AN INVESTIGATION OF THE GROUNDWATER SOURCE AREA FOR LOST CREEK SPRING, AUSTIN, TEXAS

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ABSTRACT

Monitoring performed by the U.S. Geological Survey and the City of Austin has indicated a local source of nutrients for Lost Creek Spring. One potential source to be investigated was a wastewater holding pond on the Lost Creek Golf Course. A dye tracing study was performed to determine if water in the holding pond discharged to the spring. The dye injected into the pond was not detected in Lost Creek Spring. These data suggest that the pond is not leaking, is not leaking sufficiently to inject enough dye into the underlying perched aquifer to be detected in the spring, or that the water migration time from the pond to the spring is greater than the six week monitoring period. A potentiometric surface shows that Trinity aquifer is not the spring water source. Chemical data, including nitrogen isotopes, indicate a pronounced change in spring nutrient and ionic composition from wet to dry conditions. Nitrogen isotopes during dry conditions point to a wastewater source for the nitrogen in the water. The only nearby sources of wastewater nitrogen appear to be local onsite septic systems over 7000 ft. from the spring, a holding pond for the Barton Creek Country Club courses 5600 ft away, a second holding pond for Lost Creek 4500 ft. away, or effluent irrigation water on the Lost Creek golf course that is as close as 800 ft. to the spring.

Results from the data collected during the dye trace study suggest that more research is needed to determine the source of the nitrogen and water at Lost Creek Spring. The inconclusive dye trace results, complex hydrologic and water chemistry conditions require a more comprehensive monitoring program. If determining the source for the high nitrogen concentration is pursued, then the information collected in this study can aid in designing a monitoring program to specifically answer this question.

INTRODUCTION

Lost Creek Spring, on the south bank of Barton Creek, approximately 200 ft downstream of the Lost Creek Boulevard bridge, is at the contact of the Cretaceous-age Glen Rose Formation (Member 2) and undifferentiated Quaternary terrace/alluvial deposits (Rodda and others, 1979). The spring is noted by City of Austin staff for two unusual characteristics: for maintaining a relatively high discharge volume and for having variable water chemistry data. Lost Creek Spring is consistently discharging during drought conditions, when discharge from most other springs is dramatically reduced or completely stopped. During droughts, the spring supplies a large percentage of Barton Creek's flow. Variations in water chemistry, for example specific conductance, nitrate, and dissolved ions, appear to be related to antecedent moisture conditions. Constituent concentrations generally are low after periods of high rainfall and elevated after extended dry periods (COA, 1997; Johns and Pope, 1998).

Two hydrologic sources of groundwater for Lost Creek Spring are perched shallow aquifers or the Glen Rose Aquifer. Localized shallow groundwater exists in the terrace/alluvial deposits adjacent to Barton

Creek and its associated tributaries, continuously being recharged by the infiltration of precipitation and irrigation water. A deeper regional groundwater source could be the Trinity Aquifer, discharging from Glen Rose springs buried by the terrace/alluvial deposits. In addition, spring discharge could be from the mixing of both localized and regional groundwater sources. The water chemistry data collected at Lost Creek Spring have been evaluated by City of Austin staff in an attempt to identify the groundwater source.

Nitrate-nitrogen levels in the spring discharge are highly variable and elevated compared to background (as indicated by water chemistry from springs in rural settings), with an average concentration of 1.82 mg/l. The elevated nitrogen levels in this reach of Barton Creek are believed to have caused high densities of filamentous algae (COA, 1997). In an effort to determine the source of nitrogen observed at Lost Creek Spring, City of Austin staff analyzed water samples for nitrogen isotopes. During wet conditions, isotopic data are inconclusive. However, during dry conditions, the data indicate a wastewater source for the nitrogen levels detected at the spring (COA, 1997). A wastewater effluent holding pond located at the Lost Creek Country Club and its wastewater irrigation system have been identified as possible nitrogen sources, because of their proximity to the spring and location on the terrace deposits associated with the spring. Since nitrogen isotopes are insufficient to specifically identify the location of the nitrogen input, a groundwater tracing study was conducted from December 1999 to April 2000. The goal of the study was to determine if the effluent holding pond was leaking into the shallow ground water and impacting the springs and seeps immediately downstream of the golf course.

PROJECT DESIGN AND METHODS

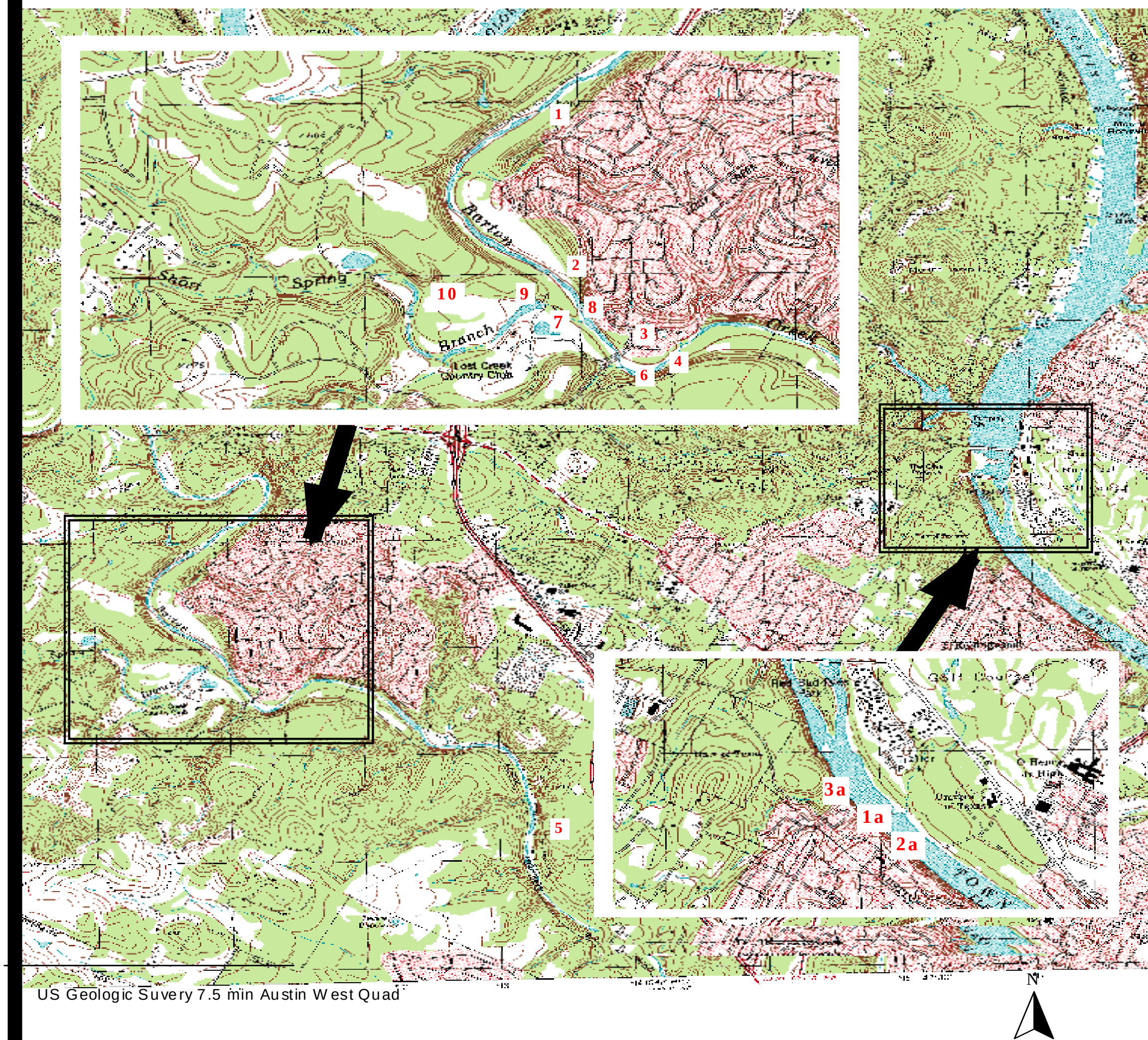
The Lost Creek trace was designed to determine if the effluent holding pond closest to Barton Creek was leaking and affecting shallow ground water and nearby Lost Creek Spring. The Lost Creek Golf Course effluent pond was constructed in the 1960s near the confluence of Barton Creek and Short Spring Branch. Little information about its design is available; however, it is believed to have a clay liner. The volume of the pond is 8.5 acre-feet and it receives 300,000 gpd of treated effluent (Javier Marchin, personal communication).

Ten monitoring locations were selected for the study (Figure 1). Monitoring locations were selected to identify potential discharge points of the shallow ground water system and to identify potential external sources of dyes or other organics that may interfere with the trace. Three sites, the effluent holding pond, Lost Creek Spring, and the mouth of Short Spring Branch, were monitored daily for 3 weeks. Weekly samples were collected at all sites for 6 weeks. In addition, biweekly samples were collected at Cold Springs, above Cold Springs, and below Cold Springs as a precautionary step to ensure that fluorescein dye used in the study was not interfering with Barton Spring/Edward Aquifer Conservation District’s tracing of the Barton Springs segment of Edwards Aquifer. In order to characterize the natural background fluorescence levels, background receptors and water samples were collected by City of Austin staff and analyzed by Ewers Water Consultants, Inc. Background fluorescence was determined at six monitoring sites: Effluent Holding Pond, Short Spring Branch Lower Pond, Short Spring Branch Upper Pond, Barton Creek upstream of Lost Creek Golf Course, Barton Creek downstream of Lost Creek Golf Course, and Lost Creek Spring. No background fluorescence was detected.

Activated charcoal dye receptors and water samples were shipped within 24 hours from collection to Ewers Water Consultants, Inc. laboratory in individually labeled, polyethylene “Zip Lock” bags. They were sent by Airborne Express, Inc. at ambient temperature in crush-proof express boxes. All samples were stored on ice or refrigerated until shipping. Dye identification was performed using a Shimadzu spectro-fluoro-photometer using synchronous excitation-emission scans at an interval of 18 nm and at a range of 470 nm to 600 nm. Detailed laboratory procedures and quality assurance/quality control methods can be obtained by contacting Ralph O. Ewers, Ph.D.,. of EWC at (606) 623-8464 or 160 Redwood Drive, Richmond, Kentucky 40475.

Figure 1

Lost Creek Golf Course Dye Tracing Montoring Locations



Monitoring locations shown above are indicated on Figure 1 as follows:

1. Barton Creek Upstream of Lost Creek Golf Course
2. Barton Creek at Cart Crossing
3. Barton Creek at Lost Creek Bridge
4. Barton Creek downstream of Lost Creek Spring
5. Barton Creek at Recharge Pool
6. Lost Creek Spring*
7. Effluent Holding Pond*
8. Short Spring Branch Mouth*
9. Short Spring Branch Lower Pond
10. Short Spring Branch Upper Pond

<u>Precautionary Additional Sites</u>

1a. Cold Springs
2a. Upstream of Cold Springs
3a. Downstream of Cold Springs

Weekly water samples were also collected over a 4-week period from the effluent pond's inflow, the effluent pond near the pump house, and Lost Creek Spring during November 1999. The water chemistry data collected were compared to historical water chemistry data from the springs and nearby wells. The water chemistry data aided researchers in selecting the appropriate dye and in characterizing the water chemistry of the area. The sampling schedule was as follows:

<u>Daily and Weekly Monitoring Sites</u>

1. Barton Creek Upstream of Lost Creek Golf Course
2. Barton Creek at Cart Crossing
3. Barton Creek at Lost Creek Bridge
4. Barton Creek downstream of Lost Creek Spring
5. Barton Creek at Recharge Pool
6. Lost Creek Spring*
7. Effluent Holding Pond*
8. Short Spring Branch Mouth*
9. Short Spring Branch Lower Pond
10. Short Spring Branch Upper Pond (Upstream)

* *Daily receptor collection site – Collected for 21-days*

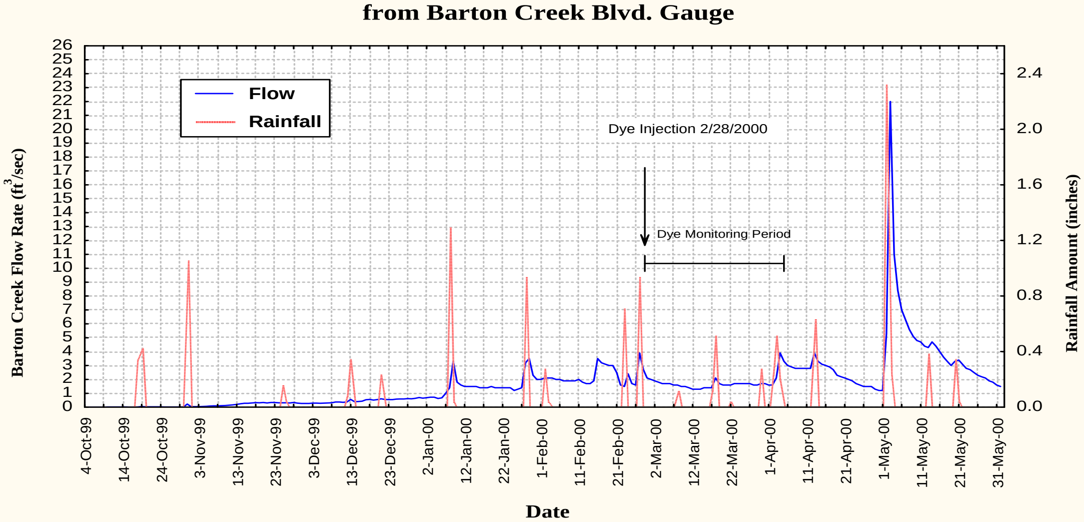
<u>Biweekly Sample Sites</u>

1a. Cold Springs
1b. Downstream of Cold Springs
1c. Upstream of Cold Springs

In preparation for the trace, the golf course was irrigated to draw down the holding pond until it had the capacity to hold 2 to 4 days of inflow. Once at this level, fluorescein dye was added to the pond and mixed by effluent entering the pond. At the same time, golf course irrigation ceased until the pond's capacity was restored to its normal level by the incoming effluent. This procedure would theoretically have allowed a slug of dye to enter the shallow ground water system through a pond leak before irrigation could spread the dye over the golf course. Once the pond reached capacity, irrigation resumed. The short period of infiltration may be problematic since the anticipated travel time for the dye-slug to reach the spring is much greater than the 2 to 4 days of storage and non-irrigation.

The local ambient moisture conditions were ideal for detecting wastewater impacts at the spring. The effects of rainwater at the spring were minimized because dye study occurred after a drought. Both rainfall and Barton Creek's flow were uniform during the study. Barton Creek's flow rate remained around 2 cubic feet per second and only two rainfall events of over 0.5 inch occurred during the study period (Figure 2). In addition, consistent discharge rates were visually observed at Lost Creek Springs.

Figure 2
Comparison of Barton Creek's Flow vs. Rainfall from Barton Creek Blvd. Gauge

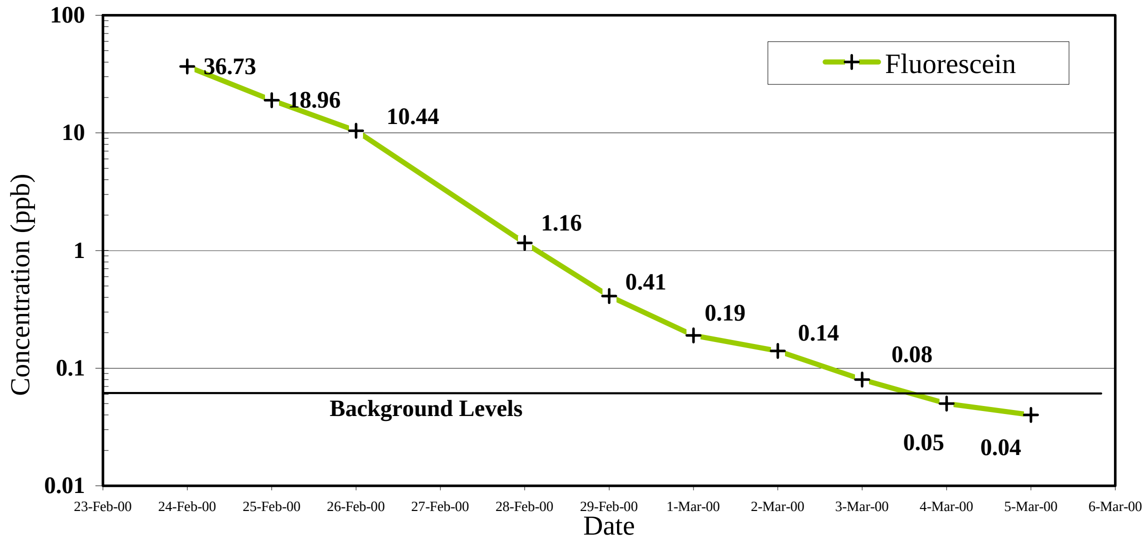


On February 23, 2000, at 12:05, 2.5 lbs of fluorescein dye was diluted in 1 liter of water added to the effluent pond. Aliquots of the dye were poured around the edge of the pond and in front of the effluent discharge pipe. The inflow of effluent aided in dispersing the dye throughout the pond. By 13:45 the dye was well dispersed. Dye receptors and water samples were collected daily for 21 days, and weekly receptor and water samples were collected for 6 weeks.

RESULTS

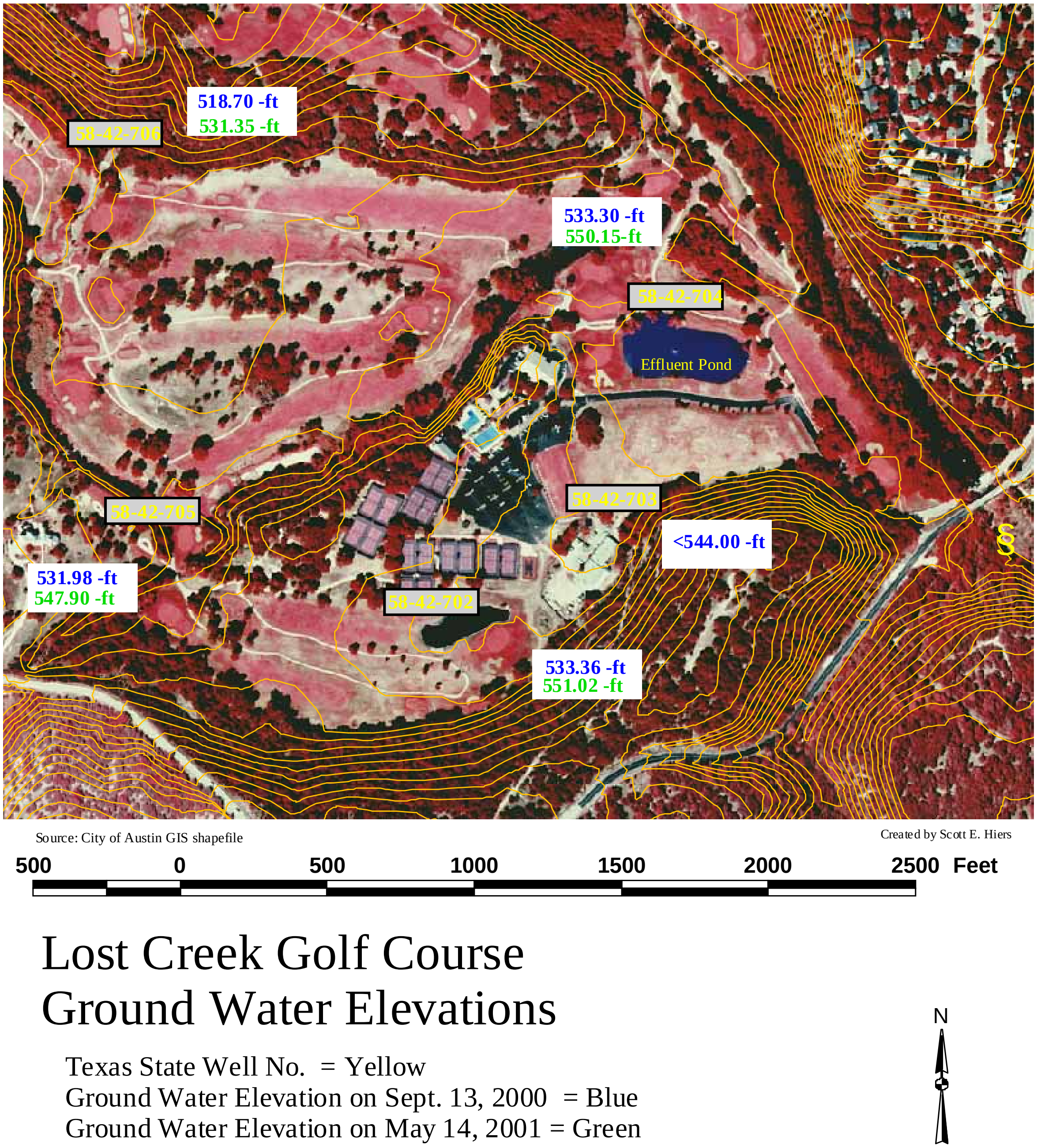
Results from the background sampling indicated that there is a slight level of fluorescein in the effluent holding pond. This is common in wastewater since fluorescein is a commonly used dye. No background levels of fluorescein were detected at the other background receptor sites: Short Spring Branch Lower Pond, Short Spring Branch Upper Pond, Barton Creek upstream of Lost Creek Golf Course, Barton Creek downstream of Lost Creek Golf Course, and Lost Creek Spring. Except for the effluent holding pond, no fluorescein dye from the trace was detected at any of the monitoring sites. The dye concentration in the holding pond on February 24, 2000 was 36.73 ppb. Nine days after the dye injection, the concentration of fluorescein in the effluent pond dropped to background levels of less than 0.05 ppb (Figure 3).

Figure 3
Fluorescein Concentrations at Effluent Holding Pond



Since the dye trace was inconclusive, water chemistry data and ground water elevation data were analyzed. Ground water elevation measurements were taken on September 13, 2000, under conditions similar to those during the February tracing. The data indicate that the regional water table of the Trinity Aquifer is at least 50 ft lower than the perched shallow water discharging at the springs and the groundwater gradient is to the northwest, away from the spring (Figure 4). The potentiometric surface indicates that the Trinity Aquifer is not a source of water for Lost Creek Spring.

Figure 4



The water chemistry of the effluent, Lost Creek Spring, and available well data were also examined to aid in determining the source of the spring water. Lost Creek Spring samples included samples collected in conjunction with effluent samples and those collected since 1990 during the City's ground water investigations in the Barton Creek watershed (Table 1). Significant differences in ground water chemistry exist between Lost Creek Spring, the effluent pond, and its inflow (Figure 5). Higher average concentrations of total Kjeldahl nitrogen, ammonia nitrogen, dissolved orthophosphorus, and total nitrogen were found in the effluent pond inflow and effluent pond. Average nitrate nitrogen was higher in the spring. As shown by the range in results, all the nutrient data are highly variable.

The physical water chemistry data were also highly variable and show significantly higher levels for pH and turbidity in the effluent pond (Figure 6). Conductivity concentrations are higher at Lost Creek Spring and show more variability than those observed in the effluent pond. The greater variability is possibly a result of the large data set for the spring, or a result of seasonal effects. The median conductivity concentration is approximately 300 uS/cm higher at Lost Creek Spring than in the effluent pond. Some of the difference in variability in conductivity data can be explained by the large data set for Lost Creek Spring, However, visual inspection of the raw data confirms that on the days when all three sites were sampled the highest conductivity concentrations are reported at the spring. Metal concentrations are similar for the effluent pond and springs, except for iron and zinc (Figure 7). If effluent is contributing to the spring, the lower metal concentrations at the springs may be due to the removal of metals by sorption to clay colloids and organic matter in soil, a major mechanism for heavy metal removal (EPA, 1981).

Ion data for Lost Creek Spring, the effluent holding pond, the effluent pond inflow, and wells within 1.5 miles of the golf course were plotted on a Piper diagram (Figure 8) for comparison. In general, the data are highly variable for most sites. Variation in the chemistry of the shallow perched water feeding Lost Creek Spring could be a seasonal phenomenon or could be related to overlying land use. Large variations in the deeper ground water indicate dramatic temporal changes or influences by surface factors. It appears that some of the well data and Lost Creek Spring data have similar ionic signatures, at least at times. However, there are not enough data on the effluent pond to conclude if there are any relationships among any of the monitoring sites.

CONCLUSIONS

The dye used to trace water in the Lost Creek golf course effluent holding pond was not detected in Lost Creek Spring. This suggests that either the pond is not leaking, or it is not leaking sufficiently to inject enough dye into the underlying perched aquifer to be detected in the spring, or that the water migration time from the pond to the spring is greater than the 6-week monitoring period. A potentiometric surface of the underlying Trinity aquifer shows that water levels are well below the elevation of the Lost Creek Spring outlet, and the gradient is also away from the spring, indicating that the Trinity is not the spring’s water source. Chemical data, including nitrogen isotopes, indicate a pronounced change in spring nutrient and ionic composition from wet to dry conditions. Nitrogen isotopes during dry conditions point to a wastewater source for the nitrogen in the water. The only nearby sources of wastewater nitrogen appear to be local onsite septic systems over 7000 ft from the spring, a holding pond for the Barton Creek Country Club courses 5600 ft away, a second holding pond for Lost Creek 4500 ft away, or effluent irrigation water on the Lost Creek golf course that is as close as 800 ft to the spring.

RECOMMENDATIONS

Results from the data collected during the dye trace study suggest that more research is needed to determine the source of the nitrogen and water at Lost Creek Spring. The inconclusive dye trace results and complex hydrologic and water chemistry conditions require a more comprehensive monitoring program. If determining the source for the high nitrogen concentration is pursued, then the information collected in this study can aid in designing a monitoring program to specifically answer this question. The following recommendations should be considered:

1. To determine the “natural” or background water chemistry of terrace/alluvial springs, sampling of Lost Creek Spring, effluent ponds, effluent irrigation systems, wells and terrace/alluvial springs should be conducted. Based on the observed variability of historic water quality data, a sampling program should be designed to ensure that unbiased sampling techniques are used and a sufficient amount of data is collected to produce meaningful results.

2. Additional dye trace studies in the golf course area could help determine the groundwater travel times for terrace/alluvial deposits in the area. Identifying and dye tracing of other possible nitrogen sources around the Lost Creek Spring may produce conclusive results.

3. Monitoring the water levels wells over wet and dry periods would aid in determining the deeper groundwater movement and flow paths for different moisture conditions.

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Figure 6: Physical Water Chemistry Parameters

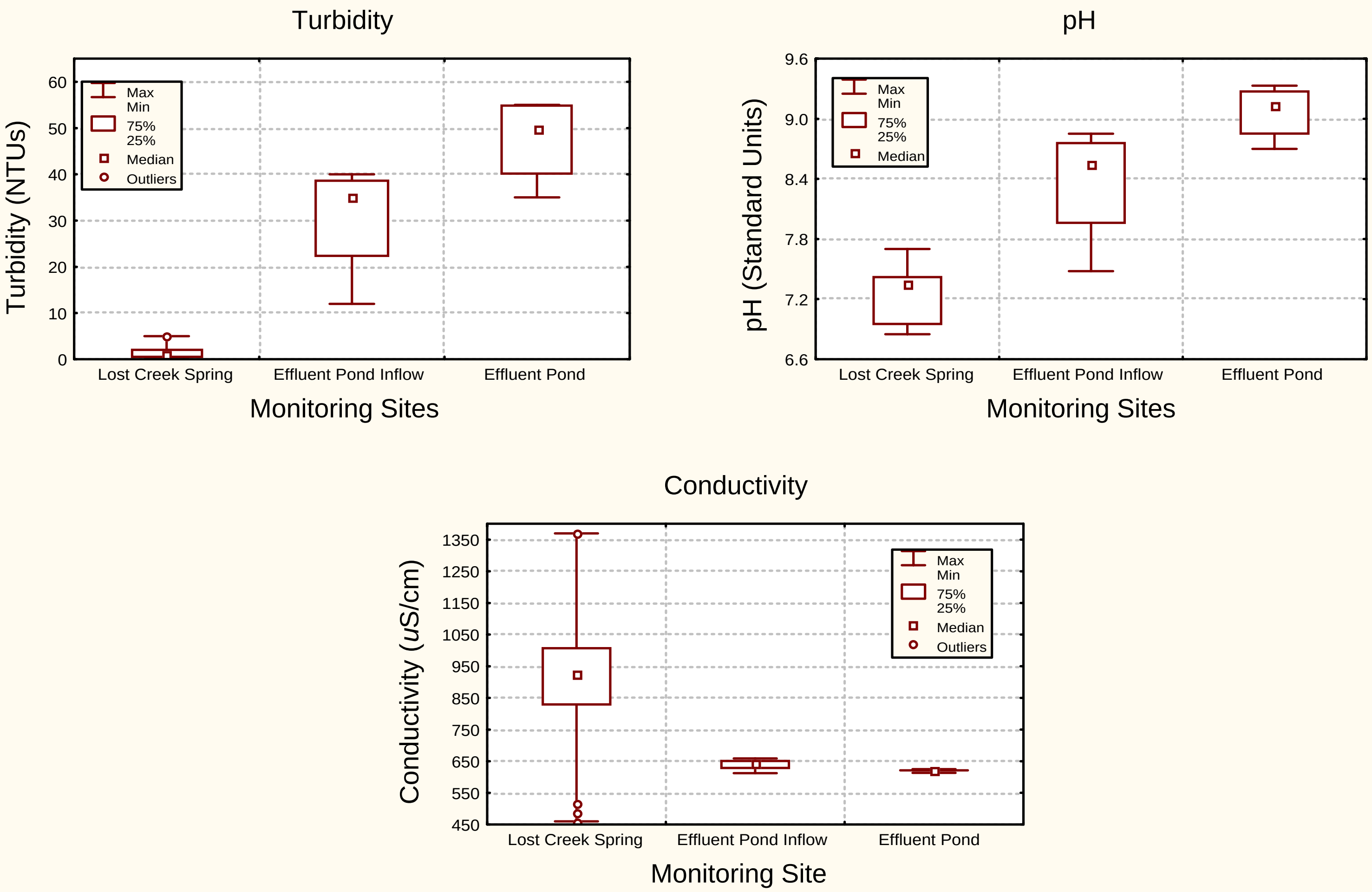

Figure 7: Metal Concentrations

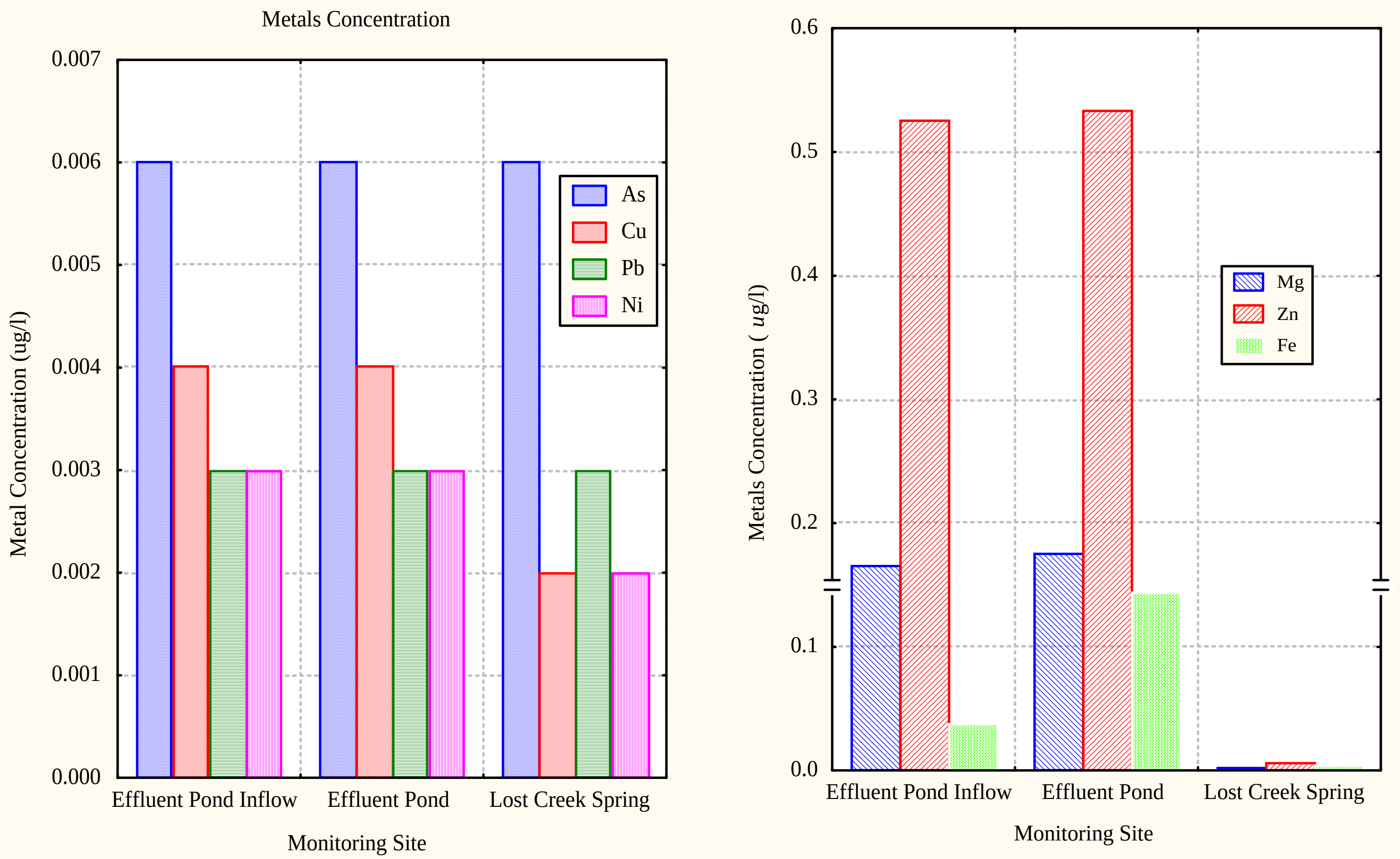

Figure 8. Comparison of Ion Data in the Lost Creek Area

Source: City of Austin Texas Water Development Board Data

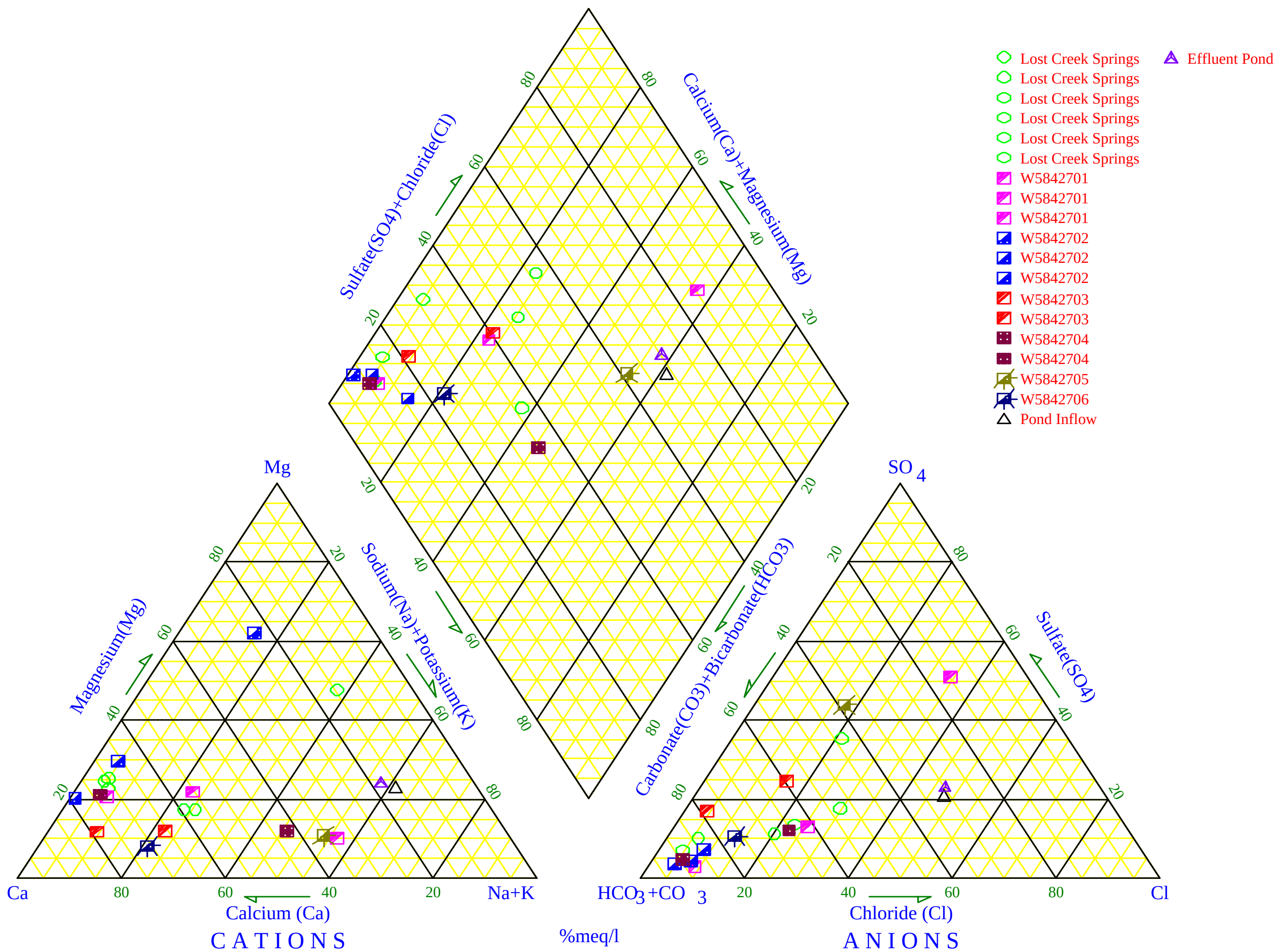

Figure 8 (continued): Average Ion Data

Source: City of Austin Texas Water Development Board Data