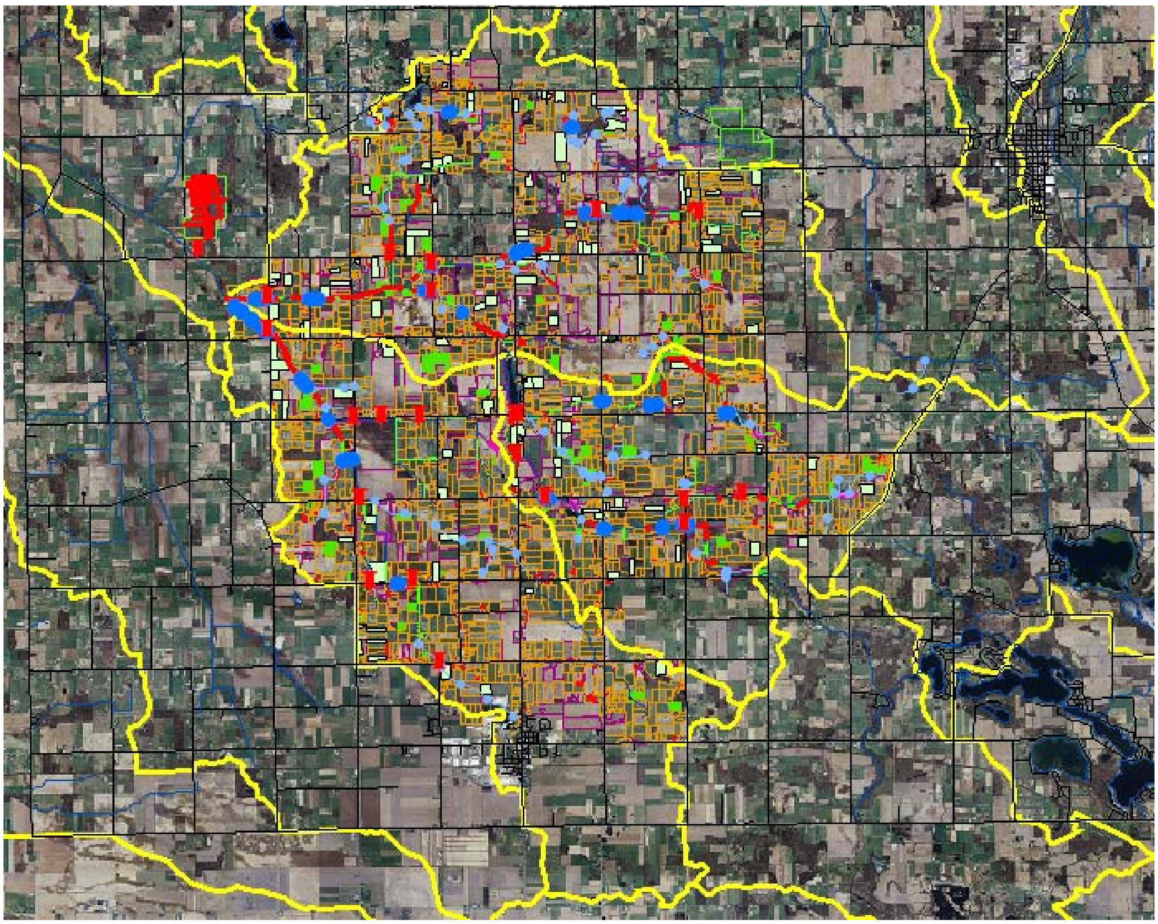
Little Elkhart River Watershed Management Plan

12 April 2007



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Project Mission and Vision Statements

Vision

The headwaters region of the Little Elkhart River Watershed will provide clean water for agriculture, economic, residential, and recreational needs in a fair, balanced, and sustainable way.

Mission

Establish a diverse group of stakeholders within the watershed in a cooperative effort to protect, restore, and educate the public of the importance of the Little Elkhart River Watershed as a critical component of the St. Joseph River System.

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INTRODUCTION

The LaGrange County Soil and Water Conservation District (SWCD) reviewed its water quality improvement efforts across the county to determine areas that need additional focus. The eastern portion contains the “lake country” and has been the center of attention of for many years with numerous projects implementing water quality improvement practices designed to reduce non-point source pollution. The western portion of the county has received less attention and that convinced the LaGrange County SWCD staff to focus its next major project in this region of the county. The Little Elkhart River drainage constitutes a major portion of western LaGrange County and was selected as a focal watershed. The Little Elkhart River system presents unique challenges with the preponderance of landowners belonging to the Amish community. Traditionally they have been reluctant to accept federal/state cost-share funds for conservation-based projects. However, the six county Indiana SWCDs that lie within the St. Joseph River Basin have an on-going 319 Grant (administered by LaGrange County SWCD) for Livestock Management within the basin. Since 1999, the livestock specialist working in conjunction with NRCS and SWCD staff has established a close relationship with the Amish community opening the opportunity to develop and implement a long-range, detailed plan for the watershed.

The Little Elkhart River is a sub-watershed within the St. Joseph River Basin. The St. Joseph River has received significant attention in its urbanized centers of South Bend, Mishawaka, and Elkhart concerning water quality issues initially associated with point source pollution. A relatively recent focus has centered on non-point source pollution throughout the basin with an emphasis centered in areas where agriculture is the main land use practice. Studies conducted by Indiana and Michigan state/county agencies have demonstrated tributaries of the mainstream are the major contributor of non-point source pollutants.

The Little Elkhart River is primarily influenced by agricultural practices and is on the IDEM 303(d) list of impaired waters. The focus of this plan is on the headwaters located in western LaGrange County with a small portion extending into Noble County (Figure 1). The target area is defined by the hydrologic unit codes Bontrager Ditch-Emma Lake, Bontrager Ditch-Hostetler Ditch, and the Little Elkhart River Ditch (Topeka). Combined, these three sub-watersheds of the Little Elkhart River total 33, 814 acres. These headwaters are influenced by agricultural practices, a growing “cottage” industry, septic systems, and an increase of impervious surfaces near the ditches. Previous water quality testing has shown high levels of phosphate, nitrate, e-coli and impaired biotic communities. Emma Lake, which lies within Bontrager Ditch-Emma Lake, is listed on the IDEM 303(d) list of impaired waters for *E.coli*.

Although much attention is given to organic compounds and bacteria pollutants, Indiana Department of Natural Resource studies have indicated silt loading as a major limiting factor on the fish community within the Little Elkhart River system. Ledet (1991) listed the Little Elkhart River as a cool to coldwater environment but silt loading prevented fish species usually associated from becoming established.

Building partnerships within the target area and with leadership that influence plan implementation is crucial for its success as a template to improve water quality in the Little Elkhart River drainage. Partnerships were successfully achieved with an aggressive mailing campaign, numerous public meetings, announcements of the plan at other county functions, newspaper articles, and one-on-one contacts with landowners residing in the sub-watersheds. As a result of the outreach program the public is well aware of the plan, its purpose, and what it can do for them in the quest for cleaner water.

Public Input

Public meetings were held periodically during the development of this plan. Announced public meetings were held within the watershed every six months during the first 18 months after initiation. The inputs from these meetings provided valuable guidance in both the water testing and land use inventory phases. Many smaller meetings were held each quarter to provide input in an informal setting. The informal meetings proved to be the most useful in securing valuable information. The last three announced public meetings were held during the final 6 months to ensure all major concerns had been addressed. Formal presentation of the completed plan was presented on 10 April, 2007.

The public expressed concerns and input within the sub-watersheds from the beginning of the outreach program. However, after the first public meeting it became evident that Amish residents were reluctant to voice opinions in public. Instead, they would voice their concerns in a more private, one-on-one situation. Once the plan development became common knowledge, landowners would phone, write, speak out after public meetings, and voice their concerns/input directly to individuals working on the management plan. In many cases information came from residents that did not attend meetings but learned of the plan through others with more direct knowledge. Public opinions are expressed throughout this document but a consolidated list is below:

1. Many had concerns over livestock in the ditch system. This continually came up at all public meetings. Although not all landowners agreed it was a serious problem the majority recognized the NPS pollution potential. In most cases those concerned were located immediately downstream of problem areas.

2. Barnyards with direct runoff access to ditches were mentioned at each public meeting. These problem areas were clearly visible to all landowners and perhaps esthetics of the situation played an equal role in their identification. No matter what the motivation, landowners surrounding these locations clearly had concerns.

3. Improperly installed septic systems came up at the second public meeting. The concern was centered on septic systems that might be “straight-piped” directly into the ditch or those connected into field drainage tiles. Several locations of potential violations were called into the SWCD office or given to committee members to include in the investigation of land use.

4. Improper usage of chemicals in surface waters was relayed to the Amish committee members after a public meeting. In this specific case a landowner was dumping battery acid into a pond adjacent to an open ditch. The purpose was to lower the pH for irrigation onto blueberry patches to help induce better growth. This problem

was addressed immediately by advising the landowner of alternative solutions to help with blueberry growth. The situation will be monitored closely.

5. Rapid population growth in the area was expressed at every meeting. The community clearly recognized the problems associated with increased population. Some expressed concerns over construction, both housing and the cottage industry. Initially, the concern seemed to be associated with land availability for such growth not water quality. However, after the first public meeting presentation the connection with water quality became apparent to all.

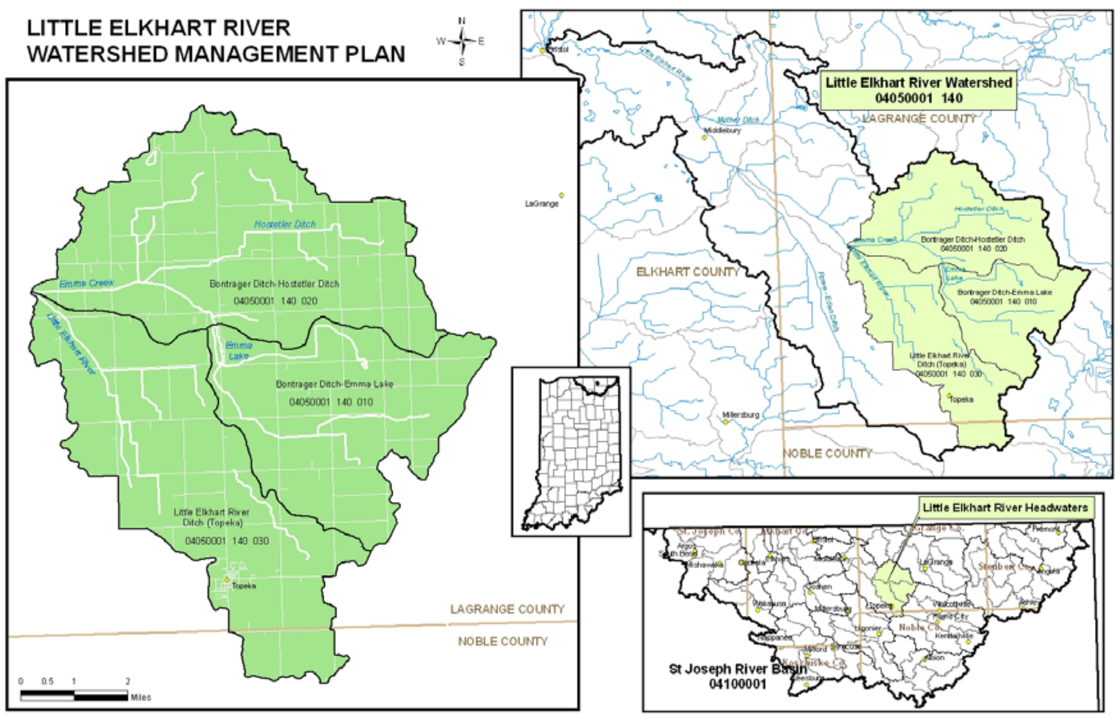
Steering Committee

Plan development was lead by a steering committee made up of watershed landowners, county, state, and federal officials and met each quarter. The landowners had equal representation from the Amish and English communities and represented both business and farming interests. County representation consisted of a commissioner, surveyor, public health officer, and the SWCD. The state was well represented by the region's state representative, Purdue University Extension, and Indiana's newly formed Department of Agriculture. Federal representation was from the NRCS District Conservationist. Together this group provided a well-rounded forum whose guidance was crucial in developing this plan, and will prove essential in its implementation.

Description of Watershed

Location and Size

The watershed management plan comprises the headwaters region of the Little Elkhart River located in West-central LaGrange County, Indiana. Specifically it involves three 14 digit Hydrologic Unit Code watersheds; Bontrager Ditch-Emma Lake (04050001140010), Bontrager Ditch-Hostetler Ditch (04050001140020), and Little Elkhart River Ditch-Topeka (04050001140030). Bontrager Ditch-Emma Lake has a surface area of 8,691 acres, Bontrager Ditch-Hostetler Ditch with 13,240 acres, and the Little Elkhart Ditch-Topeka covering 11,883 acres for a total surface area of 33,814 acres. The map below depicts the three sub-water shed's location within Indiana, the St. Joseph River drainage, and the Little Elkhart River drainage.



Geology, Topography, and Hydrology

The entire watershed is located within northeastern Indiana's glaciated till plain. Subsoil levels are made up almost exclusively of course glacial deposits; sand and gravel. Surface soils are primarily loamy outwash material. General soil patterns indicate the majority of the area is Bayer-Oshtemo with a small portion falling into the Gilford category. Bayer-Oshtemo are very well drained, medium to moderately course textured soils and Gilford comprising very poorly drained, moderately course to course textured soils.

The topography is unremarkable with a relief of only 35 feet. The lowest areas are 890 feet above sea level with the highest reaching 925 feet above sea level.

The hydrology of the watershed is influenced by the glacial till overlying Mississippian age bedrock. Moving surface waters are generally restricted to a ditch system to enhance drainage of agricultural ground and comprises approximately 71 miles in linear length. With a high water table combined with porous soils, moderate rain events constitute significant rises in flowing surface waters. Emma Lake's inflow comprises two ditched inlets and a single outlet. Rainbow Lake is controlled solely by water table levels, precipitation, and with a small finger ditch on the south side.

Land-Use and Natural History

LaGrange County was first organized on May14, 1832 with the first settlement near Howe where the Pottawatomi Indianans had established a village on the Pigeon River. The first county seat was at Lima and later moved to the town of LaGrange due to its central location. In 1844 a new courthouse was constructed that still is in use today. Lagrange County has held an annual agricultural fair since 1852; the longest history of such an event in Indiana.

The headwaters region of the Little Elkhart River was primarily settled by English immigrants for its fertile soils that were conducive for agricultural. Eden Township was named for those fertile soils. Amish immigrants have a more recent history but today comprise the majority of residents within the watershed. Agriculture is the primary land use in this region.

Population

The total population for LaGrange County taken during the 2000 Census was 34, 909 which places it in the midrange of populated counties in the state. The Amish community comprised 37% or slightly over 12,900 individuals. An interesting fact is Lagrange County is ranked as 14th in Indiana for population increase and the headwaters region of the Little Elkhart River is the fastest growing area within the county. According to the U.S. Census Bureau, LaGrange County's current population has grown to 37,291 or a 7% increase since the last full census. The rapid growth is primarily within the Amish community that comprises nearly 75% of the population within the headwaters region targeted by this watershed management plan. The population estimate for the three HUCs is 8,900 individuals. It is estimated that 7120 (80%) individuals are on septic systems. The remaining 1780 individuals are on the town of Topeka's wastewater treatment system.

Water Quality Testing

Water quality testing began in June 2005 and continues through March 2007. Due to the time constraints for publication of this document, only 19 months (June 2006 – December 2006) of data will be included for initial analysis. Proceeding data will be included as an addendum at a later date. It is felt little change will occur in results over the final several months that could alter conclusions determined from the first 19 months of the testing cycle.

A synoptic study approach was selected to give a representative analysis of the entire study area. Six sites per HUC, for a total of 18, were selected with 3 additional sites added in February 2006. Site TPK1 was added to offset site 11 which had no flow for most of the testing cycle. TPK2 was added to isolate high total phosphorus loading coming from the town of Topeka. RH1 was added to convince the landowner of site 5 that he indeed was contributing NPS pollution to Emma Lake.

Parameters collected and analyzed monthly at each site were pH, temperature, dissolved oxygen, total dissolved solids, turbidity, *E. coli*, nitrates, total phosphorous, total suspended solids, and biochemical oxygen demand. Flow data was collected at sites 1, 2, 3, 6, 9, 12, 13, 15, and 16. In addition a continuous flow monitor was installed at the confluence of all three HUCs (Figure 1). For a detailed explanation of sampling procedures see the Quality Assurance Project Plan, Appendix 12.

After data analysis was completed, site 11 data was excluded due to bias. The site demonstrated extended periods of zero flow resulting in extreme bias during the collection of samples. Since the water level was low it was virtually impossible to collect without sediment agitation resulting in levels of nitrates, total phosphorus, turbidity, and total suspended solid that were not representative. Statistical checks for outliers clearly demonstrated that site samples were compromised.

Data is presented in chart form to provide a visual representation for ease of interpretation. Although each chart is not mentioned specifically, the data are available for each site as a comparison in developing a full understanding of water quality throughout the headwaters region of the Little Elkhart River. In addition pay close attention to “Y” axis labeling since recorded levels can vary substantially between sites.

Analysis

The parameters sampled for analysis were selected for several important reasons. First, they indicate the general health of the aquatic system. For each parameter there is a value range considered normal if the surface waters are not experiencing a detrimental influence, whether caused by natural or human inputs. Second, if thresholds are exceeded these selected parameters help in isolating the cause of pollution aiding in implementing a solution.

pH

During the testing cycle pH generally remained within normal limits (6.5-8.5) and is unremarkable even though some site readings remained more stable than others (Figures 2 -8). There was significant statistical difference between HUCs, but again levels were within normal limits (Appendix 1**)**.

Temperature

Temperature cycled with seasons as expected (Figure 9), however there was no statistical difference between HUCs (Appendix 2). Temperature ranges by site are displayed in Figures 10-15. Temperature did play a role in dissolved oxygen levels as expected; regression analysis demonstrated a positive correlation.

During the summer months temperatures did not reach levels that would be considered detrimental to most macroinvertebrate or warm water (>20°Celcsius) vertebrate life. On several sites various fish, clam, and mussel species where observed throughout the testing cycle. These sites coupled with high dissolved oxygen levels demonstrated an abundance of life. More details on biology will be given during the macroinvertebrate section.

Dissolved Oxygen

Generally, dissolved oxygen remained at good to high levels throughout the majority of the headwaters region (Figure 16-22). However, sites 7 and 8 (Figure 19) demonstrated consistent low dissolved oxygen during the warmer production months. Both sites were "choked" with vegetation, both rooted and non-rooted. Flow rates were restricted and likely contributed to low levels that were recorded.

Site 12 dissolved oxygen levels (Figure 20) were consistently higher than any other sites throughout the testing cycle. This site had sand/gravel bottom with shallow ripple areas both upstream and downstream. Flow rates were good throughout testing. Ripple areas coupled with good flow contributed greatly to the high dissolved oxygen levels observed.

There was a strong statistical difference between HUCs (Appendix 3) and generally can be explained by higher flow rates, more ripple areas, and deeper water levels on the Bontrager Ditch–Hostetler Ditch HUC.

Total Dissolved Solids

Total dissolved solids remained consistent in the midrange level throughout the testing cycle (Figure 23). Statistical analysis demonstrated weak significant differences between sites or HUCs (Appendix 4). Individual site readings can be found on Figures 24-29.

Turbidity

Generally when looking at the headwaters as a whole, turbidity remained fairly low. However, virtually every site experienced an occasional spike (Figures 30-36). In many instances spikes could be explained by visually observing livestock in the ditch system upstream of the test site. A good example was test site 14 (Figure 35) which demonstrated higher readings throughout the testing cycle. The cause of the higher readings could be explained by visual confirmation of livestock disturbances upstream.

Another example is test site 12 (Figure 34) which remained clear with one exception. In this case the cause was traced to livestock released into an upstream pasture after heavy rainfall. Ditch bank damage made by livestock was evident with large volumes of material pushed directly into the ditch channel.

Spikes in turbidity after a heavy rainfall event were evident. Visual inspection of livestock induced ditch bank damage after major rain events clearly demonstrated fresh erosion from increased water levels and flow. In every situation that involved damaged banks, deposits of soil material was observed directly downstream. On sites 2, 12, 13, 14, 15, and 17 heavy deposits occurred directly downstream of each site after a 4-6 inch rain event. In the case of site 2, surface water dynamics were changed significantly, resulting in relocation of flow sampling 15 feet upstream. Further discussion of ditch bank damage is in the land use inventory section.

Lack of crop field buffering was a contributing factor in turbidity spikes after heavy rainfall. Field observations found soil deposits at the edge of ditch banks with clear signs of these deposits moving over the bank edge and reaching moving surface waters. An excellent example is site 8 where a large spike occurred on 3 October 2006 after a major rainfall event. In this case soil deposits were observed extending from field edges down the ditch bank. In addition this site had clear signs of bank sloughing from the increased flow and direct field runoff. The land use inventory section will discuss this problem in more detail.

Although difficult to estimate sediment contributions, natural streambed erosion must play some role in increases in turbidity levels after high rainfall events. However, turbidity levels were much higher at sites that had livestock induced damage to the bank system and sites with little crop field buffering.

Statistical analysis did show a significant difference between the Bontrager Ditch-Hostetler Ditch and the Little Elkhart River Ditch-Topeka (Appendix 5). Bontrager Ditch-Emma Lake fell in the middle with similarities to the other two HUCs.

Overall observations indicated that livestock in the ditch systems and damaged ditch banks are the leading cause for higher turbidity readings. Lack of field buffering was a contributor but at a lower level.

E.coli

E.coli generally remained at high levels throughout the testing cycle although wide fluctuations occurred at each site (Figures 37-45). The lowest concentrations where found during the winter when livestock was restricted due to ice and frozen ground. During cold months livestock spent little time in the water but chose to drink from the edge and depart immediately after getting their fill. However, during most of the year livestock readily moved directly into ditch channels where they were observed "loafing" during extremely high ambient temperatures. On many occasions they were observed urinating and defecating directly into the surface waters upstream of water testing sites.

The late summer and fall period of 2006 was extremely wet with above average monthly total rainfall. Many testing sites had increased levels of *E.coli*. There may be several contributing factors. First is increased runoff from barnyards and adjacent pasture areas. Another factor may be increased runoff from fresh manure on roadways. Since the area is predominately Amish, road surfaces contain a higher level of manure. With surrounding soil completely saturated for an extended period it is likely there is some influence from roadway runoff after heavy rainfall events. A second influence may be faulty or improperly installed septic systems. Although this is impossible to tell from the testing methods used, there is other circumstantial evidence. Past health department well testing did indicate up to 80% of the wells contained high levels of nitrates. With ground saturated, lateral flow from faulty or failed septic systems was possibly occurring, especially with the very porous soils in the headwaters region. Other evidence is septic systems that hook directly into tiles or "straight pipe" directly into ditches. Both examples were found during the land use inventory. Although DNA analysis is controversial today for separation of species specific *E.coli*, it would be beneficial to separate human as a group. Until separation is possible it will be difficult to know the exact influence.

The *E.coli* levels observed are a direct human health risk in the region. Several of the deeper pools (usually associated immediately downstream of road crossing culverts) are used by local children for swimming. With the EPA excepted level of no more 235 colonies/100ml of water for full body contact, these pools are not safe for swimming activities.

Loading calculations produced large numbers of colonies within surface waters on a yearly basis. Bontrager Ditch-Emma Lake averages 166.944 trillion colonies per year, Bontrager Ditch-Hostetler Ditch with 508.252 trillion colonies per year, and the Little Elkhart River Ditch-Topeka with a yearly average of 100.095 trillion colonies. These numbers are difficult to grasp, but an acceptable number would be approximately 50 trillion colonies per year. To achieve this target loading, the yearly average for each site should not exceed 2000 colonies per 100mls of water. More discussion on this topic occurs in the Land use inventory section.

Statistical analysis demonstrated no significant difference between HUCs (Appendix 6) but clearly *E.coli* is a major NPS pollutant in all three HUCs.

Nitrates

Nitrates generally remained in the low to moderate range (ten mg/l would be considered high and unsafe to drink). However, there were several sites 16, 17, and 18 (Figure 52) that consistently tested higher. In several cases readings exceeded 10mg/l which is cause for concern. These sites have livestock influence but also have suspect septic systems. Public involvement revealed some septic drains connected directly to area tiles or tiles ran directly beneath septic drain fields. In one instance a direct pipe from gray water was suspected to be directly upstream of site 18. Another influence was the extremely wet year the region experienced so lateral flow may be an influence.

Almost every site (Figures 46-53) experienced spikes associated with high rainfall events. Test Site 2 (Figure 47) was an interesting case of fluctuating levels. Directly upstream of this site livestock are commonly observed in the ditch and the dirt barnyard slopes gently to the ditch. There is virtually no vegetation to inhibit nutrient flow after rainfall. In this case it is likely livestock alone causing the sudden spikes in nitrate levels.

Another interesting site is TPK2 (Figure 50) which averaged as the 4^{th} worst (Figure 53). This site is the storm water discharge for the town of Topeka and must be accessed through a “manhole” cover. Storm water discharge is separated from the wastewater treatment facility which gives us insight to runoff problems. The treatment facility consistently tests very low on nitrates but the storm water drainage tests fairly high. A unique aspect of this town is the Amish transportation influence that leaves considerable manure deposits on the street system. The town does clean manure from the streets but this year has been unusually wet with high rainfall events. This makes manure pick-up difficult at best. The town also has a livestock sale barn on the northern edge that concentrates horse traffic several times weekly. Evidence suggests manure is a significant influence. Another aspect is lawn fertilization. Although difficult to quantify, research in other areas of the country have demonstrated this is a real concern and likely an influence on nutrient loading.

Loading calculations can be seen on Figures 54 and 55. The Bontrager-Hostetler Ditch drainage clearly stands out with the highest level of loading with 41.8 tons or 37.9 metric tons per year of nitrates flowing within the system. Little Elkhart Ditch-Topeka follows with 15.6 tons or 14.2 metric tons per year and lastly the Bontrager Ditch-Emma lake tributary with 4.9 tons or 4.5 metric tons per year. See the water flow section for more details on loading calculations.

Statistical analysis demonstrated a significant difference between HUCs (Appendix 7) with Bontrager Ditch-Emma Lakes and Little Elkhart River Ditch-Topeka tributaries being similar and the Bontrager Ditch -Hostetler Ditch system with higher levels.

Total Phosphorus

Total phosphorus (TP) varied among sites (Figures 56-63) with most sites averaging close to the 0.3 mg/l target limit set for these tributaries. The two worst sites were TPK1 and TPK2 (Figures 60). Again we have some interesting historical data from the wastewater treatment facility to help draw some conclusions to the cause. As mentioned in the nitrates section, TPK2 is the storm water discharge for the town of Topeka. TPK1 (Figure 1) is slightly downstream after the discharge has entered the open ditch system. Figure 63 shows an average decrease in TP but it remains well above the 0.3 mg/l target. The wastewater treatment facility consistently tests at or below 0.1 mg/l so it has little influence on the TP levels entering the ditch. Again, runoff must be a major contributing factor as mentioned in the nitrates section. Over-fertilization of lawns within the town is highly suspect. The wet year with above average rainfall likely resulted in many fertilizers being washed into the storm water system and carried downstream. Of course manure runoff plays a significant role in this scenario as discussed in the nitrates section.

Sites 8, 10, and 14 had excessive levels of TP (Figures 59 and 61). Site 8 can be attributed to a few spikes but sites 10 and 14 remained consistently high. It is difficult to isolate all causes for these two sites but site 14 clearly had significant ground disturbances occurring upstream as evidenced by turbidity and total suspended solids data levels. Livestock influences are the likely source for site 14.

Statistical analysis demonstrated a significant difference between HUCs with Bontrager Ditch-Emma Lake and Bontrager-Hostetler Ditch being similar and the Little Elkhart River Ditch-Topeka having the highest levels (Appendix 8). However, when comparing loading (Figures 64 and 65) Bontrager Ditch-Hostetler Ditch comes out on top with 5.2 tons or 4.8 metric tons per year. Little Elkhart River Ditch-Topeka had load calculations indicating 3.6 tons or 3.2 metric tons per year. The Bontrager Ditch-Emma Lake tributary was significantly lower with 1.1 tons or 1 metric ton per year. Again this is flow relation that is discussed in the water flow section below.

Total Suspended Solids

Generally total suspended solids (TSS) remained fairly low (Figures 66-73). However, large spikes did occur after high rainfall events, livestock activity directly upstream, upstream, ditch dredging, and with new construction next to the ditch matrix. As mentioned in the turbidity section above, site 14 (Figure 71) tested higher than the other sites. The cause was livestock with direct access to the ditch. Livestock induced influences is the major cause of sedimentation.

Statistically there was no significant difference between HUCS on TSS data (Appendix 9). However, coupled with flow data, Bontrager Ditch-Hostetler Ditch (HUC 20) had the highest results with 251 tons or 227.8 metric tons per year (Figures74 and 75) flowing in the system. The Little Elkhart River Ditch-Topeka (HUC 30) followed with 161.5 tons or 146.6 metric tons per year with the Bontrager Ditch-Emma Lake (HUC10) tributary considerably lower at 43.7 tons or 39.6 metric tons per year. Sedimentation of the little

Elkhart River system is certainly a concern. The target is a reduction from a current total of 456.2 tons yearly to 205.2 tons.

Biochemical Oxygen Demand

Biochemical oxygen demand was somewhat scattered (Figure 76) but statically there was no significant deference between HUCs (Appendix 10). Looking at site averages (Figure 83) the sites varied from 26 to 50% consumption of dissolved oxygen during the incubation stage. All sites did have spikes in consumption rates (Figures 77-82), but the values overall were within reasonable levels.

Flow

Flow was calculated by several methods during the testing cycle. Automatic level sampling was collected using a flow monitor located at the confluence of the three target HUCs (Figure 1). Manual calculations using a flow meter were collected at the sites mentioned in the paragraph below. A cross section of elevation was taken at each sampling site and entered into a HOBOware software package provided with the flow monitor. Flow data was then entered into the HOBOware software package to establish a modified Manning Curve allowing calculations of nutrient, total suspended solids, and *E.coli* loading of the surface waters.

Average flow by site can be seen on Figures 84 and 85. Sites 9, 12, 13, and 15 stand out with highest averages. Site 9 has numerous springs that feed into the ditch just upstream resulting in a significant and consistent flow throughout the testing cycle. When examining flow by HUC (Figures 86 and 87), Bontrager Ditch-Hostetler Ditch (HUC 20) and the Little Elkhart River Ditch-Topeka (HUC30) were similar. The Bontrager Ditch-Emma Lake (HUC 10) had significantly less flow throughout the testing cycle. Couple flow data with nutrient data it becomes clear why loading was higher on HUC 20. For example total phosphorus was higher in HUC 30 but HUC 20 is contributing a higher load downstream because of the higher flow.

Statistical analysis demonstrated a significant difference in flow between HUCs. Although there are differences in comparisons; HUC 10 and HUC 30 were similar and HUC 20 and HUC 30 were similar. HUCS 10 and 20 were separated significantly (Appendix 11).

Macroinvertebrates

Macroinvertebrates were sampled on four occasions (July 2005, October 2005, July 2006, and October 2006) during the testing cycle. During sampling point values were established based on the variety of macroinvertebrates observed. These values were then averaged and assigned a rating of poor, fair, good, or excellent. Site 11 was removed from analysis for the other parameters listed above. This site for the majority of the testing cycle had zero flow and generally was a stagnant pool. However for macroinvertebrate sampling it does represent what can be expected in areas that remain stagnant for much of the year. The results are listed below.

Site	**Rating**	**Site**	**Rating**	**Site**	**Rating**
1	Good	7	Good	13	Excellent
2	Fair	8	Fair	14	Excellent
3	Fair	9	Good	15	Excellent
4	Excellent	10	Fair	16	Good
5	Good	11	Poor	17	Good
6	Good	12	Excellent	18	Fair

Generally macroinvertebrates are established and doing well within the headwaters region of the Little Elkhart River. However, most sites did have variations during the sampling cycle. Sites 12, 13, 14, and 15 consistently resulted in an "excellent" rating. These sites have sand/gravel substrate, good flow year-round, and have the typical ripple/pool development generally associated with main channel streams.

Land Use Inventory

The land use inventory consisted of visual inspection of all lands adjacent to surface waters along the ditch system and a minimum of 50% of all lands not adjacent to surface waters within the three target HUCs. This approach provided valuable insight when correlating water testing results with land use practices, especially when testing indicated high levels of NPS pollution. Another benefit was landowner contact. A positive relationship was built with many community residents which will prove crucial during the implementation phase.

Figure 88 displays all layers collected during the land use inventory and demonstrates the total area visually inspected. The figure clearly shows that the objectives outlined in the previous paragraph were met. The various color coding and symbols give a synaptic view of data differentiation and construes the magnitude of the data. Breaking data into each layer is necessary for explanation and for affective viewing. This breakdown is described below.

Figure 89 displays ditch extensions that due not appear on the hydrology layer. Mapping these extensions is important in several respects. First, they tie together drainage by including unmapped finger ditches and isolated finger ditches that connect to main ditch channels by subsurface tile. Second, this is very important in understanding NPS pollution flow patterns and isolating critical problem areas associated with water quality test data interpretation. The county surveyor, whom serves on the steering committee, proved invaluable in subsurface tile location.

Surface water drainage with unmapped extensions total 179,004 feet for Bontrager Ditch Emma Lake; 109,687 feet for Bontrager Ditch-Hostetler Ditch; and 87,740 feet for the Little Elkhart River Ditch-Topeka. This is a sum total of 376,431 feet or 71.29375 statute miles (114.7117 kilometers) of surface waters with major tiles tying finger ditches into main channels for all three HUCs.

Figure 90 depicts traditional row crop plantings and constitutes approximately 30% or 10,144 acres of surface area for the headwaters region. This is important because in surrounding agricultural areas that do not have a high Amish population this percentage is generally much higher; in some cases approaching 65%.

A significant problem with the cropped areas along ditches is that only 2% percentage have buffers installed. It is estimated that 400 acres of filter strips must be planted throughout the headwaters region at a cost of $260,000.

In addition, the inventory revealed that no-till practices are not being employed in this region. This is important in the implementation phase of this project. Landowners must be targeted and encouraged to participate in Farm Bill no-till incentives to reduce NPS pollution inputs.

Figure 91 displays hay fields in the target HUCs. These fields make up approximately 4% or 1352 acres of surface area. In most cases hay fields are periodically rotated with pasture or row crops.

Figure 92 is a visual representation of pasture within the headwaters region. These fields constitute approximately 55% or 18,598 acres of surface area. This is very important since in other agricultural areas this number is closer to 20%. It is clear that the Amish community utilizes the land for livestock. However it is important to note that pasture is traditionally rotated with row crops but the relative percentages between both land use practices remains somewhat stable. Another important inference is that with such an increase in pasture ground there is a dramatic and more uniform livestock influence in the region.

Figure 93 depicts pastured woodlots. This a minor influence in most respects with less than 1% of surface acres under influence or approximately 300 acres. In a few areas these woodlots remain wet much of the season which causes some concern for NPS pollution infiltration into surface waters due to livestock access. However this influence is considered minor.

Fenced areas along open surface waters are shown on Figure 94. Standing alone it reveals little information, however when combined with livestock access (Figure 95) the problem of livestock influence on surface waters emerges very clearly. From this point it gets somewhat complicated in calculating just how much of the ditch system has livestock access. Approximately 30% of the ditches have some access or 113,000 feet. Of that rather large number approximately 35,000 feet needs fenced. The remaining footage has fence but livestock are aloud to freely access the ditch bank side either all year or part of the year. In this case exclusion is somewhat simple by providing alternative watering sources. In the case of new fencing many of the fields have partial fence on some of the field perimeters. Since the entire perimeter of each field adjacent to surface waters (not just the field edge that is directly adjacent to ditch banks) will require livestock exclusion, it is estimated that at least 65,000 feet of fence will need to be installed to complete livestock exclusion at a cost of $130,000.

In the case of alternative watering there is not a simple solution. Many landowners insist in having some limited access to the system for watering livestock. In these cases rocked crossings or watering areas with very limited access to surface waters will be installed. To ensure livestock remain on rocked areas fencing along or around the in-water perimeter will be required. It is estimated that a minimum of 75 sites will need some type of alternative watering system, either limited access or complete exclusion systems. This will cost approximately $112,500.

Figure 96 displays livestock access problems very well and presents an overview to the seriousness of the situation and the influence it has on NPS pollution within the ditch system. Coupling this figure with water quality testing results reveals a focused pattern as to the sources of much of the NPS pollution contribution to the ditch system. Livestock access to open surface waters is the leading cause of direct NPS pollution influx. There are 43 known ditch bank damage areas within the headwaters region. It is estimated the cost of repair will be a minimum of $110,000. In addition it is estimated that 10 waste management systems will need to be installed at a cost of $200,000. There are 3 major barnyard problems that will need addressed during implementation of this plan. This cost it difficult to estimate but $200,000 is not unrealistic.

Sensitive areas which consist of wetlands either swamps, marsh, or wooded can be seen on Figure 97. These are classified as sensitive for their filtering characteristics in removing surface water contaminants. Sensitive areas constitute approximately 2% of the surface area or 675 acres. Preservation of these remaining areas is essential.

Although much more difficult to control, and not shown on the sensitive areas figure, woodlots constitute only 5% of or 1700 acres of the surface area. This is a small percentage when compared with other parts of Northeastern Indiana. Wooded areas do serve as significant soil stabilizer and future management plans must consider the loss of the few remaining woodlots as a negative impact.

Impervious surfaces, such as roads, buildings, driveways, etc., constitute nearly 4% or 1350 acres. This number is important because construction in this region continues to accelerate. Surface water runoff models clearly demonstrate when impervious surface levels reach 10% of the total, severe flooding can occur even with minor rainfall events. Any future management must consider the growing population and increased impervious surfaces that inevitably follow.

Conclusion

A brief summarization of data is in order to bring all sampling into perspective. First the critical areas are defined as locations that need filter strips (Figure 98), fencing for livestock exclusion (Figure 99), and ditch bank damage repair (Figure 96). Location of these sites can easily be construed from the land use figures. In addition traditional farming practices adjacent to the ditch system (Figure 98) need to be replaced with no-till practices. Water quality testing and the land use inventory clearly demonstrated the most dramatic affect on reducing NPS pollution is to address the above issues immediately upon plan implementation. BMP priority is listed below:

1. Fence livestock from surface waters. This will have an immediate impact in reducing nutrient, sedimentation, and *E.coli* loading. Alternative watering source installation will be required.
2. Repair ditch bank damage. After livestock have been fenced from surface waters, stabilizing bank damage will reduce sedimentation after heavy rainfall events.
3. Install filter/buffer strips. In many cases this BMP will be included with fencing/bank repair. After fencing/bank repair issues have been addressed, ditch bank buffering in association with traditional row crop practices should follow. Conservation tillage will be encouraged in conjunction with buffering.
4. Install waste management systems on barnyards adjacent to surface waters. This is an important BMP but will require time to implement. Special engineering designs are required.

Using the EPA Region 5 load model a significant reduction in nitrates, total phosphorus and *E.coli* can be archived by implementing all BMPs associated with the problems discussed in the previous paragraph. According to calculations a 55% reduction in sedimentation and nitrates will occur. Reviewing Figures 74 and 54 this equates to 251 tons/year reduction in sediments, and 34.3 tons in nitrates for the headwaters region. The model indicated a 71% reduction in phosphorus. Figure 64 displays current loading; this equates to a reduction of 7 tons/year in phosphorus loading and allows achievement of reducing annual average readings of 0.3 mg/l. Although much more difficult to estimate, load reduction calculations suggest *E.coli* can be reduced by as much as 55% which brings the target loading discussed in the water quality testing section of 50 trillion colonies average for all three HUCs much closer to reality to reality. The table below will help visualize the **yearly reduction** of each contaminant, *E.coli* numbers are given in trillions of colonies:

	HUC 10	HUC 20	HUC 30	Total
Nitrates	2.7 tons	23 tons	8.6 tons	34.3 tons
Phosphorus	0.8 tons	3.7 tons	2.5 tons	7 tons
Sediment	24 tons	138 tons	89 tons	25 tons
E.coli	91.8	279.5	55	426.3

BMP Costs

The cost estimate for implementation is as follows:

Filter Strips (buffers)	$ 260,000
Fencing	$ 130,000
Alternative Watering	$ 112,000
Bank Stabilization	$ 110,000
Waste Management Systems	$ 200,000
Barnyard Relocation	$ 200,000
Conservation Tillage	$ 60,000
Monitoring (Supplies/Equipment)	$ 40,000
Contracted Personnel	$ 500,000
TOTAL	**$1,612,000**

There are many sources of funding available to accomplish implementation. Currently, a paired watershed study is underway to validate plan implementation. This is funded by an EPA 319 Grant through the Indiana Department of Environmental Management. In this study the Bontrager Ditch-Emma Lake HUC will be the treatment with Bontrager Ditch-Hostetler Ditch HUC the control. Monitoring both water quality and land use will continue for an additional four years. A two year study underway is funded by the Great Lakes Commission for $75,000. Two demonstration sites, one in the Bontrager Ditch-Emma Lake HUC and the other in the Bontrager Ditch-Hostetler Ditch HUC, have been established to gather livestock movement data and as an educational tool for headwater residents. A Lake and River Enhancement Grant through the Indiana Department of Natural Resources for $318,000 has been received with work beginning this spring. Many of these funds will be used for waste management systems, conservation tillage, bank stabilization, and filter strips. A 319 Grant awarded to the LaGrange County Pheasants Forever Chapter 592 will focus plantings in 2008 in the headwaters region. Farm Bill programs will be focused in the region to assist in funding efforts. A commitment letter from the Natural Resource Conservation Service giving high priority to our efforts is in hand. The majority of outreach will be paid through Lagrange County and through volunteer help.

Private endowments and industry will be solicited for donations. A local Recreation Vehicle manufacturer in Topeka has pledged donating a large specialty vehicle for water quality lab expansion. This expansion is anticipated to accommodate additional field personnel and will be housed at the Lagrange County Soil and Water Conservation District’s Natural Resource Learning Center.

Watershed Problems and Sources

Up to this point problems have been discussed throughout the document. Below is a consolidated list for quick reference. Although there are many isolated situations causing degradation, **ten major contributors** have been identified. These sources have been expressed at public meetings held during the development of the plan, by the steering committee, by historical data, water testing program, and through the land use inventory. First, it is important to review the water testing results that reveal the NPS pollution problems. The list below indicates degraded water quality and outlines the **true problems** within the headwaters region:

- Total Phosphorus exceeds the target 0.3 mg/l average at most sites.
- Nitrates occasionally exceed the water quality standard of 10 mg/l.
- Average sedimentation exceeds yearly target loading of 205.2 tons.
- *E.coli* consistently exceeds 235 colonies per 100mls of water.

Now that we know what the problems are, what land uses are causing the degradation? These are the sources of the problems listed above that need addressed to improve water quality at or below the target threshold. These sources are listed below:

1. *Direct livestock access to surface water system.* During the land-use inventory over 30% of surface waters within the target Hydrologic Unit Codes have direct access resulting in high total phosphorus, nitrates, *E.coli*, and sedimentation levels. The sedimentation is a result of livestock induced ditch bank erosion and nutrients are from animal waste.
2. *Direct barnyard runoff into surface waters.* Several barnyards throughout the watershed have cemented barnyards tapering or “stair-stepping” directly into ditches. This is a significant source of nutrient and *E.coli* loading even after minor rainfall events.
3. *Livestock Manure Management*. LaGrange County has ordinances addressing manure management for new or expanding livestock operations with 50 or more animals. However, a great number of landowners within the target area have fewer than 50 animals and are not required to have a filed manure management plan approved by a specialist.
4. *Lack of Proper Ditch-Bank Buffering***.** Approximately 2% of the ditch-bank system that contain row crops have proper filter strips to reduce sediment runoff.
5. *Nutrient and Pest Management.* Conventional grain crop practices continue to dominate many agriculture fields in the watershed. Research has clearly demonstrated that no-till and reduced-till practices significantly reduce nutrient, sediment, and pesticide runoff from reaching surface waters. Although pesticide contamination was not evaluated for this plan, it is likely occurring and convincing producers to switch to no-till/reduced-till practices will reduce the problem.
6. *Improper or Faulty Septic Systems.* Lagrange County has a history of high nitrate levels in fresh water wells. Nutrient levels have exceeded EPA/IDEM Standards

in up to 80% of resident wells tested by the county health department. This has been attributed to porous soils, shallow wells, in a small number of cases improper manure management, and improper or faulty septic systems. In addition, there are residents hooking septic discharge to tile drainage systems resulting in direct contamination of the ditches. With the documented data for well contamination, it is suspected that water saturated soil is conducive to lateral flow of nutrients into surface waters.

7. *Urban Runoff*. Topeka is the largest urban area within the HUC 14 watersheds addressed in this plan. Water quality testing has shown the high levels of total phosphorus emanating from the storm water discharge. It is speculated that lawn fertilization is the likely cause. Other potential problematic toxins that enter surface waters through storm water runoff were not tested. However, their presence is nearly assured but the concentration levels are unknown. The town of Emma, much smaller than Topeka, similarly contributes to NPS pollution runoff but at lower concentrations.
8. *Impervious Surfaces.* The impervious surface area has reached 4% in the target area and continues to grow annually. This is due to the increasing population and industrialization. Impervious surfaces increase runoff flow levels after rainfall events resulting in increased NPS pollutants moving into surface waters. The unique aspect of this region is horse drawn vehicles make up a significant portion of the traffic. After moderate to significant rain events manure runoff from roads and parking lots is suspect in contributing nutrient/*E.coli* loading in surrounding surface waters.
9. *Population Increase.* With the rapidly growing population, zoning issues have become complicated for county leaders. Water quality concerns are addressed in county ordnances but will need periodic review.

Goals and Objectives

The Little Elkhart River Watershed Management Plan seeks to improve water quality in the river by addressing non-point source pollution in the headwaters region. To accomplish these goals and objectives a broad stakeholder group must be established and maintained throughout the implementation phase. In addition, it is important for this group to expand efforts throughout the Little Elkhart River drainage in both planning and implementation not only to improve water quality within but to improve water quality in the St. Joseph River. Partnering with private and government institutions is vital and entails crossing county jurisdictions. This of course is a complicated task that requires astute leaders within the oversight group.

The following goals and objectives address the primary concerns of: nutrients, sediments, pathogens, and toxins. These are universal concerns throughout the river drainage and in general application these goals and objectives apply equally well downstream of the headwaters region.

Objectives are prioritized as high (implemented in zero to three years), moderate (implemented in four to seven years), and low (implemented in seven to eleven years). It is important to note that many tasks, once begun, must be maintained to prevent a "backslide" in improvements made to water quality.

Although not mentioned specifically in the land use inventory section, there is a prioritization of BMP implementation by HUC. The Bontrager Ditch-Emma Lake HUC is the first priority for several important reasons. First, BMP installation will have the most impact on NPS pollution in the short term. Second, it is the treatment in a paired watershed study that is underway. This study was mentioned briefly in the land use inventory section but is explained further in the monitoring plan section that follows goals and objectives.

The Little Elkhart River Ditch-Topeka HUC is the second priority for BMP installation for one reason only; the Bontrager Ditch-Hostetler Ditch HUC is the control for the paired watershed study. The "control" does not receive BMP installation for the life of the study. This is done to validate NPS pollution reduction in the treatment HUC. In other words, were the installed BMPs really affective or was it just yearly variations influenced by weather.

Goal #1

Establish a stakeholder group to oversee watershed management plan implementation, promote public awareness, and sustain funding to meet goals and objectives within timelines.

A Expand current steering committee to include additional key stakeholders as identified by the current committee within the watershed to enhance implementation success.

Priority
High (0-3 years)

Implementation Timeframe
Six months

Partners
Stakeholder group

Milestones
Hold meeting within first quarter

Indicators
Consensus reached on responsibilities of stakeholder group for coordinating implementation of the watershed management plan.

B Develop funding strategy to sustain implementation and administration operations costs.

Priority
High

Implementation Timeframe
Ongoing

Partners
Stakeholder group

Milestones
- Identify funding sources (6 months)
- Design funding strategy (6 months)
- Implement funding strategy (Year 2)
- Secure operational funding (Year 2/Ongoing)

Indicators
- Documented funding sources
- Grant proposals submitted
- Private funding solicited
- Records of funding received and solicited

Goal #2

Reduce agriculture induced non-point source pollution from the headwaters so that surface waters are improved.

A Install 65,000 feet of fence to keep livestock out of surface waters and provide alternative watering sources for owners identified in the land use inventory.

Priority
High

Implementation Timeframe
1-3 years

Partners
LaGrange County SWCD
NRCS
Friends of the St. Joe River Association
Indiana Department of Agriculture
Indiana Division of Soil Conservation
Indiana Division of Fish and Wildlife
Producers

Milestones
- Provide cost-share incentives to landowners (Year 1-3)
- 15,000 feet of fence installed (Year 1)
- 40,000 feet of fence installed (Year 2)
- 65,000 feet of fence installed (Year 3)
- Develop a comprehensive outreach program for continued education (Ongoing)

Indicators
- 25% reduction of nitrates after 3 years
- 55% nitrates load reduction after 5 years
- 30% reduction of total phosphorus after 3 years
- 71% reduction of total phosphorus after 5 years
- 10% reduction of total suspended solids after 3 years
- 15% reduction of total suspended solids after 5 years
- 25% reduction of *E.coli* after 3 years
- 55% reduction of *E.coli* after 5 years

B Repair 43 sites that have livestock induced ditch bank damage.

Priority
High

Implementation Timeframe
1-3 years

Partners
LaGrange SWCD

NRCS
Friends of the St. Joe River Association
Indiana Department of Agriculture
Indiana Division of Soil Conservation
Indiana Division of Fish and Wildlife
Producers

Milestones
- 10 sites repaired (Year 2)
- 25 sites repaired (Year 3)
- 43 sites repaired (Year 4)

Indicators
- 5% reduction in total suspended solids by year 3
- 10% reduction of total suspended solids by year 4
- 15% reduction of total suspended solids by year 5

C Install 10 waste management systems.

Priority
High

Implementation Timeframe
1-3 years

Partners
LaGrange SWCD
NRCS
Friends of the St. Joe River Association
Indiana Department of Agriculture
Indiana Division of Soil Conservation
Indiana Division of Fish and Wildlife
Producers

Milestones
- Provide cost-share incentives (Year 2-3)
- NRCS approved designs (Year 2)

Indicators
- 2 waste management systems installed by year 2
- 10 waste management systems installed by year 3

D Plant 400 acres filter/buffer strips where required adjacent to surface waters.

Priority
High

Implementation Timeframe
1-3 years

Partners
LaGrange SWCD
NRCS
Friends of the St. Joe River Association
Indiana Department of Agriculture
Indiana Division of Soil Conservation
Indiana Division of Fish and Wildlife
Producers

Milestones
- Provide cost-share incentives (Year 1-3)
- 200 acres of filter strips installed (Year 2)
- 400 acres of filter strips installed (Year 3)
- Develop a comprehensive outreach program for continued education (Ongoing)

Indicators
- 15% reduction of total suspended solids after 3 years
- 25% reduction of total suspended solids after 5 years

E Promote no-till and reduced-till practices on all fields adjacent to surface waters.

Priority
High

Implementation Timeframe
Ongoing

Partners
LaGrange SWCD
NRCS
Friends of the St. Joe River Association
Indiana Department of Agriculture
Indiana Division of Soil Conservation
Indiana Division of Fish and Wildlife
Producers

Milestones
- 100% landowner contact that practice conventional tillage (Ongoing)
- Provide cost-share incentives (Ongoing)
- Develop a comprehensive outreach program for continued education (Ongoing)

Indicators
- Number of producers that enroll in incentive programs
- Increase in no-till/reduced-till acreage documented with tillage transects

F Continue the water quality testing program to monitor goal success.

Priority
High

Implementation Timeframe
Ongoing

Partners
LaGrange County SWCD
NRCS Earth Team
Hoosier River Watch

Milestones
- Solicit funding sources to continue testing program
- Develop public involvement program
- Publish testing results

Indicators
- Funding secured to continue monitoring program
- Public participation in testing program
- Media releases and brochure

Combined BMP Installation Indicators
- A 25% reduction in nitrates and sedimentation after 3 years
- A 30% reduction in total phosphorus after 3 years
- A 25% reduction in *E.coli* after 3 years
- A 55% reduction in nitrates and sedimentation after 5 years
- A 71% reduction in total phosphorus after 5 years
- A 55% reduction in *E.coli* after 5 years

Goal #3

Reduce non-point source pollution from faulty or improper septic systems from the headwaters so that surface waters are improved.

A Work with county leadership to develop a comprehensive septic system plan.

Priority
Moderate (4-7 years)

Implementation Timeline
4 years

Partners
LaGrange County SWCD
LaGrange County Commissioners
LaGrange County Health Department
LaGrange County Planning Commission
LaGrange County Health Board
LaGrange County Sewer District

Milestones
- Meetings with county commissioners and appropriate county boards (Year 4-7)
- Develop outreach program (Year 4)
- Develop Comprehensive plan (Year 6)

Indicators
- Semi-annual meetings with county officials
- Educational brochure development
- Change to county comprehensive plan

B Develop a county-wide septic system inspection program

Priority
Low (8-11 years)

Implementation Timeline
8 years

Partners
LaGrange County SWCD
LaGrange County Health Department

Milestones
- Consensus from county leadership that inspection program is needed (Year 8)
- Consolidate information on existing inspection programs (Year 8)
- Inform septic system owners (Year 9)
- Faulty septic systems repaired or replaced

Indicators
- Inspection program developed
- Septic system owners contacted about inspection
- Number of faulty septic systems repaired or replaced
- Improved water quality

Goal #4

Reduce urban run-off induced non-point source pollution from headwaters so that surface waters are improved.

A Develop a comprehensive outreach program to educate urban/lake residents on NPS pollution concerns and how they can participate to improve surface waters surrounding their communities.

Priority
High

Implementation Timeline
2 years

Partners
LaGrange County SWCD
Town Leadership
Friends of the St. Joe River Association
LaGrange County Lakes Council

Milestones
- Media articles outlining urban runoff and its effects
- Brochures and flyers for urban residents
- Workshops/tours for urban/lake residents
- Bi-annual survey developed

Indicators
- Annual media articles
- Number of brochures and flyers circulated
- Attendance at workshops/tours by town and lake residents
- Survey results

Goal #5

Monitor and control impervious surfaces development in headwaters so that water quality is maintained.

A Develop a program to monitor impervious surface develop with the watershed.

Priority
Moderate

Implementation Timeline
4 years

Partners
LaGrange County SWCD
NRCS
LaGrange County Planning Commission
Purdue University

Milestones
- Monitoring program

Indicators
- Shapefile of impervious surfaces for GIS systems

B Work with county planning commission to minimize effects of new construction on surface waters within the watershed.

Priority
Moderate

Implementation Timeline
4 years

Partners
LaGrange County SWCD
LaGrange County Planning Commission
Purdue University

Milestones
- Runoff effects on surface waters considered for new building permits

Indicators
- Change to county comprehensive plan

Goal #6

Control effects of population growth on water quality through aggressive county planning.

A Work with county leadership to minimize the effects of population growth on surface waters of within the watershed.

Priority
Moderate

Implementation Timeline
4 years

Partners
LaGrange County SWCD
LaGrange County Planning Commission
Purdue University

Milestones
- New housing/personal building construction effects on surface waters considered by planning commission

Indicators
- Change to county comprehensive plan

Goal #7

Continue plan development and implementation throughout the Little Elkhart River drainage.

A Expand the Little Elkhart River watershed management plan to include the entire river drainage.

Priority
High

Implementation Timeline
1-3 years

Partners
LaGrange and Elkhart County SWCDs
NRCS
Friends of the St. Joe River Association
Indiana Department of Agriculture
Indiana Division of Soil Conservation

Indiana Division of Fish and Wildlife
Producers

Milestones

- Seek additional funding (Year 1)
- Complete additional water testing and land-use inventory (Year 2)
- Complete addendum to current headwater WMP (Year 2)
- Begin BMP implementation for additional watershed HUCs (Year 2)

Indicators

- Funding secured
- Watershed management plan for entire Little Elkhart River drainage
- Improved water quality through Little Elkhart River drainage

Monitoring Plan

Continued monitoring for land use changes and water quality is essential for success. A minimum of 7 years continuous monitoring followed by semi-annual sampling is critical. This is necessary for several reasons. First, validate the effectiveness of BMP implementation. Second, document if target loadings are achieved. Third, ensure land use changes in the future are not impairing the surface waters.

The paired watershed study for the headwaters region will provide detailed documentation in both water quality testing and effectiveness of BMP implementation. The Bontrager Ditch-Emma Lake HUC is the treatment with the Bontrager Ditch-Hostetler Ditch HUC the control. The control HUC will receive no BMP installation during the life of the study. The control is used to validate the effectiveness of BMPs that are installed. BMP installation in the treatment area will begin immediately after an additional 8 months of water quality testing has been completed. Thirty months (22 have already been completed) of data are required to establish a solid baseline. Testing will occur at the same locations used during the plan development and will follow Quality Assurance Project Plan (QAPP) guidelines. In addition the Indiana Department of Environmental Management's (IDEM) biological section will conduct a detailed "Stressor ID Study". The sampling for this will occur at 85 sites along the entire Little Elkhart River drainage. The biological and water chemistry data will be more in-depth providing valuable insight both before and after BMP installation.

Monitoring land use changes is essential. Since this area has the fastest growing population in the county, land use changes will occur on a more rapid scale. These changes can and will likely affect the water quality of the Little Elkhart River drainage if not properly monitored and managed. Lagrange County is currently developing a comprehensive GIS system to help monitor and manage important influences such as new construction. Using these GIS layers coupled with visual data collection will provide useful information. A yearly land use transect of the drainage will be conducted in conjunction with the paired watershed study.

After the study is complete, semi-annual water quality testing is essential to monitor the affects of land use changes. The Lagrange SWCD will conduct the testing and follow a QAPP established with IDEM.

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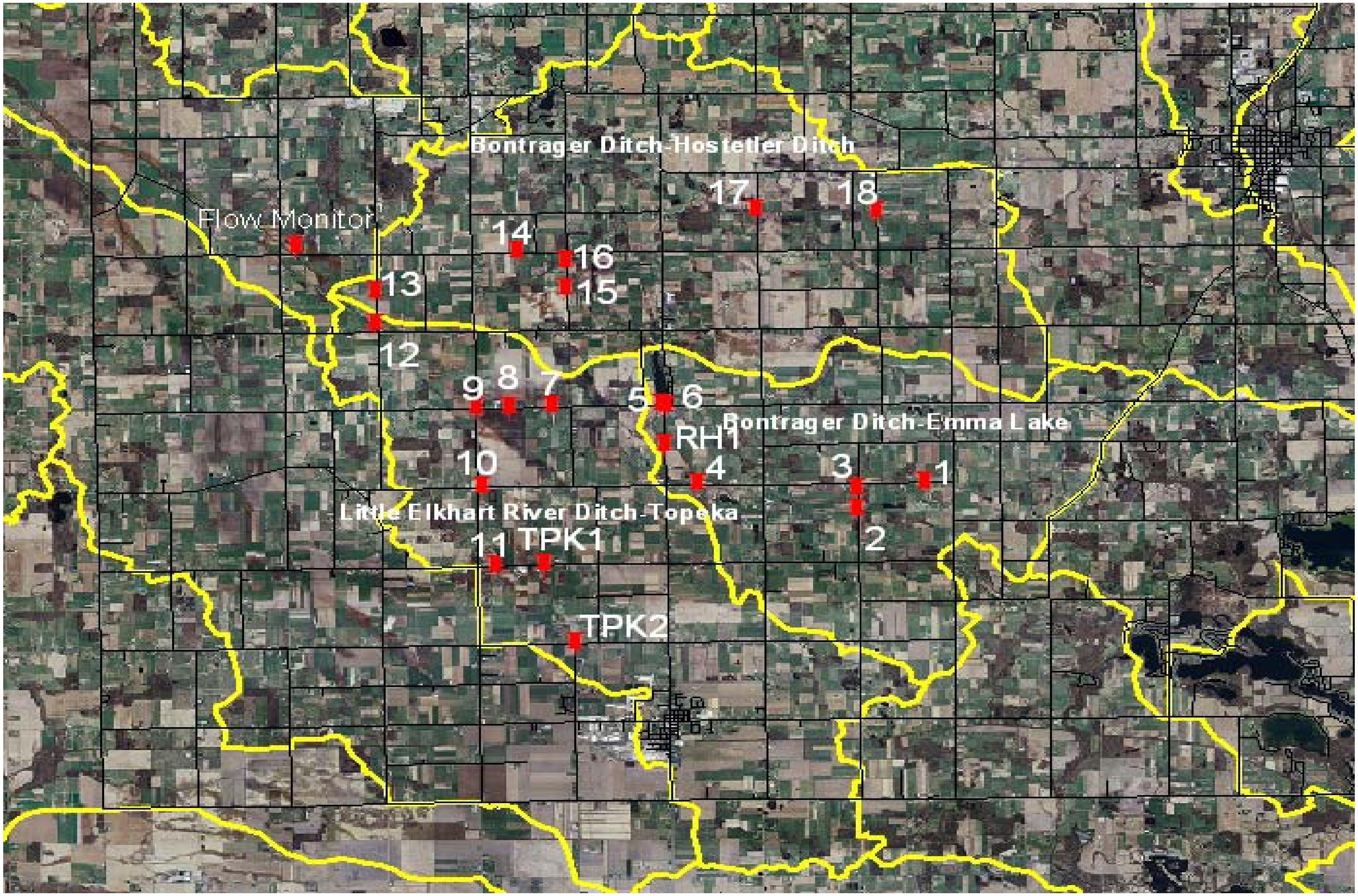


Figure 1: Map of watershed displaying water quality testing sites.

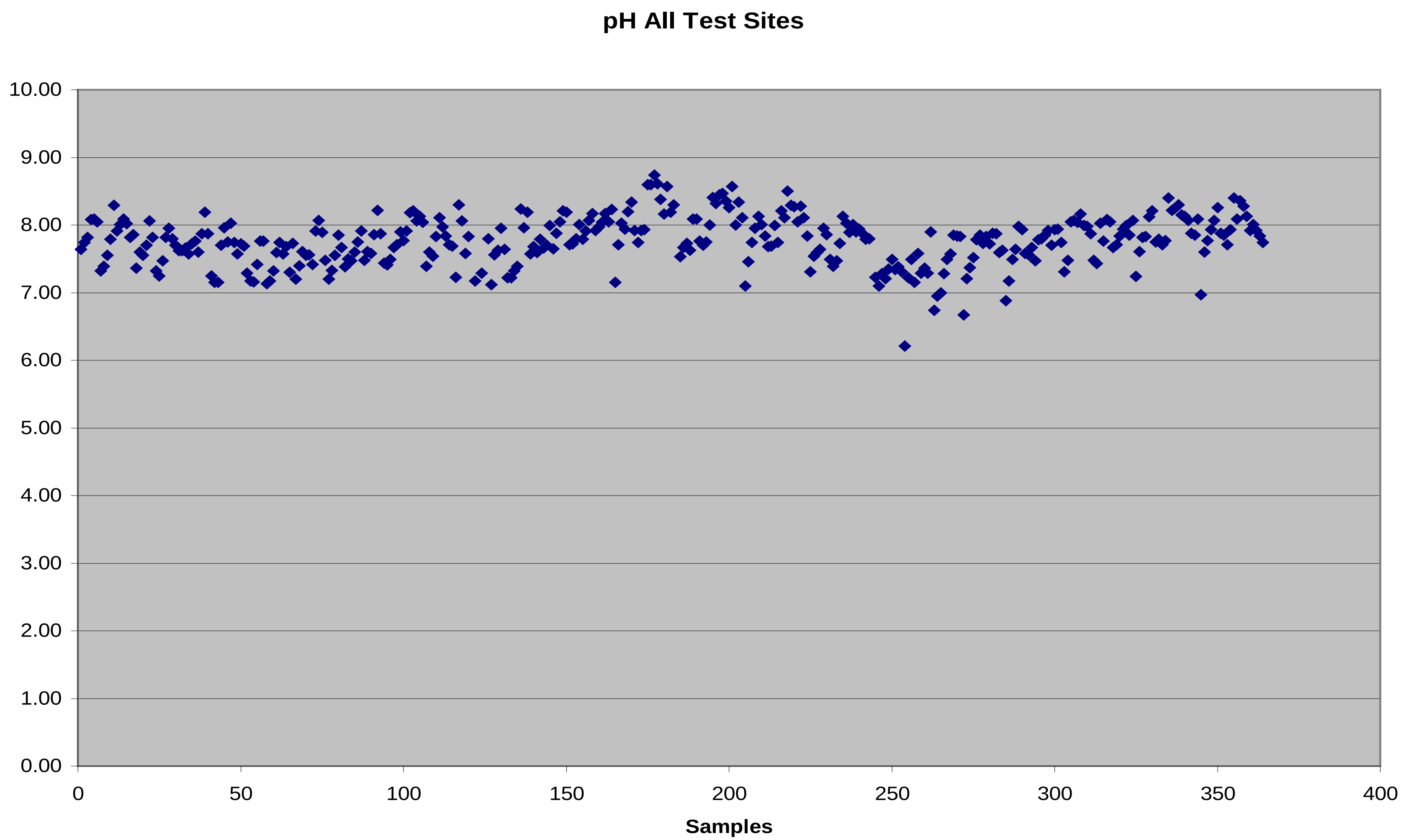


Figure 2**:** Scatter plot of pH for all sites.

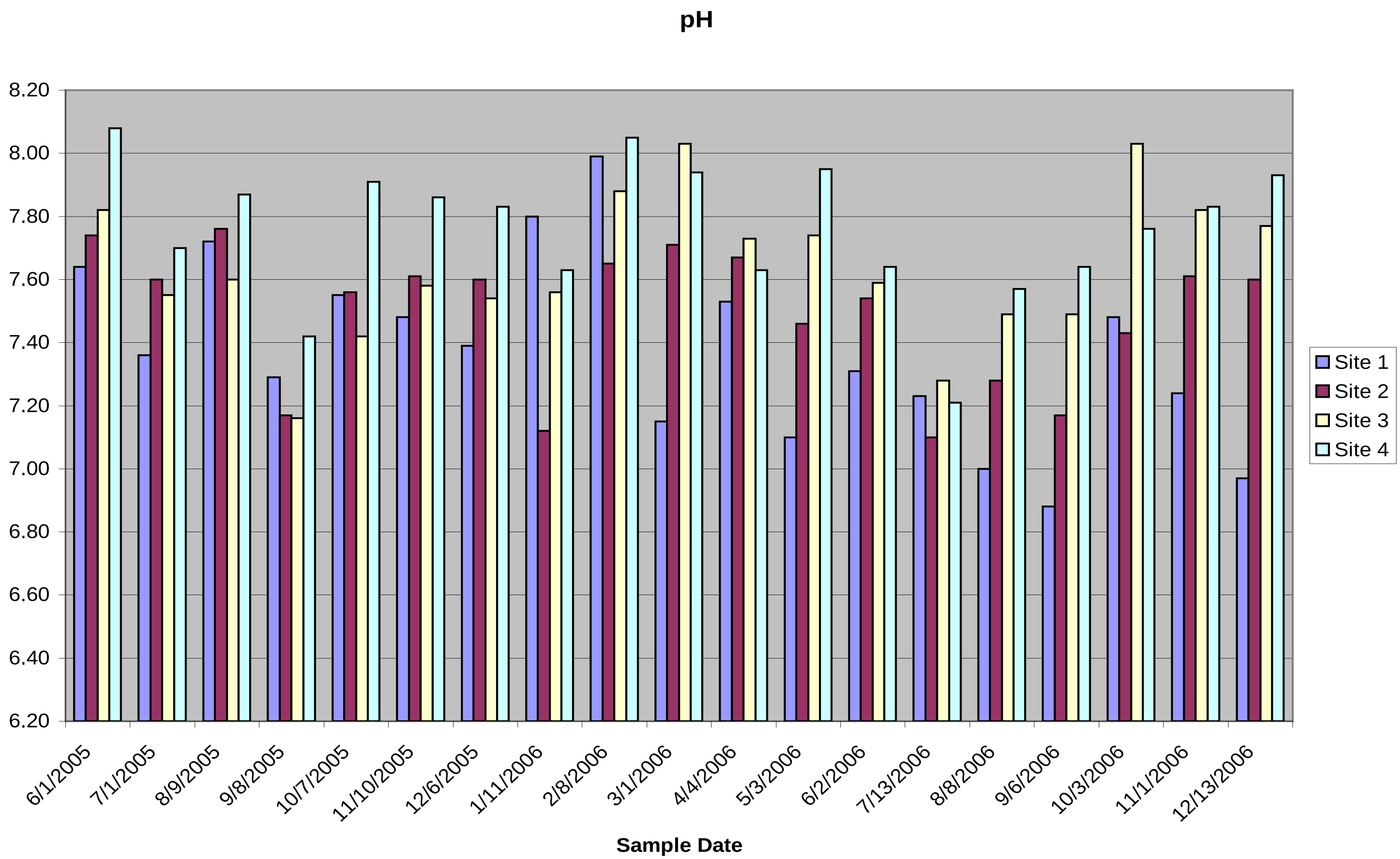


Figure 3: Graphical depiction of pH for test sites 1 through 4.

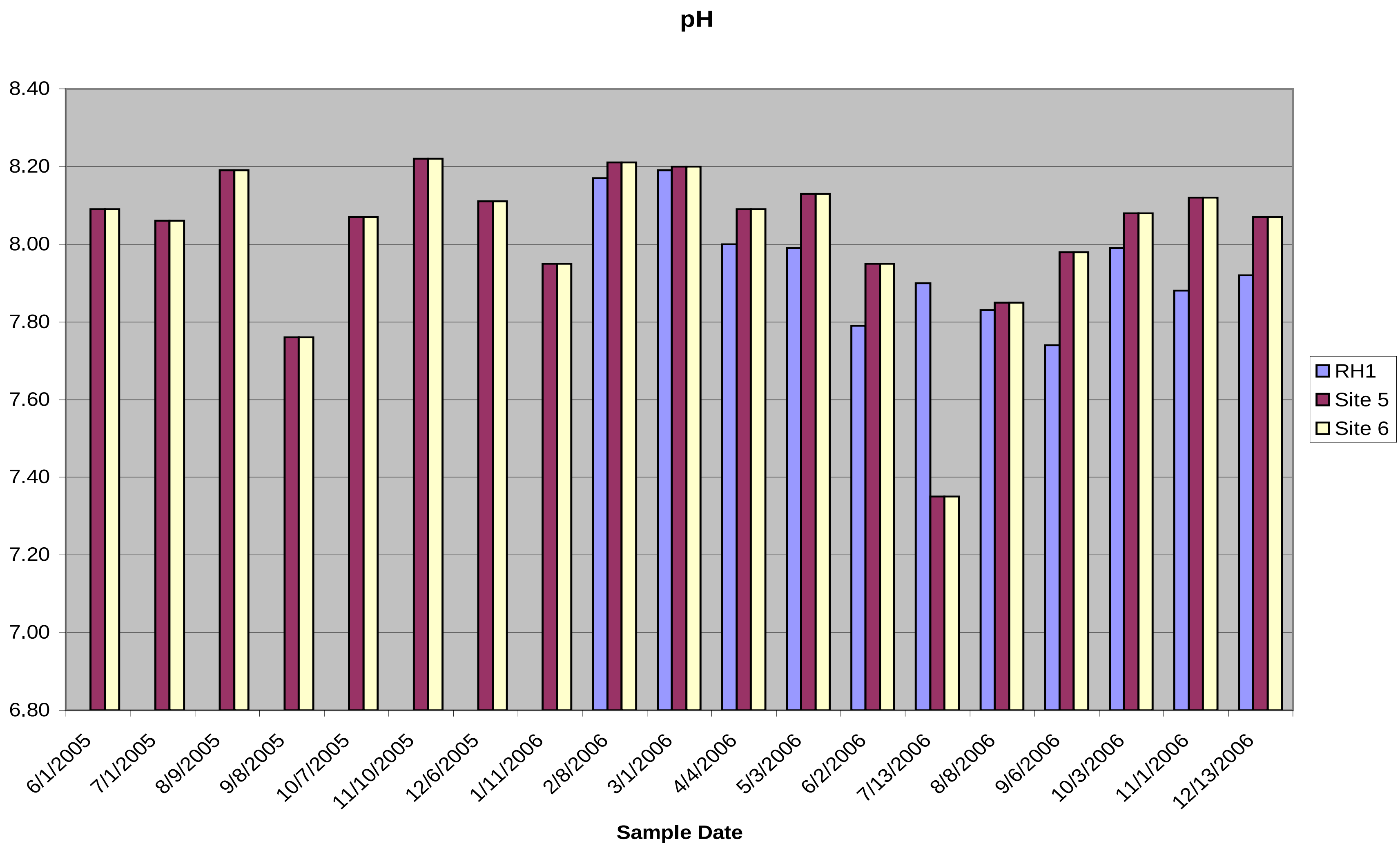


Figure 4: Graphical depiction of pH for test sites RH1 through 6.

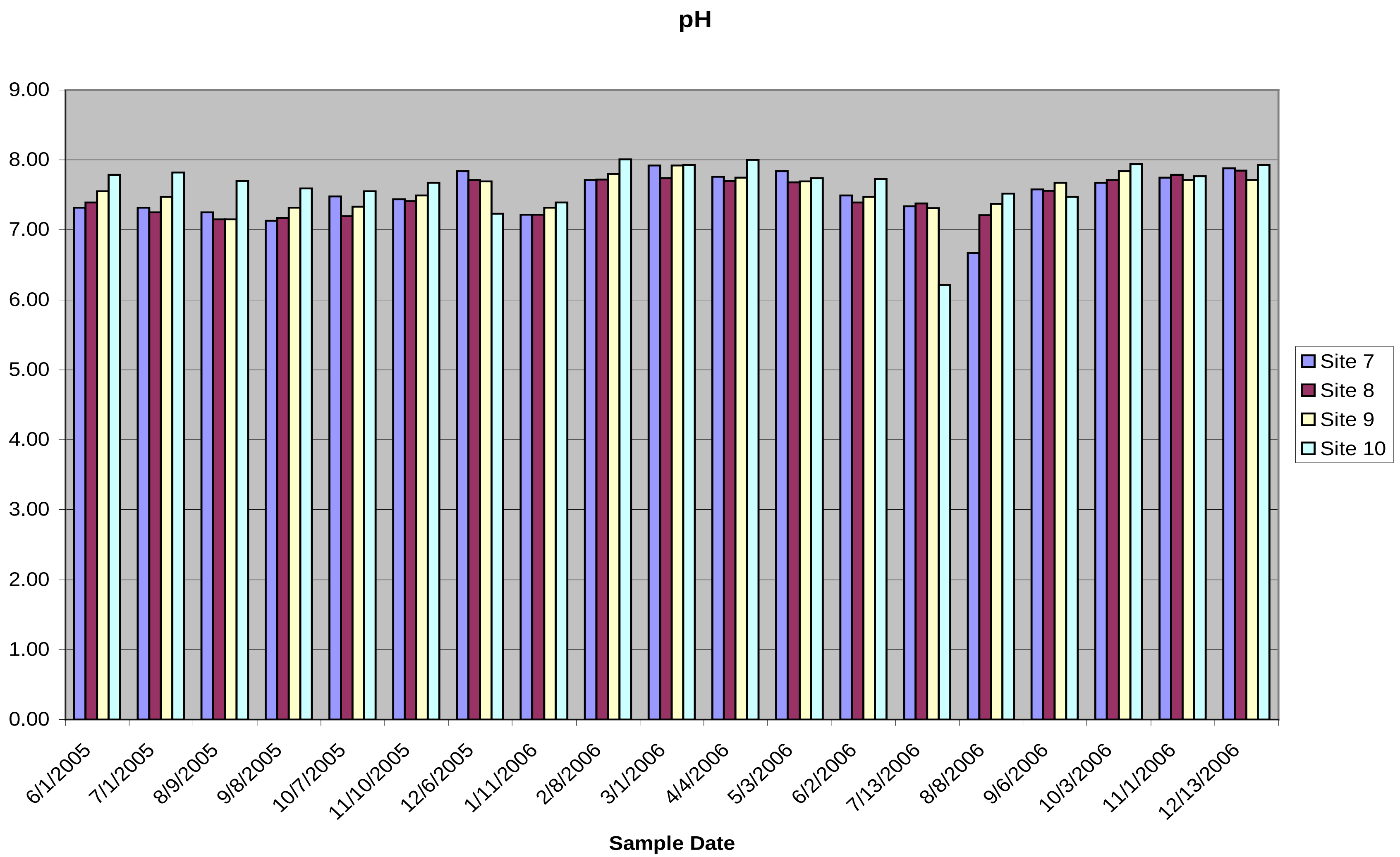


Figure 5: Graphical depiction of pH for test sites 7through 10.

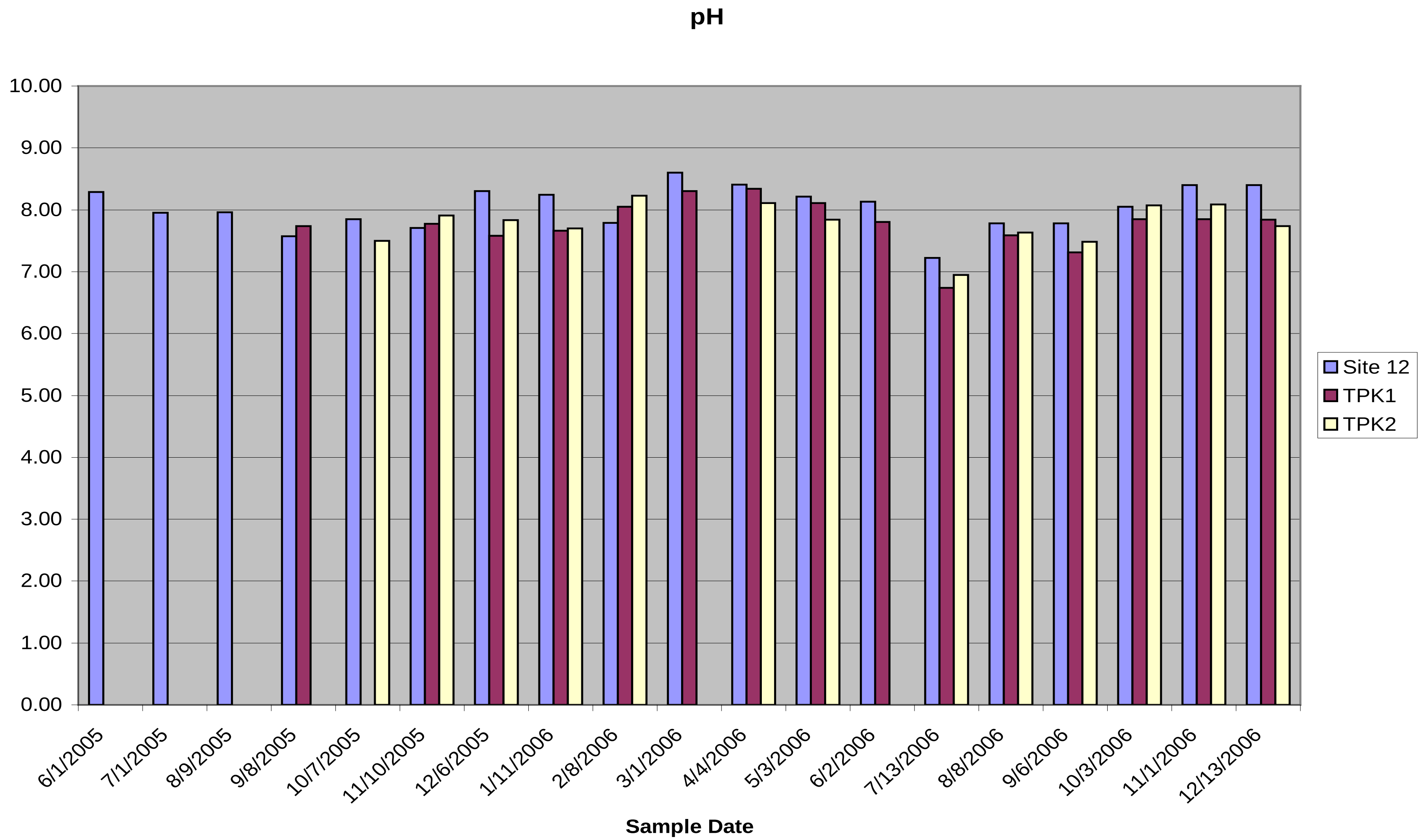


Figure 6: Graphical depiction of pH for test sites 12 through TPK2.

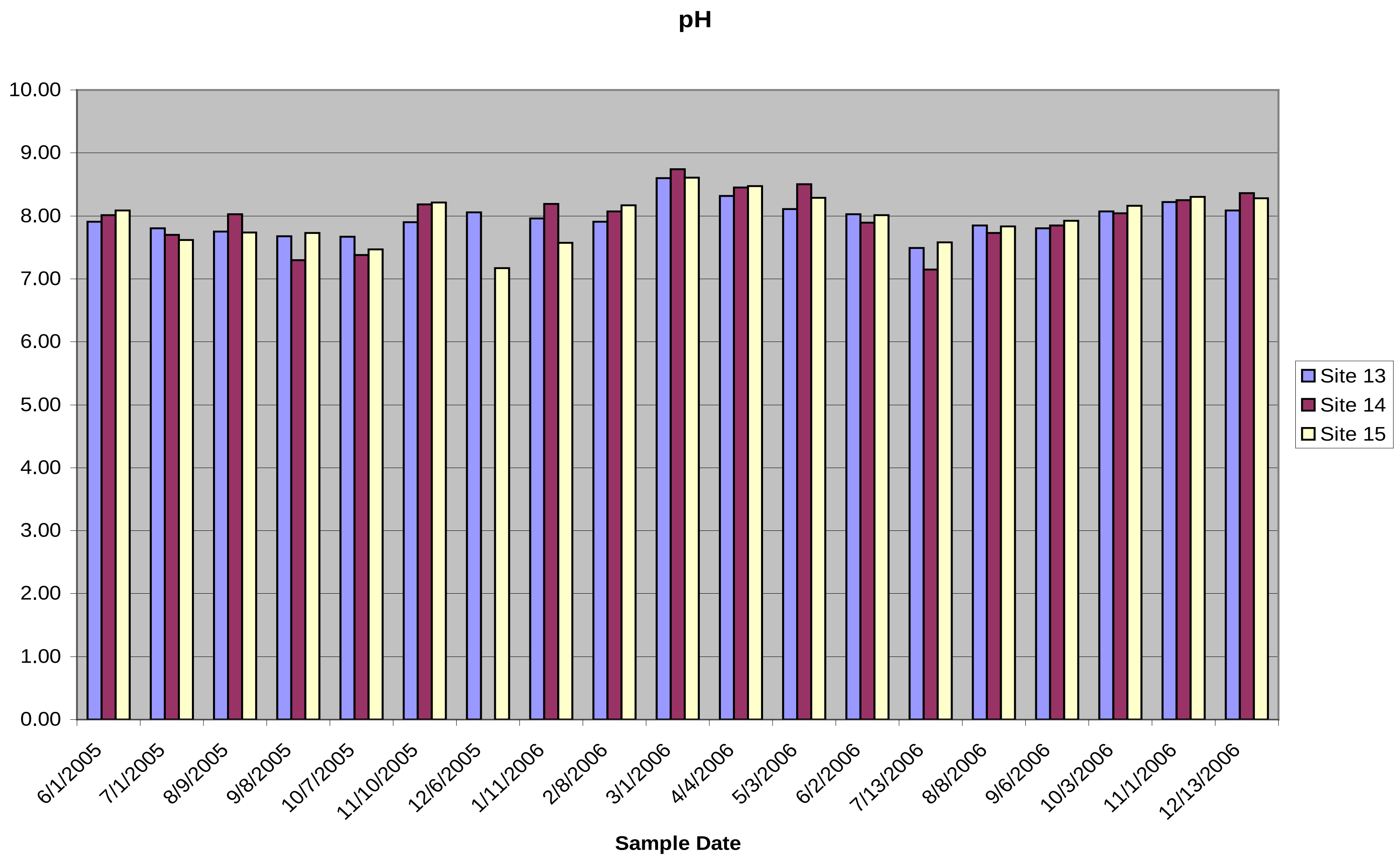


Figure 7: Graphical depiction of pH for test sites 13-15.

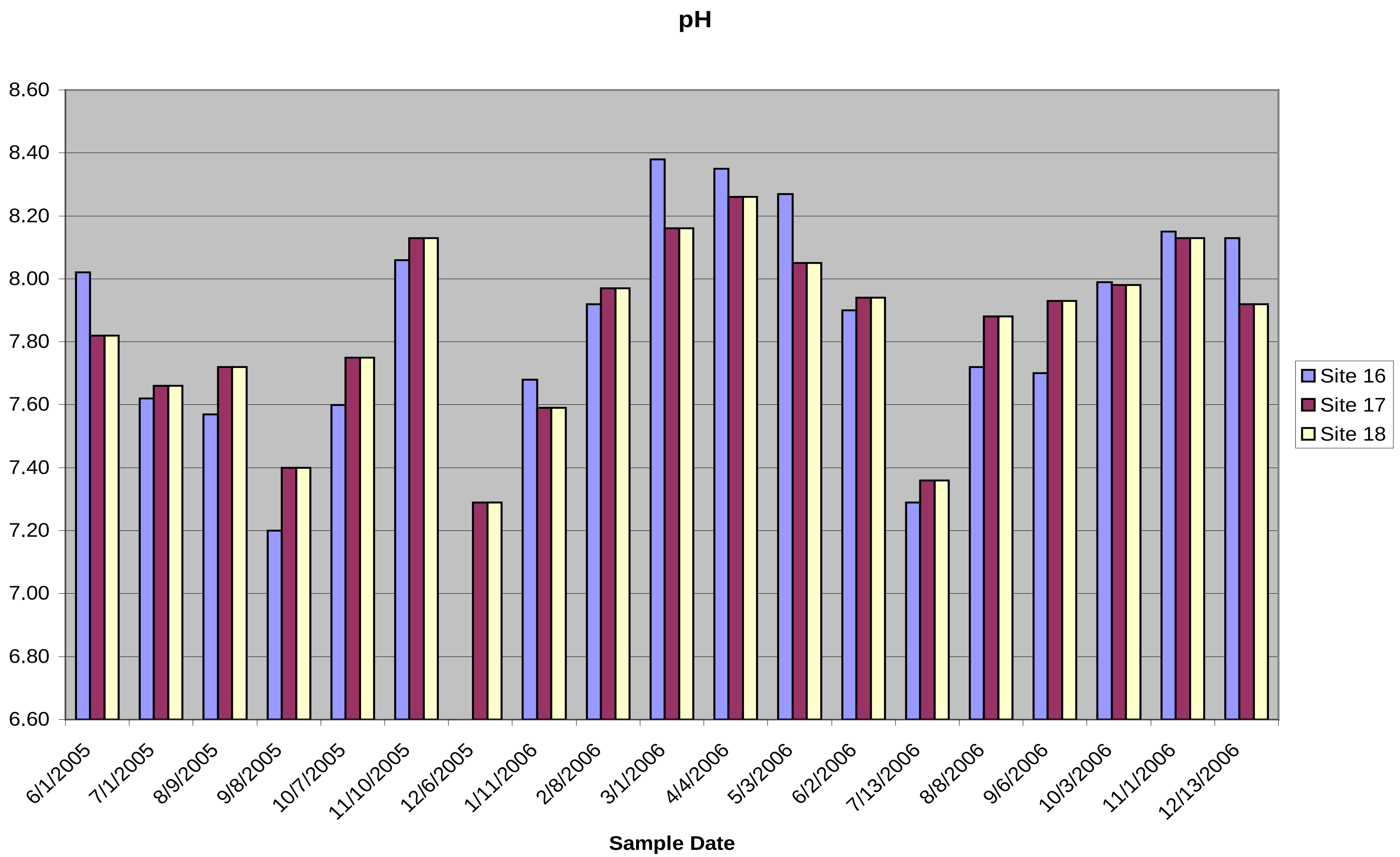


Figure 8: Graphical depiction of pH for test sites 16-18.

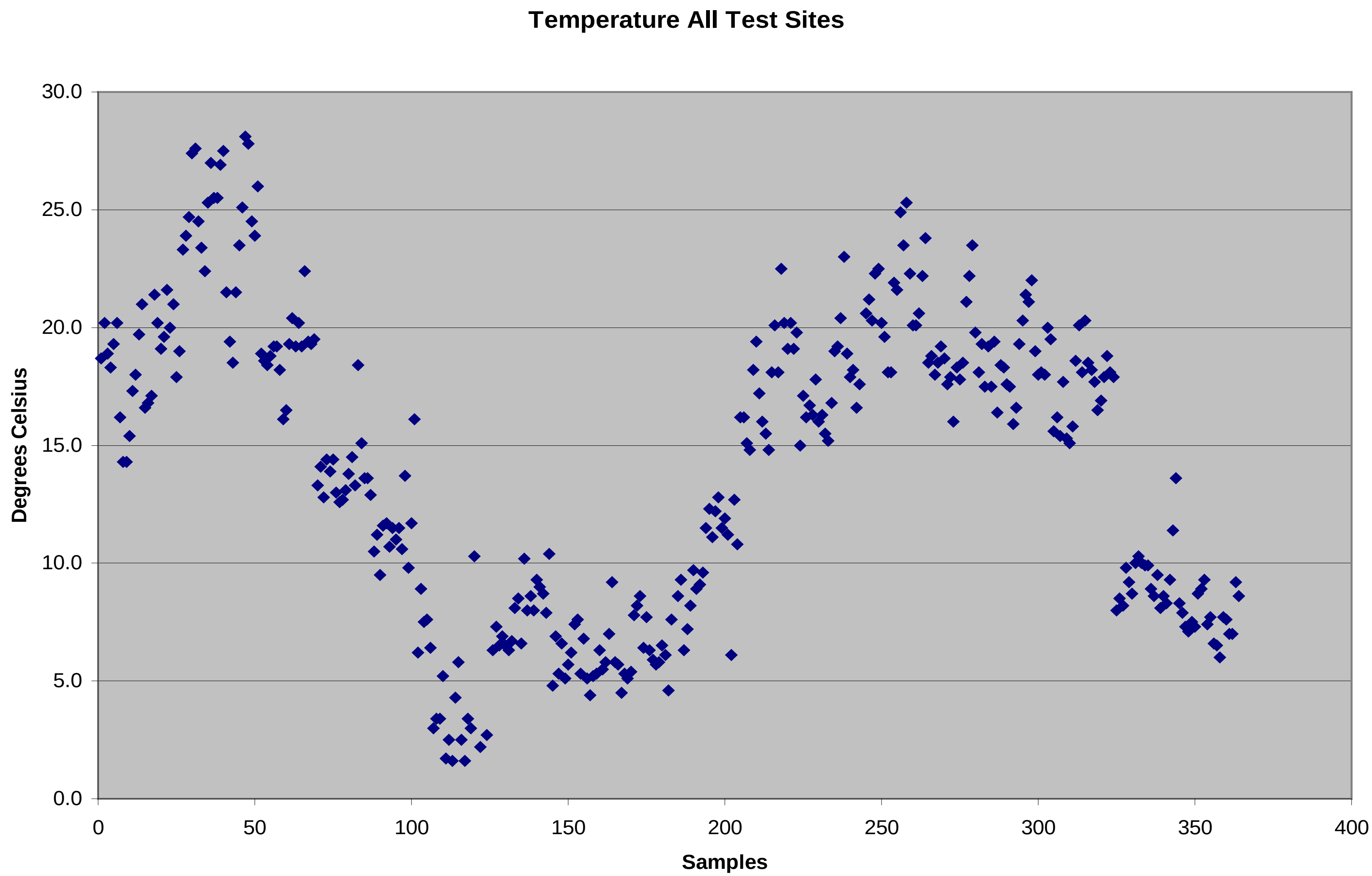


Figure 9: Scatter plot of temperature for all sites. Chart demonstrates seasonal fluctuations.

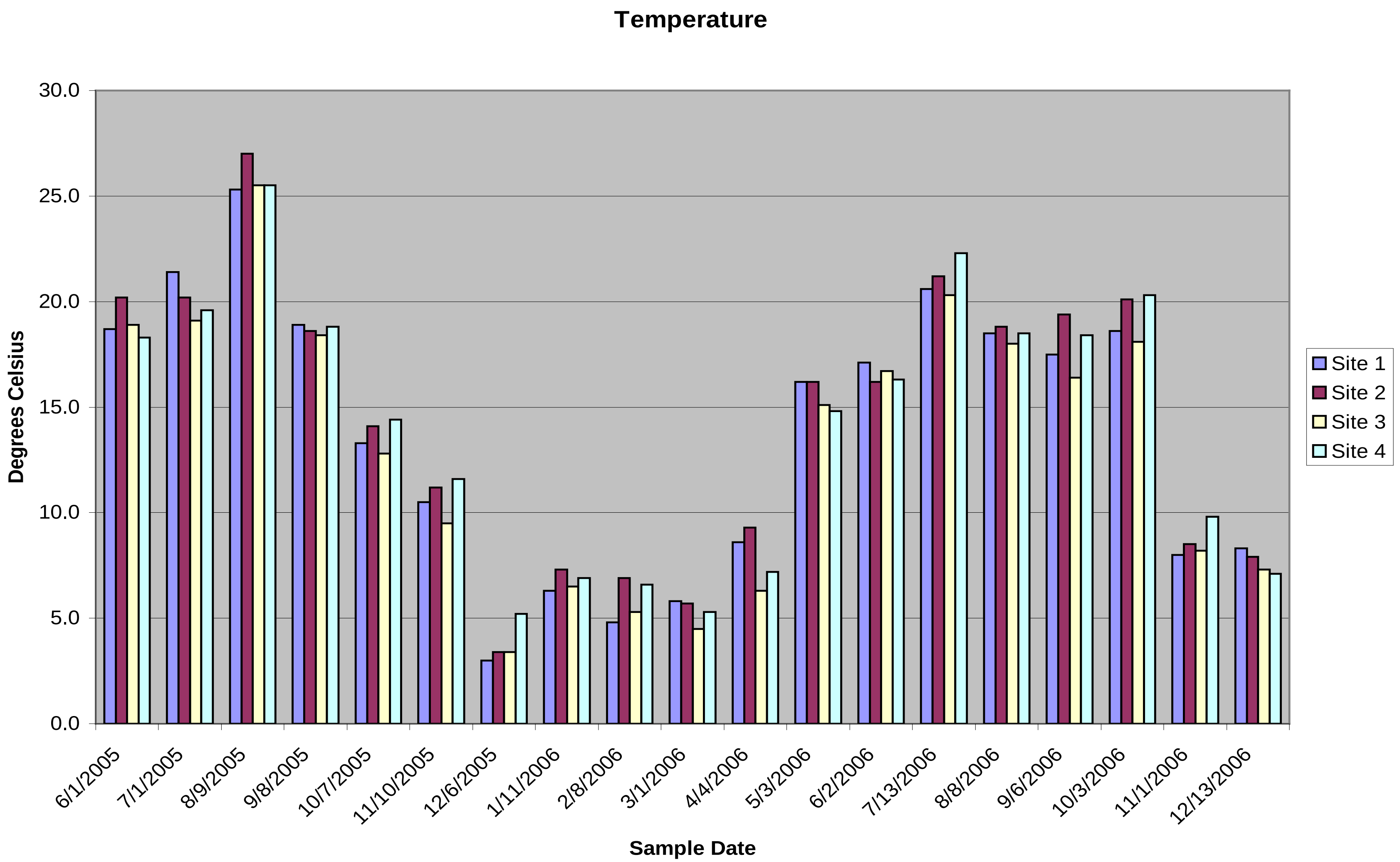


Figure 10: Graphical depiction of temperature for test sites 1 through 4.

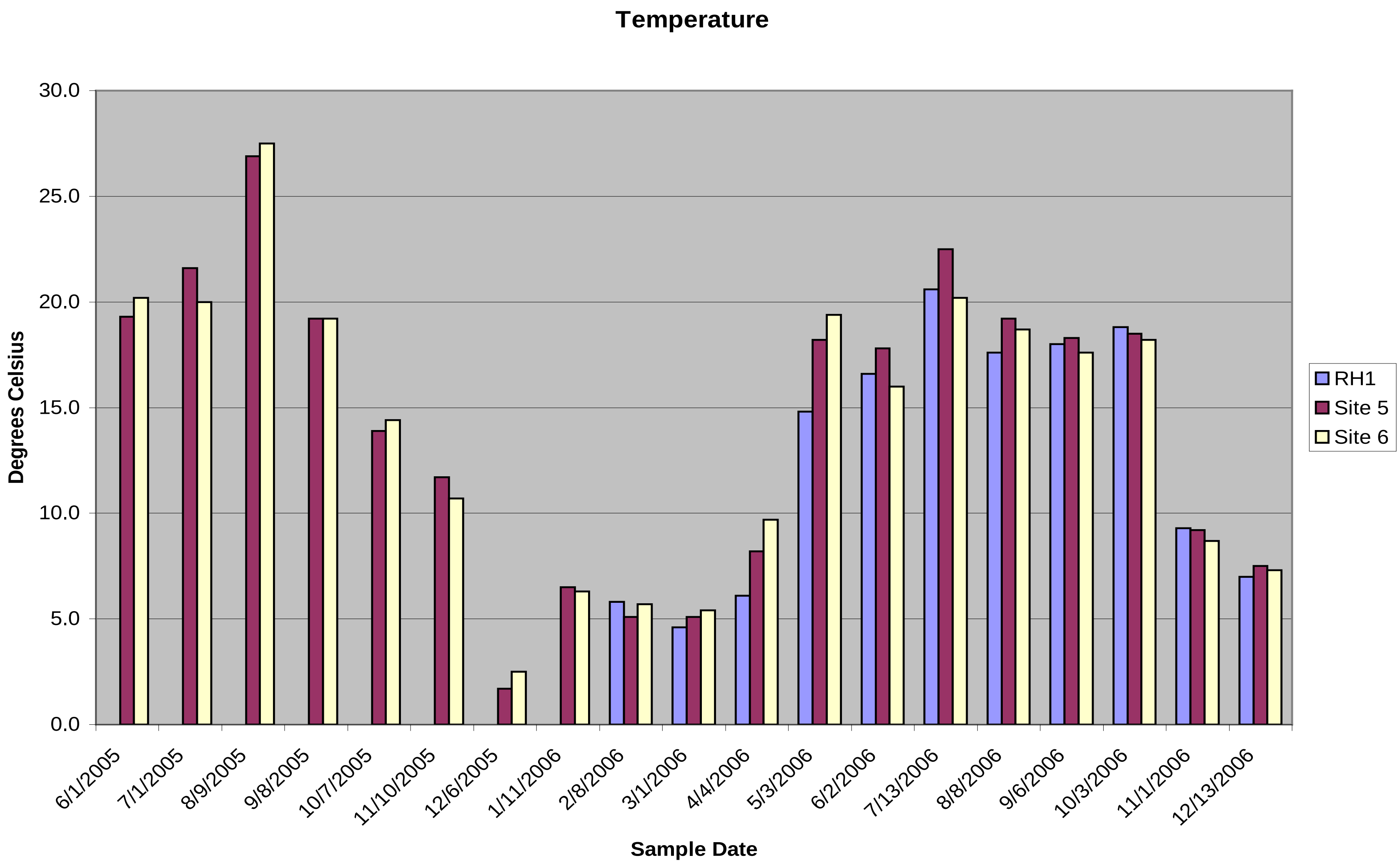


Figure 11: Graphical depiction of temperature for test sites RH1 through 6.

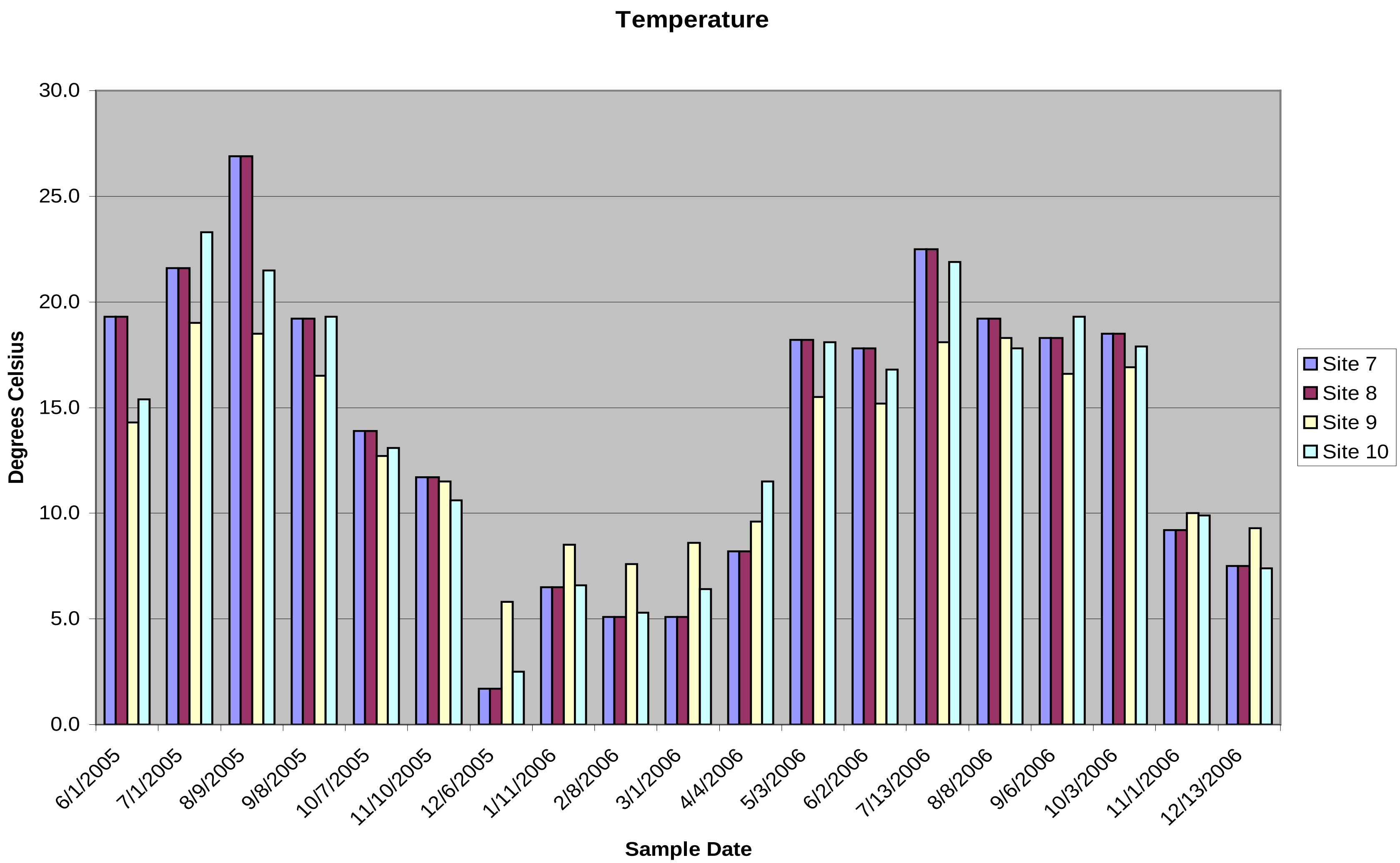


Figure 12: Graphical depiction of temperature for test sites 7 through 10.

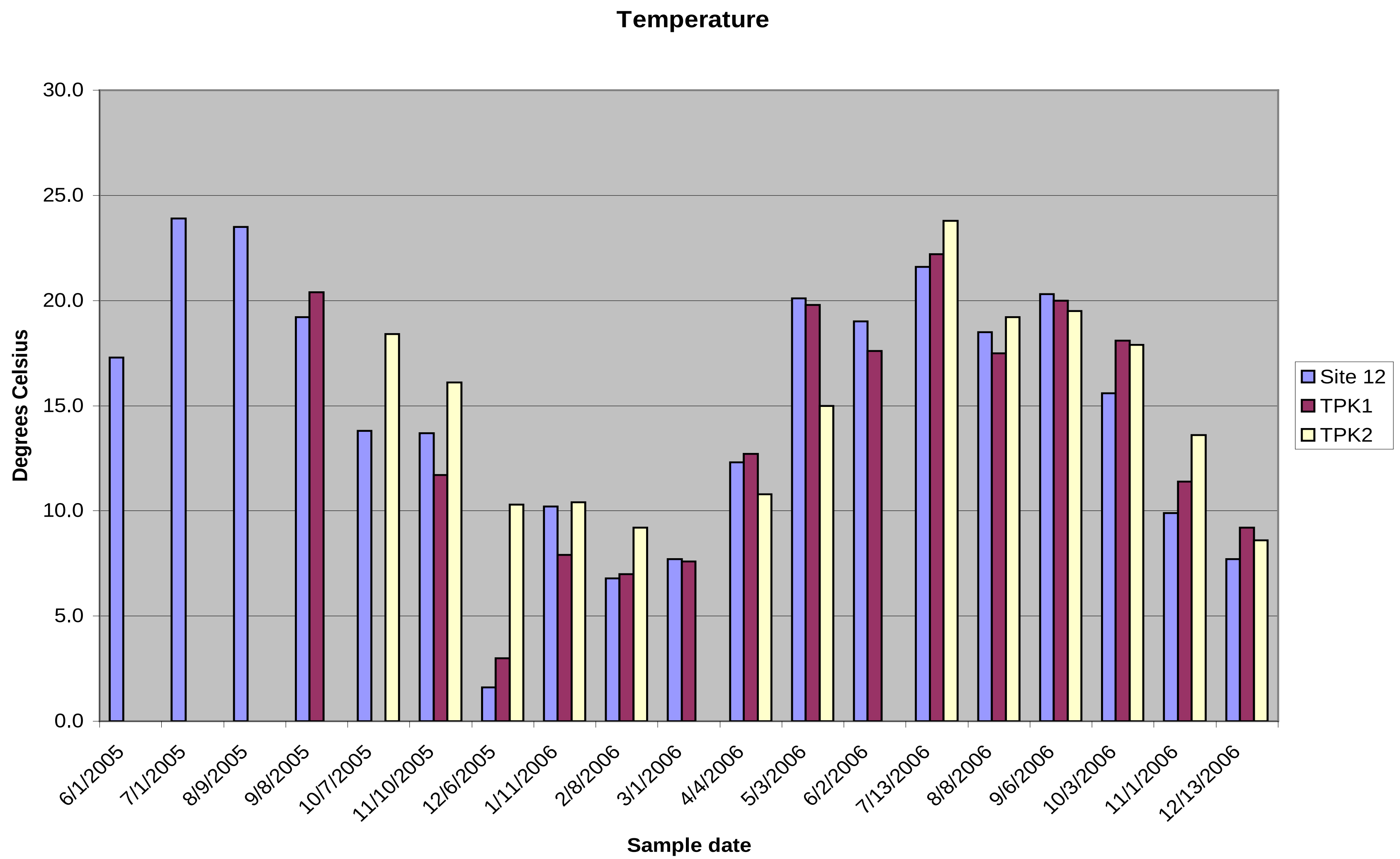


Figure 13: Graphical depiction of temperature for test sites 12 through TPK2.

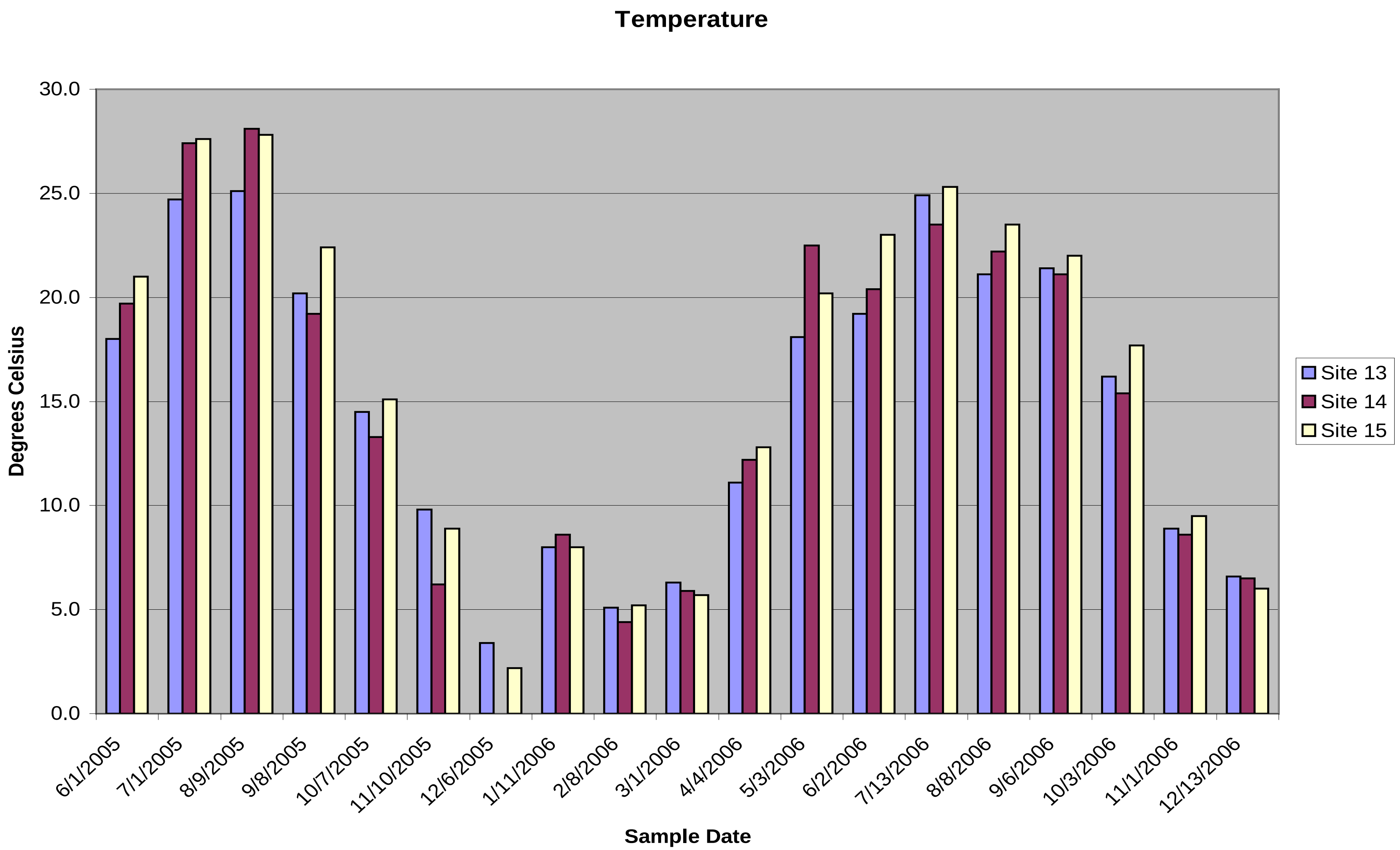


Figure 14: Graphical depiction of temperature for test sites 13-15.

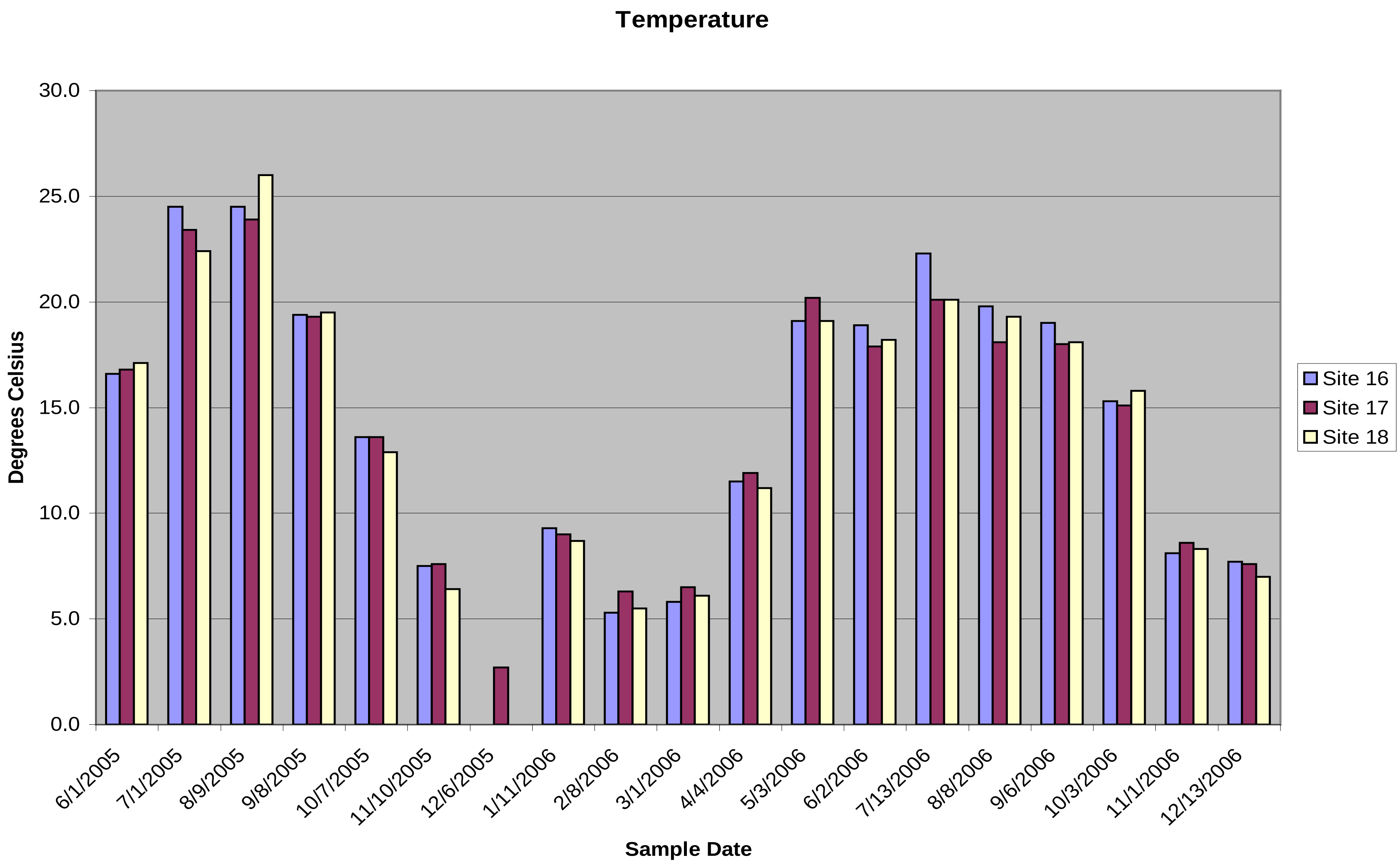


Figure 15: Graphical depiction of temperature for test sites 16 through 18.

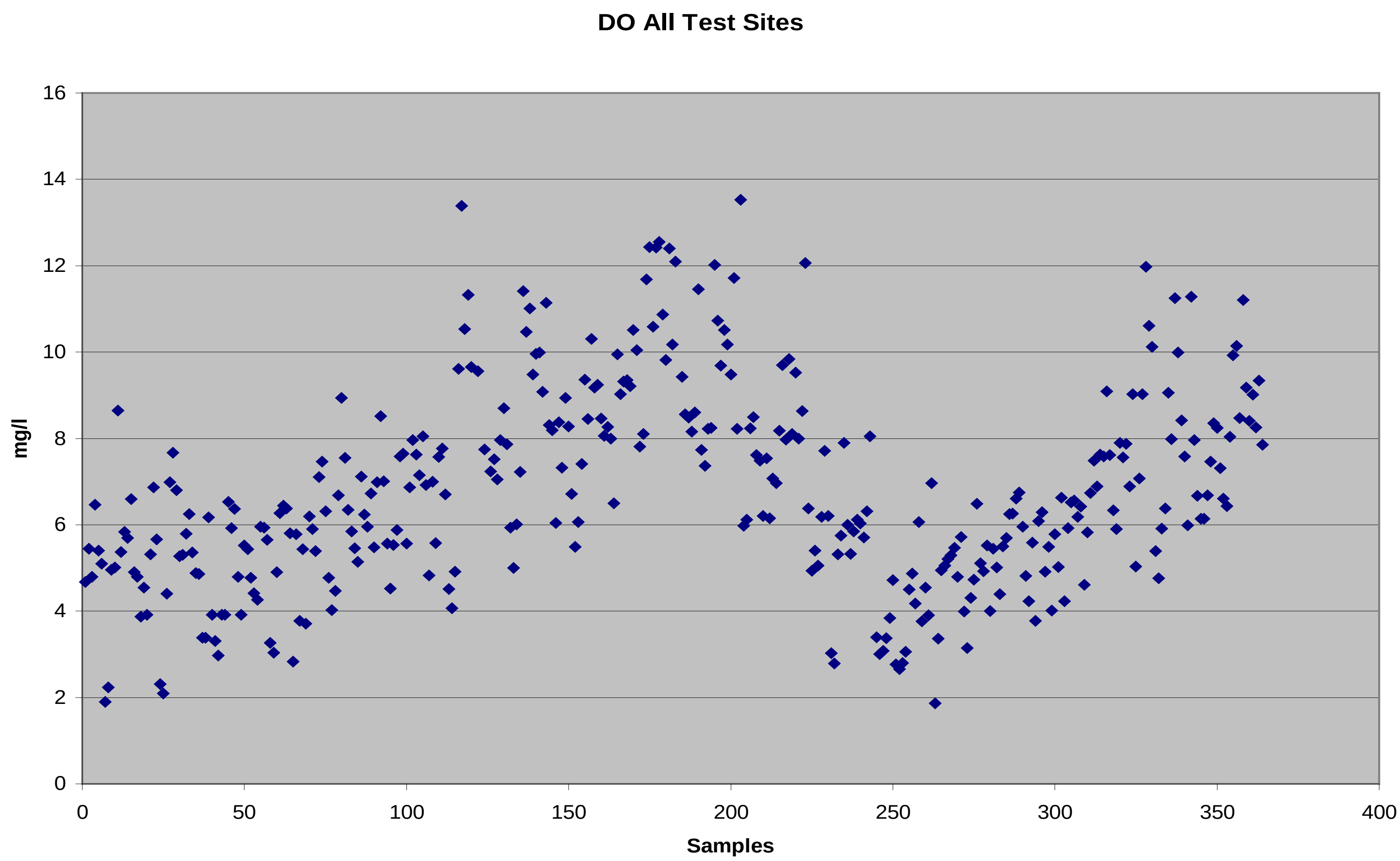


Figure 16: Dissolved oxygen for all sites. Chart demonstrates seasonal fluctuations. The Y axis represents milligrams per liter of water.

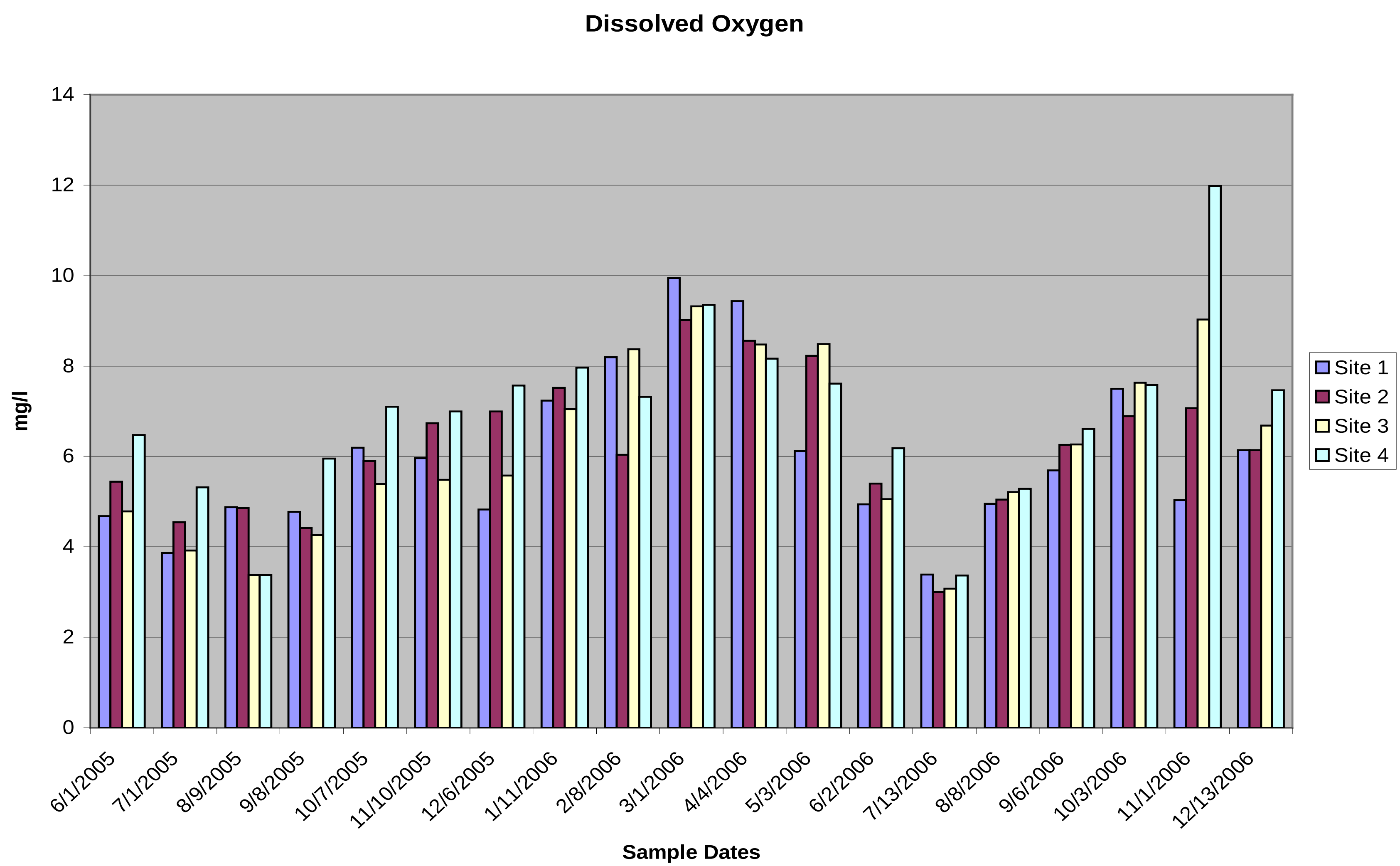


Figure 17: Graphical depiction of dissolved oxygen for test sites 1 through 4. The Y axis represents milligrams per liter of water.

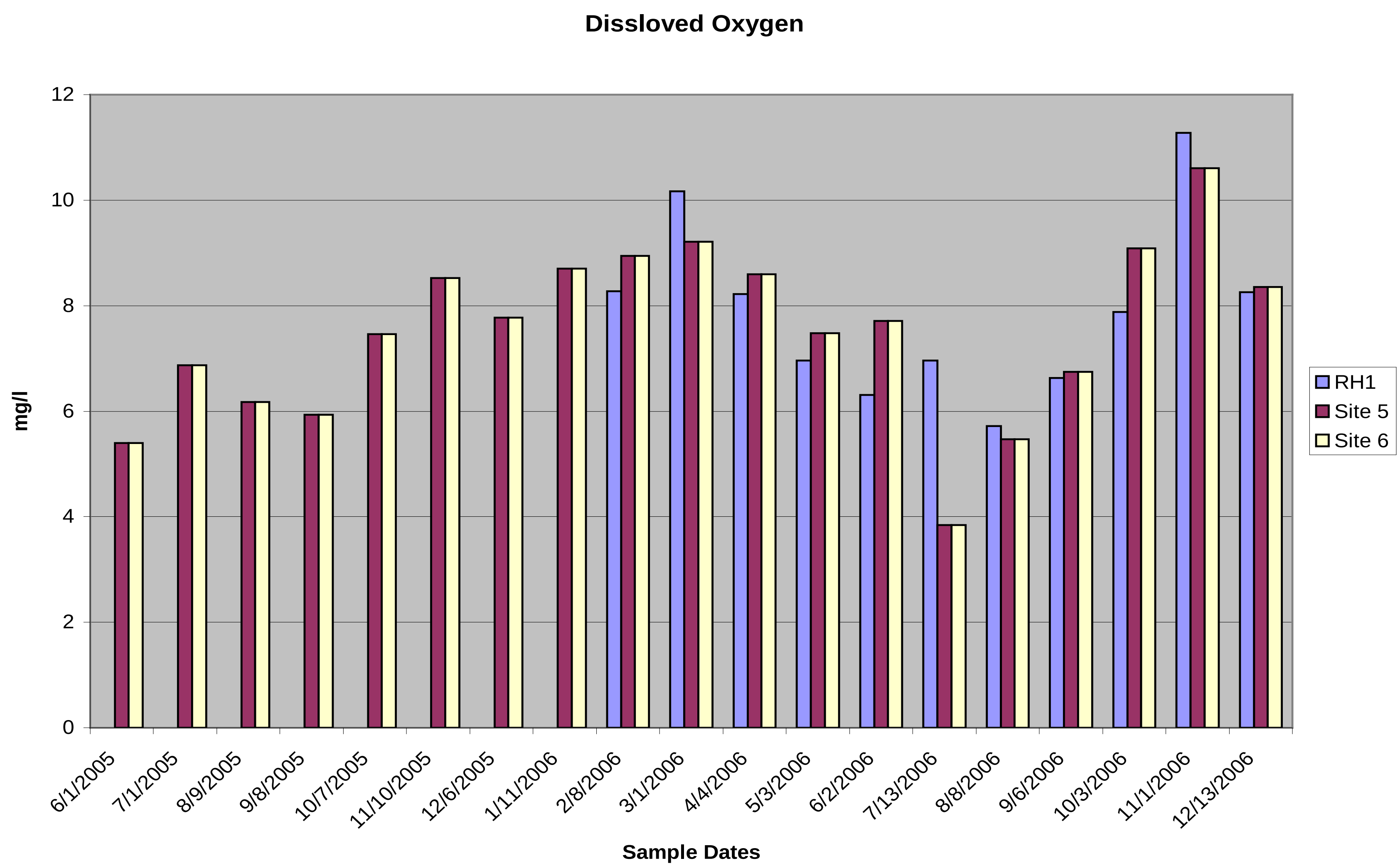


Figure 18: Graphical depiction of dissolved oxygen for test sites RH1 through 6. The Y axis represents milligrams per liter of water.

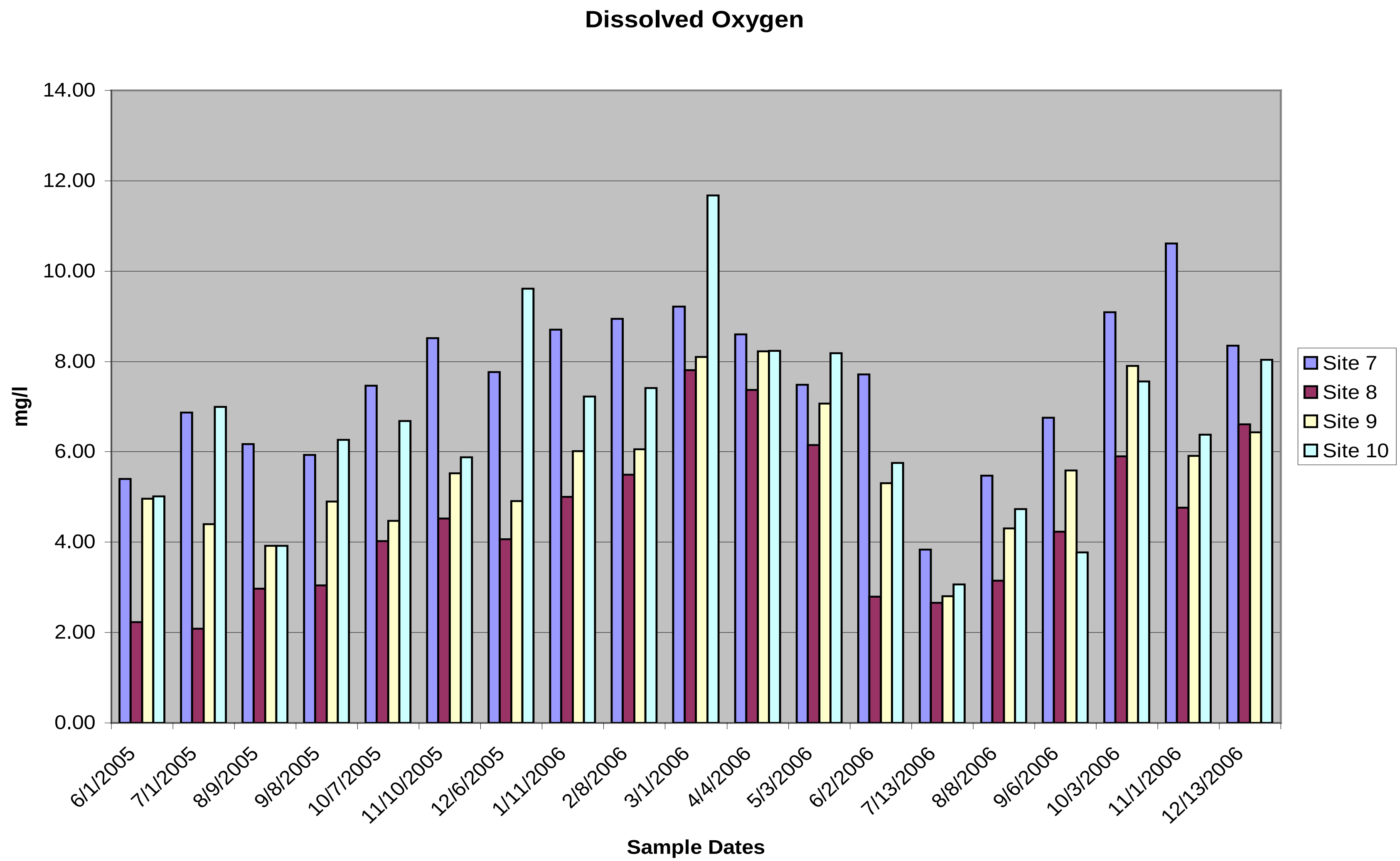


Figure 19: Graphical depiction of dissolved oxygen for test site 7 through 10. The Y axis represents milligrams per liter of water.

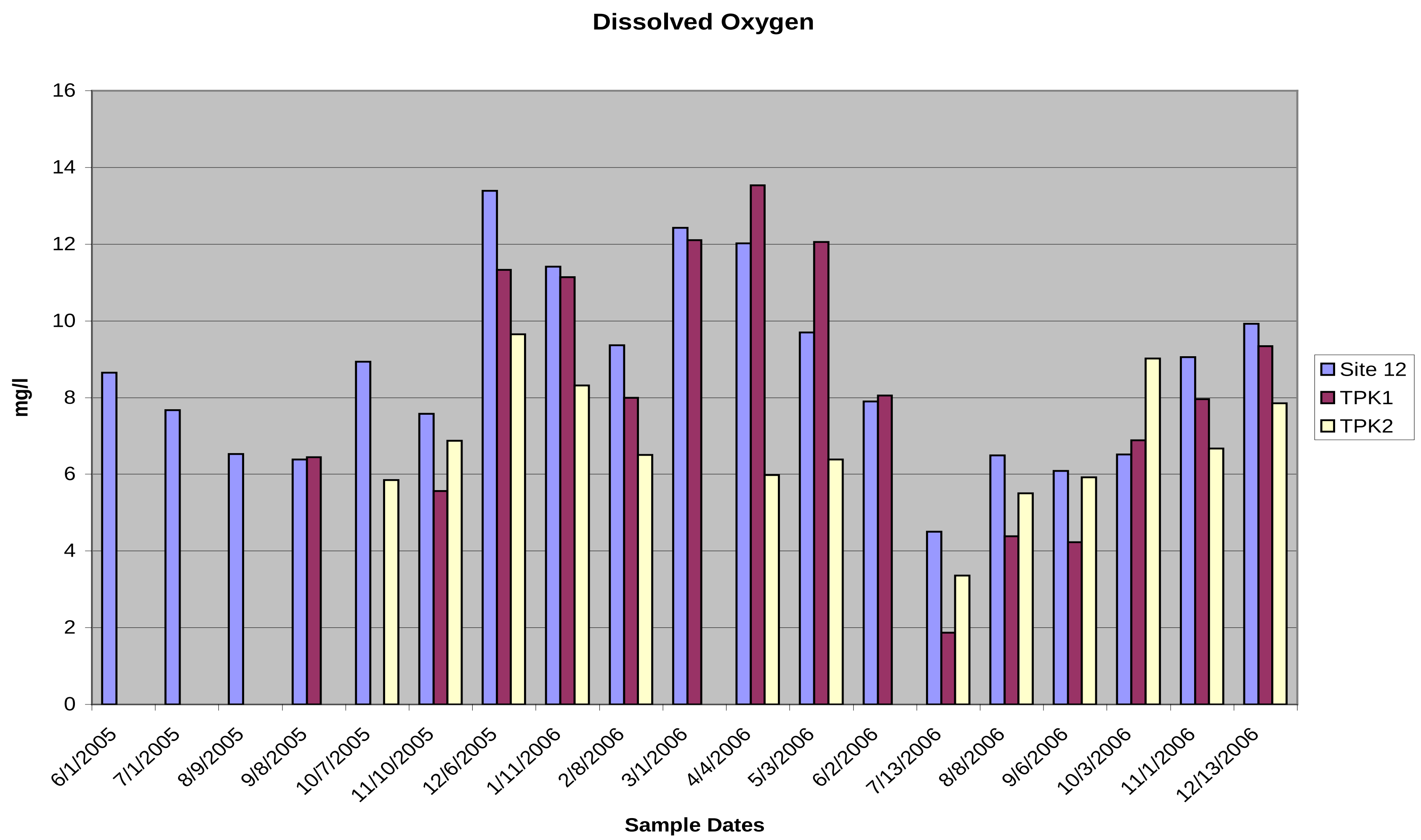


Figure 20: Graphical depiction of dissolved oxygen for test sites 12 through TPK2. The Y axis represents milligrams per liter of water.

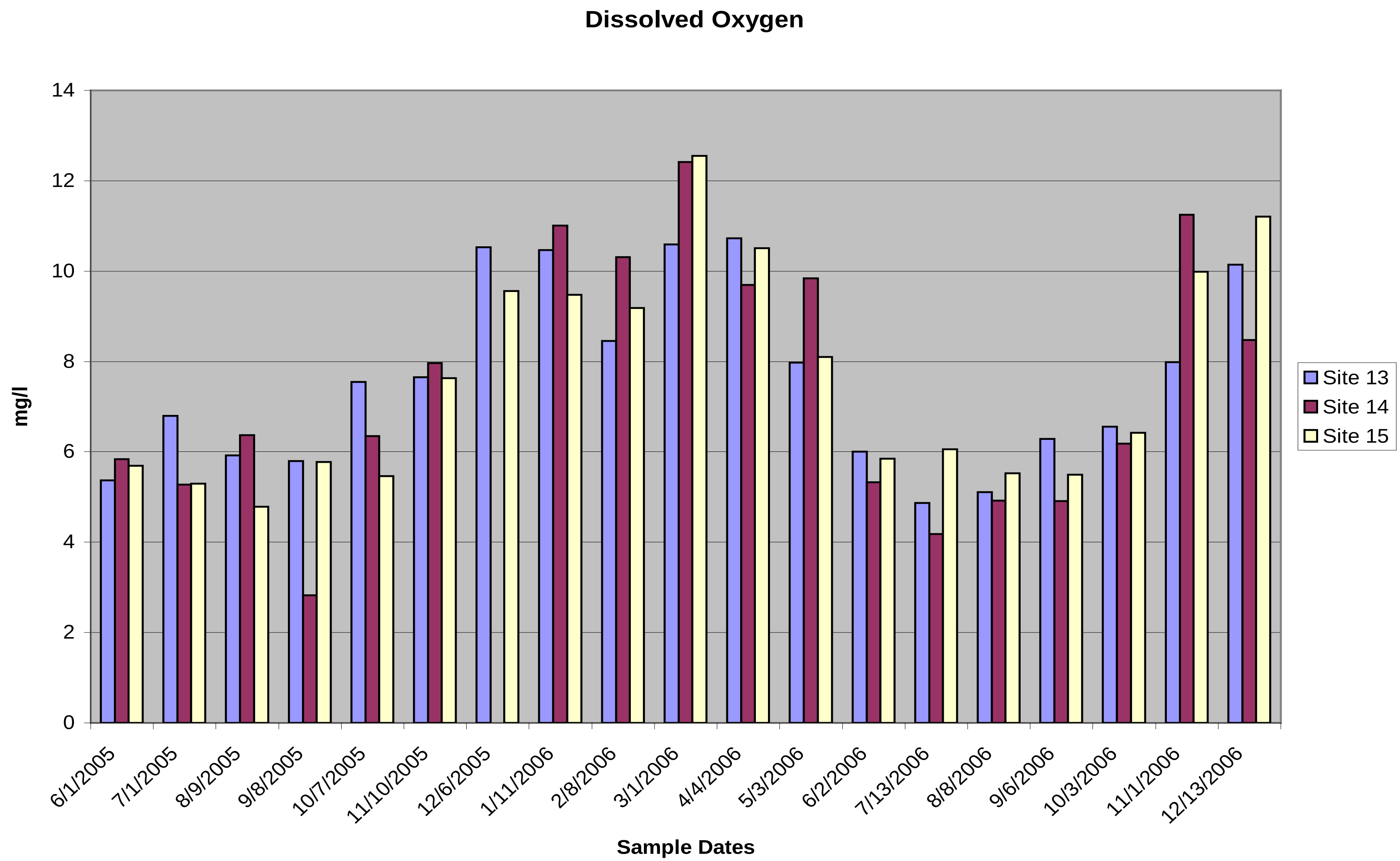


Figure 21: Graphical depiction of dissolved oxygen for test sites 13 through 14. The Y axis represents milligrams per liter of water.

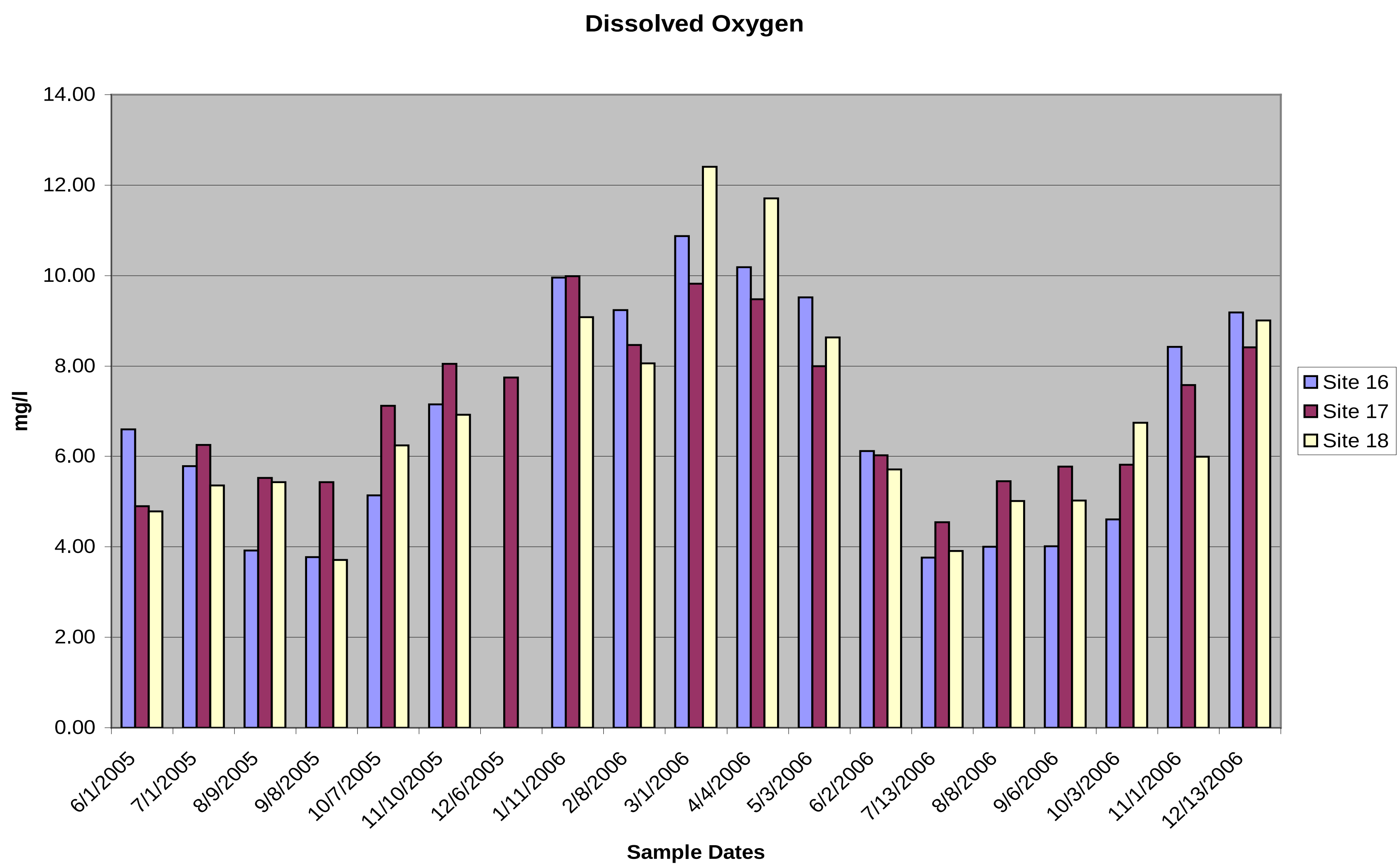


Figure 22: Graphical depiction of dissolved oxygen for test sites 16-18. The Y axis represents milligrams per liter of water.

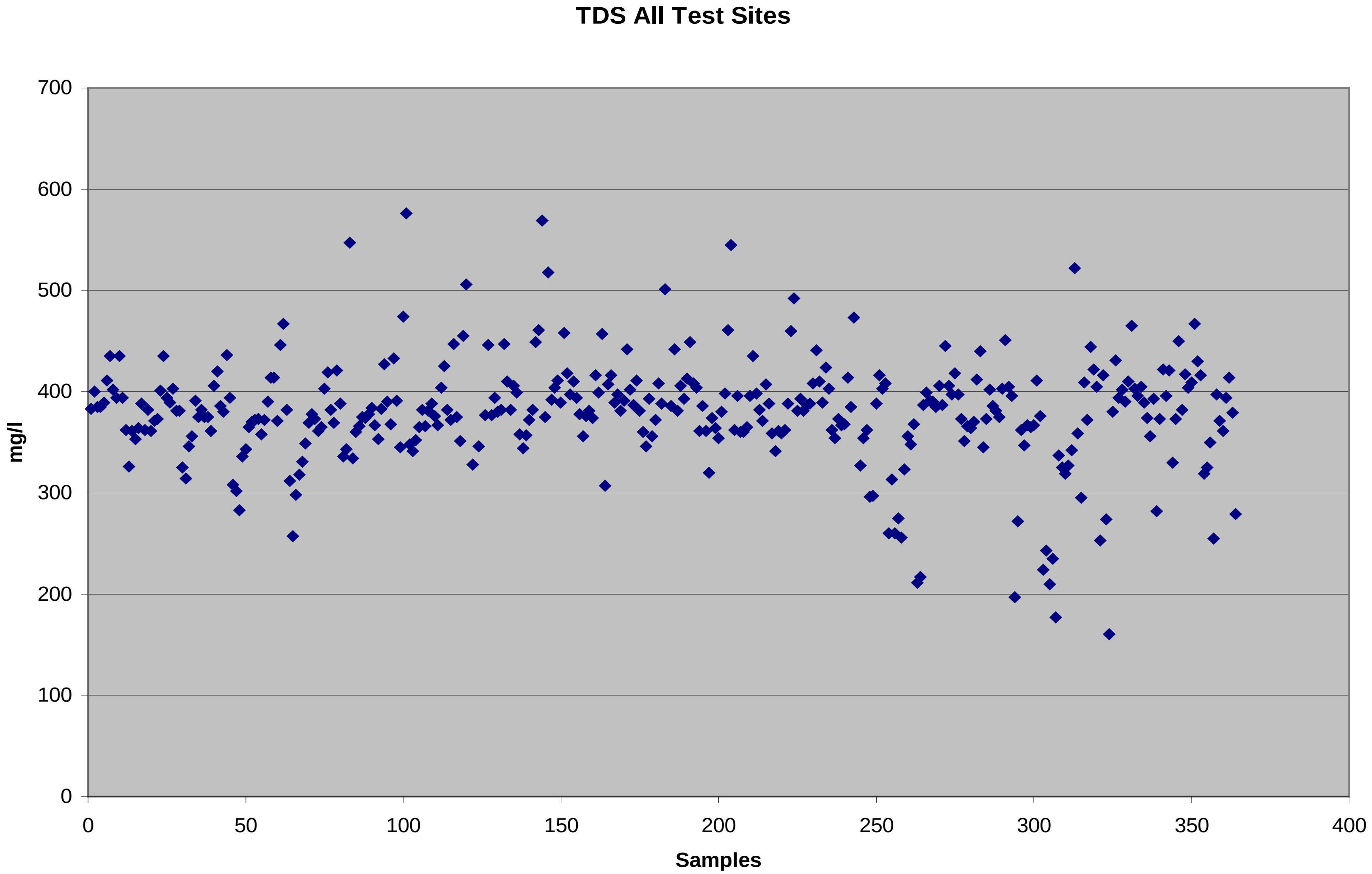


Figure 23: Total dissolved solids for all sites by date collected. The Y axis represents milligrams per liter of water.

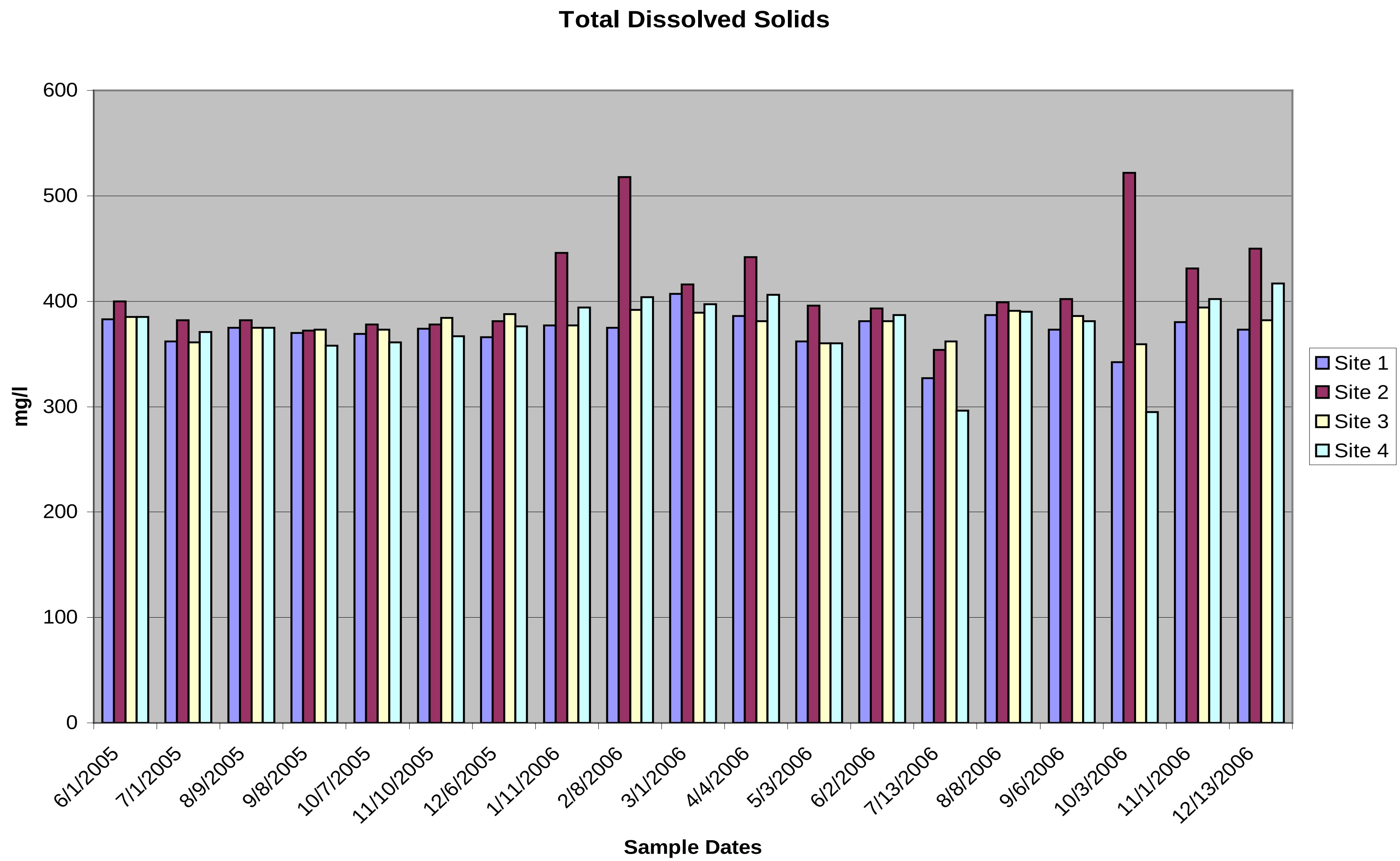


Figure 24: Graphical depiction of total dissolved solids for test sites 1 through 4. The Y axis represents milligrams per liter of water.

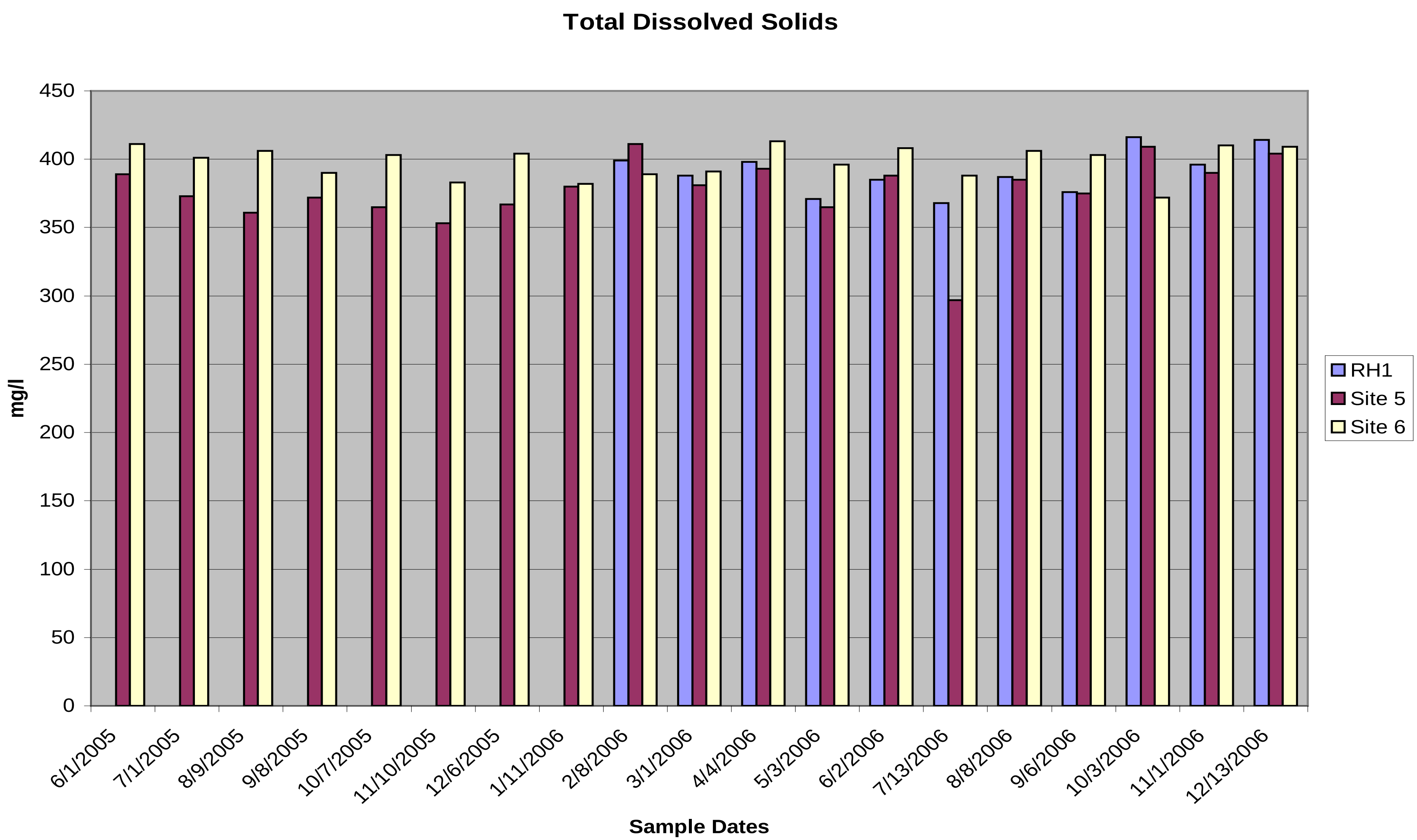


Figure 25: Graphical depiction of total dissolved solids for test sites RH1 through 6. The Y axis represents milligrams per liter of water.

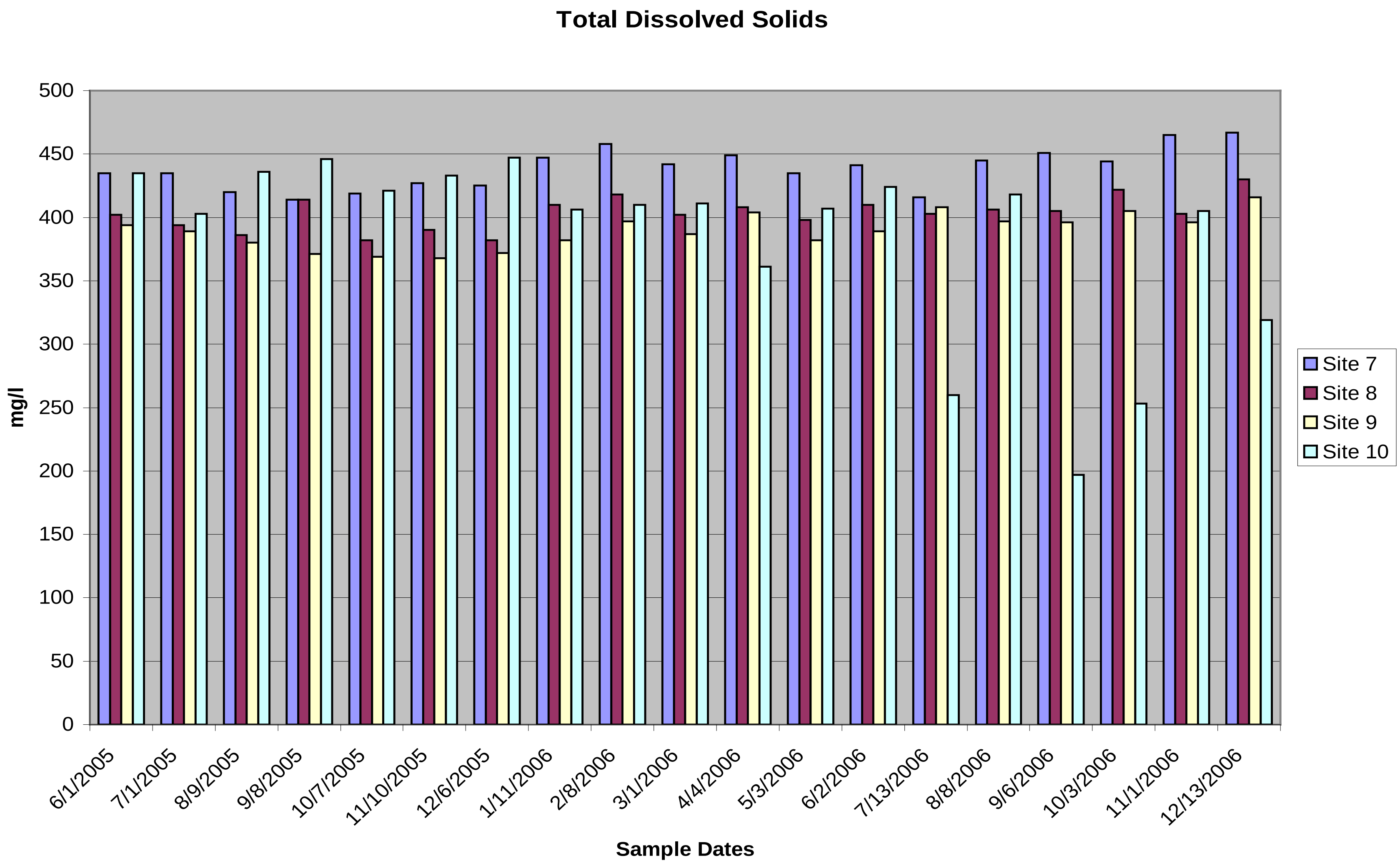


Figure 26: Graphical depiction of total dissolved solids for test sites 7 through 10. The Y axis represents milligrams per liter of water.

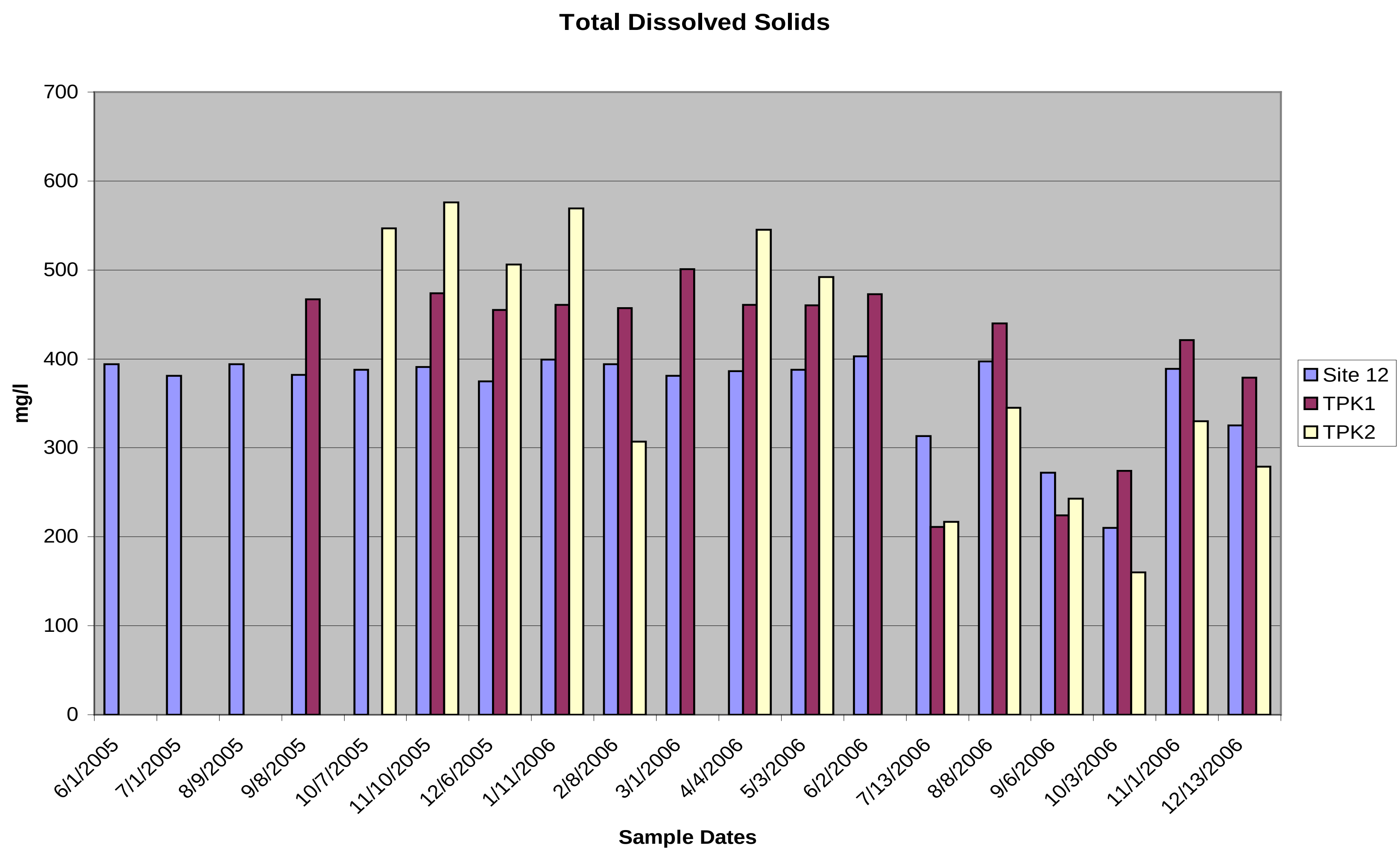


Figure 27: Graphical depiction of total dissolved solids for test sites 12 through TPK2. The Y axis represents milligrams per liter of water.

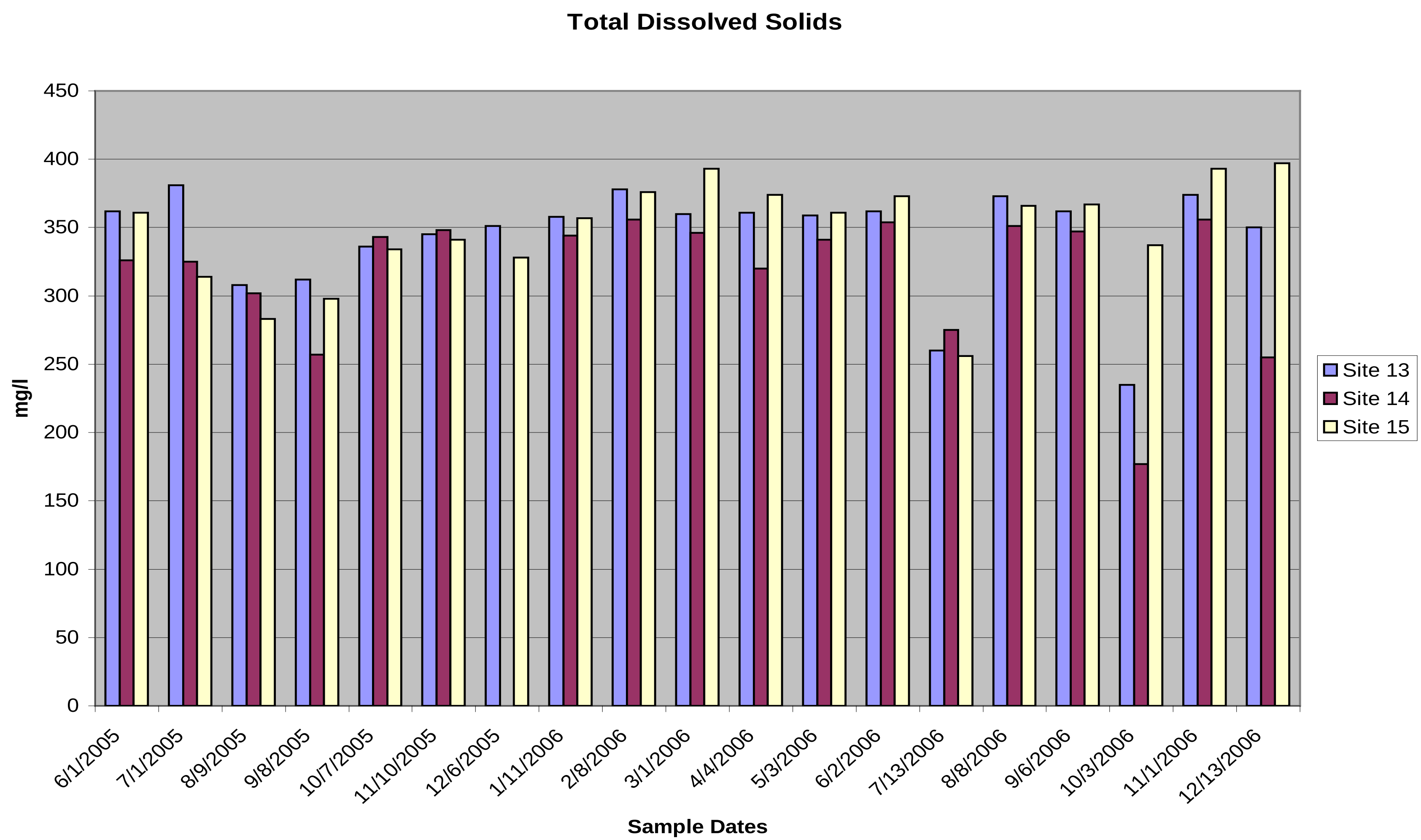


Figure 28: Graphical depiction of total dissolved solids for test sites 13 through 15. The Y axis represents milligrams per liter of water.

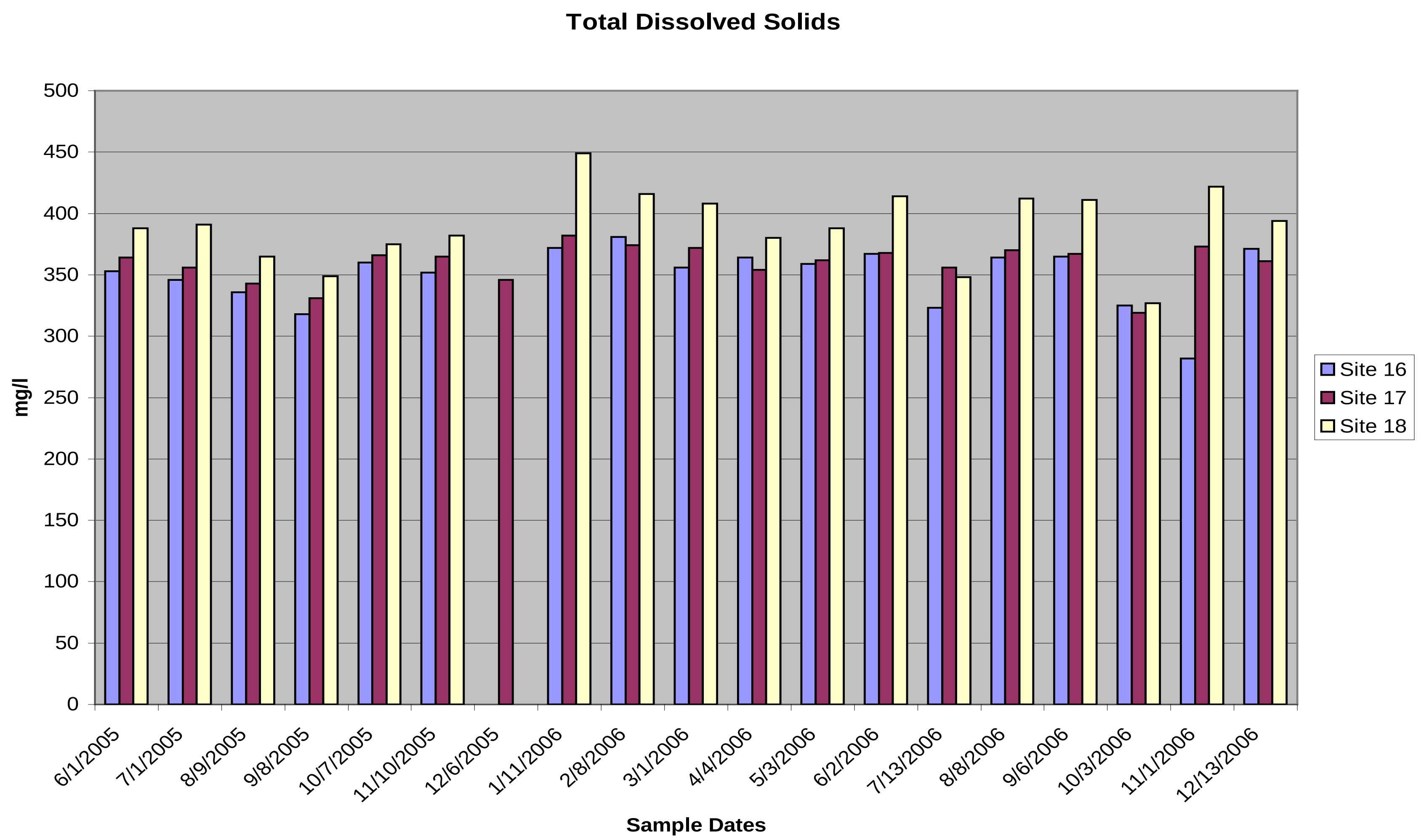


Figure 29: Graphical depiction of total dissolved solids for test sites 136through 18. The Y axis represents milligrams per liter of water.

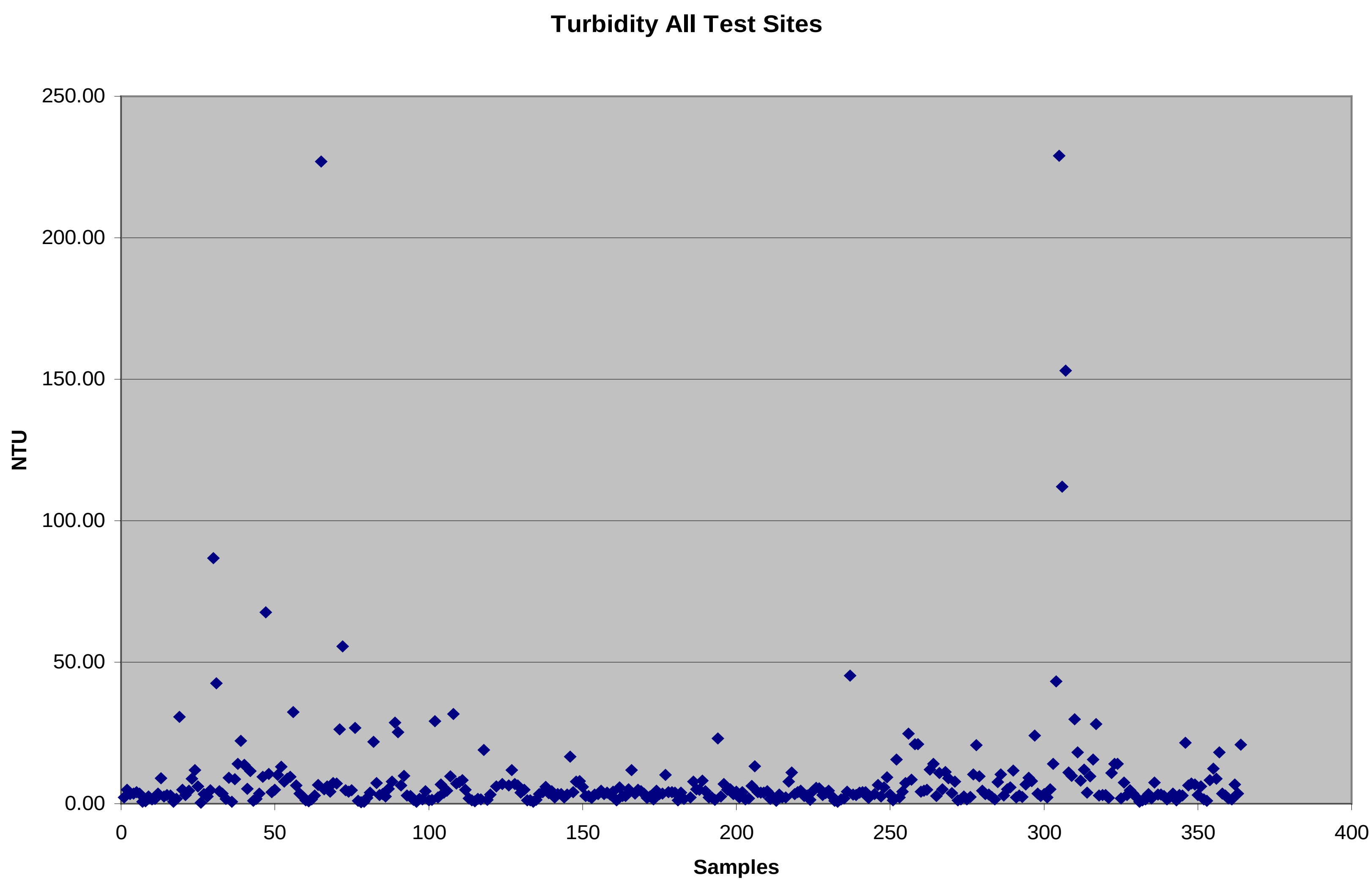


Figure 30: Scatter plot of turbidity for all sites combined. The Y axis represents nephelometer turbidity units.

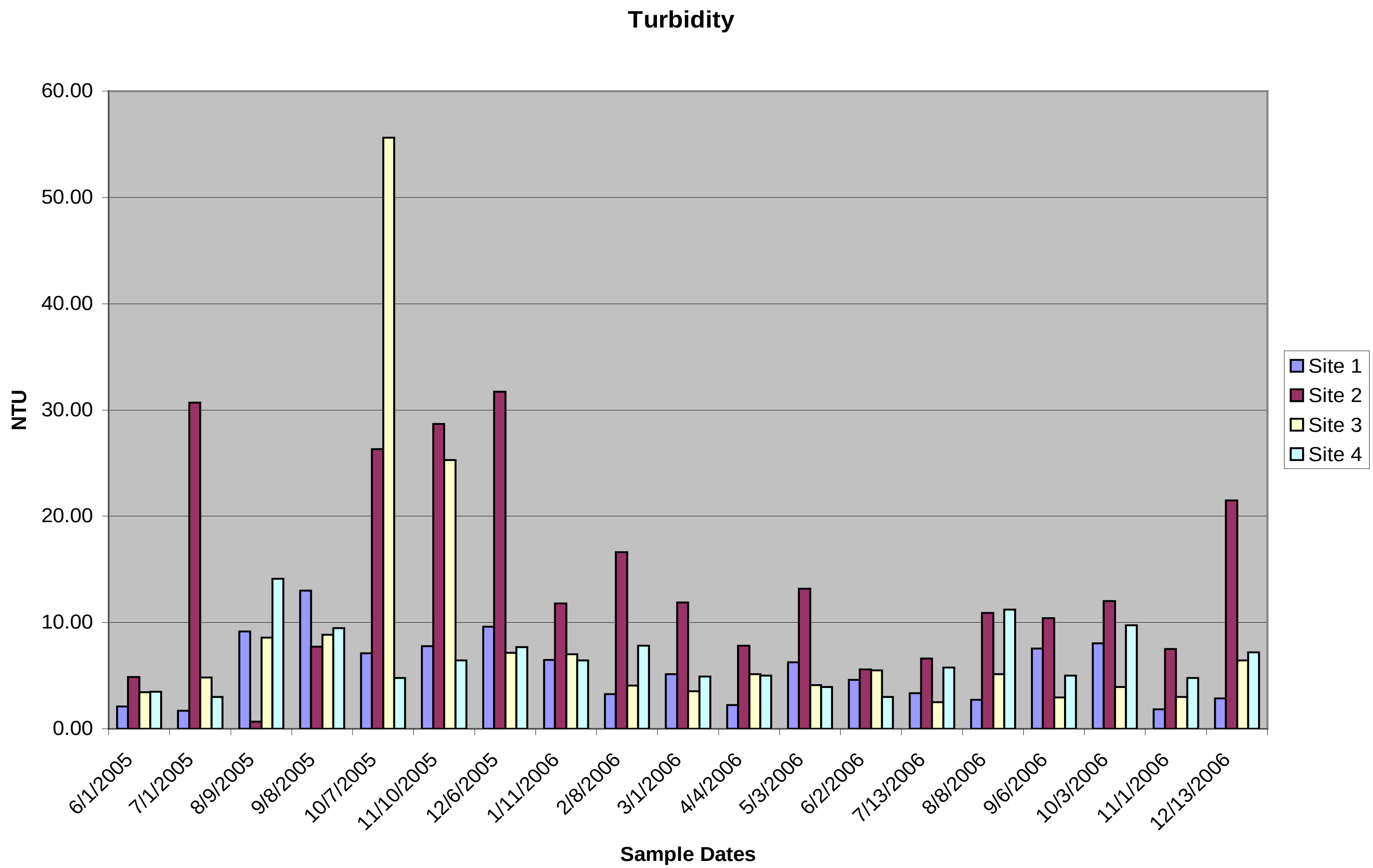


Figure 31: Graphical depiction of turbidity for test sites 1 through 4. The Y axis represents nephelometer turbidity units.

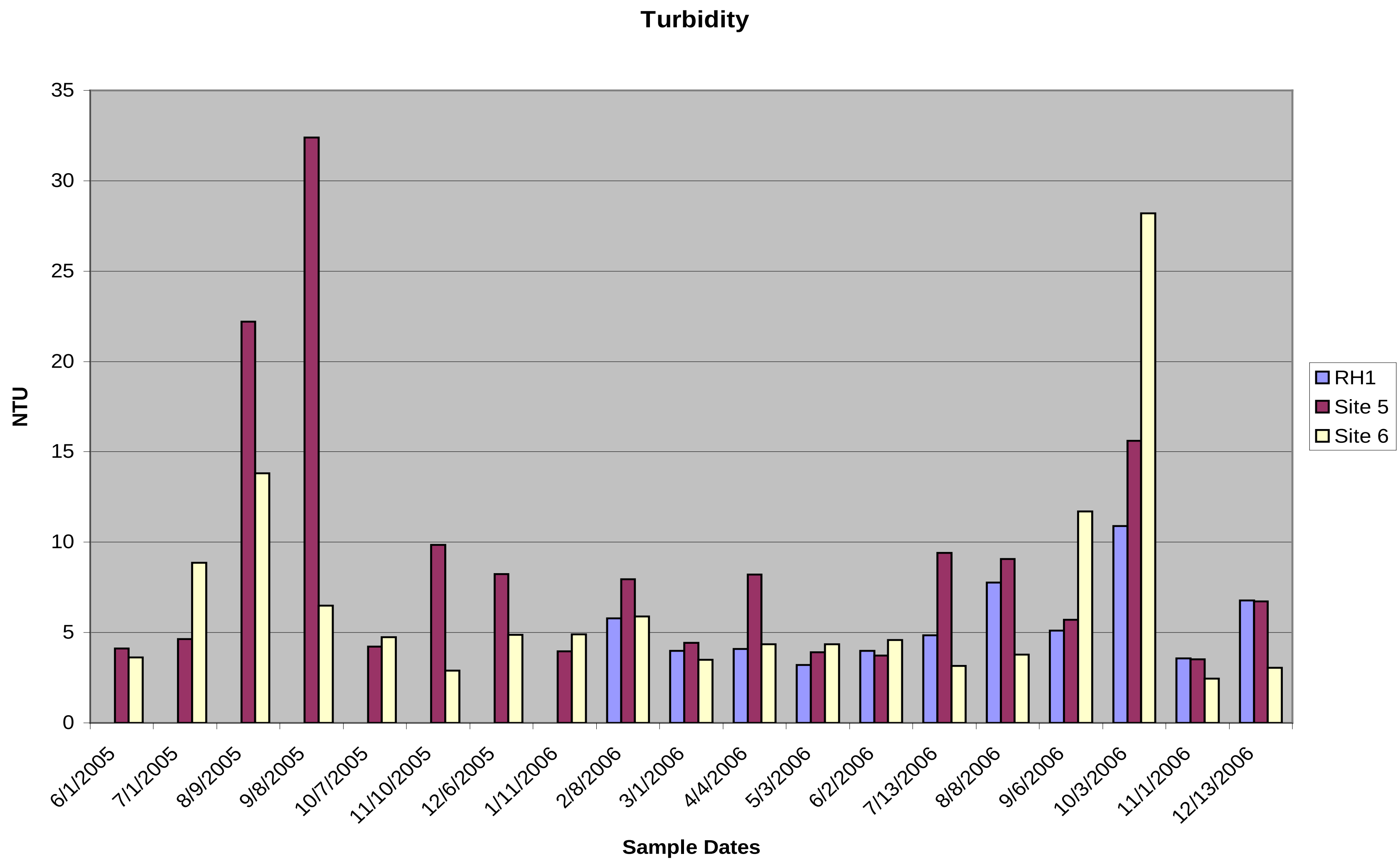


Figure 32: Graphical depiction of turbidity for test sites RH1 through 6. The Y axis represents nephelometer turbidity units.

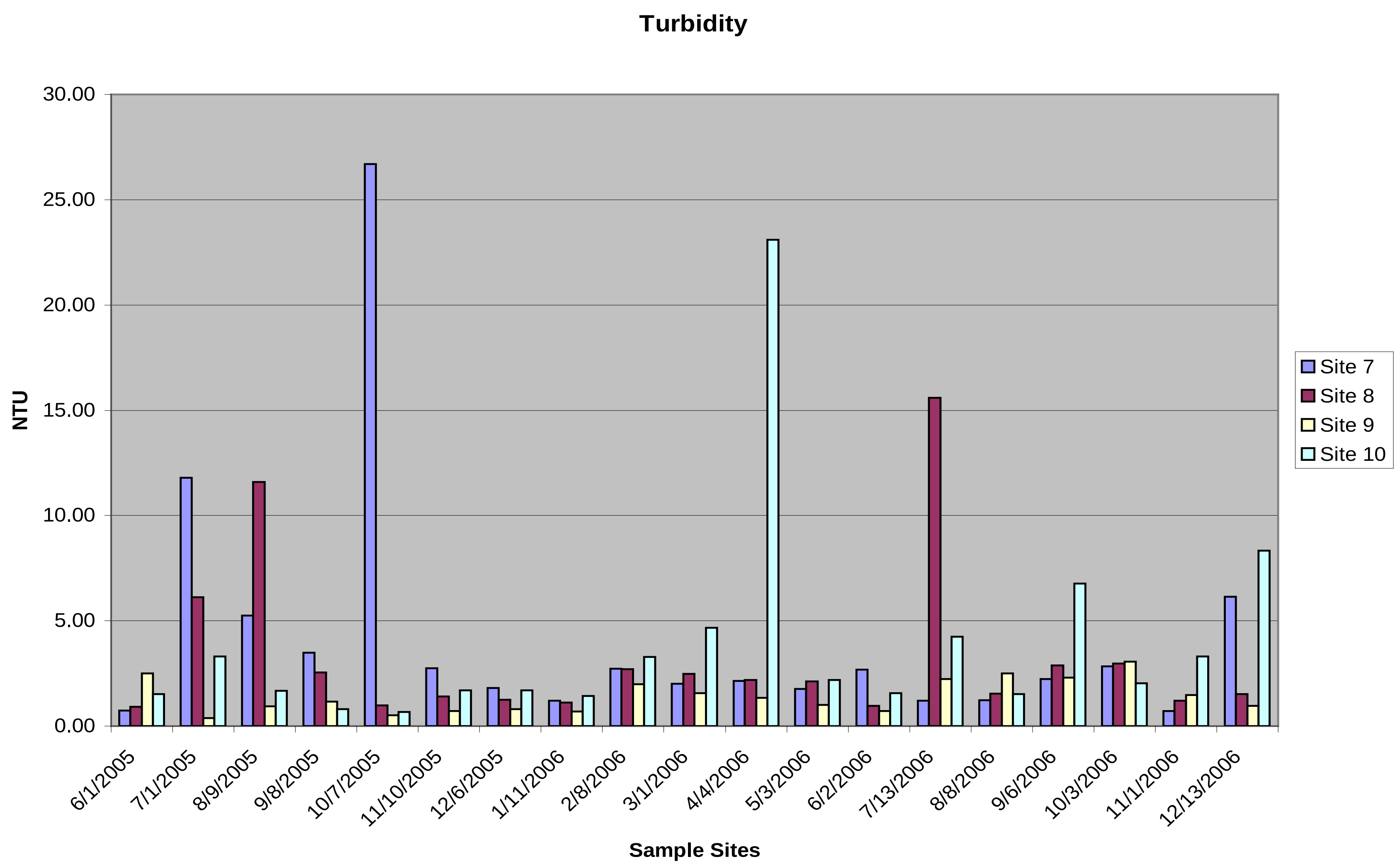


Figure 33: Graphical depiction of turbidity for test sites 7 through 10. The Y axis represents nephelometer turbidity units.

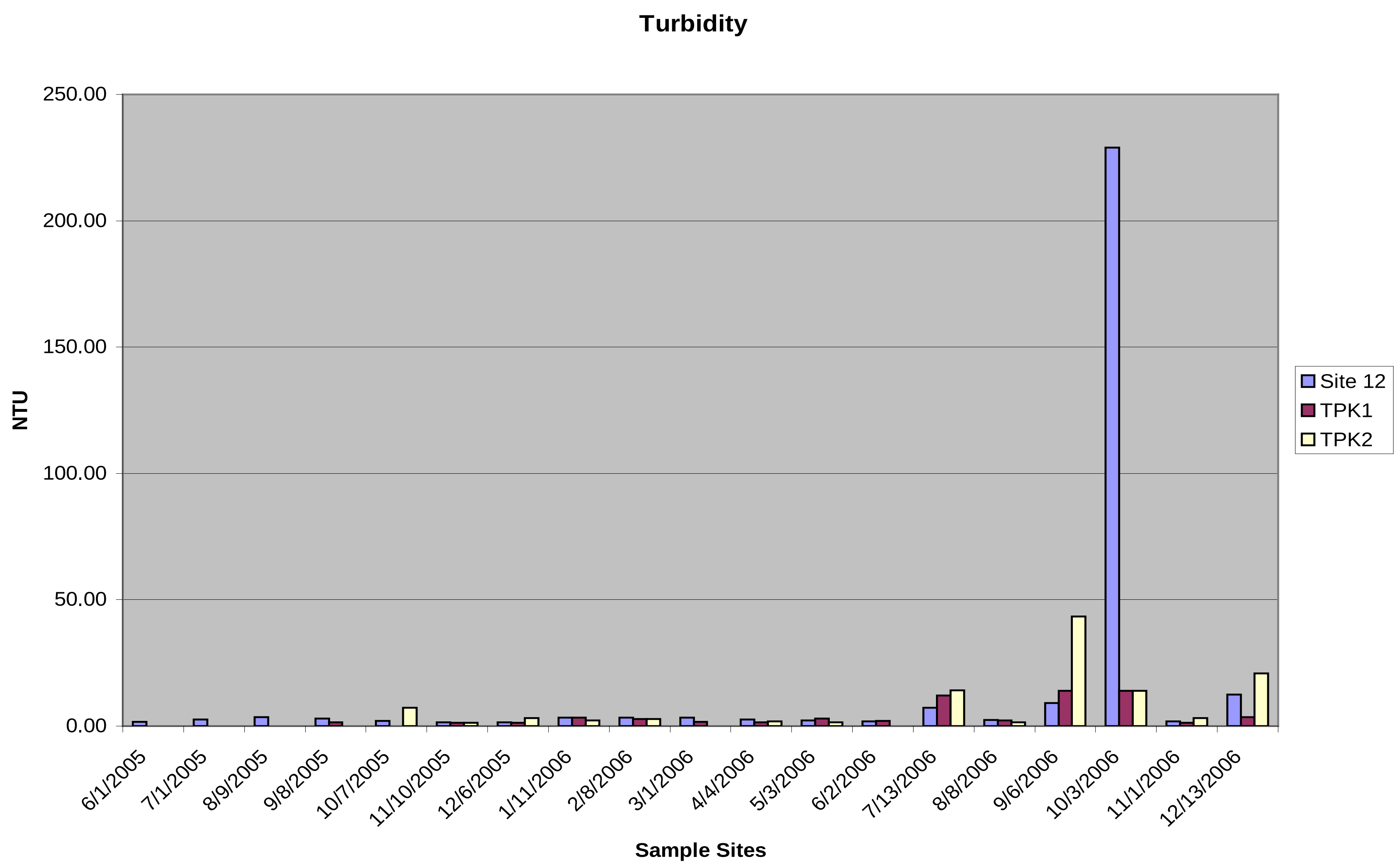


Figure 34: Graphical depiction of turbidity for test sites 12 through TPK2. The Y axis represents nephelometer turbidity units.

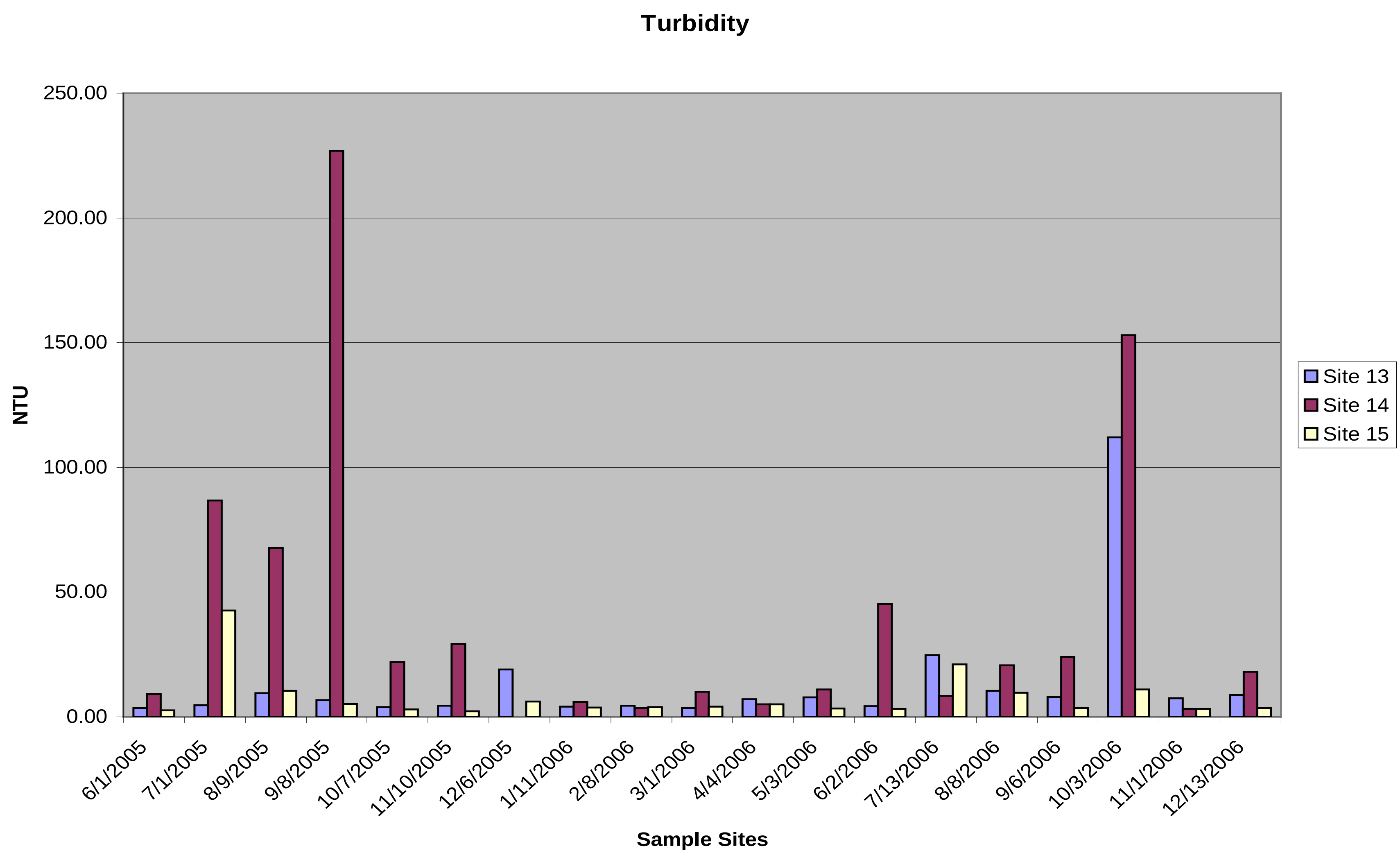


Figure 35: Graphical depiction of turbidity for test sites 13 through 15. The Y axis represents nephelometer turbidity units.

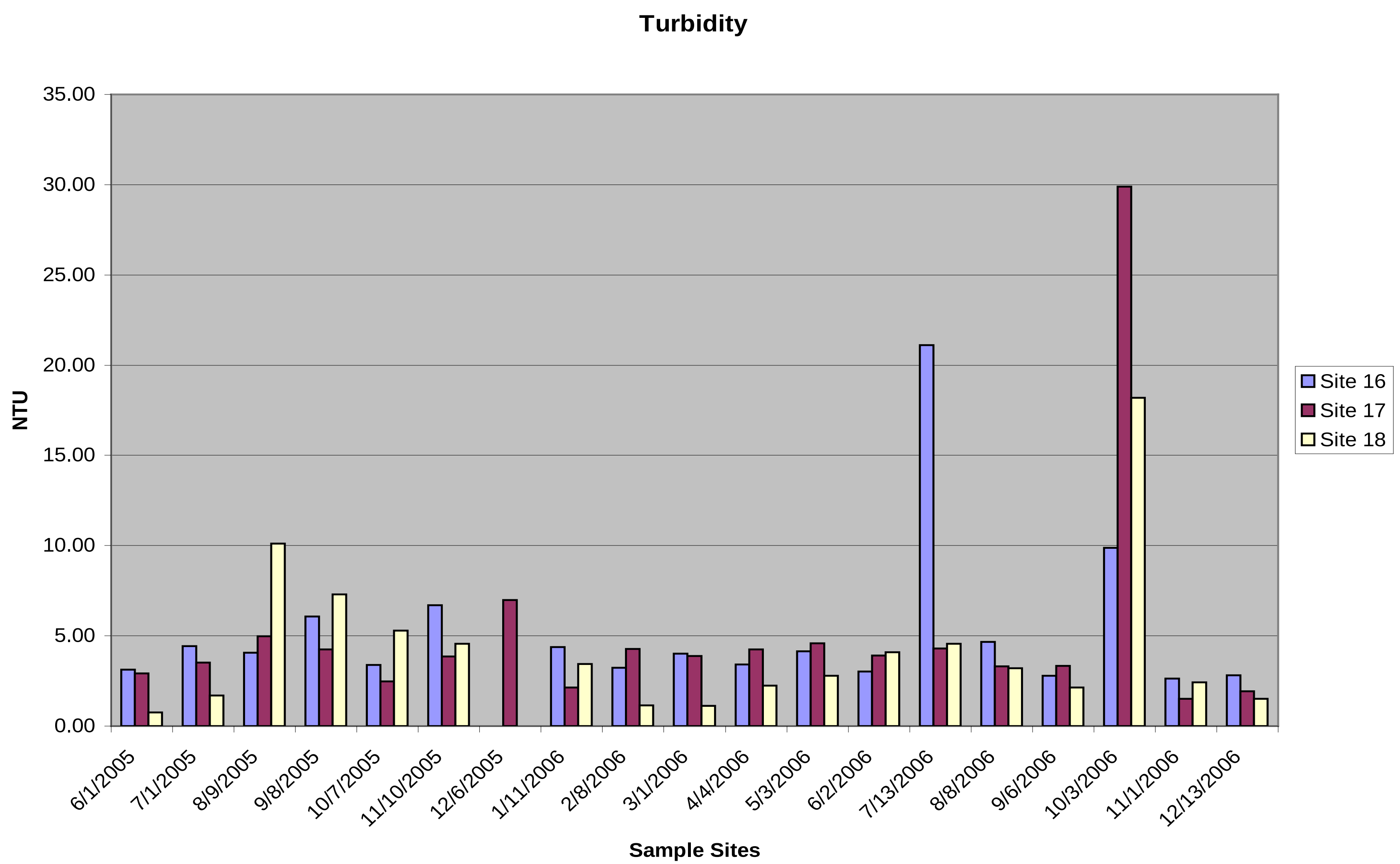


Figure 36: Graphical depiction of turbidity for test sites 16 through 18. The Y axis represents nephelometer turbidity units.

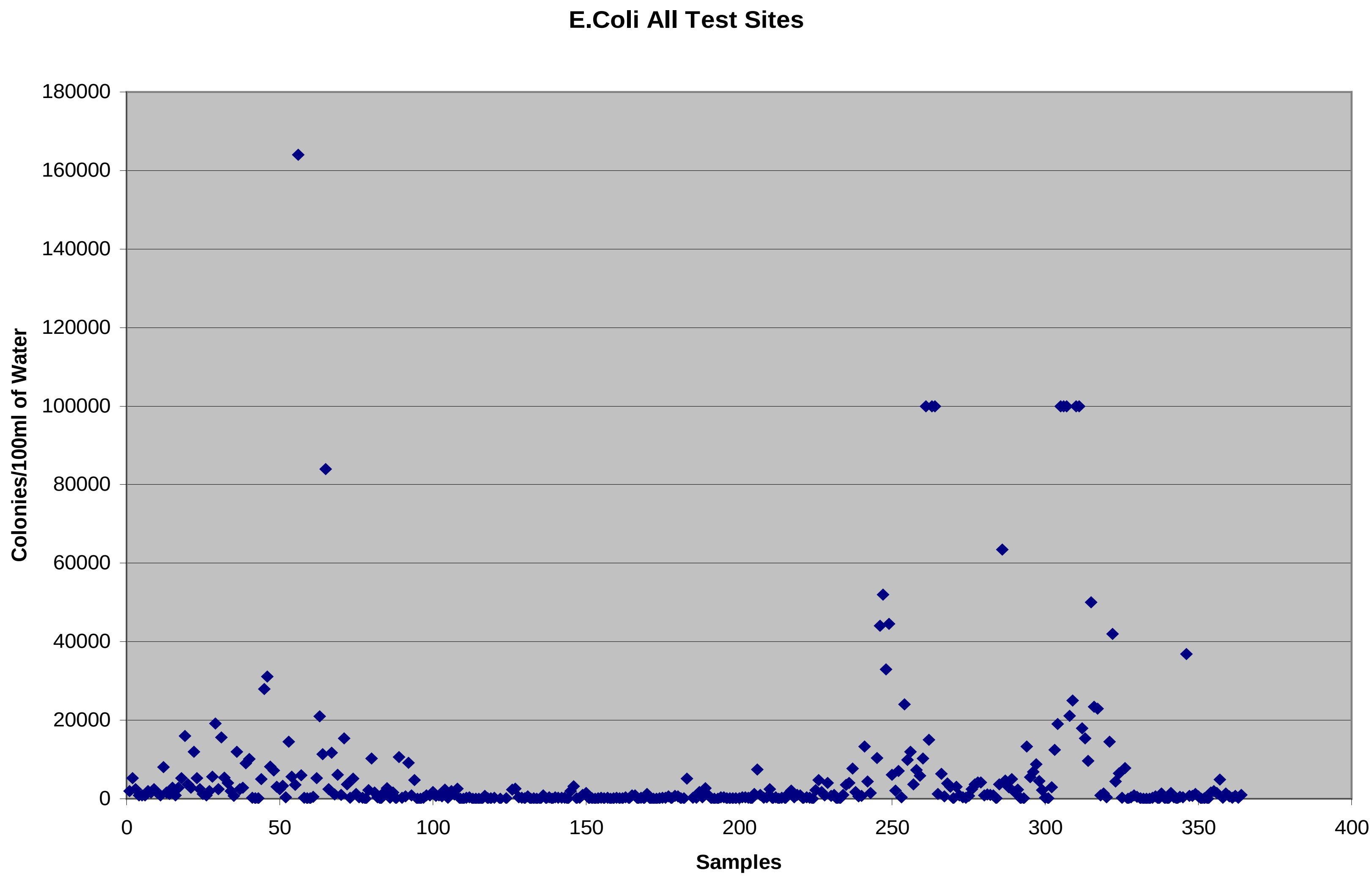


Figure 37: Scatter plot of *E.coli* for all sites combined.

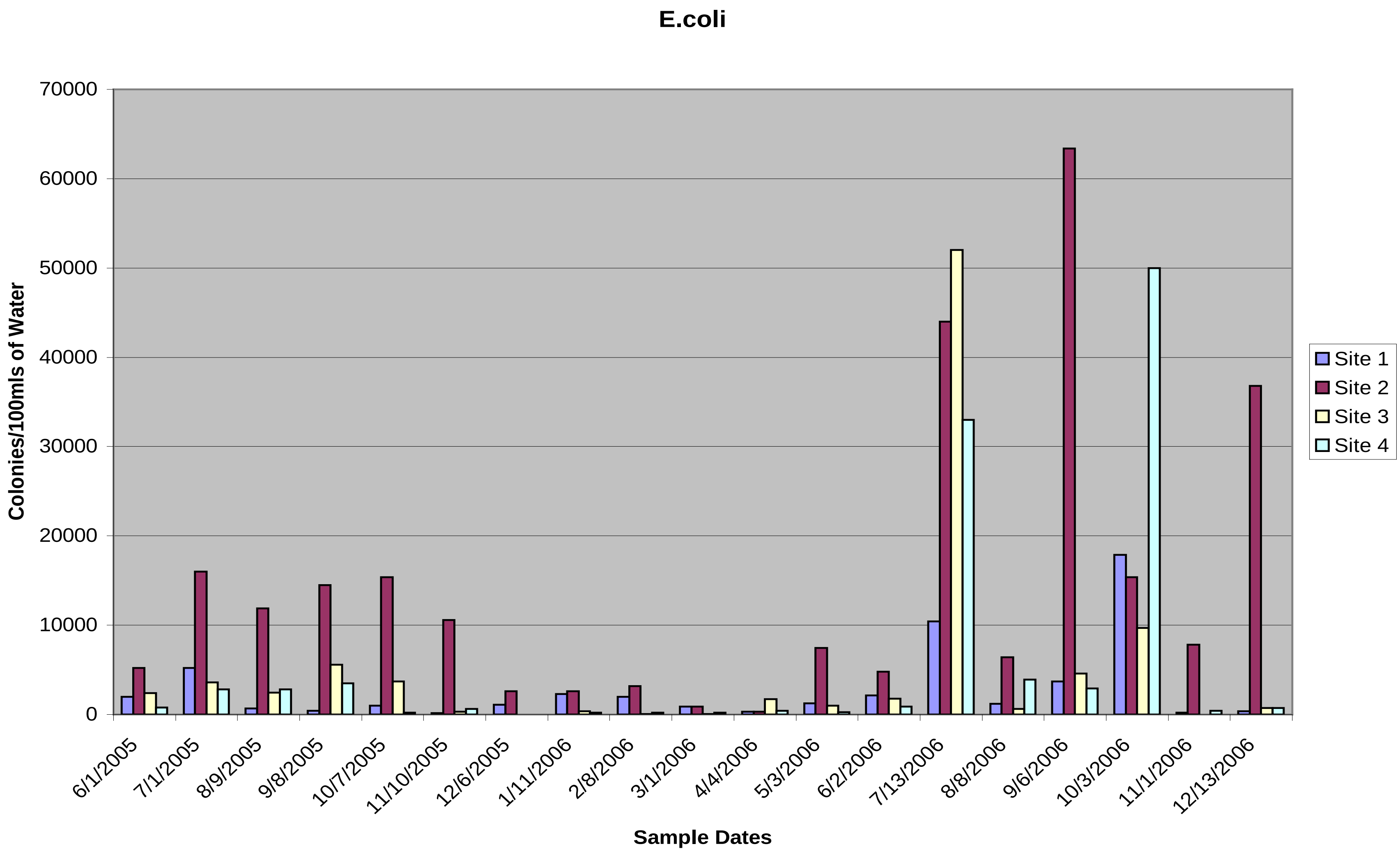


Figure 38: Graphical depiction of *E.coli* for test sites 1 through 4.

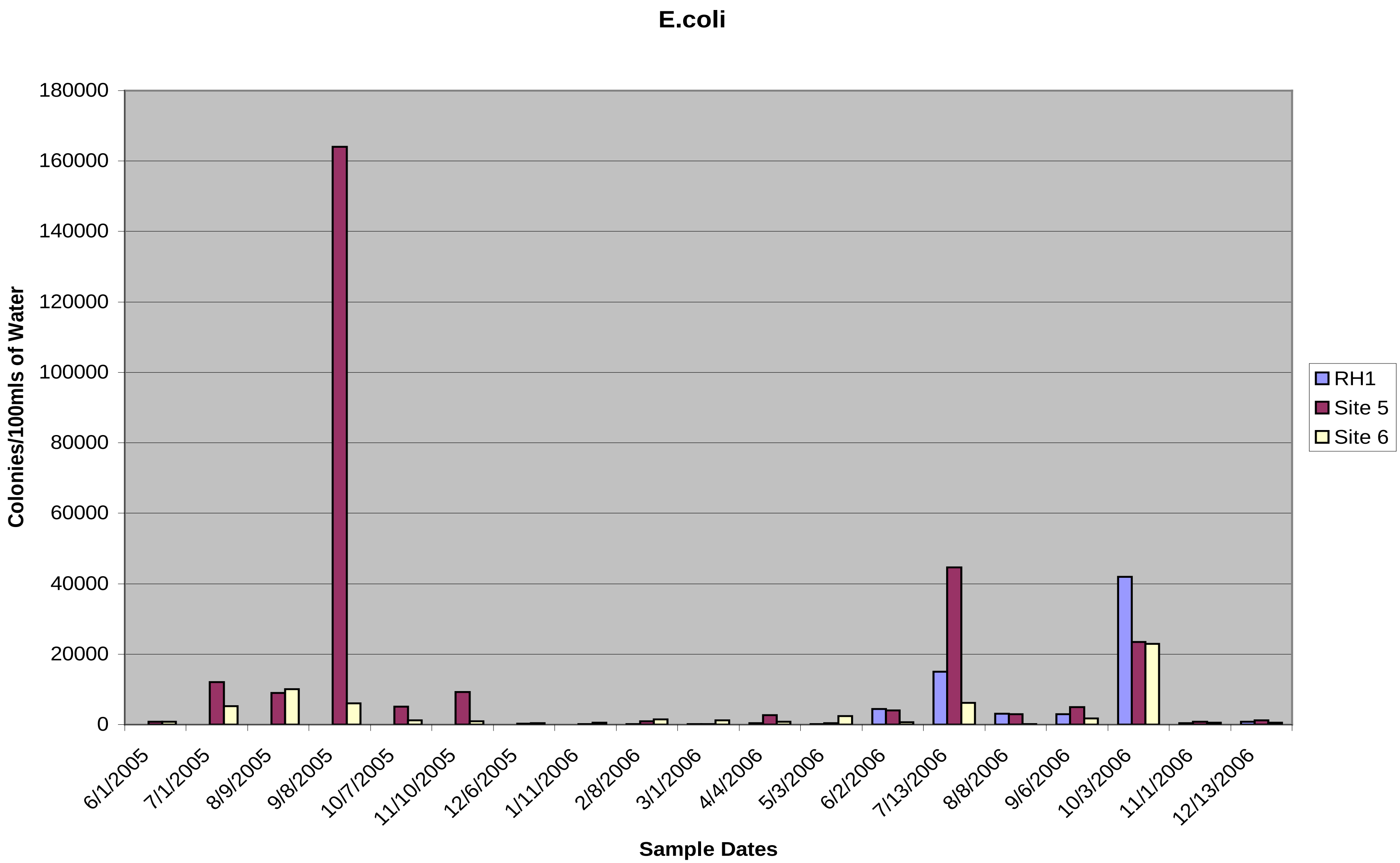


Figure 39: Graphical depiction of *E.coli* for test sites RH1 through 6.

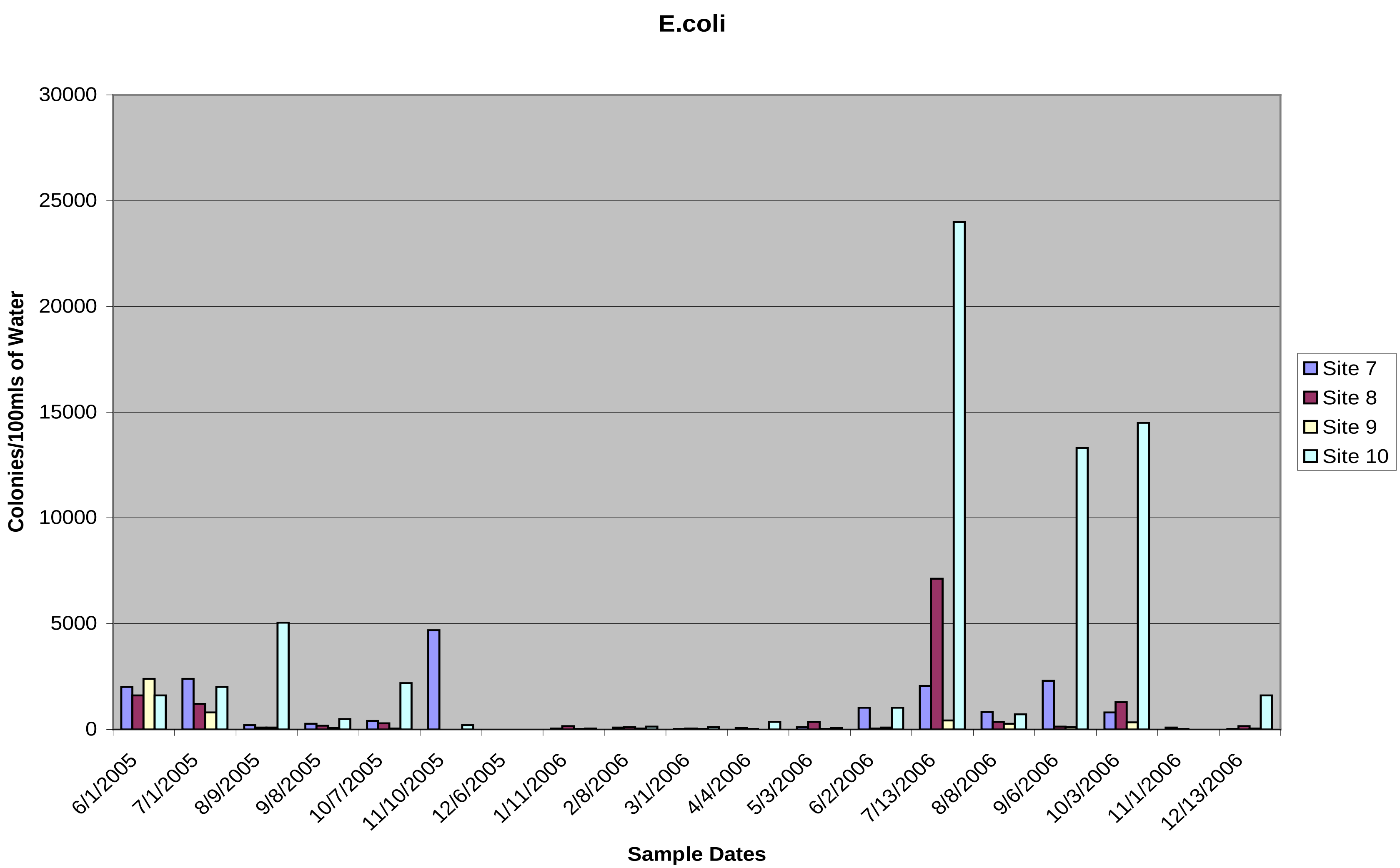


Figure 40: Graphical depiction of *E.coli* for test sites 7 through 10.

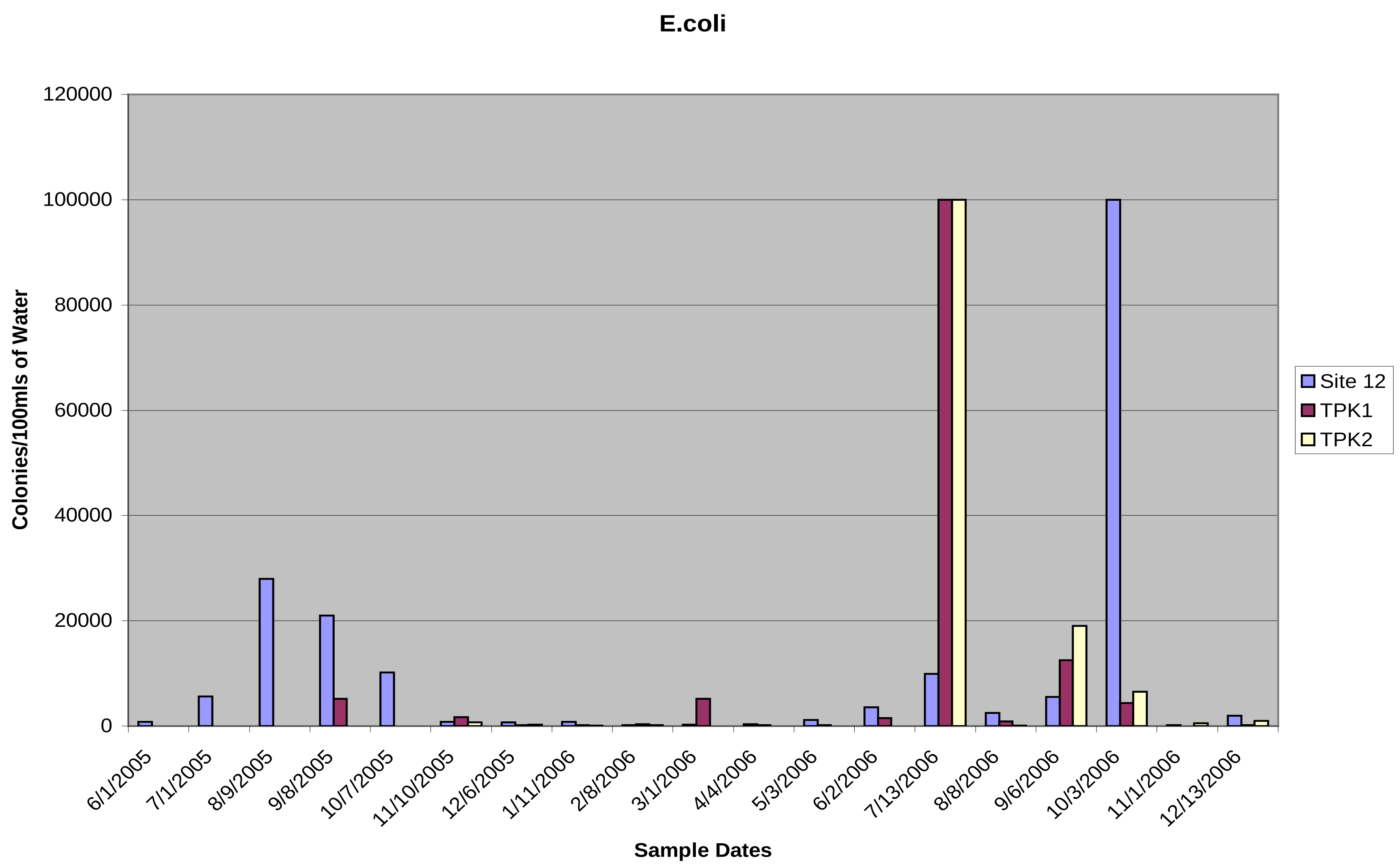


Figure 41: Graphical depiction of *E.coli* for test sites 12 through TPK2.

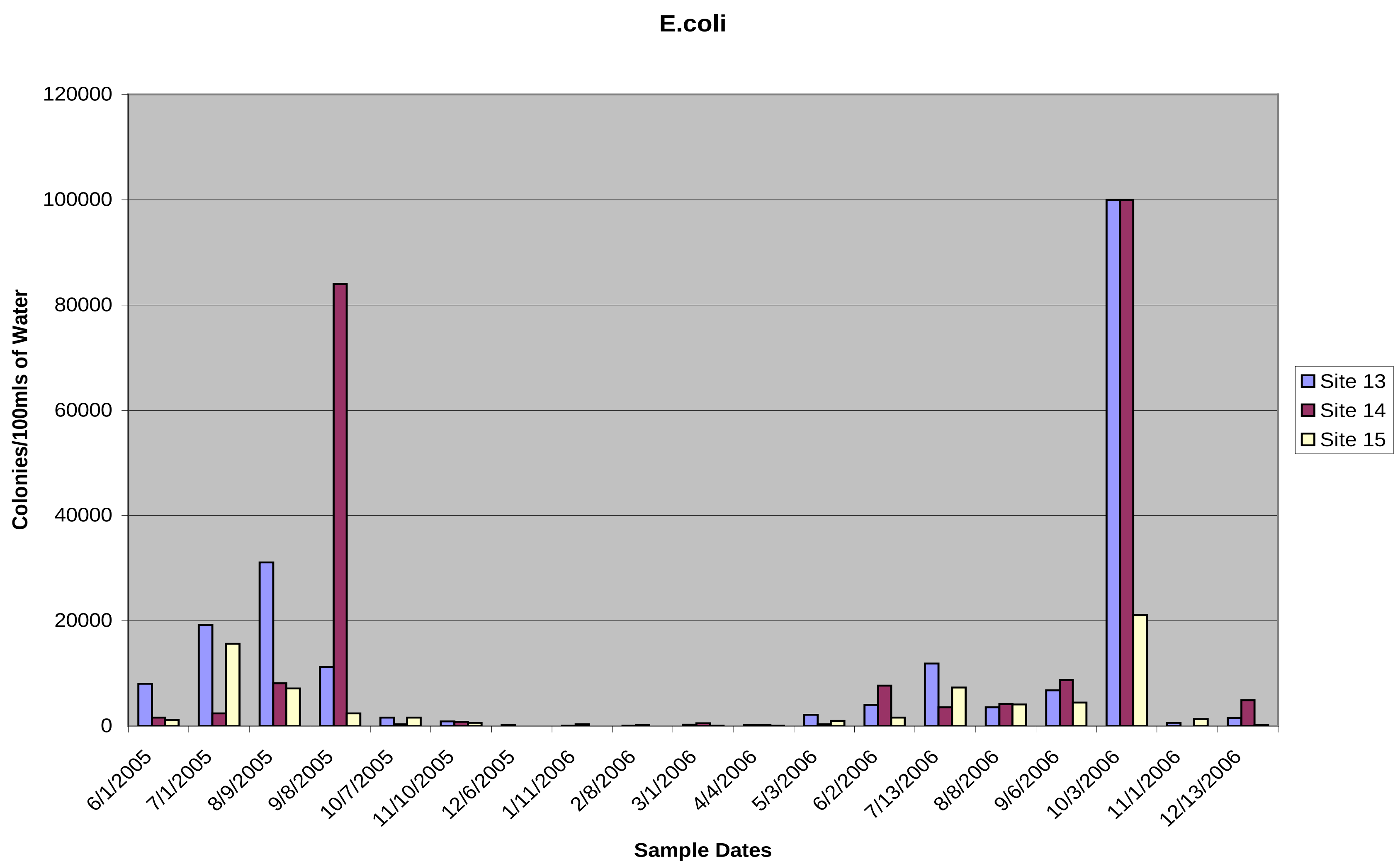


Figure 42: Graphical depiction of *E.coli* for test sites 13 through 15.

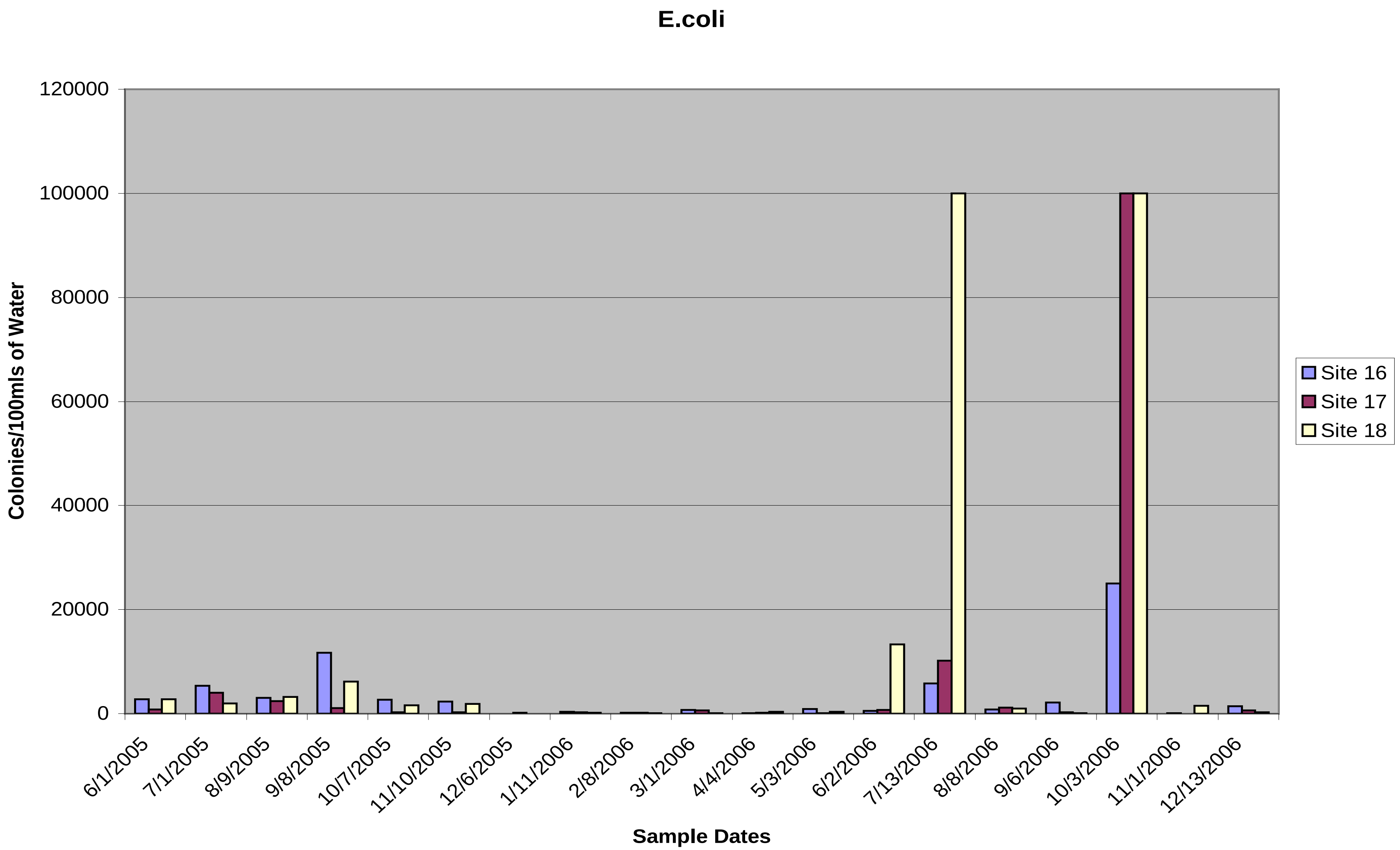


Figure 43: Graphical depiction of *E.coli* for test sites 16 through 18.

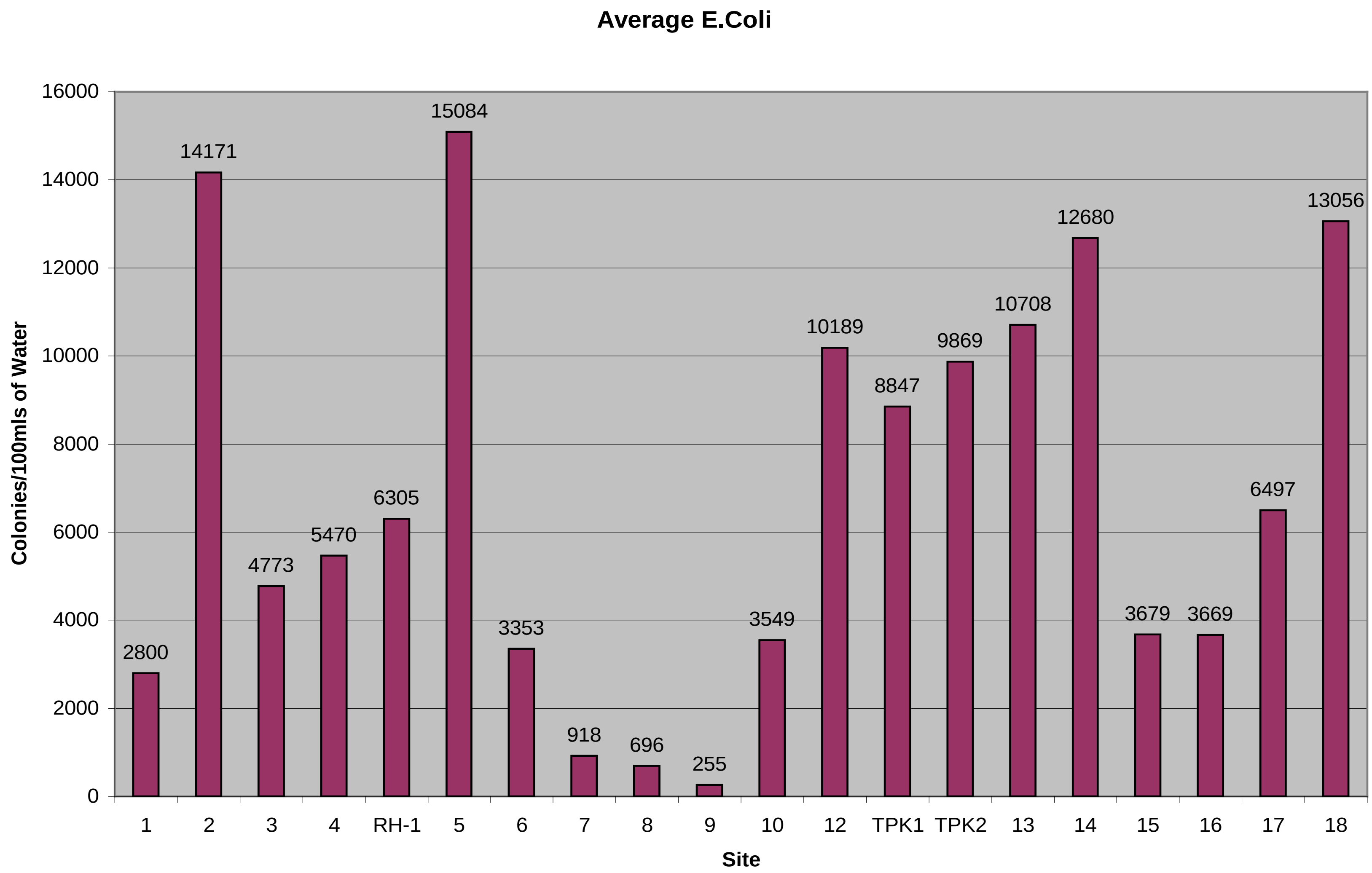


Figure 44: Average *E.coli* by site. The target level is 2000 colonies per 100mls of water.

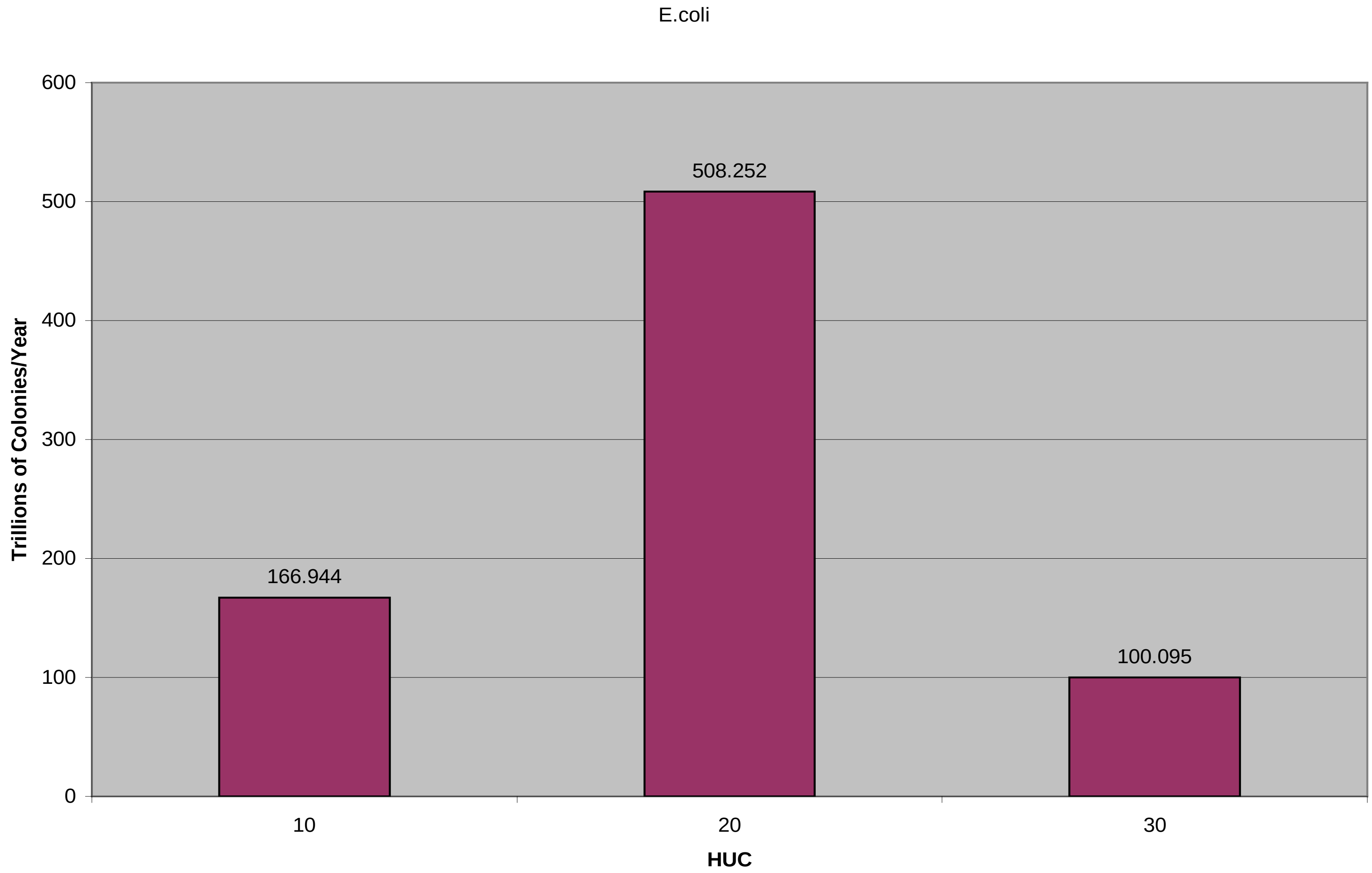


Figure 45: Yearly loading of *E.coli* by HUC.

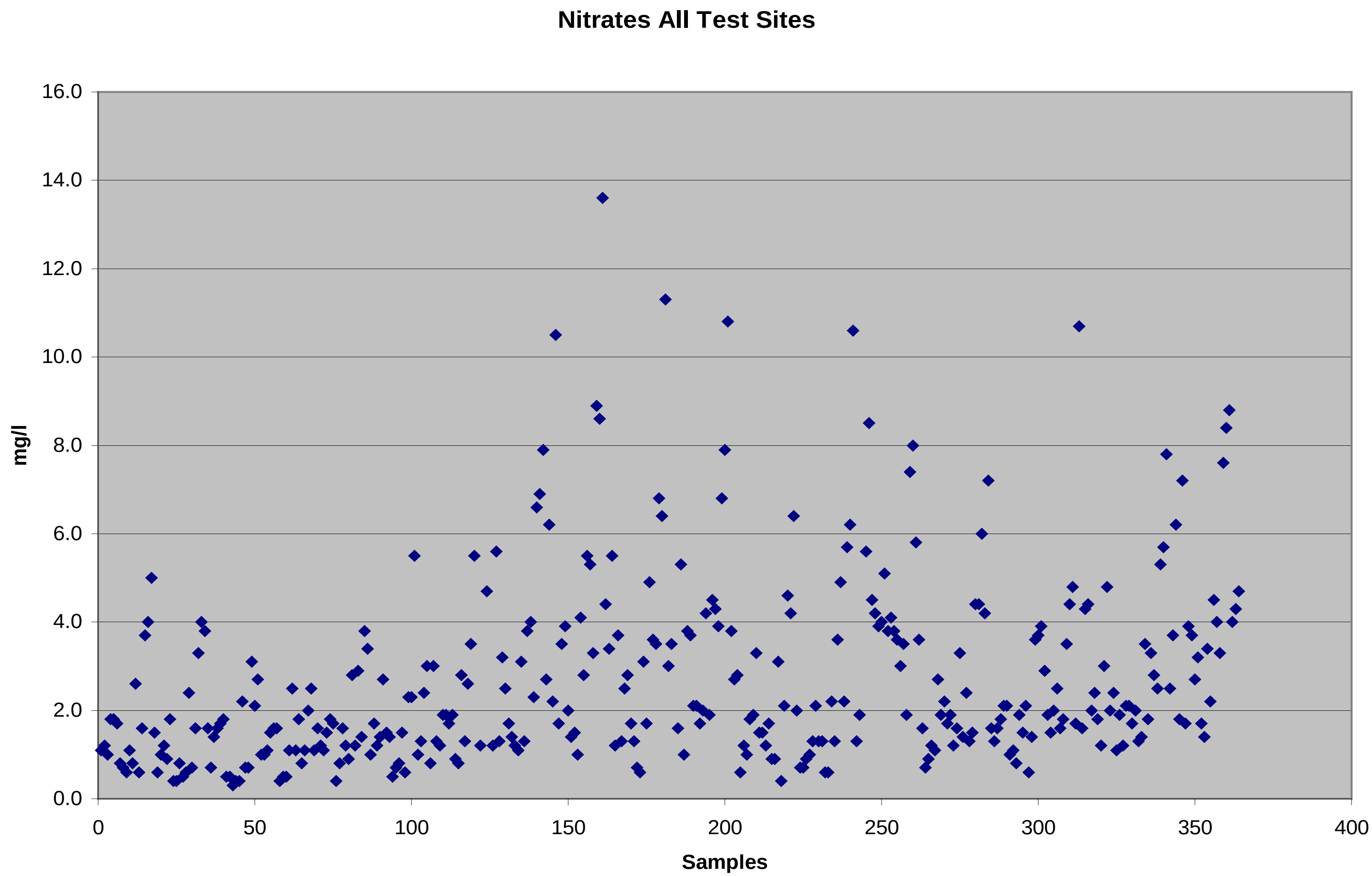


Figure 46: Scatter plot of nitrates for all sites combined. The Y axis represents milligrams per liter of water.

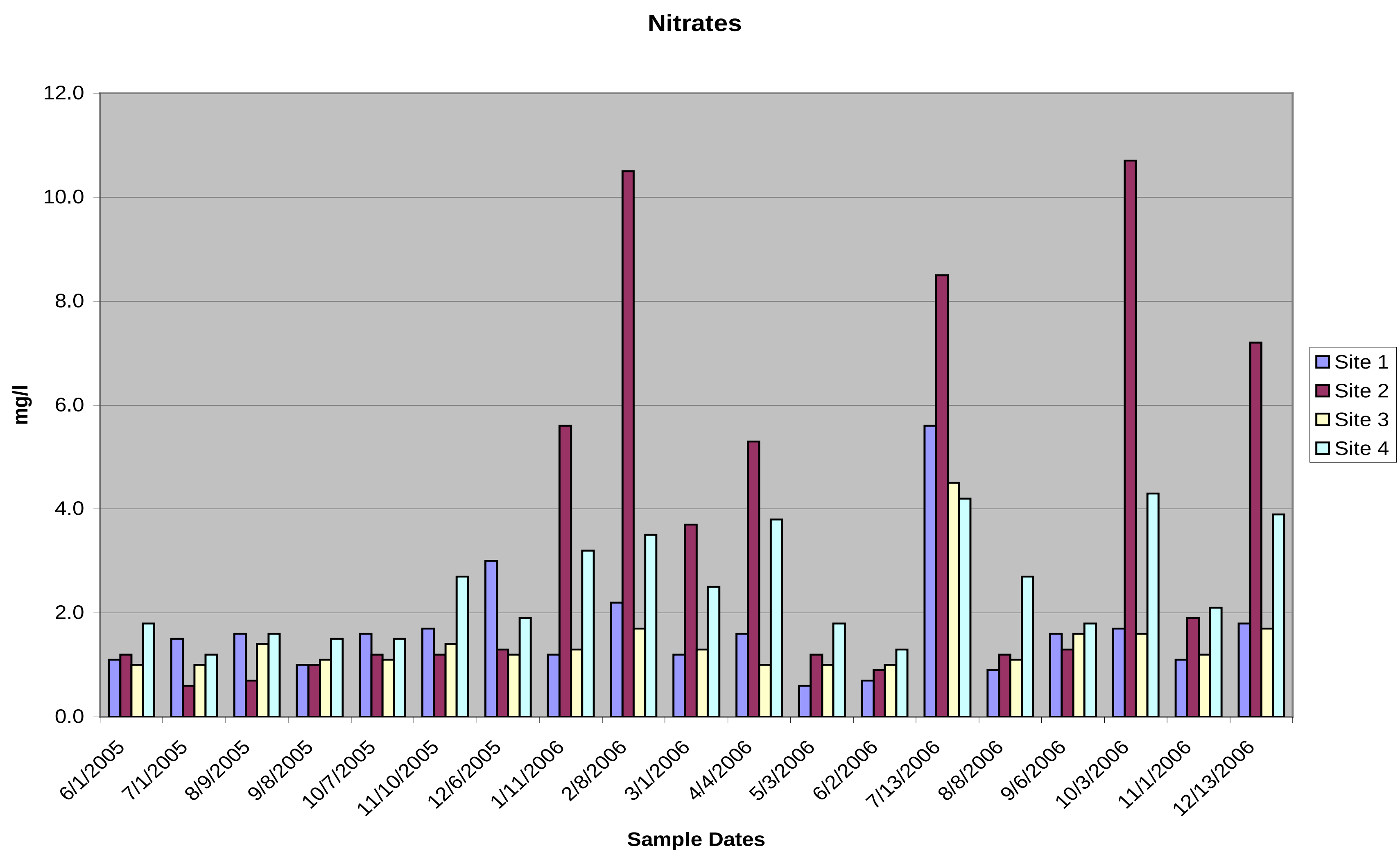


Figure 47: Graphical depiction of nitrates for test sites 1 through 4. The Y axis represents milligrams per liter of water.

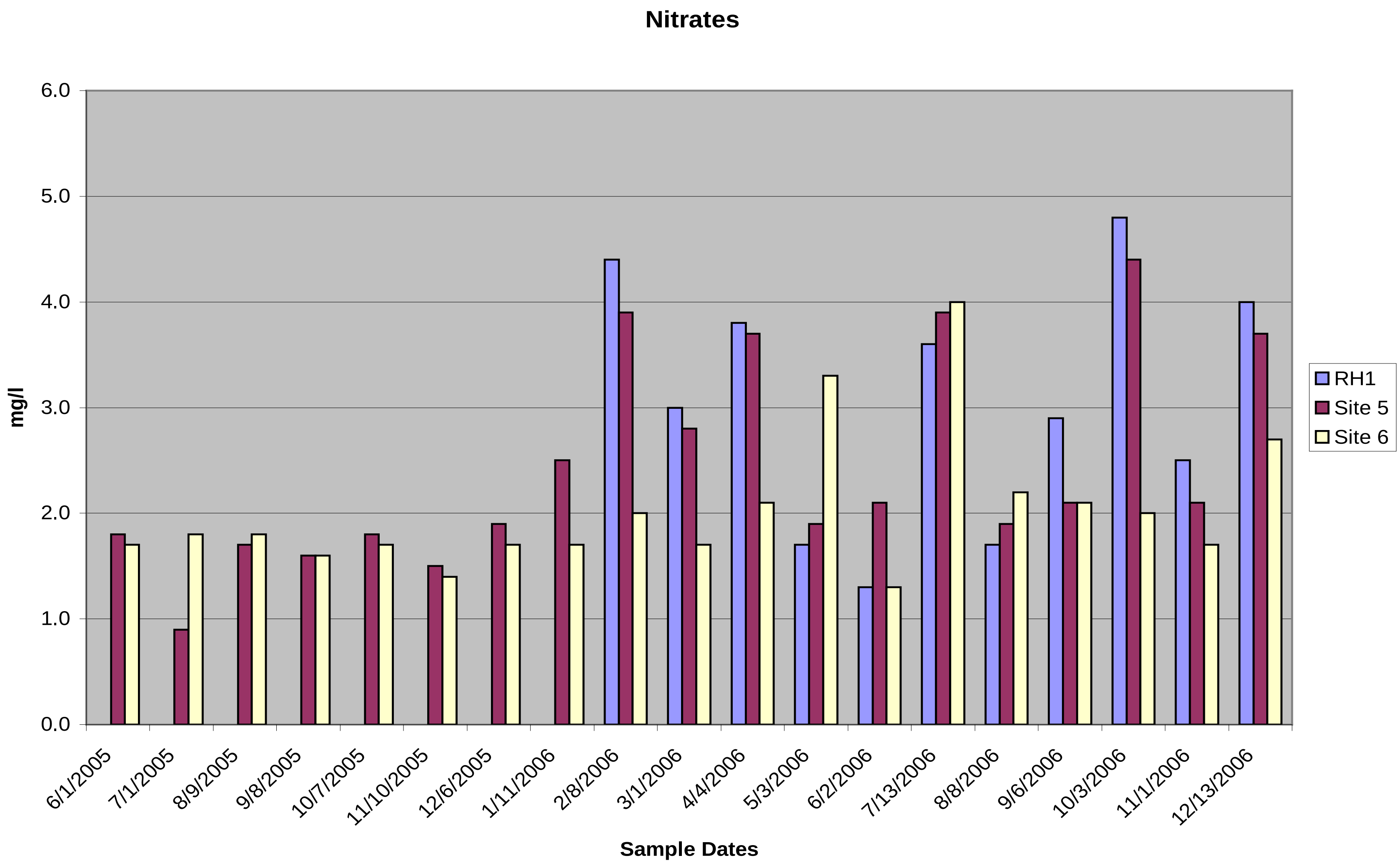


Figure 48: Graphical depiction of nitrates for test sites RH1 through 6. The Y axis represents milligrams per liter of water.

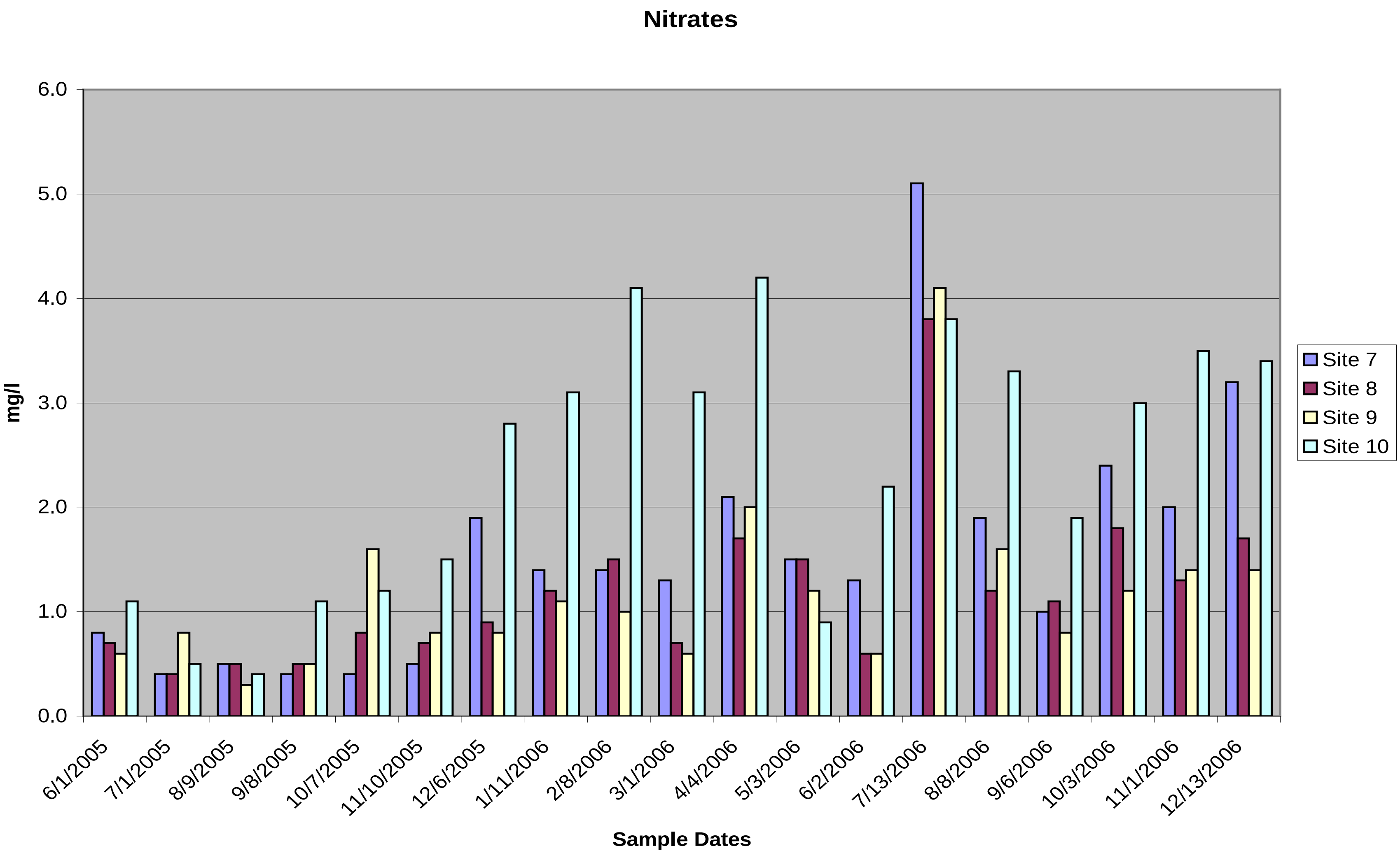


Figure 49: Graphical depiction of nitrates for test sites 7 through 10. The Y axis represents milligrams per liter of water.

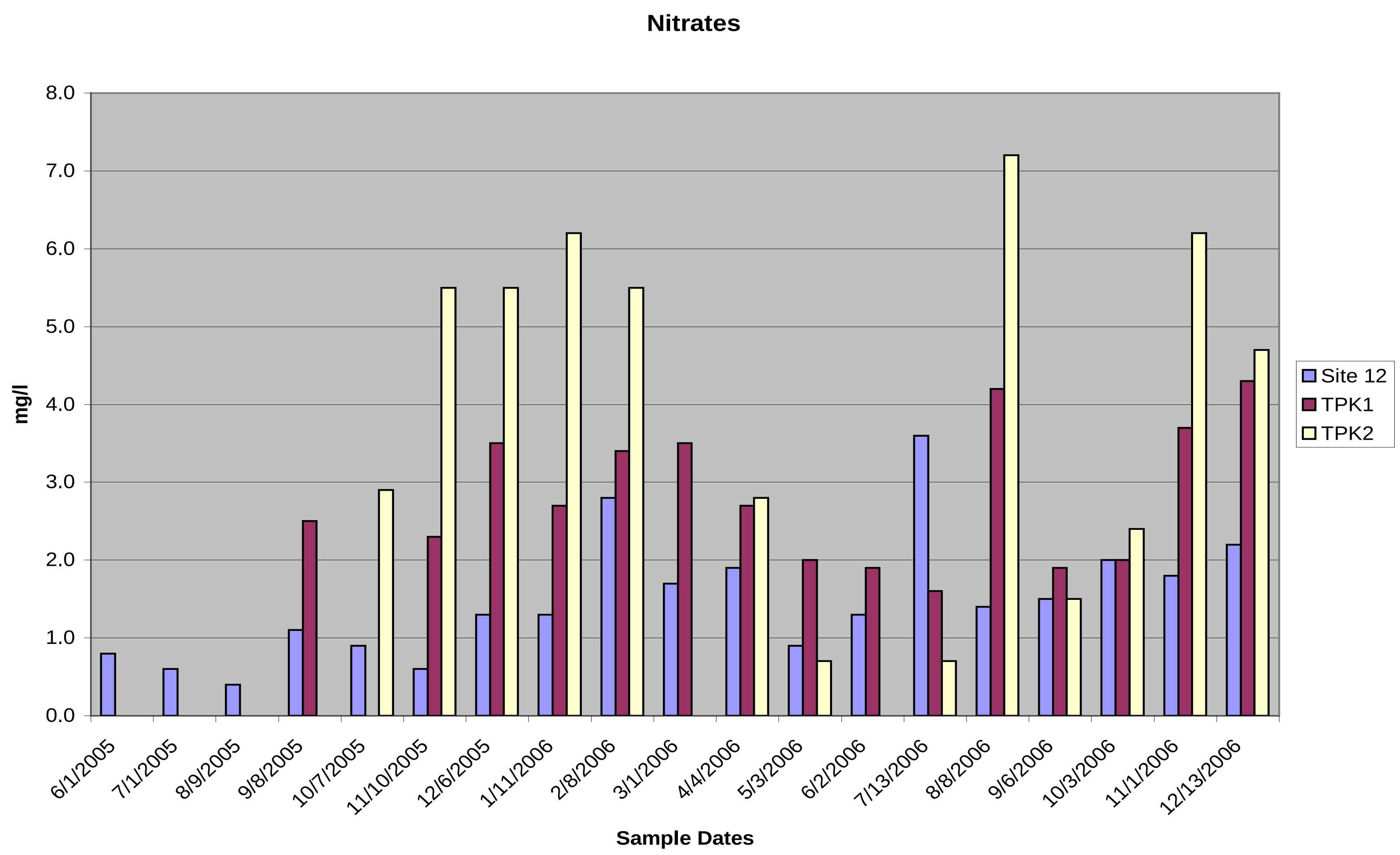


Figure 50: Graphical depiction of nitrates for test sites 12 through TPK2. The Y axis represents milligrams per liter of water.

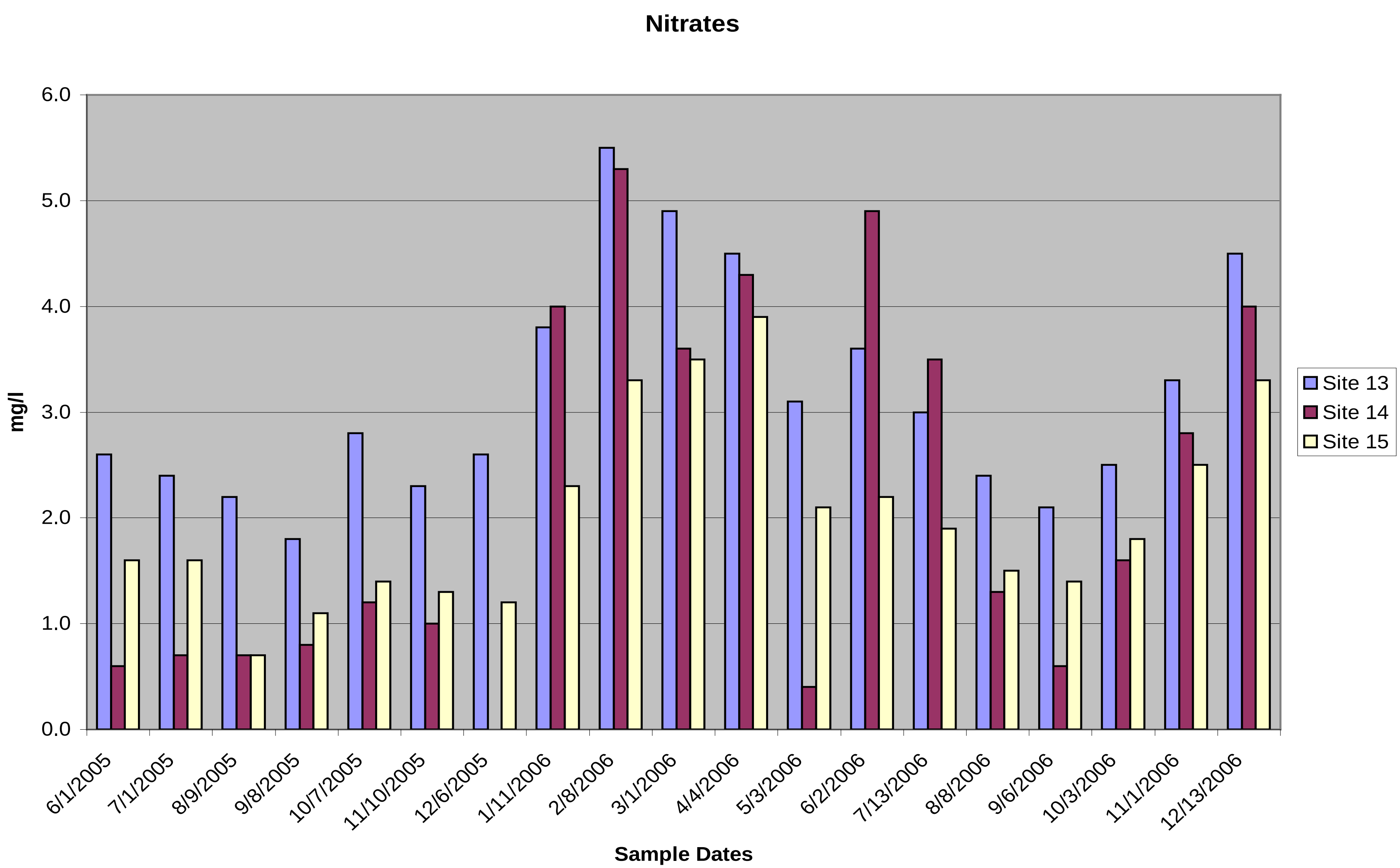


Figure 51: Graphical depiction of nitrates for test sites 13 through 15. The Y axis represents milligrams per liter of water.

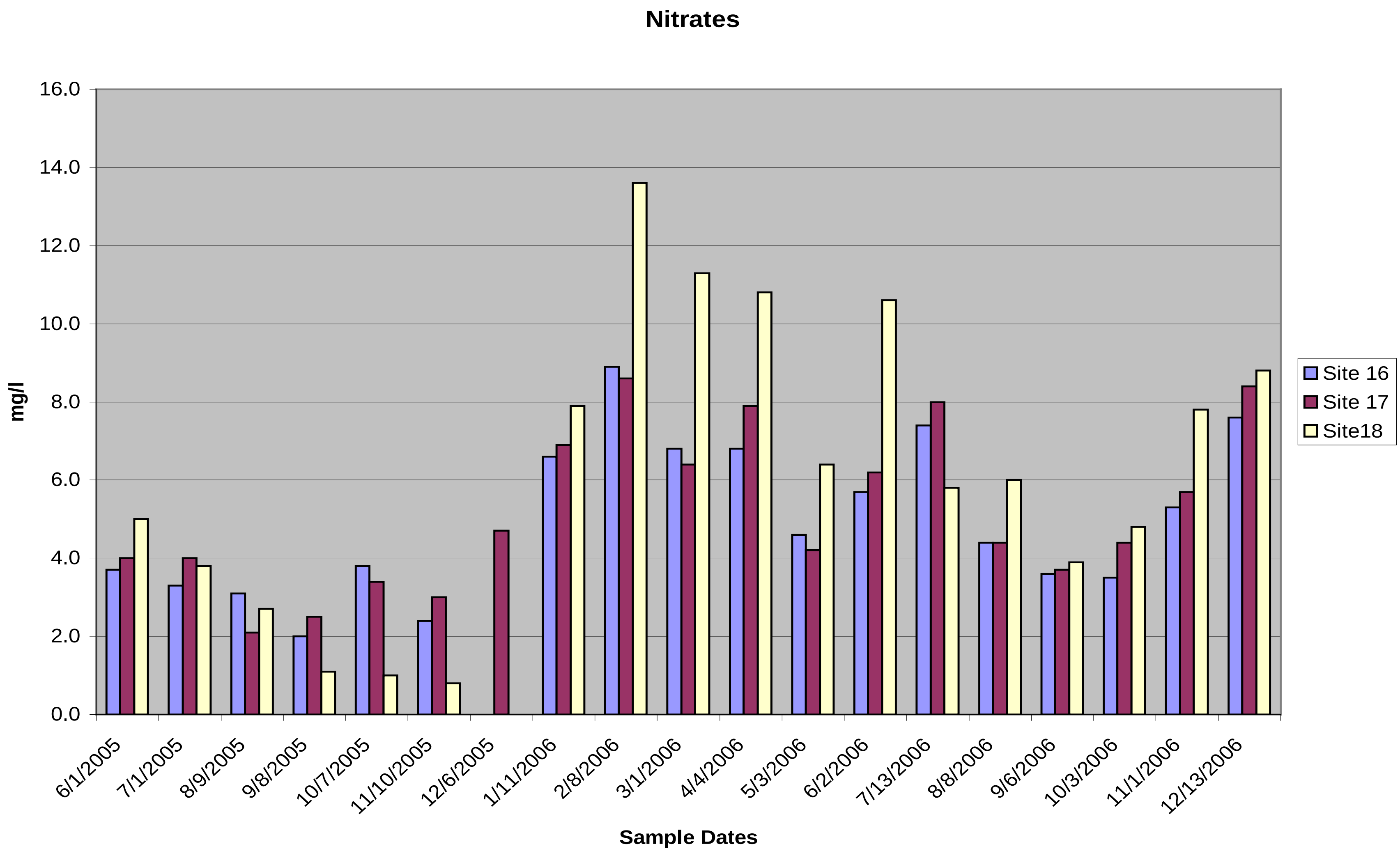


Figure 52: Graphical depiction of nitrates for test sites 16 through 18. The Y axis represents milligrams per liter of water.

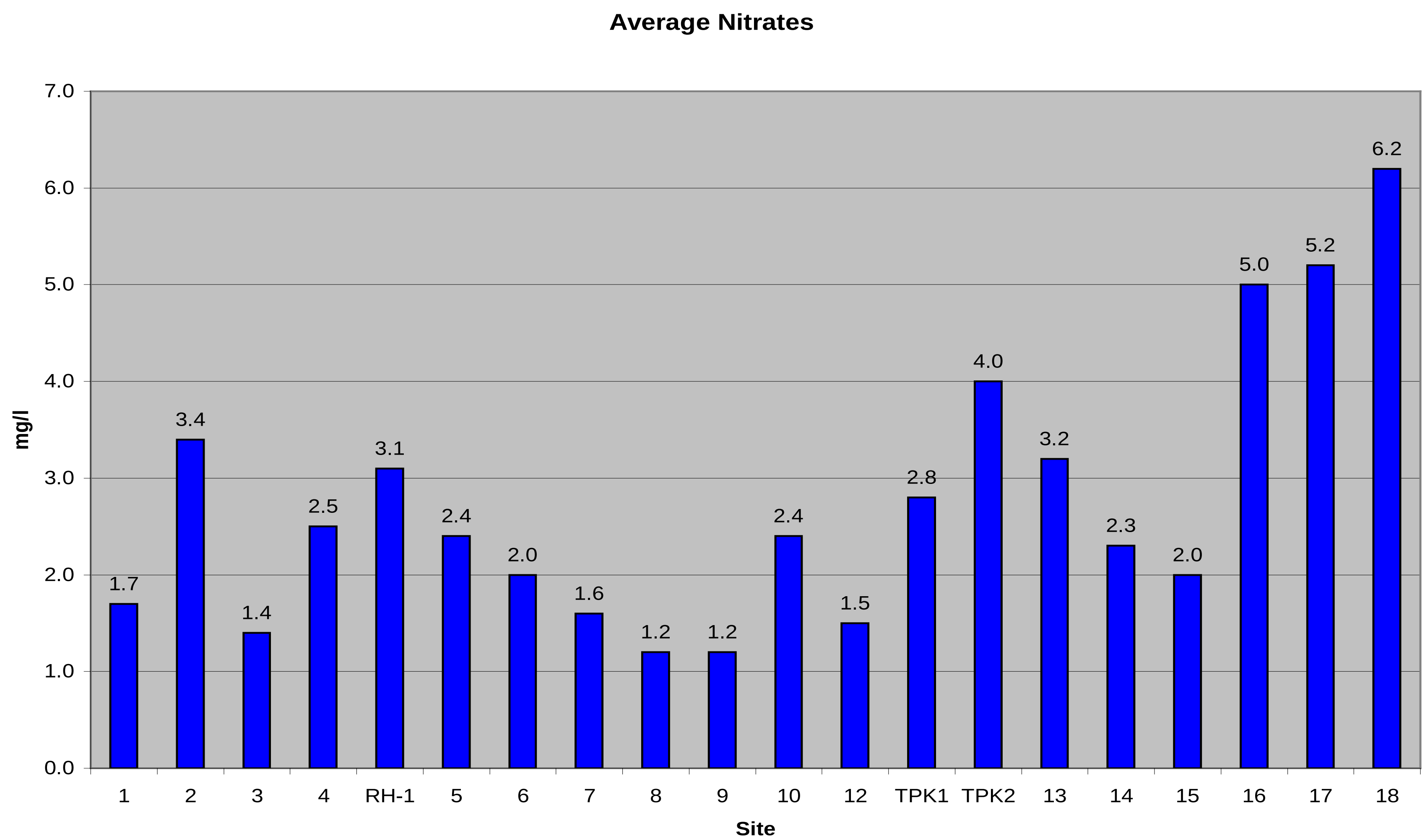


Figure 53: Average nitrates by site. The Y axis represents milligrams per liter of water.

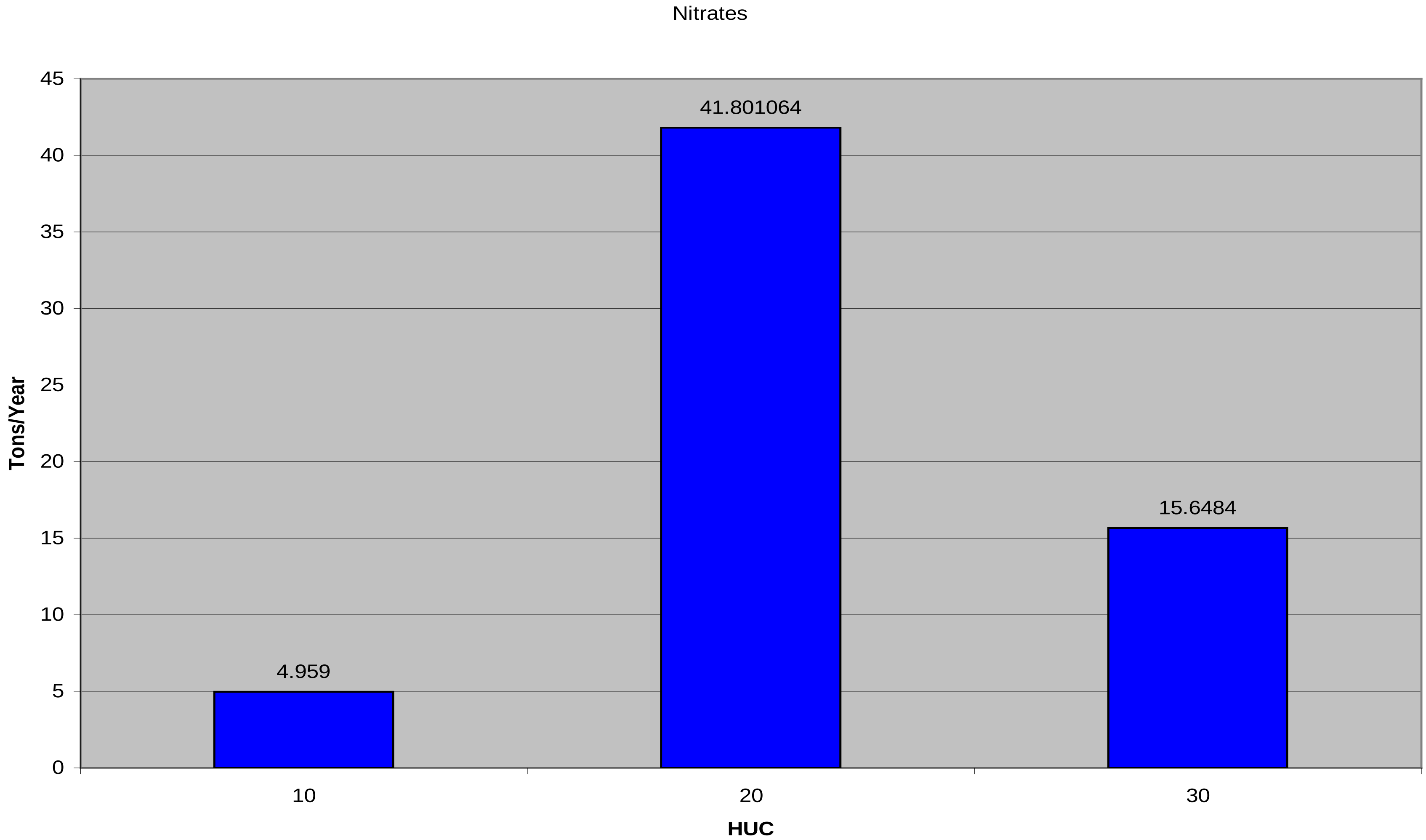


Figure 54: Yearly loading of nitrates in tons-US. HUC numbers correspond to the last 2 digits in the 14 digit code.

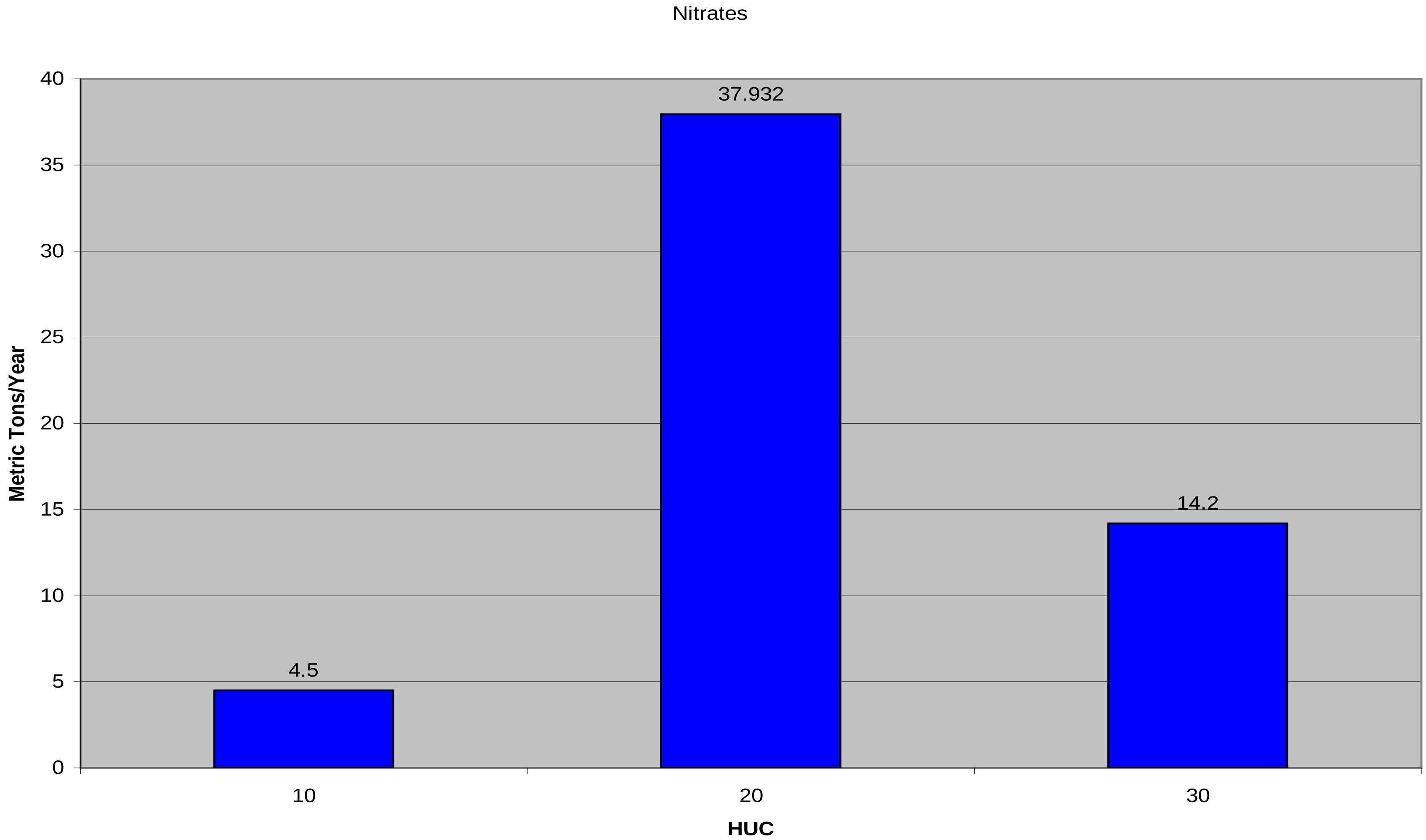


Figure 55: Yearly loading of nitrates in metric tons. HUC numbers correspond to the last 2 digits in the 14 digit code.

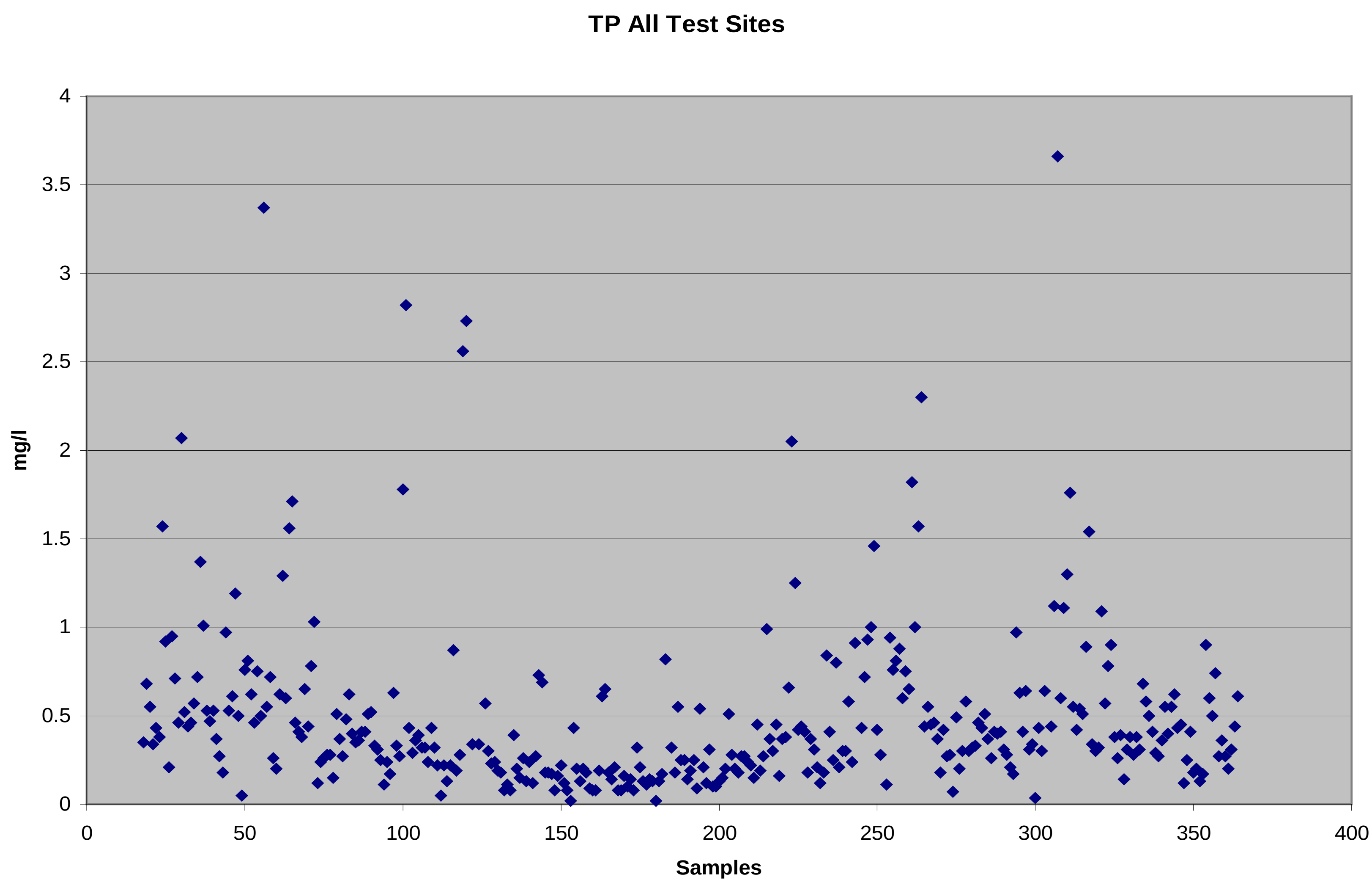


Figure 56: Scatter plot of total phosphorus for all sites combined. The Y axis represents milligrams per liter of water.

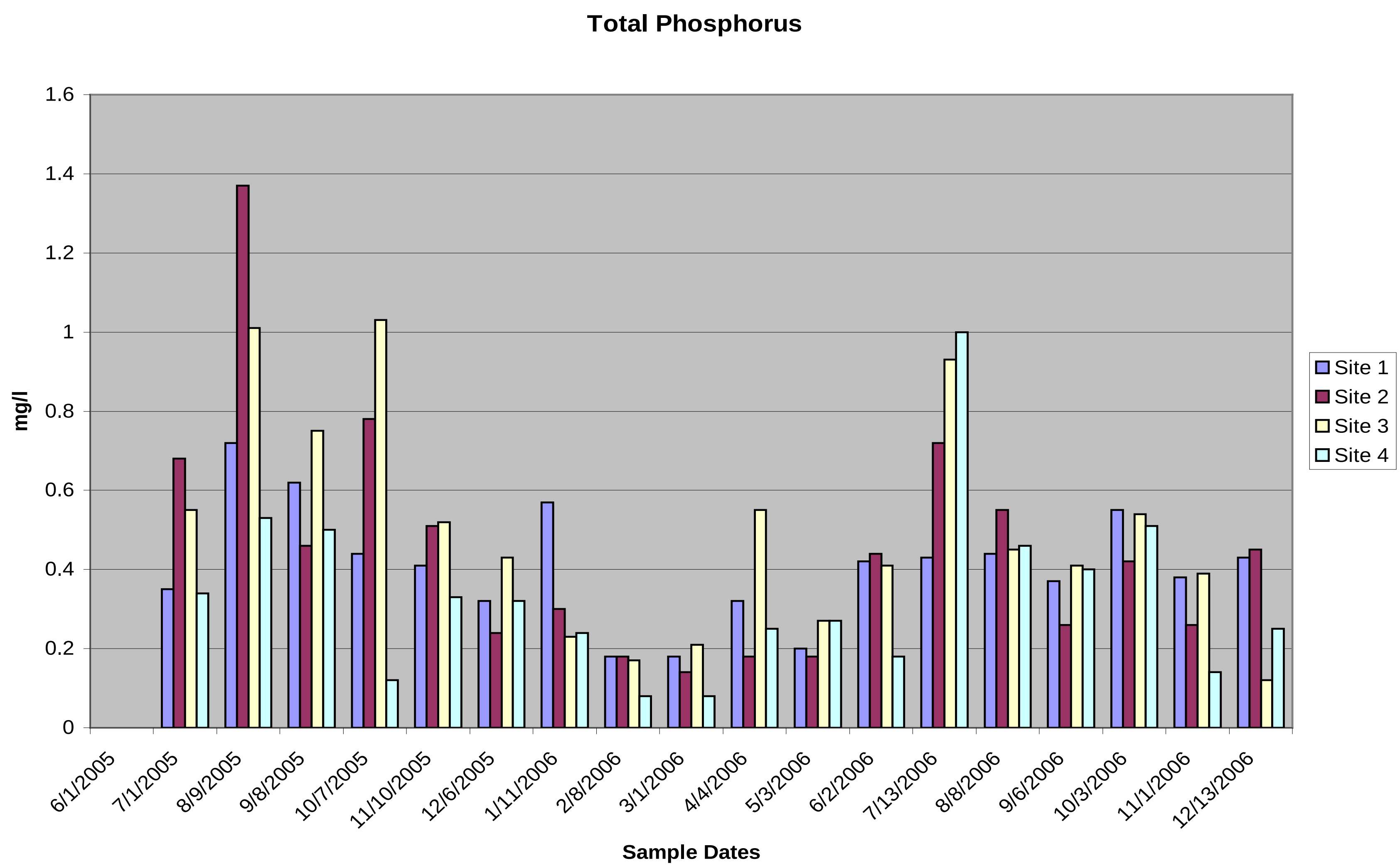


Figure 57: Graphical depiction of total phosphorus for test sites 1 through 4. The Y axis represents milligrams per liter of water.

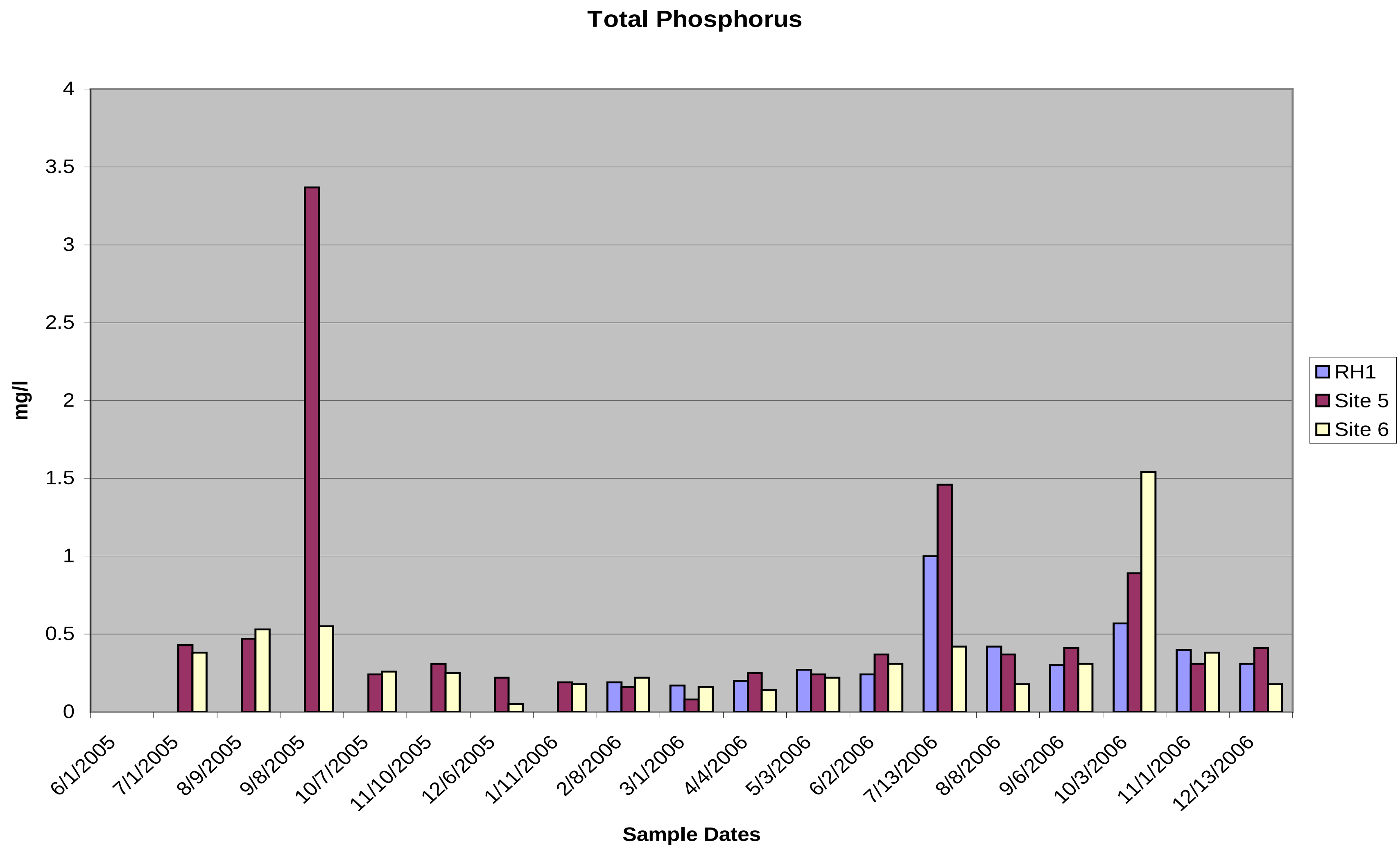


Figure 58: Graphical depiction of total phosphorus for test sites RH1 through 6. The Y axis represents milligrams per liter of water.

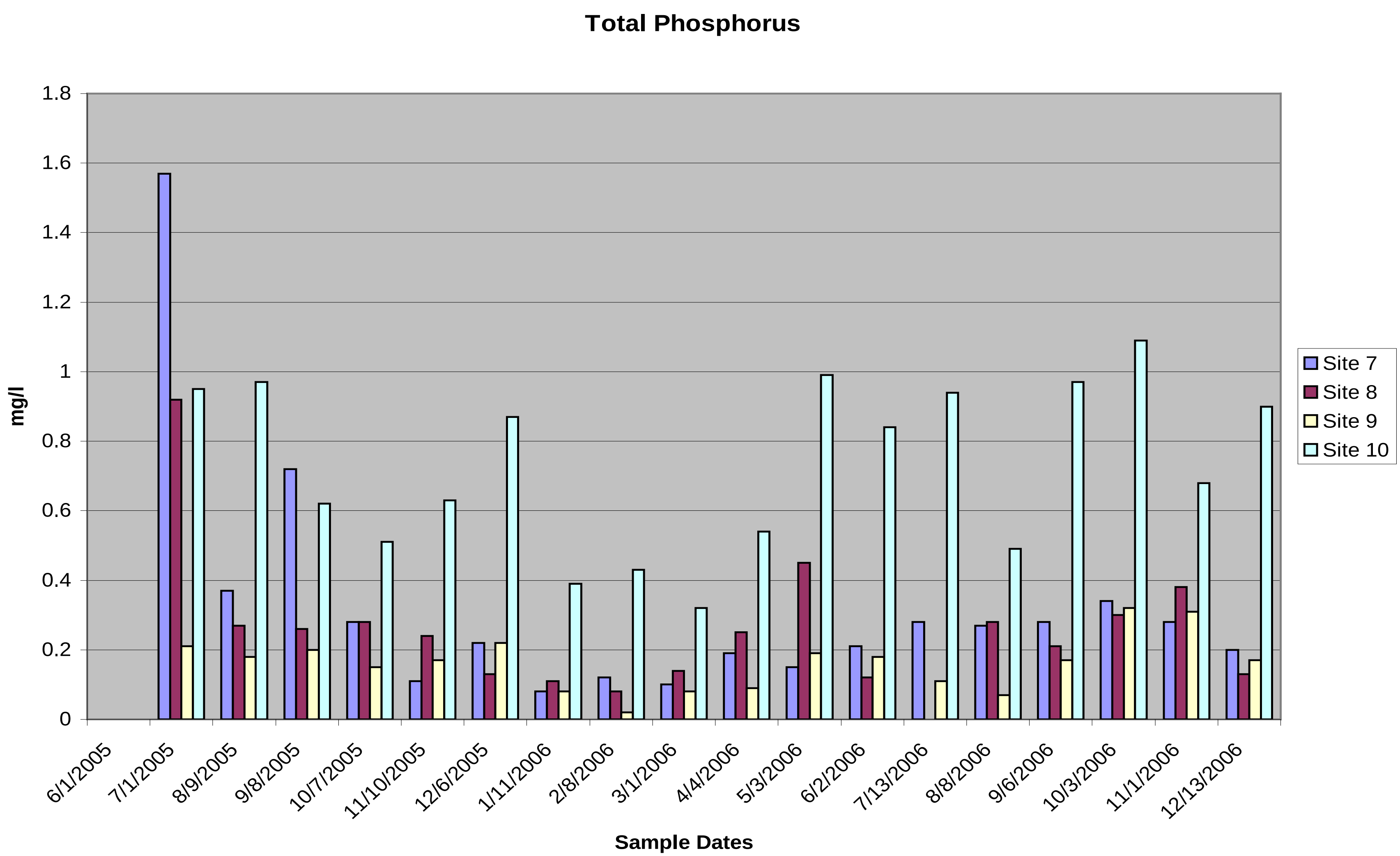


Figure 59: Graphical depiction of total phosphorus for test sites 7 through 10. The Y axis represents milligrams per liter of water.

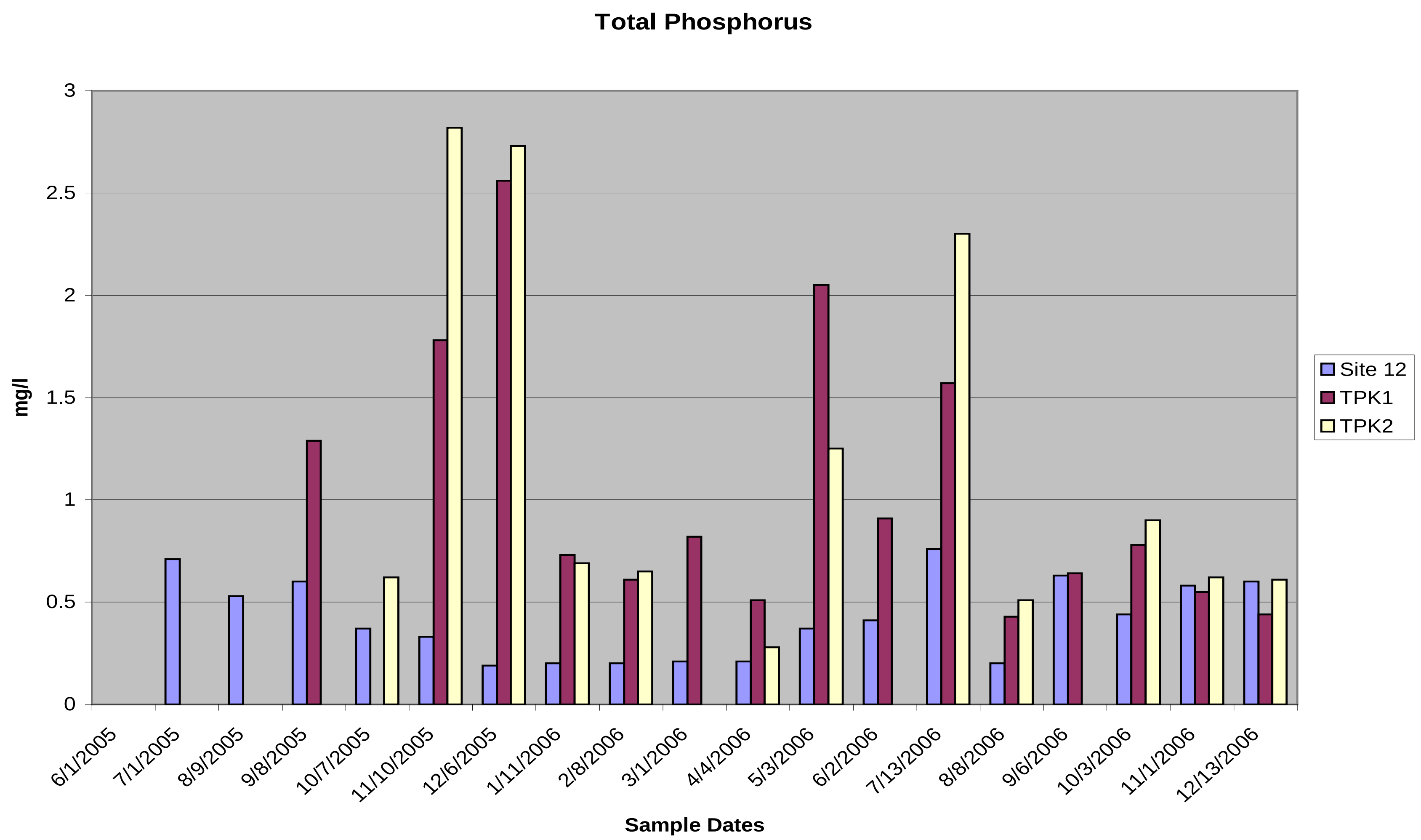


Figure 60: Graphical depiction of total phosphorus for test sites 12 through TPK2. The Y axis represents milligrams per liter of water.

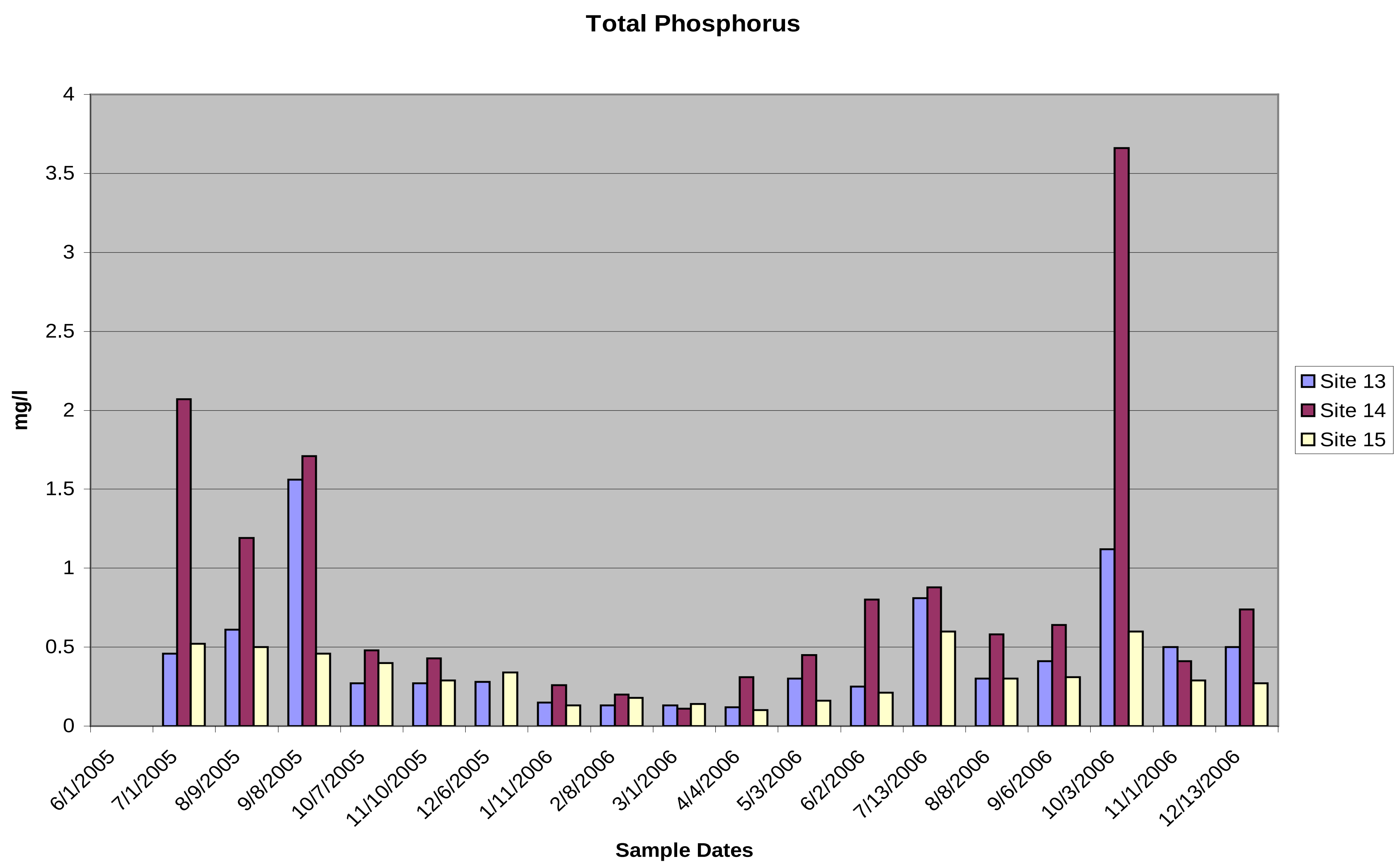


Figure 61: Graphical depiction of total phosphorus for test sites 13 through 15. The Y axis represents milligrams per liter of water.

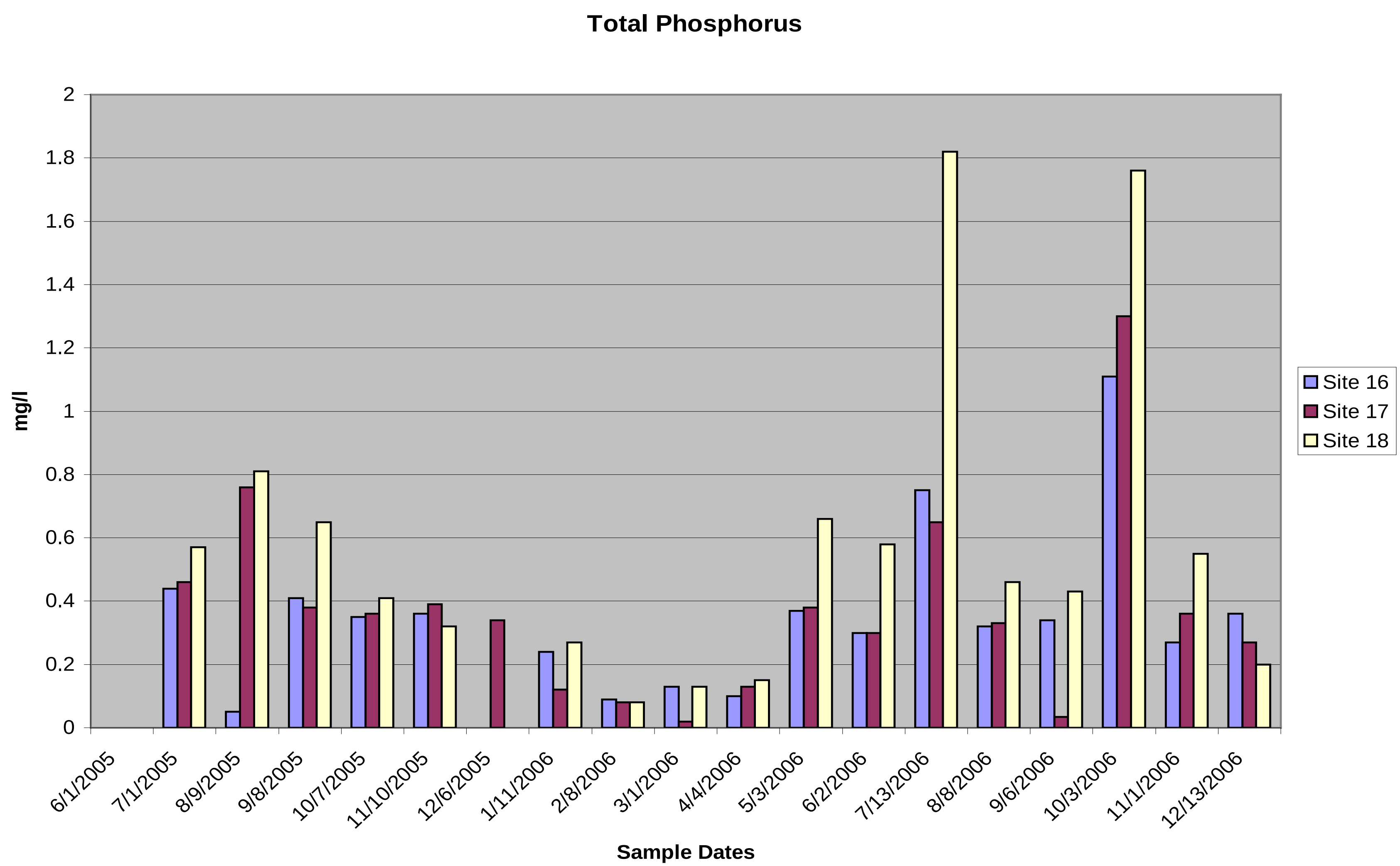


Figure 62: Graphical depiction of total phosphorus for test sites 16 through 18. The Y axis represents milligrams per liter of water.

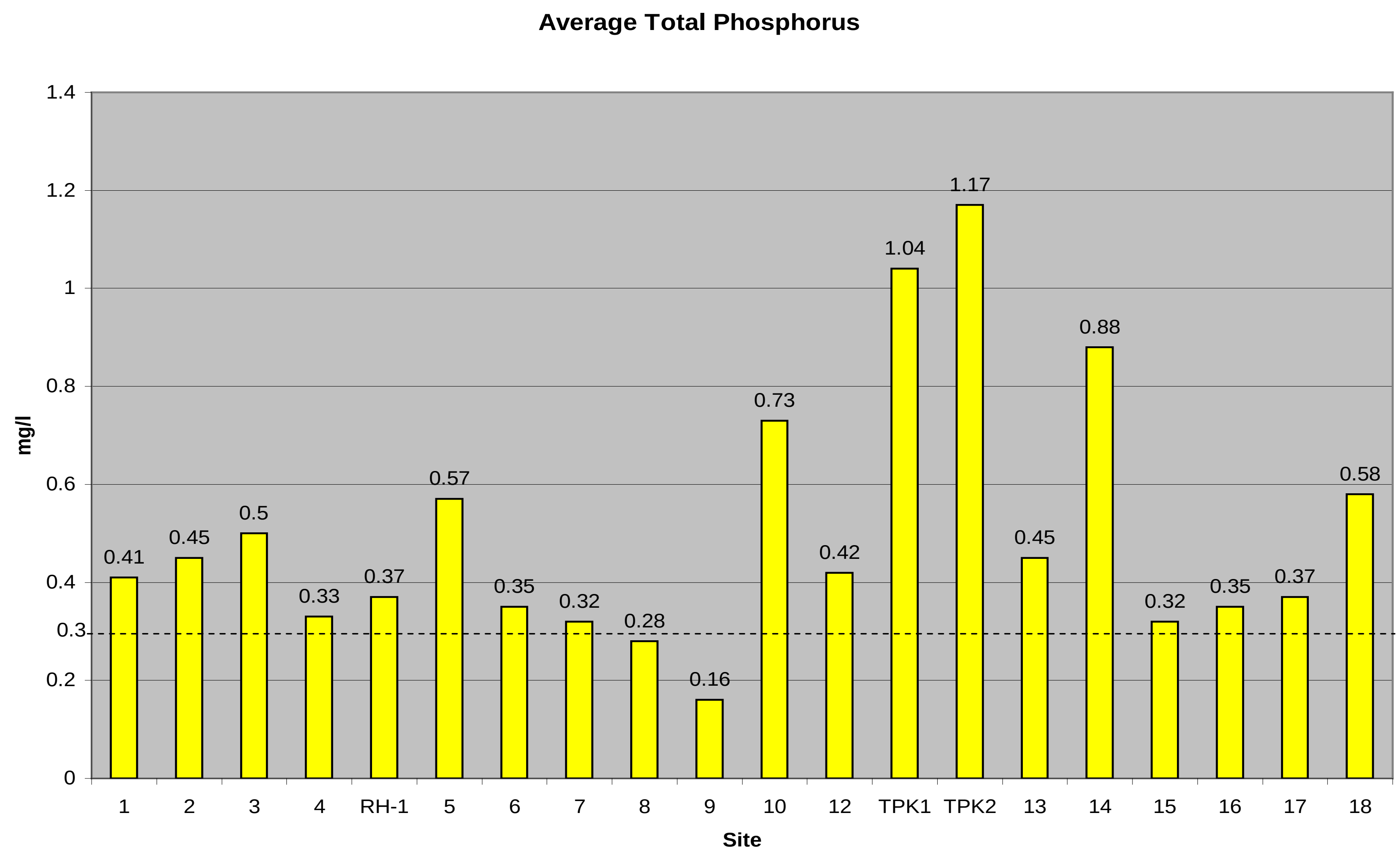


Figure 63: Average total phosphorus for by site. The Y axis represents milligrams per liter of water. Dashed line at 0.3 signifies target level.

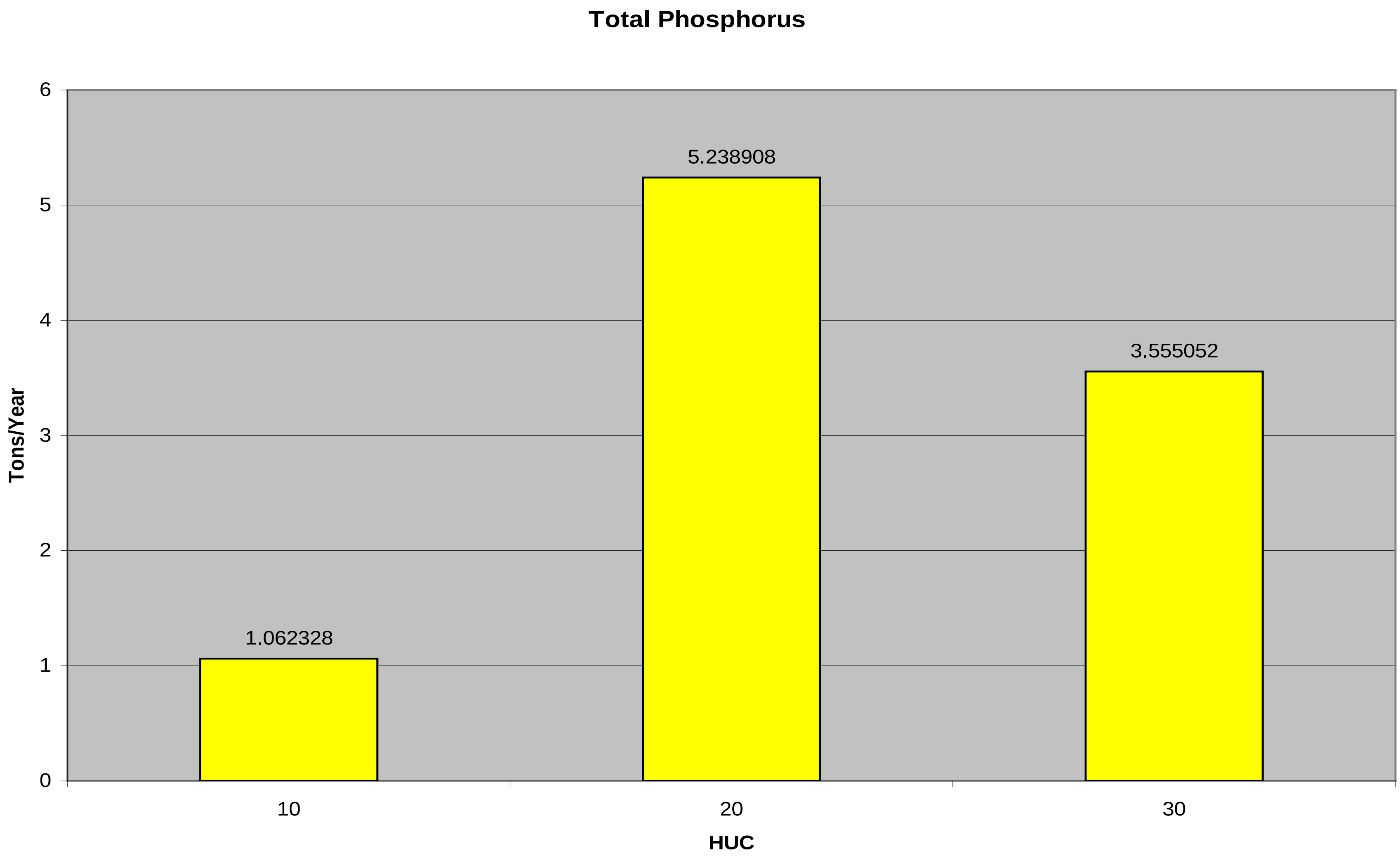


Figure 64: Yearly loading of total phosphorus in tons-US. HUC numbers correspond to the last 2 digits in the 14 digit code.

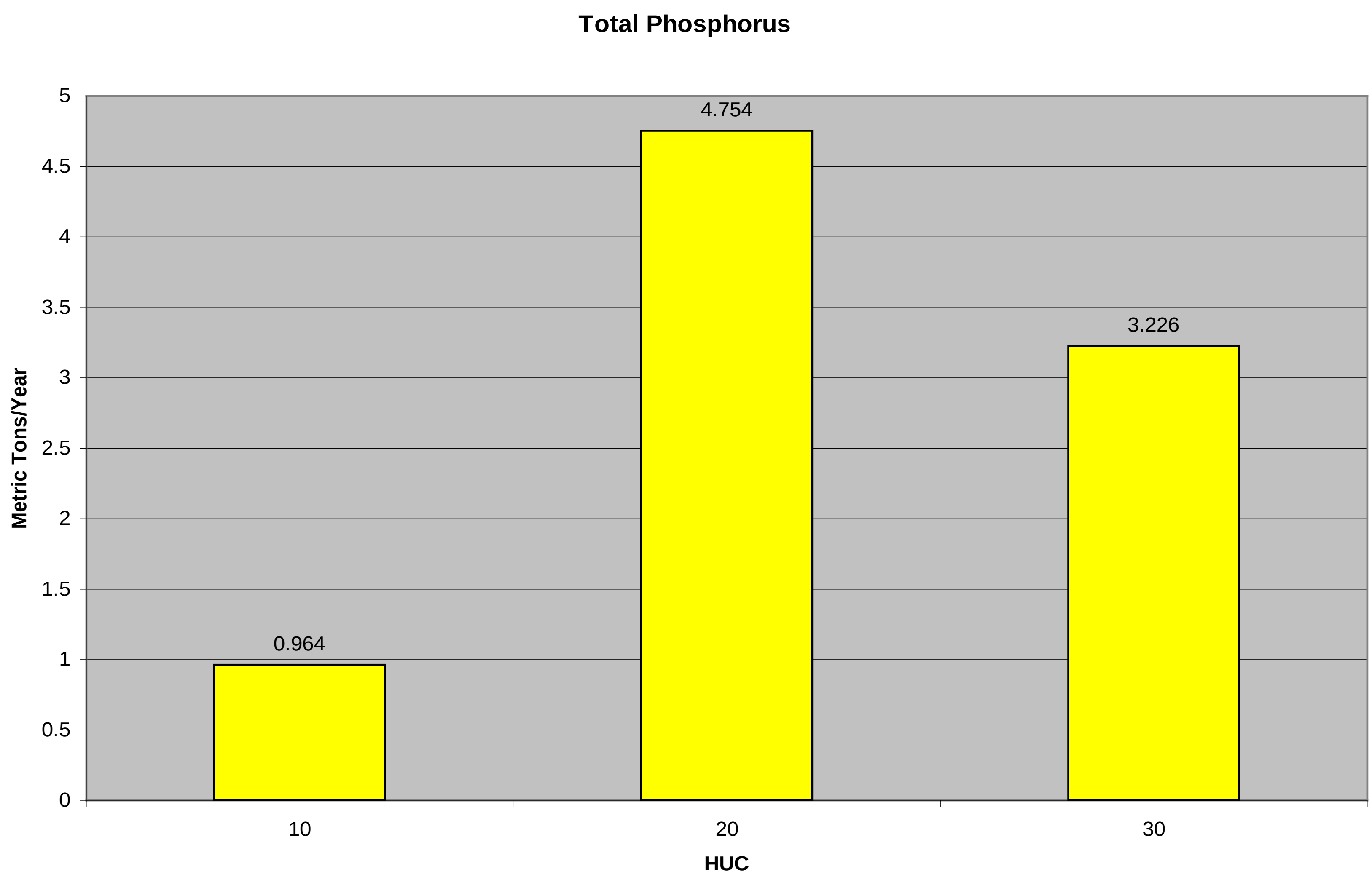


Figure 65: Yearly loading of total phosphorus in metric tons. HUC numbers correspond to the last 2 digits in the 14 digit code.

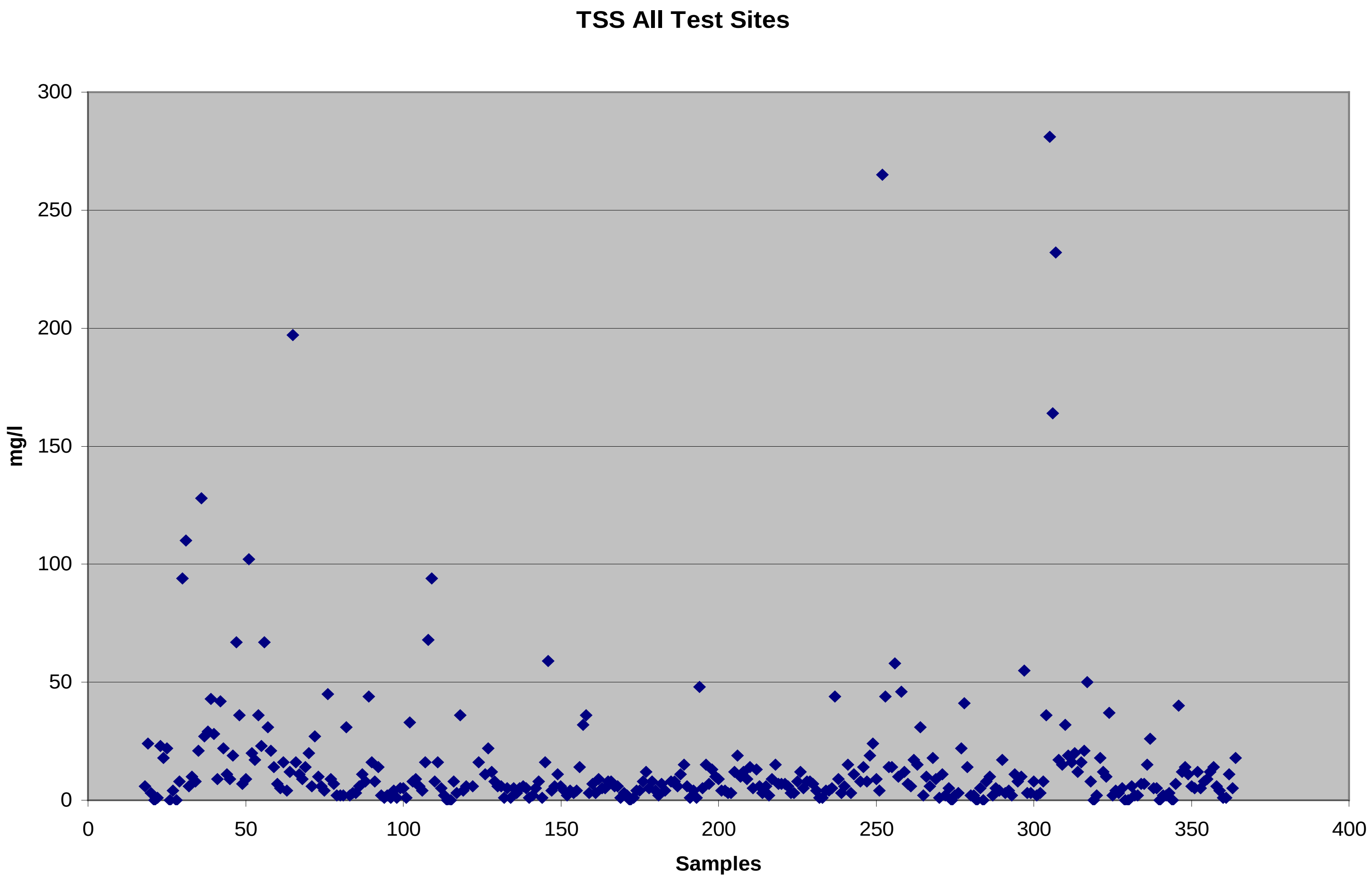


Figure 66: Scatter plot of total suspended solids for all sites. The Y axis represents milligrams per liter of water.

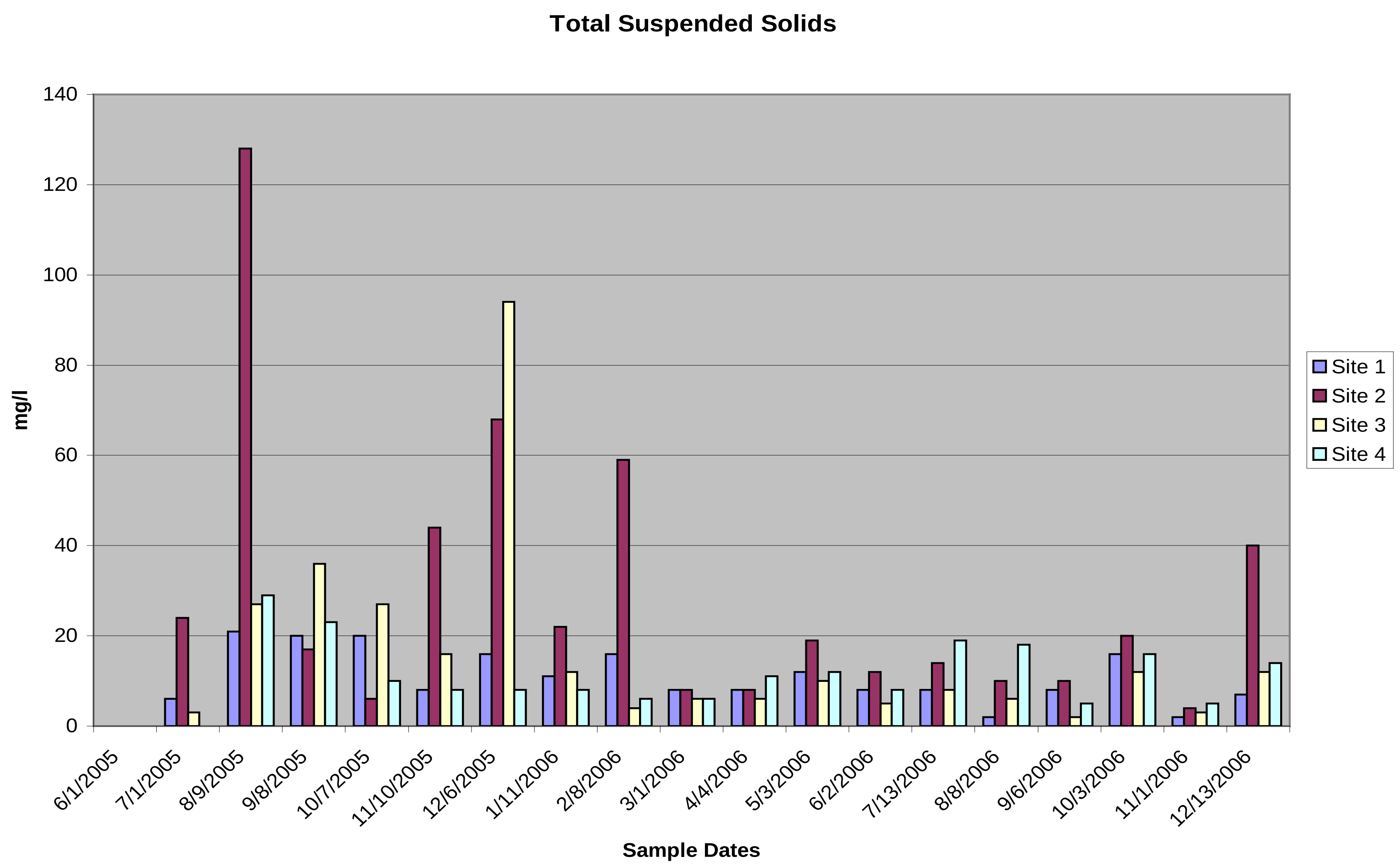


Figure 67: Graphical depiction of total suspended solids for test sites 1 through 4. The Y axis represents milligrams per liter of water.

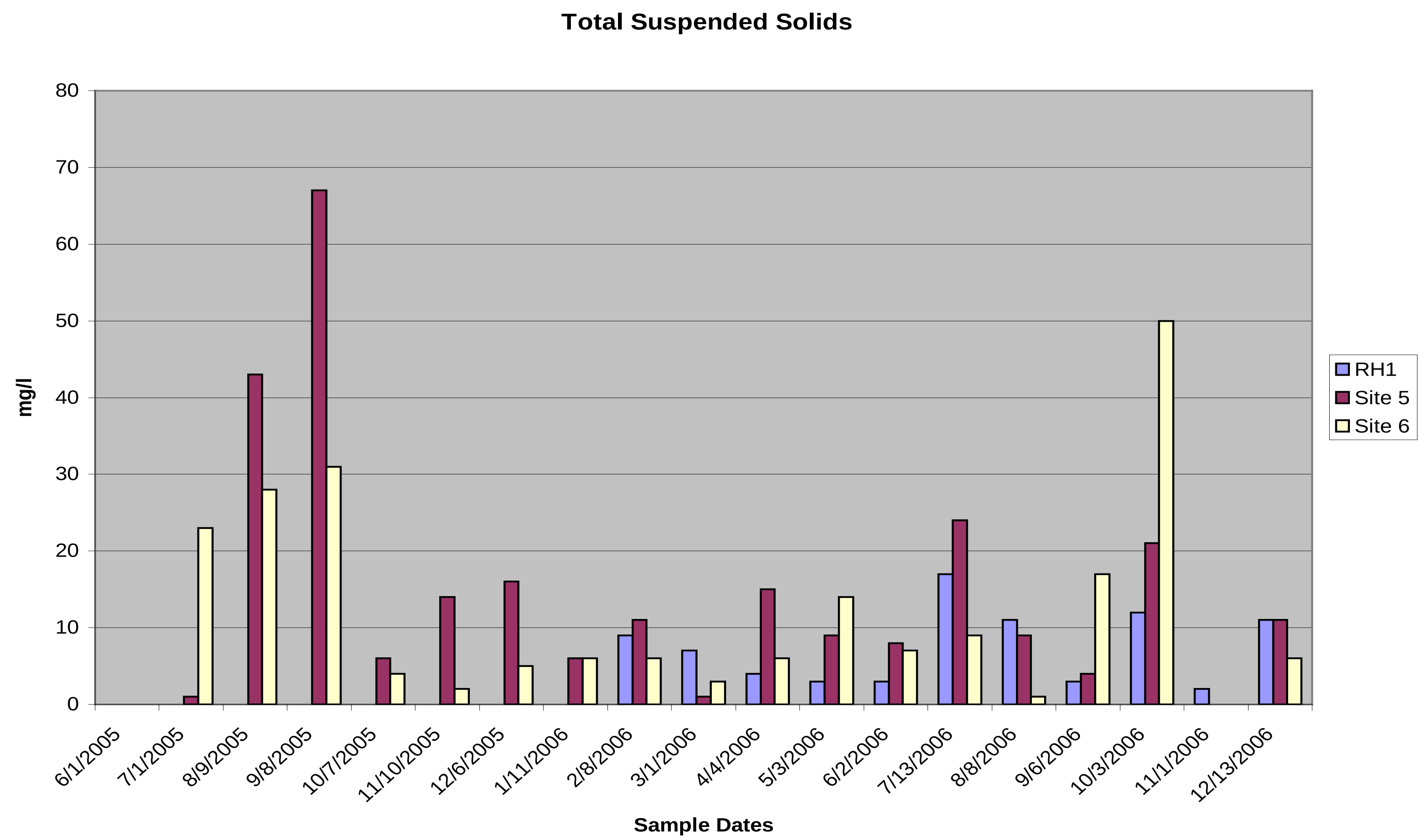


Figure 68: Graphical depiction of total suspended solids for test sites RH1 through 6. The Y axis represents milligrams per liter of water.

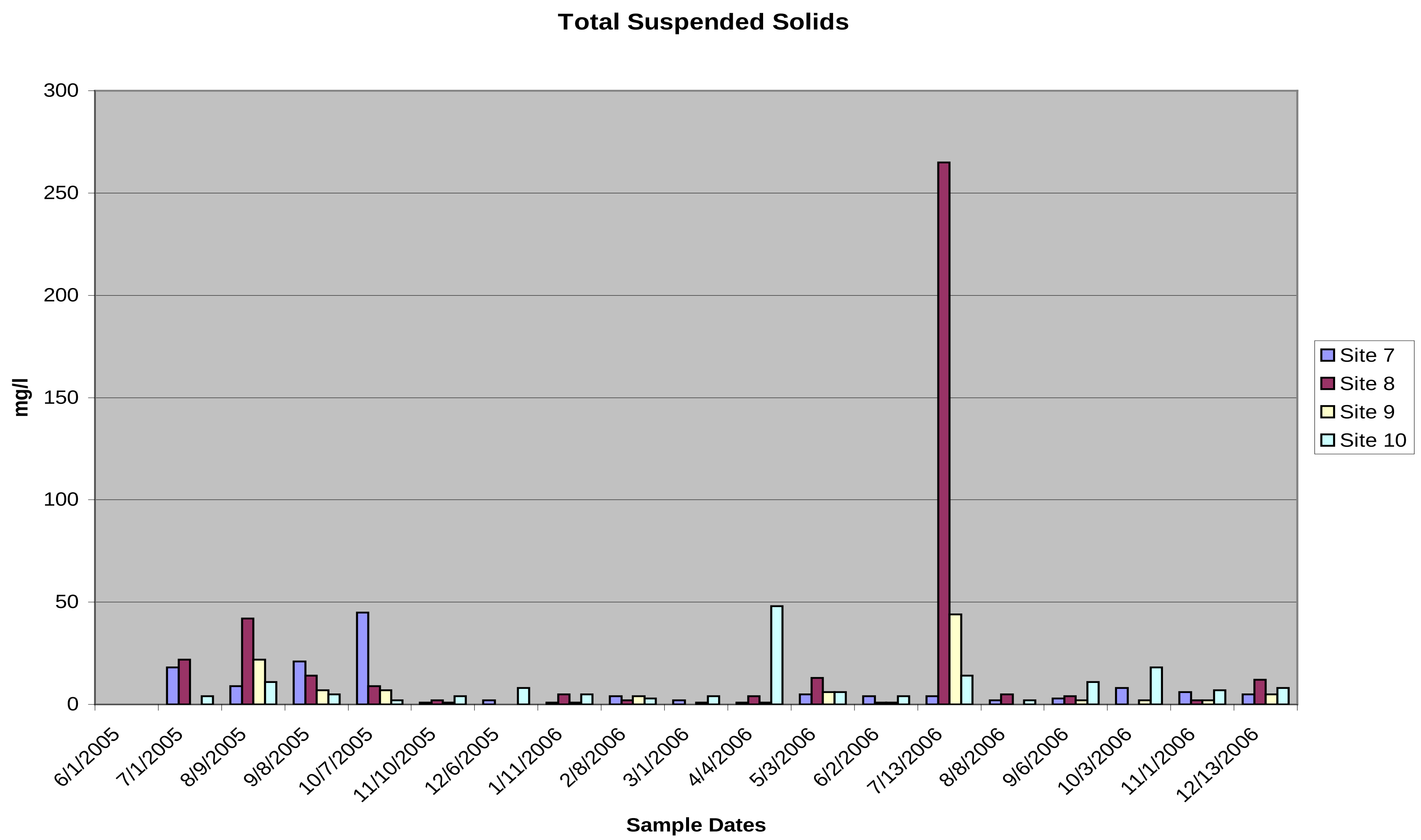


Figure 69: Graphical depiction of total suspended solids for test sites 7 through 10. The Y axis represents milligrams per liter of water.

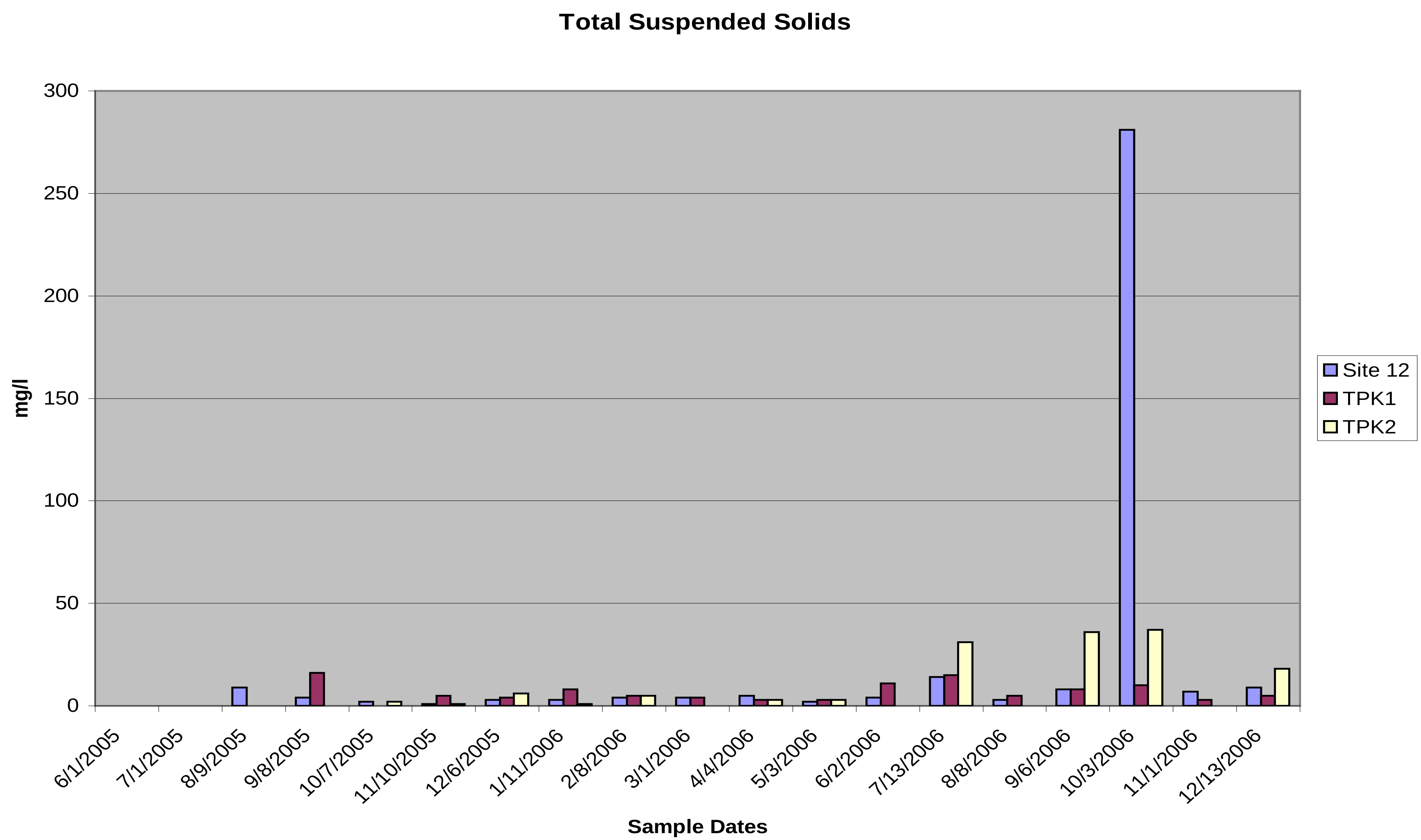


Figure 70: Graphical depiction of total suspended solids for test sites 12 through TPK2. The Y axis represents milligrams per liter of water.

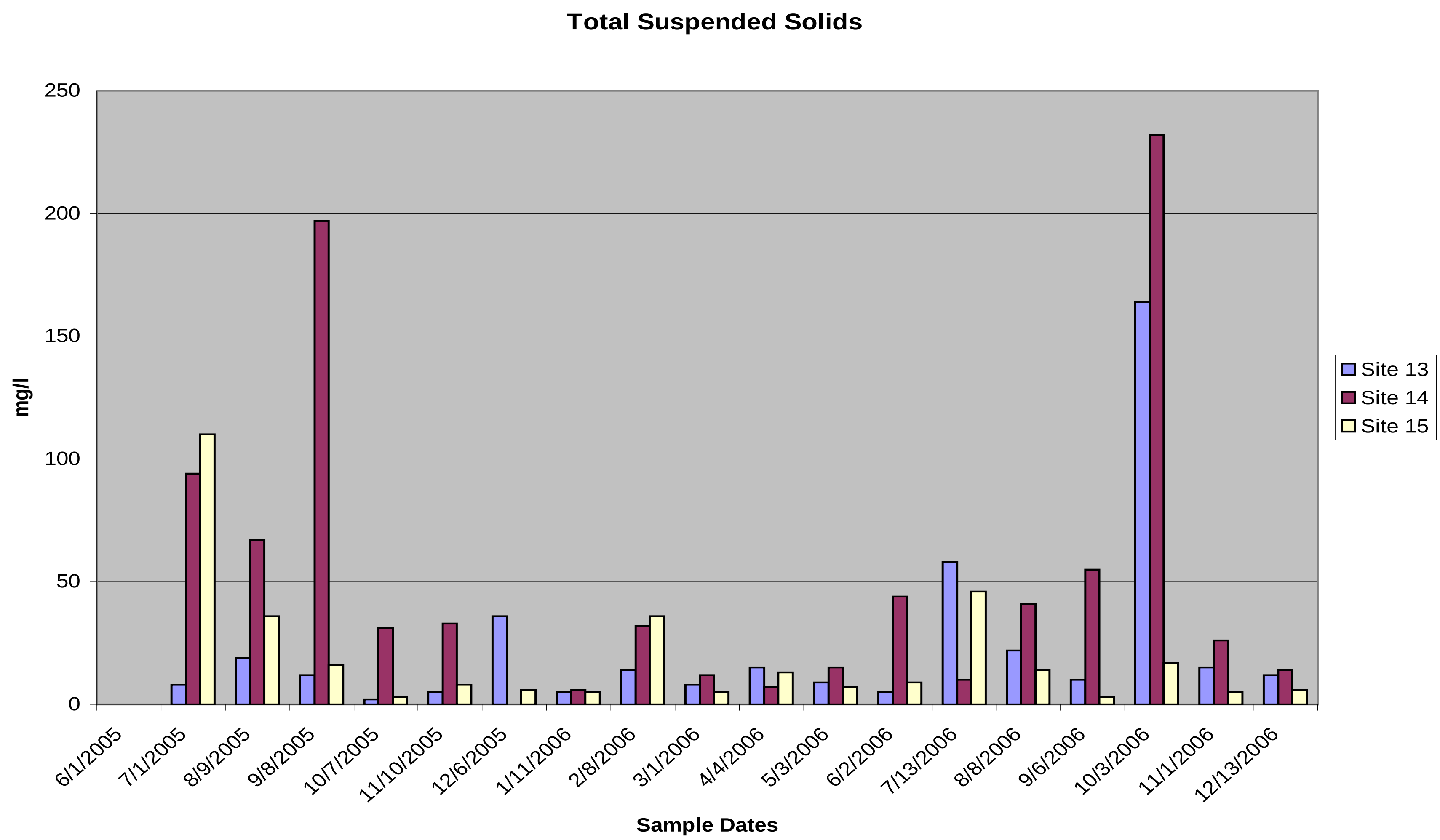


Figure 71: Graphical depiction of total suspended solids for test sites 13 through 15. The Y axis represents milligrams per liter of water.

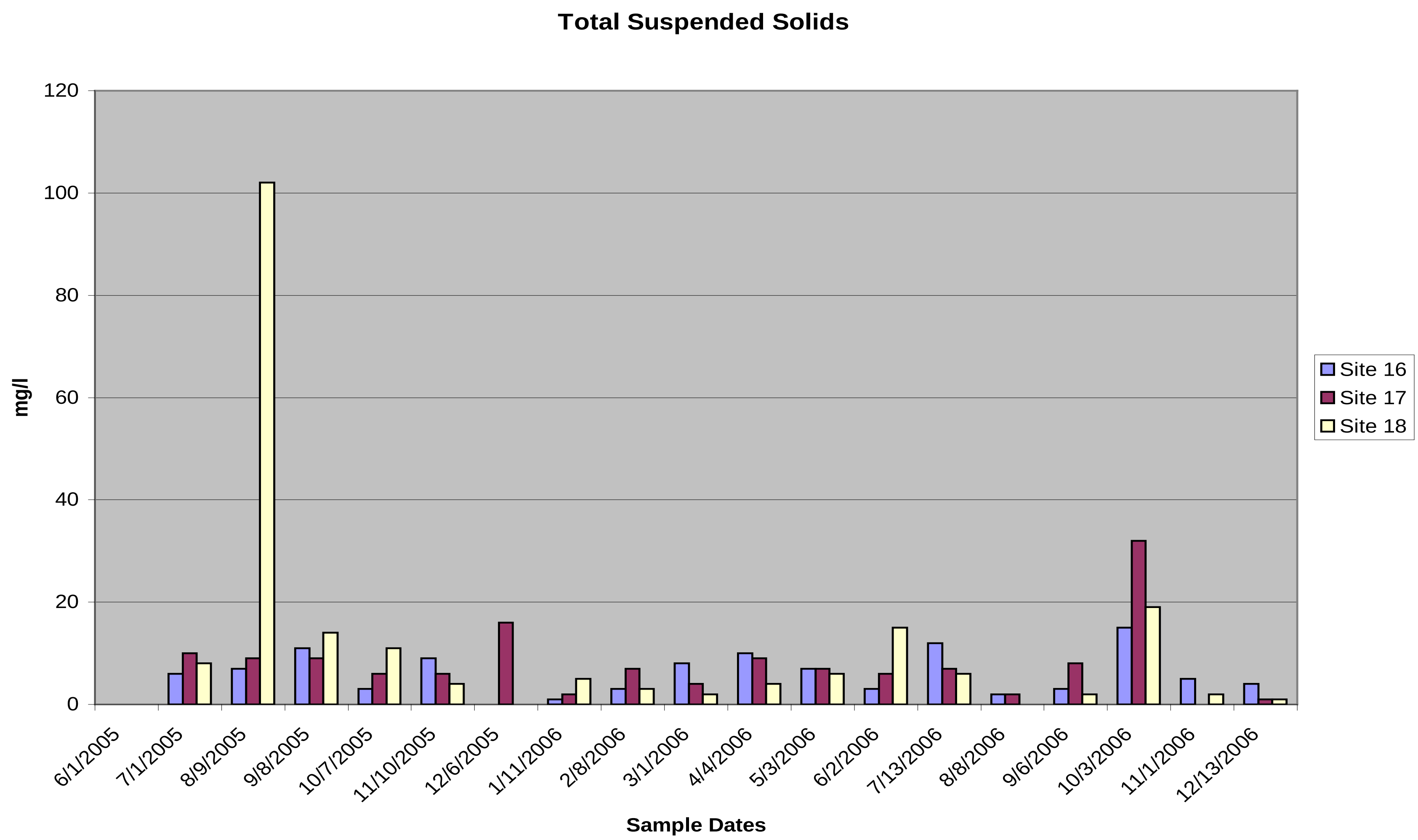


Figure 72: Graphical depiction of total suspended solids for test sites 16 through 18. The Y axis represents milligrams per liter of water.

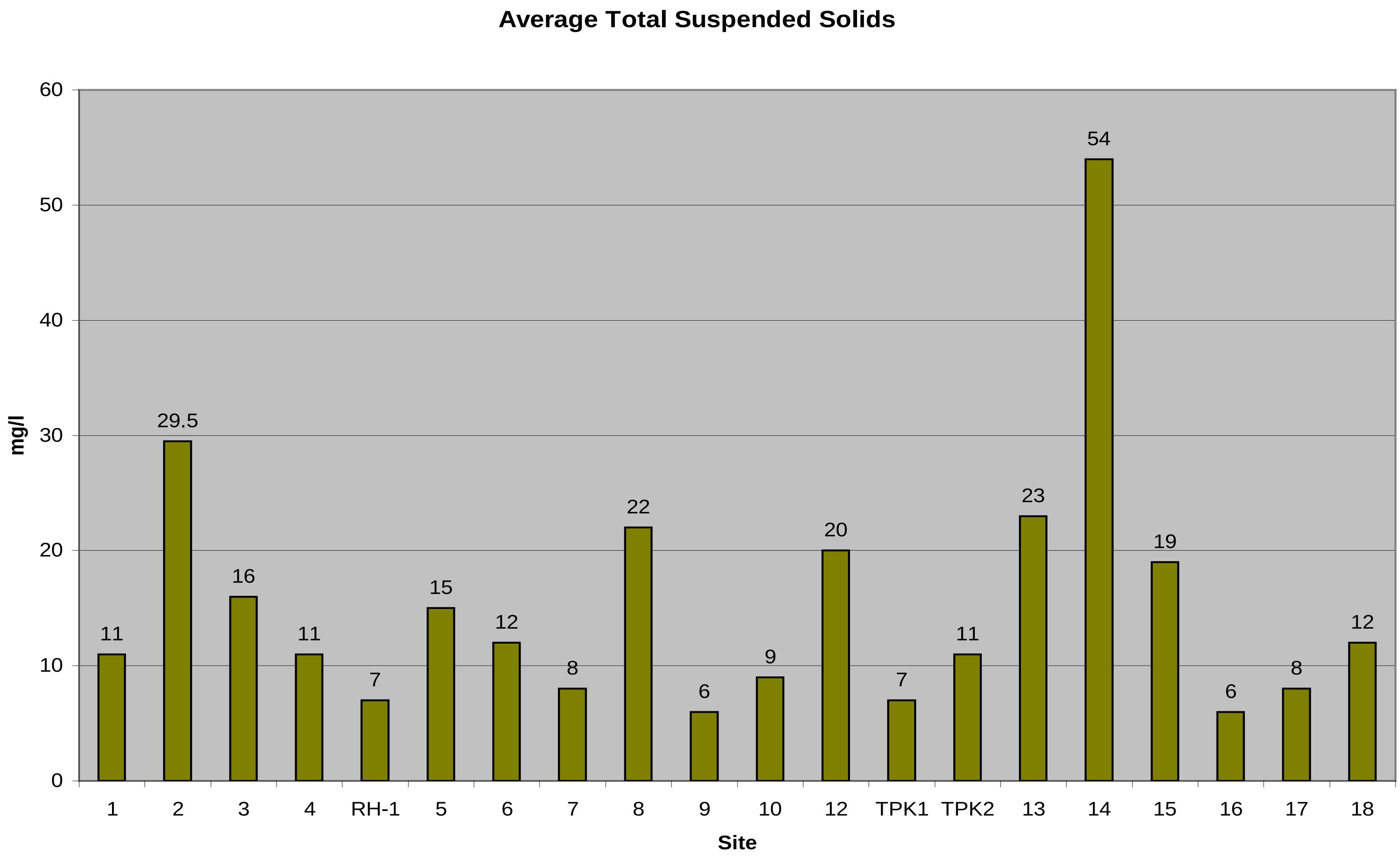


Figure 73: Average total suspended solids by site. The Y axis represents milligrams per liter of water.

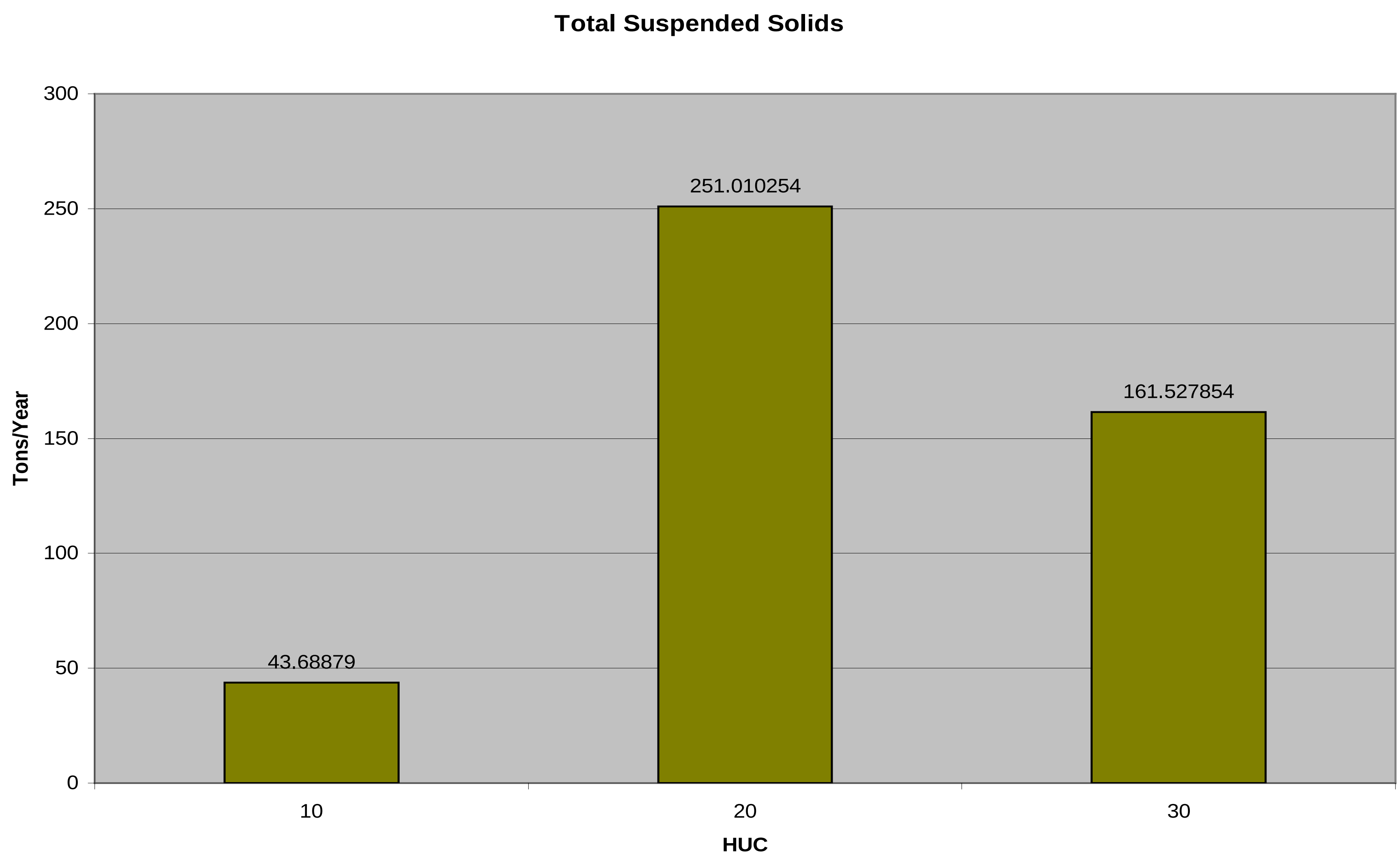


Figure 74: Yearly loading of total suspended solids in tons-US. HUC numbers correspond to the last 2 digits in the 14 digit code.

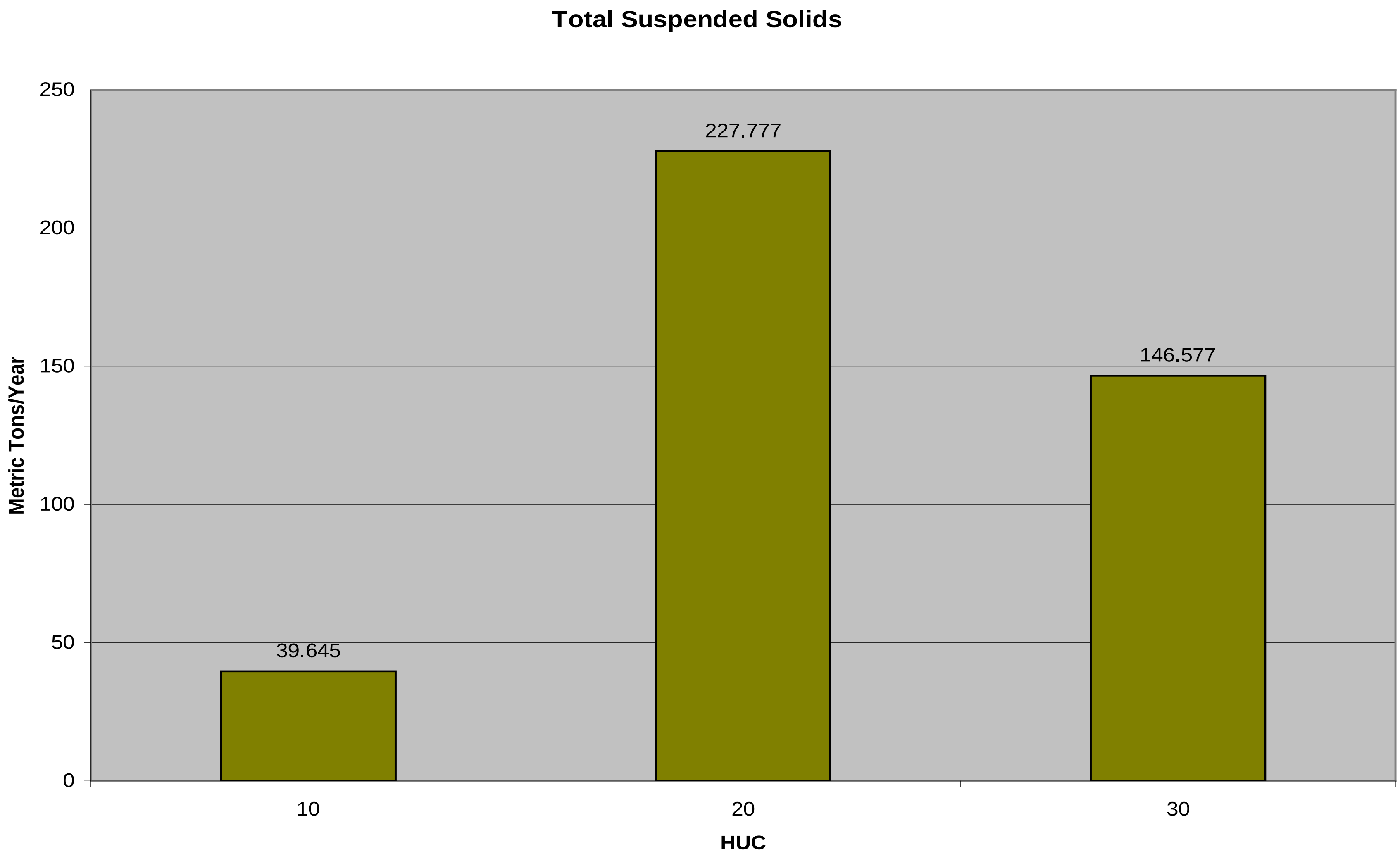


Figure 75: Yearly loading of total suspended solids in metric tons. HUC numbers correspond to the last 2 digits in the 14 digit code.

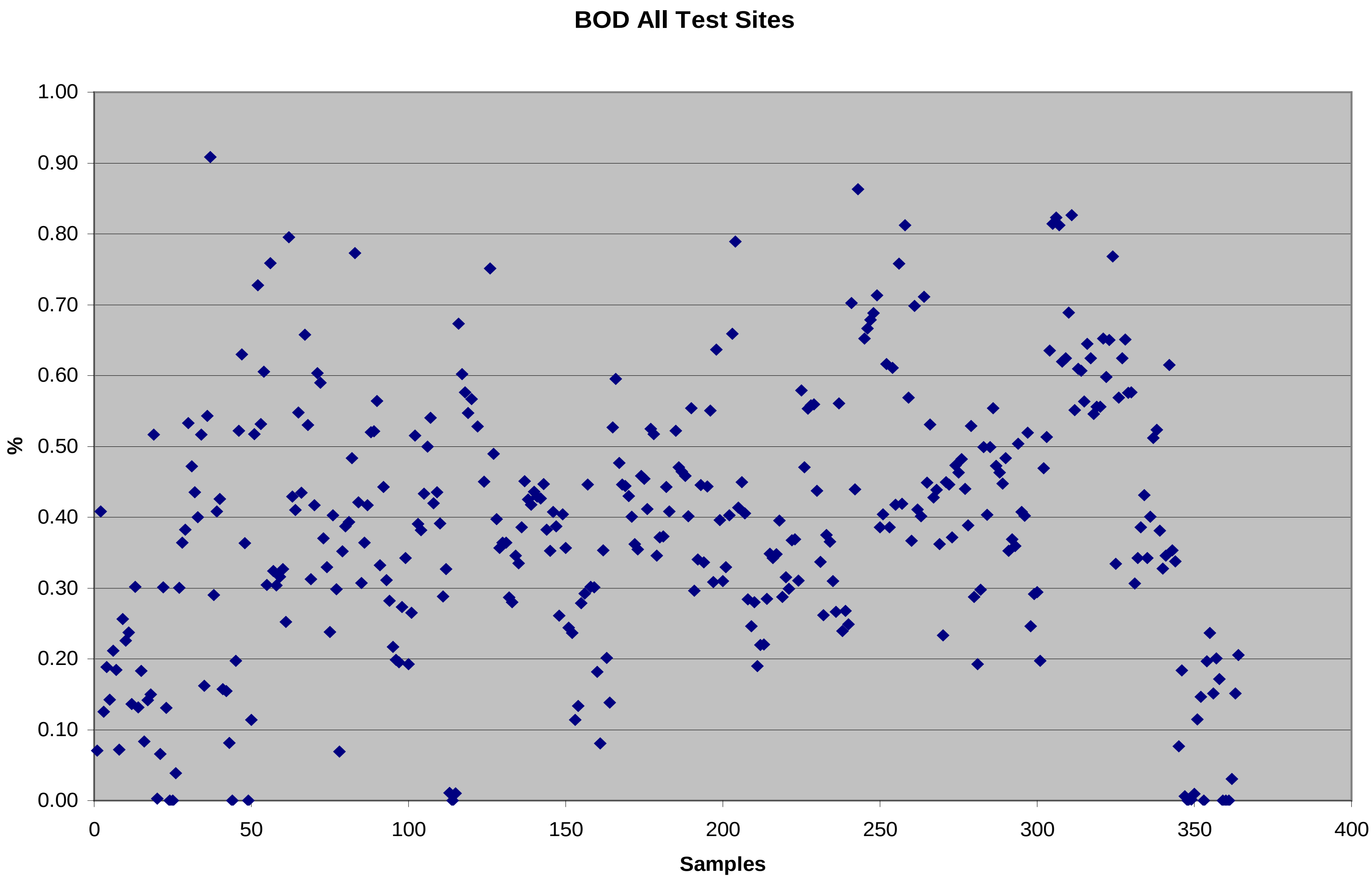


Figure 76: Scatter plot of biochemical oxygen demand for all sites. Multiply figures by 100 to get consumption rate percentage.

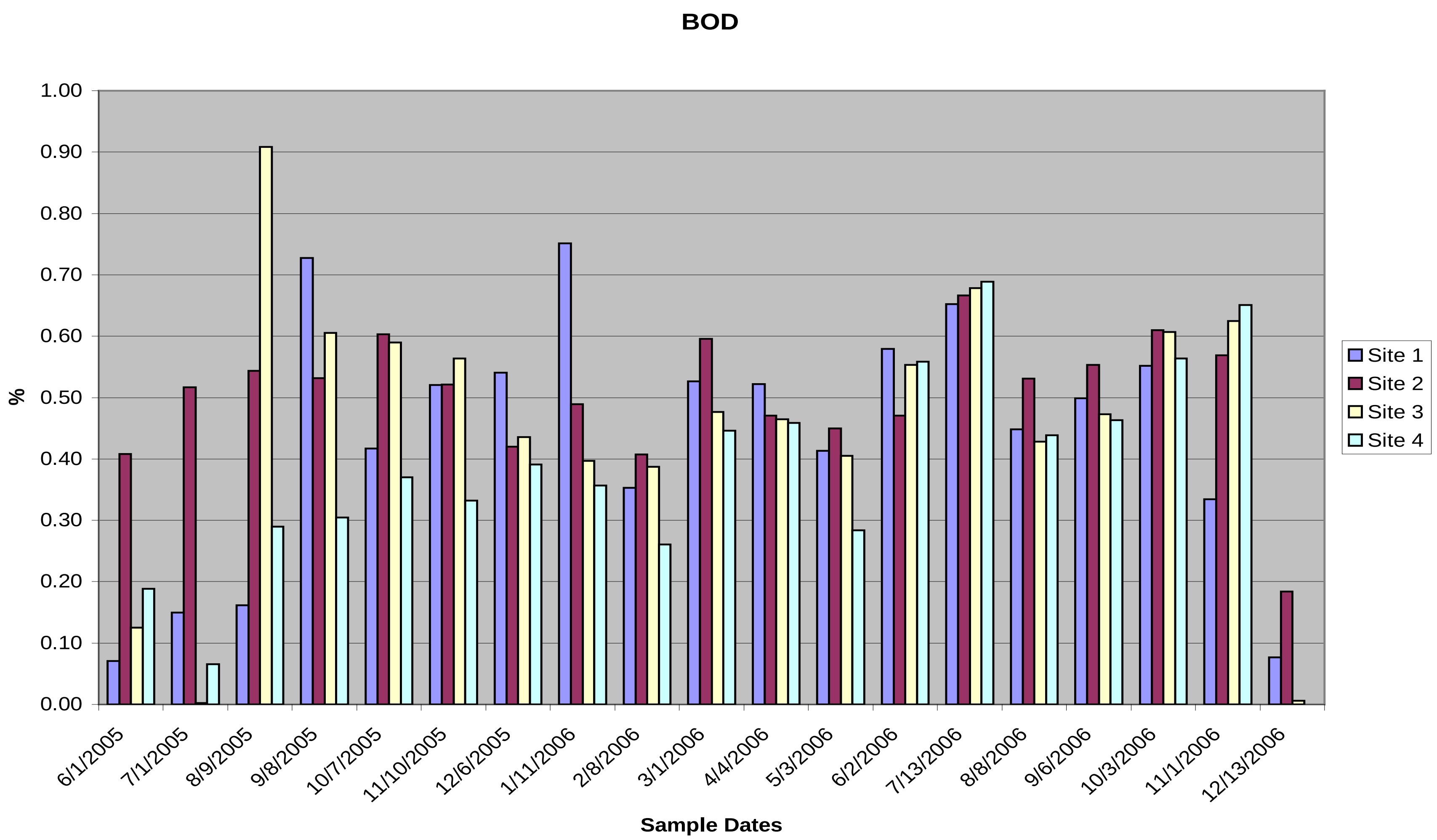


Figure 77: Graphical depiction of biochemical oxygen demand for sites 1 through 4. Multiply figures by 100 to get consumption rate percentage.

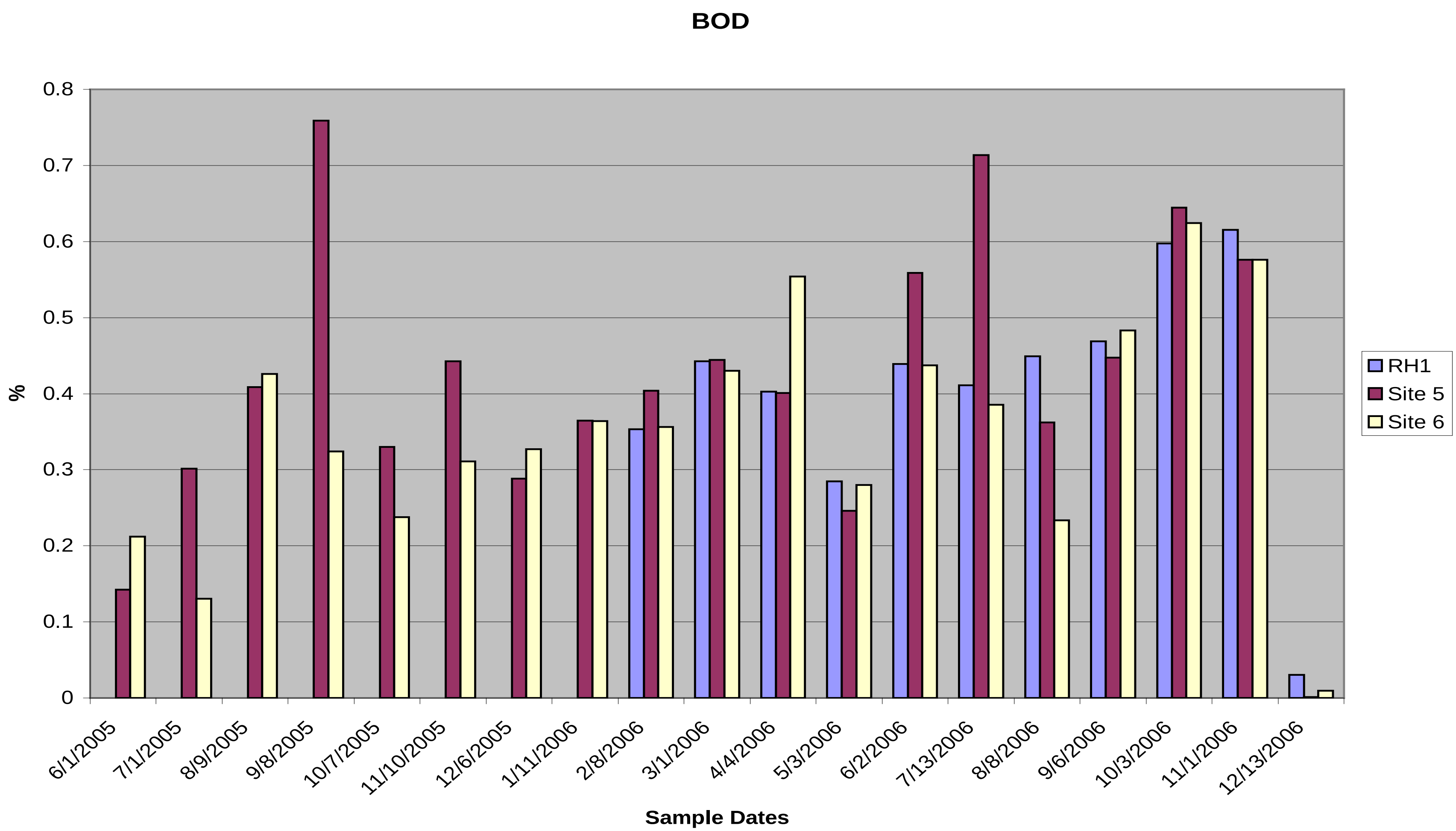


Figure 78: Graphical depiction of biochemical oxygen demand for sites RH1 through 6. Multiply figures by 100 to get consumption rate percentage.

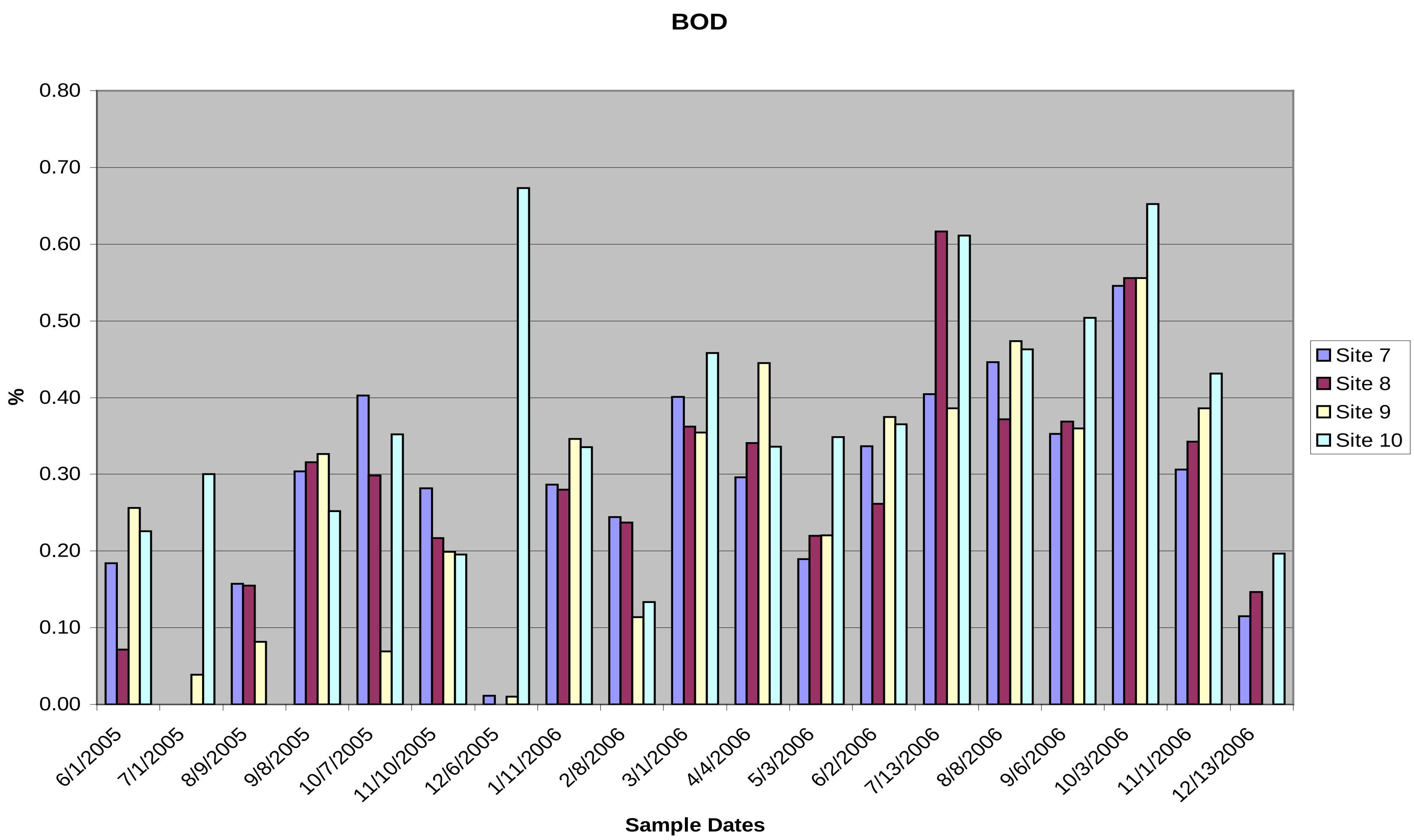


Figure 79: Graphical depiction of biochemical oxygen demand for sites 7 through 10. Multiply figures by 100 to get consumption rate percentage.

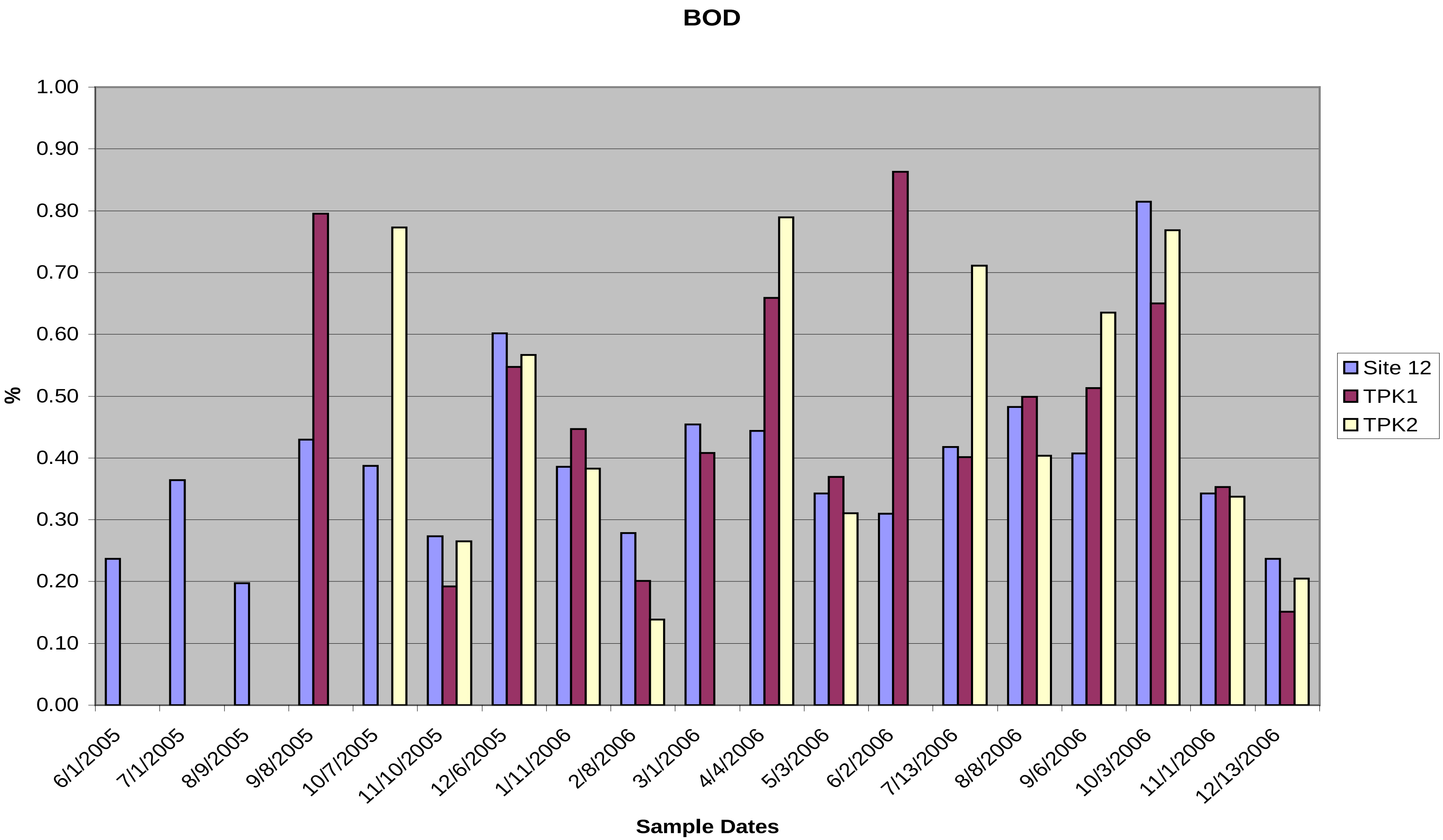


Figure 80: Graphical depiction of biochemical oxygen demand for sites 12 through TPK2. Multiply figures by 100 to get consumption rate percentage.

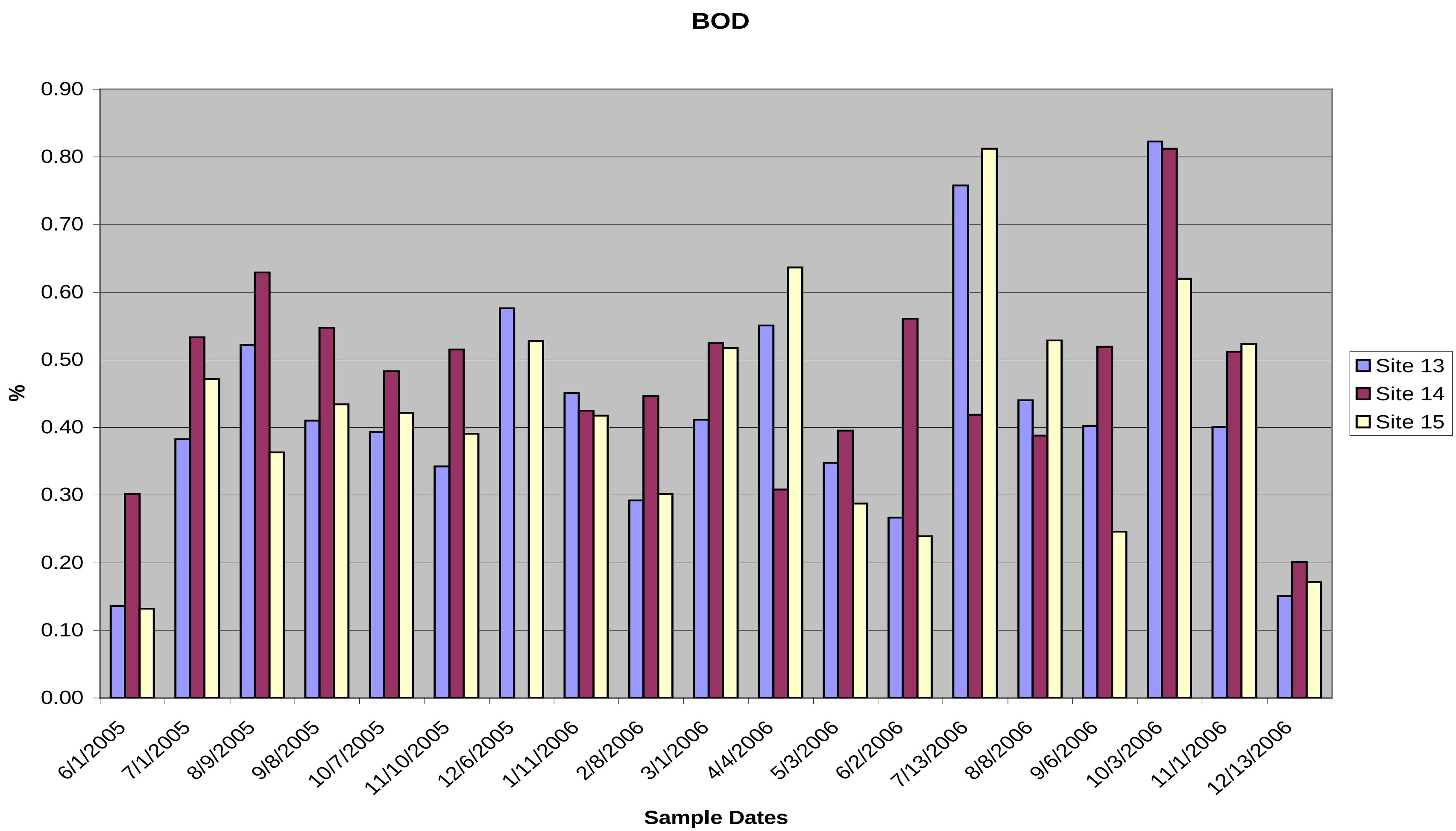


Figure 81: Graphical depiction of biochemical oxygen demand for sites 13 through 15. Multiply figures by 100 to get consumption rate percentage.

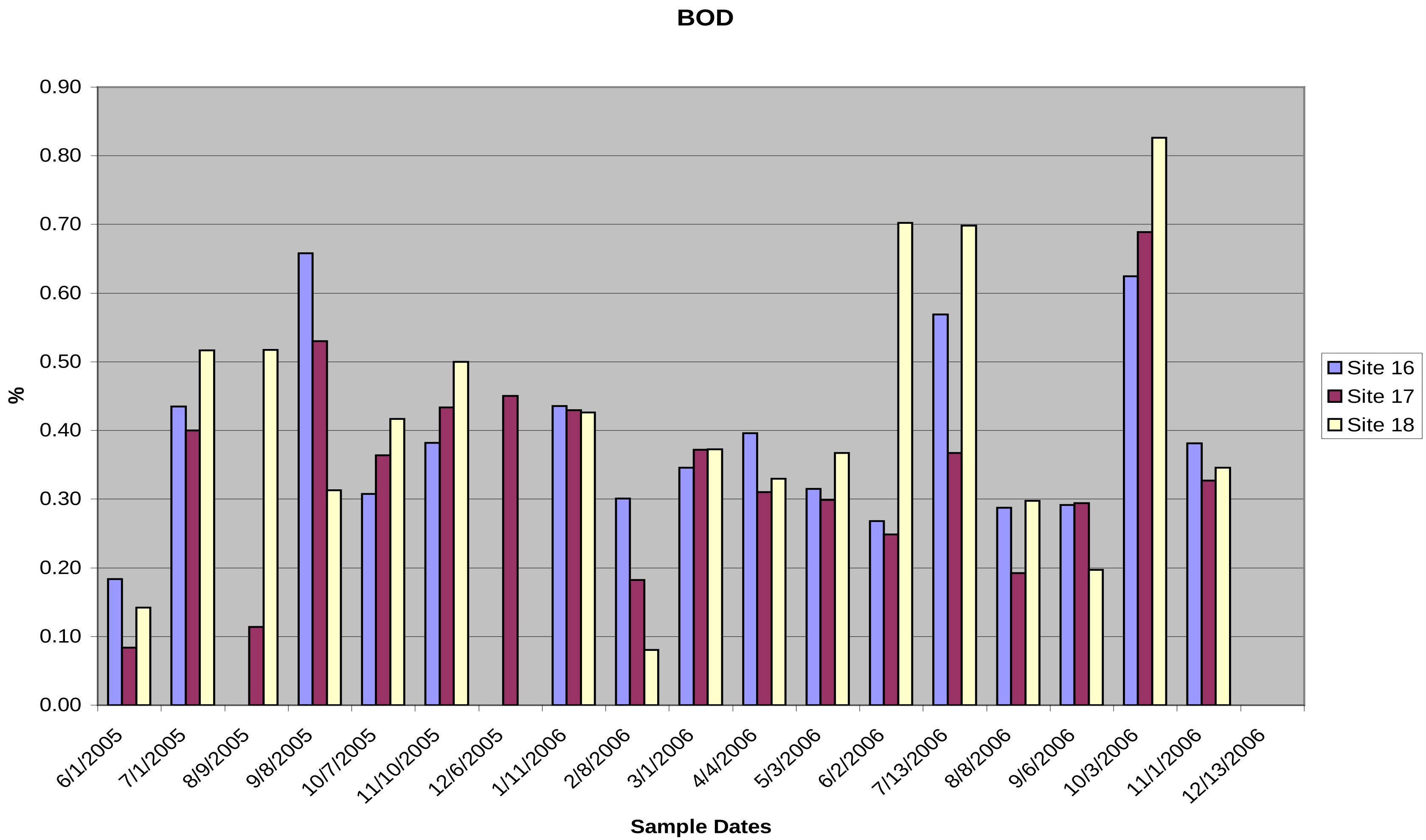


Figure 82: Graphical depiction of biochemical oxygen demand for sites 16 through 18. Multiply figures by 100 to get consumption rate percentage.

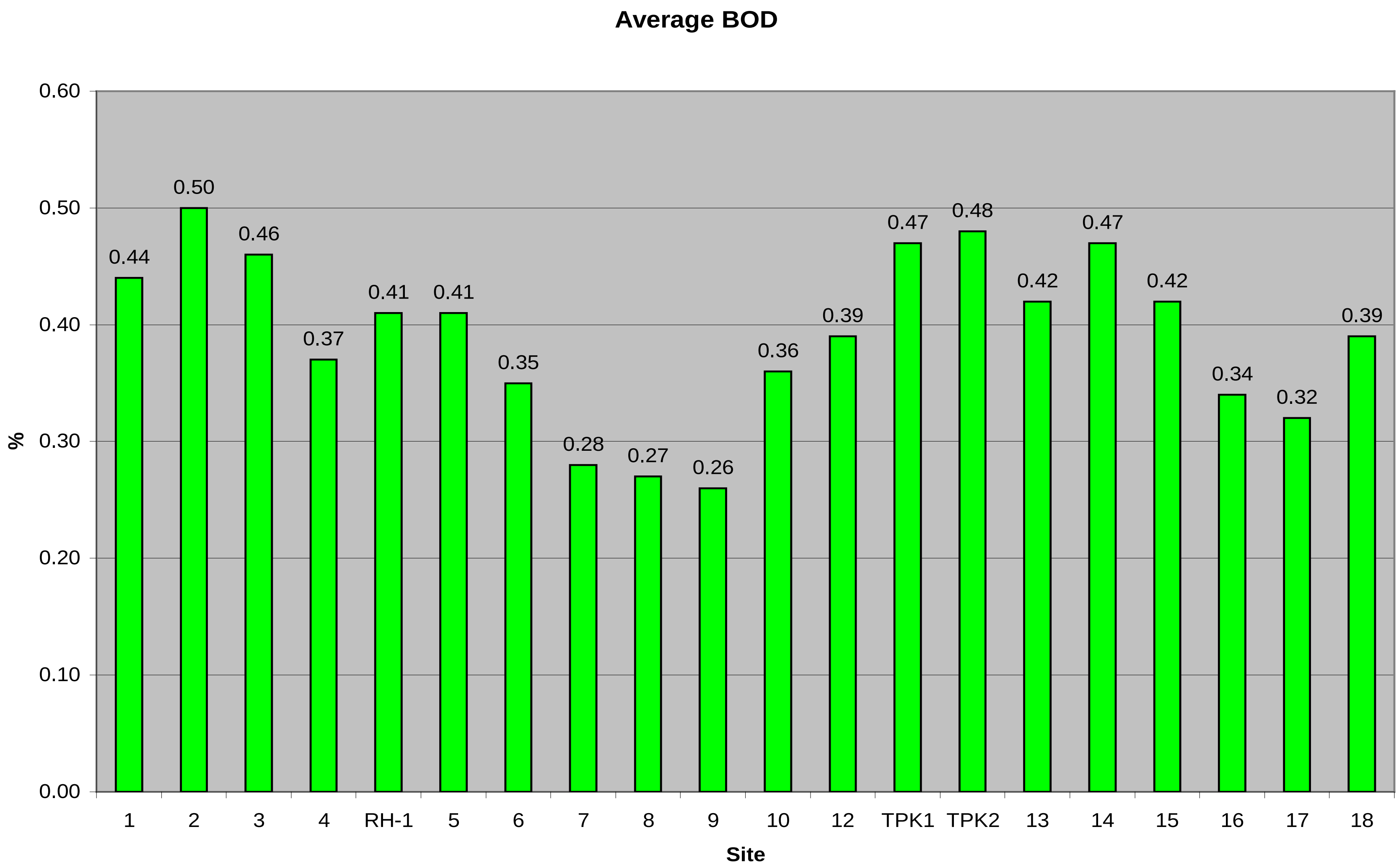


Figure 83: Average biochemical oxygen demand by site. Multiply figures by 100 to get consumption rate percentage.

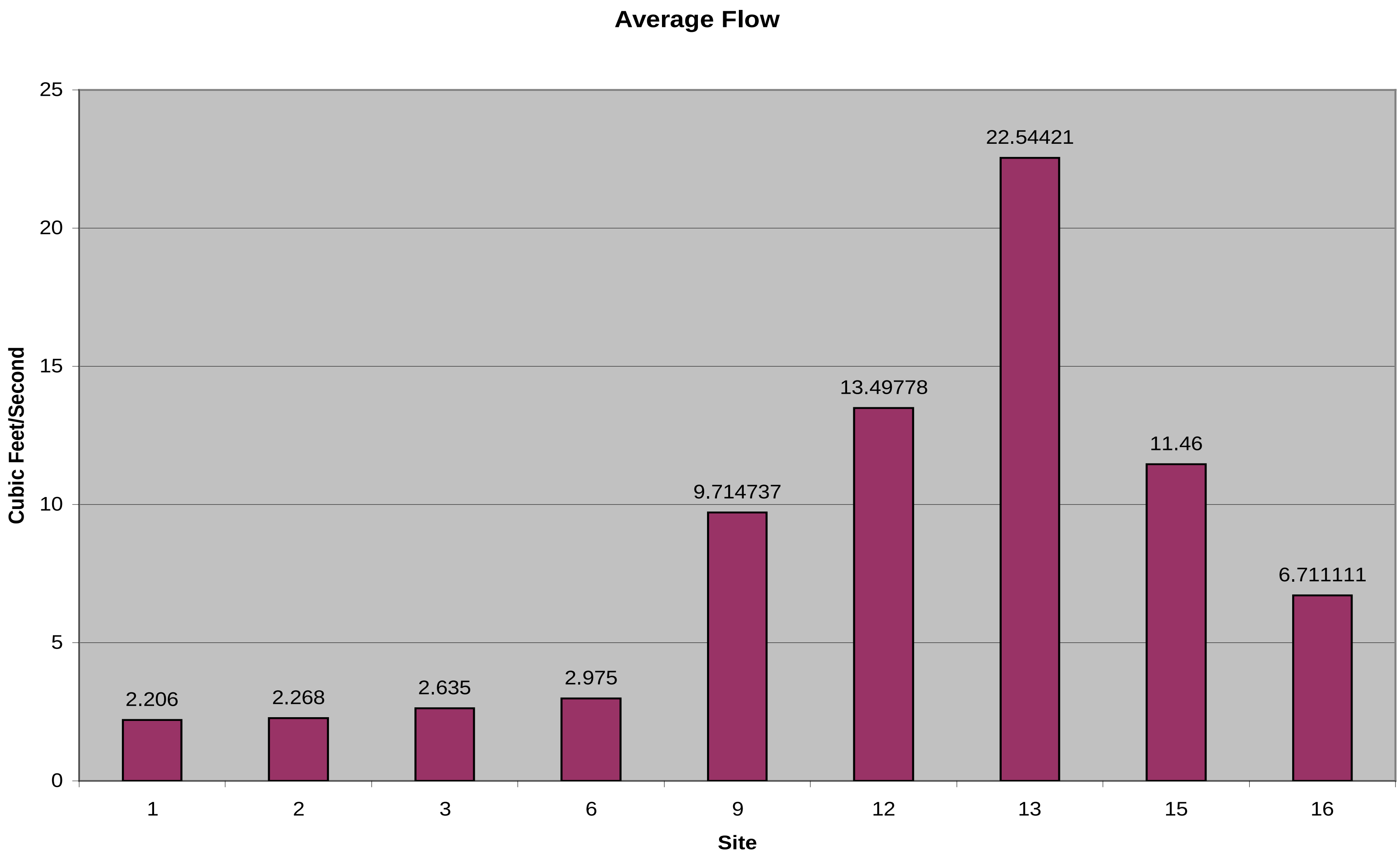


Figure 84: Average flow by site in cubic feet per second.

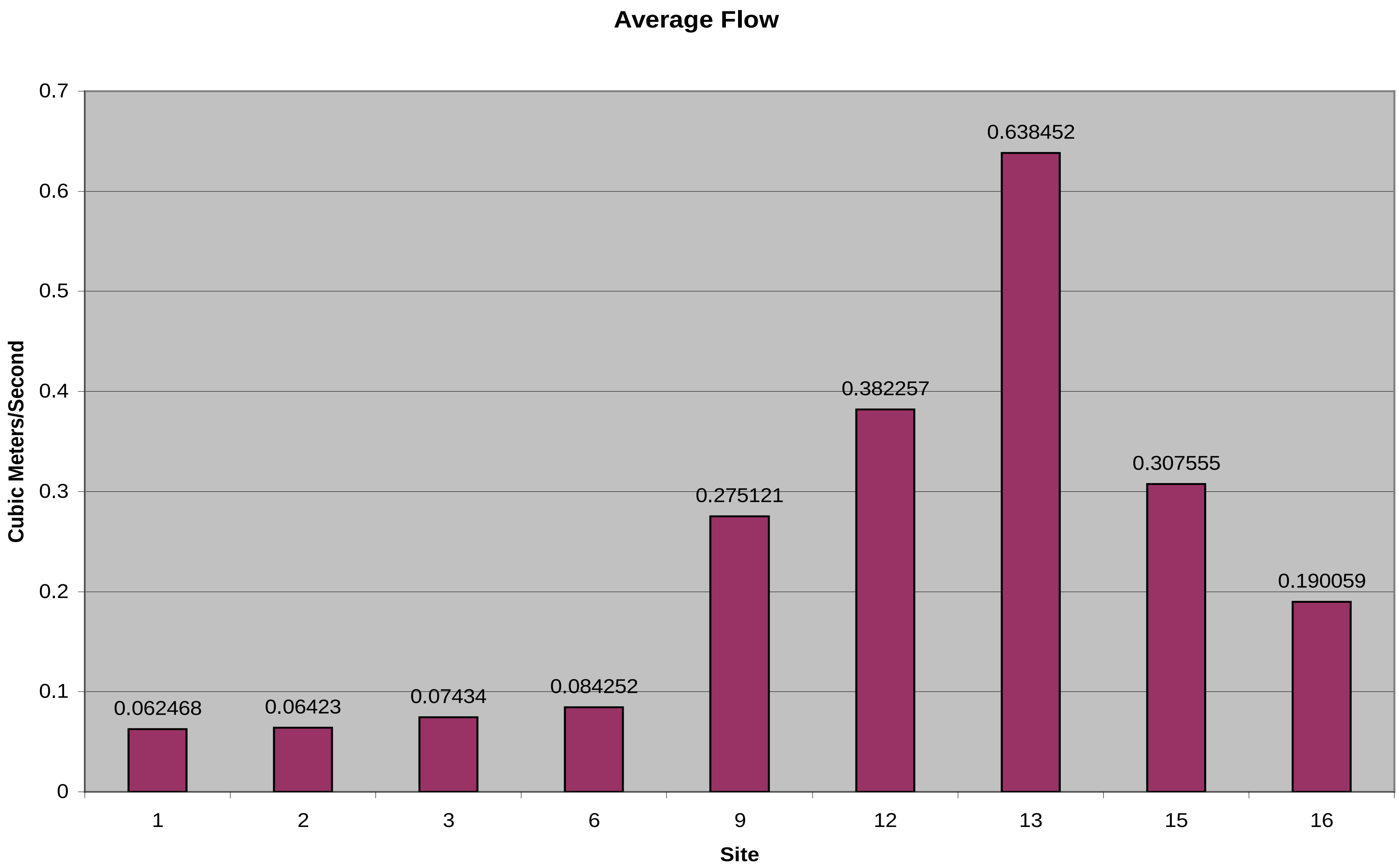


Figure 85: Average flow per site in cubic meters per second.

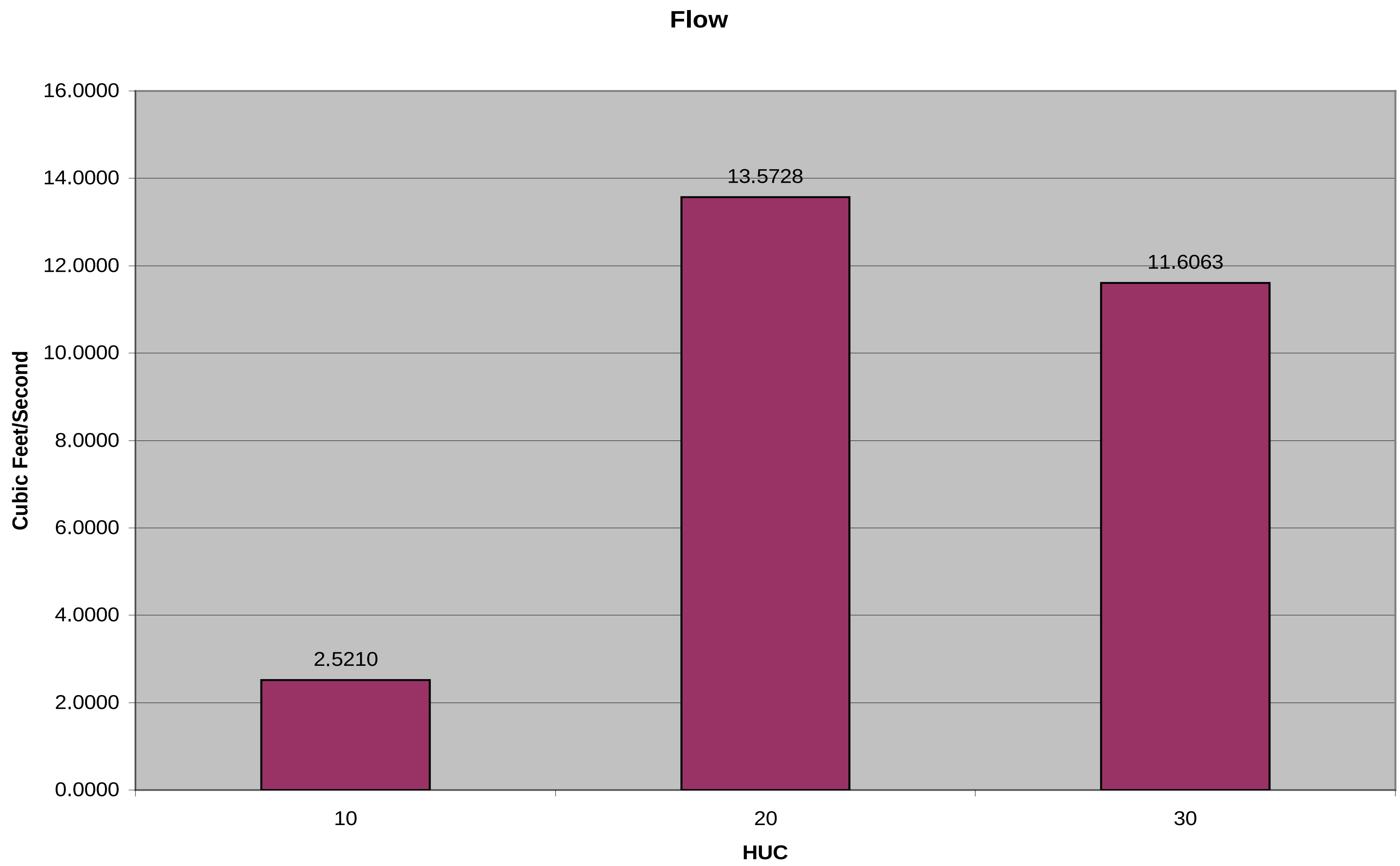


Figure 86: Average flow per HUC in cubic feet per second. HUC numbers correspond to the last 2 digits in the 14 digit code.

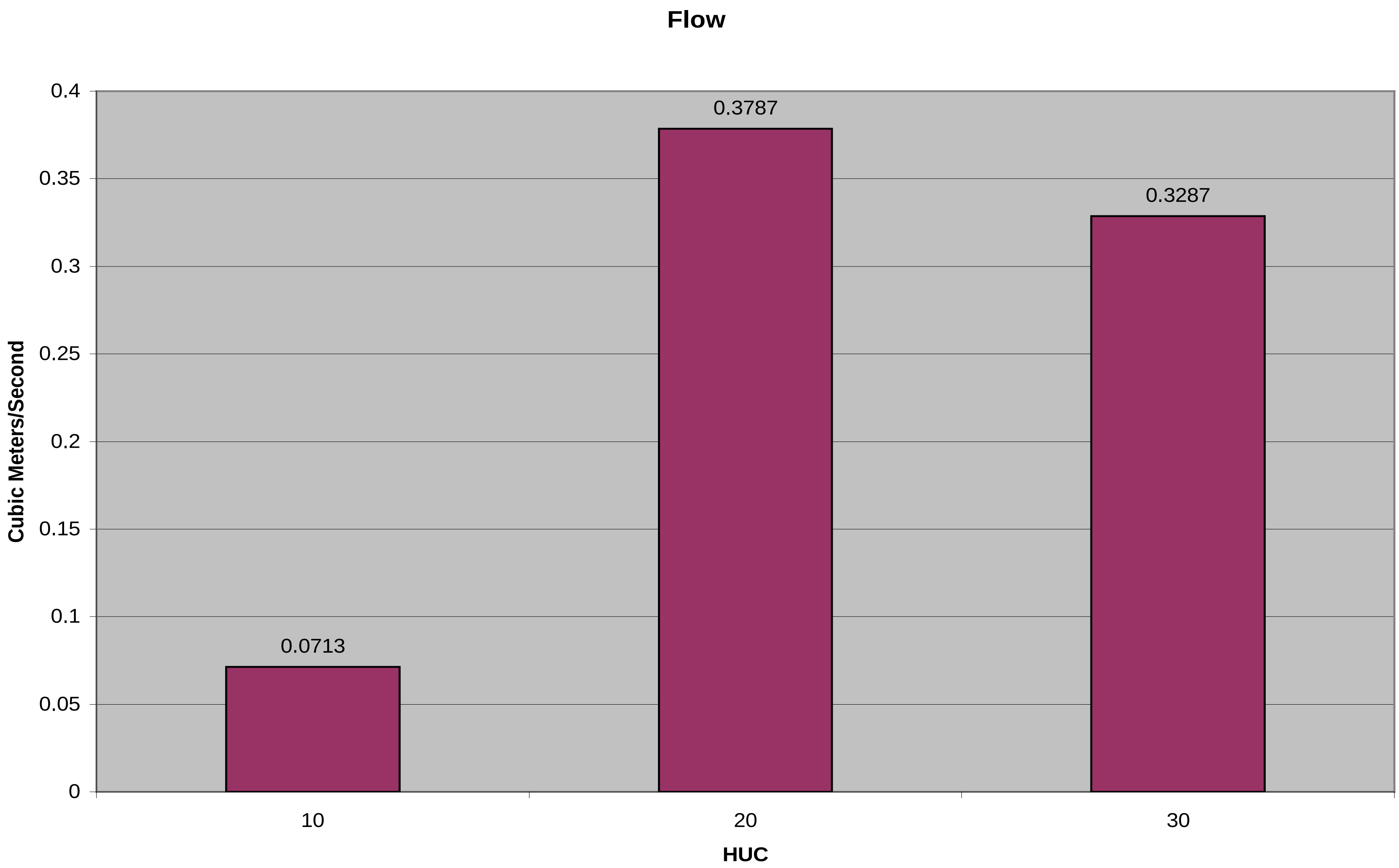


Figure 87: Average flow per HUC in cubic meters per second. HUC numbers correspond to the last 2 digits in the 14 digit code.

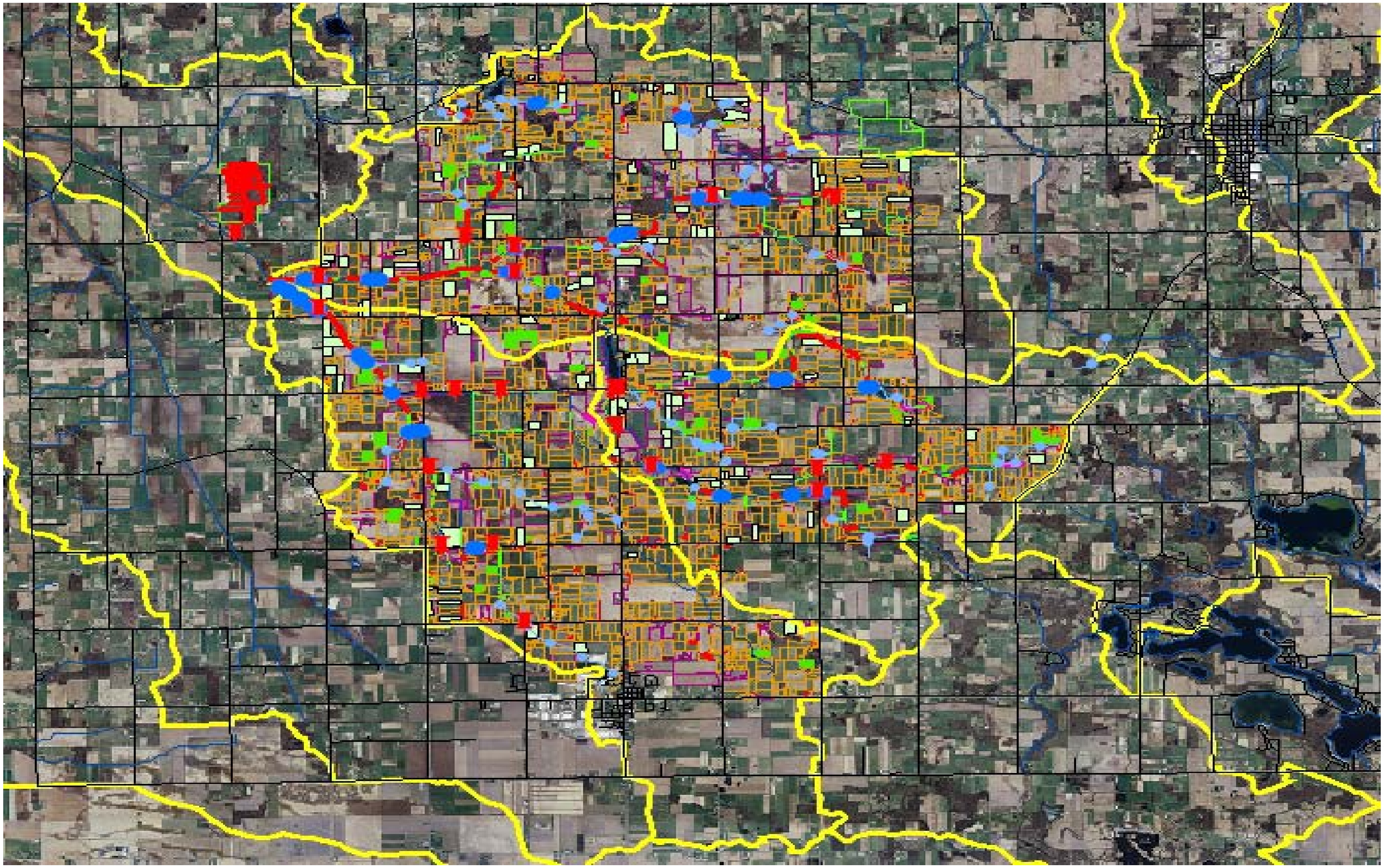


Figure 88: Overview of land use inventory with all layers overlapped.

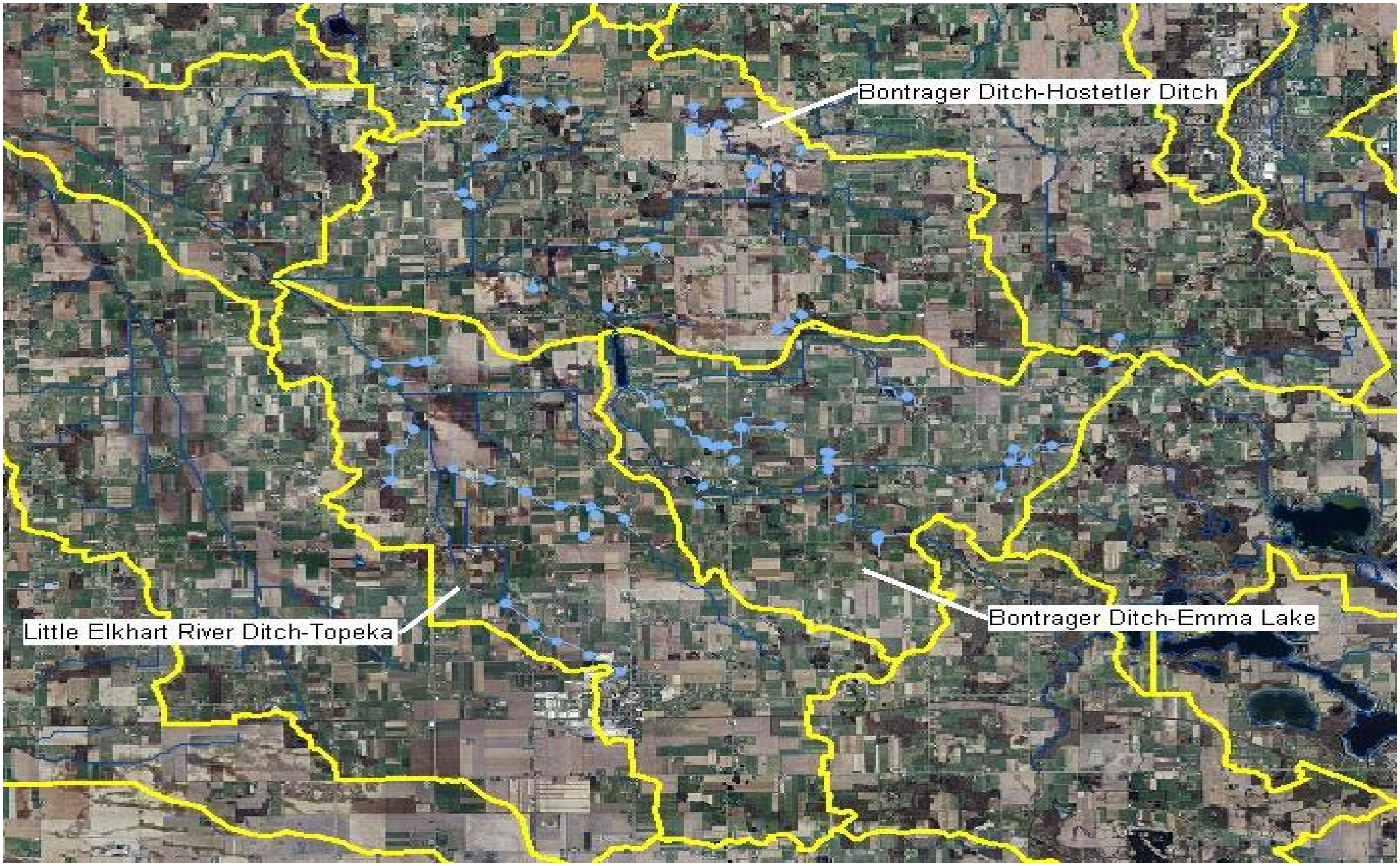


Figure 89: Ditch extensions (depicted in light blue) not shown on surface water map.

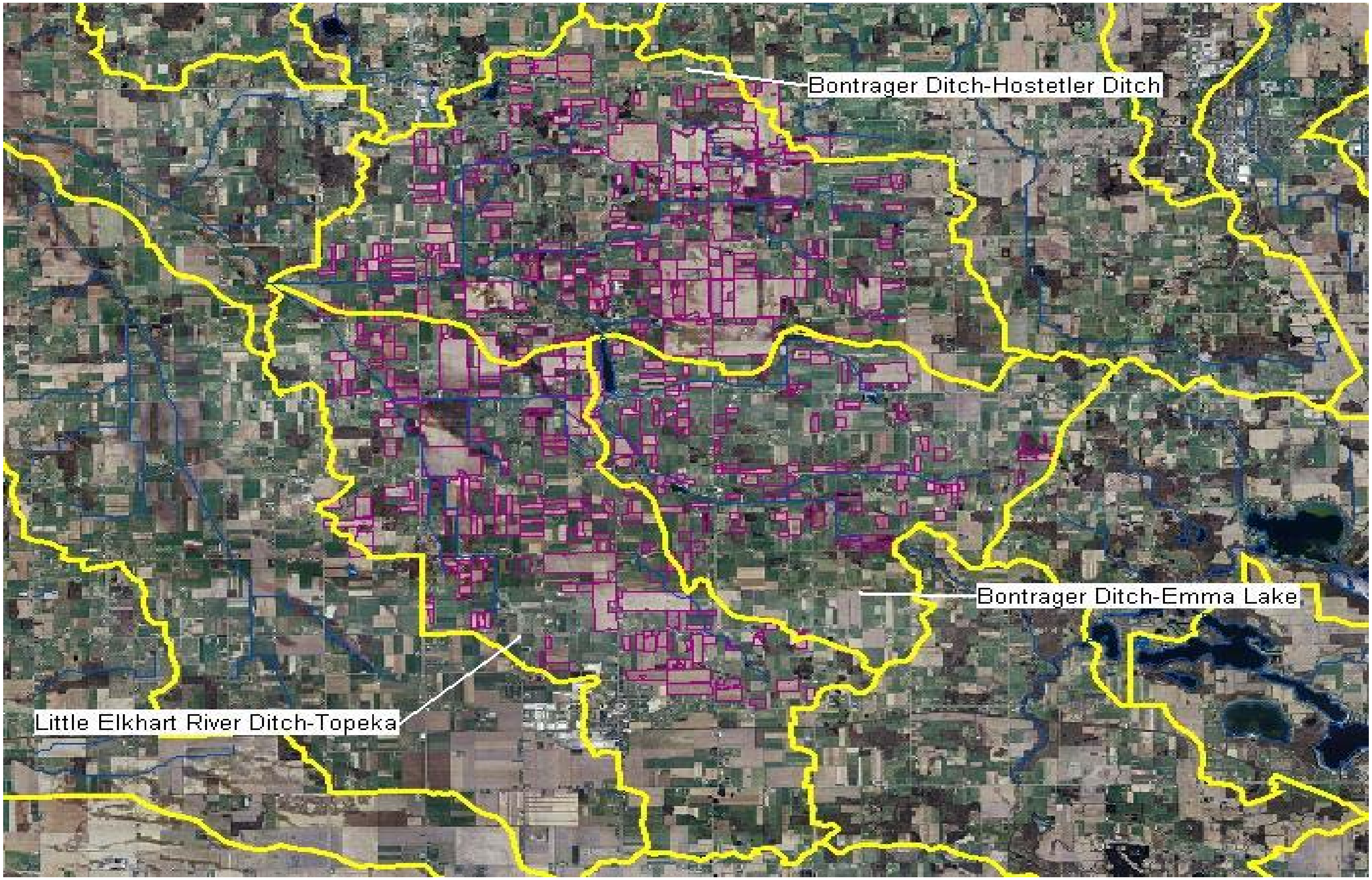


Figure 90: Traditional row crop fields depicted by magenta rectangles.

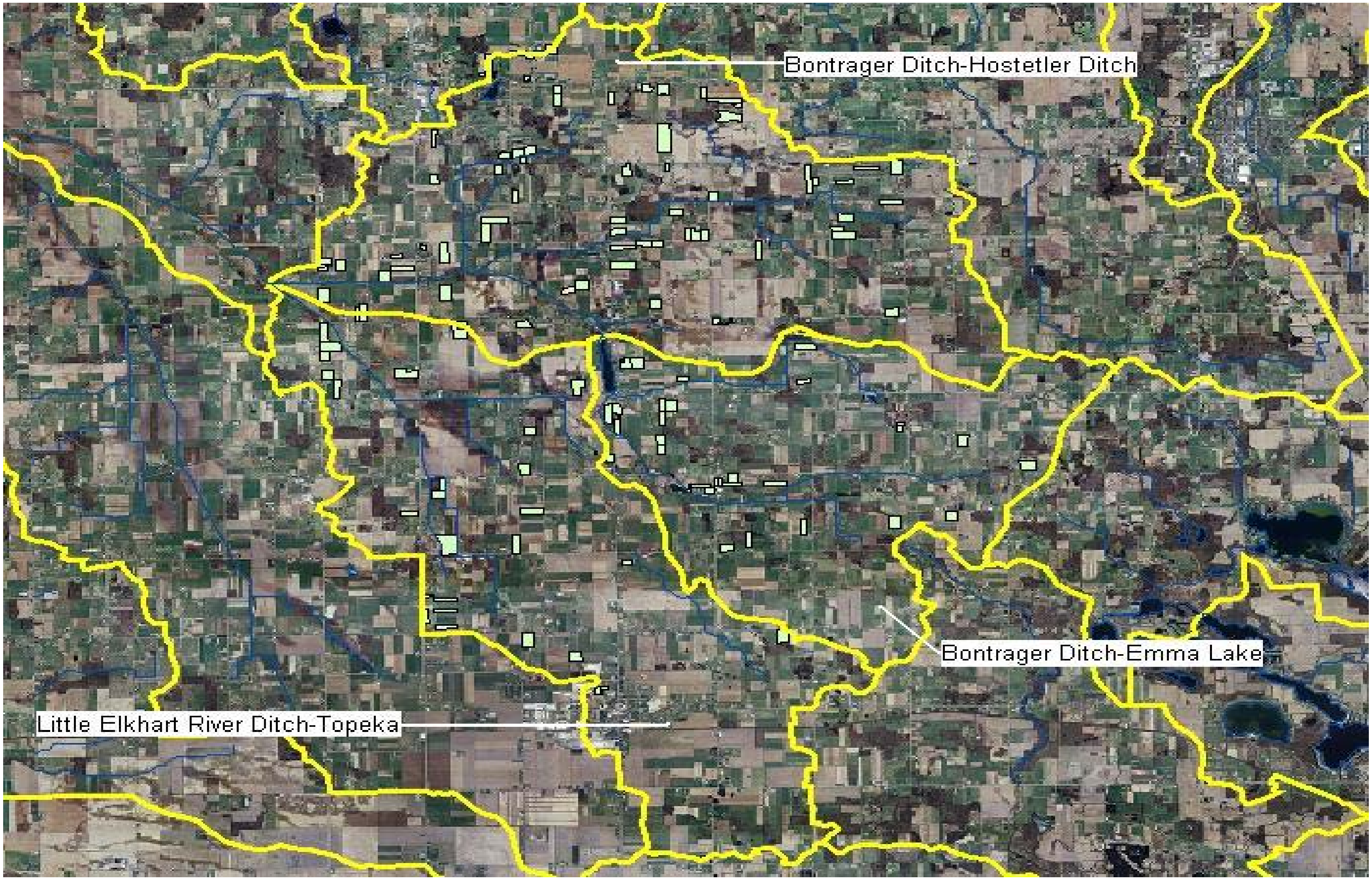


Figure 91: Hay fields depicted in solid light yellow rectangles.

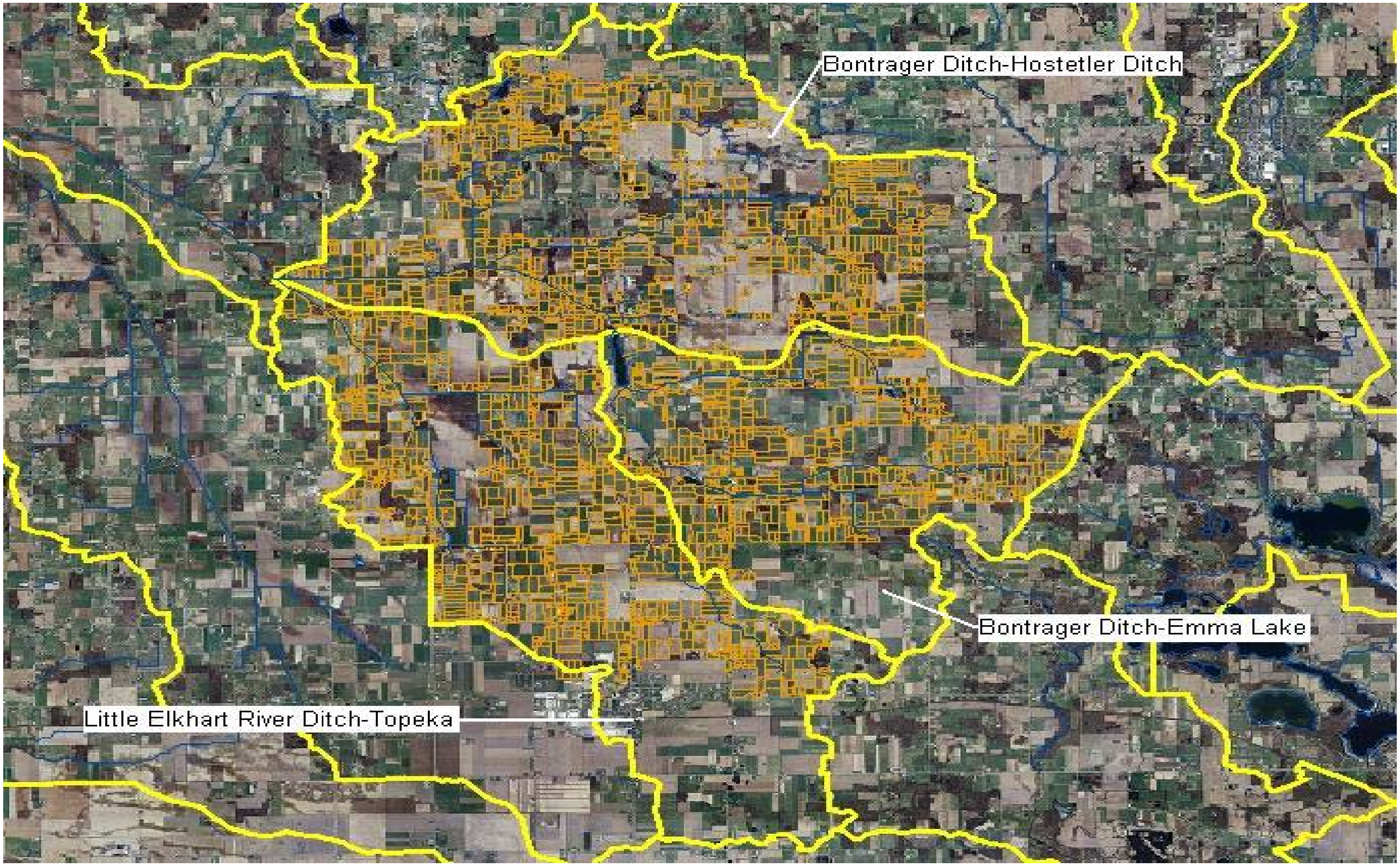


Figure 92: Pasture depicted as yellow rectangles.

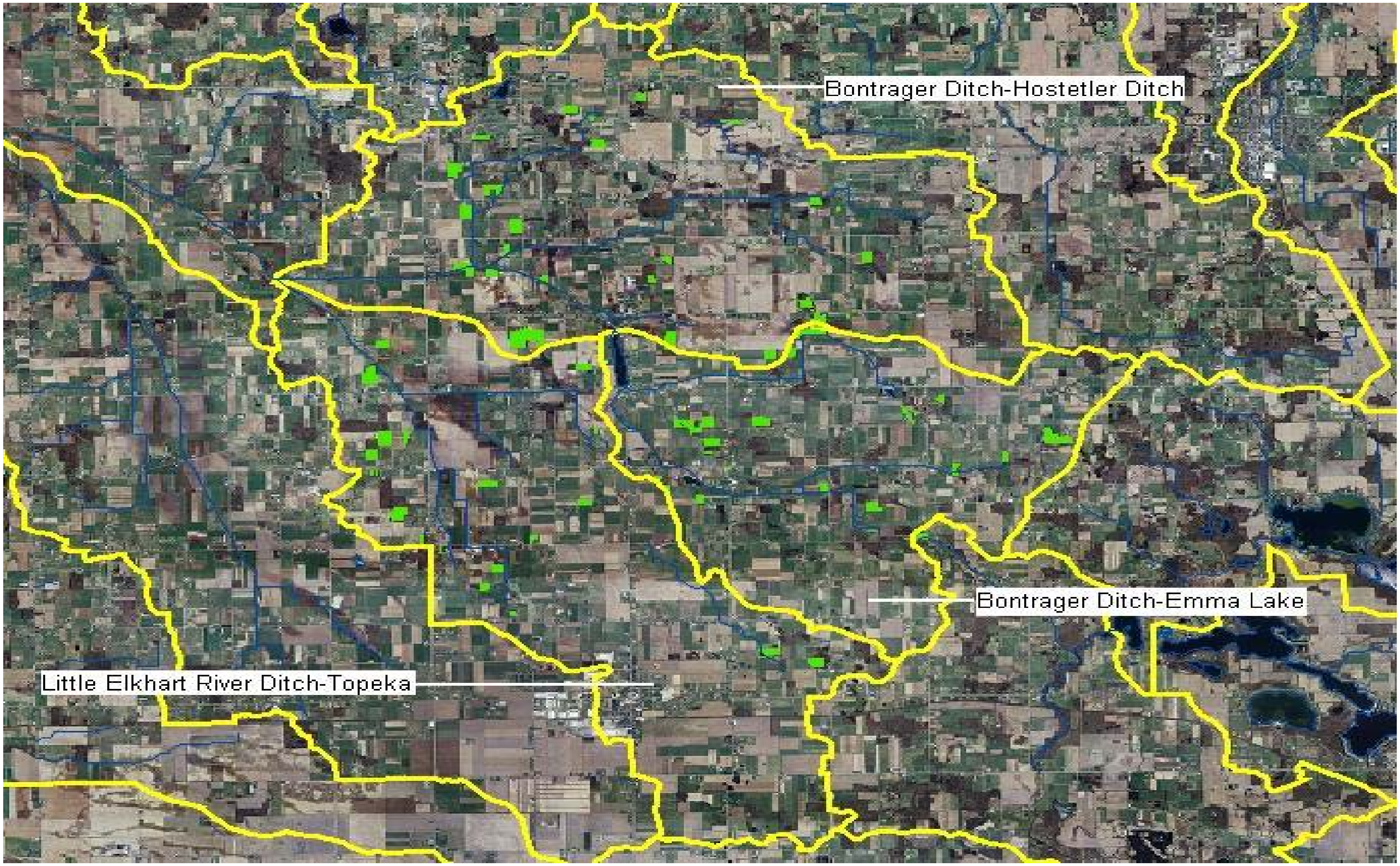
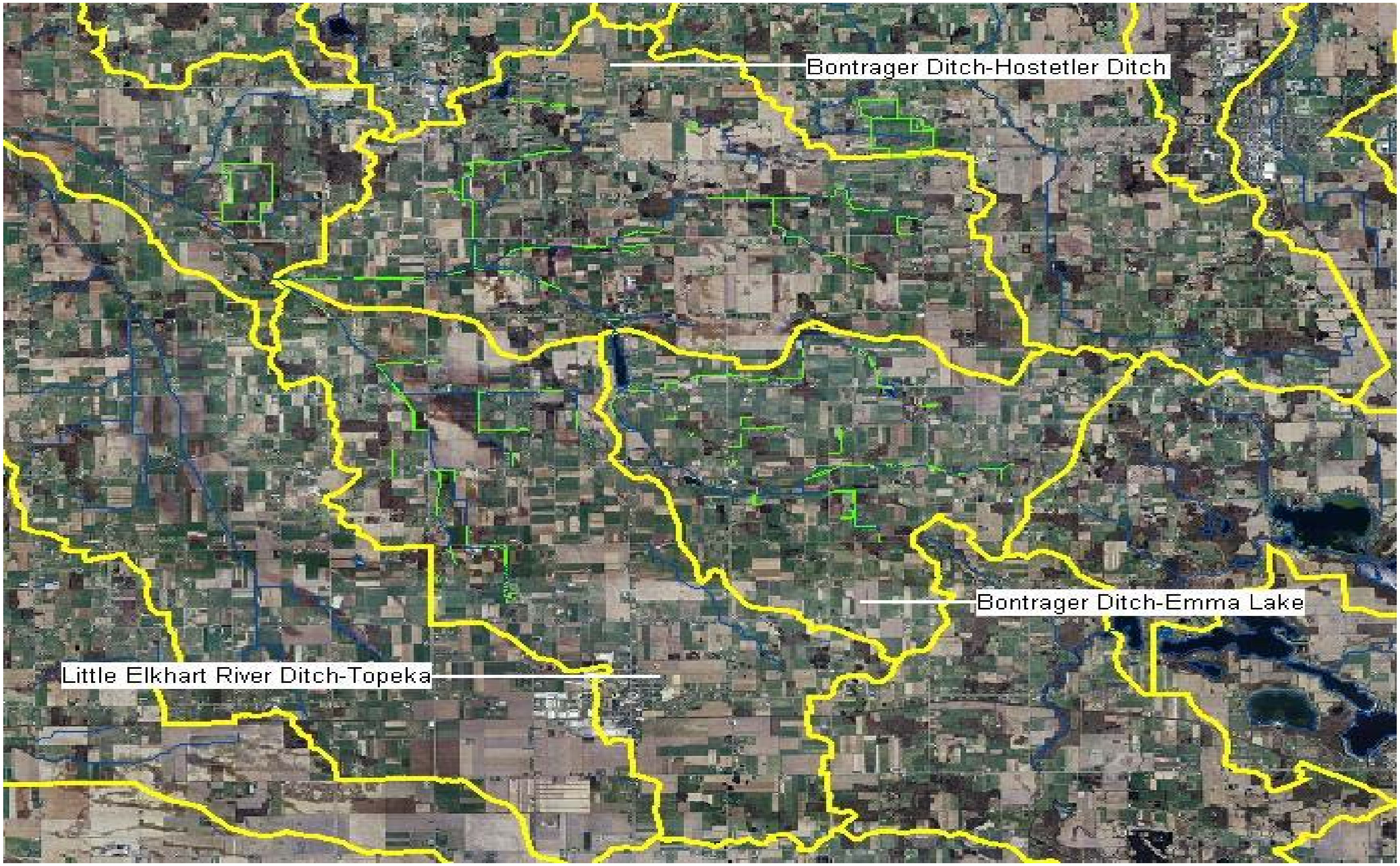


Figure 93: Pastured woodlots depicted as solid green rectangles.



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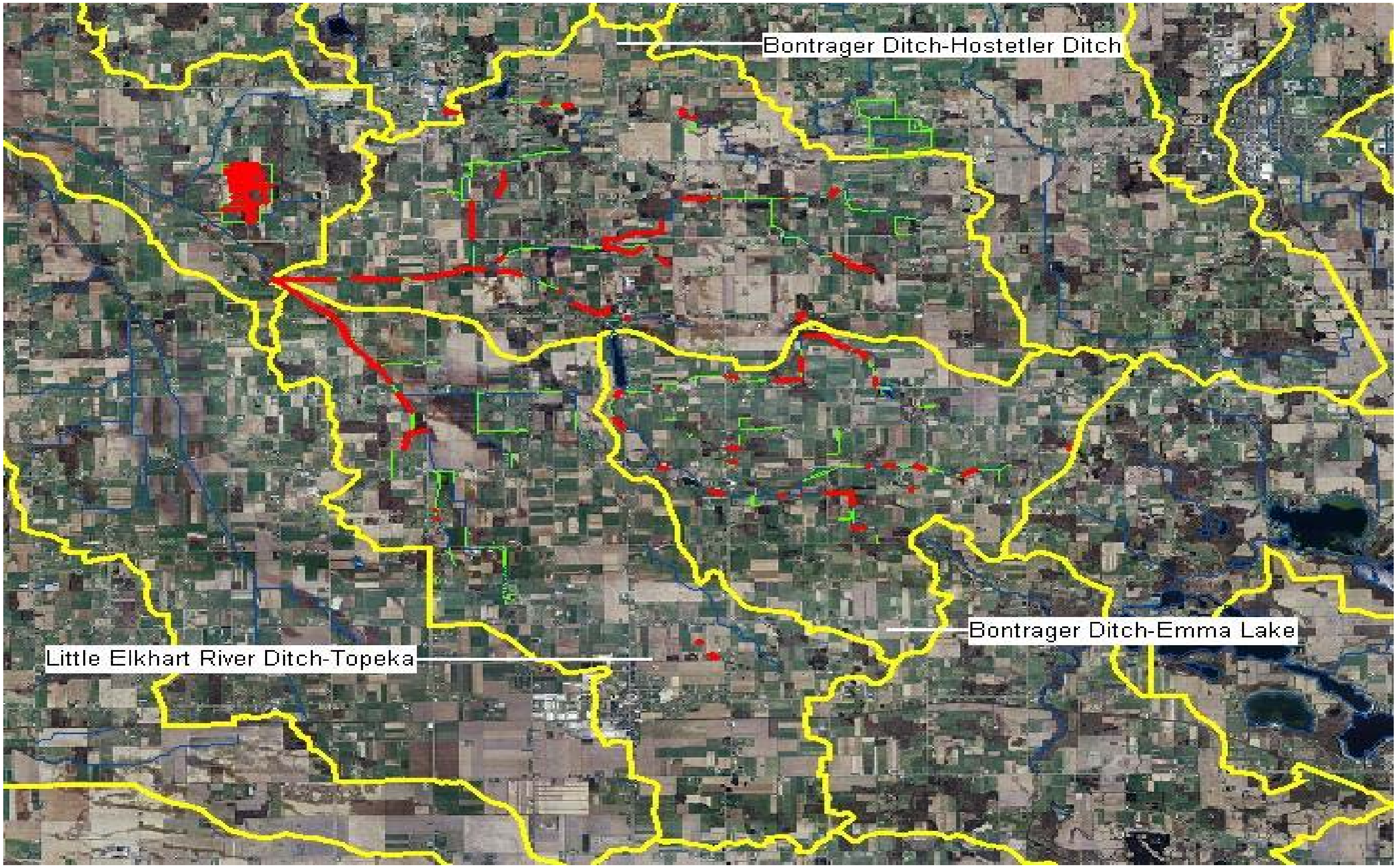

Figure 95: Fenced areas with livestock access overlaid in red.

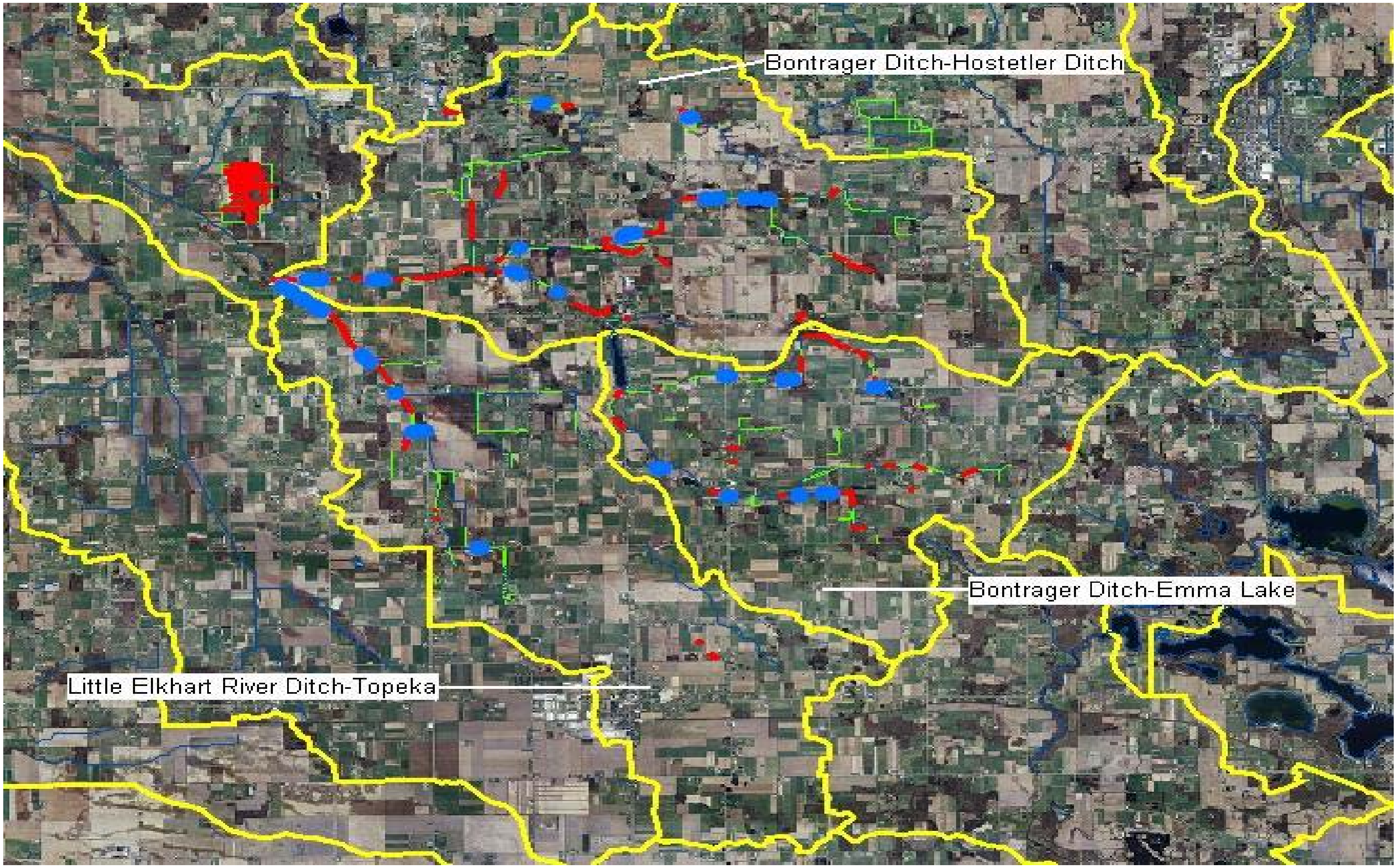

Figure 96: Critical Areas map for ditch bank damage represented in blue overlaid with fenced areas (green lines) and livestock access within fenced areas (red).

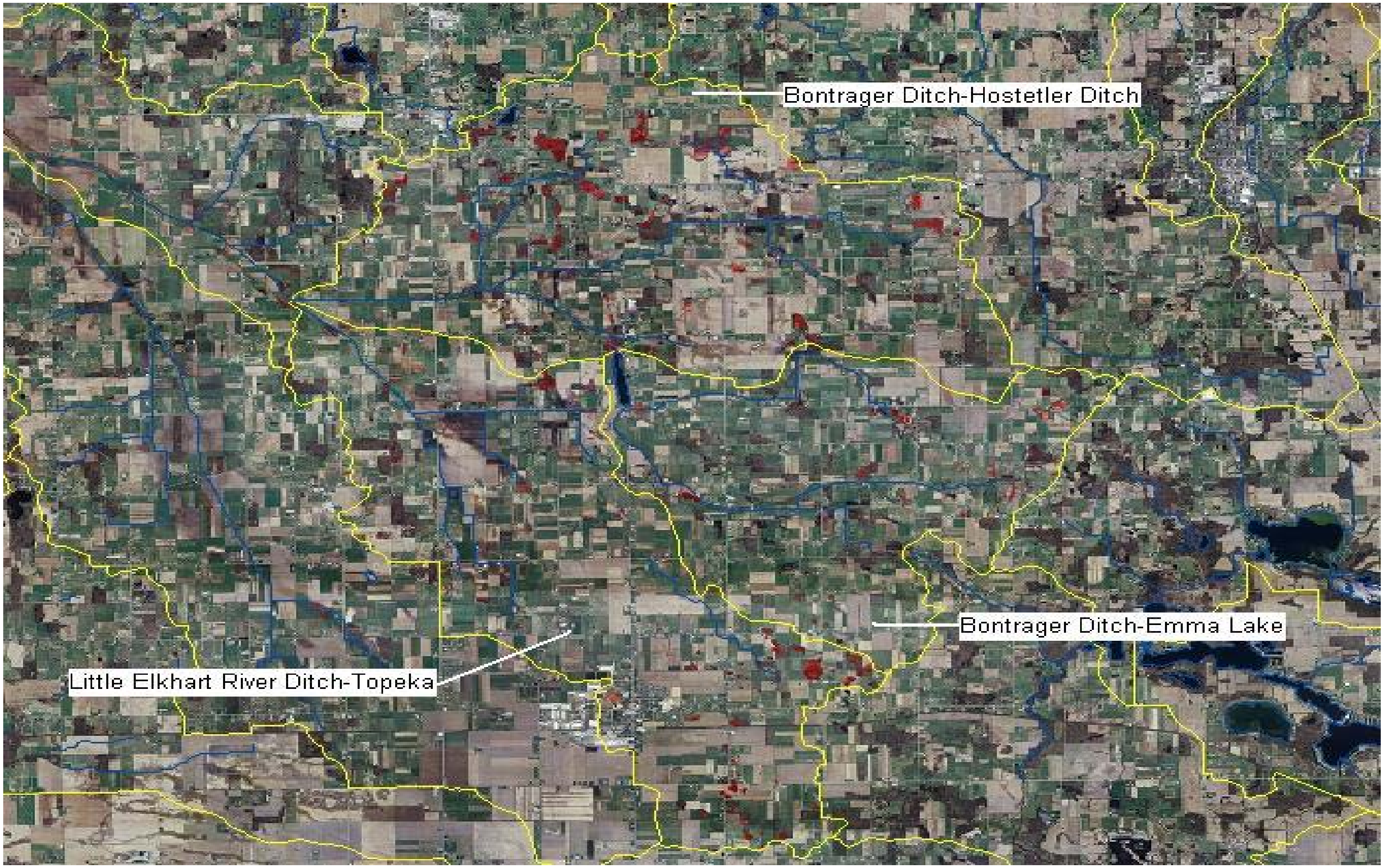

Figure 97: Sensitive areas depicted in dark brown.

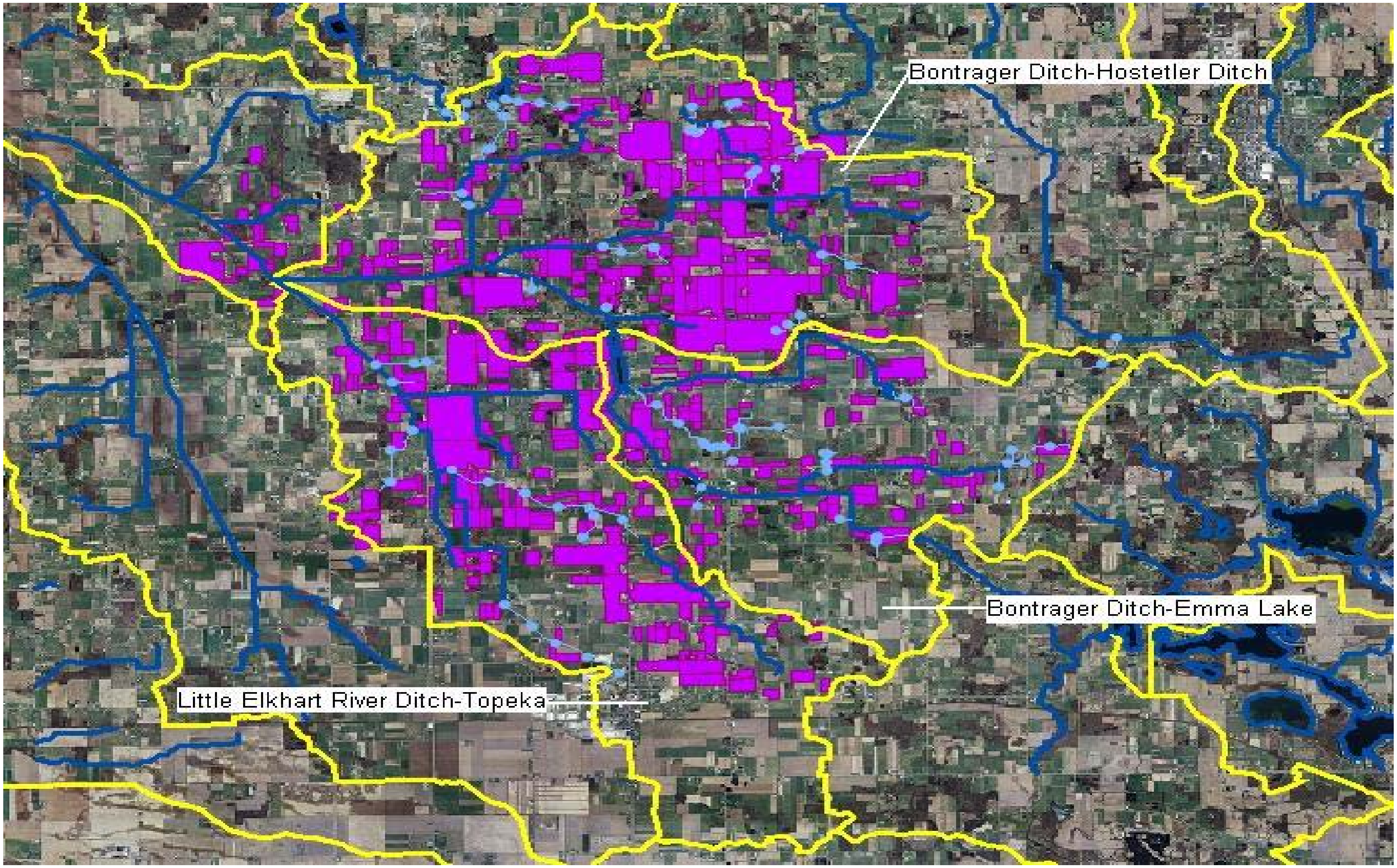

Figure 98: Critical Areas map that require filter strips which are all fields adjacent to surface waters. Traditional row crop fields are in magenta with surface waters shown as dark or light blue lines.

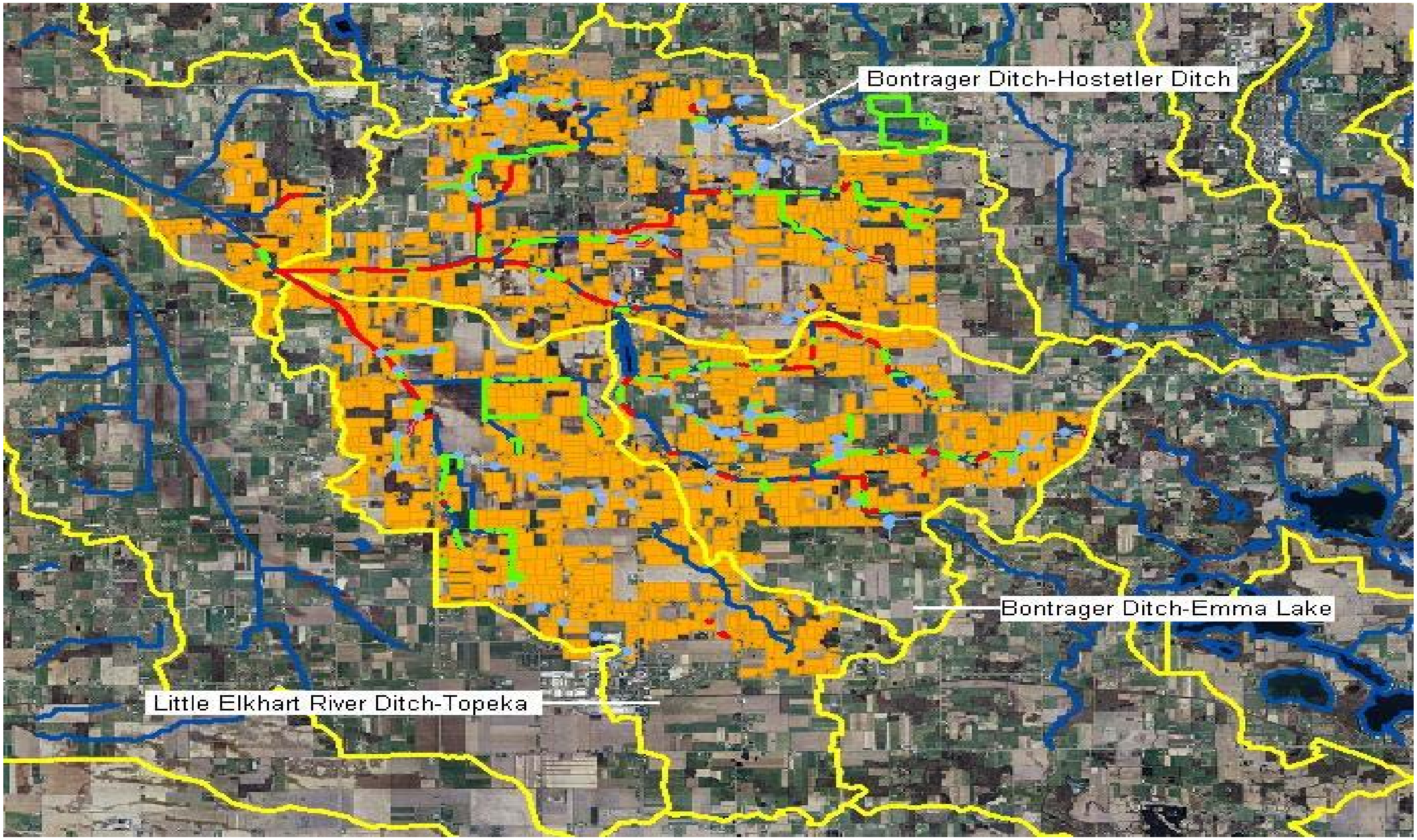

Figure 99: Critical Areas map that require livestock exclusion fence which are all pastured fields adjacent to surface waters. Pastured fields are in dark yellow, existing fence in light green, existing fence with surface water access in red and surface waters in dark or light blue.

One-Way AOV for pH by HUC

Source	DF	SS	MS	F	P
HUC	2	6.2084	3.10420	28.0	0.0000
Error	356	39.4822	0.11091		
Total	358	45.6906			

Grand Mean 7.7696   CV 4.29

		Chi-Sq	DF	P
Bartlett's Test of Equal Variances		0.10	2	0.9496
Cochran's Q	0.3388			
Largest Var / Smallest Var	1.0507			

Component of variance for between groups   0.02558
Effective cell size   117.0

HUC	N	Mean	SE
10	144	7.6990	0.0278
20	130	7.9403	0.0292
30	85	7.6281	0.0361

Tukey HSD All-Pairwise Comparisons Test of pH by HUC

HUC	Mean	Homogeneous Groups
20	7.9403	A
10	7.6990	B
30	7.6281	B

Alpha 0.05
Critical Q Value 3.314
There are 2 groups (A and B) in which the means
are not significantly different from one another.

Appendix 1: One-Way ANOVA and all pairwise comparisons test for pH by HUC.

One-Way AOV for Temp by HUC

Source	DF	SS	MS	F	P
HUC	2	133.2	66.6163	1.67	0.1894
Error	356	14188.6	39.8556		
Total	358	14321.8			

Grand Mean 14.201   CV 44.46

		Chi-Sq	DF	P
Bartlett's Test of Equal Variances		8.66	2	0.0132
Cochran's Q	0.4154			
Largest Var / Smallest Var	1.8191			

Component of variance for between groups	0.22869
Effective cell size	117.0

HUC	N	Mean	SE
10	144	13.789	0.5261
20	130	15.007	0.5537
30	85	13.666	0.6848

Appendix 2: One-Way ANOVA for temperature by HUC.

One-Way AOV for DO by HUC

Source	DF	SS	MS	F	P
HUC	2	92.56	46.2819	9.23	0.0001
Error	356	1785.37	5.0151		
Total	358	1877.93			

Grand Mean 6.7860 CV 33.00

		Chi-Sq	DF	P
Bartlett's Test of Equal Variances		5.87	2	0.0532
Cochran's Q	0.3811			
Largest Var / Smallest Var	1.4955			

Component of variance for between groups 0.35265
Effective cell size 117.0

HUC	N	Mean	SE
10	144	6.5278	0.1866
20	130	7.4414	0.1964
30	85	6.2211	0.2429

Tukey HSD All-Pairwise Comparisons Test of DO by HUC

HUC	Mean	Homogeneous Groups
20	7.4414	A
10	6.5278	B
30	6.2211	B

Alpha 0.05
Critical Q Value 3.314
There are 2 groups (A and B) in which the means
are not significantly different from one another.

Appendix 3: One-Way ANOVA and all pairwise comparisons test for dissolved oxygen by HUC.

One-Way AOV for TDS by HUC

Source	DF	SS	MS	F	P
HUC	2	311069	155535	3.22	0.0410
Error	356	1.718E+07	48264		
Total	358	1.749E+07			

Grand Mean 390.47   CV 56.26

		Chi-Sq	DF	P
Bartlett's Test of Equal Variances		478	2	0.0000
Cochran's Q	0.9370			
Largest Var / Smallest Var	66.315			

Component of variance for between groups   916.691
Effective cell size   117.0

HUC	N	Mean	SE
10	144	420.71	18.308
20	130	353.56	19.268
30	85	395.68	23.829

Tukey HSD All-Pairwise Comparisons Test of TDS by HUC

HUC	Mean	Homogeneous Groups
10	420.71	A
30	395.68	AB
20	353.56	B

Alpha   0.05
Critical Q Value 3.314
There are 2 groups (A and B) in which the means
are not significantly different from one another.

Appendix 4: One-Way ANOVA and all pairwise comparisons test for total dissolved solids by HUC.

One-Way AOV for Turb by HUC

Source	DF	SS	MS	F	P
HUC	2	4607	2303.72	5.34	0.0052
Error	356	153581	431.41		
Total	358	158189			

Grand Mean 8.7819   CV 236.51

	Chi-Sq	DF	P
Bartlett's Test of Equal Variances	368	2	0.0000
Cochran's Q 0.9194			
Largest Var / Smallest Var 28.285			

Component of variance for between groups   16.0000
Effective cell size   117.0

HUC	N	Mean	SE
10	144	7.602	1.7309
20	130	13.177	1.8217
30	85	4.059	2.2529

Tukey HSD All-Pairwise Comparisons Test of Turb by HUC

HUC	Mean	Homogeneous Groups
20	13.177	A
10	7.6020	AB
30	4.0591	B

Alpha 0.05
Critical Q Value 3.314
There are 2 groups (A and B) in which the means
are not significantly different from one another.

Appendix 5: One-Way ANOVA and all pairwise comparisons test for turbidity by HUC.

One-Way AOV for E.Coli by HUC

Source	DF	SS	MS	F	P
HUC	2	1.061E+09	5.306E+08	1.51	0.2232
Error	356	1.254E+11	3.523E+08		
Total	358	1.264E+11			

Grand Mean 6742.0   CV 278.41

		Chi-Sq	DF	P
Bartlett's Test of Equal Variances		15.1	2	0.0005
Cochran's Q	0.4769			
Largest Var / Smallest Var	2.0224			

Component of variance for between groups   1523067
Effective cell size   117.0

HUC	N	Mean	SE
10	144	6626.1	1564.2
20	130	8613.3	1646.3
30	85	4076.4	2035.9

Appendix 6: One-Way ANOVA for *E.coli* by HUC.

One-Way AOV for Nitrate by HUC

Source	DF	SS	MS	F	P
HUC	2	163.08	81.5400	19.9	0.0000
Error	356	1458.90	4.0980		
Total	358	1621.98			

Grand Mean 2.7058   CV 74.81

		Chi-Sq	DF	P
Bartlett's Test of Equal Variances		35.9	2	0.0000
Cochran's Q	0.5570			
Largest Var / Smallest Var	2.6486			

Component of variance for between groups   0.66179
Effective cell size   117.0

HUC	N	Mean	SE
10	144	2.2174	0.1687
20	130	3.6000	0.1775
30	85	2.1659	0.2196

Tukey HSD All-Pairwise Comparisons Test of Nitrate by HUC

HUC	Mean	Homogeneous Groups
20	3.6000	A
10	2.2174	B
30	2.1659	B

Alpha 0.05
Critical Q Value 3.314
There are 2 groups (A and B) in which the means
are not significantly different from one another.

Appendix 7: One-Way ANOVA and all pairwise comparisons test for nitrates by HUC.

One-Way AOV for TP by HUC

Source	DF	SS	MS	F	P
HUC	2	4.834	2.41718	6.49	0.0017
Error	338	125.826	0.37226		
Total	340	130.660			

Grand Mean 0.5093   CV 119.80

		Chi-Sq	DF	P
Bartlett's Test of Equal Variances		116	2	0.0000
Cochran's Q	0.7344			
Largest Var / Smallest Var	6.9990			

Component of variance for between groups   0.01839
Effective cell size   111.2

HUC	N	Mean	SE
10	137	0.4139	0.0521
20	123	0.4791	0.0550
30	81	0.7164	0.0678

Tukey HSD All-Pairwise Comparisons Test of TP by HUC

HUC	Mean	Homogeneous Groups
30	0.7164	A
20	0.4791	B
10	0.4139	B

Alpha   0.05
Critical Q Value   3.314
There are 2 groups (A and B) in which the means
are not significantly different from one another.

Appendix 8: One-Way ANOVA and all pairwise comparisons test for total phosphorus by HUC.

One-Way AOV for TSS by HUC

Source	DF	SS	MS	F	P
HUC	2	4662	2330.78	2.42	0.0908
Error	339	326996	964.59		
Total	341	331657			

Grand Mean 15.582   CV 199.32

		Chi-Sq	DF	P
Bartlett's Test of Equal Variances		90.7	2	0.0000
Cochran's Q	0.5892			
Largest Var / Smallest Var	5.7827			

Component of variance for between groups   12.2406
Effective cell size   111.6

HUC	N	Mean	SE
10	137	13.956	2.6534
20	123	20.301	2.8004
30	82	11.220	3.4298

Appendix 9: One-Way ANOVA for total suspended solids by HUC.

One-Way AOV for BOD~01 by HUC

Source	DF	SS	MS	F	P
HUC	2	0.1171	0.05856	1.72	0.1797
Error	356	12.0877	0.03395		
Total	358	12.2048			

Grand Mean 0.3891   CV 47.36

		Chi-Sq	DF	P
Bartlett's Test of Equal Variances		3.12	2	0.2097
Cochran's Q	0.4007			
Largest Var / Smallest Var	1.4081			

Component of variance for between groups 2.103E-04
Effective cell size 117.0

HUC	N	Mean	SE
10	144	0.4025	0.0154
20	130	0.3951	0.0162
30	85	0.3572	0.0200

Appendix 10: One-Way ANOVA biochemical oxygen demand by HUC.

One-Way AOV for Flow by HUC

Source	DF	SS	MS	F	P
HUC	2	3820.1	1910.06	10.4	0.0001
Error	146	26838.3	183.82		
Total	148	30658.4			

Grand Mean 8.9193   CV 152.01

		Chi-Sq	DF	P
Bartlett's Test of Equal Variances		161	2	0.0000
Cochran's Q	0.9164			
Largest Var / Smallest Var	47.235			

Component of variance for between groups   38.8886
Effective cell size   44.4

HUC	N	Mean	SE
10	56	2.583	1.8118
20	74	13.510	1.5761
30	19	9.715	3.1105

Tukey HSD All-Pairwise Comparisons Test of Flow by HUC

HUC	Mean	Homogeneous Groups
20	13.510	A
30	9.7147	AB
10	2.5829	B

Alpha   0.05
Critical Q Value   3.314
There are 2 groups (A and B) in which the means
are not significantly different from one another.

Appendix 11: One-Way ANOVA and all pairwise comparisons test for flow by HUC.

APPENDIX 12
Quality Assurance Project Plan

Quality Assurance Project Plan

for

Little Elkhart River Watershed Management Plan

ARN # A305-4-142

Prepared by:

David P. Arrington
Watershed Coordinator
LaGrange County SWCD

Prepared for:

Indiana Department of Environmental Management
Office of Water Management
Watershed Management Section

June 2005

Approved By:

Project Manager:	______________________ David Arrington	________ Date
WMS QA Manager:	______________________ Betty Ratcliff	________ Date
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Planning Branch Chief:	______________________ Martha Clark Mettler	________ Date

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Section 1: Study Description

Historical Information

The St. Joseph River has had significant attention in it's urbanized centers of South Bend, Mishawaka, and Elkhart concerning water quality issues initially associated with point source pollution. A relatively recent focus has centered on non-point source pollution throughout the basin with an emphasis on agricultural water runoff associated with crop planting and livestock land-use practices. Studies conducted by Indiana and Michigan state/county agencies have demonstrated tributaries of the mainstream are the major contributors of non-point source pollutants. The Little Elkhart River lies within the St. Joseph River Basin.

The Little Elkhart River Basin is primarily influenced by agricultural practices and is on the IDEM 303(d) list of impaired waters. Water quality testing has shown high levels of phophate, nitrate, e-coli, and impaired biotic cummunities. Emma Lake, which lies within the study area is on the list of impaired waters for biotic cummunities.

Although much attention is given to organic compounds and bacteria pollutants, Indiana DNR studies have indicated silt loading as a major limiting factor on the fish community within the Little Elkhart River system. Ledet(1991) listed the Little Elkhart River as a cool to coldwater environment but silt loading prevented fish species usually associated from becoming established. Federal, state, and county officials have established, through visual confirmation, areas within the target area that contain direct bank erosion. These observations indicated direct cattle access to ditches as a primary cause.

The study area presents unique challenges with approximately 75% of the landowners belonging to the Amish community. This is the fastest growing region of the county according to the U.S. Censis Data, and has a rapidly expanding Amish "cottage industry". Many of these small businesses are locating adjacent to ditches and small tributuaries of the Little Elkhart River. The impact of these growing businessess have not been explored to date.

This will be the first comprehensive water quality study conducted on these watersheds. Historical water quality analysis has been spotty and inconsistant. Parameters that were tested were incomplete and cannot be used for comparisons.

Study Goals

Goal 1: The primary goal of water quality testing is to establish a baseline to prioritize target locations for implemetation of future and current cost-share funds.

Goal 2: The secondary goal is to establish a baseline for future water quality testing to evaluate the effectiveness of established Best Management Practices.

Study Site

The project area is the headwater region of the Little Elkhart River located in the West/Southwest portion of LaGrange County (Appendix A). It comprises three contiguous HUC 14 watersheds:
04050001140010 - Bontrager Ditch/Emma Lake 8,691 acres
04050001140010 - Bontrager Ditch/Hostetler Ditch 13,240 acres
04050001140010 - Little Elkhart Ditch (Topeka) 11,883 acres
Total 33,814 acres
Six sites per HUC 14 watershed will be sampled monthly during "ice-out" seasons (Appendix A). Sampling locations were selected to capture and isolate "finger" tributaries along each major ditch channel. This approach will allow isolation of areas that demonstrate high levels of non-point source pollutants and focus attention on land-use issues causing the abnormalities.

Sampling Design

A synoptic approach was chosen for this study to give a representative analysis of the entire study area. Originally a probabalistic approach was considered but required too many sampling sites to maintain complete randomness. The synoptic approach will provide data that isolates segments and "finger" tributaries and will reveal trends that may require intervention during current and future implementation of BMPs. In addition, it will provide a solid baseline for water testing after BMPs have been established, enabling a quantitative evaluation on the effectiveness of the BMP practices.
Six sites have been selected for each HUC 14 for a total of 18 water quality testing sites (Appendix A). During the study samples from each site will be collected on a monthly basis for 18 months and analyzed for dissolved oxygen, biochemical oxygen demand, *E. coli*, pH, temperature, total phosphate, nitrates, total dissolved solids, total suspended solids and turbidity. Stream flow will be measured on a monthly basis (at the same time as parameter samples are taken) at sites 1,5,6,9,10,12,13,15, and 16 (Appendix A). Microinvertibrates samples will be collected twice each year (Spring/Fall) at each site.
Habitat sampling will occur twice during the study period. Sampling will take place during low flow conditions in summer to provide information on habitat availability during the highest period of stress. Habitat quality will be assessed using the Ohio Environmental Protection Agency (OEPA) Qualitative Habitat Evaluation index (QHEI) protocol (OEPA, 1989).
Electronic field instruments will be used to collect data at each site on dissolved oxygen, pH, temperature, and turbidity. Total phosphate, nitrates, biological oxygen demand, total suspended solids and *E. coli* will be collected for analysis in our lab.
This sampling approach will allow LaGrange County Soil and Water Conservation District to achieve the goals of this project. The data will enhance the county's education program by providing solid water quality information to land owners.

Study Schedule

Sampling will begin in May 2005 and will end in October 2006 (Table 1). Analysis of data will be on-going throughout the study to identify trends and steer current implentation programs to problematic locations. Macroinvertebrates sampling will begin in May and will end in September 2006 for a total of four sampling dates at each sampling site. Results of testing will be reported at each steering committee and public meeting.

The major constraint during the sampling cycle will be during winter when many of the sites will be frozen. Every attempt will be made to sample as many sites as possible during winter.

Table 1: Study Schedule

Activity	Start Date	End Date
Sample collection: DO, BOD, Temp, pH, TP, NO_3, Turb, TDS, TSS, *E. coli* and flow. (monthly all sites)	May, 2005	Oct., 2006
Flow (monthly at sites: 1,5,6,9,10,12,13,15, and 16)	May, 2005	Oct., 2006
Microinvertebrate collection (semi-annually all sites)	June, 2005	Sept., 2006
Habitat Evaluation (twice all sites)	Aug., 2005	Aug., 2006
Analysis (on-going)	Aug., 2005	Nov., 2006

Section 2: Study Organization and Responsibility

Key Personnel

David Arrington - Watershed Coordinator
910 S. Detroit Street LaGrange, IN 46761 (260) 463-3471 ext. 3,
david.arrington@IN.nacdnet.net
Responsible for coordination of project: data collection, QA, data analysis, meetings, documentation and write-up.

Dona Hunter - Program Manager
910 S. Detroit Street LaGrange, IN 46761 (260) 463-3471 ext. 3, dona.hunter@IN.nacdnet.net
Overall program manager.

Julie Deihm - Water Quality Technician
910 S. Detroit Street LaGrange, IN 46761 (260) 463-3471 ext. 3, julie.deihm@IN.nacdnet.net
Water quality testing, data management.

Barb Frymier - Lab Technician
910 S. Detroit Street LaGrange, IN 46761 (260) 463-3471 ext. 3
E-coli analysis, data management.

Project Organization

Both techncians report to the watershed coordinator concerning all water testing issues. The water quality technician will be principally responsible for field data collection and lab sample collection. The lab technician will be responsible for E. coli testing and will assist in macroinvertibrate analysis. The watershed coordinator has overall responsibility for the study.

Section 3: Data Quality Objectives

Precision and Accuracy

Field Chemistry Parameters

Field equipment will be calibrated in accordance with manufacturer's specifications. Replicate samples will be taken with the following field equipment: Hach instruments sensION 156 (DO, pH, Temp, TDS), 2100P Turbidmeter, and Global Water Flow Probe. One replicate sample will be taken during each sampling cycle or 1 replicate per 18 samples. Precision will be calculated using the RPD method:

$$RPD = \frac{(C - C') \times 100\%}{(C + C')/2}$$

Where:
C = the larger of two values
C' = the smaller of two values

Laboratory Water Chemistry Parameters

Grab samples will be collected for total phosphate, total suspended solids and nitrate at each site for analysis with the Hach DR 2500 Spectrophotometer. BOD samples will be collected and analyzed using the HACH BOD Trak and incubator. Total suspended solids will be analyzed by establishing a conversion factor applied to turbidity measurements. Establishing the conversion factor will be in cooperation with Nathan Rice of IDEM. One duplicate sample will be collected during each sampling cycle or 1 duplicate per 18 samples. One blank will be collected during each sampling event for comparison in the laboratory. In addition, standards will be used in accordance with manufacturer's guidelines. *E. coli* samples will be collected using sterile containers with duplicates of each sample analyzed using the Easy Gel method with incubator. Precision will be measured using the RPD method.

The electronic field instruments will be calibrated each day before sampling, this will insure an accuracy within the limits of each device. In the labratory, strict addherence to procedures and consistant calibration of the spectrophtometer in accordance to manufacturer's specifications will be employed. The BOD Trak will be calibrated before each use in accordance with manufacturers specifications.

Macroinvertebrates and Habitat Parameters

For macroinvertebrates and habitat analysis, both technicians are River Watch trained with over 10 years experience in collection and analysis. The lab technician has a M.S. in microbiology. To ensure precision, the watershed coordinator, and both technicians will particiapate in the sampling. The habitat evaluation will be conducted independently with any discrepancies finalized by the watershed coordinator.

GPS Coordinates

All 18 sites have been recorded with a Garmin GPS Map76 and loaded into an ArcView program. A shapefile layer will be provided to IDEM. Coordinates are listed as UTM UPS NAD 83, Zone 16. Coordinates are listed below and can be correlated with site numbers shown on the site overview map (Appendix A).

1. ***0626061 4604620** east side of culvert*
2. ***0624962 4604023** east side of culvert*
3. ***0624950 4604457** east side of culvert*
4. ***0622210 4604501** north side of road*
5. ***0621612 4606112** north side of road*
6. ***0621744 4606101** open ditch directly south of field corner post*
7. ***0620046 4606061** west side of culvert*
8. ***0619230 4606037** west of "south finger ditch", in front of wood duck house*
9. ***0618455 4606015** east side of SR 5*
10. ***0618602 4604403** north side of road*
11. ***0618895 4603385** north side of road*
12. ***0617435 4609219** west side of bridge*
13. ***0617405 4608784** west side of bridge*
14. ***0619113 4609209** east side of culvert*
15. ***0619942 4609476** west side of bridge*
16. ***0619931 4609036** west side of bridge*
17. ***0621563 4609271** east side of culvert*
18. ***0625168 4610152** south side of culvert*

Completeness

Field and Laboratory Chemistry Parameters

The sampling schedule is aggressive to allow room for missed measurements. In this study quantitative and qualitative analysis will be achieved if 75% of measurements are taken for each site and for each parameter (Table 2). All sites have been surveyed for access and proper sampling hydrology. However, during extreme climatic events aquiring samples at some locations may become impossible. The most plausable constraint will be during winter months when ice conditions may make sampling difficult at best. In addition, during drought conditions flow may stop on several "finger" drainages.

% completeness=(number of valid measurements) x 100% = 243 x 100% = 75%
(number of valid measurements expected) 324

Macroinvertebrates and Habitat Parameters

In order to achieve the desired level of completeness for this study 100% of habitat and macroinvertibrates analysis must be completed (Table 2). This should be attainable since there is flexibilty in selecting sampling dates that are conducive to achieve 100% collection.

Table 2: Data Quality Objectives

Parameter	Precision	Accuracy	Completeness
DO, pH, Turb, Temp, TDS, TSS	RPD<5%	Instrument limits See Table 4	75%
BOD, TP, NO_3	RPD<5%	Instrument limits See Table 4	75%
E. coli	RPD<10%	High	75%
Flow	RPD<5%	±3% + zero stability zs=±0.1m/sec	75%
Macroinvertebrate	High	High	100%
Habitat	High	High	100%

Representativeness

In using the synaptic approach, a relatively even representation of water quality throughout the sub-watersheds will be achieved. Test sites were selected and field varified to isloate segements of each watershed yet allow easy access for personnel. If extremely high levels of contaminants are found in any given segment (higher than surrounding segments) additional sites may be added to futher isolate the source. If this occurs, then an appendum will be submitted.

Comparability

Data collected from this study will not be compared to other studies but will provide a baseline for future sampling to assess the effectiveness of water quality improvement practices. It is intended to follow sampling procedures used here in future projects administered by LaGrange County SWCD. Methods used will meet EPA-approved standards.

Section 4: Sampling Procedures

Water Chemistry Sampling

Water chemistry samples will be taken at each station to test the parameters listed in Table 3. Temperature, dissolved oxygen, pH, turbidity, total dissolved solids and flow measurements will be made in the field using the following instruments: Hach sensION 156 for temperature, dissolved oxygen, total dissolved solids, and pH; Hach 2100P turbidmeter for turbidity; and the Global Water Flow Probe for stream flow. All measurements will be taken accordng to the standard operating procedures provided by the manufacturer of the equipment. Project personnel will record water chemistry field measurements on standardized field data sheets (Appendix B).

Flow measurements will be taken utilizing protocols outlined in Marsh-McBirdy (1990). A tape measure will be staked across the width of the channel prior to any measurements being taken. If the stream is less than 2" deep, then multiple point velocity measurements will be taken throughout the width of the channel. Channel depths will measured at a minimum of five points across the channel. Discharge will be calculated using the following formula:

$$\text{Discharge} = \frac{(\Sigma d_i)\ w*v}{(n+1)}$$

where d equals stream depth, n equals the number of stream depths measured, w equals the width of the stream, and v equals the velocity of the stream (0.9 times the fastest velocity recorded). The equation has been modified from EPA (1997).

If the stream is greater than 2" deep, then the trapezoid channel method will be utilized to calculate stream discharge. The interval width, thus the number of flow measurements recorded across the channel, is determined by channel width. If the channel width is less than 15', then the interval width will be equal to the stream width divided by 5. If the channel width is greater than 15', then the interval width will be equal to the channel width multiplied by 0.1. Stream depths will be recorded at the right and left edges of the predetermined trapezoid (SI_0 and SI_1). Flow measurements will be recorded at the midpoint of each trapezoid ($SI_{1/2}$). All data will be recorded on the data sheet included in Appendix C. Discharge will be calculated using an Excel spreadsheet to minimize errors.

Grab samples will be collected for the remaining parameters: total phosphorus, nitrates, BOD, total suspended solids and* E. coli*. Samples will be placed in prepared containers. Sample collection will follow the method outlined in EPA Volunteer Stream Monitoring: A Methods Manual (1997). The tecnician will wade into the center of the streams thalweg to collect the water sample. The technician will then invert a clean sample bottle into the thalweg. The same procedure will be followed for a separate* E. coli *sample. At a depth of 8 to 12 inches below the water surface, the technician will turn the bottle into the current and allow collection of water. If the stream depth is shallower than 16", water collection will be midway between the surface and bottom. Once the bottle is full the technician will scoop the bottle toward the surface.

The sample containers will be labeled with date, time, technician initials, site, and parameter to be analyzed. All samples will be stored on ice and transported to the laboratory for immediate analysis. Technicians collecting samples will complete laboratory analysis. Water chemistry analysis will be in accordance with specified procedures as outlined in the manual for the DR 2500.* E. coli *samples will be prepared using the Coliform Easygel method.

Macroinvertebrate Sampling

Macroinvertebrate sampling will follow procedures described in the Hoosier Riverwatch Volunteer Stream Monitoring Training Manual (2001).

Habitat Evaluation

Habitat evaluation will be conducted at each site using the Ohio EPA's Quality Habitat Evaluation Index (QHEI). Assessments will be noted on the QHEI data sheets.

Table3 : Sampling Procedures

Parameter	Sampling Frequency	Sampling Method	Sample Container	Sample Volume	Holding Time
DO, pH, TDS	**Monthly**	**Meter Hach sensION156**	**NA**	**NA**	**In field**
Turb	**Monthly**	**Meter Hach 2100 Portable**	**100mL vial**	**100ml**	In field
Temp	**Monthly**	**Meter Hach sensION156**	**NA**	**NA**	In field
TP, NO_3, TSS	**Monthly**	**Hach DR2500**	**500mL plastic bottle**	**25mL**	**28 days**
BOD	**Monthly**	**Hach BOD Trak**	**250mL dark bottle**	**250mL**	**24 hours**
Flow	**Monthly**	**Global Water Flow Probe**	**NA**	**NA**	In field
E. coli	**Monthly**	**Coliform Easygel**	**250mL sterile plastic cup**	**1mL**	**8 hours**
Habitat	**Summer**	**Ohio QHEI**	**NA**	**NA**	**In field**
Macro invertebrate	**Semi-annually**	**Kick Net**	**NA**	**NA**	**In field**

Section 5: Custody Procedures

Samples that require transportation will be clearly labled with date, time, technician initials, site, and parameter to be measured. Analysis of samples will occur in the labratory by the same individual.
Samples will be placed on ice in a small cooler for transportation that is clearly labled with "Water Samples" on the outside. Since the same individual will be doing the analysis, no transfer sheets are required.

Section 6: Calibration Procedures and Frequency

The multi-parameter meter, the turbidity meter, and the spectrophotometer will require calibration. Calibration procedures will be followed for the field meters before sampling begins that day. The spectrophotometer will be calibrated before each sampling cycle for each parameter being measured.
Calibration will be in accordance with manufacturer's instructions.

Section 7: Sample Analysis Procedures

Equipment used in the field and labratory present data in usable form and require no analytical methods by the technician. For **E. coli*****, procedures using the Coliscan Easygel method will be employed. Macroinvertibrate sampling will follow Hoosier Riverwatch guidelines.***
Table 4 lists analytical procedures and performance range for electronic equipment or each parameter .

Table 4: Analytical Procedures

Parameter	Analytical Method	Performance Range and Detection Limits	Units
DO TDS	Hach sensION 156	0 to 20; 0.1 0 to 42; 0.1	mg/L g/L
pH	***Hach sensION 156***	***-2 to 19.99***	***actual***
Turb	***Hach 2100P***	***0 to 1000; 0.1***	***NTU***
Temp	***Hach sensION 156***	***-10 to 110; 0.1***	***^{0}C***
TP	***Hach DR 2500***	***Wavelength 365 to 880 nm; 0.5 nm***	***mg/L***
NO_3, TSS	***Hach DR 2500***	***Wavelength 365 to 880 nm; 0.5 nm***	***mg/L***
BOD	***Hach BODTrak***	***0 to 700 mg/l; 0.1***	***mg/L***
E. coli	***Coliscan Easygel***	***NA***	***Colonies/ 100ml***
macroinvertibrates	***Direct count***	***NA***	***count***

Section 8: Quality Control Procedures

Quality control and accuracy will be achieved by strict adherence to written protocol. To achieve precision in field measurements, replicate measurements will be taken at 1 of the 18 sampling sites for each sampling event. Field equipment will be properly calibrated before each sampling event in accordance with manufacturer's guidelines. To achieve precision in the laboratory, a duplicate sample will be taken at 1 of the 18 sampling sites for each sampling event. Laboratory equipment will be calibrated according to manufacturers guidelines. In addition, field blanks will be taken once during each sampling event and used for equipment calibration along with standards. In the laboratory reference standards and blanks will be used as necessary to assure data quality. For macroinvertebrate sampling and habitat evaluations, strict adherence to protocol will be followed by all personnel. Any discrepancies in data will be resolved by the watershed coordinator.

Section 9: Data Reduction, Analysis, Review, and Reporting

Data Reduction

Field and lab equipment will do necessary conversion of raw data into meaningful units. Statistical approaches will be determined after four months of sampling and consultation with Purdue University's Department of Natural Resources.

Data Analysis

Final analysis approaches will be determined after four months of sampling and consultation with Purdue University. It is likely correlation and regression analysis will be employed along with ANOVA techniques.

Data Review

The watershed coordinator will review data on a monthly basis for errors and omissions.

Data Reporting

Reporting data to the public will occur at each public meeting. For public distribution the data will be kept in simplistic formats such as graphs and tables. Correlations with EPA acceptable levels will be in table format. Data will be presented by the watershed coordinator.

All raw data and data analysis results generated as part of this grant project will be submitted in an electronic format with the Final Report to the IDEM Project Manager or Quality Assurance Manager. The format will be compatible with the software currently used by IDEM.

Section 10: Performance and System Audits

Performance audits for each section will be performed once each quarter by the program manager. Systems audits will be conducted semi-annually by an external scientist. IDEM reserves the right to conduct external performance and/or systems audits of any component of this study.

Section 11: Preventative Maintenance

Preventative maintenance will be performed in accordance with the associated equipment manual.

An ample supply of batteries will be kept with field equipment. In addition, any parts associated with equipment that have limited time performance will have duplicates readily available.

Section 12: Data Quality Assessment

Precision and Accuracy

Data will be reviewed after each collection stage for validity. For invalid data (data that does not meet criteria outlined in Table 2) the effected sites will be immediately resampled. All data determined to be accurate will be considered valid and will be reported even if completeness objectives are not met.

Water chemistry data will be checked with blanks randomly each month. If data has been compromised the sampling process will be immediately repeated for the effected parameter at all sites. **E. coli** ***analaysis (colony counts) will be conducted by both technicians. If there is discepancy in counts the watershed coordinator will conduct a count in an attempt to resolve the difference. If unable to resolve the descrepency, samples will be retaken for the effected sites. Biological monitoring will be conducted by both technicians and the watershed coordinator to ensure agreement on identification. Habitat evaluations will be***

conducted independantly by tecnicians and the watershed coordinator. The watershed coordinator will make all final decisions concering descrepancies.

Completeness

Data will meet completeness criteria if percentages outlined in Section 3 are met for each parameter.
If completeness goals are not met data will still be used. Data will be qualified by association with time of year and flow rates.

Section 13: Corrective Action

Unusually high/low readings in the field will be used to trigger a potential corrective action. Corrective action will be an immediate equipment check and recalibration followed by another site sample. In the labratory unusually high/low readings and positive blanks will trigger corrective action. Corrective action will include an equipment check and recalibration. Positive blanks will require resampling.

Section 14: Quality Assurance Reports

Quality Assurance (QA) reports will be submitted to IDEM's Watershed Management Section every three months as part of the Quarterly Progress Report and/or Final Report. All items listed in IDEM's QAPP guidelines for this section will be addressed in quarterly reports.

References

Ledet, N.D. 1991. Little Elkhart River, LaGrange and Elkhart counties. Indiana Department of Natural Resource Report.

Marsh - McBirney. 1990. Model 2000 Installation and Operations Manual

Ohio Environmental Protection Agency. 1989. Biological criteria for the protection of aquatic life: Volume III. Standardized biological field sampling and laboratory methods for assessing fish and macroinvertebrate communities. Division of Water Quality Monitoring and Assessment, Columbus, Ohio.

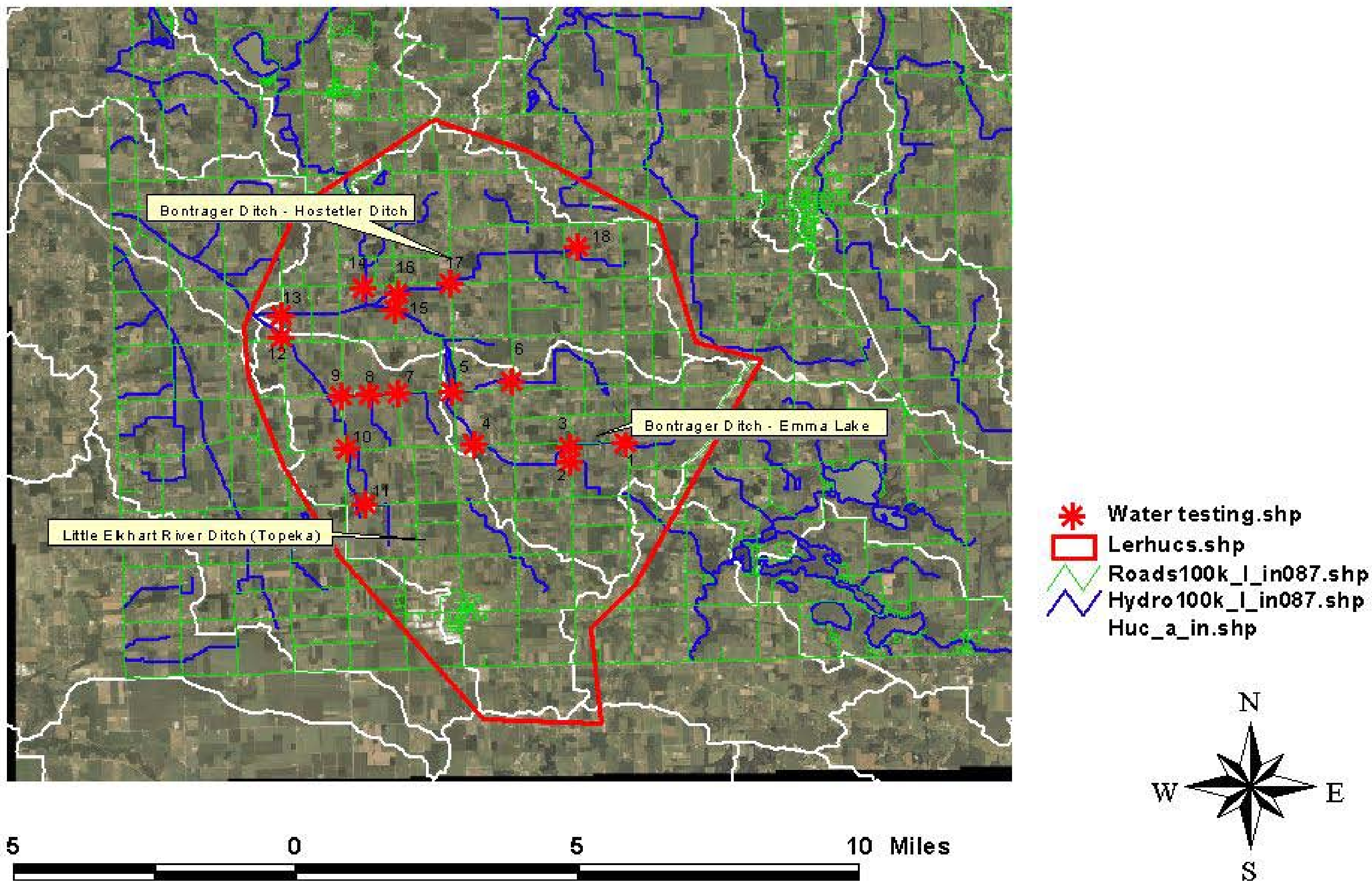
U.S.Environmental Protection Agency. 1997. Volunteer Stream Monitoring. A Methods Manual. EPA-841-B-97-003.

Volunteer Stream Monitoring Training Manual: Hoosier Riverwatch - Indiana's Volunteer Stream Monitoring Program. Indiana Department of Natural Resources, March 2001.

Appendix A

Water Quality Sample Site Map

WMP Overview Map



Appendix B

Water Sampling Field Log Sheet

WATER QUALITY SAMPLING FIELD LOG

SITE NUMBER AND LOCATION: ____
DATE: _____________________ PROJECT NAME: ___________________________
TIME: ______________
FIELD CREW: ___________________________________
WEATHER CONDITIONS: ____
OTHER OBSERVATIONS: ____
EQUIPMENT CALIBRATION (Date): ______________________

FIELD PARAMETERS	REPLICATE (if taken)	
pH: ____________	pH: ___________	RPD = _______
Temp: __________	Temp: _________	RPD = _______
DO: ____________	DO: ___________	RPD = _______
TDS: ___________	TDS: ___________	RPD = _______
Turb: ___________	Turb: __________	RPD= _______
Calculated Flow: _____________		

Relative Percent Difference (RPD)= $\frac{(\text{sample1}-\text{sample2})}{((\text{sample1}+\text{sample2})/2)}$

<u>LAB PARAMETERS</u>

E. Coli: __________
Nitrate: __________
TP: _____________
BOD: ____________
TSS: ____________
Field Crew Leader Signature: _________________________

Appendix C

Discharge Measurement Sheet

DISCHARGE MEASUREMENT

Site: ____________________ Date: _________ Time: ________
Project#: _________________ Project Name: ________________
Crew Members: _______________________ Equipment: ___________________
Site Physical Description:
____

If stream is <2" deep:
Stream width: ______ feet
Stream Depths: ______, ______, ______, _____, _____, _____, _____, _____, _____feet
U: _____, _____, _____, _____, _____, _____, _____, _____, _____, _____ ft/s
U_{max}: _____ft/s

If stream is >2" deep:
Stream width: ______ feet
Interval Width (IW) (If W<15', then IW=W/5. If W>15', then IW=W*0.1): _____ feet

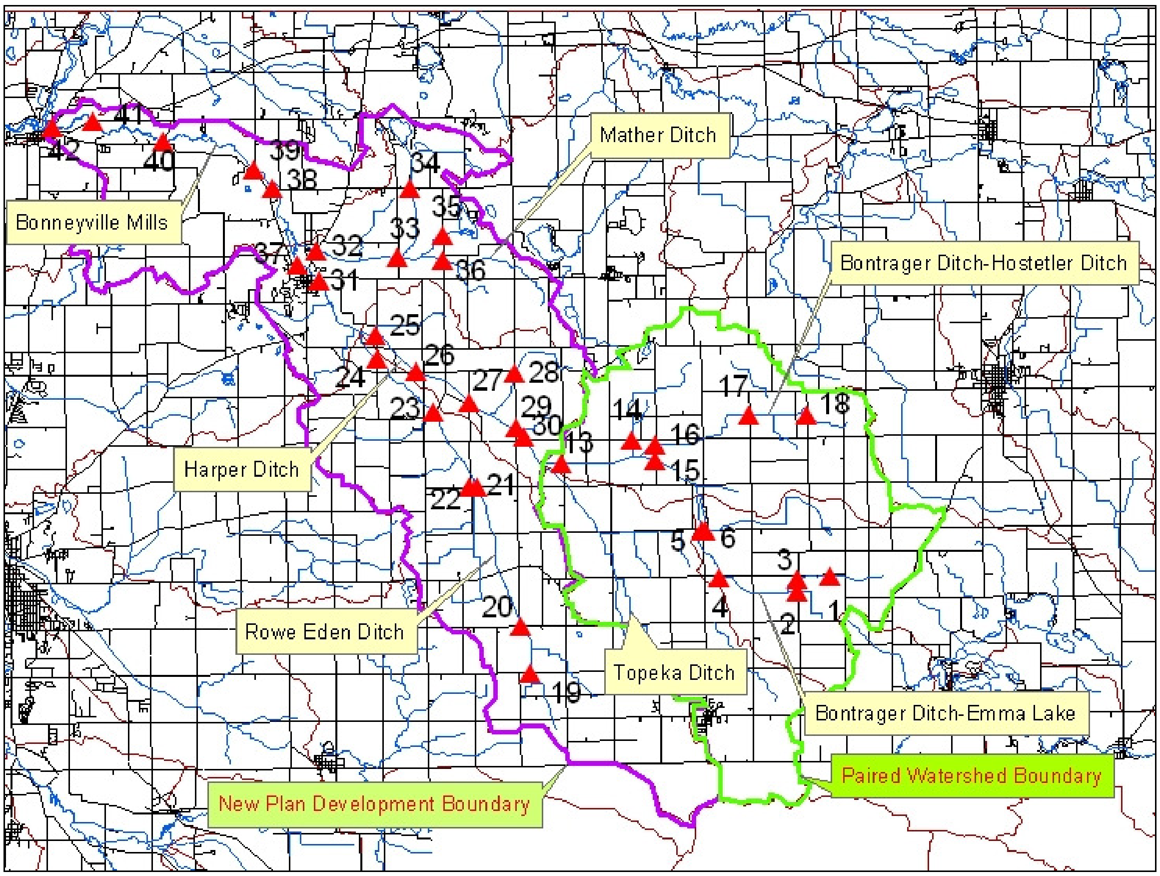
Segment	SI_0 Location Depth	SI_1 Location Depth	½ IW Location Depth	$U_{0.4}$ Set Depth Rate
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				
11				
12				
13				
14				
15				

Field Crew Leader Signature: ________________________________

Little Elkhart River Watershed Management Plan Addendum

August 2009

(Revised pp. 28-31 January 2011)



Prepared by:
David Arrington
Watershed Coordinator
LaGrange County SWCD

Funded by:
EPA 319 Grant
And
Indiana Department of Environmental Management

Project Mission and Vision Statements

Vision

The region of the Little Elkhart River Watershed will provide clean water for agriculture, economic, residential, and recreational needs in a fair, balanced, and sustainable way.

Mission

Establish a diverse group of stakeholders within the watershed in a cooperative effort to protect, restore, and educate the public of the importance of the Little Elkhart River Watershed as a critical component of the St. Joseph River System.

Table of Contents

INTRODUCTION

The LaGrange County Soil and Water Conservation District (SWCD) reviewed its water quality improvement efforts across the county to determine areas that need additional focus. The eastern portion contains the "lake country" and has been the center of attention for many years with numerous projects implementing water quality improvement practices designed to reduce non-point source pollution. The western portion of the county has received less attention and that convinced the LaGrange County SWCD staff to focus its next major project in this region of the county. The Little Elkhart River drainage constitutes a major portion of western LaGrange County and was selected as a focal watershed. The Little Elkhart River system presents unique challenges with the preponderance of landowners belonging to the Amish community. Traditionally they have been reluctant to accept federal/state cost-share funds for conservation-based projects. However, the six county Indiana SWCDs that lie within the St. Joseph River Basin had two 319 Grants (administered by LaGrange County SWCD) for Livestock Management within the basin. Since 1999, the livestock specialist working in conjunction with the Natural Resource Conservation Service (NRCS) and SWCD staff has established a close relationship with the Amish community opening the opportunity to develop and implement a long-range, detailed plan for the watershed.

In 2003, the LaGrange SWCD began work on a Watershed Management Plan (WMP) for the headwaters region of the Little Elkhart River. This plan was completed in April 2007 for the 14 digit Hydrologic Unit Code subwatersheds; Bontrager Ditch-Emma Lake (04050001140010), Bontrager Ditch-Hostetler Ditch (04050001140020), and the Little Elkhart River Ditch-Topeka (04050001140030). Although written to stand alone, this plan is essentially an addendum of that initial effort. To fully understand the scope of the project, readers should review the original headwaters WMP which is available at the LaGrange County SWCD.

The Little Elkhart River is a subwatershed within the St. Joseph River Basin which flows east to west draining into Lake Michigan. The St. Joseph River has received significant attention in its urbanized centers of South Bend, Mishawaka, and Elkhart concerning water quality issues initially associated with point source pollution. A relatively recent focus has centered on non-point source pollution throughout the basin with an emphasis centered in areas where agriculture is the main land use practice. Studies conducted by Indiana and Michigan state/county agencies have demonstrated tributaries of the mainstream are the major contributor of non-point source pollutants.

Indiana Department of Natural Resource studies have indicated silt loading as a major limiting factor on the cold water fish community within the Little Elkhart River system. Ledet (1991) listed the Little Elkhart River as a cool to coldwater environment but silt loading prevented fish species usually associated from maintaining an established population. The river history demonstrates that salmonid species once thrived through its reach. According to Ledet's study, silt loading is preventing the possibility of spawning due to egg suffocation. The Indiana Department of Natural Resources (DNR) stocks this stream annually with trout but has not attempted to re-establish a viable breeding population due to the silt loading.

Recreational uses of the river include canoeing and fishing. The LaGrange-Elkhart Chapter of Trout Unlimited (TU) has focused much of their attention on this drainage. Besides Rainbow Trout being stocked annually by the Indiana DNR, the TU chapter stocks German Brown Trout.

Building partnerships within the target area and with leadership that influence plan implementation is crucial for WMP success in improving water quality in the Little Elkhart River drainage. As accomplished in the original headwaters region WMP, partnerships were successfully achieved in the remaining four HUC 14s with an aggressive mailing campaign, numerous public meetings, announcements of the WMP at other county functions, newspaper articles, and one-on-one contacts with landowners residing in the subwatersheds. As a result of the outreach program the public is well aware of the plan, its purpose, and what it can do for them in the quest for cleaner water.

Another aspect that will make implementation of this plan successful is the on-going implementation of the existing Watershed Management Plan for the headwaters region that was completed in April 2007. Under that WMP a paired watershed study, funded by an IDEM 319 Grant and the IDNR Lake and River Enhancement program, the LaGrange SWCD has been very effective in achieving landowner cooperation in implementing best management practices (BMPs) throughout the treatment subwatershed. The outreach program and the aggressive water quality testing data have been instrumental in convincing the Amish community to participate in cost-share programs. To date, 100% of target property landowners have or are in the process of implementing BMPs designed to significantly reduce NPS pollution.

Public Input

The public expressed concerns and input within the subwatersheds from the beginning of the outreach program begun under the original WMP developed for the headwaters region (April 2007). However, after the first public meeting it became evident that Amish residents were reluctant to voice opinions in public. Instead, they would voice their concerns in a more private, one-on-one situation. Once the plan development became common knowledge, landowners would phone, write, speak out after public meetings, and voice their concerns/input directly to individuals working on the management plan. In many cases information came from residents that did not attend meetings but learned of the plan through others with more direct knowledge.

Armed with experience gained while developing the headwaters WMP, public input for this plan was achieved through one-on-one conversations and small meetings held throughout the watershed. In many cases, the Amish steering committee members held small public meetings or passed WMP development information on to fellow landowners when opportunities arose at gatherings not necessarily geared for the WMP. Gatherings included impromptu meetings at public auctions, grain elevators, sale barns, weddings, and after church services. It cannot be overstressed the importance of having Amish representation on the steering committee. Without them, plan implementation would be difficult if not impossible. Public opinions are expressed throughout this document but a consolidated list is below. Concerns were very similar to those found in the headwaters WMP.

1. Many had concerns over livestock in the ditch system. This continually came up at all public meetings. Although not all landowners agreed it was a serious problem the majority recognized the NPS pollution potential. In most cases those concerned were located immediately downstream of problem areas.
2. Barnyards with direct runoff to ditches were mentioned at each public meeting. The barnyards have cemented ramps that down slope into the ditch system. These problem areas were clearly visible to all landowners and perhaps aesthetics of the situation played an equal role in their identification. No matter what the motivation, landowners surrounding these locations clearly had concerns.
3. Improperly installed septic systems came up during impromptu meetings. The concern was centered on septic systems that might be "straight-piped" directly into the ditch or those connected into field drainage tiles. Several locations of potential violations were called into the SWCD office or given to committee members to include in the investigation of land use.
4. Point source pollution from a cheese factory that was verified through water testing. Extreme levels of total phosphorus, ammonia, total suspended solids, turbidity, and low dissolved oxygen were discovered. For the first time Amish landowners in the vicinity of the discharge area for the factory publicly voiced their concern for the impaired water resulting from this plant. The LaGrange SWCD has pursued this problem separately with assistance from IDEM.
5. Rapid population growth in the area was expressed at every meeting. The community clearly recognized the problems associated with increased human population. Some expressed concerns over construction (both housing and the "cottage" industry) and the potential for increase in NPS pollution.

Steering Committee

Plan development was led by a steering committee made up of watershed landowners, county, state, and federal officials and met each quarter. The original steering committee from the headwaters WMP remained intact with additional members added from the four HUC 14s represented in this plan. At each steering committee meeting both the existing WMP implementation and the development of this plan was discussed. This proved extremely successful in keeping the original WMP for the headwaters region a living document and attaining positive progress in completing its goals and objectives. In addition the knowledge gained from the experienced steering committee members alleviated many of the "growing pains" of establishing an all new membership. The final result was very effective and productive meetings. In addition several of the Amish members took a leadership role in developing our workshops and field days.

The landowners had representation from the Amish and English communities and represented both business and farming interests. County representation consisted of a commissioner, surveyor, public health officer, LaGrange County SWCD, and Elkhart SWCD. The state was well represented by the region's State Senator Marlin Stutzman, Purdue University Extension, and Indiana's newly formed Department of Agriculture. Federal representation was from the NRCS District Conservationist for LaGrange and Elkhart counties. Together this group provided a well-rounded forum whose guidance was crucial in developing this plan, and will prove essential in its implementation.

Description of Watershed

Location and Size

This watershed management plan comprises the four western subwatersheds of the Little Elkhart River located in Western LaGrange County, and Northeastern Elkhart County, Indiana. Specifically it involves the 14 digit Hydrologic Unit Code subwatersheds; Little Elkhart River/Rowe Eden Ditch (04050001140040), Little Elkhart River/Harper Ditch (04050001140050), Little Elkhart River/Mather Ditch (04050001140060) and Little Elkhart River/Bonneyville Mills (04050001140070). Little Elkhart River/Rowe Eden Ditch has a surface area of 19,297 acres, Little Elkhart River/Harper Ditch with 6,612 acres, Little Elkhart River/Mather Ditch with 11,527 acres, and the Elkhart River/Bonneyville Mills covering 11,732 acres for a total surface area of 49,168 acres. The map below depicts the four sub-watershed locations within Indiana, the St. Joseph River drainage, and the Little Elkhart River drainage.

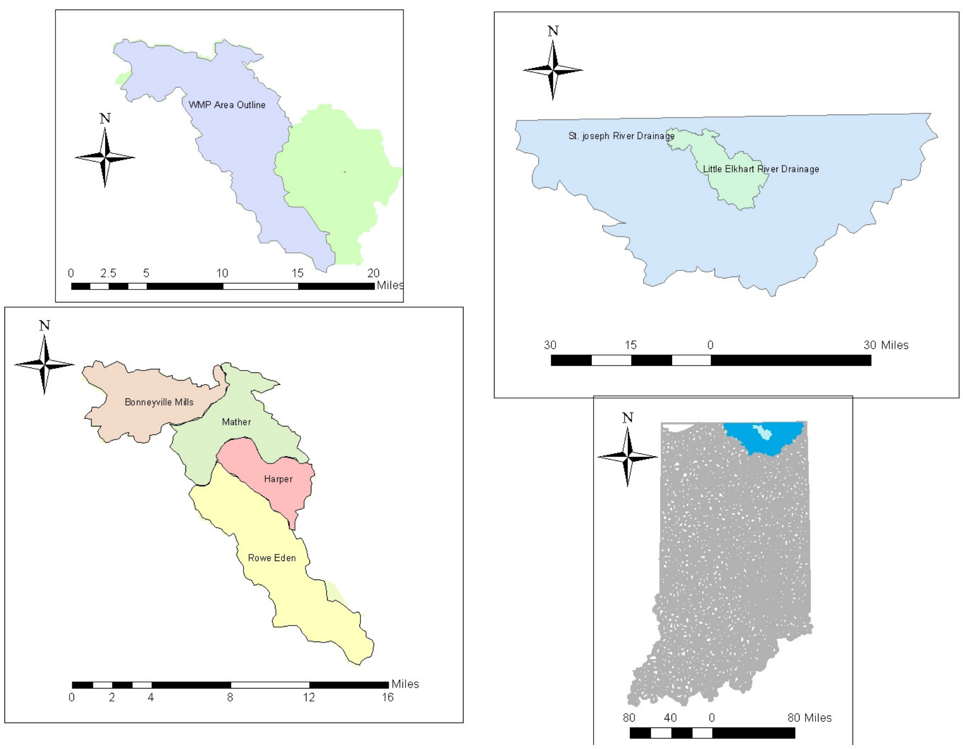


Figure 1: Map depicting location of subwatersheds.

Geology, Topography, and Hydrology

The geology, topography, and hydrology of the four HUC14s represented in this plan are essentially identical to that found in the headwaters region WMP. The entire watershed is located within northeastern Indiana's glaciated till plain. Subsoil levels are made up almost exclusively of coarse glacial deposits; sand and gravel. Surface soils are primarily loamy outwash material. General soil patterns indicate the majority of the area is Bayer-Oshtemo with a small portion falling into the Gilford category. Bayer-Oshtemo are very well drained, medium to moderately coarse textured soils and Gilford comprising very poorly drained, moderately coarse to coarse textured soils.

The topography is unremarkable with a relief of only 35 feet. The lowest areas are 890 feet above sea level with the highest reaching 925 feet above sea level. Due to the relatively flat terrain there is little concern of highly erodeable land (HEL).

The hydrology of the watershed is influenced by the glacial till overlying Mississippian age bedrock. Moving surface waters are generally restricted to a ditch system to enhance drainage of agricultural ground and comprises approximately 123 miles in linear length. With a high water table combined with porous soils, moderate rain events constitute significant rises in flowing surface waters.

There are several lakes and ponds throughout the drainage. The largest, with housing adjacent to the shoreline, are Cass and Hunter lakes located in the Mather Ditch subwatershed.

Land-Use and Natural History

LaGrange County was first organized on May14, 1832 with the first settlement near Howe where the Pottawatomi Indians had established a village on the Pigeon River. The first county seat was at Lima and later moved to the town of LaGrange due to its central location. In 1844 a new courthouse was constructed that still is in use today. LaGrange County has held an annual agricultural fair since 1852; the longest history of such an event in Indiana.

Elkhart County was first organized on April 1, 1830 with the original county seat located in the small settlement of Dunlap. In 1831 Goshen became the seat due to its central location. Elkhart County was named after the Elkhart River which received its name from an island in the St. Joseph River that resembles an elk heart. This later translated into “Elkhart”.

The region of the Little Elkhart River was primarily settled by English immigrants for its fertile soils that were conducive for agricultural uses. Eden Township in LaGrange County was named for those fertile soils. Amish immigrants have a more recent history but today comprise the majority of rural residents within the watershed. Agriculture is the primary land use in this region.

Population

The total population for LaGrange County taken during the 2000 Census was 34,909 which place it in the midrange of populated counties in the state. The Amish community comprised 37% or slightly over 12,900 individuals. According to the U.S. Census Bureau, LaGrange County’s current population has grown to 37,291 or a 7% increase since the last full census. An interesting fact is LaGrange County is ranked as 14^{th} in Indiana for population increases and the region of the Little Elkhart River is the fastest growing area within the county. The rapid growth is primarily within the Amish community. This is important to note due to horses being maintained by each household for transportation. Many households also maintain other livestock for food and income. Of the estimated 3,023 individuals that reside in the Little Elkhart River drainage, 75% or 2,116 belong to the Amish community.

According to the 2000 Census Elkhart County had a population of 182,791. The current population is estimated to be 197,791 or a 7.6% increase since the last full census. However, the vast majority of this population is located in the larger urban areas of Goshen and Elkhart. Within the confines of the Little Elkhart River drainage, Middlebury has a population of 3,205 and Bristol with 1,651. Based on a population density map the estimated total population of the drainage within Elkhart County is 5,356 individuals. The rural areas comprise approximately 60% Amish or 1,200 individuals.

Water Quality Testing

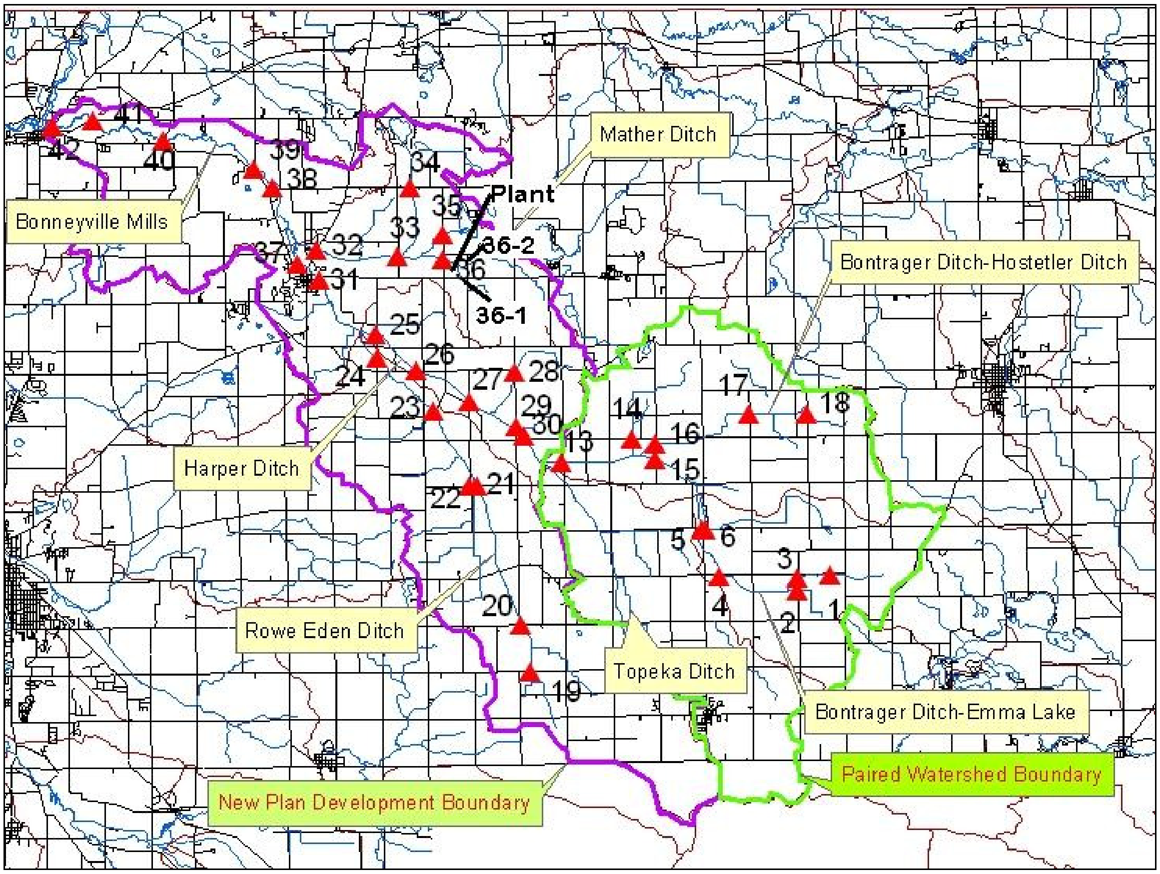


Figure 2: Map depicting location of water testing sites. Note sites 1-18 are located in the original WMP area (outlined in green). Plant depicts point source pollutant location.

Historical data for this drainage system is problematic. There has not been any long-term data collection to date that can be quantified in a statistical analysis or that can be used for comparison purposes with other drainage systems.

The Little Elkhart River is on the IDEM 303(d) list of impaired waters for *E.coli*. Testing results verified that impairment. The land use inventory clearly demonstrated that livestock issues are the major contributor of not only *E.coli* but nutrient and sediment loading as well.

Water quality testing began in January 2008 and continues through October 2011. Due to the time constraints for publication of this document, only 12 months (January 2008 – December 2008) of data will be included for initial analysis. Proceeding data will be included as an addendum at a later date.

A synoptic study approach was selected to give a representative analysis of the entire study area. Six sites per HUC, for a total of 24, were selected. Parameters collected and analyzed monthly at each site were pH, temperature, dissolved oxygen, total dissolved solids, turbidity, *E. coli*, nitrates, ammonia, total phosphorous, total suspended solids, and biochemical oxygen demand. Flow data was collected at sites 19, 23, 24, 25, 27, 30, 32, 33, 34, 36, 39, 40, and 42 (Figure 2). Macroinvertebrate sampling occurred during late summer. In addition a continuous flow monitor was installed at site 30 (Figure 2). For a detailed explanation of sampling procedures see the Quality Assurance Project Plan, Appendix 10. Note that Figure 2 includes test sites for ongoing work within the original headwaters WMP region. It is included to demonstrate the scope of work being completed within the Little Elkhart River drainage.

Data is presented in chart form to provide a visual representation for ease of interpretation. Although each chart is not mentioned specifically, the data are available for each site as a comparison in developing a full understanding of water quality throughout the Little Elkhart River. In addition, pay close attention to "Y" axis labeling since recorded levels can vary substantially between sites.

During data collection site 36 located in Mather Ditch indicated an extreme pollution source upstream. After locating and isolating the source it was discovered to be a point source problem. IDEM was notified and has taken corrective steps to resolve the situation. Since site 36 is a point source problem, data from that site will be treated separately from all other sites in the analysis process. Another important note that will be discussed in this section, site 36 did induce bias in downstream analysis of NPS pollution.

An important note is potential toxins from urban areas are likely entering into the Little Elkhart River system through storm water runoff after rain events. Vehicle fluids such as oil, antifreeze, power steering, brake, and transmission contain many known toxins. Leakage of these fluids is inevitable. Although not sampled for, potential toxins are addressed in the goals section.

Analysis

The parameters sampled for analysis were selected for several important reasons. First, they indicate the general health of the aquatic system. For each parameter there is a value range considered normal if the surface waters are not experiencing a detrimental influence, whether caused by natural or human inputs. Second, if thresholds are exceeded these selected parameters help in isolating the cause of pollution aiding in implementing a solution. Statistical comparisons were made to aid in prioritizing sub-watersheds for the implementation of best management practices.

<u>pH</u>

The surface water pH generally remains within normal limits (6.5-8.5) and is somewhat unremarkable. Averages by site and HUC were near the upper limit or near 8.0 (Figures 11-33, pages 43-65). Bonneyville Mills and Harper Ditch HUCs averaged slightly higher than Mather Ditch and Rowe Eden Ditch. Statistical analysis (Appendix 1) indicated significant difference with all-pairwise comparison analysis indicating Bonneyville Mills HUC being the most different from Mather and Rowe Eden Ditches. Although there is a statistical difference, this is not an important issue. Averages by site and HUC are shown below. Refer to Figure 2 for site number location.

	Rowe Eden		*Harper*		*Mather*		*Bonneyville Mills*	
	Site	*pH*	*Site*	*pH*	*Site*	*pH*	*Site*	*pH*
	19	*7.96*	*25*	*8.10*	*31*	*8.16*	*37*	*8.17*
	20	*7.83*	*26*	*8.22*	*32*	*8.23*	*38*	*8.14*
	21	*7.91*	*27*	*8.16*	*33*	*8.02*	*39*	*8.22*
	22	*7.96*	*28*	*8.08*	*34*	*7.76*	*40*	*8.23*
	23	*8.11*	*29*	*7.80*	*35*	*7.80*	*41*	*8.24*
	24	*8.13*	*30*	*8.09*	*36*	*N/A*	*42*	*8.24*
HUC Average		*7.97*		*8.07*		*7.99*		*8.21*

Table 1: pH averages by site and HUC.

Temperature

Statistical analysis (Appendix 2) indicated no significant difference between all sites or HUC comparisons. The highest temperatures were recorded during June and July with a gradual cool-down throughout the fall months (Figures 34-56, pages 66-88). A rapid warm-up period started in April with the monthly differential occurring between May and June. Temperatures were slightly cooler on the deeper/higher velocity sites such as the main channel of the river. An important note is that in many cases temperatures in the lateral ditches during June and July were at or exceeded the maximum of 20 degrees Celsius for cold water fish. These higher temperatures in the lateral ditches can be attributed to low water volume, shallow depths, and lack of shade from the intense sunlight. Averages by site and HUC are shown below. Refer to Figure 2 for site number location.

	Rowe Eden		*Harper*		*Mather*		*Bonneyville Mills*	
	Site	*°C*	*Site*	*°C*	*Site*	*°C*	*Site*	*°C*
	19	*13.4*	*25*	*13.9*	*31*	*12.7*	*37*	*13.0*
	20	*13.5*	*26*	*13.8*	*32*	*12.7*	*38*	*12.1*
	21	*13.8*	*27*	*13.8*	*33*	*14.3*	*39*	*12.4*
	22	*13.1*	*28*	*14.2*	*34*	*13.2*	*40*	*12.6*
	23	*14.2*	*29*	*13.6*	*35*	*13.6*	*41*	*12.7*
	24	*13.8*	*30*	*13.9*	*36*	*N/A*	*42*	*12.7*
HUC Average		*13.8*		*13.9*		*13.3*		*12.6*

Table 2: Temperature averages by site and HUC.

Dissolved Oxygen

Dissolved oxygen remained at good to high levels throughout the majority of the mainstream sites except during summer months. Generally levels at or above 6 mg/l are needed to maintain cold water fish species. However levels as low as 5.5 mg/l can be tolerated for short periods. Generally the shallow, low shade, lateral ditch systems had the lowest concentration of dissolved oxygen and during summer months fell well below levels needed for cold water fish species. The deeper, higher velocity mainstream sites still indicated that the summer period induces dissolved oxygen levels low enough to be a major stressor on cold water fish species. Statistical analysis (Appendix 3) indicated no significant difference but deeper/higher velocity mainstream sites recorded slightly higher dissolved oxygen levels (Figures 57-79, pages 89-111). Averages by site and HUC are shown below. Refer to Figure 2 for site number location.

	Rowe Eden		*Harper*		*Mather*		*Bonneyville Mills*	
	Site	*mg/l*	*Site*	*mg/l*	*Site*	*mg/l*	*Site*	*mg/l*
	19	*6.09*	*25*	*6.11*	*31*	*6.52*	*37*	*6.39*
	20	*6.09*	*26*	*6.59*	*32*	*6.45*	*38*	*6.50*
	21	*5.31*	*27*	*6.67*	*33*	*5.70*	*39*	*6.28*
	22	*5.66*	*28*	*6.82*	*34*	*5.62*	*40*	*6.08*
	23	*5.78*	*29*	*5.26*	*35*	*5.36*	*41*	*6.46*
	24	*6.25*	*30*	*7.00*	*36*	*N/A*	*42*	*6.42*
HUC Average		*5.88*		*6.41*		*5.93*		*6.39*

Table 3: Dissolved oxygen averages by site and HUC.

Total Dissolved Solids

Total dissolved solids levels generally remained within normal levels (<750 mg/l) at all sites. Statistically (Appendix 4) there were significant differences between HUCs with Rowe Eden and Mather Ditches demonstrating the largest significance. With data levels well below the maximum, tabular form by site is not displayed but is available upon request. Averages by site and HUC are shown below. Refer to Figure 2 for site number location.

	Rowe Eden		*Harper*		*Mather*		*Bonneyville Mills*	
	Site	*mg/l*	*Site*	*mg/l*	*Site*	*mg/l*	*Site*	*mg/l*
	19	*586*	*25*	*425*	*31*	*426*	*37*	*426*
	20	*448*	*26*	*423*	*32*	*369*	*38*	*423*
	21	*449*	*27*	*428*	*33*	*371*	*39*	*419*
	22	*396*	*28*	*380*	*34*	*334*	*40*	*408*
	23	*508*	*29*	*433*	*35*	*255*	*41*	*403*
	24	*434*	*30*	*431*	*36*	*N/A*	*42*	*401*
HUC Average		*464*		*421*		*350*		*414*

Table 4: Total dissolved solids averages by site and HUC.

Turbidity

Turbidity levels generally were within limits (≤10.4 NTU) with occasional spikes due to ditch cleaning operations or extreme wet weather conditions which occurred during the winter months and July of 2008 (Figures 80-102, pages 112-134). However, several sites remained at high levels indicating a localized source that was identified during the land use inventory. Although One Way ANOVA showed a slight significance, All-Pairwise Comparisons (Tukey) indicated no separation between HUCs (Appendix 5). Averages by site and HUC are shown below. Refer to Figure 2 for site number location.

	Rowe Eden		*Harper*		*Mather*		*Bonneyville Mills*	
	Site	*NTU*	*Site*	*NTU*	*Site*	*NTU*	*Site*	*NTU*
	19	*8*	*25*	*7*	*31*	*6*	*37*	*6*
	20	*7*	*26*	*8*	*32*	*5*	*38*	*7*
	21	*45*	*27*	*9*	*33*	*4*	*39*	*6*
	22	*7*	*28*	*12*	*34*	*2*	*40*	*6*
	23	*29*	*29*	*9*	*35*	*3*	*41*	*6*
	24	*10*	*30*	*8*	*36*	*N/A*	*42*	*6*
HUC Average		*17*		*9*		*4*		*6*

Table 5: Turbidity averages by site and HUC.

E.coli

E.coli generally remained at moderate to high levels throughout the testing cycle although wide fluctuations occurred at each site (Figures 103-125, pages 135-157). The lowest concentrations were found during the winter when livestock was restricted due to ice and frozen ground. During cold months livestock spent little time in the water but chose to drink from the edge and depart immediately after getting their fill. However, during most of the year livestock readily moved into ditch channels where they were observed "loafing" during extremely high ambient temperatures. On many occasions they were observed urinating and defecating directly into the surface waters upstream of water testing sites. Statistical analysis (Appendix 6) demonstrated no significant difference between HUCs. However, the lateral ditch systems were higher in counts than mainstream sites. This was expected since livestock with direct surface water access generally occurred in the narrow, shallow, slower velocity lateral ditches.

The winter period of 2008 was extremely wet with above average monthly total rainfall and snowmelt events. Many testing sites had increased levels of *E.coli.* There may be several contributing factors. First is increased runoff from barnyards and adjacent pasture areas. Another factor may be increased runoff from fresh manure on roadways. Since the area is predominately Amish, road surfaces contain a higher level of manure. With surrounding soil completely saturated for an extended period it is likely there is some influence from roadway runoff after heavy rainfall/snowmelt events. A second influence may be faulty or improperly installed septic systems. With ground saturated, lateral flow from faulty or failed septic systems was possibly occurring, especially with the very porous soils. Other evidence is septic systems that hook directly into tiles or "straight pipe" directly into ditches. Both examples were found during the land use inventory. Although DNA analysis is controversial today for separation of species specific *E.coli*, it would be beneficial to separate human as a group. Until separation is possible it will be difficult to know the exact influence.

The *E.coli* levels observed are a direct human health risk in the region. Several of the deeper pools (usually associated immediately downstream of road crossing culverts) are used by local children for swimming. With the EPA accepted level of no more 235 colonies/100ml of water for full body contact, the Little Elkhart drainage is not safe for swimming activities. Averages by site and HUC are shown below. Refer to Figure 2 for site number location.

	Rowe Eden		*Harper*		*Mather*		*Bonneyville Mills*	
	Site	*c/100ml*	*Site*	*c/100ml*	*Site*	*c/100ml*	*Site*	*c/100ml*
	19	*4658*	*25*	*850*	*31*	*844*	*37*	*676*
	20	*1642*	*26*	*1204*	*32*	*310*	*38*	*842*
	21	*283*	*27*	*1258*	*33*	*1179*	*39*	*854*
	22	*779*	*28*	*6300*	*34*	*300*	*40*	*633*
	23	*3725*	*29*	*7858*	*35*	*1150*	*41*	*367*
	24	*1421*	*30*	*2608*	*36*	*N/A*	*42*	*436*
HUC Average		*2088*		*3347*		*757*		*635*

Table 6: E.coli averages by site and HUC.

Nitrates

Nitrates remained at high levels (>1.5 mg/l) throughout the testing cycle (Figures 126-148, pages 158-180). A significant portion of these higher numbers in the lateral ditches can be attributed to livestock with direct access. Although there was a statistical difference (Appendix 7) between HUCs with Bonneyville Mills and Harper having slightly higher levels of nitrates over Mather and Rowe Eden ditches. Levels can be reduced with proper installation of best management practices. Averages by site and HUC are shown below. Refer to Figure 2 for site number location.

Rowe Eden		*Harper*		*Mather*		*Bonneyville Mills*	
Site	*mg/l*	*Site*	*mg/l*	*Site*	*mg/l*	*Site*	*mg/l*
19	*3.3*	*25*	*2.7*	*31*	*3.0*	*37*	*2.9*
20	*1.8*	*26*	*2.9*	*32*	*2.0*	*38*	*2.8*
21	*1.1*	*27*	*2.6*	*33*	*1.8*	*39*	*2.8*
22	*1.2*	*28*	*2.0*	*34*	*3.0*	*40*	*2.8*
23	*1.8*	*29*	*3.8*	*35*	*0.8*	*41*	*2.8*

24	3.2		30	2.8	36	N/A	42	2.6
HUC Average	2.0			2.8		2.1		2.8

Table 8: Nitrate averages by site and HUC.

Ammonia

Ammonia levels remained fairly low (≤0.21 mg/l) except for sites 23, and 33. Site 23 has a barnyard that is cemented to the ditch edge resulting in high levels of livestock manure runoff during rain events. Site 33 is a direct result of inputs from the cheese plant point source problem located upstream. It is important to note that ammonia levels are affected by pH and temperature. In certain conditions ammonia will volatize very rapidly. By using site averages a relative comparison can be made to help pinpoint source causes. Averages by site and HUC are shown below. Refer to Figure 2 for site number location.

	Rowe Eden		Harper		Mather		Bonneyville Mills	
	Site	mg/l	Site	mg/l	Site	mg/l	Site	mg/l
	19	0.18	25	0.04	31	0.02	37	0.05
	20	0.06	26	0.05	32	0.20	38	0.06
	21	0.04	27	0.04	33	0.24	39	0.06
	22	0.14	28	0.20	34	0.10	40	0.04
	23	0.49	29	0.11	35	0.17	41	0.04
	24	0.03	30	0.04	36	N/A	42	0.03
HUC Average		0.08		0.08		0.14		0.04

Table 9: Ammonia averages by site and HUC.

Total Phosphorus

Total phosphorus levels were much lower than expected (based on data collected for the original headwaters WMP) throughout all four HUCs (Figures 149-171, pages 181-203). Although spikes were observed after rainfall events at some sites, with the highest in the Mather ditch system, generally the levels were close to or below the threshold of 0.3 mg/l of surface water. Site 36, the point source problem, induced some influence downstream to sites 32 and 33, and likely induced higher levels to the junction of the St. Joseph River. Although not readily visible in the table below high loading events at site 36 could be traced downstream. There were no significant land use issues directly downstream to explain the higher levels. The remaining sites with higher levels were all due to livestock issues directly upstream of the sampling location. Statistical analysis did indicate significant differences between HUCs (Appendix 8). Averages by site and HUC are shown below. Refer to Figure 2 for site number location.

	Rowe Eden		Harper		Mather		Bonneyville Mills	
	Site	mg/l	Site	mg/l	Site	mg/l	Site	mg/l
	19	0.77	25	0.32	31	0.27	37	0.24
	20	0.28	26	0.34	32	1.35	38	0.39
	21	0.22	27	0.34	33	2.40	39	0.37
	22	0.26	28	0.74	34	0.18	40	0.30
	23	0.52	29	0.30	35	0.24	41	0.29
	24	0.28	30	0.36	36	N/A	42	0.34
HUC Average		0.38		0.40		0.89		0.32

Table 10: Total phosphorus by site and HUC.

Total Suspended Solids

The maximum level of 25 mg/l was selected due to the cold water fishery of this drainage. Total suspended solids (Figures 172-194, pages 204-226) were periodically elevated at sites with direct livestock access. On several occasions during sampling livestock were observed directly upstream of water data collection sites. Although averages may seem low to moderate at most sites, when coupled with flow data and volume data it equates to a moderate NPS pollution problem (cold water fish spawning intolerance). The most significant loading occurs after high rainfall events where erosion, caused by livestock induced bank damage, causes large amounts of sediment to deposit into the stream system. Statistical analysis (Appendix 8) indicated no significant differences between HUCs. Averages by site and HUC are shown below. Refer to Figure 2 for site number location.

	Rowe Eden		Harper		Mather		Bonneyville Mills	
	Site	mg/l	Site	mg/l	Site	mg/l	Site	mg/l
	19	10	25	11	31	7	37	7
	20	8	26	11	32	7	38	11
	21	7	27	19	33	8	39	8
	22	6	28	13	34	6	40	6
	23	29	29	12	35	7	41	10
	24	15	30	11	36	N/A	42	8
HUC Average		12		12		7		8

Table 11: Total suspended solids by site and HUC.

Biochemical Oxygen Demand

Biochemical oxygen demand is the oxygen consumption of microorganisms during the process of breaking down organic matter. Values of 50% or greater indicate a problem in the health of the aquatic system.

Biochemical oxygen demand (BOD) is somewhat scattered but all sites are well below 50% consumption. Since BOD is unremarkable, detailed data will be included in the final report at the end of the project (late 2011).

Flow

Flow is essential in calculating pollution loading for each HUC and for establishing target reduction after BMP implementation. Table 12 below depicts average yearly volume flow at each site by HUC. Flow can vary significantly during high rain and dry period events (captured in these averages). Detailed data will be included in the final report at the end of the project (late 2011).

Rowe Eden		*Harper*		*Mather*		*Bonneyville Mills*	
Site	*ft^3/sec*	*Site*	*ft^3/sec*	*Site*	*ft^3/sec*	*Site*	*ft^3/sec*
19	*6.98*	*25*	*293.31*	*32*	*49.28*	*39*	*571.84*
23	*98.98*	*27*	*222.47*	*33*	*36.34*	*40*	*307.57*
24	*166.23*	*30*	*158.65*	*34*	*34.77*	*42*	*425.29*

Table 12: Average yearly volume in cubic feet per second by site by HUC.

Pollutant loading per HUC is indicated in Table 13 below. Loading values are critical to develop the true picture of the problem. Although high flow sites may have low relative readings per liter, when multiplied by the average volume of water passing sites the results are significantly higher loads. There is a cumulative affect for downstream sites such as those located in the Bonneyville Mills HUC.

	Rowe Eden	*Harper*	*Mather*	*Bonneyville*	*Total*
Nitrates	*240 tons*	*591 tons*	*88 tons*	*1171 tons*	*2090 tons*
Phosphorus	*34 tons*	*74 tons*	*52 tons*	*147 tons*	*307 tons*
Sediment	*1783 tons*	*3018 tons*	*277 tons*	*2218 tons*	*7296 tons*

Table 13: NPS yearly load in tons by pollutant and HUC.

Macroinvertebrates

Macroinvertebrate assessments are essential in establishing the overall health of an aquatic system. In addition to sampling life forms, the streams habitat availability plays an important role. The table below depicts a simplified combination of habitat and life form sampling to give an overall health rating for each site. There is a direct correlation between substrate and macroinvertebrate species diversity. Although some sites received a poor rating, they did contain a large biomass of macroinvertebrates (not diversity) that play an important role in the ecosystem. In general the lateral systems received a poor rating and likely have little chance for improvement. These systems are maintained or dredged on a periodic basis to allow adequate drainage of agricultural land. Two-stage or tiered ditches would be helpful in maintaining the health of the substrate.

Rowe Eden		*Harper*		*Mather*		*Bonneyville Mills*	
Site	*Rating*	*Site*	*Rating*	*Site*	*Rating*	*Site*	*Rating*
19	*Poor*	*25*	*Good*	*31*	*Good*	*37*	*Fair*
20	*Poor*	*26*	*Good*	*32*	*Poor*	*38*	*Excellent*
21	*Poor*	*27*	*Good*	*33*	*Fair*	*39*	*Excellent*
22	*Poor*	*28*	*Poor*	*34*	*Fair*	*40*	*Excellent*
23	*Fair*	*29*	*Good*	*35*	*Fair*	*41*	*Excellent*
24	*Good*	*30*	*Good*	*36*	*Poor*	*42*	*Excellent*

Table 14: Macroinvertebrate rating by site by HUC.

Site 36

During the testing cycle it became evident there was a serious pollution source directly upstream (Figure 2). Through isolation testing it was found the cheese plant located less than ¼ mile upstream was a point source influence. Weekly testing began at site 36 and isolation sites to compound data that was sent to IDEM. IDEM verified that a permit violation had occurred and corrected the situation with the plant. This point source problem did influence downstream sites due to the large volume of point source pollution being discharged into the stream. Over the 12 months of water testing the average dissolved oxygen was 3.09 mg/l, total dissolved solids 871.62 mg/l, turbidity 38 NTU, total suspended solids 207.95 mg/l, and total phosphorus at 35.91 mg/l. Although not reflected in the year's testing average used in compiling data for this document, recent results have shown a tremendous reduction in point source pollution from the plant. The site will be monitored on a weekly basis throughout 2009 to verify plant compliance with IDEM's directives.

Land Use Inventory

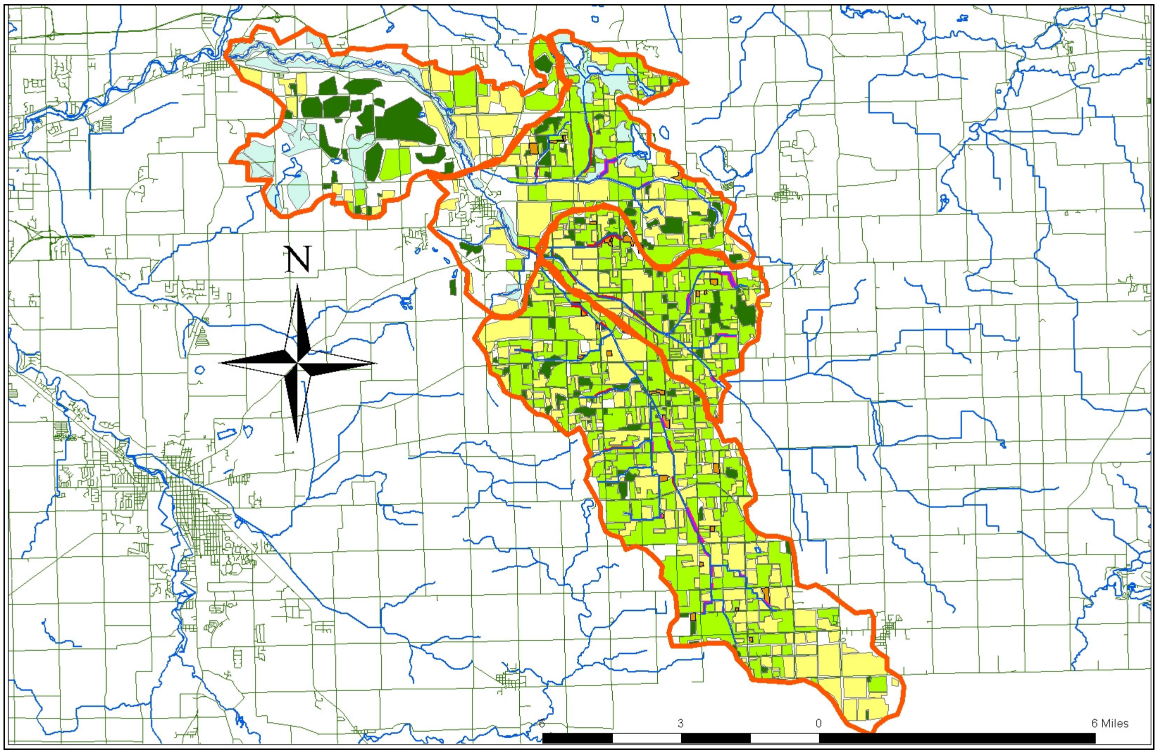


Figure 3: Map depicting all layers (individually separated in subsequent maps) of land use inventory. Expanded map can be seen on Figure 195.

The land use inventory consisted of visual inspection of all lands adjacent to surface waters along the ditch system and a minimum of 10% of all lands not adjacent to surface waters within the four target HUC14s. This approach provided valuable insight when correlating water testing results with land use practices, especially when testing indicated high levels of NPS pollution. Another benefit was landowner contact. A positive relationship was built with many community residents which will prove crucial during the implementation phase.

The inventory and water testing data indicated that livestock issues are the major source of NPS pollution contributing to the Little Elkhart river system. Livestock with direct access to the stream system not only contribute nutrients and *E.coli* loading, they contribute sediment loading due to ditch bank damage.

Figure 3 displays all layers collected during the land use inventory and demonstrates the total area visually inspected. The various color coding and symbols give a synaptic view of data differentiation and construes the magnitude of the data. Breaking data into each layer is necessary for explanation and for affective viewing. This breakdown is described below.

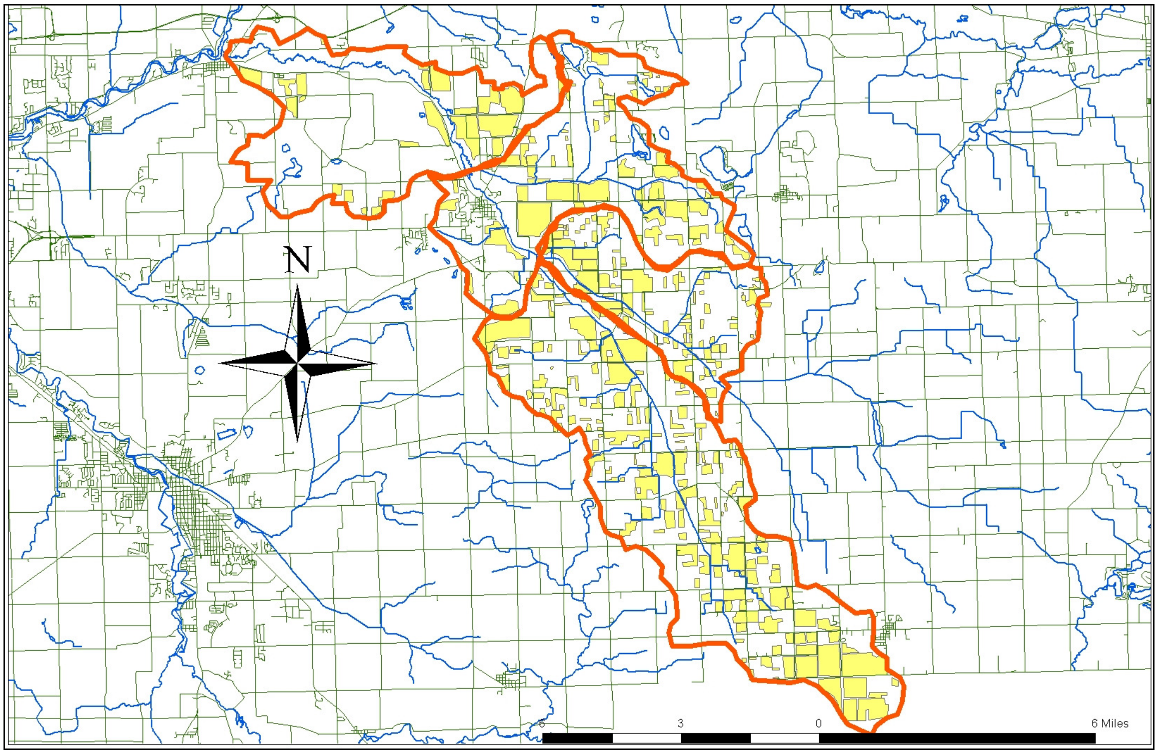


Figure 4: Map depicting row crop locations. Expanded map can be seen on Figure 196.

Figure 4 depicts traditional row crop plantings and constitutes approximately 40% or 19,667 acres of surface area for the region. This is important because in surrounding agricultural areas that do not have a high Amish population this percentage is generally much higher; in some cases approaching 65%.

A significant problem with the cropped areas along the ditch system is that only 25% have buffers installed. Buffers are important filters to reduce nutrient and sediment loading. It is estimated that 75 acres of filter strips must be planted throughout the watershed at a cost of $36,500.

In addition, the inventory revealed that no-till practices are not being employed at significant levels in this region. No-till practices reduce erosion and nutrient runoff into surface waters. Landowners must be targeted and encouraged to participate in Farm Bill no-till incentives to reduce NPS pollution inputs.

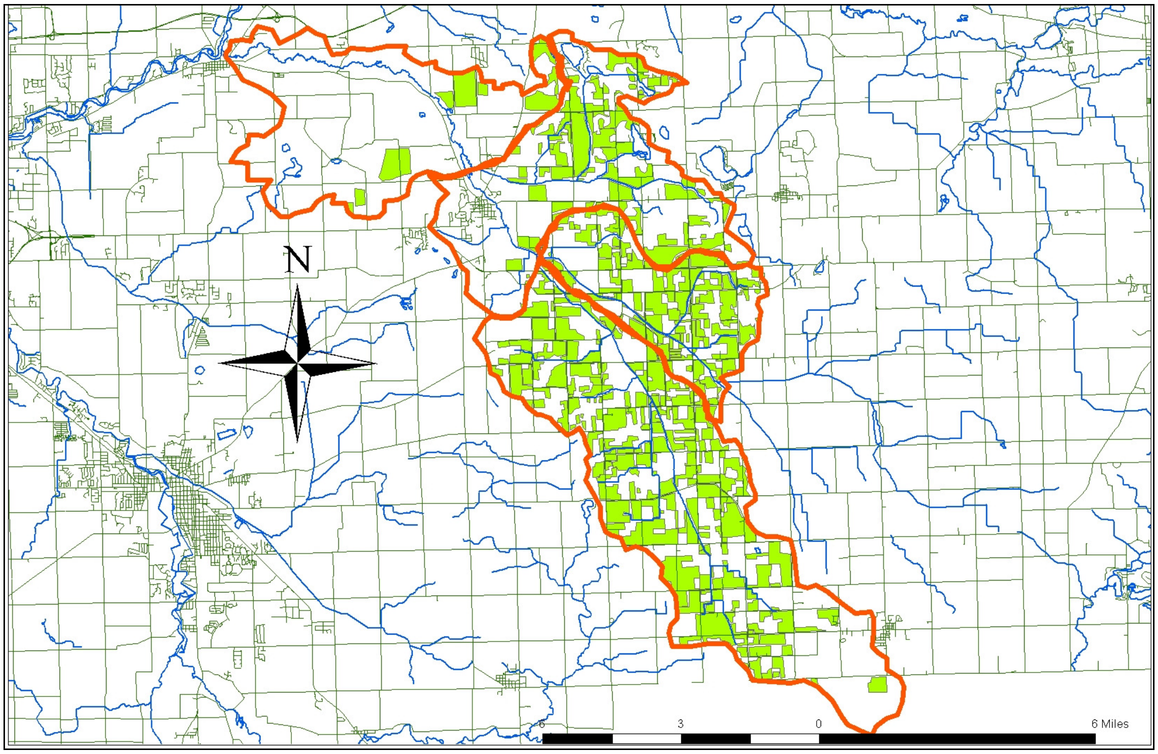


Figure 5: Map depicting pasture/hay field locations. Expanded map can be seen on Figure 197.

Figure 5 is a visual representation of pasture/hay fields within the drainage. These fields constitute approximately 47% or 23,108 acres of surface area. This is very important since in other agricultural areas in Indiana this number is closer to 20%. It is clear that the Amish community utilizes the land for livestock. However it is important to note that pasture is traditionally rotated with row crops but the relative percentages between both land use practices remains somewhat stable. Another important inference is that with such an increase in pasture ground there is a dramatic and more uniform livestock influence in the region.

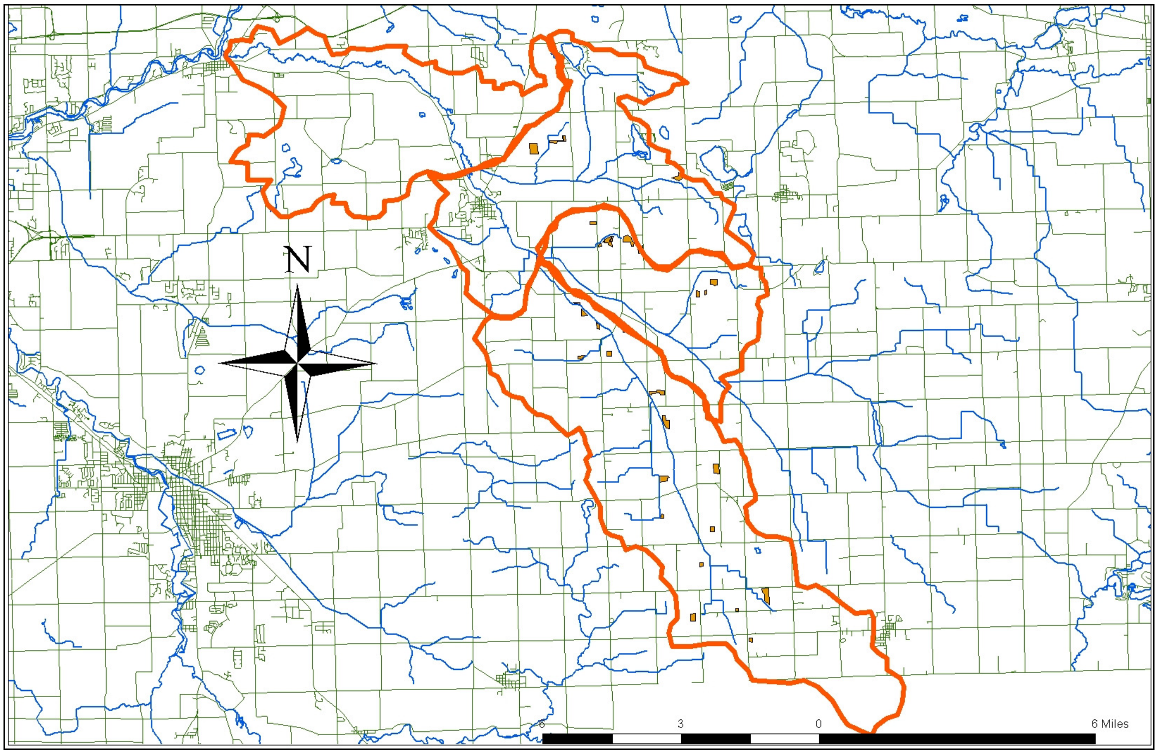


Figure 6: Map depicting pastured woodlot locations. Expanded map can be seen on Figure 198.

Figure 6 depicts pastured woodlots. This a minor influence in most respects with 1% of surface acres under influence or approximately 494 acres. However, in a few areas these woodlots remain wet much of the season which causes some concern for NPS pollution infiltration into surface waters due to livestock access. After large rainfall events, these areas drain directly into adjacent ditches. Due to the porous subsurface soils, there is a high possibility of lateral subsurface movement of NPS pollutants into the ditch system. This influence is considered minor in comparison with livestock that have direct access to moving surface waters.

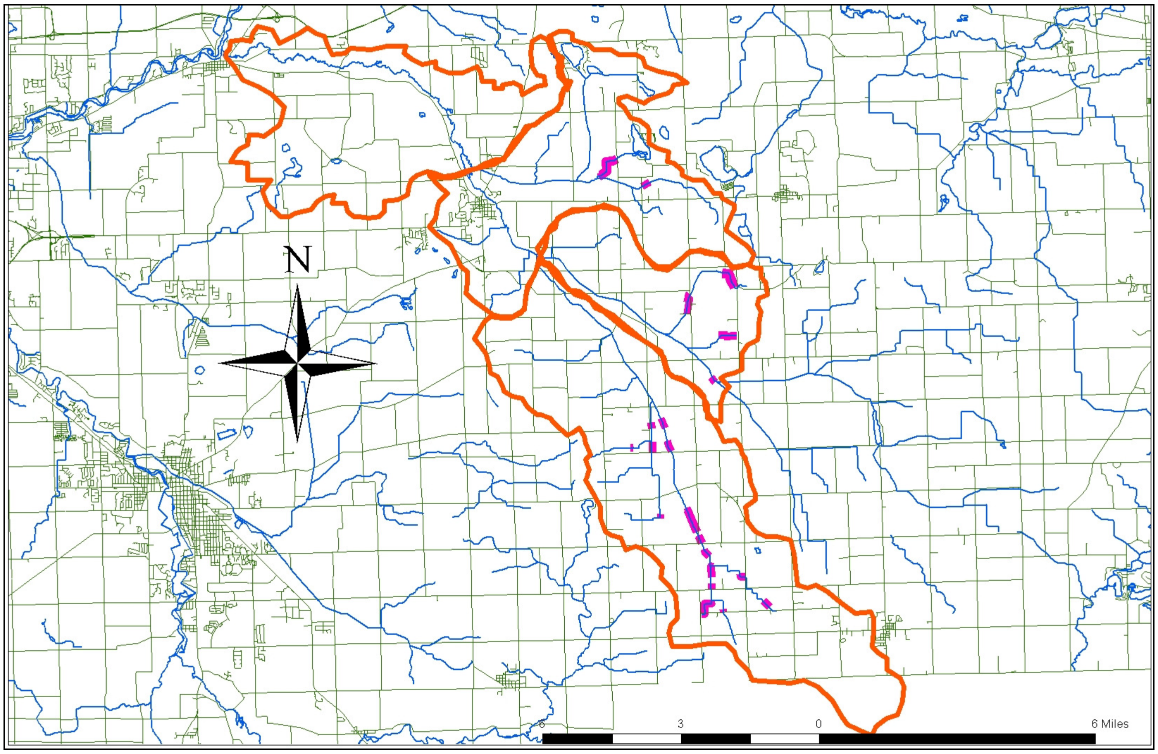


Figure 7: Map depicting existing fence locations adjacent to surface waters. Expanded map can be seen on Figure 199.

Fenced areas along open surface waters are shown on Figure 7. Standing alone it reveals little information, however when combined with livestock access (Figure 8) the problem of livestock influence on surface waters emerges very clearly. Figure 203 depicts the combination of fenced areas with livestock access. From this point it gets somewhat complicated in calculating just how much of the ditch system has livestock access. Approximately 20% of the ditches have some livestock access. Of that rather large number approximately 20,000 feet adjacent to surface waters need fenced. The remaining footage has fence but livestock are allowed to freely access the ditch bank side either all year or part of the year. In this case exclusion is somewhat simple by providing alternative watering sources. In the case of new fencing many of the fields have partial fence on some of the field perimeters. Since the entire perimeter of each field adjacent to surface waters (not just the field edge that is directly adjacent to ditch banks) will require livestock exclusion, it is estimated that at least 35,000 feet of fence will need to be installed to complete livestock exclusion at a cost of $88,000.

In the case of alternative watering there is not a simple solution. Many landowners insist in having some limited access to the system for watering livestock. In these cases rocked crossings or watering areas with very limited access to surface waters will be installed. To ensure livestock remain on rocked areas fencing along or around the in-water perimeter will be required. It is estimated that a minimum of 15 sites will need some type of alternative watering system, either limited access or complete exclusion systems. This will cost approximately $52,500.

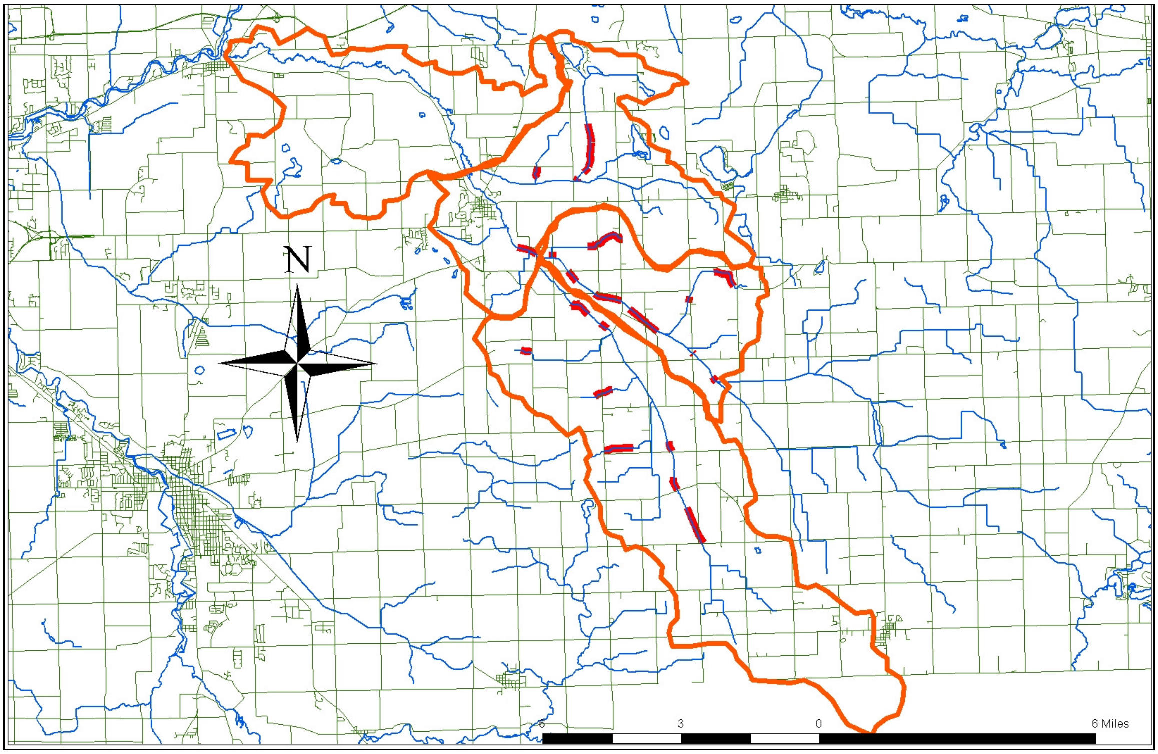


Figure 8: Map depicting locations with direct livestock access to surface waters. Expanded map can be seen on Figure 200.

Figure 8 displays livestock access problems very well and presents an overview to the seriousness of the situation and the influence it has on NPS pollution within the ditch system. Coupling this figure with water quality testing results reveals a focused pattern as to the sources of much of the NPS pollution contribution to the ditch system. Livestock access to open surface waters is the leading cause of direct NPS pollution influx. There are 14 known ditch bank damage areas within the region. It is estimated the cost of repair will be a minimum of $50,000. In addition it is estimated that 3 waste management systems will need to be installed at a cost of $90,000. There is one major barnyard problem that will need addressed during implementation of this plan. This cost is difficult to estimate but $50,000 is not unrealistic.

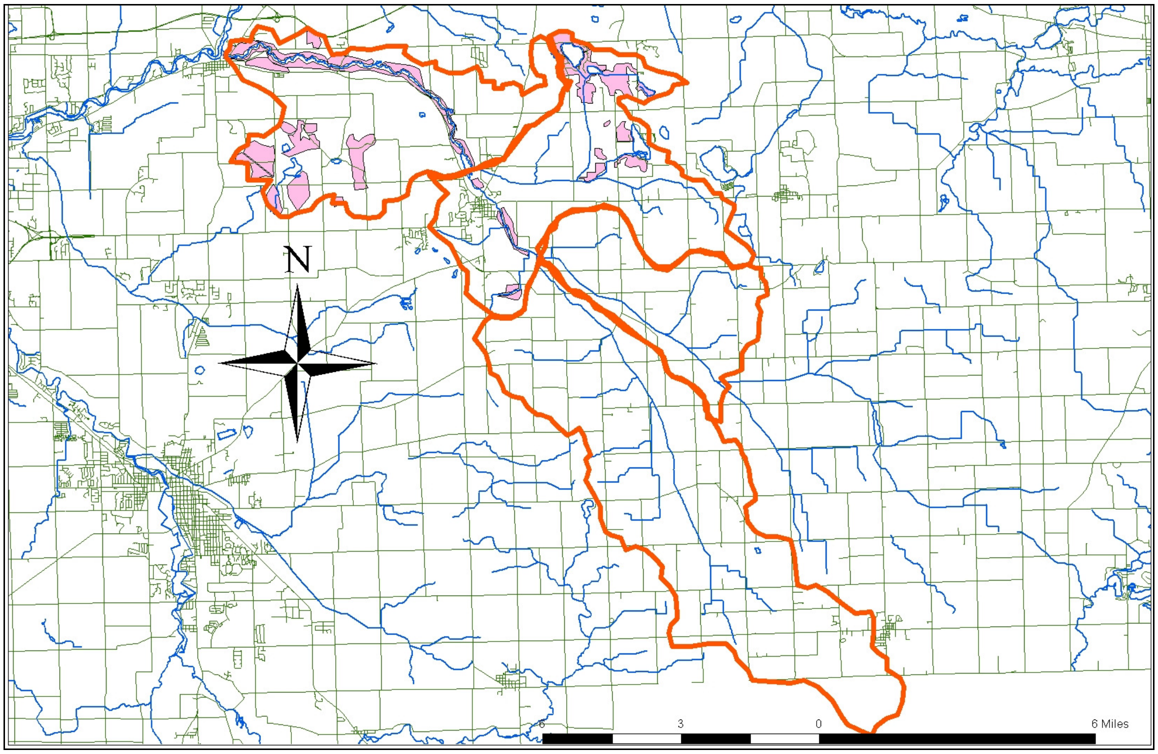


Figure 9: Map depicting sensitive area locations. Expanded map can be seen on Figure 201.

Sensitive areas which consist of wetlands either swamps, marsh, or wooded can be seen on Figure 9. These are classified as sensitive for their filtering characteristics in removing surface water contaminants. Sensitive areas constitute approximately 2% of the surface area or 983 acres. Preservation of these remaining areas is essential. Note that sensitive area preservation is listed under Goal 5 as a moderate timeline action. These areas have already been identified as sensitive by both counties but continued support and monitoring is important.

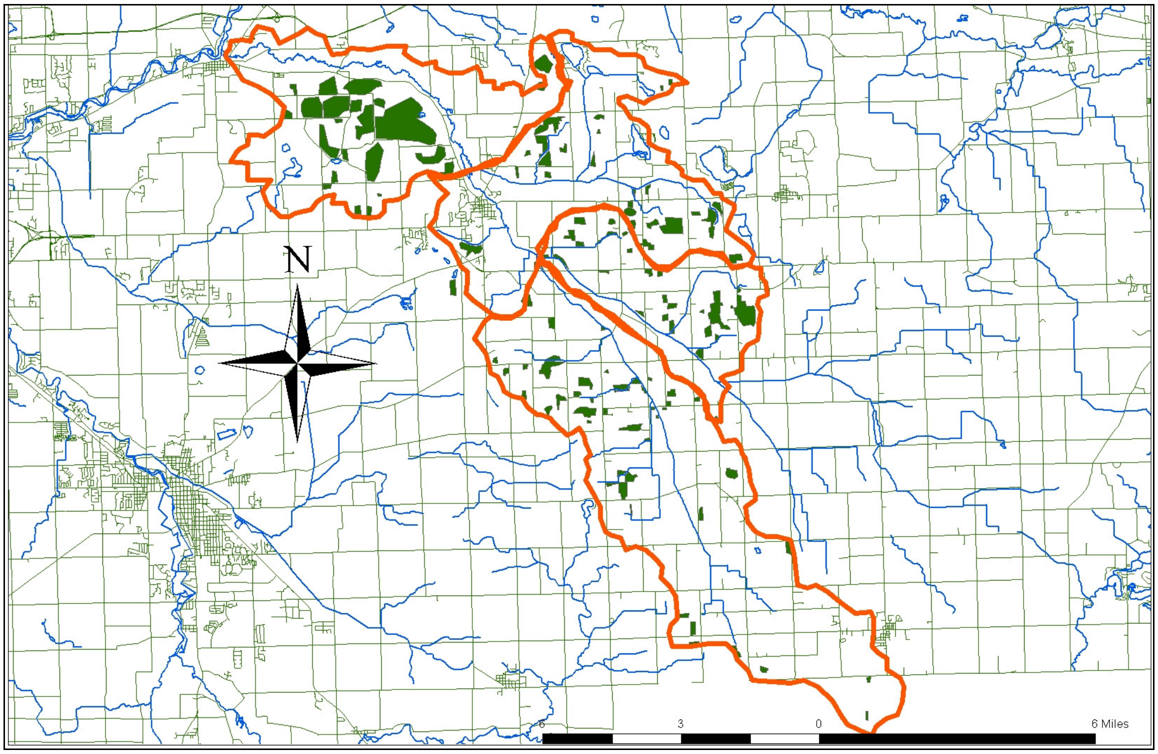


Figure 10: Map depicting non-grazed woodlots. Expanded map can be seen on Figure 202.

Non-grazed woodlots (Figure 10) constitute only 4% of or 1966 acres of the surface area. This is a small percentage when compared with other parts of northeastern Indiana (15%). Wooded areas do serve as a significant soil stabilizer and management plans must consider the loss of the few remaining woodlots as a negative impact. Fortunately, residents within this drainage are working closely with Indiana DNR Foresters to manage and maintain woodlot health.

Impervious surfaces (Figure 204), such as roads, buildings, driveways, etc., constitute nearly 6% or 2950 acres. This number is important because construction in this region continues to accelerate. Any management must consider the growing population and increased impervious surfaces that inevitably follow.

Watershed Problems and Sources

Up to this point problems have been discussed throughout the document. Below is a consolidated list for quick reference. Although there are many isolated situations causing degradation, **eight major contributors** have been identified. These sources have been expressed by the public, by the steering committee, by historical data, water testing program, and through the land use inventory. First, it is important to review the water testing results that reveal the NPS pollution problems. The list below indicates degraded water quality and outlines the **problem causes** within the region:

- Total Phosphorus exceeds the target of 0.3 mg/l average at most sites.
- Nitrates exceed the target of 1.5 mg/l average at most sites.
- Average sedimentation exceeds yearly target loading of 820 tons.
- *E.coli* consistently exceeds the human health standard of 235 colonies per 100mls of water.

Now that we know what the problems are, what land uses are causing the degradation? The sources of the causes listed above that need addressed to improve water quality at or below the target threshold can be found below:

1. *Direct livestock access to surface water system.* During the land-use inventory over 20% of surface waters within the target Hydrologic Unit Codes have livestock present with direct access to streams resulting in high total phosphorus, nitrates, *E.coli*, and sedimentation levels. The sedimentation is a result of livestock induced ditch bank erosion and nutrients from animal waste.
2. *Direct barnyard runoff into surface waters.* One barnyard was identified with cemented surface tapering directly into the ditch. This is a significant source of nutrient and *E.coli* loading even after minor rainfall events.
3. *Areas in Need of Livestock Manure Management*. LaGrange County has ordinances addressing manure management for new or expanding livestock operations with 50 or more livestock. However, a great number of landowners within the target area have fewer than 50 animals and are not required to have a filed manure management plan (MMP) approved by a specialist. MMPs address nutrient loading in manure. The purpose is to plan land applications of manure to reduce soil saturation of nutrients and reduce surface water contamination.
4. *Lack of Proper Ditch-Bank Buffering***.** Approximately 25% of the ditch-bank systems that contain row crops have proper filter strips to reduce sediment runoff. The remaining 75% of row crops adjacent to a ditch-bank system need a riparian buffer installed.
5. *Areas in Need of Nutrient Management.* Conventional grain crop practices continue to dominate many agriculture fields in the watershed. Research has clearly demonstrated that no-till and reduced-till practices significantly reduce nutrient and sediment runoff from reaching surface waters.
6. *Improper or Faulty Septic Systems.* Although not specific to the Little Elkhart River drainage, studies conducted (LaGrange County Health Department 2005) have shown up to 75% of septic systems do not operate properly. It was found that they were either improperly installed (including improper locations), not maintained, or are completely inoperative. Due to the porous soils in the watershed, it is suspected that lateral movement of NPS pollutants from faulty septic systems into moving surface waters is a likely scenario. Several sites with evidence of septic system "straight-piping" or tile connections were reported to the LaGrange County health department.
7. *Urban Runoff.* Middlebury and Bristol are the only urban areas within the HUC 14 subwatersheds addressed in this plan. It is speculated that lawn fertilization is the likely cause of nutrient loading induced from these urban areas. Although not tested

for, other potential problematic toxins that enter surface waters through storm water runoff may be present.

8. *Impervious Surfaces.* The impervious surface area has reached 6% in the target area and continues to grow annually. This is due to the increasing population and industrialization. Impervious surfaces increase runoff flow levels after rainfall events resulting in increased NPS pollutants moving into surface waters. The unique aspect of this region is horse drawn vehicles make up a significant portion of the traffic. After moderate to significant rain events manure runoff from roads and parking lots is suspect in contributing nutrient/*E.coli* loading in surrounding surface waters.

Critical Areas

The previous sections have described the framework to define critical areas more precisely. The watershed problems and sources section lists water quality problems that are ranked according to priority for implementation. The first five, direct livestock access, direct barnyard runoff, areas in need of livestock manure management, lack of proper ditch-bank buffering, and areas in need of nutrient management constitute the critical area definition for initial implementation dollars. Agricultural landowners with these NPS pollution issues are scattered across the entire watershed. The initial land use inventory identified these locations; however, land use is a fluid environment which will result in additional locations being identified for BMP implementation on a periodic basis. Due to changing land use conditions, Figures 4-8 are not all inclusive for BMP implementation. Water quality testing and the land use inventory clearly demonstrated that the most dramatic affect on reducing NPS pollution is to address the above issues immediately upon plan implementation. BMP installation is an equally fluid environment with many target locations requiring multiple and in some cases innovative BMPs. Development of the cost-share criteria for the implementation phase will undoubtedly require updates with additional BMPs on a periodic basis.

Conclusion

Water quality testing and the land use inventory clearly demonstrated the most dramatic affect on reducing NPS pollution is to address critical area issues immediately upon plan implementation. BMP priority is listed below; however this is not an all inclusive list of BMPs but a general category addressing specific problems. For example, waste management on barnyards may involve many additional BMPs such as roof guttering, alternative watering facilities, water diversions, grassed waterways, and dry stack facilities for manure storage.

1. Fence livestock from surface waters. This will have an immediate impact in reducing nutrient, sedimentation, and *E.coli* loading. Alternative watering source installation will be required.
2. Repair ditch bank damage. After livestock have been fenced from surface waters, stabilizing bank damage will reduce sedimentation after heavy rainfall events.
3. Install filter/buffer strips. In many cases this BMP will be included with

fencing/bank repair. After fencing/bank repair issues have been addressed, ditch bank buffering in association with traditional row crop practices should follow. Conservation tillage will be encouraged in conjunction with buffering.

4. Install waste management systems on barnyards adjacent to surface waters. This is an important BMP but will require time to implement. Special engineering designs are required.

Using the EPA Region 5 load model a significant reduction in nitrates, total phosphorus and sediment can be achieved by implementing all BMPs associated with the problems discussed in the previous paragraph. According to calculations a 55% reduction in sedimentation and nitrates will occur. This equates to 3513 tons/year reduction in sediments, and 1149 tons/year in nitrates for the region. The model indicated a 71% reduction in phosphorus. This equates to a reduction of 218 tons/year in phosphorus loading and allows achievement of reducing annual average readings to 0.3 mg/l. The table below will help visualize the **yearly reduction** of each contaminant:

	Rowe Eden	Harper	Mather	Bonneyville	Total
Nitrates	132 tons	325 tons	48 tons	644 tons	1149 tons
Phosphorus	24 tons	53 tons	37 tons	104 tons	218 tons
Sediment	981 tons	1660 tons	152 tons	1220 tons	3513 tons

Watershed Management Plan Implementation Costs

The cost estimate for implementation is as follows:

Filter Strips (buffers)	$ 36,500
Fencing	$ 88,000
Alternative Watering	$ 52,500
Bank Stabilization	$ 50,000
Waste Management Systems	$ 90,000
Barnyard Relocation	$ 50,000
Conservation Tillage	$ 100,000
Monitoring (Supplies/Equipment)	$ 20,000
Contracted Personnel	$ 300,000
TOTAL	**$ 697,000**

There are many sources of funding available to accomplish implementation. Currently, an EPA 319 Grant through the Indiana Department of Environmental Management and a Lake and River Enhancement Grant from the Indiana Department of Natural Resources are available to begin implementation of this watershed management plan. The recent Farm Bill will be employed in the region to compliment the current grants. Technical assistance will be provided by the NRCS.

Goals and Objectives

The Little Elkhart River Watershed Management Plan seeks to improve water quality in the river by addressing non-point source pollution in the region. To accomplish the goals and objectives mentioned below, a broad stakeholder group must be established and maintained throughout the implementation phase. Partnering with private and government institutions is vital and entails crossing county jurisdictions. This of course is a complicated task that requires astute leaders within the oversight group.

The following goals and objectives address the primary concerns of: nutrients, sediment, pathogens and toxins. These are universal concerns throughout the river drainage and in general application these goals and objectives apply equally well downstream of the headwaters region.

Objectives are prioritized as high (implemented in zero to three years), moderate (implemented in four to seven years), and low (implemented in seven to eleven years). It is important to note that many tasks, once begun, must be maintained to prevent a backslide in improvements made to water quality.

Goal #1

Establish a stakeholder group to oversee watershed management plan implementation, promote public awareness, and sustain funding to meet goals and objectives within timelines.

A Expand current steering committee to include additional key stakeholders as identified by the current committee within the watershed to enhance implementation success.

Priority
High

Implementation Timeframe
Within the first six months

Partners
Stakeholder group

Milestones
Hold meeting within first quarter

Indicators of Success
Consensus reached on responsibilities of stakeholder group for coordinating implementation of the watershed management plan.

B Develop funding strategy to sustain implementation and administration operations costs.

Priority
High

Implementation Timeframe
Ongoing

Partners
Stakeholder group

Milestones
- Identify funding sources (6 months)
- Design funding strategy (6 months)
- Implement funding strategy (Year 2)
- Secure operational funding (Year 2/Ongoing)

Indicators of Success
- Documented funding sources
- Grant proposals submitted
- Private funding solicited
- Records of funding received and solicited

Goal #2

Reduce agriculture induced non-point source pollution from the region so that surface waters are improved.

A Install 35,000 feet of fence to keep livestock out of surface waters and provide alternative watering sources for owners identified in the land use inventory.

Priority
High

Implementation Timeframe
1-3 years

Partners
LaGrange County SWCD
Elkhart County SWCD
NRCS
Friends of the St. Joe River Association
Indiana Department of Environmental Management
Indiana Department of Agriculture
Indiana Division of Fish and Wildlife

Producers

Milestones
- 25% reduction of nitrates after 3 years
- 55% nitrates load reduction after 5 years
- 30% reduction of total phosphorus after 3 years
- 71% reduction of total phosphorus after 5 years
- 10% reduction of total suspended solids after 3 years
- 15% reduction of total suspended solids after 5 years
- 25% reduction of *E.coli* after 3 years
- 55% reduction of *E.coli* after 5 years

Indicators of Success
- Provide cost-share incentives to landowners (Year 1-3)
- Feet of fence installed
- Develop a comprehensive outreach program for continued education (Ongoing)

B Repair 17 sites that have livestock induced ditch bank damage.

Priority
High

Implementation Timeframe
1-3 years

Partners
LaGrange County SWCD
Elkhart County SWCD
NRCS
Friends of the St. Joe River Association
Indiana Department of Environmental Management
Indiana Department of Agriculture
Indiana Division of Fish and Wildlife
Producers

Milestones
- 5% reduction in total suspended solids by year 3
- 10% reduction of total suspended solids by year 4
- 15% reduction of total suspended solids by year 5

Indicators of Success
- Number of sites installed

C Install 3 waste management systems (barnyards with direct runoff).

Priority
High

Implementation Timeframe
1-3 years

Partners
LaGrange County SWCD
Elkhart County SWCD
NRCS
Friends of the St. Joe River Association
Indiana Department of Environmental Management
Indiana Department of Agriculture
Indiana Division of Soil Conservation
Indiana Division of Fish and Wildlife
Producers

Milestones
- 2 waste management systems installed by year 2
- 3 waste management systems installed by year 3

Indicators of Success
- Number of waste management systems installed
- Number of NRCS approved designs

D Plant 75 acres filter/buffer strips where required adjacent to surface waters.

Priority
High

Implementation Timeframe
1-3 years

Partners
LaGrange County SWCD
Elkhart County SWCD
NRCS
Friends of the St. Joe River Association
Indiana Department of Environmental Management
Indiana Department of Agriculture
Indiana Division of Soil Conservation
Indiana Division of Fish and Wildlife

Producers

Milestones
- 15% reduction of total suspended solids after 3 years
- 25% reduction of total suspended solids after 5 years

Indicators of Success
- Cost-share incentives provided
- Acres of filter strips installed
- Ongoing outreach program for continued education

E Promote no-till and reduced-till practices on all fields adjacent to surface waters.

Priority
High

Implementation Timeframe
Ongoing

Partners
LaGrange County SWCD
Elkhart County SWCD
NRCS
Friends of the St. Joe River Association
Indiana Department of Agriculture
Producers

Milestones
- 100% landowner contact that practice conventional tillage (Year 2)
- Develop a comprehensive outreach program for continued education (Year 2)

Indicators of Success
- Number of producers that enroll in incentive programs
- Increase in no-till/reduced-till acreage documented with tillage transects

F Continue the water quality testing program to monitor goal success.

Priority
High

Implementation Timeframe
Ongoing

Partners
LaGrange County SWCD
Elkhart County SWCD
NRCS Earth Team
Hoosier River Watch

Milestones
- Solicit funding sources to continue testing program (Year 1)
- Develop public involvement program (Year 1)
- Publish testing results (Yearly)

Indicators of Success
- Funding secured to continue monitoring program
- Public participation in testing program
- Media releases and brochure

Combined BMP Installation Milestones
- A 25% reduction in nitrates and sedimentation after 3 years
- A 30% reduction in total phosphorus after 3 years
- A 25% reduction in *E.coli* after 3 years
- A 55% reduction in nitrates and sedimentation after 5 years
- A 71% reduction in total phosphorus after 5 years
- A 55% reduction in *E.coli* after 5 years

Goal #3

Reduce non-point source pollution from faulty or improper septic systems from the region so that surface waters are improved.

A Work with county leadership to develop a comprehensive septic system ordinance.

Priority
Moderate

Implementation Timeline
4 years

Partners
LaGrange/Elkhart County SWCDs
LaGrange/Elkhart County Commissioners
LaGrange/Elkhart County Health Departments
LaGrange/Elkhart County Planning Commissions
LaGrange/Elkhart County Health Boards
LaGrange/Elkhart County Sewer Districts

Milestones

- Meetings with county commissioners and appropriate county boards (Year 4-7)
- Develop outreach program (Year 4)
- Develop Comprehensive plan (Year 6)

Indicators of Success

- Semi-annual meetings with county officials
- Educational brochure development
- Change to county comprehensive plan

B Develop a county-wide septic system inspection program

Priority

Low

Implementation Timeline

8 years

Partners

LaGrange/Elkhart County SWCDs
LaGrange/Elkhart County Health Departments

Milestones

- Consensus from county leadership that inspection program is needed (Year 8)
- Consolidate information on existing inspection programs (Year 8)
- Educate septic system owners (Year 9)
- Faulty septic systems repaired or replaced (Year 10)

Indicators of Success

- Inspection program developed
- Number of septic system owners contacted about inspection
- Number of faulty septic systems repaired or replaced
- Improved water quality

Goal #4

Reduce urban run-off induced non-point source pollution from the region so that surface waters are improved.

A Develop a comprehensive outreach program to educate urban/lake residents on NPS pollution concerns and how they can participate to improve surface waters surrounding their communities.

Priority
High

Implementation Timeline
2 years

Partners
LaGrange County SWCD
Elkhart County SWCD
Town Leadership
Friends of the St. Joe River Association
LaGrange County Lakes Council

Milestones
- Yearly media articles outlining urban runoff and its effects
- Yearly brochures and flyers for urban residents
- Yearly workshops/tours for urban/lake residents
- Bi-annual urban resident survey developed

Indicators of Success
- Annual media articles
- Number of brochures and flyers circulated
- Attendance at workshops/tours by town and lake residents
- Survey results

Goal #5

Monitor and control impervious surfaces development in the region so that water quality is maintained.

A Develop a program to monitor impervious surface development within the watershed.

Priority
Moderate

Implementation Timeline
4 years

Partners
LaGrange County SWCD
Elkhart County SWCD
NRCS
LaGrange County Planning Commission
Elkhart County Planning Commission
Purdue University

Milestones
- Shapefile of impervious surfaces for GIS systems (Year 4)

Indicators of Success
- Monitoring program

B Work with county planning commission to minimize effects of new construction on surface waters within the watershed and protect sensitive areas.

Priority
Moderate

Implementation Timeline
4 years

Partners
LaGrange County SWCD
Elkhart County SWCD
LaGrange County Planning Commission
Elkhart County Planning Commission
Purdue University

Milestones
- Runoff effects on surface waters considered for new building permits within 2 years

Indicators of Success
- Change to county comprehensive plan ordinance

Monitoring Plan

Continued monitoring for land use changes and water quality is essential for success. A minimum of 7 years continuous monitoring is critical. This is necessary for several reasons. First, validate the effectiveness of BMP implementation. Second, document if target loadings are achieved.

Monitoring land use changes is essential. Since this area has the fastest growing population in the county, land use changes will occur on a more rapid scale. These changes can and will likely affect the water quality of the Little Elkhart River drainage if not properly monitored and managed. Lagrange County is currently developing a comprehensive GIS system to help monitor and manage important influences such as new construction. Using these GIS layers coupled with visual data collection will provide useful information. A yearly land use transect of the drainage will be conducted in conjunction with the paired watershed study. Elkhart County has a comprehensive GIS system in place.

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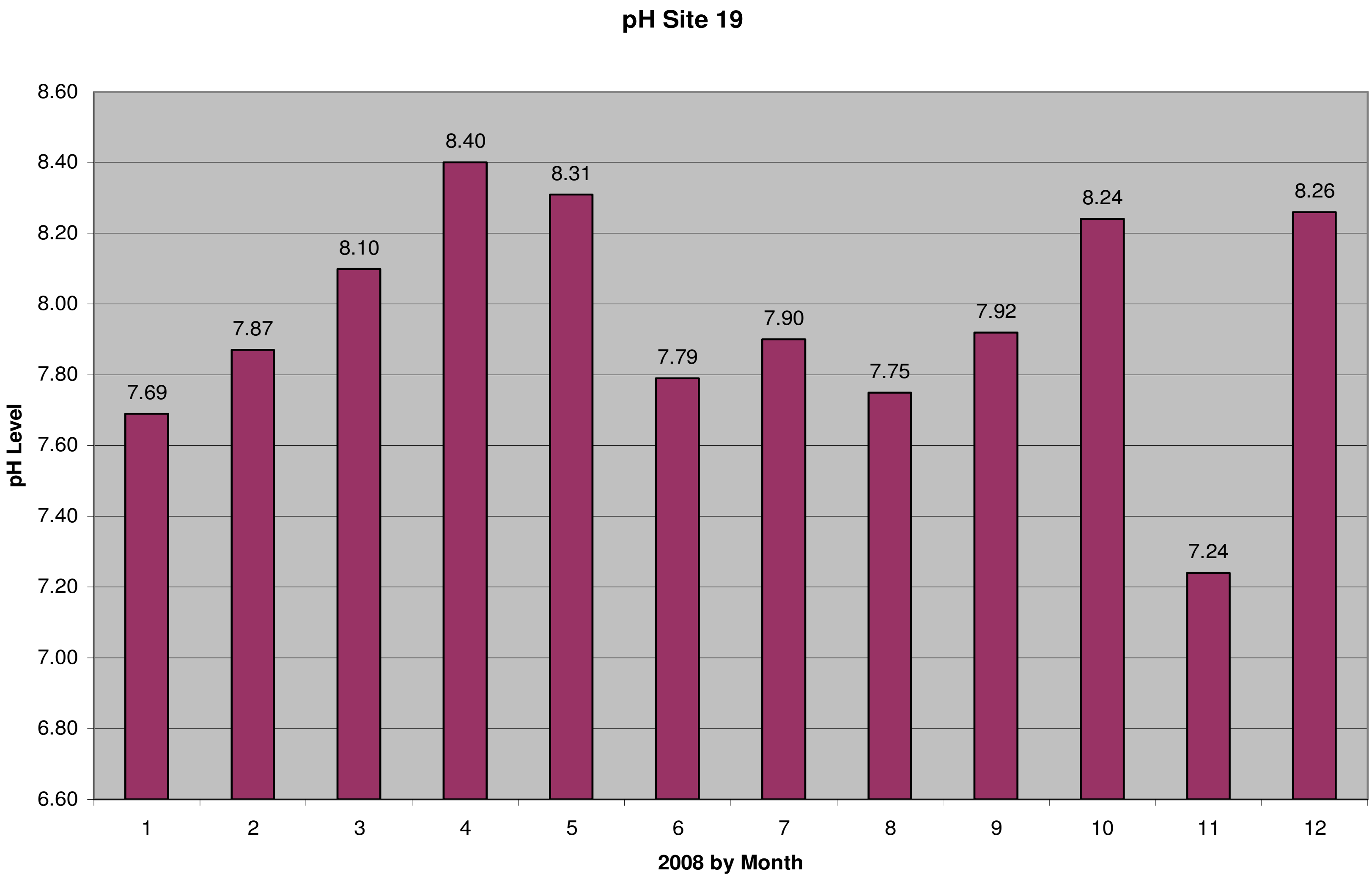

Figure 11: Monthly pH for site 19 with 7.96 as the yearly average.

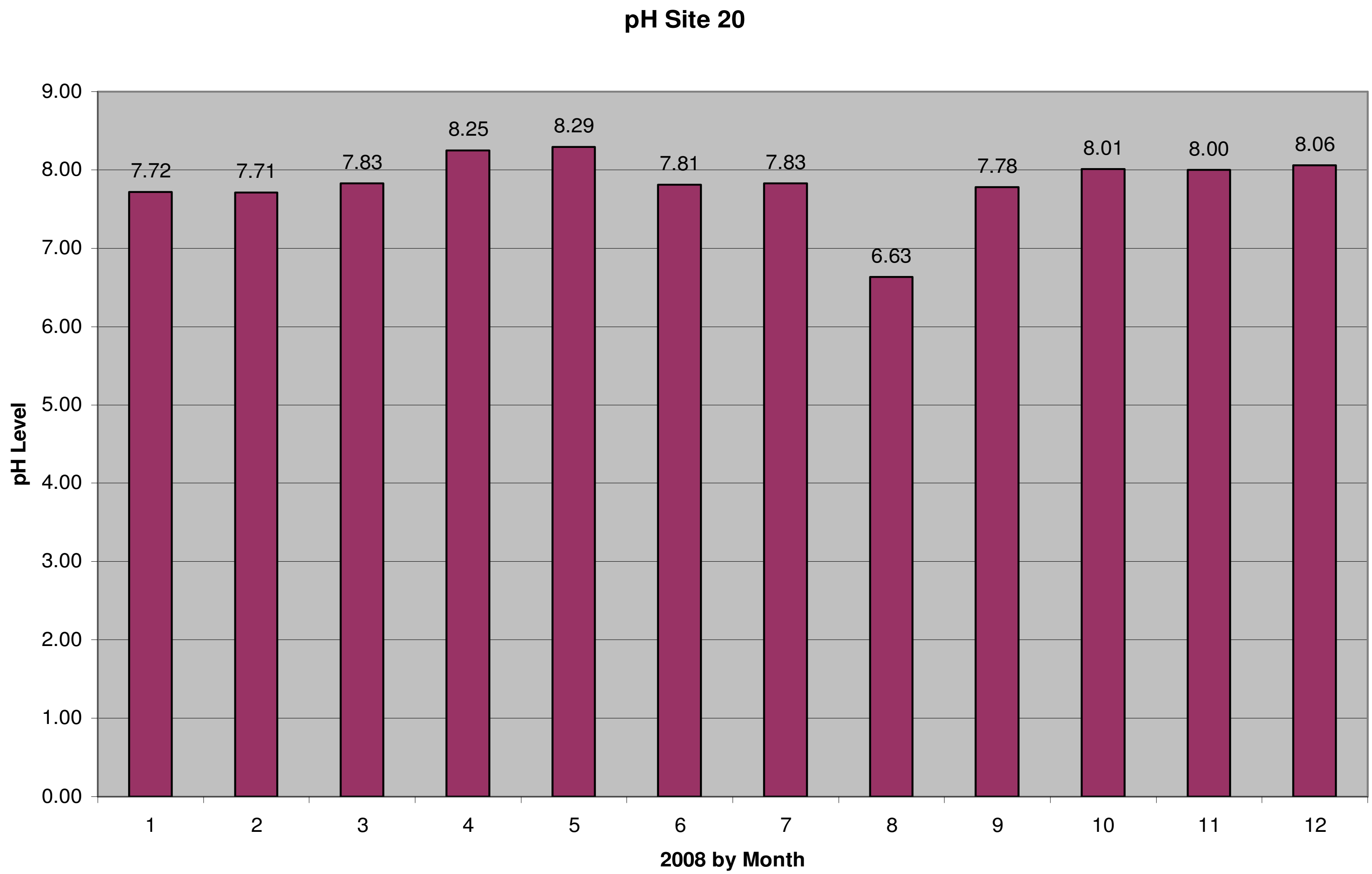

Figure 12: Monthly pH for site 20 with 7.93 as the yearly average.

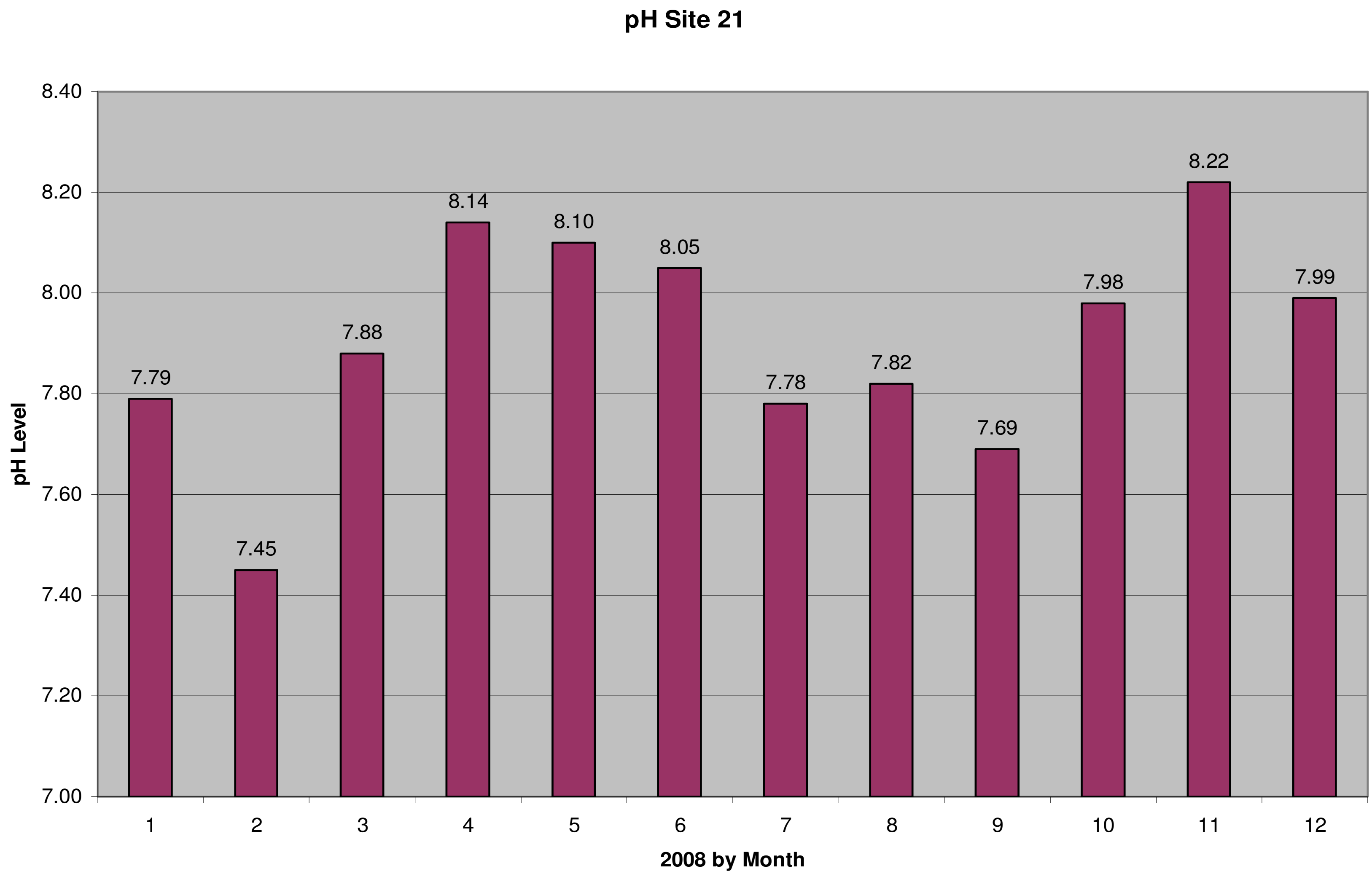

Figure 13: Monthly pH for site 21 with 7.91 as the yearly average.

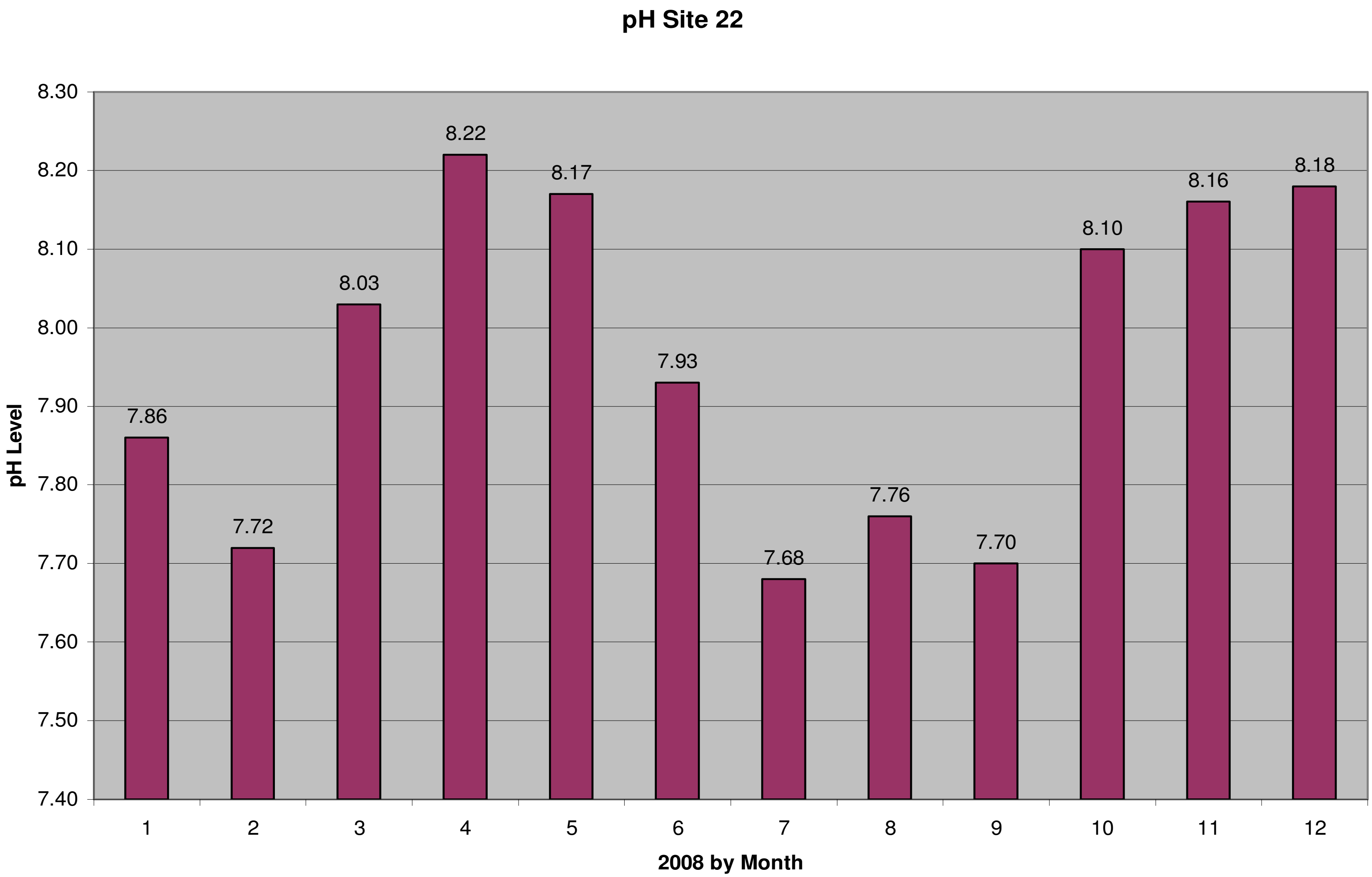

Figure 14: Monthly pH for site 22 with 7.96 as the yearly average.

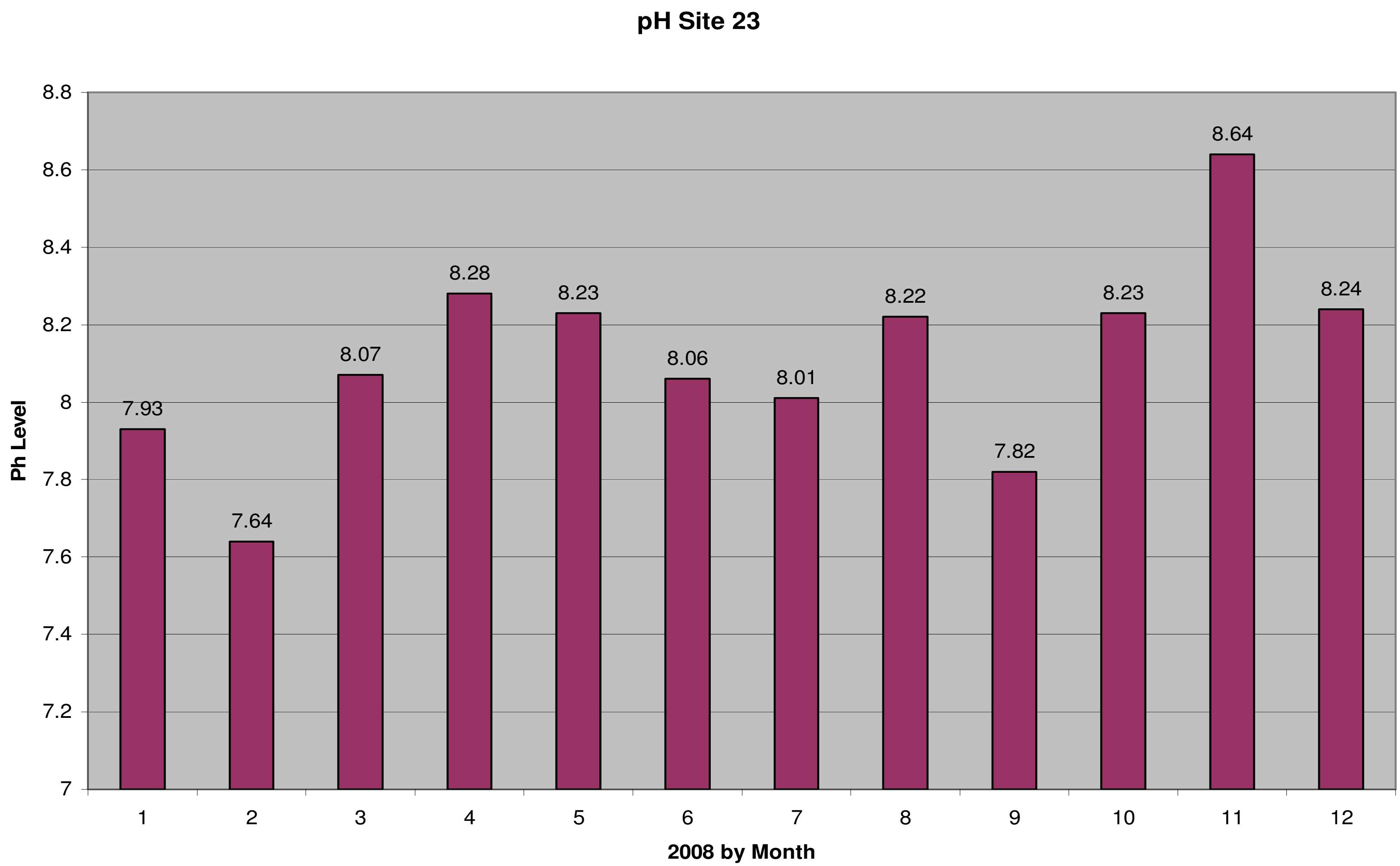

Figure 15: Monthly pH for site 23 with 8.11 as the yearly average.

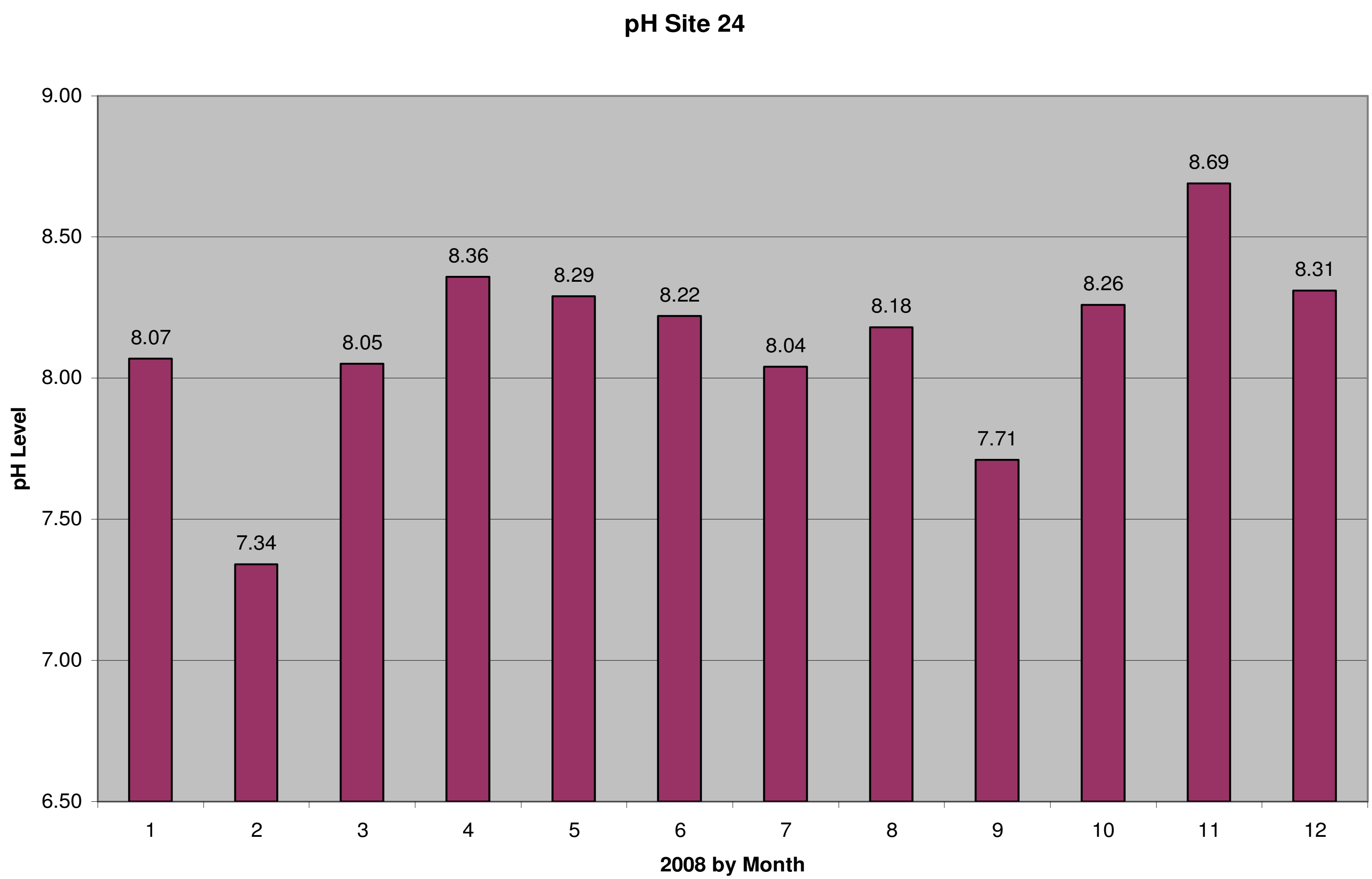

Figure 16: Monthly pH for site 24 with 8.13 as the yearly average.

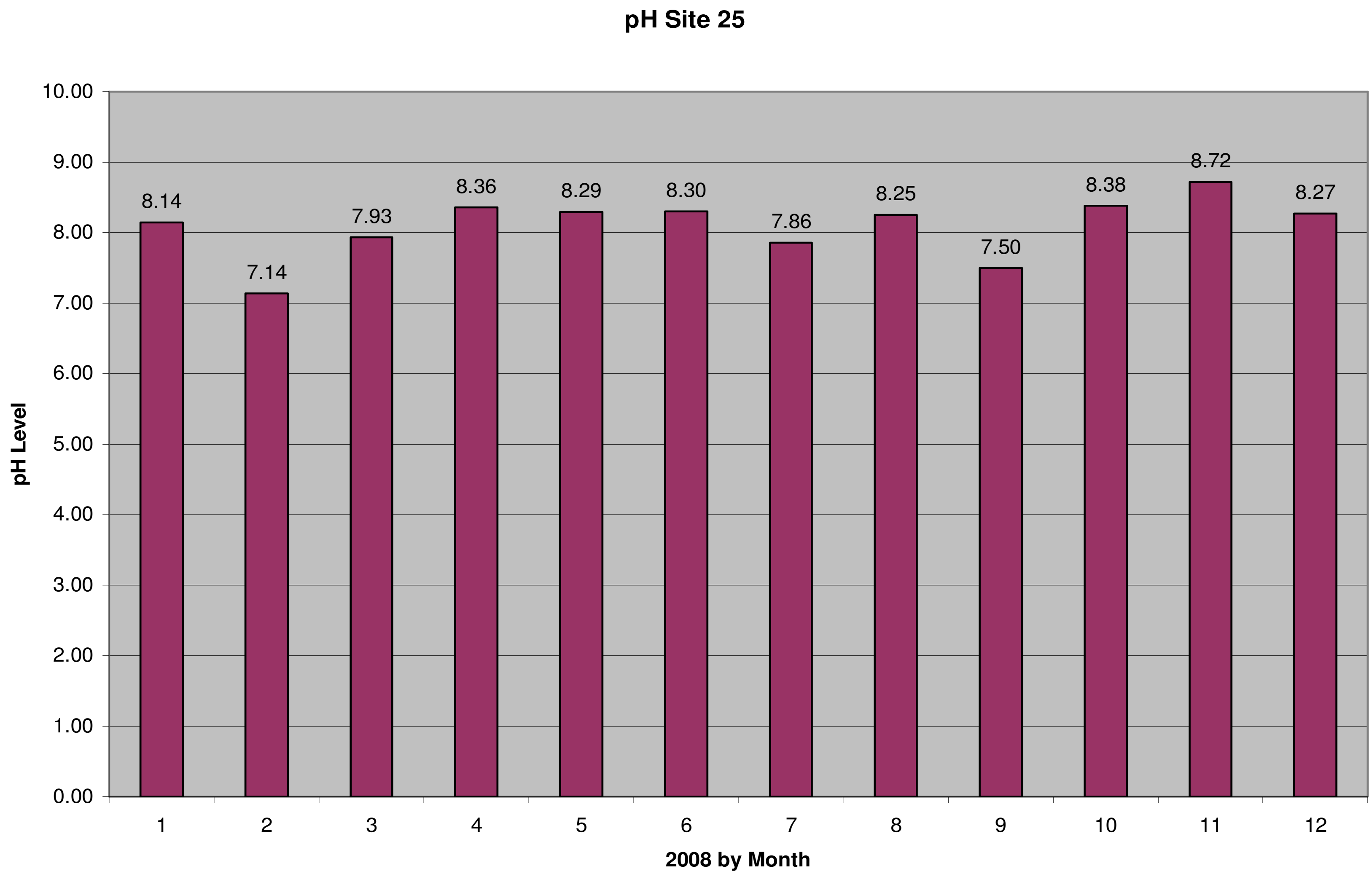

Figure 17: Monthly pH for site 25 with 8.10 as the yearly average.

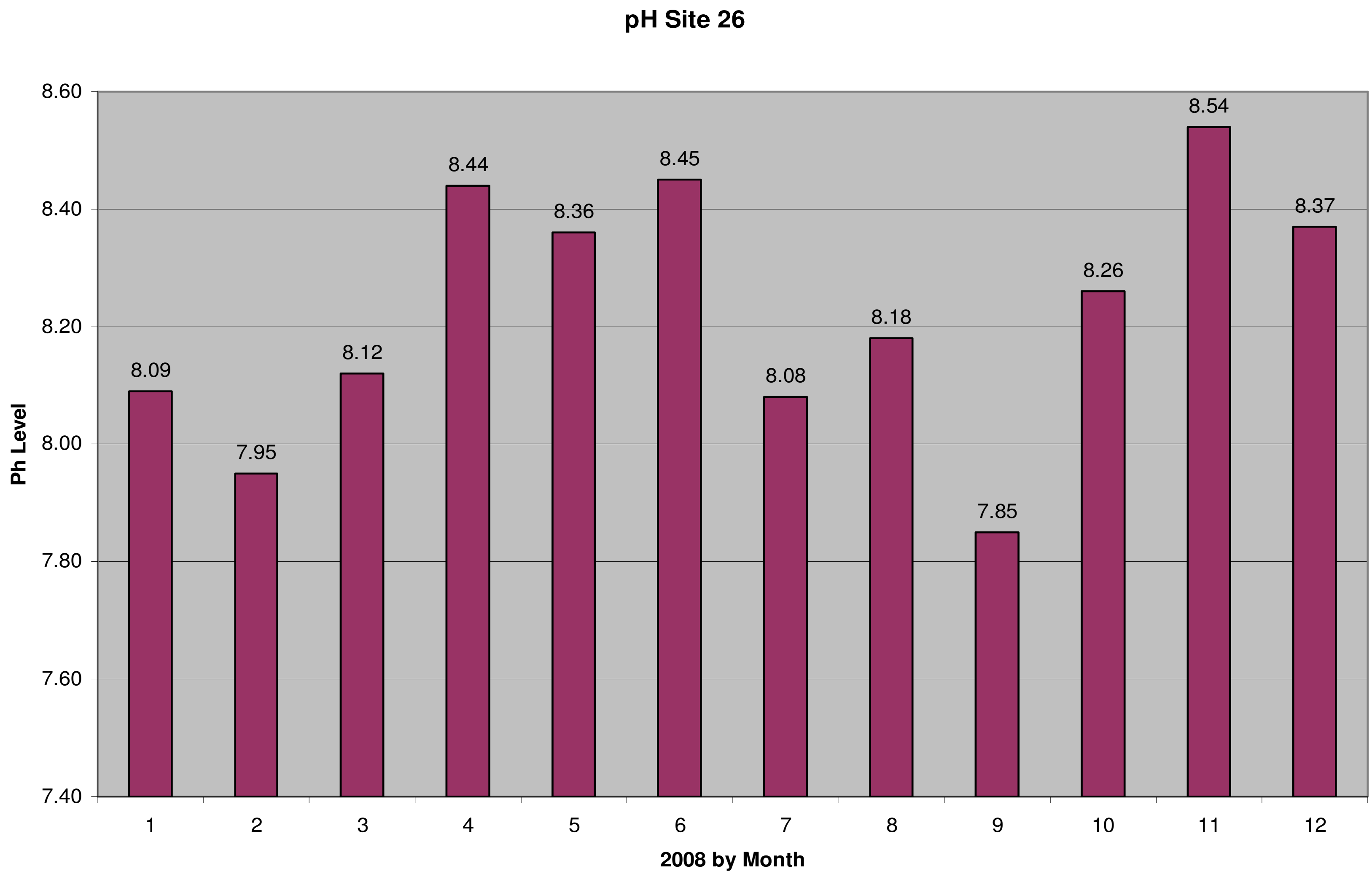

Figure 18: Monthly pH for site 26 with 8.22 as the yearly average.

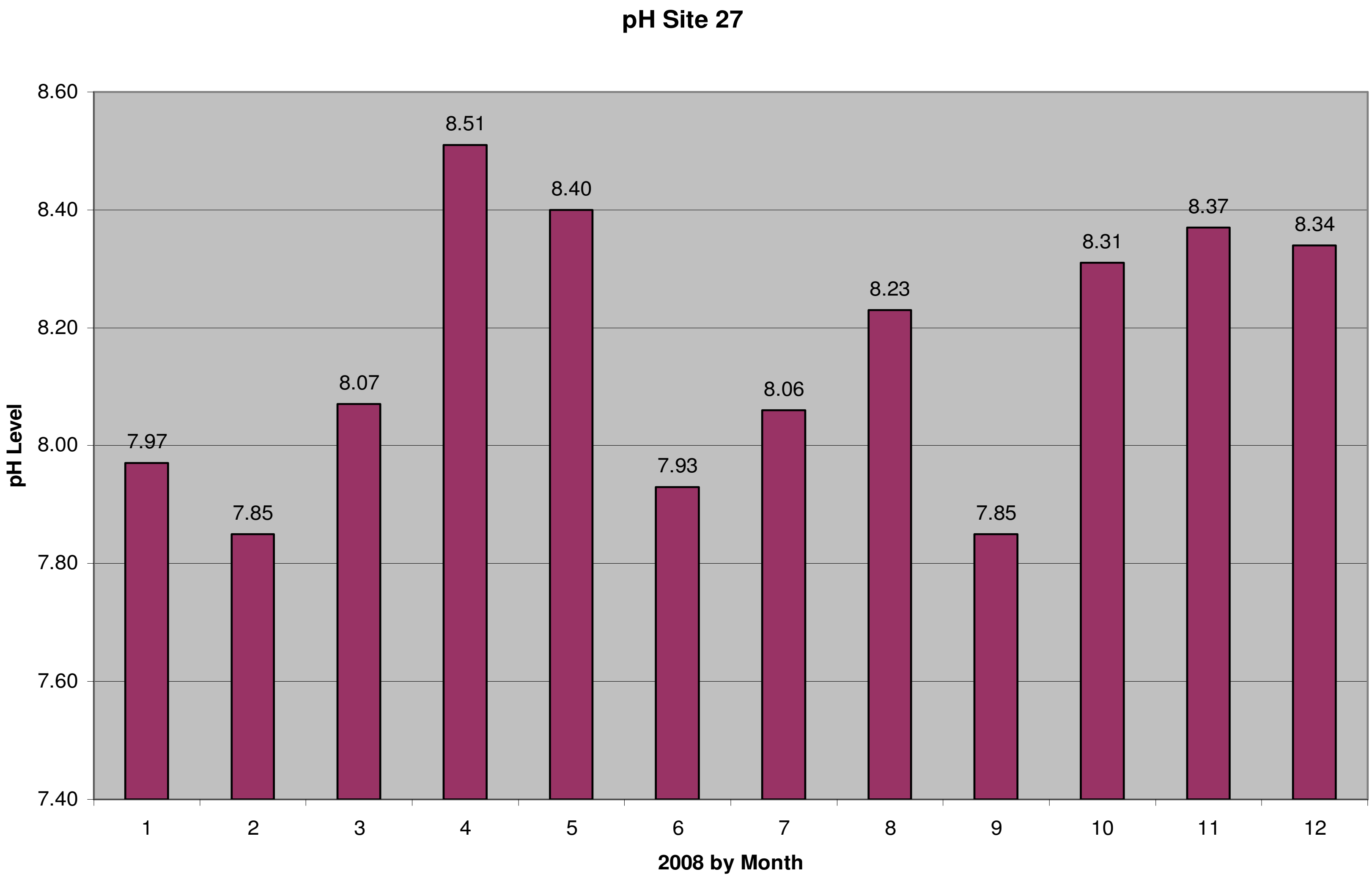

Figure 19: Monthly pH for site 27 with 8.16 as the yearly average.

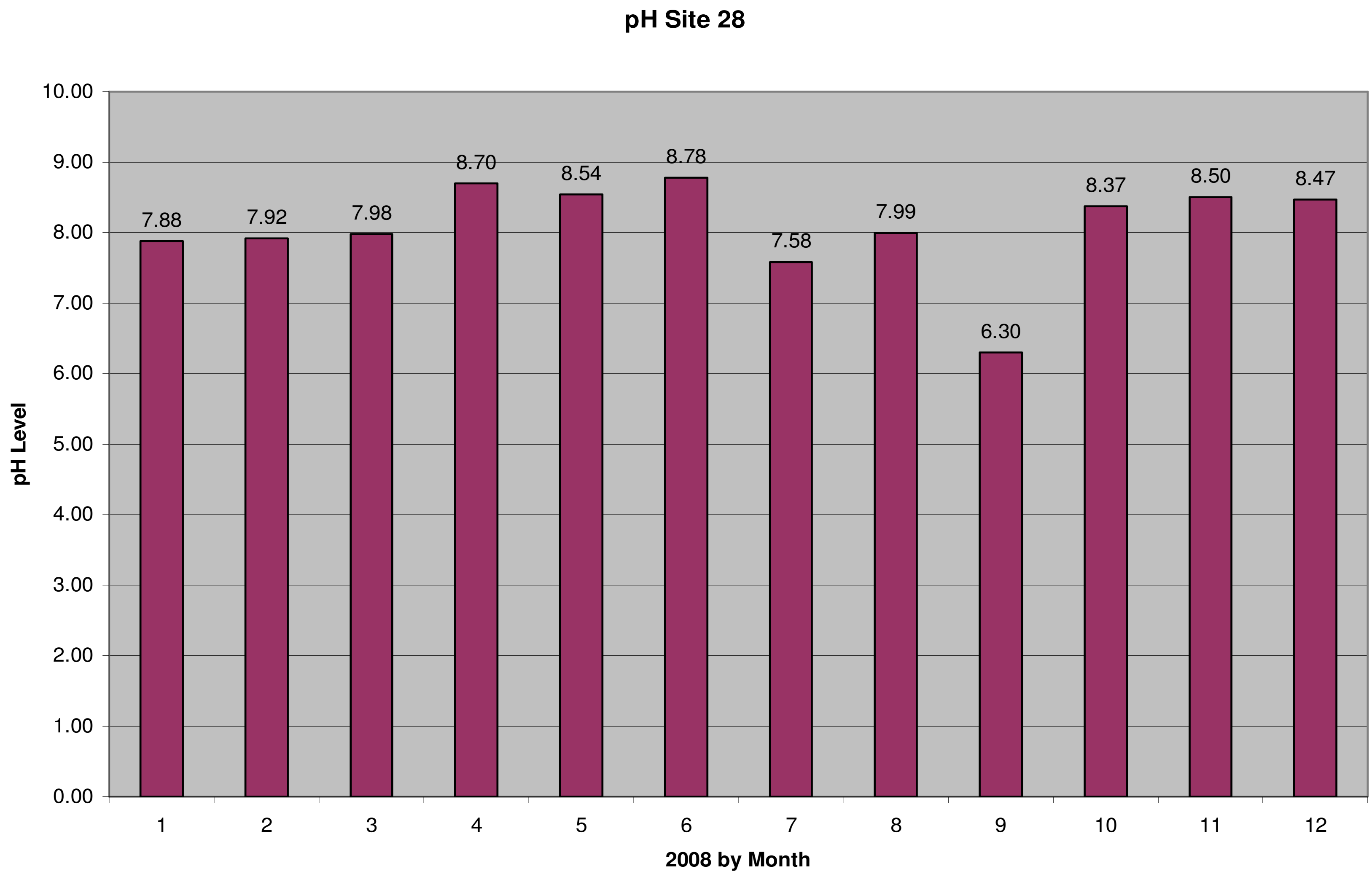

Figure 20: Monthly pH for site 28 with 8.16 as the yearly average.

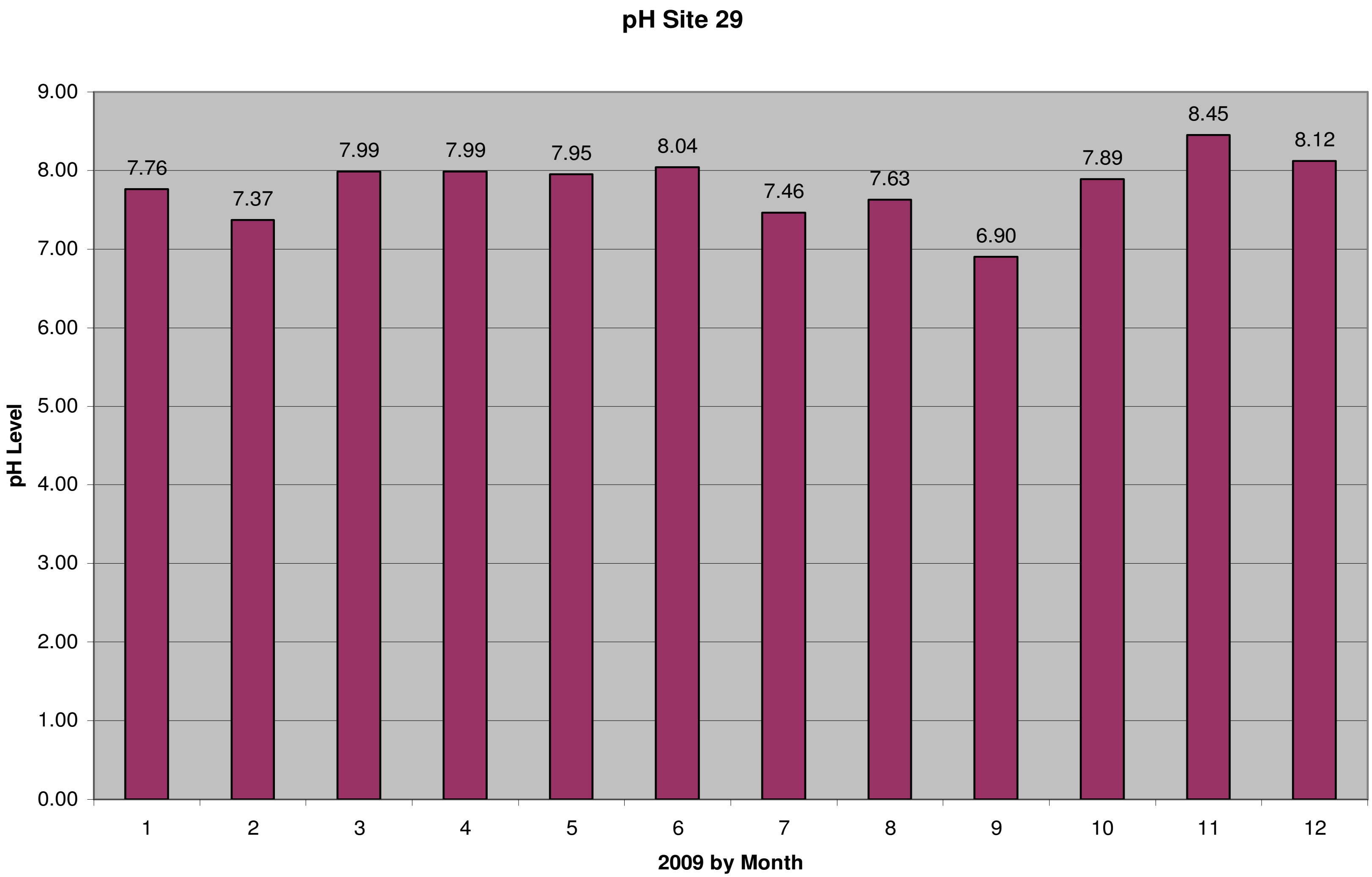

Figure 21: Monthly pH for site 29 with 7.80 as the yearly average.

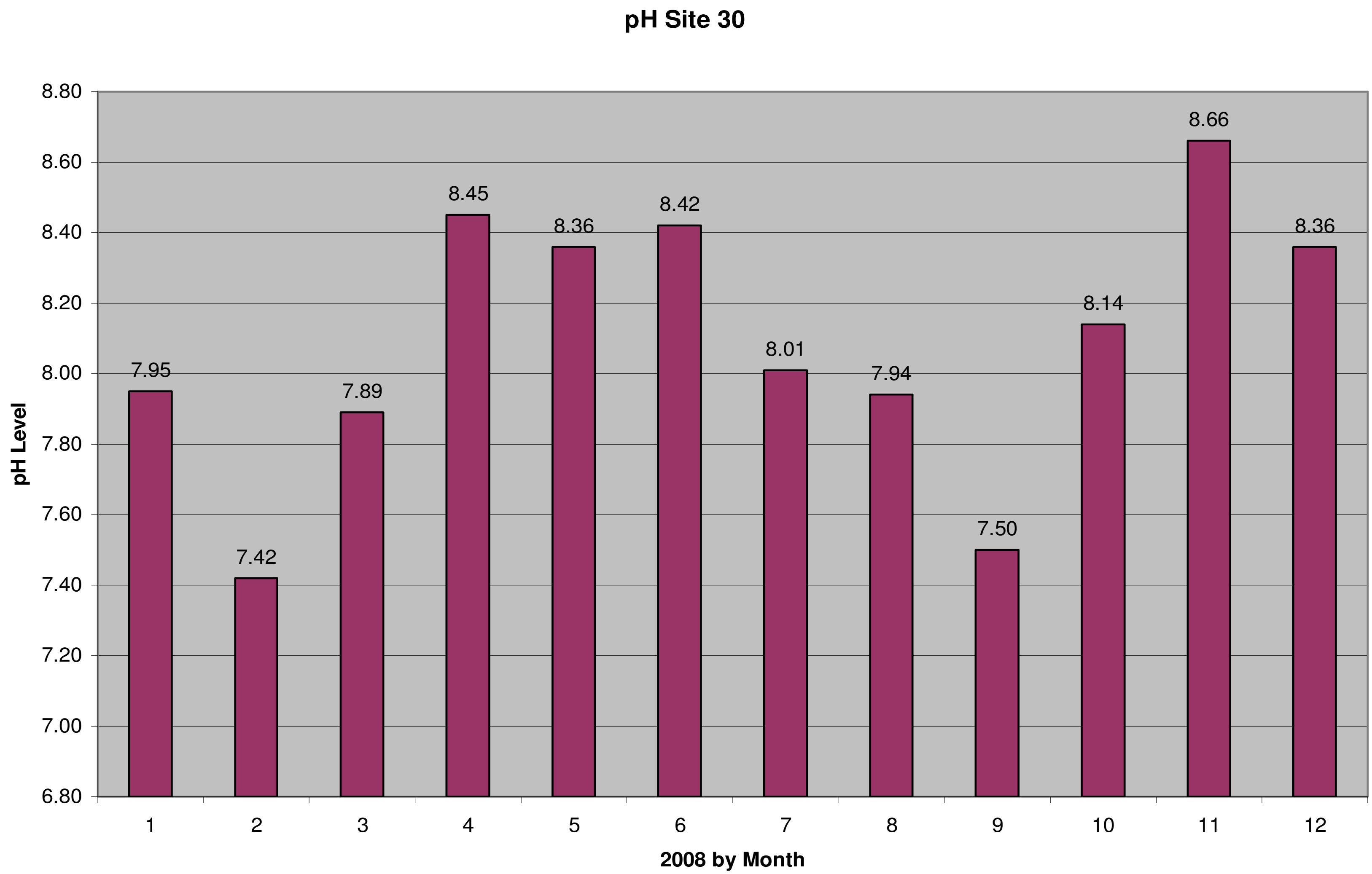

Figure 22: Monthly pH for site 30 with 8.09 as the yearly average.

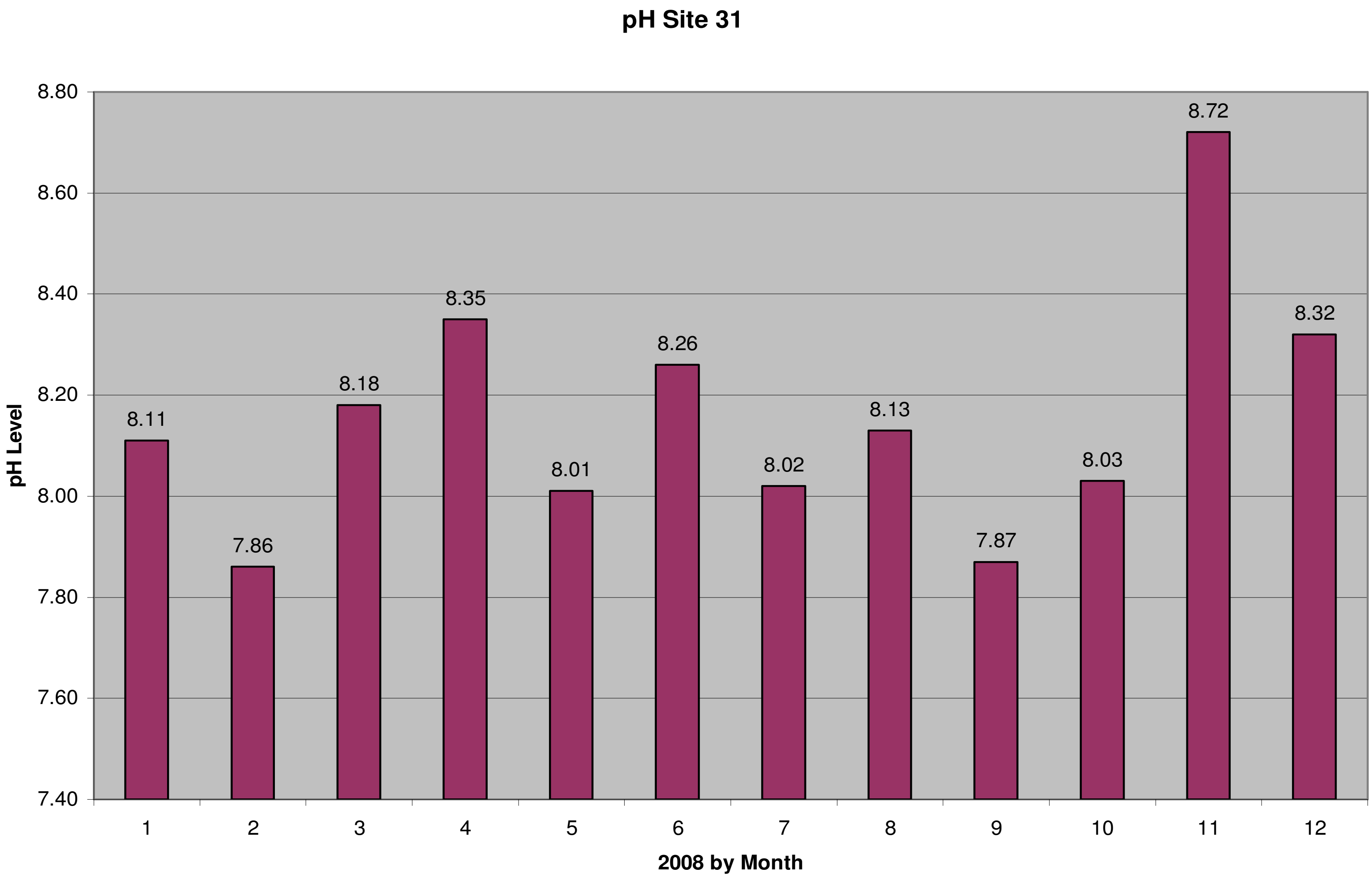

Figure 23: Monthly pH for site 31 with 8.16 as the yearly average.

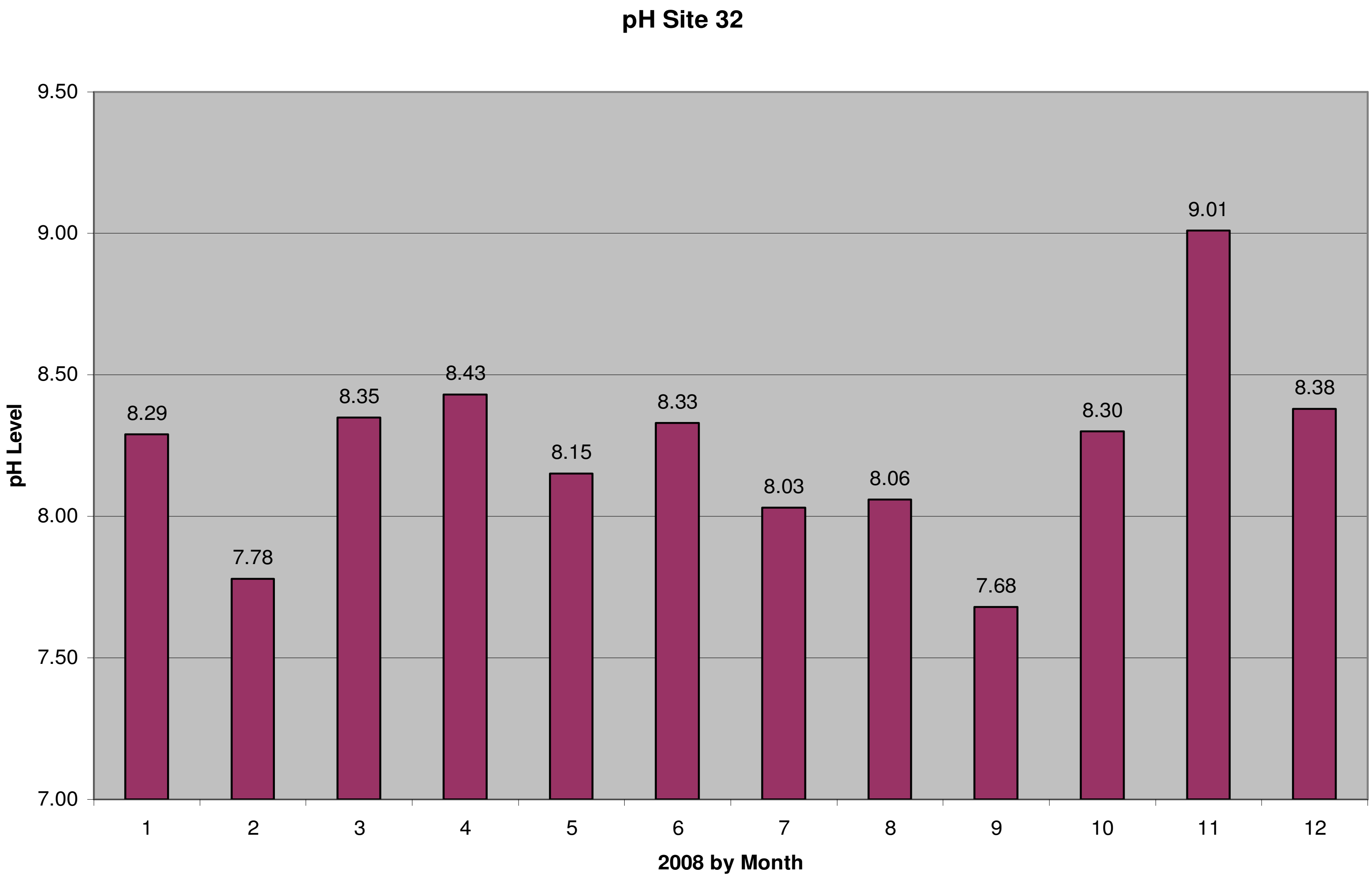

Figure 24: Monthly pH for site 32 with 8.23 as the yearly average.

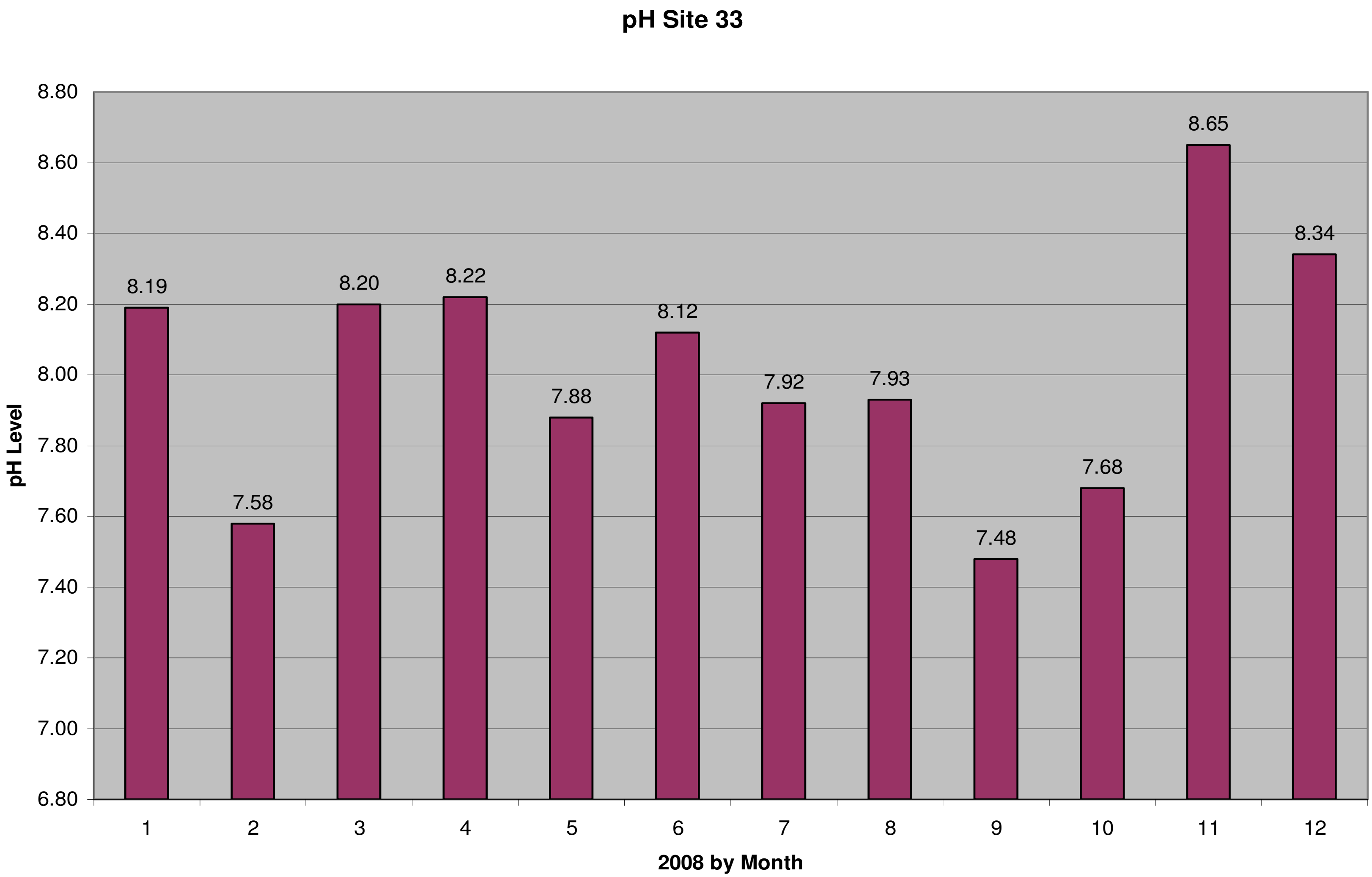

Figure 25: Monthly pH for site 33 with 8.02 as the yearly average.

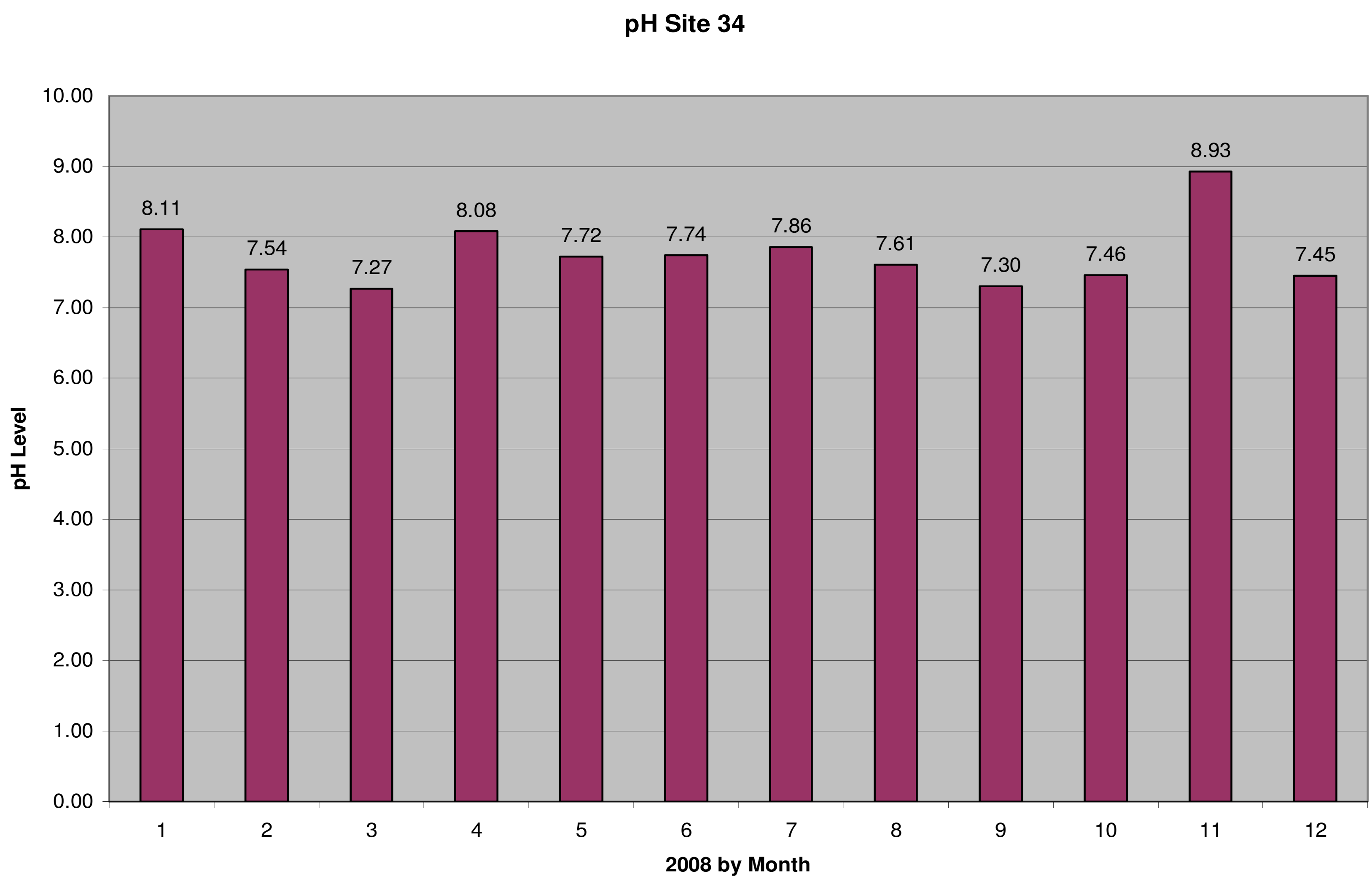

Figure 26: Monthly pH for site 34 with 7.76 as the yearly average.

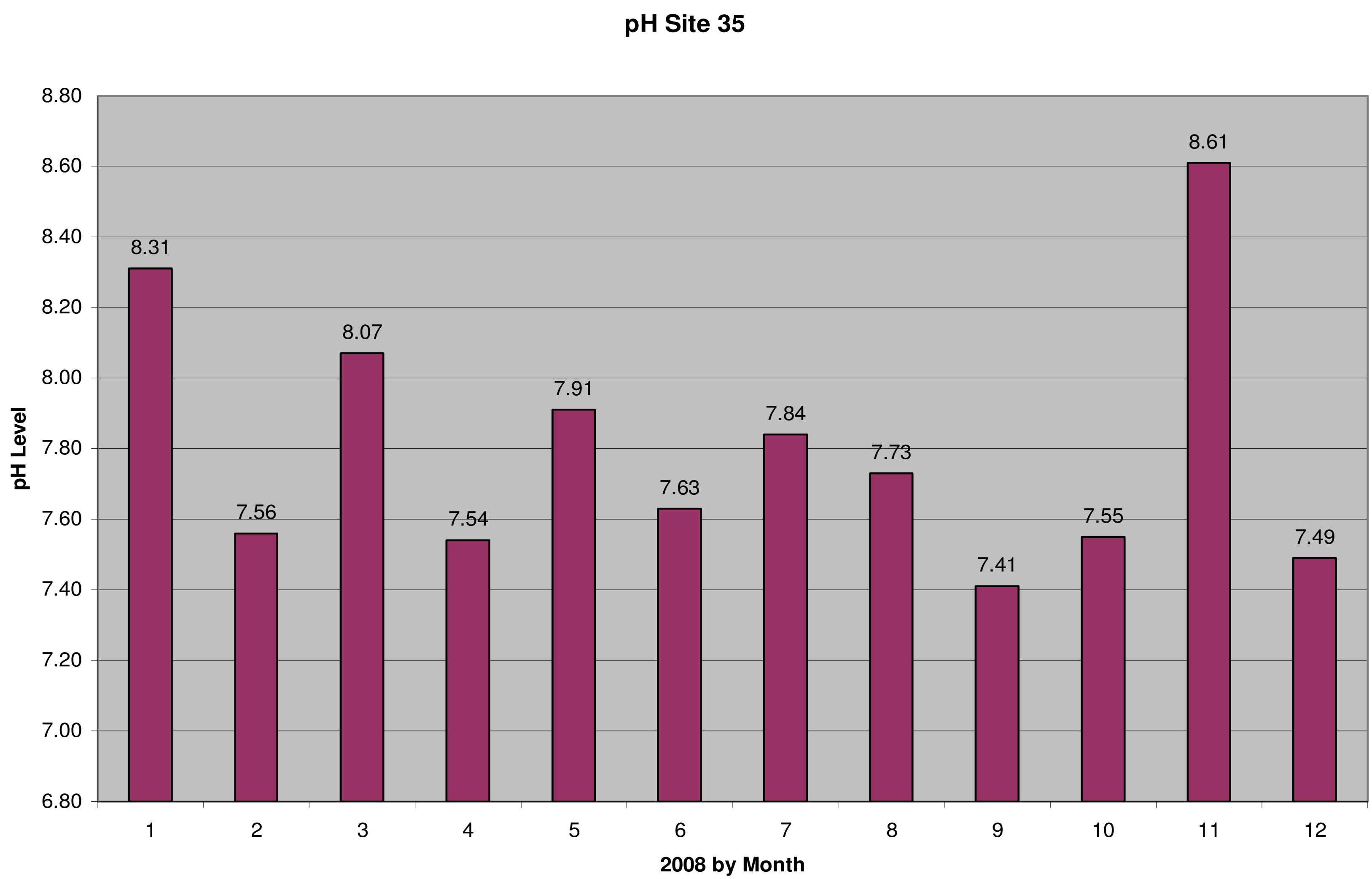

Figure 27: Monthly pH for site 35 with 7.80 as the yearly average.

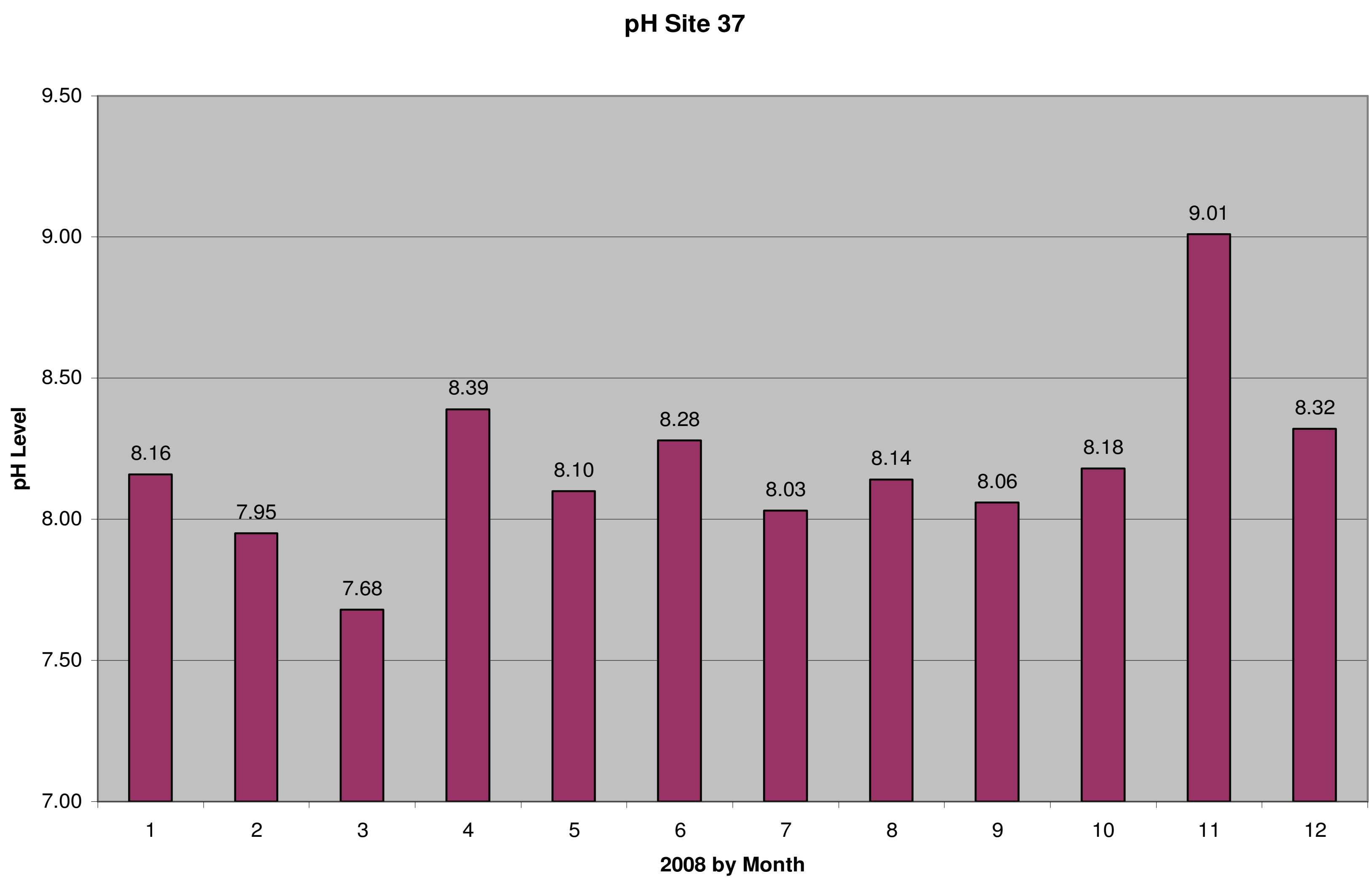

Figure 28: Monthly pH for site 37 with 8.19 as the yearly average.

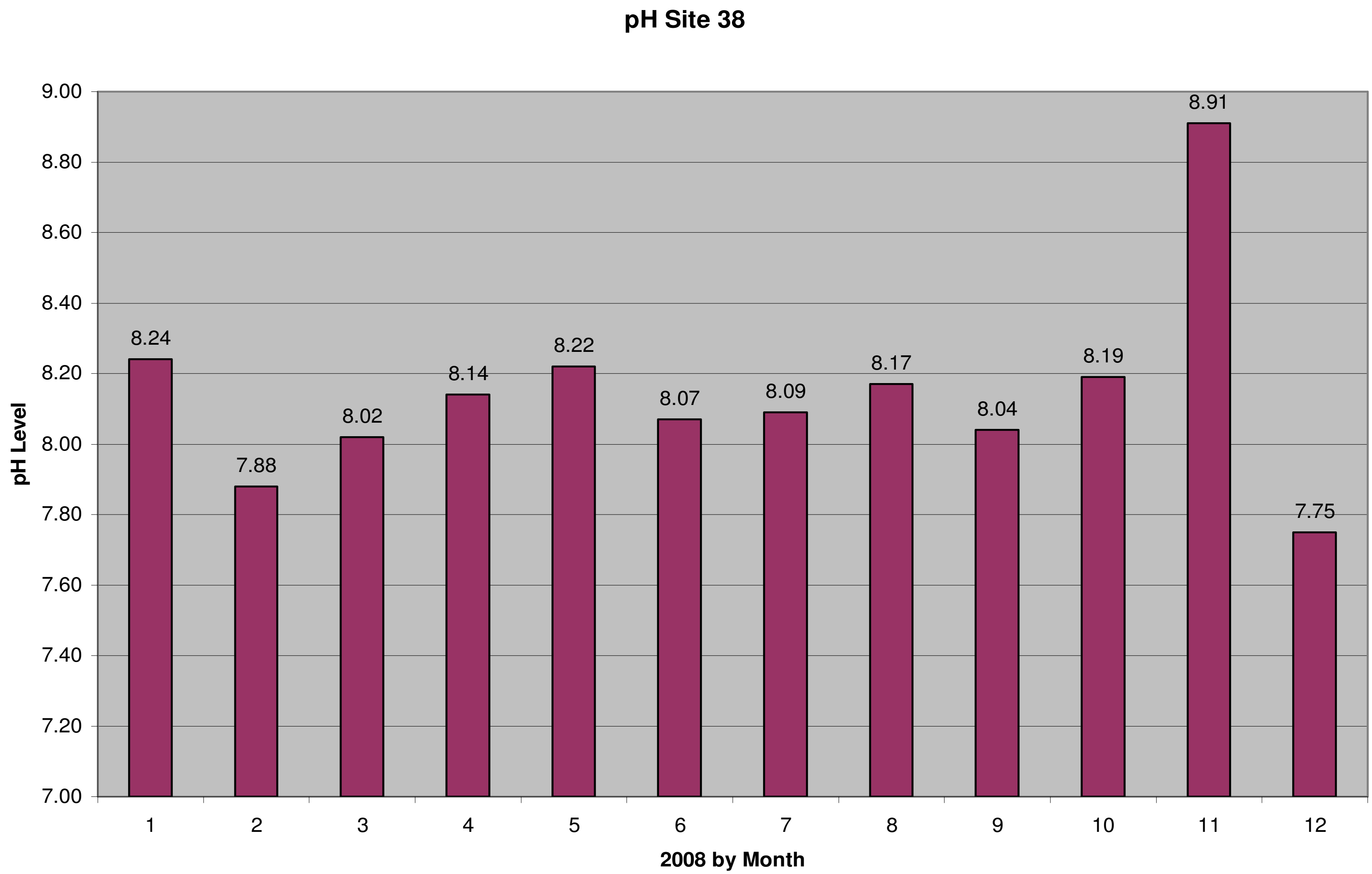

Figure 29: Monthly pH for site 38 with 8.14 as the yearly average.

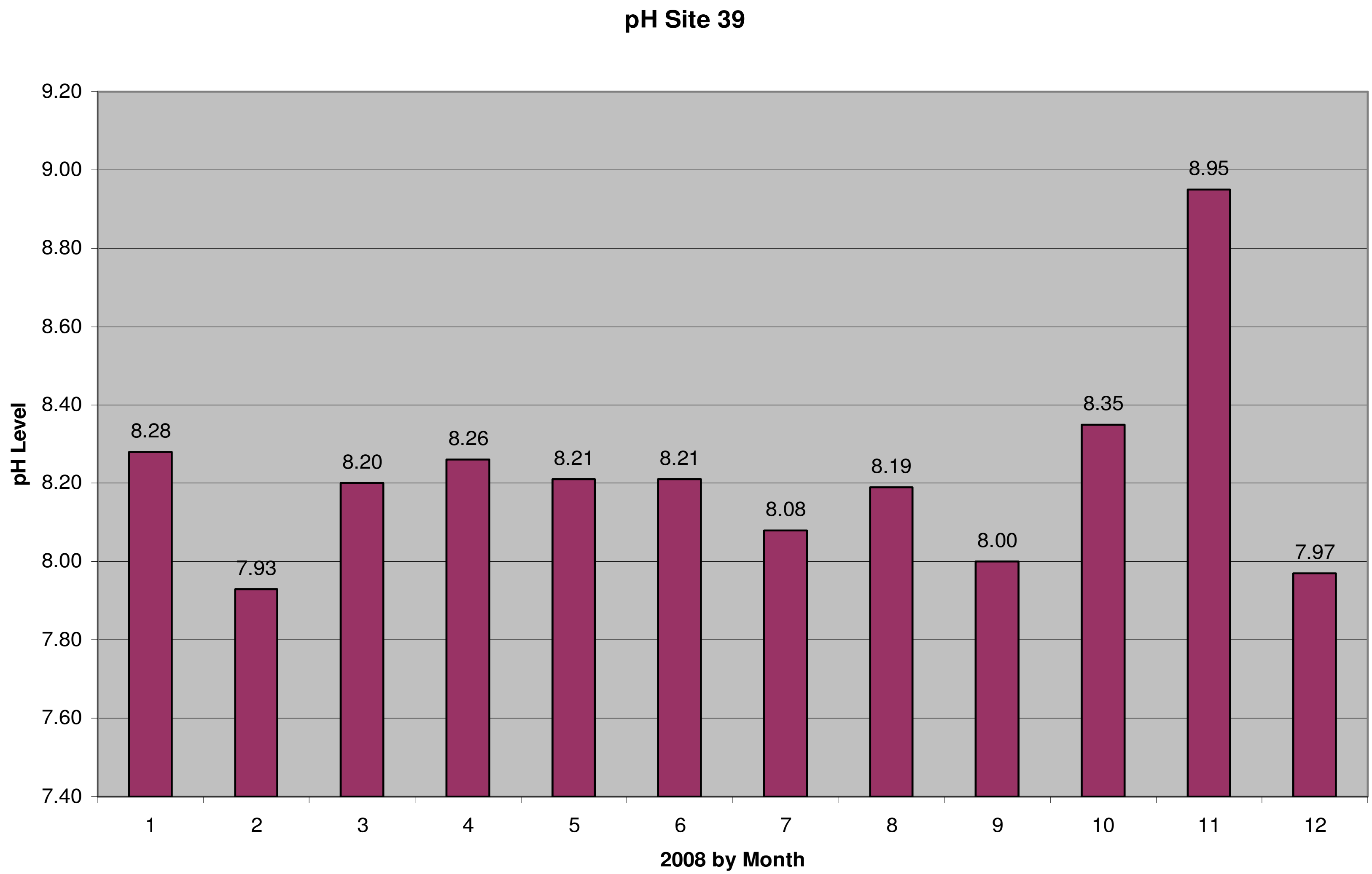

Figure 30: Monthly pH for site 39 with 8.22 as the yearly average.

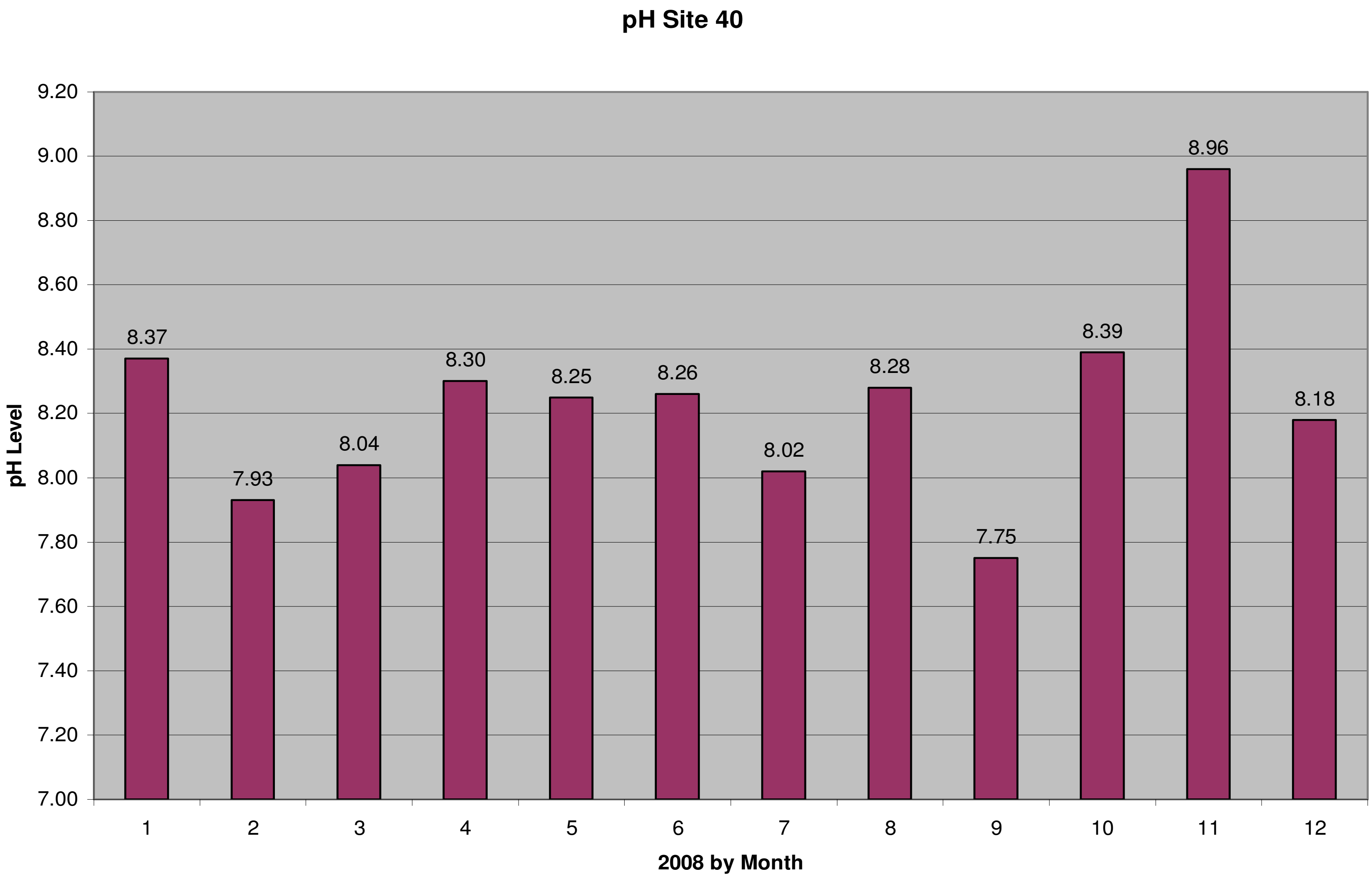

Figure 31: Monthly pH for site 40 with 8.23 as the yearly average.

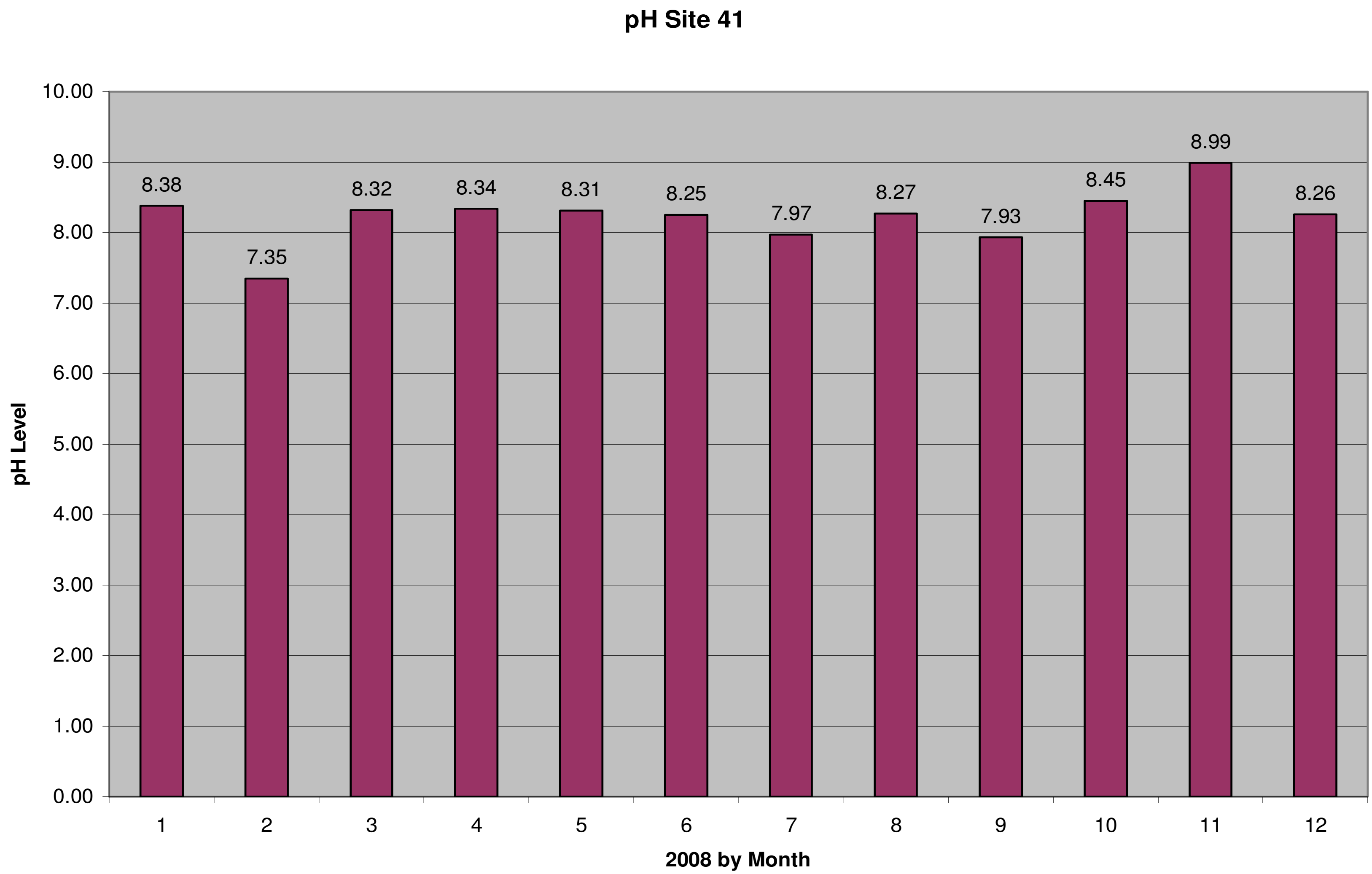

Figure 32: Monthly pH for site 41 with 8.24 as the yearly average.

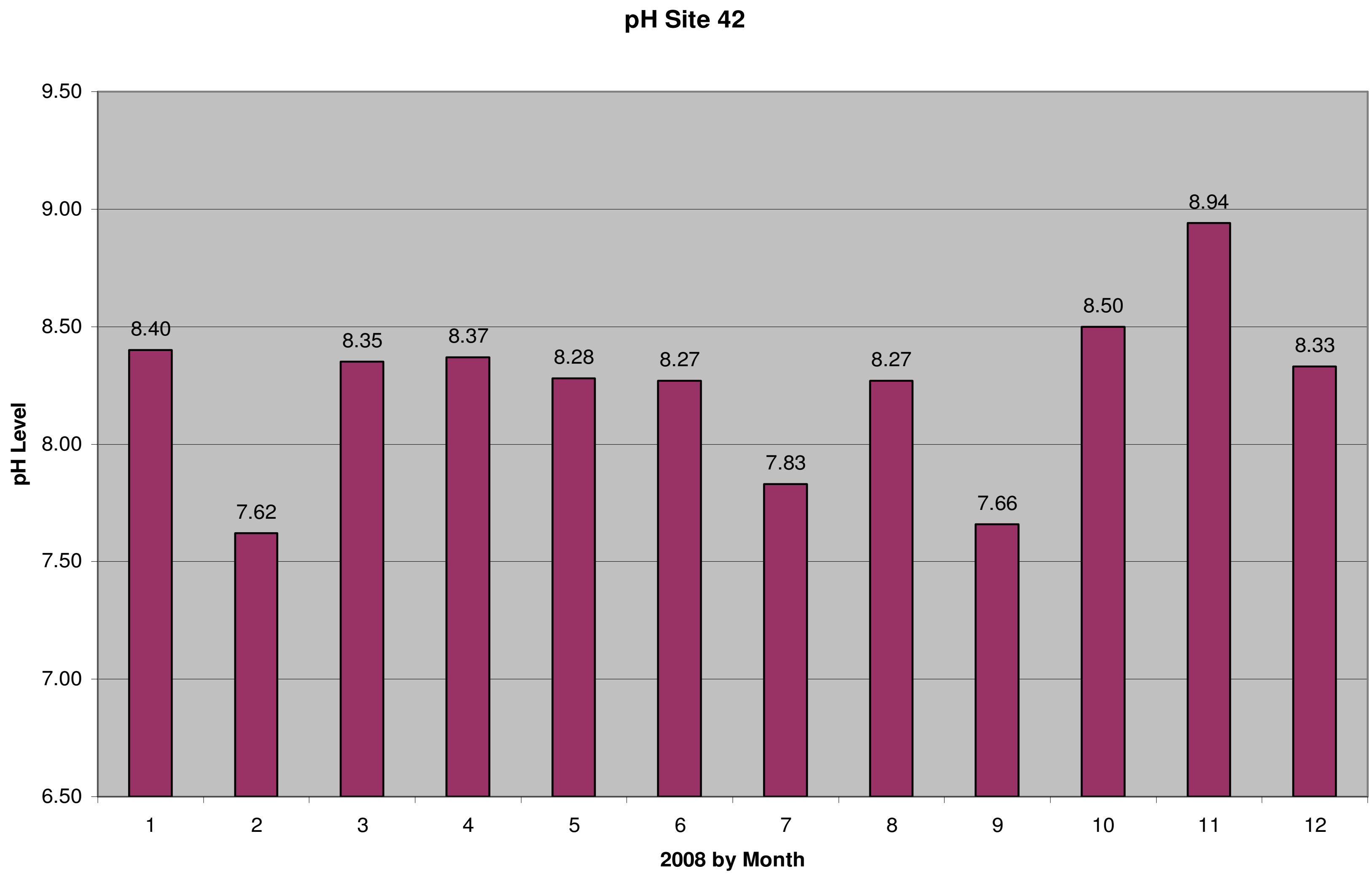

Figure 33: Monthly pH for site 42 with 8.24 as the yearly average.

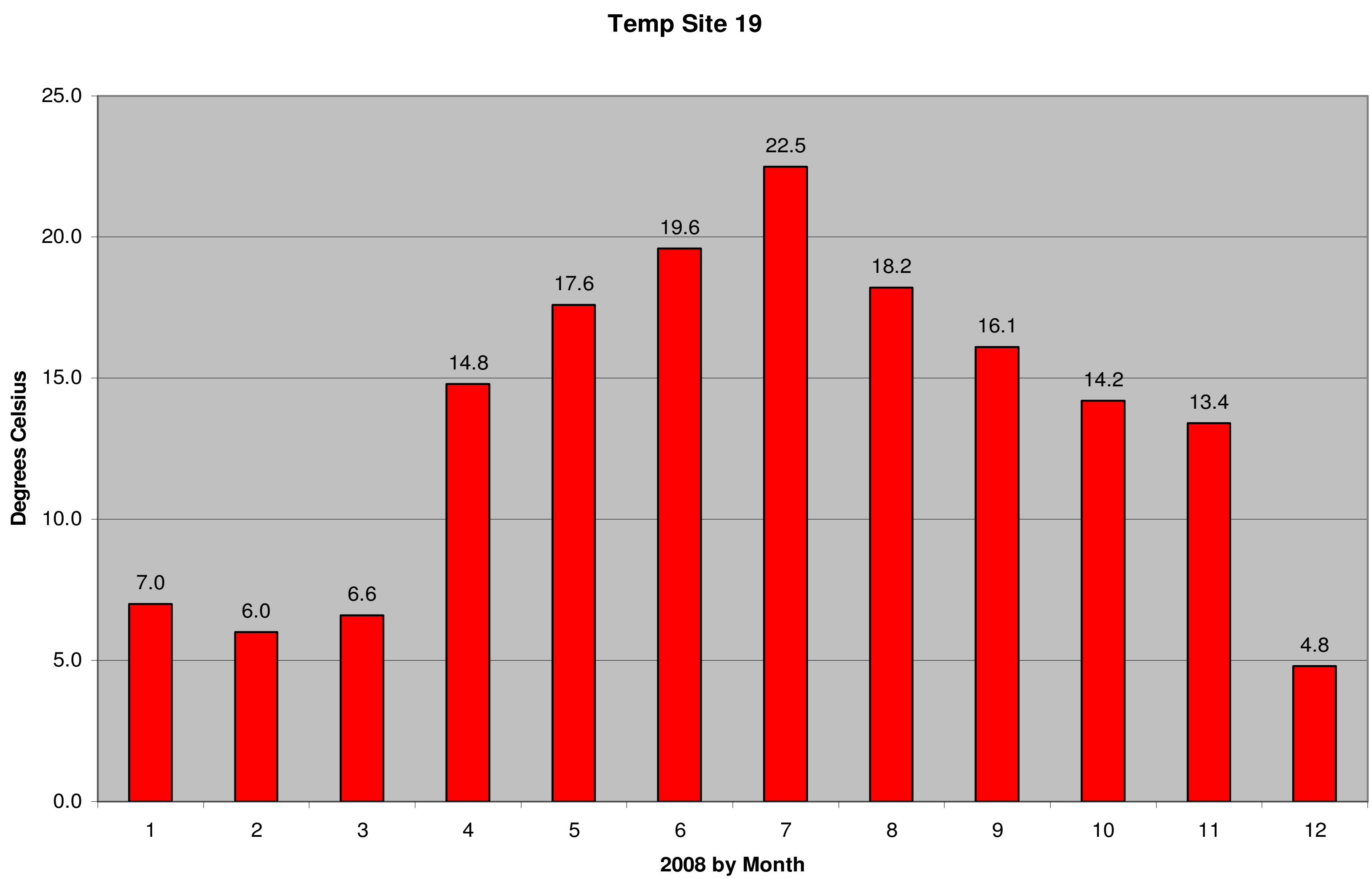

Figure 34: Monthly temperature for site 19 with 13.4 degrees Celsius as the yearly average.

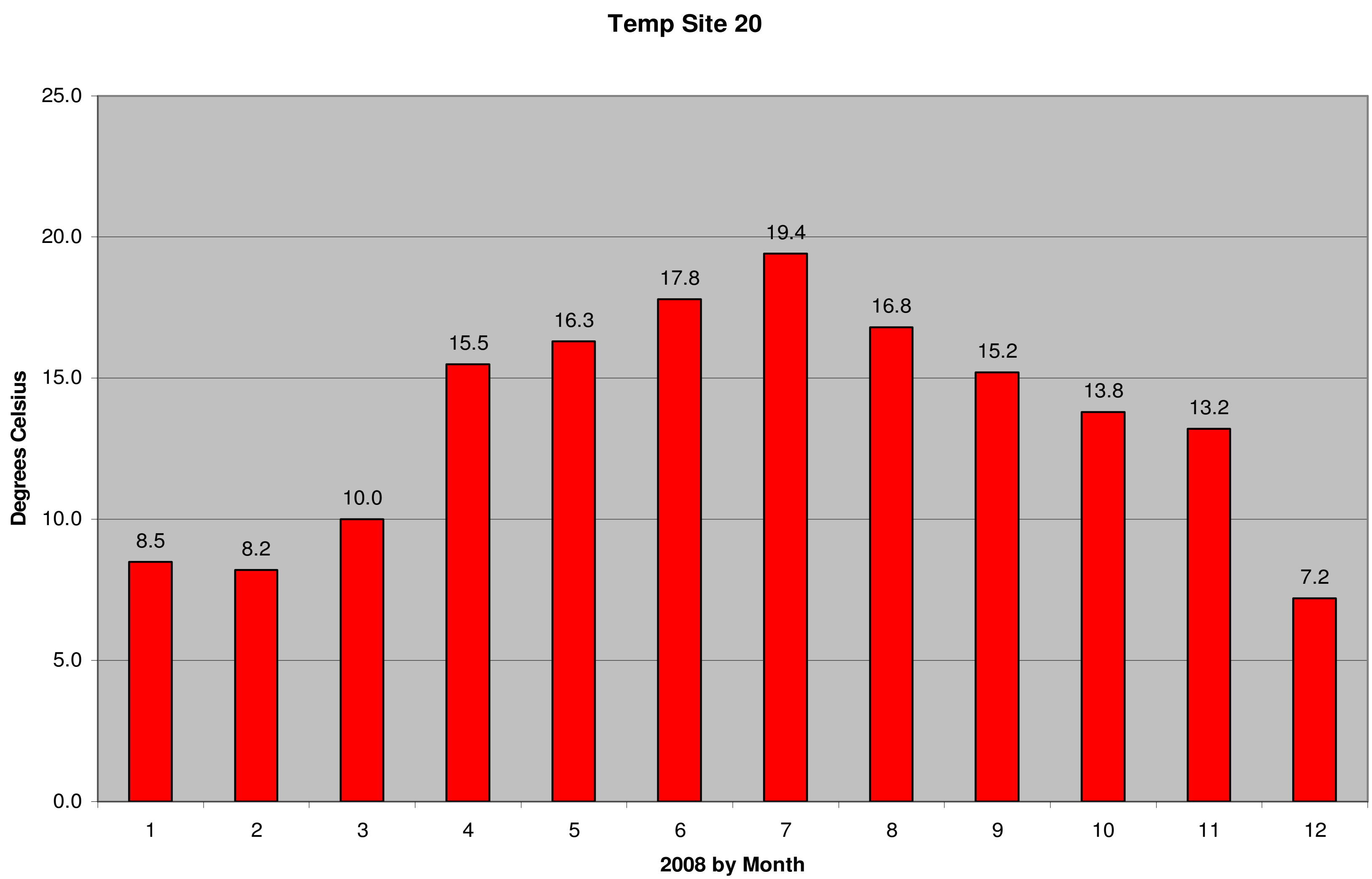

Figure 35: Monthly temperature for site 20 with 13.5 degrees Celsius as the yearly average.

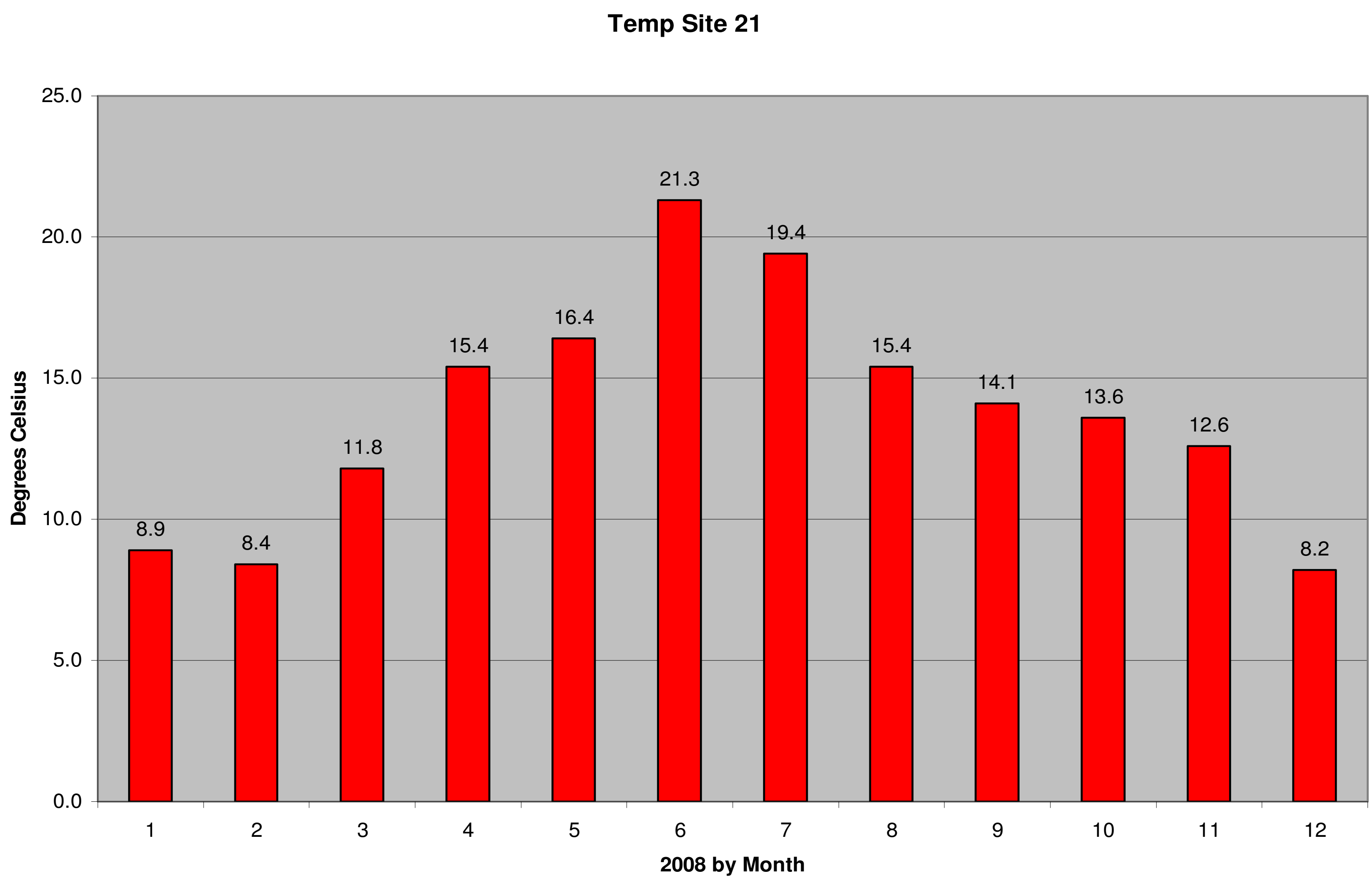

Figure 36: Monthly temperature for site 21 with 13.8 degrees Celsius as the yearly average.

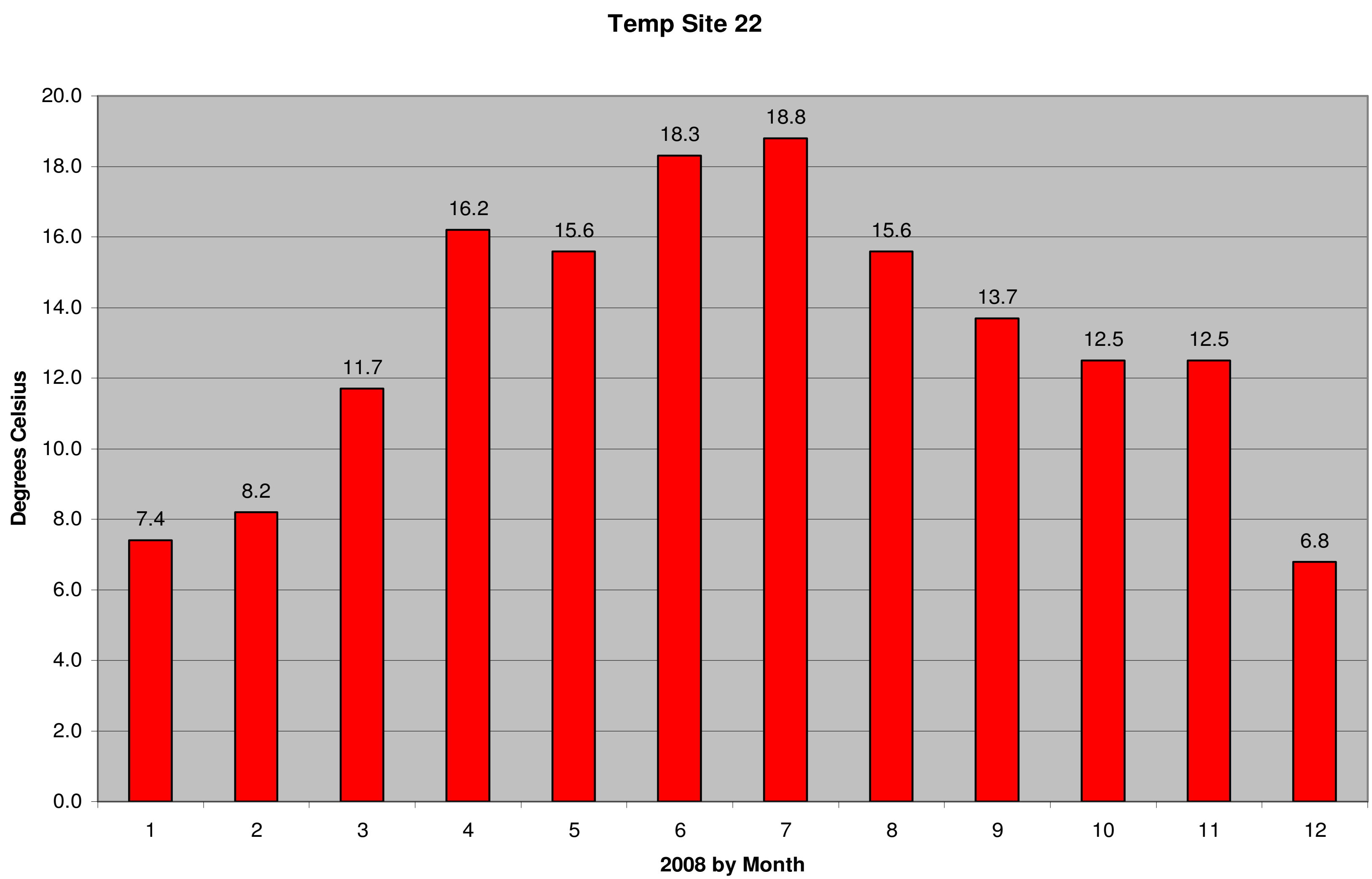

Figure 37: Monthly temperature for site 22 with 13.1 degrees Celsius as the yearly average.

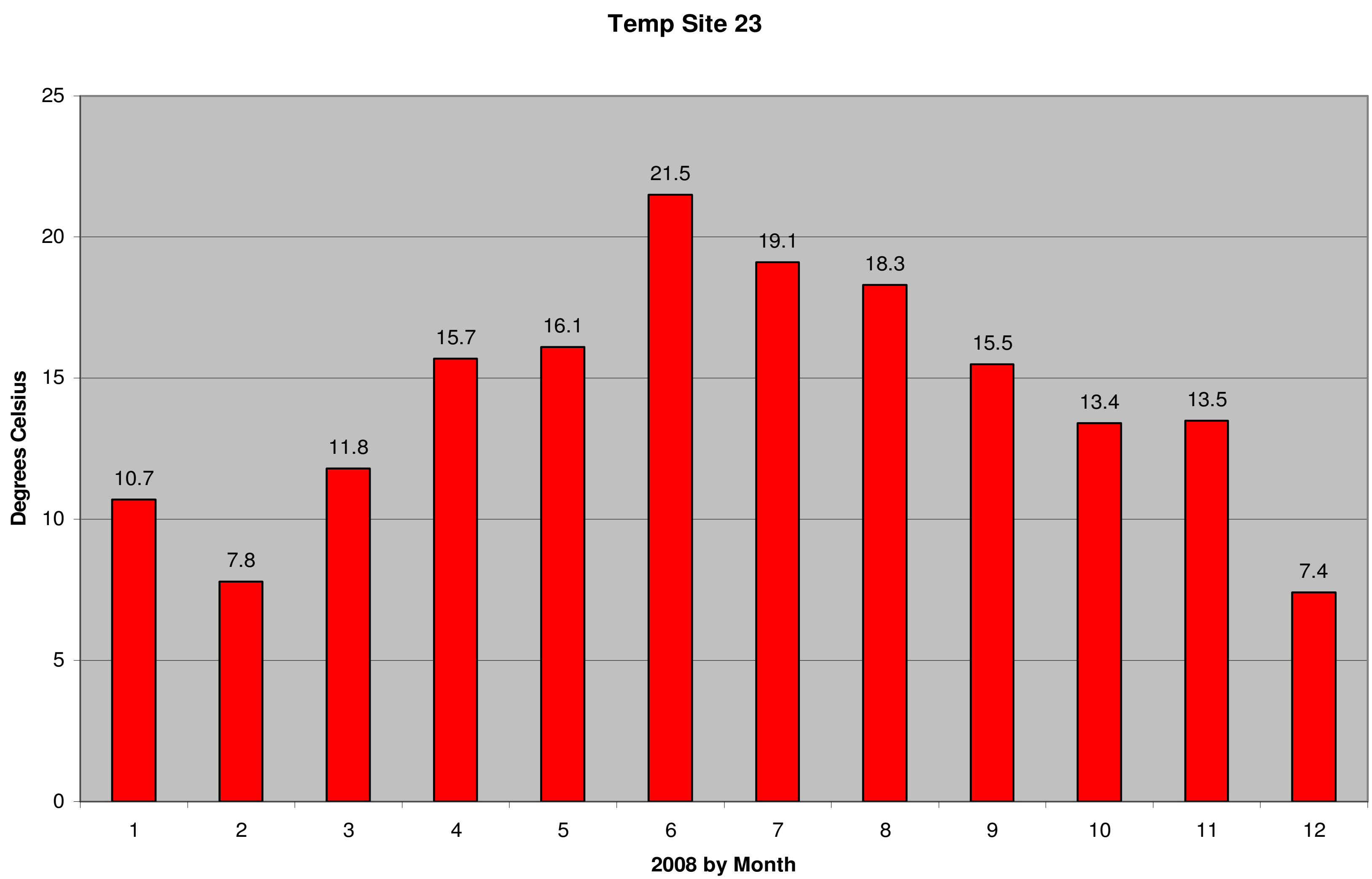

Figure 38: Monthly temperature for site 23 with 14.2 degrees Celsius as the yearly average.

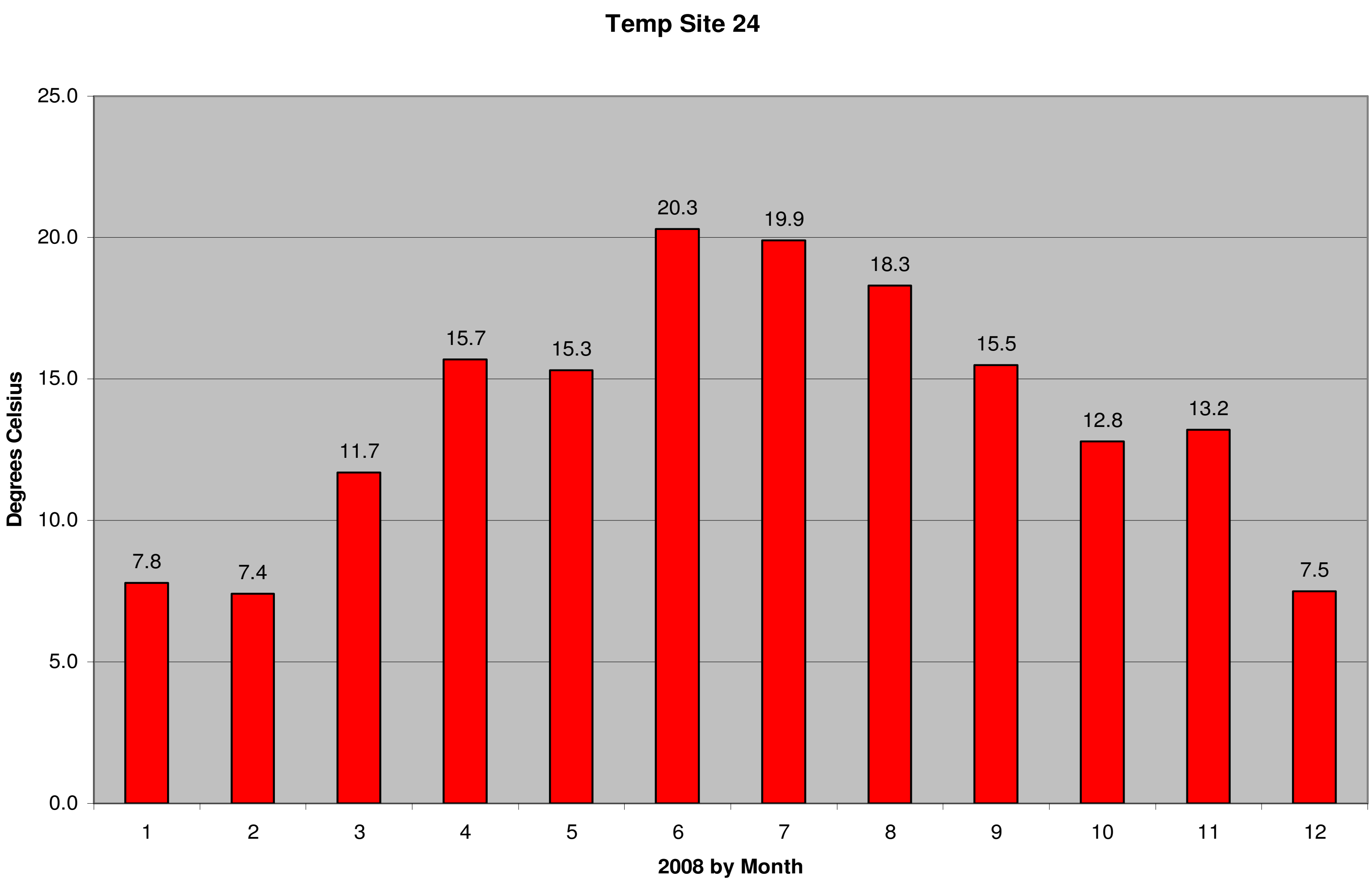

Figure 39: Monthly temperature for site 24 with 13.8 degrees Celsius as the yearly average.

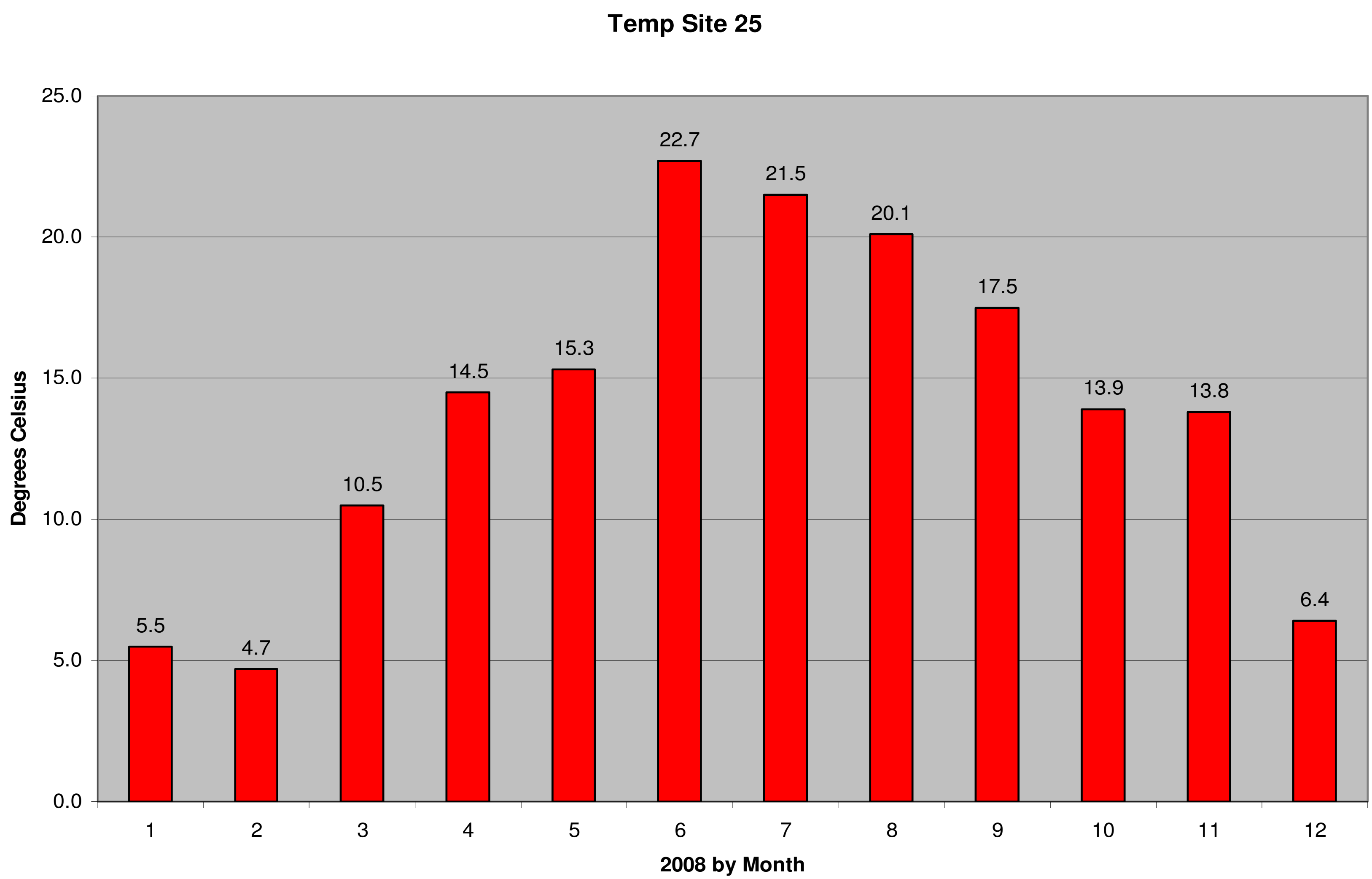

Figure 40: Monthly temperature for site 25 with 13.9 degrees Celsius as the yearly average.

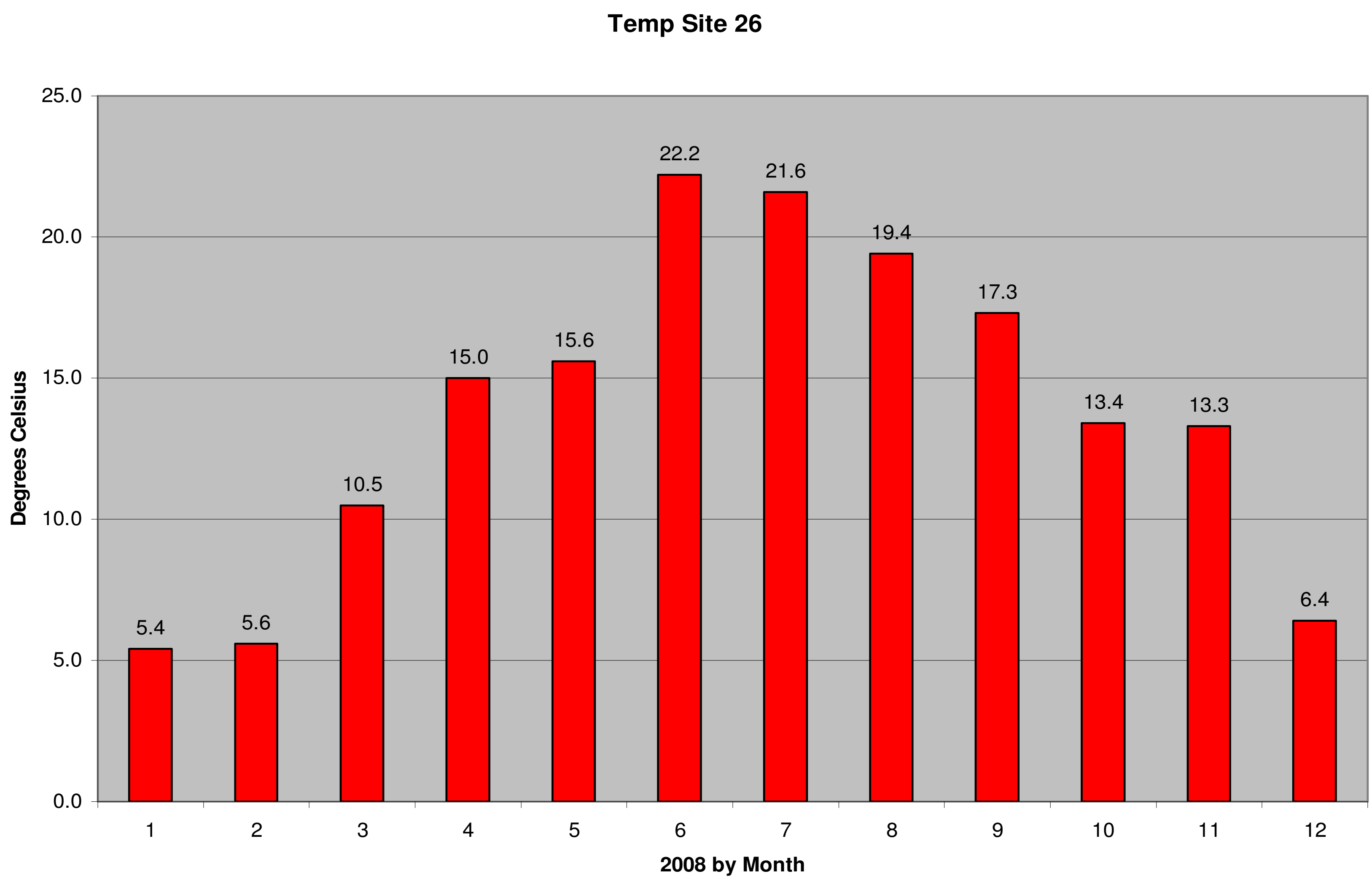

Figure 41: Monthly temperature for site 26 with 13.6 degrees Celsius as the yearly average.

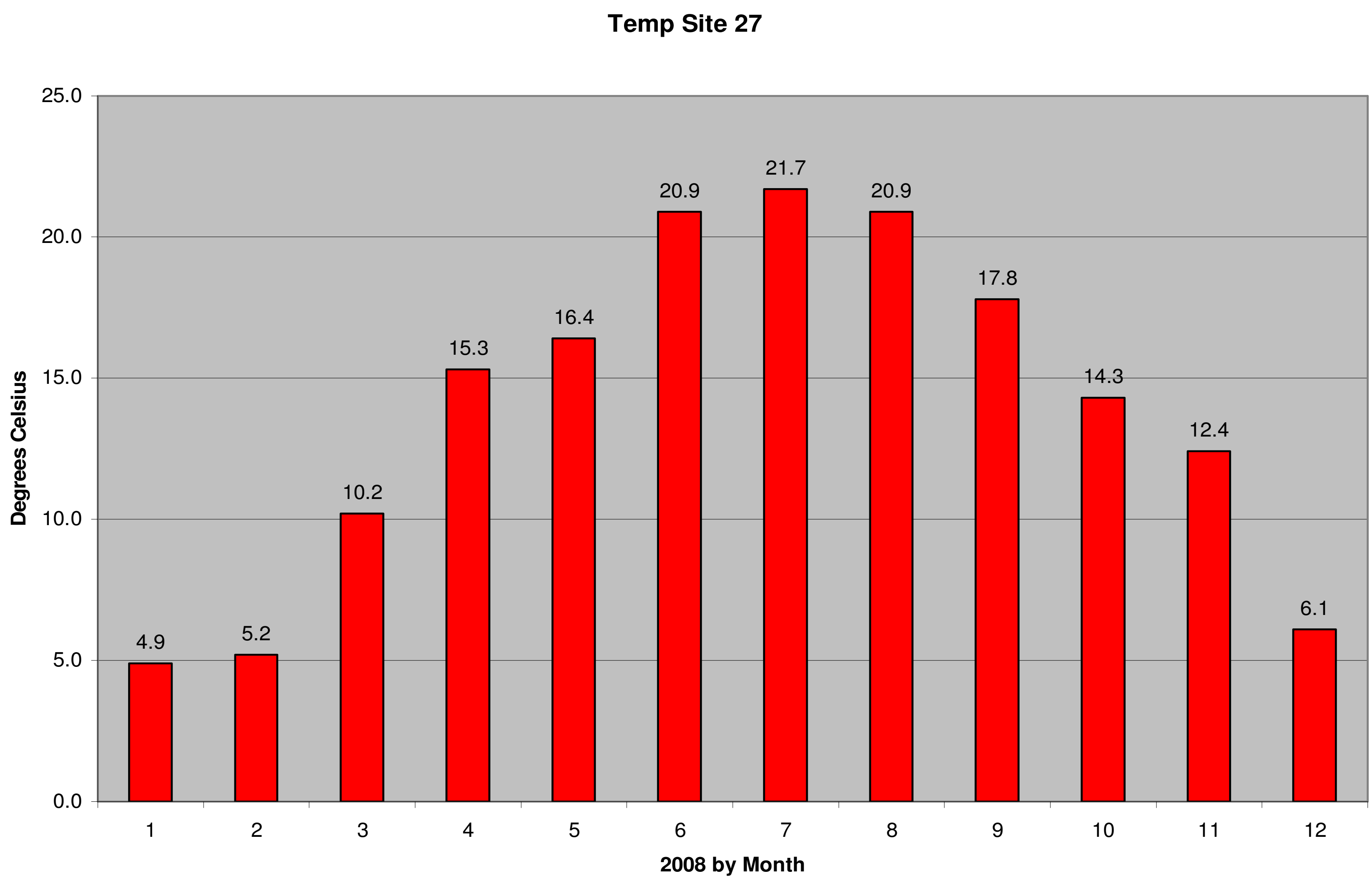

Figure 42: Monthly temperature for site 27 with 13.8 degrees Celsius as the yearly average.

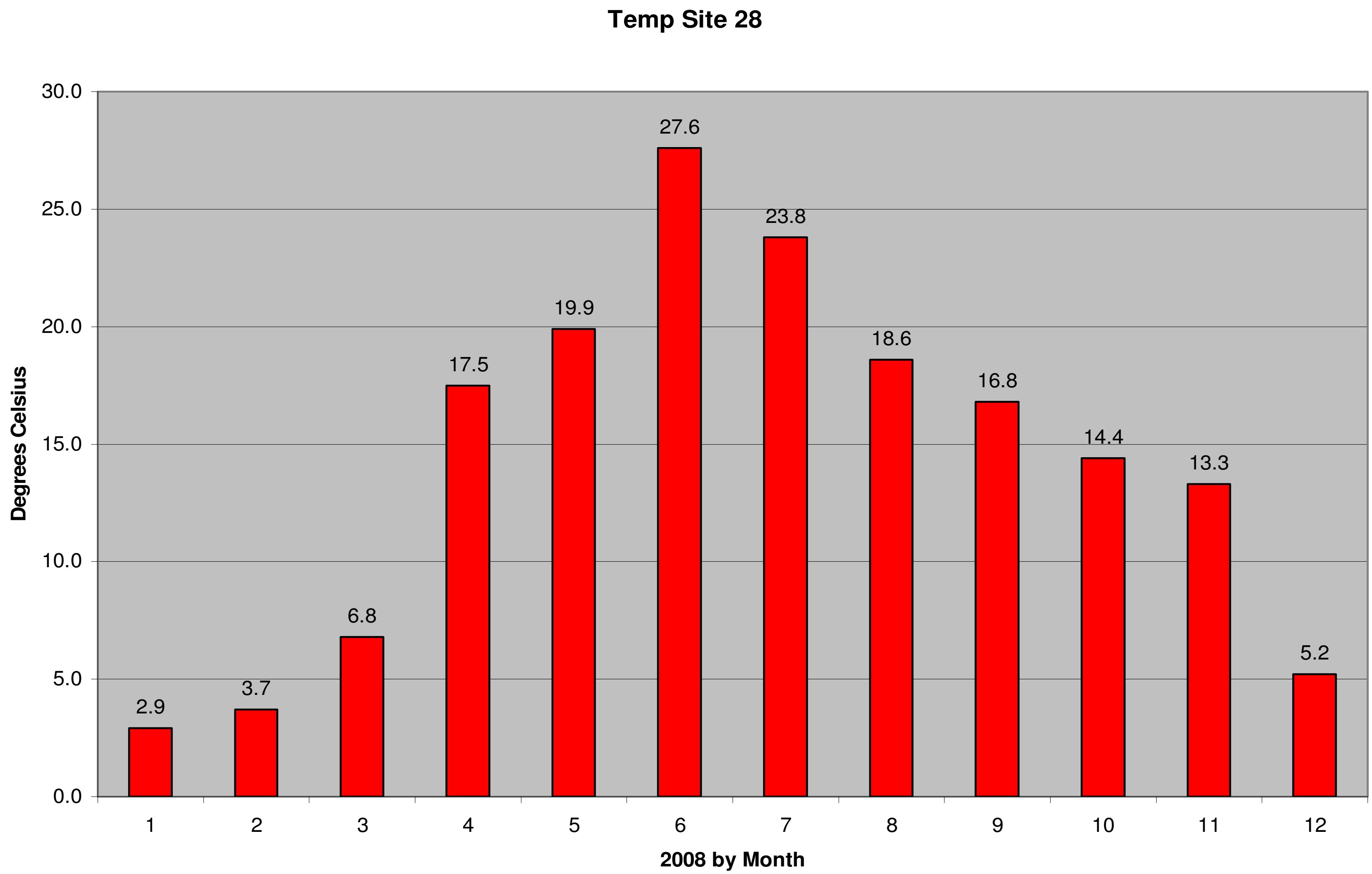

Figure 43: Monthly temperature for site 28 with 14.2 degrees Celsius as the yearly average.

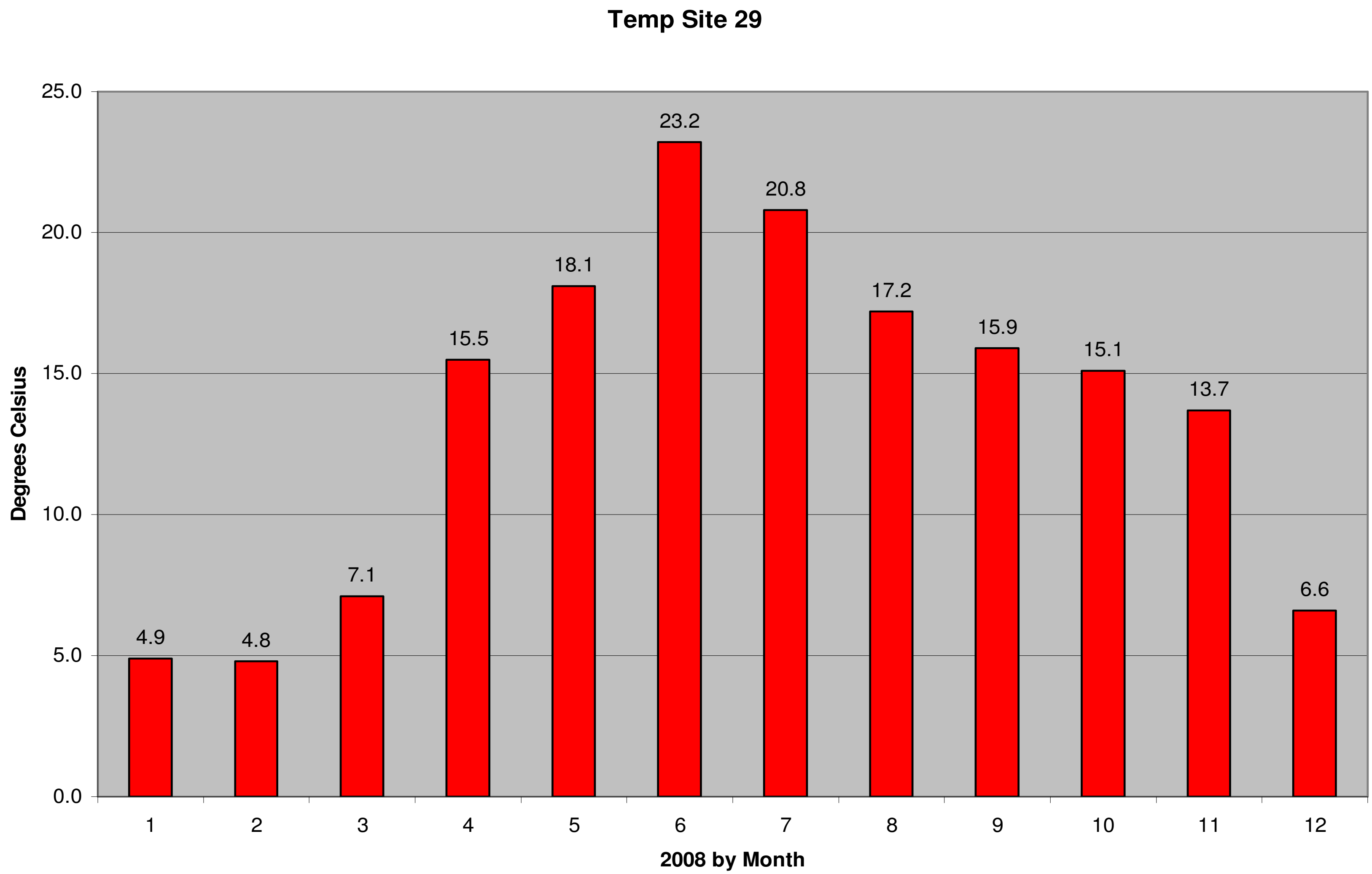

Figure 44: Monthly temperature for site 29 with 13.6 degrees Celsius as the yearly average.

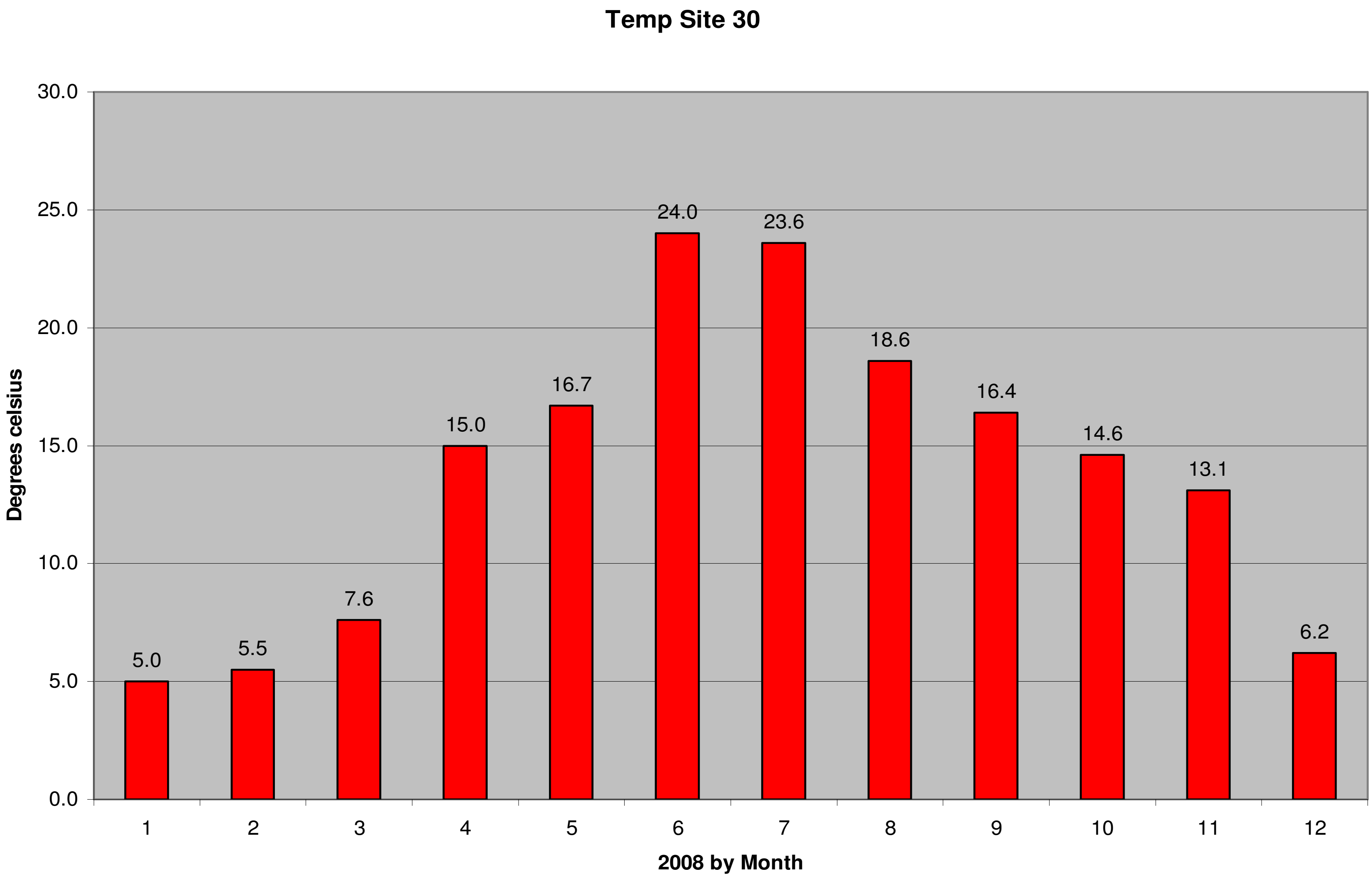

Figure 45: Monthly temperature for site 30 with 13.9 degrees Celsius as the yearly average.

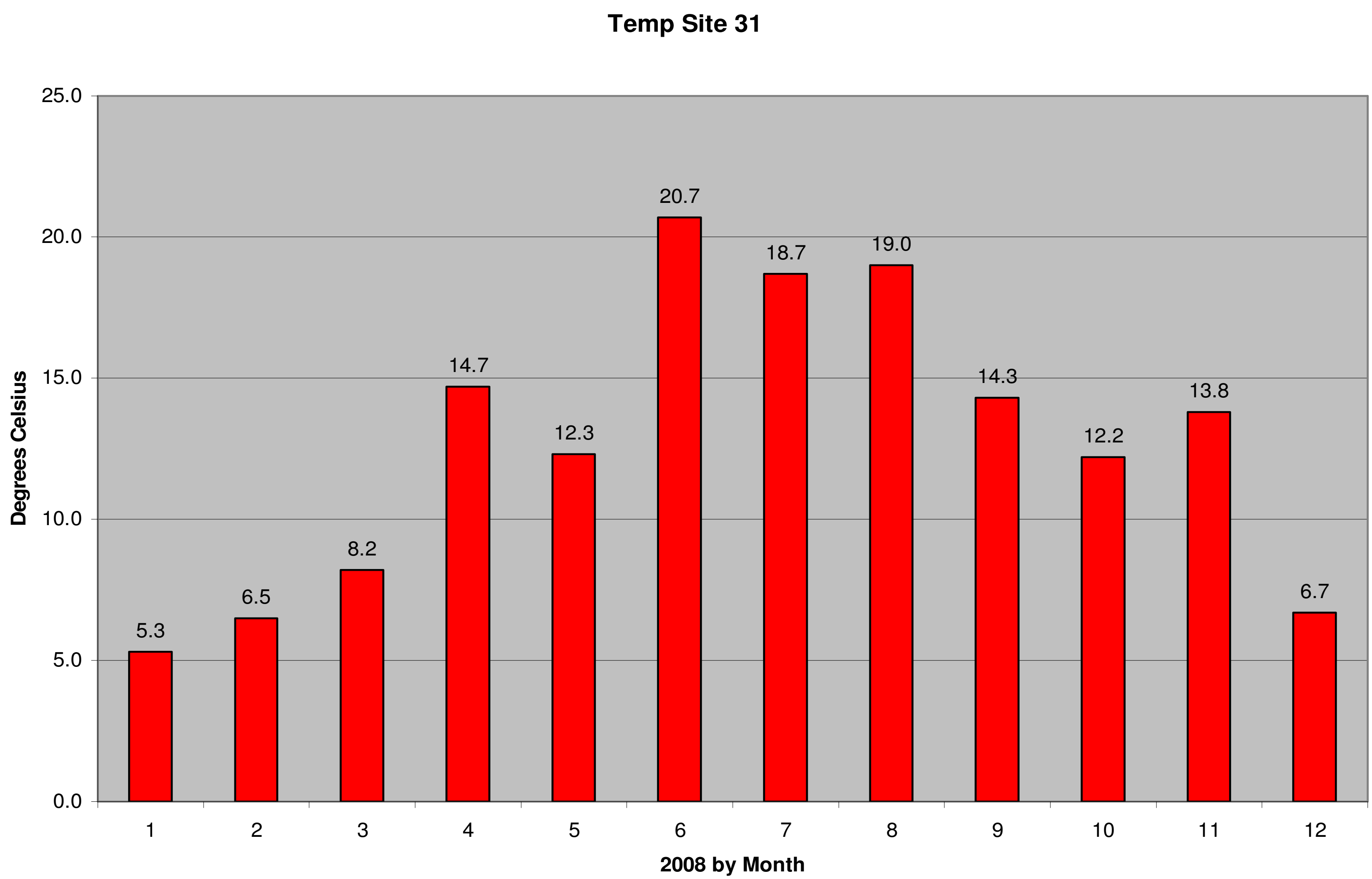

Figure 46: Monthly temperature for site 31 with 12.7 degrees Celsius as the yearly average.

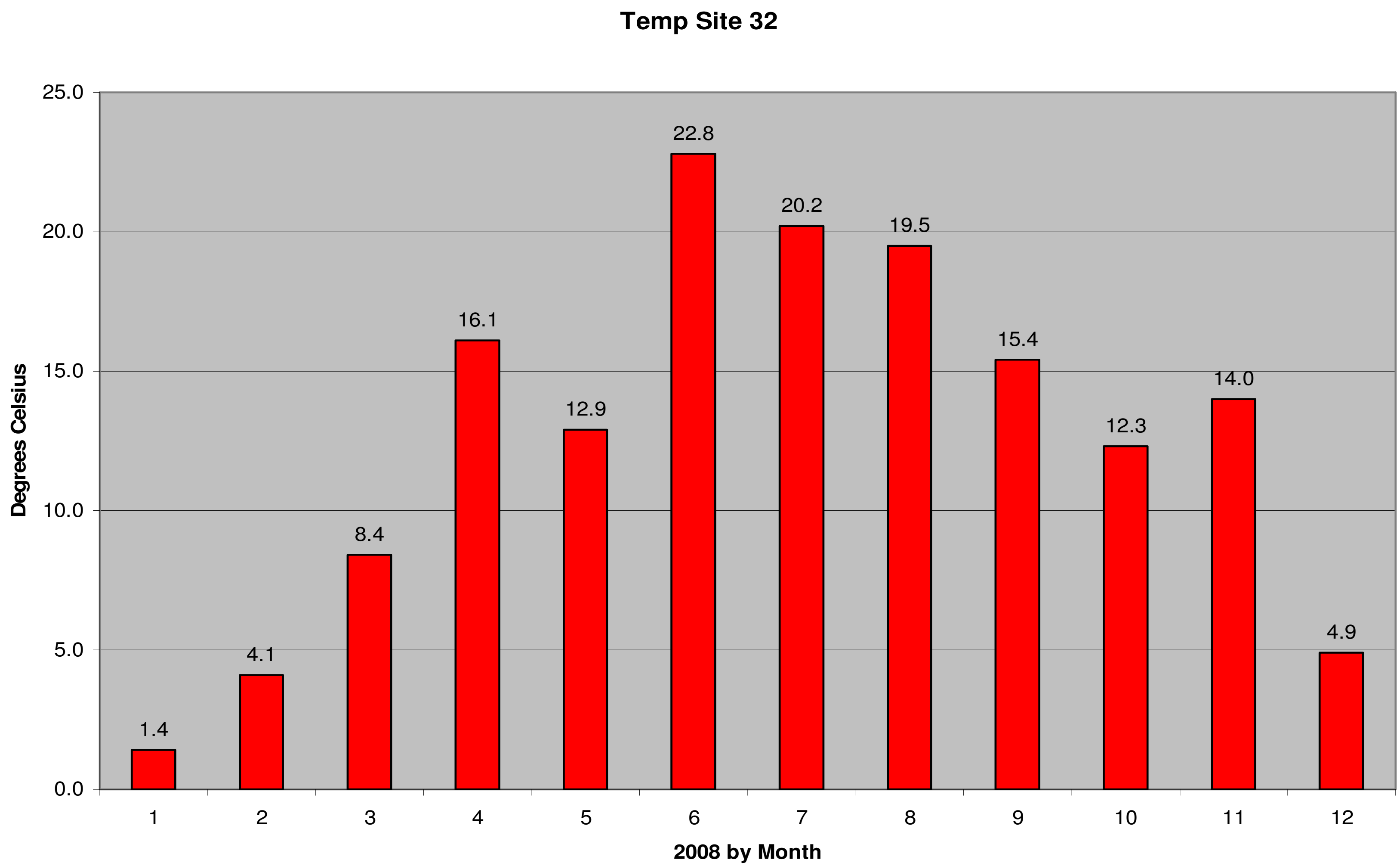

Figure 47: Monthly temperature for site 32 with 12.7 degrees Celsius as the yearly average.

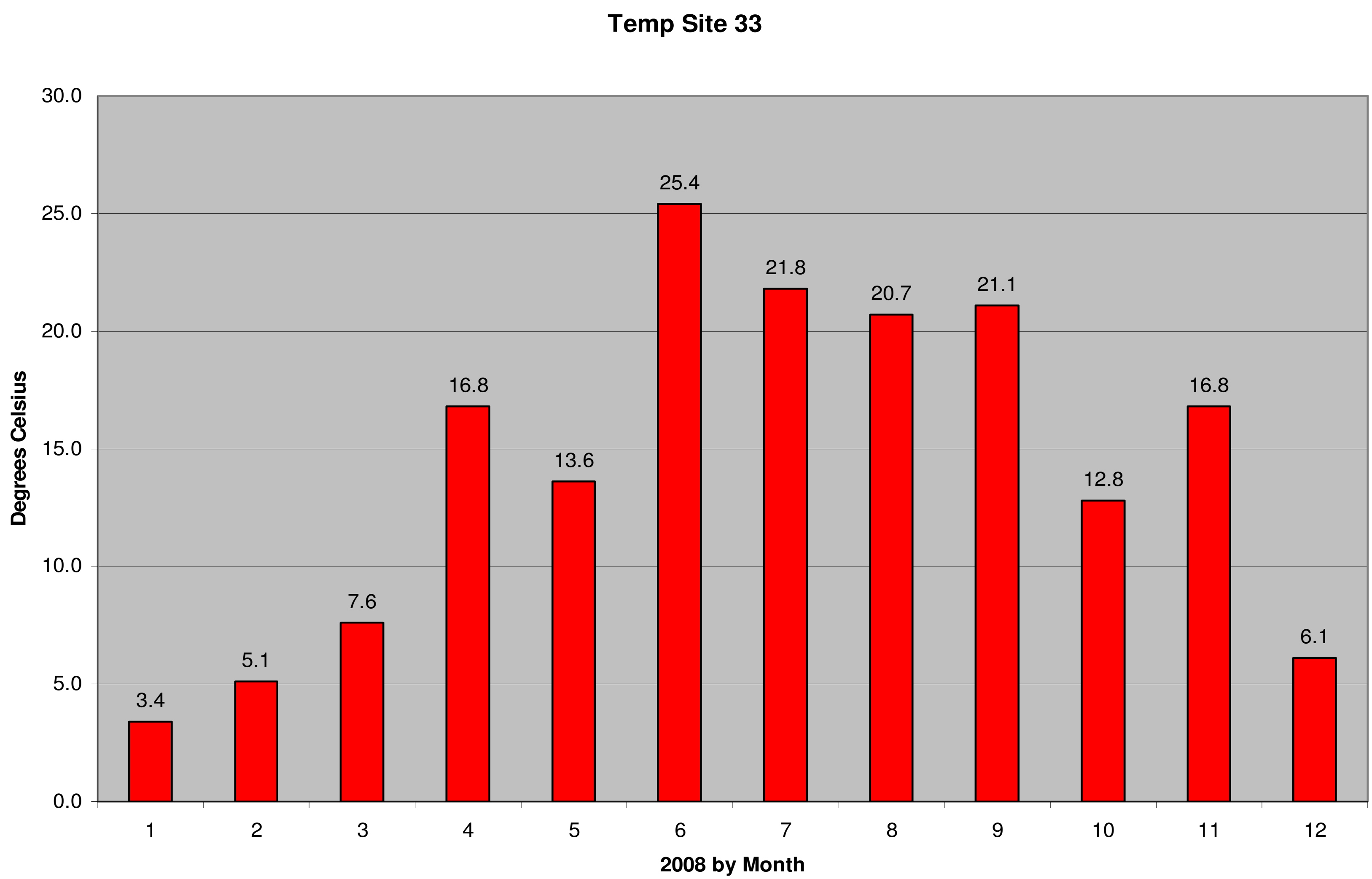

Figure 48: Monthly temperature for site 33 with 14.3 degrees Celsius as the yearly average.

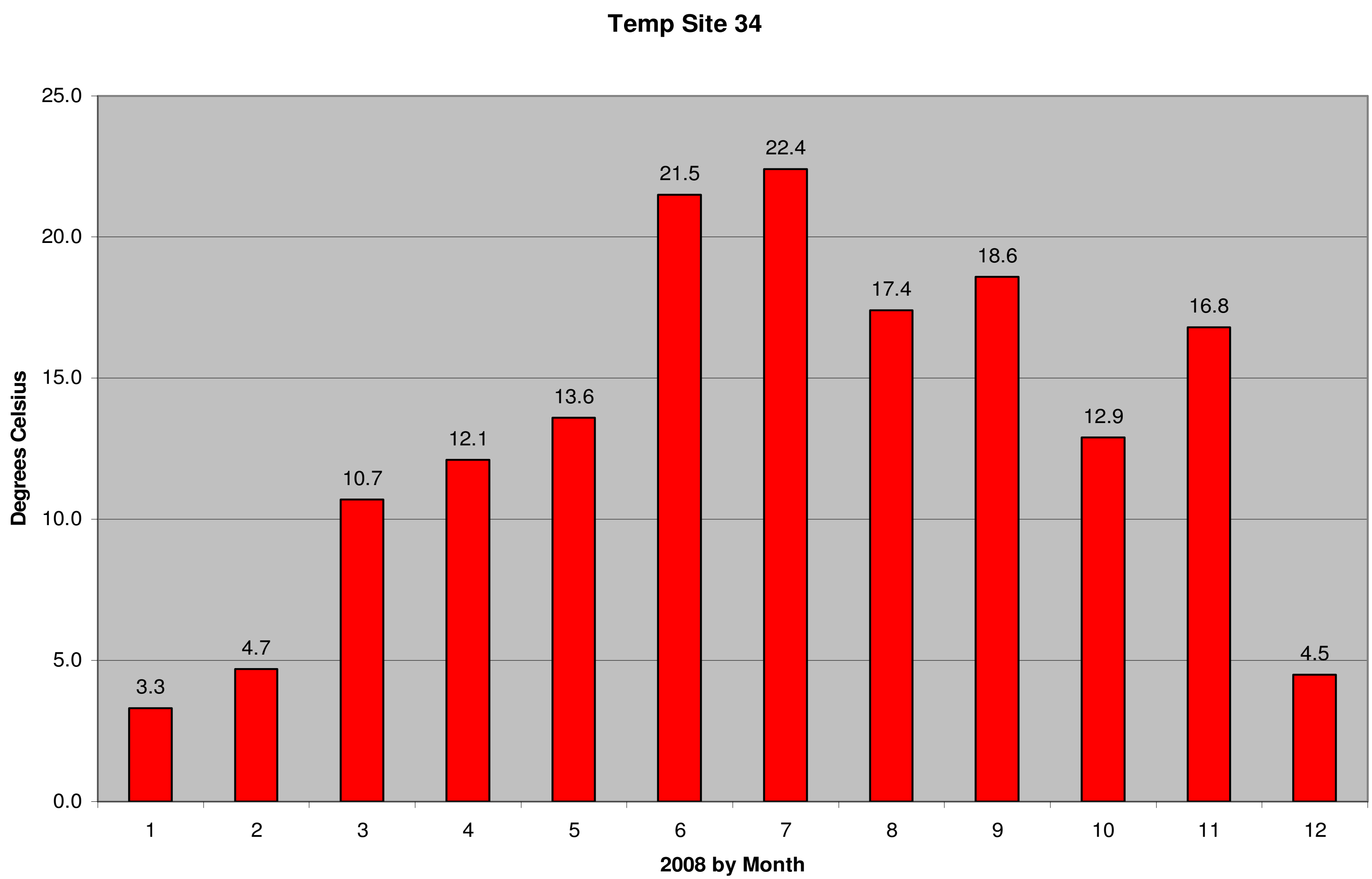

Figure 49: Monthly temperature for site 34 with 13.2 degrees Celsius as the yearly average.

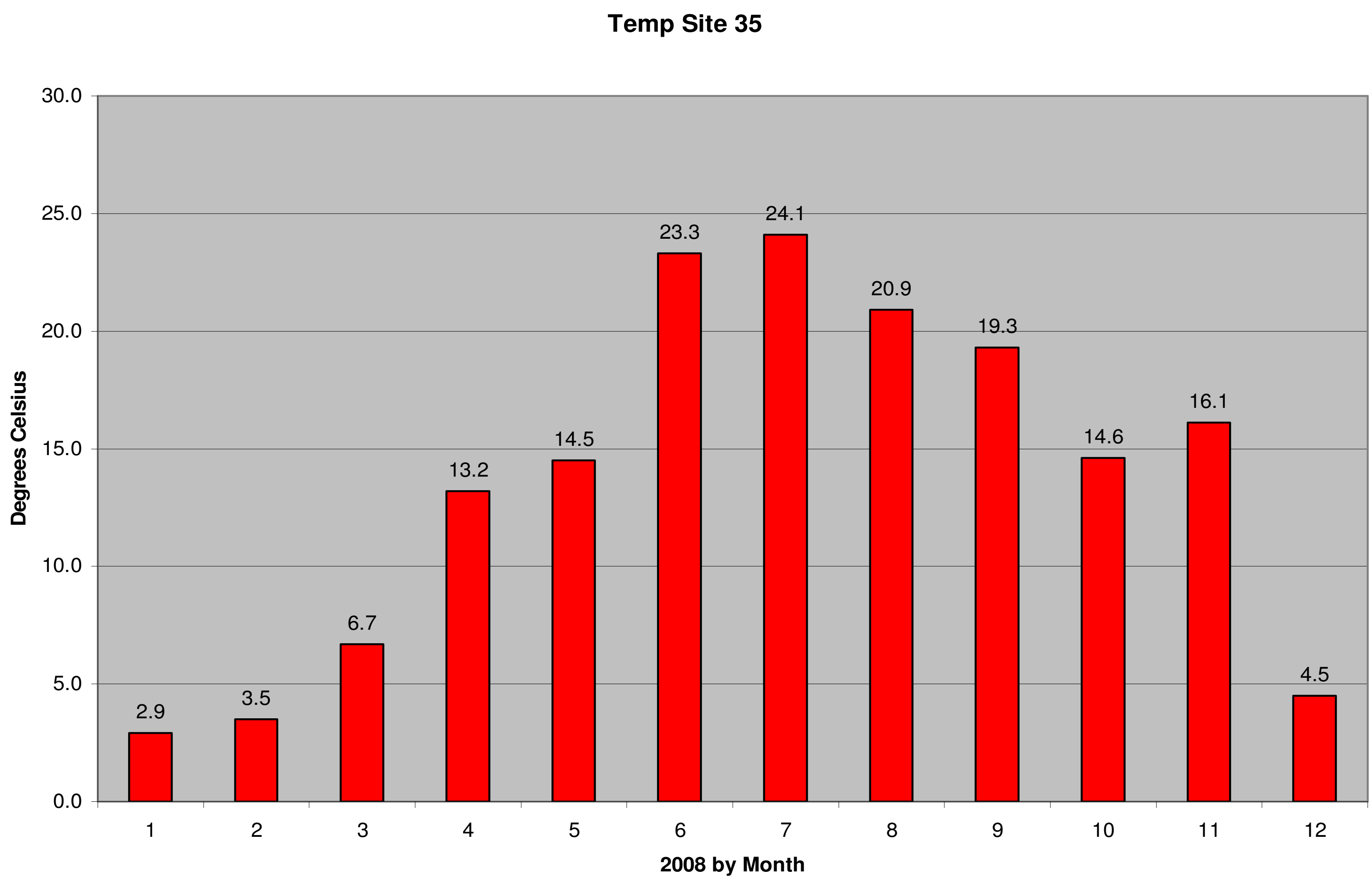

Figure 50: Monthly temperature for site 35 with 13.6 degrees Celsius as the yearly average.

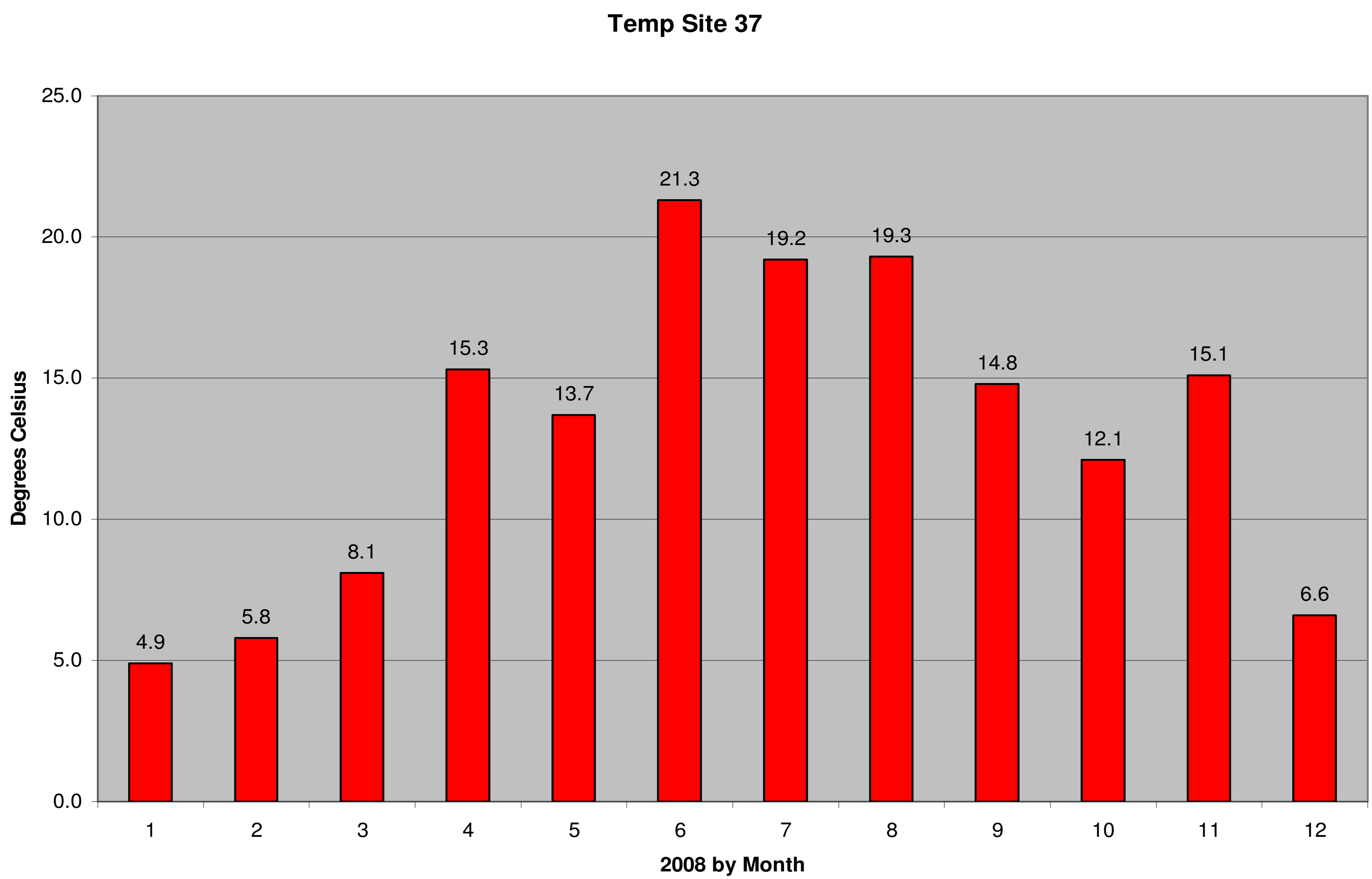

Figure 51: Monthly temperature for site 37 with 13.0 degrees Celsius as the yearly average.

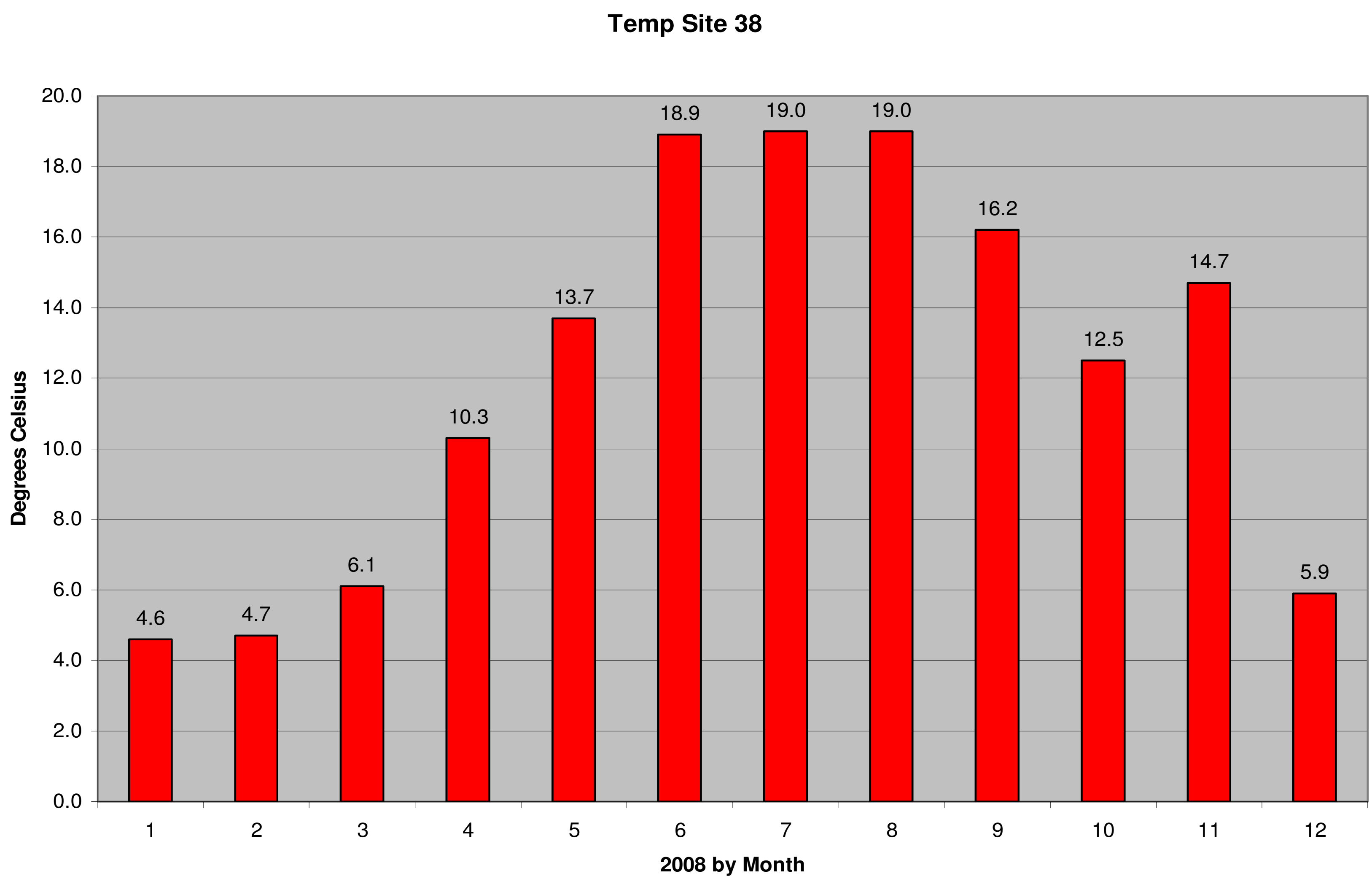

Figure 52: Monthly temperature for site 38 with 12.1 degrees Celsius as the yearly average.

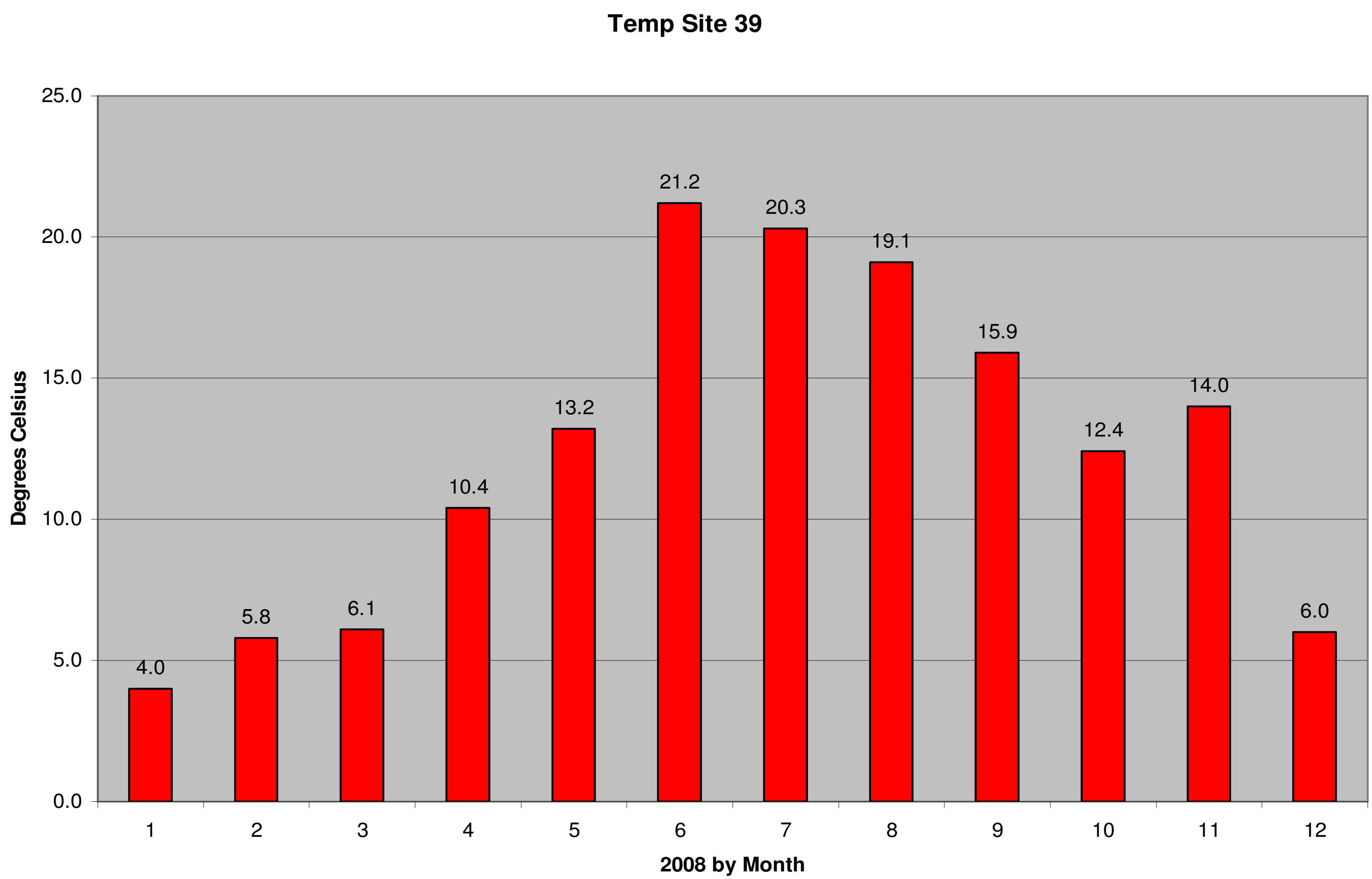

Figure 53: Monthly temperature for site 39 with 12.4 degrees Celsius as the yearly average.

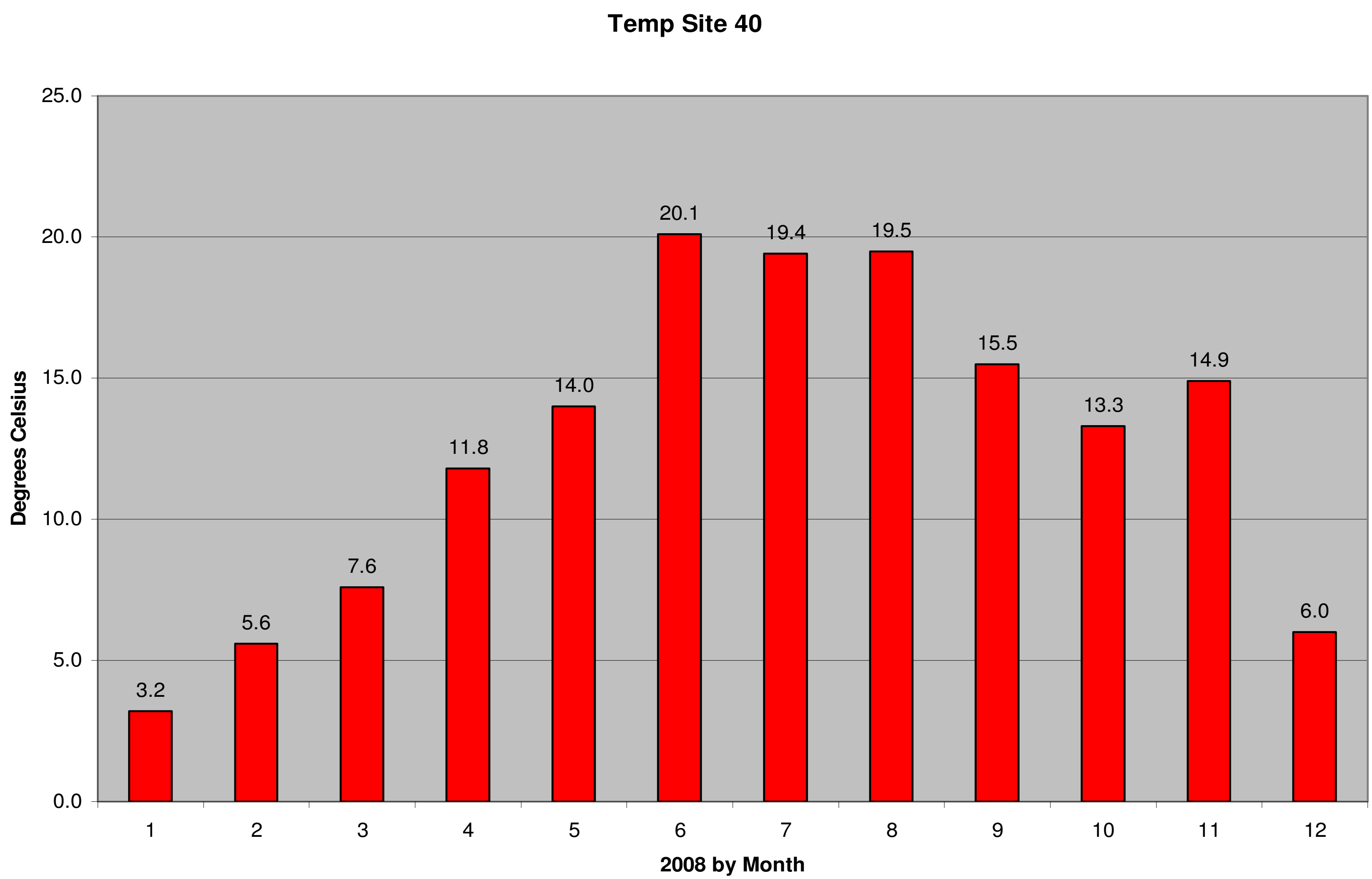

Figure 54: Monthly temperature for site 40 with 12.6 degrees Celsius as the yearly average.

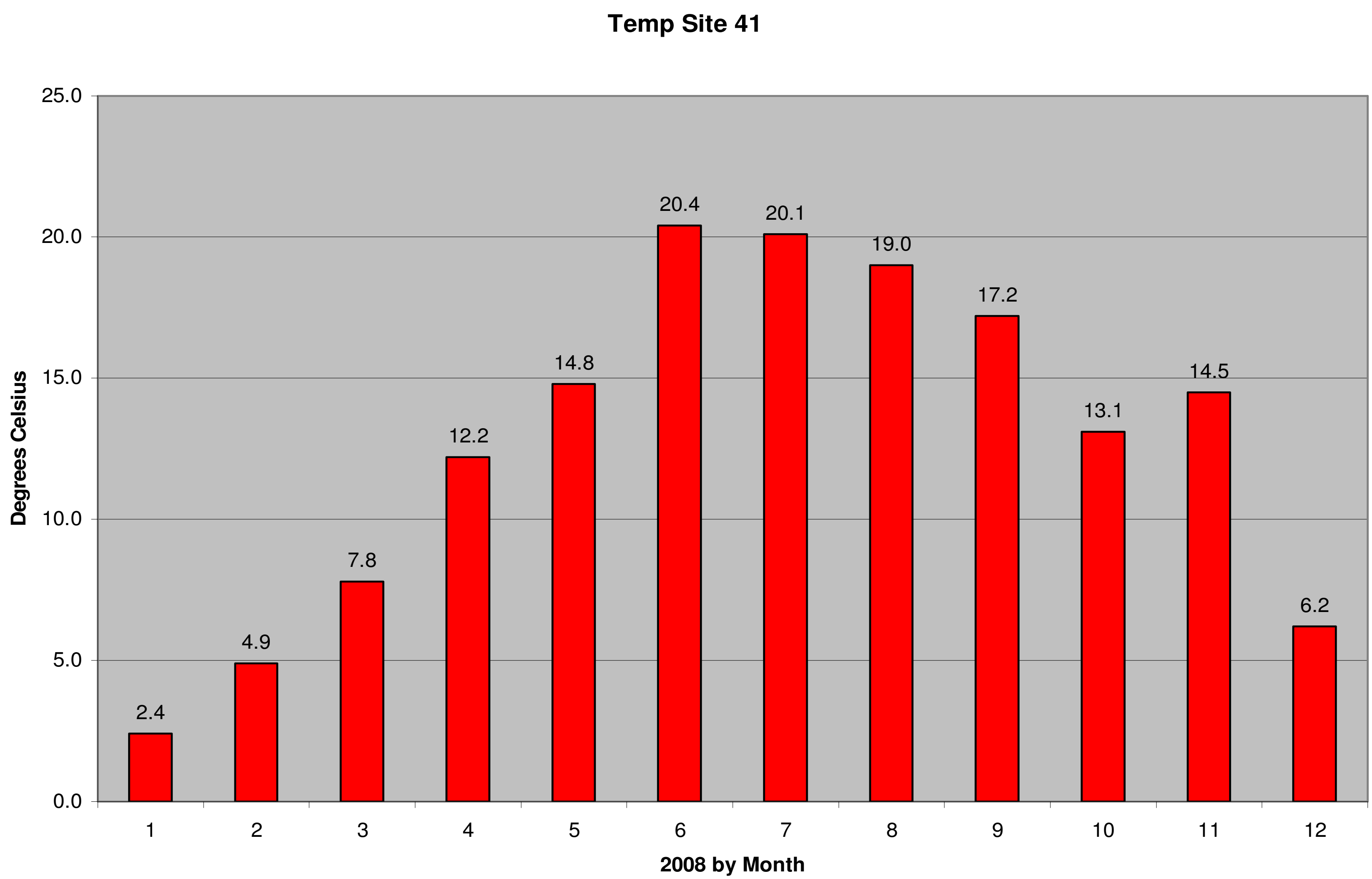

Figure 55: Monthly temperature for site 41 with 12.7 degrees Celsius as the yearly average.

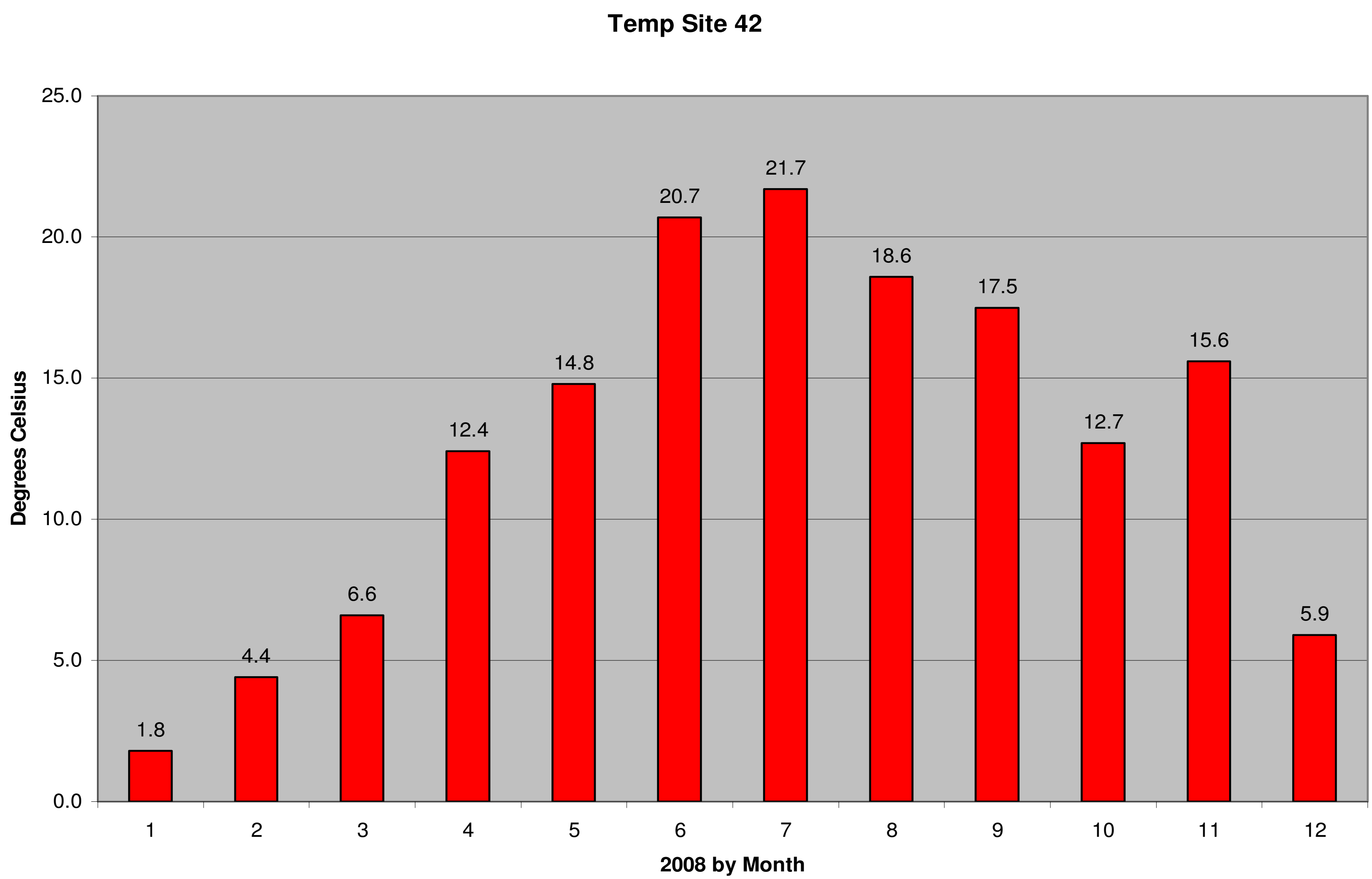

Figure 56: Monthly temperature for site 42 with 12.7 degrees Celsius as the yearly average.

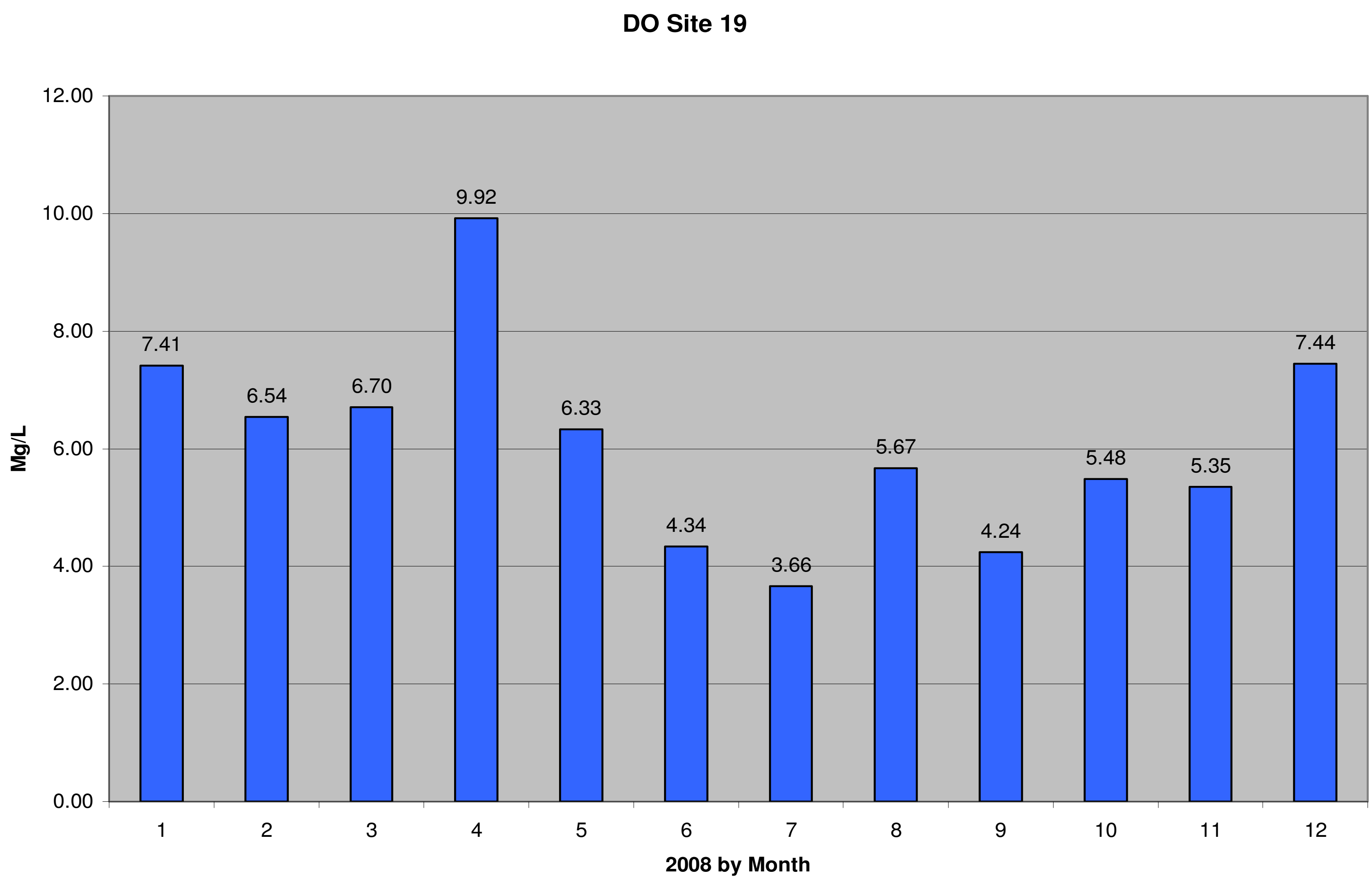

Figure 57: Monthly dissolved oxygen for site 19 with 6.09 milligrams per liter as the yearly average.

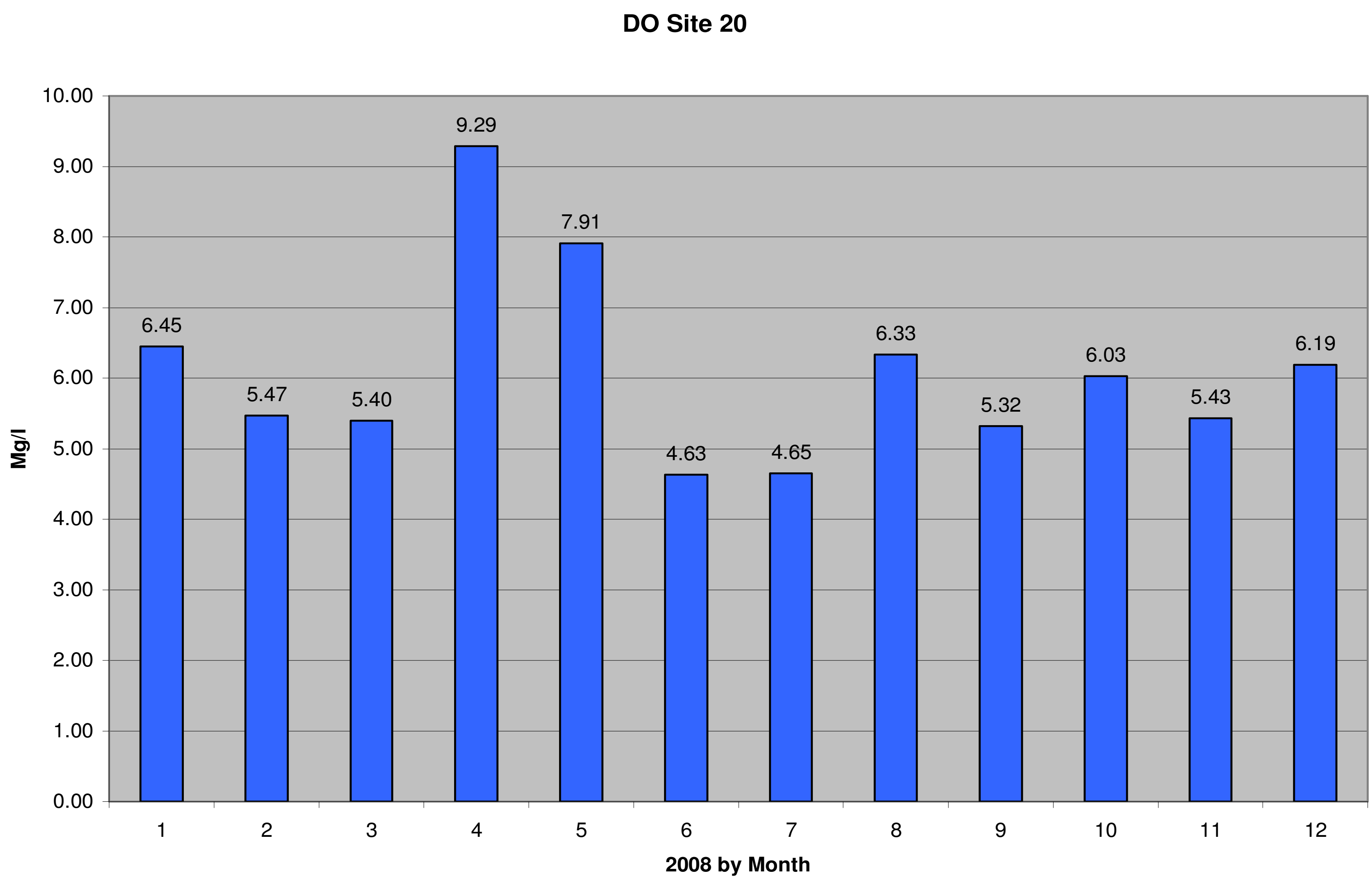

Figure 58: Monthly dissolved oxygen for site 20 with 6.09 milligrams per liter as the yearly average.

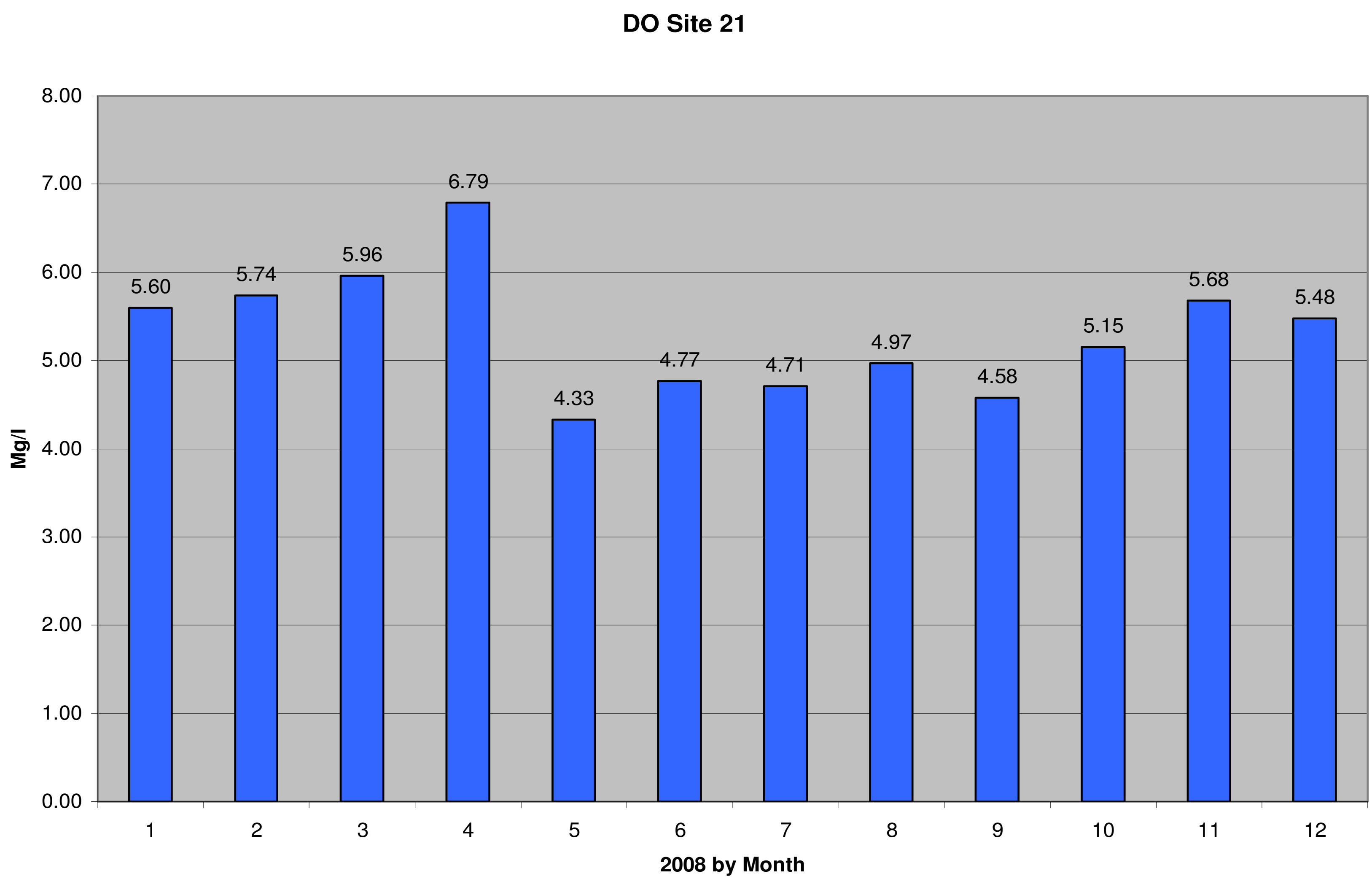

Figure 59: Monthly dissolved oxygen for site 21 with 5.31 milligrams per liter as the yearly average.

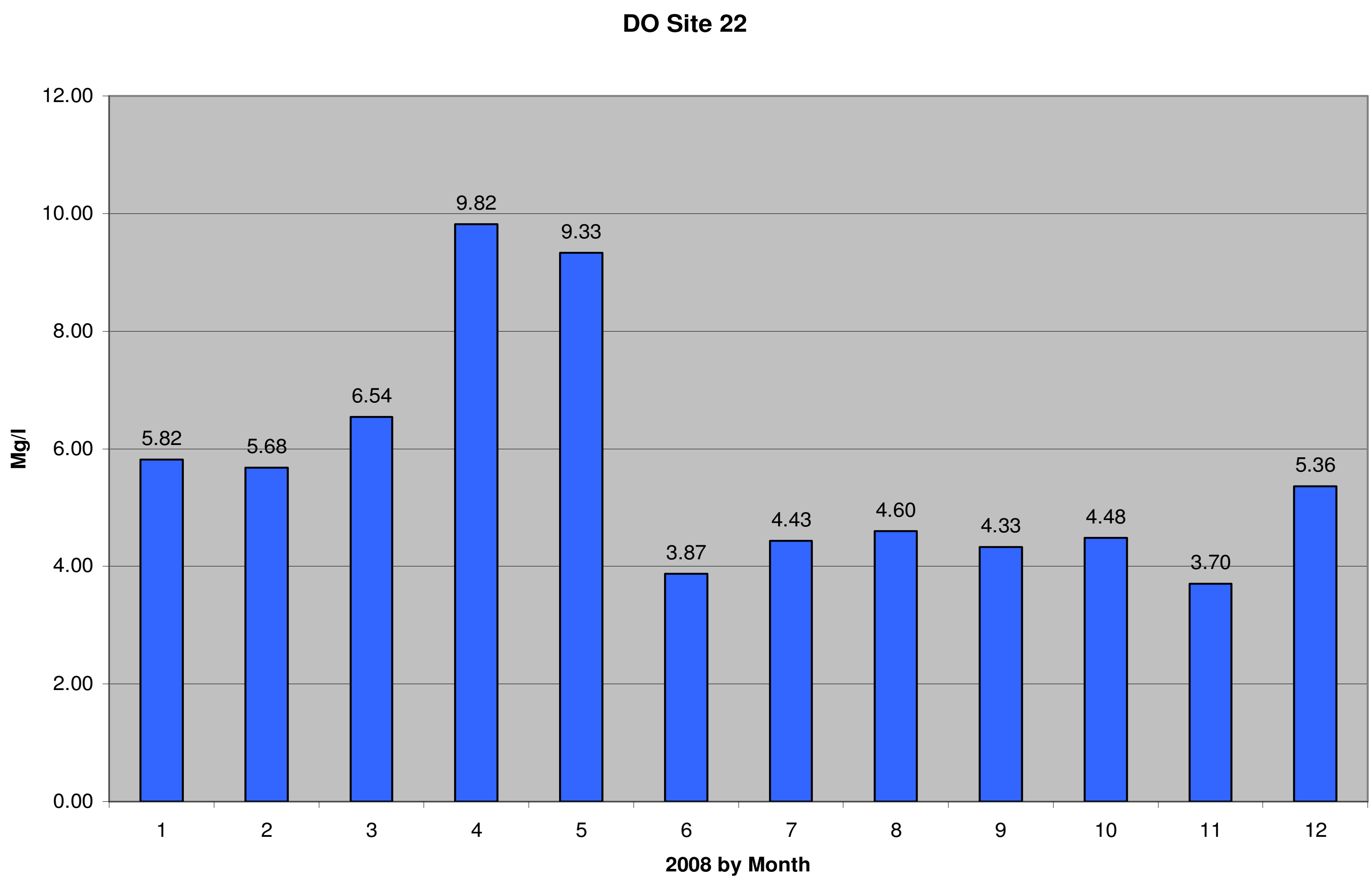

Figure 60: Monthly dissolved oxygen for site 22 with 5.66 milligrams per liter as the yearly average.

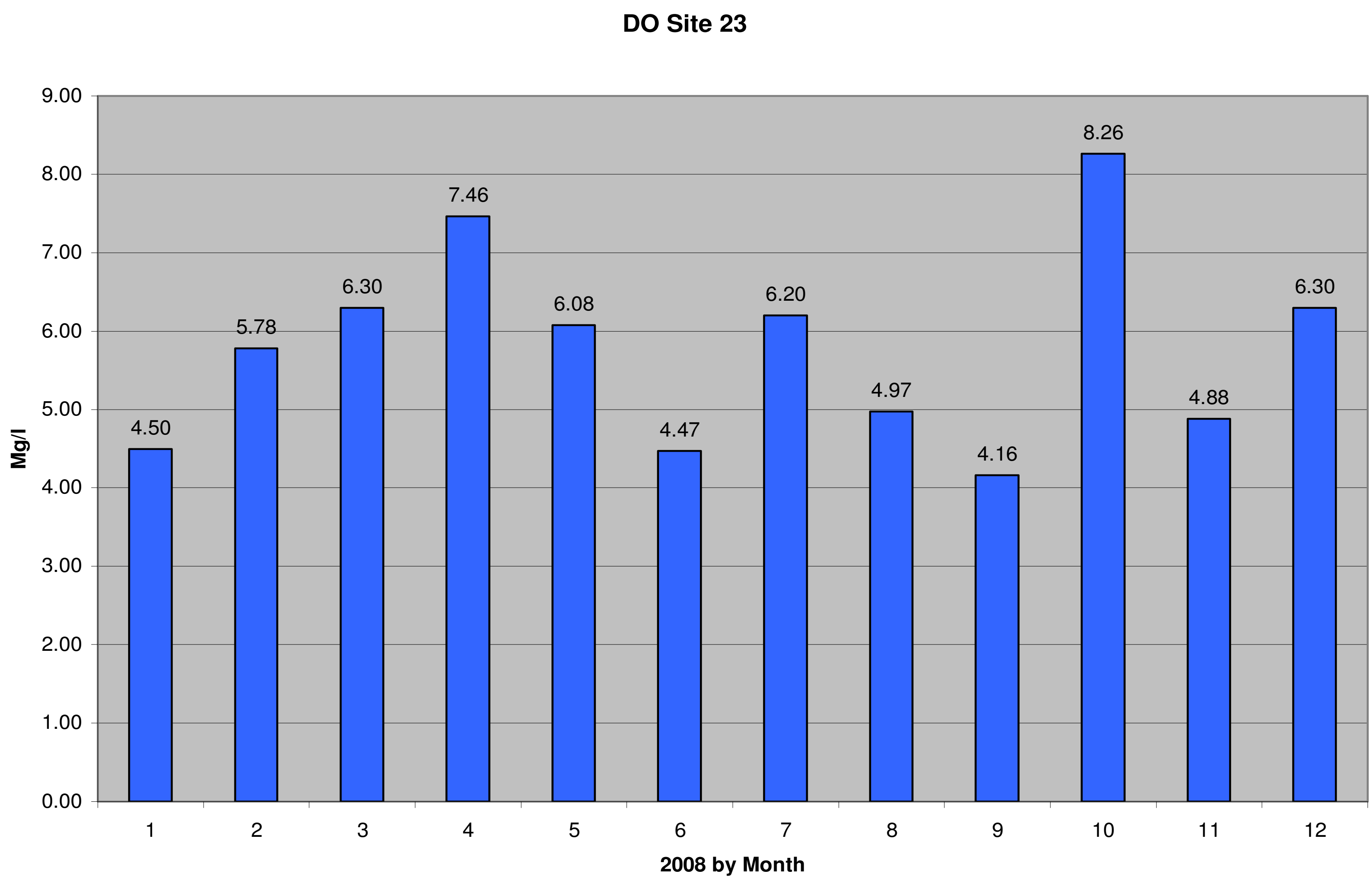

Figure 61: Monthly dissolved oxygen for site 23 with 5.78 milligrams per liter as the yearly average.

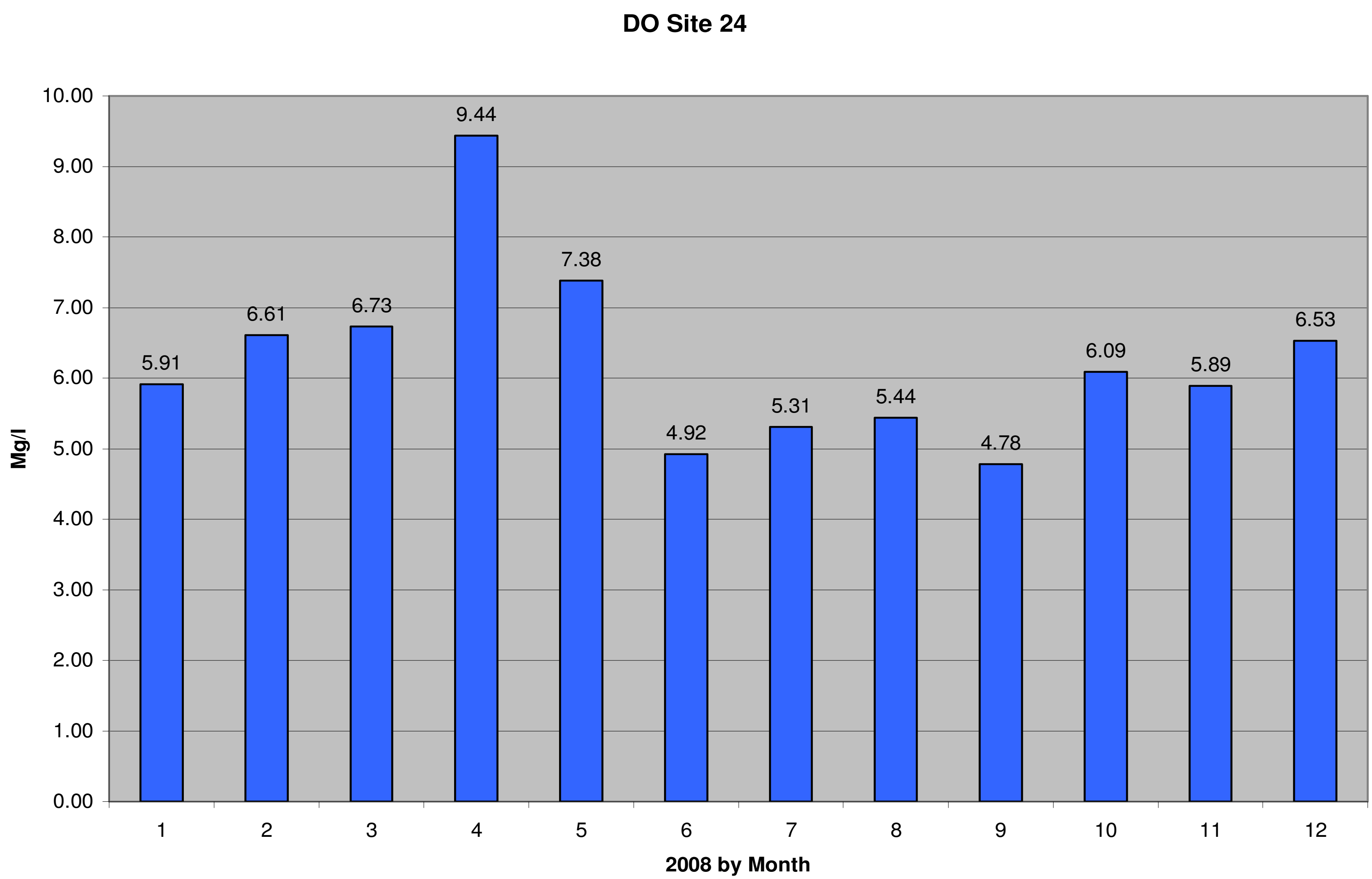

Figure 62: Monthly dissolved oxygen for site 24 with 6.25 milligrams per liter as the yearly average.

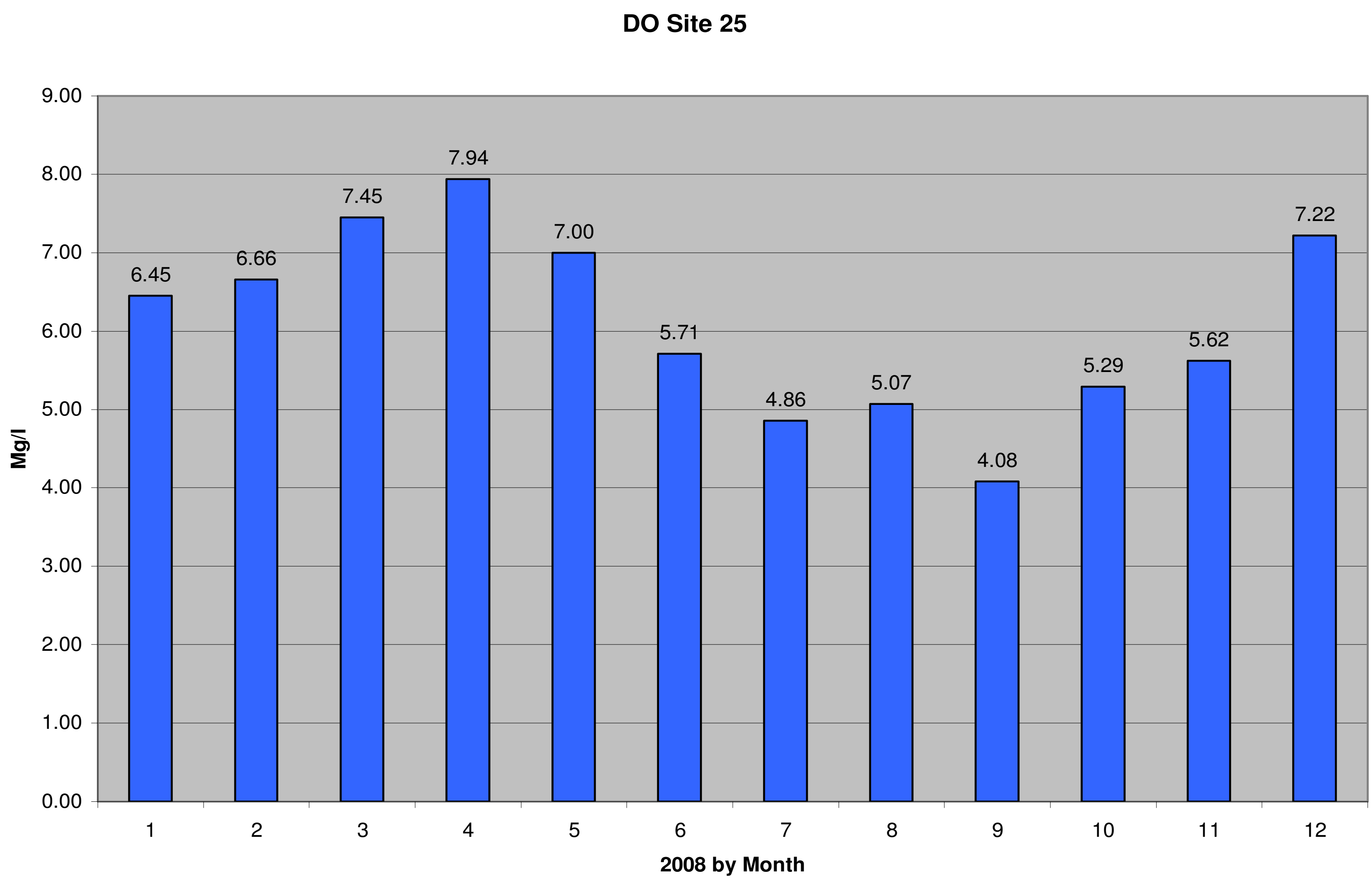

Figure 63: Monthly dissolved oxygen for site 25 with 6.11 milligrams per liter as the yearly average.

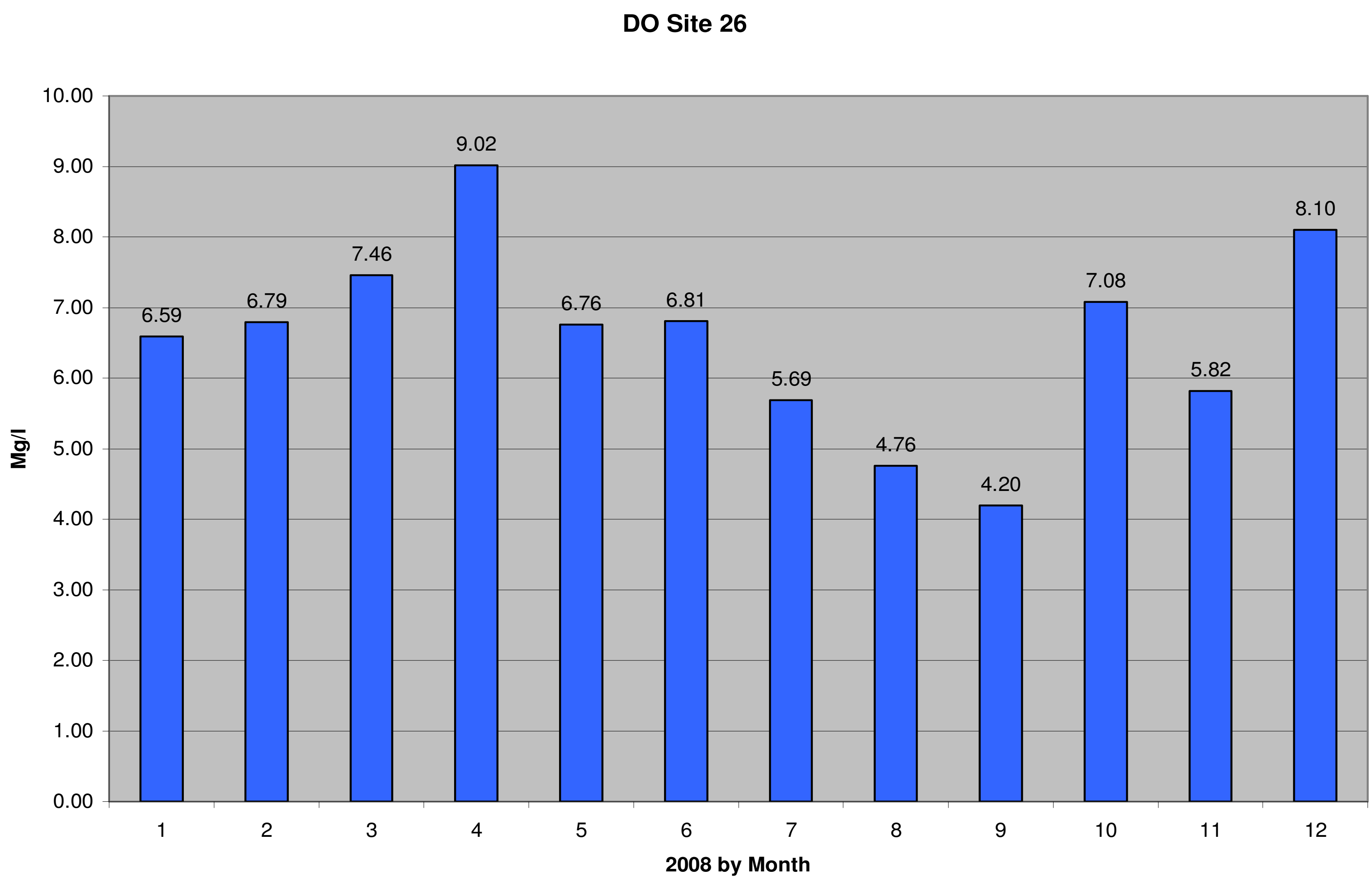

Figure 64: Monthly dissolved oxygen for site 26 with 6.59 milligrams per liter as the yearly average.

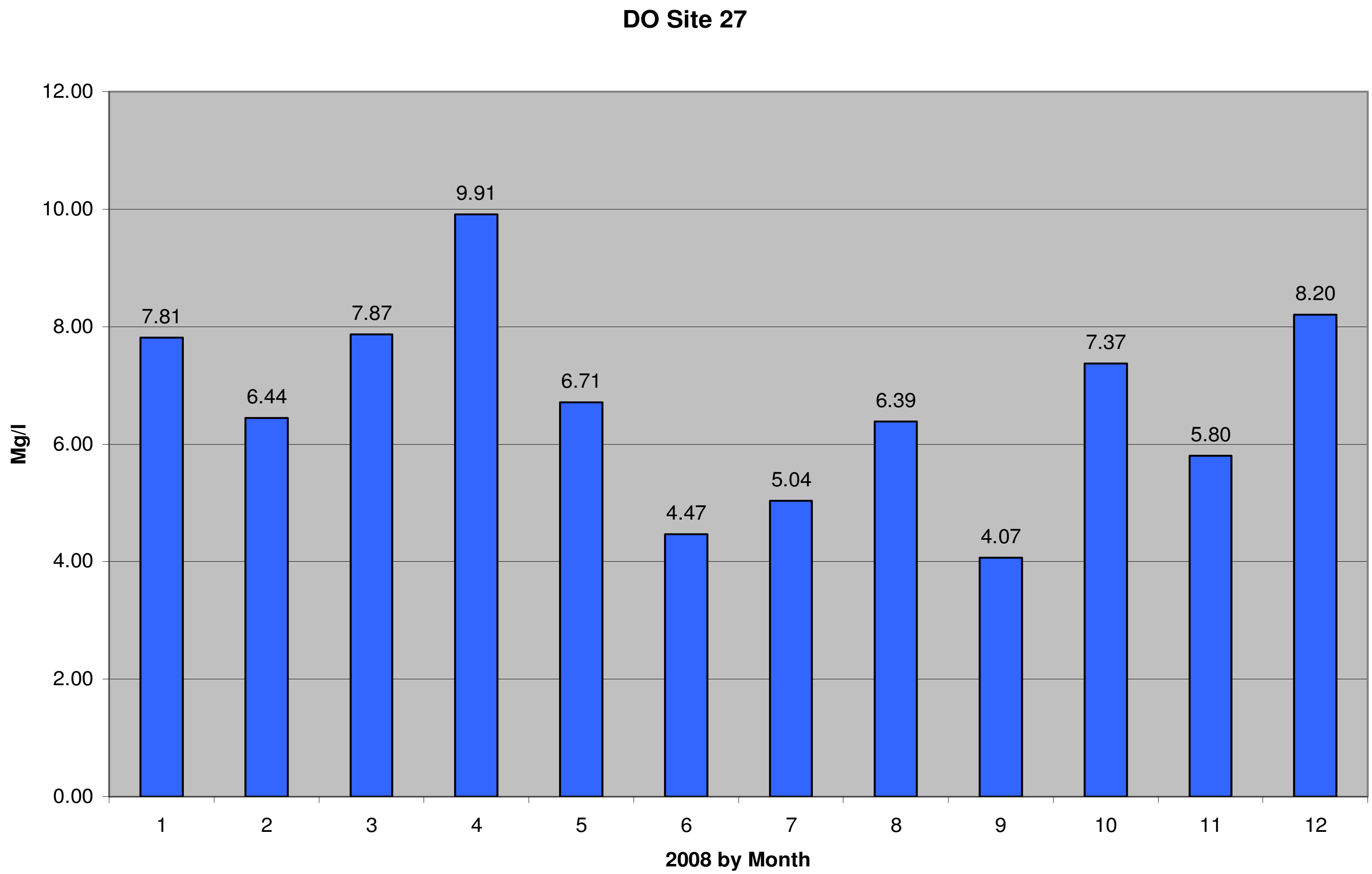

Figure 65: Monthly dissolved oxygen for site 27 with 6.67 milligrams per liter as the yearly average.

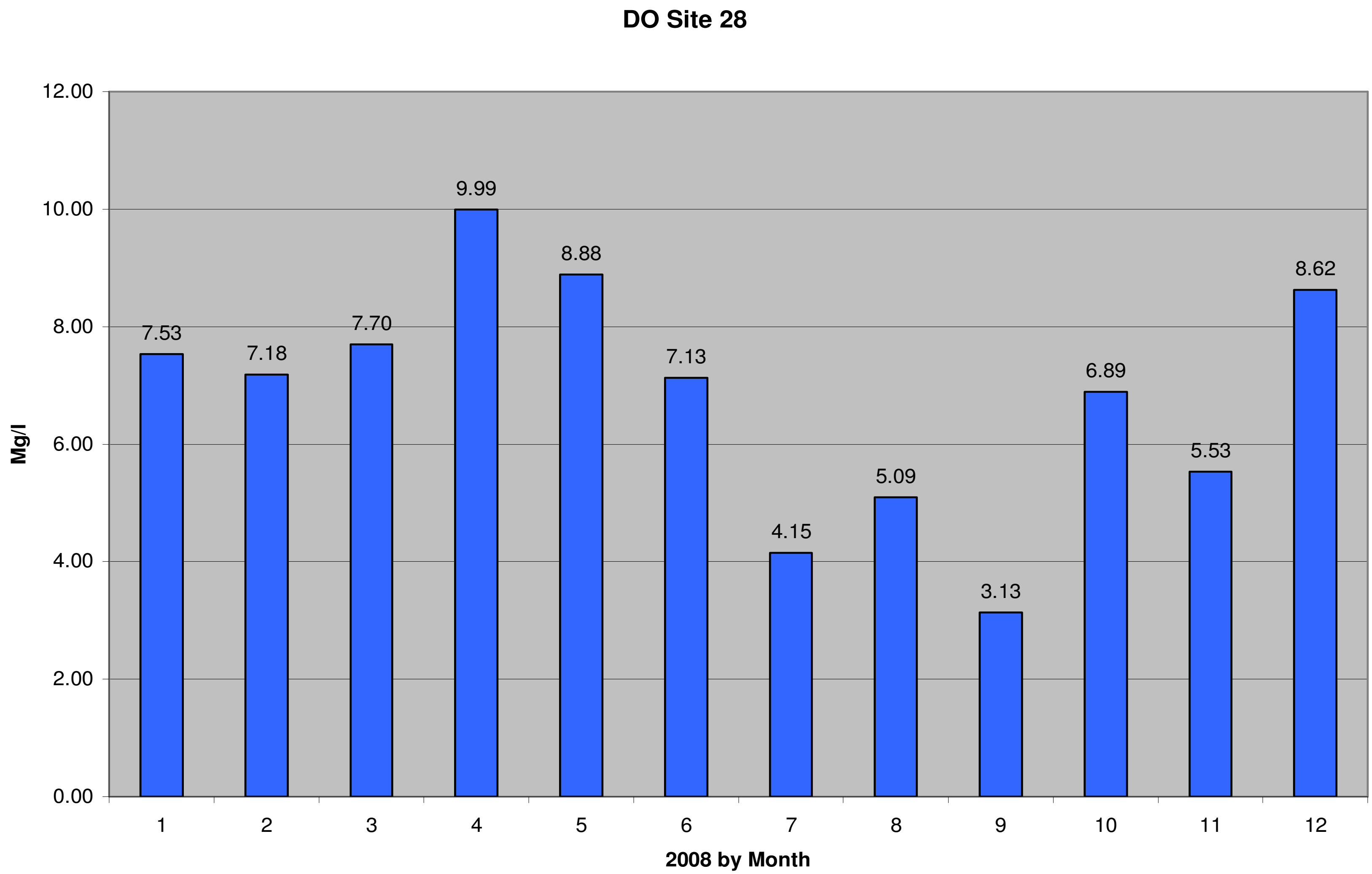

Figure 66: Monthly dissolved oxygen for site 28 with 6.82 milligrams per liter as the yearly average.

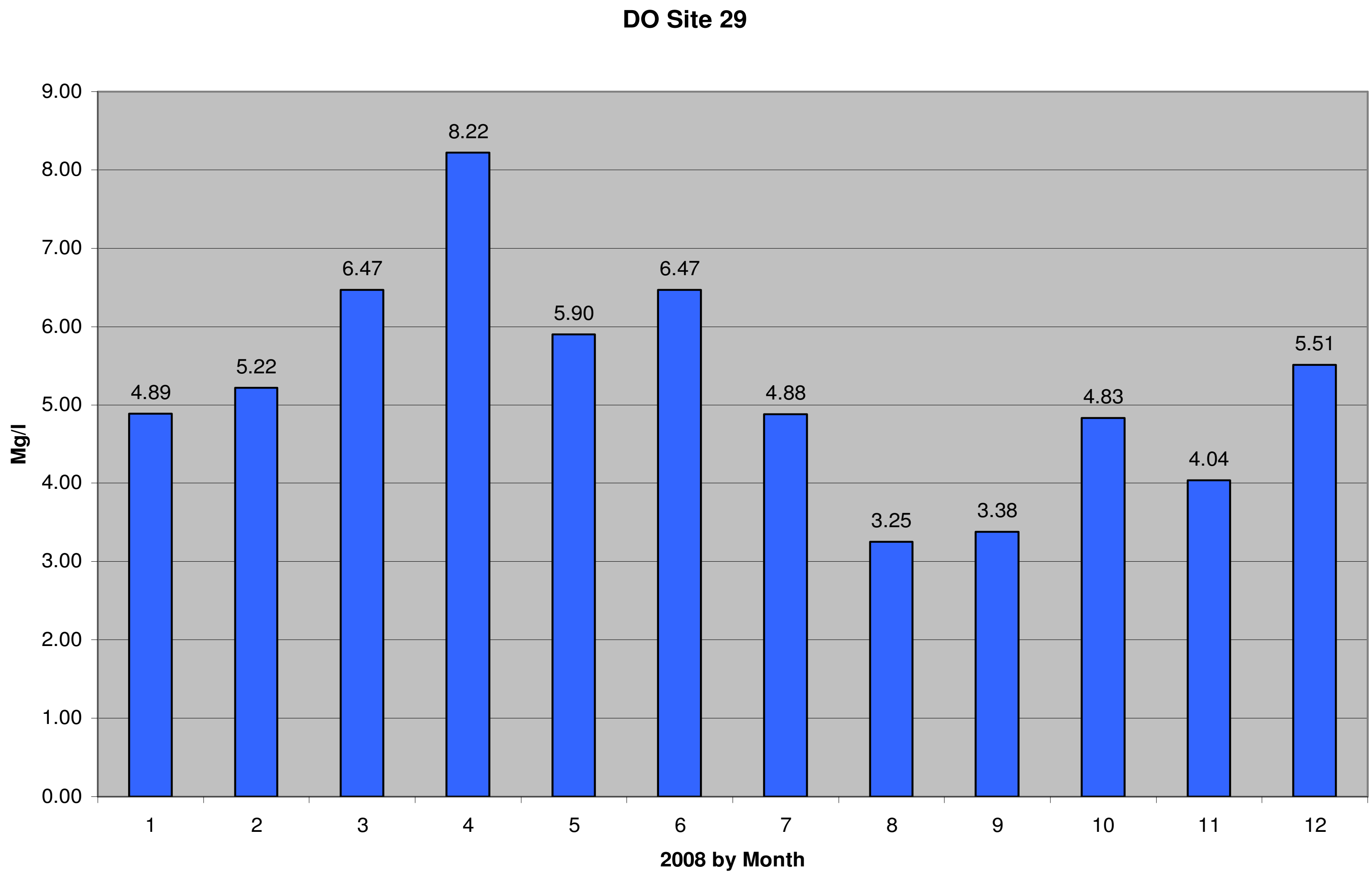

Figure 67: Monthly dissolved oxygen for site 29 with 5.26 milligrams per liter as the yearly average.

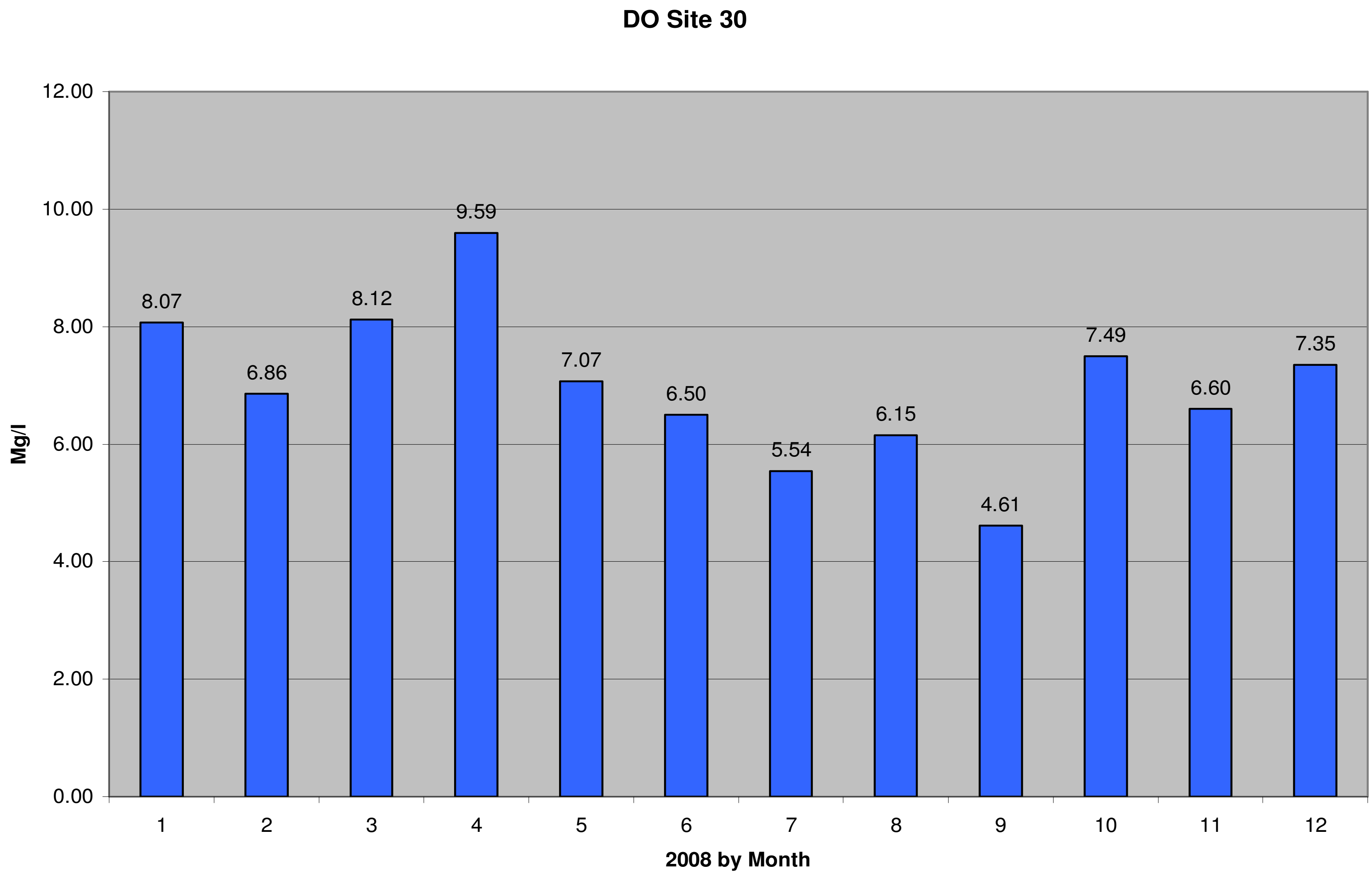

Figure 68: Monthly dissolved oxygen for site 30 with 7.00 milligrams per liter as the yearly average.

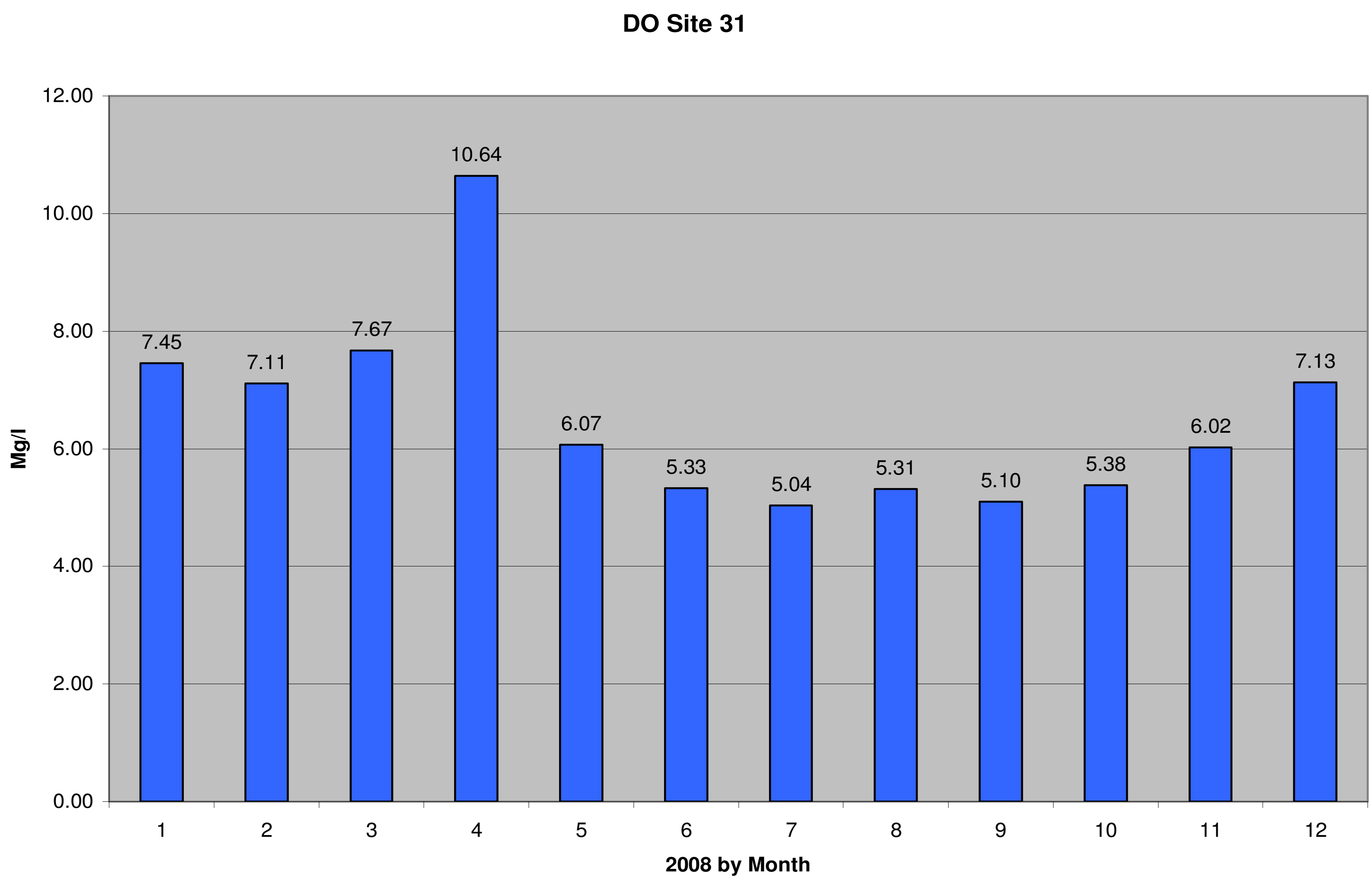

Figure 69: Monthly dissolved oxygen for site 31 with 6.52 milligrams per liter as the yearly average.

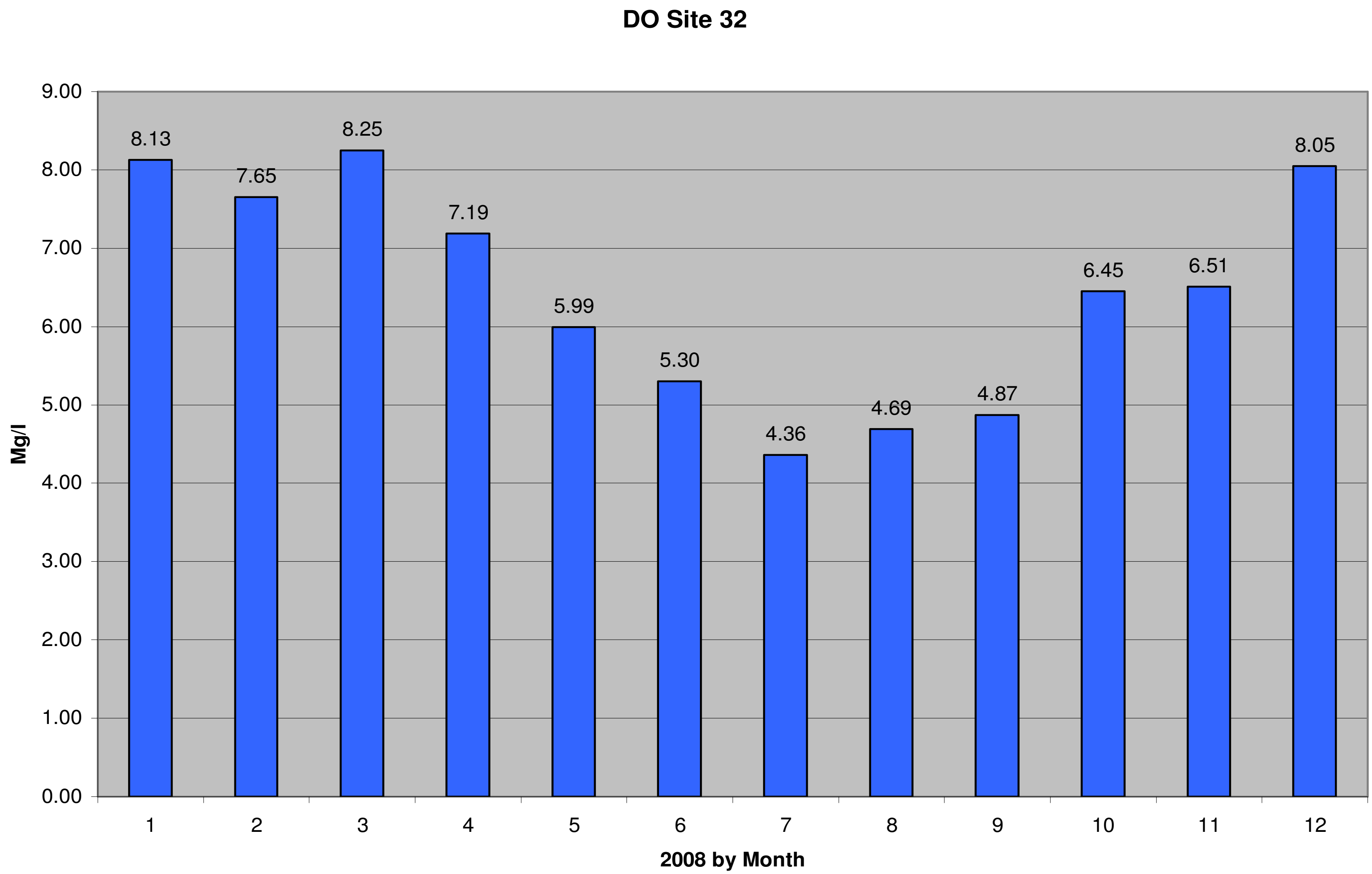

Figure 70: Monthly dissolved oxygen for site 32 with 6.45 milligrams per liter as the yearly average.

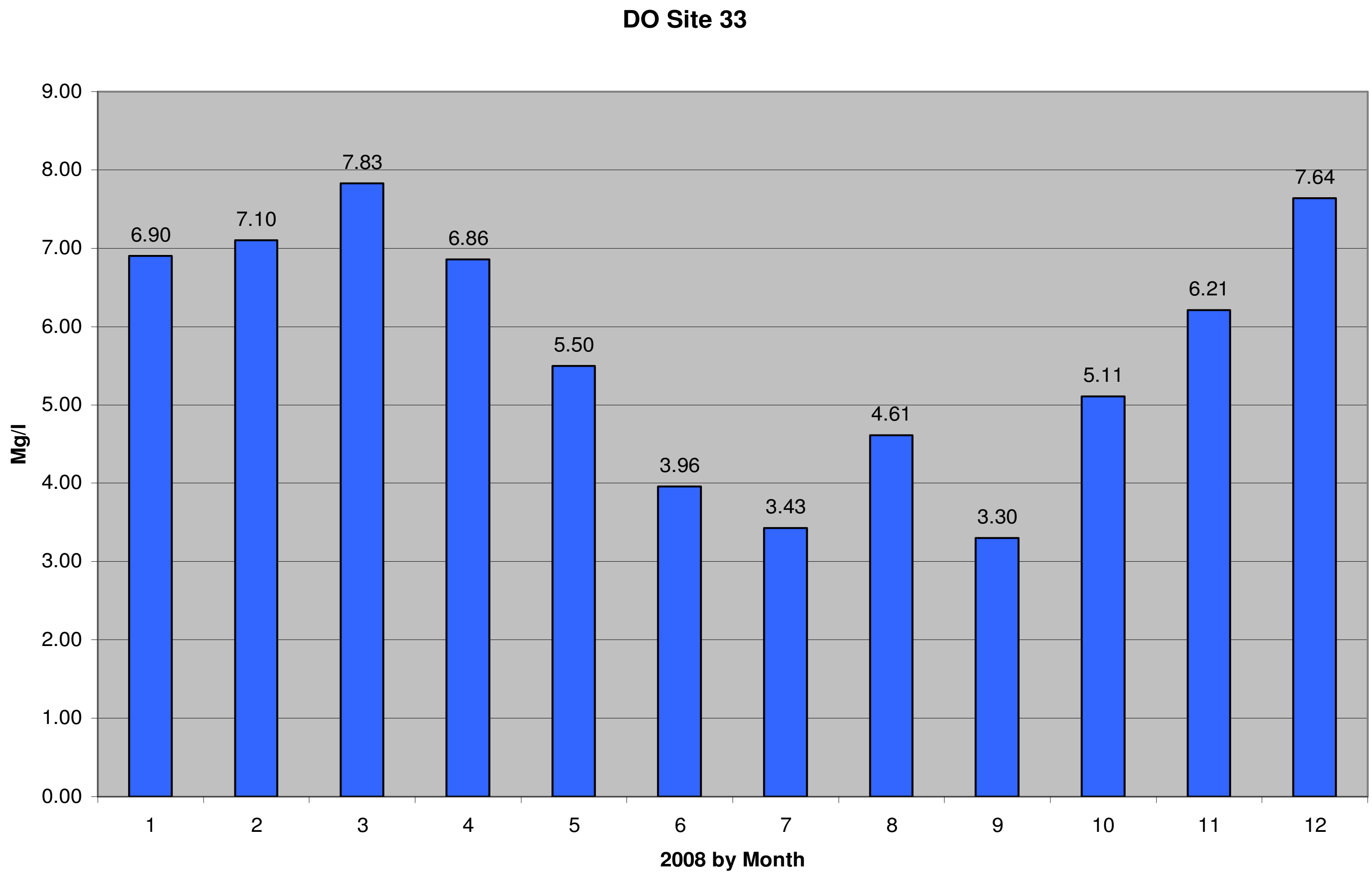

Figure 71: Monthly dissolved oxygen for site 33 with 5.70 milligrams per liter as the yearly average.

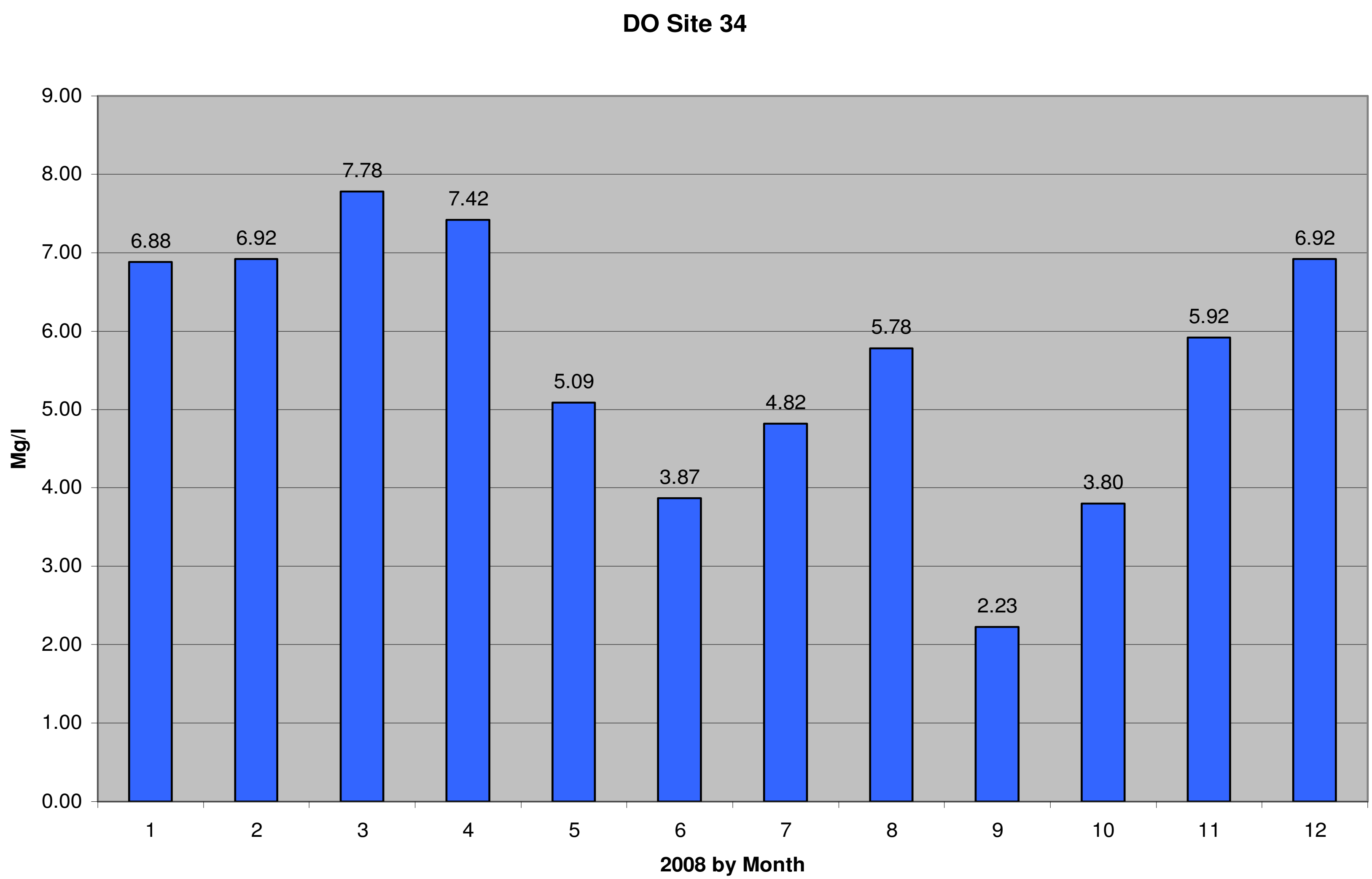

Figure 72: Monthly dissolved oxygen for site 34 with 5.62 milligrams per liter as the yearly average.

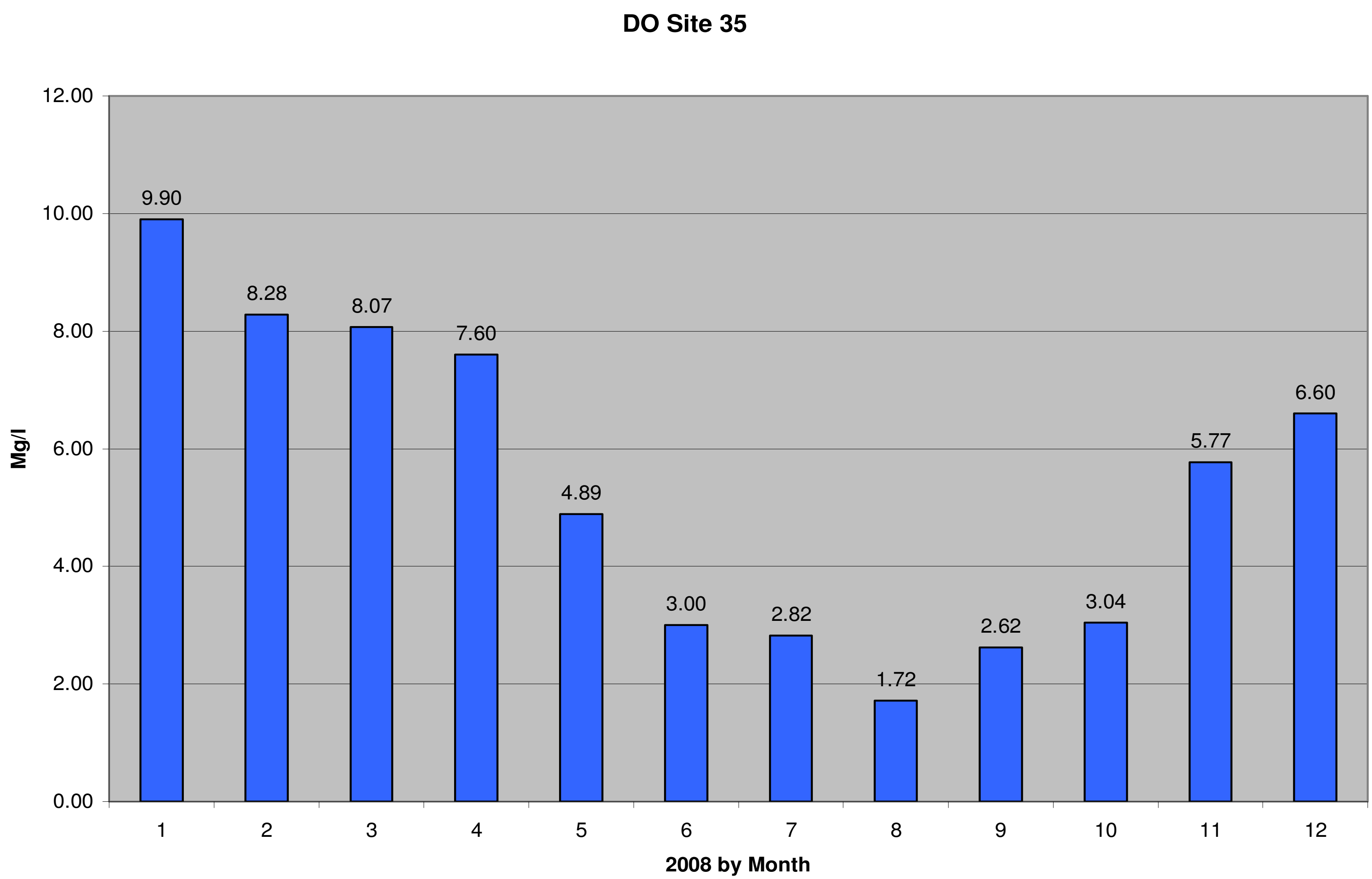

Figure 73: Monthly dissolved oxygen for site 35 with 5.36 milligrams per liter as the yearly average.

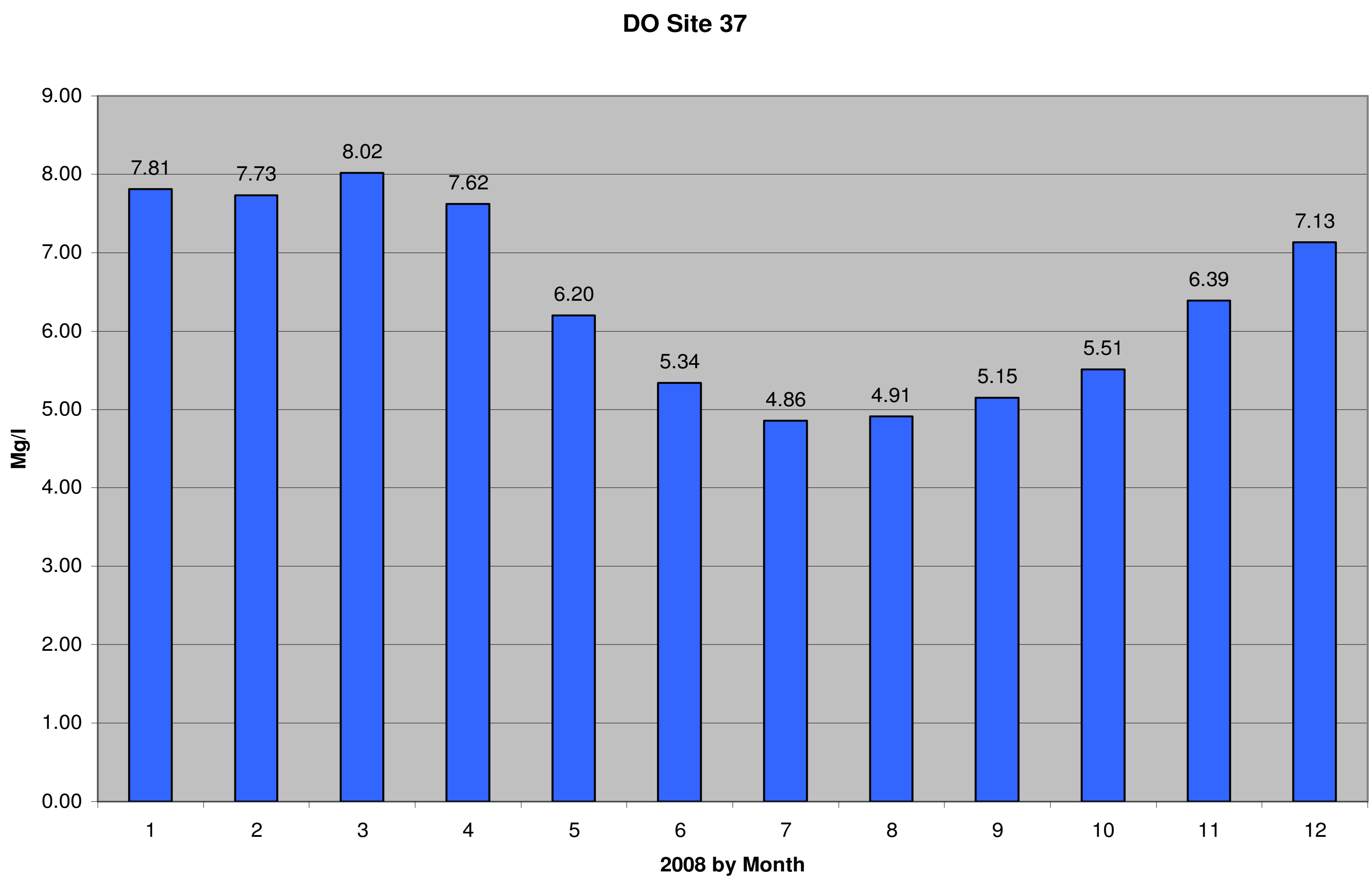

Figure 74: Monthly dissolved oxygen for site 37 with 6.39 milligrams per liter as the yearly average.

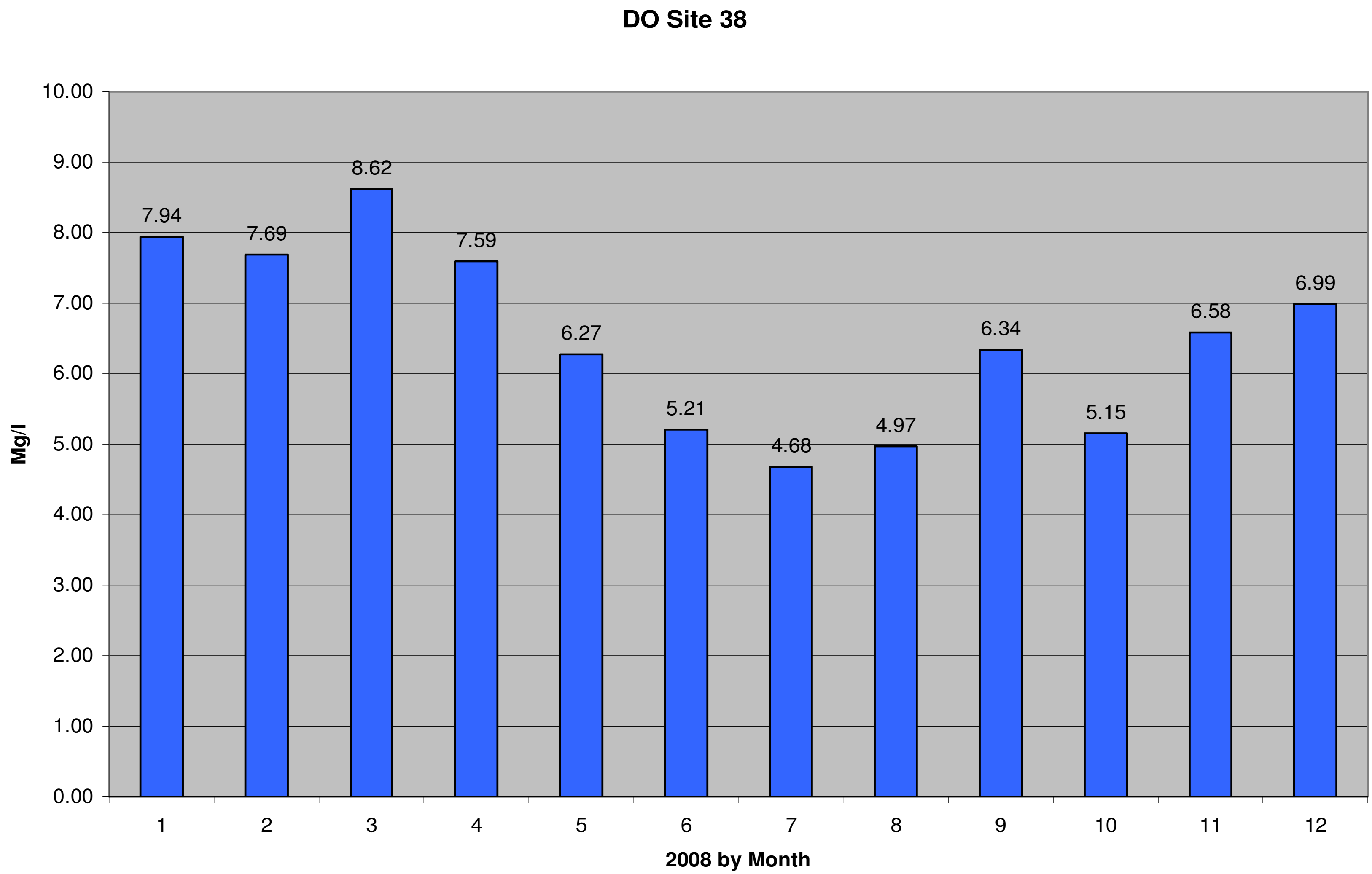

Figure 75: Monthly dissolved oxygen for site 38 with 6.50 milligrams per liter as the yearly average.

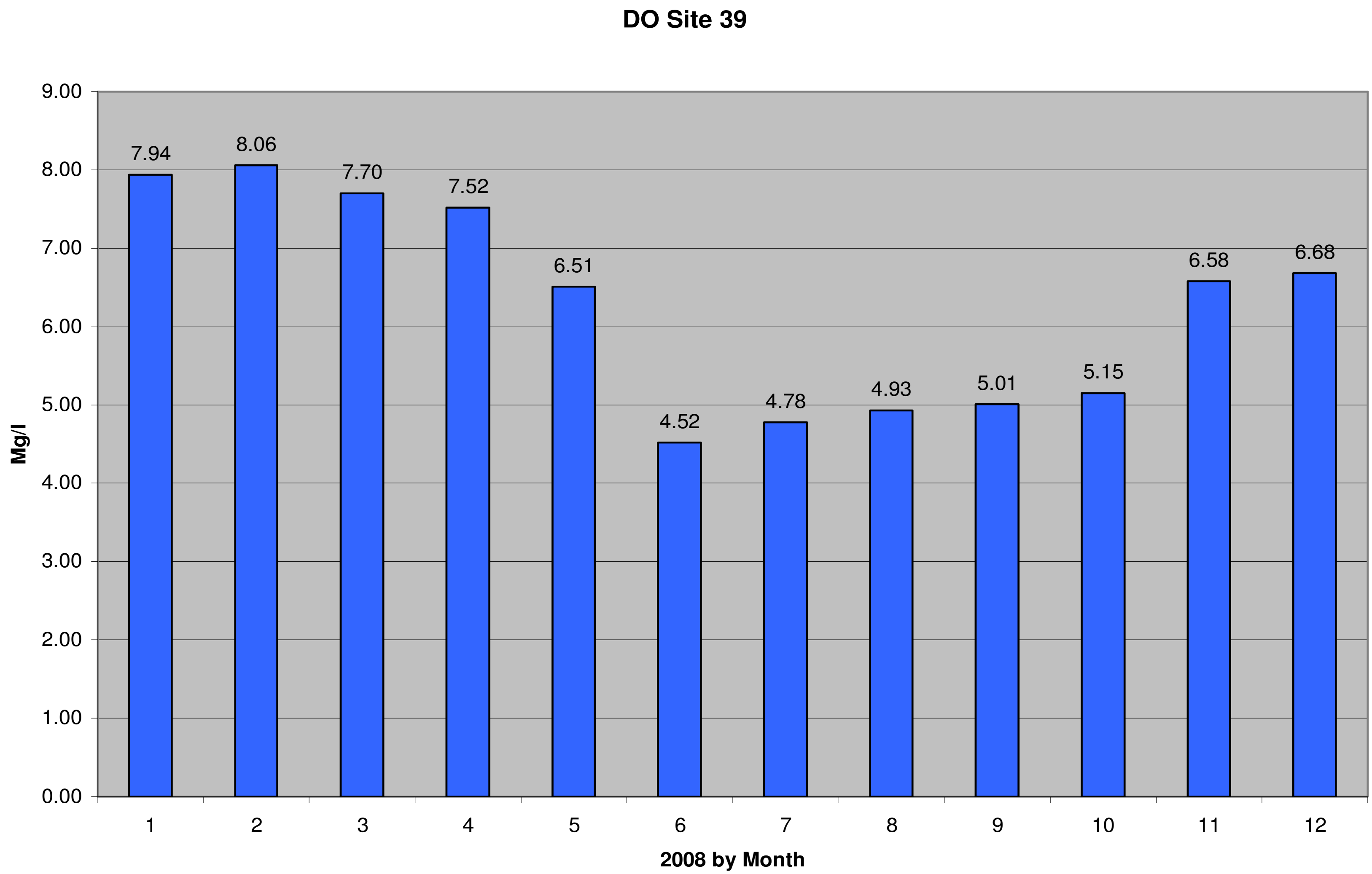

Figure 76: Monthly dissolved oxygen for site 39 with 6.28 milligrams per liter as the yearly average.

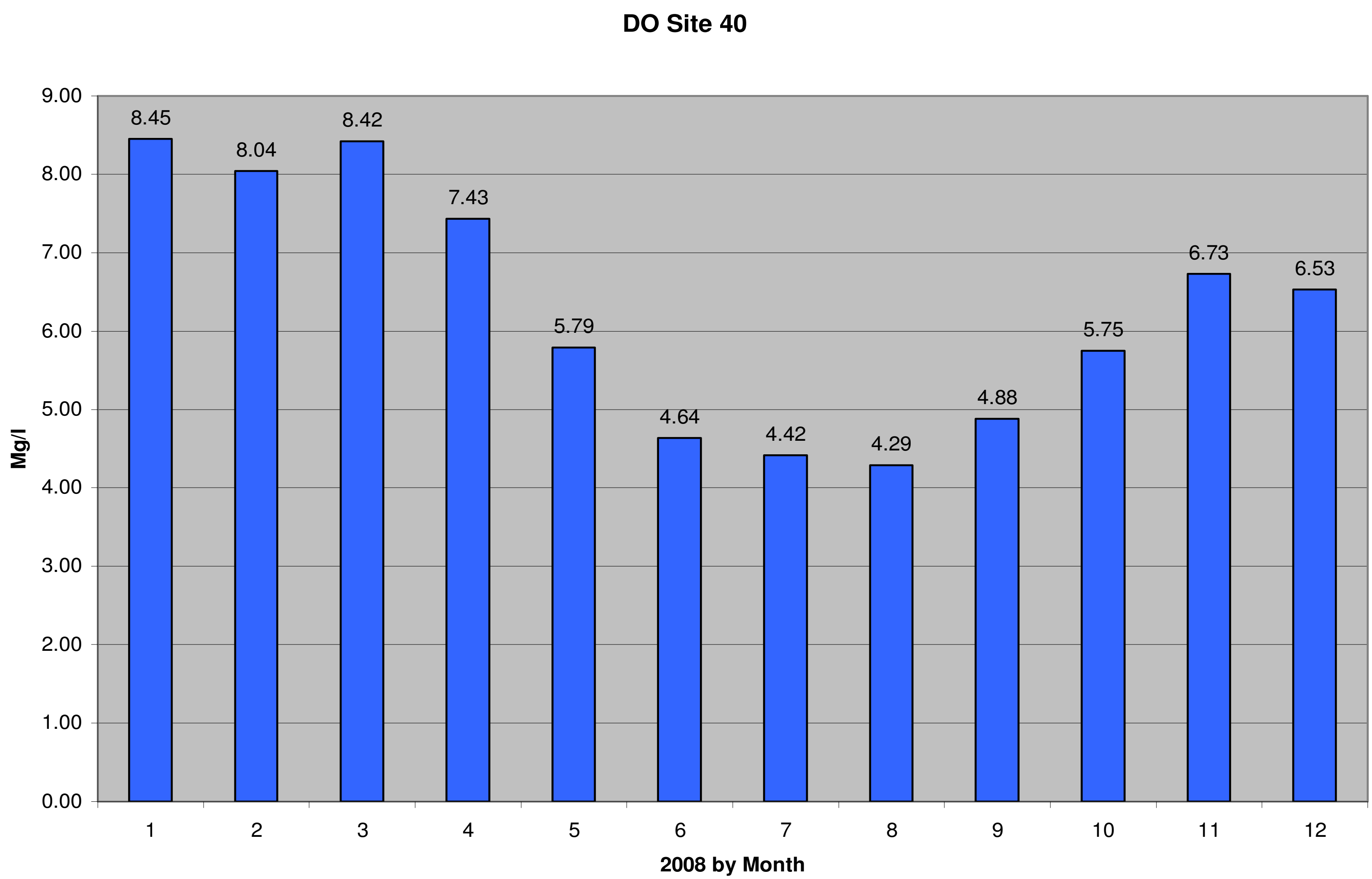

Figure 77: Monthly dissolved oxygen for site 40 with 6.08 milligrams per liter as the yearly average.

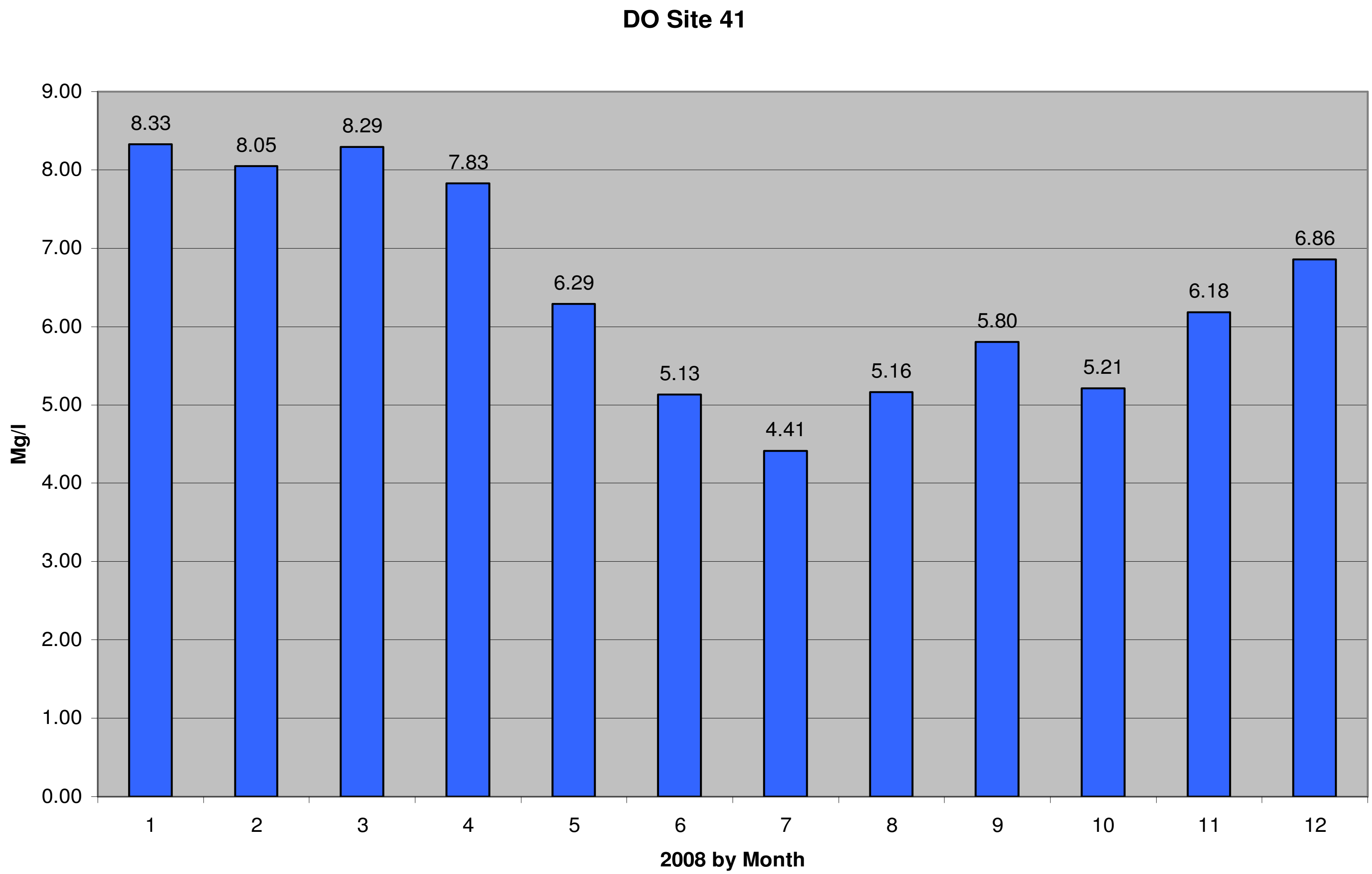

Figure 78: Monthly dissolved oxygen for site 41 with 6.46 milligrams per liter as the yearly average.

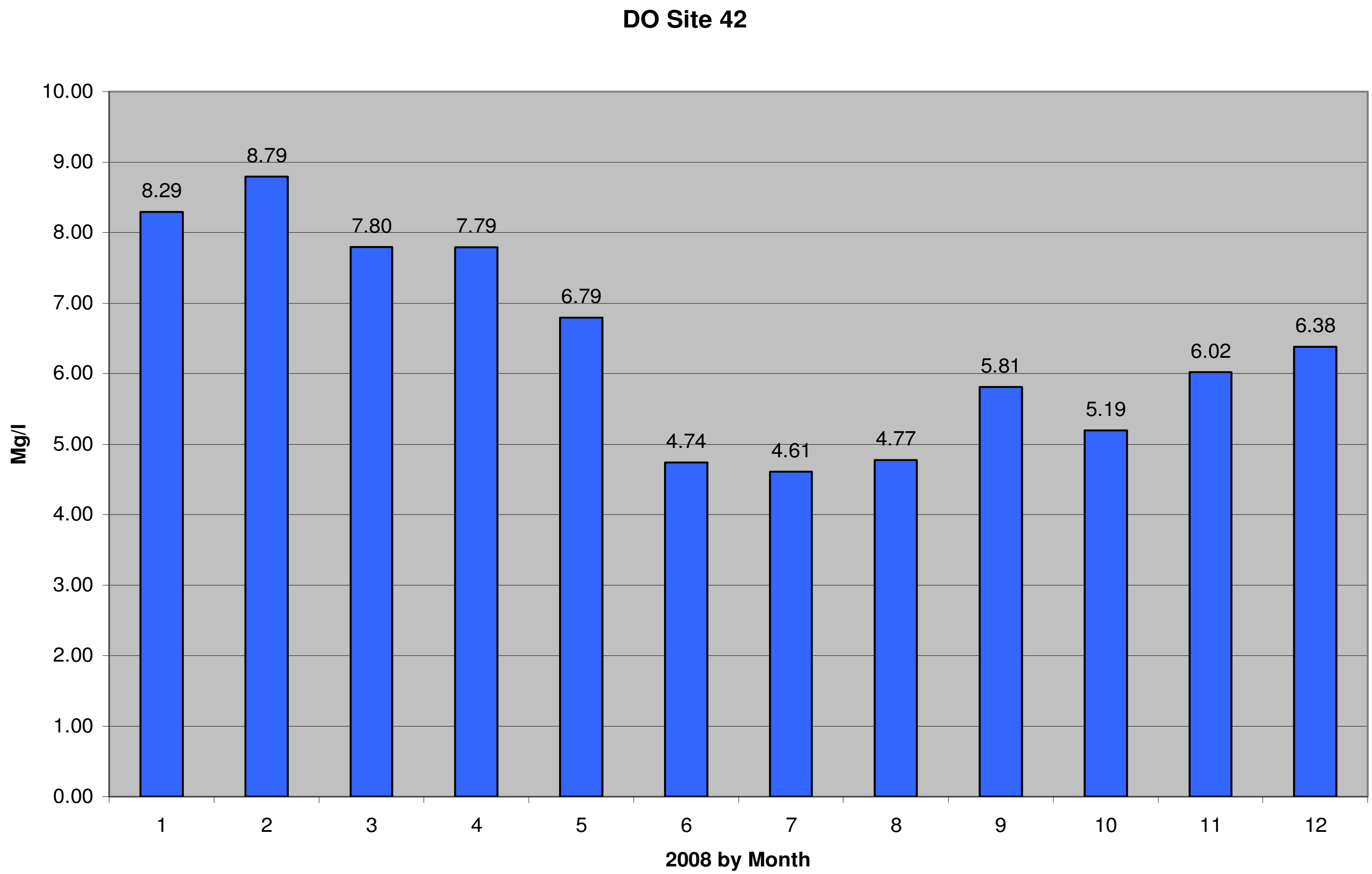

Figure 79: Monthly dissolved oxygen for site 42 with 6.42 milligrams per liter as the yearly average.

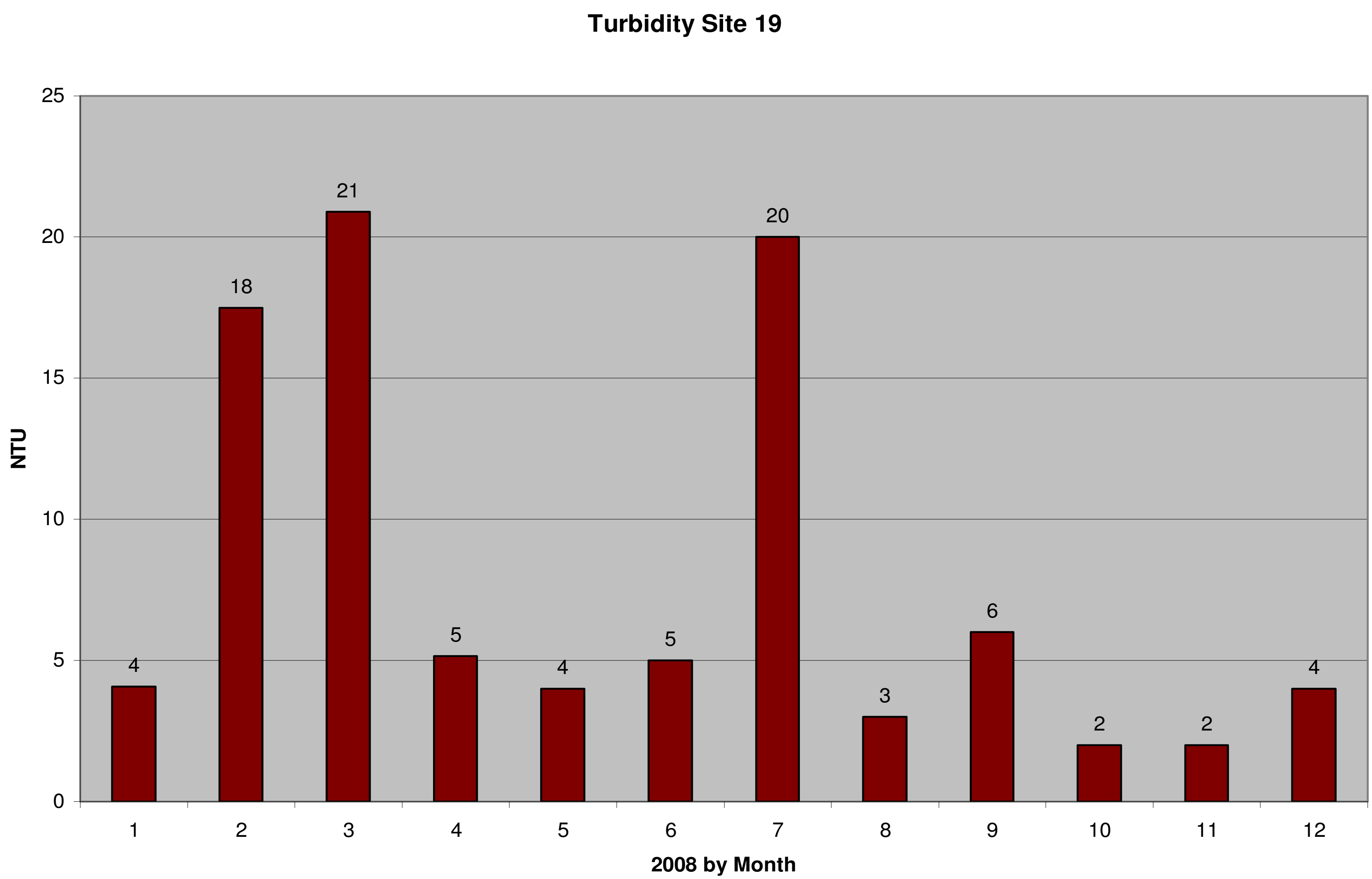

Figure 80: Monthly turbidity for site 19 with 8 nephelometer turbidity units as the yearly average.

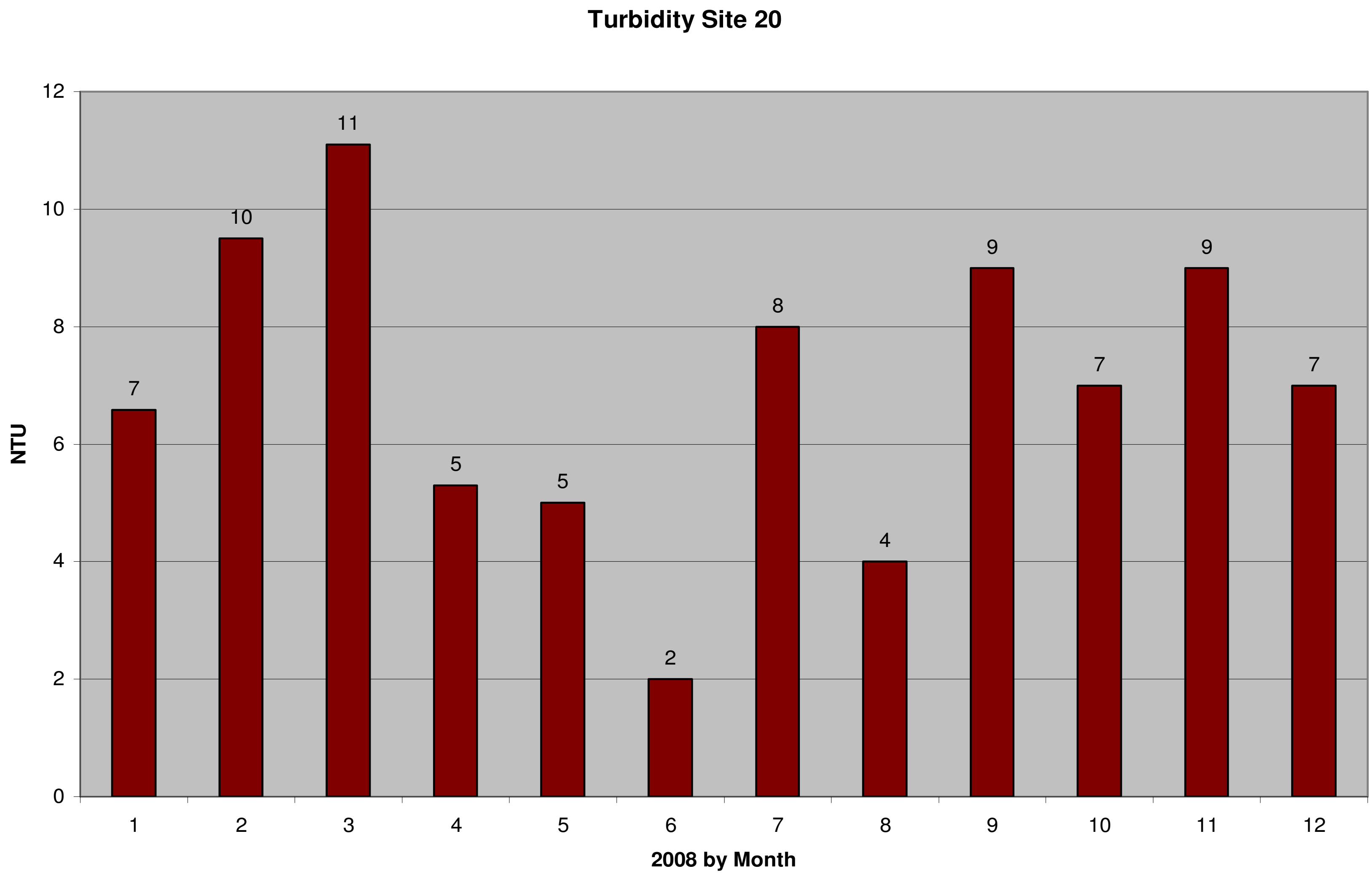

Figure 81: Monthly turbidity for site 20 with 7 nephelometer turbidity units as the yearly average.

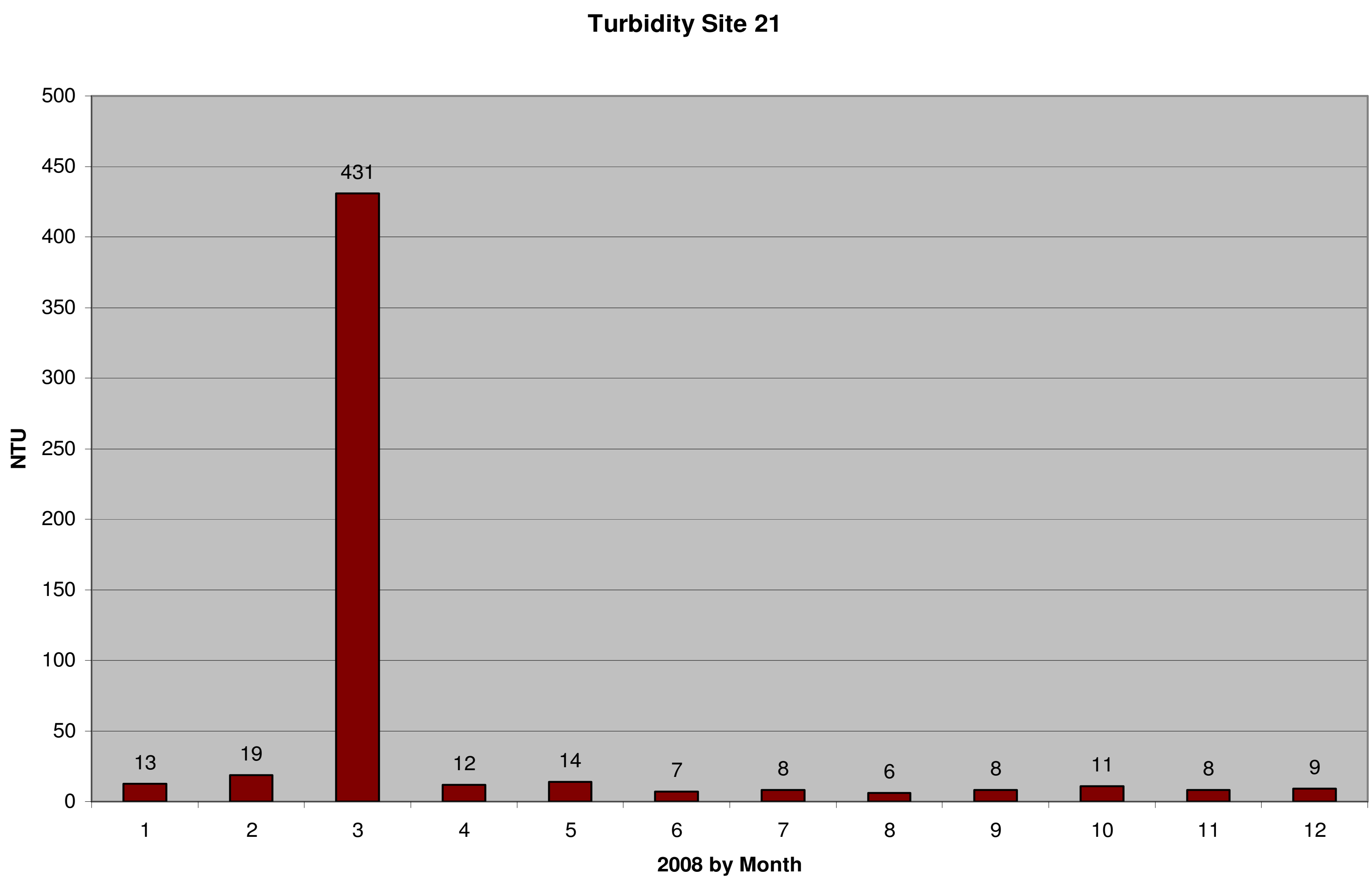

Figure 82: Monthly turbidity for site 21 with 45 nephelometer turbidity units as the yearly average.

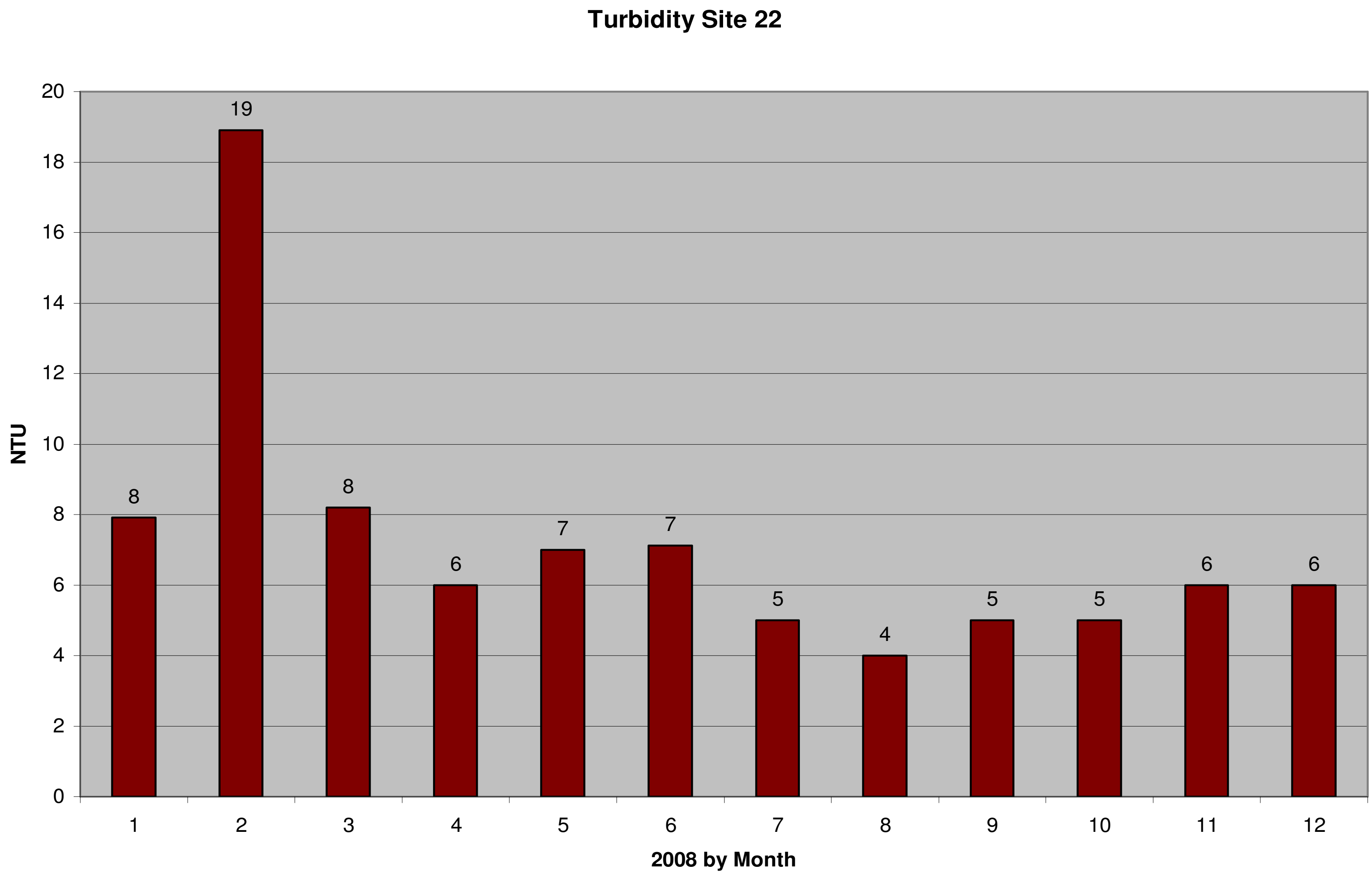

Figure 83: Monthly turbidity for site 22 with 7 nephelometer turbidity units as the yearly average.

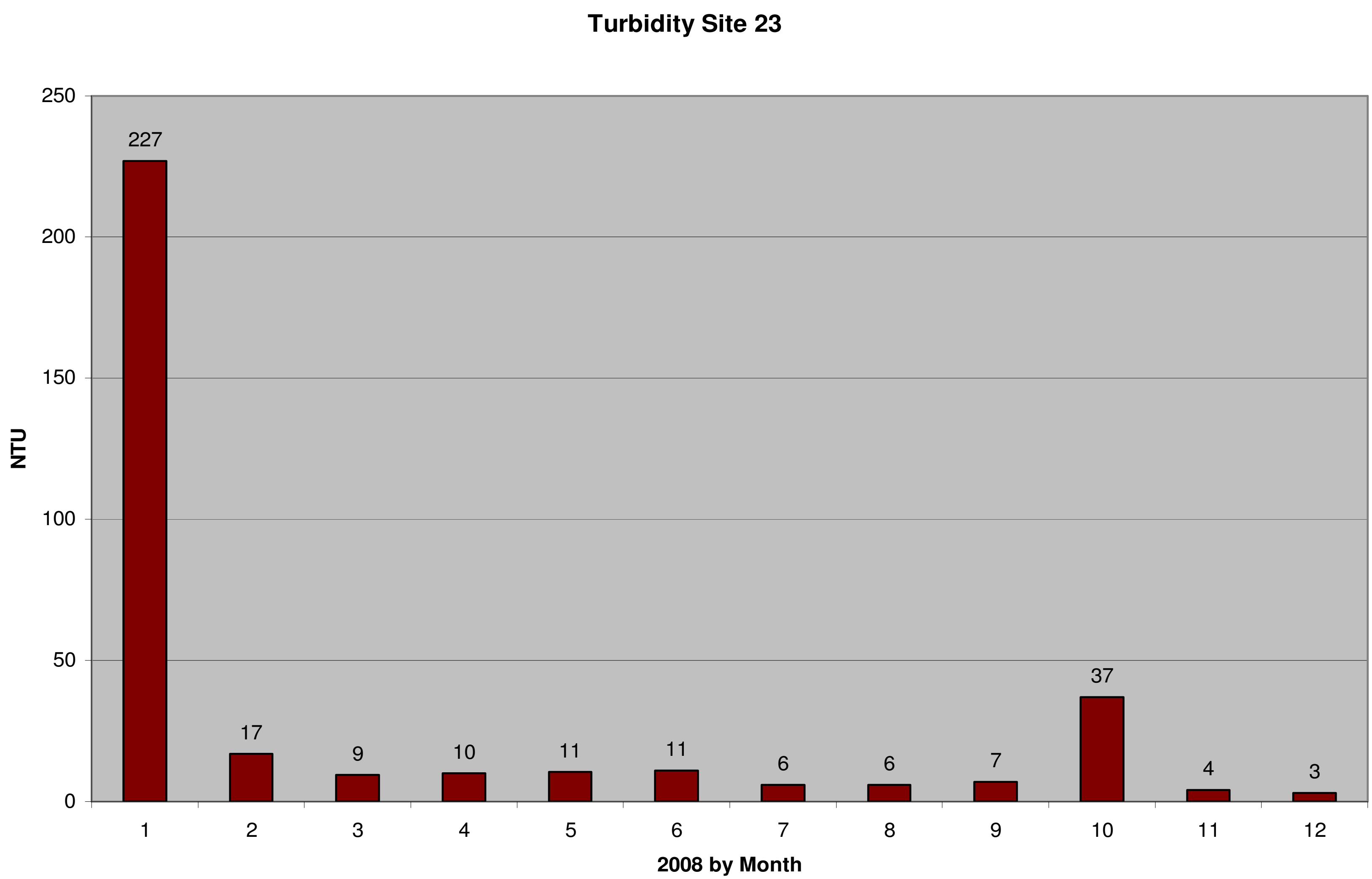

Figure 84: Monthly turbidity for site 23 with 29 nephelometer turbidity units as the yearly average.

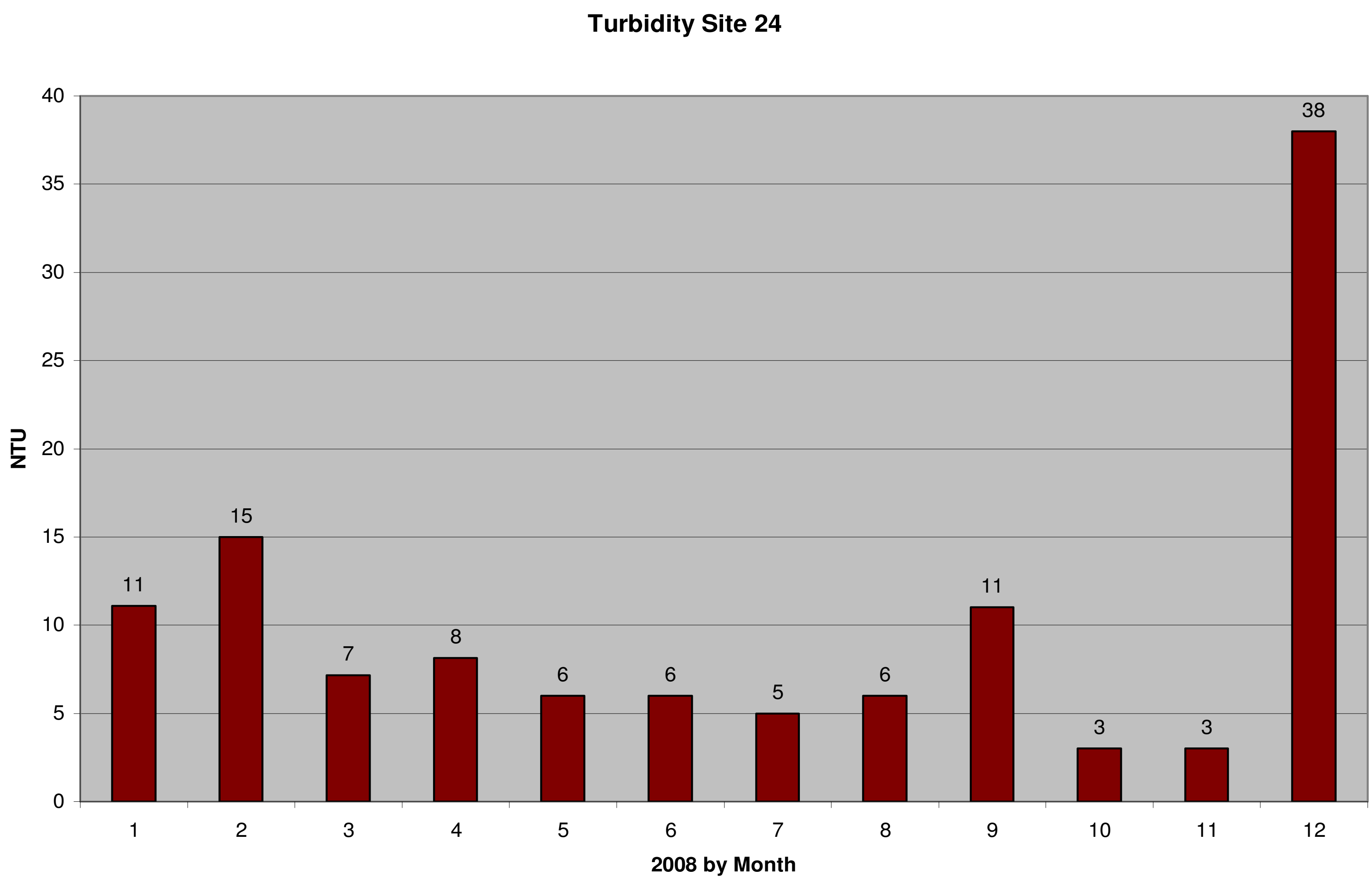

Figure 85: Monthly turbidity for site 24 with 10 nephelometer turbidity units as the yearly average.

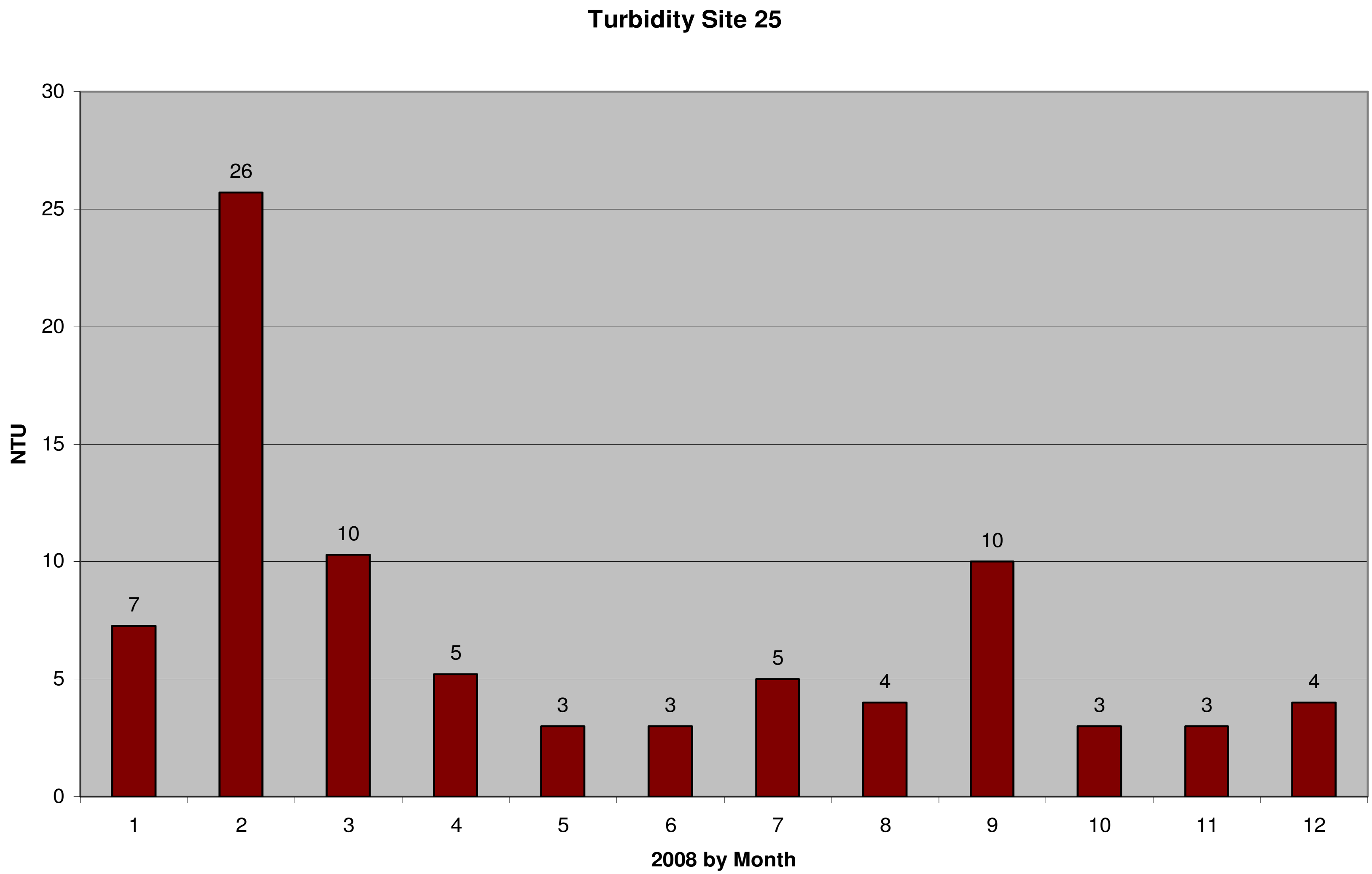

Figure 86: Monthly turbidity for site 25 with 7 nephelometer turbidity units as the yearly average.

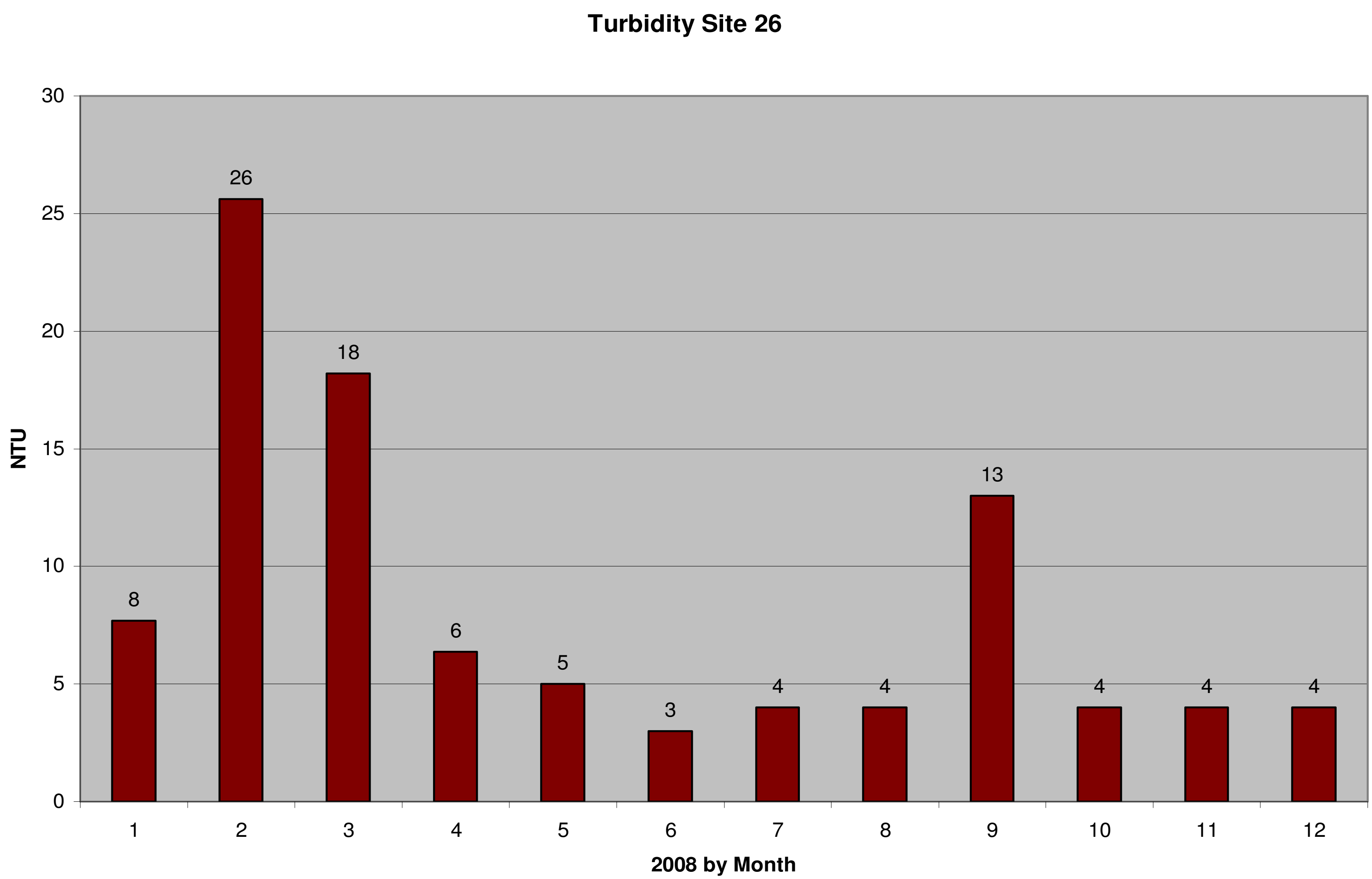

Figure 87: Monthly turbidity for site 26 with 8 nephelometer turbidity units as the yearly average.

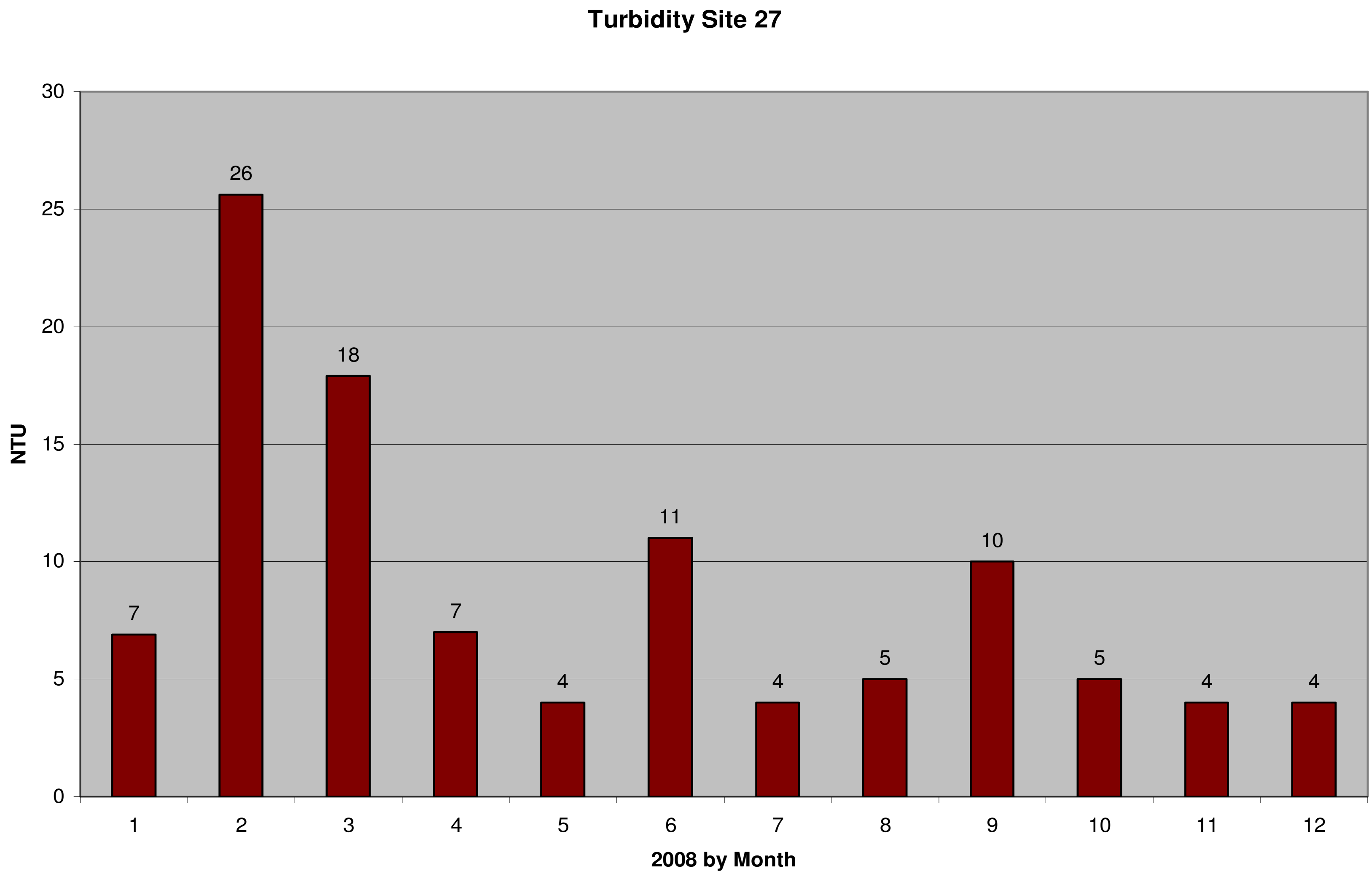

Figure 88: Monthly turbidity for site 27 with 9 nephelometer turbidity units as the yearly average.

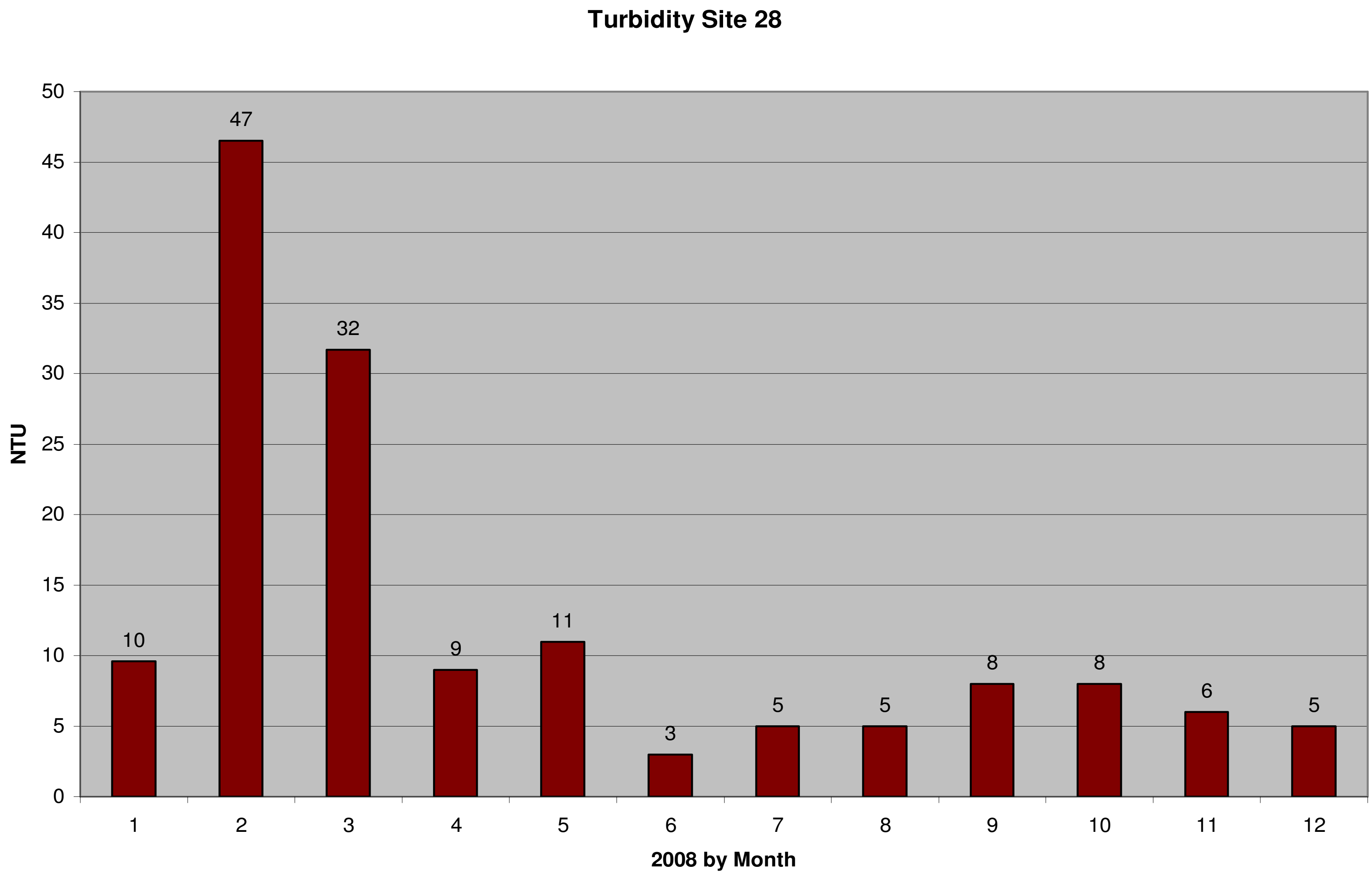

Figure 89: Monthly turbidity for site 28 with 12 nephelometer turbidity units as the yearly average.

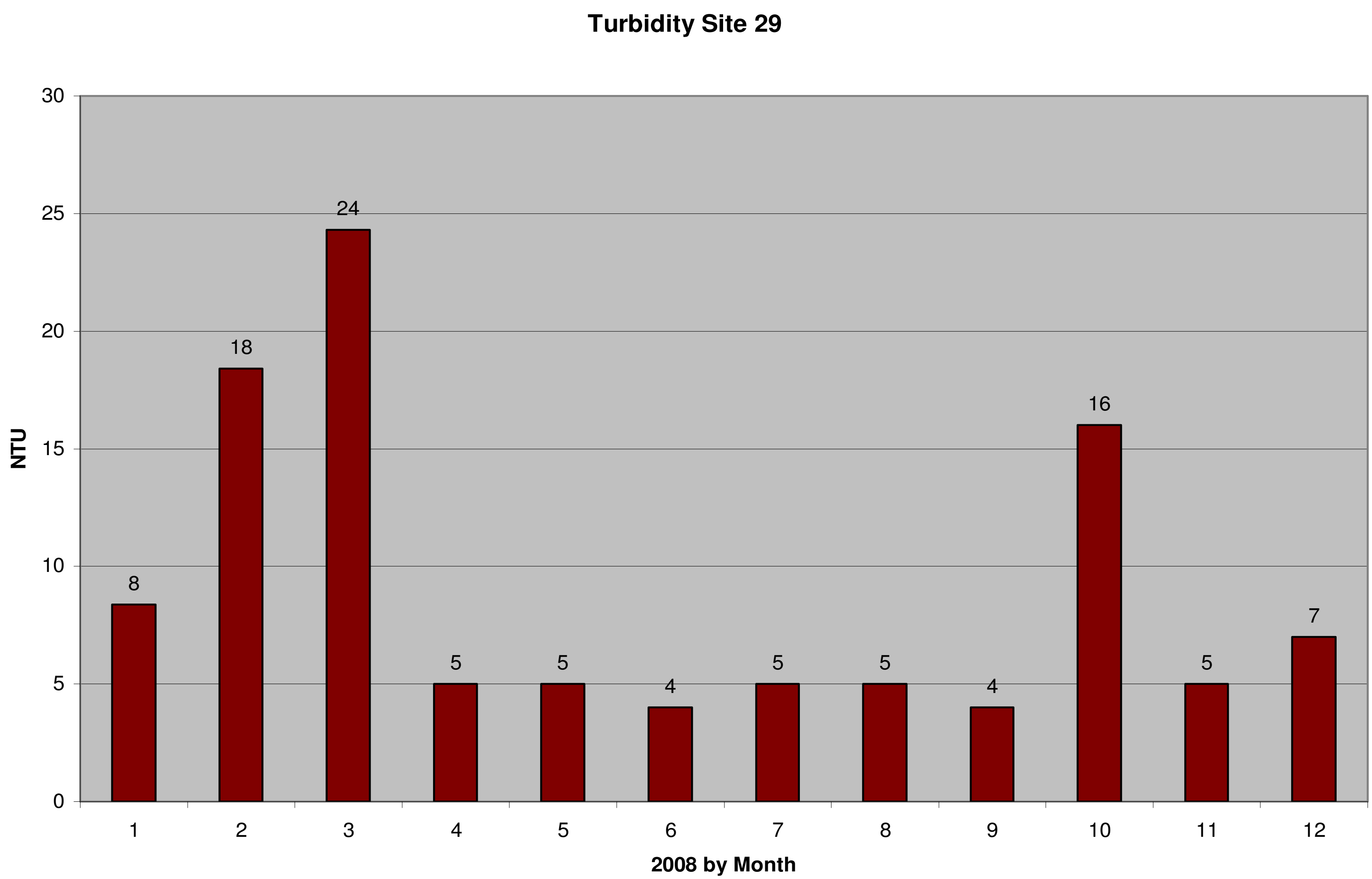

Figure 90: Monthly turbidity for site 29 with 9 nephelometer turbidity units as the yearly average.

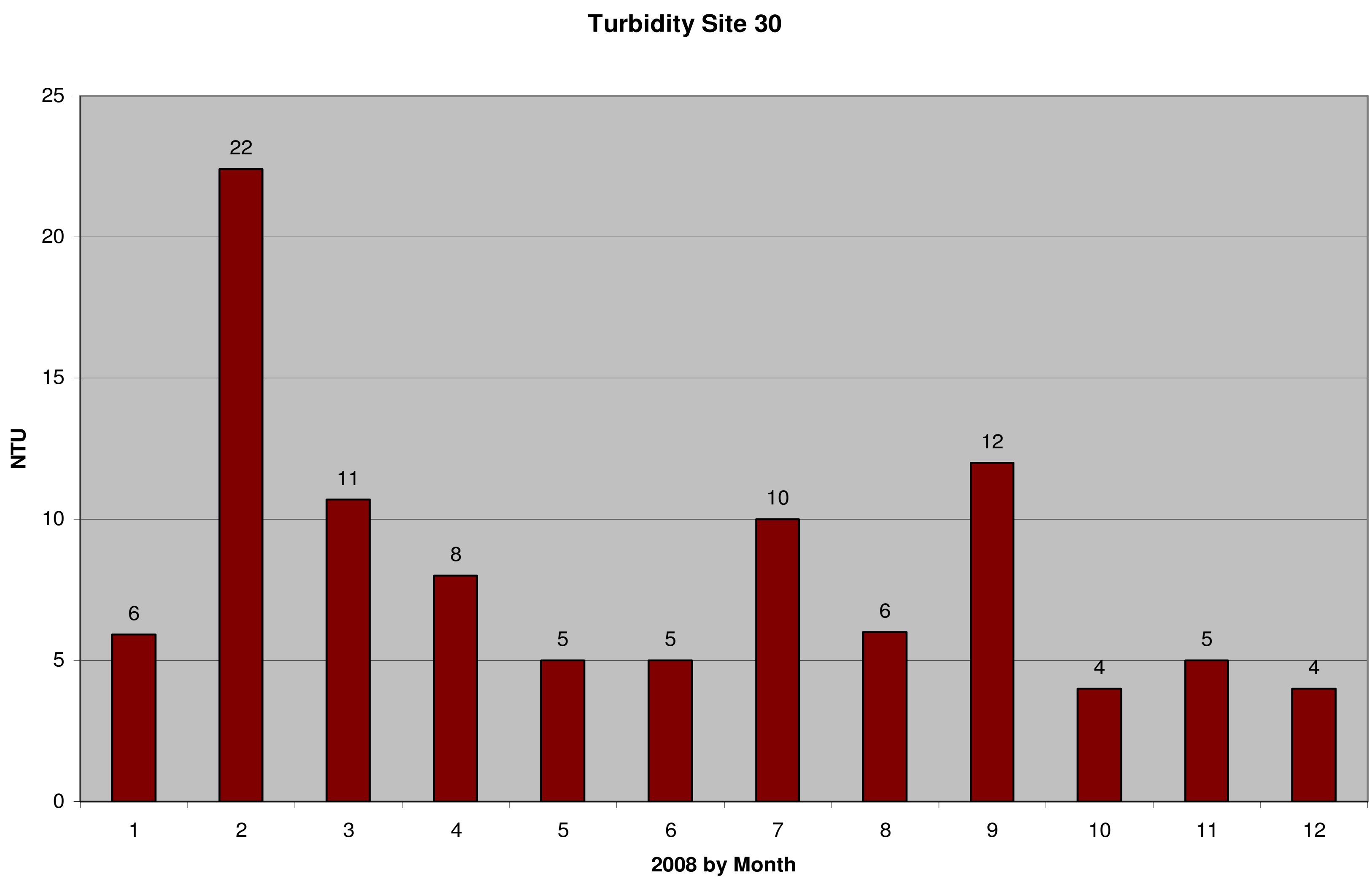

Figure 91: Monthly turbidity for site 30 with 8 nephelometer turbidity units as the yearly average.

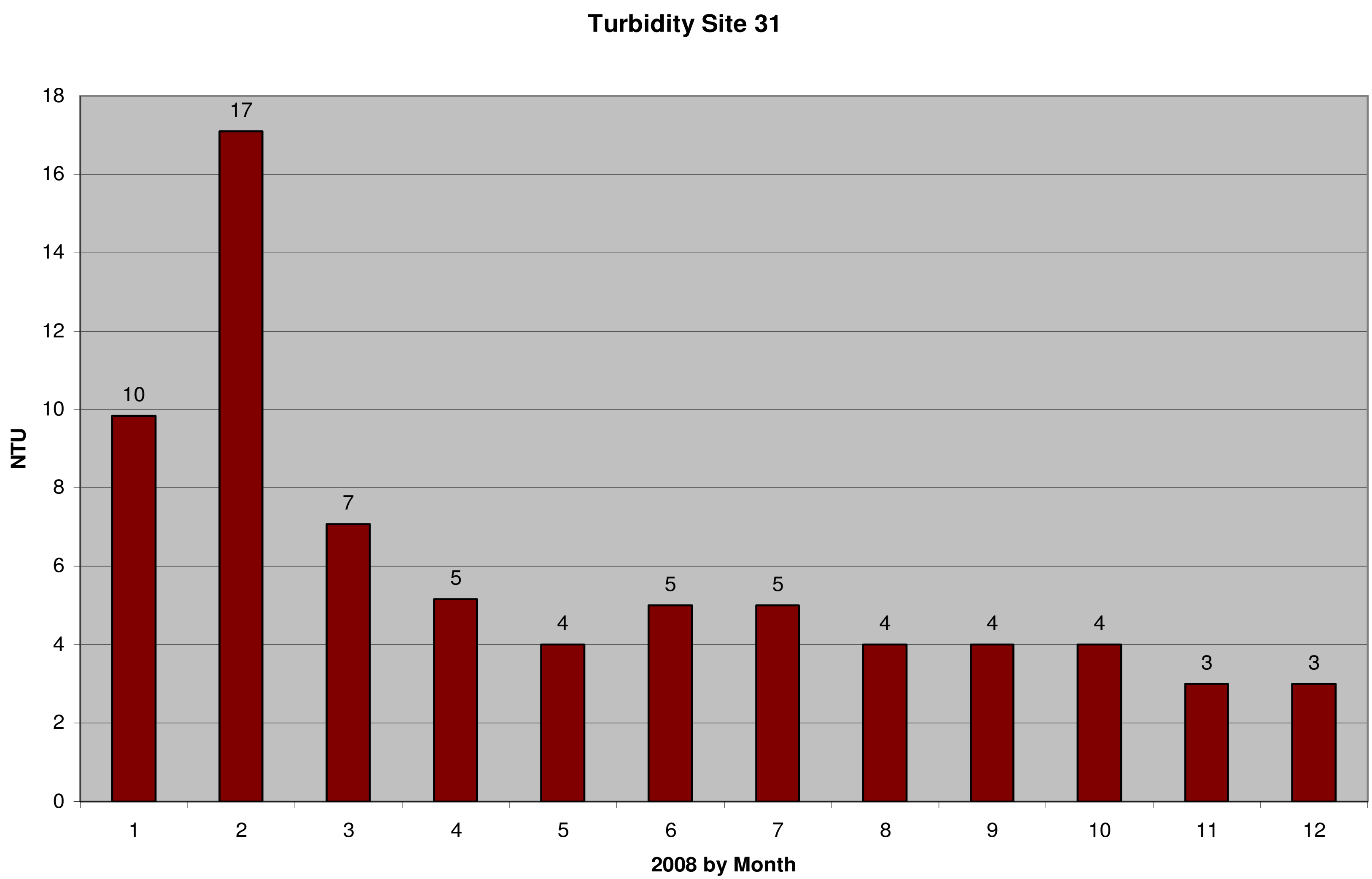

Figure 92: Monthly turbidity for site 31 with 6 nephelometer turbidity units as the yearly average.

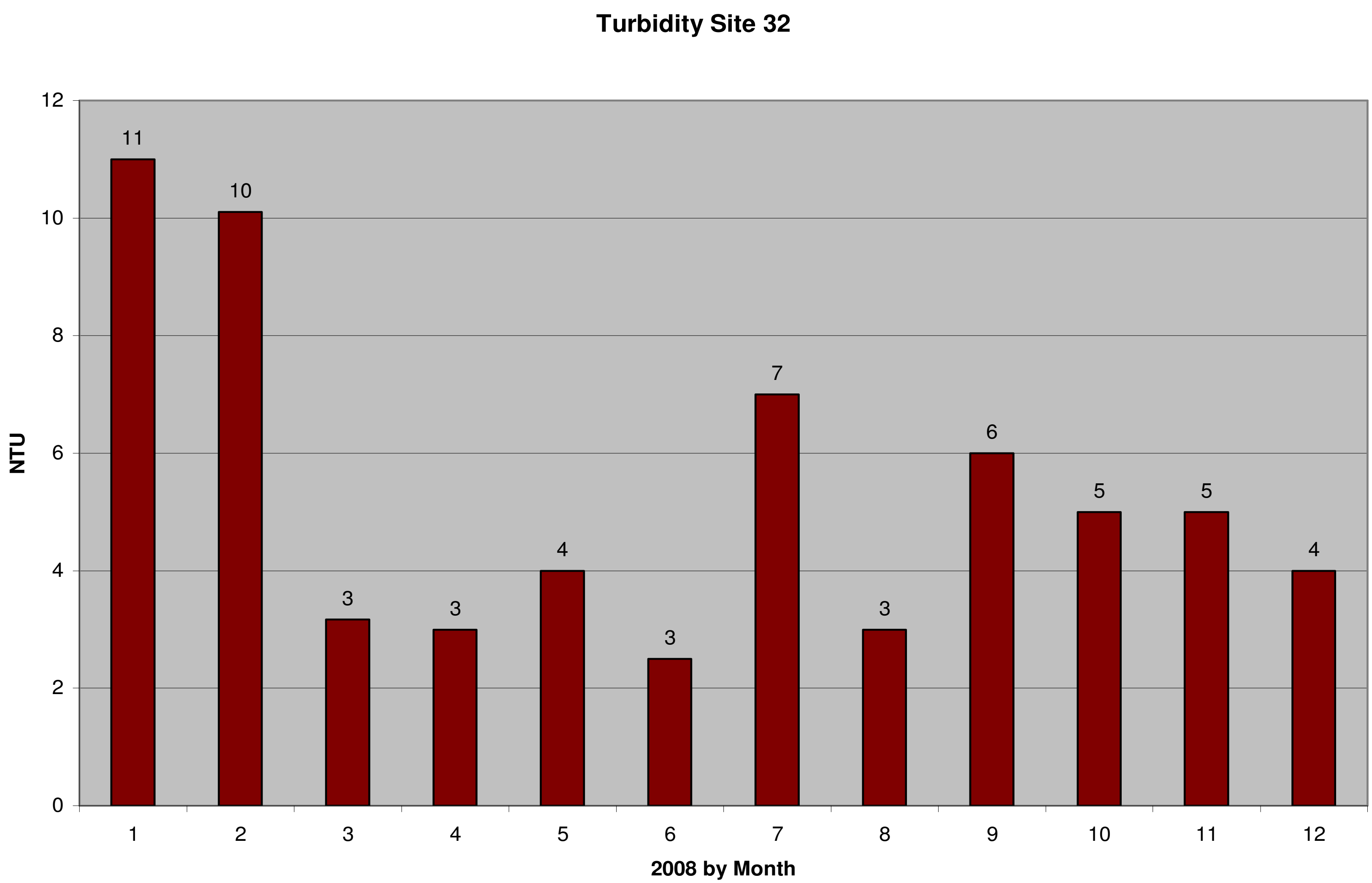

Figure 93: Monthly turbidity for site 32 with 5 nephelometer turbidity units as the yearly average.

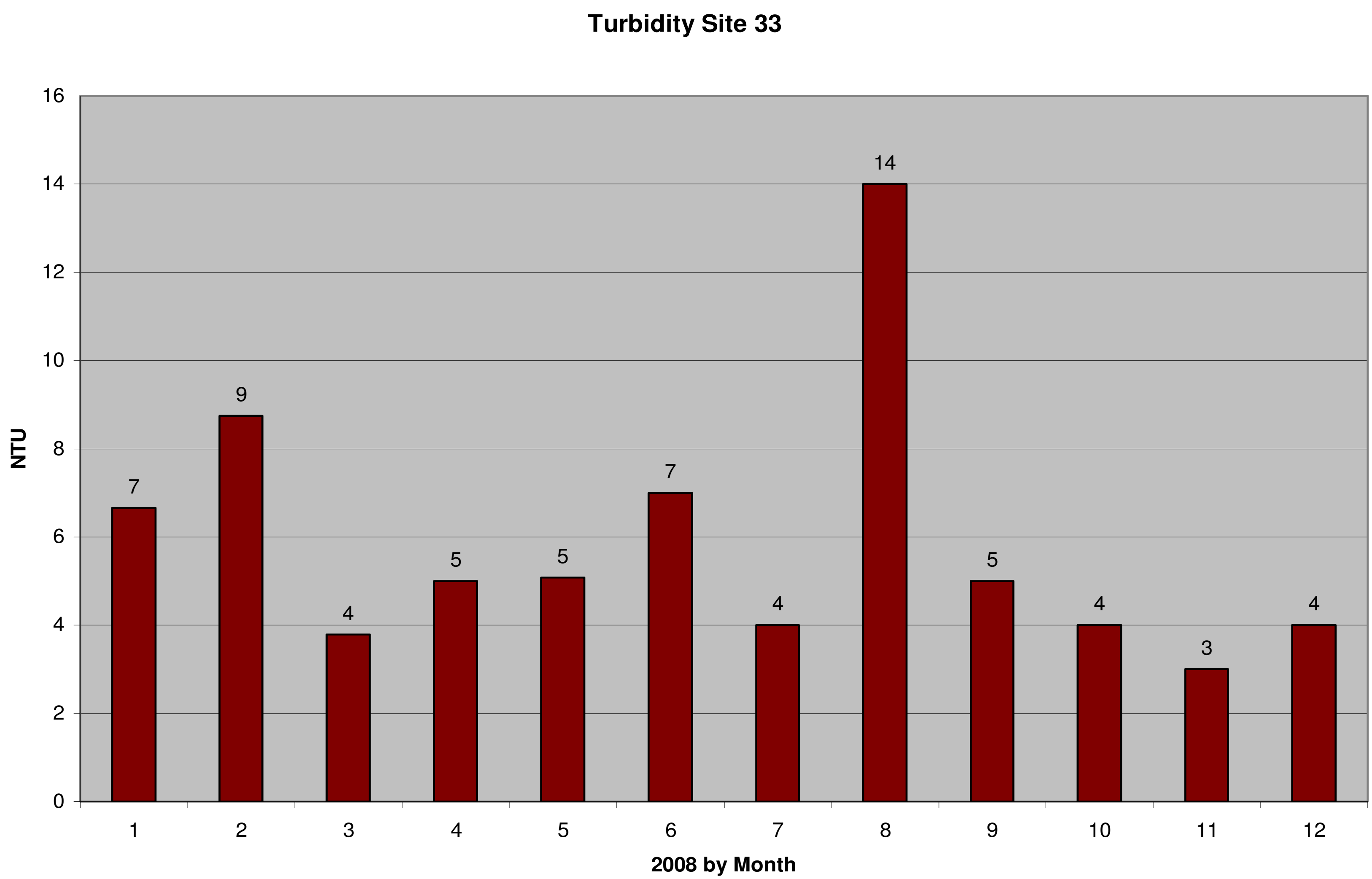

Figure 94: Monthly turbidity for site 33 with 6 nephelometer turbidity units as the yearly average.

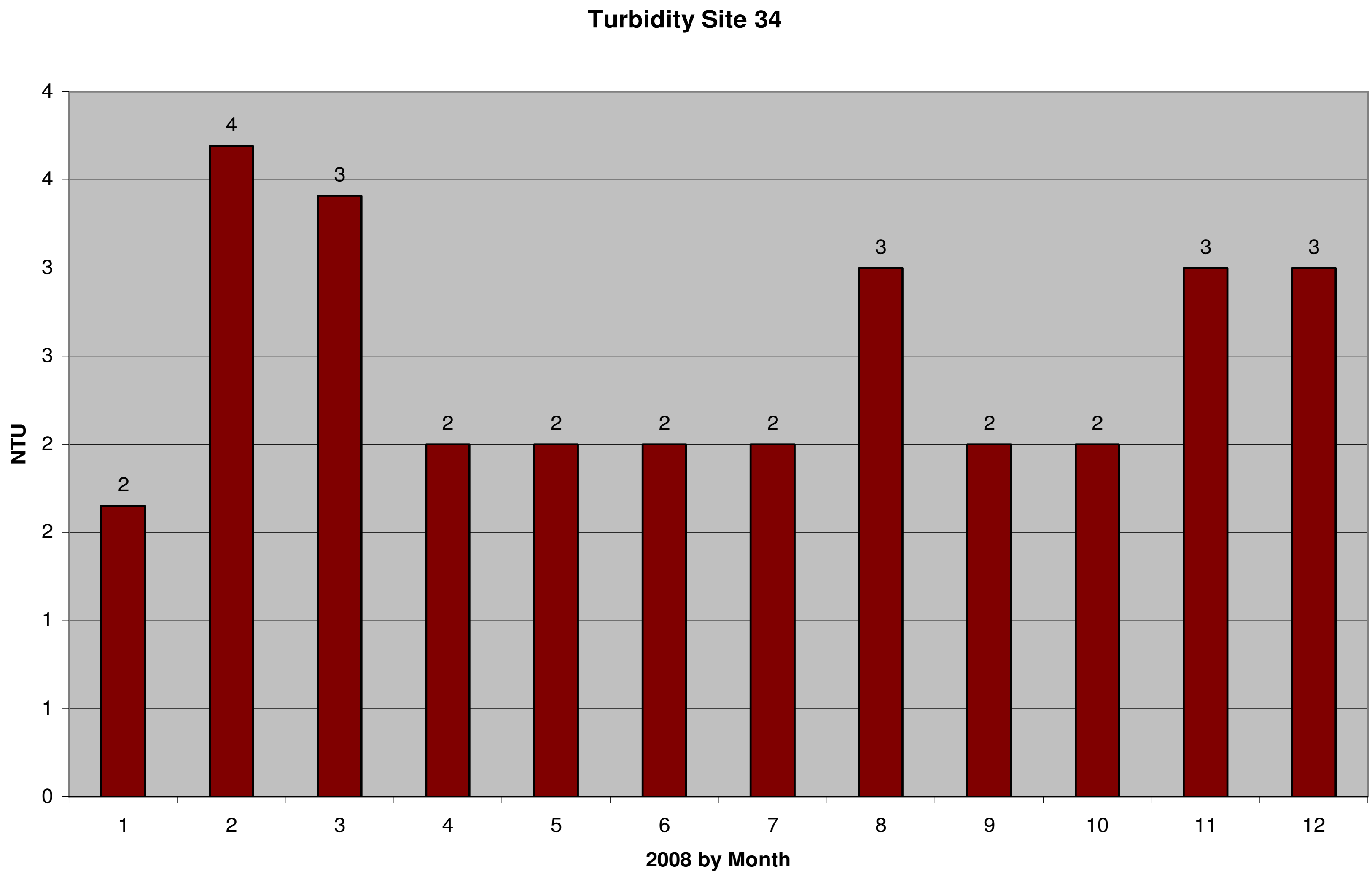

Figure 95: Monthly turbidity for site 34 with 2 nephelometer turbidity units as the yearly average.

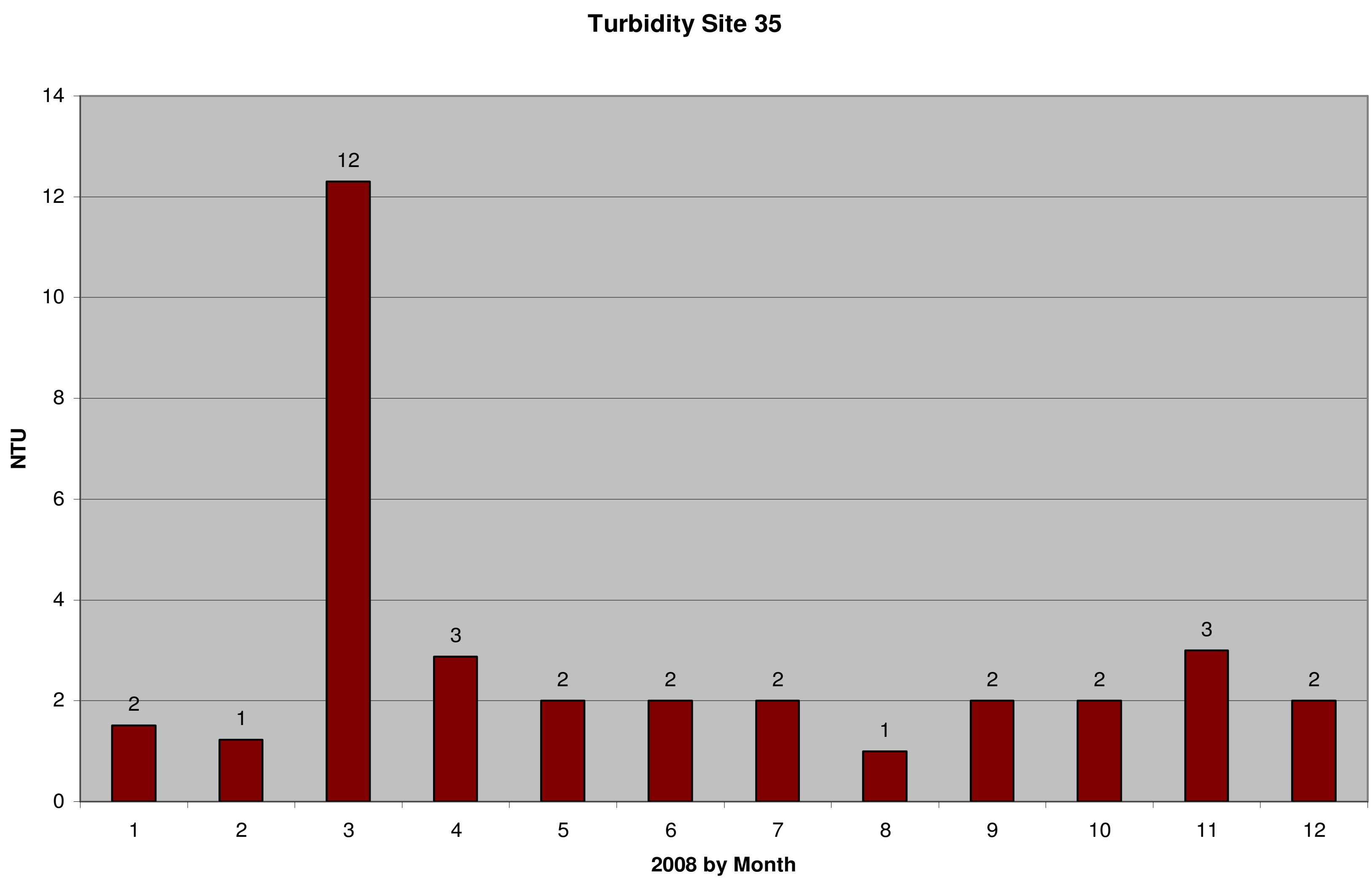

Figure 96: Monthly turbidity for site 35 with 3 nephelometer turbidity units as the yearly average.

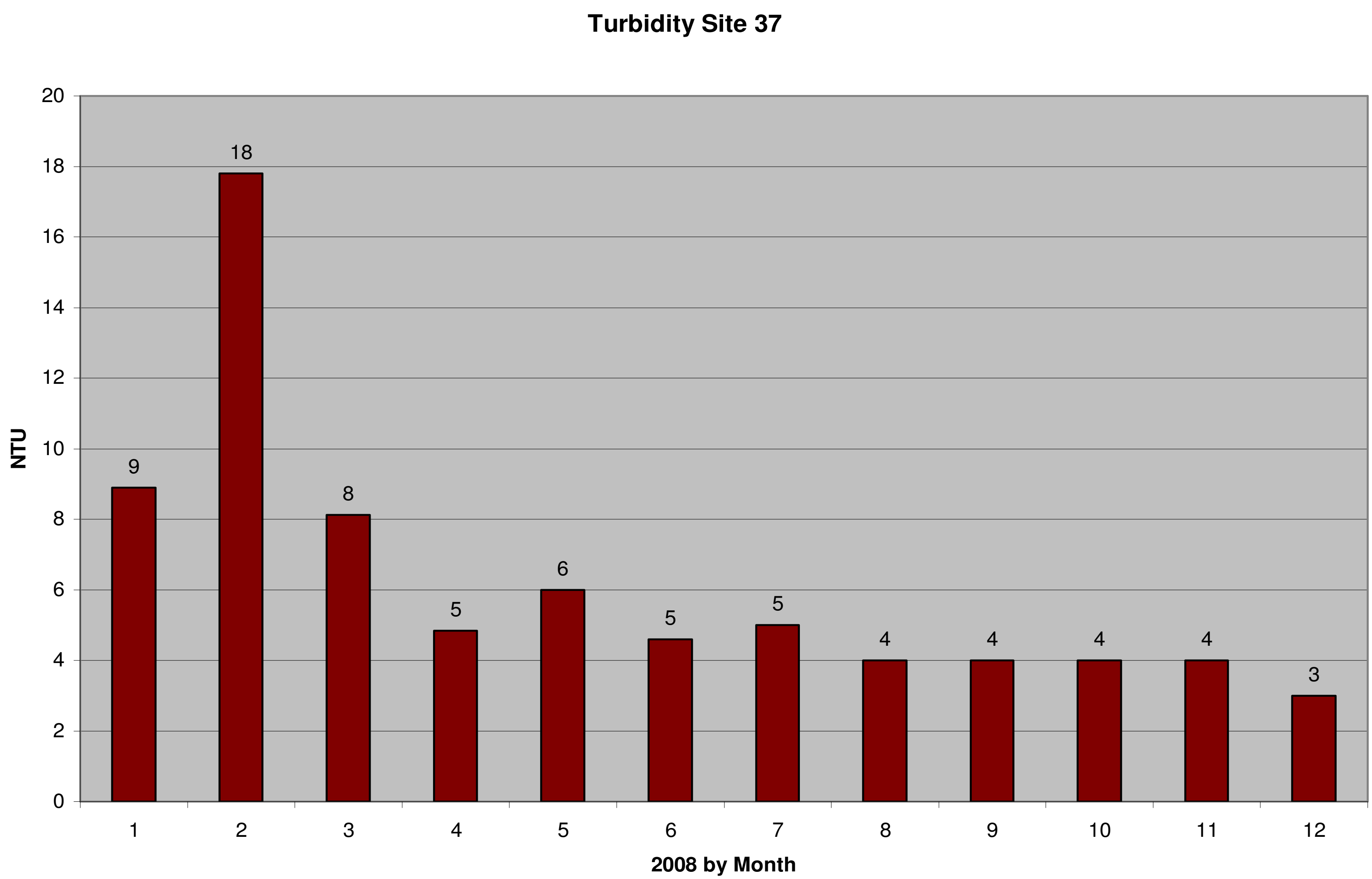

Figure 97: Monthly turbidity for site 37 with 6 nephelometer turbidity units as the yearly average.

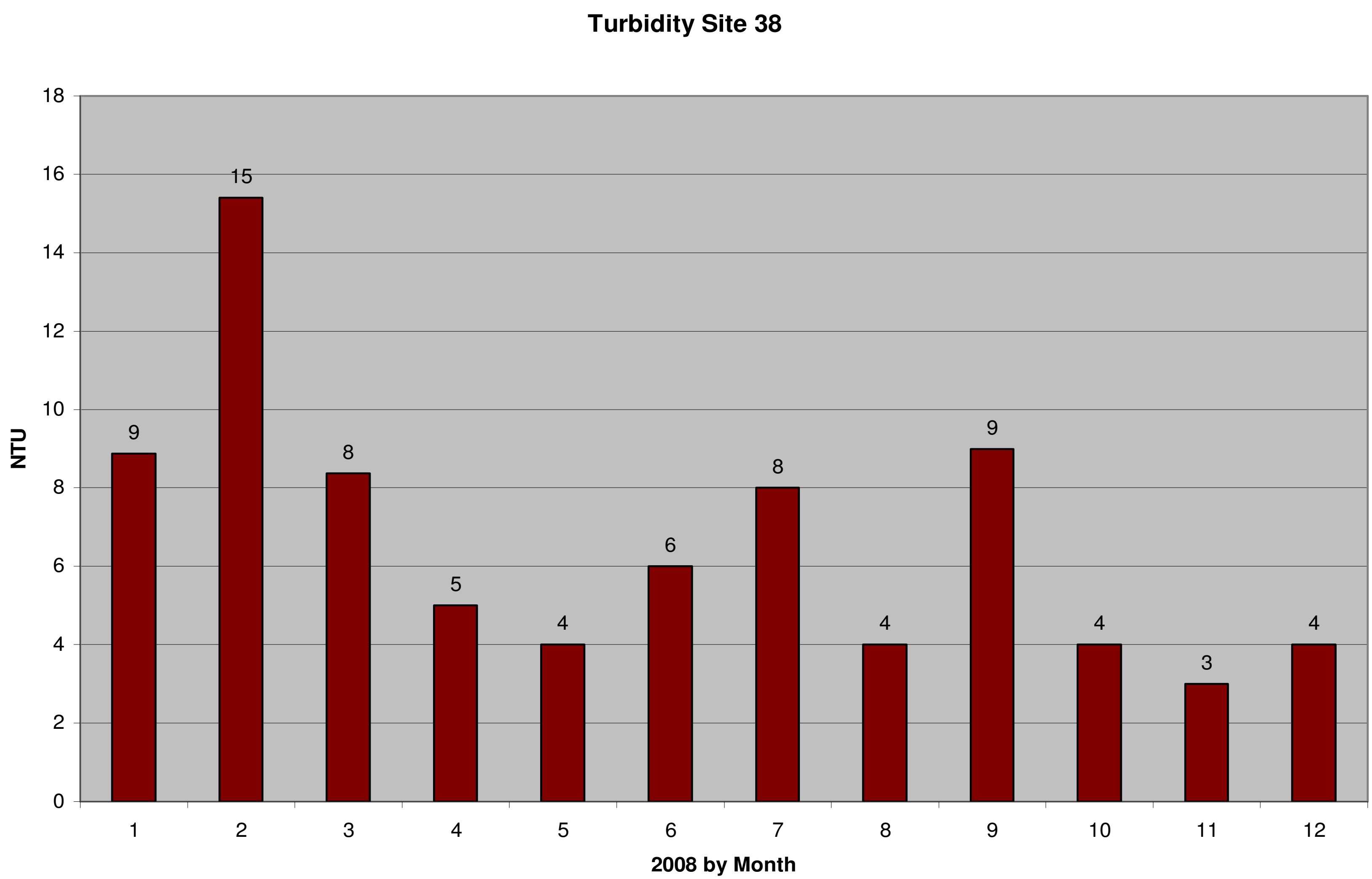

Figure 98: Monthly turbidity for site 38 with 7 nephelometer turbidity units as the yearly average.

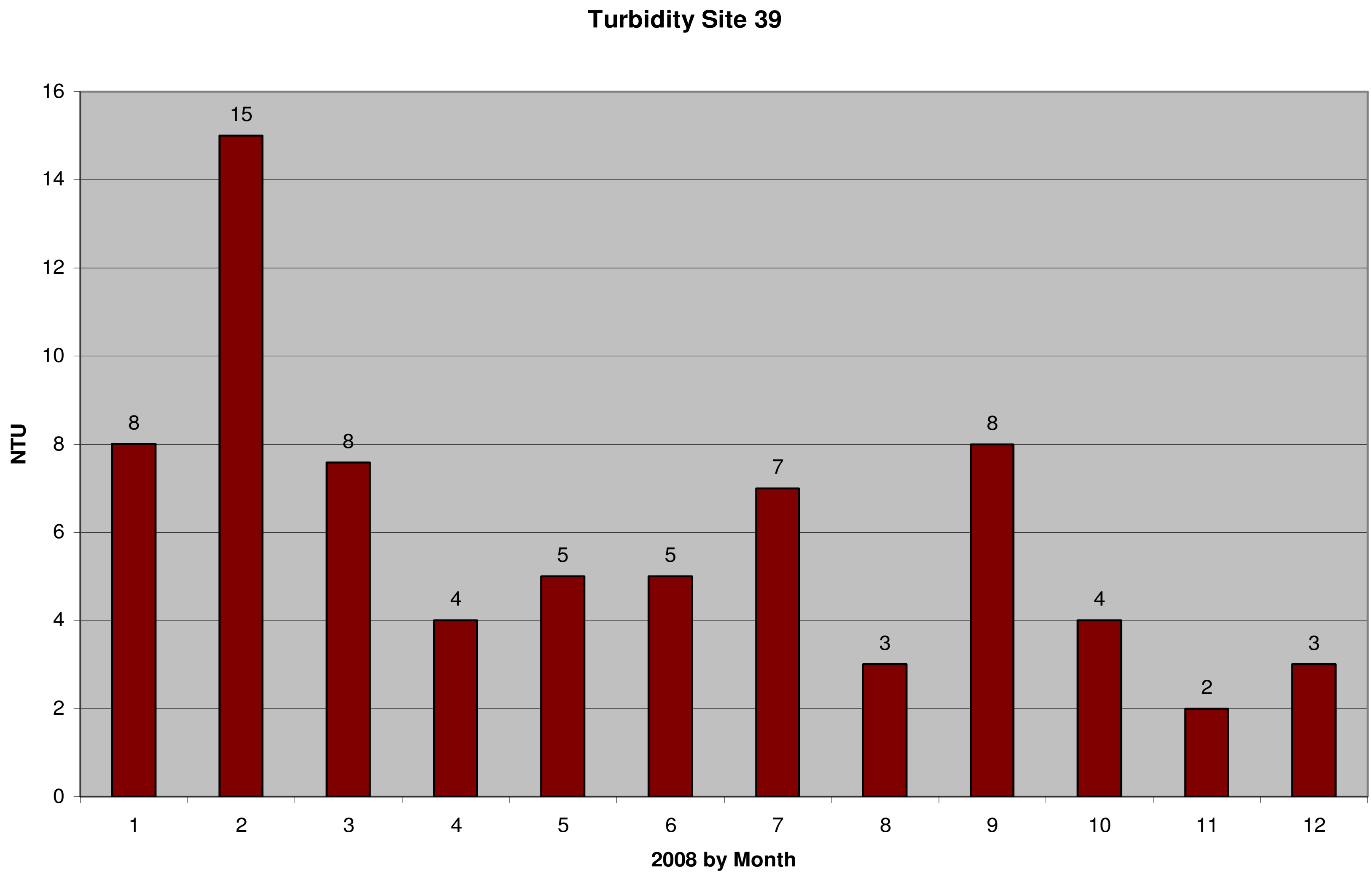

Figure 99: Monthly turbidity for site 39 with 6 nephelometer turbidity units as the yearly average.

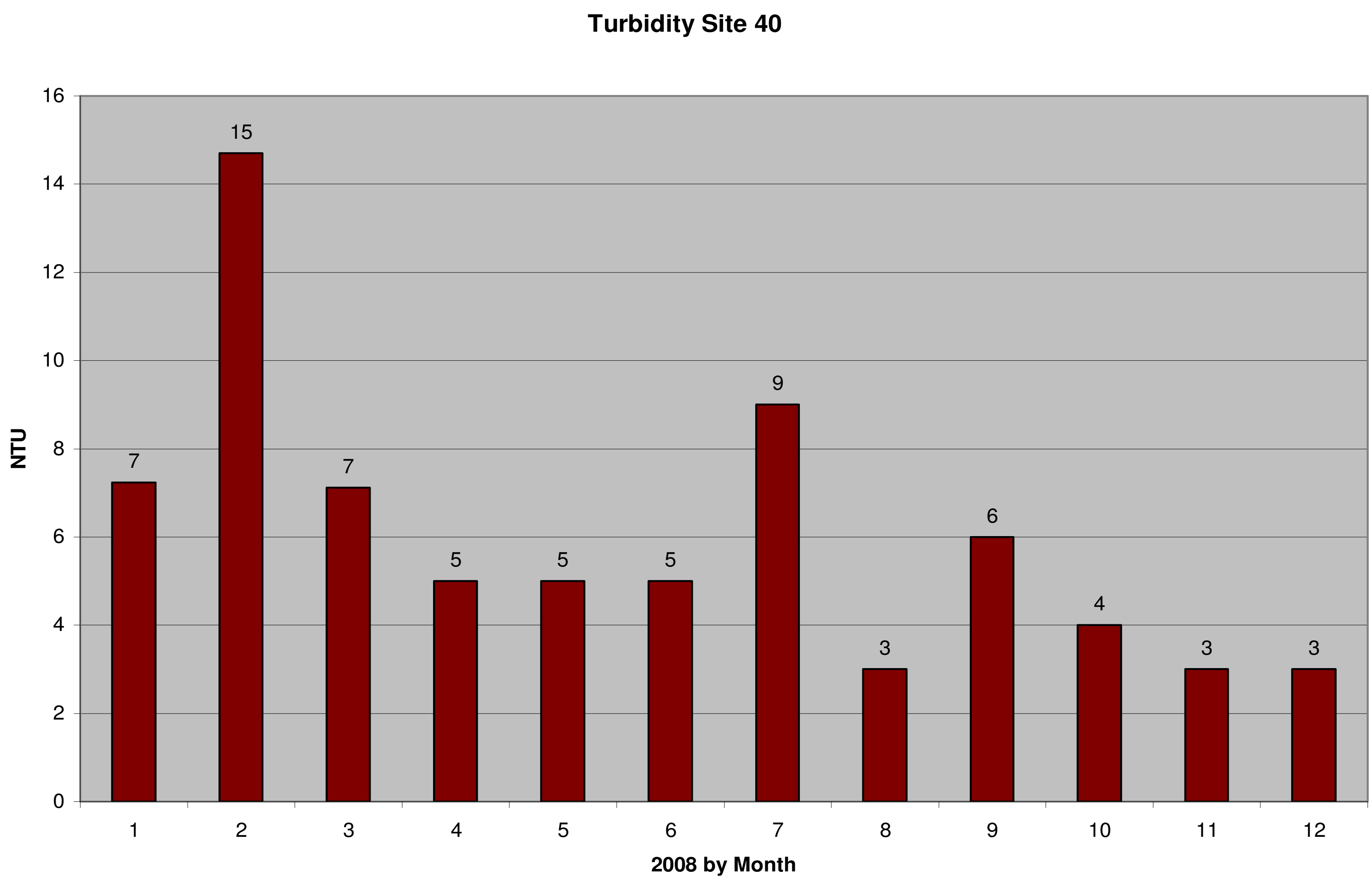

Figure 100: Monthly turbidity for site 40 with 6 nephelometer turbidity units as the yearly average.

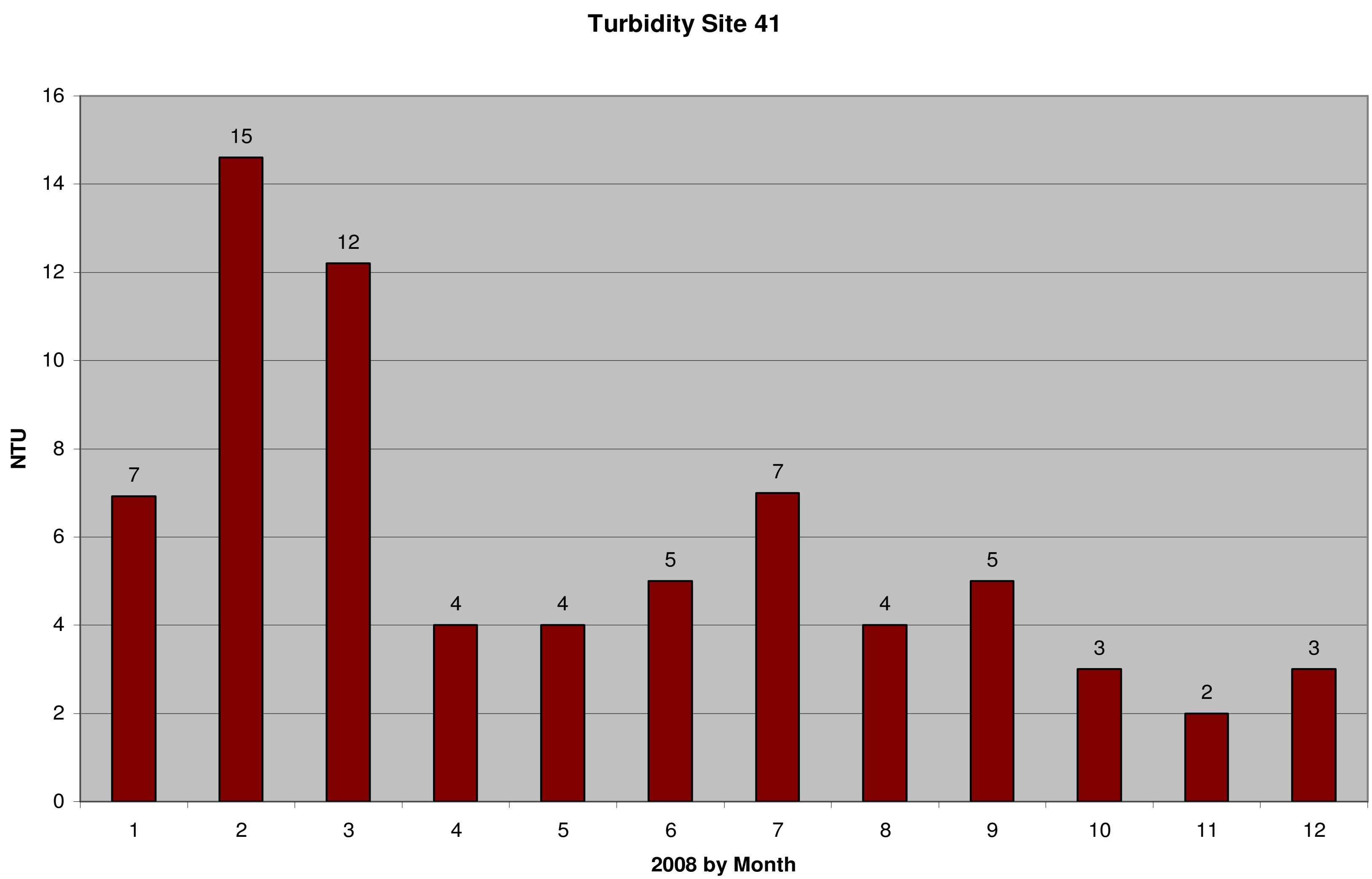

Figure 101: Monthly turbidity for site 41 with 6 nephelometer turbidity units as the yearly average.

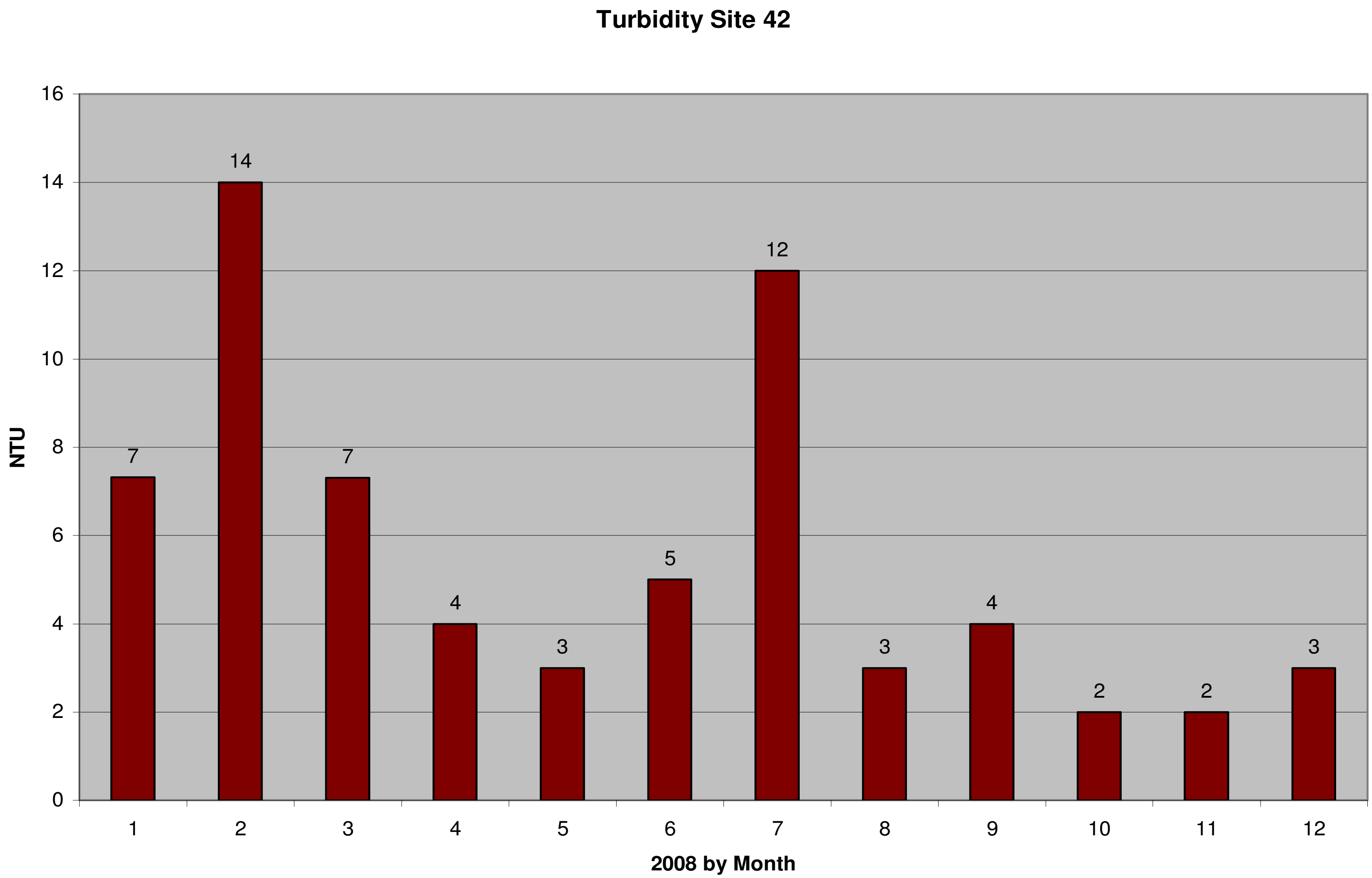

Figure 102: Monthly turbidity for site 42 with 6 nephelometer turbidity units as the yearly average.

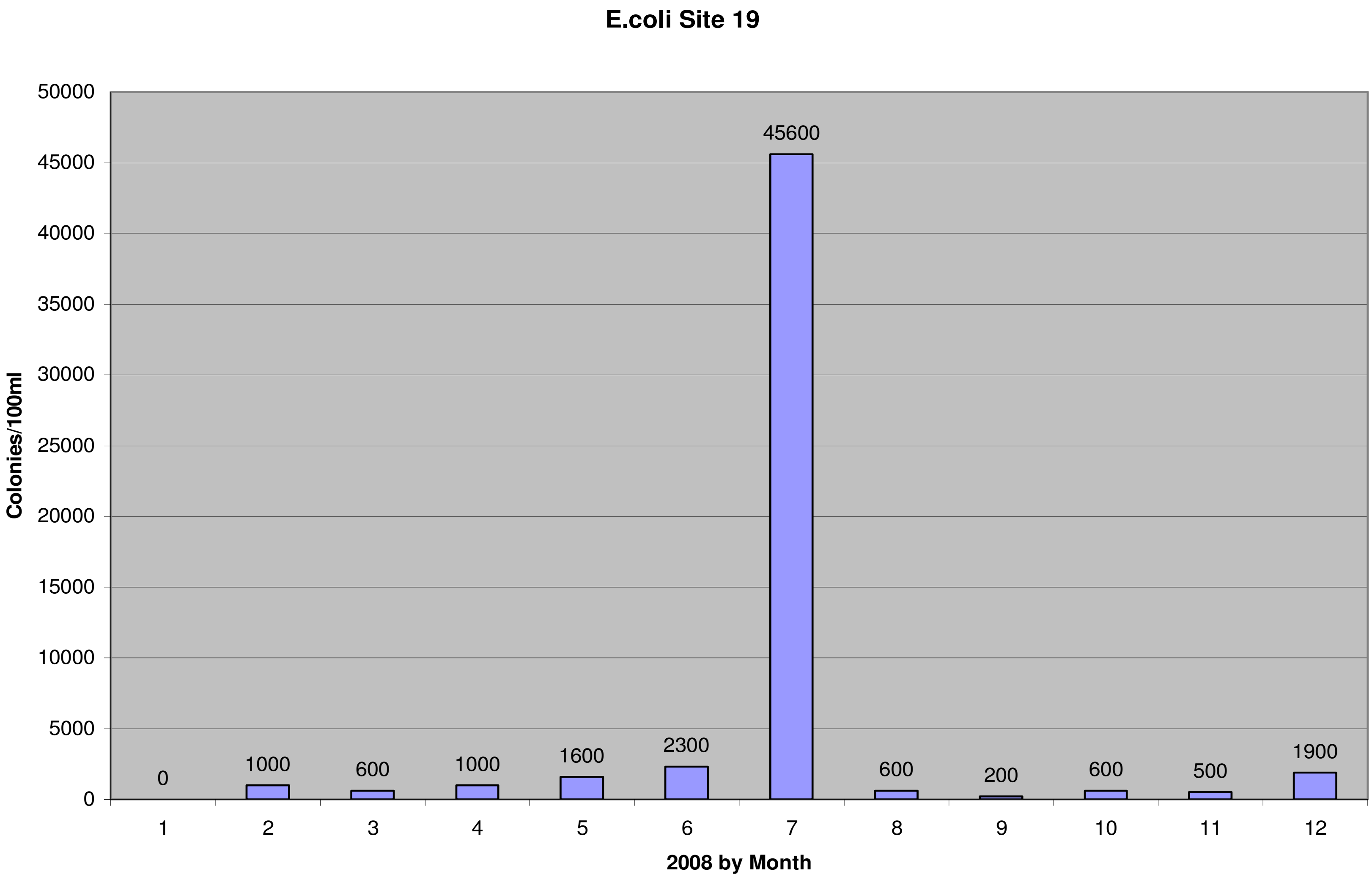

Figure 103: Monthly *E.coli* for site 19 with 4658 colonies per 100 milliliters of water as the yearly average.

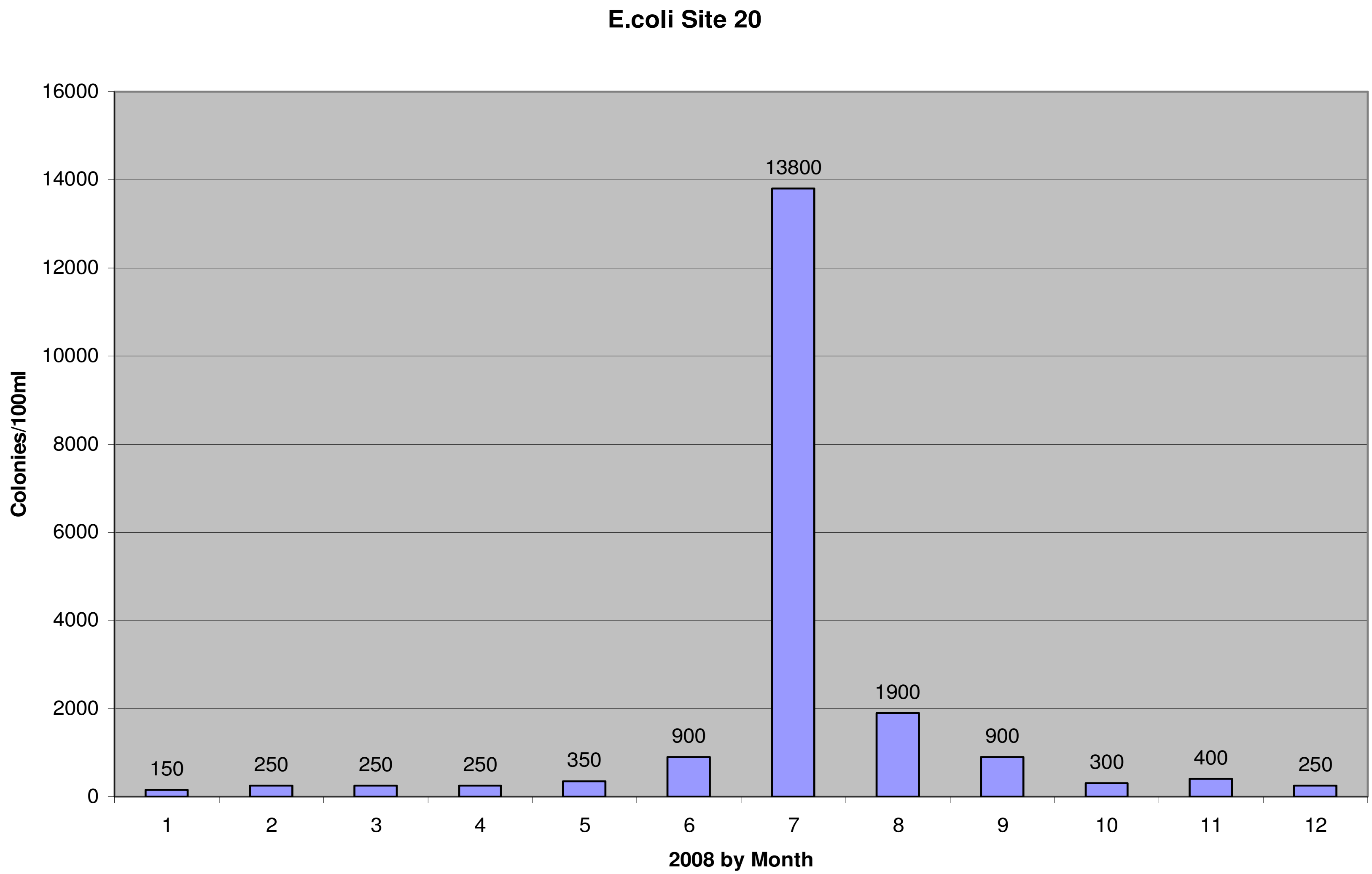

Figure 104: Monthly *E.coli* for site 20 with 1641 colonies per 100 milliliters of water as the yearly average.

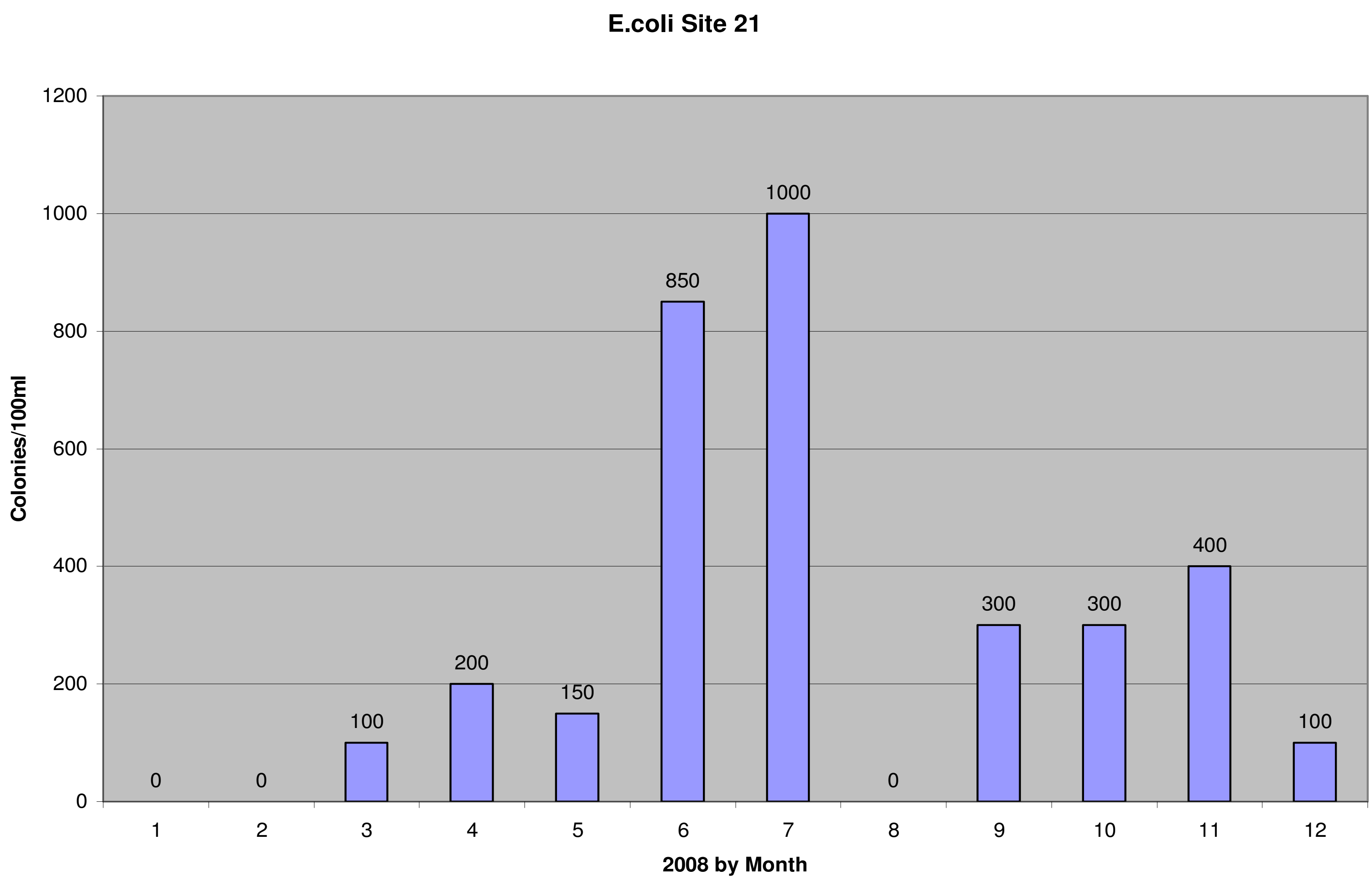

Figure 105: Monthly *E.coli* for site 21 with 283 colonies per 100 milliliters of water as the yearly average.

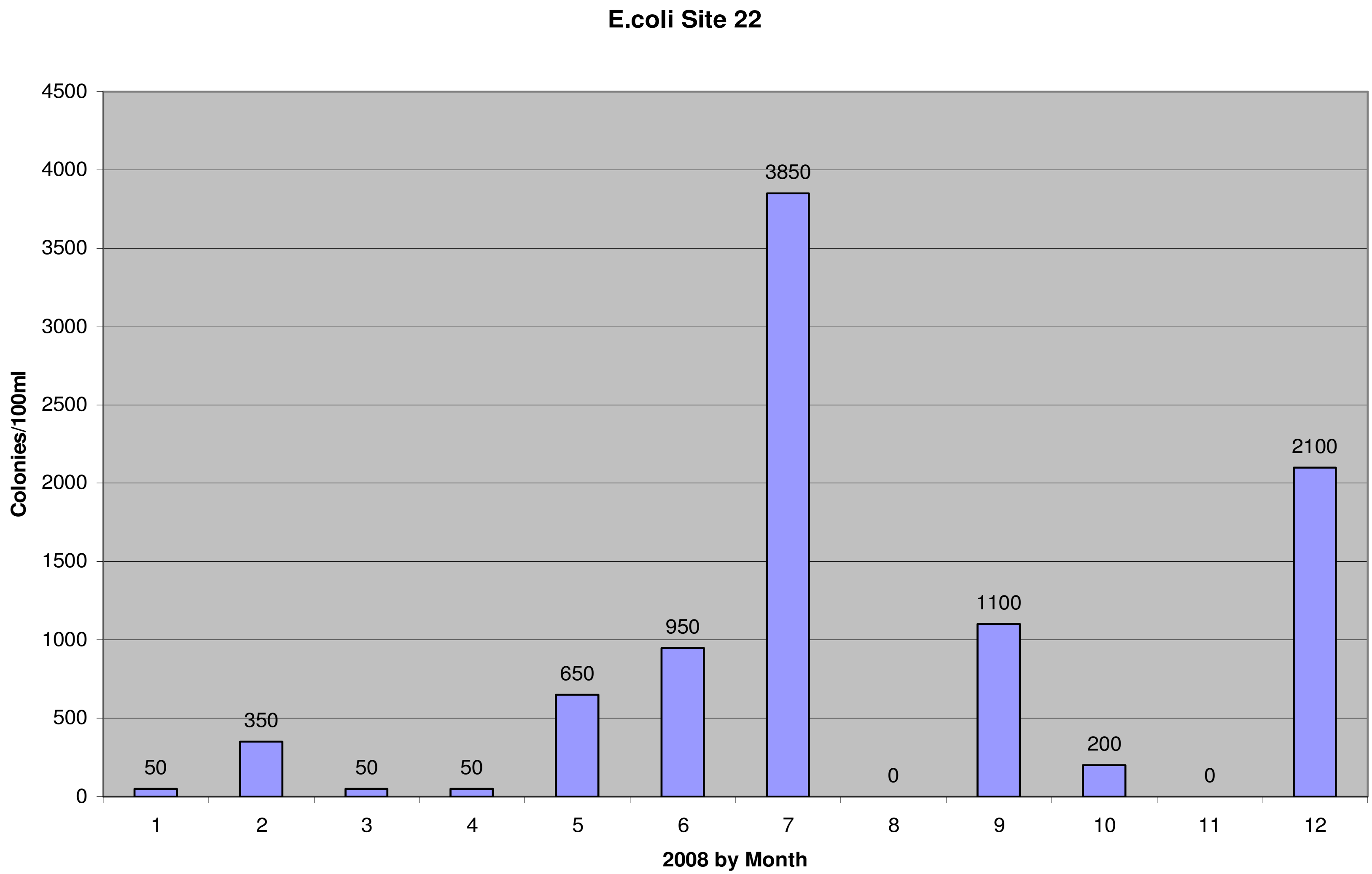

Figure 106: Monthly *E.coli* for site 22 with 779 colonies per 100 milliliters of water as the yearly average.

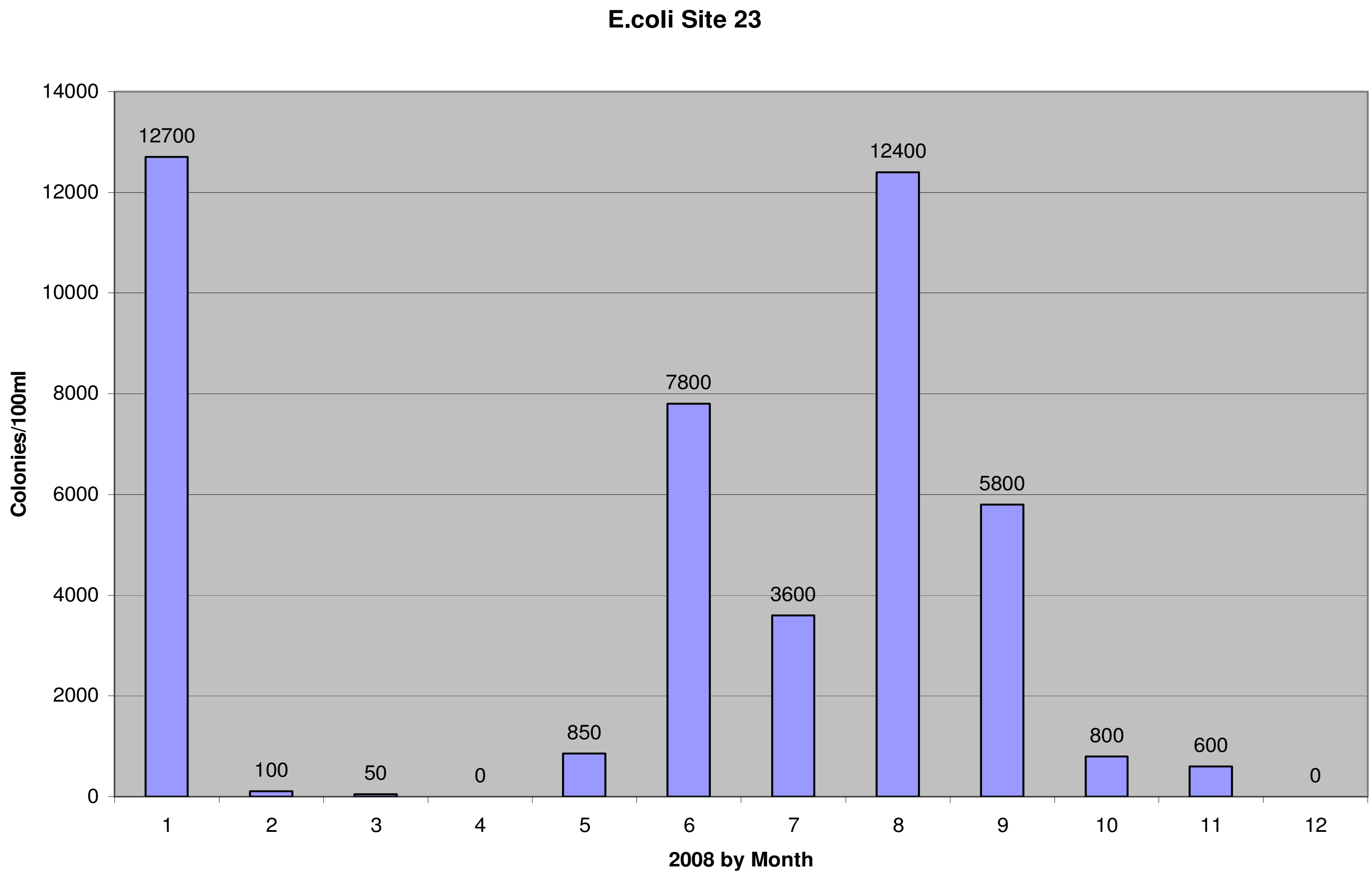

Figure 107: Monthly *E.coli* for site 23 with 3725 colonies per 100 milliliters of water as the yearly average.

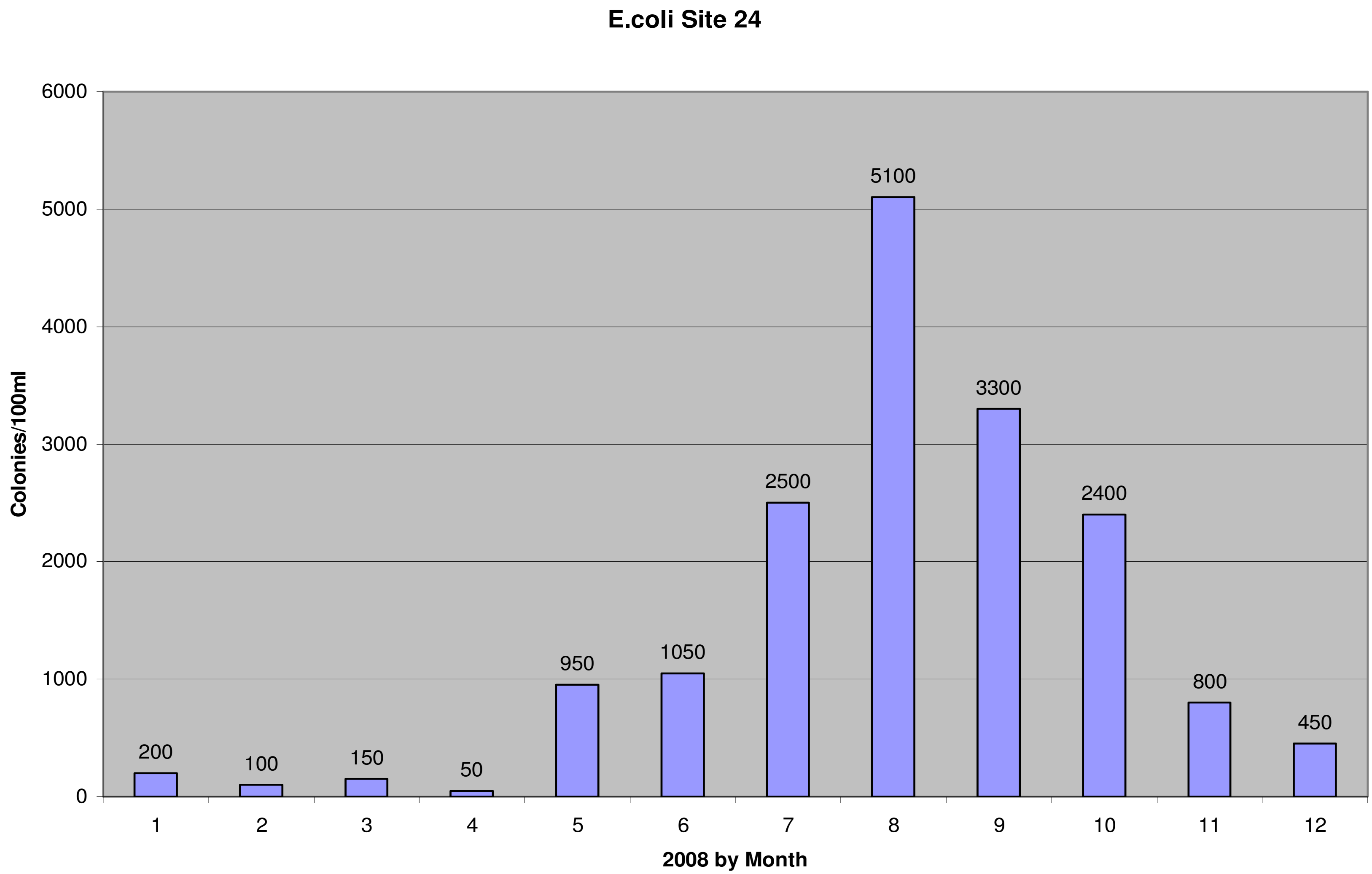

Figure 108: Monthly *E.coli* for site 24 with 1421 colonies per 100 milliliters of water as the yearly average.

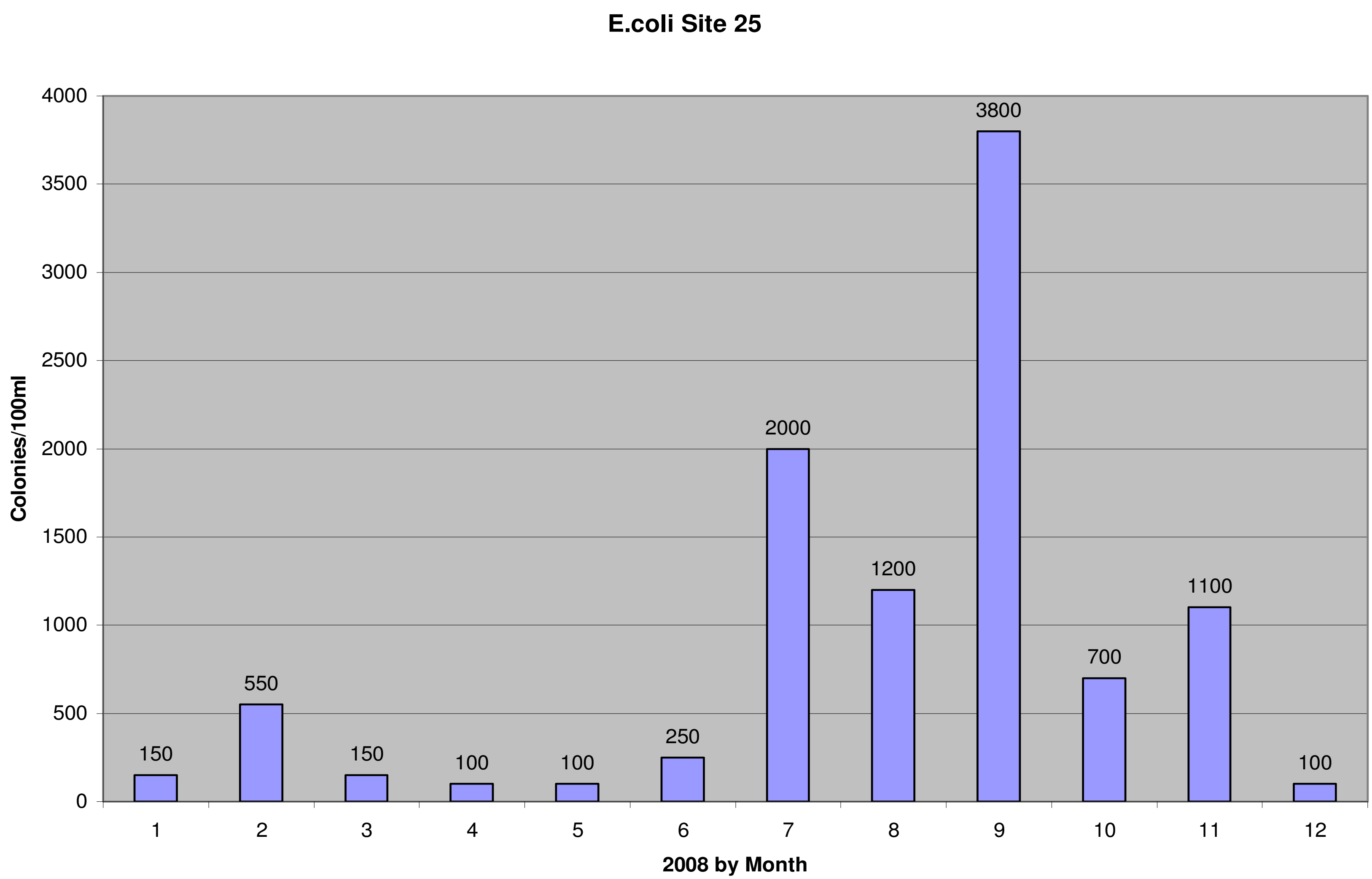

Figure 109: Monthly *E.coli* for site 25 with 850 colonies per 100 milliliters of water as the yearly average.

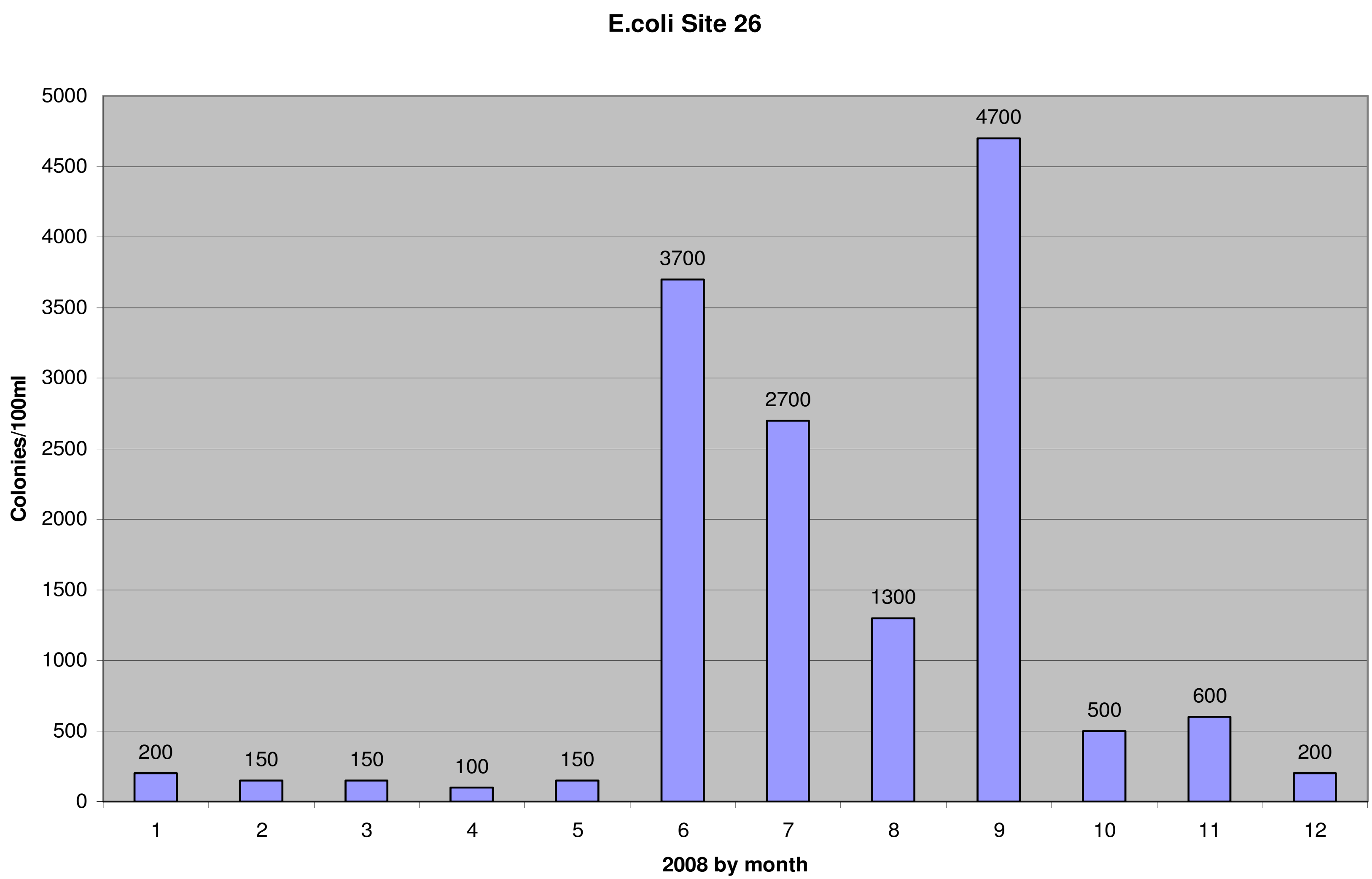

Figure 110: Monthly *E.coli* for site 26 with 1204 colonies per 100 milliliters of water as the yearly average.

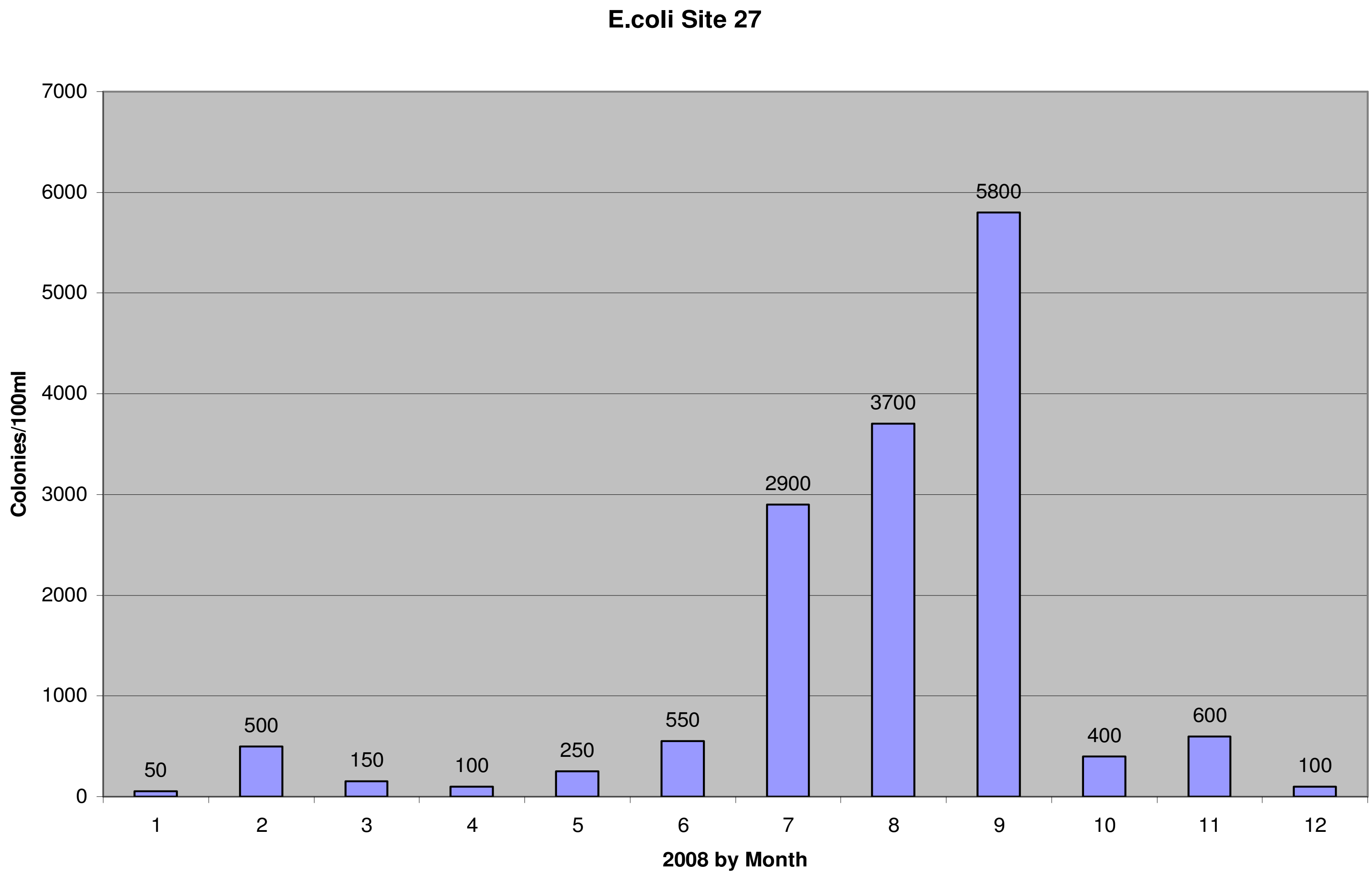

Figure 111: Monthly *E.coli* for site 27 with 1258 colonies per 100 milliliters of water as the yearly average.

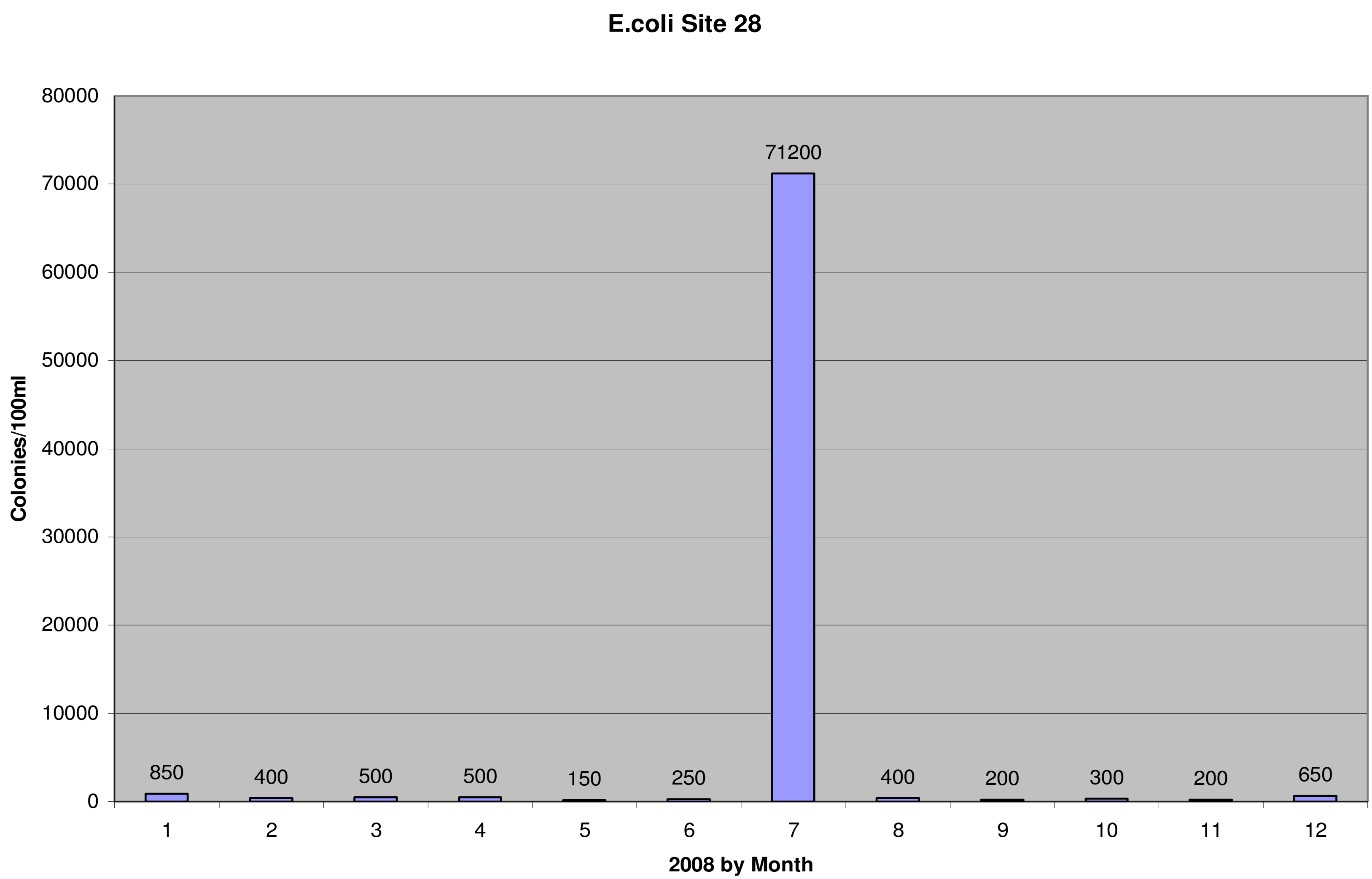

Figure 112: Monthly *E.coli* for site 28 with 6300 colonies per 100 milliliters of water as the yearly average.

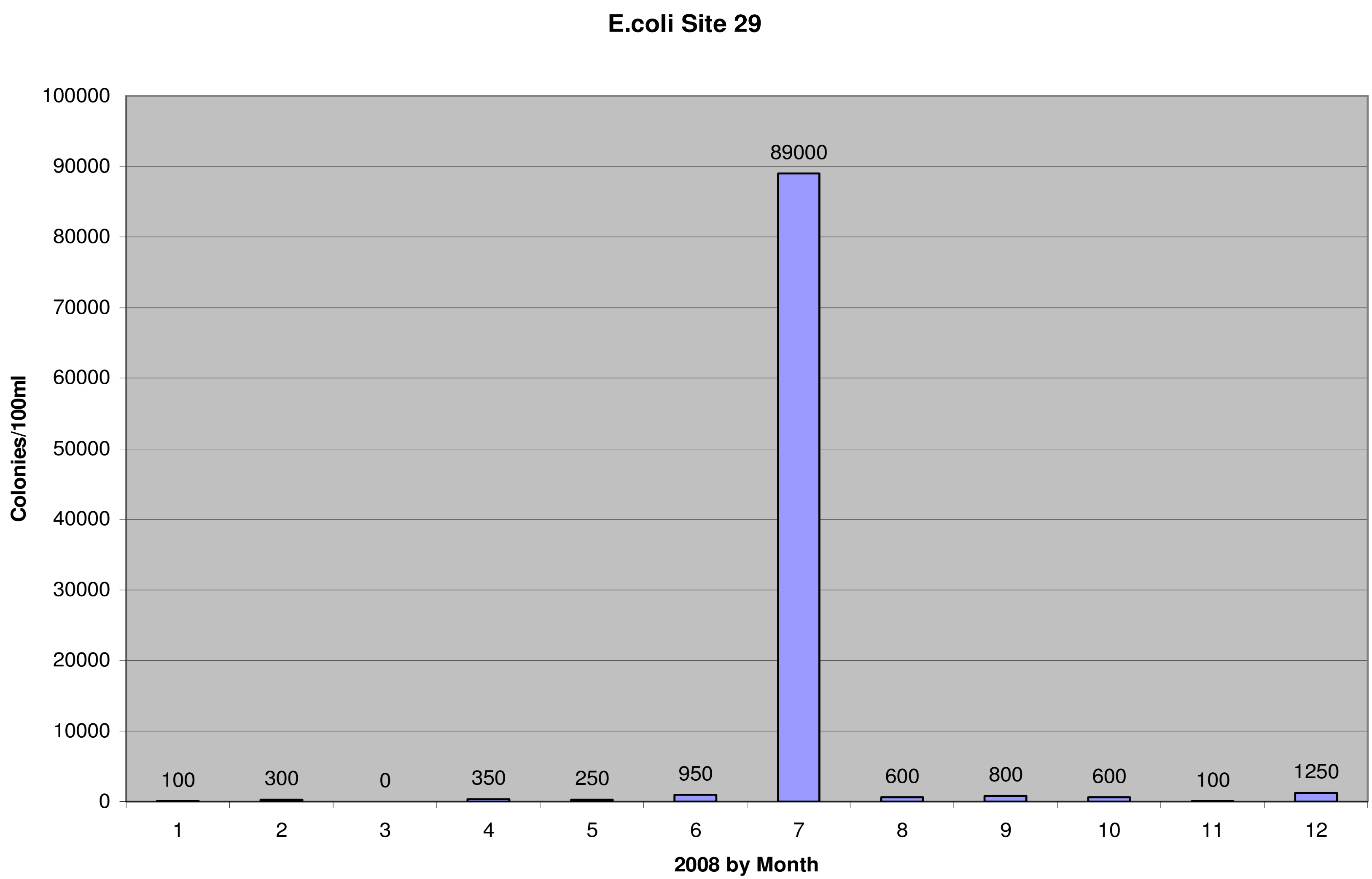

Figure 113: Monthly *E.coli* for site 29 with 7858 colonies per 100 milliliters of water as the yearly average.

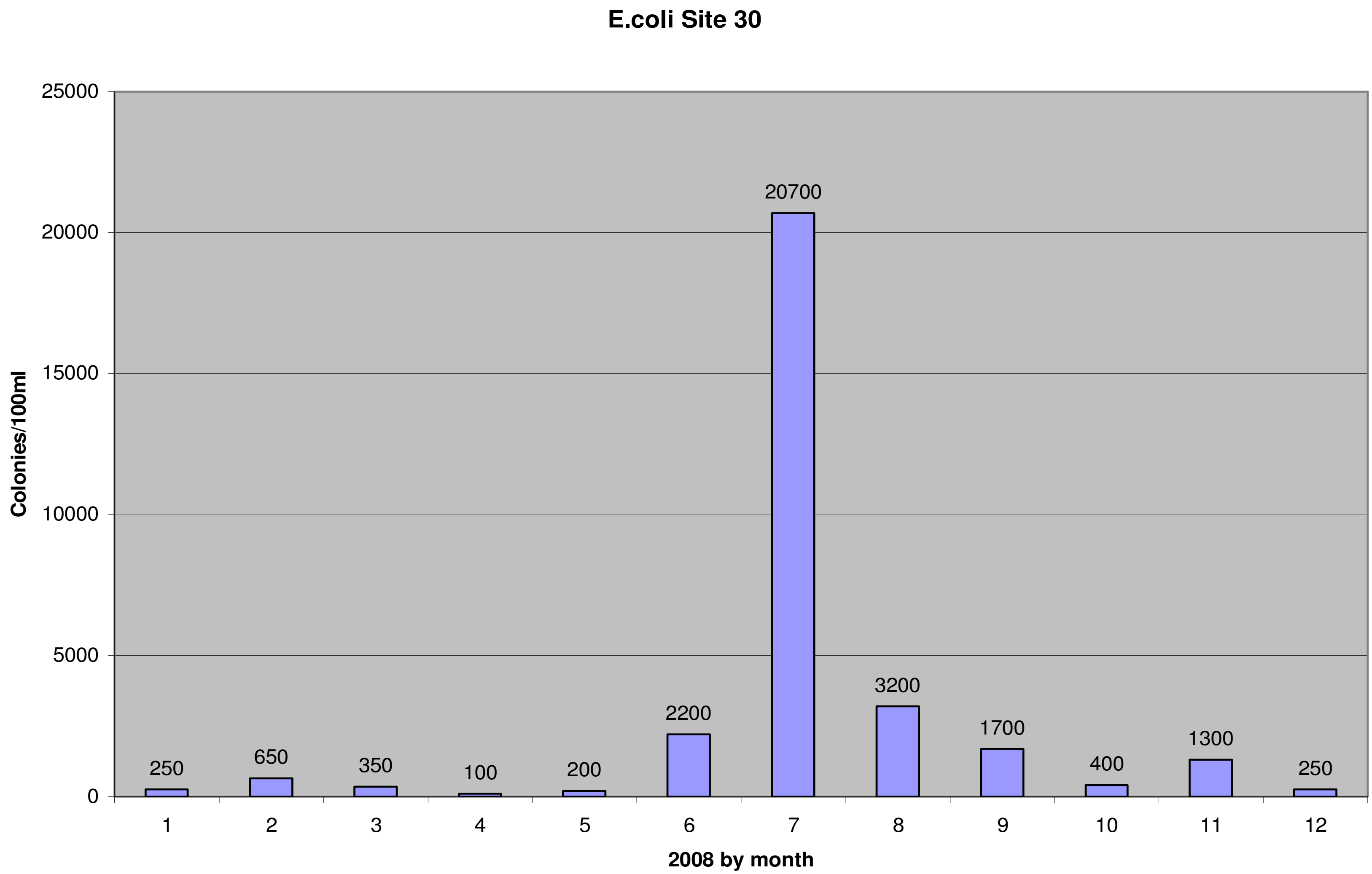

Figure 114: Monthly *E.coli* for site 30 with 2608 colonies per 100 milliliters of water as the yearly average.

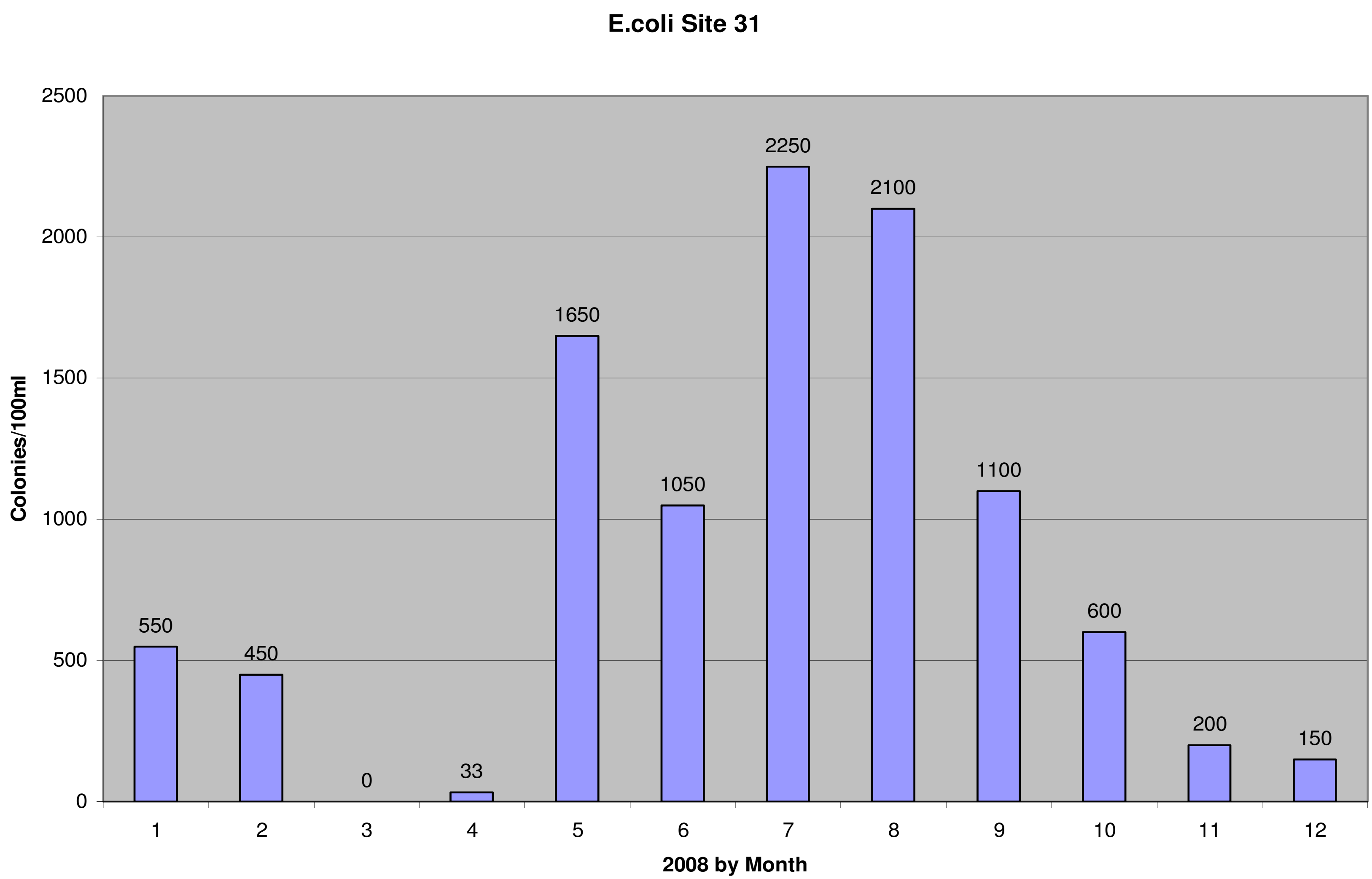

Figure 115: Monthly *E.coli* for site 31 with 844 colonies per 100 milliliters of water as the yearly average.

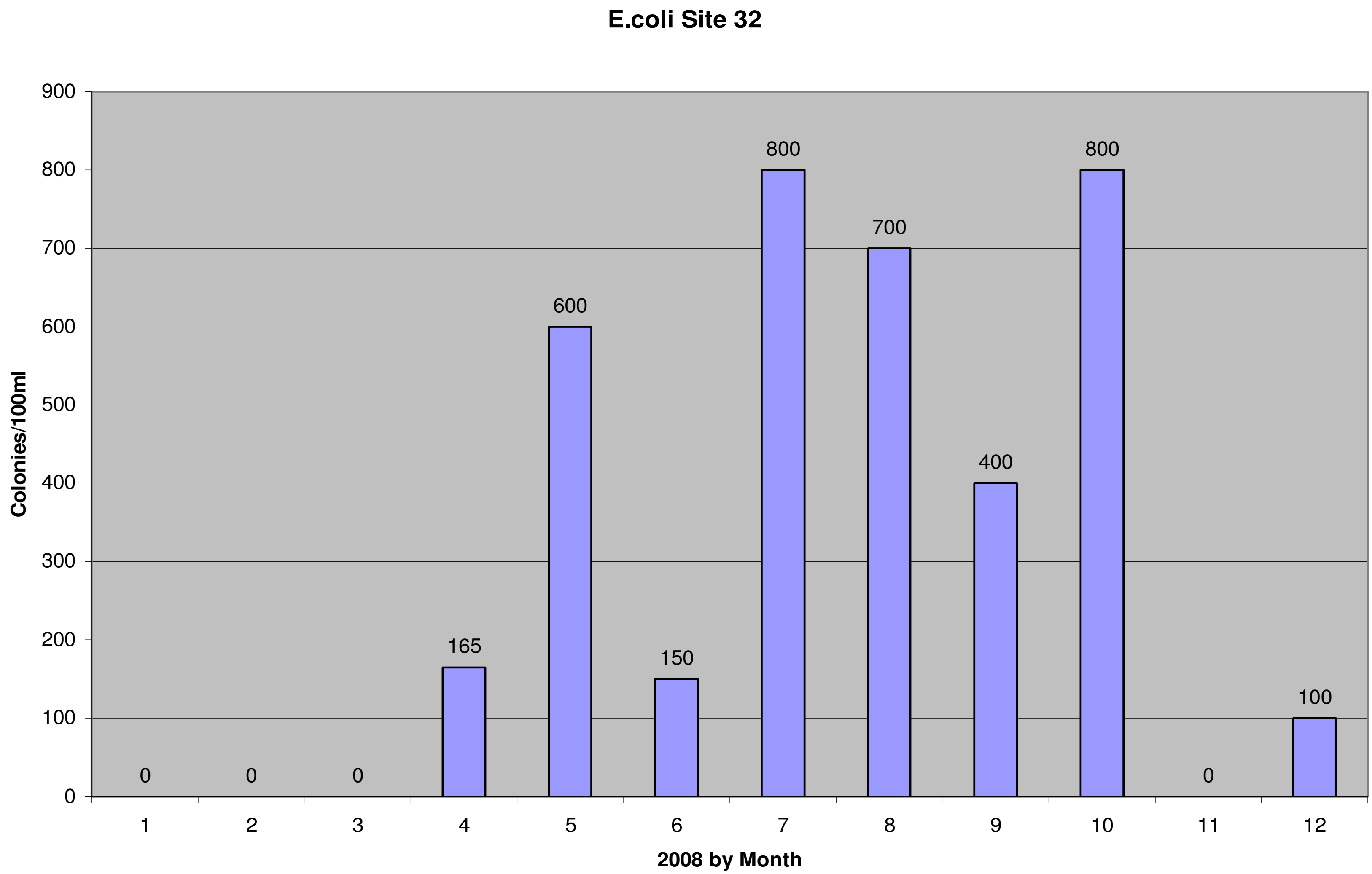

Figure 116: Monthly *E.coli* for site 32 with 310 colonies per 100 milliliters of water as the yearly average.

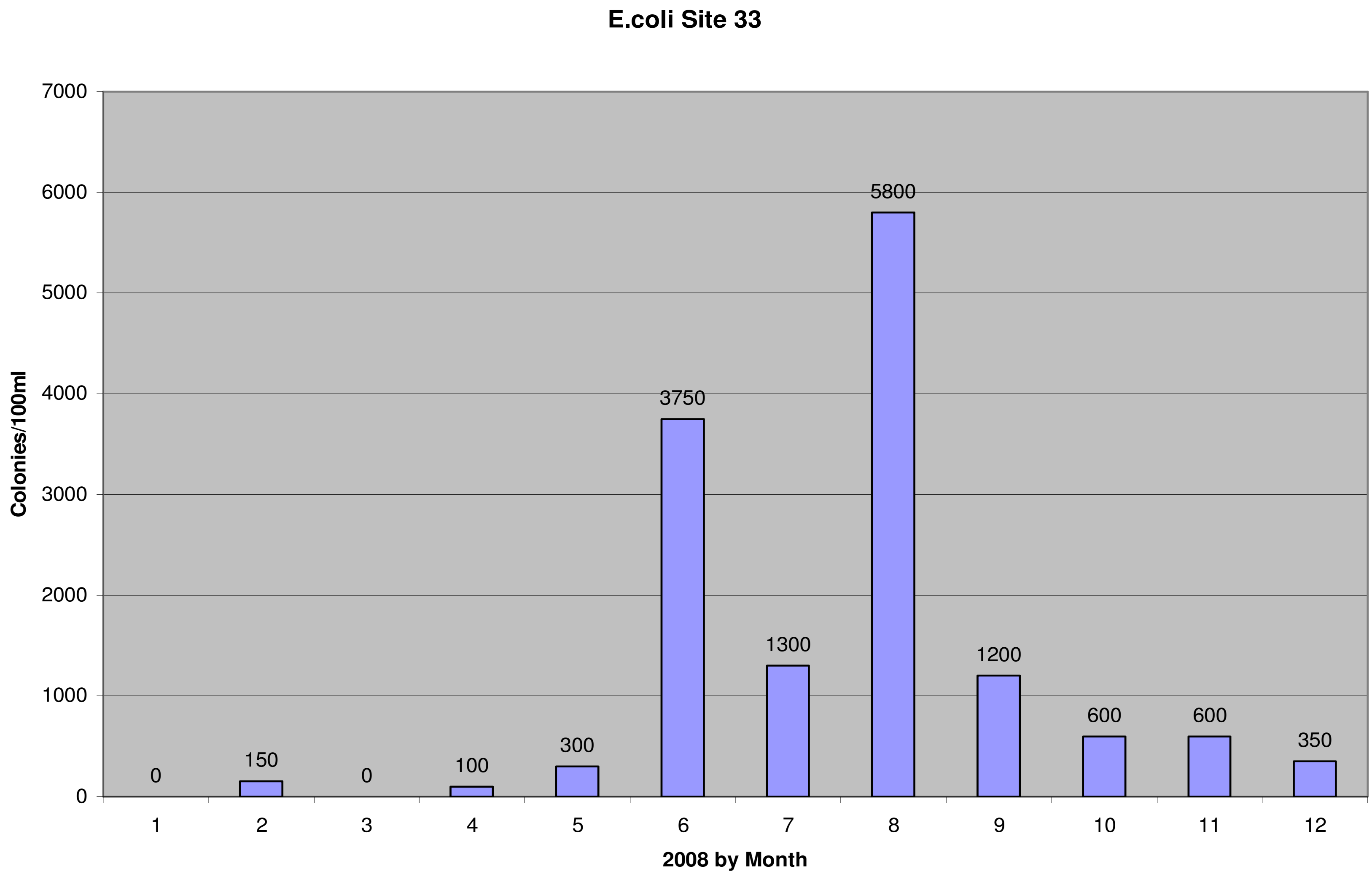

Figure 117: Monthly *E.coli* for site 33 with 1179 colonies per 100 milliliters of water as the yearly average.

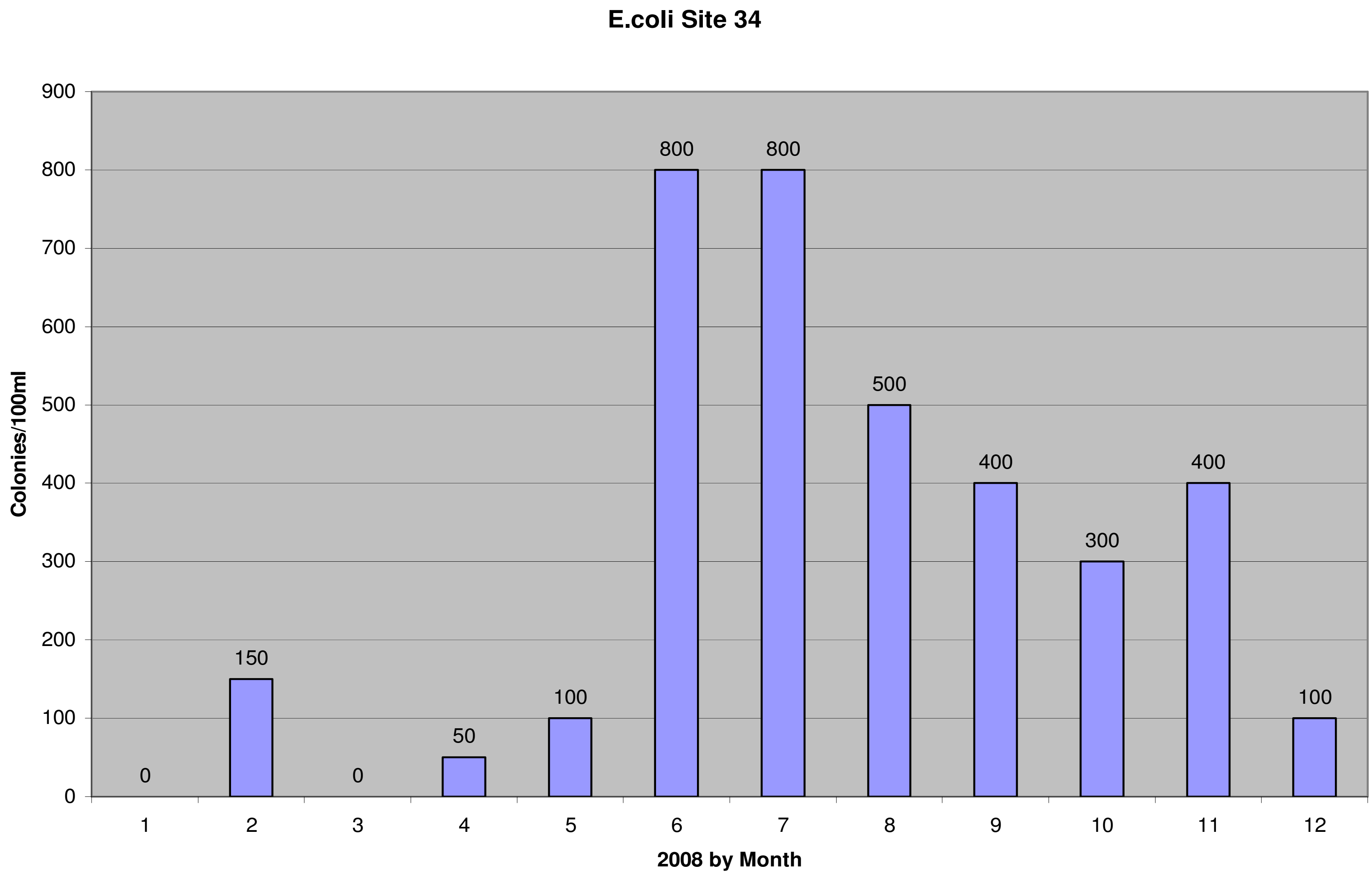

Figure 118: Monthly *E.coli* for site 34 with 300 colonies per 100 milliliters of water as the yearly average.

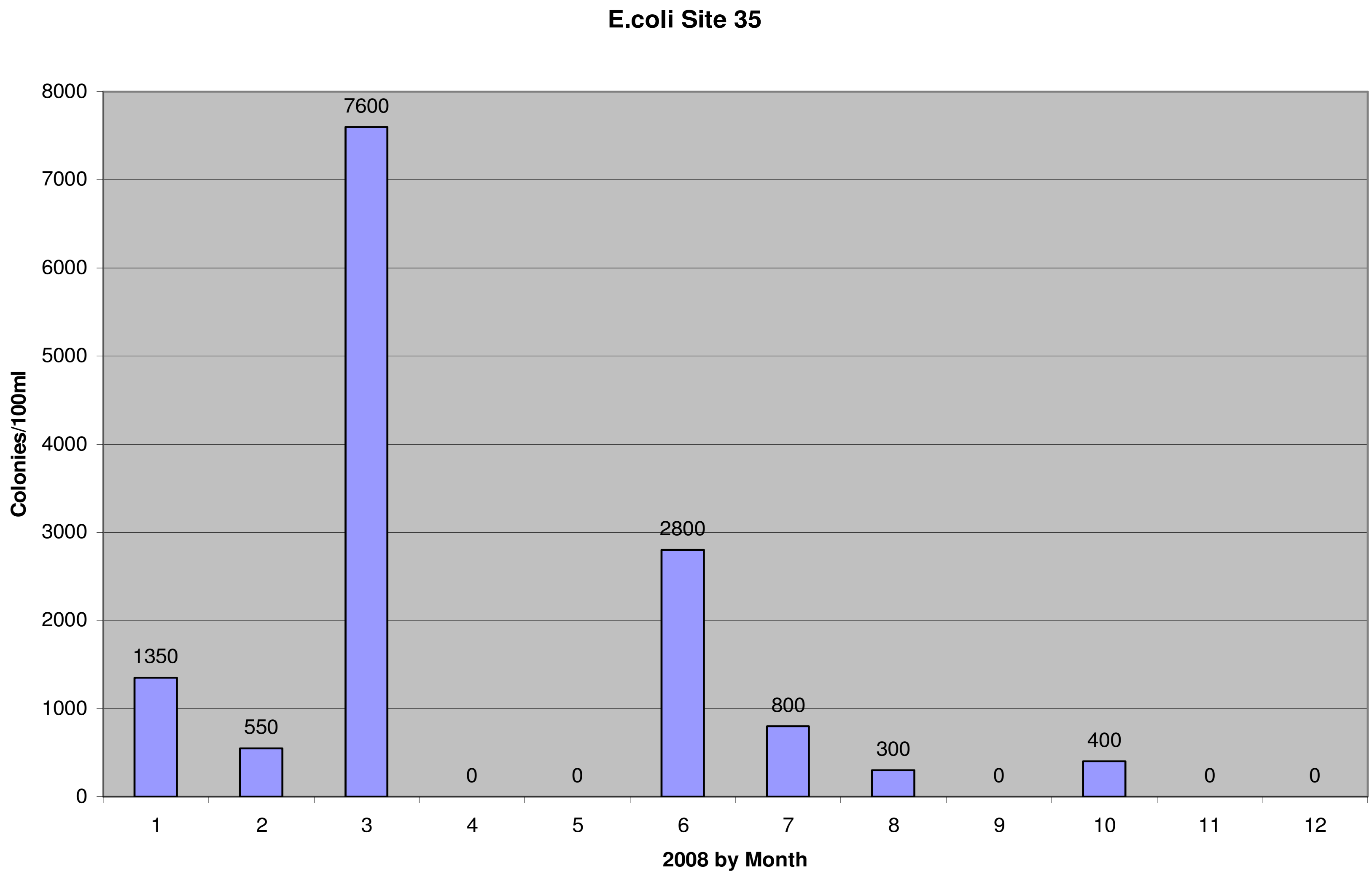

Figure 119: Monthly *E.coli* for site 35 with 1150 colonies per 100 milliliters of water as the yearly average.

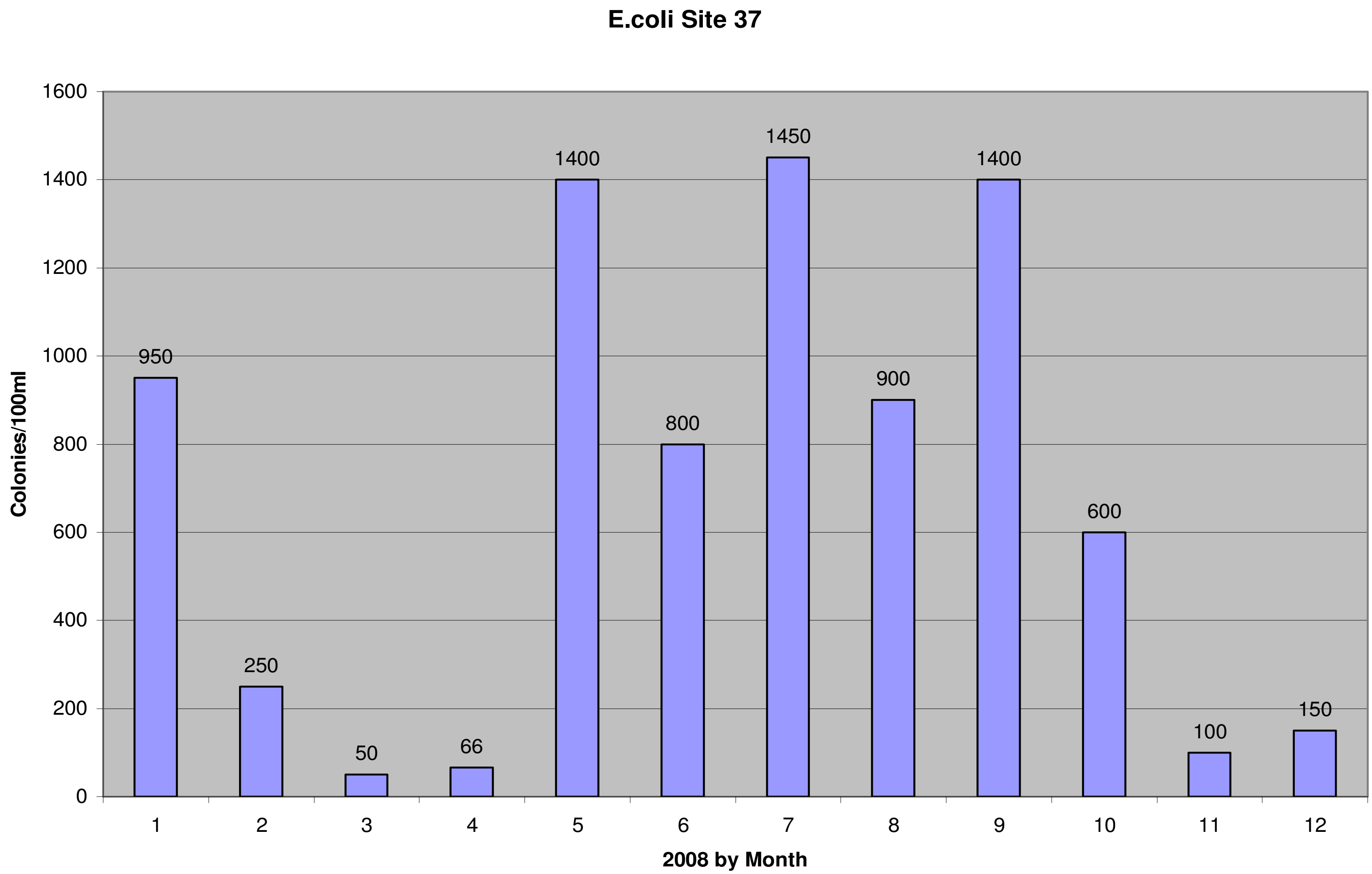

Figure 120: Monthly *E.coli* for site 37 with 676 colonies per 100 milliliters of water as the yearly average.

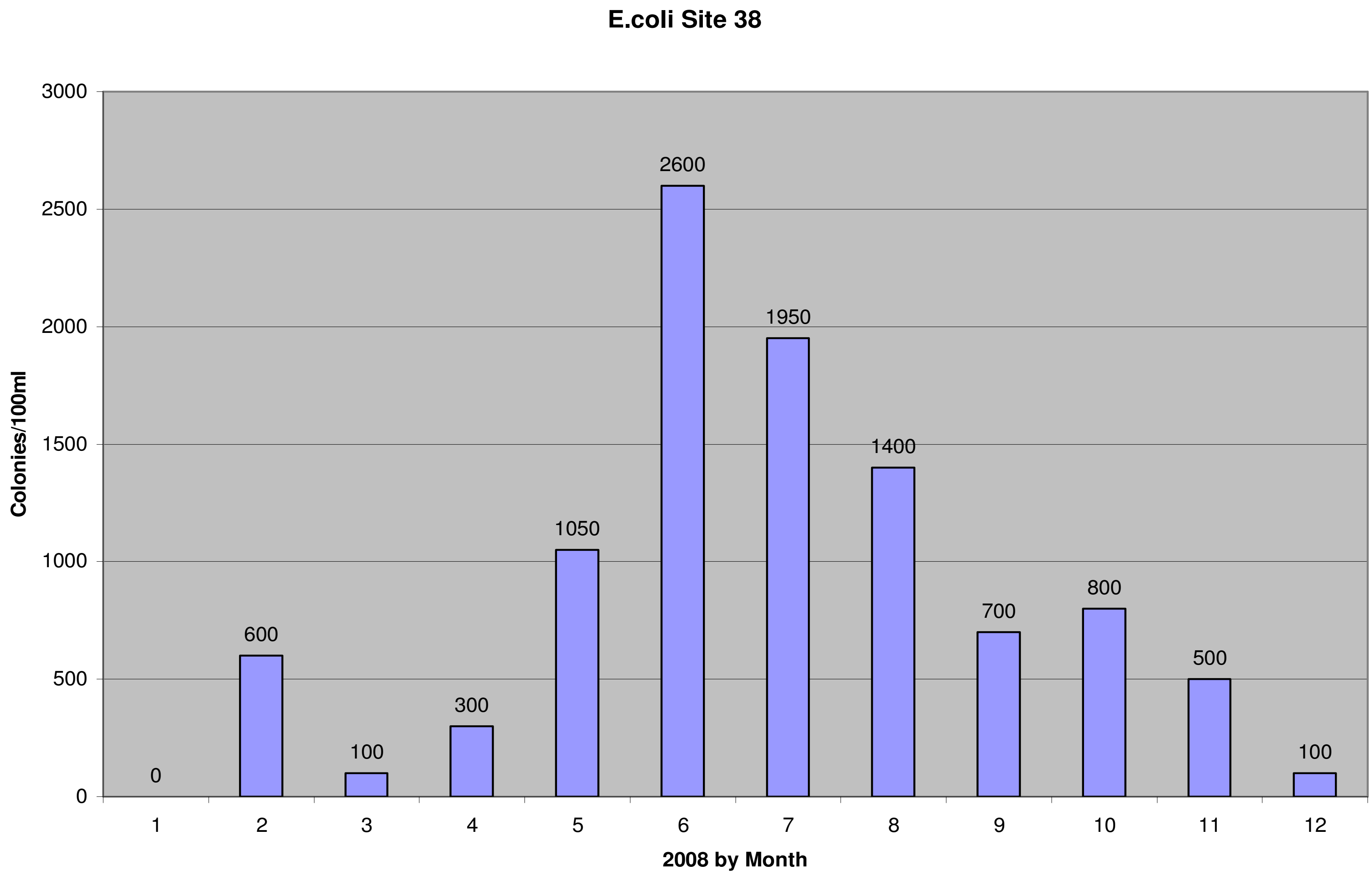

Figure 121: Monthly *E.coli* for site 38 with 842 colonies per 100 milliliters of water as the yearly average.

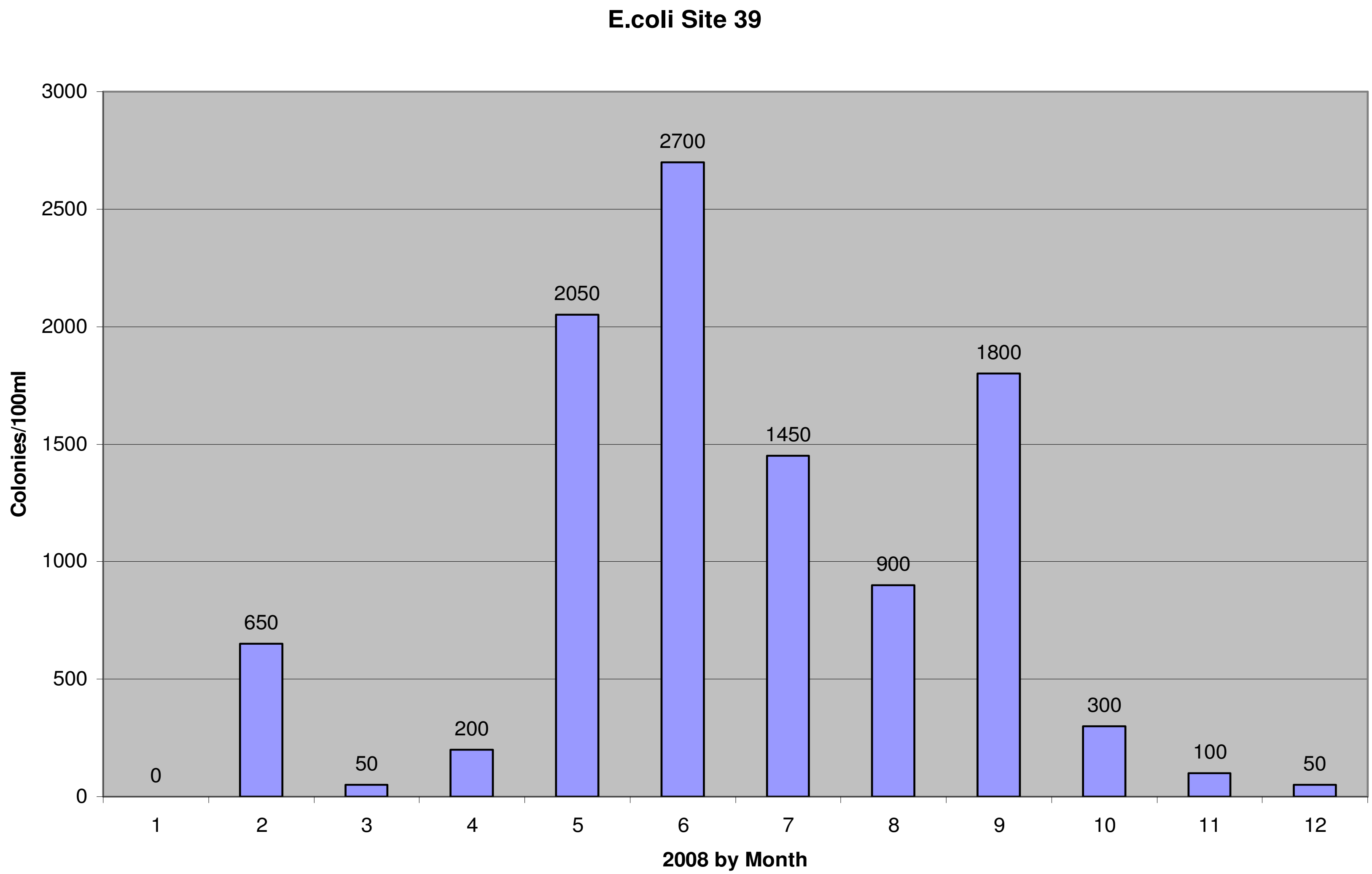

Figure 122: Monthly *E.coli* for site 39 with 854 colonies per 100 milliliters of water as the yearly average.

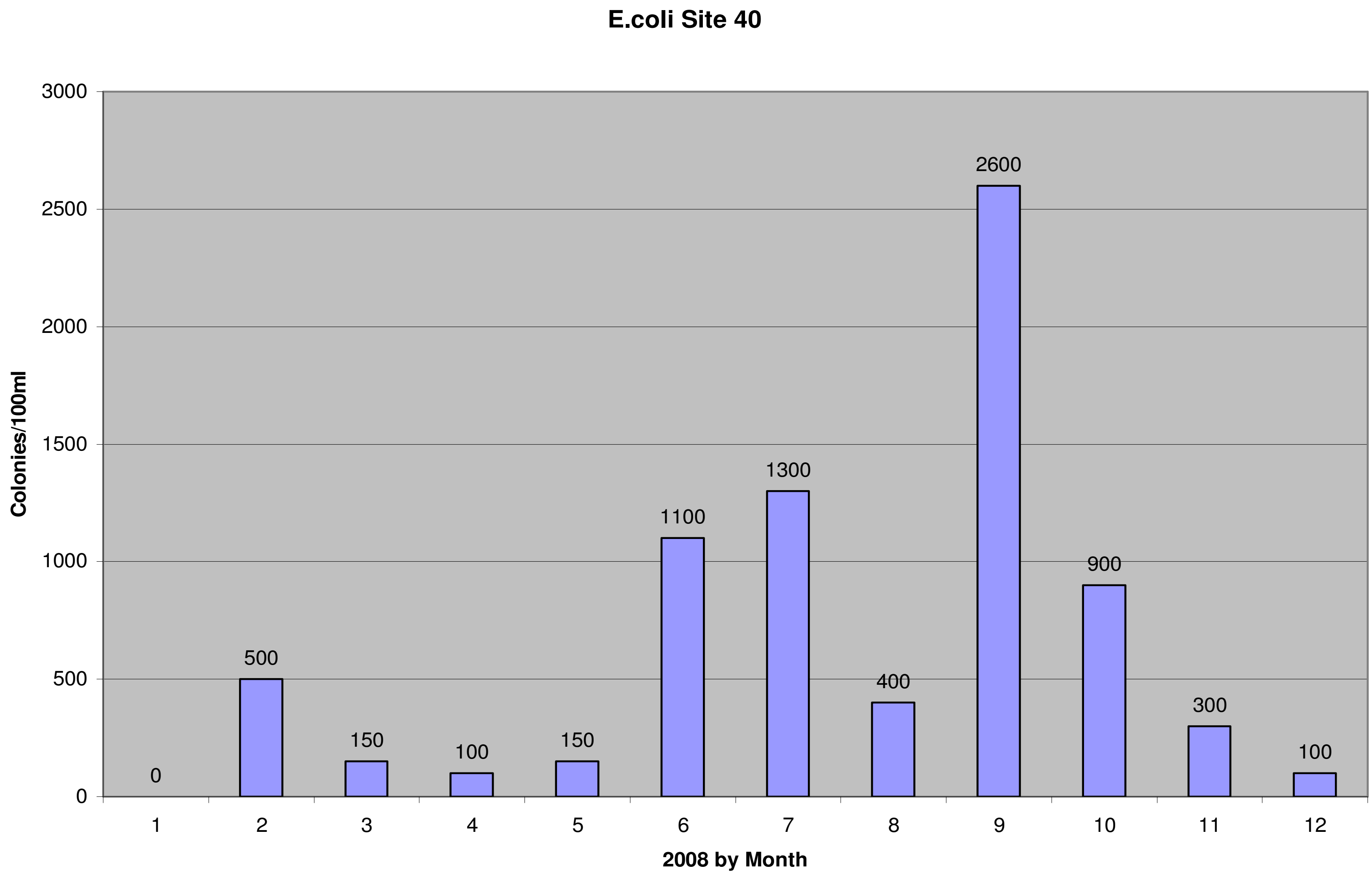

Figure 123: Monthly *E.coli* for site 40 with 633 colonies per 100 milliliters of water as the yearly average.

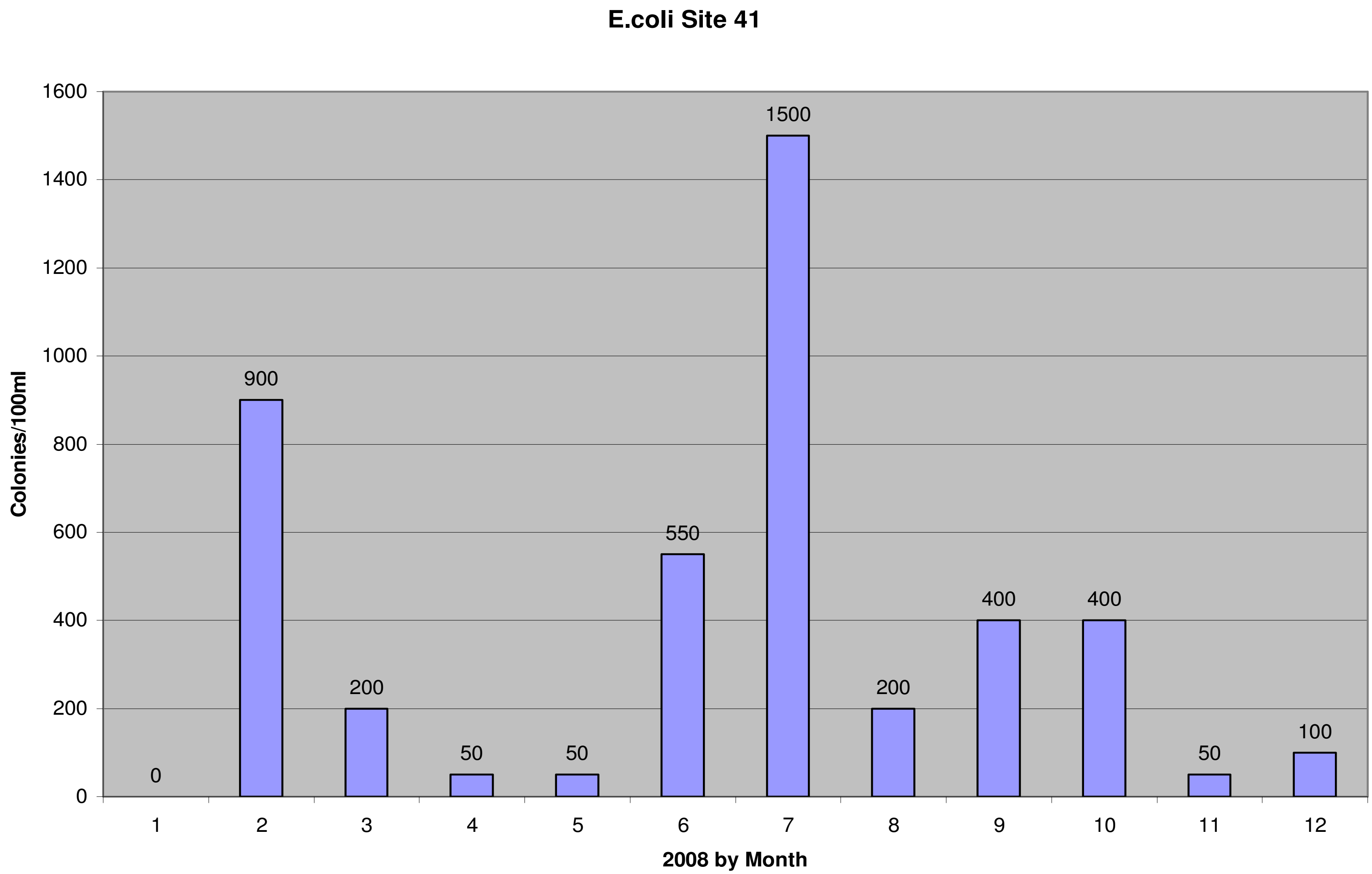

Figure 124: Monthly *E.coli* for site 41 with 367 colonies per 100 milliliters of water as the yearly average.

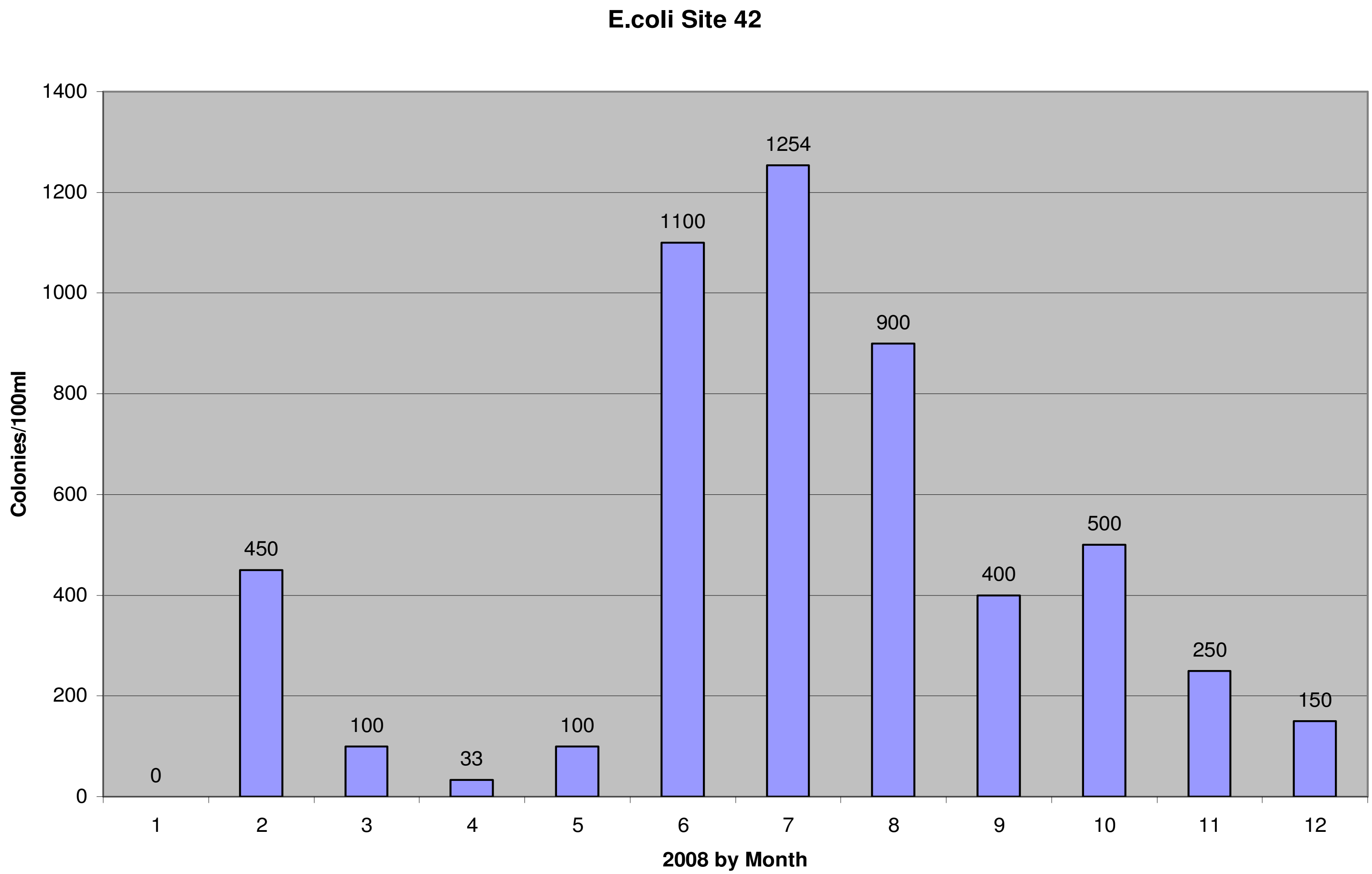

Figure 125: Monthly *E.coli* for site 42 with 436 colonies per 100 milliliters of water as the yearly average.

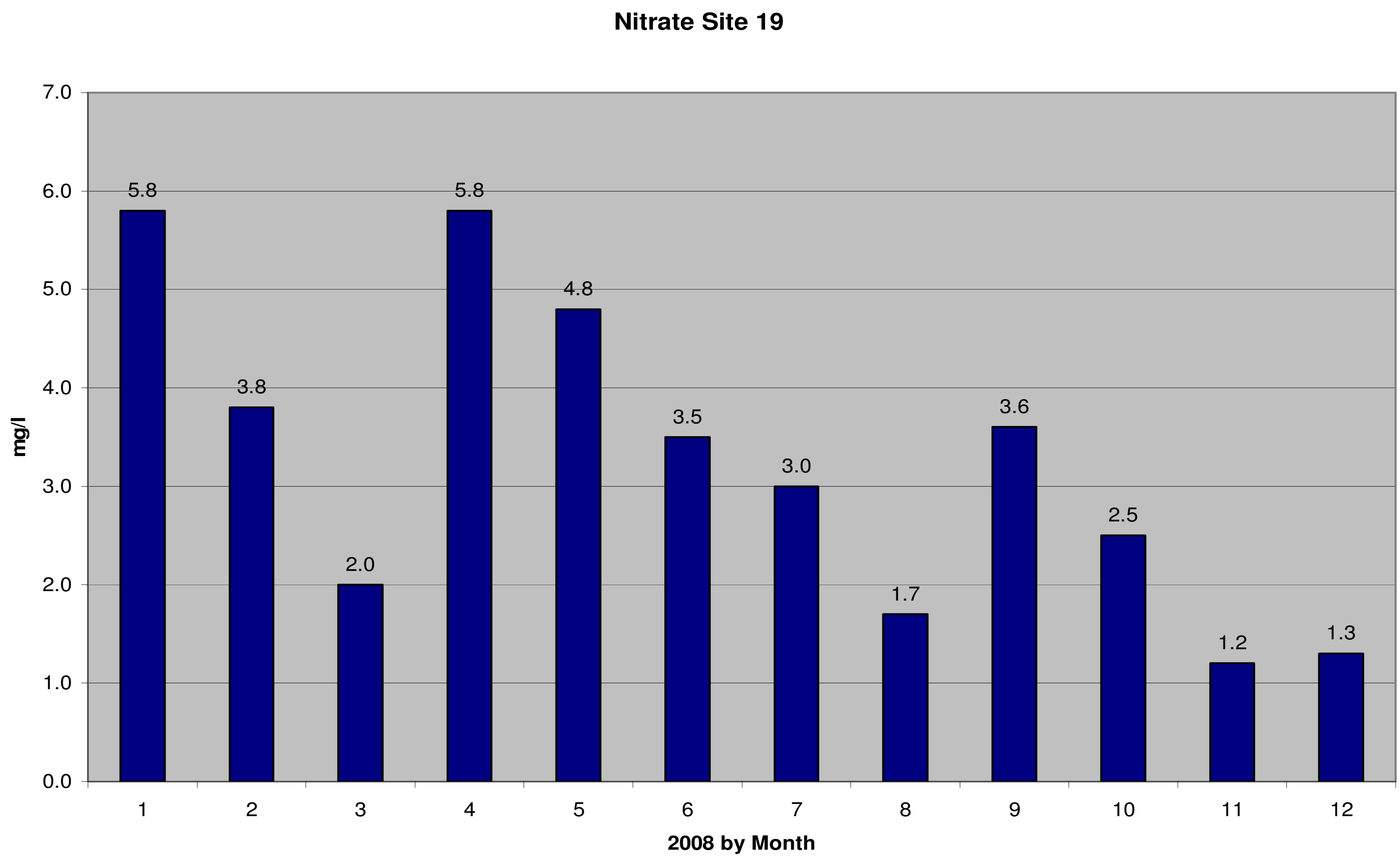

Figure 126: Monthly total nitrates for site 19 with 3.3 milligrams per liter as the yearly average.

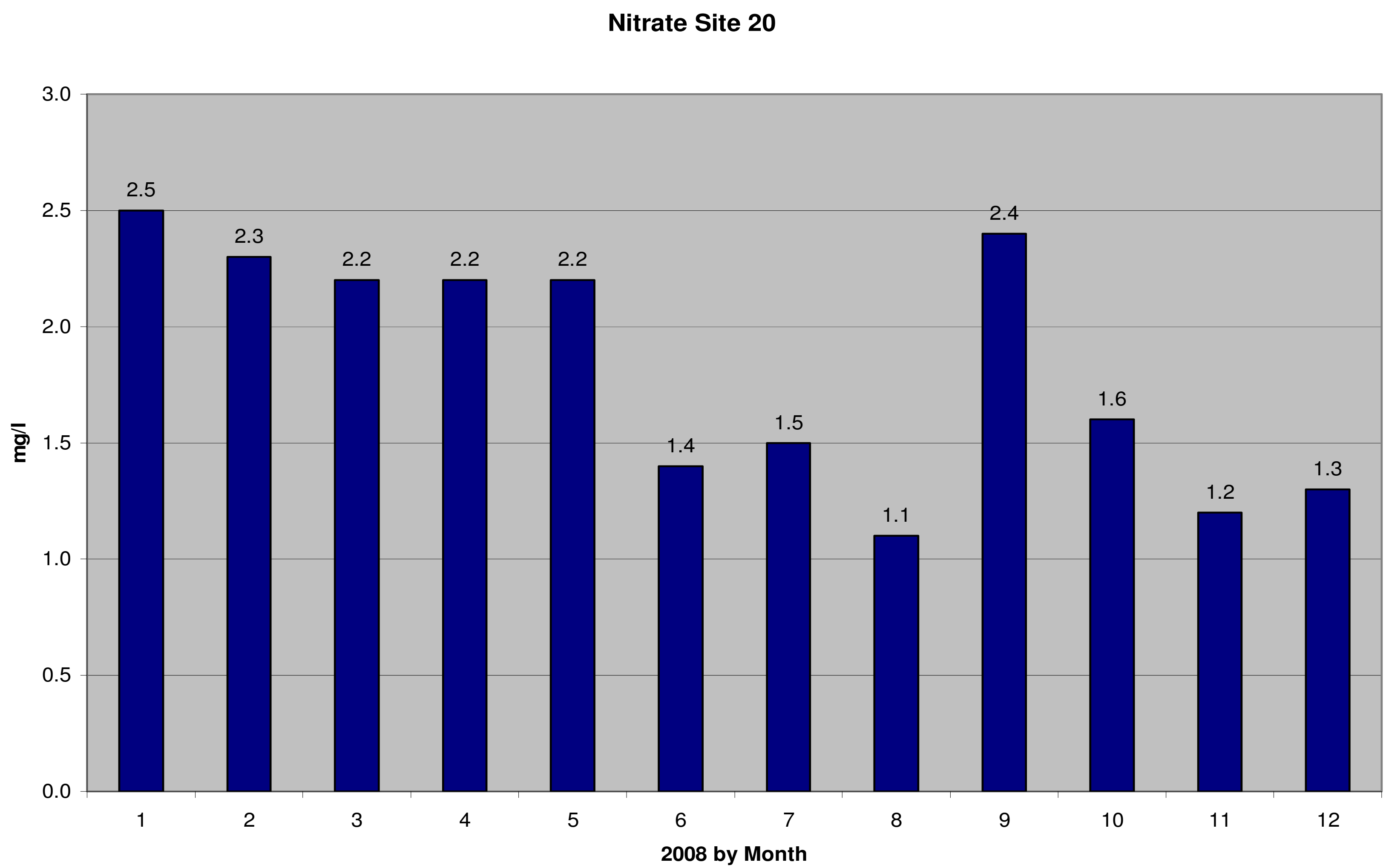

Figure 127: Monthly total nitrates for site 20 with 1.8 milligrams per liter as the yearly average.

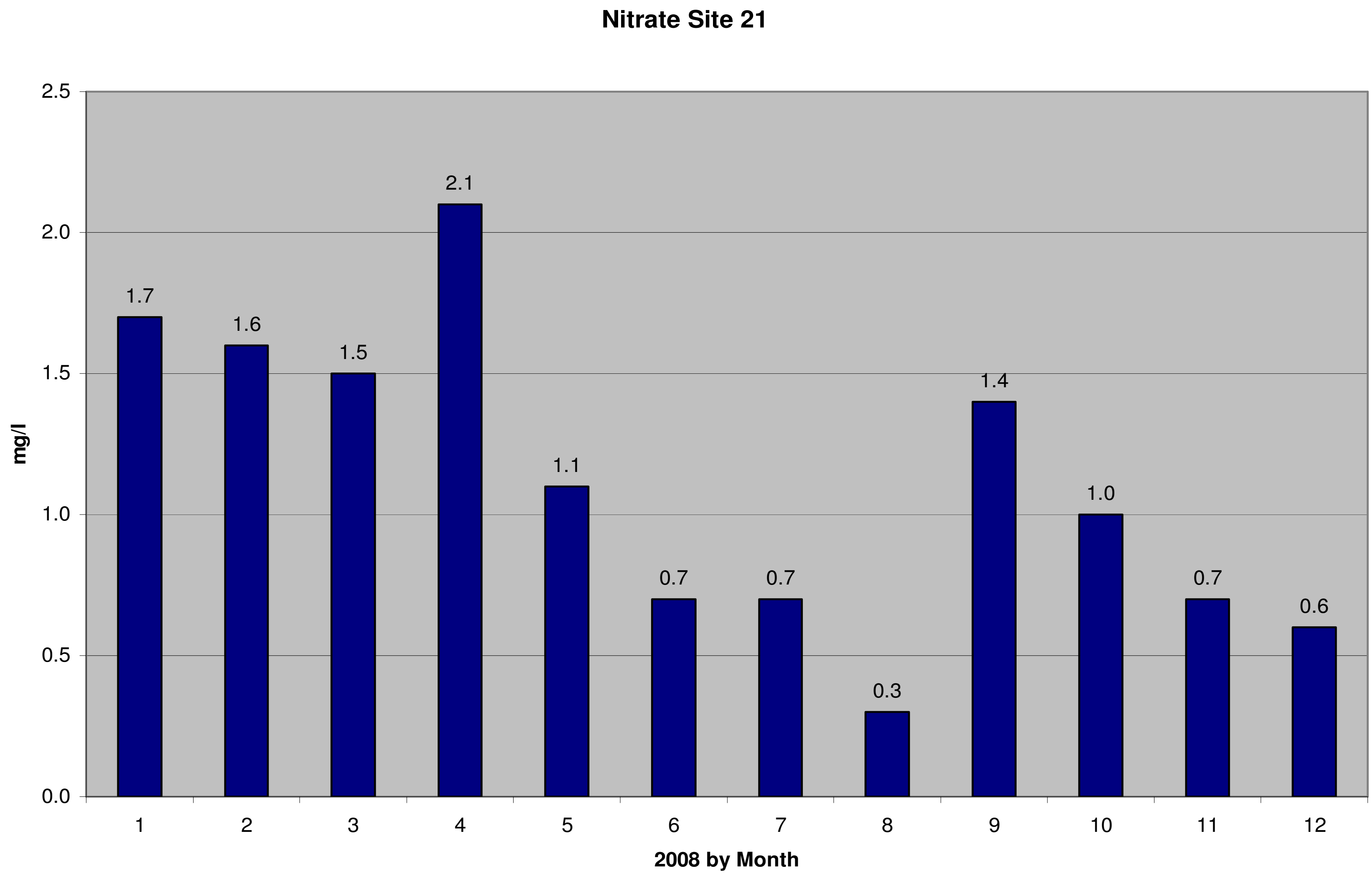

Figure 128: Monthly total nitrates for site 21 with 1.1 milligrams per liter as the yearly average.

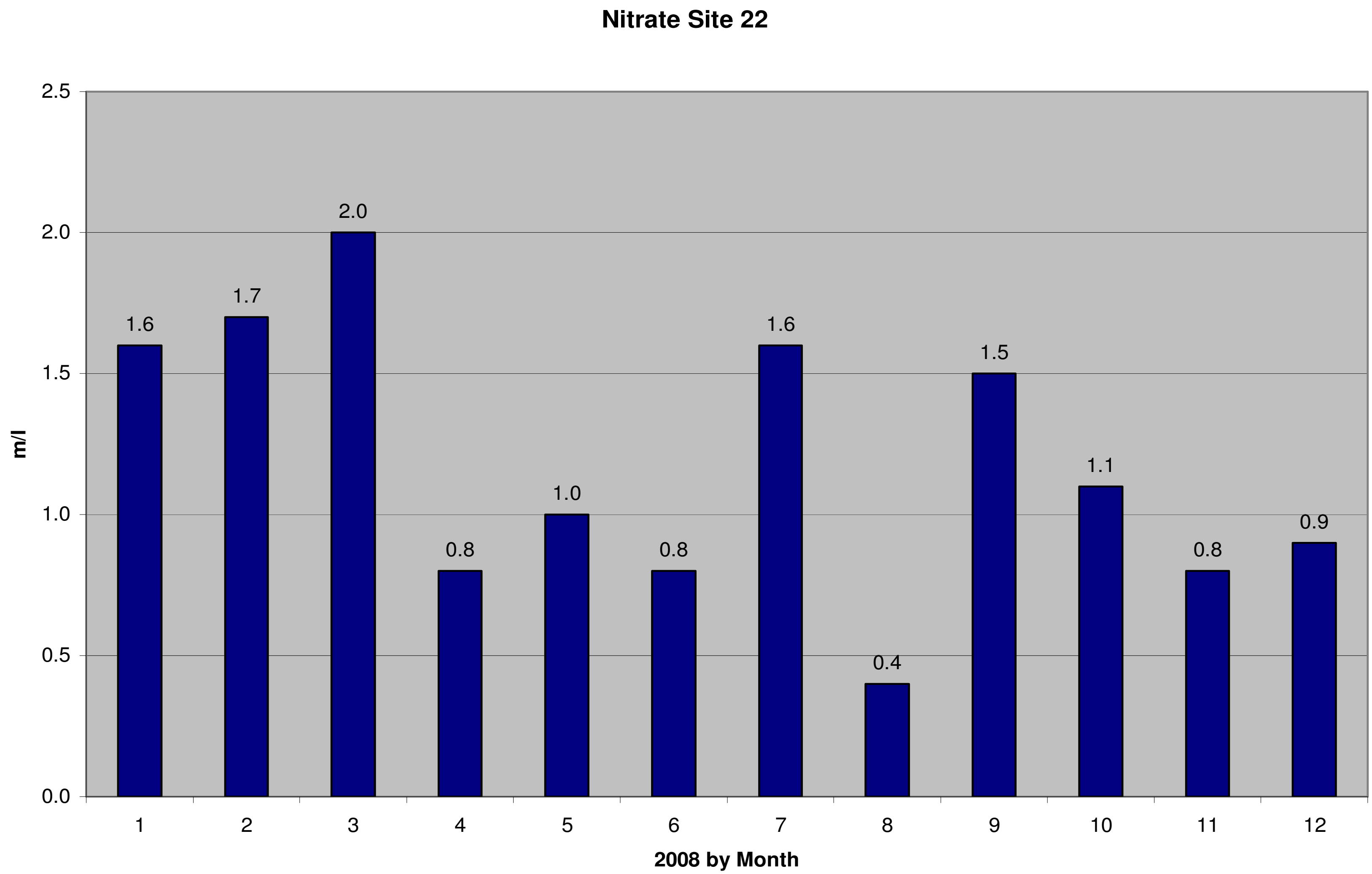

Figure 129: Monthly total nitrates for site 22 with 1.2 milligrams per liter as the yearly average.

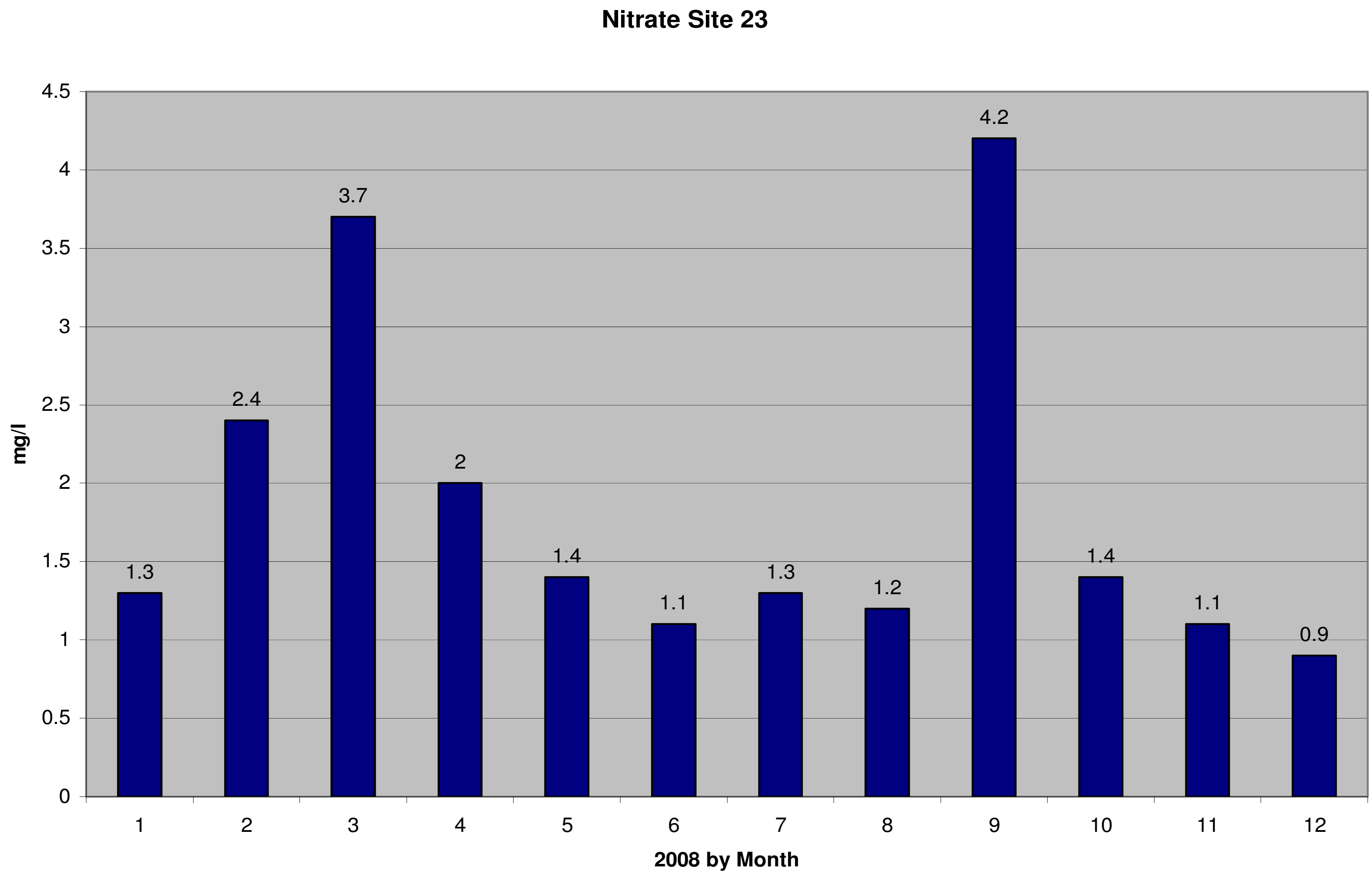

Figure 130: Monthly total nitrates for site 23 with 1.8 milligrams per liter as the yearly average.

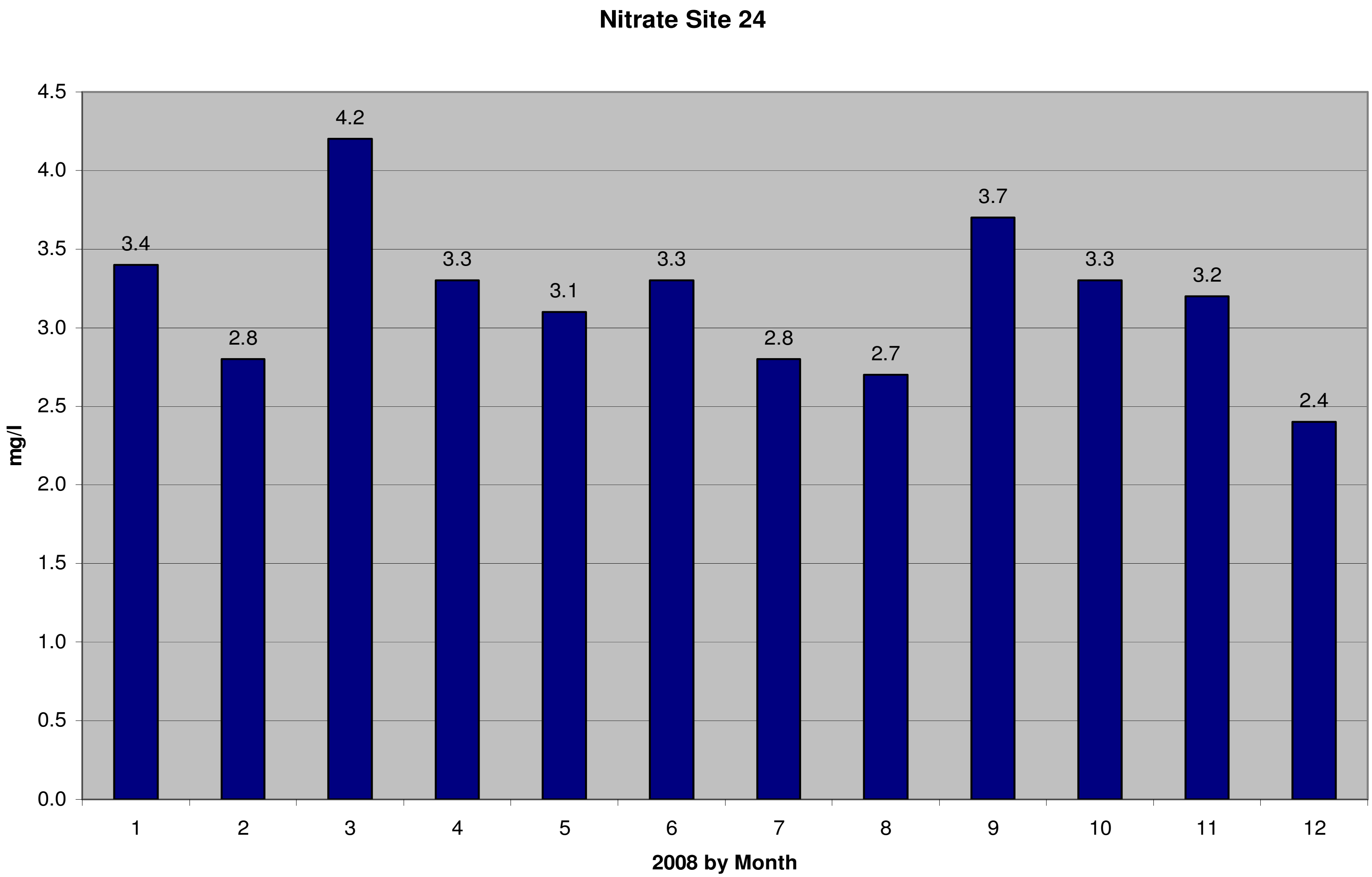

Figure 131: Monthly total nitrates for site 24 with 3.2 milligrams per liter as the yearly average.

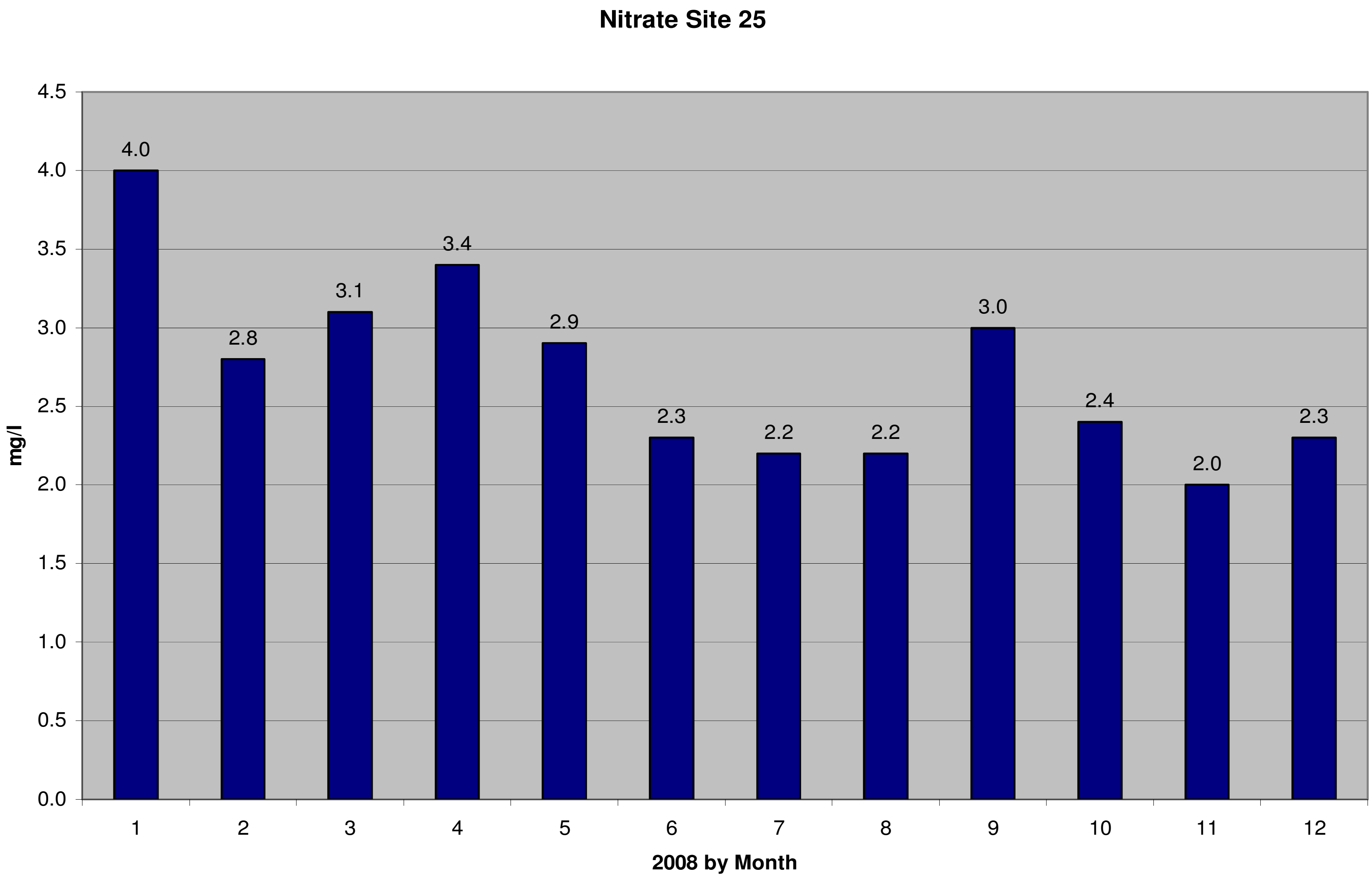

Figure 132: Monthly total nitrates for site 25 with 2.7 milligrams per liter as the yearly average.

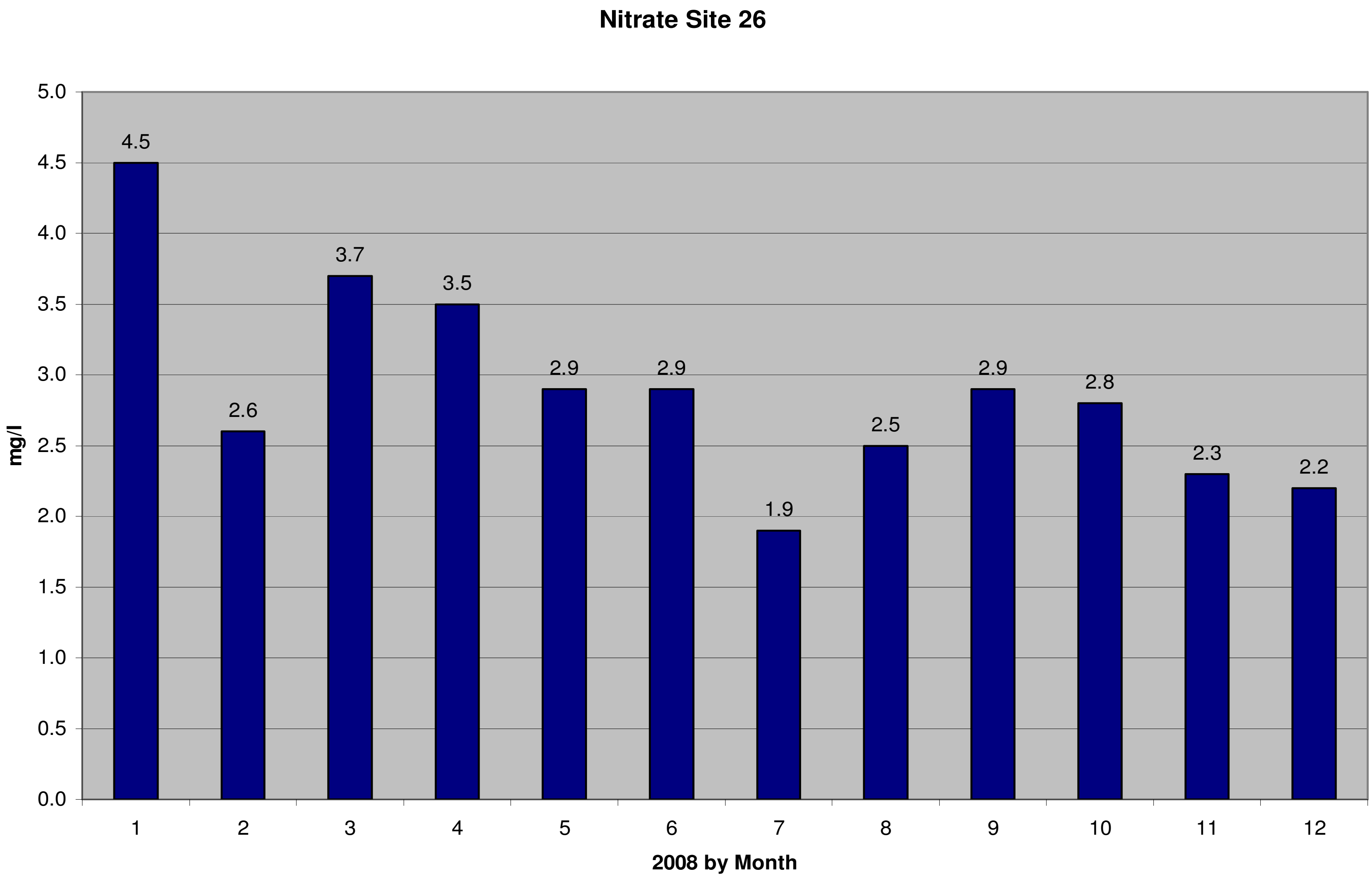

Figure 133: Monthly total nitrates for site 26 with 2.9 milligrams per liter as the yearly average.

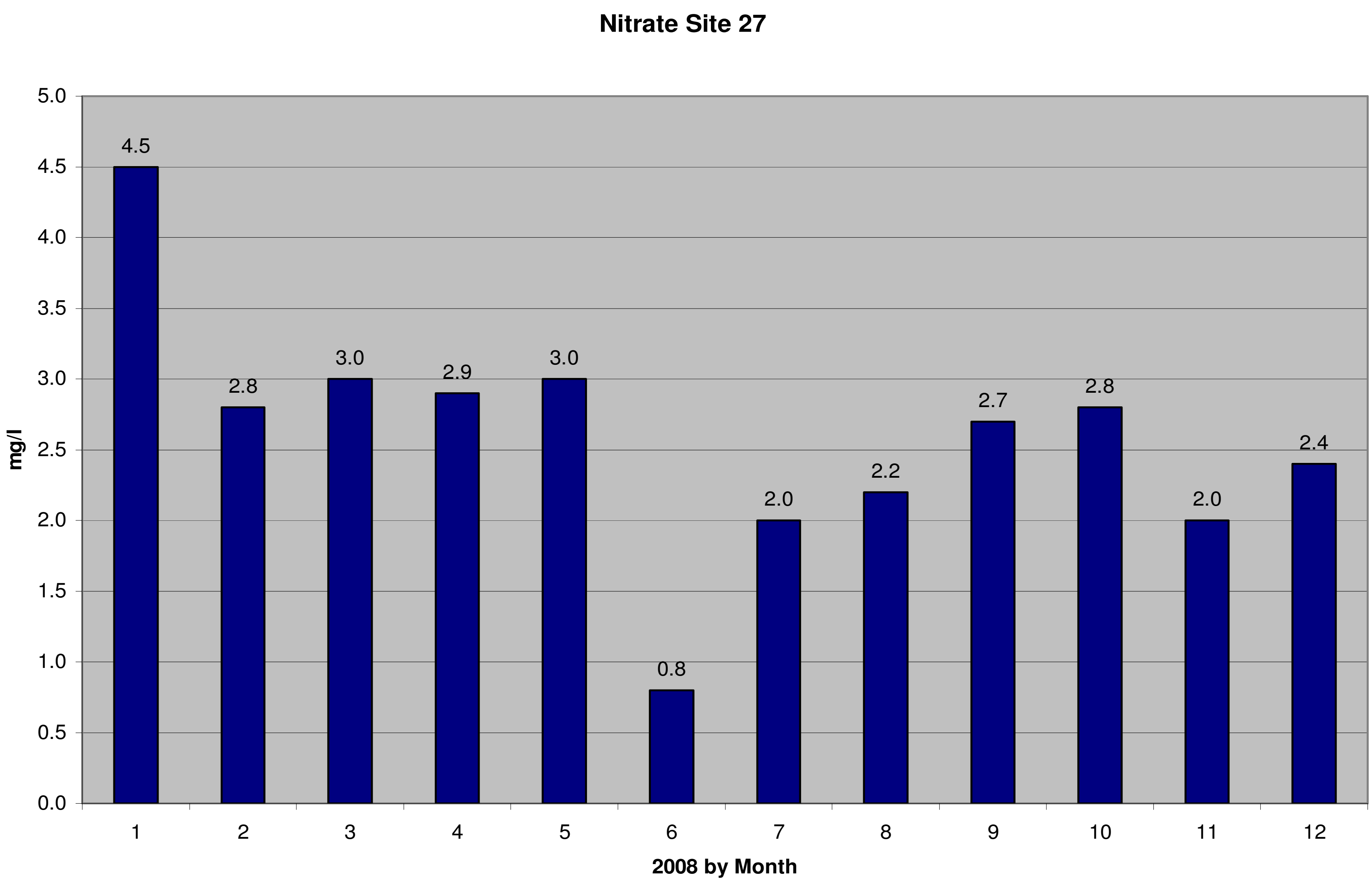

Figure 134: Monthly total nitrates for site 27 with 2.6 milligrams per liter as the yearly average.

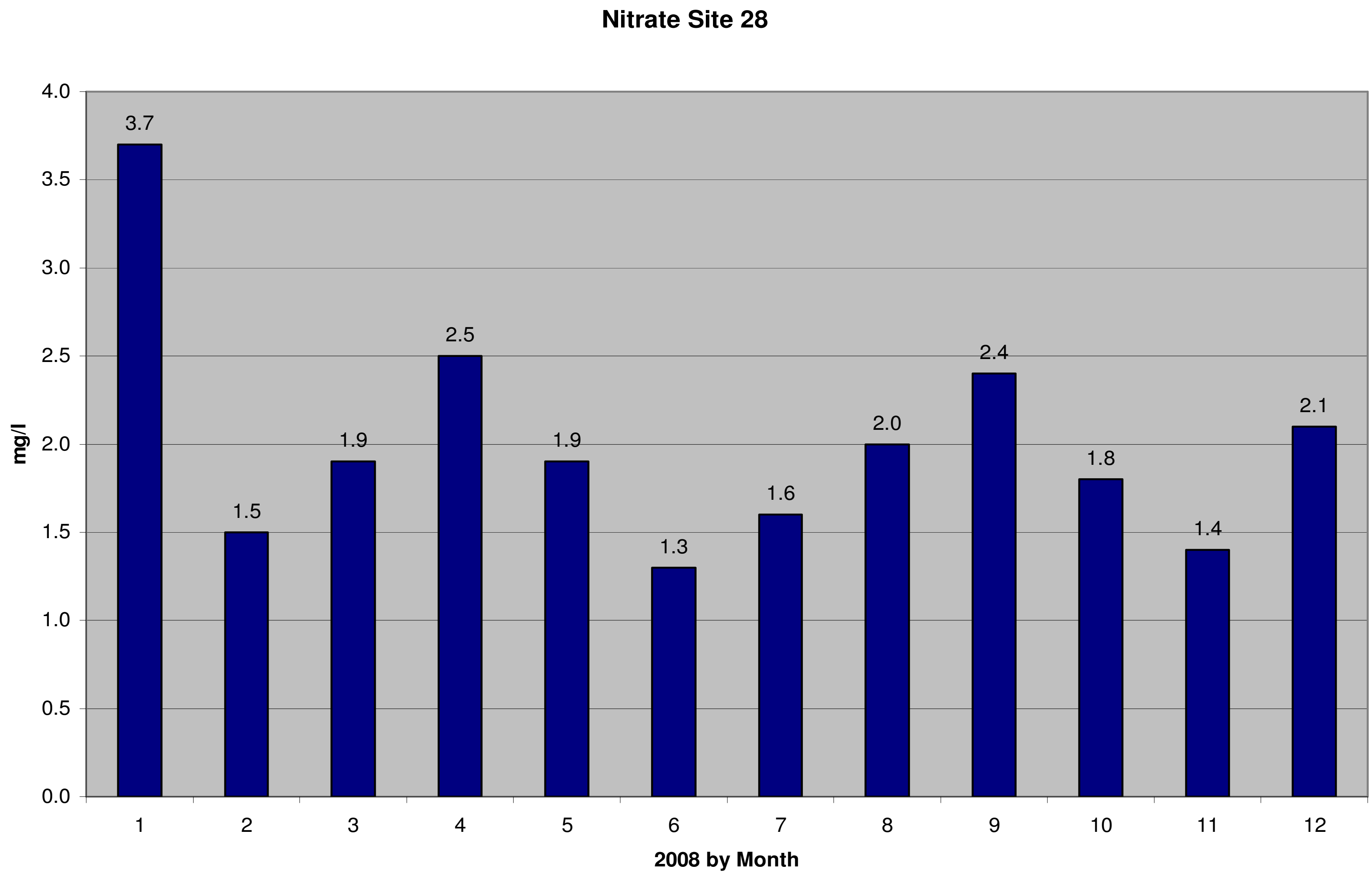

Figure 135: Monthly total nitrates for site 28 with 2.0 milligrams per liter as the yearly average.

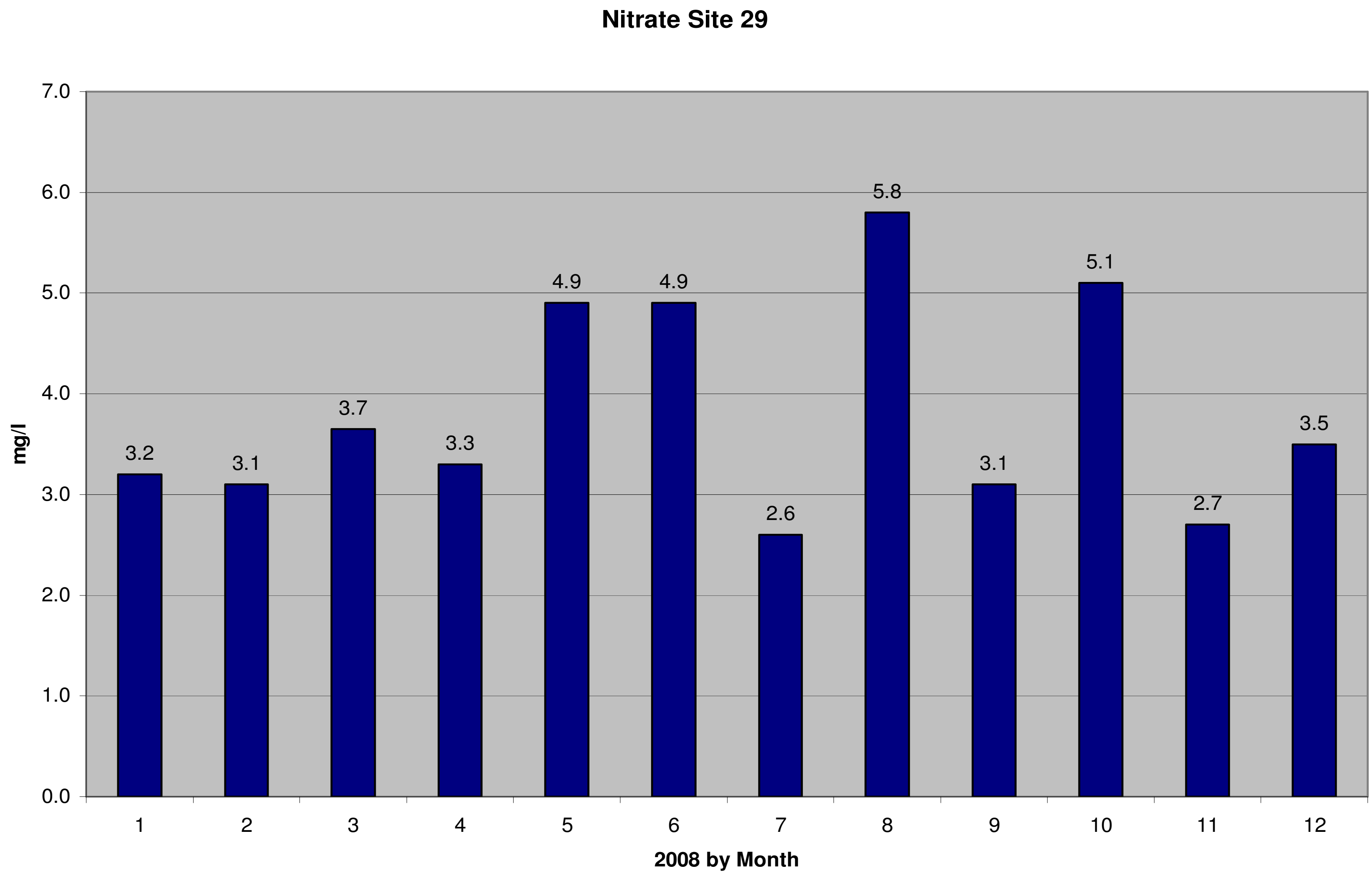

Figure 136: Monthly total nitrates for site 29 with 3.8 milligrams per liter as the yearly average.

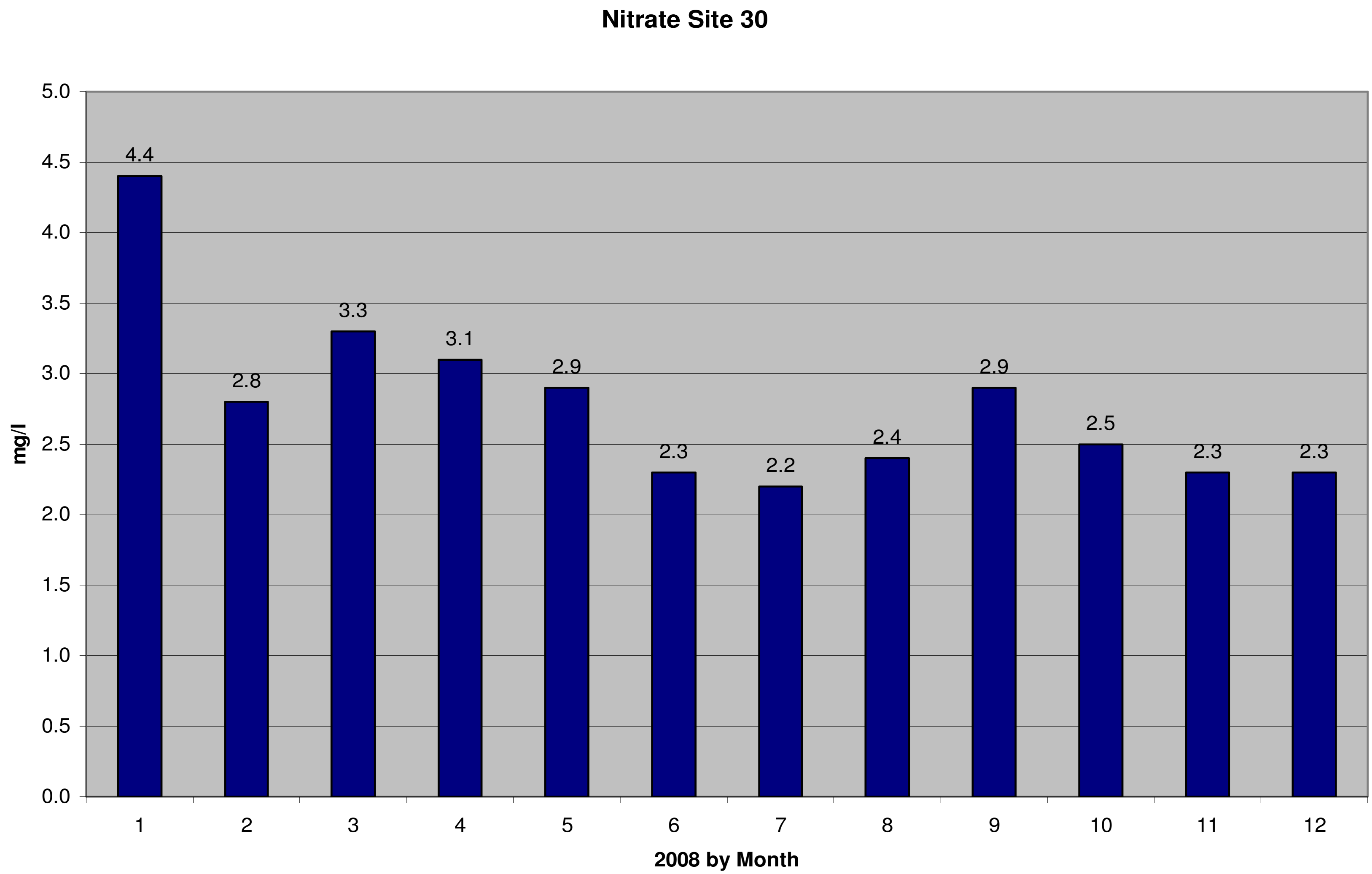

Figure 137: Monthly total nitrates for site 30 with 2.8 milligrams per liter as the yearly average.

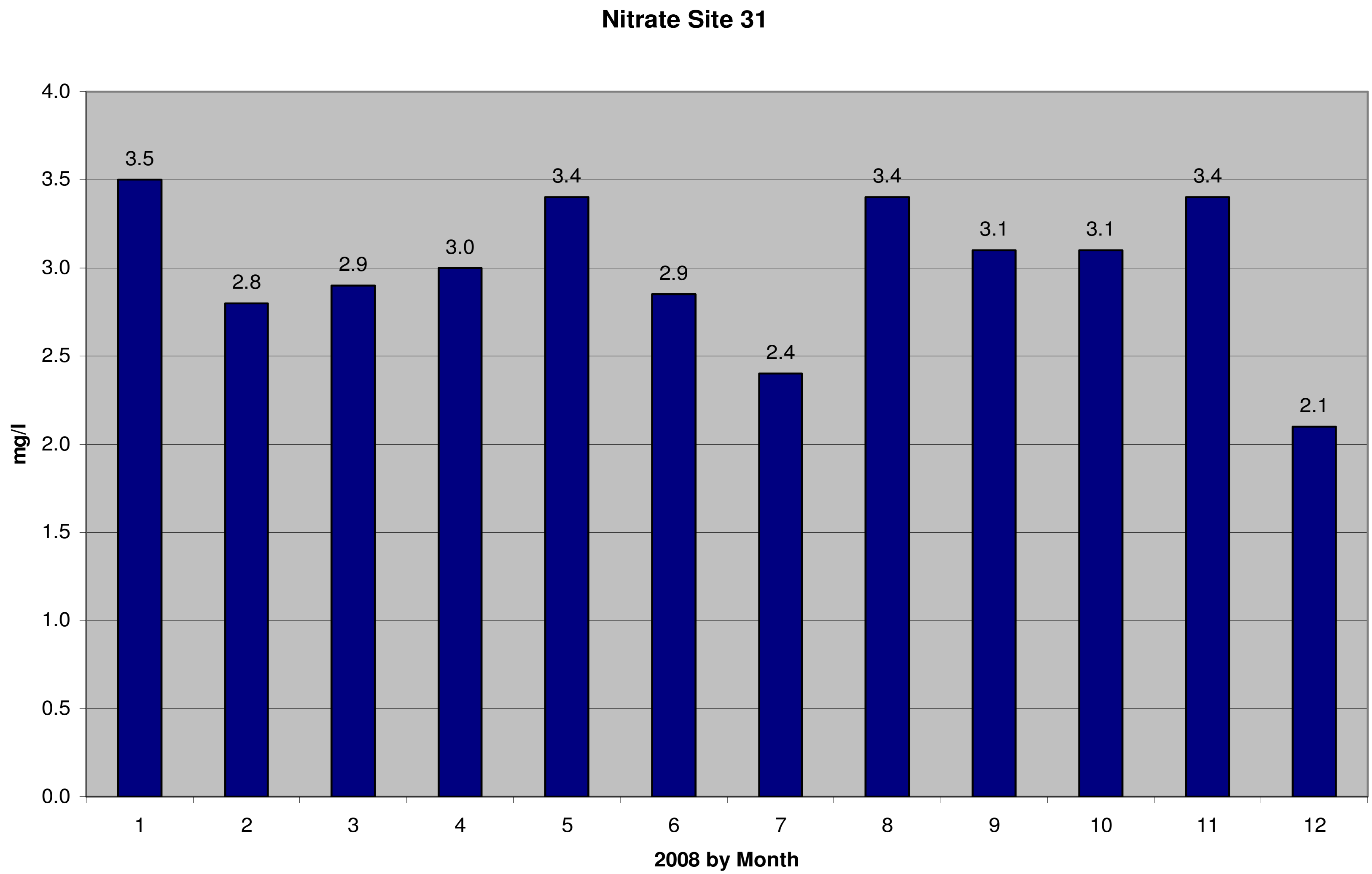

Figure 138: Monthly total nitrates for site 31 with 3.0 milligrams per liter as the yearly average.

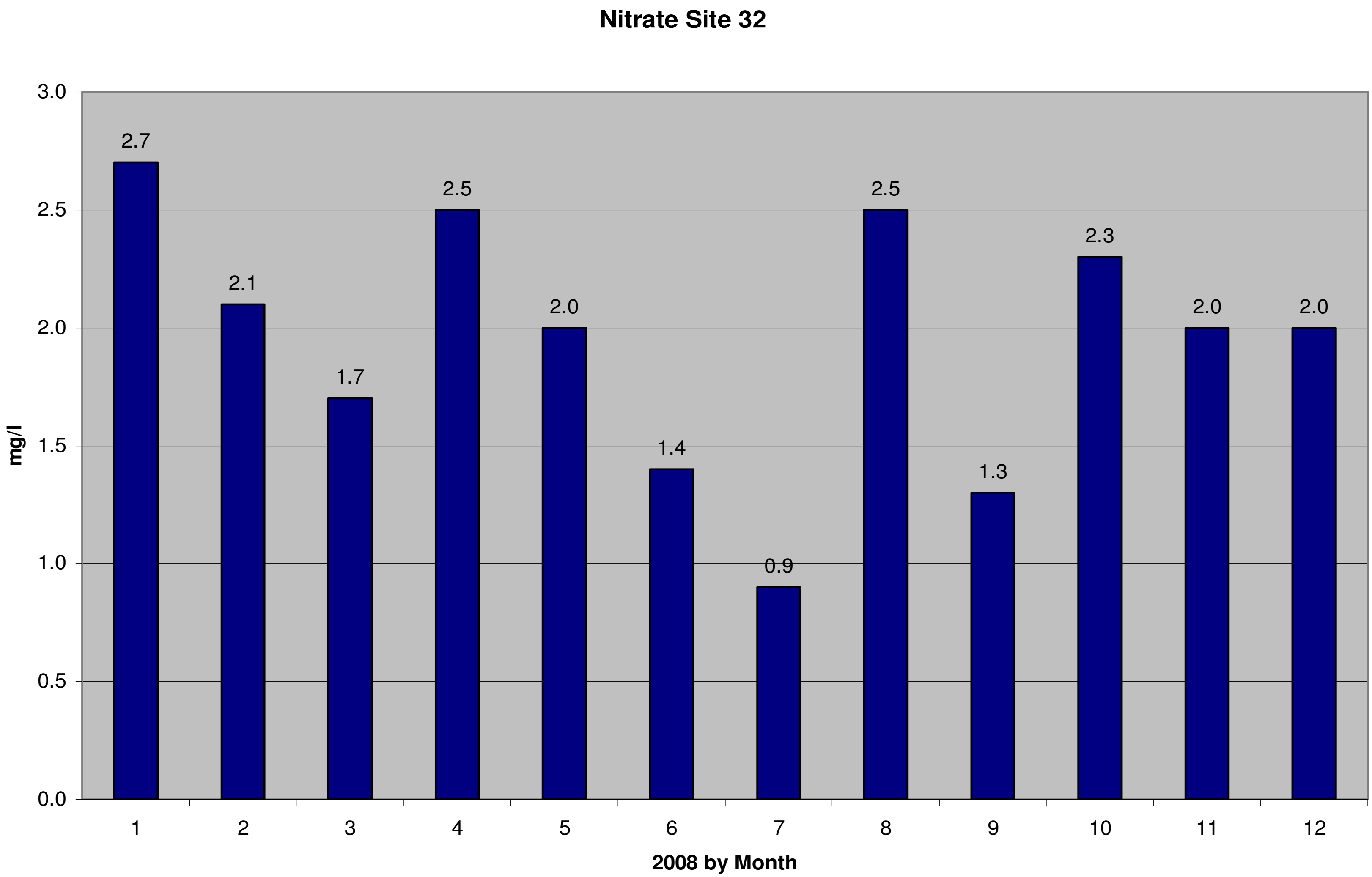

Figure 139: Monthly total nitrates for site 32 with 2.0 milligrams per liter as the yearly average.

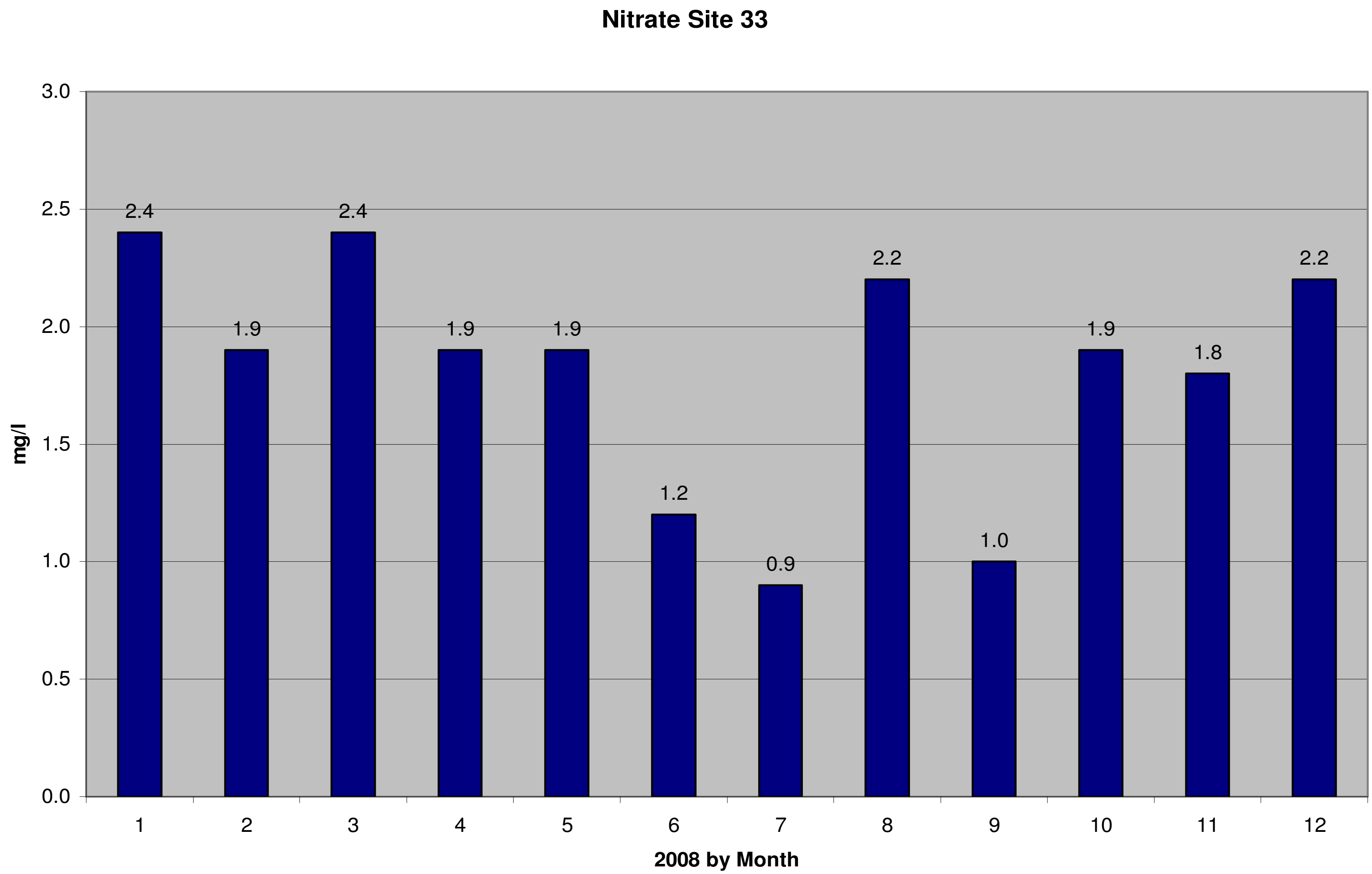

Figure 140: Monthly total nitrates for site 33 with 1.8 milligrams per liter as the yearly average.

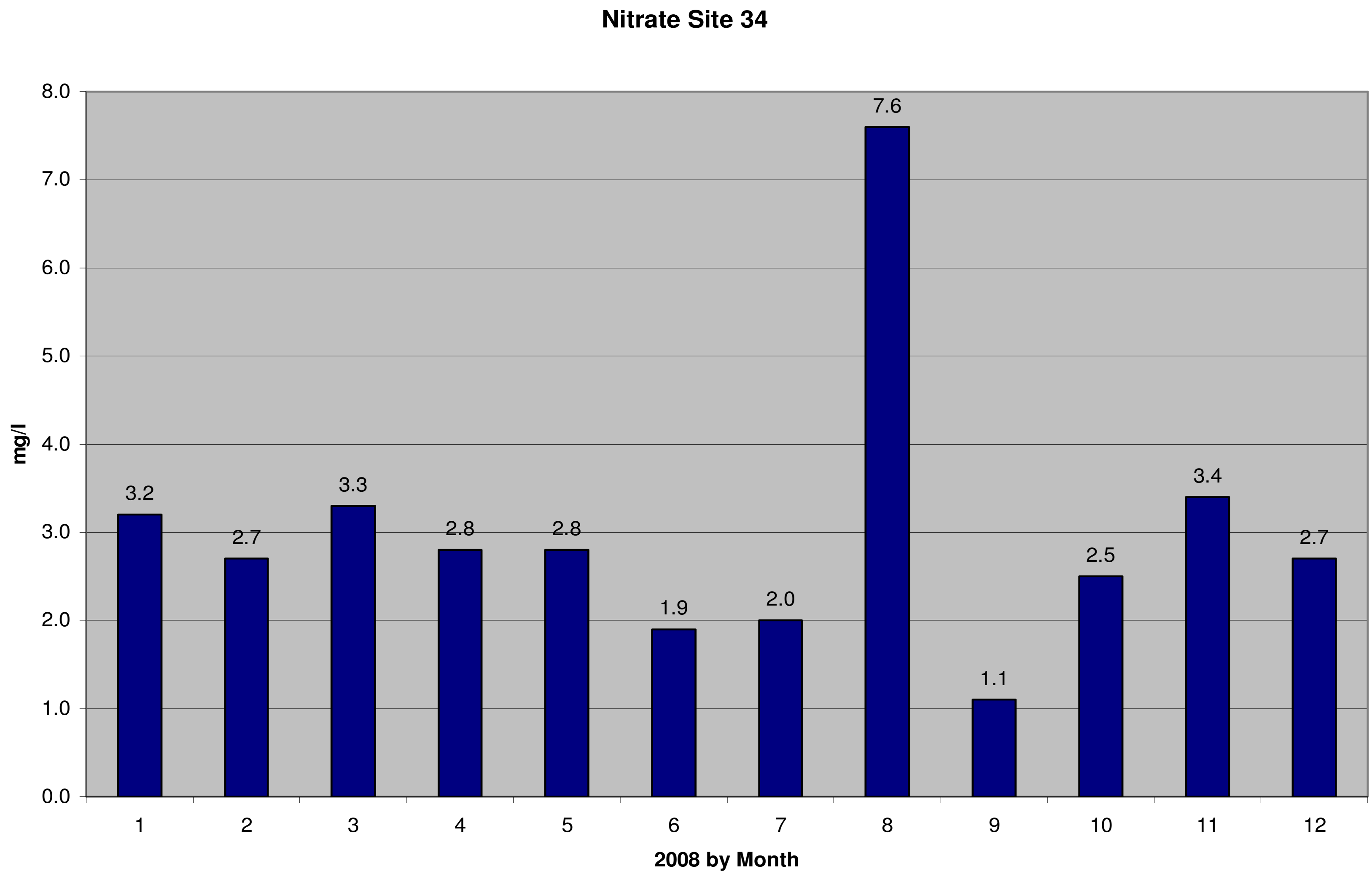

Figure 141: Monthly total nitrates for site 34 with 3.0 milligrams per liter as the yearly average.

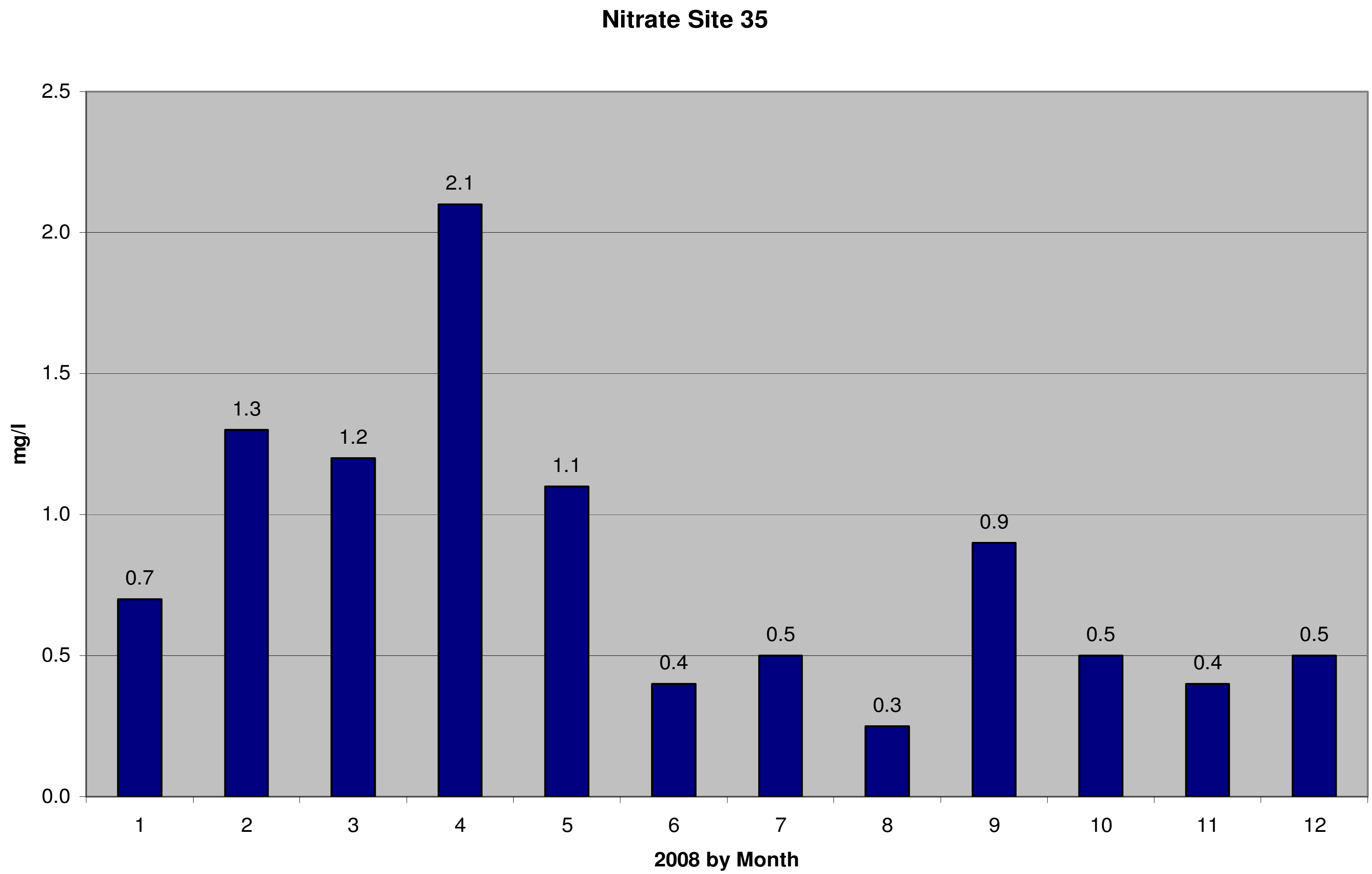

Figure 142: Monthly total nitrates for site 35 with 0.8 milligrams per liter as the yearly average.

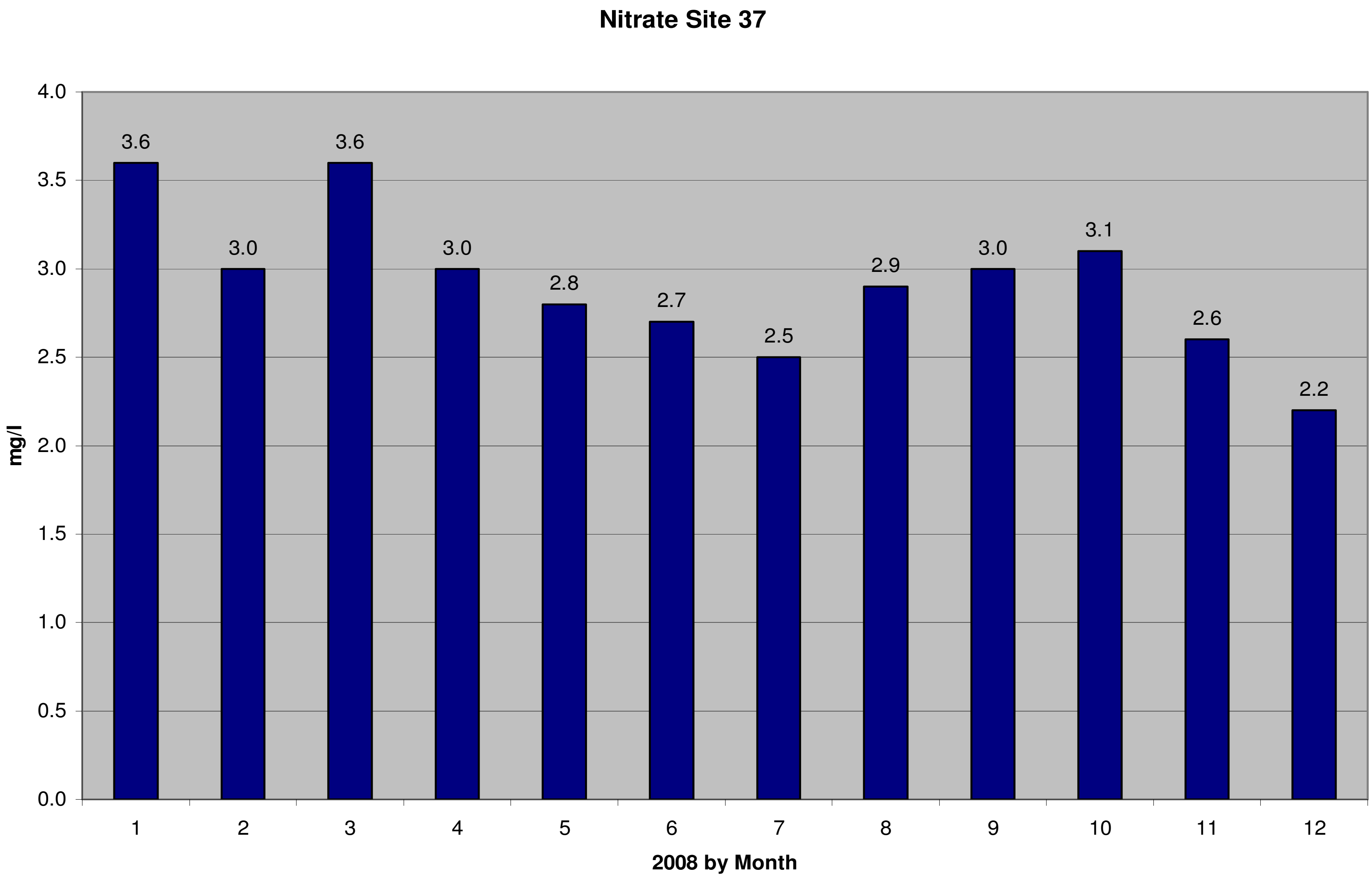

Figure 143: Monthly total nitrates for site 37 with 2.9 milligrams per liter as the yearly average.

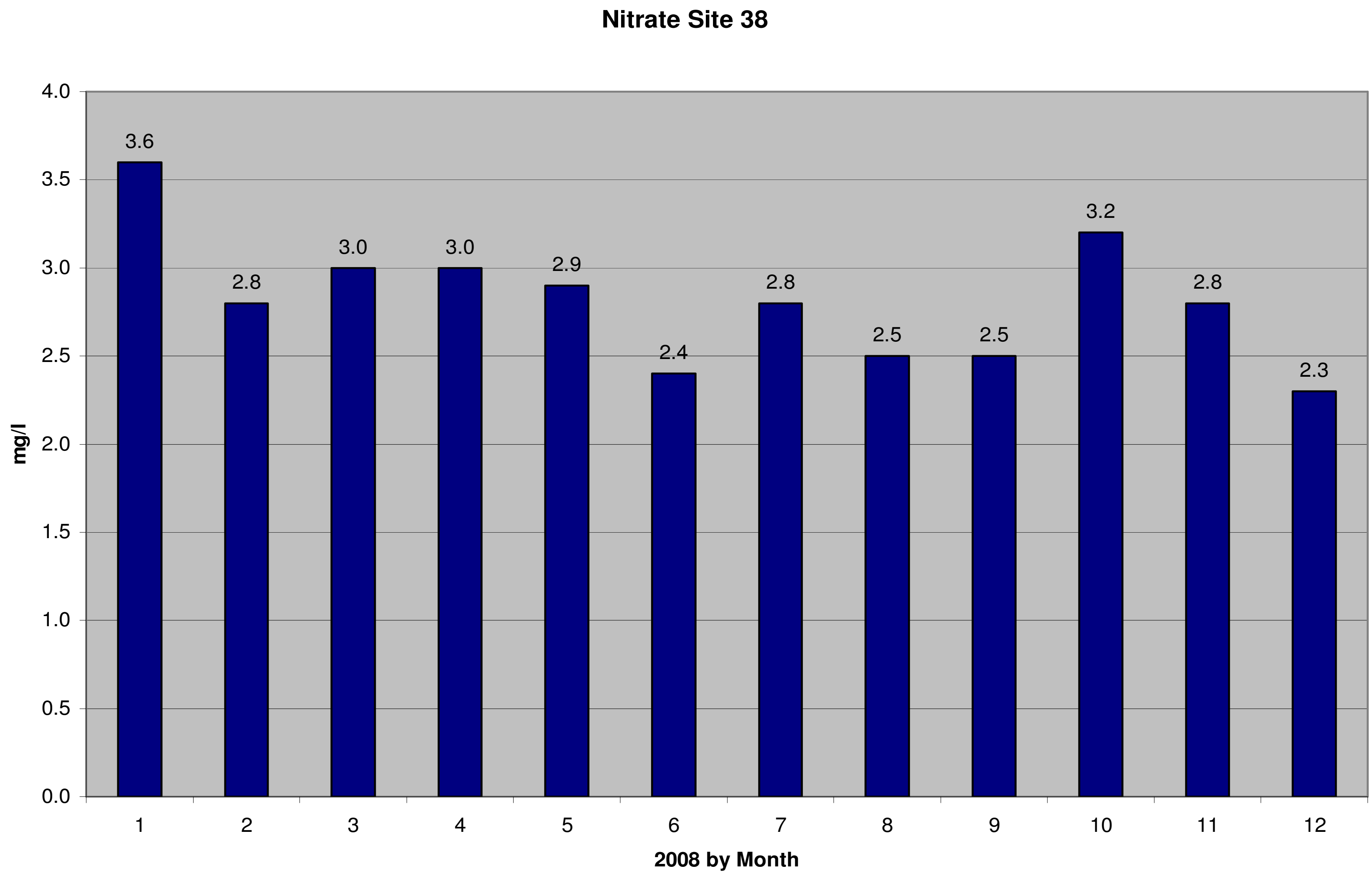

Figure 144: Monthly total nitrates for site 38 with 2.8 milligrams per liter as the yearly average.

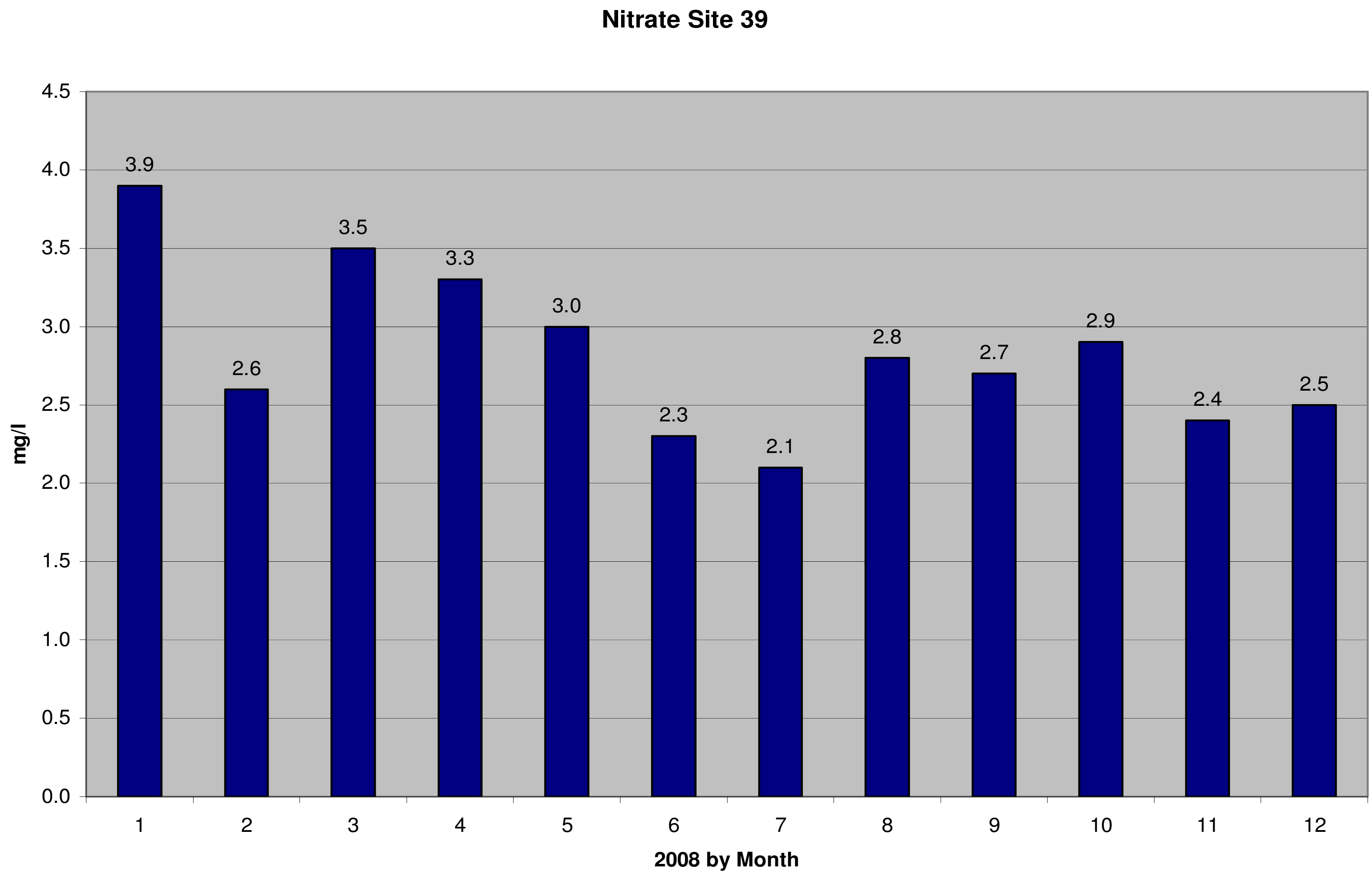

Figure 145: Monthly total nitrates for site 39 with 2.8 milligrams per liter as the yearly average.

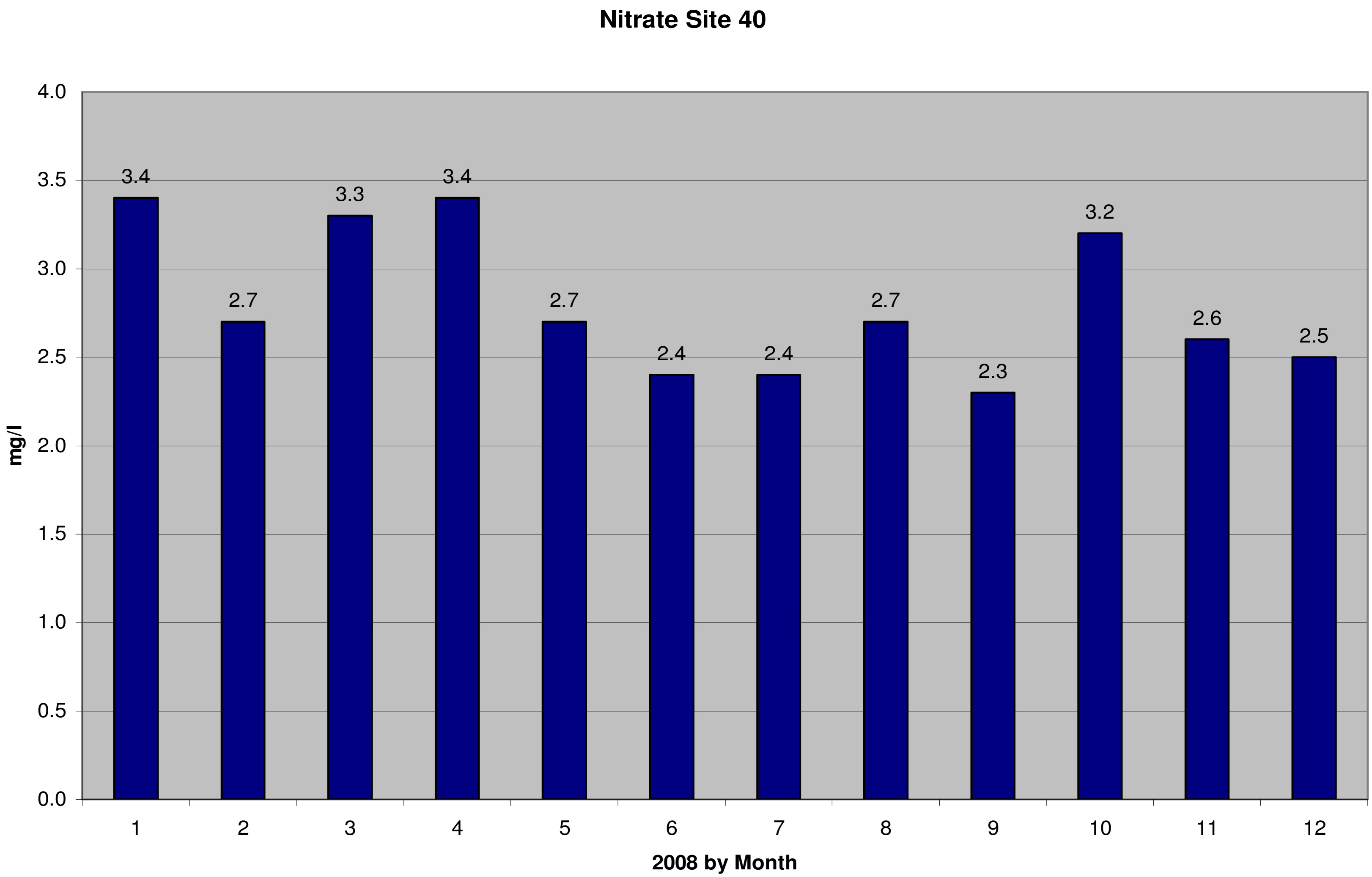

Figure 146: Monthly total nitrates for site 40 with 2.8 milligrams per liter as the yearly average.

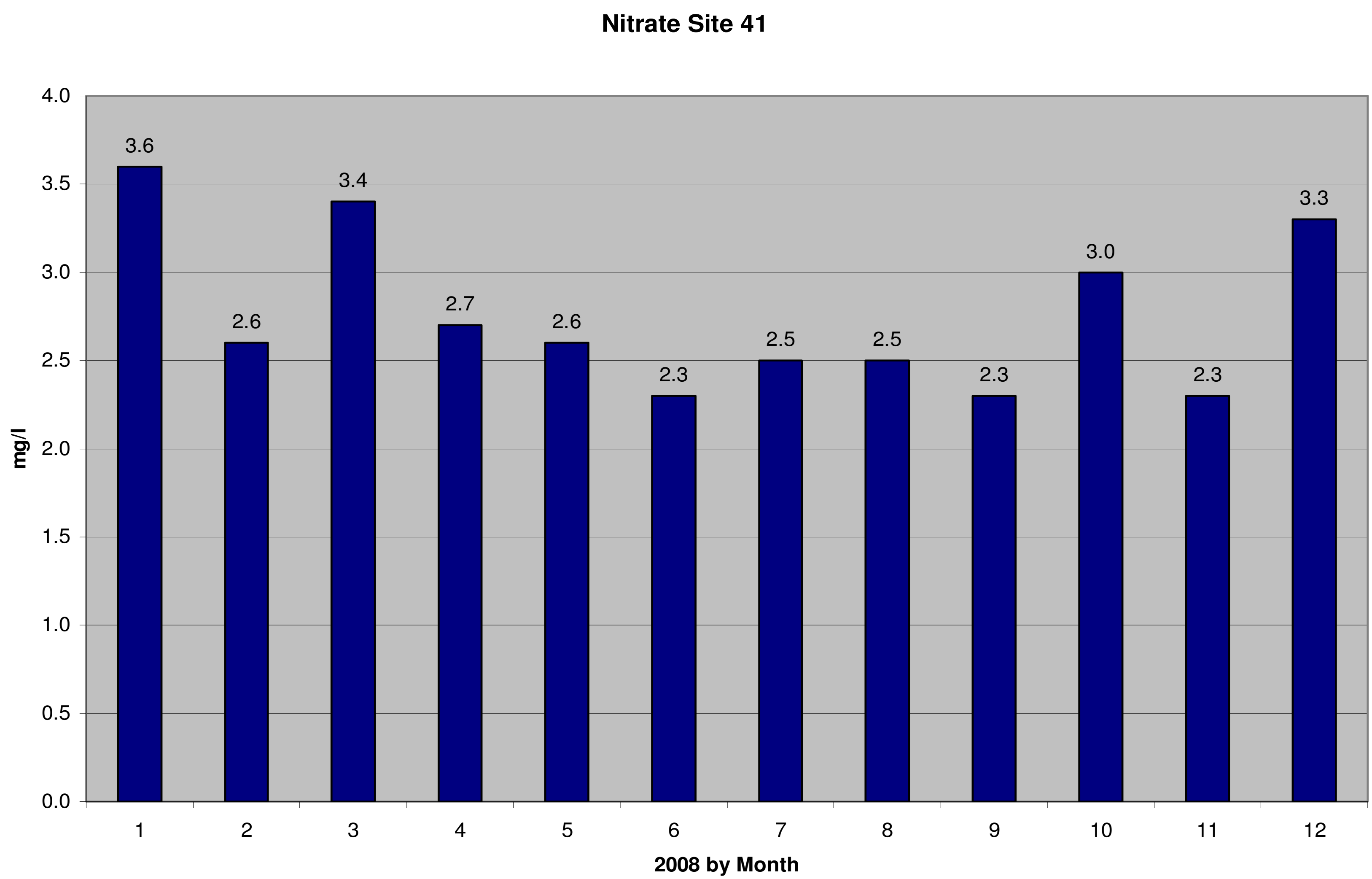

Figure 147: Monthly total nitrates for site 41 with 2.8 milligrams per liter as the yearly average.

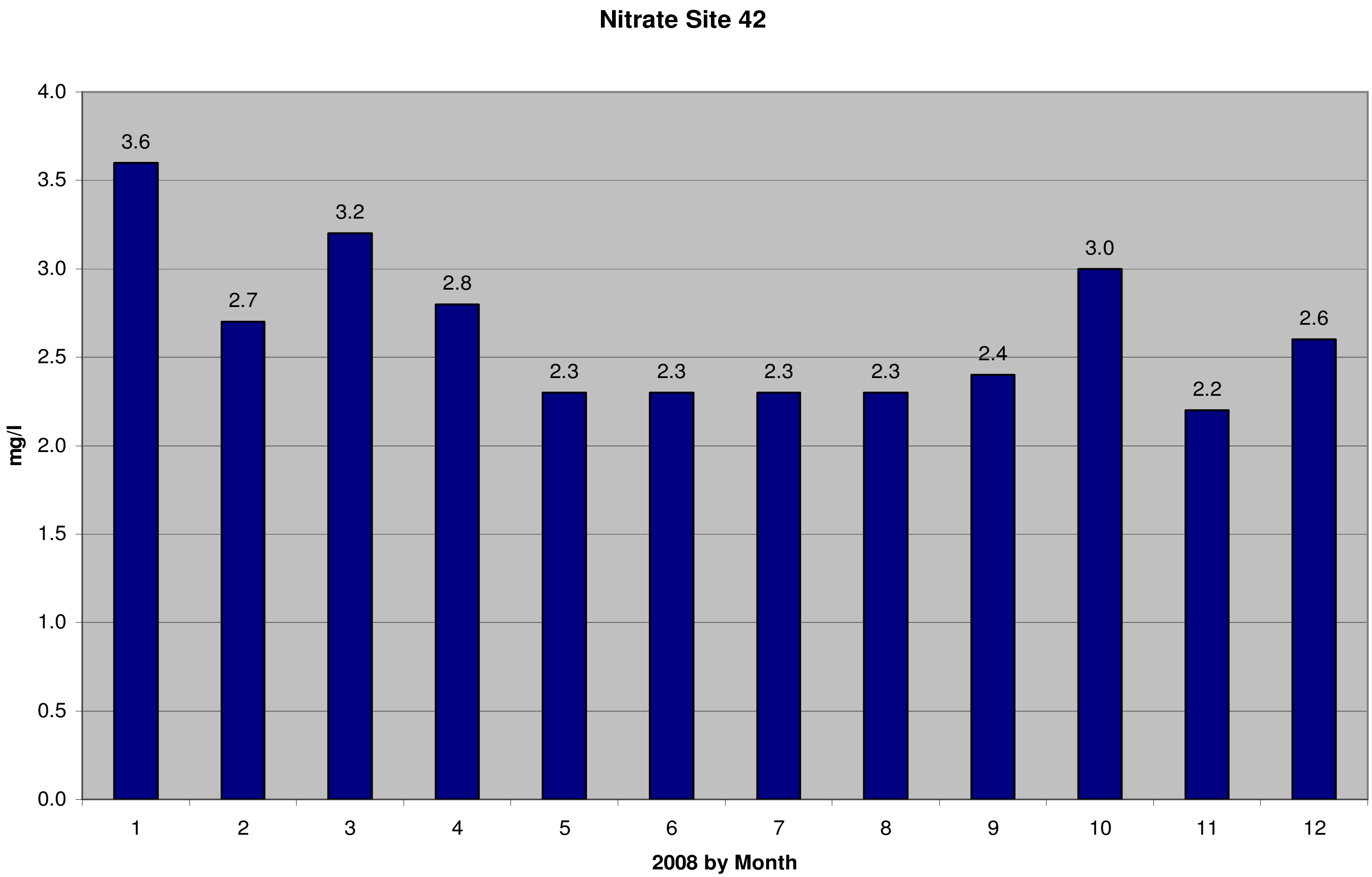

Figure 148: Monthly total nitrates for site 42 with 2.6 milligrams per liter as the yearly average.

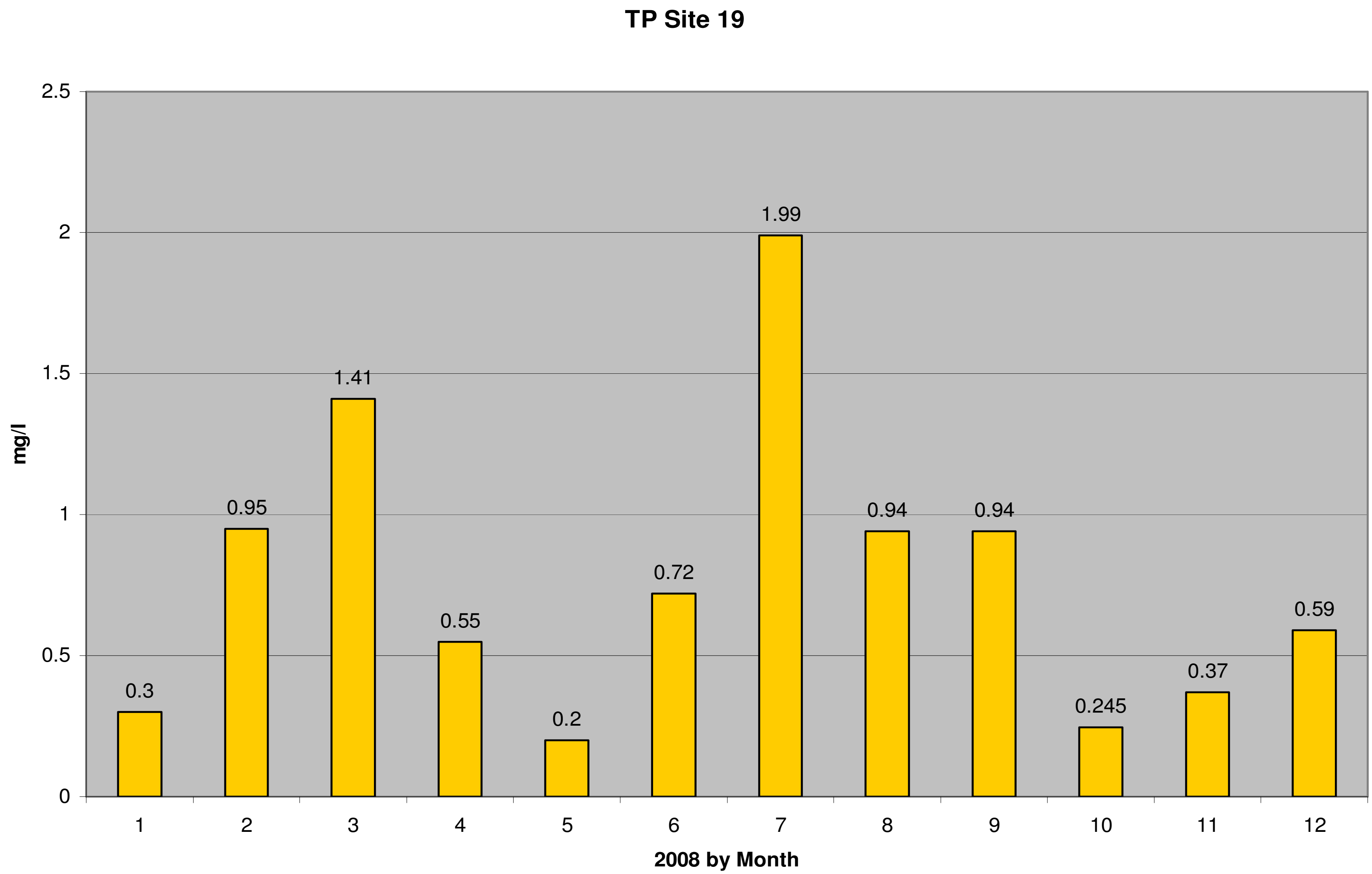

Figure 149: Monthly total phosphorus for site 19 with 0.77 milligrams per liter as the yearly average.

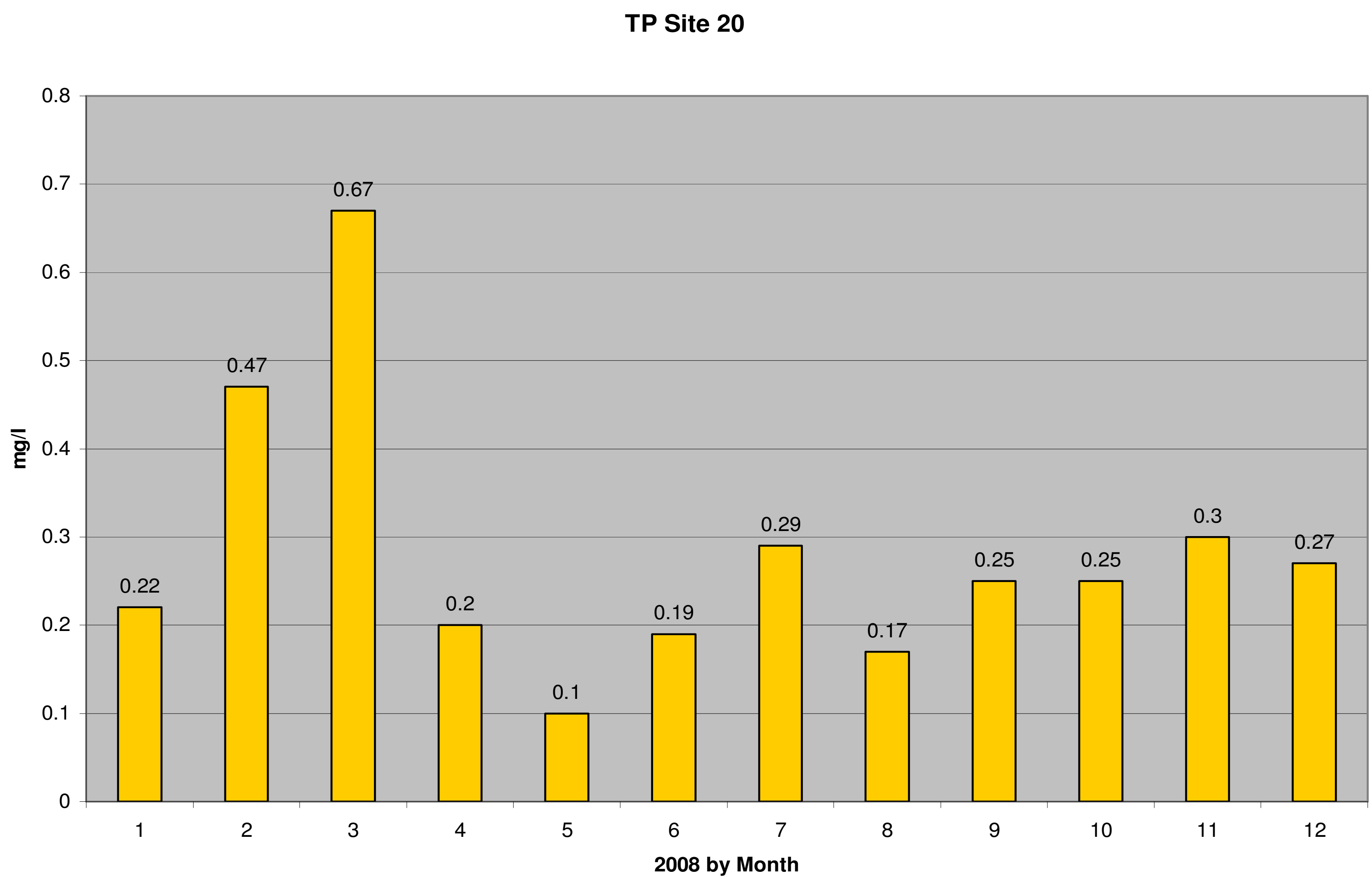

Figure 150: Monthly total phosphorus for site 20 with 0.28 milligrams per liter as the yearly average.

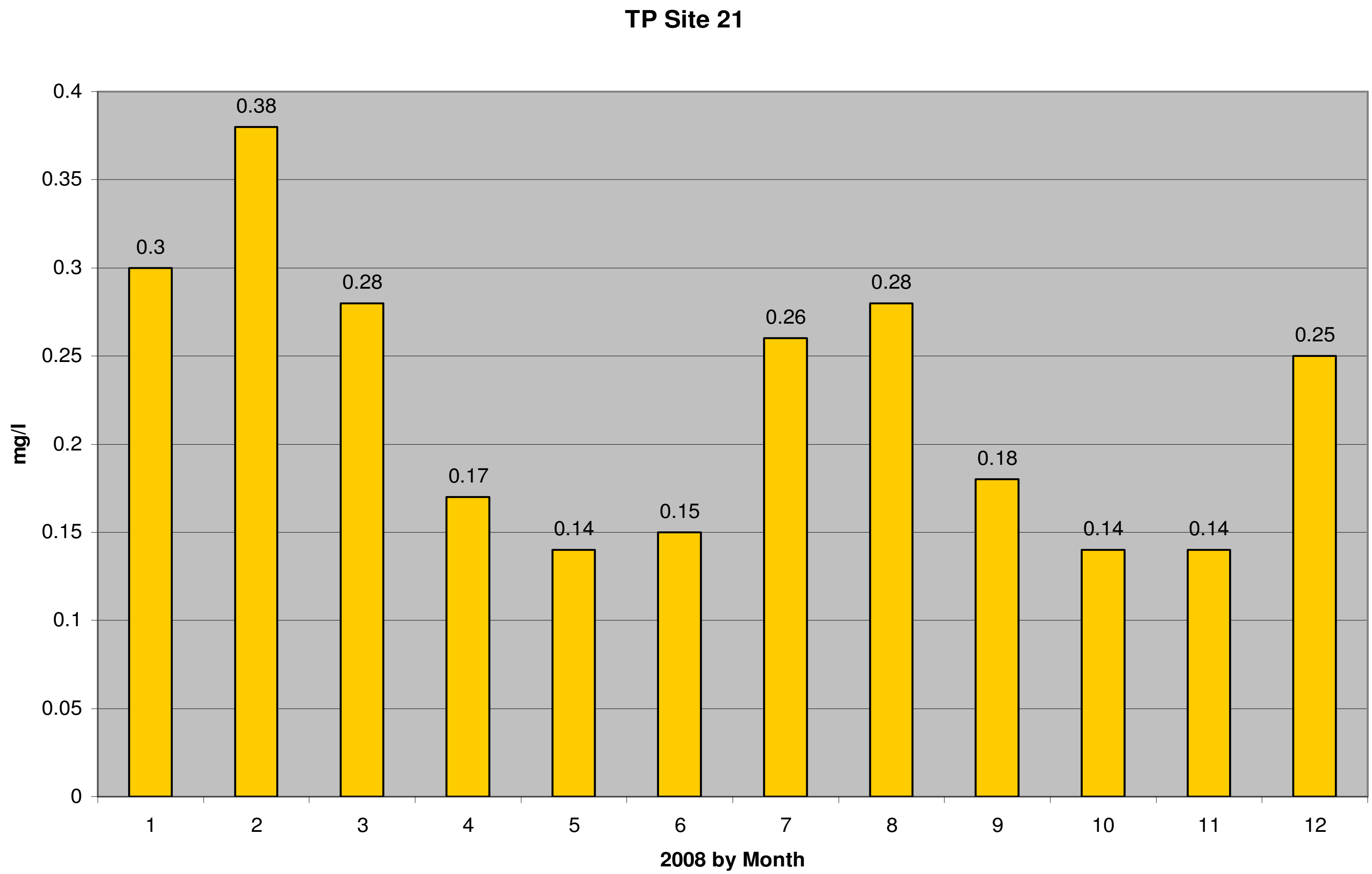

Figure 151: Monthly total phosphorus for site 21 with 0.22 milligrams per liter as the yearly average.

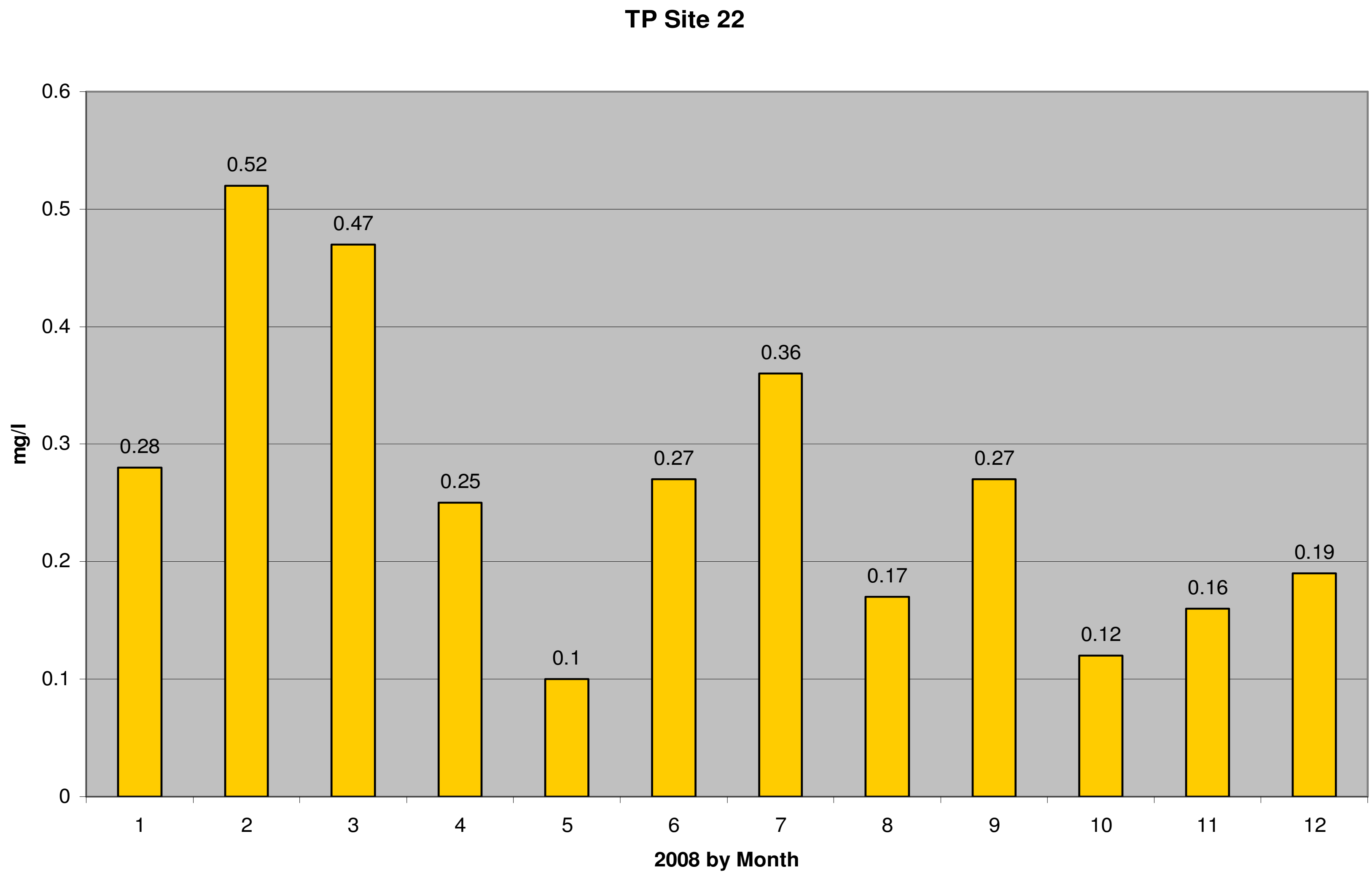

Figure 152: Monthly total phosphorus for site 22 with 0.26 milligrams per liter as the yearly average.

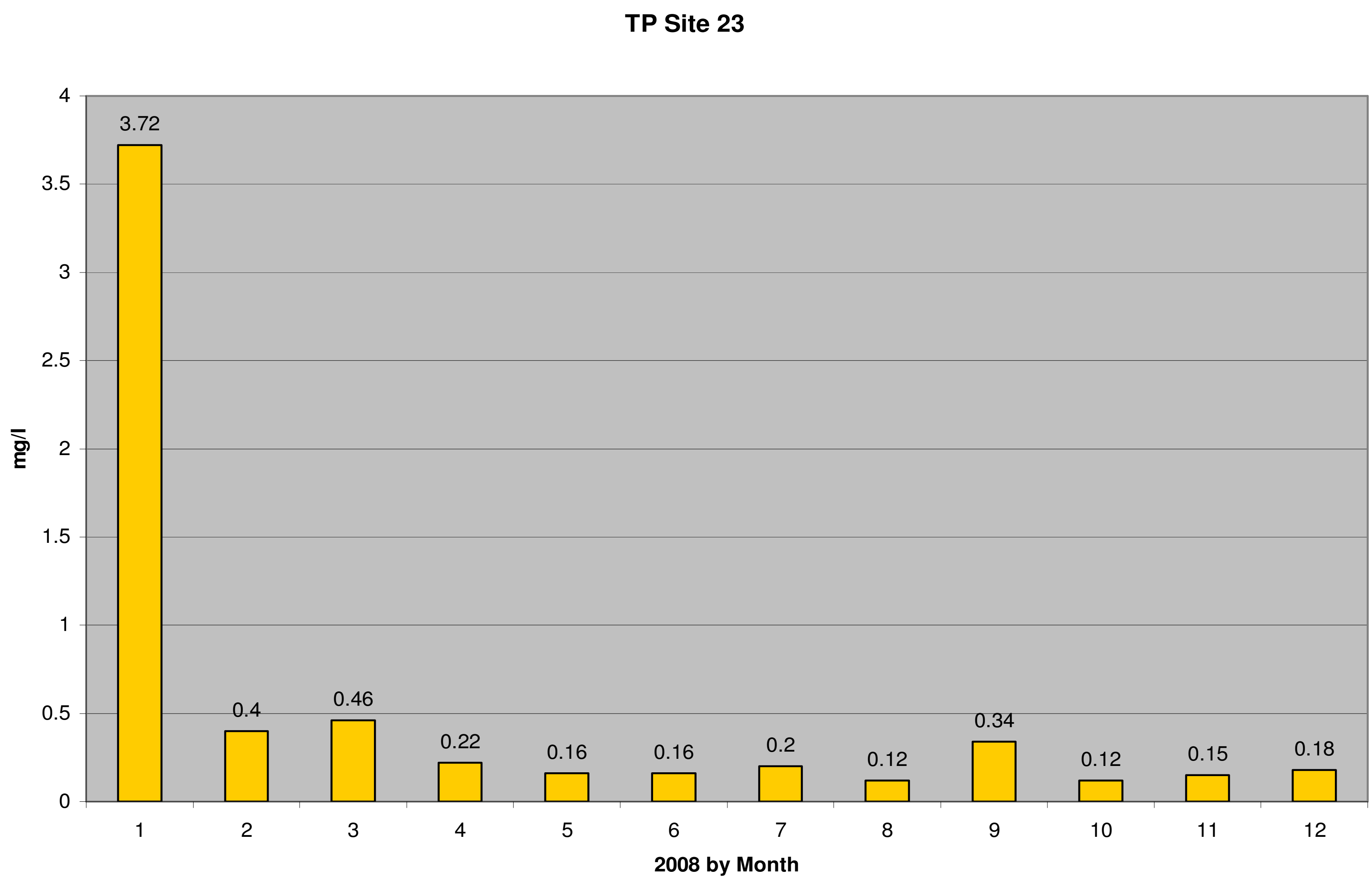

Figure 153: Monthly total phosphorus for site 23 with 0.52 milligrams per liter as the yearly average.

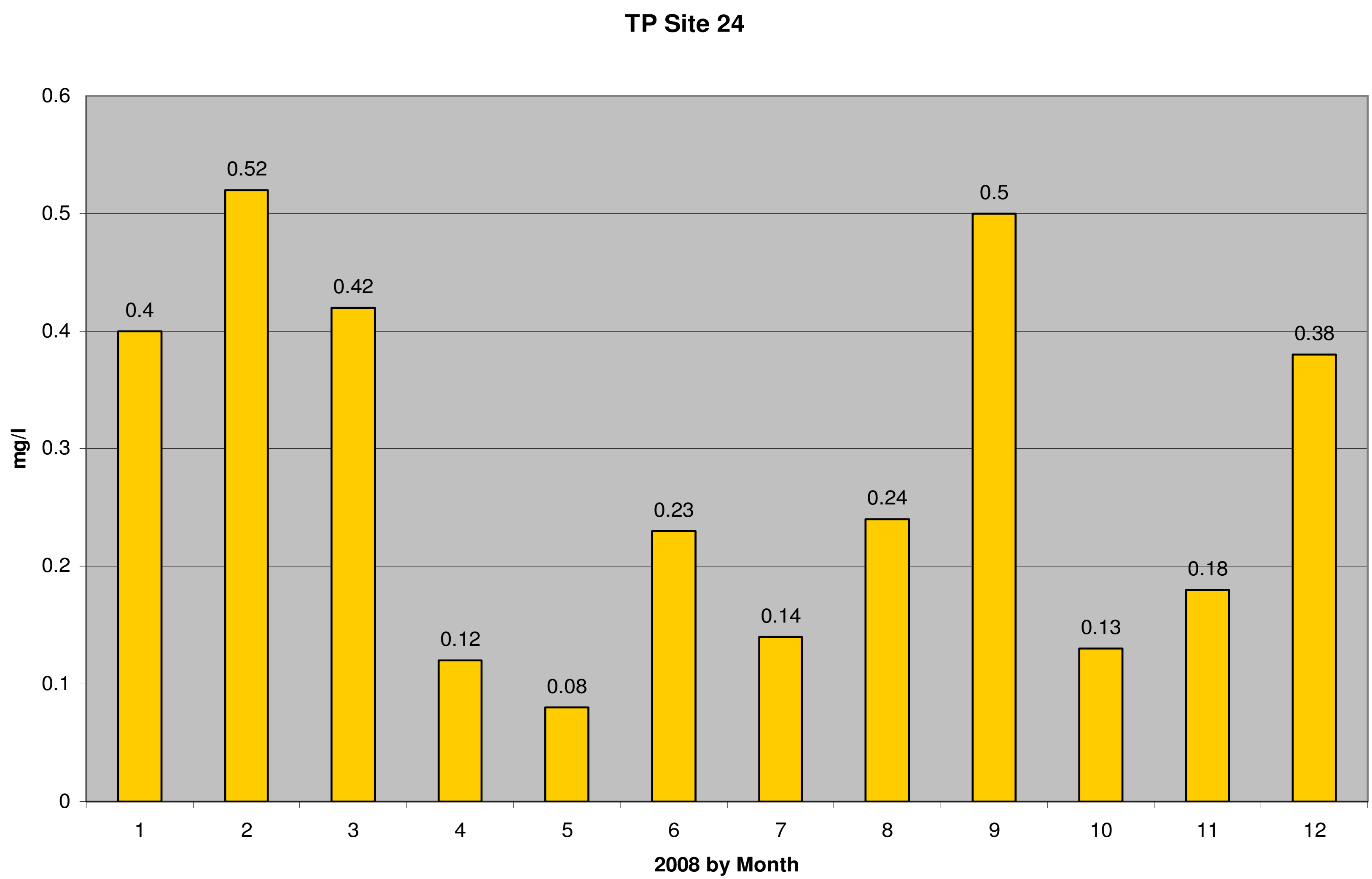

Figure 154: Monthly total phosphorus for site 24 with 0.28 milligrams per liter as the yearly average.

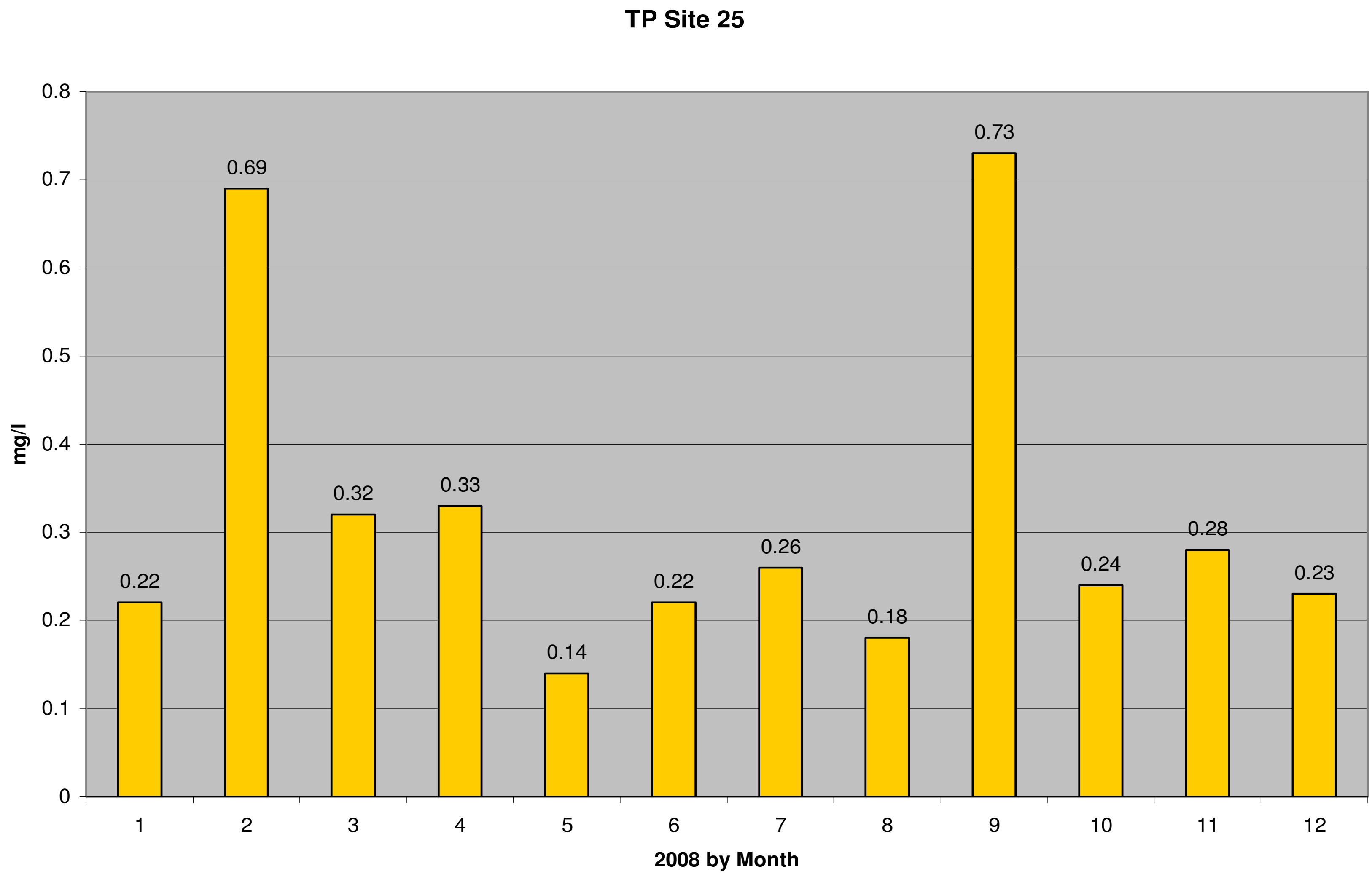

Figure 155: Monthly total phosphorus for site 25 with 0.32 milligrams per liter as the yearly average.

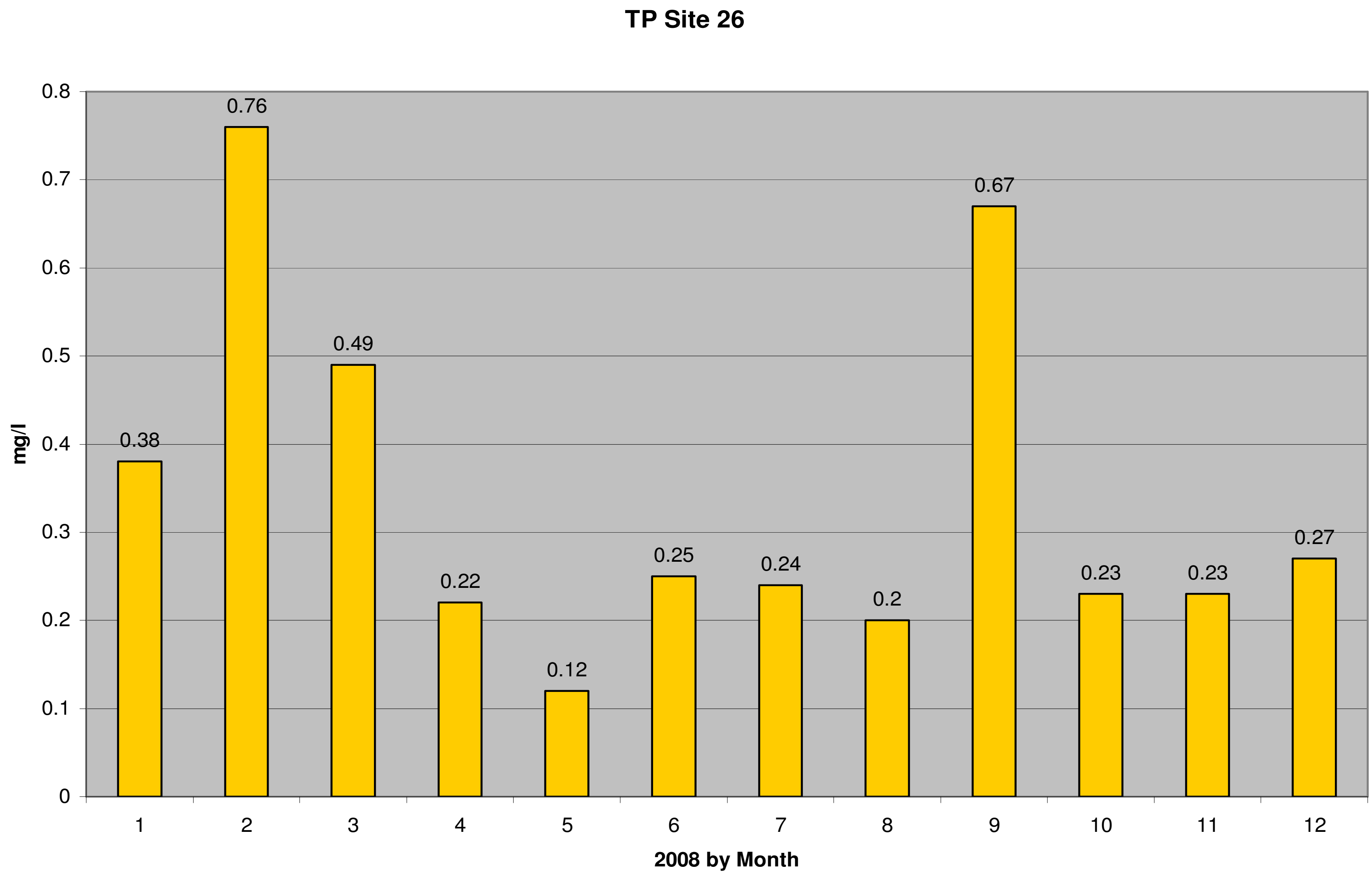

Figure 156: Monthly total phosphorus for site 26 with 0.34 milligrams per liter as the yearly average.

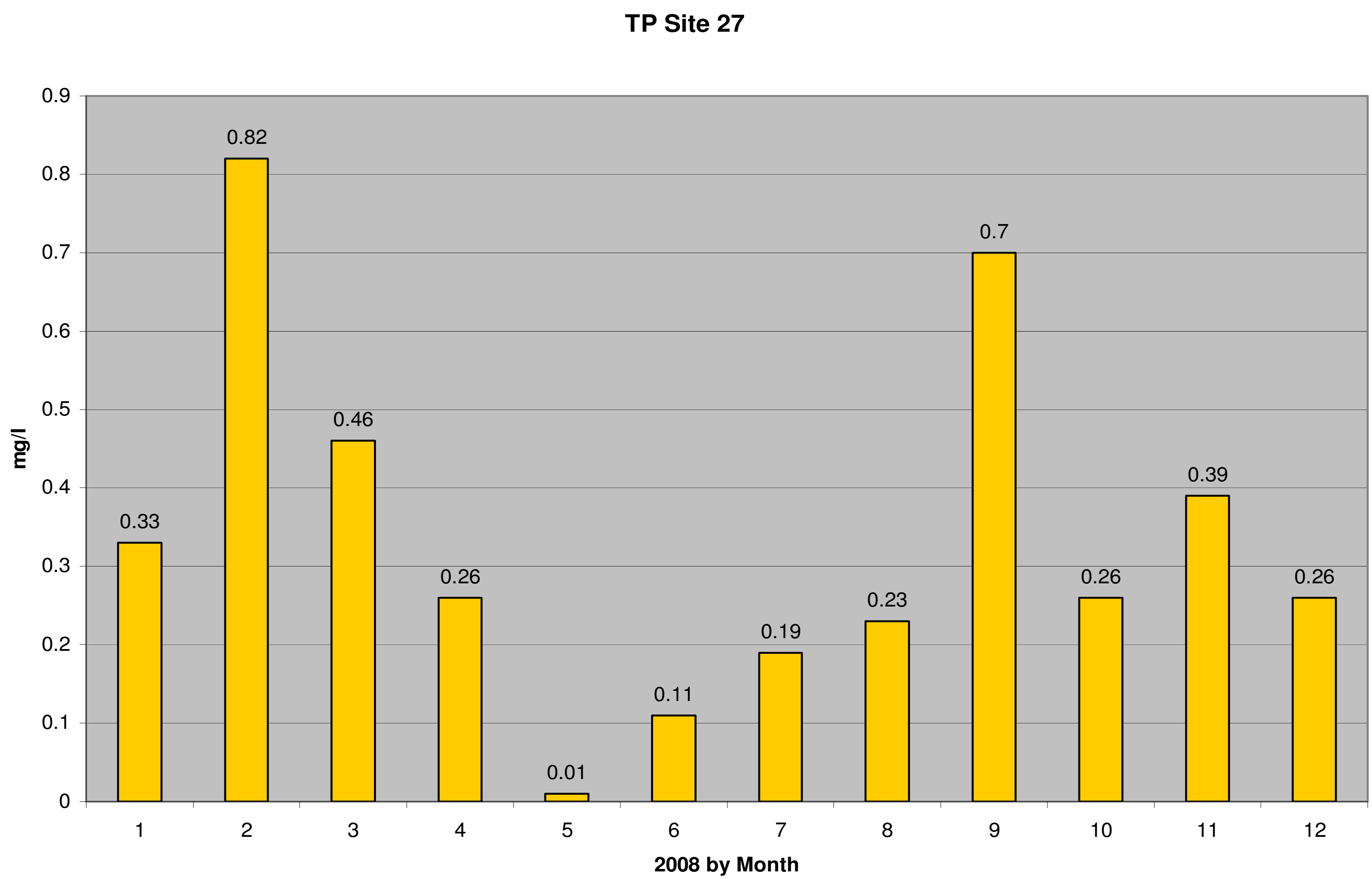

Figure 157: Monthly total phosphorus for site 27 with 0.34 milligrams per liter as the yearly average.

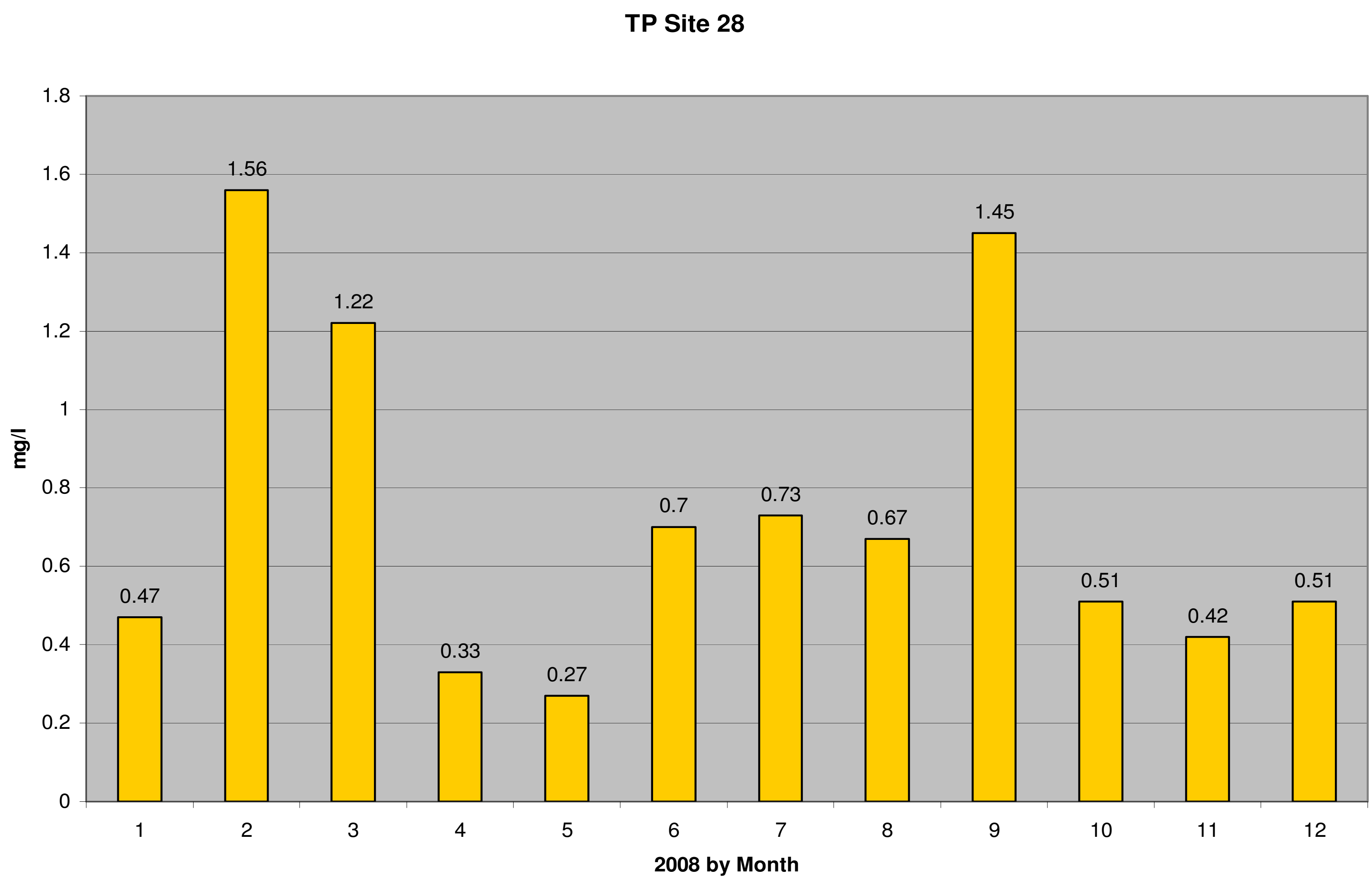

Figure 158: Monthly total phosphorus for site 28 with 0.74 milligrams per liter as the yearly average.

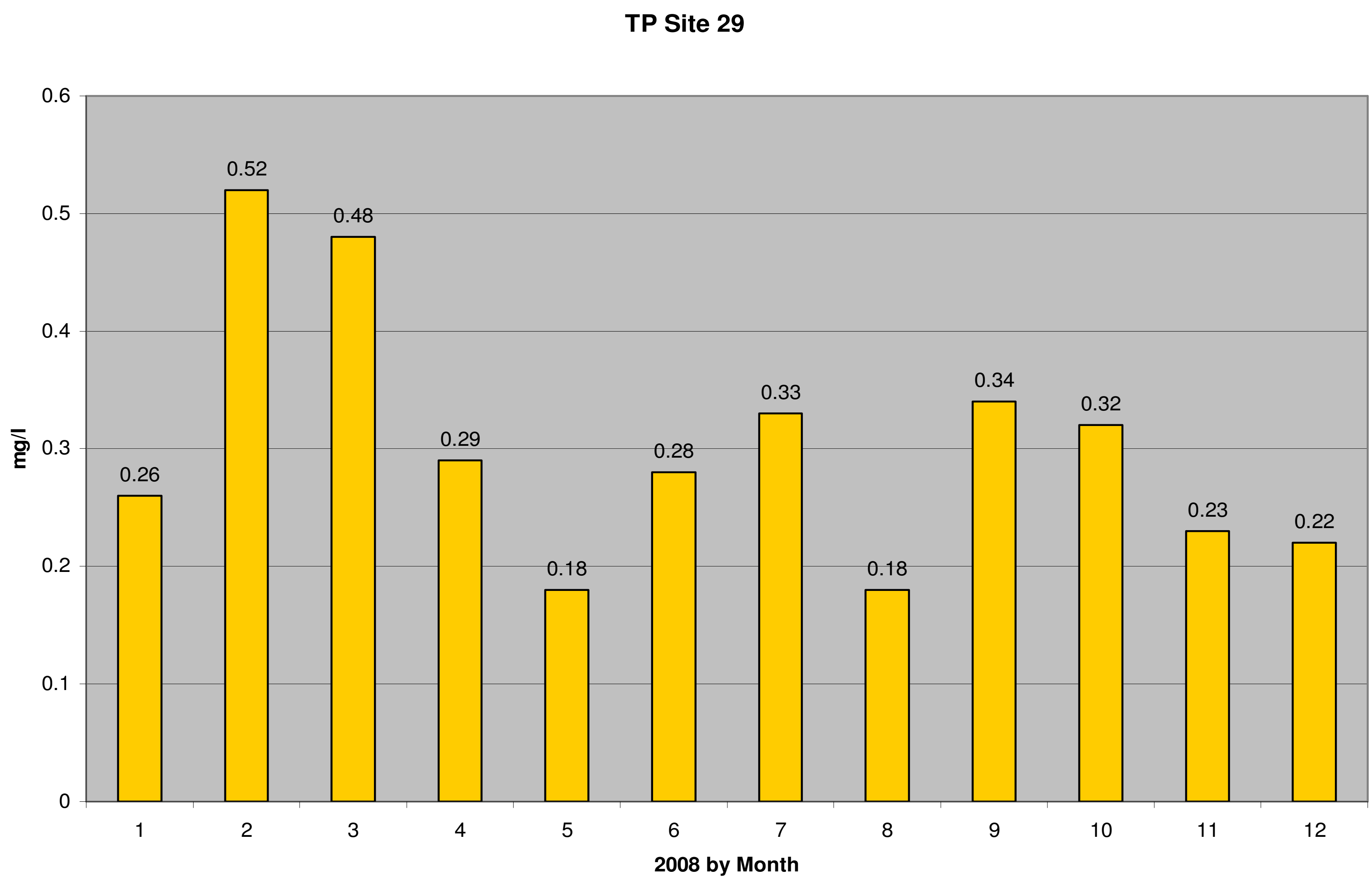

Figure 159: Monthly total phosphorus for site 29 with 0.30 milligrams per liter as the yearly average.

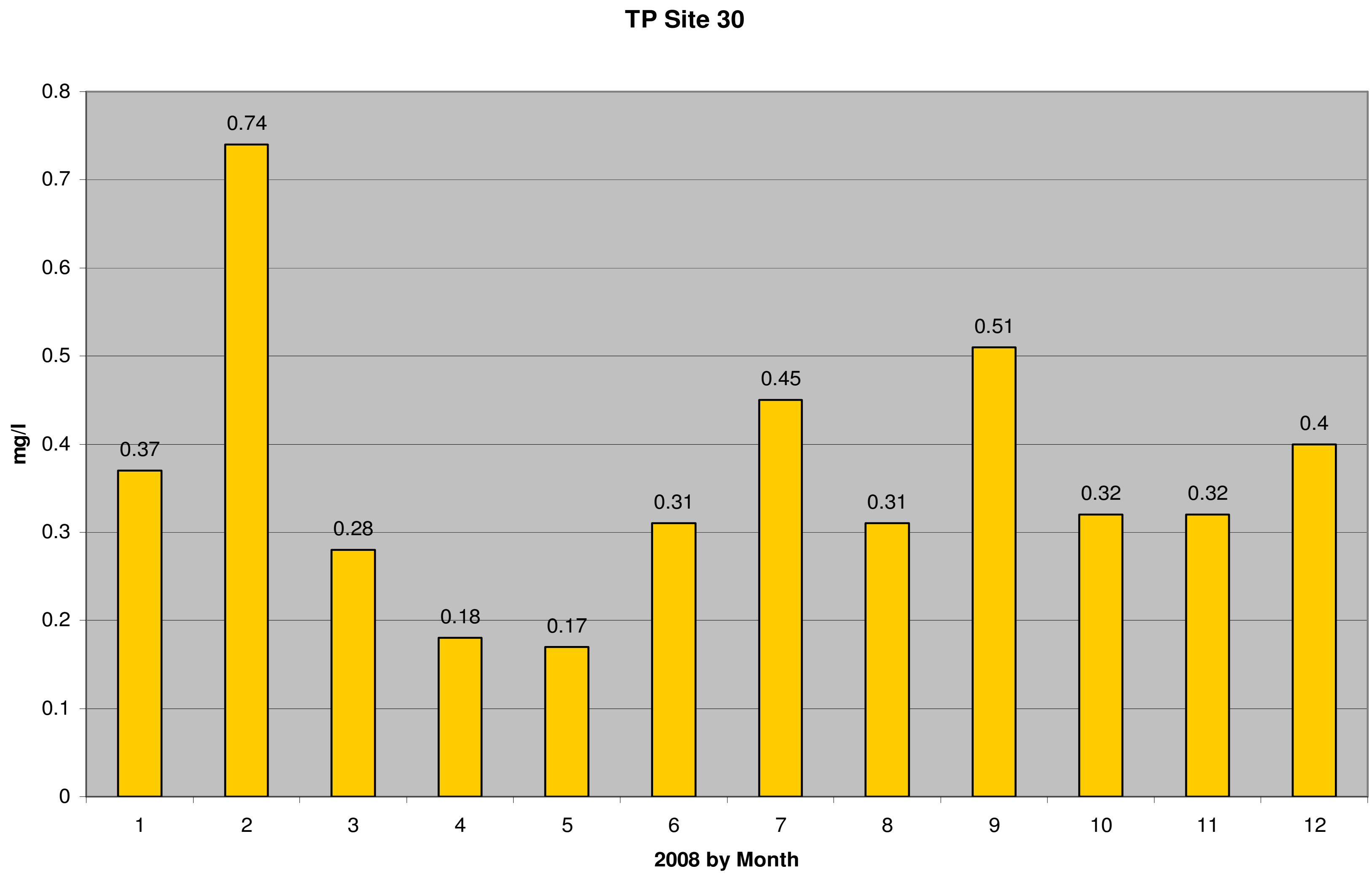

Figure 160: Monthly total phosphorus for site 30 with 0.36 milligrams per liter as the yearly average.

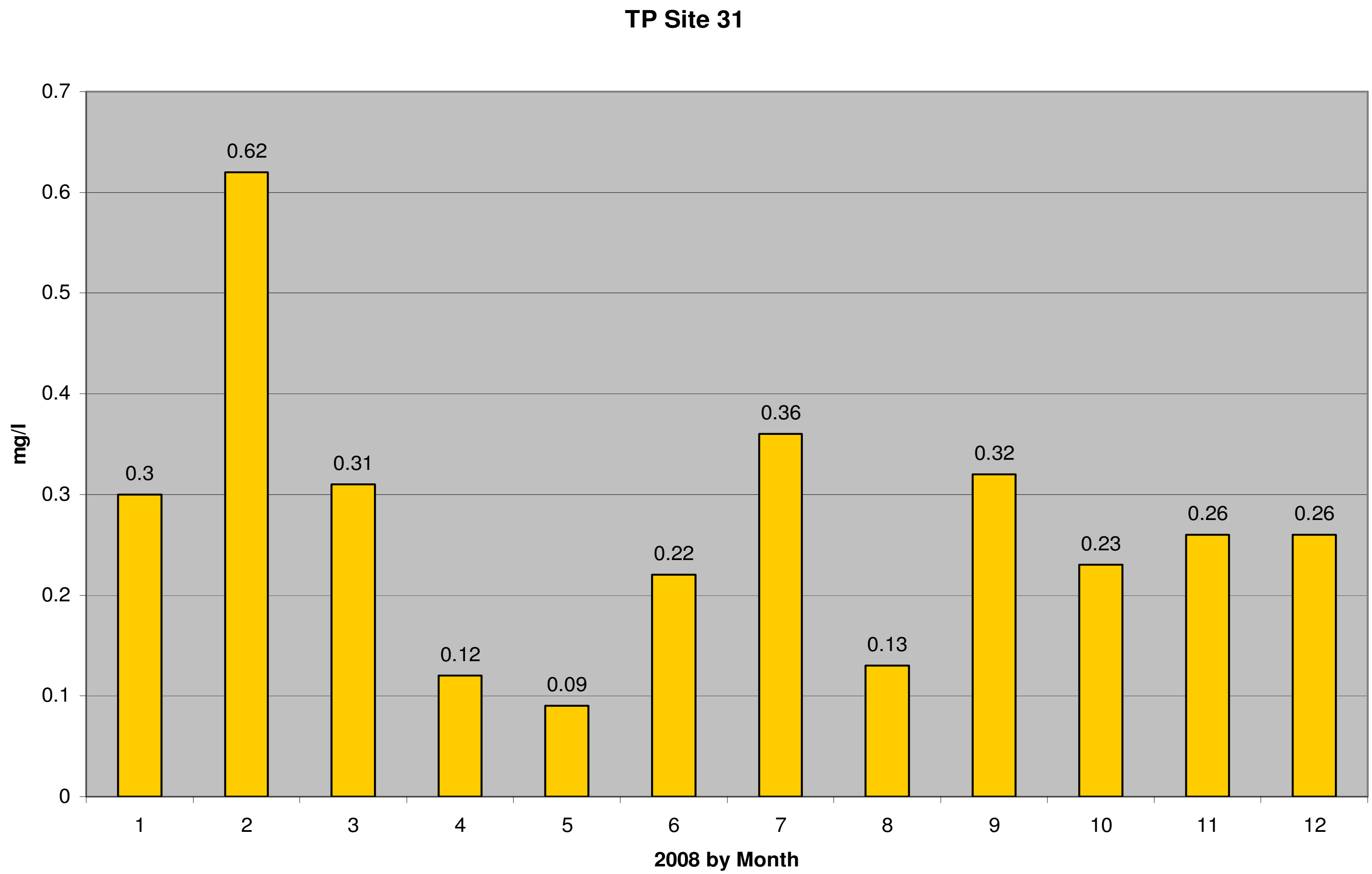

Figure 161: Monthly total phosphorus for site 31 with 0.27 milligrams per liter as the yearly average.

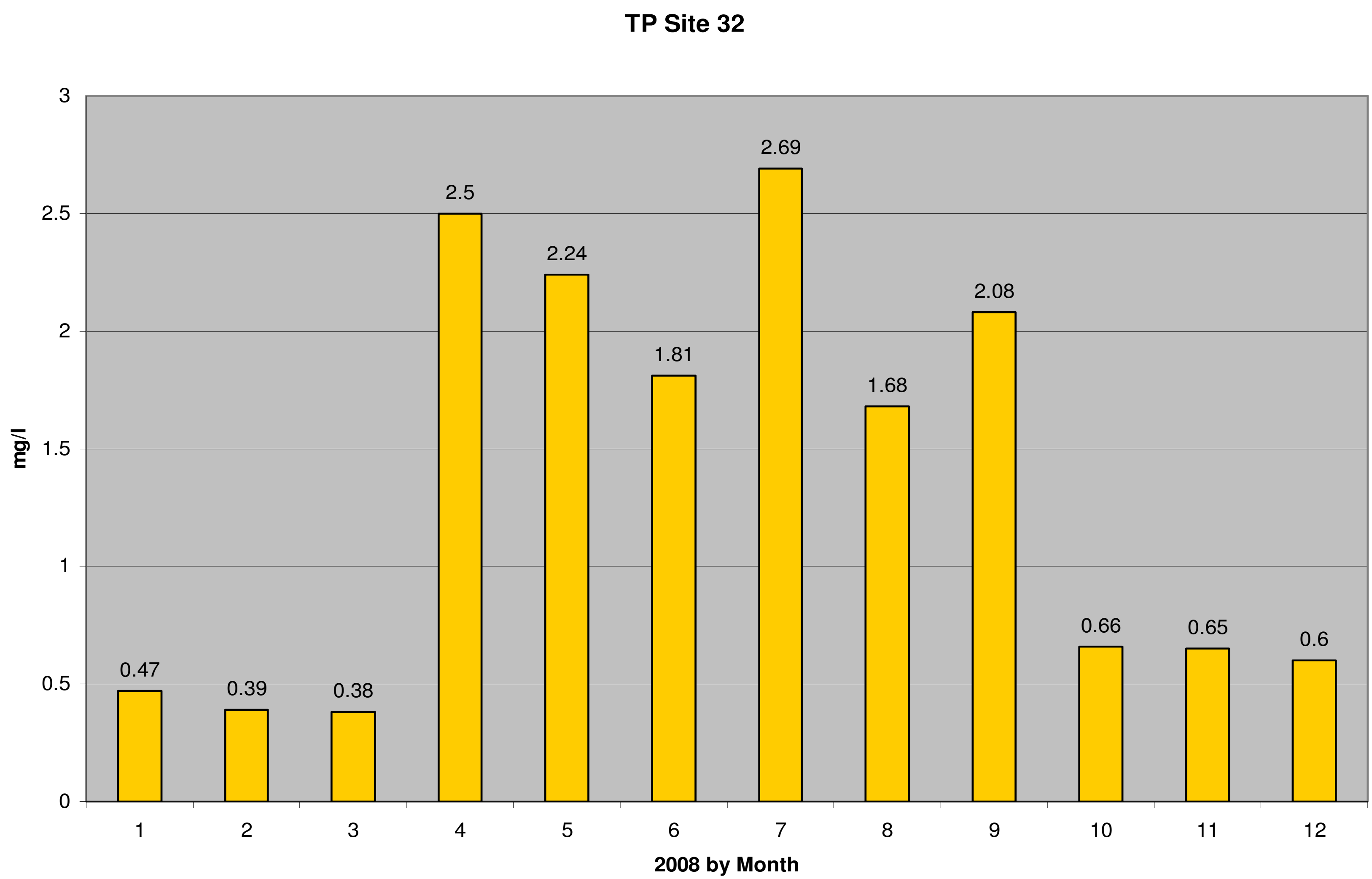

Figure 162: Monthly total phosphorus for site 32 with 1.35 milligrams per liter as the yearly average.

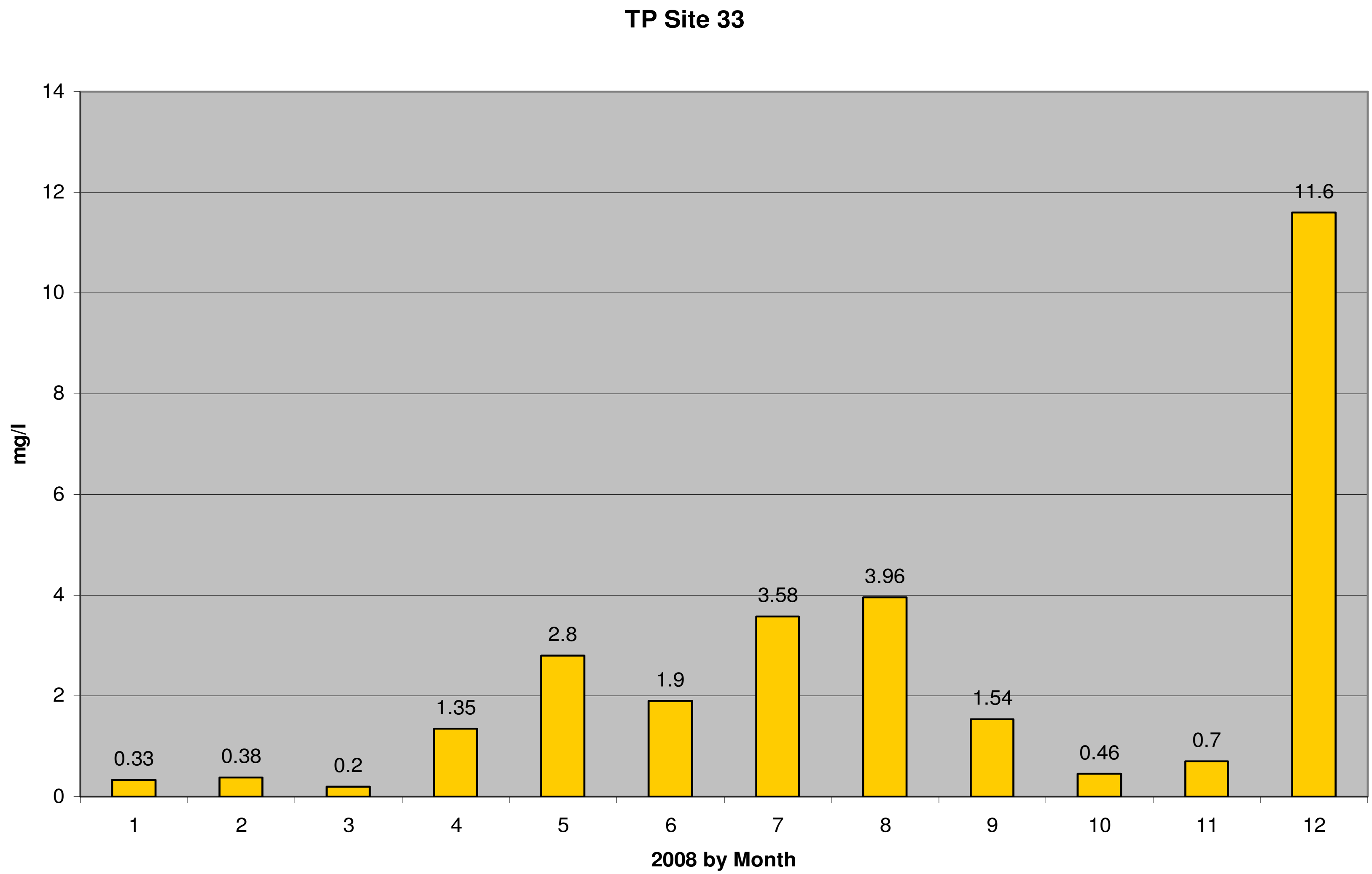

Figure 163: Monthly total phosphorus for site 33 with 2.40 milligrams per liter as the yearly average.

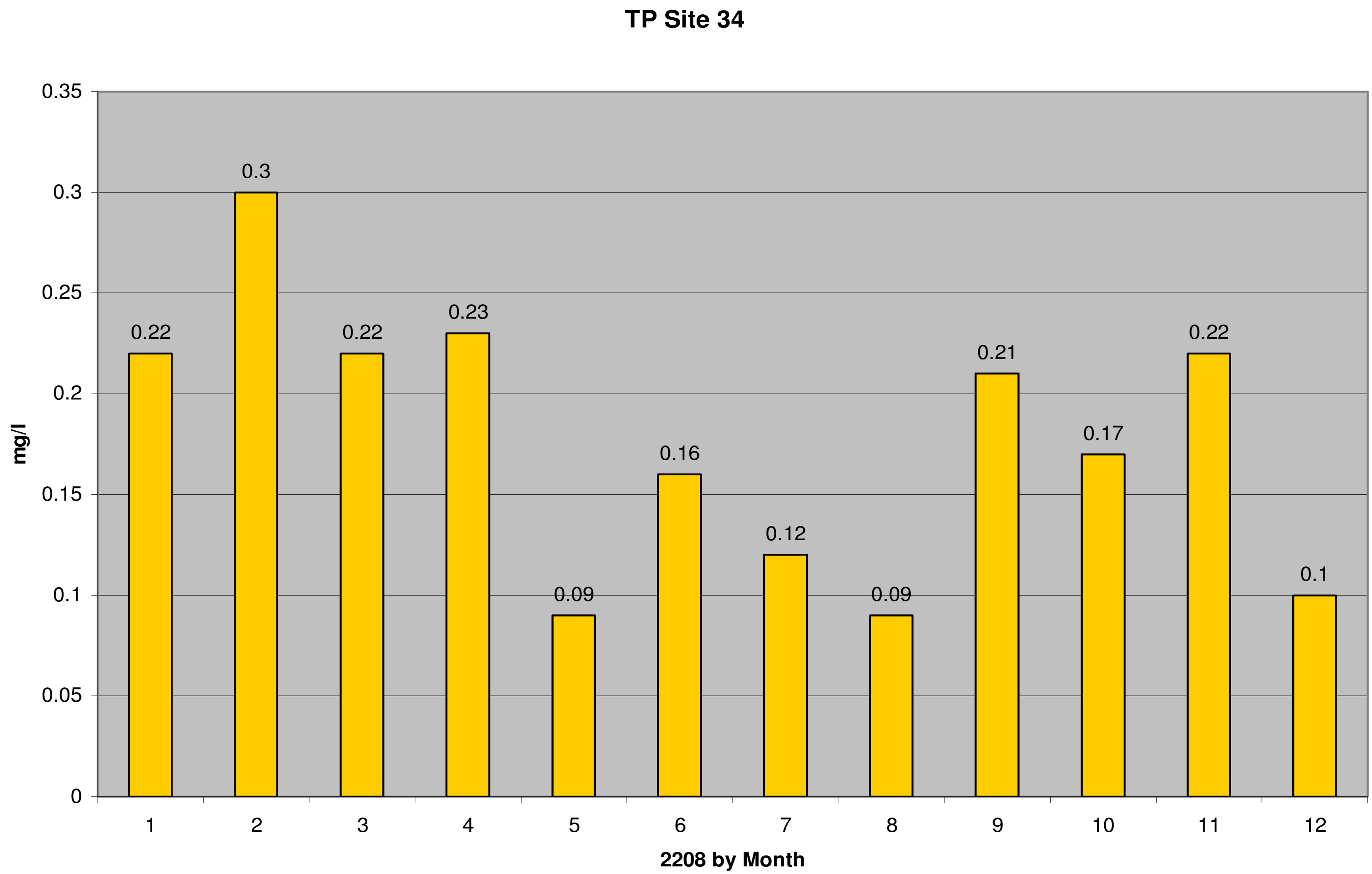

Figure 164: Monthly total phosphorus for site 34 with 0.18 milligrams per liter as the yearly average.

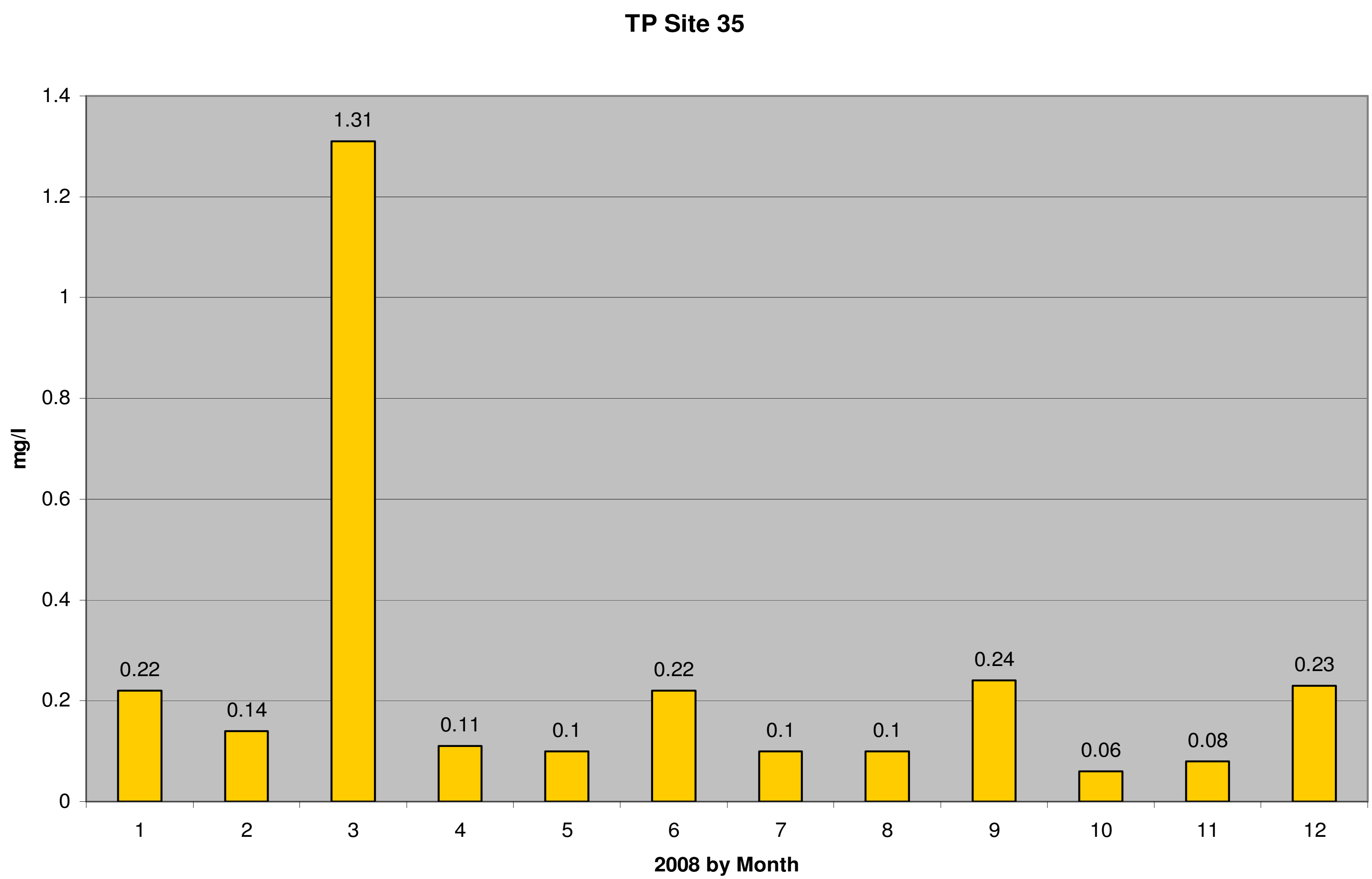

Figure 165: Monthly total phosphorus for site 35 with 0.24 milligrams per liter as the yearly average.

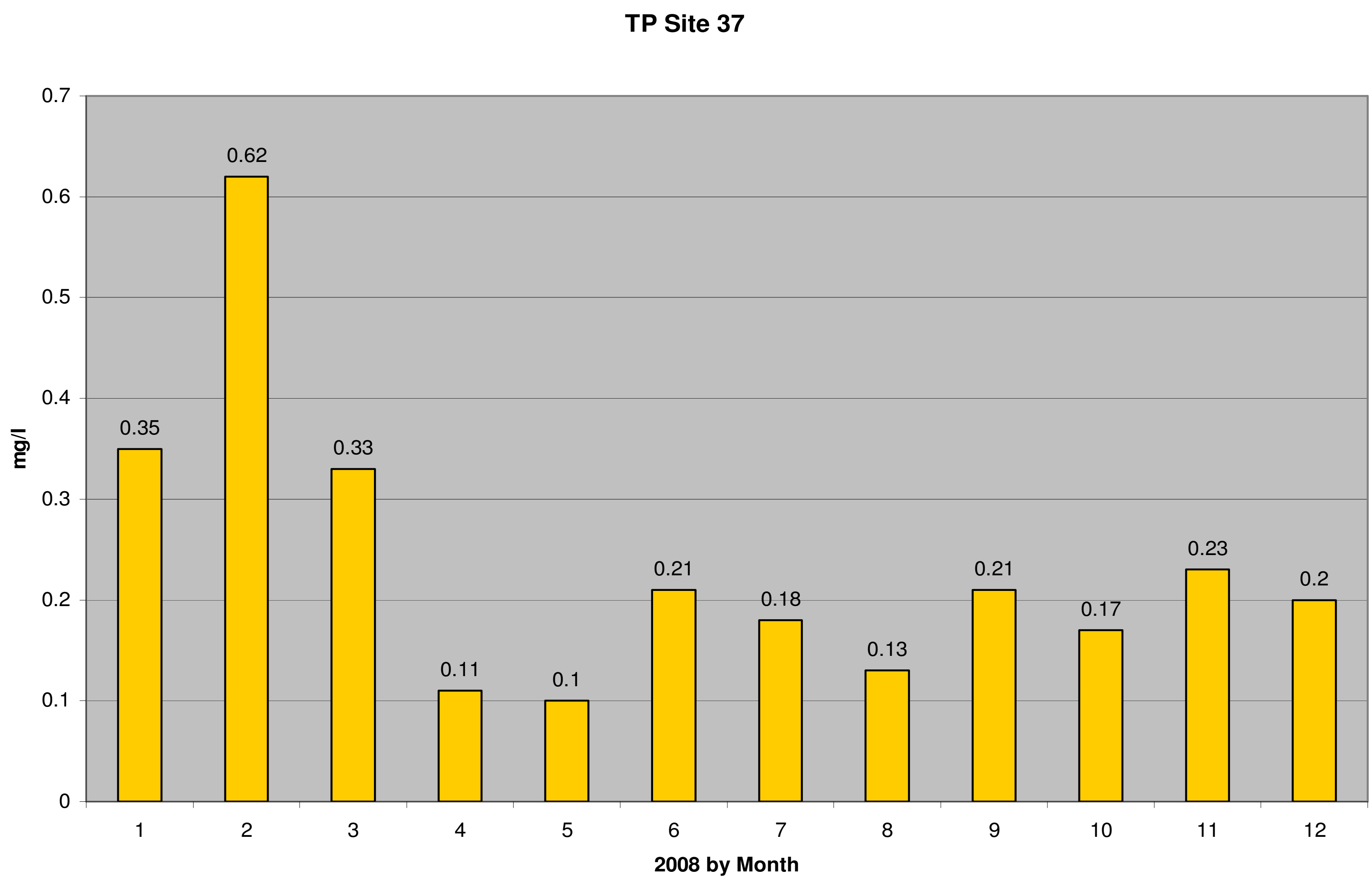

Figure 166: Monthly total phosphorus for site 37 with 0.24 milligrams per liter as the yearly average.

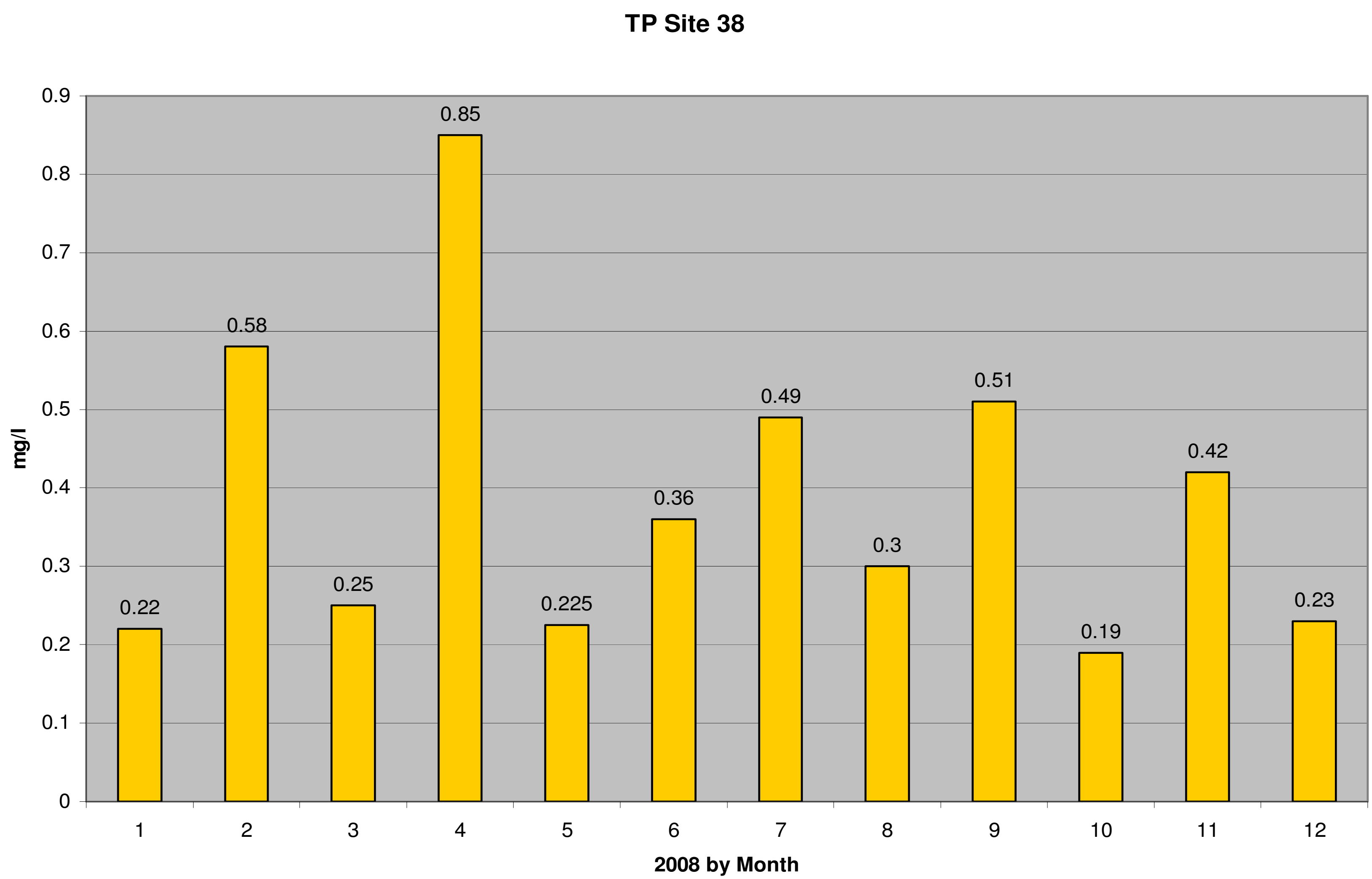

Figure 167: Monthly total phosphorus for site 38 with 0.39 milligrams per liter as the yearly average.

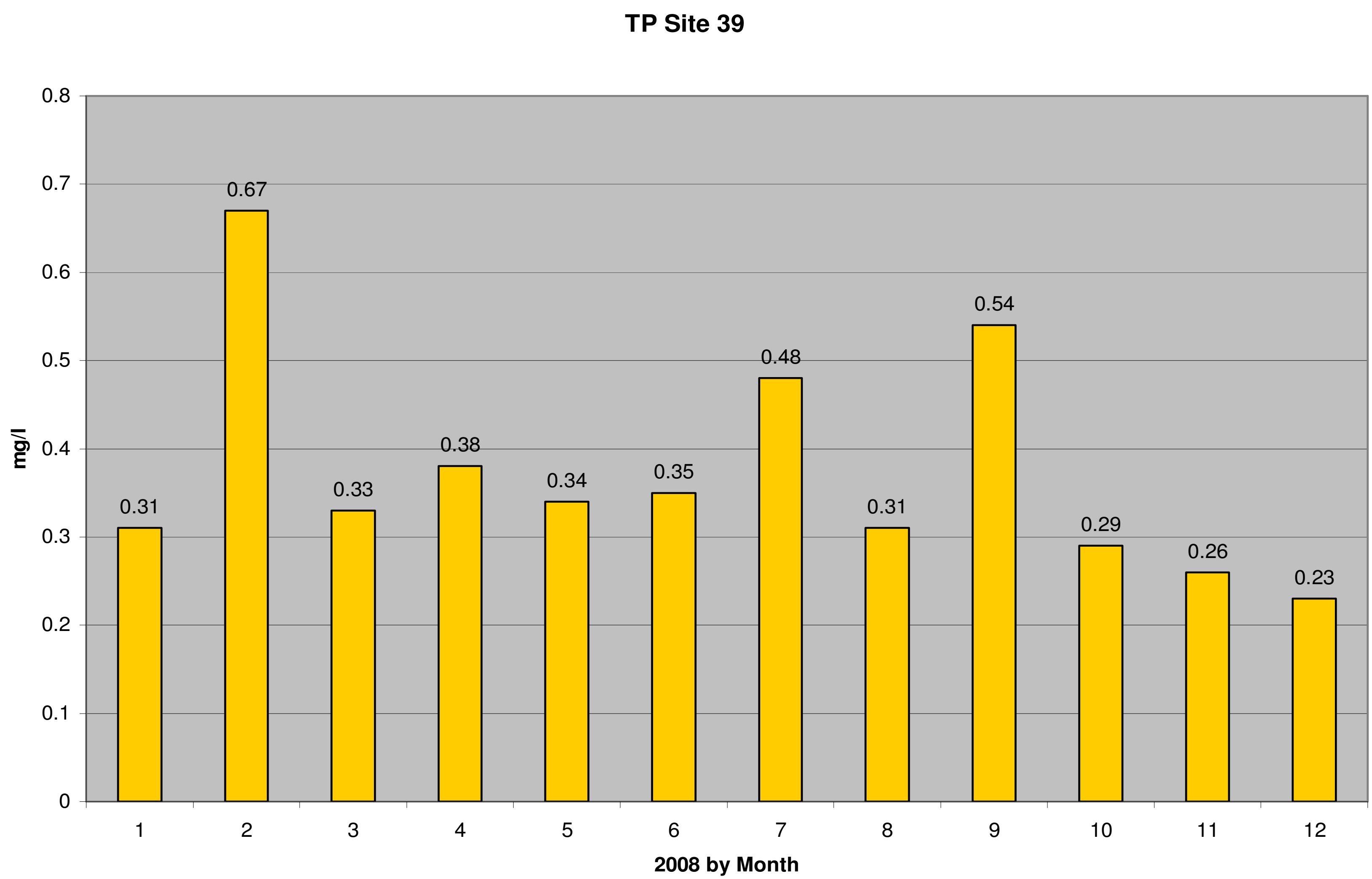

Figure 168: Monthly total phosphorus for site 39 with 0.37 milligrams per liter as the yearly average.

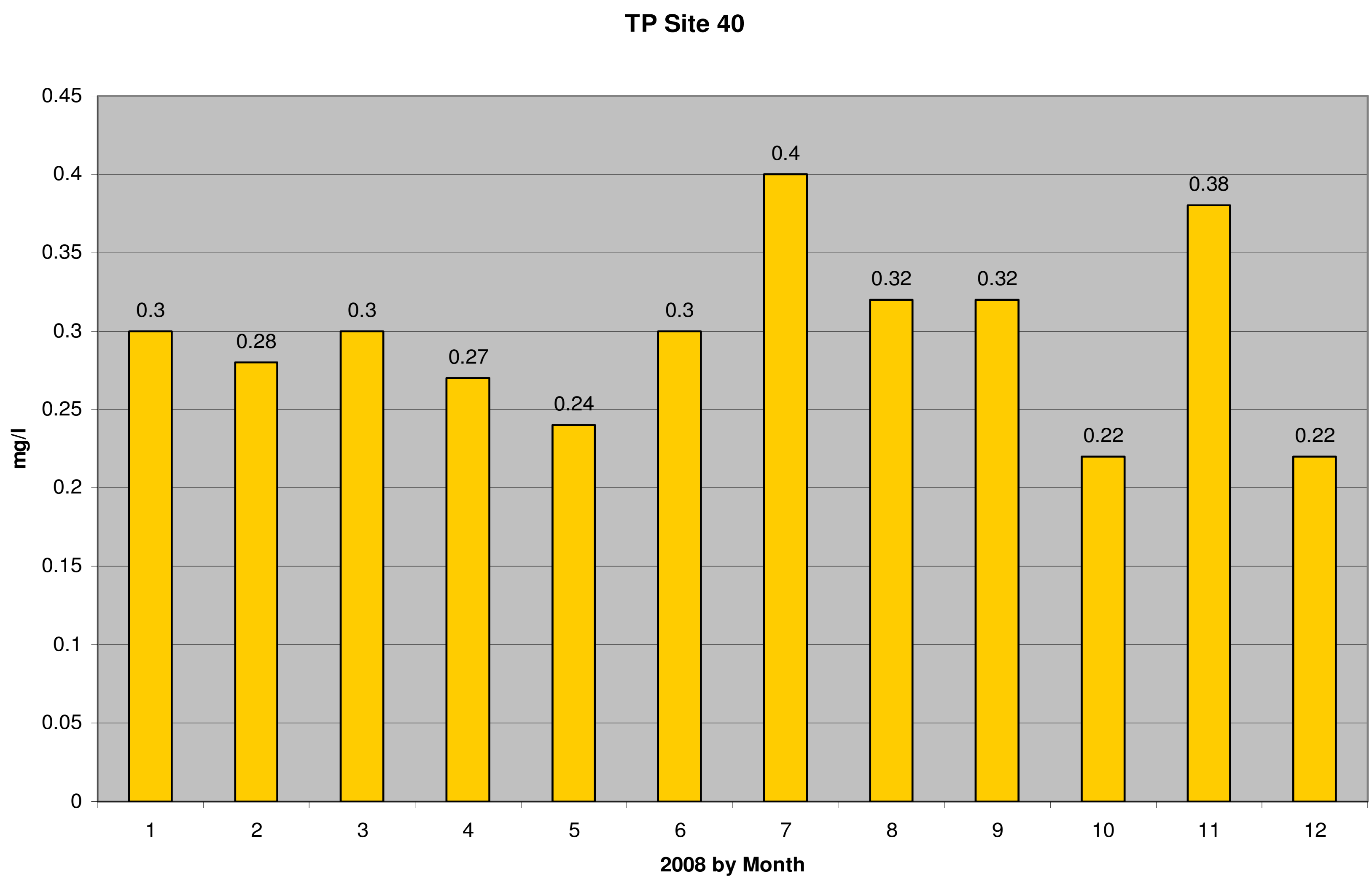

Figure 169: Monthly total phosphorus for site 40 with 0.30 milligrams per liter as the yearly average.

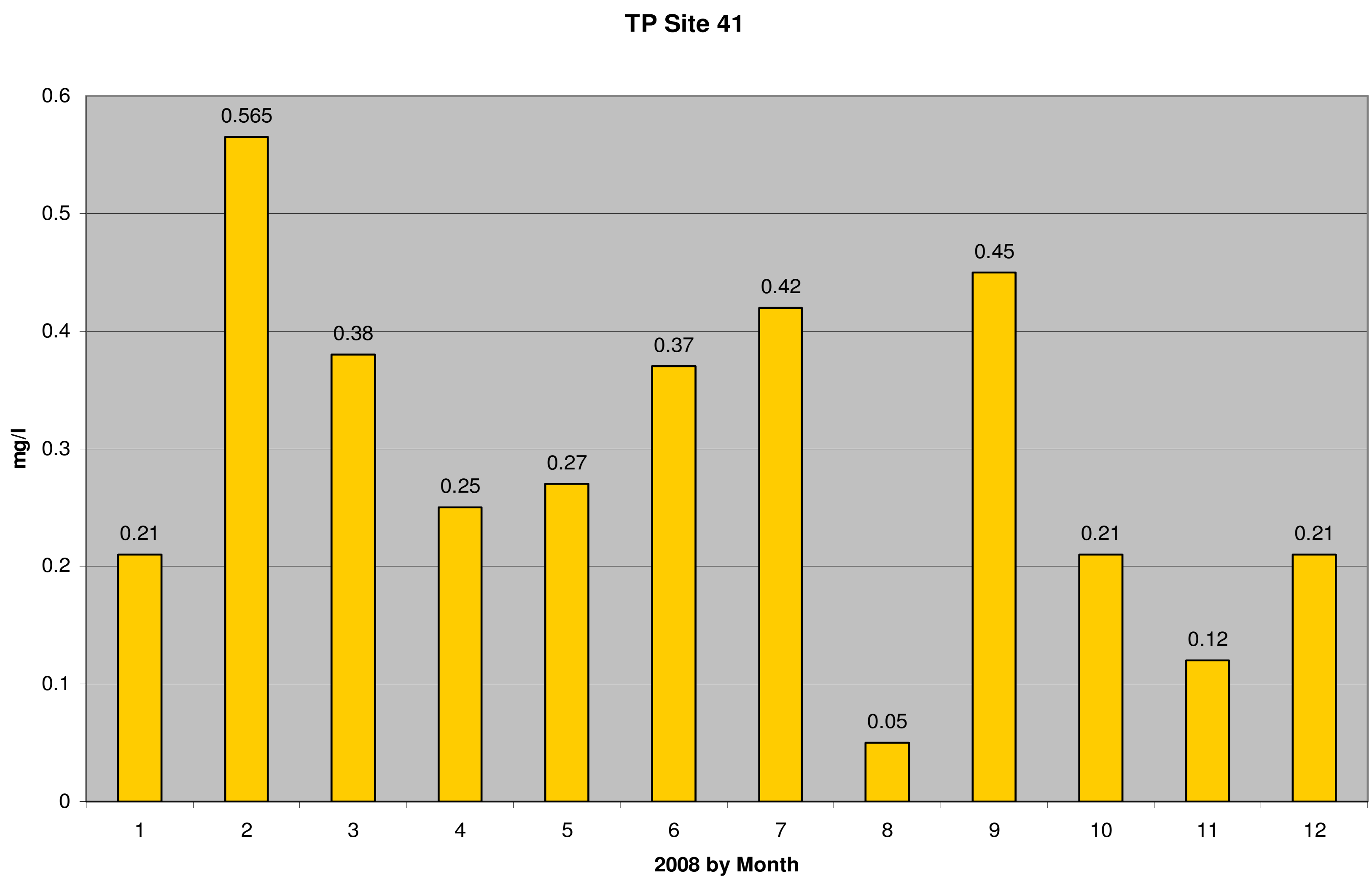

Figure 170: Monthly total phosphorus for site 41 with 0.29 milligrams per liter as the yearly average.

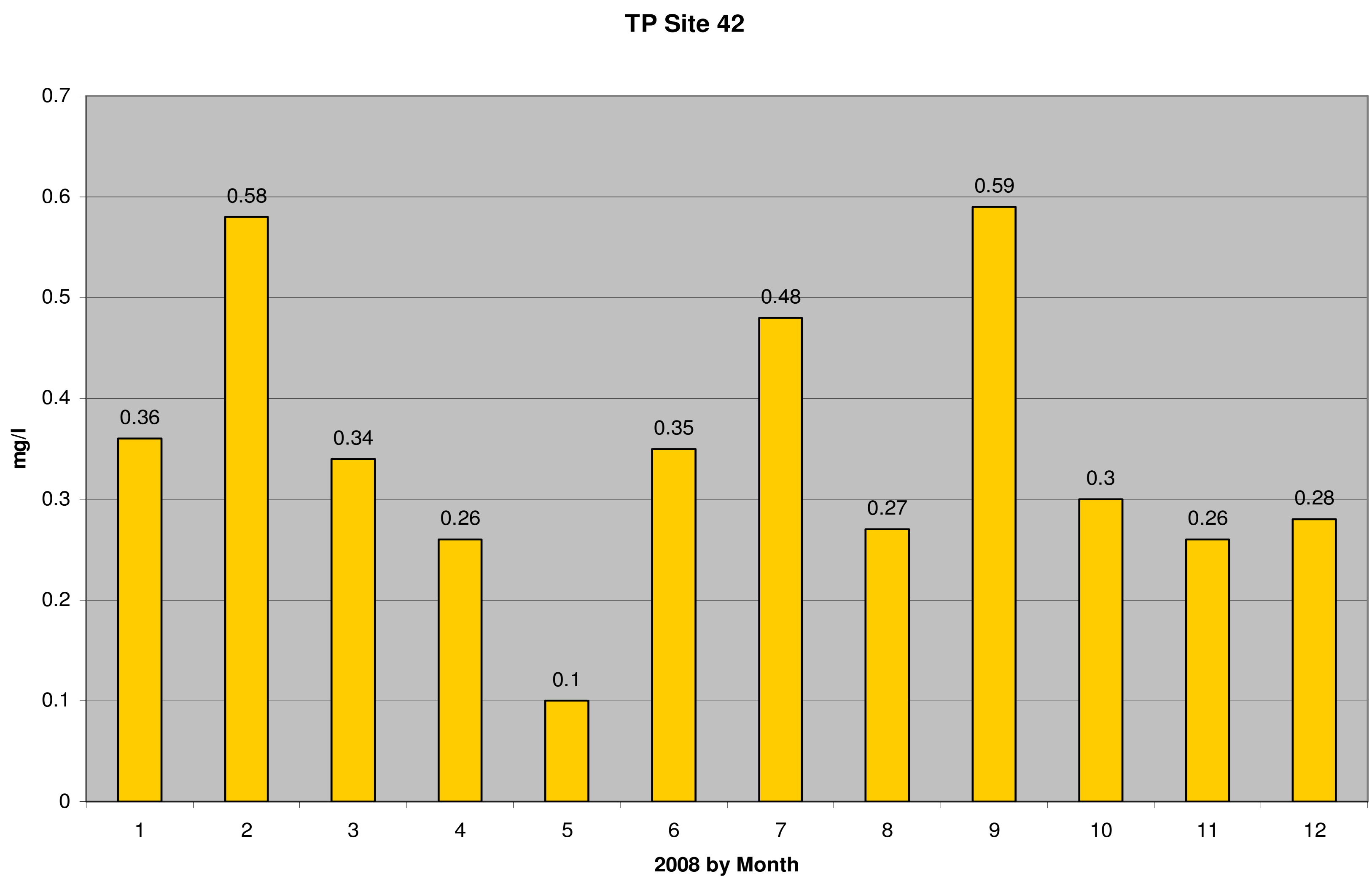

Figure 171: Monthly total phosphorus for site 42 with 0.34 milligrams per liter as the yearly average.

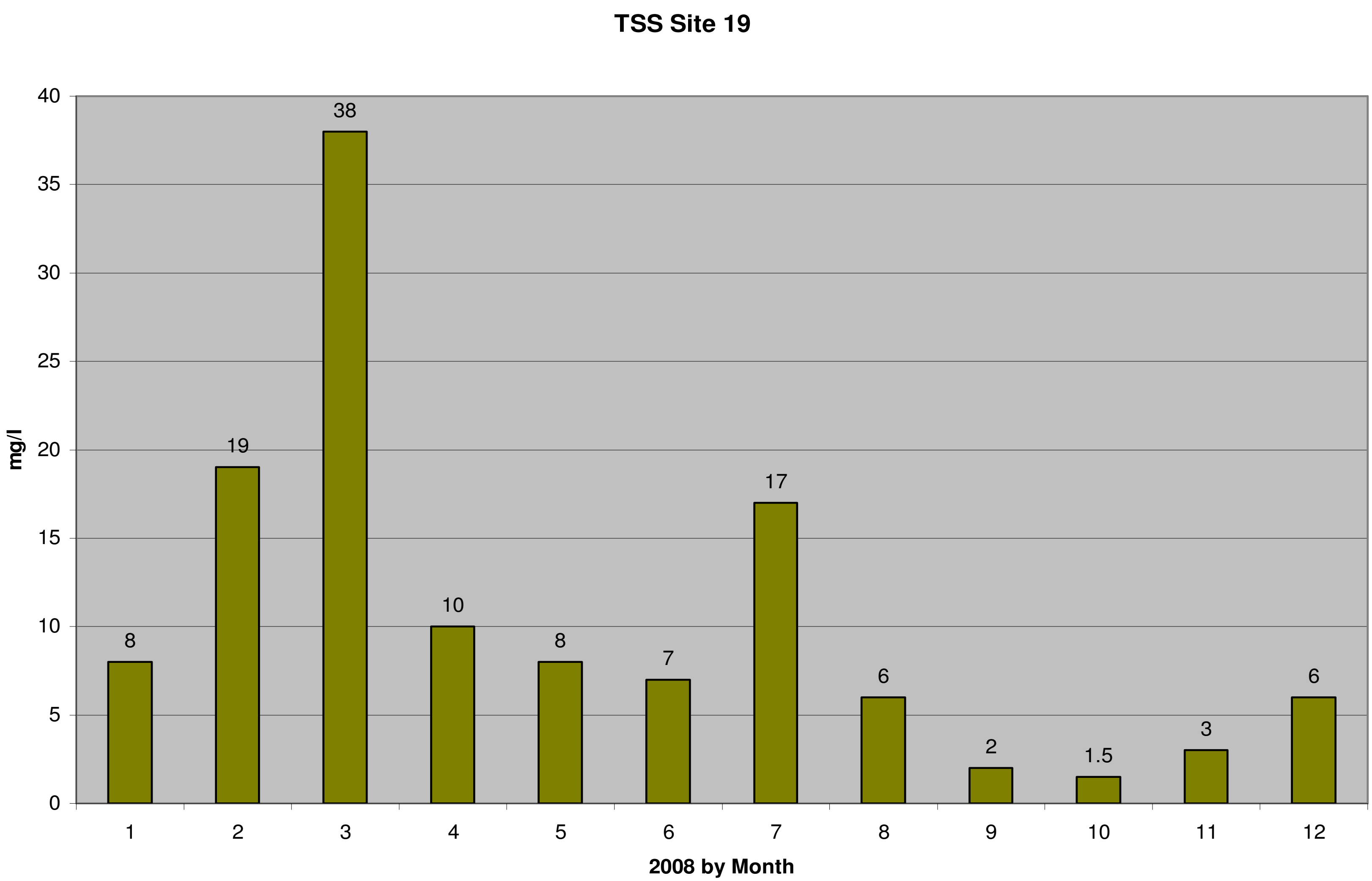

Figure 172: Monthly total suspended solids for site 19 with 10 milligrams per liter as the yearly average.

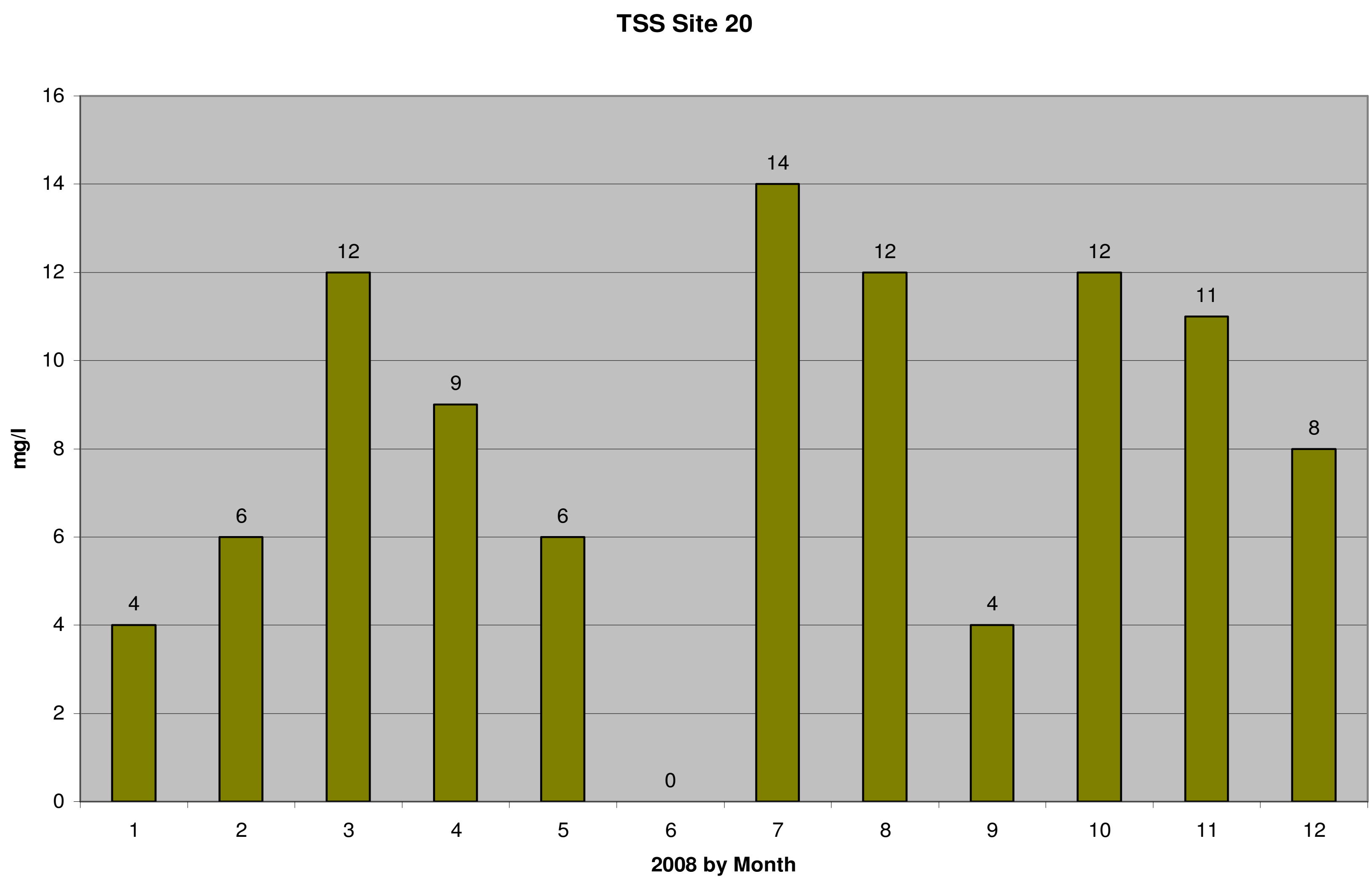

Figure 173: Monthly total suspended solids for site 20 with 8 milligrams per liter as the yearly average.

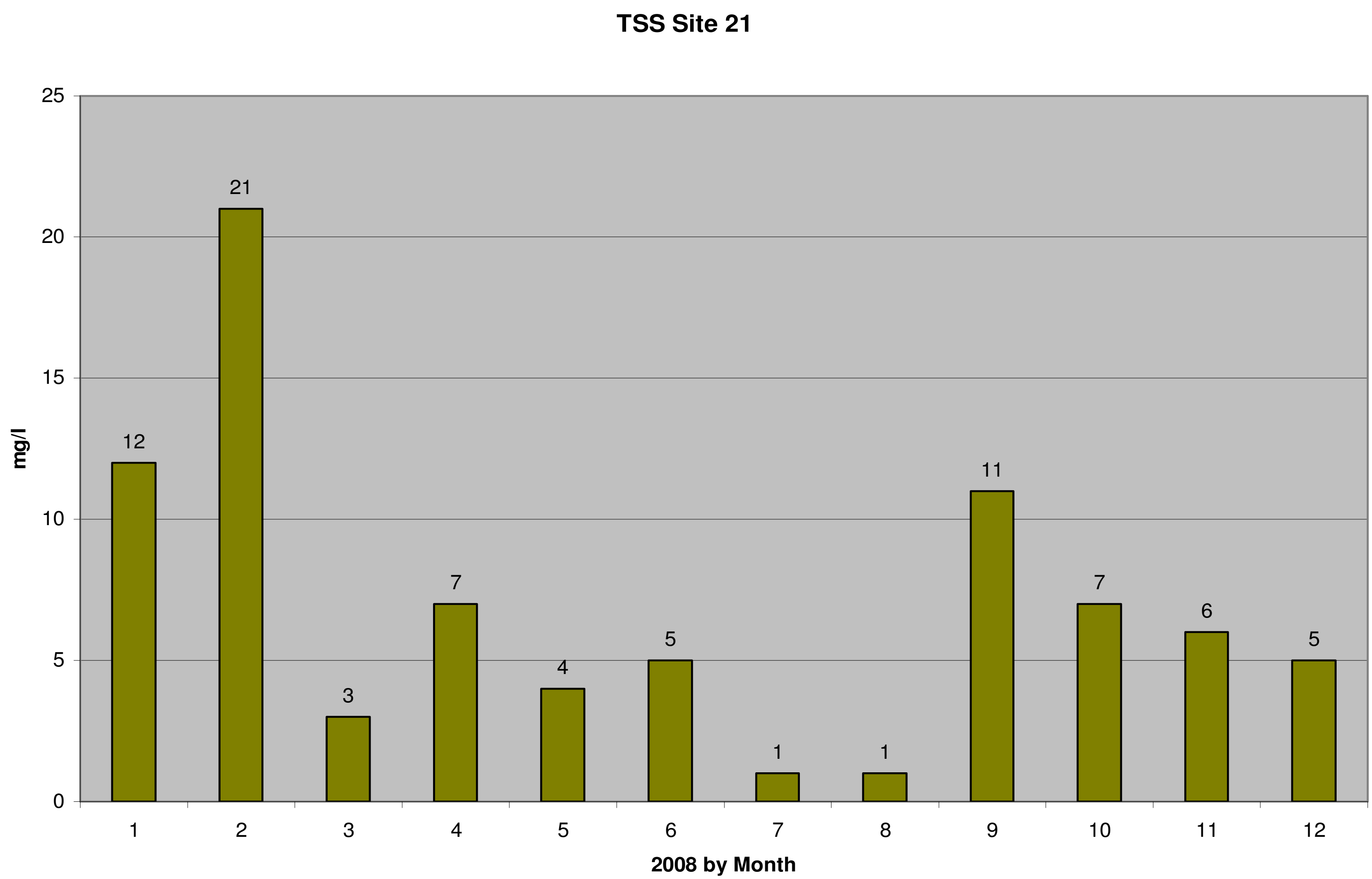

Figure 174: Monthly total suspended solids for site 21 with 7 milligrams per liter as the yearly average.

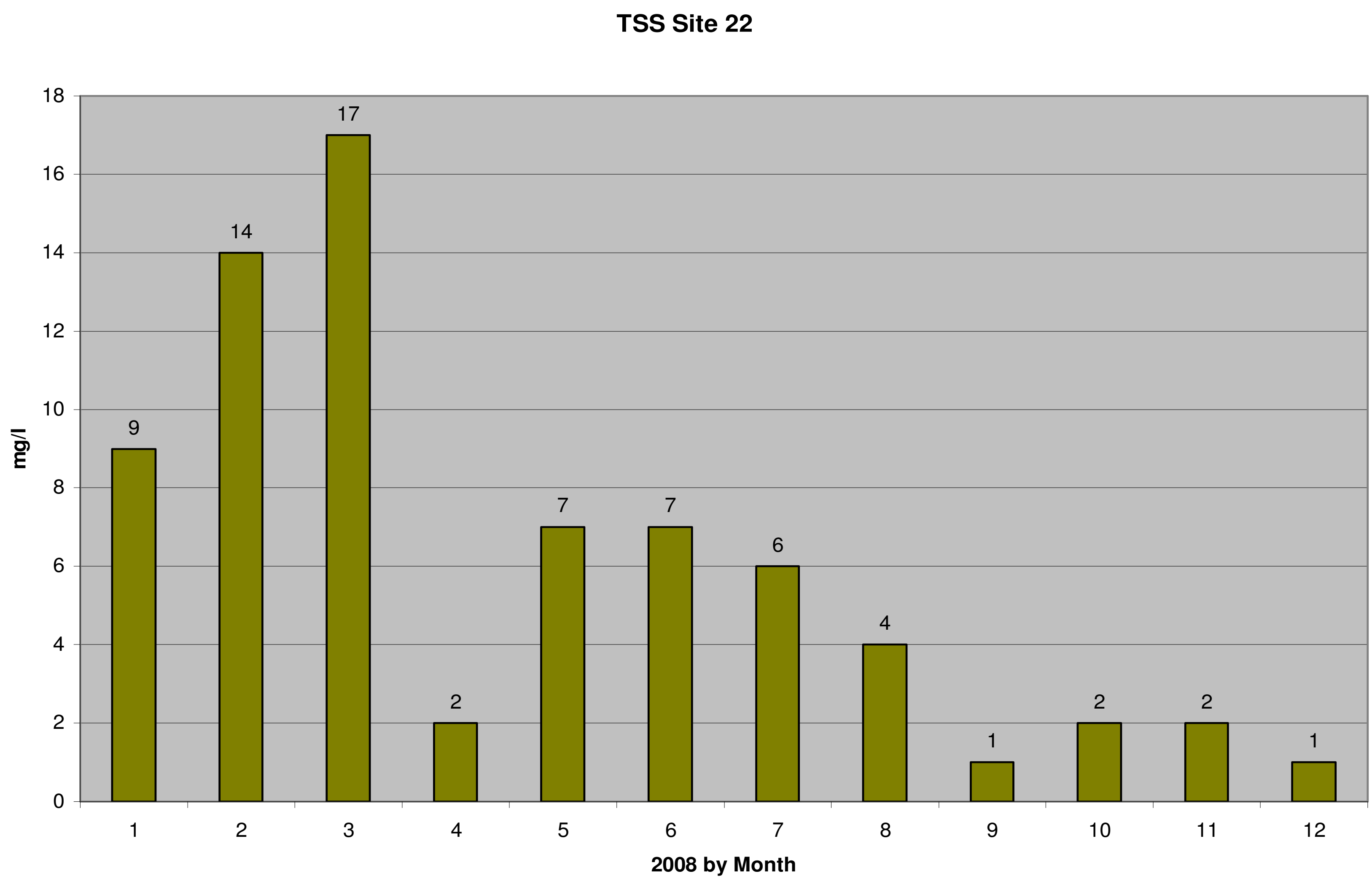

Figure 175: Monthly total suspended solids for site 22 with 6 milligrams per liter as the yearly average.

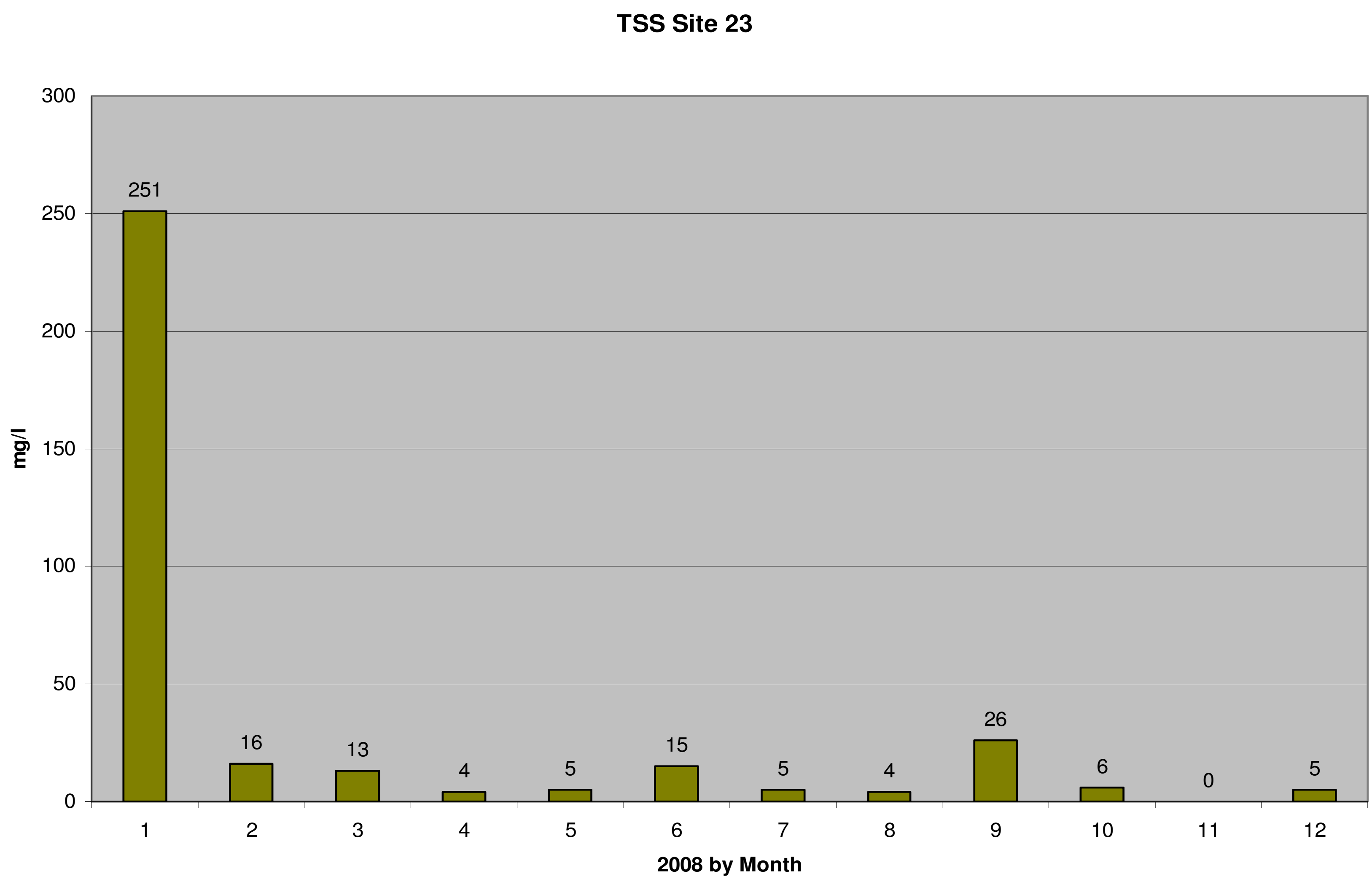

Figure 176: Monthly total suspended solids for site 23 with 29 milligrams per liter as the yearly average.

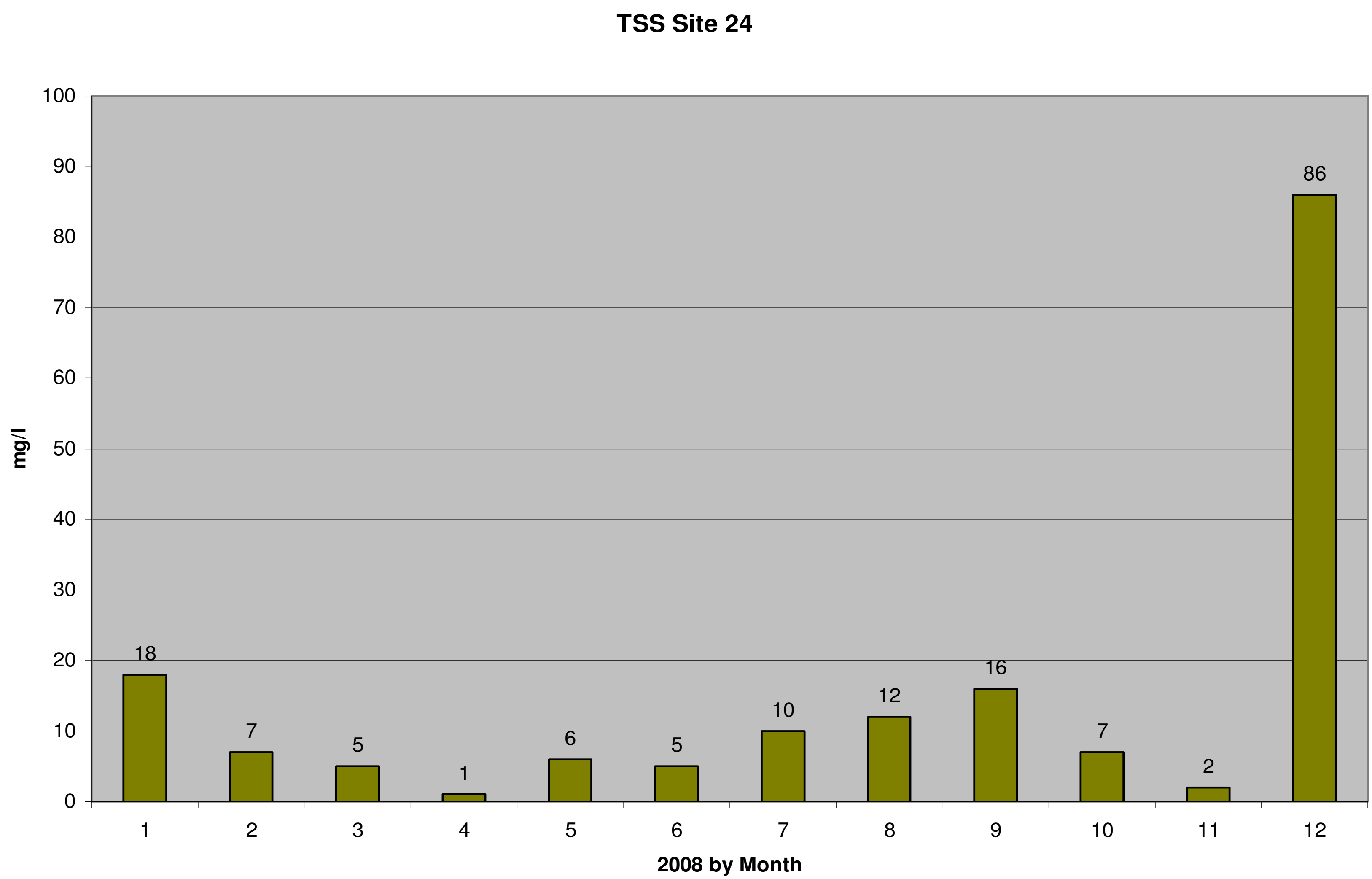

Figure 177: Monthly total suspended solids for site 24 with 15 milligrams per liter as the yearly average.

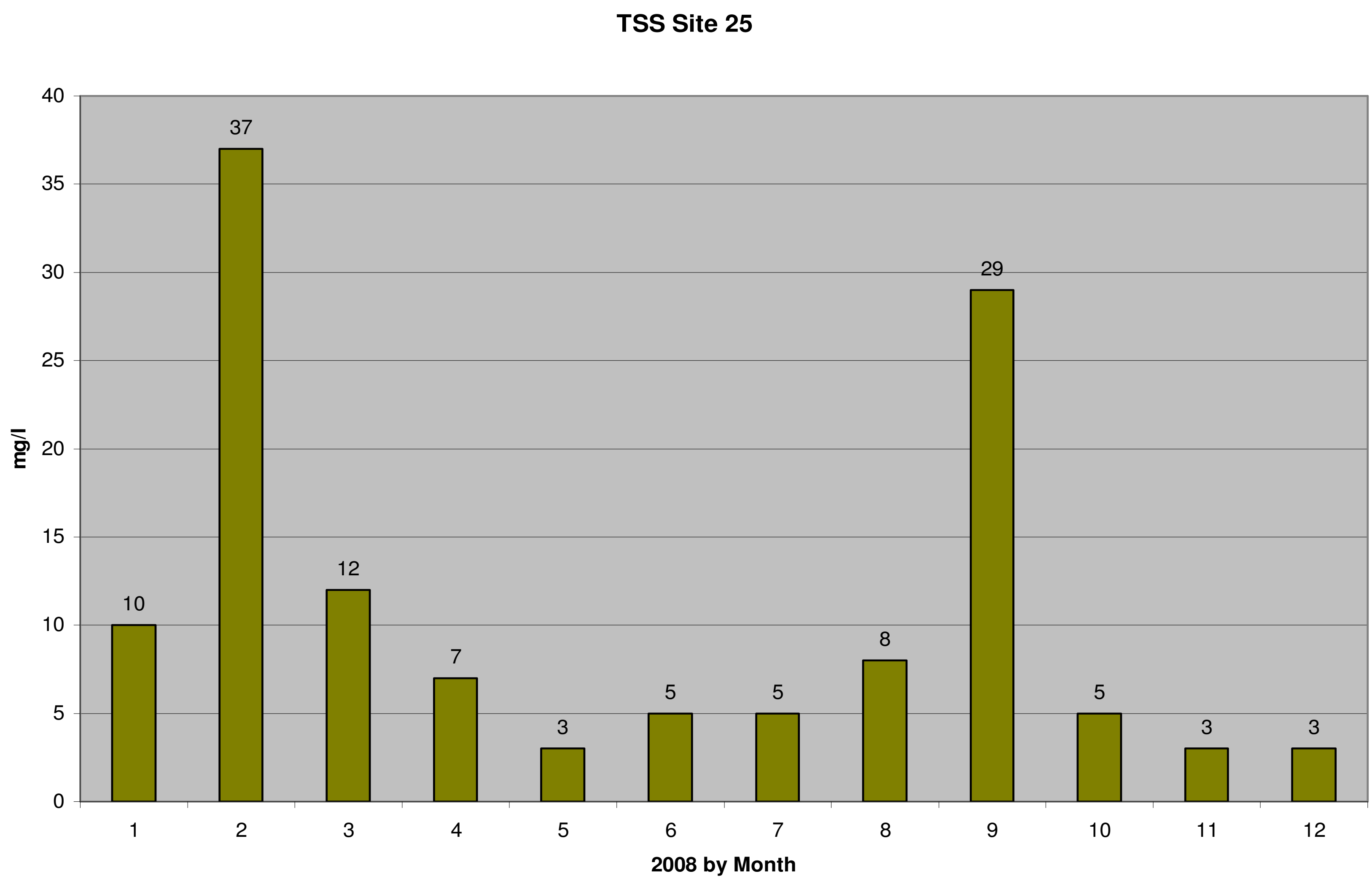

Figure 178: Monthly total suspended solids for site 25 with 11 milligrams per liter as the yearly average.

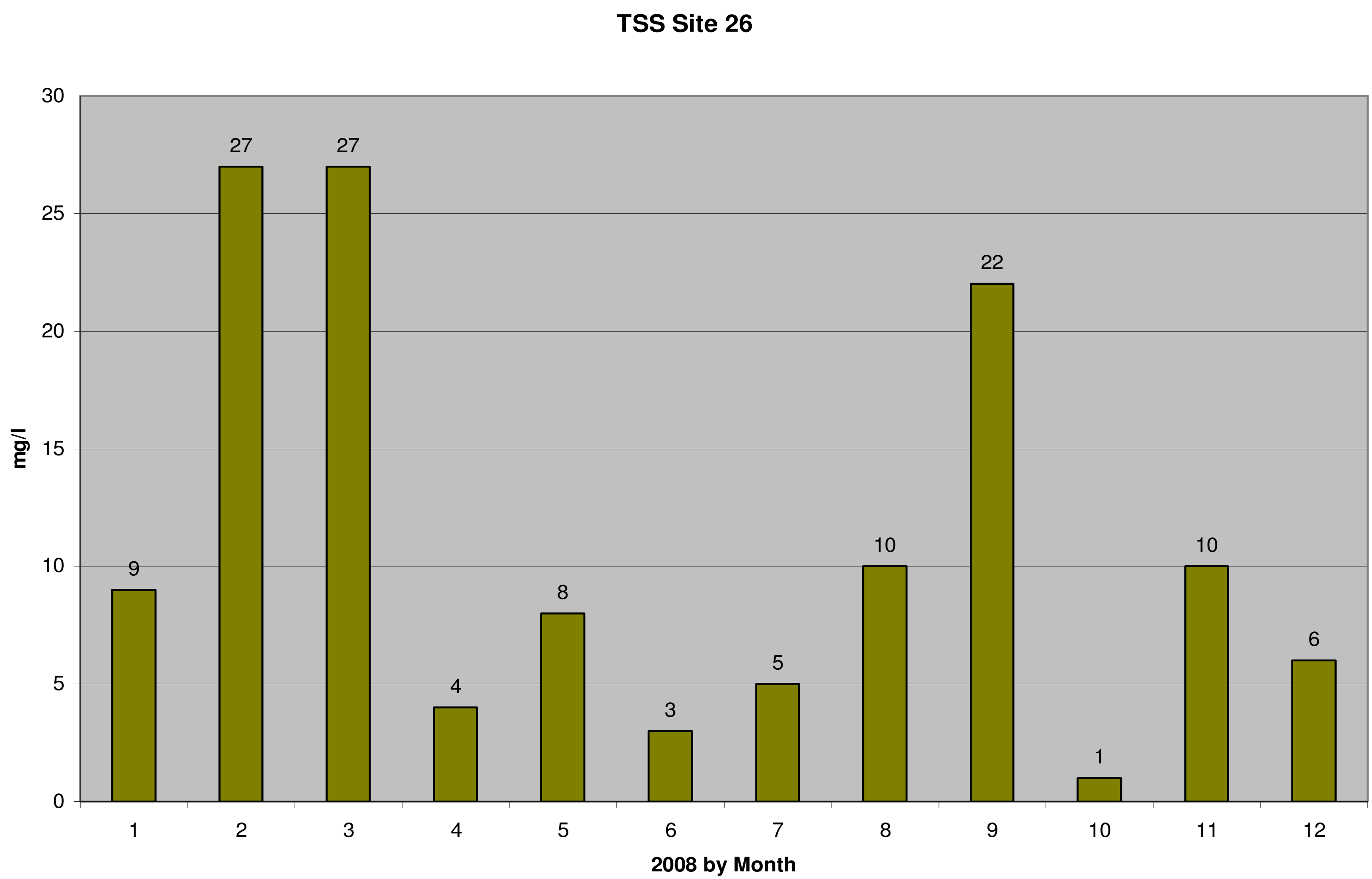

Figure 179: Monthly total suspended solids for site 26 with 11 milligrams per liter as the yearly average.

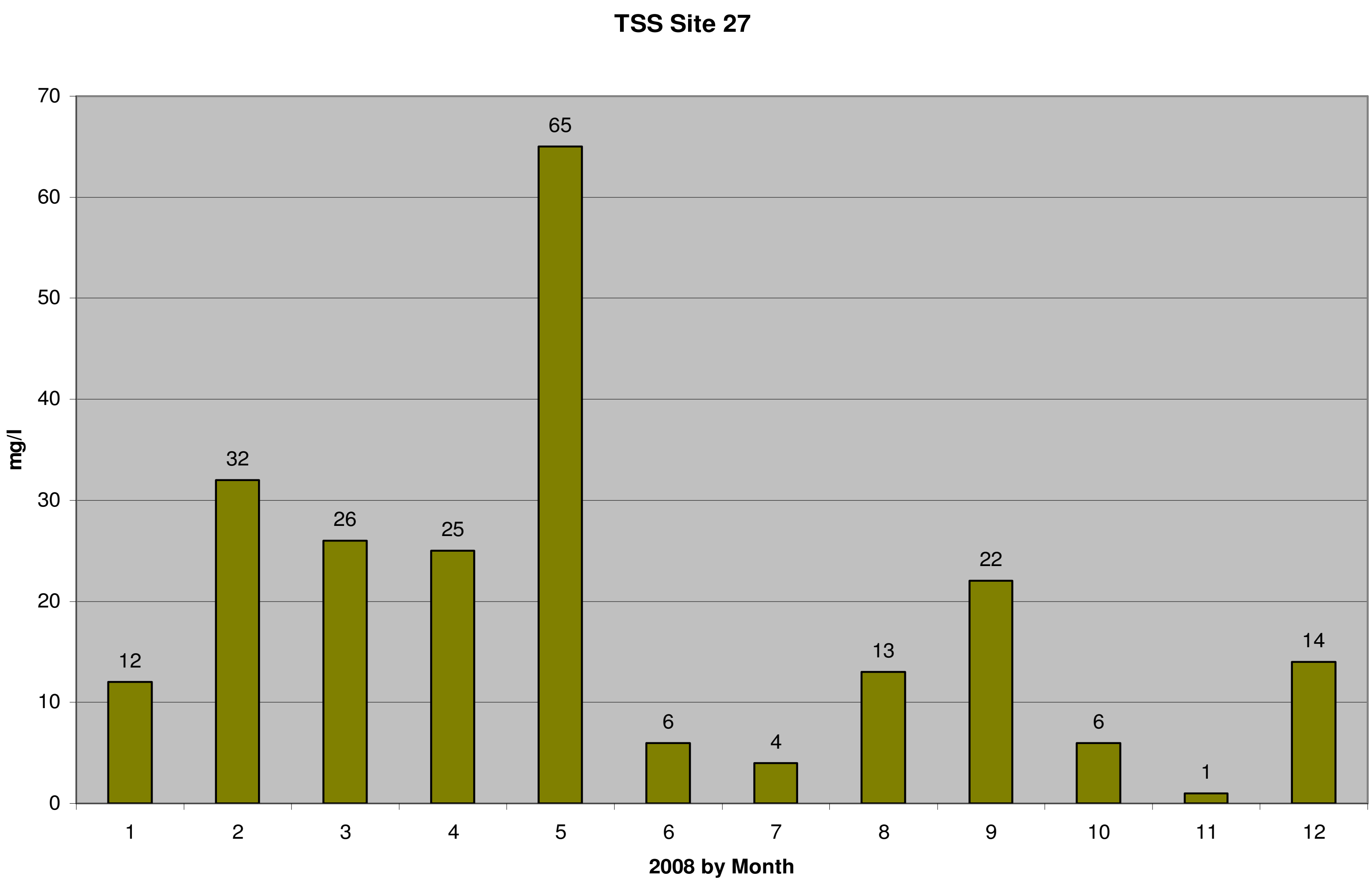

Figure 180: Monthly total suspended solids for site 27 with 19 milligrams per liter as the yearly average.

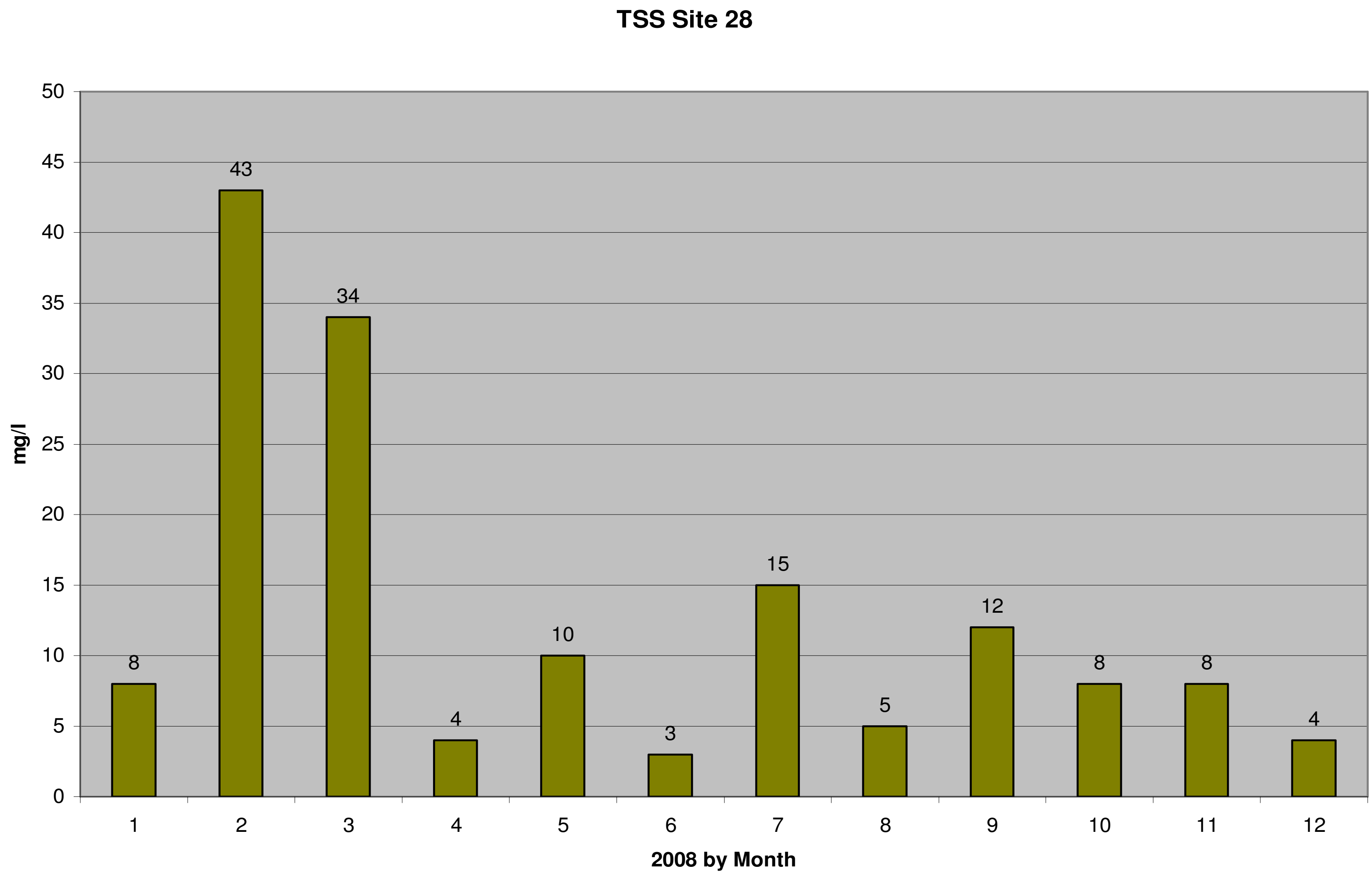

Figure 181: Monthly total suspended solids for site 28 with 13 milligrams per liter as the yearly average.

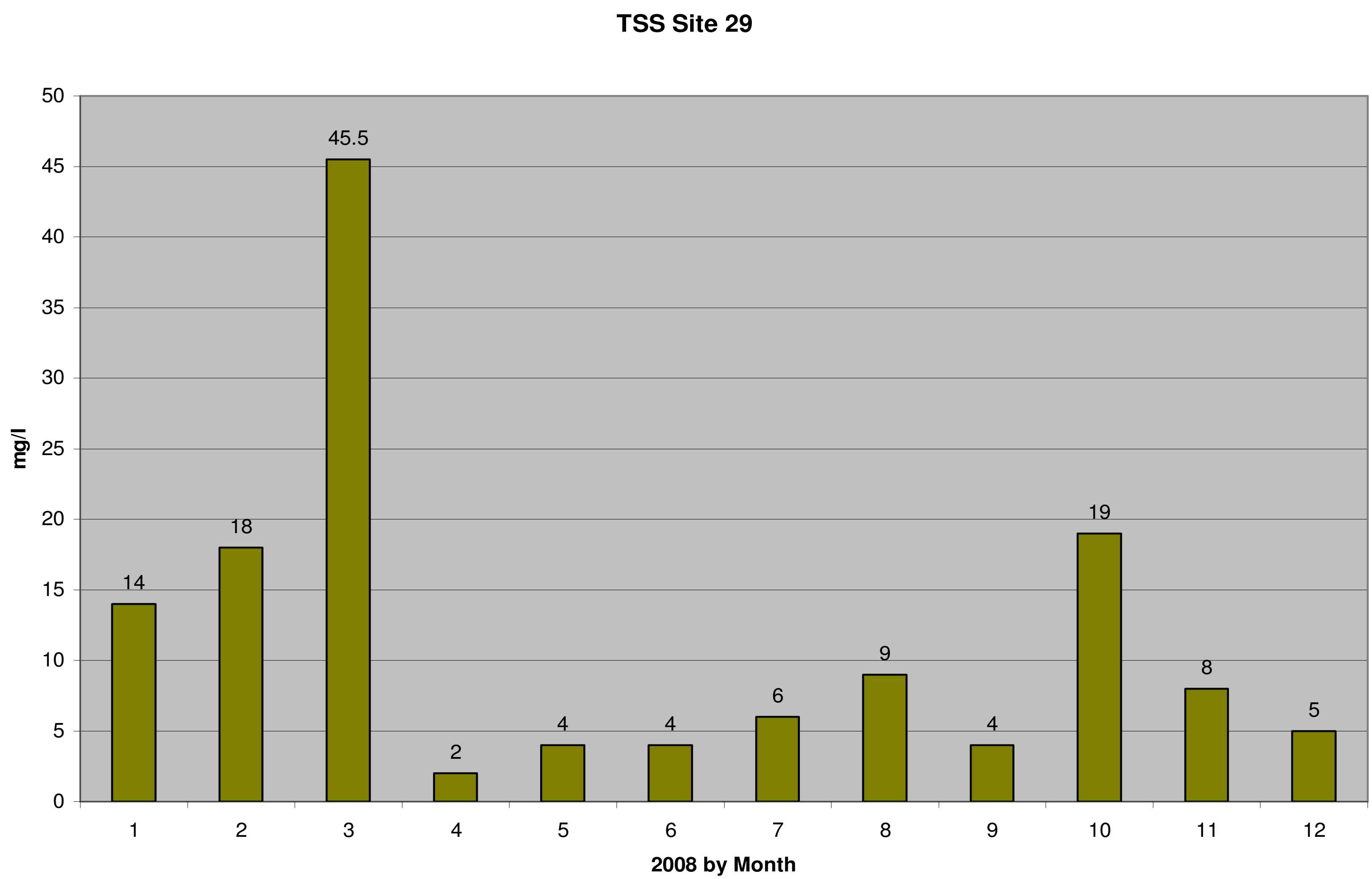

Figure 182: Monthly total suspended solids for site 29 with 12 milligrams per liter as the yearly average.

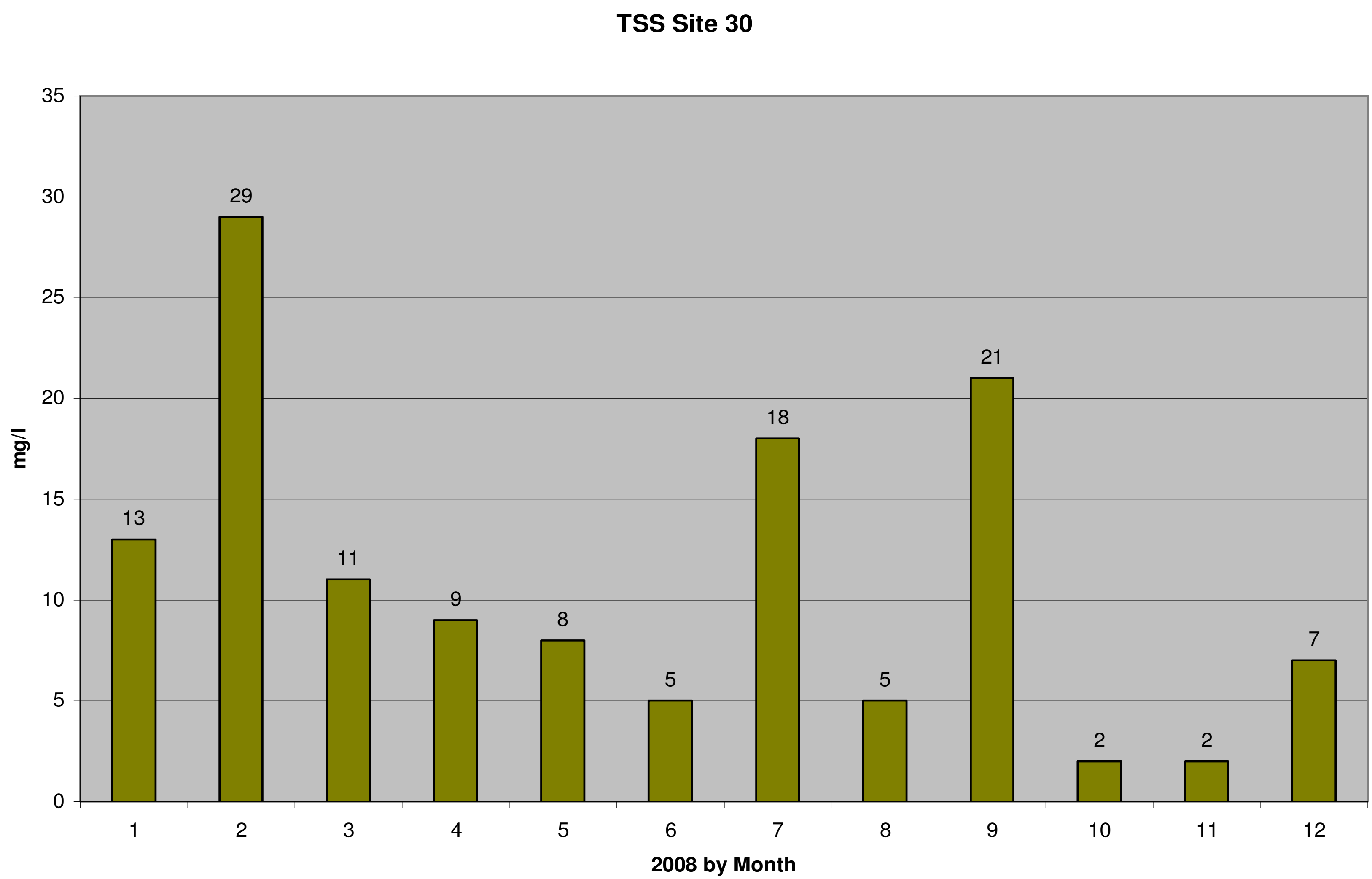

Figure 183: Monthly total suspended solids for site 30 with 11 milligrams per liter as the yearly average.

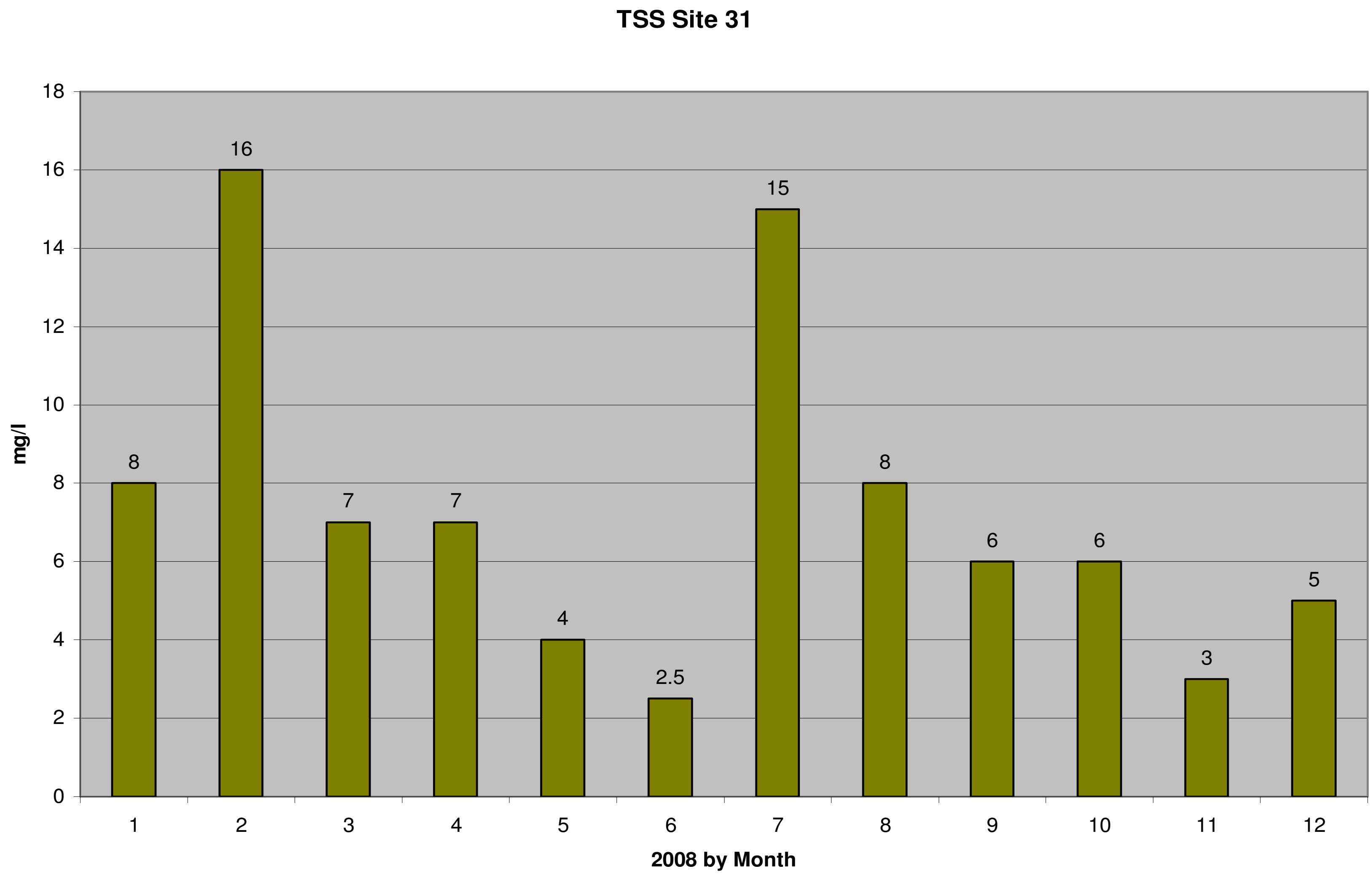

Figure 184: Monthly total suspended solids for site 31 with 7 milligrams per liter as the yearly average.

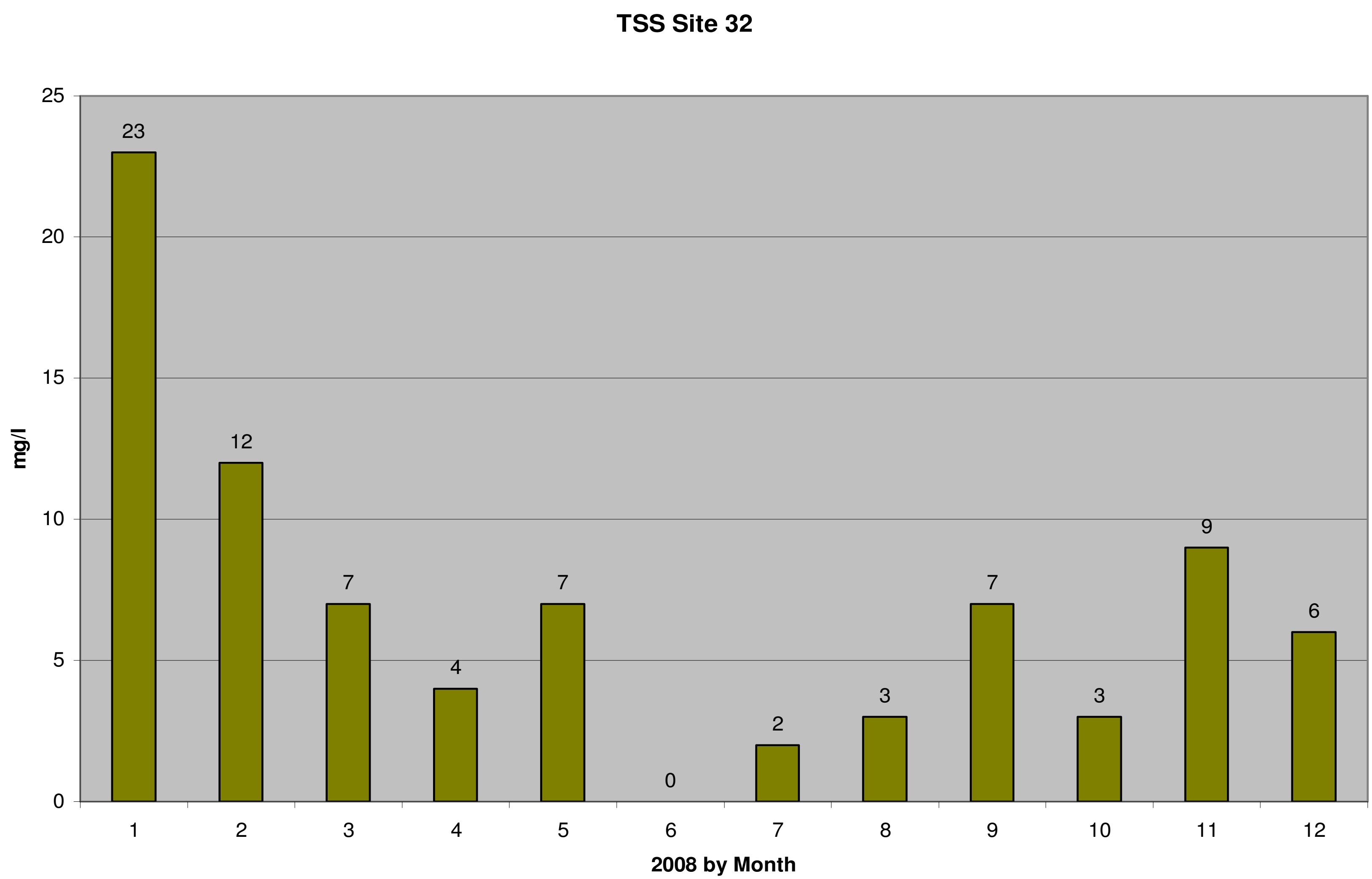

Figure 185: Monthly total suspended solids for site 32 with 7 milligrams per liter as the yearly average.

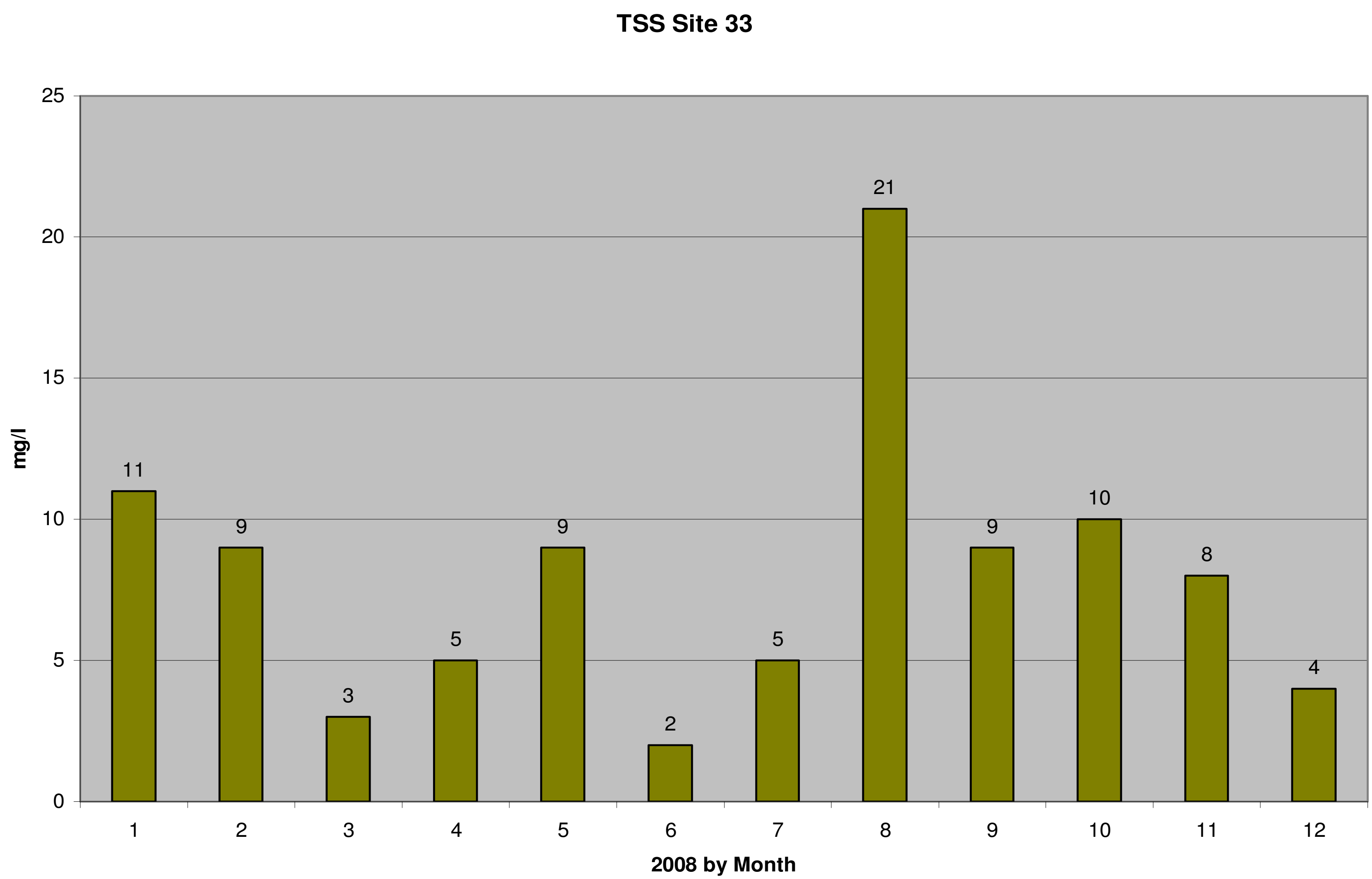

Figure 186: Monthly total suspended solids for site 33 with 8 milligrams per liter as the yearly average.

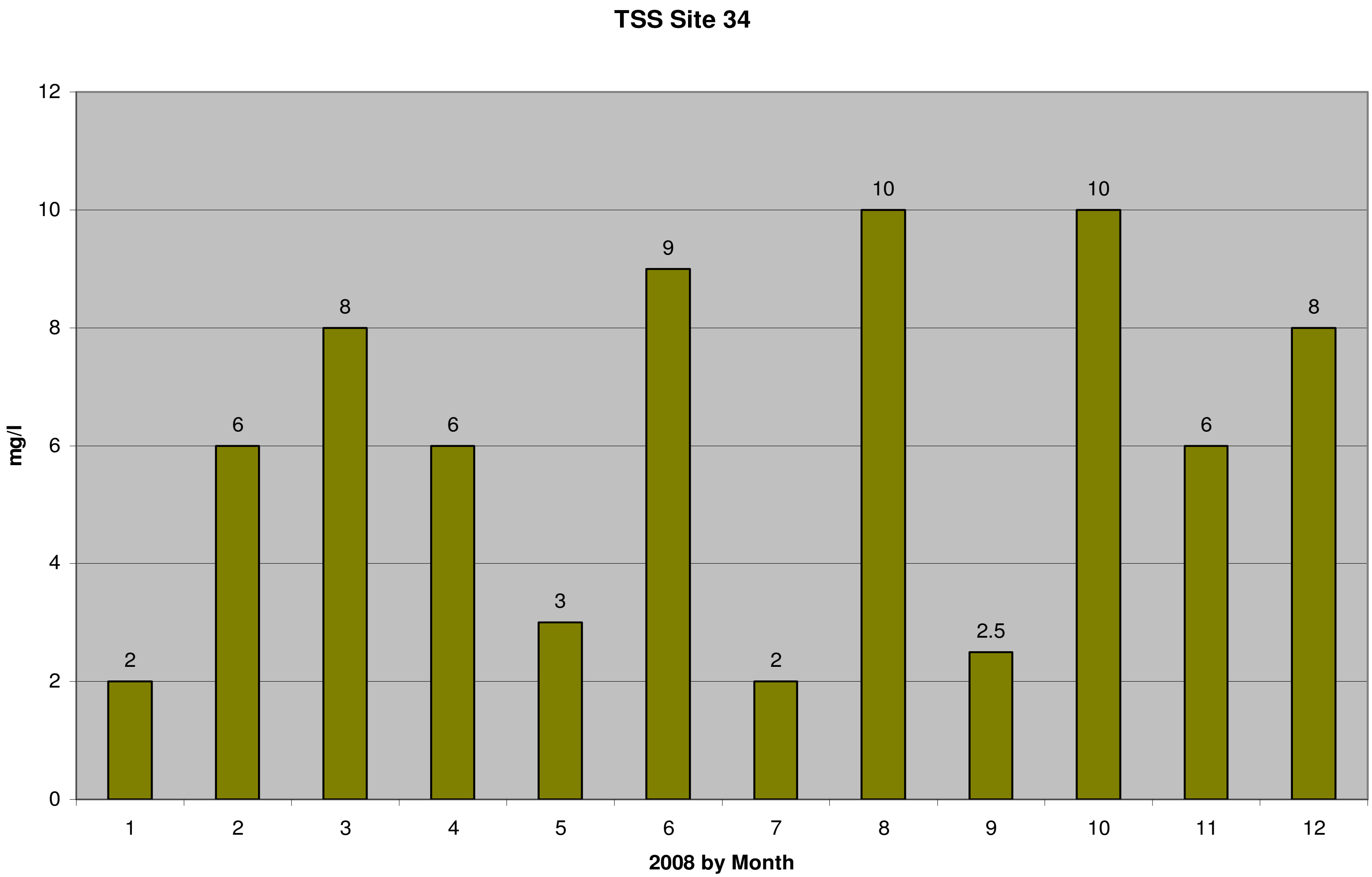

Figure 187: Monthly total suspended solids for site 34 with 6 milligrams per liter as the yearly average.

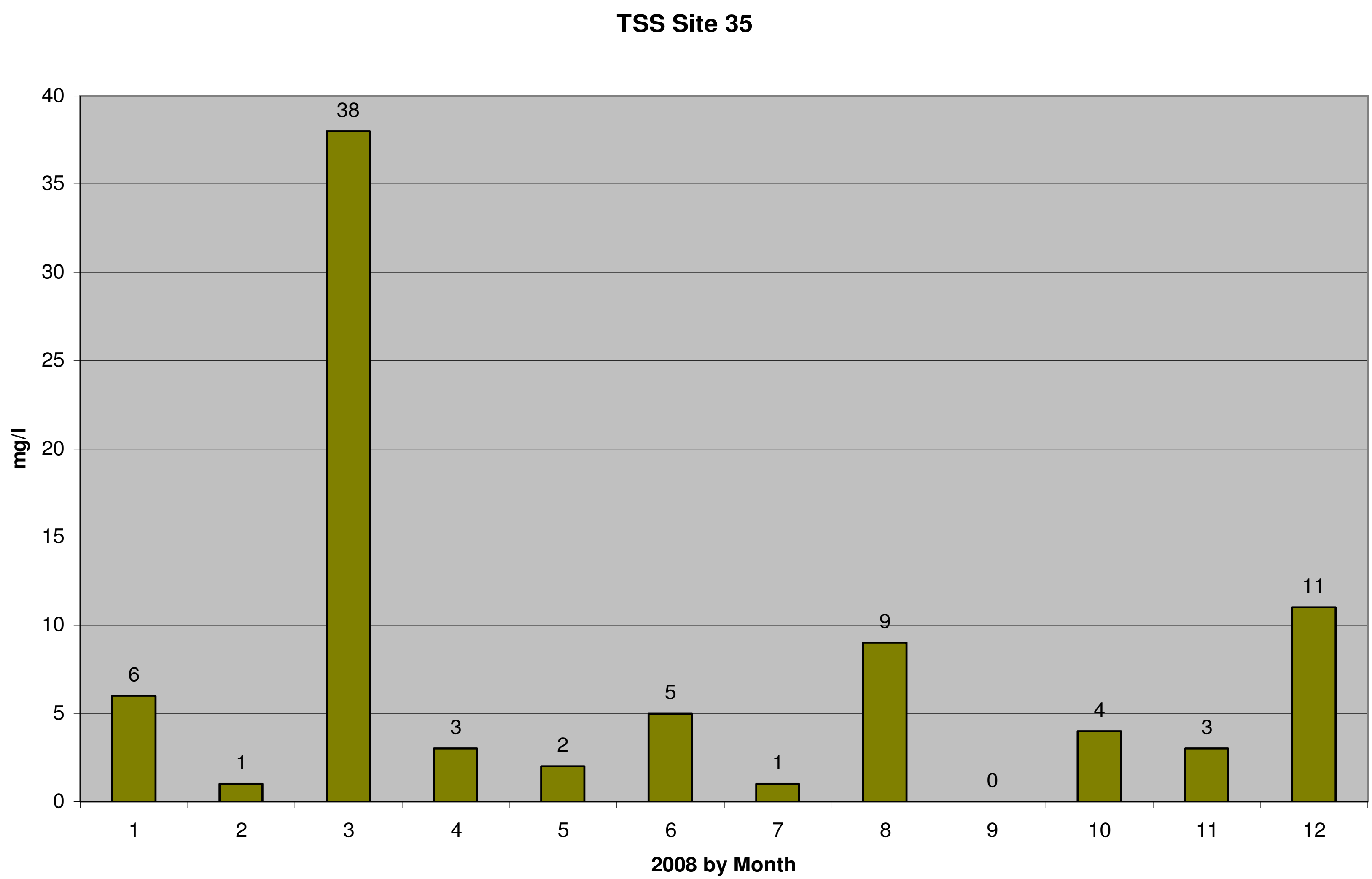

Figure 188: Monthly total suspended solids for site 35 with 7 milligrams per liter as the yearly average.

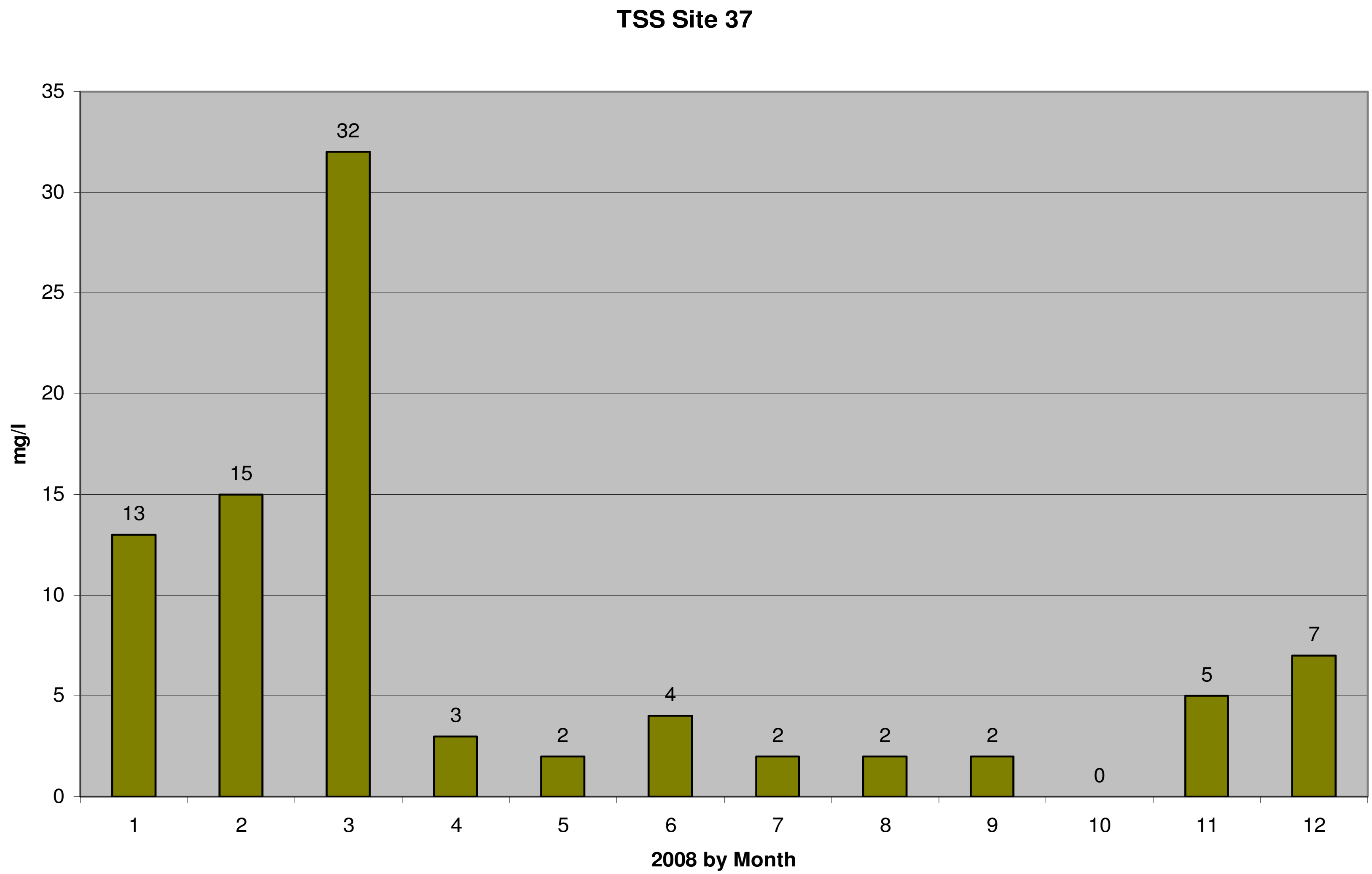

Figure 189: Monthly total suspended solids for site 37 with 7 milligrams per liter as the yearly average.

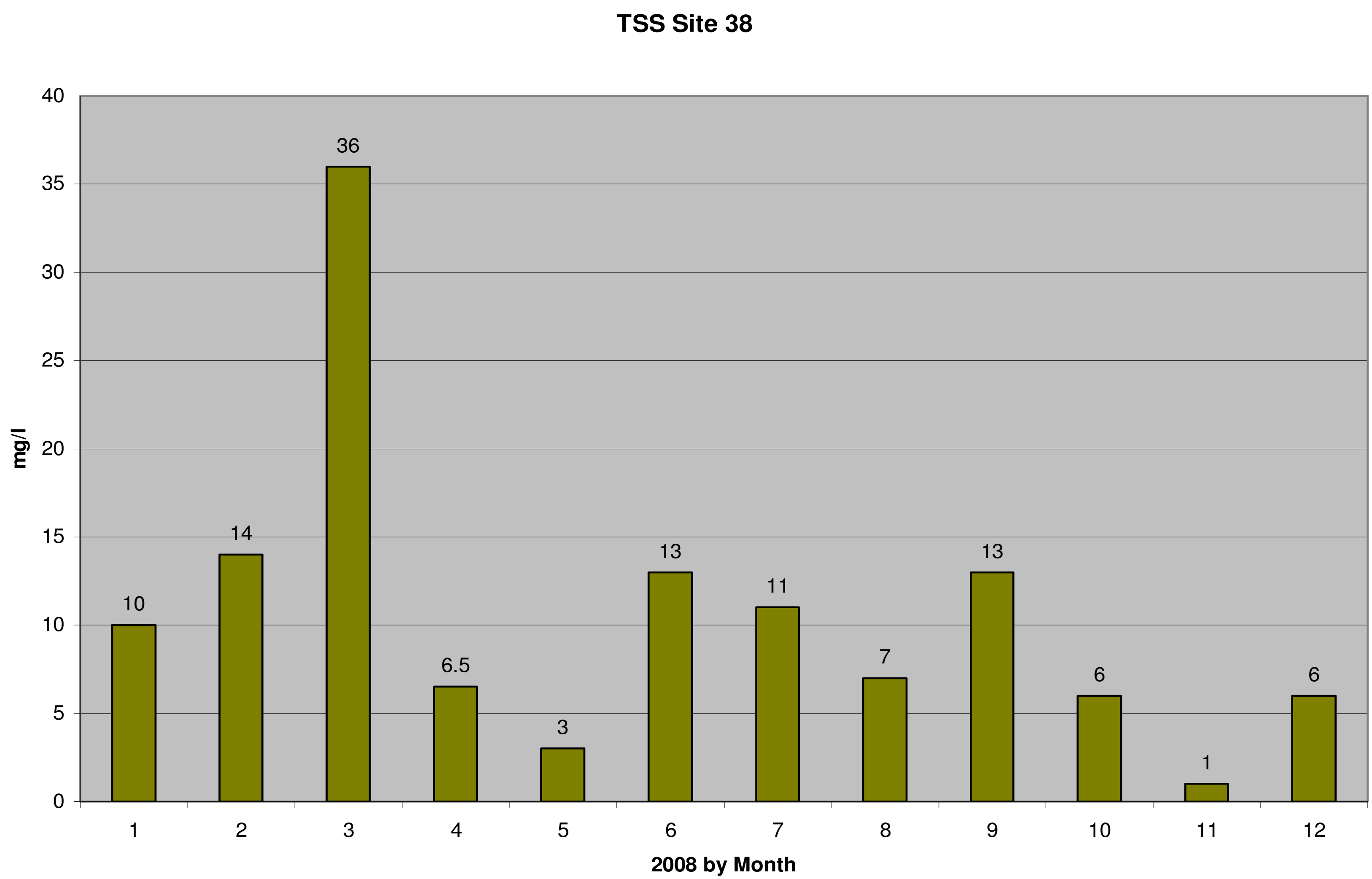

Figure 190: Monthly total suspended solids for site 38 with 11 milligrams per liter as the yearly average.

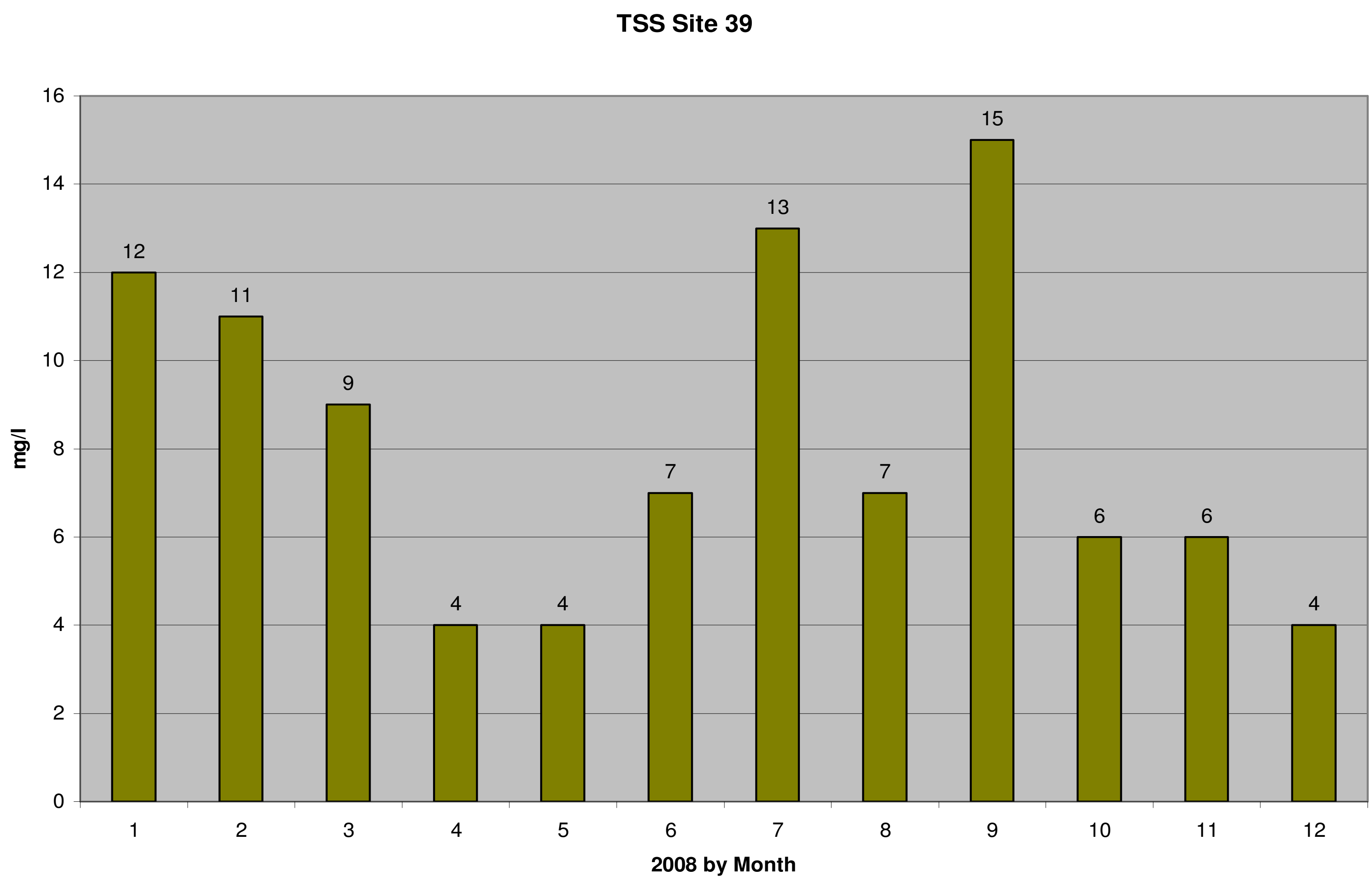

Figure 191: Monthly total suspended solids for site 39 with 8 milligrams per liter as the yearly average.

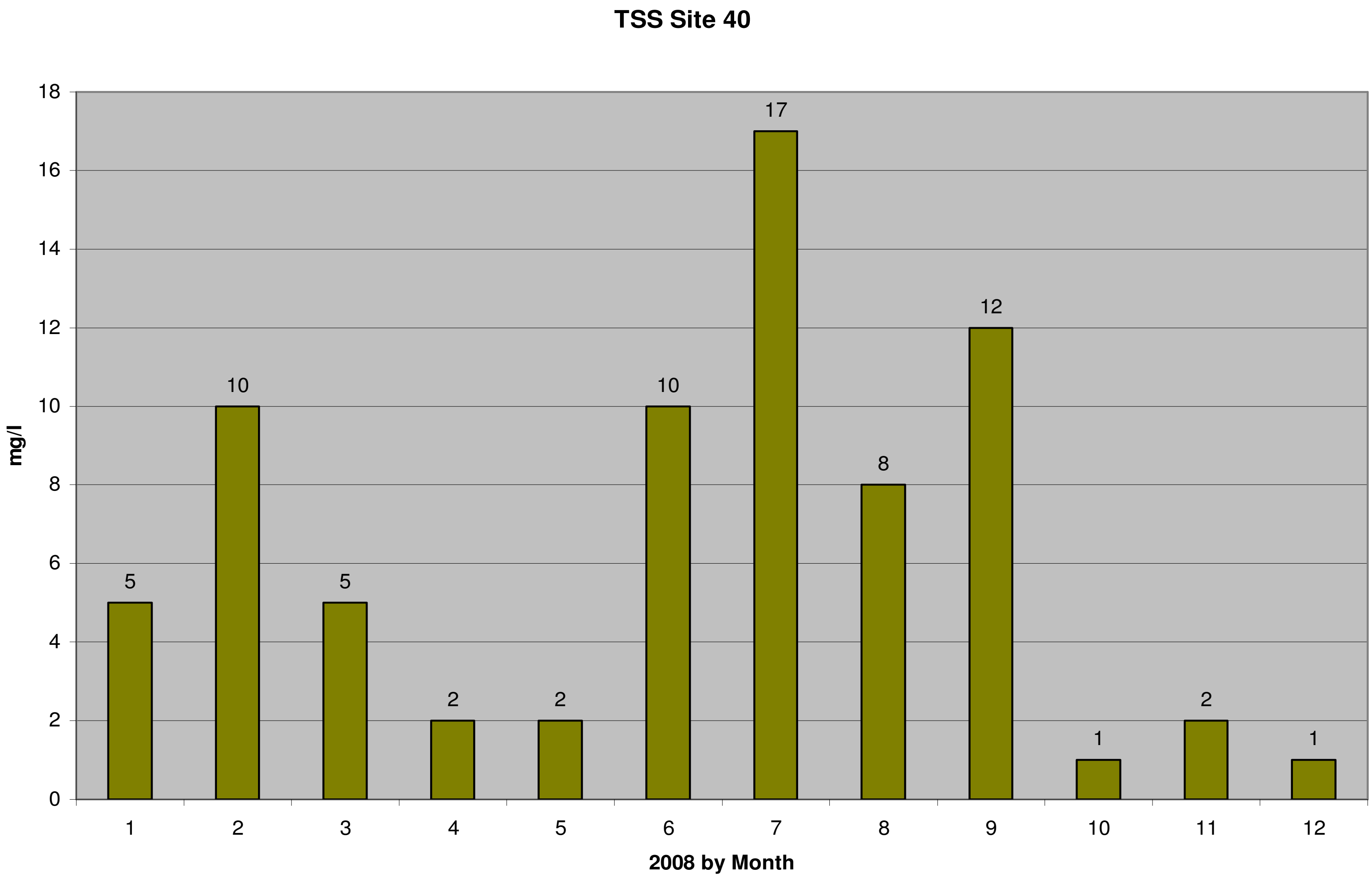

Figure 192: Monthly total suspended solids for site 40 with 6 milligrams per liter as the yearly average.

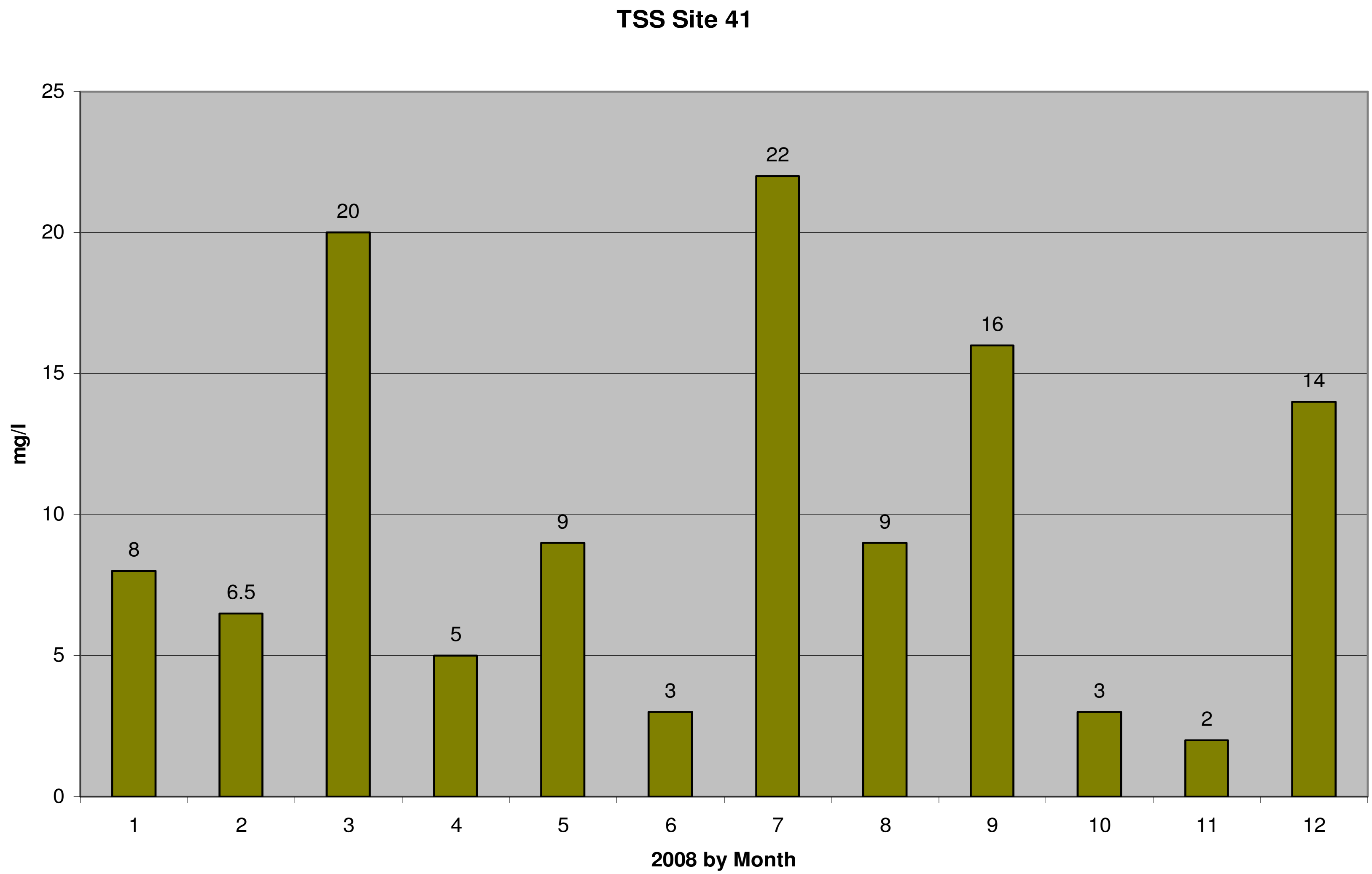

Figure 193: Monthly total suspended solids for site 41 with 10 milligrams per liter as the yearly average.

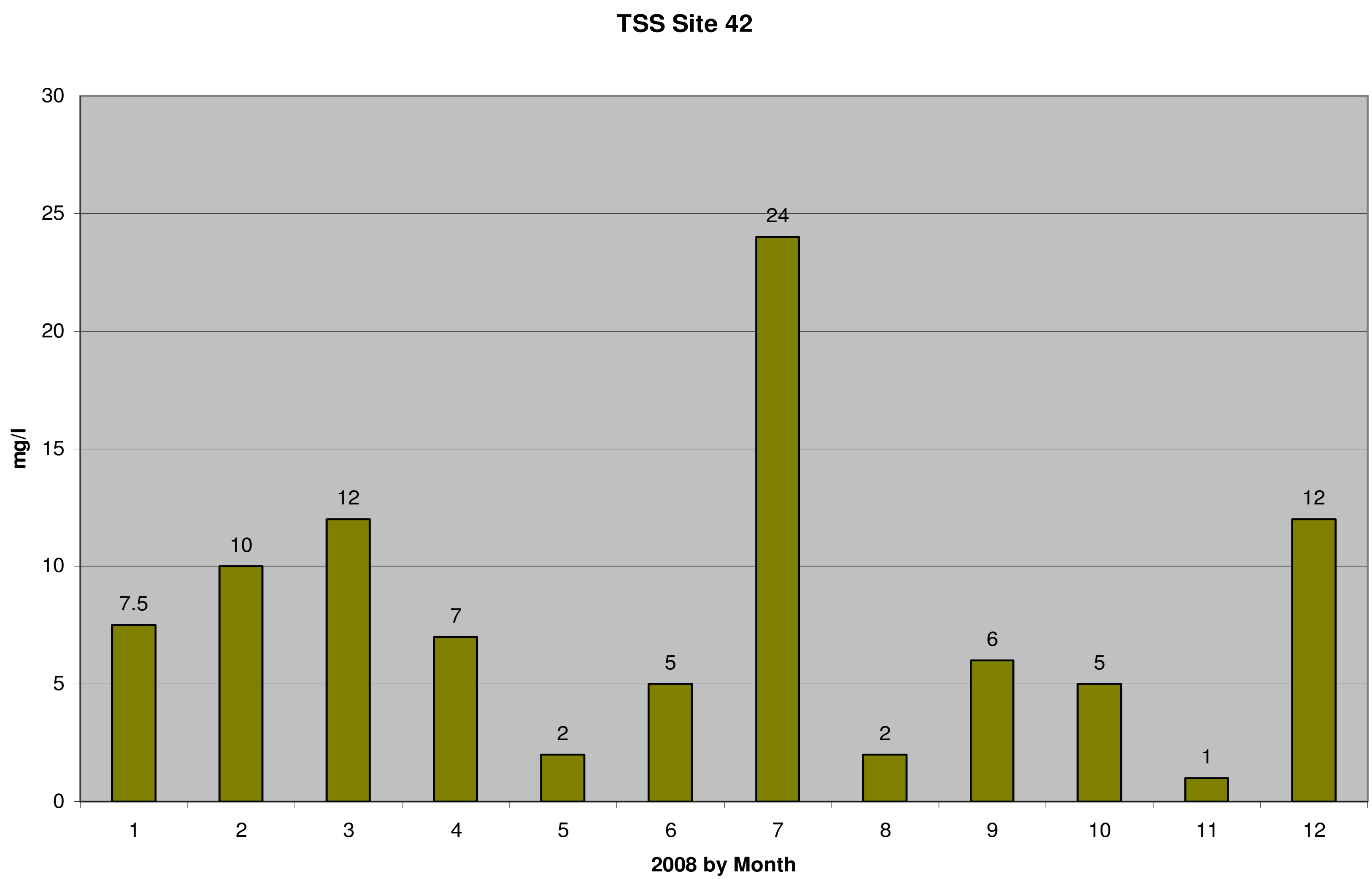

Figure 194: Monthly total suspended solids for site 42 with 8 milligrams per liter as the yearly average.

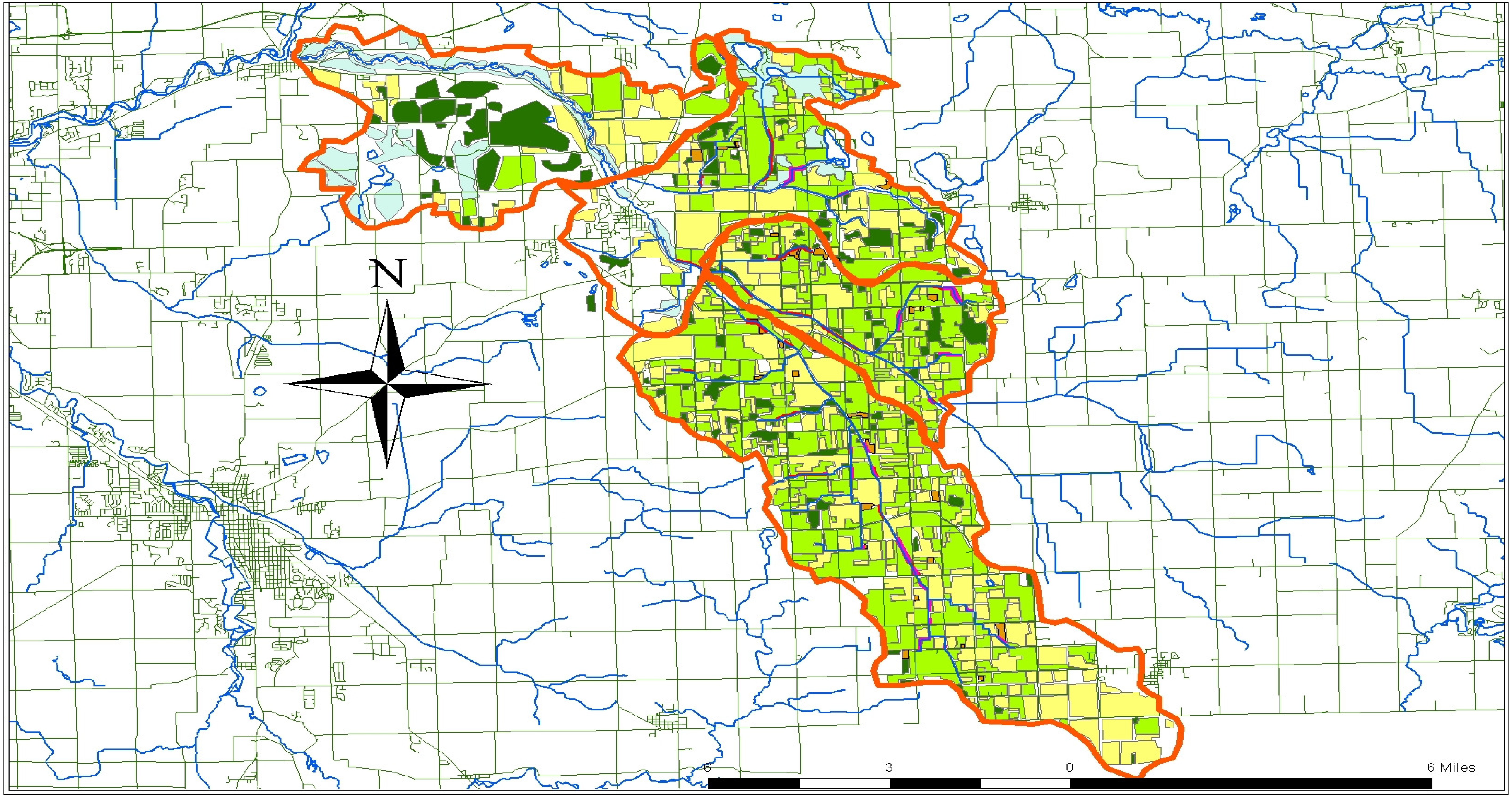

Figure 195: Map depicting all layers (individually separated in subsequent maps) of land use inventory.

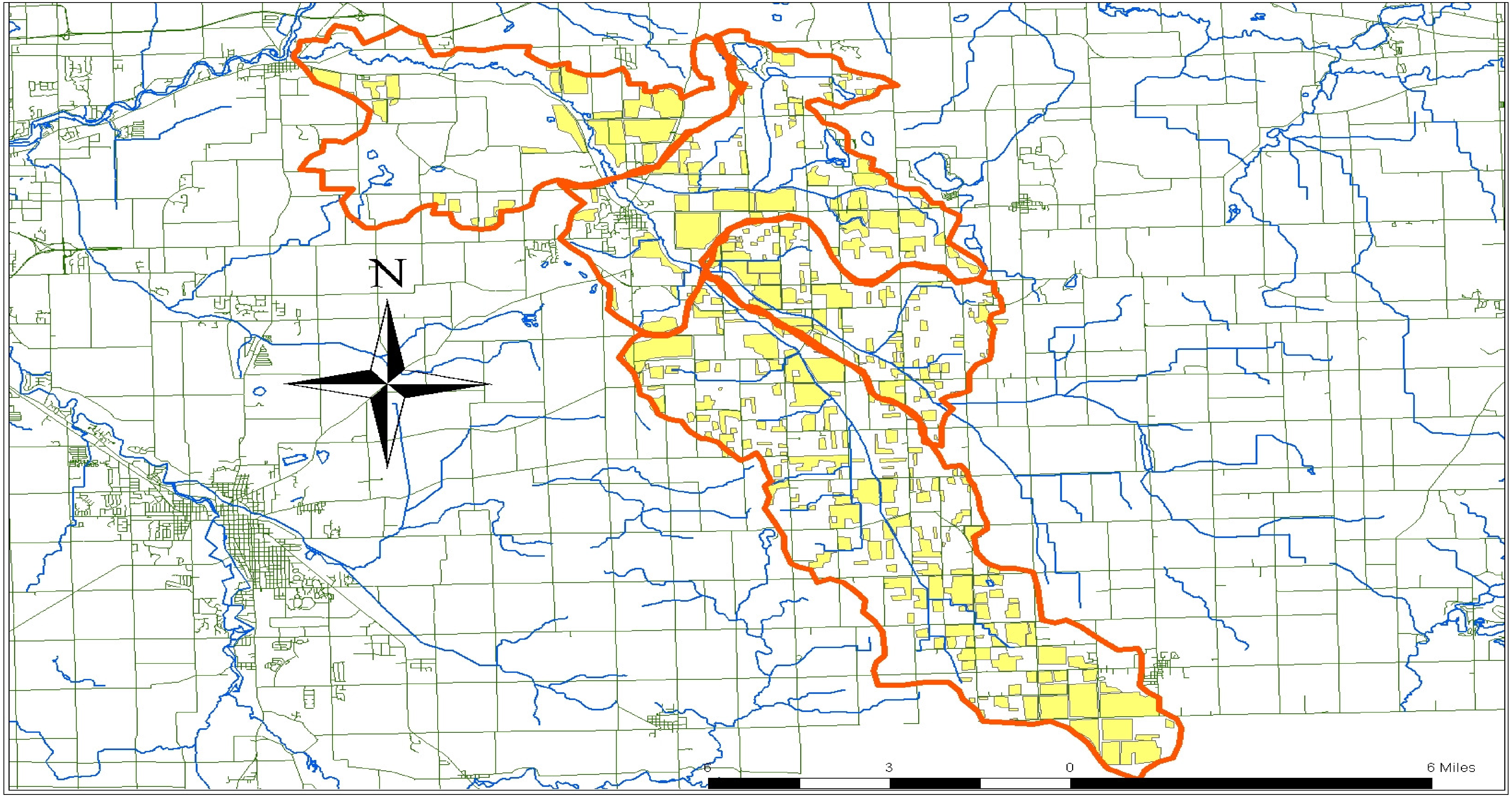

Figure 196: Map depicting row crop locations.

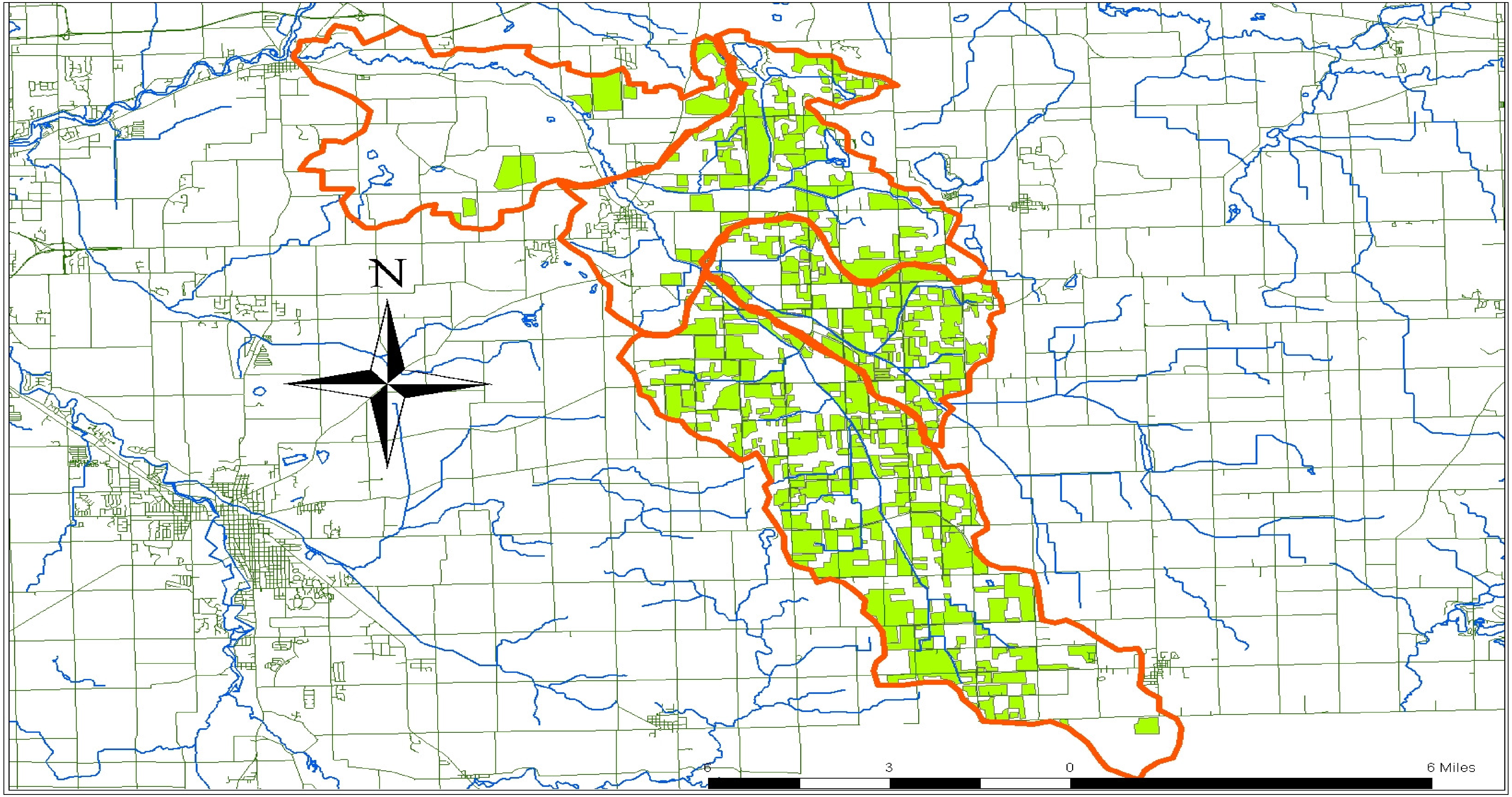

Figure 197: Map depicting pasture/hay field locations.

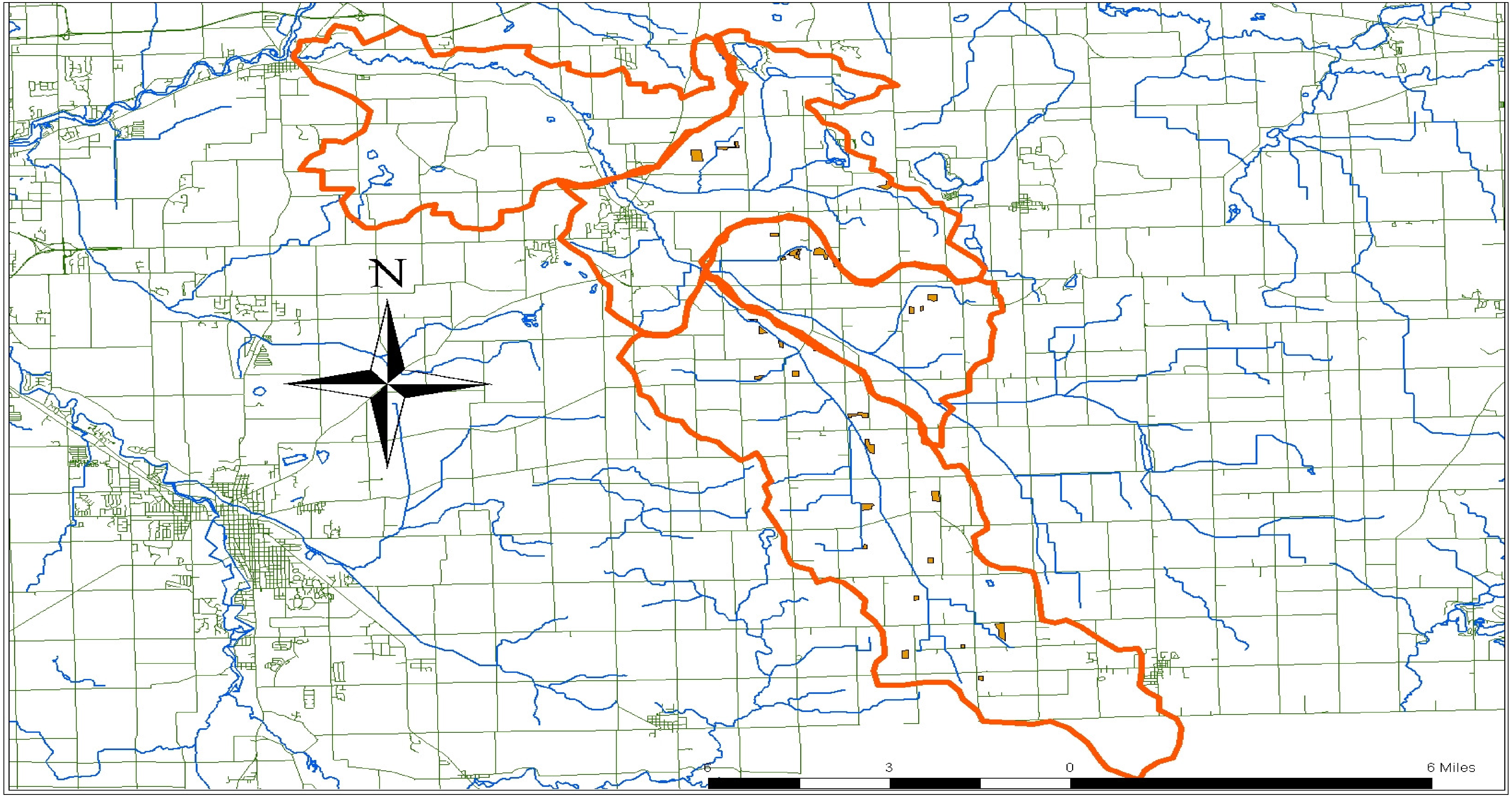

Figure 198: Map depicting pastured woodlot locations.

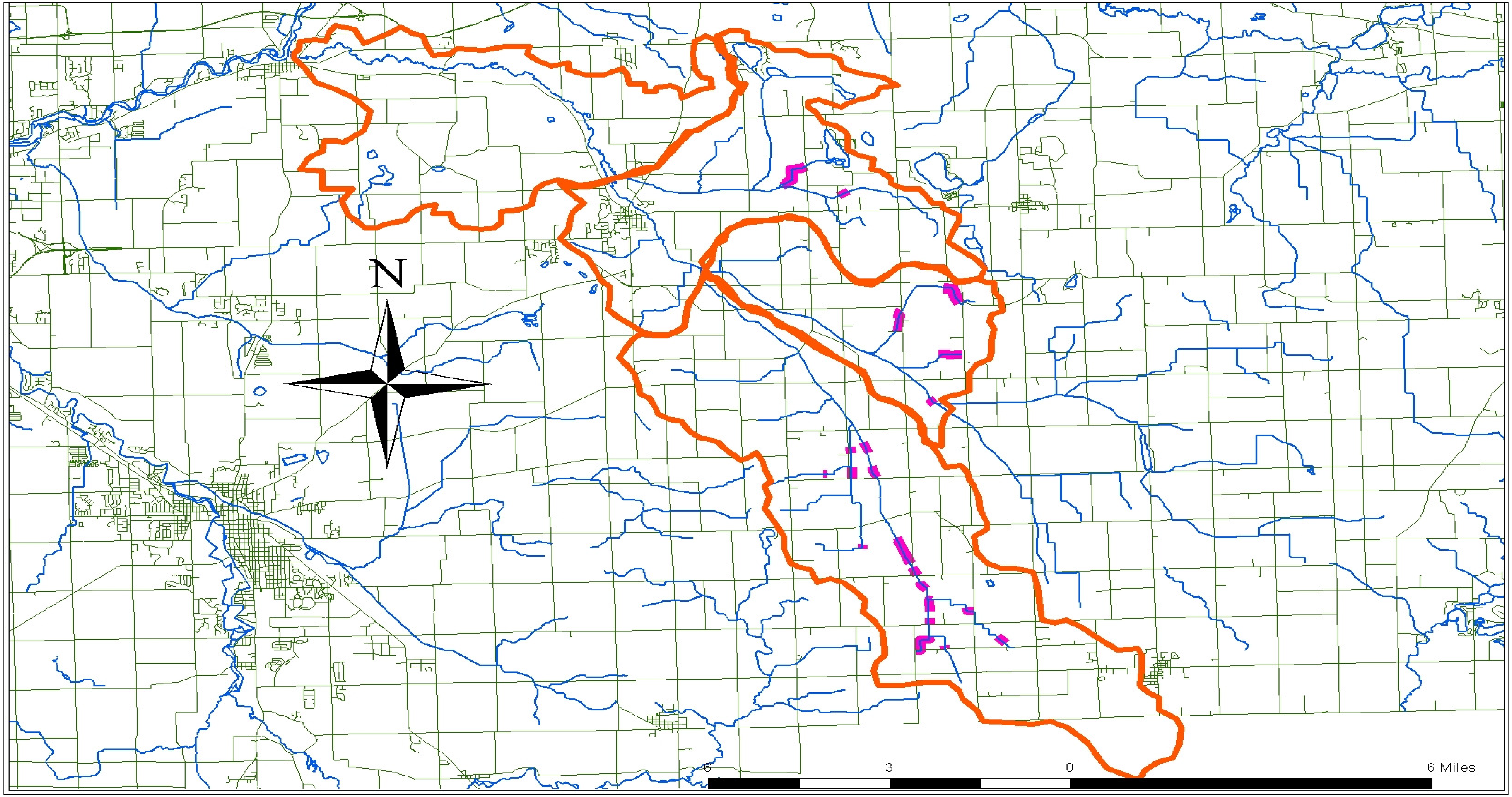

Figure 199: Map depicting existing fence locations adjacent to surface waters.

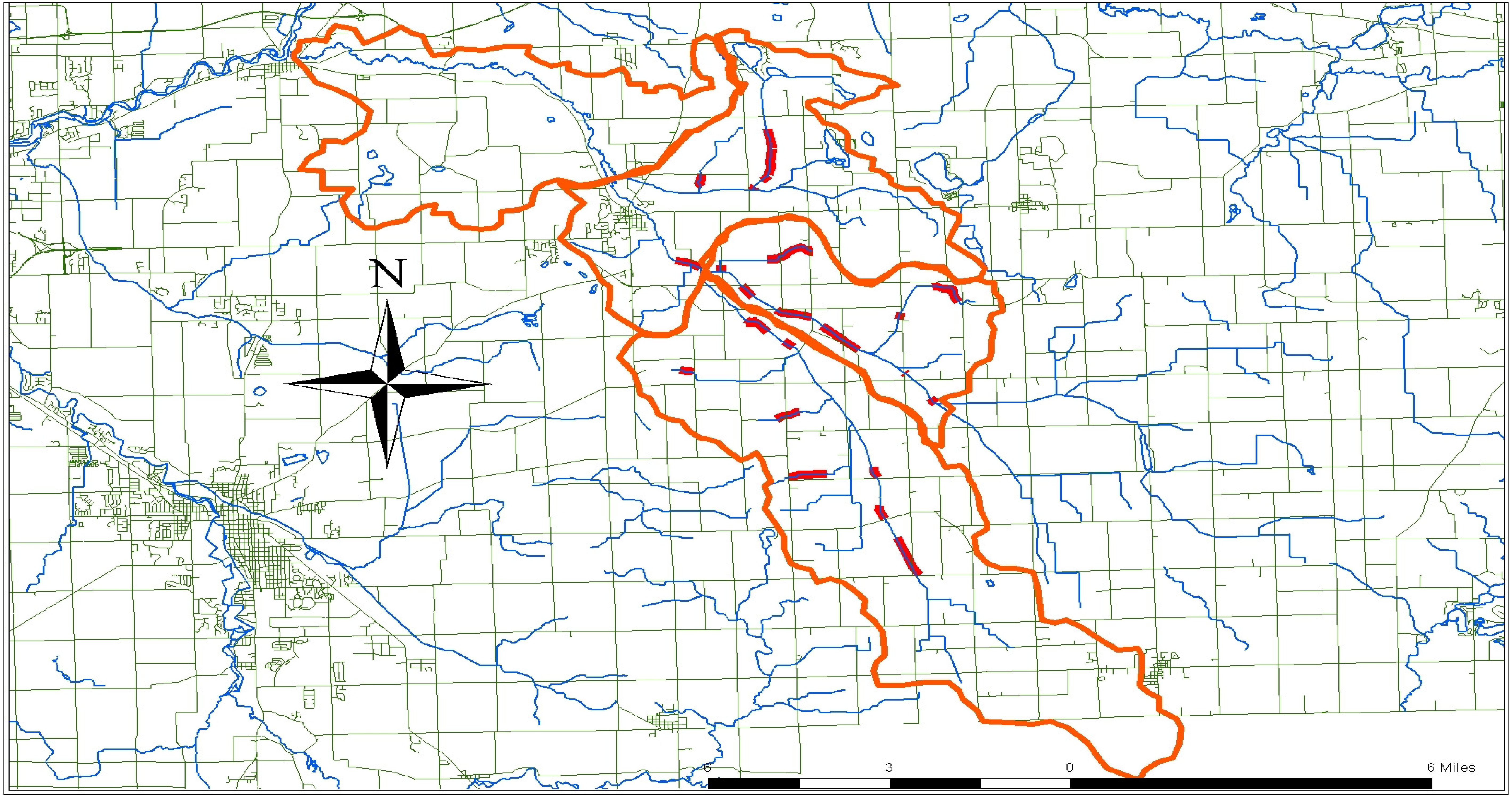

Figure 200: Map depicting locations with direct livestock access to surface waters.

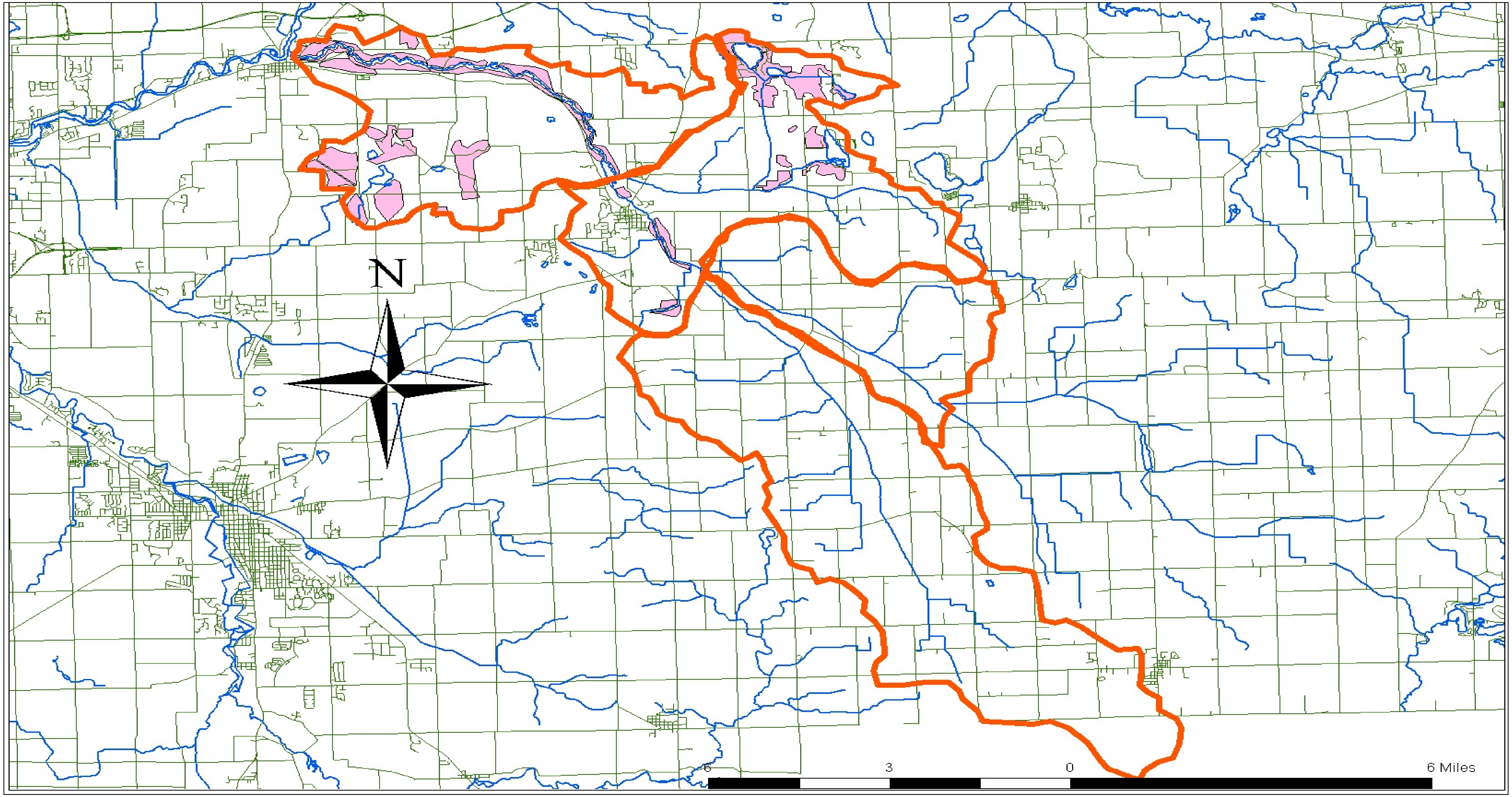

Figure 201: Map depicting sensitive area locations.

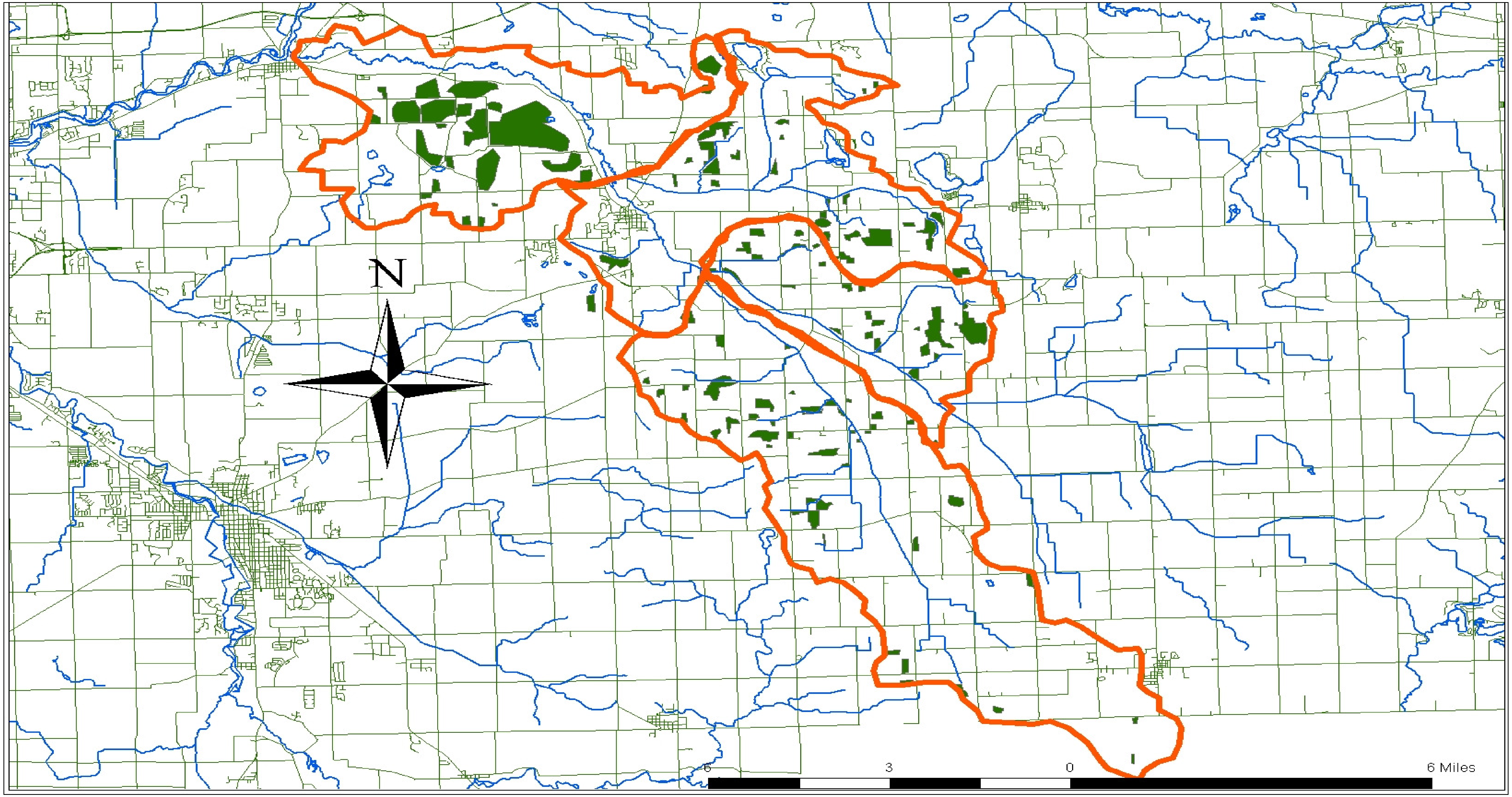

Figure 202: Map depicting non-grazed woodlots.

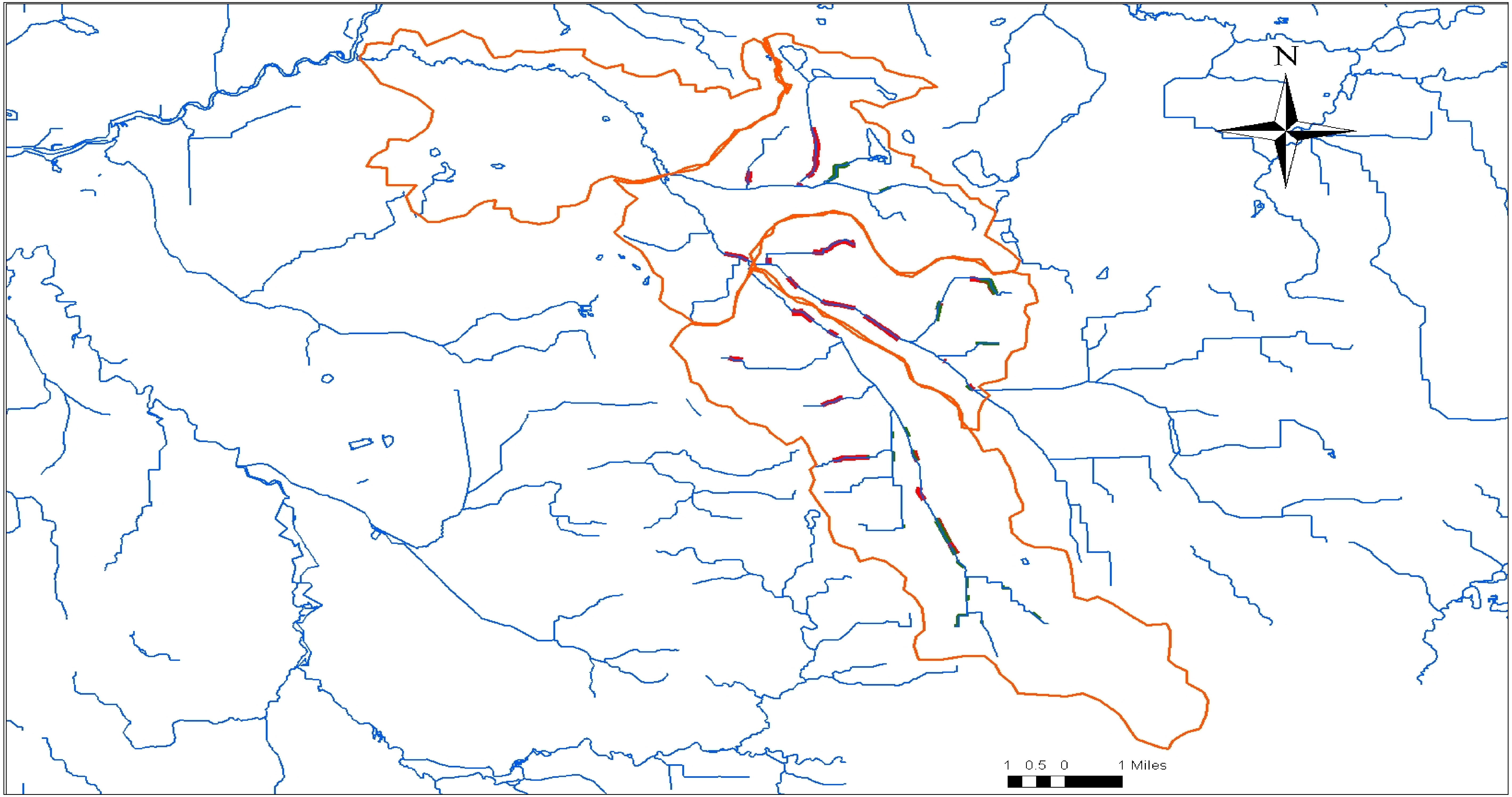

Figure 203: Map depicting existing fence and livestock access along surface waters. Fence color was changed to green to enhance contrast. Road infrastructure was deleted to reduce visual interference.

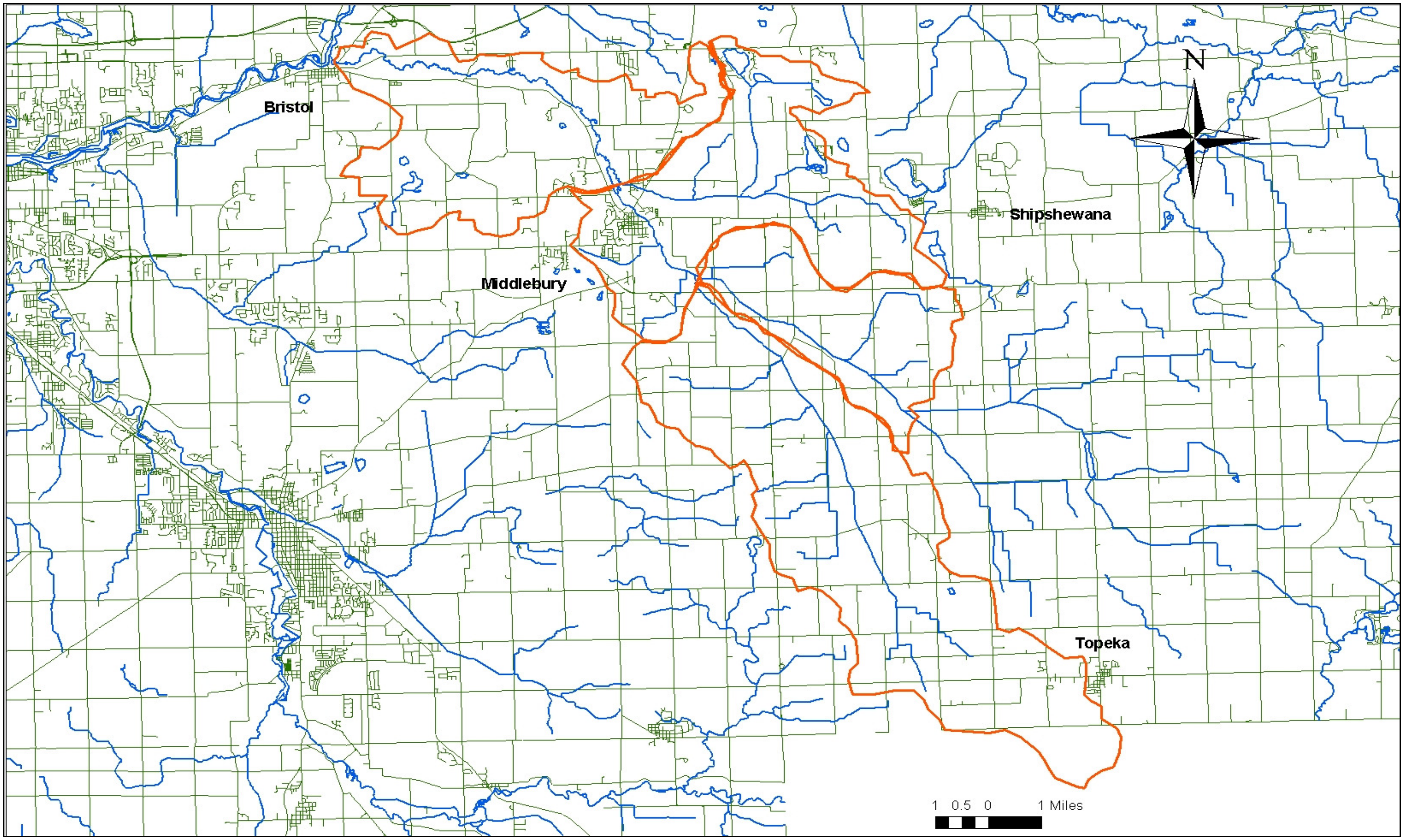

Figure 204: Map depicting road infrastructure. Note all other impervious surfaces are not shown.

Statistix 8.1

One-Way AOV for pH by Site

Source	DF	SS	MS	F	P
Site	3	2.5067	0.83556	6.37	0.0003
Error	277	36.3558	0.13125		
Total	280	38.8625			

Grand Mean 8.0627   CV 4.49

		Chi-Sq	DF	P
Bartlett's Test of Equal Variances		10.3	3	0.0162
Cochran's Q	0.3404			
Largest Var / Smallest Var	1.8509			

Component of variance for between groups   0.01005
Effective cell size   70.1

Site	N	Mean	SE
Bonneyvill	72	8.2086	0.0427
Harper	72	8.0747	0.0427
Mather	60	7.9927	0.0468
Rowe Eden	77	7.9695	0.0413

Tukey HSD All-Pairwise Comparisons Test of pH by Site

Site	Mean	Homogeneous Groups
Bonneyvill	8.2086	A
Harper	8.0747	AB
Mather	7.9927	B
Rowe Eden	7.9695	B

Alpha   0.05
Critical Q Value   3.632

Appendix 1: ANOVA and TUKEY calculations for pH.

Statistix 8.1

One-Way AOV for Temp by Site

Source	DF	SS	MS	F	P
Site	3	77.89	25.9649	0.78	0.5063
Error	277	9228.73	33.3167		
Total	280	9306.63			

Grand Mean 13.407   CV 43.05

	Chi-Sq	DF	P
Bartlett's Test of Equal Variances	12.8	3	0.0051
Cochran's Q 0.3162			
Largest Var / Smallest Var 2.2237			

Component of variance for between groups -0.10493
Effective cell size 70.1

Site	N	Mean	SE
Bonneyvill	72	12.589	0.6802
Harper	72	13.860	0.6802
Mather	60	13.295	0.7452
Rowe Eden	77	13.836	0.6578

Appendix 2: ANOVA calculations for temperature.

Statistix 8.1

One-Way AOV for DO by Site

Source	DF	SS	MS	F	P
Site	3	17.417	5.80562	2.44	0.0644
Error	277	658.139	2.37595		
Total	280	675.556			

Grand Mean 6.1559   CV 25.04

		Chi-Sq	DF	P
Bartlett's Test of Equal Variances		8.89	3	0.0308
Cochran's Q	0.3595			
Largest Var / Smallest Var	1.9515			

Component of variance for between groups   0.04895
Effective cell size   70.1

Site	N	Mean	SE
Bonneyvill	72	6.3885	0.1817
Harper	72	6.4075	0.1817
Mather	60	5.9313	0.1990
Rowe Eden	77	5.8782	0.1757

Appendix 3: ANOVA calculations by HUC for dissolved oxygen.

Statistix 8.1

One-Way AOV for TSS by Site

Source	**DF**	**SS**	**MS**	**F**	**P**
Site	3	1648.7	549.552	1.83	0.1410
Error	277	82957.9	299.487		
Total	280	84606.6			

Grand Mean 10.254   CV 168.76

		Chi-Sq	**DF**	**P**
Bartlett's Test of Equal Variances		223	3	0.0000
Cochran's Q	0.7939			
Largest Var / Smallest Var	23.931			

Component of variance for between groups   3.56909
Effective cell size   70.1

Site	**N**	**Mean**	**SE**
Bonneyvill	72	8.299	2.0395
Harper	72	12.604	2.0395
Mather	60	7.033	2.2342
Rowe Eden	77	12.396	1.9722

Appendix 4: ANOVA calculations by HUC for total dissolved solids.

Statistix 8.1

One-Way AOV for Turb by Site

Source	DF	SS	MS	F	P
Site	3	6870	2290.15	2.76	0.0424
Error	277	229570	828.77		
Total	280	236440			

Grand Mean 9.4804   CV 303.66

		Chi-Sq	DF	P
Bartlett's Test of Equal Variances		638	3	0.0000
Cochran's Q	0.9716			
Largest Var / Smallest Var	289.76			

Component of variance for between groups   20.8578
Effective cell size   70.1

Site	N	Mean	SE
Bonneyvill	72	6.042	3.3927
Harper	72	8.889	3.3927
Mather	60	4.500	3.7166
Rowe Eden	77	17.130	3.2807

Tukey HSD All-Pairwise Comparisons Test of Turb by Site

Site	Mean	Homogeneous Groups
Rowe Eden	17.130	A
Harper	8.8889	A
Bonneyvill	6.0417	A
Mather	4.5000	A

Alpha   0.05
Critical Q Value   3.632

Appendix 5: ANOVA and TUKEY calculations for turbidity.

Statistix 8.1

One-Way AOV for E by Site

Source	DF	SS	MS	F	P
Site	3	3.411E+08	1.137E+08	2.04	0.1079
Error	277	1.540E+10	5.561E+07		
Total	280	1.574E+10			

Grand Mean 1753.9   CV 425.17

		Chi-Sq	DF	P
Bartlett's Test of Equal Variances		497	3	0.0000
Cochran's Q	0.8364			
Largest Var / Smallest Var	391.05			

Component of variance for between groups   829048
Effective cell size   70.1

Site	N	Mean	SE
Bonneyvill	72	634.8	878.83
Harper	72	3346.5	878.83
Mather	60	756.6	962.71
Rowe Eden	77	2088.3	849.82

Appendix 6: ANOVA calculations for *E.coli*.

Statistix 8.1

One-Way AOV for Nitrate by Site

Source	DF	SS	MS	F	P
Site	3	36.768	12.2559	13.1	0.0000
Error	277	259.351	0.9363		
Total	280	296.119			

Grand Mean 2.4466   CV 39.55

		Chi-Sq	DF	P
Bartlett's Test of Equal Variances		69.9	3	0.0000
Cochran's Q	0.3729			
Largest Var / Smallest Var	7.6412			

Component of variance for between groups   0.16156
Effective cell size   70.1

Site	N	Mean	SE
Bonneyvill	72	2.7944	0.1140
Harper	72	2.8028	0.1140
Mather	60	2.1167	0.1249
Rowe Eden	77	2.0455	0.1103

Statistix 8.1

Tukey HSD All-Pairwise Comparisons Test of Nitrate by Site

Site	Mean	Homogeneous Groups
Harper	2.8028	A
Bonneyvill	2.7944	A
Mather	2.1167	B
Rowe Eden	2.0455	B

Alpha   0.05
Critical Q Value   3.632

Appendix 7: ANOVA and TUKEY calculations for nitrates.

Statistix 8.1

One-Way AOV for TP by Site

Source	DF	SS	MS	F	P
Site	3	12.982	4.32743	6.25	0.0004
Error	277	191.781	0.69235		
Total	280	204.763			

Grand Mean 0.4780   CV 174.07

	Chi-Sq	DF	P
Bartlett's Test of Equal Variances	398	3	0.0000
Cochran's Q	0.8934		
Largest Var / Smallest Var	132.19		

Component of variance for between groups   0.05188
Effective cell size   70.1

Site	N	Mean	SE
Bonneyvill	72	0.3219	0.0981
Harper	72	0.3993	0.0981
Mather	60	0.8868	0.1074
Rowe Eden	77	0.3790	0.0948

Statistix 8.1

Tukey HSD All-Pairwise Comparisons Test of TP by Site

Site	Mean	Homogeneous Groups
Mather	0.8868	A
Harper	0.3993	B
Rowe Eden	0.3790	B
Bonneyvill	0.3219	B

Alpha   0.05
Critical Q Value   3.632

Appendix 8: ANOVA and TUKEY calculations for total phosphorus.

Statistix 8.1

One-Way AOV for TSS by Site

Source	DF	SS	MS	F	P
Site	3	1648.7	549.552	1.83	0.1410
Error	277	82957.9	299.487		
Total	280	84606.6			

Grand Mean 10.254   CV 168.76

		Chi-Sq	DF	P
Bartlett's Test of Equal Variances		223	3	0.0000
Cochran's Q	0.7939			
Largest Var / Smallest Var	23.931			

Component of variance for between groups   3.56909
Effective cell size   70.1

Site	N	Mean	SE
Bonneyvill	72	8.299	2.0395
Harper	72	12.604	2.0395
Mather	60	7.033	2.2342
Rowe Eden	77	12.396	1.9722

Appendix 9: ANOVA calculations for total phosphorus.

APPENDIX 10
Quality Assurance Project Plan

Quality Assurance Project Plan

for

Little Elkhart River Watershed Management Plan/
Paired Watershed Study

ARN # A305-7-182 & A305-7-79

Prepared by:

David P. Arrington
Watershed Coordinator
LaGrange County SWCD

Prepared for:

Indiana Department of Environmental Management
Office of Water Management
NPS/TMDL Section

February 2008

Approved By:

Note: Signed copy on file with Lagrange County SWCD and IDEM

Project Manager:	______________________ David P. Arrington	________ Date
NPS/TMDL QA Manager:	______________________ Betty Ratcliff	________ Date
NPS/TMDL Section Chief:	______________________ Andrew Pelloso	________ Date
Planning Branch Chief:	______________________ Marylou Renshaw	________ Date

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Section 1: Study Description

Historical Information

The St. Joseph River has had significant attention in it's urbanized centers of South Bend, Mishawaka, and Elkhart concerning water quality issues associated with point source pollution. A relatively recent focus has centered on non-point source pollution with an emphasis on agricultural runoff associated with crop planting and livestock management. Studies conducted by Indiana and Michigan state/county agencies have demonstrated tributaries of the mainstream are the major contributors of non-point source pollutants. The Little Elkhart River lies within the St. Joseph River Basin. The Little Elkhart River Basin is primarily influenced by agricultural practices and is on the IDEM 303(d) list of impaired waters. Water quality testing during the "headwaters" watershed management plan development, ARN#A305-4-142, demonstated high levels of phosphorus, nitrate, e-coli, and impaired biotic communities. Emma Lake, which lies within the study area, is on the list of impaired waters.

The study area presents unique challenges with approximatetly 50% of the landowners belonging to the Amish community. This is the fastest growing segment of the population along the Little Elkhart River drainage. The Lagrange County SWCD has established a close working relationship with the Amish community resulting in positive cooperation in both water quality testing and BMP installation.

Data collected under this QAPP is a continuation of 30 months already collected under the old QAPP dated June 2005. procedures will reamain consistant with old QAPP.

Study Goals

Goal 1: The primary goal is to establish a baseline in the 4 new HUCs listed under ARN# A305-7-182.

Objective 1: Establish baseline data that is comparible with paired watershed sites.

Objective 2: Isolate problematic segements for BMP insallation prioritization.

Goal 2: Demonstarte a significant difference between watersheds under ARN#A305-7-79.

Objective 1: Continue collecting baseline data before and after BMP installation.

Objective 2: Establish all BMPs in treatment watershed by Fall 2008.

Objective 3: Demonstrate statistical difference in collection parameters by study end date.

Study Site

The project area is the entire drainage of the Little Elkhart River consisting of 7 HUC14s (Appendix A). Water quality testing will be conducted in all but the Little

Elkhart Ditch (Topeka) which was completed under the headwaters watershed management plan in April 2007. Under this study data will be collected in watersheds:
04050001140010 – Bontrager Ditch/ Emma Lake (Treatment Watershed)
04050001140020 – Bontrager Ditch/Hostetler Ditch (Control Watershed)
04050001140040 – Little Elkhart River/Rowe Eden Ditch
04050001140050 – Little Elkhart River/Harper Ditch
04050001140060 – Little Elkhart River/ Mather Ditch
04050001140070 – Little Elkhart River/Bonneyville Mills
Six sites per HUC14 have been selected and will be sampled monthly during the "ice-out" season (Appendix A).

Sampling Design

A synoptic approach was chosen for both studies to give a representative analysis of the 6 HUC 14s involved. The synoptic approach will provide data that isolates segments and "finger" tributaries revealing trends that may require intervention during current and future implementation of BMPs.
Data has been collected on six sites on the Bontrager/Emma Lake and Bontrager/Hostetler Ditch tributaries since May 2005. Monitoring will continue on these 12 sites to compare differences after BMP installation on the Bontrager/Emma Lake and the Bontrager/Hostetler Tributaries. A solid baseline has been established for the paired watershed study. After BMPs have been established in the treatment watershed additional parameter collection at existing sites will determine effectiveness. If deemed necessary additional sites will be added for quantitative analysis. The remaining 4 HUC14s will have six sites each tested to establish a baseline and select target locations for BMP implementation (Appendix A). Macroinveretebrates will be sampled yearly using mIBI precedures. Habitat quality will be assesed usng the Qualitative Evaluation index protocol (OEPA 1989).
Electronic field instruments will be used to collect data at each site on dissolved oxygen, pH, temperature, total dissolved solids, and turbidity. Sites 5 and 13 have ISCO 6712 autosamplers installed to collected multiple samples during high rain events. These samplers are set for 1 inch of rain in 4 hours. Samples are automatically collected each hour for 24 hours. Rainfall, flow velocity, and flow volume are collected on a continuous basis every 5 minutes and will be downloaded periodically using a laptop computer at each site. Site 30 has a HOBO Flow Monitor installed to provide temerature, flow velocity and volume continuously at 5 minute intervals. Data on site is collected using a "shuttle" followed by PC download.
Total phosphorus, nitrates, biological oxygen demand, total suspended solids, ammonia and **E.coli** *will be collected for lab analysis. The paired watershed study sites will be tested each spring for the presence of Atrazine. If detected, monthly testing will continue until no detectable Atrazine is present.*

Study Schedule

Sampling under this QAPP will begin January 2008 and will continue through October 2011 (Table 1). Analysis of data will be on-going throughout the study to indentify and stear current implemetation programs to problematic locations.

Macroinvertebrate sampling will begin late summer 2008 and will end late summer 2011.

The major constraint during sampling will be during winter when many sites may be frozen. Every attempt will be made to sample as many sites as possible during winter.

Table1: Study Schedule

Activity	Start Date	End Date
Sample collection: DO, BOD, Temp, pH, TP, NO_3, Turb, TDS, TSS, NH_4, *E. coli* and flow. (monthly all sites, weekly-Feb thru July at sites 5 and 13)	Jan. 2008	Oct. 2011
Flow (monthly at sites: 1,5,6,13,15,16, 19, 23, 24, 25, 27, 30, 32, 33, 34, 36, 39, 40, 42)	Jan. 2008	Oct., 2011
Macroinvertebrate collection (semi-annually all sites)	Summer 2008	Summer 2011
Habitat Evaluation (twice all sites)	Summer 2008	Summer 2011
Atrazine (sites 5 and13)	Mar. 2008	Jun. 2011
Analysis (on-going)	Jan. 2008	Oct. 2011

Section 2: Study Organization and Responsibility

Key Personnel

David Arrington - Watershed Coordinator
910 S. Detroit Street LaGrange, IN 46761 (260) 463-3471 ext. 3,
david.arrington@IN.nacdnet.net
Responsible for coordination of project: data collection, QA, data analysis, meetings, documentation and write-up.

Dona Hunter - Program Manager
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Overall program manager.

Julie Diehm - Water Quality Technician
910 S. Detroit Street LaGrange, IN 46761 (260) 463-3471 ext. 3, julie.deihm@IN.nacdnet.net
Water quality testing, data management.

Mark Diehm – Water Quality Technician
910 S. Detroit Street LaGrange, IN 46761 (260) 463-3471 ext. 3, julie.deihm@IN.nacdnet.net
Water quality testing, data management.

Project Organization

Both technicians report to the watershed coordinator concerning all water testing issues. The water quality technicians are principally responsible for field data collection and lab sample analysis. The watershed coordinator has overall responsibility for the study.

Section 3: Data Quality Objectives

Precision Accuracy

Field Chemistry Parameters

Field equipment will be calibrated in accordance with manufacturer's specifications. Replicate/field blank samples will be taken with the following field equipment: Hach instruments sensION 156 (DO, pH, Temp, TDS), 2100 Turbidmeter, Global Water Flow Probe, HOBO Flow Monitor and ISCO 6712 Autosampler. Two replicate samples and two field blanks will be taken during each sampling cycle or 1 replicate/blank per 20 samples. Precision will be calculated using the RPD method:

$$RPD = \frac{(C-C')x100\%}{(C+C')/2}$$

Where:

C=the larger of two values
C'=the smaller of two values

Laboratory Water Chemistry Parameters

Grab samples will be collected for atrazine, total phorsphorus, nitrates, ammonia and total suspended solids at each site for analysis with the Hach DR2500 Spectrophotometer. Antrazine will be collected in spring for sites 5 and13 will be continued only as long as presence is detected. BOD samples will be collected at each site and analyzed using the Hach BOD Trak and incubator with temperature setting at manual specifications. Two duplicate samples and two field blanks will be taken per sampling cycle or 1 duplicate/blank per 20 samples. Standards will be used in accordance with manufacturer's guidelines. **E. coli** *samples will be collected using sterile containers with duplicates of each sample analyzed using the Easy Gel method with incubator set at 35°C for 24 hours. Precision will measured using the RPD method. The laboratory is located at the Par Gil Natural Resources Learning Center, 250 North SR9, LaGrange, IN 46761. The phone number is 260-463-8822.*

The electronic field instruments will be calibrated before each sampling cycle to insure accuracy within the limits of each device. In the laboratory, strict adherence to procedures and consistant calibration of the Hach DR2500 in accordance with manufacturer's specifications employed. The ISCO 6712 Autosamplers and HOBO Flow Monitor will be maintained in accordance with manufacturer's specifications and recalibrated monthly.

Macroinvertibrates and Habitat Parameters

Both technicians are fully trained with 14 years experience in collection and data analysis. To ensure precision the watershed coordinator will participate in the sampling. Habitat evaluation will be conducted independently with any discrepancies finalized by the watershed coordinator.

GPS Coordinates
All 36 sites have been recorded with a Garmin GPS Map76 and loaded into an ArcGIS program. A shapefile layer will be provided to IDEM. Coordinates are listed as UTM UPS NAD 83, Zone 16. Coordinates are listed below and can be correlated with triangled site numbers shown on the site overview map (Appendix A).

1) *0626061 4604620 east side of culvert*
2) *0624962 4604023 east side of culvert*
3) *0624950 4604457 east side of culvert*
4) *0622210, 4604501 north side of road*
5) *0621612, 4606112 north side of road*
6) *0621744, 4606101 open ditch directly south of field corner post*
13) *0617405, 4608784 west side of bridge*
14) *0619113, 4609209 east side of culvert*
15) *0619942, 4609476 west side of bridge*
16) *0619931, 4609036 west side of bridge*

17) 0621563, 4609271 east side of culvert
18) 0625168, 4610152 south side of culvert
19) 0615718, 4601075 north side of culvert
20) 0615268, 4602994 west side of bridge
21) 0613760, 4607464 south side of road
22) 0613566, 4607461 south side of road
23) 0612480, 4610047 west side of bridge
24) 0610908, 4611824 CR43 north of CR16, culvert
25) 0610192, 4612634 CR43 north of US20, west side of bridge
26) 0611600, 4611426 bridge, 050N
27) 0613427, 4610431 060S 1100W, west side of bridge
28) 0615063, 4611364 south of 1000W/050N intersection, culvert
29) 0615063, 4609352 1000W and 100S, bridge
30) 0615291, 4609105 west side of bridge
31) 0608208, 4614547 CR16, culvert
32) 0608075, 4615453 CR13, south of bridge
33) 0610908, 4615340 CR16 culvert
34) 0611331, 4617777 CR10, bridge
35) 0612447, 4616132 1150W, culvert
36) 0612462, 4615291 1150W, culvert
37) 0607577, 4614981 Botanical Garden, bridge
38) 0606491, 4617664 CR10, bridge
39) 0605908, 4618387 CR35, bridge
40) 0602773, 4619429 Bonneyville Mills Cty Park, bridge
41) 0600400, 4619948 CR120, bridge
42) 0598826, 4619704 SR15, bridge

Completeness

Field and Laboratory Chemistry Parameters

The sampling schedule is aggressive to allow room for missed measurements. In this study quantitative and qualitative analysis will be achieved if 75% of measurements are taken for each site and for each parameter (Table 2). All sites have been surveyed for access and proper sampling hydrology. However, during extreme climatic events acquiring samples at some locations may become impossible. The most plausable constraint will be during winter months when ice conditions may make sampling difficult at best. In addition, during drought conditions flow may stop on several "finger" drainages.

$$\% \text{ completeness} = \frac{\text{(number of valid measurements)} \times 100\%}{\textbf{(number of valid measurements expected)}} = \frac{1296 \times 100\%}{\textbf{1728}} = 75\%$$

Macroinvertebrates and Habitat Parameters

In order to achieve the desired level of completeness for this study 100% of habitat and macroinvertibrates analysis must be completed (Table 2). This should be attainable since there is flexibilty in selecting sampling dates that are conducive to achieve 100% collection.

Table 2: Data Quality Objectives

Parameter	Precision	Accuracy	Completeness
DO, pH, Turb, Temp, TDS, TSS	RPD<5%	Instrument limits See Table 4	75%
BOD, TP, NO_3, NH_4, Atrazine	RPD<5%	Instrument limits See Table 4	75%
E. coli	RPD<10%	High	75%
Flow	RPD<5%	$\pm$3% + zero stability zs=$\pm$0.1m/sec	75%
Macroinvertebrate	High	High	100%
Habitat	High	High	100%

Representativeness

In using the synoptic approach, a relatively even representation of water quality throughout the sub-watersheds will be achieved. Test sites were selected and field varified to isolate segments of each watershed and allow easy access for personnel. If extremely high levels of contaminants are found in any given segment (higher than surrounding segments) additional sites may be added to futher isolate the source. If this occurs, then an appendum will be submitted.

Comparability

Data collected from this study will not be compared to other studies but will provide a baseline for future sampling to assess the effectiveness of water quality improvement practices. It is intended to follow sampling procedures used here in future projects administered by LaGrange County SWCD. Methods used will meet EPA-approved standards.

Section 4: Sampling Procedures

Water Chemistry Sampling

Water chemistry samples will be taken at each station to test the parameters listed in Table 3. Temperature, dissolved oxygen, pH, turbidity, total dissolved solids and flow measurements will be made in the field using the following instruments: Hach sensION 156 for temperature, dissolved oxygen, total dissolved solids, and pH; Hach 2100P Turbidmeter for turbidity; and the Global Water Flow Probe, ISCO Autosampler, and HOBO Flow Monitor for stream flow. All measurements will be taken accordng to the standard operating procedures provided by the manufacturer of the equipment. Project personnel will record water chemistry field measurements on standardized field data sheets (Appendix B).

Flow measurements will be taken utilizing protocols outlined in Marsh-McBirdy (1990). A tape measure will be staked across the width of the channel prior to any measurements being taken. If the stream is less than 2" deep, then multiple point velocity measurements will be taken throughout the width of the channel. Channel depths will measured at a minimum of five points across the channel. Discharge will be calculated using the following formula:

$$\text{Discharge} = \frac{(\Sigma d_i)\ w*v}{(n+1)}$$

where d equals stream depth, n equals the number of stream depths measured, w equals the width of the stream, and v equals the velocity of the stream (0.9 times the fastest velocity recorded). The equation has been modified from EPA (1997).

If the stream is greater than 2" deep, then the trapezoid channel method will be utilized to calculate stream discharge. The interval width, thus the number of flow measurements recorded across the channel, is determined by channel width. If the channel width is less than 15', then the interval width will be equal to the stream width divided by 5. If the channel width is greater than 15', then the interval width will be equal to the channel width multiplied by 0.1. Stream depths will be recorded at the right and left edges of the predetermined trapezoid (SI_0 and SI_1). Flow measurements will be recorded at the midpoint of each trapezoid ($SI_{1/2}$). All data will be recorded on the data sheet included in Appendix C. Discharge will be calculated using an Excel spreadsheet to minimize errors.

Grab samples will be collected for the remaining parameters: total phosphorus, nitrates, atrazine, BOD, total suspended solids, ammonia and **E. coli**. ***Samples will be placed in prepared containers. Sample collection will follow the method outlined in EPA Volunteer Stream Monitoring: A Methods Manual (1997). The technician will wade into the center of the streams thalweg to collect the water sample. The technician will then invert a clean sample bottle into the thalweg. The same procedure will be followed for a separate*** **E. coli** ***sample. At a depth of 8 to 12 inches below the water surface, the technician will turn the bottle into the current and allow collection of water. If the stream depth is shallower than 16", water collection will be midway between the surface and bottom. Once the bottle is full the technician will "scoop" the bottle toward the surface.***

The sample containers will be labeled with date, time, technician initials, site, and parameter to be analyzed. All samples will be stored on ice and transported to the laboratory for immediate analysis. Technicians collecting samples will complete laboratory analysis. Water chemistry analysis will be in accordance with specified procedures as outlined in the manual for the DR 2500. **E. coli** ***samples will be prepared using the Coliform Easygel method.***

Macroinvertebrate Sampling

Macroinvertebrate sampling will follow procedures described in the macroinvertebrate Index of Biotic Integrity (mIBI).

Habitat Evaluation

Habitat evaluation will be conducted at each site using the Ohio EPA's Quality Habitat Evaluation Index (QHEI). Assessments will be noted on the QHEI data sheets.

Table 3: Sampling Procedures

Parameter	Sampling Frequency	Sampling Method	Sample Container	Sample Volume	Holding Time
DO	Monthly*	Field Meter-Hach sensION156	N/A	N/A	In field
pH	Monthly*	Field Meter-Hach sensION156	N/A	N/A	In field
TDS	Monthly*	Field Meter-Hach sensION156	N/A	N/A	In field
Turb	Monthly*	Field Meter-Hach 2100 Portable	100mL vial	100ml	In field
Temp	Monthly*	Field Meter-Hach sensION156/ISCO 6712	N/A	N/A	In field
TP	Monthly*	Grab Sample	500mL plastic bottle	25mL	7 days
TSS	Monthly*	Grab Sample	500mL plastic bottle	25mL	7 days
NO_3	Monthly*	Grab Sample	500mL plastic bottle	25mL	7 days
NH_4	Monthly*	Grab Sample	500mL plastic bottle	25mL	7 days
BOD	Monthly*	Grab Sample	250mL dark bottle	250mL	24 hours
E. coli	Monthly*	Grab Sample	250mL sterile plastic cup	1mL	8 hours
Flow	Monthly*	Global Water Flow Probe/ISCO 6712/HOBO Flow Monitor	N/A	N/A	In field
Habitat	Annually	QHEI	N/A	N/A	In field
Macro invertebrate	Annually	mIBI	N/A	N/A	In field

***NOTE: ISCO 6712 Autosamplers located at sites 5 and 13 will collect velocity, volume, rainfall, and temperature every five minutes. When rainfall reaches 1 inch in 4 hours 24 samples will be collected hourly and each sample will be analyzed for TP, NO_3, TSS, BOD, NH_4 and *E. coli* in the laboratory. All parameters will be collected weekly at sites 5 and 13 from February thru July. The HOBO flow monitor is located at site 30 and will collect velocity and temperature data every 5 minutes.**

Section 5: Custody Procedures

Samples that require transportation will be clearly labled with date, time, technician initials, site, and parameter to be measured. Analysis of samples will occur in the labratory by the same individual and will occur the same day as collection.
Samples will be placed on ice in a small cooler for transportation that is clearly labled with "Water Samples" on the outside. Since the same individual will be doing the analysis, no transfer sheets are required.

Calibration Procedures and Frequency

The multi-parameter meter, the turbidity meter, autosamplers, HOBO flow monitor and the spectrophotometer will require calibration. Calibration procedures will be followed for the field meters before sampling begins that day. The spectrophotometer will be calibrated before each sampling cycle for each parameter being measured. The autosamplers will be recalibrated monthly. The HOBO flow monitor requires recalibration every 2 years by the manufacturer. To provide barametric compensation a second HOBO flow monitor has been installed at site 30 to measure atmospheric pressure. Computer software automatically merges data from both monitors and provides calibration measures to collected data from submerged sampler.
Calibration will be in accordance with manufacturer's instructions.

Section 7: Sample Analysis Procedures

Equipment used in the field and labratory present data in usable form and require no analytical methods by the technician. For **E. coli*****, procedures using the Coliscan Easygel method will be employed. Macroinvertibrate and habitat sampling will follow procedural guidelines listed for mIBI/QHEI sampling prototcols.***
Table 4 lists analytical procedures and performance range for electronic equipment or each parameter .

Table 4: Analytical Procedures

Parameter	Analytical Method	Performance Range or Detection Limits	Units
DO	Hach sensION 156 Electronic Meter EPA 360.1	0 to 20; 0.1mg/l	mg/L
TDS	Hach sensION 156 Electronic Meter EPA 130.1	0 to 42; 0.1g/l	g/L
pH	***Hach sensION 156*** Electronic Meter ***EPA 150.2***	***-2 to 19.99;0.1SU***	***Standard Units***
Turb	***Hach 2100P Portable Meter EPA 180.1***	***0 to 1000; 0.1NTU***	***NTU***
Temp	***Hach sensION 156*** Electronic Meter ***EPA 170.1***	***-10 to 110; 0.1°C***	***^{0}C***
TP	***Hach DR 2500 Method 8190 EPA 360.3***	***0.06 to 3.5 mg/l; 0.01mg/l***	***mg/L***
NH_4	***Hach DR 2500 Method 10023 EPA 350.1***	***0.02 to 2.50mg/l;0.01mg/l***	***Mg/l***
NO_3,	***Hach DR 2500 Method 10020 EPA 352.1***	***0.2 to 30.0mg/l; 0.1mg/l***	***mg/L***
TSS	***Hach DR 2500 Method 8006 EPA 160.2***	***O to 750;0.1mg/l***	***mg/l***
Atrazine	***Hach DR 2500 Method 10050***	***<0.5ppb, >0.5 but<3.0ppb, >3.0ppb***	***ppb***
BOD	***Hach BODTrak Users Manual***	***0 to 20; 0.01mg/l***	***mg/L***
E. coli	***Coliscan Easygel incubated at 35°C for 24 hours***	***N/A***	***Colonies/100 ml***
Flow	***Global Water Flow Probe/ISCO 6712/HOBO Flow Monitor Manuals***	***0.1 to 30***	***FPS***
Habitat	***QHEI***	***N/A***	***N/A***
macroinvertibrates	***IDEM Macro Program SOPs Dufour, Ronda. (Undated)*** **Guide to Appropriate Metric Selection for Calculating the mIBI for IN Streams and Rivers.**	***N/A***	***N/A***

Section 8: Quality Control Procedures

Quality control and accuracy will be achieved by strict adherence to written protocol. To achieve precision in field measurements, replicate measurements and field blanks will be taken at 2 of the 36 sampling sites for each sampling event. Field equipment will be properly calibrated before each sampling event in accordance with manufacturer's guidelines. To achieve precision in the laboratory, a duplicate sample and field blank will be taken at 2 of the 36 sampling sites for each sampling event. Laboratory equipment will be calibrated according to manufacturers guidelines. In the laboratory reference standards and blanks will be used as necessary to assure data quality. Collection containers/equipment will be washed/maintained within manual outlined protocols.
For macroinvertebrate sampling and habitat evaluations, strict adherence to protocol will be followed by all personnel. Any discrepancies in data will be resolved by the watershed coordinator.

Section 9: Data Reduction, Analysis, Review, and Reporting

Data Reduction

Field and lab equipment will do necessary conversion of raw data into meaningful units. Statistical approaches will be determined after four months of sampling and consultation with Purdue University's Department of Natural Resources.

Data Analysis

Final analysis approaches will be determined after four months of sampling and consultation with Purdue University. It is likely correlation and regression analysis will be employed along with ANOVA techniques.

Data Review

The watershed coordinator will review data on a monthly basis for errors and omissions.

Data Reporting

Reporting data to the public will occur at each public meeting. For public distribution the data will be kept in simplistic formats such as graphs and tables. Correlations with EPA acceptable levels will be in table format. Data will be presented by the watershed coordinator.
All raw data and data analysis results generated as part of this grant project will be submitted in an electronic format with the Final Report to the IDEM Project Manager or Quality Assurance Manager. The format will be in ACCESS database and will include all required fields for NPS reporting.

Section 10: Performance and System Audits

Performance audits for each section will be performed once each quarter by the program manager. Systems audits will be conducted semi-annually by an external scientist.
IDEM reserves the right to conduct external performance and/or systems audits of any component of this study.

Section 11: Preventative Maintenance

Preventative maintenance will be performed in accordance with the associated equipment manual.
An ample supply of batteries will be kept with field equipment. In addition, any parts associated with equipment that have limited time performance will have duplicates readily available.

Section 12: Data Quality Assessment

Precision and Accuracy

Data will be reviewed after each collection stage for validity. For invalid data (data that does not meet criteria outlined in Table 2) the effected sites will be immediately resampled. All data determined to be accurate will be considered valid and will be reported even if completeness objectives are not met.
Water chemistry data will be checked with blanks randomly each month. If data has been compromised the sampling process will be immediately repeated for the effected parameter at all sites. **E. coli** *analysis (colony counts) will be conducted by both technicians. If there is discepancy in counts the watershed coordinator will conduct a count in an attempt to resolve the difference. If unable to resolve the descrepency, samples will be retaken for the effected sites. Biological monitoring will be conducted by one technician and the watershed coordinator to ensure agreement on identification. Habitat evaluations will be conducted independantly by one tecnician and the watershed coordinator. The watershed coordinator will make all final decisions concering discrepancies.*

Completeness

Data will meet completeness criteria if percentages outlined in Section 3 are met for each parameter.
If completeness goals are not met data will still be used. Data will be qualified by association with time of year and flow rates.

Section 13: Corrective Action

Unusually high/low readings in the field will be used to trigger a potential corrective action. Corrective action will be an immediate equipment check and recalibration followed by another site sample. In the labratory unusually high/low readings and positive blanks will trigger corrective action. Corrective action will include an equipment check and recalibration. Positive blanks will require resampling.

Section 14: Quality Assurance Reports

Quality Assurance (QA) reports will be submitted to IDEM's Watershed Management Section every three months as part of the Quarterly Progress Report and/or Final Report.

References

Ledet, N.D. 1991. Little Elkhart River, LaGrange and Elkhart counties. Indiana Department of Natural Resource Report.
Marsh - McBirney. 1990. Model 2000 Installation and Operations Manual

Ohio Environmental Protection Agency. 1989. Biological criteria for the protection of aquatic life: Volume III. Standardized biological field sampling and laboratory methods for assessing fish and macroinvertebrate communities. Division of Water Quality Monitoring and Assessment, Columbus, Ohio.

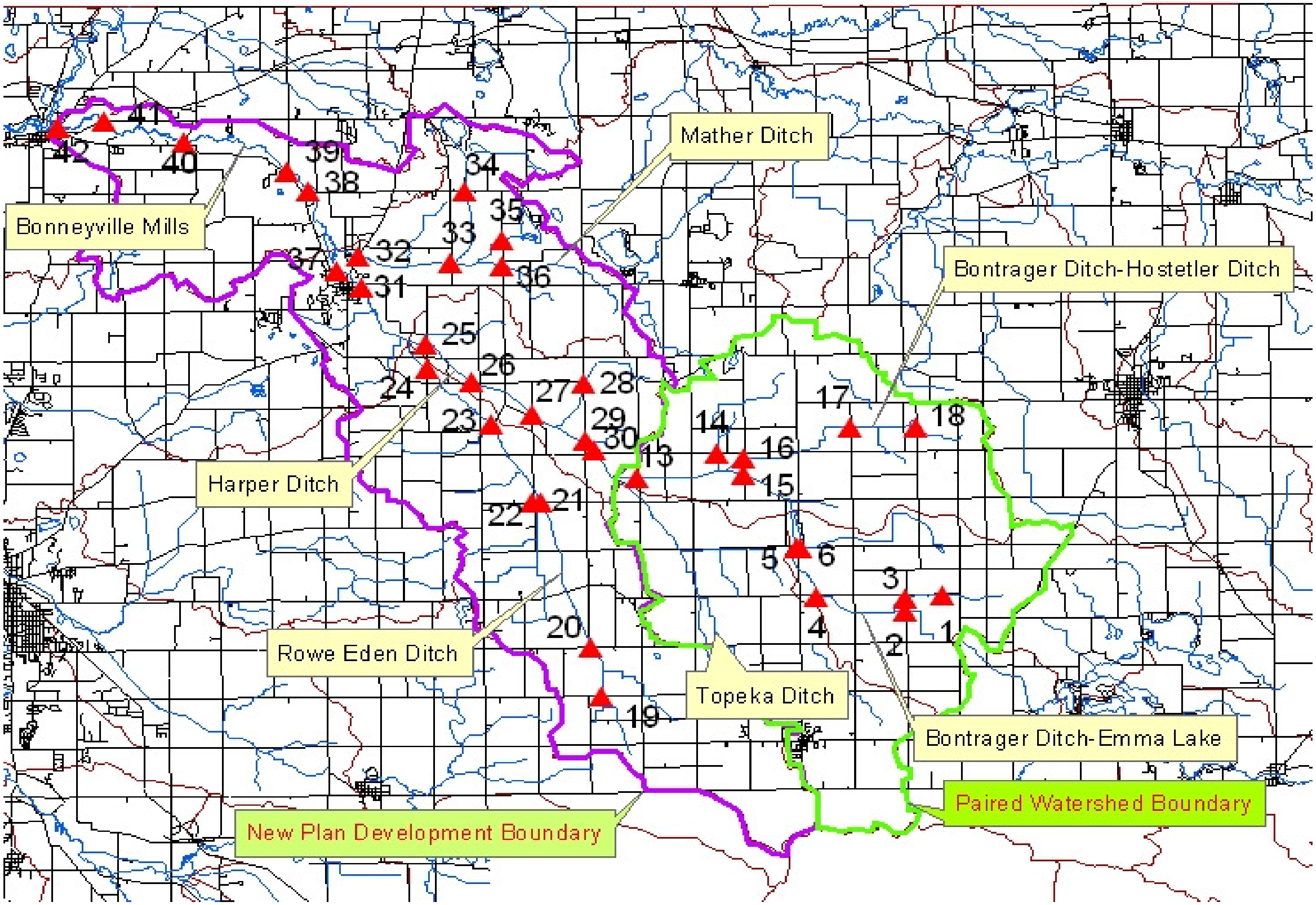
U.S.Environmental Protection Agency. 1997. Volunteer Stream Monitoring. A Methods Manual. EPA-841-B-97-003.

Volunteer Stream Monitoring Training Manual: Hoosier Riverwatch - Indiana's Volunteer Stream Monitoring Program. Indiana Department of Natural Resources, March 2001.

Appendix A

Water Quality Sample Site Map

OVERVIEW MAP



Appendix B

Water Sampling Field Log Sheet

WATER QUALITY SAMPLING FIELD LOG

SITE NUMBER AND LOCATION: ____
DATE: ____________________ PROJECT NAME: __________________________
TIME: _____________
FIELD CREW: _________________________________
WEATHER CONDITIONS: ____
OTHER OBSERVATIONS: ____
EQUIPMENT CALIBRATION (Date): _____________________

FIELD PARAMETERS	REPLICATE/Field Blank (if taken)	
pH: ___________	pH: ___________	RPD = _______
Temp: _________	Temp: _________	RPD = _______
DO: ___________	DO: ___________	RPD = _______
TDS: __________	TDS: __________	RPD = _______
Turb: __________	Turb: __________	RPD= _______
Calculated Flow: ____________		

Relative Percent Difference (RPD)= $\frac{(\text{sample1}-\text{sample2})}{((\text{sample1}+\text{sample2})/2)}$

LAB PARAMETERS

E. Coli: _________
Nitrate: _________
TP: ____________
BOD: ___________
TSS: ___________
Field Crew Leader Signature: ________________________

Appendix C

Discharge Measurement Sheet

DISCHARGE MEASUREMENT

Site: ____________________ Date: __________ Time: _________
Project#: _________________ Project Name: ________________
Crew Members: _______________________ Equipment: ___________________
Site Physical Description: ____

If stream is <2” deep:
Stream width: ______ feet
Stream Depths: ______, ______, ______, _____, _____, _____, _____, _____, _____feet
U: _____, _____, _____, _____, _____, _____, _____, _____, _____, _____ ft/s
U_{max}: _____ft/s

If stream is >2” deep:
Stream width: ______ feet
Interval Width (IW) (If W<15’, then IW=W/5. If W>15’, then IW=W*0.1): _____ feet

Segment	SI_0		SI_1		½ IW		$U_{0.4}$	
	Location	Depth	Location	Depth	Location	Depth	Set Depth	Rate
1								
2								
3								
4								
5								
6								
7								
8								
9								
10								
11								
12								
13								
14								
15								

Field Crew Leader Signature: ________________________________