Terrell Creek
2009 Preliminary Report

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Introduction

The objective of this monitoring project was to collect water quality data from Terrell Creek to support the environmental programs at the Cherry Point Refinery. We collected monthly water samples from four sites in Terrell Creek to measure nutrients (total nitrogen, nitrate/nitrite, ammonium, total phosphorus, and soluble phosphate) and total suspended solids.

Historically Terrell Creek flowed freely from its headwaters into Birch Bay. The creek was dammed in ~1950 to create Lake Terrell, which is managed by the Washington Department of Fish & Wildlife to provide winter habitat for waterfowl. The height of Lake Terrell is regulated by the Washington Department of Fish and Wildlife. The lake is drained every year during spring and early summer to support a warm water sport fishery (Sunich, 2005). In 2009, the lake was drawn down during April and May to manage invasive macrophytes (S. Weingarten, personal communication, May 11, 2009). As a result, there was not enough outflow from the lake during the summer months to maintain flow in Terrell Creek, and the creek became stagnant.

Our first water samples were collected on May 11, 2009, while the creek was flowing. Additional samples were collected on June 12, July 8, and August 20, at which point the creek had little or no flow. The final samples were collected on September 17, when the creek was again flowing.

Sampling Methods

All water samples were collected by Johannes Janson, a graduate student at Western Washington University. Originally, seven sites were to be sampled; however, three of the sites had intermittent saltwater intrusion, so the water quality analyses could not be completed (Figure 1). Water samples were collected in Terrell Creek by sampling just below the surface using one liter Nalgene bottles. Immediately after collection, the samples were placed on ice in a cooler, and then transported to the Institute for Watershed Studies at Western Washington University for analysis. The methods used for each analysis are summarized in Table 1 and all water quality data are listed in Table 2.

Results and Discussion

Nitrogen

Nitrogen is an important plant nutrient that is often elevated in creeks that flow through agricultural or residential areas. We measured *total nitrogen*, which includes organic nitrogen (e.g., nitrogen from decaying plants and suspended organic particles) and dissolved inorganic nitrogen (ammonium, nitrite, and nitrate), but not dissolved nitrogen gas (N_2); *nitrate/nitrite*, and *ammonium*. Nitrate and nitrite are often measured together. In most aerated streams, nitrate is the major form of dissolved inorganic nitrogen; nitrite, when present, is usually at such a low concentration that it is difficult to measure accurately. Ammonium concentrations are usually low in aerated streams, but may be elevated in agricultural areas, especially if there is a near-by source of fertilizer or animal manure that leaches into the stream.

Total nitrogen concentrations in Terrell Creek were generally high, ranging from 713-3806 µg-N/L (Table 2; Figure 2). Overall, the total nitrogen concentrations were slightly lower on May 11 (873-1053 µg-N/L) and slightly higher on August 20 (1020-2807 µg-N/L), but there was no consistent pattern among the sites. Inorganic nitrogen (nitrite, nitrate, and ammonium) usually represented less than 50% of the total nitrogen in the sample, indicating that much of the total nitrogen was in the form of organic nitrogen:

Organic N = Total N – (Nitrite + Nitrate + Ammonium)

The nitrate/nitrite concentrations in Terrell Creek were fairly low and 30% of the samples were below the detection limit of 10 µg-N/L (Table 2; Figure 3). The only site with consistently high nitrate/nitrite concentrations was Site 2, which had concentrations ranging from 42.2 µg-N/L on May 11 to >1500 µg-N/L on August 20. Site 2 is directly adjacent to Grandview Road. It is possible that runoff from Grandview Road may be a contributor, or there may be a nearby source of nitrate/nitrite. Common nitrate sources can include agricultural and residential runoff or a high density of alders (*Alnus*) in the riparian zone.[1]

Ammonium was above detection (>10 µg-N/L) on all sampling dates at Sites 1-3, and was especially high at Site 1 (Table 2; Figure 4). The presence of ammonium in surface water usually indicates a nearby source because it is rapidly taken up by plants for growth or converted into nitrite and nitrate by bacteria or lost via evaporation. Sources of ammonium include agricultural

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1 Alders have microbiota associated with their roots that convert N_2 into nitrate that can be used by the alders for growth. Nitrate is very soluble, so it is quite common to measure high nitrate concentrations in streams with alders in the riparian zone.

runoff and animal wastes, as described above, but also include any upstream source containing large amounts of decaying organic matter. When sampling the creek on June 12, Johannes Janson observed a large number of dead and decaying snails. These snails appeared to have washed downstream from Lake Terrell. The putrefaction of the snail bodies could have contributed to the high concentration of ammonium at Site 1. Regardless of whether the ammonium in Terrell Creek was generated by decomposition of organic matter or flowed into the stream from the watershed, its persistence at those sites was likely due to the stagnant conditions, which prevented or reduced the natural loss of ammonium from the stream.

According to the U.S. Environmental Protection Agency (1996), chronic ammonium concentrations higher than 70 µg/L can be harmful to fish and other aquatic animals. The ammonium concentrations were higher than 300 µg/L at Site 1 on four sampling dates and higher than 100 µg-N/L at Site 2 on four sampling dates (Table 2). This indicates a potential problem for aquatic organisms residing in the upper portion of Terrell Creek. Reestablishing a more constant flow to the creek might help ameliorate the accumulation of ammonium at these sites.

Phosphorus

Like nitrogen, phosphorus is an important plant nutrient that is often elevated in creeks that flow through agricultural or residential areas. We measured *total phosphorus*, which includes both organic and inorganic forms of phosphorus, and *soluble reactive phosphate* (orthophosphate), which is very easily taken up by plants and microbiota. As a result, the amount of soluble reactive phosphate in surface water is usually very low, and high concentrations often indicate a nearby source.

Much of the phosphorus measured as total phosphorus is associated with soil particles (U.S. Geological Survey, 1999), so high total phosphorus concentrations might be expected in streams receiving large amounts of sediment in surface runoff. The relationship between soluble reactive phosphate and suspended sediments is more complex because soluble phosphate can adsorb onto particles and move with sediments or may move with water like dissolved forms of nitrogen.

Total phosphorus concentrations often exceeded 100 µg-P/L at Sites 1, 3, and 4 (Table 2; Figure 5). Site 3, in particular, had very high total phosphorus concentrations (>100 µg-P/L) and soluble reactive phosphate concentrations (>50 µg-P/L) on all sampling dates (Table 2; Figure 6). The source of this phosphorus is unknown, but was probably not from the decomposing organic matter (snails) that was present in the upper portion of the creek because the phosphorus concentrations were much lower upstream.

Total Suspended Solids

Total suspended solids concentrations were generally low at all sites, ranging from 2.1-44.3 mg/L (Table 2; Figure 7). Site 4 had the highest total suspended solids concentrations on all dates (16.8-44.3 mg/L). The high solids concentration at Site 4 seems to be associated with a rusty red, ferrous precipitate that was present in the Site 4 samples in significant quantities. The exact nature and source of the suspended precipitate is unknown, but may be related to the underlying geology or soil chemistry at the site. The most unusual result was that high total phosphorus concentrations were not necessarily related to high suspended solids concentrations. This was probably because the samples were collected during periods of low or no creek flow. The sediments in the samples were more likely to have originated from the creek bed than the watershed, and therefore may not have added much additional phosphorus to the creek.

References

Sunich, J. M. 2005. Terrell Creek Water Quality Monitoring Project Internship Report. Huxley College of the Environment. Western Washington University. Bellingham, WA.

U.S. Environmental Protection Agency. 1996. Drinking water regulations and health advisories: U. S. Environmental Protection Agency Report. EPA-B-96-001.

U.S. Geological Survey. 1999. The quality of our nations waters—nutrients and pesticides: U.S. Geological Survey Circular 1225, 82p.

Analyte	Method Reference[2]	Detection Limit/ Sensitivity
Nitrogen - ammonium	SM4500-NH3 H., flow injection phenate	10 µg NH_3-N/L
Nitrogen - nitrate/nitrite	SM4500-NO3 I., flow injection, Cd reduction	10 µg NO_3-N/L
Nitrogen - total	SM4500-NO3 I., flow injection, persulfate digest	10 µg N/L
Phosphorus - ortho	SM4500-P G., flow injection	3 µg PO_4-P/L
Phosphorus - total	SM4500-P G., flow injection, persulfate digest	5 µg P/L
Total suspended solids	SM2540 D., gravimetric	2 mg/L

Table 1: Summary of analytical methods for the Terrell Creek project

2 APHA, 2005. Standard Methods for the Examination of Water and Wastewater, 20th Ed., American Public Health Association, American Water Works Association, and Water Environment Federation, Washington, D.C.

Site	Date	T. Nitrogen (µg-N/L)	Nitrite / Nitrate (µg-N/L)	Ammonium (µg-N/L)	T. Phosphorus (µg-P/L)	Soluble Phosphate (µg-P/L)	T. Suspended Solids (mg/L)
TC1	May 11, 2009	873	<10	19.5	41.7	<3.0	NA
TC2		936	42.4	36.3	51.9	5.3	NA
TC3		1053	116.3	62.5	>100	237.2	NA
TC4		908	85.3	30.3	>100	106	NA
TC1	June 12, 2009	3806	13.2	>300	>100	37.1	8.3
TC2		847	269.7	134.1	48.1	17.3	3.0
TC3		713	52.2	57.1	>100	95.4	4.3
TC4		1339	<10	<10	>100	21.9	16.8
TC1	July 8, 2009	2142	136.5	>300	>100	20.1	6.6
TC2		1328	518.5	261.6	33.2	9.6	3.5
TC3		788	21.2	16.4	>100	90.2	6.9
TC4		2073	<10	<10	>100	17.6	17.8
TC1	August 20, 2009	1162	55.9	>300	20.1	24.5	9.4
TC2		2807	>1500	172.5	64.6	25.7	2.1
TC3		1020	42.6	43.3	>100	909.5	18.0
TC4		1797	<10	15.0	50.4	37.1	26.5
TC1	Sept. 17, 2009	1532	11.8	457.9	>100	46.6	<2.0
TC2		1854	1046.9	147.6	71.1	22.9	<2.0
TC3		873	<10	34.3	>100	771	6.8
TC4		3030	<10	<10	680.1	19.6	44.3

Table 2: Water quality data from Terrell Creek, June-September 2009.

Figure 1: Terrell Creek 2009 sampling sites. Sites shown in yellow had salt water intrusion and were not included in this study. Map source: Landsat TM5, July 30, 2000. Provided by US Geological Survey.

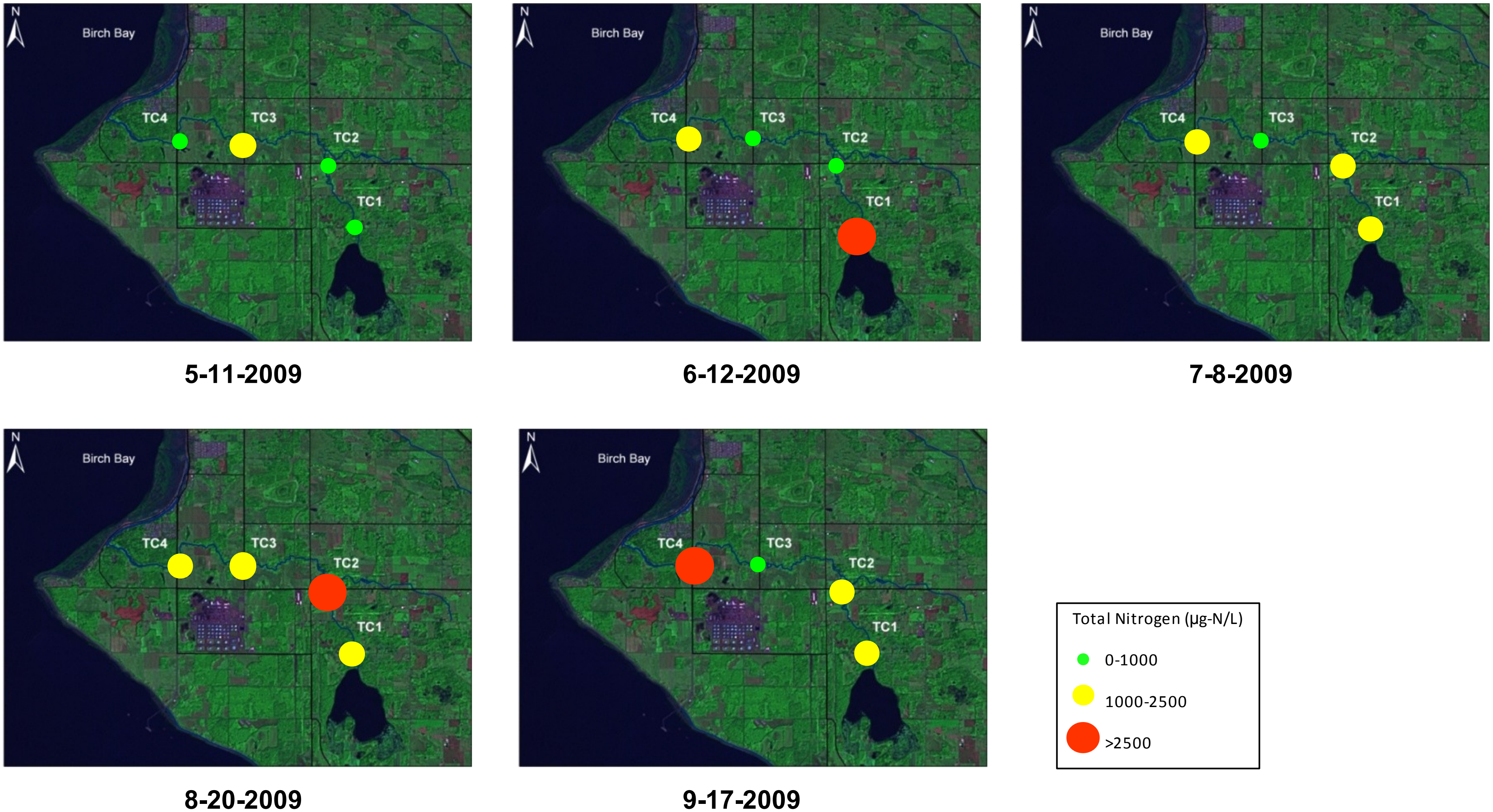

Figure 2: Total nitrogen concentrations at Sites 1-4 by date.

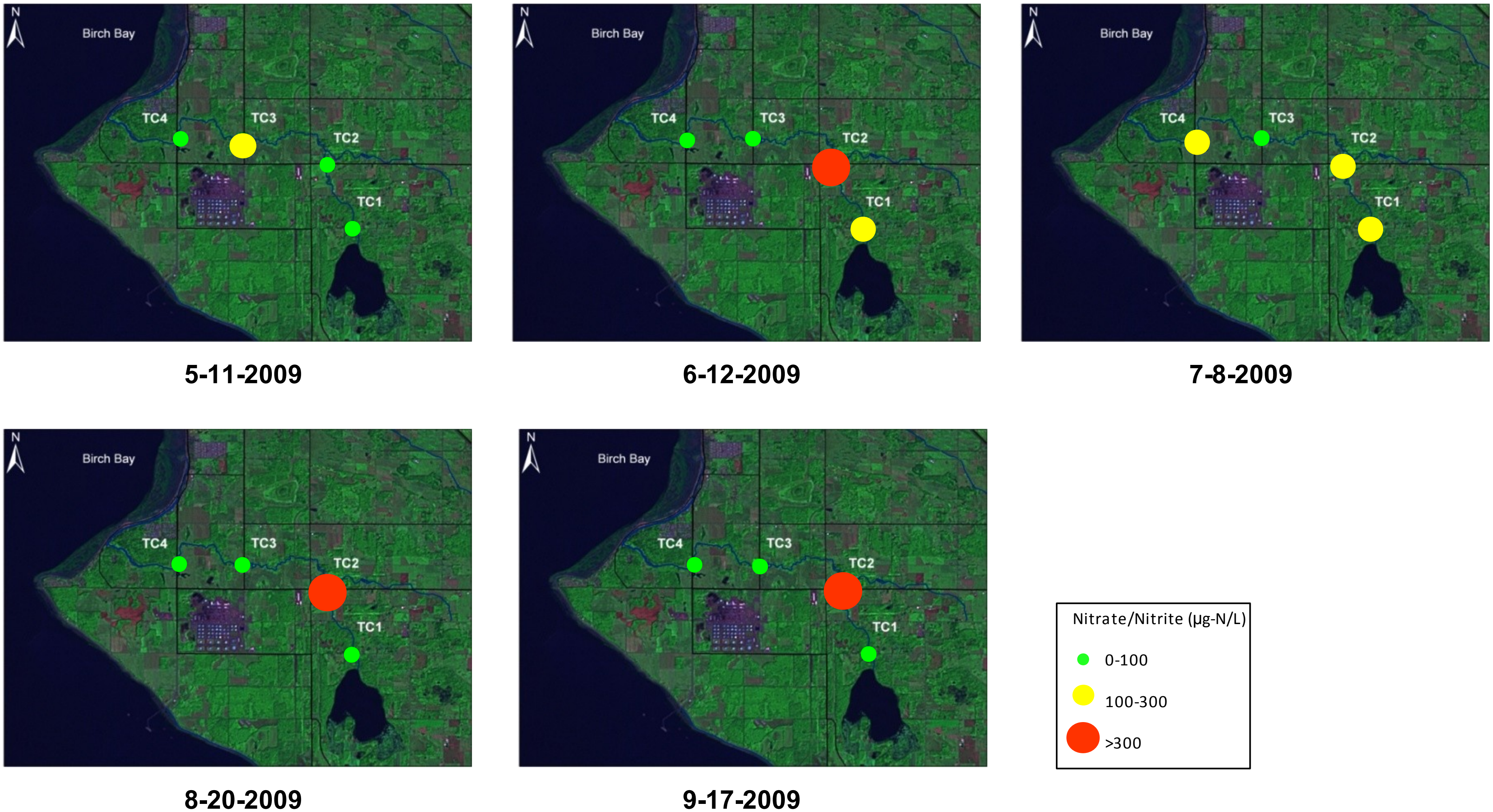

Figure 3: Nitrate/nitrite concentrations at Sites 1-4 by date.

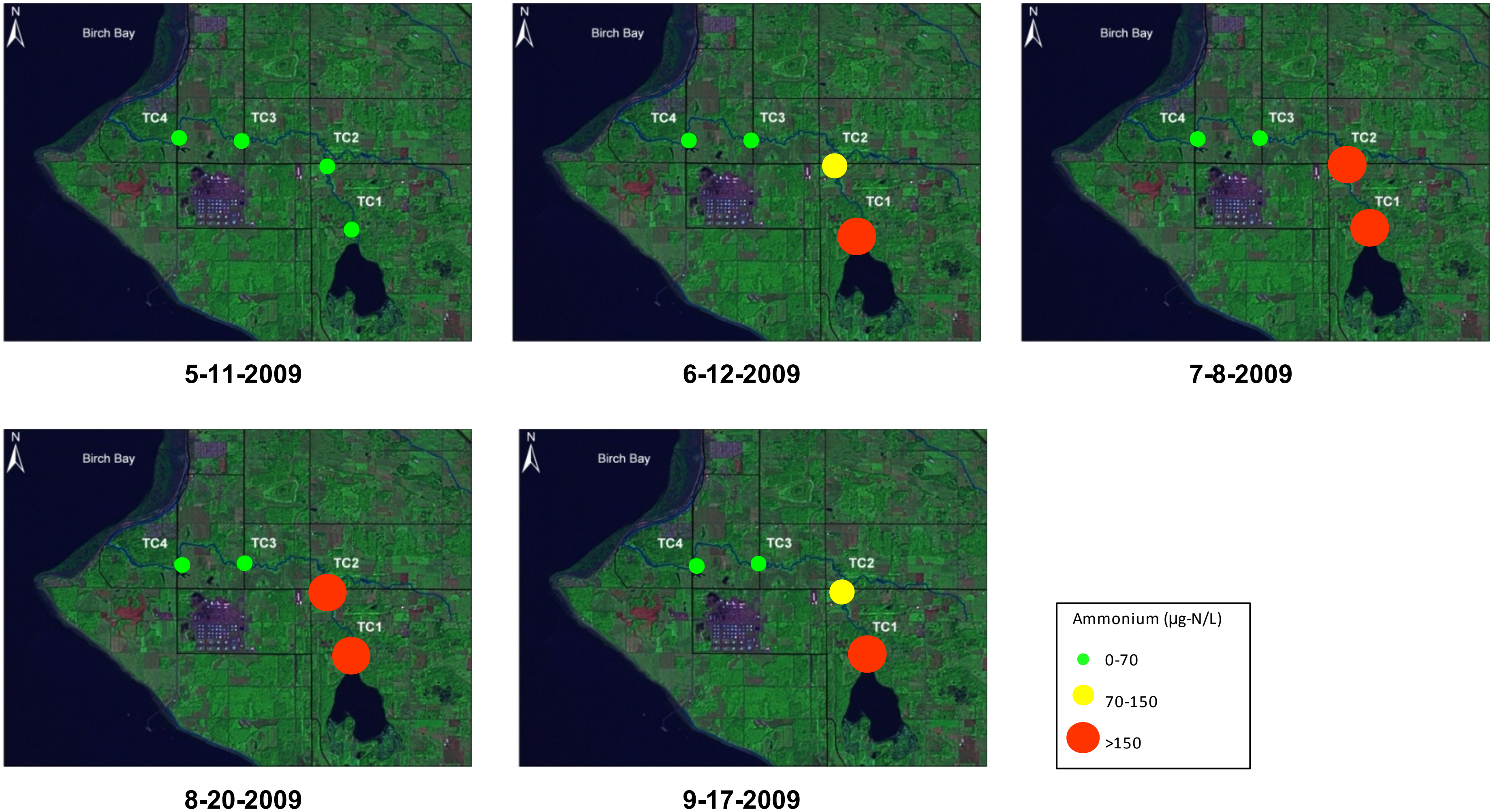

Figure 4: Ammonium concentrations at Sites 1-4 by date.

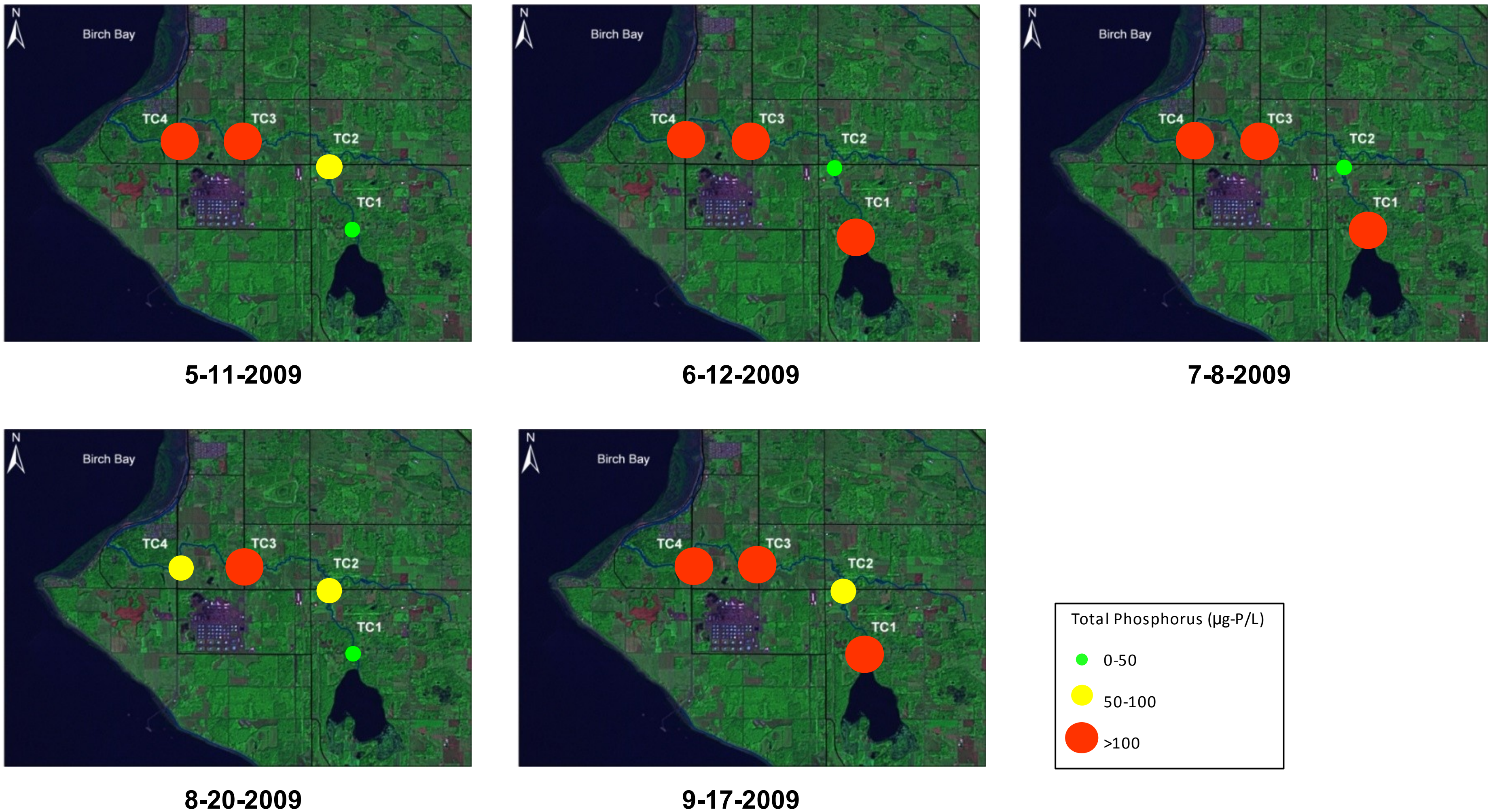

Figure 5: Total phosphorus concentrations at Sites 1-4 by date.

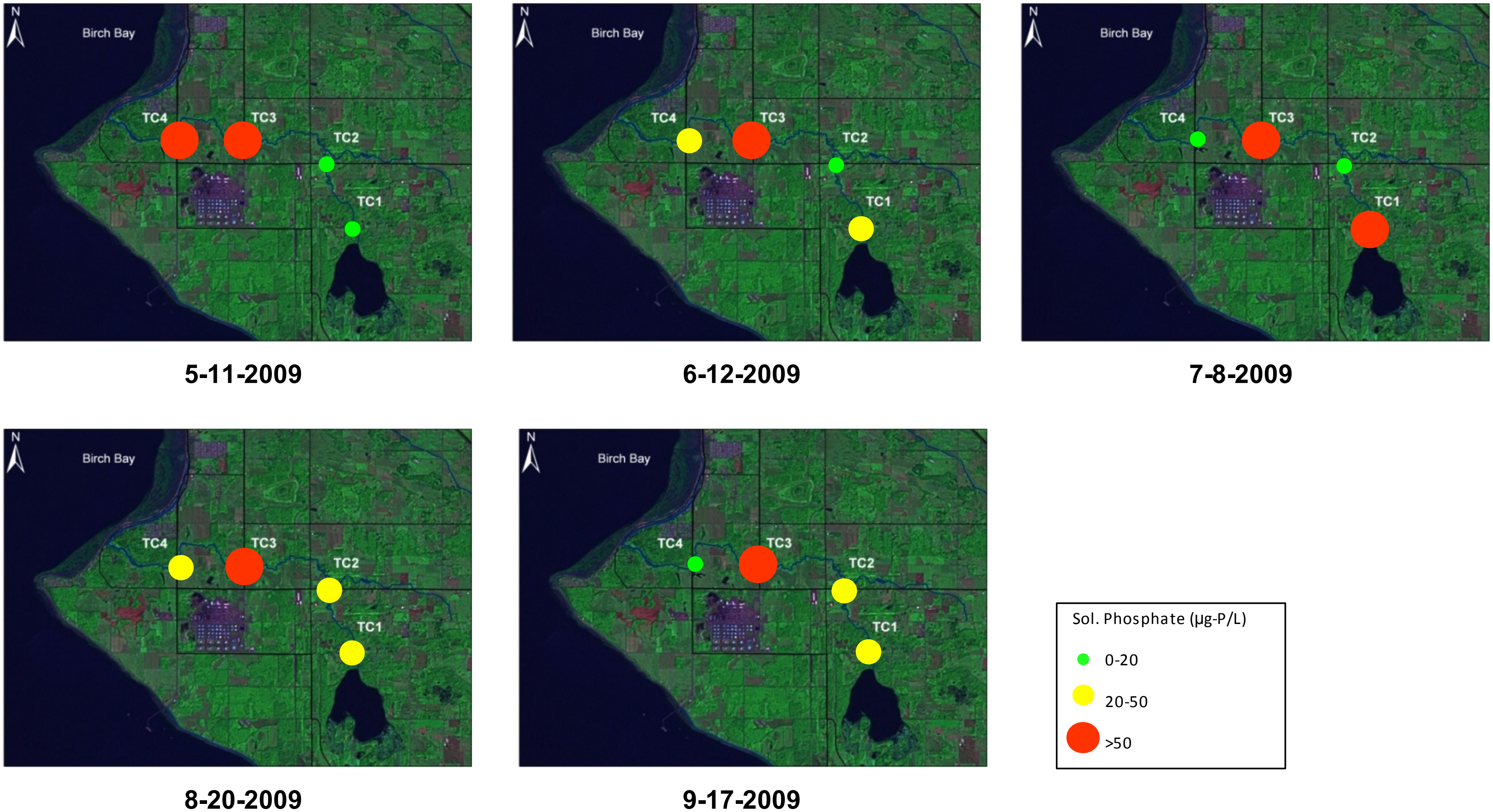

Figure 6: Soluble reactive phosphate concentrations at Sites 1-4 by date.

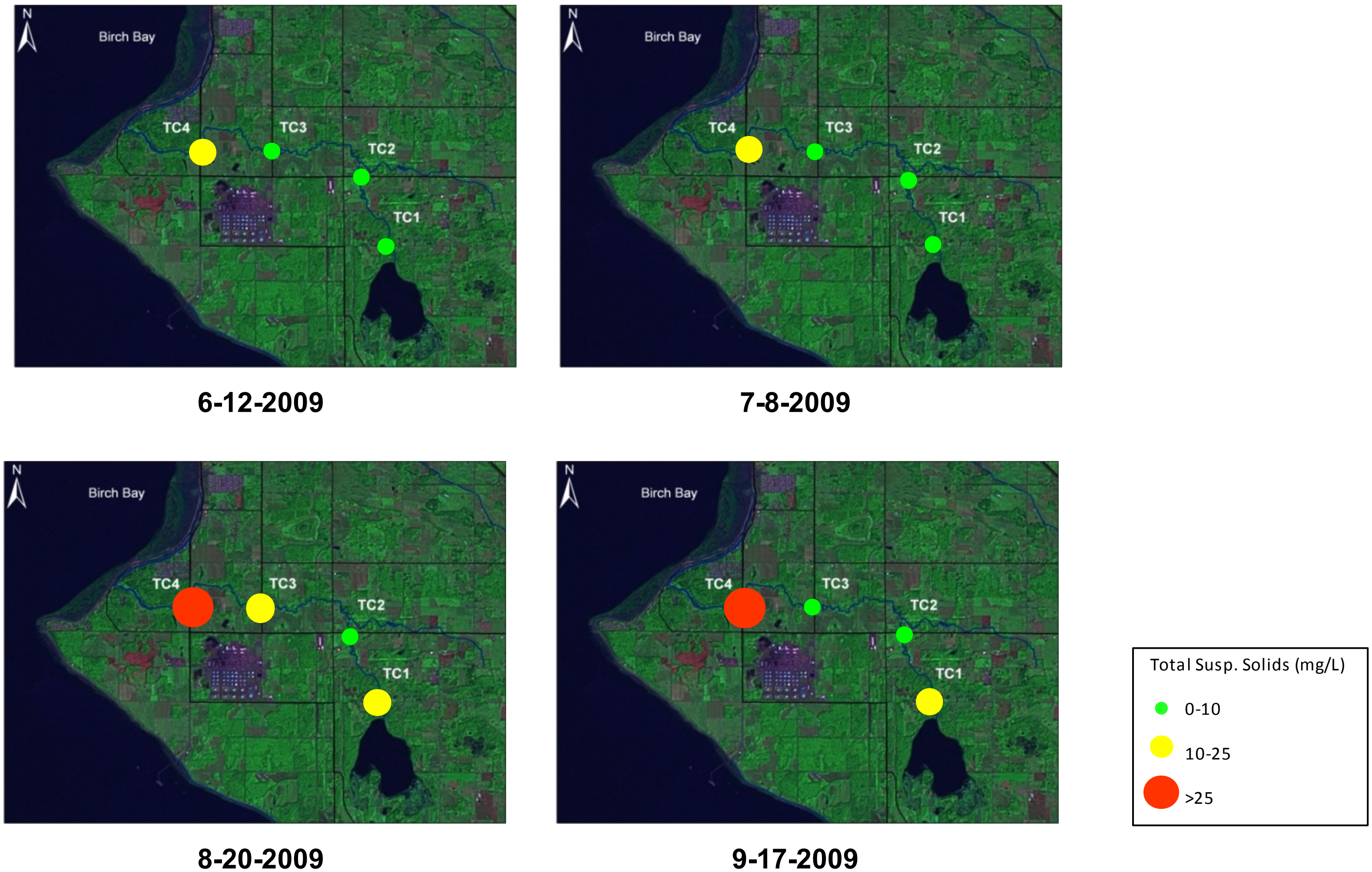

Figure 7: Total suspended solids concentrations at Sites 1-4 by date.