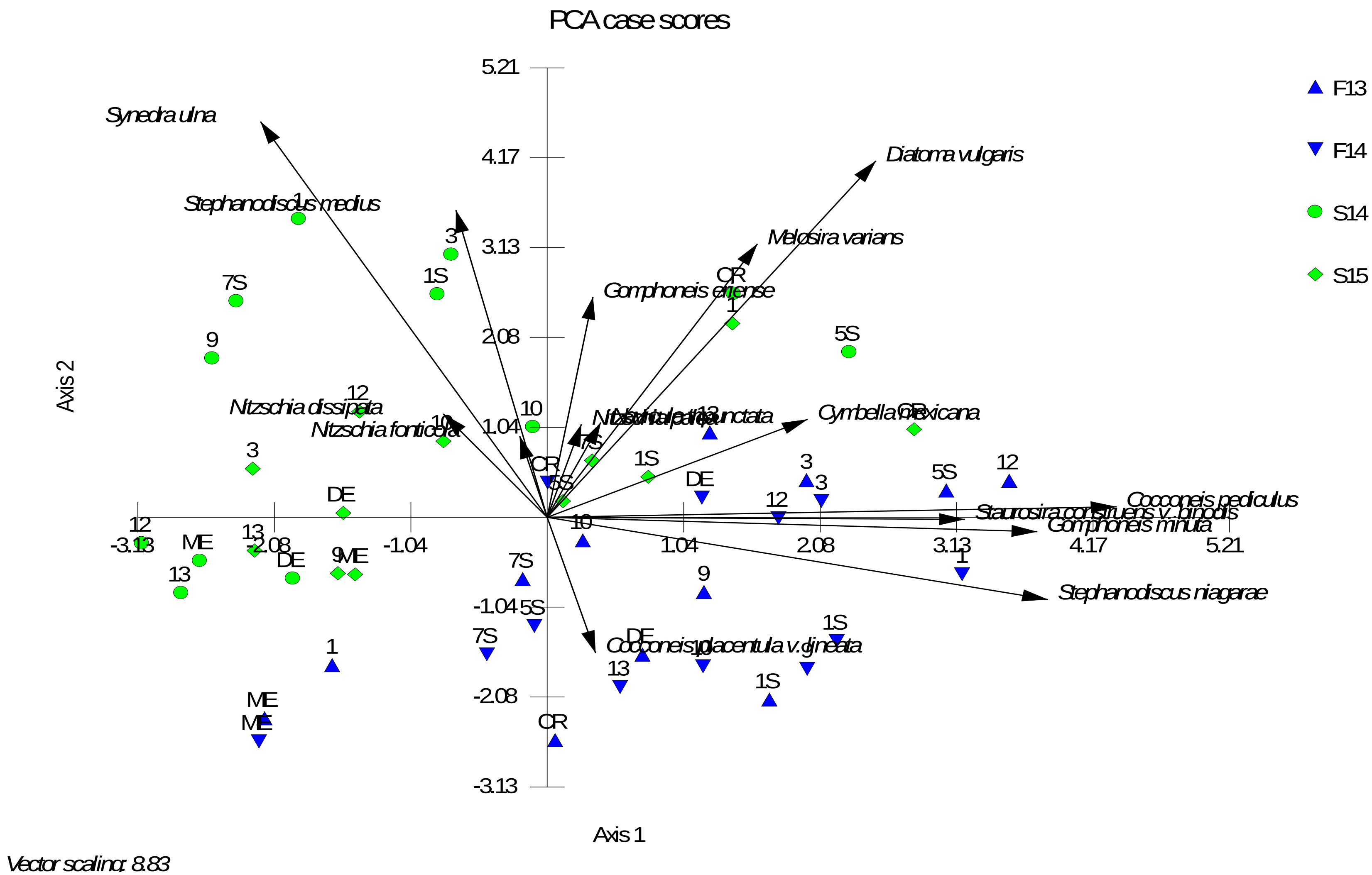
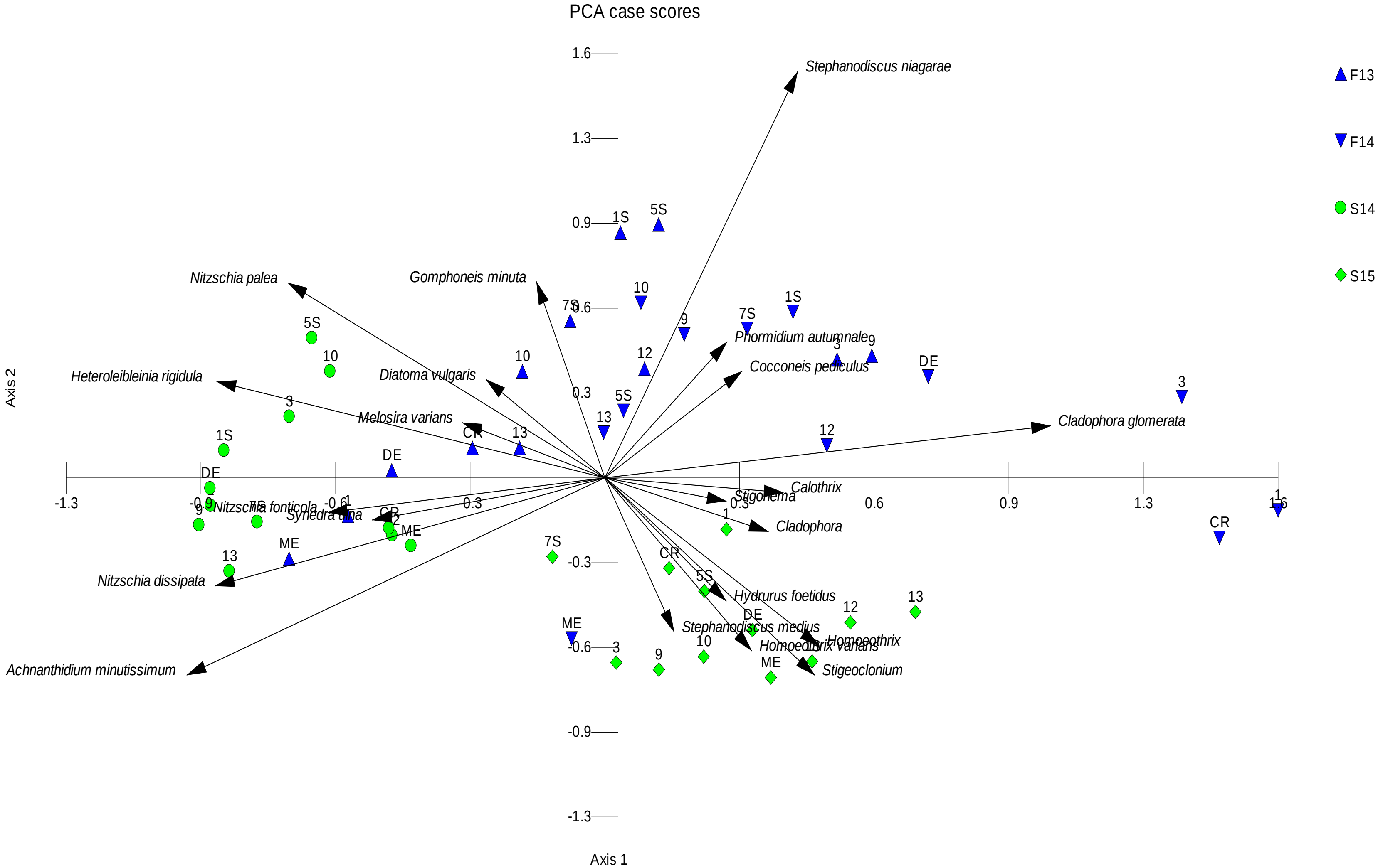


Figure 24. **Principal Components Analysis (PCA) plotting the 48 cases of each site/sampling date along gradients of mean biovolumes of the top 20 diatom taxa collected in the 2-year study. Note that longer arrows represent stronger gradients, and short arrows represent weaker gradients.**



Vector scaling: 2.62

Figure 25. Principal Components Analysis (PCA) plotting the 48 cases of each site/sampling date along gradients of mean biovolumes of the top 25 periphyton taxa (both diatom and soft cell algae) collected in the 2-year study. Note that longer arrows represent stronger gradients, and short arrows represent weaker gradients.

Pre-SWW vs. Post-SWW Comparisons

Statistical analysis of density and biovolume results was limited to paired t-tests, comparing average results of pre-SWW to post-SWW by season (fall and spring). Density and biovolume results from the post-SWW study (2013-2015) were compared to baseline study results from 1999-2001 looking primarily at Sites 1 through 10, which were consistently sampled for periphyton in both studies. For density, no significant differences were detected for spring sampling (p=0.107), but for fall sampling, post-SWW densities at Sites 1 through 10 were significantly higher (p=0.008) than those in the pre-SWW study. For biovolumes, no significant differences were detected for fall sampling (p=0.148), but for spring sampling, a marginal level of significance was detected (p=0.055), indicating post-SWW biovolumes are likely higher than pre-SWW spring biovolumes.

Due to the differences in how periphyton samples were processed and analyzed in the baseline study in comparison to the standardized EPA/USGS methodology used in this current study, essentially a 100-count subsample versus a combination 600-valve count and 300 cell count, it is difficult to make a comparison of pre- and post-SWW conditions using the estimates of density, biovolumes, or taxa richness that are derived from these methods, as we cannot qualify whether differences are due to changes in the populations over time or due to differences in methodology. Thus, despite our t-tests, we cannot say with certainty that periphyton densities, biovolumes, or taxa richness have changed from the baseline study (see Appendix VI Tables 1-3, Appendix VII Figures 1-3). For instance, the two methods produced a large difference in the number of taxa due to a greater number of organisms being counted. Taxa richness in the post-SWW samples were double those seen in the baseline samples (Appendix VI Tables 1-3, Appendix VII Figure 3).

However, the generation of a suite of autecological metrics based upon the original diatom cell counts assisted in comparisons of the communities and their responses to ecological conditions during pre-SWW and post-SWW sampling periods. Eighteen diatom metrics, based on Community Structure, Inorganic and Organic Nutrients, Metals, and Sediment were calculated on data sets from 1999-2001 and 2013-2015. Results are given in Appendix Tables 4-11 in Appendix VI, and a selection of metrics are graphed for comparisons in Appendix Figures 4-12 in Appendix VII.

Statistical analysis of autecological metric results was limited to paired t-tests (n=7), comparing average metric results of pre-SWW to post-SWW by season (fall and spring). Metric results from the post-SWW study (2013-2015) were compared to baseline study results from 1999-2001 looking primarily at Sites 1 through 10, which were consistently sampled in both studies. Results of those test runs are available in Table 10.

Nearly all of these selected metrics showed significant (p=0.02) pre- to post-SWW differences during the spring collection period, whereas the metric results for fall collections did not detect any significant differences between pre-SWW and post-SWW samples (Table 10), save for one metric. For the percent of Cosmopolitan Taxa, Sites 1-10 in the lower Deschutes River during the post-SWW fall collection efforts showed an overall average of 90.8% compared with an overall average of 78.3% from fall 1999 and 2001 (Table 10), an increase of 12.5% that is statistically significant (p=0.030).

Table 10. Results of statistical comparisons (paired t-test) between Pre- and Post-SWW averages of selected autecological diatom metrics for spring and fall sampling collections for 7 sites below the Project (Sites 1, 1S, 3, 5S, 7S, 9, and 10).

Metrics	Fall				Spring			
	Pre-SWW	Post-SWW	Difference (Pre-Post)	p-value	Pre-SWW	Post-SWW	Difference (Pre-Post)	p-value
Community Structure								
Cosmopolitan Taxa Percent	78.3	90.8	-12.5	**0.03**	93.6	91.6	2.0	0.16
Dominant Taxon Percent	24.7	46.0	-21.3	0.22	60.0	34.0	26.0	**0.02**
Shannon H (log2)	3.6	3.0	0.6	0.47	2.0	3.4	-1.4	**0.02**
Inorganic Nutrients								
Eutraphentic Taxa Percent	58.6	71.3	-12.7	0.30	71.2	50.2	21.0	**0.02**
Nitrogen Autotroph Taxa Percent	43.2	33.1	10.1	0.58	30.6	63.9	-33.3	**0.02**
Metals								
Alkaliphilous Taxa Percent	60.5	49.7	10.8	0.58	25.8	56.9	-31.1	**0.02**
Disturbance Taxa Percent	6.6	4.1	2.5	0.38	10.4	22.7	-12.2	0.11
Metals Tolerant Taxa Percent	25.4	41.7	-16.3	0.58	62.5	16.5	46.0	**0.02**
Organic Nutrients								
Low DO Taxa Percent	16.6	40.3	-23.7	0.38	61.0	15.1	45.8	**0.02**
Nitrogen Heterotroph Taxa Percent	38.4	58.3	-19.9	0.30	66.3	29.7	36.6	**0.02**
Pollution Index	2.2	1.9	0.3	0.47	1.7	2.3	-0.7	**0.02**
Polysaprobous Taxa Percent	38.8	55.8	-17.0	0.38	66.6	35.7	30.9	**0.02**
Sediment								
Motile Taxa Percent	59.2	70.6	-11.4	0.38	72.3	43.8	28.5	**0.02**
Siltation Taxa Percent	59.5	70.0	-10.5	0.47	72.3	43.4	28.9	**0.02**

These results suggest that post-SWW conditions during the fall season are similar to those seen during pre-SWW, but could indicate greater variability during the fall, preventing our test from detecting significant differences.

Most of the metrics showing significant changes in pre- to post-SWW spring sampling suggest an improvement in water quality conditions. Results for statistical analysis for Community Structure metrics indicate a significant decrease in the percent dominant taxon by 26%, and an increase in diversity, suggesting an improvement in the spring for the diatom community. However, this may also be the result of the more intensive sampling methodology used in the current study compared to the baseline, pre-SWW study.

For metrics describing Inorganic Nutrient levels, Sites 1-10 during the spring sampling period showed a significant decrease (p=0.02) in the overall average percent of eutraphentic taxa in post-SWW collection efforts from 71.2% for pre-SWW to 50.2% for post-SWW (Appendix VII Figure 4). The overall average percent of Nitrogen Autotroph Taxa rose from 30.6% in pre-SWW spring collections to 63.9% in post-SWW spring (Table 10; Appendix VII Figure 7). Similarly for Organic Nutrients metrics, significant changes from pre- to post-SWW spring collections suggest substantial improvements in water quality, as indicated by the diatom communities. The overall average of the percent of Low Dissolved Oxygen taxa, Nitrogen Heterotroph Taxa, and Polysaprobous Taxa all were significantly less (p=0.02) for post-SWW, indicating general improvement in nutrient conditions. For the Pollution Tolerance Index (PTI, Bahls 1992), statistical analysis shows a significant increase (p=0.02) in the overall average PTI score during the spring, increasing from a pre-SWW score of 1.7 to a score of 2.3 for post-SWW spring collections (Table 10; Appendix VII Figure 11). A higher PTI score approaching "3" indicates less pollution tolerant species.

For autecological metrics concerned with metals, Sites 1-10 during the spring sampling period showed a significant increase (p=0.02) in the overall average percent of alkaliphilous taxa in post-SWW spring collection efforts, increasing from 25.8% to 56.9% (Table 10; Appendix VII Figure 6), possibly as a result of the increased pH levels seen in the lower Deschutes River. Statistical analyses also revealed a significant decrease in the percent of metal tolerant taxa in post-SWW spring collections as well, dropping 40% to 16.5% (Table 10).

Finally, autecological metrics concerned with sedimentation revealed a significant decrease (p=0.02) of nearly 30% in both the percent of motile taxa and siltation taxa present (both metrics are very similar) for Sites 1-10 during the spring collection efforts (Table 10; Appendix VII Figure 12).

Further examination of results for the autecological metrics revealed another interesting trend. At the shallow-water sites sampled (Sites 1S, 5S, and 7S) during the fall collection events, those locations show metric scores that are often notably higher or lower than all other sites (Appendix VII Figures 4-12), with the results indicating poorer water quality conditions based upon those results. The shallow water sites' results were higher for percent dominant taxa, eutraphentic taxa, low DO taxa, nitrogen heterotroph taxa, and siltation indicator taxa. Those shallow-water sites also had noticeably lower metric scores for nitrogen autotroph taxa, alkaliphilous taxa, and PTI scores. These metric results show that diatom taxa are present at these sites during the fall sampling period that are generally indicative of poorer water quality conditions. Habitat conditions in these areas of shallow, near-shoreline waters, especially over the warmer summer and early fall periods, could be conducive to diatom taxa that thrive more readily under stressful conditions.

Gravel Augmentation Sites

All sample-count and metric summary data for 2013-2015 collections in the gravel augmentation sites and Site 3 are available in Appendix II Table 9 and Appendix III Table 9, respectively.

Sampling within the gravel augmentation sites downstream of the Reregulation Dam revealed benthic macroinvertebrate mean densities ranging from 9,378 individuals/m^2 at Site G2 in spring 2015, to 57,297 individuals/m^2 at Site G3 in fall 2013. Mean densities were significantly higher ($p<0.04$) at Sites G1 and G3 in fall 2013, both compared to the densities at the control site, Site 3, and Site G2 (Figure 26). Site G2 densities did not differ seasonally or from the control site. Densities among the sites did not differ during spring collections, or in fall 2014.

Mean taxa richness among the sites during fall 2013 was significantly higher at Site 3 ($p=0.023$) than Sites G1 and G3 (Figure 27). Mean taxa richness among the sites during the other three seasonal collections was not significantly different ($p\geq0.37$). In addition, mean taxa richness within each of the gravel augmentation sites was significantly higher ($p\leq0.034$) during the spring 2015 collection than mean taxa richness during the fall 2013. Total taxa richness recorded for the gravel augmentation sites showed the same trends as mean taxa richness results, and ranged from a low of 23 taxa during fall 2013 at all gravel augmentation sites to 36 taxa at Site G2 in spring 2015 (Figure 28).

The community compositions within the gravel augmentation sites revealed mostly non-insect taxa (range of 80.8% to 98.1%), comprised of oligochaetes, the polychaete *Manayunkia speciosa,* snails (*Fluminicola* and *Vorticifex*), and planarians (flatworms) during all four seasonal collections (Figure 29). In comparison, Site 3 was slightly less dominated by non-insect taxa (range of 34% to 82.7%), with increased contributions of Trichoptera in the fall season (both years), and Trichoptera and chironomids in the spring season (both years), along with a larger contribution of Other Diptera (Simuliidae) in spring 2015. Non-insect contributions were lowest in spring 2015 at the gravel augmentation sites, as well, ranging from 80.8% at Site G2 to 90.6% at Site G1, which resulted in increased contributions of mayflies, caddisflies, and chironomids during that period (Figure 29).

The corresponding relative abundances of the functional feeding groups showed gravel augmentation sites consisted of varying proportions of collector-gatherers, scrapers/grazers, and filter-feeders. The gravel augmentation sites showed increases in filter-feeder contributions during both fall sampling periods, as well as spring 2014 (Figure 30), but those increases were not significantly different ($p>0.05$). The increased abundance of simuliid blackfly larvae, at Site 3 which are filter-feeders, explains the increase in spring 2015.

Scores for the Modified Hilsenhoff Biotic Index (MHBI) were calculated for each sample collected at Site 3 and at the gravel augmentation sites. Mean scores at gravel augmentation sites ranged from 5.64 at Site G3 in fall 2014 and at Site G2 in spring 2015, to 6.45 at Site G3 in fall 2013. Mean scores showed that during fall 2013, MHBI scores were significantly higher ($p\leq0.045$) at Sites G1 and G3 than Sites 3 and G2 (Figure 31). During spring 2014, MBHI scores at all gravel augmentation sites were significantly higher (p≤0.015) than the MHBI score at Site 3 (5.02). MBHI scores were not significantly different (p>0.17) among sites in fall 2014 and spring 2015 sampling collections.

Likewise, scores for the ODEQ Impairment Index were calculated for each site and seasonal collection. These multimetric scores can range from 10-50. For gravel augmentation sites, index scores ranged from 18 at several sites and seasonal collections, to 26 at Site G2 in spring 2014 compared to a range of 20-28 for Site 3 (Figure 32). The highest index scores were recorded in spring 2014 and spring 2015 at Sites 3 and G2.

The gravel augmentation sites were unique in that the occurrence of high densities of the polychaete *Manayunkia speciosa* was extremely isolated to their locations.[3] During the study, Sites G1 and G3 recorded polychaete densities exceeding 10,000 individuals/m^2, and Site G2 had densities around 2,000 to 7,000 individuals/m^2 (Figure 33). The polychaete was also detected at most of the other sampling sites in the lower river, although at much lower densities. At the upstream reference sites, Manayunkia was only detected in samples from the Crooked River site. The polychaete is a filter-feeder, so the increased presence also explains the higher filter-feeding contributions at the gravel augmentation sites in comparison to the control site.

Also unique to the gravel augmentation sites was the occurrence of *Urnatella gracilis,* often called goblet worms, small, sessile (i.e., fixed to the substrate), colonial animals that resemble cnidarian hydroids (*Hydra*). Their occurrence was largely limited to the fall seasonal sampling periods within the gravel augmentation sites, as well as a more limited amount at Sites 1S, 3, and 9 (Figure 34). Many specimens were found containing completely engulfed or partially-engulfed zooplankton, which were observed as abundant in the sites downstream from the Reregulation dam. These goblet worms were not counted in the macroinvertebrate samples, as they are small pieces of a colony, and are not included in macroinvertebrate metrics. However, their abundance is very likely related to zooplankton presence and other particulates released by the dam.

[3] *This species has been implicated in the lifecycle of several salmonid diseases.*

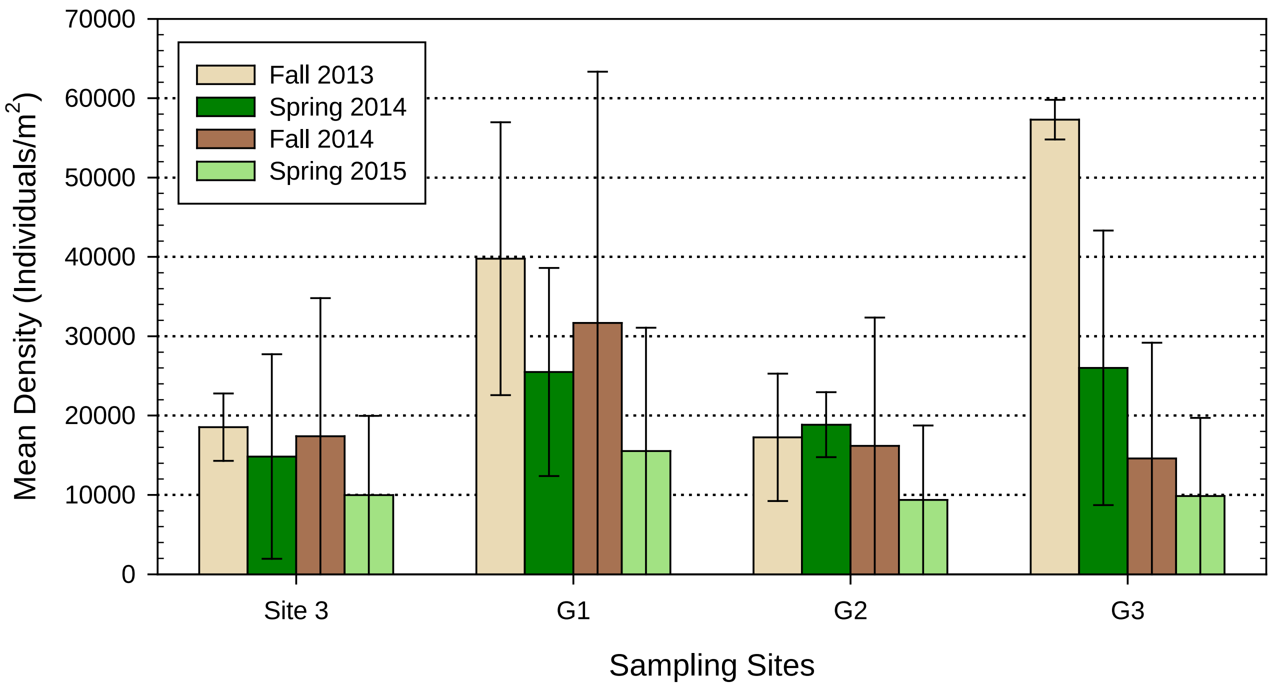


Figure 26. Benthic macroinvertebrate mean density estimate (with 95% confidence intervals) at three gravel augmentation sites and the control site (Site 3) in the lower Deschutes River downstream from the re-regulation dam.

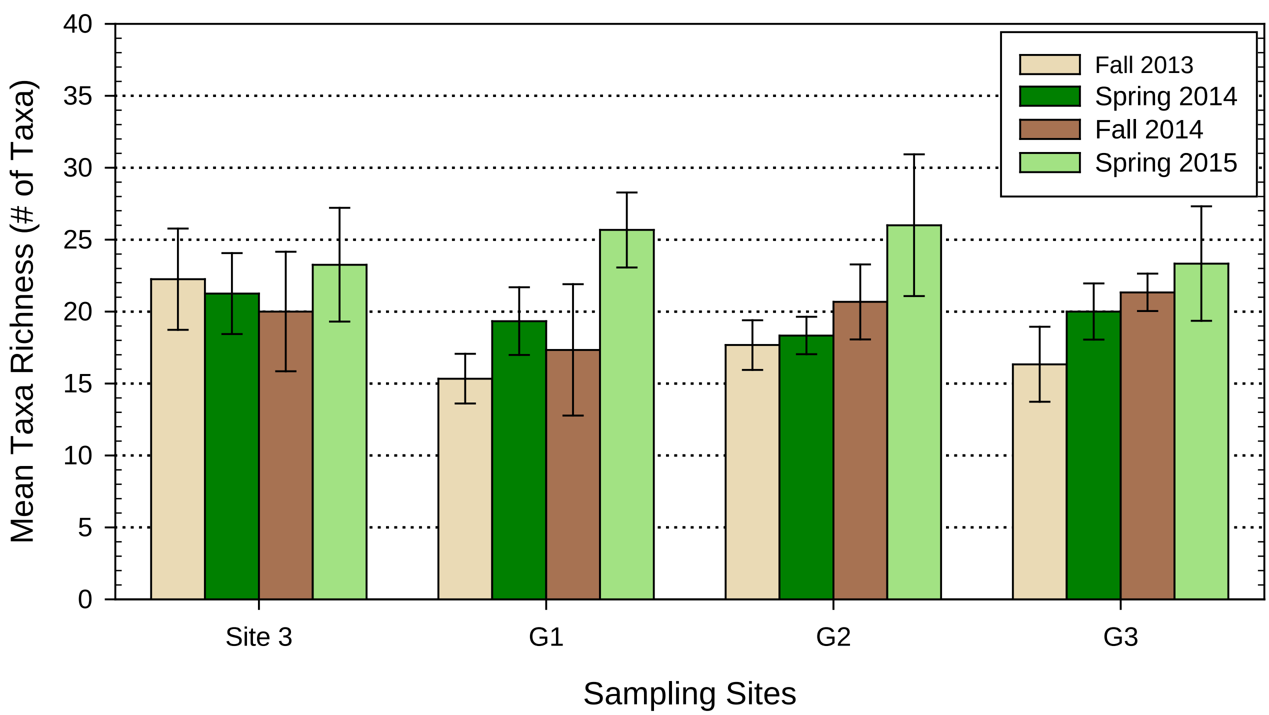


Figure 27. Benthic macroinvertebrate mean taxa richness at three gravel augmentation sites and the control site (Site 3) in the lower Deschutes River downstream from the re-regulation dam.

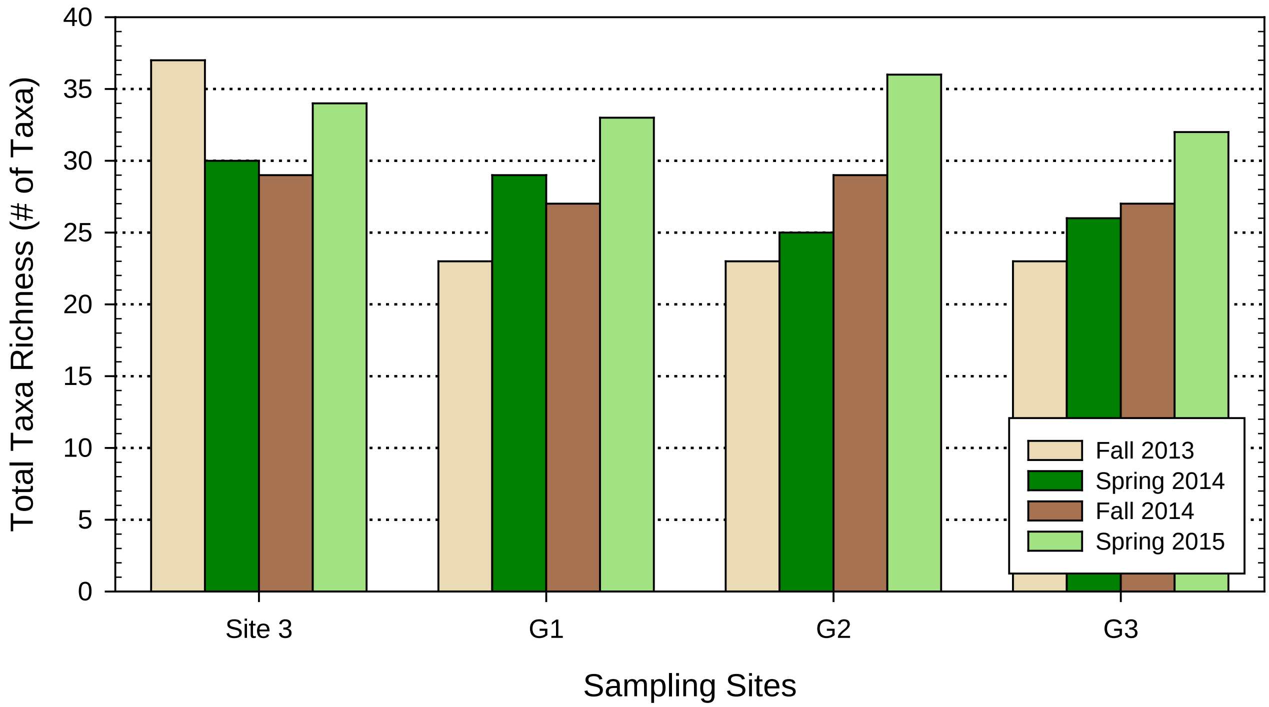


Figure 28. Benthic macroinvertebrate total taxa richness at three gravel augmentation sites and the control site (Site 3) in the lower Deschutes River downstream from the re-regulation dam.

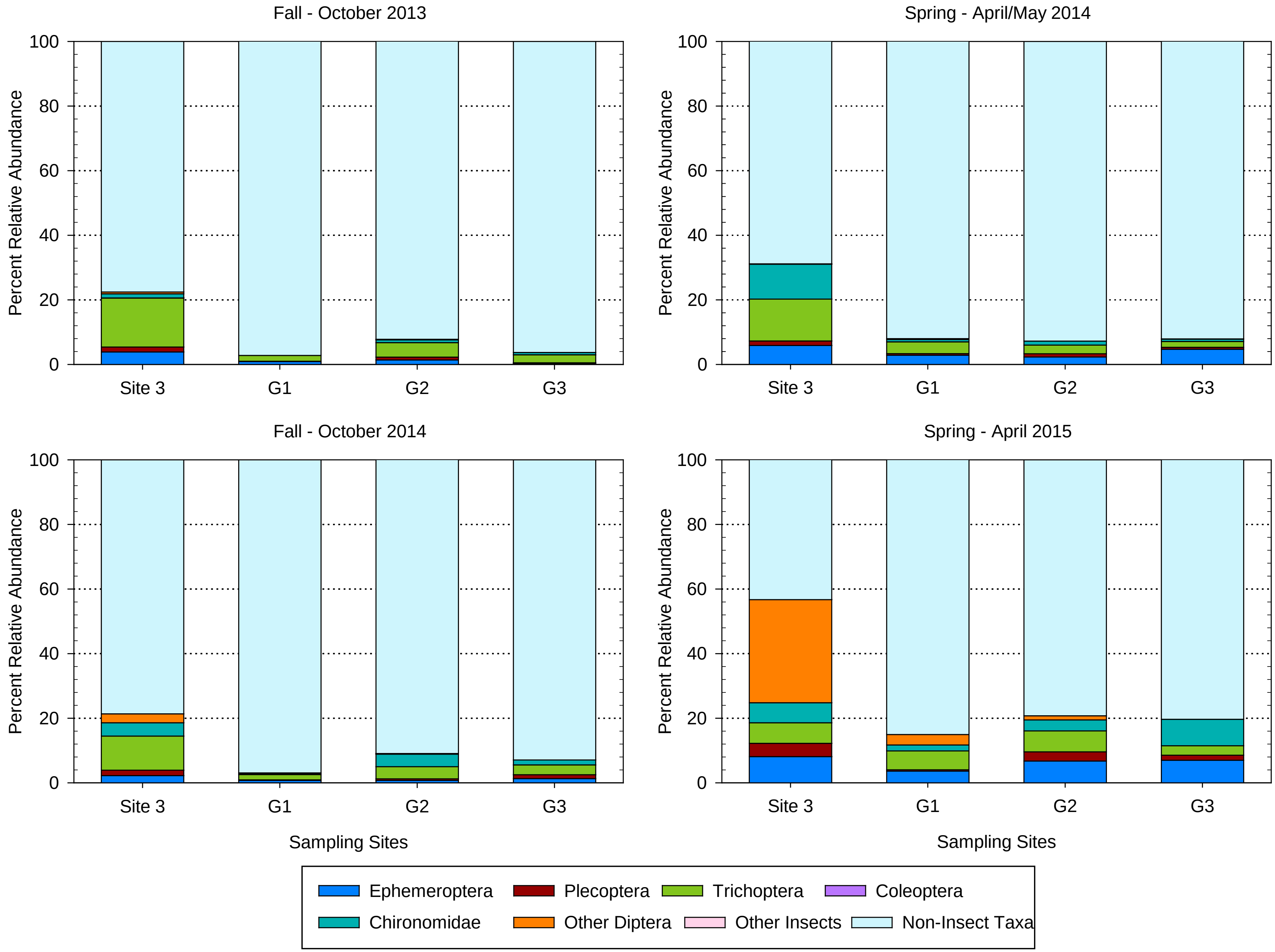


Figure 29. Relative abundances of major taxonomic groups of benthic macroinvertebrates at three gravel augmentation sites and the control site (Site 3) in the lower Deschutes River downstream from the re-regulation dam.

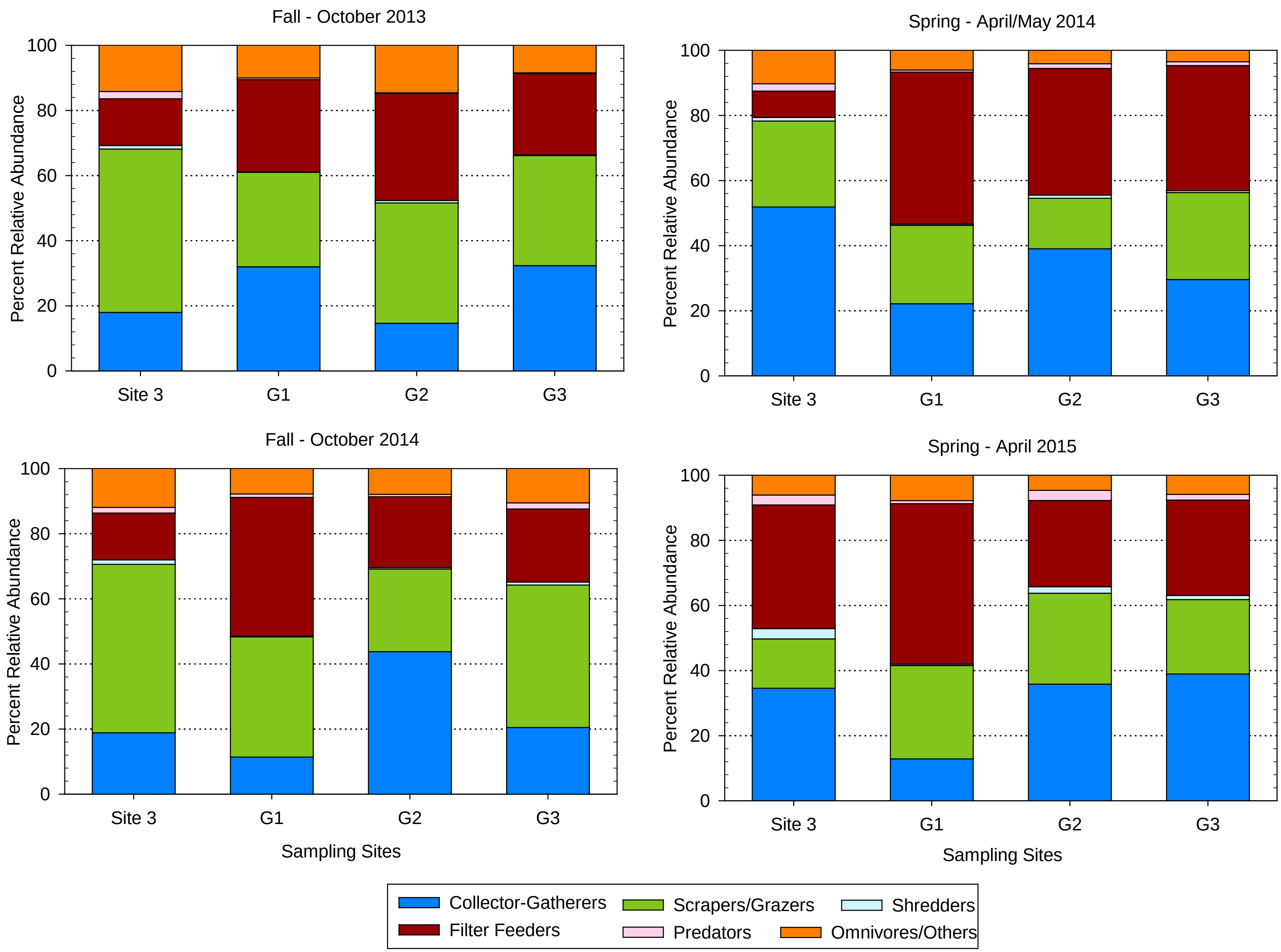


Figure 30. Relative abundances of functional feeding groups of benthic macroinvertebrates at three gravel augmentation sites and the control site (Site 3) in the lower Deschutes River downstream from the re-regulation dam.

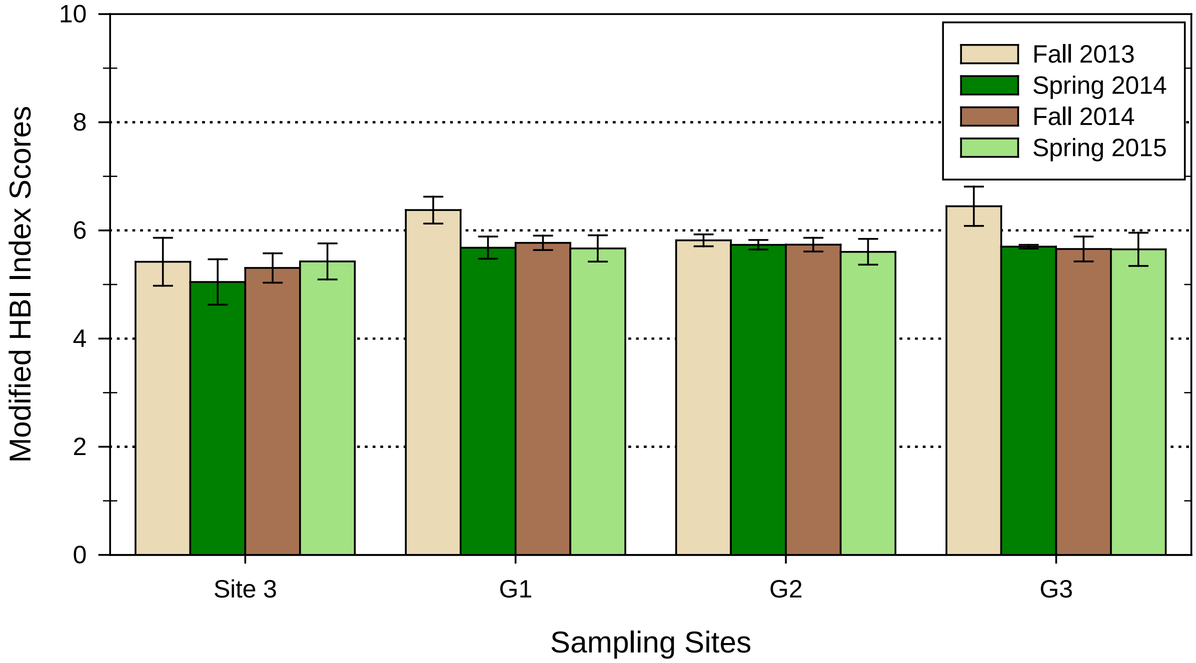


Figure 31. **Tolerance scores for the Modified Hilsenhoff Biotic Index (MHBI) for benthic macroinvertebrates at three gravel augmentation sites and the control site (Site 3) in the lower Deschutes River downstream from the re-regulation dam.**

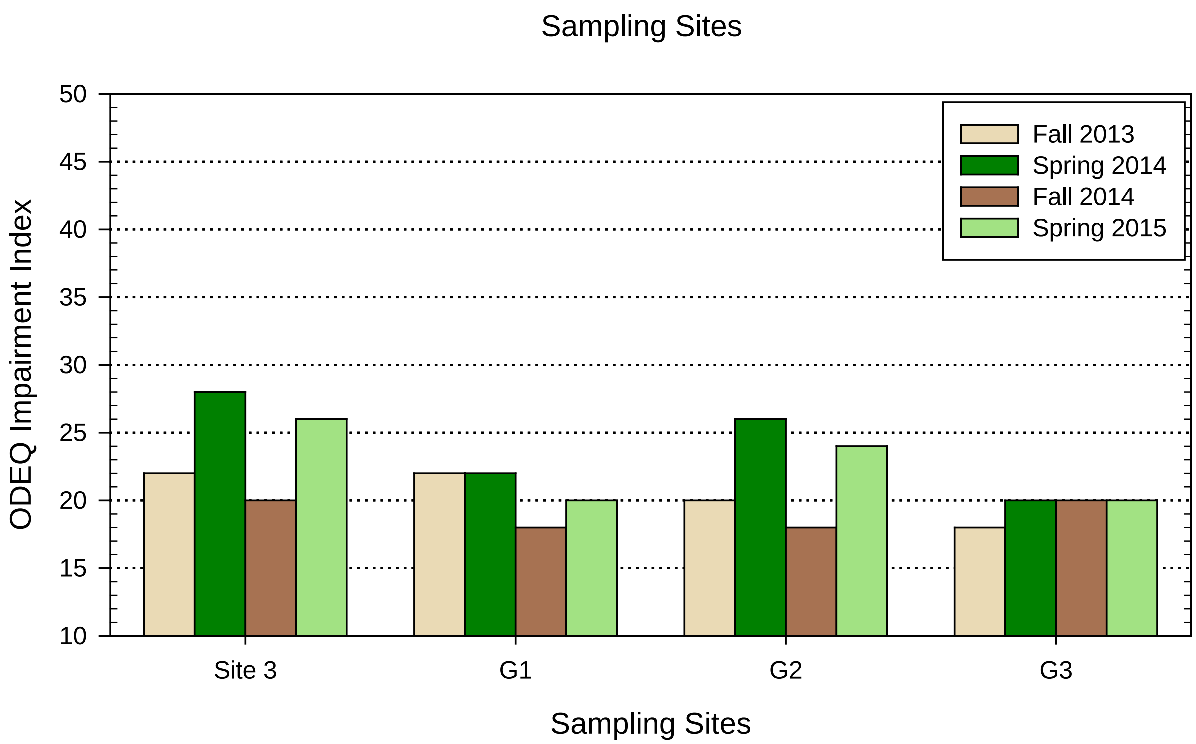


Figure 32. **Index score totals for the ODEQ Impairment Index for benthic macroinvertebrates at three gravel augmentation sites and the control site (Site 3) in the lower Deschutes River downstream from the re-regulation dam.**

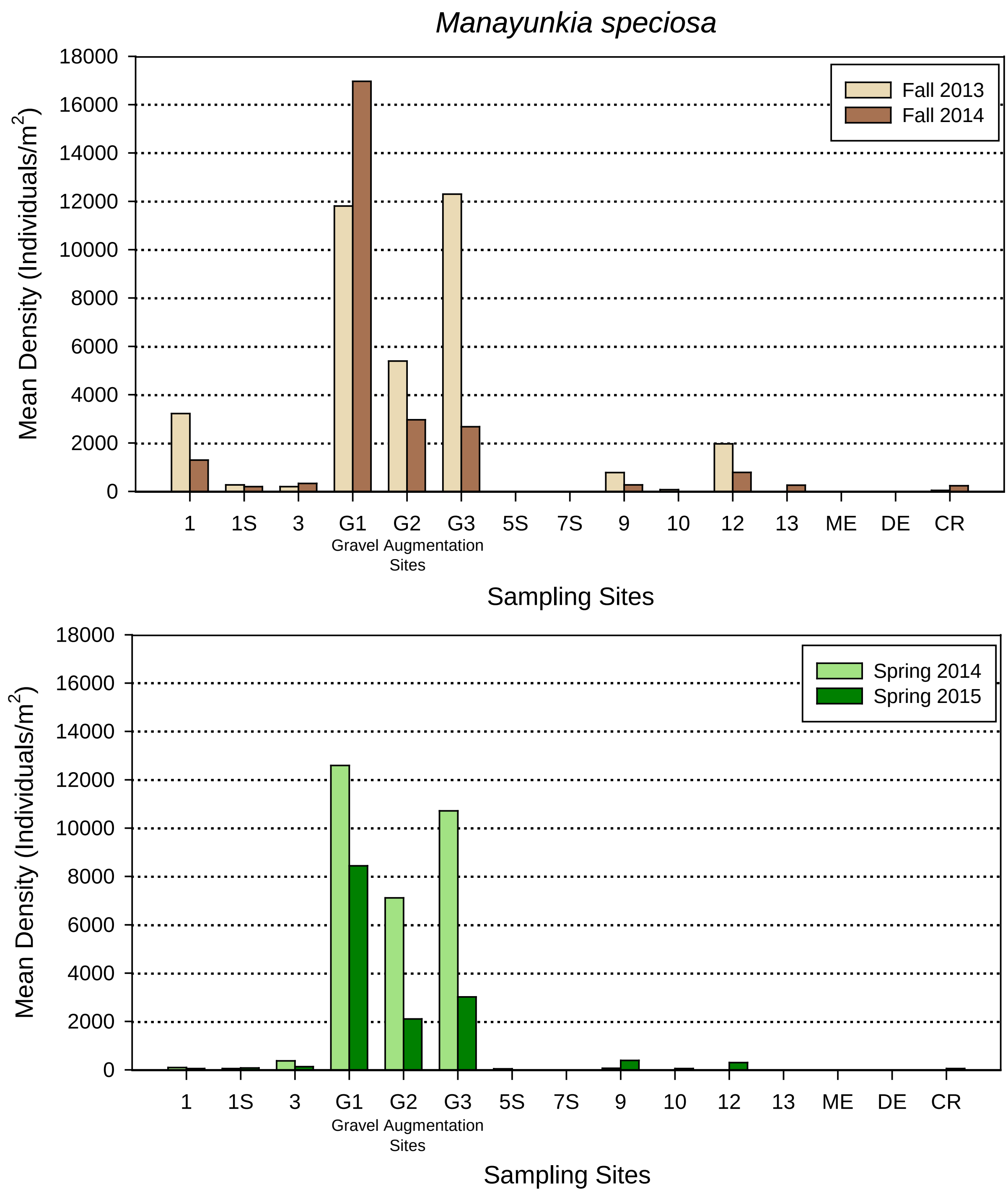


Figure 33. Density estimates of the polychaete *Manayunkia speciosa* in the lower Deschutes River downstream from the re-regulation dam and three reference sites.

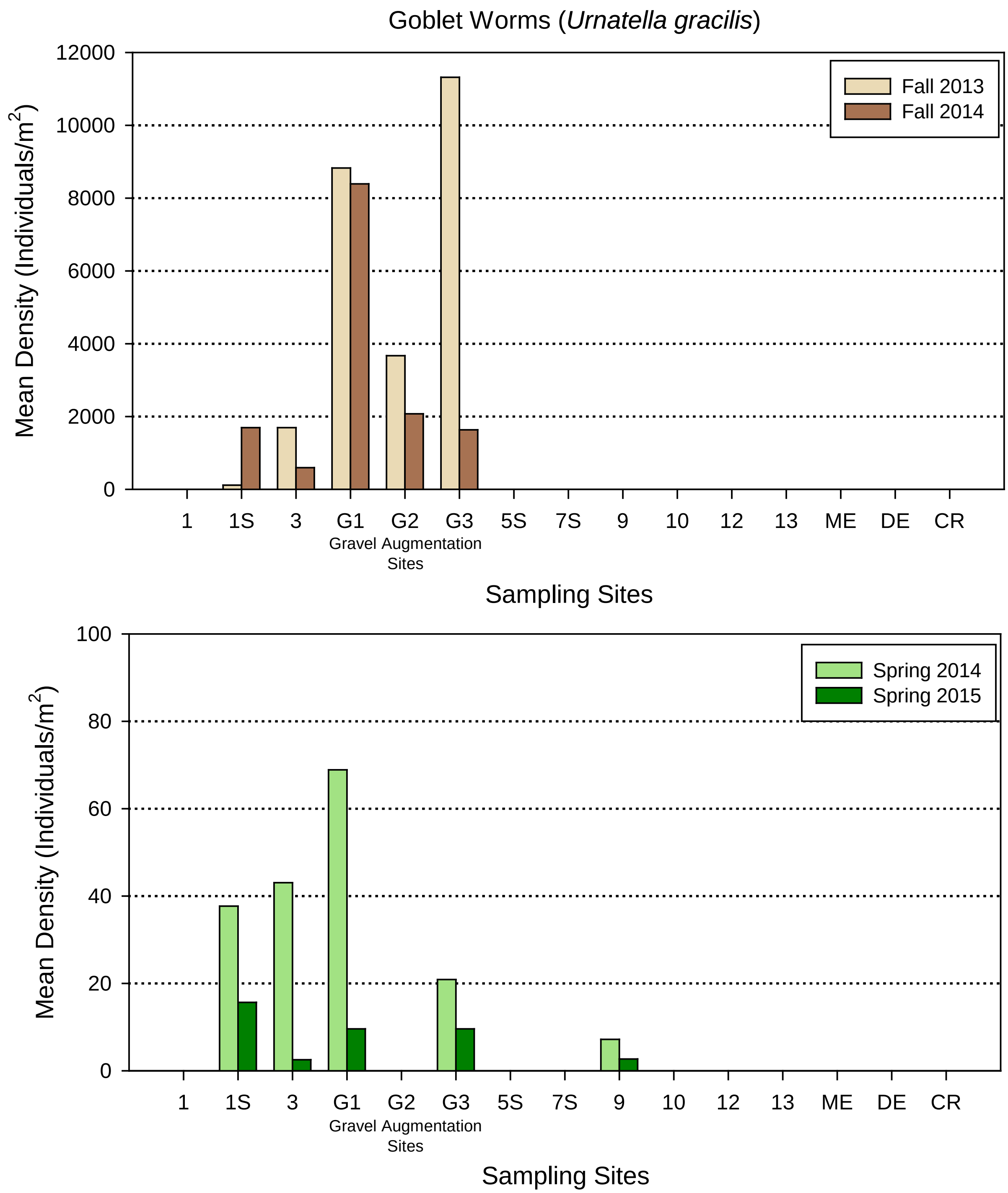


Figure 34. Density estimates of the ectoproct *Urnatella gracilis* (goblet worm) in the lower Deschutes River downstream from the Reregulation dam and three reference sites.

DISCUSSION

Macroinvertebrate and periphyton communities are naturally complex and dynamic, varying tremendously due to normal seasonal and annual environmental variation, periodic large-scale environmental disturbances, and simple chance. This assessment employed a spatially and temporally stratified sampling design to evaluate project effects on the aquatic community. The evaluation was based on three lines of inference: 1) longitudinal trends downstream from the project, 2) comparisons of sites downstream and upstream of the project, 3) comparisons of pre- vs. post-SWW samples.

First, project effects can be inferred from spatial patterns downstream from the reservoir discharge. Benthic communities at any given point on the stream continuum reflect environmental conditions at that point which in turn are influenced by the aggregate of conditions at and upstream of each site. Sites immediately downstream from the project will be most heavily influenced by reservoir discharge and operations. Significant differences in macroinvertebrate and periphyton characteristics along the river continuum will provide an indication of project effects. The Serial Discontinuity Concept (SDC) (Ward and Stanford 1983) predicts that in response to the interruption of the river continuum, the stream system will also tend to reset itself toward natural or unregulated conditions with increasing distance downstream from the dam or river regulation (Stanford and Ward 2001). That is not to say that areas further downstream may not be affected but rather, the current extent of sampling should be adequate to identify substantive changes that might have occurred.

Second, project effects may be inferred from comparisons of sites downstream and upstream from the reservoir. Sample sites upstream from the reservoir can be considered at least somewhat representative of conditions that are not affected by the SWW. Upstream sites do not represent perfect controls because similar riverine habitats do not occur downstream and upstream. Upstream samples must come from three smaller streams whose confluence now occurs in the reservoir. However, upstream sites can provide useful reference points describing normal conditions and variability at sites unaffected by reservoir operations.

Finally, comparisons of before and after samples among areas provides the most robust basis for inference of SWW effects. The study employed a “Before-After, Control-Impact” (BACI) experimental design, examining differences over time above and below the project and along a longitudinal gradient downstream from the project.

Macroinvertebrates

The lower Deschutes River supports a tremendously productive and diverse aquatic ecosystem. Benthic macroinvertebrate numbers typically reach 10,000 or more individual organisms per square meter of substrate in productive riffle habitats. These densities are in the high range of values reported for temperate rivers and streams throughout the region (Table 11).

Table 11. Example benthic macroinvertebrate densities (individuals/m^2) reported for western U.S. streams.

Location	State	Density Range	Reference
lower Deschutes River	OR	4,000-35,000	This study
lower Sprague River	OR	8,100-23,200	Nightengale & Reiser 2005
12 stream sites from Western Pilot EMAP	WY, MT, CO	2,000-20,000	Peterson and Zumberge 2006
41 streams and rivers of Blue Mountain Ecoregion	OR, WA, ID	200-17,500	Li et al. 1995
Okanogan River	WA	6,100-15,000	Nightengale 2002
Yakima River	WA	500-14,700	Nightengale 2002
15 streams in Salmon, Yakima, Klickitat & Wind River subbasins	WA, OR, ID	4,500-11,700	Kohler et al. 2012
Salmonberry River (Nehalem basin)	OR	2,000-8,000	Fergusson 2013

The benthic macroinvertebrate community was diverse, with most sites supporting 30 to 50 taxa. Insects generally predominated, although non-insect taxa were also abundant in certain times and places. Mayflies (Ephemeroptera) and caddisflies (Trichoptera) were the most abundant insect taxa with midges (*Chironomidae*), other flies (Diptera), and beetles (Coleoptera) also well represented. Stoneflies were not numerically abundant but were widely distributed and contributed substantially to the invertebrate biomass by virtue of their often large size. Non-insect taxa included oligochaete worms, flatworms, and snails. Collector-gatherers, scraper/grazers, and filter feeders were all well-represented among macroinvertebrate species. This pattern is typical where primary productivity is driven by periphyton and particulate organic matter. Shredders, predators, and omnivores comprised a relatively small proportion of the community by number.

Seasonal differences were apparent across years between fall and spring samples. Macroinvertebrate densities in fall were almost double those of spring as large numbers of smaller, younger organisms were present. Taxa richness was generally similar as the same taxa were generally represented in varying proportions in both seasons with minor differences among the less-abundant taxa. Caddisfly larvae (Trichoptera) were generally more abundant in the fall while the relative abundance of dipteran larvae (chironomids and simuliids) and mayfly nymphs (Ephemeroptera) was greater in spring. Non-insect taxa were relatively more abundant in fall than spring. Fall collections were generally higher in scrapers/grazers (mostly snails) and filter-feeding taxa (largely hydropsychid caddis larvae and blackfly larvae), whereas collector-gatherer taxa predominated in spring.

Annual variation in consecutive sampling years was relatively low in relation to seasonal and spatial patterns. Organism density and taxa richness were particularly consistent. Species composition was more variable.

Distinct longitudinal patterns were observed downstream from the project and many of these patterns were statistically significant. While high densities of organisms were documented at all sites, taxa richness was substantially lower immediately downstream from the project than in sites farther downstream. Non-insect taxa including oligochaete worms, flatworms, and snails predominated at sample sites within 4 miles of the project (Sites 1-3). Insects at these sites were primarily dipterans (chironomids and simuliids) versus the mayfly and caddisfly larvae prevalent in sites farther downstream.

Filter feeders and omnivores were abundant immediately downstream from the project, particularly in fall. Filter-feeding caddisflies (Hydropsychidae) in the fall and blackfly larvae (Simuliidae) in the spring are likely taking advantage of zooplankton and phytoplankton entrained from Lake Billy Chinook. Omnivores, primarily flatworms (Class Turbellaria) prey on small invertebrates, such as rotifers, protists, or zooplankton and also feed on detritus (dead particulate organic matter) likely supplied by the Project. Site differences in functional feeding groups were less pronounced in spring when reservoir primary productivity was likely much less of an influence downstream.

Downstream from the immediate project influence, the macroinvertebrate community generally varied from site to site with no obvious longitudinal pattern. Densities and taxa richness were consistently high with a diverse species composition including mayflies, caddisflies, and dipterans as well as a variety of other insect and non-insect taxa. Collector/gatherers, scraper/grazers, and filter-feeders were all well represented. Collector/gatherers feed on fine particulate organic matter and represent the broadest assemblage of taxa. Near the dam, oligochaetes comprise the largest proportion of collector-gatherers. Downstream, this functional feeding group is represented by a variety of mayflies, caddisflies, and chironomid larvae. Scraper/grazers include large numbers of gastropods (snails, limpets) feeding on the periphyton and macrophyte growth prevalent throughout the lower river. Filter feeders including Hydropsychidae caddisflies take advantage of food resources introduced by the watershed, as well as upstream processing of coarser food resources into smaller particles.

The general distribution of the benthic macroinvertebrate community in the lower Deschutes River shows a distinct difference between the sites immediately downstream of the Project, and those sites below Shitike Creek. The occurrence of this apparent separation of BMI community types is a clear demonstration of the serial discontinuity concept (SDC) (Ward and Stanford 1983; Stanford and Ward 2001), showing that in response to the interruption of the river continuum by the Project, the lower Deschutes River has a tendency to return to natural or unregulated conditions as the distance from the Project increases. A review of the SDC by Ellis and Jones (2013) further described that there are likely two recovery SDC gradients that exist in regulated rivers: a shorter, resource subsidy gradient recovering within 1–4 kilometers downstream of an impoundment and a longer, thermal gradient extending much farther downstream. Results from both the baseline study and this current study show the shorter gradient below the Project. The extent of the longer gradient is less clear, but results suggest that the BMI community reaches its peak in recovery around Sites 9 and 10, near the confluence with Warm Springs River.

A hypothesis that tributary inputs downstream from the project may have an effect on macroinvertebrate and periphyton communities was one of the original hypotheses in the pre-SWW baseline study. Initial baseline study sample sites were established to investigate this possibility. While conditions at any site along the river continuum reflect the aggregate effects of upstream influences, relative contributions of tributaries are small in comparison with the river mainstem and large effects were not apparent in either the baseline or post-SWW study.

Macroinvertebrate communities in the Deschutes and Metolius rivers upstream from the project are generally less dense but similarly diverse to downstream sites below the immediate influence of the project. Densities in the Crooked River were substantially greater than the other two upstream sites and similar to densities documented throughout the lower river. The benthic community in upstream sites included many of the same taxa observed in lower river sites although the assemblage was distinctly different in terms of the percentage of major taxa, particularly due to an increased abundance of Tanypodinae midges. The Metolius site was further distinguished by the prevalence of insect taxa – non-insects did not comprise a substantial portion of the sample in any collection.

Differences in pre- and post-SWW macroinvertebrate community composition provide some evidence for implementation effects that were most apparent in the area immediately downstream from the project. Study results did not identify large changes in the macroinvertebrate community before and after SWW implementation, but seasonal changes in community composition were apparent and consistent with shifts in life cycle timing, which may be explained by changing temperature patterns downstream from the project. Most every species that was present or common before SWW implementation was also present or common after SWW implementation but changes in relative seasonal numbers were apparent. Changes were complex. Some taxa appear to have decreased while others have increased. For instance, filter-feeding Hydropsychidae caddisfly larvae increased at Sites 5 through 10 in fall. *Ephemerella* mayfly larvae increased significantly at Sites 1 through 10 in fall but not in spring. Giant Salmonflies (*Pteronarcys californica*) increased significantly in fall post-SWW but no difference was apparent in spring. Golden Stones (*Hesperoperla pacifica*) decreased significantly spring post-SWW but no difference was observed in fall.

The change in temperature as a result of the SWW operations may explain the density shifts noted for several of the key taxa of interest. Temperature directly affects macroinvertebrates by regulating their metabolic rates, influencing both the growth and timing of their development from egg to adult. Changes in temperature can influence the length of the incubation period, hatching success and duration, and the instigation or termination of diapauses that are brought on by extreme conditions (Ward 1992; Williams and Feltmate 1992). In larval development, larvae usually develop faster with higher temperatures, as ingestion and assimilation rates of food increases (Williams and Feltmate 1992). Most importantly, temperature is involved in the timing of life cycles, as well as the frequency of those life cycles, or voltinism (Ward 1992; Williams and Feltmate 1992). A seasonal change in temperature often acts as an environmental cue for emergence in aquatic insects, but increasing the water temperature can result in earlier emergence; decreasing it delays emergence (Williams and Feltmate 1992). Early emergence was noted during this study during spring sampling, with observations of emerging giant salmonflies (*Pteronarcys californica*) in late April. According to Schollmeyer (1994), the hatch for this species on the lower Deschutes River takes place in May-June, suggesting that emergence is earlier than it was during the pre-SWW period.

Therefore, a shift in life history timing can produce very different results among years when sampling occurs during fixed sampling periods (April/May and October, for this study). A taxon collected in a given month prior to the shift may be abundant as larvae because emergence has not occurred. However, earlier emergence with increased temperature may produce much lower numbers in a sample collected in the same month following the timing shift. Likewise, an earlier emergence would result in earlier egg depositions, and warmer temperature could also decrease the incubation period during the spring and summer, resulting in more larvae hatching earlier, thus increasing densities of certain taxa during the fall sampling period that would be missed if water temperatures were cooler.

Organism densities and species diversity were consistently high in both pre- and post-SWW samples, although finer patterns need to be considered with caution. Organism densities increased in many pre- versus post-SWW samples but this difference appears to be at least partially an artifact of differences in methodology of the two studies. Differences were largely attributed to increases in non-insect taxa at virtually all sites. Because of the widespread nature of this change, we are led to believe that the difference could be that sample preservation methods in the baseline study were not effective for these soft-bodied organisms. Comparisons of taxa richness were also affected by changes in sampling and laboratory analysis protocols. Subsampling after the first pre-SWW sample year reduced incidence of rare taxa as fewer total organisms were identified.

Some differences were also noted between pre- and post-SWW sampling periods in species composition of reference sites upstream. For instance, *Antocha* craneflies were widely distributed in pre-SWW samples above and below the project but nearly absent post-SWW from almost all sites including the Deschutes and Crooked Rivers upstream from the project. Significant numbers were observed post-SWW only in the Metolius River, a unique spring-dominated system with minimal development compared to the Crooked and Deschutes systems. Most likely, this change is a result of a broader environmental pattern as opposed to a project-related effect. It is unknown whether this pattern represents normal annual variability or a longer term trend. However, this observation highlights the value of the upstream reference sites in distinguishing project from non-project changes.

Additional information on *Antocha* numbers in the upper Deschutes Basin is available from two BLM reports by Mark Vinson of Utah State University (Vinson 2005; Vinson and Dinger 2007). Samples were collected in these studies from sites at or near the reference sites sampled during the PGE study in the Crooked River in 2004 (Vinson 2005), and on the Deschutes (above the project) in 2005-2006 (Vinson and Dinger 2007). Both BLM surveys found *Antocha* numbers to be low or absent in the samples at the reference sites. Counts of only 1-7 individuals/m^2 were noted. In comparison, baseline study counts in 1999-2001 were 7-71 individuals/m^2 at the upper Deschutes site, and 30-160 individuals/m^2 at the Crooked River site.

So, while *Antocha* numbers have declined downstream from the project since 2001, similar declines occurred upstream from the project. BLM study results suggest that the upstream decline might have occurred before implementation of the SWW. The causes of these changes remain unclear. While SWW effects may have been a factor downstream, we cannot preclude the possibility that changes resulted from other environmental factors common to all sample areas due to a lack of data for the periods of 2001-2009 (pre-SWW) and 2010-2013 (post-SWW).

Results of any individual number or statistic also need to be considered in the context of all the other results rather than individual metrics considered in isolation. There are so many taxa, metrics, and indices that some differences between locations, seasons, periods and treatments are inevitable. The challenge is to understand what the little pieces are telling us without also losing track of the bigger picture.

Periphyton

Attached benthic algae in the lower Deschutes River included a large and diverse diatom community but a few "soft" algae species generally dominated the biovolume. Taxa richness ranged from 17 to 56 diatom taxa while soft algae included only 3 to 10 taxa, depending on sample site.

Seasonal and annual variation in periphyton was substantial in post-SWW samples. Periphyton densities, biovolumes, or taxa richness from the baseline study are not comparable because of differences in processing and analysis in the standardized EPA/USGS methodology used in the post-SWW study and less rigorous methods used in the baseline study. Diatom and soft algae densities were consistently greater in spring than fall while biovolume of both was generally greater in the fall. Large differences among years were also observed in post-SWW samples particularly for soft algae. Numbers were substantially greater in fall 2014 than fall 2013, and spring 2015 than spring 2014. No apparent seasonal or spatial trends in taxa richness were observed during the post-SWW study. We also note that spring and fall samples do not represent peak production periods which occur in summer. <u>Spring and fall periods were</u>

sampled for consistency with the baseline study as indicators of Project effects, rather than as descriptors of the full scope of seasonal primary productivity.

No consistent longitudinal spatial trend for periphyton densities, biovolumes or taxa richness was apparent in post-SWW samples from Lower Deschutes sites downstream from the Project. Any site differences that occurred were dwarfed by annual and seasonal variability. We also note that periphyton biovolumes are also heavily influenced by sampling depth and proximity to shoreline. During sampling trips, we observed thicker algal growth in very shallow shoreline areas with very low stream velocities. Autecological metric scores in post-SWW samples of shallow-water sites (Sites 1S, 5S, and 7S) during fall were often notably higher or lower than other sites and generally indicative of diatom taxa that exist under stressful water quality conditions.

The taxa assemblage in reference sites upstream from the Project was distinctly different than the taxa present at the lower Deschutes River sites. For instance, reference sites were distinguished from the other sites based on an increased abundance of the diatoms *Achnanthidium gracillimum* and *Encyonema silesiacum*. However, no consistent differences were documented in periphyton densities, biovolumes or taxa richness between lower Deschutes sites and reference sites upstream from the Project.

Autecological metrics describing diatom communities and their responses to ecological conditions can be compared between pre-SWW and post-SWW sampling periods. Pre- vs. post-SWW comparisons were made via non-parametric paired t-tests with a selected number of autecological metrics calculated from the diatom assemblages for the 7 Lower Deschutes sites shared between the baseline study and this study. Twelve of the 14 diatom metrics calculated showed a significant difference in post-SWW spring collections. Changes included reductions in percentages of eutraphentic taxa, low DO taxa, and siltation taxa; increases in the Pollution Tolerance Index and percent nitrogen autotroph taxa. However, this may also be the result of the more intensive sampling methodology used in the current study compared to the baseline, pre-SWW study. No significant pre- vs. post- SWW differences were detected for the autecological metrics for fall sampling efforts.

Gravel Augmentation Sites

A secondary goal of this study is to determine how the benthic macroinvertebrate community has responded to gravel augmentation. Three sites downstream of the Project have been augmented with gravel in accordance with the Lower River Gravel Study Plan. A nearby site (Site 3) sampled for the post-SWW assessment served as a control for augmentation sites. Gravel augmentation occurred in 2008. Our sampling began in 2013, giving the macroinvertebrate community approximately five years to colonize the new gravel.

Benthic macroinvertebrate densities at gravel sites were significantly higher and taxa richness was significantly lower than at the control site during fall 2013. Some of the highest oligochaete and gastropod densities of the study were documented at gravel sites in fall 2013. Densities and taxa richness were not significantly different among the sites for the other three seasonal collections. Taxa richness, modified HBI scores, and the ODEQ Impairment Index scores gradually improved at gravel sites as the study progressed.

Gravel augmentation sites supported uniquely high densities of the polychaete *Manayunkia speciosa* (10,000 individuals/m^2). This filter-feeding species also occurred at several other sampling sites, although at much lower densities. Also unique to the gravel augmentation sites was the occurrence of Entoprocta, a primitive moss-like colony forming animal, *Urnatella gracilis*, often called goblet worms. Their occurrence was largely limited to the fall sampling periods exclusively within both the gravel augmentation sites, as well as a more limited amount at Sites 1S and 3; spring densities were much lower. While not counted in the macroinvertebrate samples, their abundance is very likely related to zooplankton presence and other particulates released by the dam. It is probable that the polychaetes originate from the reservoirs upstream (Ratliff 1983), and have colonized these gravel augmentation sites because they have little to no competition for space or resources. As demonstrated in Figure 33, the polychaetes are present at other lower Deschutes sites, but these other sites are not new and "clean", thus the established macroinvertebrate assemblage presents a significant amount of competition that prevents polychaetes from having an advantage.

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APPENDIX I - SITE DESCRIPTIONS

Site 1 – Downstream from Reregulating Dam

This site is located 0.1 mile downstream of the Reregulating Dam at RM 99.9. The sampling area is a gravel and cobble riffle situated near the head of a large island located adjacent to the eastern bank of the river. During baseline studies, four "shallow" invertebrate samples 1.0 ft depth) along the margin of the river (varial zone) were obtained in addition to four "normal" samples (> 1.0 ft depth) at this site.

During post-project sampling Sites 1 and 1S just downstream from the dam, at Buzzard Island, were accessed using a 14' whitewater raft. The current site location is identical to where the baseline study coordinates and field notes placed it. Site 1S is designated as a "shallow" site, meaning at samples were taken at water depths under 12 inches, and thus were located closer to the shoreline. Site 1 samples were collected further out in the channel, in depths largely between 1 and 2 feet. The riffle area at this site was extensive, but featured numerous large macrophyte beds in October 2013. Velocities were also high, running between 2 ft/s to 3.7 ft/s for sampling.

Appendix I Figure 1. **Site 1 and 1S locations collected in 2013-2015 (white squares indicate the upstream and downstream extents).**

Appendix I Figure 2. **Site 1/1S collected in October 2013, looking upstream from downstream end.**

Appendix I Figure 3. **Site 1/1S collected in October 2014, looking downstream from upstream end.**

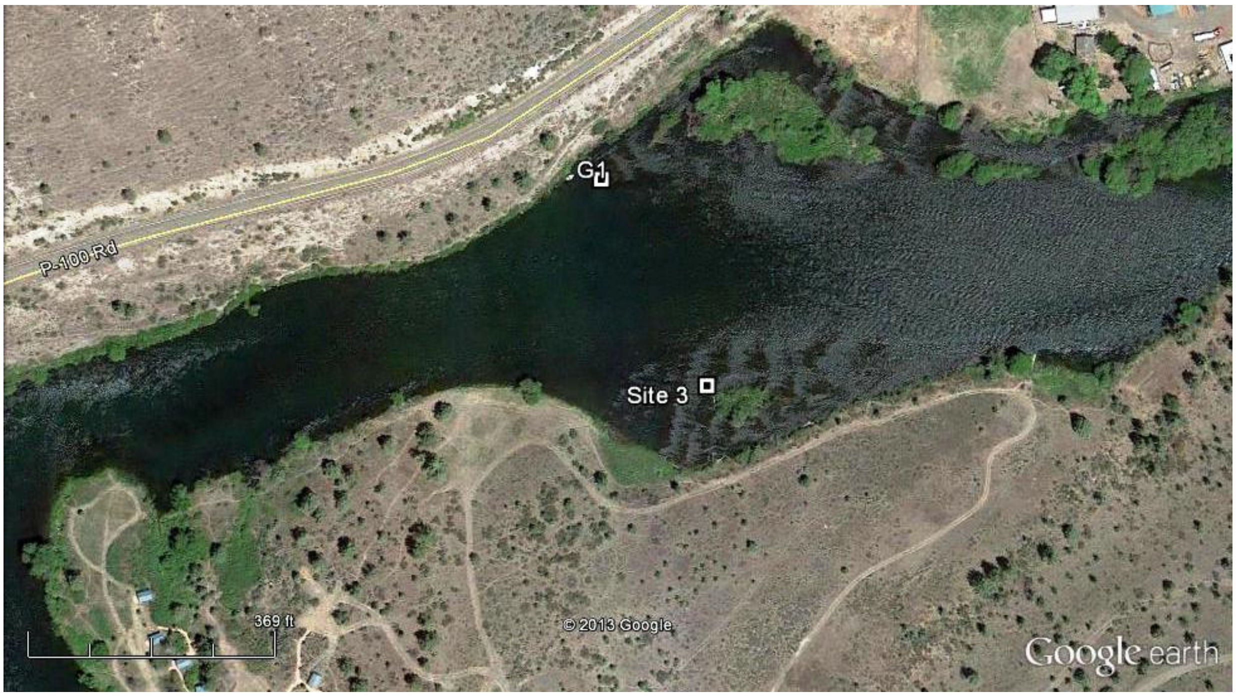
Site 2 -

This site is located 0.5 mile downstream of the Reregulating Dam, and is situated along the western bank of the river immediately downstream of the U.S. Geological Survey (USGS) gaging station (RM 99.5). Baseline sampling was conducted within a cobble and gravel run situated between the west bank of the river and a submerged island.

Appendix I Figure 4. Location of baseline sampling site (Latitude: 44.730578° Longitude: -121.243709°).

Site 3 – Dizney Island

This site is located 1.0 mile downstream of the Reregulating Dam at Disney Riffle (RM 99.0). The sampling area is gravel and cobble dominated riffle located along the head of an island situated adjacent to the west bank of the river. Samples are collected at the head of Dizney Island. The current site location is identical to where the baseline study coordinates and field notes placed it. Samples are taken on the main channel side of the island. Substrate present at this site forms spawning swales, allowing sampling at a variety of depths. Samples in 1 ft of water were taken at the crests of a swale, whereas samples in depths of up to 2.5 to 3 ft of water were taken at the bottom of swales.



Appendix I Figure 5.   Site 3 and Gravel Augmentation Site G1 locations collected in 2013-2015.

Appendix I Figure 6. Site 3 collected in April 2015, looking downstream from upstream end.

Appendix I Figure 7. Site 3 collected in October 2014, looking upstream from downstream end.

Site 4 – Upstream from Shitake Creek

This sampling site is located 2.5 miles downstream of the Reregulating Dam above the confluence of Shitike Creek (RM 97.5). The sampling area is a cobble and gravel run located along the mid-section of a small island located adjacent to the western bank of the river.

Appendix I Figure 8. **Location of baseline sampling site (Latitude: 44.744945° Longitude: -121.229695°).**

Site 5s - Lumber Mill Island

This is a shallow sampling site situated just downstream of the confluence of Shitike Creek (RM 96.0). The sampling area is located along the west side of an island located across from the Warm Springs log mill. Samples are collected from a shallow gravel and cobble riffle located near the head of the island.

This site is accessed from the Warm Springs boat launch along Highway 26 using a 14' whitewater raft. The crew drifted downstream to Site 5S, located near the right bank off of Lumber Mill Island. An extensive riffle had formed along the main channel side of the island, from the top of the island, downstream. Baseline study coordinates and field notes from May 2000 indicated that baseline sampling may have occurred a short distance downstream, which was now a slower glide/riffle habitat. The site location was relocated slightly upstream of the baseline coordinates, due to the extensive shallow riffle habitat located near the head of the island.

Appendix I Figure 9. **Site 5S location collected in 2013-2015 (white square) in comparison with baseline study site coordinates (green circle).**

Appendix I Figure 10. **Site 5S collected in October 2013, looking downstream from upstream end of the site, near the upper end of the island.**

Appendix I Figure 11. **Site 5S collected in April 2014, looking upstream from downstream end of the site.**

Site 6

This sampling site is located at a large island situated just downstream of the BLM Mecca Flats Campground and boat ramp (RM 94.5). The sampling area is a cobble and gravel dominated run located along the head of the island.

Appendix I Figure 12. Location of baseline sampling site (Latitude: 44.776023° Longitude: -121.207373°).

Site 7s

This sampling site is situated downstream of an irrigation return located on the eastern bank of the river (RM 90.4). The sampling site is a shallow gravel and cobble riffle situated between a series of small islands. Shallow areas « 1.0 ft depth) were sampled at this site. Site 7S is accessed by raft. The site is located at approximately River Mile 90.4, upstream from Trout Creek, along a series of small islands in the center of the channel. The current site location is very close to where the baseline study coordinates and field notes placed it.

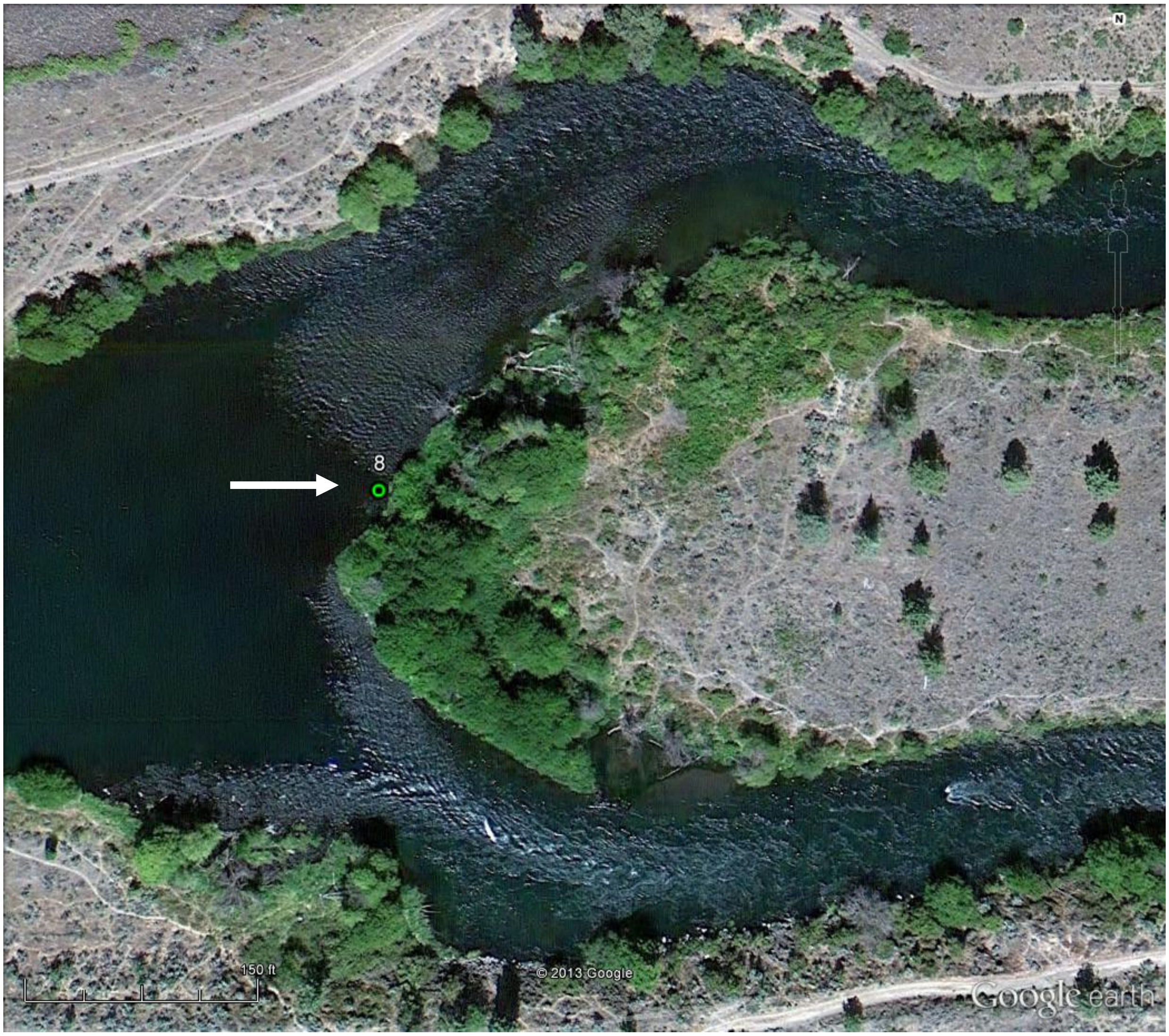
Appendix I Figure 13. **Site 7S location collected in 2013-2015, along the left side of a series of three small islands, and upstream of the larger island.**

Appendix I Figure 14. Site 7S collected in April 2014, along the left side of a series of three small islands looking downstream from upstream end of the site.

Appendix I Figure 15. Site 7S collected in April 2014, looking upstream from downstream end of the site.

Site 8 – Upstream from Trout Creek

The site is located along the upper edge of a large island located upstream of the confluence of Trout Creek (RM 88.0). The sampling area is a gravel and cobble riffle situated along the upper western edge of the island. Two sets of samples were acquired at this site: a "normal" set (> 1.0 ft depth) and a "shallow" set « 1.0 ft depth).

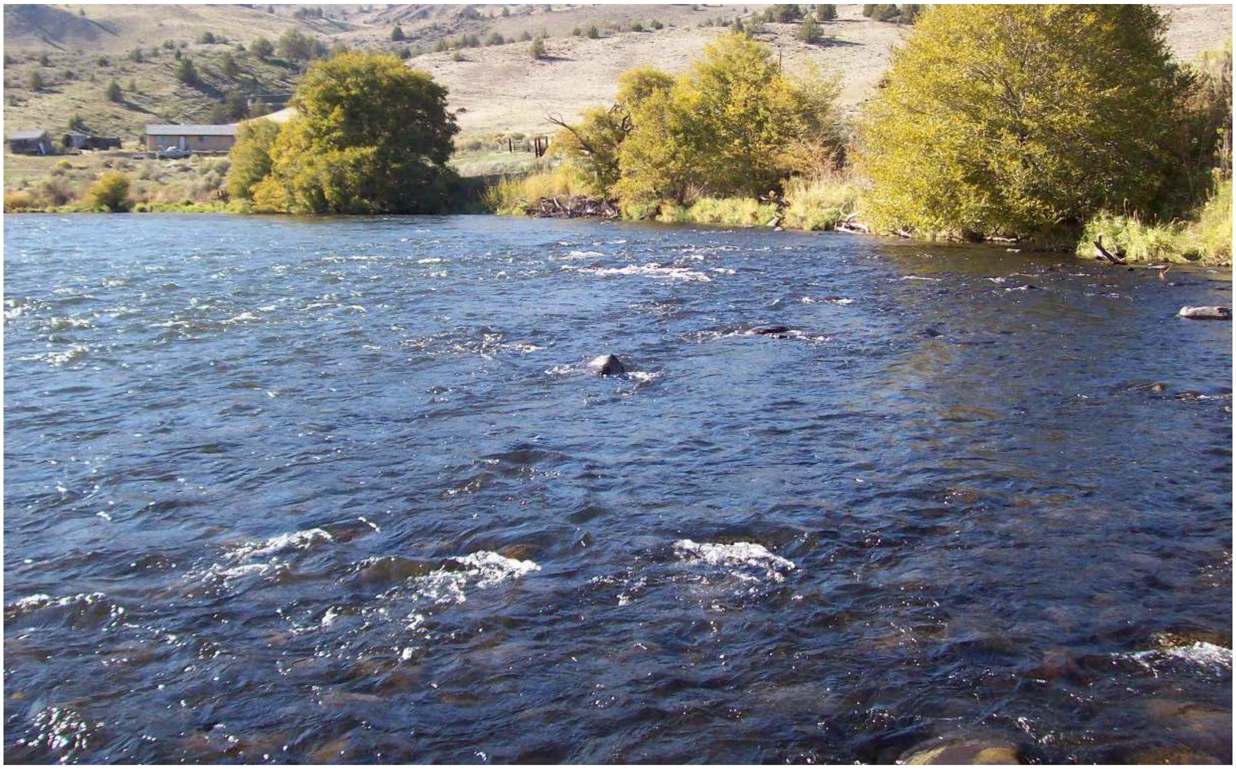


Appendix I Figure 16. Location of baseline sampling site (Latitude: 44.807386° Longitude: -121.110194°).

Site 9 - Above Warm Springs River

This site is situated downstream of Trout Creek and upstream of Warm Springs River (RM 85.0). The sampling area is located within a cobble riffle containing gravel patches, which is adjacent to the western bank of the river. Site 9 is sample by raft. The current site location is identical to where the baseline study coordinates and field notes placed it, along the left bank. The site is designated as a "deep" site, meaning that samples were to be collected within a range of depths from 1 to 3 ft. Substrate is large, consisting of large cobble and small, angular boulders. Rocks were covered with slippery algae, making walking within the site difficult. Kick sampling in larger substrates is difficult, so kick samples were taken in pockets of gravel and cobble located amongst the larger boulders, approximately 10-30 ft from the right bank.

Appendix I Figure 17. **Site 9 collection location in 2013-2015, upstream of the mouth of Warm Springs River.**



Appendix I Figure 18. Site 9 collected in October 2013, upstream of the mouth of Warm Springs River, looking upstream from downstream end of the site.

Appendix I Figure 19. Site 9 collected in October 2014, looking downstream from the upstream end of the site.

Site 10 – Below Warm Springs River

This site is located downstream of the Warm Springs River (RM 84.0). The site is situated along the west bank of the river along the upper edge of an island. Substrates at this site are dominated by gravels and small cobbles. Site 10 is sampled by raft. The current site location is identical to where the baseline study coordinates and field notes placed it, along the left bank, looking downstream. The site is designated as a “deep” site, meaning that samples were to be collected within a range of depths from 1 to 3 ft. Substrate is similar to that seen at Site 9, consisting of large cobble and small, angular boulders. Rocks were covered in slippery algae, making walking within the site difficult. Kick sampling was conducted along the river left bank, approximately 10-30 ft from the shoreline.

Appendix I Figure 20. Site 10 collection location in 2013-2015, downstream of the mouth of Warm Springs River.

Appendix I Figure 21. **Site 10 collected in October 2013, looking upstream from the downstream end of the site.**

Appendix I Figure 22. **Site 10 collected in May 2014, looking downstream from the upstream end of the site.**

Site 11 – Upstream from White River

This invertebrate sampling site is located upstream of the confluence of the White River (RM 48.0). The sampling area is situated at a bend of the river along the eastern bank just downstream of the BLM Surf City Campground. Substrates are dominated by gravels and small cobbles.

Appendix I Figure 23. **Location of baseline sampling site (Latitude: 45.223099° Longitude: -121.080838°).**

Site 12– Sandy Beach

The most downstream site established on the Deschutes River is located downstream of the White River confluence at the BLM Sandy Beach boating access (RM 45.5). The sampling area contained a cobble and gravel riffle that was situated within a number of small islands located on the west bank of the river. This site is accessed the site by vehicle. Site coordinates and field notes provided from the May 2000 field efforts indicated that the sampling site was located just upstream of the boat launch, in a riffle area with moderate flows (1-2 ft/s), and a cobble/gravel mixture. Current conditions at these coordinates revealed a backwater area with current velocities of less than 1 ft/s, small, angular cobbles and boulders, and large amounts of macrophytes. At the bottom of this area is a bedrock sill, with channels cut through the bedrock allowing water to flow out. It would appear that large woody debris has lodged itself against this bedrock sill, blocking water, and eventually converting this sampling area from a riffle to a side channel pool. As such, the baseline site was no longer acceptable for comparable kick samples; therefore, the crew conducted additional reconnaissance, and relocated the sampling site a short distance downstream, below the boat launch, in a stretch of shoreline riffle with large cobble and small boulders, with pockets of gravel and small cobble located throughout.

Appendix I Figure 24. Site 12 collection location in 2013-2015, (white square) in comparison with baseline study site coordinates (green circle).

Appendix I Figure 25. **Site 12 location according to baseline coordinates and field notes from May 2000.**

Appendix I Figure 26. **Site 12 collected in May 2014, located just downstream from the Sandy Beach boat launch, looking upstream from midpoint of the sampling reach.**

Appendix I Figure 27. Site 12 collected in October 2013, located just downstream from the Sandy Beach boat launch.

Site 13 – Macks Canyon Campground/Boat Launch

Site 13 was established in a riffle located along the left river bank, upstream of the Mack's Canyon Campground and boat launch area. Substrate is a cobble/gravel mixture with low sand, with current velocities ranging from 1.5 ft/s to 3.5 ft/s. This is a new site established for the current study – this site was not sampled during the baseline.

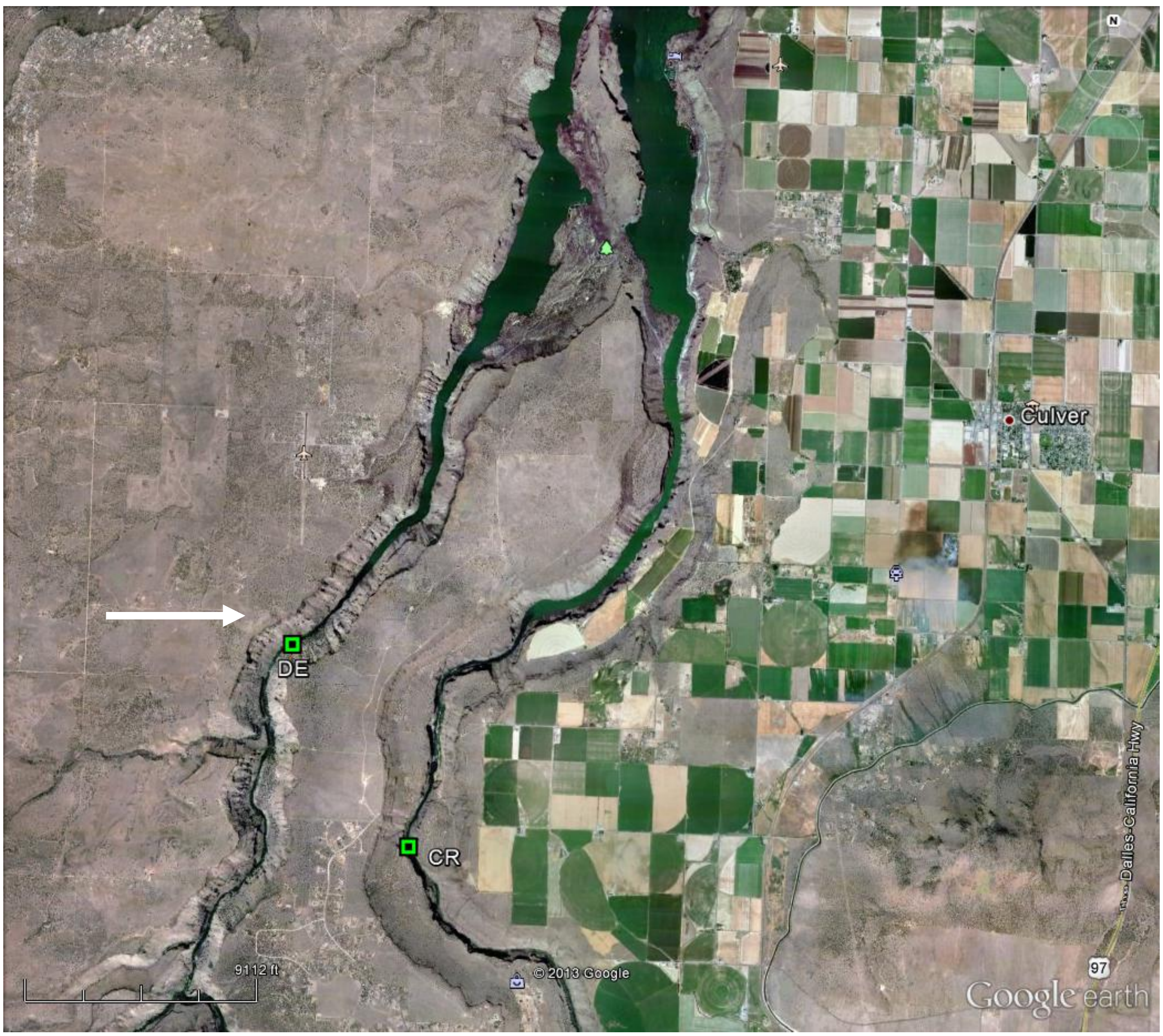
Appendix I Figure 28. Site 13 collection location in 2013-2015, located just upstream of the Mack's Canyon Boat Launch.

Appendix I Figure 29. **Site 13 collected in October 2013, looking upstream from the downstream end.**

Appendix I Figure 30. **Site 13 collected in April 2015, looking downstream from the upstream end.**

Site Upper Deschutes River (DE)

The sampling site on the Deschutes River was located 0.2 miles above the lake. The sampling area was a gravel bar located along the southern bank of the river immediately downstream of a USGS gaging station. This site was accessed from the Crooked River boat launch on Lake Billy Chinook. PGE provided transportation with a motor boat up the Deschutes River Arm of the lake, and accompanied the crew up to the USGS gage (14076500), where the reference site was located in a riffle immediately downstream of the gaging station. Current velocities were very high in the riffle, ranging from 2.6 f/s to 4.0 ft/s. As a result, samples contained large amounts of gravel that were flushed up and into the kick net.



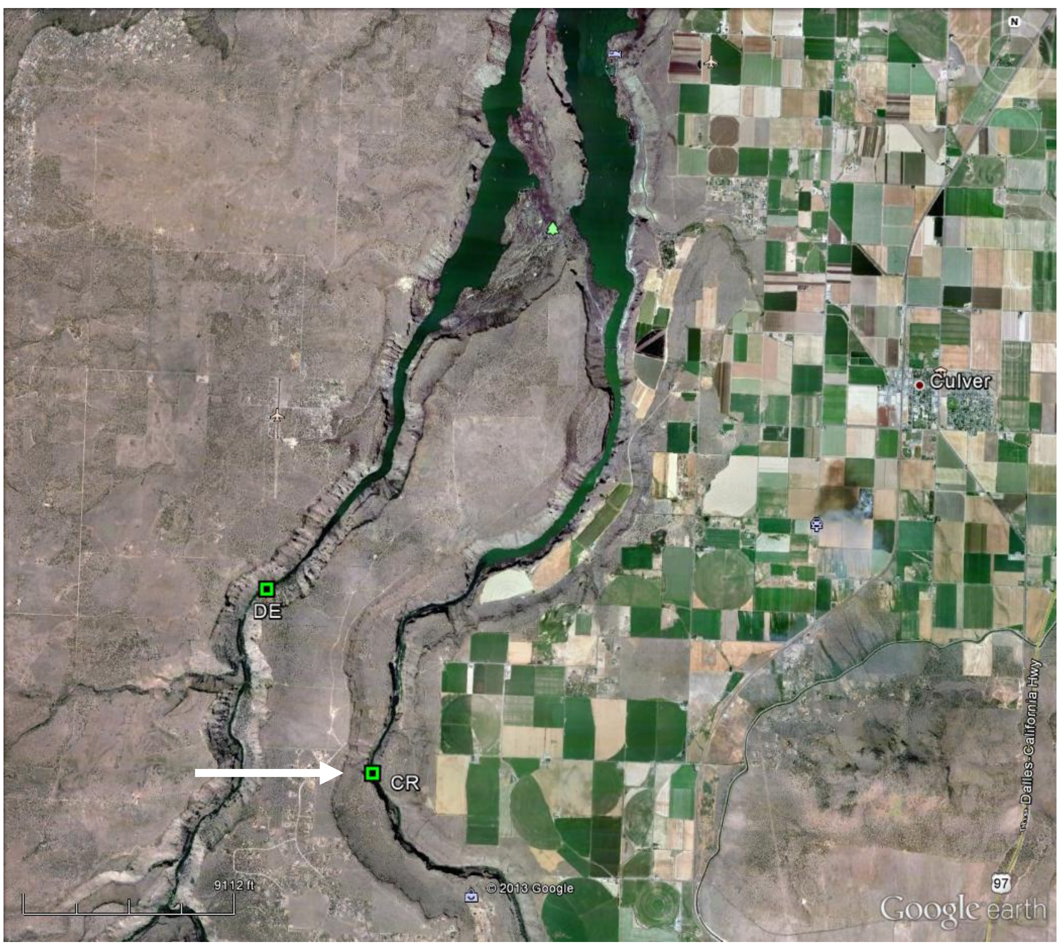
Appendix I Figure 31. Location of baseline sampling site (Latitude: 44.498574° Longitude: -121.320853°).

Appendix I Figure 32. **Deschutes River reference site collected in October 2013 (white square) at the USGS gage (14076500).**

Appendix I Figure 33. **Deschutes River reference site collected in October 2013 just downstream of the USGS gage.**

Site Crooked River (CR)

The sampling site on the Crooked River was located approximately 1.5 miles above the lake (or 0.5 mile above Opal Springs). Sampling involved contact with the personnel at the Opal Springs Dam facility to gain access to the site. The crew accessed the site from the boating ramp in the dam's pool area with the use of a small motor boat. Investigation of the original baseline study site coordinates revealed no suitable habitat to sample; the area was dominated by large boulders, with the shoreline edge that dropped off immediately. In October 2013, a new reference site was established between the two lowermost rapids in that lower reach of the Crooked River above Opal Springs Dam, in a series of pocket waters behind and around large boulders, featuring the cobble and gravel substrates, depths, and velocities necessary for kick samples. Between October 2013 and April 2014 the site condition was markedly different, with substrates completely covered with sands and fine sediment. Therefore, in April, sampling was moved downstream along that shoreline to the lowermost riffle area, approximately 350 feet downstream from location of the October sampling site. This location was located on the west side of the canyon; the site received ample sunlight, and rocks were covered with algal growth. The location provided multiple shallow riffles and runs, with large, angular cobble-sized stones at depths near 1 foot, and velocities ranging from 1.2-1.7 f/s. Any depth increases in this section of the Crooked River during future visits would still result in accessible riffle habitat for sampling at this location. Therefore, the Crooked River reference site was relocated to this location for the duration of the study.



Appendix I Figure 34. Location of baseline sampling site (Latitude: 44.476983° Longitude: -121.301820°).

Appendix I Figure 35. **Crooked River reference site collected in Spring 2014, (white circle) in comparison with October 2013 (red circle) and the baseline study site coordinates (green square). Opal Springs Dam is further downstream, to the left.**

Appendix I Figure 36. **Crooked River reference site collected in October 2013, looking downstream from the upstream end.**

Appendix I Figure 37. Crooked River reference site collected in May 2014, approximately 350 feet downstream of the site visited in October 2013, which is upstream to the left, just around the bend of the river.

Appendix I Figure 38. Crooked River reference site collected in October 2014, upstream looking downstream.

Site Metolius River (ME)

The baseline sampling site on the Metolius River was located 0.1 miles above the lake just downstream of the USFS Monty Campground. The sampling area was located adjacent to the southern bank of the river within a large cobble-dominated run possessing gravel patches. Site coordinates taken from the baseline study field notes for May 2000 marked a location that had large boulders that had created a slow-water area with large amounts of silt. As a result, the crew conducted additional site reconnaissance. The river bank in this reach is fairly steep, and drops sharply down into the river. Water depths increase a short distance from the bank, giving limited access to areas that provide the targeted 1 to 3 ft depths for sampling. Much of the substrate is large cobble to boulder size, with only limited amounts of the cobble/gravel combination that is targeted for kick samples. After considerable searching, the crew located and established a new reference sampling location on the right bank (looking downstream), approximately 342 ft. upstream of the old site coordinates. Velocities were fairly high, and two samples collected exceeded the preferred 3 ft/s velocity upper range.

Appendix I Figure 39. Location of Metolius sampling site (Latitude: 44.620376° Longitude: -121.474642°).

Appendix I Figure 40. **Metolius River reference site collected in October 2013 (white square) in comparison with baseline study site coordinates (green square). Monty Campground is shown in the upper left hand corner.**

Appendix I Figure 41. **Metolius River reference site collected in May 2014, looking upstream from the downstream end.**

Gravel Augmentation Sites (G1, G2, G3)

Three gravel augmentation sites were sampled between River Miles 99 and 97. Site G1, termed the Jason Smith site, was located across the river on bank left (looking downstream) from Site 3, Dizney Island. Site G2, termed Paxton Riffle, is located approximately 1 mile downstream along the right bank, and is accessible from Highway 26. Site G3, termed the Warm Springs site, is located at the head of a side channel just upstream of the Warm Springs boat launch along Highway 26.

Appendix I Figure 42.   Site 3 and Gravel Augmentation Site G1 locations collected in October 2013.

Appendix I Figure 43. **Gravel Augmentation Site G1 location collected in October, looking downstream from upstream end. (*Some objects may be larger than they appear.*)**

Appendix I Figure 44. **Gravel Augmentation Site G2 location collected in October 2013.**

Appendix I Figure 45. **Gravel Augmentation Site G2 collected in October 2013, looking from right bank.**

Appendix I Figure 46. **Gravel Augmentation Site G3 location collected in October 2013. Note the Warm Springs Boat Launch area to the bottom right.**

Appendix I Figure 47. Gravel Augmentation Site G3 location collected in October 2013, looking downstream from upstream end.

Appendix I Figure 48. Gravel Augmentation Site G3 location collected in April 2015, looking upstream from downstream end.

APPENDIX II – MACROINVERTEBRATE ABUNDANCE BY PERIOD & SITE

Appendix II Table 1. **Pooled Benthic Invertebrate sampling abundance data obtained from the lower Deschutes for October 1999. Counts are total estimated abundance from four composited kick samples (0.743 m^2 or 8 ft^2 in area).**

Taxonomic Group	Sample sites – October 1999															
	1	1S	2	3	4	5S	6	7S	8	8S	9	10	11	12	ME	DE
EPHEMEROPTERA (mayflies)																
Baetidae																
Acentrella insignificans	5					19	5	265	44	209	94	71	32	22		20
Baetis bicaudatus	13	5		1	2	4	4	9	6		7	14	6	3	43	
Baetis tricaudatus	319	136	46	90	26	58	26	276	105	409	186	243	108	13	436	9
Ephemerellidae																
Attenella															1	
Caudatella															3	
Drunella doddsi															30	
Drunella spinifera	4							9	14	13	40	89	21	8	7	
Ephemerella						4	1	37	12	38	18	17	3	5		1
Serratella tibialis					1	1		25	10	9	11	13	2	2	2	
Immature	6			1	3	42	2	327	274	997	233	577	27	48	12	5
Heptageniidae																
Cinygmula															2	
Epeorus								2	8	5	2	33		3	1	
Epeorus longimanus														1	1	
Heptagenia/Nixe/Leucrocuta								2	2		6	6		5		
Rhithrogena	22	8	3	6	14	14	69	989	144	562	32	526	91	50	135	11
Immature	7	2		8	4	1	3	2	67		6	14	1	90	4	9
Leptophlebidae																
Paraleptophlebia bicornata									1							3
Paraleptophlebia temporalis						3	1	3	4	21	2	19	3	15	6	1
Paraleptophlebia											2				2	6
Siphlonuridae																
Ameletus															1	1
Tricorythidae																
Tricorythodes								1				3	1	1		1
MEGALOPTERA																
Sialidae																
Sialis																1
PLECOPTERA (stoneflies)																
Capniidae																
Paracapnia																1
Leuctridae																
Megaleuctra														2		34
Moselia															1	

Taxonomic Group	Sample sites – October 1999															
	1	**1S**	**2**	**3**	**4**	**5S**	**6**	**7S**	**8**	**8S**	**9**	**10**	**11**	**12**	**ME**	**DE**
immature						3		10		4						12
Chloroperlidae																
Sweltsa		1										2			2	30
Neumouridae																
Malenka		1														
Zapada cinctipes	1						1			2				1	97	
Zapada Oregonensis Gr.															4	
immature															1	
Perlidae																
Doroneuria															2	
Hesperoperla pacifica	96	15	6	67	66	50	48	223	92	144	86	151	11	1	21	2
Perlodidae																
Osobenus														2		
Skwala				3		21		37	12	20	1	11	20	4		11
Immature					1	19		122	60	104	9	50	18	22	4	2
Pteronarcyidae																
Pteronarcys californica	37	14	43	93	372	8	77	49	61	47	6	46		1		21
TRICHOPTERA (caddisflies)																
Apataniidae																
Pedomoecus															4	
Brachycentridae																
Amiocentrus	263	242	28	32	23	31		59	69	69	92	48	16	34	10	3
Brachycentrus											1	1				
Micrasema	16	31		1					1						32	1
Glossosomatidae																
Glossosoma	30		3	12	34	10	25	92	174	90	11	99	195	3	4	12
Protoptila						11	314	10	191	42		1	81	40		
Hydropsychidae																
Arctopysche grandis															31	
Cheumatopsyche	3				3			48	31	26	16	51	13	9	3	
Hydropsyche	430	14	132	112	135	24	98	654	1190	441	954	2236	385	35		17
Immature	98	3	35	49	114	8	17	298	475	327	601	730	271	11	5	
Hydroptilidae																
Hydroptila	2	6				19	1	6	1	1				15		23
Leucotrichia									1	2	37		16	18		
Lepidostomatidae																
Lepidostoma															2	
Limnephilidae																
Hesperophylax					1											
Psychomiidae																

Taxonomic Group	Sample sites – October 1999															
	1	1S	2	3	4	5S	6	7S	8	8S	9	10	11	12	ME	DE
Psychomyia								4	1	5	23	28	2	27		66
Rhyacophilidae																
Rhyacophila Hyalinata Gr.	10	6	18	5	10	2	3	3	3	21	1	5	5	1	8	
Rhyacophila Brunnea Gr.	4		1		3				3	1		3			4	
Rhyacophila sp.				1	1	1		1	1	1		7	1		1	
Uenoidae																
Oligophlebodes															3	
LEPIDOPTERA (moths)																
Pyralidae																
Petrophila								3		10	27	2	9	73		
COLEOPTERA (beetles)																
Elmidae																
Cleptelmis	1															
Heterlimnius					1	3	31	17	18	10		59	3	1		3
Lara		1													3	
Narpus	1							3	2			6	7	3		
Optioservus	1		1	1	6	59	187	222	140	293	61	560	386	130	9	96
Zaitzevia				1		9	34	29	5	18	1	9	4		3	25
Immature															1	
DIPTERA (true flies)																
Chironomidae																
Chironominae/Chironomini		7		2		2			1	1				21		4
Tanytarsini		1		1		1		3		1	1			6	15	2
Tanypodinae		1							1	1	1			2	1	
Diamesinae	1	10				3	1	6	4	65		4		1	6	10
Orthocladiinae	530		8	66	7	486	4	849	128	998	231	66	24	67	365	29
Dixidae																
Dixa												1				
Empididae																
Hemerodromia	2				2	4	5	24	5	4	6	45	106	15	4	6
Oreogeton	2	1	1		1		1	1					1		2	
Simuliidae																
Simulium	32	63				1		20	5	22	58	20	4		7	1
Tipulidae																
Antocha	7	1	4	6	12	13	4	19	14	14	10	20	17		19	5
Dicranota														6	7	13
Hexatoma						2	1					1		1		
Tipula		7				1				1						
NON-INSECT TAXA																

Taxonomic Group	Sample sites – October 1999															
	1	**1S**	**2**	**3**	**4**	**5S**	**6**	**7S**	**8**	**8S**	**9**	**10**	**11**	**12**	**ME**	**DE**
Turbellaria (flatworms)																
Planariidae	670	1182	901	420	402	104	274			3		1	9	5	3	
Aschelminthes																
Nematoda (roundworms)	2	1		2	2	9	4	12	5	3		7	3	3	2	1
Annelida																
Hirudinea (leeches)													1			
Oligochaeta (earthworms)																
Lumbricidae	77	108	58	13	95	63	786	75	5	152	120	273	166	219	5	14
Gastropoda (snails)																
Ancylidae (limpets)	20				1						43					
Ferrissia																
Hydrobiidae																
Fluminicola	93	1647	1575	1183	620	85	972	7	364	274	44	73	72	315	4	
Lymnaeidae																
Fossaria	1	34	39	115	577	3	930	4	16	4		2				1
Physidae																
Physella		191	107	153	137	159	113	1	13	50	2	17	41	9		
Planorbidae																
Planorbella					2						1				3	
Vorticifex	624	5722	838	682	771	528	1603	14	959	1418	442	890	223	1900	26	13
Pelecypoda (clams, mussels)																
Sphaeriidae				15	1						2	2		14	2	
Amphipoda (scuds, sideswimmers)																
Gammarus	28	111	7	15	17	23	1		2	4						
Hyalella azteca																1
Decapoda																
Pacifasticus							1							1		1
Hydracarina (water mites)	3			2	2	12	1	17	16	19	2	9	5	35	3	1
TOTAL INDIVIDUALS	**3461**	**9572**	**3854**	**3158**	**3469**	**1923**	**5648**	**4889**	**4760**	**6975**	**3529**	**7161**	**2410**	**3319**	**1415**	**529**

Appendix II Table 2. **Pooled Benthic Invertebrate sampling abundance data obtained from the lower Deschutes for May 2000 (spring). Counts are total estimated abundance from four composited kick samples (0.743 m^2 or 8 ft^2 in area).**

Taxonomic Group	Sampling Sites – May 2000										
	1	1S	3	5S	7S	9	10	12	ME	DE	CR
EPHEMEROPTERA (mayflies)											
Baetidae											
Acentrella insignificans	4	5	12	13	44	155	264	349		12	3
Baetis bicaudatus			1		1	3	2	3	86		6
Baetis tricaudatus	437	108	185	61	93	38	179	100	337	6	71
Ephemerellidae											
Attenella				12				1	16		
Caudatella				3	13	18	30		1		
Drunella coloradensis/flavilinea	6	1	15	15	161	182	138	19		25	
Drunella doddsi									7		
Drunella spinifera	1	1				1		7	2		
Ephemerella	65	7	25	54	710	760	773	291	17	11	5
Serratella tibialis											
Immature	1		3	43	102	107	173	10	8	1	
Heptageniidae											
Cinygmula								31	190	8	
Epeorus	5	2	7	14	46	85	129	36	121	2	
Epeorus longimanus		1				25		22			
Heptagenia/Nixe/Leurocuta		1				33		13			
Rhithrogena	20	24	20	23	40	72	72	53	32	49	3
Immature						8					
Leptophlebiidae											
Paraleptophlebia bicornata											
Paraleptophlebia temporalis				1	1	2		1	1		
Paraleptophlebia								3			
Siphlonuridae											
Ameletus								3	2		
Tricorythidae											
Tricorythodes						24	3	27			16
MEGALOPTERA											
Sialidae											
Sialis											

Taxonomic Group	Sampling Sites – May 2000										
	1	1S	3	5S	7S	9	10	12	ME	DE	CR
ODONATA (dragonflies/damselflies)											
Coenagrionidae						2					
PLECOPTERA (stoneflies)											
Capniidae											
Paracapnia											
Leuctridae											
Megaleuctra											
Moselia											
Immature											
Chloroperlidae											
Sweltsa				2	1					6	
Immature									11		
Nemouridae											
Malenka											
Zapada cinctipes									1		
Zapada Oregonensis Gr.									1		
Immature											
Perlidae											
Claassenia								2			
Doroneuria											
Hesperoperla pacifica	107	11	40	55	76	144	114	38	36	1	
Immature				5			6	1			
Perlodidae											
Isoperla						38					
Osobenus											
Skwala											
Immature	1			16	167	43	123	65	2	1	1
Pteronarcyidae											
Pteronarcys californica	54	15	105	101	213	40	59	34		7	18
TRICHOPTERA (caddisflies)											
Apataniidae											
Pedomoecus									18		
Brachycentridae											
Amiocentrus	315	185	94	102	345	121	126	120			
Brachycentrus									6		

Taxonomic Group	Sampling Sites – May 2000										
	1	1S	3	5S	7S	9	10	12	ME	DE	CR
Micrasema									70	1	
Glossosomatidae											
Glossosoma	5		1	3	47	5	88	13	7	4	35
Protoptila			1	3	27		9	10		2	916
Hydropsychidae											
Arctopsyche grandis											
Cheumatopsyche	68	1			13	196	37	6			35
Hydropsyche	822	31	100	178	1688	1030	1391	437		2	198
Immature	58		10	7	132	110	55	1			64
Hydroptilidae											
Hydroptila			2			1		15			
Leucotrichia				1		1	3	1			1
Ochrotrichia											2
Lepidostomatidae											
Lepidostoma											20
Limnephilidae											
Dicosmoecus		2					1	6			
Hesperophylax											
Onocosmoecus		1									
Polycentropodidae											
Nyctiophylax											
Psychomiidae											
Psychomyia		1		1	9	32	11	16		8	
Rhyacophilidae											
Rhyacophila Angelita Gr.									30		
Rhyacophila Betteni Gr.	2	1		3	3	6	4				4
Rhyacophila Hyalinata Gr.	10						1				
Rhyacophila vemna/Brunnea Gr.	9	3	2	1	7				14		
Rhyacophila sp.	7	4	1		5	6	19	4	9	2	
Uenoidae											
Neophylax									12		
LEPIDOPTERA (moths)											
Pyralidae											
Petrophila					3	6	2	30			
COLEOPTERA (beetles)											

Taxonomic Group	Sampling Sites – May 2000										
	1	**1S**	**3**	**5S**	**7S**	**9**	**10**	**12**	**ME**	**DE**	**CR**
Elmidae											
Ampumixis								6			
Cleptelmis											
Dubiraphia											
Heterlimnius	2		1	13	69	9	175	9	14	15	
Lara			1						2		
Narpus				1	13		6	2	6	1	4
Optioservus	1		1	9	152	122	549	197	24	41	249
Zaitzevia				6	36	6	26	5			70
Psephenidae						1		1			
DIPTERA (true flies)											
Blephariceridae									1		
Ceratopogonidae											
Chironomidae											
Chironominae/Chironomini				1				102			89
Tanytarsini									9		
Tanypodinae				3		6	1	9			
Diamesinae	4	155	1	6		72	17	15	58	2	57
Orthocladiinae	3161	1967	963	3949	3386	3792	1080	1368	311	147	54
Dixidae											
Dixa											
Empididae											
Chelifera	3	1		18	41	17	61	36	1		5
Hemerodromia									1		
Oreogeton									16	3	
Simuliidae											
Simulium	22	33		1	13	8	7	1	15		1
Tipulidae											
Antocha	121	59	9	36	199	83	165	139	91	9	119
Dicranota									5		
Hexatoma				5							
Limnophila									25		
Tipula											
NON-INSECT TAXA											
Turbellaria (flatworms)											

Taxonomic Group	Sampling Sites – May 2000										
	1	1S	3	5S	7S	9	10	12	ME	DE	CR
Planariidae	239	588	583	13	1			7	2		
Aschelminthes											
Nematoda (roundworms)	10	7	15	75	66	10	80	42	9	3	23
Annelida											
Hirudinea (leeches)			2				1				
Oligochaeta (earthworms)											
Lumbricidae	32	75	273	408	75	16	510	173	49	25	3
Tubificidae			9		9				4		
Gastropoda (snails)											
Ancylidae (limpets)	7	1					1				
Ferrissia											
Hydrobiidae											
Fluminicola											3
Lymnaeidae											
Fossaria	79	585	1409	11	8	21	48	90			1
Physidae											
Physella		40	56			1	3	1			
Planorbidae											
Planorbella			1						1		1
Vorticifex	183	483	505	6	1	138	75	285			80
Pleuroceridae											
Juga											
Pelecypoda (clams, mussels)											
Sphaeriidae	2		16					6			
Amphipoda (scuds, sideswimmers)											
Gammarus	14	20		3		1					1
Hyalella azteca	2		1	1							
Decapoda											
Pacifasticus						1					
Isopoda											
Ostracoda											
Hydracarina (water mites)	5	1	2	6	55	11	16	38	2		8
TOTAL INDIVIDUALS	**5884**	**4420**	**4472**	**5288**	**8071**	**7609**	**6633**	**4300**	**1683**	**394**	**2166**

Appendix II Table 3. **Pooled benthic invertebrate sampling abundance data obtained from the lower Deschutes River for May 2001 (spring). Counts are total estimated abundances from four composited kick samples (0.743 m^2 or 8 ft^2 in area).**

Taxonomic Group	Sampling Sites – May 2001									
	1	1S	3	5S	7S	9	10	ME	DE	CR
EPHEMEROPTERA (mayflies)										
Baetidae										
Acentrella insignificans		7	7	5	173	86	170	11	77	15
Baetis bicaudatus	5						10	213		3
Baetis tricaudatus	216	41	155	612	195	110	335	821	32	136
Ephemerellidae										
Attenella				10	405		645	30		
Caudatella	3					27	90	42	1	
Drunella coloradensis/flavilinea			17	322	238	91	230	2	27	
Drunella doddsi								10		
Drunella spinifera					10					
Ephemerella	26		73	1090	2498	791	1570	20	12	
Serratella tibialis										
Immature	7		9	65	685	190	120			
Heptageniidae										
Cinygmula								89		
Epeorus	3		11	21					4	
Epeorus longimanus					100	109	120	174		
Heptagenia/Nixe/Leurocuta	11					57			2	1
Rhithrogena	6	4	7	4	10	21	30	31	104	
Immature	13			6				2	2	
Leptophlebiidae										
Paraleptophlebia bicornata										
Paraleptophlebia temporalis										
Paraleptophlebia sp.				3		10		5		
Siphlonuridae										
Ameletus										
Tricorythidae										
Tricorythodes						11	15			
MEGALOPTERA										
Sialidae										
Sialis										

Taxonomic Group	Sampling Sites – May 2001									
	1	1S	3	5S	7S	9	10	ME	DE	CR
ODONATA										
Coenagrionidae										
PLECOPTERA (stoneflies)										
Capniidae										
Paracapnia										
Leuctridae										
Megaleuctra										
Moselia										
Immature								10		
Chloroperlidae										
Sweltsa									8	1
Immature										
Nemouridae										
Malenka										
Nemoura								1		
Zapada cinctipes			7	6						
Zapada Oregonensis Gr.										
Immature								3		
Perlidae										
Claassenia										
Doroneuria										
Hesperoperla pacifica	48	18	40	209	348	50	85	12	4	
Immature	12	4						3		
Perlodidae										
Cultus								4		
Isoperla	3			25		34			1	
Osobenus										
Skwala										
Immature			6	39	188	60	125	3	12	
Pteronarcyidae										
Pteronarcys californica	72	71	117	182	353	52	110		21	
TRICHOPTERA (caddisflies)										
Apataniidae										
Pedomoecus								29		
Brachycentridae										

Taxonomic Group	Sampling Sites – May 2001									
	1	1S	3	5S	7S	9	10	ME	DE	CR
Amiocentrus	298	44	294	438	1108	850	2790		24	13
Brachycentrus								11		
Micrasema	2							69		
Glossosomatidae										
Glossosoma	53		18	190	165	8	100	16	11	14
Protoptila	3			19	485	17	125		37	
Hydropsychidae										
Arctopsyche grandis								7		
Cheumatopsyche	30	3			28	252	80			
Hydropsyche	423	19	153	272	1605	774	1720		17	42
Immature	40	3			20	10	10			3
Hydroptilidae										
Hydroptila		3		24		8	30	2	7	17
Leucotrichia						5				1
Lepidostomatidae										
Lepidostoma		3								
Limnephilidae										
Dicosmoecus		4								
Hesperophylax										
Onocosmoecus										
Immature								3		
Polycentropodidae										
Nyctiophylax										
Psychomiidae										
Psychomyia					58	80	55		21	
Rhyacophilidae										
Rhyacophila Angelita Gr.								27		
Rhyacophila Betteni Gr.										30
Rhyacophila Hyalinata Gr.										
Rhyacophila vemna/Brunnea Gr.	6		11					10		
Rhyacophila sp.	21		3	6	18	39	90	5	6	21
Uenoidae										
Neophylax					10			12		
Oligophlebodes								3		
LEPIDOPTERA (moths)										

Taxonomic Group	Sampling Sites – May 2001									
	1	1S	3	5S	7S	9	10	ME	DE	CR
Pyralidae										
Petrophila						25				
COLEOPTERA (beetles)										
Dytiscidae										
Immature				6						
Elmidae										
Ampumixis				17	265	20	170		18	14
Cleptelmis										
Dubiraphia										
Heterlimnius		4		22	395	38	1035	4	38	4
Lara										
Microcylloepus							15			
Narpus					40				1	
Optioservus				34	383	194	1640	3	55	41
Zaitzevia				4	28	5	125		10	18
Immature										
Psephenidae										
Psephenus							10			
DIPTERA (true flies)										
Athericidae										
Atherix				6					1	
Blephariceridae										
Ceratopogonidae										
Chironomidae										
Chironominae/Chironomini			4		8			17	9	
Tanytarsini									20	5
Tanypodinae			3	7	8	89	10		2	
Diamesinae	24	58	54	6	10	43	70	36	25	
Orthocladiinae	1037	869	1413	1445	1835	1081	2835	211	357	299
Dixidae										
Dixa										
Empididae										
Chelifera				3				2		1
Hemerodromia				27	30	94	230	8	3	3
Oreogeton								18		

Taxonomic Group	Sampling Sites – May 2001									
	1	1S	3	5S	7S	9	10	ME	DE	CR
Simuliidae										
Simulium	122	133	9		15	5	100	15		
Tipulidae										
Antocha	67		31	103	270	236	450	52	53	41
Dicranota								3		
Hexatoma										
Limnophila								1	1	
Tipula										
NON-INSECT TAXA										
Turbellaria (flatworms)										
Planariidae	18	1242	21	4					1	
Aschelminthes										
Nematoda (roundworms)	18	11	71	101	125	139	110	9	12	5
Annelida										
Hirudinea (leeches)										
Oligochaeta (earthworms)			18	28	98	239	295	3	64	2
Lumbricidae		66								
Tubificidae		4								
Gastropoda (snails)										
Ancylidae (limpets)										
Ferrissia	3									
Hydrobiidae										
Fluminicola	27	1173	2615	137	18	14	135			
Lymnaeidae										
Lymnaea										
Fossaria										
Physidae										
Physella		73	41	22						
Planorbidae										
Planorbella										
Vorticifex	42	449	247	109	10	315	165		3	16
Pleuroceridae										
Juga		19	125	4						
Pelecypoda (clams, mussels)										
Sphaeriidae										

Taxonomic Group	Sampling Sites – May 2001									
	1	**1S**	**3**	**5S**	**7S**	**9**	**10**	**ME**	**DE**	**CR**
Amphipoda (scuds, sideswimmers)										
Gammarus	23	66	77		10	5				1
Hyalella azteca	1									
Decapoda										
Pacifasticus						8				
Isopoda										
Ostracoda										
Hydracarina (water mites)	14		33	25	195	63	165	3	1	2
TOTAL INDIVIDUALS	**2697**	**4391**	**5690**	**5658**	**12443**	**6355**	**16215**	**2065**	**1104**	**749**

Appendix II Table 4. **Pooled Benthic Invertebrate sampling abundance data obtained from the lower Deschutes River for October 2001 (fall). Counts are total estimated abundances from four composited kick samples (0.743 m^2 or 8 ft^2 in area).**

Taxonomic Group	Sampling Sites – October 2001									
	1	1S	3	5S	7S	9	10	ME	DE	CR
EPHEMEROPTERA (mayflies)										
Baetidae										
Acentrella insignificans	15	10	15	6	9	31	83	46	20	18
Baetis bicaudatus	88			2				10		22
Baetis tricaudatus		322	35	93	43	144	107	743	54	494
Ephemerellidae										
Attenella								30		
Caudatella								17		
Drunella coloradensis/flavilinea										
Drunella doddsi								24		
Drunella spinifera				11	4		27	9		
Ephemerella				71	43	35	112			
Serratella tibialis						8				
Immature	8			60	46	8	138	26	3	
Heptageniidae										
Cinygmula										
Epeorus	5						4		8	
Epeorus longimanus					1			4		
Heptagenia/Nixe/Leurocuta						8	5	1	4	
Rhithrogena		3	7		17	4	32	168	29	
Immature			5		1			10	4	
Leptophlebiidae										
Paraleptophlebia bicornata										
Paraleptophlebia temporalis								17	29	
Paraleptophlebia sp.							21			
Siphlonuridae										
Ameletus										
Tricorythidae										
Tricorythodes										
MEGALOPTERA										
Sialidae										
Sialis										

Taxonomic Group	Sampling Sites – October 2001									
	1	1S	3	5S	7S	9	10	ME	DE	CR
ODONATA										
Coenagrionidae										
PLECOPTERA (stoneflies)										
Capniidae										
Paracapnia										
Immature								1	58	1
Leuctridae										
Megaleuctra									19	
Moselia										
Immature								4		
Chloroperlidae										
Sweltsa										
Immature										
Nemouridae										
Malenka										
Nemoura										
Zapada cinctipes								28		2
Zapada Oregonensis Gr.								6		
Immature										
Perlidae										
Claassenia						4				
Doroneuria								13		
Hesperoperla pacifica	45	7	5	78	21	72	174	26	36	
Immature								24		
Perlodidae										
Cultus										
Isoperla										
Osobenus										
Skwala				2	1		9	4	26	
Immature				10	9		15	7	10	
Peltoperlidae										
Yoraperla								4		1
Pteronarcyidae										
Pteronarcys californica	21	9	8	33	15	35	55		25	1
HEMIPTERA (true bugs)										

Taxonomic Group	Sampling Sites – October 2001									
	1	**1S**	**3**	**5S**	**7S**	**9**	**10**	**ME**	**DE**	**CR**
Corixidae								1		
TRICHOPTERA (caddisflies)										
Apataniidae										
Pedomoecus								9		
Brachycentridae										
Amiocentrus	823	297	27	325	123	139	155	15	5	117
Brachycentrus										
Micrasema	10							151	2	1
Glossosomatidae										
Glossosoma	8	10		12	82	4	127	53	114	53
Protoptila					92	23	4			
Hydropsychidae										
Arctopsyche grandis								20		
Cheumatopsyche	36				16	423	118			
Hydropsyche	138	19	5	43	238	895	1816	3	102	10
Immature	43		13	7	25	54	121	16	7	11
Hydroptilidae										
Hydroptila				3		6	8		2	5
Leucotrichia						40				52
Lepidostomatidae										
Lepidostoma										
Limnephilidae										
Dicosmoecus										
Hesperophylax										
Onocosmoecus										
Polycentropodidae										
Nyctiophylax										
Psychomiidae										
Psychomyia						37	4		27	
Rhyacophilidae										
Rhyacophila Angelita Gr.								57		
Rhyacophila Betteni Gr.										15
Rhyacophila Hyalinata Gr.										
Rhyacophila vemna/Brunnea Gr.	13				1			12		
Rhyacophila sp.	46				3	32	12	15	13	11

Taxonomic Group	Sampling Sites – October 2001									
	1	1S	3	5S	7S	9	10	ME	DE	CR
Uenoidae										
Neophylax										
Oligophlebodes										
LEPIDOPTERA (moths)										
Pyralidae										
Petrophila					2	251	106			
COLEOPTERA (beetles)										
Dytiscidae										
Immature										
Elmidae										
Ampumixis				3	15	15	202		42	16
Cleptelmis										
Dubiraphia										
Heterlimnius				29	64	15	27	6	89	49
Lara								1		
Narpus				2	14			3	30	3
Optioservus	8			7	288	69	1187	6	188	17
Zaitzevia					18	4	56		59	22
Immature										
Psephenidae										
Psephenus										
DIPTERA (true flies)										
Athericidae										
Atherix									1	
Blephariceridae										
Ceratopogonidae										
Chironomidae										
Chironominae/Chironomini		2						7	4	1
Tanytarsini										
Tanypodinae					2	4	4	2		
Diamesinae				5	1	449	78	40	2	
Orthocladiinae	76	26		58	15	700	420	635	38	35
Dixidae										
Dixa										
Empididae										

Taxonomic Group	Sampling Sites – October 2001									
	1	1S	3	5S	7S	9	10	ME	DE	CR
Chelifera					1					
Hemerodromia	8	1			11	18	35	5	19	1
Oreogeton				2				33	1	
Simuliidae										
Simulium	5	43	5	2		9			1	28
Stratiomyidae								21	1	1
Tipulidae										
Antocha	18			4	25	13	43	58	37	22
Dicranota								25		
Hexatoma										
Limnophila								7		
Tipula										
NON-INSECT TAXA										
Turbellaria (flatworms)										
Planariidae	1300	1987	1236	66						
Aschelminthes										
Nematoda (roundworms)	31	7	8	71	32	17	4	48	36	5
Annelida										
Hirudinea (leeches)					2					
Oligochaeta (earthworms)	28	59	182	135	152	79	733	108	418	16
Lumbricidae										
Tubificidae										
Gastropoda (snails)										
Ancylidae (limpets)	88					14			6	
Ferrissia										
Hydrobiidae										
Fluminicola	1445	1588	2166	74	69	13	285			
Lymnaeidae										
Lymnaea										
Fossaria			209	12		4	21			
Physidae										
Physella	18	357	253	803	27	2	127			
Planorbidae										
Planorbella										
Vorticifex	5328	835	1435	1348	231	414	493	4	223	165

Taxonomic Group	Sampling Sites – October 2001									
	1	**1S**	**3**	**5S**	**7S**	**9**	**10**	**ME**	**DE**	**CR**
Pleuroceridae										
Juga				22	6		15			
Pelecypoda (clams, mussels)										
Sphaeriidae								2		
Amphipoda (scuds, sideswimmers)										
Gammarus	248	26	29	28		16	4		1	
Hyalella azteca				2	2		4			1
Decapoda										
Pacifasticus						3			2	
Isopoda										
Ostracoda										
Hydracarina (water mites)			3	10	16	19	19	19	3	22
TOTAL INDIVIDUALS	**9900**	**5608**	**5646**	**3439**	**1783**	**4130**	**7010**	**2604**	**1798**	**1218**

Appendix II Table 5. **Benthic Invertebrate sampling abundance data obtained from the lower Deschutes River for October 2013 (fall). Counts are total estimated abundances from four composited kick samples (0.743 m^2 or 8 ft^2 in area). "Comp" are abundances estimated from 4-kick composites with 500-counts, and "Pool" are abundances based on pooled results from 4-kick samples replicates (300-counts).**

Taxonomic Group	Sampling Sites – October 2013											
	1	1S	3	5S	7S	9	10	12	13	ME	DE	CR
	Comp	Pool	Pool	Comp	Pool	Pool	Comp	Comp	Comp	Comp	Comp	Comp
EPHEMEROPTERA (mayflies)												
Baetidae	128	35	23		16	58	51			69	48	
Acentrella insignificans						49	51	51	21		16	
Baetis bicaudatus	43		11	85		201	256		21	128		10
Baetis tricaudatus	342	400	307	229	329	795	924	77	21	315	144	49
Diphetor hageni												
Ephemerellidae			11	28	11	41				5		
Attenella										10		
Caudatella										30		
Drunella doddsi										177		
Drunella spinifera					5	56	51		43	34		
Ephemerella			48	86	295	327	1385	26	171		16	
Serratella tibialis					5							
Heptageniidae						11						
Cinygmula												
Epeorus			28	142	25	12	51				11	
Epeorus longimanus												
Heptagenia												
Heptagenia/Nixe/Ecdyonurus /Leucrocuta						63		38	21			
Rhithrogena					114	85	103		192	172	325	
Leptophlebidae												
Paraleptophlebia bicornata												
Paraleptophlebia temporalis						19						
Paraleptophlebia												
Ameletidae												
Ameletus										5		
Leptohyphidae												
Tricorythodes												

Taxonomic Group	Sampling Sites – October 2013											
	1	1S	3	5S	7S	9	10	12	13	ME	DE	CR
	Comp	Pool	Pool	Comp	Pool	Pool	Comp	Comp	Comp	Comp	Comp	Comp
MEGALOPTERA												
Sialidae												
Sialis												
PLECOPTERA (stoneflies)												
Capniidae												
Paracapnia												
Utacapnia											11	
Leuctridae												
Megaleuctra												
Moselia												
Chloroperlidae												
Plumiperla												
Sweltsa											37	
Neumouridae												
Malenka												
Zapada cinctipes										94		
Zapada Oregonensis Gr.												
Perlidae												
Doroneuria												
Hesperoperla pacifica	1	3	53	115	279	71	105		1	13	23	
Perlodidae												
Cultus												
Isoperla					5				21		11	
Osobenus								13		5		
Skwala					5						53	
Pteronarcyidae												
Pteronarcys californica	48	2	133	94	113	42	54		1		19	1
TRICHOPTERA (caddisflies)												10
Apataniidae												
Pedomoecus												
Brachycentridae		5										
Amiocentrus	107	6	65	1226	135	670	615	270	64			286
Brachycentrus				58						10	5	
Micrasema		50			4							

Taxonomic Group	Sampling Sites – October 2013											
	1	1S	3	5S	7S	9	10	12	13	ME	DE	CR
	Comp	Pool	Pool	Comp	Pool	Pool	Comp	Comp	Comp	Comp	Comp	Comp
Glossosomatidae (pupae)		1			16							
Glossosoma	64	61	123	2739	1445	101	1540	179	833	69	454	286
Protoptila					25			51	534		21	
Helicopsychidae												
Helicopsyche												
Hydropsychidae	85	1			32	141	103				1	
Arctopysche grandis										130		
Cheumatopsyche	64	31	74	1	241	1456	1082	335	2201			
Hydropsyche	1266	186	1227	2029	2014	3327	7455	195	1988			81
Hydroptilidae												
Hydroptila								51	791		16	276
Leucotrichia	21			28		59	103		21			
Ochrotrichia												
Lepidostomatidae												
Lepidostoma												
Limnephilidae												
Eocosmoecus												
Hesperophylax												
Psychomiidae												
Psychomyia									107			
Rhyacophilidae										15		
Rhyacophila angelita												
Rhyacophila Arnaudi	1	1	12	29	1	12	4					
Rhyacophila Betteni Gr.												1
Rhyacophila Hyalinata Gr.												
Rhyacophila Brunnea Gr.			42							31		
Rhyacophila narvae												
Rhyacophila Sibirica Gr.										44		
Rhyacophila sp.		5		28		25	51			79		10
Uenoidae												
Neophylax												
Oligophlebodes										5		
Philopotamidae												
Dolophilodes										10		

Taxonomic Group	Sampling Sites – October 2013											
	1	1S	3	5S	7S	9	10	12	13	ME	DE	CR
	Comp	Pool	Pool	Comp	Pool	Pool	Comp	Comp	Comp	Comp	Comp	Comp
LEPIDOPTERA (moths)												
Pyralidae												
Petrophila				28		53	51	26	299			
COLEOPTERA (beetles)												
Elmidae							51					
Ampumixis				28							5	
Cleptelmis												
Dubiraphia												
Heterlimnius	21		9	199				13	64		21	
Lara										5		
Narpus				28				13	21	5	16	20
Optioservus				256	150	212	1541	230	256	5	117	30
Zaitzevia				1	362						69	10
DIPTERA (true flies)												
Blephariceridae												
Agathon												
Ceratopogoniidae												
Palpomyia bezzia complex												
Probezzia												
Chironomidae (pupae)			18		5	9		90	107	144	27	20
Chironominae/Chironomini			11	28		29		26	64			30
Tanytarsini						9		13		30	16	148
Tanypodinae				28		16						
Diamesinae				28	5	9	51	13	43	39		49
Orthocladiinae	150	68	109	343	52	457	154	90	321	369	91	89
Cricotopus (Nostocladius)	21		1							208		
Tanyderidae												
Protanyderus								1				
Dixidae												
Dixa												
Athericidae												
Atherix							51				9	
Empididae										44		
Clinocera										5		

Taxonomic Group	Sampling Sites – October 2013											
	1	1S	3	5S	7S	9	10	12	13	ME	DE	CR
	Comp	Pool	Pool	Comp	Pool	Pool	Comp	Comp	Comp	Comp	Comp	Comp
Chelifera					5					54		39
Hemerodromia			23		9	57	359	13	235		11	39
Neoplasta			13									
Oreogeton										44		
Simuliidae												
Simulium	107	220	39		4	40			21	15	11	
Tipulidae										5		
Antocha										70		
Dicranota										11		
Hexatoma												
Limnophila												
Tipula												
NON-INSECT TAXA												
Nemertea	21	23	43			18		13	107			
Turbellaria (flatworms)												
Planariidae	4209	3350	1839	86				38	235	5		187
Aschelminthes												
Nematoda (roundworms)	43	36	26	199	157	117	410	51	43	30	139	39
Annelida												
Hirudinea (leeches)												
Erpobdellidae			1									
Glossophoniidae			1									
Helobdella stagnalis												
Oligochaeta (earthworms)												
Haplotaxidae												
Haplotaxis					73	101	205		43			
Lumbricidae	406	135	162		298	61	205		577			89
Lumbriculidae						250				30		
Naididae	705	1465	1590	1681	2084	2003	6000	1037	491	84	789	956
Polycheata												
Manayunkia speciosa	2393	200	143		20	578	51	1460	21			30
Gastropoda (snails)												
Ancylidae (limpets)												
Ferrissia			11		9							

Taxonomic Group	Sampling Sites – October 2013											
	1	1S	3	5S	7S	9	10	12	13	ME	DE	CR
	Comp	Pool	Pool	Comp	Pool	Pool	Comp	Comp	Comp	Comp	Comp	Comp
Hydrobiidae												
Fluminicola	1090	2287	2095	1709	518	662	1128	691	641	10		
Lymnaeidae	4		1		2	1			1			
Fisherola nuttalli (another limpet)	43					71						
Galba (=Fossaria)	21	86	52	57	77							
Physidae												
Physa/Physella	64	106	337	741	29	16		64	21			20
Planorbidae												
Planorbella												10
Vorticifex	577	528	4564	3790	591	2667	2052	1896	470		21	1911
Pleuroceridae												
Juga newberryi	46	291	140	29	398							
Pelecypoda (clams, mussels)												
Sphaeriidae		5	13		9	63	154	77	21	5	5	10
Amphipoda (scuds, sideswimmers)												
Gammarus	491		307	85	5	241			85			
Hyalella		111			16							90
Decapoda												
Pacifasticus						4			2			
Isopoda												
Ostracoda		9	13			21						20
Hydracarina (water mites)	43	36	62	427	263	101	359	192	278	44	21	79
Entoprocta												
Urnatella gracilis		85	1259			11						
TOTAL INDIVIDUALS	**12626**	**9831**	**15038**	**16698**	**10255**	**15501**	**26809**	**7332**	**11523**	**2708**	**2582**	**4921**
without Urnatella	**12626**	**9746**	**13779**	**16698**	**10255**	**15490**	**26809**	**7332**	**11523**	**2708**	**2582**	**4921**

Appendix II Table 6. **Benthic Invertebrate sampling abundance data obtained from the lower Deschutes River for April/May 2014 (spring). Counts are total estimated abundances from four composited kick samples (0.743 m^2 or 8 ft^2 in area). "Comp" are abundances estimated from 4-kick composites with 500-counts, and "Pool" are abundances based on pooled results from 4-kick samples replicates (300-counts).**

Taxonomic Group	Sampling Sites – April/May 2014											
	1	1S	3	5S	7S	9	10	12	13	ME	DE	CR
	Comp	Pool	Pool	Comp	Pool	Pool	Comp	Comp	Comp	Comp	Comp	Comp
EPHEMEROPTERA (mayflies)												
Baetidae				57	26	37	8		43			
Acentrella insignificans	12	73	67	213	139	195	40	121	256		48	1
Baetis bicaudatus			24	57	22	12	8	51	21			61
Baetis tricaudatus	209	103	265	557	311	436	240	154	363	294	80	263
Diphetor hageni							8					
Ephemerellidae					8	14						
Attenella				14						9		
Caudatella										26	16	
Drunella doddsi										19		
Drunella spinifera			65		56	113	24			6	104	
Ephemerella	12	14	272	386	554	613	152	173	406	28		
Serratella tibialis											4	
Heptageniidae												
Cinygmula										81	12	
Epeorus			4	14	89	33	136	68	43	78	28	
Epeorus longimanus												
Heptagenia						21			1			
Heptagenia/Nixe/Ecdyonurus /Leucrocuta						12						
Rhithrogena					6	12	16		171	34	333	
Leptophlebidae												
Paraleptophlebia bicornata												
Paraleptophlebia temporalis												
Paraleptophlebia											4	
Ameletidae												
Ameletus												
Leptohyphidae												
Tricorythodes						7		17				

Taxonomic Group	Sampling Sites – April/May 2014											
	1	1S	3	5S	7S	9	10	12	13	ME	DE	CR
	Comp	Pool	Pool	Comp	Pool	Pool	Comp	Comp	Comp	Comp	Comp	Comp
MEGALOPTERA												
Sialidae												
Sialis										2		
PLECOPTERA (stoneflies)												
Capniidae												
Paracapnia												
Utacapnia												
Leuctridae												
Megaleuctra												
Moselia												
Chloroperlidae												
Plumiperla										2		
Sweltsa												
Neumouridae												
Malenka				14								
Zapada cinctipes												
Zapada Oregonensis Gr.												
Perlidae												
Doroneuria										4		
Hesperoperla pacifica	1	23	27	16	109	53	41	70	23	10	27	
Perlodidae												
Cultus							8	17		2		
Isoperla						8			21		1	
Osobenus										2		
Skwala						12						
Pteronarcyidae												
Pteronarcys californica	74	16	148	130	206	50	42	34	65		53	12
TRICHOPTERA (caddisflies)												
Apataniidae												
Pedomoecus												
Brachycentridae						14						
Amiocentrus	116	118	859	825	1421	1174	505	1608	256		12	14
Brachycentrus											4	
Micrasema		6								17		

Taxonomic Group	Sampling Sites – April/May 2014											
	1	1S	3	5S	7S	9	10	12	13	ME	DE	CR
	Comp	Pool	Pool	Comp	Pool	Pool	Comp	Comp	Comp	Comp	Comp	Comp
Glossosomatidae (pupae)			3	28	46	23		17	21			1
Glossosoma			24	158	20	7	48	52	363	11	8	
Protoptila				28	52		24	120	577		8	
Helicopsychidae												
Helicopsyche									128			
Hydropsychidae		3		14				17	43			
Arctopysche grandis												
Cheumatopsyche		7	1	14	138	211	99	68	235			
Hydropsyche	376	592	736	299	580	956	163	499	1350		101	1
Hydroptilidae												12
Hydroptila		14							150			110
Leucotrichia	12	13		14								
Ochrotrichia					4							
Lepidostomatidae												
Lepidostoma												
Limnephilidae												
Eocosmoecus							8		66			
Hesperophylax												
Psychomiidae												
Psychomyia					4				64			
Rhyacophilidae												
Rhyacophila angelita										9		
Rhyacophila Arnaudi												1
Rhyacophila Betteni Gr.						5	8					13
Rhyacophila Hyalinata Gr.												
Rhyacophila Brunnea Gr.		14		1						2		
Rhyacophila narvae										11		
Rhyacophila Sibirica Gr.										36		
Rhyacophila sp.			18			38		17		2	4	
Uenoidae												
Neophylax										19		
Oligophlebodes												
Philopotamidae												
Dolophilodes												

Taxonomic Group	Sampling Sites – April/May 2014											
	1	1S	3	5S	7S	9	10	12	13	ME	DE	CR
	Comp	Pool	Pool	Comp	Pool	Pool	Comp	Comp	Comp	Comp	Comp	Comp
LEPIDOPTERA (moths)												
Pyralidae												
Petrophila						8						
COLEOPTERA (beetles)												
Elmidae												
Ampumixis											12	
Cleptelmis					6					2	36	
Dubiraphia												
Heterlimnius					119	14	8					
Lara												1
Narpus					13							
Optioservus				299	297	205	618	171	128		116	12
Zaitzevia				57	23		32	34	43		84	24
DIPTERA (true flies)												
Blephariceridae												
Agathon										2		
Ceratopogoniidae												
Palpomyia bezzia complex											48	
Probezzia							8					
Chironomidae (pupae)	221	304	187	412	190	331	80	616	192	38	44	159
Chironominae/Chironomini					8	19	16	139	43		20	
Tanytarsini		4	47			7		189	21	9	4	49
Tanypodinae		6			6	17						
Diamesinae							8			29		
Orthocladiinae	1012	1927	1140	2222	982	1368	282	1610	792	141	256	893
Cricotopus (Nostocladius)										73		
Tanyderidae												
Protanyderus								17				
Dixidae												
Dixa												
Athericidae												
Atherix				1			1		21		1	
Empididae												
Clinocera												

Taxonomic Group	Sampling Sites – April/May 2014											
	1	1S	3	5S	7S	9	10	12	13	ME	DE	CR
	Comp	Pool	Pool	Comp	Pool	Pool	Comp	Comp	Comp	Comp	Comp	Comp
Chelifera												
Hemerodromia			3	14	21	10	32	85	214		4	
Neoplasta				14						4		
Oreogeton										6		
Simuliidae												
Simulium	35	110	16	14	10	14	8	68	21	13		
Tipulidae												
Antocha										32		
Dicranota										2		
Hexatoma										4		
Limnophila												
Tipula												
NON-INSECT TAXA												
Nemertea		31	6			7						
Turbellaria (flatworms)												
Planariidae	431	822	754	114	8		8		21			
Aschelminthes												
Nematoda (roundworms)	209	399	10	100	112	64	168	17	85	19	100	
Annelida												
Hirudinea (leeches)						5						
Erpobdellidae												
Glossophoniidae												
Helobdella stagnalis												
Oligochaeta (earthworms)	559	2783	3156	1479	1943	795	984	1350	2286	109	948	6717
Haplotaxidae												
Haplotaxis	35				45		72		64		20	
Lumbricidae	23	348	133	100	45	154	136		171			
Lumbriculidae						110				13		
Naididae												
Polycheata												
Manayunkia speciosa	70	36	275	28		45	8					
Gastropoda (snails)												
Ancylidae (limpets)												
Ferrissia									21			

Taxonomic Group	Sampling Sites – April/May 2014											
	1	**1S**	**3**	**5S**	**7S**	**9**	**10**	**12**	**13**	**ME**	**DE**	**CR**
	Comp	**Pool**	**Pool**	**Comp**	**Pool**	**Pool**	**Comp**	**Comp**	**Comp**	**Comp**	**Comp**	**Comp**
Hydrobiidae												
Fluminicola	780	587	1228	128	187	37	224	376	641			
Lymnaeidae												
Fisherola nuttalli (another limpet)	58	4				48						
Galba (=Fossaria)	58	15	11	14	43	5	40	17				
Physidae												
Physa/Physella	35		46	1			8					
Planorbidae												
Planorbella										2		
Vorticifex	186	205	1143	142	38	319	208	547	342			24
Pleuroceridae												
Juga newberryi	361	27	82	14	166		40					
Pelecypoda (clams, mussels)												
Sphaeriidae					10	28	240	51	21	4		
Amphipoda (scuds, sideswimmers)												
Gammarus	23	45	190			21						
Hyalella		49										12
Decapoda												
Pacifasticus						1			1			1
Isopoda												12
Ostracoda		7	7			7						
Hydracarina (water mites)	23	35	85	156	206	336	16	873	1132	4	8	183
Entoprocta												
Urnatella gracilis		28	32			5						
TOTAL INDIVIDUALS	**4931**	**8768**	**11061**	**8151**	**8274**	**8042**	**4823**	**9266**	**10931**	**1211**	**2548**	**8578**
without Urnatella	**4931**	**8740**	**11029**	**8151**	**8274**	**8036**	**4823**	**9266**	**10931**	**1211**	**2548**	**8578**

Appendix II Table 7. **Benthic Invertebrate sampling abundance data obtained from the lower Deschutes River for October 2014 (fall). Counts are total estimated abundances from four composited kick samples (0.743 m2 or 8 ft2 in area). "Comp" are abundances estimated from 4-kick composites with 500-counts, and "Pool" are abundances based on pooled results from 4-kick samples replicates (300-counts).**

Taxonomic Group	Sampling Sites – October 2014											
	1	1S	3	5S	7S	9	10	12	13	ME	DE	CR
	Comp	Pool	Pool	Comp	Pool	Pool	Comp	Comp	Comp	Comp	Comp	Comp
EPHEMEROPTERA (mayflies)												
Baetidae		13										
Acentrella insignificans				23	19	117	45		63			
Acentrella turbida												
Baetis bicaudatus		8									20	
Baetis tricaudatus	214	405	195	538	272	145	490	23	188	1007	89	1388
Diphetor hageni												
Ephemerellidae												
Attenella												
Caudatella												
Drunella doddsi										35		
Drunella grandis grandis												
Drunella spinifera					1	24	89			23		
Ephemerella	21		116	1258	411	685	3028		188	23	16	
Serratella tibialis						1						
Heptageniidae												
Cinygmula												
Epeorus				23	29	64	268				12	
Epeorus longimanus												
Heptagenia												
Heptagenia/Nixe/Ecdyonurus /Leucrocuta						70		116	104			
Rhithrogena					168	114	401	140	630	318	93	
Leptophlebidae												
Paraleptophlebia bicornata												
Paraleptophlebia temporalis					4							
Paraleptophlebia					8	13	45	23		12		
Ameletidae												
Ameletus												

Taxonomic Group	Sampling Sites – October 2014											
	1	1S	3	5S	7S	9	10	12	13	ME	DE	CR
	Comp	Pool	Pool	Comp	Pool	Pool	Comp	Comp	Comp	Comp	Comp	Comp
Leptohyphidae												
Tricorythodes												
MEGALOPTERA												
Sialidae												
Sialis												
PLECOPTERA (stoneflies)												
Capniidae										12		
Paracapnia												
Utacapnia												
Leuctridae												
Megaleuctra												
Moselia												
Chloroperlidae												
Plumiperla												
Sweltsa											4	
Neumouridae										6		
Malenka												
Zapada cinctipes				23						156		
Zapada Oregonensis Gr.										6		
Perlidae												
Claassenia sabulosa											1	
Doroneuria										7	4	
Hesperoperla pacifica	1	5	42	245	197	39	269	28	21	7	60	
Perlodidae												
Cultus												
Isoperla					12		45	93	42		8	
Osobenus												
Skwala				47	1		45			12	9	
Pteronarcyidae												
Pteronarcys californica	50	4	171	34	52	27	52	7			22	1
TRICHOPTERA (caddisflies)												
Apataniidae												
Pedomoecus										1		
Brachycentridae												

Taxonomic Group	Sampling Sites – October 2014											
	1	**1S**	**3**	**5S**	**7S**	**9**	**10**	**12**	**13**	**ME**	**DE**	**CR**
	Comp	**Pool**	**Pool**	**Comp**	**Pool**	**Pool**	**Comp**	**Comp**	**Comp**	**Comp**	**Comp**	**Comp**
Amiocentrus	22	86	24	48	51	124	267	189	21		8	301
Brachycentrus				23				23		29		21
Micrasema										93		
Glossosomatidae (pupae)	21		9		7		46	47	21			
Glossosoma	64		18	281	175		1158	1304	627	29	80	64
Protoptila					48			1047	669			
Helicopsychidae												
Helicopsyche									42			
Hydropsychidae	176	52		47	9	54	45	23	21			
Arctopsyche grandis										49		
Cheumatopsyche	64	82	40	117	167	667	402	143	587			
Hydropsyche	1797	754	1315	2220	1708	2159	4280	1567	2242		281	194
Hydroptilidae												
Hydroptila									418			
Leucotrichia						106			146			65
Ochrotrichia												
Lepidostomatidae												
Lepidostoma												
Limnephilidae						8						
Dicosmoecus												
Eocosmoecus												
Hesperophylax												
Psychomiidae												
Psychomyia						37						
Rhyacophilidae		10										
Rhyacophila Alberta Gr.												
Rhyacophila angelita												
Rhyacophila Arnaudi	89	15	2	1	1	9	1					
Rhyacophila Betteni Gr.											4	
Rhyacophila Coloradensis Gr.												
Rhyacophila Hyalinata Gr.												
Rhyacophila Brunnea Gr.	21	1	68		14					12		
Rhyacophila narvae												
Rhyacophila Sibirica Gr.										87		

Taxonomic Group	Sampling Sites – October 2014											
	1	1S	3	5S	7S	9	10	12	13	ME	DE	CR
	Comp	Pool	Pool	Comp	Pool	Pool	Comp	Comp	Comp	Comp	Comp	Comp
Rhyacophila sp.						9			84	1		1
Uenoidae												
Neophylax										12		
Oligophlebodes												
Philopotamidae												
Dolophilodes												
LEPIDOPTERA (moths)												
Pyralidae												
Petrophila					4	176	45	93	461			64
Crambidae												
COLEOPTERA (beetles)												
Elmidae												
Ampumixis				1	8						4	
Cleptelmis										12		
Dubiraphia												
Heterlimnius										12		
Lara										6		1
Narpus									21	6	16	
Optioservus				163	363	104	2317	583	188		44	21
Zaitzevia		10		70	178	24	534		21		85	43
Immature											8	21
Psephenidae												
Psephenus							45					
DIPTERA (true flies)												
Blephariceridae												
Agathon												
Ceratopogoniidae												
Dasyhelea												
Palpomyia bezzia complex												
Probezzia												
Chironomidae (pupae)	64	41	58	326	44	97	45	140		278	56	981
Chironominae/Chironomini			10		4		45	23	21		8	
Tanytarsini		38			5					58	12	533
Tanypodinae						7					4	

Taxonomic Group	Sampling Sites – October 2014											
	1	1S	3	5S	7S	9	10	12	13	ME	DE	CR
	Comp	Pool	Pool	Comp	Pool	Pool	Comp	Comp	Comp	Comp	Comp	Comp
Diamesinae									21	52	4	
Prodiamesinae			9								4	
Orthocladiinae	256	242	521	1894	123	762	936	443	314	503	81	2499
Cricotopus (Nostocladius)										214	4	
Tanyderidae												
Protanyderus												
Dixidae												
Dixa												
Athericidae												
Atherix						16					13	
Empididae												
Clinocera			12							29	4	
Chelifera												
Hemerodromia					44	51	445		42	1	28	85
Neoplasta		10	9							12	5	21
Oreogeton												
Roederiodes												
Ephydridae												
Simuliidae												
Simulium	235	883	308	933	88	9	45	24	43	6	8	448
Tipulidae												
Antocha										40		21
Dicranota										38		
Hexatoma												
Limnophila												
Tipula												
NON-INSECT TAXA												
Nemertea												
Turbellaria (flatworms)												
Planariidae	1728	3314	981	186					272			
Aschelminthes												
Nematoda (roundworms)	129	52	66	93	152	28	356	1	42	58	149	64
Annelida												
Hirudinea (leeches)				1								

Taxonomic Group	Sampling Sites – October 2014											
	1	1S	3	5S	7S	9	10	12	13	ME	DE	CR
	Comp	Pool	Pool	Comp	Pool	Pool	Comp	Comp	Comp	Comp	Comp	Comp
Erpobdellidae												
Glossophoniidae												
Helobdella stagnalis												
Oligochaeta (earthworms)	2177	1427	1110	2357	526	533	2940	842	439	58	840	108
Haplotaxidae												
Haplotaxis	43	13		1			401	48	42		23	
Lumbricidae	256	620	566	23	21	55		71	106	6		
Lumbriculidae	64	197	68	70	139	141	623	465	230			85
Naididae	107			47	33	26		233	543		16	5183
Polycheata												
Manayunkia speciosa	960	146	243			200		582	188			171
Gastropoda (snails)												
Ancylidae (limpets)												
Ferrissia												
Hydrobiidae												
Fluminicola	704	2906	2667	116	256	158	801	512	1087			
Potamopyrgus antipodarum												
Lymnaeidae		1	2		4	2		1				
Fisherola nuttalli (another limpet)	85				4							
Galba (=Fossaria)	107	144	74	23	53		45					
Physidae												
Physa/Physella	128	133	193	26		12	89					21
Planorbidae												
Planorbella												
Vorticifex	1003	1442	2965	442	126	1467	2315	3118	878		4	21
Pleuroceridae												
Juga newberryi	256	368	384	2	87							
Pelecypoda (clams, mussels)												
Sphaeriidae			18		9	9	134	23	21		8	
Amphipoda (scuds, sideswimmers)												
Gammarus	64	792	632	117		133		23				175
Hyalella		18				28						
Decapoda												
Pacifasticus				1		8						

Taxonomic Group	Sampling Sites – October 2014											
	1	**1S**	**3**	**5S**	**7S**	**9**	**10**	**12**	**13**	**ME**	**DE**	**CR**
	Comp	**Pool**	**Pool**	**Comp**	**Pool**	**Pool**	**Comp**	**Comp**	**Comp**	**Comp**	**Comp**	**Comp**
Isopoda												22
Ostracoda		13		1		15			21			
Hydracarina (water mites)	85	33	39	629	231	230	401	279	627	12	24	320
Entoprocta		1258	440			4						
Urnatella gracilis												
TOTAL INDIVIDUALS	**10991**	**15537**	**13375**	**12452**	**5851**	**8766**	**23531**	**12279**	**11740**	**3332**	**2163**	**12945**
without Urnatella	**10991**	**14279**	**12935**	**12452**	**5851**	**8763**	**23531**	**12279**	**11740**	**3332**	**2163**	**12945**

Appendix II Table 8. **Benthic Invertebrate sampling abundance data obtained from the lower Deschutes River for April 2015 (spring). Counts are total estimated abundances from four composited kick samples (0.743 m^2 or 8 ft^2 in area). "Comp" are abundances estimated from 4-kick composites with 500-counts, and "Pool" are abundances based on pooled results from 4-kick samples replicates (300-counts).**

Taxonomic Group	Sampling Sites – April 2015											
	1	1S	3	5S	7S	9	10	12	13	ME	DE	CR
	Comp	Pool	Pool	Comp	Pool	Pool	Comp	Comp	Comp	Comp	Comp	Comp
EPHEMEROPTERA (mayflies)												
Baetidae												
Acentrella insignificans		17	17	125	141	237	39	36	67		43	18
Acentrella turbida											5	
Baetis bicaudatus	110					23	39		13	77		36
Baetis tricaudatus	329	572	251	264	209	230	99	188	296	763	47	323
Diphetor hageni												
Ephemerellidae										10		
Attenella				10	8	34	119	23	13	58	5	
Caudatella												
Drunella doddsi										19		
Drunella "not *doddsi*"	18		88	137	124	146	217	48	14		47	
Drunella grandis grandis												
Drunella spinifera												
Ephemerella	55	2	193	536	969	836	474	303	755		5	
Serratella tibialis					4	29	98					
Heptageniidae												
Cinygmula										174	5	
Epeorus			2	137	63	120	729	211	27	261	24	
Epeorus longimanus												
Heptagenia												
Heptagenia/Nixe/Ecdyonurus /Leucrocuta						76		12				
Rhithrogena					85	29		23	283	87	456	18
Leptophlebidae												
Paraleptophlebia bicornata												
Paraleptophlebia temporalis												
Paraleptophlebia						5	20					
Ameletidae												

Taxonomic Group	Sampling Sites – April 2015											
	1	1S	3	5S	7S	9	10	12	13	ME	DE	CR
	Comp	Pool	Pool	Comp	Pool	Pool	Comp	Comp	Comp	Comp	Comp	Comp
Ameletus												
Leptohyphidae												
Tricorythodes												
MEGALOPTERA												
Sialidae												
Sialis												
PLECOPTERA (stoneflies)												
Capniidae												
Paracapnia												
Utacapnia												
Leuctridae												
Megaleuctra												
Moselia												
Chloroperlidae												
Plumiperla										10		
Sweltsa											5	
Neumouridae												
Malenka												
Zapada cinctipes			5			6						
Zapada Oregonensis Gr.												
Perlidae												
Claassenia sabulosa												
Doroneuria								12		10		
Hesperoperla pacifica	56	2	60	55	69	42	87	48	57	68	1	
Perlodidae												
Cultus									1			
Isoperla					2		20	12			5	
Osobenus												
Skwala					21	6			13			
Pteronarcyidae												
Pteronarcys californica	55	20	197	89	117	9	42	25	86		47	1
TRICHOPTERA (caddisflies)												
Apataniidae												
Pedomoecus										19		

Taxonomic Group	Sampling Sites – April 2015											
	1	**1S**	**3**	**5S**	**7S**	**9**	**10**	**12**	**13**	**ME**	**DE**	**CR**
	Comp	**Pool**	**Pool**	**Comp**	**Pool**	**Pool**	**Comp**	**Comp**	**Comp**	**Comp**	**Comp**	**Comp**
Brachycentridae		18		10				12		29		18
Amiocentrus	38	8	26	1	29	82	98	116	40		9	127
Brachycentrus												
Brachycentrus americanus										29		
Micrasema										174		
Glossosomatidae (pupae)	18		18	220	39	4	158	106	162			1
Glossosoma	18		65	209	101	8	513	198	419		10	127
Protoptila				10	103		118	234	216		57	
Helicopsychidae												
Helicopsyche												
Hydropsychidae	128	20	10			1		12	67			
Arctopysche grandis										20		
Cheumatopsyche	18			11	49	170	20	71	283			
Hydropsyche	483	128	313	634	1011	1184	1599	1752	2906		38	19
Hydroptilidae												36
Hydroptila					8				13			54
Leucotrichia						48			40			18
Ochrotrichia												36
Lepidostomatidae												
Lepidostoma												
Limnephilidae												
Dicosmoecus		6		1		9	20	1				
Eocosmoecus												
Hesperophylax												
Psychomiidae												
Psychomyia						8		12	1			
Rhyacophilidae												
Rhyacophila Alberta Gr.										10		
Rhyacophila angelita										48	1	
Rhyacophila Arnaudi								12				
Rhyacophila Betteni Gr.		4	5		12	13	20					3
Rhyacophila Coloradensis Gr.				10								
Rhyacophila Hyalinata Gr.												
Rhyacophila Brunnea Gr.	1		4	1	2					31		

Taxonomic Group	Sampling Sites – April 2015											
	1	1S	3	5S	7S	9	10	12	13	ME	DE	CR
	Comp	Pool	Pool	Comp	Pool	Pool	Comp	Comp	Comp	Comp	Comp	Comp
Rhyacophila narvae										10		
Rhyacophila Sibirica Gr.											9	
Rhyacophila sp.			14	10		3			13	19		
Uenoidae												
Neophylax										19		
Oligophlebodes												
Philopotamidae												
Dolophilodes												
LEPIDOPTERA (moths)												
Pyralidae												
Petrophila						67		24	15			18
Crambidae										10		
COLEOPTERA (beetles)												
Elmidae												
Ampumixis					3			12		10		
Cleptelmis								12				
Dubiraphia												
Heterlimnius												
Lara												
Narpus					3			12	13	10	14	
Optioservus				84	179	168	1912	479	148	10	161	
Zaitzevia				42	160	2	238	23	13		190	54
Psephenidae												
Psephenus												
DIPTERA (true flies)												
Blephariceridae												
Agathon												
Ceratopogoniidae												
Dasyhelea											66	
Palpomyia bezzia complex												
Probezzia												
Chironomidae (pupae)	37	152	128	94	72	103	59	70	40	184	24	75
Chironominae/Chironomini					9	39	1	12				36
Tanytarsini		17	5		4	13		70		97		36

Taxonomic Group	Sampling Sites – April 2015											
	1	1S	3	5S	7S	9	10	12	13	ME	DE	CR
	Comp	Pool	Pool	Comp	Pool	Pool	Comp	Comp	Comp	Comp	Comp	Comp
Tanypodinae				10	6	31	23	13				
Diamesinae			12	11	1	1			13	174	9	
Prodiamesinae												
Orthocladiinae	585	1152	376	503	263	741	198	131	108	1648	560	600
Cricotopus (Nostocladius)										215		
Tanyderidae												
Protanyderus												
Dixidae												
Dixa												
Athericidae												
Atherix								1			14	
Empididae												
Clinocera												
Chelifera												
Hemerodromia		5		10	30	50	197	70	41		24	
Neoplasta		11	1					23		58	9	18
Oreogeton												
Roederiodes										48		
Ephydridae										10		
Simuliidae												
Simulium	2290	2299	3107	242	34	384	295	58	217	174		36
Tipulidae									27			
Antocha		1								136		
Dicranota										10		
Hexatoma												
Limnophila												
Tipula												
NON-INSECT TAXA												
Nemertea												
Turbellaria (flatworms)												
Planariidae	1483	1818	208	73	3							
Aschelminthes												
Nematoda (roundworms)	146	865	85	126	160	61	414	116	108	58	104	36
Annelida												

Taxonomic Group	Sampling Sites – April 2015											
	1	1S	3	5S	7S	9	10	12	13	ME	DE	CR
	Comp	Pool	Pool	Comp	Pool	Pool	Comp	Comp	Comp	Comp	Comp	Comp
Hirudinea (leeches)												
Erpobdellidae												
Glossophoniidae												
Helobdella stagnalis												
Oligochaeta (earthworms)	585	1562	480	230	313	138	670	279	269	77	14	
Haplotaxidae												
Haplotaxis	55	13			15	4	198	12			12	
Lumbricidae		190	61		3	21	20					
Lumbriculidae	219	466	8		111	2	20				14	18
Naididae	1298	1294	774	1076	691	106	1044	710	202	39	574	7941
Polycheata												
Manayunkia speciosa	37	58	97			286	39	221				36
Gastropoda (snails)												
Ancylidae (limpets)												
Ferrissia												
Hydrobiidae	6	1			1	1						
Fluminicola	1061	515	289	42	69	8	59	116	108			
Potamopyrgus antipodarum			87									
Lymnaeidae		2		1	5				5			
Fisherola nuttalli (another limpet)	18	4			3	18						
Galba (=Fossaria)	55		64	10	6							
Physidae												
Physa/Physella	37	6	5									18
Planorbidae		13										
Planorbella										10	9	
Vorticifex	110	46	165	10	28	140	177	431	13			126
Pleuroceridae												
Juga newberryi	421	31	105	12	51		39					
Pelecypoda (clams, mussels)												
Sphaeriidae				10	12	9	59			10		
Amphipoda (scuds, sideswimmers)												
Gammarus	18	5	51	10	6						5	
Hyalella												
Decapoda												

Taxonomic Group	Sampling Sites – April 2015											
	1	1S	3	5S	7S	9	10	12	13	ME	DE	CR
	Comp	Pool	Pool	Comp	Pool	Pool	Comp	Comp	Comp	Comp	Comp	Comp
Pacifasticus						8			2			
Isopoda												18
Ostracoda			10	10		2						
Hydracarina (water mites)	37	39	33	199	211	218	98	303	94	29	24	216
Entoprocta												
Urnatella gracilis		12	2			2						
TOTAL INDIVIDUALS	**9824**	**11375**	**7416**	**5282**	**5623**	**5979**	**10289**	**6661**	**7227**	**4958**	**2649**	**10115**
without Urnatella	**9824**	**11364**	**7414**	**5282**	**5623**	**5977**	**10289**	**6661**	**7227**	**4958**	**2649**	**10115**

Appendix II Table 9. Benthic Invertebrate sampling abundance data obtained from the lower Deschutes River gravel augmentation sites and control, 2013-2015. Counts are total estimated abundances from pooled kick sample replicates (300-counts). “Control” abundances are estimated from pooled results from 4-kick samples replicates (0.743 m^2 or 8 ft^2 in area), and “G1, G2, and G3” are abundances based on pooled results from 3-kick samples replicates (0.557 m^2 or 6 ft^2 in area).

Taxonomic Group	***Fall 2013***				***Spring 2014***				***Fall 2014***				***Spring 2015***			
	Control	***G1***	***G2***	***G3***	***Control***	***G1***	***G2***	***G3***	***Control***	***G1***	***G2***	***G3***	***Control***	***G1***	***G2***	***G3***
N of samples	***4***	***3***	***3***	***3***	***4***	***3***	***3***	***3***	***4***	***3***	***3***	***3***	***4***	***3***	***3***	***3***
EPHEMEROPTERA (mayflies)																
Baetidae	23															
Acentrella insignificans		28			67	13		21					17	24	19	11
Baetis bicaudatus	11				24										4	
Baetis tricaudatus	307	192	90	70	265	280	208	325	195	27	73	43	251	171	175	94
Ephemerellidae	11															
Drunella "not *doddsi*" sp.													88	7	5	8
Drunella spinifera					65			17								
Ephemerella	48				272	85	19	264	116	72		47	193	55	58	168
Serratella tibialis																3
Heptageniidae																
Epeorus	28		18		4		8	53					2	8	57	11
Rhithrogena															4	
MEGALOPTERA																
Sialidae																
Sialis											10					
PLECOPTERA (stoneflies)																
Neumouridae																
Zapada cinctipes													5	3	7	
Perlidae																
Hesperoperla pacifica	53	2	6		27	8	3	4	42		2	22	60		36	13
Pteronarcyidae																
Pteronarcys californica	133	18	70	83	148	35	92	60	171	17	38	57	197	14	94	54
TRICHOPTERA (caddisflies)											10					
Brachycentridae																
Amiocentrus	65	16	9	96	859	16	103		24	15	15	5	26	3	25	
Glossosomatidae (pupae)					3				9				18			
Glossosoma	123	13			24	13	12		18			12	65			
Hydropsychidae			11	1						26		30	10		5	
Cheumatopsyche	74	32	72	192	1			39	40	66	59	57		15	25	36
Hydropsyche	1227	372	253	482	736	468	162	203	1315	27	238	128	313	247	232	98
Hydroptilidae																
Leucotrichia														3		

Taxonomic Group	Fall 2013				Spring 2014				Fall 2014				Spring 2015			
	Control	**G1**	**G2**	**G3**	**Control**	**G1**	**G2**	**G3**	**Control**	**G1**	**G2**	**G3**	**Control**	**G1**	**G2**	**G3**
Rhyacophilidae																
Rhyacophila Arnaudi	12		2						2	1	1	4				
Rhyacophila Betteni Gr.								6					5			
Rhyacophila Brunnea Gr.	42					1	1		68			12	4		11	
Rhyacophila sp.					18					27			14	8	5	8
LEPIDOPTERA (moths)										9						
Pyralidae																
Petrophila								6								
COLEOPTERA (beetles)																
Elmidae																
Heterlimnius	9															
DIPTERA (true flies)																
Chironomidae (pupae)	18				187		47	7	58		29	13	128	16	59	64
Chironominae/Chironomini	11			201					10	1	6					9
Tanytarsini					47						6		5	5		59
Tanypodinae						13									1	
Diamesinae													12	8	1	5
Prodiamesinae									9							
Orthocladiinae	109		62	32	1140	74	89	92	521	36	366	78	376	70	120	165
Cricotopus (Nostocladius)	1															
Empididae																
Clinocera									12							
Hemerodromia	23				3										4	
Neoplasta	13								9				1		5	
Simuliidae																
Simulium	39		21		16	45			308	18	9		3107	155	53	
NON-INSECT TAXA																
Nemertea	43			32	6											
Turbellaria (flatworms)																
Planariidae	1839	1411	1141	591	754	556	396	421	981	739	508	174	208	309	121	96
Aschelminthes																
Nematoda (roundworms)	26	32			10	8	91	144	66	62	39	158	85	21	61	3
Annelida																
Hirudinea (leeches)		26		37						62	7					
Erpobdellidae	1						1									
Glossophoniidae	1		1													
Helobdella stagnalis						16	11	1								11
Oligochaeta (earthworms)					3156	2190	3281	3092	1110	592	2154	1233	480	273	669	565
Lumbricidae	162	64	113	69	133	146	263	368	566	363	367	24	61	111	33	128
Lumbriculidae									68	159	981	225	8	146	169	210

Taxonomic Group	***Fall 2013***				***Spring 2014***				***Fall 2014***				***Spring 2015***			
	Control	***G1***	***G2***	***G3***	***Control***	***G1***	***G2***	***G3***	***Control***	***G1***	***G2***	***G3***	***Control***	***G1***	***G2***	***G3***
Naididae	1590	6188	1132	9748							76	80	774	161	429	421
Polycheata																
Manayunkia speciosa	143	6580	3006	6854	275	7019	3964	5972	243	9457	1651	1490	97	4703	1174	1680
Gastropoda (snails)																
Ancylidae																
Ferrissia	11	32		32												
Hydrobiidae			1							1	1			7	1	
Fluminicola	2095	1590	806	3553	1228	1352	644	1254	2667	1656	986	1770	289	532	605	473
Potamopyrgus antipodarum													87			
Lymnaeidae	1	1		4					2	1		2		1	1	2
Fisherola nuttalli						30				27				90		3
Galba (=Fossaria)	52	13	9	69	11	40	29	6	74	78	79	86	64	34	77	5
Physidae																
Physa/Physella	337	70	132	279	46	53	8	6	193	134	117	54	5	20	34	23
Planorbidae																
Planorbella						16										
Vorticifex	4564	4536	2333	6754	1143	1283	902	1608	2965	2968	762	1716	165	943	559	708
Pleuroceridae																
Juga newberryi	140	44	72	132	82	54	25	89	384	107	103	16	105	10	71	19
Pelecypoda (clams, mussels)																
Sphaeriidae	13	96	48	302		48	78	176	18	201	137	136		16	82	42
Amphipoda																
Gammarus	307	772	197	2128	190	291	19	148	632	695	174	436	51	414	118	262
Hyalella				101		13					6	10				
Decapoda																
Pacifasticus												5		2		
Ostracoda	13			96	7	34	13	99		9		10	10	10	5	8
Hydracarina (water mites)	62	41	9		85	16	40	22	39		9		33	45	16	29
Entoprocta									440	4677	1157	910				
Urnatella gracilis	1259	4920	2046	6310	32	38		12					2	5		5
TOTAL INDIVIDUALS	**15038**	**27088**	**11661**	**38248**	**11061**	**14253**	**10507**	**14514**	**13375**	**22330**	**10174**	**9039**	**7416**	**8665**	**5227**	**5497**
without *Urnatella*	**13779**	**22168**	**9616**	**31938**	**11029**	**14215**	**10507**	**14502**	**12935**	**17653**	**9017**	**8129**	**7414**	**8660**	**5227**	**5492**

APPENDIX III – MACROINVERTEBRATE SUMMARY METRICS BY PERIOD & SITE

Appendix III Table 1. Summary of metrics calculated for benthic invertebrate samples obtained from the lower Deschutes River for October 1999 (fall). Metrics are estimated from four composited kick samples (0.743 m^2 or 8 ft^2 in area).

Metric	Sampling Sites – October 1999															
	1	**1S**	**2**	**3**	**4**	**5S**	**6**	**7S**	**8**	**8S**	**9**	**10**	**11**	**12**	**ME**	**DE**
Total Abundance (#/sample)	3461	9572	3854	3158	3469	1923	5648	4889	4760	6975	3529	7161	2410	3319	1415	529
Density (#/sq-m)	4658	12883	5187	4250	4669	2588	7602	6580	6406	9388	4750	9638	3244	4467	1904	712
Taxa Richness (# taxa)	35	30	20	30	35	41	36	44	48	48	41	47	38	50	54	44
Mayfly Richness (# taxa)	6	4	2	5	5	7	7	11	11	8	11	11	9	12	14	11
Stonefly Richness (# taxa)	3	4	2	3	3	4	3	4	4	6	4	5	2	7	7	8
Caddisfly Richness (# taxa)	8	5	5	6	8	7	5	9	12	11	8	10	9	10	11	6
Sensitive Taxa (# taxa)	2	1	0	1	1	2	1	3	2	2	2	2	2	3	8	3
Sediment Sensitive Taxa (# taxa)	1	0	1	1	1	1	1	2	2	2	2	2	2	2	2	2
Modified Hilsenhoff Biotic Index	4.57	5.49	4.97	5.02	4.87	5.12	5.15	3.10	3.96	3.95	4.25	3.76	4.02	5.30	4.04	3.13
% Tolerant Taxa	34.8	80.7	70.0	71.6	63.4	47.1	69.7	20.2	57.1	36.4	46.1	53.7	47.8	75.5	3.4	33.5
% Sediment Tolerant Taxa	20.5	63.3	27.1	30.7	44.5	39.8	60.8	2.3	21.1	23.5	16.3	16.8	18.6	64.4	4.2	8.9
% Dominant (single taxon)	19.4	59.8	40.9	37.5	21.5	27.4	28.3	20.2	25.0	20.3	27.0	31.2	16.0	57.2	30.7	18.1
Abundance by Major Taxa (%)																
Ephemeroptera	10.9	1.6	1.3	3.4	1.4	7.6	2.0	39.8	14.5	32.4	18.1	22.7	12.2	8.0	48.3	12.7
Plecoptera	3.9	0.3	1.3	5.2	12.3	5.2	2.2	9.0	4.7	4.6	2.9	3.6	2.0	1.0	9.3	21.4
Trichoptera	24.7	3.2	5.6	6.7	9.0	5.5	8.1	24.0	45.0	14.7	49.2	44.8	40.9	5.8	7.5	23.1
Coleoptera	0.1	0.0	0.0	0.1	0.2	3.7	4.5	5.5	3.5	4.6	1.8	8.9	16.6	4.0	1.1	23.4
Chironomidae	15.3	0.2	0.2	2.2	0.2	25.5	0.1	17.5	2.8	15.3	6.6	1.0	1.0	2.9	27.3	8.5
Other Diptera	1.2	0.8	0.1	0.2	0.4	1.1	0.2	1.3	0.5	0.6	2.1	1.2	5.3	0.7	2.7	4.7
Other Insects	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.1	0.8	0.0	0.4	2.2	0.0	0.2
Non-Insect Taxa	43.9	94.0	91.5	82.3	76.5	51.5	83.0	2.7	29.0	27.6	18.6	17.8	21.6	75.4	3.7	6.0
Abundance by Food Group (%)																
Collector-Gatherers	35.4	5.4	3.7	6.7	5.2	39.2	15.9	40.3	14.5	42.7	28.7	20.2	17.1	14.7	64.5	43.3
Scrapers/Grazers	23.1	79.4	66.6	68.4	60.5	45.3	74.6	28.3	43.9	40.0	20.7	31.3	46.4	79.6	15.9	27.0
Shredders	1.6	0.6	1.1	3.0	10.4	0.6	1.4	1.3	1.3	0.8	0.2	0.7	0.3	0.2	9.9	13.0
Filter Feeders	16.3	0.8	4.3	5.6	9.8	2.1	2.1	20.9	35.7	11.7	46.3	42.5	27.9	2.3	4.7	3.8
Predators	3.6	0.3	0.7	2.5	2.5	6.2	1.1	9.2	4.5	4.7	4.1	5.3	8.0	3.0	4.8	12.7
Omnivores	20.2	13.5	23.6	13.8	11.7	6.6	4.9	0.0	0.0	0.1	0.0	0.0	0.4	0.2	0.2	0.2
Multimetric Analysis																
Taxa Richness (score)	3	3	3	3	3	5	5	5	5	5	5	5	5	5	5	5

Metric	Sampling Sites – October 1999															
	1	1S	2	3	4	5S	6	7S	8	8S	9	10	11	12	ME	DE
Mayfly Richness (score)	3	3	1	3	3	3	3	5	5	3	5	5	5	5	5	5
Stonefly Richness (score)	3	3	1	3	3	3	3	3	3	5	3	3	1	5	5	5
Caddisfly Richness (score)	3	3	3	3	3	3	3	5	5	5	3	5	5	5	5	3
Sensitive Taxa (score)	3	1	1	1	1	3	3	3	3	3	3	3	3	3	5	3
Sediment Sensitive Taxa (score)	3	1	3	3	3	3	3	3	3	3	3	3	3	3	3	3
Modifed HBI (score)	3	1	3	1	3	1	1	5	5	5	3	5	3	1	3	5
% Tolerant Taxa (score)	3	1	1	1	1	1	1	3	1	3	1	1	1	1	5	3
% Sediment Tolerant (score)	3	1	1	1	1	1	1	5	3	3	3	3	3	1	5	5
% Dominant (score)	5	1	1	3	3	3	3	3	3	3	3	3	5	1	3	5
Total Score	**32**	**18**	**18**	**22**	**24**	**26**	**26**	**40**	**36**	**38**	**32**	**36**	**34**	**30**	**44**	**42**

Appendix III Table 2. **Summary of metrics calculated for benthic invertebrate samples obtained from the lower Deschutes River for May 2000 (spring). Metrics are estimated from four composited kick samples (0.743 m^2 or 8 ft^2 in area).**

Metrics	Sampling Sites – May 2000										
	1	**1S**	**3**	**5S**	**7S**	**9**	**10**	**12**	**ME**	**DE**	**CR**
Total Abundance (#/sample)	5884	4420	4472	5288	8071	7609	6633	4300	1683	394	2166
Density (#/sq-m)	7919	5949	6019	7117	10863	10241	8927	5783	2265	530	2915
Taxa Richness (# taxa)	35	34	34	41	38	45	42	52	46	26	33
Mayfly Richness (# taxa)	7	9	7	9	9	13	9	16	12	7	6
Stonefly Richness (# taxa)	3	2	2	4	4	3	3	4	5	4	2
Caddisfly Richness (# taxa)	8	9	7	8	9	9	11	10	8	6	8
Sensitive Taxa (# taxa)	1	1	1	1	2	3	2	2	7	1	1
Sediment Sensitive Taxa (# taxa)	1	1	1	2	2	2	2	2	1	2	1
Modified Hilsenhoff Biotic Index	4.61	4.90	5.18	4.73	3.82	3.92	3.60	4.2	3.71	3.44	2.75
% Tolerant Taxa	20.0	26.3	46.6	4.0	23.7	20.4	32.2	25.4	1.7	10.9	30.3
% Sediment Tolerant Taxa	7.1	28.1	50.6	8.8	3.6	3.7	12.1	16.6	10.4	8.6	10.2
% Dominant (single taxon)	53.7	44.5	31.5	74.7	42.0	49.8	21.0	31.8	20.0	37.3	42.3
Abundance by Major Taxa (%)											
Ephemeroptera	9.2	3.4	6.0	4.5	15.0	19.9	26.6	22.5	48.7	28.9	4.8
Plecoptera	2.8	0.6	3.2	3.4	5.7	3.5	4.6	3.3	3.0	3.8	0.9
Trichoptera	22.0	5.2	4.7	5.7	28.2	19.8	26.3	14.6	9.9	4.8	58.9
Coleoptera	0.1	0.0	0.1	0.5	3.3	1.8	11.4	5.1	2.7	14.5	14.9
Chironomidae	53.8	48.0	21.6	74.9	42.0	50.9	16.6	34.7	22.5	37.8	9.2
Other Diptera	2.5	2.1	0.2	1.1	3.1	1.4	3.5	4.1	9.2	3.0	5.8
Other Insects	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.7	0.0	0.0	0.0
Non-Insect Taxa	9.7	40.7	64.2	9.9	2.7	2.6	11.1	14.9	4.0	7.1	5.5
Abundance by Food Group (%)											
Collector-Gatherers	69.4	57.8	35.1	88.3	56.3	61.3	43.7	57.8	58.1	63.5	22.6
Scrapers/Grazers	6.2	25.9	45.3	2.3	12.8	16.8	26.4	25.0	25.5	29.7	59.7
Shredders	0.9	0.4	2.4	1.9	2.8	0.5	1.0	1.0	4.8	2.3	1.9
Filter Feeders	16.5	1.5	2.8	3.5	22.9	17.7	22.5	10.5	1.8	0.5	13.8
Predators	2.6	0.7	1.4	3.6	5.2	3.7	6.4	5.6	9.7	4.1	1.9
Omnivores	4.3	13.8	13.0	0.3	0.0	0.0	0.0	0.2	0.1	0.0	0.0
Multimetric Analysis											
Taxa Richness (score)	3	3	3	5	5	5	5	5	5	3	3

Metrics	Sampling Sites – May 2000										
	1	**1S**	**3**	**5S**	**7S**	**9**	**10**	**12**	**ME**	**DE**	**CR**
Mayfly Richness (score)	3	5	3	5	5	5	5	5	5	3	3
Stonefly Richness (score)	3	1	1	3	3	3	3	3	3	3	1
Caddisfly Richness (score)	3	5	3	3	5	5	5	5	3	3	3
Sensitive Taxa (score)	1	1	1	1	3	3	3	3	5	1	1
Sediment Sensitive Taxa (score)	3	3	3	3	3	3	3	3	3	3	3
Modifed HBI (score)	3	3	1	3	5	5	5	3	5	5	5
% Tolerant Taxa (score)	3	3	1	5	3	3	3	3	5	5	3
% Sediment Tolerant (score)	5	1	1	5	5	5	3	3	3	5	3
% Dominant (score)	1	1	3	1	1	1	3	3	3	3	1
Total Score	**28**	**26**	**20**	**34**	**38**	**38**	**38**	**36**	**40**	**34**	**26**

Appendix III Table 3. **Summary of metrics calculated for benthic invertebrate samples obtained from the lower Deschutes River for May 2001 (spring). Metrics are estimated from four composited kick samples (0.743 m^2 or 8 ft^2 in area).**

Metrics	Sampling Sites – May 2001									
	1	1S	3	5S	7S	9	10	ME	DE	CR
Total Abundance (#/sample)	2697	4391	5690	5658	12443	6355	16215	2065	1104	749
Density (#/sq-m)	3630	5910	7658	7615	16747	8553	21824	2779	1486	1008
Taxa Richness (# taxa)	29	24	29	38	37	40	38	43	38	24
Mayfly Richness (# taxa)	7	3	6	8	8	10	10	12	8	4
Stonefly Richness (# taxa)	3	2	4	4	3	3	3	4	4	1
Caddisfly Richness (# taxa)	7	6	4	6	8	9	8	12	7	6
Sensitive Taxa (# taxa)	2	0	0	0	1	1	2	8	1	1
Sediment Sensitive Taxa (# taxa)	1	0	1	1	2	2	2	2	2	1
Modified Hilsenhoff Biotic Index	4.29	4.79	4.76	3.34	2.84	3.63	3.53	4.10	3.65	4.56
% Tolerant Taxa	20.3	41.2	57.6	11.4	17.5	29.1	26.1	0.4	14.2	18.4
% Sediment Tolerant Taxa	4.2	13.9	8.1	4.7	3.0	12.6	5.7	2.9	11.0	7.9
% Dominant (single taxon)	38.5	28.3	46.0	25.5	20.1	17.0	17.5	39.8	32.3	39.9
Abundance by Major Taxa (%)										
Ephemeroptera	10.8	1.2	4.9	37.8	34.7	23.7	20.6	70.2	23.6	20.7
Plecoptera	5.0	2.1	3.0	8.1	7.1	3.1	2.0	1.7	4.2	0.1
Trichoptera	32.5	1.8	8.4	16.8	28.1	32.1	30.8	9.4	11.1	18.8
Coleoptera	0.0	0.1	0.0	1.5	8.9	4.0	18.4	0.3	11.1	10.3
Chironomidae	39.3	21.1	25.9	25.8	15.0	19.1	18.0	12.8	37.4	40.6
Other Diptera	7.0	3.0	0.7	2.5	2.5	5.3	4.8	4.8	5.3	6.0
Other Insects	0.0	0.0	0.0	0.0	0.0	0.4	0.0	0.0	0.0	0.0
Non-Insect Taxa	5.4	70.7	57.1	7.6	3.7	12.3	5.4	0.7	7.3	3.5
Abundance by Food Group (%)										
Collector-Gatherers	61.5	25.0	35.2	54.6	44.2	48.9	57.4	70.2	67.5	73.2
Scrapers/Grazers	6.9	39.2	55.1	29.2	31.7	24.8	25.0	18.8	22.5	11.6
Shredders	2.7	1.7	2.2	3.3	3.2	0.8	0.7	4.0	2.0	0.0
Filter Feeders	22.8	3.6	2.8	4.8	13.4	16.4	11.8	1.6	3.4	6.7
Predators	4.5	0.8	2.9	7.8	7.4	8.9	5.0	5.0	4.5	8.4
Omnivores	1.5	29.8	1.7	0.1	0.1	0.2	0.0	0.0	0.1	0.1
Multimetric Analysis										
Taxa Richness (score)	3	3	3	5	5	5	5	5	5	3

Metrics	Sampling Sites – May 2001									
	1	**1S**	**3**	**5S**	**7S**	**9**	**10**	**ME**	**DE**	**CR**
Mayfly Richness (score)	3	1	3	3	3	5	5	5	3	3
Stonefly Richness (score)	3	1	3	3	3	3	3	3	3	1
Caddisfly Richness (score)	3	3	3	3	3	5	3	5	3	3
Sensitive Taxa (score)	3	1	1	1	1	1	3	5	1	1
Sediment Sensitive Taxa (score)	3	1	3	3	3	3	3	3	3	3
Modifed HBI (score)	3	3	3	5	5	5	5	3	5	3
% Tolerant Taxa (score)	3	3	1	5	3	3	3	5	5	3
% Sediment Tolerant (score)	5	3	5	5	5	3	5	5	3	5
% Dominant (score)	3	3	1	3	3	5	5	3	3	3
Total Score	**32**	**22**	**26**	**36**	**34**	**38**	**40**	**42**	**34**	**28**

Appendix III Table 4. Summary of metrics calculated for benthic invertebrate samples obtained from the lower Deschutes River for October 2001 (Fall). Metrics are estimated from four composited kick samples (0.743 m^2 or 8 ft^2 in area).

Metrics	Sampling Sites – October 2001									
	1	1S	3	5S	7S	9	10	ME	DE	CR
Total Abundance (#/sample)	9900	5608	5646	3439	1783	4130	7010	2604	1798	1218
Density (#/sq-m)	13324	7548	7599	4629	2400	5559	9435	3505	2420	1639
Taxa Richness (# taxa)	25	19	17	32	36	39	39	48	40	28
Mayfly Richness (# taxa)	4	3	3	5	6	6	8	11	7	3
Stonefly Richness (# taxa)	2	2	2	3	3	3	3	8	5	2
Caddisfly Richness (# taxa)	6	3	2	4	6	9	8	9	7	7
Sensitive Taxa (# taxa)	1	0	0	3	1	0	1	10	3	1
Sediment Sensitive Taxa (# taxa)	1	1	0	1	1	2	2	2	2	1
Modified Hilsenhoff Biotic Index	5	5	5	6	4	4	4	4	4	5
% Tolerant Taxa	74.1	51.4	75.8	72.0	58.8	54.0	70.9	5.5	55.7	23.6
% Sediment Tolerant Taxa	54.5	22.3	36.8	67.6	24.7	12.4	20.4	7.8	37.7	16.7
% Dominant (single taxon)	53.8	35.4	38.4	39.2	16.2	21.7	25.9	28.5	23.2	40.6
Abundance by Major Taxa (%)										
Ephemeroptera	1.2	6.0	1.1	7.1	9.2	5.8	7.5	42.4	8.4	43.8
Plecoptera	0.7	0.3	0.2	3.6	2.6	2.7	3.6	4.5	9.7	0.4
Trichoptera	11.3	5.8	0.8	11.3	32.5	40.0	33.7	13.5	15.1	22.6
Coleoptera	0.1	0.0	0.0	1.2	22.4	2.5	21.0	0.6	22.7	8.8
Chironomidae	0.8	0.5	0.0	1.8	1.0	27.9	7.2	26.3	2.4	3.0
Other Diptera	0.3	0.8	0.1	0.2	2.1	1.0	1.1	5.7	3.3	4.3
Other Insects	0.0	0.0	0.0	0.0	0.1	6.1	1.5	0.0	0.0	0.0
Non-Insect Taxa	85.7	86.6	97.8	74.8	30.1	14.1	24.3	7.0	38.3	17.2
Abundance by Food Group (%)										
Collector-Gatherers	10.9	11.4	5.1	20.2	27.1	41.4	27.6	67.8	51.1	66.0
Scrapers/Grazers	67.5	48.9	66.1	68.9	48.4	22.1	42.5	10.1	27.3	25.1
Shredders	0.3	0.2	0.2	1.4	1.7	0.8	0.7	6.5	3.7	0.6
Filter Feeders	2.6	1.2	0.5	1.2	17.2	31.6	25.2	1.5	6.2	3.9
Predators	1.6	0.4	0.4	6.0	5.7	3.5	3.8	13.3	7.5	4.2
Omnivores	17.1	37.9	27.8	2.4	0.0	0.5	0.1	0.9	4.1	0.2
Multimetric Analysis										
Taxa Richness (score)	3.0	3.0	1.0	3.0	5.0	5.0	5.0	5.0	5.0	3.0

Metrics	Sampling Sites – October 2001									
	1	**1S**	**3**	**5S**	**7S**	**9**	**10**	**ME**	**DE**	**CR**
Mayfly Richness (score)	3.0	1.0	1.0	3.0	3.0	3.0	3.0	5.0	3.0	1.0
Stonefly Richness (score)	1.0	1.0	1.0	3.0	3.0	3.0	3.0	5.0	3.0	1.0
Caddisfly Richness (score)	3.0	1.0	1.0	3.0	3.0	5.0	3.0	5.0	3.0	3.0
Sensitive Taxa (score)	1.0	1.0	1.0	3.0	1.0	1.0	1.0	5.0	3.0	1.0
Sediment Sensitive Taxa (score)	3.0	3.0	1.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0
Modifed HBI (score)	1.0	3.0	1.0	1.0	3.0	3.0	3.0	3.0	3.0	3.0
% Tolerant Taxa (score)	1.0	1.0	1.0	1.0	1.0	1.0	1.0	5.0	1.0	3.0
% Sediment Tolerant (score)	1.0	3.0	1.0	1.0	3.0	3.0	3.0	5.0	1.0	3.0
% Dominant (score)	1.0	3.0	3.0	3.0	5.0	3.0	3.0	3.0	3.0	1.0
Total Score	**18.0**	**20.0**	**12.0**	**24.0**	**30.0**	**30.0**	**28.0**	**44.0**	**28.0**	**22.0**

Appendix III Table 5. **Summary of metrics calculated for benthic invertebrate samples obtained from the lower Deschutes River for October 2013 (fall). Metrics are estimated from four composited kick samples (0.743 m^2 or 8 ft^2 in area). "Comp" are abundances estimated from 4-kick composites with 500-counts, and "Pool" are abundances based on pooled results from 4-kick samples replicates (300-counts).**

Metrics	Sampling Sites – October 2013											
	1	1S	3	5S	7S	9	10	12	13	ME	DE	CR
	Comp	Pool	Pool	Comp	Pool	Pool	Comp	Comp	Comp	Comp	Comp	Comp
Total Abundance (#/sample)	12,626	9,746	13,779	16,698	10,255	15,490	26,809	7,332	11,523	2,708	2,582	4,921
Density (#/sq-m)	16,988	13,113	18,540	22,467	13,798	20,841	36,072	9,865	15,504	3,644	3,474	6,621
Taxa Richness (# taxa)	28	27	38	34	40	44	32	32	43	40	32	32
Mayfly Richness (# taxa)	2	1	4	4	6	9	7	4	7	8	5	2
Stonefly Richness (# taxa)	2	2	2	2	4	2	2	1	3	3	6	1
Caddisfly Richness (# taxa)	6	7	6	8	7	7	7	6	8	8	5	6
Sensitive Taxa (# taxa)	1	0	1	1	1	2	2	1	2	7	1	1
Sediment Sensitive Taxa (# taxa)	1	1	1	1	1	1	1	1	2	3	1	1
Modified Hilsenhoff Biotic Index	5.04	5.33	5.49	4.58	4.66	5.17	4.92	5.67	4.44	3.82	4.27	5.73
% Tolerant Taxa	21.9	26.8	47.5	39.0	32.1	42.4	37.6	35.4	43.7	0.4	6.7	35.3
% Sediment Tolerant Taxa	4.2	7.7	27.5	20.6	8.0	14.1	5.7	19.9	3.2	3.2	0.6	29.3
% Dominant (single taxon)	33.3	34.4	33.1	22.7	20.3	21.5	27.8	25.9	19.1	13.6	30.6	38.8
Abundance by Major Taxa (%)												
Ephemeroptera	4.1	4.5	3.1	3.4	7.8	11.1	10.7	2.6	4.3	34.9	21.7	1.2
Plecoptera	0.4	0.1	1.4	1.3	3.9	0.7	0.6	0.2	0.2	4.1	6.0	0.0
Trichoptera	12.7	3.6	11.2	36.8	38.1	37.4	40.9	14.8	56.8	14.5	19.3	19.3
Coleoptera	0.2	0.0	0.1	3.1	5.0	1.4	5.9	3.5	3.0	0.5	8.9	1.2
Chironomidae	1.4	0.7	1.0	2.6	0.6	3.4	0.8	3.1	4.6	29.2	5.2	6.8
Other Diptera	0.8	2.3	0.5	0.0	0.2	0.6	1.5	0.2	2.2	9.2	1.2	1.6
Other Insects	0.0	0.0	0.0	0.2	0.0	0.3	0.2	0.3	2.6	0.0	0.0	0.0
Non-Insect Taxa	80.4	89.0	82.7	52.7	44.4	45.0	39.4	75.3	26.4	7.6	37.8	69.9
Abundance by Feeding Group (%)												
Collector-Gatherers	15.1	22.9	17.3	23.7	36.0	32.9	37.1	23.1	18.4	50.3	47.5	35.3
Scrapers/Grazers	15.3	34.5	53.3	57.0	33.1	25.9	24.5	44.0	35.4	16.2	37.4	51.5
Shredders	0.5	0.5	1.0	0.7	1.1	0.3	0.2	0.2	0.2	11.7	1.8	0.4
Filter Feeders	31.0	6.7	10.9	12.5	22.6	36.2	33.0	28.4	36.9	7.0	1.5	5.4
Predators	0.9	1.1	2.0	5.0	7.1	3.1	5.2	3.8	6.3	14.7	11.8	3.4
Omnivores	37.2	34.4	15.6	1.0	0.0	1.6	0.0	0.5	2.8	0.2	0.0	4.0

Metrics	Sampling Sites – October 2013											
	1	**1S**	**3**	**5S**	**7S**	**9**	**10**	**12**	**13**	**ME**	**DE**	**CR**
	Comp	**Pool**	**Pool**	**Comp**	**Pool**	**Pool**	**Comp**	**Comp**	**Comp**	**Comp**	**Comp**	**Comp**
Multimetric Analysis												
Taxa Richness (score)	3	3	5	3	5	5	3	3	5	5	3	3
Mayfly Richness (score)	1	1	3	3	3	5	3	3	3	3	3	1
Stonefly Richness (score)	1	1	1	1	3	1	1	1	1	1	3	1
Caddisfly Richness (score)	3	3	3	3	3	3	3	3	3	3	3	3
Sensitive Taxa (score)	1	1	1	1	1	3	3	1	3	5	1	1
Sediment Sensitive Taxa (score)	3	3	3	3	3	3	3	3	3	5	3	3
Modifed HBI (score)	1	1	1	3	3	1	3	1	3	5	3	1
% Tolerant Taxa (score)	3	3	1	3	3	3	3	3	3	5	5	3
% Sediment Tolerant (score)	5	5	1	3	5	3	5	3	5	5	5	1
% Dominant (score)	3	3	3	3	3	3	3	3	5	5	3	3
Total Score	**24**	**24**	**22**	**26**	**32**	**30**	**30**	**24**	**34**	**42**	**32**	**20**

Appendix III Table 5. **Summary of metrics calculated for benthic invertebrate samples obtained from the lower Deschutes River for April/May 2014 (spring). Metrics are estimated from four composited kick samples (0.743 m^2 or 8 ft^2 in area). "Comp" are abundances estimated from 4-kick composites with 500-counts, and "Pool" are abundances based on pooled results from 4-kick samples replicates (300-counts).**

Metrics	Sampling Sites – April/May 2014											
	1	1S	3	5S	7S	9	10	12	13	ME	DE	CR
	Comp	Pool	Pool	Comp	Pool	Pool	Comp	Comp	Comp	Comp	Comp	Comp
Total Abundance (#/sample)	4,931	8,740	11,029	8,151	8,274	8,036	4,823	9,266	109,31	1,211	2,548	8,578
Density (#/sq-m)	6,635	11,759	14,839	10,968	11,133	10,813	6,489	12,467	14,707	1,630	3,428	11,541
Taxa Richness (# taxa)	24	31	31	34	37	45	41	31	38	41	32	23
Mayfly Richness (# taxa)	3	3	6	6	7	10	8	6	7	9	9	3
Stonefly Richness (# taxa)	2	2	2	3	2	4	3	3	3	5	3	1
Caddisfly Richness (# taxa)	3	7	5	7	7	6	7	6	9	8	6	7
Sensitive Taxa (# taxa)	0	0	2	1	2	2	2	2	1	6	2	1
Sediment Sensitive Taxa (# taxa)	0	0	1	1	2	1	1	1	2	1	1	0
Modified Hilsenhoff Biotic Index	5.19	5.26	5.02	4.62	4.31	4.32	4.70	4.65	4.43	4.14	4.18	5.83
% Tolerant Taxa	27.6	12.8	23.2	9.1	13.3	16.4	22.1	24.8	21.1	0.4	9.9	59.8
% Sediment Tolerant Taxa	9.6	2.1	8.6	1.6	2.2	7.1	4.6	15.5	2.5	9.9	0.0	58.4
% Dominant (single taxon)	20.5	31.8	28.6	27.3	23.5	17.0	20.4	17.4	20.9	24.3	37.2	78.3
Abundance by Major Taxa (%)												
Ephemeroptera	4.7	2.2	6.3	15.9	14.7	18.7	13.1	6.3	11.9	47.5	24.7	3.8
Plecoptera	1.5	0.4	1.6	2.0	3.8	1.5	1.9	1.3	1.0	1.7	3.2	0.1
Trichoptera	10.2	8.8	14.9	17.0	27.4	30.2	17.7	25.9	29.8	8.8	5.4	1.8
Coleoptera	0.0	0.0	0.0	4.4	5.5	2.7	13.6	2.2	1.6	0.2	9.7	0.4
Chironomidae	25.0	25.6	12.5	32.3	14.3	21.7	8.0	27.6	9.6	23.9	12.7	12.8
Other Diptera	0.7	1.3	0.2	0.5	0.4	0.3	1.0	1.8	2.3	5.3	2.1	0.0
Other Insects	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.2	0.0	0.0
Non-Insect Taxa	57.8	61.7	64.6	27.9	33.9	24.7	44.6	34.9	43.8	12.5	42.2	81.0
Abundance by Feeding Group (%)												
Collector-Gatherers	44.6	65.5	55.4	78.3	70.7	65.8	53.5	63.4	45.8	59.4	62.2	95.1
Scrapers/Grazers	30.2	9.9	23.0	10.3	11.4	9.1	28.2	14.8	23.7	20.3	19.8	1.7
Shredders	1.5	0.3	1.3	1.8	2.6	0.6	1.0	0.4	1.2	7.4	2.1	0.2
Filter Feeders	9.8	8.6	9.7	4.5	8.9	15.9	10.7	9.6	15.5	2.1	4.3	0.6
Predators	4.7	5.8	1.9	3.7	6.2	8.3	6.3	11.7	13.7	10.7	11.7	2.3
Omnivores	9.2	9.9	8.6	1.4	0.1	0.3	0.2	0.2	0.2	0.0	0.0	0.2

Metrics	Sampling Sites – April/May 2014											
	1	1S	3	5S	7S	9	10	12	13	ME	DE	CR
	Comp	Pool	Pool	Comp	Pool	Pool	Comp	Comp	Comp	Comp	Comp	Comp
Multimetric Analysis												
Taxa Richness (score)	3	3	3	3	5	5	5	3	5	5	3	3
Mayfly Richness (score)	1	1	3	3	3	5	3	3	3	5	5	1
Stonefly Richness (score)	1	1	1	1	1	3	1	1	1	3	1	1
Caddisfly Richness (score)	1	3	3	3	3	3	3	3	5	3	3	3
Sensitive Taxa (score)	1	1	3	1	3	3	3	3	1	5	3	1
Sediment Sensitive Taxa (score)	1	1	3	3	3	3	3	3	3	3	3	1
Modifed HBI (score)	1	1	1	3	3	3	3	3	3	3	3	1
% Tolerant Taxa (score)	3	5	3	5	5	3	3	3	3	5	5	1
% Sediment Tolerant (score)	5	5	5	5	5	5	5	3	5	5	5	1
% Dominant (score)	3	3	3	3	3	5	3	5	3	3	3	1
Total Score	**20**	**24**	**28**	**30**	**34**	**38**	**32**	**30**	**32**	**40**	**34**	**14**

Appendix III Table 6. Summary of metrics calculated for benthic invertebrate samples obtained from the lower Deschutes River for October 2014 (fall). Metrics are estimated from four composited kick samples (0.743 m^2 or 8 ft^2 in area). "Comp" are abundances estimated from 4-kick composites with 500-counts, and "Pool" are abundances based on pooled results from 4-kick samples replicates (300-counts).

Metrics	Sampling Sites – October 2014											
	1	1S	3	5S	7S	9	10	12	13	ME	DE	CR
	Comp	Pool	Pool	Comp	Pool	Pool	Comp	Comp	Comp	Comp	Comp	Comp
Total Abundance (#/sample)	10,991	14,279	12,935	12,452	5,851	8,763	23,531	12,279	11,740	3,332	2,163	12,945
Density (#/sq-m)	14,789	19,212	17,404	16,754	7,873	11,790	31,661	16,521	15,796	4,483	2,910	17,417
Taxa Richness (# taxa)	27	29	29	35	39	42	33	30	37	38	39	28
Mayfly Richness (# taxa)	2	2	2	4	8	9	7	4	5	6	5	1
Stonefly Richness (# taxa)	2	2	2	4	4	2	4	3	2	6	7	1
Caddisfly Richness (# taxa)	6	5	6	6	7	8	5	6	9	9	4	6
Sensitive Taxa (# taxa)	0	1	0	0	1	1	1	0	0	5	2	0
Sediment Sensitive Taxa (# taxa)	1	0	1	1	1	1	1	1	1	2	1	1
Modified Hilsenhoff Biotic Index	5.14	5.20	5.28	4.58	4.10	4.57	4.07	4.40	4.29	4.3	4.72	6.43
% Tolerant Taxa	29.1	34.8	47.5	20.0	37.5	43.1	34.5	36.7	38.6	0.3	14.7	3.6
% Sediment Tolerant Taxa	12.5	13.7	21.9	10.3	10.0	16.6	15.4	24.6	7.7	1.7	0.1	0.9
% Dominant (single taxon)	19.8	23.2	22.9	18.9	29.2	24.6	18.2	25.4	19.1	30.2	38.8	40.0
Abundance by Major Taxa (%)												
Ephemeroptera	2.1	3.0	2.4	14.8	15.6	14.1	18.5	2.5	10.0	42.5	10.6	10.7
Plecoptera	0.5	0.1	1.6	2.8	4.5	0.8	1.7	1.0	0.5	6.1	5.0	0.0
Trichoptera	20.5	7.0	11.4	22.0	37.2	36.2	26.3	35.4	41.5	9.4	17.2	5.0
Coleoptera	0.0	0.1	0.0	1.9	9.4	1.5	12.3	4.7	2.0	1.0	7.3	0.7
Chironomidae	2.9	2.3	4.6	17.8	3.0	9.9	4.4	4.9	3.0	33.2	8.0	31.0
Other Diptera	2.1	6.3	2.5	7.5	2.3	0.9	2.1	0.2	0.7	3.8	2.7	4.4
Other Insects	0.0	0.0	0.0	0.0	0.1	2.0	0.2	0.8	3.9	0.0	0.0	0.5
Non-Insect Taxa	71.8	81.4	77.4	33.2	28.0	34.8	34.4	50.5	38.3	4.0	49.2	47.7
Abundance by Feeding Group (%)												
Collector-Gatherers	29.3	21.7	20.7	53.5	31.5	32.0	39.9	20.4	18.9	60.1	58.3	82.3
Scrapers/Grazers	21.5	35.0	48.8	8.7	22.6	25.9	32.0	56.7	44.9	11.8	10.8	2.0
Shredders	0.5	0.0	1.3	0.5	0.9	0.4	0.2	0.1	0.2	14.9	1.9	0.0
Filter Feeders	29.4	13.7	14.9	26.8	33.9	35.4	20.8	19.4	26.4	4.3	14.3	10.6
Predators	3.0	0.9	1.8	8.2	11.1	4.7	7.0	3.3	7.3	8.9	14.7	3.8
Omnivores	16.3	28.8	12.5	2.4	0.0	1.6	0.0	0.2	2.3	0.0	0.0	1.3

Metrics	Sampling Sites – October 2014											
	1	1S	3	5S	7S	9	10	12	13	ME	DE	CR
	Comp	Pool	Pool	Comp	Pool	Pool	Comp	Comp	Comp	Comp	Comp	Comp
Multimetric Analysis												
Taxa Richness (score)	3	3	3	3	5	5	3	3	5	5	5	3
Mayfly Richness (score)	1	1	1	3	3	5	3	3	3	3	3	1
Stonefly Richness (score)	1	1	1	3	3	1	3	1	1	3	3	1
Caddisfly Richness (score)	3	3	3	3	3	3	3	3	5	5	3	3
Sensitive Taxa (score)	1	1	1	1	1	1	1	1	1	5	3	1
Sediment Sensitive Taxa (score)	3	1	3	3	3	3	3	3	3	3	3	3
Modifed HBI (score)	1	1	1	3	3	3	3	3	3	3	3	1
% Tolerant Taxa (score)	3	3	1	3	3	3	3	3	3	5	5	5
% Sediment Tolerant (score)	3	3	3	3	5	3	3	3	5	5	5	5
% Dominant (score)	5	3	3	5	3	3	5	3	5	3	3	1
Total Score	**24**	**20**	**20**	**30**	**32**	**30**	**30**	**26**	**34**	**40**	**36**	**24**

Appendix III Table 7. **Summary of metrics calculated for benthic invertebrate samples obtained from the lower Deschutes River for April 2015 (spring). Metrics are estimated from four composited kick samples (0.743 m^2 or 8 ft^2 in area). "Comp" are abundances estimated from 4-kick composites with 500-counts, and "Pool" are abundances based on pooled results from 4-kick samples replicates (300-counts).**

Metrics	Sampling Sites – April 2015											
	1	1S	3	5S	7S	9	10	12	13	ME	DE	CR
	Comp	Pool	Pool	Comp	Pool	Pool	Comp	Comp	Comp	Comp	Comp	Comp
Total Abundance (#/sample)	9,824	11,364	7,414	5,282	5,623	5,977	10,289	6,661	7,227	4,958	2,649	10,115
Density (#/sq-m)	13,218	15,290	9,975	7,106	7,565	8,043	13,844	8,962	9,724	6,671	3,564	13,610
Taxa Richness (# taxa)	27	30	34	35	45	47	37	41	37	39	34	27
Mayfly Richness (# taxa)	4	3	5	6	8	11	9	8	8	7	9	4
Stonefly Richness (# taxa)	2	2	3	2	4	4	3	4	4	3	4	1
Caddisfly Richness (# taxa)	5	4	6	9	8	9	7	8	9	10	6	7
Sensitive Taxa (# taxa)	1	0	0	0	0	1	1	1	1	5	0	1
Sediment Sensitive Taxa (# taxa)	1	0	1	1	1	2	1	2	2	1	1	1
Modified Hilsenhoff Biotic Index	5.56	5.63	5.54	4.44	4.01	4.10	4.02	4.34	3.55	4.38	4.33	7.33
% Tolerant Taxa	17.7	5.0	10.9	12.1	20.8	22.2	29.2	32.6	37.2	0.3	12.0	2.9
% Sediment Tolerant Taxa	7.0	6.1	3.5	0.5	3.2	1.8	1.8	4.8	0.5	2.3	0.7	1.2
% Dominant (single taxon)	23.3	20.2	41.9	20.4	18.0	19.8	18.6	26.3	40.2	33.2	21.7	78.5
Abundance by Major Taxa (%)												
Ephemeroptera	5.2	5.2	7.4	22.9	28.5	29.5	17.8	12.7	20.3	29.2	24.0	3.9
Plecoptera	1.1	0.2	3.5	2.7	3.7	1.1	1.4	1.4	2.2	1.8	2.2	0.0
Trichoptera	7.2	1.6	6.1	21.2	24.1	25.6	24.7	37.9	57.6	8.2	4.7	4.3
Coleoptera	0.0	0.0	0.0	2.4	6.1	2.8	20.9	8.1	2.4	0.6	13.8	0.5
Chironomidae	6.3	11.6	7.0	11.7	6.3	15.5	2.7	4.4	2.2	46.7	22.4	7.4
Other Diptera	23.3	20.4	41.9	4.8	1.1	7.3	4.8	2.3	3.9	8.8	4.3	0.5
Other Insects	0.0	0.0	0.0	0.0	0.0	1.1	0.0	0.4	0.2	0.2	0.0	0.2
Non-Insect Taxa	56.9	61.0	34.0	34.3	30.0	17.1	27.6	32.8	11.1	4.5	28.6	83.1
Abundance by Feeding Group (%)												
Collector-Gatherers	33.9	47.8	32.7	57.6	55.6	46.6	35.5	29.8	25.6	64.2	61.3	91.8
Scrapers/Grazers	17.7	5.4	10.8	13.9	13.2	11.5	36.0	27.5	20.1	12.1	27.3	3.7
Shredders	0.6	0.2	2.7	1.7	2.1	0.4	0.6	0.6	1.7	8.0	2.3	0.0
Filter Feeders	30.1	22.4	47.6	17.2	19.7	34.3	19.6	33.0	48.1	7.2	1.4	1.4
Predators	2.4	8.2	2.7	8.0	9.1	7.1	8.3	9.1	4.5	8.2	7.4	2.7
Omnivores	15.3	16.0	3.5	1.6	0.2	0.1	0.0	0.0	0.0	0.2	0.2	0.4

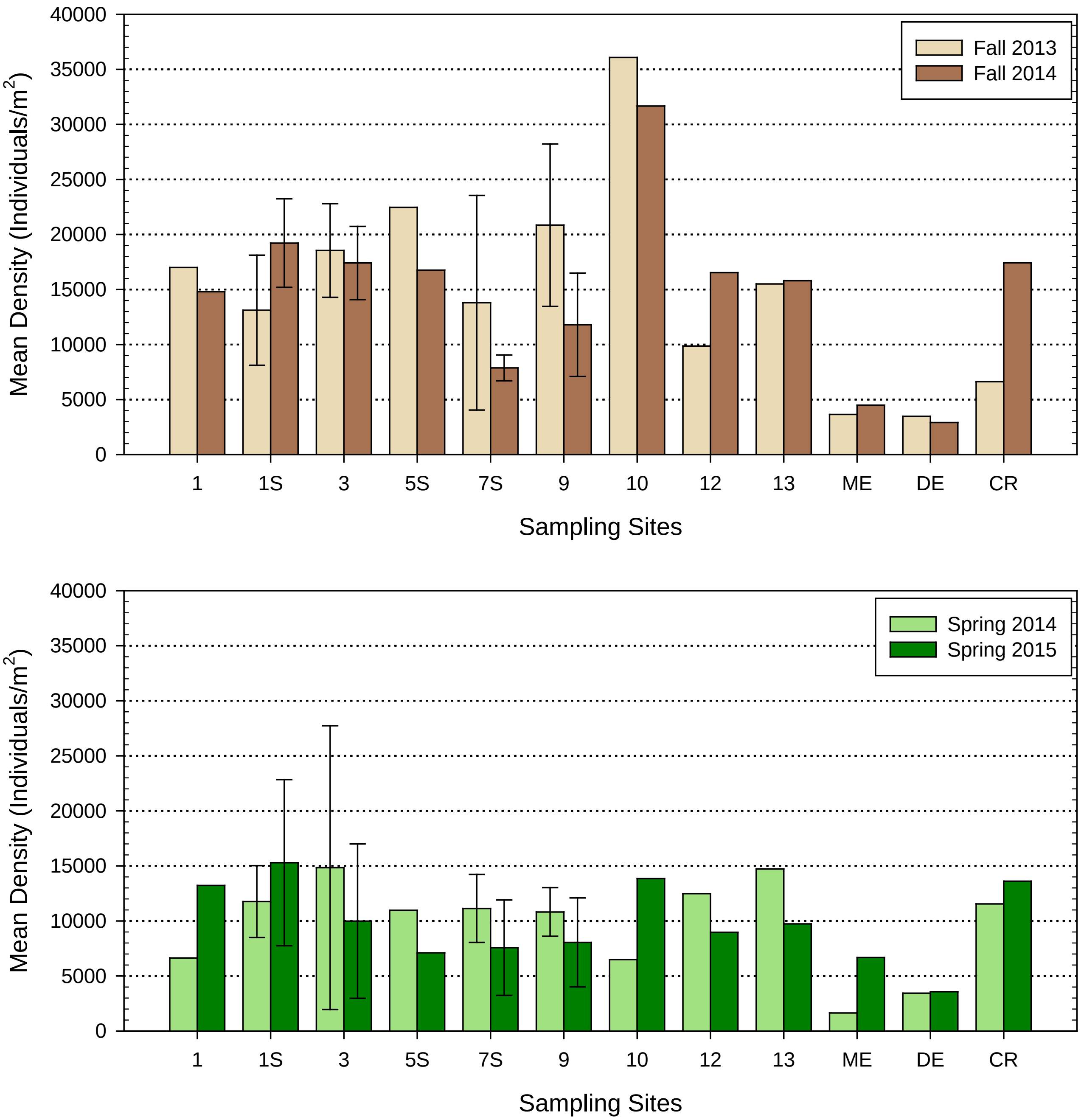
Metrics	Sampling Sites – April 2015											
	1	**1S**	**3**	**5S**	**7S**	**9**	**10**	**12**	**13**	**ME**	**DE**	**CR**
	Comp	**Pool**	**Pool**	**Comp**	**Pool**	**Pool**	**Comp**	**Comp**	**Comp**	**Comp**	**Comp**	**Comp**
Multimetric Analysis												
Taxa Richness (score)	3	3	3	3	5	5	5	5	5	5	3	3
Mayfly Richness (score)	3	1	3	3	3	5	5	3	3	3	5	3
Stonefly Richness (score)	1	1	1	1	3	3	1	3	3	1	3	1
Caddisfly Richness (score)	3	3	3	5	3	5	3	3	5	5	3	3
Sensitive Taxa (score)	1	1	1	1	1	1	1	1	1	5	1	1
Sediment Sensitive Taxa (score)	3	1	3	3	3	3	3	3	3	3	3	3
Modifed HBI (score)	1	1	1	3	3	3	3	3	5	3	3	1
% Tolerant Taxa (score)	5	5	5	5	3	3	3	3	3	5	5	5
% Sediment Tolerant (score)	5	5	5	5	5	5	5	5	5	5	5	5
% Dominant (score)	1	3	1	3	5	5	5	3	1	3	3	1
Total Score	**26**	**24**	**26**	**32**	**34**	**38**	**34**	**32**	**34**	**38**	**34**	**26**

Appendix III Table 8. **Summary of metrics calculated for invertebrate samples obtained from gravel augmentation sites and the control, Site 3, from the lower Deschutes River, 2013-2015. Counts are total estimated abundances from pooled kick sample replicates (300-counts). Site 3 abundances are estimated from pooled results from 4-kick samples replicates (0.743 m^2 or 8 ft^2 in area), and G1, G2, and G3 are abundances based on pooled results from 3-kick samples replicates (0.557 m^2 or 6 ft^2 in area).**

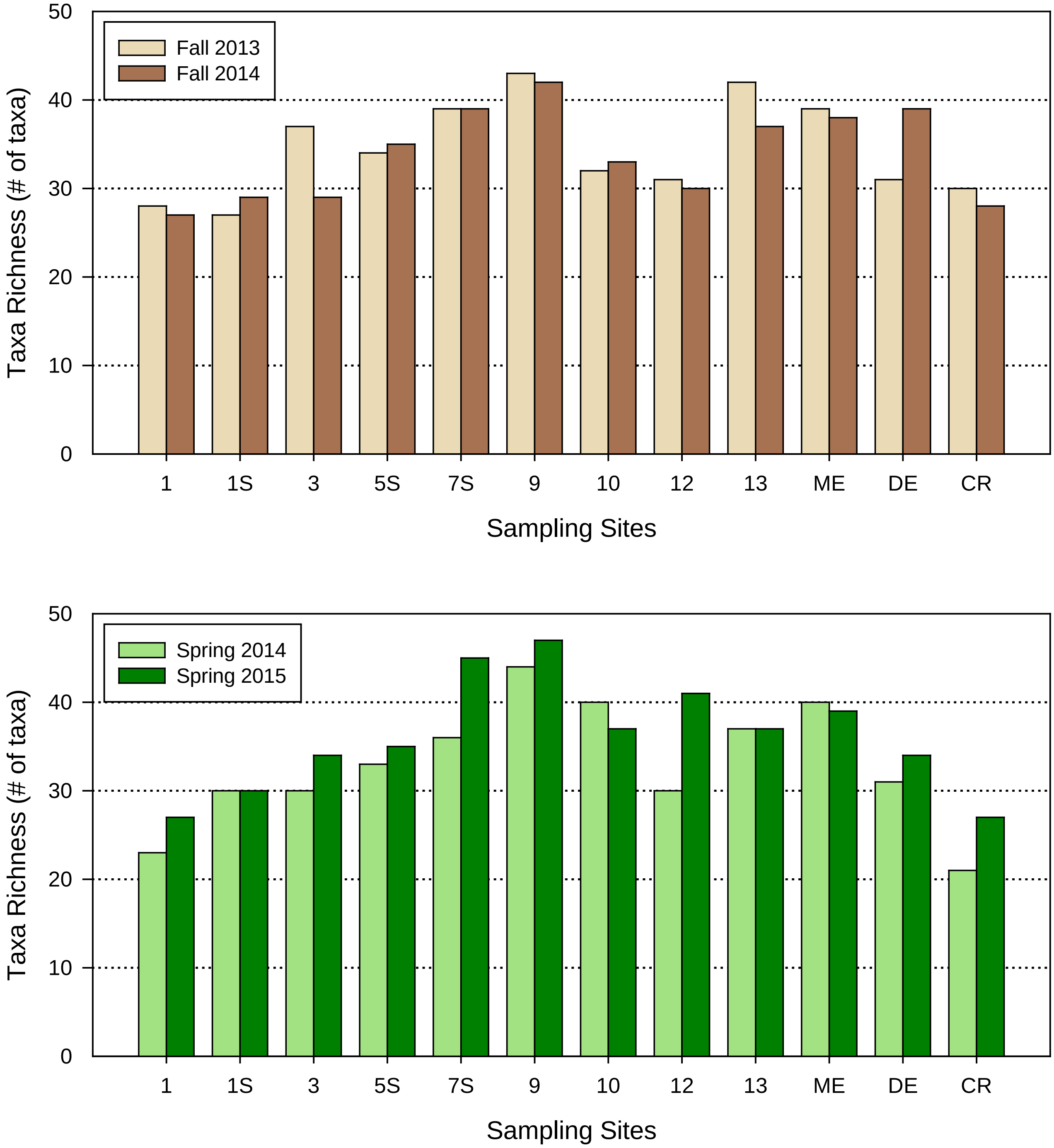
Metric	Fall 2013				Spring 2014				Fall 2014				Spring 2015			
	3	G1	G2	G3	3	G1	G2	G3	3	G1	G2	G3	3	G1	G2	G3
Total Abundance (#/sample)	13,779	22,168	9,616	31,938	11,029	14,215	10,507	14,502	12,935	17,653	9,017	8,129	7,414	8,660	5,227	5,492
Density (#/sq-m)	18,540	39,770	17,250	57,297	14,839	25,501	18,849	26,016	17,404	31,670	16,177	14,584	9,975	15,536	9,378	9,853
Taxa Richness (# taxa)	37	23	23	23	30	29	25	26	29	27	29	27	34	33	36	32
Mayfly Richness (# taxa)	4	2	2	1	6	3	3	5	2	2	1	2	5	5	7	6
Stonefly Richness (# taxa)	2	2	2	1	2	2	2	2	2	1	2	2	3	2	3	2
Caddisfly Richness (# taxa)	6	4	4	3	5	4	4	3	6	5	4	6	6	5	5	3
Sensitive Taxa (# taxa)	1	0	0	0	2	0	0	1	0	0	0	0	0	0	1	0
Sediment Sensitive Taxa (# taxa)	1	1	0	0	1	1	1	0	1	0	0	1	1	0	0	0
Modified Hilsenhoff Biotic Index	5.49	6.33	5.84	6.45	5.02	5.73	5.74	5.70	5.28	5.82	5.72	5.64	5.54	5.77	5.64	5.74
% Tolerant Taxa	47.5	25.1	30.0	31.8	23.2	18.7	12.7	17.2	47.5	24.5	20.9	39.3	10.9	19.1	24.6	22.1
% Sediment Tolerant Taxa	27.5	15.7	19.7	16.9	8.6	7.6	6.8	8.8	21.9	15.3	29.1	26.9	3.5	10.7	15.5	15.2
% Dominant (single taxon)	33.1	29.7	31.3	30.5	28.6	49.4	37.7	41.2	22.9	53.6	23.9	21.8	41.9	54.3	22.5	30.6
Abundance by Major Taxa (%)																
Ephemeroptera	3.1	1.0	1.1	0.2	6.3	2.7	2.2	4.7	2.4	0.6	0.8	1.1	7.4	3.1	6.2	5.3
Plecoptera	1.4	0.1	0.8	0.3	1.6	0.3	0.9	0.4	1.6	0.1	0.4	1.0	3.5	0.2	2.6	1.2
Trichoptera	11.2	2.0	3.6	2.4	14.9	3.5	2.6	1.7	11.4	0.9	3.6	3.0	6.1	3.2	5.8	2.6
Coleoptera	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Chironomidae	1.0	0.0	0.6	0.7	12.5	0.6	1.3	0.7	4.6	0.2	4.5	1.1	7.0	1.1	3.5	5.5
Other Diptera	0.5	0.0	0.2	0.0	0.2	0.3	0.0	0.0	2.5	0.1	0.1	0.0	41.9	1.8	1.2	0.0
Other Insects	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.0	0.0	0.0	0.0	0.0
Non-Insect Taxa	82.7	97.0	93.6	96.4	64.6	92.6	92.9	92.4	77.4	98.1	90.5	93.8	34.0	90.6	80.8	85.3
Abundance by Feeding Group (%)																
Collector-Gatherers	17.3	29.3	14.6	32.6	55.4	20.0	38.3	29.4	20.7	7.2	45.2	21.7	32.7	12.2	33.9	33.8
Scrapers/Grazers	53.3	28.4	35.1	33.9	23.0	20.0	15.5	20.8	48.8	28.2	22.7	45.0	10.8	19.0	27.0	22.7
Shredders	1.0	0.1	0.7	0.3	1.3	0.2	0.9	0.4	1.3	0.1	0.4	0.7	2.7	0.2	1.9	1.0
Filter Feeders	10.9	31.9	35.5	24.5	9.7	53.3	40.0	44.1	14.9	55.5	23.3	22.6	47.6	59.4	30.0	34.9
Predators	2.0	0.5	0.2	0.2	1.9	0.4	1.4	1.3	1.8	0.9	0.7	2.4	2.7	0.9	2.6	1.2
Omnivores/Others	15.6	9.8	13.9	8.5	8.6	6.0	3.9	3.9	12.5	8.2	7.7	7.6	3.5	8.4	4.6	6.5

Metric	Fall 2013				Spring 2014				Fall 2014				Spring 2015			
	3	G1	G2	G3	3	G1	G2	G3	3	G1	G2	G3	3	G1	G2	G3
Multimetric Analysis																
Taxa Richness (score)	5	3	3	3	3	3	3	3	3	3	3	3	3	3	5	3
Mayfly Richness (score)	3	1	1	1	3	1	1	3	1	1	1	1	3	3	3	3
Stonefly Richness (score)	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Caddisfly Richness (score)	3	3	3	1	3	3	3	1	3	3	3	3	3	3	3	1
Sensitive Taxa (score)	1	1	1	1	3	1	1	1	1	1	1	1	1	1	1	1
Sediment Sensitive Taxa (score)	3	3	1	1	3	3	3	1	3	1	1	3	3	1	1	1
Modifed HBI (score)	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
% Tolerant Taxa (score)	1	3	3	3	3	3	5	3	1	3	3	3	5	3	3	3
% Sediment Tolerant (score)	1	3	3	3	5	5	5	5	3	3	1	1	5	3	3	3
% Dominant (score)	3	3	3	3	3	1	3	1	3	1	3	3	1	1	3	3
Total Score	22	22	20	18	28	22	26	20	20	18	18	20	26	20	24	20

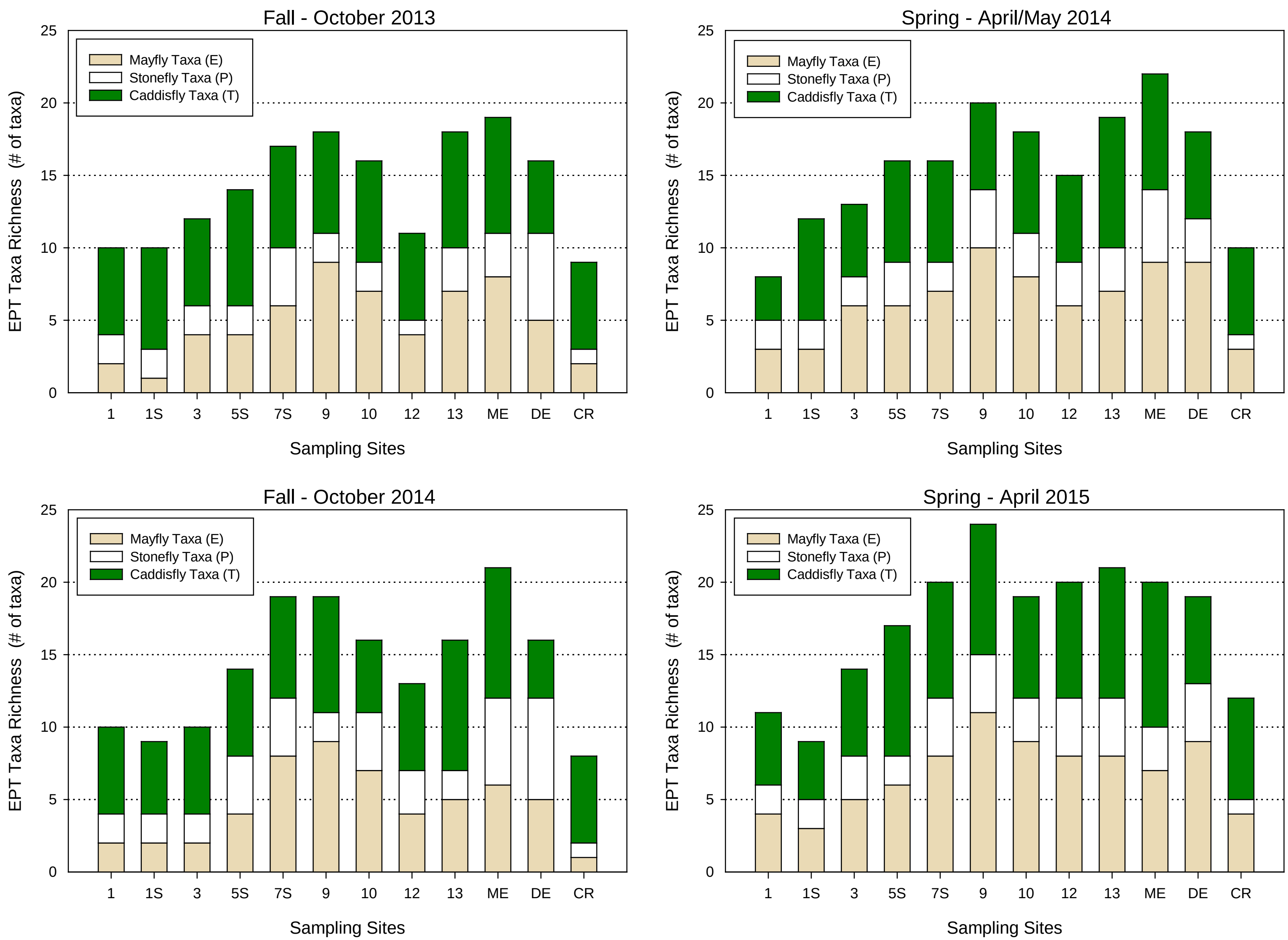
APPENDIX IV - ADDITIONAL MACROINVERTEBRATE RESULT FIGURES



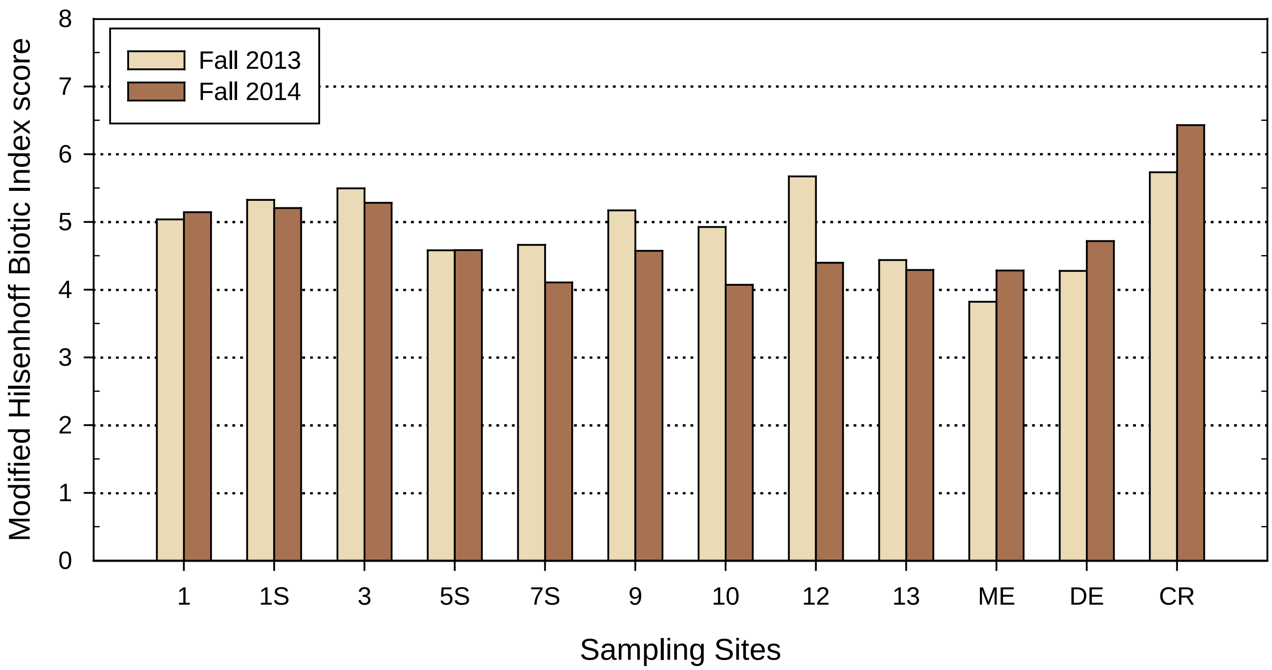
Appendix IV Figure 1. **Mean benthic invertebrate densities in the lower Deschutes River downstream from the re-regulation dam and three reference sites for fall (upper) and spring (lower) collection efforts in 2013-2015. Those sites with replicate samples display 95% confidence intervals.**

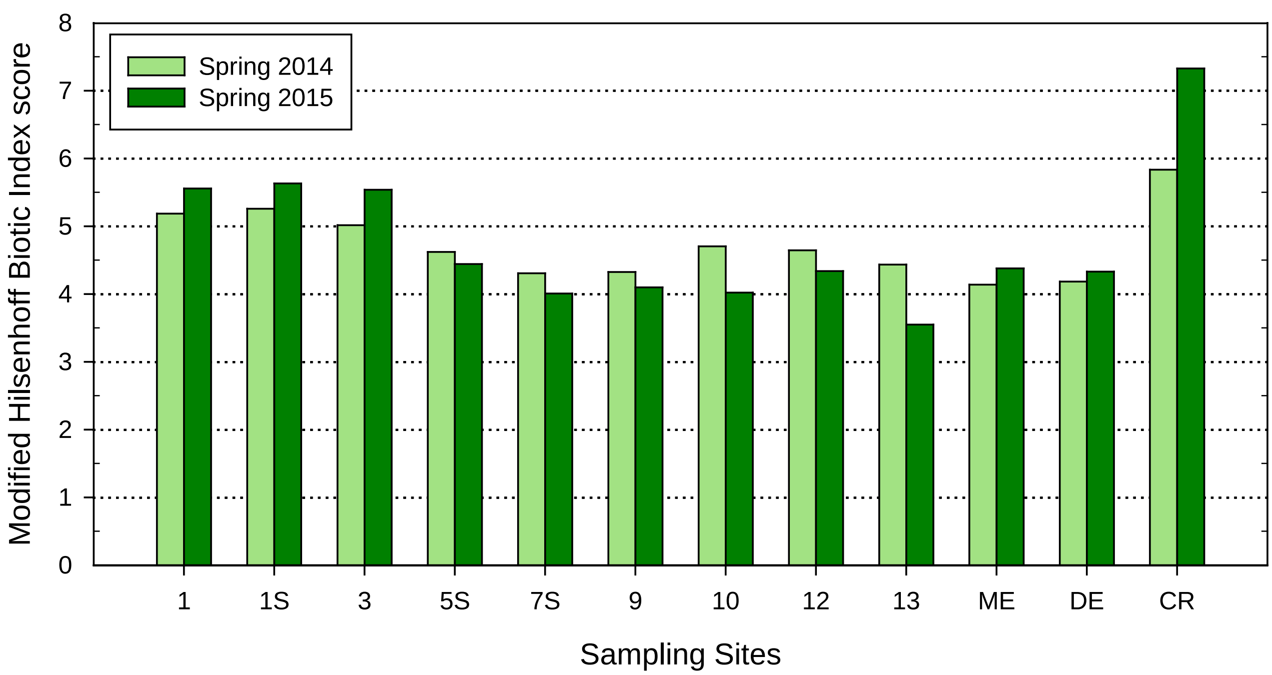


Appendix IV Figure 2. **Benthic invertebrate total taxa richness in the lower Deschutes River downstream from the re-regulation dam and three reference sites for fall (upper) and spring (lower) collection efforts in 2013-2015.**

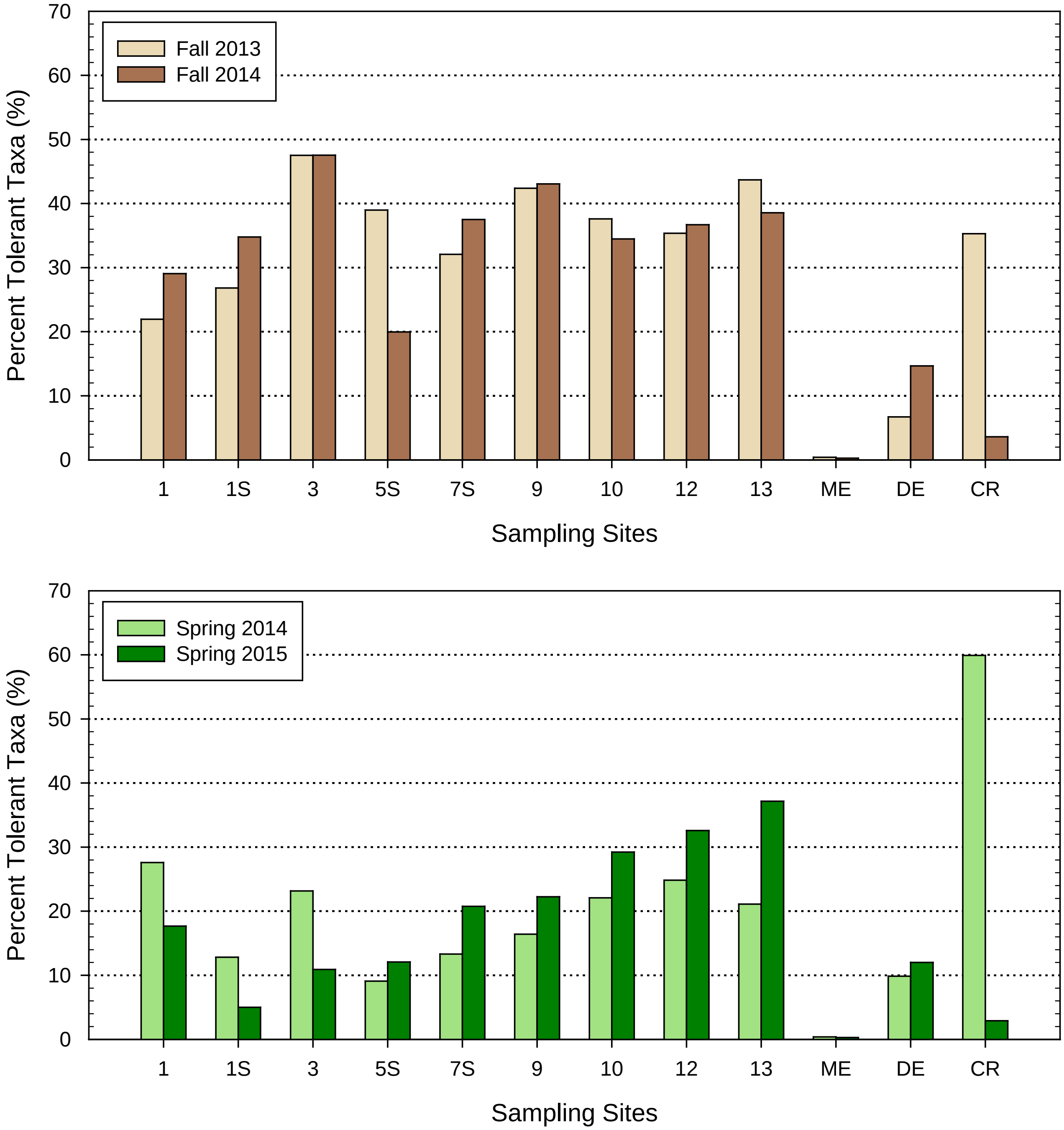


Appendix IV Figure 3. Total EPT taxa richness in the lower Deschutes River downstream from the re-regulation dam and three reference sites for fall (left) and spring (right) collection efforts in 2013-2015.

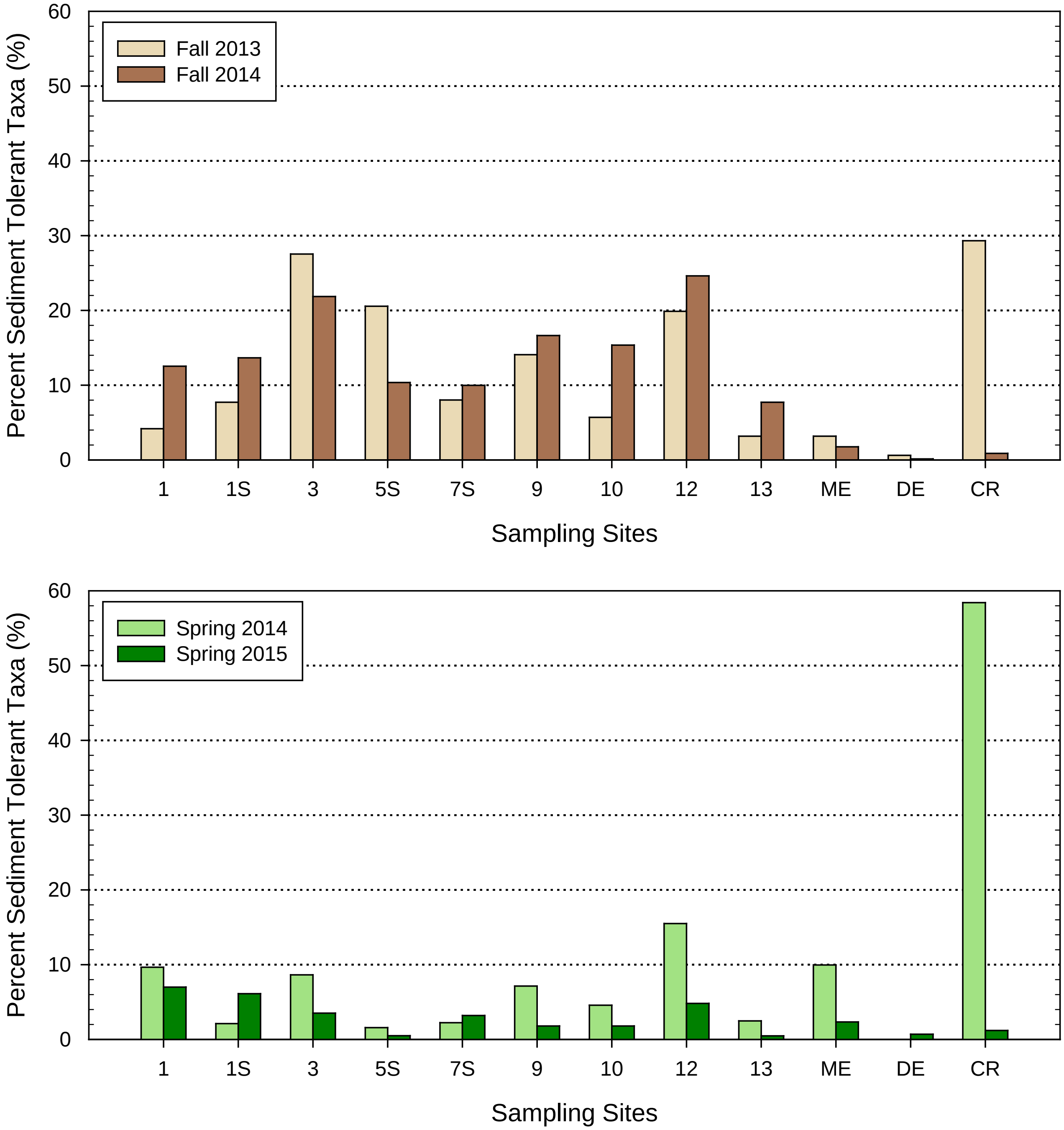




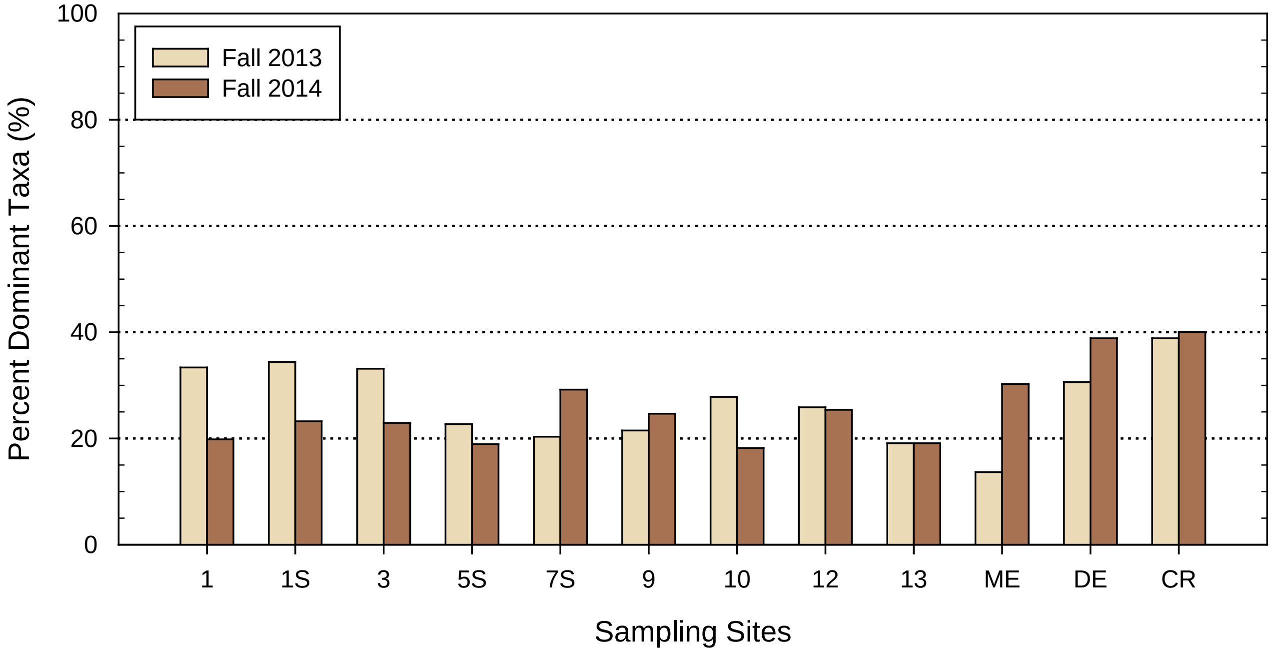
Appendix IV Figure 4. **Modified Hilsenhoff Biotic Index (MHBI) scores in the lower Deschutes River downstream from the re-regulation dam and three reference sites for fall (upper) and spring (lower) collection efforts in 2013-2015. Lower scores indicate healthy stream conditions.**

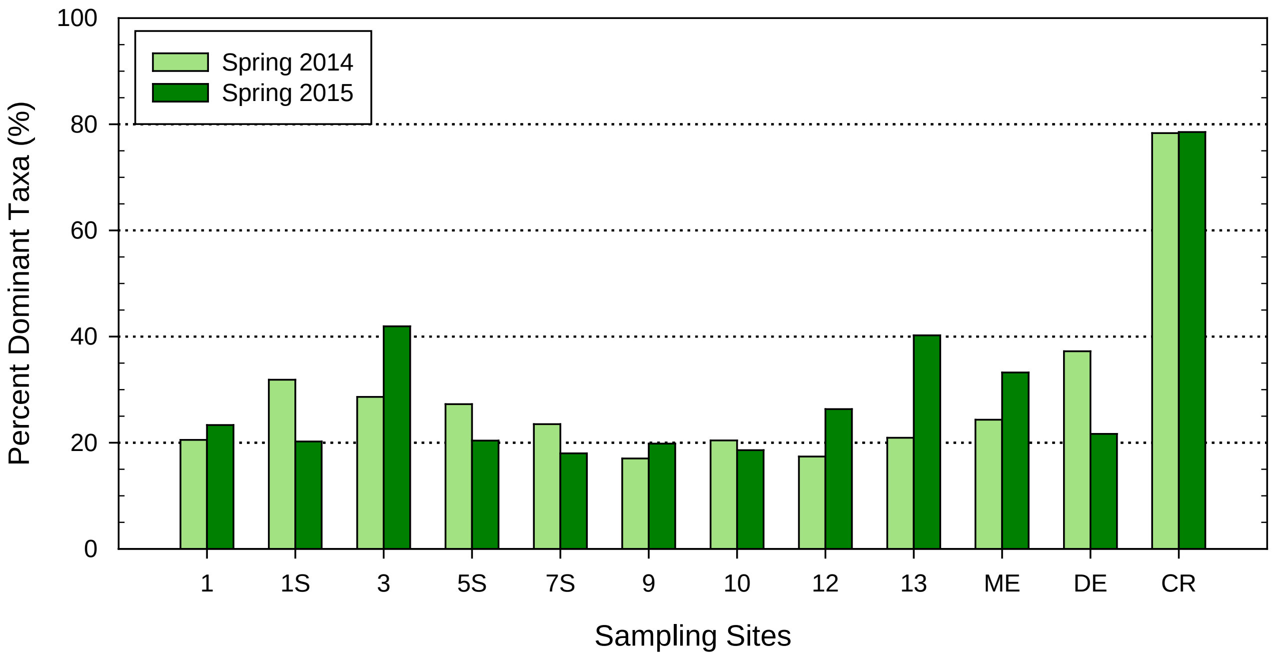


Appendix IV Figure 5. **Relative abundances of benthic invertebrate taxa classified as "tolerant" in the lower Deschutes River downstream from the re-regulation dam and three reference sites for fall (upper) and spring (lower) collection efforts in 2013-2015.**

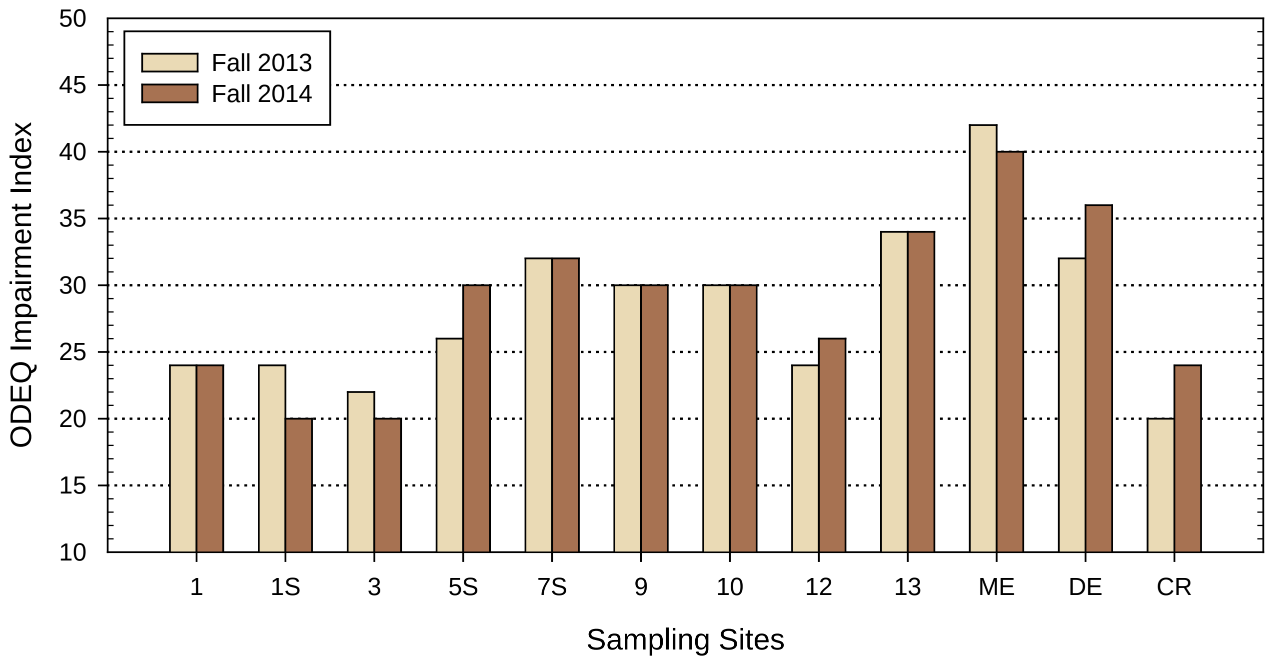


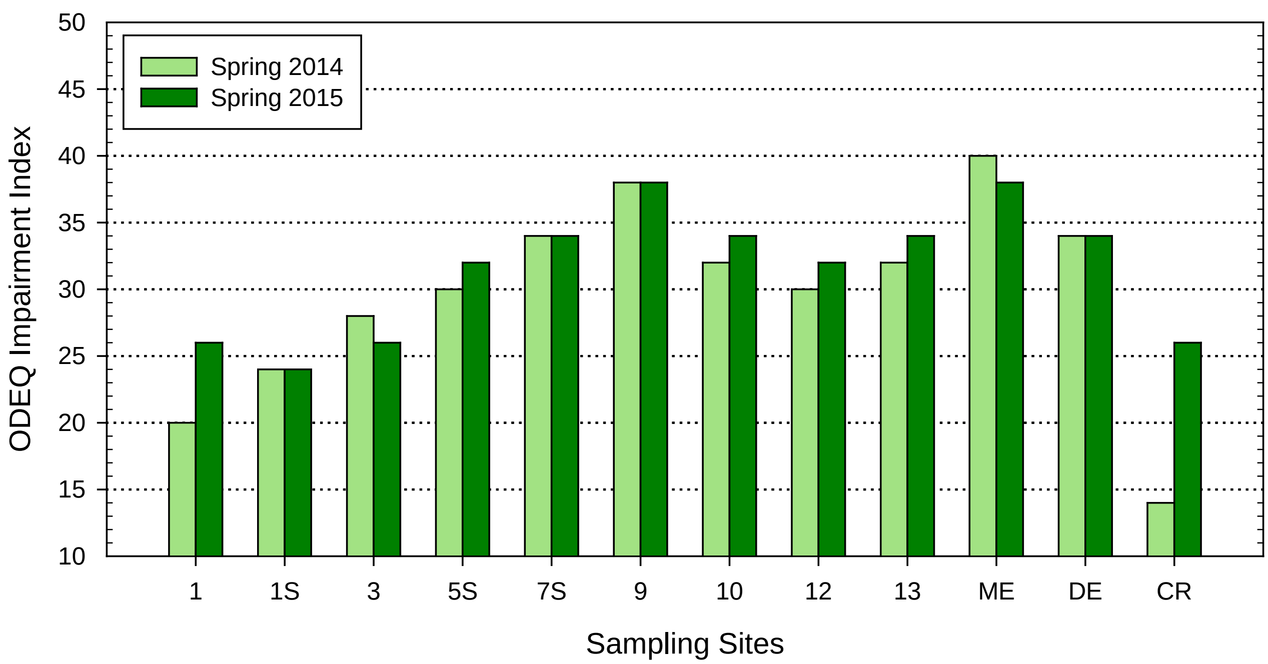
Appendix IV Figure 6. **Relative abundances of benthic invertebrate taxa classified as "sediment tolerant" in the lower Deschutes River downstream from the re-regulation dam and three reference sites for fall (upper) and spring (lower) collection efforts in 2013-2015.**



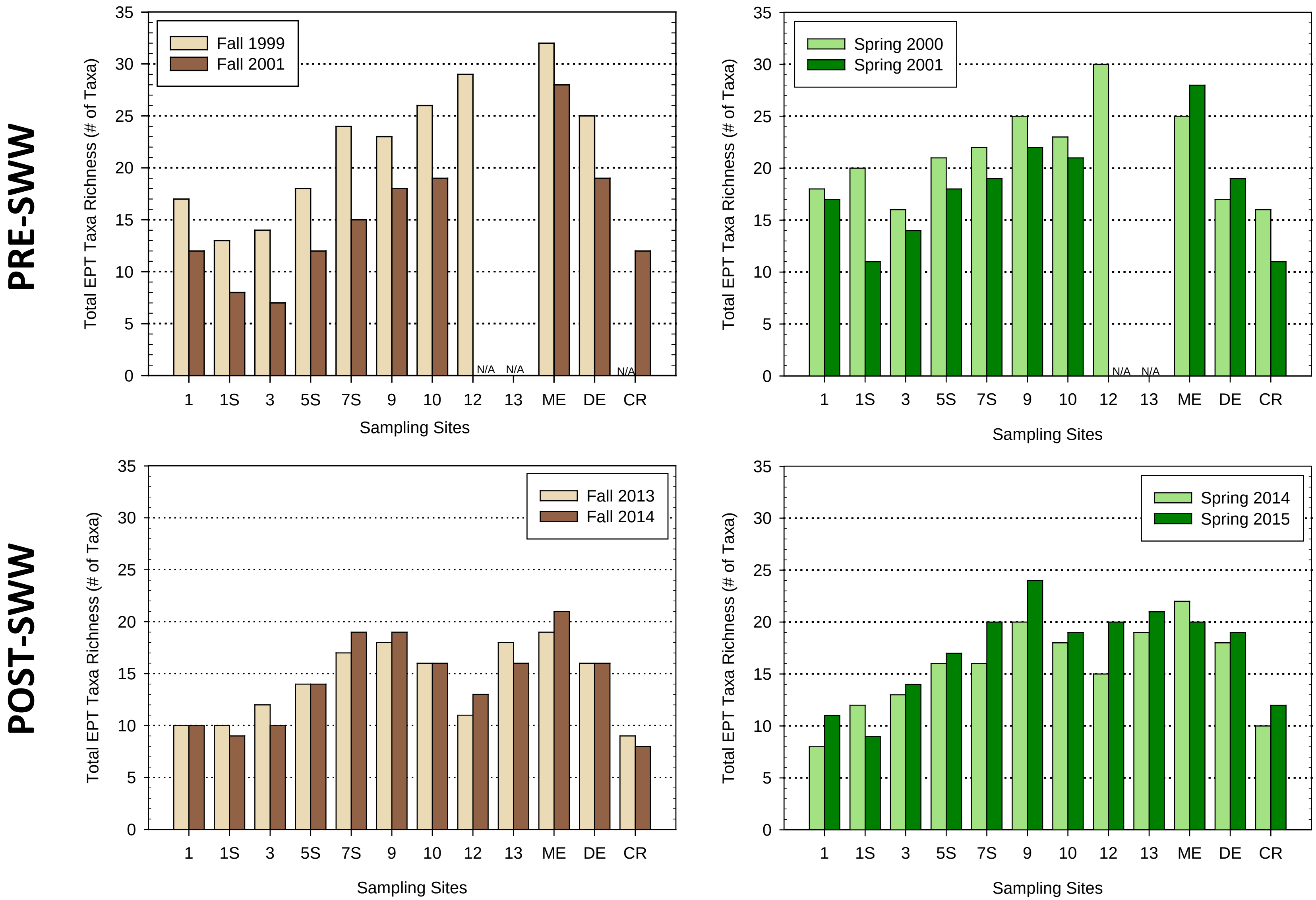


Appendix IV Figure 7. **Relative abundances of the single most abundant (dominant) benthic invertebrate taxon in the lower Deschutes River downstream from the re-regulation dam and three reference sites for fall (upper) and spring (lower) collection efforts in 2013-2015.**

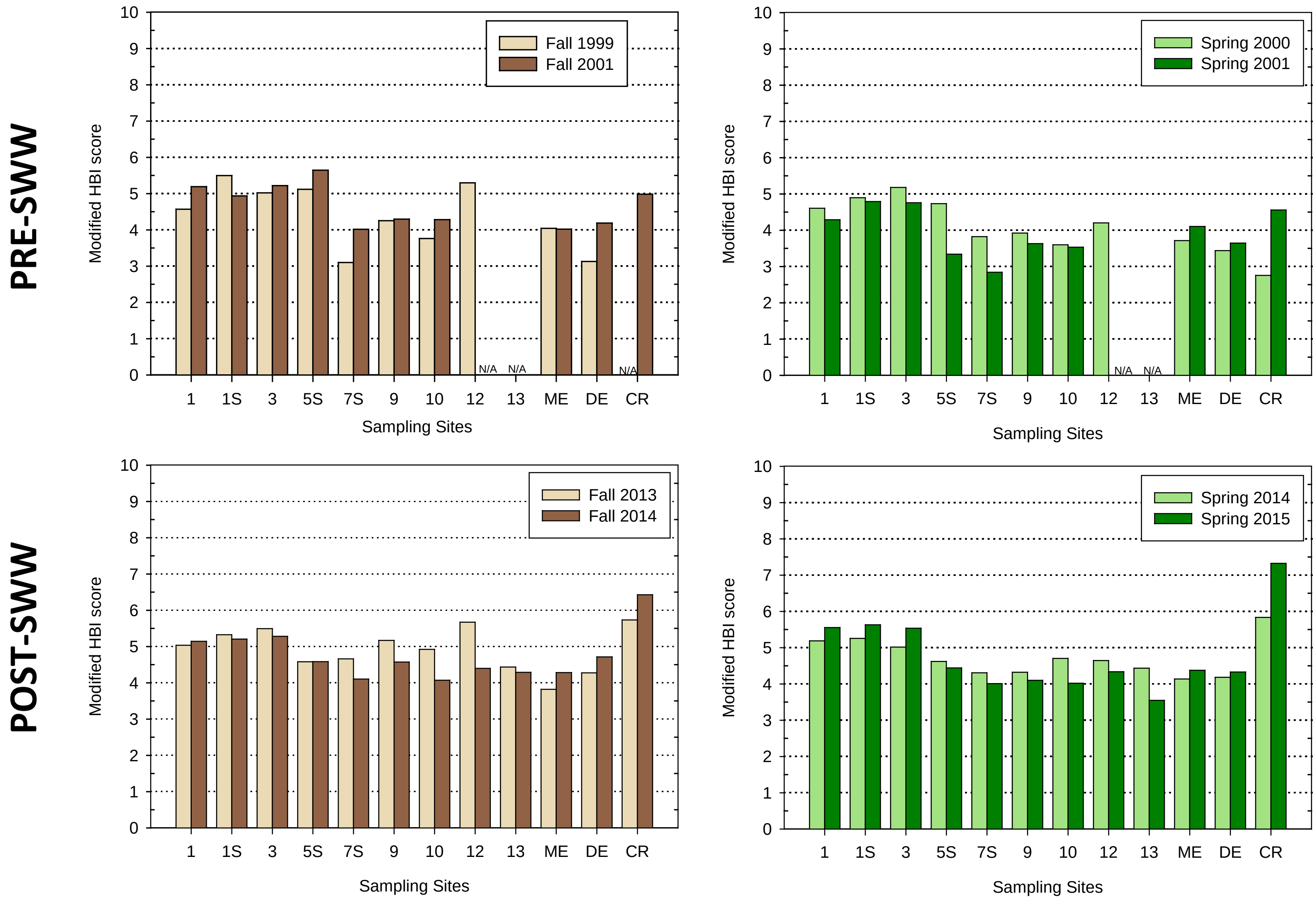




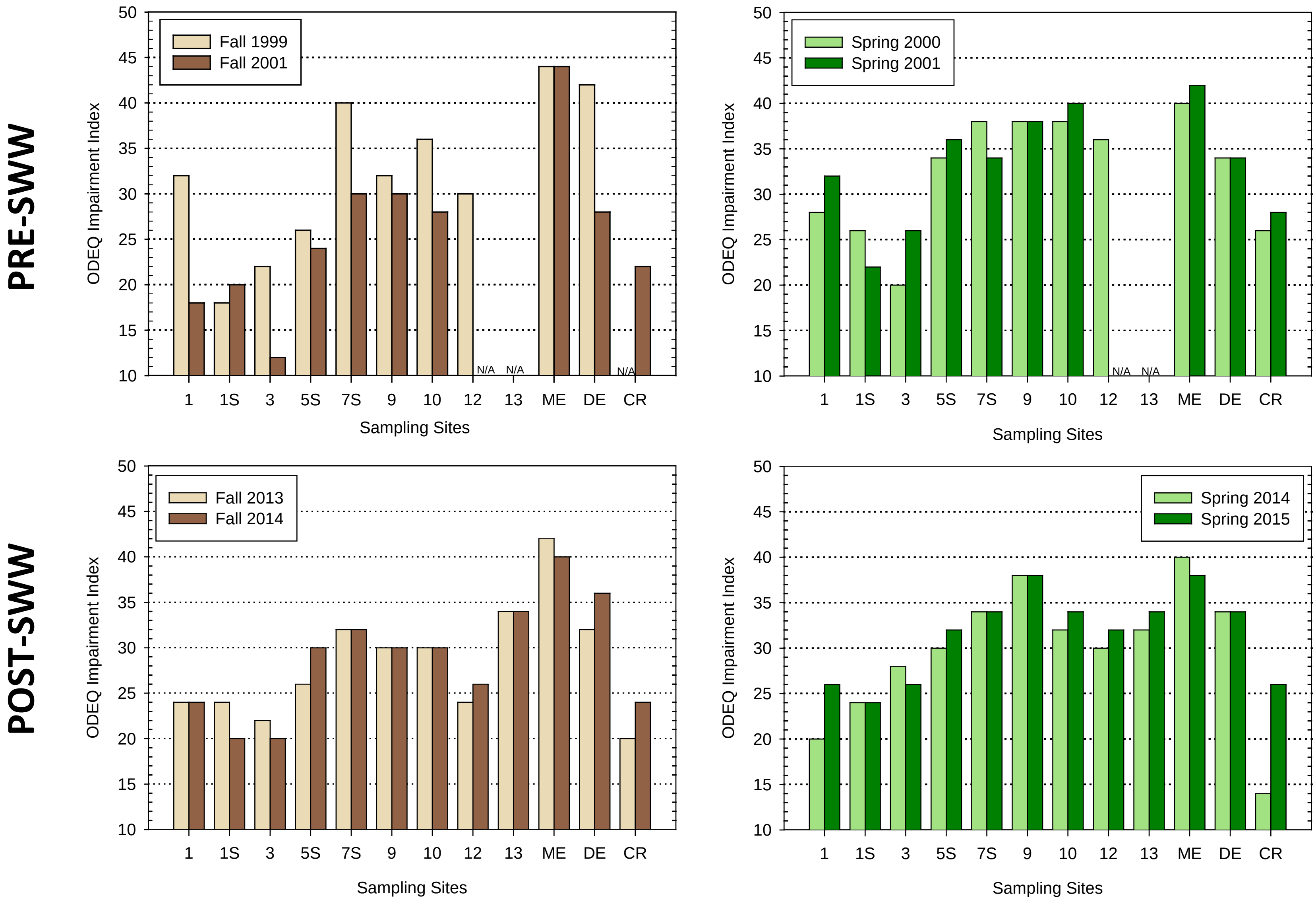
Appendix IV Figure 8. **ODEQ Impairment Index scores in the lower Deschutes River downstream from the re-regulation dam and three reference sites for fall (upper) and spring (lower) collection efforts in 2013-2015. Higher scores indicate less stream impairment.**



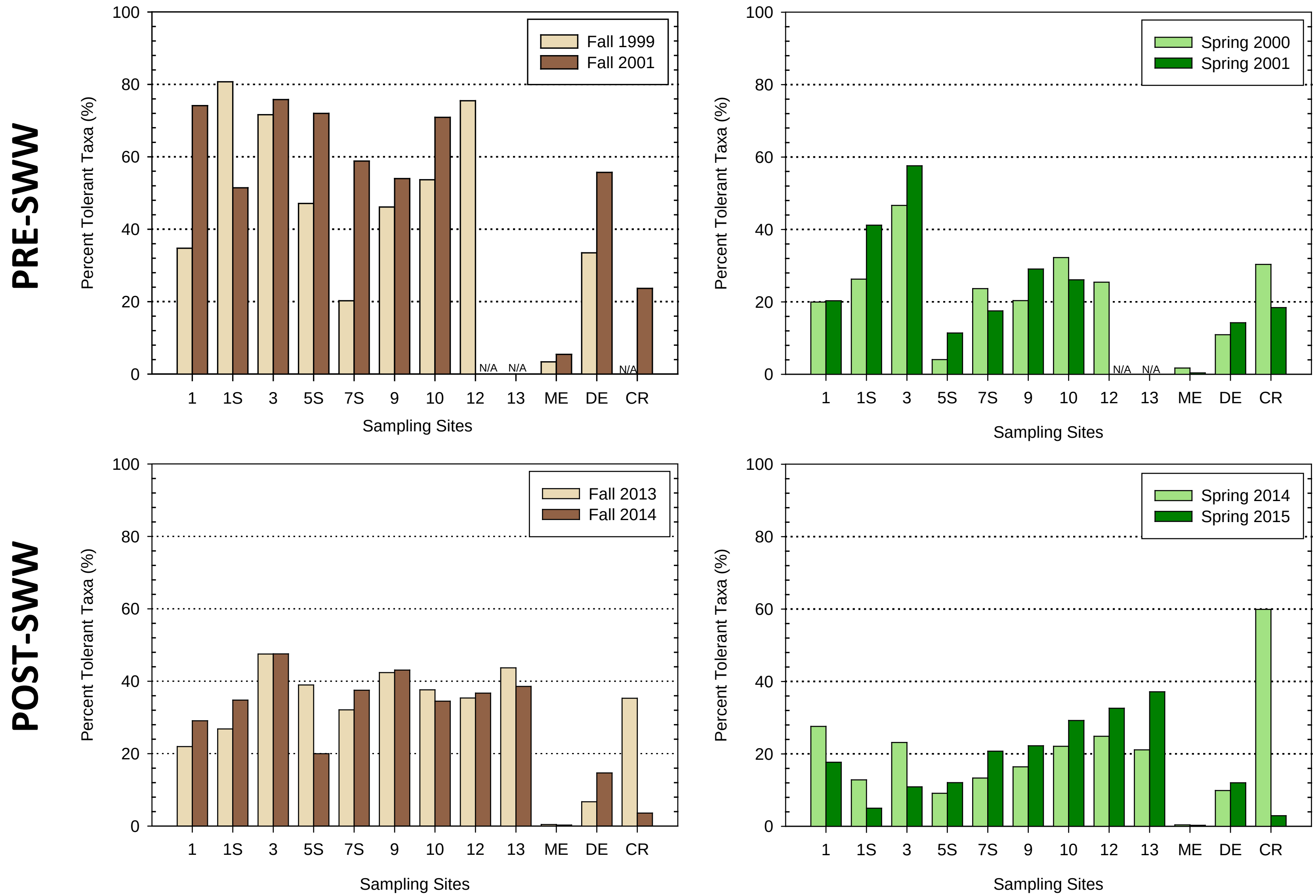
Appendix IV Figure 9. **Total EPT Taxa Richness in the lower Deschutes River downstream from the re-regulation dam and three reference sites for both baseline (Pre-SWW) and current (Post-SWW) studies. Note that fall 1999 and spring 2000 results reflect full sample counts, thus the higher taxa richness.**



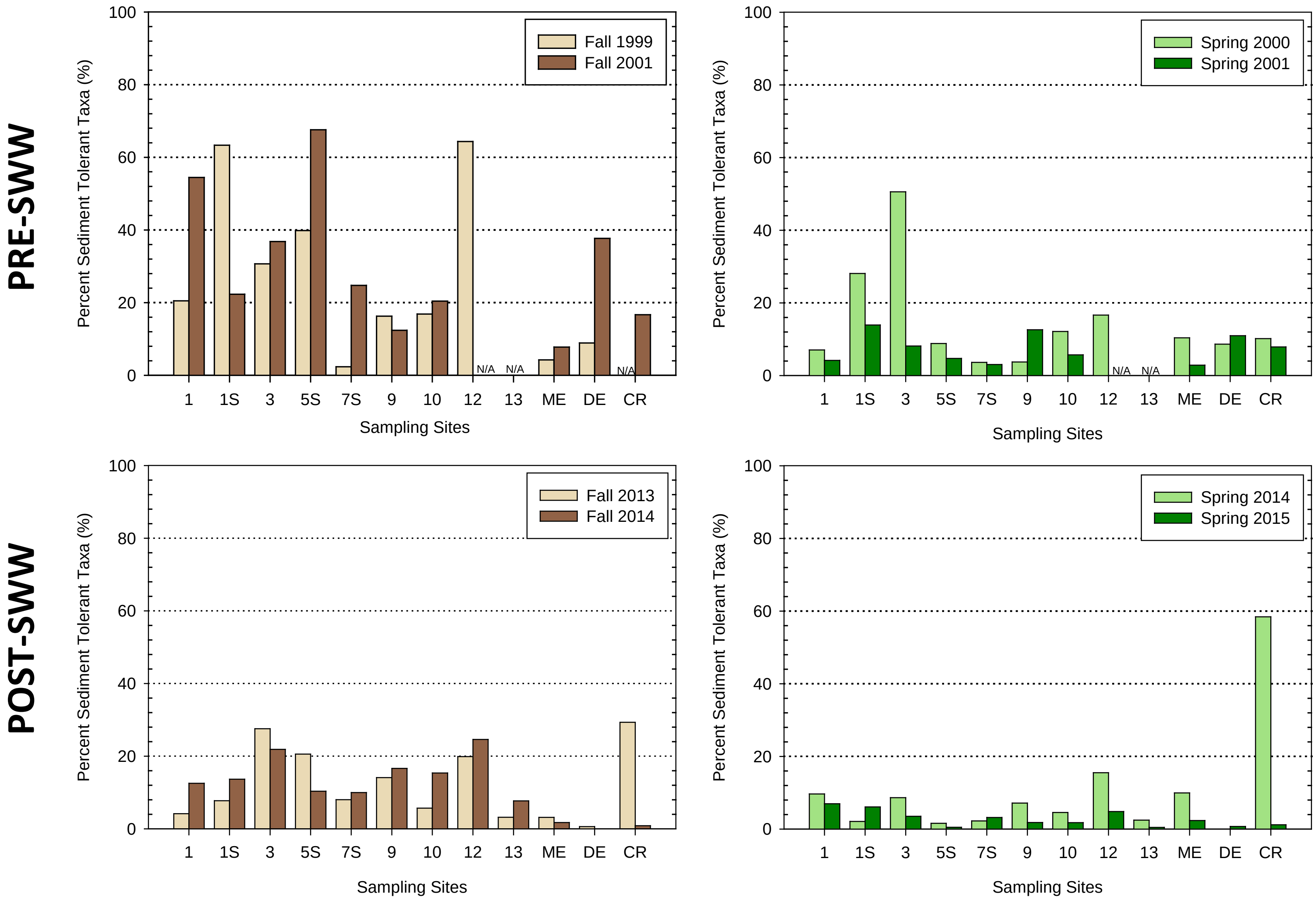
Appendix IV Figure 10. Modified Hilsenhoff Biotic Index (MHBI) scores in the lower Deschutes River downstream from the re-regulation dam and three reference sites for both baseline (Pre-SWW) and current (Post-SWW) studies. Lower scores indicate healthy stream conditions.



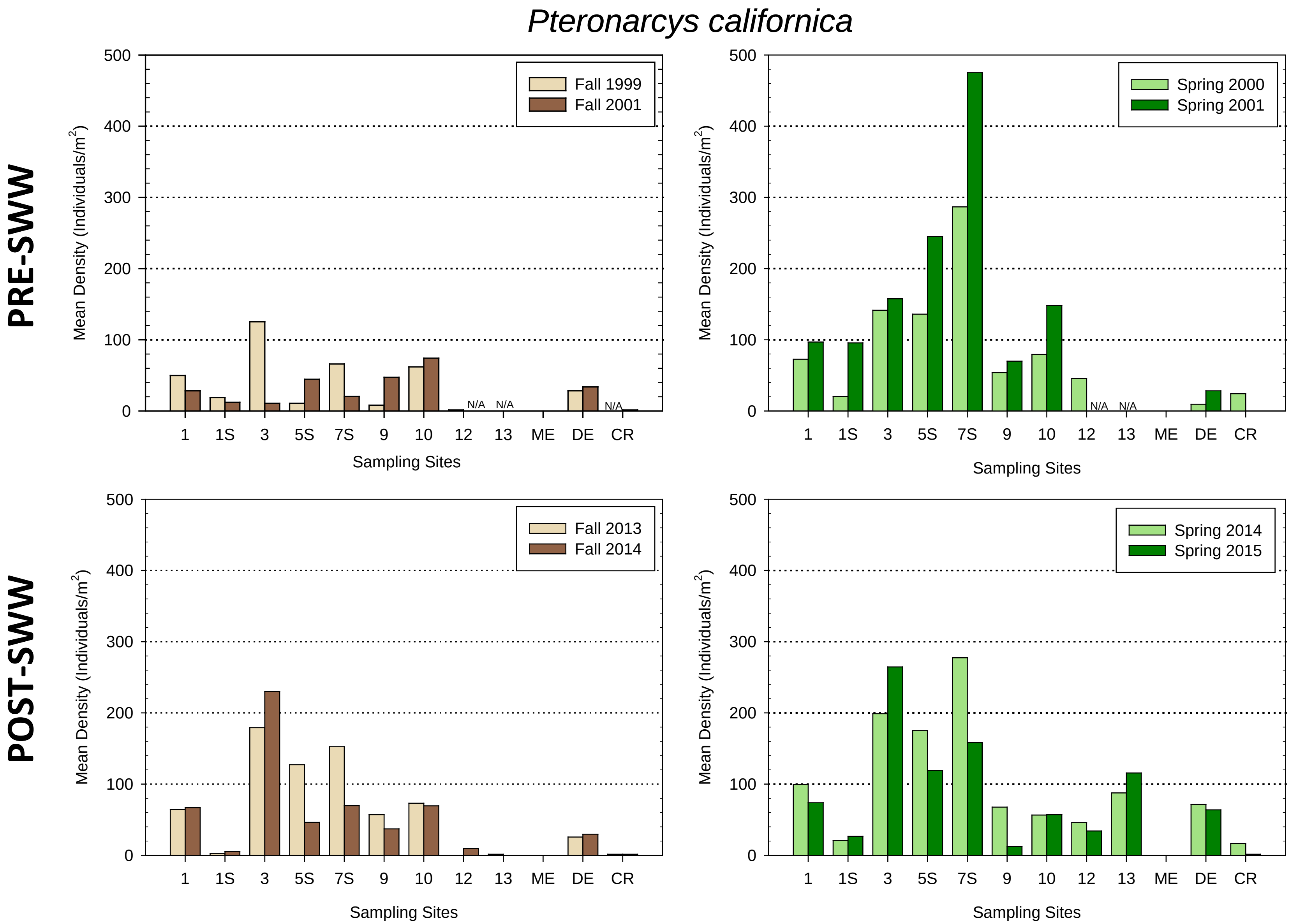
Appendix IV Figure 11. ODEQ Impairment Index scores in the lower Deschutes River downstream from the re-regulation dam and three reference sites for both baseline (Pre-SWW) and current (Post-SWW) studies. Higher scores indicate less stream impairment.



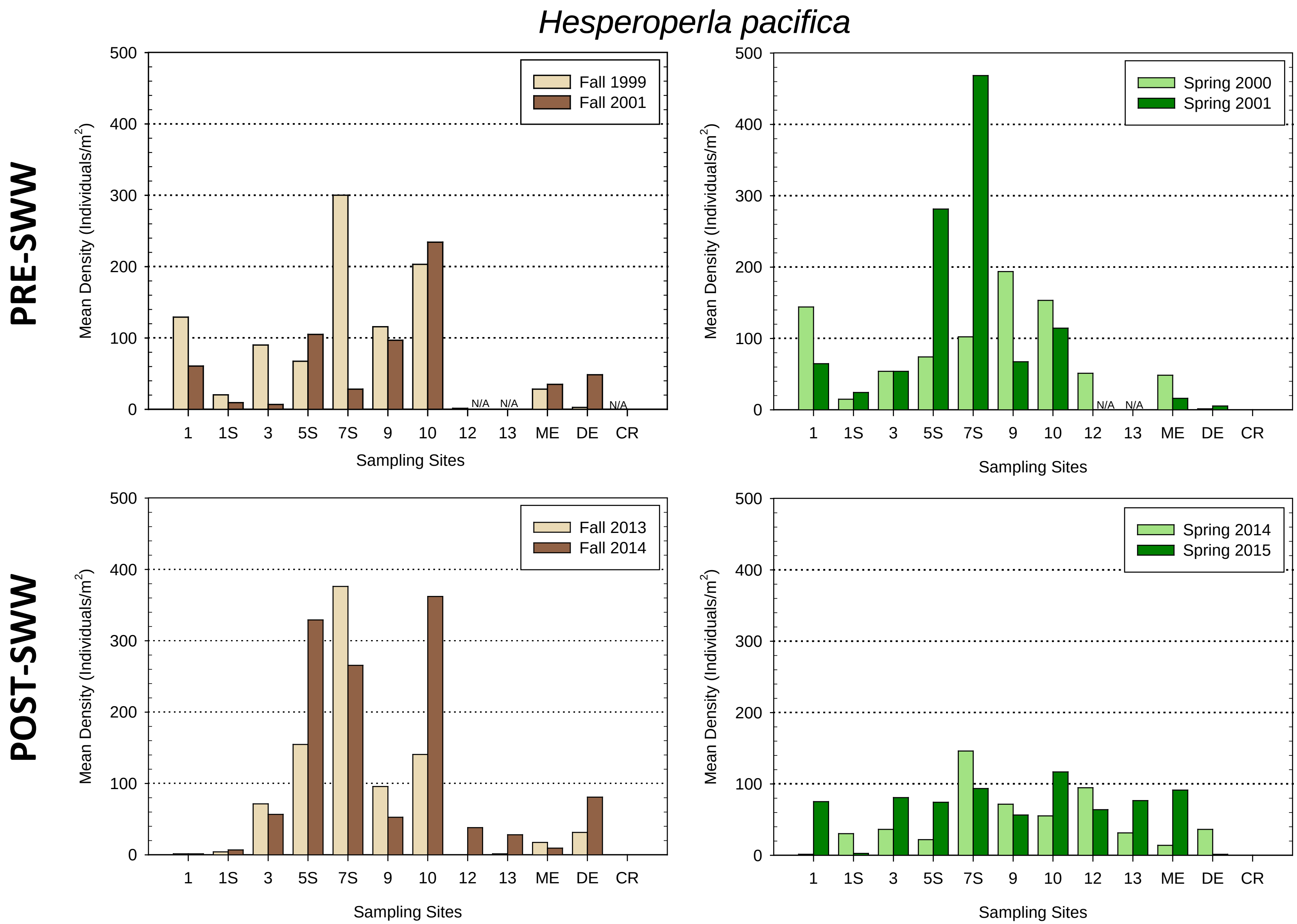
Appendix IV Figure 12. **Relative abundances of benthic invertebrate taxa classified as "tolerant" in the lower Deschutes River downstream from the re-regulation dam and three reference sites for both baseline (Pre-SWW) and current (Post-SWW) studies.**



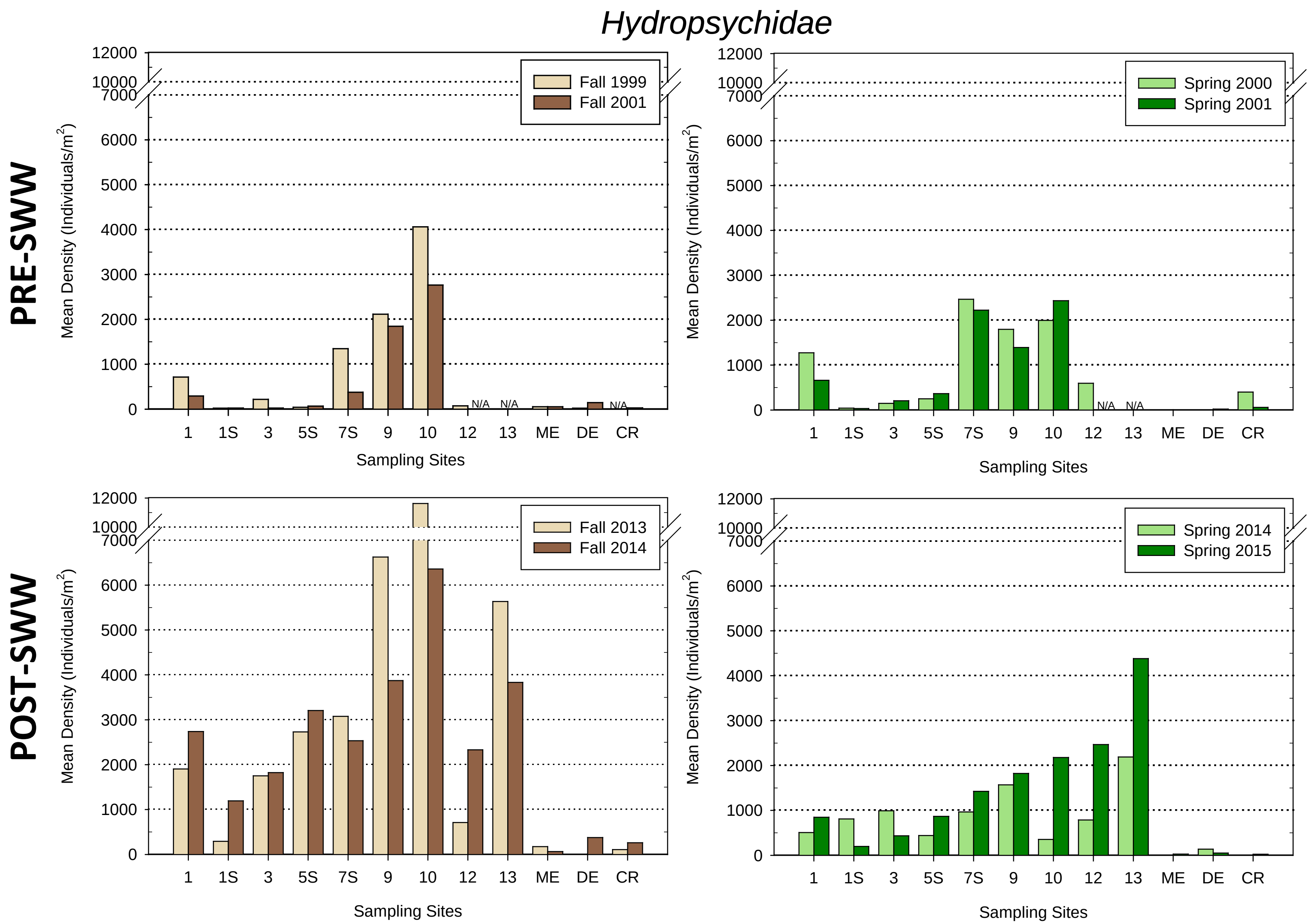
Appendix IV Figure 13. Relative abundances of benthic invertebrate taxa classified as "sediment tolerant" in the lower Deschutes River downstream from the re-regulation dam and three reference sites for both baseline (Pre-SWW) and current (Post-SWW) studies.



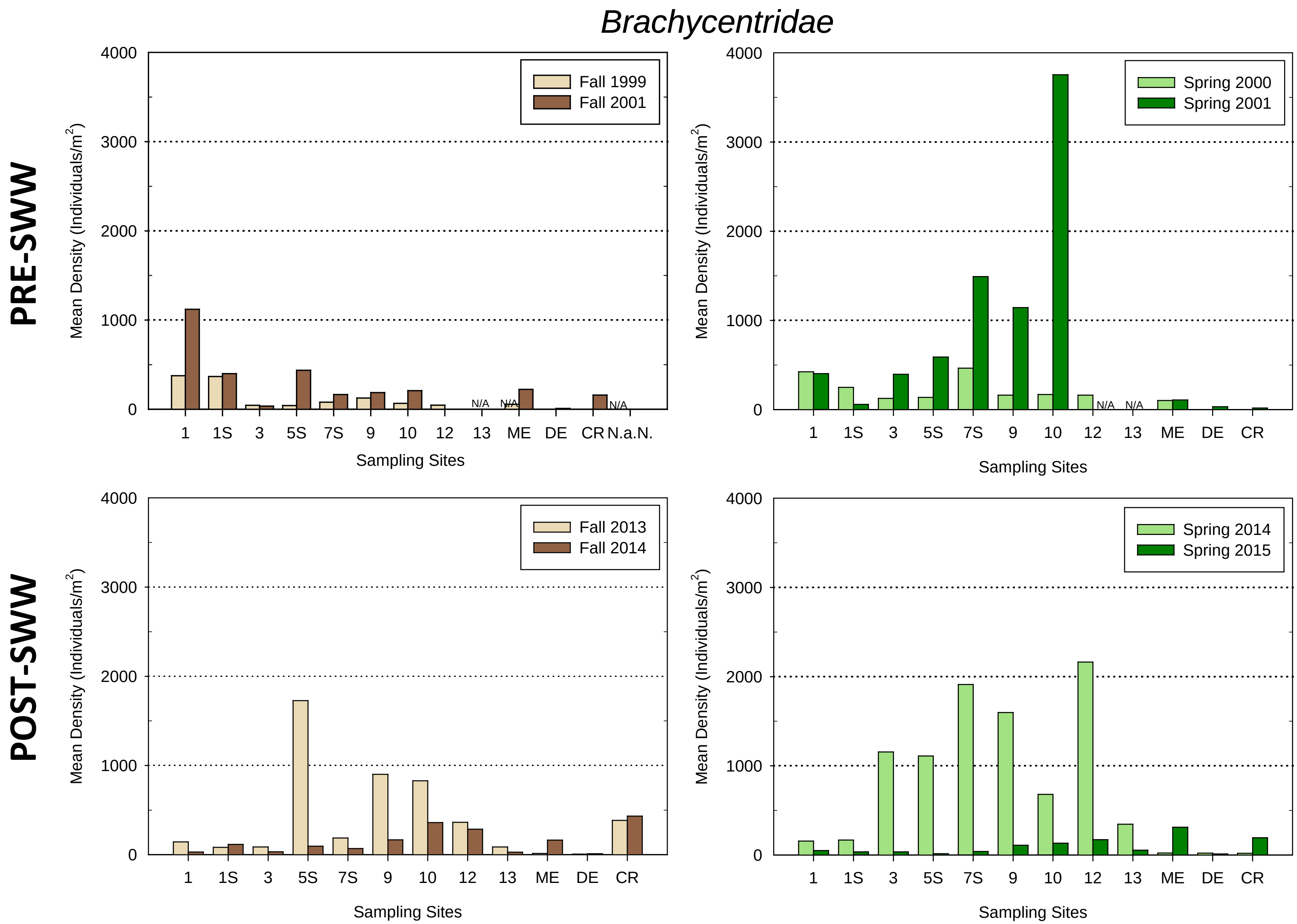
Appendix IV Figure 14. ***Pteronarcys*** **stonefly nymph densities in the lower Deschutes River downstream from the re-regulation dam and three reference sites for both baseline (Pre-SWW) and current (Post-SWW) studies.**



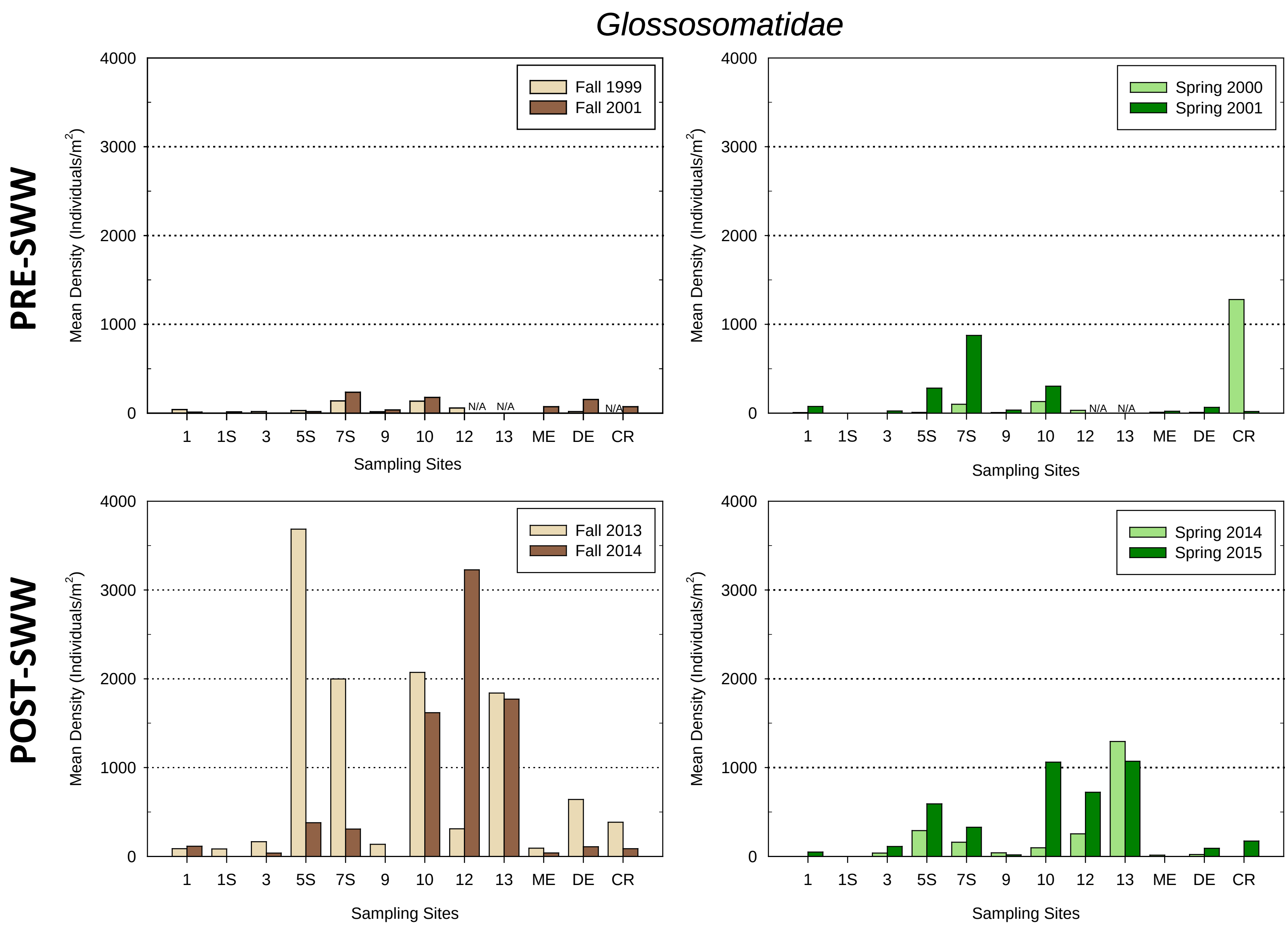
Appendix IV Figure 15. ***Hesperoperla*** **stonefly nymph densities in the lower Deschutes River downstream from the re-regulation dam and three reference sites for both baseline (Pre-SWW) and current (Post-SWW) studies.**



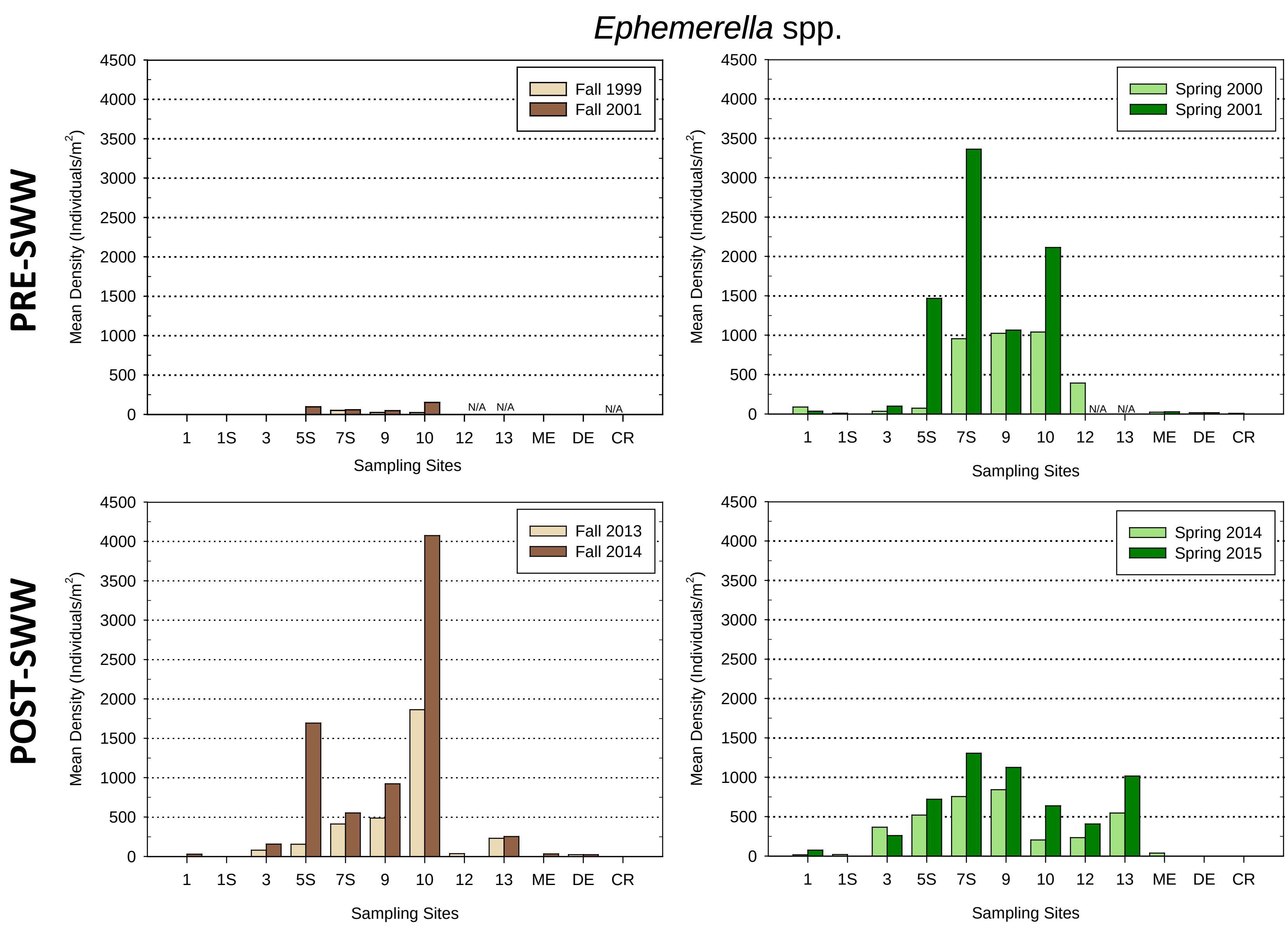
Appendix IV Figure 16. Hydropyschidae caddisfly larvae densities in the lower Deschutes River downstream from the re-regulation dam and three reference sites for both baseline (Pre-SWW) and current (Post-SWW) studies.



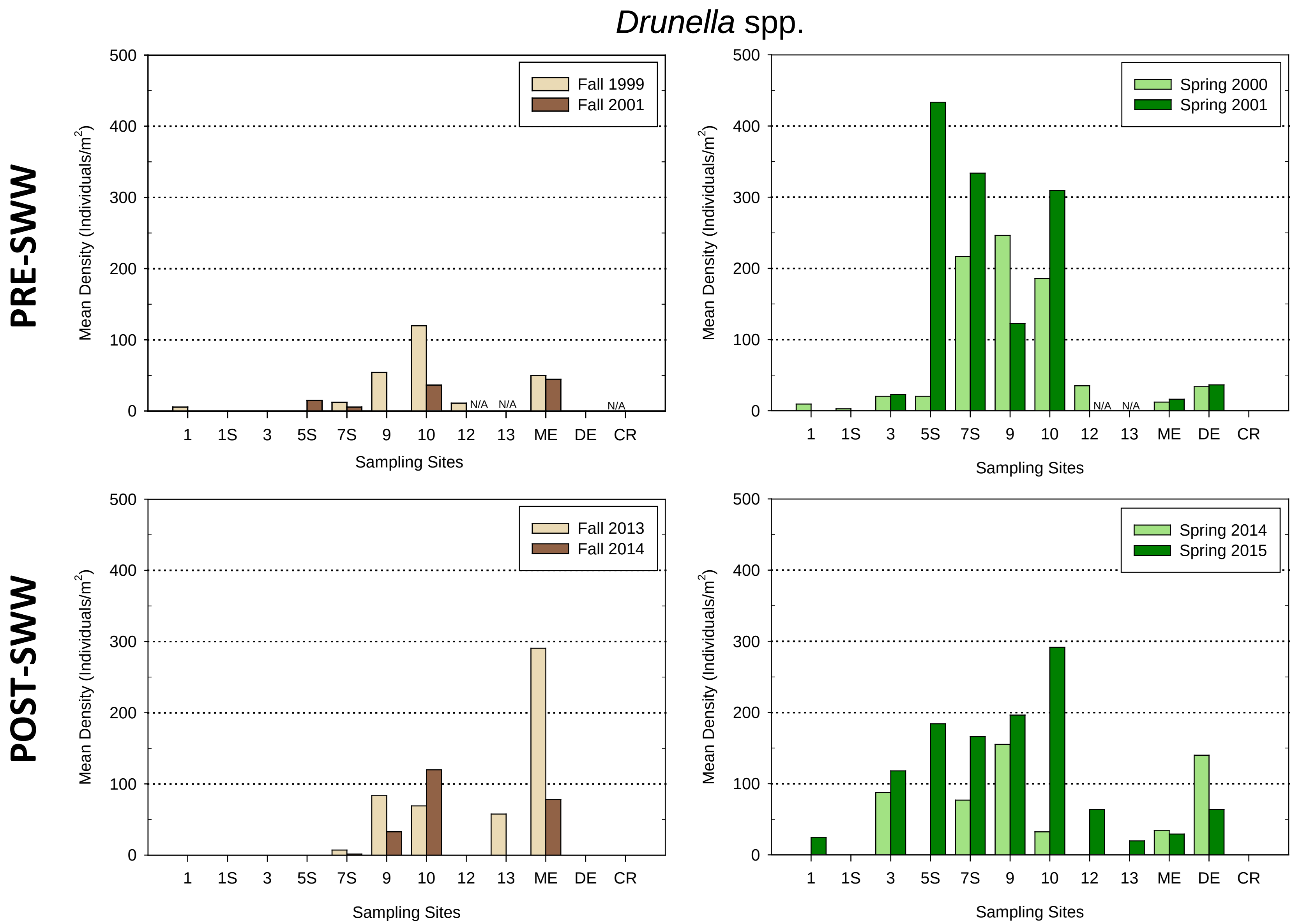
Appendix IV Figure 17. Brachycentridae caddisfly larvae densities in the lower Deschutes River downstream from the re-regulation dam and three reference sites for both baseline (Pre-SWW) and current (Post-SWW) studies.



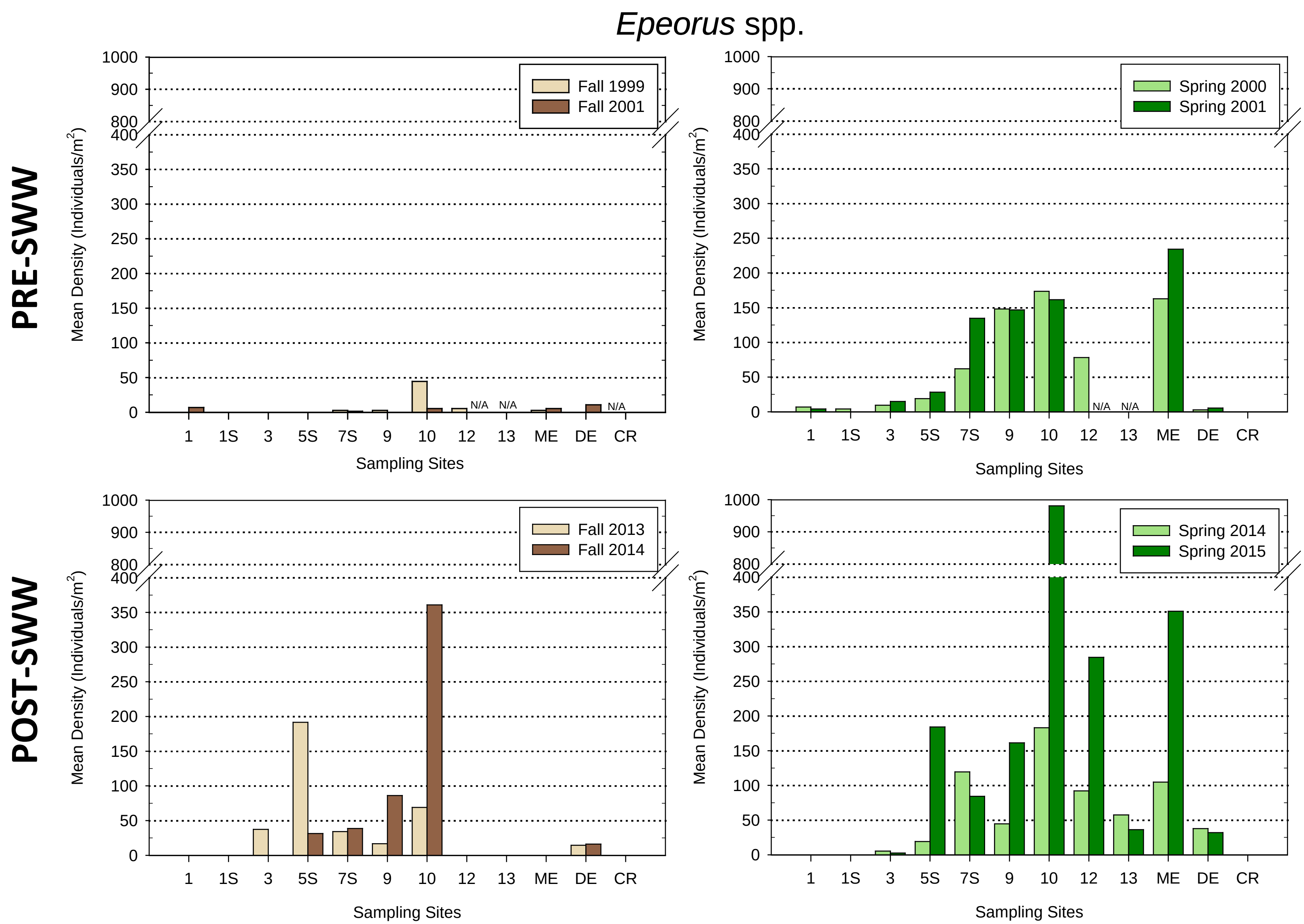
Appendix IV Figure 18. Glossosomatidae caddisfly larvae densities in the lower Deschutes River downstream from the re-regulation dam and three reference sites for both baseline (Pre-SWW) and current (Post-SWW) studies.



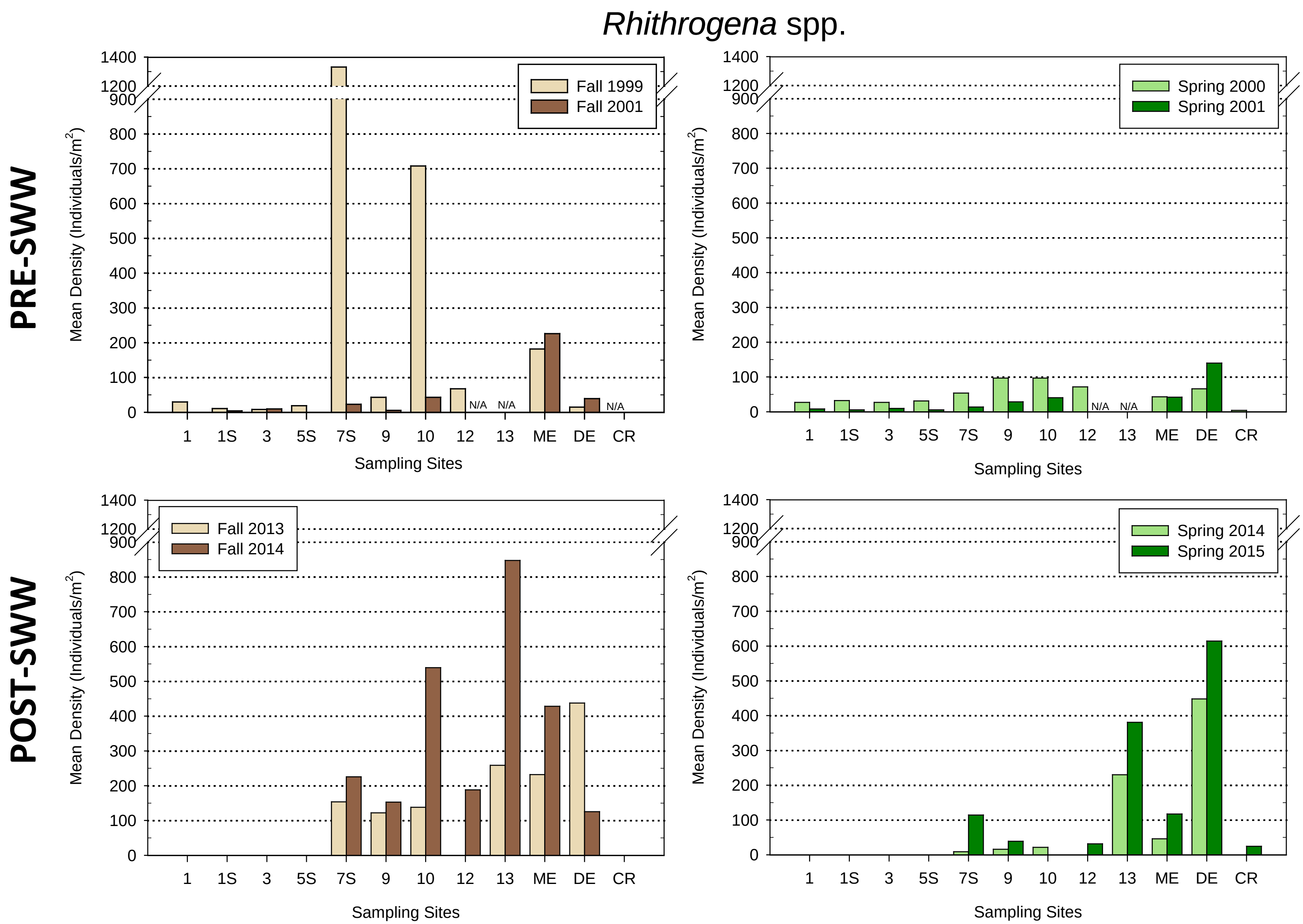
Appendix IV Figure 19. ***Ephemerella* spp. mayfly nymph densities in the lower Deschutes River downstream from the re-regulation dam and three reference sites for both baseline (Pre-SWW) and current (Post-SWW) studies.**



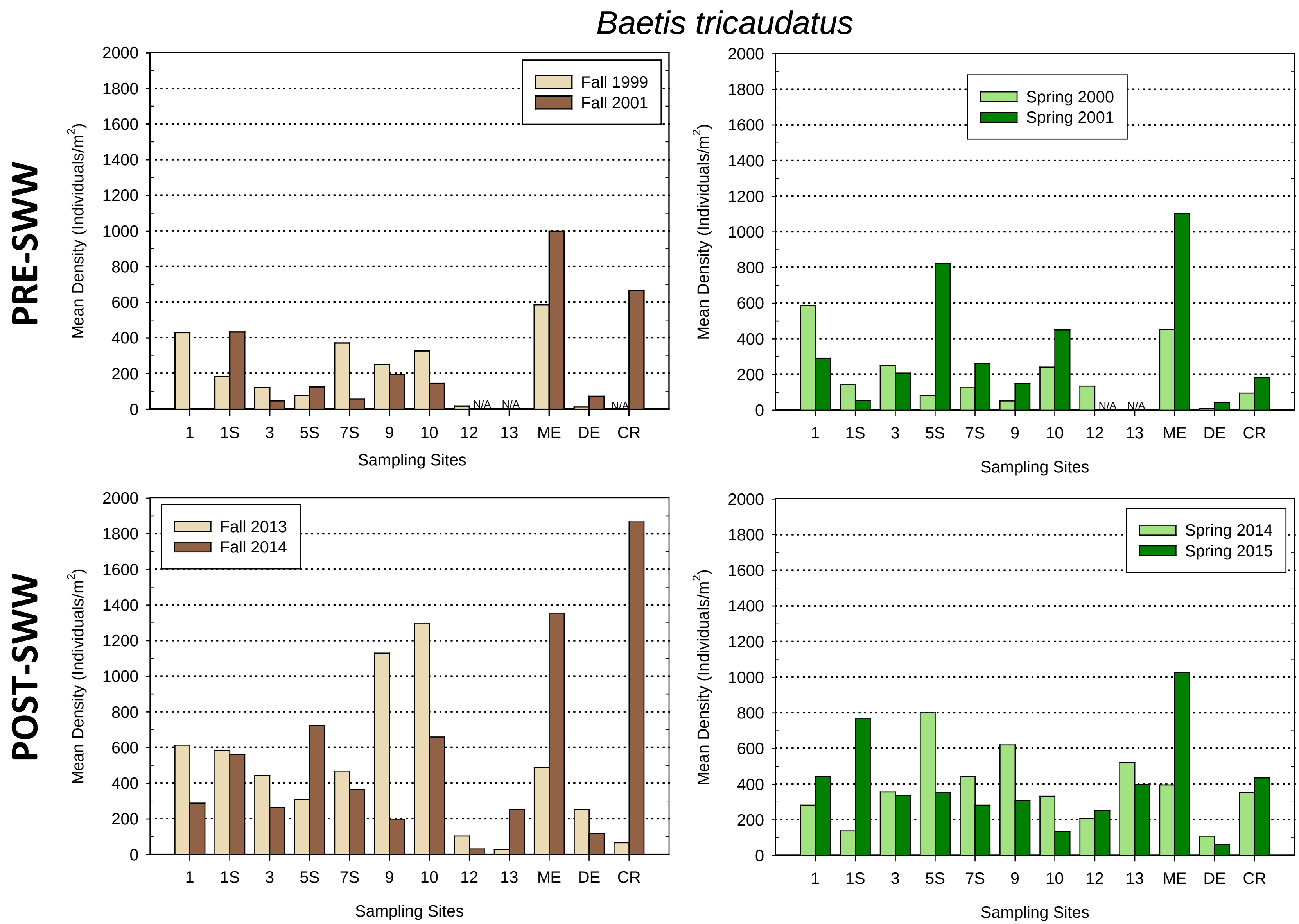
Appendix IV Figure 20. ***Drunella*** **spp. mayfly nymph densities in the lower Deschutes River downstream from the re-regulation dam and three reference sites for both baseline (Pre-SWW) and current (Post-SWW) studies.**



Appendix IV Figure 21. ***Epeorus*** **spp. mayfly nymph densities in the lower Deschutes River downstream from the re-regulation dam and three reference sites for both baseline (Pre-SWW) and current (Post-SWW) studies.**



Appendix IV Figure 22. ***Rhithrogena*** **spp. mayfly nymph densities in the lower Deschutes River downstream from the re-regulation dam and three reference sites for both baseline (Pre-SWW) and current (Post-SWW) studies.**



Appendix IV Figure 23. *Baetis tricaudatus* mayfly nymph densities in the lower Deschutes River downstream from the re-regulation dam and three reference sites for both baseline (Pre-SWW) and current (Post-SWW) studies.

APPENDIX V – PERIPHYTON SAMPLE COUNT RESULTS BY PERIOD & SITE

Appendix V Table 1. **Summary of 600-valve counts for diatom taxa for composite periphyton samples obtained from the lower Deschutes for October 2013 (fall).**

Taxonomic Group	Sampling Sites – October 2013											
	1	1S	3	5S	7S	9	10	12	13	ME	DE	CR
N of samples	1	1	1	1	1	1	1	1	1	1	1	1
Achnanthes subhudsonis v. kraeuselii										1		
Achnanthidium affine	2											9
Achnanthidium exiguum		1				1						
Achnanthidium minutissimum	26	5	30	3	8	34	83	33	61	160	107	392
Achnanthidium rivulare												1
Amphora copulata							1					1
Amphora inariensis			2			2					2	
Amphora pediculus				2		2	1		1	3	5	6
Amphora veneta							1					
Asterionella formosa						1	1					
Aulacoseira ambigua			5									
Aulacoseira granulata							3		2			
Aulacoseira subarctica			4	1			1	1			1	
Cocconeis klamathensis			5	1		2	1	5	1		2	
Cocconeis pediculus		2	18	1		3		5			1	2
Cocconeis placentula	1	5	8			12	38	17	4	37	7	2
Cocconeis placentula v. euglypta		1	2	2		9	15	2		11	11	2
Cocconeis placentula v. lineata	5	5	23		6	36	56	9	8	13	19	6
Cocconeis rugosa								1				1
Cyclostephanos invisitatus			6		1		1	2				
Cymbella cistula								2				
Cymbella mexicana								6	2			
Cymbellonitzschia diluviana										1	3	
Diatoma mesodon										1		
Diatoma moniliformis				1						2		
Diatoma tenuis							1					
Diatoma vulgaris			5	3	3	2	5	2	5			
Encyonema auerswaldii			1			1						
Encyonema mesianum								1				
Encyonema minutum											2	
Encyonema prostratum												2

Taxonomic Group	Sampling Sites – October 2013											
	1	1S	3	5S	7S	9	10	12	13	ME	DE	CR
Encyonema silesiacum								9	12	16	4	
Eolimna minima	2		1			15				9	3	
Epithemia sorex			1						2			
Fragilaria crotonensis	3		108	6	1	19	29	5	7			
Fragilaria vaucheriae	1	3	16			6			5	6	1	
Frustulia amphipleuroides										1		
Geissleria acceptata							1				18	
Gomphoneis eriense			1				3	9	13			
Gomphoneis minuta		5		3				11	37		2	1
Gomphonema angustatum							1					
Gomphonema kobayasii			1				2					
Gomphonema minutum	4		7			1		2			1	3
Gomphonema olivaceum						1						4
Gomphonema parvulum							8					1
Gomphonema rhombicum		13	6	15		9	14	25	24	4	4	26
Gomphonema subclavatum										5		
Gomphosphenia sp. 1 Idaho DW ANSP		1										
Gyrosigma acuminatum			1									
Hannaea arcus										1		
Hantzschia amphioxys								1				
Karayevia suchlandtii											2	
Luticola mutica							1					
Mayamaea atomus										2	4	
Melosira varians			1	2							5	
Navicula antonii	87		4			13	5	2		10	11	
Navicula capitatoradiata							1					
Navicula caterva										7		
Navicula concentrica										4		
Navicula cryptocephala		2										
Navicula cryptotenella	5	2	9	2	2	67	20	13	38	26	25	8
Navicula cryptotenelloides											2	
Navicula gregaria										2	5	
Navicula notha						4				6		
Navicula sp. 1										2		
Navicula submuralis										1		

Taxonomic Group	Sampling Sites – October 2013											
	1	1S	3	5S	7S	9	10	12	13	ME	DE	CR
Navicula tripunctata			9	2		15	13	11	14	2	5	2
Navicula trivialis				2								
Nitzschia agnita												1
Nitzschia amphibia			3									17
Nitzschia archibaldii					7			2		15		
Nitzschia communis							1					
Nitzschia dissipata	8	4	6		3	23	13	93	94	120	24	
Nitzschia fonticola	21	27	17	8	8	39	25	5	17	19	10	4
Nitzschia frustulum	24	48	13	31	16	41	34	125	210	23	15	1
Nitzschia gracilis				2								
Nitzschia inconspicua	357	34	71	31	77	113	62	127	49	22	200	44
Nitzschia lacuum										17		
Nitzschia liebethruthii							2					
Nitzschia palea	42	418	6	437	458	58	70	20	24	2	17	37
Nitzschia paleacea											3	
Nitzschia perminuta			1			2						
Nitzschia pumila											2	
Nitzschia pura	4		14									
Nitzschia radicula						1	1					
Nitzschia recta									4			
Nitzschia sinuata v. delognei						1						
Nitzschia sociabilis												1
Nitzschia tropica	1		7	4		6	6	4				
Opephora martyi		1										
Parlibellus protracta								1				
Planothidium frequentissimum											3	2
Planothidium lanceolatum			1			3	3			38	10	2
Planothidium robustum			1									
Pseudostaurosira brevistriata		2								3	1	8
Reimeria sinuata	2		1			2	4	5	2		6	
Rhoicosphenia abbreviata	5	3	29	6		18	14	10	9	14	37	14
Sellaphora pupula			1									
Sellaphora seminulum			2									
Staurosira construens v. binodis	6	6	56	30	1	19	30	15	6		1	
Staurosira construens v. venter	1		4				11	10		2	19	
Staurosirella pinnata	4		1					2	1	1		

Taxonomic Group	Sampling Sites – October 2013											
	1	1S	3	5S	7S	9	10	12	13	ME	DE	CR
Stephanodiscus hantzschii	1	2	14	1	1	10	9		1			
Stephanodiscus medius	4	1	29	3	5	5	10	1	2			
Stephanodiscus minutulus	1	2	5		2	4	1	1	1			
Stephanodiscus niagarae		6	42	5	1	5	5	5				
Synedra mazamaensis		1	3						3			
Synedra rumpens								1				
Tabellaria flocculosa										1		
TOTALS	**617**	**600**	**601**	**604**	**600**	**605**	**607**	**601**	**659**	**610**	**600**	**600**

Appendix V Table 2. Summary of 300-count for non-diatom soft algae taxa for composite periphyton samples obtained from the lower Deschutes for October 2013 (fall).

Taxonomic Group	Sampling Sites – October 2013											
	1	**1S**	**3**	**5S**	**7S**	**9**	**10**	**12**	**13**	**ME**	**DE**	**CR**
NON-DIATOM ALGAE												
Anabaena										48		
Anabaena circinalis			2				1					
Ankyra judayi	1						1					
Aphanizomenon flos-aquae			1				2					
Aphanocapsa	1		5			1						
Aphanocapsa elachista		1					1					
Calothrix									2			
Calothrix parietina										25		3
Ceratium hirundinella		1	1									
Cladophora glomerata						1			1			
Heteroleibleinia kuetzingii	212	128	207	66	258	117	214	265	224	160	206	282
Heteroleibleinia rigidula	40	33		8	49		6	36	18	10	28	
Mougeotia											1	
Oscillatoria limosa			6		3		2			11	13	
Phormidium autumnale	40	139	84	240	157	212	66	1	39	39	20	1
Phormidium inundatum										54	20	17
Pseudanabaena catenata	1					19						
Stigeoclonium lubricum	8				1			1	2			
Ulothrix zonata								1			1	
Xenococcus			17			5						
TOTALS	**303**	**302**	**323**	**314**	**468**	**355**	**293**	**304**	**286**	**347**	**289**	**303**

Appendix V Table 3. **Summary of 600-valve counts for diatom taxa for composite periphyton samples obtained from the lower Deschutes for April/May 2014 (spring).**

Taxonomic Group	Sampling Sites – April/May 2014											
	1	**1S**	**3**	**5S**	**7S**	**9**	**10**	**12**	**13**	**ME**	**DE**	**CR**
N of samples	1	1	1	1	1	1	1	1	1	1	1	1
DIATOM												
Achnanthes subhudsonis v. kraeuselii										1		
Achnanthidium affine	2		4	3	1					1		2
Achnanthidium deflexum												2
Achnanthidium exiguum												2
Achnanthidium gracillimum												12
Achnanthidium minutissimum	85	64	96	214	232	327	145	252	306	291	144	108
Achnanthidium rivulare					1		2	2		1		1
Adlafia minuscula			1									
Amphora pediculus				1				2		1		8
Asterionella formosa	1		2		2	2	2		1			
Aulacoseira crenulata				1		1						
Cocconeis pediculus				1								2
Cocconeis placentula	1	1	3	3	1				2	13	1	6
Cocconeis placentula v. euglypta										3		
Cocconeis placentula v. lineata	1			2			2	2	1	3		9
Cyclostephanos invisitatus	12	14	8	16	6	2	9	4	9			1
Cyclostephanos tholiformis	2			20	22	4	19	4	2	2		
Cyclotella atomus	4	8	4	2	3	1	3	2	3			
Cymbella affinis							2					
Cymbella mexicana												1
Denticula kuetzingii				2								
Diatoma mesodon										6		
Diatoma moniliformis	7	4	4	10	46	53	117	78	34	52		6
Diatoma vulgaris	6	8	8	14	14	6	14					16
Encyonema minutum											1	
Encyonema muelleri			2									
Encyonema reichardtii										1		4
Encyonema silesiacum					1		3	8	2	5	23	6
Eolimna minima									3	1		1
Epithemia turgida								1				

Taxonomic Group	Sampling Sites – April/May 2014											
	1	1S	3	5S	7S	9	10	12	13	ME	DE	CR
Fragilaria								1				
Fragilaria capucina		8										
Fragilaria crotonensis	5		3		10		2				1	
Fragilaria vaucheriae	17	17	8	1	2			2		7		
Gomphoneis								4				
Gomphoneis eriense	1		1		2					1		6
Gomphoneis minuta		6		9			5				1	
Gomphonema					1	6			4	8		6
Gomphonema angustatum						2		1				
Gomphonema kobayasii										5	1	
Gomphonema minutum									2			
Gomphonema olivaceoides				2								
Gomphonema olivaceum				2						44		2
Gomphonema olivaceum v. calcareum										1		
Gomphonema rhombicum									11	2		
Hannaea arcus					2					2	4	3
Mayamaea atomus								1			12	1
Melosira varians	4	1	7	3								13
Navicula antonii	1			1	2		4		3	1	13	
Navicula caterva										4		
Navicula concentrica										1		
Navicula cryptocephala								1				
Navicula cryptotenella	2				1		2		2	5		
Navicula cryptotenelloides							4	1	3	10	2	
Navicula gregaria											2	
Navicula lanceolata												2
Navicula menisculus							1			1		
Navicula subminuscula							1					
Navicula tripunctata	2			1	2	2	2		5	1		10
Nitzschia								2				1
Nitzschia amphibia												2
Nitzschia archibaldii			2	8	3	3	14	2		2	11	
Nitzschia dissipata	55	36	31	34	43	17	35	52	31	57	104	100
Nitzschia fonticola	135	127	53	47	54	37	36	42	32	7	26	83
Nitzschia fossilis	3		4	2	2	2	5	3	1			

Taxonomic Group	Sampling Sites – April/May 2014											
	1	**1S**	**3**	**5S**	**7S**	**9**	**10**	**12**	**13**	**ME**	**DE**	**CR**
Nitzschia frustulum	5	14	20	8	6	3	8	4	8	3	18	14
Nitzschia heufleriana												2
Nitzschia inconspicua	5	53	113	68	24	15	9	55	104	9	61	26
Nitzschia linearis				1								
Nitzschia palea	188	192	154	39	61	87	68	29	5	19	127	58
Nitzschia paleacea	7	9	5	15	19	2	21	9	1		27	
Nitzschia perminuta									4			
Nitzschia pura									2		1	
Nitzschia sociabilis												1
Pinnularia							2					
Pinnularia borealis			1									
Planothidium									1		2	
Planothidium frequentissimum								3			1	
Planothidium lanceolatum			3		1			1		8		1
Pseudostaurosira brevistriata			14		2		14	6				15
Reimeria sinuata				3				4		1	6	
Rhoicosphenia abbreviata		2	4	1			1	6	5	13	4	14
Rossithidium nodosum										1		
Sellaphora seminulum												2
Staurosira construens									1			
Staurosira construens v. binodis				1								34
Staurosira construens v. venter	26	3		7	2	14	13		2	3	6	15
Staurosirella pinnata				8								
Stephanocyclus meneghiniana		2	6	3	4	1	2	1	1			
Stephanodiscus hantzschii				7	2			3				
Stephanodiscus medius	8	5	13	1	5	2	13	4				
Stephanodiscus minutulus	4	13	11	25	11	5	7	7	6			
Stephanodiscus neoastraea					5	2	5					
Stephanodiscus niagarae			1	1			1					
Synedra acus			1									
Synedra mazamaensis	2	6	4	3	3	1	1					
Synedra ulna	9	6	9	10	2	3	6	1	3	3	1	1
Thalassiosira weissflogii		1										
Tryblionella apiculata												1
TOTALS	**600**	**600**	**600**	**600**	**600**	**600**	**600**	**600**	**600**	**600**	**600**	**600**

Appendix V Table 4. **Summary of 300-count for non-diatom soft algae taxa for composite periphyton samples obtained from the lower Deschutes for April/May 2014 (spring).**

Taxonomic Group	Sampling Sites – April/May 2014											
	1	**1S**	**3**	**5S**	**7S**	**9**	**10**	**12**	**13**	**ME**	**DE**	**CR**
NON-DIATOM ALGAE												
Anabaena			1						4			
Calothrix parietina									6	6		
Heteroleibleinia kuetzingii	47		58		24		41	46	76	54	57	
Heteroleibleinia rigidula	260	201	449	240	282	175	385	459	475	281	317	40
Hydrurus foetidus										3		3
Oscillatoria limosa											1	
Phormidium	30	102	35	17	55	43	63	9	43	24		35
Phormidium autumnale	56	50	25	43	45	17	43	44	10	39	13	29
Pteromonas angulosa	2		10			1			8		16	9
Scenedesmus communis												1
Scenedesmus dimorphus									1		1	
Scenedesmus quadricauda			2			1						
Stigeoclonium lubricum					1				1	4	5	1
TOTALS	**395**	**353**	**580**	**300**	**407**	**237**	**532**	**558**	**624**	**411**	**410**	**118**

Appendix V Table 5. **Summary of 600-valve counts for diatom taxa for composite periphyton samples obtained from the lower Deschutes for October 2014 (fall).**

Taxonomic Group	Sampling Sites – October 2014											
	1	1S	3	5S	7S	9	10	12	13	ME	DE	CR
N of samples	1	1	1	1	1	1	1	1	1	1	1	1
DIATOM												
Achnanthes										1		
Achnanthidium affine												2
Achnanthidium deflexum												5
Achnanthidium gracillimum												3
Achnanthidium minutissimum	22	3	17	19	4	37	57	10	91	238	39	128
Achnanthidium pyrenaicum	2											
Achnanthidium rivulare				1								4
Amphora												2
Amphora copulata		1								1		
Amphora inariensis											2	
Amphora pediculus	2			1	1					1		26
Asterionella formosa			3									
Aulacoseira	2						1					
Aulacoseira granulata v. angustissima	2		7		1							
Aulacoseira italica	2											
Chamaepinnularia bremensis									1			
Cocconeis klamathensis			4				1	6			79	1
Cocconeis pediculus	36	9	30			1		12			63	7
Cocconeis placentula	8	8	6	5	8	6	5	6	8	64	18	16
Cocconeis placentula v. euglypta										11		3
Cocconeis placentula v. lineata	2		5	4	3	3	1	5	2	44	12	14
Cyclostephanos invisitatus		2	4			2	2	3	1			
Cyclostephanos tholiformis	2		3				1					
Cymatopleura elliptica												1
Cymbella affiniformis			2									
Cymbella affinis									3		1	
Cymbella janischii												1
Cymbella mexicana	2											
Cymbella proxima						3		1	9		2	
Cymbella subturgidula								6	4			

Taxonomic Group	Sampling Sites – October 2014											
	1	**1S**	**3**	**5S**	**7S**	**9**	**10**	**12**	**13**	**ME**	**DE**	**CR**
Cymbellonitzschia diluviana												2
Diatoma mesodon			1									1
Diatoma moniliformis	4	1				1	3					1
Diatoma vulgaris	28	3	3	2	4	5	5	1			6	3
Didymosphenia geminata										1		
Diploneis ovalis												1
Encyonema auerswaldii				1		1		2				1
Encyonema minutum											4	
Encyonema silesiacum						5		3	16	9	13	1
Encyonopsis subminuta			1									
Epithemia turgida										2		
Eucocconeis flexella											2	
Fistulifera saprophila										2		
Fragilaria												1
Fragilaria capucina	4											
Fragilaria crotonensis	30	12	61	2	3	5	3	8	4		1	
Fragilaria vaucheriae	24	11	7	2	9	4	8	7	9	3	2	
Frustulia amphipleuroides										1		
Geissleria acceptata					2		2			8		2
Gomphoneis eriense			1	1				2	2		4	2
Gomphoneis mammilla									2			
Gomphoneis minuta	6	2	2	5		9	3	4	3		8	2
Gomphonema			1	2	10	12	8	12	6	4	14	2
Gomphonema kobayasii							1			1		
Gomphonema minutum	6	2	3			3	1				1	1
Gomphonema olivaceum			1		2					1		
Gomphonema rhombicum		1	1	1				40	22		4	3
Hannaea arcus								1				
Karayevia clevei			1									3
Karayevia laterostrata		1										
Karayevia suchlandtii									2			
Mayamaea atomus			2							5		
Melosira varians	2		1								3	1
Navicula									2	2		
Navicula antonii	2			2		2			2	2	5	4
Navicula capitatoradiata			1					2	3		2	3

Taxonomic Group	Sampling Sites – October 2014											
	1	1S	3	5S	7S	9	10	12	13	ME	DE	CR
Navicula caterva										2		
Navicula concentrica										2		
Navicula cryptocephala									2			
Navicula cryptotenella	18	1	1		4	3	2	5	25	15	10	6
Navicula cryptotenelloides	4		2	1	2		1	5	6	7	7	1
Navicula gregaria										2		
Navicula hustedtii										2		
Navicula menisculus	2				1	1	2					
Navicula radiosa					1							1
Navicula reichardtiana										1	1	
Navicula tripunctata	4		2		2			3	8	3		7
Nitzschia	4									5		2
Nitzschia amphibia	2		2			1						36
Nitzschia archibaldii	6	1	36	3		2	4		2		2	
Nitzschia dissipata	14	5	10	14	2	4	3	42	51	82	13	8
Nitzschia filiformis	2											
Nitzschia fonticola	44	20	21	34	10	92	69	112	144	7	27	111
Nitzschia fossilis	14	1	3		2			15	8		2	
Nitzschia frustulum	18	15	17	30	19	58	46	43	61	5	36	63
Nitzschia gracilis	4											
Nitzschia inconspicua	22	30	58	93	27	28	31	10	57	8	25	45
Nitzschia linearis		1										
Nitzschia palea	32	445	28	313	451	279	272	214	9		109	16
Nitzschia paleacea	6		5	16		13	22		10			2
Nitzschia perminuta	2									5		1
Nitzschia subacicularis			34	1			2					
Parlibellus protracta											1	
Planothidium				1						2		2
Planothidium dubium												2
Planothidium frequentissimum										3		1
Planothidium lanceolatum			1							38		2
Planothidium rostratum												1
Pseudostaurosira brevistriata	12		4								11	11
Reimeria sinuata			1	19	6		2		1	3		
Rhoicosphenia abbreviata	52	9	35	15	5	2	1	6	4	5	37	11
Sellaphora pupula												1

Taxonomic Group	Sampling Sites – October 2014											
	1	**1S**	**3**	**5S**	**7S**	**9**	**10**	**12**	**13**	**ME**	**DE**	**CR**
Staurosira construens	18		2						1	1		
Staurosira construens v. binodis	18	6	41	5		3	13	5	5			
Staurosira construens v. venter	62	6	82	1	14	8	14	3	10	1	22	19
Staurosirella pinnata			3		1		3		1			
Stephanocyclus meneghiniana			2									
Stephanodiscus hantzschii	6		3	1	4							
Stephanodiscus minutulus	20	3	9	5	1	2	7	2	1		2	
Stephanodiscus niagarae	18	1	26		1	1	3	1	2		2	
Synedra mazamaensis	8		3			4	1	2			1	
Synedra ulna			1					1			7	3
Synedra ulna v. contracta												1
TOTALS	**600**	**600**	**600**	**600**	**600**	**600**	**600**	**600**	**600**	**600**	**600**	**600**

Appendix V Table 6. **Summary of 300-count for non-diatom soft algae taxa for composite periphyton samples obtained from the lower Deschutes for October 2014 (fall).**

Taxonomic Group	Sampling Sites – October 2014											
	1	1S	3	5S	7S	9	10	12	13	ME	DE	CR
NON-DIATOM ALGAE												
Anabaena	3	2	3									
Aphanothece minutissima			6									
Calothrix								86	40			
Calothrix parietina									80	3		
Chamaesiphon confervicola	48											
Chamaesiphon incrustans	13		13							6	21	
Chamaesiphon minimus	16		19		23					3	92	
Cladophora glomerata	86		10								2	60
Heteroleibleinia kossinskajae	6			75		45	53			5	82	
Heteroleibleinia kuetzingii	26	128	173	113	151	60	207	139	60	275	55	
Hydrococcus			29									
Hydrurus foetidus										2		
Phormidium							3			3		
Phormidium autumnale	102	160	41	113	126	195	37	64	120	3	21	150
Pseudanabaena catenata			6									
Pseudopediastrum boryanum												30
Stigeoclonium								11				
Xenococcus gracilis		10									27	60
TOTALS	**300**	**300**	**300**	**301**	**300**	**300**	**300**	**300**	**300**	**300**	**300**	**300**

Appendix V Table 7. **Summary of 600-valve counts for diatom taxa for composite periphyton samples obtained from the lower Deschutes for April 2015 (spring).**

Taxonomic Group	Sampling Sites – April 2015											
	1	**1S**	**3**	**5S**	**7S**	**9**	**10**	**12**	**13**	**ME**	**DE**	**CR**
N of samples	1	1	1	1	1	1	1	1	1	1	1	1
DIATOM												
Achnanthes conspicua										1		
Achnanthidium affine					2							12
Achnanthidium deflexum			2		1							
Achnanthidium gracillimum												25
Achnanthidium kriegeri							1				1	
Achnanthidium minutissimum	14	20	77	33	230	257	110	84	124	301	159	314
Achnanthidium pyrenaicum												4
Achnanthidium rivulare					2	2					1	4
Adlafia minuscula											1	
Amphora pediculus		2	1		1		1	2	1	6	1	1
Asterionella formosa	3					1	3		2			
Aulacoseira		1										
Aulacoseira crenulata	3	2	2		1		3			5		
Aulacoseira granulata v. angustissima				2				8	2			
Chamaepinnularia bremensis										1		
Cocconeis klamathensis								1				
Cocconeis pediculus	6	1		1								1
Cocconeis placentula	5	8	3	4	1	4	34	14	9	20	2	5
Cocconeis placentula v. euglypta										1		
Cocconeis placentula v. lineata	2				1	1	9	3	3	1		
Cocconeis pseudolineata	3	4		10	2	2	31	10	2	7		2
Cyclostephanos invisitatus	16	5			1		1	3				
Cyclostephanos tholiformis	19	9	6	8	2	16	22	10	10			
Cyclotella atomus		7			4		3		3			
Cymbella mexicana		1										1
Cymbella subturgidula				2								
Diadesmis contenta				2								
Diatoma mesodon										2		
Diatoma moniliformis	4			1	1	1	8	4	27	9		8
Diatoma vulgaris	17	3		2	1		1	3		3	2	28

Taxonomic Group	Sampling Sites – April 2015											
	1	**1S**	**3**	**5S**	**7S**	**9**	**10**	**12**	**13**	**ME**	**DE**	**CR**
Encyonema silesiacum	4		1				1	6	4	3	6	8
Encyonema ventricosum												2
Encyonopsis microcephala									2	1		
Eolimna minima		2						2	6	4		
Fragilaria crotonensis	7	6				1	3	9				
Fragilaria nanana	1											
Fragilaria vaucheriae	4	12	6	5	10	1	11	7	1	7		
Geissleria acceptata			3	1				1	2			
Gomphoneis eriense					2	2	5	2		3	5	4
Gomphoneis herculeana					4							
Gomphoneis minuta	2				6		1					3
Gomphonema	4	2	4	4		2	1	10	1			2
Gomphonema angustatum						3	1	1				
Gomphonema kobayasii										5	14	
Gomphonema minutum	2	1	1				2	3			6	
Gomphonema olivaceoides										4		
Gomphonema olivaceum							2	4		4		
Gomphonema rhombicum			1	1	4		2	4		1		
Hannaea arcus										3	2	
Hantzschia amphioxys	2											
Mayamaea atomus									1			
Melosira varians	1											
Navicula	3									2		
Navicula antonii		1	4	2	1	2	5	1	2	2	1	
Navicula capitatoradiata	2								1			
Navicula cari											1	
Navicula caterva			1									1
Navicula cryptocephala										2		
Navicula cryptotenella	3			1	2		2	4	15	13		1
Navicula cryptotenelloides	4	3	1			1		2	15	14	4	1
Navicula gregaria										6		
Navicula lanceolata								2				
Navicula recens								1				
Navicula subminuscula					1							1
Navicula tenelloides										1		
Navicula tripunctata	1		1					8	2	10		2

Taxonomic Group	Sampling Sites – April 2015											
	1	1S	3	5S	7S	9	10	12	13	ME	DE	CR
Navicula wiesneri										3		
Nitzschia		2										2
Nitzschia amphibia					2							
Nitzschia archibaldii	6	2				4	1		4		5	
Nitzschia dissipata	10	8	7	4	7	24	10	5	13	62	61	23
Nitzschia fonticola	32	85	30	42	51	39	16	30	38	7	24	46
Nitzschia fossilis	3	3		1	1	1				1		2
Nitzschia frustulum	13	22	19	6	14	10	10	18	15	8	12	19
Nitzschia gracilis	2				1		2				3	
Nitzschia heufleriana	1											
Nitzschia incognita										1		
Nitzschia inconspicua	13	108	287	142	51	31	25	49	175	21	150	16
Nitzschia palea	9	4	61	144	63	91	3	8	3	10	118	49
Nitzschia paleacea	1	2	5		6	7			1	2	4	1
Nitzschia perminuta		13				2	2		1	4		
Nitzschia radicula										1		
Opephora olsenii		1					1					
Planothidium								1				
Planothidium frequentissimum		1	2						1		1	
Planothidium lanceolatum			1	1		3	1	1		22	3	
Planothidium rostratum	2											
Reimeria sinuata				14		2	1	2	4		7	
Rhoicosphenia abbreviata	5	3	7	12	1	2	23	39	17	12	3	5
Rossithidium nodosum										1	1	
Rossithidium pusillum										1		
Simonsenia delognei									2			
Staurosira construens	3							2				
Staurosira construens v. binodis	84	47	3	7	3	4	2	9	1			6
Staurosira construens v. venter	39	43	6	9	8	9	8	15	6		2	
Staurosirella pinnata	1			5		1	1	1		1		
Stephanocyclus meneghiniana	1							1		1		
Stephanodiscus hantzschii	5	3	9	12	12	9	25	23	15			
Stephanodiscus medius	203	95	34	117	82	53	174	155	52			
Stephanodiscus minutulus	6	49	8		6	9	22	23	15			
Stephanodiscus neoastraea		3						3	1			
Synedra acus	9			2			1					

Taxonomic Group	Sampling Sites – April 2015											
	1	1S	3	5S	7S	9	10	12	13	ME	DE	CR
Synedra mazamaensis	14	14	6	3	12	3	7	4	1			1
Synedra ulna	6		1				2	2	1			
Tabularia fasciculata		2										
TOTALS	**600**	**600**	**600**	**600**	**600**	**600**	**600**	**600**	**601**	**600**	**600**	**600**

Appendix V Table 8. **Summary of 300-count for non-diatom soft algae taxa for composite periphyton samples obtained from the lower Deschutes for April 2015 (spring).**

Taxonomic Group	Sampling Sites – April 2015											
	1	**1S**	**3**	**5S**	**7S**	**9**	**10**	**12**	**13**	**ME**	**DE**	**CR**
NON-DIATOM ALGAE												
Calothrix									184			
Chamaesiphon	203	196		53	49	7	41	139				
Chamaesiphon confervicola										2		
Chamaesiphon incrustans	35	7	37	7	3	2	9	26		25	41	2
Chamaesiphon minimus						28	18		12			15
Cladophora	3							1				
Heteroleibleinia	8		14	6	4		4	4		7	12	20
Homoeothrix	24						233	146	95	234	216	
Homoeothrix varians		25	201	108	185	171						145
Hydrurus foetidus										2	27	
Leptolyngbya	3	1								2	2	2
Monoraphidium							1					
Nostoc										2		
Phormidium	22						1	32				
Phormidium autumnale		2	12	46	19	33				34		63
Pseudanabaena mucicola			4			3						2
Rivularia									25			
Stigeoclonium		69	5	6		12				2	6	34
Stigonema												1
Ulothrix								1				
Ulothrix zonata											1	
Xenococcus	4	9	33	75	55	62				3	1	18
TOTALS	**302**	**309**	**306**	**301**	**315**	**318**	**307**	**349**	**316**	**313**	**306**	**302**

APPENDIX VI – PERIPHYTON SUMMARY METRICS BY PERIOD & SITE

Appendix VI Table 1. **Summary of density and biovolume estimates calculated for periphyton samples collected at invertebrate sampling sites in fall 2013 and spring 2014.**

Metrics	Sampling Sites 2013-2014											
	1	**1S**	**3**	**5S**	**7S**	**9**	**10**	**12**	**13**	**ME**	**DE**	**CR**
Fall-October 2013												
Density (#/cm^2)												
Diatoms	351,980	314,893	105,016	581,531	390,391	105,420	87,850	780,782	1,720,782	236,573	102,567	317,055
"Soft" Algae	1,085,185	1,376,208	125,220	2,546,595	4,120,256	369,701	64,244	2,375,580	4,260,430	334,219	13,659	1,454,962
Total	*1,437,165*	*1,691,101*	*230,236*	*3,128,126*	*4,510,647*	*475,121*	*152,095*	*3,156,362*	*5,981,211*	*570,792*	*116,226*	*1,772,017*
Biovolume (μm^3/cm^2)												
Diatoms	2.85E+07	1.90E+08	2.78E+08	3.31E+08	1.10E+08	5.69E+07	5.43E+07	9.20E+08	1.33E+09	4.87E+07	2.24E+07	4.58E+07
"Soft"Algae	4.09E+07	8.47E+07	5.59E+06	2.14E+08	2.06E+08	1.52E+08	1.88E+06	4.64E+08	1.56E+08	1.79E+07	4.06E+06	9.91E+06
Total	*6.95E+07*	*2.75E+08*	*2.84E+08*	*5.45E+08*	*3.17E+08*	*2.09E+08*	*5.61E+07*	*1.38E+09*	*1.49E+09*	*6.66E+07*	*2.64E+07*	*5.57E+07*
Taxa Richness												
Diatoms	25	26	48	26	17	39	44	40	31	39	40	29
"Soft" Algae	7	5	8	3	5	6	8	5	6	7	7	4
Total	32	31	56	29	22	45	52	45	37	46	47	33
Spring-April/May 2014												
Density (#/cm^2)												
Diatoms	2,654,072	2,914,984	1,915,309	1,125,733	990,586	1,321,564	839,218	1,037,199	752,182	283,062	2,151,531	2,031,596
"Soft" Algae	2,838,360	1,048,040	1,200,058	1,023,264	2,502,013	831,275	1,809,438	15,255,612	1,051,597	2,863,250	2,950,035	64,526
Total	*5,492,432*	*3,963,024*	*3,115,367*	*2,148,997*	*3,492,599*	*2,152,839*	*2,648,657*	*16,292,811*	*1,803,779*	*3,146,312*	*5,101,566*	*2,096,122*
Biovolume (μm^3/cm^2)												
Diatoms	8.21E+08	9.56E+08	7.42E+08	5.30E+08	2.34E+08	2.16E+08	3.34E+08	1.51E+08	8.50E+07	5.17E+07	3.34E+08	1.04E+09
"Soft" Algae	2.58E+08	9.89E+07	1.12E+08	9.91E+07	2.39E+08	8.01E+07	1.68E+08	1.49E+09	9.69E+07	2.64E+08	2.79E+08	1.24E+07
Total	*1.08E+09*	*1.05E+09*	*8.54E+08*	*6.29E+08*	*4.73E+08*	*2.96E+08*	*5.02E+08*	*1.64E+09*	*1.82E+08*	*3.15E+08*	*6.12E+08*	*1.06E+09*
Taxa Richness												
Diatoms	29	24	33	41	37	26	38	36	33	41	26	42
"Soft" Algae	5	3	7	3	5	5	4	4	9	7	7	7
Total	*34*	*27*	*40*	*44*	*42*	*31*	*42*	*40*	*42*	*48*	*33*	*49*

Appendix VI Table 2. Summary of density, biovolume, and taxa richness estimates calculated for periphyton samples collected at invertebrate sampling sites in fall 2014 and Spring 2015.

Metrics	Sampling Sites 2014-2015											
	1	1S	3	5S	7S	9	10	12	13	ME	DE	CR
Fall-October 2014												
Density (#/cm^2)												
Diatoms	29,531	189,308	24,286	29,611	116,533	102,037	160,533	110,400	118,940	157,333	14,873	11,440
"Soft" Algae	320,560	8,230,769	509,306	656,000	3,924,720	2,749,722	9,378,300	2,446,800	2,812,000	7,800,000	84,151	121,739
Total	*350,091*	*8,420,077*	*533,592*	*685,611*	*4,041,253*	*2,851,759*	*9,538,833*	*2,557,200*	*2,930,940*	*7,957,333*	*99,024*	*133,179*
Biovolume (µm^3/cm^2)												
Diatoms	5.22E+07	7.02E+07	4.38E+07	7.51E+06	3.58E+07	3.97E+07	6.33E+07	4.59E+07	5.37E+07	6.26E+07	1.48E+07	9.18E+06
"Soft" Algae	1.25E+10	4.27E+08	8.19E+08	3.86E+07	1.46E+08	1.84E+08	1.37E+08	3.30E+08	1.67E+08	8.14E+07	1.05E+08	1.85E+09
Total	*1.26E+10*	*4.98E+08*	*8.63E+08*	*4.61E+07*	*1.82E+08*	*2.24E+08*	*2.00E+08*	*3.76E+08*	*2.20E+08*	*1.44E+08*	*1.20E+08*	*1.86E+09*
Taxa Richness												
Diatoms	46	27	52	30	29	32	35	35	40	41	40	56
"Soft" Algae	8	4	9	3	3	3	4	4	4	8	7	4
Total	*54*	*31*	*61*	*33*	*32*	*35*	*39*	*39*	*44*	*49*	*47*	*60*
Spring-April 2015												
Density (#/cm^2)												
Diatoms	929,326	972,800	2,014,320	1,229,600	3,940,480	1,384,160	103,111	98,368	125,902	128,749	3,540,493	9,673,707
"Soft" Algae	306,949	4,055,040	21,689,360	11,818,080	37,915,840	25,511,840	1,128,000	363,263	5,139,934	1,352,664	6,382,631	35,429,120
Total	*1,236,274*	*5,027,840*	*23,703,680*	*13,047,680*	*41,856,320*	*26,896,000*	*1,231,111*	*461,632*	*5,265,836*	*1,481,413*	*9,923,124*	*45,102,827*
Biovolume (µm^3/cm^2)												
Diatoms	4.91E+08	2.98E+08	2.32E+08	2.75E+08	1.04E+09	2.01E+08	3.39E+07	3.04E+07	1.81E+07	2.10E+07	4.86E+08	3.87E+09
"Soft" Algae	1.37E+09	9.82E+08	5.67E+08	4.66E+08	1.00E+09	9.26E+08	1.18E+08	6.17E+08	1.03E+09	2.06E+08	1.36E+10	6.08E+09
Total	*1.86E+09*	*1.28E+09*	*8.00E+08*	*7.41E+08*	*2.04E+09*	*1.13E+09*	*1.52E+08*	*6.47E+08*	*1.05E+09*	*2.27E+08*	*1.41E+10*	*9.95E+09*
Taxa Richness												
Diatoms	48	40	32	32	38	34	46	48	42	47	29	33
"Soft" Algae	8	7	7	7	6	8	7	7	4	10	8	10
Total	*56*	*47*	*39*	*39*	*44*	*42*	*53*	*55*	*46*	*57*	*37*	*43*

Appendix VI Table 3. **Summary of baseline total density, total biovolume, and total taxa richness estimates calculated for periphyton samples collected at invertebrate sampling sites in 1999-2001.**

Metrics	Sampling Sites 1999-2001											
	1	1S	3	5S	7S	9	10	12	13	ME	DE	CR
Fall-October 1999												
Total Density (#/cm^2)	69,965	20,445	14,694	345,767	228,507	39,318	333,467	595,867	–	32,473	152,832	–
Total Biovolume (μm^3/cm^2)	4.31E+07	9.68E+06	1.01E+07	2.74E+08	1.65E+08	1.40E+07	1.47E+08	1.57E+08	–	1.66E+07	3.03E+07	–
Total Taxa Richness	27	22	18	21	22	23	17	18	–	13	16	–
Spring-May 2000												
Total Density (#/cm^2)	2.38E+06	683,333	1.73E+06	1.20E+06	2.28E+06	1.75E+06	811,800	936,362	–	92,933	212,137	–
Total Biovolume (μm^3/cm^2)	4.58E+08	3.00E+08	7.43E+08	8.71E+08	9.04E+08	7.96E+08	4.11E+08	5.02E+08	–	2.41E+07	8.37E+07	–
Total Taxa Richness	11	13	14	15	15	13	20	22	–	20	21	–
Spring-May 2001												
Total Density (#/cm^2)	3.56E+06	5.23E+06	1.26E+07	9.56E+06	5.17E+06	5.71E+06	5.11E+06	886,313	–	7,297	4.38E+06	3.94E+06
Total Biovolume (μm^3/cm^2)	1.50E+09	2.57E+09	5.15E+09	6.83E+09	3.37E+09	2.57E+09	2.40E+09	6.76E+08	–	2.44E+06	1.89E+09	1.18E+09
Total Taxa Richness	11	12	14	12	11	13	15	16	–	18	16	12
Fall-October 2001												
Total Density (#/cm^2)	172,883	204,724	67,892	294,191	75,883	1.36E+06	1.55E+06	1.26E+06	–	92,933	212,137	430,866
Total Biovolume (μm^3/cm^2)	6.31E+07	5.74E+07	1.82E+07	1.08E+08	3.22E+07	9.69E+08	7.43E+08	3.67E+08	–	2.41E+07	8.37E+07	5.50E+07
Total Taxa Richness	24	19	24	23	21	13	18	22	–	24	9	16

Appendix VI Table 4. Summary of diatom metrics calculated for periphyton samples collected at invertebrate sampling sites in Fall – October 1999.

Diatom Metrics	Sampling Sites – October 1999											
	1	1S	3	5S	7S	9	10	12	13	ME	DE	CR
Community Structure												
Cosmopolitan Taxa Percent	76.8	85.9	80.2	67.9	77.2	78.7	81.4	64.1	–	67.7	77.4	–
Dominant Taxon Percent	12.6	15.6	27.1	22.9	15.8	15.4	35.4	27.2	–	30.3	17.9	–
Shannon H (log2)	4.18	4.03	3.54	3.72	3.84	3.88	3.16	3.26	–	2.98	3.46	–
Species Richness	27	22	18	21	22	23	17	18	–	13	16	–
Inorganic Nutrients												
Eutraphentic Taxa Percent	44.2	62.5	65.6	47.7	43.0	56.6	69.9	56.3	–	56.6	48.1	–
Nitrogen Autotroph Taxa Percent	62.1	79.7	62.5	24.8	46.5	52.2	33.6	26.2	–	71.7	45.3	–
Rhopalodiales Percent	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	–	1.0	0.0	–
Metals												
Abnormal Cells Percent	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	–	0.0	0.0	–
Acidophilous Taxa Percent	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	–	0.0	0.0	–
Alkaliphilous Taxa Percent	78.9	82.8	90.6	44.0	60.5	69.1	45.1	43.7	–	71.7	53.8	–
Disturbance Taxa Percent	7.4	6.3	0.0	3.7	5.3	7.4	1.8	4.9	–	7.1	17.0	–
Metals Tolerant Taxa Percent	9.5	10.9	9.4	33.0	19.3	16.2	40.7	29.1	–	10.1	18.9	–
Organic Nutrients												
Low DO Taxa Percent	0.0	1.6	0.0	22.9	8.8	7.4	35.4	27.2	–	0.0	14.2	–
Nitrogen Heterotroph Taxa Percent	21.1	14.1	25.0	41.3	25.4	26.5	50.4	43.7	–	1.0	38.7	–
Pollution Index	2.63	2.69	2.56	2.00	2.39	2.38	1.92	1.95	–	2.75	2.32	–
Polysaprobous Taxa Percent	16.8	15.6	24.0	41.3	18.4	24.3	46.0	36.9	–	17.2	27.4	–
Sediment												
Motile Taxa Percent	47.4	28.1	41.7	69.7	51.8	52.9	69.9	77.7	–	19.2	60.4	–
Siltation Taxa Percent	48.4	28.1	41.7	69.7	51.8	52.9	70.8	77.7	–	18.2	60.4	–

Appendix VI Table 5. Summary of diatom metrics calculated for periphyton samples collected at invertebrate sampling sites in spring – May 2000.

Diatom Metrics	Sampling Sites – May 2000											
	1	1S	3	5S	7S	9	10	12	13	ME	DE	CR
Community Structure												
Cosmopolitan Taxa Percent	89.2	91.8	96.5	85.4	93.1	89.4	81.1	82.9	–	73.7	80.0	–
Dominant Taxon Percent	75.7	50.0	46.1	32.0	57.7	54.0	23.4	18.1	–	23.2	20.0	–
Shannon H (log2)	1.40	2.46	2.51	2.86	2.27	2.46	3.64	3.67	–	3.67	3.65	–
Species Richness	11	13	14	15	15	13	20	22	–	20	21	–
Inorganic Nutrients												
Eutraphentic Taxa Percent	81.6	63.9	60.9	46.6	66.2	71.7	60.4	41.9	–	46.5	33.9	–
Nitrogen Autotroph Taxa Percent	14.1	36.1	41.7	54.4	33.1	32.7	55.0	62.9	–	79.8	60.0	–
Rhopalodiales Percent	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	–	0.0	0.0	–
Metals												
Abnormal Cells Percent	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	–	0.0	0.0	–
Acidophilous Taxa Percent	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	–	0.0	0.0	–
Alkaliphilous Taxa Percent	7.6	29.5	33.9	44.7	26.9	35.4	63.1	59.0	–	63.6	48.7	–
Disturbance Taxa Percent	8.7	14.8	18.3	17.5	12.3	8.0	5.4	18.1	–	23.2	20.0	–
Metals Tolerant Taxa Percent	76.8	51.6	51.3	33.0	59.2	55.8	30.6	17.1	–	16.2	21.7	–
Organic Nutrients												
Low DO Taxa Percent	75.7	50.0	46.1	33.0	57.7	54.0	24.3	14.3	–	1.0	10.4	–
Nitrogen Heterotroph Taxa Percent	77.3	59.0	57.4	38.8	62.3	62.0	36.9	28.6	–	6.1	17.4	–
Pollution Index	1.35	1.78	1.94	2.15	1.74	1.73	2.19	2.40	–	2.61	2.44	–
Polysaprobous Taxa Percent	78.9	57.4	52.2	45.6	63.1	62.8	38.7	27.6	–	22.2	20.0	–
Sediment												
Motile Taxa Percent	86.0	63.9	65.2	47.6	70.8	71.7	59.5	48.6	–	30.3	47.8	–
Siltation Taxa Percent	86.0	64.8	64.4	47.6	70.8	71.7	59.5	46.7	–	30.3	47.0	–

Appendix VI Table 6. **Summary of diatom metrics calculated for periphyton samples collected at invertebrate sampling sites in Spring – May 2001.**

Diatom Metrics	Sampling Sites – May 2001											
	1	1S	3	5S	7S	9	10	12	13	ME	DE	CR
Community Structure												
Cosmopolitan Taxa Percent	99.3	95.4	98.8	97.5	98.3	98.3	96.9	92.7	–	68.7	93.4	93.7
Dominant Taxon Percent	72.5	74.7	88.3	72.3	58.1	70.2	76.5	16.4	–	31.3	77.8	44.1
Shannon H (log2)	1.55	1.55	0.85	1.32	1.76	1.59	1.44	3.31	–	3.42	1.50	2.09
Species Richness	11	12	14	12	11	13	15	16	–	18	16	12
Inorganic Nutrients												
Eutraphentic Taxa Percent	79.7	81.0	91.4	74.8	60.2	77.5	80.8	42.7	–	34.9	83.7	50.4
Nitrogen Autotroph Taxa Percent	21.7	21.3	9.8	25.8	39.8	22.1	20.4	60.0	–	74.7	18.3	52.0
Rhopalodiales Percent	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	–	0.0	0.0	0.0
Metals												
Abnormal Cells Percent	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	–	0.0	0.0	0.0
Acidophilous Taxa Percent	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	–	0.0	0.0	0.0
Alkaliphilous Taxa Percent	16.7	17.8	7.2	26.4	20.3	17.2	14.9	70.0	–	51.8	12.5	18.1
Disturbance Taxa Percent	10.9	5.8	4.3	0.9	20.9	11.9	6.7	16.4	–	31.3	6.2	44.1
Metals Tolerant Taxa Percent	73.2	75.3	89.0	73.0	58.4	70.5	76.9	29.1	–	10.8	78.6	33.9
Organic Nutrients												
Low DO Taxa Percent	72.5	74.7	88.3	72.3	58.1	70.2	76.5	9.1	–	0.0	77.8	33.1
Nitrogen Heterotroph Taxa Percent	78.3	77.6	90.0	73.0	59.6	76.8	78.8	37.3	–	3.6	79.4	45.7
Pollution Index	1.46	1.43	1.19	1.51	1.80	1.50	1.43	2.35	–	2.74	1.36	2.17
Polysaprobous Taxa Percent	76.1	80.5	90.7	76.1	60.8	73.0	77.7	41.8	–	20.5	79.0	35.4
Sediment												
Motile Taxa Percent	79.7	81.6	90.5	75.8	61.1	77.9	80.8	43.6	–	21.7	82.9	45.7
Siltation Taxa Percent	79.7	81.6	90.5	75.8	61.1	77.9	80.8	43.6	–	18.1	83.3	45.7

Appendix VI Table 7. Summary of diatom metrics calculated for periphyton samples collected at invertebrate sampling sites in fall – October 2001.

Diatom Metrics	Sampling Sites – October 2001											
	1	1S	3	5S	7S	9	10	12	13	ME	DE	CR
Community Structure												
Cosmopolitan Taxa Percent	75.0	78.6	74.5	70.4	82.7	86.5	80.4	77.9	–	90.5	94.8	79.8
Dominant Taxon Percent	15.4	21.4	12.2	15.3	14.4	67.7	55.4	20.4	–	41.0	65.4	28.9
Shannon H (log2)	3.94	3.46	4.12	4.09	3.90	1.96	2.48	3.71	–	3.14	1.58	2.92
Species Richness	24	19	24	23	21	13	18	22	–	24	9	16
Inorganic Nutrients												
Eutraphentic Taxa Percent	56.7	51.0	60.2	56.1	49.0	80.2	77.2	69.9	–	31.4	28.8	51.9
Nitrogen Autotroph Taxa Percent	41.4	40.8	39.8	37.8	50.0	18.8	15.2	33.6	–	82.9	66.7	40.4
Rhopalodiales Percent	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	–	0.0	0.0	0.0
Metals												
Abnormal Cells Percent	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	–	0.0	0.0	0.0
Acidophilous Taxa Percent	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	–	0.0	0.0	0.0
Alkaliphilous Taxa Percent	73.1	60.2	59.2	67.3	60.6	20.8	34.8	76.1	–	49.5	15.0	55.8
Disturbance Taxa Percent	15.4	21.4	10.2	2.0	8.7	2.1	1.1	2.7	–	41.0	65.4	28.9
Metals Tolerant Taxa Percent	23.1	15.3	19.4	18.4	12.5	68.8	58.7	24.8	–	4.8	15.0	1.9
Organic Nutrients												
Low DO Taxa Percent	5.8	0.0	12.2	10.2	4.8	67.7	55.4	2.7	–	1.0	15.0	1.0
Nitrogen Heterotroph Taxa Percent	39.4	38.8	38.8	39.8	31.7	75.0	70.7	53.1	–	9.5	28.8	42.3
Pollution Index	2.14	2.36	2.14	2.13	2.39	1.42	1.49	2.18	–	2.77	2.50	2.22
Polysaprobous Taxa Percent	50.0	38.8	44.9	38.8	36.5	75.0	72.8	38.9	–	7.6	15.7	36.5
Sediment												
Motile Taxa Percent	55.8	59.2	60.2	67.4	54.8	83.3	87.0	69.9	–	33.3	32.7	54.8
Siltation Taxa Percent	56.7	59.2	61.2	66.3	54.8	83.3	88.0	69.9	–	32.4	33.3	54.8

Appendix VI Table 8. Summary of diatom metrics calculated for periphyton samples collected at invertebrate sampling sites in fall – October 2013.

Diatom Metrics	Sampling Sites – October 2013											
	1	1S	3	5S	7S	9	10	12	13	ME	DE	CR
Community Structure												
Cosmopolitan Taxa Percent	97.9	94.5	75.5	89.9	98.5	91.6	89.0	85.2	87.0	89.3	93.8	90.3
Dominant Taxon Percent	57.9	69.7	18.0	72.4	76.3	18.7	13.7	21.1	31.9	26.2	33.3	65.3
Shannon H (log2)	2.37	1.96	4.44	1.87	1.39	4.23	4.34	3.83	3.54	3.86	3.70	2.23
Species Richness	25	26	48	26	17	39	44	40	31	39	40	29
Inorganic Nutrients												
Eutraphentic Taxa Percent	86.6	87.3	44.8	86.3	95.3	60.3	57.5	56.1	50.4	34.6	60.0	24.5
Nitrogen Autotroph Taxa Percent	14.3	11.5	62.7	11.4	7.3	43.1	59.5	40.1	39.0	81.3	46.7	75.0
Rhopalodiales Percent	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.0
Metals												
Abnormal Cells Percent	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Acidophilous Taxa Percent	0.0	0.0	0.0	0.0	0.0	0.7	0.0	0.0	0.0	1.3	0.0	0.0
Alkaliphilous Taxa Percent	87.2	24.7	76.7	22.0	20.8	79.3	66.6	76.2	72.8	63.0	71.3	22.7
Disturbance Taxa Percent	4.2	0.8	5.0	0.5	1.3	5.6	13.7	5.5	9.3	26.2	17.8	65.3
Metals Tolerant Taxa Percent	7.3	70.2	4.3	72.4	76.3	13.6	13.3	5.0	6.2	12.0	7.3	6.7
Organic Nutrients												
Low DO Taxa Percent	7.3	70.0	3.8	72.5	76.5	13.7	14.3	3.3	3.8	2.1	4.2	6.3
Nitrogen Heterotroph Taxa Percent	69.0	83.7	18.5	83.1	92.0	39.2	30.3	45.3	43.1	9.5	41.2	16.7
Pollution Index	2.07	1.45	2.64	1.42	1.29	2.30	2.47	2.45	2.45	2.65	2.41	2.74
Polysaprobous Taxa Percent	65.5	76.8	20.3	78.5	89.7	34.7	26.0	26.3	14.0	16.2	42.8	17.2
Sediment												
Motile Taxa Percent	89.6	89.2	28.1	86.3	95.2	66.8	42.8	68.1	69.0	47.9	60.0	20.3
Siltation Taxa Percent	89.3	89.2	27.3	85.9	95.2	65.8	42.0	67.1	68.3	47.4	57.3	19.2

Appendix VI Table 9. Summary of diatom metrics calculated for periphyton samples collected at invertebrate sampling sites in spring – April/May 2014.

Diatom Metrics	Sampling Sites – April/May 2014											
	1	1S	3	5S	7S	9	10	12	13	ME	DE	CR
Community Structure												
Cosmopolitan Taxa Percent	98.3	98.0	96.7	91.3	93.3	96.5	90.5	96.7	95.8	93.7	97.3	88.5
Dominant Taxon Percent	31.3	32.0	25.7	35.7	38.7	54.5	24.2	42.0	51.0	48.5	24.0	18.0
Shannon H (log2)	3.14	3.20	3.53	3.67	3.40	2.48	3.82	3.13	2.72	3.12	3.25	4.01
Species Richness	29	24	33	41	37	26	38	36	33	41	26	42
Inorganic Nutrients												
Eutraphentic Taxa Percent	42.3	53.7	59.7	33.7	32.8	29.7	46.7	34.8	30.5	30.2	46.0	29.8
Nitrogen Autotroph Taxa Percent	61.0	49.0	45.0	67.0	73.8	79.5	72.8	79.5	73.0	87.5	55.8	74.2
Rhopalodiales Percent	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.0
Metals												
Abnormal Cells Percent	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.3	0.0	0.0
Acidophilous Taxa Percent	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Alkaliphilous Taxa Percent	51.7	51.7	55.2	47.3	44.7	28.2	54.5	47.7	42.2	39.8	46.8	65.5
Disturbance Taxa Percent	14.2	10.7	16.0	35.7	38.7	54.5	24.2	42.0	51.0	48.5	24.0	20.0
Metals Tolerant Taxa Percent	35.3	37.7	28.5	9.2	14.0	14.8	15.3	8.3	1.8	6.7	31.7	11.5
Organic Nutrients												
Low DO Taxa Percent	31.3	32.3	26.7	8.2	11.2	14.7	11.8	5.5	1.5	3.3	21.5	10.2
Nitrogen Heterotroph Taxa Percent	34.8	45.3	50.8	23.8	19.3	18.0	18.2	17.0	20.3	5.3	40.8	19.5
Pollution Index	2.22	2.10	2.12	2.54	2.52	2.54	2.35	2.58	2.67	2.75	2.27	2.67
Polysaprobous Taxa Percent	40.8	51.0	54.2	30.5	29.3	27.8	39.7	33.5	27.0	17.5	42.5	20.0
Sediment												
Motile Taxa Percent	67.2	71.8	64.0	38.3	36.2	28.0	35.3	34.7	34.0	20.5	68.3	52.0
Siltation Taxa Percent	67.2	71.8	63.8	37.3	36.2	28.0	35.0	33.5	34.0	20.2	67.3	50.7

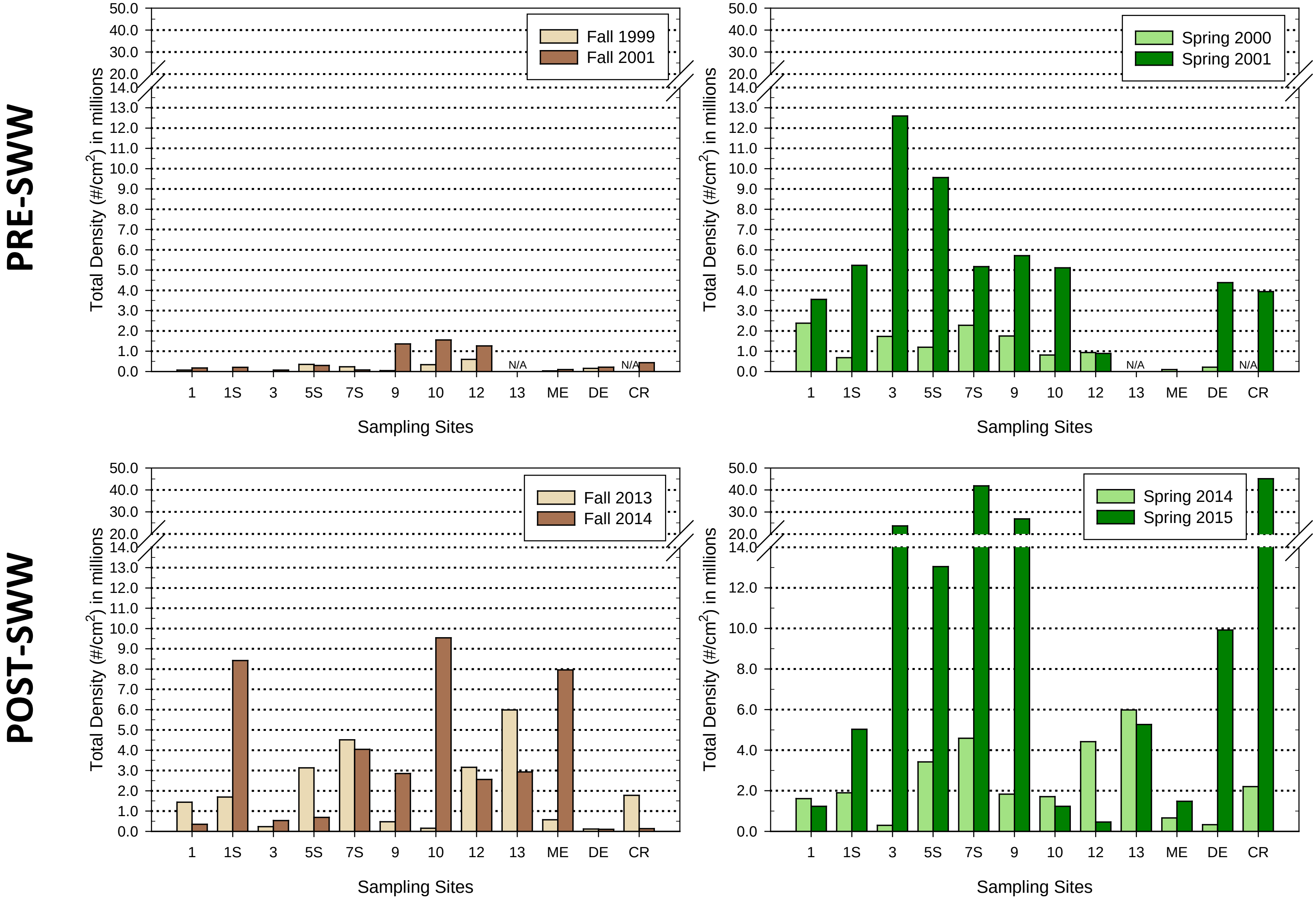
Appendix VI Table 10. Summary of diatom metrics calculated for periphyton samples collected at invertebrate sampling sites in fall – October 2014.

Diatom Metrics	Sampling Sites – October 2014											
	1	1S	3	5S	7S	9	10	12	13	ME	DE	CR
Community Structure												
Cosmopolitan Taxa Percent	84.0	97.8	71.8	96.7	97.2	94.0	93.0	84.3	87.8	93.3	79.3	87.0
Dominant Taxon Percent	10.3	74.2	13.7	52.2	75.2	46.5	45.3	35.7	24.0	39.7	18.2	21.3
Shannon H (log2)	4.81	1.84	4.51	2.68	1.83	2.92	3.06	3.41	3.88	3.33	4.20	4.09
Species Richness	46	27	52	30	29	32	35	35	40	41	40	56
Inorganic Nutrients												
Eutraphentic Taxa Percent	43.0	89.2	42.3	81.7	88.8	67.7	67.2	51.7	29.8	32.5	53.2	43.3
Nitrogen Autotroph Taxa Percent	68.7	16.7	69.7	22.0	12.8	30.2	33.7	38.2	61.3	87.5	47.5	64.3
Rhopalodiales Percent	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.0
Metals												
Abnormal Cells Percent	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Acidophilous Taxa Percent	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.5	0.0	0.0
Alkaliphilous Taxa Percent	79.3	23.7	76.2	38.8	20.3	40.3	40.0	48.2	69.5	51.7	51.0	70.0
Disturbance Taxa Percent	3.7	0.5	2.8	3.2	0.7	6.2	9.5	1.7	15.2	39.7	6.5	21.8
Metals Tolerant Taxa Percent	11.0	76.0	7.2	55.2	76.7	50.2	50.3	37.3	7.3	9.2	21.3	4.0
Organic Nutrients												
Low DO Taxa Percent	6.3	74.2	5.5	52.3	75.8	46.5	45.3	35.7	1.5	0.3	18.2	2.7
Nitrogen Heterotroph Taxa Percent	15.0	81.7	19.7	75.5	83.5	63.2	61.8	44.5	22.8	3.0	28.8	27.2
Pollution Index	2.61	1.41	2.55	1.70	1.37	1.87	1.87	2.12	2.63	2.78	2.43	2.64
Polysaprobous Taxa Percent	20.3	81.7	20.0	71.8	82.2	55.8	57.5	40.2	17.8	11.8	28.0	19.2
Sediment												
Motile Taxa Percent	33.7	86.7	37.2	87.8	88.3	80.5	76.3	75.2	65.3	28.5	40.3	56.8
Siltation Taxa Percent	33.3	86.5	37.0	84.5	87.2	80.5	76.0	75.2	65.2	27.5	40.0	51.5

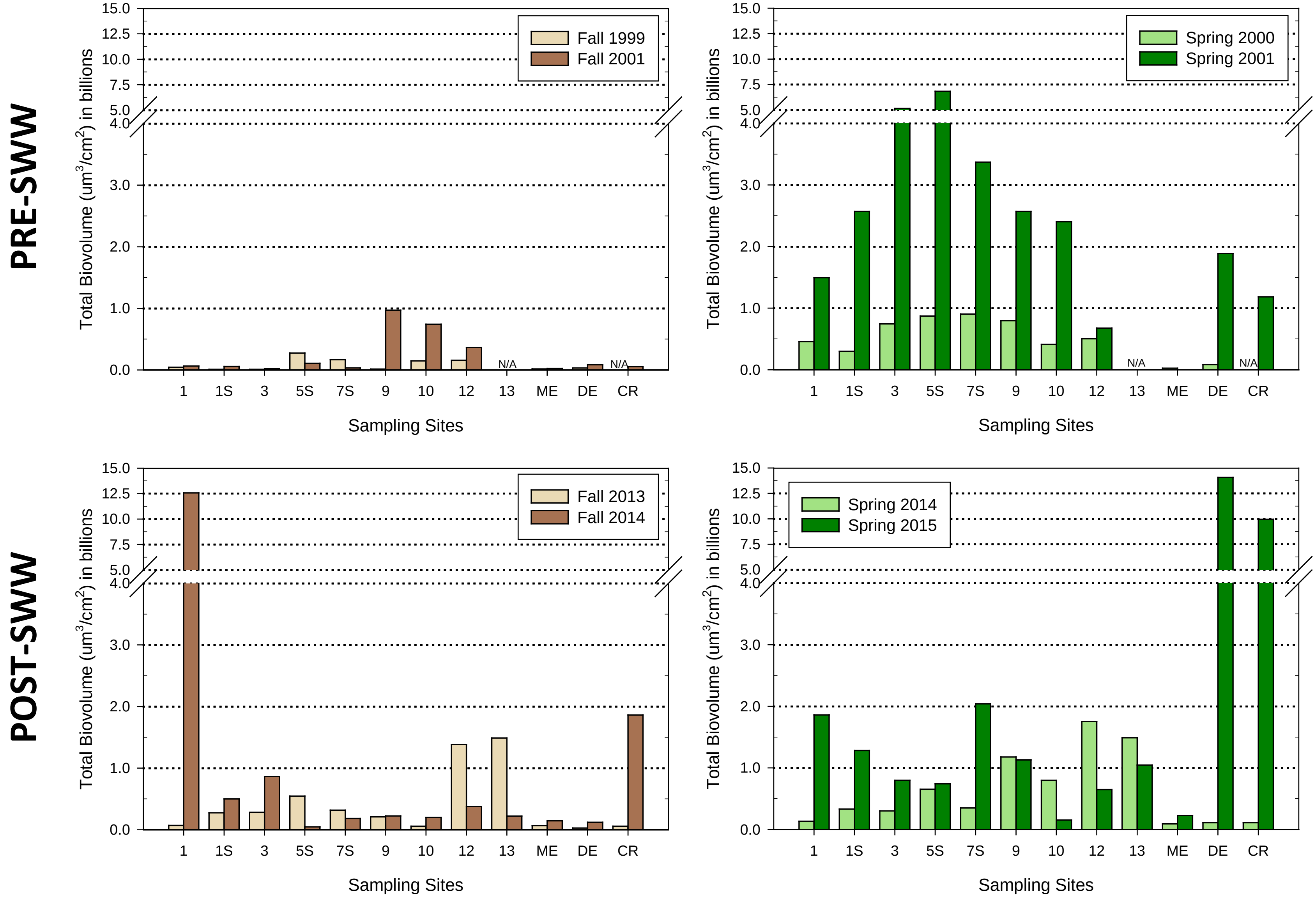
Appendix VI Table 11. Summary of diatom metrics calculated for periphyton samples collected at invertebrate sampling sites in spring – April 2015.

Diatom Metrics	Sampling Sites – April 2015											
	1	1S	3	5S	7S	9	10	12	13	ME	DE	CR
Community Structure												
Cosmopolitan Taxa Percent	74.2	82.8	95.7	93.2	92.7	93.2	86.3	89.2	95.5	88.2	94.8	92.7
Dominant Taxon Percent	33.8	18.0	47.8	24.0	38.3	42.8	29.0	25.8	29.1	52.3	26.5	50.2
Shannon H (log2)	3.95	3.93	2.91	3.28	3.25	3.10	3.85	4.16	3.66	2.89	3.00	3.28
Species Richness	48	40	32	32	38	34	46	48	42	33	29	47
Inorganic Nutrients												
Eutraphentic Taxa Percent	50.5	55.2	74.5	76.5	43.2	38.8	65.3	63.7	59.6	18.3	50.8	25.7
Nitrogen Autotroph Taxa Percent	80.7	69.3	31.7	45.2	68.3	70.5	80.8	74.0	55.7	75.2	46.5	84.5
Rhopalodiales Percent	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Metals												
Abnormal Cells Percent	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.3	0.3	0.2	0.0
Acidophilous Taxa Percent	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Alkaliphilous Taxa Percent	82.5	88.8	72.7	64.7	45.3	36.7	72.7	75.2	71.4	30.5	44.8	40.3
Disturbance Taxa Percent	2.3	3.3	12.8	5.5	38.3	42.8	18.3	14.0	20.6	56.5	26.5	50.2
Metals Tolerant Taxa Percent	3.0	3.3	12.3	25.0	13.2	17.0	2.7	4.0	2.7	9.7	22.0	8.0
Organic Nutrients												
Low DO Taxa Percent	2.5	1.5	11.7	26.0	12.7	16.7	4.7	5.7	4.0	8.3	19.7	3.5
Nitrogen Heterotroph Taxa Percent	7.2	23.5	63.5	50.7	24.8	24.7	10.5	16.8	35.9	14.3	47.3	7.7
Pollution Index	2.42	2.43	2.15	2.02	2.46	2.45	2.46	2.43	2.36	2.73	2.29	2.75
Polysaprobous Taxa Percent	11.5	31.7	63.5	51.2	26.0	25.3	17.0	21.5	42.6	14.2	47.0	14.5
Sediment	74.2	82.8	95.7	93.2	92.7	93.2	86.3	89.2	95.5	88.2	94.8	92.7
Motile Taxa Percent	33.8	18.0	47.8	24.0	38.3	42.8	29.0	25.8	29.1	52.3	26.5	50.2
Siltation Taxa Percent	3.95	3.93	2.91	3.28	3.25	3.10	3.85	4.16	3.66	2.89	3.00	3.28

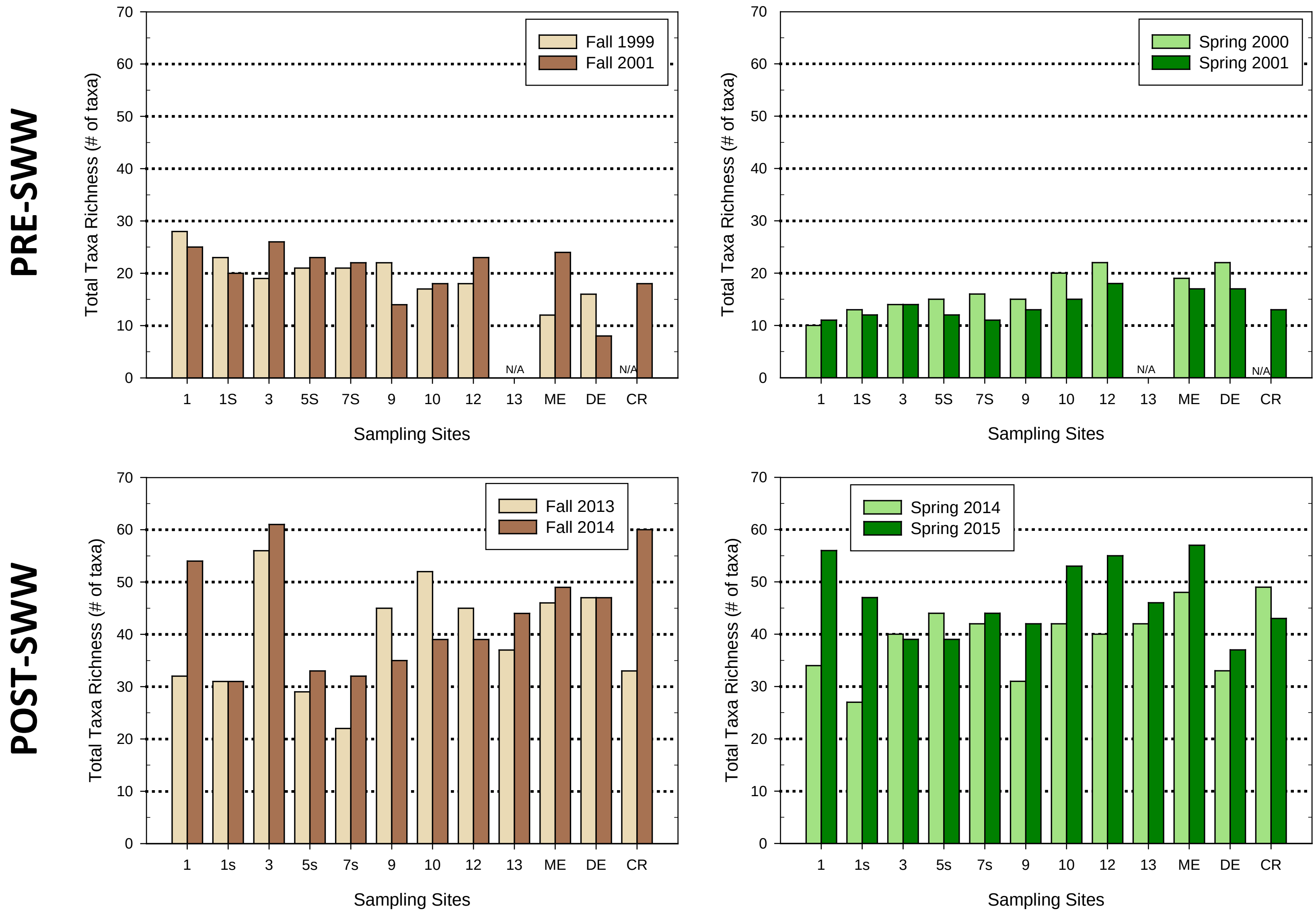
APPENDIX VII – ADDITIONAL PERIPHYTON RESULT FIGURES



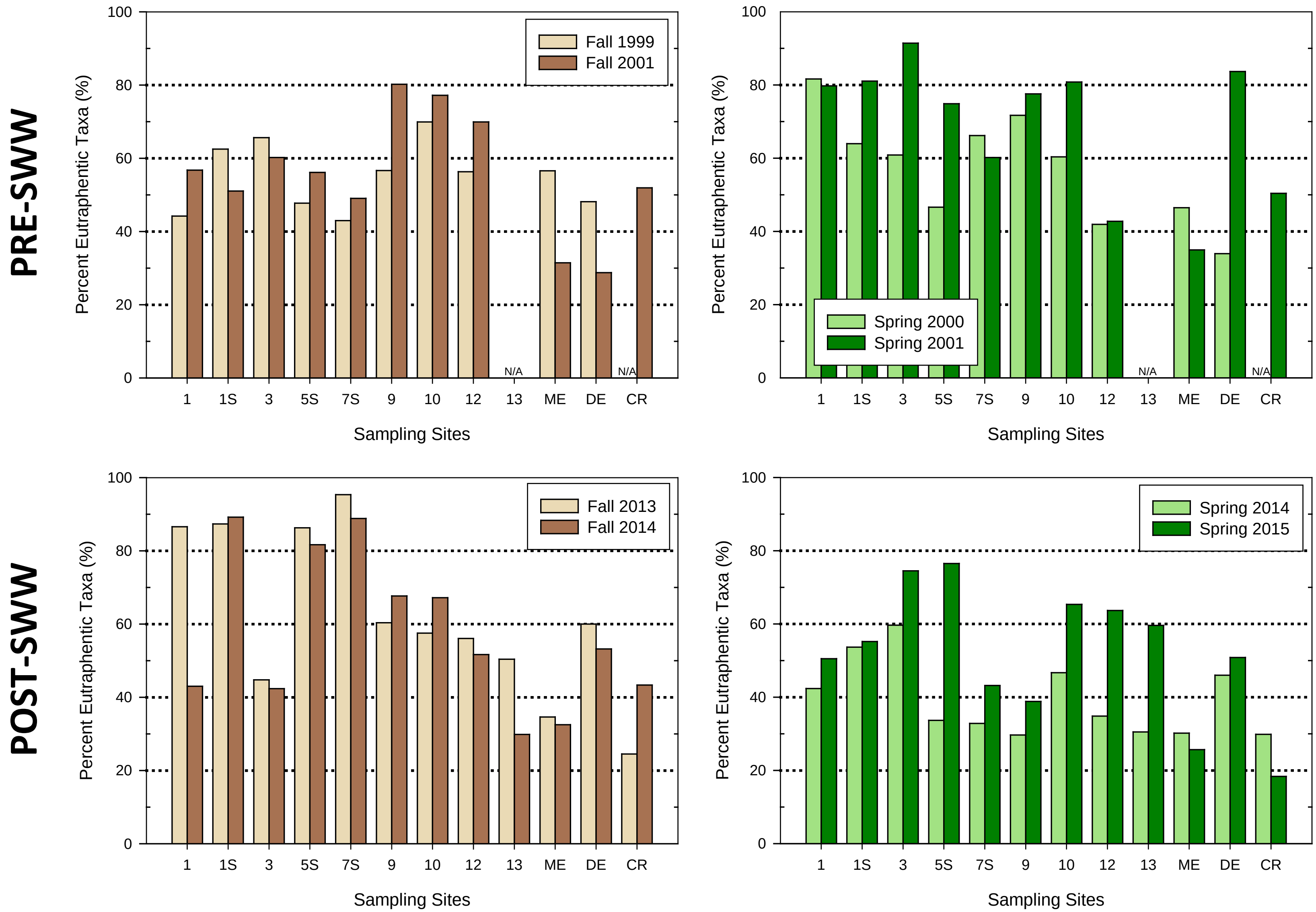
Appendix VII Figure 1. **Estimates of total periphyton density (numbers/cm^2) from composite periphyton samples collected in the lower Deschutes River downstream from the re-regulation dam and three reference sites for both baseline (Pre-SWW) and current (Post-SWW) studies.**



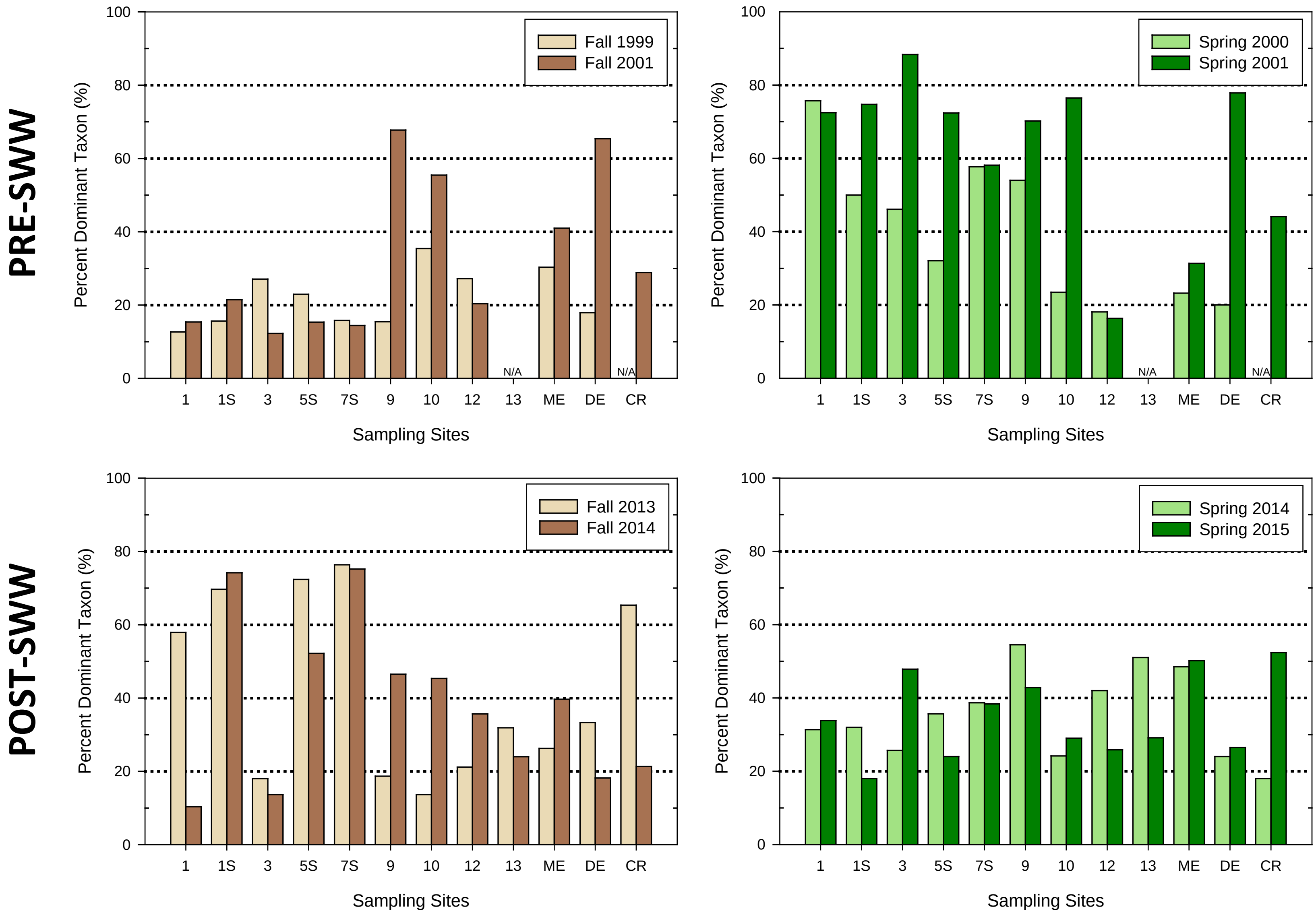
Appendix VII Figure 2. Estimates of total periphyton biovolumes (µm^3/cm^2) from composite periphyton samples collected in the lower Deschutes River downstream from the re-regulation dam and three reference sites for both baseline (Pre-SWW) and current (Post-SWW) studies.



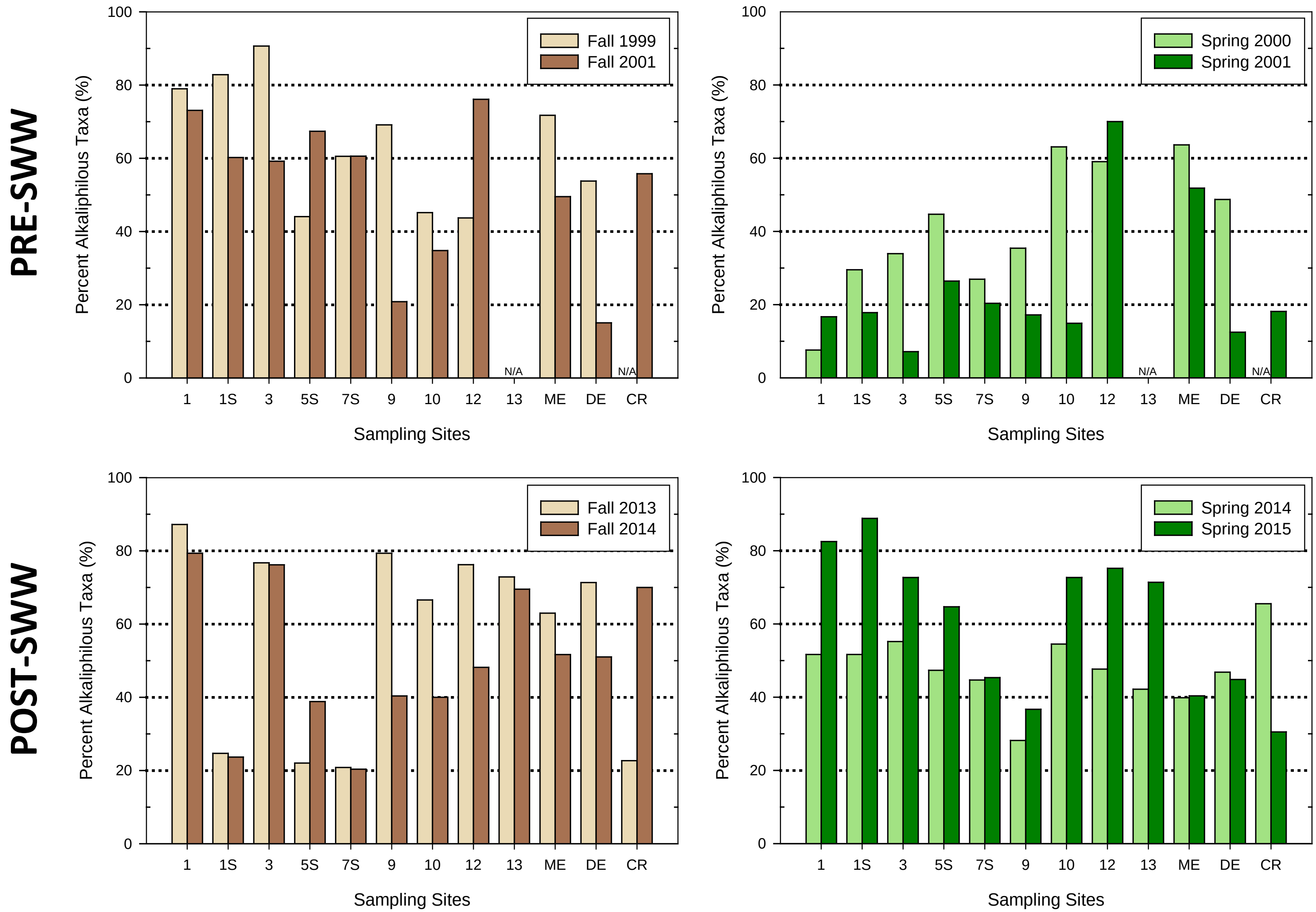
Appendix VII Figure 3. Estimates of total taxa richness from composite periphyton samples collected in the lower Deschutes River downstream from the re-regulation dam and three reference sites for both baseline (Pre-SWW) and current (Post-SWW) studies.



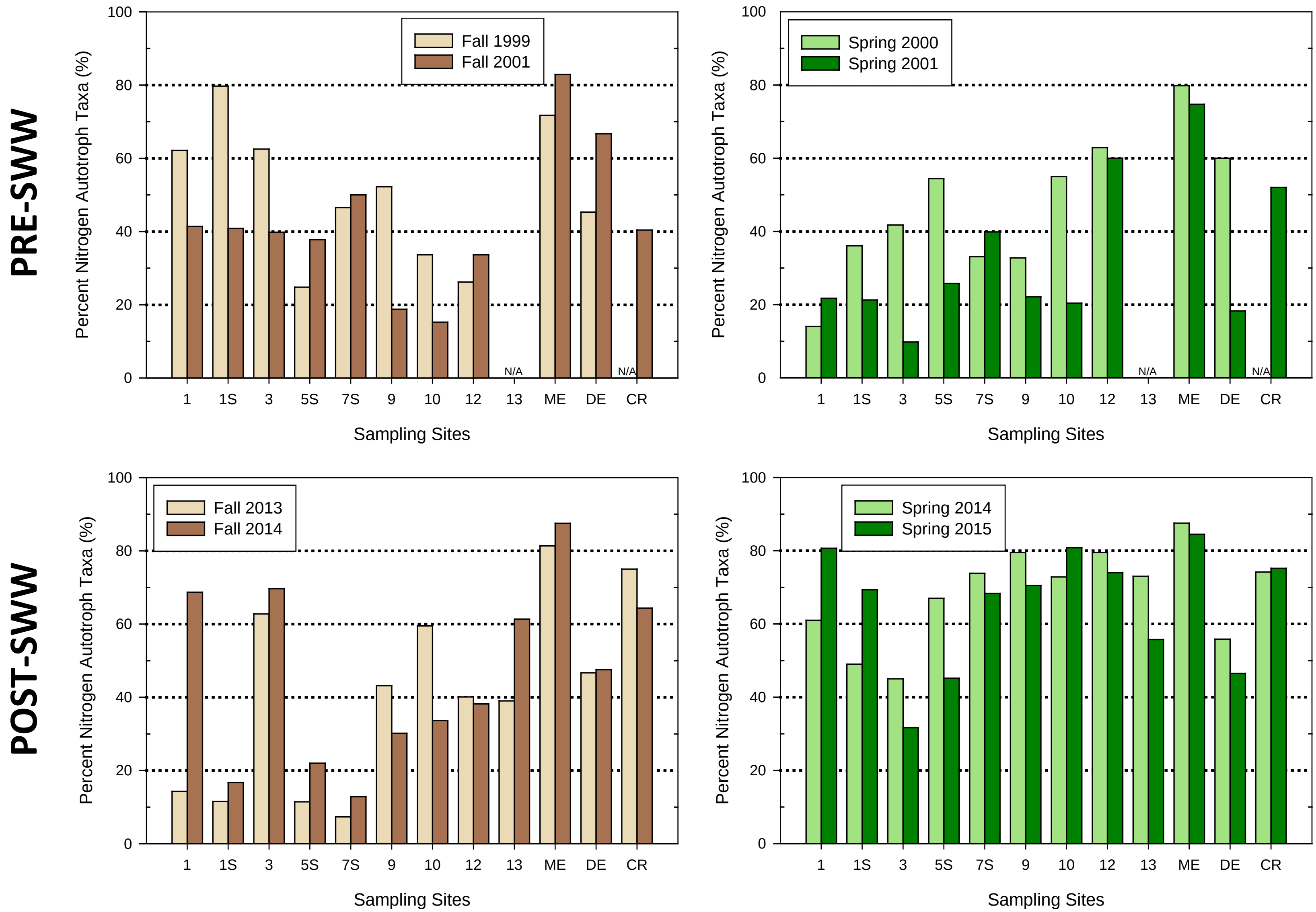
Appendix VII Figure 4. Percent relative abundances of diatom taxa classified as "eutraphentic" in composite periphyton samples collected from sites in the lower Deschutes River downstream from the re-regulation dam and three reference sites for both baseline (Pre-SWW) and current (Post-SWW) studies.



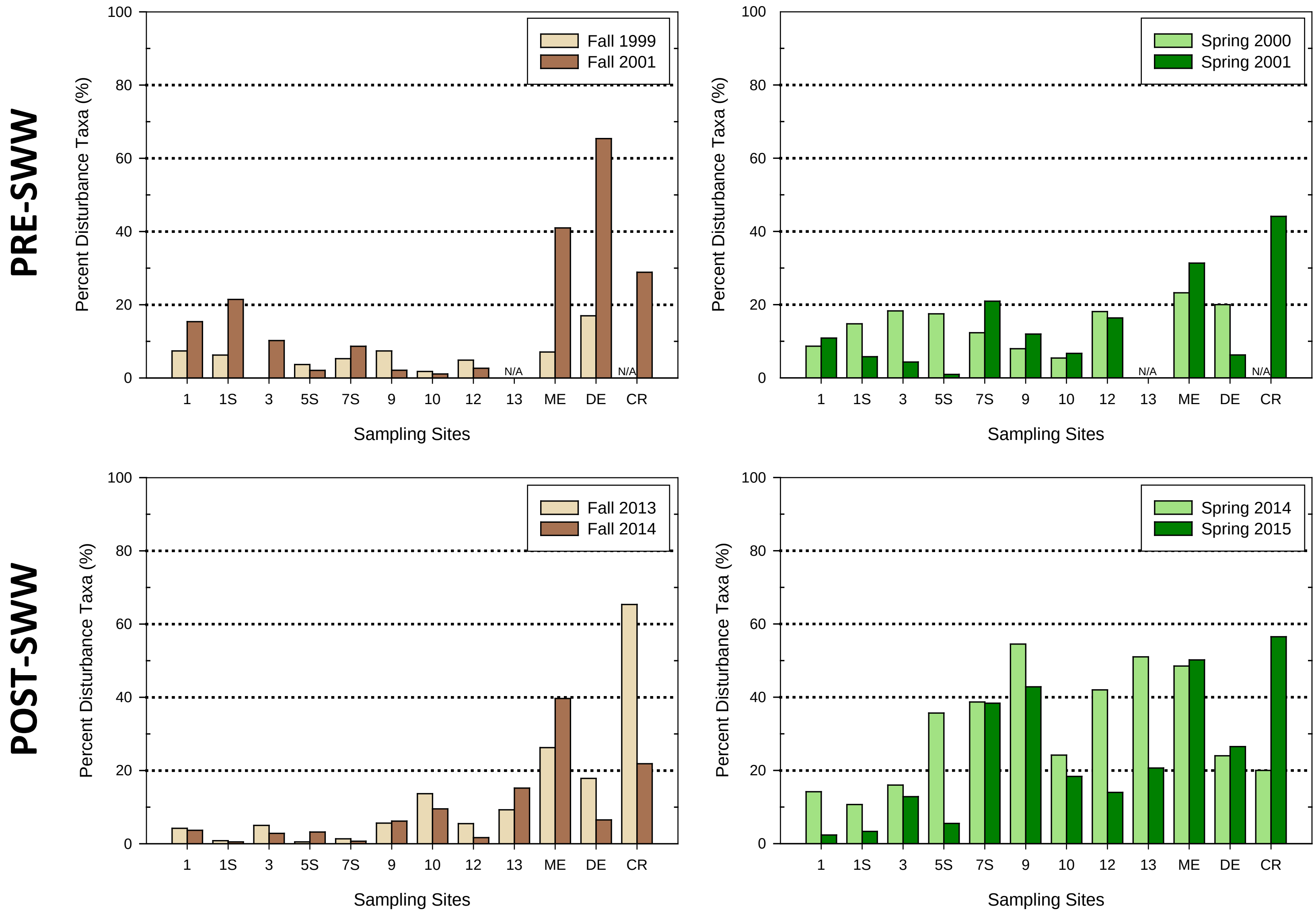
Appendix VII Figure 5. **Percent relative abundances of single most abundant (dominant) diatom taxon in composite periphyton samples collected from sites in the lower Deschutes River downstream from the re-regulation dam and three reference sites for both baseline (Pre-SWW) and current (Post-SWW) studies.**



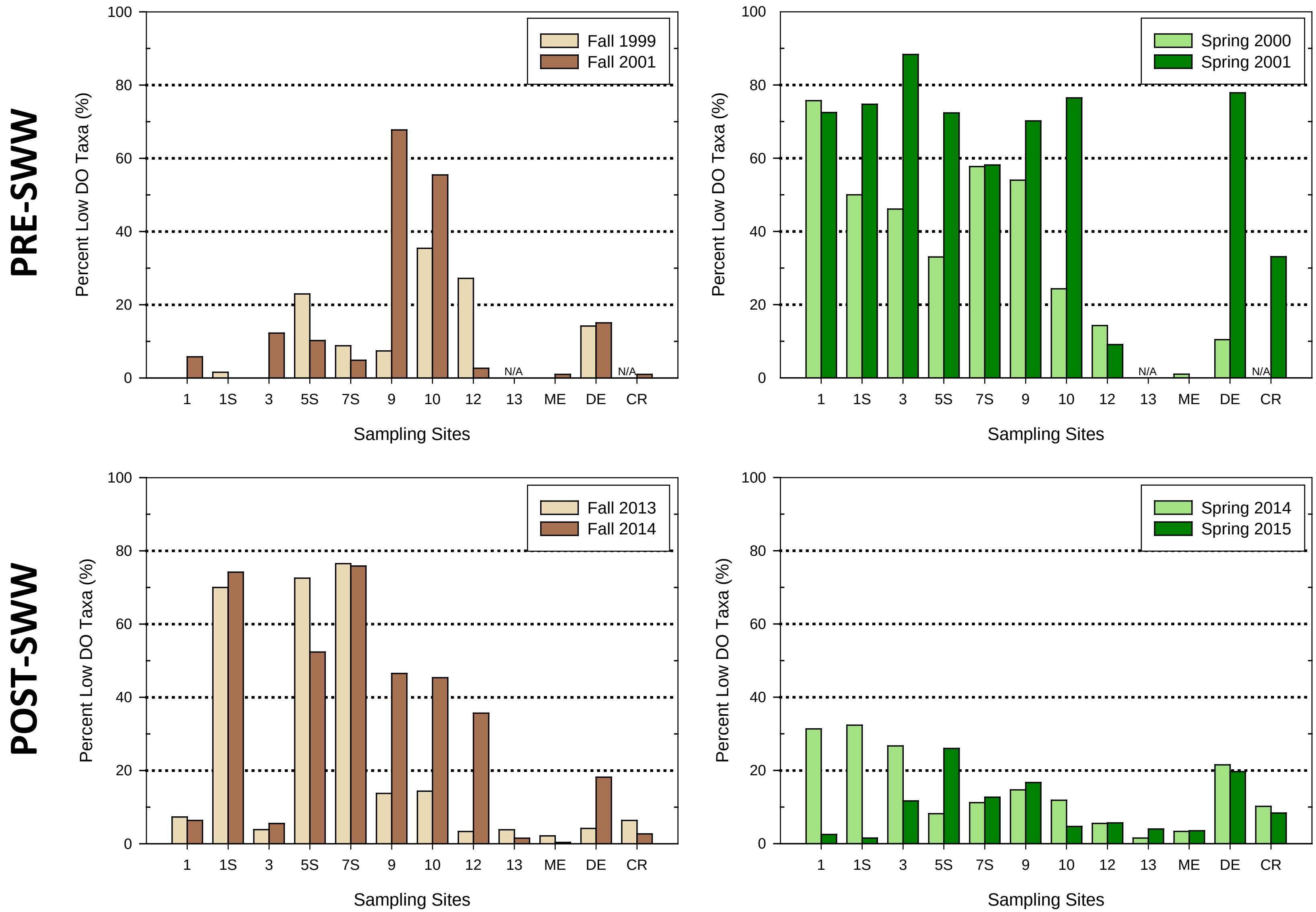
Appendix VII Figure 6. Percent relative abundances of alkalibiontic and alkaliphilous diatom taxa in composite periphyton samples collected from sites in the lower Deschutes River downstream from the re-regulation dam and three reference sites for both baseline (Pre-SWW) and current (Post-SWW) studies.



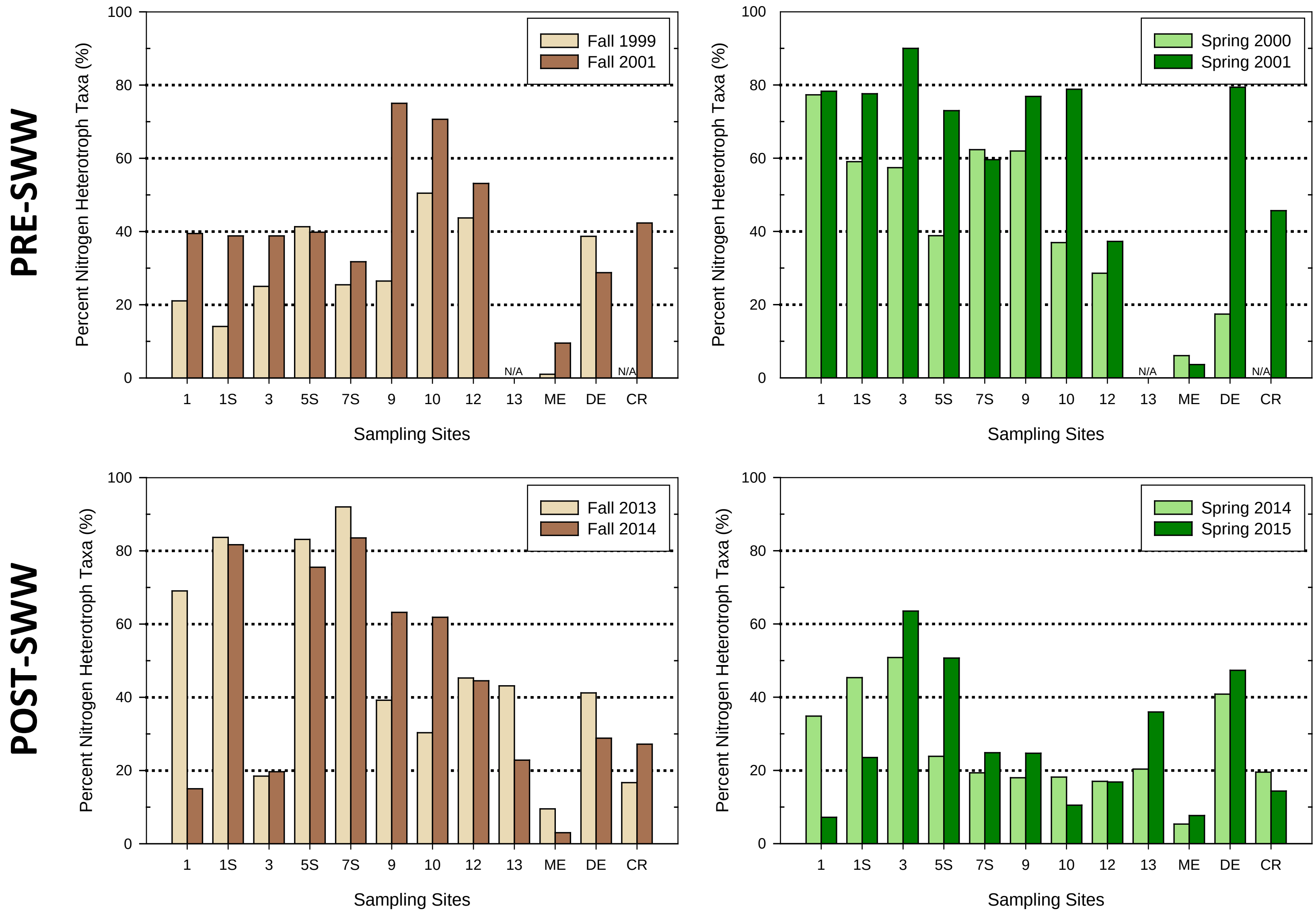
Appendix VII Figure 7. Percent relative abundances of diatom taxa classified as "nitrogen autotrophs" in composite periphyton samples collected from sites in the lower Deschutes River downstream from the re-regulation dam and three reference sites for both baseline (Pre-SWW) and current (Post-SWW) studies.



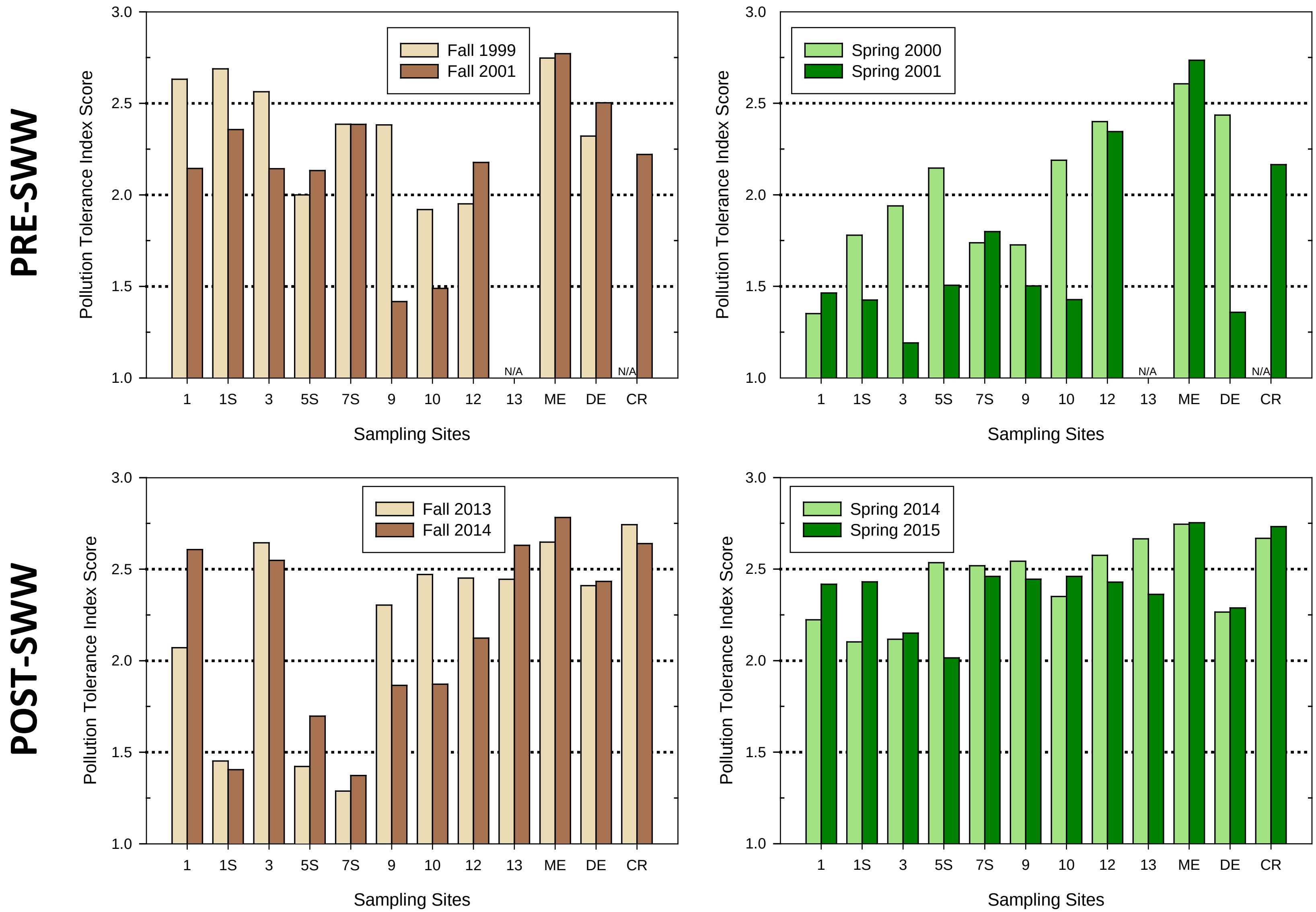
Appendix VII Figure 8. **Percent relative abundances of diatom disturbance taxa *Achnanthidium minutissimum* in composite periphyton samples collected from sites in the lower Deschutes River downstream from the re-regulation dam and three reference sites for both baseline (Pre-SWW) and current (Post-SWW) studies.**



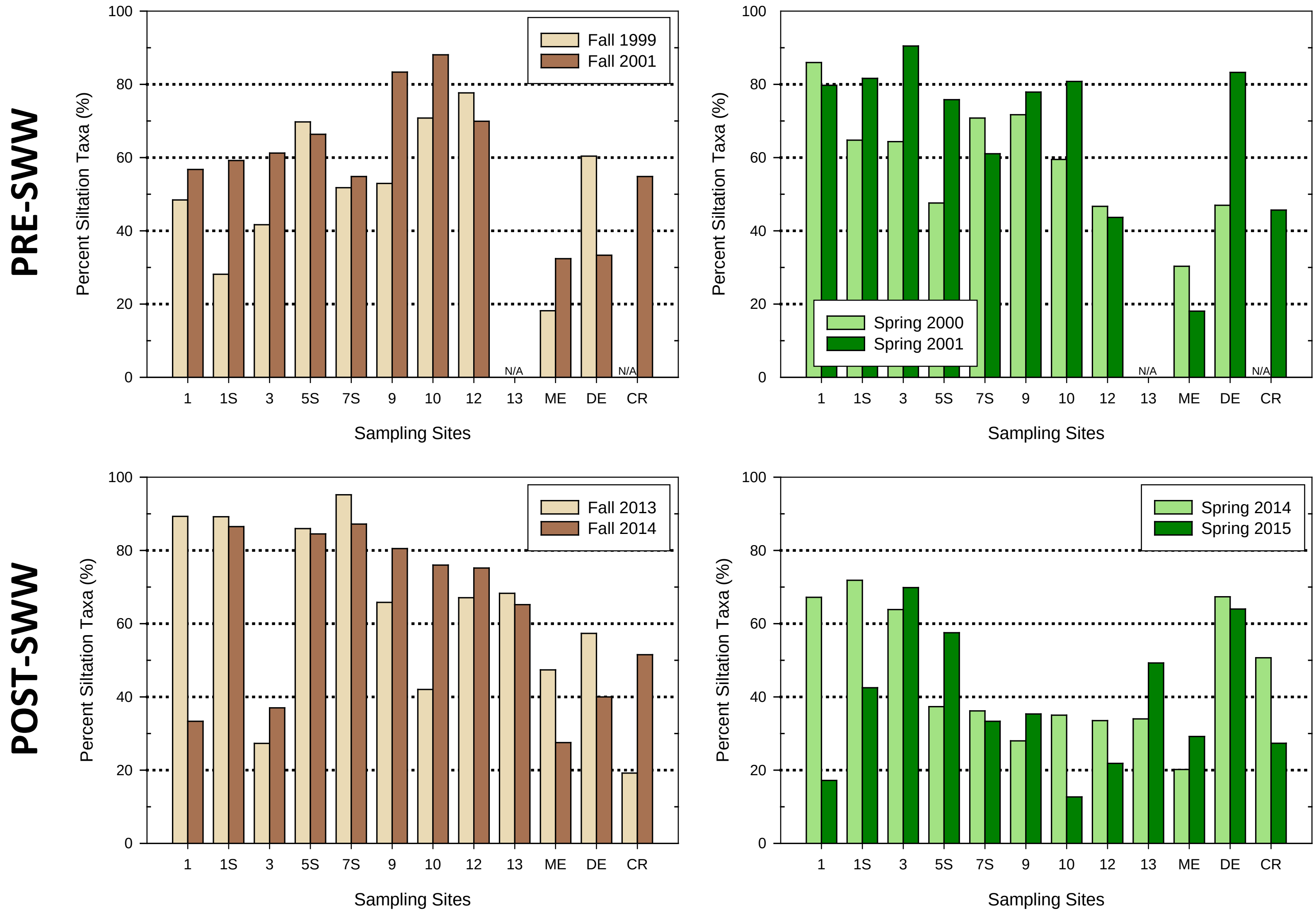
Appendix VII Figure 9. **Percent relative abundance of low and very low oxygen demand diatom taxa in composite periphyton samples collected from sites in the lower Deschutes River downstream from the re-regulation dam and three reference sites for both baseline (Pre-SWW) and current (Post-SWW) studies.**



Appendix VII Figure 10. **Percent relative abundance of nitrogen heterotroph diatom taxa in composite periphyton samples collected from sites in the lower Deschutes River downstream from the re-regulation dam and three reference sites for both baseline (Pre-SWW) and current (Post-SWW) studies.**



Appendix VII Figure 11. **Pollution tolerance index (PTI) scores for diatom taxa in composite periphyton samples collected from sites in the lower Deschutes River downstream from the re-regulation dam and three reference sites for both baseline (Pre-SWW) and current (Post-SWW) studies. Scores range from 1 (most tolerant of pollution) to 3 (sensitive to pollution).**



Appendix VII Figure 12. Percent relative abundance of diatom taxa indicative of siltation in composite periphyton samples collected from sites in the lower Deschutes River downstream from the re-regulation dam and three reference sites for both baseline (Pre-SWW) and current (Post-SWW) studies.