YUROK TRIBE

Klamath River Estuary Wetlands Bioassessment Report: 2012-2013

Yurok Tribe Environmental Program
PO Box 1027, Klamath, California 95548

Prepared by:
Bill Patterson, Environmental Protection Specialist-Wetlands,
Yurok Tribe Environmental Program

I. Introduction

This report summarizes the methods and results of benthic macroinvertebrate (BMI) sampling and water quality monitoring conducted on wetlands of the Klamath River Estuary (KRE) within the Yurok Indian Reservation (YIR) boundaries for water year 2012 (WY12) and 2013 (WY13). The Yurok Tribe Environmental Program (YTEP) collected BMI samples at five wetlands sites during May 2012, February 2013, and August 2013 in an effort to assess the physical habitat and biological conditions during the sampling period. Water quality monitoring was conducted between the months February 2012 and August 2013. This effort was part of an endeavor to build multiple layers of scientific information documenting wetland condition over time and space as part of YTEP's long term monitoring goals. This is the first report in which YTEP has collected taxonomic information on BMI community assemblages specifically in wetlands. However, YTEP has collected similar data in freshwater tributaries (streams) within the Lower Klamath River since 2003. This summary is part of YTEP's comprehensive program of monitoring and assessment of the chemical, physical, and biological integrity of the Klamath River and its associated aquatic habitats in a scientific and defensible manner.

II. Background

The Klamath River Watershed

The Klamath River system drains much of northwestern California and south-central Oregon (Figure 1). Thus, even activities taking place on land hundreds miles off the YIR can affect water conditions within YIR boundaries. For example, upriver hydroelectric and diversion projects have altered natural flow conditions for decades. The majority of water flowing through the YIR is derived from scheduled releases of impounded water from the Upper Klamath Basin that is often of poor quality with regards to human needs as well as the needs of fish and wildlife.

Some historically perennial streams now have ephemeral lower reaches and seasonal fish migration blockages which may be influenced by inadequate dam releases from water diversion projects along the Klamath and Trinity Rivers. The releases contribute to lower main stem levels and excessive sedimentation which in turn causes subsurface flow and aggraded deltas. Additionally, the lower slough areas of some of the Lower Klamath tributaries that enter the estuary experience eutrophic conditions during periods of low flow. These can create water quality barriers to fish migration when dissolved oxygen levels are inadequate for migrating fish. The Klamath River is on California State Water Resource Control Board's (SWRCB) 303(d) List as impaired for temperature, dissolved oxygen, and nutrients and portions of the Klamath River were recently listed as impaired for microcystin and sedimentation.

The basin's fish habitat has also been greatly diminished in area and quality during the past century by accelerated sedimentation from mining, timber harvest practices, and road construction, as stated by Congress in the Klamath River Act of 1986. Management of private lands in the basin (including fee land within YIR boundaries) has been for the last 100 years, and continues to be, dominated by timber harvest.

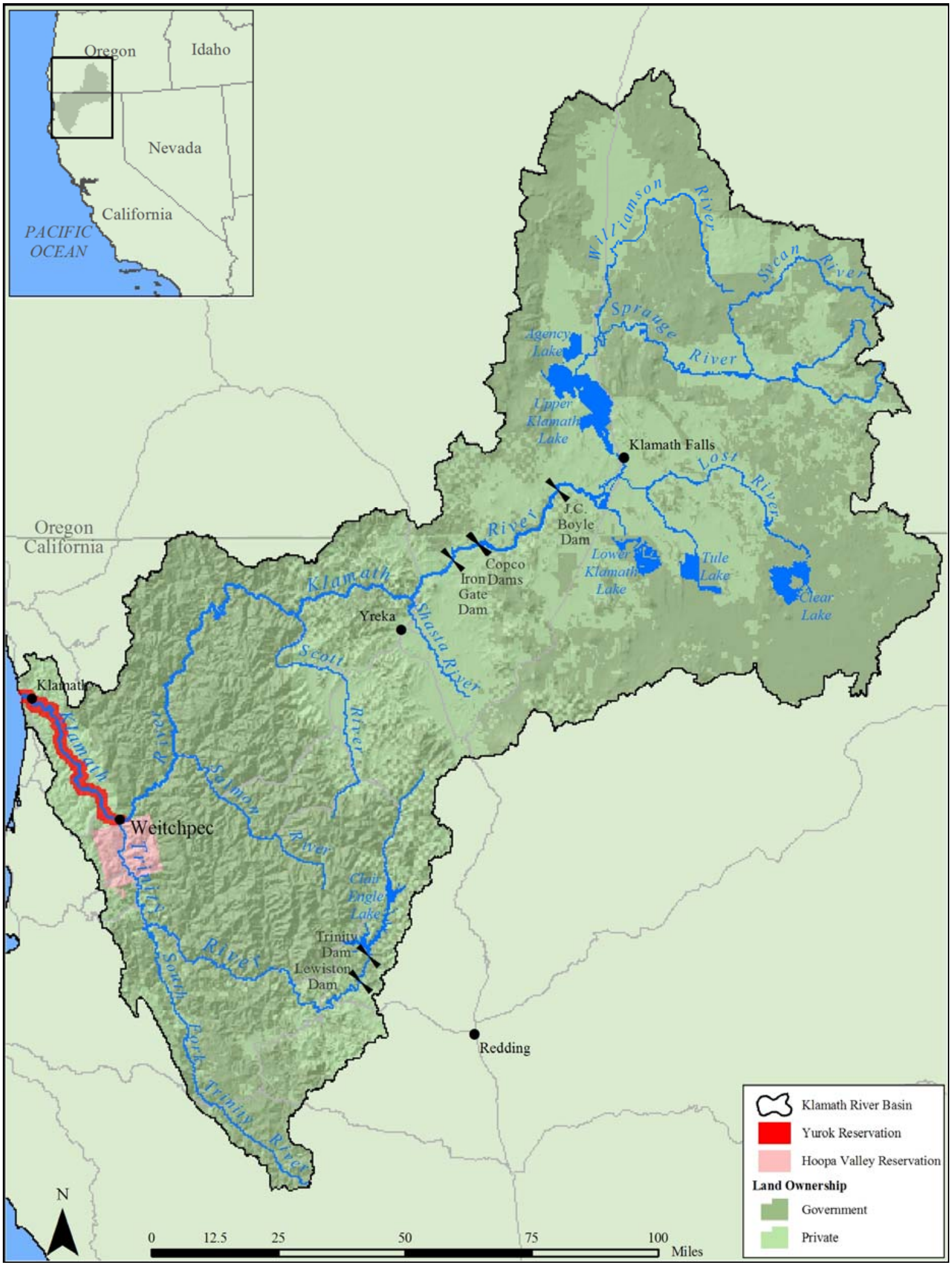

Figure 1: Klamath River Basin Map

The Klamath River

Yurok people utilized a large and diverse cultural landscape that extended along the northern California coast and inland up the Klamath River and surrounding mountains. The traditional names for the Yurok people living on the upper region of the Klamath River, lower region of the Klamath River, and the coast within Yurok Ancestral Territory are the Petch-ik-lah, Pohlik-la, and Nr'r'nr people, respectively. However, they have come to be known as the Yurok, which is the Karuk name meaning "downriver." The ancestral territory of the Yurok people is comprised of a narrow strip along the Pacific Ocean stretching north from the village on the Little River (Me'tsko or Srepor) in Humboldt County to the mouth of Damnation Creek in Del Norte County. In addition to the Yurok coastal lands, Yurok ancestral territory extends inland along the Klamath River from the mouth of the river at Requa (Re'kwoi) to the confluence of Slate Creek and the Klamath River (Constitution of the Yurok Tribe Art. 1, Sec. 1).

The health of the Klamath River and associated fisheries has been central to the life of the Yurok Tribe since time immemorial fulfilling subsistence, commercial, cultural, and ceremonial needs and continues to be so today. Yurok oral tradition reflects this. The Yurok did not use terms for north or east, but rather spoke of direction in terms of the flow of water (Kroeber 1925). The Yurok word for salmon, *nepuy*, refers to "that which is eaten". Likewise, the local waterways and watershed divides have traditionally defined Yurok aboriginal territories. Yurok ancestral land covers about 360,000 acres and is distinguished by the Klamath and Trinity Rivers, their surrounding lands, and the along the Pacific Coast extending from Little River to Damnation Creek. The September 2002 Klamath River fish kill, where a conservative estimate of 33,000 fish died in the lower Klamath before reaching their natal streams to spawn, was a major tragedy for the Yurok people and has served as a motivation for increased fisheries and watershed protection and restoration priorities for the Tribe within the Klamath River watershed and on the Yurok Reservation.

The Yurok Indian Reservation

The current YIR consists of a 55,890-acre corridor extending for one mile on each side of the Klamath River, approximately 45 miles from above the Trinity River confluence to the Pacific Ocean, including the channel (Figure 2). There are approximately two dozen major anadromous tributaries within the YIR boundary. The mountains defining the river valley reach over 3,000 feet elevation. Along most of the river, the valley is quite narrow with rugged steep slopes. Tectonic uplift and down cutting by stream channels over time has created high-relief topography throughout the region. Depending on the location within the watershed, soils are both colluvial and alluvial overlain with a dense humic layer. Transitions in vegetation occur with changes in elevation throughout the reservation.

The dominant vegetation communities in the region are Sitka Spruce-Grand Fir Forest, Redwood Forest, and Riparian. Most of the YIR is comprised of a mix of old growth and regenerated stands of Redwood, Douglas fir, Cedar, Tan Oak, Alder, and Madrone and associated understory and plan communities.

The majority of the lands in the YIR are fee lands, (mostly owned by Green Diamond Resource Company), which are managed intensively for timber products. A small portion of the YIR consists of public lands managed by Redwood National/State Parks (RNSP), the United States Forest Service (USFS) and private landholdings. The Yurok Tribe owns approximately 13,000 acres within the YIR, 25,000 outside the YIR, and manages the landscape for multiple uses to meet the needs of the Yurok Tribal membership.

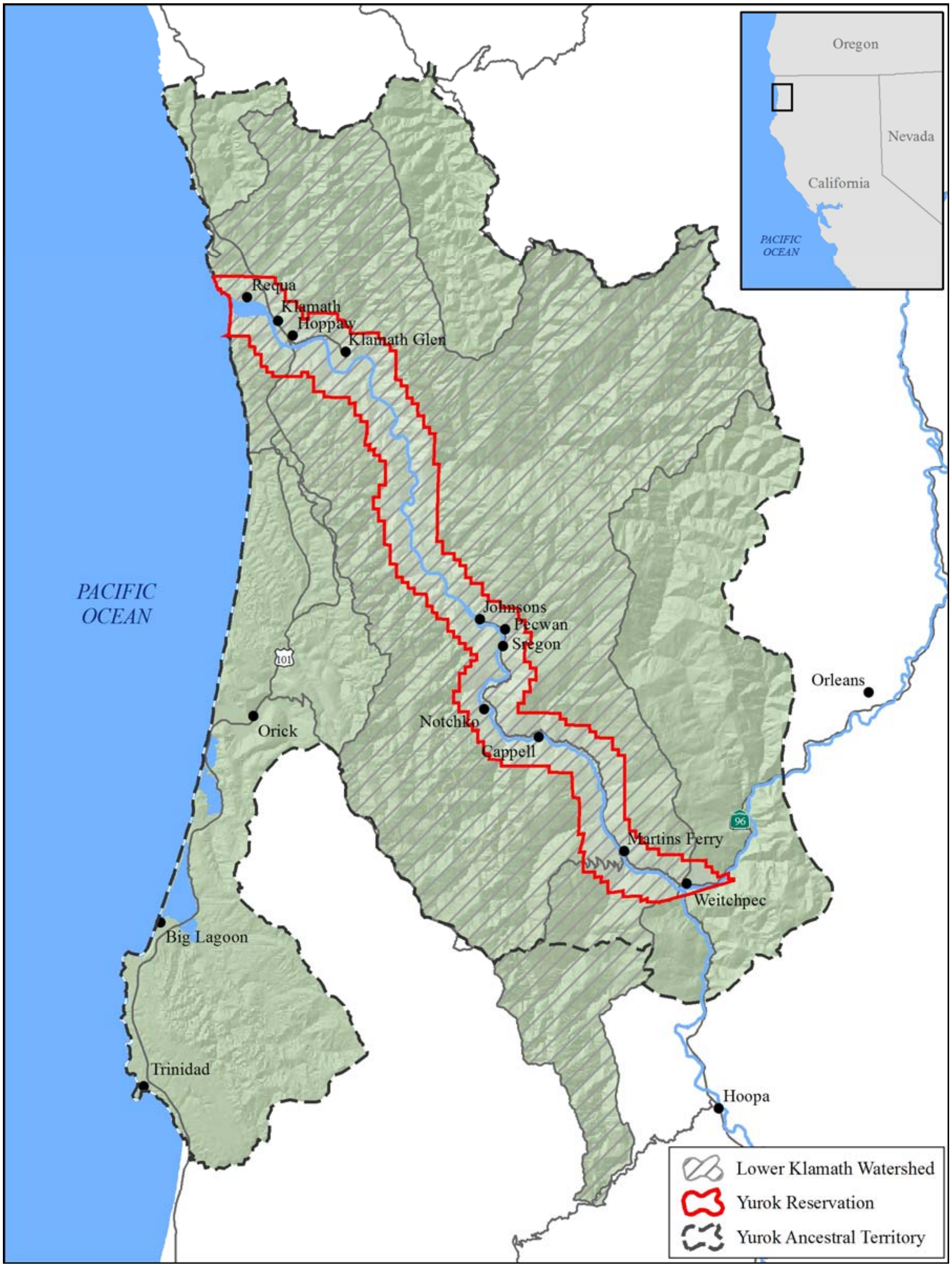

Figure 3: Map of Yurok Indian Reservation and Yurok Ancestral Territory

Yurok Tribe Environmental Program's Wetlands Program

In 1998 YTEP was created to protect and restore tribal natural resources through high quality scientific practices. YTEP is dedicated to improving and protecting the natural and cultural resources of the Yurok Tribe through collaboration and cooperation with local, private, state, tribal, and federal entities such as the Yurok Tribe Fisheries Program (YTFP), US Fish and Wildlife Service (USFWS), the United States Environmental

Protection Agency (USEPA), Green Diamond Resource Company, the North Coast Regional Water Quality Control Board (NCRWQCB), and the United States Geological Survey (USGS). Funding allocated under the Clean Water Act Section 106 primarily funds YTEP's water quality monitoring activities and was the initial focus of the Wetlands Program. US EPA Wetland Program Development Grant (WPDG) has the funded the development of the YTEP Wetlands Program beginning in 2007. The WPDG funded YTEP to develop its previous studies; Assessing KRE Wetland Complexes (WCs) using the California Rapid Assessment Method (CRAM) in 2008, and a wetland water quality study recently undertaken in 2010. A Wetlands Program Plan was developed and approved by US EPA in 2009 and identified the future goals and tasks to be pursued in future years of program development. The Wetlands Program moved into YTEP's Community and Ecosystems Division in 2013 to reflect the shifting focus to community structure, ecologic functions, climate change planning and development of the regulatory framework for future wetlands protection. Wetlands restoration work continues to fall under the Yurok Tribe Fisheries Program. The two departments work collaboratively to monitor and assess wetlands conditions within the Yurok Reservation with a focus on improving fisheries habitat important to key subsistence species important to Yurok people.

Benthic Macroinvertebrate Sampling

Evaluating the biological community of a wetland, stream or river through assessments of BMIs provides a sensitive and cost effective means of determining condition. Macroinvertebrates, being greater than 0.5mm in size (invertebrates large enough to be seen with the naked eye) are fairly stationary, and are responsive to human disturbances. In addition, the relative sensitivity or tolerances of many macroinvertebrates to water quality conditions is well known. The objective of studying macroinvertebrate communities is to monitor the general health and water quality conditions of wetlands connected to the KRE. According to the California Stream Bioassessment Procedure (CSBP) developed by the California Water Resources Control Board (CWRCB) BMI communities indicate physical and habitat characteristics that determine the stream integrity and ecological health. In 2012 the State of California developed a method for collecting macoinvertebrates in depressional wetlands as part of a standardized bioassessment method which included collection of algae and physical habitat data (Fetscher 2012). YTEP has adopted only the macroinvertebrate portion of this method due to funding and staffing constraints.

III. Site Selection

Klamath River Estuary Wetlands

Wetland sites in this study were selected based on the existence of previous wetland condition assessment data. Originally these sites were selected based on their significance as vital habitats for fish and wildlife as a part of the KRE. For further information on this selection process please refer to the previous YTEP report: *Klamath River Estuary Wetlands Restoration Prioritization* (Patterson, 2009). Building upon previous work conducted by YTEP allows for a multi layered approach to understanding wetland conditions and strengthens the natural resource management decision making process. YTEP has developed the monitoring and assessment goals for the Wetlands Program following US EPA's 1-2-3 framework. In 2008 YTEP inventoried wetlands within the KRE and in 2009 YTEP used the California Rapid Assessment Method (CRAM) to assess their wetland condition. This standardized assessment method was used to provide the level 2 information within the framework, and was useful to YTEP but higher level, functional assessment data was needed for a thorough understanding of wetland condition specific to restoration guidance. In 2010 YTEP conducted an intensive assessment of water quality within KRE wetlands, thus serving as level 3 data, and providing insight into how the water quality conditions might serve juvenile salmonids.

The KRE wetlands consist of 6 distinct Wetland Complexes (WCs): Salt Creek (SLC), Panther Creek WC (PC), Spruce Creek WC (SPC), the South Slough Wetland Complex (SSC), Richardson Creek WC (RC), and Waukell

Creek Wetland Complex (WC) (Figure 4). These wetlands are classified as tributary fed depressional wetlands, the exception being the South Slough complex which is classified as estuarine. The South Slough complex was omitted from BMI sampling because of its unique hydrologic classification and lack of method applicability.

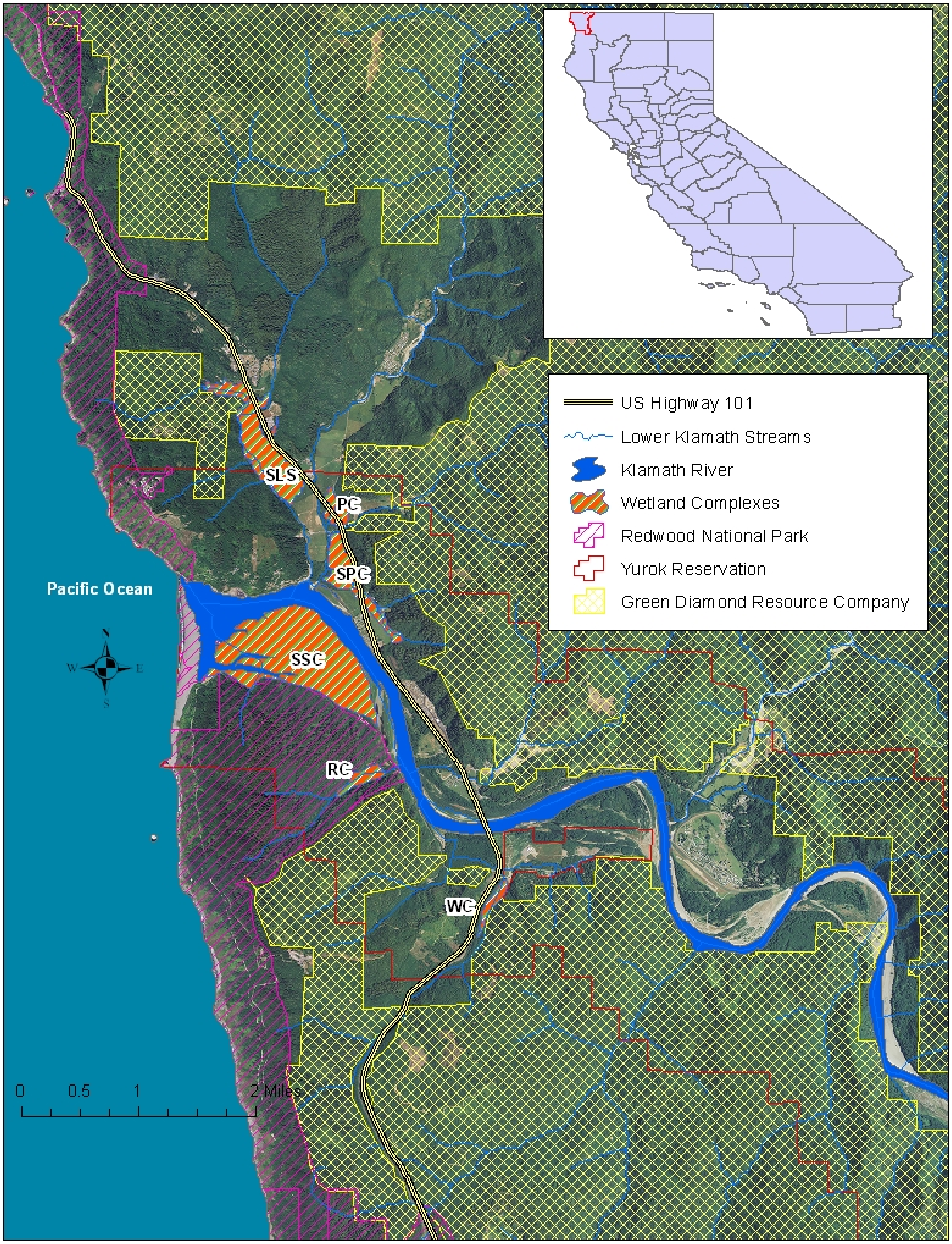

Figure 4: KRE WCs and surrounding land use.

IV. Methods

YTEP sampled BMI populations in selected KRE wetlands during the May 2012, February 2013, and August 2013. Sampling was performed using the multi-habitat methods located in the State of CA Surface Water Ambient Monitoring Program (SWAMP) *Standard Operating Procedures (SOP) for Collection of Macroinvertebrates, Algae, and Associated Physical Habitat Data in California Depressional Wetlands* (Fetscher 2012). This protocol also includes the collection of algae, water quality parameters and physical habitat conditions. YTEP has adopted only the macroinvertebrate portion of this method. In addition to sampling within the index period of the samples were taken in February, and August, to capture changes in community composition, and assess sources of food for juvenile salmonids at times when they utilize these habitats. This method which employs a D-frame aquatic net, can be described as a qualitative or semi-quantitative sampling approach for lentic systems (Merritt and Cummins 2008).

As per the SWAMP protocol, each WC has 10 evenly spaced sampling nodes from which BMI samples are taken. These sampling nodes are spaced by first determining the wetland perimeter. YTEP differed in the approach to determining the sampling node locations due to several factors. First, the WCs are rather large and difficult to navigate through due to large areas of dense brush and deep water. Simply pacing off the perimeter as per the protocol is not feasible, YTEP instead used ArcGIS, existing wetland boundary layers, and created sampling nodes on a map. This map was then uploaded into a handheld Trimble Geo XT GPS unit. YTEP staff then used the GPS unit to locate each sample node. Secondly, not all locations along the wetland perimeter can actually be sampled for BMIs because they lacked standing water. In fact large portions of the WCs consist of densely vegetated with saturated soils and are either void of open water, or experience significant changes in the open water shoreline due to fluctuating water levels throughout the year. These portions are more commonly referred to as fringe wetlands. To deal with the conditions encountered, YTEP proceeded to the target sample node and if no sample could be taken there, staff proceeded perpendicularly to the wetland boundary or towards the center of open water, until standing water was encountered. A GPS point was then recorded for the actual sample node (Figures 5-9).

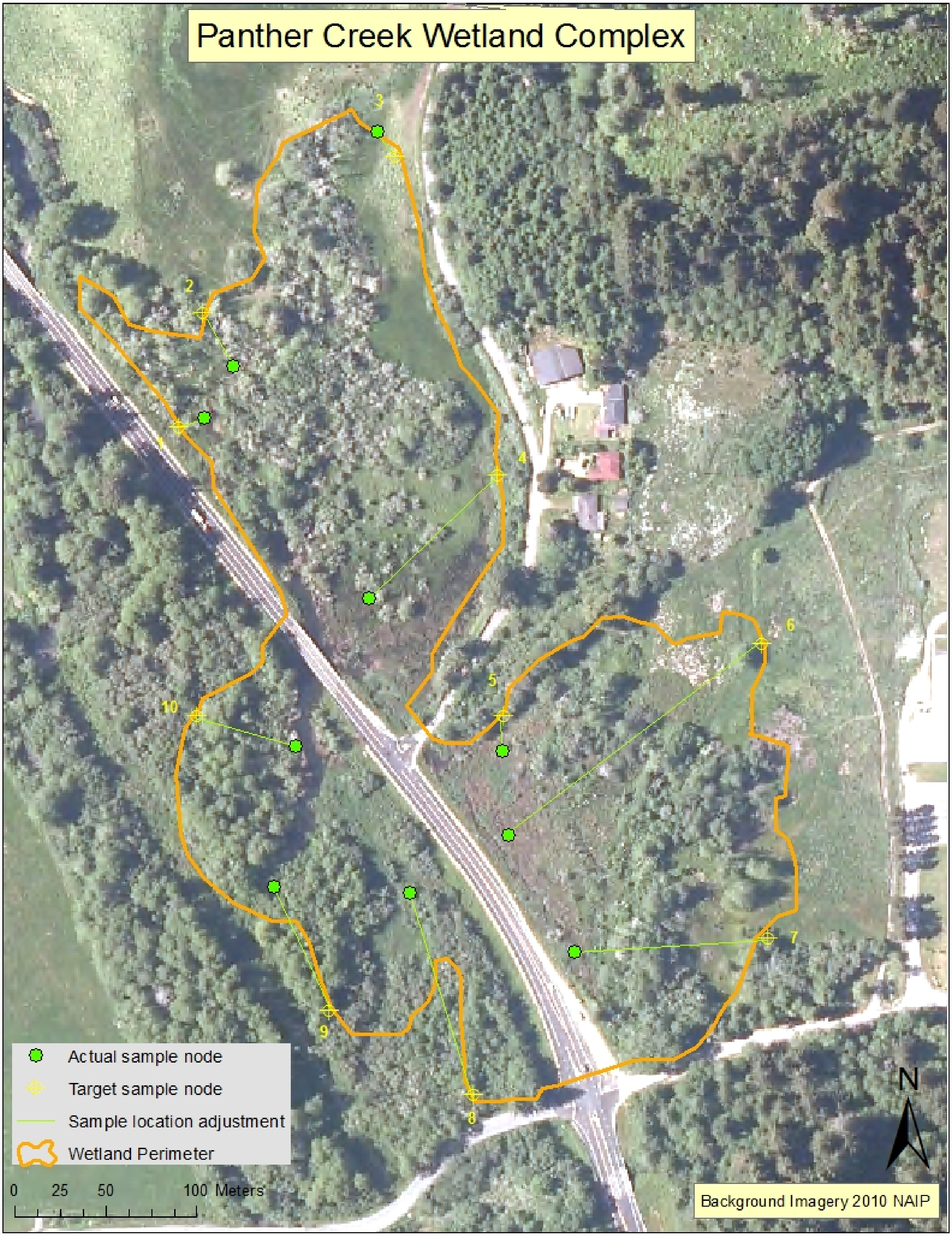

Figure 5: Sampling Locations within Panther Creek Wetland Complex

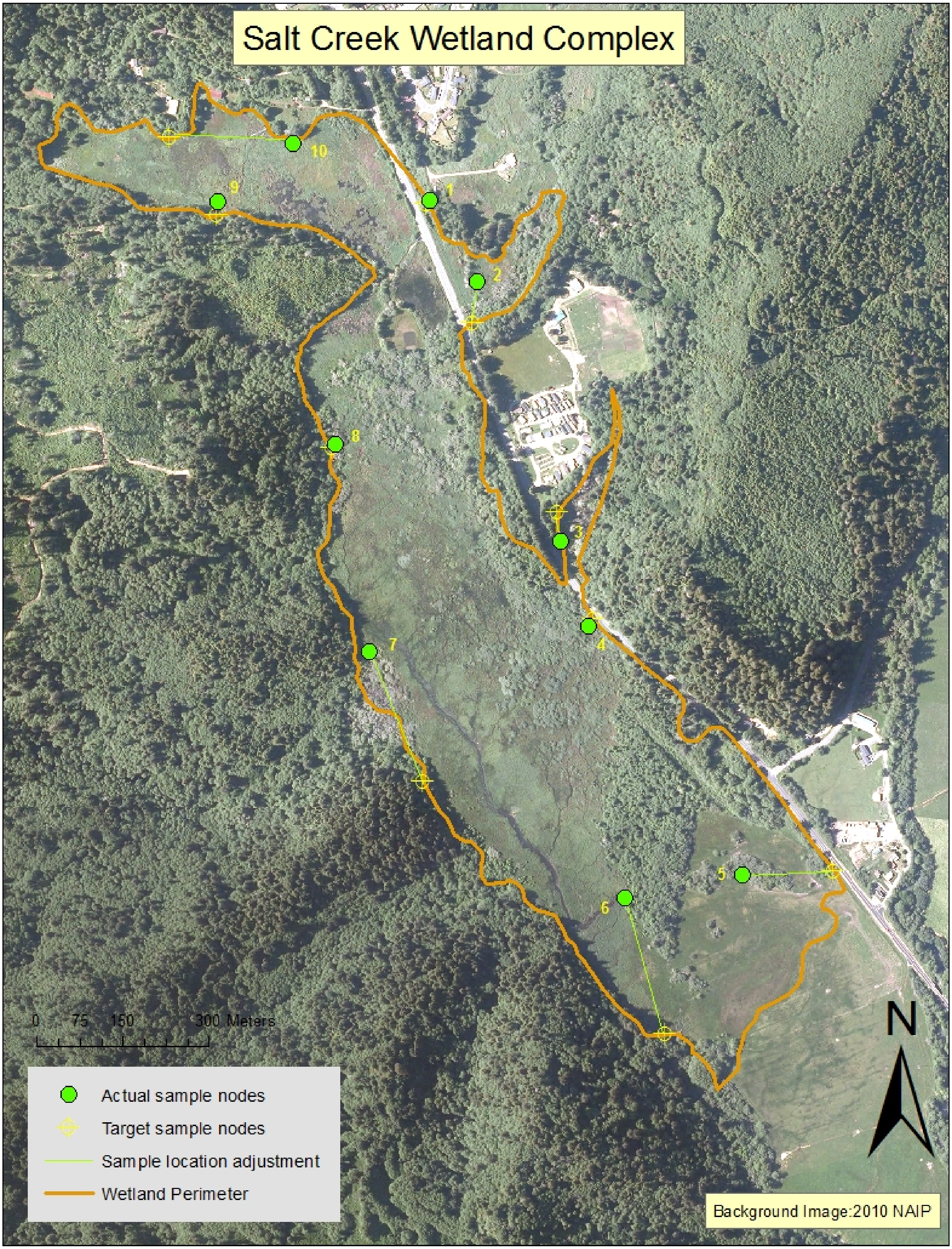

Figure 6: Sampling Locations within Salt Creek Wetland Complex

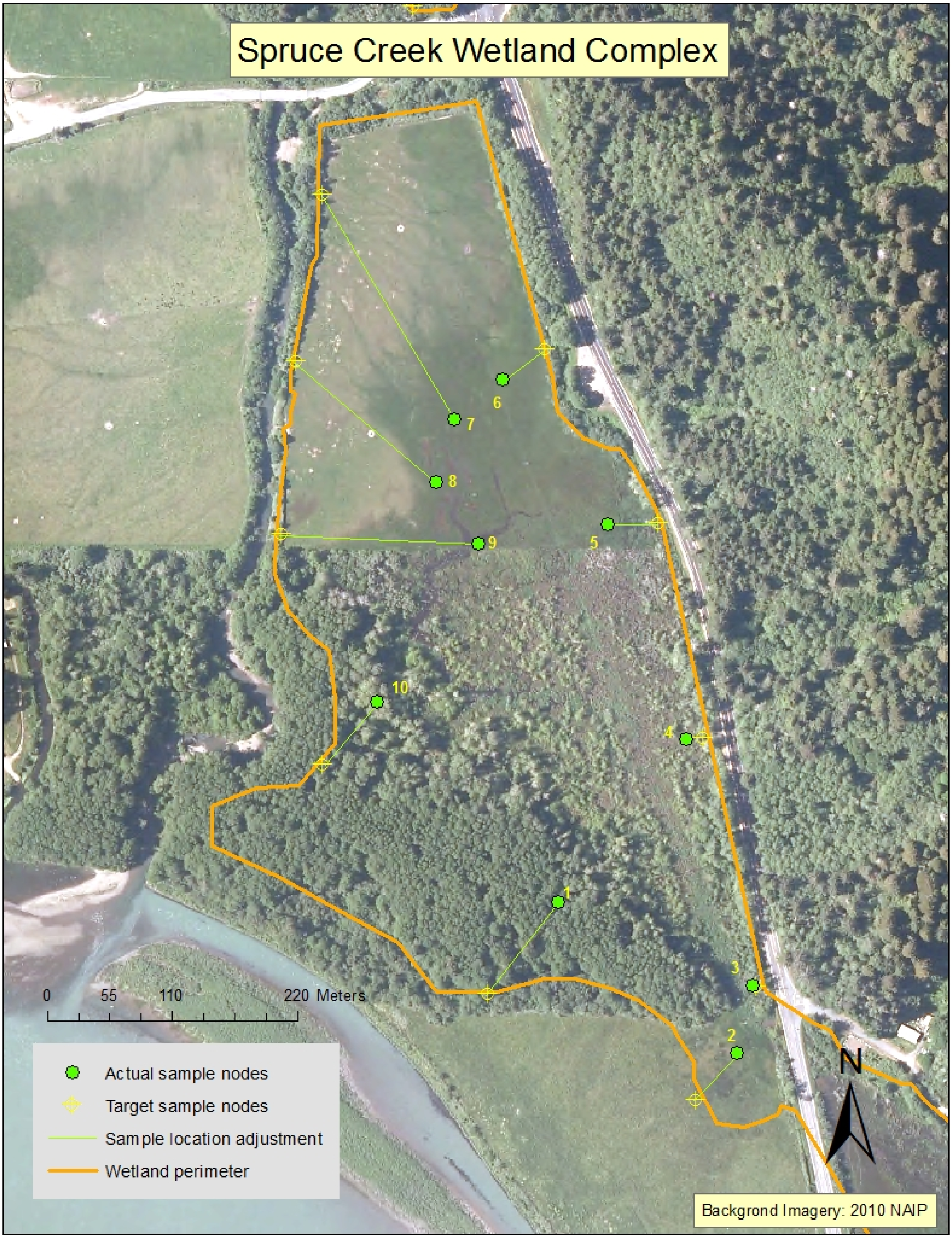

Figure 7: Sampling Locations within Spruce Creek Wetland Complex

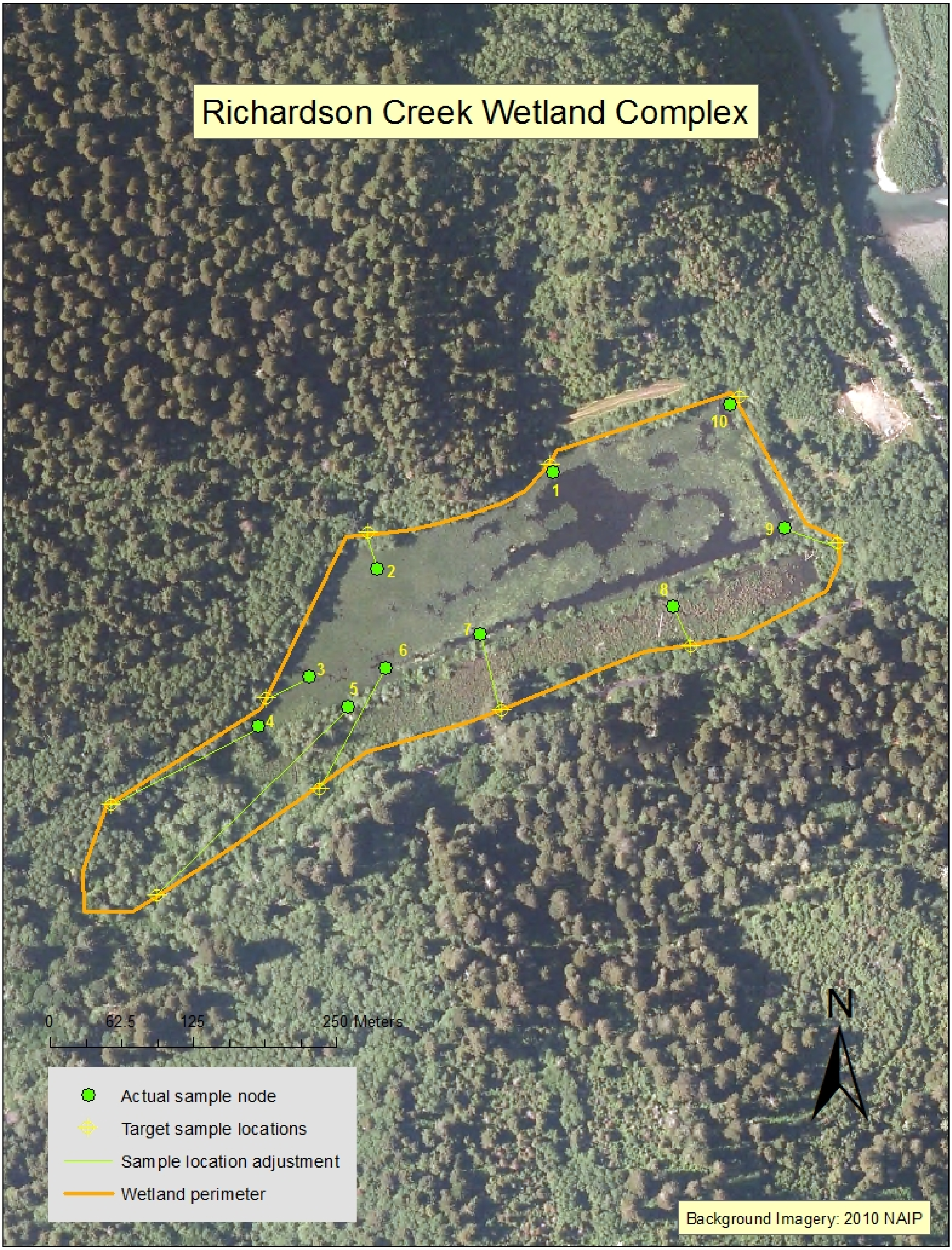

Figure 8: Sampling Locations within Richardson Creek Wetland Complex

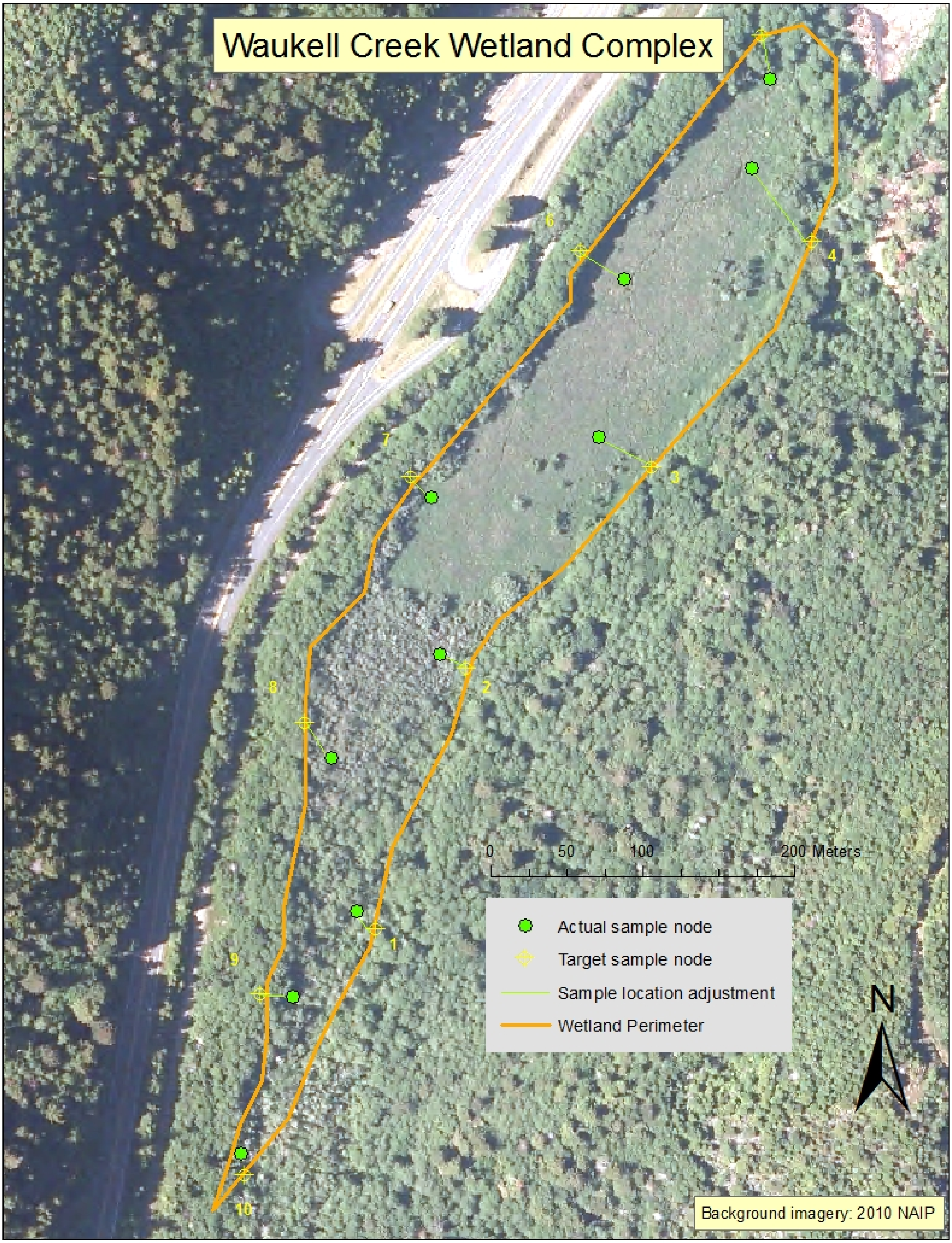

Figure 9: Sampling Locations within Waukell Creek WC

The Wetlands Specialist and two AmeriCorps members collected specimens which were sent to a lab where a certified taxonomist identified and calculated the number and types of species. A variety of quality control measures were undertaken in the BMI sampling methods. Sample labels were properly completed, including the sample identification code, date, wetland name, sampling location, and collector's name, then placed into the sample container. Chain-of-custody forms, when needed, included the same information as the sample container labels. After sampling had been completed at a given site, all nets, pans, and other equipment that had come in contact with the samples were rinsed thoroughly, examined carefully, and picked free of organisms and debris. The equipment was examined again prior to use at the next sampling site.

Data generated in the field and laboratory is reviewed prior to being released internally or to an outside agent. Laboratory processing is contracted to Jonathan Lee, a qualified local CSBP taxonomist and California Bioassessment Laboratories Network (CAMLnet) member. The CSBP has three levels of BMI identification. Level 3 is the professional level equivalent and requires identification of BMIs to a standard level of taxonomy, usually the genus and/or species.

Figure 10: Project Field Staff collecting data

If questionable macroinvertebrates are encountered, the California Department of Fish and Wildlife (CDFW) Aquatic Bioassessment Laboratory is used as a reference to verify the specimens. After processing the samples, the biological matrices are received from the taxonomist in an Excel spreadsheet format identifying the sample ID and the breakdown of BMI species into standard taxonomic levels.

Figure: 11: BMI samples received from the Taxonomist

Water Temperature Monitoring

YTEP deployed HOBO U22 (manufactured by Onset Inc.) continuous water temperature loggers (Figure 12) in select WCs from February 2012 to August 2013. Each selected WC contained 2 data loggers to capture spatial changes throughout each complex. Water temperature monitoring occurred according to a quality assurance document approved by the USEPA (Patterson 2009). In addition to monitoring in four of the five complexes where BMI sampling occurred, the south slough complex of the KRE and 3 wetland restoration projects were also monitored (Figure 13).

Figure 12: Data logger

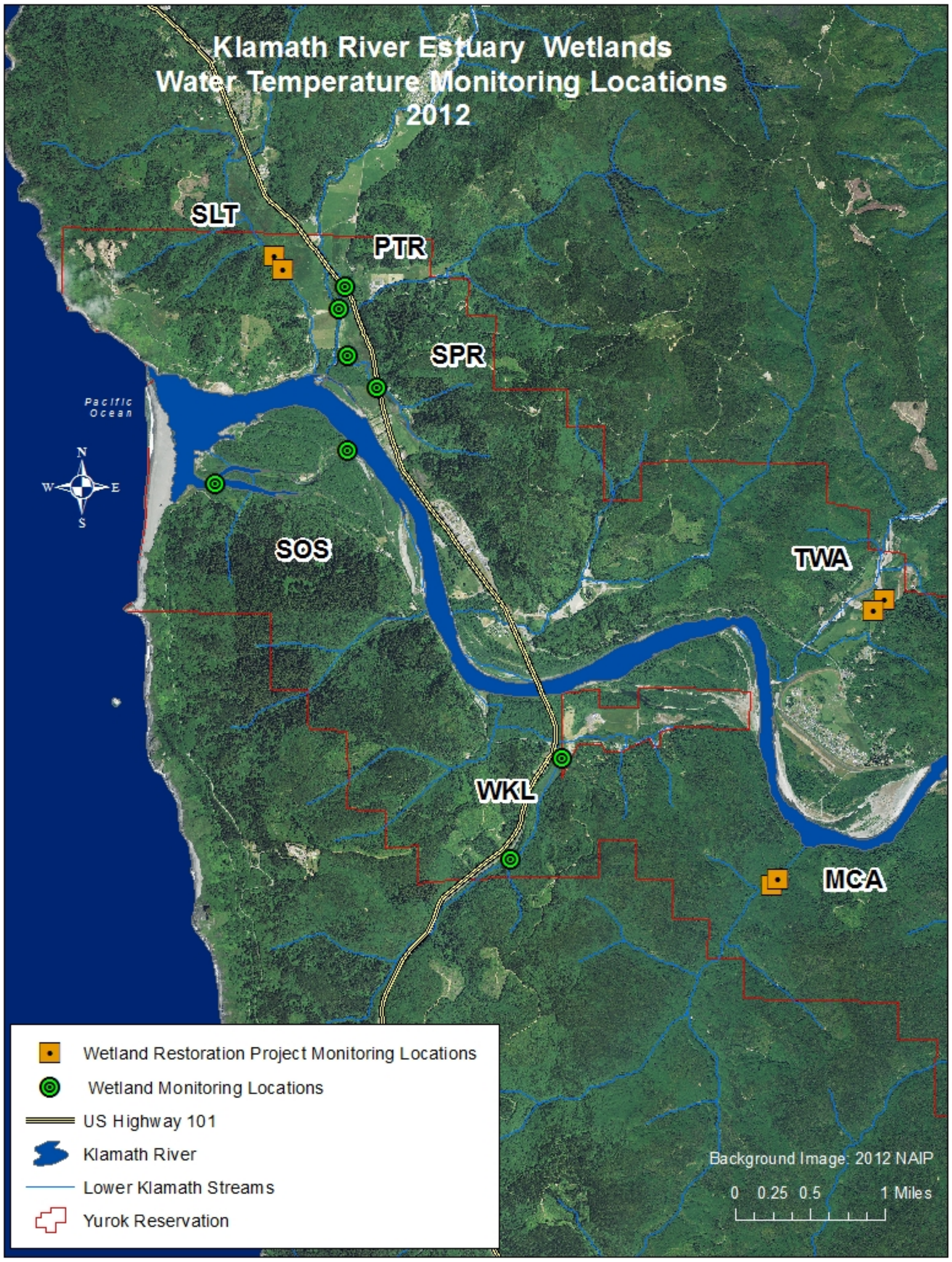

Figure 13: Water temperature monitoring locations. Salt Creek restoration project (SLT), Panther Creek WC (PTR), Spruce Creek WC (SPR), Waukell Creek WC (WKL), South Slough WC(SOS), Turwar Creek Alcove restoration project (TWA), and McGarvey Creek Alcove restoration project (MCA).

V. Results

Results from three distinct sampling events have been summarized in the following sections. BMI samples were collected in May 2012, February 2013, and August of 2013. BMI results have been evaluated using the following: Primary Metrics, Northern California Freshwater Depressional Wetlands IBI, Northern California Freshwater streams-Klamath Mountain region IBI, Functional Feeding Groups, and Tolerance Values. In addition, water temperature profiles have been collected for several wetland complexes, which can serve as background information.

Primary Metrics

Metric scores can be used to describe the BMI community structure, identify stressors, and determine disturbance status of aquatic habitats. The following is a brief description of primary metrics calculated for YTEP's results obtained from wetland sampling efforts. These metrics are commonly used in YTEP's tributary BMI studies because they have proven to be useful in the Pacific Northwest (Fore et al. 1996; Karr and Chu 1999) and Northern California (Harrington et al. 1999) for assessing stream health.

- *Taxa Richness:* A richness measure. The total number of distinct taxa in a sample. Reflects health of the community through measurement of the variety of taxa present. Generally increases with increasing water quality, habitat diversity, and/or habitat suitability (Plafkin et al. 1989)

- *EPT Taxa Richness:* A richness measure. The total number of Ephemeroptera (Mayfly), Plecoptera (Stonefly), and Trichoptera (Caddisfly) taxa present. These orders are considered generally sensitive to disturbance. Expected to decrease with human induced disturbance.

- *Percent Sensitive EPT Index:* A composition measure. Proportion of sample composed of Ephemeroptera, Plecoptera and Trichoptera taxa which have been assigned a tolerance value of 0 to 3. Expected to decrease with degraded habitat.

- *Percent Dominant Taxon:* A Tolerance/Intolerance measure. Percent contribution of the most numerous taxon present in a sample. A community dominated by relatively few taxa would indicate environmental stress (Plafkin et al. 1989). Expected to increase with stress).

- *Tolerance Value:* A tolerance/intolerance measure. A biotic index which evaluates tolerance of BMIs to organic enrichment. Taxa tolerant of organic enrichment are also generally tolerant of warm water, fine sediment, and heavy filamentous algal growth (Wisseman 1996). Scale is 0 through 10, 0 being highly intolerant and 10 being highly tolerant of organic enrichment. The tolerance value is calculated as: $\mathrm{TV}=\_(n_i\ t_i)/N$, where n_i is the number of individuals in a taxon, t_i is the tolerance value for that taxon, and N is the total number of individuals in the sample. Value expected to increase with stressed environment. Tolerance values are from California Department of Fish and Game (2003) listed values, however, as more data is gathered, are subject to modification.

- *Shannon's Diversity Index (H):* A diversity index is a mathematical measure of taxa diversity in a community. Shannon's index accounts for both abundance and evenness of the taxa present. The proportion of taxa is relative to the total number of taxa (p_i) is calculated, and then multiplied by the natural log of this proportion (lnp*i*). The resulting product is summed across taxa, and multiplied by -1: $\boldsymbol{H}=-\_p_i \mathrm{ln} p_i$; Diversity is expected to decrease with disturbance.

- *Relative abundance:* A measure of the overall productivity of the site. This metric is calculated by using a sub sample to estimate the overall number of individuals found in a sample. Karr and Chu (1999) consider relative abundance to be a poor candidate for use in stream monitoring because of the great natural variation that can occur. However, the use of this metric in wetlands, is dependent on stable conditions, which are perhaps more prevalent than in streams.

Table 1: Primary Metric Scores, all WCs, May 2012.

Wetland Complex	Date Sampled	Total # of Specimens	Taxa Richness	EPT Richness	% Sensitive EPT	% Dominant Taxon	Tolerance Value	Shannon's D.I.	Relative Abundance
Panther	5/7/2012	500	36	4	10	36	5.9	2.5	1745
Waukell	5/9/2012	510	38	10	3	33	6.5	2.3	3462
Salt	5/16/2012	500	36	7	2	23	6.5	2.6	5313
Richardson	5/17/2012	523	30	3	0	27	7.6	2.2	15280
Spruce	5/24/2012	508	24	0	0	31	7.9	2.0	14488

Table 2: Primary Metric Scores, all WCs, February 2013.

Wetland Complex	Date Sampled	Total # of Specimens	Taxa Richness	EPT Richness	% Sensitive EPT	% Dominant Taxon	Tolerance Value	Shannon's D.I.	Relative Abundance
Panther	8/4/2013	532	37	5	6	35	6.7	2.6	6384
Waukell	8/5/2013	528	26	4	11	42	5.5	2.1	7798
Salt	8/7/2013	514	43	6	3	28	6.8	2.7	3138
Richardson	8/6/2013	516	21	0	0	49	8.7	1.8	4128
Spruce	8/12/2013	523	29	1	1	38	7.2	2.1	8368

Table 3: Primary Metric Scores, all WCs, August 2013.

Wetland Complex	Date Sampled	Total # of Specimens	Taxa Richness	EPT Richness	% Sensitive EPT	% Dominant Taxon	Tolerance Value	Shannon's D.I.	Relative Abundance
Panther	2/19/2013	504	36	6	18	31	6.1	2.5	3633
Waukell	2/13/2013	500	38	17	21	13	5.3	3.1	1199
Salt	2/14/2013	513	36	7	7	22	6.8	2.7	3024
Richardson	2/27/2013	504	24	1	1	43	8.2	1.9	8848
Spruce	3/6/2013	504	34	3	2	29	7.5	2.3	5902

Making sense of primary metric scores can be difficult if there is no reference to compare to. As a part of other studies YTEP collected BMI data in four streams during spring and summer months of 2010 (Table 4), 2011(Table 5) and 2012 (Table 6) (YTEP 2010, YTEP 2011, YTEP 2012). Three years of data have been used to account for annual variation. These data sets can provide a generalized range of scores for Lower Klamath streams. Primary metric scores for those sampling events have been summarized in the following tables. Consideration was given to using average scores for comparison between wetland and streams, but this would eliminate the observed variation between sites. Rather, comparisons are made using the ranges of scores, and were determined using averages of highs and lows in all sampling events, and only the samples occurring in spring and summer have been used (February 2013 sample omitted).

Table 4: Primary Metric Scores, Lower Klamath Streams 2010.

Stream	Date Sampled	Total # of Specimens	Taxa Richness	EPT Richness	% Sensitive EPT	% Dominant Taxon	Tolerance Value	Shannon's D.I.	Relative Abundance
McGarvey	6/29/2010	520	46	28	34	33	4.0	2.8	2818
Lower Turwar	6/28/2010	511	31	15	19	35	4.6	2.2	1485
Upper Turwar	7/12/2010	505	39	20	22	31	4.2	2.6	1347
Tully	7/15/2010	508	43	21	24	18	4.0	2.9	1016
Blue	8/6/2010	511	36	19	20	43	4.6	2.3	4816

Table 5: Primary Metric Scores, Lower Klamath Streams 2011.

Stream	Date Sampled	Total # of Specimens	Taxa Richness	EPT Richness	% Sensitive EPT	% Dominant Taxon	Tolerance Value	Shannon's D.I.	Relative Abundance
McGarvey	6/2/2011	500	41	24	43	15	3.4	2.9	1845
Lower Turwar	6/9/2011	500	32	19	16	67	5.1	1.5	1769
Upper Turwar	6/20/2011	500	35	21	22	52	4.6	2.0	4600
Tully	6/21/2011	500	46	21	22	36	4.2	2.7	1271
Blue	8/4/2011	500	48	24	22	22	4.6	2.8	2128

Table 6: Primary Metric Scores, Lower Klamath Streams 2012.

Stream	Date Sampled	Total # of Specimens	Taxa Richness	EPT Richness	% Sensitive EPT	% Dominant Taxon	Tolerance Value	Shannon's D.I.	Relative Abundance
McGarvey	5/15/2012	511	53	30	35	15	3.4	3.2	1136
Lower Turwar	5/18/2012	500	31	19	39	28	3.5	2.2	756
Upper Turwar	6/8/2012	501	37	20	17	44	4.7	2.3	1927
Tully	7/10/2012	505	49	25	20	19	4.2	2.8	1180
Blue	7/27/2012	400	37	21	37	23	3.8	2.9	400*

Wetland Complex	Date Sampled	Total # of Specimens	Taxa Richness	EPT Richness	% Sensitive EPT
Panther	8/4/2013	532	37	5	6
Waukell	8/5/2013	528	26	4	11
Salt	8/7/2013	514	43	6	3
Richardson	8/6/2013	516	21	0	0
Spruce	8/12/2013	523	29	1	1

In comparison of wetlands and streams, generalized trends (ranges) between primary metric scores appear to follow traditional expectations. In wetlands the metric EPT Taxa Richness was significantly lower than in streams, having a range from 0-10 compared to 18-26.Sensative EPT was significantly lower in KRE WCs, with a range of 0-10 compared to 17-38. Also, the metric Tolerance Value had ranges shifted higher in KRE WCs, with a range of 5.7-7.5 compared to 3.5–4.7 for streams. Shannon’s D.I. had a range of lower numbers, 1.9 to 2.5 in WCs, 2.2 to 3.5 in streams.

However, several primary metrics were very comparable between wetlands and streams, with close median values. Taxa Richness had a range of 24-40 in wetlands, and a similar range of 31-53 was found in streams. Also, the metric % Dominant Taxon had a range of 25-40 in wetlands, and a similar range of 16-50 was noted in streams.

Due to differences in sampling methods between wetlands and streams it is difficult to make an accurate comparison of the Relative Abundance metric. BMIs in streams are captured using a kick method aimed at capturing free flowing organisms, while BMIs in WCS are captured in a still water environment and are likely attached to the benthos, which is minimally disturbed. Wetland samples often had a varying volume of material between sites which may have influenced this metric. The basis for the Relative Abundance metric is as follows: The Taxonomist will determine the percentage of the sample that it takes to reach his 500 count sub sample, and use this number to calculate Relative Abundance for the entire sample. Based on this information it appears that WCs in general have a Relative Abundance much higher than in streams; the metric scores in WCs ranged from 1,700- 15,000, compared to 1,000-5,000 in streams.

Indices of Biological Integrity

According to the US EPA guidance on developing a an Index of Biological Integrity (IBI) for wetland macroinvertebrates (US EPA 2002) several advantages to conducting BMI studies is that; 1) they are commonly and widely distributed in many types of wetlands; 2) They respond with a range of sensitivities to many kinds of stressors; 3) Aquatic invertebrates are important in wetland food webs of wildlife; and 4) many aquatic invertebrates complete their lifecycles in wetlands and they are exposed directly to physical, chemical, and biological stressors within the wetland.

YTEP is comparing wetland BMI communities to that of streams because of their commonality as juvenile salmonid food sources and both can serve as indicators of habitat condition. However, it should be thoroughly noted that wetlands are not to be scaled according to stream standards. If so, it would be expected that wetlands would show more tolerant species and less of the species which are indicators of a flow regime in streams, and overall wetlands would score low as a stream. However, growth rates of juvenile salmonids in wetlands habitats has shown to be significantly increased when compared to that of free flowing habitats, thus increasing their chances for ocean survival (Beesley and Fiori 2004; Beesley and Fiori 2007). The availability of wetland macroinvertebrate food sources for juvenile salmonids may be one reason for this.

Currently one IBI has been developed for freshwater wetlands in Northern California (Lunde and Resh 2011) which standardizes macroinvertebrate community assemblages in response to urbanization. In addition, there is an established IBI for Northern California streams with the Klamath mountain region (Rhen and Ode 2005) which can be used to compare macroinvertebrate data collected in wetlands to that of streams. Although this comparison has some obvious downfalls, such as physiological differences between lentic and lotic systems, and the fact that the most common species found in system each differ (Lunde and Resh 2011), the comparison may provide some insight considering that wetlands and streams both function as fish habitat. The KRE WCs are in fact fed by tributaries, giving them unique consideration. Typically a depressional wetland is thought of an area consisting of a pond like feature, surrounding on all sides by uplands and perhaps isolated. However, a depressional wetland may also be tributary fed and connected to surface waters (CWMW 2013). At this time a standardized IBI does not exist for wetlands within the KRE region which is specifically correlated to local stressors.

BMI IBI's offer a standardized score for comparison of distinct wetlands and their conditions (Table 7). The range of scores is placed into categories for grading and can be used to set priorities such as monitoring an assessment objectives and or restoration goals and objectives.

Table 7: IBI Scoring Key

Total Metric Score	**Value**
0-20	very poor
21-40	poor
41-60	fair
61-80	good
81-100	very good
>52	"unimpaired"

Within the IBI development for Northern California (Nor Cal) Freshwater Depressional Wetlands metrics were statistically analyzed to show there their correlation to impacts from urbanization which consisted of measures of water quality (temperature, dissolved oxygen, specific conductance, nitrogen, phosphorous, etc.), urbanized land cover with 1km of the wetland, hydrologic connectivity to other aquatic habitats, upland buffers, and invasive predators (Lunde and Resh 2011).

The Nor Cal IBI for Freshwater Depressional Wetlands is based on impacts from urbanization in the San Francisco-Mendocino County area, approximately 200 miles south and therefore is not applicable to the Lower Klamath area due to a lack of validation. In fact the Lower Klamath area is actually very rural. As previously stated there is no current applicable IBI within the region, and the best available science will be employed. Due to a lack of urbanization, it may be expected that wetlands within this study will show relatively high scores based on this IBI.

In the development of the Nor Cal IBI for Freshwater Depressional Wetlands (Lunde and Resh 2011) the following metrics are used to characterize the BMI community assemblage in response to impacts from urbanization:

- % 3 Dominant Taxa
- % Tanypodinae/Chironomidae
- % Coleoptera
- % EOT
- Scraper Richness
- EOT Richness
- Oligochaeta Richness
- Predator Richness

Table 8: Nor Cal Freshwater Depressional Wetlands IBI Scores, all WCs, May 2012.

Wetland Complex	Date Sampled	Total # of Specimens	% 3 Dominant Taxa	% Tanypodinae / Chironomidae	% Coleoptera	% EOT	Scraper Richness	EOT Richness	Oligochaeta Richness	Predator Richness	Overall Score
Panther	5/7/2012	500	53	12	1	14	5	5	2	13	70
Waukell	5/9/2012	510	60	11	1	7	6	8	1	9	69
Salt	5/16/2012	500	51	10	1	7	3	7	1	13	69
Richardson	5/17/2012	523	62	11	1	1	3	4	1	9	69
Spruce	5/24/2012	508	69	5	0	0	2	0	2	8	45

Table 9: Nor Cal Freshwater Depressional Wetlands IBI Scores, all WCs, February 2013.

Wetland Complex	Date Sampled	Total # of Specimens	% 3 Dominant Taxa	% Tanypodinae / Chironomidae	% Coleoptera	% EOT	Scraper Richness	EOT Richness	Oligochaeta Richness	Predator Richness	Overall Score
Panther	2/19/2013	504	56	16	0	20	4	7	1	15	73
Waukell	2/13/2013	500	31	20	1	27	4	12	2	8	75
Salt	2/14/2013	513	44	25	0	8	5	8	1	13	69
Richardson	2/27/2013	504	74	5	0	2	1	3	1	9	44
Spruce	3/6/2013	504	64	12	1	3	3	4	1	13	65

Table 10: Nor Cal Freshwater Depressional Wetlands IBI Scores, all WCs, August 2013.

Wetland Complex	Date Sampled	Total # of Specimens	% 3 Dominant Taxa	% Tanypodinae / Chironomidae	% Coleoptera	% EOT	Scraper Richness	EOT Richness	Oligochaeta Richness	Predator Richness	Overall Score
Panther	8/4/2013	504	53	15	1	8	5	6	1	13	75
Waukell	8/5/2013	528	66	4	0	17	3	4	1	8	64
Salt	8/7/2013	514	53	18	1	6	5	7	1	14	73
Richardson	8/6/2013	517	76	24	0	3	2	1	1	8	51
Spruce	8/12/2013	523	69	2	1	4	4	2	1	11	56

Based upon the May 2012 samples and the overall IBI scores for Nor CAL Freshwater Depressional Wetlands, all the WCs are in “Good” condition, except for one, Spruce Creek WC. Spruce falls into the lower range of the “Fair” category (Table 8). In comparing scores from other sampling events, no drastic changes are noted other than for Spruce Creek WC which had a 20 point gain in the winter (Feb 2013, Table 9), and Richardson Creek WC, which had a 25 point loss in the same time frame. Because the IBI was not developed for winter data, these changes should not necessarily be inferred to be a change in condition.

In the development of the IBI for freshwater streams in Northern California-Klamath Mountains, the following metrics were used to characterize the BMI community assemblage in response to impacts from timber harvest (Rhen and Ode 2005). Results from BMI sampling in WCs have been summarized within this IBI (Tables 11-13).

- EPT Richness
- Coleoptera Richness
- Diptera Richness
- % Intolerant Individuals
- % Non-Gastropod Scrapers
- % Predator Individuals
- % Shredder Taxa
- % Non-Insect Taxa

Table 11: Nor Cal Streams IBI scores, all WCs, May 2012

Wetland Complex	Date Sampled	Total # of Specimens	EPT Richness	Coleoptera Richness	Diptera Richness	% Intolerant Individuals	% Non-Gastropod Scrapers	% Predator Individuals	% Shredder Taxa	% Non-Insect Taxa	Overall Score
Panther	5/7/2012	500	4	4	4	3	0	19	6	53	35
Waukell	5/9/2012	510	10	3	9	2	1	4	11	37	38
Salt	5/16/2012	500	7	2	8	4	0	9	14	42	39
Richardson	5/17/2012	523	3	1	5	0	0	7	7	57	19
Spruce	5/24/2012	508	0	2	5	1	0	4	0	63	15

Table 12: Nor Cal Streams IBI scores, all WCs, February 2013

Wetland Complex	Date Sampled	Total # of Specimens	EPT Richness	Coleoptera Richness	Diptera Richness	% Intolerant Individuals	% Non-Gastropod Scrapers	% Predator Individuals	% Shredder Taxa	% Non-Insect Taxa	Overall Score
Panther	2/19/2013	504	6	1	5	2	0	18	8	53	30
Waukell	2/13/2013	500	17	2	5	21	4	17	21	26	58
Salt	2/14/2013	513	7	1	4	0	0	15	8	53	26
Richardson	2/27/2013	504	1	0	3	0	0	7	4	63	13
Spruce	3/6/2013	504	3	2	5	0	0	8	3	59	20

Table 13: Nor Cal Streams IBI scores, all WCs, August 2013

Wetland Complex	Date Sampled	Total # of Specimens	EPT Richness	Coleoptera Richness	Diptera Richness	% Intolerant Individuals	% Non-Gastropod Scrapers	% Predator Individuals	% Shredder Taxa	% Non-Insect Taxa	Overall Score
Panther	8/4/2013	504	5	2	4	4	0	17	8	54	30
Waukell	8/5/2013	528	4	1	4	11	0	9	8	50	26
Salt	8/7/2013	514	6	2	10	4	0	17	7	47	39
Richardson	8/6/2013	517	0	1	4	0	0	11	0	62	14
Spruce	8/12/2013	523	1	2	8	2	0	11	3	52	26

Based on the May 2012(recommended index period) KRE WCs fall within the “Poor” and “Very Poor” categories when Nor Cal Stream IBI scores are applied (Table 11). This categorization does change throughout the next two sampling events, except for a slight improvement in the Waukell WC overall score during February 2013. Although the IBI score is not necessarily applicable to the wetlands, the IBI does appear to be useful in picking up difference in condition between wetlands. Spruce Creek WC scored the lowest in both IBIs, and also scored very low in the CRAM evaluation performed by YTEP (Patterson 2010).

A comparison between wetlands and streams has been to test applicability of a stream IBI in Tributary fed depressional wetlands of the KRE WCs. The following tables have been adapted from 3 macroinvertebrate studies performed by YTEP in 2010, 2011, and 2012 (Table 14-16) (YTEP 2010, YTEP 2011, YTEP 2012). Data from four streams have been used to generate an average range of scores for Lower Klamath streams, which can be compared to an average range for WCs, similar to the comparison made for primary metrics. Three years of data have been used to account for annual variation.

Table 14: IBI Scores, Lower Klamath Streams 2010.

Stream	Date Sampled	Total # of Specimens	EPT Richness	Coleoptera Richness	Diptera Richness	% Intolerant Individuals	% Non-Gastropod Scrapers	% Predator Individuals	% Shredder Taxa	% Non-Insect Taxa	Overall Score
McGarvey	6/29/2010	520	28	4	6	27	13	17	11	17	70
Lower Turwar	6/28/2010	511	15	3	5	17	8	14	6	23	51
Upper Turwar	7/12/2010	505	20	8	5	21	17	23	8	15	75
Tully	7/15/2010	508	21	7	8	22	29	16	14	14	83
Blue	8/6/2010	511	19	4	5	22	9	53	11	22	68

Table 15: IBI Scores, Lower Klamath Streams 2011.

Stream	Date Sampled	Total # of Specimens	EPT Richness	Coleoptera Richness	Diptera Richness	% Intolerant Individuals	% Non-Gastropod Scrapers	% Predator Individuals	% Shredder Taxa	% Non-Insect Taxa	Overall Score
McGarvey	6/2/2011	500	24	3	5	36	12	15	15	22	66
Lower Turwar	6/9/2011	500	19	2	6	17	3	15	16	16	60
Upper Turwar	6/20/2011	500	21	5	5	22	14	17	9	11	73
Tully	6/21/2011	500	21	8	9	20	22	18	11	17	81
Blue	8/4/2011	500	24	5	9	25	11	35	8	21	76

Table 16: IBI Scores, Lower Klamath Streams 2012.

Stream	Date Sampled	Total # of Specimens	EPT Richness	Coleoptera Richness	Diptera Richness	% Intolerant Individuals	% Non-Gastropod Scrapers	% Predator Individuals	% Shredder Taxa	% Non-Insect Taxa	Overall Score
McGarvey	5/15/2012	511	30	5	5	27	25	12	13	21	73
Lower Turwar	5/18/2012	500	19	4	5	39	25	22	3	10	74
Upper Turwar	6/8/2012	501	20	6	7	16	9	23	5	11	70
Tully	7/10/2012	505	25	8	8	18	27	18	14	16	84
Blue	7/27/2012	400	21	5	6	37	23	10	8	14	75

It is apparent that the Nor Cal stream IBI metrics are significantly different between WCs and streams, and the differences are as anticipated for most metrics. For most metrics the differences were very discernible; meaning there was virtually no overlap in score ranges. The metric scores for EPT Richness range from 0-10 in WCs, and 18-28 in streams. Coleoptera Richness metric scores range from 1-3 in WCs compared to 3-8 in streams. % Intolerant Individuals metric scores ranged from 0-11 in WCs, compared to 17-33 in streams. % Non-Gastropod Scrapers metric scores ranged from 0-2 in WCs, compared to 8-25 in streams. % Predator Individuals metric scores ranged from 8-17 in WCs and 15-35 in streams. % Non-Insect Taxa metric scores ranged from 35-63 in WCs compared to 12-22 in streams.

However, 2 metrics showed comparable ranges (i.e. some degree of overlap) for the metric scores between WCs and streams, Diptera Richness, and % Shredder Taxa, and should be given special consideration taking into account these similarities. Diptera Richness metric scores ranged from 4-8 in streams, compared to 5-8 in streams. % Shredder Taxa metric scores ranged from 0-14 in WCs, compared to 8-15 in streams.

Functional Feeding Groups

Each individual macroinvertebrate can be classified by its mode or habit of survival into functional feeding groups (FFG). This habit is dependent on particle size of food sources and sediment (Merrit and Cummins 2008). Assessment of the dependence of an aquatic macroinvertebrate community upon a given food source can be evaluated using FFG analysis (Merritt and Cummins 2008). This approach will highlight the interactions between insect morpho-behavioral adaptions and food sources, as well as provide a functional analysis of the BMI community as opposed to structural (Merritt and Cummins 2008).

Table 17: FFG descriptions. Adapted from Merritt and Cummins 2008; and Ode 2003.

Functional Feeding Group	Abbreviation	Subdivision of Functional Group		General Partcilce Size of food source (microns)
		Dominant Food	Feeding Mechanism	
Shredders	SH	Living vascular hydrophyte plant tissue; Decomposing Vascular plant tissue -coarse particulate orgnaic matter (CPOM)	Herbivores-chewers and miners of live macrophytes; Detrivores-Chewers of CPOM; Gougers-excavate and gallery, wood	$>10^3$
Collectors / Gatherers	CG	Decomposing fine partcilate organic matter (CPOM)	Detrivores-gatherers or deposit (sediment) feeders (includes feeders on loose surface films)	$<10^3$
Scrapers	SC	Periphyton-attached algae and associated material	Herbivores-grazing scrapers of mineral and organic surfaces	$<10^3$
Piercer Herbivore	PH	Living vascular hydrophyte cell and tissue fluids or fillamentous (macroscopic) algal cell fluids	Herbivores-pierces tissues or cells and sucks fluid	$>10^2$->10^3
Predators	P	Living animal tissue	Engulfers-carnivores, attack prey and ingest whole animal parts; Piercers-carnivores, attack prey, pierce tissues and cells and suck fluids	$>10^3$
Parasites	PA	Living animal tissue	Internal parasites of eggs, larvae and pupae.External parasites of larvae, prepupae and pupae in cocoons, pupal cases or mines. Also, external parasites of adult spiders.	$>10^3$
Xylophage	XY	Wood	Herbivore-chewers of woody plant tissue	$>10^3$
Collector / Filterer	CF	Decomposing fine particulate matter (CPOM)	Detritivores-filterers or suspension feeders	$<10^3$
Omnivore	OM	Various living and non-living plant and animal tissue	Scavengers-chewers, seek out various food sources which are ingested.	$>10^3$
Macrophyte Herbivore	MH	Living vascualar macrophyte tissue	Chewers and miners of live macrophytes	$>10^3$

Table 18: FFGs, all sites, May 2012 (note: The predominant FFG has been highlighted).

Panther			Waukell			Salt			Richardson			Spruce		
Type	Count	Percentage	Type	Count	Percentage	Type	Count	Percentage	Type	Count	Percentage	Type	Count	Percentage
P	94	18.8	P	20	3.9	P	46	9.2	P	37	7.1	P	18	3.5
CF	26	5.2	CF	84	16.5	CF	13	2.6	CF	36	6.9	CF	75	14.8
SC	50	10.0	SC	186	36.5	SC	85	17.0	SC	6	1.1	SC	31	6.1
PA	1	0.2	PA	0	0.0	PA	0	0.0	PA	0	0.0	PA	0	0.0
CG	278	55.6	CG	212	41.6	CG	344	68.8	CG	442	84.5	CG	384	75.6
SH	44	8.8	SH	8	1.6	SH	7	1.4	SH	2	0.4	SH	0	0.0
MH	7	1.4	MH	0	0.0	MH	5	1.0	MH	0	0.0	MH	0	0.0
Total	500	100.0	Total	510	100.0	Total	500	100.0	Total	523	100.0	Total	508	100.0

Table 19: FFGs, all sites, February 2013 (note: The predominant FFG been highlighted).

Panther			Waukell			Salt			Richardson			Spruce		
Type	Count	Percentage	Type	Count	Percentage	Type	Count	Percentage	Type	Count	Percentage	Type	Count	Percentage
P	89	17.66	P	87	17.40	P	77	15.01	P	35	6.94	P	41	8.13
CF	25	4.96	CF	5	1.00	CF	16	3.12	CF	67	13.29	CF	10	1.98
SC	44	8.73	SC	70	14.00	SC	55	10.72	SC	2	0.40	SC	100	19.84
PA	0	0.00	PA	1	0.20	PA	0	0.00	PA	0	0.00	PA	2	0.40
CG	254	50.40	CG	297	59.40	CG	331	64.52	CG	396	78.57	CG	342	67.86
SH	91	18.06	SH	40	8.00	SH	33	6.43	SH	4	0.79	SH	9	1.79
MH	1	0.20	MH	0	0.00	MH	0	0.00	MH	0	0.00	MH	0	0.00
PH	0	0.00	PH	0	0.00	PH	1	0.19	PH	0	0.00	PH	0	0.00
XY	0	0.00	XY	0	0.00	XY	0	0.00	XY	0	0.00	XY	0	0.00
OM	0	0.00	OM	0	0.00	OM	0	0.00	OM	0	0.00	OM	0	0.00
Total	504	100	Total	500	100	Total	513	100	Total	504	100	Total	504	100

Table 20: FFGs, all sites, August 2013 (note: The predominant FFG has been highlighted).

Panther			Waukell			Salt			Richardson			Spruce		
FFG	Count	Percentage	FFG	Count	Percentage	FFG	Count	Percentage	FFG	Count	Percentage	FFG	Count	Percentage
P	92	17.3	P	48	9.1	P	85	16.5	P	57	11.0	P	55	10.5
CF	47	8.8	CF	9	1.7	CF	28	5.4	CF	142	27.5	CF	52	9.9
SC	20	3.8	SC	38	7.2	SC	40	7.8	SC	5	1.0	SC	11	2.1
PA	1	0.2	PA	5	0.9	PA	0	0.0	PA	0	0.0	PA	0	0.0
CG	339	63.7	CG	372	70.5	CG	339	66.0	CG	311	60.3	CG	395	75.5
SH	25	4.7	SH	54	10.2	SH	6	1.2	SH	0	0.0	SH	7	1.3
MH	8	1.5	MH	2	0.4	MH	10	1.9	MH	1	0.2	MH	0	0.0
PH	0	0.0	PH	0	0.0	PH	1	0.2	PH	0	0.0	PH	0	0.0
XY	0	0.0	XY	0	0.0	XY	0	0.0	XY	0	0.0	XY	0	0.0
OM	0	0.0	OM	0	0.0	OM	5	1.0	OM	0	0.0	OM	3	0.6
Total	532	100.0	Total	528	100.0	Total	514	100.0	Total	516	100.0	Total	523	100.0

The most dominant FFG through all WCs and throughout the 3 sampling events was Collector/Gatherer (CG). This type on average comprises 60-75 % of the community throughout all WCs. In general, the remaining percentage (25-40 %) of FFG types are composed of Predators (P), Scrapers (SC), Collector/Filterers (CF), and to a smaller extent Shredders (SH). Within WCs there does not appear to be any consistent ranking by proportion for these lesser dominant types. Very rarely did a type other than CG break the 20% mark, which occurred on two occasions. In Waukell WC during May 2012, SC comprised 36.5 %, while CG made up 41% (the lowest of any site at any time), indicating Waukell may offer a relative increase in habitats enabling FFG type diversity. In Richardson WC, in August 2013, CF comprised 27.5%, along with 60.3%CG. This increase in CF compared to other sampling events may be due to the dense proliferation of macroalgae throughout the water column observed during this sampling event coupled with low dissolved oxygen levels.

Tolerance Values

Tolerant taxa inhabit a wide range of habitats and tolerate a wide range of conditions. The number of tolerant taxa may not change with impairment, but the relative abundance of tolerant organisms tends to increase as the amount of impairment to the site increases. This might be measured by the proportion of known taxa, or by the proportion represented by the dominant two or three taxa to the sample count (US EPA 2002).

Tolerance values assigned to stream invertebrates may not be applicable to wetlands invertebrates because many wetlands invertebrates are tolerant of, or adapted to, the fluctuating oxygen condition in wetlands. However for wetlands there is little or no existing information on their tolerances to human caused impairments (US EPA 2002). In addition, some wetland macroinvertebrates have adapted into “wetland specialists”. For example, water boatmen; backswimmers; diving beetles and marsh beetles; fairy shrimp, clam shrimp, and tadpole shrimp; mosquitoes; marsh flies; biting midges; horse and deer flies; the snails in the families Physidae, Lymnaeidae, and Planorbidae; and fingernail clams (Wissinger 1999).

For the purposes of this study, tolerance values are obtained from the CAMLnet (Ode, 2003) and for specific species not encountered in CAMLnet, from the Nor Cal Freshwater depressional wetland IBI document (Lunde and Resh 2011). Values range from 1-10 for each individual encountered. Generally speaking, the higher the tolerance value, the more likely the species is to be found in poor water quality conditions.

Table 21: Tolerance Values, WCs, May 2012 (note: The predominant tolerance value has been highlighted).

Panther			Waukell			Salt			Richardson			Spruce		
TV	Count	Percentage	TV	Count	Percentage	TV	Count	Percentage	TV	Count	Percentage	TV	Count	Percentage
1	6	1.2	1	2	0.4	1	6	1.2	1	0	0.0	1	0	0.0
2	10	2.0	2	9	1.8	2	13	2.6	2	2	0.4	2	5	1.0
3	35	7.0	3	6	1.2	3	3	0.6	3	1	0.2	3	0	0.0
4	15	3.0	4	13	2.5	4	20	4.0	4	2	0.4	4	0	0.0
5	70	14.0	5	59	11.6	5	55	11.0	5	24	4.6	5	10	2.0
6	234	46.8	6	230	45.1	6	214	42.8	6	99	18.9	6	157	30.9
7	32	6.4	7	19	3.7	7	18	3.6	7	12	2.3	7	7	1.4
8	88	17.6	8	146	28.6	8	142	28.4	8	334	63.9	8	172	33.9
9	4	0.8	9	0	0.0	9	1	0.2	9	0	0.0	9	0	0.0
10	6	1.2	10	25	4.9	10	28	5.6	10	49	9.4	10	157	30.9
Total	500	100.0	Total	510	99.8	Total	500	100.0	Total	523	100.0	Total	508	100.0

Table 22: Tolerance Values, all WCs, February 2013(note: The predominant tolerance value has been highlighted).

Panther			Waukell			Salt			Richardson			Spruce		
TV	Count	Percentage	TV	Count	Percentage	TV	Count	Percentage	TV	Count	Percentage	TV	Count	Percentage
0	0	0.00	0	32	6.40	0	0	0.00	0	0	0.00	0	0	0.00
1	4	0.79	1	20	4.00	1	1	0.19	1	0	0.00	1	0	0.00
2	5	0.99	2	55	11.00	2	1	0.19	2	0	0.00	2	1	0.20
3	88	17.46	3	17	3.40	3	33	6.43	3	4	0.79	3	9	1.79
4	1	0.20	4	39	7.80	4	5	0.97	4	0	0.00	4	4	0.79
5	21	4.17	5	52	10.40	5	22	4.29	5	13	2.58	5	29	5.75
6	206	40.87	6	127	25.40	6	196	38.21	6	46	9.13	6	187	37.10
7	33	6.55	7	43	8.60	7	42	8.19	7	3	0.60	7	13	2.58
8	120	23.81	8	79	15.80	8	158	30.80	8	314	62.30	8	111	22.02
9	6	1.19	9	0	0.00	9	3	0.58	9	4	0.79	9	2	0.40
10	20	3.97	10	36	7.20	10	52	10.14	10	120	23.81	10	148	29.37
Total	504	100	Total	500	100	Total	513	100	Total	504	100	Total	504	100

Table 23: Tolerance Values, all WCs, August 2013 (note: The predominant tolerance value has been highlighted).

Panther			Waukell			Salt			Richardson			Spruce		
TV	Count	Percentage	TV	Count	Percentage	TV	Count	Percentage	TV	Count	Percentage	TV	Count	Percentage
0	0	0.0	0	0	0.0	0	0	0.0	0	0	0.0	0	0	0.0
1	0	0.0	1	56	10.6	1	11	2.1	1	0	0.0	1	0	0.0
2	11	2.1	2	1	0.2	2	8	1.6	2	1	0.2	2	12	2.3
3	20	3.8	3	0	0.0	3	5	1.0	3	0	0.0	3	7	1.3
4	8	1.5	4	38	7.2	4	6	1.2	4	1	0.2	4	0	0.0
5	30	5.7	5	85	16.1	5	36	7.0	5	6	1.2	5	31	5.9
6	208	39.8	6	261	49.4	6	187	36.4	6	44	8.5	6	221	42.3
7	36	6.9	7	17	3.2	7	41	8.0	7	27	5.2	7	5	1.0
8	147	28.2	8	54	10.2	8	186	36.2	8	169	32.8	8	122	23.3
9	9	1.7	9	0	0.0	9	13	2.5	9	17	3.3	9	13	2.5
10	53	10.2	10	16	3.0	10	21	4.1	10	251	48.6	10	112	21.4
Total	522	100.0	Total	528	100.0	Total	514	100.0	Total	516	100	Total	523	100

Tolerance values appear to be dominated by the same values (6 and 8) throughout sampling events. However, significant changes in Panther and Waukell WCs occurred during the February 2013 sampling event; an increase in the value of 3 in Panther, and rise in value 2 in Waukell. Conversely, Richardson WC showed an increase in the percentage of value 10 during the February 2013 sample (Table 22) when compared to May 2012 (Table 21).

Water Temperature

Water temperature plays a key role in the metabolism, growth, development, and reproduction of aquatic insects (Anderson and Cummins 1979). One of the major factors determining the distribution of aquatic insects along gradients of elevation and latitude is water temperature (Vannote and Sweeney 1980). Differing water temperatures between WCs are one factor in why macro invertebrate sample results differ between complexes. From May to October in 2012 and 2013, water temperatures were clearly stratified throughout the complexes (Figure 14). Although the water temperature is a factor in differing macroinvertebrate communities between complexes, it was not a goal of this study to quantify this relationship. Rather, the temperature data can be best used to evaluate optimal conditions for juvenile salmonids. By evaluating temperature and food sources, the functionality of WCs as rearing habitat becomes better understood.

During the project time period (February 2012 to August 2013) YTEP collected water temperature data within each WC (excluding Richardson Creek Wetland Complex) using continuous water temperature loggers. A data gap occurring in each temperature profile occurred in May-June 2013, while data loggers were calibrated. This data gap has been linearly interpolated and caution should be used when making an inference about this time period. Temperature data was collected to provide background information on these wetland habitats and followed the procedures outlined YTEP's USEPA- approved quality assurance document for water quality monitoring in wetlands (Patterson, 2010). In 2010 YTEP implemented a comprehensive water quality study to characterize several important water quality parameters and their relationship to juvenile salmonid habitat function. For staffing and funding reasons a comprehensive approach to water quality monitoring was not implemented in this study. For more in depth look at KRE WC water quality refer to the report "Klamath River Estuary Wetlands 2010 Water Quality Monitoring Report – *Investigating Relationships with CRAM, Water Quality and Juvenile Salmonid Habitat Function* (Patterson and Beesley 2011). Temperature data here within the following report has been evaluated based upon the optimal temperatures (thresholds) for juvenile salmonids previously outlined in 2010 (Figures 11-18)

Water temperature data for each site has been analyzed using the following statistics, the daily average 7 day average temperature (Figure 14), the daily maximum seven day running average temperature, and the daily minimum 7 day running average temperature (Figures 15-21).

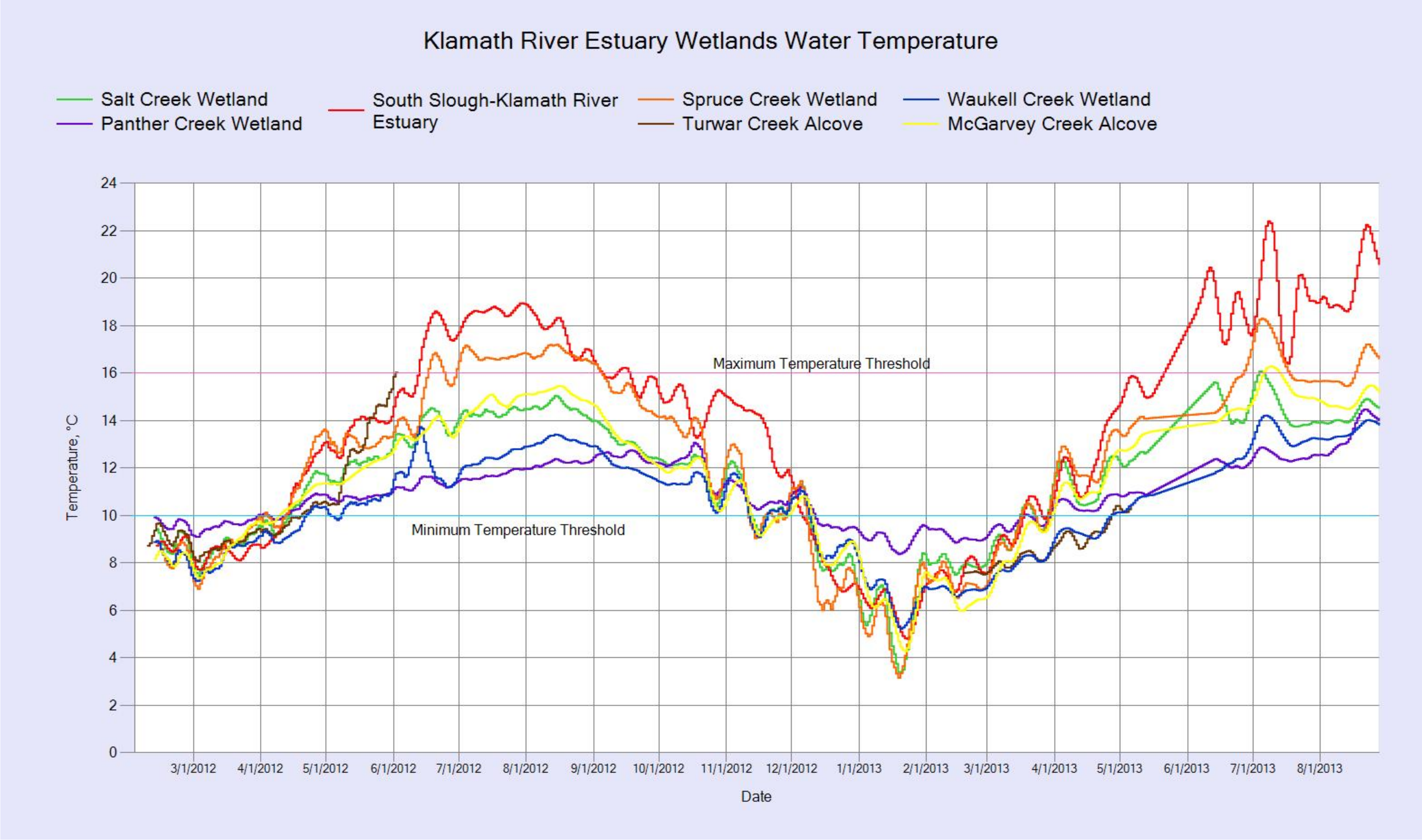

Figure 14: Water Temperature, all sites. During winter months all sites were similar in temperature, below optimal conditions for juvenile salmonids; yet Panther Creek WC was visibly warmer. During summer months significant stratification exists, showing Panther and Waukell to be the coolest, while the South Slough and Spruce complexes exceeded optimal conditions. (Note: A linearly interpolated data gap exists for all sites from mid-May 2013 to mid- June 2013 and appears as an uncharacteristically straight portion of the temperature profile, this interpolation is also apparent in the following graphs.)

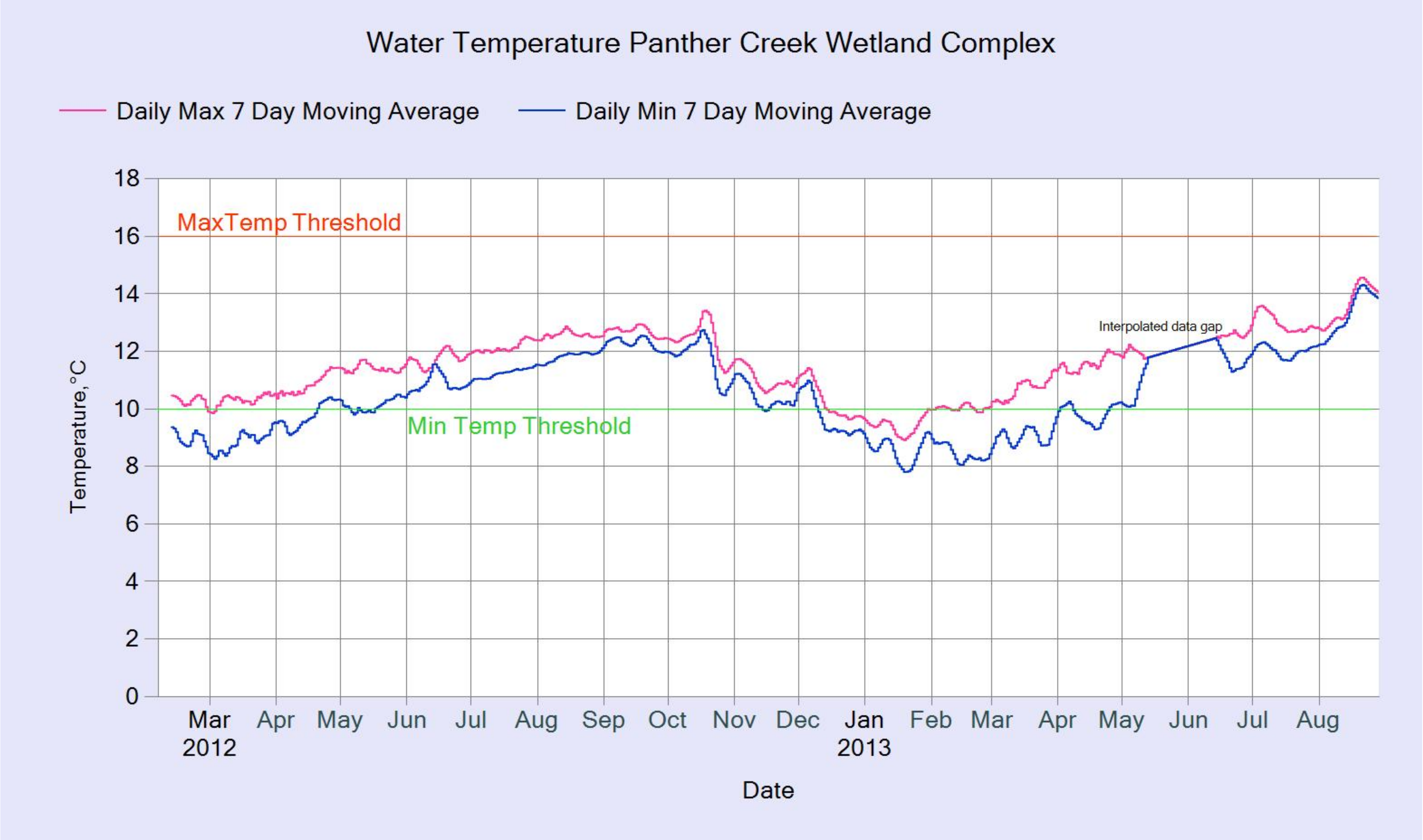

Figure 15: Water Temperature, Panther Creek Wetland Complex. Appearing to be the most optimal of all complexes, Panther Creek WC showed cool temperatures in summer warmer temperatures in the winter when compared to other complexes. Temperatures are relatively stable throughout the seasons, and on a daily basis.

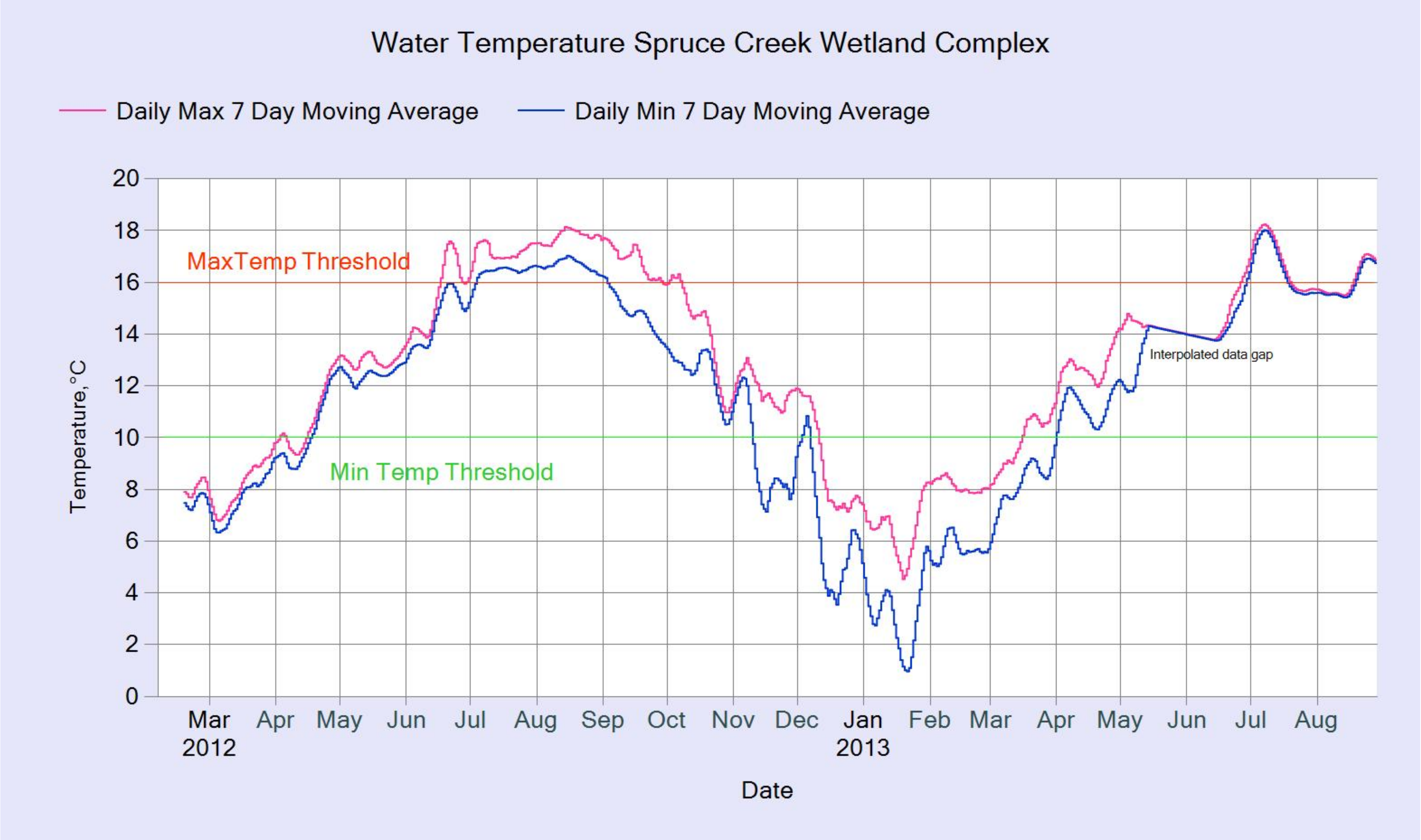

Figure 16: Water Temperature, Spruce Creek WC. Optimal temperatures here were present in the spring months, April to June and in fall months September -November. Due to the extremely low rainfall and cold air temperatures, water temperature daily minimums plummeted in January 2013 to the lowest of all sites.

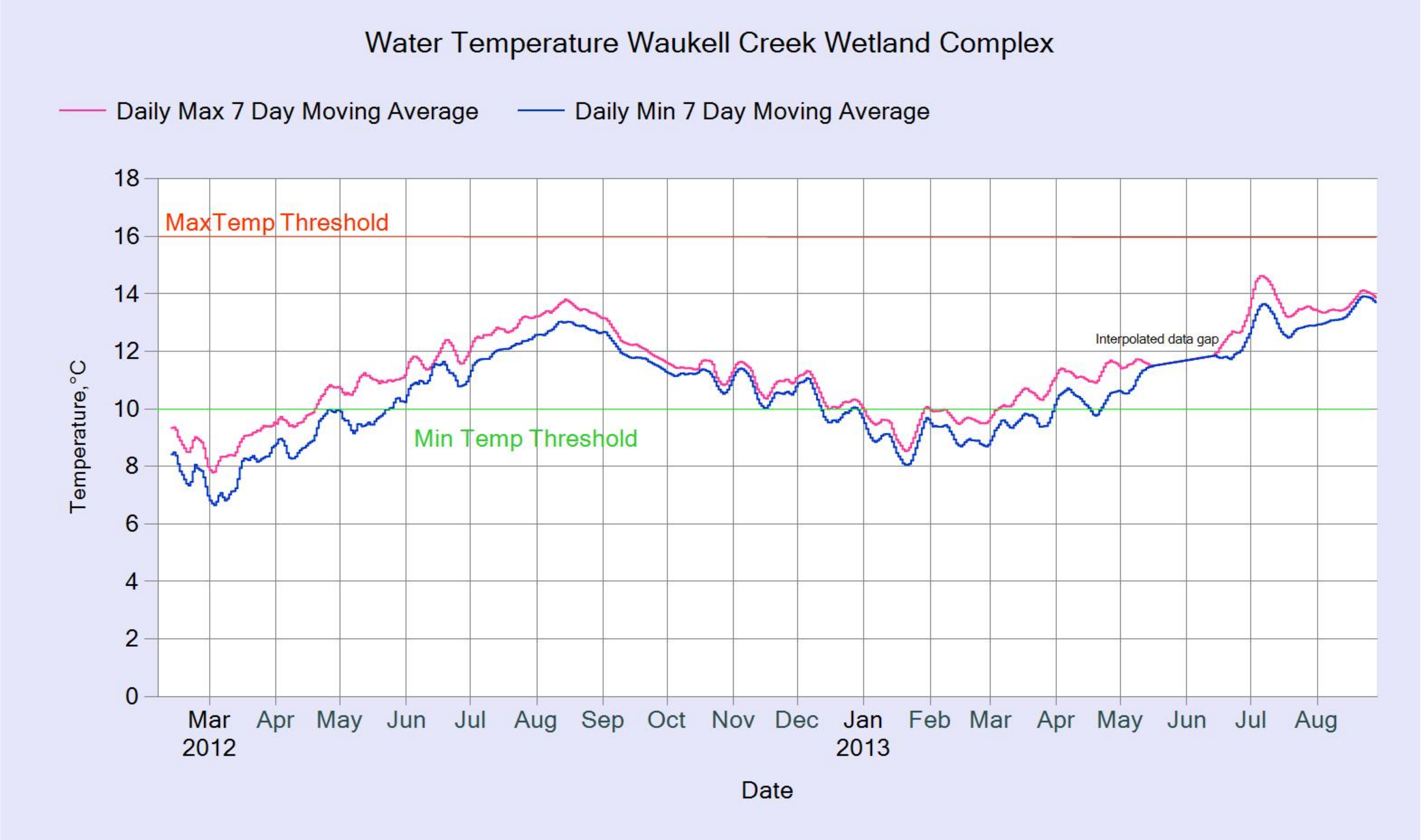

Figure 17: Water Temperature, Waukell Creek WC. Optimal temperatures existed during most moths, with minimum temps dropping below threshold in the winter and extending through April. Throughout the year the difference between daily minima and maxima are relatively small when compared to other complexes, likely due to the abundance of dense vegetative cover.

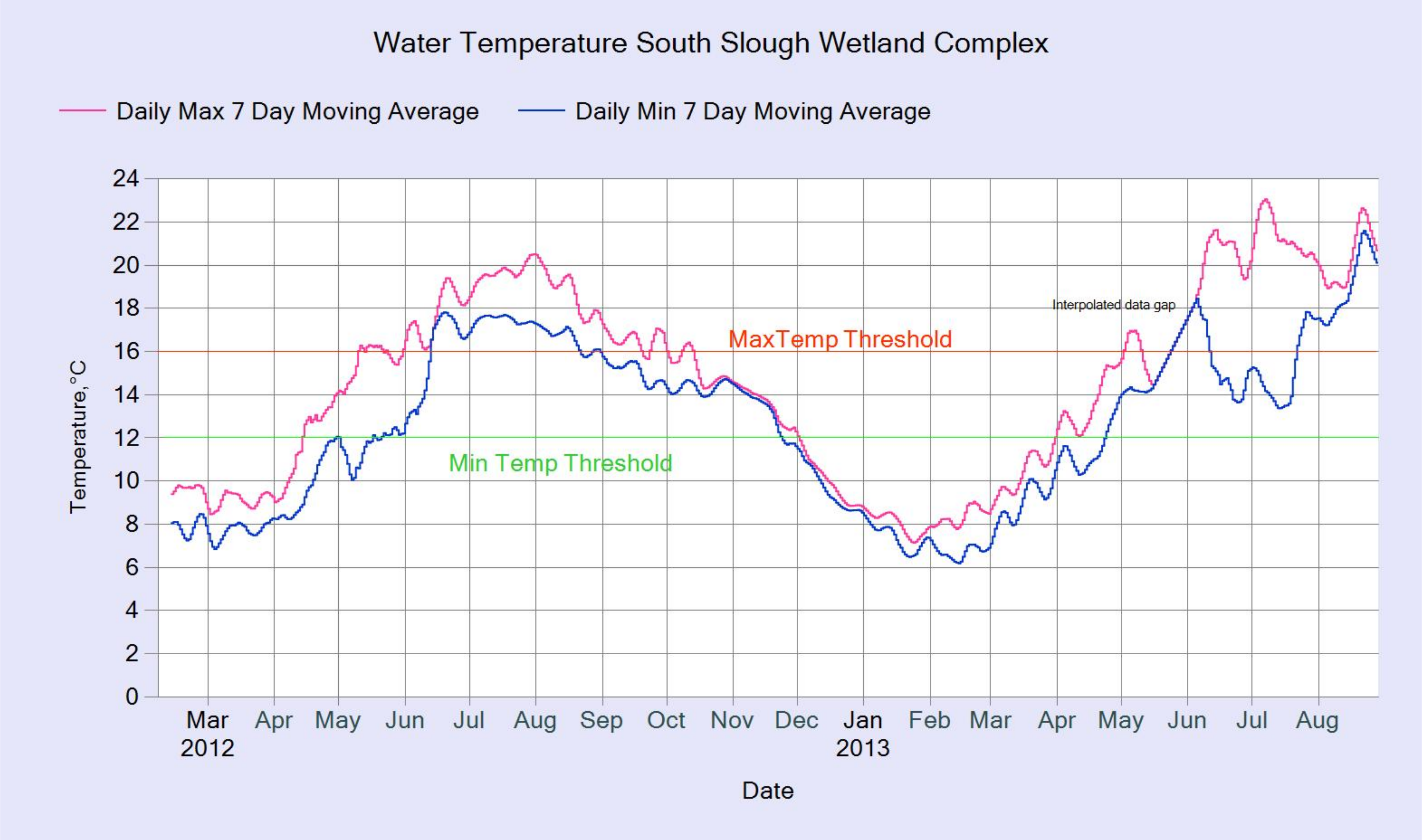

Figure 18: Water Temperature, South Slough WC. Of all sites the extremes were located here. In summer it is the warmest, significantly exceeding maximum threshold from May through October. Minimum temperatures in winter fell well below optimal beginning in December, and extending through March. Optimal conditions here existed for the shortest time of all complexes with year round standing water.

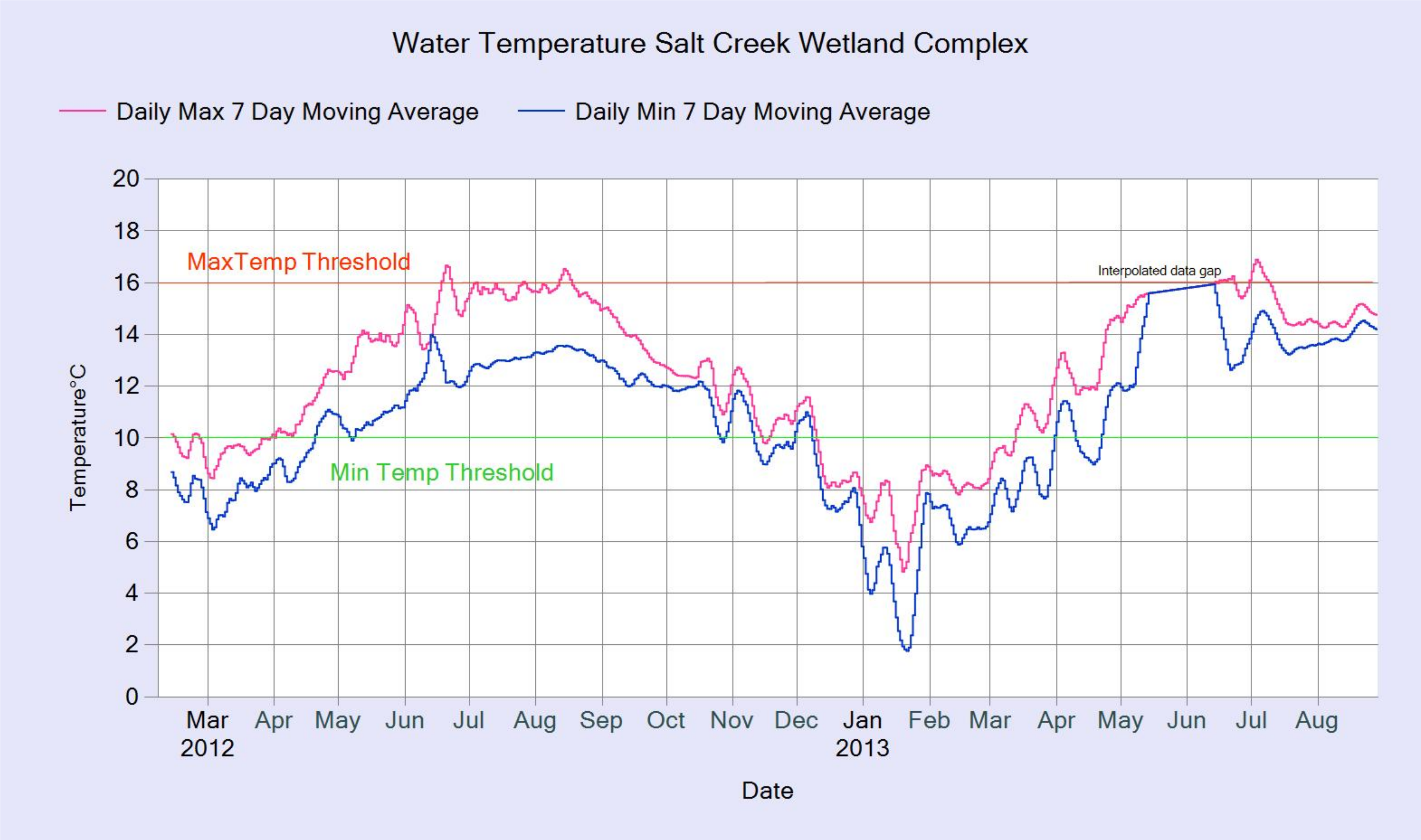

Figure 19: Water Temperature, Salt Creek WC. Water temperatures here were optimal for most of the year, excluding the winter when temperatures dropped below optimal. However, a significant daily variation between minima and maxima is observed in the spring and summer

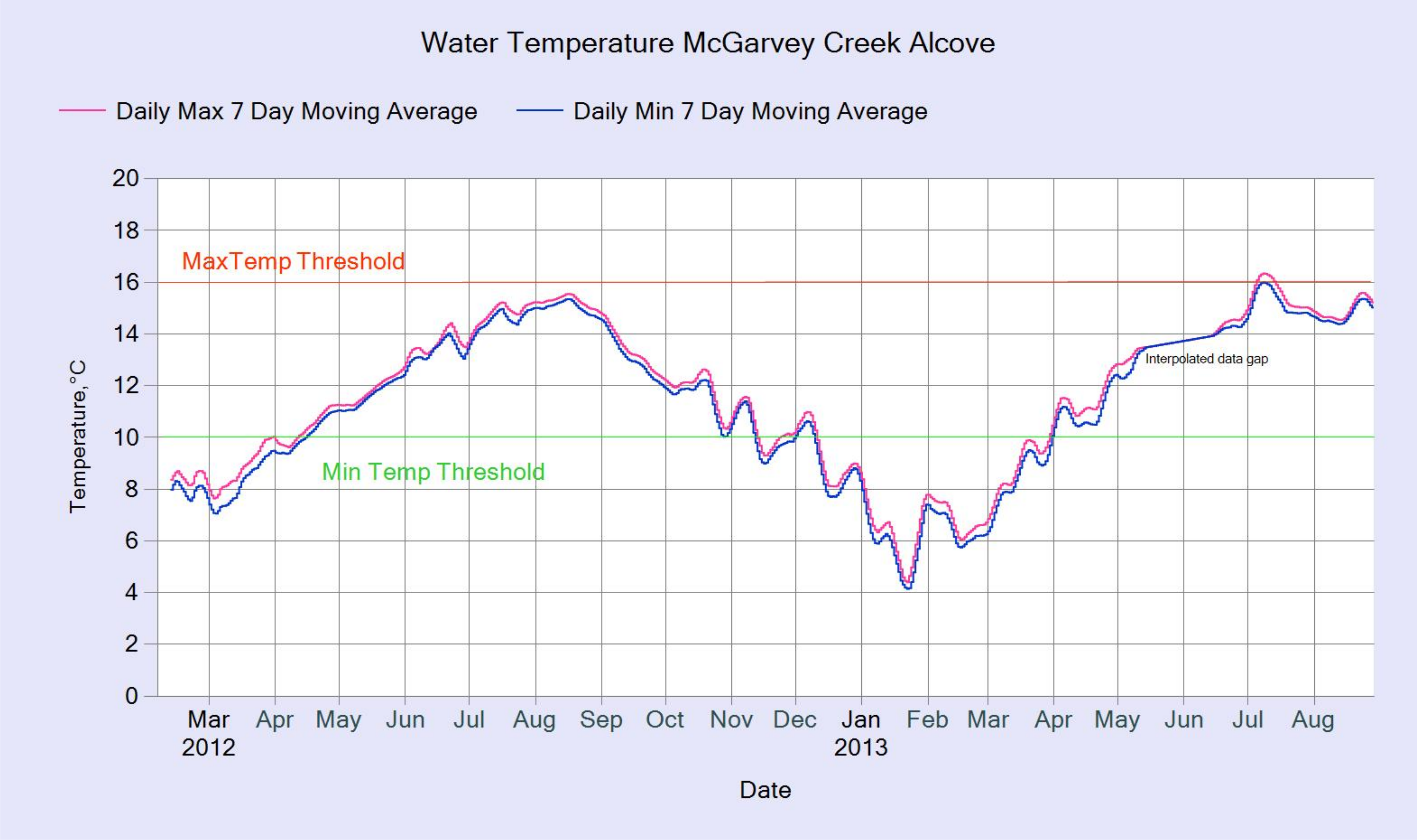

Figure 20: Water Temperature, McGarvey Creek Alcove. Water temperatures were optimal for most of the year, dropping below minimum threshold temperature for winter months. The daily minima and maxima are very close throughout the year in this complex.

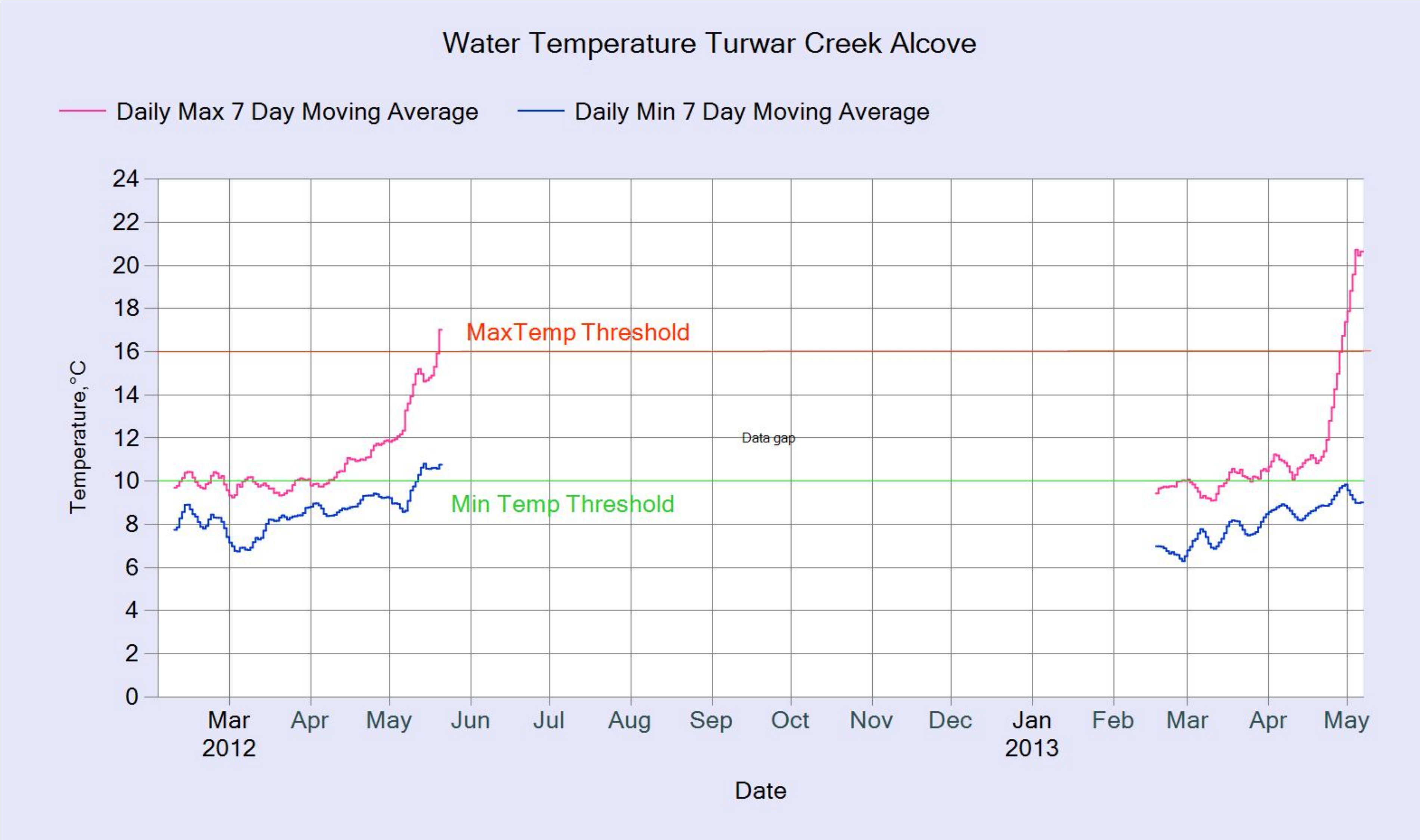

Figure 21: Water Temperature, Turwar Creek Alcove. Limited data exists for the alcove for several reasons; one, the alcove goes dry typically in early May. Water is present again, depending on rainfall, usually by mid-November. Second, Data was not collected during November 2012 and February 2013 due to data logger malfunction. Based on available data, optimal conditions appear to be present April and shortly thereafter in early to mid-May water temperatures rise as the alcove dries.

VI. Discussion

Benthic Macroinvertebrate Sampling

Initial investigations in BMI communities found in freshwater wetlands of the KRE are useful in documenting baseline conditions for tracking trends over time. In making comparisons between WCs some similarities can be seen, providing useful insight to common conditions within the KRE region. This information can be used to understand stressors, which are controlled or perhaps influenced through land use management, restoration projects, mitigation projects, etc.

Although a diverse range of BMIs were encountered, several families of BMIs were consistently encountered as dominant in KRE WCs, thus highly influencing metric scores. The single most encountered species were those belonging to the order of dipterans (true flies), predominantly the family of Chironomidae (non-biting midges), and specifically the sub-family *Chironominae* (Figure 22) followed by *Tanypodinae* (Figure 23).

Figure 22: Chironomidae *Chironominae* larvae

Figure 23*:* Chironomidae *Tanypodinae* larvae

Chironominae are classified as collector/gatherers, and have a tolerance value of 6, while *Tanypodinae* are predators and have a tolerance value of 7. Chironomids are known to feed on a variety of substances (Merritt and Cummins 2004). Chironomids have four life stages: egg larva, pupa and adult. The duration of the larval stage is dependent upon environmental conditions, such as water temperature and food sources (Merritt and Cummins 2004), but most are univoltine of trivoltine (1-3 generation per year) in seasonal climates (Tokeshi 1995).

Secondarily, dominant BMIs encountered included the family of oligochaetes (aquatic worms), specifically the genus *Tubifidica* (Figure 24). *Tubifidica* are collector/gatherers and have a tolerance value of 10. Often an indicator of pollution, oligochaetes can tolerate anoxic conditions, and they are most commonly found in soft sediments rich in organic matter (Pennak 1978). Oligochaetes may reproduce by fragmentation, but most are sexually reproducing hermaphrodites (Peckarsky et al 1990).

Figure 25: Oligochaetae *Tubifidica*

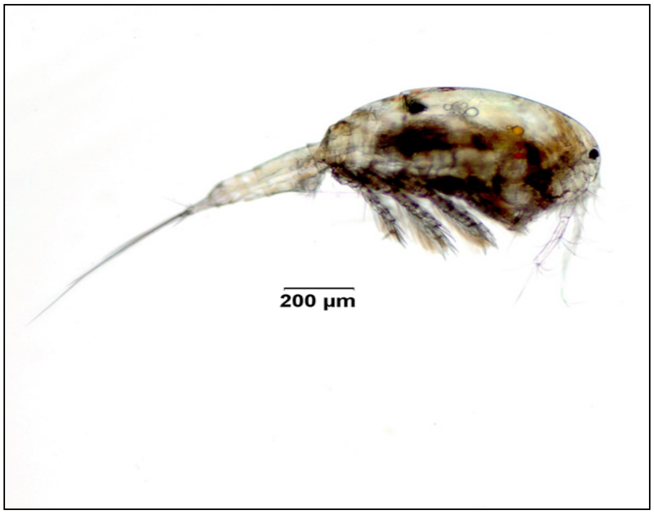

Figure 26: Copepodae Cyclopidae *Macrocyclops*

Another BMI commonly encountered were copepods, or crustaceans. The family Cyclopidae was particularly numerous, with genus identification being somewhat difficult, but presumed to be *Macrocyclop*s (Figure 26). *Macrocyclops* are collector/gatherers with a tolerance value of 8. The species has been known to feed on mosquito larvae, and used in vector control. The species is relatively small and a food source for planktonic feeders. The copepod population peaks in September and October (Merritt and Cummins 2004).

Not nearly as common aforementioned, yet still a numerous BMI encountered, were cladocerans of the genera *Ilyocryptus* and *Eurycerus*. These crustaceans are commonly known as water fleas (Figure 27). These species are classified as collector/filterers and collector/gatherers and both have a tolerance value of 8. These herbivores mainly feed on phytoplankton, decaying organic material, and bacteria .They reproduce by parthenogenesis, a process in which favorable conditions causes asexual cloning of females, and poor environmental conditions causes sexual reproduction with males (Smith and Work 2001). Their life expectancy has been documented at anywhere between 25 and 100 days (Pennak 1978).

Figure 27: Cladocerae Iilyocryptidae *Ilyocrptus*

Figure 28: Basommatophora Planorbidae *Menetus*

In addition, a high number of aquatic snails were commonly encountered. These gastropods, belonging to the order Bassomatophora, were mostly identified as the family Planorbidae, and most commonly the genus *Menetus* (Figure 28). *Menetus* are classified as scrapers and have a tolerance value of 6. This organism respires utilizing a pulmonate or lung rather than gills. These hermaphroditic individuals reproduce sexually, often extruding gelatinous egg containing sacs onto vegetation (Pennak 1978).

Although not encountered as frequently overall, in specific WCs during February 2013, trichopterans and ephemopterans were found in numbers which made them secondary dominants. The trichopterans (Caddis fly larvae), genus *Limnephilus* (Figure 29) of the family Limnephilidae, were the most common encountered. *Limnephilus* are classified as shredders and have tolerance value of 3. Most shredder species feed on fungi and bacteria attaching to decomposing leaf material. Known for the cases in which they build and inhabit, these species create protection from predators and can gain an internal respiratory advantage. This species is univoltine in reproduction (1 generation per year) (Merritt and Cummins 2004).

Figure 29: Trichoptera Limnephilidae *Limnephilus*

Figure 30: Ephemeroptera Leptophlebiidae *Paraleptophlebia*

Ephemopterans (mayflies), when encountered were predominantly comprised predominantly of 3 genera: *Paraleptophlebia*, of the Leptophlebiidae family, *Cinygma* of the Heptageniidae family, and *Siphlonurus* of the Siphlonuridae family. *Paraleptophlebia* (Figure 30), the most common, are collector/gatherers with a tolerance value of 4. *Cinygm*a are classified as scrapers and have a tolerance value of 2. *Siphlonurus* are classified as collector/gatherers and have a tolerance value of 7. These species feed on a variety of detritus, algae and some macrophyte animal material. These species are univoltine, with temperature playing a large role in hatching (Merritt and Cummins 2004).

Although a regionally validated wetland IBI is not available, YTEP plans to use the best available IBI's and basic evaluation of FFGs and Tolerance Values. YTEP has been able to develop baseline BMI data in wetlands, as well as compare these WCs to one another.

In evaluation of BMI samples for comparison between sites the emphasis has been placed upon those samples (May 2012) which coincided within the recommended sampling index period. An index period is recommended to avoid variation in BMI assemblages coinciding with seasonal changes. During the index period BMIs are large enough to be identified, yet, have not yet emerged. (Barbour et al.1999; Trigal et al. 2006; Lunde et al.

2010). The index period in specific areas of California can vary based on climate, and annual rainfall variations, and for the Lower Klamath region has been established as May 1st to July 15th.

In evaluating seasonal variation of macroinvertebrate community assemblages within each complex, the following tables have been created which show the results for each sampling event. The temporal differences in each score and /or metric can provide a glimpse into the dynamic fluctuations occurring at the ecosystem level.

Spruce Creek Wetland Complex

Samples Collected May 2012:

The two most dominant BMIs encountered in May of 2012 within Spruce Creek WC, were first oligochaetes followed by dipterans (chironomids). IBI scores for Spruce Creek are the lowest of all WCs found in the KRE, consisting of a 45 in the Nor Cal wetland IBI, and 15 in the Nor Cal stream IBI. Compared to other KRE WCs these were significantly lower scores (Table 8, 11). In comparative evaluation of primary metrics Spruce Creek had the lowest Taxa Richness, EPT Taxa, Sensitive EPT, and Shannon's DI (Table 1). It scored the highest of all complexes in, Tolerance Value, and second highest in Relative Abundance (Table 1). The dominant FFG found, was collector /gatherer (CG), representing 75.9 % of individuals encountered (Table 18). The tolerance values of individuals encountered appear to represent moderately high tolerant conditions in general. 30.91% had a value of 6, 33.86% had a value of 8 and 30.91% had a tolerance value of 10. The next closest percentage of individuals with a tolerance value of 10 was 9.37 % found in the Richardson complex (Table 21).

Seasonal Variation:

The dominant BMIs encountered during February and August of 2013, were the same as May 2012, consisting of first oligochaetes, followed by dipterans (chironomids). The Nor Cal Freshwater Depressional Wetlands IBI score had a significant difference between samples taken at each of the three sampling events (Table 24). The highest overall score is likely in large part due to the increase in one metric score in the March 2013 Sample (% Tanypodinae/Chironomidae) (Table 24).

Table 24: Nor Cal Freshwater Depressional Wetlands IBI scores, Spruce Creek WC

Wetland Complex	Date Sampled	Total # of Specimens	% 3 Dominant Taxa	% Tanypodinae / Chironomidae	% Coleoptera	% EOT	Scraper Richness	EOT Richness	Oligochaeta Richness	Predator Richness	Overall Score
Spruce	5/24/2012	508	68.5	5.2	0.4	0.0	2.0	0.0	2.0	8.0	45.0
Spruce	3/6/2013	504	64.3	11.7	0.8	3.0	3.0	4.0	1.0	13.0	65.0
Spruce	8/12/2013	523	69.0	2.3	0.6	3.8	4.0	2.0	1.0	11.0	56.3

The Nor Cal streams IBI score were highest during August of 2013, due in large part to the increase in the metric score for % Predator Individuals, and a decrease in the metric score for % Non-Insect Taxa (Table 25).

Table 25: Nor Cal Streams IBI scores, Spruce Creek WC

Wetland Complex	Date Sampled	Total # of Specimens	EPT Richness	Coleoptera Richness	Diptera Richness	% Intolerant Individuals	% Non-Gastropod Scrapers	% Predator Individuals	% Shredder Taxa	% Non-Insect Taxa	Overall Score
Spruce	5/24/2012	508	0.0	2.0	5.0	1.0	0.0	4.0	0.0	63.0	15.0
Spruce	3/6/2013	504	3.0	2.0	5.0	0.2	0.0	8.1	2.9	58.8	20.0
Spruce	8/12/2013	523	1.0	2.0	8.0	2.0	0.0	11.0	3.0	52.0	26.0

Primary Metric scores revealed the highest scores for Taxa Richness occurring in August 2013, a 10 point change from samples collected in May 2012. The metric score for Percent Dominant Taxon was significant higher in the February 2013 sample (Table 26).

Table 26: Primary Metric Scores, Spruce Creek WC

Date:	5/17/2012	3/6/2013	8/12/2013
Total:	508.0	523.0	504.0
Taxa Richness:	24.0	29.0	34.0
EPT Richness:	0.0	1.0	3.0
Sensitive EPT:	0.0	1.3	1.8
% Dominant Taxon:	30.9	37.9	29.4
Tolerance Value:	7.9	7.2	7.5
Shannon's D.I.:	2.0	2.1	2.3
Estimated Relative Abundance:	14488.0	8368.0	5902.0

FFG analysis revealed dominance in the Collector/Gatherer (CG) class for all three samples (Table 27). Scrapers (SC), Predators (P), and Collector/Filterer (CF) make up the remaining community assemblage and slightly fluctuate in percentage between events.

Table 27: FFGs, Spruce Creek WC

Spruce 5/24/2012			Spruce 3/6/2013			Spruce 8/12/2013		
Type	Count	Percentage	Type	Count	Percentage	Type	Count	Percentage
P	18	3.5	P	41	8.1	P	55	10.5
CF	75	14.8	CF	10	2.0	CF	52	9.9
SC	31	6.1	SC	100	19.8	SC	11	2.1
PA	0	0.0	PA	2	0.4	PA	0	0.0
CG	384	75.6	CG	342	67.9	CG	395	75.5
SH	0	0.0	SH	9	1.8	SH	7	1.3
MH	0	0.0	MH	0	0.0	MH	0	0.0
Total	508	100.0	Total	504	100.0	Total	523	100.0

In general, tolerance values for BMI community assemblages for all three samples remained above 5. Consistently values of 6, 8 and 10 are found making up the largest percentages, and fluctuate slightly in proportions between sampling events (Table 28).

Table 28: Tolerance Values, Spruce Creek WC

Spruce 5/24/2012			Spruce 3/6/2013			Spruce 8/12/2013		
TV	Count	Percentage	TV	Count	Percentage	TV	Count	Percentage
0	0	0.0	0	0	0.0	0	0	0.0
1	0	0.0	1	0	0.0	1	0	0.0
2	5	1.0	2	1	0.2	2	12	2.3
3	0	0.0	3	9	1.8	3	7	1.3
4	0	0.0	4	4	0.8	4	0	0.0
5	10	2.0	5	29	5.8	5	31	5.9
6	157	30.9	6	187	37.1	6	221	42.3
7	7	1.4	7	13	2.6	7	5	1.0
8	172	33.9	8	111	22.0	8	122	23.3
9	0	0.0	9	2	0.4	9	13	2.5
10	157	30.9	10	148	29.4	10	112	21.4
Total	508	100.0	Total	504	100.0	Total	523	100.0

Figure 22: Upper Spruce Creek WC, sampling in May 2012.


Figure 23: Middle Spruce Creek WC. (Note the barb wire fence, the complex is surrounded by cattle ranching activities). Picture taken May 2012

Richardson Creek Wetland Complex

Samples Collected May 2012:

The two most dominant BMIs encountered in May of 2012 within Richardson WC, were first cladocerans followed by copepods. IBI scores for Richardson included a 68.75 in the Nor Cal stream IBI and a 19 in the Freshwater wetland IBI, ranking second lowest of all WCs (Tables 5, 8). Although the Nor Cal stream IBI score was similar to other WCs, the Wetland IBI score was significantly lower than the others (Table 5). Primary metrics revealed evidence of putting Richardson in second lowest position of all WCs, in regards to Taxa Richness, EPT Taxa, Sensitive EPT, and Shannon's DI (Table 1). Conversely Richardson scored the highest in Relative Abundance, and second highest in Tolerance Value (Table 1). The dominant FFG encountered was collector/ Gatherer (CG) representing 84.51% of individuals encountered (Table 12). Evaluation of Tolerance Values showed that conditions favor tolerant species in general. Of all individuals encountered 68.3% had a value of 8, while 18.93% had a value of 6, and 9.37% had a value of 10 (Table 15).

Seasonal Variation:

During February 2013, the dominant BMIs encountered were copepods, followed by oligochaetes. In August of 2013, oligochaetes were dominant followed by cladocerans. Nor Cal Freshwater Wetlands IBI scores showed differing scores for all three sampling events, the highest score occurred in May 2012. The most apparent change in a metric score was the Lower % 3 Dominant Taxa occurring in May 2012, and a significantly higher % Tanypodinae/Chironomidae occurring in August 2013 (Table 23).

Table 29: Nor Cal Freshwater Depressional Wetlands IBI scores, Richardson Creek WC

Wetland Complex	Date Sampled	Total # of Specimens	% 3 Dominant Taxa	% Tanypodinae / Chironomidae	% Coleoptera	% EOT	Scraper Richness	EOT Richness	Oligochaeta Richness	Predator Richness	Overall Score
Richardson	5/17/2012	523	61.8	11.0	1.3	1.0	3.0	4.0	1.0	9.0	68.8
Richardson	2/27/2013	504	74.4	4.8	0.0	1.8	1.0	3.0	1.0	9.0	43.8
Richardson	8/6/2013	517	76.4	23.8	0.2	3.3	2.0	1.0	1.0	8.0	51.3

Nor Cal Streams IBI scores remained low for all sampling events. The highest score occurred in May 2012, apparently due to a higher metric for % Shredder Taxa, and a lower metric score for % Non-Insect Taxa. Higher scores for % Predators occurred in August 2013 (Table 24).

Table 30: Nor Cal Streams IBI scores, Richardson Creek WC

Wetland Complex	Date Sampled	Total # of Specimens	EPT Richness	Coleoptera Richness	Diptera Richness	% Intolerant Individuals	% Non-Gastropod Scrapers	% Predator Individuals	% Shredder Taxa	% Non-Insect Taxa	Overall Score
Richardson	5/17/2012	523	3.0	1.0	5.0	0.0	0.0	7.0	7.0	57.0	19.0
Richardson	2/27/2013	504	1.0	0.0	3.0	0.0	0.0	6.9	4.2	62.5	13.0
Richardson	8/6/2013	517	0.0	1.0	4.0	0.0	0.0	11.0	0.0	62.0	14.0

Only two of the primary metrics were significantly different between sampling events; % Dominant Taxon was lowest in May 2012, and almost twice that value in February 2012. Conversely Taxa Richness was highest in May 2012, and lowest in February 2013 (Table 25).

Table 31: Primary Metric Scores, Richardson Creek WC

Date:	5/17/2012	2/27/2013	8/6/2013
Total:	523.0	516.0	504.0
Taxa Richness:	30.0	21.0	24.0
EPT Richness:	3.0	0.0	1.0
Sensitive EPT:	0.4	0.0	0.8
% Dominant Taxon:	26.8	48.6	43.1
Tolerance Value:	7.6	8.7	8.2
Shannon's D.I.:	2.2	1.8	1.9
Estimated Relative Abundance:	15280.0	4128.0	8848.0

Collector/Gatherer (CG) made up the dominant portion of FFGs, followed by Collector /Filterer (CF), and Predators (P). The later three appear to moderately fluctuate between sampling events, although Collector/Filterers, did show a significant increase in August 2013 (Table 26).

Table 32: FFGs, Richardson Creek WC

Richardson 5/17/2012			Richardson 2/27/2013			Richardson 8/6/2013		
Type	Count	Percentage	Type	Count	Percentage	Type	Count	Percentage
P	37	7.1	P	35	6.9	P	57	11.0
CF	36	6.9	CF	67	13.3	CF	142	27.5
SC	6	1.1	SC	2	0.4	SC	5	1.0
PA	0	0.0	PA	0	0.0	PA	0	0.0
CG	442	84.5	CG	396	78.6	CG	311	60.3
SH	2	0.4	SH	4	0.8	SH	0	0.0
MH	0	0.0	MH	0	0.0	MH	1	0.2
Total	523	100.0	Total	504	100.0	Total	516	100.0

In general tolerance values remained above 5 for all sampling events. Values of 8 remained consistently dominant in all three events, with a noticeable increase in values of 10 in the August 2013 sample (Table 27).

Table 33: Tolerance Values, Richardson Creek WC

Richardson 5/17/2012			Richardson 2/27/2013			Richardson 8/6/2013		
TV	Count	Percentage	TV	Count	Percentage	TV	Count	Percentage
0	0	0.0	0	0	0.0	0	0	0.0
1	0	0.0	1	0	0.0	1	0	0.0
2	2	0.4	2	0	0.0	2	1	0.2
3	1	0.2	3	4	0.8	3	0	0.0
4	2	0.4	4	0	0.0	4	1	0.2
5	24	4.6	5	13	2.6	5	6	1.2
6	99	18.9	6	46	9.1	6	44	8.5
7	12	2.3	7	3	0.6	7	27	5.2
8	334	63.9	8	314	62.3	8	169	32.8
9	0	0.0	9	4	0.8	9	17	3.3
10	49	9.4	10	120	23.8	10	251	48.6
Total	523	100	Total	504	100	Total	516	100

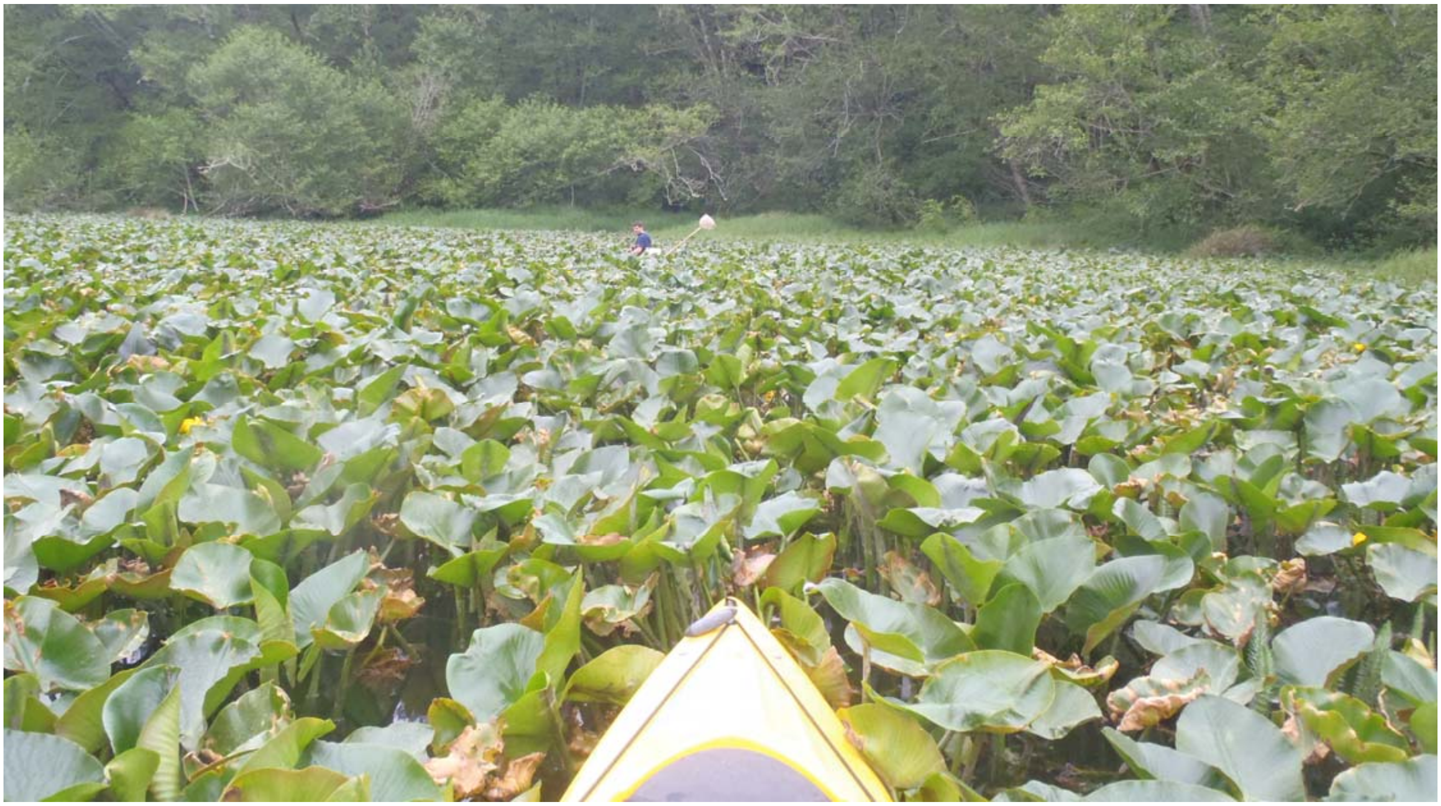

Figure 24: Richardson Creek WC, most of the complex is accessible only by kayak due to dense vegetation. Picture taken in May 2012.

Figure 25: Yellow Pond Lilies dominate the Richardson Creek WC. Picture taken in May 2012.

Salt Creek Wetland Complex

Samples Collected May 2012:

The two most dominant BMIs encountered during May 2012 within Salt Creek WC were dipterans (chironomids) followed by gastropods. The Nor Cal Stream IBI for Salt Creek was the highest among WCs with a score of 39 (Table 8), yet still represents poor stream condition. The Nor Cal wetland IBI score was 68.75, which placed it in even ranks with Panther and Waukell (Table 5). Primary metrics revealed the second highest scores in Taxa Richness, and EPT Richness, the highest score in Shannon's DI, and lowest in % Dominant Taxon (Table 1). The dominant FFG was Collector / Gatherer (CG) representing 68.8% of individuals encountered (Table 12). Tolerance values of individuals encountered appeared to represent tolerant conditions in general. 42.8% of individuals had a value of 6, and 28.63% had a value of 8 (Table 15).

Seasonal Variation:

During February of 2013, chironomids were dominant followed by copepods. Likewise, In August of 2013, chironomids were dominant followed by copepods. Nor Cal Freshwater Depressional Wetlands IBI scores remained very similar in all three sampling events. Metric scores were also very similar except for February 2013 % Tanypodinae/Chironomidae which was significantly higher, but in that same sampling event % 3 Dominant Taxa was significantly lower (Table 28).

Table 34: Nor Cal Freshwater Depressional Wetlands IBI Scores, Salt Creek WC

Wetland Complex	Date Sampled	Total # of Specimens	% 3 Dominant Taxa	% Tanypodinae / Chironomidae	% Coleoptera	% EOT	Scraper Richness	EOT Richness	Oligochaeta Richness	Predator Richness	Overall Score
Salt	5/16/2012	500	51.0	10.2	0.6	6.8	3.0	7.0	1.0	13.0	68.8
Salt	2/14/2013	513	44.1	24.7	0.2	7.8	5.0	8.0	1.0	13.0	68.8
Salt	8/7/2013	514	53.1	18.3	0.8	6.2	5.0	7.0	1.0	14.0	72.5

Nor Cal Streams IBI scores were similar in May 2012, and August 2013, but had a significantly lower score in February 2013. In February 2013 a higher metric score for % Non-Insect Taxa was present. In addition, metric scores for Diptera Richness, and % Tolerant Individuals were lower in February 2013 (Table 29).

Table 35: Nor Cal Streams IBI scores

Wetland Complex	Date Sampled	Total # of Specimens	EPT Richness	Coleoptera Richness	Diptera Richness	% Intolerant Individuals	% Non-Gastropod Scrapers	% Predator Individuals	% Shredder Taxa	% Non-Insect Taxa	Overall Score
Salt	5/16/2012	500	7.0	2.0	8.0	4.0	0.0	9.0	14.0	42.0	39.0
Salt	2/14/2013	513	7.0	1.0	4.0	0.4	0.2	15.0	8.3	52.8	26.0
Salt	8/7/2013	514	6.0	2.0	10.0	4.0	0.0	17.0	7.0	47.0	39.0

Primary metrics scores were similar for all sampling events. A noticeable increase in sensitive EPT occurred in February 2013, along with noticeable increases in % Dominant Taxon, and Taxa Richness in August 2013.

Table 36: Primary Metrics, Salt Creek WC

Date	5/16/12	2/14/13	8/7/13
Total:	500.0	513.0	514.0
Taxa Richness:	36.0	36.0	43.0
EPT Richness:	7.0	7.0	6.0
Sensitive EPT:	2.2	6.6	3.1
% Dominant Taxon:	23.2	21.6	27.6
Tolerance Value:	6.5	6.8	6.8
Shannon's D.I.:	2.6	2.7	2.7
Estimated Relative Abundance:	5313.0	3024.0	3138.0

FFGs were in large part dominated by Collector/Gatherer (CG), and followed by Predators (P), Scrapers (SC), and Collector /Filterers (CF). Shredders (SH) reached a noticeable percentage in February 2013 (Table 31).

Table 37: FFGs, Salt Creek WC

Salt 5/16/12			Salt 2/14/13			Salt 8/7/13		
Type	Count	Percentage	Type	Count	Percentage	Type	Count	Percentage
P	46	9.2	P	77	15.0	P	85	16.5
CF	13	2.6	CF	16	3.1	CF	28	5.4
SC	85	17.0	SC	55	10.7	SC	40	7.8
PA	0	0.0	PA	0	0.0	PA	0	0.0
CG	344	68.8	CG	331	64.5	CG	339	66.0
SH	7	1.4	SH	33	6.4	SH	6	1.2
MH	5	1.0	MH	0	0.0	MH	10	1.9
Total	500	100.0	Total	512	100.0	Total	512	100.0

Low tolerance values were found in Salt Creek WC during all sampling events, yet dominant tolerance values were consistently 5 and above. Largest tolerance values present were 6 and 8 in all sampling events (Table 32).

Table 38: Tolerance Values, Salt Creek WC

Salt 5/16/12			Salt 2/14/13			Salt 8/7/13		
TV	Count	Percentage	TV	Count	Percentage	TV	Count	Percentage
1	6	1.2	1	1	0.2	1	11	2.1
2	13	2.6	2	1	0.2	2	8	1.6
3	3	0.6	3	33	6.4	3	5	1.0
4	20	4.0	4	5	1.0	4	6	1.2
5	55	11.0	5	22	4.3	5	36	7.0
6	214	42.8	6	196	38.2	6	187	36.4
7	18	3.6	7	42	8.2	7	41	8.0
8	142	28.4	8	158	30.8	8	186	36.2
9	1	0.2	9	3	0.6	9	13	2.5
10	28	5.6	10	52	10.1	10	21	4.1
Total	500	100.0	Total	513	100.0	Total	514	100.0

Figure 26: Salt Creek WC, sampling node 3, one of the only locations encountered exhibiting dense surface algae. Picture taken in May 2012.

Figure 27: Salt Creek WC. Although densely vegetated, beaver dams, as pictured here create deep water pockets within the complex. Picture taken in May 2012.

Waukell Creek Wetland Complex

Samples Collected May 2012:

The two dominant species encountered during May 2012 in Waukell WC were gastropods, followed by chironomids. The IBI scores for the Waukell complex show nearly identical scores to that of Salt Creek. The Nor Cal Stream IBI score was 38 (Table 8) and the Nor Cal Wetland IBI score was 68.75 (Table 5). Evaluation of Primary Metrics revealed that Waukell scored the highest in Taxa Richness and EPT Richness, second highest in sensitive EPT, but also second highest in %Dominant Taxon (Table 1). The dominant FFG encountered was Collector / Gatherer (CG) representing 41.57%. However it should be noted that the highest percentage of Scrapers (SC) found anywhere in all WCs was found here representing 36.47% of individuals encountered. In addition, Collector/Filterers (CF) made up 16.47% the highest population encountered across all sites (Table 12). Waukell Creek WC is the only site where 3 FFG's greater than 15% were encountered (Table 12). Tolerance values of individuals encountered depict tolerant conditions in general. 41.5% had a value of 6, 28.63% had a value of 8 (Table 15).

Seasonal Variation:

In February 2013, dominant BMIS encountered were first chironomids, followed by ephemopterans. In August 2013, dominant BMIs were chironomids, followed by trichopterans. Nor Cal Freshwater Depressional Wetlands IBI scores showed slightly different scores in each of the sampling events. The highest score occurred in February 2013, the lowest occurring in August 2013. In February 2013, significant difference in the metric scores for % 3 Dominant Taxa, and %Tanypodinae/Chironomidae occurred. In addition, a higher metric score for % EOT was noticeable, as was EOT Richness (Table 33).

Table 39: Nor Cal Freshwater Depressional Wetlands IBI Scores, Waukell Creek WC

Wetland Complex	Date Sampled	Total # of Specimens	% 3 Dominant Taxa	% Tanypodinae / Chironomidae	% Coleoptera	% EOT	Scraper Richness	EOT Richness	Oligochaeta Richness	Predator Richness	Overall Score
Waukell	5/9/2012	510	60.0	10.9	0.6	7.3	6.0	8.0	1.0	9.0	68.8
Waukell	2/13/2013	500	31.2	20.0	0.6	26.6	4.0	12.0	2.0	8.0	75.0
Waukell	8/5/2013	528	65.9	3.5	0.2	17.0	3.0	4.0	1.0	8.0	63.8

The Nor Cal streams IBI scores varied widely between sampling events. The highest score occurred in February 2013, and the lowest in August 2013. A noticeable increase in EPT Richness is present in the February 2013 sample, as is % Tolerant Individuals, % Predator Individuals and % Shredder Taxa (Table 34).

Table 40: Nor Cal Streams IBI, Waukell Creek WC

Wetland Complex	Date Sampled	Total # of Specimens	EPT Richness	Coleoptera Richness	Diptera Richness	% Intolerant Individuals	% Non-Gastropod Scrapers	% Predator Individuals	% Shredder Taxa	% Non-Insect Taxa	Overall Score
Waukell	5/9/2012	510	10.0	3.0	9.0	2.0	1.0	4.0	11.0	37.0	38.0
Waukell	2/13/2013	500	17.0	2.0	5.0	21.4	4.2	17.4	21.1	26.3	58.0
Waukell	8/5/2013	528	4.0	1.0	4.0	11.0	0.0	9.0	8.0	50.0	26.0

The primary metric Sensitive EPT showed an increase in score from February to August samples. % Dominant Taxon showed a sharp increase in score when comparing the February 2013 sample to that of the August 2013 sample. EPT richness was highest in August 2013, and lowest in February 2013 (Table 35).

Table 41: Primary Metrics, Waukell Creek WC

Date:	5/9/2013	2/13/2013	8/5/2013
Total:	510.0	528.0	500.0
Taxa Richness:	38.0	26.0	38.0
EPT Richness:	10.0	4.0	17.0
Sensitive EPT:	2.9	10.6	20.6
% Dominant Taxon:	33.3	41.9	13.0
Tolerance Value:	6.5	5.5	5.3
Shannon's D.I.:	2.3	2.1	3.1
Estimated Relative Abundance:	3462.0	7798.0	1199.0

Collector/Gatherer (CG) made up the largest portion of the BMI community assemblage FFGs in all three sampling events. In large part Predators (P,) Scrapers (SC), and Collector/Filterers made up the remaining percentages yet fluctuated between samples. Shredders made up a noticeable portion of the February and August 2013 samples (Table 36).

Table 42: FFGs, Waukell Creek Wetland Creek Complex

Waukell 5/9/2012			Waukell 2/13/2013			Waukell 8/5/2013		
Type	Count	Percentage	Type	Count	Percentage	Type	Count	Percentage
P	20	3.9	P	87	17.4	P	48	9.1
CF	84	16.5	CF	5	1.0	CF	9	1.7
SC	186	36.5	SC	70	14.0	SC	38	7.2
PA	0	0.0	PA	1	0.2	PA	5	0.9
CG	212	41.6	CG	297	59.4	CG	372	70.5
SH	8	1.6	SH	40	8.0	SH	54	10.2
MH	0	0.0	MH	0	0.0	MH	2	0.4
Total	510	100.0	Total	500	100.0	Total	528	100.0

Tolerance values in general were above 5, yet tolerant individuals were found in small numbers. Values 5, 6 and 8 were consistently dominant in all three sampling events. In February 2013, tolerance values appeared to make a noticeable shift towards a more balanced distribution.

Table 43: Tolerance Values, Waukell Creek WC

Waukell 5/9/2012			Waukell 2/13/2013			Waukell 8/5/2013		
TV	Count	Percentage	TV	Count	Percentage	TV	Count	Percentage
0	0	0.0	0	32	6.4	0	0	0.0
1	2	0.4	1	20	4.0	1	56	10.6
2	9	1.8	2	55	11.0	2	1	0.2
3	6	1.2	3	17	3.4	3	0	0.0
4	13	2.5	4	39	7.8	4	38	7.2
5	59	11.6	5	52	10.4	5	85	16.1
6	230	45.1	6	127	25.4	6	261	49.4
7	19	3.7	7	43	8.6	7	17	3.2
8	146	28.6	8	79	15.8	8	54	10.2
9	0	0.0	9	0	0.0	9	0	0.0
10	25	4.9	10	36	7.2	10	16	3.0
Total	510	99.8	Total	500	100	Total	528	100.0

Figure 28: Upper Waukell Creek WC. A transition zone between stream and wetland habitat where flowing water is pictured in May 2012.

Figure 29: Waukell Creek WC, a dense canopy of Reed Canary Grass envelopes the shallow water marsh. Picture taken in May 2012.

Panther Creek Wetland Complex

Samples Collected May 2012:

The two dominant BMIs encountered in May 2012 within Panther WC were chironomids followed by gastropods. The Nor Cal Wetland IBI score for panther Creek was highest among all WCs with a score of 70 (Table 5). The stream IBI score for panther was a 35 (Table 8). Primary metric evaluation showed that Panther scored the highest in Sensitive EPT, and also % Dominant Taxon, second highest in Taxa Richness and Shannon’s DI, and third highest in EPT Richness. Panther also scored the lowest in Tolerance Value (Table 1). The dominant FFG was Collector / Gatherer (CG) representing 55.65 of individuals encountered. In addition, Predators (P) made up 18.8% of individuals encountered, as well as Shredders (SH) making up 8.8%. These two FFG’s (P) and (SH) were by far the biggest populations of these encountered out of all complexes. In general the FFGs in Panther appear to be the most evenly distributed compared to all other sites (Table 12). The tolerance values of individuals encountered in Panther appear to represent tolerant conditions. 46.8% of individuals had a value of 6, and 17.6% had a value of 8 (Table 15).

Seasonal Variation:

During February 2013, the two dominant BMIs encountered were chironomids followed by trichopterans. In August 2013, the dominant BMIs were chironomids followed by copepods. Nor Cal Freshwater Depressional Wetlands IBI scores were very similar throughout all three sampling events. A minor difference in the metric scores for % EOT likely accounted for the small changes in overall score (Table 38).

Table 44: Nor Cal Freshwater Depressional Wetlands IBI Scores, Panther Creek WC

Wetland Complex	Date Sampled	Total # of Specimens	% 3 Dominant Taxa	% Tanypodinae / Chironomidae	% Coleoptera	% EOT	Scraper Richness	EOT Richness	Oligochaeta Richness	Predator Richness	Overall Score
Panther	5/7/2012	500	53.0	12.3	0.8	13.8	5.0	5.0	2.0	13.0	70.0
Panther	2/19/2013	504	55.6	16.1	0.2	19.6	4.0	7.0	1.0	15.0	72.5
Panther	8/4/2013	504	53.2	15.0	1.3	8.1	5.0	6.0	1.0	13.0	75.0

Nor Cal Streams IBI scores were also very similar for all three sampling events. All metric scores appear to be very similar as well (Table 39).

Table 45: Nor Cal Streams IBI Scores, Panther Creek WC

Wetland Complex	Date Sampled	Total # of Specimens	EPT Richness	Coleoptera Richness	Diptera Richness	% Intolerant Individuals	% Non-Gastropod Scrapers	% Predator Individuals	% Shredder Taxa	% Non-Insect Taxa	Overall Score
Panther	5/7/2012	500	4.0	4.0	4.0	3.0	0.0	19.0	6.0	53.0	35.0
Panther	2/19/2013	504	6.0	1.0	5.0	1.8	0.0	17.7	8.3	52.8	30.0
Panther	8/4/2013	504	5.0	2.0	4.0	4.0	0.0	17.0	8.0	54.0	30.0

Primary metrics all appeared to be very similar in all three sampling events. A noticeable change in Sensitive EPT scores did occur, with higher scores in August 2013, and lower scores in February 2013 (Table 40).

Table 46: Primary Metrics, Panther Creek WC

Date:	5/7/2012	2/19/2013	8/4/2013
Total:	500.0	532.0	504.0
Taxa Richness:	36.0	37.0	36.0
EPT Richness:	4.0	5.0	6.0
Sensitive EPT:	10.0	5.6	18.3
% Dominant Taxon:	36.0	34.8	31.3
Tolerance Value:	5.9	6.7	6.1
Shannon's D.I.:	2.5	2.6	2.5
Estimated Relative Abundance:	1745.0	6384.0	3633.0

Collector/Gatherer (CG) made up the dominant portion of FFGs throughout all three sampling events. Predators (P) made up the next largest portion consistently, followed by Scrapers (SC), Shredders (SH), and collector/Filterers (CF). Shredders (SH) were most prevalent in the February 2013 sample (Table 41).

Table 47: FFGs, Panther Creek WC

Panther 5/7/2012			Panther 2/19/2013			Panther 8/4/2013		
Type	Count	Percentage	Type	Count	Percentage	FFG	Count	Percentage
P	94	18.8	P	89	17.7	P	92	17.3
CF	26	5.2	CF	25	5.0	CF	47	8.8
SC	50	10	SC	44	8.7	SC	20	3.8
PA	1	0.2	PA	0	0.0	PA	1	0.2
CG	278	55.6	CG	254	50.4	CG	339	63.7
SH	44	8.8	SH	91	18.1	SH	25	4.7
MH	7	1.4	MH	1	0.2	MH	8	1.5
Total	500	100	Total	504	100	Total	532	100.0

Tolerance values were in general above 5, with small portions of tolerant individuals present in all three samples. The lowest number of tolerant individuals occurred in the August 2013. A noticeable count of values of 3 was present in the February 2013. Values of 6 dominated tolerance values in all three samples, followed by values of 8. In august 2013 a noticeable increase in values of 10 was present (Table 42).

Table 48: Tolerance Values, Panther Creek WC

Panther 5/7/2012			Panther 2/19/2013			Panther 8/4/2013		
TV	Count	Percentage	TV	Count	Percentage	TV	Count	Percentage
0	0	0.0	0	0	0.0	0	0	0.0
1	6	1.2	1	4	0.8	1	0	0.0
2	10	2.0	2	5	1.0	2	11	2.1
3	35	7.0	3	88	17.5	3	20	3.8
4	15	3.0	4	1	0.2	4	8	1.5
5	70	14.0	5	21	4.2	5	30	5.7
6	234	46.8	6	206	40.9	6	208	39.8
7	32	6.4	7	33	6.5	7	36	6.9
8	88	17.6	8	120	23.8	8	147	28.2
9	4	0.8	9	6	1.2	9	9	1.7
10	6	1.2	10	20	4.0	10	53	10.2
Total	500	100.0	Total	504	100	Total	522	100

Figure 30: Panther Creek WC. Consisting of deep water habitats, floating mats of fringing vegetation often created false banks where water depths were up to 4 feet deep. Picture taken in May 2012.

Figure 31: Lower Panther Creek WC, due to conditions sampling nodes were accessed by boat. Picture taken in May 2012.

Macroinvertebrates as potential food sources for juvenile salmonids

KRE wetlands function as vital life stage habitats considered “last chance” rearing areas (Beesley and Fiori 2004) for out- migrating juvenile salmonids. Positioned near the mouth of the river, these habitats play a key role in the growth of salmon smolt prior to ocean entry, thus influencing their chances for survival (Nicholas and Hankin 1989, Wallace 1995, Beesley and Fiori 2004, Hiner and Brown 2004,). Comprehensive monitoring approaches employed by the Yurok Tribal Fisheries Program (YTFP) utilizing passive integrated transponder (PIT) tags have shown continued use of off estuary wetland habitats by juvenile salmonids emanating from throughout the Klamath River Basin (Wallace 2001; Hiner and Brown 2004; Beesley and Fiori 2004; Gale 2009, Silloway 2009, Silloway 2010). Studies have shown that juveniles rearing in similar flood plain habitats can yield larger growth rates compared to those in fee flowing high gradient habitats (Nickelson et al. 1992; Lestelle 2007). There is some evidence that warmer temperatures which likely occur in a coastal still water environment can provide a metabolic advantage in feeding juveniles (Holby 1988).

The most recent investigations into juvenile salmonid diet in the KRE proper took place in 1992 by the California Department of Fish and Game (Wallace 1995). This study employed pelagic, epibenthic and benthic strata sampling, in concurrence with an examination of juvenile fish stomach contents. Results from this study showed the most abundant species available were dipterans (chironomids), isopods, and amphipods. The density of these species was greatest near the benthos strata. The diet contents appeared be correlated to which organisms were most readily available. Juvenile salmonids are known to be opportunistic and feed on what is most abundant (MacDonald et al. 1990). Diet data showed that a shift occurred from primarily dipterans in the spring to amphipods in summer, and suggested that they switched to ephemeropterans in the fall. According to Healey (1991) seasonal changes in diet are typical. There were however exceptions, indicating that juvenile salmonids may be selective foragers as well; isopods were clearly avoided in the lower estuary regardless of being the highest encountered organism available. Although this study performed by Biologist Mike Wallace was a great snapshot in time for juvenile salmonid diet in the KRE proper, it did not address the juvenile salmon diet occurring in off- estuary wetlands.

Many predatory species of fish feed extensively on chironomids at some point in their life cycle, particularly the juvenile stage, and as fish get older and larger in size they may decrease feeding on chironomids (Merrit et al. 2008). Understanding juvenile salmonid diet is complex, and typically consists of a dynamic interaction between water temperature, metabolism, behavior, and food availability (Pert 1993). Several studies investigating juvenile salmon diet have shown the chironomidae family to be the majority of the salmon diet (Lott 2004, Bottom et. al. 2008, Sather et. al. 2008). Juvenile salmonids have been shown to be opportunistic and take advantage of available food sources (Waters 1969). As a population of invertebrates, chironomids for example, decrease in number during their annual life cycle; fish feeding upon them may seek other sources. Optimal foraging theory (Werner and Hall 1974; Gerking 1994) illustrates that fish consuming larger proportions of drifting invertebrates will likely expend less energy than when actively pursuing benthic or emerging prey.

Studies have shown that floods can release food sources into streams and can create opportunistic feeding sources (Maciolek 1952; Pert 1993). Also during floods juvenile salmonids move into inundated vegetation, floodplains, and other sources of refuge (Tschaplinski and Hartman 1983) and take advantage of alternative food sources. KRE wetlands and the macroinvertebrate communities they support play a key role in providing a recharge of in-stream feeding opportunities during high flows, and also as serve as important over-wintering refugia habitats with foraging opportunities unique from in stream conditions. The data presented here in this report can provide information regarding food source options for juvenile salmonids in the off-estuary KRE wetlands.

The dominant species encountered during the three sampling events in this report have been identified as belonging to the family of Chironomidae. Due to their overwhelming presence, metric scores and results tables previously presented in this report have been heavily influenced by this family of insects. Understanding the reasons for this proliferation is important also recognizing limitations or stressors to the habitats in which they exist.

Chironomidae is the most widespread of all aquatic insect families, exhibiting a great amount of diversity and ability to adapt. The range of conditions in which they can exist is larger than any other family of aquatic insects. Due to the large number of members within the family and specific morphological, physiological, and behavioral adaptions of each, chironomids are often used by ecologists to partition ecological conditions in aquatic systems (Merrit et al. 2008). One metric, for example, that examines the number of chironomid species is Chironomid Richness, which has been shown to be related to stream order (Coffman 1989). The majority of chironomids found in our study were identified as belonging to the genus, *tanypodinae* and *chironominae*, indicating that diversity within this family is limited. However based on the evidence of chironomids making up the dominant food sources of juvenile salmonids (previously mentioned), and the fact that there is a high relative abundance of these species in KRE wetlands, it is likely that food sources available for juvenile salmonids are adequate and juvenile diet in these habitats is predominately chironomids.

Some evidence has shown that floods in free flowing habitats (such as the KRE estuary proper) can strip the benthos of an invertebrate community (Pert 1993), suggesting that lentic habitats may offer or more stable invertebrate community. Also, in the lower estuary proper where salt water influence is high, the macroinvertebrate community may be depressed, due to a lower number of macroinvertebrates specialized to live in salt water (Merritt et al 2008). Additionally, the lower KRE estuary also is shown to have a lower number of preferred prey for juvenile salmonids (Wallace 1995). Evidence suggests that KRE WCs may offer improved food sources to that of the KRE proper, thus improving rearing in these habitats, and providing an advantage to juveniles that seek out KRE WCs.

The wetland habitats of the KRE and associated tributaries play a key role in not only providing a recharge of in stream food availability in high flows, but also offer additional areas for foraging when access is available. Although understanding juvenile salmonid diet in KRE habitats is incomplete without a more comprehensive approach, including examining fish contents, this initial investigation is very useful in understanding background information on BMI community and can direct more sensitive ecological questions, and study designs.

Sediment

In a study of a Northern California stream quantifying juvenile salmonid food available in the water column, (drift) was not good indicator of what the juveniles ate or how much. The study suggested that fish were most likely seeking out food sources in benthos and littoral vegetation during low flows (Pert 1993). During BMI sample collection YTEP staff encountered benthos substrate composed of fine sediment and decomposing organic matter (muck) at all wetland sites. Although an obvious predominance of this substrate existed, no quantitative analysis of sediment distribution was conducted. In field observations sediment substrate as opposed to other substrates such as sand, gravel, cobble, varied mildly between WCs, yet small proportionately. An increase in fine sediment benthos appears to be a factor limiting BMI diversity and productivity in KRE wetland habitats.

Areas of fine sediment in running water are unstable and do not allow a foothold for macroinvertebrates. Fine sediment also fills in areas around cobble substrates reducing usable habitat. Lenat et al. (1981), in North Carolina streams, found that during high flows the addition of sediment simply reduced the available habitat and therefore invertebrate density. Exposed cobble/rubble substrates act as refugia but the number of exposed surfaces is reduced by sediment input. Lenat et al. (1981) also noted a stable sand community which developed during low flow conditions. This consisted of tolerant small grazers capable of rapid colonization and reproduction which utilized increased periphyton growing on the stable sand. Relative abundance and tolerance values would increase in stable sand.

Fine sediment is inherently increased in these areas due to primarily unnatural conditions such as logging and agricultural practices (Gale 2000, Beesley and Fiori 2004, Beesley and Fiori 2007). Fine sediment reduces the area of substrate available for colonization by macroinvertebrates. Soil substrate appears to be influenced in relationship to the unique physical characteristics found at each site, such flow velocity, channel alterations, soil disturbance, and vegetative cover. This fine sediment is present due to a combination of natural and unnatural conditions. Based on past physical habitat assessments of streams performed by YTEP (2006-2012), in general, flowing streams of the Lower Klamath River are not characterized by vast areas of fine sediment substrate as in wetlands encountered, and therefore it is a large determinant (along with water quality conditions) in why differing macroinvertebrate communities can be expected. Suspended sediment traveling through the tributaries which feed into the wetlands has a tendency to settle out in these low velocity/slack water areas.

VII. Recommendations

Continued wetland macroinvertebrate sampling

Wetland BMI data can be useful in the future in understanding changes to wetland condition, functions, and as potential food sources for juvenile salmonids. Currently, an IBI for KRE wetlands is lacking, making a truly accurate assessment of the BMI communities difficult. An IBI can only be created through a comprehensive and rigorous data collection and analysis effort.

In the face of climate change and potential sea level rise, KRE wetlands and the associated food web will likely be impacted in the future. Other potential changes/impacts include hydrological changes from human development, and dam removal. Possible increases in wetland condition may occur to due to up slope watershed restoration efforts to reduce sediment load, and on site wetland restoration efforts. By monitoring changes in condition and function occurring in wetlands, natural resource specialists can better protect these crucial habitats. Investigating the BMI community response to changes in salinity may prove useful in modeling future climate change impacts.

Developing linkages with wetland features

On a finer scale, making linkages between specific characteristics within WCs and the related BMIs that inhabit them would provide insightful information. Substrate composition is likely a key factor influencing BMI assemblages, and when the effects of substrate are understood, functional restoration objectives can be designed. Likewise, investigating vegetation characteristics of KRE WCs such as predominant monocultures, invasive species, woody debris, etc. may provide an understanding of certain macroinvertebrate habitat niches, which can be used to develop beneficial eco-system based restoration objectives.

Examining Juvenile Salmonid Diet

Understanding the feeding habits of juvenile salmonids in KRE wetlands is important in determining the strengths and limitations and of each WC as rearing habitat. By examining stomach contents and comparing them with which sources are available in the benthos, water column and vegetative layers, diet preferences may be revealed. Additionally, growth rates associated with diet preferences may provide insight into an optimal diet.

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