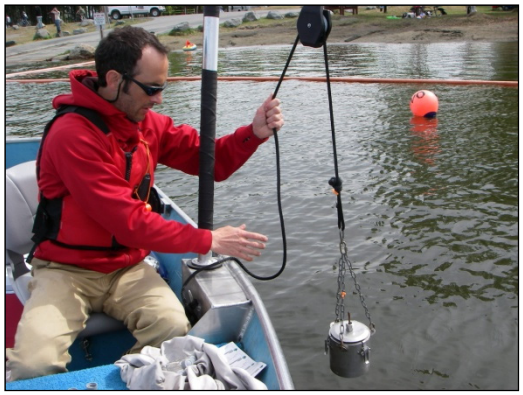
ALASKA
Department of
Environmental
Conservation

WATER QUALITY MONITORING

BIG LAKE, ALASKA

FINAL Report
January 2010

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Prepared for:

State of Alaska
Department of Environmental Conservation
Division of Water
Non-Point Source Water Pollution Control

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ACRONYMS AND ABBREVIATIONS

°C ..... Degrees Celsius
°F ..... Degrees Fahrenheit
µg/L ..... Micrograms per liter
AAC..... Alaska Administrative Code
ADEC ..... Alaska Department of Environmental Conservation
BTEX..... Benzene, toluene, ethylbenzene, and xylenes
EPA..... U.S. Environmental Protection Agency
GPH ..... Gallons per hour
IDW ..... Investigation-derived waste
m ..... Meters
OASIS ..... OASIS Environmental, Inc.
ppb ..... Parts per billion
QA..... Quality assurance
QAPP ..... Quality Assurance Project Plan
QC..... Quality control
RPD..... Relative percent difference
TAH..... Total aromatic hydrocarbons
USGS..... United States Geological Survey

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EXECUTIVE SUMMARY

OASIS Environmental, Inc. (OASIS) performed water quality monitoring at Big Lake, Alaska, for the Alaska Department of Environmental Conservation (ADEC) during the summer of 2009 to determine loading of petroleum hydrocarbons, the volume of impaired waters, and how motorized watercraft may affect the loading process. The monitoring included collection of water samples from 12 discrete sample sites on 13 different sample dates. In addition, some of the sample dates included intensive sampling efforts for which multiple samples were collected from three of the sample sites throughout the day to track the pattern of hydrocarbon concentrations. OASIS also observed and measured watercraft activity on these intensive sample dates to attempt to correlate watercraft types and activities with results for hydrocarbons samples.

Analytical results demonstrate that the water quality standard for total aromatic hydrocarbons (TAH) is frequently exceeded on holiday weekends. In fact, slightly more than 50% of all samples collected on sample dates associated with Memorial Day, Independence Day, and Labor Day weekends had a TAH concentration greater than the water quality standard. In contrast, only about 7% of samples collected on other days during 2009 had TAH concentrations greater than the water quality standard. The sample sites that had the highest percentage of exceedances for the TAH water quality standard were the locations near watercraft launch sites: BL-4 at the South Shore State Recreation Site, BL-6 at the Southport Marina, BL-8 at the Burkeshore Marina, and BL-10 at the North Shore State Recreation Site.

The volume of impaired waters in Big Lake varied in a pattern consistent with the TAH data: namely, the largest estimated volumes occurred on holiday weekends. For instance, the median volume of impaired waters for holiday weekends was 1.8 billion gallons, or approximately 6% of the lake's volume, while the median volume of impaired waters for the other sample dates was 58 million gallons, or approximately 0.2% of the lake's volume.

Daily mass loads for TAH also were calculated for the four samples dates (May 24, May 25, July 5, and July 6) that OASIS observed and measured watercraft activity. These dates corresponded to Memorial Day and Independence Day holiday weekends, and all four days also experienced daily high temperatures more than 10 degrees Fahrenheit above averages. Therefore, these four days are assumed to represent worst case scenarios for loading because of increased watercraft activity from the holiday weekend and excellent recreational weather. The calculated daily loadings are the following:

MAY 24 = 14.9 GALLONS OF TAH
MAY 25 = 10.5 GALLONS OF TAH
JULY 5 = 11.2 GALLONS OF TAH
JULY 6 = 8.62 GALLONS OF TAH

The results of the water quality monitoring indicate that Big Lake is impaired for petroleum hydrocarbons, which means that concentrations of petroleum hydrocarbons

exceed the state water quality standard; however, the exceedances mostly occur during expected high-use days and are focused near watercraft launches where watercraft conditions and density are likely to magnify hydrocarbon concentrations. Therefore, corrective actions should focus on potential methods to improve water quality for these high-use days, particularly near the identified locations where persistently elevated TAH concentrations occur.

1. INTRODUCTION

Under Notice-to-Proceed No. 18-2011-26-11, the Alaska Department of Environmental Conservation (ADEC) tasked OASIS Environmental, Inc. (OASIS) with conducting water quality monitoring at Big Lake, Alaska (Figure 1). The purpose of the monitoring was to assess concentrations of dissolved-phased petroleum hydrocarbons in the water column and gather data regarding motorized watercraft usage in Big Lake. OASIS collected water samples from 12 discrete sample sites on 13 different sample dates. In addition, OASIS made observations of motorized watercraft usage on four of these sample dates. This report presents the findings and recommendations based on the data collection.

1.1. Objectives

The objectives for water quality monitoring in Big Lake were the following:

- Collect petroleum hydrocarbon data in Big Lake during the open water months (May–September 2009) for a variety of use times to determine if water quality exceeds water quality standards.
- Increase the understanding of the relationship between motorized watercraft usage and petroleum hydrocarbon loading to the lake.

1.2. Scope of Work

The scope of work used to meet the objectives outlined above involved collecting water samples and water quality parameters from 12 sample sites on 13 different days. This was accomplished by using a combination of standard sampling events, where each sample location was sampled once per day, and intensive sampling events, where three sample locations were sampled five times during a single day. In addition, OASIS made observations of motorized watercraft usage on four of the intensive sample days during Memorial Day and Independence Day weekends. Section 3.1 details the entire sample program. The resulting data from these activities have been used to estimate the volume of impaired waters in Big Lake, the likely maximum load of petroleum hydrocarbons in Big Lake on a daily basis, and the trend of dissolved-phase hydrocarbon concentrations on a daily basis.

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2. BACKGROUND

This section summarizes the environmental setting, previous investigations, and regulatory background for Big Lake. Section 8 lists all referenced materials.

2.1. Environmental Setting

The United States Geological Survey (USGS) produced *Overview of Environmental and Hydrogeologic Conditions near Big Lake, Alaska* in 1995 for the Federal Aviation Administration to document the hydrology and geology of the area. The report summarizes the following information about Big Lake's hydrology:

> Big Lake covers an area of about 12 square kilometers [4.6 square miles or 3,000 acres]… Big Lake consists of an east and west basin connected by a constriction near the middle of the lake. The lake contains 22 islands and the shoreline length, excluding islands, is about 27 kilometers [16.8 miles]. The surface elevation of the lake is about 44 meters [144 feet] and it has a mean depth of about 9 meters [30 feet]. Meadow Creek is the major inlet stream and Fish Creek is the lake outlet…During 1983-84, the USGS conducted a limnological study…The results of the study…[*showed that*]…the lake was dimictic (stratifies in the summer and winter) and circulated in May and October. Thermal stratification was well developed and persistent from June through September. The spring circulation failed to completely reaerate the hypolimnion…

2.2. Previous Investigations

ADEC has conducted two previous evaluations of petroleum hydrocarbons in Big Lake. The original investigation occurred in 2004 during which 55 water samples were collected from depths of 0.15 meters (m), 0.5 m, 1.5 m, and 5 m at 14 sample sites on three different dates (May 15, May 29, and June 12). Analytical results showed that eight samples exceeded the water quality standard of 10 micrograms per liter (µg/L) for total aromatic hydrocarbons (TAH), which is the sum of benzene, toluene, ethylbenzene, and xylenes (BTEX). All eight exceedances occurred in the shallow intervals (0.15 m or 0.5 m) on May 29 or June 12 from BL-2, BL-5, BL-6, BL-7, BL-8, and BL-10 (OASIS 2004).

The second investigation occurred in 2005 during which 61 water samples were collected from depths of 0.15 m and 0.5 m at five sample sites on six different dates (May 12, May 28, July 3, July 23, August 20, and September 4). Analytical results showed that 11 samples exceeded the TAH standard. The shallow interval at BL-10 exceeded the standard during four sampling events, and the shallow interval at BL-8 exceeded the standard during two sampling events. The deep interval of BL-10 exceeded the standard during three sampling events, and the deep interval at BL-8 exceeded the standard during two sampling events (OASIS 2006).

Table 1 summarizes the scope and results of the previous investigations.

TABLE 1: PREVIOUS INVESTIGATIONS

Sample Dates	Number of Sample Sites	Number of Samples	Sample Depths	Exceedances of TAH Standard
2004 (May 15, May 29, June 12)	14	55	0.15, 0.5, 1.5, 5 m	May 29: 0.15 m at BL-2, BL-5, BL-6, BL-7, BL-8, BL-10 June 12: 0.15 m and 0.5 m at BL-10
2005 (May 12, May 28, July 3, July 23, Aug 20)	5	61	0.15 and 0.5 m	May 28: 0.15 m and 0.5 m at BL-10 July 3: 0.15 m and 0.5 m at BL-10 July 23: 0.15 m at BL-8 and BL-10, and 0.5 m at BL-8 and BL-10 Aug 20: 0.15 m at BL-8 and BL-10, and 0.5 m at BL-8

2.3. Regulatory Framework

In 2006, ADEC listed Big Lake as an impaired water body under the federal Clean Water Act Section 303(d) for petroleum hydrocarbon pollution exceeding state water quality standards in 18 Alaska Administrative Code [AAC] 70. This listing in ADEC's *2008 Integrated Water Quality Monitoring and Assessment Report* occurred as the result of water sampling conducted in 2004 and 2005 by ADEC.

Alaska water quality standards and the degree of degradation that may not be exceeded are contained in 18 AAC 70, *Water Quality Standards*, and its supporting document *Alaska Water Quality Criteria Supporting for Toxic and Other Deleterious Organic and Inorganic Substances* (ADEC 2008b). Table 2 outlines water use classes, subclasses, and petroleum hydrocarbon standards for fresh water bodies.

TABLE 2: ALASKA WATER QUALITY STANDARDS

Fresh Water Use Class and Subclass	Petroleum Hydrocarbon Standard
Water Supply– Drinking Water	May not cause a visible sheen upon the surface of the water. May not exceed concentrations that individually or in combination impart odor or taste as determined by organoleptic tests.
Water Supply– Agriculture	May not cause a visible sheen upon the surface of the water.
Water Supply– Aquaculture	Total aqueous hydrocarbons (TaqH) in the water column may not exceed 15 µg/L. TAH in the water column may not exceed 10 µg/L. There may be no concentrations of petroleum hydrocarbons, animal fats, or vegetable oils in shoreline or bottom sediments that cause deleterious effects to aquatic life. Surface waters and adjoining shorelines must be virtually free from floating oil, film, sheen, or discoloration.
Water Supply– Industrial	May not make the water unfit or unsafe for the use.
Water Recreation– Contact and Secondary Recreation	May not cause a film, sheen, or discoloration on the surface or floor of the water body or adjoining shorelines. Surface waters must be virtually free from floating oils.
Growth and Propagation of Fish, Shellfish, Other Aquatic Life, and Wildlife	Same as Water Supply– Aquaculture

The standards that were assessed during water quality monitoring were "may not cause a visible sheen on the surface of the water" and the TAH standard of 10 µg/L.

3. MONITORING ACTIVITES

This section presents a summary of the field activities that occurred to meet the objectives outlined in Section 1.1. The strategy and methodology used for field activities were presented in a sample plan (OASIS 2009a), which is available for review by request from ADEC. The fieldwork consisted of these principal actions:

- Collection of water samples from 12 sample sites on 13 different sample dates.
- Observation of motorized watercraft on two days during both Memorial Day and Independence Day weekends.

Appendix A contains a copy of field notes from field activities, and Appendix B presents photographs depicting field activities.

3.1. Water Sampling

ADEC designed the sampling program so that water samples were collected from key sites based on findings from the 2004 and 2005 assessments. Table 3 lists the sample sites and the rationale for sampling each site. Figure 2 presents the locations of the sample sites. Appendix C contains position data for the sample sites.

TABLE 3: SAMPLE SITES

Site	Description and Rationale
BL-1	Historical USGS sample site at the deepest area of the west basin. Serves as a control site for the project.
BL-2	Existing sample site that is a major traffic lane between the two basins. This site has previously exceeded the water quality standard for TAH.
BL-3	Historical USGS sample site at the deepest area of the east basin. Serves as a control site for the project. There is boat traffic in this area.
BL-4	Existing sample site near the South Shore State Recreation Site. This area is the most heavily used basin in the lake.
BL-5	Existing sample site that is a traffic lane for the bay to the southwest. This site has previously exceeded the water quality standard for TAH.
BL-6	Existing sample site near Southport Marina. This site has previously exceeded the water quality standard for TAH.
BL-7	Existing sample site located where Fish Creek drains from Big Lake. This is a popular fishing area as well as a high use traffic lane. This site has previously exceeded the water quality standard for TAH.
BL-8	Existing sample site located near Burkeshore Marina. This site has previously exceeded the water quality standard for TAH.
BL-10	Existing sample site near the North Shore State Recreation Site. This area is heavily used for launching boats, swimming, camping, and personal watercraft operation. This site has previously exceeded the water quality standard for TAH.
BL-11	Existing sample site in the east basin near the mouth of Meadow Creek.
BL-26	New sample site located in the middle of the bay near the North Shore State Recreation Site and west of location BL-10. Location will assess attenuation of hydrocarbons commonly detected at sample site BL-10.
BL-27	New sample site located in the main traffic lane for users leaving North Shore State Recreation Site. Location will assess the area between the north bay and east basin.

In addition, ADEC designed the sample schedule to collect samples on dates that should represent a variety of watercraft usage patterns. These sample dates were divided into

"standard" sample days and "intensive" sample days to reflect the frequency of sampling that occurred for each day. There were seven intensive sample days: four days over Memorial Day weekend and three days over Independence Day weekend. Table 4 presents the sample dates, the type of sampling that occurred, and the reasoning for sampling on each day.

TABLE 4: SAMPLE SCHEDULE

Sample Date	Day of Week	Type	Reason
May 13, 2009	Wednesday	Standard	Low watercraft activity– Establish baseline lake conditions for the summer and determine hydrocarbon accumulation from winter activities
May 23, 2009	Saturday	Intensive	High watercraft activity– Memorial Day weekend
May 24, 2009	Sunday	Intensive	High watercraft activity– Memorial Day weekend
May 25, 2009	Monday	Intensive	High watercraft activity– Memorial Day
May 26, 2009	Tuesday	Intensive	Low watercraft activity– Monitor lake conditions following holiday
June 17, 2009	Wednesday	Standard	Low watercraft activity– Mid-week sample date
June 27, 2009	Saturday	Standard	Moderate to high watercraft activity– Weekend day
July 4, 2009	Saturday	Intensive	High watercraft activity– Independence Day
July 5, 2009	Sunday	Intensive	High watercraft activity– Independence Day weekend
July 6, 2009	Monday	Intensive	High watercraft activity– Independence Day weekend
July 25, 2009	Saturday	Standard	Moderate to high watercraft activity– Weekend day
August 15, 2009	Saturday	Standard	Moderate to high watercraft activity– Weekend day
September 7, 2009	Monday	Standard	High watercraft activity– Labor Day

The following subsections detail the sampling rationale and execution for "standard" and "intensive" sample days.

3.1.1. Standard Sample Day

Following the protocol outlined in the project-specific Quality Assurance Project Plan (QAPP), a "standard" sample day entailed a single sample event for each sample site. This approach provided a discrete snapshot of water quality in Big Lake for each "standard" sample day.

OASIS field personnel began "standard" sample days by launching the sample boat at approximately 13:45 hours from the South Shore State Recreation Site. Sampling activities commenced at approximately 14:00 hours. Sampling occurred in a repetitive order to minimize temporal variability between different "standard" sample days. Table 5 lists the order in which sites were sampled.

TABLE 5: SAMPLE SITE ORDER FOR STANDARD SAMPLE DAYS

Site
BL-4
BL-7
BL-8
BL-27
BL-26
BL-10
BL-11
BL-1
BL-2
BL-3
BL-5
BL-6

Table 6 lists the sample depths and parameters for which sampling occurred at each sample site.

TABLE 6: SAMPLING PROGRAM FOR STANDARD SAMPLE DAYS

Sample Site	Sample Depth	Sample Parameters
BL-1	0.15 meters	BTEX, Water quality
BL-2	0.15 meters	BTEX, Water quality
BL-3	0.15 meters	BTEX, Water quality
BL-4	0.15 meters and 0.5 meters	BTEX, Water quality
BL-5	0.15 meters	BTEX, Water quality
BL-6	0.15 meters	BTEX, Water quality
BL-7	0.15 meters	BTEX, Water quality
BL-8	0.15 meters and 0.5 meters	BTEX, Water quality
BL-10	0.15 meters and 0.5 meters	BTEX, Water quality
BL-11	0.15 meters	BTEX, Water quality
BL-26	0.15 meters	BTEX, Water quality
BL-27	0.15 meters	BTEX, Water quality

Notes: Water quality parameters measured included pH, temperature, specific conductivity, and dissolved oxygen.
0.15 meters is approximately 6 inches. 0.5 meters is approximately 20 inches.

Water quality parameters were collected for one of two purposes depending on the sample site: 1) for all sample sites except BL-11, water quality parameters determined the location and thickness of the lake's thermocline, which is the portion of the water body where water temperature rapidly changes between the epilimnion, the layer of warm water at the surface, and the hypolimnion, the underlying layer of cold water; and 2) for sample site BL-11, water quality parameters assessed the degree of influence from Meadow Creek, based on changes primarily to the specific conductivity of the water. For the former reason, water quality data was used with the analytical results for BTEX samples to assess the depth and resulting volume of water that may be impaired, based on the assumption that mixing of hydrocarbons tapers off in the thermocline as the water cools, and for the latter reason, water quality data was used with analytical results for BTEX samples to assess the contribution of hydrocarbons from upgradient in the watershed.

OASIS field personnel measured water quality parameters using a YSI® 556 multi-probe meter. OASIS field personnel collected BTEX samples using a Wildco® hydrocarbon sampler. BTEX samples were analyzed by U.S. Environmental Protection Agency (EPA) method 624 for the determination of TAH.

3.1.2. Intensive Sample Day

Following the protocol outlined in the project-specific QAPP, an "intensive" sample day included multiple sample events for sample sites BL-10, BL-26, and BL-27, as well as single sample events for the other sample sites. This plan allowed for an analysis of the trend of TAH concentrations during the boating day at the intensive sample sites. In addition, the sample design, combined with watercraft usage observations described in Section 3.2, yielded the data necessary to estimate loading of petroleum hydrocarbons in Big Lake: contaminant concentrations, lake characteristics, and watercraft data.

OASIS field personnel began "intensive" sample days by launching the sample boat at approximately 08:45 hours from the North Shore State Recreation Site. Sampling activities commenced at approximately 09:00 hours at sample site BL-27, followed by sampling activities at BL-26, and then at BL-10. This order was repeated again at 12:00 hours, 15:00 hours, 18:00 hours, and 21:00 hours, so that BL-27, BL-26, and BL-10 were sampled five times per "intensive" sample day. In the interim between intensive sample efforts at BL-10, BL-26, and BL-27, OASIS field personnel sampled the other nine sample sites. Table 7 shows the order, times, depths, and parameters for which sampling occurred at each sample site on "intensive" sample days.

TABLE 7: SAMPLING PROGRAM FOR INTENSIVE SAMPLE DAYS

Sample Site	Sample Time	Sample Depth	Sample Parameters
BL-10	09:00, 12:00, 15:00, 18:00, 21:00	0.15 meters and 0.5 meters	BTEX, Water quality
BL-26	09:00, 12:00, 15:00, 18:00, 21:00	0.15 meters	BTEX, Water quality
BL-27	09:00, 12:00, 15:00, 18:00, 21:00	0.15 meters	BTEX, Water quality
BL-3	Between 10:00 and 12:00	0.15 meters	BTEX, Water quality
BL-5	Between 10:00 and 12:00	0.15 meters	BTEX, Water quality
BL-11	Between 10:00 and 12:00	0.15 meters	BTEX, Water quality
BL-1	Between 13:00 and 15:00	0.15 meters	BTEX, Water quality
BL-2	Between 13:00 and 15:00	0.15 meters	BTEX, Water quality
BL-7	Between 13:00 and 15:00	0.15 meters	BTEX, Water quality
BL-8	Between 16:00 and 18:00	0.15 meters and 0.5 meters	BTEX, Water quality
BL-4	Between 16:00 and 18:00	0.15 meters and 0.5 meters	BTEX, Water quality
BL-6	Between 16:00 and 18:00	0.15 meters	BTEX, Water quality

Note: 0.15 meters is approximately 6 inches. 0.5 meters is approximately 20 inches.

The purpose of collecting water quality parameters was the same as outlined in Section 3.1.1. In addition, similar to a "standard" sample day, OASIS field personnel measured water quality parameters using a YSI® 556 multi-probe meter; OASIS field personnel collected BTEX samples using a Wildco® hydrocarbon sampler; and BTEX samples were analyzed by EPA method 624 for the determination of TAH.

3.1.3. Sampling Process

Field personnel conducted water sampling from a 22-foot, v-hull boat powered with a 4-stroke, 35-horsepower engine. The field team navigated to the sample sites using an onboard GPS unit with stored waypoints. When the boat was approximately 100 feet from the sample site, the boat operator turned off the engine to allow the boat to coast to the sample site. When the boat reached the sample site, the field team deployed an anchor to maintain sample position.

For sampling at all sample sites, the following activities occurred:

- Lowered weighted, graduated polyethylene tubing that was connected to a peristaltic pump over the side of the boat to a depth of 0.15 m below water surface. Using a battery-powered peristaltic pump, drew water up through a flow cell and measured pH, temperature, specific conductivity, and dissolved oxygen using the YSI® multi-probe meter. Parameters were recorded when readings stabilized.
- Performed the first step again at 0.5 m, and then at 1 m increments beginning at 1 m and ending at 10 m or the bottom of the water body, whichever was less.
- Collected samples for analysis of BTEX by placing three uncapped 40-millilter amber sample vials in the Wildco® hydrocarbon sampler and lowering the sampler over the side of the boat so that inlet ports on the top of the sampler were at a depth of 0.15 m. The sampler released air bubbles as it filled, and when the bubbles ceased (i.e., when the sample chamber filled) the sampler was brought to the surface. At this point, the sample bottles were retrieved from inside the sampler where they were immersed in water. The bottles were field-preserved with hydrochloric acid and capped so that no headspace remained in the bottles. Sample protocol followed the USGS report “Field Guide for Collecting Samples for Analysis of Volatile Organic Compounds in Stream Water for the National Water Quality Assessment Program” (USGS 1997).
- For sample sites BL-4, BL-8, and BL-10, the previous step also was performed at a depth of 0.5 m.

The field team also collected a single control sample per sample day to assess potential hydrocarbon contribution from the sample boat’s outboard engine. This sample is designated as “outboard sample” in Tables 9-21. The sample was taken at sample sites BL-4, BL-27, and BL-11 depending on sample date. Section 3.3 explains the reason for the various sample sites. The protocol for the collection of the control sample was that after anchoring at the sample site the Wildco® hydrocarbon sampler was deployed off the stern of the boat directly adjacent to the outboard engine following the procedures detailed in the third bullet above.

3.2. Watercraft Usage

OASIS field personnel monitored motorized watercraft usage patterns on four of the seven “intensive” sample days: May 24, May 25, July 5, and July 6. The purpose was to

gather watercraft usage data to be used in conjunction with sample analytical data to estimate daily loading of petroleum hydrocarbons to Big Lake. The strategy for monitoring watercraft involved the placement of an observer at the South Shore State Recreation Site and the placement of an interviewer at the North Shore State Recreation Site.

The observer at the South Shore State Recreation Site counted the number of motorized watercraft during each hour for a 12-hour period from 09:00 to 21:00 hours. Each watercraft was counted only once per hour. The observer identified, if possible, the type of engine (2-stroke or 4-stroke) on each motorized watercraft. Appendix D contains the completed forms used for recording observations.

The interviewer located at the North Shore State Recreation Site conducted brief, voluntary surveys of users at the public boat launch. For lake users who were launching, the interviewer counted the watercraft, noted the time of launch, and, if feasible, asked the user what type and size of engine was being used. For lake users returning to the launch area, the interviewer verified the number of hours the user was on the lake. Appendix E contains the form that the interviewer used for recording observations.

Lastly, the field team collecting water samples also made general use observations at each sample site for all sample days to augment watercraft usage data.

3.3. Sample Plan Deviations

OASIS prepared a sample plan that outlined the strategy and methodology for the collection of water samples and motorized watercraft data (OASIS 2009a). A couple of the executed activities deviated from the plan. The following list identifies the deviations:

- The sample plan called for the collection of a water sample off the stern of the boat directly adjacent to the outboard at the start of the day to assess potential hydrocarbon contribution from the sample watercraft. However, after receipt of analytical data from Memorial Day weekend sample activities, it became apparent that data associated with the contribution sample collected at the start of the day near sample site BL-27 were proving ambiguous because of the hydrocarbons already present in the water column. Therefore, the OASIS project manager and ADEC project manager decided to move the collection of the outboard sample to sample site BL-11, which had shown consistently low levels of hydrocarbons during Memorial Day weekend. So the contribution sample location moved and was no longer collected at the beginning of the day.
- Five samples from July 4 were lost when the samples froze overnight in cold storage causing the septa to burst. The affected samples were the shallow sample at BL-4 and the following intensive samples from the 18:00 hour sampling: shallow sample and its duplicate from BL-10, deep sample from BL-10, and sample from BL-26.

3.4. Investigation-Derived Waste

Water quality assessment field activities generated solid and aqueous investigation-derived waste (IDW). Solid IDW included used personal protective equipment and sampling equipment, which included disposable nitrile gloves and used paper towels. These materials were contained in trash bags and disposed of at the Anchorage landfill. Aqueous IDW included unused water matrix inside the Wildco® hydrocarbon sampler, which was dumped overboard.

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4. FINDINGS

This section presents the observations and analytical results from the 12 sample sites over the 13 sample dates at Big Lake during 2009. The section discusses the results for water quality parameters, hydrocarbon samples, and watercraft observations. Appendix F contains laboratory analytical reports.

4.1. Water Quality Parameters

The water quality parameters of pH, temperature, specific conductivity, and dissolved oxygen were measured at each sample site during every sample date. Appendix G contains complete data tables for pH, temperature, specific conductivity, and dissolved oxygen readings. The findings for temperature and the resulting thermocline data are discussed in this subsection.

Three sample sites had sufficient depth to yield the necessary data for evaluating Big Lake's thermocline during the entire summer season: BL-1, BL-3, and BL-26. The thermocline is defined as temperature change of 1 degree Celsius (°C) or more per meter. The depth of the thermocline is important to document because it is assumed that mixing of the water column begins to cease within the increasingly colder, denser water of the thermocline. In other words, any hydrocarbons in the warmer, overlying epilimnion will be prevented from mixing deeper into the lake by the denser water encountered in the thermocline. Table 8 contains the depth profile for the epilimnion and the thickness of the thermocline for sample sites BL-1, BL-3, and BL-26 during each sample event. Graph 1 presents charts of the thermocline per sample site for each sample date.

TABLE 8: EPILIMNION AND THERMOCLINE PROFILES

Sample Day	BL-1		BL-3		BL-26	
	Epilimnion	Thermocline	Epilimnion	Thermocline	Epilimnion	Thermocline
May 13	0–1 meters	1–2 meters	0–1 meter	1–2 meters	0–1 meter	1–2 meters
May 23	0–5 meters	5–8 meters	0–4 meters	4–7 meters	0–2 meters	2–6 meters
May 24	0–4 meters	4–7 meters	0–3 meters	3–7 meters	0–2 meters	2–6 meters
May 25	0–3 meters	3–6 meters	0–3 meters	3–6 meters	0–2 meters	2–6 meters
May 26	0–4 meters	4–7 meters	0–2 meters	2–6 meters	0–1 meter	1–6 meters
June 17	0–4 meters	4–7 meters	0–3 meters	3–7 meters	0–3 meters	3–6 meters
June 27	0–5 meters	5–8 meters	0–5 meters	5–9 meters	0–4 meters	4–7 meters
July 4	0–4 meters	4–9 meters	0–4 meters	4–9 meters	0–3 meters	3–8 meters
July 5	0–4 meters	4–9 meters	0–4 meters	4–9 meters	0–3 meters	3–8 meters
July 6	0–4 meters	4–9 meters	0–3 meters	3–8 meters	0–2 meters	2–8 meters
July 25	0–5 meters	5–9 meters	0–5 meters	5–9 meters	0–5 meters	5–8 meters
August 15	0–6 meters	6–10 meters	0–6 meters	6–10 meters	0–6 meters	6–8 meters
September 7	0–7 meters	7–10 meters	0–8 meters	8–10 meters	0–7 meters	7–8 meter

Notes: 1 m = 3.3 ft, 2 m = 6.6 ft, 3 m = 9.8 ft, 4 m = 13.1 ft, 5 m = 16.4 ft, 6 m = 19.7 ft, 7 m = 23.0 ft, 8 m = 26.2 ft, 9 m = 29.5 ft, 10 m = 32.8 ft

In general, the depth of the epilimnion was very shallow at the start of the season after winter, and then increased in depth to its maximum at the end of summer on Labor Day (September 7). On the other hand, the thickness of the thermocline followed a cyclical pattern with the smallest measurements occurring at the start and end of summer, and

the largest measurements occurring around mid-summer (Independence Day weekend). This cyclical pattern is symptomatic of the spring and fall turnover of the lake that occurs with spring thaw and winter freeze, respectively.

4.2. Hydrocarbon Samples

This subsection discusses analytical results for hydrocarbon samples collected on 13 sample dates at 12 sample sites during the summer season. The subsection presents data by sample date, sample site, and intensive sample results.

4.2.1. Sample Dates

This subsection discusses analytical results by sample date. The statistic of central tendency used to describe the data is the median. The median is the middle point of a data set, as opposed to the average of the data set. The median is a better representative of "average" for these data because the data do not truly represent a uniform population for which an average concentration may be derived. This is because many parts of the lake are completely or nearly completely unaffected by hydrocarbons and therefore are not similar to other parts of the lake, such as areas near boat launches, that have elevated levels of hydrocarbons as discussed below.

4.2.1.1. May 13, 2009

Sixteen total samples were collected on May 13, 2009, a standard sample day: 12 shallow (0.15 m) samples, three deep (0.5 m) samples, and one outboard control sample. Table 9 presents the analytical results, and Figure 3 shows the results by sample site.

No analytical result exceeded the water quality standard for TAH. Seven of the 12 sample sites had a detectable concentration for TAH. The maximum detected concentration for TAH was 3.9 µg/L in the shallow sample from sample site BL-8 near Burkeshore Marina. The median concentration for the day, excluding the outboard control sample, was 0.20 µg/L.

The outboard sample, collected at the initial sample site for the day (BL-4), had no detectable concentration of TAH; therefore, it is assumed the emissions from the operation of the sample boat had minimal to no impact on analytical results during sample activities.

4.2.1.2. May 23, 2009

Thirty-two total samples were collected on May 23, 2009, an intensive sample day: 15 shallow (0.15 m) samples from the intensive sample sites (BL-10, BL-26, and BL-27), five deep (0.5 m) samples from the intensive sample sites, nine shallow (0.15 m) samples from the standard sample sites, two deep (0.5 m) samples from the standard sample sites, and one outboard control sample. Table 10 presents the analytical results, and Figure 4 shows the results by sample site. Please note that the analytical results for intensive sample sites BL-10, BL-26, and BL-27 in Table 10 and Figure 4 represent averages of the five intensive samples collected on May 23, 2009.

Four samples exceeded the water quality standard for TAH: the shallow sample from BL-8 (12 µg/L), the deep sample from BL-8 (14 µg/L), the shallow sample from BL-10 (39 µg/L), and the deep sample from BL-10 (36 µg/L). All sample sites except BL-11 had a detectable concentration of TAH. The median concentration for the day, excluding the outboard control sample, was 5.5 µg/L.

The outboard sample, collected at the initial sample site for the day (BL-27), had a TAH concentration of 2.9 µg/L, which was less than the result (5.9 µg/L) for the corresponding sample collected at BL-27. In addition, given that the sample from site BL-11 was collected later in the day and had no detectable concentration of TAH, it is assumed that emissions from the operation of the sample boat had minimal to no impact on analytical results during sample activities.

4.2.1.3. May 24, 2009

Thirty-two total samples were collected on May 24, 2009, an intensive sample day: 15 shallow (0.15 m) samples from the intensive sample sites (BL-10, BL-26, and BL-27), five deep (0.5 m) samples from the intensive sample sites, nine shallow (0.15 m) samples from the standard sample sites, two deep (0.5 m) samples from the standard sample sites, and one outboard control sample. Table 11 presents the analytical results, and Figure 5 shows the results by sample site. Please note that the analytical results for intensive sample sites BL-10, BL-26, and BL-27 in Table 11 and Figure 5 represent averages of the five intensive samples collected on May 24, 2009.

Ten samples exceeded the water quality standard for TAH: the sample from BL-2 (10 µg/L), the shallow sample from BL-4 (29 µg/L), the deep sample from BL-4 (33 µg/L), the sample from BL-6 (16 µg/L), the shallow sample from BL-8 (13 µg/L), the deep sample from BL-8 (10 µg/L), the shallow sample from BL-10 (48 µg/L), and the deep samples from BL-10 (47 µg/L), BL-26 (12 µg/L), and BL-27 (11 µg/L). All sample sites except BL-11 had a detectable concentration of TAH. The median concentration for the day, excluding the outboard control sample, was 11 µg/L.

The outboard sample, collected at the initial sample site for the day (BL-27), had a TAH concentration of 9.3 µg/L, which was less than the result (11 µg/L) for the corresponding sample collected at BL-27. In addition, given that the sample from site BL-11 was collected later in the day and had no detectable concentration of TAH, it is assumed that emissions from the operation of the sample boat had minimal to no impact on analytical results during sample activities.

4.2.1.4. May 25, 2009

Thirty-two total samples were collected on May 25, 2009, an intensive sample day: 15 shallow (0.15 m) samples from the intensive sample sites (BL-10, BL-26, and BL-27), five deep (0.5 m) samples from the intensive sample sites, nine shallow (0.15 m) samples from the standard sample sites, two deep (0.5 m) samples from the standard sample sites, and one outboard control sample. Table 12 presents the analytical results, and Figure 6 shows the results by sample site. Please note that the analytical results for

intensive sample sites BL-10, BL-26, and BL-27 in Table 12 and Figure 6 represent averages of the five intensive samples collected on May 25, 2009.

Eleven samples exceeded the water quality standard for TAH: the sample from BL-2 (11 µg/L), the sample from BL-3 (11 µg/L), the shallow sample from BL-4 (23 µg/L), the deep sample from BL-4 (22 µg/L), the sample from BL-6 (14 µg/L), the shallow sample from BL-8 (12 µg/L), the deep sample from BL-8 (11 µg/L), the shallow sample from BL-10 (39 µg/L), and the deep samples from BL-10 (43 µg/L), BL-26 (17 µg/L), and BL-27 (17 µg/L). All sample sites had a detectable concentration of TAH. The median concentration for the day, excluding the outboard control sample, was 12 µg/L.

The outboard sample, collected at the initial sample site for the day (BL-27), had a TAH concentration of 15 µg/L, which was slightly less than the result (17 µg/L) for the corresponding sample collected at BL-27. In addition, given that the sample from site BL-11 was collected later in the day and had a TAH concentration of only 0.64 µg/L, it is assumed that emissions from the operation of the sample boat had minimal to no impact on analytical results during sample activities.

4.2.1.5. May 26, 2009

Thirty-two total samples were collected on May 26, 2009, an intensive sample day: 15 shallow (0.15 m) samples from the intensive sample sites (BL-10, BL-26, and BL-27), five deep (0.5 m) samples from the intensive sample sites, nine shallow (0.15 m) samples from the standard sample sites, two deep (0.5 m) samples from the standard sample sites, and one outboard control sample. Table 13 presents the analytical results, and Figure 7 shows the results by sample site. Please note that the analytical results for intensive sample sites BL-10, BL-26, and BL-27 in Table 13 and Figure 7 represent averages of the five intensive samples collected on May 26, 2009.

Twelve samples exceeded the water quality standard for TAH: the sample from BL-2 (14 µg/L), the sample from BL-3 (18 µg/L), the shallow sample from BL-4 (12 µg/L), the deep sample from BL-4 (13 µg/L), the sample from BL-5 (15 µg/L), the sample from BL-6 (14 µg/L), the shallow sample from BL-8 (12 µg/L), the deep sample from BL-8 (15 µg/L), the shallow sample from BL-10 (18 µg/L), and the deep samples from BL-10 (17 µg/L), BL-26 (11 µg/L), and BL-27 (14 µg/L). All sample sites had a detectable concentration of TAH. The median concentration for the day, excluding the outboard control sample, was 14 µg/L.

The outboard sample, collected at the initial sample site for the day (BL-27), had a TAH concentration of 17 µg/L, which was slightly more than the result (14 µg/L) for the corresponding sample collected at BL-27. Given that the sample from site BL-11 was collected later in the day and had a TAH concentration of only 0.91 µg/L, it is assumed that emissions from the operation of the sample boat had minimal to no impact on analytical results during sample activities.

4.2.1.6. June 17, 2009

Sixteen total samples were collected on June 17, 2009, a standard sample day: 12 shallow (0.15 m) samples, three deep (0.5 m) samples, and one outboard control sample. Table 14 presents the analytical results, and Figure 8 shows the results by sample site.

Two samples exceeded the water quality standard for TAH: the shallow sample at BL-4 (17 µg/L) and the deep sample at BL-4 (14 µg/L). All sample sites except BL-11, BL-26, BL-27, and the outboard control sample at BL-11 had a detectable concentration for TAH. The median concentration for the day, excluding the outboard control sample, was 0.51 µg/L.

The outboard sample was collected at sample site BL-11 for this event because the originally proposed site, BL-4, was suspected to have detectable concentrations of TAH from regular boat activity near the public launch. For this reason, the outboard sample site was relocated to sample site BL-11, which analytical data from the earlier sample events showed was generally free from detectable concentrations of TAH. This change allowed for more meaningful analysis of whether the sample boat's outboard engine was impacting sample results. The analytical results for the outboard sample at BL-11 had no detectable concentration of TAH; therefore, it is assumed the emissions from the operation of the sample boat had minimal to no impact on analytical results during sample activities.

4.2.1.7. June 27, 2009

Sixteen total samples were collected on June 27, 2009, a standard sample day: 12 shallow (0.15 m) samples, three deep (0.5 m) samples, and one outboard control sample. Table 15 presents the analytical results, and Figure 9 shows the results by sample site.

Two samples exceeded the water quality standard for TAH: the shallow sample at BL-10 (18 µg/L) and the deep sample at BL-10 (17 µg/L). All sample sites except for BL-1, the shallow sample at BL-4, the deep sample at BL-4, and BL-7 had a detectable concentration for TAH. The median concentration for the day, excluding the outboard control sample, was 2.6 µg/L.

The outboard sample, collected again at sample site BL-11, had a TAH concentration of 2.3 µg/L, which was nearly identical to the result (2.4 µg/L) for the corresponding sample collected at BL-11. In addition, given that the sample from site BL-1 was collected later in the day and had no detectable concentration of TAH, it is assumed that emissions from the operation of the sample boat had minimal to no impact on analytical results during sample activities.

4.2.1.8. July 4, 2009

Thirty-two total samples were collected on July 4, 2009, an intensive sample day: 15 shallow (0.15 m) samples from the intensive sample sites (BL-10, BL-26, and BL-27), five deep (0.5 m) samples from the intensive sample sites, nine shallow (0.15 m)

samples from the standard sample sites, two deep (0.5 m) samples from the standard sample sites, and one outboard control sample. However, four samples (shallow sample from BL-4, shallow sample from BL-10 at 18:00 hours, deep sample from BL-10 at 18:00 hours, and BL-26 at 18:00 hours) were not analyzed because the sample vials froze overnight and ruptured the septa. Table 16 presents the analytical results, and Figure 10 shows the results by sample site. Please note that the analytical results for intensive sample sites BL-10, BL-26, and BL-27 in Table 16 and Figure 10 represent averages of the intensive samples collected on July 4, 2009.

Eight samples exceeded the water quality standard for TAH: the deep sample from BL-4 (62 µg/L), the sample from BL-6 (20 µg/L), the shallow sample from BL-8 (20 µg/L), the deep sample from BL-8 (16 µg/L), the shallow sample from BL-10 (76 µg/L), and the deep samples from BL-10 (84 µg/L), BL-26 (13 µg/L), and BL-27 (11 µg/L). All sample sites had a detectable concentration of TAH. The median concentration for the day, excluding the outboard control sample, was 12 µg/L.

The outboard sample, collected again at sample site BL-11, had the lowest TAH concentration (1.0 µg/L) of any sample collected on July 4; therefore, it is assumed that emissions from the operation of the sample boat had minimal to no impact on analytical results during sample activities.

4.2.1.9. July 5, 2009

Thirty-two total samples were collected on July 5, 2009, an intensive sample day: 15 shallow (0.15 m) samples from the intensive sample sites (BL-10, BL-26, and BL-27), five deep (0.5 m) samples from the intensive sample sites, nine shallow (0.15 m) samples from the standard sample sites, two deep (0.5 m) samples from the standard sample sites, and one outboard control sample. Table 17 presents the analytical results, and Figure 11 shows the results by sample site. Please note that the analytical results for intensive sample sites BL-10, BL-26, and BL-27 in Table 17 and Figure 11 represent averages of the five intensive samples collected on July 5, 2009.

Twelve samples exceeded the water quality standard for TAH: the sample from BL-2 (16 µg/L), the sample from BL-3 (13 µg/L), the shallow sample from BL-4 (70 µg/L), the deep sample from BL-4 (62 µg/L), the sample from BL-5 (15 µg/L), the sample from BL-6 (24 µg/L), the sample from BL-7 (14 µg/L), the shallow sample from BL-8 (20 µg/L), the deep sample from BL-8 (22 µg/L), the shallow sample from BL-10 (54 µg/L), and the deep samples from BL-10 (55 µg/L) and BL-27 (13 µg/L). All sample sites had a detectable concentration of TAH. The median concentration for the day, excluding the outboard control sample, was 16 µg/L.

The outboard sample, collected again at sample site BL-11, had a TAH concentration of 1.2 µg/L, which was slightly more than the result (0.96 µg/L) for the corresponding sample collected at BL-11. However, since the outboard control sample and the sample from site BL-11 were the lowest concentrations detected on July 5, 2009, it is assumed that emissions from the operation of the sample boat had minimal to no impact on analytical results during sample activities.

4.2.1.10. July 6, 2009

Thirty-two total samples were collected on July 6, 2009, an intensive sample day: 15 shallow (0.15 m) samples from the intensive sample sites (BL-10, BL-26, and BL-27), five deep (0.5 m) samples from the intensive sample sites, nine shallow (0.15 m) samples from the standard sample sites, two deep (0.5 m) samples from the standard sample sites, and one outboard control sample. Table 18 presents the analytical results, and Figure 12 shows the results by sample site. Please note that the analytical results for intensive sample sites BL-10, BL-26, and BL-27 in Table 18 and Figure 12 represent averages of the five intensive samples collected on July 5, 2009.

Eight samples exceeded the water quality standard for TAH: the sample from BL-2 (11 µg/L), the sample from BL-3 (13 µg/L), the deep sample from BL-4 (14 µg/L), the sample from BL-5 (12 µg/L), the sample from BL-6 (27 µg/L), the sample from BL-7 (11 µg/L), the shallow sample from BL-8 (12 µg/L), and the deep sample from BL-8 (11 µg/L). All sample sites had a detectable concentration of TAH. The median concentration for the day, excluding the outboard control sample, was 11 µg/L.

The outboard sample, collected again at sample site BL-11, had a TAH concentration of 0.98 µg/L, which was greater than the result (0.21 µg/L) for the corresponding sample collected at BL-11. However, since the outboard control sample and the sample from site BL-11 were the lowest concentrations detected on July 6, 2009, it is assumed that emissions from the operation of the sample boat had minimal impact on analytical results during sample activities.

4.2.1.11. July 25, 2009

Sixteen total samples were collected on July 25, 2009, a standard sample day: 12 shallow (0.15 m) samples, three deep (0.5 m) samples, and one outboard control sample. Table 19 presents the analytical results, and Figure 13 shows the results by sample site.

Two samples exceeded the water quality standard for TAH: the shallow sample from BL-10 (11 µg/L) and the deep sample from BL-10 (11 µg/L). Seven sample sites had no detectable concentration for TAH: BL-1, BL-5, BL-7, BL-11, BL-26, BL-27, and the outboard control sample. The median concentration for the day, excluding the outboard control sample, was 0.26 µg/L.

Given that the outboard sample had no detectable concentration of TAH, it is assumed that emissions from the operation of the sample boat had minimal to no impact on analytical results during sample activities.

4.2.1.12. August 15, 2009

Sixteen total samples were collected on August 15, 2009, a standard sample day: 12 shallow (0.15 m) samples, three deep (0.5 m) samples, and one outboard control sample. Table 20 presents the analytical results, and Figure 14 shows the results by sample site.

One sample was detected at the water quality standard for TAH: the shallow sample from BL-10 (10 µg/L). Another sample exceeded the water quality standard for TAH: the deep sample from BL-10 (22 µg/L). Five sample sites had no detectable concentration for TAH: BL-1, BL-6, BL-8 (shallow and deep samples), BL-11, and the outboard control sample. The median concentration for the day, excluding the outboard control sample, was 0.31 µg/L.

Given that the outboard sample had no detectable concentration of TAH, it is assumed that emissions from the operation of the sample boat had minimal to no impact on analytical results during sample activities.

4.2.1.13. September 7, 2009

Sixteen total samples were collected on September 7, 2009, a standard sample day: 12 shallow (0.15 m) samples, three deep (0.5 m) samples, and one outboard control sample. Table 21 presents the analytical results, and Figure 15 shows the results by sample site.

Five samples exceeded the water quality standard for TAH: the shallow sample from BL-4 (23 µg/L), the deep sample from BL-4 (13 µg/L), the sample from BL-6 (12 µg/L), the shallow sample from BL-10 (34 µg/L), and the deep sample from BL-10 (33 µg/L). Three sample sites had no detectable concentration for TAH: BL-1, BL-11, and the outboard control sample. The median concentration for the day, excluding the outboard control sample, was 6.1 µg/L.

Given that the outboard sample had no detectable concentration of TAH, it is assumed that emissions from the operation of the sample boat had minimal to no impact on analytical results during sample activities.

4.2.2. Sample Sites

This subsection discusses analytical results by sample site. As with previous subsection on sample dates, the statistic of central tendency used to describe the data is the median, or the middle point of a data set.

4.2.2.1. BL-1

Sample site BL-1 is a historical sample site established by the USGS at the deepest area of the west basin. For this project, BL-1 was assumed to be a control site because of minimal expected inputs of hydrocarbons in the area. Table 22 presents the analytical results from BL-1 for all 13 sample events, and Graph 2 shows the TAH data in chart format.

No sample from BL-1 exceeded the water quality standard for TAH. The maximum concentration was 8.5 µg/L on May 24. On five occasions (May 13, June 27, July 25, August 15, and September 7), there was no detectable concentration of TAH. The median TAH concentration for the sample site was 1.3 µg/L.

4.2.2.2. BL-2

Sample site BL-2 is located in the major traffic lane between the two basins of Big Lake. Table 23 presents the analytical results from BL-2 for all 13 sample events, and Graph 3 shows the TAH data in chart format.

Five samples from BL-2, all on holiday weekends, exceeded the water quality standard for TAH: May 24 (10 µg/L), May 25 (11 µg/L), May 26 (14 µg/L), July 5 (16 µg/L), and July 6 (11 µg/L). The sample site had a detectable concentration of TAH for all 13 sample dates. The median TAH concentration for the sample site was 7.3 µg/L.

4.2.2.3. BL-3

Sample site BL-3 is a historical sample site established by the USGS at the deepest area of the east basin. For this project, BL-3 was assumed to be a control or baseline location for the east basin. Table 24 presents the analytical results from BL-3 for all 13 sample events, and Graph 4 shows the TAH data in chart format.

Four samples from BL-3, all on holiday weekends, exceeded the water quality standard for TAH: May 25 (11 µg/L), May 26 (18 µg/L), July 5 (13 µg/L), and July 6 (13 µg/L). The sample site had a detectable concentration of TAH on all 13 sample dates except for May 13. The median TAH concentration for the sample site was 4.5 µg/L.

4.2.2.4. BL-4

Sample site BL-4 is located near the boat launch at the South Shore State Recreation Site. Samples were collected from a shallow depth of 0.15 m and a deep depth of 0.5 m at BL-4. Table 25 presents the analytical results from BL-4 for both sample depths for all 13 sample events, and Graph 5 shows the TAH data in chart format

For the shallow location, six samples from BL-4 exceeded the water quality standard for TAH: May 24 (29 µg/L), May 25 (23 µg/L), May 26 (12 µg/L), June 17 (17 µg/L), July 5 (70 µg/L), and September 7 (23 µg/L). On two occasions (May 13 and June 27), there was no detectable concentration of TAH. The median TAH concentration for the shallow location at BL-4 was 10 µg/L.

For the deep location, eight samples from BL-4 exceeded the water quality standard for TAH: May 24 (33 µg/L), May 25 (22 µg/L), May 26 (13 µg/L), June 17 (14 µg/L), July 4 (62 µg/L), July 5 (62 µg/L), July 6 (14 µg/L), and September 7 (13 µg/L). On two occasions (May 13 and June 27), there was no detectable concentration of TAH. The median TAH concentration for the deep location at BL-4 was 13 µg/L.

4.2.2.5. BL-5

Sample site BL-5 is located in a traffic lane for a populated bay in the southern portion of the east basin. Table 26 presents the analytical results from BL-5 for all 13 sample events, and Graph 6 shows the TAH data in chart format.

Three samples from BL-5, all on holiday weekends, exceeded the water quality standard for TAH: May 26 (15 µg/L), July 5 (15 µg/L), and July 6 (12 µg/L). On one occasion (July

25), there was no detectable concentration of TAH. The median TAH concentration for the sample site was 5.0 µg/L.

4.2.2.6. BL-6

Sample site BL-6 is located near Southport Marina and a fueling station. Table 27 presents the analytical results from BL-6 for all 13 sample events, and Graph 7 shows the TAH data in chart format.

Seven samples from BL-6, all on holiday weekends, exceeded the water quality standard for TAH: May 24 (16 µg/L), May 25 (14 µg/L), May 26 (14 µg/L), July 4 (20 µg/L), July 5 (24 µg/L), July 6 (27 µg/L), and September 7 (12 µg/L). On one occasion (August 15), there was no detectable concentration of TAH. The median TAH concentration for the sample site was 12 µg/L.

4.2.2.7. BL-7

Sample site BL-7 is located where Fish Creek drains from Big Lake. This is a popular fishing area as well as a high-use traffic lane. Table 28 presents the analytical results from BL-7 for all 13 sample events, and Graph 8 shows the TAH data in chart format.

Two samples from BL-7, both on Independence Day weekend, exceeded the water quality standard for TAH: July 5 (14 µg/L) and July 6 (11 µg/L). On three occasions (May 13, June 27, and July 25), there was no detectable concentration of TAH. The median TAH concentration for the sample site was 3.6 µg/L.

4.2.2.8. BL-8

Sample site BL-8 is located near Burkeshore Marina. Samples were collected from a shallow depth of 0.15 m and a deep depth of 0.5 m at BL-8. Table 29 presents the analytical results from BL-8 for both sample depths for all 13 sample events, and Graph 9 shows the TAH data in chart format.

For the shallow location, seven samples from BL-8, all on holiday weekends, exceeded the water quality standard for TAH: May 23 (12 µg/L), May 24 (13 µg/L), May 25 (12 µg/L), May 26 (12 µg/L), July 4 (20 µg/L), July 5 (20 µg/L), and July 6 (12 µg/L). On one occasion (August 15), there was no detectable concentration of TAH. The median TAH concentration for the shallow location at BL-8 was 12 µg/L.

For the deep location, seven samples from BL-8, all on the same holiday weekend days as the shallow location, exceeded the water quality standard for TAH: May 23 (14 µg/L), May 24 (10 µg/L), May 25 (11 µg/L), May 26 (15 µg/L), July 4 (16 µg/L), July 5 (22 µg/L), and July 6 (11 µg/L). On one occasion (August 15), there was no detectable concentration of TAH. The median TAH concentration for the deep location at BL-8 was 10 µg/L.

4.2.2.9. BL-10

Sample site BL-10 is located near the public swim area at the North Shore State Recreation Site. Samples were collected from a shallow depth of 0.15 m and a deep depth of 0.5 m at BL-8. Table 30 presents the analytical results from BL-10 for both

sample depths for all 13 sample events, and Graph 10 shows the TAH data in chart format. Please note that the analytical results for the intensive samples from May 23–26 and July 4–6 in Table 30 and Graph 10 represent averages of the five intensive samples collected on those intensive sample dates. Evaluation of analytical results from intensive sample dates occurs in Section 4.3.

For the shallow location at BL-10, ten samples exceeded the water quality standard for TAH. The exceedances occurred on seven days associated with holiday weekends: May 23 (39 µg/L), May 24 (48 µg/L), May 25 (39 µg/L), May 26 (18 µg/L), July 4 (76 µg/L), July 5 (54 µg/L), and September 7 (34 µg/L). The other three days when exceedances occurred were June 27 (18 µg/L), July 25 (11 µg/L), and August 15 (10 µg/L). The shallow location had a detectable concentration of TAH for all 13 sample dates. The median TAH concentration for the shallow location was 18 µg/L.

For the deep location at BL-10, ten samples also exceeded the water quality standard for TAH. The exceedances occurred on seven days associated with holiday weekends: May 23 (36 µg/L), May 24 (47 µg/L), May 25 (43 µg/L), May 26 (17 µg/L), July 4 (84 µg/L), July 5 (55 µg/L), and September 7 (33 µg/L). The other three days when exceedances occurred were June 27 (17 µg/L), July 25 (11 µg/L), and August 15 (22 µg/L). The deep location had a detectable concentration of TAH for all 13 sample dates. The median TAH concentration for the deep location was 22 µg/L.

4.2.2.10. BL-11

Sample site BL-11 is located at the mouth of Meadow Creek. Table 31 presents the analytical results from BL-11 for all 13 sample events, and Graph 11 shows the TAH data in chart format.

No sample from BL-11 exceeded the water quality standard for TAH. The maximum concentration was 3.5 µg/L on July 4. On seven occasions (May 13, May 23, May 24, June 17, July 25, August 15, and September 7), there was no detectable concentration of TAH. The median TAH concentration for the sample site was no detectable concentration.

4.2.2.11. BL-26

Sample site BL-26 is located in the middle of North Bay. Table 32 presents the analytical results from BL-26 for all 13 sample events, and Graph 12 shows the TAH data in chart format. Please note that the analytical results for the intensive samples from May 23–26 and July 4–6 in Table 32 and Graph 12 represent averages of the five intensive samples collected on those intensive sample dates. Evaluation of analytical results from intensive sample dates occurs in Section 4.3.

Four samples from BL-26, all on holiday weekends, exceeded the water quality standard for TAH: May 24 (12 µg/L), May 25 (17 µg/L), May 26 (11 µg/L), and July 4 (13 µg/L). On two occasions (June 17 and July 25), there was no detectable concentration of TAH. The median TAH concentration for BL-26 was 4.9 µg/L.

4.2.2.12. BL-27

Sample site BL-27 is located in the main traffic lane for users leaving North Bay and the North Shore State Recreation Site. Table 33 presents the analytical results from BL-27 for all 13 sample events, and Graph 13 shows the TAH data in chart format. Please note that the analytical results for the intensive samples from May 23–26 and July 4–6 in Table 33 and Graph 13 represent averages of the five intensive samples collected on those intensive sample dates. Evaluation of analytical results from intensive sample dates occurs in Section 4.3.

Five samples from BL-27, all on holiday weekends, exceeded the water quality standard for TAH: May 24 (11 µg/L), May 25 (17 µg/L), May 26 (14 µg/L), July 4 (11 µg/L), and July 5 (13 µg/L). On two occasions (June 17 and July 25), there was no detectable concentration of TAH. The median TAH concentration for BL-27 was 5.6 µg/L.

4.2.3. Intensive Samples

This subsection discusses analytical results on intensive sample days. As with previous subsections on sample dates and sample sites, the statistic of central tendency used to describe the data is the median, or the middle point of a data set.

4.2.3.1. Memorial Day Weekend

Table 34 presents the analytical results for samples collected over four days on Memorial Day weekend (Saturday through Tuesday). Samples were collected five times per day at regular time intervals for three sample sites: BL-10, BL-26, and BL-27. Therefore, 20 samples were collected per sample site during the four days of intensive sampling.

All 20 samples from the shallow interval at BL-10 exceeded the water quality standard for TAH. The maximum concentration was 72 µg/L at 21:00 hours on Saturday, May 24. The median concentration for the shallow interval was 37 µg/L.

Nineteen of the 20 samples from the deep interval at BL-10 exceeded the water quality standard for TAH. The exception was the last sample collected during the intensive sampling effort (May 26 at 21:00 hours), which had a concentration of 8.1 µg/L. The maximum concentration was 72 µg/L at 21:00 hours on Saturday, May 24. The median concentration for the deep interval was 37 µg/L.

Thirteen of the 20 samples from BL-26 exceeded the water quality standard for TAH. None of the samples from Saturday, May 23, exceeded the standard, while all five samples from both May 24 and May 25 exceeded the standard. The remaining three exceedances occurred on Tuesday, May 26. The maximum concentration was 21 µg/L at 18:00 hours on Monday, May 25. The median concentration for BL-26 was 12 µg/L.

Thirteen of the 20 samples from BL-27 exceeded the water quality standard for TAH. None of the samples from Saturday, May 23, exceeded the standard, while all five samples from both May 25 and May 26 exceeded the standard. The remaining three exceedances occurred in the last three samples from Tuesday, May 24. The maximum

concentration was 19 µg/L at 18:00 hours on Monday, May 25. The median concentration for BL-27 was 13 µg/L.

Graph 14 depicts the trend of TAH concentrations per sample site. The shallow and deep samples from BL-10 had significantly higher concentrations than the results from sites BL-26 and BL-27. In fact, 39 of the 40 samples collected from both the shallow and deep locations at BL-10 exceeded the water quality standard for TAH. The only exception was the last sample collected from the deep location at 21:00 hours on Tuesday, May 26 (the last sample collected for the intensive sampling event). The maximum TAH concentration was 72 µg/L, which was measured in both the shallow and deep locations from BL-10 at 21:00 hours on Saturday, May 24. The TAH concentrations generally rose at BL-10 as the day progressed on May 23, May 24, and May 25. The last day, Tuesday, May 26, appears to show a decreasing trend as the day progressed.

TAH concentrations at BL-26 and BL-27 closely followed each other. Concentrations were less than the TAH standard all day on Saturday, May 23, and then were above the standard all day on May 24 and May 25. Concentrations began to decrease on Tuesday, May 26, but mostly were greater than the TAH standard.

Concentrations at BL-10 generally exhibited a pattern of daily loading and nightly decay, while concentrations at BL-26 and BL-27 showed a consistent loading through Monday, May 25 (Memorial Day), and then a gradual decay on May 26.

4.2.3.2. Independence Day Weekend

Table 35 presents the analytical results for samples collected over three days on Independence Day weekend (Saturday through Monday). Samples were collected five times per day at regular time intervals for three sample sites: BL-10, BL-26, and BL-27. Therefore, 15 samples should have been collected per sample site during the four days of intensive sampling, but samples from 18:00 hours on July 4 were lost for B-10 and BL-26 when they froze and ruptured in cold storage. The result is that 14 samples were collected and analyzed from sample sites BL-10 (shallow and deep) and BL-26, and 15 were collected and analyzed from sample site BL-27.

Ten of the 14 samples from the shallow interval at BL-10 exceeded the water quality standard for TAH. All four of the samples from Saturday, July 4, and all five of the samples from July 5 exceeded the standard. The remaining exceedance occurred at 18:00 hours on Monday, July 6. The maximum concentration was 114 µg/L at 21:00 hours on Saturday, July 4. The median concentration for the shallow interval was 46 µg/L.

Nine of the 14 samples from the deep interval at BL-10 exceeded the water quality standard for TAH. None of the samples from Monday, July 6, exceeded the standard, while all four samples from Saturday, July 4, and all five samples from July 5 exceeded the standard. The maximum concentration was 129 µg/L at 15:00 hours on Saturday, July 4. The median concentration for the deep interval was 49 µg/L.

Five of the 14 samples from BL-26 exceeded the water quality standard for TAH. None of the samples from Monday, July 6, exceeded the standard, while two samples from

Saturday, July 4 (15:00 and 21:00 hours), and the last three samples from July 5 exceeded the standard. The maximum concentration was 21 µg/L at 21:00 hours on Saturday, July 4. The median concentration for BL-26 was 5.2 µg/L.

Five of the 15 samples from BL-27 exceeded the water quality standard for TAH. None of the samples from Monday, July 6, exceeded the standard, while the last two samples from Saturday, July 4, and the last three samples from July 5 exceeded the standard. The maximum concentration was 18 µg/L at 18:00 hours on Sunday, July 5. The median concentration for BL-27 was 9.4 µg/L.

Graph 15 depicts the trend of TAH concentrations per sample site. The shallow and deep samples from BL-10 had significantly higher concentrations than the results from sites BL-26 and BL-27 on July 4 and 5. The maximum TAH concentration was 129 µg/L, which was measured in the deep sample from BL-10 at 18:00 hours on Saturday, July 4.

TAH concentrations at BL-26 and BL-27 closely followed each other. Concentrations began each day at less than the TAH standard, but rose above the standard by the 15:00 hour for July 4 and 5. Monday, July 6, saw steady concentrations less than the TAH standard all day.

Concentrations at all three sample sites generally exhibited a pattern of daily loading and nightly decay for the Independence Day weekend.

4.3. Watercraft Usage

OASIS field personnel counted the number of motorized watercraft that were visibly operating during sampling at each sample site for all 13 sample dates. Table 36 presents the data for motorized watercraft usage. July 5 was the busiest day based on the number (183) of total motorized watercraft counted for all sample dates, although July 4 had an almost equal watercraft count (181). June 17 was the quietest day with only 12 motorized watercraft counted. The median day was May 25, Memorial Day, with 63 motorized watercraft counted. BL-2 was the busiest sample site based on the number (177) of total motorized watercraft counted for all sample sites. BL-11 was the quietest with only 17 motorized watercraft counted. The median motorized watercraft count by sample site was 66.

The observer at the South Shore State Recreation Site monitored motorized watercraft craft on May 24 and 25 and July 5 and 6. Table 37 presents the data for total watercraft counts by hour and visual identification of 2-stroke and 4-stroke engine types. A total of 618 boating hours were observed on May 24 and 25, while 483 boating hours were observed on July 5 and 6. The two days over Memorial Day weekend had nearly 28% more watercraft hours observed than the two days over Independence Day weekend. The percentage of visually identified 2-stroke engines was much higher over Memorial Day weekend (17.8%) than over Independence Day weekend (2.1%), although visual identification is difficult, especially from the shore while using binoculars. In addition, the observer was unable to identify at least one-third of the engines during the four days of observations.

The interviewer at the North Shore Recreation Site monitored motorized watercraft launchings on May 24 and 25 and July 5 and 6. Table 38 presents the data for the interviewer findings. The interviewer witnessed 71 launchings (54 boats and 17 personal watercraft) over the four days and was able to obtain complete engine data from 34 of the users: 30 4-stroke engines with an average horsepower of 170, and 4 2-stroke engines with an average horsepower of 90. The 71 observed watercraft averaged 3.3 hours of operation per day.

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5. QUALITY ASSURANCE REVIEW

The analytical results for all field quality control (QC) and laboratory quality assurance (QA) samples were evaluated. The data were reviewed to determine the integrity of the reported analytical results and ensure analytical results met data quality objectives as presented in the QAPP (OASIS 2009b). Appendix H contains a complete QA/QC review. Appendix I presents a QA summary of the analytical data using ADEC's Laboratory Data Review Checklist.

The following list provides a brief review of data quality objectives:

- All work was performed by OASIS personnel who are qualified individuals as per 18 AAC 75.990(100).
- Completeness–98.9% of samples collected were analyzed, thereby meeting the data quality objective of 90%.
- Accuracy–All primary, matrix spike/matrix spike duplicate, laboratory control, and method blank samples met method criteria for surrogate recoveries.
- Precision–Only one field duplicate set had a relative percent difference (RPD) outside of the data quality objective of 30%: Primary sample 09-BL-0627-08-15-SW and duplicate sample 09-BL-0627-121-15-SW exceeded the recommended RPD of 30% in BTEX analysis. Associated results have been flagged "J" as values are considered estimated. Lastly, RPDs for matrix spike/matrix spike duplicate and laboratory control samples also met criteria.
- Comparability–Samples were collected and analyzed in a manner that allowed analytical results to be compared to each other. Laboratory reporting limits met or were below established water quality criteria.
- Representativeness–Water samples were collected in a manner that minimally disturbed the water column and retrieved the sample matrix from the desired depth. Analysis of trip blank samples indicated that no cross-contamination occurred during the project.

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6. EVALUATION OF FINDINGS

This section provides additional analysis and interpretation of the results described in Section 4. The purpose is to understand the trend of dissolved-phase hydrocarbon concentrations on a daily and seasonal basis; to understand the relationship between motorized watercraft usage and petroleum hydrocarbon loading to the lake; to estimate the volume of impaired waters; and to estimate the daily maximum load of petroleum hydrocarbons in Big Lake.

6.1. Hydrocarbon Trends

6.1.1. Seasonal

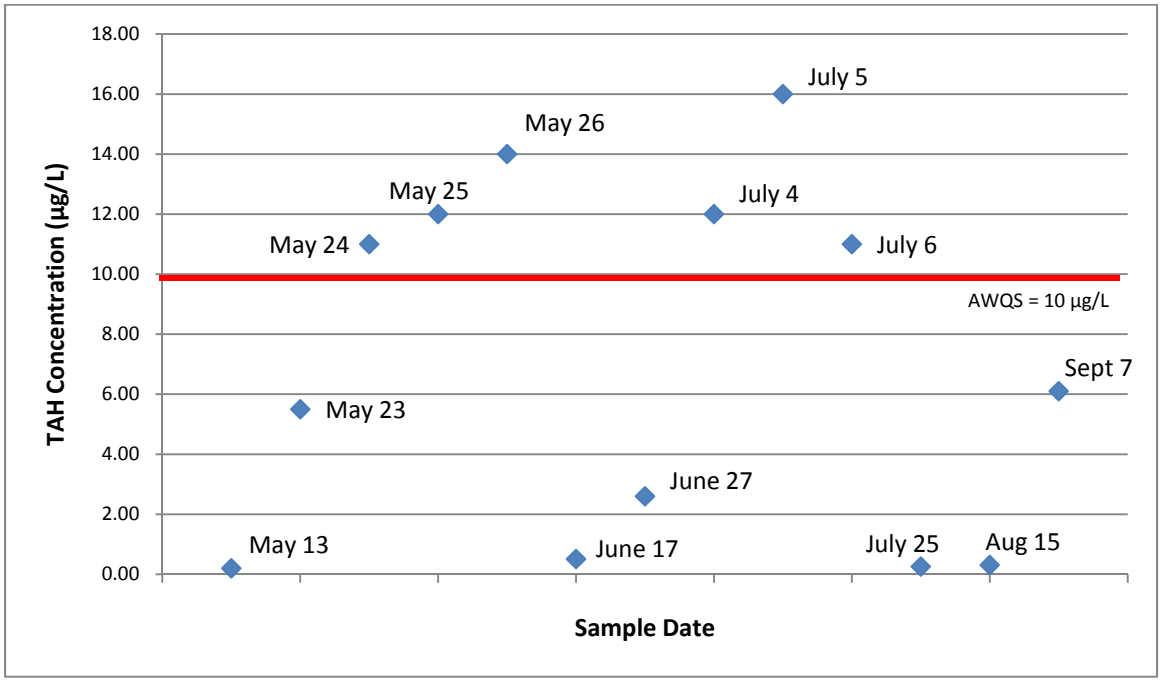
Table 39 shows the median TAH concentration by sample date and the number of sample sites that exceeded the water quality standard for TAH for each sample date. As discussed in Section 4, the statistic of central tendency used to describe the data is the median, or the middle point of a data set, since the lake does not truly represent a uniform population from which an average concentration may be meaningfully derived. Please note that average concentrations were used for the five samples from the intensive sample sites BL-10, BL-26, and BL-27 on intensive sample days.

TABLE 39: HYDROCARBON METRICS BY SAMPLE DATE

Sample Date	Median TAH Concentration (µg/L)	Number of Sample Sites Exceeding TAH Standard	Percentage of Sample Sites Exceeding TAH Standard
May 13	0.20	0/12	0%
May 23	5.5	2/12	17%
May 24	11	7/12	58%
May 25	12	7/12	58%
May 26	14	9/12	75%
June 17	0.51	1/12	8%
June 27	2.6	1/12	8%
July 4	12	6/12	50%
July 5	16	9/12	75%
July 6	11	7/12	58%
July 25	0.26	1/12	8%
August 15	0.31	1/12	8%
September 7	6.1	3/12	25%

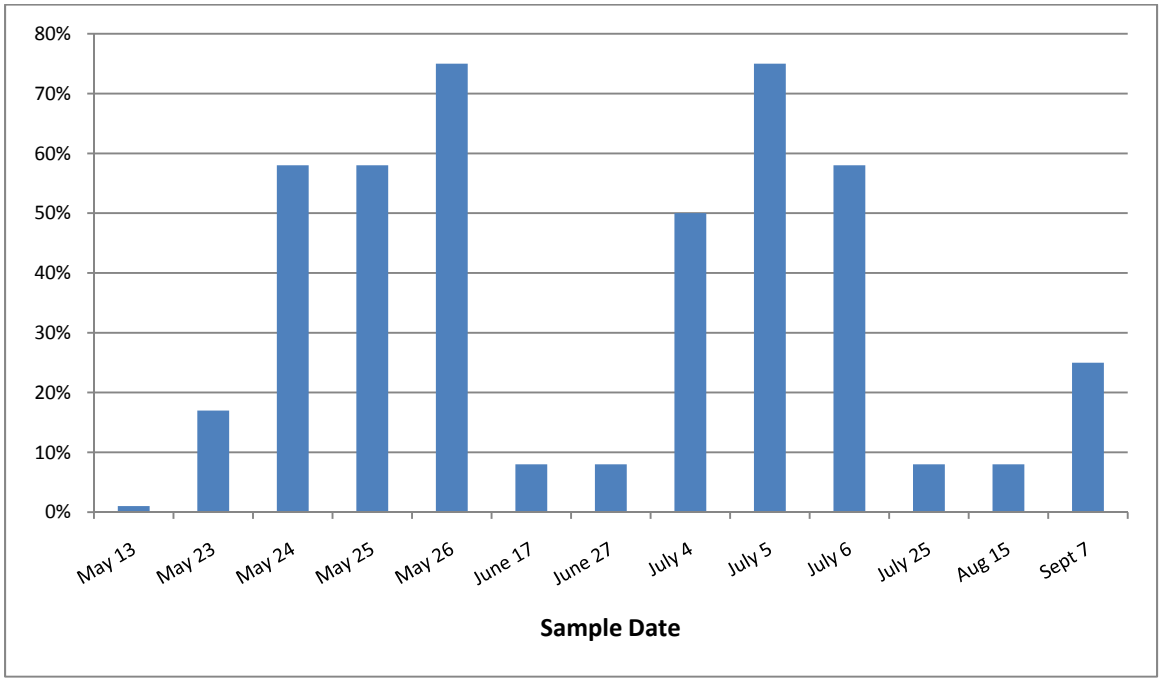
Graph 16 visually presents the median TAH concentrations by sample date with the TAH standard of 10 µg/L for reference. Graph 17 depicts the frequency that sample sites exceeded the TAH standard by sample date.

GRAPH 16: MEDIAN TAH CONCENTRATION FOR SAMPLE DATES



Note: AWQS = Alaska water quality standard for TAH is 10 µg/L.

GRAPH 17: FREQUENCY OF SAMPLE SITES EXCEEDING TAH STANDARD BY SAMPLE DATE



Note: Holiday weekend days included May 23-26 (Saturday – Tuesday), July 4-6 (Saturday – Monday), and September 7 (Monday).

The data in Table 39 and Graphs 16 and 17 demonstrate the pressure that holiday weekends place on water quality at Big Lake. The median TAH concentration for all of the eight holiday weekend sample dates (May 23–26, July 4–6, and September 7) was at least one-half the water quality standard for TAH (5 µg/L), and the median TAH concentrations for six of the holiday weekend days exceeded the TAH standard. The other five sample dates (two weekdays and three weekends) all had median TAH concentrations less than approximately one-quarter of the TAH standard (2.5 µg/L), and four of the sample dates had median TAH concentrations less one-tenth of the TAH standard (1 µg/L). The percentage of sample sites exceeding the TAH standard for each sample date also follows the pattern of median TAH concentrations. Namely, that holiday weekends had much higher percentages of sample sites exceeding the TAH standard than non-holiday weekend sample dates.

These data trends also apply for the number of sample sites with a TAH concentration greater than the standard. For instance, for all samples collected on the eight sample dates associated with holiday weekends, 50 out of 96 sample sites (52%) exceeded the water quality standard for TAH. This result may be interpolated to say that it is likely that one-half of the east basin in Big Lake is impaired at any given time on a holiday weekend. On the other hand, only four out of the 60 samples (6.7%) associated with the other five non-holiday weekend days exceeded the water quality standard for TAH.

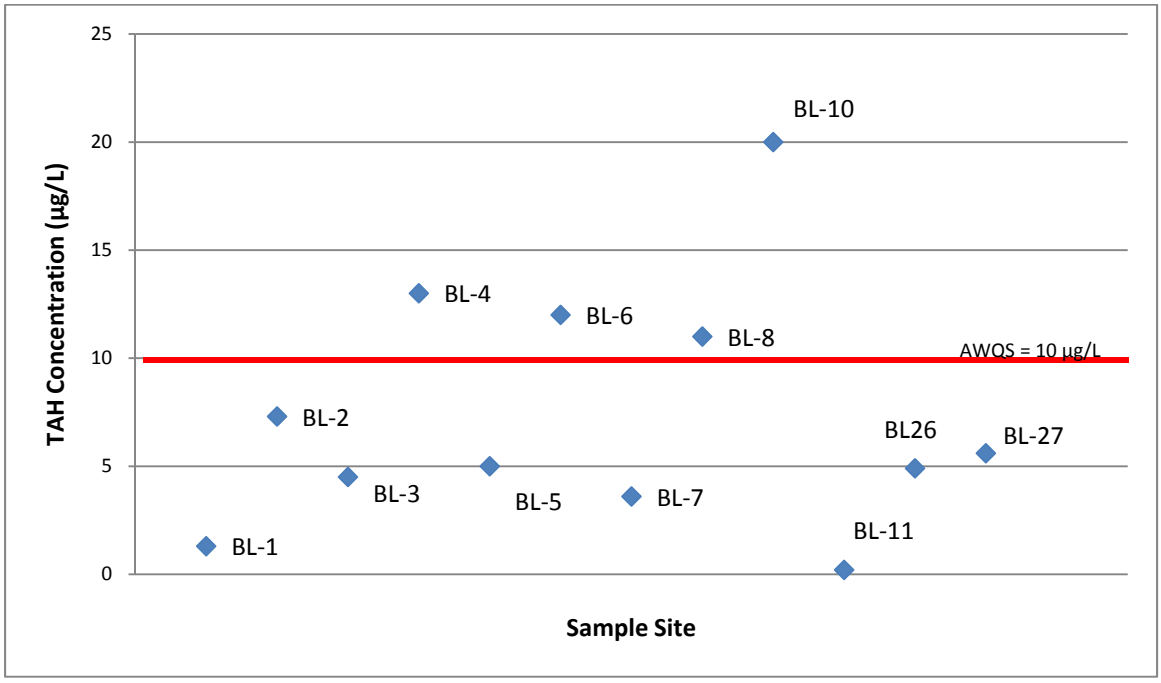
Table 40 shows the median TAH concentration by sample site and the number of times per sample site that a sample exceeded the water quality standard for TAH on the 13 sample dates. For sample sites with a shallow and deep sample (BL-4, BL-8, and BL-10), the median metric includes both shallow and deep samples.

TABLE 40: HYDROCARBON METRICS BY SAMPLE SITE

Sample Date	Median TAH Concentration (µg/L)	Number of Times Sample Site Exceeded TAH Standard	Percentage of Time Sample Site Exceeded TAH Standard
BL-1	1.3	0/13	0%
BL-2	7.3	5/13	38%
BL-3	4.5	4/13	31%
BL-4	13	14/26	54%
BL-5	5.0	3/13	23%
BL-6	12	7/13	54%
BL-7	3.6	2/13	15%
BL-8	11	14/26	54%
BL-10	20	20/26	77%
BL-11	< 0.20	0/13	0%
BL-26	4.9	4/13	31%
BL-27	5.6	5/13	38%

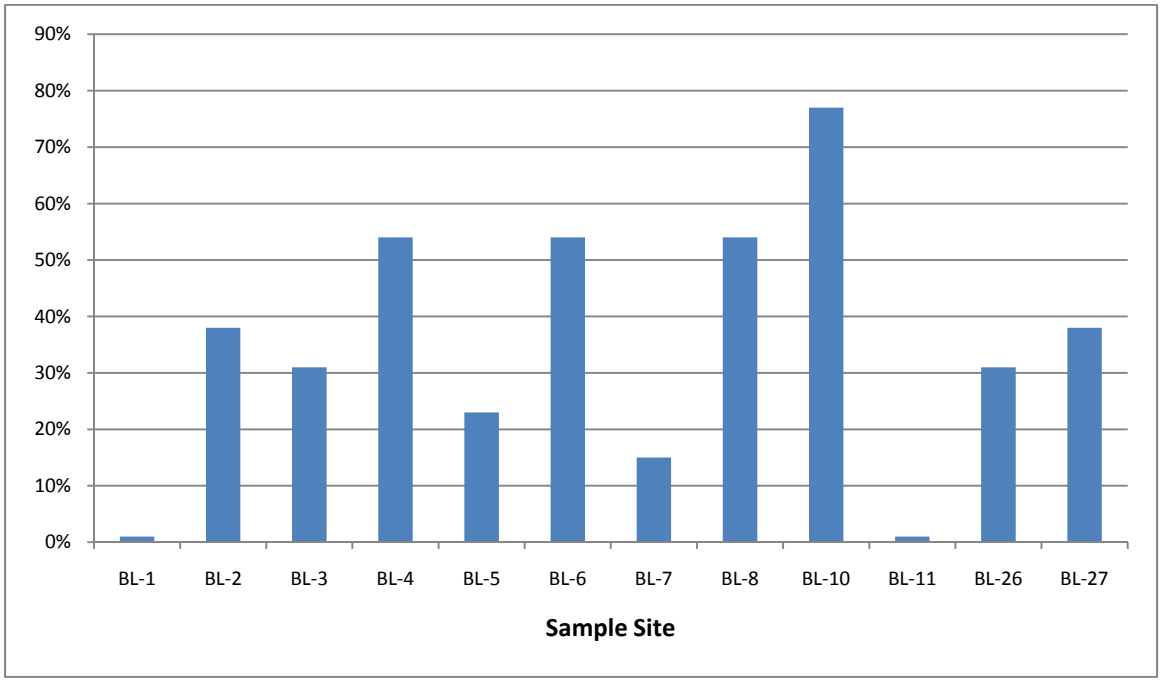
Graph 18 visually presents the median TAH concentrations by sample site with the TAH standard of 10 µg/L for reference. Graph 19 depicts the frequency that each sample site exceeded the TAH standard.

GRAPH 18: MEDIAN TAH CONCENTRATION FOR SAMPLE SITES



Note: AWQS = Alaska water quality standard for TAH is 10 µg/L.

GRAPH 19: FREQUENCY OF SAMPLE SITES EXCEEDING TAH STANDARD



Note: Sample sites BL-4, BL-6, BL-8, and BL-10 have watercraft launches.

The data in Table 40 and Graphs 18 and 19 show the sample sites, and hence the areas of Big Lake, where water quality is jeopardized. The most impacted areas are the sample sites that had a frequency of greater than 50% for exceeding the water quality standard: BL-4, BL-6, BL-8, and BL-10. These four sample sites are also launch points for watercraft: BL-4 is at South Shore State Recreation Site, BL-6 is at Southport Marina, BL-8 is at Burkeshore Marina, and BL-10 is at North Shore State Recreation Site. These sample sites likely receive additional water quality pressure because recently fueled watercraft may have residual hydrocarbons on their exteriors; cold starting engines are more prone to increased emissions; and the launches also create a density of watercraft that is not likely to occur at other locations. The other locations with an elevated frequency (greater than 25%) of exceeding the water standard for TAH are BL-2, BL-3, BL-26, and BL-27. These four locations are similar in that they are main thoroughfares at Big Lake. BL-2 is located in the passage that connects the lake's two basins; BL-3 is located in the center of the east basin, and therefore most traffic within the basin is likely to pass through this area; and BL-26 and BL-27 are located in the traffic lane for watercraft using the launch at North Shore State Recreation Site to access the rest of Big Lake.

6.1.2. Daily

Conducting intensive sample events on successive sample dates allowed for additional understanding of how hydrocarbons load in Big Lake. Section 4.2.3 details the results for the two holiday weekends during which intensive sampling occurred, including a graphical trend chart for both holiday weekends.

The data for BL-10, located near the launch for the North Shore State Recreation Site, exhibited persistent concentrations above the water quality standard for TAH. The intensive sampling also demonstrated that sample site BL-10 experienced rapid changes in hydrocarbon concentrations over a 24-hour cycle. In general, concentrations increased during the day as the total number of watercraft passing through the area increased. However, the reprieve of watercraft traffic during the night brought about a rapid decay of hydrocarbons as demonstrated by the change in analytical results between the 21:00 hour and the 09:00 hour sample on the following day.

The data for BL-26 and BL-27 exhibited different trends for Memorial Day and Independence Day weekends. Memorial Day weekend showed concentrations that continued to load through the high traffic days of Saturday, Sunday, and the holiday on Monday, but the concentrations were much less than the concentrations measured at BL-10. These findings suggest that sample sites BL-26 and BL-27 were likely more influenced by a general mixing of TAH pollutants throughout the lake's water column in contrast to the daily, cyclical pattern of concentrations at BL-10, which appears more indicative of discrete inputs of pollutants from individual watercraft.

The data from Independence Day weekend for BL-26 and BL-27, however, is more similar to the data for BL-10 because of the observed daily, cyclical pattern of TAH concentrations. The reasons for the change are likely complex, but the 10 degree

Fahrenheit (°F) increase in water temperature from Memorial Day to Independence Day weekend is likely a major contributing factor because warmer water tends to release volatile compounds much more readily.

The mechanics of how hydrocarbons are loading and decaying are a worthwhile examination, but are not essential to defining the trends observed during the intensive sampling. The important finding is that the intensive results have shown that Big Lake may experience at least two trends in hydrocarbon loading: a daily pattern of increasing concentrations followed by a night of concentration decay, or a day-over-day pattern of increasing concentrations until watercraft traffic subsides.

6.2. Volume of Impaired Waters

The calculation of the volume of impaired waters required the following broad, key assumptions:

- The estimation of the area to be included around a sample site that exceeded the water quality standard for TAH was based on results from surrounding sites. If the sample site was an isolated exceedance, meaning that adjacent sample sites did not exceed the TAH standard, then the impacted area was considered to be approximately 15 acres. If adjacent sample sites exceeded the TAH standard, then all areas between the sample sites were assumed to exceed the TAH standard, thereby greatly increasing the acreage of impaired waters.
- The depth of impaired waters for each sample event was assumed to be the average of the total depth of each sample site or the average thickness of the epilimnion as measured at BL-3, whichever was less for each sample site. No mixing of hydrocarbons in the thermocline was assumed in order to derive a conservative estimate of impaired waters.

These assumptions yielded the volumes of impaired waters for Big Lake detailed in Table 41 for each sample date.

TABLE 41: VOLUME OF IMPAIRED WATERS

Sample Date	Surface Area of Impaired Waters (Acres)	Average Depth of Impaired Waters (Meters)	Volume of Impaired Waters (Millions of Gallons)	Percentage of Impaired Waters
May 13	0	1.0	0	0%
May 23	30	3.0	96	0.33%
May 24	430	2.4	1,100	3.8%
May 25	1,100	2.4	2,800	9.7%
May 26	1,300	1.8	2,500	8.6%
June 17	15	2.4	38	0.13%
June 27	15	3.6	58	0.20%
July 4	290	3.0	930	3.2%
July 5	1,300	3.0	4,200	14%
July 6	1,000	2.4	2,600	9.0%
July 25	15	3.6	58	0.20%
August 15	15	4.1	66	2.3%
September 7	100	4.8	510	1.8%

Note: Big Lake contains approximately 29 billion gallons of water (USGS 1995).

The median impacted surface area is 100 acres (approximately 3.3% of Big Lake's area), and the median volume of impaired waters is 510,000,000 gallons (approximately 1.8% of Big Lake's volume). However, the difference between the holiday weekend sample dates and other sample dates is striking. For the holiday weekend dates, the median impacted surface area is 715 acres (approximately 24% of Big Lake's surface area), and the median volume of impaired waters is 1,800,000,000 gallons (approximately 6.2% of Big Lake's volume). Meanwhile, for other sample dates, the median impacted surface area is 15 acres (approximately 0.5% of Big Lake's surface area), and the median volume of impaired waters is 58,000,000 gallons (approximately 0.2% of Big Lake's volume).

6.3. Hydrocarbon Loading

The calculation of the mass of petroleum hydrocarbons loading into Big Lake on a daily basis is determined by a simple equation:

$$\textbf{MASS = RATE * TIME} \quad \textbf{(1)}$$

where "Rate" is the amount of TAH entering Big Lake per hour and "Time" is the amount of boating hours per day. The following describes the derivation of "Rate" and "Time."

6.3.1. Rate

Four factors directly affect the derivation of "Rate":

- Volume (V) of fuel used by both 2-stroke and 4-stroke engines per hour (i.e., gallons per hour [GPH])
- Inefficiency (I) of both 2-stroke and 4-stroke engines (i.e., percentage of fuel lost during combustion)
- Percentage of TAH in gasoline (G)
- Percentage of TAH lost during combustion that dissolves in water (S)

These factors are expressed in the following equation:

$$\textbf{RATE = V * I * G * S} \quad \textbf{(2)}$$

Given that "V * I" varies based on 2-stroke and 4-stroke engines, the following equation defines the product of "V * I":

$$\textbf{V * I} = (\textbf{V}_2 * \textbf{I}_2) * \textbf{P}_2) + ((\textbf{V}_4 * \textbf{I}_4) * \textbf{P}_4) \quad \textbf{(3)}$$

where the "2" subscript applies to 2-stroke engines and the "4" subscript applies to 4-stroke engines, and "P" is the percentage of 2-stroke or 4-stroke engines on Big Lake.

A number of broad assumptions are necessary to estimate the factors for Equation 3. These assumptions are the following:

- The percentage of watercraft with 2-stroke or 4-stroke engines is based on the results of the interviewer stationed at the North Shore State Recreation Site on

May 24, May 25, July 5, and July 6. The interviewer witnessed 71 launchings (54 boats and 17 personal watercraft) over the four days and was able to obtain complete engine data from 34 of the users: 30 4-stroke engines with an average horsepower of 170, and 4 2-stroke engines with an average horsepower of 90. These data have been extrapolated to assume that 88% of motorized watercraft on Big Lake have 4-stroke engines with an average horsepower of 170, and that 12% of motorized watercraft on Big Lake have 2-stroke engines with an average horsepower of 90.

- For 4-stroke engines, performance data for a Yamaha 150 horsepower engine (Yamaha F150TXR) has been used to approximate engine activity on Big Lake. Although the average 4-stroke engine had 170 horsepower, that is not a regularly manufactured engine size. Generally, 150 horsepower or 200 horsepower are the closest sizes. The 150-horsepower engine has been used so as to not potentially overestimate the average engine output, and thus overestimate hydrocarbon loading.
- For 2-stroke engines, performance data for a Yamaha 90 horsepower engine (Yamaha 90TLR) was used to approximate engine activity on Big Lake.
- For a normal boating hour on Big Lake, the engine is used approximately one-half of the time in an idle throttle and the other one-half in a full throttle (i.e., on-step). Therefore, the average operating assumption is that the engine is being used in mid-step throttle. For the Yamaha F150TXR, the gallons per hour usage at mid-step throttle is 4.0. For the Yamaha 90TLR, the gallons per hour usage at mid-step throttle is 4.2 (Yamaha 2009).
- For 2-stroke engines, 25% to 30% of fuel consumed may exit the cylinder unburned (EPA 1996). The use of a 4-stroke engine reduces fuel lost in the combustion process by 75% to 95% (ODEQ 1999). Therefore, an average estimate of the inefficiency for a 2-stroke engine is 27.5%, and for a 4-stroke engine the inefficiency is 4.1% (0.275 * 0.15).

These assumptions yield the following result for Equation 3:

V * I = ((4.2 GPH * 0.275) *0.12) + ((4.0 GPH * 0.041) * 0.88) = 0.139 GPH + 0.144 GPH = 0.283 GPH

The following assumptions have been employed for Equation 2:

- Available data for Tesoro and Flint Hills regular gasoline were used to estimate the percentage of TAH in gasoline (Geosphere 2005). The average amount of TAH in the gasoline for these two refiners is 36.9%.
- An existing study showed that an estimated 35% to 40% of emitted hydrocarbons likely stay dissolved in water while the remainder is released to the atmosphere (St. Croix 1997). Therefore, 37.5% has been used to estimate the amount of emitted hydrocarbons that dissolve in Big Lake.

These assumptions, combined with the result for Equation 3, yield the following result for Equation 2:

RATE = 0.283 GPH * 0.369 * 0.375 = 0.039 GPH

Therefore, the average motorized watercraft emits 0.039 GPH of TAH to Big Lake while in use. For scaling purposes, 0.039 GPH is equal to approximately 5 fluid ounces, or slightly more than ½ cup of TAH per hour.

6.3.2. Time

Two factors directly affect the derivation of "Time":

- The number of motorized watercraft per day on Big Lake
- The number of operating hours per motorized watercraft

Unfortunately, estimating these two factors with available data is problematic. The following summarizes the findings from the sample events and also expounds on the difficulties of estimating the two factors:

- Personnel on the sample boat counted visible, operating motorized watercraft at each sample site. However, this technique did not allow for a method to extrapolate watercraft counts from individual sample sites to a lake-wide watercraft count. In addition, there is no feasible method to extrapolate the number of operating hours per watercraft from this technique.
- The observer at the South Shore State Recreation Site made counts of visible motorized watercraft every hour from 09:00 to 21:00 on May 23 and 24 and July 5 and 6. The observer made an effort to not re-count the same watercraft during the same hour, so as not to over-count operating hours. Since the observer was at a fixed location, the counts are limited to the watercraft visible from the South Shore State Recreation Site, which includes most of the east basin. Although all watercraft on the lake were most certainly not counted because of the observer's fixed location, there likely is no better location for obtaining a more accurate count of watercraft on Big Lake given the wide vantage from the South Shore State Recreation Site and the density of watercraft usage in the east basin. Therefore, the observer's data is probably the best available estimate of operating hours per motorized watercraft; however, the data only represent four days of use. On the other hand, the four days of data likely represent peak conditions given that they occurred on Memorial Day and Independence Day weekends, and some of the highest TAH concentrations were measure on these dates.
- The interviewer at the North Shore State Recreation Site made the most accurate counts of operating hours because the interviewer was able to document when watercraft users left the launch and when they returned. Similar to the data for the observer, this information was only collected on May 24 and 25 and July 5 and 6. The interviewer was unable to collect watercraft numbers data that accurately reflect the number of watercraft on Big Lake per day given the limited vantage from the North Shore State Recreation Site; therefore, the operating hours data would have to be used in conjunction with watercraft counts

from other sources. However, as previously noted there are no accurate watercraft counts available.

The result is that there was no single method that produced the necessary data for boat count and operating hours to estimate the "Time" factor. Given the available data, the most reliable appears to be the number of motorized watercraft hours counted by the observer at the South Shore State Recreation Site; therefore, the following list shows the estimated watercraft hours for four days of observation with a factor increase of 5% to conservatively account for other watercraft on Big Lake that the observer at the South Shore State Recreation Site did not see per hour:

- May 24 = 363 hours * 1.05 = 381 hours
- May 25 = 255 hours * 1.05 = 268 hours
- July 5 = 273 hours * 1.05 = 287 hours
- July 6 = 210 hours * 1.05 = 221 hours

6.3.3. Mass

The loading of TAH for May 24, May 25, July 5, and July 6 is estimated using Equation 1 and the factors that were defined in Sections 6.3.1 and 6.3.2. The results are:

MAY 24 = 0.039 GPH * 381 HOURS = 14.9 GALLONS OF TAH
MAY 25 = 0.039 GPH * 268 HOURS = 10.5 GALLONS OF TAH
JULY 5 = 0.039 GPH * 287 HOURS = 11.2 GALLONS OF TAH
JULY 6 = 0.039 GPH * 221 HOURS = 8.62 GALLONS OF TAH

These numbers represent a likely worst case scenario for summer activities at Big Lake because the evaluated days occurred on holiday weekends, and weather conditions on these days also were prime for watercraft activities as seen in Table 42.

TABLE 42: WEATHER CONDITIONS

Sample Date	High Temperature (°F)	Average High Temperature (°F)
May 24	66.6	53.3
May 25	69.4	56.2
July 5	81.2	68.2
July 6	84.3	68.6

Note: Weather data from PWS KAKWILLO2, Willow, Alaska

Lastly, the estimated loading data may be checked by comparing the derived results to the actual median TAH concentrations measured on May 24, May 25, July 5, and July 6. The comparison is accomplished by dividing the daily loading estimates into the estimated impaired waters for Big Lake from Table 41. This yields an average concentration of gallons of TAH per gallons of water for each sample date. Table 43 shows these calculations and also the median TAH concentrations from the 12 sample sites for each sample date. The median TAH concentrations are expressed in µg/L, which is essentially equivalent to parts per billion (ppb). If the resulting gallons of TAH per gallons of water is also expressed in ppb, a similar result would provide additional

confidence in both the estimated volume of impaired waters and the estimated loading of TAH per sample date because both metrics are measuring central tendency for concentrations in Big Lake.

TABLE 43: COMPARISON OF ESTIMATED AND MEASURED CONCENTRATION METRICS

Sample Date	TAH Load/Impaired Waters (Gallons of TAH Per Gallons of Water)	Median TAH Concentration (µg/L)
May 24	14.9 / 1,100,000,000 = 14 ppb	11
May 25	10.5 / 2,800,000,000 = 3.8 ppb	12
July 5	11.2 / 4,200,000,000 = 2.7 ppb	16
July 6	8.6 / 2,600,000,000 = 3.3 ppb	11

While not spot-on consistent, these results show a strong equivalency, and further support the legitimacy of the estimations for daily loading and volume of impaired waters. Reasons for the slight discrepancies may include factors such as underestimating actual loading; overestimating the volume of impaired waters; biasing high the median TAH concentration by the inclusion of the four sample sites near launches; and the fact that one metric is an average and the other is a median, which are different measurements of central tendency.

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7. SUMMARY

OASIS conducted water quality monitoring at Big Lake, Alaska, on behalf of ADEC. OASIS collected water samples from 12 discrete sample sites on 13 different sample dates using a combination of standard sampling events (in which each sample site was sampled once per day) and intensive sampling events (in which three sample sites were sampled five times during a single day). In addition, OASIS made observations of motorized watercraft usage on four of the intensive sample days during Memorial Day and Independence Day weekends.

The objectives of the monitoring were to assess concentrations of dissolved-phased petroleum hydrocarbons in the water column and to gather data regarding motorized watercraft usage. Anticipated outcomes of meeting the objectives were to understand the trend of dissolved-phase hydrocarbon concentrations on a daily and seasonal basis; to understand the relationship between motorized watercraft usage and petroleum hydrocarbon loading to the lake; to estimate the volume of impaired waters; and to estimate the daily maximum load of petroleum hydrocarbons in Big Lake.

7.1. Conclusions

The following conclusions are drawn from analysis of the analytical data and observations:

- No sheens were observed at any time by the sample team. This implies that lake users are generally exercising sufficient management practices for watercraft maintenance and operation.
- Slightly more than 50% of the samples collected on holiday weekends (Memorial Day, Independence Day, and Labor Day weekends) had analytical results for TAH that exceeded the water quality standard, while approximately 7% of samples collected on the other days had analytical results that exceeded the water quality standard for TAH.
- Samples collected from sample sites BL-4, BL-6, BL-8, and BL-10 had TAH concentrations exceed the water quality standard for more than half of the 13 sample dates. These four locations are similar in that they are all located adjacent to a watercraft launch: BL-4 is located at the South Shore State Recreation Site; BL-6 is located at Southport Marina; BL-8 is located at Burkeshore Marina; and BL-10 is located at North Shore State Recreation Site.
- The trend of TAH concentrations at the three intensive sample sites was not always consistent. Sample site BL-10 showed the most variation in numeric concentrations, but the least variation in the daily pattern of concentration change. Sample sites BL-26 and BL-27 generally exhibited consistent concentrations for both holiday weekends, but the daily pattern of concentration change varied between Memorial Day and Independence Day weekends. In general, concentrations at BL-10 exceeded the water quality standard for TAH,

while approximately one-half of the samples from BL-26 and BL-27 exceeded the TAH standard.

- Estimates on the area of impaired waters at Big Lake ranged from no impact on May 13 to 1,300 acres on both May 26 (the Tuesday following Memorial Day weekend) and July 5. Big Lake covers an area of approximately 3,000 acres; therefore, impacts on May 26 and July 5 affected more than 40% of the lake's surface area. The estimated volume of water impacted by TAH was as large as 4.2 billion gallons on July 5, which accounts for approximately 14% of the lake's volume. Five of the holiday weekend days (May 24, May 25, May 26, July 5, and July 6) had estimated volumes of impacted water over 1 billion gallons.
- Estimates of hydrocarbon loading in Big Lake were made for intensive sample dates May 24, May 25, July 5, and July 6. The hourly watercraft counts made by the observer at the South Shore State Recreation Site and the engine data gathered by the interviewer at the North Shore State Recreation Site, combined with research data regarding marine engine performance and emissions, allowed for a calculation of a daily mass of TAH pollutants entering Big Lake. The estimates are the following:

MAY 24 = 14.9 GALLONS OF TAH
MAY 25 = 10.5 GALLONS OF TAH
JULY 5 = 11.2 GALLONS OF TAH
JULY 6 = 8.6 GALLONS OF TAH

- These estimates likely represent the upper end of worst case scenarios because the four days in question occurred on holiday weekends that had high temperatures more than 10°F above average. Therefore, it is assumed that motorized watercraft activity was high as people enjoyed the nice summertime conditions.

7.2. Recommendations

The water quality standard for TAH that was frequently exceeded was the one that addresses growth and propagation of fish and aquatic life. This standard protects the most sensitive trophic levels (i.e., the bottom of the food chain) in Big Lake. Therefore, while exceedance of this standard has little to no direct and immediate impact to human health, continual exceedance of the standard poses a long-term threat to the overall productivity of Big Lake, which could eventually affect human interaction with Big Lake.

Reasonable solutions are not clearly evident at this point. While the institution of watercraft and engine restrictions is the most obvious solution and one that may appeal to some, the majority of users have clearly stated that Big Lake is a recreational water body, and its users should be free to engage in legal activities involving all types of motorized watercraft. Therefore, solutions to the water quality issues should begin with the majority at Big Lake who want unencumbered access to the lake, because without

the support of the Big Lake community, any attempt by ADEC to improve water quality likely will be ignored.

ADEC is obligated by law to oversee the improvement and attainment of water quality, because the sample events from 2004, 2005, and now 2009 have shown that there is a documented impairment for petroleum hydrocarbons in Big Lake. This obligation by ADEC may be met with the production of a Total Maximum Daily Load for Big Lake. However, additional controls or mitigative actions will be necessary to ensure that busy holiday weekends do not continue to cause non-attainment of the water quality standard for TAH.

Therefore, ADEC needs recommendations on small changes that can be implemented to improve water quality. The following are some ideas:

- Enacting a clean boating campaign that recommends practices to minimize hydrocarbon outputs, such as no idling near boat launches, clean fueling practices, personal inspection of bilge water before discharge, limiting maintenance activities on or near the lake, and promoting the storage and use of oil absorbent pads on individual watercraft.
- Personal inspection facilities for motorized watercraft at the launches. Analytical data have shown that launches are the most problematic locations in Big Lake. Possible reasons include cold starts of engines and contaminated equipment from recent maintenance and fueling operations. These facilities, located at safe distances away from the launches and lake, could include wash-down stations where outboards and fuel tanks may be rinsed with water and hoses for supplying water to engines so that the engines may be warmed up prior to lake entry. These facilities would require catchment devices to contain potentially contaminated rinse water.
- A policy that requires watercraft plugs to be removed only after the watercraft is a required distance away from the launch ramp.
- A policy that specifically addresses watercraft usage on holiday weekends, which have been shown to be the most problematic times for water quality in Big Lake, such as hours of operation to allow more time for the lake to purge hydrocarbons in the water column.
- A policy that addresses the use of 2-stroke engines on Big Lake. While only 10%–15% of watercraft engines on Big Lake are 2-stroke, these engines account for 50% of the hydrocarbon pollution entering Big Lake.
- A community watch program to monitor activities at Big Lake. Many people are aware of stories involving unsafe or illegal activities at Big Lake. This is mentioned because there appears to be a culture of acceptance at Big Lake for these types of actions. A gradual change in attitudes will improve water quality by eliminating these specific incidents and by promoting better boating practices and awareness.

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TABLES

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Table 9
Analytical Results for May 13, 2009
Big Lake Water Quality Monitoring

Sample Site	Sample Depth (m)	Benzene (µg/L)	Toluene (µg/L)	Ethylbenzene (µg/L)	Xylenes (µg/L)	TAH (µg/L)
BL-1	0.15	ND (0.20)	ND (1.0)	ND (0.20)	ND (0.60)	NQ
BL-2	0.15	0.27	ND (1.0)	ND (0.20)	ND (0.60)	0.27
BL-3	0.15	ND (0.20)	ND (1.0)	ND (0.20)	ND (0.60)	NQ
BL-4	0.15	ND (0.20)	ND (1.0)	ND (0.20)	ND (0.60)	NQ
	Outboard Sample	ND (0.20)	ND (1.0)	ND (0.20)	ND (0.60)	NQ
	0.5	ND (0.20)	ND (1.0)	ND (0.20)	ND (0.60)	NQ
BL-5	0.15	0.20	ND (1.0)	ND (0.20)	ND (0.60)	0.20
BL-6	0.15	0.21	ND (1.0)	ND (0.20)	ND (0.60)	0.21
BL-7	0.15	ND (0.20)	ND (1.0)	ND (0.20)	ND (0.60)	NQ
BL-8	0.15	0.58	1.8	0.24	1.3	3.9
	Duplicate	0.54	1.7	0.22	1.2	3.7
	0.5	0.54	1.6	ND (0.20)	1.0	3.1
BL-10	0.15	0.42	1.2	ND (0.20)	0.80	2.4
	Duplicate	0.44	1.2	ND (0.20)	0.83	2.5
	0.5	0.20	ND (1.0)	ND (0.20)	ND (0.60)	0.20
BL-11	0.15	ND (0.20)	ND (1.0)	ND (0.20)	ND (0.60)	NQ
BL-26	0.15	0.24	ND (1.0)	ND (0.20)	ND (0.60)	0.24
BL-27	0.15	0.46	1.4	ND (0.20)	0.82	2.7

Notes: Value in parantheses is the laboratory reporting limit.

Outboard sample at BL-4 collected from a depth of 0.15 m adjacent to outboard.

Key:

m = Meters
µg/L = Micrograms per liter
ND = Not detected
NQ = Not quantified
TAH = Total aromatic hydrocarbons

Table 10
Analytical Results for May 23, 2009
Big Lake Water Quality Monitoring

Sample Site	Sample Depth (m)	Benzene (µg/L)	Toluene (µg/L)	Ethylbenzene (µg/L)	Xylenes (µg/L)	TAH (µg/L)
BL-1	0.15	0.24	ND (1.0)	ND (0.20)	ND (0.60)	0.24
BL-2	0.15	0.90	2.4	0.39	2.2	5.9
BL-3	0.15	0.46	1.1	ND (0.20)	0.89	2.5
BL-4	0.15	0.78	2.3	0.28	1.6	5.0
	0.5	1.1	3.5	0.41	2.3	7.3
BL-5	0.15	0.41	ND (1.0)	ND (0.20)	0.76	1.2
BL-6	0.15	0.91	2.5	0.26	1.8	5.5
BL-7	0.15	0.79	2.1	0.31	2.0	5.2
BL-8	0.15	1.8	5.1	0.61	4.0	**12**
	Duplicate	1.9	5.3	0.62	4.0	**12**
	0.5	2.2	5.9	0.70	4.7	**14**
BL-10	0.15	5.8	17	2.3	14	**39**
	0.5	5.4	16	2.2	13	**36**
BL-11	0.15	ND (0.20)	ND (1.0)	ND (0.20)	ND (0.60)	NQ
BL-26	0.15	0.89	3.4	0.38	2.2	4.9
BL-27	0.15	0.98	3.2	0.45	2.1	5.9
	Outboard Sample	0.52	1.3	ND (0.20)	1.1	2.9

Notes: Value in parantheses is the laboratory reporting limit.
Bolded values exceed Alaska water quality standard of 10 µg/L for TAH.
Analytical results for BL-10, BL-26, and BL-27 are averages of five intensive samples per sample site.
Outboard sample at BL-27 collected from a depth of 0.15 m adjacent to outboard.

Key:
m = Meters
µg/L = Micrograms per liter
ND = Not detected
NQ = Not quantified
TAH = Total aromatic hydrocarbons

Table 11
Analytical Results for May 24, 2009
Big Lake Water Quality Monitoring

Sample Site	Sample Depth (m)	Benzene (µg/L)	Toluene (µg/L)	Ethylbenzene (µg/L)	Xylenes (µg/L)	TAH (µg/L)
BL-1	0.15	1.2	3.9	0.52	2.9	8.5
BL-2	0.15	1.6	5.0	0.56	3.3	**10**
BL-3	0.15	1.0	3.0	0.38	2.7	7.1
BL-4	0.15	4.7	13	2.0	9.5	**29**
	0.5	5.1	15	1.9	11	**33**
BL-5	0.15	0.95	2.5	0.33	2.5	6.3
BL-6	0.15	2.6	7.3	0.83	5.2	**16**
BL-7	0.15	0.94	2.5	0.35	2.5	6.3
BL-8	0.15	2.2	5.6	0.78	4.4	**13**
	Duplicate	2.2	5.4	0.73	4.4	**13**
	0.5	1.6	4.3	0.57	3.7	**10**
BL-10	0.15	7.3	21	3.0	17	**48**
	0.5	7.1	20	2.9	16	**47**
BL-11	0.15	ND (0.20)	ND (1.0)	ND (0.20)	ND (0.60)	NQ
BL-26	0.15	1.9	5.2	0.69	4.3	**12**
BL-27	0.15	1.7	4.7	0.61	3.9	**11**
	Outboard Sample	1.3	3.9	0.56	3.5	9.3

Notes: Value in parantheses is the laboratory reporting limit.
Bolded values exceed Alaska water quality standard of 10 µg/L for TAH.
Analytical results for BL-10, BL-26, and BL-27 are averages of five intensive samples per sample site.
Outboard sample at BL-27 collected from a depth of 0.15 m adjacent to outboard.

Key:
m = Meters
µg/L = Micrograms per liter
ND = Not detected
NQ = Not quantified
TAH = Total aromatic hydrocarbons

Table 12
Analytical Results for May 25, 2009
Big Lake Water Quality Monitoring

Sample Site	Sample Depth (m)	Benzene (µg/L)	Toluene (µg/L)	Ethylbenzene (µg/L)	Xylenes (µg/L)	TAH (µg/L)
BL-1	0.15	0.74	2.3	0.24	1.2	4.5
BL-2	0.15	1.7	4.8	0.62	3.6	**11**
BL-3	0.15	1.7	4.5	0.67	4.1	**11**
BL-4	0.15	3.4	9.6	1.5	8.0	**23**
	0.5	3.3	9.5	1.5	8.1	**22**
BL-5	0.15	1.5	4.2	0.58	3.5	9.8
BL-6	0.15	2.2	5.7	0.82	5.0	**14**
BL-7	0.15	1.3	3.5	0.52	3.2	8.5
BL-8	0.15	2.0	5.1	0.68	4.4	**12**
	Duplicate	2.0	5.2	0.65	4.3	**12**
	0.5	1.9	4.6	0.63	4.0	**11**
BL-10	0.15	6.0	17	2.5	13	**39**
	0.5	6.7	19	2.7	14	**43**
BL-11	0.15	0.23	ND (1.0)	ND (0.20)	0.41	0.64
BL-26	0.15	2.6	7.4	0.94	6.0	**17**
BL-27	0.15	2.6	7.3	0.94	5.8	**17**
	Outboard Sample	2.5	6.8	0.74	4.7	**15**

Notes: Value in parantheses is the laboratory reporting limit.
Bolded values exceed Alaska water quality standard of 10 µg/L for TAH.
Analytical results for BL-10, BL-26, and BL-27 are averages of five intensive samples per sample site.
Outboard sample at BL-27 collected from a depth of 0.15 m adjacent to outboard.

Key:
m = Meters
µg/L = Micrograms per liter
ND = Not detected
TAH = Total aromatic hydrocarbons

Table 13
Analytical Results for May 26, 2009
Big Lake Water Quality Monitoring

Sample Site	Sample Depth (m)	Benzene (µg/L)	Toluene (µg/L)	Ethylbenzene (µg/L)	Xylenes (µg/L)	TAH (µg/L)
BL-1	0.15	1.0	3.1	0.51	2.6	7.2
BL-2	0.15	2.2	6.1	0.90	5.1	**14**
BL-3	0.15	2.8	7.7	0.83	6.4	**18**
BL-4	0.15	1.8	5.0	0.70	4.4	**12**
	0.5	1.9	5.3	0.86	4.8	**13**
BL-5	0.15	2.6	7.0	0.74	4.8	**15**
BL-6	0.15	2.2	5.9	0.74	5.4	**14**
BL-7	0.15	1.5	3.8	0.63	3.9	9.8
BL-8	0.15	2.0	5.3	0.69	4.5	**12**
	Duplicate	1.9	4.7	0.71	4.4	**12**
	0.5	2.3	6.0	0.83	5.5	**15**
BL-10	0.15	2.8	7.7	1.2	6.5	**18**
	0.5	2.7	7.3	1.1	6.3	**17**
BL-11	0.15	0.23	ND (1.0)	ND (0.20)	0.68	0.91
BL-26	0.15	1.7	4.5	0.60	4.2	**11**
BL-27	0.15	2.2	6.0	0.84	5.4	**14**
	Outboard Sample	2.9	7.8	0.87	5.9	**17**

Notes: Value in parantheses is the laboratory reporting limit.
Bolded values exceed Alaska water quality standard of 10 µg/L for TAH.
Analytical results for BL-10, BL-26, and BL-27 are averages of five intensive samples per sample site.
Outboard sample at BL-27 collected from a depth of 0.15 m adjacent to outboard.

Key:
m = Meters
µg/L = Micrograms per liter
ND = Not detected
TAH = Total aromatic hydrocarbons

Table 14
Analytical Results for June 17, 2009
Big Lake Water Quality Monitoring

Sample Site	Sample Depth (m)	Benzene (µg/L)	Toluene (µg/L)	Ethylbenzene (µg/L)	Xylenes (µg/L)	TAH (µg/L)
BL-1	0.15	0.21	ND (1.0)	ND (0.20)	1.1	1.3
BL-2	0.15	0.26	ND (1.0)	ND (0.20)	0.48	0.74
BL-3	0.15	0.42	ND (1.0)	ND (0.20)	ND (0.60)	0.42
BL-4	0.15	2.9	7.4	1.0	5.5	**17**
	0.5	2.2	6.2	0.77	4.6	**14**
BL-5	0.15	0.41	ND (1.0)	ND (0.20)	ND (0.60)	0.41
BL-6	0.15	0.51	ND (1.0)	ND (0.20)	ND (0.60)	0.51
BL-7	0.15	0.38	ND (1.0)	ND (0.20)	ND (0.60)	0.38
BL-8	0.15	0.57	ND (1.0)	ND (0.20)	0.80	1.4
	Duplicate	0.54	ND (1.0)	ND (0.20)	ND (0.60)	0.5
	0.5	0.61	ND (1.0)	ND (0.20)	0.79	1.4
BL-10	0.15	0.24	ND (1.0)	ND (0.20)	ND (0.60)	0.24
	Duplicate	0.21	ND (1.0)	ND (0.20)	ND (0.60)	0.21
	0.5	0.22	ND (1.0)	ND (0.20)	0.40	0.62
BL-11	0.15	ND (0.20)	ND (1.0)	ND (0.20)	ND (0.60)	NQ
	Outboard Sample	ND (0.20)	ND (1.0)	ND (0.20)	ND (0.60)	NQ
BL-26	0.15	ND (0.20)	ND (1.0)	ND (0.20)	ND (0.60)	NQ
BL-27	0.15	ND (0.20)	ND (1.0)	ND (0.20)	ND (0.60)	NQ

Notes: Value in parantheses is the laboratory reporting limit.

Bolded values exceed Alaska water quality standard of 10 µg/L for TAH.

Outboard sample at BL-11 collected from a depth of 0.15 m adjacent to outboard.

Key:

m = Meters
µg/L = Micrograms per liter
ND = Not detected
NQ = Not quantified
TAH = Total aromatic hydrocarbons

Table 15
Analytical Results for June 27, 2009
Big Lake Water Quality Monitoring

Sample Site	Sample Depth (m)	Benzene (µg/L)	Toluene (µg/L)	Ethylbenzene (µg/L)	Xylenes (µg/L)	TAH (µg/L)
BL-1	0.15	ND (0.20)	ND (1.0)	ND (0.20)	ND (0.60)	NQ
BL-2	0.15	0.56	1.6	ND (0.20)	1.4	3.6
BL-3	0.15	0.75	1.9	0.21	1.6	4.5
BL-4	0.15	ND (0.20)	ND (1.0)	ND (0.20)	ND (0.60)	NQ
	0.5	ND (0.20)	ND (1.0)	ND (0.20)	ND (0.60)	NQ
BL-5	0.15	0.43	ND (1.0)	ND (0.20)	0.71	1.1
BL-6	0.15	0.52	1.0	ND (0.20)	1.1	2.6
BL-7	0.15	ND (0.20)	ND (1.0)	ND (0.20)	ND (0.60)	NQ
BL-8	0.15	1.0 J	2.8 J	0.27 J	2.1 J	6.2 J
	Duplicate	2.0 J	4.7 J	0.54 J	3.4 J	**11 J**
	0.5	1.1	2.4	0.22	1.8	5.5
BL-10	0.15	2.8	7.0	0.98	7.0	**18**
	Duplicate	2.6	6.7	0.89	6.2	**16**
	0.5	2.6	6.7	0.95	6.5	**17**
BL-11	0.15	0.32	1.1	ND (0.20)	0.99	2.4
	Outboard Sample	0.35	1.1	ND (0.20)	0.89	2.3
BL-26	0.15	0.43	ND (1.0)	ND (0.20)	0.84	1.3
BL-27	0.15	0.60	1.7	ND (0.20)	1.6	3.9

Notes: Value in parantheses is the laboratory reporting limit.

Bolded values exceed Alaska water quality standard of 10 µg/L for TAH.

Outboard sample at BL-11 collected from a depth of 0.15 m adjacent to outboard.

Key:

J = Estimated result
m = Meters
µg/L = Micrograms per liter
ND = Not detected
NQ = Not quantified
TAH = Total aromatic hydrocarbons

Table 16
Analytical Results for July 4, 2009
Big Lake Water Quality Monitoring

Sample Site	Sample Depth (m)	Benzene (µg/L)	Toluene (µg/L)	Ethylbenzene (µg/L)	Xylenes (µg/L)	TAH (µg/L)
BL-1	0.15	0.71	1.1	ND (0.20)	0.80	2.6
BL-2	0.15	1.7	3.0	0.37	2.5	7.6
BL-3	0.15	1.1	1.4	ND (0.20)	2.0	4.5
BL-4	0.15					
	0.5	11	27	3.5	20	**62**
BL-5	0.15	1.4	1.3	ND (0.20)	2.3	5.0
BL-6	0.15	3.7	8.2	0.90	6.7	**20**
BL-7	0.15	0.59	ND (1.0)	ND (0.20)	0.80	1.4
BL-8	0.15	3.7	8.4	1.1	7.1	**20**
	Duplicate	3.5	8.2	1.0	6.4	**19**
	0.5	3.1	6.7	0.80	5.4	**16**
BL-10	0.15	13	31	4.4	28	**76**
	0.5	14	34	4.8	31	**84**
BL-11	0.15	0.70	1.4	0.29	1.1	3.5
	Outboard Sample	0.41	ND (1.0)	ND (0.20)	0.62	1.0
BL-26	0.15	2.9	4.1	0.59	5.4	**13**
BL-27	0.15	2.5	3.5	0.48	4.7	**11**

Notes: Value in parantheses is the laboratory reporting limit.
Bolded values exceed Alaska water quality standard of 10 µg/L for TAH.
Analytical results for BL-10, BL-26, and BL-27 are averages of intensive samples from the sample site.
Outboard sample at BL-11 collected from a depth of 0.15 m adjacent to outboard.
Sample from 0.15 m at BL-4 was lost when it froze and ruptured.

Key:
m = Meters
µg/L = Micrograms per liter
ND = Not detected
TAH = Total aromatic hydrocarbons

Table 17
Analytical Results for July 5, 2009
Big Lake Water Quality Monitoring

Sample Site	Sample Depth (m)	Benzene (µg/L)	Toluene (µg/L)	Ethylbenzene (µg/L)	Xylenes (µg/L)	TAH (µg/L)
BL-1	0.15	0.76	1.4	0.22	1.70	4.1
BL-2	0.15	2.5	5.8	0.94	6.9	**16**
BL-3	0.15	2.8	4.5	0.43	5.0	**13**
BL-4	0.15	10	27	4.6	28	**70**
	0.5	9.2	24	4.1	25	**62**
BL-5	0.15	3.3	5.4	0.49	5.6	**15**
BL-6	0.15	4.0	8.5	1.4	9.9	**24**
BL-7	0.15	2.4	4.2	0.74	7.0	**14**
BL-8	0.15	3.4	7.3	1.2	8.4	**20**
	Duplicate	3.4	7.3	1.2	8.3	**20**
	0.5	3.6	7.9	1.3	8.9	**22**
BL-10	0.15	9.2	19	2.8	23	**54**
	0.5	9.7	20	2.7	22	**55**
BL-11	0.15	0.27	ND (1.0)	ND (0.20)	0.69	0.96
	Outboard Sample	0.33	ND (1.0)	ND (0.20)	0.84	1.2
BL-26	0.15	2.2	4.1	0.57	4.3	9.4
BL-27	0.15	2.9	3.4	0.63	5.9	**13**

Notes: Value in parantheses is the laboratory reporting limit.
Bolded values exceed Alaska water quality standard of 10 µg/L for TAH.
Analytical results for BL-10, BL-26, and BL-27 are averages of five intensive samples per sample site.
Outboard sample at BL-11 collected from a depth of 0.15 m adjacent to outboard.

Key:
m = Meters
µg/L = Micrograms per liter
ND = Not detected
TAH = Total aromatic hydrocarbons

Table 18
Analytical Results for July 6, 2009
Big Lake Water Quality Monitoring

Sample Site	Sample Depth (m)	Benzene (µg/L)	Toluene (µg/L)	Ethylbenzene (µg/L)	Xylenes (µg/L)	TAH (µg/L)
BL-1	0.15	1.1	1.6	ND (0.20)	1.7	4.4
BL-2	0.15	2.6	2.9	0.35	4.8	**11**
BL-3	0.15	3.3	3.7	0.31	5.4	**13**
BL-4	0.15	2.6	2.2	0.23	3.9	8.9
	0.5	3.4	4.1	0.47	6.0	**14**
BL-5	0.15	3.1	3.7	0.32	5.0	**12**
BL-6	0.15	5.4	9.1	1.2	11	**27**
BL-7	0.15	2.8	2.6	0.30	5.2	**11**
BL-8	0.15	3.0	2.7	0.32	5.5	**12**
	Duplicate	2.9	2.7	0.31	5.1	**11**
	0.5	3.0	2.4	0.28	5.3	**11**
BL-10	0.15	3.1	3.7	0.71	4.9	9.6
	0.5	2.5	1.5	ND (0.20)	3.7	6.7
BL-11	0.15	0.21	ND (1.0)	ND (0.20)	ND (0.60)	0.21
	Outboard Sample	0.28	ND (1.0)	ND (0.20)	0.70	0.98
BL-26	0.15	0.87	ND (1.0)	ND (0.20)	1.2	1.8
BL-27	0.15	1.2	ND (1.0)	ND (0.20)	1.4	2.6

Notes: Value in parantheses is the laboratory reporting limit.
Bolded values exceed Alaska water quality standard of 10 µg/L for TAH.
Analytical results for BL-10, BL-26, and BL-27 are averages of five intensive samples per sample site.
Outboard sample at BL-11 collected from a depth of 0.15 m adjacent to outboard.

Key:
m = Meters
µg/L = Micrograms per liter
ND = Not detected
NQ = Not quantified
TAH = Total aromatic hydrocarbons

Table 19
Analytical Results for July 25, 2009
Big Lake Water Quality Monitoring

Sample Site	Sample Depth (m)	Benzene (µg/L)	Toluene (µg/L)	Ethylbenzene (µg/L)	Xylenes (µg/L)	TAH (µg/L)
BL-1	0.15	ND (0.20)	ND (1.0)	ND (0.20)	ND (0.60)	NQ
BL-2	0.15	0.55	ND (1.0)	ND (0.20)	0.48	1.0
BL-3	0.15	0.26	ND (1.0)	ND (0.20)	ND (0.60)	0.26
BL-4	0.15	1.2	2.8	0.32	2.0	6.3
	0.5	1.2	2.6	0.31	1.8	5.9
BL-5	0.15	ND (0.20)	ND (1.0)	ND (0.20)	ND (0.60)	NQ
BL-6	0.15	0.47	ND (1.0)	ND (0.20)	0.68	1.2
BL-7	0.15	ND (0.20)	ND (1.0)	ND (0.20)	ND (0.60)	NQ
BL-8	0.15	0.23	ND (1.0)	ND (0.20)	ND (0.60)	0.23
	Duplicate	0.24	ND (1.0)	ND (0.20)	ND (0.60)	0.24
	0.5	0.41	ND (1.0)	ND (0.20)	ND (0.60)	0.41
BL-10	0.15	2.4	4.4	0.51	3.8	**11**
	Duplicate	2.3	4.2	0.56	3.9	**11**
	0.5	2.3	4.2	0.48	3.6	**11**
BL-11	0.15	ND (0.20)	ND (1.0)	ND (0.20)	ND (0.60)	NQ
	Outboard Sample	ND (0.20)	ND (1.0)	ND (0.20)	ND (0.60)	NQ
BL-26	0.15	ND (0.20)	ND (1.0)	ND (0.20)	ND (0.60)	NQ
BL-27	0.15	ND (0.20)	ND (1.0)	ND (0.20)	ND (0.60)	NQ

Notes: Value in parantheses is the laboratory reporting limit.

Bolded values exceed Alaska water quality standard of 10 µg/L for TAH.

Outboard sample at BL-11 collected from a depth of 0.15 m adjacent to outboard.

Key:

m = Meters
µg/L = Micrograms per liter
ND = Not detected
NQ = Not quantified
TAH = Total aromatic hydrocarbons

Table 20
Analytical Results for August 15, 2009
Big Lake Water Quality Monitoring

Sample Site	Sample Depth (m)	Benzene (µg/L)	Toluene (µg/L)	Ethylbenzene (µg/L)	Xylenes (µg/L)	TAH (µg/L)
BL-1	0.15	ND (0.20)	ND (1.0)	ND (0.20)	ND (0.60)	NQ
BL-2	0.15	0.37	ND (1.0)	ND (0.20)	0.43	0.80
BL-3	0.15	0.33	ND (1.0)	ND (0.20)	0.75	1.1
BL-4	0.15	0.21	ND (1.0)	ND (0.20)	ND (0.60)	0.21
	0.5	0.23	ND (1.0)	ND (0.20)	ND (0.60)	0.23
BL-5	0.15	0.36	ND (1.0)	ND (0.20)	0.85	1.2
BL-6	0.15	ND (0.20)	ND (1.0)	ND (0.20)	ND (0.60)	NQ
BL-7	0.15	0.64	1.5	ND (0.20)	1.1	3.2
BL-8	0.15	ND (0.20)	ND (1.0)	ND (0.20)	ND (0.60)	NQ
	Duplicate	ND (0.20)	ND (1.0)	ND (0.20)	ND (0.60)	NQ
	0.5	ND (0.20)	ND (1.0)	ND (0.20)	ND (0.60)	NQ
BL-10	0.15	1.7	4.2	0.57	3.5	**10**
	Duplicate	1.5	4.3	0.57	3.4	9.8
	0.5	3.7	9.3	1.4	8.0	**22**
BL-11	0.15	ND (0.20)	ND (1.0)	ND (0.20)	ND (0.60)	NQ
	Outboard Sample	ND (0.20)	ND (1.0)	ND (0.20)	ND (0.60)	NQ
BL-26	0.15	0.31	ND (1.0)	ND (0.20)	ND (0.60)	0.31
BL-27	0.15	0.48	1.1	ND (0.20)	0.81	2.4

Notes: Value in parantheses is the laboratory reporting limit.

Bolded values exceed Alaska water quality standard of 10 µg/L for TAH.

Outboard sample at BL-11 collected from a depth of 0.15 m adjacent to outboard.

Key:

m = Meters
µg/L = Micrograms per liter
ND = Not detected
NQ = Not quantified
TAH = Total aromatic hydrocarbons

Table 21
Analytical Results for September 7, 2009
Big Lake Water Quality Monitoring

Sample Site	Sample Depth (m)	Benzene (µg/L)	Toluene (µg/L)	Ethylbenzene (µg/L)	Xylenes (µg/L)	TAH (µg/L)
BL-1	0.15	ND (0.20)	ND (1.0)	ND (0.20)	ND (0.60)	NQ
BL-2	0.15	1.3	3.1	0.41	2.5	7.3
BL-3	0.15	1.2	2.3	0.28	2.3	6.1
BL-4	0.15	2.9	8.7	1.6	10	**23**
	0.5	1.9	4.9	0.86	5.6	**13**
BL-5	0.15	1.2	2.2	0.26	2.0	5.7
BL-6	0.15	2.1	5.2	0.66	4.3	**12**
BL-7	0.15	0.69	1.6	ND (0.20)	1.3	3.6
BL-8	0.15	1.2	2.8	0.36	2.3	6.7
	Duplicate	1.2	2.7	0.36	2.2	6.5
	0.5	0.98	2.0	0.26	1.6	4.8
BL-10	0.15	5.7	14	2.0	12	**34**
	Duplicate	5.6	14	1.9	12	**34**
	0.5	5.4	14	1.9	12	**33**
BL-11	0.15	ND (0.20)	ND (1.0)	ND (0.20)	ND (0.60)	NQ
	Outboard Sample	ND (0.20)	ND (1.0)	ND (0.20)	ND (0.60)	NQ
BL-26	0.15	1.1	1.9	0.23	2.0	5.2
BL-27	0.15	1.1	2.1	0.26	2.1	5.6

Notes: Value in parantheses is the laboratory reporting limit.

Bolded values exceed Alaska water quality standard of 10 µg/L for TAH.

Outboard sample at BL-11 collected from a depth of 0.15 m adjacent to outboard.

Key:

m = Meters
µg/L = Micrograms per liter
ND = Not detected
NQ = Not quantified
TAH = Total aromatic hydrocarbons

Table 22
Analytical Results for Sample Site BL-1
Big Lake Water Quality Monitoring

Sample Date	Sample Depth (m)	Benzene (µg/L)	Toluene (µg/L)	Ethylbenzene (µg/L)	Xylenes (µg/L)	TAH (µg/L)
13-May	0.15	ND (0.20)	ND (1.0)	ND (0.20)	ND (0.60)	NQ
23-May	0.15	0.24	ND (1.0)	ND (0.20)	ND (0.60)	0.24
24-May	0.15	1.2	3.9	0.52	2.9	8.5
25-May	0.15	0.74	2.3	0.24	1.2	4.5
26-May	0.15	1.0	3.1	0.51	2.6	7.2
17-Jun	0.5	0.21	ND (1.0)	ND (0.20)	1.1	1.3
27-Jun	0.15	ND (0.20)	ND (1.0)	ND (0.20)	ND (0.60)	NQ
4-Jul	0.15	0.71	1.1	ND (0.20)	0.80	2.6
5-Jul	0.15	0.76	1.4	0.22	1.70	4.1
6-Jul	0.15	1.1	1.6	ND (0.20)	1.7	4.4
25-Jul	0.15	ND (0.20)	ND (1.0)	ND (0.20)	ND (0.60)	NQ
15-Aug	0.15	ND (0.20)	ND (1.0)	ND (0.20)	ND (0.60)	NQ
7-Sep	0.15	ND (0.20)	ND (1.0)	ND (0.20)	ND (0.60)	NQ

Notes: Value in parantheses is the laboratory reporting limit.

Key:

m = Meters
µg/L = Micrograms per liter
ND = Not detected
NQ = Not quantified
TAH = Total aromatic hydrocarbons

Table 23
Analytical Results for Sample Site BL-2
Big Lake Water Quality Monitoring

Sample Date	Sample Depth (m)	Benzene (µg/L)	Toluene (µg/L)	Ethylbenzene (µg/L)	Xylenes (µg/L)	TAH (µg/L)
13-May	0.15	0.27	ND (1.0)	ND (0.20)	ND (0.60)	0.27
23-May	0.15	0.90	2.4	0.39	2.2	5.9
24-May	0.15	1.6	5.0	0.56	3.3	**10**
25-May	0.15	1.7	4.8	0.62	3.6	**11**
26-May	0.15	2.2	6.1	0.90	5.1	**14**
17-Jun	0.5	0.26	ND (1.0)	ND (0.20)	0.48	0.74
27-Jun	0.15	0.56	1.6	ND (0.20)	1.4	3.6
4-Jul	0.15	1.7	3.0	0.37	2.5	7.6
5-Jul	0.15	2.5	5.8	0.94	6.9	**16**
6-Jul	0.15	2.6	2.9	0.35	4.8	**11**
25-Jul	0.15	0.55	ND (1.0)	ND (0.20)	0.48	1.0
15-Aug	0.15	0.37	ND (1.0)	ND (0.20)	0.43	0.80
7-Sep	0.15	1.3	3.1	0.41	2.5	7.3

Notes: Value in parantheses is the laboratory reporting limit.
Bolded values exceed Alaska water quality standard of 10 µg/L for TAH.

Key:
m = Meters
µg/L = Micrograms per liter
ND = Not detected
TAH = Total aromatic hydrocarbons

Table 24
Analytical Results for Sample Site BL-3
Big Lake Water Quality Monitoring

Sample Date	Sample Depth (m)	Benzene (µg/L)	Toluene (µg/L)	Ethylbenzene (µg/L)	Xylenes (µg/L)	TAH (µg/L)
13-May	0.15	ND (0.20)	ND (1.0)	ND (0.20)	ND (0.60)	NQ
23-May	0.15	0.46	1.1	ND (0.20)	0.89	2.5
24-May	0.15	1.0	3.0	0.38	2.7	7.1
25-May	0.15	1.7	4.5	0.67	4.1	**11**
26-May	0.15	2.8	7.7	0.83	6.4	**18**
17-Jun	0.5	0.42	ND (1.0)	ND (0.20)	ND (0.60)	0.42
27-Jun	0.15	0.75	1.9	0.21	1.6	4.5
4-Jul	0.15	1.1	1.4	ND (0.20)	2.0	4.5
5-Jul	0.15	2.8	4.5	0.43	5.0	**13**
6-Jul	0.15	3.3	3.7	0.31	5.4	**13**
25-Jul	0.15	0.26	ND (1.0)	ND (0.20)	ND (0.60)	0.26
15-Aug	0.15	0.33	ND (1.0)	ND (0.20)	0.75	1.1
7-Sep	0.15	1.2	2.3	0.28	2.3	6.1

Notes: Value in parantheses is the laboratory reporting limit.

Bolded values exceed Alaska water quality standard of 10 µg/L for TAH.

Key:

m = Meters
µg/L = Micrograms per liter
ND = Not detected
NQ = Not quantified
TAH = Total aromatic hydrocarbons

Table 25
Analytical Results for Sample Site BL-4
Big Lake Water Quality Monitoring

Sample Date	Sample Depth (m)	Benzene (µg/L)	Toluene (µg/L)	Ethylbenzene (µg/L)	Xylenes (µg/L)	TAH (µg/L)
13-May	0.15	ND (0.20)	ND (1.0)	ND (0.20)	ND (0.60)	NQ
	0.5	ND (0.20)	ND (1.0)	ND (0.20)	ND (0.60)	NQ
23-May	0.15	0.78	2.3	0.28	1.6	5.0
	0.5	1.1	3.5	0.41	2.3	7.3
24-May	0.15	4.7	13	2.0	9.5	**29**
	0.5	5.1	15	1.9	11	**33**
25-May	0.15	3.4	9.6	1.5	8.0	**23**
	0.5	3.3	9.5	1.5	8.1	**22**
26-May	0.15	1.8	5.0	0.70	4.4	**12**
	0.5	1.9	5.3	0.86	4.8	**13**
17-Jun	0.15	2.9	7.4	1.0	5.5	**17**
	0.5	2.2	6.2	0.77	4.6	**14**
27-Jun	0.15	ND (0.20)	ND (1.0)	ND (0.20)	ND (0.60)	NQ
	0.5	ND (0.20)	ND (1.0)	ND (0.20)	ND (0.60)	NQ
4-Jul	0.15					
	0.5	11	27	3.5	20	**62**
5-Jul	0.15	10	27	4.6	28	**70**
	0.5	9.2	24	4.1	25	**62**
6-Jul	0.15	2.6	2.2	0.23	3.9	8.9
	0.5	3.4	4.1	0.47	6.0	**14**
25-Jul	0.15	1.2	2.8	0.32	2.0	6.3
	0.5	1.2	2.6	0.31	1.8	5.9
15-Aug	0.15	0.21	ND (1.0)	ND (0.20)	ND (0.60)	0.21
	0.5	0.23	ND (1.0)	ND (0.20)	ND (0.60)	0.23
7-Sep	0.15	2.9	8.7	1.6	10	**23**
	0.5	1.9	4.9	0.86	5.6	**13**

Notes: Value in parantheses is the laboratory reporting limit.
Sample from 0.15 m on July 4 was lost when it froze and ruptured.
Bolded values exceed Alaska water quality standard of 10 µg/L for TAH.

Key:
m = Meters
µg/L = Micrograms per liter
ND = Not detected
NQ = Not quantified
TAH = Total aromatic hydrocarbons

Table 26
Analytical Results for Sample Site BL-5
Big Lake Water Quality Monitoring

Sample Date	Sample Depth (m)	Benzene (µg/L)	Toluene (µg/L)	Ethylbenzene (µg/L)	Xylenes (µg/L)	TAH (µg/L)
13-May	0.15	0.20	ND (1.0)	ND (0.20)	ND (0.60)	0.20
23-May	0.15	0.41	ND (1.0)	ND (0.20)	0.76	1.2
24-May	0.15	0.95	2.5	0.33	2.5	6.3
25-May	0.15	1.5	4.2	0.58	3.5	9.8
26-May	0.15	2.6	7.0	0.74	4.8	**15**
17-Jun	0.5	0.41	ND (1.0)	ND (0.20)	ND (0.60)	0.41
27-Jun	0.15	0.43	ND (1.0)	ND (0.20)	0.71	1.1
4-Jul	0.15	1.4	1.3	ND (0.20)	2.3	5.0
5-Jul	0.15	3.3	5.4	0.49	5.6	**15**
6-Jul	0.15	3.1	3.7	0.32	5.0	**12**
25-Jul	0.15	ND (0.20)	ND (1.0)	ND (0.20)	ND (0.60)	NQ
15-Aug	0.15	0.36	ND (1.0)	ND (0.20)	0.85	1.2
7-Sep	0.15	1.2	2.2	0.26	2.0	5.7

Notes: Value in parantheses is the laboratory reporting limit.
Bolded values exceed Alaska water quality standard of 10 µg/L for TAH.

Key:
m = Meters
µg/L = Micrograms per liter
ND = Not detected
NQ = Not quantified
TAH = Total aromatic hydrocarbons

Table 27
Analytical Results for Sample Site BL-6
Big Lake Water Quality Monitoring

Sample Date	Sample Depth (m)	Benzene (µg/L)	Toluene (µg/L)	Ethylbenzene (µg/L)	Xylenes (µg/L)	TAH (µg/L)
13-May	0.15	0.21	ND (1.0)	ND (0.20)	ND (0.60)	0.21
23-May	0.15	0.91	2.5	0.26	1.8	5.5
24-May	0.15	2.6	7.3	0.83	5.2	**16**
25-May	0.15	2.2	5.7	0.82	5.0	**14**
26-May	0.15	2.2	5.9	0.74	5.4	**14**
17-Jun	0.5	0.51	ND (1.0)	ND (0.20)	ND (0.60)	0.51
27-Jun	0.15	0.52	1.0	ND (0.20)	1.1	2.6
4-Jul	0.15	3.7	8.2	0.90	6.7	**20**
5-Jul	0.15	4.0	8.5	1.4	9.9	**24**
6-Jul	0.15	5.4	9.1	1.2	11	**27**
25-Jul	0.15	0.47	ND (1.0)	ND (0.20)	0.68	1.2
15-Aug	0.15	ND (0.20)	ND (1.0)	ND (0.20)	ND (0.60)	NQ
7-Sep	0.15	2.1	5.2	0.66	4.3	**12**

Notes: Value in parantheses is the laboratory reporting limit.

Bolded values exceed Alaska water quality standard of 10 µg/L for TAH.

Key:

m = Meters
µg/L = Micrograms per liter
ND = Not detected
NQ = Not quantified
TAH = Total aromatic hydrocarbons

Table 28
Analytical Results for Sample Site BL-7
Big Lake Water Quality Monitoring

Sample Date	Sample Depth (m)	Benzene (µg/L)	Toluene (µg/L)	Ethylbenzene (µg/L)	Xylenes (µg/L)	TAH (µg/L)
13-May	0.15	ND (0.20)	ND (1.0)	ND (0.20)	ND (0.60)	NQ
23-May	0.15	0.79	2.1	0.31	2.0	5.2
24-May	0.15	0.94	2.5	0.35	2.5	6.3
25-May	0.15	1.3	3.5	0.52	3.2	8.5
26-May	0.15	1.5	3.8	0.63	3.9	9.8
17-Jun	0.5	0.38	ND (1.0)	ND (0.20)	ND (0.60)	0.38
27-Jun	0.15	ND (0.20)	ND (1.0)	ND (0.20)	ND (0.60)	NQ
4-Jul	0.15	0.59	ND (1.0)	ND (0.20)	0.80	1.4
5-Jul	0.15	2.4	4.2	0.74	7.0	**14**
6-Jul	0.15	2.8	2.6	0.30	5.2	**11**
25-Jul	0.15	ND (0.20)	ND (1.0)	ND (0.20)	ND (0.60)	NQ
15-Aug	0.15	0.64	1.5	ND (0.20)	1.1	3.2
7-Sep	0.15	0.69	1.6	ND (0.20)	1.3	3.6

Notes: Value in parantheses is the laboratory reporting limit.

Bolded values exceed Alaska water quality standard of 10 µg/L for TAH.

Key:

m = Meters
µg/L = Micrograms per liter
ND = Not detected
NQ = Not quantified
TAH = Total aromatic hydrocarbons

Table 29
Analytical Results for Sample Site BL-8
Big Lake Water Quality Monitoring

Sample Date	Sample Depth (m)	Benzene (µg/L)	Toluene (µg/L)	Ethylbenzene (µg/L)	Xylenes (µg/L)	TAH (µg/L)
13-May	0.15	0.58	1.8	0.24	1.3	3.9
	duplicate	0.54	1.7	0.22	1.2	3.7
	0.5	0.54	1.6	ND (0.20)	1.0	3.1
23-May	0.15	1.8	5.1	0.61	4.0	**12**
	duplicate	1.9	5.3	0.62	4.0	**12**
	0.5	2.2	5.9	0.70	4.7	**14**
24-May	0.15	2.2	5.6	0.78	4.4	**13**
	duplicate	2.2	5.4	0.73	4.4	**13**
	0.5	1.6	4.3	0.57	3.7	**10**
25-May	0.15	2.0	5.1	0.68	4.4	**12**
	duplicate	2.0	5.2	0.65	4.3	**12**
	0.5	1.9	4.6	0.63	4.0	**11**
26-May	0.15	2.0	5.3	0.69	4.5	**12**
	duplicate	1.9	4.7	0.71	4.4	**12**
	0.5	2.3	6.0	0.83	5.5	**15**
17-Jun	0.15	0.57	ND (1.0)	ND (0.20)	0.80	1.4
	duplicate	0.54	ND (1.0)	ND (0.20)	ND (0.60)	0.5
	0.5	0.61	ND (1.0)	ND (0.20)	0.79	1.4
27-Jun	0.15	1.0 J	2.8 J	0.27 J	2.1 J	6.2 J
	duplicate	2.0 J	4.7 J	0.54 J	3.4 J	**11 J**
	0.5	1.1	2.4	0.22	1.8	5.5
4-Jul	0.15	3.7	8.4	1.1	7.1	**20**
	duplicate	3.5	8.2	1.0	6.4	**19**
	0.5	3.1	6.7	0.80	5.4	**16**
5-Jul	0.15	3.4	7.3	1.2	8.4	**20**
	duplicate	3.4	7.3	1.2	8.3	**20**
	0.5	3.6	7.9	1.3	8.9	**22**
6-Jul	0.15	3.0	2.7	0.32	5.5	**12**
	duplicate	2.9	2.7	0.31	5.1	**11**
	0.5	3.0	2.4	0.28	5.3	**11**
25-Jul	0.15	0.23	ND (1.0)	ND (0.20)	ND (0.60)	0.23
	duplicate	0.24	ND (1.0)	ND (0.20)	ND (0.60)	0.24
	0.5	0.41	ND (1.0)	ND (0.20)	ND (0.60)	0.41
15-Aug	0.15	ND (0.20)	ND (1.0)	ND (0.20)	ND (0.60)	NQ
	duplicate	ND (0.20)	ND (1.0)	ND (0.20)	ND (0.60)	NQ
	0.5	ND (0.20)	ND (1.0)	ND (0.20)	ND (0.60)	NQ
7-Sep	0.15	1.2	2.8	0.36	2.3	6.7
	duplicate	1.2	2.7	0.36	2.2	6.5
	0.5	0.98	2.0	0.26	1.6	4.8

Notes: Value in parantheses is the laboratory reporting limit.
Bolded values exceed Alaska water quality standard of 10 µg/L for TAH.

Key:
J = Estimated result
m = Meters
µg/L = Micrograms per liter
ND = Not detected
NQ = Not quantified
TAH = Total aromatic hydrocarbons

Table 30
Analytical Results for Sample Site BL-10
Big Lake Water Quality Monitoring

Sample Date	Sample Depth (m)	Benzene (µg/L)	Toluene (µg/L)	Ethylbenzene (µg/L)	Xylenes (µg/L)	TAH (µg/L)
13-May	0.15	0.42	1.2	ND (0.20)	0.80	2.4
	0.5	0.20	ND (1.0)	ND (0.20)	ND (0.60)	0.20
23-May	0.15	5.8	17	2.3	14	**39**
	0.5	5.4	16	2.2	13	**36**
24-May	0.15	7.3	21	3.0	17	**48**
	0.5	7.1	20	2.9	16	**47**
25-May	0.15	6.0	17	2.5	13	**39**
	0.5	6.7	19	2.7	14	**43**
26-May	0.15	2.8	7.7	1.2	6.5	**18**
	0.5	2.7	7.3	1.1	6.3	**17**
17-Jun	0.15	0.24	ND (1.0)	ND (0.20)	ND (0.60)	0.24
	0.5	0.22	ND (1.0)	ND (0.20)	0.40	0.62
27-Jun	0.15	2.8	7.0	0.98	7.0	**18**
	0.5	2.6	6.7	0.95	6.5	**17**
4-Jul	0.15	13	31	4.4	28	**76**
	0.5	14	34	4.8	31	**84**
5-Jul	0.15	9.2	19	2.8	23	**54**
	0.5	9.7	20	2.7	22	**55**
6-Jul	0.15	3.1	3.7	0.71	4.9	9.6
	0.5	2.5	1.5	ND (0.20)	3.7	6.7
25-Jul	0.15	2.4	4.4	0.51	3.8	**11**
	0.5	2.3	4.2	0.48	3.6	**11**
15-Aug	0.15	1.7	4.2	0.57	3.5	**10**
	0.5	3.7	9.3	1.4	8.0	**22**
7-Sep	0.15	5.7	14	2.0	12	**34**
	0.5	5.4	14	1.9	12	**33**

Notes: Value in parantheses is the laboratory reporting limit.
Bolded values exceed Alaska water quality standard of 10 µg/L for TAH.
Analytical results for May 23-26 and July 4-6 are averages of five intensive samples from BL-10.

Key:
m = Meters
µg/L = Micrograms per liter
ND = Not detected
TAH = Total aromatic hydrocarbons

Table 31
Analytical Results for Sample Site BL-11
Big Lake Water Quality Monitoring

Sample Date	Sample Depth (m)	Benzene (µg/L)	Toluene (µg/L)	Ethylbenzene (µg/L)	Xylenes (µg/L)	TAH (µg/L)
13-May	0.15	ND (0.20)	ND (1.0)	ND (0.20)	ND (0.60)	NQ
23-May	0.15	ND (0.20)	ND (1.0)	ND (0.20)	ND (0.60)	NQ
24-May	0.15	ND (0.20)	ND (1.0)	ND (0.20)	ND (0.60)	NQ
25-May	0.15	0.23	ND (1.0)	ND (0.20)	0.41	0.64
26-May	0.15	0.23	ND (1.0)	ND (0.20)	0.68	0.91
17-Jun	0.5	ND (0.20)	ND (1.0)	ND (0.20)	ND (0.60)	NQ
27-Jun	0.15	0.32	1.1	ND (0.20)	0.99	2.4
4-Jul	0.15	0.70	1.4	0.29	1.1	3.5
5-Jul	0.15	0.27	ND (1.0)	ND (0.20)	0.69	0.96
6-Jul	0.15	0.21	ND (1.0)	ND (0.20)	ND (0.60)	0.21
25-Jul	0.15	ND (0.20)	ND (1.0)	ND (0.20)	ND (0.60)	NQ
15-Aug	0.15	ND (0.20)	ND (1.0)	ND (0.20)	ND (0.60)	NQ
7-Sep	0.15	ND (0.20)	ND (1.0)	ND (0.20)	ND (0.60)	NQ

Notes: Value in parantheses is the laboratory reporting limit.

Key:

m = Meters
µg/L = Micrograms per liter
ND = Not detected
NQ = Not quantified
TAH = Total aromatic hydrocarbons

Table 32
Analytical Results for Sample Site BL-26
Big Lake Water Quality Monitoring

Sample Date	Sample Depth (m)	Benzene (µg/L)	Toluene (µg/L)	Ethylbenzene (µg/L)	Xylenes (µg/L)	TAH (µg/L)
13-May	0.15	0.24	ND (1.0)	ND (0.20)	ND (0.60)	0.24
23-May	0.15	0.89	3.4	0.38	2.2	4.9
24-May	0.15	1.9	5.2	0.69	4.3	**12**
25-May	0.15	2.6	7.4	0.94	6.0	**17**
26-May	0.15	1.7	4.5	0.60	4.2	**11**
17-Jun	0.5	ND (0.20)	ND (1.0)	ND (0.20)	ND (0.60)	NQ
27-Jun	0.15	0.43	ND (1.0)	ND (0.20)	0.84	1.3
4-Jul	0.15	2.9	4.1	0.59	5.4	**13**
5-Jul	0.15	2.2	4.1	0.57	4.3	9.4
6-Jul	0.15	0.87	ND (1.0)	ND (0.20)	1.2	1.8
25-Jul	0.15	ND (0.20)	ND (1.0)	ND (0.20)	ND (0.60)	NQ
15-Aug	0.15	0.31	ND (1.0)	ND (0.20)	ND (0.60)	0.31
7-Sep	0.15	1.1	1.9	0.23	2.0	5.2

Notes: Value in parantheses is the laboratory reporting limit.

Bolded values exceed Alaska water quality standard of 10 µg/L for TAH.

Analytical results for May 23-26 and July 4-6 are averages of five intensive samples from BL-26.

Key:

m = Meters
µg/L = Micrograms per liter
ND = Not detected
NQ = Not quantified
TAH = Total aromatic hydrocarbons

Table 33
Analytical Results for Sample Site BL-27
Big Lake Water Quality Monitoring

Sample Date	Sample Depth (m)	Benzene (µg/L)	Toluene (µg/L)	Ethylbenzene (µg/L)	Xylenes (µg/L)	TAH (µg/L)
13-May	0.15	0.46	1.4	ND (0.20)	0.82	2.7
23-May	0.15	0.98	3.2	0.45	2.1	5.9
24-May	0.15	1.7	4.7	0.61	3.9	**11**
25-May	0.15	2.6	7.3	0.94	5.8	**17**
26-May	0.15	2.2	6.0	0.84	5.4	**14**
17-Jun	0.5	ND (0.20)	ND (1.0)	ND (0.20)	ND (0.60)	NQ
27-Jun	0.15	0.60	1.7	ND (0.20)	1.6	3.9
4-Jul	0.15	2.5	3.5	0.48	4.7	**11**
5-Jul	0.15	2.9	3.4	0.63	5.9	**13**
6-Jul	0.15	1.2	ND (1.0)	ND (0.20)	1.4	2.6
25-Jul	0.15	ND (0.20)	ND (1.0)	ND (0.20)	ND (0.60)	NQ
15-Aug	0.15	0.48	1.1	ND (0.20)	0.81	2.4
7-Sep	0.15	1.1	2.1	0.26	2.1	5.6

Notes: Value in parantheses is the laboratory reporting limit.

Bolded values exceed Alaska water quality standard of 10 µg/L for TAH.

Analytical results for May 23-26 and July 4-6 are averages of five intensive samples from BL-10.

Key:

m = Meters
µg/L = Micrograms per liter
ND = Not detected
NQ = Not quantified
TAH = Total aromatic hydrocarbons

Table 34
Analytical Results for Intensive Samples on Memorial Day Weekend
Big Lake Water Quality Monitoring

			May 23, 2009					May 24, 2009					May 25, 2009					May 26, 2009				
			BL-10			BL-26	BL-27	BL-10			BL-26	BL-27	BL-10			BL-26	BL-27	BL-10			BL-26	BL-27
		Depth (m)	0.15		0.5	0.15	0.15	0.15		0.5	0.15	0.15	0.15		0.5	0.15	0.15	0.15		0.5	0.15	0.15
Time	Compound	Units	Primary	Duplicate				Primary	Duplicate				Primary	Duplicate				Primary	Duplicate			
9:00	Benzene	µg/L	2.9	2.8	3.0	0.50	0.50	5.0	4.8	5.4	1.90	1.5	4.5	4.4	4.8	2.2	2.2	3.5	3.8	3.8	1.5	2.8
	Toluene	µg/L	8.9	8.4	9.2	ND (1.0)	1.2	15	15	16	5.1	4.0	13	13	13	6.2	6.3	9.6	10	11	3.7	7.7
	Ethylbenzene	µg/L	1.1	1.1	1.1	ND (0.20)	ND (0.20)	2.2	2.2	2.5	0.78	0.57	2.1	2.0	2.1	0.68	0.70	1.2	1.3	1.3	0.37	0.86
	Xylenes	µg/L	7.2	6.8	7.5	0.79	1.1	13	12	14	4.5	3.8	11	11	11	4.5	4.6	6.8	7.4	7.8	2.9	5.9
	TAH	µg/L	**20**	**19**	**21**	1.3	2.8	**35**	**34**	**38**	**12**	9.9	**31**	**30**	**31**	**14**	**14**	**21**	**23**	**24**	8.5	**17**
12:00	Benzene	µg/L	2.3	---	2.1	0.28	0.39	5.7	---	5.0	1.5	1.4	5.7	---	6.1	2.0	2.6	3.0	---	2.9	2.3	2.3
	Toluene	µg/L	7.1	---	6.2	ND (1.0)	ND (1.0)	17	---	15	4.1	3.7	17	---	17	5.5	6.9	8.0	---	8.0	5.8	6.3
	Ethylbenzene	µg/L	0.86	---	0.74	ND (0.20)	ND (0.20)	2.5	---	2.2	0.64	0.50	2.5	---	2.6	0.82	1.0	1.2	---	1.2	0.82	0.94
	Xylenes	µg/L	5.3	---	4.8	ND (0.60)	0.59	14	---	13	3.9	3.6	13	---	14	5.1	6.0	7	---	7.2	5.5	5.9
	TAH	µg/L	**16**	---	**14**	0.28	0.98	**39**	---	**35**	**10**	9.2	**38**	---	**40**	**13**	**17**	**19**	---	**19**	**14**	**15**
15:00	Benzene	µg/L	7.1	5.9	7.6	0.97	1.3	7.2	6.9	6.7	1.8	1.6	6.1	6.2	5.5	2.7	2.6	2.5	2.4	2.4	1.6	2.1
	Toluene	µg/L	20	18	22	2.8	3.7	18	18	18	4.9	4.6	17	16	15	7.0	6.9	6.7	6.6	6.4	4.0	5.7
	Ethylbenzene	µg/L	2.7	2.6	3.1	0.35	0.51	2.7	2.8	2.7	0.73	0.69	2.6	2.5	2.4	1.0	1.0	1.1	1.1	1.0	0.54	0.85
	Xylenes	µg/L	16	15	18	2.6	3.2	16	15	14	4.3	3.9	14	13	12	6.3	6.2	5.9	5.8	5.6	3.8	5.3
	TAH	µg/L	**46**	**42**	**51**	6.7	8.7	**44**	**43**	**41**	**12**	**11**	**40**	**38**	**35**	**17**	**17**	**16**	**16**	**15**	9.9	**14**
18:00	Benzene	µg/L	8.2	8.0	7.3	1.4	1.3	7.6	7.2	7.3	2.2	2.2	5.4	5.6	8.8	3.1	2.7	2.7	3.0	3.0	1.8	2.0
	Toluene	µg/L	25	23	22	3.9	3.7	22	22	21	6.2	6.5	15	16	25	9.2	8.2	7.8	8.5	8.3	5.1	5.5
	Ethylbenzene	µg/L	3.2	3.0	2.9	0.42	0.40	3.0	3.0	2.8	0.71	0.75	2.1	2.1	3.3	1.2	1.1	1.3	1.2	1.3	0.72	0.82
	Xylenes	µg/L	19	18	17	2.8	2.6	17	17	16	4.6	4.7	11	11	18	7.7	6.6	7.0	7.1	7.6	4.7	5.4
	TAH	µg/L	**55**	**52**	**49**	8.5	8.0	**50**	**49**	**47**	**14**	**14**	**34**	**35**	**55**	**21**	**19**	**19**	**20**	**20**	**12**	**14**
21:00	Benzene	µg/L	8.6	---	6.9	1.3	1.4	11	---	11	2.0	1.7	8.5	---	8.4	3.2	2.9	2.5	---	1.3	1.5	1.8
	Toluene	µg/L	26	---	20	3.6	4.0	32	---	32	5.6	4.6	23	---	24	9.0	8.1	6.4	---	3.0	4.0	4.8
	Ethylbenzene	µg/L	3.5	---	3.0	0.38	0.45	4.4	---	4.4	0.59	0.56	3.1	---	3.2	1.0	0.90	1.0	---	0.52	0.56	0.71
	Xylenes	µg/L	21	---	17	2.6	3.0	25	---	25	4.1	3.3	17	---	17	6.5	5.8	6.0	---	3.3	4.1	4.4
	TAH	µg/L	**59**	---	**47**	7.9	8.9	**72**	---	**72**	**12**	**10**	**52**	---	**53**	**20**	**18**	**16**	---	8.1	**10**	**12**

Notes: Value in parantheses is the laboratory reporting limit.
Bolded values exceed Alaska water quality standard of 10 µg/L for TAH.
Samples from BL-10 and BL-26 on July 4 were lost when the samples froze overnight.

Key:
m = Meters
µg/L = Micrograms per liter
ND = Not detected
TAH = Total aromatic hydrocarbons

Table 35
Analytical Results for Intensive Samples on Independence Day Weekend
Big Lake Water Quality Monitoring

			July 4, 2009					July 5, 2009					July 6, 2009				
			BL-10			BL-26	BL-27	BL-10			BL-26	BL-27	BL-10			BL-26	BL-27
		Depth (m)	0.15		0.5	0.15	0.15	0.15		0.5	0.15	0.15	0.15		0.5	0.15	0.15
Time	Compound	Units	Primary	Duplicate				Primary	Duplicate				Primary	Duplicate			
9:00	Benzene	µg/L	7.2	7.2	6.3	1.8	1.8	10	11	10	1.7	2.4	3.4	3.4	3.1	1.1	1.2
	Toluene	µg/L	13	13	11	1.3	1.3	19	20	20	ND (1.0)	1.2	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)
	Ethylbenzene	µg/L	1.8	1.8	1.6	ND (0.20)	ND (0.20)	2.6	2.6	2.6	ND (0.20)	ND (0.20)	ND (0.20)	ND (0.20)	ND (0.20)	ND (0.20)	ND (0.20)
	Xylenes	µg/L	14	14	13	3.1	3.4	22	23	23	2.1	4.0	5.4	5.1	4.4	0.92	1.2
	TAH	µg/L	**36**	**36**	**32**	6.2	6.5	**54**	**57**	**56**	3.8	7.6	8.8	8.5	7.5	2.0	2.4
12:00	Benzene	µg/L	8.0	---	10	2.2	2.4	9.0	---	7.6	1.6	2.8	3.4	---	3.3	0.33	1.3
	Toluene	µg/L	16	---	23	2.4	2.5	18	---	15	ND (1.0)	2.0	ND (1.0)	---	ND (1.0)	ND (1.0)	ND (1.0)
	Ethylbenzene	µg/L	2.2	---	3.0	0.33	0.33	3.1	---	2.4	ND (0.20)	ND (0.20)	ND (0.20)	---	ND (0.20)	ND (0.20)	ND (0.20)
	Xylenes	µg/L	16	---	21	3.9	4.3	25	---	21	1.7	4.6	6.0	---	6.2	ND (0.60)	1.4
	TAH	µg/L	**42**	---	**57**	8.8	9.5	**55**	---	**46**	3.3	9.4	9.4	---	9.5	0.33	2.7
15:00	Benzene	µg/L	19	20	22	3.4	2.4	8.3	8.1	8.7	2.5	2.6	2.1	2.1	1.9	1.7	1.1
	Toluene	µg/L	46	45	54	4.9	2.7	17	17	18	3.8	3.9	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)
	Ethylbenzene	µg/L	6.3	6.6	7.3	0.60	0.35	2.8	2.8	2.8	0.62	0.60	ND (0.20)	ND (0.20)	ND (0.20)	ND (0.20)	ND (0.20)
	Xylenes	µg/L	39	40	46	6.0	4.1	22	22	22	6.0	6.8	3.3	3.3	2.8	2.5	1.5
	TAH	µg/L	**110**	**112**	**129**	**15**	9.6	**50**	**50**	**52**	**13**	**14**	5.4	5.4	4.7	4.2	2.6
18:00	Benzene	µg/L					2.8	9.1	9.5	12	2.3	3.4	4.2	4.1	1.8	0.63	0.88
	Toluene	µg/L					5.3	20	21	26	4.5	5.2	5.7	6.3	1.4	ND (1.0)	ND (1.0)
	Ethylbenzene	µg/L					0.61	3.4	3.3	3.2	0.71	0.79	0.71	0.57	ND (0.20)	ND (0.20)	ND (0.20)
	Xylenes	µg/L					5.4	25	25	24	6.1	8.2	6.8	6.2	2.3	0.7	1.1
	TAH	µg/L					**14**	**58**	**59**	**65**	**14**	**18**	**17**	**17**	5.5	1.4	2.0
21:00	Benzene	µg/L	18	---	18	4.2	3.0	9.8	---	10	3.1	3.4	2.3	---	2.2	0.57	1.5
	Toluene	µg/L	47	---	47	7.8	5.8	19	---	21	3.9	4.9	1.6	---	1.5	ND (1.0)	ND (1.0)
	Ethylbenzene	µg/L	7.2	---	7.1	0.85	0.63	2.3	---	2.4	0.38	0.51	ND (0.20)	---	ND (0.20)	ND (0.20)	ND (0.20)
	Xylenes	µg/L	42	---	44	8.4	6.1	21	---	22	5.8	6.0	3.0	---	2.8	0.68	1.8
	TAH	µg/L	**114**	---	**116**	**21**	**16**	**52**	---	**55**	**13**	**15**	6.9	---	6.5	1.3	3.3

Notes: Value in parantheses is the laboratory reporting limit.

Bolded values exceed Alaska water quality standard of 10 µg/L for TAH.

Samples from BL-10 and BL-26 on July 4 were lost when the samples froze overnight.

Key:

m = Meters

µg/L = Micrograms per liter

ND = Not detected

TAH = Total aromatic hydrocarbons

Table 36
Number of Motorized Watercraft Observed during Sample Activities
Big Lake Water Quality Monitoring

Sample Date	Sample Site												Total
	BL-1	BL-2	BL-3	BL-4	BL-5	BL-6	BL-7	BL-8	BL-10	BL-11	BL-26	BL-27	
13-May	2	2	3	1	1	1	0	4	1	0	0	0	15
23-May	9	7	9	4	2	4	4	13	8	5	5	4	74
24-May	1	18	14	10	3	4	2	11	5	5	8	3	84
25-May	2	16	10	3	2	3	0	15	3	0	6	3	63
26-May	1	2	2	4	1	10	1	0	1	0	3	2	26
17-Jun	1	3	3	0	1	0	0	0	1	1	2	0	12
27-Jun	6	10	16	1	13	2	0	8	1	1	5	8	71
4-Jul	16	33	17	18	11	12	10	21	10	2	20	11	181
5-Jul	26	43	20	8	23	8	6	18	6	1	15	9	183
6-Jul	7	17	9	1	3	4	0	3	1	2	3	1	51
25-Jul	6	22	6	1	0	0	3	10	6	0	11	6	71
15-Aug	1	1	7	1	4	0	0	3	8	0	4	5	34
7-Sep	0	3	6	4	7	4	3	5	5	0	3	7	47
Total	78	177	122	56	71	52	29	111	55	17	84	60	911

Note: Watercraft counts for BL-10, BL-26, and BL-27 on May 23-26 and July 4-6 represent averages from five intensive sample events.

Table 37
Observer Findings from Intensive Sample Dates
Big Lake Water Quality Monitoring

Sample Date	Time	Total Number of Motorized Watercraft	Number of 2-strokes	Number of 4-strokes	Number of Unknown Engine Types
24-May	9:00	7	2	4	1
	10:00	24	4	11	9
	11:00	30	5	10	15
	12:00	42	5	19	18
	13:00	54	7	22	25
	14:00	49	7	19	23
	15:00	45	6	22	17
	16:00	45	7	24	14
	17:00	28	3	12	13
	18:00	19	3	14	2
	19:00	12	0	7	5
	20:00	8	1	5	2
	Total	363	50	169	144
25-May	9:00	8	0	6	2
	10:00	24	0	14	10
	11:00	27	3	14	10
	12:00	28	2	17	9
	13:00	31	0	16	15
	14:00	29	1	16	12
	15:00	29	0	19	10
	16:00	23	0	17	6
	17:00	23	1	18	4
	18:00	18	0	12	6
	19:00	11	0	3	8
	20:00	4	0	0	4
	Total	255	7	152	96
5-Jul	9:00	15	0	11	4
	10:00	35	0	22	13
	11:00	31	1	22	8
	12:00	33	0	21	12
	13:00	40	0	26	14
	14:00	20	0	14	6
	15:00	22	0	12	10
	16:00	22	1	13	8
	17:00	22	0	14	8
	18:00	18	0	13	5
	19:00	15	0	12	3
	Total	273	2	180	91
6-Jul	9:00	7	0	2	5
	10:00	14	0	6	8
	11:00	14	0	9	5
	12:00	19	1	11	7
	13:00	31	1	12	18
	14:00	28	1	6	21
	15:00	26	0	13	13
	16:00	22	1	12	9
	17:00	21	0	13	8
	18:00	15	0	11	4
	19:00	9	0	7	2
	20:00	4	0	1	3
	Total	210	4	103	103

Note: Observations for 20:00 hours were not made on July 5.

Table 38
Interviewer Findings from Intensive Sample Dates
Big Lake Water Quality Monitoring

Date	Watercraft Number	Watercraft Type	Engine Type	Horsepower	Launch Time	Return Time	Number of Hours
24-May	1	Boat	4-stroke	35	11:00	Not Observed	8+
	2	Boat	4-stroke	35	11:45	Not Observed	7.25+
	3	Boat	4-stroke	255	12:00	17:00	5
	4	Boat	4-stroke	Unknown	12:00	16:25	4.25
	5	Waverunner	Unknown	Unknown	12:30	Not Observed	6.5+
	6	Boat	4-stroke	190	13:15	17:50	4.5
	7	Boat	Unknown	200	13:30	Not Observed	5.5+
	8	Boat	4-stroke	215	13:40	17:15	3.5
	9	Boat	4-stroke	Unknown	14:30	Not Observed	4.5+
	10	Boat	Unknown	Unknown	15:30	Not Observed	3.5+
	11	Boat	Unknown	130	16:15	Not Observed	2.75+
	12	Waverunner	Unknown	Unknown	16:30	Not Observed	2.5+
	13	Waverunner	Unknown	Unknown	16:30	Not Observed	2.5+
	14	Waverunner	Unknown	Unknown	16:30	Not Observed	2.5+
	15	Waverunner	Unknown	Unknown	16:30	Not Observed	2.5+
	16	Boat	4-stroke	35	17:30	Not Observed	1.5+
	17	Boat	Unknown	Unknown	17:30	18:15	0.45
25-May	1	Boat	2-stroke	Unknown	9:45	11:45	2
	2	Boat	Unknown	Unknown	10:20	11:15	1
	3	Boat	4-stroke	35	11:20	12:30	1.25
	4	Boat	2-stroke	15	11:20	15:00	3.75
	5	Boat	4-stroke	200	11:20	Not Observed	7.75+
	6	Boat	Unknown	Unknown	11:35	12:00	0.5
	7	Boat	4-stroke	35	11:45	14:00	2.25
	8	Boat	Unknown	115	11:45	18:00	6.25
	9	Waverunner	Unknown	Unknown	13:15	15:50	2.5
	10	Waverunner	Unknown	Unknown	13:15	18:20	5
	11	Waverunner	Unknown	Unknown	13:15	18:20	5
	12	Waverunner	Unknown	Unknown	13:25	18:15	4.75
	13	Waverunner	Unknown	Unknown	13:25	18:15	4.75
	14	Boat	4-stroke	110	13:30	15:30	2
	15	Boat	4-stroke	200	14:30	Not Observed	4.5+
	16	Boat	2-stroke	7.5	15:00	18:25	3.5
	17	Boat	Unknown	Unknown	15:00	17:20	2.25
	18	Waverunner	Unknown	Unknown	15:20	Not Observed	3.75+
	19	Waverunner	Unknown	Unknown	15:20	Not Observed	3.75+
	20	Boat	4-stroke	Unknown	15:35	Not Observed	3.5+
	21	Boat	4-stroke	35	15:45	17:00	1.25
	22	Boat	4-stroke	100	18:15	Not Observed	0.75+

Table 38
Interviewer Findings from Intensive Sample Dates
Big Lake Water Quality Monitoring

Date	Watercraft Number	Watercraft Type	Engine Type	Horsepower	Launch Time	Return Time	Number of Hours
5-Jul	1	Boat	4-stroke	150	9:30	11:50	2.25
	2	Boat	Unknown	225	11:15	14:00	2.75
	3	Boat	Unknown	200	12:10	18:00	5.75
	4	Boat	4-stroke	90	12:20	Not Observed	6.75+
	5	Boat	4-stroke	85	12:30	Not Observed	6.5+
	6	Boat	4-stroke	90	12:30	17:45	5.25
	7	Boat	Unknown	250	12:45	16:00	3.25
	8	Boat	Unknown	Unknown	13:00	Not Observed	6+
	9	Boat	Unknown	225	13:30	15:40	2.25
	10	Waverunner	Unknown	Unknown	13:50	16:50	3
	11	Waverunner	Unknown	Unknown	13:50	16:50	3
	12	Boat	4-stroke	90	14:00	19:00	5
	13	Boat	4-stroke	125	14:00	16.25	2.5
	14	Waverunner	Unknown	Unknown	14:05	16:00	2
	15	Boat	4-stroke	50	14:35	16:40	2
	16	Boat	4-stroke	200	14:45	16:50	2
	17	Boat	4-stroke	200	14:50	18:05	3.25
	18	Waverunner	Unknown	Unknown	15:00	Not Observed	4+
	19	Waverunner	Unknown	Unknown	15:00	Not Observed	4+
	20	Boat	4-stroke	Unknown	16:05	Not Observed	3+
	21	Boat	4-stroke	90	16:10	Not Observed	2.75+
	22	Boat	Unknown	115	16:50	Not Observed	2.25+
	23	Boat	4-stroke	400	17:15	Not Observed	1.75+
	24	Boat	4-stroke	454	17:35	Not Observed	1.5+
	25	Boat	Unknown	115	17:35	Not Observed	1.5+
	26	Boat	4-stroke	460	17:40	Not Observed	1.25+
6-Jul	1	Boat	4-stroke	50	11:15	13:40	2.5
	2	Boat	4-stroke	460	13:10	Not Observed	5.75+
	3	Boat	2-stroke	135	14:10	Not Observed	4.75+
	4	Boat	4-stroke	125	16:30	Not Observed	2.5+
	5	Boat	4-stroke	454	16:50	Not Observed	2.25+
	6	Boat	2-stroke	200	17:00	Not Observed	2+

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FIGURES

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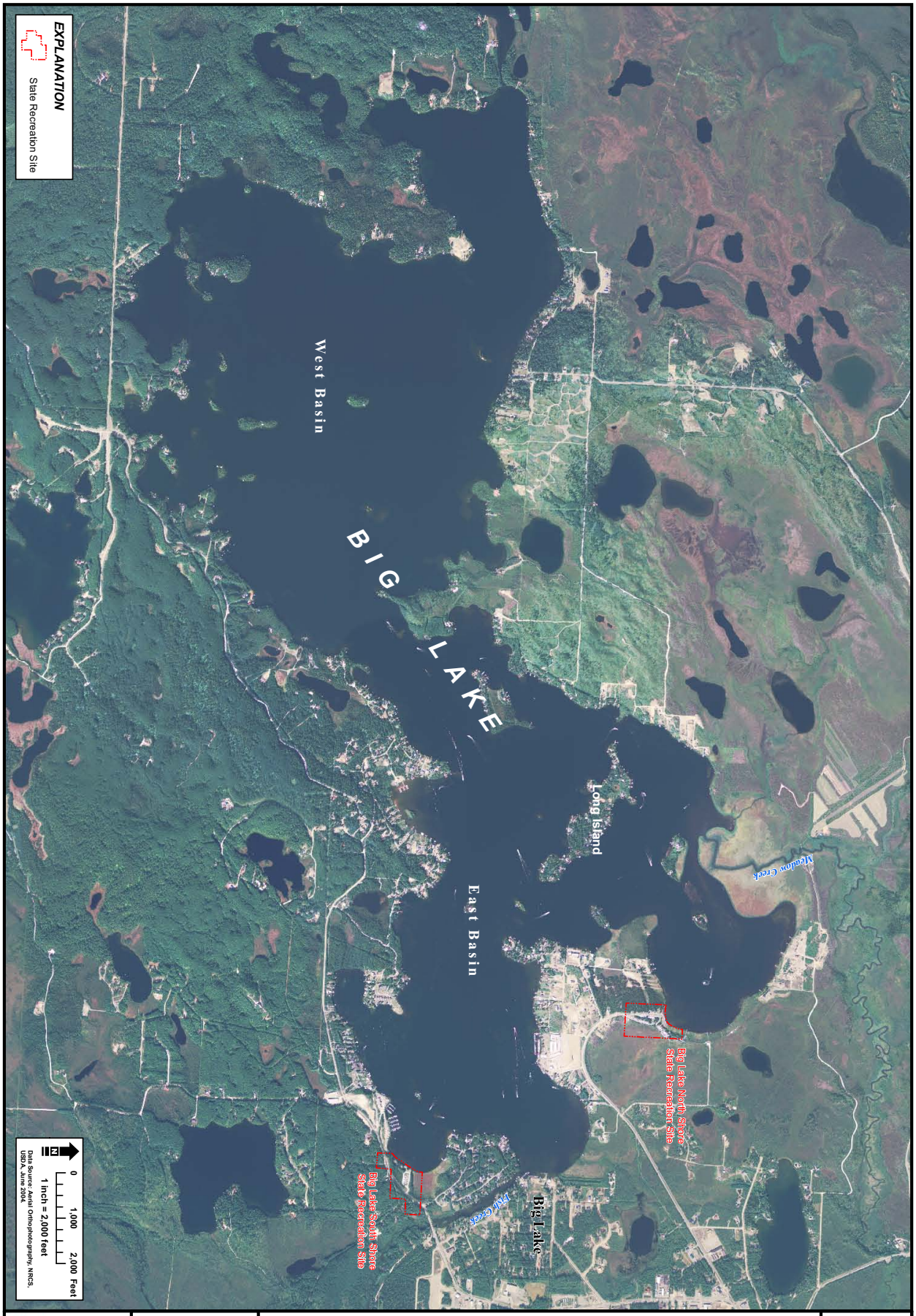

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DATE: OCT 2009
CHKD: BM
DRWN: CS
PROJ: 14-154

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SITE PLAN

ALASKA DEPARTMENT OF ENVIRONMENTAL CONSERVATION
BIG LAKE WATER QUALITY MONITORING
BIG LAKE, ALASKA

FIGURE
1

FIGURE 2

SAMPLE SITES

ALASKA DEPARTMENT OF ENVIRONMENTAL CONSERVATION
BIG LAKE WATER QUALITY MONITORING
BIG LAKE, ALASKA

DATE: OCT 2009
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FIGURE 3

TAH RESULTS FOR MAY 13, 2009

ALASKA DEPARTMENT OF ENVIRONMENTAL CONSERVATION
BIG LAKE WATER QUALITY MONITORING
BIG LAKE, ALASKA

DATE: OCT 2009
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DRWN: CS
PROJ: 14-154

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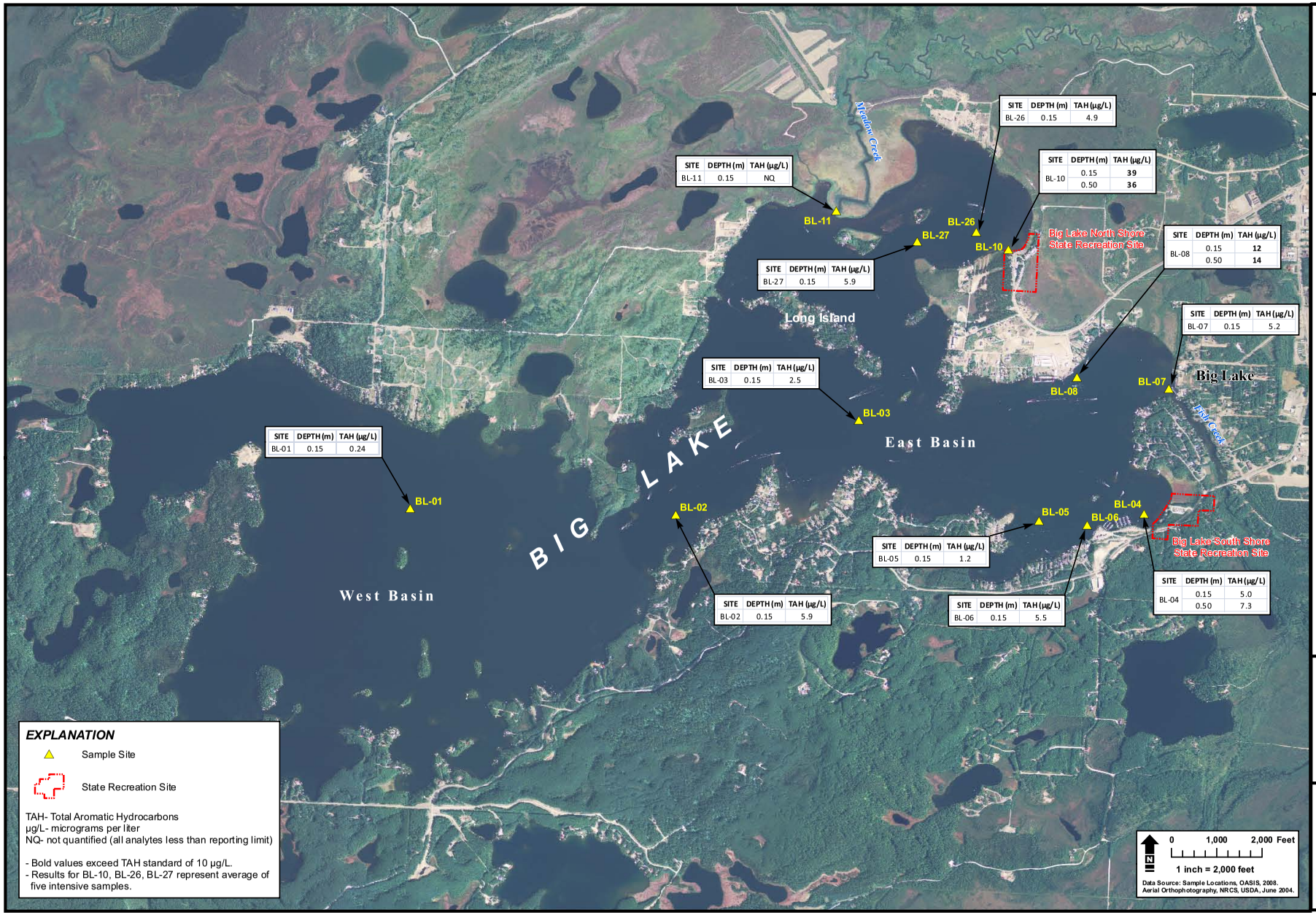

FIGURE 4

TAH RESULTS FOR MAY 23, 2009

ALASKA DEPARTMENT OF ENVIRONMENTAL CONSERVATION
BIG LAKE WATER QUALITY MONITORING
BIG LAKE, ALASKA

DATE: OCT 2009
CHKD: BM
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PROJ: 14-154

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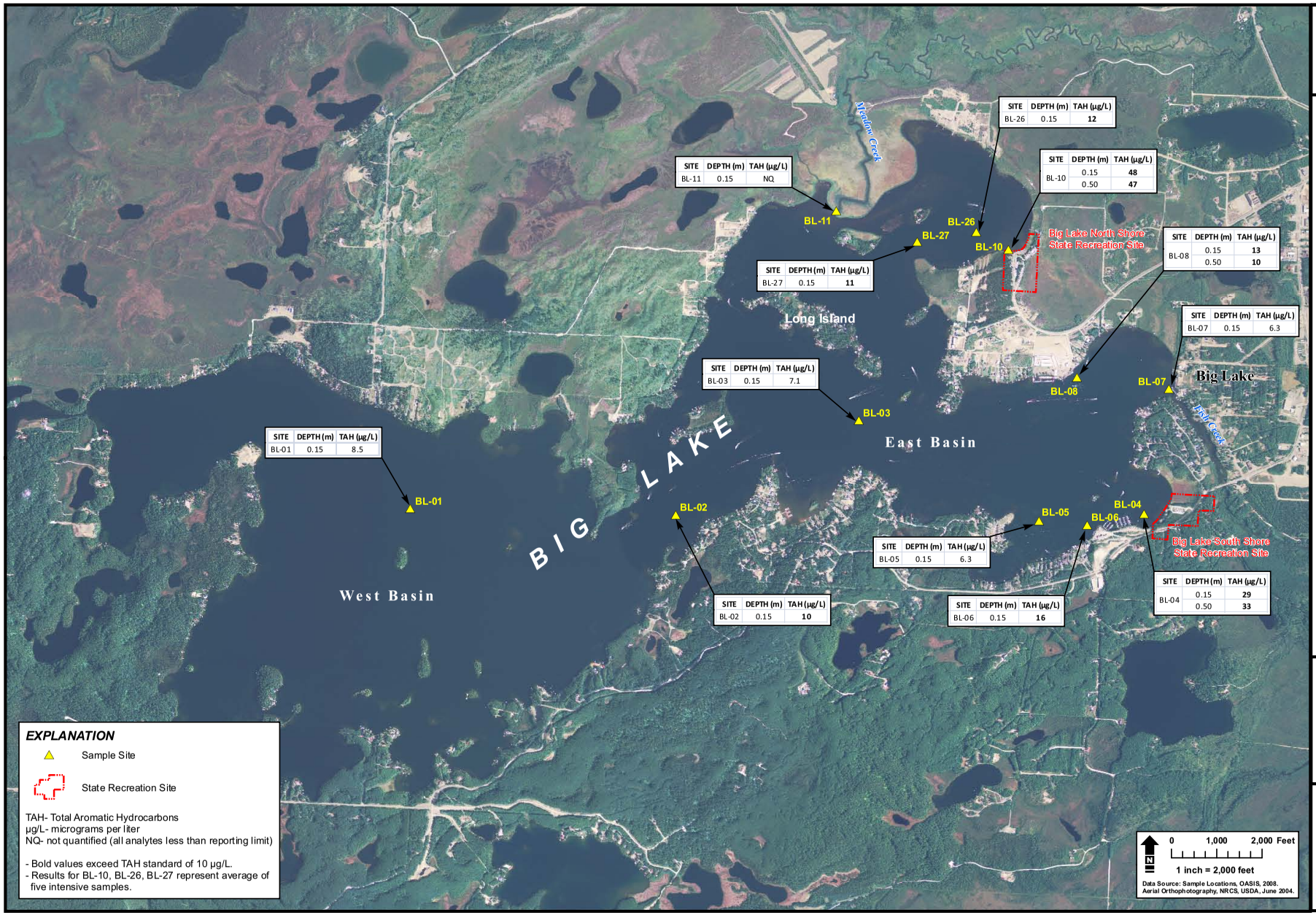

FIGURE 5

TAH RESULTS FOR MAY 24, 2009

ALASKA DEPARTMENT OF ENVIRONMENTAL CONSERVATION
BIG LAKE WATER QUALITY MONITORING
BIG LAKE, ALASKA

DATE: OCT 2009
CHKD: BM
DRWN: CS
PROJ: 14-154

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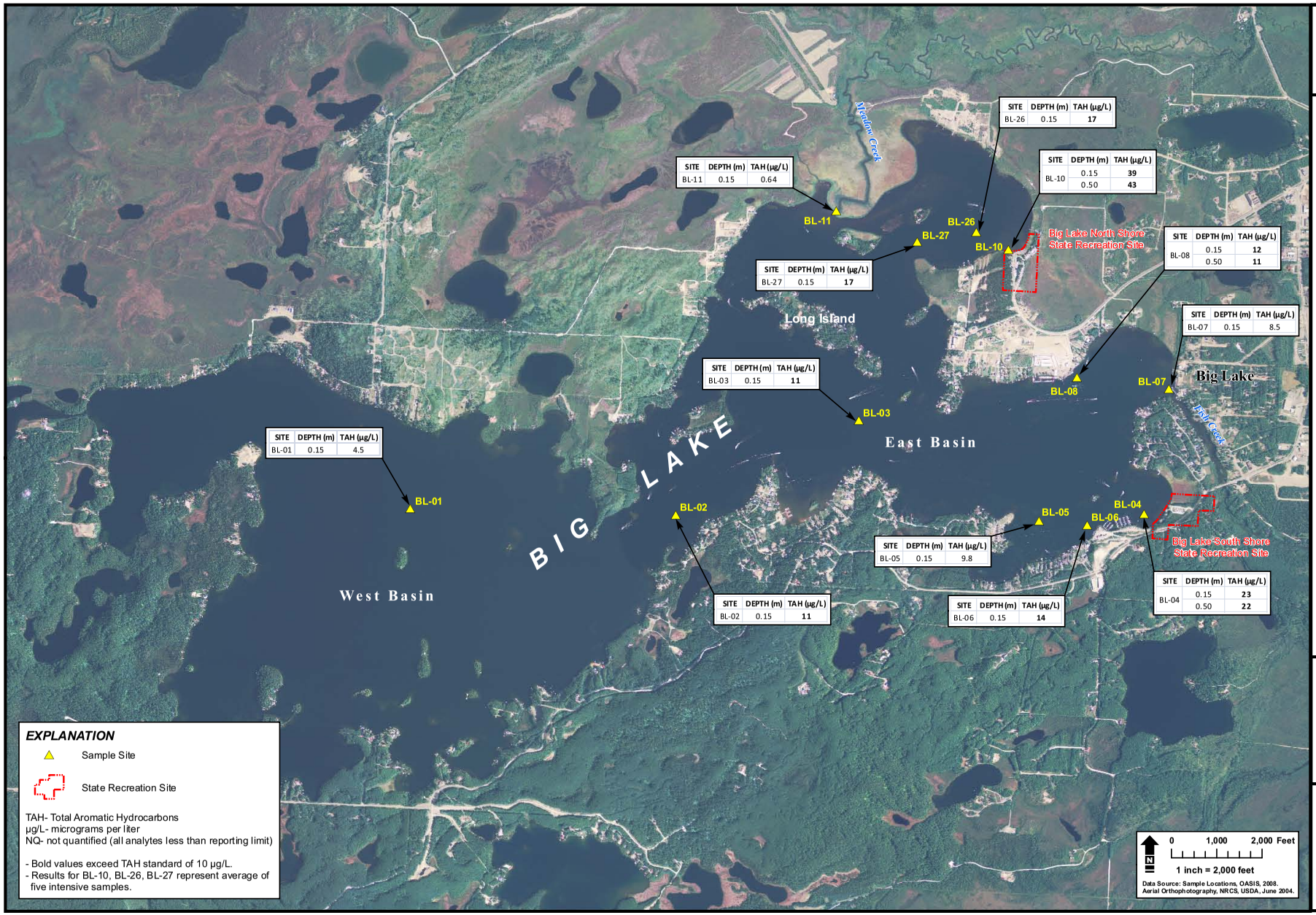

FIGURE 6

TAH RESULTS FOR MAY 25, 2009

ALASKA DEPARTMENT OF ENVIRONMENTAL CONSERVATION
BIG LAKE WATER QUALITY MONITORING
BIG LAKE, ALASKA

DATE: OCT 2009
CHKD: BM
DRWN: CS
PROJ: 14-154

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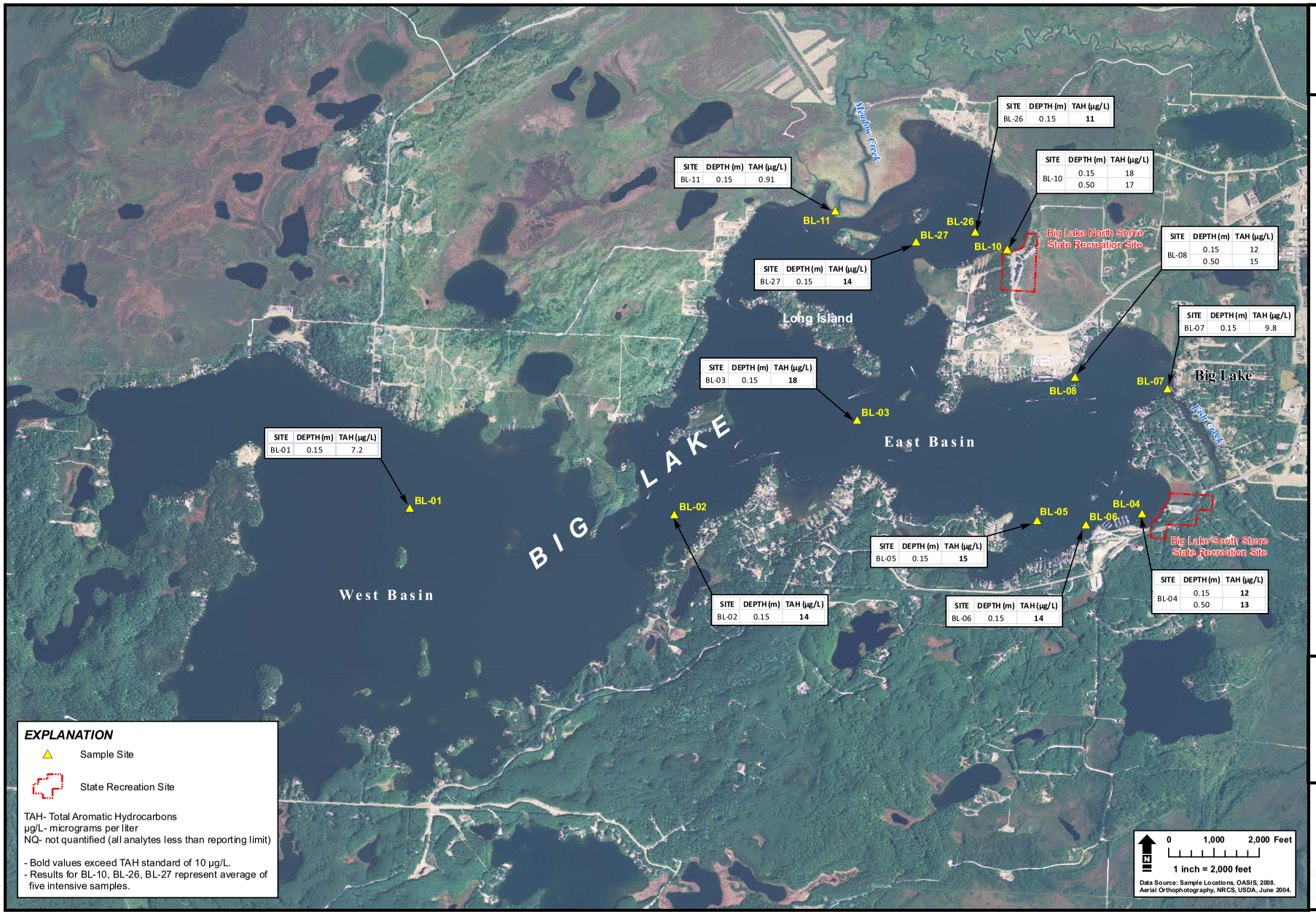

FIGURE 7

TAH RESULTS FOR MAY 26, 2009

ALASKA DEPARTMENT OF ENVIRONMENTAL CONSERVATION
BIG LAKE WATER QUALITY MONITORING
BIG LAKE, ALASKA

DATE: OCT 2009
CHKD: BM
DRWN: CS
PROJ: 14-154

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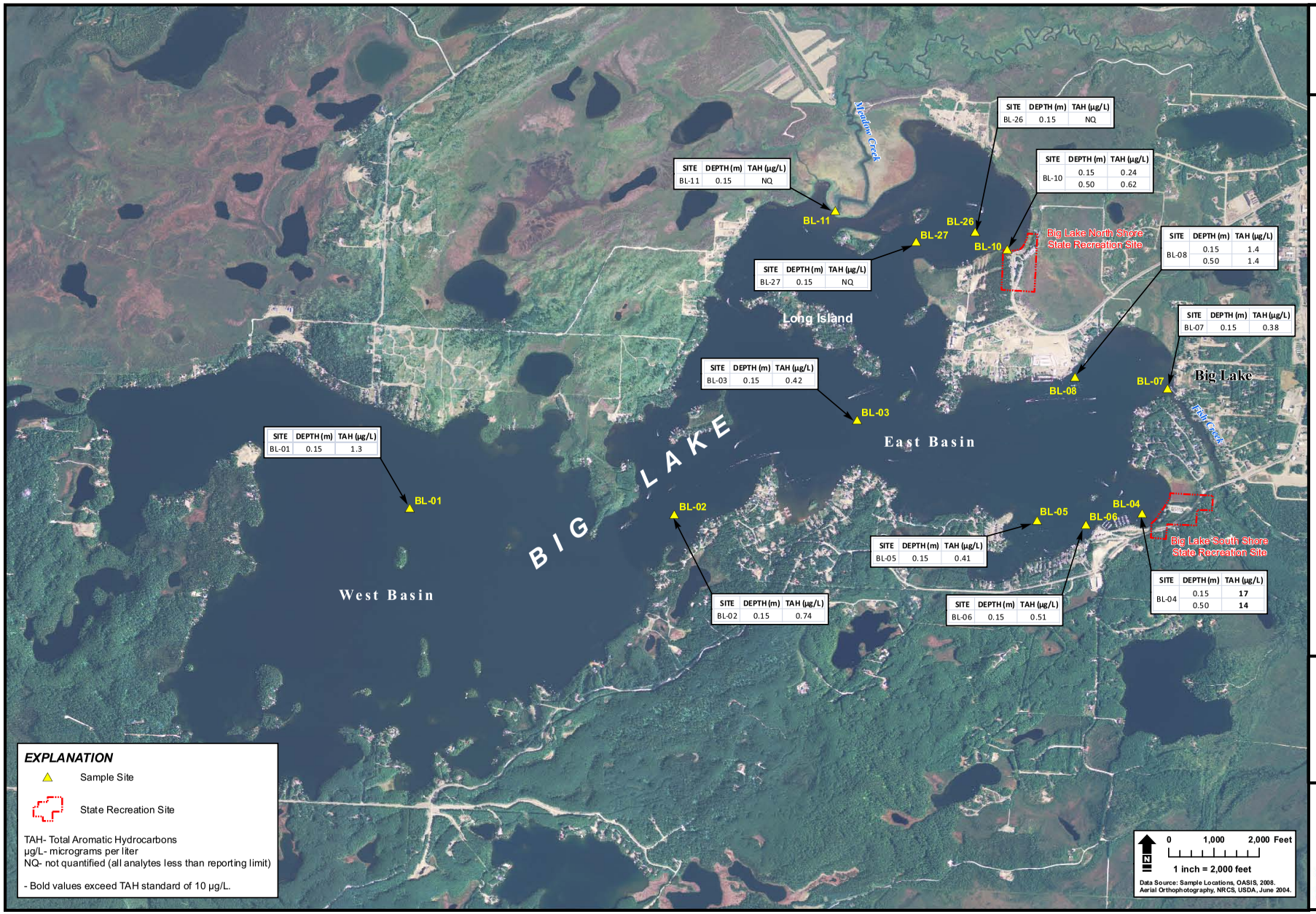

FIGURE 8

TAH RESULTS FOR JUNE 17, 2009

ALASKA DEPARTMENT OF ENVIRONMENTAL CONSERVATION
BIG LAKE WATER QUALITY MONITORING
BIG LAKE, ALASKA

DATE: OCT 2009
CHKD: BM
DRWN: CS
PROJ: 14-154

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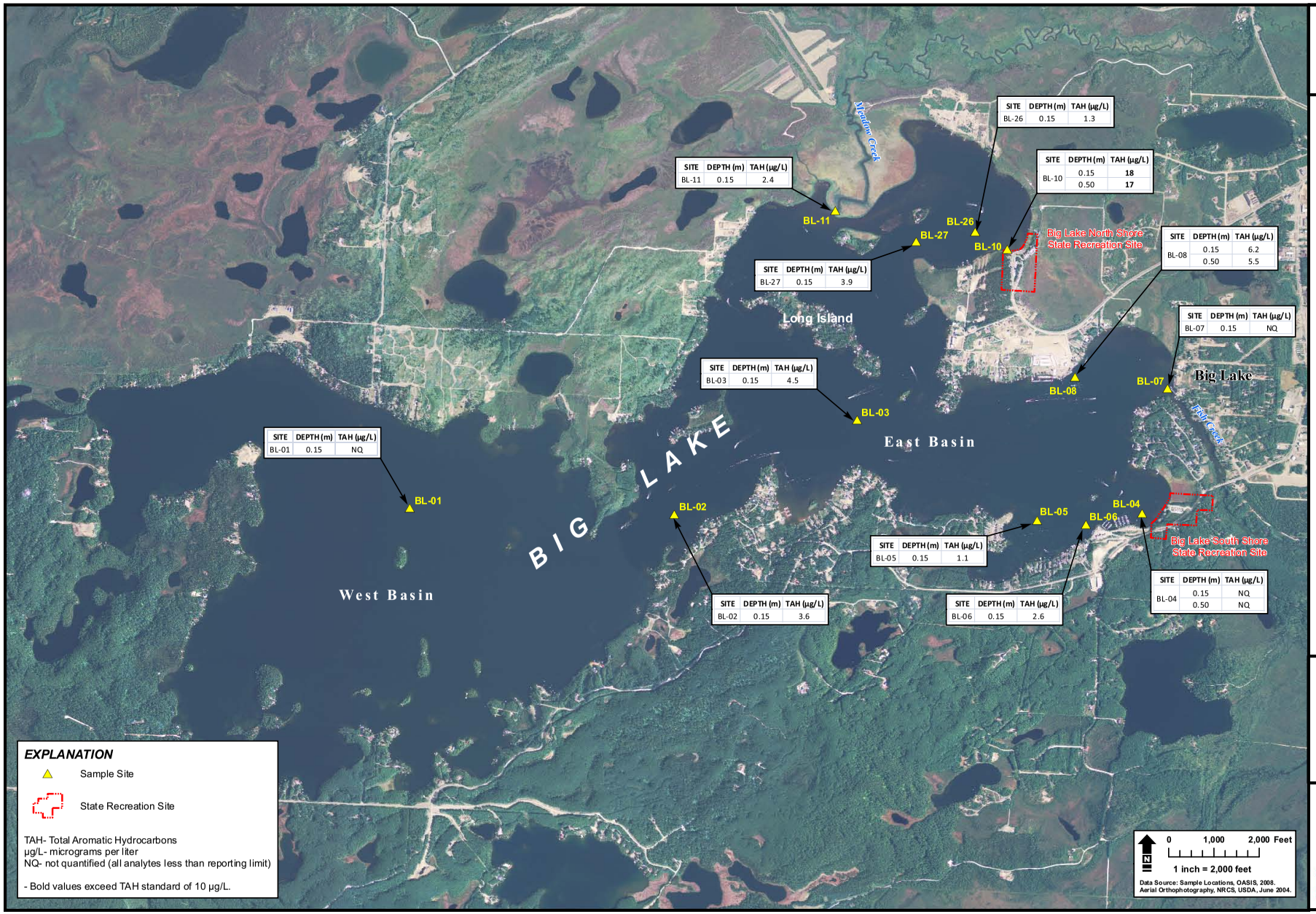

FIGURE 9

TAH RESULTS FOR JUNE 27, 2009

ALASKA DEPARTMENT OF ENVIRONMENTAL CONSERVATION
BIG LAKE WATER QUALITY MONITORING
BIG LAKE, ALASKA

DATE: OCT 2009
CHKD: BM
DRWN: CS
PROJ: 14-154

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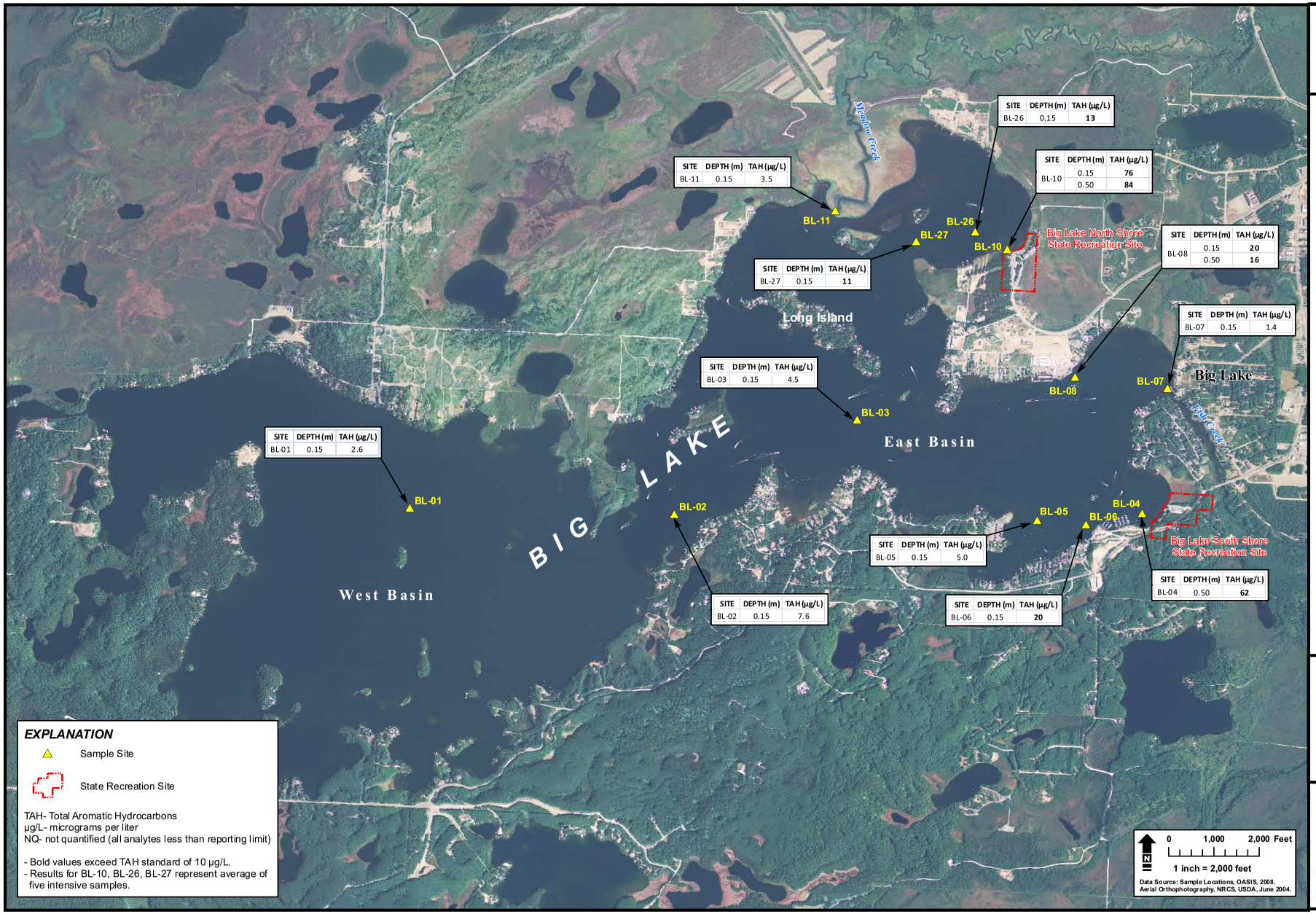

FIGURE 10

TAH RESULTS FOR JULY 4, 2009

ALASKA DEPARTMENT OF ENVIRONMENTAL CONSERVATION
BIG LAKE WATER QUALITY MONITORING
BIG LAKE, ALASKA

DATE: OCT 2009
CHKD: BM
DRWN: CS
PROJ: 14-154

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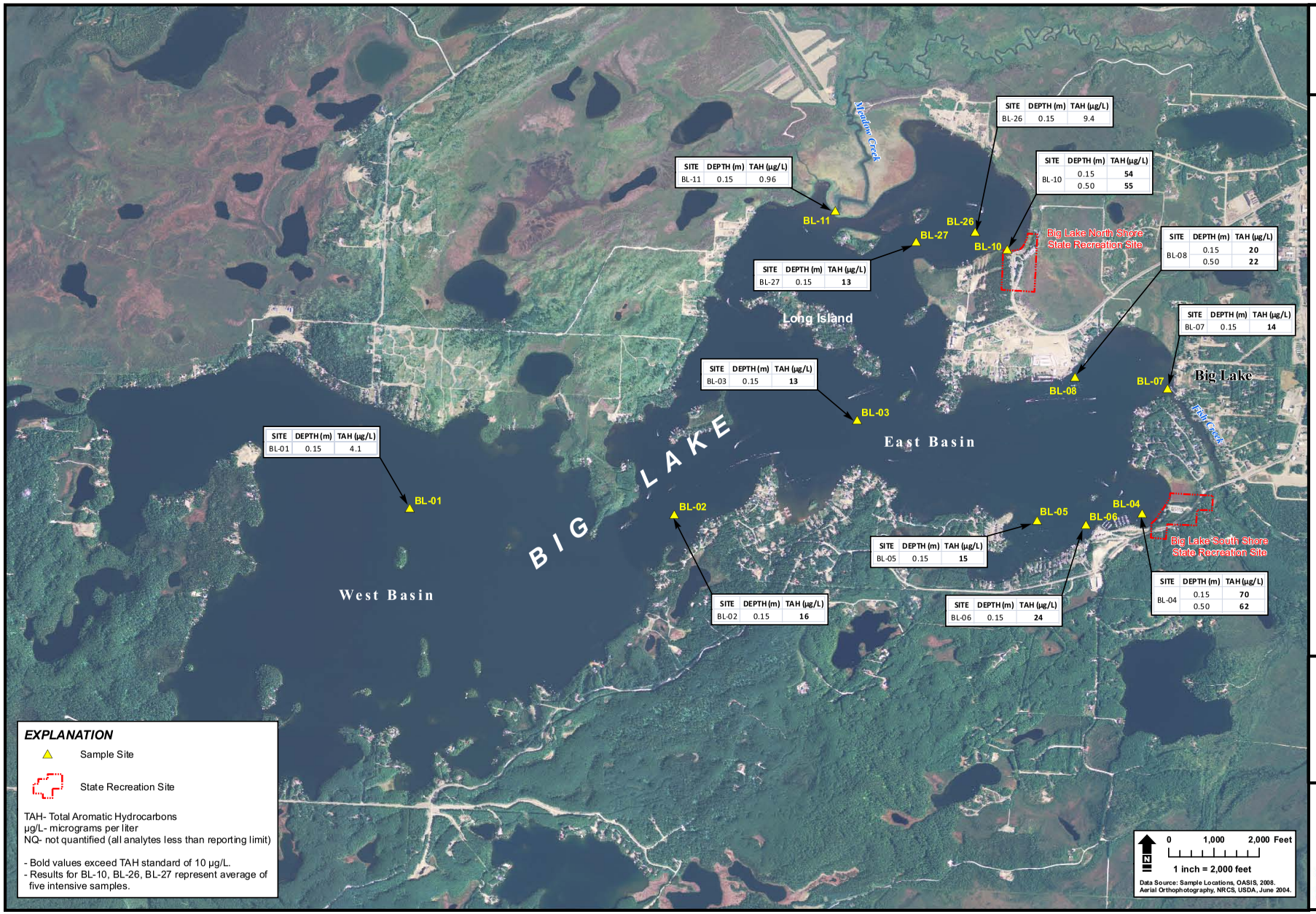

FIGURE 11

TAH RESULTS FOR JULY 5, 2009

ALASKA DEPARTMENT OF ENVIRONMENTAL CONSERVATION
BIG LAKE WATER QUALITY MONITORING
BIG LAKE, ALASKA

DATE: OCT 2009
CHKD: BM
DRWN: CS
PROJ: 14-154

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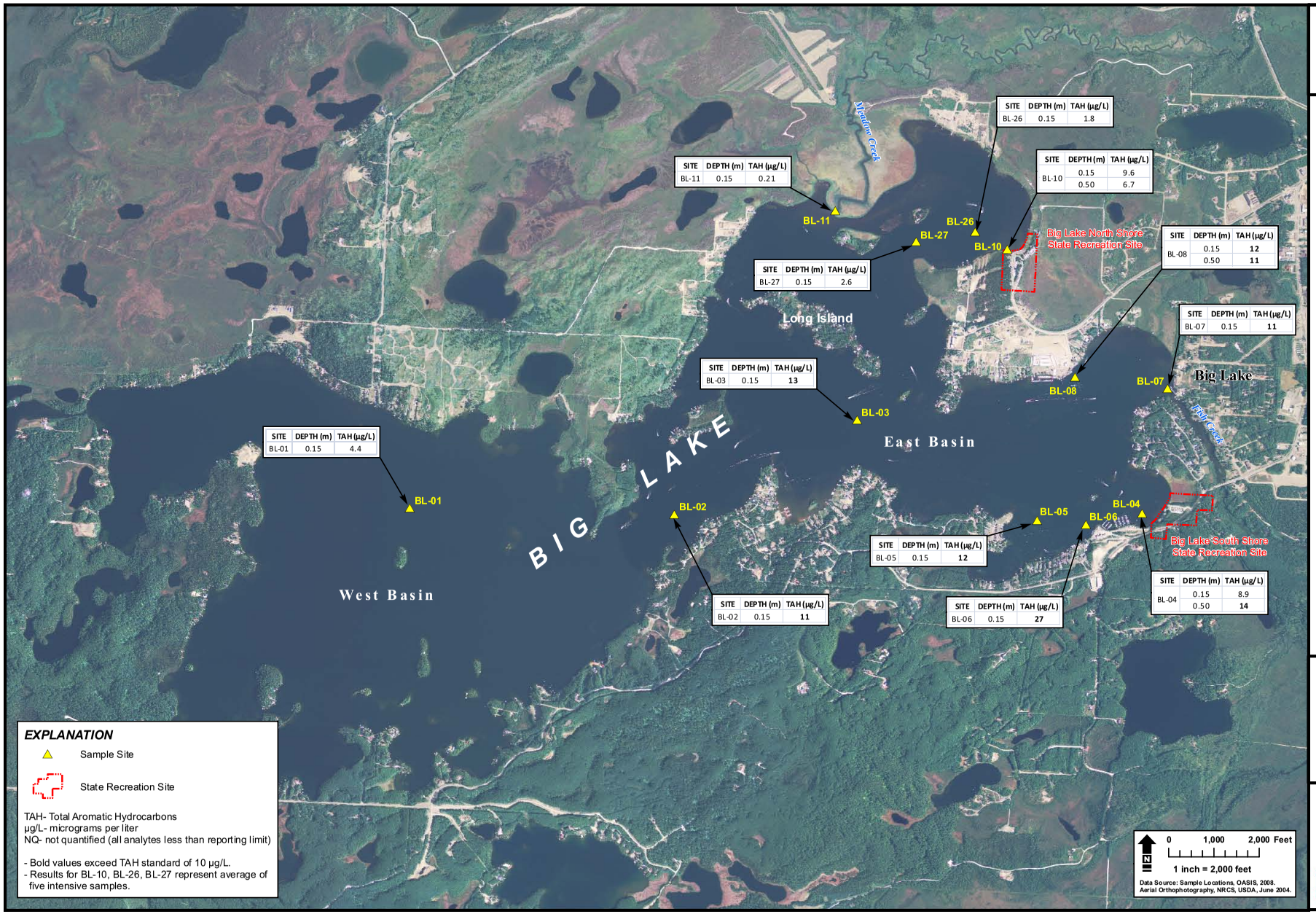

FIGURE 12

TAH RESULTS FOR JULY 6, 2009

ALASKA DEPARTMENT OF ENVIRONMENTAL CONSERVATION
BIG LAKE WATER QUALITY MONITORING
BIG LAKE, ALASKA

DATE: OCT 2009
CHKD: BM
DRWN: CS
PROJ: 14-154

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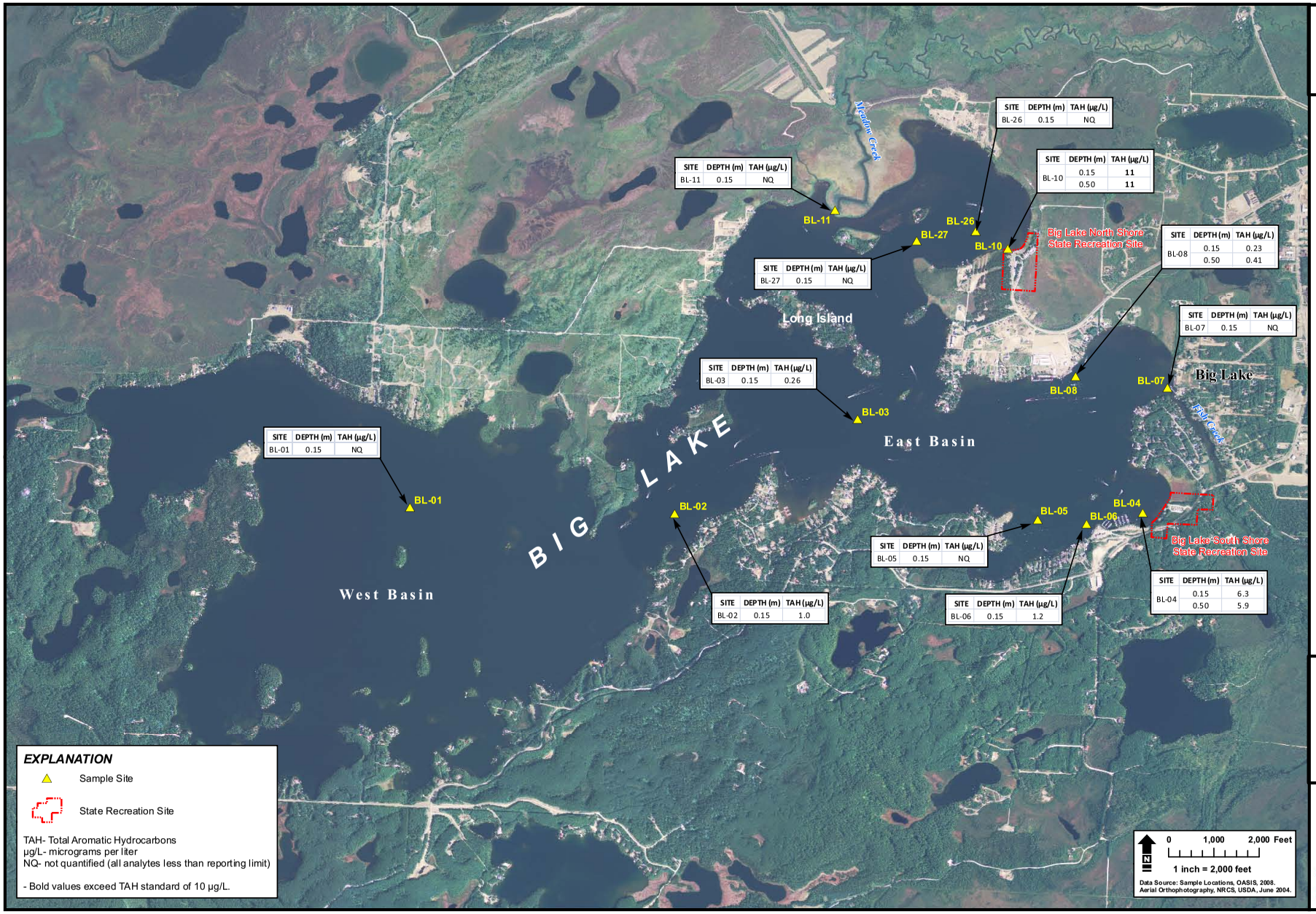

FIGURE 13

TAH RESULTS FOR JULY 25, 2009

ALASKA DEPARTMENT OF ENVIRONMENTAL CONSERVATION
BIG LAKE WATER QUALITY MONITORING
BIG LAKE, ALASKA

DATE: OCT 2009
CHKD: BM
DRWN: CS
PROJ: 14-154

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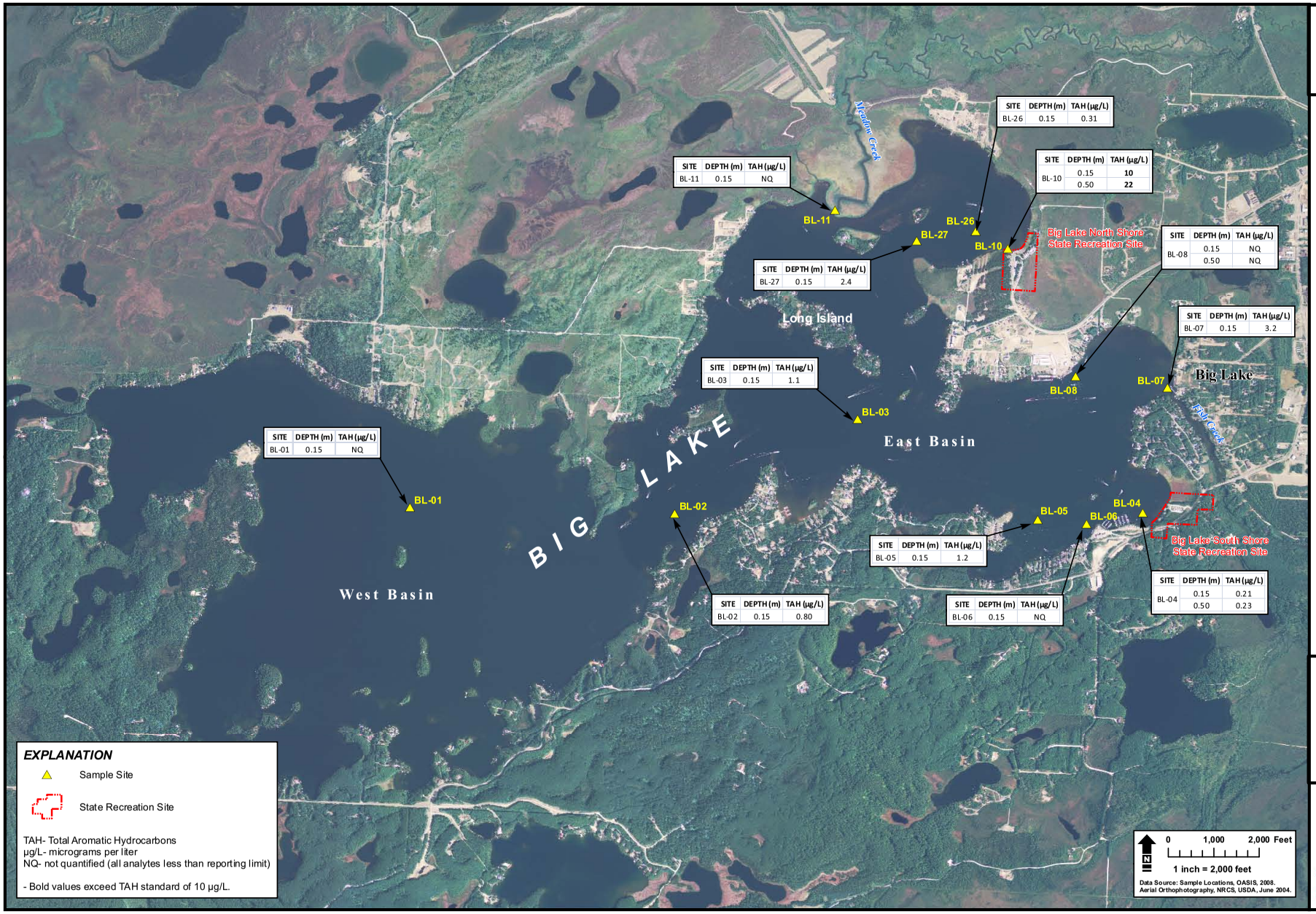

FIGURE 14

TAH RESULTS FOR AUGUST 15, 2009

ALASKA DEPARTMENT OF ENVIRONMENTAL CONSERVATION
BIG LAKE WATER QUALITY MONITORING
BIG LAKE, ALASKA

DATE: OCT 2009
CHKD: BM
DRWN: CS
PROJ: 14-154

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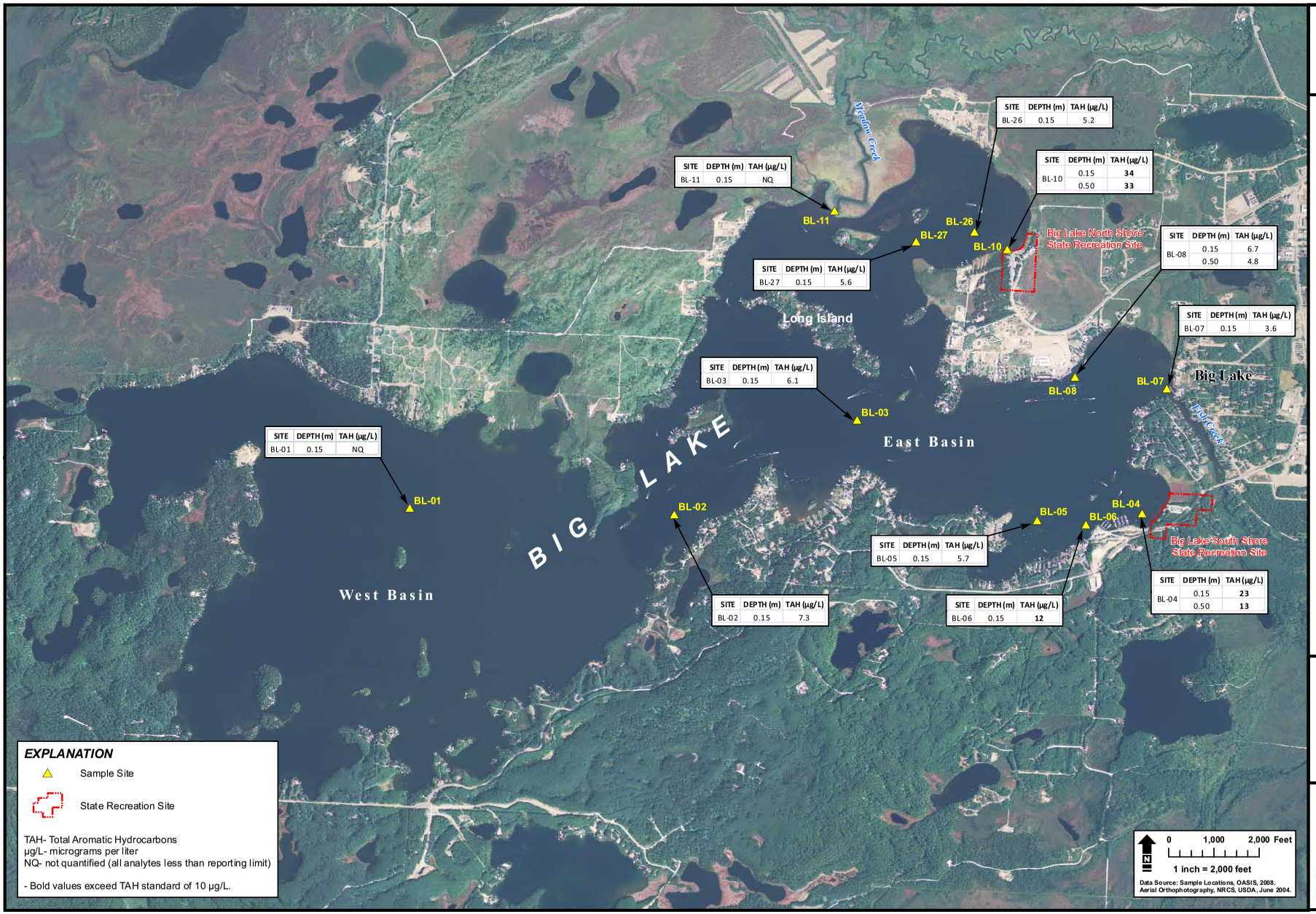

FIGURE 15

TAH RESULTS FOR SEPTEMBER 7, 2009

ALASKA DEPARTMENT OF ENVIRONMENTAL CONSERVATION
BIG LAKE WATER QUALITY MONITORING
BIG LAKE, ALASKA

DATE: OCT 2009
CHKD: BM
DRWN: CS
PROJ: 14-154

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GRAPHS

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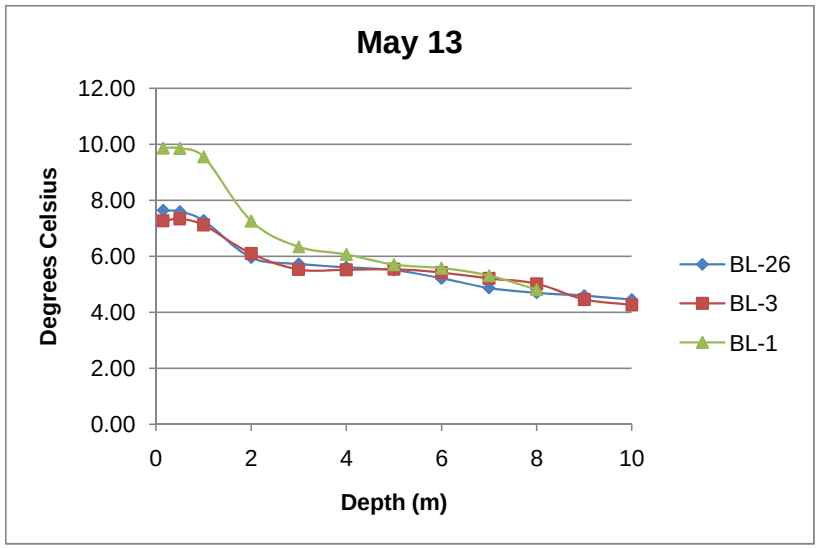
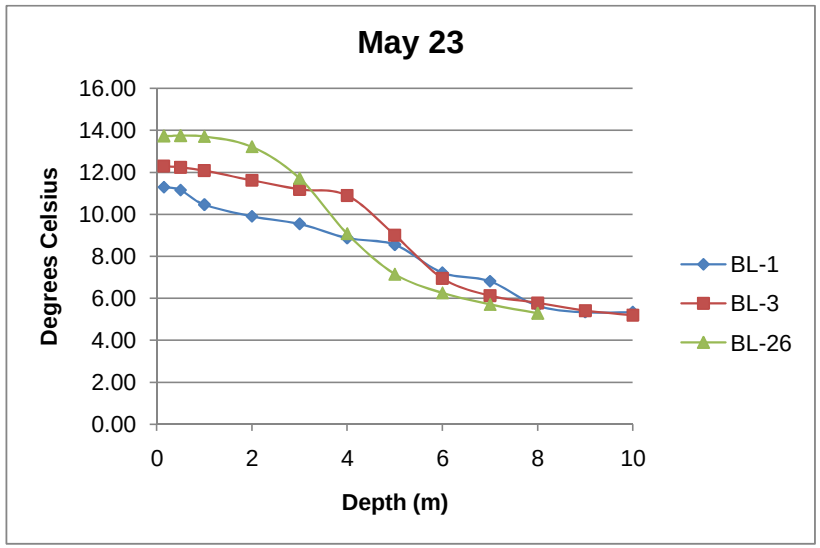
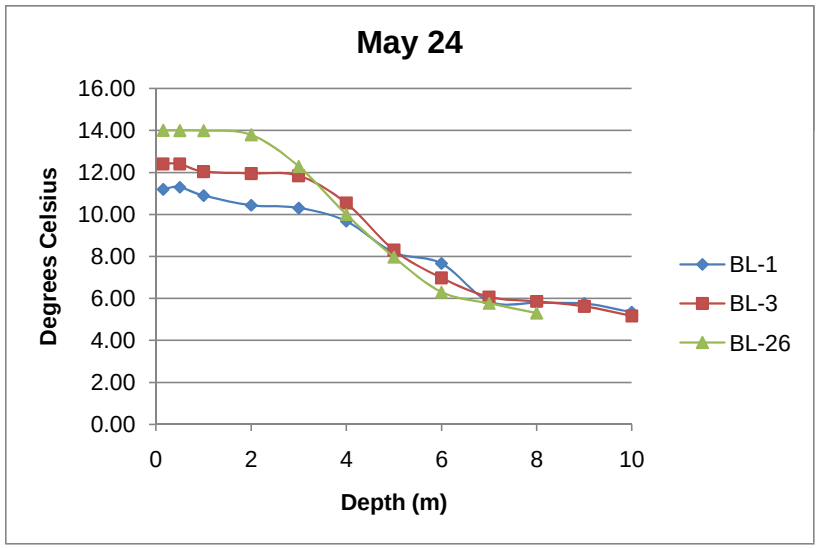
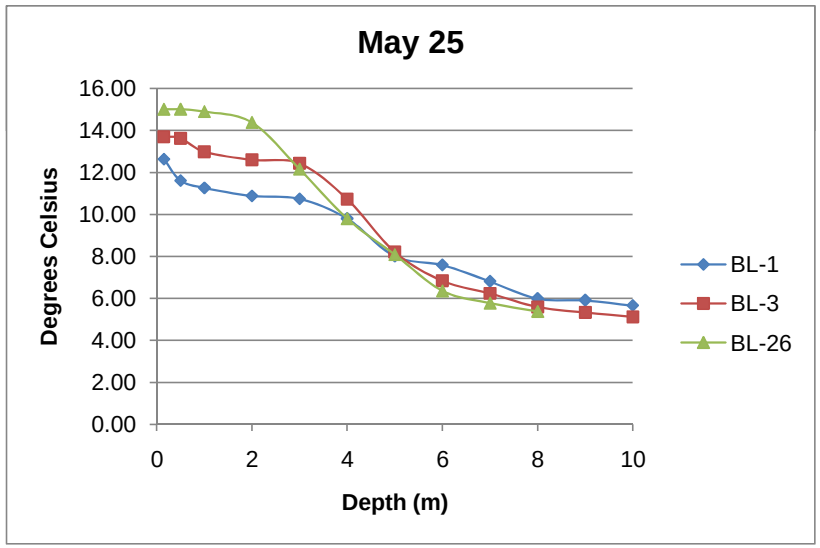
Graph 1
Thermoclines for Sample Sites BL-1, BL-3, and BL-26
Big Lake Water Quality Monitoring

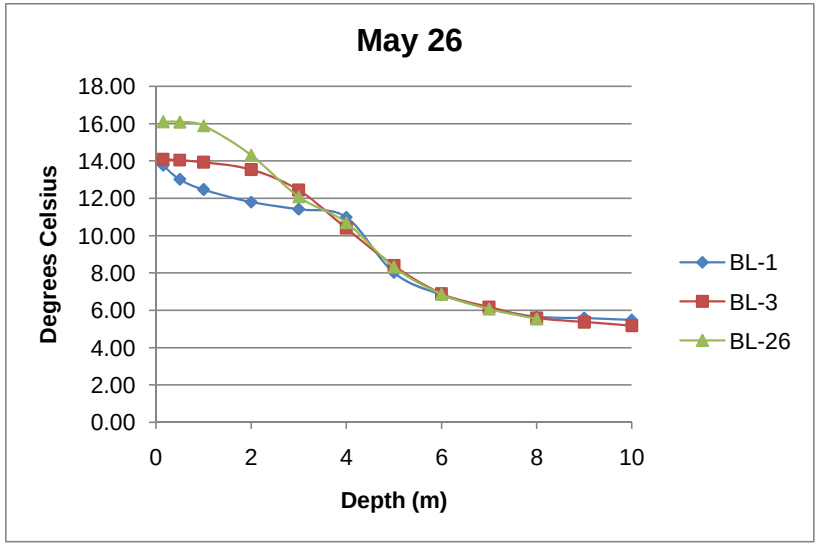


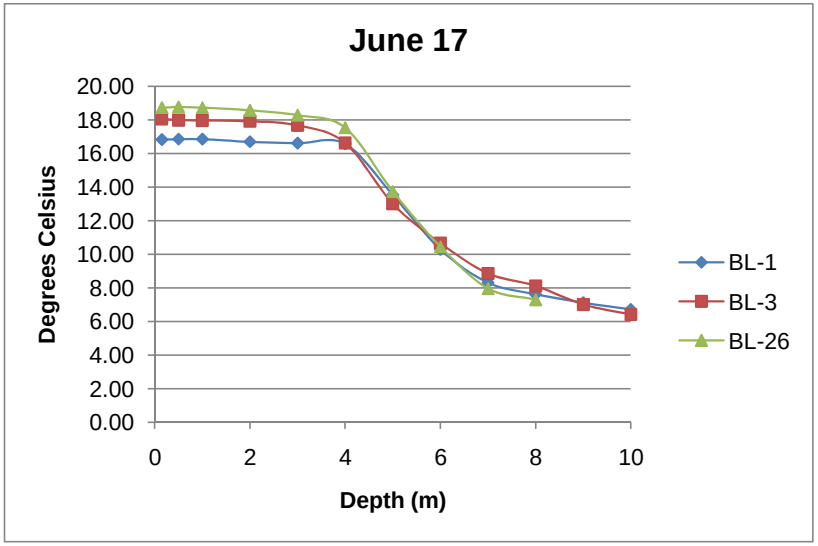


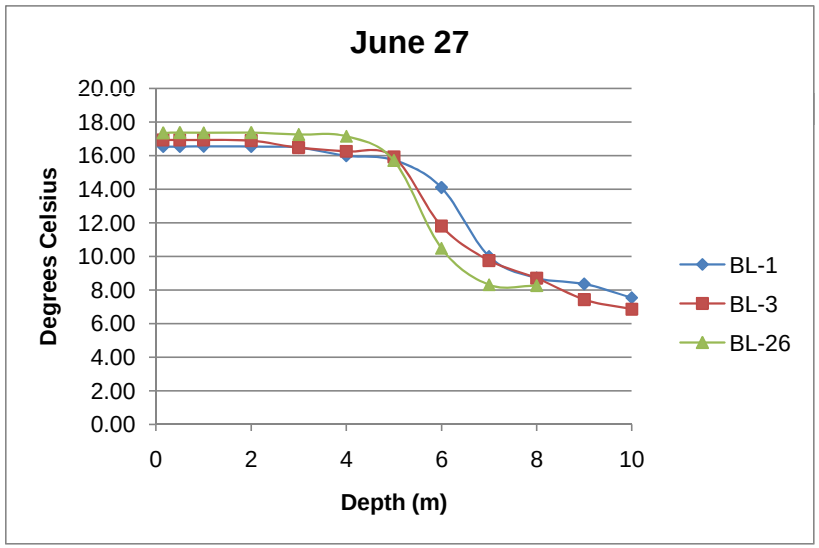


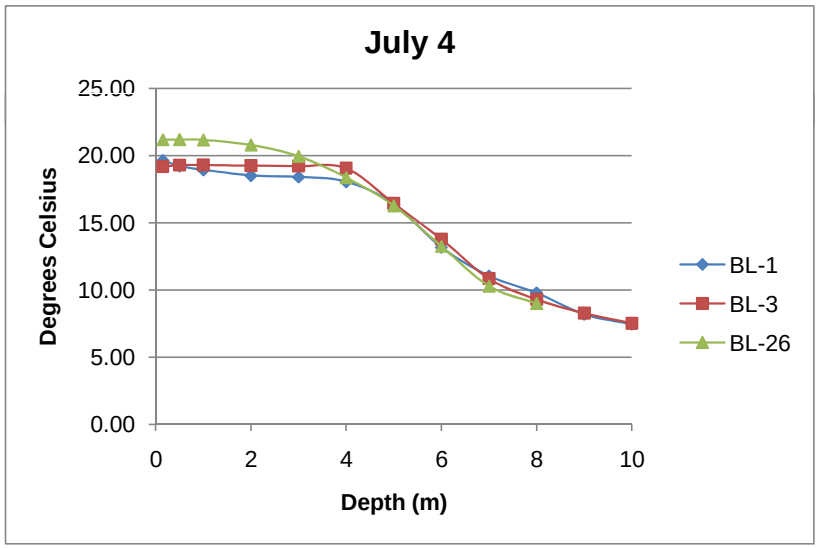


Graph 1
Thermoclines for Sample Sites BL-1, BL-3, and BL-26
Big Lake Water Quality Monitoring

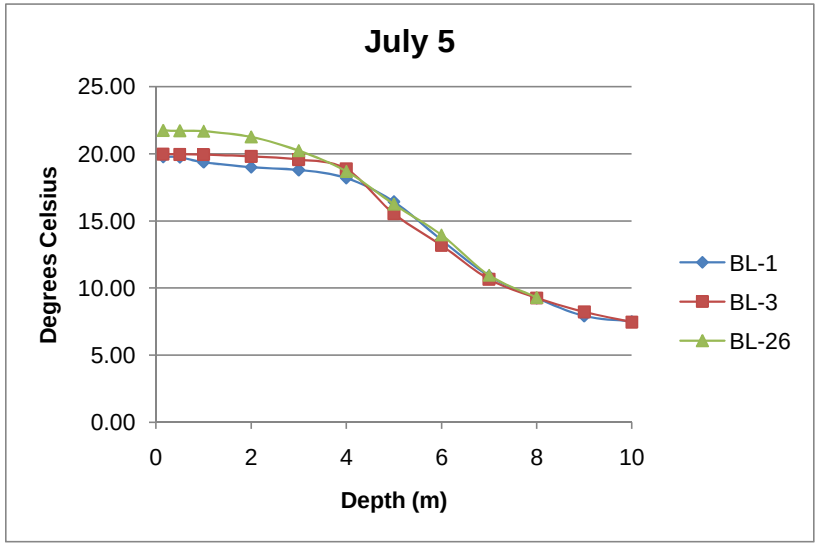


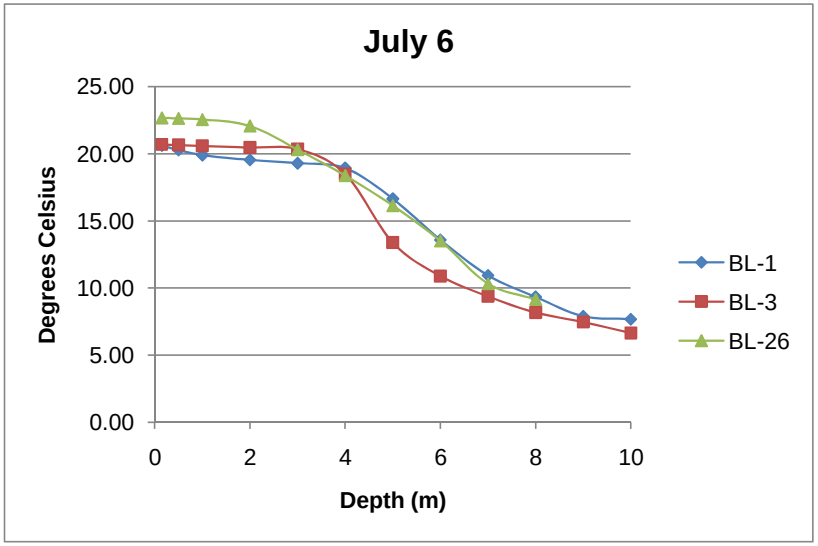


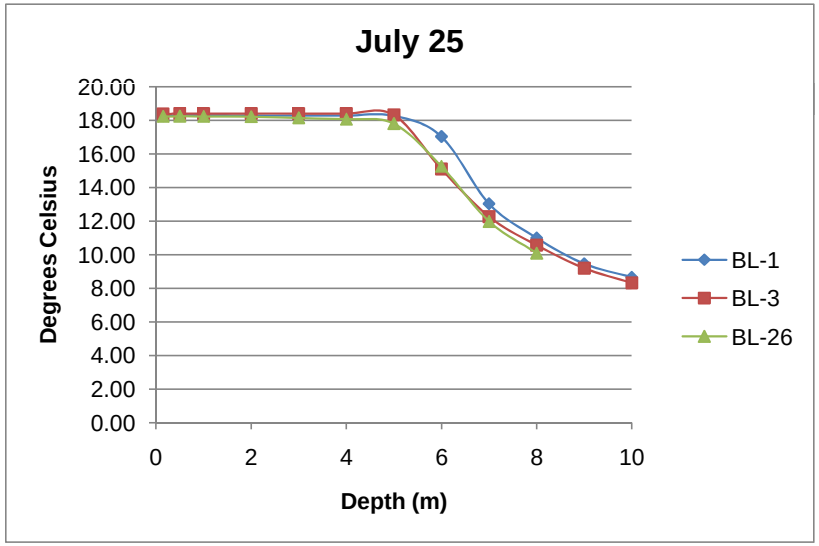


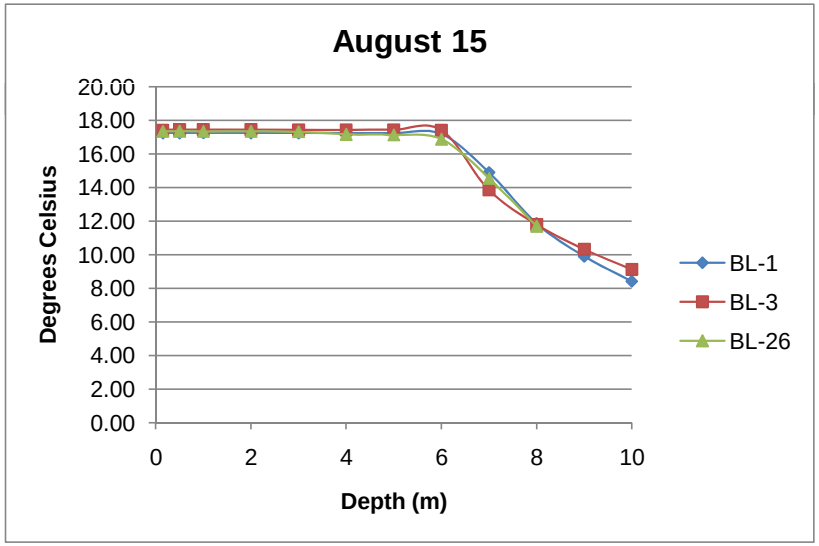


Graph 1
Thermoclines for Sample Sites BL-1, BL-3, and BL-26
Big Lake Water Quality Monitoring

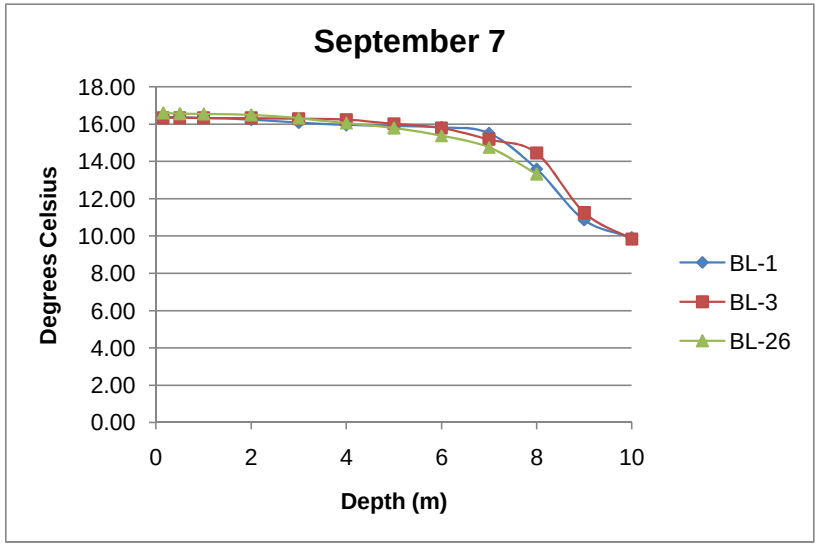


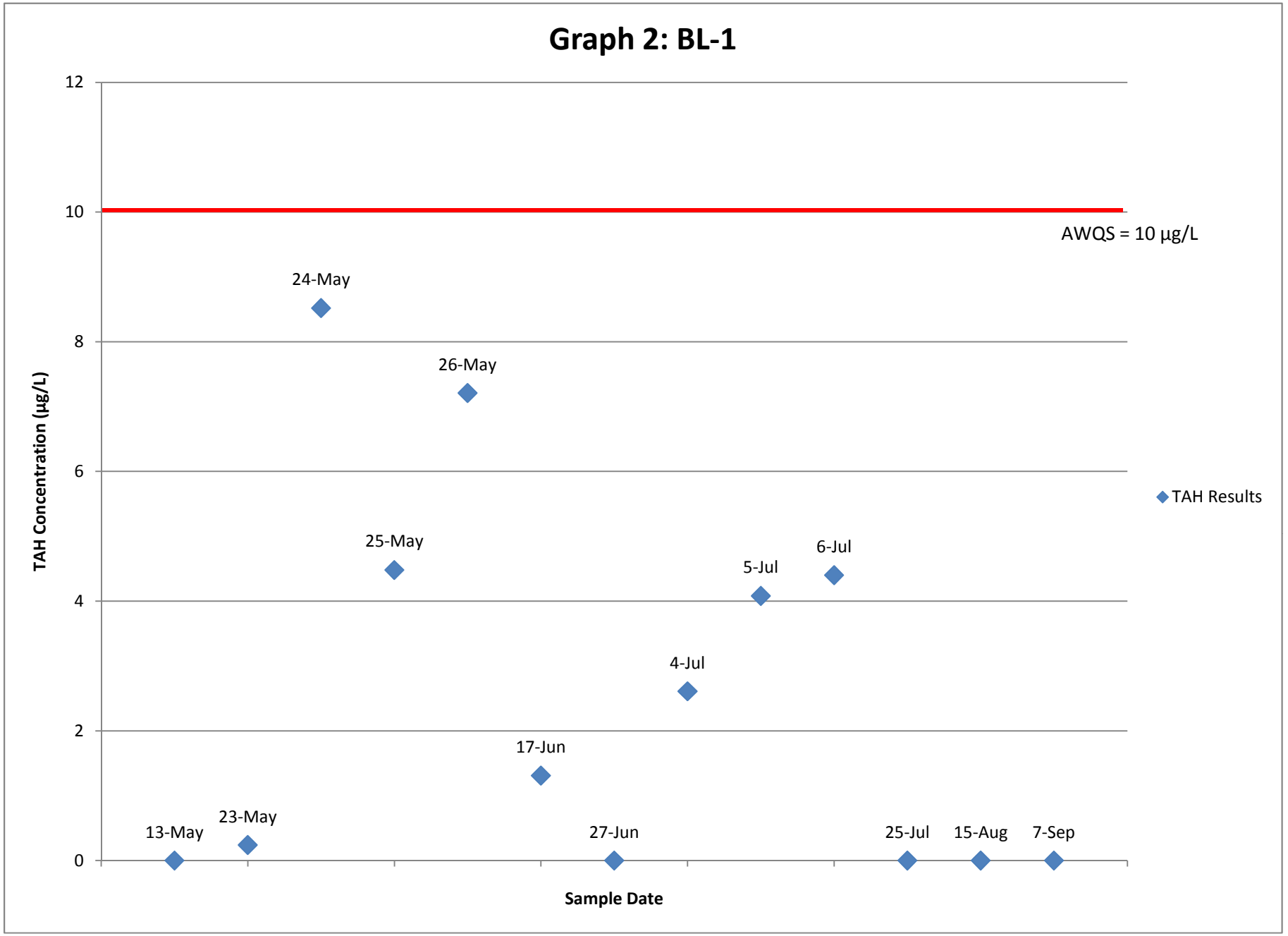


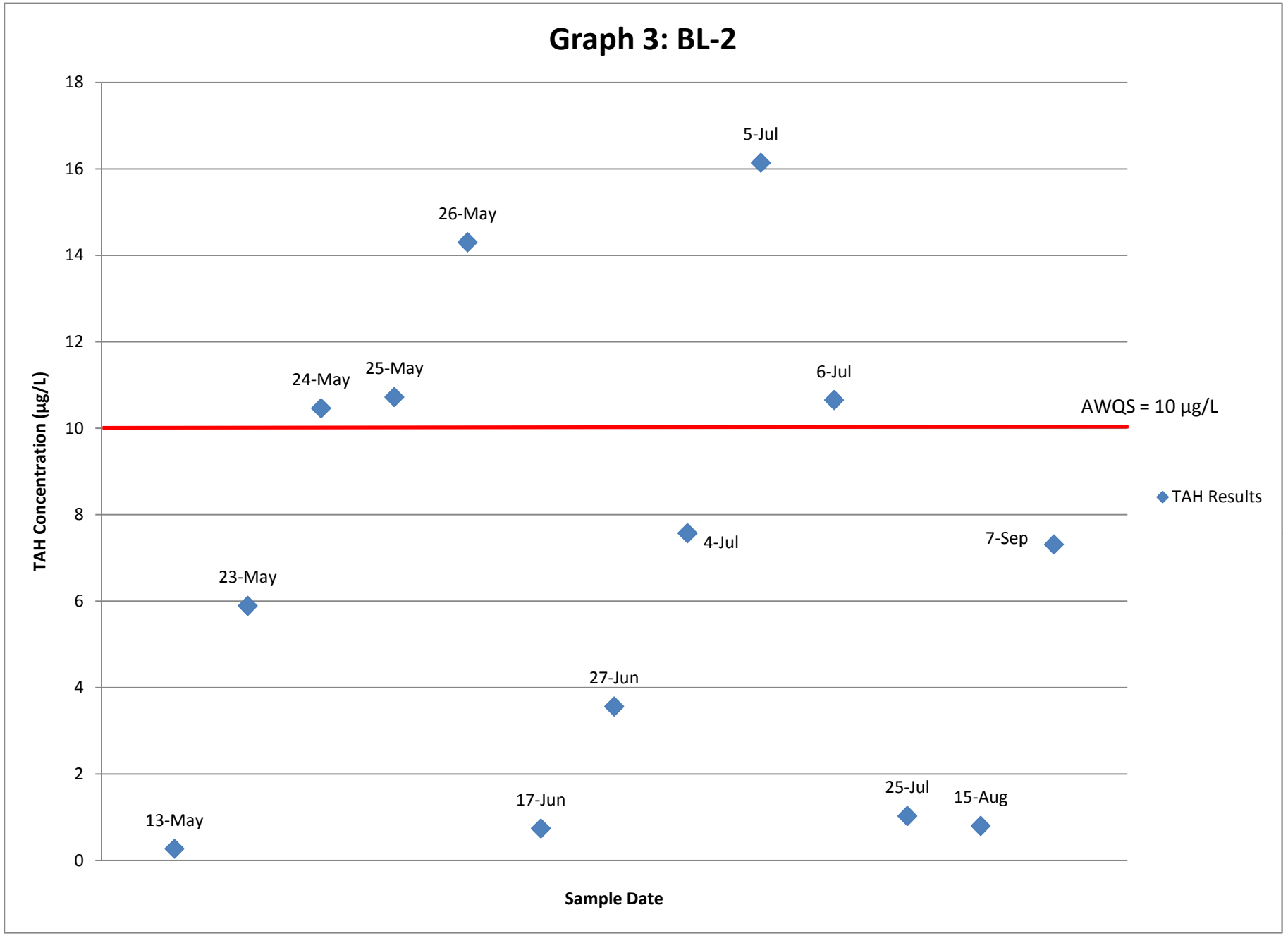


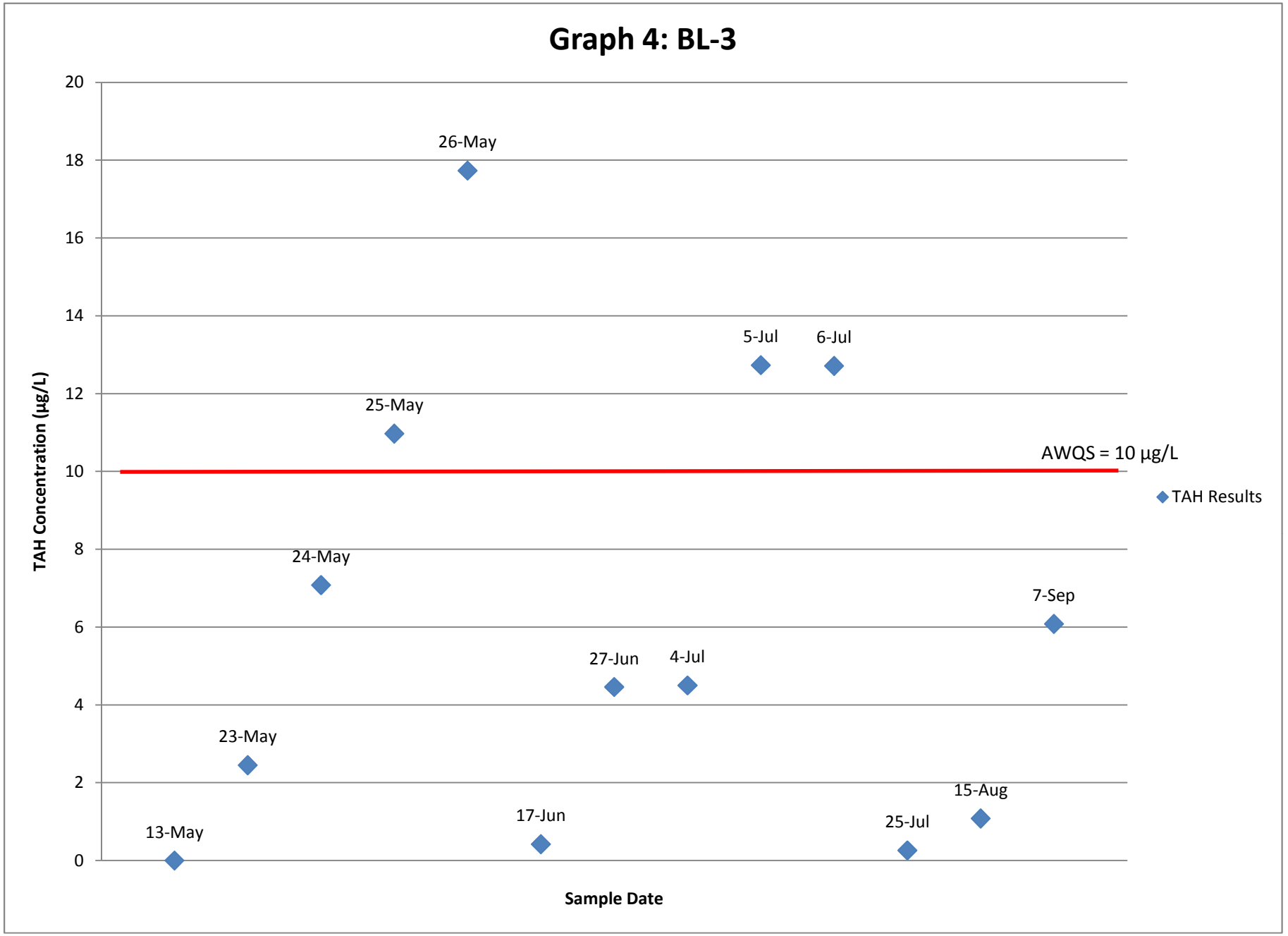


Graph 1
Thermoclines for Sample Sites BL-1, BL-3, and BL-26
Big Lake Water Quality Monitoring

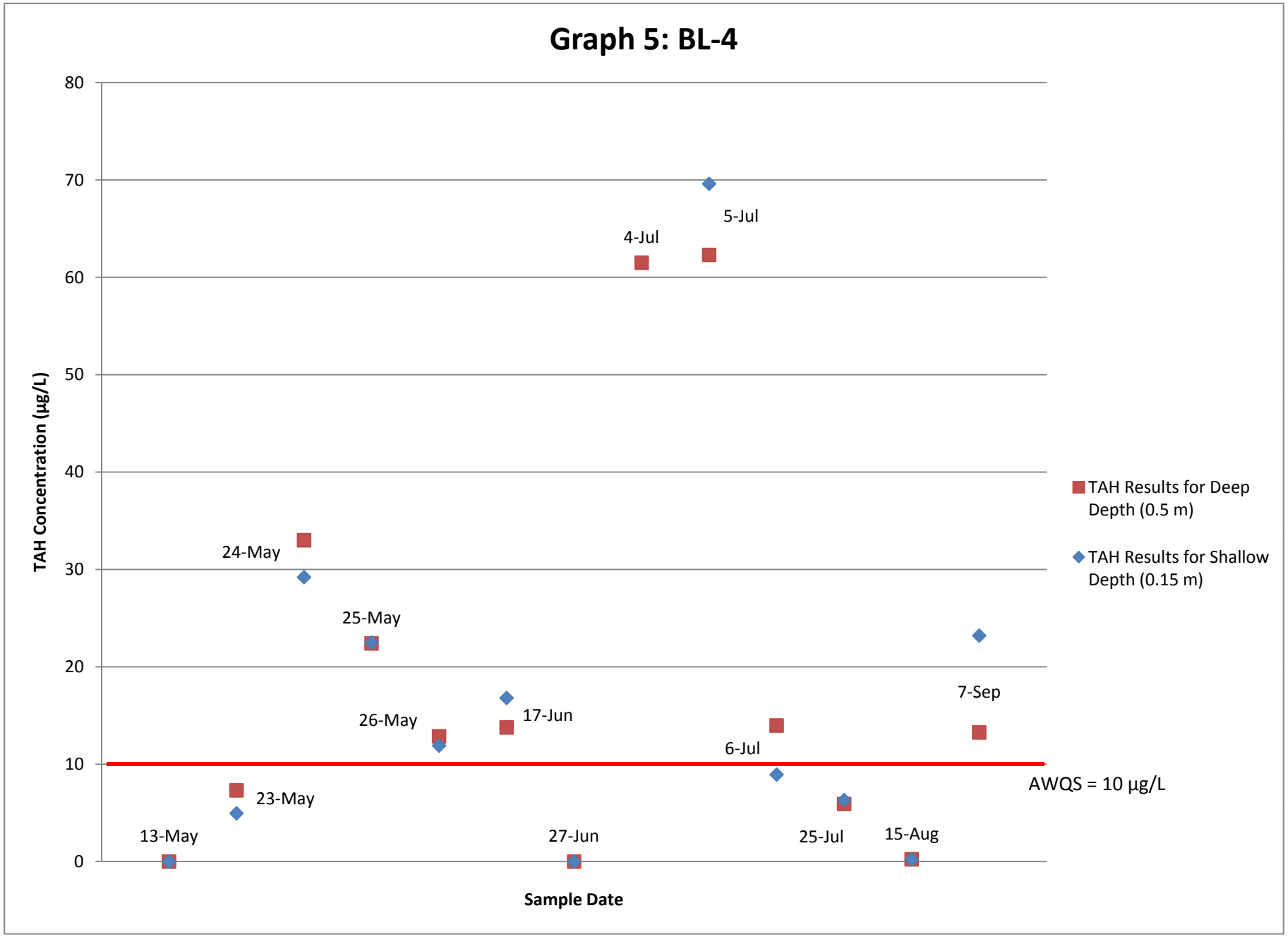


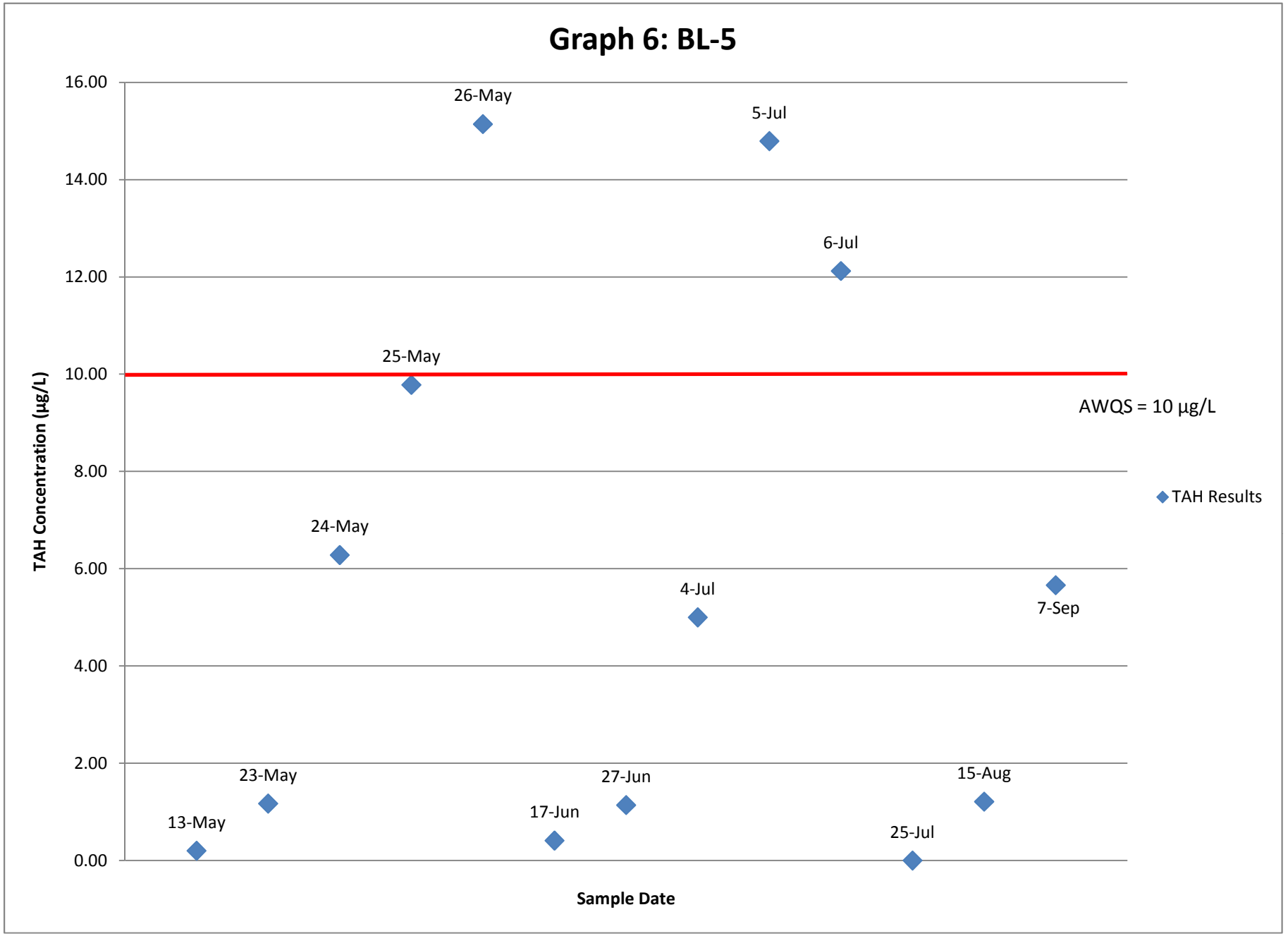

Graph 2: BL-1
12
10
8
6
4
2
0
TAH Concentration (µg/L)
AWQS = 10 µg/L
24-May
26-May
25-May
5-Jul
6-Jul
4-Jul
17-Jun
13-May
23-May
27-Jun
25-Jul
15-Aug
7-Sep
TAH Results
Sample Date

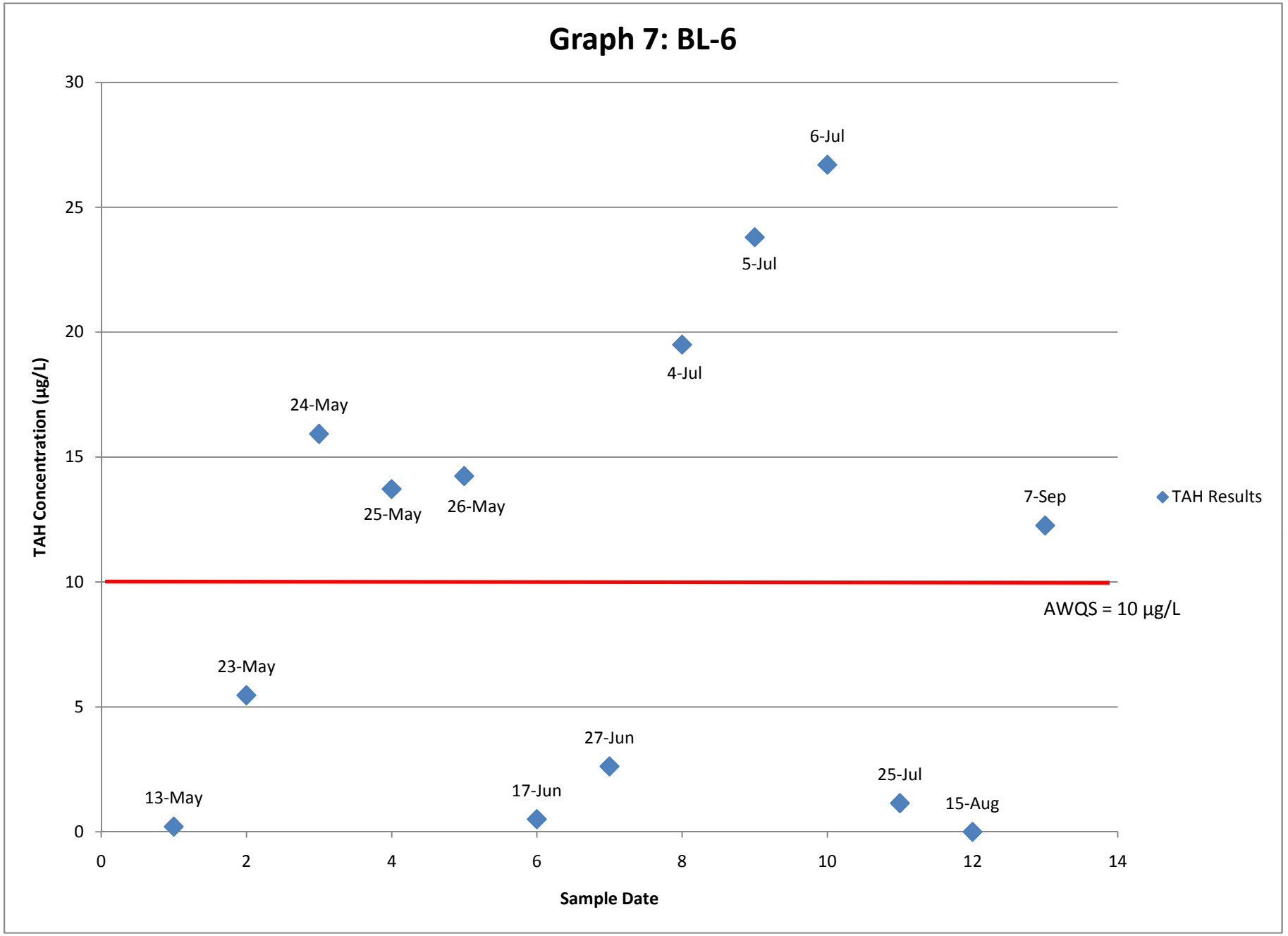

Graph 3: BL-2
18
16
14
12
10
8
6
4
2
0
TAH Concentration (µg/L)
Sample Date
5-Jul
26-May
24-May
25-May
6-Jul
AWQS = 10 µg/L
TAH Results
4-Jul
7-Sep
23-May
27-Jun
13-May
17-Jun
25-Jul
15-Aug

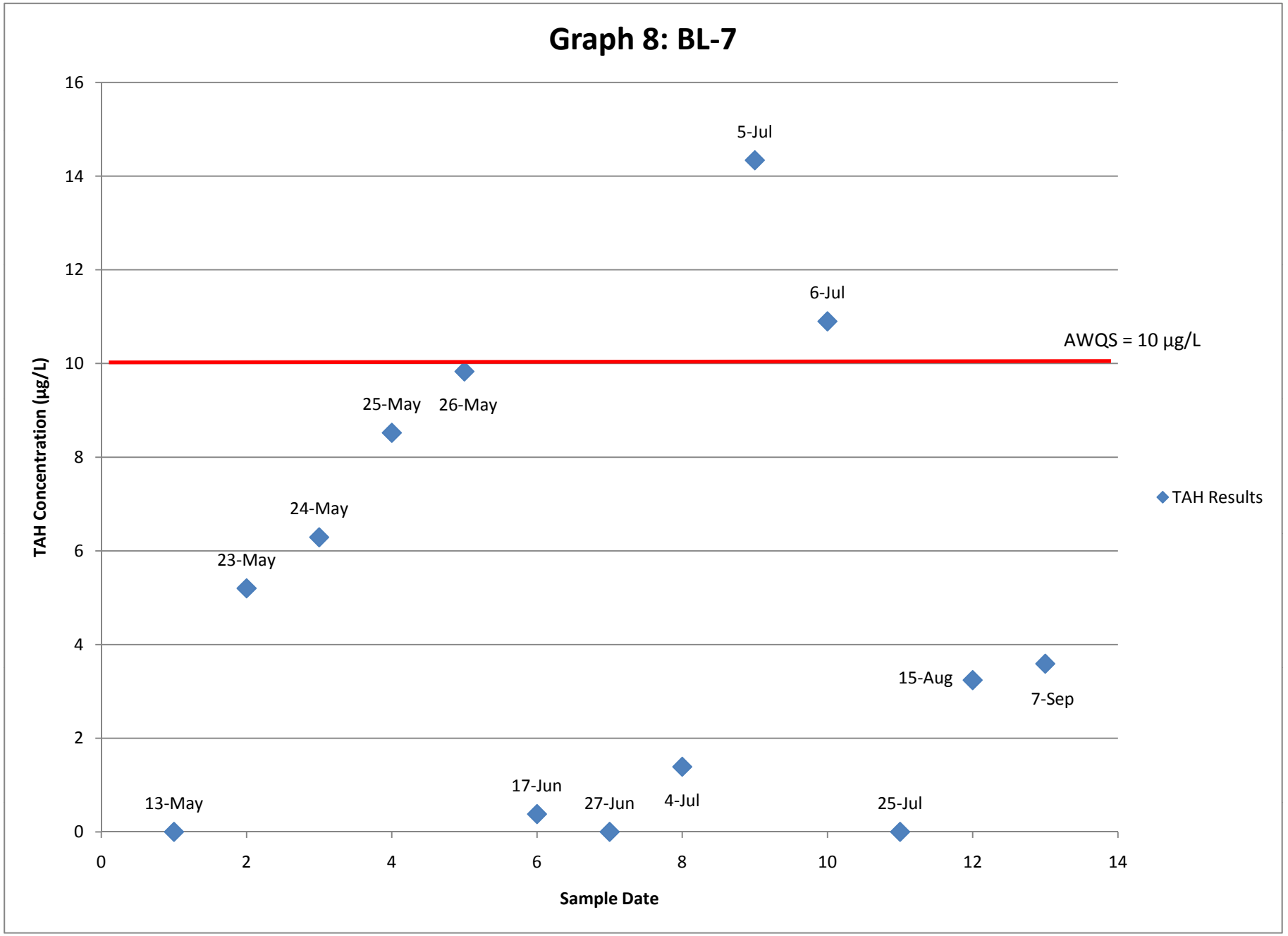

Graph 4: BL-3
TAH Concentration (µg/L)
20
18
16
14
12
10
8
6
4
2
0
26-May
5-Jul
6-Jul
25-May
AWQS = 10 µg/L
TAH Results
24-May
7-Sep
27-Jun
4-Jul
23-May
15-Aug
17-Jun
25-Jul
13-May
Sample Date

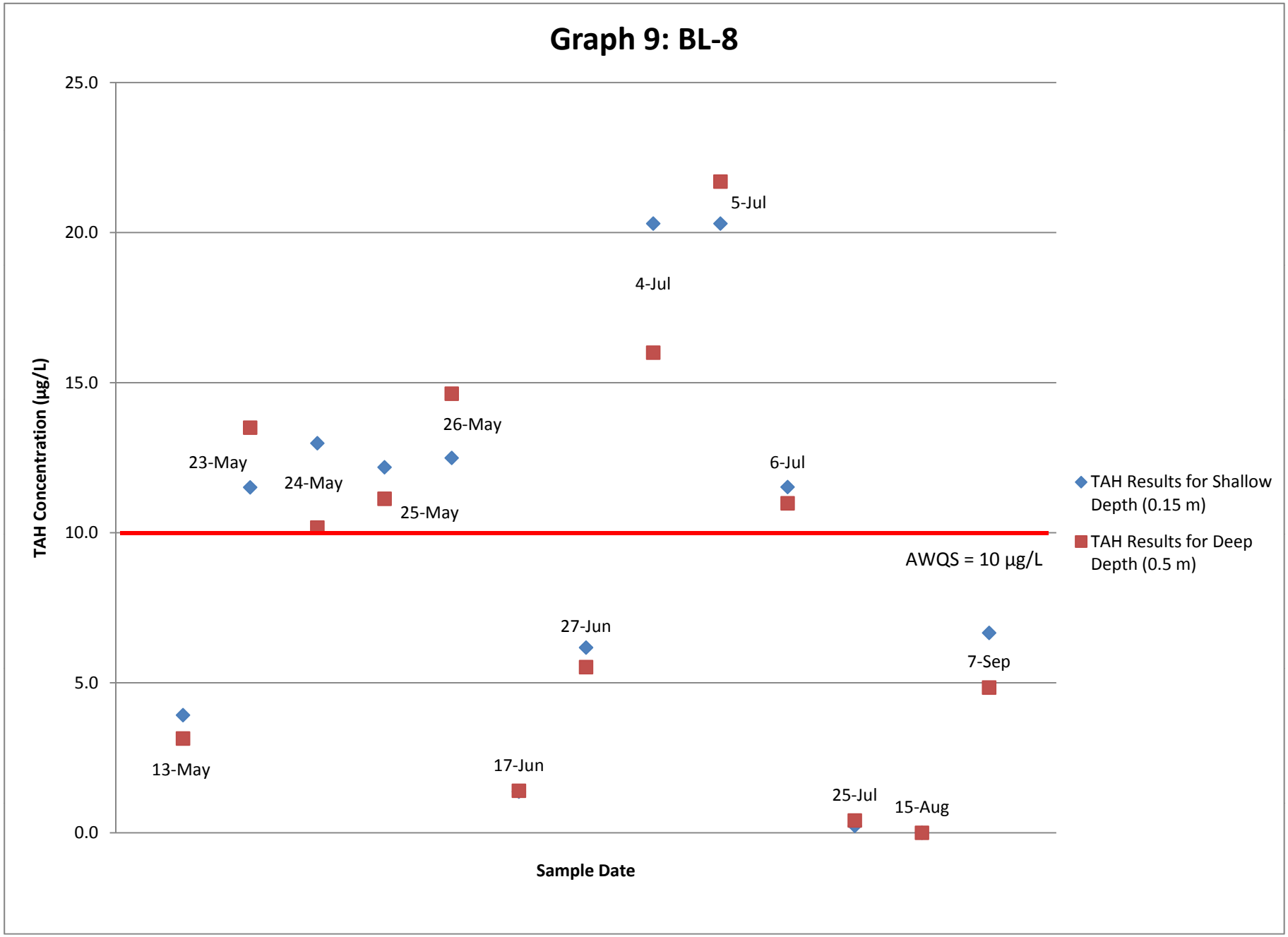
Graph 5: BL-4

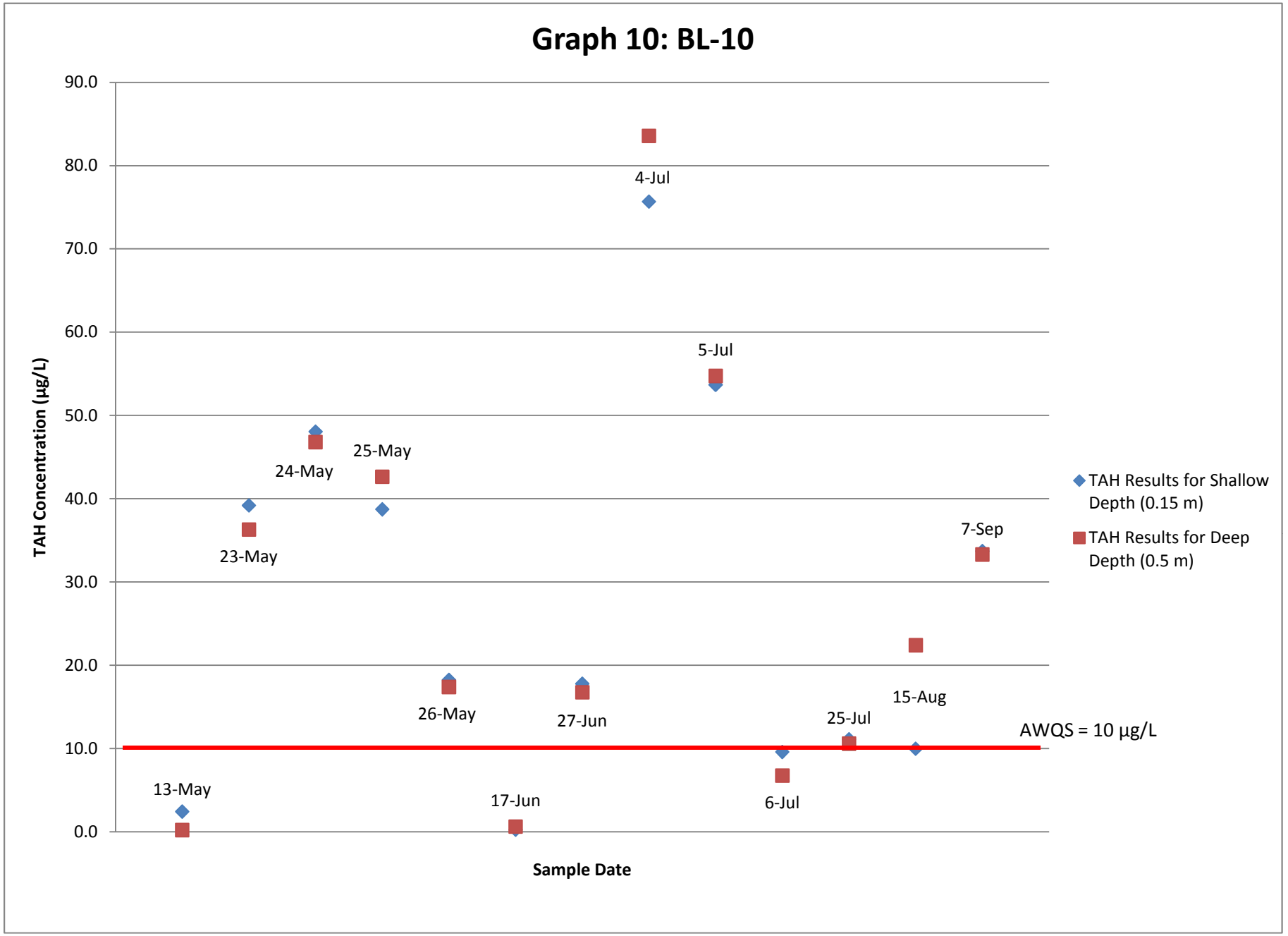

80
70
60
50
40
30
20
10
0
TAH Concentration (µg/L)
Sample Date
13-May
23-May
24-May
25-May
26-May
27-Jun
17-Jun
4-Jul
5-Jul
6-Jul
25-Jul
15-Aug
7-Sep
AWQS = 10 µg/L
TAH Results for Deep Depth (0.5 m)
TAH Results for Shallow Depth (0.15 m)

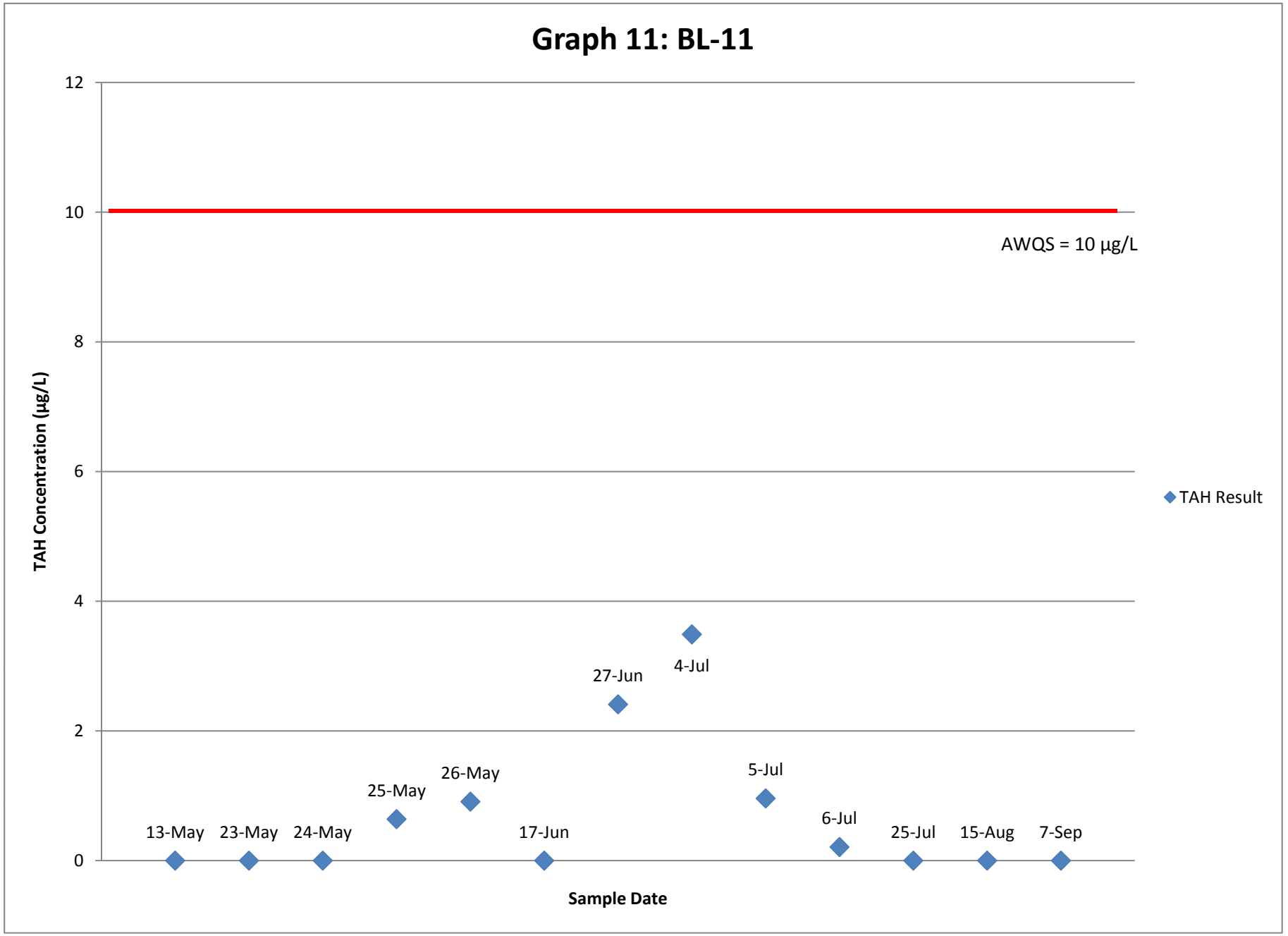

Graph 6: BL-5
16.00
14.00
12.00
10.00
8.00
6.00
4.00
2.00
0.00
TAH Concentration (µg/L)
Sample Date
26-May
5-Jul
6-Jul
25-May
24-May
4-Jul
7-Sep
23-May
27-Jun
15-Aug
13-May
17-Jun
25-Jul
AWQS = 10 µg/L
TAH Results

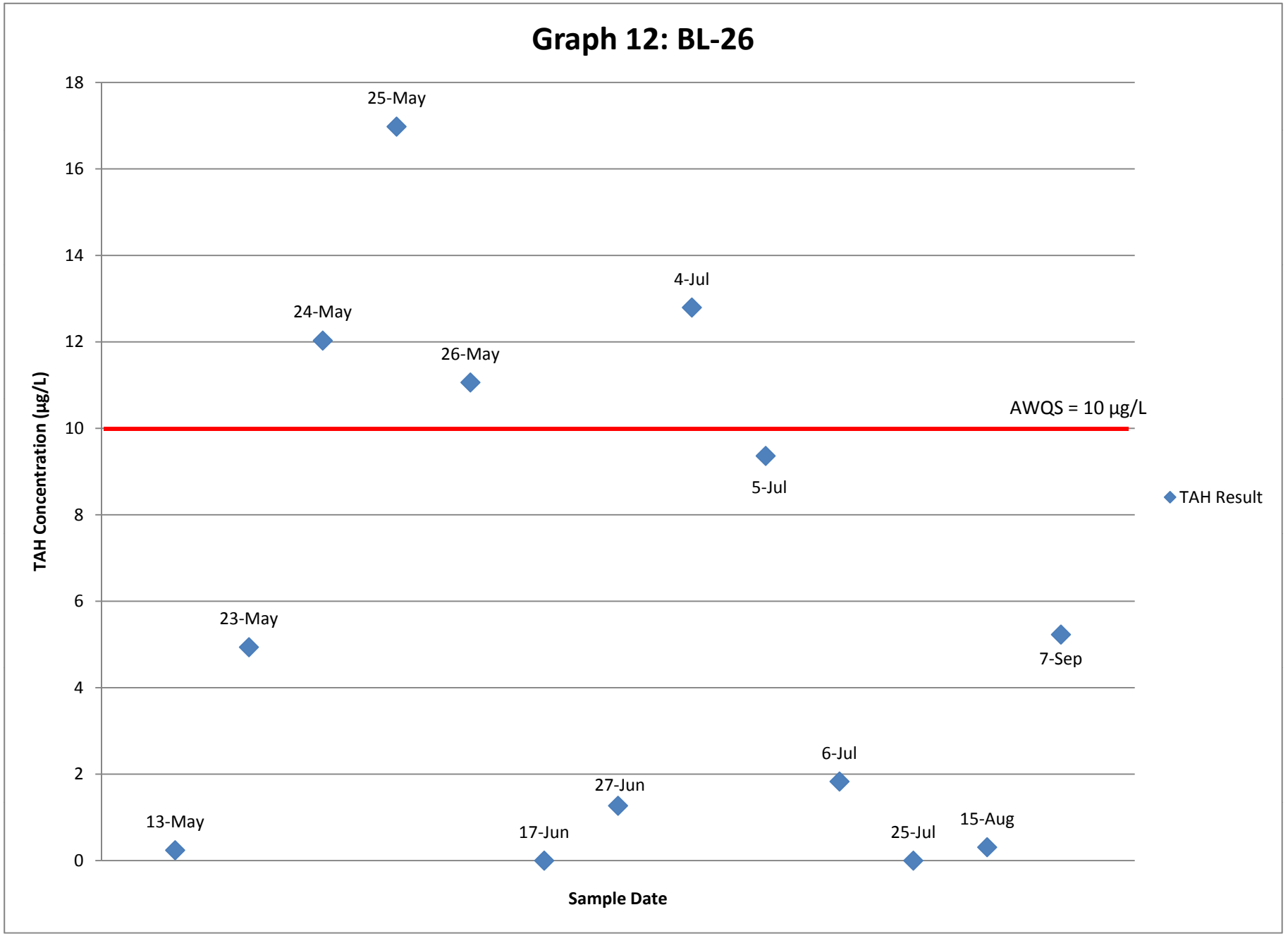

Graph 7: BL-6
TAH Concentration (µg/L)
Sample Date
TAH Results
AWQS = 10 µg/L
6-Jul
5-Jul
4-Jul
24-May
25-May
26-May
7-Sep
23-May
13-May
27-Jun
17-Jun
25-Jul
15-Aug
0
5
10
15
20
25
30
0
2
4
6
8
10
12
14

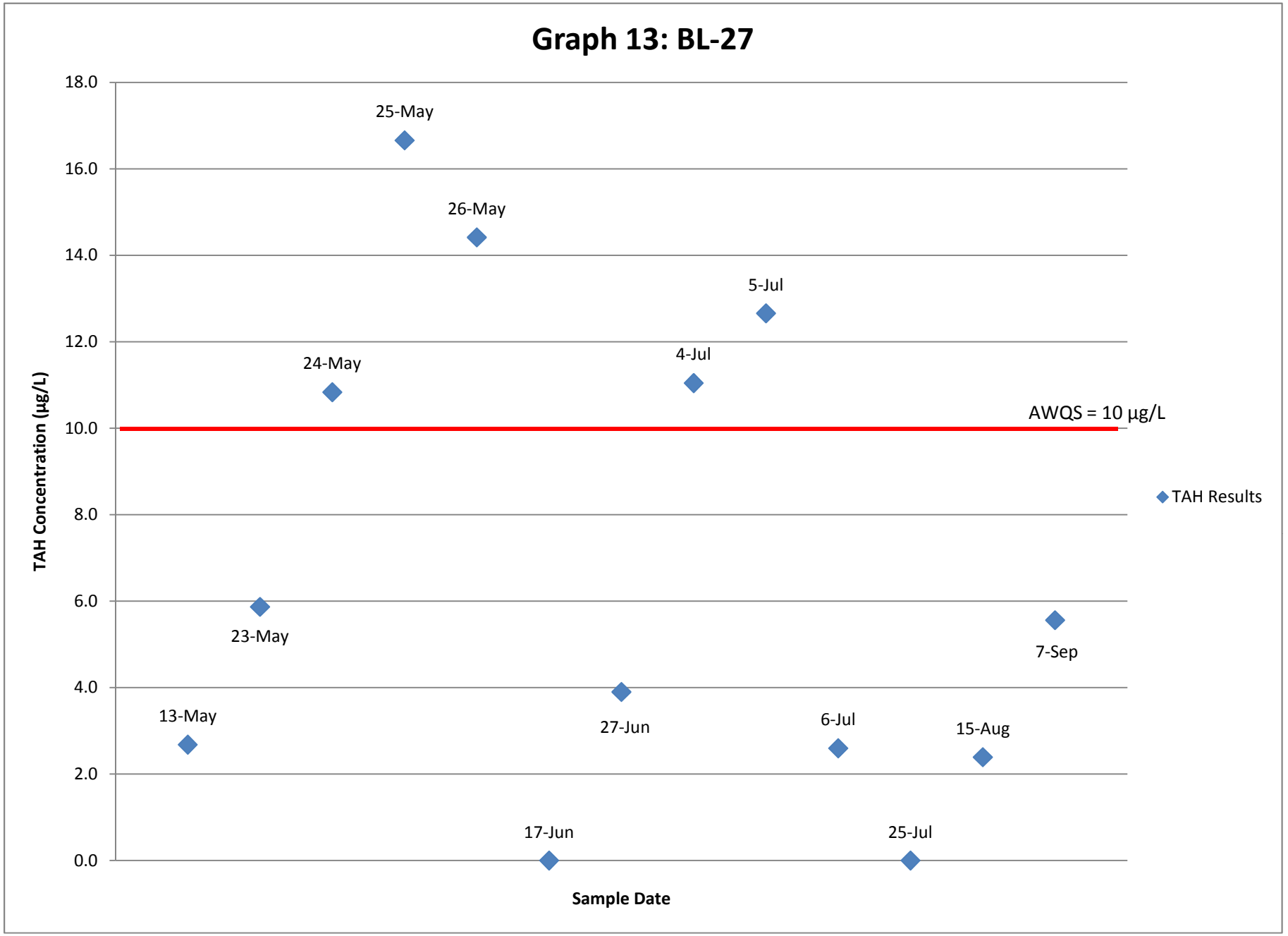

Graph 8: BL-7
TAH Concentration (µg/L)
Sample Date
AWQS = 10 µg/L
TAH Results
5-Jul
6-Jul
25-May
26-May
24-May
23-May
15-Aug
7-Sep
13-May
17-Jun
27-Jun
4-Jul
25-Jul
0
2
4
6
8
10
12
14
16


Graph 9: BL-8
25.0
20.0
15.0
10.0
5.0
0.0
TAH Concentration (µg/L)
Sample Date
AWQS = 10 µg/L
13-May
23-May
24-May
25-May
26-May
27-Jun
17-Jun
4-Jul
5-Jul
6-Jul
25-Jul
15-Aug
7-Sep
TAH Results for Shallow Depth (0.15 m)
TAH Results for Deep Depth (0.5 m)

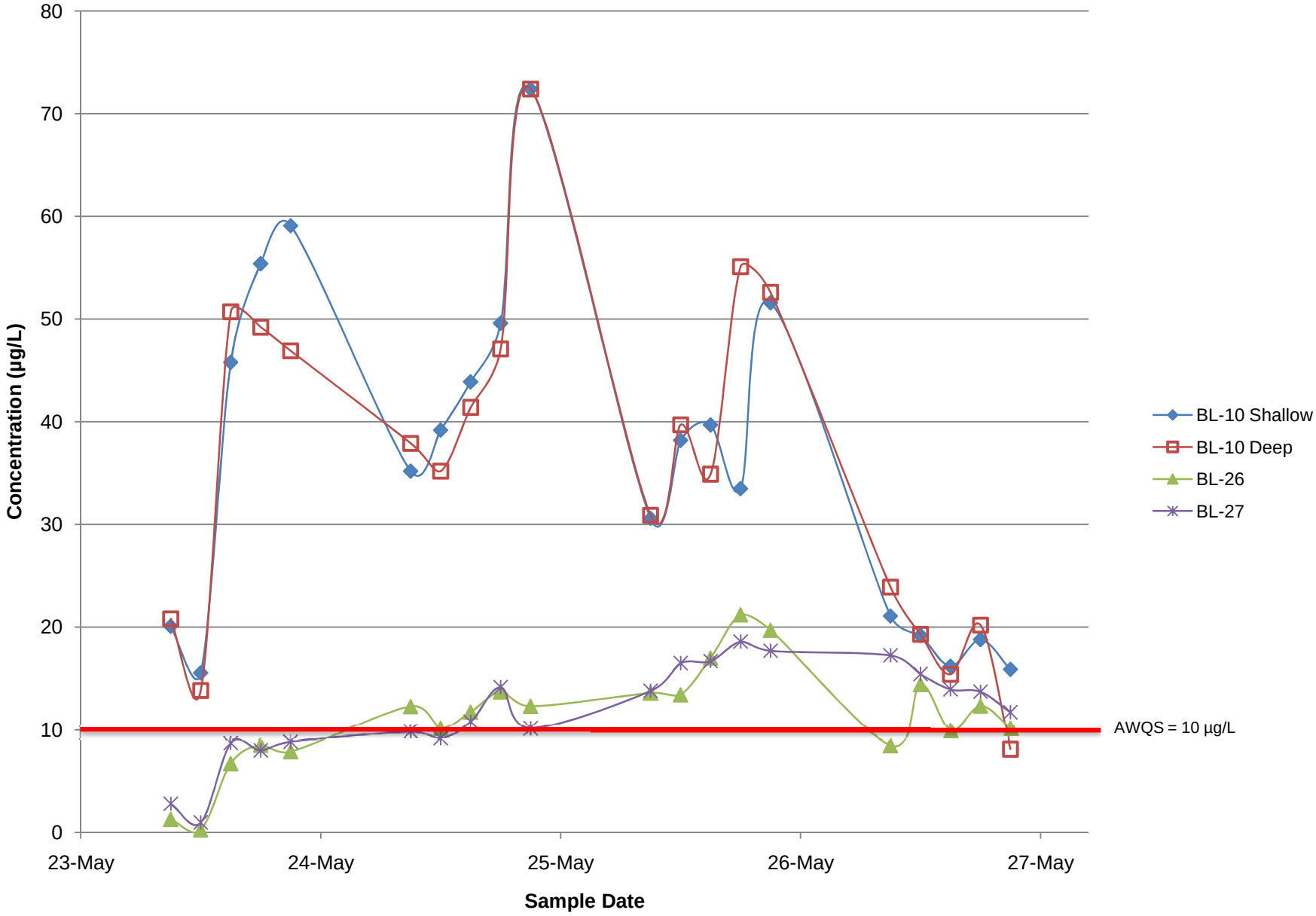

Graph 10: BL-10
90.0
80.0
70.0
60.0
50.0
40.0
30.0
20.0
10.0
0.0
TAH Concentration (µg/L)
Sample Date
13-May
23-May
24-May
25-May
26-May
17-Jun
27-Jun
4-Jul
5-Jul
6-Jul
25-Jul
15-Aug
7-Sep
AWQS = 10 µg/L
TAH Results for Shallow Depth (0.15 m)
TAH Results for Deep Depth (0.5 m)


Graph 11: BL-11
12
10
8
6
4
2
0
TAH Concentration (µg/L)
AWQS = 10 µg/L
TAH Result
13-May
23-May
24-May
25-May
26-May
17-Jun
27-Jun
4-Jul
5-Jul
6-Jul
25-Jul
15-Aug
7-Sep
Sample Date


Graph 12: BL-26
18
16
14
12
10
8
6
4
2
0
TAH Concentration (µg/L)
25-May
4-Jul
24-May
26-May
AWQS = 10 µg/L
5-Jul
TAH Result
23-May
7-Sep
6-Jul
27-Jun
13-May
17-Jun
25-Jul
15-Aug
Sample Date


Graph 13: BL-27
18.0
16.0
14.0
12.0
10.0
8.0
6.0
4.0
2.0
0.0
TAH Concentration (µg/L)
25-May
26-May
5-Jul
24-May
4-Jul
AWQS = 10 µg/L
TAH Results
23-May
7-Sep
13-May
27-Jun
6-Jul
15-Aug
17-Jun
25-Jul
Sample Date

Graph 14: TAH Concentrations for Intensive Samples on Memorial Day Weekend



Graph 15: TAH Concentrations for Intensive Samples on Independence Day Weekend