Clackamas Watershed Assessment
Summer 2011
Student Watershed Research Project
Portland State University

Clackamas River Basin Council

Abstract

The purpose of the Portland State University (PSU) Clackamas Watershed Assessment was to investigate samples from various streams of the Clackamas watershed in order to answer questions about water quality. The ongoing investigation, that is in its fourth year of data collection, was comprised of a series of tests to examine the physical and chemical properties of the watershed. In addition, macroinvertebrate analysis was conducted to provide further insight into stream health.

The water quality tests for each sub-basin produced a variety of results. Eagle Creek featured generally healthy waters. Deep Creek had acceptable conditions in general, but macroinvertebrate data revealed less diversity. Some Rock Creek sites showed high levels of ammonia and turbidity. Richardson Creek showed continued high ammonia levels.

Recommendations to maintain and improve water quality include 1) increased monitoring, 2) removal of invasive species, 3) keeping debris and toxins away from water ways, and 4) controlling the level of chemical use.

Introduction

The Clackamas watershed provides numerous invaluable benefits to our community. Its' waters are used for irrigating crops, recreation, travel, and drinking. The Clackamas River provides drinking water for almost 400,000 individuals. The salmon and other edible fish which reside there are consumed for food. Its' landscapes and vegetation are a source of natural beauty. For all of these reasons and more, the effects of human activities on watershed health should be carefully studied to ensure the watershed can continue to provide these benefits for future generations.

While a variety of factors can be measured when examining the health of a watershed, one factor of particular significance is the quality of the stream water. Stream water quality affects not only the ability of aquatic life to thrive, but also the ability of communities to use the water for their needs. Water quality can be altered by many human activities, including industry processes, pesticide use, fertilizer use, runoff from urban lands, and untreated wastewater. When too many of these pollutants enter the stream, the water quality becomes poor, and the many beneficial uses of the watershed are put at risk.

Water quality is analyzed by the chemical and physical properties of the water as well as by the presence or absence of certain types of aquatic life. The data collected is compared to established standards for safe levels, and is also used to establish trends in water quality over time. Equipped with good water quality data, communities served by the

Clackamas watershed can have a greater awareness of the ways that human activities — particularly urban development — impact the health of streams.

As part of a course in water quality monitoring during the summer 2011 academic term, a group of students at PSU collected water quality data on various streams in the Clackamas watershed. The students examined numerous parameters, including stream temperature , turbidity, pH, dissolved oxygen, phosphorus, nitrate, and ammonia. All of these factors greatly affect water quality. Furthermore, macroinvertebrate organisms present in the stream were studied to further analyze stream health.

The Xerces Society provided the students the opportunity to assist in a fresh water mussel survey of the Clackamas River basin. Not only do these mussels provide services to a freshwater ecosystem, they also provide information on the conditions within a stream where they may be present. Assuming a mussel lives a hundred years and could filter approximately 18 gallons of water a day, it could filter 657,000 gallons of water in its' lifetime.

Parameters Tested & Methodology

Temperature

Temperature significantly affects the physical and chemical properties of a stream, as well as the health of aquatic life. Aquatic organisms have narrow temperature ranges in which they thrive, and will become stressed and die when outside of those ranges for too long. As water temperatures rise, the level of dissolved oxygen in the water decreases, and the growth rate of bacteria and algae increases. Water temperature can be increased by 1) a loss of shading in the riparian zone; 2) release of standing water into the stream; or 3) releasing municipal or industrial wastewater into the stream.

Temperatures of the various testing sites were collected using a non-mercury thermometer on a Celsius scale. Three trials were performed; for each trial, the bulb of the thermometer was placed a few inches below flowing water for at least one minute. In addition, air temperature was recorded several feet above surface water and out of direct sunlight.

Temperature graphing uses the 17.8°C surface water temperature as the upper limit during non-spawning seasons.

Turbidity

Turbidity is a measure of how particles suspended in water affect water clarity. It is an important indicator of suspended sediment and erosion levels. Typically it will increase sharply during and after a rainfall, which causes sediment to be carried into the creek. Elevated turbidity will also raise water temperature, lower dissolved oxygen, prevent light from reaching aquatic plants, which reduces their ability to photosynthesize, and harm fish gills and eggs.

Turbidity can be caused by soil erosion, suspended algae, human activities, wind, waves, and other kinds of physical disturbances. Turbidity was measured with a Hach 2100P Turbidimeter, which measures light scattered at a right angle.

Dissolved oxygen (DO)

Most aquatic life requires DO — the oxygen gas dissolved in water — for respiration. Generally, higher DO levels are always favorable. High DO levels depend on low water temperatures, low altitudes, and low levels of salinity. As any of these factors increase, the level of DO decreases. A decrease in DO can also be caused by decomposition of organic matter, microorganism respiration, and high levels of ammonia. Water turbulence and photosynthesis by aquatic plants can increase DO levels. Dissolved oxygen was measured using the Winkler titration method.

pH

pH is a measure of acidity/alkalinity of the water. Aquatic life generally requires pH levels between 6.5 and 8.5. Outside of those limits, aquatic life suffers, especially their growth and reproductive cycles. pH can be raised by algal blooms or basic compounds released by industrial processes. pH can be lowered by certain byproducts of combustion engines, acidic compounds released by industrial processes, oxidation of sulfide-containing sediments, and decomposition of organic matter. pH was measured three separate times using a pH color comparison wheel.

Phosphorus

Phosphorus is a naturally-occurring compound which serves important biological functions. However, excessive phosphorus levels in the water can cause rapid algal growth rates. When the algae die, their decomposition consumes dissolved oxygen and may produce toxins. Sources of phosphorus include certain soils, manure, runoff from agricultural or urban lands, and improperly treated wastewater.

Nitrogen

Measured as Ammonia and Nitrate

Nitrogen, another essential component of living things, can be found in many different forms on land, in water, and in the atmosphere. The two forms which plants and algae can use are ammonia (NH_3) and nitrate (NO_3); these compounds are present in stream water. However, when levels of ammonia become too high, the stream becomes deprived of dissolved oxygen through a process called nitrification. In addition, above certain concentrations, both ammonia and nitrate are toxic.

Macroinvertebrates

Macroinvertebrate data was gathered in four sub-basins: Clear Creek, Deep Creek, Eagle Creek and Rock Creek. The data was gathered to provide an additional method of analyzing overall stream health in conjunction with non-biotic snapshot sampling methods. Macroinvertebrates are a supplemental indicator of seasonal stream health. The presence or absence of sensitive species can show if any drastic changes have occurred in the past. Each species has certain tolerance levels to various parameters. Future monitoring and data acquisition within each basin will help us to document any biotic changes if they occur.

Macroinvertebrate samples were collected using a "three-Kick" technique in a single area slightly downstream from the chemical sampling area. These macroinvertebrates were collected in a standard 500-micron mesh D-net held slightly downstream from the kicking area. Agitation was continued for a period of 90 seconds; large stones were rubbed by hand to improve sample collection.

The collected aggregate was then placed in an 18 cell -sampling grid and 5 cells were randomly selected, These cells were decanted into examination trays where they were examined to identify and count each live specimen. After tallies were completed, the macroinvertebrates were returned to their collection location in an effort to minimize impact on the stream.

Using macroinvertebrate tally data, water quality was rated according to the Pollution-Sensitive and Tolerant-Order Index and OWEB (Oregon Watershed Enhancement Board) Level 2 analysis.

Results

Consult the tables and graphs below for data collected at each creek. Graphs are classified by sub-basin; each graph contains data for all sites tested at that sub-basin. In addition to the current year's data, data for the previous three years is included when available. Any bars which are missing in the bar graphs indicate a lack of data for the years or sites where those bars would be expected. In the Ammonia results where the site code has an asterisk indicates the concentration (< 0.01mg/l), is below the detection limit for the method used The bold horizontal lines found in many of the bar graphs represent healthy standards for the parameters tested.

Table 1. Water Quality Standards

Parameter	Surface Water	Spawning	Drinking Water
ph	6.5 - 8.5		6.5 - 8.5
Temperature (°C)	</= 17.8	</= 12.8	
DO (mg/L)	>/= 6.0	>/= 11.0	
DO (% sat)	>/= 90%	>/= 95%	
Turbidity (NTU)	< 5		
Phosphorus (mg/L)	< 0.1		
Nitrate (mg/L)	< 10		< 10

Table 2. Site Legend

Sub-Basin	Site Code	Stream Name	Location
Clear Creek	CLE000	Clear Creek	Carver Park
	CLE019	Clear Creek	Metzler Park
	GCK001	Goose Creek	Barton Park
	GCK002	Goose Creek	Eagle Creek
	CLA024	Clackamas River	Barton Park Boat Ramp
Deep Creek	NFD001	N. Fork Deep Creek	Boring
	NFD002	N. Fork Deep Creek	Boring
	NFD003	N. Fork Deep Creek	Boring
	NFD004	N. Fork Deep Creek	Boring
	DEP001	Deep Creek	Damascus
	DEP002	Deep Creek	Damascus
Eagle Creek	ECK001	Eagle Creek	Bonnie Lure State Park
	EGL001	Eagle Creek	Estacada
	EGL002	Eagle Creek	Estacada
	EGL005	Eagle Creek	Estacada
Richarson Creek	RCH000	Richardson Creek	Damascus
	RCH001	Richardson Creek	Damascus
	RCH002	Richardson Creek	Damascus
	RCH003	Richardson Creek	Damascus
	RCH004	Richardson Creek	Damascus
Rock Creek	RCK000	Rock Creek	Damascus
	RCK001	Rock Creek	Damascus
	RCK002	Rock Creek	Damascus
	RCK003	Rock Creek	Damascus
	SEB002	Sieben Creek	Hwy 212/224

Eagle Creek Sub-Basin

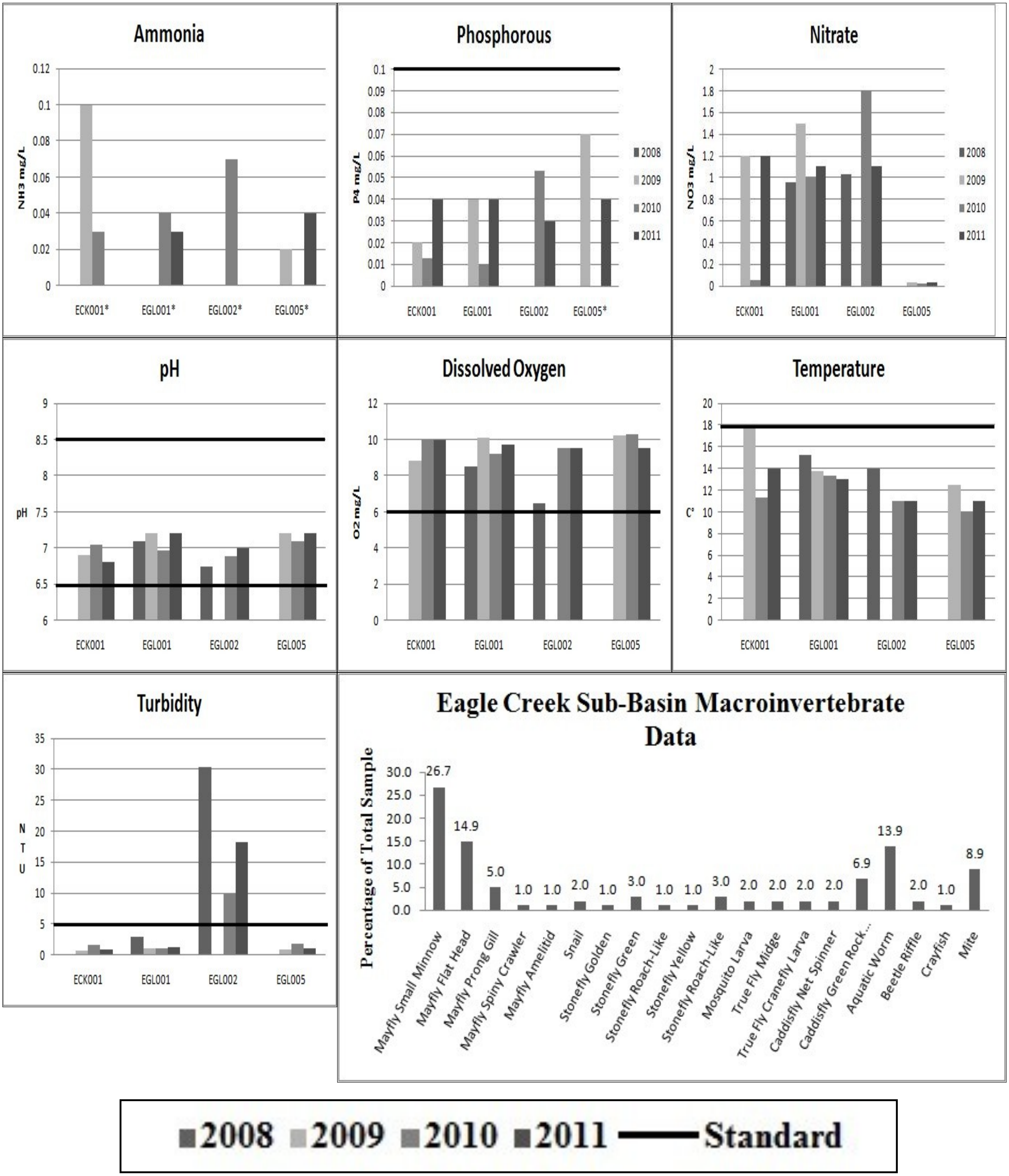

Figure 1. Eagle Creek Sub-Basin Data

Clear Creek, Goose Creek, and Clackamas Mainstem Sub-Basin

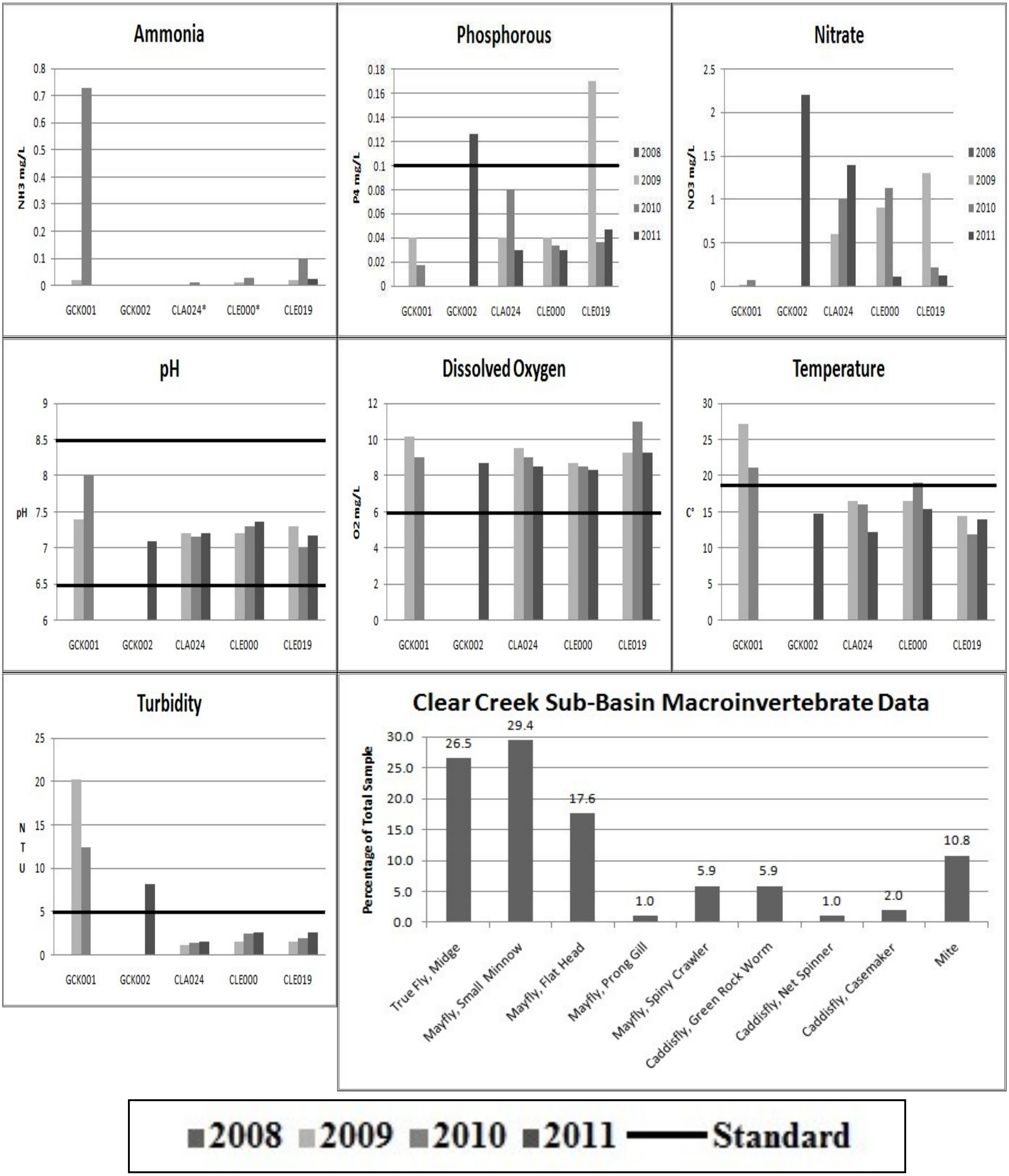

Figure 2. Clear Creek Sub-Basin Data

Deep Creek Sub-Basin

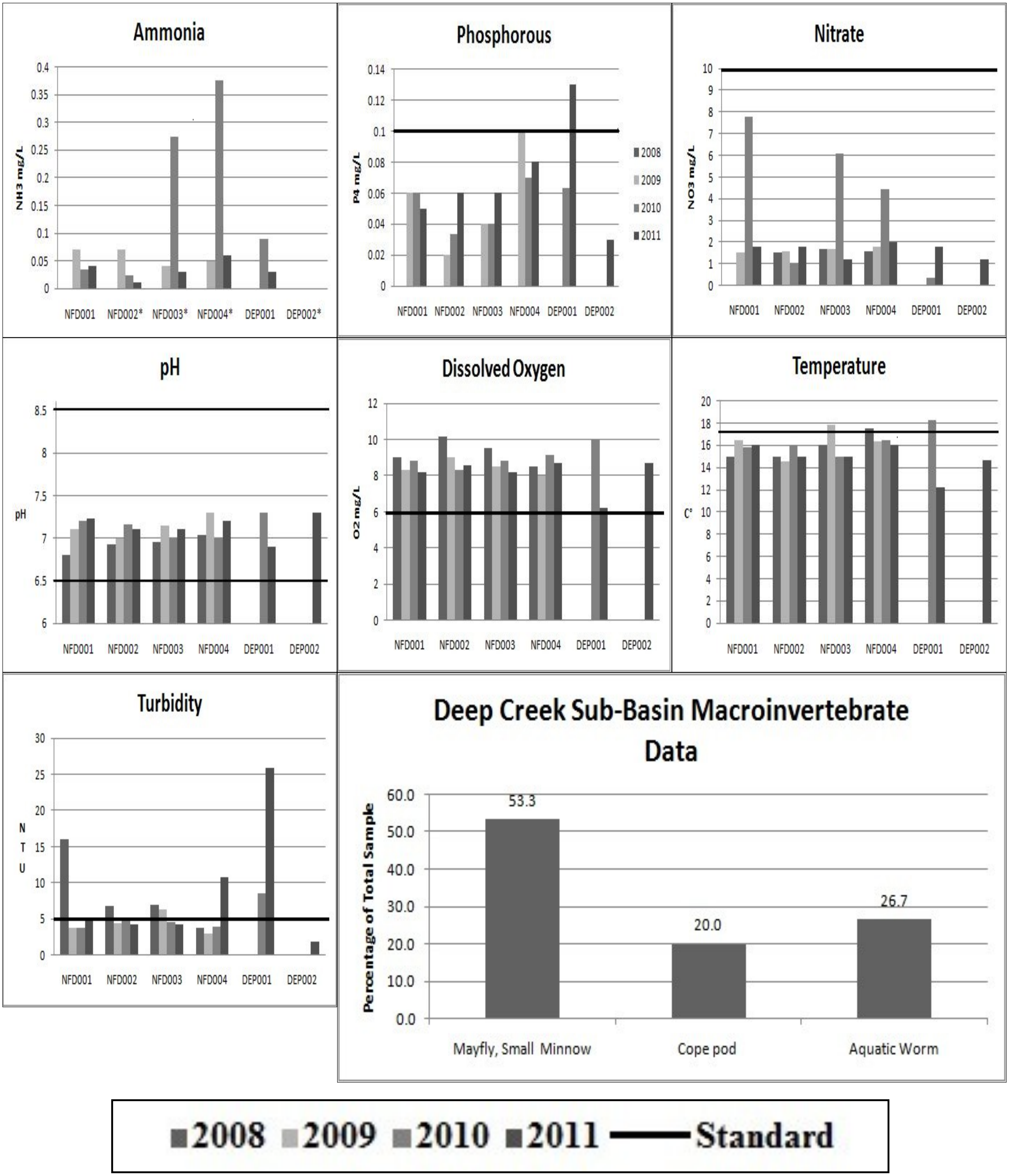

Figure 3. Deep Creek Sub-Basin Data

__Rock Creek Sub-Basin__

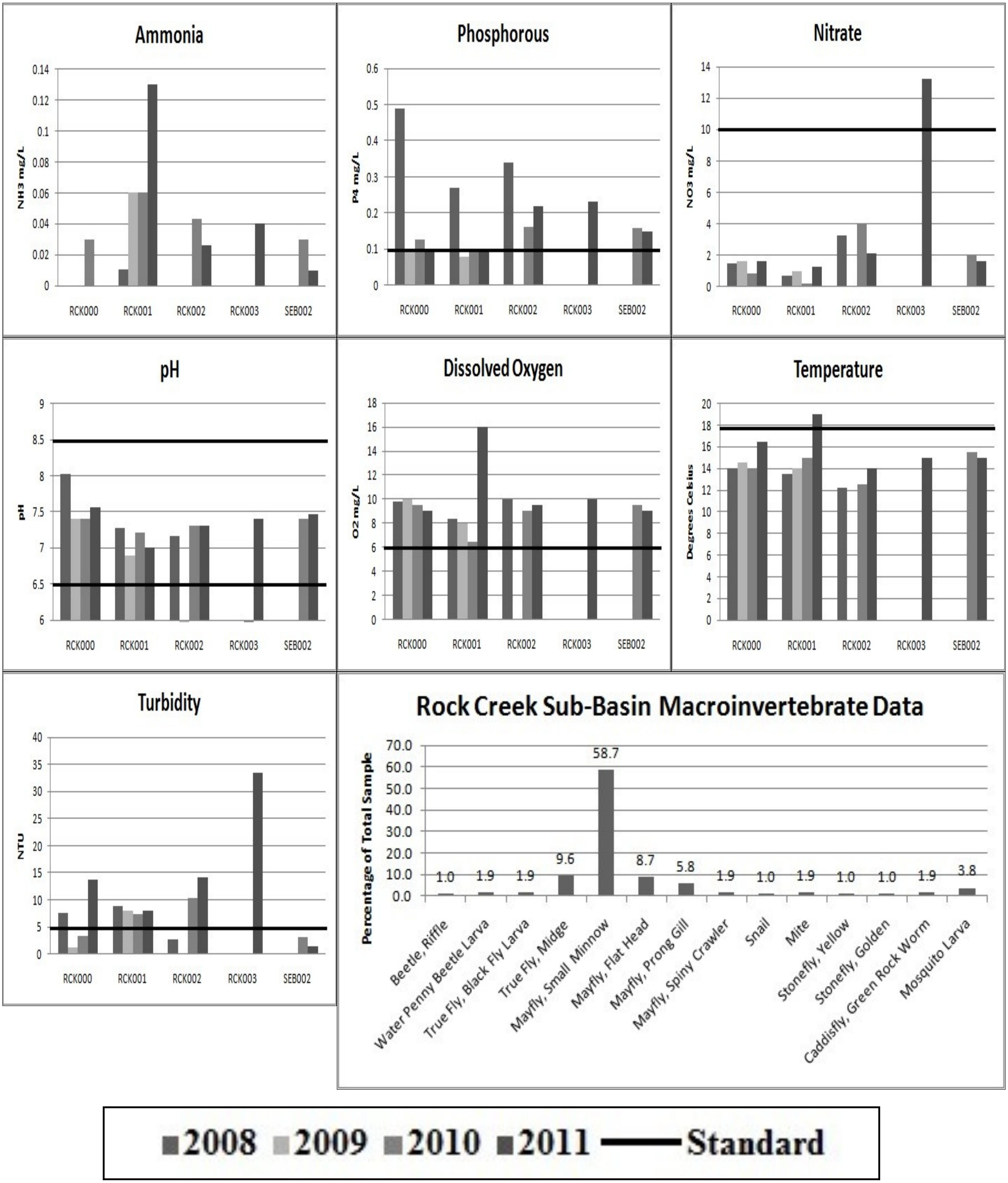

Figure 4. Rock Creek Sub-Basin Data

Richardson Creek Sub-Basin

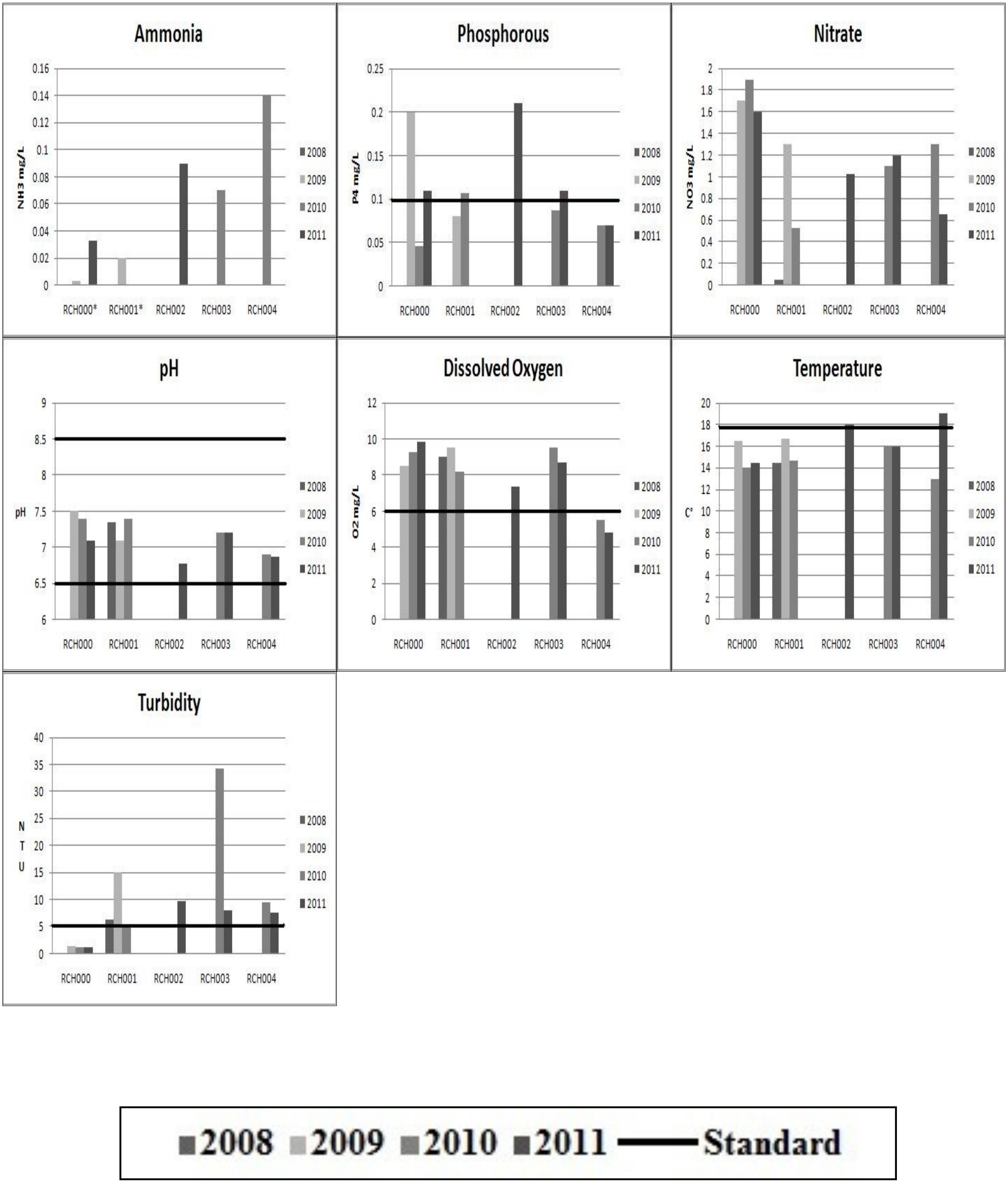

Figure 5. Richardson Creek Sub-Basin Data

Discussion

General

2009 - 2011 data were each collected over the course of a few weeks starting in late June. By comparison, all data for 2008 were collected on a single day in late July. Due to these differences in time and duration of data collection, it is possible that changes observed between 2008 and 2011 may not reflect true changes in the parameters tested.

It is also speculated that the relatively cool temperatures indicated by this year's data are the result of an unseasonably wet and cool month of June. Higher rainfall increases the flow rate of streams as well as snow pack at higher elevations, both which tend to cause water temperatures to drop.

The methods utilized by the macroinvertebrate team provided limited samples that were never in excess of 400 specimens. This is in contrast to the 500+ specimen threshold mandated by the Oregon DEQ. However, the analysis metrics utilized — the Level 1 Sensitive & Tolerant Organisms and the Level 2 OWEB — both are considered stable enough to provide significant, accurate and precise analyses in all six instances.

The macroinvertebrate sample results from each basin showed some correlation between other parameters we tested. The Eagle Creek Basin was one of our healthier basins, and provides a good contrast to the Deep Creek Basin which appears to have severe impairment. The array of macroinvertebrates found within Eagle Creek is significantly greater than what was found within Deep Creek. The temperature, turbidity and nitrate readings in the Deep Creek Basin were greater than at Eagle Creek and the other macroinvertebrate sites tested. This suggests a correlation between a healthy environment for aquatic macroinvertebrates, and overall stream health with, low water temperature, low turbidity and nitrate level readings.

Eagle Creek

With few exceptions, the sites tested at Eagle Creek had clear waters and an abundance of trees and shrubs. Each of the sites tested for Eagle Creek had significantly varying degrees of shading over the stream channel. Invasive plant species included blackberries, reed canary grass, and buttercups. No litter was found at any sites. Water color varied from clear to green to brown. Weather conditions were generally cloudy to partly sunny.

An assessment of results for Eagle Creek shows generally favorable water quality conditions with few exceptions. Temperature and pH readings at all sites were well within acceptable ranges in 2011.

Phosphorus and nitrate levels at all sites were significantly below the water quality standard's maximum value. Dissolved oxygen levels were above the minimum standard.

The ammonia readings were in an acceptable range at all sites. While three sites had healthy turbidity readings, turbidity at EGL002 was above the upper limit. The high turbidity at EGL002 could be due to low stream level, which made the sample difficult to collect.

Macroinvertebrate data indicated that the Eagle Creek sub-basin is not impaired and supports adequate macroinvertebrate populations.

Clear Creek, Goose Creek, and Clackamas Mainstem

Invasive species include, blackberry, English ivy, giant knotweed, and reed canary grass. Caddisflies have been absent in previous years but were present this year. However, overall macroinvertebrate data analysis suggests stream disturbance exists. Adequate macroinvertebrate populations are not supported by this sub basin.

CLE00 and GCK001 had been above the temperature quality standard in 2010, but readings fell within the standard in 2011. The water temperature at CLA024 had been above the quality standard for salmonid spawning in previous years. Conversely, the temperature at site CLE019 tested higher than in previous years and was found to be above the standard for spawning. This year the temperature reading was within the acceptable limits. Dissolved oxygen measurements were also lower than in previous years and below acceptable spawning standards. A new site in 2011, GCK002 exceeded the standard for turbidity. Phosphorus, nitrate, ammonia and pH level were comparable to previous years at all sites within this sub-basin.

Deep Creek

There were six sites where sampling took place for Deep Creek. DEP002 is a new location this year with data for only 2011. The locations consisted mainly of vegetation (trees, grass and shrubs) and cobble, gravel and mud for stream substrate. The weather was overcast when sampling took place for all locations and there was light rain while sampling at DEP001. There was one live mussel found at NFD003 and dead mussels along the margin of the streams at NFD002 and NFD003. Himalayan blackberry, creeping buttercup, and giant knotweed were the dominant invasive species at most sites. Reed canary grass, English ivy, yellow flag iris, and Herb Robert were also found in the Deep Creek sub basin. Crawdads were also found at NFD001.

All turbidity readings except for DEP002 were above acceptable levels. Readings for DEP001 and NFD004 increased significantly from previous years. DEP001 went from 8.49 in 2010 to 25.9 in 2011 and NFD004 increased from 3.91 in 2010 to 10.7 in 2011. NFD002 and NFD003 had a decrease in turbidity from previous years. Temperatures decreased or stayed the same from previous years. Temperatures were bellow 17.8ºC. There was a significant drop in temperature for DEP001 from 18.3ºC in 2010 to 12.2ºC in 2011. Phosphorus levels were within acceptable levels for all but DEP001. DEP001 had phosphorus levels of .13 mg/L. pH levels were well within standards for all sites. Acceptable levels for phosphorus are bellow 0.1 mg/L and pH should be between 6.5 - 8.5. All sites had DO concentrations at acceptable levels. DEP001 had a decrease in concentration from 10 mg/L in 2010 to 6.2 mg/L in 2011. While all sites had concentrations at acceptable levels, there was a decrease from previous years. There was a decrease in ammonia levels in all sites but NFD001, which had only a slight increase to 0.04 mg/L in 2010 from 0.035 mg/L in 2010. Nitrate levels were well below the acceptable 10 mg/L concentration for all sites. Levels increased for DEP001 from previous year with a reading of 1.8 mg/L in 2011 vs. 0.35 mg/L in 2010. There was a decrease in nitrate concentration at all other sites from previous years.

Macroinvertebrate data was gathered at the Boring Trail Station in Deep Creek sub-basin. This site showed signs of severe impairment with a 2011 OWEB score of 10, and was limited in sensitive species present. There was quite an increase in Ephemeroptera (Small Minnow Mayfly) to 53.3% in 2011 from 13% in 2010. It should be noted that this family of mayfly is more tolerant of pollution. This was a less diverse sample than previously found as there were only three types of aquatic insects present. The Oligochaetae (Worm) sample was also significantly smaller than previous year with a drop from 62% in 2010 to 26.7% in 2011.

Richardson Creek

The sites tested had a range of stream shading, with RCH000 having the fullest shading and RCH002 and RCH004 having very little to no stream shading. The dominant invasive species along the creek was Himalayan Blackberry. Cobble and boulders typified the stream bed substrate at all sites except for RCH004, which was lined with plastic sheeting and boulders. RCH004 also had aerators in the water to provide additional flow during the summer season. Weather conditions ranged from sunny to overcast during sample collections. RCH001 was not accessible, so no stream sample was collected in 2011.

RCH002 and RCH004 both had temperatures above the 17.8 °C threshold in the snapshots taken this year. The other two sites had temperatures safely below the threshold. Except for at RCH000, all the turbidity levels exceeded the standard, which is less than 5 NTU. Except for at RCH004, all the phosphorous levels were above the upper threshold. The turbidity and phosphorous levels in Richardson creek may affect stream health.

The pH readings for Richardson Creek were within safe limits, as were nitrate concentrations. Dissolved oxygen levels met the minimum standard, except for RCH004. RCH004 had 4.8 mg/L dissolved oxygen.

There is no clear standard for ammonia levels. However, the average is about 0.05 mg/L for Willamette valley streams. RCH002 exceeded this average, with a reading of 0.09 mg/L. All other sites were below the average, and most of the sites had readings of <0.01 mg/L.

Rock Creek

Land uses within the Rock Creek sub-basin and at sample sites include commercial, industrial and residential development as well as forested areas. Streamside vegetation was dominated by trees at all sites sampled on Rock Creek and the Sieben Creek site. Himalayan blackberry was the dominant invasive species. Weather was overcast on all sample days.

All Rock Creek sites and the Sieben Creek sites were shallow, heavily shaded with slow flows. RCK000 sample site was also shallow but flows were faster due to the volume of water present in this lower reach and the proximity to the confluence with the Clackamas River. In-stream substrate on both creeks included mud, rock and cobble on which low levels of algae were present. Water color was reported similar to previous years: clear at all sights except RCK001 which was reported as gray/murky. Smells of petroleum-based products and sewer were reported at RCK003 both upstream and downstream from an culverted outfall. Water temperatures increased slightly at all sites on Rock Creek and decreased slightly at Sieben Creek. The water temperature at RCK001 exceeded the surface water standard.

Turbidity increased at all Rock Creek sites and decreased at Sieben Creek. RCK000 approximately tripled from last year and RCK003 was more than double the average for the rest of the Rock Creek sites. All Rock Creek water samples exceeded the turbidity standard for surface water. All pH readings taken within the Rock Creek sub-basin were comparable to previous years and within the surface water standard. Dissolved oxygen measurements were comparable with previous year and did not drop below the minimum threshold standard for surface water. Dissolved oxygen levels at RCK001 were more than twice as high as last year.

All sites had nitrate levels well below the upper threshold for surface water standards except RCK003 which was 3mg/L above the standard. Phosphorous level increased at RCK002, and RCK002, RCK003 and SEB002 exceed surface water standards. There are no clear standards for ammonia level. However, the average ammonia levels for Willamette Valley streams is approximately 0.05mg/L. RCK001 was well above this average as ammonia levels were approximately 0.13mg/L.

Macroinvertebrate analysis from RCK000 of the Rock Creek sub-basin indicates the overall diversity of aquatic insects has approximately doubled to include pollution sensitive species such as the Golden Stonefly (*Plecoptera perlidae*) and the Yellow Stonefly (*Plectoera perlodidae*). Overall change from last year is the presence of all EPT species: stonefly, mayfly and caddisfly. The OWEB Level 2 Assessment score increased from 14 to 16.

Recommendations

To maintain or improve water quality throughout the Clackamas watershed, some general recommendations can be made:

1) Keep septic tanks well-maintained to prevent untreated waste from entering waterways.

2) Remove invasive plant species and increase native vegetation; both of these practices will provide better shading and cooling to streams.

3) Keep all yard debris, garbage, and chemicals away from streams.

4) Reduce use of fertilizers and pesticides whenever possible; use compost or mulch as an alternative.

Recommended areas of further study include:

1) Investigate high ammonia concentration at CLE019 to determine whether it is naturally occurring or influenced by something upstream or in the groundwater.

2) Increase the frequency of monitoring to capture more data and present a more comprehensive picture of water quality throughout the year.

Special Thanks to Our Partners in the Clackamas River Watershed

Clackamas River Basin Council

Water Environmental Services

Clackamas County

Clackamas River Water District

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