# Fireworks Pollutant Detection
# Pilot Study

# Lake Shoecraft and Mongo Pond

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## Background

Snohomish County Surface Water Management (SWM) is required by its' Phase 1 Municipal Stormwater Permit to maintain a water quality complaint response program. In the summers of 2007 and 2008, shortly after July 4th, citizens living near Lake Shoecraft reported concerns for water quality due to the discharge of fireworks over and into the lake.

Staff of SWM responded to the concern in 2008 through development of a comprehensive strategy. The strategy included conducting research to determine the pollutants associated with fireworks waste, development of public outreach message, coordination with the Snohomish County Fire Marshalls Office, and development and implementation of a water quality sampling strategy for Lake Shoecraft and Mongo Pond during the summers of 2008 and 2009.

A public outreach message regarding impacts from fireworks waste on surface waters was developed in 2008 in coordination with the Fire Marshall's Office, posted on the County website and incorporated into the fireworks display instruction guide (Appendix A).

Considering the dilution of pollutants in Lake Shoecraft, timing of complaint and storm events, SWM determined that sampling in 2008 should take place in an urban environment where discharge from the storm drainage system led to a smaller body of water. The result was a July 29th, 2008 sampling effort in Mongo Pond, a detention system and the headwaters of Little Bear Creek. The objective was to identify if perchlorate salts and heavy metals associated with fireworks waste could be detected after July 4th. Results of the 2008 sampling effort in Mongo Pond led SWM to conduct additional sampling of Lake Shoecraft and Mongo pond in 2009.

This report summarizes coordination, sampling and analysis efforts in 2008 – 2009, and provides recommendations for further action.

## Introduction

Recent attention has been paid to the impact of fireworks displays on surface and ground water quality. Wilkin et. al. (2007) found that perchlorate concentrations in Lake Wintersmith, Oklahoma showed significant variations, centered around the timing of fireworks displays.

Perchlorate is a man made chemical, but is also naturally occurring. It is commonly used as a rocket propellant. The majority of sites where perchlorate has been detected in soils and ground water are associated with the manufacturing and testing of solid rocket fuel by the Department of Defense (EPA 2005). Perchlorate salts of potassium and ammonia are the primary oxidants in pyrotechnics mixtures. Perchlorate salts are highly soluble in water and not easily degraded, posing a threat to ecological systems.

In 2007, the Massachusetts Department of Environmental Protection (MADEP) released a multi-year study that linked areas that had hosted annual fireworks displays to perchlorate contaminated public wells. The study and others led Massachusetts to development of the nation's only drinking water standard for perchlorate, set at 2 parts per billion.

Heavy metals such as aluminum, barium, cobalt, copper, magnesium, potassium, strontium and zinc, to name a few, are employed to produce the brilliant colors and flash associated with pyrotechnics displays. Firework displays can result in discharges of heavy metals to our air, soil and waterbodies.

Beginning in 2008, SWM began implementation of a strategy to identify levels of heavy metals and perchlorate in surface waters pre vs. post July 4$^{th}$ celebrations. Areas chosen for study included Lake Shoecraft and Mongo Pond. Data are used to educate the public about the impacts that fireworks displays have on surface waters, and best management practices they may employ to reduce polluted discharges.

## Study Design

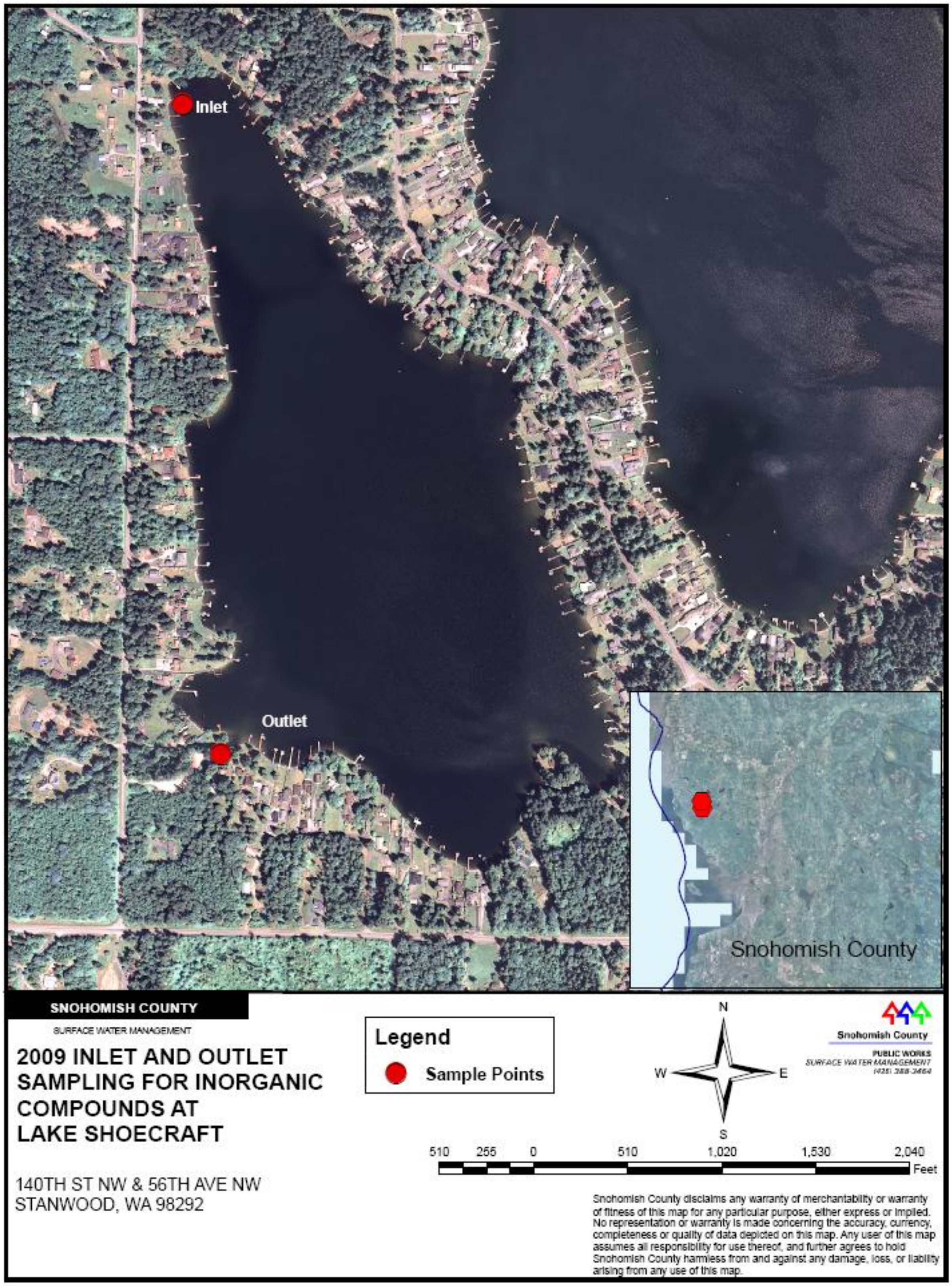
The objective of the fireworks pilot study was to determine if a suite of heavy metals and/or perchlorate was detectable in surface waters within Lake Shoecraft and Mongo Pond pre vs. post 4$^{th}$ of July fireworks displays. Basic physical and chemical parameters were also gathered in situ, using a calibrated Hydrolab$^{TM}$ Minisonde to provide indicators of a stressed system. Lake Shoecraft was chosen based upon citizens' complaints and Mongo Pond because it represented a highly urbanized environment where fireworks waste was observed to litter streets and drainage systems that discharge into the pond.

### Lake Shoecraft

Lake Shoecraft is located in the Seven Lakes area of Snohomish County, just north of the Tulalip Reservation and east of Lake Goodwin (Figure 1). Lake Goodwin drains into Lake Shoecraft which then flows into Tulalip Creek. The Tulalip Hatchery uses water from Tulalip Creek for rearing of coho, chinook and chum salmon.

Lake Shoecraft is 132 acres in size and the shoreline is nearly 100% developed with approximately 115 single family homes (Thornburgh and Williams 2001). The average depth of the lake is 5.5 meters, contributing to strong stratification in the summer months.

Figure 1. Lake Shoecraft



Snohomish County SWM has a record of water quality data for Lake Shoecraft dating back to 1994, including measurements for clarity, total phosphorus, chlorophyll *a, and* algal growth. The lake was classified by Williams and Reynolds (2003) as being in healthy condition. A complete description of Lake Shoecraft and water quality data may be found at http://www1.co.snohomish.wa.us/Departments/Public_Works/Divisions/SWM/Work_Areas/Water_Quality/Lakes/LakeShoecraft.htm

Surface waters of Lake Shoecraft were sampled near shore for field and laboratory analysis of those parameters identified in table 1. Samples were gathered near the inlet from Lake Goodwin and outlet during a dry period on June 23rd and again on July 6th, 2009. The objective was to identify whether the suite of heavy metals and/or perchlorate could be detected pre vs. post July 4th fireworks displays surrounding the lake.

Table 1. Lake Shoecraft and Mongo Pond Analytical Parameters

| Parameter | Units | Method Detection Limit and/or Resolution | Hold Time | Preservation | Analytical Methods |
|---|---|---|---|---|---|
| **Field Constituents** | | | | | |
| Temperature | °C | ±0.10°C | NA | NA | SM2550B-F |
| Dissolved Oxygen | mg/l | 0.1 mg/l | NA | NA | HACH 10360 |
| Specific Conductance | us/cm | ±1% of reading | NA | NA | EPA 120.1 |
| Turbidity | NTU | 0.1 NTU | NA | NA | EPA 180.1 |
| pH | Units | ±0.2 units | NA | NA | EPA150.1M |
| **Lab Constituents** | | | | | |
| Parameter | Units | Method Detection Limit | Hold Time | Preservation | Analytical Methods |
| Calcium | mg/l | 0.05 | 6 mo | $HNO_3$ to pH<2 | EPA 200.7 |
| Potassium | mg/l | 0.10 | 6 mo | $HNO_3$ to pH<2 | EPA 200.7 |
| Magnesium | mg/l | 0.05 | 6 mo | $HNO_3$ to pH<2 | EPA 200.7 |
| Sodium | mg/l | 0.05 | 6 mo | $HNO_3$ to pH<2 | EPA 200.7 |
| Silver | mg/l | 0.01 | 6 mo | $HNO_3$ to pH<2 | EPA 200.7 |
| Aluminum | mg/l | 0.01 | 6 mo | $HNO_3$ to pH<2 | EPA 200.7 |
| Arsenic | mg/l | 0.01 | 6 mo | $HNO_3$ to pH<2 | EPA 200.7 |
| Boron | mg/l | 0.05 | 6 mo | $HNO_3$ to pH<2 | EPA 200.7 |
| Barium | mg/l | 0.0005 | 6 mo | $HNO_3$ to pH<2 | EPA 200.7 |

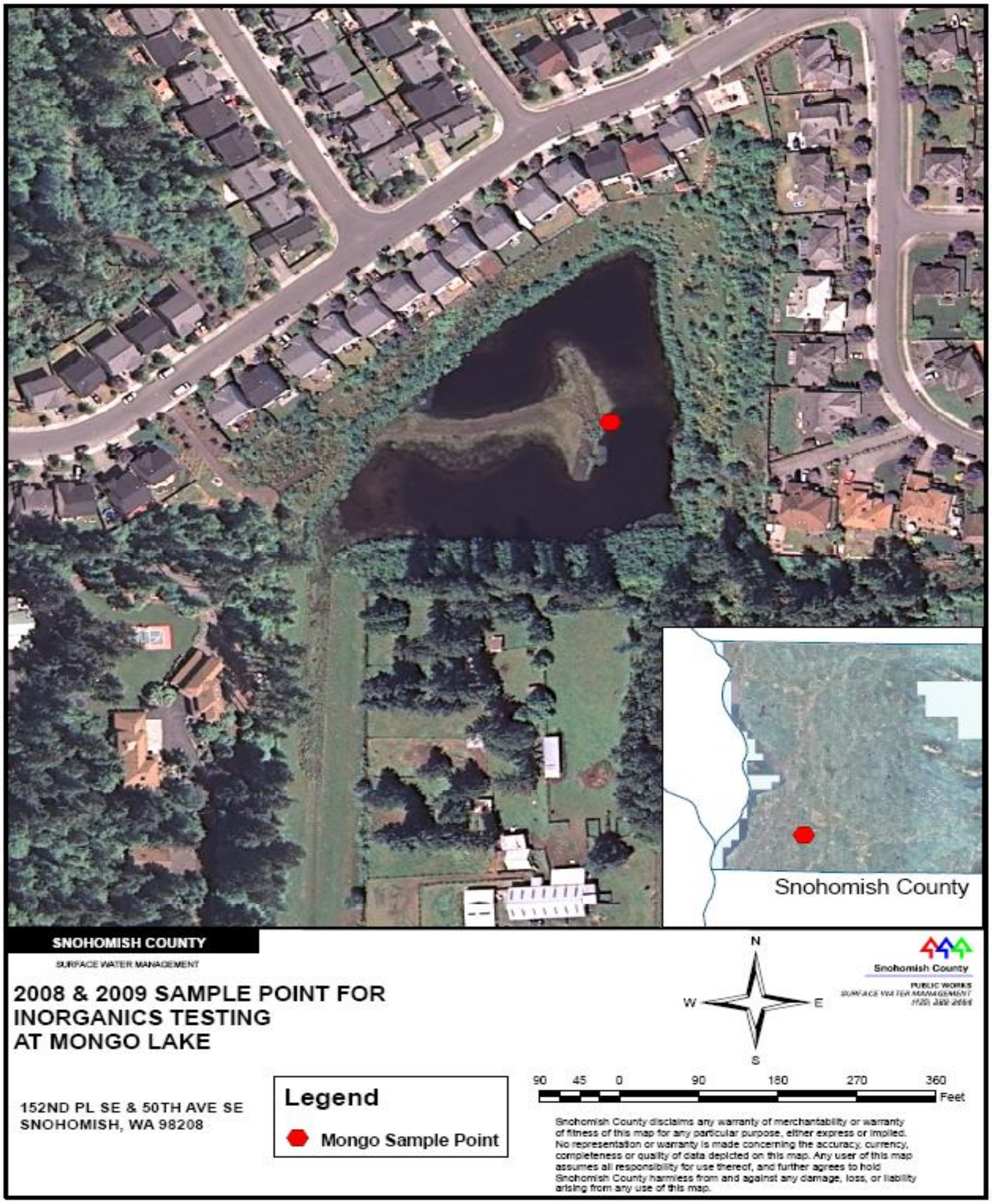
Table 1. Continued. Lake Shoecraft and Mongo Pond Analytical Parameters

| **Lab Constituents (Water Samples)** | | | | | |
|---|---|---|---|---|---|
| Parameter | Units | Method Detection Limit | Hold Time | Preservation | Analytical Methods |
| Beryllium | mg/l | 0.0005 | 6 mo | $HNO_3$ to pH<2 | EPA 200.7 |
| Cadmium | mg/l | 0.0005 | 6 mo | $HNO_3$ to pH<2 | EPA 200.7 |
| Cobalt | mg/l | 0.001 | 6 mo | $HNO_3$ to pH<2 | EPA 200.7 |
| Chromium | mg/l | 0.001 | 6 mo | $HNO_3$ to pH<2 | EPA 200.7 |
| Copper | mg/l | 0.001 | 6 mo | $HNO_3$ to pH<2 | EPA 200.7 |
| Iron | mg/l | 0.005 | 6 mo | $HNO_3$ to pH<2 | EPA 200.7 |
| Mercury | mg/l | 0.010 | 6 mo | $HNO_3$ to pH<2 | EPA 200.7 |
| Lithium | mg/l | 0.005 | 6 mo | $HNO_3$ to pH<2 | EPA 200.7 |
| Manganese | mg/l | 0.0005 | 6 mo | $HNO_3$ to pH<2 | EPA 200.7 |
| Molybdenum | mg/l | 0.005 | 6 mo | $HNO_3$ to pH<2 | EPA 200.7 |
| Nickel | mg/l | 0.005 | 6 mo | $HNO_3$ to pH<2 | EPA 200.7 |
| Phosphorus | mg/l | 0.01 | 6 mo | $HNO_3$ to pH<2 | EPA 200.7 |
| Lead | mg/l | 0.01 | 6 mo | $HNO_3$ to pH<2 | EPA 200.7 |
| Sulfur | mg/l | 0.05 | 6 mo | $HNO_3$ to pH<2 | EPA 200.7 |
| Antimony | mg/l | 0.01 | 6 mo | $HNO_3$ to pH<2 | EPA 200.7 |
| Selenium | mg/l | 0.01 | 6 mo | $HNO_3$ to pH<2 | EPA 200.7 |
| Silicon | mg/l | 0.05 | 6 mo | $HNO_3$ to pH<2 | EPA 200.7 |
| Tin | mg/l | 0.005 | 6 mo | $HNO_3$ to pH<2 | EPA 200.7 |
| Strontium | mg/l | 0.005 | 6 mo | $HNO_3$ to pH<2 | EPA 200.7 |
| Titanium | mg/l | 0.001 | 6 mo | $HNO_3$ to pH<2 | EPA 200.7 |
| Thallium | mg/l | 0.01 | 6 mo | $HNO_3$ to pH<2 | EPA 200.7 |
| Vanadium | mg/l | 0.010 | 6 mo | $HNO_3$ to pH<2 | EPA 200.7 |
| Yttrium | mg/l | 0.0005 | 6 mo | $HNO_3$ to pH<2 | EPA 200.7 |
| Zinc | mg/l | 0.005 | 6 mo | $HNO_3$ to pH<2 | EPA 200.7 |
| Perchlorate | ug/l | 4 | 28 days | 4 Deg C | EPA 314.0 |
| Perchlorate | ug/l | 0.1 | 28 days | 4 Deg C | EPA 331.0 |

## Mongo Pond

Mongo Pond is a man made detention system which drains approximately ½ a square mile of residential areas and serves as the primary headwaters of Little Bear Creek (Figure 2). Little Bear Creek discharges to the Sammamish River and Lake Washington. In June 2009, field staff observed unidentified warm water fish nests on the south side of the man made dike leading to the sampling station. No physical or chemical water quality data has previously been gathered by SWM for Mongo Pond.

Figure 2. Mongo Pond



Surface waters of Mongo Pond were sampled near shore for those parameters identified in table 1 on July 29th 2008, June 23 and July 13, 2009. The July 29, 2008 sample event took place after several storm events, which may have diluted a signature of pollutants. The June 23, 2009 sample event took place during an extensive dry period, while the July 13, 2009 sample event took place immediately following the first storm event following July 4th. The objective was to determine if the post July 4th storm event resulted in polluted stormwater discharges to Mongo Pond carrying levels of heavy metals and perchlorate above those found prior to July 4th.

## Water Quality Standards

Surface water quality standards for Washington State are found in Washington State Administrative Code (WAC 173-201A). Standards protect designated uses assigned to all surface waters of the state. Lakes are to be protected for the designated uses of: Core summer salmonid habitat; and extraordinary primary contact recreation. Numeric criteria established in WAC 173-201 are not intended for application to human created waters managed primarily for the removal or containment of pollution. This provision applies to Mongo Pond. Waters covered under that provision must be managed so that they do not create an unreasonable risk to human health or use of the water, and discharges from these systems must meet down gradient surface and ground water quality standards.

Table 2 identifies the parameters of interest for this study and the associated water quality standard. Many toxic substances sampled for do not have state established criteria, including perchlorate. Toxic substances sampled for, with established criteria are found in table 2.

Table 1 Identifies the State of Washington's water quality standards under WAC 173-201A.

| Parameter | Value | |
|---|---|---|
| Temperature (7-day average of daily max. temp) | 16.0°C | |
| Dissolved Oxygen (Lowest 1-day minimum) | 9.5 mg/L | |
| Turbidity (Should not exceed) | 5 NTU over background when background is 50 NTU or less, or A 10 percent increase in turbidity when the background turbidity is more than 50 NTUs | |
| pH | pH shall be within the range of 6.5 to 8.5, with a human-caused variation within the above range of less than 0.2 units | |
| **Toxic Substances** | **Acute ug/l** | **Chronic ug/l** |
| Arsenic [c] | 360.0 [a] | 190.0 [b] |
| Cadmium [c] | 3.7 [a] | 1.03 [b] |
| Chromium (Hex) [c] | 15.0 [a] | 10.0 [b] |
| Chromium (Tri) [c] | 548.7 [a] | 178.0 [b] |
| Copper [c] | 17.02 [a] | 11.35 [b] |
| Lead [c] | 64.58 [a] | 2.52 [b] |
| Mercury | 2.1 [a] | 0.012 [b,d] |
| Nickel [c] | 1415.41 [a] | 157.19 [b] |
| Selenium | 20 [a, d] | 5 [b,d] |
| Silver [c] | 3.45 [e] | NA |
| Zinc [c] | 114.45 [a] | 104.51 [b] |

[a =] A 1 hour average concentration not be exceeded more than once every three years on the average.
[b =] A 4 day average concentration not to be exceeded more than once every three years on the average.
[c =] Hardness and /or dissolved fraction dependent, assumed hardness of 100 mg/l. Result corrected for dissolved fraction using appropriate multiplier as identified by Nunallee and Shervey September 2003.
[d =] Total recoverable fraction
[e =] Instantaneous concentration not to be exceeded at any time

## Results

Field and lab parameter results for Lake Shoecraft and Mongo Pond are found in tables 3 and 4 respectively. Lab parameter results are provided only when detections of an analyzed parameter (table 1) are found during either a pre or post July 4[th] sample event. Otherwise, lab results were below method detection limits.

Data were reviewed for quality assurance. All samples were preserved, submitted to the contract laboratory and analyzed within required hold times. Two results as identified by asterisks in table 3 and one result in table 4 are qualified due to matrix spike recoveries outside acceptable limits. All other data are considered acceptable for pilot study objectives.

**Lake Shoecraft**

Table 3. Lake Shoecraft Results

| Parameter | Inlet | | Outlet | |
|---|---|---|---|---|
| | June 23, 2009 10:30am | July 6, 2009 10:05am | June 23, 2009 10:10am | July 6th, 2009 10:20am |
| **Field Constituents** | | | | |
| Temperature (°C) | 19.97 | 21.15 | 18.96 | 19.76 |
| Dissolved Oxygen (mg/l) | 9.19 | 8.60 | 8.76 | 8.09 |
| Specific Conductance (us/cm) | 98.0 | 101.5 | 98.0 | 102.5 |
| Turbidity (NTU) | 0.72 | 0.81 | 1.92 | 1.60 |
| pH (units) | 7.57 | 7.08 | 7.09 | 7.47 |
| **Lab Constituents** | | | | |
| Parameter | Inlet | | Outlet | |
| | June 23, 2009 10:30am | July 6, 2009 10:05am | June 23, 2009 10:10am | July 6th, 2009 10:20am |
| Calcium (mg/l) | 6.5 | 6.3 | 6.5 | 6.5 |
| Potassium (mg/l) | 1.6 | 1.6* | 1.6 | 1.6 |
| Magnesium (mg/l) | 6.3 | 4.8 | 6.2 | 5.0 |
| Sodium (mg/l) | 6.5 | 5.9* | 6.5 | 5.9 |
| Aluminum (mg/l) | 0.05 | 0.02 | < 0.01 | 0.22 |
| Barium (mg/l) | 0.0109 | 0.0115 | 0.0110 | 0.0134 |
| Chromium (mg/l) | < 0.001 | 0.002 | < 0.001 | < 0.001 |
| Copper (mg/l) | < 0.001 | < 0.001 | < 0.001 | 0.002 |
| Iron (mg/l) | 0.036 | 0.029 | 0.039 | 0.249 |
| Manganese (mg/) | 0.0111 | 0.0093 | 0.0122 | 0.0139 |
| Molybdenum (mg/l) | 0.008 | < 0.005 | < 0.005 | < 0.005 |
| Phosphorus (mg/l) | 0.45 | 0.01 | 0.47 | 0.06 |
| Silicon (mg/l) | < 0.05 | 0.35 | < 0.05 | 0.64 |
| Sulfur (mg/l) | 1.6 | 1.5 | 1.6 | 1.6 |
| Strontium (mg/l) | 0.0484 | 0.0480 | 0.0486 | 0.0501 |
| Zinc (mg/l) | < 0.001 | <0.001 | <0.001 | 0003 |
| Perchlorate (ug/l) | < 0.1 | 1.3 | < 0.1 | 2.0 |

* Matrix spike recoveries for Potassium and Sodium were outside control limits. Results confounded by matrix interference.

**Mongo Pond**

Table 4. Mongo Pond Results

| Parameter | 2008 | 2009 | |
|---|---|---|---|
| | July 29, 2008 | June 23, 2009 12:01pm | July 13th, 2009 10:30am |
| **Field Constituents** | | | |
| Temperature (°C) | NA | 19.91 | 19.49 |
| Dissolved Oxygen (mg/l) | NA | 5.66 | 8.15 |
| Specific Conductivity (us/cm) | NA | 62.0 | 38.2 |
| Turbidity (NTU) | NA | 1.37 | 2.30 |
| pH (units) | NA | 6.89 | 7.45 |
| **Lab Constituents** | | | |
| Parameter | 2008 | 2009 | |
| | July 29, 2008 | June 23, 2009 12:01pm | July 13th, 2009 10:30am |
| Calcium (mg/l) | 4.5 | 5.1 | 4.5 |
| Potassium (mg/l) | 0.24 | 0.86 | 0.39* |
| Magnesium (mg/l) | 0.80 | 1.1 | 0.95 |
| Sodium (mg/l) | 1.5 | 1.7 | 2.0 |
| Aluminum (mg/l) | 0.08 | 0.11 | 0.11 |
| Arsenic (mg/l) | 0.04 | 0.03 | 0.01 |
| Barium (mg/l) | 0.0043 | 0.0136 | 0.0047 |
| Cobalt (mg/l) | 0.004 | < 0.001 | < 0.001 |
| Chromium (mg/l) | 0.001 | 0.008 | < 0.001 |
| Copper (mg/l) | < 0.005 | < 0.005 | 0.003 |
| Iron (mg/l) | 1.11 | 0.477 | 0.415 |
| Manganese (mg/) | 0.0280 | 0.0277 | 0.0143 |
| Molybdenum (mg/l) | 0.006 | < 0.005 | < 0.005 |
| Phosphorus (mg/l) | < 0.01 | 0.48 | 0.03 |
| Silicon (mg/l) | 0.32 | < 0.05 | 0.14 |
| Sulfur (mg/l) | 0.92 | 1.2 | 1.1 |
| Strontium (mg/l) | 0.0224 | 0.0292 | 0.0265 |
| Vanadium (mg/l) | 0.010 | < 0.005 | < 0.005 |
| Zinc (mg/l) | 0.005 | 0.034 | 0.003 |
| Perchlorate (ug/l) | < 4.0 | < 0.1 | 6.2 |

* Matrix spike recovery for Potassium was outside control limits. Result confounded by matrix interference.

Temperature
Although one time grab measurements for water temperature exceeded the criteria at all stations on all dates, WAC 173-201A-200-1(c) requires that water temperature is measured by the 7-day average of the daily maximum. It was outside the scope of this study to conduct continuous temperature monitoring. Therefore, no comparison to temperature criteria is made.

Dissolved Oxygen
All measurements for dissolved oxygen in Lake Shoecraft for all dates were below the required 1 day lowest dissolved oxygen criteria of 9.5 mg/l. This may have been due to measurements being taken from the lake surface, near shore, where limited mixing occurs.

Williams and Reynolds (2003) indicate that vertical profiles of dissolved oxygen show strong stratification between the warmer oxygenated upper waters and cooler oxygen depleted bottom water. Given shallow depths at the near shore inflow and outflow sampling locations, it's unlikely that attempted profiling would show a similar or pronounced trend.

Specific Conductance
There are no state water quality standards for conductivity. A primary measure of ionic activity, specific conductance can indicate the relative contribution of dissolved pollutants, including heavy metals, in a waterbody. Typically, fresh waterbodies in more urbanized areas have conductivities above 200 us/cm, while those in less developed areas of Snohomish County are often near or below 100 us/cm.

During the 2009 sample events, conductivity in Lake Shoecraft was higher than that found in Mongo Pond. While higher than Mongo Pond, conductivities near 100 us/cm were constant between 2008 and 2009 and do not give cause for alarm.

Mongo Pond experienced a near two-fold decrease in conductivity between the 2009 sample events. We would have expected to see an increase in conductivity with increased stormwater pollutants. The decrease could have been due in part to the increase in stormwater inputs carrying few pollutants.

pH
All pH measurements for Lake Shoecraft were within state standards. Although numeric criteria are not applicable, Mongo Pond also exhibited pH within state standards.

Perchlorate reduction can occur at metal surfaces under acidic pH conditions (Long et. al. 2005), but these conditions were not found at any sample location.

Turbidity
Background turbidity shall not exceed 5 nephlometer units (NTU) above background when background is 50 NTU or less. The inlet sample location on Lake Shoecraft can be considered background for turbidity, while downstream is considered the outlet. As such, values for turbidity on Lake Shoecraft are found within state standards.

Metals
Of the metals identified in table 2, assuming a hardness of 100 mg/l, no result for Lake Shoecraft or Mongo Pond exceeded acute or chronic criteria. Toxicity for certain metals exhibits an inverse relationship with hardness. For example, a hardness of 100 mg/l results in an acute criteria for dissolved copper of 17.02 ug/l, while decreasing hardness to 50mg/l, results in an acute criteria for dissolved copper of 8.86 ug/l. If a hardness of 50 mg/l were assumed, all results would have remained below criteria.

While several results for both Lake Shoecraft and Mongo Pond were found above detection limits, none exhibited trends which would indicate impacts due to discharge of fireworks. Wilkin et. al. (2007) found similar results where spikes in concentrations of strontium, barium, calcium, sodium, copper, antimony, aluminum and magnesium were not detectable. Reasons for non-detections of metals are not certain, but may be attributed to their lower mass abundance compared to perchlorate in fireworks.

Perchlorate
Perchlorate levels from all stations sampled prior to July 4$^{th}$, 2009, were non-detectable. However, sampling post July 4$^{th}$ found that perchlorate levels increased by over 10 and 20 times at the Lake Shoecraft inlet and outlet respectively, and by 60 times at Mongo Pond.

Perchlorate is an inorganic anion, consisting of four atoms of oxygen and one atom of chlorine. It is released into the environment when highly soluble perchlorate salts are dissolved in water. Perchlorate is not easily degraded and does not bind well to other mineral surfaces (Trumpolt et. al. 2005). Due to these factors, perchlorate can persist for decades and move freely within bodies of water.

Perchlorate is believed to have first been identified in Chilean nitrates over 100 years ago (Jackson 2005). Similarly, it was indicated by (Longmire 2005) to exist naturally at levels ranging from 0.2 – 0.4 ug/l in groundwaters of northern New Mexico. The naturally occurring presence of perchlorate is thought to be associated with arid environments where evapotransporation exceeds precipitation and concentrated in soils or sediment under climactic and geologic conditions similar to natural nitrate (Orris 2005).

Most of the perchlorate contamination in the United States is attributed to the use of ammonium perchlorate as an oxidizer and primary ingredient in solid rocket fuel (Trumpolt 2005). Defense and aerospace industries purchase more than 90 percent of all perchlorate manufactured, or roughly 20 million pounds per year (EPA 2005). A smaller percentage is used in the manufacturing and use of mining explosives, Chilean fertilizer, fireworks, safety flares, vehicle air bag inflators and chemical reagents for lab studies. Like solid rocket fuel, ammonium perchlorate is the primary oxidizing agent used in manufacturing of fireworks.

Detonation of fireworks is expected to lead to the quantitative conversion of perchlorate to chloride following the decomposition reaction (Wilkin et. al. 2007).

Current methods to differentiate anthropogenic and naturally occurring perchlorate sources include stable isotope analysis, surrogate analysis, geologic evaluation, and aerial photography. Although these forensic techniques have not been employed, an observed source of perchlorate around Lake Shoecraft and Mongo Pond has been waste from spent fireworks. Debris was documented in stormwater drainage systems discharging to Mongo Pond and residents of Lake Shoecraft engage in fireworks displays. Further, the EPA’s 2004 list of known perchlorate releases in the United States does not include locations in Snohomish County.

While concentrations of perchlorate attenuate from processes such as dilution, precipitation, biological or chemical reduction, adsorption and ion exchange; detections of perchlorate at similar concentrations near the inlet and outlet of Lake Shoecraft suggest widespread contamination two days after July 4$^{th}$, 2009. Wilkin et. al. (2007) found that perchlorate values in Lake Wintersmith, Oklahoma peaked 14 hours after July 4$^{th}$ 2006. According to residential comment, July 4$^{th}$ of 2009 resulted in fewer displays on Lake Shoecraft than in previous years.

Wilkin et. al. (2007), found mean background levels of perchlorate in Wintersmith Lake, Oklahoma preceding July 4$^{th}$, 2006 of 0.043 ug/l, while a maximum concentration of 44.2 ug/l was detected following July 4$^{th}$ events. Concentrations decreased towards background levels within 20 – 80 days depending upon the sample location.  Attenuation correlated with surface water temperature, but not conductivity, pH or surface water inputs due to storm events (Wilkin et. al. 2007).

As mentioned previously, MADEP is investigating sources of perchlorate contamination in the state. Investigation reveals that the primary source of perchlorate contamination appears to originate from commercial fireworks displays. Residue is suspected to have contributed to perchlorate contamination of groundwater and water supply wells in various locations (Wilkin et. al. 2007).

As a result of this and other work, several states have set advisory levels for perchlorate in drinking water that vary between 1 – 18 ug/l (Crane et. al. 2005). California's Office of Environmental Health (2004) has recently set a public health goal for drinking water (maximum contaminant level) of 6 ug/l.

California's review of perchlorate for drinking water goals included a comprehensive summary of the toxicological effects of perchlorate on humans and animals, but did not evaluate effects on fish. Mongo Pond is believed to harbor freshwater perch or blue gill, while Lake Shoecraft was stocked in May of 2009 by the Washington State Department of Fish and Wildlife with 5000 rainbow trout (WDFW 2009). A literature search did not produce information on effects of perchlorate on rainbow trout.

Crane et. al. (2005) showed that after 28 days of exposure to perchlorate at 10,000 and 100,000 ug/l, fathead minnows were developmentally stunted with a lack of scales and poor pigmentation, were lower in weight and length than control fish.

## Conclusion

Results indicate that the discharge of fireworks waste into both Lake Shoecraft and Mongo Pond resulted in detection of perhclorate at levels which, given the literature, are believed to be of low threat to human health or the environment. Neither body of water is used as a drinking water source. Bioaccumulation of perchlorate in food fish taken from Lake Shoecraft is unknown.

Basic physical and chemical in situ parameters did not indicate stressed systems. Heavy metals associated with fireworks were not detected in either water body after July 4$^{th}$, 2009 events. This suggests that further study may concentrate on perchlorate as the primary pollutant of concern.

Snohomish County Water Pollution Control Code (SCC 7.53) prohibits the discharge of pollutants to surface waters and public drainage systems. It is recommended that citizens implement the best management practices outlined in Appendix A.

# Appendix A

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**The following message was posted on the SWM website late June of 2009 and ran past July 4th.**

**Surface Water Management Division**
**Fireworks Impact on Water Quality**

A message to citizens about the impacts of fireworks on surface waters.

Fireworks contain pollutants including heavy metals and perchlorate, a chemical used to propel fireworks. When fireworks are detonated over a water body or waste materials are not properly disposed of, pollutants can enter the storm drainage systems, rivers, lakes and potentially groundwater.

Snohomish County Water Pollution Control Code (SCC 7.53) prohibits the discharge of pollutants into the storm drainage system, and natural water bodies including groundwater. Individuals and organizations responsible for fireworks displays should minimize the discharge of pollutants to our waters by following the recommendations below:

- Request low (or no) perchlorate containing fireworks. This may require that you make inquiries with your suppliers and/or manufacturers;
- Refrain from discharging fireworks from or into public sidewalks and roadways which may contain storm drainage systems;
- Institute rigorous "housekeeping" practices. Unburned aerial shell fragments and other debris contain high levels of pollutants. Individuals, fireworks companies or display sponsors should remove all visible shell debris, and dispose of in accordance with applicable codes and manufacturer’s instructions. Please exercise caution while collecting and removing debris during low-light periods;
- Contain and/or promptly address runoff in cases where water is used to douse duds or misfired materials.

If you have questions about the information here or would like to report a concern about impacts to water quality, please call the Surface Water Management Water Quality Complaint Hotline at 425-388-6481.

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