Regional Stormwater Monitoring Program Third Term 2011 - 2015

Final Comprehensive Report

North Central Texas Council of Governments

July 25, 2016

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Notice

This document and its contents have been prepared and are intended solely for the North Central Texas Council of Governments (NCTCOG's) information and use in relation to reporting of the third permit term monitoring results of the Regional Stormwater Monitoring Program.

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This document has 172 pages, including the cover but not including the pages of the appendices.

Document history

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Acknowledgments

Completion of this report would not have been possible without the stakeholders that funded the project and took the time to respond to the multiple data requests required to assemble this report. These include multiple participants from the Cities of Arlington, Dallas, Fort Worth, Garland, Irving, Mesquite, and Plano and representatives from the North Texas Tollway Authority (and VRX Global) and the Texas Department of Transportation – Dallas District and Environmental Affairs Division.

Past and present field data collection crews and laboratory representatives spent multiple nights, weekends, and holidays to collect samples following storm events. We would like to acknowledge Dougherty Sprague Environmental (dse), Inc., and Freese and Nichols, Inc. (FNI). FNI contributed heavily to field data collection as well as storm event reporting duties. FNI assisted and later led the biomonitoring activities and reporting for the Cities of Plano and Garland. TTI Environmental Laboratories served as the contract laboratory for the monitoring conducted by Atkins, FNI, and dse and accepted samples submitted 24 hours a day.

Lastly, a special acknowledment to present and past representatives of the North Central Texas Council of Governments Environment and Development Department that provided oversight and guidance to all program participants.

Executive Summary

On October 17, 2011, the North Central Texas Council of Governments (NCTCOG) retained Atkins (in association with Freese and Nichols; Dougherty Sprague Environmental, Inc., and TTI Environmental Laboratories) under a Contract for Consulting Services to develop a comprehensive monitoring plan and perform long-term systematic stormwater quality monitoring at 17 in-stream stations across the Dallas-Fort Worth Metroplex area to collect quarterly samples, analyze them, and assist with determining long-term trends and potentially assessing impacts of stormwater on receiving streams. The monitoring was performed in the jurisdiction of seven entities, each holding a TPDES stormwater discharge permit (Cities of Arlington, Garland, Irving, Mesquite, Plano, and roadway authorities North Texas Tollway Authority (NTTA) and TxDOT-Dallas District). In addition, Atkins was under contract to develop a comprehensive monitoring plan and perform biomonitoring activities at two Plano watersheds and two Garland watersheds during the permit term. Fort Worth and Dallas watersheds were monitored by their own staff. The program administered by the NCTCOG was known as the Regional Wet Weather Characterization Program (RWWCP).

The primary goals of the RWWCP during the third permit term were to continue the assessment of urban impact on receiving stream water quality and to document any improvement presumably resulting from local BMP implementation. In order to document locally implemented BMPs, Atkins reviewed each entities Storm Water Management Plan (SWMP) and identified regional BMP categories. The BMPs were assumed to be implemented throughout the jurisdiction of the identified entity.

The United States Environmental Protection Agency (USEPA) and the State of Texas do not promulgate wet-weather specific in-stream water quality standards. However, for the purposes of water quality assessment, Atkins reviewed the Texas Surface Water Quality Standards (TSWQS), TCEQ nutrient screening levels, the National Stormwater Quality Database (NSQD), and criteria proposed by the National Rivers and Streams Assessment (NRSA) to generate “benchmarks” for monitored parameters for each monitored stream segment.

Data presented in this report was organized and analyzed by subwatershed. This approach allowed for the analysis of potential pollution sources, best management practices (BMPs), and monitoring recommendations specific to the subwatershed. For each subwatershed, the number of occurrences of benchmark values exceeded was tallied. For purposes of comparison of the regional dataset and for identification of priority areas and pollutants, these occurrences per pollutant category were adjusted per the number of samples collected in each subwatershed of the permit term and then the subwatersheds were ranked and split into tiers.

Atkins provided recommendations for future monitoring terms including data collection and documentation related to water quality in monitored subwatersheds, sampling site selection, and adjustments to the bioassessment and wet weather monitoring parameter set.

The NCTCOG and the participants intend to continue monitoring efforts using an in-stream monitoring approach. The information summarized in this report should provide NCTCOG and the participants information to support the development of a plan for continuing in-stream monitoring and a tool to guide local storm water management.

1. Introduction

"Water is the most critical resource issue of our lifetime and our children's lifetime. The health of our waters is the principal measure of how we live on the land." – Luna Leopold

1.1. Urban Stormwater Quality

Urban populations within the United States increased by more than 12 percent from 2000 to 2010 and is anticipated to continue to grow (US Census Bureau, 2012). Urban population growth requires modification of the landscape in the form of infrastructure ultimately altering the chemical composition of stormwater runoff. Stormwater runoff from urban landscapes is a remaining principal contributor to water quality impairment of waterbodies nationwide (NRC, 2009). Urban stormwater runoff quality is degraded due to contact with chemical and microbial contaminants from transportation networks, residential and commercial developments, and other altered landscapes within the urban environment. The velocity and volume of stormwater discharges is also impacted by development causing damage to aquatic habitats and stream function. Wastewater inputs in the urban environment can also contribute to stream degradation. The diagram below from the United States Environmental Protection Agency (USEPA) illustrates these pathways and identifies stressors that may be observed in the stream.

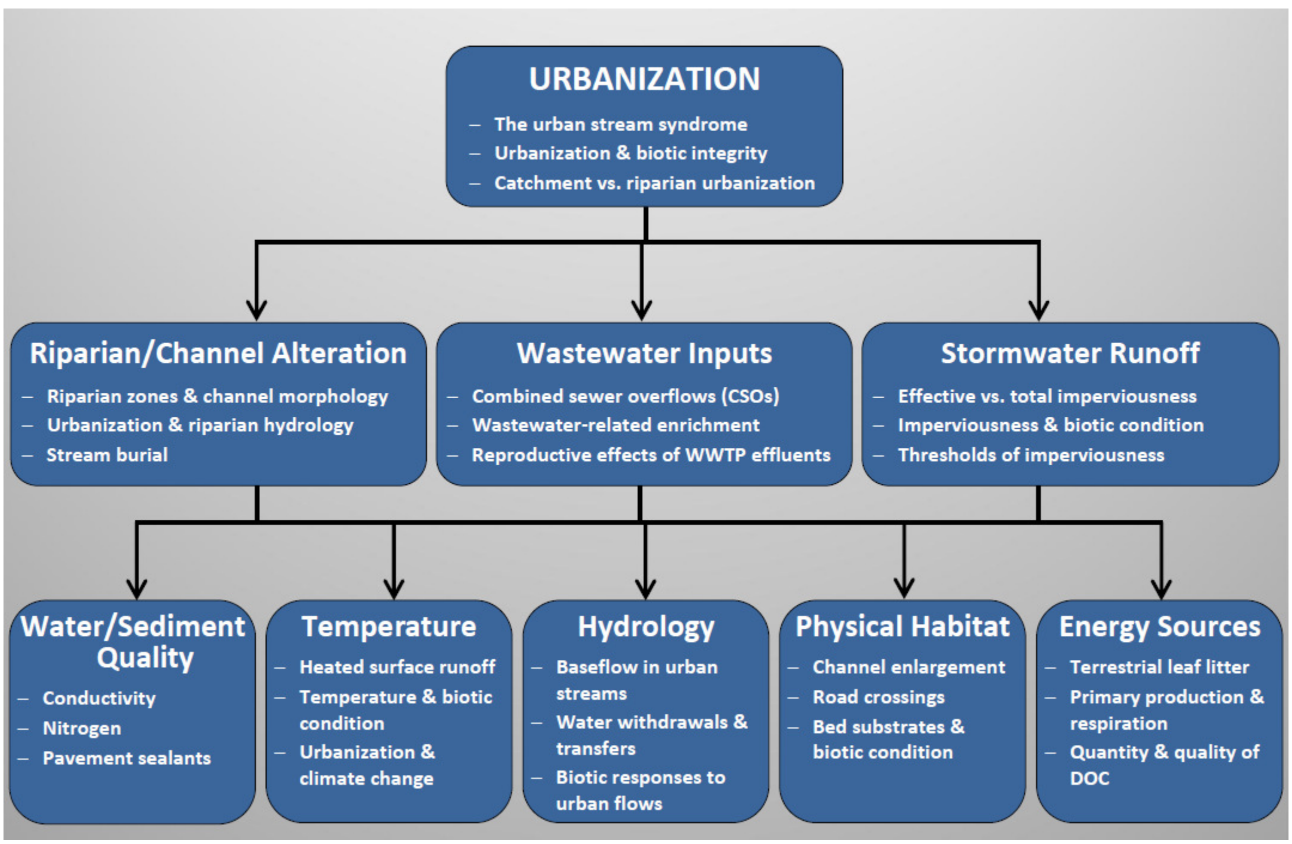

Figure 1-1 Schematic Illustrating Urbanization Effects on Stream Ecosystems (USEPA, 2016a)

1.1.1. History

Stormwater was unregulated at the federal level prior to 1972, when Congress amended the Federal Water Pollution Control Act to address growing public concern regarding surface water pollution. The amendment became commonly known as the Clean Water Act (CWA). The CWA provided EPA the authority to implement pollution control programs and made discharges of any pollutant from a point source into navigable waters unlawful without obtaining a permit following the CWA framework known as the National Pollutant Discharge Elimination System (NPDES). The 1972 amendment focused mainly on industrial and municipal wastewaters and was successful at implementing pollution control measures for those process waters. However, water quality impairments continued throughout the 1970s and 1980s due to a variety of causes including stormwater runoff. To address stormwater, Section 402(p) was added to the CWA that established a two phase approach through the NPDES program. The Phase I Stormwater Rule was issued by EPA in 1990 and was required for operators of municipal separate storm sewer systems (MS4s) serving populations over 100,000; for runoff associated with industrial activity; and for runoff from construction sites five acres or larger. The Phase II Stormwater Rule was issued by EPA in 1999 and expanded requirements to small MS4s in urban areas and to construction sites between one and five acres.

1.1.2. Permit Requirements

Federal regulation of stormwater stems from Section 402 of the CWA, Parts 122 and 126 of Title 40 of the Code of Federal Regulations. The State of Texas assumed the authority to administer the NPDES program in 1998. The Texas Commission on Environmental Quality (TCEQ) Texas Pollutant Discharge Elimination System (TPDES) program now has federal regulatory authority over discharges of pollutants to Texas surface water, with the exception of discharges associated with oil, gas, and geothermal exploration and development activities, which are regulated by the Railroad Commission of Texas. State regulation of stormwater stems from Chapter 26 of the Texas Water Code. State regulations are found in Part I of Title 30 of the Texas Administrative Code. In general, the statutory and regulatory framework requires operators of facilities or systems that discharge pollutants in stormwater runoff to waters of the United States to obtain and maintain authorization for the discharge in the form of a permit. Currently the regulatory framework requires the implementation of programmatic controls (i.e., BMPs) to reduce or eliminate pollutants in stormwater to the maximum extent practicable.

Section 303 of the CWA requires that waters attain designated uses and achieve water quality criteria to protect those uses. If waters do not meet these quality standards, they are deemed impaired, which will trigger the development and implementation of total maximum daily loads (TMDL). TMDLs establish pollutant load allocations, and for point sources, required load reductions are implemented via permit changes.

Under the CWA, the Phase I MS4 permit requires the development and implementation of a stormwater management program (SWMP), which defines BMPs, measurable goals, responsible parties, and an implementation schedule of control measures. The MS4 permit requires annual implementation activities, annual reporting, adjustments to BMPs that needing improvement, and identification of new BMPs where necessary. Stormwater monitoring (wet weather characterization) is a requirement of the Phase I MS4 permit.

1.1.3. Regional Stormwater Quality Issues

The Dallas-Fort Worth regional urban population growth rate has been among the fastest in the nation since 1990 (US Census Bureau, 2012). In addition to census tracking, the North Central Texas Council of Governments (NCTCOG) has documented growth in population and the number of cities in the region from 1880 to 2010 (Figure 1-2).

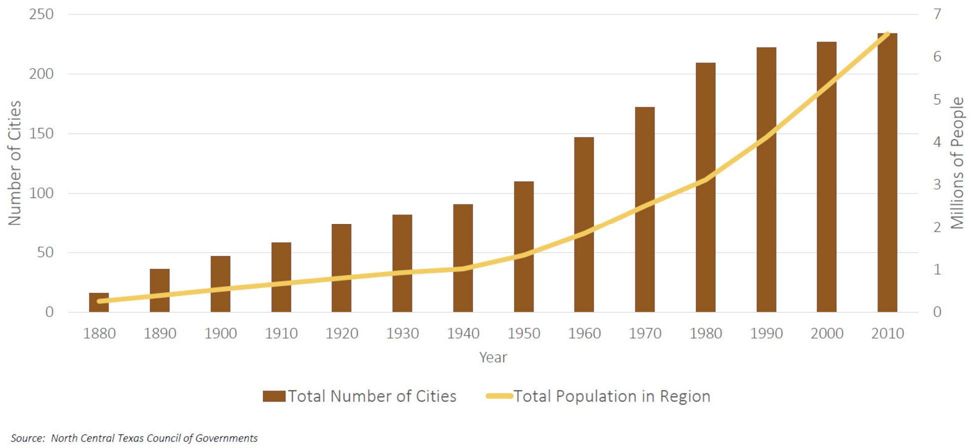

Figure 1-2 North Central Texas City and Population Counts

Incidental to this population growth, surface water quality stream segment impairments affecting Phase I communities as recorded by TCEQ in biannual surface water quality inventories have increased more than fivefold since 1992 (Figure 1-3). The surface water quality inventory describes the status of the state's waters, as required by Sections 305(b) and 303(d) of the CWA. It summarizes the condition of the state's surface waters, including concerns for public health, fitness for use by aquatic species and other wildlife, and specific pollutants and their possible sources. The number of segments affecting Phase I communities in the Dallas-Fort Worth region with EPA approved TMDLs has been also been increasing steadily since 2002 (Figure 1-3).

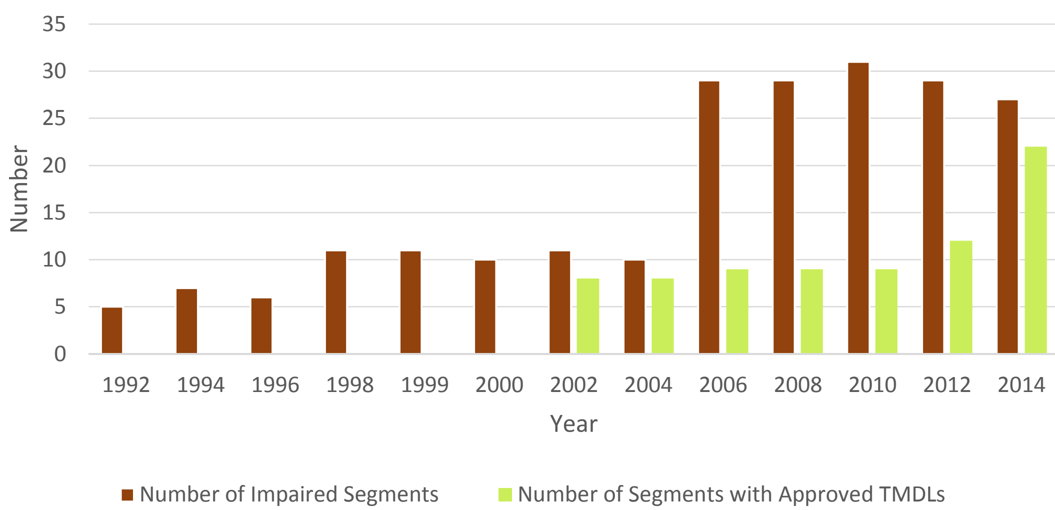

Figure 1-3 North Central Texas Surface Water Quality Impairments Affecting Phase I Communities (1992 to 2014)

Of stream segments that receive stormwater from Phase I regulated entities in the NCTCOG region, the most recent (2014) TCEQ Texas Integrated Report for the Clean Water Act Sections 305(b) and 303(d) identified twenty-seven water quality stream segment impairments (Table 1-1). Bacteria impairments predominate the list affecting a majority of Phase I regulated entities in the region. Dioxin and PCBs are a concern for the Upper Trinity River and major tributaries near the central urban centers of Dallas and Fort Worth. Legacy pollutants (aldrin and dieldrin) are a concern for waterbodies west of Fort Worth (Lake Worth and the West Fork Trinity River. Sulfate and total dissolved solids are a concern in the East Fork of the Trinity River below Lake Ray Hubbard and pH is a concern for Grapevine Lake.

Table 1-1 2014 Index of Water Quality Stream Segment Impairments Affecting Phase I Communities in the Dallas-Fort Worth Region

TCEQ Segment Number	TCEQ Segment Name	Impairment
0805	Upper Trinity River	Bacteria; dioxin and PCBs in edible tissue
0806	West Fork Trinity River Below Lake Worth	Dioxin and PCBs in edible tissue
0806E	Sycamore Creek	Bacteria
0807	Lake Worth	Aldrin & dieldrin in fish tissue; PCBs in edible tissue
0808	West Fork Trinity River Below Eagle Mountain Reservoir	Aldrin & dieldrin in fish tissue; PCBs in edible tissue
0819	East Fork Trinity River	Sulfate & Total Dissolved Solids
0820B	Rowlett Creek	Bacteria
0822A	Cottonwood Branch	Bacteria
0822B	Grapevine Creek	Bacteria
0826	Grapevine Lake	pH
0828A	Village Creek	Bacteria
0829	Clear Fork Trinity River Below Benbrook Lake	Dioxin & PCBs in edible tissue
0838C	Walnut Creek	Bacteria; dioxin & PCBs in edible tissue
0841	Lower West Fork Trinity River	Bacteria; dioxin & PCBs in edible tissue
0841A	Mountain Creek Lake	Dioxin & PCBs in edible tissue
0841F	Cottonwood Creek	Bacteria
0841G	Dalworth Creek	Bacteria
0841H	Delaware Creek	Bacteria
0841J	Estelle Creek	Bacteria
0841K	Fish Creek	Bacteria
0841L	Johnson Creek	Bacteria
0841M	Kee Branch	Bacteria
0841N	Kirby Creek	Bacteria
0841R	Rush Creek	Bacteria
0841T	Village Creek	Bacteria
0841U	West Irving Creek	Bacteria
0841V	Crockett Branch	Bacteria

Segments with approved TMDLs receiving stormwater runoff from Phase I regulated entities in the NCTCOG region fall under four TMDL projects listed below:

- Dallas and Tarrant County Legacy Pollutants
  - Nine Total Maximum Daily Loads for Legacy Pollutants in Streams and a Reservoir in Dallas and Tarrant Counties: For Segments 0805, 0841, and 0841A (approved June 27, 2001)
- Fort Worth Legacy Pollutants
  - Eleven Total Maximum Daily Loads for Legacy Pollutants in Streams and Reservoirs in Fort Worth: For Segments 0806, 0806A, 0806B, 0829, and 0829A (approved May 24, 2001)
- Lake Worth Watershed
  - One Total Maximum Daily Load for Polychlorinated Biphenyls (PCBs) in Fish Tissue in Lake Worth: For Segment 0807 (adopted August 10, 2005)
- Greater Trinity Region TMDLs
  - Two Total Maximum Daily Loads for Indicator Bacteria in Cottonwood Branch and Grapevine Creek: For Segments 0822A and 0822B (approved May 30, 2012)
  - Thirteen Total Maximum Daily Loads for Indicator Bacteria in Lower West Fork Trinity River and Tributaries: For Segments 0841, 0841B, 0841C, 0841E, 0841G, 0841H, 0841J, 0841L, 0841M, 0841R, 0841T, and 0841U (approved November 7, 2013)
  - Two Total Maximum Daily Loads for Indicator Bacteria in the Upper Trinity River: For Segment 0805 (approved August 3, 2011)

Most of the existing TMDLs are for bacteria impairments. Dioxin, PCBs, and legacy pollutants (aldrin and dieldrin) constitute the remainder of the existing TMDLs. In addition, there is a TMDL project in development to assess PCBs in fish tissue in the Upper Trinity River. This project is for segments 0805, 0806, 0829, and 0841.

1.2. North Central Texas Council of Governments Regional Stormwater Management Program

1.2.1. Regional Stormwater Monitoring Program

1.2.1.1. Background

During the application phase of the EPA's NPDES large and medium MS4 (Phase I) permitting program in the 1990s, Dallas-Fort Worth area cities, including Arlington, Dallas, Fort Worth, Garland, Irving, Mesquite, and Plano, along with the Dallas and Fort Worth Districts of the Texas Department of Transportation (TxDOT) , worked with the NCTCOG to form a regional partnership and strategy to conduct wet-weather monitoring activities. This partnership developed a regional monitoring program. A network of 30 monitoring sites was negotiated with EPA Region 6. The 30 sites represented small, single predominant land uses. From 1992 through 1994, 210 storm events were sampled for 188 constituents. The data was used for the application process for their NPDES stormwater permits.

After the application phase, the permit phase (first permit term) required a continuation of monitoring activities. The regional program participants analyzed the application period data in order to improve the program and to find cost-effectiveness. The resulting analysis determined that several sites could be discontinued and several of the 188 constituents were never detected and could therefore be dropped from the monitoring list (NCTCOG, 2003). The regional program went forward with a new set of parameters and monitoring locations. From 1997 through 2001, over 330 samples were collected from a 22 site network for 33 constituents. Most of these samples were collected from areas with a small watershed consisting of a predominant land use type. At the conclusion of the monitoring activities, the monitoring partners recognized a need to characterize general urban runoff and its impact to receiving streams.

During the permit renewal phase (second permit term) and moving toward a TPDES permit, the regional program participants proposed a strategy of in-stream monitoring during wet-weather conditions to find a means to more accurately evaluate receiving water impacts (NCTCOG, 2003). The revised program was termed the Regional Wet Weather Characterization Program (RWWCP) and was added as an option in the Texas Pollutant Discharge Elimination System (TPDES) Municipal Separate Storm Sewer System (MS4) permits issued to the Phase I North Central Texas governmental entities. The North Texas Tollway Authority (NTTA) joined the regional program and the TxDOT-Fort Worth District became a co-permittee with the cities of Fort Worth and Arlington and was no longer required to conduct wet weather monitoring; however, all other partners remained the same. The goal of the in-stream monitoring program was to determine long-term water quality trends, assess the impacts of stormwater on receiving stream quality, and establish a potential tool to evaluate BMP effectiveness. The permit option was approved by the TCEQ on April 15, 2003. During the second permit term, 24 watersheds were monitored using a 77 monitoring site network from 2007 to 2009. A total of 285 samples were collected with each watershed being sampled once per year (Figure 1-4).

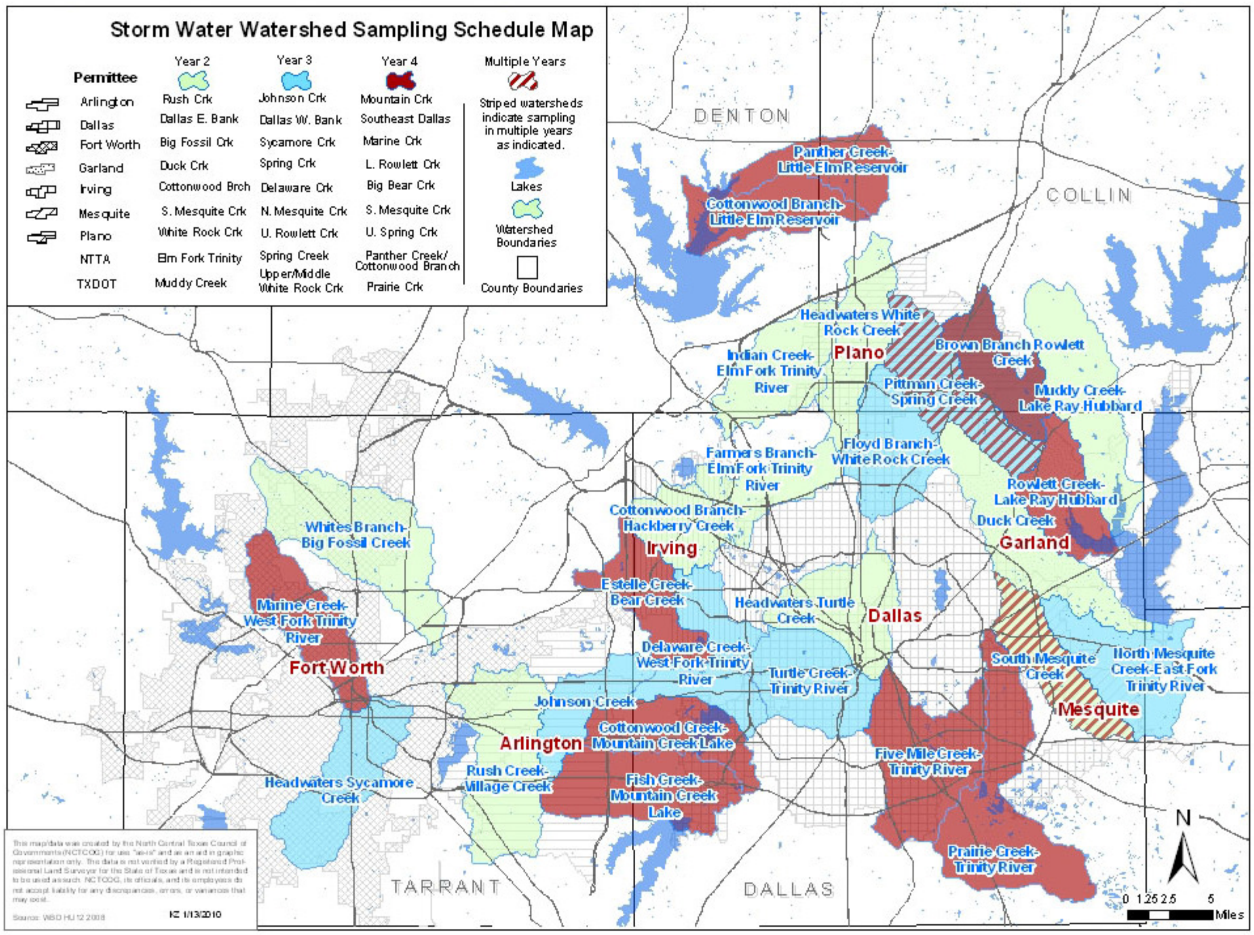

Figure 1-4 NCTCOG RWWCP Second Permit Term Monitored Watersheds

An assessment of the second permit term's sampling effort resulted in the following recommendations for modifying the RWWCP in the third permit term (2011 to 2016): obtain additional data to establish long-term, in-stream water quality trends; increase the frequency of monitoring in watersheds; refine the sampling site selection process; conduct more rapid bioassessments in other jurisdictions; and revise the pollutants monitored. During the third permit term, the RWWCP continued in-stream watershed monitoring and the assessment of urban impacts on receiving stream water quality as well as initiated documentation of local BMP implementation in order to track potential improvement in future terms.

1.2.1.2. Third Permit Term Monitoring Partners

The RWWCP exists as an option (Part IV.A.1) in the TPDES MS4 permits issued to the Phase I North Central Texas governmental entities. The approved RWWCP must meet or exceed the goals of the

Representative Monitoring requirement (Part IV.A.2). The RWWCP language exists outside of each permit, allowing for greater flexibility in this unique program. The RWWCP officially began its five-year implementation plan for all participants on June 17, 2011 with the issuance of the City of Garland's TPDES MS4 permit. As documented in the February 11, 2011 approval letter from TCEQ (Appendix A), all participants in the RWWCP received credit for sampling based on this start date regardless of permit renewal issuance dates. Year 1 of the Regional Monitoring Program was considered to be from January through December 2011. Year 2 and subsequent years also followed the calendar year schedule (e.g.; Year 2, January through December 2012) in accordance with the schedule outlined in the RWWCP and approved by TCEQ.

The permit requirements for collecting storm event data, seasonal loadings, and event mean concentrations as found in Parts IV.A.4 and IV.A.5 of the permit do not apply to the RWWCP, yet the Regional Monitoring Program does include collection and reporting of storm event data. Each program participant must coordinate with all other program participants on any proposed amendments to the RWWCP.

The cities of Arlington, Dallas, Fort Worth, Garland, Irving, Mesquite, Plano, NTTA, and TxDOT – Dallas District participated in the third permit term program. Permit numbers for each participant are included in Table 1-2.

Table 1-2 List of Permittees Participating in the RWWCP

Permittee	TPDES Permit Number	Date Issued
Arlington	WQ0004635000	4/26/2012
Dallas	WQ0004396000	10/6/2011
Fort Worth	WQ0004350000	7/29/2011
Garland	WQ0004682000	6/17/2011
Irving	WQ0004691000	8/6/2014
Mesquite	WQ0004641000	10/18/2011
Plano	WQ0004775000	12/2/2015
North Texas Tollway Authority	WQ0004400000	8/5/2011
TXDOT-Dallas District	WQ0004521000	4/27/2012

1.2.1.3. Regional Monitoring Contract

On October 17, 2011, NCTCOG retained Atkins (in association with Freese and Nichols; Dougherty Sprague Environmental, Inc., and TTI Environmental Laboratories) under a Contract for Consulting Services to develop a comprehensive monitoring plan and perform long-term systematic stormwater quality monitoring at 17 in-stream stations across the Dallas-Fort Worth Metroplex area to collect quarterly samples, analyze them, and assist with determining long-term trends and potentially assessing impacts of stormwater on receiving streams. The monitoring was performed in the jurisdiction of seven entities, each holding a TPDES stormwater discharge permit (Cities of Arlington, Garland, Irving, Mesquite, Plano, and roadway authorities NTTA and TxDOT-Dallas District). In addition, Atkins was under contract to develop a comprehensive monitoring plan and perform biomonitoring activities at two Plano watersheds and two Garland watersheds during the permit term. Fort Worth and Dallas watersheds were monitored by their own staff.

Stormwater monitoring was conducted four times a year (quarterly) for four years, starting in 2012 and ending in 2015 (Atkins, 2014a). Arlington, Garland, and Irving watersheds were monitored at three sites (upstream, midstream, and downstream) and the Plano watersheds were monitored at two locations. Mesquite and the roadway authorities monitored two separate watersheds each year with single monitoring locations in each watershed.

Biomonitoring was conducted twice a year for four years, starting in 2012 and ending in 2015 (Atkins, 2014b). For both Garland and Plano, two watersheds were monitored for the first two years and then two separate watersheds were monitored the final two years.

This report describes the monitoring locations, summarizes the annual monitoring activities, analyzes and discusses the data, and provides conclusions and recommendations for future monitoring. All sample collection occurred during the period from January 1, 2012, through December 31, 2015, with the exception of the City of Fort Worth, which will also conduct chemical sampling and bioassessments in 2016. The City of Fort Worth 2016 data is not included in this report.

For this project, Atkins (in association with Freese and Nichols; Dougherty Sprague Environmental, Inc., and TTI Environmental Laboratories) performed the following tasks:

- Procured all necessary stormwater quality equipment.
- Conducted initial and refresher training for monitoring staff and stakeholders.
- Developed a monitoring plan and quality assurance project plan for stormwater collection.
- Developed a monitoring plan for bioassessment monitoring.
- Assisted seven entities with the selection of monitoring sites for each monitoring year.
- Deployed and installed monitoring equipment for seven entities each monitoring year.
- Tracked and monitored weather for qualifying storms.
- Developed event summary reports for each successful event and submitted to the NCTCOG for review and posting to the NCTCOG's on-line web data viewer.
- Conducted routine maintenance on all monitoring equipment.
- Reviewed annual reports developed by the NCTCOG for submission to the TCEQ.
- Analyzed data from these activities.
- Compiled this report to present the results of in-stream monitoring during wet weather conditions to assist with developing a baseline data set, evaluating the data for trends and recommending activities for future monitoring efforts.

1.2.1.4. Assessment Basin and Monitored Watersheds

Through the RWWCP, municipal regional partners effectively monitored at least 50 percent of their jurisdictional area (jurisdictional coverage was not considered in the selection of the two transportation agency watersheds). All of the jurisdictional areas fall within the Trinity River Basin. The West Fork and Clear Fork of the Trinity River flow through jurisdictional areas on the western side of the Dallas-Fort Worth Metroplex receiving flow from Parker, Tarrant, and Wise counties before joining the main stem in Dallas County. The Elm Fork enters jurisdictional areas from the north from Denton County and converges with the West Fork in Dallas County. The river is called the Trinity downstream of the West Fork/Elm Fork confluence. The East Fork passes on the eastern side of the Dallas-Fort Worth Metroplex receiving flow from Collin, Dallas, and Kaufman counties.

The Natural Resource Conservation Service (NRCS), in collaboration with several other federal agencies, developed the Watershed Boundary Dataset (WBD) which was released in 2008. The watershed boundaries are defined as “drainage areas delineated to nest in a multi-level, hierarchical drainage system” (USDA NRCS, 2004). They are characterized by 6-digit, 8-digit, 10-digit, and 12-digit hydrologic unit codes which are associated with the specific hierarchical level (e.g. basin (HUC6) to sub-basin (HUC8) to watershed (HUC10) to subwatershed (HUC12)). These hydrologic boundaries were delineated and georeferenced to the USGS 1:24,000 scale topographic base map, meeting National Map Accuracy Standards (NMAS). The drainage level displayed in maps in this report is the subwatershed (HUC12) level. The NCTCOG identified subwatersheds within the Dallas-Fort Worth Metroplex by using these HUC12 level cataloging units. These cataloging units are referred to within this report as “watersheds”. In many cases, the monitored streams represent only a fraction of the HUC12 watershed. These drainage areas are also identified based upon the location of the monitoring stations within the larger watersheds.

The Regional partners conducted chemical sampling within 24 watersheds and performed rapid bioassessments (biological monitoring) within 14 watersheds, with substantial overlap between the two sampling approaches. Only the cities of Dallas, Fort Worth, Garland, and Plano performed rapid bioassessments.

Figure 1-5 provides a graphical representation of the watersheds sampled during the third permit term.

1.2.2. Purpose and Use of Data Collection

Chemical monitoring and bioassessments assess the status of a water body relative to the primary goal of the Clean Water Act (CWA). Instream chemical data during wet weather events is useful for documenting and tracking the success or failure of stormwater management in the region. Biological assemblages reflect overall ecological integrity (i.e., chemical, physical, and biological integrity) of the stream. Both chemical and bioassessment data provide direct measurements of water quality and aquatic life use criteria that the Texas Surface Water Quality Standards (TSWQS) are meant to protect. Therefore, both chemical and bioassessment monitoring can be an effective tool for planning water quality monitoring and management activities.

Long term measurement of instream chemical data as well as biological assemblages integrate the effects of different stressors as well as integrating the stresses over time and thus provide a broad measure of their aggregate impact over time. Both chemical and biological data is of direct interest to the public as a measure of a pollution free environment.

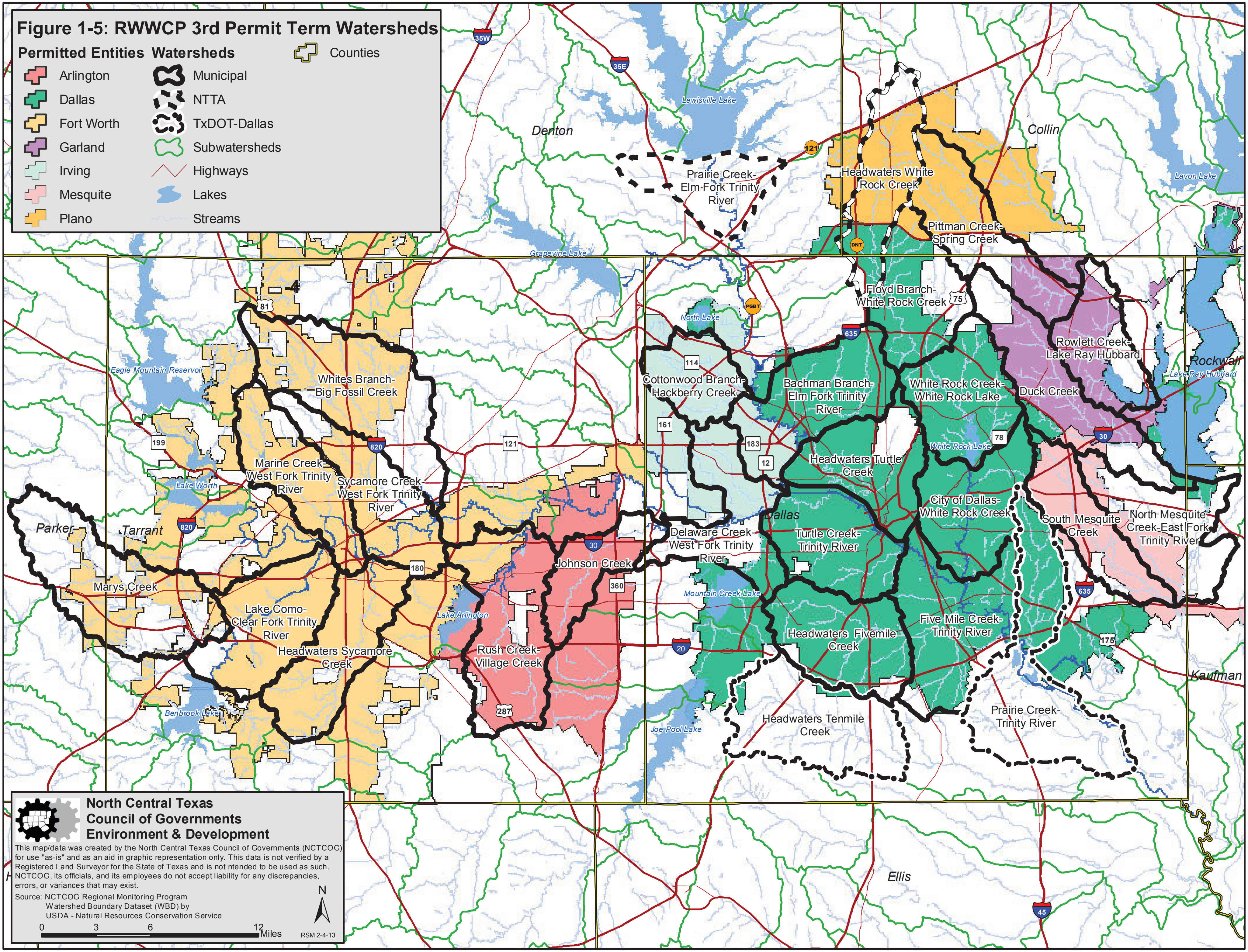
Figure 1-5: RWWCP 3rd Permit Term Watersheds
Permitted Entities
Arlington
Dallas
Fort Worth
Garland
Irving
Mesquite
Plano
Watersheds
Municipal
NTTA
TxDOT-Dallas
Subwatersheds
Highways
Lakes
Streams
Counties
Denton
Collin
Parker
Tarrant
Dallas
Rockwall
Kaufman
Ellis
Lewisville Lake
Lavon Lake
Grapevine Lake
Eagle Mountain Reservoir
North Lake
Lake Worth
Lake Ray Hubbard
White Rock Lake
Mountain Creek Lake
Lake Arlington
Benbrook Lake
Joe Pool Lake
Prairie Creek-Elm Fork Trinity River
Headwaters White Rock Creek
Pittman Creek-Spring Creek
Floyd Branch-White Rock Creek
Rowlett Creek-Lake Ray Hubbard
Duck Creek
White Rock Creek-White Rock Lake
Bachman Branch-Elm Fork Trinity River
Cottonwood Branch-Hackberry Creek
Whites Branch-Big Fossil Creek
Marine Creek-West Fork Trinity River
Sycamore Creek-West Fork Trinity River
Headwaters Turtle Creek
City of Dallas-White Rock Creek
South Mesquite Creek
North Mesquite Creek-East Fork Trinity River
Delaware Creek-West Fork Trinity River
Turtle Creek-Trinity River
Johnson Creek
Marys Creek
Lake Como-Clear Fork Trinity River
Headwaters Sycamore Creek
Rush Creek-Village Creek
Headwaters Fivemile Creek
Five Mile Creek-Trinity River
Headwaters Tenmile Creek
Prairie Creek-Trinity River
35W
35E
121
DNT
PGBT
75
635
114
161
183
12
78
30
81
199
820
121
180
360
20
287
175
45
North Central Texas Council of Governments Environment & Development
This map/data was created by the North Central Texas Council of Governments (NCTCOG) for use "as-is" and as an aid in graphic representation only. This data is not verified by a Registered Land Surveyor for the State of Texas and is not ntended to be used as such. NCTCOG, its officials, and its employees do not accept liability for any discrepancies, errors, or variances that may exist.
Source: NCTCOG Regional Monitoring Program
Watershed Boundary Dataset (WBD) by
USDA - Natural Resources Conservation Service
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0 3 6 12 Miles
RSM 2-4-13

2. Third Term Program Elements

2.1. Sampling Methodologies

2.1.1. Chemical Monitoring

Most of the RWWCP participants are performing chemical sampling on one watershed within their jurisdiction for two consecutive years and then moving to a second watershed for another two years. Exceptions include the cities of Dallas, Fort Worth, Mesquite, and TxDOT-Dallas District. Due to the size of their jurisdictional area, Dallas selected eight watersheds and Fort Worth selected six watersheds for chemical and/or biological monitoring. Mesquite has a unique situation where only two watersheds and the two creeks of those watersheds are almost wholly contained within the city limits. Mesquite chose to establish permanent in-stream monitoring stations in each of the two creeks and to sample them concurrently all four years. An acceptable second sampling site for TxDOT-Dallas' Prairie Creek-Trinity River watershed could not be located due to physical and land ownership constraints. Therefore TxDOT-Dallas chose to conduct sampling at one location in each of their two watersheds for all four years (similar to Mesquite). Refer to Appendix A for documentation.

For chemical monitoring, grab samples were collected during the first flush and analyzed for E. coli, total coliforms, oil and grease, and pH. An additional first flush sample and four subsequent samples collected at equal time intervals were taken over the first two hours of the event and combined for a composite sample. Samples were collected for no more than two hours, regardless of storm duration. The grab samples were obtained either manually or from some type of automated collection device to better address safety concerns.

Sampling was conducted only on qualifying events which were defined as satisfying the following requirements: 1) antecedent dry period of 72 hours minimum, 2) rainfall volume of 0.10 inch minimum, and a 3) quantifiable increase in water surface elevation attributable to stormwater runoff. Rain gauges were deployed in each watershed to support the assessment of local wet weather conditions.

Chemical samples were collected with automatic sampling equipment that allowed the collection of water through a stainless steel strainer and flexible sampling tubing using a peristaltic pump. Samples were then pumped into four 1-gallon glass containers located in a stormwater sampler shelter. The automatic samplers were also equipped with bubbler flow modules that activated the samplers based on an increase in water surface elevation in the stream conveyance channel. Upon successful collection, the samples were preserved in ice and delivered immediately to the laboratory for analysis.

2.1.2. Bioassessments

Dallas, Fort Worth, Garland, and Plano conducted bioassessments. EPA and TCEQ have developed an array of methods and approaches that can be used in conducting bioassessments. Both of these regulatory entities have developed manuals outlining these various steps. As EPA states in their manual, Rapid Bioassessment Protocols for Use in Streams and Wadeable Rivers: Periphyton, Benthic Macroinvertebrates, and Fish, 2nd Ed. (1999) the protocols described are not "intended to be used as a rigid protocol without regional modifications. Instead, they provide options for agencies or groups that wish to implement rapid biological assessment and monitoring techniques."

As such, the regional program participants that are implementing bioassessments performed bioassessments based upon protocols as set forth in applicable EPA and TCEQ manuals. These protocols are detailed in their respective documents (see next section), but generally involve habitat assessment, a measurement of standard field physical conditions, and collection and identification of macroinvertebrates and possibly other biota. Watershed parameters were compared to a baseline standard to determine the habitat's health, through use of a reference site or other methods.

2.1.3. Overview of Protocols

2.1.3.1. "Regional" Stormwater Monitoring and Bioassessment Protocols

The cities of Arlington, Garland, Irving, Mesquite, Plano, the North Texas Tollway Authority, and TxDOT-Dallas District contracted with Atkins (in association with Freese and Nichols; Dougherty Sprague Environmental, Inc., and TTI Environmental Laboratories) to assist with the field collection and analysis of their stormwater samples.

Atkins prepared the Regional Stormwater Monitoring Program: Monitoring Program and Quality Assurance Project Plan for Wet Weather Equipment Deployment and Sampling Protocol, 2011-2016 (Atkins, 2014a) and Regional Stormwater Monitoring Program: Bioassessment Monitoring Plan, 2011-2016 (Atkins, 2014b) as the protocols for the listed MS4s.

All chemical sampling sites were equipped with automatic samplers (ISCO 6712, ISCO 730 Bubbler Module) that contained four 1-gallon glass sample containers. The sampler collected 0.5-gallon aliquots every 30 minutes after the initial sample for 120 minutes. Sample container one, or the grab sample container, contained one 1-gallon aliquot, sample containers two and three contained two 0.5-gallon aliquots, and sample container four contained one 0.5-gallon aliquot. All of the upstream sampling sites included a tipping bucket rain gauge (ISCO 674) to verify rainfall amounts and antecedent dry periods. Graduated cylinder rain gauges were used at some of the other sites. In the event that the on-site rain gauge information was not applicable (e.g., malfunction or qualifying storm was located only at the mid- or downstream stations), an online rain gauge was used to verify the rainfall amount and antecedent dry period. Atkins used TTI Laboratories to carry out any analysis of samples collected. Laboratory certification information is available in the Annual Regional Wet Weather Characterization Program Monitoring Report for North Central Texas Year 2 through Year 5 (NCTCOG, 2013; NCTCOG, 2014; NCTCOG, 2015; NCTCOG, 2016).

Rapid bioassessment monitoring was conducted for the cities of Garland and Plano. Benthic macroinvertebrate and fish communities were sampled and data compared with metrics from the Texas Commission on Environmental Quality (TCEQ). Habitat, water chemistry, and flow were also measured in each trip. Streams evaluated were in the Texas Blackland Prairie ecoregion (Ecoregion 32). Within an ecoregion, soils, climate, landforms, and vegetation are expected to be similar. Reference conditions for benthic macroinvertebrates and fish inhabiting wadeable streams in the Texas Blackland Prairie ecoregion are described by TCEQ. Evaluating benthic macroinvertebrates and fish communities with the TCEQ-established metrics to calculate aquatic life use may indicate whether the streams have been impacted by human activities.

The cities of Dallas and Fort Worth conduct their operations separately and have developed protocol documents to address the minor variances in their programs.

2.1.3.2. City of Dallas Protocol

The City of Dallas uses the "Regional" Stormwater Monitoring and Bioassessment Protocols (described above) as their base protocols for stormwater sampling and bioassessment activities with exceptions noted in correspondence contained in Appendix B. The City of Dallas utilizes city personnel to operate their own equipment and to collect stormwater samples. City of Dallas staff also conduct bioassessment activities. The protocol documents include maps of Dallas' 2012 through 2015 stormwater sampling and bioassessment sites.

The City of Dallas uses the ISCO 6712 model with ISCO 674 Rain Gauge and ISCO 750 Flow Meter for stormwater sample collection. The City of Dallas uses a program script designed to collect and analyze samples for parameters with short hold time from the three sampling stations in one rain event. Sampler equipment is programmed to activate at a one-inch level rise within a one-hour period. At activation, the sampler collects two-one gallon samples (1st flush). Then after fifteen minutes, the sampler fills the remaining two one gallon jars (composite) over an hour period in five equal aliquots. The City of Dallas used TTI Laboratories to carry out any analysis of samples collected. Laboratory certification information is available in the Annual Regional Wet Weather Characterization Program Monitoring Report for North Central Texas Year 2 through Year 5 (NCTCOG, 2013; NCTCOG, 2014; NCTCOG, 2015; NCTCOG, 2016).

The City of Dallas performs rapid bioassessment protocol (RBP) monitoring as a part of the RWWCP and conducts additional RBP monitoring beyond the regional program as part of their individual MS4 Permit Stormwater Management Program. The City uses the rapid bioassessment protocols (RBP) as set forth in the TCEQ “Surface Water Quality Monitoring Procedures, Volume 2: Methods for Collecting and Analyzing Biological Community and Habitat Data (TCEQ, 2007, RG-416). The RBP monitoring evaluates the chemical, physical, and biological in-stream features that promote a healthy and diverse habitat; as such they provide a good assessment of overall watershed health. The RBP monitoring program involves performing an Aquatic Life Use (ALU) assessment through benthic macro-invertebrate collection, habitat assessment, and evaluating water quality samples.

Two sampling events were conducted in accordance with the index periods established by TCEQ for biological sampling:

- Spring Period (March 15 to June 30): Targets spring’s optimal conditions for biological community growth.
- Summer Period (July 1 to September 30): Reflects impacts from typical summer low flows and higher water temperatures.

Under the RBP, each water body is given a composite score that is determined through evaluation of numbers and diversity of macro invertebrates, water quality parameters, stream habitat features and other metrics. A sample of each monitoring site’s macro invertebrate community determines the sites’ Aquatic Life Use (ALU) metric. Since 2005, the City of Dallas has used the Benthic Macro-invertebrate Index of Biotic Integrity (IBI) to test ALU. A sample from each monitoring site is tested according to the IBI.

2.1.3.3. City of Fort Worth Protocol

The City of Fort Worth developed a separate protocol, City of Fort Worth Regional Wet Weather Characterization Program Monitoring Plan (City of Fort Worth, 2012), for conducting their stormwater sampling and bioassessment activities. The City of Fort Worth utilizes city personnel to operate their own equipment and to collect stormwater samples. City of Fort Worth staff also conduct bioassessment activities. The protocol document includes location information for Fort Worth’s stormwater sampling and bioassessment sites.

The City of Fort Worth identified chemical sampling sites for 2016. The watersheds and site selection for those years was determined following completion of Year 3 (2014) sampling activities and is based on assessment of the chemical, physical and biological impacts to the receiving waters during 2012-2014 monitoring. For 2016, Fort Worth will collect samples from the Lake Como – Clear Fork Trinity River and Whites Branch – Big Fossil Creek watersheds. Fort Worth will use the same sample site locations for those watersheds as in previous years. The data from the City of Fort Worth 2016 sample collection was not available for this report.

Automatic water samplers (ISCO 3700 or other) were deployed at the site(s) to be monitored prior to the rain event. The samplers were programmed to initiate sampling at a 1.0 inch rise in the receiving stream water level. Upon activation, the sampler collected a “first flush” grab sample and the first of four sub-samples for a time-weighted composite sample. Subsequent sub-samples were collected at 30-minute intervals. The City of Fort Worth Water Department Centralized Water and Wastewater Laboratory conducted analysis of most parameters and subcontracted analysis of the remaining parameters to Accutest Laboratories. Laboratory certification information is available in the Annual Regional Wet Weather Characterization Program Monitoring Report for North Central Texas Year 2 through Year 5 (NCTCOG, 2013; NCTCOG, 2014; NCTCOG, 2015; NCTCOG, 2016).

The City of Fort Worth performs rapid bioassessments on representative creeks within six watersheds twice per year as a part of the RWWCP monitoring program and to satisfy their storm water monitoring program requirements. Methods for bioassessments are based on protocols set forth in TCEQ, USEPA, and Texas

Parks and Wildlife guidance documents. A description of methodology may be found in the full bioassessment reports provided in the Annual Regional Wet Weather Characterization Program Monitoring Report for North Central Texas Year 2 through Year 5 (NCTCOG, 2013; NCTCOG, 2014; NCTCOG, 2015; NCTCOG, 2016). Regional rapid bioassessments included habitat assessment, chemical and physical water quality parameter evaluation, sample collection and analysis of benthic macroinvertebrate and fish communities. Sampling was conducted during late spring (June) and fall (October) 2015 on at least two sites on each creek.

Habitat assessments are based on USEPA guidelines for high gradient streams as outlined in Rapid Bioassessment Protocol for Use in Streams and Wadeable Rivers, second edition (EPA 841-B-99-002). Macroinvertebrate data analysis included two different methods. One analysis is an USEPA based comparison method, where the collected macroinvertebrate community metric scores at a site are generated based on a comparison to a reference site community and assigned a degree of impairment. The second analysis is the TCEQ-based Index of Biotic Integrity (IBI). The metric calculation scores at a site for the IBI are compared to values in TCEQ guidelines and each site is assigned an aquatic life use rating. As such, individual sites may be compared to themselves year to year on a seasonal basis (spring to spring and fall to fall) to demonstrate community changes within each reach.

Collected fish were analyzed using the protocol detailed in the Texas Parks and Wildlife publication Regionalization of the Index of Biotic Integrity for Texas Streams (Linam, G., Kleinsasser, L., Mayes, K., June 2002). The metrics in this method were specifically developed for each Texas ecoregion. The metric calculation scores for the IBI are compared to values found in the guidance document and each site is assigned an aquatic life use rating.

2.2. Sample Collection Schedule

Table 2-1 contains information on the watersheds monitored and number of samples collected and bioassessments conducted for each of the monitoring partners during the third permit term.

Table 2-1 RWWCP Sampling Schedule

Jurisdiction / Watershed	Number of Samples to be Collected[1]				
	2012	2013	2014	2015	2016[2]
Arlington					
Johnson Creek	12C	12C			
Rush Creek			12C	12C	
Dallas					
Headwaters Turtle Creek	12C		12C		
Turtle Creek-Trinity River	12C		12C		
City of Dallas-White Rock Creek		12C		12C	
Five Mile Creek-Trinity River		12C		12C	
Bachman Branch-Elm Fork Trinity River	2B	2B	2B	2B	
Floyd Branch-White Rock Creek	2B	2B	2B	2B	
Headwaters Five Mile Creek	2B	2B	2B	2B	
White Rock Creek-White Rock Lake	2B	2B	2B	2B	
Fort Worth					
Headwaters Sycamore Creek	4B	4B	2C / 4B	4B	4B
Lake Como-Clear Fork Trinity River	2C / 4B	4B	4B	4B	2C / 4B
Marine Creek-West Fork Trinity River	2C / 4B	4B	4B	2C / 4B	4B
Mary's Creek	4B	4B	2C / 4B	4B	4B
Sycamore Creek-West Fork Trinity River	4B	2C / 4B	4B	2C / 4B	4B
Whites Branch-Big Fossil Creek	4B	2C / 4B	4B	4B	2C / 4B
Garland					
Duck Creek	12C / 2B	12C / 2B			
Rowlett Creek-Lake Ray Hubbard			12C / 2B	12C / 2B	
Irving					
Delaware Creek-West Fork Trinity River	12C	12C			
Cottonwood Branch-Hackberry Creek			12C	12C	
Mesquite					
N. Mesquite Creek-East Fork Trinity River	4C	4C	4C	4C	
South Mesquite Creek	4C	4C	4C	4C	
Plano					
Headwaters White Rock Creek	8C / 2B	8C / 2B			
Pittman Creek-Spring Creek			8C / 2B	8C / 2B	
North Texas Tollway Authority					
Headwaters White Rock Creek	8C	8C			
Prairie Creek-Elm Fork Trinity River			8C	8C	
TxDOT-Dallas[3]					
Headwaters Ten Mile Creek	4C	4C	4C	4C	
Prairie Creek-Trinity River	4C	4C	4C	4C	

Notes:

1. "B" Signifies bioassessment samples, "C" signifies chemical samples.
2. The City of Fort Worth will conduct sampling in 2016, which is after the 5-year timeframe of the current RWWCP.
3. This represents a change from the approved RWWCP. This change was documented in the Year 1 Regional Wet Weather Characterization Program Annual Monitoring Report, dated February 2012 (Appendix B, "Proposed Minor Amendment to the Regional Wet Weather Characterization Plan for the TxDOT-Dallas District Sampling Schedule"). This document is provided along with other RWWCP documentation in Appendix A of this report.

2.3. Monitored Parameters

Each sample was analyzed for 17 parameters which are listed in Table 2-2. Although specific conductivity and temperature are not required parameters under the approved Regional Wet Weather Characterization Plan, these parameters were collected in addition to the parameters listed in Table 2-2 at most chemical monitoring locations. Analytical methods, sample hold times, minimum laboratory reporting limits, and method detection limits are available in Atkins, 2014a.

Table 2-2 Regional Parameter Set

Parameter	Method of Collection
Oil and Grease	Grab
pH	Grab
E. Coli	Grab
Total Coliforms	Grab
Total Dissolved Solids (TDS)	Composite
Total Suspended Solids (TSS)	Composite
Biochemical Oxygen Demand (BOD)	Composite
Chemical Oxygen Demand (COD)	Composite
Total Nitrogen	Composite
Dissolved Phosphorus	Composite
Total Phosphorus	Composite
Carbaryl	Composite
Total Arsenic	Composite
Total Chromium	Composite
Total Copper	Composite
Total Lead	Composite
Total Zinc	Composite

3. Third Permit Term Monitoring Activities

This section summarizes the monitoring activities for each year. Details of the individual monitoring results (e.g., laboratory data and field summaries) can be found in the Annual Regional Wet Weather Characterization Program Monitoring Report for North Central Texas Year 2 through Year 5 (NCTCOG, 2013; NCTCOG, 2014; NCTCOG, 2015; NCTCOG, 2016).

3.1. 2012 Monitoring Activity Description

The 2012 Watersheds and Monitoring Sites map (Figure 3-1) shows the watersheds sampled in Year 2 (2012) as well as the location of the chemical sampling stations and bioassessment sites. Table 3-1 contains the corresponding list of Year 2 chemical monitoring and bioassessment sites that are part of the RWWCP along with detailed location information.

3.1.1. Chemical Sampling

All samples were successfully collected and analyzed in Year 2 (January to December 2012), with one exception. Samples collected by the City of Fort Worth were not analyzed for carbaryl due to an unintentional error in the list of parameters provided by the City of Fort Worth to the contract laboratory. The list of parameters has been corrected for samples to be collected and analyzed in 2013.

Sampling data and annual summary statistics can be found in the Annual Regional Wet Weather Characterization Program Monitoring Report for North Central Texas Year 2 (NCTCOG, 2013).

3.1.2. Bioassessments

Dallas, Fort Worth, Garland and Plano conducted bioassessment activities in Year 2. All scheduled bioassessments were successfully conducted. An overview of bioassessment activities is provided below. For complete details, refer to bioassessment reports in the Annual Regional Wet Weather Characterization Program Monitoring Report for North Central Texas Year 2 (NCTCOG, 2013).

3.1.2.1. City of Dallas

All scheduled bioassessments were conducted successfully. Two sampling events were conducted in accordance with the index periods established by TCEQ for biological sampling:

- Spring Period (March 15 to June 30): Targets spring’s optimal conditions for biological community growth.
- Summer Period (July 1 to September 30): Reflects impacts from typical summer low flows and higher water temperatures.

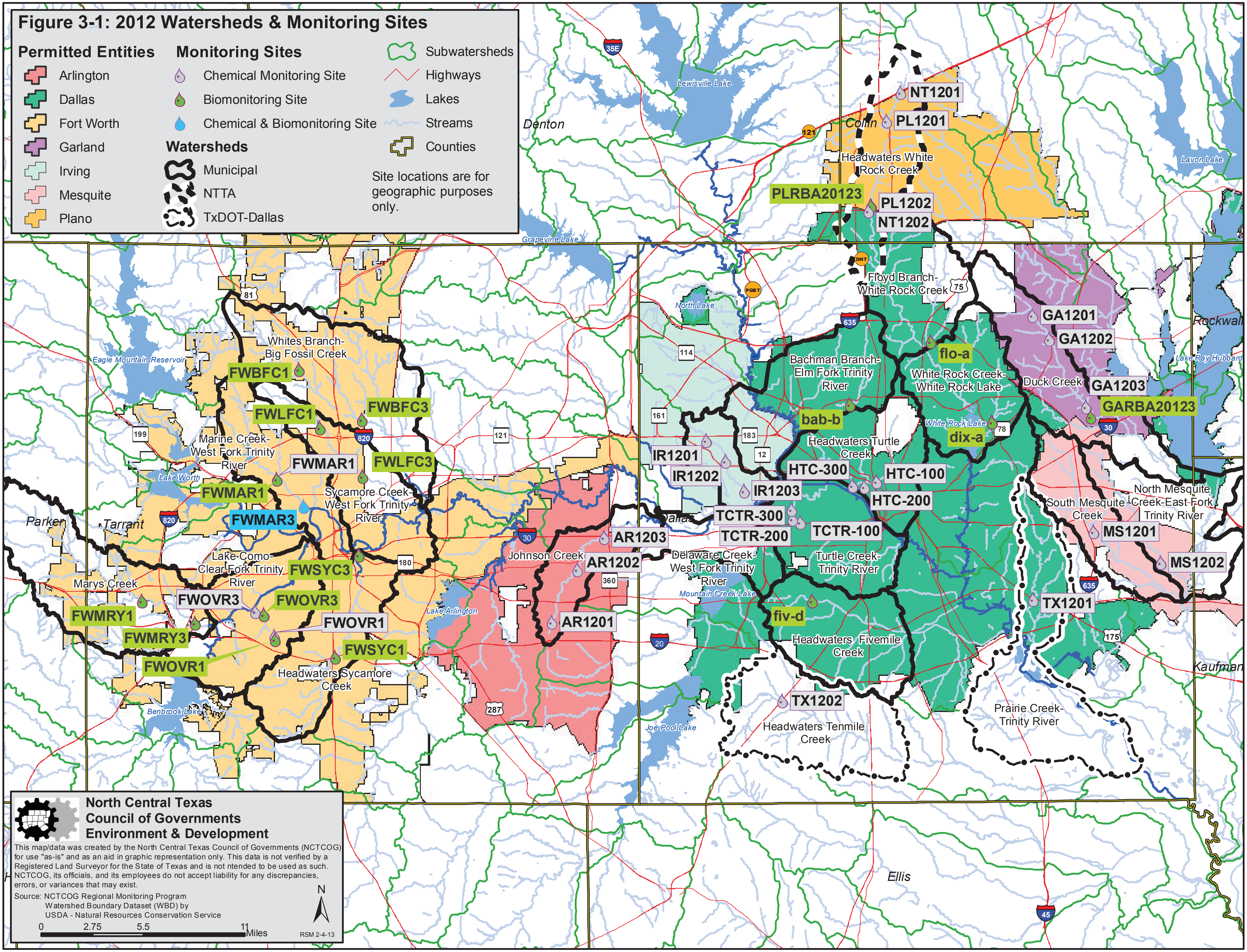


Figure 3-1: 2012 Watersheds & Monitoring Sites
Permitted Entities
Arlington
Dallas
Fort Worth
Garland
Irving
Mesquite
Plano
Monitoring Sites
Chemical Monitoring Site
Biomonitoring Site
Chemical & Biomonitoring Site
Watersheds
Municipal
NTTA
TxDOT-Dallas
Subwatersheds
Highways
Lakes
Streams
Counties
Site locations are for geographic purposes only.
Denton
Collin
Parker
Tarrant
Dallas
Rockwall
Kaufman
Ellis
Lewisville Lake
Grapevine Lake
Lavon Lake
Eagle Mountain Reservoir
Lake Worth
Benbrook Lake
Lake Arlington
North Lake
Mountain Creek Lake
Joe Pool Lake
White Rock Lake
Lake Ray Hubbard
NT1201
PL1201
Headwaters White Rock Creek
PLRBA20123
PL1202
NT1202
Floyd Branch-White Rock Creek
GA1201
GA1202
flo-a
Bachman Branch-Elm Fork Trinity River
White Rock Creek-White Rock Lake
Duck Creek
GA1203
GARBA20123
bab-b
dix-a
Headwaters Turtle Creek
IR1201
IR1202
HTC-300
HTC-100
IR1203
HTC-200
North Mesquite Creek-East Fork Trinity River
South Mesquite Creek
TCTR-300
TCTR-200
TCTR-100
MS1201
AR1203
Delaware Creek-West Fork Trinity River
Turtle Creek-Trinity River
MS1202
Johnson Creek
AR1202
TX1201
fiv-d
AR1201
Headwaters Fivemile Creek
TX1202
Headwaters Tenmile Creek
Prairie Creek-Trinity River
Whites Branch-Big Fossil Creek
FWBFC1
FWBFC3
FWLFC1
Marine Creek-West Fork Trinity River
FWMAR1
FWLFC3
Sycamore Creek-West Fork Trinity River
FWMAR3
Lake Como-Clear Fork Trinity River
FWSYC3
Marys Creek
FWOVR3
FWMRY1
FWOVR1
FWMRY3
FWSYC1
FWOVR1
Headwaters Sycamore Creek
North Central Texas Council of Governments Environment & Development
This map/data was created by the North Central Texas Council of Governments (NCTCOG) for use "as-is" and as an aid in graphic representation only. This data is not verified by a Registered Land Surveyor for the State of Texas and is not ntended to be used as such. NCTCOG, its officials, and its employees do not accept liability for any discrepancies, errors, or variances that may exist.
Source: NCTCOG Regional Monitoring Program
Watershed Boundary Dataset (WBD) by
USDA - Natural Resources Conservation Service
0 2.75 5.5 11 Miles
N
RSM 2-4-13

Table 3-1 Year 2 (2012) Chemical Sampling and Bioassessment Site Locations

Table 3-1: Year 2 (2012) Chemical Sampling and Bioassessment Site Locations				
Jurisdiction / Watershed	Station ID	Location	Latitude/Longitude	# of samples in 2012[1]
Arlington				
Johnson Creek	AR1201	Johnson Creek at Matlock Road	32.6930000 / -97.1165556	4C
	AR1202	Johnson Creek at Meadowbrook Park	32.7338333 / -97.0924389	4C
	AR1203	Johnson Creek at Six Flags	32.7588056 / -97.0670278	4C
Dallas				
Headwaters Turtle Creek	HTC-100	3505 Maple Avenue at Turtle Creek	32.7995770 / -96.8130450	4C
	HTC-200	Market Center Boulevard Bridge at Turtle Creek	32.7958500 / -96.8242030	4C
	HTC-300	2240 Irving Boulevard at Turtle Creek	32.7969010 / -96.8350340	4C
Turtle Creek-Trinity River	TCTR-100	3805 Pipestone Road at Mican Channel	32.7684940 / -96.8843680	4C
	TCTR-200	3951 La Reunion Parkway at Mican Channel	32.7711350 / -96.8913620	4C
	TCTR-300	4300 Singleton Boulevard at Mican Channel	32.7788600 / -96.8926320	4C
Bachman Branch-Elm Fork Trinity	bab-b	0.25 mile south of Midway Road and W. Northwest Hwy intersection at Bachman Branch	32.8604418 / -96.8369522	2B
Floyd Branch – White Rock Creek	flo-a	Heading West on Forest Lane (towards US 75), turn Right onto gravel road underneath DART Rail	32. 9090690 / -96.7601368	2B
White Rock Creek-White Rock Lake	dix-a	Northeast of Peavy Road and E. Lake Highlands intersection at Dixon Branch	32.8446960 / -96.7047586	2B
Headwaters Five Mile Creek	fiv-d	Westmoreland Road and Pentagon Pkwy intersection at Five Mile Creek	32.7064408 / -96.8745138	2B
Fort Worth				
Headwaters Sycamore Creek	FWSYC1	IH 35W Northbound frontage road beneath SE Loop 820 eastbound	32.6677 / -97.3178	2B
	FWSYC3	Dead end of Scott St. west of Beach St.	32.7475 / -97.2949	2B
Lake Como-Clear Fork Trinity River	FWOVR1	South Dr. west of Trail Lake Dr. in Foster Park	32.6846 / -97.3741	1C
	FWOVR1	NW of Granbury Rd and Trail Lake Dr.	32.6820 / -97.3738	2B
	FWOVR3	4600 Bellaire Dr S. west of Hulen St.	32.7040 / -97.3920	1C
	FWOVR3	Overton Park West south of intersection with Bellaire	32.7017 / -97.3839	2B
Sycamore Creek – West Fork Trinity River	FWLFC1	2200 block Cantrell Sansom	32.8478 / -97.3297	2B
	FWLFC3	Dead end of Mesquite Rd. south of 3800 Long Ave.	32.8095 / -97.2909	2B
White's Branch - Big Fossil Creek	FWBFC1	West of and parallel to Pepperidge Lane	32.8854 / -97.3421	2B
	FWBFC3	N. Beach St. north of Paula Ridge	32.8536 / -97.2904	2B
Marine Creek – West Fork Trinity River	FWMAR1	3500 Macie, bridge crossing in Buck Sansom Park	32.8079 / -97.3703	1C
	FWMAR1	West of Angle Avenue in Buck Sansom Park	32.8069 / -97.3691	2B
	FWMAR3	Saunders Park south of Mule Alley and downstream of JV1A	32.7862 / -97.3460	1C / 2B
Mary's Creek	FWMRY1	3900 block Longvue (FM 2871)	32.7133 / -97.4966	2B
	FWMRY3	Winscott Road (Vickery Blvd.) in South Z Boaz Park	32.6954 / -97.4477	2B
Garland				
Duck Creek	GA1201	Duck Creek at Shiloh Bridge	32.9282718 / -96.6651928	4C
	GA1202	Duck Creek between Forest North and South	32.9090727 / -96.6503388	4C
	GA1203	Duck Creek Under La Prada Bridge	32.8554635 / -96.6168702	4C
	GARBA20123	Duck Creek at Oates Drive	32.8477778 / -96.6125000	2B
Irving				
Delaware Creek	IR1201	Delaware Creek at Pilgrim Drive	32.8339167 / -96.9706111	4C
	IR1202	Delaware Creek at Sowers Road	32.8175600 / -96.9528400	4C
	IR1203	Delaware Creek at Oakdale Road	32.7938200 / -96.9363500	4C

Table 3-1: Year 2 (2012) Chemical Sampling and Bioassessment Site Locations				
Jurisdiction / Watershed	Station ID	Location	Latitude/Longitude	# of samples in 2012[1]
Mesquite				
South Mesquite Creek	MS1201	North of New Market Road (in Park)	32.7572500 / -96.6119444	4C
North Mesquite Creek	MS1202	North Mesquite Creek at Edward's Church	32.7321111 / -96.5505000	4C
Plano				
Headwaters White Rock Creek	PL1201	Preston-Hedgcoxe Plaza at White Rock Creek	33.0827500 / -96.7983889	4C
	PL1202	North of Plano Parkway at White Rock Creek	33.0164546 / -96.8138784	4C
	PLRBA20123	White Rock Creek at West Plano Parkway	33.0163889 / -96.8141667	2B
North Texas Tollway Authority				
Headwaters White Rock Creek	NT1201	SH 121 at White Rock Creek	33.1046550 / -96.7849991	4C
	NT1202	President George Bush Highway at White Rock Creek	33.0120351 / -96.8165633	4C
TxDOT-Dallas				
Prairie Creek	TX1201	Prairie Creek at Hwy 175	32.7048611 / -96.6697778	4C
Headwaters Ten Mile Creek	TX1202	Highway 67, between Main Street and Danieldale Road	32.6284060 / -96.9038780	4C

Notes:

1. "B" Signifies bioassessment samples, "C" signifies chemical samples.

3.1.2.2. City of Fort Worth

Rapid bioassessments were performed on stream monitoring sites in 2012 during two separate sampling events. One sampling event occurred in spring 2012 (May 2012) and the second took place in fall 2012 (October 2012). Table 3-1 includes the primary bioassessment sites for the City of Fort Worth for each watershed. The City of Fort Worth Sampling Protocol identifies an additional bioassessment site for each watershed that may be used as an alternative depending on local conditions at the time of sampling.

Macroinvertebrates were collected quantitatively, using a Surber sampler with a 500 µm mesh to sample riffle areas at each site. Bottom substrate within the 12"x12" Surber frame area (0.09 m^2) was disturbed to dislodge organisms. Three replicate samples were collected within each reach, and individual sample locations were recorded. Collected samples were transferred from the Surber sampler to sample containers and preserved in the field with 95% ethanol. Following transport to an in-house laboratory, macroinvertebrates in the samples were separated from the debris and identified. Most organisms were identified to family level with several noted exceptions. In accordance with the current City of Fort Worth SOP, Chironomidae was identified to sub-family, Turbellaria and Hirudinea were identified to class, and Nematoda was identified to phylum.

Fish communities were assessed at selected sites along the creeks during the spring 2012 sampling period. The sites included the most downstream sites on Mary's Creek (MRY3), Big Fossil Creek (BFC3), Sycamore Creek, (SYC3), Marine Creek (MAR3), Overton Park Creek (OVR3), and Little Fossil Creek (LFC3). A backpack shocker was used to collect fish at these sites. Collected fish were identified, enumerated and released back into the streams from which they were collected.

3.1.2.3. Cities of Garland and Plano

Stream rapid bioassessments were conducted on Duck Creek in Garland and White Rock Creek in Plano in 2012. Each creek was sampled at one location in May and at the same location again in September. Benthic macroinvertebrate and fish communities were sampled and data compared with metrics from the TCEQ. Habitat, water chemistry, and flow were also measured in each trip.

3.2. 2013 Monitoring Activity Description

The 2013 Watersheds and Monitoring Sites map (Figure 3-2) shows the watersheds sampled in Year 3 (2013) as well as the location of the chemical sampling stations and bioassessment sites. Table 3-2 contains the corresponding list of Year 3 chemical monitoring and bioassessment sites that are part of the RWWCP along with detailed location information.

3.2.1. Chemical Sampling

All samples were successfully collected and analyzed in Year 3 (January to December 2013). During Year 2 (January to December 2012), the City of Fort Worth was unable to analyze carbaryl samples due to an unintentional error in the list of parameters provided by the City of Fort Worth to the contract laboratory. Makeup samples were collected and analyzed for carbaryl for the Year 2 sites during 2013.

Sampling data and annual summary statistics can be found in the Annual Regional Wet Weather Characterization Program Monitoring Report for North Central Texas Year 3 (NCTCOG, 2014).

3.2.2. Bioassessments

Dallas, Fort Worth, Garland and Plano conducted bioassessment activities in Year 3. All scheduled bioassessments were successfully conducted. An overview of bioassessment activities is provided below. For complete details, refer to bioassessment reports in the Annual Regional Wet Weather Characterization Program Monitoring Report for North Central Texas Year 3 (NCTCOG, 2014).

3.2.2.1. City of Dallas

All scheduled bioassessments were conducted successfully. Two sampling events were conducted in accordance with the index periods established by TCEQ for biological sampling:

- Spring Period (March 15 to June 30): Targets spring's optimal conditions for biological community growth.
- Summer Period (July 1 to September 30): Reflects impacts from typical summer low flows and higher water temperatures.

3.2.2.2. City of Fort Worth

Rapid bioassessments were performed on stream monitoring sites in 2013 during two separate sampling events. One sampling event occurred in spring 2013 (May 2013) and the second took place in fall 2013 (October 2013). Table 3-2 includes the primary bioassessment sites for the City of Fort Worth for each watershed. The City of Fort Worth Sampling Protocol identifies an additional bioassessment site for each watershed that may be used as an alternative depending on local conditions at the time of sampling.

Macroinvertebrates were collected quantitatively, using a Surber sampler with a 500 µm mesh to sample riffle areas at each site. Bottom substrate within the 12"x12" Surber frame area (0.09 m^2) was disturbed to dislodge organisms. At sites with low flow, the substrate within the Surber frame was removed and placed into a sieve bucket for washing. Any bugs and debris that flowed into the net portion of the Surber sampler were collected along with the sieve bucket contents. Three replicate samples were collected at each site, and individual sample locations were recorded. Collected samples were transferred from the Surber sampler to sample containers and preserved in the field with 95% ethanol. Following transport to an in-house laboratory, macroinvertebrates in the samples were separated from the debris and identified. Most organisms were identified to family level with several noted exceptions. In accordance with the current City of Fort Worth SOP, Chironomidae was identified to sub-family, Turbellaria and Hirudinea were identified to class, and Nematoda was identified to phylum.

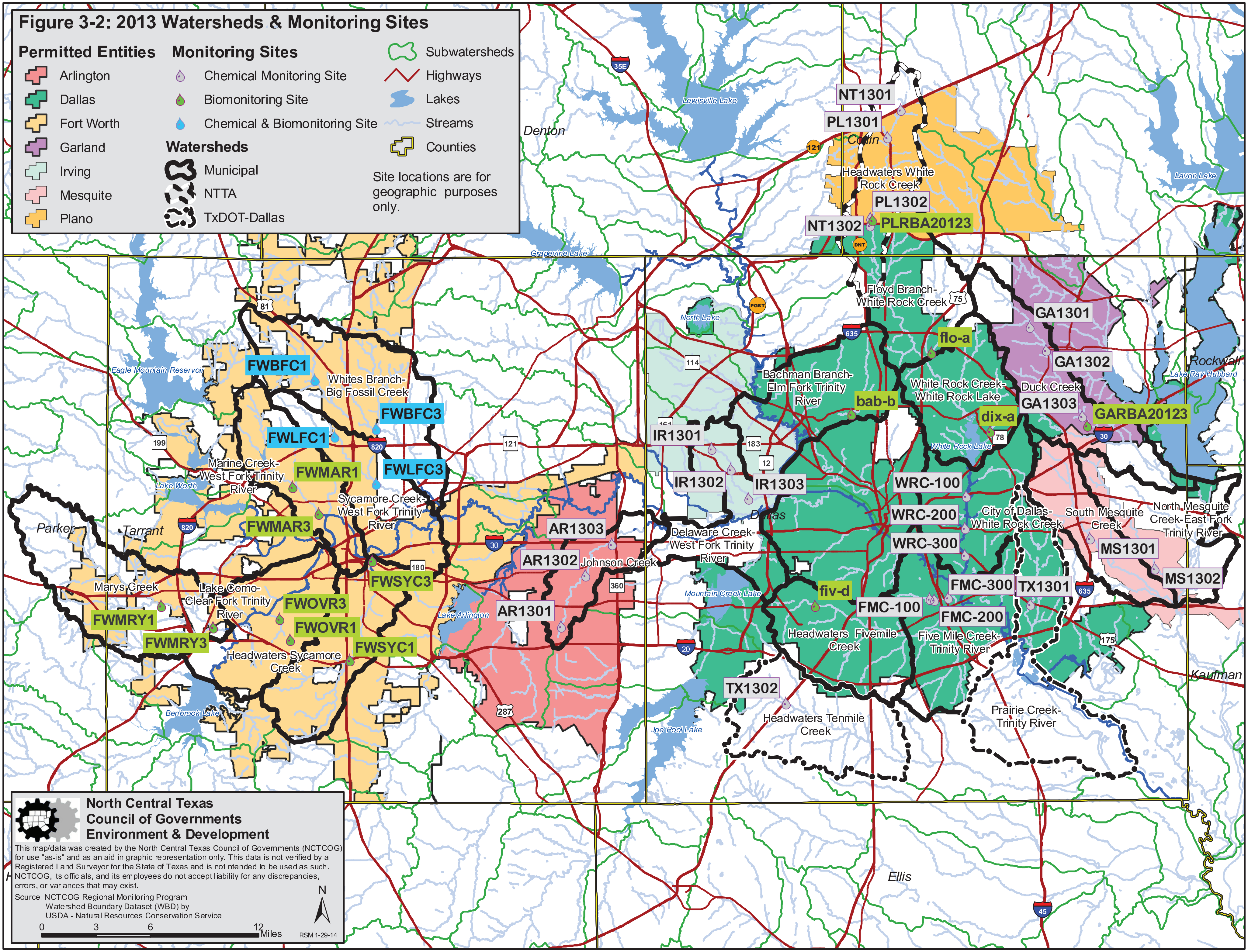


Figure 3-2: 2013 Watersheds & Monitoring Sites
Permitted Entities
Arlington
Dallas
Fort Worth
Garland
Irving
Mesquite
Plano
Monitoring Sites
Chemical Monitoring Site
Biomonitoring Site
Chemical & Biomonitoring Site
Watersheds
Municipal
NTTA
TxDOT-Dallas
Subwatersheds
Highways
Lakes
Streams
Counties
Site locations are for geographic purposes only.
NT1301
PL1301
PL1302
NT1302
PLRBA20123
GA1301
GA1302
GA1303
GARBA20123
flo-a
bab-b
dix-a
IR1301
IR1302
IR1303
WRC-100
WRC-200
WRC-300
FMC-100
FMC-200
FMC-300
TX1301
TX1302
MS1301
MS1302
fiv-d
AR1301
AR1302
AR1303
FWBFC1
FWBFC3
FWLFC1
FWLFC3
FWMAR1
FWMAR3
FWSYC1
FWSYC3
FWOVR1
FWOVR3
FWMRY1
FWMRY3
Headwaters White Rock Creek
Floyd Branch-White Rock Creek
Bachman Branch-Elm Fork Trinity River
White Rock Creek-White Rock Lake
Duck Creek
City of Dallas-White Rock Creek
South Mesquite Creek
North Mesquite Creek-East Fork Trinity River
Delaware Creek-West Fork Trinity River
Johnson Creek
Headwaters Fivemile Creek
Five Mile Creek-Trinity River
Headwaters Tenmile Creek
Prairie Creek-Trinity River
Whites Branch-Big Fossil Creek
Marine Creek-West Fork Trinity River
Sycamore Creek-West Fork Trinity River
Lake Como-Clear Fork Trinity River
Marys Creek
Headwaters Sycamore Creek
Denton
Collin
Dallas
Tarrant
Parker
Rockwall
Kaufman
Ellis
Lewisville Lake
Grapevine Lake
North Lake
Lavon Lake
Lake Ray Hubbard
White Rock Lake
Eagle Mountain Reservoir
Lake Worth
Lake Arlington
Mountain Creek Lake
Joe Pool Lake
Benbrook Lake
North Central Texas Council of Governments Environment & Development
This map/data was created by the North Central Texas Council of Governments (NCTCOG) for use "as-is" and as an aid in graphic representation only. This data is not verified by a Registered Land Surveyor for the State of Texas and is not ntended to be used as such. NCTCOG, its officials, and its employees do not accept liability for any discrepancies, errors, or variances that may exist.
Source: NCTCOG Regional Monitoring Program
Watershed Boundary Dataset (WBD) by
USDA - Natural Resources Conservation Service
0 3 6 12 Miles
N
RSM 1-29-14

Table 3-2 Year 3 (2013) Chemical Sampling and Bioassessment Site Locations

Table 3-2: Year 3 (2013) Chemical Sampling and Bioassessment Site Locations				
Jurisdiction / **Watershed**	**Station ID**	**Location**	**Latitude/Longitude**	**# of samples in 2013[1]**
Arlington				
Johnson Creek	AR1301	Johnson Creek at Matlock Road	32.6930000 / -97.1165556	4C
	AR1302	Johnson Creek at Meadowbrook Park	32.7338333 / -97.0924389	4C
	AR1303	Johnson Creek at Six Flags	32.7588056 / -97.0670278	4C
Dallas				
Five Mile Creek-Trinity River	FMC-100	3200 Linfield Road at Honey Springs Branch	32.710769 / -96.765777	4C
	FMC-200	4400 Vandervoort Drive at Honey Springs Branch	32.709680 / -96.760929	4C
	FMC-300	8000 Carbondale St. at Honey Springs Branch	32.711500 / -96.747856	4C
City of Dallas-White Rock Creek	WRC-100	3800 Samuell Blvd. at White Rock Creek	32.792756 / -96.728893	4C
	WRC-200	5000 Scyene Rd. at White Rock Creek	32.766982 / -96.730564	4C
	WRC-300	5100 C. F. Hawn Frwy at White Rock Creek	32.745551 / -96.730780	4C
Bachman Branch-Elm Fork Trinity	bab-b	0.25 mile south of Midway Road and W. Northwest Hwy intersection at Bachman Branch	32.8604418 / -96.8369522	2B
Floyd Branch – White Rock Creek	flo-a	Heading West on Forest Lane (towards US 75), turn Right onto gravel road underneath DART Rail	32. 9090690 / -96.7601368	2B
White Rock Creek-White Rock Lake	dix-a	Northeast of Peavy Road and E. Lake Highlands intersection at Dixon Branch	32.8446960 / -96.7047586	2B
Headwaters Five Mile Creek	fiv-d	Westmoreland Road and Pentagon Pkwy intersection at Five Mile Creek	32.7064408 / -96.8745138	2B
Fort Worth				
Headwaters Sycamore Creek	FWSYC1	IH 35W Northbound frontage road beneath SE Loop 820 eastbound	32.6677 / -97.3178	2B
	FWSYC3	Dead end of Scott St. west of Beach St.	32.7475 / -97.2949	2B
Lake Como-Clear Fork Trinity River	FWOVR1	NW of Granbury Rd and Trail Lake Dr	32.6820 / -97.3738	2B
	FWOVR3	Overton Park West south of intersection with Bellaire	32.7017 / -97.3839	2B
Sycamore Creek – West Fork Trinity River	FWLFC1	2200 block Cantrell Sansom	32.8478 / -97.3297	1C / 2B
	FWLFC3	Dead end of Mesquite Rd. south of 3800 Long Ave.	32.8095 / -97.2909	1C / 2B
White's Branch - Big Fossil Creek	FWBFC1	West of and parallel to Pepperidge Lane	32.8854 / -97.3421	1C / 2B
	FWBFC3	N. Beach St. north of Paula Ridge	32.8536 / -97.2904	1C / 2B
Marine Creek – West Fork Trinity River	FWMAR1	West of Angle Avenue in Buck Sansom Park	32.8069 / -97.3691	2B
	FWMAR3	Saunders Park south of Mule Alley and downstream of JV1A	32.7862 / -97.3460	2B
Mary's Creek	FWMRY1	3900 block Longvue (FM 2871)	32.7133 / -97.4966	2B
	FWMRY3	Winscott Road (Vickery Blvd.) in South Z Boaz Park	32.6954 / -97.4477	2B
Garland				
Duck Creek	GA1301	Duck Creek at Shiloh Bridge	32.9282718 / -96.6651928	4C
	GA1302	Duck Creek between Forest North and South	32.9090727 / -96.6503388	4C
	GA1303	Duck Creek Under La Prada Bridge	32.8554635 / -96.6168702	4C
	GARBA20123	Duck Creek at Oates Drive	32.8477778 / -96.6125000	2B
Irving				
Delaware Creek	IR1301	Delaware Creek at Pilgrim Drive	32.8339167 / -96.9706111	4C
	IR1302	Delaware Creek at Sowers Road	32.8175600 / -96.9528400	4C
	IR1303	Delaware Creek at Oakdale Road	32.7938200 / -96.9363500	4C
Mesquite				
South Mesquite Creek	MS1301	North of New Market Road (in Park)	32.7572500 / -96.6119444	4C
North Mesquite Creek	MS1302	North Mesquite Creek at Edward's Church	32.7321111 / -96.5505000	4C

Table 3-2: Year 3 (2013) Chemical Sampling and Bioassessment Site Locations				
Jurisdiction / Watershed	Station ID	Location	Latitude/Longitude	# of samples in 2013[1]
Plano				
Headwaters White Rock Creek	PL1301	Preston-Hedgcoxe Plaza at White Rock Creek	33.0827500 / -96.7983889	4C
	PL1302	North of Plano Parkway at White Rock Creek	33.0164546 / -96.8138784	4C
	PLRBA20123	White Rock Creek at West Plano Parkway	33.0163889 / -96.8141667	2B
North Texas Tollway Authority				
Headwaters White Rock Creek	NT1301	SH 121 at White Rock Creek	33.1046550 / -96.7849991	4C
	NT1302	President George Bush Highway at White Rock Creek	33.0120351 / -96.8165633	4C
TxDOT-Dallas				
Prairie Creek	TX1301	Prairie Creek at Hwy 175	32.7048611 / -96.6697778	4C
Headwaters Ten Mile Creek	TX1302	Highway 67, between Main Street and Danieldale Road	32.6284060 / -96.9038780	4C

Notes:
1. "B" Signifies bioassessment samples, "C" signifies chemical samples.

Fish communities were assessed at selected sites along the creeks during the spring 2013 sampling period. The sites included the most downstream sites on Mary's Creek (MRY3), Big Fossil Creek (BFC3), Sycamore Creek, (SYC3), Marine Creek (MAR3), Overton Park Creek (OVR3), and Little Fossil Creek (LFC3). A backpack shocker was used to collect fish at these sites. Collected fish were identified, enumerated and released back into the streams from which they were collected.

3.2.2.3. Cities of Garland and Plano

Stream rapid bioassessments were conducted on Duck Creek in Garland and White Rock Creek in Plano in 2013. Each creek was sampled at one location in June and at the same location again in September. Benthic macroinvertebrate and fish communities were sampled and data compared with metrics from the TCEQ. Habitat, water chemistry, and flow were also measured in each trip.

3.3. 2014 Monitoring Activity Description

The 2014 Watersheds and Monitoring Sites map (Figure 3-3) shows the watersheds sampled in Year 4 (2014) as well as the location of the chemical sampling stations and bioassessment sites. Table 3-3 contains the corresponding list of Year 4 chemical monitoring and bioassessment sites that are part of the RWWCP along with detailed location information.

3.3.1. Chemical Sampling

All samples were successfully collected and analyzed in Year 4 (January to December 2014). For City of Dallas sample site HTC-300, the first quarter sample was not collected due to site flooding during a qualifying rainfall event late in the quarter. A makeup sample was collected at HTC-300 in the second quarter to replace the missed first quarter sample in addition to the scheduled second quarter sample.

For four sites, the field parameters of pH, temperature, and specific conductivity for one sample per site was not determined due to inadvertent error. Makeup samples were collected subsequent to discovery of the omission and tested for the missing parameters. The sites, original collection date, and makeup sample date are provided in the Table 3-4. Sampling protocols were reviewed with field personnel to minimize the potential for future errors.

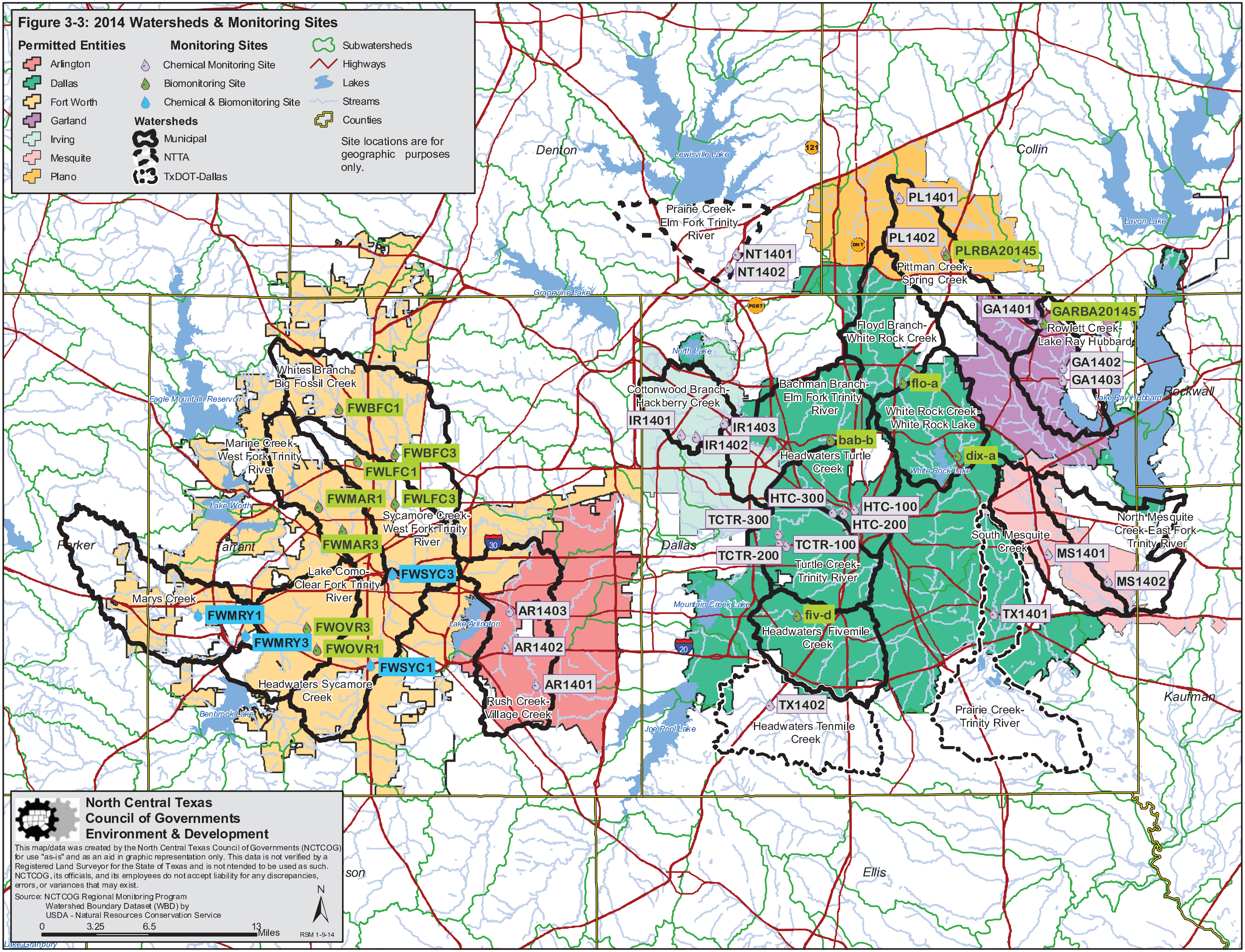


Figure 3-3: 2014 Watersheds & Monitoring Sites
Permitted Entities
Arlington
Dallas
Fort Worth
Garland
Irving
Mesquite
Plano
Monitoring Sites
Chemical Monitoring Site
Biomonitoring Site
Chemical & Biomonitoring Site
Watersheds
Municipal
NTTA
TxDOT-Dallas
Subwatersheds
Highways
Lakes
Streams
Counties
Site locations are for geographic purposes only.
Denton
Collin
Lewisville Lake
Lavon Lake
Grapevine Lake
North Lake
Eagle Mountain Reservoir
Lake Worth
Lake Arlington
Benbrook Lake
Joe Pool Lake
Mountain Creek Lake
White Rock Lake
Lake Ray Hubbard
Rockwall
Parker
Tarrant
Dallas
Kaufman
Ellis
son
Lake Granbury
Prairie Creek-Elm Fork Trinity River
PL1401
PL1402
PLRBA20145
NT1401
NT1402
Pittman Creek-Spring Creek
GA1401
GARBA20145
Rowlett Creek-Lake Ray Hubbard
GA1402
GA1403
Floyd Branch-White Rock Creek
Bachman Branch-Elm Fork Trinity River
flo-a
White Rock Creek-White Rock Lake
Cottonwood Branch-Hackberry Creek
IR1401
IR1403
IR1402
bab-b
Headwaters Turtle Creek
dix-a
HTC-300
HTC-100
HTC-200
TCTR-300
TCTR-100
TCTR-200
Turtle Creek-Trinity River
South Mesquite Creek
North Mesquite Creek-East Fork Trinity River
MS1401
MS1402
TX1401
fiv-d
Headwaters Fivemile Creek
TX1402
Headwaters Tenmile Creek
Prairie Creek-Trinity River
Whites Branch-Big Fossil Creek
FWBFC1
FWBFC3
Marine Creek-West Fork Trinity River
FWLFC1
FWMAR1
FWLFC3
Sycamore Creek-West Fork Trinity River
FWMAR3
Lake Como-Clear Fork Trinity River
FWSYC3
Marys Creek
FWMRY1
FWMRY3
FWOVR3
FWOVR1
FWSYC1
Headwaters Sycamore Creek
AR1403
AR1402
AR1401
Rush Creek-Village Creek
121
DNT
PGBT
30
20
North Central Texas Council of Governments Environment & Development
This map/data was created by the North Central Texas Council of Governments (NCTCOG) for use "as-is" and as an aid in graphic representation only. This data is not verified by a Registered Land Surveyor for the State of Texas and is not ntended to be used as such. NCTCOG, its officials, and its employees do not accept liability for any discrepancies, errors, or variances that may exist.
Source: NCTCOG Regional Monitoring Program
Watershed Boundary Dataset (WBD) by
USDA - Natural Resources Conservation Service
0 3.25 6.5 13 Miles
N
RSM 1-9-14

Table 3-3 Year 4 (2014) Chemical Sampling and Bioassessment Site Locations

Table 3-3: Year 4 (2014) Chemical Sampling and Bioassessment Site Locations				
Jurisdiction / Watershed	Station ID	Location	Latitude/Longitude	# of samples in 2014[1]
Arlington				
Rush Creek	AR1401	Rush Creek and Sublett Road	32.648889 / -97.146389	4C
	AR1402	Kee Branch and Pleasant Ridge Road	32.682222 / -97.178056	4C
	AR1403	Rush Creek and Woodland Park Boulevard	32.713889 / -97.172778	4C
Dallas				
Headwaters Turtle Creek	HTC-100	3505 Maple Avenue at Turtle Creek	32.7995770 / -96.8130450	4C
	HTC-200	Market Center Boulevard Bridge at Turtle Creek	32.7958500 / -96.8242030	4C
	HTC-300	2240 Irving Boulevard at Turtle Creek	32.7969010 / -96.8350340	4C
Turtle Creek-Trinity River	TCTR-100	3805 Pipestone Road at Mican Channel	32.7684940 / -96.8843680	4C
	TCTR-200	3951 La Reunion Parkway at Mican Channel	32.7711350 / -96.8913620	4C
	TCTR-300	4300 Singleton Boulevard at Mican Channel	32.7788600 / -96.8926320	4C
Bachman Branch-Elm Fork Trinity	bab-b	0.25 mile south of Midway Road and W. Northwest Hwy intersection at Bachman Branch	32.8604418 / -96.8369522	2B
Floyd Branch – White Rock Creek	flo-a	Heading West on Forest Lane (towards US 75), turn Right onto gravel road underneath DART Rail	32. 9090690 / -96.7601368	2B
White Rock Creek-White Rock Lake	dix-a	Northeast of Peavy Road and E. Lake Highlands intersection at Dixon Branch	32.8446960 / -96.7047586	2B
Headwaters Five Mile Creek	fiv-d	Westmoreland Road and Pentagon Pkwy intersection at Five Mile Creek	32.7064408 / -96.8745138	2B
Fort Worth				
Headwaters Sycamore Creek	FWSYC1	IH 35W Northbound frontage road beneath SE Loop 820 eastbound	32.6677 / -97.3178	1C / 2B
	FWSYC3	Dead end of Scott St. west of Beach St.	32.7475 / -97.2949	1C / 2B
Lake Como-Clear Fork Trinity River	FWOVR1	NW of Granbury Rd and Trail Lake Dr	32.6820 / -97.3738	2B
	FWOVR3	Overton Park West south of intersection with Bellaire	32.7017 / -97.3839	2B
Sycamore Creek – West Fork Trinity River	FWLFC1	2200 block Cantrell Sansom	32.8478 / -97.3297	2B
	FWLFC3	Dead end of Mesquite Rd. south of 3800 Long Ave.	32.8095 / -97.2909	2B
White's Branch - Big Fossil Creek	FWBFC1	West of and parallel to Pepperidge Lane	32.8854 / -97.3421	2B
	FWBFC3	N. Beach St. north of Paula Ridge	32.8536 / -97.2904	2B
Marine Creek – West Fork Trinity River	FWMAR1	West of Angle Avenue in Buck Sansom Park	32.8069 / -97.3691	2B
	FWMAR3	Saunders Park south of Mule Alley and downstream of JV1A	32.7862 / -97.3460	2B
Mary's Creek	FWMRY1	3900 block Longvue (FM 2871)	32.7133 / -97.4966	1C / 2B
	FWMRY3	Winscott Road (Vickery Blvd.) in South Z Boaz Park	32.6954 / -97.4477	1C / 2B
Garland				
Rowlett Creek – Lake Ray Hubbard	GA1401	Rowlett Creek at SH 78	32.959902 / -96.614854	4C
	GA1402	Rowlett Creek at Centerville Road/Castle Drive	32.920519 / -96.593322	4C
	GA1403	Rowlett Creek at Hwy 66	32.909367 / -96.593372	4C
	GARBA20145	Rowlett Creek below Atchison Topeka and Santa Fe Railroad bridge	32.960095 -96.612327	2B
Irving				
Cottonwood Branch - Hackberry Creek	IR1401	Cottonwood Creek at Belt Line Road	32.866856 / -96.991267	4C
	IR1402	Cottonwood Creek at N. Story Road	32.864935 / -96.976876	4C
	IR1403	Cottonwood Creek at Highway 114	32.876944 / -96.946667	4C
Mesquite				
South Mesquite Creek	MS1401	North of New Market Road (in Park)	32.7572500 / -96.6119444	4C
North Mesquite Creek	MS1402	North Mesquite Creek at Edward's Church	32.7321111 / -96.5505000	4C

Table 3-3: Year 4 (2014) Chemical Sampling and Bioassessment Site Locations				
Jurisdiction / Watershed	Station ID	Location	Latitude/Longitude	# of samples in 2014[1]
Plano				
Pittman Creek – Spring Creek	PL1401	Spring Creek and Legacy	33.072194 / -96.760417	4C
	PL1402	Spring Creek and 16th Street	33.021317 / -96.712406	4C
	PLRBA20145	Spring Creek and 16th Street	33.021317 / -96.712406	2B
North Texas Tollway Authority				
Prairie Creek – Elm Fork Trinity River	NT1401	Unnamed Tributary at SRT N. of Hebron Pkwy	33.024741 / -96.931512	4C
	NT1402	Unnamed Tributary at SRT N. of Marchant Blvd	33.013832 / -96.939749	4C
TxDOT-Dallas				
Prairie Creek	TX1401	Prairie Creek at Hwy 175	32.7048611 / -96.6697778	4C
Headwaters Ten Mile Creek	TX1402	Highway 67, between Main Street and Danieldale Road	32.6284060 / -96.9038780	4C

Notes:

1. “B” Signifies bioassessment samples, “C” signifies chemical samples.

Table 3-4 Year 4 Field Parameter Make-Up Samples

Jurisdiction	Sample Site	Original Sample Date	Makeup Sample Date
Irving	IR1403	7/16/2014	11/4/2014
Mesquite	MS1401	2/25/2014	3/15/2014
North Texas Tollway Authority	NT1401	4/3/2014	5/25/2014
North Texas Tollway Authority	NT1402	4/13/2014	5/25/2014

Sampling data and annual summary statistics can be found in the Annual Regional Wet Weather Characterization Program Monitoring Report for North Central Texas Year 4 (NCTCOG, 2015).

3.3.2. Bioassessments

Dallas, Fort Worth, Garland and Plano conducted bioassessment activities in Year 4. All scheduled bioassessments were successfully conducted. An overview of bioassessment activities is provided below. For complete details, refer to bioassessment reports in the Annual Regional Wet Weather Characterization Program Monitoring Report for North Central Texas Year 4 (NCTCOG, 2015).

3.3.2.1. City of Dallas

All scheduled bioassessments were conducted successfully. Two sampling events were conducted in accordance with the index periods established by TCEQ for biological sampling:

- Spring Period (March 15 to June 30): Targets spring’s optimal conditions for biological community growth.
- Summer Period (July 1 to September 30): Reflects impacts from typical summer low flows and higher water temperatures.

3.3.2.2. City of Fort Worth

Sampling was conducted during spring (May) and fall (October) 2014 on at least two sites on each creek. Fish were collected during fall at the most downstream sites on each creek. Table 3-3 includes the primary bioassessment sites for the City of Fort Worth for each watershed. The City of Fort Worth Sampling Protocol identifies an additional bioassessment site for each watershed that may be used as an alternative depending on local conditions at the time of sampling.

3.3.2.3. Cities of Garland and Plano

Stream rapid bioassessments were conducted on Rowlett Creek in Garland and Spring Creek in Plano in 2014. Each creek was sampled at one location in May and at the same location again in September. Benthic macroinvertebrate and fish communities were sampled and data compared with metrics from the TCEQ. Habitat, water chemistry, and flow were also measured in each trip.

3.4. 2015 Monitoring Activity Description

The 2015 Watersheds and Monitoring Sites map (Figure 3-4) shows the watersheds sampled in Year 5 (2015) as well as the location of the chemical sampling stations and bioassessment sites. Table 3-5 contains the corresponding list of Year 5 chemical monitoring and bioassessment sites that are part of the RWWCP along with detailed location information.

3.4.1. Chemical Sampling

All samples were successfully collected and analyzed in Year 5 (January to December 2015). Sampling data and annual summary statistics can be found in the Annual Regional Wet Weather Characterization Program Monitoring Report for North Central Texas Year 5 (NCTCOG, 2016).

3.4.2. Bioassessments

Dallas, Fort Worth, Garland and Plano conducted bioassessment activities in Year 5. All scheduled bioassessments were successfully conducted. An overview of bioassessment activities is provided below. For complete details, refer to bioassessment reports in the Annual Regional Wet Weather Characterization Program Monitoring Report for North Central Texas Year 5 (NCTCOG, 2016).

3.4.2.1. City of Dallas

All scheduled bioassessments were conducted successfully. Two sampling events were conducted in accordance with the index periods established by TCEQ for biological sampling:

- Spring Period (March 15 to June 30): Targets spring's optimal conditions for biological community growth.
- Summer Period (July 1 to September 30): Reflects impacts from typical summer low flows and higher water temperatures.

3.4.2.2. City of Fort Worth

Sampling was conducted during spring (May) and fall (October) 2014 on at least two sites on each creek. Fish were collected during fall at the most downstream sites on each creek. Table 3-5 includes the primary bioassessment sites for the City of Fort Worth for each watershed. The City of Fort Worth Sampling Protocol identifies an additional bioassessment site for each watershed that may be used as an alternative depending on local conditions at the time of sampling.

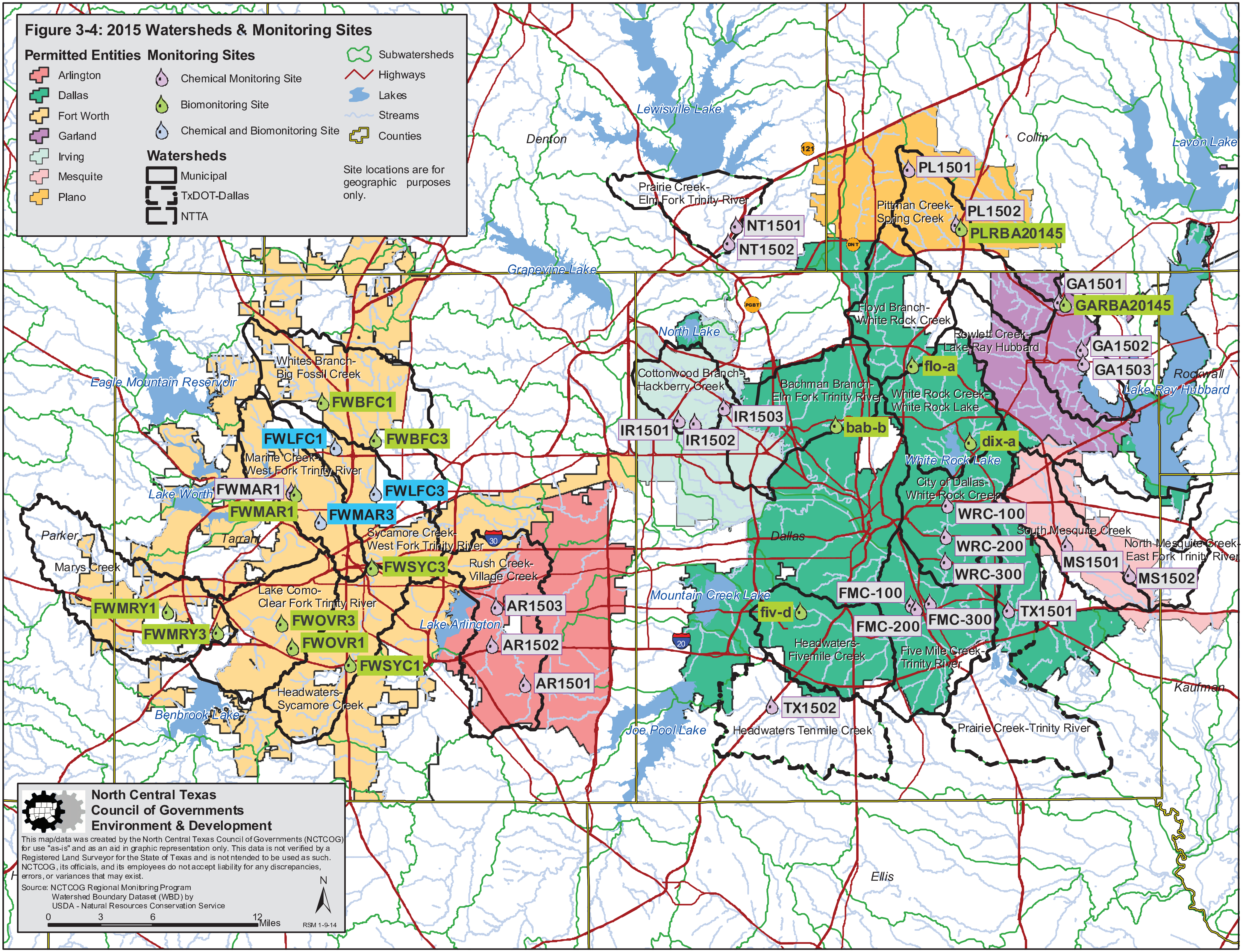


Figure 3-4: 2015 Watersheds & Monitoring Sites

Table 3-5 Year 5 (2015) Chemical Sampling and Bioassessment Site Locations

Jurisdiction / Watershed	Station ID	Location	Latitude/Longitude	# of samples in 2015[1]
Arlington				
Rush Creek	AR1501	Rush Creek and Sublett Road	32.648889 / -97.146389	4C
	AR1502	Kee Branch and Pleasant Ridge Road	32.682222 / -97.178056	4C
	AR1503	Rush Creek and Woodland Park Boulevard	32.713889 / -97.172778	4C
Dallas				
Five Mile Creek-Trinity River	FMC-100	3200 Linfield Road at Honey Springs Branch	32.710769 / -96.765777	4C
	FMC-200	4400 Vandervoort Drive at Honey Springs Branch	32.709680 / -96.760929	4C
	FMC-300	8000 Carbondale St. at Honey Springs Branch	32.711500 / -96.747856	4C
City of Dallas-White Rock Creek	WRC-100	3800 Samuell Blvd. at White Rock Creek	32.792756 / -96.728893	4C
	WRC-200	5000 Scyene Rd. at White Rock Creek	32.766982 / -96.730564	4C
	WRC-300	5100 C. F. Hawn Frwy at White Rock Creek	32.745551 / -96.730780	4C
Bachman Branch-Elm Fork Trinity	bab-b	0.25 mile south of Midway Road and W. Northwest Hwy intersection at Bachman Branch	32.8604418 / -96.8369522	2B
Floyd Branch – White Rock Creek	flo-a	Heading West on Forest Lane (towards US 75), turn Right onto gravel road underneath DART Rail	32. 9090690 / -96.7601368	2B
White Rock Creek-White Rock Lake	dix-a	Northeast of Peavy Road and E. Lake Highlands intersection at Dixon Branch	32.8446960 / -96.7047586	2B
Headwaters Five Mile Creek	fiv-d	Westmoreland Road and Pentagon Pkwy intersection at Five Mile Creek	32.7064408 / -96.8745138	2B
Fort Worth				
Headwaters Sycamore Creek	FWSYC1	IH 35W Northbound frontage road beneath SE Loop 820 eastbound	32.6677 / -97.3178	2B
	FWSYC3	Dead end of Scott St. west of Beach St.	32.7475 / -97.2949	2B
Lake Como-Clear Fork Trinity River	FWOVR1	NW of Granbury Rd and Trail Lake Dr	32.6820 / -97.3738	2B
	FWOVR3	Overton Park West south of intersection with Bellaire	32.7017 / -97.3839	2B
Sycamore Creek – West Fork Trinity River	FWLFC1	2200 block Cantrell Sansom	32.8478 / -97.3297	1C / 2B
	FWLFC3	Dead end of Mesquite Rd. south of 3800 Long Ave.	32.8095 / -97.2909	1C / 2B
White's Branch - Big Fossil Creek	FWBFC1	West of and parallel to Pepperidge Lane	32.8854 / -97.3421	2B
	FWBFC3	N. Beach St. north of Paula Ridge	32.8536 / -97.2904	2B
Marine Creek – West Fork Trinity River	FWMAR1	3500 Macie, bridge crossing in Buck Sansom Park	32.8079 / -97.3703	1C
	FWMAR1	West of Angle Avenue in Buck Sansom Park	32.8069 / -97.3691	2B
	FWMAR3	Saunders Park south of Mule Alley and downstream of JV1A	32.7862 / -97.3460	1C / 2B
Mary's Creek	FWMRY1	3900 block Longvue (FM 2871)	32.7133 / -97.4966	2B
	FWMRY3	Winscott Road (Vickery Blvd.) in South Z Boaz Park	32.6954 / -97.4477	2B
Garland				
Rowlett Creek – Lake Ray Hubbard	GA1501	Rowlett Creek at SH 78	32.959902 / -96.614854	4C
	GA1502	Rowlett Creek at Centerville Road/Castle Drive	32.920519 / -96.593322	4C
	GA1503	Rowlett Creek at Hwy 66	32.909367 / -96.593372	4C

Table 3-5: Year 5 (2015) Chemical Sampling and Bioassessment Site Locations				
Jurisdiction / **Watershed**	**Station ID**	**Location**	**Latitude/Longitude**	**# of samples in 2015[1]**
	GARBA20145	Rowlett Creek below Atchison Topeka and Santa Fe Railroad bridge	32.960095 / -96.612327	2B
Irving				
Cottonwood Branch - Hackberry Creek	IR1501	Cottonwood Creek at Belt Line Road	32.866856 / -96.991267	4C
	IR1502	Cottonwood Creek at N. Story Road	32.864935 / -96.976876	4C
	IR1503	Cottonwood Creek at Highway 114	32.876944 / -96.946667	4C
Mesquite				
South Mesquite Creek	MS1501	North of New Market Road (in Park)	32.7572500 / -96.6119444	4C
North Mesquite Creek	MS1502	North Mesquite Creek at Edward's Church	32.7321111 / -96.5505000	4C
Plano				
Pittman Creek – Spring Creek	PL1501	Spring Creek and Legacy	33.072194 / -96.760417	4C
	PL1502	Spring Creek and 16th Street	33.021317 / -96.712406	4C
	PLRBA20145	Spring Creek and 16th Street	33.021317 / -96.712406	2B
North Texas Tollway Authority				
Prairie Creek – Elm Fork Trinity River	NT1501	Unnamed Tributary at SRT N. of Hebron Pkwy	33.024741 / -96.931512	4C
	NT1502	Unnamed Tributary at SRT N. of Marchant Blvd	33.013832 / -96.939749	4C
TxDOT-Dallas				
Prairie Creek	TX1501	Prairie Creek at Hwy 175	32.7048611 / -96.6697778	4C
Headwaters Ten Mile Creek	TX1502	Highway 67, between Main Street and Danieldale Road	32.6284060 / -96.9038780	4C

Notes:

1. "B" Signifies bioassessment samples, "C" signifies chemical samples.

3.4.2.3. Cities of Garland and Plano

Stream rapid bioassessments were conducted on Rowlett Creek in Garland and Spring Creek in Plano in 2014. Each creek was sampled at one location in May and at the same location again in September. Benthic macroinvertebrate and fish communities were sampled and data compared with metrics from the Texas Commission on Environmental Quality TCEQ. Habitat, water chemistry, and flow were also measured in each trip.

4. Third Permit Term Monitored Watershed Characterizations

4.1. Entity Implemented Best Management Practices

The primary goals of the RWWCP during the third permit term were to continue the assessment of urban impact on receiving stream water quality and to document any improvement presumably resulting from local BMP implementation. In order to document locally implemented BMPs, a review of each entities Storm Water Management Plan (SWMP) was performed and regional BMP categories were determined. As determined by the SWMP, BMPs implemented by participating entities are shown in Table 4-1. The BMPs are presumably implemented throughout the jurisdiction of the identified entity. Site specific BMPs located outside of the studied stream drainage areas or otherwise that were not applicable to this study were not included in the table.

Table 4-1 Locally Implemented BMPs by Participating Entity

Best Management Practices	Participating Entities[1]								
	ARL	DAL	FW	GAR	IRV	MES	NTTA	PLA	TXD
Maintenance Activities									
Pipe conveyance system repair and maintenance	X	X	X	X	X	X	X	X	X
Stream bank erosion control and drainage	X	X	X	X	X	X	X	X	X
Water quality and flood control structures	X	X	X	X	X	X	X	X	X
Provide floatables protection resources for special events/businesses	X	X	X				N/A		N/A
Employed personnel for picking up litter/floatables	X	X	X	X	X	X	X	X	X
Participate in local litter abatement program	X	X	X		X	X	X	X	X
Street sweeping	X	X	X	X	X	X	X	X	X
Deicing BMPs	X	X	X	X		X	X	X	X
Post Construction Control Measures									
Implements iSWM for new development and redevelopment		X	X						
Implements and evaluates low impact development and green infrastructure	X	X	X	X	X	X	N/A		N/A
Illicit Discharge Detection and Elimination									
Initiatives to reduce grass clippings, leaf litter and animal wastes	X	X	X			X	X		
MS4 screening and illicit discharge inspections	X	X	X	X	X	X	X	X	X

Best Management Practices	Participating Entities[1]								
	ARL	DAL	FW	GAR	IRV	MES	NTTA	PLA	TXD
Uses CCTV to monitor for illicit discharges, overflows, and leaks.	X	X	X	X	X	X		X	
Tracks and addresses sanitary sewer overflows and infiltration	X	X	X	X	X	X	N/A	X	N/A
Household hazardous waste and used vehicle motor fluid program	X	X	X	X	X	X	N/A	X	N/A
MS4 map verification and update	X	X	X	X	X		X		X
Pollution Prevention & Good Housekeeping for Municipal Operations									
Municipal facility programs	X	X	X	X	X	X	X		X
Pesticides, herbicides and fertilizer application program	X	X	X	X	X	X	X	X	X
Spill response program	X	X	X	X	X	X	X	X	X
Industrial and High Risk Runoff									
Inspections and control measures for industrial and high risk locations	X	X	X	X	X	X	X	X	X
Screening program for industrial and high risk locations	X	X	X	X	X	X	X	X	X
Construction Site Stormwater Runoff									
Use and maintenance of controls	X	X	X	X	X	X	X	X	X
Inspection of construction sites and enforcement of control measure requirements	X	X	X	X	X	X	X	X	X
Notification/training for responsible parties	X	X	X	X	X	X	X	X	X
Public Education, Outreach, Involvement and Participation									
Community education	X	X	X	X	X	X	X	X	X
School education	X	X	X	X	X	X		X	
Business education	X	X	X	X	X	X	X	X	X
Construction site operator training	X	X	X	X	X	X	X	X	X
Industrial site operator training		X	X		X		X		
Staff education	X	X	X	X	X	X	X	X	X
Community outreach	X	X	X	X	X	X	X	X	X
Visitor and tourist outreach		X	X						X
Media-based outreach	X	X	X	X	X	X	X	X	X

Best Management Practices	Participating Entities[1]								
	ARL	DAL	FW	GAR	IRV	MES	NTTA	PLA	TXD
Household hazardous waste	X	X	X	X	X	X	N/A	X	N/A
Facilitate public reporting and response	X	X	X	X	X	X	X	X	X
Volunteer opportunities	X	X	X	X		X		X	X
SWMP development and public involvement	X	X	X	X		X		X	X
Monitoring, Evaluation and Reporting									
Dry weather screening	X	X	X	X	X	X	X	X	X
Wet weather screening	X	X	X	X	X	X	X	X	X
Rapid bioassessment monitoring		X	X	X				X	
Industrial and high risk runoff monitoring	X	X	X	X	X	X	X	X	N/A

Notes:

1. ARL = City of Arlington; DAL = City of Dallas; FW = City of Fort Worth; GAR = City of Garland; IRV = City of Irving; MES = City of Mesquite; NTTA = North Texas Tollway Authority; TXD = Texas Department of Transportation – Dallas District.

4.2. Water Quality Standards Assessment

EPA and the State of Texas do not promulgate wet-weather specific in-stream water quality standards. It should be noted that for purposes of official assessment of standards attainment in the State of Texas, samples must be collected following TCEQ's *Surface Water Quality Monitoring Quality Assurance Project Plan*, *Surface Water Quality Monitoring Procedures Manual*, and *Guidance for Assessing and Reporting Surface Water Quality in Texas*. In addition to various differences in data collection techniques described in the TCEQ guidance documents, data collected under the RWWCP program is biased towards wet weather events. Therefore the numerical criteria comparisons to the data collected under the RWWCP presented within this section (and in the Appendices) is strictly for comparison purposes. For the purposes of water quality assessment, Atkins reviewed the TSWQS to generate standards for monitored parameters for each monitored stream segment. Numerical criteria (water quality parameter concentrations) established in the TSWQS provide a quantitative basis for evaluating use support and for managing point and nonpoint loadings in Texas surface waters. These criteria are used as maximum or minimum instream concentrations that may result from permitted discharges and nonpoint sources.

Each stream segment was assigned site-specific uses and criteria based upon assumed uses and criteria found in Appendix A of the TSWQS for classified segments. Aquatic life protection criteria were obtained from Table 1 of the TSWQS and where applicable for dissolved fractions, the estimated total fraction criteria were calculated utilizing segment-specific values for total suspended solids (TSS), hardness, slope (m) and intercept (b) values found in Table 6 and Appendix D of the TCEQ *Procedures to Implement the Texas Surface Water Quality Standards (June 2010).* Stream order was determined from United States Geological Survey topographic maps with a scale of 1:24,000 following Texas Water Code §26.023 Texas Surface Water Quality Standards Chapter §307.3 and used to determine waters with sustainable fisheries to calculate the human health protection criteria. Human health protection criteria were obtained from Table 2 of the TSWQS or from the federal surface water quality criteria where applicable. The estimated total fraction criteria were again calculated utilizing segment-specific values for total suspended solids (TSS), hardness, slope (m) and intercept (b) values found in Table 6 and Appendix D of the TCEQ *Procedures to Implement the Texas Surface Water Quality Standards (June 2010).* Therefore, total fraction numerical criteria comparisons to the data collected under the RWWCP presented within this section (and in the Appendices) is strictly for comparison purposes and may not represent criteria used for evaluating use support and for managing point and nonpoint loadings in Texas surface waters.

4.3. Water Quality Screening Level Assessment

Numeric criteria do not exists for all parameters that were measured. However, screening levels (instream concentrations) for nutrients have been established by the TCEQ as targets that can be directly compared to monitoring data. The TCEQ statistically derived screening levels from long-term monitoring data or published levels of concern. Nutrient screening levels were obtained from the TCEQ's *2014 Guidance for Assessing and Reporting Surface Water Quality in Texas (June, 2015)*.

4.4. Comparison to Other Data Sources

Numeric criteria and screening levels are not available for TSS, oil and grease, biochemical oxygen demand, chemical oxygen demand, total nitrogen, and conductivity. Because of the lack of numeric criteria or screening levels; TSS, oil and grease, biochemical oxygen demand, total nitrogen, and chemical oxygen demand were compared to the third quartile of the National Stormwater Quality Database (NSQD) data for each parameter. Conductivity was compared to criteria proposed by the National Rivers and Streams Assessment (NRSA) 2008–2009: A Collaborative Survey (USEPA, 2016b). In addition, for all parameters, Clear Rivers Program (CRP) data was included where available.

The NSQD is an urban stormwater runoff characterization database developed under the direction of Dr. Robert Pitt, P.E., of the University of Alabama and the Center for Watershed Protection under support from the USEPA. It is now supported as a companion project to the International Stormwater BMP Database. The NSQD is maintained as a separate stand-alone database, serving as an important resource for municipal stormwater managers and researchers who are seeking urban runoff characterization data. The NSQD can be downloaded from www.bmpdatabase.org. The NRSA presents the general overview and results of national sampling effort undertaken by the USEPA and its state and tribal partners. NRSA provides information on the ecological condition of the nation's rivers and streams and the key stressors that affect them, both on a national and an ecoregional scale. EPA used NRSA and other data to develop thresholds for good, fair, and poor designations.

The CRP data was assembled by the Trinity River Authority and TCEQ through state funds for in-stream water quality monitoring, evaluation, and decision-making. The CRP data represents ambient, in-stream concentrations during mostly dry conditions.

4.5. Monitored Subwatershed Characterization

The following subsections present data available for each monitored subwatershed along with an analysis of potential pollution sources, BMPs, and monitoring recommendations specific to the subwatershed. Only third permit term RWWCP parameters are presented and evaluated. Although data for additional parameters may have been available, evaluation of those parameters was beyond the scope of this assessment. One third term RWWCP parameter, Carbaryl, was not detected and therefore the results for Carbaryl are not discussed below.

4.5.1. Bachman Branch

The City of Dallas performed bioassessment monitoring only each monitoring year of the third permit term on Bachman Branch, a stream of a stream order greater than three draining to the Elm Fork of the Trinity River in the Bachman Branch-Elm Fork of the Trinity River watershed. The Bachman Branch-Elm Fork of the Trinity River watershed is located in Dallas County. Bachman Branch drains into Bachman Lake just prior to discharging into the Elm Fork of the Trinity River. The City of Dallas divides the Bachman Branch subwatershed into Upper Bachman Creek (see Appendix C, Figure 1) and Lower Bachman Creek (see Appendix C, Figure 2). The bioassessment monitoring station (BAB-B) is located at the Midway Road crossing approximately 0.25 stream miles downstream of the subwatershed area divide between the Upper and Lower Bachman Creek drainage areas. According to City of Dallas (2012), the Upper Bachman Creek drainage area serves approximately 6,147 acres and the Lower Bachman Creek drainage area serves approximately 2,282 acres. Nearly all of the Bachman Branch subwatershed area is within the jurisdictional limits of the City of Dallas, except for the small area located north of Interstate 635 and west of the Dallas

North Tollway which is within the jurisdictional limits of the City of Farmers Branch. NTTA contributes flow to the subwatershed through the Dallas North Tollway. TxDOT-Dallas District contributes flow to the subwatershed through Interstate 635 and State Highway 12. No TCEQ permitted wastewater outfalls exist within the subwatershed according to the *TCEQ Permitted Wastewater Outfall* shapefile accessed May 20, 2016.

4.5.1.1. Summary Statistics

No wet weather chemical monitoring data was collected within this watershed.

4.5.1.2. Water Quality Data Analysis

Monitored parameters were plotted and compared to water quality standards, screening levels, and the NSQD where applicable. Additional pesticide parameters were collected at station BAB-B by the City of Dallas outside of the RWWCP and are not presented in this report. The Bachman Branch graphs are located in Appendix D. All third term RWWCP monitored parameters were within applicable water quality standards, screening levels and comparison levels except for one instance of ammonia nitrogen exceeding the TCEQ screening level in the summer of 2014. However, the City of Dallas has tracked bacteria trends for *E. coli* at BAB-B over the period of 2009-2015. The geometric mean over the period of record (189 col/100 mL) exceeds the primary contact recreation (PCR) geometric mean standard of 126 col/100 mL. Of 15 samples collected, the City of Dallas has documented 10 exceedances of the bacteria standard over the period of record.

4.5.1.3. Biological Data Analysis

Detailed reports of the biological assessments including data summaries can be found in the Annual Regional Wet Weather Characterization Program Monitoring Report for North Central Texas Year 2 through Year 5 (NCTCOG, 2013; NCTCOG, 2014; NCTCOG, 2015; NCTCOG, 2016). The habitat assessment scores and aquatic life use scores were plotted and compared to the habitat and aquatic life use categories (see Appendix D).

Bachman Branch, in the reach studied, received habitat scores mostly in the optimum range except for the summer of 2013, when the habitat score dropped to the sub-optimum range. Aquatic life use scores were in the intermediate range. This part of Bachman Branch has an assumed aquatic life use of high and may not be considered ecologically healthy because the aquatic life use scores were consistently less than high even though habitat quality received mostly optimum scores. This is an indication that chemical factors may be impacting the biological community.

4.5.1.4. Potential Pollution Sources and BMP Recommendations

During the RWWCP Third Permit Term there was one ammonia nitrogen result that exceeded the ammonia nitrogen results where the TCEQ screening level was exceeded. There was no documented effect on the growth of aquatic plants or algae and no resulting decrease in dissolved oxygen. There were no other indicators of potential pollution observed in the Third Permit Term. Land use of the Bachman Branch drainage area was not available from the NCTCOG annual reports. However, a visual analysis of the drainage area reveals a predominately single-family residential land use. Due to the extremely infrequent nature of the exceedance, the source was most likely a single input of the pollutant to the stream. A potential source of ammonia nitrogen from this land use is over application of fertilizer on lawns and gardens. A potential BMP for this source is targeted public education of homeowners regarding fertilizer application.

4.5.1.5. Monitoring Recommendations

Data analyzed presents low indications of stream degradation or chemical indicators of water quality decline. In addition, there are no TMDLs or impairments identified for either Bachman Branch or the Elm Fork of the Trinity River. It is recommended that additional monitoring at this site be assigned a low priority. However, additional monitoring may be focused on pollutant screening in an attempt to identify the cause of impacts to the biological community.

4.5.2. Big Fossil Creek

The City of Fort Worth performed bioassessment and chemical monitoring on Big Fossil Creek (TCEQ segment 0806C), a stream with a stream order of one draining to the West Fork of the Trinity River Below Lake Worth (TCEQ segment 0806) within the White's Branch – Big Fossil Creek watershed. Additional bioassessment and chemical monitoring is scheduled for 2016.

The White's Branch – Big Fossil Creek watershed is located in north central Tarrant County. This 35,840-acre watershed is predominately open space (40.3%) and residential (32.1%) property. The open space is located in the northern part of the watershed while the residential property is primarily in the south. A few highways (14.2%) are located in this watershed, and include: IH 35W, IH 820, SH 81, SH 377, SH 183, and SH 121. The small portion of industrial (1.4%) is dispersed while the commercial (11.3%) is primarily in the eastern part of the watershed. This watershed contains 0.6% water features.

The City of Fort Worth has one bioassessment and chemical monitoring site and one chemical monitoring site only both located within the Big Fossil Creek subwatershed. The chemical monitoring site, FWBFC1, was located west of and parallel to Pepperidge Lane at the Blue Mound Rd. crossing immediately south of Harmon Rd. and north of the City of Saginaw. Much of the subwatershed upstream of this location was rural or undeveloped. The subwatershed delineated for this site covered a 4,080-acre area and consisted primarily of open space (58.7%). The majority of the open space was vacant, ranchland and farmland that was dispersed throughout the subwatershed. Residential land use (25.4%) was in the upper part of the subwatershed, and there was one main highway (9.7%) that ran through the area, which was SH 81. Commercial land use (4.8%) was located primarily in the lower part of the subwatershed. There was one industrial (0.8%) site that was just south of SH 81 in the lower subwatershed. The subwatershed contained 0.6% water features.

The chemical and bioassessment site, FWBFC3, was located at the Beach St. crossing north of Paula Ridge. Below this point, the creek flowed through Haltom City, North Richland Hills and Richland Hills before converging with Little Fossil Creek and the West Fork Trinity River. This subwatershed covered a 15,901-acre area that was composed primarily of open (52.6%) space. The majority of the open space was vacant land and ranchland. The residential land use (24.1%) was dispersed throughout the entire subwatershed. There were a couple highways (11.9%) that crossed through the drainage area and included IH 35W and SH 81. Commercial (9.9%) property was evenly dispersed throughout the subwatershed. There were a couple of industrial (0.7%) sites in the upper subwatershed. The subwatershed contained 0.8% water features.

The monitoring sites, watershed and subwatershed boundaries, and land use types are shown in Appendix C, Figure 3. The monitored subwatershed is primarily within the jurisdictional limits of the City of Fort Worth. However, the cities of Saginaw and Haslet have small portions of jurisdictional limits within the watershed. TxDOT contributes flow to the subwatershed through Interstate 35 and State Highway 81. No TCEQ permitted wastewater outfalls exist within the subwatershed according to the *TCEQ Permitted Wastewater Outfall* shapefile accessed May 20, 2016.

4.5.2.1. Summary Statistics

Summary statistics are presented in Table 4-3. The summary statistics include number of samples, minimum and maximum values, median, arithmetic mean, geometric mean, standard deviation, and coefficient of variation.

Table 4-2 Big Fossil Creek RWWCP Third Permit Term Summary Statistics

Parameter	TDS (mg/L)	TSS (mg/L)	BOD (mg/L)	COD (mg/L)	Nitrogen, Total (mg/L)	Phosphorus, Dissolved (mg/L)
No. of Samples	2	2	2	2	2	2
Minimum	179.0	26.30	2.60	20.30	0.840	0.010
Maximum	219.0	50.00	7.60	43.90	1.000	0.013
Median	199.0	38.15	5.10	32.10	0.920	0.012
Arithmetic Mean	199.0	38.15	5.10	32.10	0.920	0.012
Geometric Mean	198.0	36.26	4.45	29.85	0.917	0.011
Standard Deviation	28.3	16.76	3.54	16.69	0.113	0.002
Coefficient of Variation	0.14	0.44	0.69	0.52	0.12	0.184
	Phosphorus, Total (mg/L)	Arsenic, Total (mg/L)	Chromium, Total (mg/L)	Copper, Total (mg/L)	Lead, Total (mg/L)	Zinc, Total (mg/L)
No. of Samples	2	2	2	2	2	2
Minimum	0.060	0.002	0.001	0.006	0.002	0.010
Maximum	0.081	0.009	0.003	0.011	0.006	0.030
Median	0.071	0.005	0.002	0.009	0.004	0.020
Arithmetic Mean	0.071	0.005	0.002	0.009	0.004	0.020
Geometric Mean	0.070	0.004	0.002	0.008	0.004	0.018
Standard Deviation	0.015	0.005	0.001	0.004	0.002	0.014
Coefficient of Variation	0.211	0.869	0.670	0.444	0.616	0.682
	Oil & Grease (mg/L)	pH, Field (su)	Specific Conductivity (µS/cm)	Temperature (°F)	E. Coli (col/100 mL)	Total Coliform (col/100 mL)
No. of Samples	2	4	0	0	2	2
Minimum	0.53	7.80	-	-	43500	253000
Maximum	0.53	8.10	-	-	57900	529000
Median	0.53	7.89	-	-	50700	391000
Mean	0.53	7.92	-	-	50700	391000
Geometric Mean	0.53	7.92	-	-	50186	365837
Standard Deviation	0.00	0.13	-	-	10182	195161
Coefficient of Variation	0.00	0.02	-	-	0.20	0.50

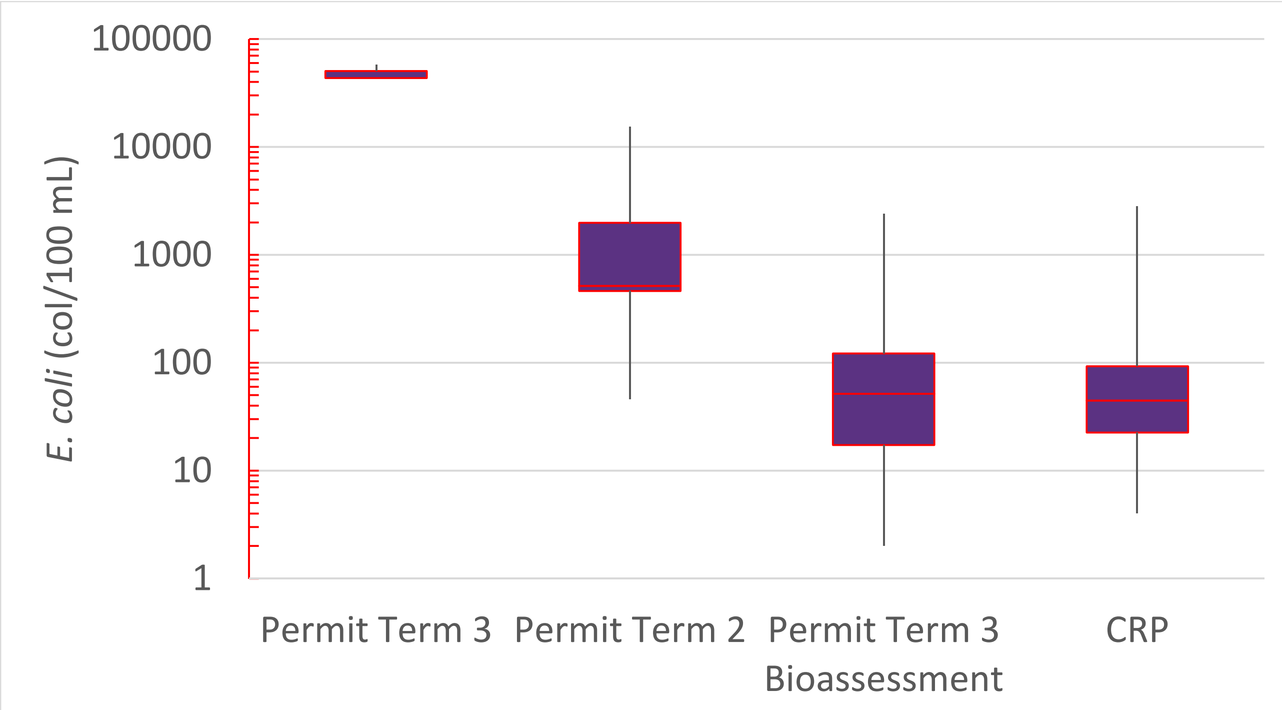
4.5.2.2. Water Quality Data Analysis

The wet weather chemical monitoring data over the permit term resulted in two data points collected in September and October 2013. These data were plotted and compared to water quality standards, screening levels, and other data sources where applicable. These graphs are located in Appendix E. The *E. coli* concentrations exceeded the single sample and geometric mean primary contact standards during the September and October 2013 wet weather chemical monitoring events.

The water quality data collected during bioassessments was also plotted and compared to water quality standards, screening levels, and other data sources including CRP data where applicable. CRP station 17133 located near BFC3 was utilized for this analysis. These graphs are also located in Appendix E. The geometric mean of the bioassessment E. coli data was 45 col/100 mL which was less than the PCR geometric mean standard of 126 col/100 mL. Ammonia nitrogen exceeded the TCEQ screening level four times during the period of October 2012 to October 2013.

Due to the exceedances discussed above and the availability of CRP, bioassessment, and wet weather chemical data, boxplots were created for *E. coli* for comparison of the datasets. These data indicate that stormwater runoff is providing a statistically significant input of *E. coli* to the stream compared to bioassessment and CRP data which was predominately collected during dry weather (see Figure 4-1).

Figure 4-1 Boxplot Comparing Wet Weather Chemical Monitoring, Bioassessment, and CRP *E. coli* Data at Big Fossil Creek



E. coli and ammonia nitrogen exceedances occurred at both monitoring stations over separate sampling events. The ammonia nitrogen exceedances occurred mainly in 2013 with one occurrence in the fall of 2012. The E. coli exceedances occurred only in 2013.

4.5.2.3. Biological Data Analysis

Detailed reports of the biological assessments including data summaries can be found in the Annual Regional Wet Weather Characterization Program Monitoring Report for North Central Texas Year 2 through Year 5 (NCTCOG, 2013; NCTCOG, 2014; NCTCOG, 2015; NCTCOG, 2016). The habitat assessment scores and aquatic life use scores were plotted and compared to the habitat and aquatic life use categories (see Appendix E). The habitat scores remained in the sub-optimum range over the third term period with the exception of optimum scores at BCF1 in the fall of 2012 and spring of 2015.

The City of Fort Worth utilized the USEPA macroinvertebrate index metric which rates sites from non-impaired to severely impaired. BCF1 was rated non-impaired over the third term period with the exception of the fall of 2014 and 2015 when it was rated slightly impaired. BCF3 was rated non-impaired over the third term period with the exception of the spring of 2012 when it was rated slightly impaired and fall of 2014 when it was rated moderately impaired. Texas macroinvertebrate index of biotic integrity (IBI) scores remained in the intermediate to high range over the third term period at both sites. The City of Fort Worth assessed the Texas Fish IBI at BFC3 in 2012 at exceptional and in 2013 and 2014 at high. Given the predominately sub-optimum habitat found at both sites, impaired to slightly impaired USEPA scores and high to intermediate IBI scores generally correspond with the available habitat indicating that water quality may not be limiting fish and macroinvertebrate communities.

4.5.2.4. Potential Pollution Sources and BMP Recommendations

During the RWWCP Third Permit Term the wet weather *E. coli* results exceeded the PCR single sample and PCR geometric mean criterion and four ammonia nitrogen results exceeded the TCEQ screening level. There was no documented effect on the growth of aquatic plants or algae and no resulting decrease in dissolved oxygen. There were no other indicators of potential pollution observed in the Third Permit Term.

Land use of the Big Fossil Creek subwatershed is predominately open followed by residential. The nutrient screening level and bacteria exceedances occurred primarily in 2013, with one ammonia nitrogen exceedance in the fall of 2012.

Given the high residential and open land use in the subwatershed, the potential source of the ammonia nitrogen loadings may be excessive lawn, garden, and agricultural fertilization. Also, legacy nutrients from agricultural land may be present in area soils. However, dissolved oxygen concentrations over the monitoring term did not fall below TCEQ criteria for aquatic life protection suggesting that the nutrient loadings were not contributing to low dissolved oxygen events.

For bacteria, potential sources may be livestock, agricultural manure application, domestic animals, wildlife, septic system failure, and illicit connections. BMPs recommended for these sources include public education for agricultural and residential land owners, and compliance inspections for illicit connections. In addition, maintenance and education for septic system owners regarding frequent maintenance and pump out may be considered. Due to sub-optimal habitat scores ranging to optimal, small stream restoration projects may be able to increase the biological productivity of the stream.

4.5.2.5. Monitoring Recommendations

Data analyzed presented occasional exceedances to ammonia nitrogen and bacteria screening and criteria levels with low to no indications of stream degradation or chemical indicators of continuous water quality decline. In addition, there are no bacteria TMDLs or impairments identified for either Big Fossil Creek or the West Fork of the Trinity River Below Lake Worth. The West Fork of the Trinity River Below Lake Worth is impaired for dioxin and PCBs in fish tissue and there is a TMDL for legacy pollutants. Additional monitoring at this site is recommended to be assigned a low priority.

4.5.3. Cottonwood Branch

The City of Irving performed chemical monitoring on Cottonwood Branch (TCEQ segment 0822A), a stream with a stream order of one draining to Hackberry Creek and the Elm Fork of the Trinity River within the Cottonwood Branch – Hackberry Creek watershed.

Cottonwood Branch – Hackberry Creek Watershed is a 13,325-acre watershed located in northeast Dallas County that includes the northern half of Irving's city limits. This watershed is composed predominately of highway acreage (39.3%) which is due to a large portion of the DFW International Airport residing in the western side of the watershed. Also contributing to this percentage are three major highways that converge within the Cottonwood Branch watershed: SH 114, IH 635, and the President George Bush Turnpike (PGBT). Throughout the watershed, there are patches of open areas (25.3%) and clusters of commercial (22.4%) areas located in the vicinity of major highways. Some of the residential (11.7%) areas are scattered along the southern edge of the watershed and there is a large residential community north of the President George Bush Turnpike, between SH 114 and IH 635. The water feature composition for this watershed is 1.2% and industrial land use is just 0.1%.

The City of Irving has three chemical monitoring sites located within the Cottonwood Branch subwatershed. The chemical monitoring site, IR1401/1501 was an upstream sampling site located north of Walnut Hill Lane where Belt Line Road crosses Cottonwood Branch Creek. The conveyance at this site was a concrete, trapezoidal, open channel chute. The subwatershed delineated for this area covers 625 acres and was estimated to be predominately 39.6% open space. The President George Bush Turnpike (SH 161) ran through this subwatershed and contributed to the highway (28.6%) land use estimate for this area. There were few large residential (20.9%) areas located upstream of IR1401/1501. One of the residential areas, north of SH 161, had adjacent commercial property. Most of the commercial (10.8%) property in this subwatershed was located along SH 161. There were no areas designated as industrial or water in this subwatershed. Note that this subwatershed was sampled in 2007 (IR0701). The land use description for IR0701 provided in the 2007 Annual Monitoring Report, which was based on the NCTCOG 2005 Regional Land Use Data, indicated that 1.1% of the area was industrial. Updates to the land use coding process used in developing the NCTCOG 2010 Regional Land Use Data resulted in those properties being classified as commercial.

The chemical monitoring site, IR1402/1502, was a midstream sampling site located south of Walnut Hill Lane where Story Lane crosses Cottonwood Branch Creek. The conveyance at this site was an unlined, natural channel. This subwatershed covered a 643-acre area and was predominately made up of residential (43.0%) property. Commercial (34.8%) property was dispersed throughout the subwatershed. There was a large commercial area in the northern part of the subwatershed and one located between Walnut Hill Lane and Northgate Drive. There were no major highways that ran through this area but Walnut Hill Lane, Northgate Drive, Beltline Road and Story Road were major roadways that contributed to the highway land use estimate (12.6%). The rest of the subwatershed was made up of 9.4% open space and 0.3% water features. There were no areas designated as industrial in this subwatershed. Note that this subwatershed was sampled in 2007 (IR0702). The land use description for IR0702 provided in the 2007 Annual Monitoring Report, which was based on the NCTCOG 2005 Regional Land Use Data, indicated that 12.6% of the area was industrial. Updates to the land use coding process used in developing the NCTCOG 2010 Regional Land Use Data resulted in those properties being classified as commercial.

The chemical monitoring site, IR1403/1503, was a downstream sampling site located south of Hidden Ridge Road where the frontage road of SH 114 crosses Cottonwood Branch Creek. The conveyance at this site was a concrete lined channel. This subwatershed delineated area covered 1,595 acres and consisted mostly of open space (39.0%). There were several residential areas that covered 25.1% of the subwatershed. Most commercial (20.6%) property was intermixed with residential and open. There was a large commercial area that started in the north central part of the subwatershed, coming very close to Cottonwood Branch and then extending almost all the way to Northgate Drive. There was a very small industrial (0.4%) area at the northwestern tip of the subwatershed. This subwatershed was composed of 12.1% highway land use and 2.7% water features. Note that this subwatershed was sampled in 2007 (IR0703). The land use description for IR0703 provided in the 2007 Annual Monitoring Report, which was based on the NCTCOG 2005 Regional Land Use Data, indicated that 6.4% of the area was industrial. Updates to the land use coding process used in developing the NCTCOG 2010 Regional Land Use Data resulted in some of the properties being classified as commercial.

The monitoring sites, watershed and subwatershed boundaries, and land use types are shown in Appendix C, Figure 4. The monitoring sites are shown as IR1501, IR1502, and IR1503. IR1401, IR1402, and IR1403 were located in the same locations, respectively. The monitored subwatershed is entirely within the jurisdictional limits of the City of Irving. A small portion upper subwatershed is occupied by the Dallas/Fort Worth International Airport. NTTA contributes flow to the subwatershed through State Highway 161 (President George Bush Turnpike). TxDOT-Dallas District contributes flow to the subwatershed through a small portion of SH 114. No TCEQ permitted wastewater outfalls exist within the subwatershed according to the *TCEQ Permitted Wastewater Outfall* shapefile accessed May 20, 2016.

4.5.3.1. Summary Statistics

Summary statistics are presented in Table 4-3. The summary statistics include number of samples, minimum and maximum values, median, arithmetic mean, geometric mean, standard deviation, and coefficient of variation.

Table 4-3 Cottonwood Branch RWWCP Third Permit Term Summary Statistics

Parameter	TDS (mg/L)	TSS (mg/L)	BOD (mg/L)	COD (mg/L)	Nitrogen, Total (mg/L)	Phosphorus, Dissolved (mg/L)
No. of Samples	24	24	24	24	24	24
Minimum	160.0	11.00	0.50	0.50	0.310	0.030
Maximum	1660.0	1006.00	27.00	78.00	7.400	0.240
Median	367.5	37.00	6.66	28.50	1.890	0.065
Arithmetic Mean	464.3	119.95	8.07	27.60	2.496	0.085
Geometric Mean	397.2	46.50	5.23	12.62	1.862	0.073
Standard Deviation	322.1	247.77	7.02	21.45	1.942	0.055
Coefficient of Variation	0.69	2.07	0.87	0.78	0.78	0.644
	Phosphorus, Total (mg/L)	Arsenic, Total (mg/L)	Chromium, Total (mg/L)	Copper, Total (mg/L)	Lead, Total (mg/L)	Zinc, Total (mg/L)
No. of Samples	24	24	24	24	24	24
Minimum	0.006	0.001	0.002	0.001	0.002	0.003
Maximum	0.590	0.005	0.023	0.040	0.006	0.132
Median	0.130	0.001	0.003	0.019	0.002	0.029
Arithmetic Mean	0.173	0.001	0.005	0.019	0.002	0.047
Geometric Mean	0.125	0.001	0.003	0.014	0.002	0.031
Standard Deviation	0.136	0.001	0.005	0.010	0.001	0.041
Coefficient of Variation	0.785	0.688	1.057	0.542	0.399	0.883
	Oil & Grease (mg/L)	pH, Field (su)	Specific Conductivity (µS/cm)	Temperature (°F)	E. Coli (col/100 mL)	Total Coliform (col/100 mL)
No. of Samples	24	24	24	24	24	24
Minimum	0.70	8.00	264	39.7	0.5	750
Maximum	12.80	9.30	749	85.6	9000	241960
Median	0.70	8.65	528	72.0	525	12500
Mean	2.12	8.63	546	67.5	1926	24905
Geometric Mean	1.30	8.62	533	65.6	215	12372
Standard Deviation	2.97	0.32	117	15.3	2877	47457
Coefficient of Variation	1.40	0.04	0.21	0.23	1.49	1.91

4.5.3.2. Water Quality Data Analysis

Monitored parameters were plotted and compared to water quality standards, screening levels, CRP and NSQD data where applicable. These graphs are located in Appendix F. CRP stations 17165, 17166, 17167, and 17168 were utilized for this analysis. Station 17165 is located near the City of Irving's upstream station and17166 is located near the City of Irving's midstream station. Station 171167 is located between the City of Irving's midstream and downstream stations and 171168 is located just downstream of the City of Irving's downstream station.

During the third permit term, there were six exceedances of the TDS TCEQ basin specific criterion, two exceedances of the pH TCEQ basin specific criterion, and thirteen exceedances of the *E. coli* PCR single sample criterion (and the geometric mean exceeded the PCR geometric mean criterion). In addition, there were three occurrences where the TSS concentration, five occurrences where the total nitrogen concentration, two occurrences where the BOD concentration, and two occurrences where the oil and grease concentration was higher than 75% of the NSQD data for those parameters. Lastly, CRP data indicated one exceedance due to low dissolved oxygen in September 2013.

Due to the exceedances and elevated concentrations discussed above and the availability of CRP and wet weather chemical data, boxplots were created for BOD, total nitrogen, pH, and *E. coli* for comparison of the datasets. The data does not indicate that stormwater runoff is providing a statistically significant different input of BOD or *E. coli* to the stream compared to CRP data which was predominately collected during dry weather (see Figures 4-2 and 4-5). However, there is a statistically significant difference between the third permit term wet weather data for pH and the CRP data indicating the stormwater runoff typically was observed to have a higher pH than dry weather flow (see Figure 4-4). There was not a statistical difference between RWWCP third permit term data and CRP data for total nitrogen, but notably the second permit term data was statistically higher than both the third permit term and CRP data (Figure 4-3).

Figure 4-2 Boxplot Comparing Wet Weather Chemical Monitoring Second and Third Permit Term and CRP BOD Data at Cottonwood Branch

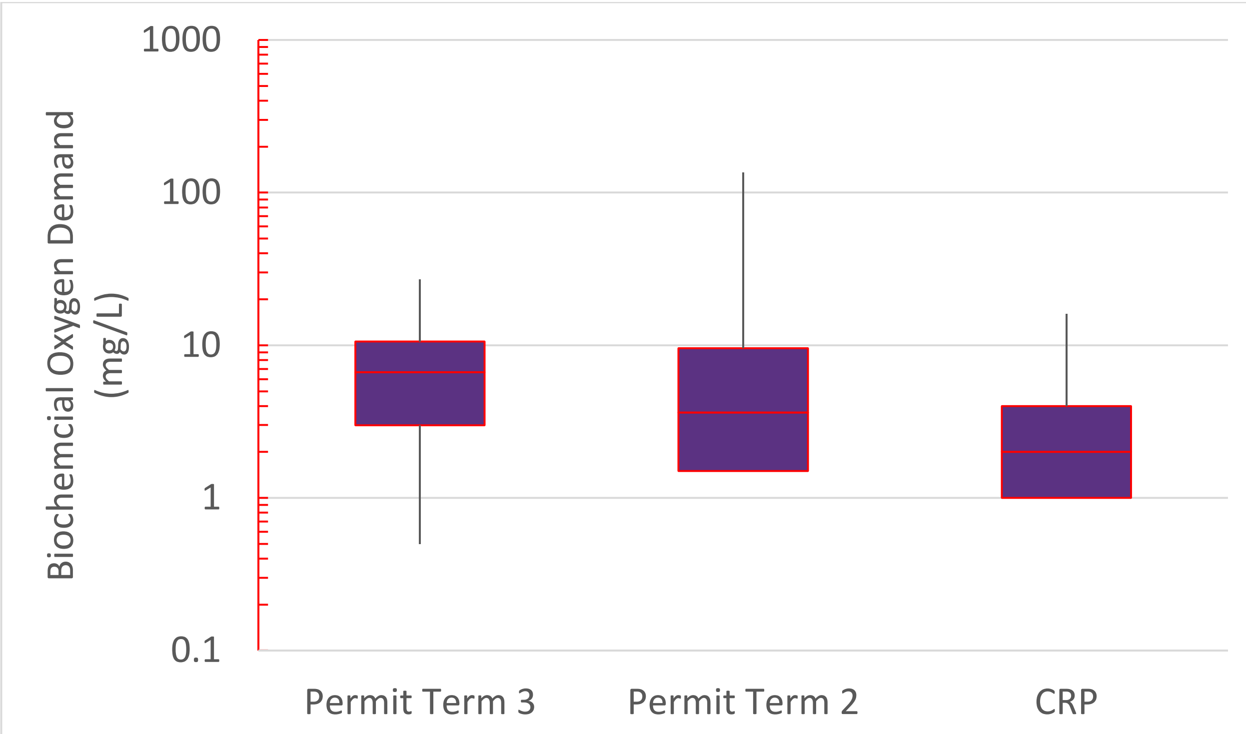


Figure 4-3 Boxplot Comparing Wet Weather Chemical Monitoring Second and Third Permit Term and CRP Total Nitrogen Data at Cottonwood Branch

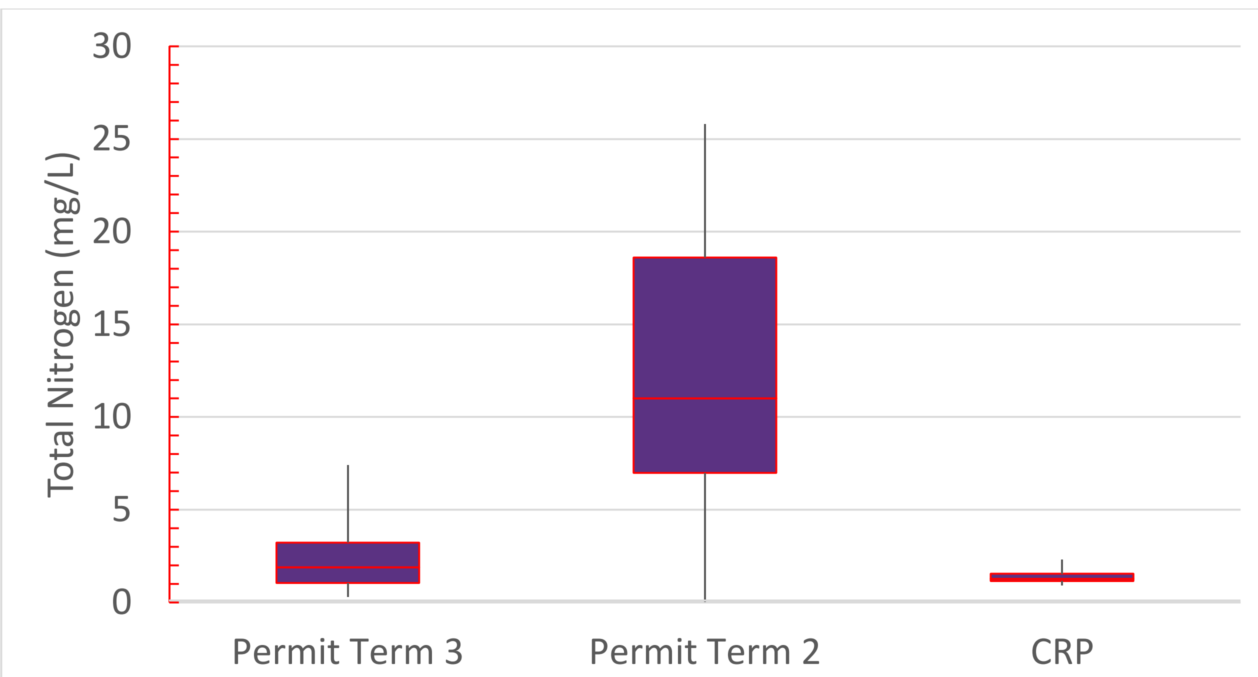


Figure 4-4 Boxplot Comparing Wet Weather Chemical Monitoring Third Permit Term and CRP pH Data at Cottonwood Branch

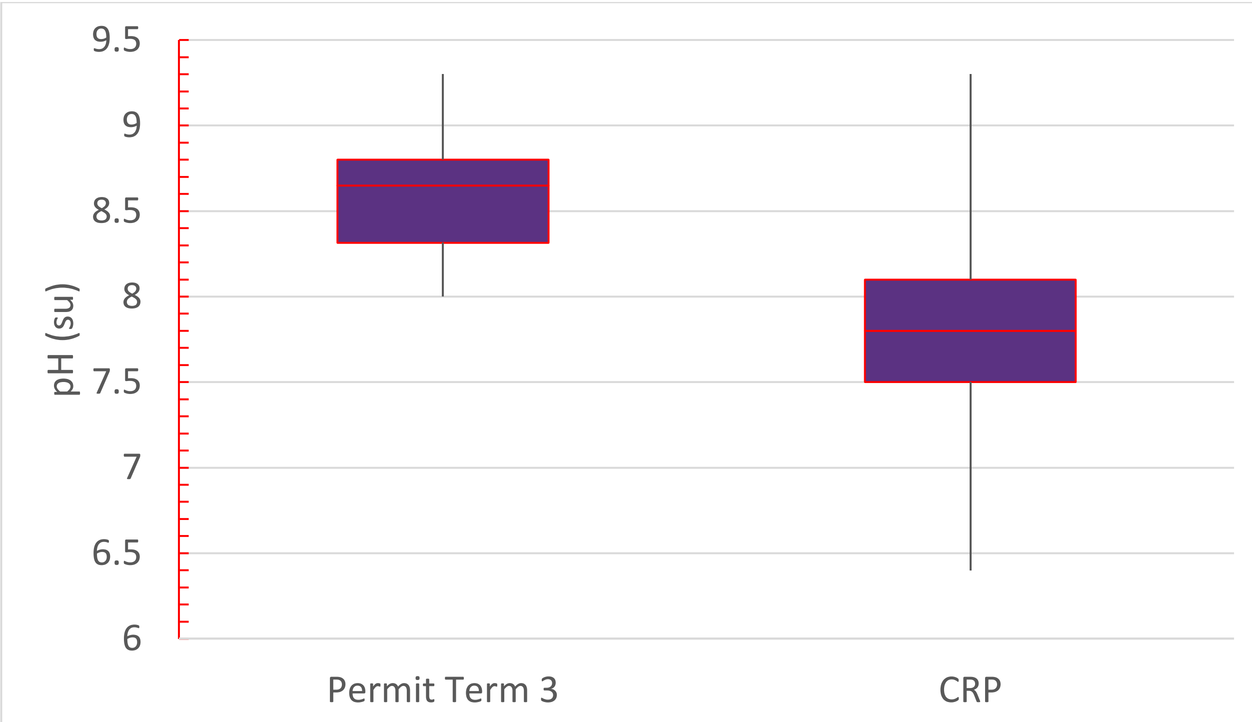
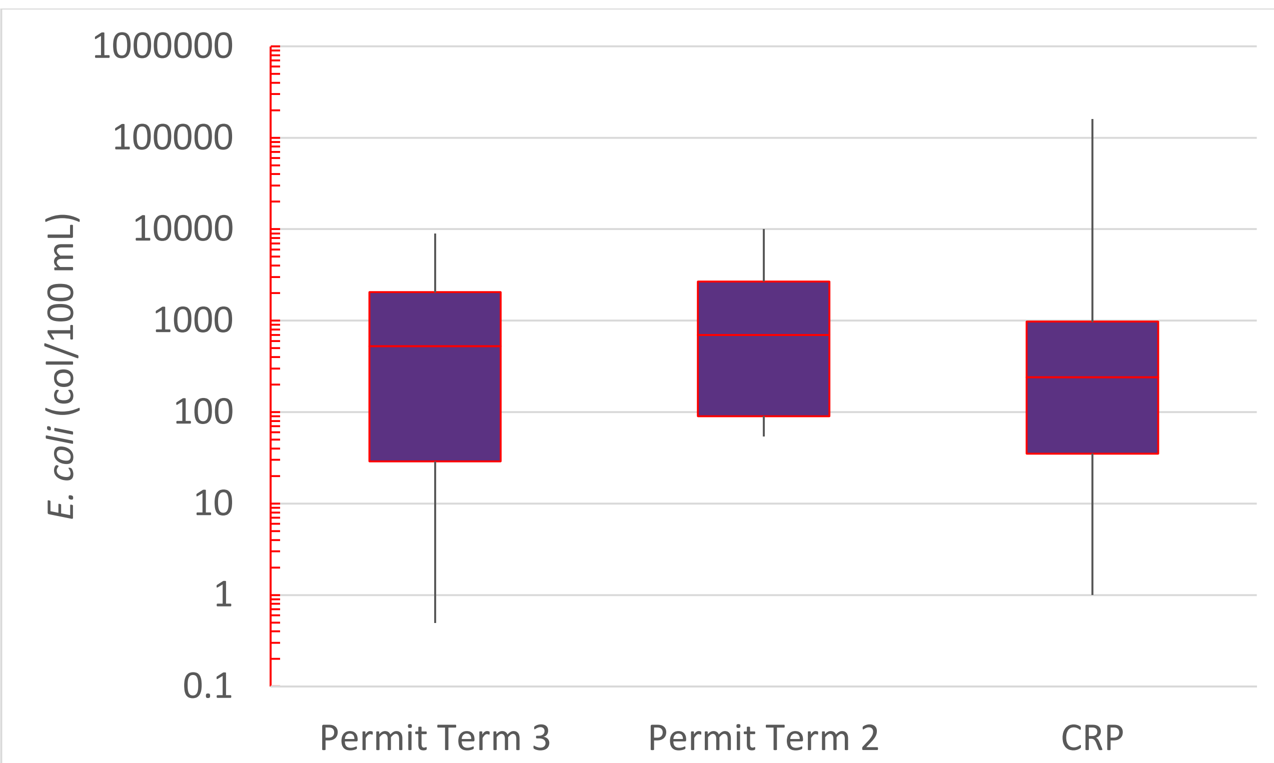


Figure 4-5 Boxplot Comparing Wet Weather Chemical Monitoring Second and Third Permit Term and CRP *E. coli* Data at Cottonwood Branch



Exceedances of the TDS TCEQ basin specific criterion occurred at all three monitoring stations over separate storm events and years. The two exceedances of the pH TCEQ basin specific criterion occurred at the downstream station in April of 2014 and April of 2015. The exceedances of the *E. coli* PCR single sample criterion occurred at all three monitoring stations over separate storm events and years. The elevated TSS concentrations occurred in July 2014 and in April and October of 2015 at the upstream monitoring station. The elevated total nitrogen concentrations occurred during the months of April, July, and October of 2015 at all monitoring stations. The elevated BOD and oil and grease concentrations occurred at the upstream and midstream monitoring stations in July of 2015.

4.5.3.3. Biological Data Analysis

No bioassessment monitoring data was collected within this watershed.

4.5.3.4. Potential Pollution Sources and BMP Recommendations

Land use of the Cottonwood Branch subwatershed is a predominately open land use with sizable commercial and residential land uses. Given the high commercial land use in the subwatershed and the lack of statistical significance to the stormwater biased dataset, the potential sources of the TDS, BOD, and oil and grease loadings may be illicit connections, unauthorized industrial discharges, or illegal dumping. The pH exceedances only occurred during stormwater runoff events at the downstream station in the spring. The downstream station is proceeded by a pond centered within a golf course. A potential source of the elevated pH may be the growth of aquatic plants and algae within the pond during that period. For bacteria, there was no statistical significance to the stormwater biased dataset. Potential sources of bacteria loading may be illicit connections, wildlife, and domestic animals. There are multiple ponds located within the stream corridor they may attract wildlife and domestic animals. Regarding total nitrogen, over fertilization in residential and commercial areas may be the primary source. A common source of TSS loadings is construction activities. A review of the aerial photography over the period shows that some minor residential development occurred in the drainage area of the upstream monitoring station just north of PGBT. The development was located just east of the stream channel.

BMPs recommended for these sources include compliance inspections for illicit connections, public education for illegal dumping, public education/training for managing the ponds located within the stream corridor, public education of home and business owners regarding fertilization and turf management, and review of review of construction inspection protocols or BMP requirements.

4.5.3.5. Monitoring Recommendations

Data analyzed presented multiple exceedances to various criteria, screening levels, and comparison datasets. In addition, there is a bacteria TMDL for Cottonwood Branch. Therefore additional monitoring at this site is recommended to be assigned a high priority. Bioassessment data collection is recommended to determine whether the biological community may be impacted by the chemical pollutants documented above.

4.5.4. Delaware Creek

The City of Irving performed chemical monitoring on Delaware Creek (TCEQ segment 0841H), a stream with a stream order of three or greater draining to the Lower West Fork of the Trinity River within the Delaware Creek – West Fork Trinity River watershed.

The Delaware Creek watershed is located within the city boundaries of Dallas, Grand Prairie, and Irving on the western side of Dallas County. Delaware Creek Watershed covers a 21,599-acre area and is predominately made up of open space (33.5%) and residential (26.8%) property. Open space is mostly found in the central portion of the watershed with the residential property located in the north and west. Major highways (16.8%) intersecting in this watershed are SH 183, SH 356, SH 12, SH 161, SH 408, SH 180, and IH 30. There are a few industrial (3.5%) sites located along some major highways such as SH 180 and IH 30 in the south and SH 356 and SH 12 in the north. The land use estimate for commercial sites is 18.0%. Commercial sites are scattered among residential property in the north and are located along major roadways in the south-central portions of the watershed. This watershed contains 1.4% water features.

The City of Irving has three chemical monitoring sites located within the Delaware Creek subwatershed. The chemical monitoring site, IR1201/1301 was an upstream sampling site located south of SH 183 along Pilgrim Drive behind a single-family residential area. The conveyance at this site was a concrete, trapezoidal channel with low vegetative cover. The subwatershed delineated for this sampling location covered a 794-acre area and consisted mostly of residential (54.3%) property and highway (23.7%) acreage. SH 183 was the only major highway going through this subwatershed area. There were several commercial (20.5%) sites located near SH 183, Belt Line Road, and Rochelle Road. The land use estimate for open space was 1.4% and there seemed to be a small section located adjacent to Delaware Creek, south of Rochelle Road. This subwatershed contained 0% industrial land use and 0.1% water features.

The chemical monitoring site, IR1202/1302 was a midstream sampling site located on the eastern side of Sowers Road, just south of Pioneer Drive. The conveyance at this site was a concrete, trapezoidal channel with low vegetative cover. The subwatershed delineated for this sampling location covered a 2,332-acre area and consisted predominately of residential (55.3%) and commercial (22.4%) property. There were several commercial areas along SH 183. SH 183 is the only major highway going through this subwatershed, which had a total of 20.4% highway. There were also a few large sections of commercial property in the south along O'Connor Road and Pioneer Drive and north of Rochelle Road along Macarthur Boulevard. Open space (2.0%) can be found mostly north of SH 183 and along Macarthur Boulevard. This subwatershed contained 0% industrial land use and no significant water (0%) features.

The chemical monitoring site, IR1203/1303 was a downstream sampling site located west of SH 12 where East Oakdale Road crosses Delaware Creek. The conveyance at this site was a natural, unlined channel with medium vegetative cover. The subwatershed delineated for this sampling location covered a 1,496-acre area and consisted predominately of residential (43.2%) acreage. SH 356 was the only major highway going through this subwatershed area (20.4%). The majority of commercial (21.9%) sites were located along SH 356. Open space (14.2%) in the southern portion seemed to follow along Delaware Creek. There were only a few small industrial (0.1%) sites in the subwatershed. This subwatershed contained no distinct water (0%) features.

The monitoring sites, watershed and subwatershed boundaries, and land use types are shown in Appendix C, Figure 5. The monitoring sites are shown as IR1301, IR1302, and IR1303. IR1201, IR1202, and IR1203 were located in the same locations, respectively. The monitored subwatershed is entirely within the jurisdictional limits of the City of Irving. TxDOT-Dallas District contributes flow to the subwatershed through SH 183 and SH 356. No TCEQ permitted wastewater outfalls exist within the subwatershed according to the *TCEQ Permitted Wastewater Outfall* shapefile accessed May 20, 2016.

4.5.4.1. Summary Statistics

Summary statistics are presented in Table 4-4. The summary statistics include number of samples, minimum and maximum values, median, arithmetic mean, geometric mean, standard deviation, and coefficient of variation.

4.5.4.2. Water Quality Data Analysis

Monitored parameters were plotted and compared to water quality standards, screening levels, CRP and NSQD data where applicable. These graphs are located in Appendix G. CRP station 17178 was utilized for this analysis. It is located near the City of Irving's downstream station. During the third permit term, there were three exceedances of the TCEQ aquatic life use estimated chronic criterion for total copper, one exceedance of the pH TCEQ basin specific criterion, and ten exceedances of the *E. coli* PCR single sample criterion (and the geometric mean exceeded the PCR geometric mean criterion). In addition, there were seven occurrences where the TSS concentration, nine occurrences where the COD concentration, ten occurrences where the recorded BOD concentration, and fifteen occurrences where the total nitrogen concentration was higher than 75% of NSQD data for each parameters.

Table 4-4 Delaware Creek RWWCP Third Permit Term Summary Statistics

Parameter	TDS (mg/L)	TSS (mg/L)	BOD (mg/L)	COD (mg/L)	Nitrogen, Total (mg/L)	Phosphorus, Dissolved (mg/L)
No. of Samples	24	24	24	24	24	24
Minimum	28.0	8.00	2.70	0.50	0.600	0.005
Maximum	428.0	452.00	69.20	165.00	22.300	0.34
Median	174.0	84.50	17.05	53.95	5.340	0.10
Arithmetic Mean	204.0	109.89	24.11	72.18	6.994	0.11
Geometric Mean	178.5	65.21	16.16	47.37	4.698	0.07
Standard Deviation	100.8	108.37	20.46	50.05	6.081	0.08
Coefficient of Variation	0.49	0.99	0.85	0.69	0.87	0.78
	Phosphorus, Total (mg/L)	Arsenic, Total (mg/L)	Chromium, Total (mg/L)	Copper, Total (mg/L)	Lead, Total (mg/L)	Zinc, Total (mg/L)
No. of Samples	24	24	24	24	24	24
Minimum	0.050	0.001	0.002	0.014	0.002	0.025
Maximum	0.680	0.011	0.021	0.059	0.019	0.350
Median	0.325	0.002	0.004	0.029	0.006	0.067
Arithmetic Mean	0.323	0.003	0.005	0.029	0.007	0.087
Geometric Mean	0.270	0.002	0.004	0.027	0.005	0.070
Standard Deviation	0.157	0.003	0.005	0.012	0.005	0.069
Coefficient of Variation	0.486	0.920	0.848	0.406	0.761	0.788
	Oil & Grease (mg/L)	pH, Field (su)	Specific Conductivity (µS/cm)	Temperature (°F)	E. Coli (col/100 mL)	Total Coliform (col/100 mL)
No. of Samples	24	24	24	24	24	24
Minimum	0.70	7.90	49	46.0	3.0	2630
Maximum	15.70	9.20	660	91.6	30000	400000
Median	1.65	8.60	247	65.6	300	25000
Mean	3.40	8.61	249	66.6	3174	54056
Geometric Mean	1.93	8.61	202	65.3	300	22063
Standard Deviation	4.16	0.31	153	13.6	6579	85933
Coefficient of Variation	1.22	0.04	0.61	0.20	2.07	1.59

Due to the exceedances and elevated concentrations discussed above and the availability of CRP and wet weather chemical data, boxplots were created for BOD, COD, total nitrogen, total copper, pH, and *E. coli* for comparison of the datasets. The boxplots do not indicate that stormwater runoff is providing a statistically significant different input of COD, pH, or *E. coli* to the stream compared to CRP data which was predominately collected during dry weather (see Figures 4-7, 4-10, and 4-11). However, there is a statistically significant difference between the third permit term wet weather data for pH and the second term wet weather and CRP data indicating that stormwater runoff had a higher pH in the third permit term than both the previous monitoring term and dry weather flow (see Figure 4-10). There was a statistical difference between RWWCP second and third permit term data and CRP data for BOD, total nitrogen, and total copper (Figure 4-6, 4-8, and 4-9) indicating that stormwater was a source of these pollutants.

Exceedances of the estimated total fraction of copper aquatic life use chronic criterion occurred at the midstream and downstream monitoring stations over separate storm events in 2012. The exceedance of the pH TCEQ basin specific criterion occurred at the upstream station in October 2012. The exceedances of the *E. coli* PCR single sample criterion occurred at all three monitoring stations over separate storm events over the period of January 2012 to January 2013. The elevated TSS concentrations occurred at the midstream and downstream stations in 2012 and 2013. The elevated BOD, COD, total nitrogen, and oil and grease concentrations occurred at all monitoring stations over separate storm events and years.

4.5.4.3. Biological Data Analysis

No bioassessment monitoring data was collected within this watershed.

Figure 4-6 Boxplot Comparing Wet Weather Chemical Monitoring Second and Third Permit Term and CRP BOD Data at Delaware Creek

Figure 4-7 Boxplot Comparing Wet Weather Chemical Monitoring Second and Third Permit Term and CRP COD Data at Delaware Creek

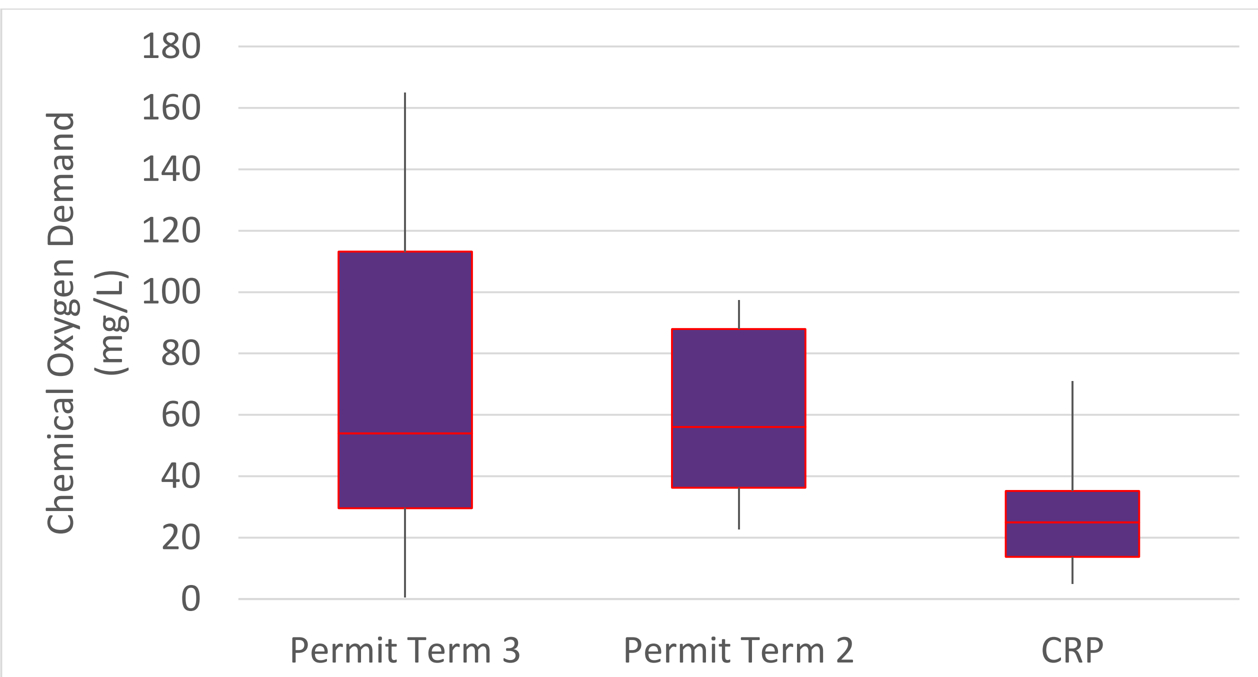


Figure 4-8 Boxplot Comparing Wet Weather Chemical Monitoring Second and Third Permit Term and CRP Total Nitrogen Data at Delaware Creek

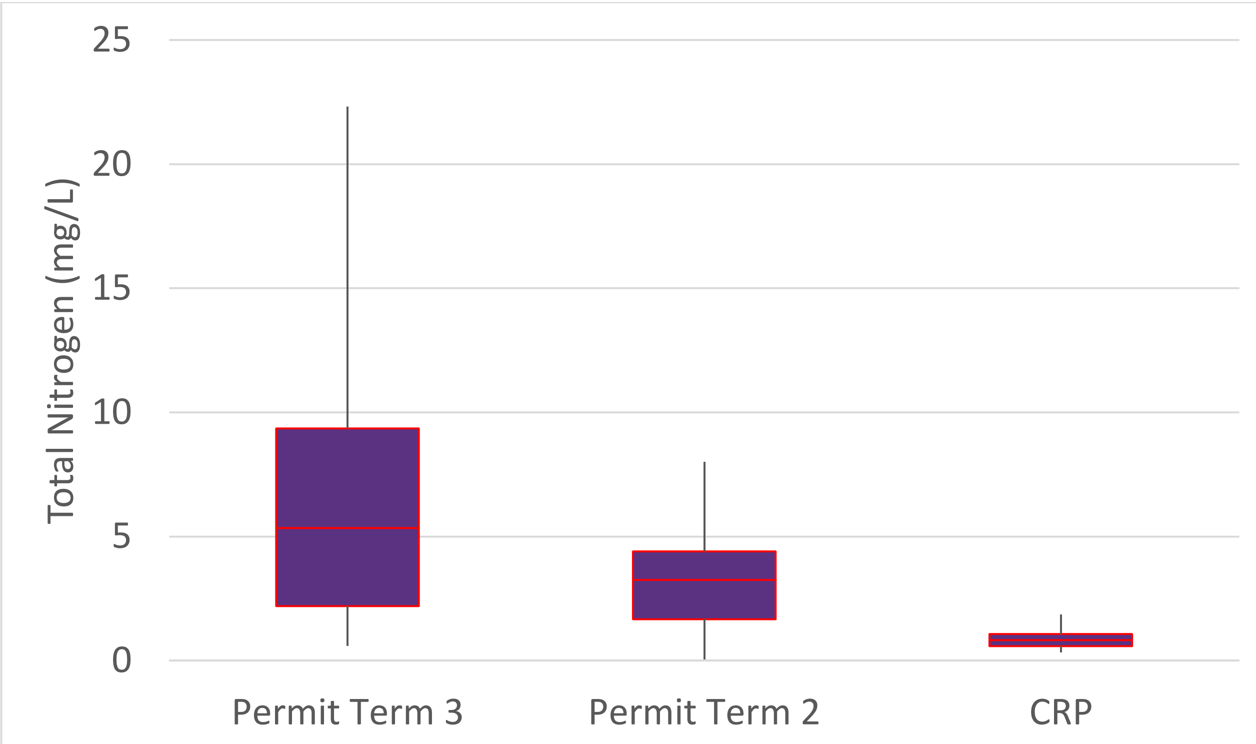


Figure 4-9 Boxplot Comparing Wet Weather Chemical Monitoring Second and Third Permit Term and CRP Total Copper Data at Delaware Creek

Figure 4-10 Boxplot Comparing Wet Weather Chemical Monitoring Second and Third Permit Term and CRP pH Data at Delaware Creek

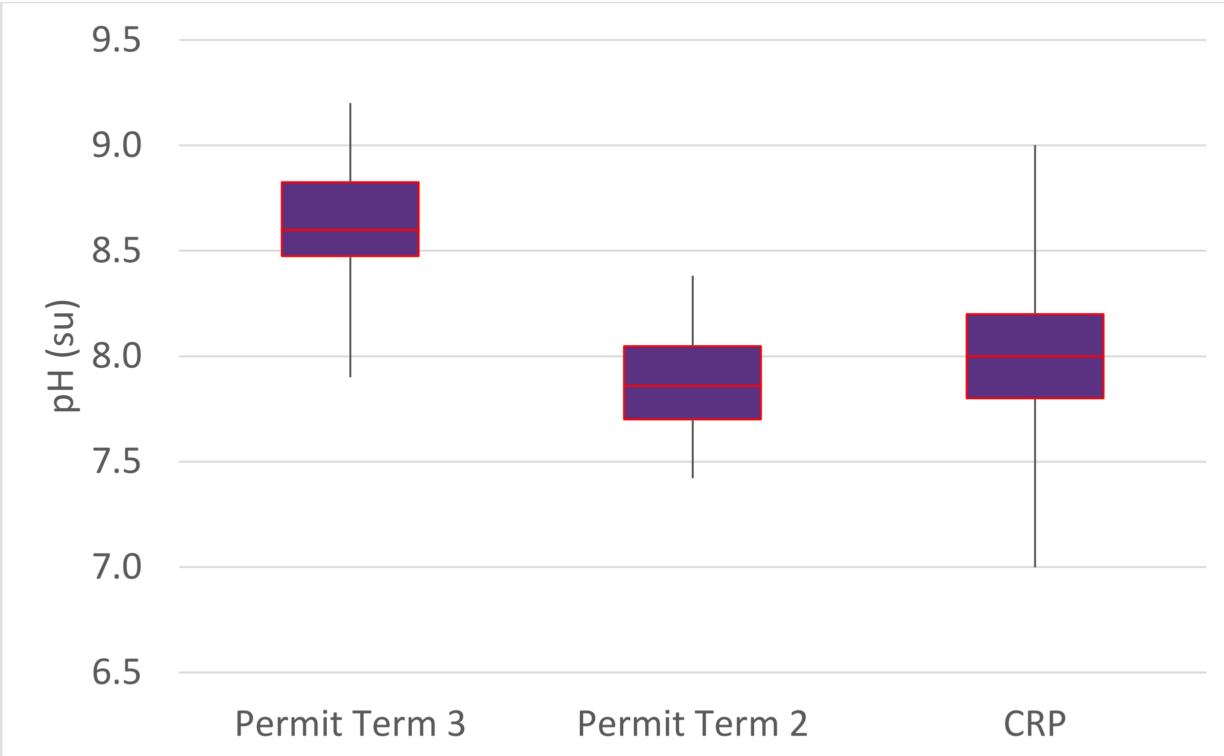
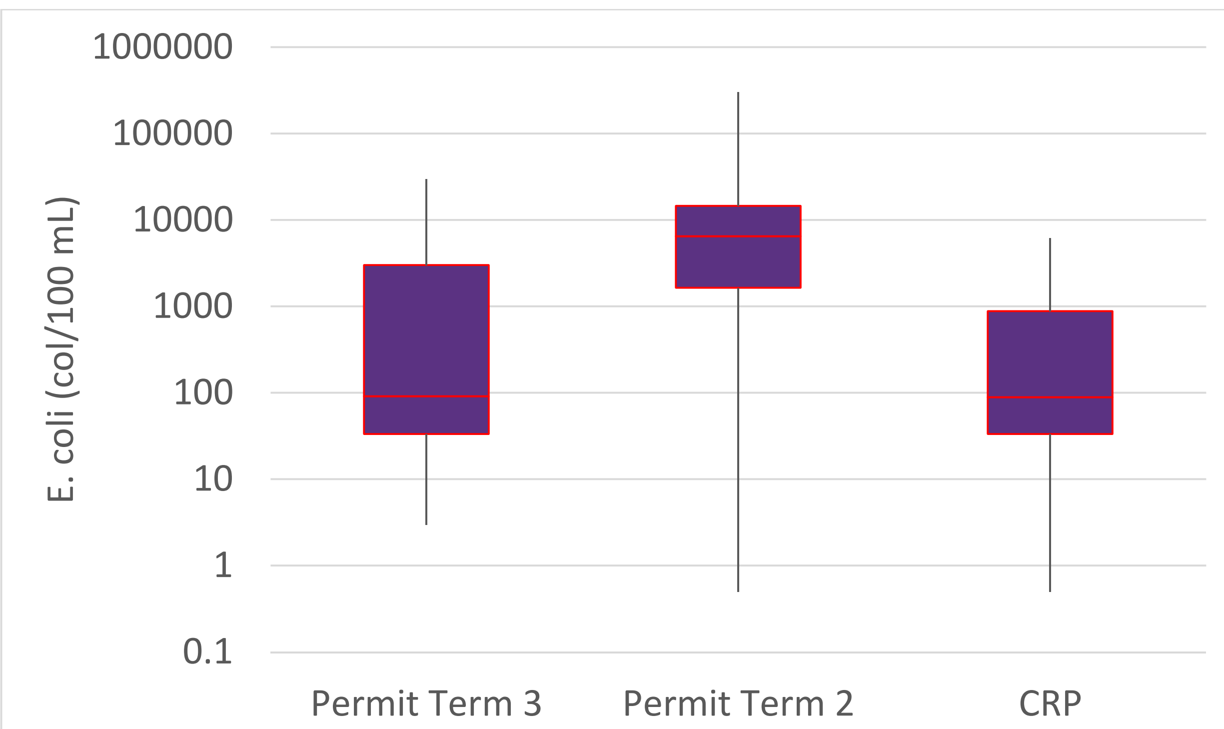


Figure 4-11 Boxplot Comparing Wet Weather Chemical Monitoring Second and Third Permit Term and CRP *E. coli* Data at Delaware Creek



4.5.4.4. Potential Pollution Sources and BMP Recommendations

Stormwater was shown to be a potential source of total copper to the stream. Stormwater is an infrequent contributor to the copper loading and for chronic exposure, the duration of exposure applicable to the most common chronic toxicity test is seven days or more (Clean Estuary Partnership, 2004). Therefore the chronic copper criterion may not be applicable and the copper concentrations observed may be suitable for aquatic life use based on typically less than seven days of exposure to stormwater runoff.

Stormwater was also shown to be a source of BOD and total nitrogen to the stream. The elevated concentrations of total nitrogen may have been a factor in elevated BOD concentrations due to increased organic matter in the stream. Land use of the Delaware Creek subwatershed is predominately residential with sizable commercial and highway land uses. Over fertilization in residential and commercial areas may be the primary source of total nitrogen. There was no statistical significant difference between the dry weather and wet weather COD data, but all recorded elevated concentrations of COD occurred during wet weather collection events. Although BOD, COD, and total nitrogen concentrations were observed to be elevated, dissolved oxygen concentrations as recorded by the TCEQ over the monitoring term did not fall below TCEQ criteria for aquatic life protection. The elevated oil and grease concentrations may have been the result of a vehicular oil leak, staining, or residential oil changes either from residential areas or from one of the numerous parking areas or roadways located in the subwatershed. Potential sources of bacteria loading may be from pets/domestic animals or illicit connections.

The pH exceedance only occurred during a stormwater runoff event at the upstream station in the fall. The upstream station is proceeded by a pond. A potential source of the elevated pH may be the growth of aquatic plants and algae within the pond during that period. Excessive growth of aquatic plants and algae could be a result of the elevated nitrogen concentrations.

A review of the aerial photography over the period did not reveal any major development or construction within the drainage area of the midstream monitoring station. However, minor construction activities may have been a source of the sediment loadings. Also, industrial/commercial activities are located within the midstream and downstream drainage areas that may have contributed to sediment loading through bulk material storage yards.

BMPs recommended for these sources include compliance inspections for illicit connections, public education of home and business owners regarding fertilization, turf management and oil and grease handling, public education for pet owners regarding pet waste management, review of construction site inspection protocols or BMP requirements, review of industrial inspection protocols or BMP requirements, and drop inlet or other parking lot treatment devices or layouts to capture oil and grease from stormwater runoff.

4.5.4.5. Monitoring Recommendations

Data analyzed presented multiple exceedances for bacteria and one exceedance to pH that may impact aquatic life use and primary contact recreation. There was also multiple exceedances to various criteria, screening levels, and comparison datasets. There is a bacteria TMDL and current impairment for Delaware Creek. Therefore additional monitoring at this site should be assigned a high priority. Bioassessment data collection is recommended to determine whether the biological community may be impacted by the chemical pollutants documented above.

4.5.5. Dixon Branch

The City of Dallas performed bioassessment monitoring only each monitoring year of the third permit term on Dixon Branch, a stream of a stream order greater than three draining to White Rock Lake in the White Rock Creek – White Rock Lake watershed. The White Rock Creek – White Rock Lake watershed is located in the northeastern portion of Dallas County (see Appendix C, Figure 6). The bioassessment monitoring station (DIX-A) is located at the Peavy Road crossing. According to City of Dallas (2012), the White Rock Creek – White Rock Lake watershed serves approximately 22,713 acres. Through visual assessment of the watershed, the Dixon Branch subwatershed appears to serve a third of the larger identified watershed. Nearly all of the Dixon Branch subwatershed area is within the jurisdictional limits of the City of Dallas, except for small areas located along the east boundary which are within the jurisdictional limits of the City of Garland. TxDOT-Dallas District contributes flow to the subwatershed through IH 635, SH 12, SH 244, and SH 78. No TCEQ permitted wastewater outfalls exist within the subwatershed according to the *TCEQ Permitted Wastewater Outfall* shapefile accessed May 20, 2016.

4.5.5.1. Summary Statistics

No wet weather chemical monitoring data was collected within this watershed.

4.5.5.2. Water Quality Data Analysis

Monitored parameters were plotted and compared to water quality standards, screening levels, and the NSQD where applicable. Additional pesticide parameters were collected at station DIX-A by the City of Dallas outside of the RWWCP and are not presented in this report.

The Dixon Branch graphs are located in Appendix H. All third term RWWCP monitored parameters were within applicable water quality standards, screening levels and comparison levels except for two instances of *E. coli* exceeding the TCEQ PCR single sample criterion in the spring of 2012 and 2013. In addition, the geometric mean of collected *E. coli* concentrations exceeded the PCR geometric mean criterion. The City of Dallas has tracked bacteria trends for *E. coli* at DIX-A over the period of 2007-2015. The geometric mean over the period of record (379 col/100 mL) exceeds the PCR geometric mean standard of 126 col/100 mL. Of 18 samples collected, the City of Dallas has documented 17 exceedances of the bacteria standard over the period of record.

4.5.5.3. Biological Data Analysis

Detailed reports of the biological assessments including data summaries can be found in the Annual Regional Wet Weather Characterization Program Monitoring Report for North Central Texas Year 2 through Year 5 (NCTCOG, 2013; NCTCOG, 2014; NCTCOG, 2015; NCTCOG, 2016). The habitat assessment scores and aquatic life use scores were plotted and compared to the habitat and aquatic life use categories (see Appendix H).

Dixon Branch, in the reach studied, received habitat scores mostly in the sub-optimum range except for the summers of 2013 and 2015, when the habitat score increased to the optimum range. Aquatic life use scores were in the intermediate range. Given the predominately sub-optimum habitat, the intermediate aquatic life use scores generally correspond with the available habitat indicating that water quality may not be limiting fish and macroinvertebrate communities.

4.5.5.4. Potential Pollution Sources and BMP Recommendations

Land use of the Dixon Branch drainage area was not available from the NCTCOG annual reports. However, a visual analysis of the drainage area reveals a mix of residential, commercial, and open land uses. Given that the bacteria exceedances occurred during dry weather monitoring, illicit connections and wildlife/domestic animals are a potential source. BMPs recommended for these sources include compliance inspections for illicit connections and public education for pet owners regarding pet waste management. Due to sub-optimal habitat scores ranging to optimal, small stream restoration projects may be able to increase the biological productivity of the stream.

4.5.5.5. Monitoring Recommendations

Data analyzed presents low to no indications of stream degradation but there is a concern regarding bacteria concentrations impacting primary contact recreation. TCEQ does not currently monitor Dixon Branch. There are no TMDLs or impairments identified for White Rock Lake. Additional monitoring at this site is recommended to be assigned a medium priority.

4.5.6. Duck Creek

The City of Garland performed chemical and bioassessment monitoring on Duck Creek (TCEQ segment 0819A), a stream with a stream order of three or greater draining to the East Fork of the Trinity River within the Duck Creek watershed.

Duck Creek watershed is a 27,180-acre watershed located on the southeastern edge of Dallas County. This watershed encompasses a small portion of Richardson, the western edge of Garland and extends to the northern tip of Mesquite and into Sunnyvale. The majority of this watershed is residential (34.4%). There is a large section of commercial (20.3%) with some industrial (13.0%) property mixed in located on the western side of the watershed. There is also a small section of mixed commercial and industrial located in the northern part of the watershed with additional commercial patches located along the major highways in the watershed. Approximately 17% is considered highway land use which includes two major highways, IH 635 and IH 30. The southern portion of the watershed contains large areas of open space (24.9%) and the overall watershed contains 0.6% water features.

The City of Garland had three chemical monitoring sites located within the Duck Creek watershed. The chemical monitoring site, GA1201/1301 was an upstream sampling site located at Shiloh Bridge south of Buckingham Road where Shiloh Road crosses Duck Creek. The conveyance at this site was an unlined channel with rocky sides on the creek bank. This subwatershed covered a 5,039-acre area and consisted predominately of residential property (38%). US 75 was the only major highway that ran through this subwatershed. However, the highway land use percentage of 21.6% also included major roadways such as Collins Boulevard, Arapaho Road, Belt Line Road, and Centennial Drive. Commercial (31.1%) property was dispersed throughout the subwatershed area and was mostly intermixed with the residential areas. There was a large area of commercial with some industrial (0.4%) property located south of US 75 in the northern tip of the Upper Duck Creek Watershed. This subwatershed also had some open space located upstream of GA1201/1301, along Duck Creek. The water feature composition for this subwatershed was 0.2%.

The chemical monitoring site, GA1202/1302 was a midstream sampling site located at between Forest North and South west of Garland Avenue on Duck Creek. The conveyance at this site was an unlined channel with rock bottom and earthen sides. The subwatershed delineated for this sampling site covered approximately 2,434 acres and consisted predominately of residential (45.6%) property. There were no major highways that ran through this area but several major roadways (Walnut Street, Jupiter Road, Shiloh Road, etc.) contributed to the highway land use estimate of 21.2%. The majority of commercial (20.5%) sites were located along major roadways in the subwatershed. There was a section of industrial (5.0%) property located upstream and west of GA1202/1302. There were a few open areas in the subwatershed which made up 7.8% of the land use composition. This subwatershed did not have any designated water bodies so the water land use composition estimate was 0%.

The chemical monitoring site, GA1203/1303 was a downstream sampling site located at Duck Creek under La Prada Bridge in the Gatewood Park area. The conveyance at this site was an unlined channel with a gravel bottom. The subwatershed delineated for this sampling site covered a 7,112-acre area and was mostly made up of residential property (38.4%). The majority of the northwestern portion of the subwatershed was a mix of commercial (26.2%) and industrial (8.1%) property. There was also commercial sites throughout the subwatershed with most located along SH 78 and other major roadways. SH 78 and a few major roadways made up the highway land use estimate of 18.4%. There were patches of open space which made up 8.8% of the subwatershed. The water feature composition for this area was 0.1%.

The monitoring sites, watershed and subwatershed boundaries, and land use types are shown in Appendix C, Figure 7. The monitoring sites are shown as GA1301, GA1302, and GA1303. GA1201, GA1202, and GA1203 were located in the same locations, respectively. The monitored subwatershed is mostly within the jurisdictional limits of the City of Garland with a portion of the upper subwatershed occupied by the City of Richardson. TxDOT-Dallas District contributes flow to the subwatershed through US 75 and SH 78. One TCEQ permitted wastewater outfall is located within the subwatershed according to the *TCEQ Permitted Wastewater Outfall* shapefile accessed May 20, 2016. The permittee is identified as the City of Garland and the outfall is located just downstream of the Centerville Road crossing.

4.5.6.1. Summary Statistics

Summary statistics are presented in Table 4-5. The summary statistics include number of samples, minimum and maximum values, median, arithmetic mean, geometric mean, standard deviation, and coefficient of variation.

4.5.6.2. Water Quality Data Analysis

Monitored parameters were plotted and compared to water quality standards, screening levels, and NSQD data where applicable. These graphs are located in Appendix I. During the third permit term, there were three exceedances of the TCEQ TDS basin specific criterion, five exceedances of the TCEQ aquatic life use estimated chronic criterion for total copper, one exceedance of the TCEQ aquatic life use estimated acute criterion for total copper, one exceedance of the TCEQ aquatic life use estimated chronic criterion and human health criterion for total lead, and fifteen exceedances of the *E. coli* PCR single sample criterion (and the *E. coli* PCR geometric mean criterion was exceeded). There were three nitrate nitrogen and two orthophosphate exceedances of the TCEQ nutrient screening criteria. In addition, there were seven occurrences where the TSS concentration, two occurrences where the BOD concentration, four occurrences where the COD concentration, and twenty occurrences where the total nitrogen concentration was higher than 75% of NSQD data for each parameter.

Due to the exceedances and elevated concentrations discussed above and the availability of bioassessment and wet weather chemical data, boxplots were created for total nitrogen and *E. coli* for comparison of the two datasets. The total nitrogen boxplot shows a statistically significant difference between the bioassessment and the wet weather data indicating that total nitrogen levels were higher during the dry period than during runoff events (Figure 4-12). The *E. coli* boxplot does not indicate that stormwater runoff is providing a statistically significant different input of *E. coli* to the stream compared to the bioassessment data which was collected during dry weather (see Figure 4-13).

Table 4-5 Duck Creek RWWCP Third Permit Term Summary Statistics

Parameter	TDS (mg/L)	TSS (mg/L)	BOD (mg/L)	COD (mg/L)	Nitrogen, Total (mg/L)	Phosphorus, Dissolved (mg/L)
No. of Samples	24	24	24	24	24	24
Minimum	104.0	5.67	1.60	0.50	0.470	0.003
Maximum	570.0	554.00	37.60	111.00	26.800	3.240
Median	201.0	55.00	8.21	20.50	8.485	0.075
Arithmetic Mean	267.1	131.28	10.19	37.52	9.905	0.292
Geometric Mean	238.0	61.13	7.85	13.54	6.709	0.070
Standard Deviation	136.0	162.76	8.45	37.87	7.692	0.702
Coefficient of Variation	0.51	1.24	0.83	1.01	0.78	2.401
	Phosphorus, Total (mg/L)	Arsenic, Total (mg/L)	Chromium, Total (mg/L)	Copper, Total (mg/L)	Lead, Total (mg/L)	Zinc, Total (mg/L)
No. of Samples	24	24	24	24	24	24
Minimum	0.025	0.001	0.002	0.016	0.002	0.026
Maximum	3.970	0.011	0.025	0.077	0.026	0.242
Median	0.270	0.002	0.004	0.030	0.004	0.056
Arithmetic Mean	0.771	0.002	0.005	0.031	0.005	0.068
Geometric Mean	0.340	0.002	0.004	0.029	0.004	0.061
Standard Deviation	1.113	0.003	0.005	0.012	0.005	0.041
Coefficient of Variation	1.443	1.098	0.957	0.394	1.058	0.608
	Oil & Grease (mg/L)	pH, Field	Specific Conductivity	Temperature (°F)	E. Coli (col/100 mL)	Total Coliform (col/100 mL)
No. of Samples	24	24	24	24	24	24
Minimum	0.70	7.20	127	47.4	8.0	300
Maximum	15.40	8.90	913	88.1	94000	234000
Median	1.15	8.20	425	64.6	435	22000
Mean	1.89	8.10	440	66.6	7773	48966
Geometric Mean	1.26	8.09	381	65.5	319	19323
Standard Deviation	2.96	0.50	230	12.5	20661	61911
Coefficient of Variation	1.57	0.06	0.52	0.19	2.66	1.26

Figure 4-12 Boxplot Comparing Wet Weather Chemical Monitoring Second and Third Permit Term and Bioassessment Total Nitrogen Data at Duck Creek

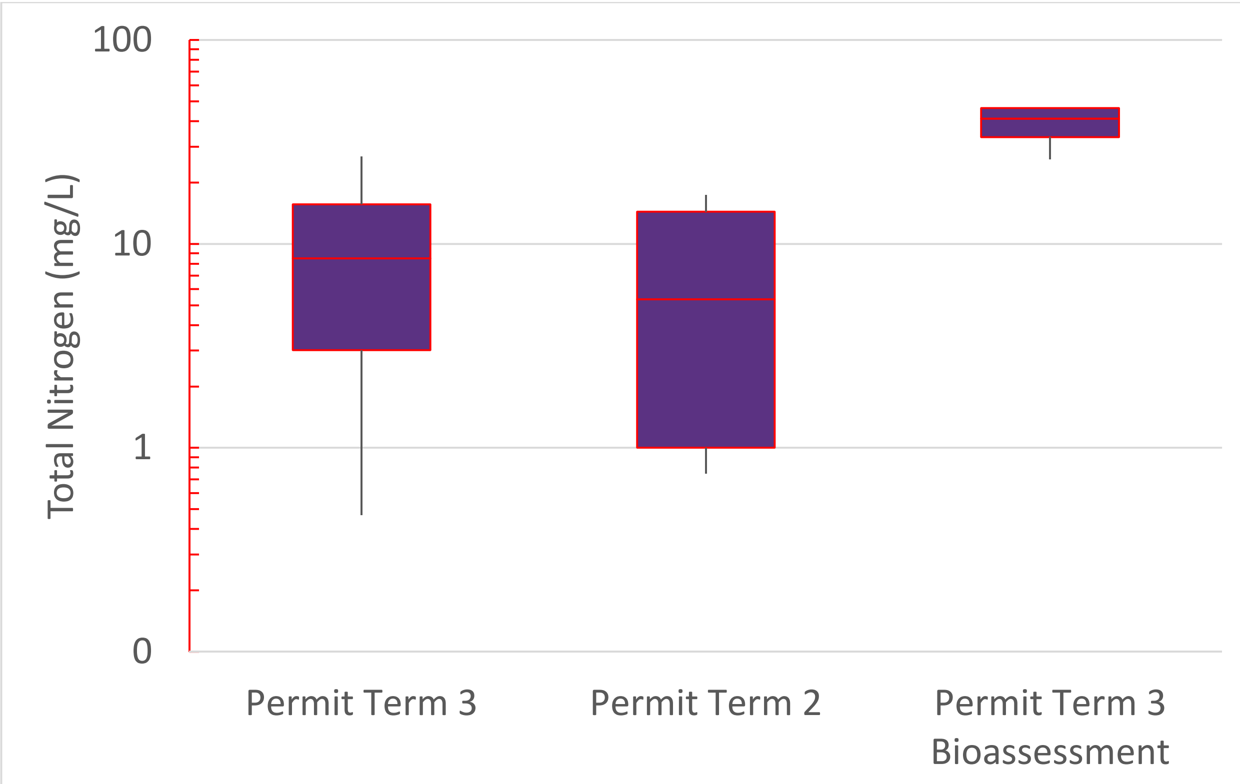
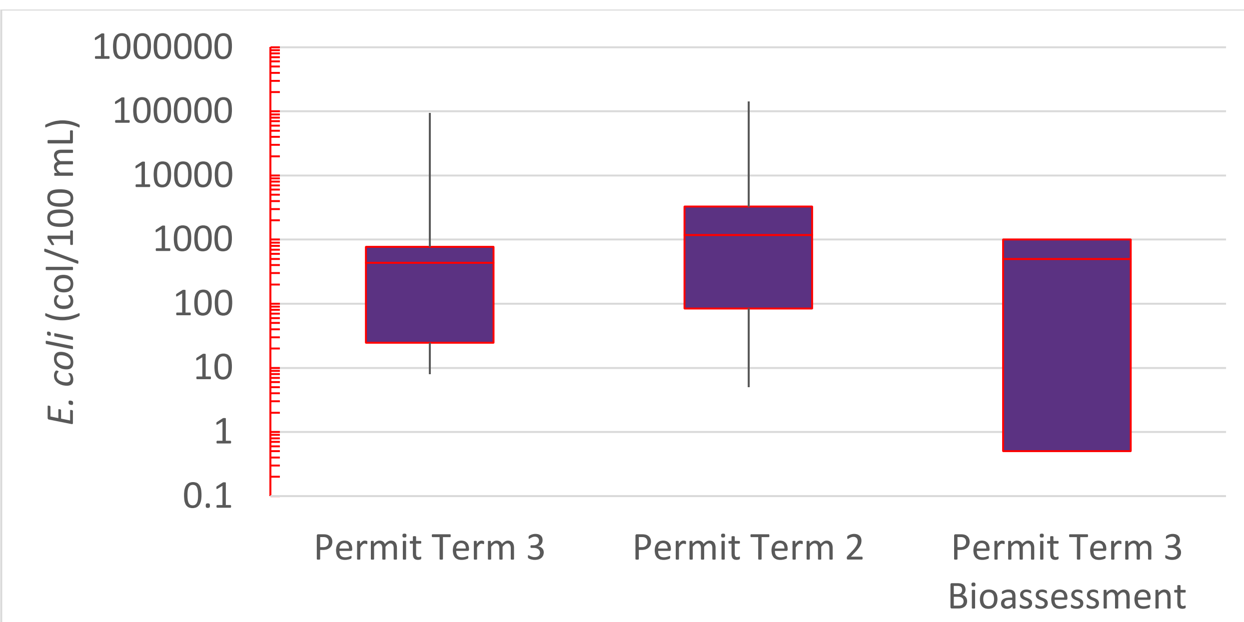


Figure 4-13 Boxplot Comparing Wet Weather Chemical Monitoring Second and Third Permit Term and Bioassessment *E. coli* Data at Duck Creek



Exceedances of the TDS basin specific criterion all occurred at the downstream monitoring station in December 2012 and January and October 2013. Copper exceedances occurred at all monitoring stations in 2012 and only the downstream station in 2013. The highest observed total copper concentration was 0.077 mg/L at the downstream station in July 2012. The lead exceedance also occurred at the downstream station in July 2012. *E. coli* PCR single sample criterion exceedances were observed at all monitoring stations with the majority occurring in 2012 and three (one at each monitoring station) in 2013. The elevated TSS, BOD, and COD concentrations occurred at the midstream and downstream stations in 2012 and 2013. The elevated total nitrogen concentrations were observed at all stations in 2012 and 2013.

4.5.6.3. Biological Data Analysis

Detailed reports of the biological assessments including data summaries can be found in the Annual Regional Wet Weather Characterization Program Monitoring Report for North Central Texas Year 2 through Year 5 (NCTCOG, 2013; NCTCOG, 2014; NCTCOG, 2015; NCTCOG, 2016). The habitat assessment scores and aquatic life use scores were plotted and compared to the habitat and aquatic life use categories (see Appendix I).

Duck Creek, in the reach studied, received a high quality habitat score, while fish community scores ranged from intermediate to high and benthic macroinvertebrate community scores ranged from limited to intermediate. This part of Duck Creek may not be considered ecologically healthy because the benthic macroinvertebrate community biotic integrity scores were consistently less than high, and the fish community scores were not consistently high even though habitat quality received a high score. This is an indication that chemical factors may be impacting the biological community. High nutrient concentrations, low pH, and flows above historical levels suggest water quality under normal to low flow conditions is substantially influenced by a treated wastewater discharge entering the creek upstream of the study area. Duck Creek appears to meet the intermediate ALU established in Texas' surface water quality standards.

4.5.6.4. Potential Pollution Sources and BMP Recommendations

The elevated concentrations of nutrients (total nitrogen, nitrate nitrogen, orthophosphate, and total phosphorus) may have been a factor in elevated BOD and COD concentrations due to increased organic matter in the stream. During the bioassessments, it was noted that an absence of substantial aquatic plant growth and DO levels below saturation was indicating nitrogen and phosphorus are not substantially assimilated by aquatic vegetation in the study reach or immediately upstream of the study reach. The lack of substantial plant growth suggests shading from trees along the creek may be preventing adequate sunlight from reaching the creek and aquatic plants from utilizing the high nutrient concentrations. Land use of the Duck Creek subwatershed is mainly residential with a lesser mix of commercial and highway land uses. Over fertilization in residential and commercial areas may be a source of these nutrients as may be the treated wastewater effluent. Although BOD, COD, and nutrient concentrations were observed to be elevated, dissolved oxygen concentrations over the monitoring term did not fall below TCEQ criteria for aquatic life protection.

The TDS, total copper, and total lead exceedances mostly were observed at the downstream monitoring station. The land use map (Appendix C, Figure 7) identifies several industrial and commercial land uses within the downstream station site drainage area. Additional sources of TDS and metals can be from illicit connections, illegal dumping, high traffic roadways, and wastewater effluent. Potential sources of bacteria loading may be from pets/domestic animals, illicit connections, or wastewater upsets.

A review of the aerial photography over the period did not reveal any major development or construction within the drainage area of the midstream or downstream monitoring stations. However, minor construction activities may have been a source of the sediment loadings or industrial/commercial activities such as bulk material storage yards.

BMPs recommended for these sources include compliance inspections for illicit connections, identification and removal of illegal dumping areas, public education of home and business owners regarding fertilization and turf management, public education for pet owners regarding pet waste management, review and inspection of wastewater treatment plant for potential maintenance or redesign, review of construction site inspection protocols or BMP requirements, and review of industrial inspection protocols or BMP requirements.

4.5.6.5. Monitoring Recommendations

Data analyzed presented multiple exceedances for bacteria, TDS, total copper, and total lead and elevated nutrients, BOD, and COD that may impact aquatic life use and primary contact recreation. The bioassessment revealed an indication that chemical factors may be impacting the biological community. There are currently no TMDLs or impairments for Duck Creek but there is a TMDL for TDS and sulfate in the East Fork of the Trinity River. Additional monitoring at this site is recommended to be assigned a high priority. It is recommended that bioassessment monitoring is continued. In order to determine the concentration of bioavailable metals, it is recommended that sampling of dissolved fractions of copper and lead is conducted.

4.5.7. Five Mile Creek

The City of Dallas performed bioassessment monitoring only each monitoring year of the third permit term on Five Mile Creek (TCEQ segment 0805D), a stream with a stream order of three or greater that drains to the Upper Trinity River in the Headwaters Five Mile Creek watershed. The Headwaters Five Mile Creek watershed is located in the southwestern portion of Dallas County (see Appendix C, Figure 8). The bioassessment monitoring station (FIV-D) is located at the Westmoreland Road and Pentagon Parkway intersection at Five Mile Creek. According to City of Dallas (2012), the Headwaters Five Mile Creek watershed serves approximately 24,117 acres. Through visual assessment of the watershed, the Five Mile Creek monitored subwatershed appears to serve a third of the larger identified watershed. Nearly all of the Five Mile Creek subwatershed area is within the jurisdictional limits of the City of Dallas, except for a small area located on the western boundary which is within the jurisdictional limits of the City of Duncanville. TxDOT-Dallas District contributes flow to the subwatershed through SH 12 and SH 303. There are two TCEQ permitted wastewater outfalls within the subwatershed according to the *TCEQ Permitted Wastewater Outfall* shapefile accessed May 20, 2016. The permittee is identified as Univar USA, Inc. and the outfalls are located at the Buckingham Road crossing.

4.5.7.1. Summary Statistics

No wet weather chemical monitoring data was collected within this watershed.

4.5.7.2. Water Quality Data Analysis

Monitored parameters were plotted and compared to water quality standards, screening levels, and the NSQD where applicable. Additional pesticide parameters were collected at station FIV-D by the City of Dallas outside of the RWWCP and are not presented in this report.

The Five Mile Creek graphs are located in Appendix J. All third term RWWCP monitored parameters were within applicable water quality standards, screening levels and comparison levels except for one instance of *E. coli* exceeding the TCEQ PCR single sample criterion in the spring of 2014 and the geometric mean of collected *E. coli* concentrations exceeded the PCR geometric mean criterion. In addition, there was one specific conductance reading greater than 1000 µS/cm in the spring of 2013, which falls in the “fair” category (below the “good” category and above the “poor” category) according to USEPA, 2016b. The City of Dallas has tracked bacteria trends for *E. coli* at FIV-D over the period of 2007-2012. The geometric mean over the period of record (150 col/100 mL) exceeds the PCR geometric mean standard of 126 col/100 mL. Of 18 samples collected, the City of Dallas has documented eight exceedances of the bacteria standard over the period of record.

4.5.7.3. Biological Data Analysis

Detailed reports of the biological assessments including data summaries can be found in the Annual Regional Wet Weather Characterization Program Monitoring Report for North Central Texas Year 2 through Year 5 (NCTCOG, 2013; NCTCOG, 2014; NCTCOG, 2015; NCTCOG, 2016). The habitat assessment scores and aquatic life use scores were plotted and compared to the habitat and aquatic life use categories (see Appendix J).

The habitat scores remained in the sub-optimal range over the third term period except for the spring of 2012 and summer of 2014, when the habitat score increased to the optimal range and the summer of 2013 when the habitat score decreased to marginal. The aquatic life use scores remained in the intermediate range over the third term period. Given the predominately sub-optimum habitat, the intermediate aquatic life use scores generally correspond with the available habitat indicating that water quality may not be limiting fish and macroinvertebrate communities.

4.5.7.4. Potential Pollution Sources and BMP Recommendations

Land use of the Five Mile Creek drainage area was not available from the NCTCOG annual reports. However, a visual analysis of the drainage area reveals a mix of residential, commercial, and open land uses. Possible sources of bacteria are illicit connections and wildlife/domestic animals. Possible sources of conductivity are roadway deicing applications, wastewater discharges, sanitary sewer connections, and concrete weathering. BMPs recommended for these sources are compliance inspections for illicit connections, public education for pet owners regarding pet waste management, inspection of wastewater discharge process for potential maintenance or redesign, and review of deicing agent application strategies to roadways. Due to sub-optimal habitat scores ranging to optimal, small stream restoration projects may be able to increase the biological productivity of the stream.

4.5.7.5. Monitoring Recommendations

Data analyzed presents low indications of stream degradation. However, bacteria concentrations have a potential to impact primary contact recreation and specific conductivity has the potential to impact aquatic life. There are no TMDLs or impairments identified for Five Mile Creek. There is a current TMDL for bacteria and for legacy pollutants for the Upper Trinity River Segment 0805. Additional monitoring at this site is recommended to be assigned a medium priority.

4.5.8. Floyd Branch

The City of Dallas performed bioassessment monitoring only each monitoring year of the third permit term on Floyd Branch, a stream with a stream order of one that drains to Cottonwood Creek (TCEQ segment 0827B) in the Floyd Branch – White Rock Creek watershed. The Floyd Branch – White Rock Creek watershed is located in the northern portion of Dallas County (see Appendix C, Figure 9). The bioassessment monitoring station (FLO-A) is located at near Forest Lane and the DART rail. According to City of Dallas (2012), the Floyd Branch – White Rock Creek watershed serves approximately 21,109 acres. Through visual assessment of the watershed, the Floyd Branch monitored subwatershed appears to serve less than a quarter of the larger identified watershed. Half of the Floyd Branch subwatershed area is within the jurisdictional limits of the City of Dallas, and the remainder is within the jurisdictional limits of the City of Richardson. TxDOT contributes flow to the subwatershed through IH 635 and SH 75. There is one TCEQ permitted wastewater outfall within the subwatershed according to the *TCEQ Permitted Wastewater Outfall* shapefile accessed May 20, 2016. The permittee is identified as the North Texas Municipal Water District and the outfall is located west of Duncanville Road and approximately 1 mile west of the main stream channel.

4.5.8.1. Summary Statistics

No wet weather chemical monitoring data was collected within this watershed.

4.5.8.2. Water Quality Data Analysis

Monitored parameters were plotted and compared to water quality standards, screening levels, and the NSQD where applicable. Additional pesticide parameters were collected at station FLO-A by the City of Dallas outside of the RWWCP and are not presented in this report.

The Floyd Branch graphs are located in Appendix K. During the third permit term, there were two exceedances of the TCEQ aquatic life use estimated chronic criterion for total copper, two exceedances of the TCEQ aquatic life use estimated acute criterion for total copper, and three exceedances of the *E. coli* PCR single sample criterion (and the *E. coli* PCR geometric mean criterion was exceeded). There were eight total phosphorus and one ammonia nitrogen exceedances of the TCEQ nutrient screening criteria. In addition, there were two specific conductance readings greater than 1000 µS/cm, which falls in the "fair" category (below the "good" category and above the "poor" category) according to USEPA, 2016b.

The City of Dallas has tracked bacteria trends for *E. coli* at FLO-A over the period of 2007-2012. The geometric mean over the period of record (542 col/100 mL) exceeds the PCR geometric mean standard of 126 col/100 mL. Of 20 samples collected, the City of Dallas has documented 20 exceedances of the bacteria standard over the period of record.

4.5.8.3. Biological Data Analysis

Detailed reports of the biological assessments including data summaries can be found in the Annual Regional Wet Weather Characterization Program Monitoring Report for North Central Texas Year 2 through Year 5 (NCTCOG, 2013; NCTCOG, 2014; NCTCOG, 2015; NCTCOG, 2016). The habitat assessment scores and aquatic life use scores were plotted and compared to the habitat and aquatic life use categories (see Appendix K).

The habitat scores remained in the sub-optimal range over the third term period except for the spring and summer of 2012 and spring of 2014, when the habitat score increased to the optimal range. The aquatic life use scores remained in the intermediate range over the third term period. Given the predominately sub-optimum habitat, the intermediate aquatic life use scores generally correspond with the available habitat indicating that water quality may not be limiting fish and macroinvertebrate communities.

4.5.8.4. Potential Pollution Sources and BMP Recommendations

Land use of the Floyd Branch drainage area was not available from the NCTCOG annual reports. However, a visual analysis of the drainage area reveals a mix of residential, commercial, and open land uses. Possible sources of bacteria include illicit connections, wildlife/domestic animals, and wastewater upsets. Over fertilization in open, residential, and commercial areas may be a source of total phosphorus and ammonia nitrogen as may be the treated wastewater effluent. Although nutrient concentrations were observed to be elevated, dissolved oxygen concentrations over the monitoring term did not fall below TCEQ criteria for aquatic life protection.

Several industrial and commercial land uses are visible in the drainage area which may be a potential source of copper and elevated specific conductance. Additional sources of copper could be from illicit connections, illegal dumping, high traffic roadways, and wastewater effluent.

BMPs recommended for these sources include compliance inspections for illicit connections, identification and removal of illegal dumping areas, public education of home and business owners regarding fertilization and turf management, public education for pet owners regarding pet waste management, and review and inspection of wastewater treatment plant for potential maintenance or redesign. Due to sub-optimal habitat scores ranging to optimal, small stream restoration projects may be able to increase the biological productivity of the stream.

4.5.8.5. Monitoring Recommendations

Data analyzed presents moderate indications of stream degradation. Bacteria concentrations have a potential to impact primary contact recreation and nutrients and copper have the potential to impact aquatic life. There are no TMDLs or impairments identified for Floyd Branch or for Cottonwood Creek. Additional monitoring at this site is recommended to be assigned a medium priority.

4.5.9. Honey Springs Branch

The City of Dallas performed chemical monitoring on Honey Springs Branch, a stream with a stream order of one draining to the Upper Trinity River (TCEQ segment 0805) within the Five Mile Creek – Trinity River watershed.

Five Mile Creek-Trinity River Watershed, is located in south-central Dallas County. This 30,303-acre watershed is predominately made up of open space (49.3%) and residential (19.3%). The open space is along the eastern and southern part of the watershed, along Five Mile Creek and its tributaries. Several highways (13.3%) go through this watershed and include: IH 20, IH 45, SH 12, SH 310, SH 175, and SH 342. The industrial area (4.3%) is located in the southern part of the watershed, south of I-20. The commercial area (12.9%) is located in the center of the watershed, along I-45. The watershed contains 0.9% water features.

The City of Dallas has three chemical monitoring sites located within the Honey Springs Branch subwatershed. The chemical monitoring site, FMC-100 was an upstream sampling site located at the creek's intersection with Linfield Road. This subwatershed covered a 720 acre area and was primarily composed of residential property (57.2%) dispersed evenly throughout. Highways accounted for 19.53% of the subwatershed, while commercial property (12.5%) was found in the center of the subwatershed. Open space (10.6%) was along the stream bank. There was one industrial (0.1%) site in the lower watershed. There were no water features in the subwatershed.

The chemical monitoring site, FMC-200 was a midstream sampling site located on the east side of Vandervoort Drive. This subwatershed covered a 450-acre area and was primarily residential (59.2%) property that was evenly distributed. Highways made up 18.9% of the area, and commercial (8.7%) property was located close by. Open space (13.2%) was fairly even throughout the drainage area. There were no industrial sites or water features in this subwatershed.

The chemical monitoring site, FMC-300 was a downstream sampling site located on the east side of Carbondale Street, downstream from the bridge crossing. This subwatershed covered a 367-acre area and was primarily composed of highway (30.2%) and commercial property (25.9%). IH 45 and SH 310 crossed through this subwatershed, and the majority of the commercial property was located along either side of the highways. There was a large industrial (2.8%) site just east of SH 310. Residential (21.8%) property was located in the upper subwatershed, while the open (19.4%) was just below it. There were no water features in this subwatershed.

The monitoring sites, watershed and subwatershed boundaries, and land use types are shown in Appendix C, Figure 10. The subwatershed area is entirely within the jurisdictional limits of the City of Dallas. TxDOT-Dallas District contributes flow to the subwatershed through IH 45 and SH 310. There are no TCEQ permitted wastewater outfalls within the subwatershed according to the *TCEQ Permitted Wastewater Outfall* shapefile accessed May 20, 2016.

4.5.9.1. Summary Statistics

Summary statistics are presented in Table 4-6. The summary statistics include number of samples, minimum and maximum values, median, arithmetic mean, geometric mean, standard deviation, and coefficient of variation.

Table 4-6 Honey Springs Branch RWWCP Third Permit Term Summary Statistics

Parameter	TDS (mg/L)	TSS (mg/L)	BOD (mg/L)	COD (mg/L)	Nitrogen, Total (mg/L)	Phosphorus, Dissolved (mg/L)
No. of Samples	24	24	24	24	24	24
Minimum	106.0	3.0	1.00	0.50	0.380	0.003
Maximum	502.0	441	200.0	106.00	14.90	0.760
Median	254.0	37.5	7.12	25.50	1.395	0.130
Arithmetic Mean	274.0	80.1	36.83	32.01	3.012	0.156
Geometric Mean	253.9	39.2	11.46	19.53	1.705	0.107
Standard Deviation	108.0	108.0	59.32	26.46	3.610	0.152
Coefficient of Variation	0.39	1.35	1.61	0.83	1.20	0.97
	Phosphorus, Total (mg/L)	Arsenic, Total (mg/L)	Chromium, Total (mg/L)	Copper, Total (mg/L)	Lead, Total (mg/L)	Zinc, Total (mg/L)
No. of Samples	24	24	24	24	24	24
Minimum	0.003	0.001	0.001	0.001	0.002	0.002
Maximum	1.070	0.010	0.044	0.023	0.032	0.155
Median	0.199	0.002	0.003	0.007	0.003	0.018
Arithmetic Mean	0.263	0.002	0.006	0.009	0.006	0.028
Geometric Mean	0.173	0.002	0.003	0.006	0.004	0.016
Standard Deviation	0.240	0.002	0.009	0.007	0.007	0.033
Coefficient of Variation	0.913	0.804	1.461	0.753	1.128	1.175
	Oil & Grease (mg/L)	pH, Field (su)	Specific Conductivity (µS/cm)	Temperature (°F)	E. Coli (col/100 mL)	Total Coliform (col/100 mL)
No. of Samples	24	24	0	0	24	0
Minimum	0.70	7.33	-	-	5	-
Maximum	4.43	8.41	-	-	54750	-
Median	0.72	7.75	-	-	525	-
Mean	1.33	7.76	-	-	3550	-
Geometric Mean	1.06	7.76	-	-	451	-
Standard Deviation	1.10	0.26	-	-	11090	-
Coefficient of Variation	0.83	0.03	-	-	3.12	-

4.5.9.2. Water Quality Data Analysis

Monitored parameters were plotted and compared to water quality standards, screening levels, and NSQD data where applicable. These graphs are located in Appendix L. During the third permit term, there was one exceedance of the TCEQ aquatic life use estimated chronic criterion for total lead, and there were sixteen exceedances of the *E. coli* PCR single sample criterion (and the *E. coli* PCR geometric mean criterion was exceeded). There were two total phosphorus exceedances of the TCEQ nutrient screening criteria. In addition, there were three occurrences where the TSS concentration, nine occurrences where the BOD concentration, one occurrence where the COD concentration, and six occurrences where the total nitrogen concentration was higher than 75% of NSQD data for those parameters.

The lead exceedance occurred at the downstream station in April 2013. *E. coli* PCR single sample criterion exceedances were observed at all monitoring stations in both monitored years. The total phosphorus screening criterion exceedances occurred at the upstream station in March and October 2015. The elevated COD concentration occurred at the upstream station in September 2015. The elevated BOD concentrations occurred at all three stations in April, September, and October of 2013. The elevated total nitrogen concentrations were observed at all stations in May of 2015, at the upstream and midstream stations in September 2015 and only at the upstream station in March 2015. The elevated TSS concentration occurred at the upstream and downstream station in September 2015 and only at the downstream station in April 2013.

4.5.9.3. Biological Data Analysis

No bioassessment monitoring data was collected within this watershed.

4.5.9.4. Potential Pollution Sources and BMP Recommendations

Land use of the Honey Springs Branch subwatershed is predominantly residential with the remainder split between commercial, highway, and open land uses. Possible sources of *E. coli* are illicit connections and wildlife/domestic animals. The elevated concentrations of nutrients (total nitrogen and total phosphorus) may have been a factor in elevated BOD and COD concentrations due to increased organic matter in the stream.

Due to the large amount of residential land use in the subwatershed, over fertilization may be a source of these nutrients. In addition, riparian alteration can affect nitrogen uptake and cycling, and turn urban riparian areas into nitrogen sources (Groffman et al. 2002, 2003). Dissolved oxygen was not measured during the permit term and therefore it is unknown whether the elevated nutrient, BOD, and COD concentrations may be impacting the aquatic community by decreasing the amount of available oxygen.

A review of the aerial photography over the period did not reveal any major development or construction within the subwatershed. However, minor construction activities may have been a source of the sediment loadings or industrial/commercial activities such as bulk material storage yards. The land use map (Appendix C, Figure 10) identifies industrial and commercial land uses within the downstream station site drainage area which is where the estimated exceedances of lead were observed. Additional sources of lead could be from illicit connections and illegal dumping.

BMPs recommended for these sources include compliance inspections for illicit connections, identification and removal of illegal dumping areas, public education of home and business owners regarding fertilization and turf management, public education for pet owners regarding pet waste management, review of construction site inspection protocols or BMP requirements, and review of industrial inspection protocols or BMP requirements.

4.5.9.5. Monitoring Recommendations

Data analyzed presents several indications of stream degradation. Bacteria concentrations have a potential to impact primary contact recreation and nutrients and lead have the potential to impact aquatic life. There are no TMDLs or impairments identified for Honey Springs Branch. There is a current TMDL for bacteria and for legacy pollutants for the Upper Trinity River Segment 0805. Additional monitoring at this site is recommended to be assigned a high priority. Dry weather chemical monitoring data is recommended to further determine potential sources of pollutants.

4.5.10. Johnson Creek

The City of Arlington performed chemical monitoring on Johnson Creek (TCEQ segment 0841L), a stream with a stream order of three or greater draining to the Lower West Fork of the Trinity River within the Johnson Creek watershed.

Johnson Creek Watershed is mostly located in Tarrant County with a small piece (north of IH 30) falling within Dallas County. Johnson Creek's 13,578-acre watershed is predominately residential (29.6%), with small patches of open areas (12.9%) spread throughout. This watershed is made up of 20.2% highway which includes four major roadways: IH 20, SH 360, SH 303, and IH 30. A significant amount of commercial (26.9%) and industrial (10.2%) property is located on both sides of SH 360 and IH 30 in the northern part of the watershed. There are also a few industrial sites located south of SH 303. This watershed is comprised of 0.3% water features. Over the last several years the upper portions of Johnson Creek watershed had significant development activity such as the Dallas Cowboys stadium, four major hotels, Johnson Creek relocation and restoration efforts, dredging of a major pond intercepting Johnson Creek near the Texas Rangers ballpark, and the "Three Bridges" project on IH 30 that involved the removal of approximately a million yards of soil and construction of new storm drain systems. All this development activity, which is now mostly complete, would have had the greatest impact on the downstream monitoring station, AR1203/1303.

The City of Arlington had three chemical monitoring sites located within the Johnson Creek subwatershed. The chemical monitoring site, AR1201/1301 was an upstream sampling site located west of Matlock Road where Medical Drive crosses Johnson Creek. The conveyance at this site was a lined stream bed with a well maintained grassy area along the channel. The subwatershed delineated for this sampling location covered a 647-acre area and consisted predominately of commercial (37.5%) and residential (29.6%) property. There were four major roadways running through this area: Arbrook Road, Matlock Road, Mayfield Road, and IH 20 (21.1% highway). There was a small patch of industrial (2.2%) land use located south of IH 20. Open areas (9.6%) were scattered throughout this drainage area and were mostly adjacent to residential property. This subwatershed contained no distinct water (0%) features.

The chemical monitoring site, AR1202/1302 was a midstream sampling site located south of East Abram Street where Dugan Street crossed Johnson Creek. The conveyance at this site was an unlined channel with maintained grass and vegetative cover consisting of medium-sized trees and brush. The subwatershed delineated for this sampling location covered a 4,838-acre area and consisted predominately of residential (44.8%) and commercial (25.9%) property. The industrial (0.8%) sites within this subwatershed were located adjacent to commercial property. There were several major roadways (18.5% highway) that ran through in this subwatershed area: Abram Street, Collins Street, Matlock Road, Cooper Street, Mayfield Road, Park Row Drive, SH 303 (Pioneer Parkway), and SH 180 (Division Street). A large patch of industrial activity was located in the southern portion along Cooper Street. Most of the open areas (10.0%) were located within residential areas and along waterways. This subwatershed contained no significant water (0%) features.

The chemical monitoring site, AR1203/1303 was a downstream sampling site located south of IH 30 near Six Flags Over Texas where East Copeland Road crosses Johnson Creek. The conveyance at this site was an open, unlined channel with gabion banks and low vegetative cover and maintained grass bordering the creek line. The subwatershed delineated for this sampling location covered a 3,539-acre area and was made up of mostly commercial (37.4%) and highway (20.7%) land use. Highways going through this area were IH 30 and SH 180 (Division Street). Several major roadways that ran through this subwatershed were Cooper Street, Collins Street, Lamar Boulevard, Sanford Street, Randol Mill Road, Six Flags Drive, and Stadium Drive/Ballpark Way. Residential (19.9%) property was mostly located in the western half of the subwatershed area up to Stadium Drive/Ballpark Way. Industrial (6.6%) sites were primarily located in the far eastern part of the subwatershed. There were some large sections of open space (14.7%) spread throughout the subwatershed area. It is important to note that Six Flags Over Texas in the northern part of the subwatershed was categorized as “Open Space” because it is designated as a “Park”. Obviously this park has a significant proportion of impervious surface, including its expansive parking lot that should be taken into account. This subwatershed contained 0.7% water features.

The monitoring sites, watershed and subwatershed boundaries, and land use types are shown in Appendix C, Figure 11. The monitoring sites are shown as AR1301, AR1302, and AR1303. AR1201, AR1202, and AR1203 were located in the same locations, respectively. The subwatershed area is within the jurisdictional limits of the City of Arlington. TxDOT contributes flow to the subwatershed through IH 30, SH 180, SH 303, and IH 20. There are no TCEQ permitted wastewater outfalls located within the subwatershed according to the *TCEQ Permitted Wastewater Outfall* shapefile accessed May 20, 2016.

4.5.10.1. Summary Statistics

Summary statistics are presented in Table 4-7. The summary statistics include number of samples, minimum and maximum values, median, arithmetic mean, geometric mean, standard deviation, and coefficient of variation.

Table 4-7 Johnson Creek RWWCP Third Permit Term Summary Statistics

Parameter	Total Dissolved Solids (mg/L)	Total Suspended Solids (mg/L)	BOD (mg/L)	COD (mg/L)	Nitrogen, Total (mg/L)	Phosphorus, Dissolved (mg/L)
No. of Samples	24	24	24	24	24	24
Minimum	92.0	2.00	3.80	0.50	0.025	0.005
Maximum	933.0	582.0	61.00	258.00	17.600	0.230
Median	307.5	52.50	11.40	58.00	3.090	0.060
Arithmetic Mean	338.2	118.79	19.30	75.52	5.875	0.064
Geometric Mean	285.1	48.82	13.62	48.00	2.604	0.040
Standard Deviation	214.5	141.36	17.46	65.21	5.849	0.055
Coefficient of Variation	0.63	1.19	0.90	0.86	1.00	0.868
	Phosphorus, Total (mg/L)	Arsenic, Total (mg/L)	Chromium, Total (mg/L)	Copper, Total (mg/L)	Lead, Total (mg/L)	Zinc, Total (mg/L)
No. of Samples	24	24	24	24	24	24
Minimum	0.050	0.001	0.002	0.012	0.002	0.023
Maximum	0.610	0.008	0.021	0.056	0.041	0.347
Median	0.230	0.004	0.005	0.023	0.005	0.046
Arithmetic Mean	0.228	0.003	0.006	0.025	0.008	0.070
Geometric Mean	0.191	0.002	0.005	0.023	0.005	0.054
Standard Deviation	0.137	0.003	0.004	0.011	0.009	0.068
Coefficient of Variation	0.599	0.742	0.650	0.435	1.181	0.977
	Oil & Grease (mg/L)	pH, Field (su)	Specific Conductivity (µS/cm)	Temperature (°F)	E. Coli (col/100 mL)	Total Coliform (col/100 mL)
No. of Samples	24	24	24	24	24	24
Minimum	0.70	7.80	100	47.0	0.5	2220
Maximum	260.0	10.00	1290	85.3	8500	150000
Median	1.75	8.45	371	68.4	29	13250
Mean	14.67	8.44	477	68.1	1055	31669
Geometric Mean	2.41	8.43	393	67.2	42	16001
Standard Deviation	52.49	0.45	303	11.3	2368	37086
Coefficient of Variation	3.58	0.05	0.64	0.17	2.25	1.17

4.5.10.2. Water Quality Data Analysis

Monitored parameters were plotted and compared to water quality standards, screening levels, NSQD, and CRP data where applicable. These graphs are located in Appendix M. CRP stations 10718, 10719, 10721, 17664, and 18311 were utilized for this analysis. Station 10721 was the most upstream station located at the SH 303 crossing a few miles above AR1201/1301. Stations 10718, 10719, 17664, and 18311 were all located downstream of AR1203/1303 between SH 360 and PGBT (prior to the Arbor Creek intersection).

During the third permit term, there were two exceedances of the TCEQ TDS basin specific criterion, one exceedance of the TCEQ aquatic life use estimated chronic criterion for total copper, two exceedances of the TCEQ aquatic life use estimated chronic criterion and human health criterion for total lead, one exceedance of the TCEQ pH basin specific criterion for maximum pH, and five exceedances of the *E. coli* PCR single sample criterion (but the *E. coli* PCR geometric mean was below the criterion). There were ten occurrences where the TSS concentration, seven occurrences where the BOD concentration, seven occurrences where the COD concentration, nine occurrences where the total nitrogen concentration, and five occurrences where the oil and grease concentration was higher than 75% of the NSQD data for those parameters. In addition, there were two specific conductance readings greater than 1,000 µS/cm in July of 2013, which fall in the "fair" category (below the "good" category and above the "poor" category) according to USEPA, 2016b. CRP data recorded two specific conductance readings greater than 2,000 µS/cm, which fall in the "poor" category during the third permit term. Dissolved oxygen measurements at CRP station 10719 fell below the minimum for aquatic life use in July of 2013.

The TDS exceedances occurred at the midstream station in January and July 2013. The total copper exceedance occurred at the midstream station in July 2012. The total lead exceedances occurred at the midstream station in July and October 2012. The pH exceedances occurred at the upstream and downstream stations in April 2013. CRP data recorded a pH exceedance just downstream (station 10719 at SH 360) in December 2013. Elevated TSS, BOD, COD, total nitrogen, and oil and grease concentrations occurred at all three stations in both monitored years.

Due to the exceedances and elevated concentrations discussed above and the availability of CRP and wet weather chemical data, boxplots were created for BOD, total copper, total lead, pH, and conductivity. The BOD and total copper boxplots show a statistically significant difference between the CRP and the wet weather data indicating that BOD and total copper concentrations were lower during the predominantly dry weather periods than during runoff events (Figures 4-14 and 4-15). The total lead and conductivity boxplots do not indicate that stormwater runoff is providing a statistically significant different input of these pollutants to the stream compared to the CRP data which was collected predominately during dry weather (see Figures 4-16 and 4-18). The pH boxplot indicates a statistically significant difference between the third permit term RWWCP data and the second permit term and CRP data.

4.5.10.3. Biological Data Analysis

No bioassessment monitoring data was collected within this watershed.

4.5.10.4. Potential Pollution Sources and BMP Recommendations

Land use of the Johnson Creek monitored subwatershed is predominately mixed residential and commercial with smaller percentages of highway and open land uses. The elevated concentrations of total nitrogen may have been a factor in elevated BOD and COD concentrations due to increased organic matter in the stream. Over fertilization in residential and commercial areas may be a source of total nitrogen. In addition, riparian alteration can affect nitrogen uptake and cycling, and turn urban riparian areas into nitrogen sources (Groffman et al. 2002, 2003). This nutrient loading may have been a factor in the dissolved oxygen exceedance recorded during CRP monitoring in July of 2013.

The TDS, total copper, and total lead exceedances mostly were observed at the midstream monitoring station. Land use in the drainage area for the midstream station is mainly residential followed by commercial but also includes SH 303. Potential sources of TDS and metals could be from illicit connections, illegal dumping, and high traffic roadways.

The pH exceedances occurred at the upstream and downstream stations. Both of these stations are proceeded by ponds occupying the stream channel. A potential source of the elevated pH may be the growth of aquatic plants and algae within the ponds. Excessive growth of aquatic plants and algae could be a result of the elevated nitrogen concentrations as well.

The elevated oil and grease concentrations may have been the result of vehicular oil leak or staining on the numerous parking areas located in the subwatershed. Major development and construction occurred within the subwatershed over the period which is the most likely source of sediment loadings.

BMPs recommended for these sources include compliance inspections for illicit connections, identification and removal of illegal dumping areas, public education of home and business owners regarding fertilization and turf management, drop inlet or other parking lot treatment devices or layouts to capture oil and grease from stormwater runoff, and review of construction site inspection protocols or BMP requirements.

4.5.10.5. Monitoring Recommendations

Data analyzed presents several indications of stream degradation. Nutrients, dissolved solids and metals have the potential to impact aquatic life. Johnson Creek has a TMDL and is impaired for bacteria. Additional monitoring at this site is recommended to be assigned a high priority. Bioassessment data collection is recommended to determine whether the biological community may be impacted by the chemical pollutants documented above. In order to determine the concentration of bioavailable metals, it is recommended that sampling of dissolved fractions of copper and lead is conducted.

Figure 4-14 Boxplot Comparing Wet Weather Chemical Monitoring Second and Third Permit Term and CRP BOD Data at Johnson Creek

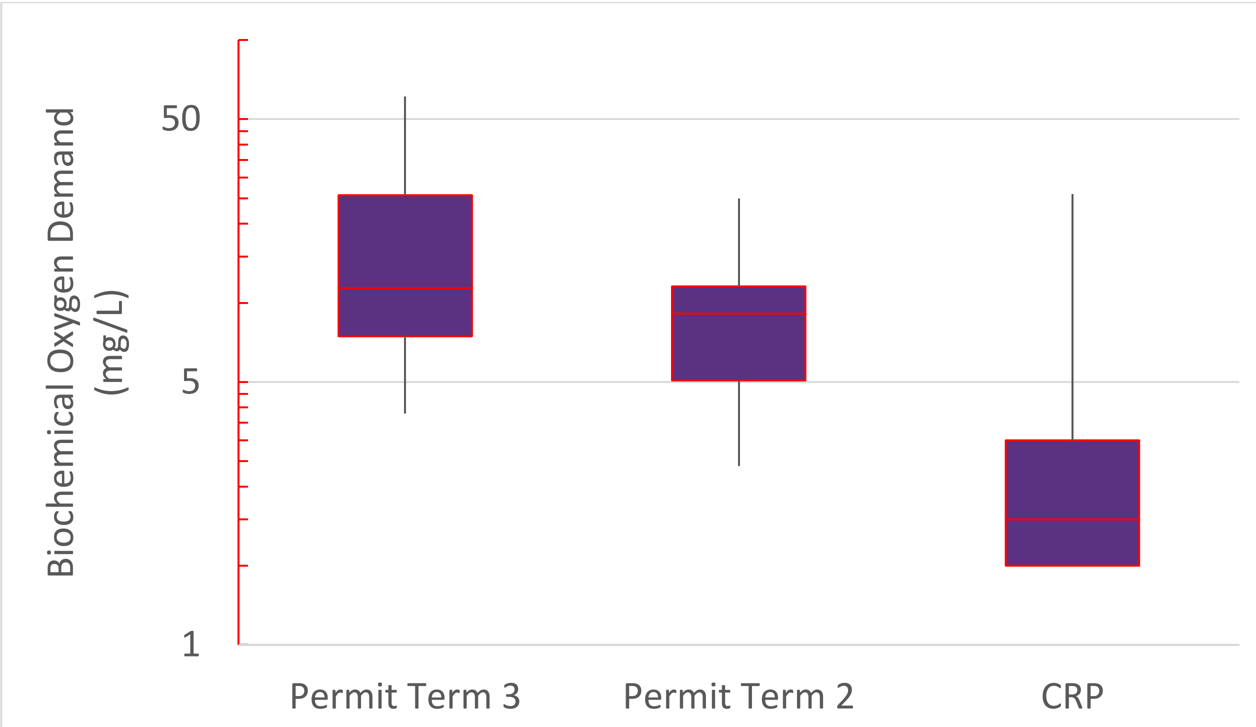


Figure 4-15 Boxplot Comparing Wet Weather Chemical Monitoring Second and Third Permit Term and CRP Total Copper Data at Johnson Creek

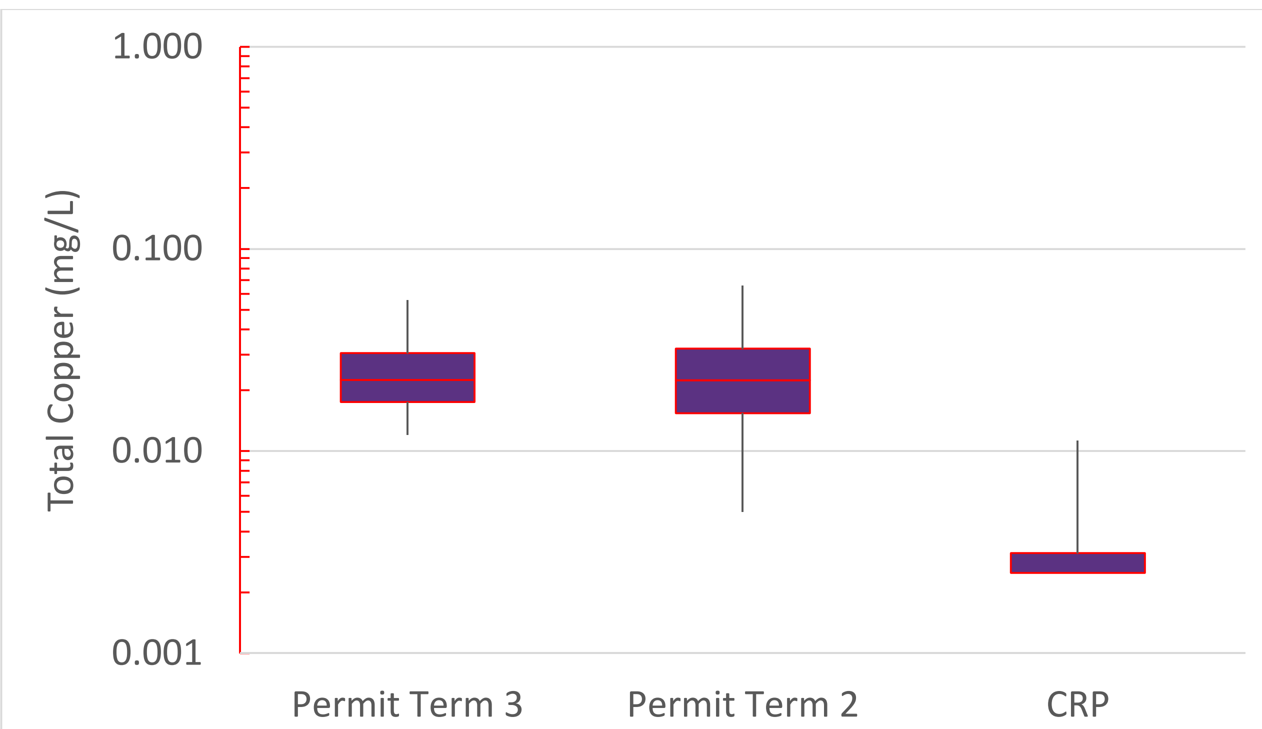


Figure 4-16 Boxplot Comparing Wet Weather Chemical Monitoring Second and Third Permit Term and CRP Total Lead Data at Johnson Creek

Figure 4-17 Boxplot Comparing Wet Weather Chemical Monitoring Second and Third Permit Term and CRP pH Data at Johnson Creek

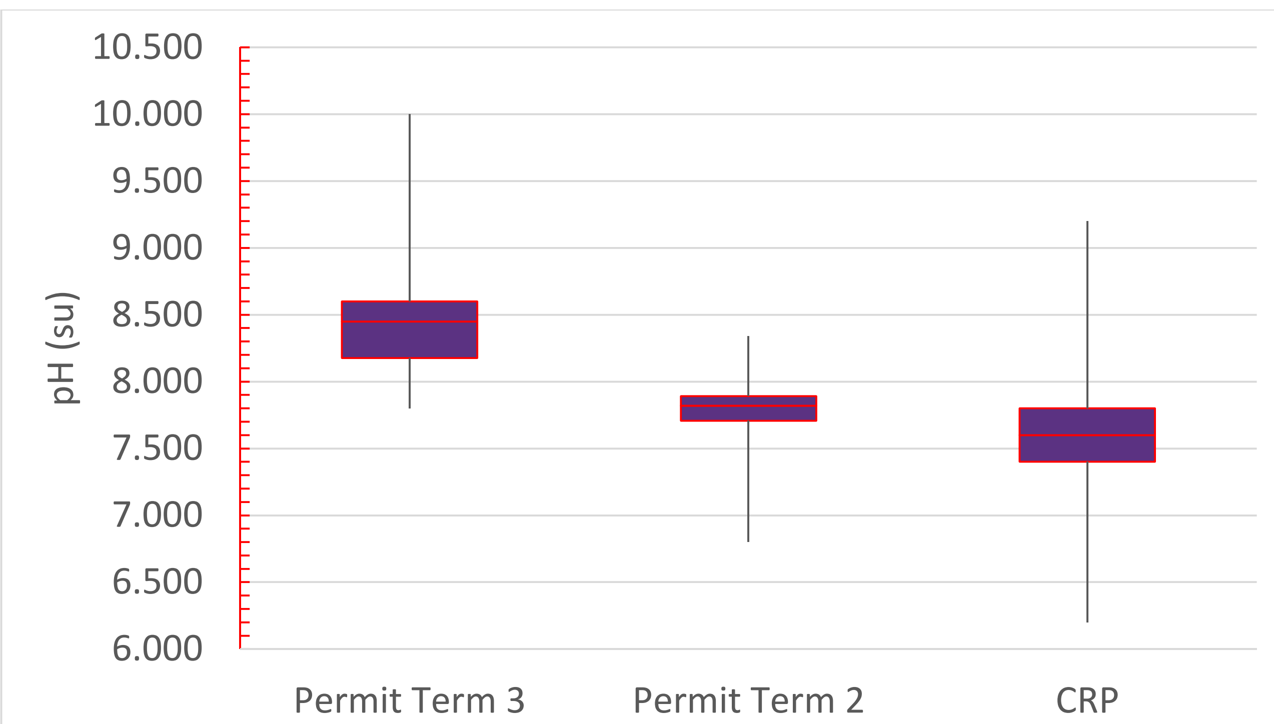
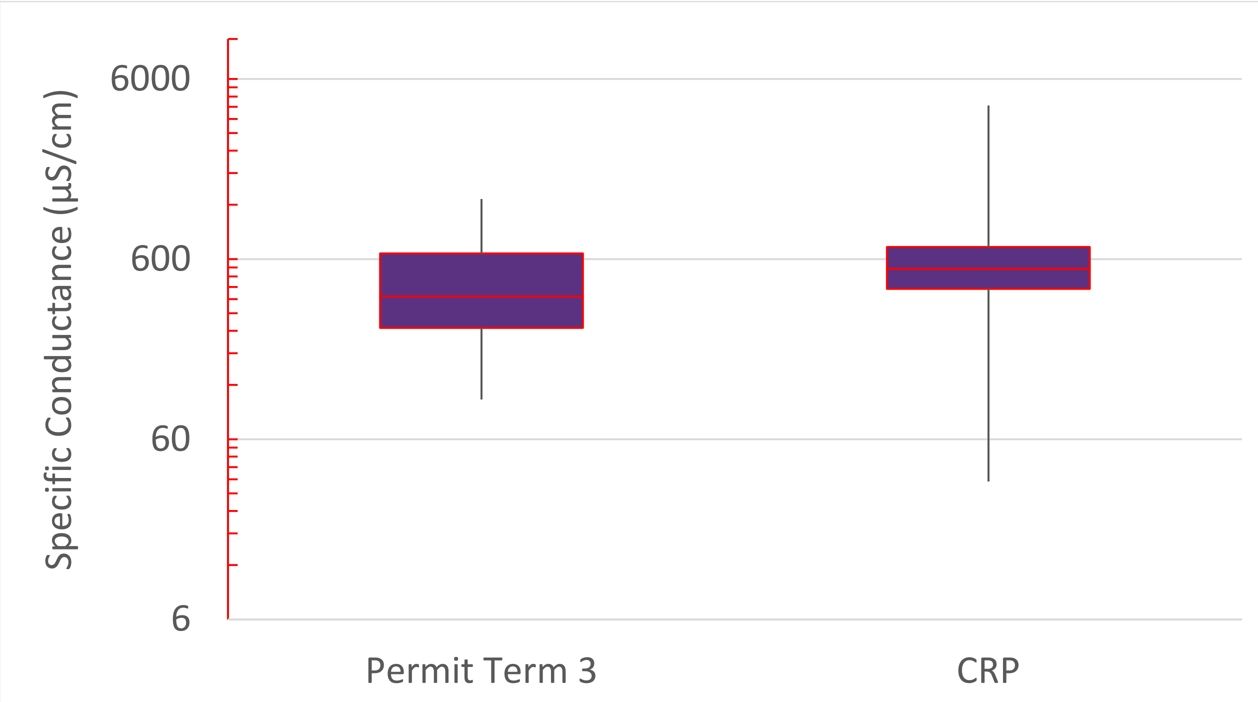


Figure 4-18 Boxplot Comparing Wet Weather Chemical Monitoring Third Permit Term and CRP Specific Conductivity Data at Johnson Creek



4.5.11. Lake Como – Clear Fork of the Trinity River

The City of Fort Worth performed bioassessment and chemical monitoring on an unnamed tributary in Overton Park to the Clear Fork of the Trinity River (TCEQ segment 0829). The stream has a stream order of two and is located within the Lake Como – Clear Fork Trinity River watershed. Additional bioassessment and chemical monitoring is scheduled for 2016.

Lake Como – Clear Fork Trinity River is located in the southwestern portion of Tarrant County and encompasses southwest Fort Worth and part of Benbrook. The 25,059-acre watershed is primarily comprised of residential (38.3%) property with significant areas of open (20.6%) areas, primarily along the Clear Fork of the Trinity River. Major highways in the watershed include IH 20, IH 30, and SH 183 and a dense street network contribute to a 21.0% highway land use. Commercial (18.2%) areas are distributed throughout the subwatershed with concentrations in the northeastern portion near downtown Fort Worth. There are a few industrial (0.7) sites in scattered locations. There are 1.2% identified water features.

The City of Fort Worth had two biological and chemical monitoring sites located on the unnamed tributary in Overton Park. The monitoring site, FWOVR1 was an upstream sampling site located in Foster Park at a bridge crossing on South Drive west of Trail Lake Drive (approximately 0.10 mile downstream). The area delineated for this sampling site was 538 acres and was dominated by residential (64.2%) land use. IH 20 crossed the upper part of the subwatershed and Granbury Road and Westcreek Drive were larger roadways (26.5% highway). Foster Park contributed to the 4.0% open area. Commercial (5.2%) land use was located near IH 20 and along other major streets. There was no industrial land use or identified water features (0%).

The monitoring site, FWOVR3 was a downstream sampling site located in a gabion-lined channel below the Bellaire Drive S. bridge crossing. The 2,481-acre watershed delineated for this sampling site was comprised primarily of residential (59.5%) land use. Hulen Mall was located in the western part of the watershed and contributed to the 12.6% commercial land use. Additional commercial areas were located along IH 20 and

Granbury Road among other major streets (22.5% highway). There were a few small industrial areas (0.4%) and identified water features (0.3%).

The monitoring sites, watershed and subwatershed boundaries, and land use types are shown in Appendix C, Figure 12. The subwatershed area is within the jurisdictional limits of the City of Fort Worth. TxDOT contributes flow to the subwatershed through IH 20. There are no TCEQ permitted wastewater outfalls located within the subwatershed according to the *TCEQ Permitted Wastewater Outfall* shapefile accessed May 20, 2016.

4.5.11.1. Summary Statistics

Summary statistics are presented in Table 4-8. The summary statistics include number of samples, minimum and maximum values, median, arithmetic mean, geometric mean, standard deviation, and coefficient of variation.

Table 4-8 Unnamed Tributary Clear Fork Trinity River RWWCP Third Permit Term Summary Statistics

Parameter	TDS (mg/L)	TSS (mg/L)	BOD (mg/L)	COD (mg/L)	Nitrogen, Total (mg/L)	Phosphorus, Dissolved (mg/L)
No. of Samples	2	2	2	2	2	2
Minimum	202.0	1.00	1.00	26.80	1.300	0.018
Maximum	334.0	20.30	11.20	41.00	1.500	0.021
Median	268.0	10.65	6.10	33.90	1.400	0.020
Arithmetic Mean	268.0	10.65	6.10	33.90	1.400	0.020
Geometric Mean	259.7	4.51	3.35	33.15	1.396	0.019
Standard Deviation	93.3	13.65	7.21	10.04	0.141	0.002
Coefficient of Variation	0.35	1.28	1.18	0.30	0.10	0.109
	Phosphorus, Total (mg/L)	Arsenic, Total (mg/L)	Chromium, Total (mg/L)	Copper, Total (mg/L)	Lead, Total (mg/L)	Zinc, Total (mg/L)
No. of Samples	2	2	2	2	2	2
Minimum	0.025	0.001	0.000	0.006	0.002	0.007
Maximum	0.130	0.001	0.001	0.007	0.002	0.027
Median	0.078	0.001	0.001	0.006	0.002	0.017
Arithmetic Mean	0.078	0.001	0.001	0.006	0.002	0.017
Geometric Mean	0.057	0.001	0.001	0.006	0.002	0.013
Standard Deviation	0.074	0.000	0.001	0.001	0.000	0.014
Coefficient of Variation	0.958	0.067	0.928	0.090	0.141	0.854
	Oil & Grease (mg/L)	pH, Field (su)	Specific Conductivity (µS/cm)	Temperature (°F)	E. Coli (col/100 mL)	Total Coliform (col/100 mL)
No. of Samples	2	4	0	0	4	2
Minimum	0.50	7.95	-	-	575	11900
Maximum	0.50	8.44	-	-	1730	46100
Median	0.50	8.32	-	-	1153	29000
Mean	0.50	8.26	-	-	1153	29000
Geometric Mean	0.50	8.25	-	-	997	23422
Standard Deviation	0.00	0.22	-	-	817	24183
Coefficient of Variation	0.00	0.03	-	-	0.71	0.83

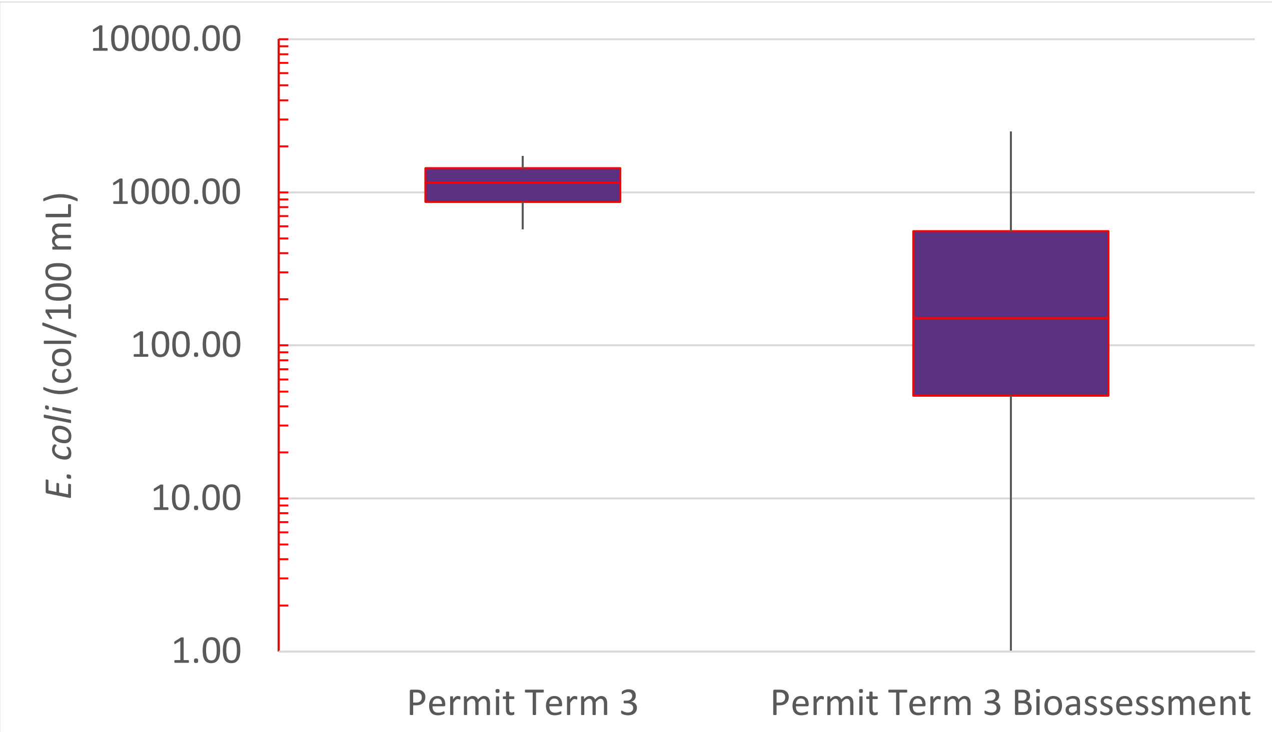
4.5.11.2. Water Quality Data Analysis

The chemical monitoring data over the permit term mostly resulted in two data points collected in December 2012. Supplementary data was collected in March and May 2012. These data were not plotted but were compared to water quality standards, screening levels, and other data sources where applicable. The *E. coli* concentrations exceeded the single sample and geometric mean primary contact standards. These results are highlighted in Table 4-8.

The water quality data collected during bioassessments was plotted and compared to water quality standards, screening levels, and other data sources. These graphs are located in Appendix N. The geometric mean of the bioassessment *E. coli* data was 170 col/100 mL which was more than the PCR geometric mean standard of 126 col/100 mL. There were four exceedances of the *E. coli* PCR single sample criterion. In May 2014, the dissolved oxygen concentration fell below the minimum for aquatic life use. Lastly, ammonia nitrogen exceeded the TCEQ screening level four times during the period.

Due to the exceedances discussed above and the availability of bioassessment and wet weather chemical data, a boxplot was created for *E. coli* for comparison of the datasets. Although there were only two data points collected during the wet weather chemical monitoring, these data indicate that stormwater runoff is providing a statistically significant input of *E. coli* to the stream compared to bioassessment data which was predominately collected during dry weather (see Figure 4-19).

Figure 4-19 Boxplot Comparing Wet Weather Chemical Monitoring Third Permit Term and Bioassessment *E. coli* Data within Unnamed Tributary to Clear Fork Trinity River



E. coli and ammonia nitrogen exceedances occurred at both monitoring stations over separate sampling events and years. The low dissolved oxygen concentration occurred at the downstream monitoring station.

4.5.11.3. Biological Data Analysis

Detailed reports of the biological assessments including data summaries can be found in the Annual Regional Wet Weather Characterization Program Monitoring Report for North Central Texas Year 2 through Year 5 (NCTCOG, 2013; NCTCOG, 2014; NCTCOG, 2015; NCTCOG, 2016). The habitat assessment scores and aquatic life use scores were plotted and compared to the habitat and aquatic life use categories (see Appendix N). The habitat scores remained in the marginal range over the third term period with the exception of sub-optimal scores at OVR1 in the spring and fall of 2013 and fall of 2014 and at OVR3 in the spring of 2012 and 2015.

The City of Fort Worth utilized the USEPA macroinvertebrate index metric which rates sites from non-impaired to severely impaired. OVR1 and OVR3 were rated moderately impaired over the third term period with the exception of the fall of 2015 when OVR3 was rated severely impaired. Texas macroinvertebrate IBI scores remained in the intermediate range over the third term period at both sites with the exception of the fall of 2013 and 2014 when OVR1 increased to high and fall of 2014 and spring of 2015 when OVR3 increased to high. The City of Fort Worth assessed the Texas Fish IBI at OVR3 in 2012 and 2013 at intermediate.

Given the predominately marginal habitat found at both sites, the tributary may not be considered ecologically healthy because the EPA macroinvertebrate index scores were consistently moderately impaired even though the Texas macroinvertebrate IBI intermediate scores suggested that the community corresponded with the available habitat. Also, the intermediate fish community scores generally corresponded with the habitat scores. One indicator identified in the bioassessments was low dissolved oxygen, which could impact the benthic macroinvertebrate community.

4.5.11.4. Potential Pollution Sources and BMP Recommendations

Land use of the unnamed tributary subwatershed is predominately residential followed by highway and commercial land uses. The potential source of the ammonia nitrogen loadings may be excessive lawn and garden fertilization. This nutrient loading may have been a factor in the low dissolved oxygen reading in May 2014. For bacteria, potential sources may be domestic animals, wildlife, and illicit connections. BMPs recommended for these sources include public education for residential land owners, public education for pet owners regarding pet waste management, and compliance inspections for illicit connections. Due to marginal habitat scores, stream restoration would benefit the biological productivity of the stream.

4.5.11.5. Monitoring Recommendations

Data analyzed presents moderate indications of stream degradation. Bacteria concentrations have a potential to impact primary contact recreation and nutrients (and potentially other unknown parameters) have the potential to impact aquatic life. The unnamed tributary does not have an identified TMDL or impairment. The Clear Fork of the Trinity River (TCEQ segment 0829) is impaired for dioxin and PCBs in fish tissue and there is a TMDL under development to assess PCBs in fish tissue. Additional monitoring at this site is recommended to be assigned a moderate priority.

4.5.12. Little Fossil Creek

The City of Fort Worth performed bioassessment and chemical monitoring on Little Fossil Creek (TCEQ segment 0806F) a stream with a stream order of two draining to Big Fossil Creek (TCEQ segment 0806C) within the Sycamore Creek – West Fork Trinity River watershed. Additional bioassessment monitoring is scheduled for 2016.

Sycamore Creek-West Fork Trinity River Watershed is located in central Tarrant County. This 22,339-acre watershed is predominately open space (28.7%) and residential (25.6%). The residential area is located in the central and southern part of the watershed, and the open space is dispersed throughout, with a large section in the southern tip of the watershed along the banks of the West Fork Trinity River. Commercial (20.0%) also makes up a large part of the watershed and is dispersed throughout. There are several highways (15.0%) that go through this watershed, including: IH 30, IH 35W, SH 183, SH 121, and SH 180. The industrial (9.5%) areas are dispersed in the north part of the watershed, as well as a large section just south of SH 121. This watershed contains 1.2% water features.

The City of Fort Worth had two biological and chemical monitoring sites located on Little Fossil Creek. The monitoring site, FWLFC1, was an upstream sampling site located in the 2200 block of Cantrell Sansom Rd. at a bridge crossing approximately 0.25 mile north of NE Loop IH 820 and 1.0 mile west of I-35W. This subwatershed covered a 3,227-acre area that was composed of open space (29.0%), commercial (24.9%) property, and residential (21.9%) property. The open space and commercial property were fairly evenly distributed throughout the subwatershed, while the residential property was limited to the upper and lower reaches of the drainage area. There were industrial (12.4%) sites through the center of the subwatershed. This drainage area contained 0.1% water features.

The monitoring site, FWLFC3, was a downstream sampling site located at the northern dead end of Mesquite Road south of 3800 Long Avenue. Little Fossil Creek flowed from this point through residential areas of Haltom City to its confluence with Big Fossil Creek and then southeast to the West Fork Trinity River. This subwatershed covered a 4,919-acre area and was comprised of open space (41.4%) and commercial (23.8%) property. Both open space and commercial land were evenly distributed throughout the watershed. There were a few highways (15.8%) in the drainage area, including IH 35W and IH 820. There were several industrial (13.9%) sites in the subwatershed. This drainage area contained 0.2% water features.

The monitoring sites, watershed and subwatershed boundaries, and land use types are shown in Appendix C, Figure 13. Much of the subwatershed area is within the jurisdictional limits of the City of Fort Worth. However, the Cities of Haltom City and Saginaw also have jurisdictional limits within the subwatershed. TxDOT contributes flow to the subwatershed through IH 820 and IH 35W. There are no TCEQ permitted wastewater outfalls located within the subwatershed according to the *TCEQ Permitted Wastewater Outfall* shapefile accessed May 20, 2016.

4.5.12.1. Summary Statistics

Summary statistics are presented in Table 4-9. The summary statistics include number of samples, minimum and maximum values, median, arithmetic mean, geometric mean, standard deviation, and coefficient of variation.

Table 4-9 Little Fossil Creek RWWCP Third Permit Term Summary Statistics

Parameter	TDS (mg/L)	TSS (mg/L)	BOD (mg/L)	COD (mg/L)	Nitrogen, Total (mg/L)	Phosphorus, Dissolved (mg/L)
No. of Samples	2	2	2	2	2	2
Minimum	133.0	6.30	4.20	24.50	0.780	0.041
Maximum	154.0	51.00	12.00	50.40	0.940	0.062
Median	143.5	28.65	8.10	37.45	0.860	0.052
Arithmetic Mean	143.5	28.65	8.10	37.45	0.860	0.052
Geometric Mean	143.1	17.92	7.10	35.14	0.856	0.050
Standard Deviation	14.8	31.61	5.52	18.31	0.113	0.015
Coefficient of Variation	0.10	1.10	0.68	0.49	0.132	0.288
	Phosphorus, Total (mg/L)	Arsenic, Total (mg/L)	Chromium, Total (mg/L)	Copper, Total (mg/L)	Lead, Total (mg/L)	Zinc, Total (mg/L)
No. of Samples	2	2	2	2	2	2
Minimum	0.120	0.004	0.002	0.006	0.002	0.018
Maximum	0.170	0.005	0.002	0.015	0.004	0.070
Median	0.145	0.005	0.002	0.010	0.003	0.044
Arithmetic Mean	0.145	0.005	0.002	0.010	0.003	0.044
Geometric Mean	0.143	0.005	0.002	0.010	0.003	0.036
Standard Deviation	0.035	0.000	0.000	0.006	0.002	0.037
Coefficient of Variation	0.244	0.061	0.043	0.562	0.566	0.830
	Oil & Grease (mg/L)	pH, Field (su)	Specific Conductivity (µS/cm)	Temperature (°F)	E. Coli (col/100 mL)	Total Coliform (col/100 mL)
No. of Samples	2	4	0	0	2	2
Minimum	0.53	7.72	-	-	2420	767000
Maximum	0.53	8.39	-	-	19400	985000
Median	0.53	7.97	-	-	10910	876000
Mean	0.53	8.01	-	-	10910	876000
Geometric Mean	0.53	8.01	-	-	6852	869192
Standard Deviation	0.00	0.33	-	-	12007	154149
Coefficient of Variation	0.00	0.04	-	-	1.10	0.18

4.5.12.2. Water Quality Data Analysis

The chemical monitoring data over the permit term mostly resulted in two data points collected in September 2013. Supplementary data was collected in October 2013. These data were not plotted but were compared to water quality standards, screening levels, and other data sources where applicable. The *E. coli* concentrations exceeded the single sample and geometric mean primary contact standards. These results are highlighted in Table 4-9.

The water quality data collected during bioassessments was plotted and compared to water quality standards, screening levels, other data sources including CRP data. CRP station 21425 was utilized for this analysis. Station 21425 is located at the same location as FWLFC3. These graphs are located in Appendix O. The geometric mean of the bioassessment *E. coli* data was 99 col/100 mL which was less than the PCR geometric mean standard of 126 col/100 mL. Ammonia nitrogen exceeded the TCEQ screening level four times during the period. In addition, there was one specific conductance reading greater than 1,000 µS/cm in June of 2015, which falls in the “fair” category (below the “good” category and above the “poor” category) according to USEPA, 2016b.

Due to the exceedances discussed above and the availability of bioassessment, CRP and wet weather chemical data, a boxplot was created for *E. coli* for comparison of the datasets. Although there were only two data points collected during the wet weather chemical monitoring, these data indicate that stormwater runoff is providing a statistically significant input of *E. coli* to the stream compared to bioassessment data which was predominately collected during dry weather (see Figure 4-20).

Figure 4-20 Boxplot Comparing Wet Weather Chemical Monitoring Third Permit Term, Bioassessment, and CRP *E. coli* Data at Little Fossil Creek

The *E. coli* exceedances occurred at the upstream monitoring station in May and June 2015 during the bioassessments and at both stations during the wet weather sampling event. One ammonia nitrogen exceedance occurred at the upstream monitoring station in October 2012 and the remaining three occurred at the downstream station in May and October 2013 and October 2014. The elevated specific conductance observation occurred at the downstream monitoring station in June 2015.

4.5.12.3. Biological Data Analysis

Detailed reports of the biological assessments including data summaries can be found in the Annual Regional Wet Weather Characterization Program Monitoring Report for North Central Texas Year 2 through Year 5 (NCTCOG, 2013; NCTCOG, 2014; NCTCOG, 2015; NCTCOG, 2016). The habitat assessment scores and aquatic life use scores were plotted and compared to the habitat and aquatic life use categories (see Appendix O). The habitat scores remained in the marginal range over the third term period with the exception of sub-optimal scores at LFC1 in the spring and fall of 2012 and spring of 2015 and at LFC3 in the spring of 2012 and 2015.

The City of Fort Worth utilized the USEPA macroinvertebrate index metric which rates sites from non-impaired to severely impaired. LFC1 and LFC3 were rated moderately impaired over the third term period with the exception of the fall of 2013 and 2014 when LFC3 was rated severely impaired. Texas macroinvertebrate IBI scores remained in the intermediate range over the third term period at both sites with the exception of the spring of 2015 when LFC3 increased to high. The City of Fort Worth assessed the Texas Fish IBI at LFC3 as intermediate in 2012 and 2014 and as high in 2013.

Given the predominately marginal habitat found at both sites, the tributary may not be considered ecologically healthy because the EPA macroinvertebrate index scores were consistently moderately impaired even though the Texas macroinvertebrate IBI intermediate scores suggested that the community corresponded with the available habitat. Also, the intermediate fish community scores generally corresponded with the habitat scores.

4.5.12.4. Potential Pollution Sources and BMP Recommendations

Land use of the subwatershed is mostly open with sizable commercial, highway, industrial, and residential land uses. The potential source of the ammonia nitrogen loadings may be excessive lawn, garden, and agricultural fertilization. However, dissolved oxygen concentrations over the monitoring term did not fall below TCEQ criteria for aquatic life protection suggesting that the nutrient loadings were not contributing to low dissolved oxygen events.

For bacteria, potential sources may be livestock, agricultural manure application, domestic animals, wildlife, septic system failure, and illicit connections. BMPs recommended for these sources include public education for agricultural and residential land owners, public education for pet owners regarding pet waste management, and compliance inspections for illicit connections. In addition, maintenance and education for septic system owners regarding frequent maintenance and pump out may be considered. Due to marginal habitat scores, stream restoration would benefit the biological productivity of the stream.

4.5.12.5. Monitoring Recommendations

Data analyzed presented occasional exceedances to ammonia nitrogen and bacteria screening and criteria levels and criteria with moderate indications of stream degradation. There are no bacteria TMDLs or impairments identified for either Little Fossil Creek or Big Fossil Creek. Therefore additional monitoring at this site is recommended to be assigned a moderate priority.

4.5.13. Marine Creek

The City of Fort Worth performed bioassessment and chemical monitoring on Marine Creek (TCEQ segment 0806D) a stream with a stream order of two draining to the West Fork of the Trinity River (TCEQ segment 0806) within the Marine Creek – West Fork Trinity River watershed. Additional bioassessment monitoring is scheduled for 2016.

Marine Creek-West Fork Trinity River is located on the western side of Fort Worth's city limits in Tarrant County. Marine Creek-West Fork Trinity River covers a 20,017-acre area and consists predominately of open space (32.0%) with dense residential (22.4%), commercial (15.2%), and industrial (5.7%) areas in the southern portion and along the western and eastern corners. The highway land use estimate for this watershed is 22.6% which includes IH Loop 820 and SH 183 (NW 28th Street). This watershed has 2.1% water features.

The City of Fort Worth had two biological and chemical monitoring sites located on Marine Creek. The monitoring site, FWMAR1, was an upstream sampling site located at the Macie Avenue bridge crossing in Buck Sansom Park. The subwatershed delineated for this sampling location covered a 7581-acre area and almost half of the area consisted of open space (49.4%), followed by residential (21.8%) properties. Highways (12.5%) including IH Loop 820 and major arterials such as Angle Avenue, Marine Creek Parkway and commercial (11.2%) properties comprised most of the remaining areas. Water (3.5%) features such as Marine Creek Reservoir on the north side of IH Loop 820 and industrial (1.6%) areas rounded out the balance of this area.

The monitoring site, FWMAR3, was a downstream sampling site accessed through Saunders Park on the south end of the Fort Worth Stockyards and north of the NE 23rd Street bridge crossing. The drainage area delineated for this site covered 5,576 acres and consisted primarily of highway (34.0%) land use, residential (25.7%) properties and open (23.2%) spaces. The remaining areas were commercial (11.9%) and industrial (4.6%) sites with scattered areas of water (0.5%) features. Highways and major roadways going through this area were SH 183 (NW 28th Street), a short section of IH Loop 820, Long Avenue, Longhorn Road, McLeroy Boulevard and all of Meacham International Airport.

The monitoring sites, watershed and subwatershed boundaries, and land use types are shown in Appendix C, Figure 14. Much of the subwatershed area is within the jurisdictional limits of the City of Fort Worth. However, a portion of the City of Saginaw is located within the upper portion of the subwatershed. TxDOT contributes flow to the subwatershed through IH 820 and SH 183. There are no TCEQ permitted wastewater outfalls located within the subwatershed according to the *TCEQ Permitted Wastewater Outfall* shapefile accessed May 20, 2016.

4.5.13.1. Summary Statistics

Summary statistics are presented in Table 4-10. The summary statistics include number of samples, minimum and maximum values, median, arithmetic mean, geometric mean, standard deviation, and coefficient of variation.

Table 4-10 Marine Creek RWWCP Third Permit Term Summary Statistics

Parameter	TDS (mg/L)	TSS (mg/L)	BOD (mg/L)	COD (mg/L)	Nitrogen, Total (mg/L)	Phosphorus, Dissolved (mg/L)
No. of Samples	2	2	2	2	2	2
Minimum	334.0	1.00	1.00	10.20	0.440	0.023
Maximum	419.0	9.00	4.20	19.70	2.000	0.076
Median	376.5	5.00	2.60	14.95	1.220	0.050
Arithmetic Mean	376.5	5.00	2.60	14.95	1.220	0.050
Geometric Mean	374.1	3.00	2.05	14.18	0.938	0.042
Standard Deviation	60.1	5.66	2.26	6.72	1.103	0.037
Coefficient of Variation	0.16	1.13	0.87	0.45	0.90	0.757
	Phosphorus, Total (mg/L)	Arsenic, Total (mg/L)	Chromium, Total (mg/L)	Copper, Total (mg/L)	Lead, Total (mg/L)	Zinc, Total (mg/L)
No. of Samples	2	2	2	2	2	2
Minimum	0.029	0.001	0.001	0.006	0.002	0.008
Maximum	0.110	0.001	0.008	0.010	0.002	0.021
Median	0.070	0.001	0.004	0.008	0.002	0.015
Arithmetic Mean	0.070	0.001	0.004	0.008	0.002	0.015
Geometric Mean	0.056	0.001	0.002	0.008	0.002	0.013
Standard Deviation	0.057	0.000	0.005	0.003	0.000	0.009
Coefficient of Variation	0.824	0.000	1.247	0.384	0.038	0.635
	Oil & Grease (mg/L)	pH, Field (su)	Specific Conductivity (µS/cm)	Temperature (°F)	E. coli (col/100 mL)	Total Coliform (col/100 mL)
No. of Samples	2	4	0	0	2	2
Minimum	0.50	8.22	-	-	137	29900
Maximum	0.53	8.65	-	-	154	72700
Median	0.52	8.28	-	-	146	51300
Mean	0.52	8.36	-	-	146	51300
Geometric Mean	0.51	8.35	-	-	145	46623
Standard Deviation	0.02	0.20	-	-	12	30264
Coefficient of Variation	0.04	0.02	-	-	0.08	0.59

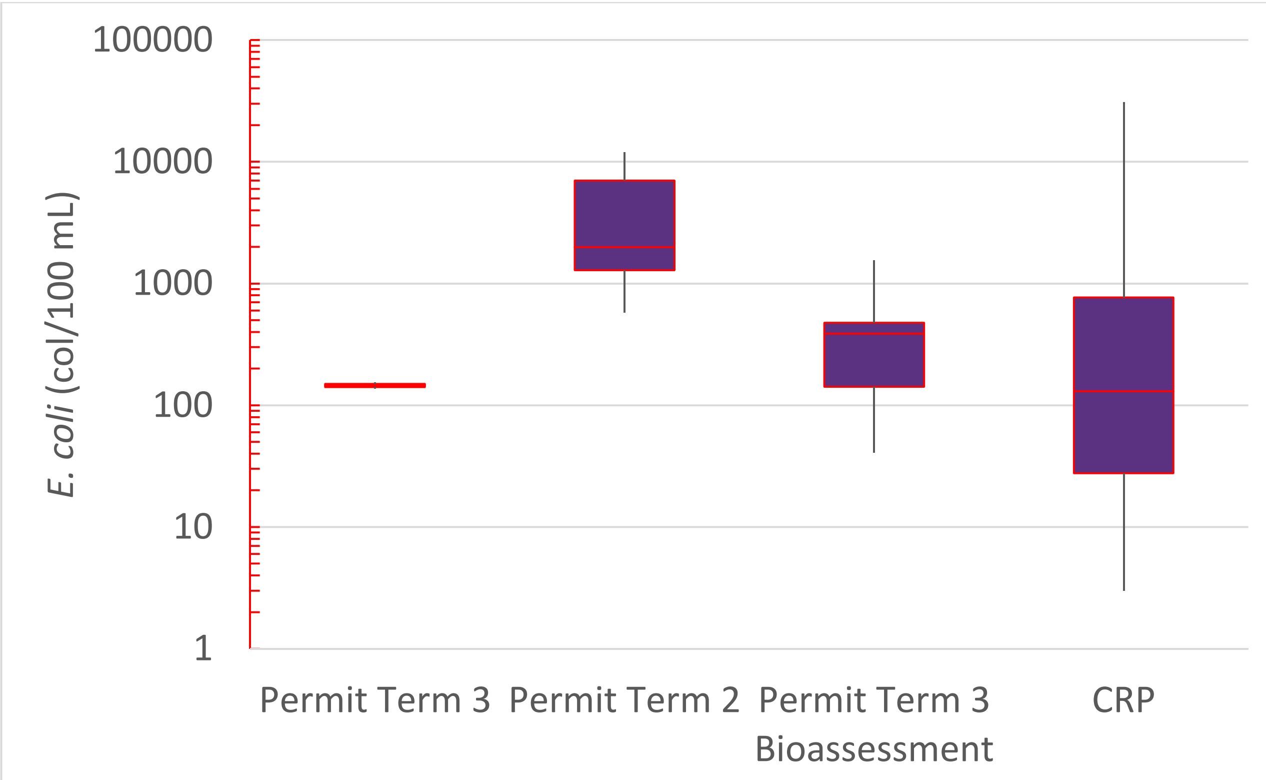
4.5.13.2. Water Quality Data Analysis

The chemical monitoring data over the permit term mostly resulted in two data points collected in December 2012. Supplementary data was collected in March 2013. These data were plotted and compared to water quality standards, screening levels, and other data sources where applicable. The graphs are located in Appendix P. The *E. coli* concentrations exceeded the geometric mean primary contact standard.

The water quality data collected during bioassessments was plotted and compared to water quality standards, screening levels, other data sources including CRP data. CRP station 17370 was utilized for this analysis. Station 17370 is located just downstream of the NE 23rd Street crossing prior to the intersection with the West Fork of the Trinity River. Graphs are located in Appendix P. The geometric mean of the bioassessment *E. coli* data was 274 col/100 mL which was more than the PCR geometric mean standard of 126 col/100 mL. There were five exceedances of the *E. coli* PCR single sample criterion. In May 2014, the dissolved oxygen concentration fell below the minimum for aquatic life use. Lastly, ammonia nitrogen exceeded the TCEQ screening level six times during the period.

Due to the exceedances discussed above and the availability of bioassessment, CRP and wet weather chemical data, a boxplot was created for *E. coli* for comparison of the datasets. According to the boxplot, there is no statistical significant difference between the third permit term wet weather, bioassessment, and CRP data. However, there is a statistically significant increase between the second permit term wet weather data and the other datasets. Therefore, there is not a clear indication that stormwater runoff is providing an input of *E. coli* to the stream compared to the datasets predominately collected during dry weather (see Figure 4-21).

Figure 4-21 Boxplot Comparing Wet Weather Chemical Monitoring Second and Third Permit Term, Bioassessment, and CRP *E. coli* Data at Marine Creek



The *E. coli* exceedances occurred predominantly at the downstream monitoring station in 2013, 2014, and 2015. There was one *E. coli* exceedance at the upstream station in October 2013. The ammonia nitrogen exceedances occurred at both monitoring stations in multiple years. The low dissolved oxygen concentration occurred at the upstream monitoring station.

4.5.13.3. Biological Data Analysis

Detailed reports of the biological assessments including data summaries can be found in the Annual Regional Wet Weather Characterization Program Monitoring Report for North Central Texas Year 2 through Year 5 (NCTCOG, 2013; NCTCOG, 2014; NCTCOG, 2015; NCTCOG, 2016). The habitat assessment scores and aquatic life use scores were plotted and compared to the habitat and aquatic life use categories (see Appendix P). The habitat scores remained in the sub-optimal range over the third term period with the exception of marginal scores at MAR1 in the spring 2012 and 2014.

The City of Fort Worth utilized the USEPA macroinvertebrate index metric which rates sites from non-impaired to severely impaired. MAR1 and MAR3 were rated moderately impaired over the third term period with the exception of the spring of 2012 when MAR3 was rated slightly impaired. Texas macroinvertebrate IBI scores remained in the intermediate range over the third term period at both sites with the exception of the spring of 2012 and 2013 when MAR1 increased to high.

Given the predominately sub-optimal habitat found at both sites, moderately impaired USEPA scores and intermediate to high IBI scores generally correspond with the available habitat indicating that water quality may not be limiting fish and macroinvertebrate communities. However, one indicator identified in the bioassessments was low dissolved oxygen which could impact the benthic macroinvertebrate community and may have been a factor in preventing higher macroinvertebrate scores.

4.5.13.4. Potential Pollution Sources and BMP Recommendations

Land use of the unnamed tributary subwatershed is predominately open followed by residential, highway and commercial land uses. The potential source of the ammonia nitrogen loadings may be excessive lawn and garden fertilization. This nutrient loading may have been a factor in the low dissolved oxygen reading in May 2014. For bacteria, potential sources may be domestic animals, wildlife, and illicit connections. BMPs recommended for these sources include public education for residential land owners, public education for pet owners regarding pet waste management, and compliance inspections for illicit connections. Due to sub-optimal to marginal habitat scores, stream restoration would benefit the biological productivity of the stream.

4.5.13.5. Monitoring Recommendations

Data analyzed presents moderate indications of stream degradation. Bacteria concentrations have a potential to impact primary contact recreation and nutrients have the potential to impact aquatic life. Marine Creek does not have an identified TMDL or impairment. The West Fork of the Trinity River (TCEQ segment 0806) is impaired for dioxin and PCBs in fish tissue. Additional monitoring at this site is recommended to be assigned a moderate priority.

4.5.14. Mary's Creek

The City of Fort Worth performed bioassessment and chemical monitoring on Mary's Creek, a stream with a stream order of three or greater draining to the Clear Fork of the Trinity River (TCEQ segment 0829) within the Mary's Creek watershed. Additional bioassessment monitoring is scheduled for 2016.

Mary's Creek Watershed is located in western Tarrant County and eastern Parker County and flows southeasterly through south Fort Worth eventually emptying into the West Fork Trinity River. Mary's Creek Watershed covers a 35,357-acre area and is predominately made up of open space (75.0%). Residential property (12.3%), commercial development (4.1%), and industrial use (0.2%) occur primarily in the far eastern portion of the subwatershed. The highway land use estimate for this watershed is 7.6%. Major highways running through this area are IH 20, IH 30, and IH 820. This watershed consists of 0.8% water features.

The City of Fort Worth had two biological and chemical monitoring sites located on Mary's Creek. The monitoring site, FWMRY1, was an upstream sampling site located just downstream of the bridge crossing at 3900 Longvue (FM 2871), approximately 1.0 mile west of West Loop IH 820. The subwatershed delineated for this sampling location covered a 22,908-acre area and was predominately made up of open space (85.6%) and some residential land use (8.6%) between the sample site and IH 30. Highways (4.1%) located in the subwatershed included IH 20, IH 30, and Hwy 80. Immediately downstream of this location was a primarily undeveloped area with on-going residential development to the south. Commercial made up just 1.1% of the land area and there were no industrial uses in the subwatershed. Water features made up 0.7% of the land area.

The monitoring site, FWMRY3, was a downstream sampling site located approximately 0.10 upstream of the Winscott Road crossing in South Z Boaz Park. Below this point, the creek continued through the City of Benbrook prior to its convergence with the Clear Fork of the Trinity River. The subwatershed delineated for this sampling location covered an 11,675-acre area and was predominately made up of open space (57.3%). Residential land use (18.2%) and associated commercial development (9.4%) were located primarily in the northern part of the subwatershed between IH 820 and Hwy 183. These roadways and IH 20 and IH 30 contributed to 14.2% highway land use. The western part of the subwatershed was largely undeveloped. There were just 0.1% industrial uses in the subwatershed. Water features made up 0.8% of the land area.

The monitoring sites, watershed and subwatershed boundaries, and land use types are shown in Appendix C, Figure 15. The City of Fort Worth and Parker and Tarrant Counties have jurisdictions occurring in the subwatershed area. TxDOT contributes flow to the subwatershed through IH 30, IH 20, IH 820, US 80, and US 183. There are no TCEQ permitted wastewater outfalls located within the subwatershed according to the *TCEQ Permitted Wastewater Outfall* shapefile accessed May 20, 2016.

4.5.14.1. Summary Statistics

Summary statistics are presented in Table 4-11. The summary statistics include number of samples, minimum and maximum values, median, arithmetic mean, geometric mean, standard deviation, and coefficient of variation.

Table 4-11 Mary's Creek RWWCP Third Permit Term Summary Statistics

Parameter	TDS (mg/L)	TSS (mg/L)	BOD (mg/L)	COD (mg/L)	Nitrogen, Total (mg/L)	Phosphorus, Dissolved (mg/L)
No. of Samples	3	3	3	3	3	3
Minimum	232.0	8.50	2.10	10.00	0.25	0.017
Maximum	286.0	166.00	8.80	85.00	3.00	0.029
Median	278.0	14.10	6.30	31.00	1.96	0.018
Arithmetic Mean	265.3	62.87	5.73	42.00	1.74	0.021
Geometric Mean	264.2	27.10	4.88	29.76	1.14	0.021
Standard Deviation	29.1	89.36	3.39	38.69	--	0.007
Coefficient of Variation	0.11	1.42	0.59	0.92	--	0.312
	Phosphorus, Total (mg/L)	Arsenic, Total (mg/L)	Chromium, Total (mg/L)	Copper, Total (mg/L)	Lead, Total (mg/L)	Zinc, Total (mg/L)
No. of Samples	3	3	3	3	3	3
Minimum	0.500	0.003	0.003	0.003	0.003	0.005
Maximum	0.500	0.007	0.019	0.013	0.015	0.060
Median	0.500	0.003	0.003	0.008	0.005	0.031
Arithmetic Mean	0.500	0.004	0.008	0.008	0.008	0.032
Geometric Mean	0.500	0.004	0.005	0.006	0.006	0.021
Standard Deviation	0.000	0.003	0.010	0.005	0.007	0.028
Coefficient of Variation	0.000	0.650	1.191	0.670	0.882	0.860
	Oil & Grease (mg/L)	pH, Field (su)	Specific Conductivity (µS/cm)	Temperature (°F)	E. Coli (col/100 mL)	Total Coliform (col/100 mL)
No. of Samples	3	3	0	0	3	3
Minimum	2.50	8.10	-	-	1300	17200
Maximum	2.50	8.48	-	-	32600	576000
Median	2.50	8.35	-	-	15000	242000
Mean	2.50	8.31	-	-	16300	278400
Geometric Mean	2.50	8.31	-	-	8598	133841
Standard Deviation	0.00	0.19	-	-	15690	281173
Coefficient of Variation	0.00	0.02	-	-	0.96	1.01

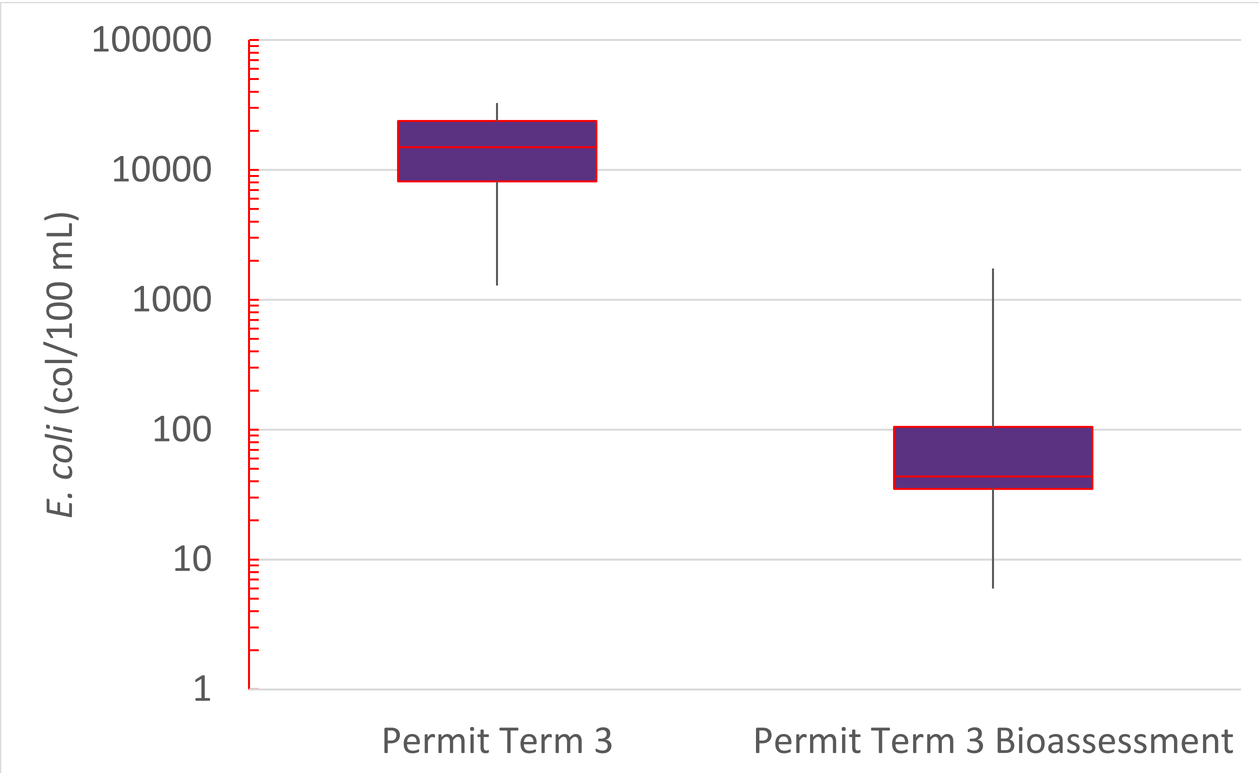
4.5.14.2. Water Quality Data Analysis

The chemical monitoring data over the permit term resulted in three data points collected in October 2014 and November 2015. These data were not plotted but were compared to water quality standards, screening levels, and other data sources where applicable. During the third permit term, there were two exceedances of the TCEQ aquatic life use estimated chronic criterion and human health criterion for total lead and three exceedances of the *E. coli* PCR single sample criterion (and the geometric mean criterion). There was one occurrence where the TSS concentration was higher than 75% of the NSQD data for that parameter. These results are highlighted in Table 4-8.

The water quality data collected during bioassessments was plotted and compared to water quality standards, screening levels, other data sources where applicable. Graphs are located in Appendix Q. The geometric mean of the bioassessment *E. coli* data was 53 col/100 mL which was less than the PCR geometric mean standard of 126 col/100 mL. Ammonia nitrogen exceeded the TCEQ screening level five times during the period and orthophosphate exceeded the TCEQ screening level once during the period.

Due to the exceedances and elevated concentrations discussed above and the availability of bioassessment and wet weather chemical data, a boxplot was created for *E. coli* for comparison of the datasets. According to the boxplot, there is a statistical significant difference between the third permit term wet weather and bioassessment data. Therefore, stormwater runoff is providing an input of *E. coli* to the stream compared to the bioassessment dataset which is predominately collected during dry weather (see Figure 4-22).

Figure 4-22 Boxplot Comparing Wet Weather Chemical Monitoring Third Permit Term and Bioassessment *E. coli* Data at Mary's Creek



During wet weather, the *E. coli* exceedances occurred at both stations but during dry weather bioassessment the *E. coli* exceedance occurred only at the upstream monitoring station in October 2015. The total lead and TSS exceedance and elevated concentration occurred at the downstream station in October 2014 during the wet weather event. The ammonia nitrogen exceedances occurred at both monitoring stations in multiple years. The orthophosphate exceedance occurred at the upstream monitoring station in June 2015.

4.5.14.3. Biological Data Analysis

Detailed reports of the biological assessments including data summaries can be found in the Annual Regional Wet Weather Characterization Program Monitoring Report for North Central Texas Year 2 through Year 5 (NCTCOG, 2013; NCTCOG, 2014; NCTCOG, 2015; NCTCOG, 2016). The habitat assessment scores and aquatic life use scores were plotted and compared to the habitat and aquatic life use categories (see Appendix Q). The habitat scores remained in the marginal range over the third term period with the exception of sub-optimal scores at MRY3 in spring 2012, 2013, and 2014 and fall 2014 and at MRY1 in spring 2015. The City of Fort Worth utilized the USEPA macroinvertebrate index metric which rates sites from non-impaired to severely impaired. MRY1 and MRY3 were rated moderately impaired over the third term period with the exception of the fall 2014 and 2015 when MRY1 was rated slightly impaired. Texas macroinvertebrate IBI scores remained in the high range over the third term period at both sites with the exception of the fall 2013 and spring 2014 when both sites decreased to intermediate.

Given the predominately marginal habitat found at both sites, moderately impaired USEPA scores and high IBI scores generally correspond with the available habitat indicating that water quality may not be limiting fish and macroinvertebrate communities.

4.5.14.4. Potential Pollution Sources and BMP Recommendations

Land use of the subwatershed is a predominately industrial land use followed by a sizable open land use. Given the open land use in the subwatershed, the potential source of the ammonia nitrogen loadings may be excessive lawn, garden, and agricultural fertilization. However, dissolved oxygen concentrations over the monitoring term did not fall below TCEQ criteria for aquatic life protection suggesting that the nutrient loadings were not contributing to low dissolved oxygen events.

The TSS and total lead elevated concentration and exceedance were observed at the downstream monitoring station. Land use in the drainage area for the downstream station has increased residential and commercial land uses and roadways included IH 20, IH 820, and IH 30. Potential sources of lead could be from illicit connections, illegal dumping, and high traffic roadways. Development and construction in these areas may have been a source of sediment loadings. For bacteria, potential sources may be livestock, agricultural manure application, domestic animals, wildlife, septic system failure, and illicit connections. BMPs recommended for these sources include public education for agricultural and residential land owners, compliance inspections for illicit connections, and review of construction site inspection protocols or BMP requirements. In addition, maintenance and education for septic system owners regarding frequent maintenance and pump out may be considered. Due to marginal habitat scores ranging to sub-optimal, stream restoration projects may be able to increase the biological productivity of the stream.

4.5.14.5. Monitoring Recommendations

Data analyzed presents moderate indications of stream degradation. Bacteria concentrations have a potential to impact primary contact recreation and nutrients and lead have the potential to impact aquatic life. The unnamed tributary does not have an identified TMDL or impairment. The Clear Fork of the Trinity River (TCEQ segment 0829) is impaired for dioxin and PCBs in fish tissue and there is a TMDL under development to assess PCBs in fish tissue. Additional monitoring at this site is recommended to be assigned a moderate priority. Dry weather chemical monitoring data is recommended to further determine potential sources of pollutants.

4.5.15. North Mesquite Creek

The City of Mesquite performed chemical monitoring on North Mesquite Creek, a stream with a stream order of one draining to the East Fork of the Trinity River (TCEQ segment 0819) within the North Mesquite Creek – East Fork Trinity River watershed.

North Mesquite Creek Watershed is located on the far eastern edge of Dallas County and partially within the Dallas city limits. North Mesquite Creek Watershed covers a 23,929-acre area and consists mostly of open space (59.9%) and residential (19.2%) property. Residential property is primarily located on the western side of the watershed with a small section along the southern edge. The highway land use estimate for this watershed is 10.1% which includes SH 80, SH 352 and other major roadways such as East Glen Boulevard, Belt Line Road, North Galloway Avenue, and Town East Boulevard. The highway estimate also includes the Mesquite Metro Airport, located at the intersection of Scyene Road and Airport Boulevard. Industrial (1.3%) sites are mostly located in the central portion of this watershed along SH 80 and SH 352. Most of the commercial (8.1%) areas are located throughout the watershed along the major roadways and intermixed with the residential areas. This watershed contains 1.4% water features.

The City of Mesquite had one chemical monitoring site located within the North Mesquite Creek subwatershed. The chemical monitoring site, MS1202/1302/1402/1502 was located between Cartwright Road and Clay Mathis Road where Edwards Church Road crosses North Mesquite Creek. The conveyance at this site was an unlined channel with gabions. The subwatershed delineated for this sampling location covered a 6,257-acre area and consists primarily of residential (34.1%) property and open space (29.0%). There were large sections of open space in the north and center of the subwatershed along the banks of North Mesquite Creek. The highway land use estimate was 19.0% which included major highways and roadways such as SH 80, Belt Line Road, East Glen Boulevard, Clay Mathis Road, and Town East Boulevard. Industrial (3.7%) sites were located south of SH 80, along SH 352, and north of East Glen Boulevard. Commercial (13.9%) property was scattered throughout the watershed, mostly located along major roads adjacent to residential areas. This subwatershed contained 0.3% water features.

The monitoring site, watershed and subwatershed boundaries, and land use types are shown in Appendix C, Figure 16. The monitoring site is shown as MS1202. MS1302, MS1402, and MS1502 were located in the same location. The subwatershed area is within the jurisdictional limits of the City of Mesquite and the City of

Sunnyval. TxDOT contributes flow to the subwatershed through SH 80 and SH 352. There are no TCEQ permitted wastewater outfalls located within the subwatershed according to the *TCEQ Permitted Wastewater Outfall* shapefile accessed May 20, 2016.

4.5.15.1. Summary Statistics

Summary statistics are presented in Table 4-12 for RWWCP chemical monitoring parameters excluding Carbaryl which was not detected. The summary statistics include number of samples, minimum and maximum values, median, arithmetic mean, geometric mean, standard deviation, and coefficient of variation.

Table 4-12 North Mesquite Creek RWWCP Third Permit Term Summary Statistics

Parameter	TDS (mg/L)	TSS (mg/L)	BOD (mg/L)	COD (mg/L)	Nitrogen, Total (mg/L)	Phosphorus, Dissolved (mg/L)
No. of Samples	16	16	16	16	16	16
Minimum	66.0	1.89	1.27	0.50	0.560	0.010
Maximum	1680	694.0	13.6	77.0	36.00	0.110
Median	321.5	47.67	5.85	17.50	2.505	0.060
Arithmetic Mean	373.0	151.4	6.16	23.68	5.701	0.061
Geometric Mean	283.4	45.84	5.13	12.48	2.710	0.055
Standard Deviation	369.4	217.86	3.58	20.82	8.968	0.024
Coefficient of Variation	0.99	1.44	0.58	0.88	1.57	0.386
	Phosphorus, Total (mg/L)	Arsenic, Total (mg/L)	Chromium, Total (mg/L)	Copper, Total (mg/L)	Lead, Total (mg/L)	Zinc, Total (mg/L)
No. of Samples	16	16	16	16	16	16
Minimum	0.050	0.001	0.002	0.002	0.002	0.003
Maximum	0.530	0.006	0.013	0.042	0.012	0.082
Median	0.180	0.003	0.002	0.015	0.002	0.028
Arithmetic Mean	0.182	0.003	0.004	0.019	0.003	0.033
Geometric Mean	0.147	0.002	0.003	0.015	0.003	0.027
Standard Deviation	0.125	0.002	0.004	0.012	0.003	0.020
Coefficient of Variation	0.685	0.683	0.878	0.624	0.795	0.619
	Oil & Grease (mg/L)	pH, Field (su)	Specific Conductivity (µS/cm)	Temperature (°F)	E. Coli (col/100 mL)	Total Coliform (col/100 mL)
No. of Samples	16	16	16	16	16	16
Minimum	0.70	7.10	136	40.0	20.0	232
Maximum	18.30	8.80	1021	86.1	5000	100000
Median	0.70	8.20	450	67.8	195	12350
Mean	3.36	8.10	510	65.2	1050	25034
Geometric Mean	1.56	8.09	431	64.1	252	9944
Standard Deviation	5.16	0.39	280	12.4	1469	28922
Coefficient of Variation	1.54	0.05	0.55	0.19	1.40	1.16

4.5.15.2. Water Quality Data Analysis

Monitored parameters were plotted and compared to water quality standards, screening levels, NSQD, and other data where applicable. These graphs are located in Appendix R. During the third permit term, there was one exceedance of the TCEQ TDS basin specific criterion, two exceedances of the TCEQ aquatic life use estimated chronic criterion for total copper, and six exceedances of the *E. coli* PCR single sample criterion (and the geometric mean criterion). There were four occurrences where the TSS concentration, six occurrences where the total nitrogen concentration, and three occurrences where the oil and grease concentration was higher than 75% of NSQD data for those parameters. In addition, there were two specific conductance readings greater than 1,000 µS/cm in April and August of 2015, which fall in the "fair" category (below the "good" category and above the "poor" category) according to USEPA, 2016b.

The TDS exceedance occurred in July 2013. The total copper exceedances occurred in April 2012 and January 2015. *E. coli* PCR single sample criterion exceedances were observed mainly in October (2012, 2014, and 2015) but also in the months of July and April. Elevated TSS, total nitrogen, and oil and grease concentrations occurred in various months and years over the monitored period.

4.5.15.3. Biological Data Analysis

No bioassessment monitoring data was collected within this watershed.

4.5.15.4. Potential Pollution Sources and BMP Recommendations

Land use of the North Mesquite Creek monitored subwatershed is fairly evenly split with residential, open, and highway land uses with a smaller percentage of commercial land uses. Possible sources of *E. coli* are illicit connections and wildlife/domestic animals. Over fertilization of the open areas and of residential lawns may be a source of total nitrogen. In addition, riparian alteration can affect nitrogen uptake and cycling, and turn urban riparian areas into nitrogen sources (Groffman et al. 2002, 2003). Potential sources of TDS, oil and grease, and metals could be from illicit connections, illegal dumping, and high traffic roadways.

A review of the aerial photography over the period did not reveal any major development or construction within the subwatershed. However, minor construction activities may have been a source of the sediment loadings. Also, industrial/commercial activities may have contributed to sediment loading through bulk material storage and earth disturbance activities.

BMPs recommended for these sources include compliance inspections for illicit connections, identification and removal of illegal dumping areas, public education of home and business owners regarding fertilization and turf management, public education for pet owners regarding pet waste management, review of construction site inspection protocols or BMP requirements, and review of industrial inspection protocols or BMP requirements.

4.5.15.5. Monitoring Recommendations

Data analyzed presented multiple exceedances for bacteria, a few exceedances for TDS and total copper, and elevated nutrients, oil and grease, and conductivity that may impact aquatic life use and primary contact recreation. There are currently no TMDLs or impairments for North Mesquite Creek but the East Fork of the Trinity River is impaired for TDS and sulfate. Therefore additional monitoring at this site is recommended to be assigned a high priority. Bioassessment data collection is recommended to determine whether the biological community may be impacted by the chemical pollutants documented above. Also, dry weather chemical monitoring data is recommended to further determine potential sources of pollutants.

4.5.16. Prairie Creek

TxDOT–Dallas District performed chemical monitoring on Prairie Creek, a stream with a stream order of three or greater draining to the Upper Trinity River (TCEQ segment 0805) within the Prairie Creek – Trinity River watershed.

Prairie Creek Watershed is located in the southeast corner of Dallas County. This watershed covers a 37,086-acre area with distinctly different land use characteristics in the southern and northern portions of the watershed, which are generally separated by IH 20. The northern part is characteristic of suburban development whereas the southern part is less developed. The overall watershed consists primarily of open space (57.8%) land use. The main highways (7.7%) that traverse this watershed are IH 20, US 175, IH 45, IH 635, SH 352, SH 12 and US 80. Most of the southern portion of Prairie Creek-Trinity River is open space. Dense areas of residential (18.3%) and commercial (9.7%) property are located in the northern part, (north of IH 20). There are a few industrial (3.6%) sites along US 175, along SH 12 between SH 352 and US 80, and dispersed in the southern portion of the watershed.. This watershed contains 0.0% water features.

TxDOT–Dallas District had one chemical monitoring site located within the Prairie Creek subwatershed. The chemical monitoring site, TX1201/1301/1401/1501 was located where US 175 crosses Prairie Creek. The conveyance at this site is a natural, unlined channel with low vegetative cover. The drainage area delineated for this site covered a 6,004-acre area and consists primarily of residential (39.8%) property and open space (21.5%). The highway estimate was 17.4% which included US 80, SH 352, US 175, SH 12, IH 635, Prairie Creek Road, Elam Road, Lake June Road, Bruton Road, St. Augustine Drive, Military Parkway, Forney Road and Samuell Boulevard. There were a few industrial (2.4%) sites located in the upper portion of the watershed. There was a large commercial (18.5%) area located in the upper watershed along Samuell Road and Big Town Boulevard with additional commercial property dispersed in the subwatershed along the major roadways and near residential areas. This drainage area contained 0.4% water features.

The monitoring site, watershed and subwatershed boundary, and land use types are shown in Appendix C, Figure 17. The monitoring site is shown as TX1201. TX1301, TX1401, and TX1501 were located in the same location. Nearly all of the Prairie Creek subwatershed area is within the jurisdictional limits of the City of Dallas, except for a small area located on the eastern boundary which is within the jurisdictional limits of the City of Balch Springs and a small portion of the upper subwatershed which is within the jurisdictional limits of the City of Mesquite. TxDOT-Dallas District contributes flow to the subwatershed through SH 175 and SH 352. There are no TCEQ permitted wastewater outfalls located within the subwatershed according to the *TCEQ Permitted Wastewater Outfall* shapefile accessed May 20, 2016.

4.5.16.1. Summary Statistics

Summary statistics are presented in Table 4-13. The summary statistics include number of samples, minimum and maximum values, median, arithmetic mean, geometric mean, standard deviation, and coefficient of variation.

Table 4-13 Prairie Creek RWWCP Third Permit Term Summary Statistics

Parameter	TDS (mg/L)	TSS (mg/L)	BOD (mg/L)	COD (mg/L)	Nitrogen, Total (mg/L)	Phosphorus, Dissolved (mg/L)
No. of Samples	16	16	16	16	16	16
Minimum	96.0	2.00	0.50	0.50	0.025	0.020
Maximum	1200	495.0	49.30	119.0	18.80	0.270
Median	273.5	19.67	5.78	26.50	4.625	0.085
Arithmetic Mean	316.1	99.13	9.23	34.09	5.588	0.100
Geometric Mean	260.2	33.38	4.66	12.56	2.671	0.080
Standard Deviation	256.4	140.78	12.02	36.26	5.350	0.072
Coefficient of Variation	0.81	1.42	1.30	1.06	0.96	0.723
	Phosphorus, Total (mg/L)	Arsenic, Total (mg/L)	Chromium, Total (mg/L)	Copper, Total (mg/L)	Lead, Total (mg/L)	Zinc, Total (mg/L)
No. of Samples	16	16	16	16	16	16
Minimum	0.025	0.001	0.002	0.009	0.002	0.017
Maximum	0.780	0.016	0.062	0.045	0.032	0.158
Median	0.215	0.001	0.004	0.024	0.004	0.037
Arithmetic Mean	0.270	0.003	0.009	0.024	0.006	0.048
Geometric Mean	0.201	0.002	0.005	0.022	0.004	0.041
Standard Deviation	0.217	0.004	0.015	0.011	0.007	0.035
Coefficient of Variation	0.804	1.197	1.709	0.451	1.211	0.721
	Oil & Grease (mg/L)	pH, Field (su)	Specific Conductivity (µS/cm)	Temperature (°F)	E. Coli (col/100 mL)	Total Coliform (col/100 mL)
No. of Samples	16	16	16	16	16	16
Minimum	0.70	7.60	121	39.2	5	400
Maximum	3.50	8.80	698	87.3	4000	380000
Median	1.10	8.15	350	66.2	625	17500
Mean	1.52	8.18	382	64.3	927	51542
Geometric Mean	1.26	8.17	331	62.8	205	11449
Standard Deviation	0.97	0.38	197	13.7	1124	94525
Coefficient of Variation	0.64	0.05	0.52	0.21	1.21	1.83

4.5.16.2. Water Quality Data Analysis

Monitored parameters were plotted and compared to water quality standards, screening levels, NSQD, and other data where applicable. These graphs are located in Appendix S. During the third permit term, there was one exceedance of the TCEQ TDS basin specific criterion, one exceedance of the TCEQ aquatic life use estimated chronic criterion for total copper, one exceedance of the TCEQ human health estimated criterion for total lead, and eight exceedances of the *E. coli* PCR single sample criterion (and the geometric mean criterion). There were two total phosphorus exceedances of the TCEQ nutrient screening criteria. In addition, there were four occurrences where the TSS concentration, two occurrences where the BOD concentration, two occurrences where the COD concentration, and nine occurrences where the total nitrogen concentration was higher than 75% of NSQD data for those parameters.

The TDS exceedance occurred in July 2014. The total copper exceedance occurred in January 2012 and the lead exceedance occurred in October 2014. *E. coli* PCR single sample criterion exceedances were observed sporadically over the monitoring period. The total phosphorus exceedances occurred in January 2012 and

July 2013. Elevated TSS, BOD, COD, and total nitrogen concentrations occurred in various months and years over the monitored period.

4.5.16.3. Biological Data Analysis

No bioassessment monitoring data was collected within this watershed.

4.5.16.4. Potential Pollution Sources and BMP Recommendations

Land use of the Prairie Creek monitored subwatershed is mostly residential with fairly evenly split percentages of open, commercial, and highway land uses. Possible sources of *E. coli* are illicit connections and wildlife/domestic animals. Over fertilization of the open areas and of residential and commercial lawns may be a source of total nitrogen. In addition, riparian alteration can affect nitrogen uptake and cycling, and turn urban riparian areas into nitrogen sources (Groffman et al. 2002, 2003). Potential sources of TDS and metals could be from illicit connections, illegal dumping, and high traffic roadways.

A review of the aerial photography over the period revealed at least one development within the upper portion of the subwatershed near the stream channel during the period of elevated TSS concentrations.

BMPs recommended for these sources include compliance inspections for illicit connections, identification and removal of illegal dumping areas, public education of home and business owners regarding fertilization and turf management, public education for pet owners regarding pet waste management, and review of construction site inspection protocols or BMP requirements.

4.5.16.5. Monitoring Recommendations

Data analyzed presented multiple exceedances for bacteria, one exceedance for TDS, total copper, and total lead, and elevated BOD, COD, and nutrients that may impact aquatic life use and primary contact recreation. There are currently no TMDLs or impairments for Prairie Creek but there is a TMDL for bacteria in the Upper Trinity River (TCEQ segment 0805) and for legacy pollutants. Therefore additional monitoring at this site is recommended to be assigned a high priority. Bioassessment data collection is recommended to determine whether the biological community may be impacted by the chemical pollutants documented above. Also, dry weather chemical monitoring data is recommended to further determine potential sources of pollutants.

4.5.17. Prairie Creek – Elm Fork of the Trinity River

NTTA performed chemical monitoring on unnamed tributaries to the Elm Fork of the Trinity River (TCEQ segment 0822). The streams had stream orders of one and are located within the Prairie Creek – Elm Fork Trinity River watershed. The monitored subwatersheds for the sample sites comprised separate drainage areas (they were not located upstream/downstream of each other).

Prairie Creek – Elm Fork Trinity River Watershed is located in Lewisville and Carrollton below Lake Lewisville. Interstate 35E skirts the western edge of the watershed while SH 121 runs from southwest to northeast through the middle of the watershed. Prairie Creek – Elm Fork Trinity River is an 15,349-acre watershed consisting of predominately open space (52.8) along the Elm Fork Trinity River floodplain. Residential property (15.9%) and associated commercial development (16.2) are located in the far west and eastern portions of the watershed. The rest of the watershed is made up of 13.2% highway, 1.4% water, and 0.5% industrial land uses.

NTTA had two chemical monitoring sites located within the Prairie Creek – Elm Fork Trinity River watershed. The monitoring site, NT1401/1501, was located just southeast of SH 121 to the north of the intersection with Marchant Boulevard. The conveyance at this site was an unlined grassy swale with sediment deposits and thick reeds and brush within the channel. This subwatershed covered a 1,089-acre area. SH 121 bisected the subwatershed, and along with the local road network contributed to a 63.1% highway land use. Residential property (18.2%) and commercial development (8.2%) made up a significant portion of the land use. Open space covered 10.5% of the land use in this subwatershed. There was no area designated as industrial or water.

The monitoring site, NT1402/1502, was located just southeast of SH 121 to the north of the intersection with Hebron Parkway. The conveyance at this site was a grassy swale with a concrete pilot channel. This monitoring station monitored a subwatershed covering a 175-acre area. SH 121 bisected the subwatershed, with highway comprising the majority (59.0%) of the land use. Open space also covered a large percentage of the land use (40.5%). Residential property (0.3%) and commercial development (0.2%) were insignificant. There were no areas designated as industrial or water.

The monitoring sites, watershed and subwatershed boundaries, and land use types are shown in Appendix C, Figure 18. The monitoring sites are shown as NT1501 and NT1502. NT1201, NT1301, NT1401 and NT1202, NT1302, NT1402 were located in the same locations, respectively. The subwatershed areas are within the jurisdictional limits of the City of Carrollton. NTTA contributes flow to the subwatershed through SH 121, the Sam Rayburn Tollway. There are no TCEQ permitted wastewater outfalls located within the subwatershed according to the *TCEQ Permitted Wastewater Outfall* shapefile accessed May 20, 2016.

4.5.17.1. Summary Statistics

Summary statistics are presented in Table 4-14. The summary statistics include number of samples, minimum and maximum values, median, arithmetic mean, geometric mean, standard deviation, and coefficient of variation.

Table 4-14 Prairie Creek – Elm Fork Trinity River RWWCP Third Permit Term Summary Statistics

Parameter	TDS (mg/L)	TSS (mg/L)	BOD (mg/L)	COD (mg/L)	Nitrogen, Total (mg/L)	Phosphorus, Dissolved (mg/L)
No. of Samples	16	16	16	16	16	16
Minimum	68.0	4.33	0.50	0.50	0.025	0.070
Maximum	1720	1368	20.0	214.0	9.590	0.430
Median	306.0	54.67	5.03	41.50	1.705	0.190
Arithmetic Mean	384.6	165.65	5.99	45.64	2.991	0.221
Geometric Mean	276.8	69.08	4.64	21.72	1.377	0.188
Standard Deviation	396.1	328.77	4.64	50.09	2.937	0.122
Coefficient of Variation	1.03	1.98	0.77	1.10	0.98	0.552
	Phosphorus, Total (mg/L)	Arsenic, Total (mg/L)	Chromium, Total (mg/L)	Copper, Total (mg/L)	Lead , Total (mg/L)	Zinc, Total (mg/L)
No. of Samples	16	16	16	16	16	16
Minimum	0.120	0.001	0.002	0.006	0.002	0.015
Maximum	0.670	0.005	1.538	0.063	0.009	0.144
Median	0.280	0.001	0.005	0.023	0.002	0.037
Arithmetic Mean	0.335	0.002	0.102	0.025	0.003	0.048
Geometric Mean	0.297	0.002	0.007	0.021	0.002	0.039
Standard Deviation	0.169	0.002	0.383	0.014	0.002	0.035
Coefficient of Variation	0.504	0.810	3.767	0.561	0.728	0.730
	Oil & Grease (mg/L)	pH, Field	Specific Conductivity	Temperature (°F)	E. Coli (col/100 mL)	Total Coliform (col/100 mL)
No. of Samples	16	16	16	16	16	16
Minimum	0.70	7.70	143	41.3	10.0	1870
Maximum	2.90	9.20	2910	80.1	4500	116000
Median	0.70	8.60	584	70.5	1175	27250
Mean	0.99	8.53	873	66.5	1544	38304
Geometric Mean	0.86	8.52	618	65.2	751	22033
Standard Deviation	0.67	0.38	768	12.4	1426	34881
Coefficient of Variation	0.68	0.04	0.88	0.19	0.92	0.91

4.5.17.2. Water Quality Data Analysis

Monitored parameters were plotted and compared to water quality standards, screening levels, NSQD, and other data where applicable. These graphs are located in Appendix T. During the third permit term, there were two exceedances of the TCEQ TDS basin specific criterion, one exceedance of the TCEQ human health and aquatic life use chronic estimated criterion for total chromium, three exceedances of the TCEQ aquatic life use estimated chronic criterion for total copper, one exceedance of the TCEQ human health estimated lead criterion for total copper, two exceedances of the TCEQ human health estimated criterion for total lead, twelve exceedances of the *E. coli* PCR single sample criterion (and the geometric mean criterion), and once exceedance of the TCEQ pH basin specific criterion. In addition, there were four occurrences where the TSS concentration, one occurrence where the COD concentration, and five occurrences where the total nitrogen concentration was higher than 75% of NSQD data for those parameters. There were three specific conductance readings greater than 1,000 µS/cm, which fall in the “fair” category and one specific conductance reading in the “poor” category according to USEPA, 2016b.

The TDS exceedances occurred at NT1401/1501 in January 2014 and October 2015. The total chromium exceedance occurred at NT1501 in April 2015. The total copper exceedances occurred at both stations in January 2014 and only at station NT1501 in April and October 2015. The lead exceedances occurred at station NT1501 in April and October 2015. *E. coli* PCR single sample criterion exceedances were observed sporadically over the monitoring period at both stations. The pH exceedance occurred at NT1402 in October 2014. Elevated TSS and total nitrogen concentrations occurred in various months and years over the monitored period. The elevated COD concentration occurred at NT1501 in October 2015. The elevated specific conductance readings occurred at NT1401/1501 in January 2014 and January, September and October 2015.

4.5.17.3. Biological Data Analysis

No bioassessment monitoring data was collected within this watershed.

4.5.17.4. Potential Pollution Sources and BMP Recommendations

Land use of the unnamed tributary subwatersheds is predominantly highway with smaller percentages of residential, open, and commercial land uses. Possible sources of *E. coli* are illicit connections and wildlife/domestic animals. Over fertilization of the open areas and of residential and commercial lawns may be a source of total nitrogen. In addition, riparian alteration can affect nitrogen uptake and cycling, and turn urban riparian areas into nitrogen sources (Groffman et al. 2002, 2003). Potential sources of TDS, COD, conductivity, and metals could be from illicit connections, illegal dumping, the high traffic roadway, and application of deicing agents during ice events. Ice events occurred in both January 2014 and 2015. A review of the aerial photography over the period revealed several developments within the drainage area for NT1401/1501 during the period which may have been a source of TSS.

BMPs recommended for these sources include compliance inspections for illicit connections, identification and removal of illegal dumping areas, public education of home and business owners regarding fertilization and turf management, public education for pet owners regarding pet waste management, review of construction site inspection protocols or BMP requirements, and review of deicing agent application strategies to roadways.

4.5.17.5. Monitoring Recommendations

Data analyzed presented multiple exceedances for bacteria and a few exceedances for TDS, total copper, total lead, and total chromium, and elevated COD and nutrients that may impact aquatic life use and primary contact recreation. There are currently no TMDLs or impairments for the unnamed tributaries or for the Elm Fork of the Trinity River (TCEQ segment 0822). In addition, there is low coverage of participating entity jurisdiction in the monitored subwatersheds. Due to the small drainage area sizes, the monitoring sites would be excellent locations to perform BMP performance studies. Additional monitoring under the RWWCP at these sites are recommended to be assigned a low priority. If monitoring is conducted, bioassessment data collection is recommended to determine whether the biological community may be impacted by the chemical pollutants documented above. Also, dry weather chemical monitoring data is recommended to further determine potential sources of pollutants.

4.5.18. Rowlett Creek

The City of Garland performed chemical and bioassessment monitoring on Rowlett Creek (TCEQ segment 0820B), a stream with a stream order of three or greater draining to Lake Ray Hubbard (TCEQ segment 0820) within the Rowlett Creek – Lake Ray Hubbard watershed.

Rowlett Creek – Lake Ray Hubbard Watershed is located in northeast Dallas County near Lake Ray Hubbard. This watershed covers a 17,257-acre area and consists predominately of residential (33.6%) property and open space (25.7%). There are several highways (16.5%) that go through this watershed.

These highways are SH 121, US 75 (Central Expressway), SH 5, PGBT, SH 78, SH 66, and IH 30. This watershed has very few industrial (1.7%) and some commercial (12.2%) sites. The industrial sites that do exist can be found mainly along roadways and near commercial property in residential areas. This watershed contains 10.3% water features which includes a portion of Lake Ray Hubbard.

The Rowlett Creek – Lake Ray Hubbard Watershed is located downstream of Pittman Creek – Spring Creek, Brown Branch – Rowlett Creek, Headwaters Rowlett Creek, and Town of Allen – Cottonwood Creek watersheds. Water quality observed in this watershed was affected by activities occurring within these upstream watersheds.

The City of Garland had three chemical monitoring sites located within the Rowlett Creek subwatershed. The chemical monitoring site, GA1401/1501 was an upstream sampling site located just west of the Highway 78 bridge. The conveyance at this site was a natural, unlined channel with rock substrate. The drainage area delineated for this site covered 76,757 acres and extended north into several upstream watersheds as noted above and beyond SH 121. The land use in this area was primarily residential property (34.3%) and open space (33.4%). Some of the highways and major roadways contributing to the highway (18.4%) land use estimate were SH 121, US 75 (Central Expressway), SH 5, PGBT, Northstar Road, Murphy Road, FM 2478 (Custer Road), Independence Parkway, FM 2170 (McDermott Drive), FM 2514 (Parker Road), 14th Street and Plano Parkway. Most of the industrial (2.6%) sites seemed to be located between Plano Parkway and 14th Street along Jupiter Road and Shiloh Road. There were also some located along US 75 (Central Expressway) and SH 5. Most of the commercial (10.9%) property was located along major roadways and near residential areas. The drainage area contained 0.4% water features.

The chemical monitoring site, GA1402/1502 was a midstream sampling site located just east of the intersection of Castle Drive and Centerville Road at Rowlett Creek. The conveyance at this site was a natural, unlined channel with medium vegetation and tree cover. The drainage area delineated for this site covered 5,179 acres and was located completely within the Rowlett Creek-Lake Ray Hubbard watershed. The land use in this area was predominately open space (38.8%) and residential (32.8%) property. The highways and major roadways that made up the highway (16.8%) land use estimate were SH 78, Country Club Road, Pleasant Valley Road, Castle Drive, Northeast Parkway, Naaman School Road, and Murphy Road. There were very few industrial (1.1%) sites in this subwatershed; but a cluster could be found on the western side along SH 78 and Buckingham Road. Most of the commercial (10.3%) property was located along major roadways such as Buckingham Road, Country Club Road, and Naaman School Road. This drainage area had 0.2% water features.

The chemical monitoring site, GA1403/1503 was a downstream sampling site located downstream of Hwy 66. The conveyance was a natural unlined channel with low vegetative cover consisting mainly of brush. The drainage area delineated for this site covered 2,026 acres and was located completely within the Rowlett Creek-Lake Ray Hubbard watershed. The land use in this area was predominately residential (36.6%), with associated commercial development comprising 13.7%. Highway 66 and E Centerville Road were the primary transportation features and contribute to the 20.9% highway land use. There were very few industrial (3.2%) sites in this subwatershed. This drainage area had 24.6% open areas and 1.0% water features.

The monitoring sites, watershed and subwatershed boundaries, and land use types are shown in Appendix C, Figure 19. The monitoring sites are shown as GA1501, GA1502, and GA1503. GA1401, GA1402, and GA1403 were located in the same locations, respectively. The subwatershed areas are within the jurisdictional limits of the City of Garland, the City of Rowlett, the City of Sachse, the City of Murphy, the City of Plano, the City of Parker, the City of Allen, the City of McKinney, the City of Frisco, and the City of Richardson. NTTA contributes flow to the subwatershed through SH 121, the Sam Rayburn Tollway and TX-190, the President George Bush Turnpike. TxDOT contributes flow through US 66, SH 78, US 75, SH 5, FM 2478 (Custer Road), FM 2170 (McDermott Drive), and FM 2514 (Parker Road). There is one TCEQ permitted wastewater outfall within the subwatershed according to the *TCEQ Permitted Wastewater Outfall* shapefile accessed May 20, 2016. The permittee is identified as the North Texas Municipal Water District and the outfall is located between the stream crossings at Los Rios Boulevard and 14th Street in Plano.

In 2014, a cofferdam was erected downstream of the downstream monitoring stations as part of a utility construction/rehabilitation project (Figure 4-23). Also, a natural debris dam formed at US66 between the midstream and downstream monitoring stations between January and July 2015 (See Figure 4-24). The natural debris dam was removed by the City of Garland. However, both obstructions were noted to reduce low flow in the stream.

Figure 4-23 Cofferdam Located Downstream of Downstream Monitoring Station

Figure 4-24 Debris Dam Located Between Midstream and Downstream Monitoring Stations

4.5.18.1. Summary Statistics

Summary statistics are presented in Table 4-15. The summary statistics include number of samples, minimum and maximum values, median, arithmetic mean, geometric mean, standard deviation, and coefficient of variation.

Table 4-15 Rowlett Creek RWWCP Third Permit Term Summary Statistics

Parameter	TDS (mg/L)	TSS (mg/L)	BOD (mg/L)	COD (mg/L)	Nitrogen, Total (mg/L)	Phosphorus, Dissolved (mg/L)
No. of Samples	24	24	24	24	24	24
Minimum	12.0	6.00	0.50	0.50	0.920	0.030
Maximum	638.0	1873	19.6	164.0	38.80	0.910
Median	457.0	70.54	2.78	16.50	8.040	0.115
Arithmetic Mean	442.3	307.79	4.76	25.01	13.58	0.209
Geometric Mean	385.8	97.83	2.88	9.99	8.11	0.146
Standard Deviation	138.1	498.74	5.10	34.81	12.78	0.203
Coefficient of Variation	0.31	1.62	1.07	1.39	0.94	0.970
	Phosphorus, Total (mg/L)	Arsenic, Total (mg/L)	Chromium, Total (mg/L)	Copper, Total (mg/L)	Lead , Total (mg/L)	Zinc, Total (mg/L)
No. of Samples	24	24	24	24	24	24
Minimum	0.090	0.001	0.002	0.002	0.002	0.007
Maximum	1.440	0.005	0.055	0.028	0.016	0.092
Median	0.255	0.001	0.003	0.018	0.002	0.033
Arithmetic Mean	0.337	0.002	0.005	0.018	0.003	0.037
Geometric Mean	0.261	0.001	0.003	0.016	0.002	0.029
Standard Deviation	0.307	0.001	0.011	0.007	0.003	0.024
Coefficient of Variation	0.911	0.765	2.034	0.375	1.076	0.661
	Oil & Grease (mg/L)	pH, Field (su)	Specific Conductivity (µS/cm)	Temperature (°F)	E. Coli (col/100 mL)	Total Coliform (col/100 mL)
No. of Samples	24	24	24	24	24	24
Minimum	0.70	6.20	210	42.3	0.5	600
Maximum	6.80	8.90	1298	83.8	2200	45000
Median	0.70	8.14	796	69.8	87	2875
Mean	1.25	8.03	826	67.7	321	8832
Geometric Mean	0.91	8.01	764	66.5	84	3648
Standard Deviation	1.53	0.67	292	12.4	549	13309
Coefficient of Variation	1.23	0.08	0.35	0.18	1.71	1.51

4.5.18.2. Water Quality Data Analysis

Monitored parameters were plotted and compared to water quality standards, screening levels, NSQD, CRP, and second and third permit term data where applicable. CRP stations 10753, 17845, and 21478 were utilized for this analysis. Station 10753 is located at the same location as the RWWCP downstream monitoring station. Station 17845 is located at the same location as the RWWCP upstream monitoring station. Station 21478 is located at the Firewheel Parkway crossing upstream of the RWWCP midstream monitoring station. Second and third permit term data included upper and lower Rowlett Creek and Spring Creek. Graphs are located in Appendix U.

During the third permit term, there were eight exceedances of the TCEQ TDS basin specific criterion, four exceedances of the TCEQ aquatic life use estimated chronic criterion for total copper, one exceedance of the TCEQ aquatic life use estimated acute criterion for total copper, one exceedance of the TCEQ aquatic life use estimated chronic criterion and human health criterion for total lead, and one pH value lower than the TCEQ basin specific criterion. There were two total phosphorus, two nitrate nitrogen, and three orthophosphate exceedances of the TCEQ nutrient screening criteria. There were eight occurrences where the TSS concentration, one occurrence where the COD concentration, and nineteen occurrences where the total nitrogen concentration was higher than 75% of NSQD data for each parameter. There were seven specific conductance readings greater than 1,000 µS/cm, which fall in the “fair” category (below the “good” category and above the “poor” category) according to USEPA, 2016b.

Due to the exceedances and elevated concentrations discussed above and the availability of bioassessment, CRP, and wet weather chemical data, boxplots were created for total nitrogen, total phosphorus, pH, and conductivity for comparison of the datasets. The total nitrogen and total phosphorus boxplots do not indicate that stormwater runoff is providing a statistically significant different input of those pollutants to the stream compared to the bioassessment and CRP data which was collected during dry weather (see Figures 4-25 and 4-26). The pH and conductivity boxplots do show a statistically significant difference between the bioassessment and CRP data and the wet weather data indicating that these pollutant levels were lower during the dry period than during runoff events (Figures 4-27 and 4-28).

Figure 4-25 Boxplot Comparing Wet Weather Chemical Monitoring Third Permit Term and CRP Total Nitrogen Data at Rowlett Creek

Figure 4-26 Boxplot Comparing Wet Weather Chemical Monitoring Third Permit Term and CRP Total Phosphorus Data at Rowlett Creek

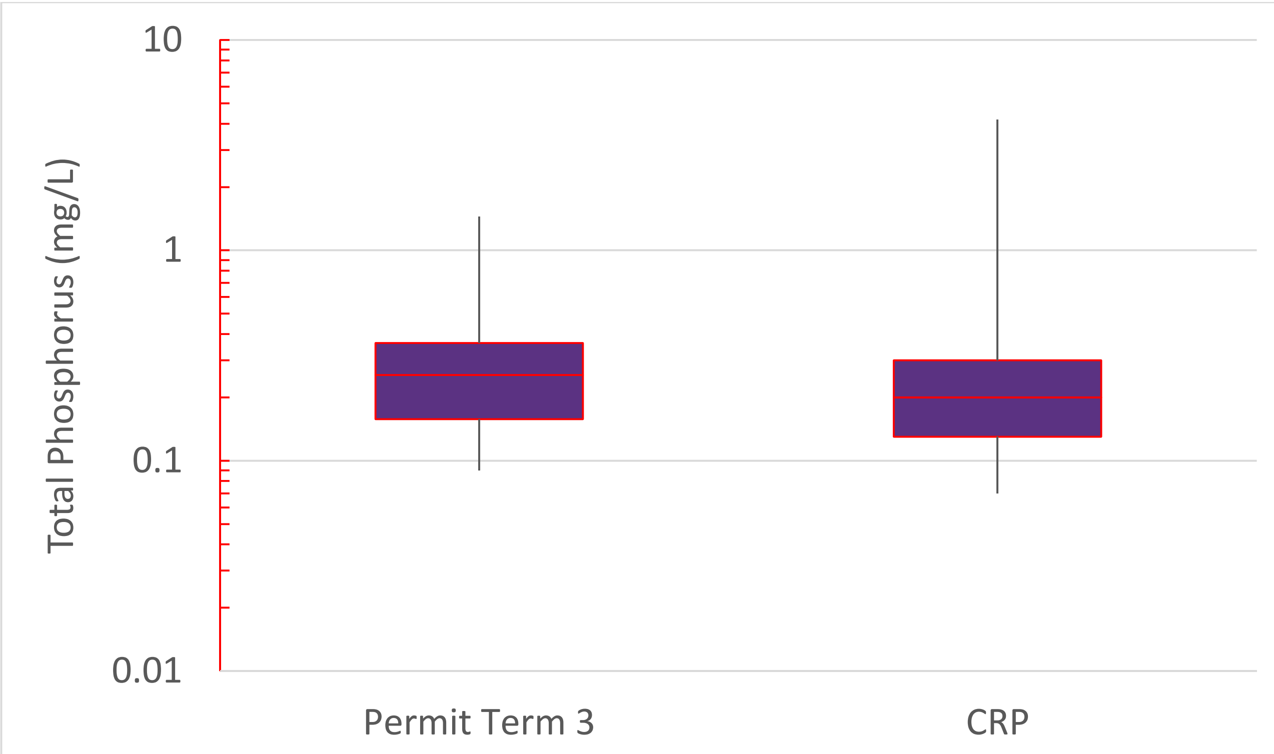


Figure 4-27 Boxplot Comparing Wet Weather Chemical Monitoring Third Permit Term, Bioassessment, and CRP pH Data at Rowlett Creek

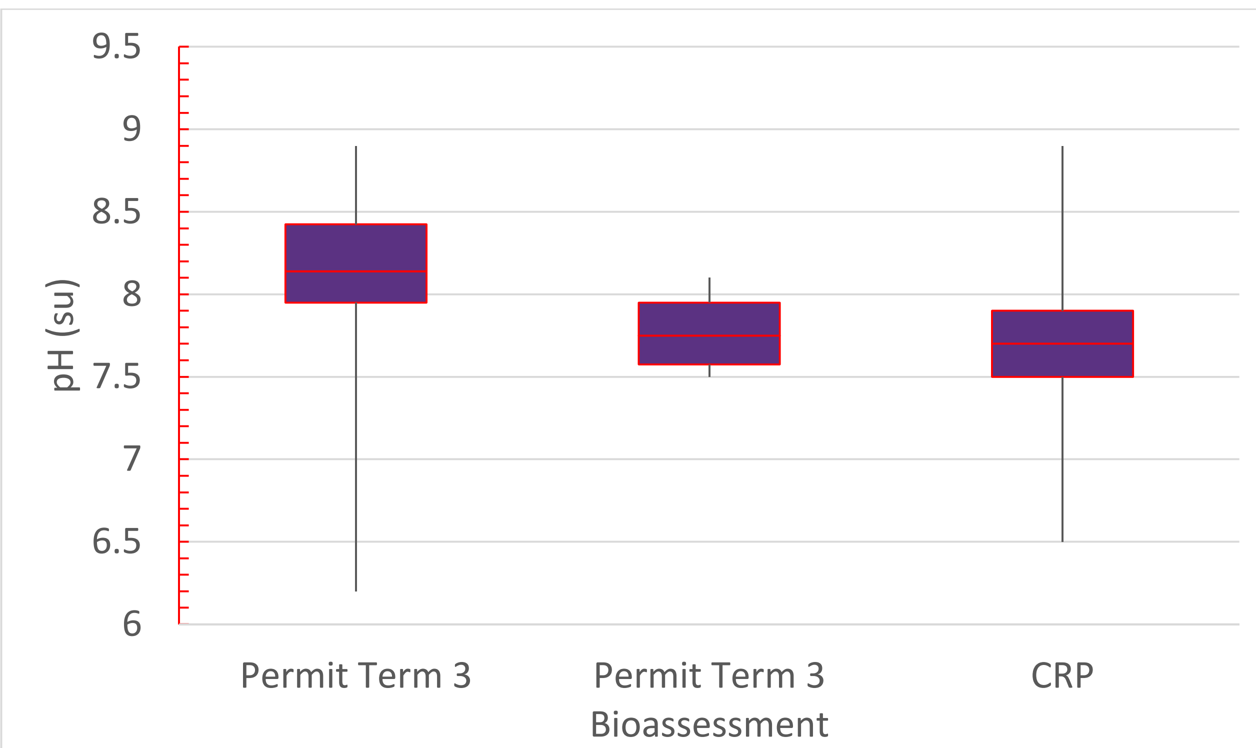
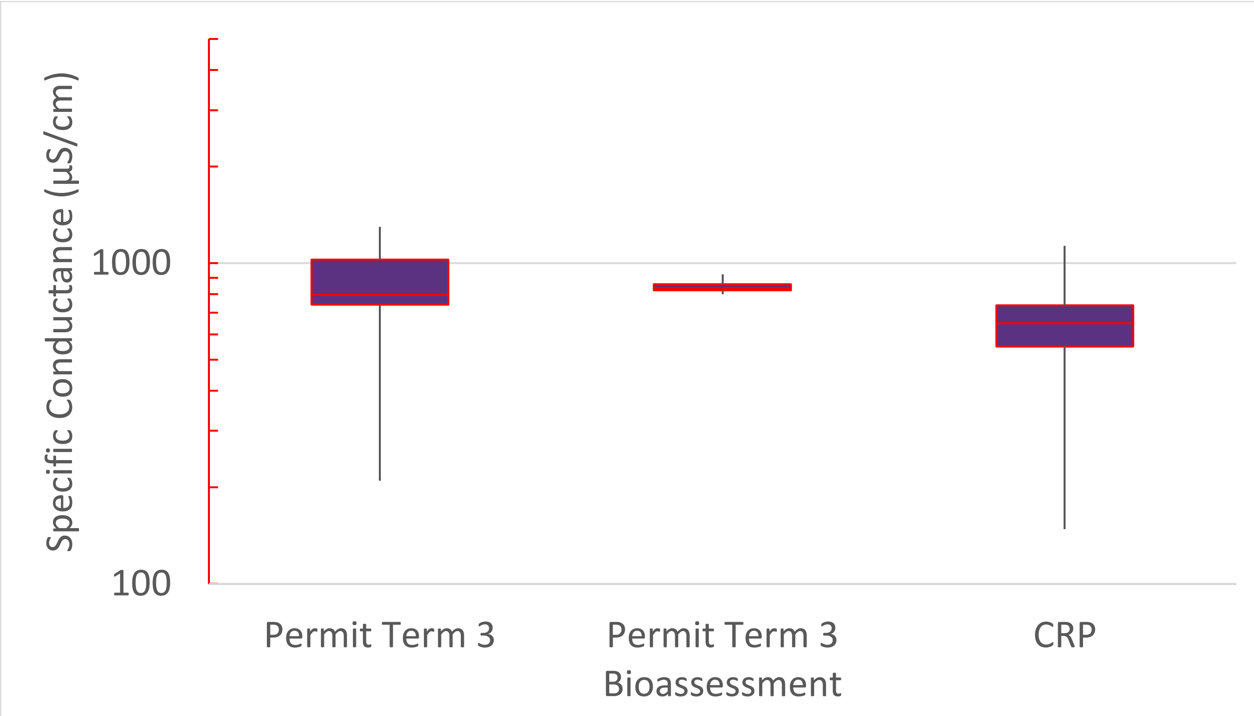


Figure 4-28 Boxplot Comparing Wet Weather Chemical Monitoring Third Permit Term, Bioassessment, and CRP Specific Conductance Data at Rowlett Creek



Boxplots were also created to compare the second and third permit term data from upper and lower Rowlett Creek and Spring Creek. This comparison was done to review the impact of upstream subwatershed available data to the receiving subwatershed. In the third permit term, there was a statistically significant increase in total nitrogen between upper Spring Creek and lower Rowlett Creek. The same statistically significant increase occurred during the second permit term between upper Spring Creek and Rowlett Creek and lower Rowlett Creek (see Figure 4-29). There was no statistical difference between the tributaries and lower Rowlett Creek during the second or third permit term for total phosphorus or *E. coli* (Figures 4-30 and 4-32). For pH, there was no statistical difference between upper Spring Creek and lower Rowlett Creek in the third permit term. However, there was a statistical difference for pH between upper Spring Creek and upper Rowlett Creek and lower Spring Creek during the second permit term (Figure 4-31).

Figure 4-29 Boxplot Comparing Wet Weather Chemical Monitoring Second and Third Permit Term Total Nitrogen Data at Rowlett Creek and Upstream Tributaries

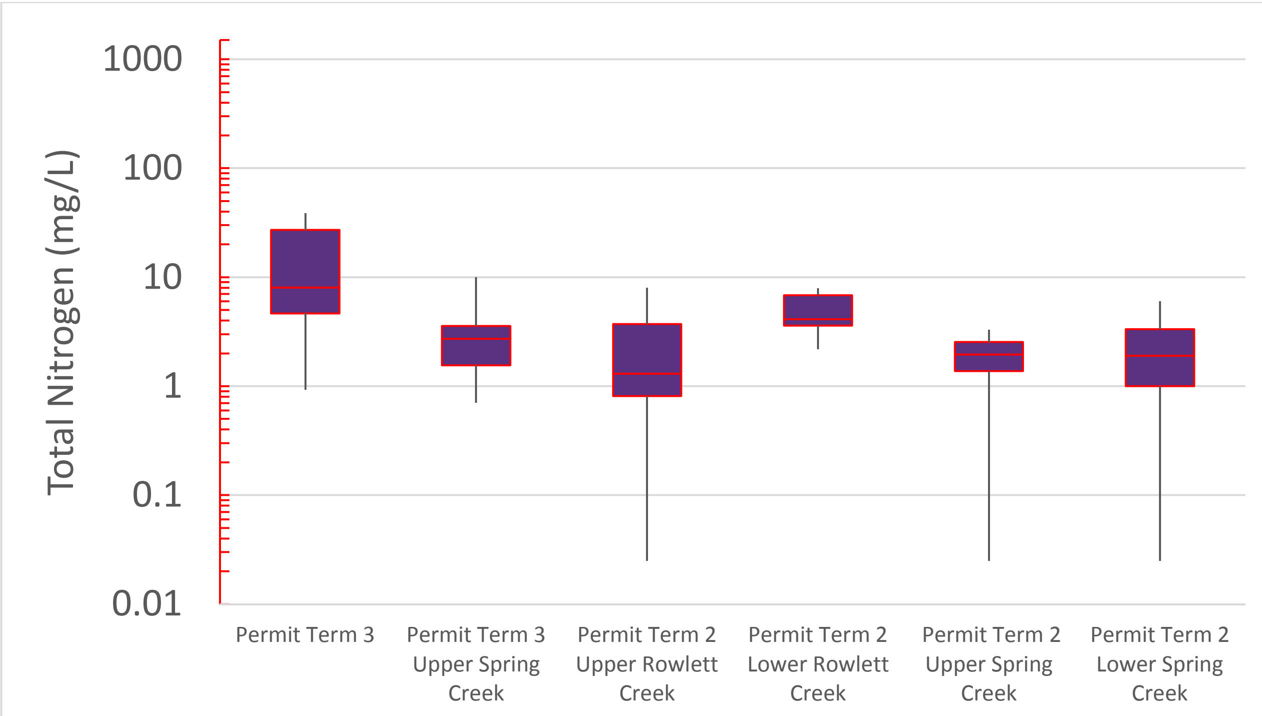


Figure 4-30 Boxplot Comparing Wet Weather Chemical Monitoring Second and Third Permit Term Total Phosphorus Data at Rowlett Creek and Upstream Tributaries

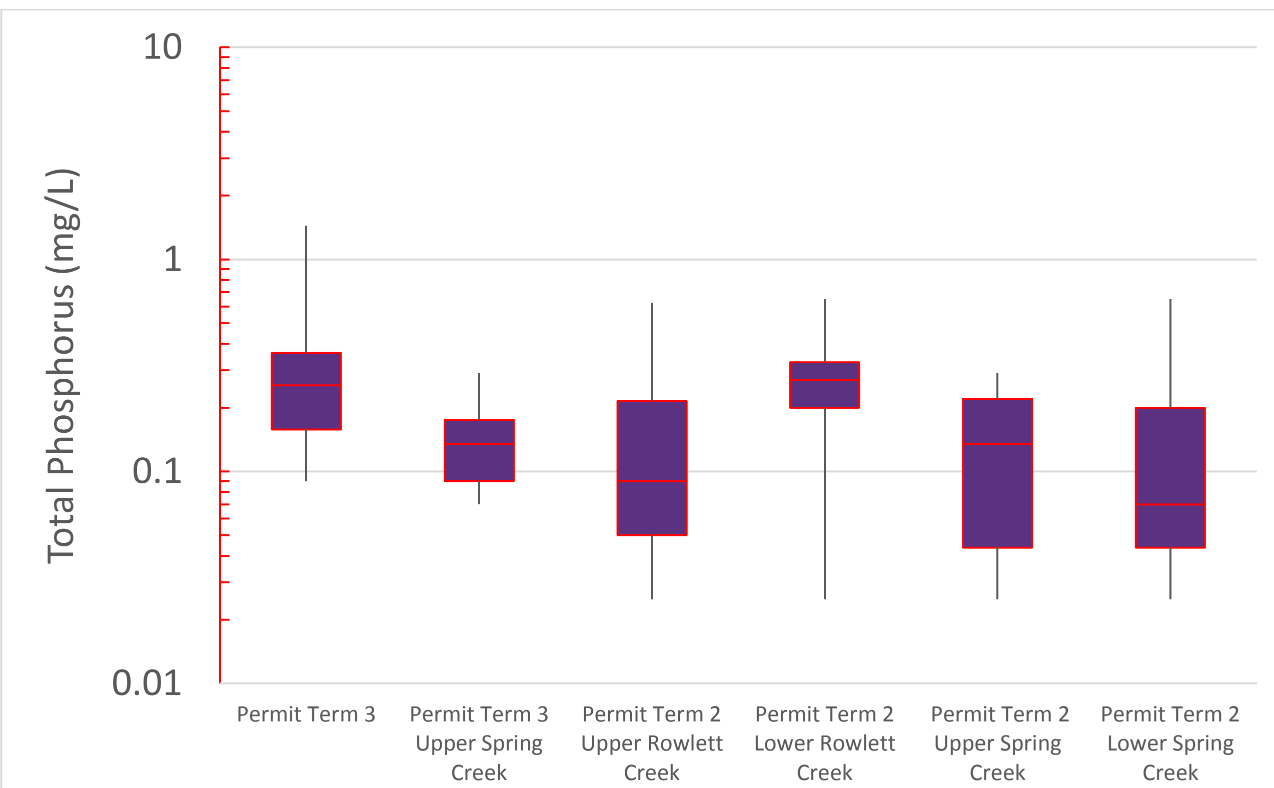


Figure 4-31 Boxplot Comparing Wet Weather Chemical Monitoring Second and Third Permit Term pH Data at Rowlett Creek and Upstream Tributaries

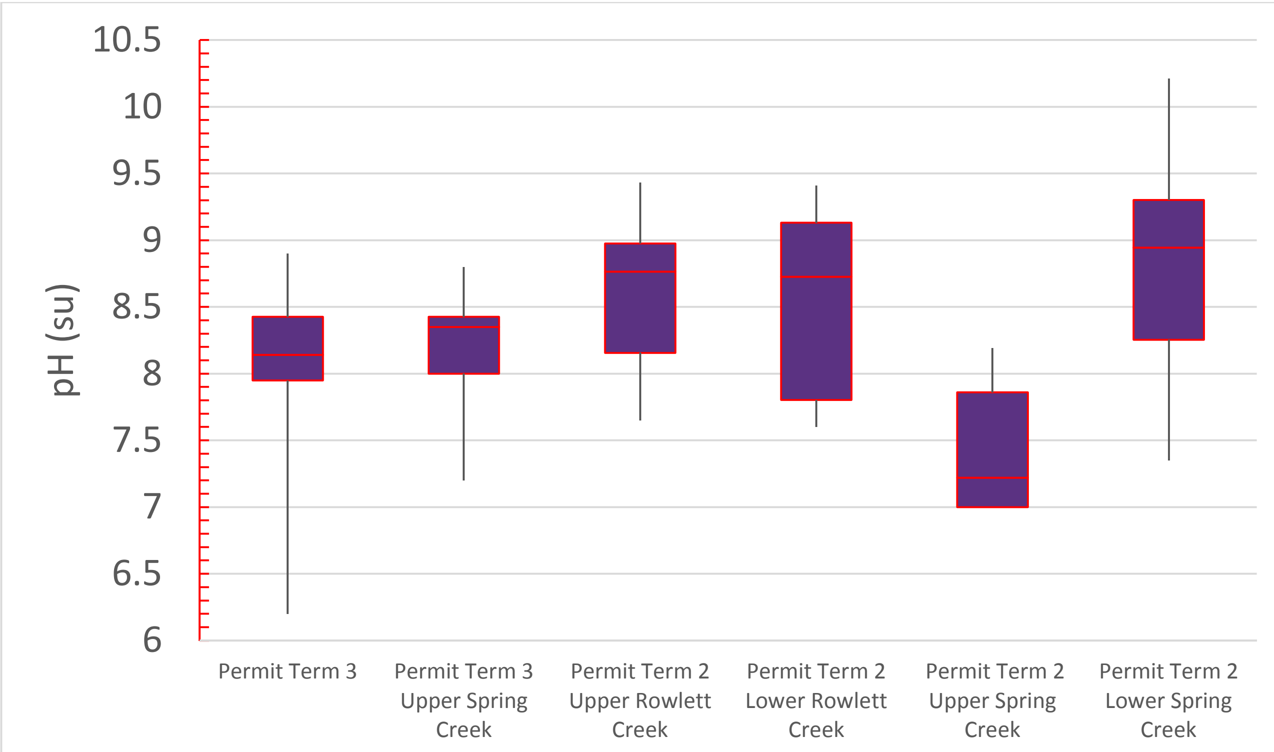
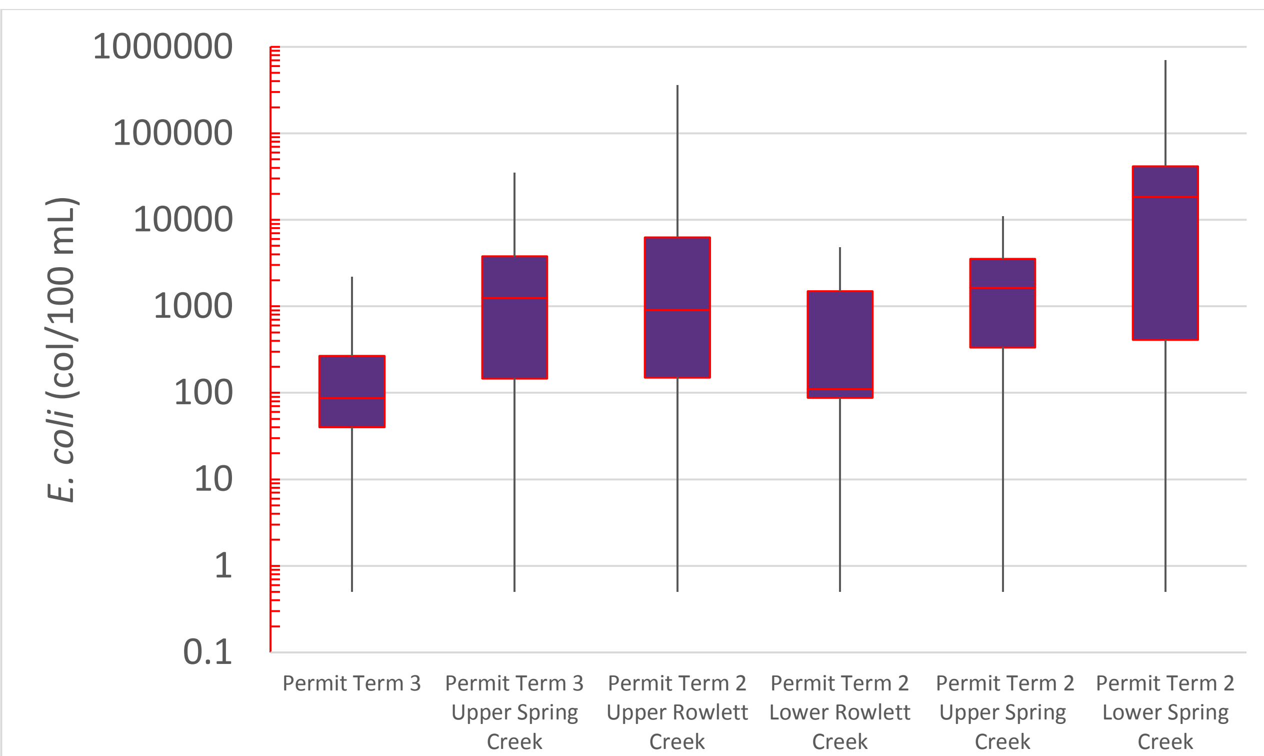


Figure 4-32 Boxplot Comparing Wet Weather Chemical Monitoring Second and Third Permit Term *E. coli* Data at Rowlett Creek and Upstream Tributaries



Exceedances of the TDS basin specific criterion occurred at the midstream and downstream monitoring stations in 2014 and 2015. Copper exceedances occurred at the upstream and downstream monitoring stations in 2014 and at the upstream and midstream monitoring stations in 2015. The lead exceedance occurred at the upstream monitoring station in April 2015. Low pH occurred at the downstream monitoring station in August 2015. Elevated TSS concentrations occurred at the upstream and midstream stations in both 2014 and 2015. The elevated COD concentration occurred at the downstream station in 2014. The elevated total nitrogen concentrations were observed at all stations in 2014 and 2015. Elevated conductivity readings occurred at the midstream and downstream stations in 2014 and at all stations in 2015.

4.5.18.3. Biological Data Analysis

Detailed reports of the biological assessments including data summaries can be found in the Annual Regional Wet Weather Characterization Program Monitoring Report for North Central Texas Year 4 and Year 5 (NCTCOG, 2015; NCTCOG, 2016). The habitat assessment scores and aquatic life use scores were plotted and compared to the habitat and aquatic life use categories (see Appendix U).

Rowlett Creek in the studied reach received a high habitat score, while the fish community IBI scores ranged from limited to intermediate to high, and benthic macroinvertebrate community IBI scores ranged from intermediate to high. This part of Rowlett Creek may not be considered to have a high aquatic life use since fish IBI were mixed, and were sometimes less than the habitat score. While the benthic macroinvertebrate community IBI met the high aquatic life use designation for all but one sampling event which was intermediate, the fish community IBI for aquatic life use was limited to intermediate to high. The intermediate fish IBI scores were most notably affected by a large proportion of invasive species (Common Carp), low diversity among native cyprinid species, a high percentage of omnivores, and low numbers of intolerant species. Chemical factors may be impacting the biological community including high levels of nitrate-nitrogen during the 2015 events, and high phosphate-phosphorus during the May 2014 and the 2015 sample events. Chemical factors like potentially toxic heavy metals or pesticides may also impact the biological community. High nutrient concentrations and flows above historical levels suggest water quality under normal to low flow conditions is substantially influenced by treated wastewater entering the creek upstream of the study area. Water quality exhibited values supportive of healthy aquatic communities. Rowlett Creek appears to meet the Intermediate ALU established in the Texas surface water quality standards.

4.5.18.4. Potential Pollution Sources and BMP Recommendations

During the bioassessments, it was noted that an absence of substantial aquatic plant growth and DO levels below saturation was indicating nitrogen and phosphorus are not substantially assimilated by aquatic vegetation in the study reach or immediately upstream of the study reach. The lack of substantial plant growth suggests shading from trees along the creek may be preventing adequate sunlight from reaching the creek and aquatic plants from utilizing the high nutrient concentrations. Land use of the Rowlett Creek subwatershed includes a fairly even mix of residential and open land uses followed by highway and commercial. Over fertilization in open and residential areas may be a source of these nutrients as may be treated wastewater effluent and illicit discharges. Although COD and nutrient concentrations were observed to be elevated, dissolved oxygen concentrations over the monitoring term did not fall below TCEQ criteria for aquatic life protection.

The land use map (Appendix C, Figure 19) identifies several industrial and commercial land uses within the subwatershed. These land uses are potential sources of TDS and metals. Other likely sources may be from illicit connections, illegal dumping, high traffic roadways, and wastewater effluent. A review of the aerial photography over the period revealed multiple development projects and construction activities within the subwatershed which is the most likely source of the sediment loadings.

BMPs recommended for these sources include compliance inspections for illicit connections, identification and removal of illegal dumping areas, public education of home and business owners regarding fertilization and turf management, review and inspection of treatment plant for potential maintenance or redesign, review of construction site inspection protocols or BMP requirements, and review of industrial inspection protocols or BMP requirements.

4.5.18.5. Monitoring Recommendations

Data analyzed presented multiple exceedances for bacteria, TDS, total copper, and total lead, and elevated COD, nutrients, and conductivity that may impact aquatic life use and primary contact recreation. Rowlett Creek is currently impaired for bacteria. Therefore, additional monitoring under the RWWCP at these sites are recommended to be assigned a high priority. It is recommended that bioassessment monitoring is continued.

4.5.19. Rush Creek

The City of Arlington performed chemical monitoring on Rush Creek (TCEQ segment 0841R), a stream with a stream order of two draining to Village Creek (TCEQ segment 0841T) within the Rush Creek – Village Creek watershed.

Rush Creek Watershed is located in southeast Tarrant County entirely within Arlington's city limits. Rush Creek's 31,000-acre watershed is predominately residential (46.1%) with open areas (22.33%) in the south (south of SH 287). This watershed is made up of 17.0% highway which includes four major roadways: IH 20, SH 287, SH 303, and SH 180. A significant amount of commercial (13.2%) and industrial (0.7%) sites are located along SH 303 and SH 180. There are also large amounts of commercial sites located along IH 20. This watershed is comprised of 0.6% water features.

The City of Arlington had three chemical monitoring sites located within the Rush Creek subwatershed. The chemical monitoring site, AR1401/1501 was an upstream sampling site located between South Bowen Road and South Cooper Street where Sublett Road crossed Rush Creek. The conveyance at this site was an unlined channel with medium sized gravel. The subwatershed delineated for this sampling location covered a 5,952-acre area and consisted predominately of 40.7% residential property and 33.4% open space. SH 287 was the only major highway (12.2%) running through this area. There were several commercial (12.6%) and industrial (0.9%) sites scattered throughout this subwatershed but most were located along SH 287. This subwatershed consisted of 0.2% water features.

The chemical monitoring site, AR1402/1502 was a midstream sampling site located at the south east corner of the Martin High School campus where West Pleasant Ridge Road crossed Kee Branch. The conveyance at this site was a concrete, trapezoidal channel. This subwatershed covered a 4,033-acre area and consisted mostly of residential property (52.6%). Two major highways (22.1%) ran through this area: IH 20 and SH 287. There was 13.0% open space and a large area of commercial (11.8%) property along IH 20, upstream of the AR1502 sampling site. A few industrial (0.5%) facilities were located within the subwatershed boundaries. The estimated water feature composition was 0.1%.

The chemical monitoring site, AR1403/1503 was a downstream sampling site located south of Pioneer Parkway where Woodland Park Boulevard crossed Rush Creek. The conveyance at this site was an unlined channel with high vegetative cover. This subwatershed covered an 8,306-acre area and was predominately made up of residential (53.9%) property. IH 20 was the only major highway (18.2%) running through this area and 12.3% of the subwatershed was considered open space. There was a large commercial (14.2%) area on the eastern edge, north and south of IH 20. There were a few industrial (0.9%) facilities scattered throughout the subwatershed. This area was composed of 0.5% water features.

The monitoring sites, watershed and subwatershed boundaries, and land use types are shown in Appendix C, Figure 20. The monitoring sites are shown as AR1501, AR1502, and AR1503. AR1401, AR1402, and AR1403 were located in the same locations, respectively. The subwatershed areas is entirely within the jurisdictional limits of the City of Arlington. TxDOT contributes flow to the subwatershed through I-20 and US 287. There are no TCEQ permitted wastewater outfalls located within the subwatershed according to the *TCEQ Permitted Wastewater Outfall* shapefile accessed May 20, 2016.

4.5.19.1. Summary Statistics

Summary statistics are presented in Table 4-16. The summary statistics include number of samples, minimum and maximum values, median, arithmetic mean, geometric mean, standard deviation, and coefficient of variation.

Table 4-16 Rush Creek RWWCP Third Permit Term Summary Statistics

Parameter	TDS (mg/L)	TSS (mg/L)	BOD (mg/L)	COD (mg/L)	Nitrogen, Total (mg/L)	Phosphorus, Dissolved (mg/L)
No. of Samples	24	24	24	24	24	24
Minimum	42.0	8.86	0.50	0.50	0.025	0.003
Maximum	1940	925.0	26.0	88.00	25.30	0.260
Median	435.5	50.00	6.92	30.50	2.155	0.110
Arithmetic Mean	537.8	169.96	8.71	31.06	3.381	0.111
Geometric Mean	398.1	69.49	6.41	17.38	1.790	0.085
Standard Deviation	430.1	258.76	6.64	23.09	4.986	0.065
Coefficient of Variation	0.80	1.52	0.76	0.74	1.47	0.591
	Phosphorus, Total (mg/L)	Arsenic, Total (mg/L)	Chromium, Total (mg/L)	Copper, Total (mg/L)	Lead, Total (mg/L)	Zinc, Total (mg/L)
No. of Samples	24	24	24	24	24	24
Minimum	0.030	0.001	0.002	0.001	0.002	0.008
Maximum	0.470	0.005	0.016	0.035	0.021	0.104
Median	0.190	0.001	0.004	0.015	0.002	0.024
Arithmetic Mean	0.202	0.002	0.005	0.015	0.004	0.042
Geometric Mean	0.161	0.001	0.004	0.012	0.003	0.033
Standard Deviation	0.129	0.001	0.003	0.008	0.004	0.029
Coefficient of Variation	0.639	0.709	0.661	0.550	1.161	0.690
	Oil & Grease (mg/L)	pH, Field (su)	Specific Conductivity (µS/cm)	Temperature (°F)	E. Coli (col/100 mL)	Total Coliform (col/100 mL)
No. of Samples	24	24	24	24	24	24
Minimum	0.70	7.80	166	40.2	0.5	1450
Maximum	5.20	8.90	1490	81.2	8000	120000
Median	0.70	8.35	646	66.3	482	13750
Mean	1.34	8.34	705	63.6	1650	19484
Geometric Mean	1.04	8.33	570	61.9	231	11822
Standard Deviation	1.18	0.33	426	14.0	2319	24757
Coefficient of Variation	0.88	0.04	0.60	0.22	1.41	1.27

4.5.19.2. Water Quality Data Analysis

Monitored parameters were plotted and compared to water quality standards, screening levels, NSQD, and CRP data where applicable. CRP stations 10791, 10792, 15103, 16896, 17190, and 17191 were utilized for this analysis. Station 10791 is located at the same location as the RWWCP upstream monitoring station. Station 17190 is located at the IH 20 Rush Creek crossing. Station 15103 is located on Kee Branch at the Bardin Road crossing. Station 10792 is located at the same location as the RWWCP midstream monitoring location. Station 16896 is located on Kee Branch at the Mayfield Road crossing. Station 17191 is located on Rush Creek near the SH 180 crossing downstream of the RWWCP downstream monitoring location. Graphs are located in Appendix V.

During the third permit term, there were five exceedances of the TCEQ TDS basin specific criterion and fifteen exceedances of the *E. coli* PCR single sample criterion (and the geometric mean criterion was exceeded). There were seven occurrences where the TSS concentration, two occurrences where the BOD concentration, and eight occurrences where the total nitrogen concentration was higher than 75% of NSQD data for each parameter. There were five specific conductance readings greater than 1,000 µS/cm, which fall in the "fair" category (below the "good" category and above the "poor" category) according to USEPA, 2016b. A dissolved oxygen measurement at CRP station 17191 fell below the minimum for spring aquatic life use in March of 2014.

Due to the exceedances and elevated concentrations discussed above and the availability of CRP and wet weather chemical data, boxplots were created for total nitrogen, conductivity, and *E. coli* for comparison of the datasets. The boxplots do not indicate that stormwater runoff is providing a statistically significant different input of pollutants to the stream compared to the CRP data which was collected during dry weather (see Figures 4-33, 4-34, and 4-35).

Figure 4-33 Boxplot Comparing Wet Weather Chemical Monitoring Second and Third Permit Term and CRP Total Nitrogen Data at Rush Creek

Figure 4-34 Boxplot Comparing Wet Weather Chemical Monitoring Third Permit Term and CRP Specific Conductance Data at Rush Creek

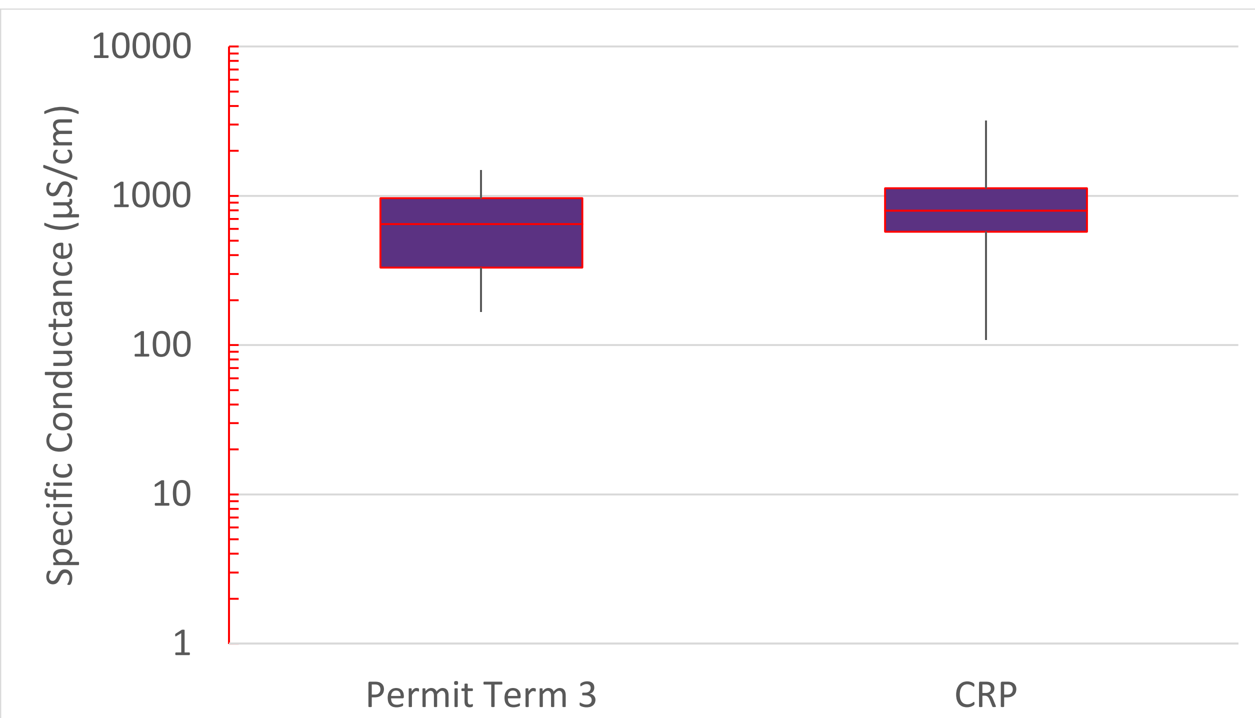
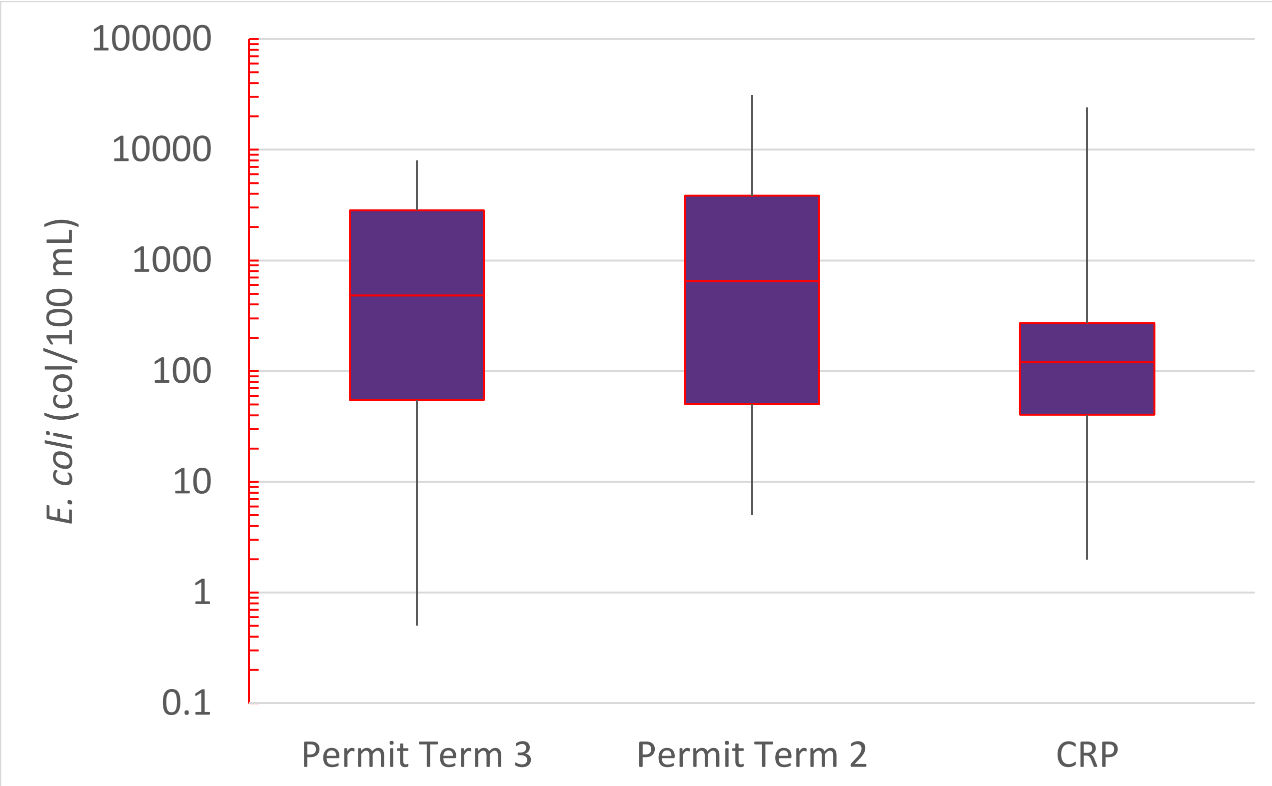


Figure 4-35 Boxplot Comparing Wet Weather Chemical Monitoring Second and Third Permit Term and CRP *E. coli* Data at Rush Creek



Exceedances of the TDS basin specific criterion occurred at all monitoring stations in 2014 with no exceedances in 2015. *E. coli* PCR single sample criterion exceedances occurred at all stations in both 2014 and 2015. Elevated TSS and total nitrogen concentrations occurred at all stations over the period. The elevated BOD concentrations occurred at the midstream and downstream stations in 2014. Elevated conductivity readings occurred at the midstream station in 2014 and at the upstream and midstream stations in 2015.

4.5.19.3. Biological Data Analysis

No bioassessment monitoring data was collected within this watershed.

4.5.19.4. Potential Pollution Sources and BMP Recommendations

Land use of the Rush Creek subwatershed is mainly residential with lower but fairly even mixes of commercial, highway, and open land uses. Stormwater was not a statistically significant source of total nitrogen, however the highest concentrations of total nitrogen were observed during runoff events and no elevated total nitrogen concentrations were observed in the CRP data. Therefore, over fertilization in open and residential areas may be a source of these spikes in nutrients as may be illicit discharges. In addition, riparian alteration can affect nitrogen uptake and cycling, and turn urban riparian areas into nitrogen sources (Groffman et al. 2002, 2003). The elevated BOD and nutrient concentrations may have impacted dissolved oxygen concentrations as the dissolved oxygen concentration at CRP station 17191 fell below the minimum for spring aquatic life use in March of 2014 (lower dissolved oxygen concentrations in 2011 prior to the third permit term).

The land use map (Appendix C, Figure 20) identifies scattered industrial and commercial land uses within the subwatershed. These land uses are potential sources of TDS and conductivity. Other likely sources may be from illicit connections, illegal dumping, and high traffic roadways. Potential sources of bacteria loading may be from pets and domestic animals or illicit connections. A review of the aerial photography over the period revealed multiple development projects and construction activities within the subwatershed, particularly in the upper portion along US 287 which is a likely source of the sediment loadings.

BMPs recommended for these sources include compliance inspections for illicit connections, identification and removal of illegal dumping areas, public education of home and business owners regarding fertilization and turf management, public education for pet owners regarding pet waste management, review of construction site inspection protocols or BMP requirements, and review of industrial inspection protocols or BMP requirements.

4.5.19.5. Monitoring Recommendations

Data analyzed presented multiple exceedances for bacteria and TDS, and elevated BOD, nutrients, and conductivity that may impact aquatic life use and primary contact recreation. Rush Creek is currently impaired for bacteria and there is a current TMDL for bacteria. Therefore, additional monitoring under the RWWCP at these sites are recommended to be assigned a high priority.

4.5.20. South Mesquite Creek

The City of Mesquite performed chemical monitoring on South Mesquite Creek a stream with a stream order of three or greater draining to the East Fork of the Trinity River (TCEQ segment 0819) within the South Mesquite Creek watershed.

South Mesquite Creek Watershed is located in eastern Dallas County, southwest of Lake Ray Hubbard. South Mesquite Creek Watershed covers a 17,840-acre area and the land use is predominantly made up of residential (31.2%) and open space (29.7%) areas which are dispersed across the entire watershed. There are patches of residential sites located along the highways (18.2%) in this area: SH 352, IH 635, US 80, and IH 30. The majority of commercial (20.1%) areas are located along the major highways. The industrial sites (0.4%) are concentrated in the western part of the watershed with a few patches along SH 352 and SH 80. This watershed has 0.4% water features.

The City of Mesquite had one chemical monitoring site located within the South Mesquite Creek subwatershed. The chemical monitoring site, MS1201/1301/1401/1501 was located north of New Market Road near Paschall Park. The conveyance at this site was a concrete-lined channel with low vegetative cover. The subwatershed delineated for this sampling location covered a 9,965-acre area and consisted mostly of residential (32.3%) property. Several highways (24.2%) went through this drainage area: SH 352, IH 30, IH 635 and US 80. Most of the commercial (26.5%) areas were located along these highways and major roadways such as Gus Thomasson Road. Open areas (16.2%) were mostly located along South Mesquite Creek or adjacent to residential property. Only a few industrial sites could be found in this area which made up 0.8% of the land use coverage. This drainage area contained 0.1% water features.

The monitoring site, watershed and subwatershed boundaries, and land use types are shown in Appendix C, Figure 21. The monitoring site is shown as MS1501. MS1201, MS1301, and MS1401 were located in the same location. The subwatershed area is mostly within the jurisdictional limits of the City of Mesquite with the northern tip within the jurisdictional limits of the City of Dallas. TxDOT contributes flow to the subwatershed through IH 30, IH 635, US 80 and SH 352. There are no TCEQ permitted wastewater outfalls located within the subwatershed according to the *TCEQ Permitted Wastewater Outfall* shapefile accessed May 20, 2016.

4.5.20.1. Summary Statistics

Summary statistics are presented in Table 4-17. The summary statistics include number of samples, minimum and maximum values, median, arithmetic mean, geometric mean, standard deviation, and coefficient of variation.

Table 4-17 South Mesquite Creek RWWCP Third Permit Term Summary Statistics

Parameter	TDS (mg/L)	TSS (mg/L)	BOD (mg/L)	COD (mg/L)	Nitrogen, Total (mg/L)	Phosphorus, Dissolved (mg/L)
No. of Samples	16	16	16	16	16	16
Minimum	158.0	9.00	0.50	0.50	0.490	0.003
Maximum	1740.0	749.0	14.60	95.00	29.40	0.160
Median	310.0	106.35	4.54	25.00	2.440	0.040
Arithmetic Mean	412.1	227.41	5.92	28.41	5.776	0.047
Geometric Mean	342.9	113.04	3.92	12.48	2.863	0.034
Standard Deviation	368.7	240.36	4.67	27.58	7.841	0.036
Coefficient of Variation	0.89	1.06	0.79	0.97	1.36	0.775
	Phosphorus, Total (mg/L)	Arsenic, Total (mg/L)	Chromium, Total (mg/L)	Copper, Total (mg/L)	Lead, Total (mg/L)	Zinc, Total (mg/L)
No. of Samples	16	16	16	16	16	16
Minimum	0.003	0.001	0.002	0.002	0.002	0.005
Maximum	0.510	0.003	0.013	0.049	0.012	0.109
Median	0.110	0.001	0.005	0.018	0.002	0.032
Arithmetic Mean	0.134	0.001	0.006	0.019	0.005	0.041
Geometric Mean	0.080	0.001	0.004	0.015	0.003	0.030
Standard Deviation	0.125	0.001	0.004	0.013	0.004	0.030
Coefficient of Variation	0.934	0.438	0.697	0.661	0.835	0.730
	Oil & Grease (mg/L)	pH, Field (su)	Specific Conductivity (µS/cm)	Temperature (°F)	E. Coli (col/100 mL)	Total Coliform (col/100 mL)
No. of Samples	16	16	16	16	16	16
Minimum	0.70	7.20	87	41.3	0.5	550
Maximum	23.50	8.90	1140	84.4	2800	150000
Median	1.10	8.30	548	69.2	88	3450
Mean	3.37	8.23	621	67.1	454	22061
Geometric Mean	1.48	8.21	536	65.8	94	5449
Standard Deviation	6.30	0.43	303	13.3	744	40498
Coefficient of Variation	1.87	0.05	0.49	0.20	1.64	1.84

4.5.20.2. Water Quality Data Analysis

Monitored parameters were plotted and compared to water quality standards, screening levels, NSQD, and other data where applicable. These graphs are located in Appendix W. During the third permit term, there were two exceedances of the TCEQ TDS basin specific criterion and two exceedances, one exceedance of the TCEQ aquatic life use estimated chronic criterion and acute criterion for total copper, respectively, and five exceedances of the *E. coli* PCR single sample criterion (but the geometric mean was below the criterion). There were seven occurrences where the TSS concentration, five occurrences where the total nitrogen concentration, one occurrence where the chemical oxygen demand, and two occurrences where the oil and grease concentration was higher than 75% of NSQD data for those parameters. In addition, there were three specific conductance readings greater than 1,000 µS/cm in October 2014 and April and September of 2015, which fall in the “fair” category (below the “good” category and above the “poor” category) according to USEPA, 2016b.

The TDS exceedance occurred in February 2014 and April 2015. The total copper exceedances occurred in January, April (acute), and October 2012. Elevated TSS concentrations occurred as follows: four in 2012 (January, April, July and October), January 2013, April 2014 and October 2015. The majority of total nitrogen exceedances occurred in 2012 (January, April, July, and October) and one in April 2015. Chemical oxygen demand and oil and grease exceedances occurred in January 2013, and April and October 2012, respectively.

4.5.20.3. Biological Data Analysis

No bioassessment monitoring data was collected within this watershed.

4.5.20.4. Potential Pollution Sources and BMP Recommendations

Approximately 80 percent of the land use of the South Mesquite Creek monitored subwatershed is almost evenly distributed between residential, commercial and highway uses. Open areas account for most of the remaining 20 percent land use. Over fertilization of the open areas and residential lawns may be a source of total nitrogen. In addition, riparian alteration can affect nitrogen uptake and cycling, and turn urban riparian areas into nitrogen sources (Groffman et al. 2002, 2003). Potential sources of TDS, TSS, COD, oil and grease, and copper could be from construction activities, illicit connections, illegal dumping, and high traffic roadways.

A review of the aerial photography over the period did not reveal any major development or construction within the subwatershed. However, minor construction activities may have been a source of the sediment loadings. Also, industrial/commercial activities may have contributed to sediment loading through bulk material storage and earth disturbance activities.

BMPs recommended for these sources include review of the illicit discharge detection programs (illicit connections, identification and removal of illegal dumping areas), public education of home and business owners regarding fertilization and turf management, review of construction site inspection protocols or BMP requirements, and review of industrial inspection protocols or BMP requirements.

4.5.20.5. Monitoring Recommendations

Data analyzed presented a few exceedances for TDS, total copper, oil and grease, and conductivity and elevated TSS and total nitrogen that may impact aquatic life use. There are currently no TMDLs or impairments for South Mesquite Creek but the East Fork of the Trinity River is impaired for TDS and sulfate. Therefore additional monitoring at this site is recommended to be assigned a high priority. Bioassessment data collection is recommended to determine whether the biological community may be impacted by the chemical pollutants documented above. If bioassessment data collection is not conducted, dry weather chemical monitoring data is recommended to further determine potential sources of pollutants.

4.5.21. Spring Creek

The City of Plano performed chemical and bioassessment monitoring on Spring Creek, a stream with a stream order of two draining to Rowlett Creek (TCEQ segment 0820B) within the Pittman Creek – Spring Creek watershed.

Pittman Creek-Spring Creek is located partially in southeastern Collin County and northcentral Dallas County. Pittman Creek-Spring Creek covers a 23,287-acre area and consists predominately of residential (42.0%) and highway (22.8%) land use. The main highways that intersect in this watershed are US 75 (Central Expressway), PGBT, and SH 78 on the southern edge. The residential areas seem to be divided between US 75 (Central Expressway) and PGBT. The open space (17.5%) is mostly located along the highways and residential areas. Most of the industrial (1.9%) sites in this watershed are located east of US 75 (Central Expressway) and north of PGBT with a few along SH 5 and Renner Road. Commercial (15.6%) property is located mostly in the central portion of the watershed around some of the major roadways and highways. This watershed contains 0.3% water features.

The City of Plano had two chemical monitoring sites located within the Spring Creek subwatershed. The chemical monitoring site, PL1401/1501 was an upstream sampling site located where Legacy Drive crossed Spring Creek in the Legacy Estates Park. The conveyance at this site was a concrete-lined channel with low vegetative cover. The drainage area delineated for this site covered a 461-acre area and primarily consisted of residential (62.9%) property. The highway estimate for this area was 29.2% which included Legacy Drive, Coit Road, and Hedgecoxe Road. There were a few open space (1.0%) areas mixed in with some residential property south of Legacy Drive. Two commercial (6.9%) sites were located where Coit Road and Hedgecoxe Road intersect. This drainage area contained no industrial (0%) sites or water (0%) features.

The chemical monitoring site, PL1402/1502 was a downstream sampling site located where 16th Street crossed Spring Creek, west of US 75 (Central Expressway) near Harrington Park. The conveyance at this site was a natural, unlined channel with medium vegetative cover of shrubs and trees. The drainage area delineated for this site covered a 5,129-acre area and primarily consisted of residential (52.1%) property and highways (24.5%). Highways and major roadways contributing to the highway estimate were US 75 (Central Expressway), Parker Road, Independence Parkway, Legacy Drive, Alma Drive, Park Boulevard, and FM 2478 (Custer Road). Open space (8.8%) was scattered throughout the subwatershed but was mostly located along Spring Creek and mixed in with the residential and commercial property. Most of the commercial (13.8%) property was located along US 75 (Central Expressway) and some of the major roadways. There was a very small section of industrial (0.6%) sites just east of the sampling site near US 75 (Central Expressway) and Park Boulevard. This drainage area contained 0.1% water features.

The monitoring sites, watershed and subwatershed boundaries, and land use types are shown in Appendix C, Figure 22. The monitoring sites are shown as PL1501 and PL1502. PL1401 and PL1402 were located in the same locations, respectively. The subwatershed areas is entirely within the jurisdictional limits of the City of Plano. TxDOT contributes flow to the subwatershed through US 75 and FM 2478. There are no TCEQ permitted wastewater outfalls located within the subwatershed according to the *TCEQ Permitted Wastewater Outfall* shapefile accessed May 20, 2016.

4.5.21.1. Summary Statistics

Summary statistics are presented in Table 4-18. The summary statistics include number of samples, minimum and maximum values, median, arithmetic mean, geometric mean, standard deviation, and coefficient of variation.

Table 4-18 Spring Creek RWWCP Third Permit Term Summary Statistics

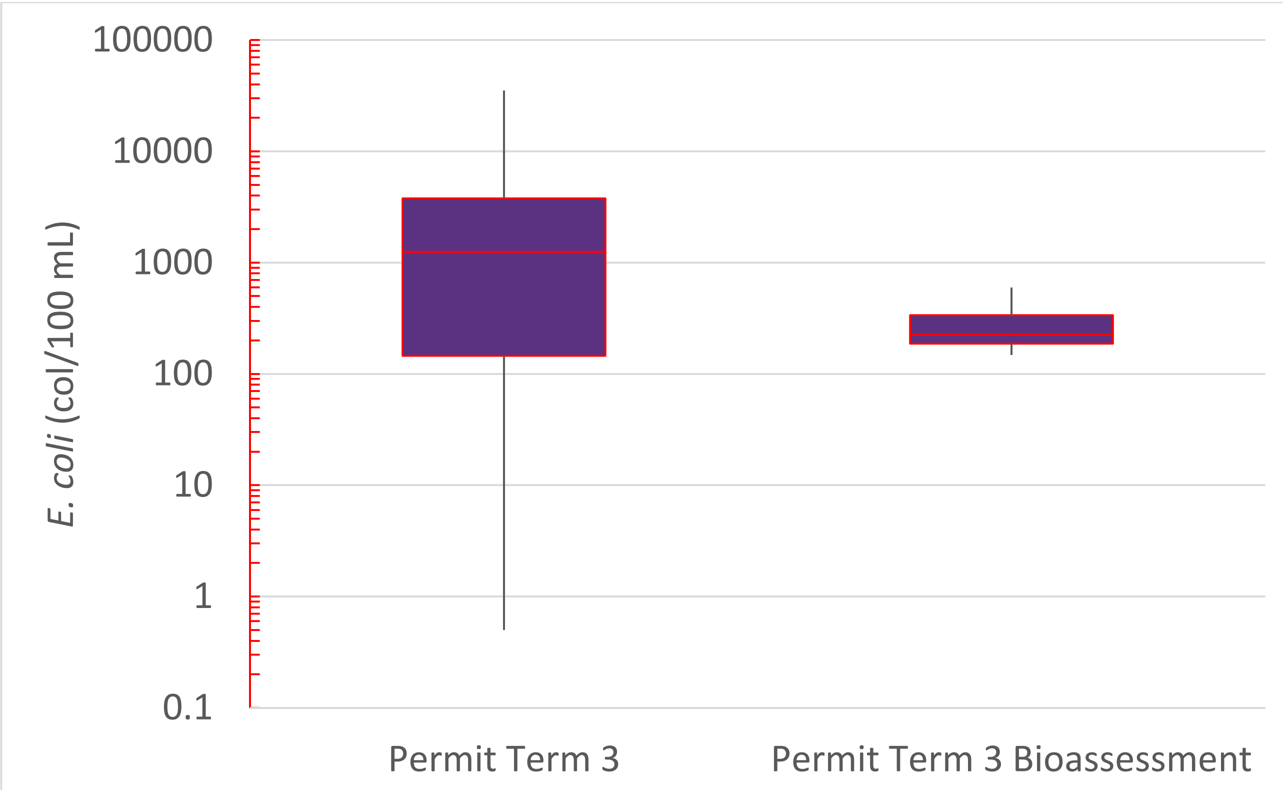
Parameter	TDS (mg/L)	TSS (mg/L)	BOD (mg/L)	COD (mg/L)	Nitrogen, Total (mg/L)	Phosphorus, Dissolved (mg/L)
No. of Samples	16	16	16	16	16	16
Minimum	32.0	15.67	0.50	0.50	0.710	0.030
Maximum	718.0	663.0	16.7	79.00	10.00	0.130
Median	132.0	106.9	6.25	31.50	2.725	0.050
Arithmetic Mean	203.0	155.2	8.07	31.67	3.366	0.061
Geometric Mean	157.5	85.08	6.30	14.57	2.562	0.056
Standard Deviation	168.8	173.4	4.83	25.34	2.806	0.027
Coefficient of Variation	0.83	1.12	0.60	0.80	0.83	0.453
	Phosphorus, Total (mg/L)	Arsenic, Total (mg/L)	Chromium, Total (mg/L)	Copper, Total (mg/L)	Lead, Total (mg/L)	Zinc, Total (mg/L)
No. of Samples	16	16	16	16	16	16
Minimum	0.070	0.001	0.002	0.004	0.002	0.010
Maximum	0.290	0.004	0.011	0.030	0.005	0.145
Median	0.135	0.001	0.003	0.022	0.002	0.032
Arithmetic Mean	0.142	0.002	0.004	0.020	0.002	0.053
Geometric Mean	0.129	0.001	0.003	0.017	0.002	0.038
Standard Deviation	0.064	0.001	0.003	0.009	0.001	0.045
Coefficient of Variation	0.449	0.741	0.792	0.447	0.343	0.856
	Oil & Grease (mg/L)	pH, Field(su)	Specific Conductivity (µS/cm)	Temperature (°F)	E. Coli (col/100 mL)	Total Coliform (col/100 mL)
No. of Samples	16	16	16	16	16	16
Minimum	0.70	7.20	78	38.6	0.5	3000
Maximum	10.1	8.80	730	78.8	35000	1300000
Median	0.70	8.35	283	70.6	1248	12600
Mean	2.03	8.21	325	64.2	4257	110263
Geometric Mean	1.20	8.20	269	62.2	516	23623
Standard Deviation	2.82	0.43	201	15.2	8665	318800
Coefficient of Variation	1.39	0.05	0.62	0.24	2.04	2.89

4.5.21.2. Water Quality Data Analysis

Monitored parameters were plotted and compared to water quality standards, screening levels, and NSQD data where applicable. The graphs are located in Appendix X. During the third permit term, there was one exceedance of the TCEQ TDS basin specific criterion, six exceedances of the TCEQ aquatic life use estimated chronic criterion for total copper, and eleven exceedances of the *E. coli* PCR single sample criterion (and the geometric mean criterion was exceeded). There were two nitrate nitrogen and one orthophosphate exceedance of the TCEQ nutrient screening criteria. There were seven occurrences where the TSS concentration, four occurrences where the total nitrogen concentration, and one occurrence where the oil and grease concentration was higher than 75% of NSQD data for each parameter.

Due to the exceedances and elevated concentrations discussed above and the availability of bioassessment and wet weather chemical data, boxplots were created for *E. coli* for comparison of the datasets. The boxplot does not indicate that stormwater runoff is providing a statistically significant different input of *E. coli* to the stream compared to the bioassessment data which was collected during dry weather (see Figure 4-36).

Figure 4-36 Boxplot Comparing Wet Weather Chemical Monitoring Third Permit Term and Bioassessment *E. coli* Data at Spring Creek



The exceedances of the TDS basin specific criterion occurred at the downstream monitoring station in October 2014. The copper exceedances occurred at both stations in 2014 and only at the upstream station in January 2015. *E. coli* PCR single sample criterion exceedances occurred at all stations in both 2014 and 2015. Elevated TSS concentrations occurred at all stations over the period. Elevated total nitrogen concentrations occurred at both station only in 2015. The elevated oil and grease concentration occurred at the downstream station in July 2015.

4.5.21.3. Biological Data Analysis

Detailed reports of the biological assessments including data summaries can be found in the Annual Regional Wet Weather Characterization Program Monitoring Report for North Central Texas Year 4 and Year 5 (NCTCOG, 2015; NCTCOG, 2016). The habitat assessment scores and aquatic life use scores were plotted and compared to the habitat and aquatic life use categories (see Appendix X).

Spring Creek in the studied reach received an intermediate habitat score for both 2014 and 2015. The fish IBI scores ranged from intermediate to high, and benthic macroinvertebrate community IBI scores ranged from limited to intermediate. The creek experiences relatively localized impacts from its small watershed. Measured chemical factors reflecting those localized impacts included high levels of phosphate-phosphorus during May 2014, high nitrate-nitrogen during the 2015 sample events, and a high E. coli count in June 2015. Water quality exhibited values supportive of healthy aquatic communities. Although Spring Creek water quality standards have not been established, the creek appears to meet the intermediate ALU designation.

4.5.21.4. Potential Pollution Sources and BMP Recommendations

Land use of the Spring Creek subwatershed is mainly residential with lower mixes of commercial, highway, and open land uses. Over fertilization in residential areas may be a source of nutrients as may be illicit discharges. In addition, riparian alteration can affect nitrogen uptake and cycling, and turn urban riparian areas into nitrogen sources (Groffman et al. 2002, 2003). Scattered commercial land uses within the subwatershed are potential sources of TDS. Other likely sources may be from illicit connections, illegal dumping, and high traffic roadways. Stormwater was not a statistically significant source of bacteria. Potential sources of bacteria loading may be from wildlife or illicit connections. One construction activity was noted within the creek in during the September bioassessment. A review of the aerial photography over the period did not reveal any major development or construction within the subwatershed. However, minor construction activities may have been a source of the sediment loadings.

BMPs recommended for these sources include compliance inspections for illicit connections, identification and removal of illegal dumping areas, public education of home and business owners regarding fertilization and turf management, and review of construction site inspection protocols or BMP requirements. Due to intermediate habitat scores, stream restoration projects may be able to increase the biological productivity of the stream.

4.5.21.5. Monitoring Recommendations

Data analyzed presented multiple exceedances for bacteria that may impact primary contact recreation. TDS and total copper exceedances and elevated TSS, nutrient, oil and grease concentrations were also noted, however the bioassessment activities did not show an impact to aquatic life. There are currently no TMDLs or impairments for Spring Creek. The downstream receiving water, Rowlett Creek, is currently impaired for bacteria. Therefore, additional monitoring under the RWWCP at these sites are recommended to be assigned a high priority. Bioassessment data collection is recommended to be continued to monitor the biological community. If bioassessments are not conducted, dry weather chemical monitoring data is recommended to increase the dry weather dataset in order to further identify potential sources of pollutants.

4.5.22. Sycamore Creek

The City of Fort Worth performed bioassessment and chemical monitoring on Sycamore Creek (TCEQ segment 0806E), a stream with a stream order of three or greater draining to the West Fork of the Trinity River Below Lake Worth (TCEQ segment 0806) within the Headwaters Sycamore Creek watershed. Additional bioassessment monitoring is scheduled for 2016.

Headwaters Sycamore Creek- Watershed is located in south-central Tarrant County and flows northeastwardly through Fort Worth eventually emptying into the West Fork Trinity River. Sycamore Creek Watershed covers a 23,679-acre area and is predominately made up of residential (36.8%) property and open space (24.2%). The commercial land use estimate is 15.2% and 3.0% for industrial. The highway land use estimate for this watershed is 20.5%. Major highways running through this area are IH 20, IH 30, IH 35W, US 287, US 287B, SH 180 and SH 303. This watershed consists of 0.2% water features.

The City of Fort Worth had two biological and chemical monitoring sites located on Sycamore Creek. The monitoring site, FWSYC1, was an upstream sampling site located where IH 20 and IH 35W converge and cross over Sycamore Creek. The subwatershed delineated for this sampling location covered an 11,289-acre area and consisted mostly of residential (42.1%) property and open space (24.4%). There were some industrial (3.0%) sites in the northern part of the area near IH 20 and IH 35W and a few patches in the south near FM-731. Major highways including IH 20 and IH 35W contributed to 18.5% of the land use composition in this subwatershed. There were a few commercial (11.9%) sites along some of the major roadways/highways such as Alta Mesa Boulevard, McCart Avenue, IH 20 and IH 35W. This subwatershed contained 0.2% water features.

The monitoring site, FWSYC3, was a downstream sampling site located just south of IH 30 where Scott Avenue ends as it reaches Sycamore Creek. The subwatershed delineated for this sampling location covered a 12,214-acre area and was predominately made up of residential (31.8%) property and open space (24.4%) primarily located along Sycamore Creek. There was also significant highway (22.3%) acreage, with IH 35W, US 287/287B, SH 180, SH 303, and IH 30 and a well-developed local street grid contributing. There were a few large commercial (18.2%) sites northeast of SH 303, west of IH 35W, and southwest of US 287 along major arterial such as Berry Street, Hemphill Street, and Seminary Drive. There was a large section of industrial property (3.1%) in the southern part of the subwatershed, just north of IH 20 and west of IH 35W and smaller patches of industrial sites were dispersed throughout the area in the west, central, and eastern sections of the subwatershed. This subwatershed contained 0.2% water features.

The monitoring sites, watershed and subwatershed boundaries, and land use types are shown in Appendix C, Figure 23. The majority of the subwatershed area is within the jurisdiction of the City of Fort Worth. TxDOT contributes flow to the subwatershed through IH 35W, US 287/287B, SH 180, SH 303, IH 20, FM 731, and IH 30. There are no TCEQ permitted wastewater outfalls located within the subwatershed according to the *TCEQ Permitted Wastewater Outfall* shapefile accessed May 20, 2016.

4.5.22.1. Summary Statistics

Summary statistics are presented in Table 4-18. The summary statistics include number of samples, minimum and maximum values, median, arithmetic mean, geometric mean, standard deviation, and coefficient of variation.

Table 4-19 Sycamore Creek RWWCP Third Permit Term Summary Statistics

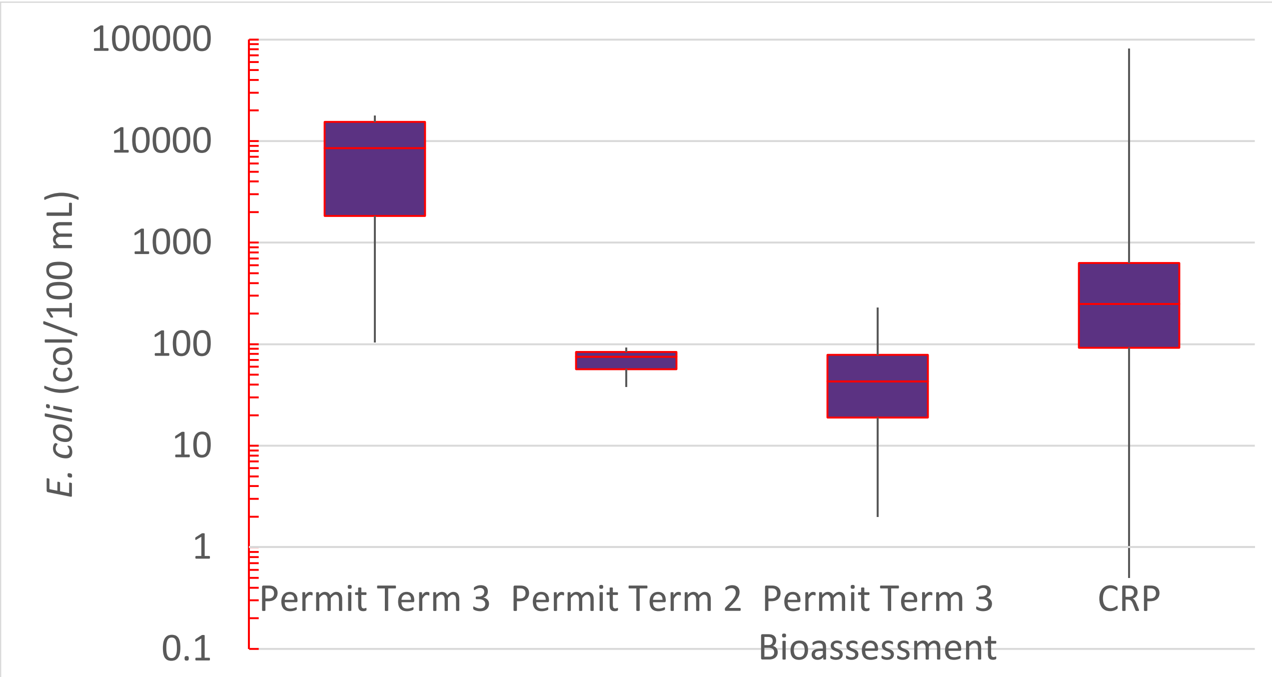
Parameter	TDS (mg/L)	TSS (mg/L)	BOD (mg/L)	COD (mg/L)	Nitrogen, Total (mg/L)	Phosphorus, Dissolved (mg/L)
No. of Samples	4	4	4	4	4	4
Minimum	196.0	50.30	4.40	15.00	0.680	0.003
Maximum	556.0	244.0	13.8	75.00	2.310	0.028
Median	273.0	89.50	7.60	41.50	1.180	0.015
Arithmetic Mean	324.5	118.3	8.35	43.25	1.338	0.015
Geometric Mean	299.6	96.34	7.69	37.30	1.200	0.012
Standard Deviation	159.9	89.57	3.94	24.61	0.724	0.010
Coefficient of Variation	0.49	0.76	0.47	0.57	0.541	0.666
	Phosphorus, Total (mg/L)	**Arsenic, Total (mg/L)**	**Chromium, Total (mg/L)**	**Copper, Total (mg/L)**	**Lead, Total (mg/L)**	**Zinc, Total (mg/L)**
No. of Samples	4	4	4	4	4	4
Minimum	0.500	0.003	0.003	0.009	0.003	0.027
Maximum	0.500	0.003	0.007	0.017	0.017	0.089
Median	0.500	0.003	0.003	0.015	0.008	0.033
Arithmetic Mean	0.500	0.003	0.004	0.014	0.009	0.045
Geometric Mean	0.500	0.003	0.003	0.013	0.006	0.040
Standard Deviation	0.000	0.000	0.002	0.003	0.007	0.029
Coefficient of Variation	0.000	0.000	0.621	0.248	0.846	0.649
	Oil & Grease (mg/L)	**pH, Field (su)**	**Specific Conductivity (µS/cm)**	**Temperature (°F)**	**E. Coli (col/100 mL)**	**Total Coliform (col/100 mL)**
No. of Samples	4	4	0	0	4	4
Minimum	2.50	8.01	-	-	104	3130
Maximum	2.50	8.53	-	-	17800	155000
Median	2.50	8.32	-	-	8550	77750
Mean	2.50	8.29	-	-	8751	78408
Geometric Mean	2.50	8.29	-	-	2843	39210
Standard Deviation	0.00	0.24	-	-	8801	68020
Coefficient of Variation	0.00	0.03	-	-	1.01	0.87

4.5.22.2. Water Quality Data Analysis

The chemical monitoring data over the permit term resulted in four data points collected in November 2014 and December 2015. These data were plotted and compared to water quality standards, screening levels, and CRP data where applicable. CRP station 17369 was utilized for this analysis. Station 17369 is located at the same location as the RWWCP downstream monitoring station. During the third permit term, there was one exceedance of the TCEQ TDS basin specific criterion, two exceedances of the TCEQ aquatic life use estimated human health criterion for total lead, and three exceedances of the *E. coli* PCR single sample criterion (and the geometric mean criterion was exceeded). There was one occurrence where the TSS concentration was higher than 75% of the NSQD data for that parameter. The water quality data collected during bioassessments was also plotted and compared to water quality standards, screening levels, and CRP data where applicable. All graphs are located in Appendix Y. The geometric mean of the bioassessment *E. coli* data was 40 col/100 mL which was less than the PCR geometric mean standard of 126 col/100 mL. Ammonia nitrogen exceeded the TCEQ screening level five times during the period.

Due to the exceedances and elevated concentrations discussed above and the availability of bioassessment and wet weather chemical data, a boxplot was created for *E. coli* for comparison of the datasets. According to the boxplot, there is a statistical significant difference between the third permit term wet weather and second permit term, bioassessment, and CRP data. Since the second and third permit term indicated different results, there is not a clear indication that stormwater runoff provides a larger input of *E. coli* to the stream compared to the datasets which were predominately collected during dry weather (see Figure 4-37).

Figure 4-37 Boxplot Comparing Wet Weather Chemical Monitoring Second and Third Permit Term, Bioassessment, and CRP *E. coli* Data at Sycamore Creek



The TDS exceedance occurred at the downstream station in December 2015. The total lead exceedance occurred during December 2015 at the upstream station and November 2014 at the downstream station. During wet weather, the *E. coli* exceedances occurred at both stations. The TSS elevated concentration occurred at the downstream station in November 2015. The ammonia nitrogen exceedances occurred only at the upstream monitoring station in multiple years. The orthophosphate exceedance occurred at the upstream monitoring station in 2012, 2013, and 2014.

4.5.22.3. Biological Data Analysis

Detailed reports of the biological assessments including data summaries can be found in the Annual Regional Wet Weather Characterization Program Monitoring Report for North Central Texas Year 2 through Year 5 (NCTCOG, 2013; NCTCOG, 2014; NCTCOG, 2015; NCTCOG, 2016). The habitat assessment scores and aquatic life use scores were plotted and compared to the habitat and aquatic life use categories (see Appendix Y). The habitat scores at SYC1 remained in the marginal range over the third term period. The habitat scores at SYC3 were mostly in the sub-optimal range with the exception of a marginal score in spring 2012. The City of Fort Worth utilized the USEPA macroinvertebrate index metric which rates sites from non-impaired to severely impaired. SYC1 and SYC3 were rated moderately impaired over the third term period with the exception of the spring 2012 when SYC3 was rated slightly impaired and the spring of 2013 when SYC1 was rated slightly impaired. Texas macroinvertebrate IBI scores remained in the high range over the third term period at both sites with the exception of the spring 2014 when both sites decreased to intermediate and fall 2015 when SYC3 decreased to intermediate.

Given the marginal to sub-optimal habitat found within the assessed areas, moderately impaired USEPA scores and high IBI scores generally correspond with the available habitat indicating that water quality may not be limiting fish and macroinvertebrate communities.

4.5.22.4. Potential Pollution Sources and BMP Recommendations

Land use of the Sycamore Creek subwatershed is mainly residential with lower but fairly even mixes of commercial, highway, and open land uses. Over fertilization in residential areas may be a source of nutrients as may be illicit discharges. Scattered commercial land uses within the subwatershed are potential sources of TDS. Other likely sources may be from illicit connections, illegal dumping, and high traffic roadways. Stormwater was not shown to be a statistically significant source of bacteria. Potential sources of bacteria loading may be from wildlife or illicit connections. One construction activity was noted within the creek in during the September bioassessment. A review of the aerial photography over the period revealed multiple development projects and construction activities within the subwatershed, particularly in the upper portion south of IH 20 and west of IH 35W which is a likely source of the sediment loadings.

BMPs recommended for these sources include compliance inspections for illicit connections, identification and removal of illegal dumping areas, public education of home and business owners regarding fertilization and turf management, and review of construction site inspection protocols or BMP requirements.

4.5.22.5. Monitoring Recommendations

Data analyzed presented exceedances for bacteria that may impact primary contact recreation. TDS and total lead exceedances and elevated TSS and nutrient concentrations were also noted, however the bioassessment activities did not show an impact to aquatic life. Sycamore Creek is currently impaired for bacteria. The West Fork of the Trinity River Below Lake Worth is impaired for dioxin and PCBs in fish tissue and there is a TMDL for legacy pollutants. Additional monitoring under the RWWCP at these sites are recommended to be assigned a high priority. Bioassessment monitoring is recommended to be continued.

4.5.23. Ten Mile Creek

TxDOT–Dallas District performed chemical monitoring on Ten Mile Creek (TCEQ segment 0805A), a stream with a stream order of three or greater draining to the Upper Trinity River (TCEQ segment 0805) within the Headwaters Ten Mile Creek watershed.

Headwaters Ten Mile Creek Watershed is located in southwestern Dallas County and contains parts of Cedar Hill, Duncanville, DeSoto, and Lancaster. The watershed covers a 29,017-acre area with predominantly residential (38.1%) and open (31.0%) areas. Major roadways located in the watershed are US 67, IH 35E, W. Belt Line Road and other local roads and streets contributing to 15.6% highway land use. Open areas are primarily located east of US 67 along Ten Mile Creek and its tributaries. Commercial property (13.8%) is dispersed throughout the watershed along the major roadways. There are a few industrial areas (1.4%) located in the northern part of the watershed.

TxDOT–Dallas District had one chemical monitoring site located within the Ten Mile Creek subwatershed. The chemical monitoring site, TX1201/1301/1401/1501 was located just downstream (east) of where US 67 crosses Ten Mile Creek. The sample site was along an unlined natural channel with low vegetative cover. The largely suburban subwatershed consisted primarily of residential (48.8%) development supported by commercial (17.2%) property along major roadways. US 67, FM1382, Santa Fe Trail, and Mountain Creek Parkway contributed along with the local street and roadway network to a 20.2% highway land use. Open (13.1%) areas were dispersed throughout the subwatershed. One small industrial (0.7%) area was located in the northern part of the subwatershed. The area contained 0.1% water features.

The monitoring site, watershed and subwatershed boundary, and land use types are shown in Appendix C, Figure 24. The monitoring site is shown as TX1402. TX1202, TX1302, and TX1502 were located in the same location. The Ten Mile Creek subwatershed area is within the jurisdictional limits of the City of Dallas, the City of Duncanville, and the City of Cedar Hill. TxDOT-Dallas District contributes flow to the subwatershed through US 67 and FM1382. There are no TCEQ permitted wastewater outfalls located within the subwatershed according to the *TCEQ Permitted Wastewater Outfall* shapefile accessed May 20, 2016.

4.5.23.1. Summary Statistics

Summary statistics are presented in Table 4-20. The summary statistics include number of samples, minimum and maximum values, median, arithmetic mean, geometric mean, standard deviation, and coefficient of variation.

Table 4-20 Ten Mile Creek RWWCP Third Permit Term Summary Statistics

Parameter	TDS (mg/L)	TSS (mg/L)	BOD (mg/L)	COD (mg/L)	Nitrogen, Total (mg/L)	Phosphorus, Dissolved (mg/L)
No. of Samples	16	16	16	16	16	16
Minimum	62.0	6.00	0.50	0.50	0.190	0.007
Maximum	2100	712.0	27.60	489.0	18.60	0.120
Median	259.0	51.00	7.07	34.00	2.315	0.030
Arithmetic Mean	367.3	149.40	8.95	61.58	4.719	0.039
Geometric Mean	263.4	61.48	5.68	20.61	1.949	0.028
Standard Deviation	471.8	220.15	7.51	116.50	6.159	0.034
Coefficient of Variation	1.28	1.47	0.84	1.89	1.31	0.877
	Phosphorus, Total (mg/L)	Arsenic, Total (mg/L)	Chromium, Total (mg/L)	Copper, Total (mg/L)	Lead, Total (mg/L)	Zinc, Total (mg/L)
No. of Samples	16	16	16	16	16	16
Minimum	0.003	0.001	0.002	0.006	0.002	0.014
Maximum	0.380	0.005	0.113	0.035	0.006	0.075
Median	0.175	0.001	0.005	0.022	0.002	0.042
Arithmetic Mean	0.161	0.002	0.014	0.020	0.003	0.041
Geometric Mean	0.107	0.001	0.006	0.017	0.003	0.037
Standard Deviation	0.108	0.001	0.028	0.011	0.001	0.017
Coefficient of Variation	0.674	0.706	2.055	0.521	0.471	0.404
	Oil & Grease (mg/L)	pH, Field (su)	Specific Conductivity (µS/cm)	Temperature (°F)	E. Coli (col/100 mL)	Total Coliform (col/100 mL)
No. of Samples	16	16	16	16	16	16
Minimum	0.70	7.40	207	38.3	0.5	350
Maximum	7.90	8.70	696	84.8	8000	200000
Median	0.70	8.25	520	68.8	635	19700
Mean	1.66	8.18	500	65.2	1499	39796
Geometric Mean	1.18	8.17	479	63.7	202	12863
Standard Deviation	1.85	0.34	136	13.8	2396	51632
Coefficient of Variation	1.12	0.04	0.27	0.21	1.60	1.30

4.5.23.2. Water Quality Data Analysis

Monitored parameters were plotted and compared to water quality standards, screening levels, NSQD, and other data where applicable. These graphs are located in Appendix Z.

During the third permit term, there was one exceedance of the TCEQ TDS basin specific criterion and nine exceedances of the *E. coli* PCR single sample criterion (and the geometric mean criterion). In addition, there were five occurrences where the TSS concentration, one occurrence where the BOD concentration, one occurrence where the COD concentration, and five occurrences where the total nitrogen concentration was higher than 75% of NSQD data for those parameters.

The TDS exceedance occurred in July 2014. *E. coli* PCR single sample criterion exceedances were observed four times in 2012 (January, April, August, and October), in January 2013, and in the months of April and October of both 2014 and 2015. Elevated TSS concentrations occurred in April and October 2012, April 2013 and April and September 2015. High BOD and COD concentrations were observed in August 2012. Most of the elevated total nitrogen concentrations occurred in 2012 (January, April, August and October) and once in April 2013.

4.5.23.3. Biological Data Analysis

No bioassessment monitoring data was collected within this watershed.

4.5.23.4. Potential Pollution Sources and BMP Recommendations

One half of the land use of the Ten Mile Creek monitored subwatershed is residential with the other half almost evenly split between highway, commercial and open space land uses. Possible sources of *E. coli* are illicit connections and wildlife/domestic animals. Over fertilization of open spaces and residential lawns may be a source of total nitrogen. In addition, riparian alteration can affect nitrogen uptake and cycling, and turn urban riparian areas into nitrogen sources (Groffman et al. 2002, 2003). Potential sources of TDS and TSS could be from construction and/or industrial activities.

A review of the aerial photography over the period did not reveal any major development or construction within the subwatershed. However, minor construction activities may have been a source of the sediment loadings. Also, industrial/commercial activities may have contributed to sediment loading through bulk material storage and earth disturbance activities.

BMPs recommended for these sources include revisions to compliance inspections for illicit connections, identification and removal of illegal dumping areas, public education of home and business owners regarding fertilization and turf management, public education for pet owners regarding pet waste management, and review of construction site and industrial activity inspection protocols or BMP requirements.

4.5.23.5. Monitoring Recommendations

Data analyzed presented multiple exceedances for bacteria, single exceedances for TDS, BOD, COD, and elevated multiple TSS and total nitrogen concentrations that may impact aquatic life use and primary contact recreation. There are currently no TMDLs or impairments for Ten Mile Creek but there is a TMDL for chlordane in fish tissue and bacteria in the Upper Trinity River (TCEQ segment 0805). Therefore additional monitoring at this site is recommended to be assigned a high priority. Also, dry weather chemical monitoring data is recommended to further determine potential sources of pollutants.

4.5.24. Turtle Creek

The City of Dallas performed chemical monitoring on Turtle Creek, a stream with a stream order of three or greater draining to the Upper Trinity River (TCEQ segment 0805) within the Headwaters Turtle Creek watershed.

Headwaters Turtle Creek Watershed is a 21,888 acre heavily urbanized watershed in the central portion of Dallas County. Several major highways including I-35E, Dallas North Tollway, State Hwy. 75, I-30, and the Woodall Rogers Expressway traverse this subwatershed. The roadway network and a majority of Dallas Love Field, which lies in the northwestern portion of the subwatershed, result in a 29.1% highway land use. Dallas' Central Business District, located at the lower end of the watershed, is a major commercial hub and along with significant commercial land use in the western portion of the subwatershed contribute to a 29.9% commercial land use. The areas on the western edge between I-35E and the Trinity River contains some large industrial areas (4.2%). Open areas along Turtle Creek and scattered throughout the subwatershed provide 8.9% open land use. The subwatershed contains 0.3% water.

The City of Dallas had three chemical monitoring sites located within the Turtle Creek subwatershed. The chemical monitoring site, HTC-100 was an upstream sampling site located in Reverchon Park east of the baseball field. The sampling site was on the west bank of the stream, which was an unlined channel with grassy banks. The subwatershed delineated for this sampling location covered a 4,396-acre area and consisted predominately of residential (55.7%) property and highways (23.3%). There was one major arterial in the northern portion of the area. Commercial (11.7%) properties encompassed much of the southern portion of this area and Southern Methodist University in the east-central edge of the drainage area. Open (8.7%) areas were scattered throughout this drainage area, including a large country club in the central portion of the area. This subwatershed contained very little distinct water (0.5%) features, mostly wide sections of Turtle Creek which flowed north to south. Industrial (0.1%) areas were almost non-existent.

The chemical monitoring site, HTC-200 was a midstream sampling site located just south of the Market Center Boulevard bridge crossing. The sampling site was on the east bank of the unlined channel with grassy side slopes. The subwatershed delineated for this sampling location covered a 2,700-acre area and consisted predominately of residential (33.7%) in the north and central portions, highway (29.6%) and commercial (28.2%) property in the south. The commercial areas along with most of the highways encompassed Turtle Creek and abutted the main channel of the Trinity River to the south. Specific highways through this area included IH 35E, Dallas North Tollway, and State Highway 354 (Harry Hines Boulevard). Open (6.7%) areas were scattered throughout this drainage area, while industrial (1.8%) was mixed in with the southern commercial properties. Water features were non-existent (0%) except for the narrow channels of Turtle Creek.

The chemical monitoring site, HTC-300 was a downstream sampling site located west of Wycliff Avenue on the south bank of Turtle Creek just before it merged with Elm Fork Creek. The unlined channel had grassy banks. The subwatershed delineated for this sampling location covered 8,620 acres and consisting predominately of commercial (37.9%), highway (29.7%) and residential (14.8%) property. Specific highways through this area included IH 35E and State Highways 183 (Airport Freeway), 354 (Harry Hines Boulevard), and 356 (Irving Boulevard). A major portion of Dallas Love Field also contributed to the highway land use percentage. The industrial (8.5%) areas were mainly north of the main stem of the Trinity River and to the east of the Elm Fork of the Trinity River. Open (9.0%) areas were mainly in the Southwest portions of the area. Water (0.2%) features were almost non-existent except for the narrow channels of Turtle Creek.

The monitoring sites, watershed and subwatershed boundaries, and land use types are shown in Appendix C, Figure 25. The subwatershed area is entirely within the jurisdictional limits of the City of Dallas. TxDOT-Dallas District contributes flow to the subwatershed through IH 35E, SH 354, SH 183 (Airport Freeway), SH 354 (Harry Hines Boulevard), and SH 356. NTTA contributes flow to the subwatershed through the Dallas North Tollway. There are no TCEQ permitted wastewater outfalls within the subwatershed according to the *TCEQ Permitted Wastewater Outfall* shapefile accessed May 20, 2016.

4.5.24.1. Summary Statistics

Summary statistics are presented in Table 4-21. The summary statistics include number of samples, minimum and maximum values, median, arithmetic mean, geometric mean, standard deviation, and coefficient of variation.

Table 4-21 Turtle Creek RWWCP Third Permit Term Summary Statistics

Parameter	TDS (mg/L)	TSS (mg/L)	BOD (mg/L)	COD (mg/L)	Nitrogen, Total (mg/L)	Phosphorus, Dissolved (mg/L)
No. of Samples	24	24	24	24	24	24
Minimum	120.0	7.00	3.57	1.00	0.025	0.010
Maximum	671.0	189.0	65.9	140.0	17.90	0.178
Median	439.5	65.00	8.52	41.00	1.930	0.080
Arithmetic Mean	404.8	80.50	13.83	45.46	5.229	0.084
Geometric Mean	369.1	65.21	10.31	30.49	2.112	0.071
Standard Deviation	151.9	48.64	13.63	35.85	6.200	0.043
Coefficient of Variation	0.38	0.60	0.99	0.79	1.19	0.514
	Phosphorus, Total (mg/L)	Arsenic, Total (mg/L)	Chromium, Total (mg/L)	Copper, Total (mg/L)	Lead, Total (mg/L)	Zinc, Total (mg/L)
No. of Samples	24	24	24	24	24	24
Minimum	0.130	0.001	0.002	0.003	0.001	0.010
Maximum	0.510	0.004	0.117	0.049	0.062	0.224
Median	0.310	0.002	0.006	0.034	0.014	0.064
Arithmetic Mean	0.305	0.002	0.014	0.031	0.019	0.092
Geometric Mean	0.288	0.002	0.007	0.027	0.012	0.073
Standard Deviation	0.100	0.001	0.025	0.012	0.017	0.061
Coefficient of Variation	0.329	0.555	1.760	0.381	0.884	0.659
	Oil & Grease (mg/L)	pH, Field (su)	Specific Conductivity (µS/cm)	Temperature (°F)	E. Coli (col/100 mL)	Total Coliform (col/100 mL)
No. of Samples	24	24	0	0	24	0
Minimum	0.70	6.99	--	--	20.0	--
Maximum	19.10	8.01	--	--	15230	--
Median	0.70	7.75	--	--	685	--
Mean	1.95	7.65	--	--	2074	--
Geometric Mean	1.08	7.64	--	--	655	--
Standard Deviation	3.80	0.29	--	--	3416	--
Coefficient of Variation	1.95	0.04	--	--	1.65	--

4.5.24.2. Water Quality Data Analysis

Monitored parameters were plotted and compared to water quality standards, screening levels, and NSQD data where applicable. These graphs are located in Appendix AA. During the third permit term, there were two exceedances of the TCEQ aquatic life use estimated chronic criterion for total copper, eight exceedances of the TCEQ aquatic life use estimated chronic and human health criteria for total lead, and there were seventeen exceedances of the *E. coli* PCR single sample criterion (and the *E. coli* PCR geometric mean criterion was exceeded). In addition, there were three occurrences where the TSS concentration, four occurrences where the BOD concentration, three occurrences where the COD concentration, and eight occurrences where the total nitrogen concentration was higher than 75% of NSQD data for those parameters.

The total copper exceedances occurred at the upstream station in September 2014 and at the downstream station in May 2012. The total lead exceedances occurred at the midstream and downstream stations in both monitored years. *E. coli* PCR single sample criterion exceedances were observed at all monitoring stations in both monitored years. The elevated TSS concentrations occurred at the midstream station in both years. The elevated BOD concentrations occurred at the upstream station in 2014. The elevated COD concentrations occurred at the upstream station in September 2014 and at the midstream station in December 2012 and September 2014. The elevated total nitrogen concentrations were observed at all stations in 2012, and only at the downstream station in April 2014.

4.5.24.3. Biological Data Analysis

No bioassessment monitoring data was collected within this watershed.

4.5.24.4. Potential Pollution Sources and BMP Recommendations

Land use of the Turtle Creek subwatershed is mainly split between residential, commercial, and highway land uses with lower percentages of industrial and open land uses. Possible sources of *E. coli* are illicit connections and wildlife or pets. The elevated concentrations of total nitrogen may have been a factor in elevated BOD and COD concentrations due to increased organic matter in the stream. Over fertilization of residential and commercial landscaping may be a source of these nutrients as may be illicit connections. In addition, riparian alteration can affect nitrogen uptake and cycling, and turn urban riparian areas into nitrogen sources (Groffman et al. 2002, 2003). Dissolved oxygen was not measured during the permit term and therefore it is unknown whether the elevated nutrient, BOD, and COD concentrations may be impacting the aquatic community by decreasing the amount of available oxygen.

A review of the aerial photography over the period revealed some development/redevelopment occurring within the midstream subwatershed. For example the construction of condominiums/townhomes at North Houston Street. These activities may have been a source of the increase sediment concentrations. Industrial and commercial land uses may have been the source of the exceedances of copper and lead. Additional sources of metals could be from illicit connections and illegal dumping.

BMPs recommended for these sources include compliance inspections for illicit connections, identification and removal of illegal dumping areas, public education of home and business owners regarding fertilization and turf management, public education for pet owners regarding pet waste management, review of construction site inspection protocols or BMP requirements, and review of industrial inspection protocols or BMP requirements.

4.5.24.5. Monitoring Recommendations

Data analyzed presents several indications of stream degradation. Bacteria concentrations have a potential to impact primary contact recreation and nutrients and metals have the potential to impact aquatic life. There are no TMDLs or impairments identified for Turtle Creek. There is a current TMDL for bacteria and for legacy pollutants for the Upper Trinity River Segment 0805. Additional monitoring at this site is recommended to be assigned a high priority. Bioassessment data collection is recommended to determine whether the biological community may be impacted by the chemical pollutants documented above.

4.5.25. Turtle Creek – Trinity River

The City of Dallas performed chemical monitoring on the Mican Channel, a stream with a stream order of three or greater draining to the Upper Trinity River (TCEQ segment 0805) within the Turtle Creek – Trinity River watershed.

Turtle Creek-Trinity River Watershed is located on the western side of Dallas County. This 22,443-acre watershed area is predominately made up of residential (31.4%) property and open space (26.7%). Most of the open space is dispersed throughout the watershed but there is an exceptionally large section of open space along the bank of the Trinity River. There are several highways (21.0%) that go through this area: IH 30, SH 12, SH 180, SH 354, and IH 35E. The majority of the industrial (7.0%) and commercial (12.9%) sites are located north of I-30 with a few others located along other major roadways in the watershed. This watershed contains 1.0% water features.

The City of Dallas has three chemical monitoring sites located within the Mican Channel subwatershed. The chemical monitoring site, TCTR-100 was an upstream sampling site located on the south side of Pipestone Road. The stream consisted of a concrete channel for base flow with grassy side slopes; the sample site was located on the north side of the channel. The subwatershed delineated for this sampling location covered a 569-acre area and consisted predominately of open (51.6%) areas and industrial (22.4%) warehouse properties. Highways (10.7%) entailed mostly SH 180 and local roads. Commercial (8.8%) and residential (6.2%) land uses lined the eastern edge and composed nearly all of the remaining area. This subwatershed contained very little distinct water (0.3%) features, and involved one small pond and various tributaries which flow north to the main stem of the Trinity River.

The chemical monitoring site, TCTR-200 was a midstream sampling site located at the intersection of La Reunion Parkway and Bastille Road. The stream consisted of a concrete channel for base flow with grassy side slopes; the sample site was located on the west side of the channel. The subwatershed delineated for this sampling location covered just 232 acres and consisted predominately of industrial (66.9%) warehouse areas followed by highways (19.8%) which would be IH 30 (Tom Landry Highway) and open (11.3%) space. There were a few commercial (2.0%) properties along the western edge by the highway. This subwatershed contained no residential areas or distinct water features.

The chemical monitoring site, TCTR-300 was a downstream sampling site located on the north side of Singleton Boulevard. The stream consisted of concrete bottom and side slopes. The subwatershed delineated for this sampling location covered just 981 acres and consisted predominately of open (35.2%) space around the industrial (28.9%) areas. Commercial (19.8%) areas near the Tom Landry Freeway and in the far southern edge of the study area comprised this category. Highways (10.5%) were IH 30 (Tom Landry Highway) and three major arterials. Three densely populated residential (4.9%) areas occupied the southern half of the site drainage area. There were 0.7% identified water features.

The monitoring sites, watershed and subwatershed boundaries, and land use types are shown in Appendix C, Figure 26. The subwatershed area is entirely within the jurisdictional limits of the City of Dallas. TxDOT-Dallas District contributes flow to the subwatershed through SH 180 and IH 30. There are no TCEQ permitted wastewater outfalls within the subwatershed according to the *TCEQ Permitted Wastewater Outfall* shapefile accessed May 20, 2016.

4.5.25.1. Summary Statistics

Summary statistics are presented in Table 4-22. The summary statistics include number of samples, minimum and maximum values, median, arithmetic mean, geometric mean, standard deviation, and coefficient of variation.

Table 4-22 Mican Channel RWWCP Third Permit Term Summary Statistics

Parameter	TDS (mg/L)	TSS (mg/L)	BOD (mg/L)	COD (mg/L)	Nitrogen, Total (mg/L)	Phosphorus, Dissolved (mg/L)
No. of Samples	24	24	24	24	24	24
Minimum	46.0	19.00	0.50	0.50	0.490	0.005
Maximum	1090.0	1053	55.1	170.0	20.70	0.150
Median	255.0	88.50	8.23	26.50	1.855	0.078
Arithmetic Mean	361.1	215.9	10.4	36.88	4.957	0.067
Geometric Mean	283.7	115.2	6.98	24.25	2.421	0.048
Standard Deviation	253.3	275.2	11.1	34.96	6.141	0.040
Coefficient of Variation	0.70	1.27	1.07	0.95	1.24	0.602
	Phosphorus, Total (mg/L)	Arsenic, Total (mg/L)	Chromium, Total (mg/L)	Copper, Total (mg/L)	Lead, Total (mg/L)	Zinc, Total (mg/L)
No. of Samples	24	24	24	24	24	24
Minimum	0.100	0.001	0.002	0.006	0.002	0.010
Maximum	1.630	0.017	0.024	0.048	0.035	0.378
Median	0.285	0.001	0.006	0.023	0.006	0.086
Arithmetic Mean	0.337	0.003	0.008	0.025	0.009	0.097
Geometric Mean	0.288	0.002	0.006	0.023	0.006	0.072
Standard Deviation	0.287	0.004	0.007	0.010	0.009	0.074
Coefficient of Variation	0.853	1.282	0.862	0.402	1.053	0.769
	Oil & Grease (mg/L)	pH, Field (su)	Specific Conductivity (µS/cm)	Temperature (°F)	E. Coli (col/100 mL)	Total Coliform (col/100 mL)
No. of Samples	24	24	0	0	24	0
Minimum	0.70	7.28	--	--	0.5	--
Maximum	9.40	9.10	--	--	64880	--
Median	0.70	7.94	--	--	1038	--
Mean	2.16	8.00	--	--	6176	--
Geometric Mean	1.43	7.99	--	--	370	--
Standard Deviation	2.32	0.38	--	--	13829	--
Coefficient of Variation	1.08	0.05	--	--	2.24	--

4.5.25.2. Water Quality Data Analysis

Monitored parameters were plotted and compared to water quality standards, screening levels, and NSQD data where applicable. These graphs are located in Appendix AB. During the third permit term, there was one exceedance of the TCEQ TDS basin specific criterion, one exceedance of the TCEQ aquatic life use estimated chronic criterion for total copper, two exceedances of the TCEQ aquatic life use estimated chronic and human health criteria for total lead, and there were fifteen exceedances of the *E. coli* PCR single sample criterion (and the *E. coli* PCR geometric mean criterion was exceeded). There was one total phosphorus exceedance of the TCEQ nutrient screening criteria. In addition, there were nine occurrences where the TSS concentration, two occurrences where the BOD concentration, one occurrence where the COD concentration, and seven occurrences where the total nitrogen concentration was higher than 75% of NSQD data for those parameters.

The TDS and total phosphorus exceedances occurred at the upstream station in April 2012. The total copper exceedance occurred at the midstream station in April 2012. The total lead exceedances occurred at the upstream and midstream stations in October 2012. *E. coli* PCR single sample criterion exceedances were observed at the upstream and midstream stations in 2012 and at all monitoring stations in 2014. The elevated TSS concentrations occurred at all stations in both years. The elevated BOD concentrations occurred at the midstream station in 2012 and 2014. The elevated COD concentration occurred at the midstream station in August 2014. The elevated total nitrogen concentrations were observed at all stations in 2012.

4.5.25.3. Biological Data Analysis

No bioassessment monitoring data was collected within this watershed.

4.5.25.4. Potential Pollution Sources and BMP Recommendations

Land use of the Mican Channel subwatershed is mainly open and industrial with lesser parts commercial and highway land uses. Possible sources of *E. coli* are illicit connections and wildlife. The elevated concentrations of total nitrogen may have been a factor in elevated BOD and COD concentrations due to increased organic matter in the stream. Over fertilization of commercial landscaping may be a source of these nutrients as may be illicit connections. In addition, riparian alteration can affect nitrogen uptake and cycling, and turn urban riparian areas into nitrogen sources (Groffman et al. 2002, 2003). Dissolved oxygen was not measured during the permit term and therefore it is unknown whether the elevated nutrient, BOD, and COD concentrations may be impacting the aquatic community by decreasing the amount of available oxygen.

A review of the aerial photography over the period revealed construction on IH 30. These activities may have been a source of the increase sediment concentrations. Industrial and commercial land uses may have been the source of the exceedances of copper and lead. Additional sources of metals could be from illicit connections and illegal dumping.

BMPs recommended for these sources include compliance inspections for illicit connections, identification and removal of illegal dumping areas, public education of home and business owners regarding fertilization and turf management, public education for pet owners regarding pet waste management, review of construction site inspection protocols or BMP requirements, and review of industrial inspection protocols or BMP requirements.

4.5.25.5. Monitoring Recommendations

Data analyzed presents several indications of stream degradation. Bacteria concentrations have a potential to impact primary contact recreation and nutrients and metals have the potential to impact aquatic life. There are no TMDLs or impairments identified for Mican Channel. There is a current TMDL for bacteria and for legacy pollutants for the Upper Trinity River Segment 0805. Additional monitoring at this site is recommended to be assigned a high priority. Bioassessment data collection is recommended to determine whether the biological community may be impacted by the chemical pollutants documented above.

4.5.26. White Rock Creek

The City of Dallas performed chemical monitoring on White Rock Creek (TCEQ segment 0805C), a stream with a stream order of three or greater draining to the Upper Trinity River (TCEQ segment 0805) within the City of Dallas – White Rock Creek watershed.

City of Dallas – White Rock Creek Watershed is located in central Dallas County. This 22,317-acre watershed is predominately made up of residential (37.0%) property and open space (27.3%). The open space is primarily in the central and southern part of the watershed, around the bank of White Rock Creek. There are several highways (19.6%) that go through this area: IH 30, SH 12, SH 175, and SH 352. The majority of the industrial (0.4%) and commercial (14.1%) sites are located south of I-30 with a few others along the other major roadways in the watershed. This watershed contains 1.6% water features.

The City of Dallas had three chemical monitoring sites located within the White Rock Creek subwatershed. The chemical monitoring site, WRC-100 was an upstream sampling site located between Samuell Boulevard and IH 30. This subwatershed covered a 6,937-acre area and consisted primarily of residential (50.1%) property in the upper reaches of the watershed. There were a few highways (20.6%) that crossed through this drainage area and included IH 30, SH 12, and SH 78. Open space (15.9%) was located around the banks of White Rock Creek. Commercial (12.8%) was located near the residential area. There was one small industrial (0.1%) site that was close to SH 12. This subwatershed contained 0.5% water features.

The chemical monitoring site, WRC-200 was a midstream sampling site located on the north side of Samuell Boulevard. This subwatershed covered an 8,484-acre area. Residential (37.3%) property and highways (22.8%) made up the majority of this subwatershed. Residential property was located in the upper part of the subwatershed. Highways that were in this drainage area included: IH 30, SH 12, SH 78, and SH 352. Commercial (18.8%) property was evenly dispersed and open space (18.8%) was primarily along the banks of White Rock Creek and included parks and recreation. There were a couple of industrial (0.9%) sites south of IH 30. This subwatershed contained 1.4% water features.

The chemical monitoring site, WRC-300 was a downstream sampling site located on the north side of Samuell Boulevard. This 4,952-acre subwatershed consisted primarily of open space (39.7%) and residential (28.2%) property. The majority of open space was parks and recreation along White Rock Creek and its tributaries. The residential property was located in the upper watershed. There were a few highways (17.9%) that intersected this subwatershed including SH 310, SH 352, and SH 175. Commercial (12.2%) property was intermixed with the residential property. There were a few industrial (0.1%) sites that were located in the upper watershed just south of SH 352. This subwatershed contained 1.9% water features.

The monitoring sites, watershed and subwatershed boundaries, and land use types are shown in Appendix C, Figure 27. The subwatershed area is entirely within the jurisdictional limits of the City of Dallas. TxDOT-Dallas District contributes flow to the subwatershed through IH 30, SH 12, SH 78, and SH352. There are no TCEQ permitted wastewater outfalls within the subwatershed according to the *TCEQ Permitted Wastewater Outfall* shapefile accessed May 20, 2016.

4.5.26.1. Summary Statistics

Summary statistics are presented in Table 4-23. The summary statistics include number of samples, minimum and maximum values, median, arithmetic mean, geometric mean, standard deviation, and coefficient of variation.

Table 4-23 White Rock Creek RWWCP Third Permit Term Summary Statistics

Parameter	TDS (mg/L)	TSS (mg/L)	BOD (mg/L)	COD (mg/L)	Nitrogen, Total (mg/L)	Phosphorus, Dissolved (mg/L)
No. of Samples	24	24	24	24	24	24
Minimum	174.0	12.00	1.00	1.00	0.840	0.003
Maximum	536.0	122.0	32.80	102.0	6.610	0.120
Median	301.0	39.00	5.04	19.00	1.195	0.050
Arithmetic Mean	297.0	48.33	13.27	25.66	2.147	0.049
Geometric Mean	287.5	40.97	7.24	14.45	1.677	0.040
Standard Deviation	77.9	29.53	12.16	27.06	1.796	0.027
Coefficient of Variation	0.26	0.61	0.92	1.05	0.84	0.556
	Phosphorus, Total (mg/L)	Arsenic, Total (mg/L)	Chromium, Total (mg/L)	Copper, Total (mg/L)	Lead, Total (mg/L)	Zinc, Total (mg/L)
No. of Samples	24	24	24	24	24	24
Minimum	0.040	0.001	0.001	0.001	0.002	0.002
Maximum	0.240	0.010	0.154	0.036	0.021	0.064
Median	0.072	0.002	0.002	0.005	0.002	0.011
Arithmetic Mean	0.090	0.002	0.011	0.007	0.004	0.017
Geometric Mean	0.081	0.002	0.002	0.004	0.003	0.011
Standard Deviation	0.048	0.002	0.034	0.008	0.004	0.017
Coefficient of Variation	0.530	0.792	3.094	1.112	1.122	1.020
	Oil & Grease (mg/L)	pH, Field (su)	Specific Conductivity (µS/cm)	Temperature (°F)	E. Coli (col/100 mL)	Total Coliform (col/100 mL)
No. of Samples	24	24	0	0	24	0
Minimum	0.70	7.23	--	--	0.5	--
Maximum	7.73	8.94	--	--	31300	--
Median	0.72	7.79	--	--	79	--
Mean	1.66	7.93	--	--	1818	--
Geometric Mean	1.10	7.92	--	--	78	--
Standard Deviation	1.98	0.41	--	--	6437	--
Coefficient of Variation	1.19	0.05	--	--	3.54	--

4.5.26.2. Water Quality Data Analysis

Monitored parameters were plotted and compared to water quality standards, screening levels, NSQD and CRP data where applicable. CRP station 18458 was utilized for this analysis. Station 18458 is located just upstream from the RWWCP downstream monitoring station. These graphs are located in Appendix AC. During the third permit term, there were five exceedances of the *E. coli* PCR single sample criterion but the geometric mean (78 col/100 mL) remained below the TCEQ criterion. There were nine occurrences where the BOD concentration, one occurrence where the COD concentration, and four occurrences where the total nitrogen concentration was higher than 75% of NSQD data for those parameters.

The elevated BOD concentrations occurred at all stations. The elevated COD concentration occurred at the midstream station in July 2013. The elevated total nitrogen concentrations were observed at all stations in 2015.

4.5.26.3. Biological Data Analysis

No bioassessment monitoring data was collected within this watershed.

4.5.26.4. Potential Pollution Sources and BMP Recommendations

Land use of the White Rock Creek subwatershed is mainly residential followed by open, highway, and commercial land uses. The elevated concentrations of total nitrogen may have been a factor in elevated BOD and COD concentrations due to increased organic matter in the stream. Over fertilization of residential lawns and open areas may be a source of these nutrients. In addition, riparian alteration can affect nitrogen uptake and cycling, and turn urban riparian areas into nitrogen sources (Groffman et al. 2002, 2003). Dissolved oxygen was not measured during the permit term and therefore it is unknown whether the elevated nutrient, BOD, and COD concentrations may be impacting the aquatic community by decreasing the amount of available oxygen. A potential BMP for this source is public education of home and business owners regarding fertilization and turf management.

4.5.26.5. Monitoring Recommendations

Data analyzed presents low indications of stream degradation or chemical indicators of water quality decline. In addition, there are no TMDLs or impairments identified for this segment of White Rock Creek. There is a current TMDL for bacteria and for legacy pollutants for the Upper Trinity River Segment 0805. It is recommended that additional monitoring at this site be assigned a medium priority. Bioassessment data collection is recommended to determine whether the biological community may be impacted by the chemical pollutants documented above.

4.5.27. White Rock Creek (Headwaters)

The City of Plano performed chemical and bioassessment monitoring and NTTA performed chemical monitoring on White Rock Creek above White Rock Lake (TCEQ segment 0827A), a stream with a stream order of three or greater draining to White Rock Lake (TCEQ segment 0827) within the Headwaters White Rock Creek watershed.

Headwaters White Rock Creek Watershed is located at the southwest corner of Collin County and includes parts of Plano (east of Dallas North Tollway), Frisco (north of SH 121), and Dallas (south of President George Bush Turnpike). Headwaters White Rock Creek is a 19,972-acre watershed consisting of predominately residential property (38.1%) dispersed throughout the watershed. The rest of the watershed is made up of 20.5% open space, 20.7% highway, 19.1% commercial, 0.8% water, and 0.7% industrial.

The City of Plano had two chemical monitoring sites located within the White Rock Creek subwatershed. The chemical monitoring site, PL1201/1301 was an upstream sampling site located east of Preston Road where Hedgcoxe Road crosses Upper White Rock Creek. The conveyance at this site was an unlined channel with high vegetative cover. This subwatershed covered a 5,228-acre area and was primarily composed of residential property (32.8%). Open space covered 26.9% of the land use in this subwatershed located primarily along White Rock Creek. Two major highways (SH 289 & SH 121) converged in this area along with other streets and roadways to contribute to 22.3% of the land use. Most of the commercial (16.6%) areas were located along SH 289 and SH 121. There were a few small industrial (0.9%) sites in dispersed locations in the subwatershed. The water feature composition for this area was 0.6%.

The chemical monitoring site, PL1202/1302 was a downstream sampling site located west of Old Shepards Park where Plano Parkway crossed White Rock Creek. The conveyance at this site was a channel with concrete sides and an earthen floor. The subwatershed delineated area for this site covered approximately 8,816 acres and was composed of mostly residential (39.0%) property. SH 298 and a small portion of the Dallas North Tollway ran through this subwatershed area and were included in the highway (20.9%) land use estimate. Most of the open space (18.4%) in this area ran along White Rock Creek. There was a large commercial (20.0%) area in the northwestern portion between Legacy Drive and Spring Creek Parkway. Other commercial property was located along major roadways adjacent to residential areas. The water feature composition for this subwatershed is 1.0%. There were a few industrial (0.7%) sites in dispersed locations in the subwatershed.

NTTA also had two chemical monitoring sites located within the White Rock Creek subwatershed. The chemical monitoring site, NT1201/1301 was an upstream sampling site located just downstream (south) of where SH 121 crossed Upper White Rock Creek. The conveyance at this site was an unlined channel with a silty bottom, grassed sides, and low vegetative cover. This subwatershed covered a 2,050-acre area and was primarily composed of residential property (42.8%). SH 121 ran across the southern portion of the subwatershed and along with the local road network contributed to a 24.4% highway land use. Open space covered 23.1% of the land use in this subwatershed located primarily along White Rock Creek and in neighborhoods. Most of the commercial (8.1%) areas were located along major roadways. There was one industrial (0.2%) site in the upper part of the subwatershed. The water feature composition for this area was 1.4%.

The chemical monitoring site, NT1202/1302 was a downstream sampling site located just downstream (south) of where the President George Bush Turnpike (PGBT) crossed White Rock Creek. This watershed covered much of the same area as PL1202 but was located downstream of PGBT whereas the Plano site was located upstream of PGBT. The conveyance at this site was an open channel with a rock bottom and some silt. The subwatershed delineated area for this site covered approximately 13,267 acres and was composed of mostly residential (34.1%) property. PGBT, SH 121, SH 289 and a small portion of the Dallas North Tollway ran through this subwatershed area and were included in the highway (21.9%) land use estimate. Most of the open space (20.6%) in this area ran along White Rock Creek and its tributaries. There were large commercial (21.8%) areas in the northwestern portion between Legacy Drive and Spring Creek Parkway and along SH 289 and SH 121. Other commercial property was located along major roadways adjacent to residential areas. The water feature composition for this subwatershed was 0.7%. There were a few industrial (1.0%) sites in dispersed locations in the subwatershed.

The monitoring sites, watershed and subwatershed boundaries, and land use types for the City of Plano stations are shown in Appendix C, Figure 28. The monitoring sites are shown as PL1301 and PL1302. PL1201 and PL1202 were located in the same locations, respectively. The monitoring sites, watershed and subwatershed boundaries, and land use types for the NTTA stations are shown in Appendix C, Figure 29. The monitoring sites are shown as NT1301 and NT1302. NT1201 and NT1202 were located in the same locations, respectively. The subwatershed area is mainly within the jurisdictional limits of the City of Plano but the upper portion of the subwatershed is within the jurisdictional limits of the City of Frisco. TxDOT contributes flow to the subwatershed through SH 289. NTTA contributes to the subwatershed through the PGBT, Sam Rayburn Tollway, and Dallas North Tollway. There are no TCEQ permitted wastewater outfalls within the subwatershed according to the *TCEQ Permitted Wastewater Outfall* shapefile accessed May 20, 2016.

4.5.27.1. Summary Statistics

Summary statistics are presented in Table 4-24. The summary statistics include number of samples, minimum and maximum values, median, arithmetic mean, geometric mean, standard deviation, and coefficient of variation.

Table 4-24 White Rock Creek (Headwaters) RWWCP Third Permit Term Summary Statistics

Parameter	TDS (mg/L)	TSS (mg/L)	BOD (mg/L)	COD (mg/L)	Nitrogen, Total (mg/L)	Phosphorus, Dissolved (mg/L)
No. of Samples	32	32	32	32	32	32
Minimum	152.0	6.00	2.00	0.50	0.025	0.005
Maximum	587.0	756.0	19.70	99.00	28.50	0.150
Median	273.0	62.17	6.44	30.00	5.650	0.050
Arithmetic Mean	291.1	148.4	8.41	35.95	7.308	0.053
Geometric Mean	277.2	65.89	6.97	15.80	4.402	0.039
Standard Deviation	94.2	202.9	5.21	30.83	6.599	0.037
Coefficient of Variation	0.32	1.37	0.62	0.86	0.90	0.696
	Phosphorus, Total (mg/L)	Arsenic, Total (mg/L)	Chromium, Total (mg/L)	Copper, Total (mg/L)	Lead, Total (mg/L)	Zinc, Total (mg/L)
No. of Samples	32	32	32	32	32	32
Minimum	0.025	0.001	0.002	0.011	0.002	0.015
Maximum	0.640	0.010	0.012	0.052	0.010	0.277
Median	0.210	0.001	0.005	0.026	0.002	0.047
Arithmetic Mean	0.235	0.003	0.005	0.028	0.004	0.057
Geometric Mean	0.183	0.002	0.004	0.026	0.003	0.049
Standard Deviation	0.146	0.003	0.003	0.010	0.003	0.045
Coefficient of Variation	0.621	0.951	0.552	0.368	0.666	0.783
	Oil & Grease (mg/L)	pH, Field (su)	Specific Conductivity (µS/cm)	Temperature (°F)	E. Coli (col/100 mL)	Total Coliform (col/100 mL)
No. of Samples	32	32	32	32	32	32
Minimum	0.70	7.50	107	47.9	6	1130
Maximum	43.6	8.70	1360	86.2	95000	800000
Median	1.85	8.20	483	68.4	635	51000
Mean	6.40	8.21	553	66.2	5583	87239
Geometric Mean	2.55	8.21	472	65.1	362	32486
Standard Deviation	10.4	0.29	310	12.2	17047	147289
Coefficient of Variation	1.63	0.04	0.56	0.18	3.05	1.69

4.5.27.2. Water Quality Data Analysis

Monitored parameters were plotted and compared to water quality standards, screening levels, NSQD and CRP data where applicable. CRP station 21556 was utilized for this analysis. Station 21556 is located between the Plano upstream and downstream monitoring stations. These graphs are located in Appendix AD. During the third permit term, there were six exceedances of the TCEQ aquatic life use estimated chronic criterion for total copper, five exceedances of the TCEQ aquatic life use estimated acute criterion for total copper, and nineteen exceedances of the *E. coli* PCR single sample criterion (and the *E. coli* PCR geometric mean criterion was exceeded). There was one total phosphorus and orthophosphate exceedance of the TCEQ nutrient screening criteria that occurred during the bioassessment chemical sampling. In addition, there were nine occurrences where the TSS concentration, two occurrences where the COD concentration, twenty-two occurrences where the total nitrogen concentration, and eight occurrences where the oil and grease concentration was higher than the NSQD averages for those parameters. Lastly, there were two specific conductance readings greater than 1,000 µS/cm, which falls in the “fair” category (below the “good” category and above the “poor” category) according to USEPA, 2016b.

Due to the exceedances and elevated concentrations discussed above and the availability of bioassessment, CRP, and wet weather chemical data, boxplots were created for total nitrogen, total phosphorus, conductivity, and *E. coli* for comparison of the datasets. According to the boxplots, there is a statistical significant difference for total nitrogen between the bioassessment data and second and third permit term wet weather and CRP data. Since the bioassessment and CRP indicated different results, there is not a clear indication that stormwater runoff provides a larger input of total nitrogen to the stream compared to the datasets that were predominately collected during dry weather (see Figure 4-38). There was a statistically significant increase between the bioassessment data and the second and third term wet weather data for total phosphorus (Figure 4-39). This indicates that stormwater is not statistically contributing more total phosphorus compared to dry weather observations. There was no statistical difference for specific conductance or *E. coli* between wet and dry weather data (Figure 4-40 and 4-41).

Figure 4-38 Boxplot Comparing Wet Weather Chemical Monitoring Second and Third Permit Term, Bioassessment, and CRP Total Nitrogen Data at White Rock Creek

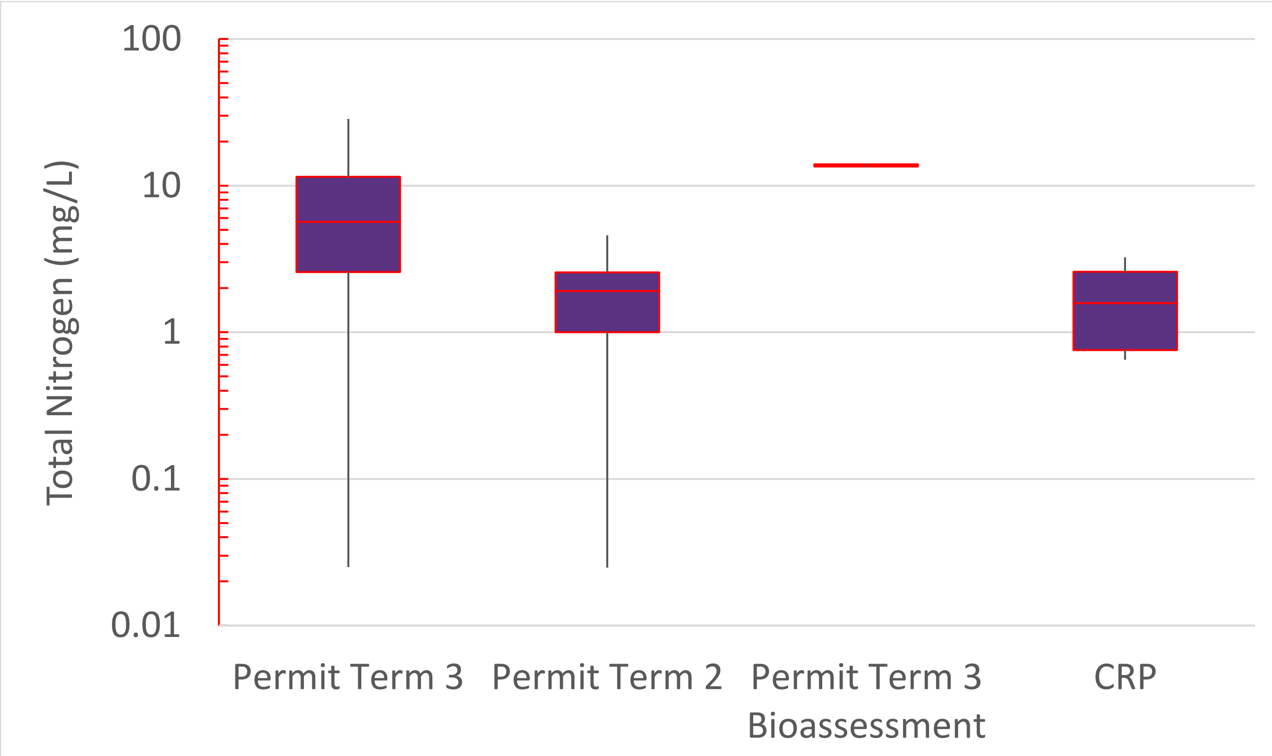


Figure 4-39 Boxplot Comparing Wet Weather Chemical Monitoring Second and Third Permit Term and Bioassessment Total Phosphorus Data at White Rock Creek

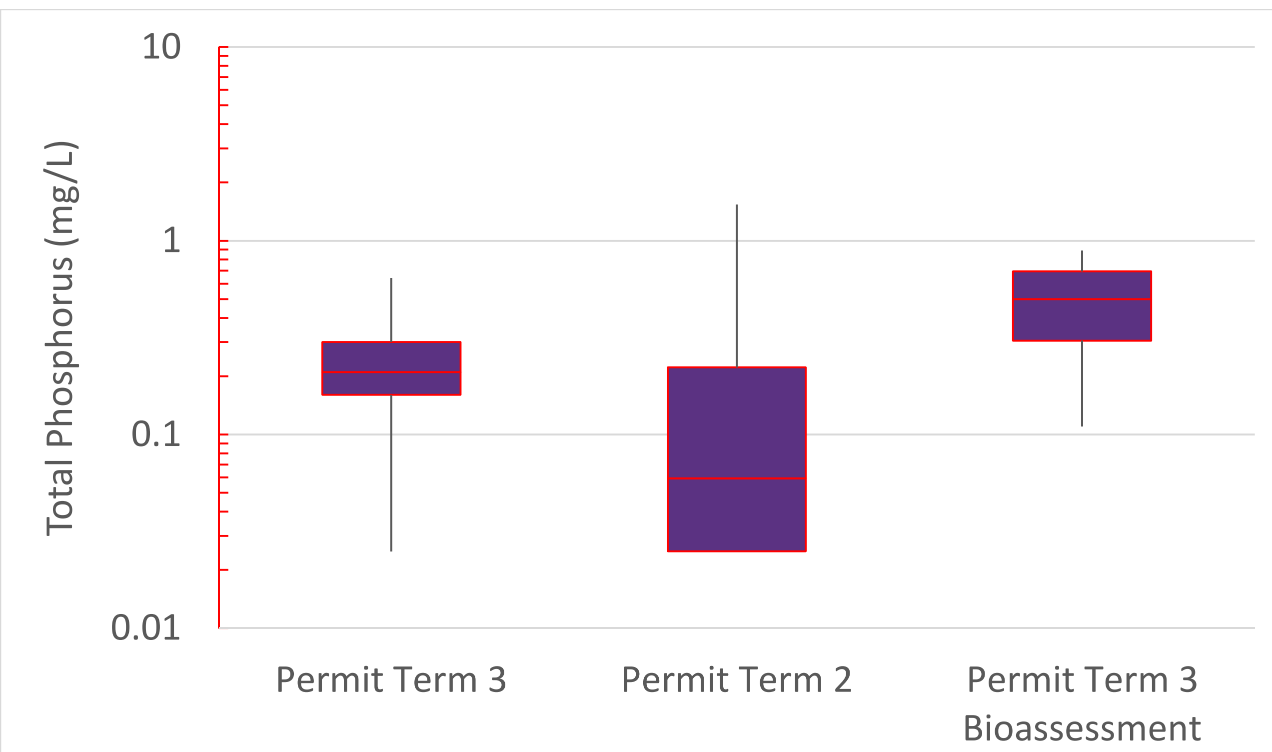


Figure 4-40 Boxplot Comparing Wet Weather Chemical Monitoring Third Permit Term, Bioassessment, and CRP Specific Conductance Data at White Rock Creek

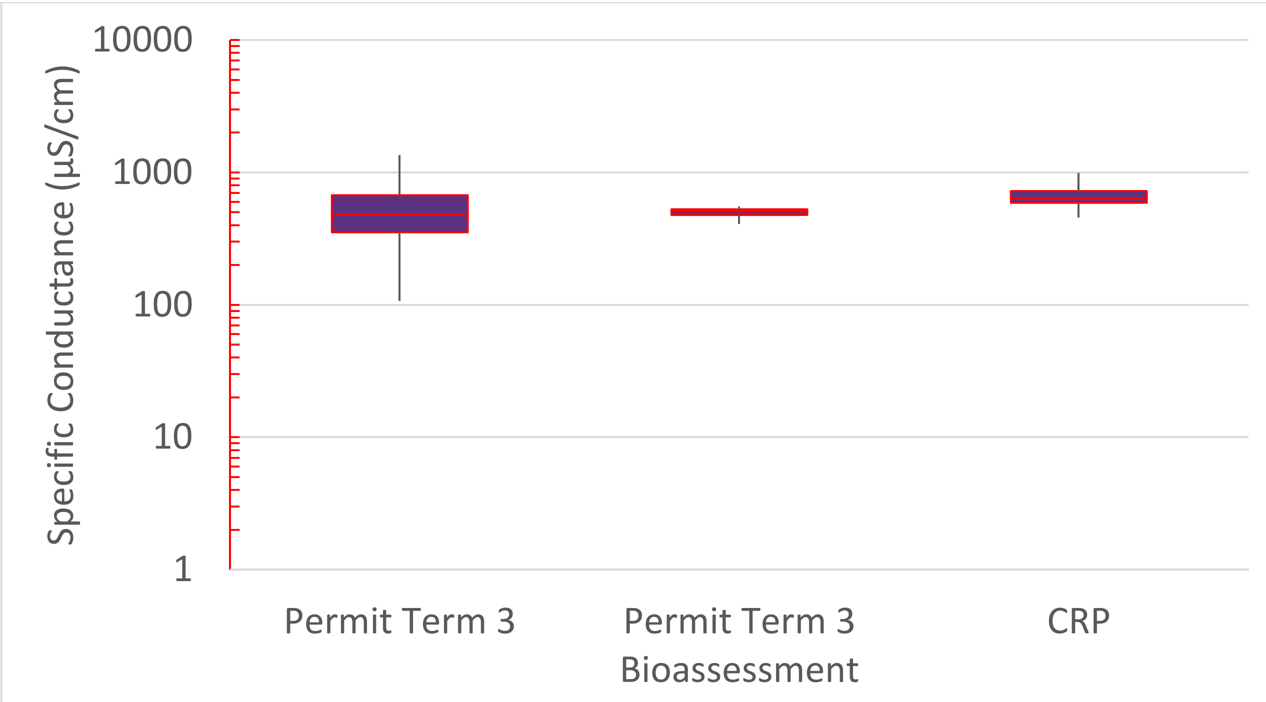
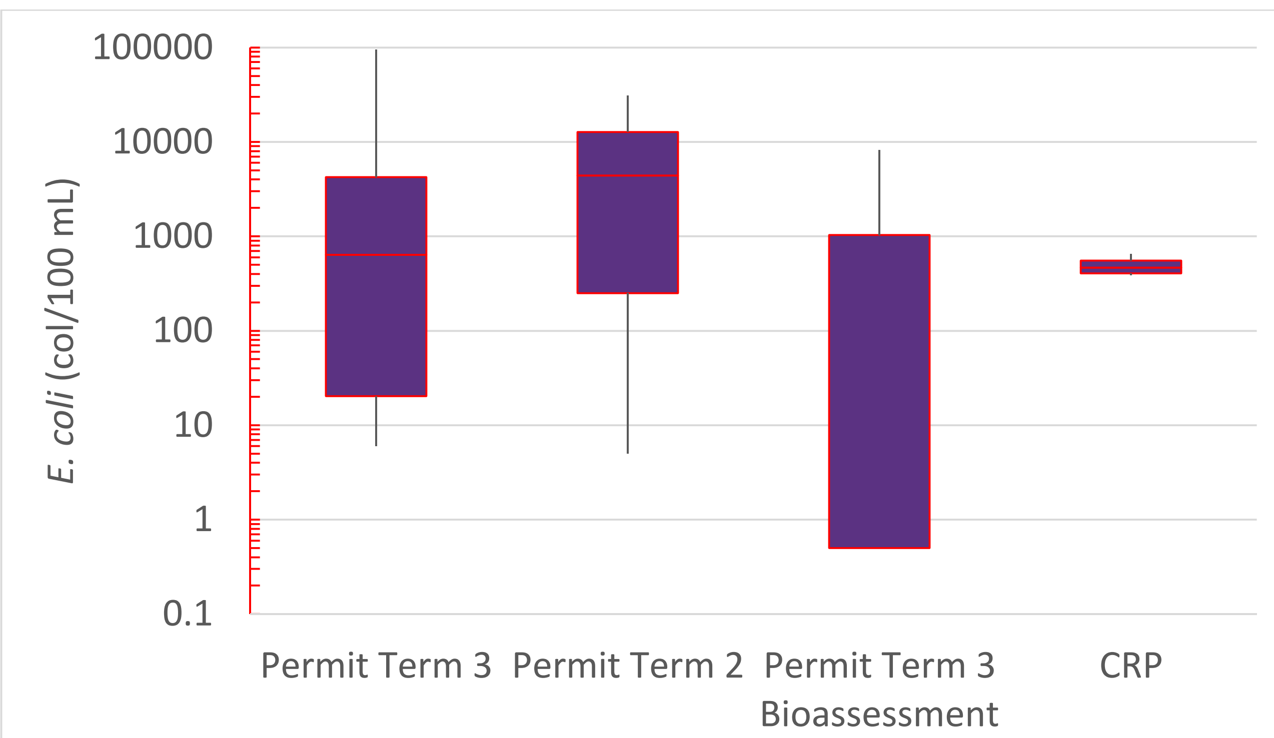


Figure 4-41 Boxplot Comparing Wet Weather Chemical Monitoring Second and Third Permit Term, Bioassessment, and CRP *E. coli* Data at White Rock Creek



The total copper exceedances occurred at all stations in 2012 and at the downstream Plano station in April 2013. *E. coli* PCR single sample criterion exceedances were observed at all stations in 2012 and 2013. The elevated TSS concentrations occurred at all stations in 2012 and at the upstream Plano station in July 2013. The elevated COD concentrations occurred at the upstream Plano station in April 2012 and July 2013. The elevated total nitrogen concentrations were observed at all stations in 2012 and at the downstream NTTA and Plano stations in 2013. Elevated oil and grease concentrations occurred at all stations over the monitoring at various dates over the monitoring term. Elevated specific conductance was measured at the downstream Plano and NTTA stations in January 2013.

4.5.27.3. Biological Data Analysis

Detailed reports of the biological assessments including data summaries can be found in the Annual Regional Wet Weather Characterization Program Monitoring Report for North Central Texas Year 2 and Year 3 (NCTCOG, 2013; NCTCOG, 2014). The habitat assessment scores and aquatic life use scores were plotted and compared to the habitat and aquatic life use categories (see Appendix AD).

The reach of White Rock Creek studied received an intermediate quality habitat score in 2012 and a high quality habitat score in 2013. The fish bioassessment scores ranged from intermediate to high, and benthic macroinvertebrate community scores ranged from limited to high. This part of White Rock Creek may be considered ecologically healthy since biological community assessment results were similar to habitat quality assessment results. The creek experiences relatively localized impacts, which do not appear to cause water quality standards to be exceeded. Water quality exhibited values supportive of healthy aquatic communities.

Anecdotal information suggests the stream ceases to flow and possibly dries up along the study reach during dry summer conditions. Cessation of flow during the summer when temperatures are highest would negatively impact animals and plants in the creek. Relatively small sources of contamination and siltation, combined with low flow conditions during summer may cumulatively impact water quality and biological communities in White Rock Creek.

Fish and benthic macroinvertebrate assessment scores were highest each year in the first sample event when stream flows were higher than during the second sample event each year when flows were lower. Fish and benthic macroinvertebrate community bioassessment scores declined on each sample date from the first through the fourth sample event. The 24-hour average dissolved oxygen (DO) similarly was lower on each subsequent sample date. These data suggest there may be a pattern of declining water quality in the study area from May 2012 through September 2013.

4.5.27.4. Potential Pollution Sources and BMP Recommendations

Land use of the White Rock Creek (headwaters) subwatershed is mainly residential followed by highway, open, and commercial land uses. The elevated concentrations of nutrients may have been a factor in the elevated COD concentrations due to increased organic matter in the stream. Over fertilization in residential areas may be a source of nutrients as may be illicit discharges. In addition, riparian alteration can affect nitrogen uptake and cycling, and turn urban riparian areas into nitrogen sources (Groffman et al. 2002, 2003). Although COD and nutrient concentrations were observed to be elevated, dissolved oxygen concentrations over the monitoring term did not fall below TCEQ criteria for aquatic life protection.

Scattered commercial land uses within the subwatershed are potential sources of metals as may be illicit discharges. Other likely sources may be from illicit connections, illegal dumping, and high traffic roadways. Stormwater was not a statistically significant source of bacteria. Potential sources of bacteria loading may be from wildlife or illicit connections. The elevated specific conductance readings were most likely the result of deicing activities preceding the sampling event in January.

A review of the aerial photography over the period revealed multiple development projects and construction activities within the subwatershed, particularly in the upper portion north of 121 which is a likely source of the sediment loadings.

BMPs recommended for these sources include compliance inspections for illicit connections, identification and removal of illegal dumping areas, public education of home and business owners regarding fertilization and turf management, review of construction site inspection protocols or BMP requirements, and review of deicing agent application strategies to roadways. Due to intermediate habitat scores, stream restoration projects may be able to increase the biological productivity of the stream.

4.5.27.5. Monitoring Recommendations

Data analyzed presents moderate indications of stream degradation and chemical indicators of water quality decline. There are no TMDLs or impairments identified for this segment of White Rock Creek or White Rock Lake. It is recommended that additional monitoring at this site be assigned a medium priority. Bioassessment data collection is recommended to be continued to monitor potential water decline. In order to determine the concentration of bioavailable metals, it is recommended that sampling of dissolved fractions of copper is conducted.

4.6. Sanitary Sewer Overflow Analysis

Reported SSO data was obtained from participating entities and filtered by monitored watersheds and year of observance. In addition, for each subwatershed water quality data was compared to TCEQ surface water quality standards, TCEQ screening levels, and NSQD data. Refer to Sections 4.2, 4.3, and 4.4 for more information regarding the development of these “benchmark” values. For each subwatershed, the number of occurrences that benchmark values were exceeded were tallied for nutrients and indicator bacteria. These occurrences were adjusted per the number of samples collected in each subwatershed of the permit term and then the subwatersheds were ranked. The volume of reported SSOs per subwatershed were plotted versus the rank of subwatersheds for both nutrients and indicator bacteria to determine whether reported SSOs may have influenced the water quality in the stream (Appendix AE). The plots demonstrate that there was not a significant relationship to the number of indicator bacteria or nutrient benchmark exceedances.

4.7. Annual Loads

The annual pollutant loading from each watershed were estimated for the parameters monitored during runoff events using the following equations:

Conventional Parameters:

Annual Pollutant Loading (lb) = Estimated Mean Annual Pollutant Concentration (mg/L) x 2.2046 x 10-6 (conversion factor) x Estimated Annual Flow Volume (L)

Bacteria:

Annual Pollutant Loading (billion colonies) = Estimated Mean Annual Pollutant Concentration (colonies/100 mL) x 1.0 x 10-8 (conversion factor) x Estimated Annual Flow Volume (L)

The Estimated Mean Annual Pollutant Concentration was calculated by taking the average of the pollutant concentrations collected through in-stream stormwater monitoring within each watershed per year. The annual flow volume was estimated using the annual precipitation and annual flow equations developed for each watershed. The annual precipitation was estimated for each watershed by utilizing rain gauges located both at the monitoring site and nearby locations, where available. Annual flow equations and description of methods can be found in Atkins, 2014a.

The City of Dallas uses the “Regional” Stormwater Monitoring Protocol as their base protocol for stormwater sampling activities. The City of Dallas does have an exception noted in correspondence contained in Appendix B regarding annual load calculation. The City of Fort Worth does not calculate annual loads due to the low number of wet weather samples collected per watershed.

Annual load tables are provided in Appendix AF.

5. Conclusions and Recommendations

Monitoring activities were conducted from 2012 to 2015 in various receiving streams in the North Central Texas region both during wet weather conditions and as part of biological monitoring efforts. The monitoring activities resulted in the collection of 395 samples, which were subsequently analyzed for total arsenic, BOD, carbaryl, COD, total copper, E. coli, field pH, total lead, total nitrogen, oil and grease, dissolved phosphorus, total phosphorus, total coliforms, TDS, TSS, and total zinc. The NCTCOG RWWCP continues to be a unique and evolving program in that it is not of the traditional outfall monitoring for storm water permitting compliance.

5.1. Entity Implemented Best Management Practices

The primary goals of the RWWCP during the third permit term were to continue the assessment of urban impact on receiving stream water quality and to document any improvement presumably resulting from local BMP implementation. Atkins reviewed each participating entity's Storm Water Management Plan (SWMP) and determined regional BMP categories. The BMPs are assumed to be implemented throughout the jurisdiction of the identified entity. There was not enough supporting data regarding specific BMP geography, temporal limits, number, and types of BMPs implemented to track effectiveness through the third permit term monitoring efforts. However, regional monitoring results obtained during the second and third permit terms will continue to serve as a baseline that can be used to evaluate the effectiveness of regional BMP implementation on in-stream water quality and health in the future.

Atkins recommends that the identification and tracking of local BMP implementation be refined before and during future RWWCP monitoring activities. It is recommended that specific geographic, temporal limits, number, and types of BMPs implemented be identified and tracked for each participating entity as part of the program efforts. In addition, pollutants targeted for removal by deployed BMP's and the level of maintenance BMP's receive should be obtained. At the conclusion of the second term, Atkins recommended that BMP implementation efforts should be documented on a five-year cycle. However, due to the complexities of each entity's storm water management program and the requirement to address total maximum daily load (TMDL) implementation and to implement changes to MS4 permits on an annual basis, Atkins recommends increasing the frequency of BMP implementation documentation to an annual basis.

While monitoring of inflows and outflows at a particular structural BMP can help determine the technological capabilities of a particular structural approach, regional in-stream monitoring can help evaluate the effect of both non-structural and structural BMP's implemented across a watershed. Regional in-stream monitoring can help assess the benefits of illicit discharge detection and elimination programs, educational programs, street sweeping programs, construction site runoff control programs, and similar efforts.

5.2. Monitored Subwatershed Characterization

Data presented in this report was organized and analyzed by subwatershed. This approach allowed for the analysis of potential pollution sources, BMPs, and monitoring recommendations specific to the subwatershed. In an effort to refine the subwatershed characterization, Atkins recommends additional documentation related to water quality in monitored subwatersheds during future RWWCP monitoring activities. Besides the BMP information discussed in the previous section, other activities to be documented (including those that may negatively affect water quality) include number/acreage of land disturbed by construction/reconstruction, number and volume of SSOs, number and volume of illicit discharges, and wastewater treatment plant discharge information.

For each subwatershed, water quality data was compared to TCEQ surface water quality standards (some of which were estimated), TCEQ screening levels, and other datasets (namely NSQD and NRSA). Refer to Sections 4.2, 4.3, and 4.4 for more information regarding the development of these "benchmark" values. For each subwatershed, the number of occurrences that benchmark values were exceeded were tallied. For purposes of comparison of the regional dataset and for identification of priority areas and pollutants, these occurrences per pollutant category were adjusted per the number of samples collected in each subwatershed of the permit term and then the subwatersheds were ranked and split into top tier, mid tier, and lower tier subgroupings (Tables 5-1, 5-2, and 5-3). Top tier represents that data for the pollutant category and subwatershed identified ranked in the lower third of identified occurrences. Mid tier represents that data for the pollutant category and subwatershed identified ranked in the middle third of identified occurrences, and lower tier represents that data for the pollutant category and subwatershed identified ranked in the highest third of identified occurrences. For example, a subwatershed with a top tier ranking for solids means that there were few to zero occurrences of a benchmark for parameters representing solids (TSS) exceeded during the monitoring term. On the other hand, a subwatershed with a lower tier ranking means that there were at least 33% more exceedances for the pollutant category than subwatersheds ranking mid tier and 67% more exceedances than subwatersheds ranking top tier. It should be noted that the number of samples collected per subwatershed varied and that for subwatersheds with fewer samples, each sample was more heavily weighted in the comparison which represents the wide statistical confidence interval presented by the low number of samples.

Table 5-1 RWWCP Third Term Wet Weather Chemical Monitoring Solids, Dissolved Solids, Nutrients, and Metals Pollutant Categories Ranking by Subwatershed

Subwatershed	Solids	Dissolved Solids	Nutrients	Metals
Big Fossil Creek	Top Tier	Top Tier	Top Tier	Top Tier
Cottonwood Branch	Mid Tier	Lower Tier	Mid Tier	Top Tier
Delaware Creek	Mid Tier	Top Tier	Lower Tier	Mid Tier
Duck Creek	Mid Tier	Lower Tier	Lower Tier	Lower Tier
Honey Springs Branch	Mid Tier	Top Tier	Mid Tier	Mid Tier
Johnson Creek	Top Tier	Lower Tier	Top Tier	Mid Tier
Lake Como - Clear Fork Trinity River	Top Tier	Top Tier	Top Tier	Top Tier
Little Fossil Creek	Top Tier	Top Tier	Top Tier	Top Tier
Marine Creek	Top Tier	Top Tier	Top Tier	Top Tier
Mary's Creek	Lower Tier	Top Tier	Top Tier	Lower Tier
North Mesquite Creek	Mid Tier	Mid Tier	Lower Tier	Mid Tier
Prairie Creek	Mid Tier	Mid Tier	Lower Tier	Mid Tier
Prairie Creek - Elm Fork Trinity River	Mid Tier	Lower Tier	Mid Tier	Lower Tier
Rowlett Creek	Lower Tier	Lower Tier	Lower Tier	Lower Tier
Rush Creek	Mid Tier	Lower Tier	Mid Tier	Top Tier
South Mesquite Creek	Lower Tier	Lower Tier	Mid Tier	Mid Tier
Spring Creek	Lower Tier	Mid Tier	Mid Tier	Lower Tier
Sycamore Creek	Mid Tier	Lower Tier	Top Tier	Lower Tier
Ten Mile Creek	Lower Tier	Mid Tier	Mid Tier	Top Tier
Turtle Creek	Mid Tier	Top Tier	Mid Tier	Lower Tier
Turtle Creek - Trinity River	Lower Tier	Mid Tier	Mid Tier	Mid Tier
White Rock Creek	Top Tier	Top Tier	Mid Tier	Top Tier
White Rock Creek (Headwaters)	Mid Tier	Top Tier	Lower Tier	Lower Tier

Table 5-2 RWWCP Third Term Wet Weather Chemical Monitoring Indicator Bacteria, pH, BOD/COD, Oil and Grease, and Specific Conductance Pollutant Categories Ranking by Subwatershed

Subwatershed	Indicator Bacteria	pH	BOD/COD	Oil and Grease	Specific Conductance
Big Fossil Creek	Lower Tier	Top Tier	Top Tier	Top Tier	--
Cottonwood Branch	Mid Tier	Lower Tier	Mid Tier	Lower Tier	Top Tier
Delaware Creek	Top Tier	Lower Tier	Lower Tier	Top Tier	Top Tier
Duck Creek	Mid Tier	Top Tier	Lower Tier	Top Tier	Top Tier
Honey Springs Branch	Lower Tier	Top Tier	Lower Tier	Top Tier	--
Johnson Creek	Top Tier	Lower Tier	Top Tier	Top Tier	Top Tier
Lake Como - Clear Fork Trinity River	Lower Tier	Top Tier	Top Tier	Top Tier	--
Little Fossil Creek	Lower Tier	Top Tier	Top Tier	Top Tier	--
Marine Creek	Mid Tier	Top Tier	Top Tier	Top Tier	--
Mary's Creek	Lower Tier	Top Tier	Top Tier	Top Tier	--
North Mesquite Creek	Top Tier	Top Tier	Top Tier	Lower Tier	Lower Tier
Prairie Creek	Mid Tier	Top Tier	Lower Tier	Top Tier	Top Tier
Prairie Creek - Elm Fork Trinity River	Lower Tier	Lower Tier	Mid Tier	Top Tier	Lower Tier
Rowlett Creek	Top Tier	Top Tier	Mid Tier	Top Tier	Lower Tier
Rush Creek	Mid Tier	Top Tier	Mid Tier	Top Tier	Lower Tier
South Mesquite Creek	Top Tier	Top Tier	Mid Tier	Lower Tier	Lower Tier
Spring Creek	Mid Tier	Top Tier	Top Tier	Lower Tier	Top Tier
Sycamore Creek	Lower Tier	Top Tier	Top Tier	Top Tier	--
Ten Mile Creek	Mid Tier	Top Tier	Lower Tier	Top Tier	Top Tier
Turtle Creek	Lower Tier	Top Tier	Lower Tier	Top Tier	--
Turtle Creek - Trinity River	Mid Tier	Top Tier	Top Tier	Top Tier	--
White Rock Creek	Top Tier	Top Tier	Lower Tier	Top Tier	--
White Rock Creek (Headwaters)	Mid Tier	Top Tier	Mid Tier	Lower Tier	Mid Tier

Table 5-3 RWWCP Third Term Bioassessment Chemical Monitoring Pollutant Categories Ranking by Subwatershed

Subwatershed	Nutrients	Metals	Indicator Bacteria	Specific Conductance	Dissolved Oxygen
Bachman Branch	Top Tier	Top Tier	Top Tier	Top Tier	Top Tier
Big Fossil Creek	Top Tier	--	Top Tier	Top Tier	Top Tier
Dixon Branch	Top Tier	Top Tier	Lower Tier	Top Tier	Top Tier
Duck Creek	Lower Tier	--	Top Tier	Top Tier	Top Tier
Five Mile Creek	Top Tier	Top Tier	Lower Tier	Lower Tier	Top Tier
Floyd Branch	Lower Tier	Lower Tier	Top Tier	Lower Tier	Top Tier
Lake Como - Clear Fork Trinity River	Top Tier	--	Lower Tier	Top Tier	Lower Tier
Little Fossil Creek	Mid Tier	--	Top Tier	Lower Tier	Top Tier
Marine Creek	Lower Tier	--	Lower Tier	Top Tier	Lower Tier
Mary's Creek	Lower Tier	--	Top Tier	Top Tier	Top Tier
Rowlett Creek	Lower Tier	--	Top Tier	Top Tier	Top Tier
Spring Creek	Mid Tier	--	Lower Tier	Top Tier	Top Tier
Sycamore Creek	Mid Tier	--	Top Tier	Top Tier	Top Tier
White Rock Creek (Headwaters)	Top Tier	--	Top Tier	Top Tier	Top Tier

5.3. Future Monitoring Recommendations

Atkins recommends that NCTCOG continue the regional wet-weather in-stream water quality monitoring approach with supplemented bioassessment activities and/or dry weather monitoring as needed. The approach provides many benefits and allows MS4 operators to assess wet weather water quality in a holistic manner. The current approach leverages MS4 operator resources, coordinates monitoring efforts, and builds on the baseline data obtained to date. In continuing the regional watershed approach, the participants should consider the program recommendations discussed below.

5.3.1. Sampling Site Selection

Sampling site selection process should be refined to address concerns expressed by EPA and TCEQ. These concerns stem from the need to restore impaired waters and to achieve the goals of the Clean Water Act. Site selection criteria that should be considered include locating sampling sites within impaired watersheds and focusing on measuring concentrations of pollutants causing watershed impairments. This will help with assessing TMDL implementation and restoration efforts. Atkins recommends that for entities performing overlapping monitoring activities (such as the transportation entities) within the same subwatershed, that credit be applied to upstream entities regarding jurisdictional coverage.

5.3.2. Bioassessments

Rapid bio-assessments are usually conducted in dry weather conditions and evaluate additional parameters (e.g., water chemistry, benthic and nekton populations, in-stream habitat, etc.) that the wet weather in-stream monitoring does not. Bioassessments are recommended to use as biological end points for storm water management programs and biological monitoring for assessing program progress. In addition, the dry weather chemical monitoring data that results from bioassessments can be compared to the wet weather monitoring data to provide information regarding the source of pollutants. Atkins recommends that the parameters that are recorded during bioassessment chemical monitoring activities be expanded to include/match those of the wet weather monitoring. This will allow for direct comparisons between the two datasets and assist with determination of pollutant sources to the stream.

5.3.3. Monitored Parameters

5.3.3.1. Pesticides and Herbicides

Carbaryl was not detected in the third permit term and Diazinon was not detected in the second permit term. There are several other pesticides and herbicides of interest for urban areas. According to USGS, 1999, the most commonly found insecticides in urban streams were Diazinon, carbaryl, chlorpyrifos, and malation. Herbicides most commonly found were atrazine, metolachor, simazine, prometon, 2,4-D, diuron, and tebuthiuron.

Legacy insecticides (aldrin and dieldrin) are a current concern for waterbodies west of Fort Worth (Lake Worth and the West Fork Trinity River) and there are existing TMDLs for aldrin and dieldrin for segments 0841A (Mountain Creek Lake), 0829A (Lake Como), and 0806A (Fosdic Lake). However, according to TCEQ, 2012 and TCEQ, 2016, dieldrin is no longer considered a contaminant of concern for the segments with existing TMDLs. Dieldrin has been banned by the EPA since 1987 but it is extremely persistent in the environment. Atkins recommends that if dieldrin continues to be detected in routine monitoring activities in downstream waterways, stormwater sampling for dieldrin may be considered as a replacement for carbaryl.

Alternatively, atrazine is one of the most commonly detected herbicide contaminating drinking water in the United States (Gilliom et al., 2007). According to communications between NCTCOG and Texas A&M AgriLife Extension Service, atrazine continues to be a commonly used herbicide in the urban environment (S. Lamanna, personal communication, June 6, 2016). Atkins recommends monitoring for atrazine and simazine may be included at no to low additional cost due to detection through the same analytical method.

5.3.3.2. Indicator Bacteria

TCEQ currently utilizes *E. coli* as an indicator for pathogens in fresh water. During both the second and third permit terms, total coliforms was included in the list of parameters to be monitored. Because there is no recognized correlation between total coliforms and fresh water pathogens by TCEQ or EPA, Atkins recommends dropping total coliforms from the list of monitoring parameters.

5.3.3.3. Nutrients

TCEQ utilizes ammonia nitrogen, nitrate nitrogen, orthophosphate, and total phosphorus for nutrient screening activities. There are currently no numeric nutrient criteria for streams in Texas. However, TCEQ initiated a Nutrient Criteria Development Advisory Workgroup and nutrient criteria development plan in 2001.

Current Texas nutrient regulation is through chlorophyll a criteria in reservoirs. In addition to adopting numeric nutrient criteria, the TCEQ regulates nutrients by applying narrative criteria to address permitted nutrient loadings at sites of concern, developing watershed rules which require nutrient reductions in wastewater discharges in or near specified water bodies, and employing the TCEQ's antidegradation policy to new and increased discharge loads of nutrients. Nutrient screening data for phosphorus, nitrogen, and chlorophyll a are also considered when identifying areas of concern in the Texas Integrated Report of Surface Water Quality. As part of the development of nutrient criteria and methodology the TCEQ will develop and consider criteria options for selected streams and rivers, tidal streams, and estuaries.

The current nutrient monitored parameters in wet weather include total phosphorus and total nitrogen. In order to compare results directly to the TCEQ nutrient screening criteria, to identify the forms of nitrogen and phosphorus impacting streams, to better determine the sources of nutrients in the stream, and to compare between wet weather chemical monitoring and bioassessment results, Atkins recommends adding ammonia nitrogen, nitrate nitrogen, and orthophosphate to the monitoring parameters for wet weather chemical monitoring (these parameters are already collected for most bioassessment activities).

5.3.3.4. Metals

In order to identify areas of concern based upon monitoring data, Atkins identified aquatic life protection and human health criteria from the TSWQS. For most metals, with the exceptions of mercury and selenium, water quality criteria are expressed as dissolved concentrations. The dissolved concentration of a metal is the bioavailable fraction of the total metal concentration. Atkins estimated total fraction criteria by calculating segment-specific values.

For the Duck Creek, Johnson Creek, and White Rock Creek (headwaters) subwatersheds, it is recommended that sampling of dissolved fractions of metals is conducted in order to determine the concentration of bioavailable metals. This sampling is recommended to be conducted during wet weather activities and would be used to determine whether concentrations of observed metals in the second and third permit term may be impacting aquatic communities in those streams.

5.3.4. Other

In addition to the tracking of BMP implementation data described in Section 5.1, Atkins recommends that land use, industrial activities, and construction activities be closely tracked during future monitoring terms to assist in the identification of specific pollutant sources. For example, construction project data may be collected from each entity and tracked over the permit term to identify the location and timeframe of the construction activities in an effort to monitor the effectiveness of construction site BMPs with greater accuracy.

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Appendix A

Regional Wet Weather Characterization Plan Proposal for the Third Permit Term Submission, Letter of Approval from TCEQ, and Minor Amendment Documentation

The North Central Texas Regional Wet Weather Characterization Plan Proposal for the Third Permit Term

I. History of the Regional Program

Since 1996, a regional storm water monitoring program has been on-going in the Dallas-Fort Worth (DFW) metropolitan area among the seven largest cities and major transportation agencies for compliance with Federal and State storm water permit requirements. During the initial permit term (1996 -2001), seven municipalities (Dallas, Fort Worth, Arlington, Irving, Garland, Plano and Mesquite) and two local districts of the Texas Department of Transportation (TxDOT) received joint approval from U.S. Environmental Protection Agency (EPA) for a regional monitoring program which utilized the assistance of a shared consultant team and the United States Geological Survey (USGS) to sample and analyze 22 outfalls primarily from small watersheds of a predominantly single land use type. Although these sample collections served to characterize typical urban runoff from these limited land use types, and were useful for estimating general pollutant loadings, they did little to evaluate impacts on actual receiving streams. In the next permit term, now administered by the Texas Commission on Environmental Quality (TCEQ), approval was obtained to utilize in-stream stations for the regional monitoring program to better assess this impact. The revised program was termed the Regional Wet Weather Characterization Program (RWWCP) and was added as an option in Part IV.A.3 of the Texas Pollutant Discharge Elimination System (TPDES) Municipal Separate Storm Sewer System (MS4) permits issued to the Phase I North Central Texas governmental entities. The primary goal of this new in-stream monitoring program was to obtain baseline data on receiving streams in the DFW Metroplex for use in determining long-term water quality trends. Since the RWWCP language existed outside of each permit, it allowed greater flexibility for making changes to the program. During this second permit term, the North Texas Tollway Authority (NTTA) joined the regional program. All other participants remained the same, except for the TxDOT-Fort Worth District who became a co-permittee with the cities of Fort Worth and Arlington and were no longer required to conduct wet weather monitoring. According to the original RWWCP protocol, municipal participants collected data from three sampling sites in the watershed (typically upstream, midstream and downstream) and the transportation agencies collected data from two sites (upstream and downstream stations only). Samples were collected quarterly from each site during a qualifying rain event and were analyzed for 18 parameters.

As an added component, the City of Fort Worth selected the Representative Rapid Bioassessment Monitoring Option (Part IV.A.2) in their permit, which allowed the chemical sampling frequency to be reduced from four times per year per site to once per year per site. In its place, two bioassessments were conducted each year at a minimum of nine sites. These bioassessments were based on protocols developed by the EPA. A summarization of this bioassessment data was included along with the chemical data in the annual regional monitoring report each year of the permit term.

II. Lessons Learned from the Most Recent Permit Term

At the end of the second permit term's sampling effort, a final summary monitoring report was prepared by the regional consultant, PBS&J, to assess the three-year sampling effort. The report found that in general, firm conclusions regarding the factors determining in-stream water quality could not be made due to the limited number of samples collected. Nevertheless, the report observed that all of the watersheds sampled had relatively consistent concentrations when compared to each other and that there was a general tendency of decreasing concentrations of parameters analyzed going from upstream to downstream. Constituent concentrations were found to be typically higher in warmer months as expected, but the length of antecedent dry period had surprisingly little influence on the in-stream water quality. Depending on parameter, the data was either higher or lower than national averages of storm water outfall data; however, it was generally higher overall relative to local ambient, dry weather data. This last finding is somewhat to be expected since storm events wash down the urban landscape and carry a higher load of pollutants than ambient conditions. As a result of these findings and a retrospective evaluation of the regional sampling program, PBS&J made the following recommendations for modifying the RWWCP in the next term:

<u>Increase the number of sampling events per site</u> - PBS&J suggested that either the frequency of monitoring during the year be increased or the same watershed be monitored for at least two years.

<u>Refine sampling site selection process</u> – This suggestion includes locating sites within impaired watersheds, focusing on impairment-causing pollutants, locating sites that foster long-term deployment, allowing for flow monitoring and minimizing vandalism.

<u>Conduct more RBAs in other jurisdictions</u> – Encourage more participating entities to include Rapid Bioassessments in the next permit term to gain a more thorough understanding of water quality impacts to urban receiving streams.

<u>Revise monitored pollutants</u> – The residential use of Diazinon was banned several years ago and has not been detected in any samples taken during this permit term. Therefore, PBS&J has recommended that Diazinon be replaced with Carbaryl, a commonly-used pesticide, for the next permit term. They also suggested that Cadmium be dropped from the parameter list since it was detected at very low levels and in less than 25 percent of the samples collected.

These recommendations were incorporated in this proposal for the next permit term.

III. Characterization of the Proposed Program

<u>*Proposed Plan for Third Permit Term*</u>

The primary goal of the monitoring program was to obtain baseline data on receiving streams in the DFW Metroplex for use in determining long-term water quality trends. This was generally achieved in the past permit term but final analysis indicated that more data is needed to establish actual trends. The Regional Storm Water Monitoring Partners of North Central Texas seek to continue documenting water quality improvements resulting from BMP effectiveness as they have over the past several years encompassing two permit terms. The regional partners would like to continue with the RWWCP because it has allowed for: 1) more coordinated and comprehensive water quality sampling; 2) more sound and reliable data collection; 3) greater cost effectiveness; and 4) a truer assessment of regional impact on stream water quality.

For this upcoming permit term, the Cities of Arlington, Dallas, Fort Worth, Garland, Irving, Mesquite and Plano, together with the North Texas Tollway Authority and TxDOT-Dallas District have agreed to continue their regional partnership to work cooperatively through the North Central Texas Council of Governments to develop a revised RWWCP. Permit numbers and relevant dates for each participant are included in Table 1.

TABLE 1: LIST OF PERMITTEES

PERMITTEE	TPDES PERMIT NUMBER	DATE ISSUED	EXPIRATION DATE
City of Arlington	WQ0004635000	5/26/2006	5/26/2011
City of Dallas	WQ0004396000	7/27/2007	2/22/2011
City of Fort Worth	WQ0004350000	2/22/2006	2/22/2011
City of Garland	WQ0004682000	12/22/2005	12/22/2010
City of Irving	WQ0004691000	5/26/2006	5/26/2011
City of Mesquite	WQ0004641000	5/26/2006	5/26/2011
City of Plano	WQ0004775000	7/20/2007	7/20/2012
North Texas Tollway Authority	WQ0004400000	2/22/2006	2/22/2011
Texas Department of Transportation-Dallas	WQ0004521000	6/30/2006	6/30/2011

The municipal regional partners have created a new sampling plan that will effectively monitor at least 50% of their jurisdictional area by the end of the permit term. This extent of jurisdictional coverage will allow a reasonable assessment of jurisdictional watersheds while striving to achieve a balance among the various goals of obtaining valid scientific information, meeting permit compliance, and addressing what is practicable for each entity. As in the previous term, this plan proposes to continue in-stream watershed monitoring, but seeks to obtain greater statistical robustness of the data by increasing the sampling period at each location to a minimum of two years. The primary goal of the RWWCP during this permit term will be to continue the assessment of urban impact on receiving stream water quality and to document any improvement presumably resulting from local BMP implementation. The data collected during this permit term will build upon the set of regional data needed from each site for meaningful trend analysis.

This proposal also includes a more comprehensive biomonitoring component. Since assessing the impact of urban runoff on receiving stream quality is a primary focus of this program, assessing the biological integrity of the streams is fundamental. With this proposed plan, 24 watersheds will be chemically monitored and 12 watersheds will be bioassessed across the region, with substantial overlap between the two sampling approaches.

A map with each entity's selected watersheds is shown in Figure 1. Specific locations of sampling sites in each watershed will be determined prior to each sampling year and will be submitted in each prior year's annual regional monitoring report. Refer to Table 2a&b for identification of the watersheds selected by each entity and their relative proportion to jurisdictional area. The relative percent and the area of the selected watersheds are indicated with bold type. Unbolded watersheds indicate unselected, shared watersheds that were selected by other entities. Most of the municipal entities were able to achieve the 50% coverage with only two watersheds; however, due to the size of their jurisdictional area, the City of Dallas selected eight watersheds and the City of Fort Worth selected six to monitor. Jurisdictional coverage was not considered in the selection of the two transportation agency watersheds.

The North Central Texas Council of Governments (NCTCOG) role in the regional monitoring program is to coordinate the overall program, obtain consultant assistance on behalf of the regional partners, assist participants in site selection and the development of the sampling protocol(s); collect and summarize the data; and generate/deliver annual compliance reports.

Sampling Metrics

Monitoring is proposed to commence January 1 of the year following the issuance of the City of Garland's permit, anticipated in mid-2011. Given the existing staggered permit expiration dates among the participants, it is likely that permit renewals issued by TCEQ will also be staggered. Consequently, the regional program will need to have written endorsement from TCEQ that participants will receive credit for any monitoring they contribute as part of the regional effort that would be applied toward their eventual permit. However, by incorporating a lag period to maintain a calendar year-based schedule, most of the participating permittees will likely have their renewals issued by then (i.e. January 1, 2011), making for a smoother transition.

Table 3 provides a detailed breakdown of the number and frequency of each partner's proposed sampling activity(ies). Most entities are chemically sampling one watershed in their jurisdiction for two consecutive years and then moving to a second watershed for another two years. There are a few exceptions to this standard pattern:

- The City of Dallas will need to sample at least six watersheds in order to achieve the 50% coverage; This will be accomplished by chemically sampling four watersheds and performing bioassessment in four additional watersheds as a part of the regional program.

- To achieve the 50% area coverage, the City of Fort Worth needs to sample six watersheds. They intend to bioassess all six watersheds at two locations twice a year for all five years of the permit term. For chemical sampling, they intend to collect in-stream samples at two sites within two watersheds each year. By the end of the third year, they will have monitored each of their six selected watersheds once. They propose to then select the top four most biologically-impaired watersheds to continue with a second sample in the remaining two years of the permit term. Table 3 reflects this sampling pattern of four watersheds being sampled twice and two watersheds being sampled once for a total of 20 chemical samples in the permit term.

- The City of Mesquite has a unique situation where there are only two watersheds in their jurisdiction and the two creeks of those watersheds are almost wholly contained within the city limits. They would prefer to establish permanent in-stream monitoring stations in each of the two creeks and to sample them concurrently all four years. Due to the relatively small size of the watersheds, they feel they can adequately assess the urban runoff impact by strategically locating a single sampling station in each watershed.

Chemical Sampling Details

Each participating entity will be responsible for final selection of sampling sites. Samples will be collected from these sites according to the schedule identified previously and analyzed for the parameters listed in the table below. Following consultant recommendations (see Section II Lessons Learned…), Diazinon has been replaced with Carbaryl, and Cadmium has been dropped from the parameter list.

Entities may use in-house staff or a consultant of their choice for sample collection. Although we encourage the use of a common laboratory for analysis to ensure consistency, entities may also select the TCEQ-approved laboratory of their choice, as long as procedures are followed and data quality objectives are met as specified in the approved regional monitoring protocol (to be finalized prior to the first sampling year).

Table 4: List of Parameters	
Parameter	**Method of Collection**
Oil & Grease	Grab
pH	Grab
E. coli	Grab
Total Coliforms	Grab
Total Dissolved Solids (TDS)	Composite
Total Suspended Solids (TSS)	Composite
Biochemical Oxygen Demand (BOD_5)	Composite
Chemical Oxygen Demand (COD)	Composite
Total Nitrogen	Composite
Dissolved Phosphorus	Composite
Total Phosphorus	Composite
Carbaryl	Composite
Total Arsenic	Composite
Total Chromium	Composite
Total Copper	Composite
Total Lead	Composite
Total Zinc	Composite

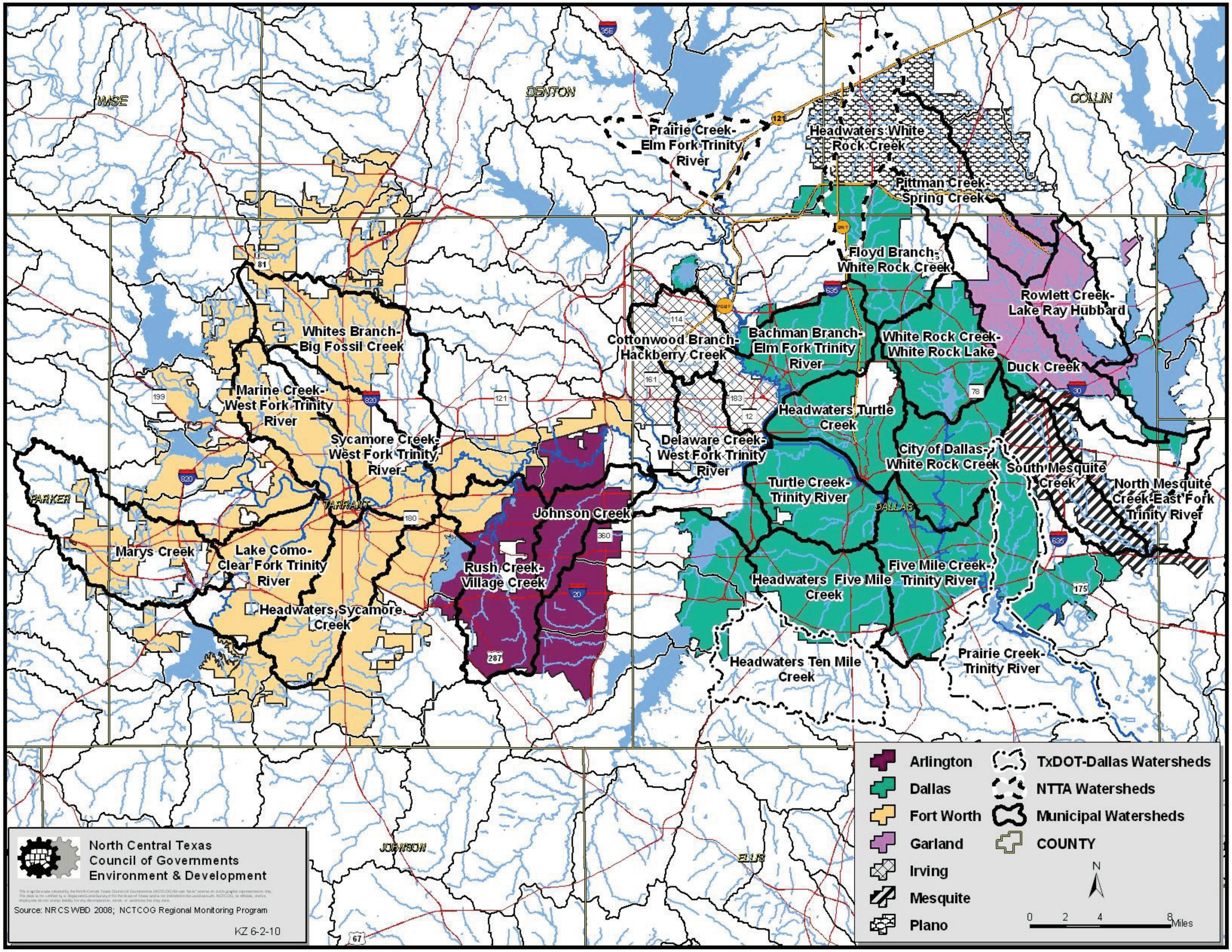


Figure 1: Regional Monitoring Entities & Selected HUC-12 Subwatersheds for Third Term Monitoring

Table 2a: RWWCP Watersheds Selected for Third Permit Term Monitoring

Area of City Sq mi. ⟶		Arlington 98.57		Dallas 385.92		Fort Worth 344.67		Garland 57.16		Irving 67.88		Mesquite 46.36		Plano 72.25	
HUC-12 Watersheds	*	% of City	HUC12 Sq. Mi.	% of City	HUC12 Sq. Mi.	% of City	HUC12 Sq. Mi.	% of City	HUC12 Sq. Mi.	% of City	HUC12 Sq. Mi.	% of City	HUC12 Sq. Mi.	% of City	HUC12 Sq. Mi.
Johnson Creek	C	**17.61%**	**17.36**												
Rush Creek-Village Creek	C	**35.51%**	**35.01**												
Bachman Branch-Elm Fork Trinity River	B			**7.98%**	**30.79**					16.16%	10.97				
City of Dallas-White Rock Creek	C			**9.00%**	**34.75**							0.27%	0.13		
Five Mile Creek-Trinity River	C			**10.79%**	**41.66**										
Floyd Branch-White Rock Creek	B			5.5%	21.3									3.1%	2.2
Headwaters Five Mile Creek	B			**9.00%**	**34.74**										
Headwaters Turtle Creek	C			**7.4%**	**28.4**										
Turtle Creek-Trinity River	C			**8.94%**	**34.5**										
White Rock Creek-White Rock Lake	B			**8.73%**	**33.7**			1.46%	0.83						
Headwaters Sycamore Creek	BC					**10.22%**	**35.22**								
Lake Como-Clear Fork Trinity River	BC					**9.79%**	**33.74**								
Marine Creek-West Fork Trinity River	BC					**8.58%**	**29.56**								
Mary's Creek	BC					**6.29%**	**21.69**								
Sycamore Creek-West Fork Trinity River	BC					**6.77%**	**23.32**								
Whites Branch-Big Fossil Creek	BC					**9.73%**	**33.52**								
Duck Creek	BC			0.92%	3.56			**42.19%**	**24.11**			5.75%	2.67		
Rowlett Creek-Lake Ray Hubbard	BC			0.63%	2.42			**29.92%**	**17.1**						
Cottonwood Branch-Hackberry Creek	C			0.04%	0.15					**29.90%**	**20.29**				
Delaware Creek-West Fork Trinity River	C			1.53%	5.91					**22.16%**	**15.04**				
North Mesquite Creek-East Fork Trinity River	C			0.39%	1.5							**26.82%**	**12.43**		
South Mesquite Creek	C			0.22%	0.85							**54.27%**	**25.16**		
Pittman Creek-Spring Creek	BC							16.04%	9.17					**25.42%**	**18.37**
Headwaters White Rock Creek	BC			1.66%	6.42									**26.2%**	**18.93**
Totals of selected (bolded) watersheds ⟶		**53.12%**	**52.37**	**67.34%**	**259.84**	**53.76%**	**185.24**	**72.11%**	**41.21**	**52.06%**	**35.33**	**81.09%**	**37.59**	**51.62%**	**37.3**

*** (C) – Chemical (B) – Bioassessment (BC) – Both Bioassessment & Chemical**

"HUC12 Sq. Mi" indicates the area of the watershed within the jurisdictional boundary

Table 2b: RWWCP Watersheds Selected for Third Permit Term Monitoring
Transportation Agencies

Area of City Sq mi. ⟶	*	Arlington 98.57		Dallas 385.92		Fort Worth 344.67		Garland 57.16		Irving 67.88		Mesquite 46.36		Plano 72.25	
HUC-12 Watersheds		% of City	HUC12 Sq. Mi.	% of City	HUC12 Sq. Mi.	% of City	HUC12 Sq. Mi.	% of City	HUC12 Sq. Mi.	% of City	HUC12 Sq. Mi.	% of City	HUC12 Sq. Mi.	% of City	HUC12 Sq. Mi.
TxDOT- Dallas Selected Watersheds															
Headwaters Ten Mile Creek	C			**0.7%**	2.5										
Prairie Creek-Trinity River	C			**4.7%**	18.0							**1.6%**	0.7		
NTTA Selected Watersheds															
Headwaters White Rock Creek	C			1.66%	6.42									**26.2%**	**18.93**
Prairie Creek-Elm Fork Trinity River	C														
Totals of all watersheds (in this table only) ⟶				**7.06%**	26.92							**1.6%**	0.7	**26.2%**	**18.93**

Table 3: Sampling Metrics

Entity	Chemical Sampling									Bioassessment Sampling				
	Annual				Permit Term					Annual			Permit Term	
	Sampling Sites per Watershed A	Number of Watersheds Sampled B	Frequency of Sampling C	Total Annual Samples D (A×B×C)	Number of Years Sampling E	Total Samples For Permit Term F (D×E)	Number of Watersheds Sampled G	Number of Samples Taken in Each Watershed H (F÷G)	Number of Samples Per Site I (H÷A)	Sites Per Water-shed Per Year J	Frequency of Sampling K	Water-sheds Per Year L	Number of Years Sampling M	Total Samples N (J×K×L×M)
Arlington	3	1	4	12	4	48	2	24	8	-	-	-	-	-
Dallas	3	2	4	24	4	96	4	24	8	1	2	4	4	32
Fort Worth	2	2	1	4	4 and 1	16 + 4	4 and 2	4 + 2	2 and 1	2	2	6	5	120
Garland	3	1	4	12	4	48	2	24	8	1	2	1	4	8
Irving	3	1	4	12	4	48	2	24	8	-	-	-	-	-
Mesquite	1	2	4	8	4	32	2	16	8	-	-	-	-	-
Plano	2	1	4	8	4	32	2	16	8	1	2	1	4	8
NTTA	2	1	4	8	4	32	2	16	8	-	-	-	-	-
TxDOT-Dallas	2	1	4	8	4	32	2	16	8	-	-	-	-	-

Grab samples will be collected during the first flush and analyzed for *E. coli*, total coliforms, oil and grease, and pH. An additional first flush sample and four subsequent samples collected at equal time intervals will be taken over the first two hours of the event and combined for a composite sample. Samples will be collected for no more than two hours, regardless of storm duration. The grab samples can be obtained either manually or from some type of automated collection device to better address safety concerns. Sampling will be conducted only on qualifying events which are defined as satisfying the following requirements: 1) Antecedent dry period of 72 hours minimum; 2) Rainfall volume of 0.10 inch minimum; and a 3) Quantifiable increase in water surface elevation attributable to storm water runoff. Rain gauges will be deployed in each watershed to support assessment of local wet weather conditions.

Bioassessments

The recent National Research Council (NRC) report *Urban Stormwater Management in the United States* recommends including bioassessments for assessing storm water management program progress. It also recommends that storm water management strategies should address all stressors to a stream which can be accomplished through biological monitoring since biota naturally integrate the environmental conditions that impact them. TCEQ has continued the option established by EPA in the MS4 permit language of allowing bioassessments to be used as a replacement for a portion of the chemical monitoring requirement. The RWWCP has always had a bioassessment component as part of its overall approach and the partners would like to continue including it. In fact, this proposal suggests a greater use of bioassessments across the region than ever before.

Both EPA and TCEQ have developed an array of methods and approaches that can be used in conducting bioassessments. Each of these regulatory entities has developed manuals outlining these various steps. As EPA states in their manual, Rapid Bioassessment Protocols for Use in Streams and Wadeable Rivers: Periphyton, Benthic Macroinvertebrates, and Fish, 2nd Ed. (1999) the protocols described are not "intended to be used as a rigid protocol without regional modifications. Instead, they provide options for agencies or groups that wish to implement rapid biological assessment and monitoring techniques."

As such, the regional program participants that are implementing bioassessments (Dallas, Fort Worth, Garland and Plano) will be performing bioassessment based upon standardized protocols as set forth in applicable EPA and TCEQ manuals. These protocols will be detailed in each annual report but generally involve habitat assessment, a measurement of standard field physical conditions, and collection and identification of macroinvertebrates and possibly other biota. Watershed parameters will be compared to a baseline standard to determine the habitat's health, through use of a reference site or other methods. The number of watersheds being sampled, stations per watershed and samples per year using bioassessment protocols are all listed in Table 3.

IV. Summary of the RWWCP Proposal for the Third Permit Term

In summary:

- Each participant has selected watersheds to achieve greater than 50% coverage of their jurisdictional area.
- To increase statistical robustness, most watersheds will be sampled for a minimum of two years.
- Most watersheds will be sampled quarterly; Fort Worth is putting a greater effort into the bioassessment sampling instead.
- The number of sites per watershed varies per entity based on local conditions.
- Arlington, Dallas, Garland, Irving, Mesquite, Plano, NTTA and TxDOT-Dallas will collect samples for the first four years of the five-year permit term.
- Fort Worth has elected to perform chemical monitoring for the entire five-year permit term.
- 17 chemical parameters will be analyzed in each storm event sample
- Dallas, Fort Worth, Garland and Plano will also do biological assessments.

TEXAS COMMISSION ON ENVIRONMENTAL QUALITY

Protecting Texas by Reducing and Preventing Pollution

February 11, 2011

Mr. Keith C. Kennedy, Manager
Environmental Programs
North Central Texas Council of Governments
P.O. Box 5888
Arlington, Texas 76005-5888

Re: Revised North Texas Regional Wet Weather Characterization Program

Dear Mr. Kennedy:

Thank you for your letter of January 12, 2011 requesting approval to implement changes to the North Central Texas Regional Wet Weather Characterization Program (RWWCP). The RWWCP includes the cities of Arlington, Dallas, Fort Worth, Garland, Irving, Mesquite and Plano, together with the North Texas Tollway Authority and TxDOT-Dallas District. We have reviewed the submittal and approve the RWWCP with the changes that you proposed.

As you stated in your letter, the primary goal of the RWWCP program has been to obtain baseline data on receiving streams in the DFW Metroplex for use in determining long-term water quality trends. While this was generally achieved in the past permit terms for the regional partners, your analysis indicated that more data is needed to establish actual trends. You stated that the regional partners propose to continue with the RWWCP because it has allowed for more coordinated and comprehensive water quality sampling; more sound and reliable data collection; greater cost effectiveness; and a truer assessment of regional impact on stream water quality. We certainly support this effort as an effective tool to monitor the MS4.

The revised sampling plan will continue in-stream watershed monitoring, will refine the sampling site selection process, and will include some changes to the pollutants monitored (i.e., diazinon is being replaced by carbaryl and cadmium is being removed). The plan will effectively monitor at least half of each regional partner's jurisdictional area by the end of their TPDES MS4 permit term and will increase the sampling period at each location to a minimum of two years. This proposal also includes a more comprehensive biomonitoring component, in that 24 watersheds will be chemically monitored and 12 watersheds will be bioassessed across the region.

You indicated that monitoring is proposed to commence January 1 of the year following the issuance of the MS4 permit for the City of Garland. This is because the permit is scheduled to be issued before the permits for the other regional partners are issued and will require a start delay. TCEQ recognizes that given the existing staggered permit expiration dates among the participants, it is likely that permit renewal dates will also be staggered. Each permittee will be given credit for that effort in their respective permit renewals.

You asked how the regional partners will be required to report data, since the previous permits have required the use of discharge monitoring report (DMR) forms to tabulate outfall data. For each regional partner that continues participating in the RWWCP, DMRs will not be required. Our staff has worked with both TCEQ and EPA enforcement staff to address this issue; and as a result, the requirement to submit DMRs has been removed when the regional sampling option is chosen.

If you have any additional questions, please contact me at your convenience, either by phone at (512) 239-2012, or at the address on this letter.

Sincerely,

Jaya Zyman-Ponebshek, Leader
Storm Water & Pretreatment Team
Wastewater Permitting Section (MC-148)
Texas Commission on Environmental Quality

JZP/CH/gv

Proposed Minor Amendment to the Regional Wet Weather Characterization Plan

for the TxDOT-Dallas District Sampling Schedule

February 22, 2012

This document outlines a proposed minor amendment to the *"North Central Texas Regional Wet Weather Characterization Plan Proposal for the Third Permit Term*" (RWWCP), dated December 2010 and approved by the TCEQ in February 2011. The RWWCP for the Third Permit term was developed in accordance with several key recommendations resulting from analysis of the sampling efforts conducted under the previous (second) monitoring term. Two key recommendations included increasing the number of sampling events per site and refining the sampling site selection process. In accordance with these recommendations, sampling scenarios for each of the Partners were developed using the best information at the time and incorporated into the approved RWWCP.

Under "Table 3: Sampling Metrics" of the RWWCP, the TxDOT-Dallas District (TxDOT) is scheduled to collect chemical samples (wet weather sampling) at two locations in one watershed for two years, and then move to a second watershed and collect samples from two sites in a second watershed for two years. This scenario would result in a total of 16 samples collected from each of the two watersheds (32 samples overall) by the end of the permit term. Under "Table 2b: RWWCP Watersheds Selected for Third Permit Term Monitoring Transportation Agencies," TxDOT selected the Prairie Creek-Trinity River and Headwaters Ten Mile Creek watersheds for the watersheds for conducting wet weather sampling.

Due to unforeseen problems with locating two sampling sites in the Prairie Creek-Trinity River watershed, TxDOT is seeking a change Table 3 to collect samples at one site within each of the two watersheds for each of the four years of the permit term. This sampling scenario still yields 16 samples from each of the watersheds and a total of 32 samples collected overall by the end of the permit term (this scenario mirrors the sampling schedule conducted by the City of Mesquite under the approved RWWCP). The attached table shows TxDOT-Dallas District's original sampling schedule and the proposed revised sampling schedule.

The following information provides justification for the proposed change to the RWWCP:

- In the previous monitoring term, TxDOT conducted chemical sampling in the Prairie Creek-Trinity River watershed at two locations during the 2009 calendar year. The downstream site (Site 0902, Prairie Creek and I-20) experienced frequent flooding and proved to be both a safety hazard and an area at high risk for equipment loss and damage. TxDOT's Site 0901, Prairie Creek and Hwy 175, did not experience flooding during the 2009 calendar year and remains a viable sampling site for the current monitoring term.
- Site 0902, Prairie Creek and I-20, has a wide floodplain that is subject to frequent flooding following moderate to large rain events. Flooding during the 2009 calendar year resulted in multiple sampling efforts at the site. Several sampling efforts were voided due to the sampling equipment being submerged underwater or the inability to access the site due to high water. Equipment was removed, cleaned, retested and redeployed. In some cases the equipment had to be replaced. It is anticipated that continued monitoring at this location will result in high

equipment replacement costs which may strain TxDOT's monitoring budget. TxDOT was the only entity required to replace key water quality monitoring equipment in the previous permit term.

- In 2011, multiple site visits were conducted throughout the Prairie Creek-Trinity River watershed to locate a replacement site for Prairie Creek and I-20 site. Various sites were evaluated and none were found suitable due to one or more of the following reasons:
  - High potential for flooding.
  - Access to sites could not be obtained due to private property issues.
  - Sites did not provide for proper securing and mounting water quality monitoring equipment for prolonged periods.
  - Various areas appeared to have high human use and might be susceptible to vandalism.
- Sampling at the Prairie Creek and Hwy 175 site for all four years of the permit term will allow for more data to be collected over a longer period of time and provide a suitable basis for future statistical comparisons and potential trends in water quality. This is consistent with the recommendations provided in the RWWCP. In addition, the Prairie Creek and Hwy 175 site is located near a USGS stream gauging station which allows for accurate pollutant loading calculations. This is the only site with an active stream gauging station at the sampling location.
- Although two viable sampling sites had been located in the other TxDOT watershed (Headwaters Ten Mile Creek), this proposed change reflects sampling at only one of the sites for all four years in order to be consistent with the Prairie Creek-Trinity River sampling scenario. The resulting higher "n" values achievable by sampling at one site in each watershed for all four years will help in statistical robustness and in comparison purposes.

This proposed amendment to the RWWCP has been considered and approved by all Monitoring Partners of the North Central Texas Regional Monitoring Program at their February 22, 2012 meeting. This proposed amendment is being submitted to the TCEQ as an appendix to Year 1 Annual Regional Wet Weather Characterization Program Monitoring Report.

North Central Texas Regional Wet Weather Characterization Plan for the Third Permit Term

Change to "Table 3: Sampling Metrics" for TxDOT-Dallas

February 22, 2012

Sampling Metrics for TxDOT-Dallas District														
	Chemical Sampling									Bioassessment Sampling				
	Annual				Permit Term					Annual			Permit Term	
Entity	Sampling Sites per Watershed A	Number of Watersheds Sampled B	Frequency of Sampling C	Total Annual Samples D (A×B×C)	Number of Years Sampling E	Total Samples For Permit Term F (D×E)	Number of Watersheds Sampled G	Number of Samples Taken in Each Watershed H (F÷G)	Number of Samples Per Site I (H÷A)	Sites Per Water-shed Per Year J	Frequency of Sampling K	Water-sheds Per Year L	Number of Years Sampling M	Total Samples N (J×K×L×M)
TxDOT-Dallas[1]	2	1	4	8	4	32	2	16	8	-	-	-	-	-
TxDOT-Dallas[2]	1	2	4	8	4	32	2	16	8	-	-	-	-	-

1 Original sampling schedule for TxDOT-Dallas from The North Central Texas Regional Wet Weather Characterization Plan Proposal for the Third Permit Term, dated 12/2010.

2 Revised sampling schedule for TxDOT-Dallas due to inability to locate a second sampling site in one of the watersheds to be sampled.

Sampling metrics for other entities remain unchanged.

Appendix B

City of Dallas Sampling Protocol

City of Dallas Stormwater Management

Concerning Atkins Regional Wet Weather Sampling Protocol,

The City of Dallas Stormwater program has reviewed the Atkins Regional Stormwater Program Protocol for Wet Weather Monitoring FY2012-2016. The City of Dallas Stormwater Management Section will follow the given Protocol with only a few needed changes. Site information located in Appendix I.

City of Dallas Stormwater Management Protocol Changes 2012

Section	Regional protocol	Dallas Protocol
2.3	**Field Sampling Organization (FSO)** Freese & Nichols and Dougherty, Sprague Environmental Inc. (FSO) will be responsible to execute the stormwater monitoring activities that includes monitoring equipment installation, maintenance, and calibration; sample collection; preparing the required reports; conducting the required equipment maintenance; validation tasks; QA tasks; and data reporting activities.	The City of Dallas will monitor stormwater activities, provide their own equipment for sample collection, will calibrate field equipment and contact equipment support services for maintenance if needed.
2.4	**Analytical Laboratory** The FSO will use TTI Environmental Laboratory to conduct sample analysis.	The City of Dallas is using Xenco and TTI Laboratories to carry out any analysis of samples collected. Contact information for Xenco Laboratories: **Name:** Monica Tobor **Company:** Xenco Laboratories **Phone #:** (214) 902 - 0300 **Address:** 9700 Harry Hines Blvd Dallas, Texas 75220
2.5	**Communications Protocol** FSO's sampling personnel may be divided into as many as seven field teams and three office leaders if necessary. Each field team will consist of one field team leader and one field assistant. The office leader will remain in communication with the field team leaders and liaise between the field teams and the laboratory. The office leader will remain aware of potential weather and traffic concerns and alert the field teams as needed.	The City of Dallas will have one field team consisting of two staff which is consistent with the sampling personnel organization of the Regional Program Protocol. Team will be responsible for communicating with the environmental laboratory and the immediate supervisor during a sampling event.
3.1	**Site Locations** The watershed maps and deployment locations can be found in Appendix A of the Regional Program Protocol	The site locations for the City of Dallas will be located in Appendix I of the Dallas Stormwater Management Protocol

3.3	**2012-2013 Planned Monitoring Stations** Five cities will conduct quarterly sampling, three cities have three stations and two cities have two sampling stations. Two roadway authorities will have two stations to be sampled each quarter	The City of Dallas will sample a total of four water sheds - each with three sampling stations - during years 2012-2013. During the first permit year two watersheds will be sampled quarterly, other two will be sampled next year and then rotate each year.
4.1	**Overview of Equipment** Sampling will be conducted using the ISCO 6712, ISCO 730, ISCO SPA 1489 Cellular Phone System, ISCO 674 Rain Gauge	The City of Dallas will be using the ISCO 6712 model with ISCO 674 Rain Gauge and ISCO 750 Flow Meter. A cellular phone system will not be installed.
4.2.5	**Programming** The sampler will activate when a one inch rise is detected. The module will then fill the first of the four one-gallon containers. Then an additional 0.5-gallon aliquot will be collected in the subsequent one-gallon containers every 30 minutes. Aliquots will continue to be collected until 120 minutes has passed from the start of sample collection	The City of Dallas will be using a different program script, in order to collect and analyze samples for parameters with short hold time from the three sampling stations in one rain event. Sampler equipment will be programmed to activate at a one-inch level rise within a one-hour period. At activation, the sampler will collect two-one gallon samples (1st flush). Then after fifteen minutes, the sampler will fill the remaining two one gallon jars (composite) over an hour period in five equal aliquots.
5.3.3	**Automatic Sampler** This section describes the sampler sequence as addressed in Section 4.2.5 above	See Section 4.2.5 above for Automatic Sampler Info. Field condition checklists – Peak 1-hour precipitation rate will not be recorded. Flow data is not needed to calculate load estimates using the “Simple Method”. Flow data will be recorded and may be used as an optional addition to the final report.
5.3.4	**Stormwater Sample Collection** Samples will be identified with a unique series of letters and numbers that indicate location and date that sample was collected. Example: AR0703 –The first two letters indicate the area watershed where the sample was collected. The next four digits indicate the site number associated calendar year of which it was sampled.	The City of Dallas will use permanent site ID to identify the sampling sites instead of the site ID changing with each calendar year. Example: TCTR-100, TCTR-200 and TCTR-300 – the alpha letters represent the water shed being sampled, three proceeding numeric digits such as 100, 200 and 300 represent the upstream, mid-stream and down steam respectively of the creek. Quarterly sampling for the same site will be identified by the Quarter number. Example TCTR-100-1, TCTR-100-2.
5.4	**Monitoring Constituents** Table 5-1 lists the constituents to be monitored and analyzed in this project.	The City of Dallas will not analyze Total Coliforms. Total Suspended Solids will be analyzed in the field with a calibrated sampling instrument (DR890).
8.0	**Flow and Pollutant Load Estimates** Annual Pollutant Loading (lb) = Estimated Mean Annual Pollutant Concentration (mg/L) * 2.2046*10-6 (conversion factor) * Estimated Annual Flow Volume (L)	The City of Dallas uses the “The Simple Method” for load calculation from the Center for Watershed Protection (CWP) 2003. <u>Chemical constituents</u> L = 0.226 * R * C * A Where: L = Annual pollutant load (lbs) R = Annual runoff (inches) C = Pollutant concentration (mg/l) A = Area (acres) 0.226 = Unit conversion factor <u>Bacteria</u> L = 103 * R * C * A Where: L = Annual load (billion colonies) R = Annual runoff (inches) C = Bacteria concentration (1,000/ ml) A = Area (acres) 103 = Unit conversion factor
9.1 10.2	**Laboratory Sample Preparation** **Laboratory Quality Assurance**	See Section 2.4 above

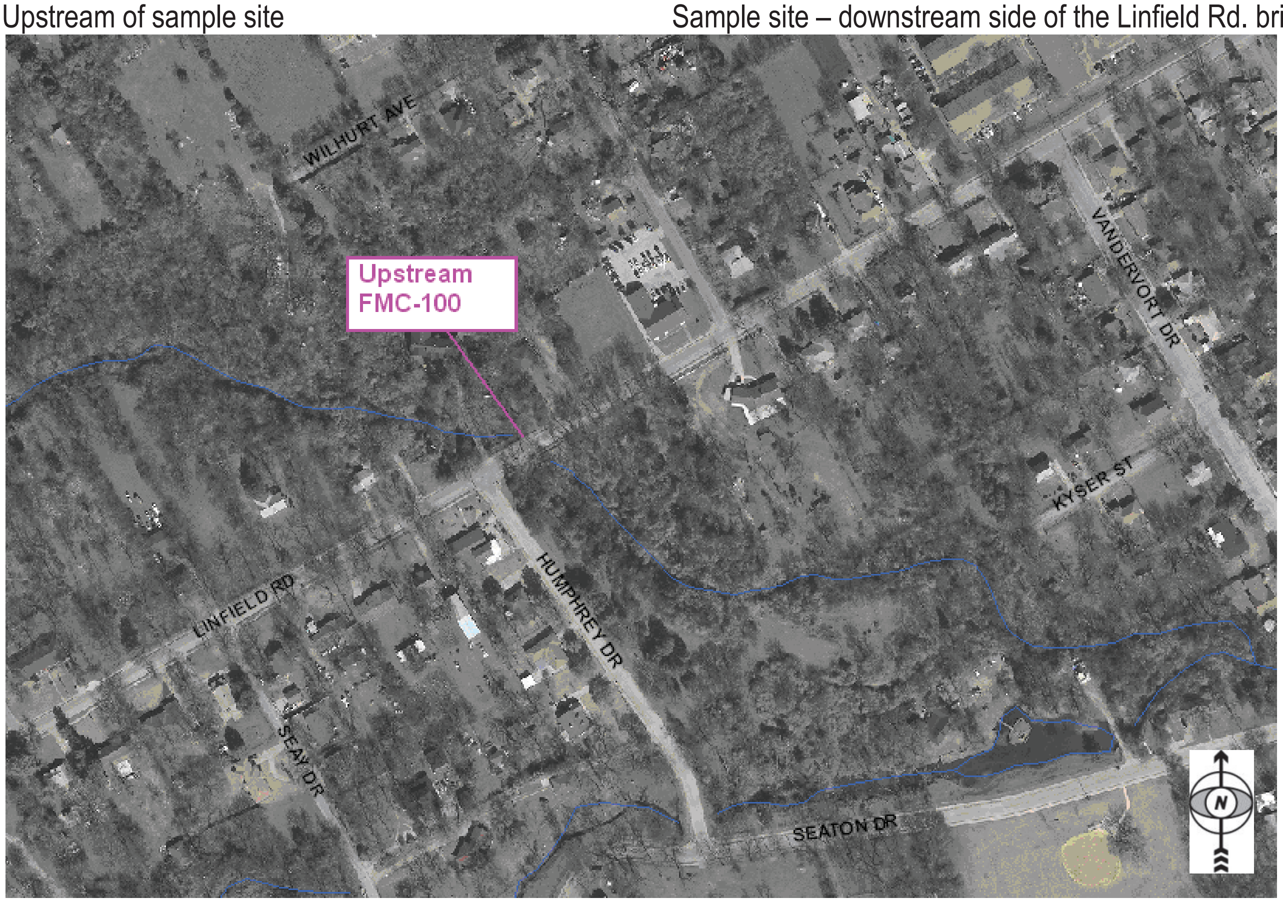
Appendix 1
Location Aerials for
City of Dallas Sampling Sites
FY2012-2016

Site ID: FMC-100
GPS Coordinates: -96.765777 32.710769
Address: 3200 Linfield Road
MAPSCO: 56X
HUC12 Watershed: Five Mile Creek-Trinity River
Waterway: Honey Springs Branch
Land Use: Residential

NOTES: The sample site is located at the creek's intersection with Linfield Road.

Upstream of sample site

Sample site – downstream side of the Linfield Rd. bridge



Site ID: FMC-200

GPS Coordinates: -96.760929 32.709680

Address: 4400 Vandervoort Drive

MAPSCO: 56Y

HUC12 Watershed: Five Mile Creek - Trinity River

Waterway: Honey Springs Branch

Land Use: Residential

NOTES: The sample site is located on the east side of Vandervoort Drive.

Sample site – downstream of the Vandervoort bridge

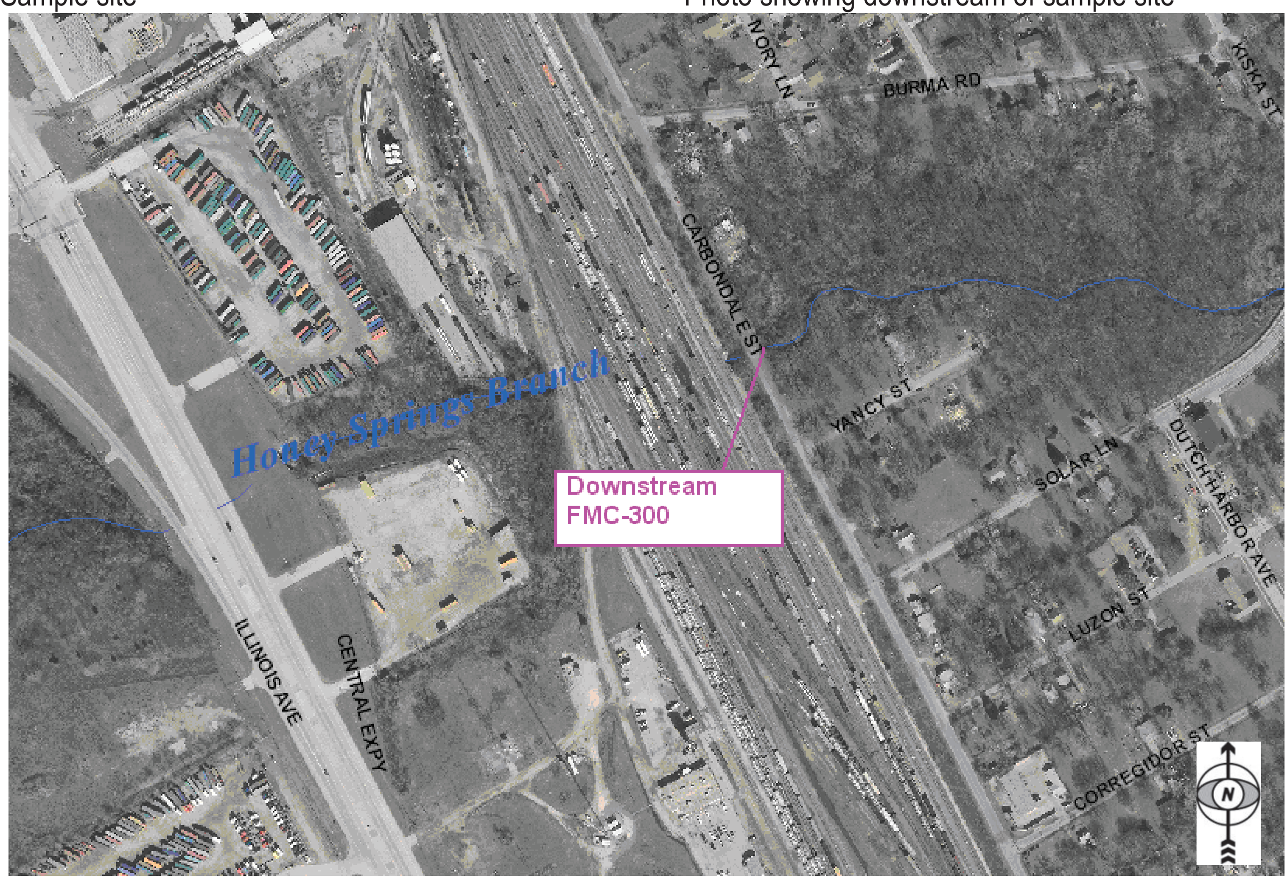
Sample site access point

Site ID: FMC-300
GPS Coordinates: -96.747856 32.711500
Address: 8000 Carbondale St.
MAPSCO: 56Z
HUC12 Watershed: Five Mile Creek - Trinity River
Waterway: Honey Springs Branch
Land Use: Industrial, residential, and dedicated-park

NOTES: The sample site is located on the east side of Carbondale Street, downstream of the bridge crossing.

Sample site

Photo showing downstream of sample site

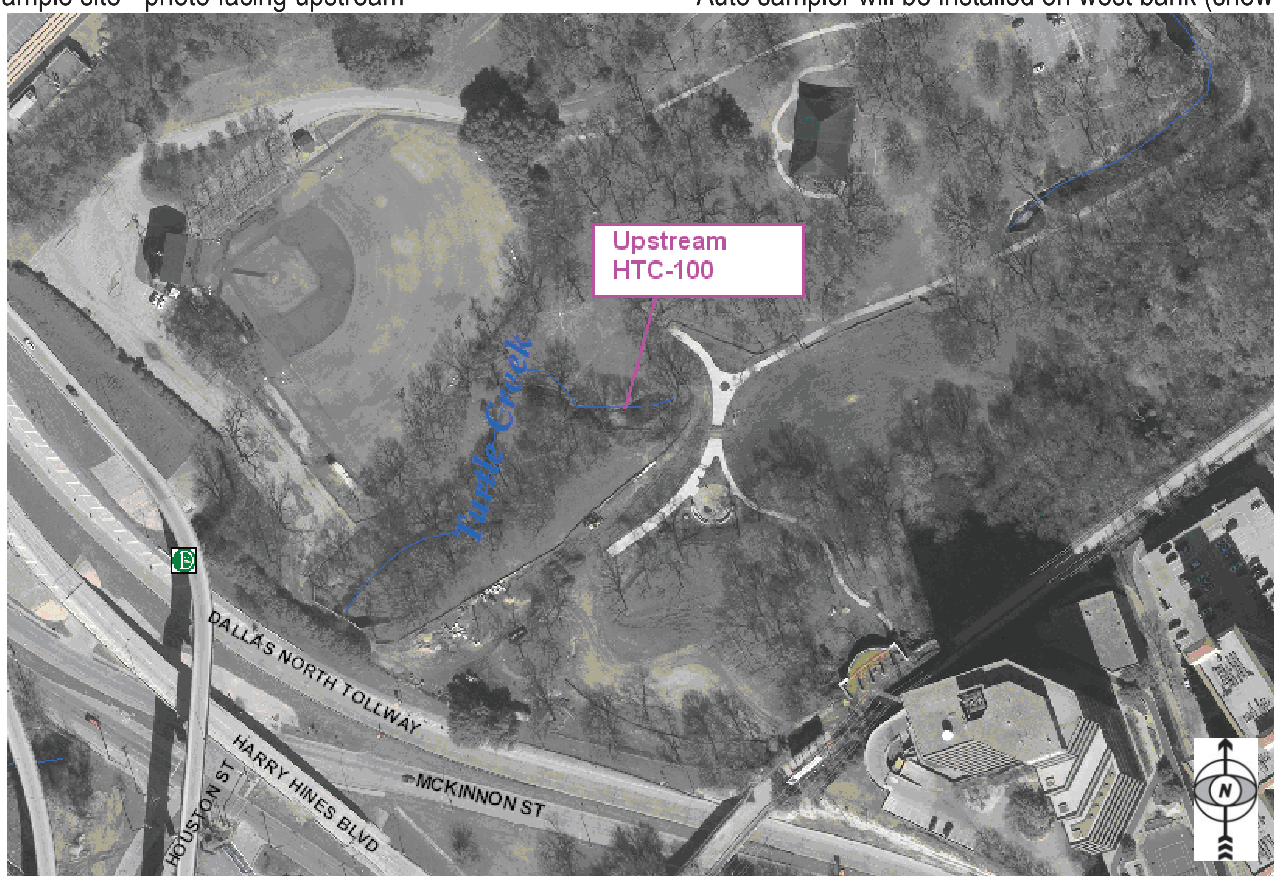


Site ID: HTC-100
GPS Coordinates: -96.813045 32.799577
Address: 3505 Maple Ave. **MAPSCO**: 45A
HUC12 Watershed: Headwaters Turtle Creek **Waterway**: Turtle Creek
Land Use: Dedicated-Park, and Residential

NOTES: The sample site is located east of the baseball field at Reverchon Park. The creek resurfaces at this location via a culvert.

Sample site - photo facing upstream

Auto sampler will be installed on west bank (shown)

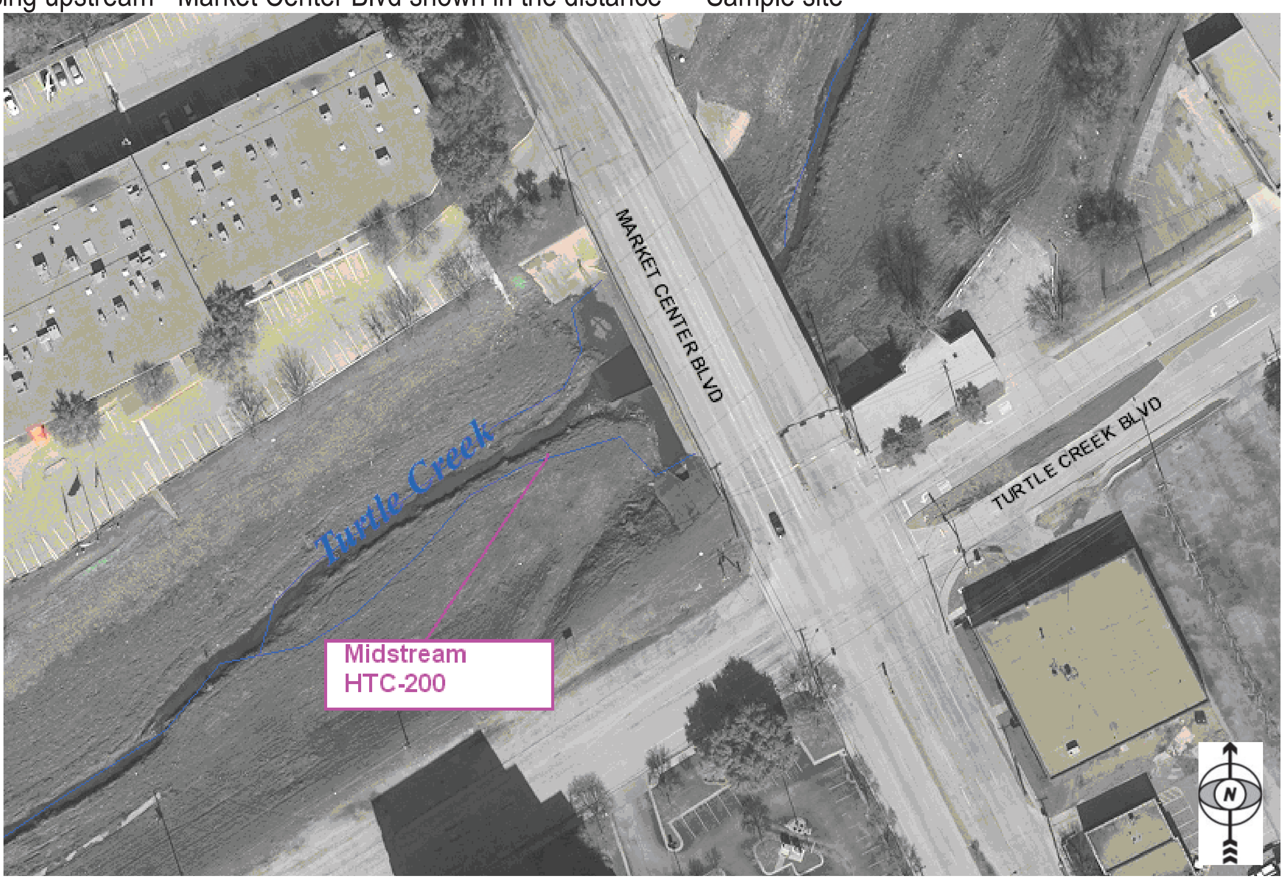


Site ID: HTC-200
GPS Coordinates: -96.824203 32.795850
Address: 1201 Turtle Creek Blvd. **MAPSCO**: 44H
HUC12 Watershed: Headwaters Turtle Creek **Waterway**: Turtle Creek
Land Use: Industrial

NOTES: The sample site is located just south of the Market Center Blvd. bridge crossing. Installment of the auto sampler is planned for the east bank, near the covered outfall.

Facing upstream - Market Center Blvd shown in the distance

Sample site

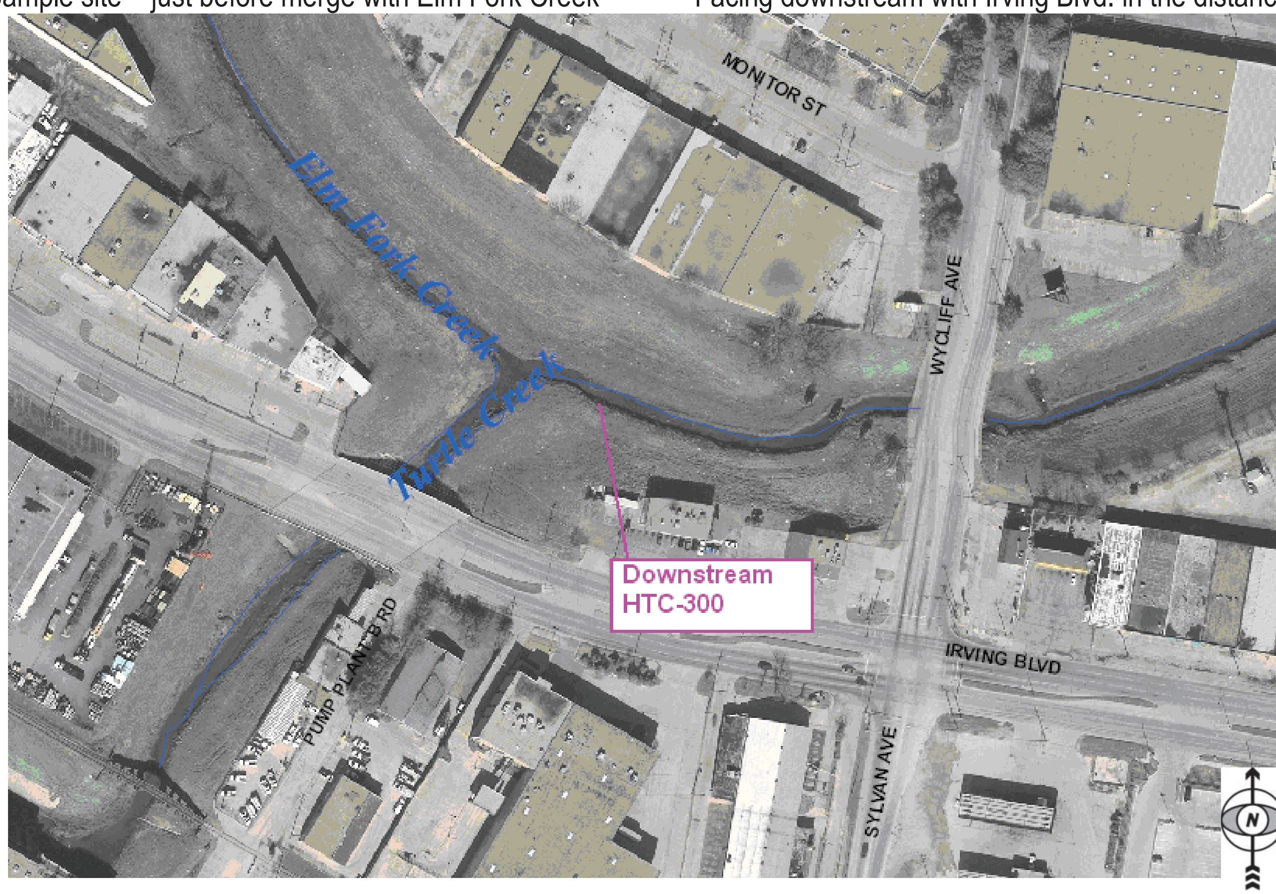


Site ID: HTC-300
GPS Coordinates: -96.835034 32.796901
Address: 2240 Irving Blvd. **MAPSCO**: 44G
HUC12 Watershed: Headwaters Turtle Creek **Waterway**: Turtle Creek
Land Use: Industrial

NOTES: The sample site is located west of Wycliff Ave, and along the south bank of Turtle Creek just before it merges with Elm Fork Creek.

Sample site – just before merge with Elm Fork Creek

Facing downstream with Irving Blvd. in the distance

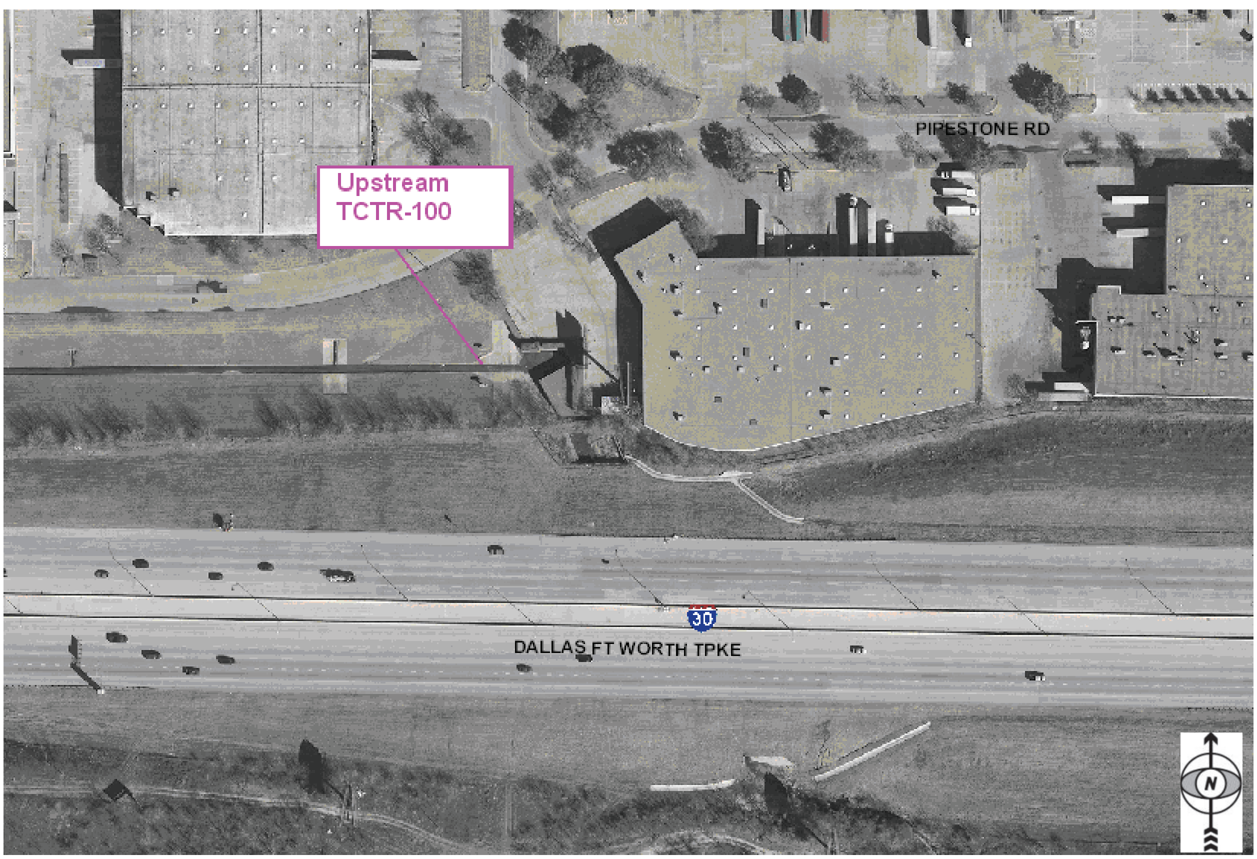


Site ID: TCTR-100
GPS Coordinates: -96.884368 32.768494
Address: 3805 Pipestone Rd.
MAPSCO: 43S
HUC12 Watershed: Turtle Creek – Trinity River
Waterway: Mican Channel
Land Use: Dedicated-Park and Industrial

NOTES: Located at the south side of Pipestone Road.

Photo shows concrete channel, facing downstream. Auto sampler will be installed on the north side (right).

Photo facing upstream - culverts crossing under I-30



Site ID: TCTR-200
GPS Coordinates: -96.891362 32.771135
Address: 3951 La Reunion Pkwy. **MAPSCO**: 42V
HUC12 Watershed: Turtle Creek – Trinity River **Waterway**: Mican Channel
Land Use: Commercial and Industrial

NOTES: Located at the intersection of La Reunion Pkwy and Bastille Rd.

Photo facing upstream, auto sampler will be installed on the west side (right)

Photo showing downstream side of sample area

Site ID: TCTR-300
GPS Coordinates: -96.892632 32.778860
Address: 4300 Singleton Blvd. **MAPSCO**: 42R
HUC12 Watershed: Turtle Creek – Trinity River **Waterway**: Mican Channel
Land Use: Commercial and Industrial

NOTES: Sample site is located on the north side of Singleton Blvd.

Sample site - photo taken facing west

Photo facing upstream from sample area

.

Site ID: WRC-100

GPS Coordinates: -96.728893 32.792756

Address: 3800 Samuell Blvd.

MAPSCO: 47F

HUC12 Watershed: White Rock Creek – White Rock Lake

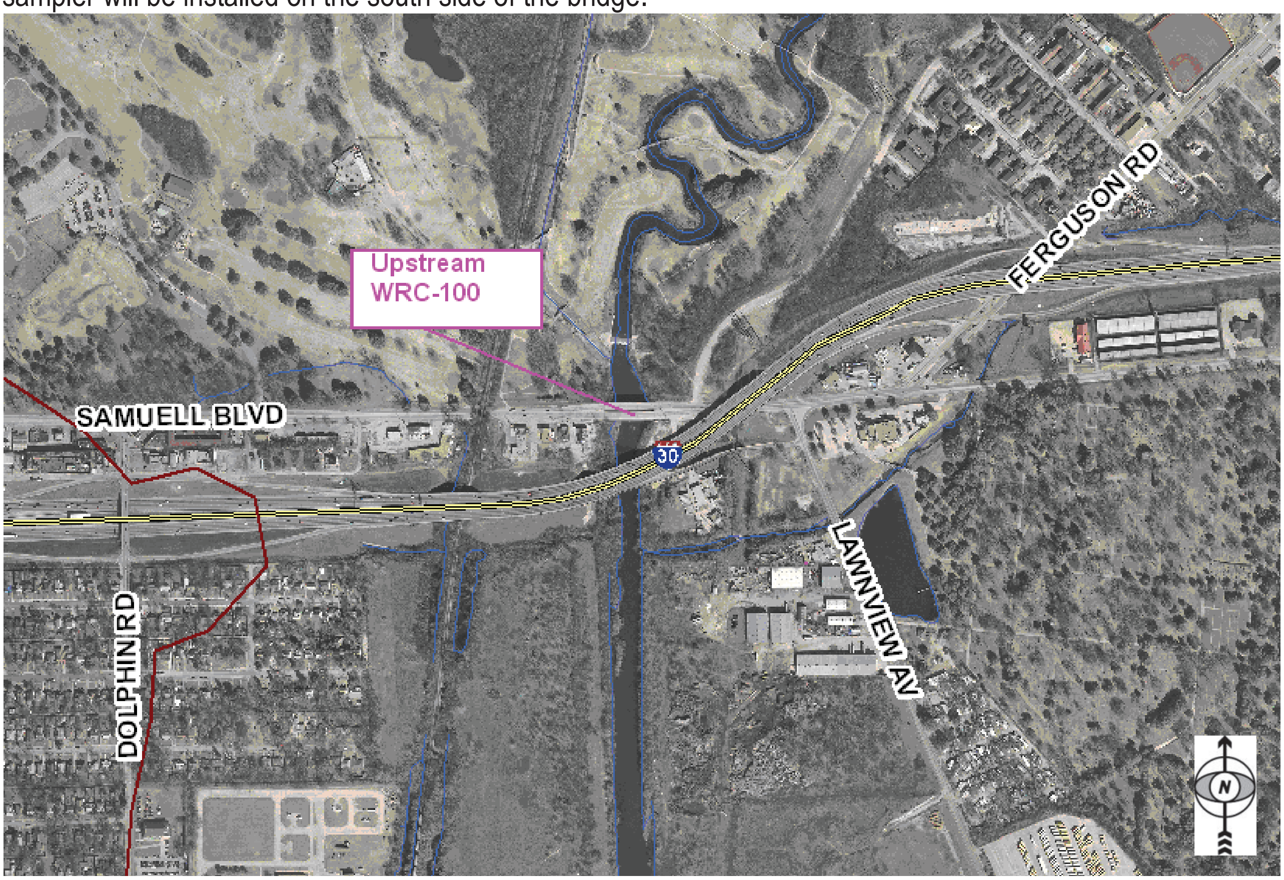
Waterway: White Rock Creek

Land Use: Dedicated-Park, Residential and Industrial

NOTES: Sample site is located between Samuell Blvd and I-30 Frwy.

Photo facing east from Samuell Blvd bridge. Auto sampler will be installed on the south side of the bridge.

Photo taken facing downstream



Site ID: WRC-200
GPS Coordinates: -96.730564   32.766982
Address: 5000 Scyene Rd.
MAPSCO: 47T
HUC12 Watershed: White Rock Creek – White Rock Lake
Waterway: White Rock Creek
Land Use: Dedicated-Park, Residential and Industrial

NOTES: Sample site is located on the north side of Samuell Blvd.

Photo taken from east bank and facing west.

Sample site on east bank

Site ID: WRC-300

GPS Coordinates: -96.730780 32.745551

Address: 5100 C. F. Hawn Frwy. **MAPSCO**: 57F

HUC12 Watershed: White Rock Creek – White Rock Lake **Waterway**: White Rock Creek

Land Use: Dedicated-Park and Industrial

NOTES: Sample site is located on the north side of Samuell Blvd.

Sample site access; facing west. Auto sampler will be installed along the east bank.

Photo shows the creek under the C. F. Hawn Frwy; facing upstream

City of Dallas
Stormwater Management

Regional Bioassessment Sampling Protocol

The City of Dallas Stormwater program has reviewed the Atkins Regional Bioassessment Program Protocol for Wet Weather Monitoring FY2011-2016. The City of Dallas Stormwater Management Section will follow the given Protocol, with the following variances, as listed below. Monitoring site information is provided in Appendix 1. Standard Bioassay data forms are provided in Appendix 2.

City of Dallas Stormwater Management
Bioassessment Protocols 2011-2016

Section	Regional protocol	Dallas Protocol
1.2	**Purpose of Document** Macroinvertebrates will be collected and other biota such as fish and mussels, will be collected depending on conditions and/or availability of resources.	The City of Dallas will be collecting macroinvertebrates and instream habitat data to support development of an index of Biotic Integrity using Rapid Bioassessment Protocols. The City will not be collecting fish and mussels as a part of the biological monitoring.
2.3	**Field Sampling Organization (FSO)** The Field Sampling Organization (FSO), Atkins will implement bioassessments based on protocols in the TCEQ Surface Water Monitoring Procedures Manual (TCEQ, 2007), which is based in part on the EPA methods (Barbour, et al, 1999). These protocols involve assessment of habitat used by fish and aquatic invertebrates, water quality, flow, fish, aquatic invertebrates, and other biota, including riparian vegetation and mussels.	The City of Dallas will conduct the bioassessment program by using a modified sampling approach adapted from EPA and TCEQ manuals. Fish and mussels are considered to be “optional” parameters under these methods and not be collected as a part of the City of Dallas analyses.
4.1	**Water Quality** A Yellow Springs Institute (YSI) water quality meter will be used for the measurement of water temperature, DO, specific conductivity and pH.	The City of Dallas will be using Dual-Input Multi-Parameter Digital Meter (HQ40d) for the measurement of water temperature, DO, specific conductivity and pH. In house Stormwater Management lab will conduct *E coli* test using the Colilert Quantitray IDEXX Quantitray 2000 method. Nitrates and phosphates will be sent to an environmental laboratory to be analyzed.
4.2	**Fish**	Refer to section 1.2
4.3	**Benthic Macroinvertebrates** Benthic macroinvertebrate samples will be analyzed by Atkins' Austin, Texas staff. A scientific collection permit must be kept with staff while in the field, and Texas Parks and Wildlife Department (TPWD) must be notified at least 24 hours prior to field sampling. The scientific collection permit will be obtained from TPWD and TCEQ prior to sample collection. Atkins will use an Olympus dissecting microscope.	The City of Dallas will conduct benthic macroinvertebrate laboratory analysis in-house. Because the city is not collecting biota that requires permitting, a valid TPWD Scientific Collection Permit is not required for collection, and TPWD will not be notified prior to field sampling for Dallas macroinvertebrates. City of Dallas will use a Leica MZ7.5 high-performance stereomicroscope equipped with a 10X ocular lens for bug sorting.

<table>
<tr><td>4.4</td><td>Mussels</td><td>Refer to section 1.2</td></tr>
<tr><td>4.5</td><td>Habitat
<table>
<tr><th>Habitat Equipment List</th><th>Parameter Equipment</th></tr>
<tr><td>Flow</td><td>Marsh-McBirney Flowmate 2000® digital flow meter</td></tr>
<tr><td>Water transparency</td><td>Secchi disk</td></tr>
</table></td><td>Once water samples have been collected, specialists will enter the creek and begin the habitat assessment and macroinvertebrate collection.

Parameters to be assessed for habitat suitability will include: available in stream cover, or amount of favorable substrate for macroinvertebrate colonization; embeddedness of bottom substrate, or amount of siltation surrounding the rocks in the creek; bottom substrate stability; flow status, or how much of the channel the water covers; flow regime, or how many different flow regimes are present; characteristics of pools; channel alteration and sinuosity; bank stability; and riparian vegetation buffer quality.
<table>
<tr><th>Habitat Equipment List</th><th>Parameter Equipment</th></tr>
<tr><td>Flow</td><td>A float, measuring reel (30m/100ft), stopwatch, and a depth stick.</td></tr>
<tr><td>Water transparency</td><td>Is determined by measuring turbidity with a HACH DR/890 Colorimeter.</td></tr>
</table></td></tr>
<tr><td>5.1</td><td>Sample Timing
Alternate sample sites after two years.
The second sample at each site each year will be collected during the period from March 15 through June 30 or October 1 through October 15.</td><td>Samples will be collected from all four sites twice each year.
The City of Dallas will collect the first sample between March 15th and June 30th. The second sample will be collected between July 1st and September 30th.</td></tr>
<tr><td>5.2</td><td>Notification: City contacts for Garland and Plano and the Atkins project manager will be notified at least seven days prior to each sampling event. TPWD Law Enforcement will be notified no more than 72 hours prior to, and no later than 24 hours prior to biological
sample collection. If excessive rain or some other event beyond the control of Atkins personnel forces cancellation of a sampling trip, city staff for Garland and Plano and the Atkins project manager will be notified the same day the decision is made to cancel sampling.</td><td>The City of Dallas is not collecting biota that requires TPWD permitting or Law Enforcement notification prior to biological sample collection.</td></tr>
<tr><td>5.4</td><td>Water Quality
A precalibrated YSI Series 600 XLM water quality meter will be placed in the stream at a secure location after 12:00 p.m. and before midnight on the day prior to biological sampling in order to measure dissolved oxygen during the night and at dawn when dissolved oxygen values may decline to levels injurious to aquatic life.</td><td>Upon arrival at a bioassessment site, a calibrated HQ40d will be placed in the stream to collect a single reading of dissolved oxygen, temperature, conductivity, and pH. The meter will be removed immediately after a reading has been recorded.

An HQ40d will not be placed in a stream overnight.</td></tr>
<tr><td>5.5</td><td>Fish</td><td>Refer to section 1.2</td></tr>
<tr><td>5.6</td><td>Benthic Macroinvertebrates</td><td>Macroinvertebrates will be collected in a proportionate manner from the habitat available in the stream reach. For example, if there is 50% root banks, 25% riffle, and 25% macrophytes, then 50% of the sampling effort will be focused on the root banks, and the remainder of the sampling effort will consist of sampling the riffle and macrophyte beds. A D-frame 500-μm mesh net is used to collect samples.</td></tr>
</table>

		Material collected with the D-frame nets will be consolidated into a 500-µm sieve bucket as one sample. The sample is then rinsed to remove the silt and sediment that will pass through the bottom of the sieve bucket. The sample is transferred to a 1-L plastic sample container and preserved with 70% isopropyl alcohol. The sample is labeled and placed on ice for transport to the City of Dallas Stormwater Management Laboratory.
5.7	**Mussels**	Refer to section 1.2
5.8	**Habitat**	At each selected site, a 100-m stream reach is selected for assessment. Ideally, the selected reach will be upstream of any bridge crossing, and will not include any major tributaries discharging into the reach. Some of the sites selected include areas downstream of bridge crossings for a variety of reasons. Stream flow will be determined by measuring water velocity, stream cross-sectional area, and stream section length. Once measurements have been taken, specialists will utilize the following equation to calculate stream flow: Flow= ALC/T Where A= Average cross-sectional area of the stream L= Length of the stream reach measured (usually 20 ft.) C= A coefficient or correction factor of 0.85 T= Time, in seconds, for the float to travel the length of L Stream flow calculations will be expressed in cubic feet per second (ft^3/sec)
6.3	**Fish**	Refer to section 1.2
6.4	**Benthic Macroinvertebrates**	Benthic Macroinvertebrate samples will be sorted in the City of Dallas Stormwater laboratory. The samples will be sorted from the detritus using a subsampling technique to obtain 175 individuals. Macroinvertebrates are sorted from the contents, placed into vials containing 70% isopropyl alcohol. Appropriate taxonomic keys will be used to identify macroinvertebrates using a Leica MZ7.5 high-performance stereomicroscope. Individual specimens will be identified to the lowest taxonomic level practicable. If staffing resources and time allows, the taxonomic level of identification will be as outlined in the TCEQ guidance document .
6.5	**Mussels**	Refer to section 1.2

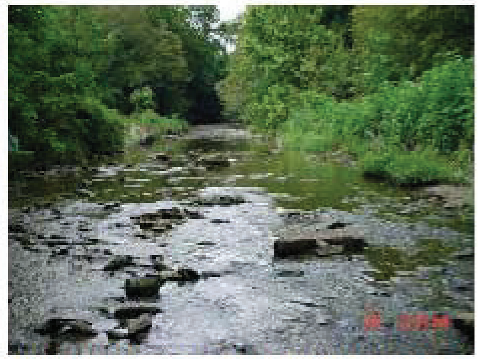
7.2	**Laboratory Quality Assurance for Water Samples** TTI Laboratories will analyze samples collected.	The City of Dallas is using Xenco and TTI Laboratories to carry out any analysis of samples collected. Contact information for Xenco Laboratories: **Name:** Monica Tobar **Company:** Xenco Laboratories **Phone #:** (214) 902 - 0300 **Address:** 9700 Harry Hines Blvd Dallas, Texas 75220
7.3	**Field Instrument/Equipment Testing, Inspection, and Maintenance Requirements**	Field equipment will be maintained according to City of Dallas in-house standard operating guidance requirements.
8.0	**Laboratory Analysis**	Refer to 7.2
9.0	**Post-Sampling Activities**	Electronic Digital Data received from contract laboratories will be downloaded into the internal City of Dallas environmental database management system (EDMS).

Appendix 1
Location Aerials for
City of Dallas Sampling Sites
FY2012-2016

Site ID: bab-b
GPS Coordinates: -96.83695217038 32.86044178986
Address: 8900 Midway Rd. **MAPSCO**: 24X
HUC12 Watershed: Bachman Branch - Elm Fork Trinity River **Waterway**: Bachman Branch
Land Use: Residential and Commercial
Reference site: smc-a, South Mesquite Creek site a

NOTES: The sample site is located approximately ¼ of a mile south of the intersection of Midway Road and Northwest Highway W. The creek can be accessed by using the concrete embankment on the southeast corner of the Midway Rd. bridge.

Creek access point on the east side of Midway Rd.

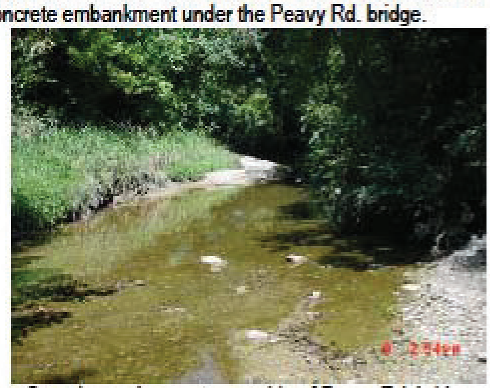


Sample reach - upstream of the Midway Rd. bridge.

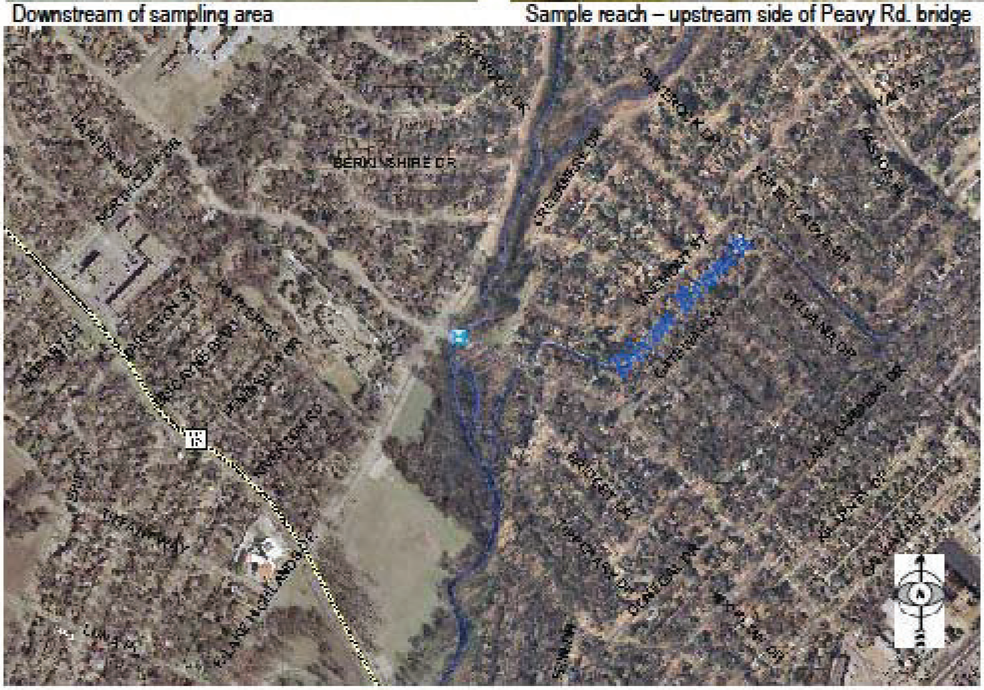
Site ID: dix-a
GPS Coordinates: -96.70475863768 32.84469604940
Address: 900 Peavy Rd **MAPSCO**: 38E
HUC12 Watershed: White Rock Creek - White Rock Lake **Waterway**: Dixon Branch
Land Use: Dedicated-Park, Residential, and Commercial
Reference site: smc-a, South Mesquite Creek site a

NOTES: Located just northeast of the Peavy Rd. & Lake Highlands E. intersection. Dixon Branch runs parallel with Lake Highlands E. The creek can be accessed by using the concrete embankment under the Peavy Rd. bridge.

Downstream of sampling area



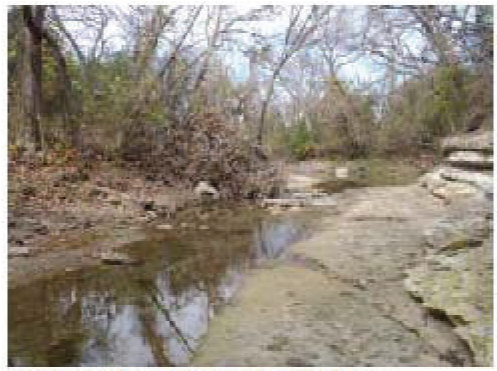
Sample reach – upstream side of Peavy Rd. bridge

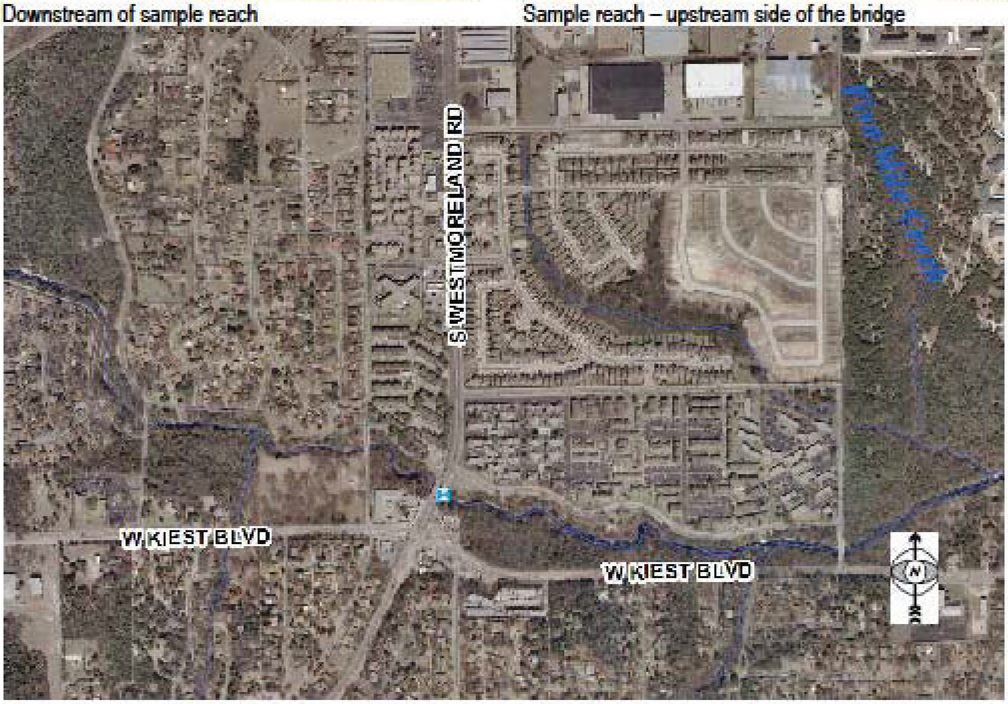


Site ID: fiv-d
GPS Coordinates: -96.87451383592 32.70644079996
Address: 3235 S. Westmoreland Rd. **MAPSCO**: 53X
HUC12 Watershed: Headwaters Five Mile Creek **Waterway**: Five Mile Creek
Land Use: Dedicated-Park, Residential, Commercial, and Industrial
Reference site: ten-d, Ten Mile Creek site d

NOTES: Located at the intersection of Westmoreland Rd. & Pentagon. The creek can be accessed by using the concrete embankment under the Westmoreland bridge.

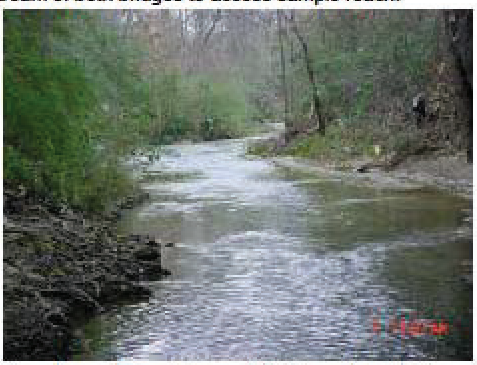

Downstream of sample reach


Sample reach – upstream side of the bridge



Site ID: flo-a
GPS Coordinates: -96.76013678672 32.90906899123
Address: 8300 Forest Lane
MAPSCO: 16Y
HUC12 Watershed: Floyd Branch - White Rock Creek
Waterway: Floyd Branch
Land Use: Residential and commercial
Reference site: ten-d, Ten Mile Creek site d

NOTES: Heading West on Forest Lane (towards US 75), turn Right onto gravel road underneath DART Rail. Walk upstream of both bridges to access sample reach.



Sample reach – upstream of the Forest Lane bridge

Facing downstream of sample reach

Appendix 2
Bioassessment Forms for
City of Dallas Sampling Sites
FY2012-2016

Stormwater Management
Oak Cliff Municipal Center
320 E. Jefferson Blvd. Rm 108
Dallas, TX 75203

PROJECT ID/SR#:		FIELD SAMPLING LOG					
	Trigger Values	Sampler:		Analyst:		Sampling Date:	
FIELD SAMPLE ID							
SAMPLING TIME							
WATERSHED NAME							
EDMS SAMPLE ID							
		GRAB	GRAB/COMPOSITE	GRAB	GRAB/COMPOSITE	GRAB	GRAB/COMPOSITE
DISSOLVED OXYGEN	3 - 6 mg/L						
pH	6.5 - 9						
SPECIFIC COND	< 800 µS/cm						
SAMPLE TEMP (H_2O)							
AMBIENT TEMP (AIR)							
AMMONIA (Strip Test)	<1m/L						
CHLORINE (11)	<1m/L						
COPPER (20)							
HARDNESS (Strip Test)							
IRON (33)							
NITRATE (Strip Test)	<0.88 mg/L (combined)						
NITRITE (Strip Test)							
PHOSPHORUS (79)	<1m/L P						
TSS (94)							
TURBIDITY (95)							
E. COLI	<400 CFU(winter) <800(summer)						
TOTAL COLIFORM	<5000 CFU(winter) <20000(summer)						
NOTES							

Samples Submitted to Contract lab__________________

Date/Initials__________________

Reviewd by Supervisor

Stream Habitat Assessment Form for Rapid Bioassessment

Average Creek Width: _____ Average Creek Depth: _____

Habitat Parameter	Condition Category				
	Optimal	Suboptimal	Marginal	Poor	SCORE
Channel Alteration	Channel alteration or dredging absent or minimal; stream with normal pattern.	Some channelization present, usually in areas of bridge abutments; evidence of past channelization, i.e., dredging, (greater than past 20 yrs) may be present, but recent channelization is not present.	Channelization may be extensive; embankments or shoring structures present on both banks; and 40 – 80% of streams reach channelized and disrupted.	Banks shored with gabion or cement; over 80% of the streams reach channelized and disrupted. In stream habitat greatly altered or removed entirely.	
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0	
Channel Sinuosity	The bends in the stream increase the length 3 to 4 times longer than if it was a straight line.	The bends in the stream increase the stream length 2 to 3 times longer than if it was in a straight line.	The bends in the stream increase the length 2 to 1 times longer than if it was in a straight line.	Channel straight; waterway has been channelized for a long distance.	
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0	
Embeddedness	Gravel, cobble, and boulder particles are 0-25% surrounded by fine sediment.	Gravel, cobble, and boulder particles are 25 – 50% surrounded by fine sediment.	Gravel, cobble, and boulder particles are 50 – 75% surrounded by fine sediment.	Gravel, cobble, and boulder particles are more than 75% surrounded by fine sediment	
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0	
Epifaunal Substrate/Available Cover	Greater than 70% of substrate favorable for epifaunal colonization and fish cover; mix of snags submerged logs, undercut banks, cobble or other stable habitat and at stage to allow full colonization potential (i.e. logs/snags that are not new fall and not transient).	40 – 70% mix of stable habitat; well suited for full colonization potential; adequate habitat for maintenance of populations; presence of additional substrate in the form of newfall, but not yet prepared for colonization (may rate at high end of scale)	20 – 40% mix of stable habitat; habitat availability less than desirable; substrate frequently disturbed or removed.	Less than 20% stable Habitat; lack of habitat is obvious; substrate unstable or lacking.	
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0	
Frequency of Riffles (HIGH GRADIENT)	Occurrence of riffles relatively frequent; ratio of distance between riffles divided by width of the stream <7:1 (generally 5 to 7); variety of habitat is key. In streams where riffles are continuos, placement of boulders or other large, natural obstruction is important.	Occurrence of riffles infrequent; distance between riffles divided by width of the stream is between 7 to 15.	Occasional riffle or bend; bottom contours provide some habitat; distance between riffles divided by the width of the stream is between 15 – 25.	Generally all flat water or shallow riffles; poor habitat; distance between riffles divided by the width of the stream is a ratio of >25.	
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0	
Bank Stability	Banks stable; evidence of erosion or bank failure absent or minimal; little potential for future problems. <5% of bank affected.	Moderately stable; infrequent, small areas of erosion mostly healed over. 5-30% of bank in reach has areas of erosion.	Moderately unstable; 30-60% of bank in reach has areas of erosion; high erosion potential during floods.	Unstable; many eroded areas; "raw" areas frequent along straight sections and bends; obvious bank sloughing; 60-100% of bank has erosional scars.	
SCORE (LB)	Left Bank 10 9	8 7 6	5 4 3	2 1 0	
SCORE (RB)	Right Bank 10 9	8 7 6	5 4 3	2 1 0	
Bank Vegetative Protection (score each bank)	More than 90% of the stream bank surfaces and immediate riparian zone covered by native vegetation, including trees, under story shrubs, or nonwoody macrophytes; vegetative disruption through grazing or mowing minimal or not evident; almost all plants allowed to grow naturally.	70 –90% of the streambank surfaces covered by native vegetation, but one class of palnts is not well-represented; disruption evident but not affecting full plant growth potential to any great extent; more than one-half of the potential plant stubble height remaining.	50 –70% of the streambank surfaces covered by vegetation; disruption obvious; patches of bare soil or closely cropped vegetation common; less than one-half of the potential plant stubble height remaining.	Less than 50% of the streambank surfaces covered by vegetation; disruption of streambank vegetation is very high; vegetation has been removed to 5 centimeters or less in average stubble height.	
SCORE (LB)	Left Bank 10 9	8 7 6	5 4 3	2 1 0	
SCORE (RB)	Right Bank 10 9	8 7 6	5 4 3	2 1 0	

Stream Habitat Assessment Form for Rapid Bioassessment

Habitat Parameter	Condition Category: Optimal	Suboptimal	Marginal	Poor	SCORE
Pool Substrate Characterization (LOW GRADIENT)	Mixture of substrate materials, with gravel and firm sand prevalent; root mats and submerged vegetation common.	Mixture of soft sand, mud, or clay; mud may be dominant; some root mats and submerged vegetation present.	All mud or clay sand bottom; little or no root mat; no submerged vegetation.	Hard-pan clay or bedrock; no root or mat vegetation.	
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0	
Pool Variability (LOW GRADIENT)	Even mix of large-shallow, large-deep, small-shallow, small-deep pools present.	Majority of pools large-deep; very few shallow.	Shallow pools much more prevalent than deep pools.	Majority of pools small-shallow or pools absent.	
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0	
Channel Flow Status	Water reaches base of both lower banks, and minimal amount of channel substrate is exposed.	Water fills >75% of the available channel; or <25% of channel substrate is exposed.	Water fills 25-75% of the available channel, and/or riffle substrates are more commonly exposed.	Very little water in channel and mostly present as standing pools.	
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0	
Riparian Vegetative Zone Width	Width of riparian zone >18 meters; human activities (i.e. parking lots, roadbeds, clear-cuts, lawns, or crops) have not impacted zone.	Width of riparian zone 12-18 meters; human activities have impacted zone only minimally.	Width of riparian zone 6-12 meters; human activities have impacted zone a great deal.	Width of riparian zone <6 meters; little or no riparian vegetation due to human activities.	
SCORE (LB)	Left Bank 10 9	8 7 6	5 4 3	2 1 0	
SCORE (RB)	Right Bank 10 9	8 7 6	5 4 3	2 1 0	
Sediment Deposition	Little or no enlargement of islands or point bars and less than 5% (20% for low gradient) of the bottom affected by sediment deposition.	Some new increases in bar formation, mostly from gravel, sand or fine sediment; 5 – 30% (20 – 50% for low gradient) of the bottom affected; slight deposition in pools.	Moderate deposition of new gravel, sand or fine sediment on old and new bars; 30 –50% (50% - 80% for low gradient) of the bottom affected; sediment deposits at obstructions, constructions, and bends; moderate deposition of pools prevalent.	Heavy deposits of fine material, increased bar development; more than 50% (80% for low gradient) of the bottom changing frequently; pools almost absent due to substantial sediment deposition.	
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0	
Velocity/Depth Regime	All 4 velocity/depth regimes present (slow-deep, slow shallow, fast deep, fast shallow). (slow is <0.3 m/s, deep is >0.5m)	Only 3 of the 4 regimes present (if fast-shallow is missing, score lower than if missing other regimes)	Only 2 of the 4 habitat regimes present (if fast-shallow or slow shallow are missing, score low)	Dominated by 1 velocity/depth regime (usually slow-deep).	
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0	
			TOTAL SCORE		

HABITAT SCORES	VALUE
OPTIMAL	160 - 200
SUB-OPTIMAL	110 - 159
MARGINAL	60 - 109
POOR	<60

Bioassessment Sampling- Field Guidelines

Equipment needed:

Water Quality Only
Multi-probe unit (TROLL, Quanta, or HQ40d)
Hach DR890
Chlorine ampules
Ice chests with ice
Gloves
Safety vest
Rubber boots and/or hip waders
Hats, sunscreen and/or bug spray
Camera
Permanent marker
Site Location Sheets
Chain of Custodies
Field Sampling Log Sheets
Field notebook
Flow Meter(s) and accessories (line level, surveyor rope, meter stick, string & rebar)
Appropriate sample bottles (see below)

Bugs (plus Water Quality)
Habitat Assessment Sheets
D-frame nets
Sieve bucket
1-L plastic, wide mouth bug bottle(s)
1-L Isopropyl alcohol (bug preservation)
Appropriate sample bottles (see below)

Field parameters:

Flow measurements
***Habitat assessment
Hach DR890 (turbidity, total suspended solids, and chlorine)
Multi-probe unit (pH, dissolved oxygen, specific conductance, and water temperature)

Laboratory Samples:

Laboratory	Sample Bottle	Sampling Parameters
External- Xenco Laboratories 9701 Harry Hines Blvd Dallas, TX 75220 214 902-0300 or TTI Environmental Laboratories 2117 Arlington Downs Rd Arlington, TX 76011 817 861-5322	1-L plastic with H2SO4	Total Phosphorous
		Nitrate-Nitrite
		Ammonia
		Carbon Oxygen Demand
	250 mL plastic with HNO3	Iron
		Copper
	250 mL plastic	MBAS Surfactants
	250 mL plastic	Hardness, Total as $CaCO_3$
	2, 1-L glass amber	***Pesticides (atrazine, simazine, dieldrin, and methoxychlor)**
Internal- SWM Laboratory	100 mL with sodium thiosulfate	*E. coli*
		Total Coliform

*Only conducted for designated bug sites

Appendix C

Watershed Land Use Maps (Obtained from NCTCOG and City of Dallas)

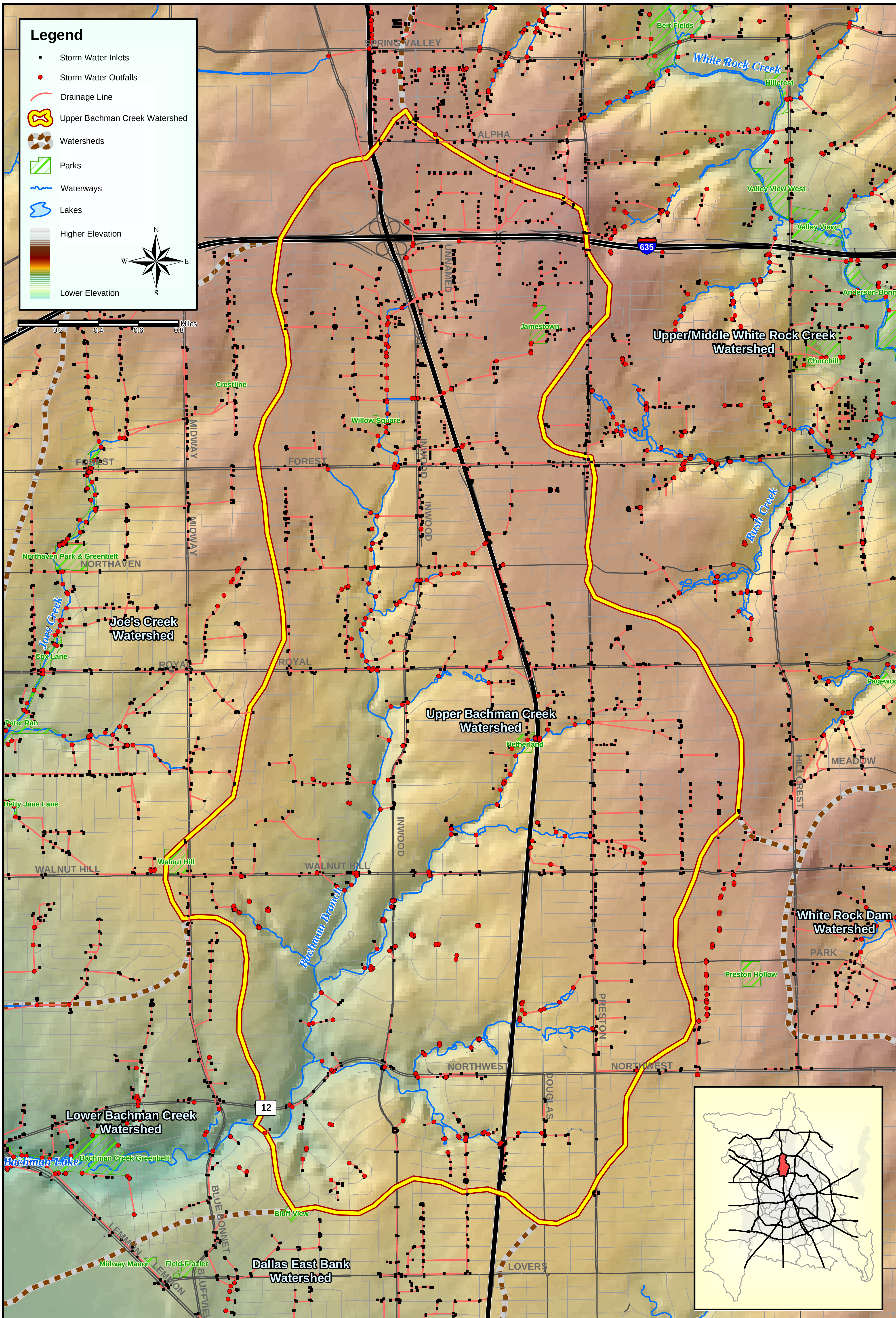


Figure 1: Upper Bachman Creek Watershed

City of Dallas
Storm Water Management
Geographic Information System

http://www.WhereDoesItGo.com (214) 948-4022 http://www.Trinity-Trudy.org

Date Created: July 2006
Coordinate System: NAD83 - US State Plane Feet
Projection: Lambert Conformal Conic

NOT TO SCALE, FOR DISPLAY PURPOSES ONLY. We endeavor to provide timely and accurate information. However, use of the information is the sole responsibility of the user.

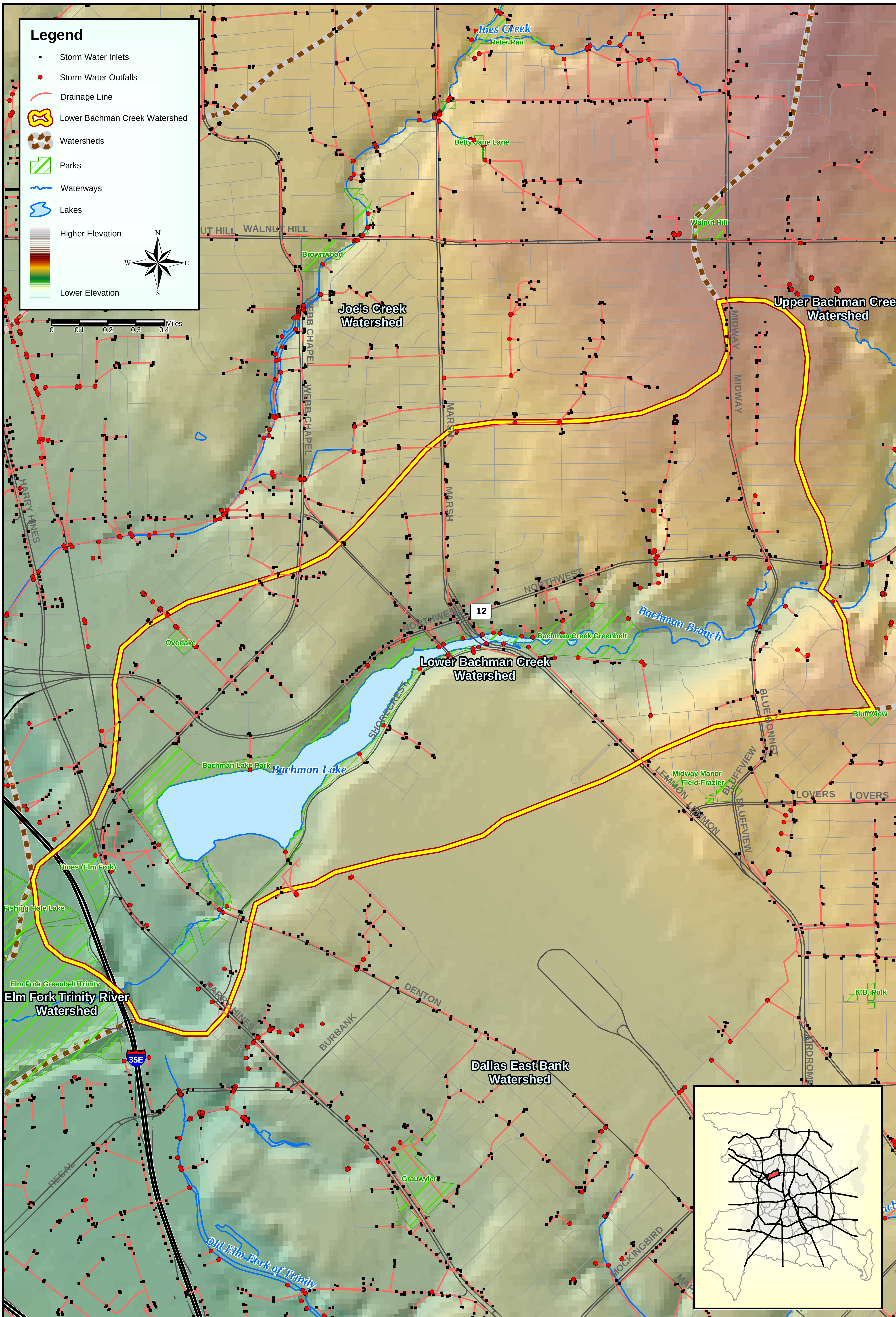


Figure 2: Lower Bachman Creek Watershed

City of Dallas
Storm Water Management
Geographic Information System

http://www.WhereDoesItGo.com (214) 948-4022 http://www.Trinity-Trudy.org

Date Created: July 2006
Coordinate System: NAD83 - US State Plane Feet
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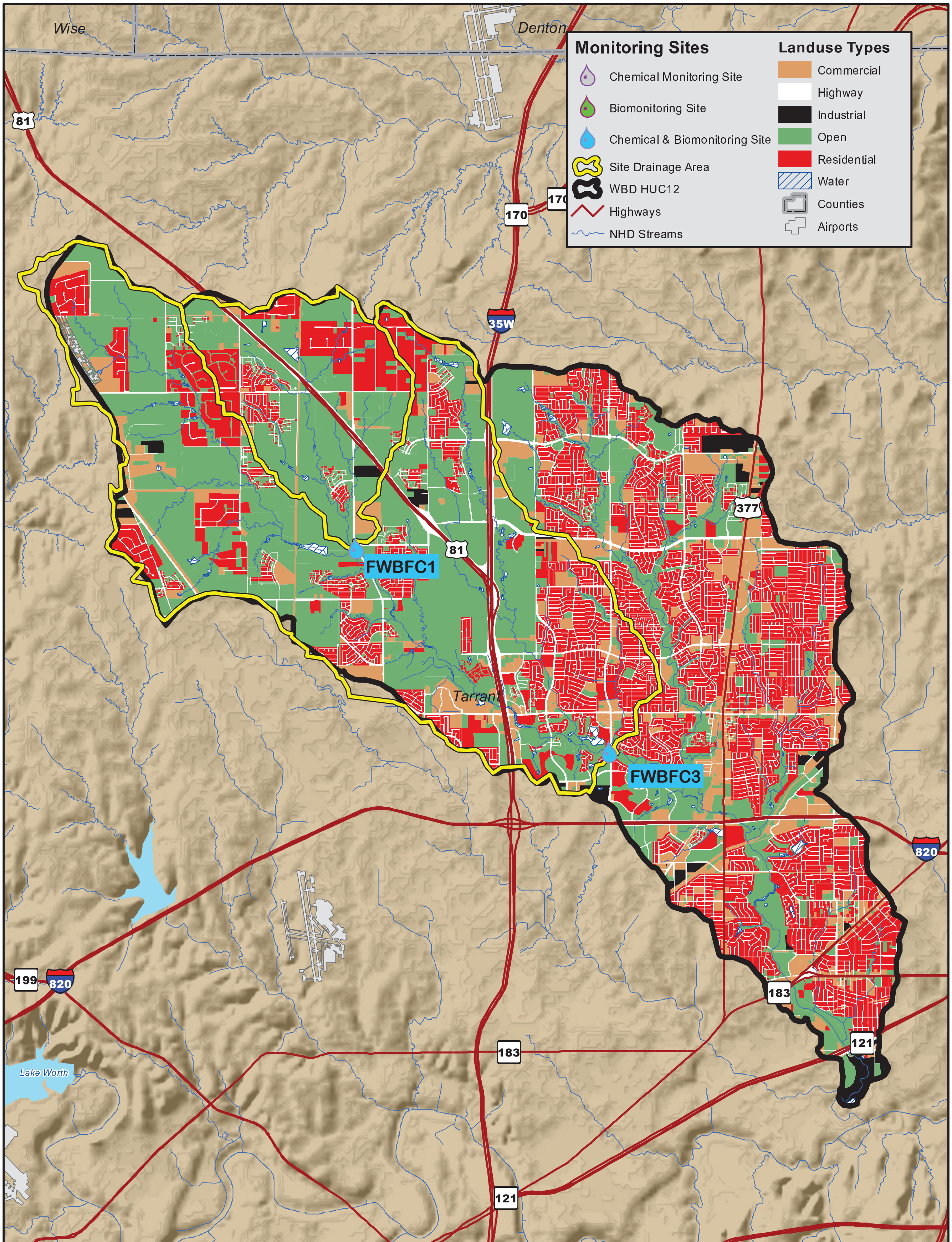

North Central Texas
Council of Governments
Environment & Development

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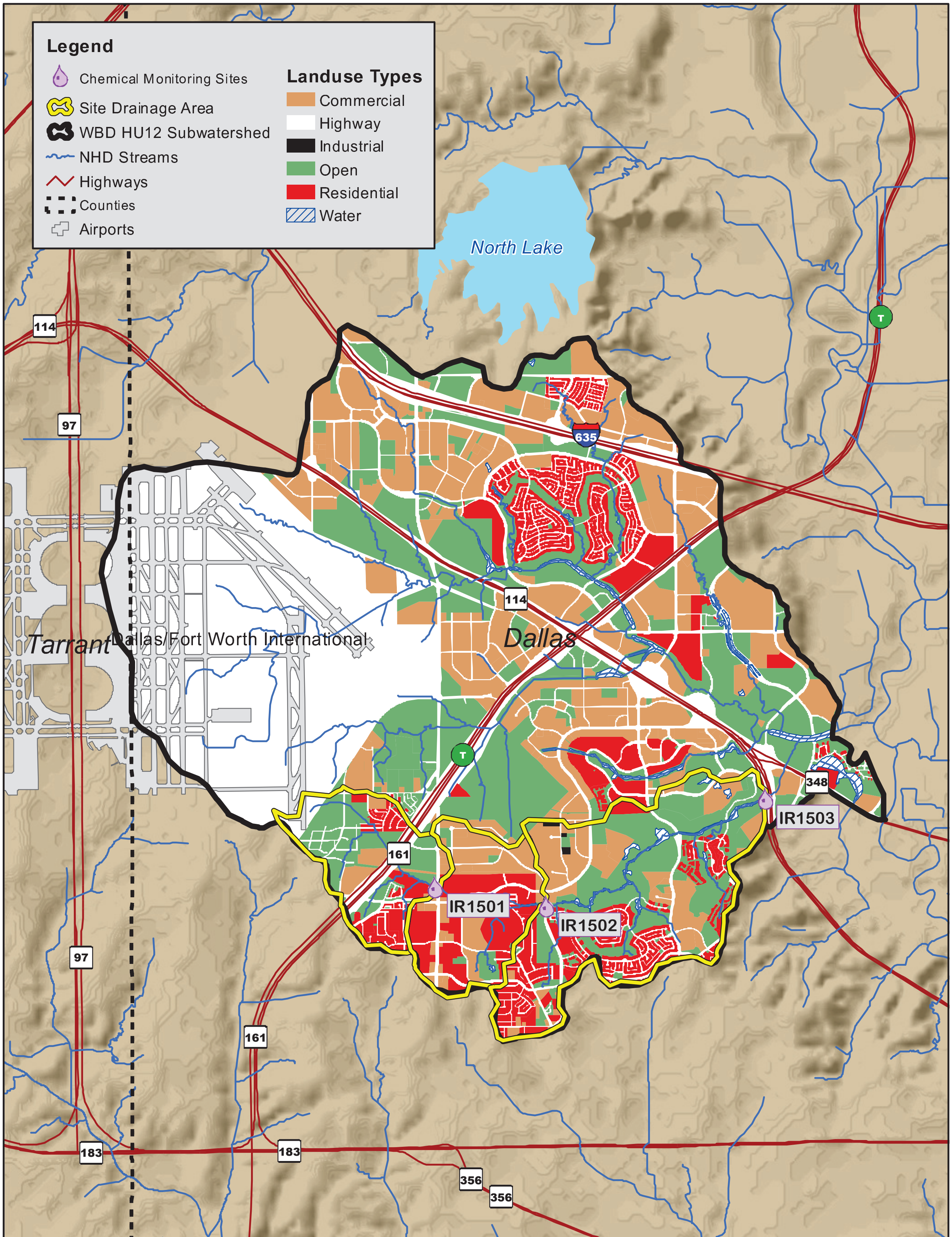
Figure 3: White's Branch - Big Fossil Creek

City of Fort Worth

Source: NCTCOG Regional Monitoring Program, Land Use Data 2010
Watershed Boundary Dataset (WBD) by
USDA - Natural Resources Conservation Service

RSM 1-17-14



North Central Texas
Council of Governments
Environment & Development

Figure 4: Cottonwood Branch Hackberry Creek Watershed

City of Irving

Source: NCTCOG Regional Monitoring Program, Land Use Data 2010
Watershed Boundary Dataset (WBD) by
USDA - Natural Resources Conservation Service

N

0 0.475 0.95 1.9 Miles

BRG 1-20-15

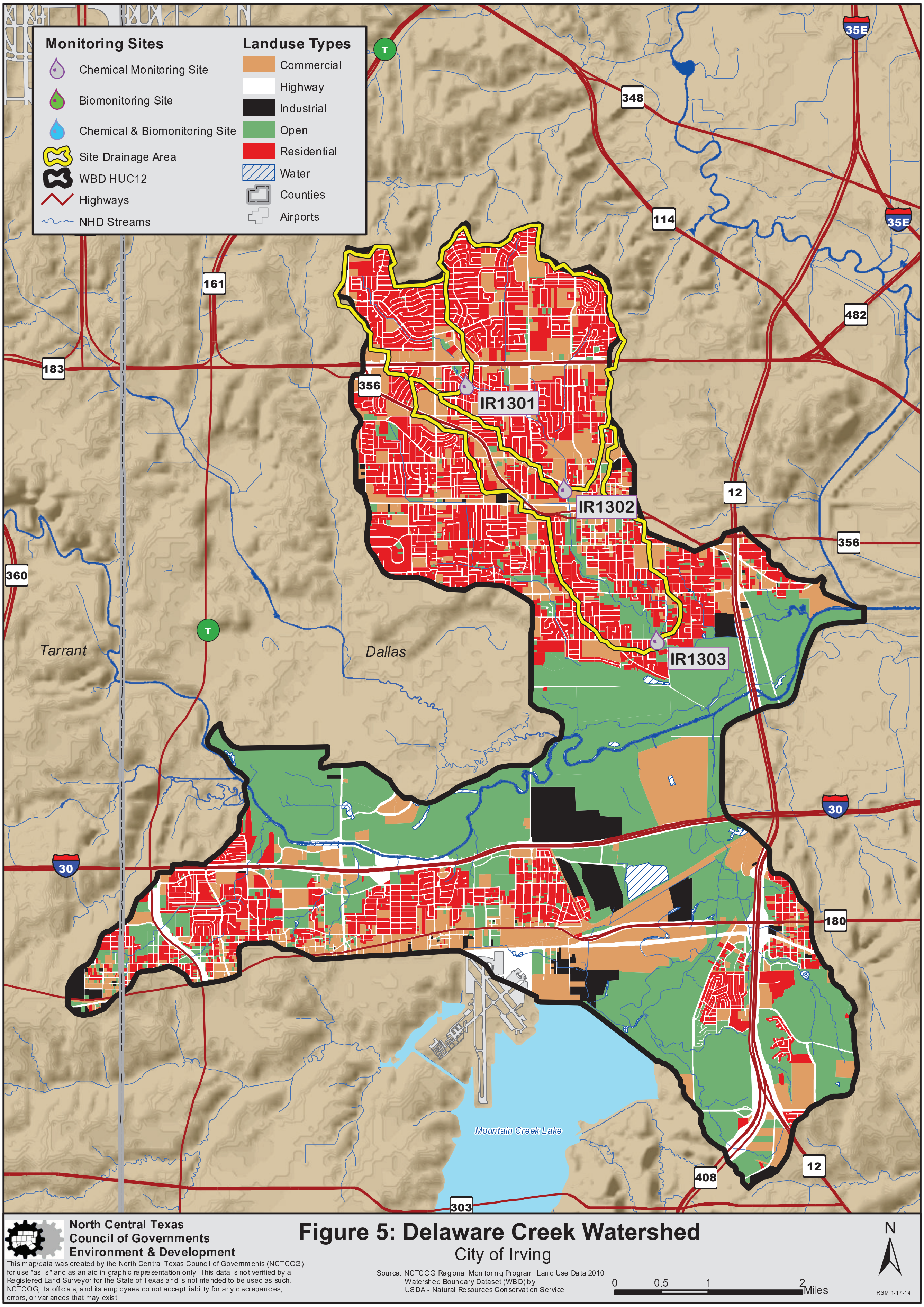


Figure 5: Delaware Creek Watershed

City of Irving

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Source: NCTCOG Regional Monitoring Program, Land Use Data 2010
Watershed Boundary Dataset (WBD) by
USDA - Natural Resources Conservation Service

RSM 1-17-14

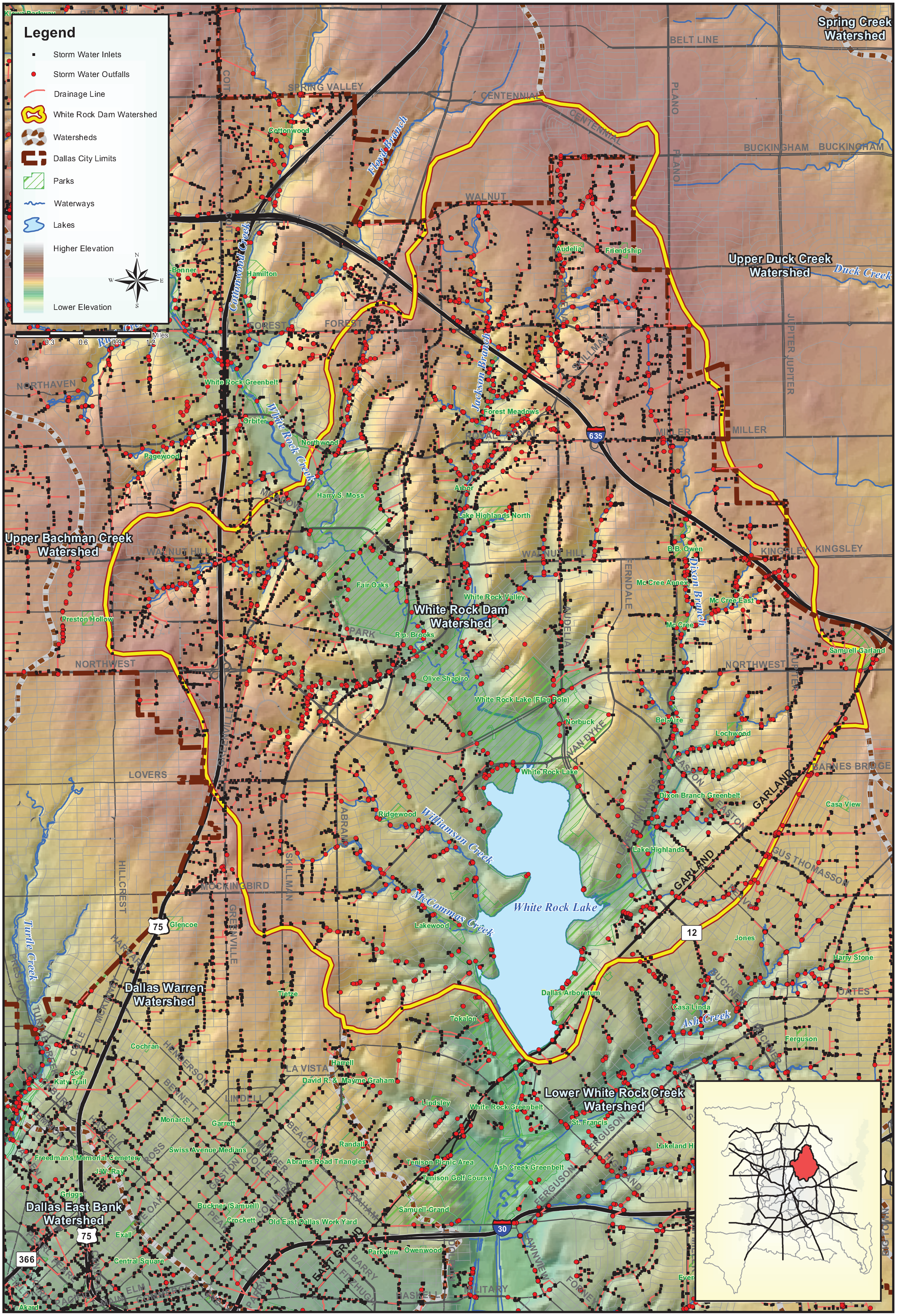

Figure 6: White Rock Creek-White Rock Lake

City of Dallas
Storm Water Management
Geographic Information System

http://www.WhereDoesItGo.com (214) 948-4022 http://www.Trinity-Trudy.org

Date Created: July 2006
Coordinate System: NAD83 - US State Plane Feet
Projection: Lambert Conformal Conic

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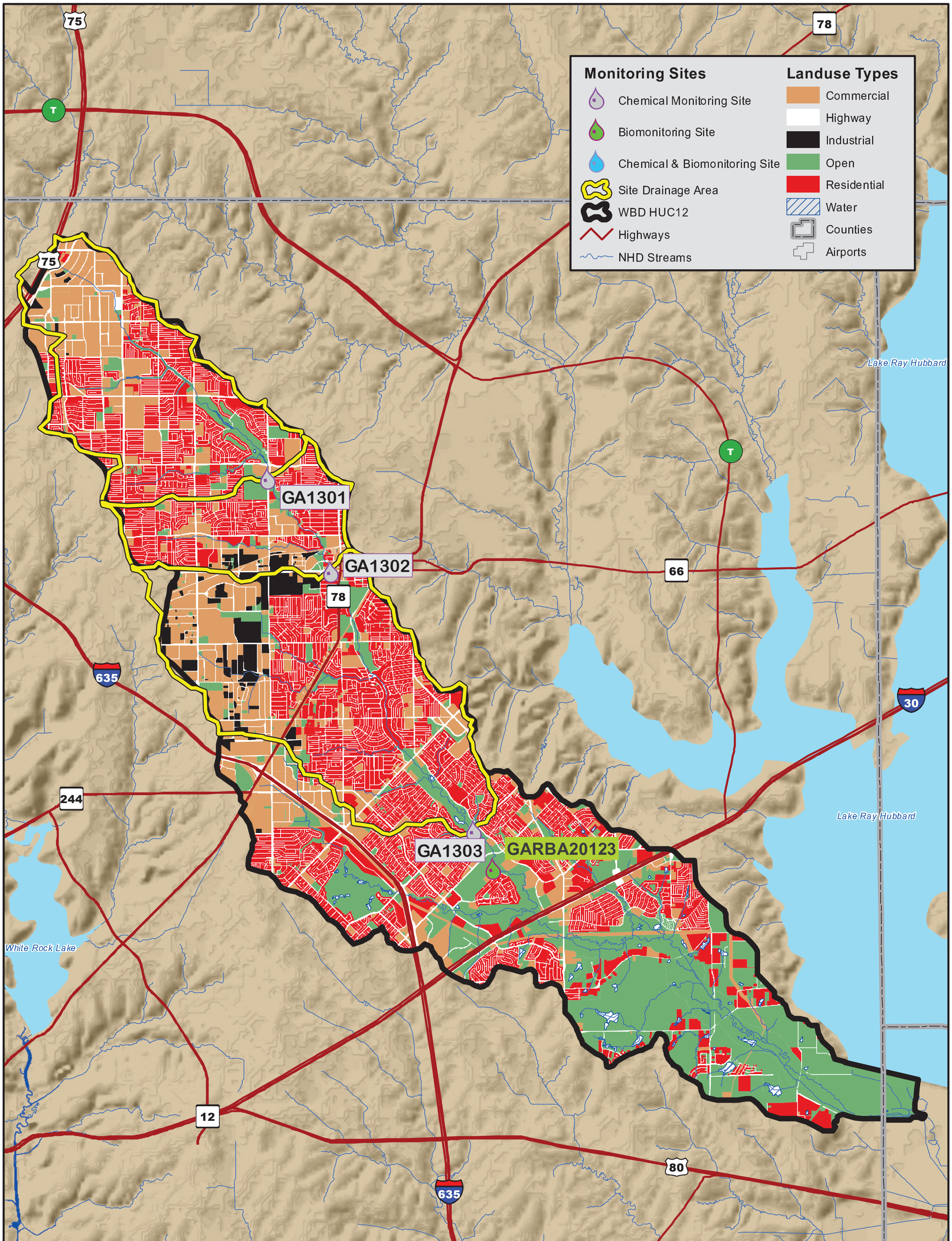

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Figure 7: Duck Creek Watershed

City of Garland

Source: NCTCOG Regional Monitoring Program, Land Use Data 2010
Watershed Boundary Dataset (WBD) by
USDA - Natural Resources Conservation Service

N

0 0.75 1.5 3 Miles

RSM 1-17-14

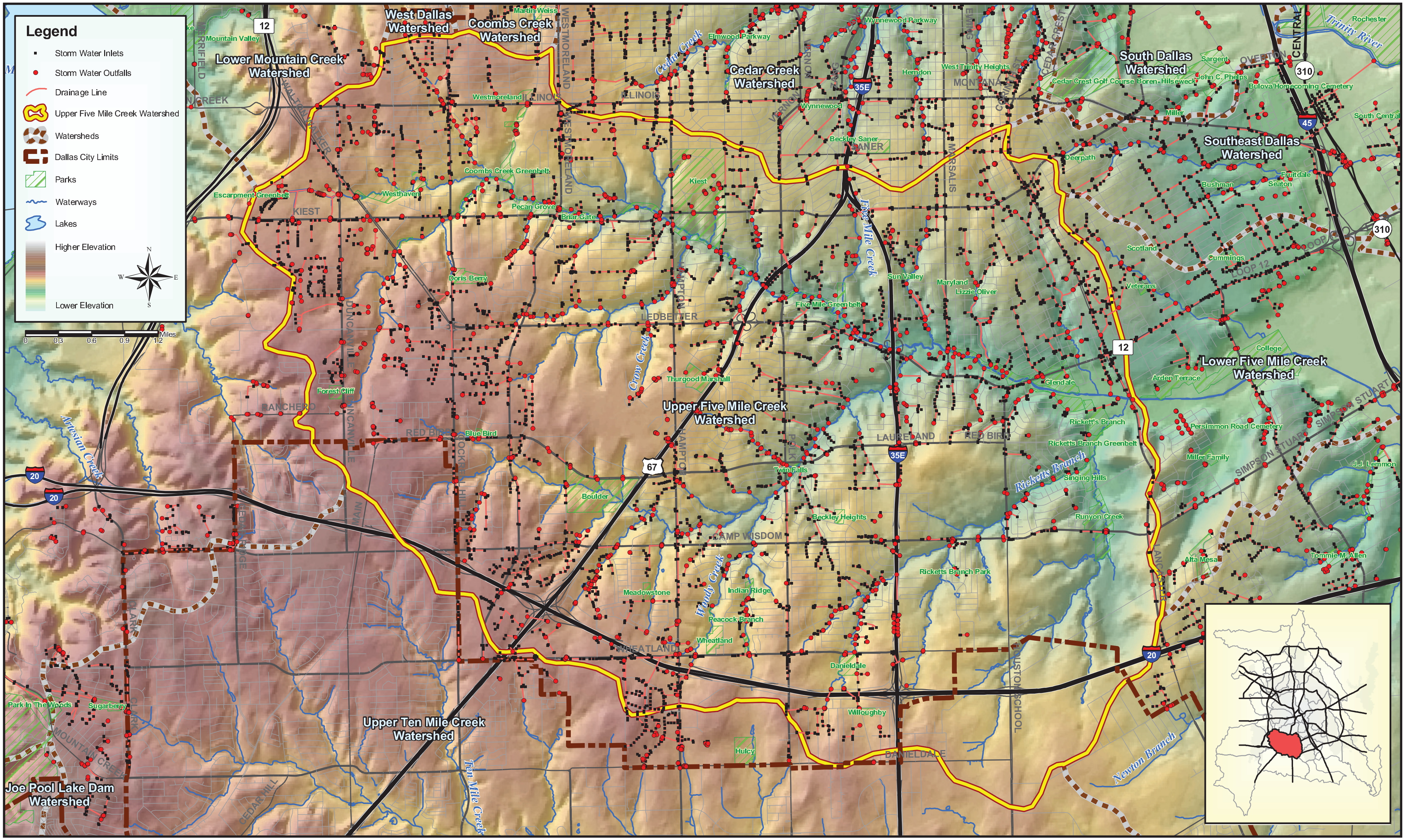

Figure 8: Headwaters Five Mile Creek

City of Dallas
Storm Water Management
Geographic Information System

http://www.WhereDoesItGo.com
(214) 948-4022
http://www.Trinity-Trudy.org

Date Created: July 2006, Projection: Lambert Conformal Conic
Coordinate System: NAD83 - US State Plane Feet
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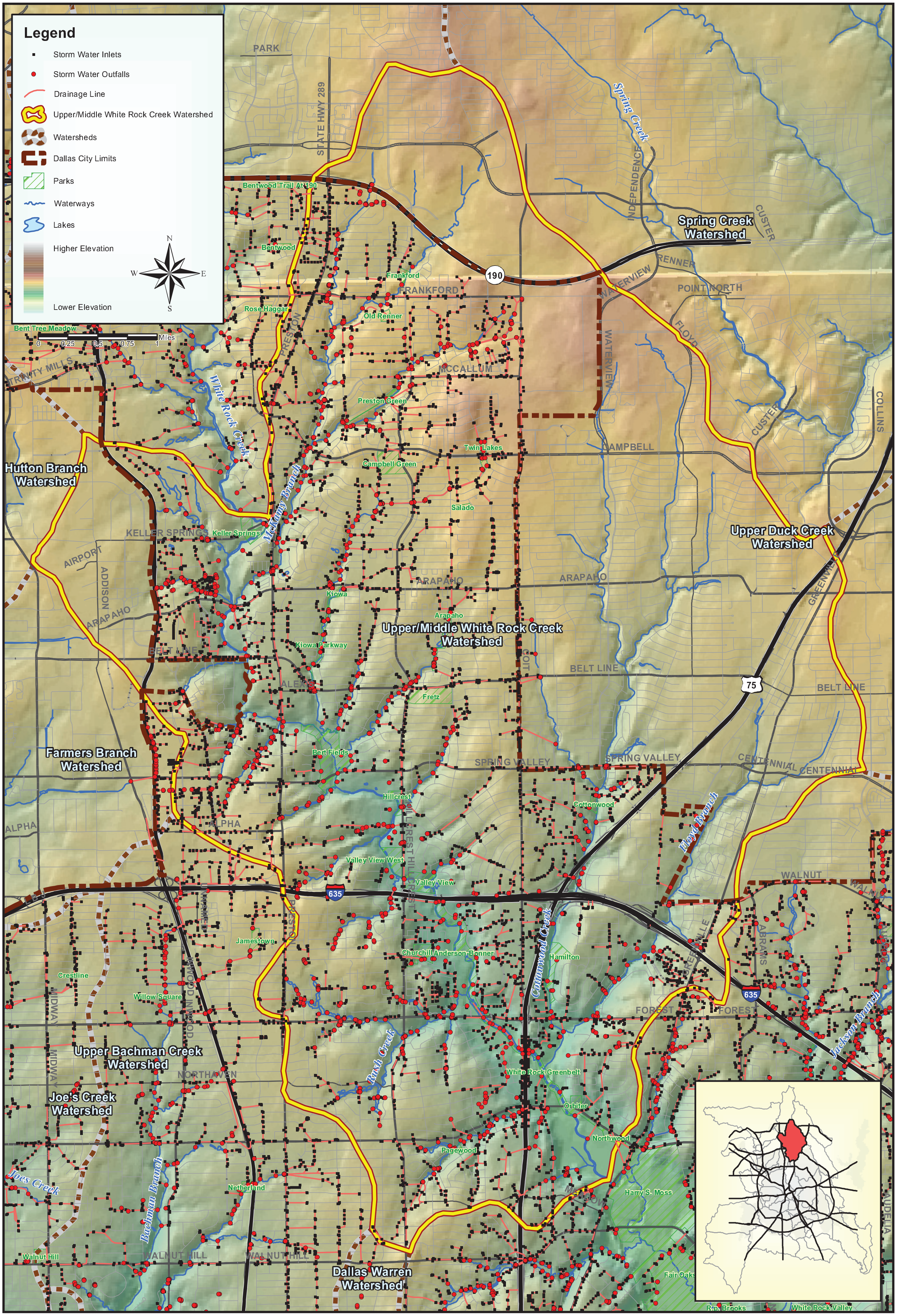

City of Dallas
Storm Water Management
Geographic Information System

Figure 9: Floyd Branch-White Rock Creek

http://www.WhereDoesItGo.com (214) 948-4022 http://www.Trinity-Trudy.org

Date Created: July 2006
Coordinate System: NAD83 - US State Plane Feet
Projection: Lambert Conformal Conic

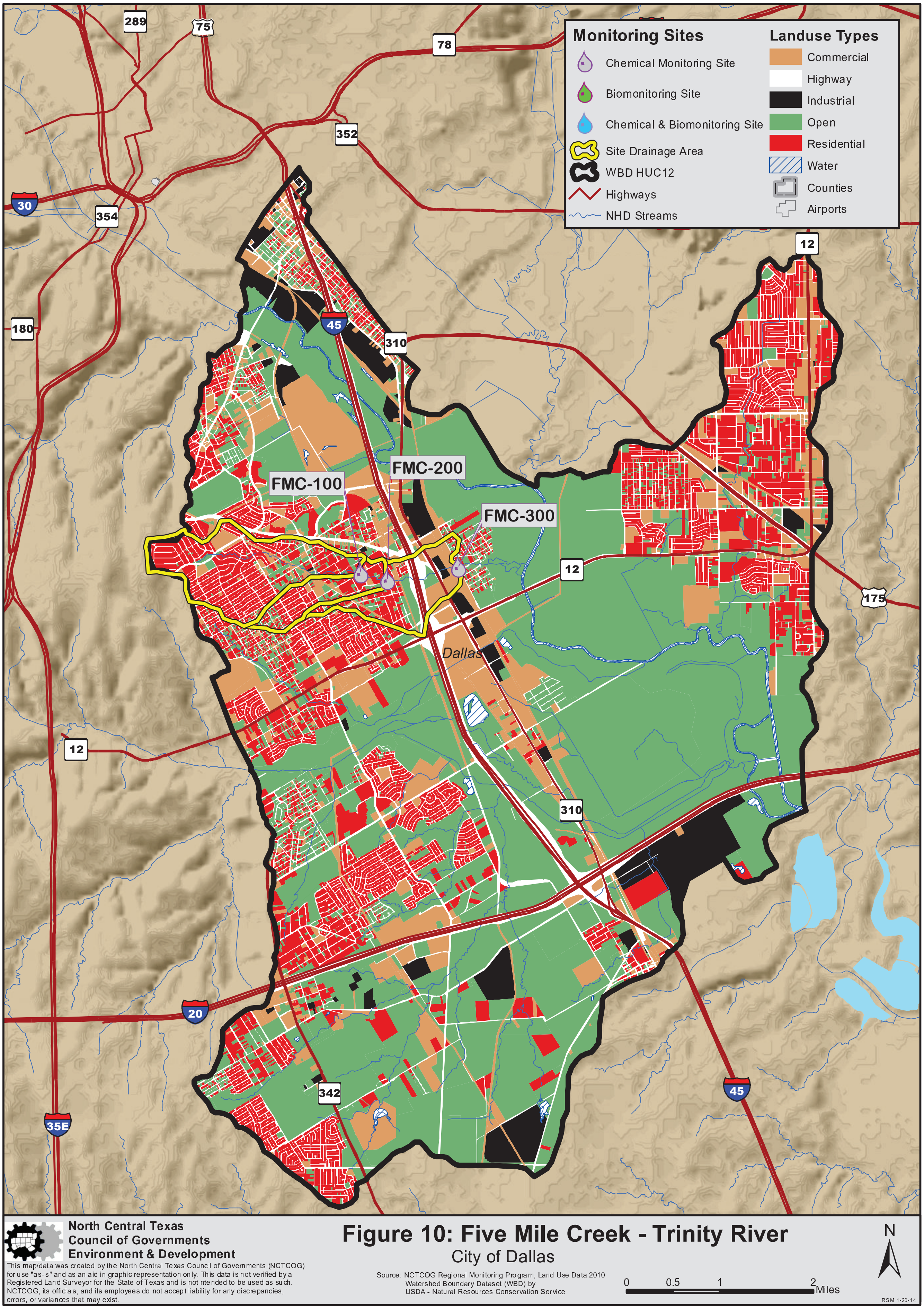

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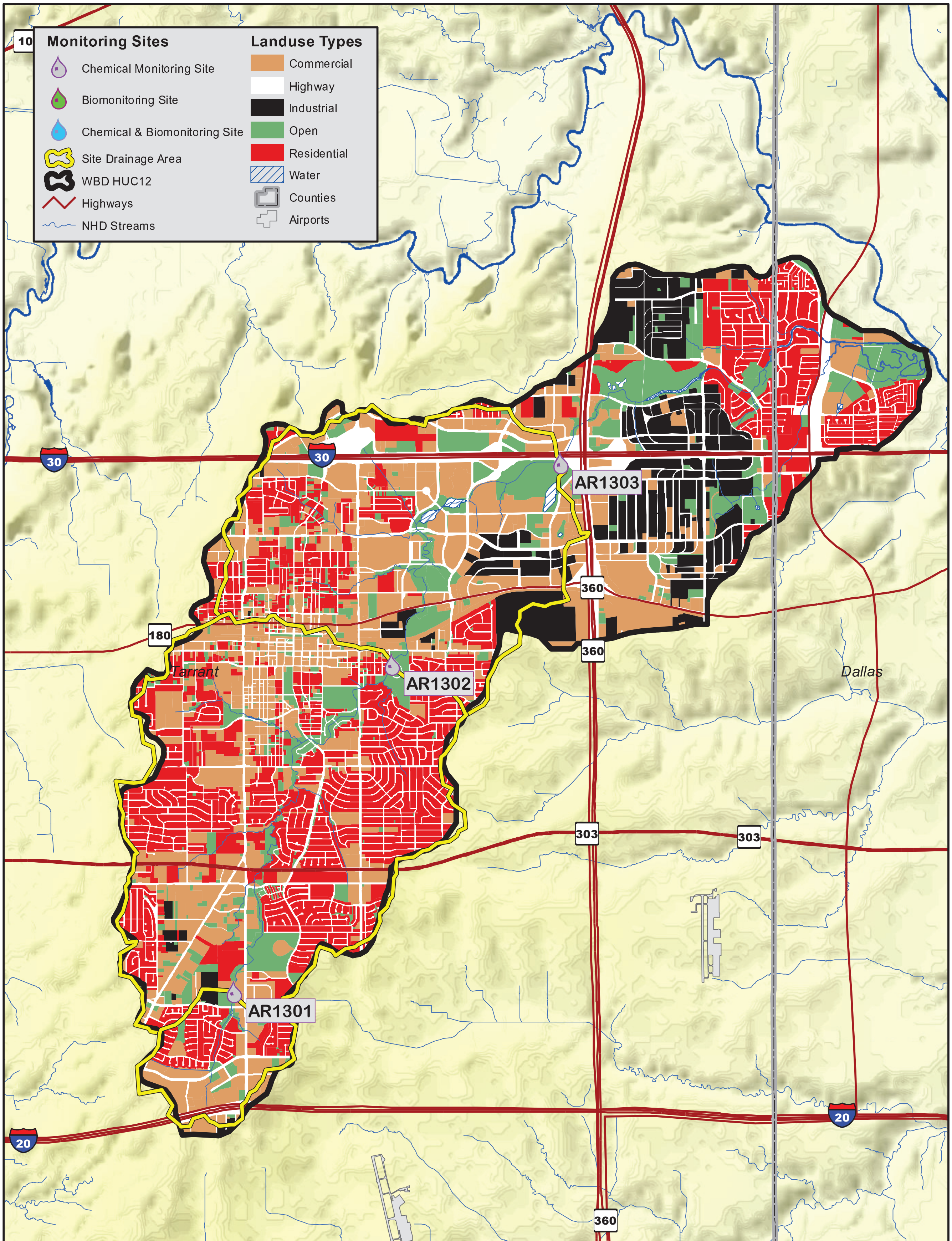
Figure 10: Five Mile Creek - Trinity River

City of Dallas

Source: NCTCOG Regional Monitoring Program, Land Use Data 2010
Watershed Boundary Dataset (WBD) by
USDA - Natural Resources Conservation Service

RSM 1-20-14



North Central Texas
Council of Governments
Environment & Development

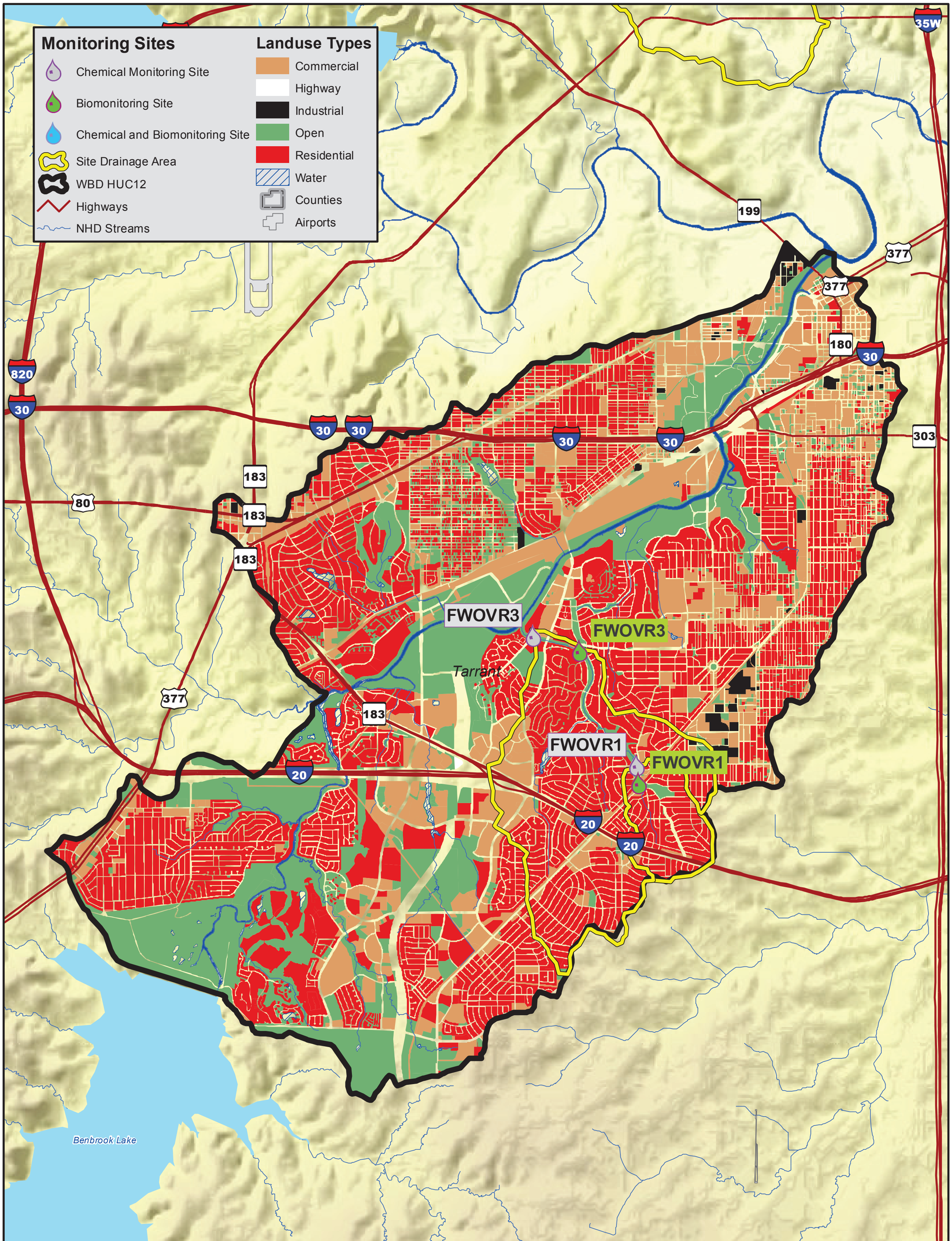
Figure 11: Johnson Creek Watershed
City of Arlington

Source: NCTCOG Regional Monitoring Program, Land Use Data 2010
Watershed Boundary Dataset (WBD) by
USDA - Natural Resources Conservation Service

0 0.5 1 2 Miles

N

RSM 1-17-14



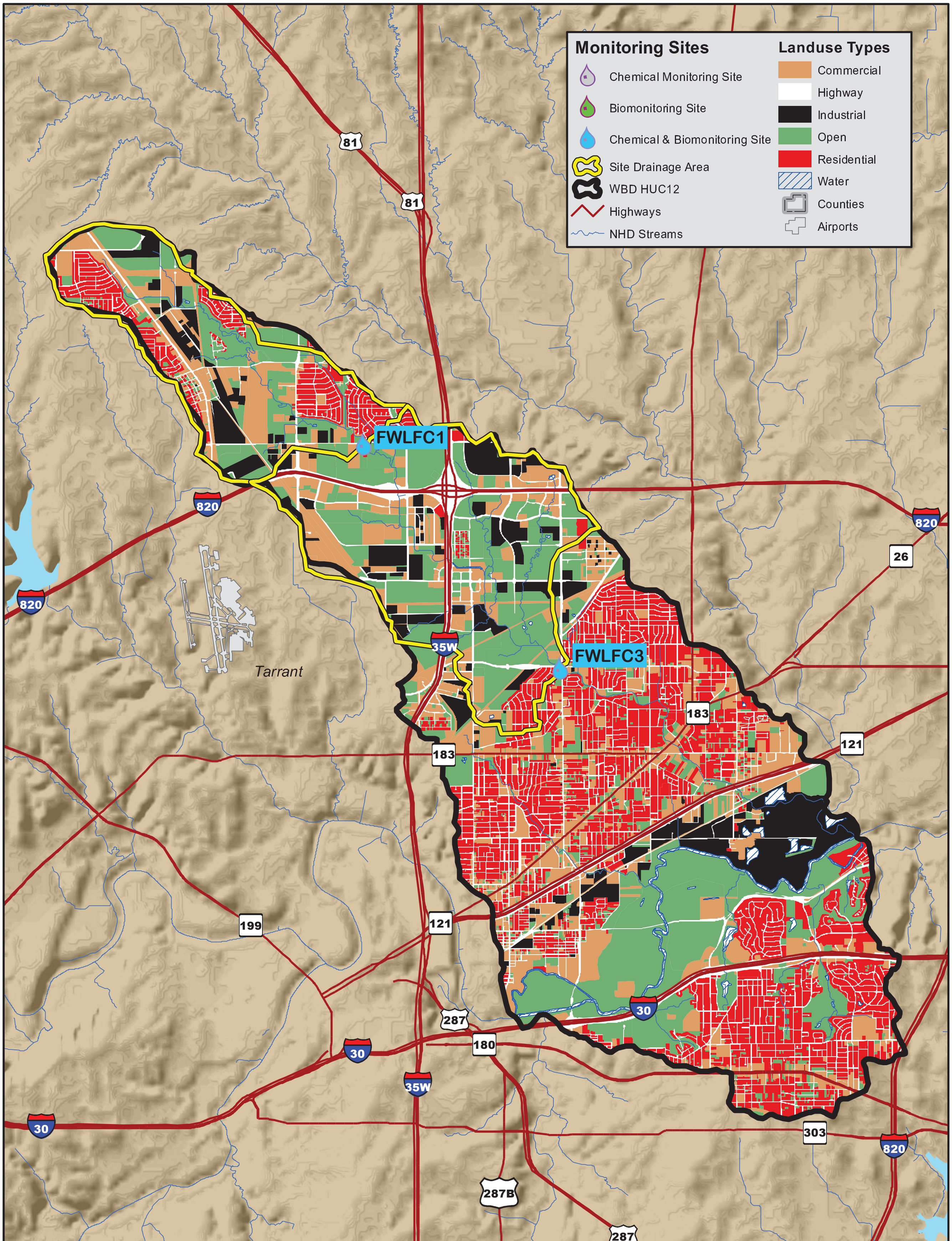
North Central Texas
Council of Governments
Environment & Development

Figure 12: Lake Como Clear Fork Trinity River Watershed

City of Fort Worth

Source: NCTCOG Regional Monitoring Program, Land Use Data 2010
Watershed Boundary Dataset (WBD) by
USDA - Natural Resources Conservation Service

RSM 2-08-13



North Central Texas
Council of Governments
Environment & Development

Figure 13: Sycamore Creek - West Fork Trinity River

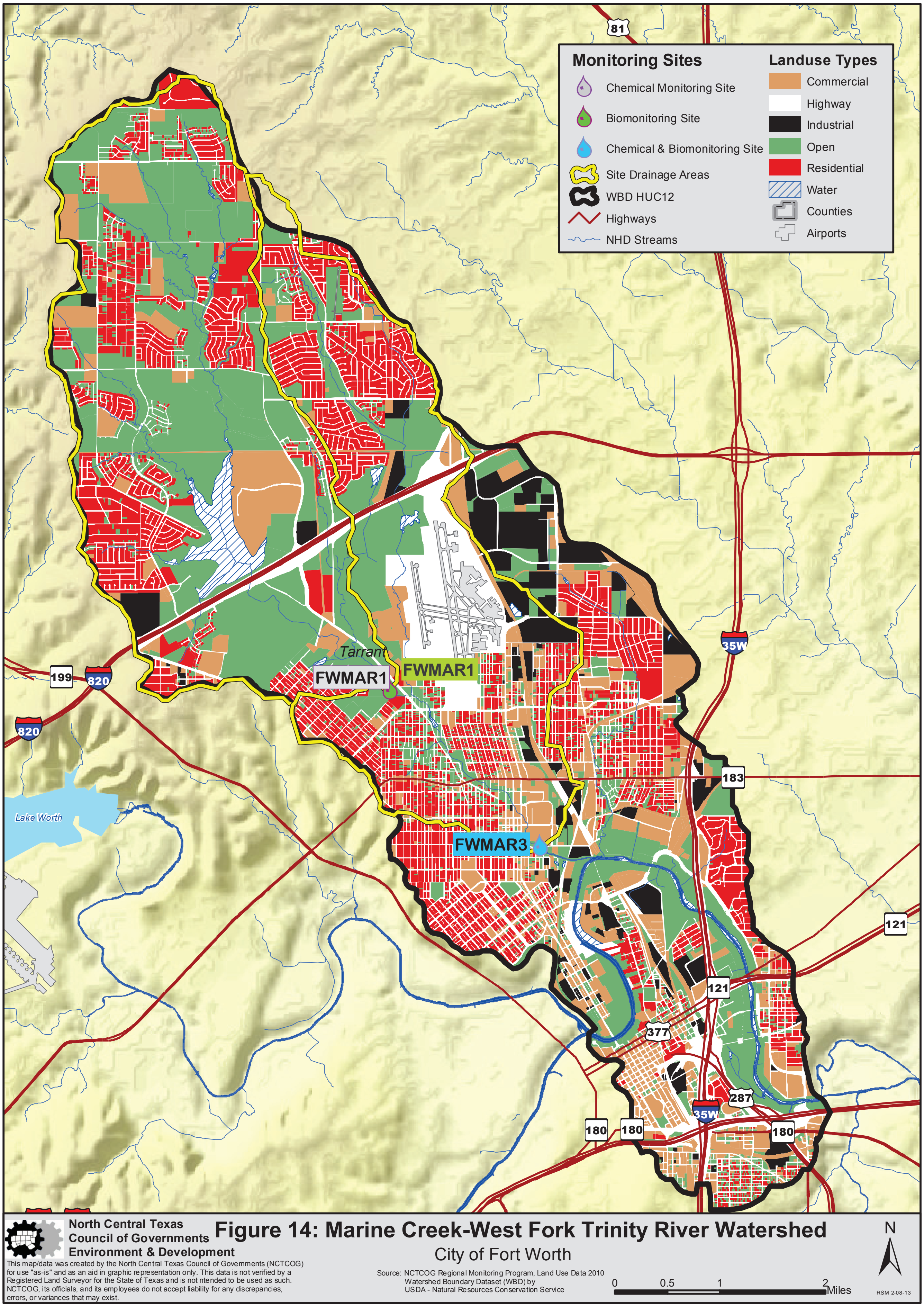
City of Fort Worth

Source: NCTCOG Regional Monitoring Program, Land Use Data 2010
Watershed Boundary Dataset (WBD) by
USDA - Natural Resources Conservation Service

N

0 0.75 1.5 3 Miles

RSM 1-17-14



North Central Texas
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Environment & Development

Figure 14: Marine Creek-West Fork Trinity River Watershed

City of Fort Worth

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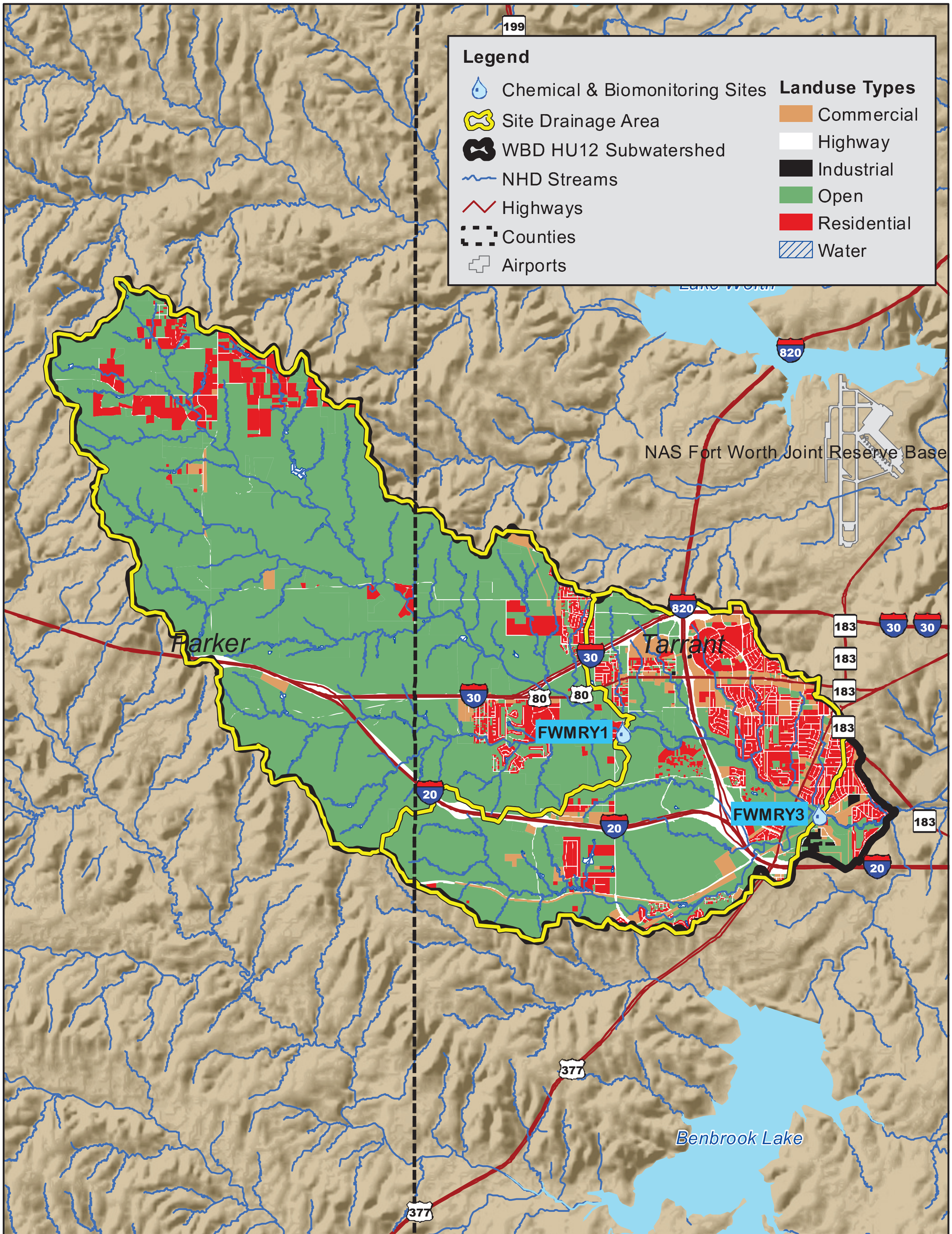
Source: NCTCOG Regional Monitoring Program, Land Use Data 2010
Watershed Boundary Dataset (WBD) by
USDA - Natural Resources Conservation Service



North Central Texas Council of Governments Environment & Development

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Figure 15: Mary's Creek Watershed

City of Fort Worth

Source: NCTCOG Regional Monitoring Program, Land Use Data 2010
Watershed Boundary Dataset (WBD) by
USDA - Natural Resources Conservation Service

BRG 1-20-15

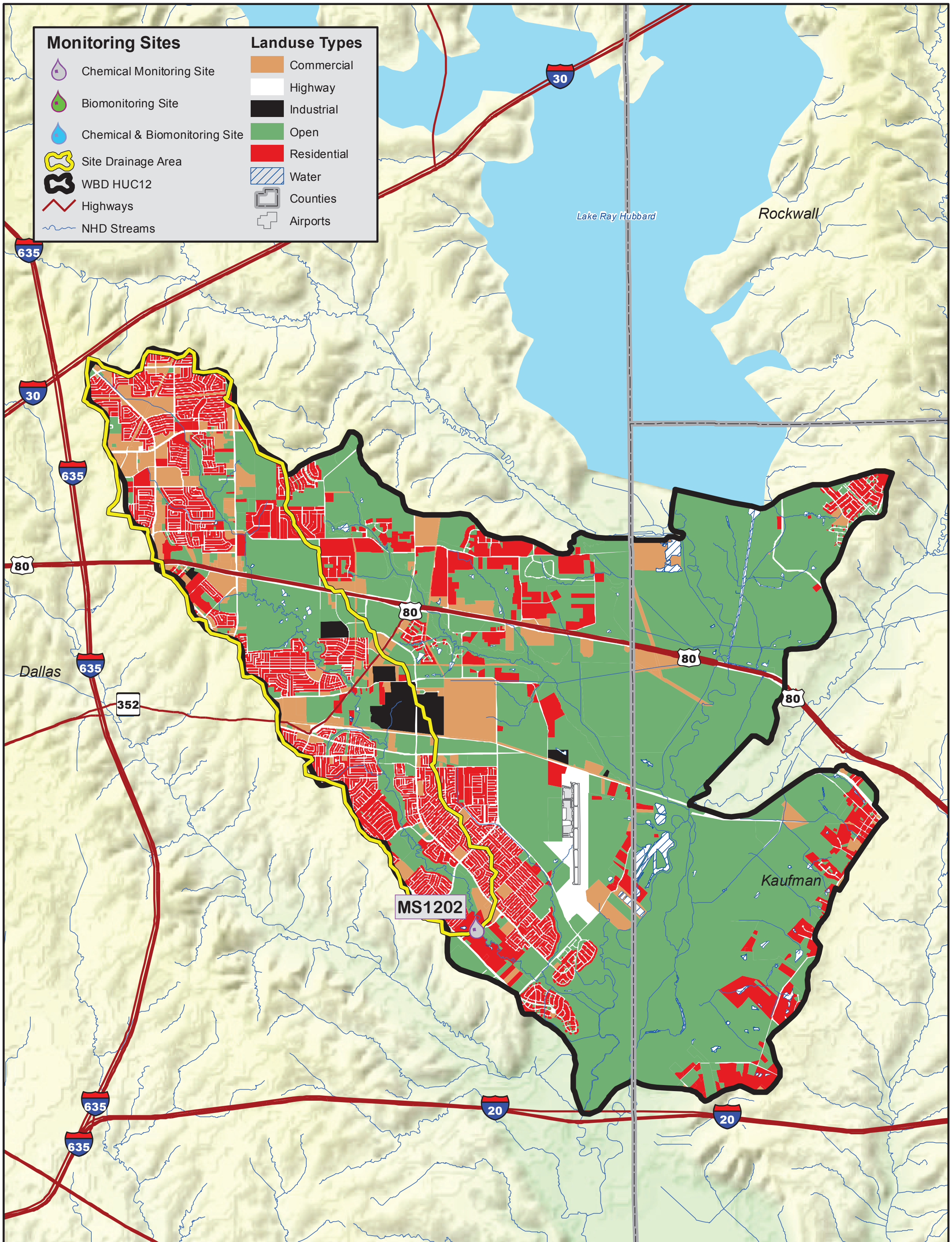

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Figure 16: North Mesquite Creek Watershed

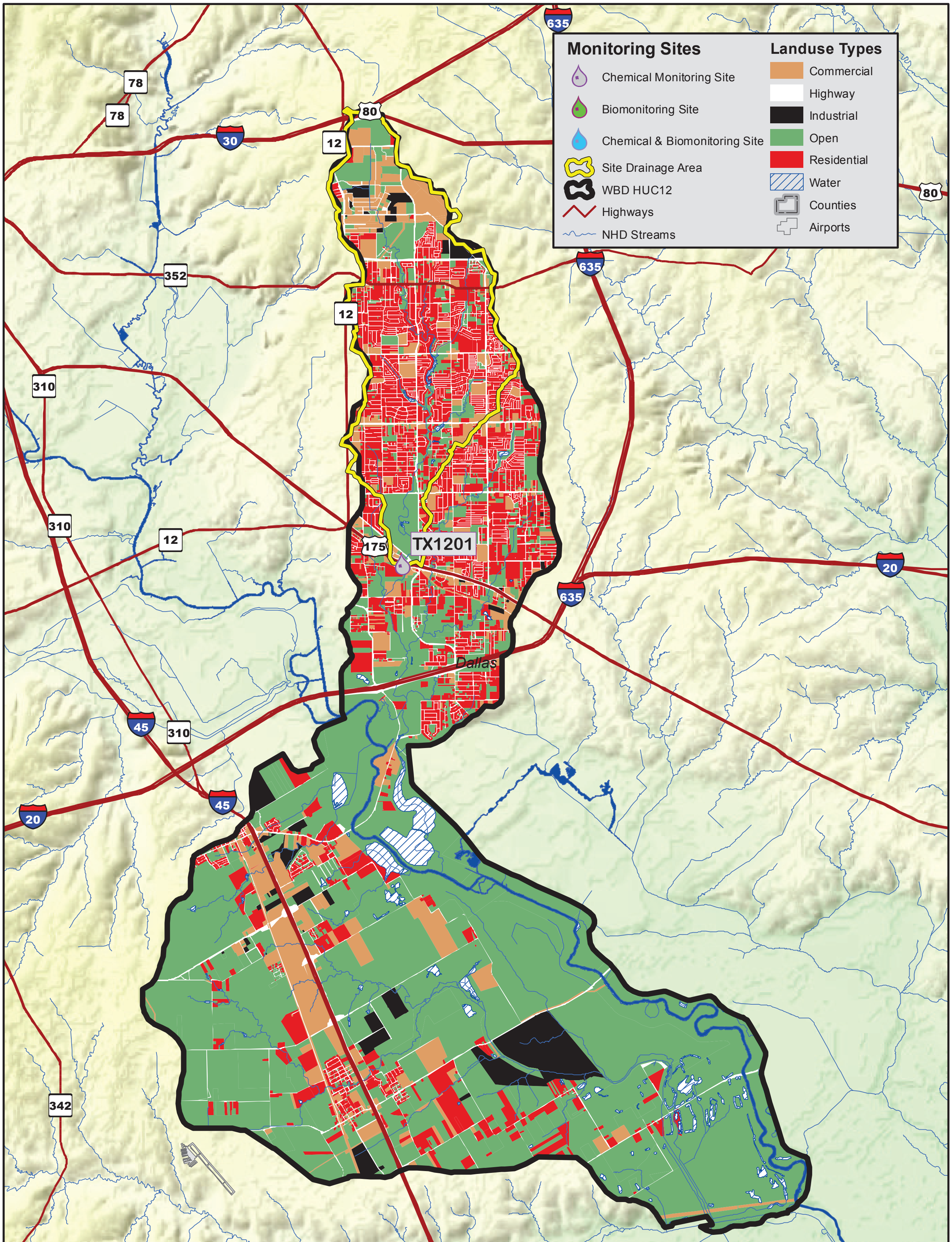
City of Mesquite

Source: NCTCOG Regional Monitoring Program, Land Use Data 2010
Watershed Boundary Dataset (WBD) by
USDA - Natural Resources Conservation Service

N

0 0.5 1 2 Miles

RSM 2-08-13



North Central Texas Council of Governments Environment & Development

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Figure 17: Prairie Creek Watershed

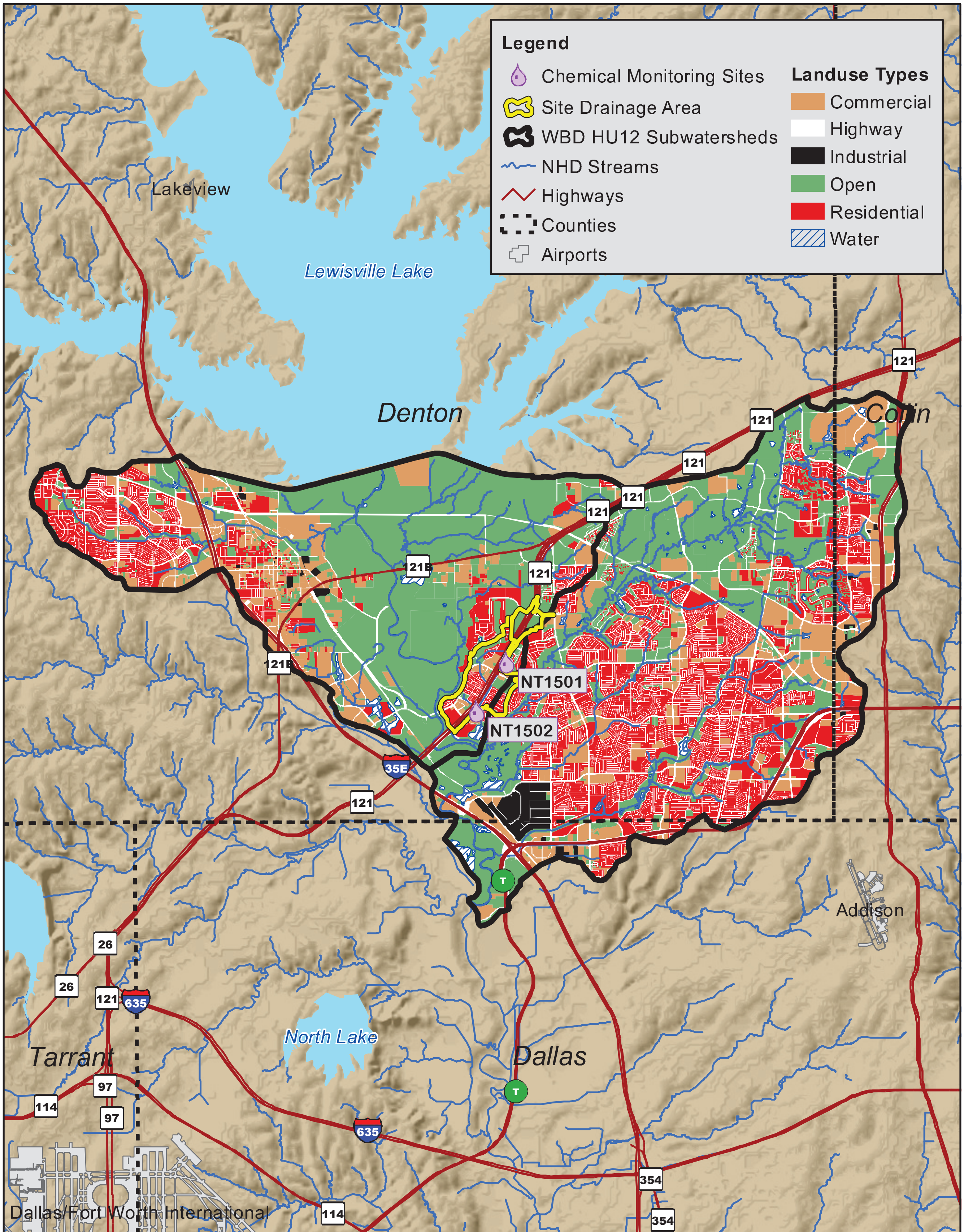
TxDOT Dallas

Source: NCTCOG Regional Monitoring Program, Land Use Data 2010
Watershed Boundary Dataset (WBD) by
USDA - Natural Resources Conservation Service

0 0.75 1.5 3 Miles

N

RSM 2-08-13



North Central Texas Council of Governments Environment & Development

Figure 18: Prairie Creek Elm Fork Trinity River Watershed

North Texas Tollway Authority

Source: NCTCOG Regional Monitoring Program, Land Use Data 2010
Watershed Boundary Dataset (WBD) by
USDA - Natural Resources Conservation Service

N

0 0.75 1.5 3 Miles

BRG 1-20-15

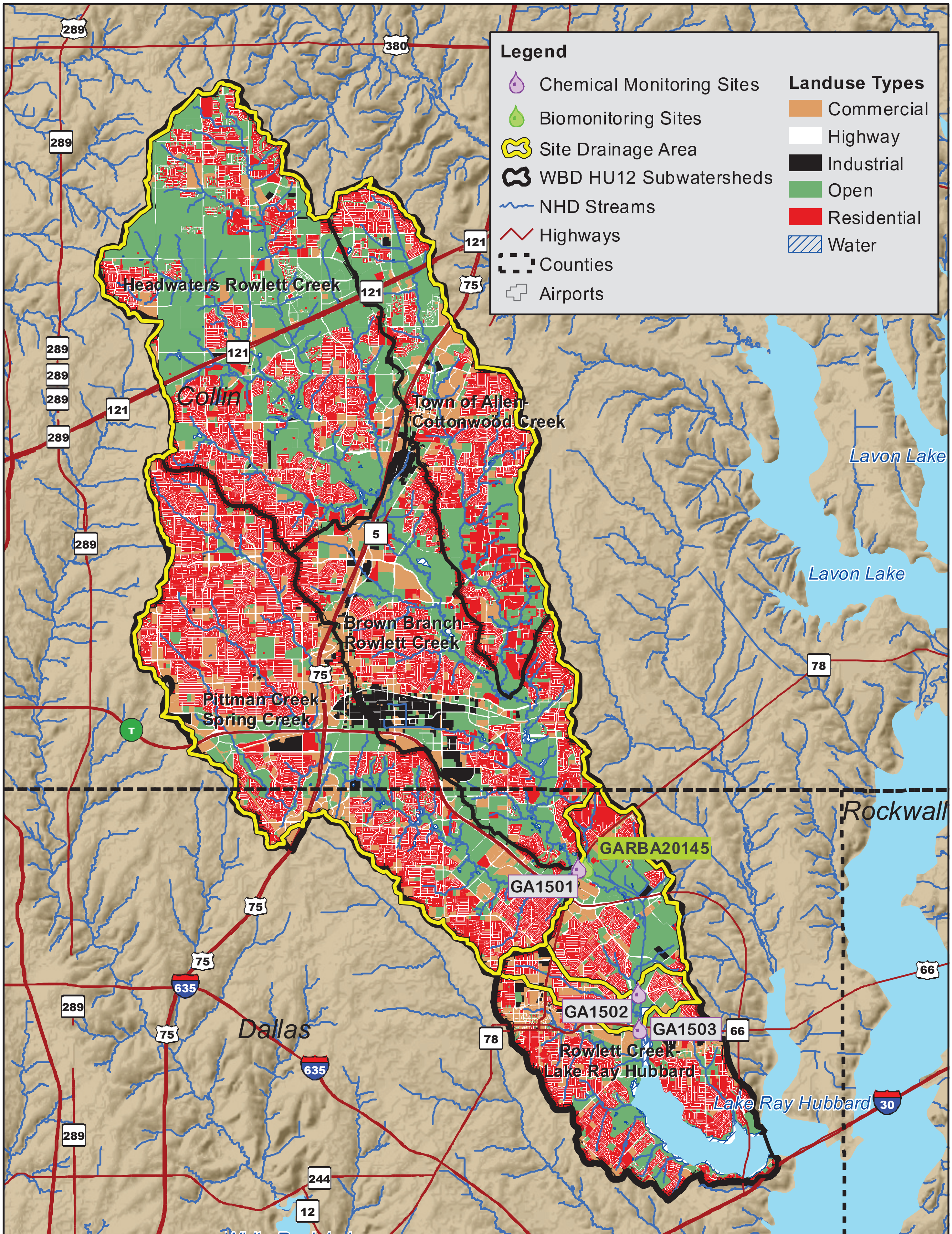


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Figure 19: Rowlet Creek Lake Ray Hubbard Watershed

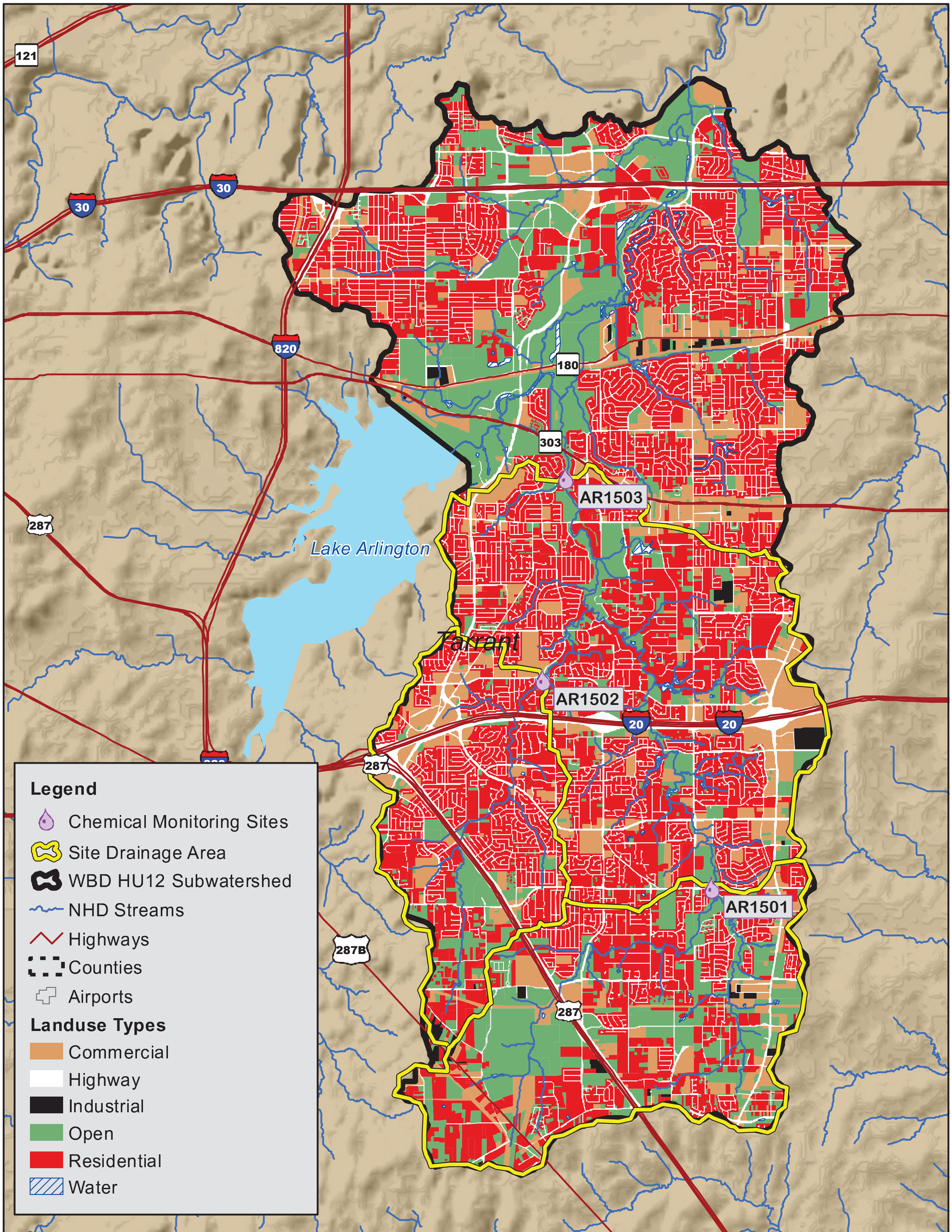
City of Garland

Source: NCTCOG Regional Monitoring Program, Land Use Data 2010
Watershed Boundary Dataset (WBD) by
USDA - Natural Resources Conservation Service

N

0 1.25 2.5 5 Miles

BRG 1-20-15



North Central Texas
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Environment & Development

Figure 20: Rush Creek Village Creek Watershed

City of Arlington

Source: NCTCOG Regional Monitoring Program, Land Use Data 2010
Watershed Boundary Dataset (WBD) by
USDA - Natural Resources Conservation Service

0 0.5 1 2 Miles

N

BRG 1-20-15

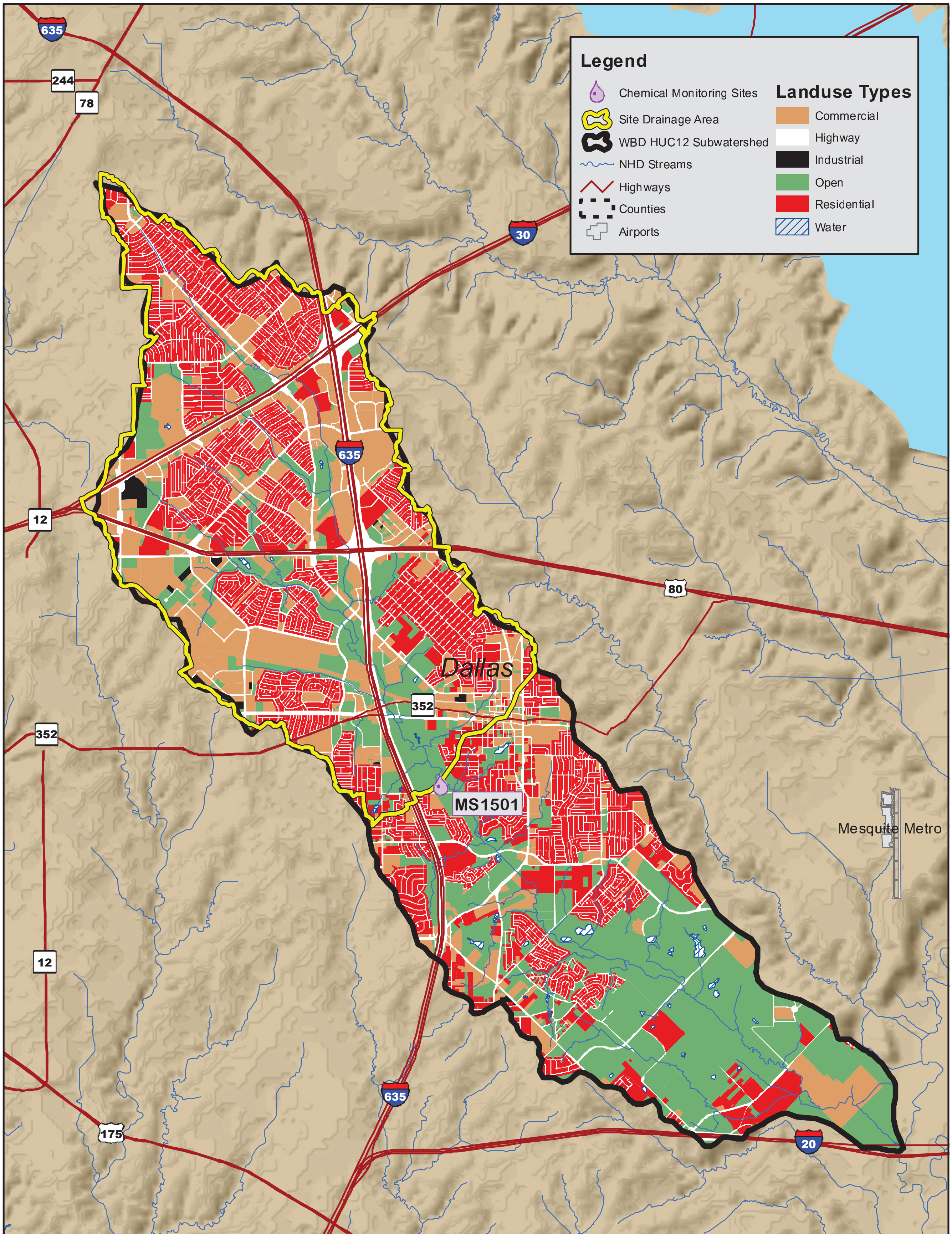

Figure 21: South Mesquite Creek Watershed

City of Mesquite

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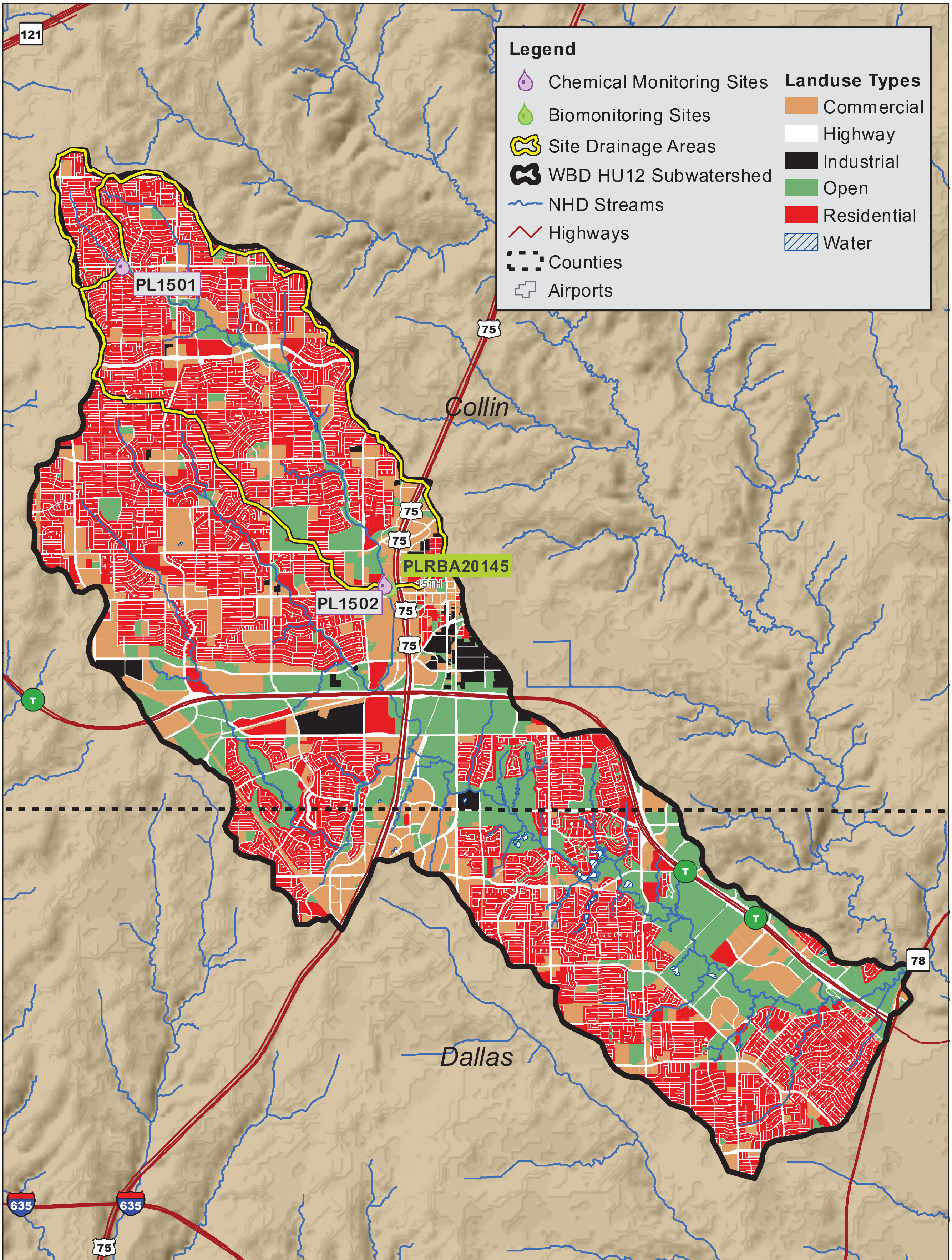
Source: NCTCOG Regional Monitoring Program, Land Use Data 2010
Watershed Boundary Dataset (WBD) by
USDA - Natural Resources Conservation Service



North Central Texas
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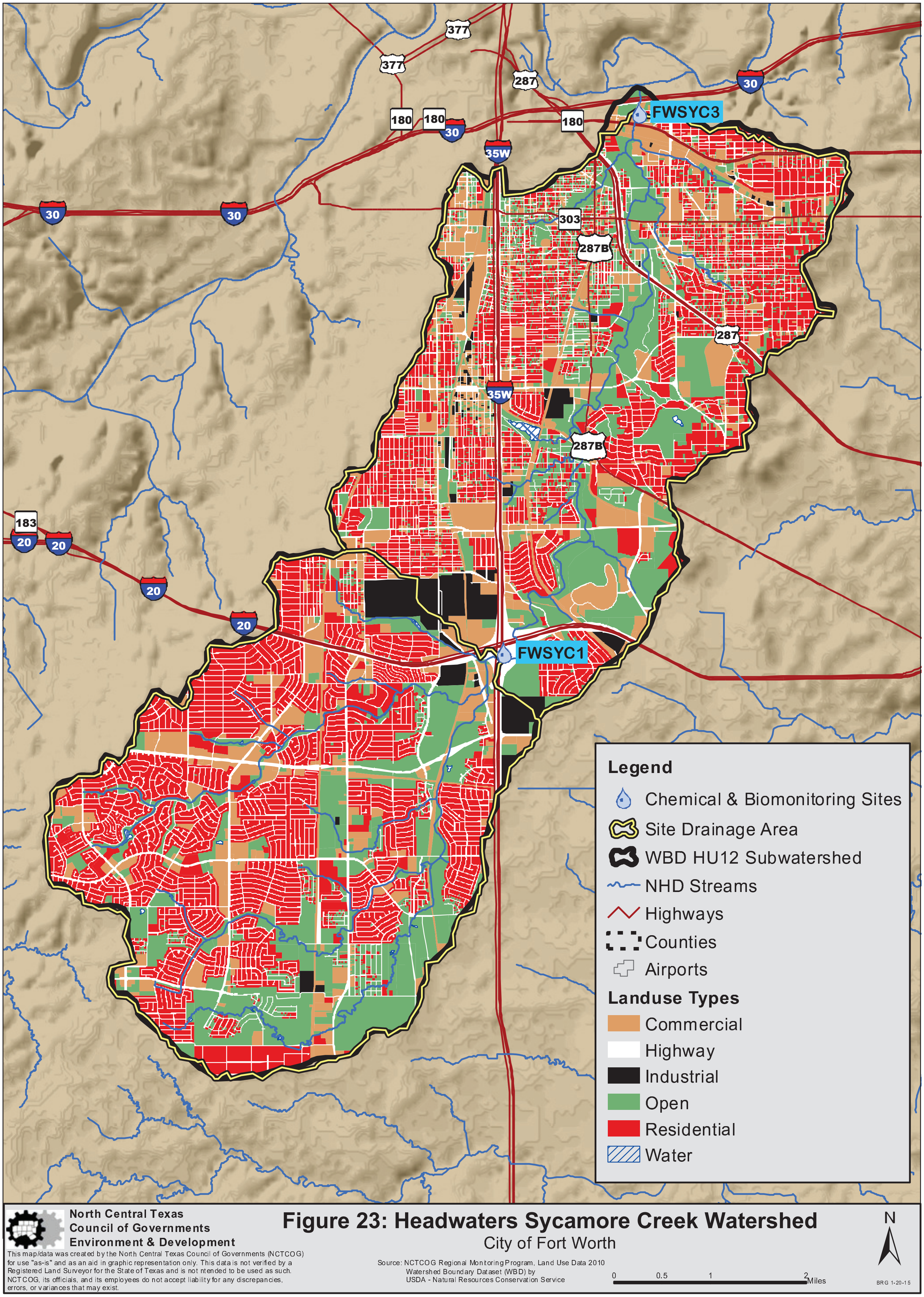
Figure 22: Pittman Creek Spring Creek Watershed

City of Plano

Source: NCTCOG Regional Monitoring Program, Land Use Data 2010
Watershed Boundary Dataset (WBD) by
USDA - Natural Resources Conservation Service

BRG 1-20-15



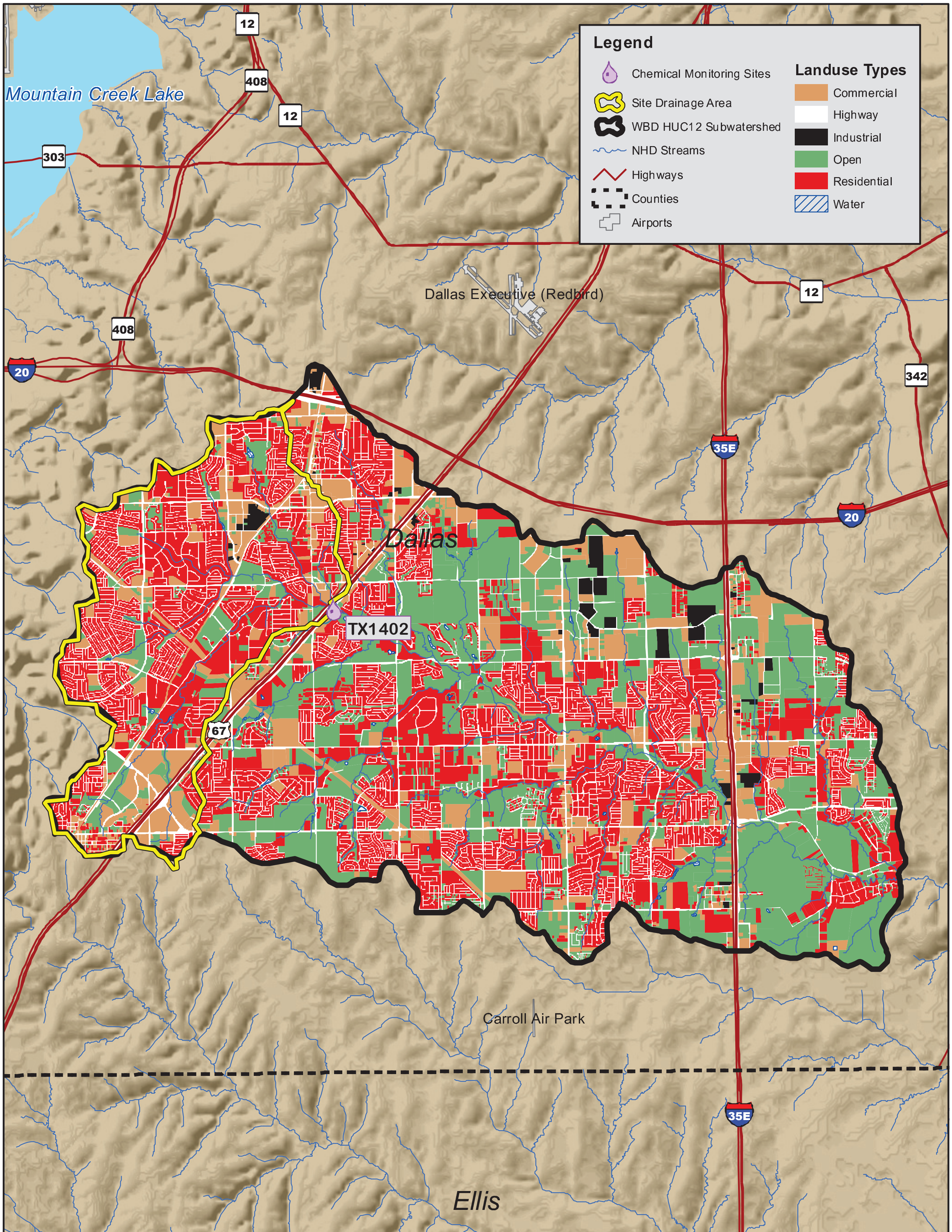
North Central Texas
Council of Governments
Environment & Development

Figure 23: Headwaters Sycamore Creek Watershed

City of Fort Worth

Source: NCTCOG Regional Monitoring Program, Land Use Data 2010
Watershed Boundary Dataset (WBD) by
USDA - Natural Resources Conservation Service

BRG 1-20-15



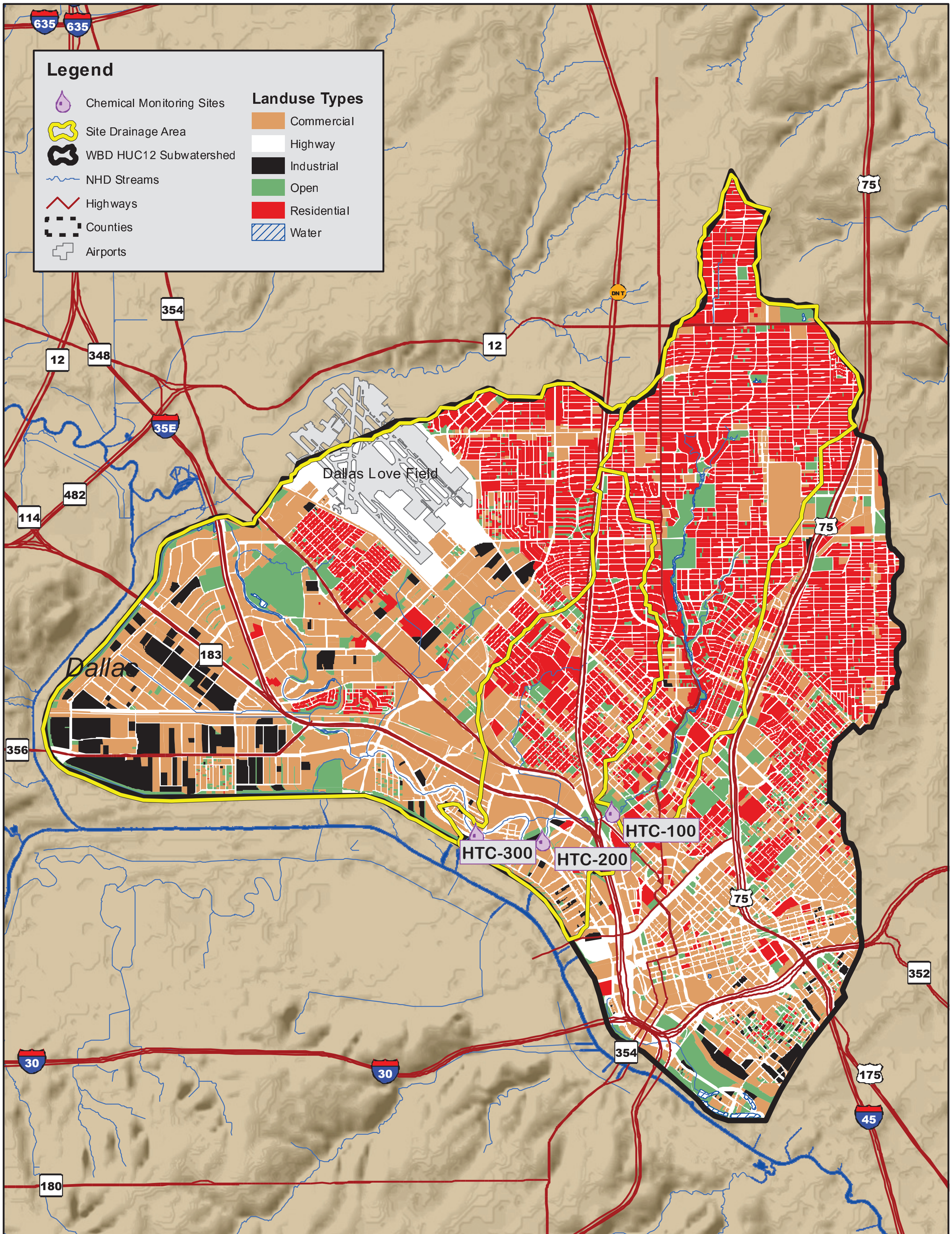
North Central Texas
Council of Governments
Environment & Development

Figure 24: Headwaters Ten Mile Creek Watershed

TxDOT Dallas

Source: NCTCOG Regional Monitoring Program, Land Use Data 2010
Watershed Boundary Dataset (WBD) by
USDA - Natural Resources Conservation Service

RSM 1-17-14



North Central Texas
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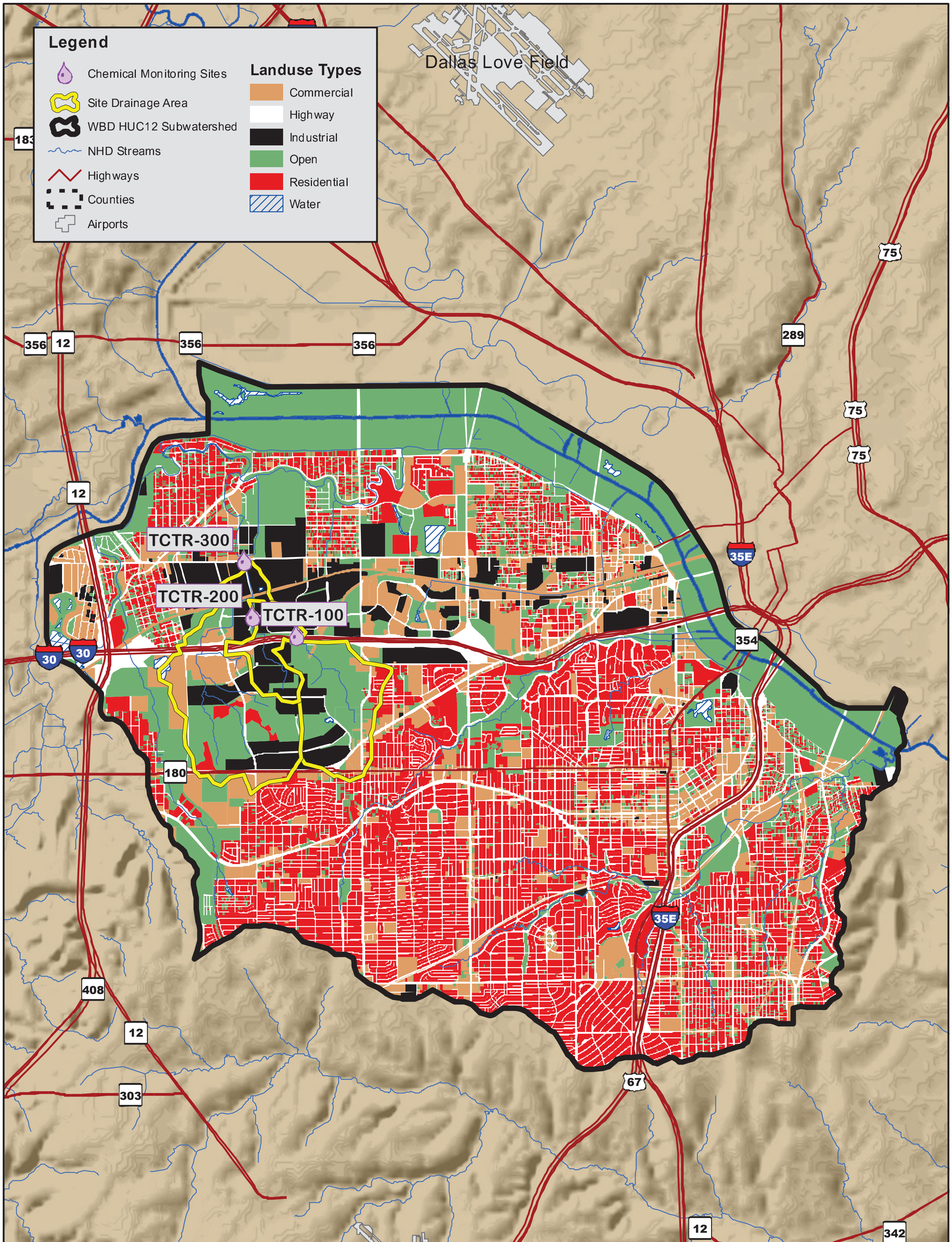
Environment & Development

Figure 25: Headwaters Turtle Creek Watershed

City of Dallas

Source: NCTCOG Regional Monitoring Program, Land Use Data 2010
Watershed Boundary Dataset (WBD) by
USDA - Natural Resources Conservation Service



North Central Texas Council of Governments Environment & Development

Figure 26: Turtle Creek Trinity River Watershed

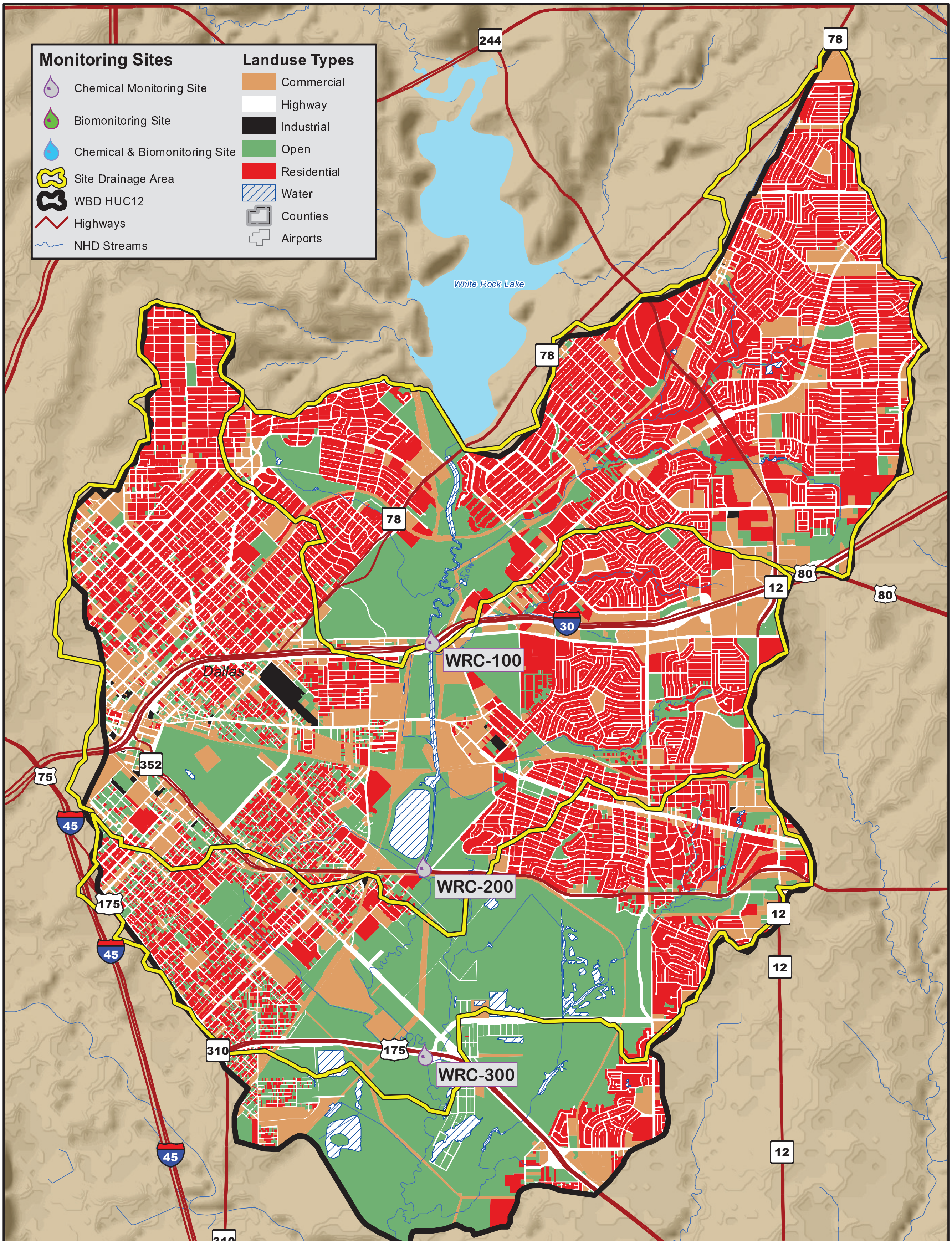
City of Dallas

Source: NCTCOG Regional Monitoring Program, Land Use Data 2010
Watershed Boundary Dataset (WBD) by
USDA - Natural Resources Conservation Service

0 0.5 1 2 Miles

N

BRG 1-20-15



North Central Texas
Council of Governments
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Figure 27: City of Dallas - White Rock Creek

City of Dallas

Source: NCTCOG Regional Monitoring Program, Land Use Data 2010
Watershed Boundary Dataset (WBD) by
USDA - Natural Resources Conservation Service

N

0 0.5 1 2 Miles

RSM 1-17-14

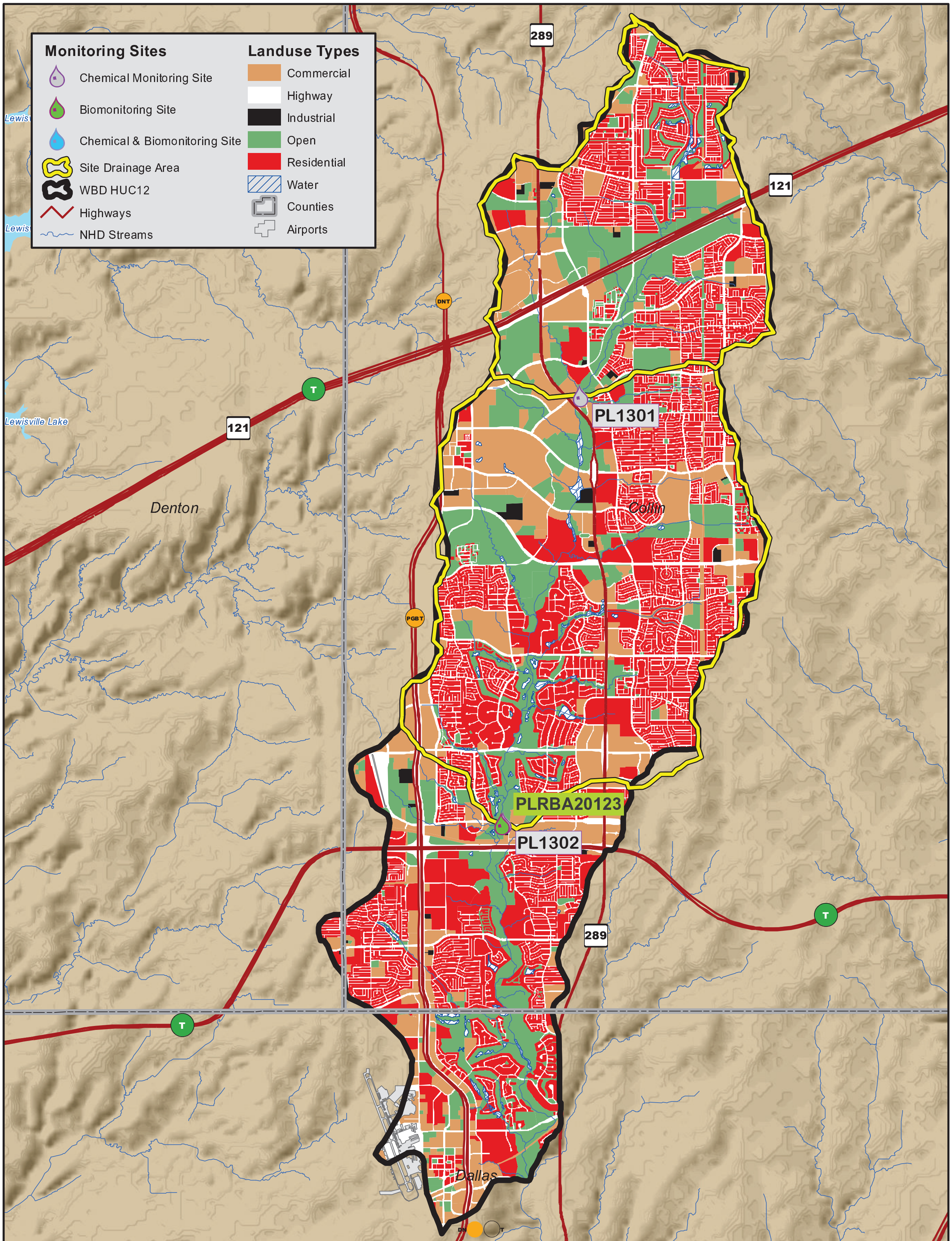

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Figure 28: Headwaters White Rock Creek Watershed

City of Plano

Source: NCTCOG Regional Monitoring Program, Land Use Data 2010
Watershed Boundary Dataset (WBD) by
USDA - Natural Resources Conservation Service

0 0.5 1 2 Miles

N

RSM 1-17-14

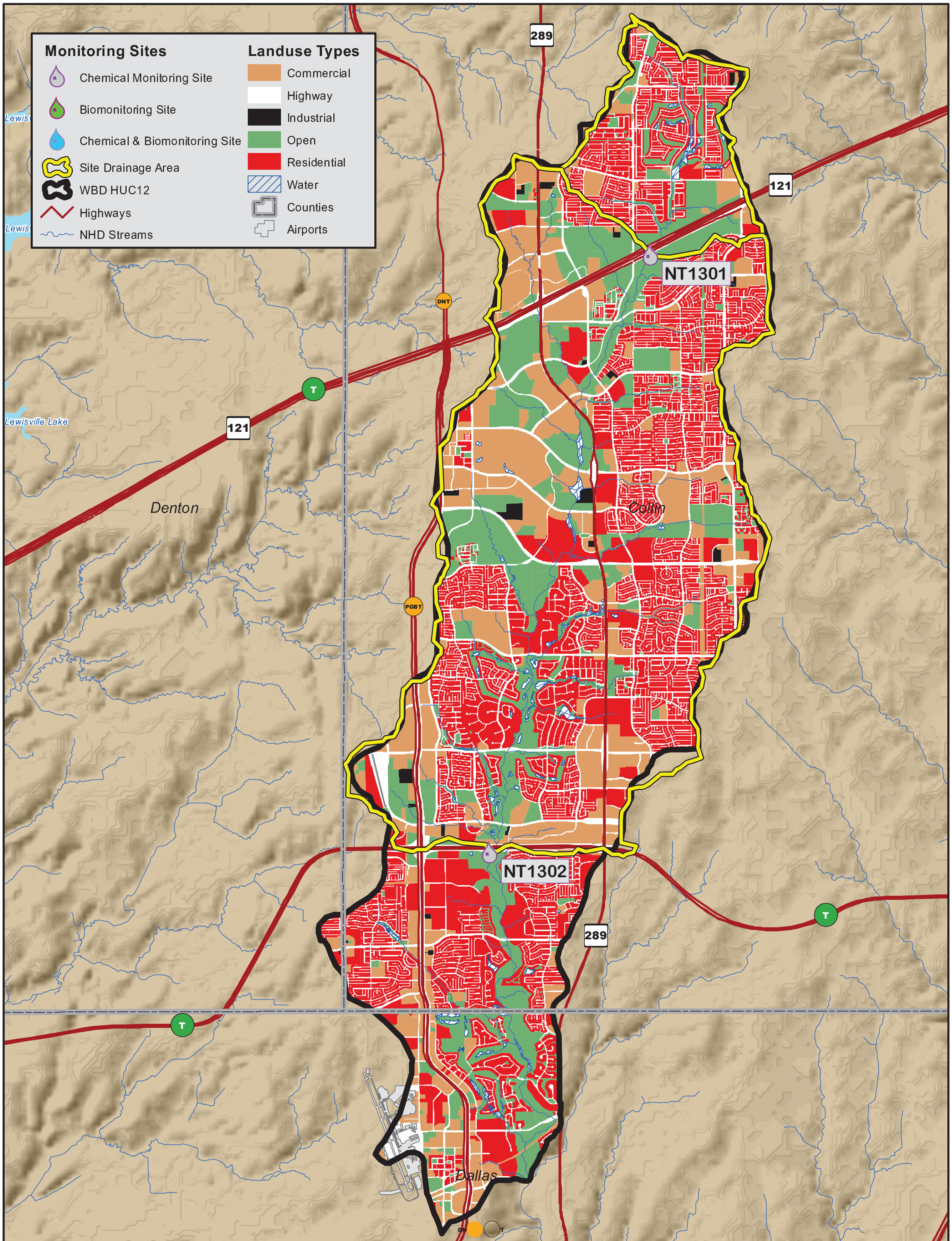

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Figure 29: Headwaters White Rock Creek Watershed

North Texas Tollway Authority

Source: NCTCOG Regional Monitoring Program, Land Use Data 2010
Watershed Boundary Dataset (WBD) by
USDA - Natural Resources Conservation Service

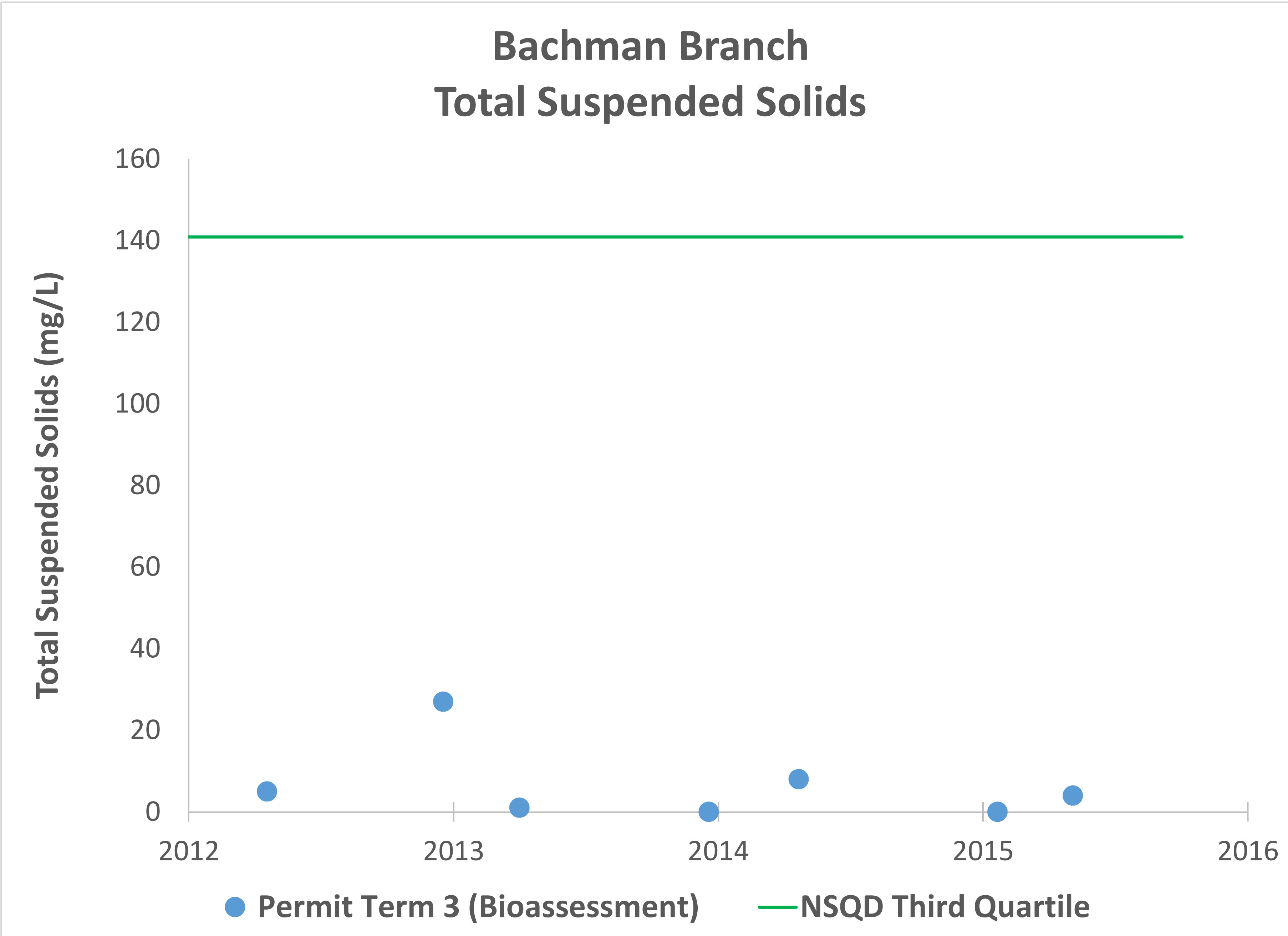
N

0 0.5 1 2 Miles

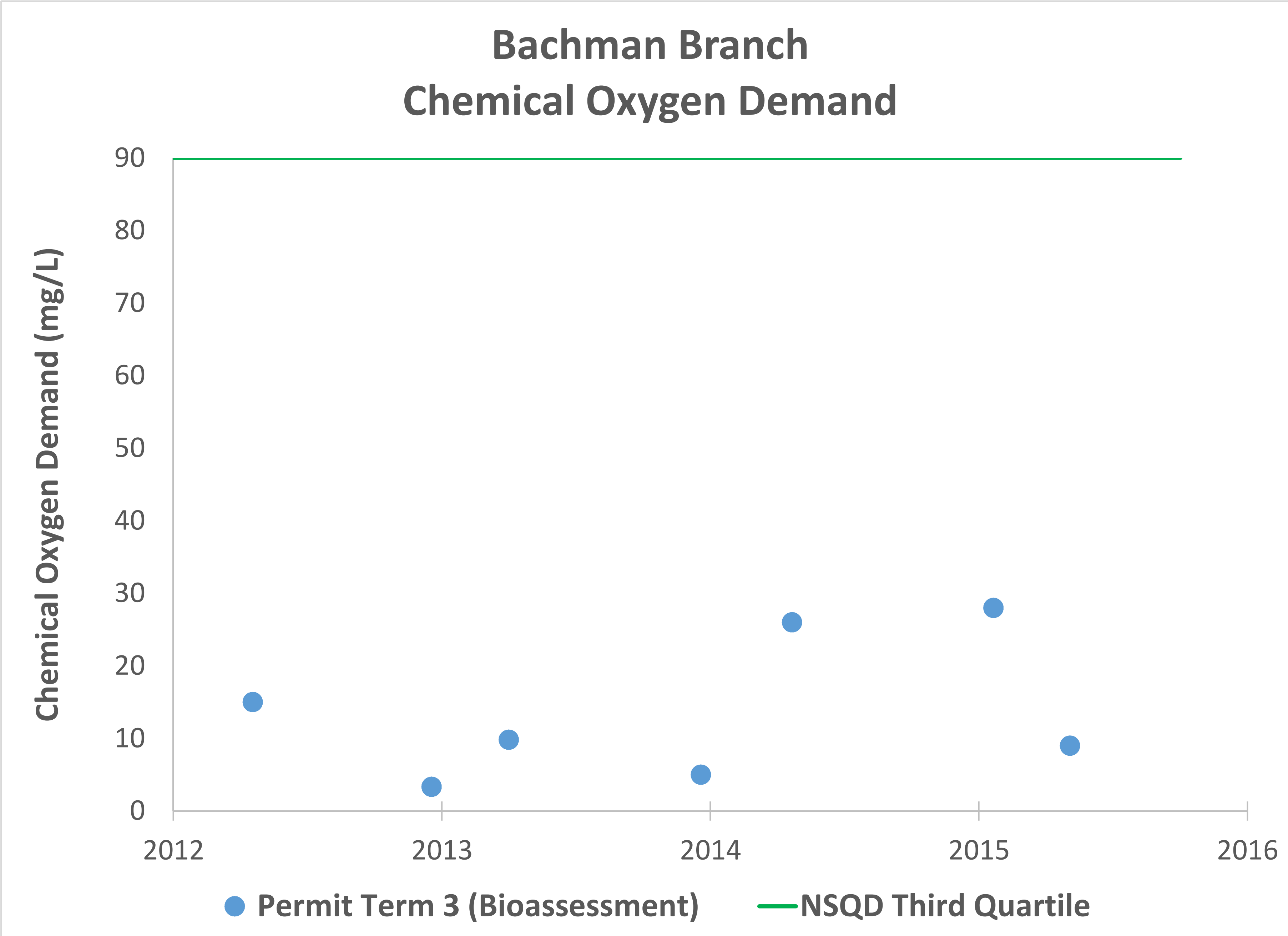
RSM 1-17-14

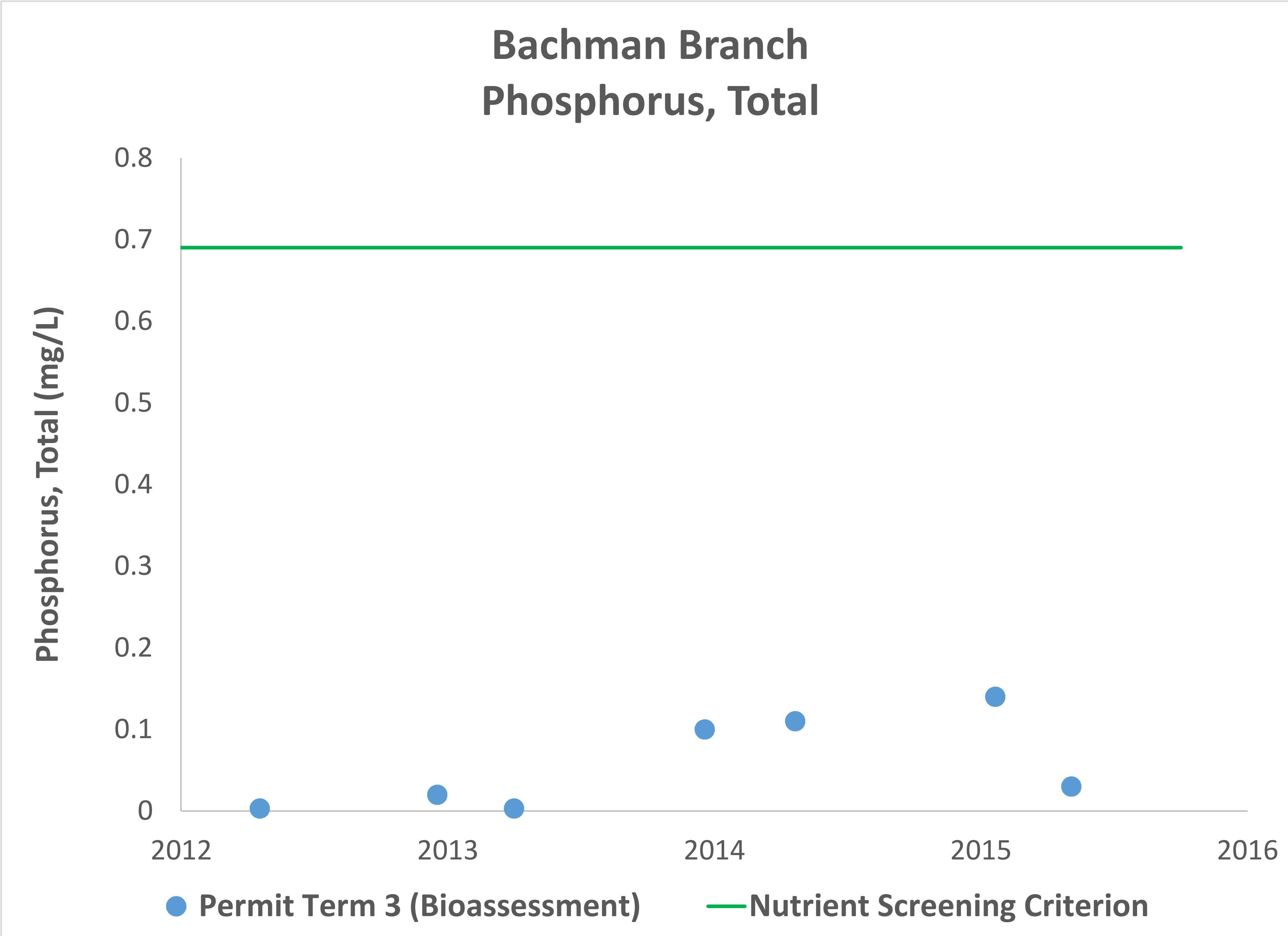
Appendix D

Bachman Branch Water Quality
Data Graphs

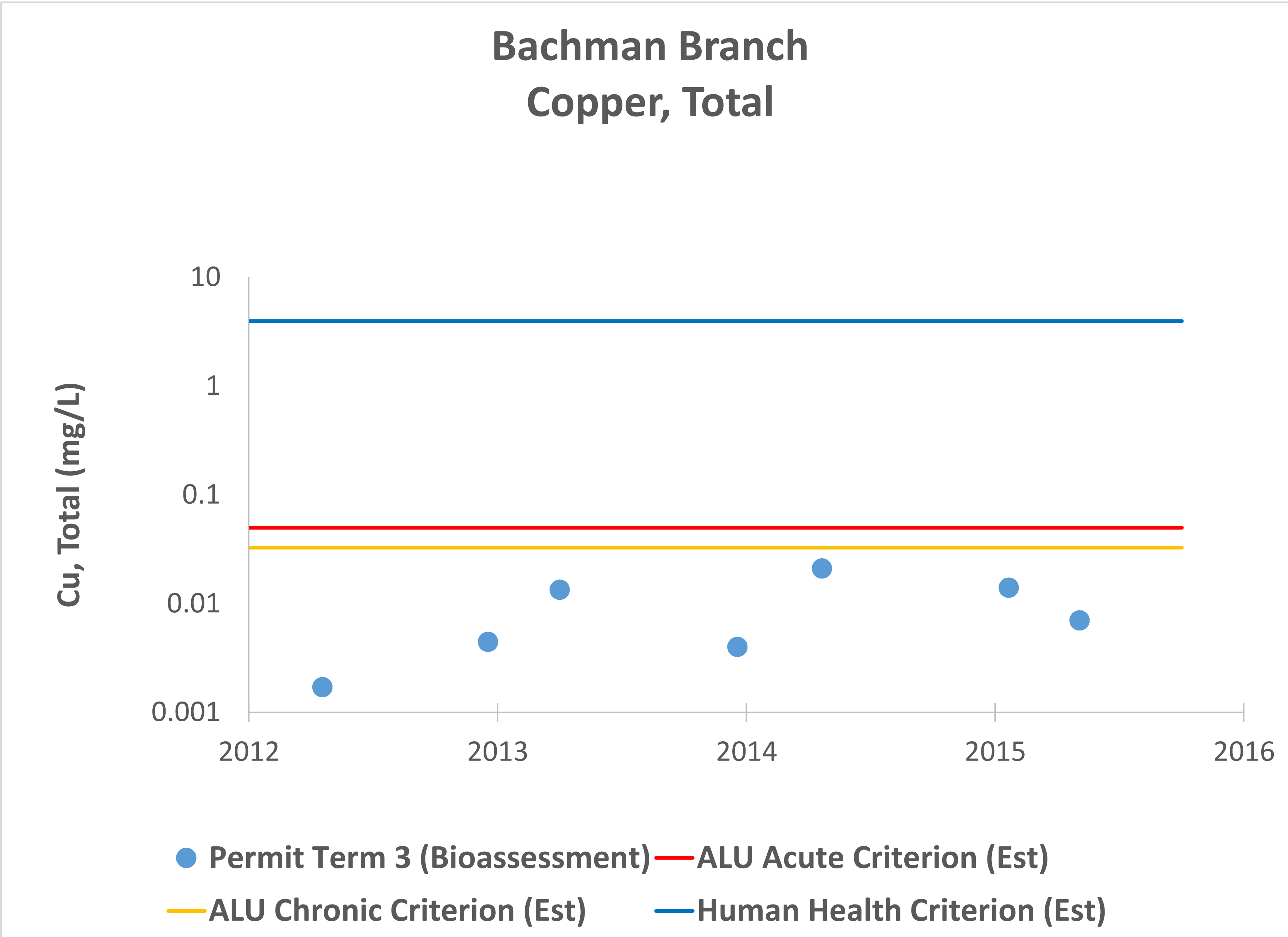


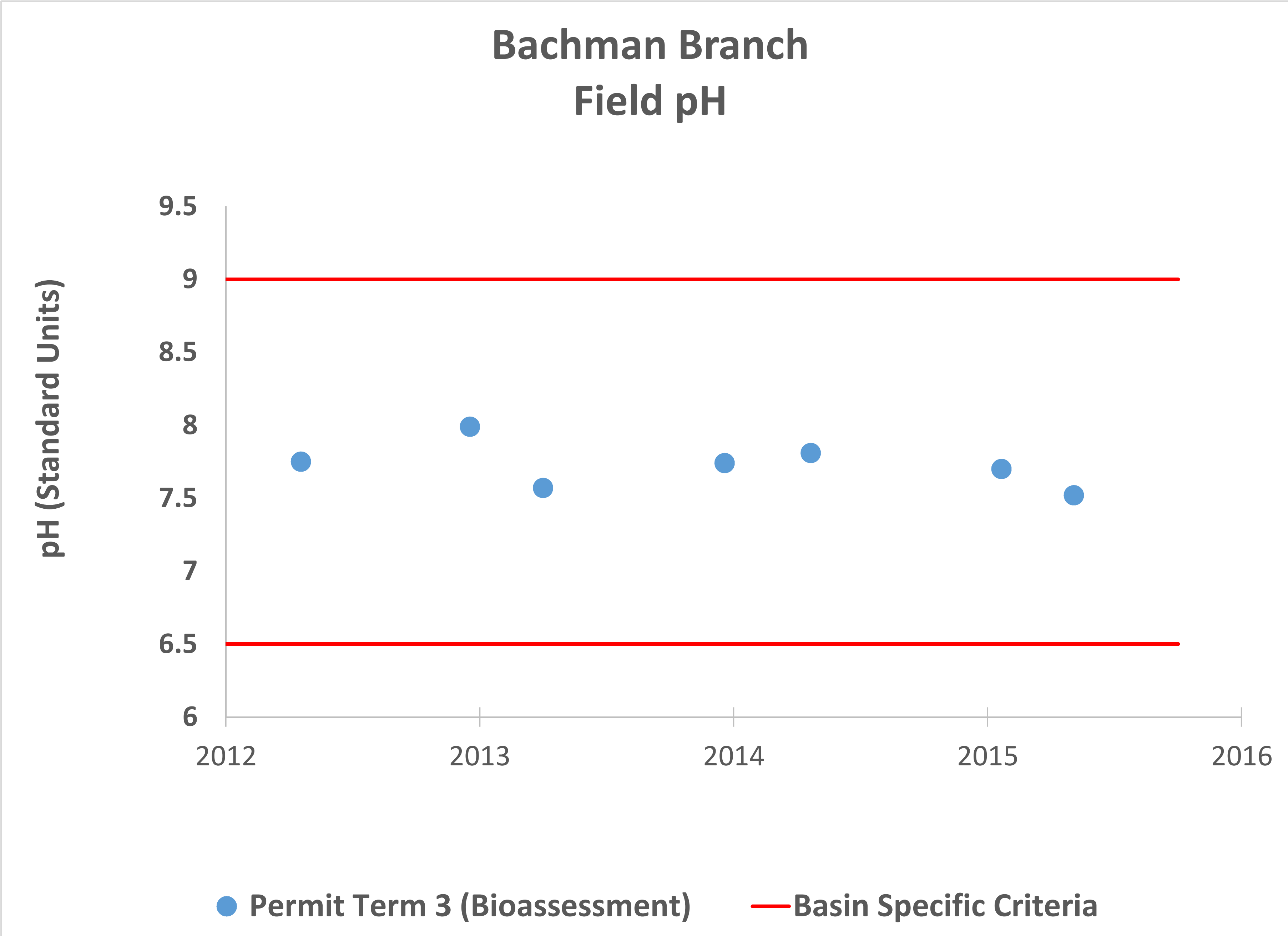
Bachman Branch
Total Suspended Solids
Total Suspended Solids (mg/L)
160
140
120
100
80
60
40
20
0
2012
2013
2014
2015
2016
Permit Term 3 (Bioassessment)
NSQD Third Quartile

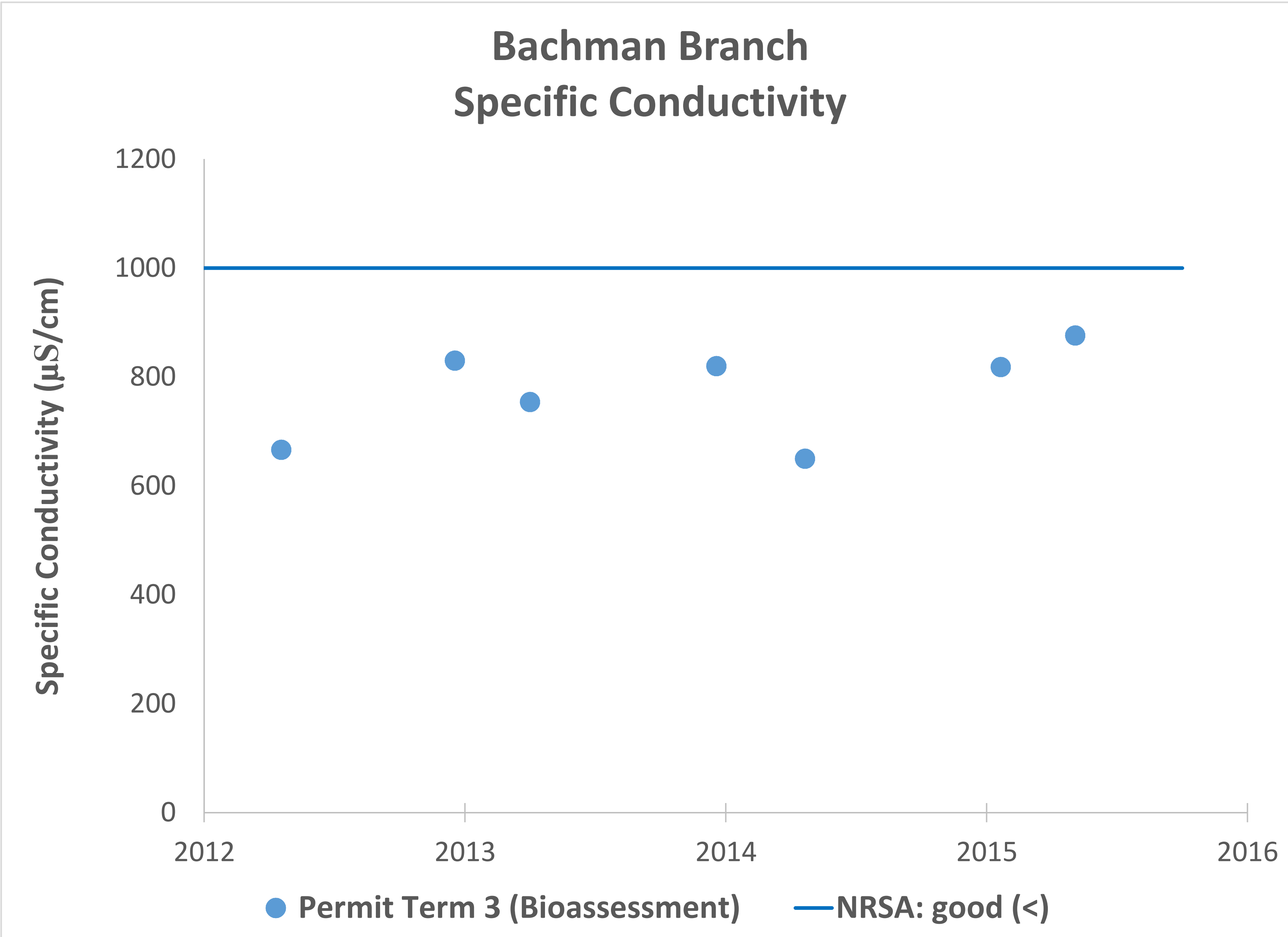

Bachman Branch
Chemical Oxygen Demand
Chemical Oxygen Demand (mg/L)
0
10
20
30
40
50
60
70
80
90
2012
2013
2014
2015
2016
Permit Term 3 (Bioassessment)
NSQD Third Quartile

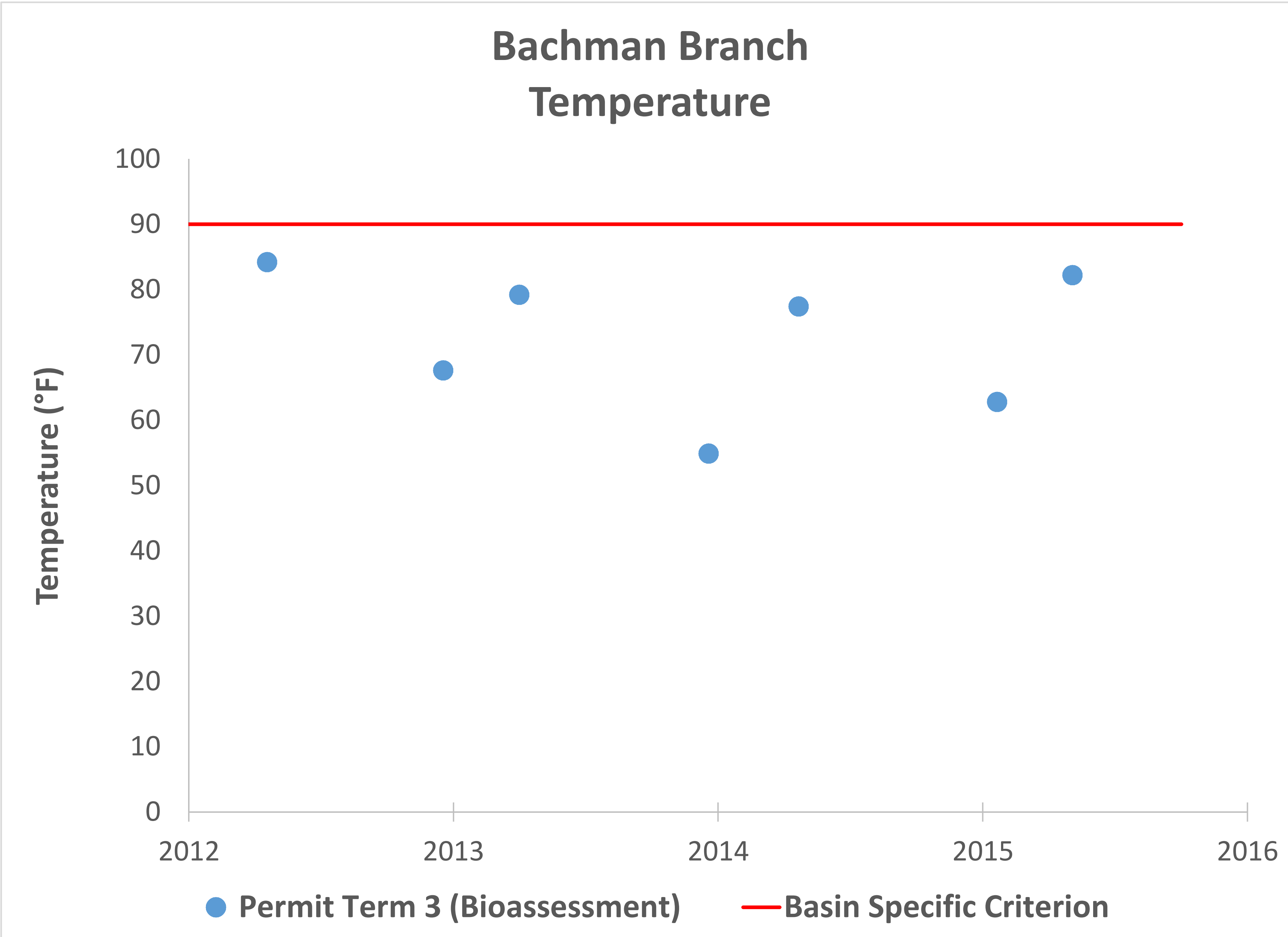


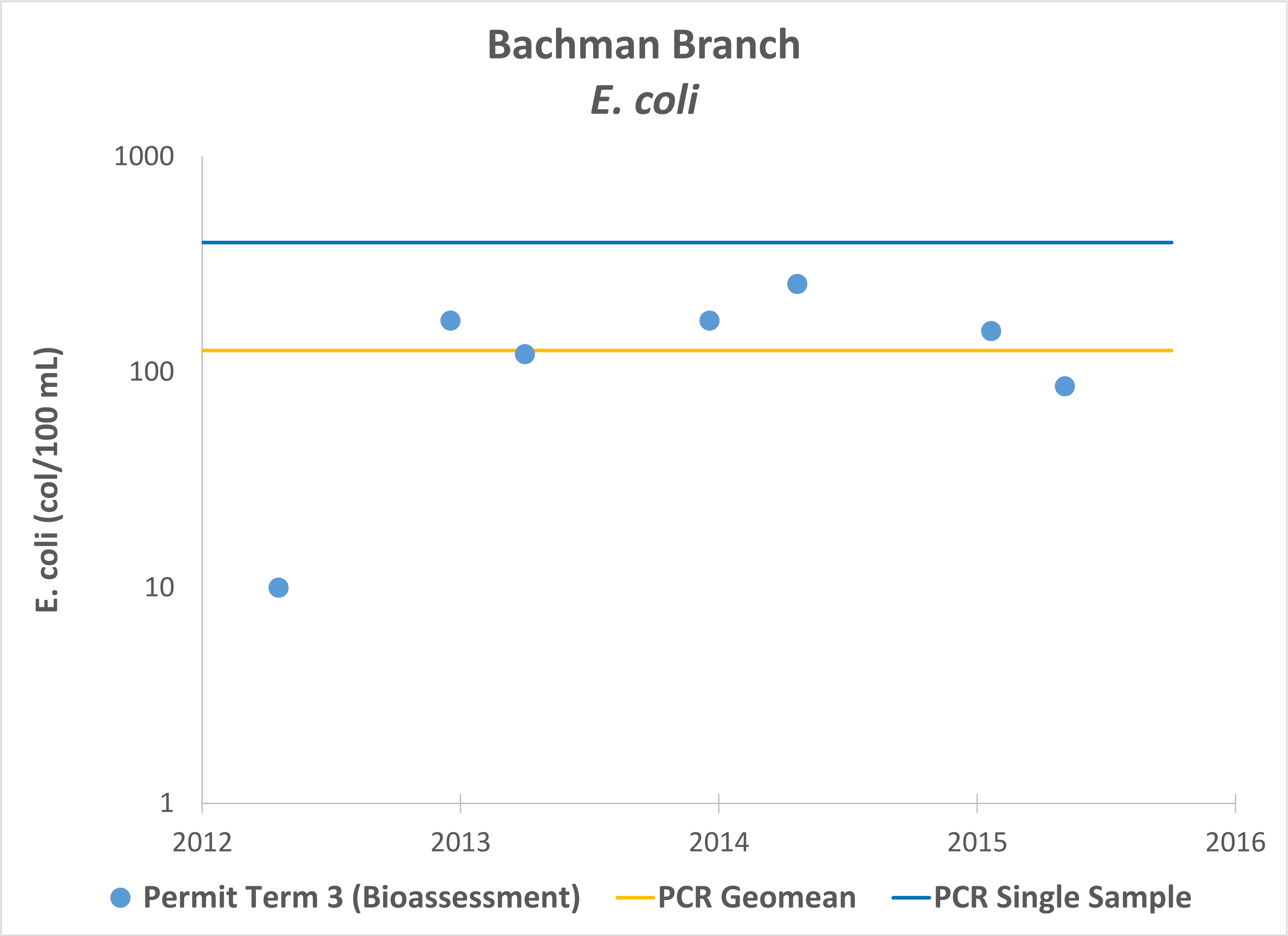
Bachman Branch
Phosphorus, Total
Phosphorus, Total (mg/L)
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
2012
2013
2014
2015
2016
Permit Term 3 (Bioassessment)
Nutrient Screening Criterion


Bachman Branch
Copper, Total
Cu, Total (mg/L)
10
1
0.1
0.01
0.001
2012
2013
2014
2015
2016
Permit Term 3 (Bioassessment)
ALU Acute Criterion (Est)
ALU Chronic Criterion (Est)
Human Health Criterion (Est)

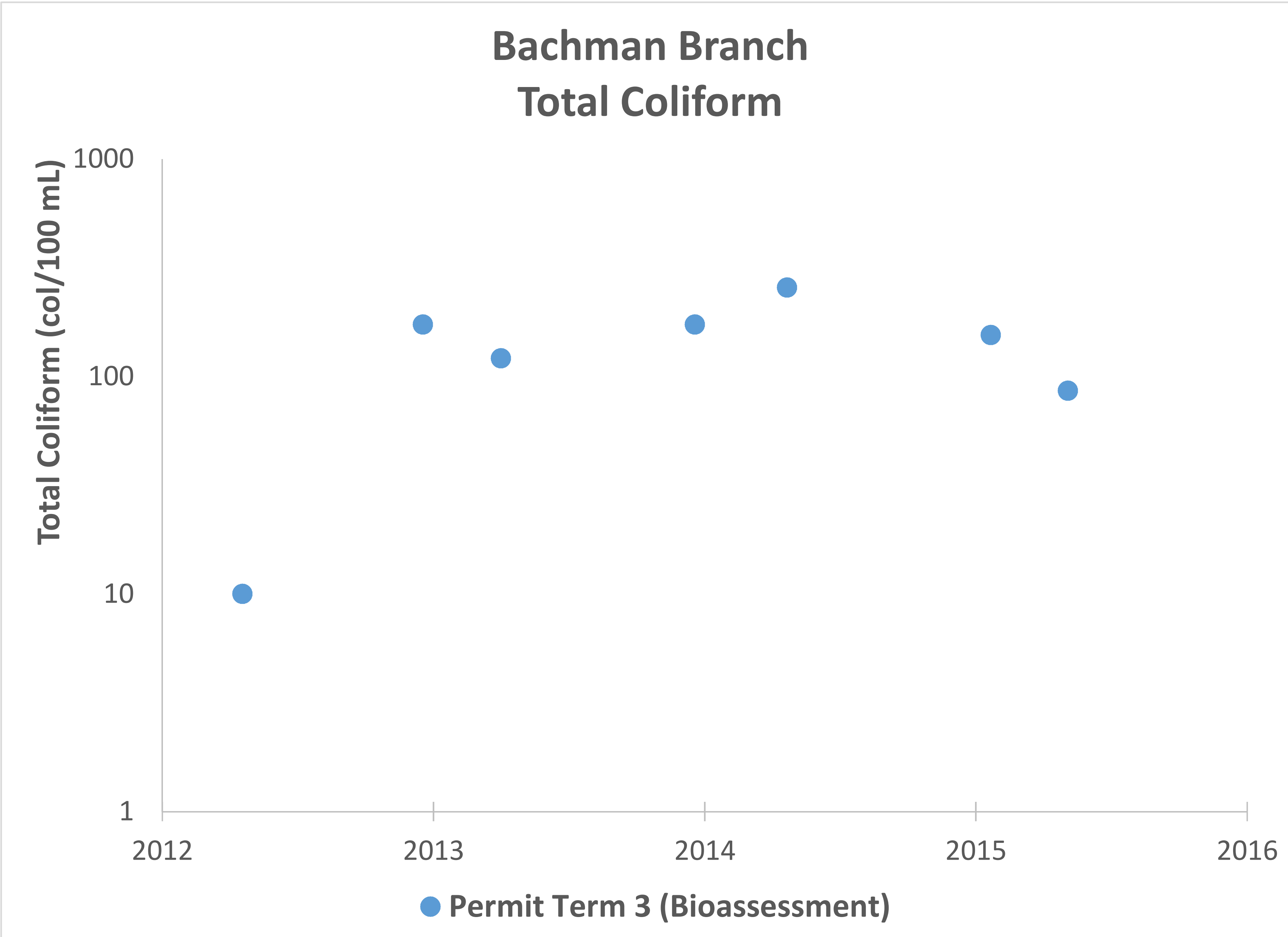

Bachman Branch
Field pH
pH (Standard Units)
9.5
9
8.5
8
7.5
7
6.5
6
2012
2013
2014
2015
2016
Permit Term 3 (Bioassessment)
Basin Specific Criteria

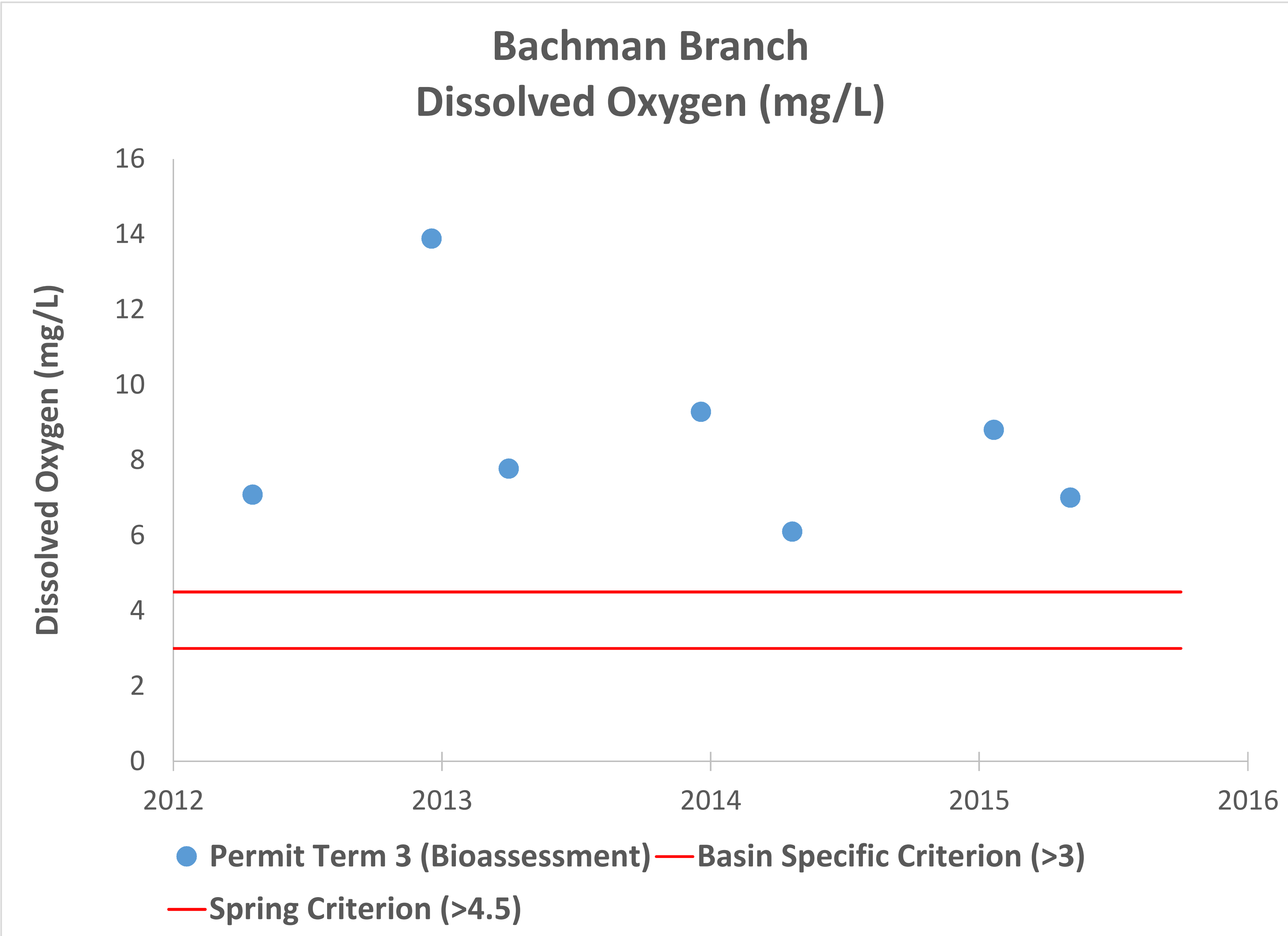

Bachman Branch
Specific Conductivity
Specific Conductivity (µS/cm)
1200
1000
800
600
400
200
0
2012
2013
2014
2015
2016
Permit Term 3 (Bioassessment)
NRSA: good (<)

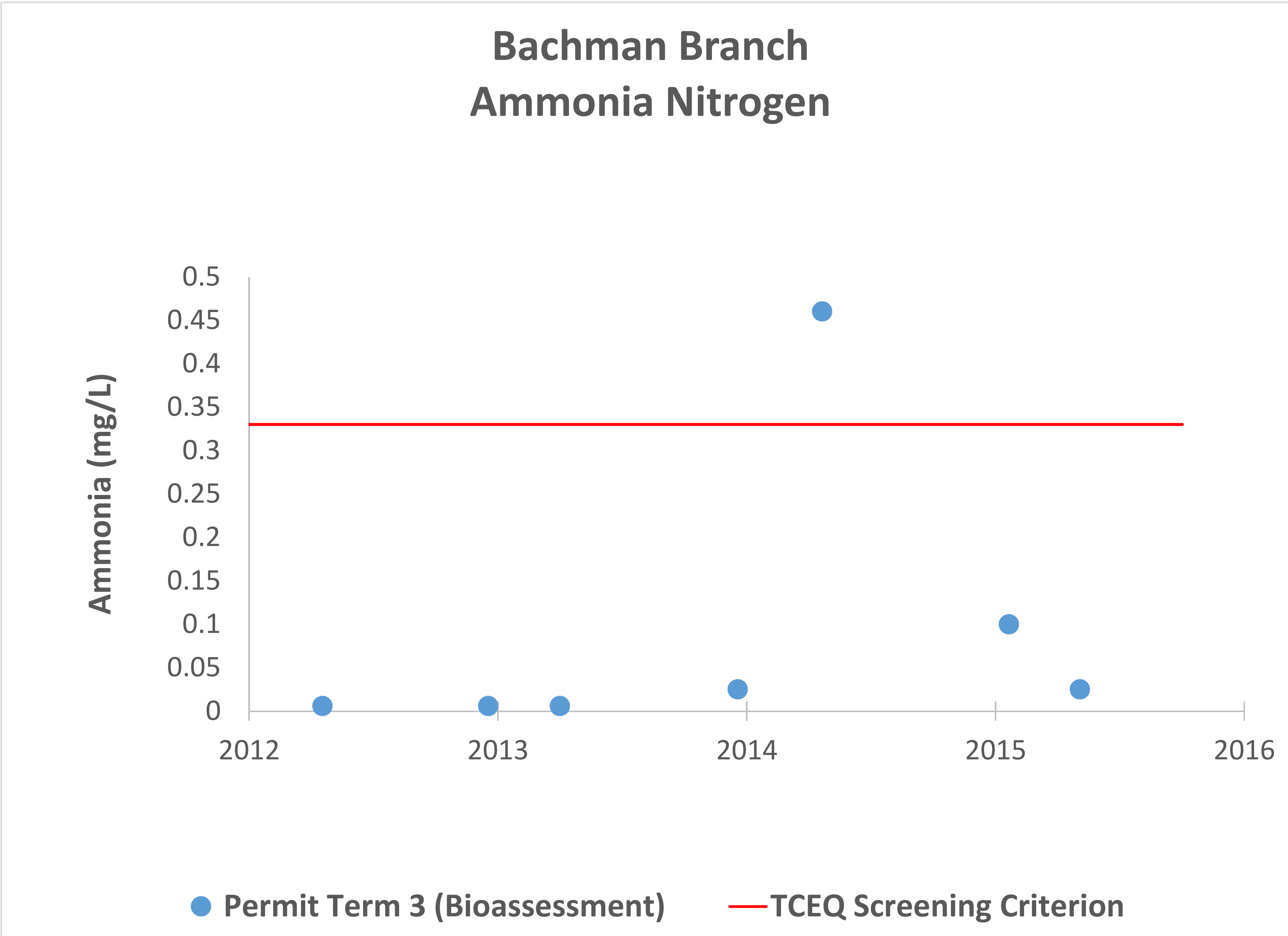

Bachman Branch
Temperature
Temperature (°F)
100
90
80
70
60
50
40
30
20
10
0
2012
2013
2014
2015
2016
Permit Term 3 (Bioassessment)
Basin Specific Criterion

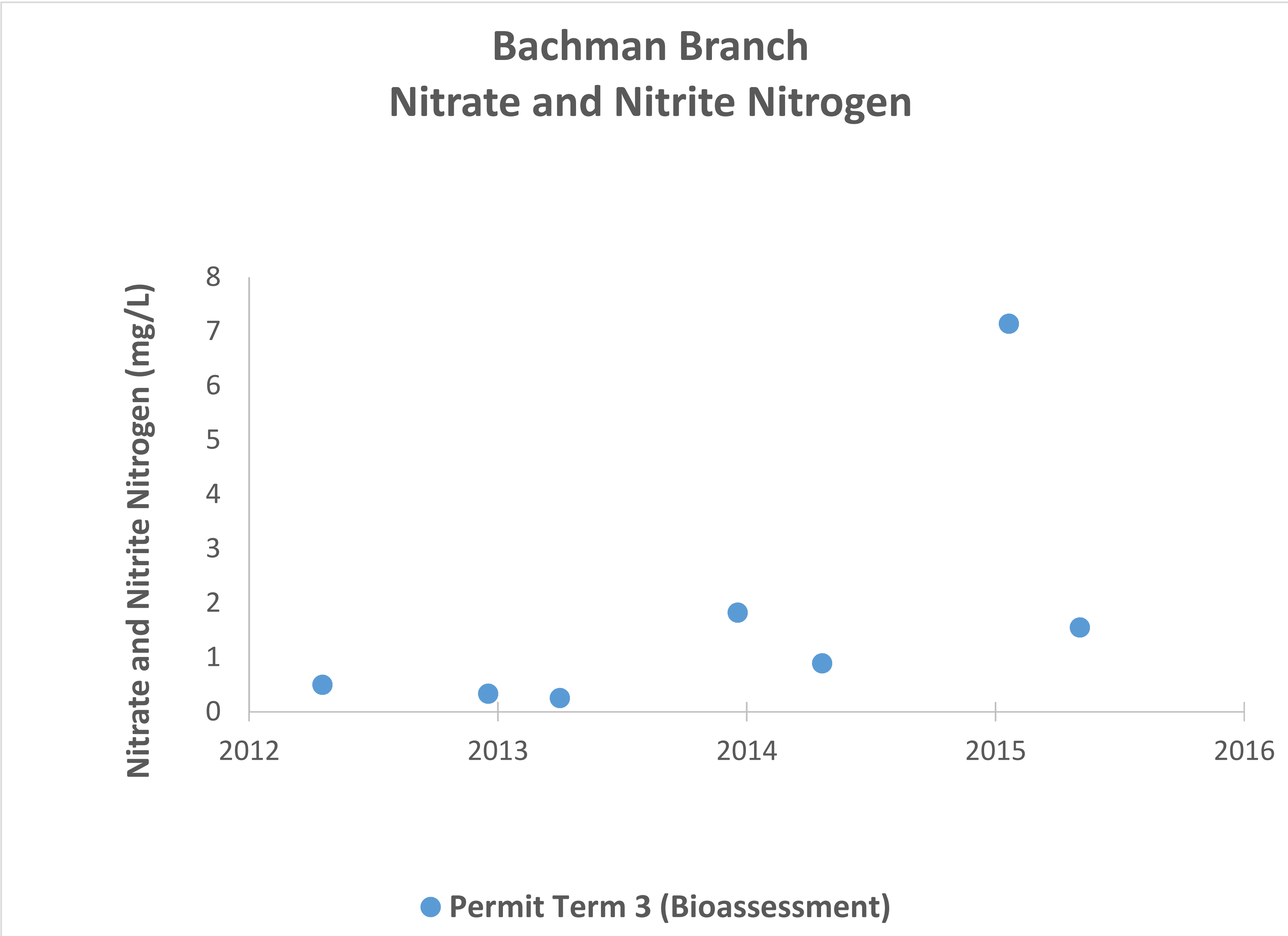


Bachman Branch
E. coli
1000
100
10
1
E. coli (col/100 mL)
2012
2013
2014
2015
2016
Permit Term 3 (Bioassessment)
PCR Geomean
PCR Single Sample


Bachman Branch
Total Coliform
Total Coliform (col/100 mL)
1000
100
10
1
2012
2013
2014
2015
2016
Permit Term 3 (Bioassessment)

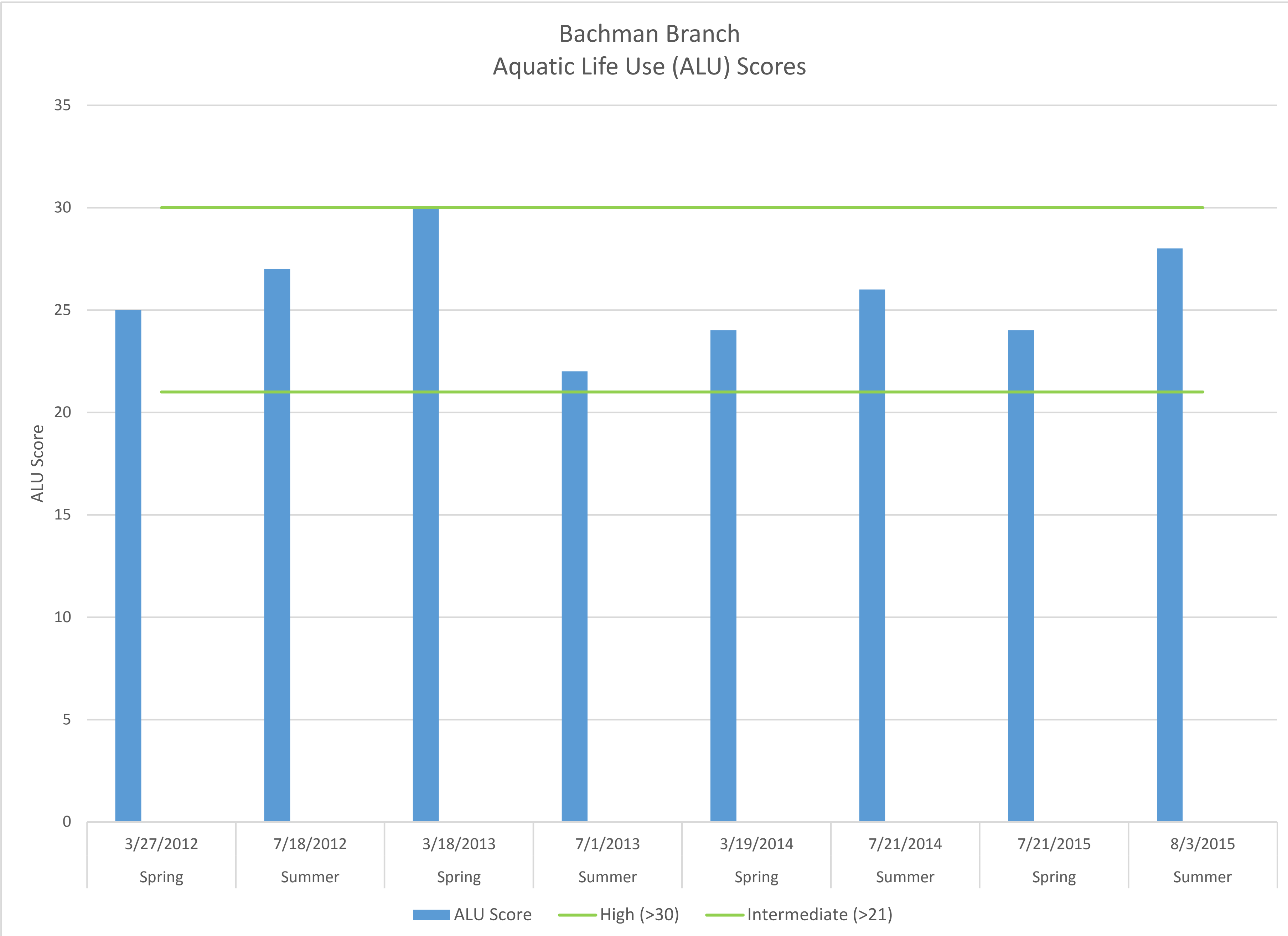

Bachman Branch
Dissolved Oxygen (mg/L)
Dissolved Oxygen (mg/L)
16
14
12
10
8
6
4
2
0
2012
2013
2014
2015
2016
Permit Term 3 (Bioassessment)
Basin Specific Criterion (>3)
Spring Criterion (>4.5)


Bachman Branch
Ammonia Nitrogen
Ammonia (mg/L)
0.5
0.45
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
2012
2013
2014
2015
2016
Permit Term 3 (Bioassessment)
TCEQ Screening Criterion



Bachman Branch
Nitrate and Nitrite Nitrogen
Nitrate and Nitrite Nitrogen (mg/L)
0
1
2
3
4
5
6
7
8
2012
2013
2014
2015
2016
Permit Term 3 (Bioassessment)

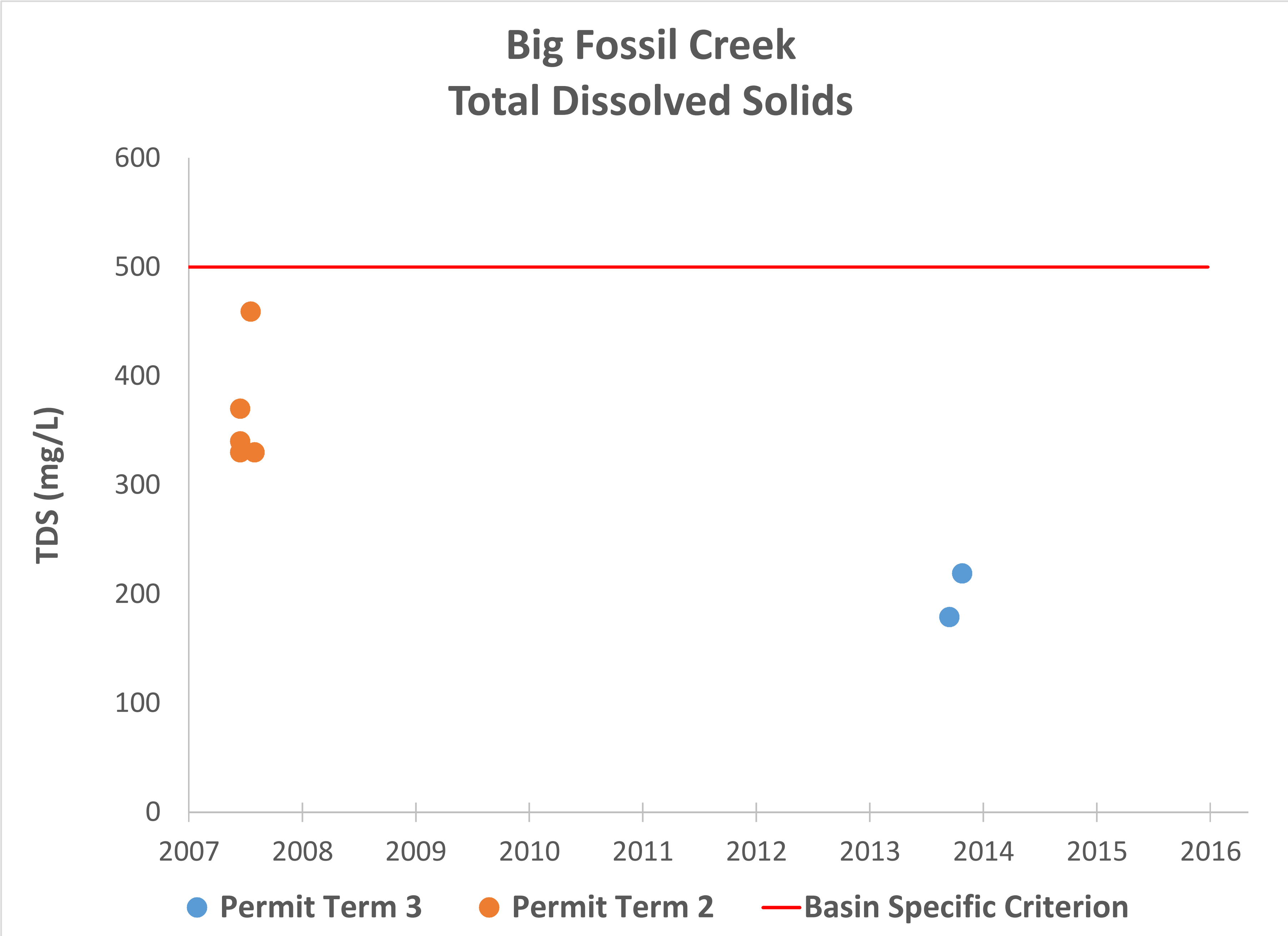

Bachman Branch
Habitat Scores
Habitat Assessment Score
250
200
150
100
50
0
3/27/2012
Spring
7/18/2012
Summer
3/18/2013
Spring
7/1/2013
Summer
3/19/2014
Spring
7/21/2014
Summer
7/21/2015
Spring
8/3/2015
Summer
Habitat Assessment Score
Optimal (>159)
Sub-optimal (>109)

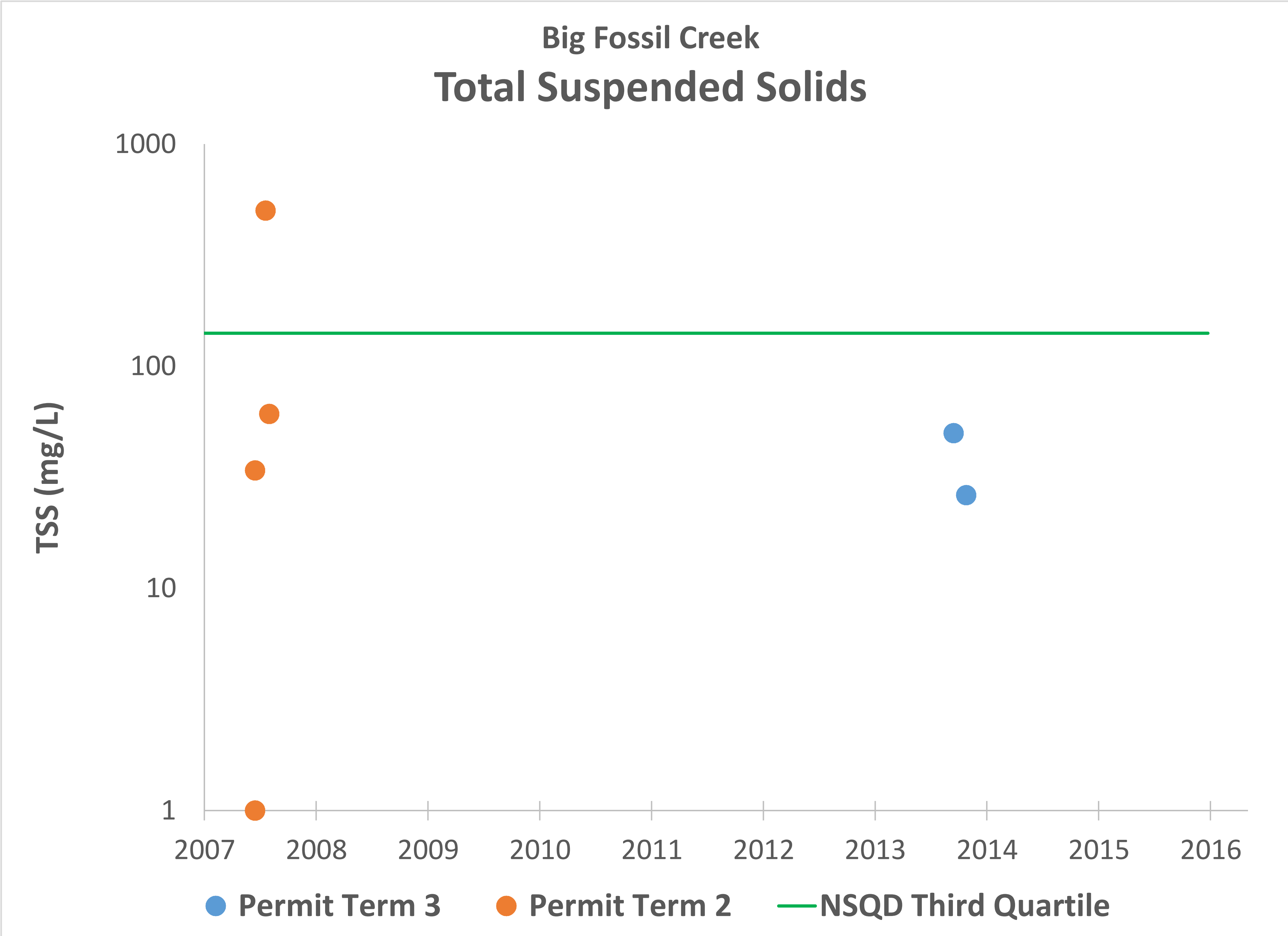


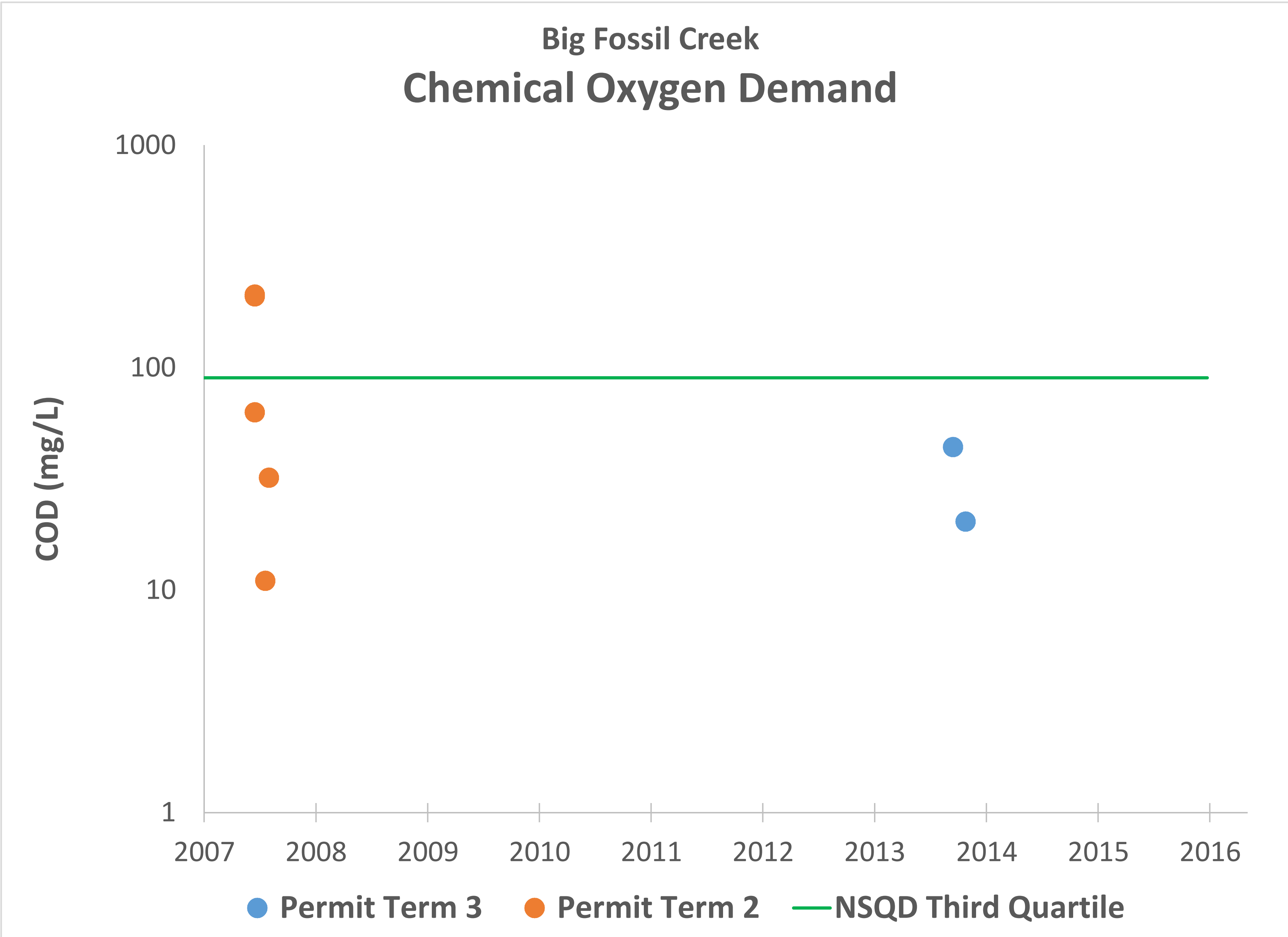
Bachman Branch
Aquatic Life Use (ALU) Scores
ALU Score
35
30
25
20
15
10
5
0
3/27/2012
Spring
7/18/2012
Summer
3/18/2013
Spring
7/1/2013
Summer
3/19/2014
Spring
7/21/2014
Summer
7/21/2015
Spring
8/3/2015
Summer
ALU Score
High (>30)
Intermediate (>21)

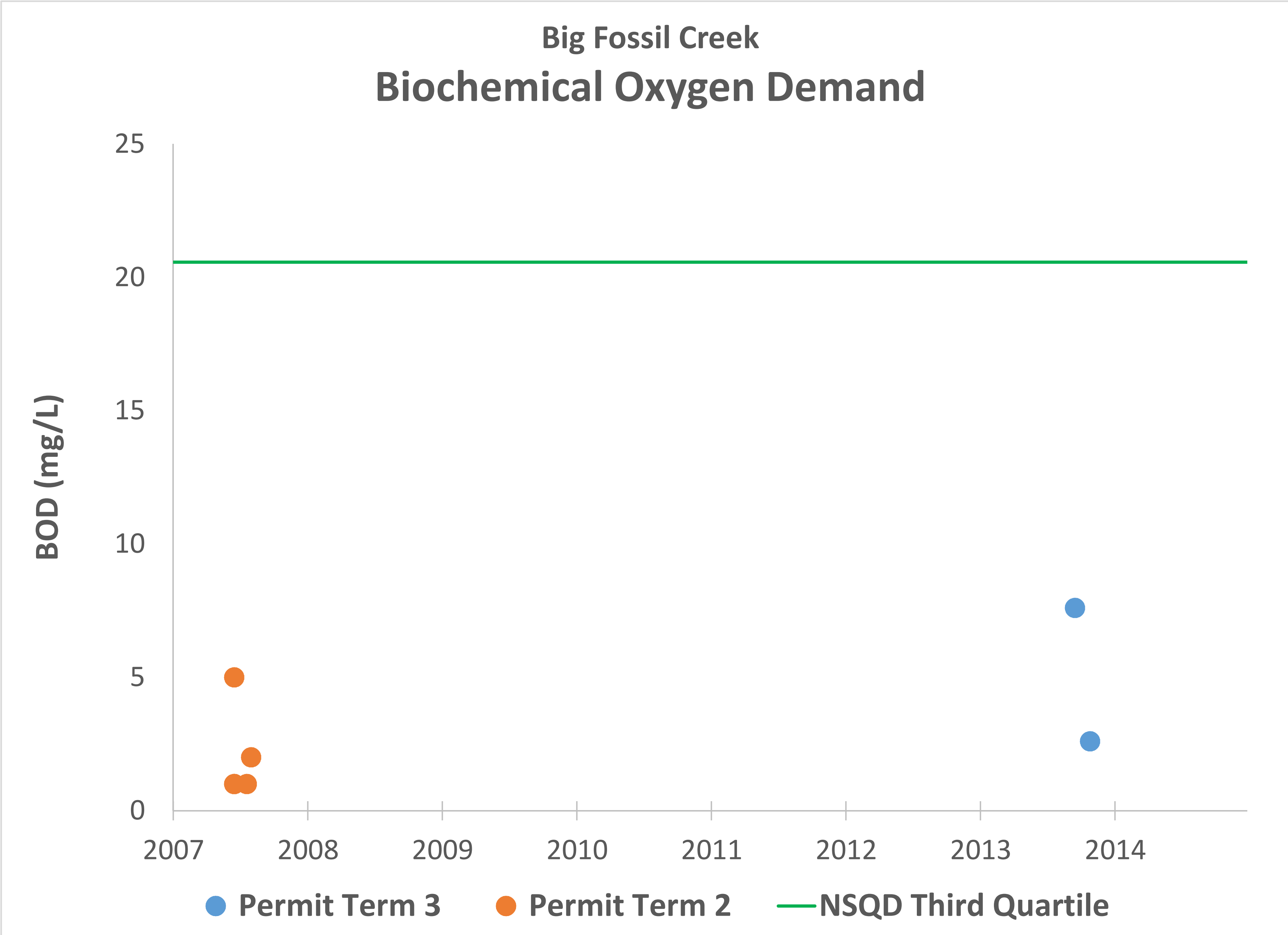
Appendix E

Big Fossil Creek Water Quality
Data Graphs

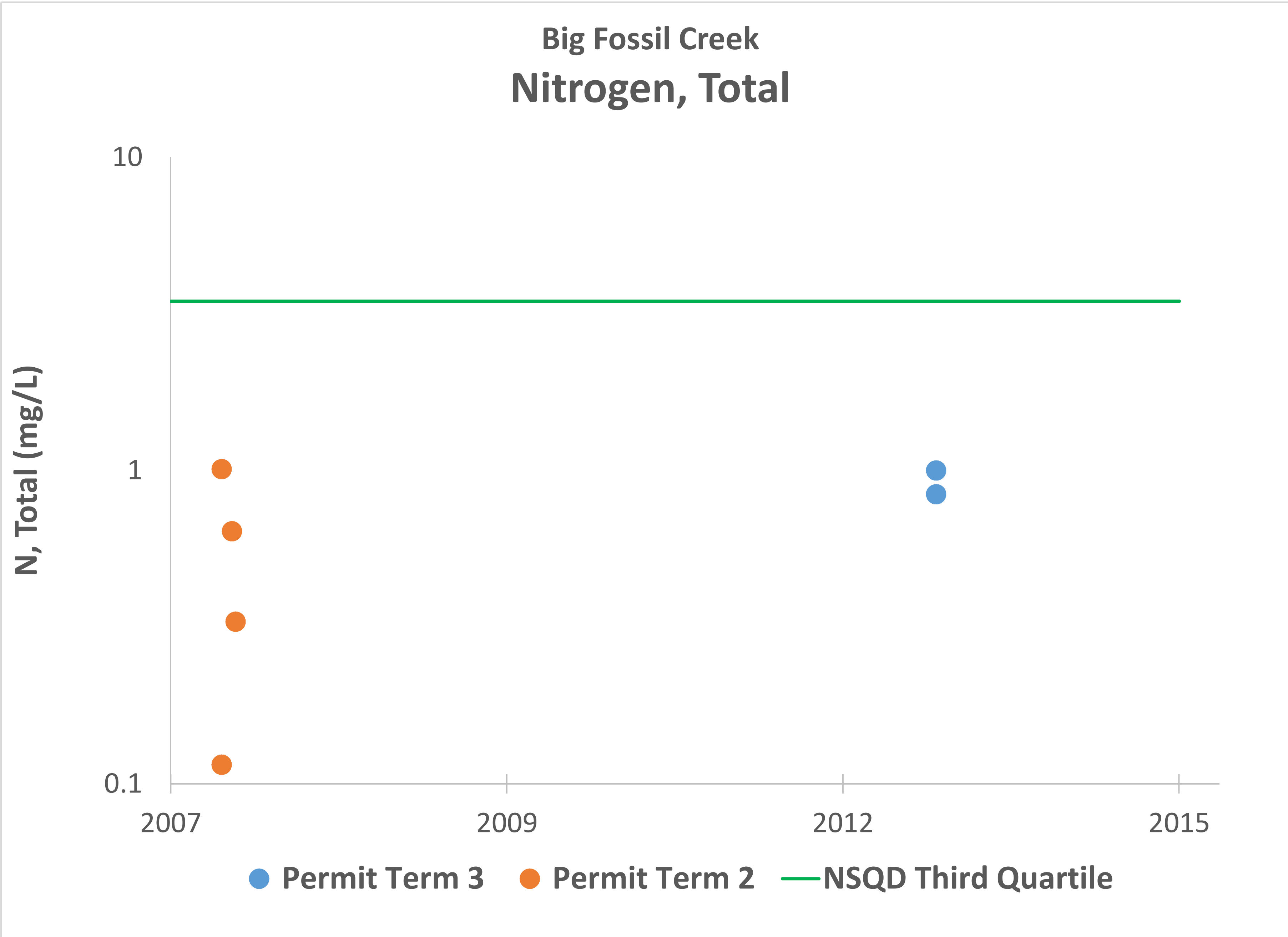

Big Fossil Creek
Total Dissolved Solids
TDS (mg/L)
600
500
400
300
200
100
0
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
Permit Term 3
Permit Term 2
Basin Specific Criterion

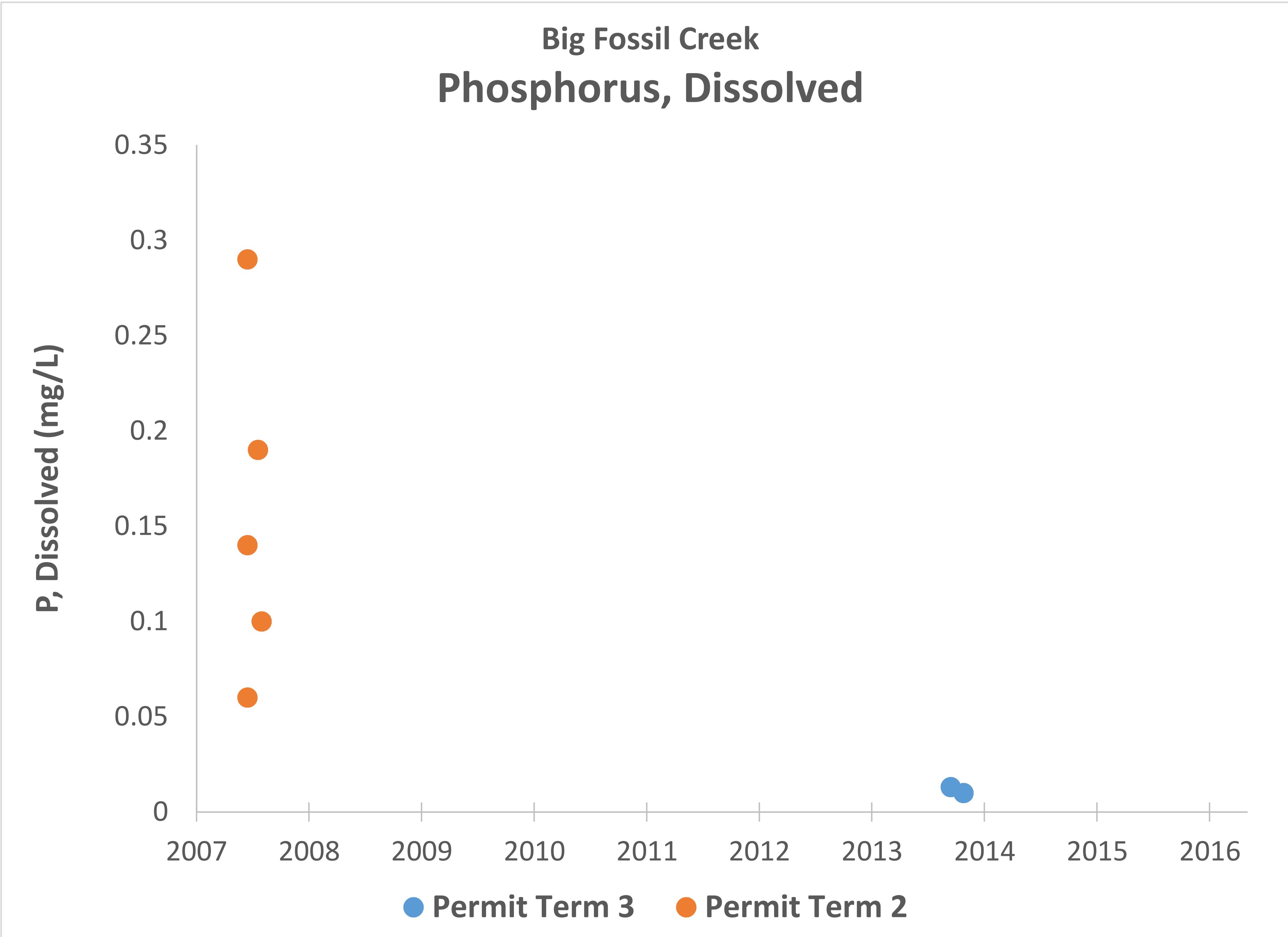

Big Fossil Creek
Total Suspended Solids
TSS (mg/L)
1000
100
10
1
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
Permit Term 3
Permit Term 2
NSQD Third Quartile

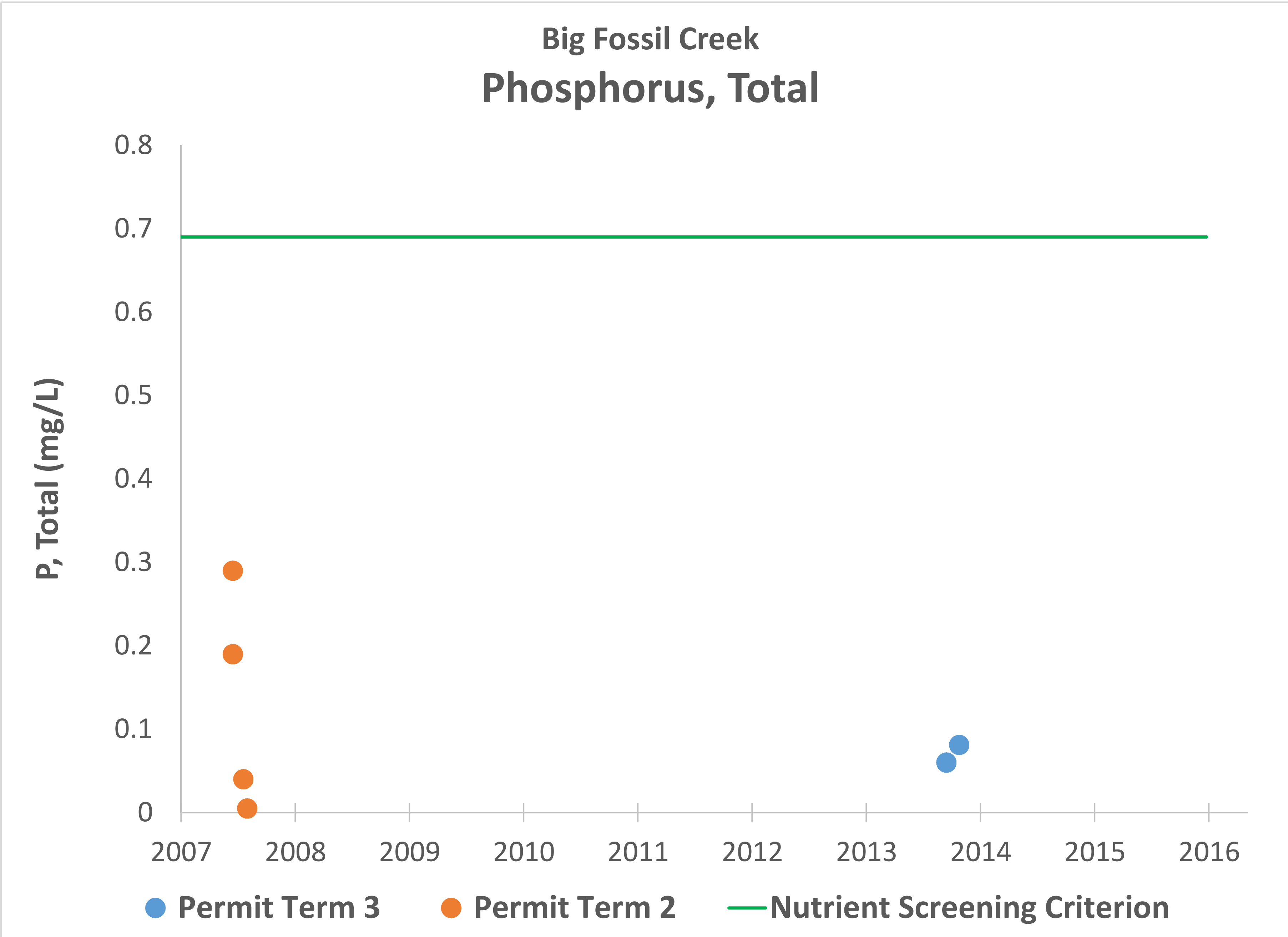

Big Fossil Creek
Chemical Oxygen Demand
COD (mg/L)
1000
100
10
1
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
Permit Term 3
Permit Term 2
NSQD Third Quartile



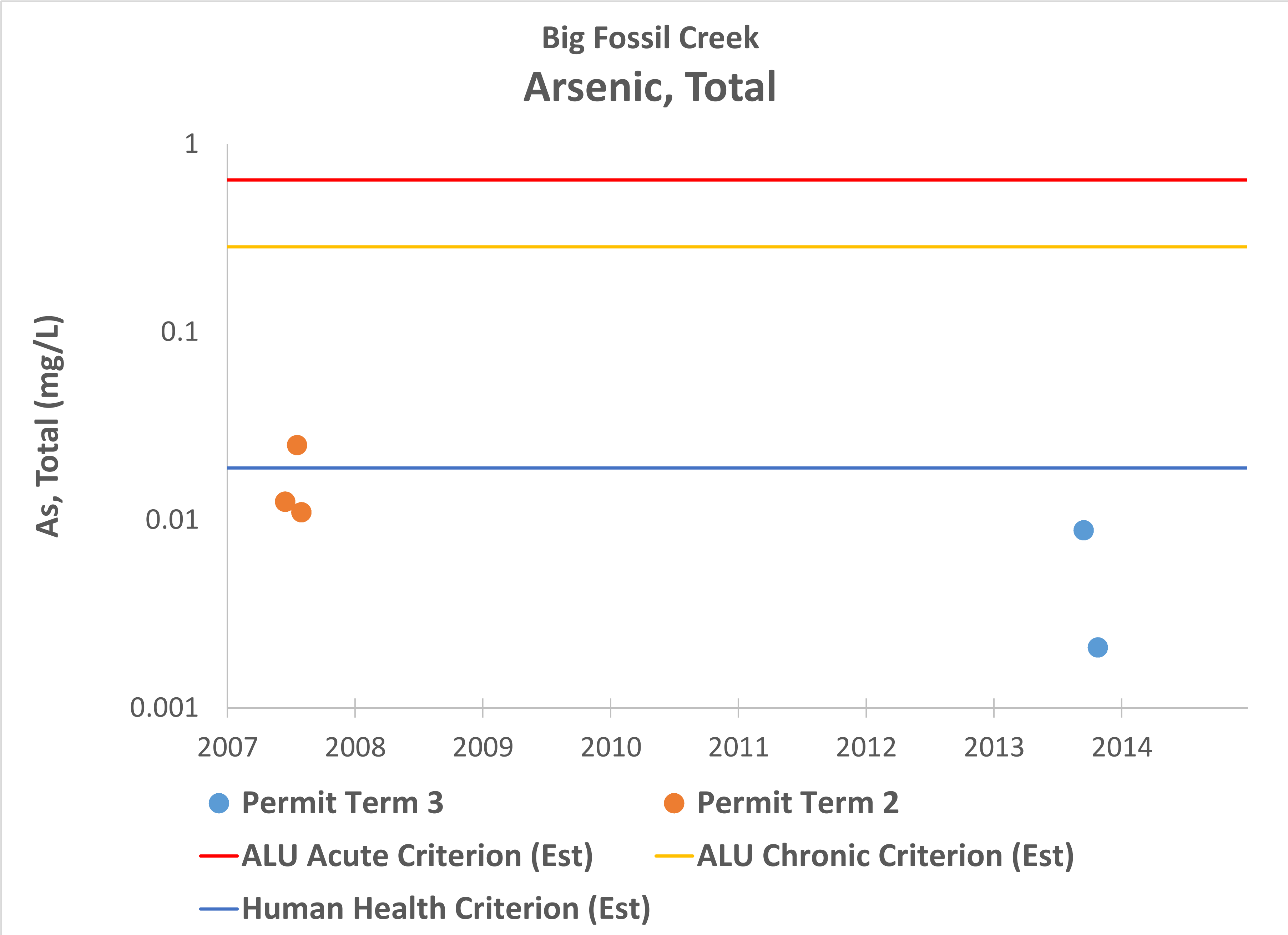
Big Fossil Creek
Biochemical Oxygen Demand
BOD (mg/L)
25
20
15
10
5
0
2007
2008
2009
2010
2011
2012
2013
2014
Permit Term 3
Permit Term 2
NSQD Third Quartile

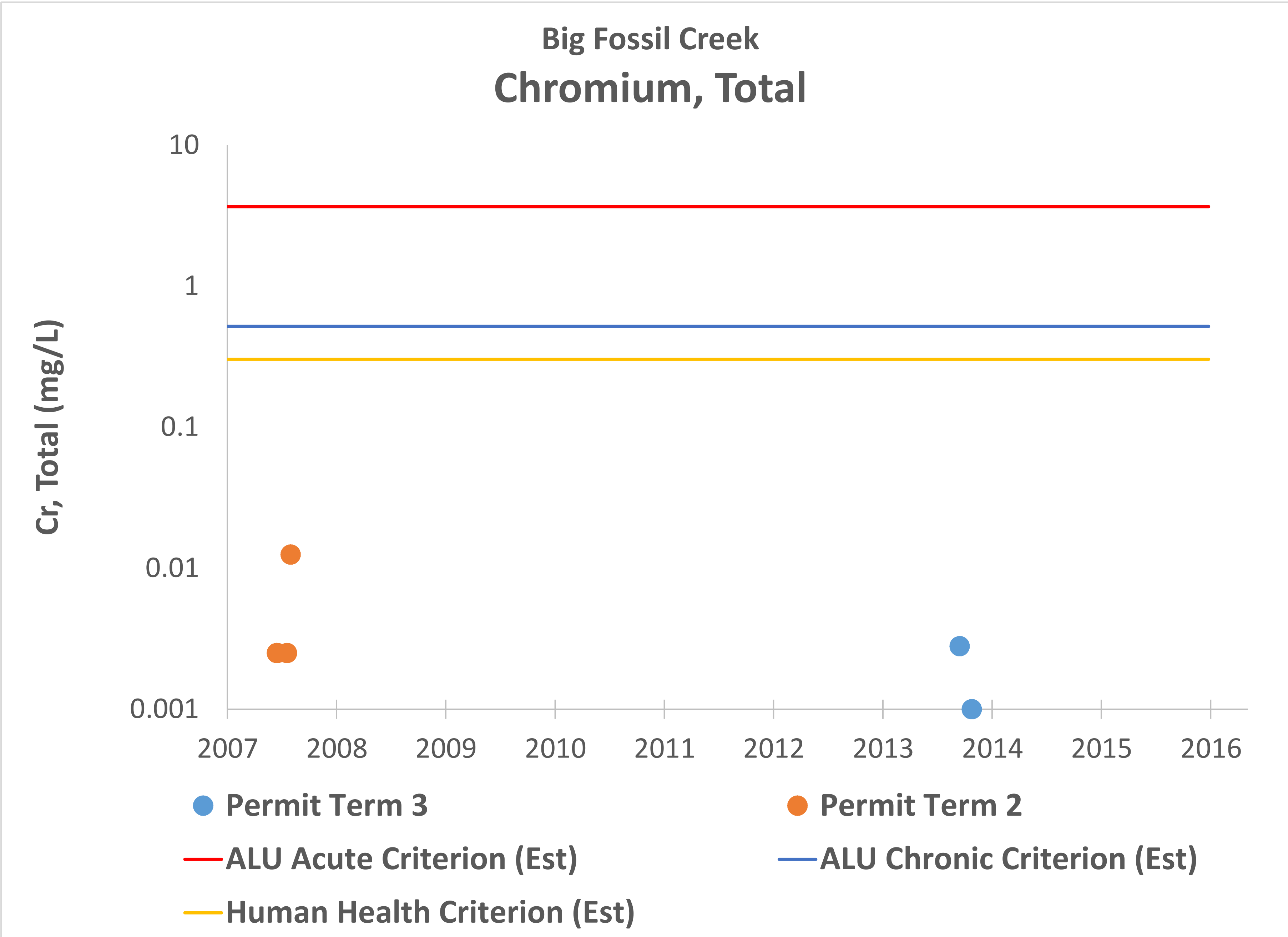

Big Fossil Creek
Nitrogen, Total
N, Total (mg/L)
10
1
0.1
2007
2009
2012
2015
Permit Term 3
Permit Term 2
NSQD Third Quartile


Big Fossil Creek
Phosphorus, Dissolved
P, Dissolved (mg/L)
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
Permit Term 3
Permit Term 2

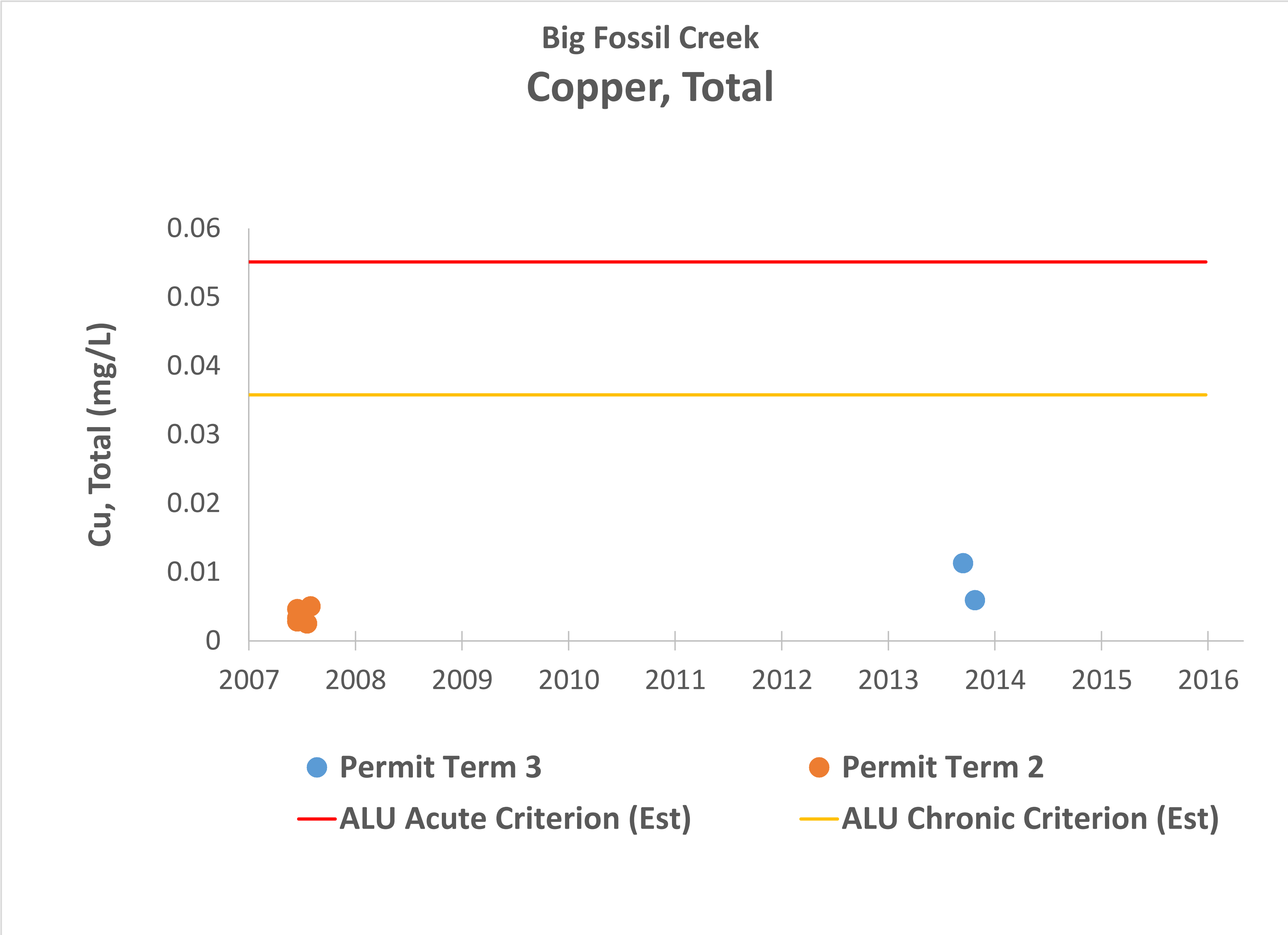


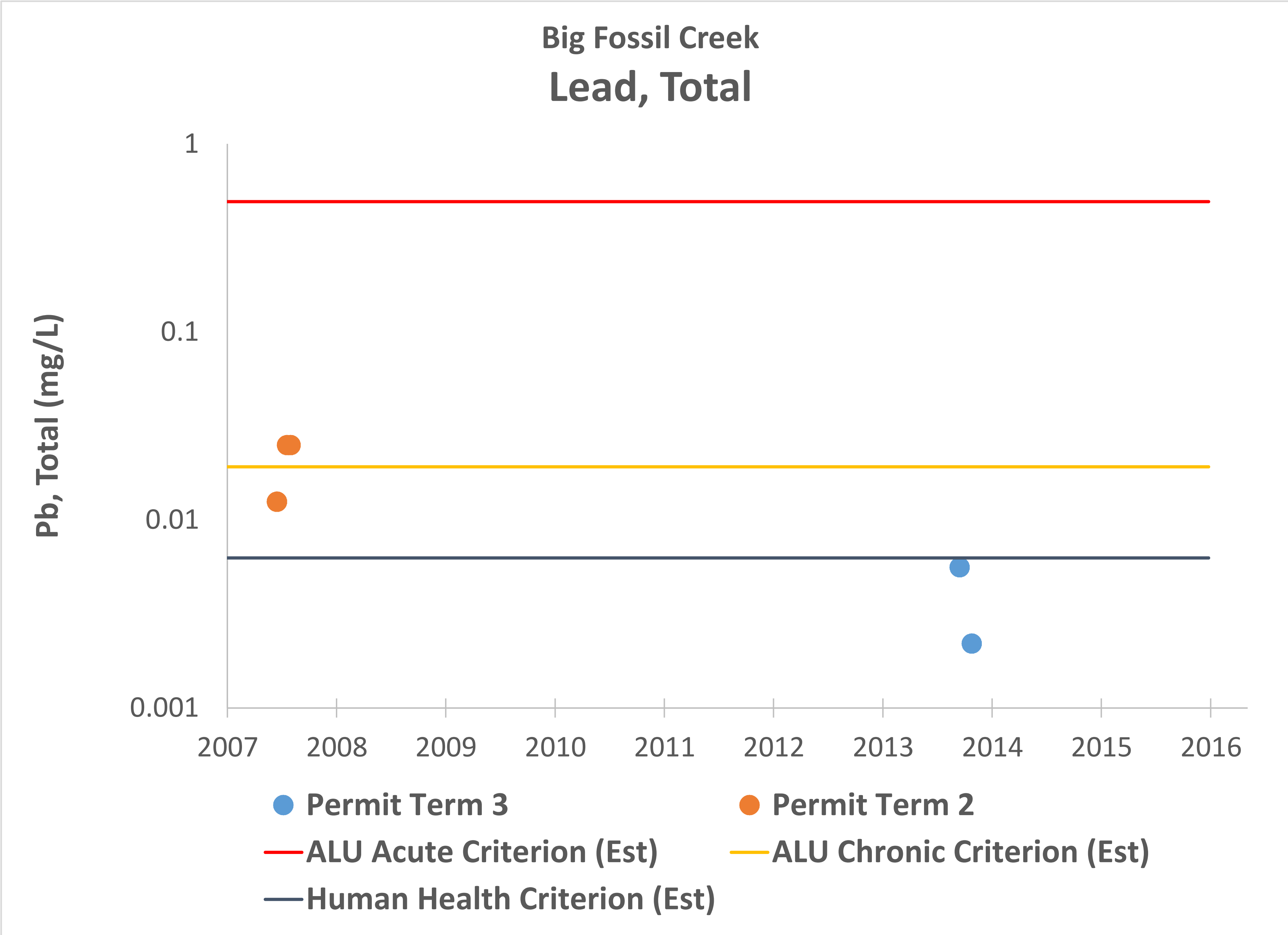
Big Fossil Creek
Phosphorus, Total
P, Total (mg/L)
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
Permit Term 3
Permit Term 2
Nutrient Screening Criterion


Big Fossil Creek
Arsenic, Total
As, Total (mg/L)
1
0.1
0.01
0.001
2007
2008
2009
2010
2011
2012
2013
2014
Permit Term 3
Permit Term 2
ALU Acute Criterion (Est)
ALU Chronic Criterion (Est)
Human Health Criterion (Est)

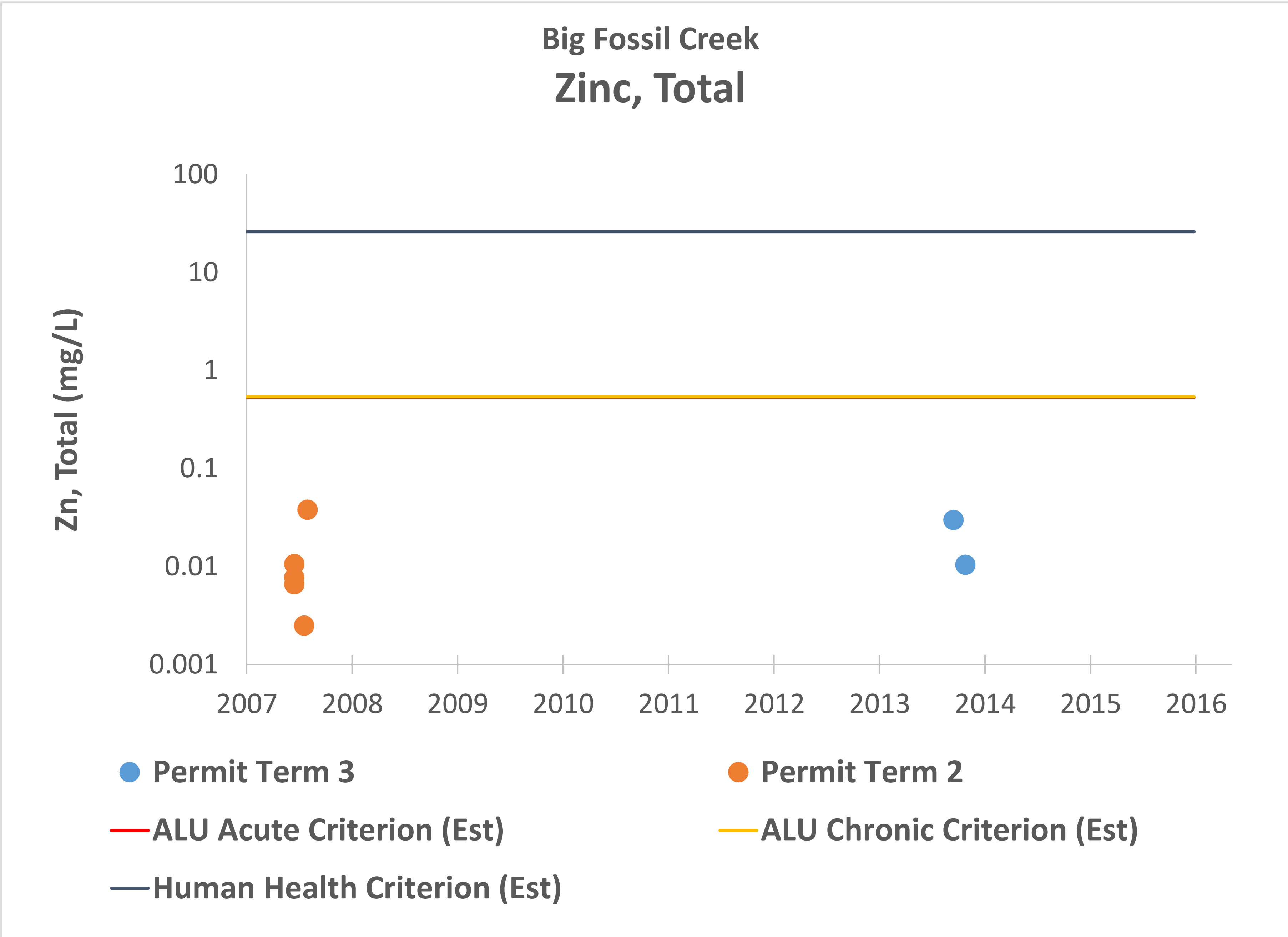


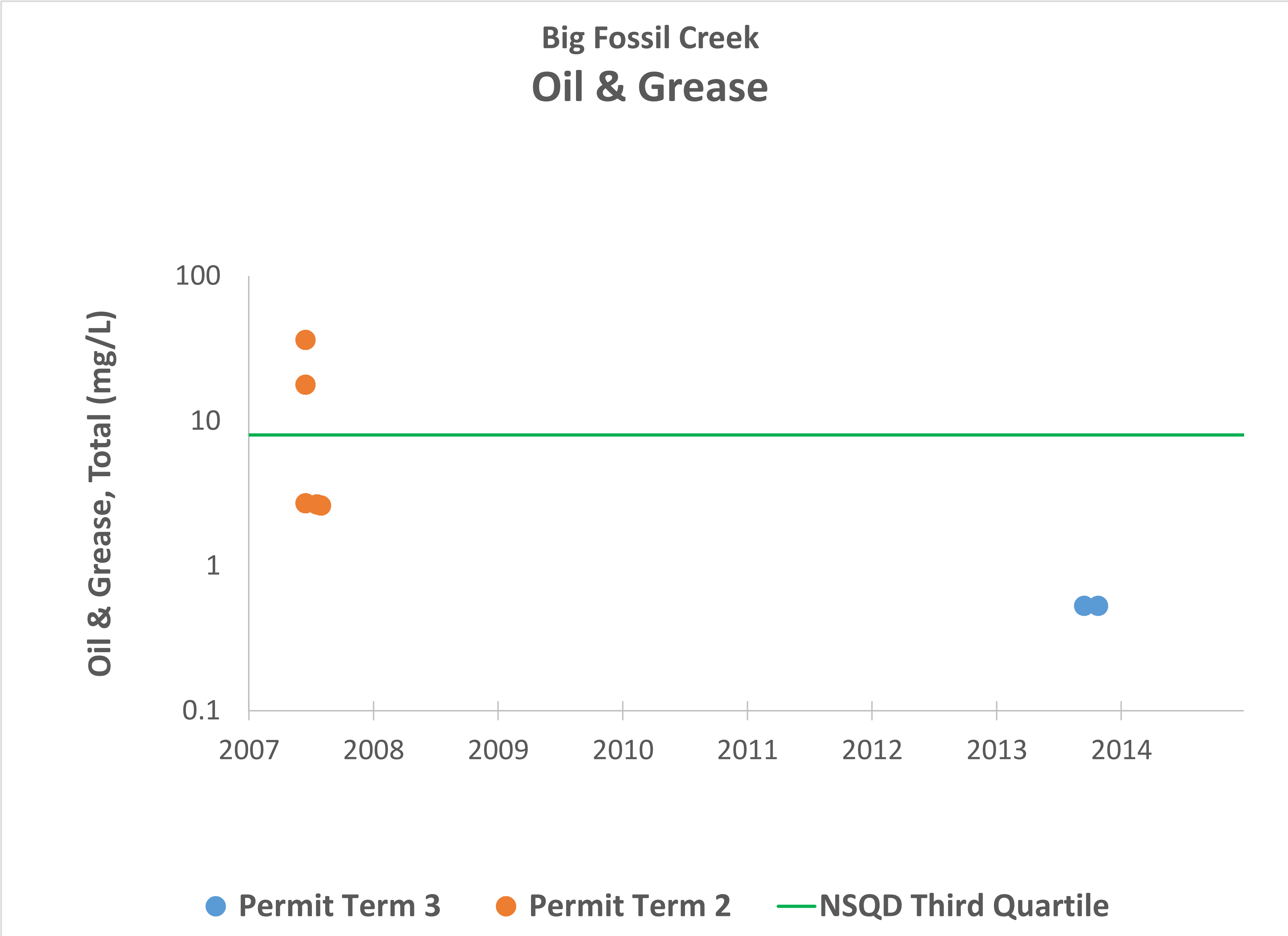
Big Fossil Creek
Chromium, Total
Cr, Total (mg/L)
10
1
0.1
0.01
0.001
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
Permit Term 3
Permit Term 2
ALU Acute Criterion (Est)
ALU Chronic Criterion (Est)
Human Health Criterion (Est)


Big Fossil Creek
Copper, Total
Cu, Total (mg/L)
0.06
0.05
0.04
0.03
0.02
0.01
0
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
Permit Term 3
Permit Term 2
ALU Acute Criterion (Est)
ALU Chronic Criterion (Est)

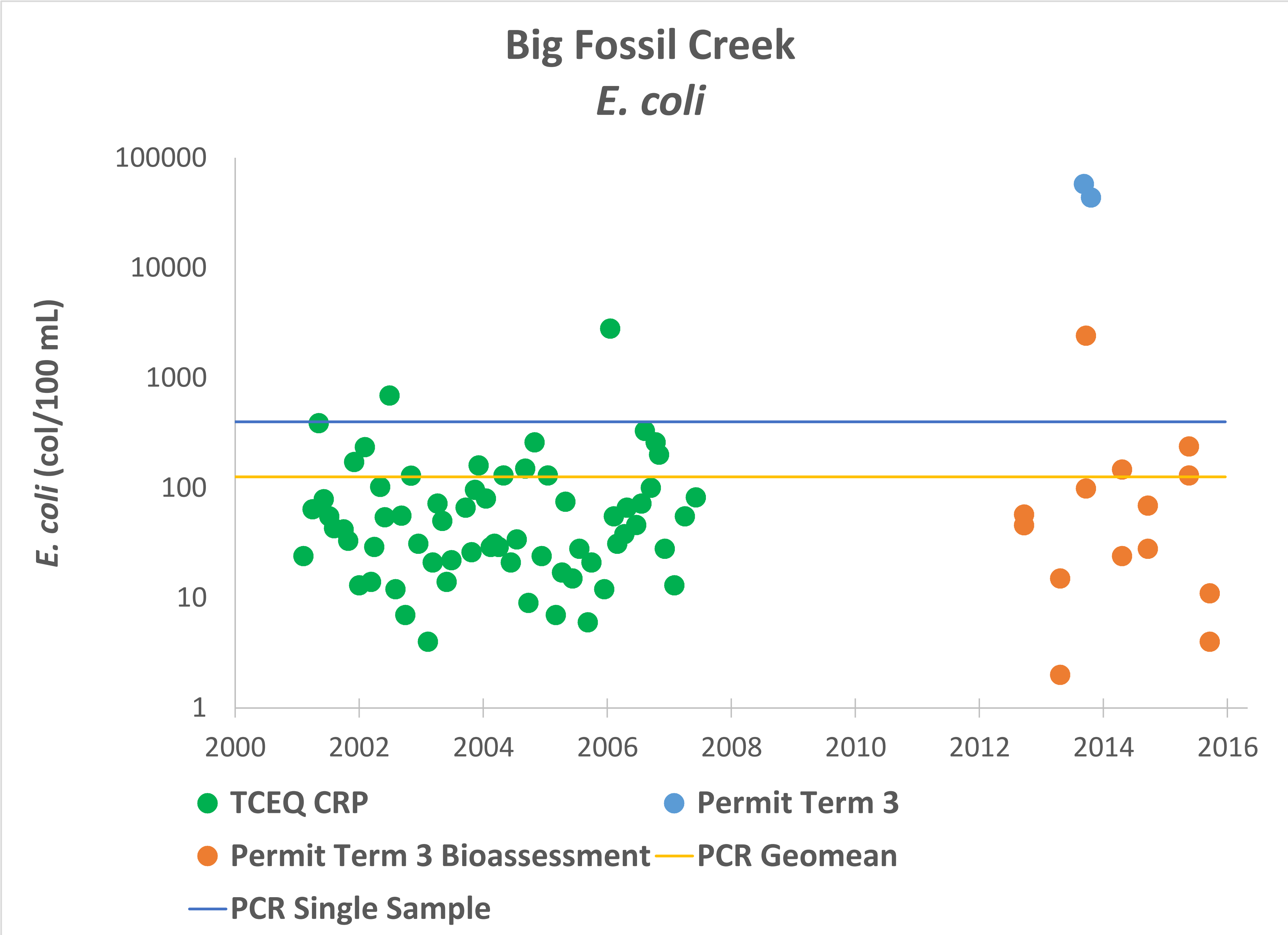


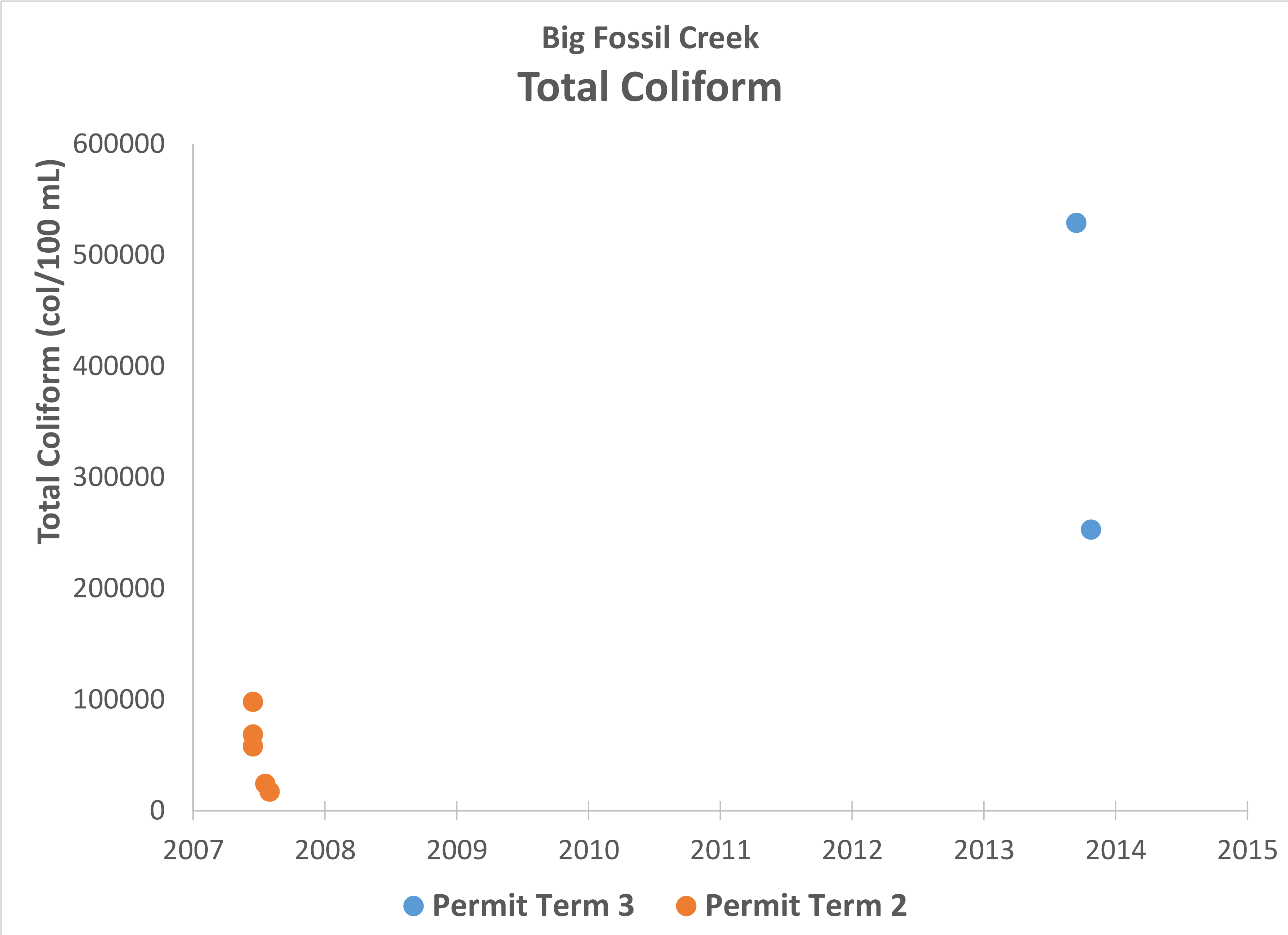
Big Fossil Creek
Lead, Total
Pb, Total (mg/L)
1
0.1
0.01
0.001
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
Permit Term 3
Permit Term 2
ALU Acute Criterion (Est)
ALU Chronic Criterion (Est)
Human Health Criterion (Est)


Big Fossil Creek
Zinc, Total
Zn, Total (mg/L)
100
10
1
0.1
0.01
0.001
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
Permit Term 3
Permit Term 2
ALU Acute Criterion (Est)
ALU Chronic Criterion (Est)
Human Health Criterion (Est)

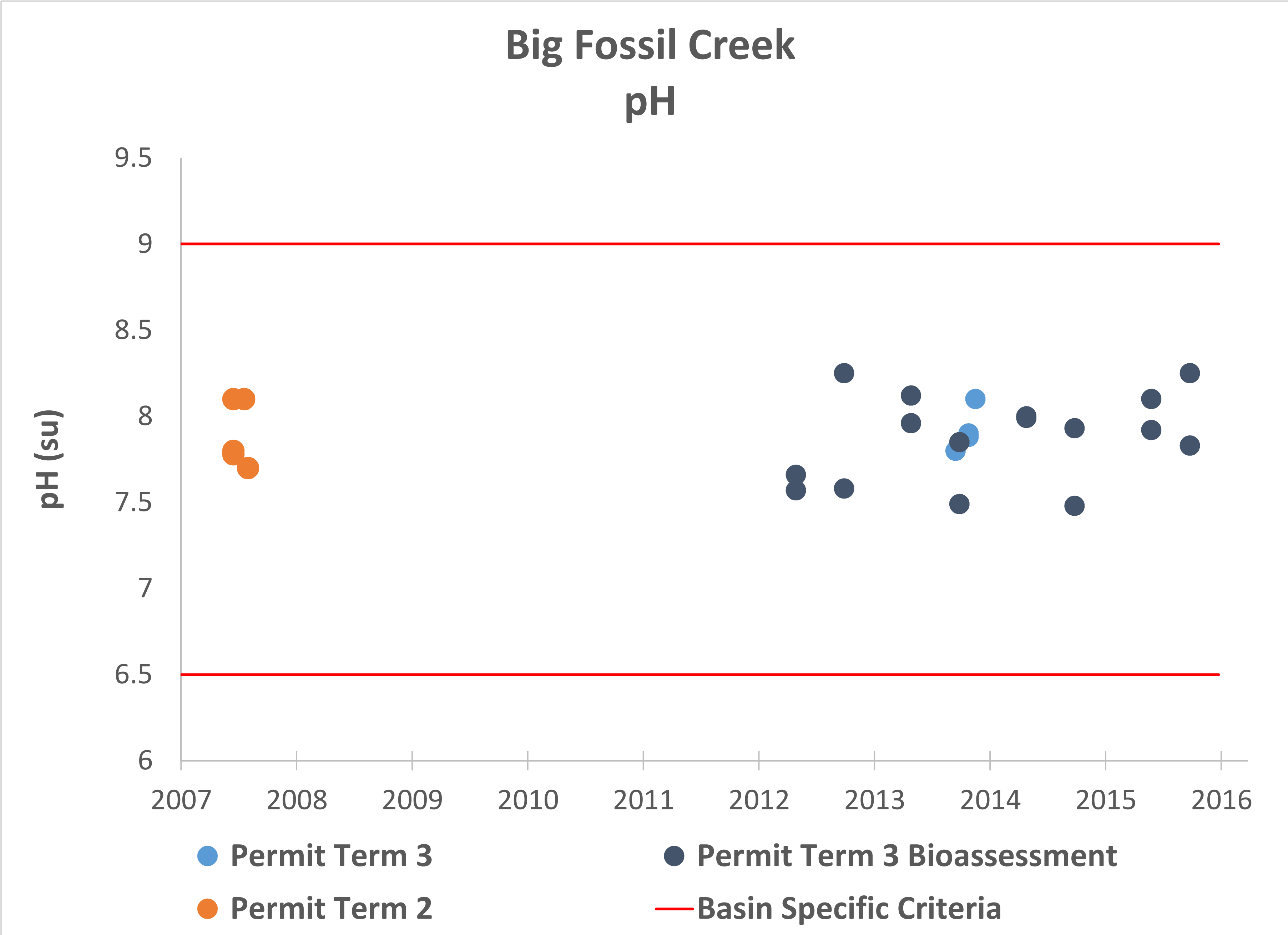


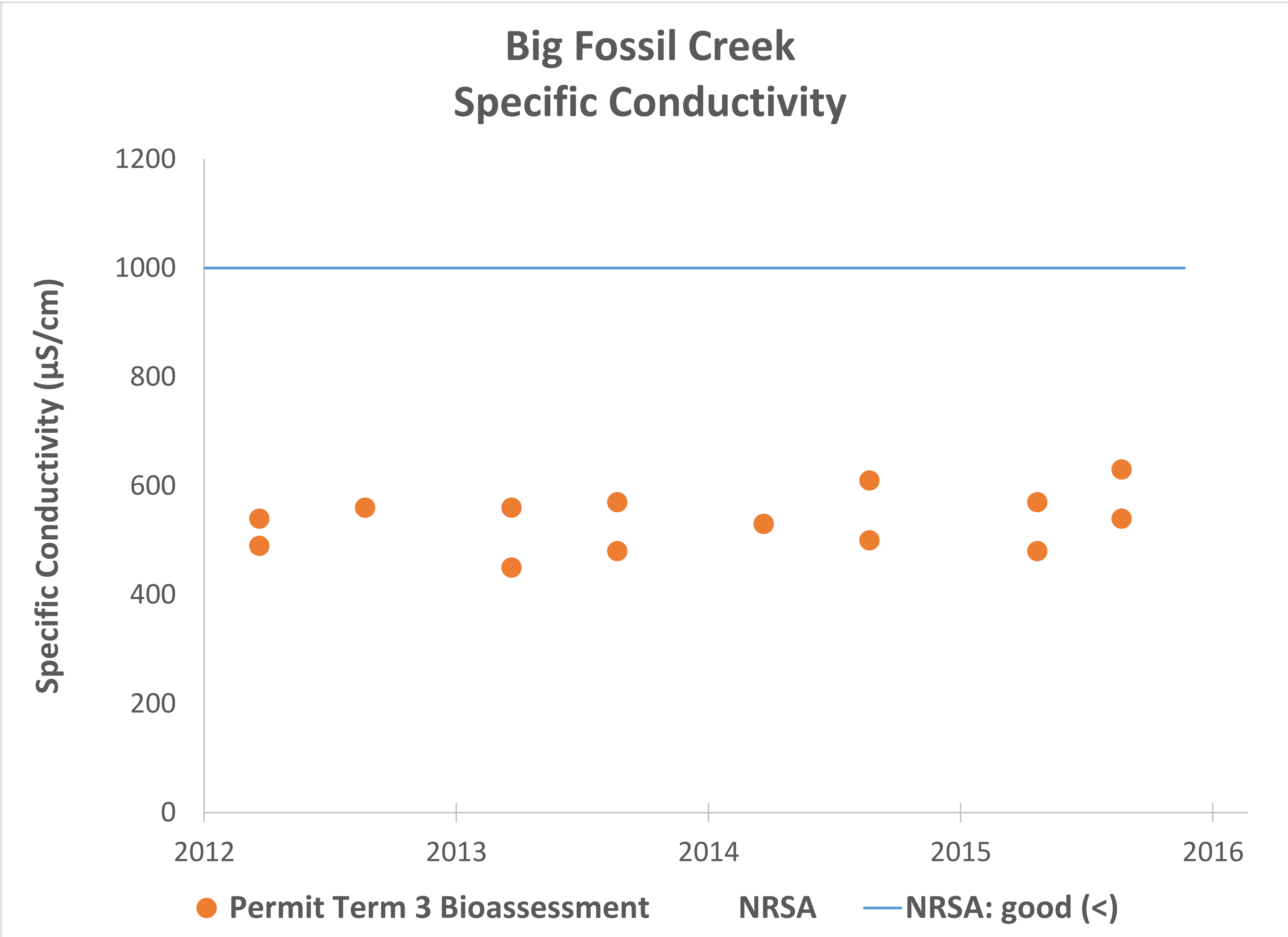
Big Fossil Creek
Oil & Grease
Oil & Grease, Total (mg/L)
100
10
1
0.1
2007
2008
2009
2010
2011
2012
2013
2014
Permit Term 3
Permit Term 2
NSQD Third Quartile

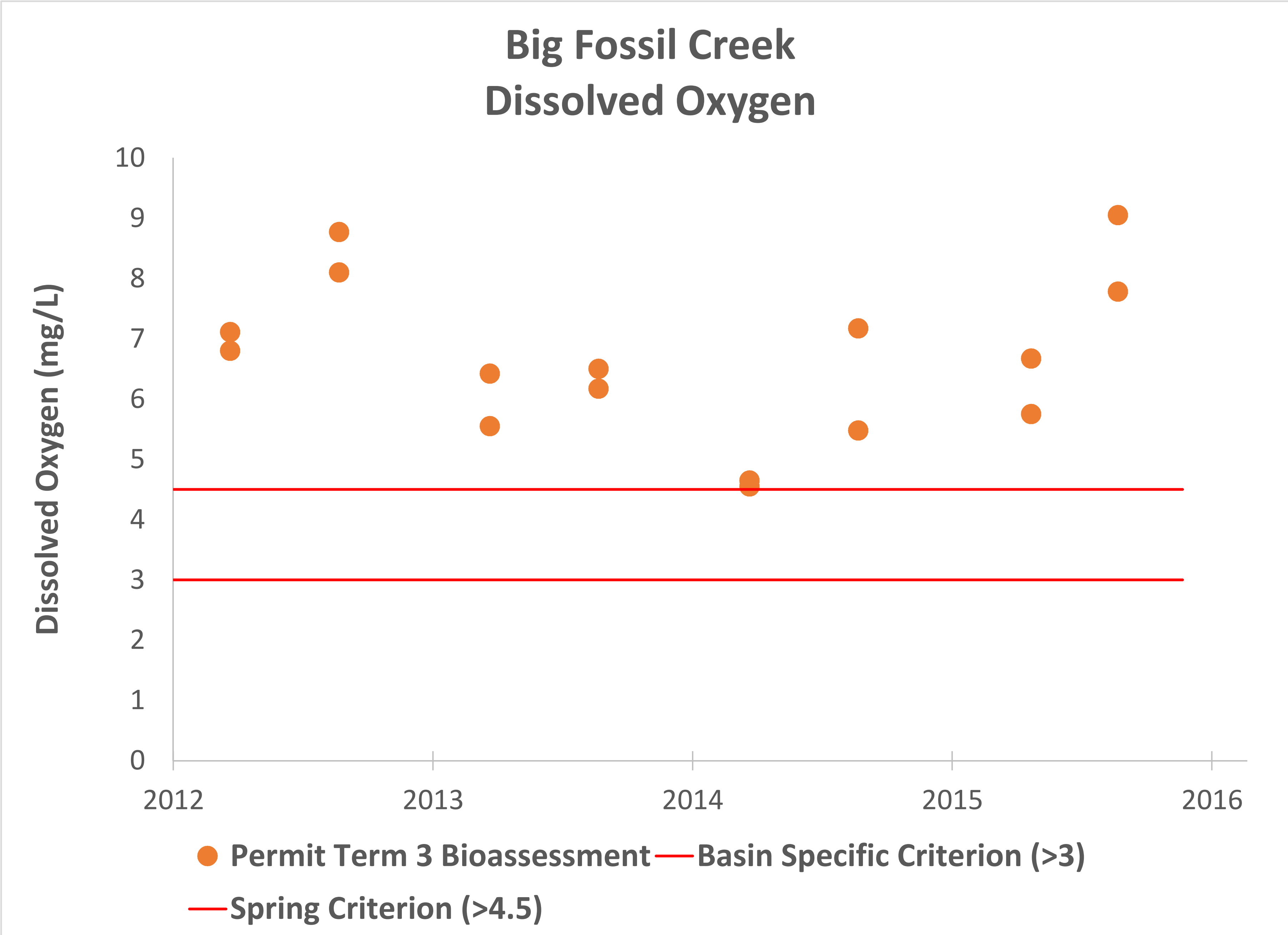

Big Fossil Creek
E. coli
E. coli (col/100 mL)
100000
10000
1000
100
10
1
2000
2002
2004
2006
2008
2010
2012
2014
2016
TCEQ CRP
Permit Term 3
Permit Term 3 Bioassessment
PCR Geomean
PCR Single Sample



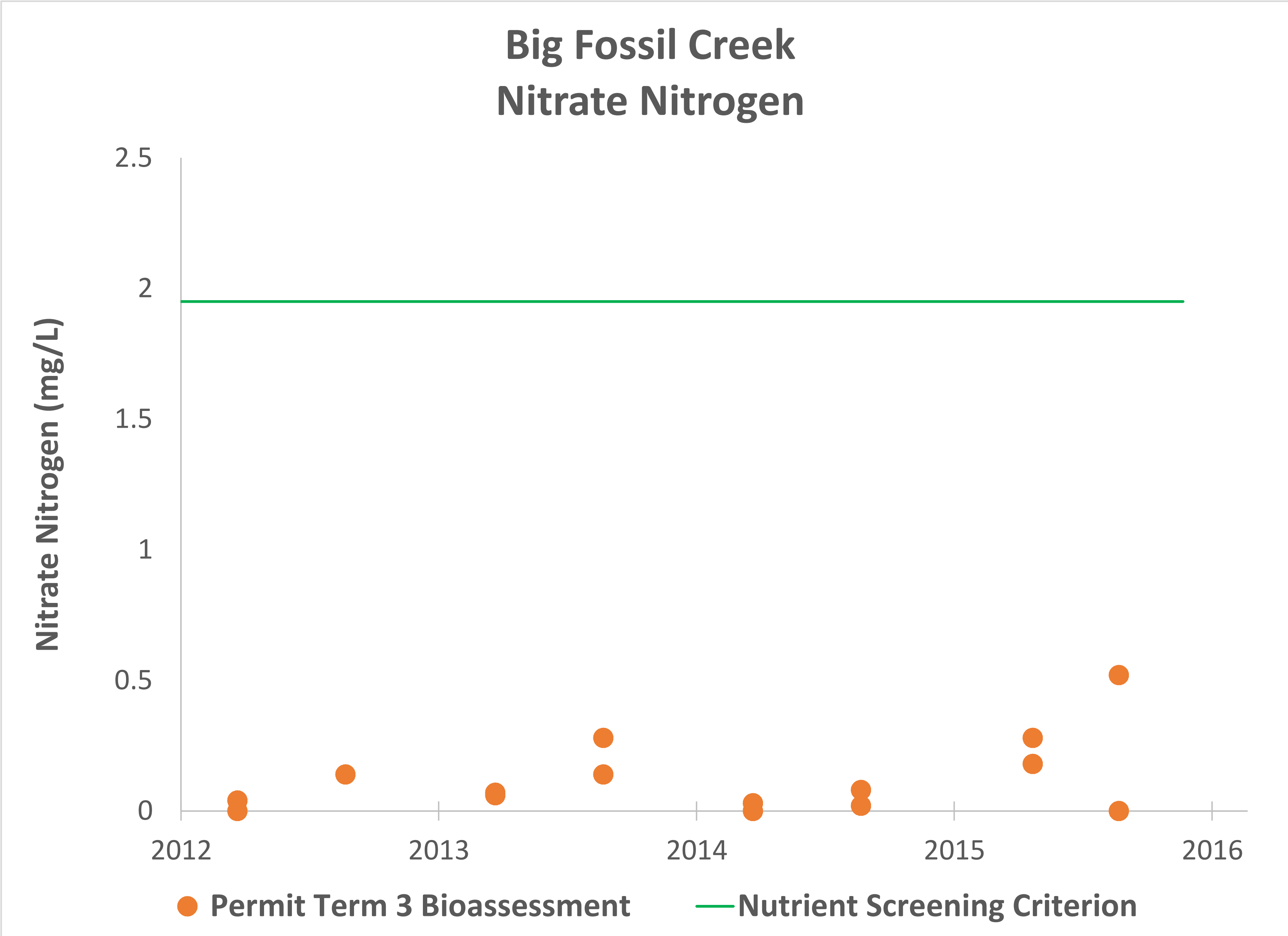
Big Fossil Creek
Total Coliform
Total Coliform (col/100 mL)
600000
500000
400000
300000
200000
100000
0
2007
2008
2009
2010
2011
2012
2013
2014
2015
Permit Term 3
Permit Term 2

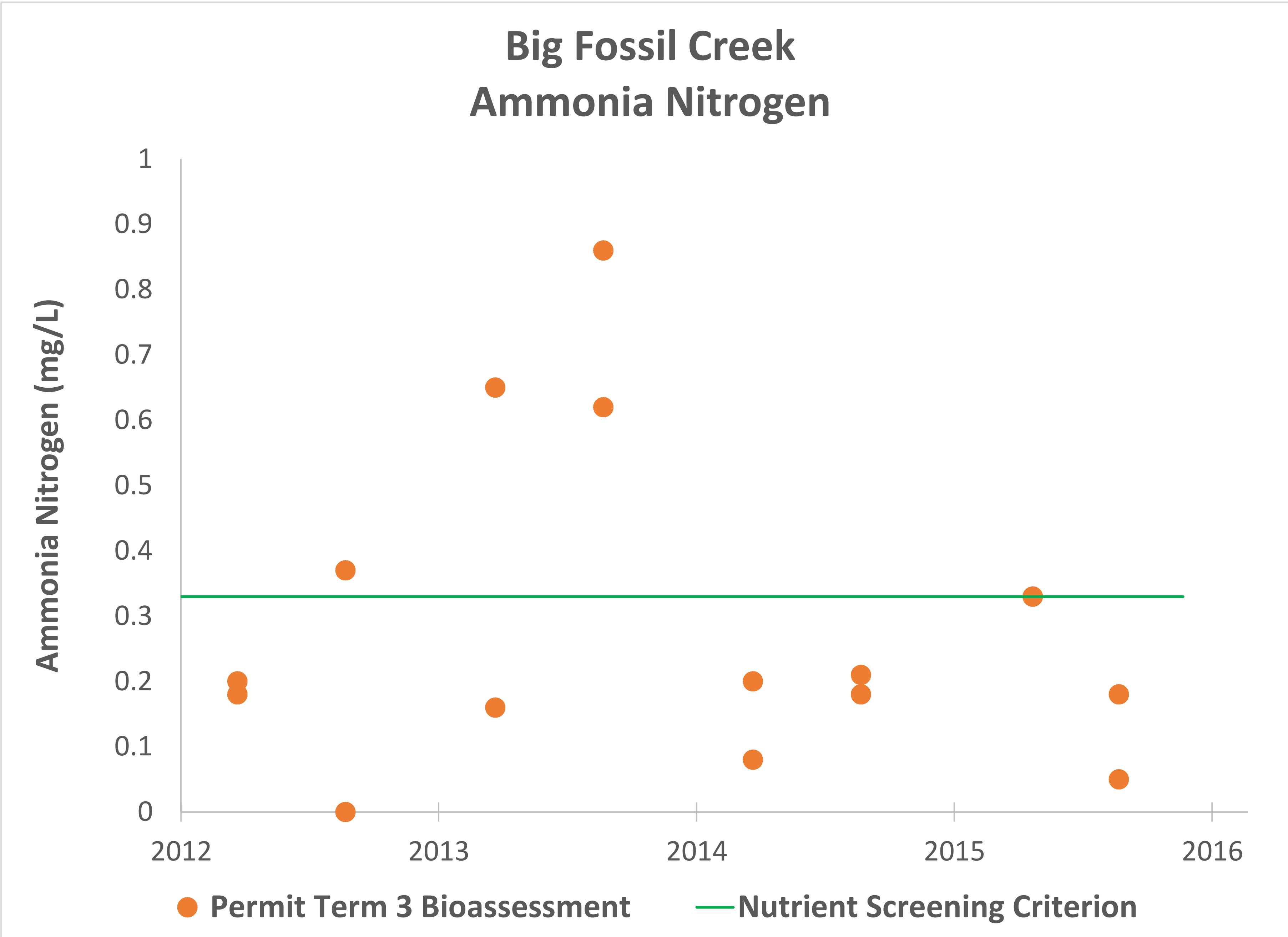

Big Fossil Creek
pH
pH (su)
9.5
9
8.5
8
7.5
7
6.5
6
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
Permit Term 3
Permit Term 3 Bioassessment
Permit Term 2
Basin Specific Criteria


Big Fossil Creek
Specific Conductivity
Specific Conductivity (µS/cm)
1200
1000
800
600
400
200
0
2012
2013
2014
2015
2016
Permit Term 3 Bioassessment
NRSA
NRSA: good (<)

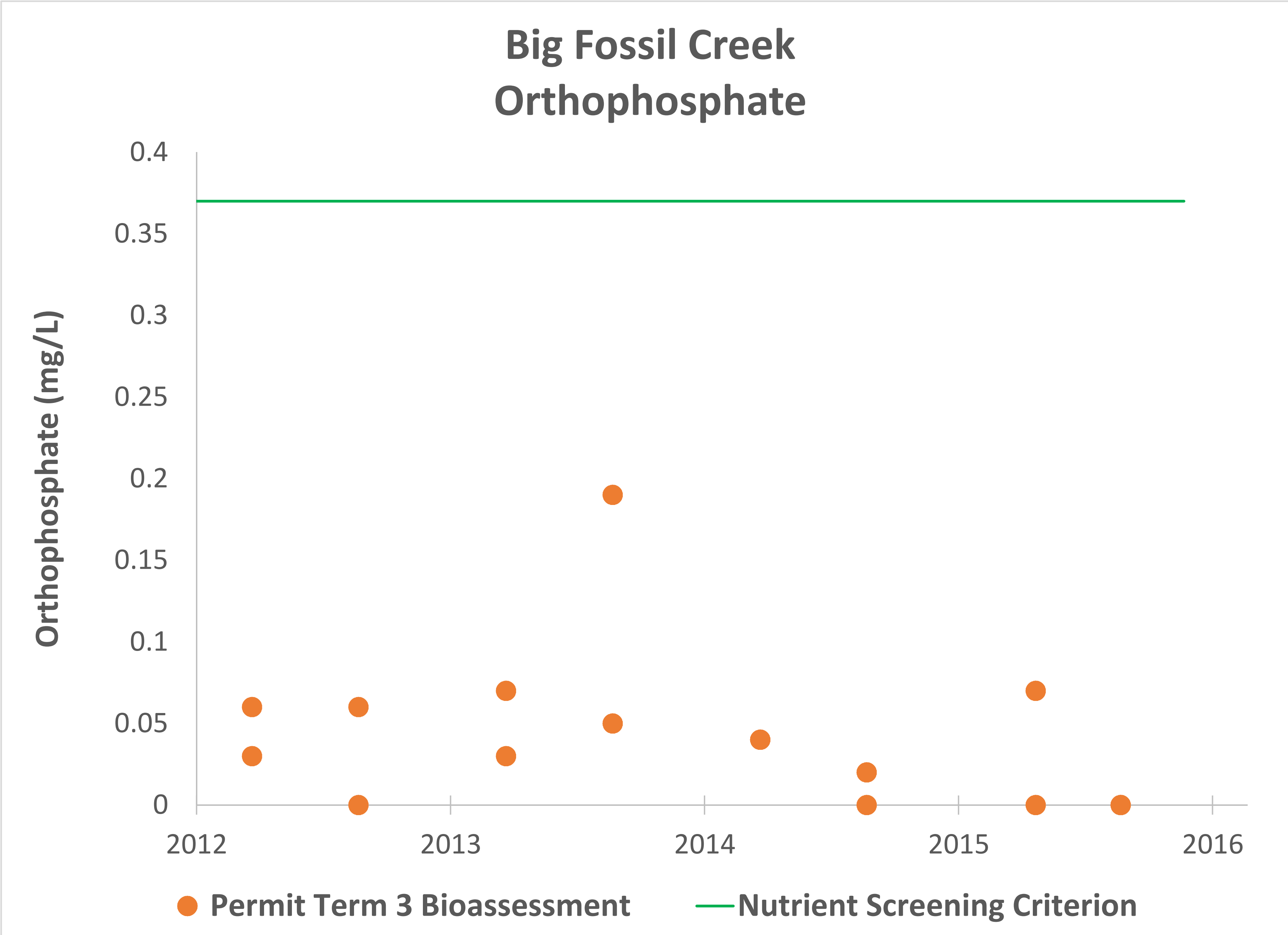


Big Fossil Creek
Dissolved Oxygen
Dissolved Oxygen (mg/L)
10
9
8
7
6
5
4
3
2
1
0
2012
2013
2014
2015
2016
Permit Term 3 Bioassessment
Basin Specific Criterion (>3)
Spring Criterion (>4.5)

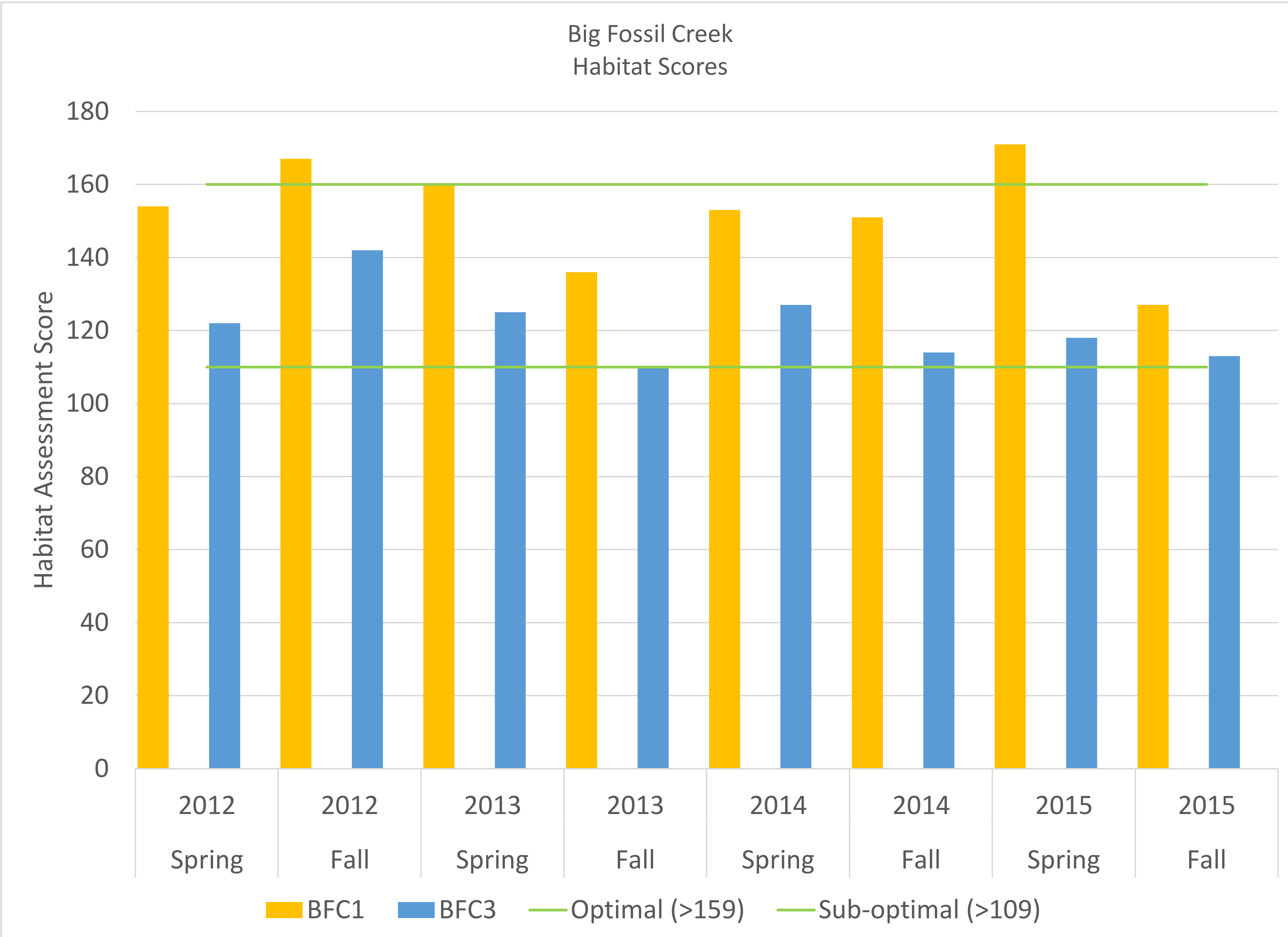

Big Fossil Creek
Nitrate Nitrogen
Nitrate Nitrogen (mg/L)
2.5
2
1.5
1
0.5
0
2012
2013
2014
2015
2016
Permit Term 3 Bioassessment
Nutrient Screening Criterion



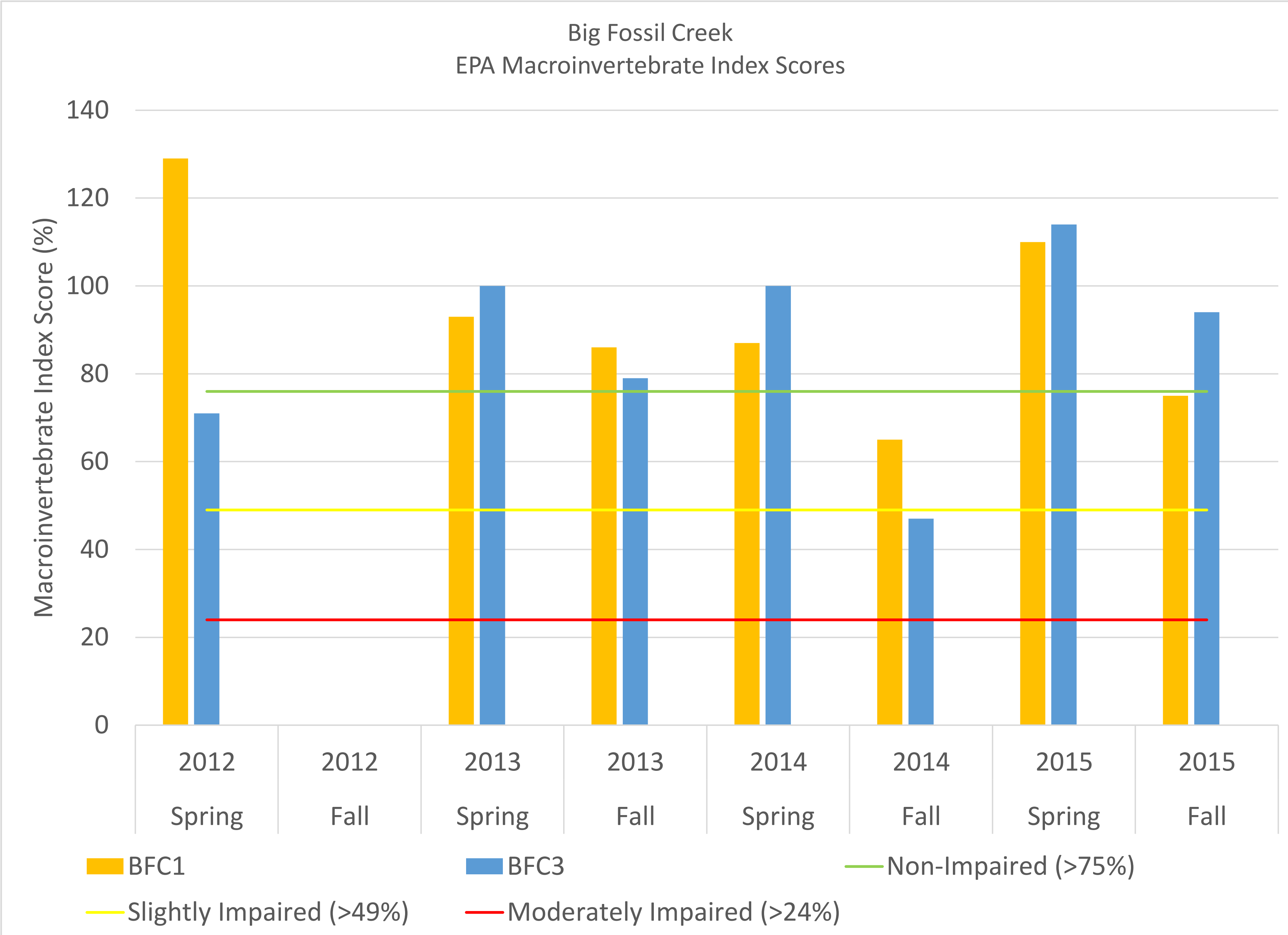
Big Fossil Creek
Ammonia Nitrogen
Ammonia Nitrogen (mg/L)
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
2012
2013
2014
2015
2016
Permit Term 3 Bioassessment
Nutrient Screening Criterion

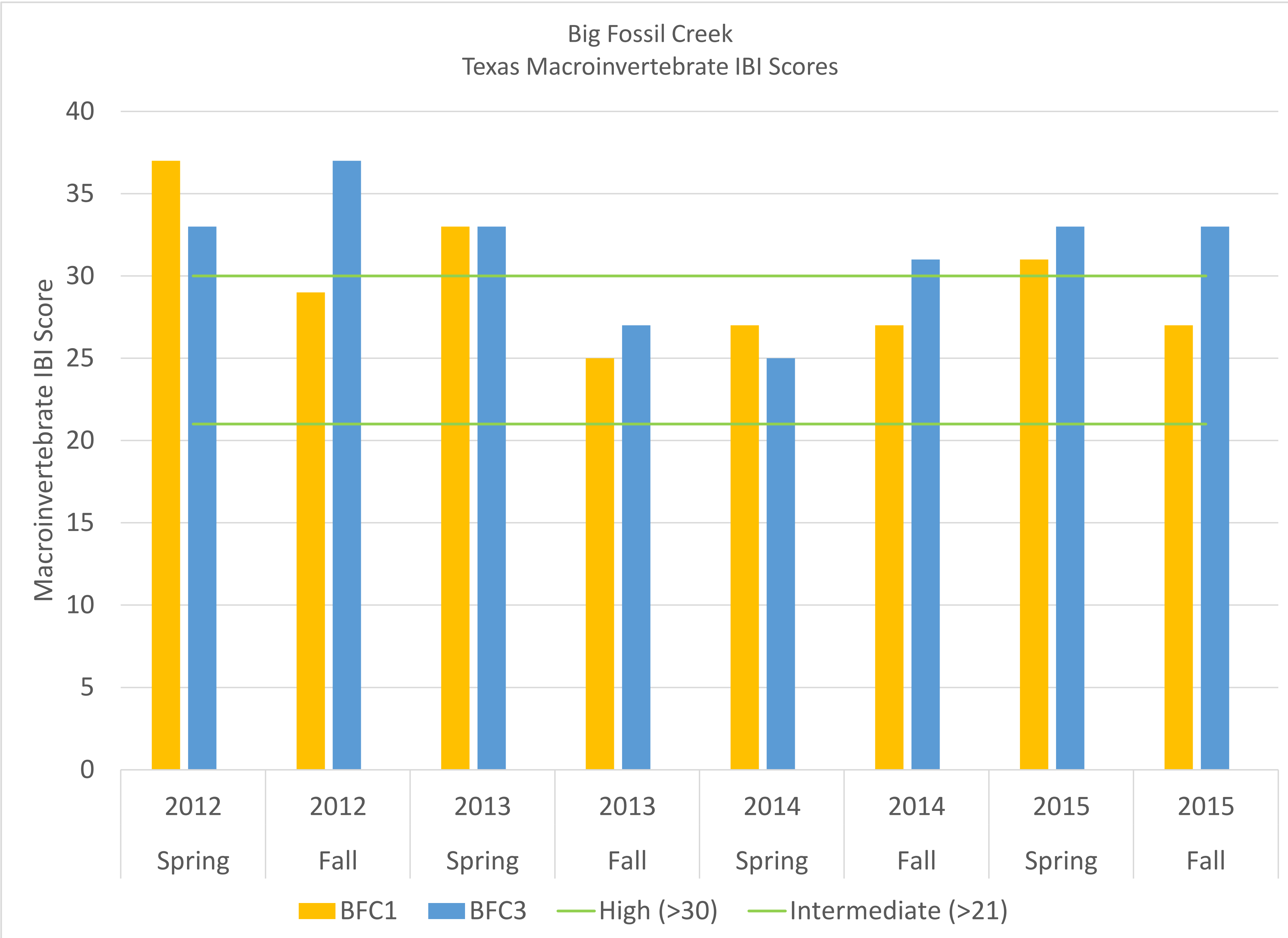


Big Fossil Creek
Orthophosphate
Orthophosphate (mg/L)
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
2012
2013
2014
2015
2016
Permit Term 3 Bioassessment
Nutrient Screening Criterion



Big Fossil Creek
Habitat Scores
Habitat Assessment Score
180
160
140
120
100
80
60
40
20
0
2012 Spring
2012 Fall
2013 Spring
2013 Fall
2014 Spring
2014 Fall
2015 Spring
2015 Fall
BFC1
BFC3
Optimal (>159)
Sub-optimal (>109)

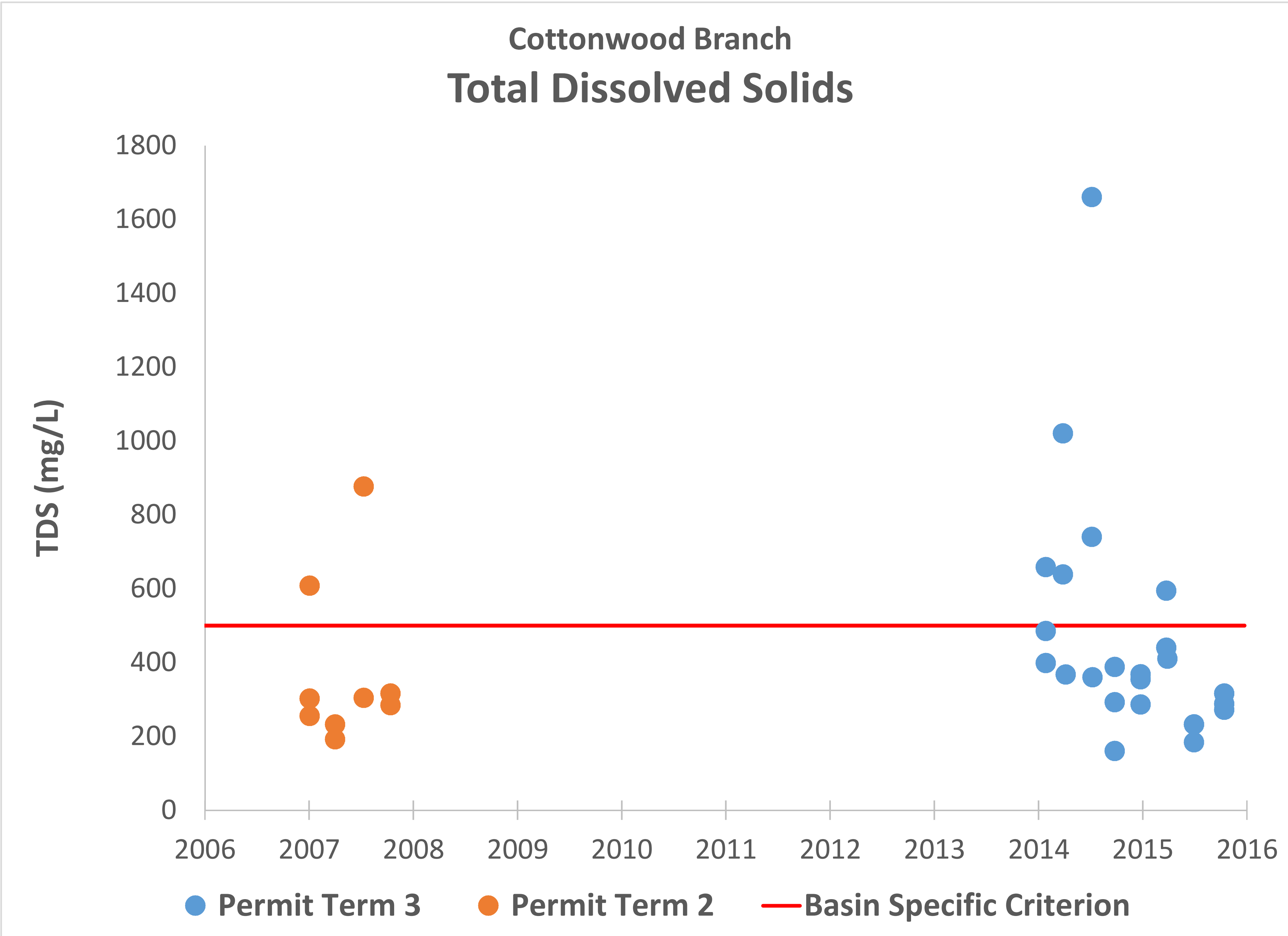

Big Fossil Creek
EPA Macroinvertebrate Index Scores
Macroinvertebrate Index Score (%)
140
120
100
80
60
40
20
0
2012 Spring
2012 Fall
2013 Spring
2013 Fall
2014 Spring
2014 Fall
2015 Spring
2015 Fall
BFC1
BFC3
Non-Impaired (>75%)
Slightly Impaired (>49%)
Moderately Impaired (>24%)



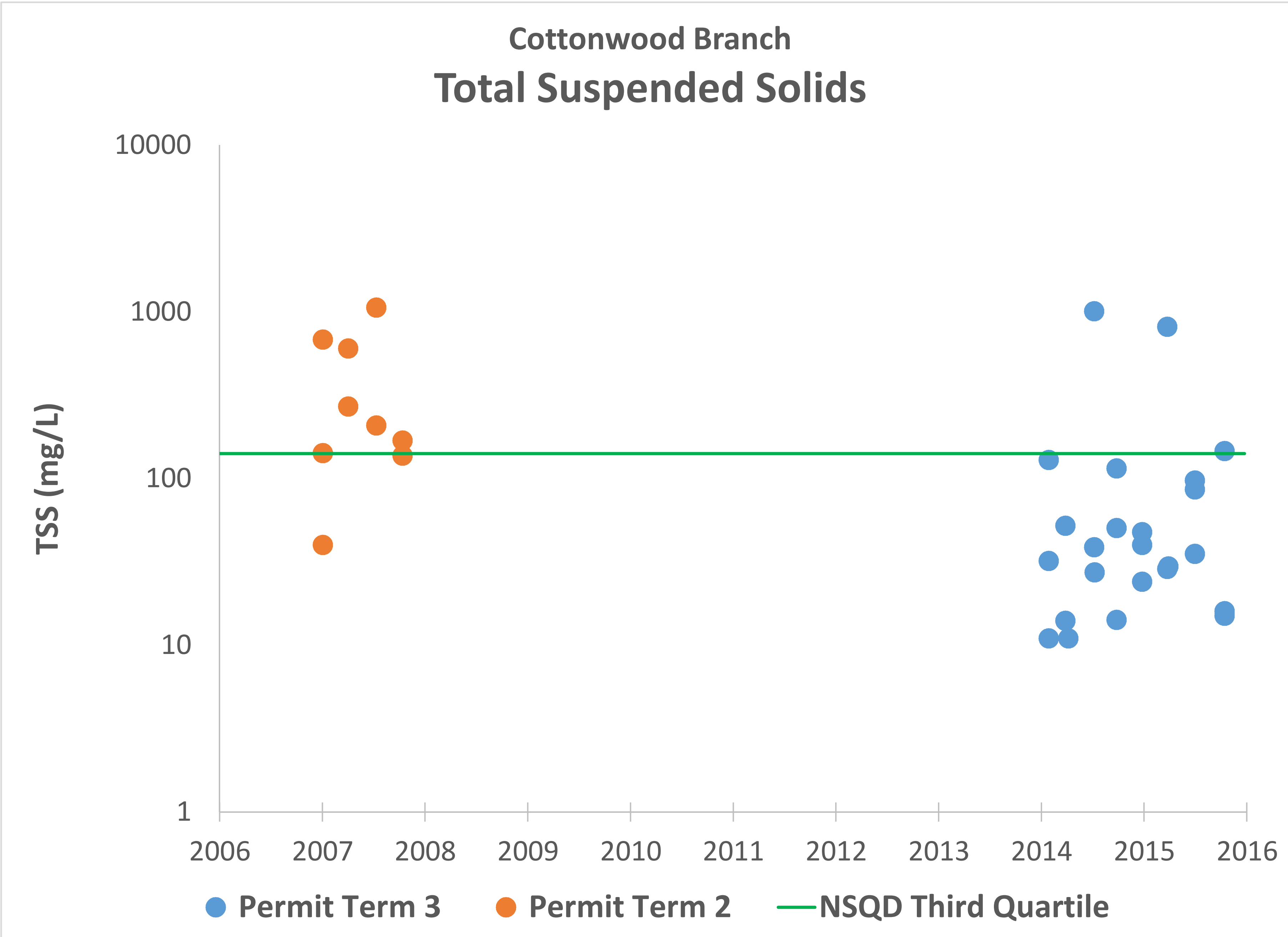
Big Fossil Creek
Texas Macroinvertebrate IBI Scores
Macroinvertebrate IBI Score
40
35
30
25
20
15
10
5
0
2012 Spring
2012 Fall
2013 Spring
2013 Fall
2014 Spring
2014 Fall
2015 Spring
2015 Fall
BFC1
BFC3
High (>30)
Intermediate (>21)

Appendix F

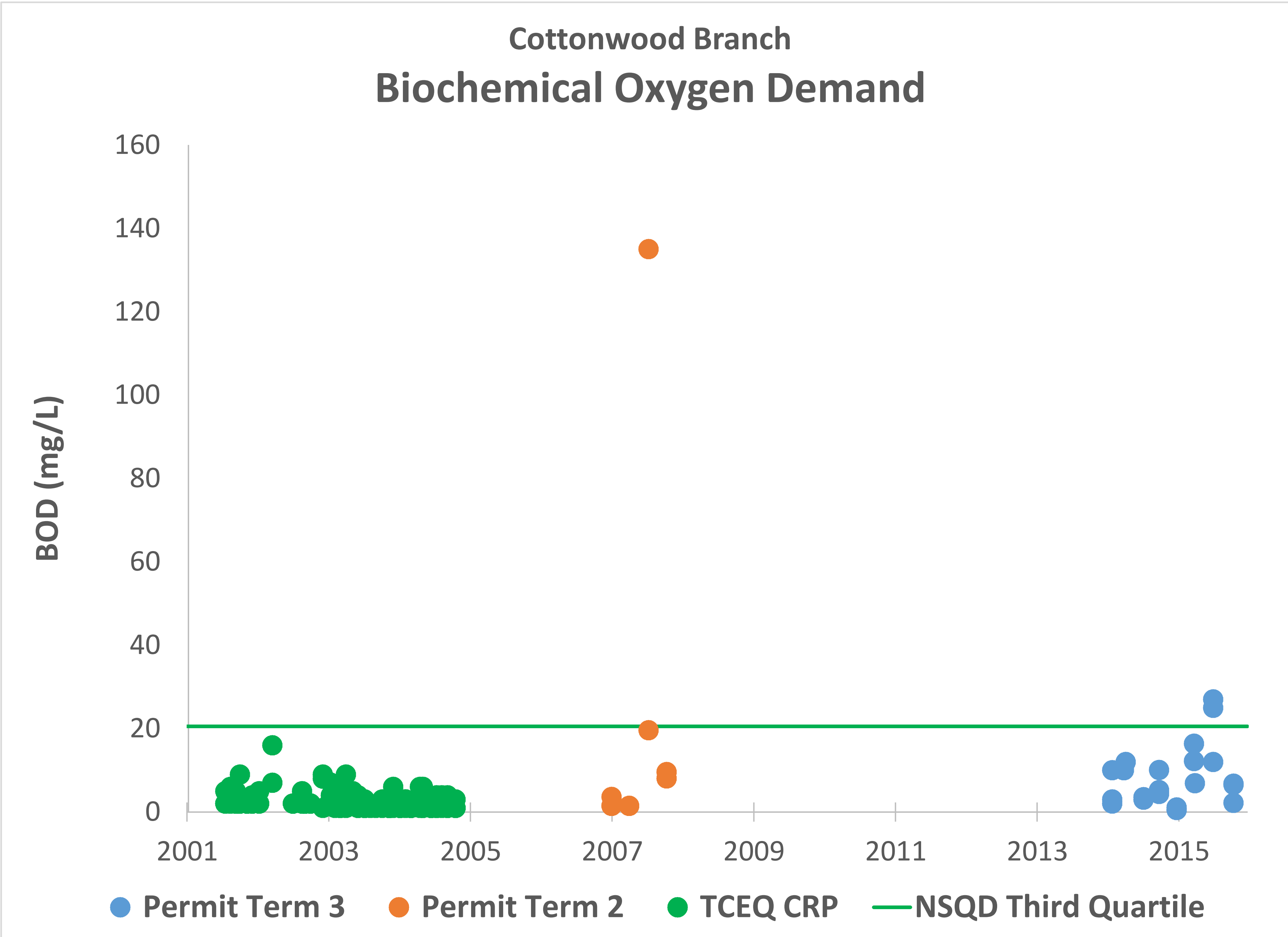
Cottonwood Branch Water Quality Data Graphs



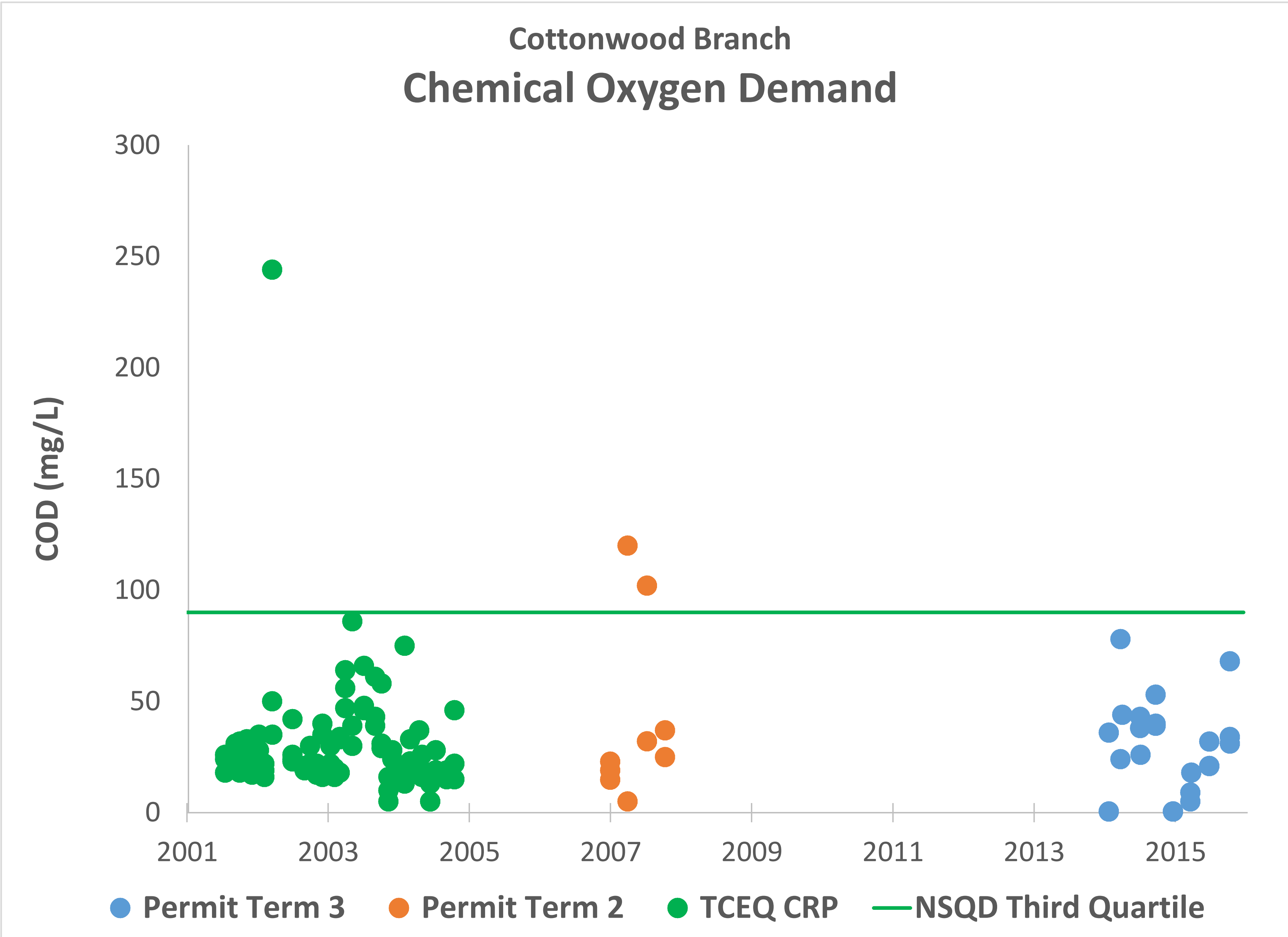
Cottonwood Branch
Total Dissolved Solids
TDS (mg/L)
0
200
400
600
800
1000
1200
1400
1600
1800
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
Permit Term 3
Permit Term 2
Basin Specific Criterion



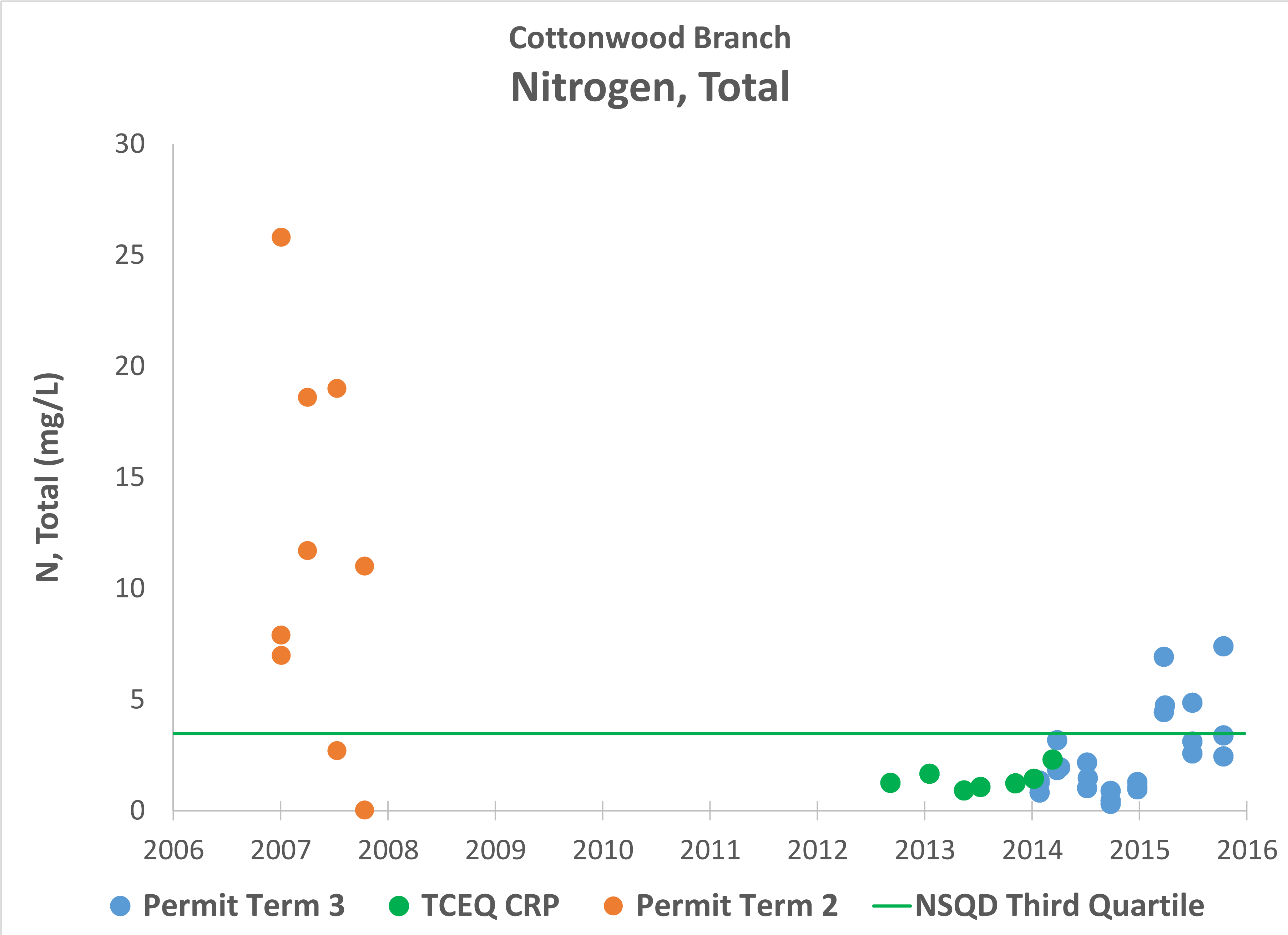
Cottonwood Branch
Total Suspended Solids
TSS (mg/L)
10000
1000
100
10
1
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
Permit Term 3
Permit Term 2
NSQD Third Quartile



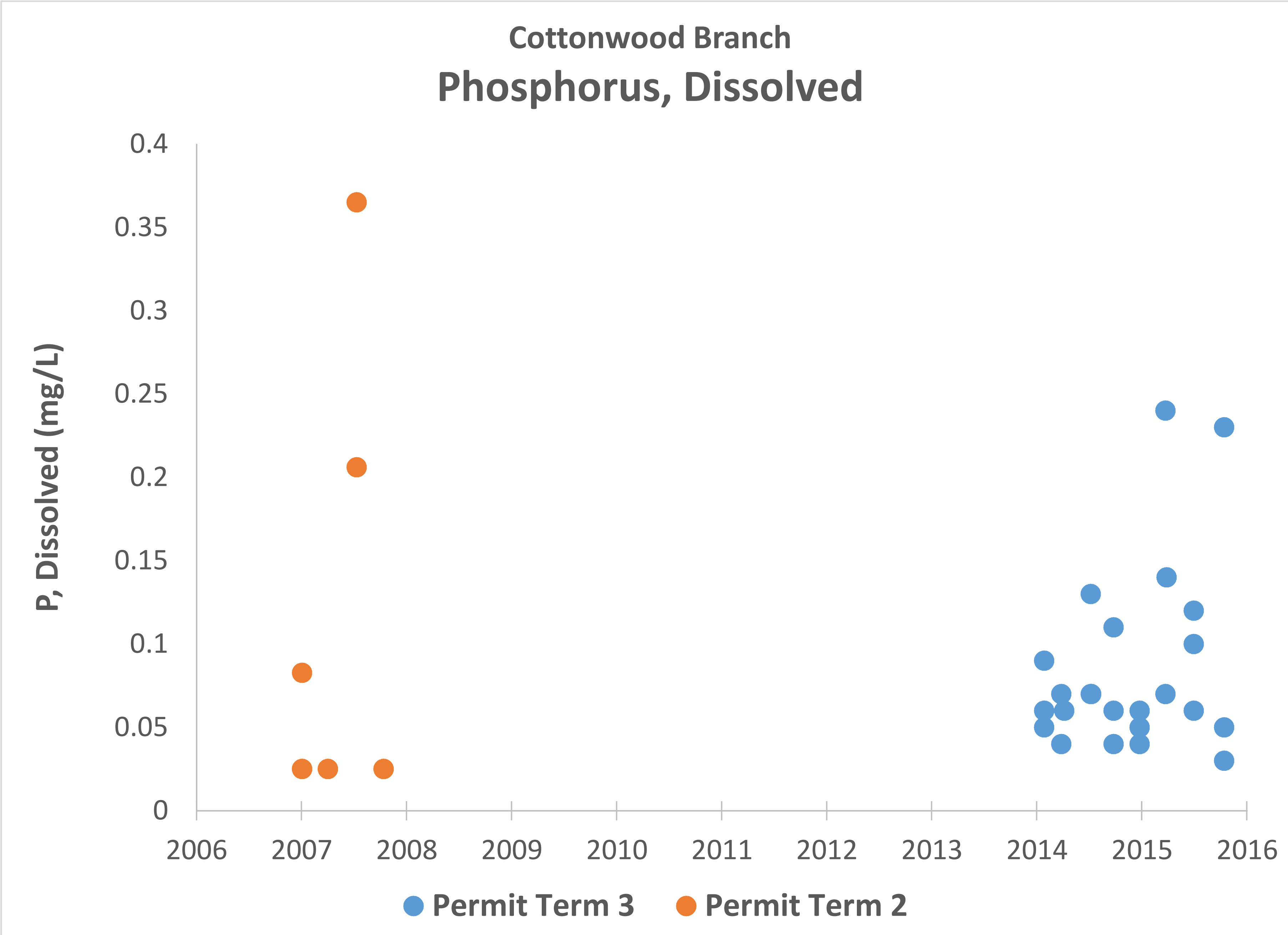
Cottonwood Branch
Biochemical Oxygen Demand
BOD (mg/L)
160
140
120
100
80
60
40
20
0
2001
2003
2005
2007
2009
2011
2013
2015
Permit Term 3
Permit Term 2
TCEQ CRP
NSQD Third Quartile

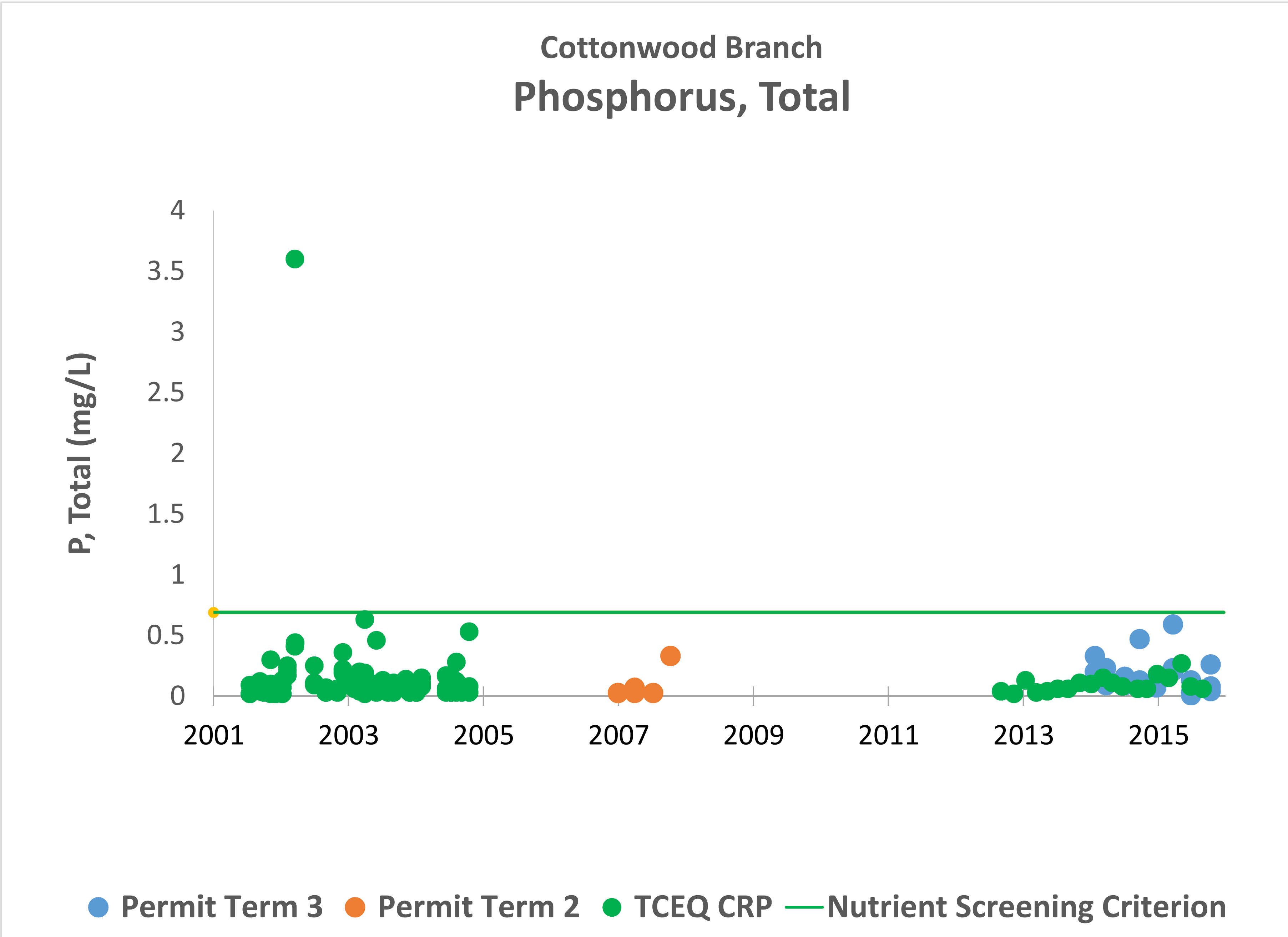


Cottonwood Branch
Chemical Oxygen Demand
COD (mg/L)
300
250
200
150
100
50
0
2001
2003
2005
2007
2009
2011
2013
2015
Permit Term 3
Permit Term 2
TCEQ CRP
NSQD Third Quartile

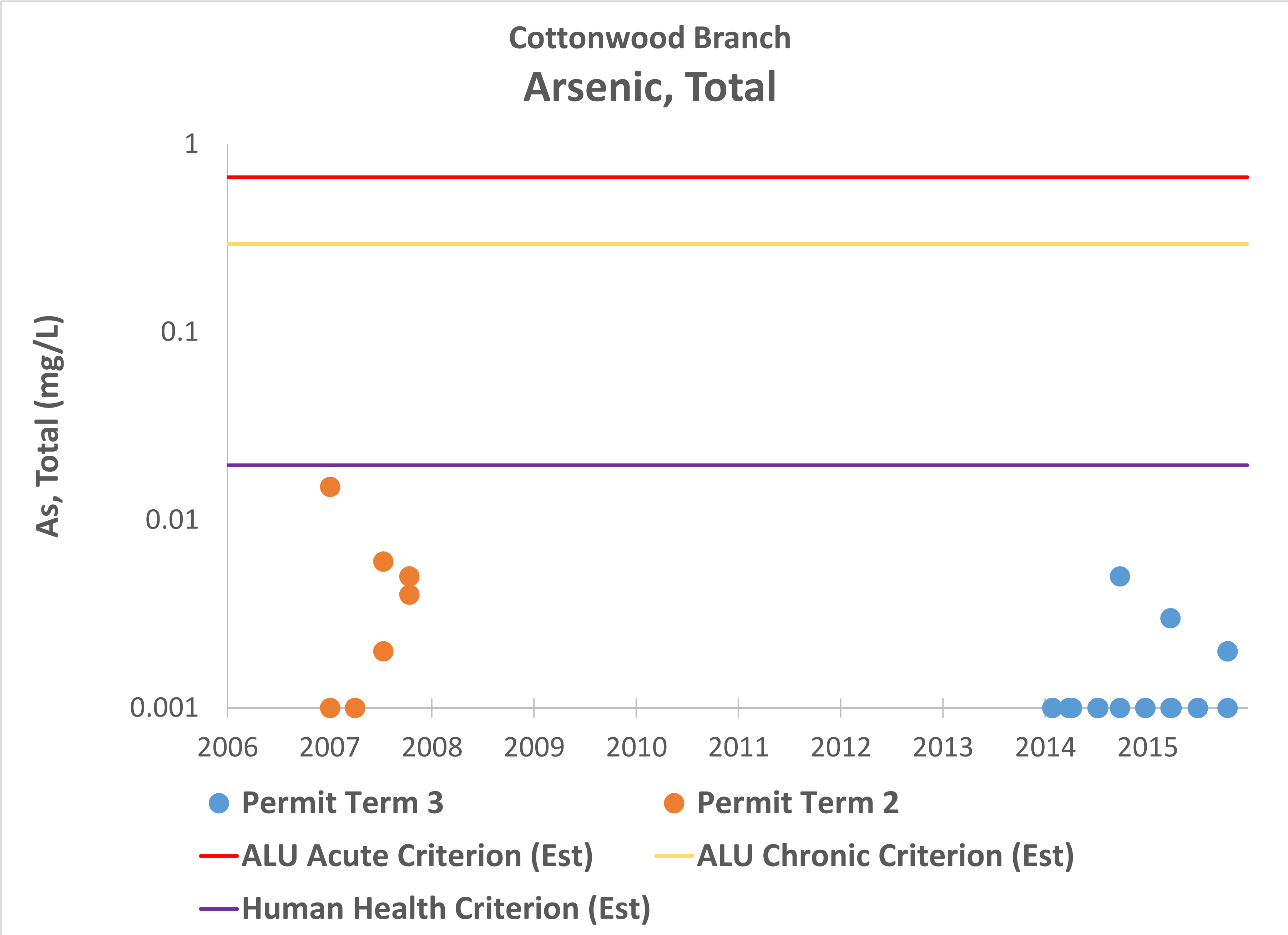


Cottonwood Branch
Nitrogen, Total
N, Total (mg/L)
30
25
20
15
10
5
0
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
Permit Term 3
TCEQ CRP
Permit Term 2
NSQD Third Quartile

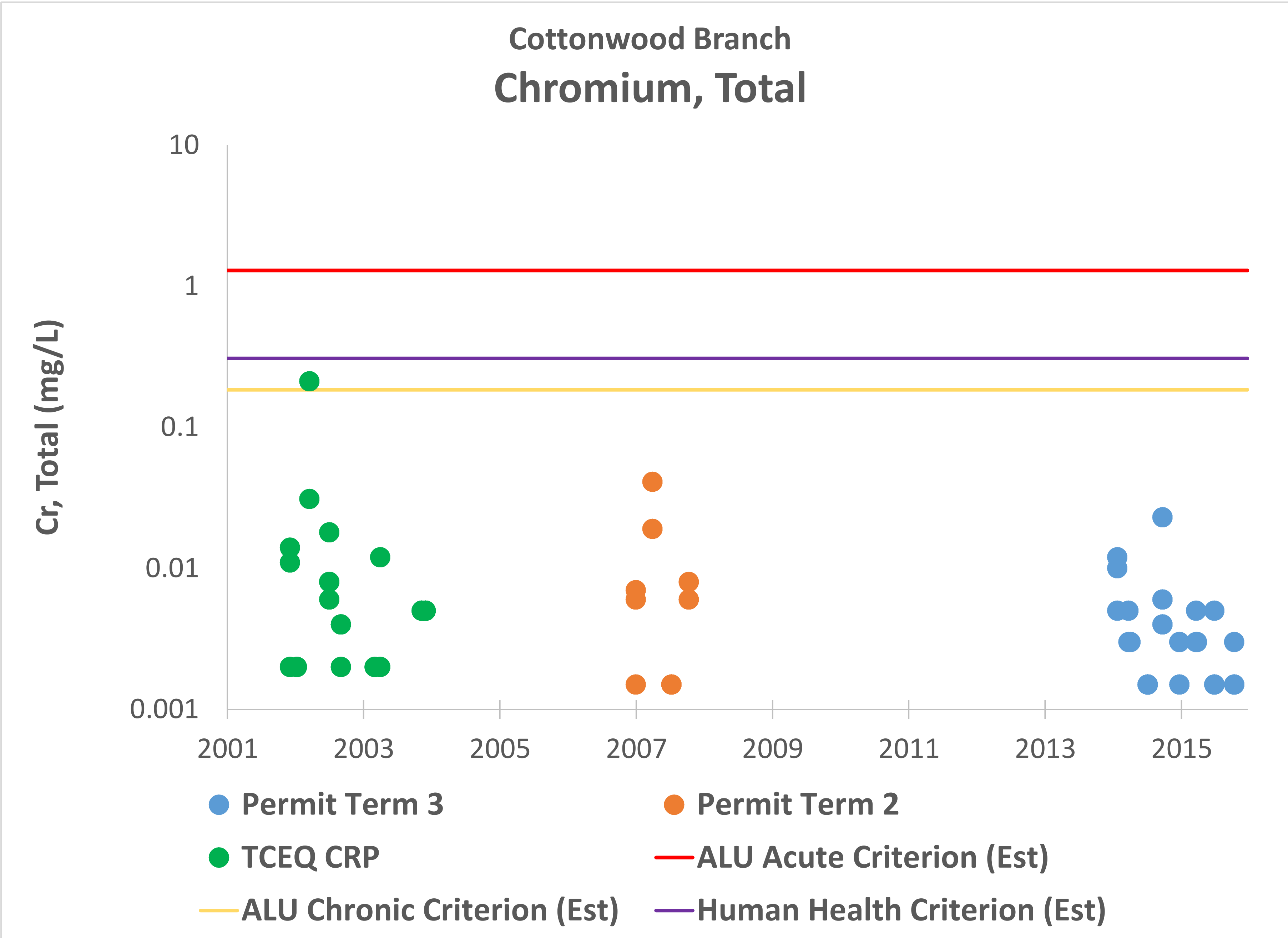

Cottonwood Branch
Phosphorus, Dissolved
P, Dissolved (mg/L)
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
Permit Term 3
Permit Term 2



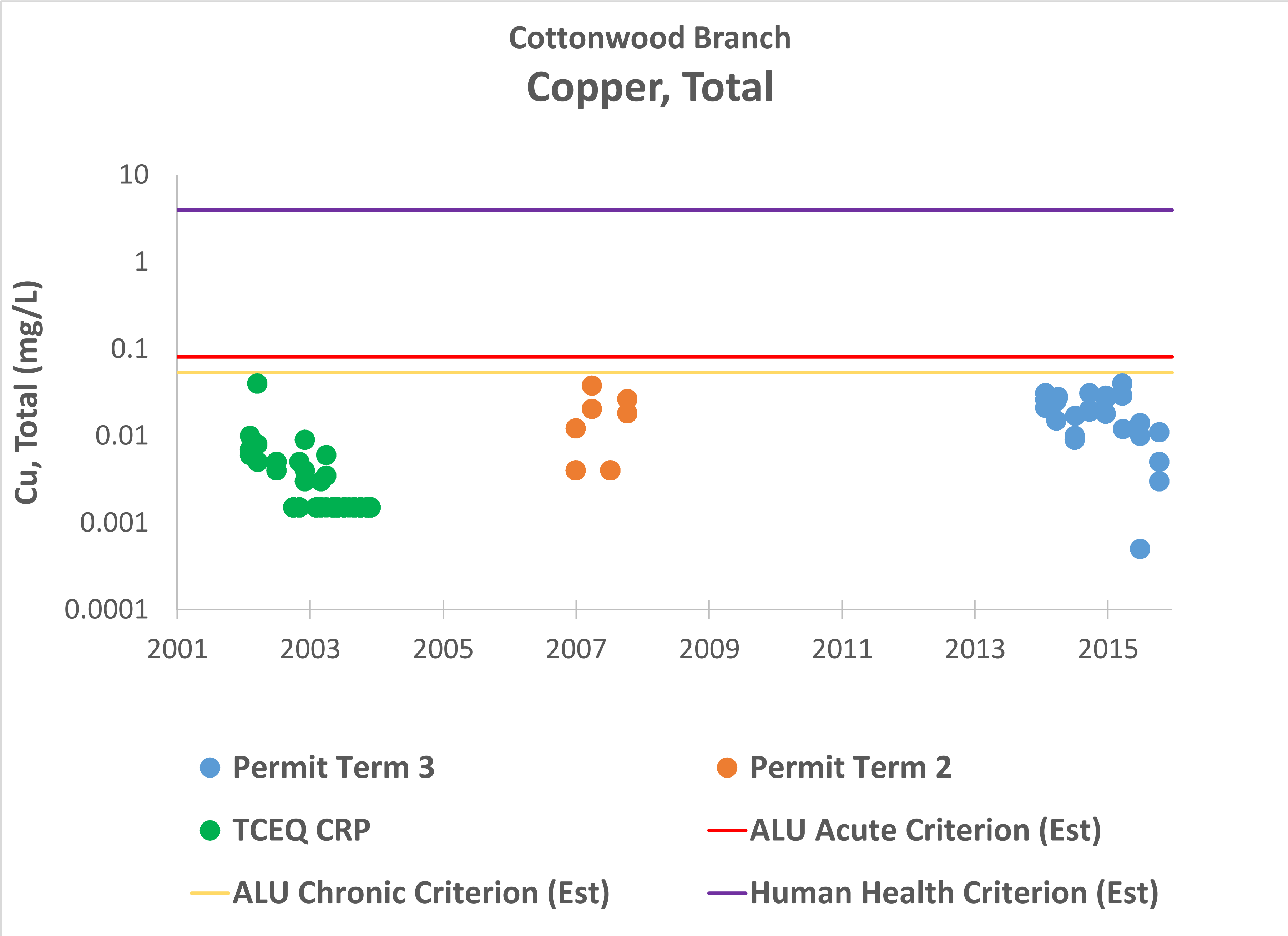
Cottonwood Branch
Phosphorus, Total
P, Total (mg/L)
4
3.5
3
2.5
2
1.5
1
0.5
0
2001
2003
2005
2007
2009
2011
2013
2015
Permit Term 3
Permit Term 2
TCEQ CRP
Nutrient Screening Criterion

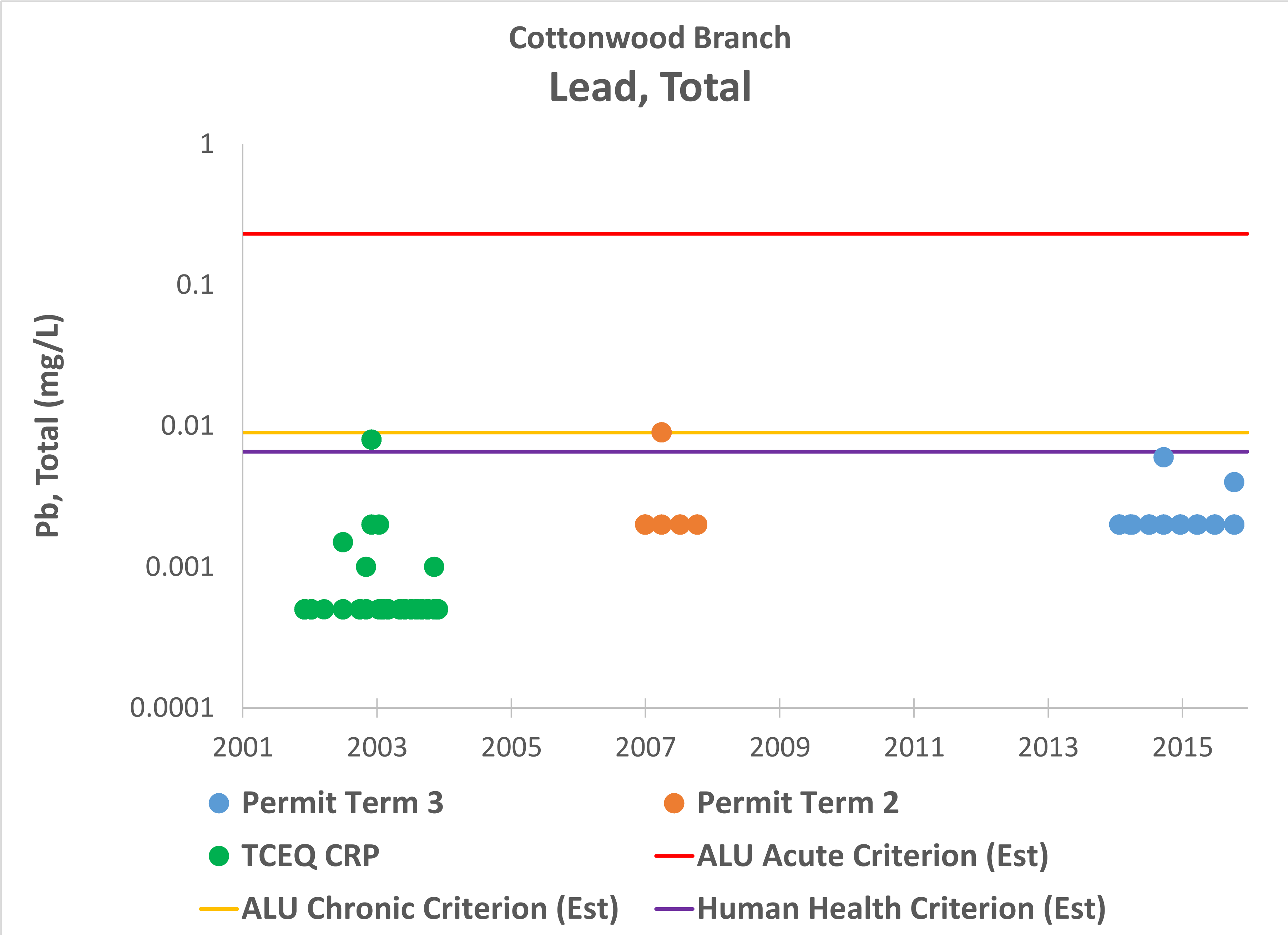


Cottonwood Branch
Arsenic, Total
As, Total (mg/L)
1
0.1
0.01
0.001
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
Permit Term 3
Permit Term 2
ALU Acute Criterion (Est)
ALU Chronic Criterion (Est)
Human Health Criterion (Est)

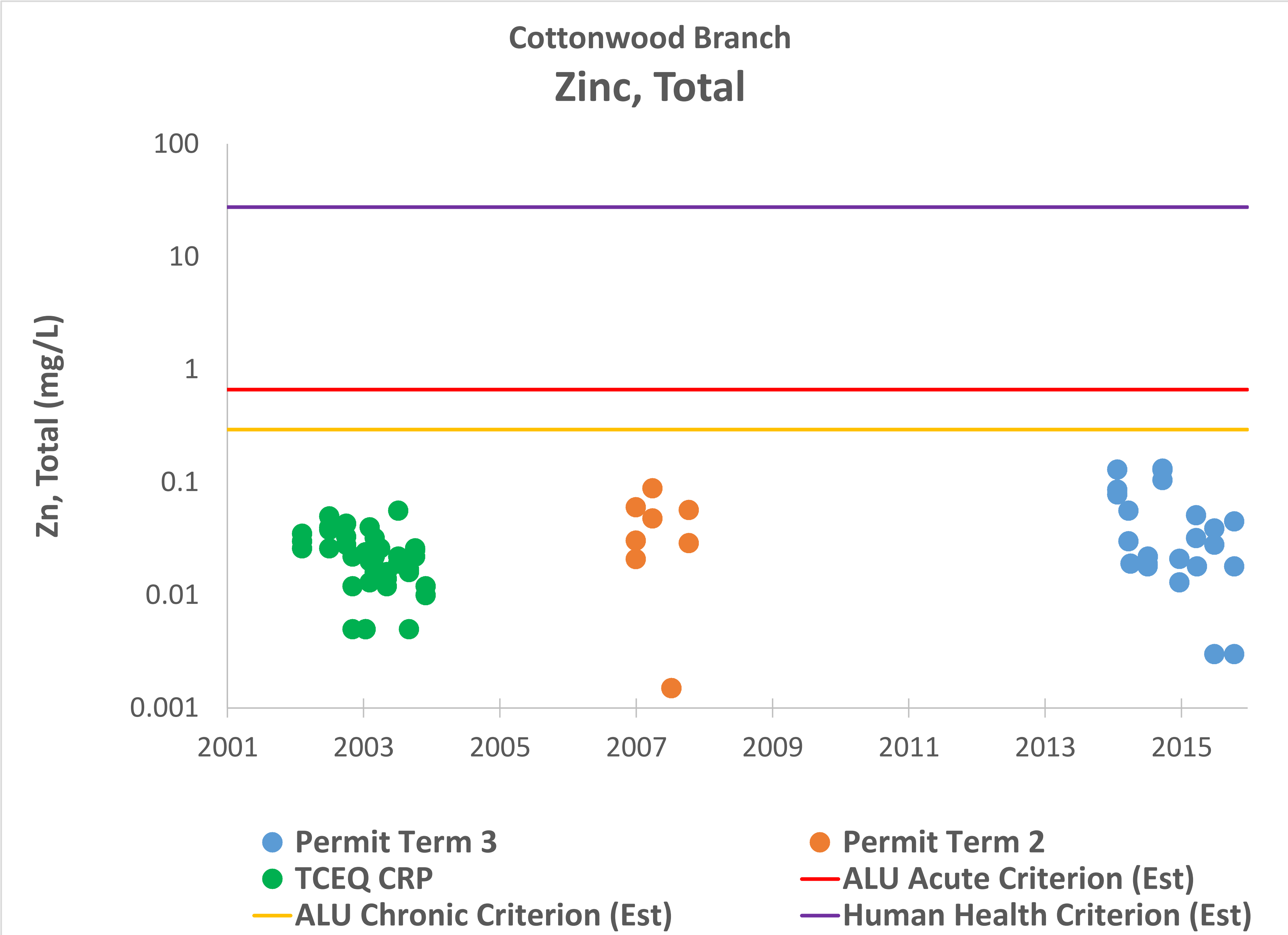


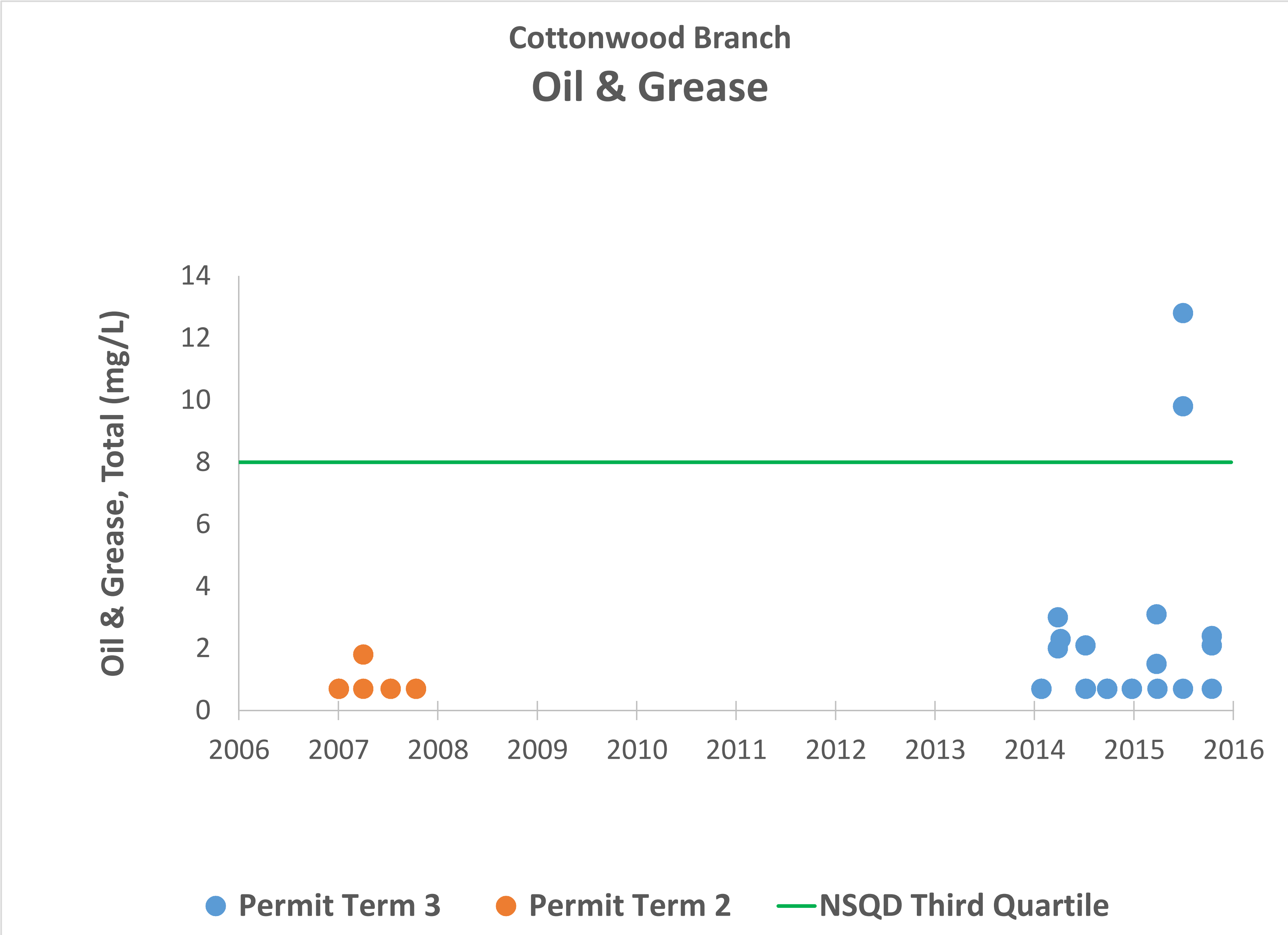
Cottonwood Branch
Chromium, Total
Cr, Total (mg/L)
10
1
0.1
0.01
0.001
2001
2003
2005
2007
2009
2011
2013
2015
Permit Term 3
Permit Term 2
TCEQ CRP
ALU Acute Criterion (Est)
ALU Chronic Criterion (Est)
Human Health Criterion (Est)


Cottonwood Branch
Copper, Total
Cu, Total (mg/L)
10
1
0.1
0.01
0.001
0.0001
2001
2003
2005
2007
2009
2011
2013
2015
Permit Term 3
Permit Term 2
TCEQ CRP
ALU Acute Criterion (Est)
ALU Chronic Criterion (Est)
Human Health Criterion (Est)

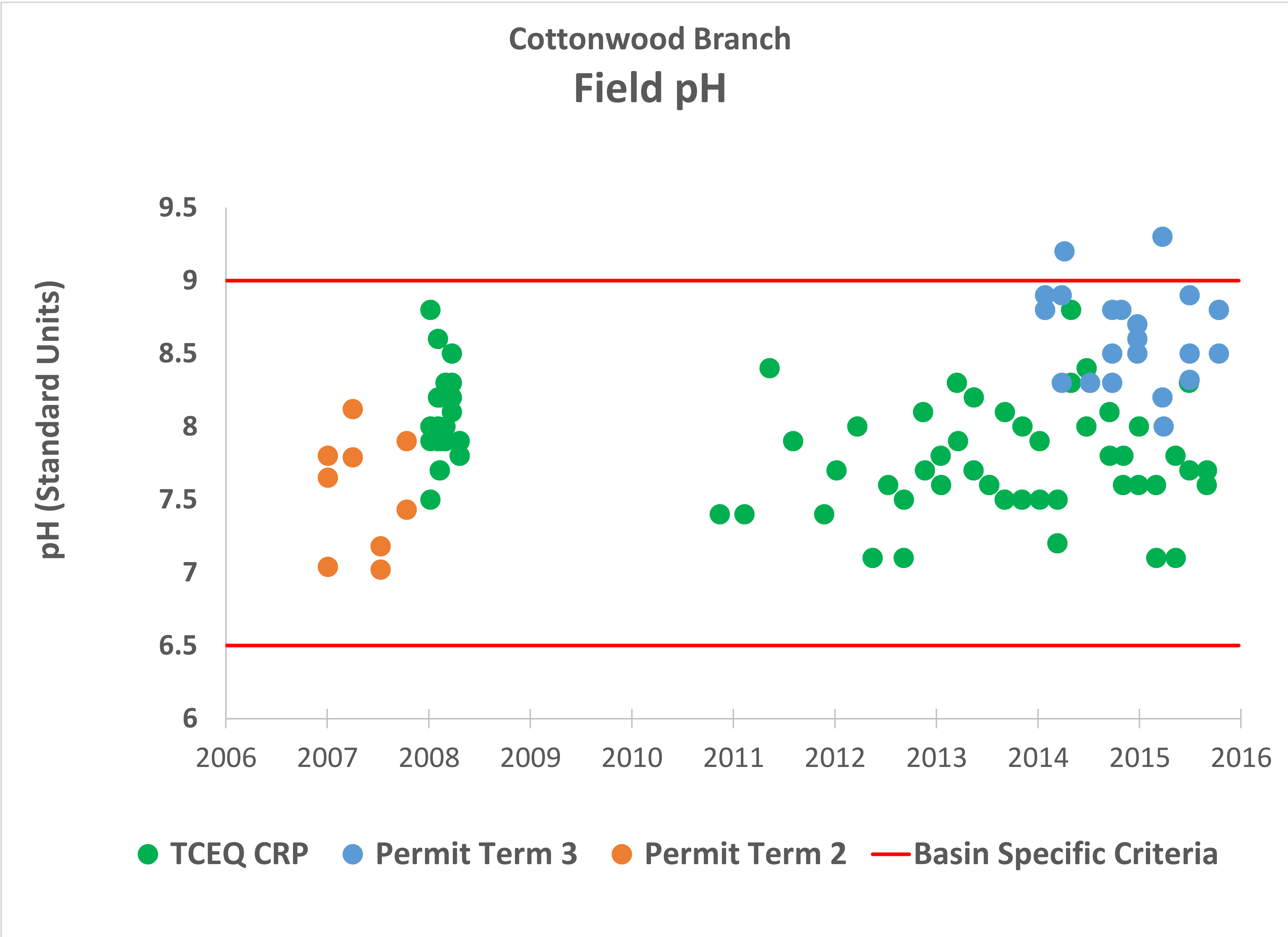


Cottonwood Branch
Lead, Total
Pb, Total (mg/L)
1
0.1
0.01
0.001
0.0001
2001
2003
2005
2007
2009
2011
2013
2015
Permit Term 3
Permit Term 2
TCEQ CRP
ALU Acute Criterion (Est)
ALU Chronic Criterion (Est)
Human Health Criterion (Est)

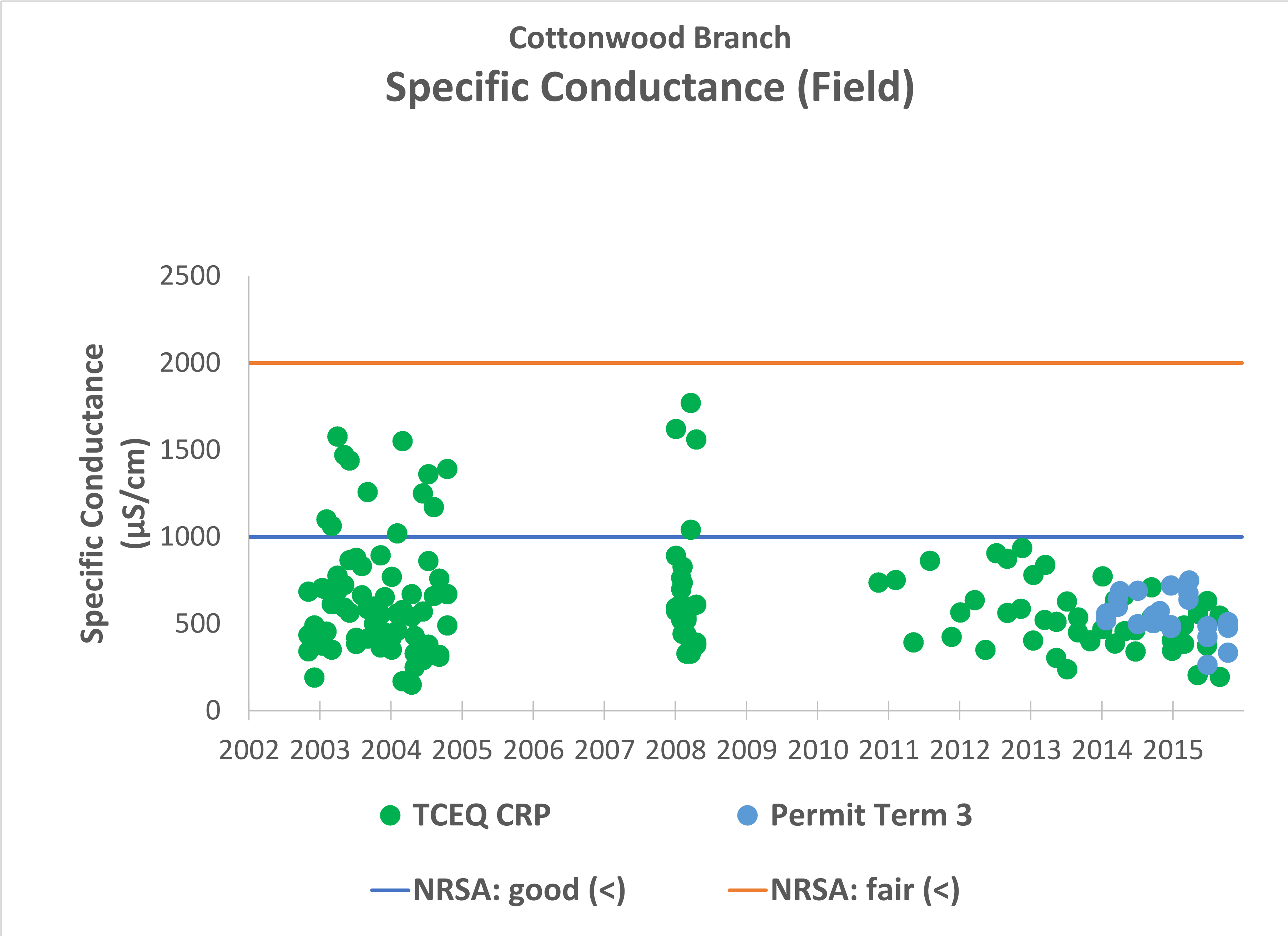

Cottonwood Branch
Zinc, Total
Zn, Total (mg/L)
100
10
1
0.1
0.01
0.001
2001
2003
2005
2007
2009
2011
2013
2015
Permit Term 3
Permit Term 2
TCEQ CRP
ALU Acute Criterion (Est)
ALU Chronic Criterion (Est)
Human Health Criterion (Est)

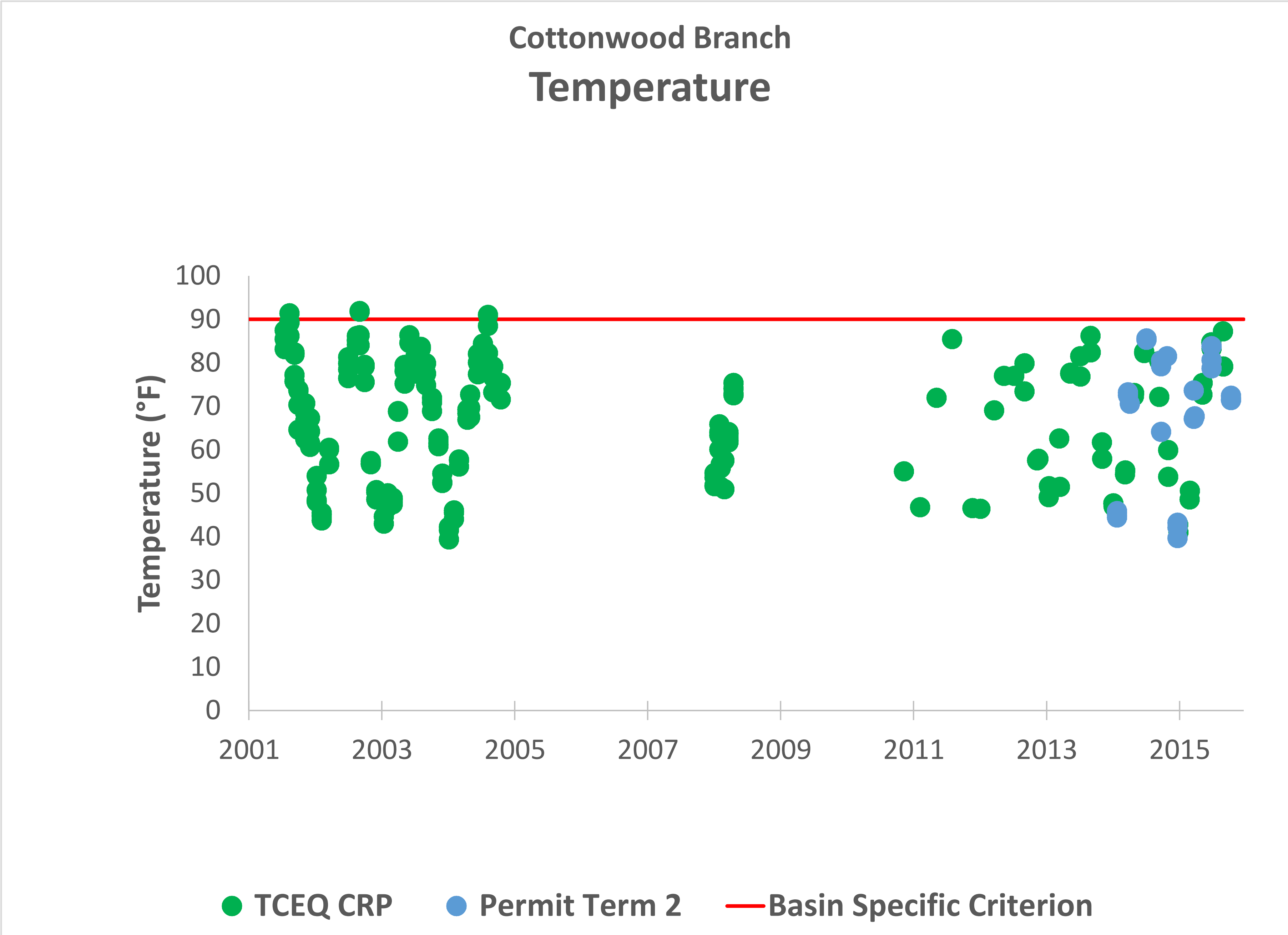


Cottonwood Branch
Oil & Grease
Oil & Grease, Total (mg/L)
0
2
4
6
8
10
12
14
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
Permit Term 3
Permit Term 2
NSQD Third Quartile

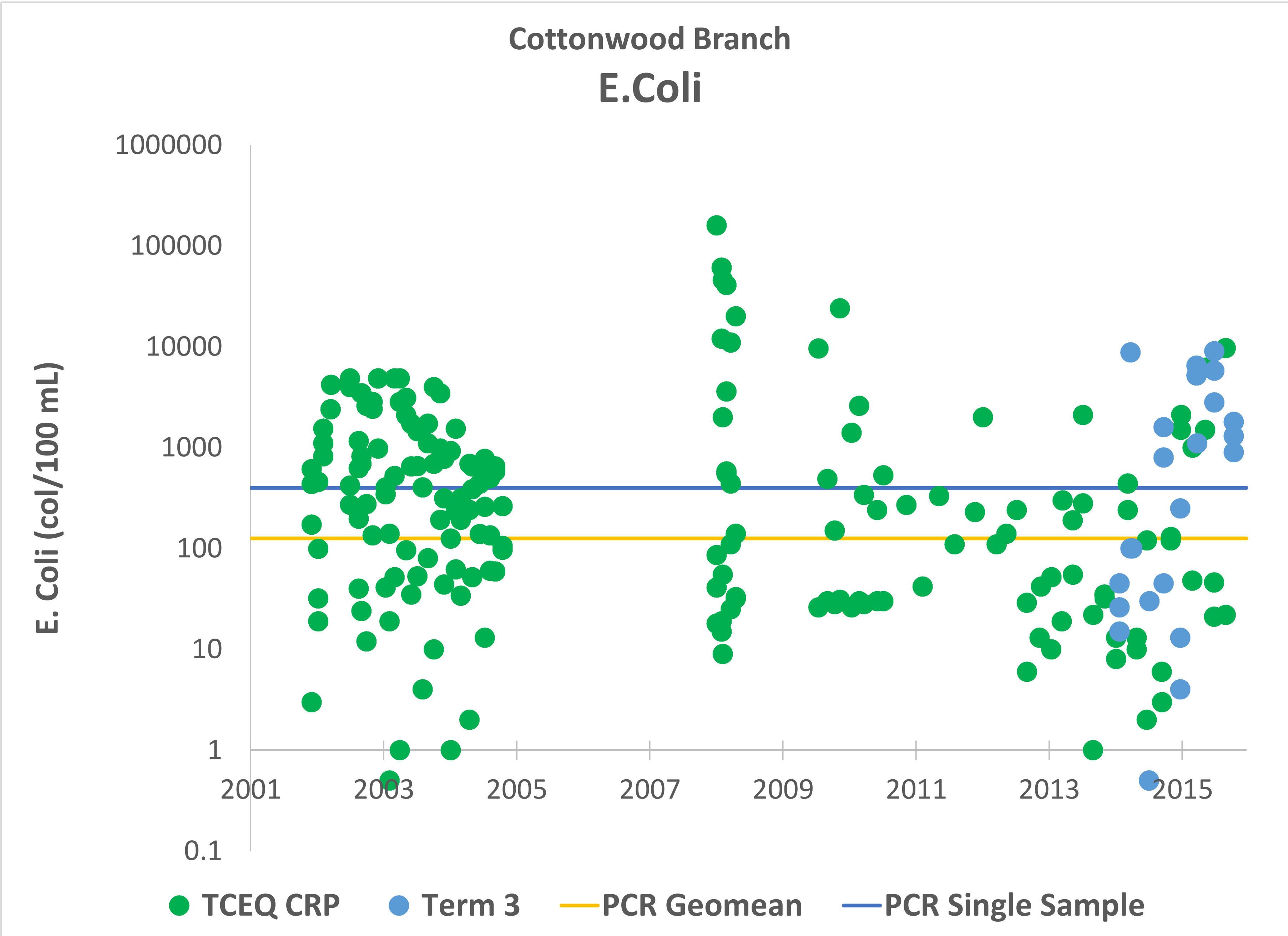


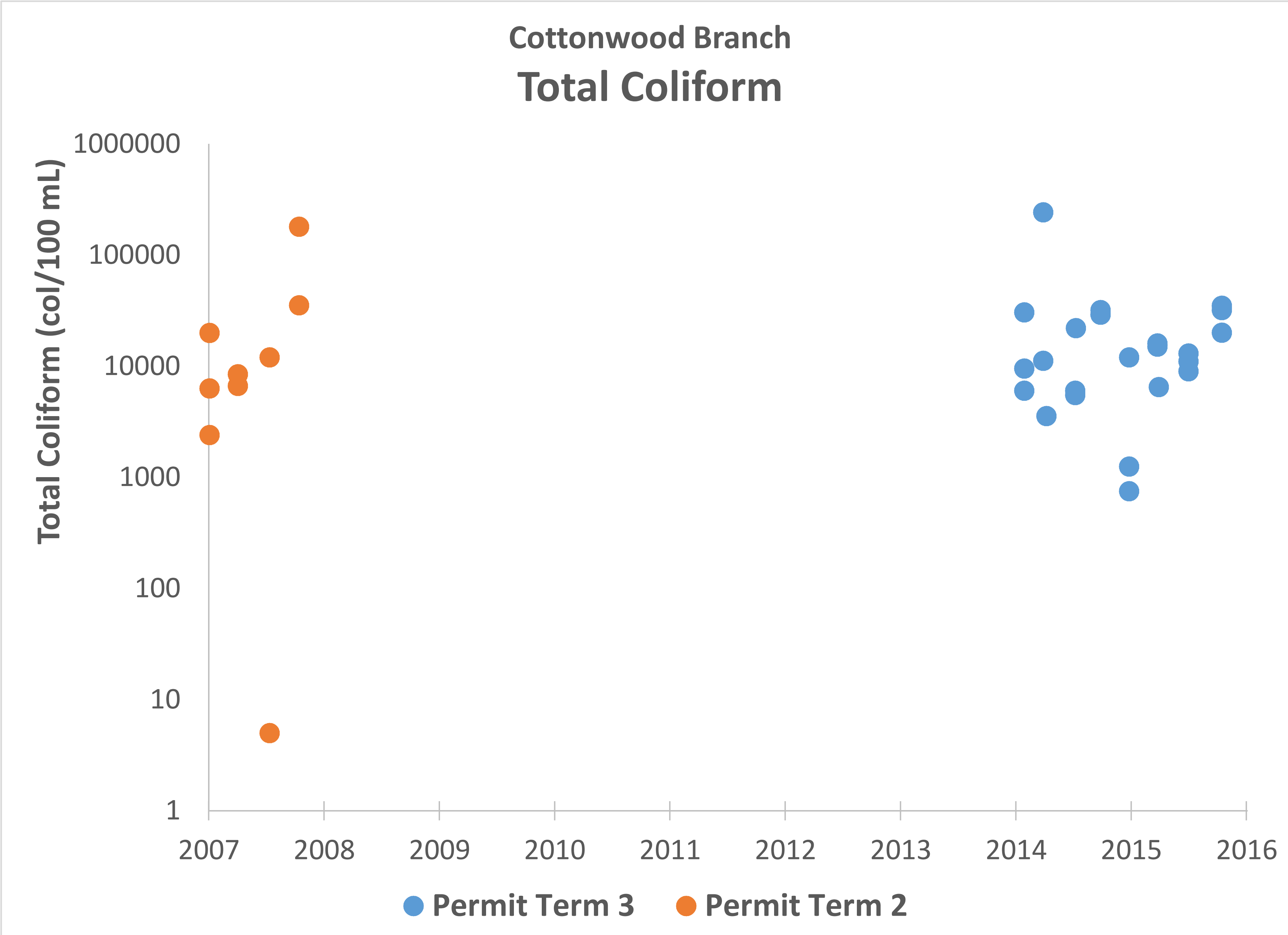
Cottonwood Branch
Field pH
pH (Standard Units)
9.5
9
8.5
8
7.5
7
6.5
6
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
TCEQ CRP
Permit Term 3
Permit Term 2
Basin Specific Criteria


Cottonwood Branch
Specific Conductance (Field)
Specific Conductance (µS/cm)
2500
2000
1500
1000
500
0
2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015
TCEQ CRP
Permit Term 3
NRSA: good (<)
NRSA: fair (<)

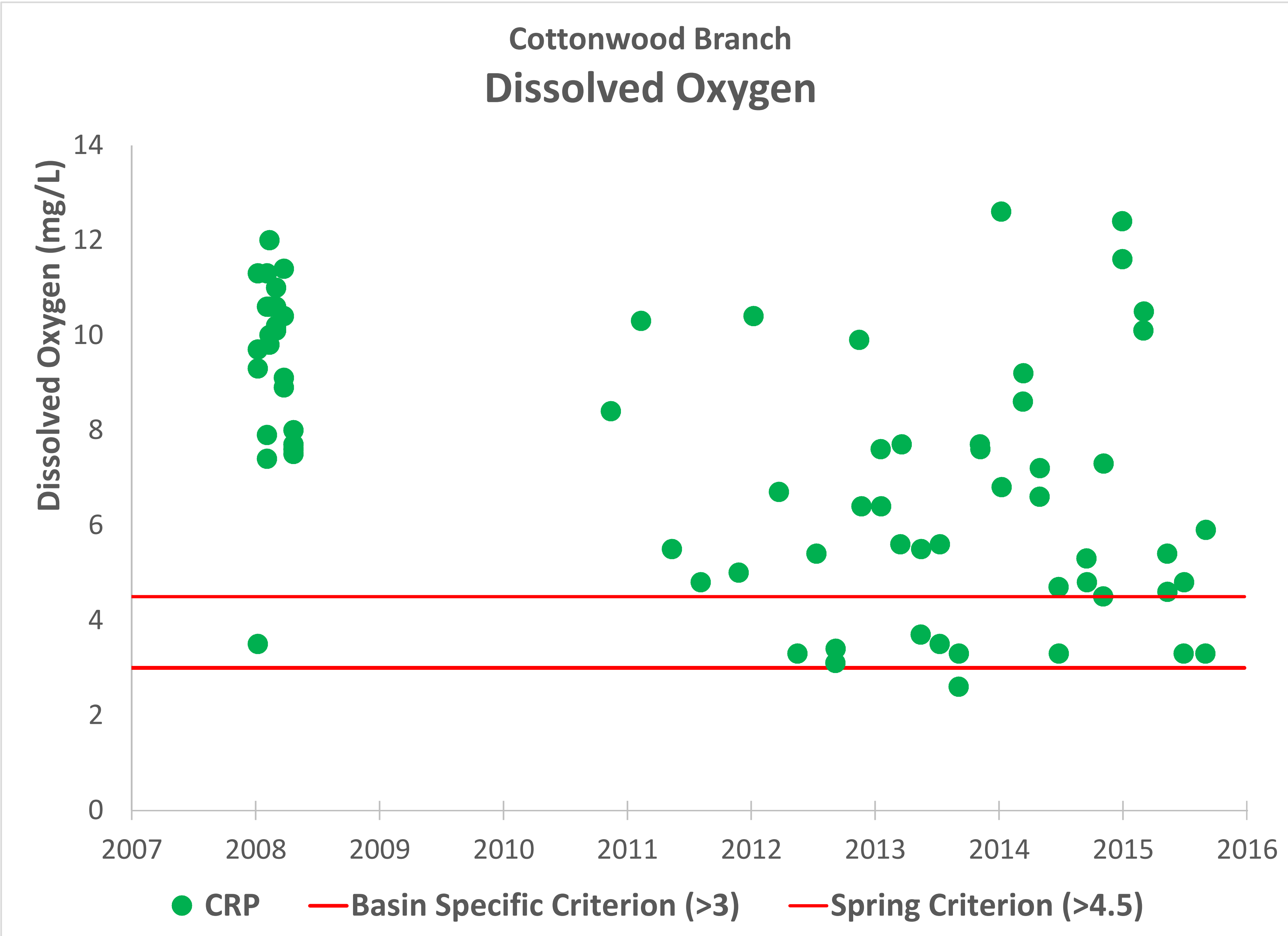


Cottonwood Branch
Temperature
Temperature (°F)
100
90
80
70
60
50
40
30
20
10
0
2001
2003
2005
2007
2009
2011
2013
2015
TCEQ CRP
Permit Term 2
Basin Specific Criterion


Cottonwood Branch
E.Coli
E. Coli (col/100 mL)
1000000
100000
10000
1000
100
10
1
0.1
2001
2003
2005
2007
2009
2011
2013
2015
TCEQ CRP
Term 3
PCR Geomean
PCR Single Sample



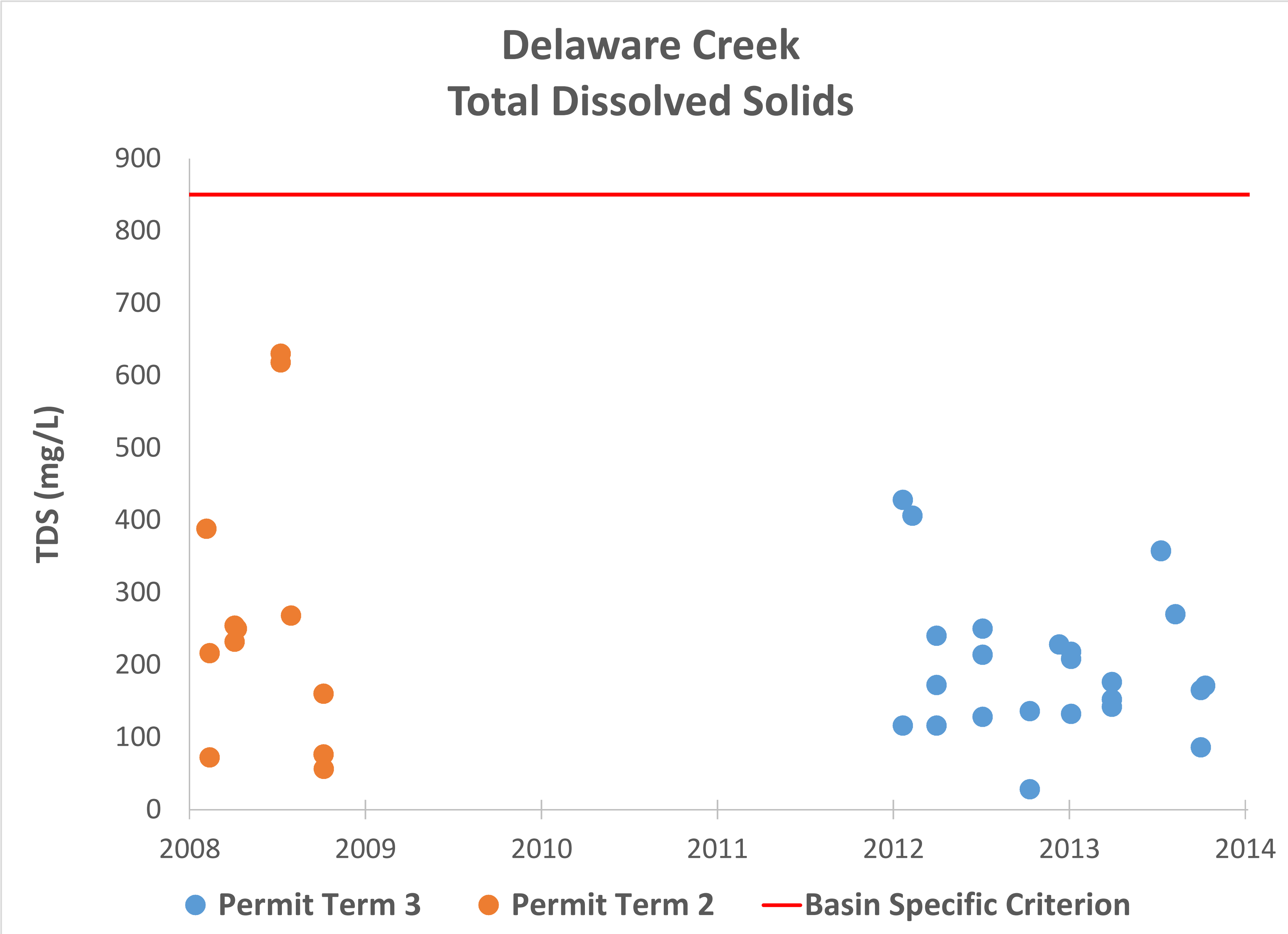
Cottonwood Branch
Total Coliform
Total Coliform (col/100 mL)
1000000
100000
10000
1000
100
10
1
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
Permit Term 3
Permit Term 2

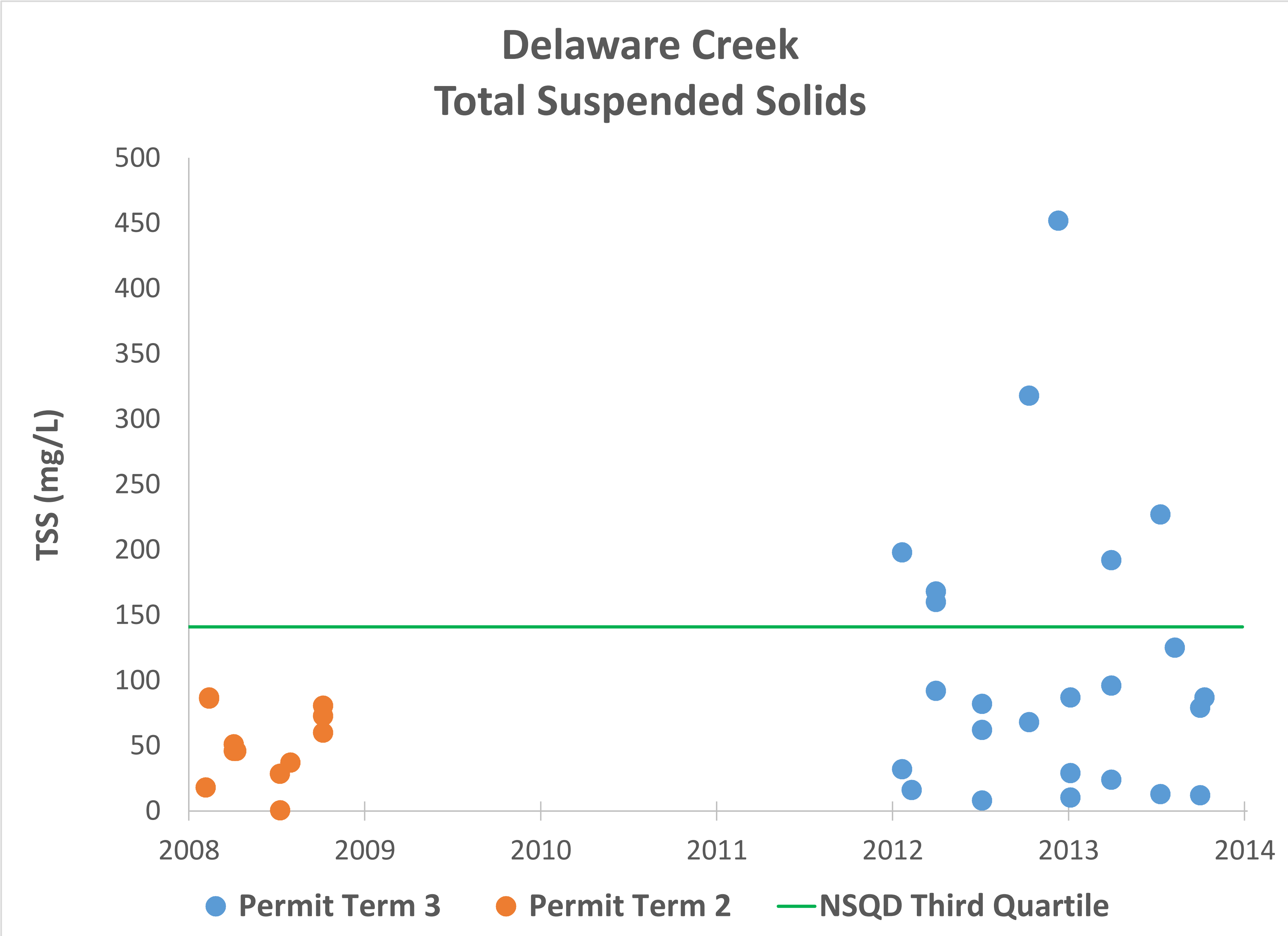


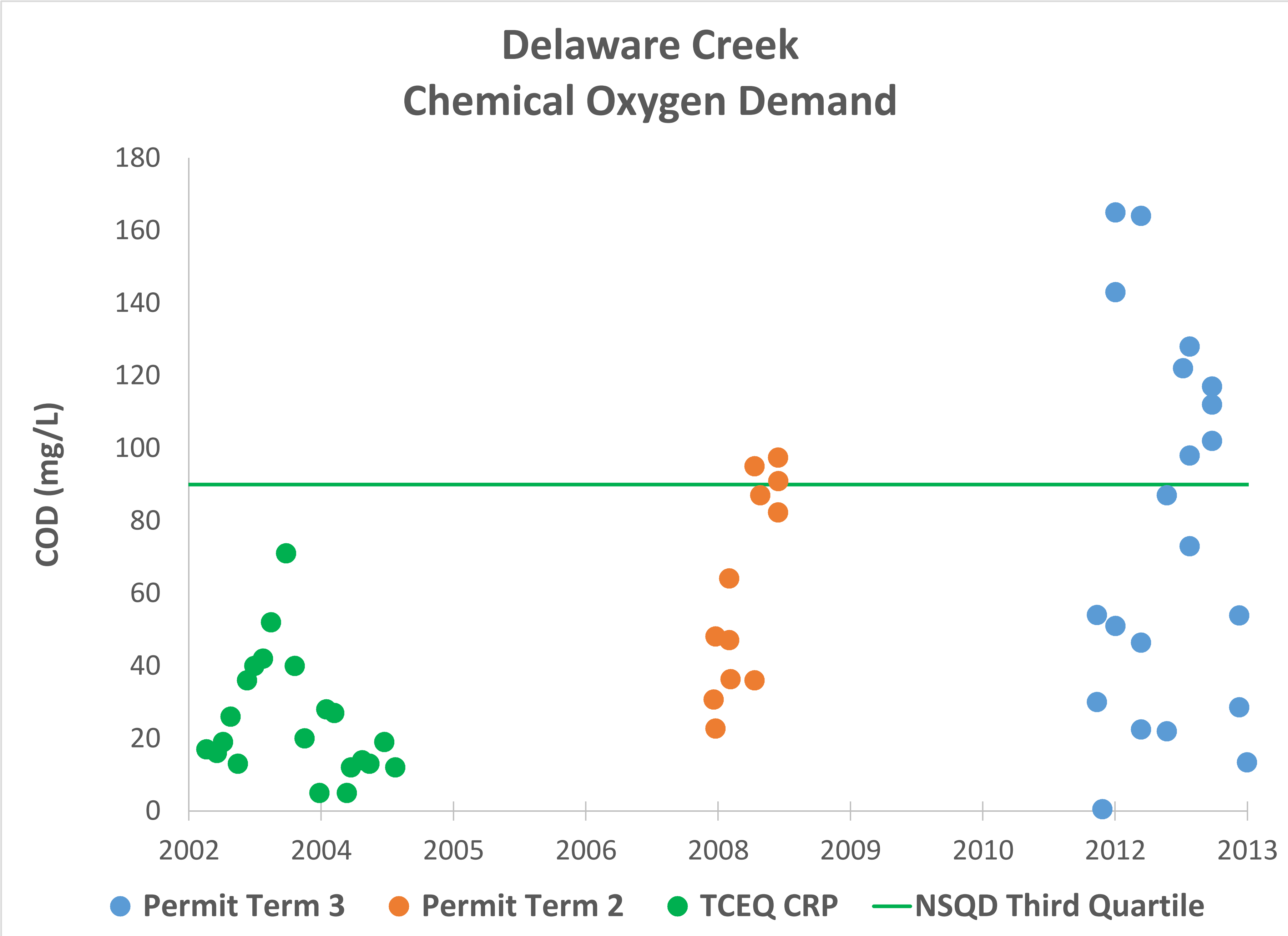
Cottonwood Branch
Dissolved Oxygen
Dissolved Oxygen (mg/L)
0
2
4
6
8
10
12
14
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
CRP
Basin Specific Criterion (>3)
Spring Criterion (>4.5)

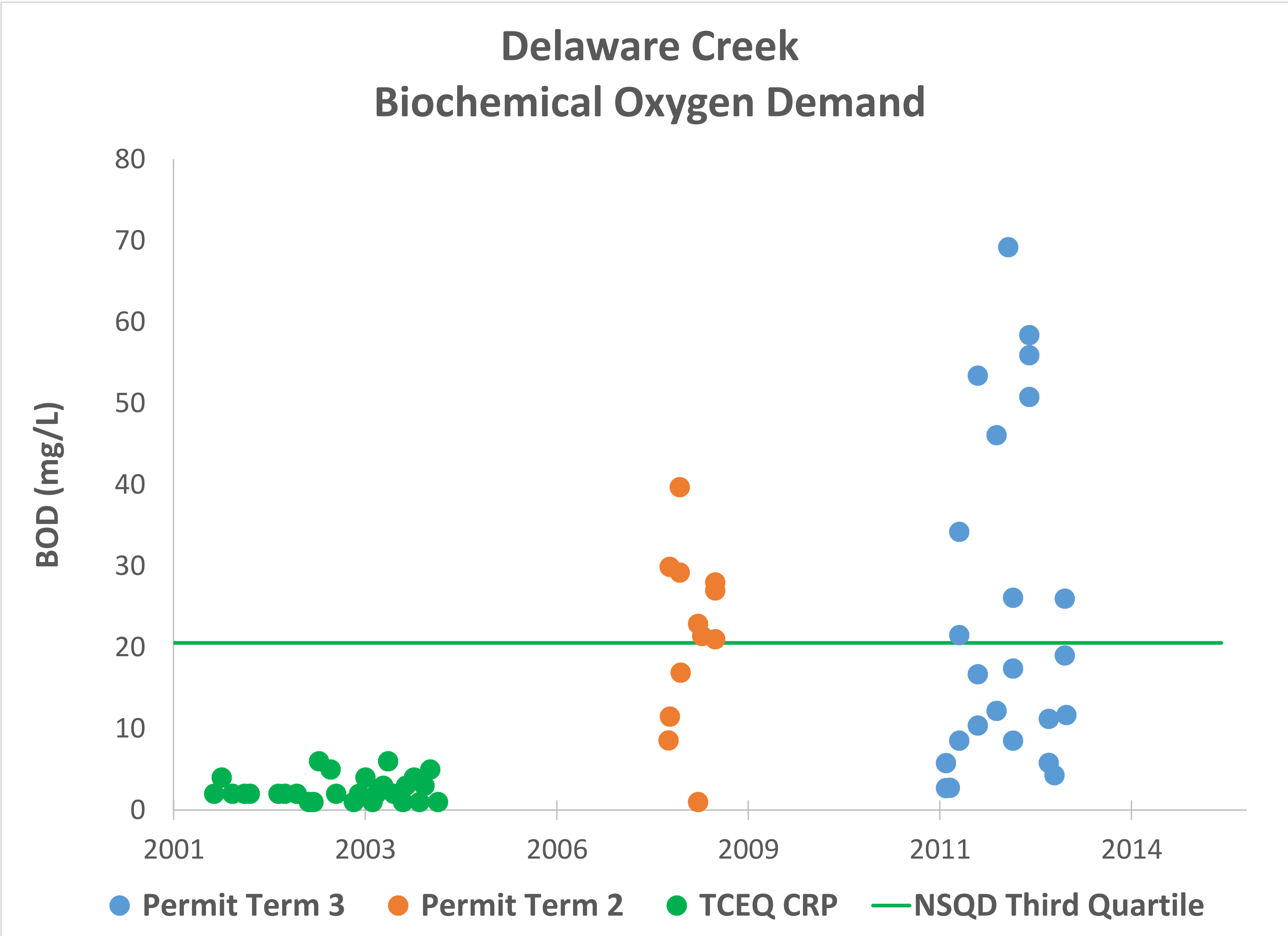
Appendix G

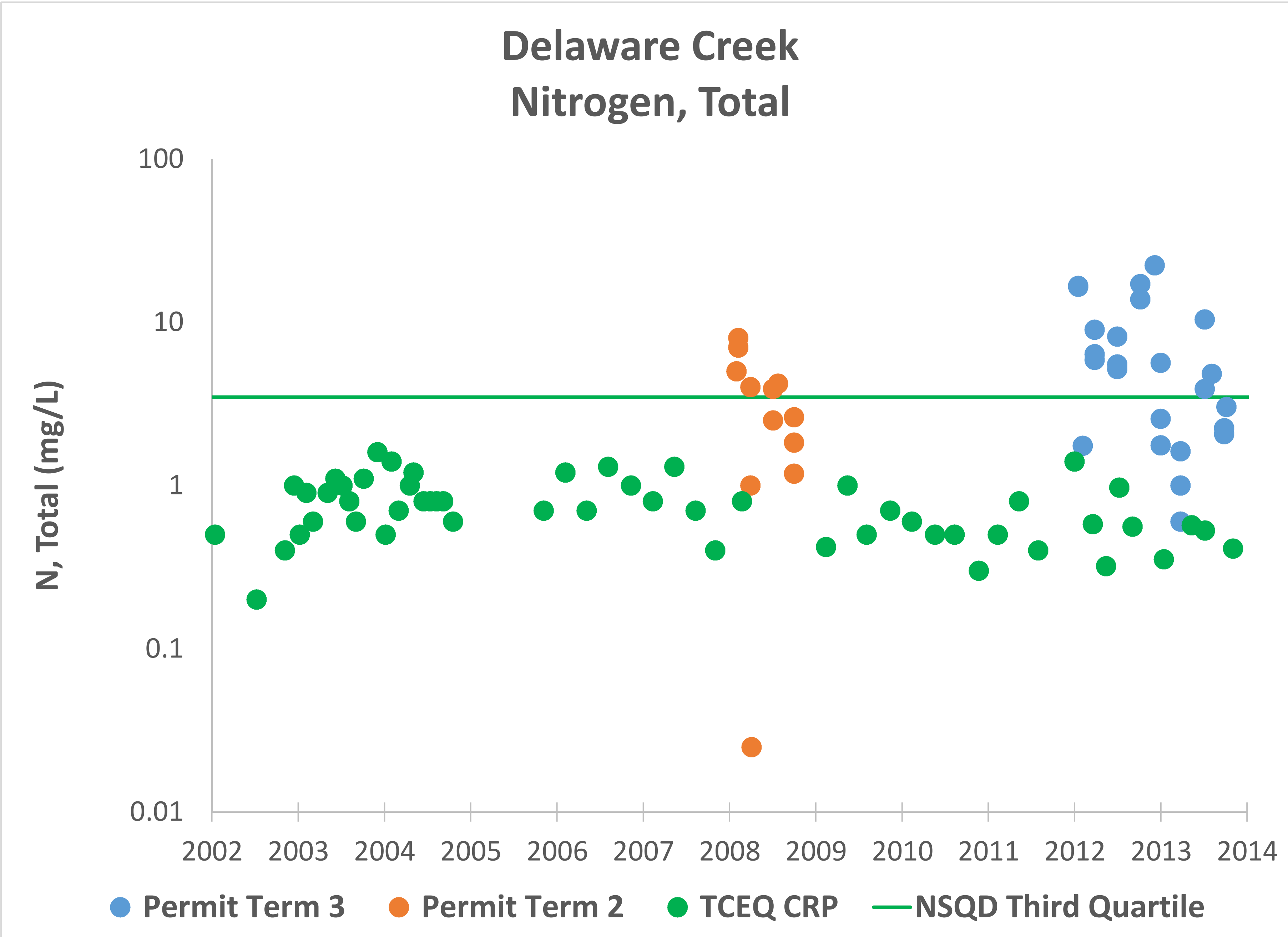
Delaware Creek Water Quality Data Graphs


Delaware Creek
Total Dissolved Solids
TDS (mg/L)
900
800
700
600
500
400
300
200
100
0
2008
2009
2010
2011
2012
2013
2014
Permit Term 3
Permit Term 2
Basin Specific Criterion

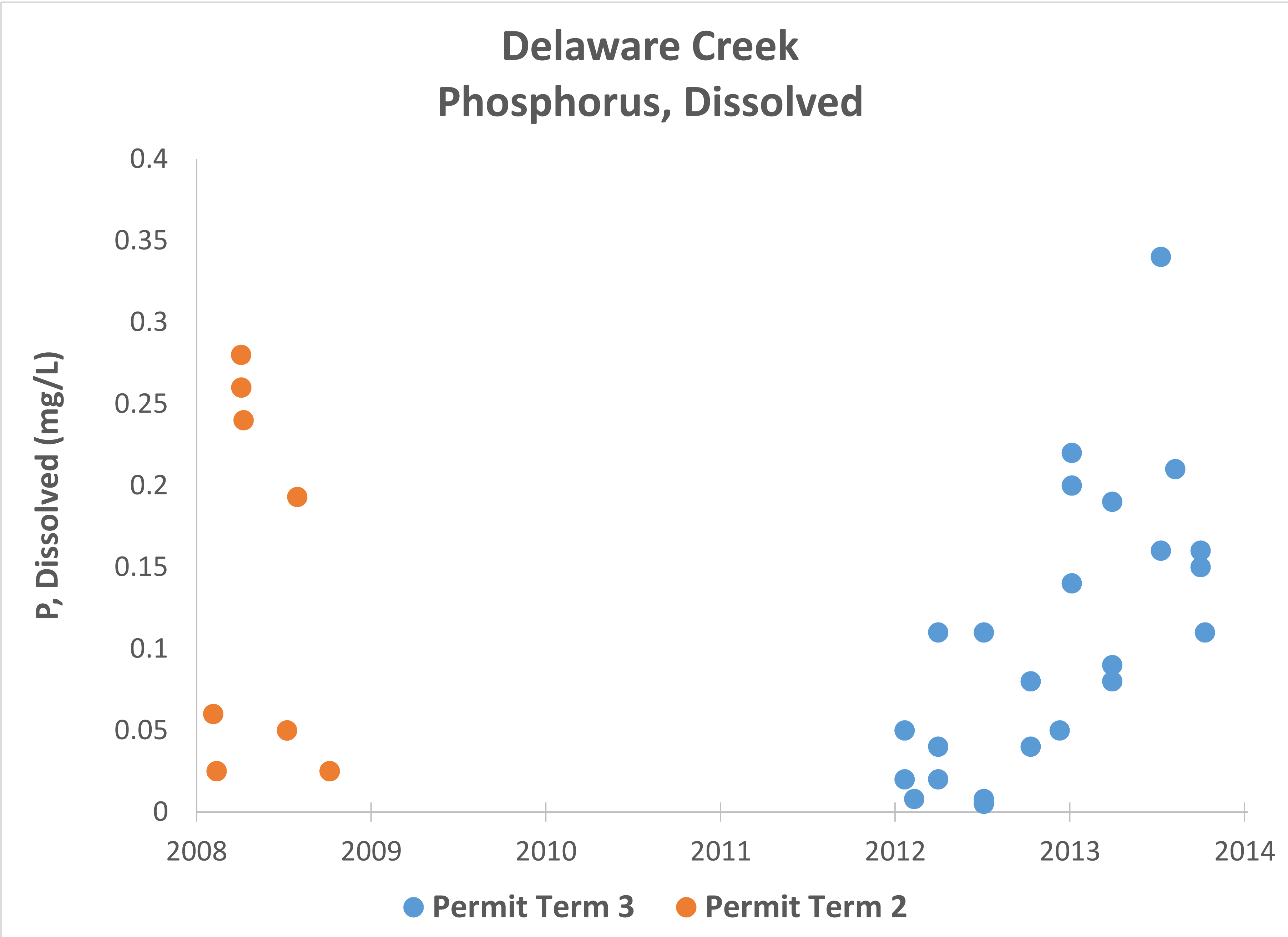

Delaware Creek
Total Suspended Solids
TSS (mg/L)
500
450
400
350
300
250
200
150
100
50
0
2008
2009
2010
2011
2012
2013
2014
Permit Term 3
Permit Term 2
NSQD Third Quartile

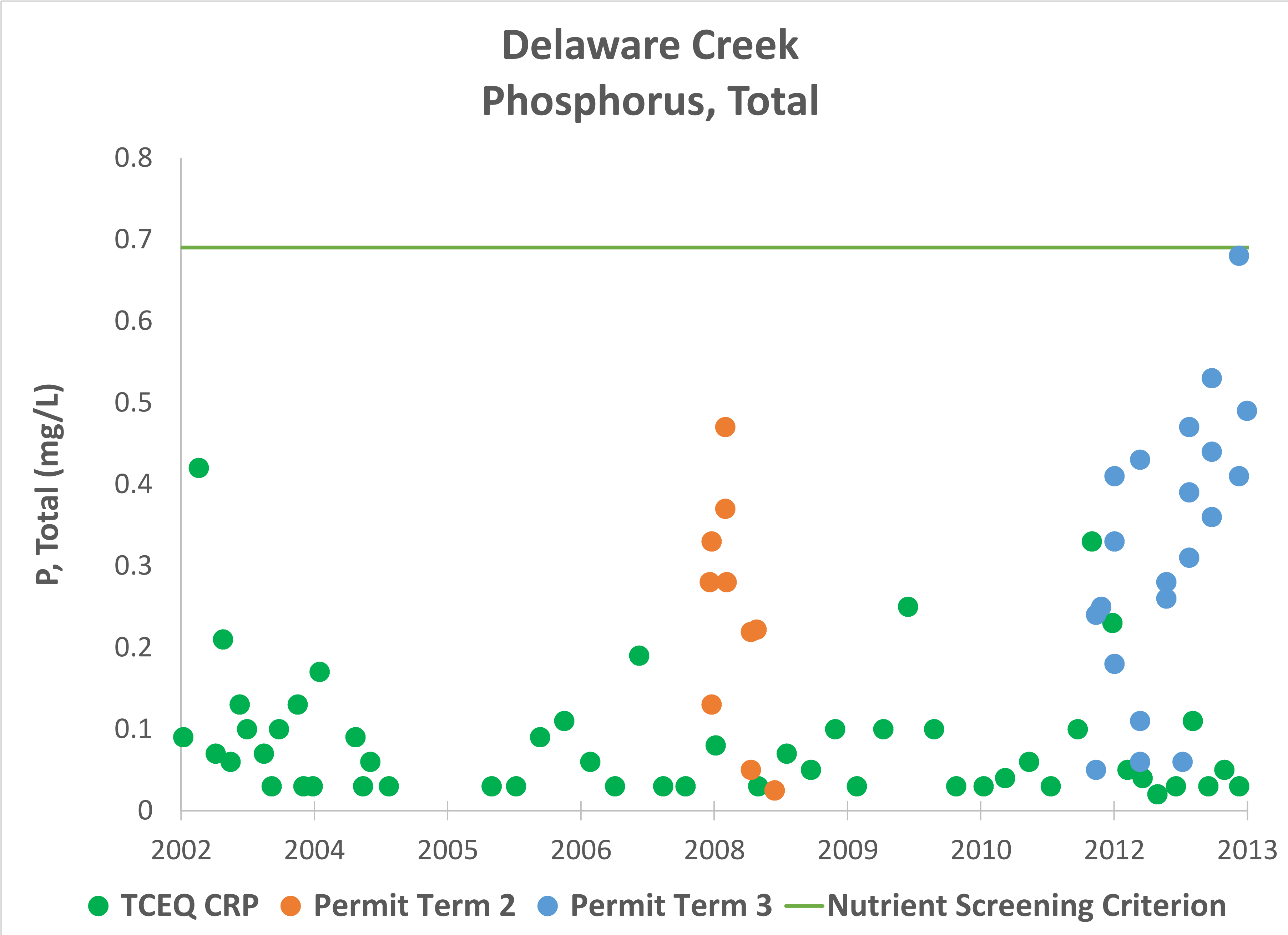

Delaware Creek
Chemical Oxygen Demand
COD (mg/L)
180
160
140
120
100
80
60
40
20
0
2002
2004
2005
2006
2008
2009
2010
2012
2013
Permit Term 3
Permit Term 2
TCEQ CRP
NSQD Third Quartile


Delaware Creek
Biochemical Oxygen Demand
BOD (mg/L)
80
70
60
50
40
30
20
10
0
2001
2003
2006
2009
2011
2014
Permit Term 3
Permit Term 2
TCEQ CRP
NSQD Third Quartile

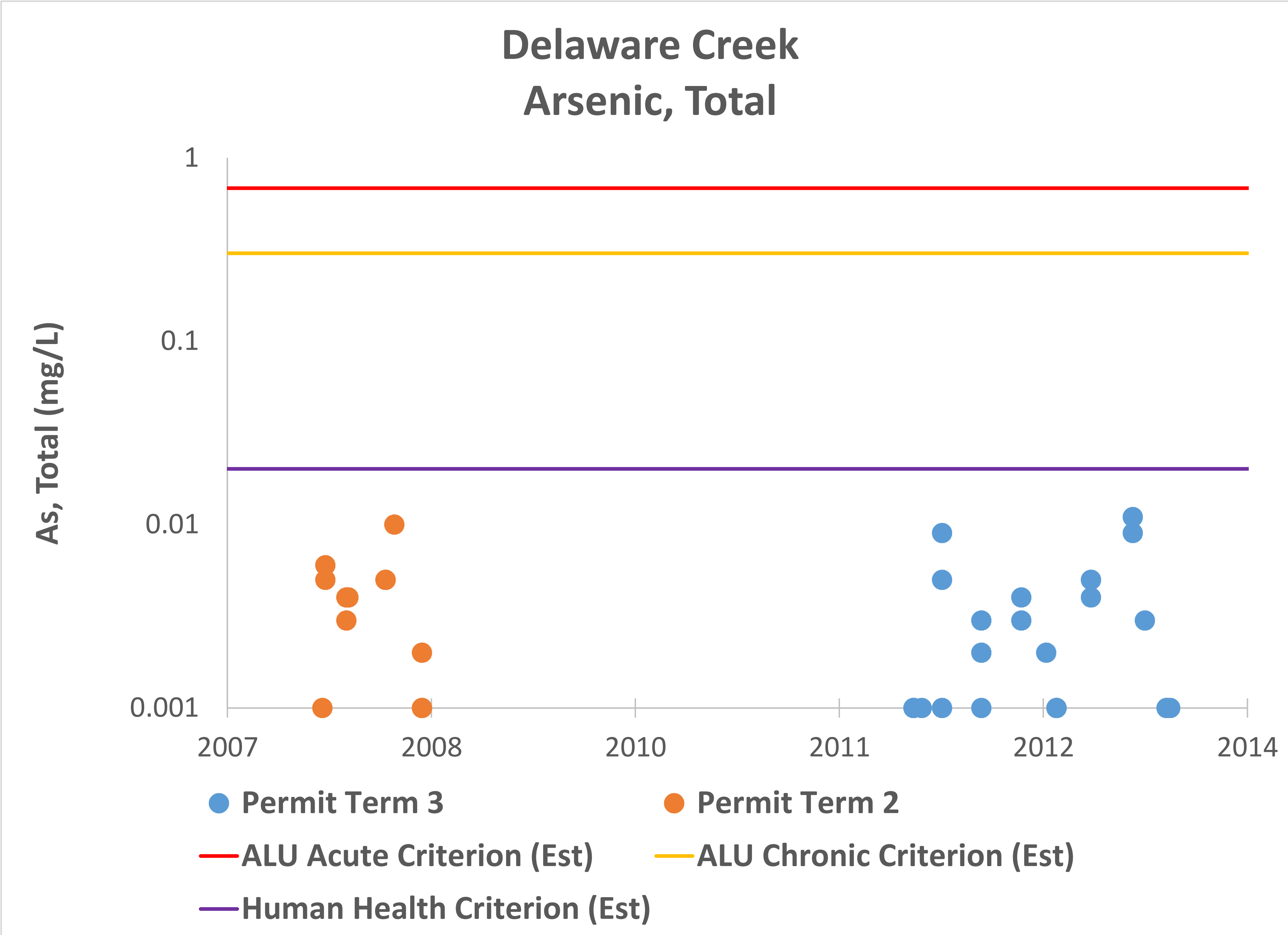


Delaware Creek
Nitrogen, Total
N, Total (mg/L)
100
10
1
0.1
0.01
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
Permit Term 3
Permit Term 2
TCEQ CRP
NSQD Third Quartile

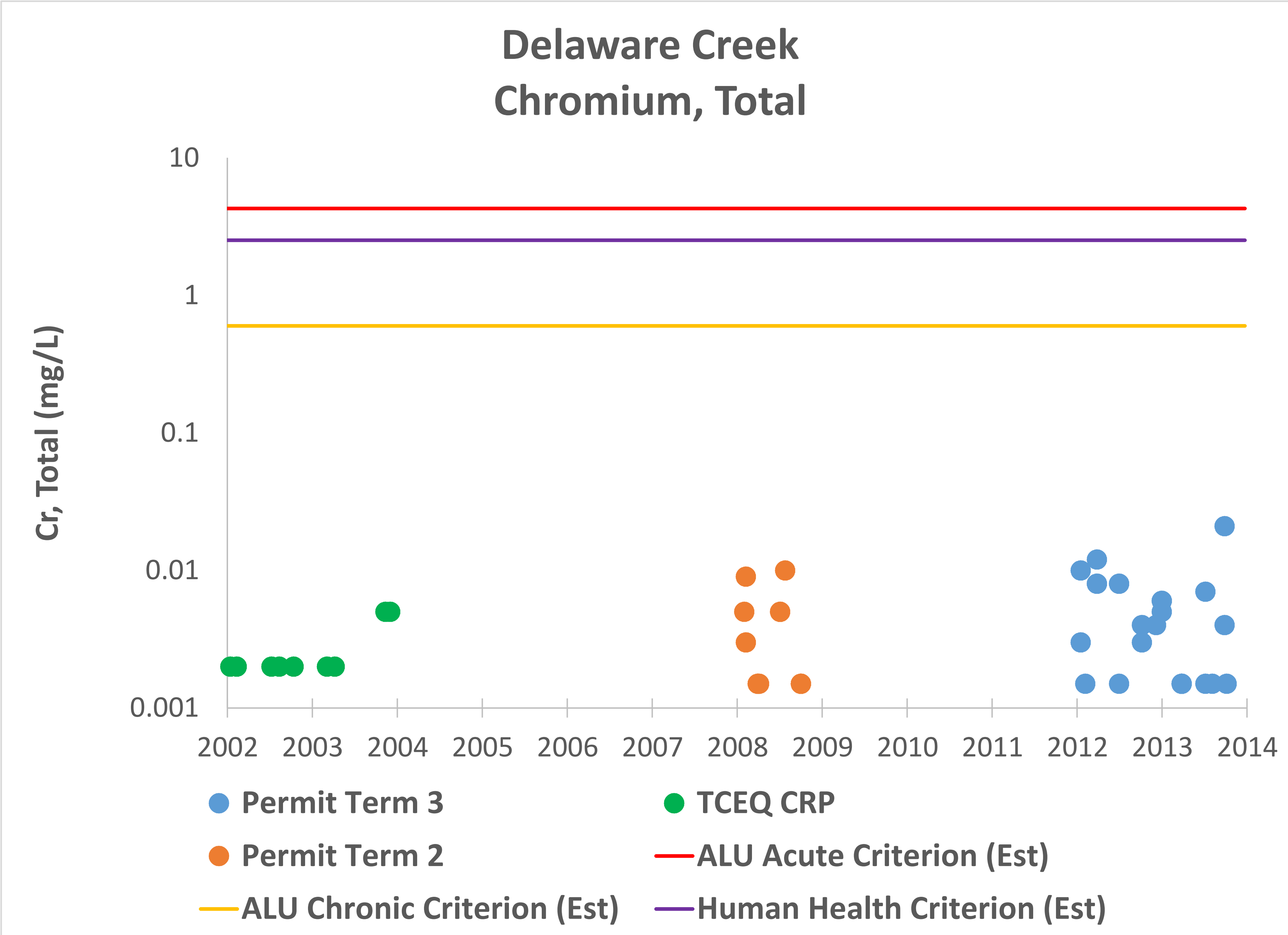

Delaware Creek
Phosphorus, Dissolved
P, Dissolved (mg/L)
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
2008
2009
2010
2011
2012
2013
2014
Permit Term 3
Permit Term 2



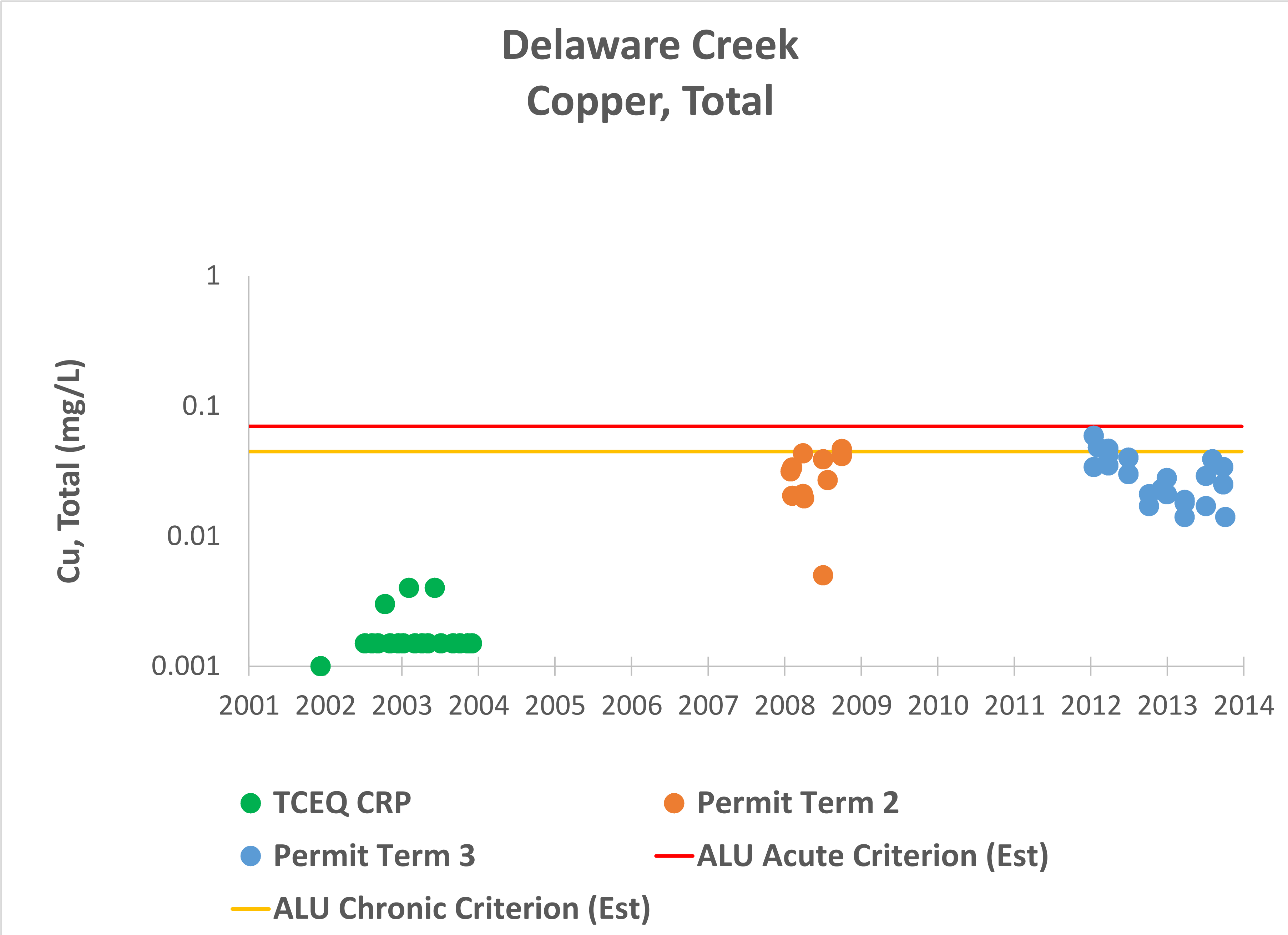
Delaware Creek
Phosphorus, Total
P, Total (mg/L)
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
2002
2004
2005
2006
2008
2009
2010
2012
2013
TCEQ CRP
Permit Term 2
Permit Term 3
Nutrient Screening Criterion

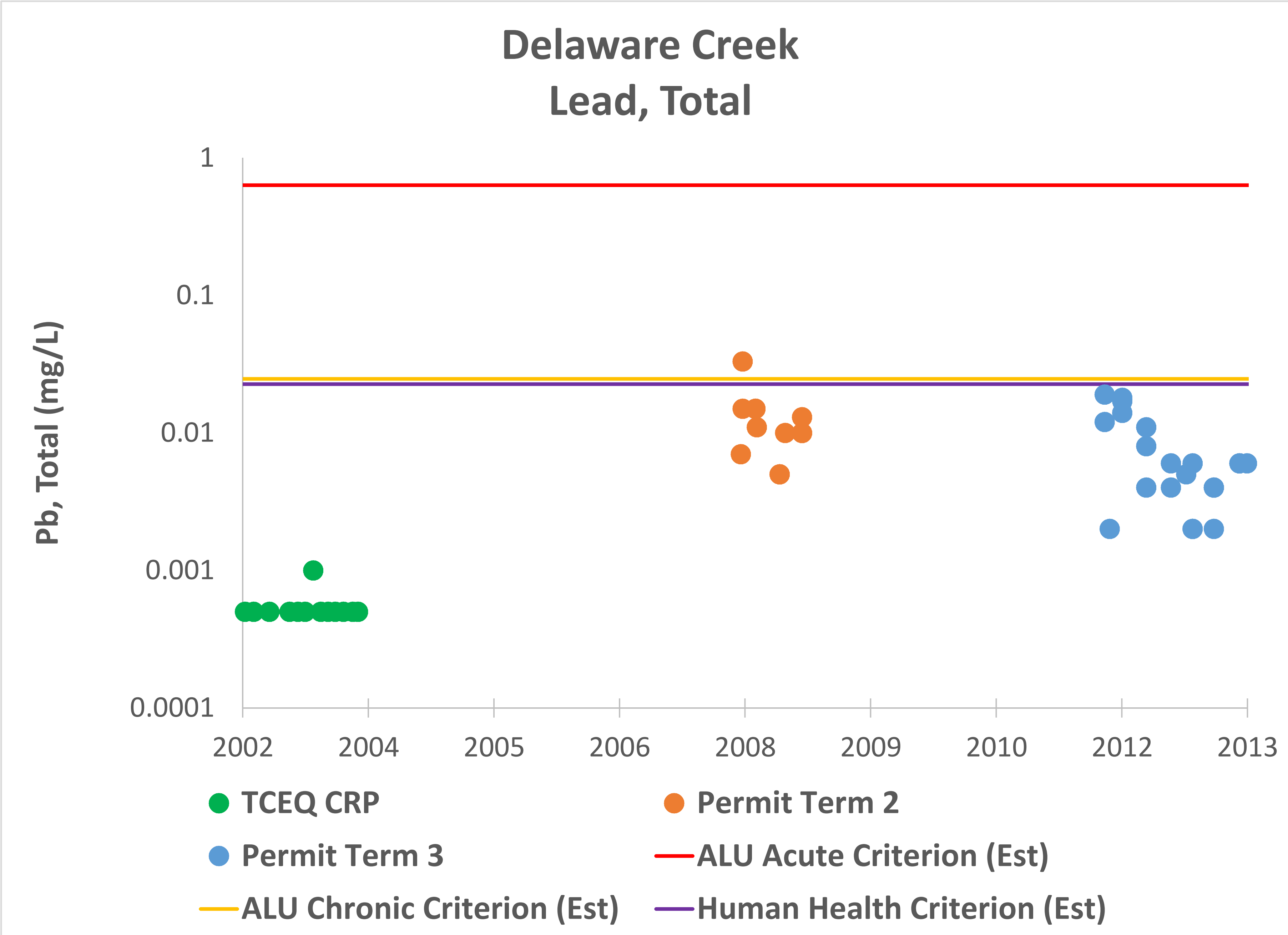


Delaware Creek
Arsenic, Total
As, Total (mg/L)
1
0.1
0.01
0.001
2007
2008
2010
2011
2012
2014
Permit Term 3
Permit Term 2
ALU Acute Criterion (Est)
ALU Chronic Criterion (Est)
Human Health Criterion (Est)

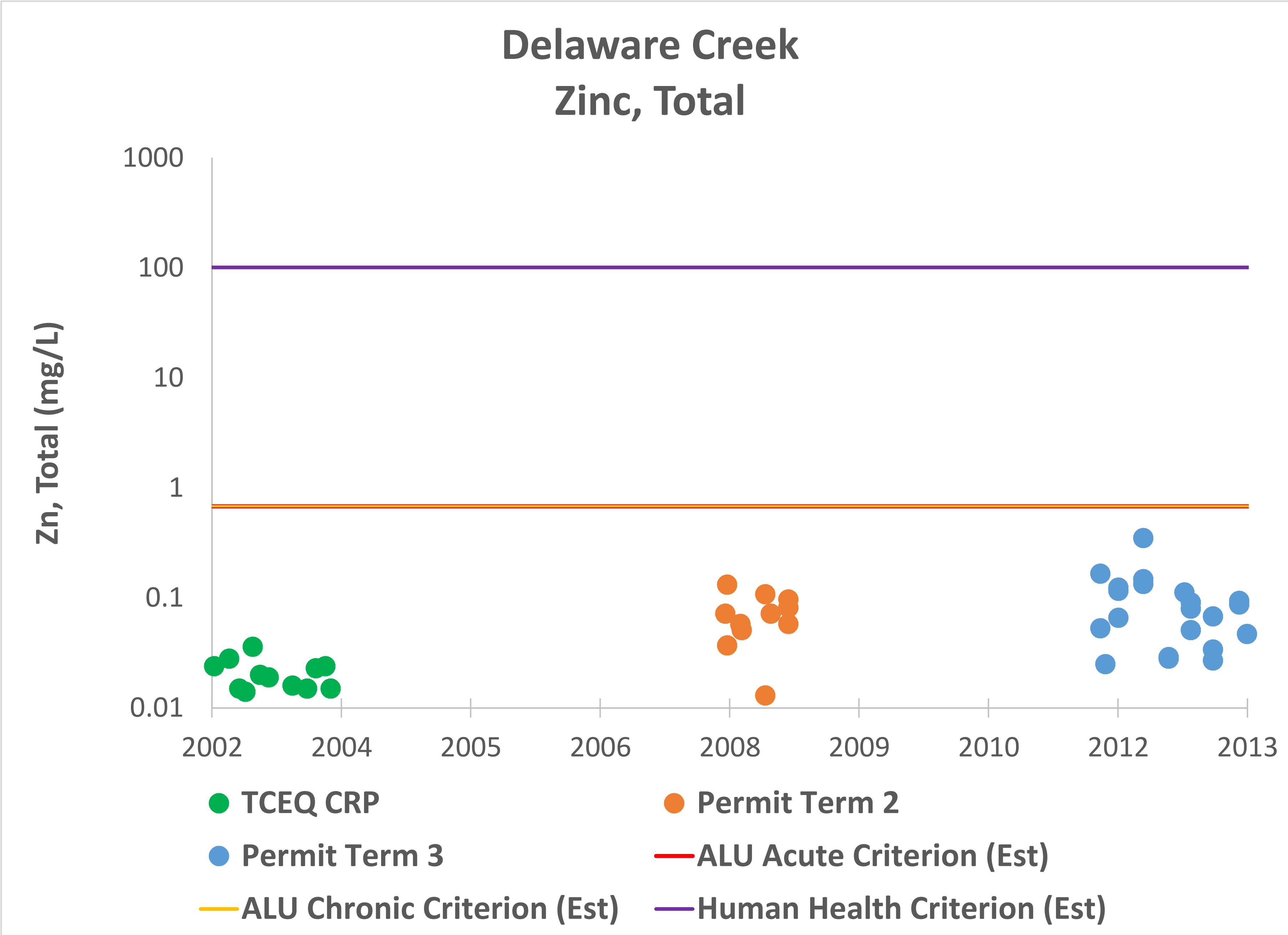


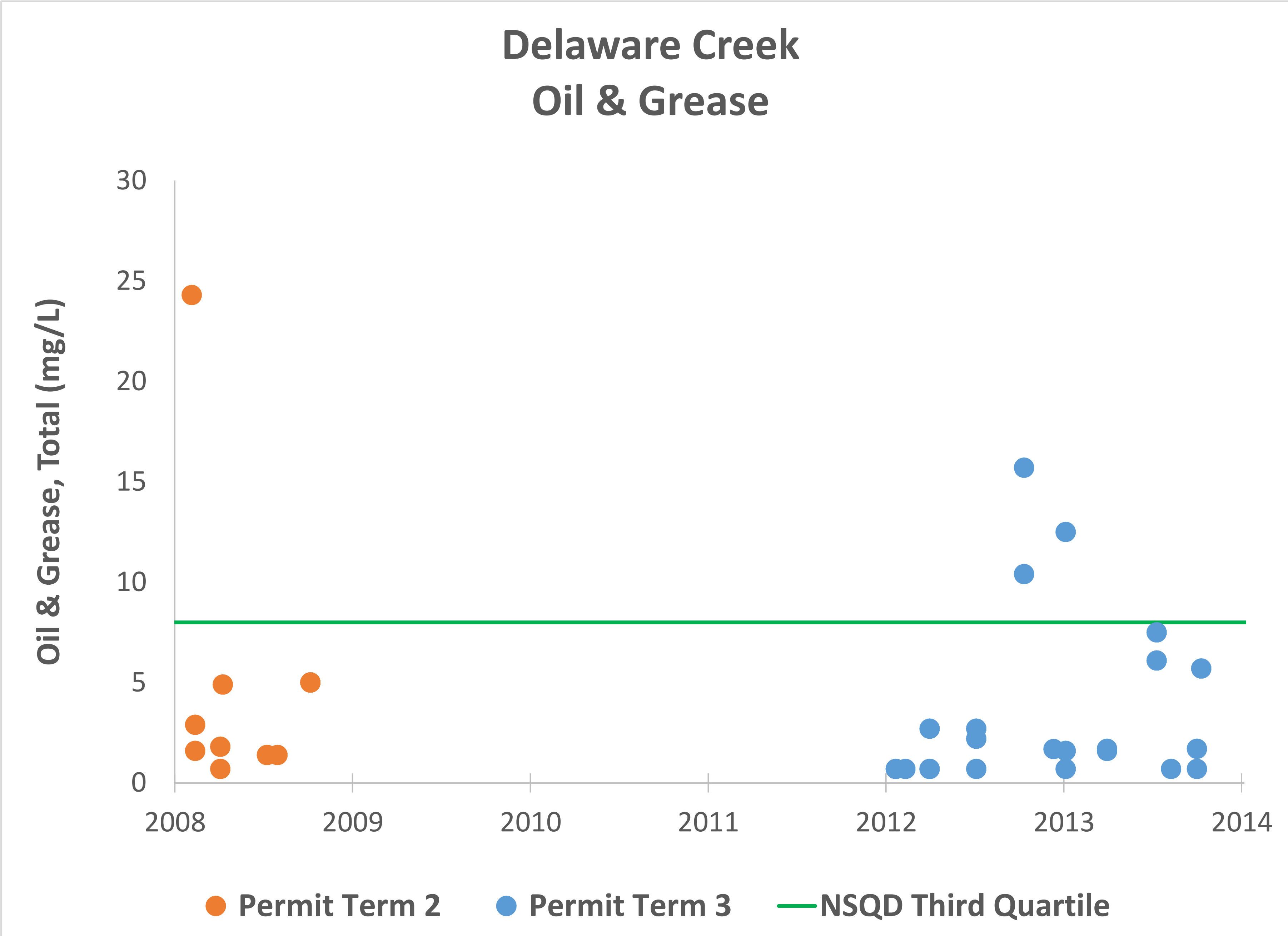
Delaware Creek
Chromium, Total
Cr, Total (mg/L)
10
1
0.1
0.01
0.001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
Permit Term 3
TCEQ CRP
Permit Term 2
ALU Acute Criterion (Est)
ALU Chronic Criterion (Est)
Human Health Criterion (Est)


Delaware Creek
Copper, Total
Cu, Total (mg/L)
1
0.1
0.01
0.001
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
TCEQ CRP
Permit Term 2
Permit Term 3
ALU Acute Criterion (Est)
ALU Chronic Criterion (Est)

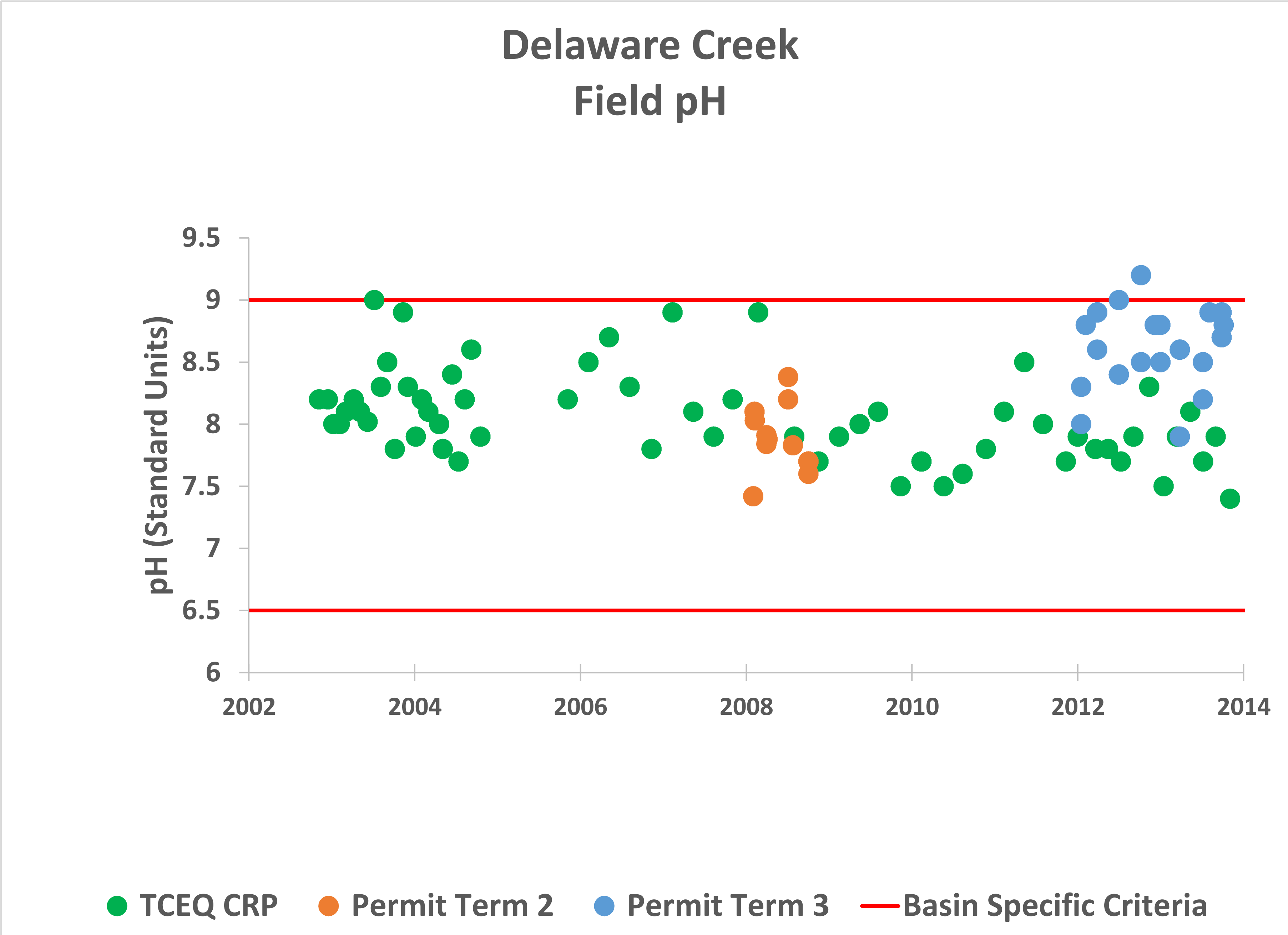


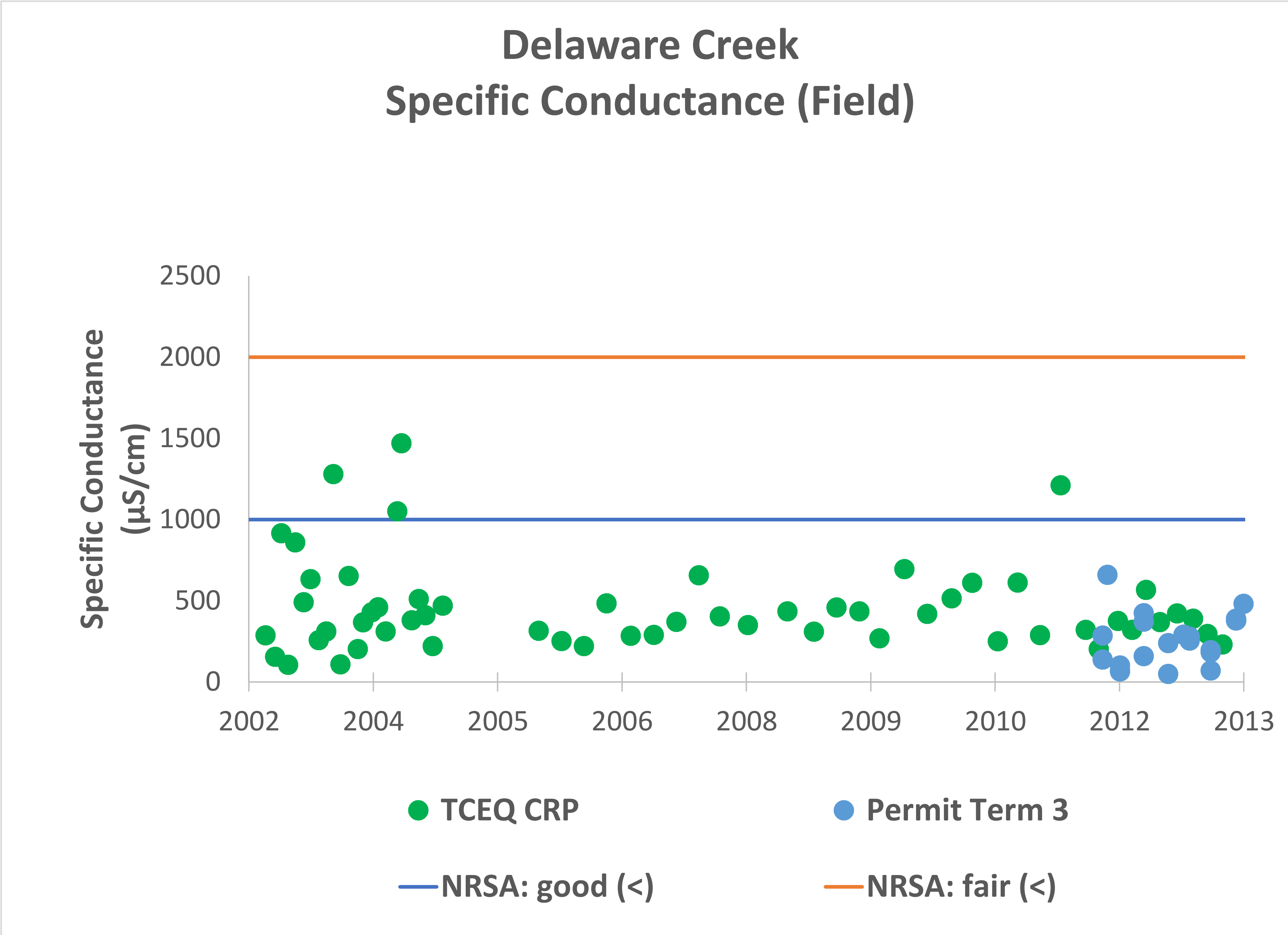
Delaware Creek
Lead, Total
Pb, Total (mg/L)
1
0.1
0.01
0.001
0.0001
2002
2004
2005
2006
2008
2009
2010
2012
2013
TCEQ CRP
Permit Term 2
Permit Term 3
ALU Acute Criterion (Est)
ALU Chronic Criterion (Est)
Human Health Criterion (Est)


Delaware Creek
Zinc, Total
Zn, Total (mg/L)
1000
100
10
1
0.1
0.01
2002
2004
2005
2006
2008
2009
2010
2012
2013
TCEQ CRP
Permit Term 2
Permit Term 3
ALU Acute Criterion (Est)
ALU Chronic Criterion (Est)
Human Health Criterion (Est)

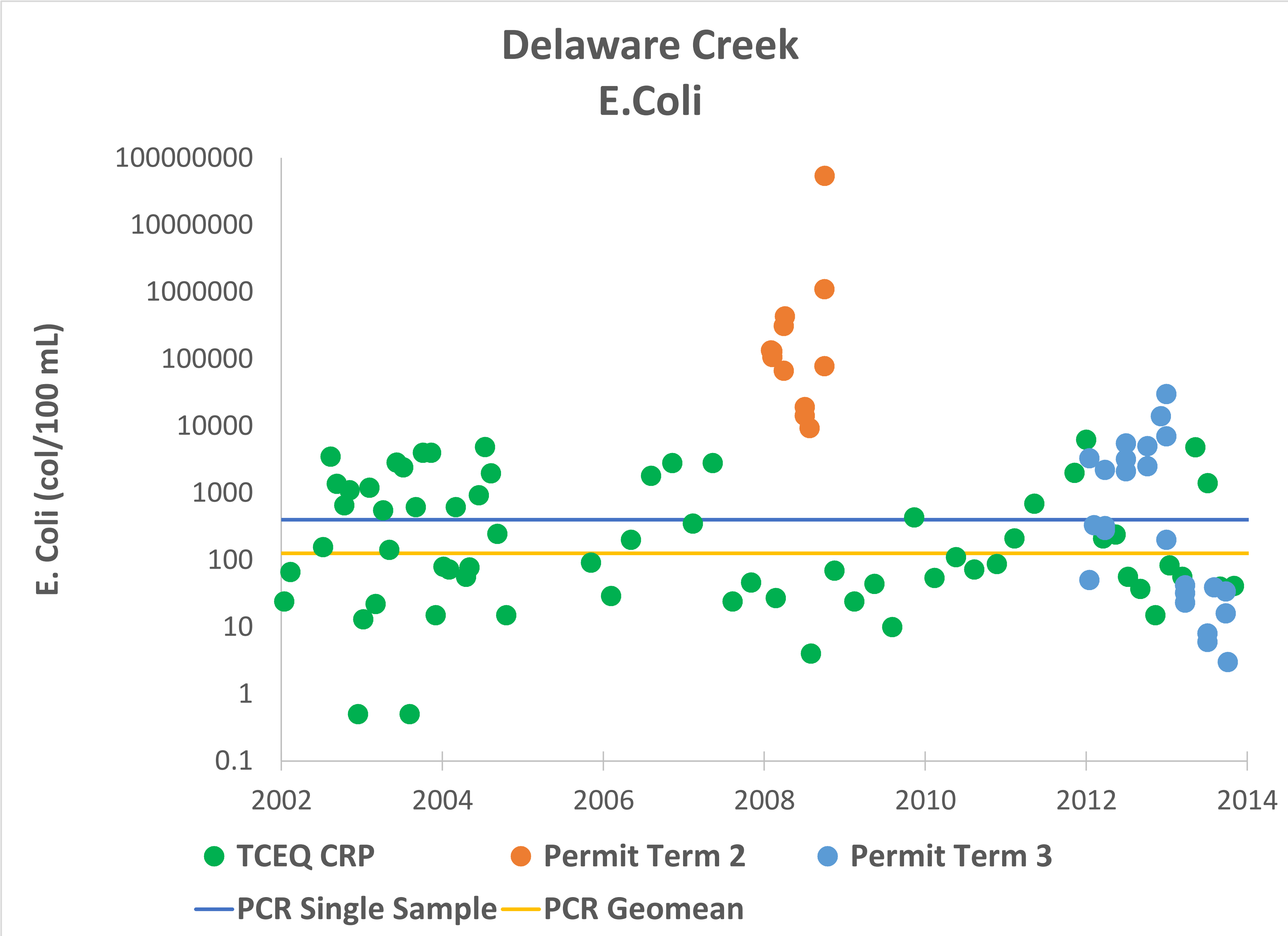


Delaware Creek
Oil & Grease
Oil & Grease, Total (mg/L)
30
25
20
15
10
5
0
2008
2009
2010
2011
2012
2013
2014
Permit Term 2
Permit Term 3
NSQD Third Quartile

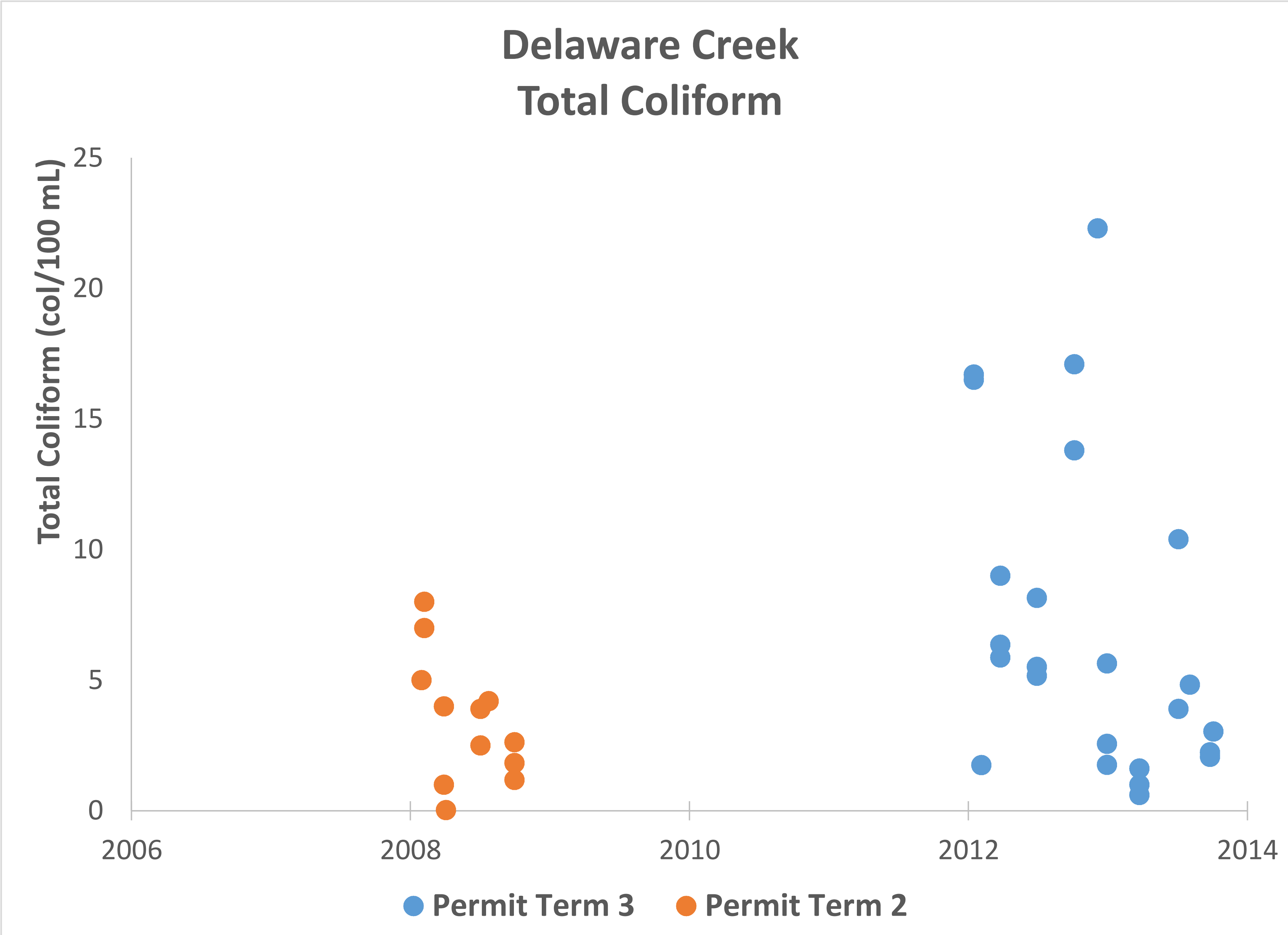

Delaware Creek
Field pH
pH (Standard Units)
9.5
9
8.5
8
7.5
7
6.5
6
2002
2004
2006
2008
2010
2012
2014
TCEQ CRP
Permit Term 2
Permit Term 3
Basin Specific Criteria

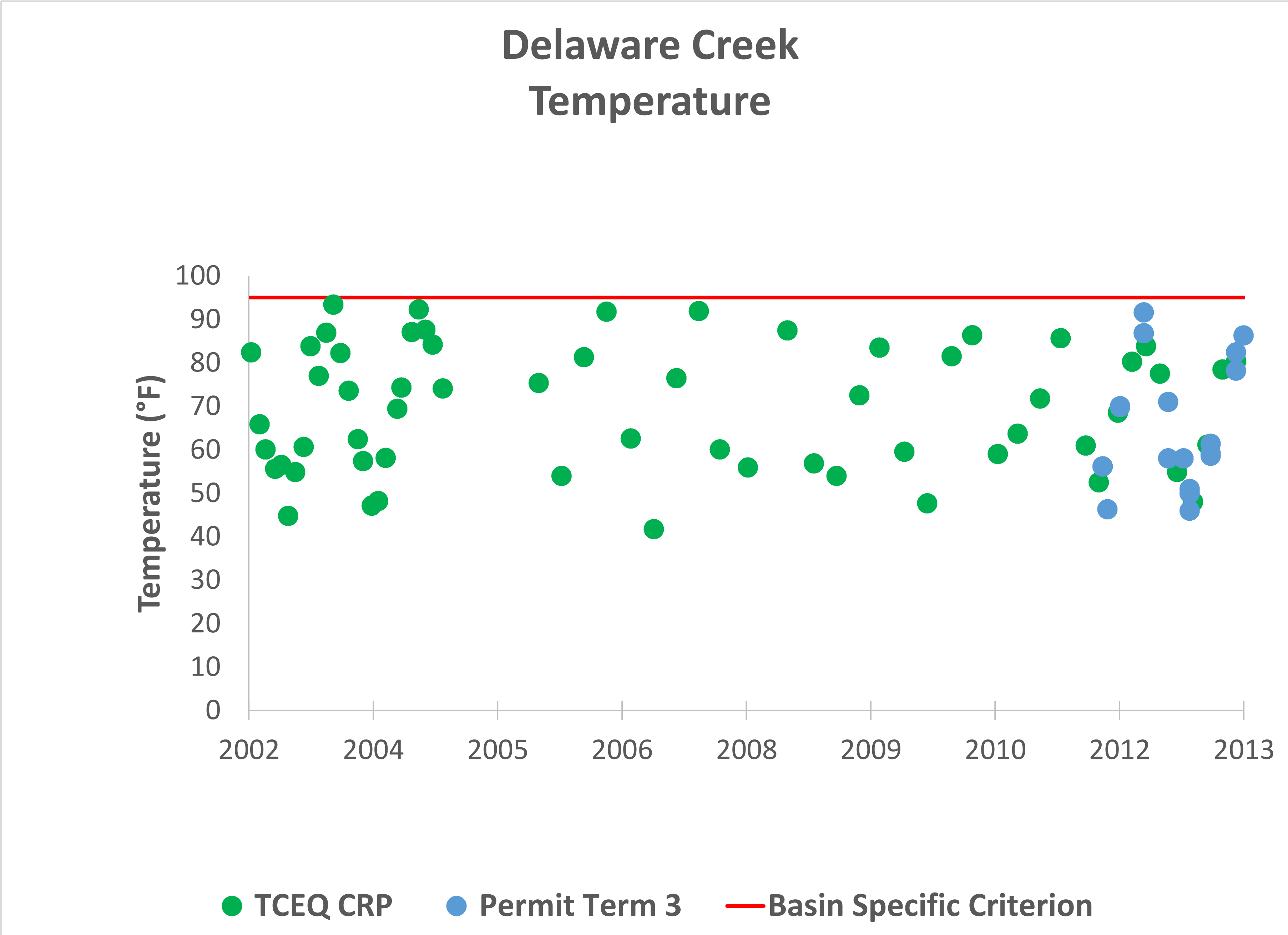


Delaware Creek
Specific Conductance (Field)
Specific Conductance (µS/cm)
2500
2000
1500
1000
500
0
2002
2004
2005
2006
2008
2009
2010
2012
2013
TCEQ CRP
Permit Term 3
NRSA: good (<)
NRSA: fair (<)

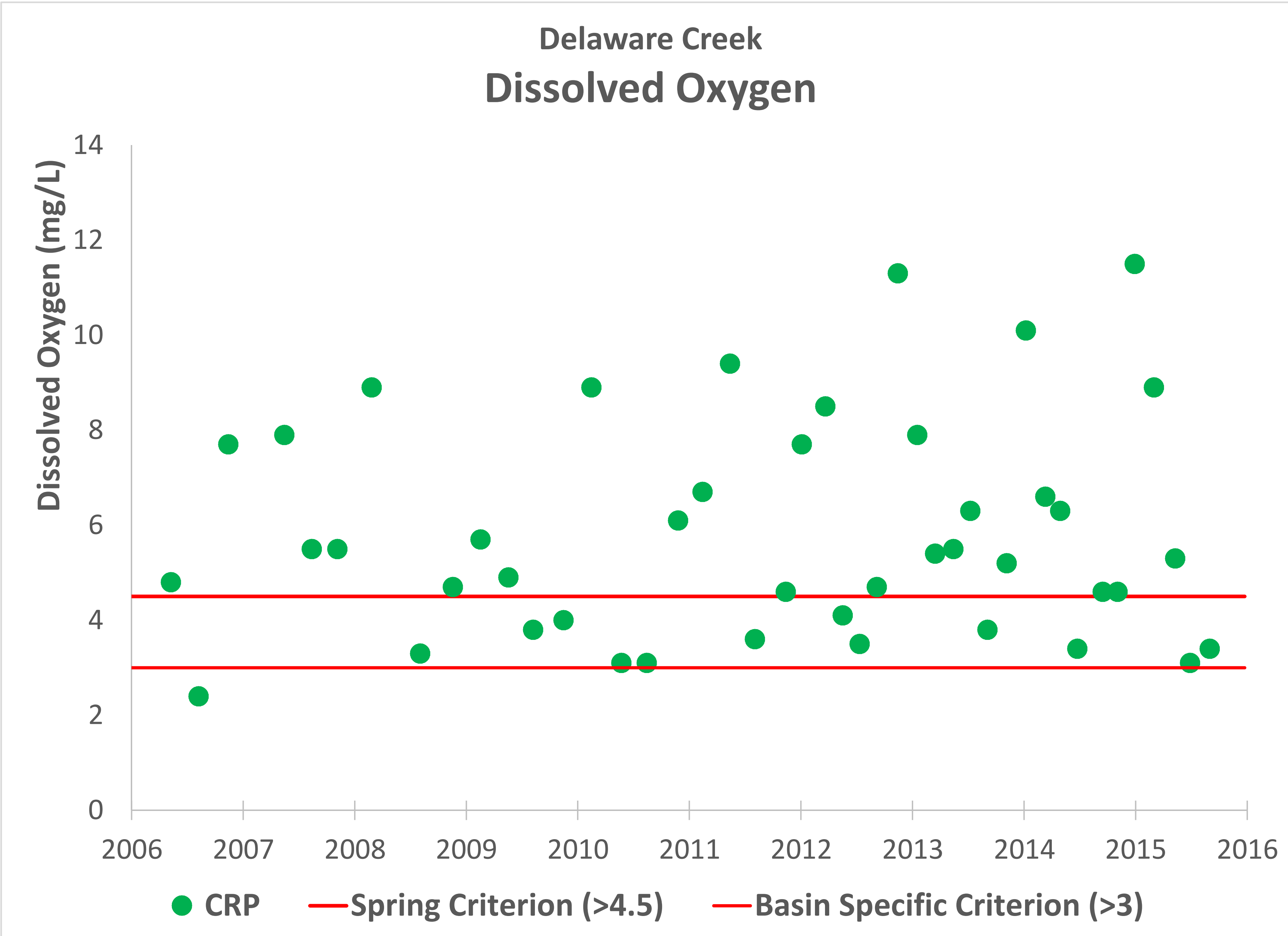


Delaware Creek
E.Coli
E. Coli (col/100 mL)
100000000
10000000
1000000
100000
10000
1000
100
10
1
0.1
2002
2004
2006
2008
2010
2012
2014
TCEQ CRP
Permit Term 2
Permit Term 3
PCR Single Sample
PCR Geomean


Delaware Creek
Total Coliform
Total Coliform (col/100 mL)
25
20
15
10
5
0
2006
2008
2010
2012
2014
Permit Term 3
Permit Term 2



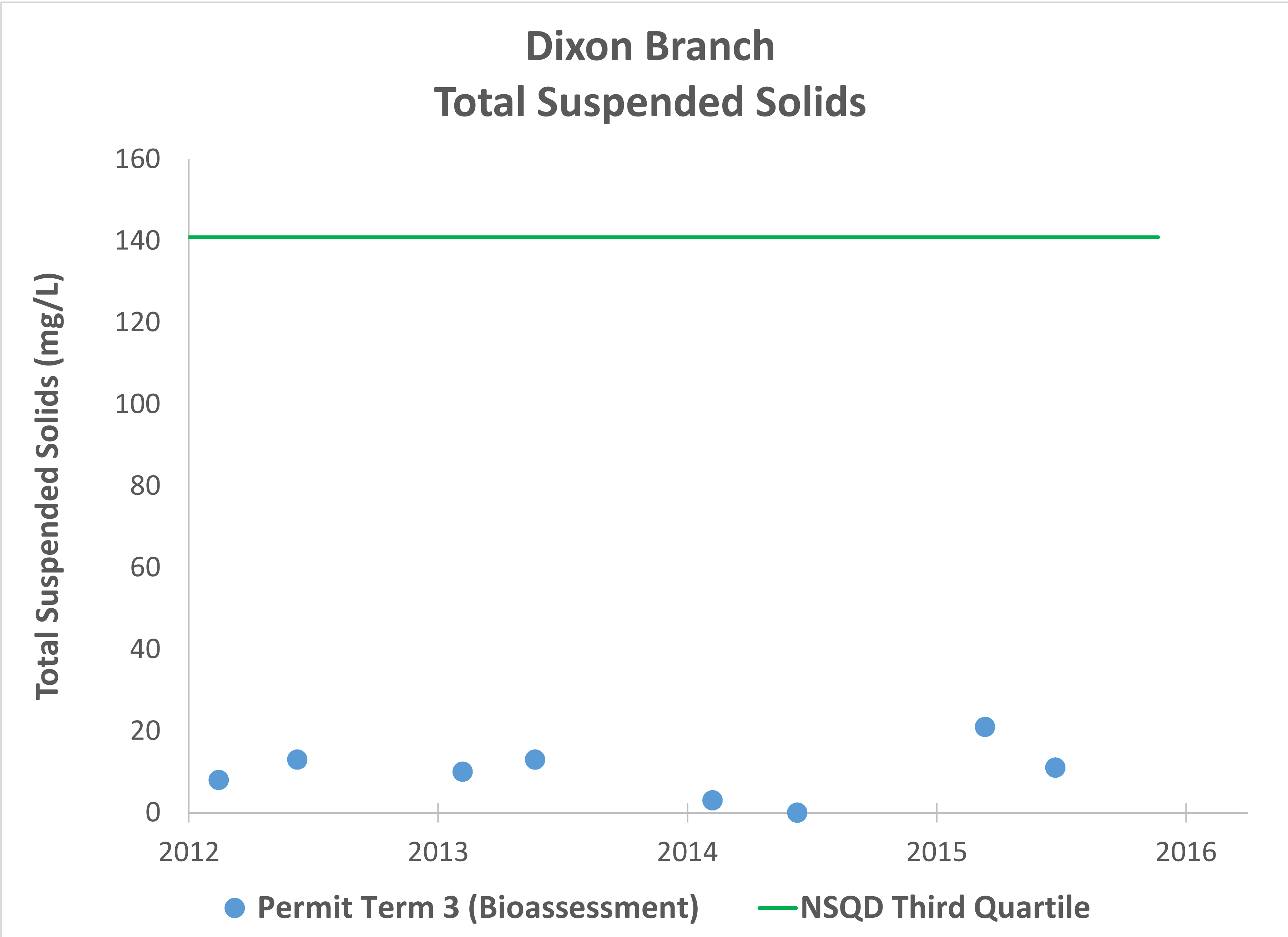
Delaware Creek
Temperature
Temperature (°F)
100
90
80
70
60
50
40
30
20
10
0
2002
2004
2005
2006
2008
2009
2010
2012
2013
TCEQ CRP
Permit Term 3
Basin Specific Criterion



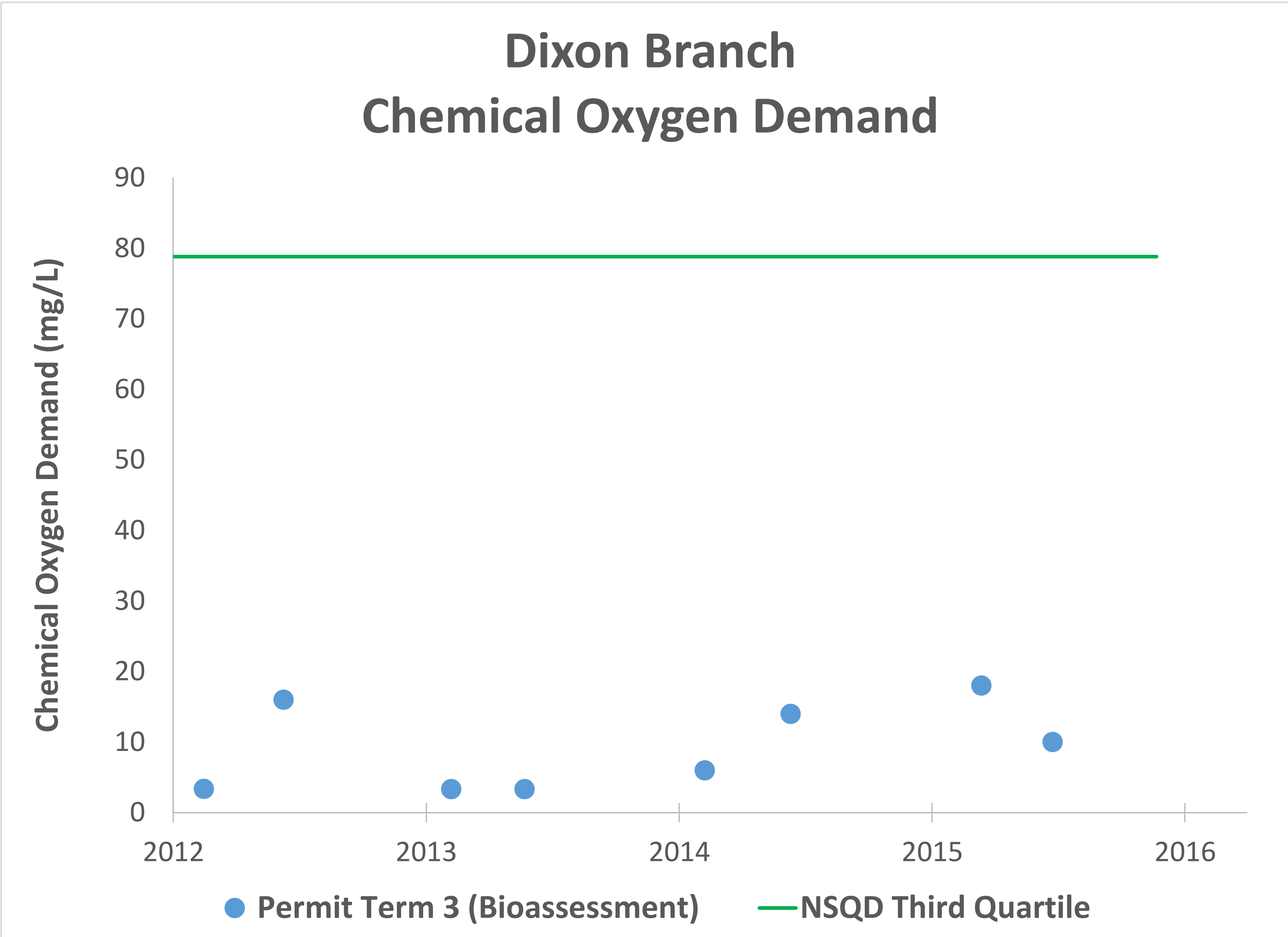
Delaware Creek
Dissolved Oxygen
Dissolved Oxygen (mg/L)
0
2
4
6
8
10
12
14
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
CRP
Spring Criterion (>4.5)
Basin Specific Criterion (>3)

Appendix H

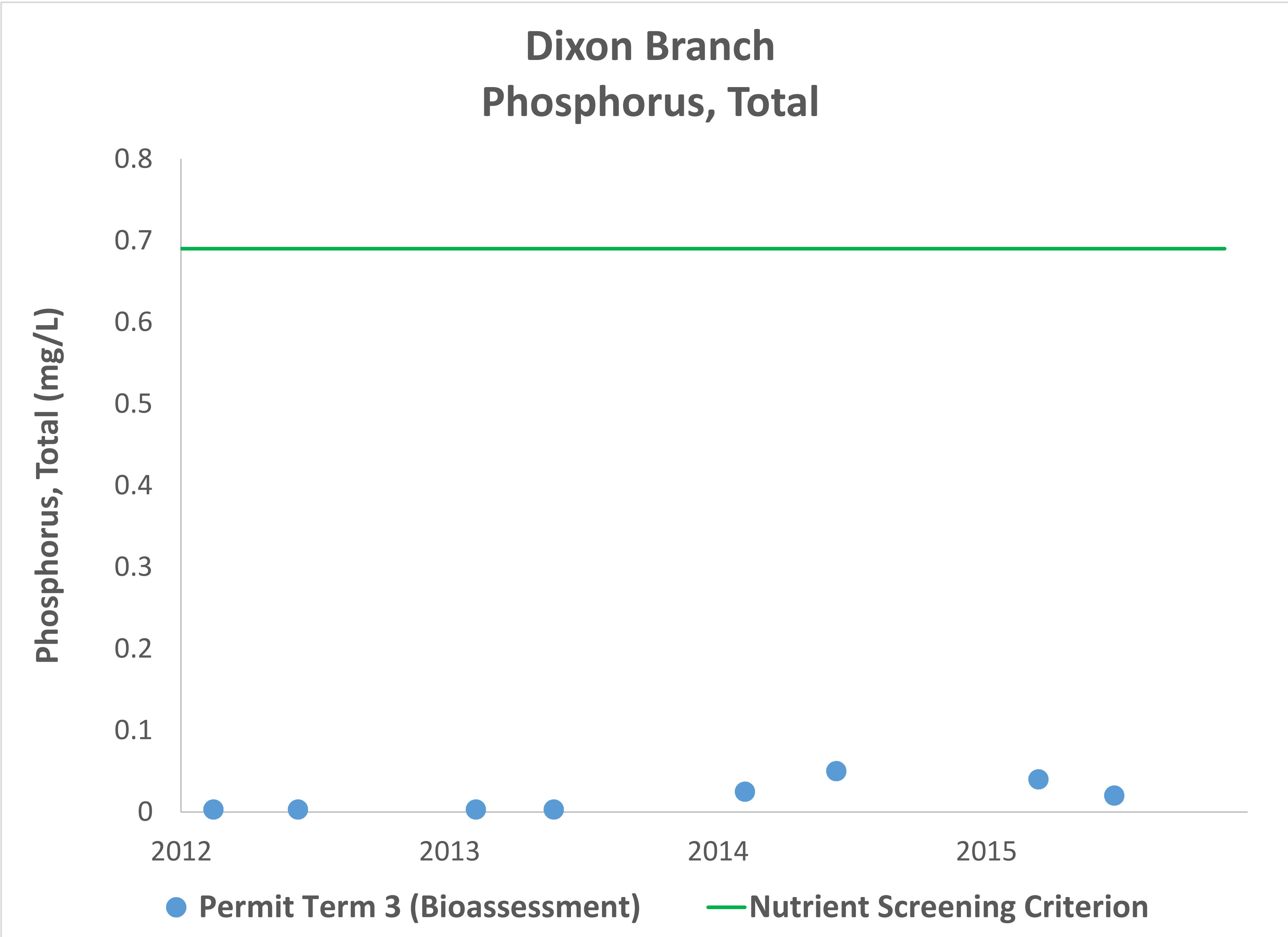
Dixon Branch Water Quality Data Graphs

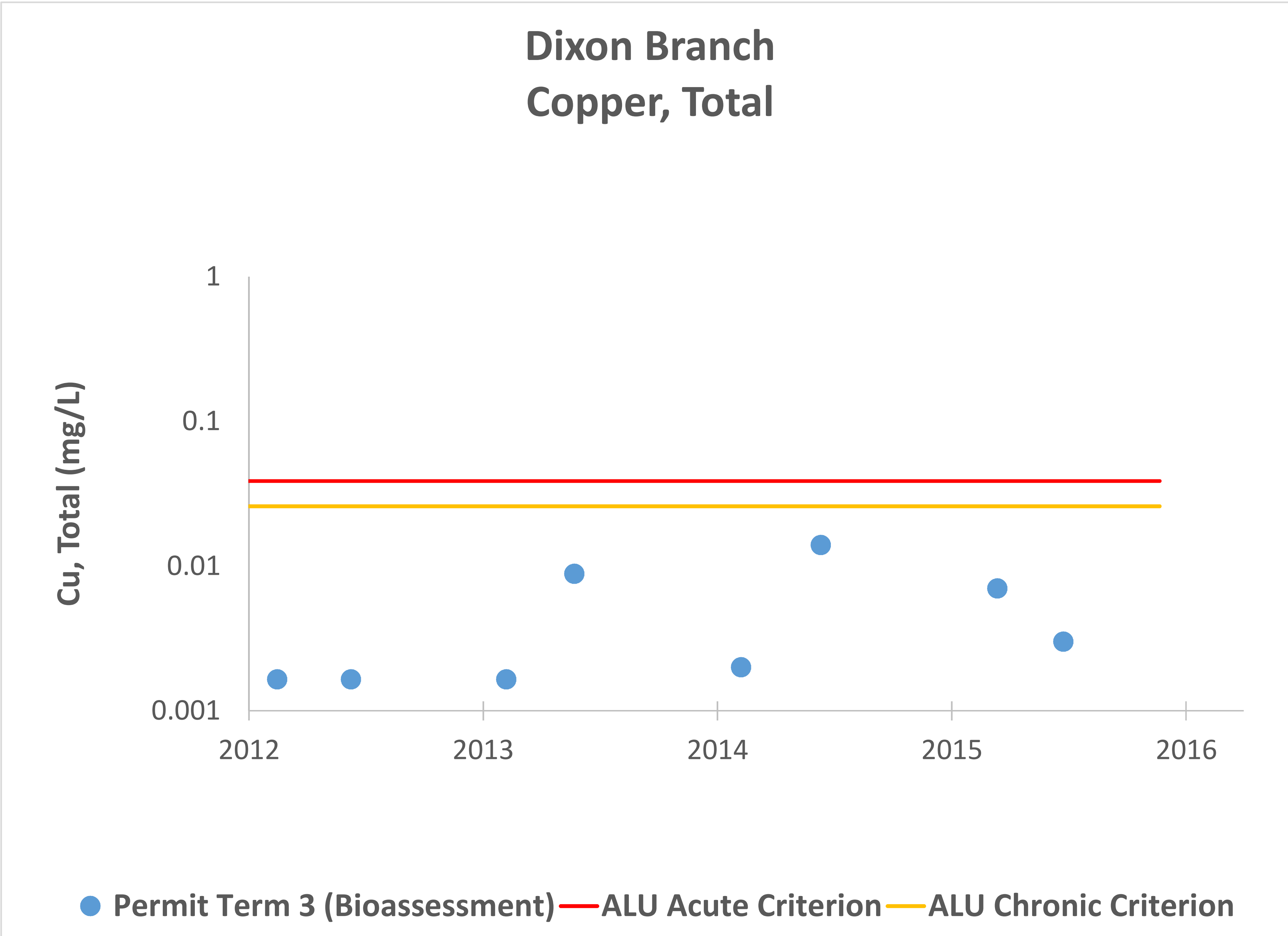


Dixon Branch
Total Suspended Solids
Total Suspended Solids (mg/L)
160
140
120
100
80
60
40
20
0
2012
2013
2014
2015
2016
Permit Term 3 (Bioassessment)
NSQD Third Quartile

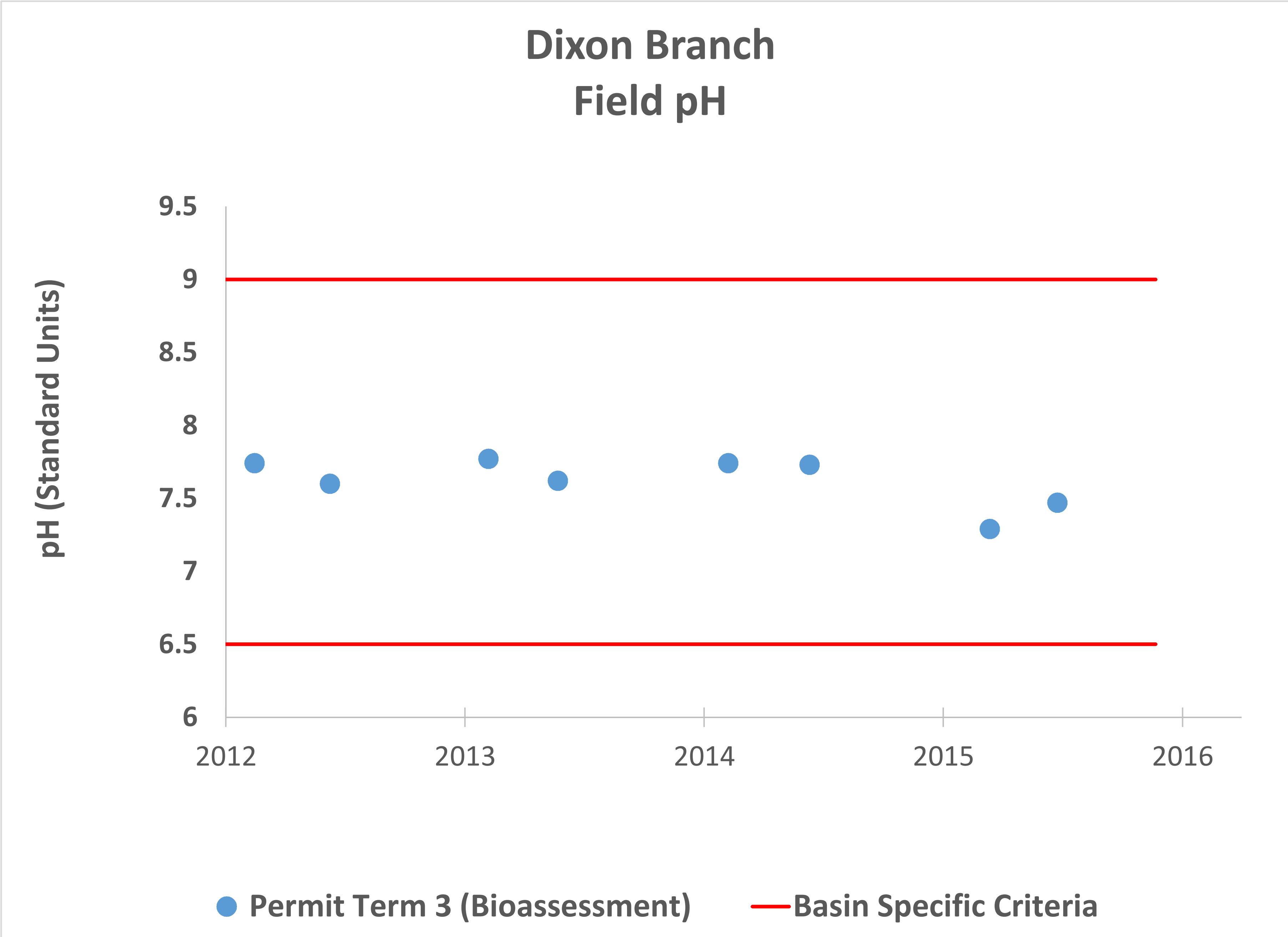


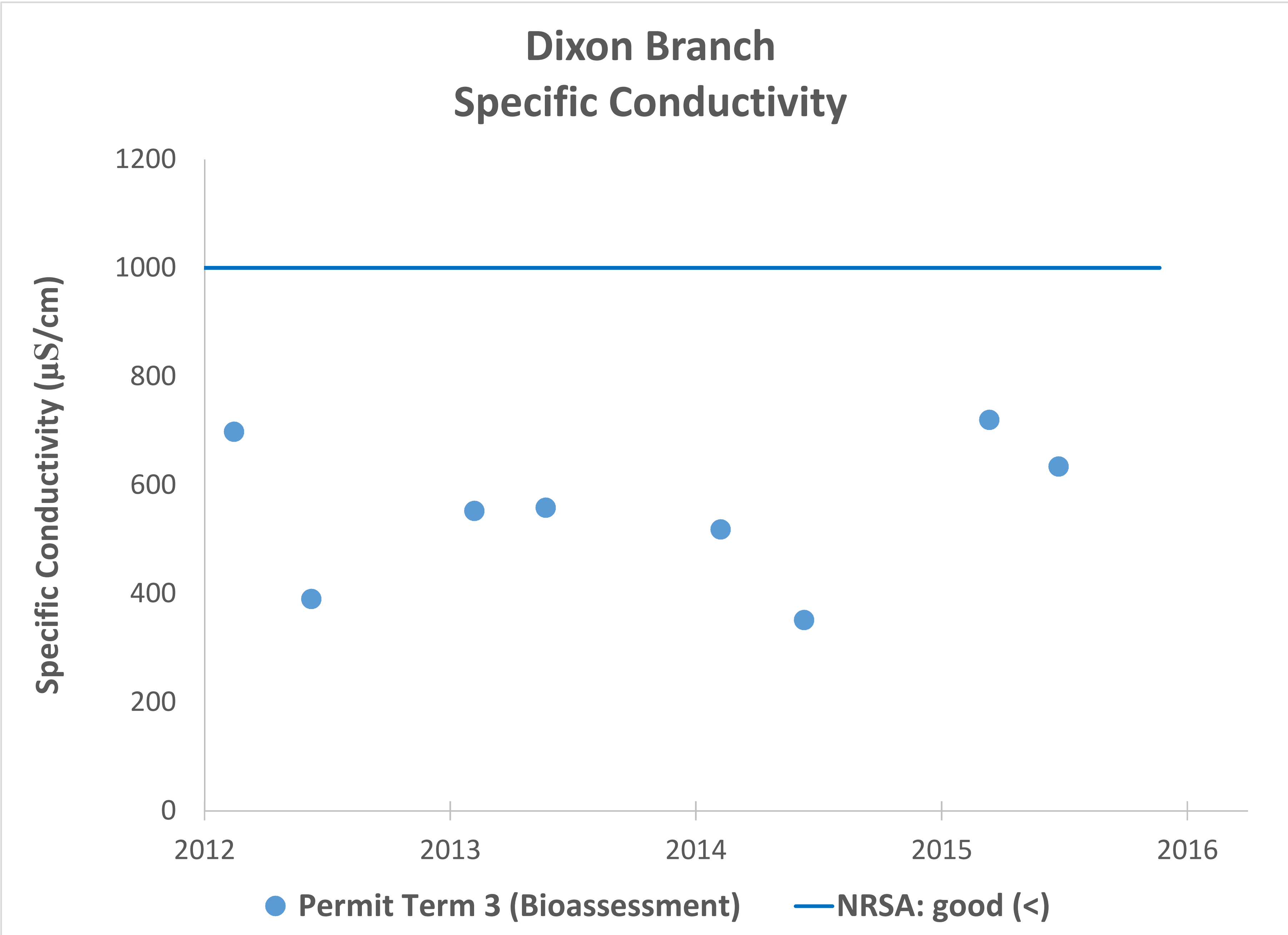
Dixon Branch
Chemical Oxygen Demand
Chemical Oxygen Demand (mg/L)
0
10
20
30
40
50
60
70
80
90
2012
2013
2014
2015
2016
Permit Term 3 (Bioassessment)
NSQD Third Quartile

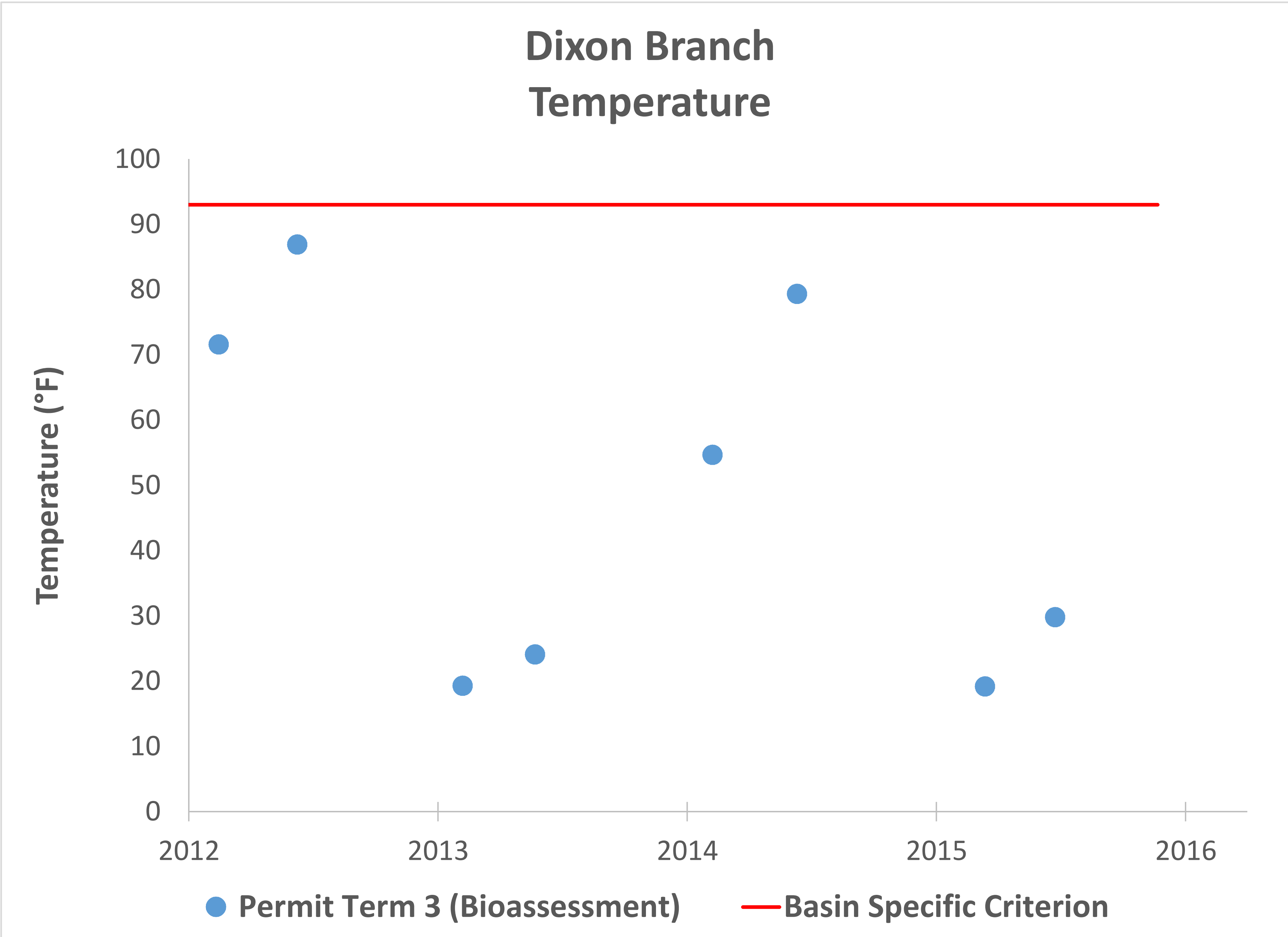

Dixon Branch
Phosphorus, Total
Phosphorus, Total (mg/L)
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
2012
2013
2014
2015
Permit Term 3 (Bioassessment)
Nutrient Screening Criterion

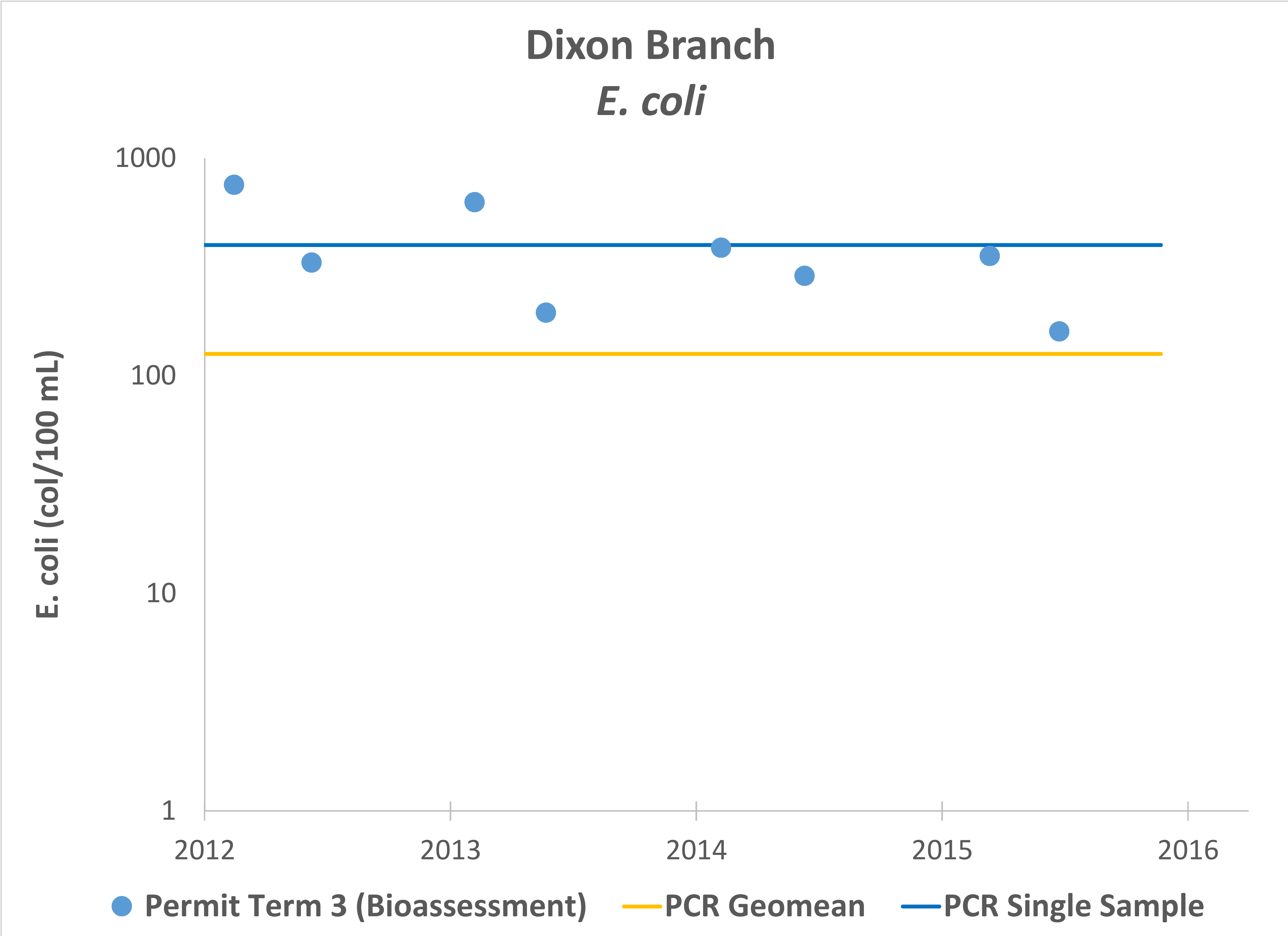


Dixon Branch
Copper, Total
Cu, Total (mg/L)
1
0.1
0.01
0.001
2012
2013
2014
2015
2016
Permit Term 3 (Bioassessment)
ALU Acute Criterion
ALU Chronic Criterion

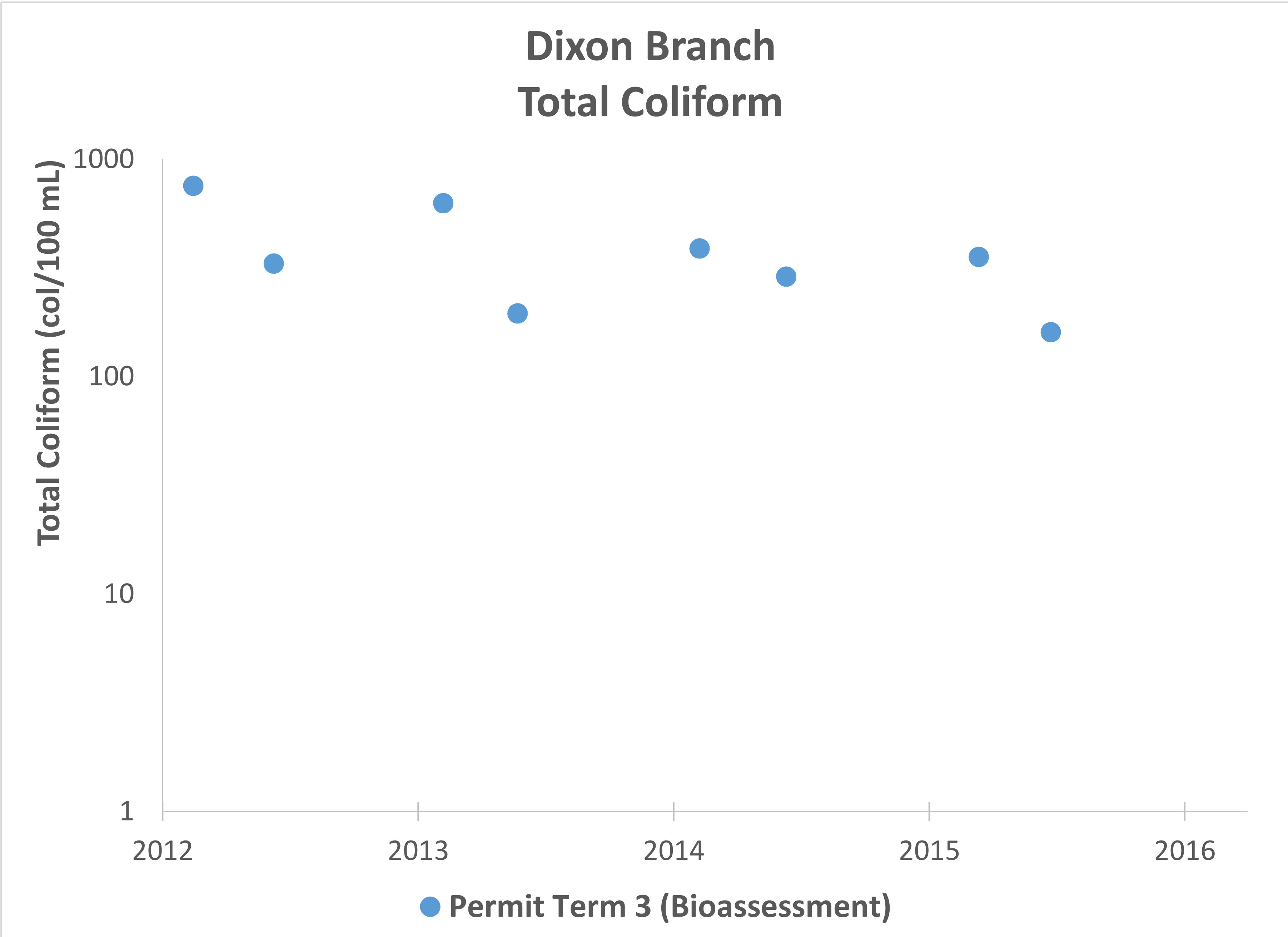

Dixon Branch
Field pH
pH (Standard Units)
9.5
9
8.5
8
7.5
7
6.5
6
2012
2013
2014
2015
2016
Permit Term 3 (Bioassessment)
Basin Specific Criteria

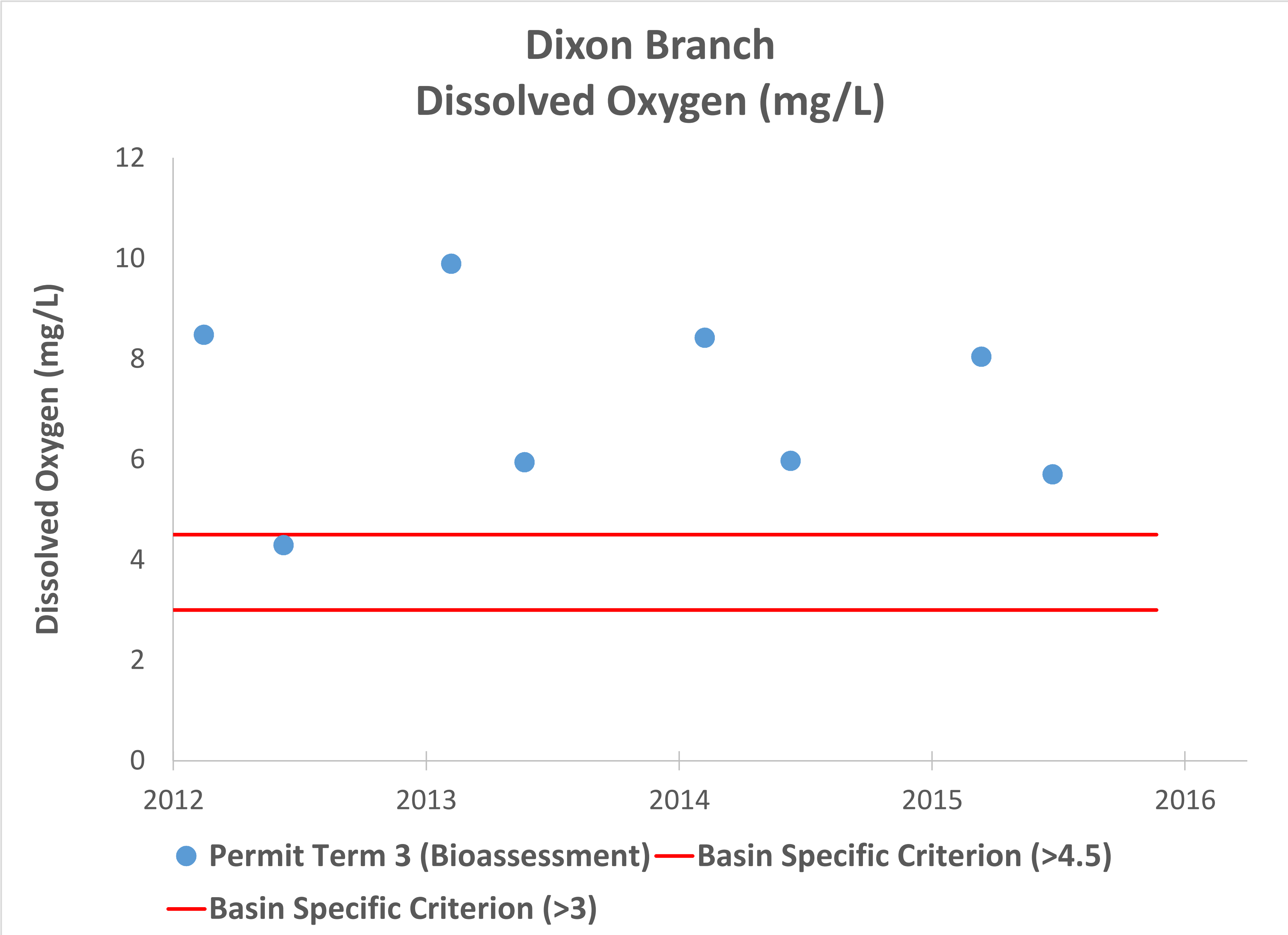

Dixon Branch
Specific Conductivity
Specific Conductivity (µS/cm)
1200
1000
800
600
400
200
0
2012
2013
2014
2015
2016
Permit Term 3 (Bioassessment)
NRSA: good (<)

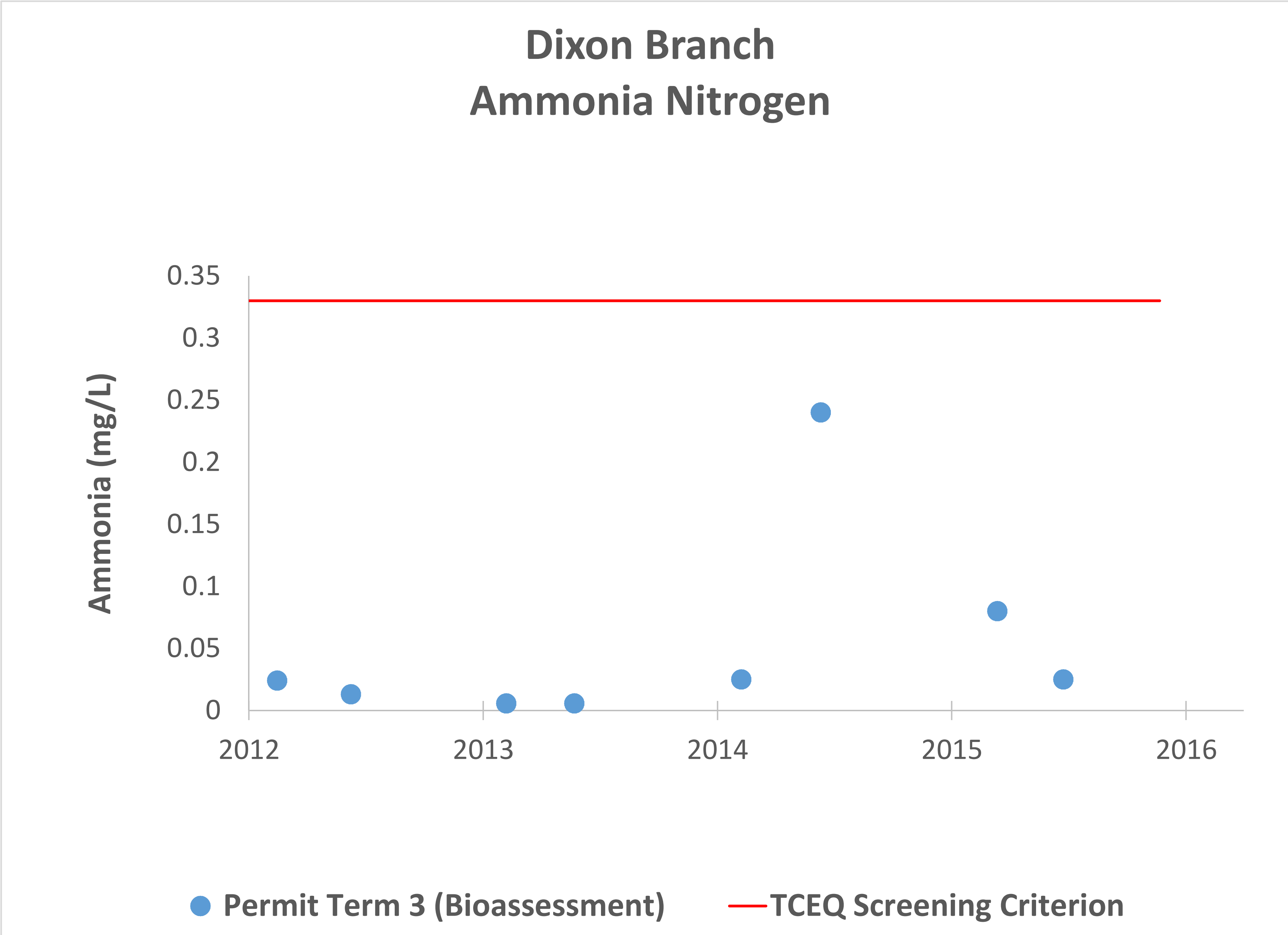

Dixon Branch
Temperature
Temperature (°F)
100
90
80
70
60
50
40
30
20
10
0
2012
2013
2014
2015
2016
Permit Term 3 (Bioassessment)
Basin Specific Criterion

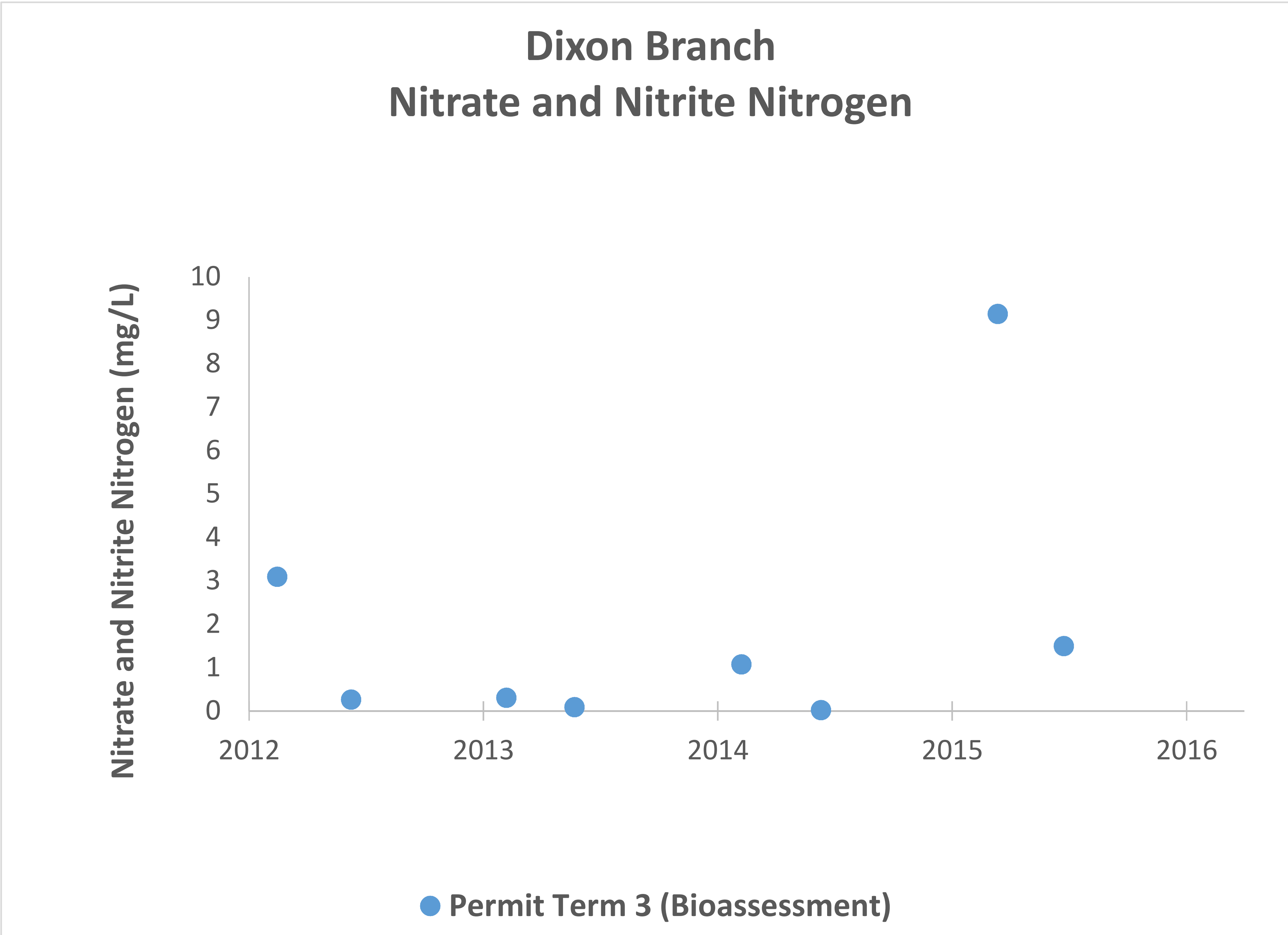


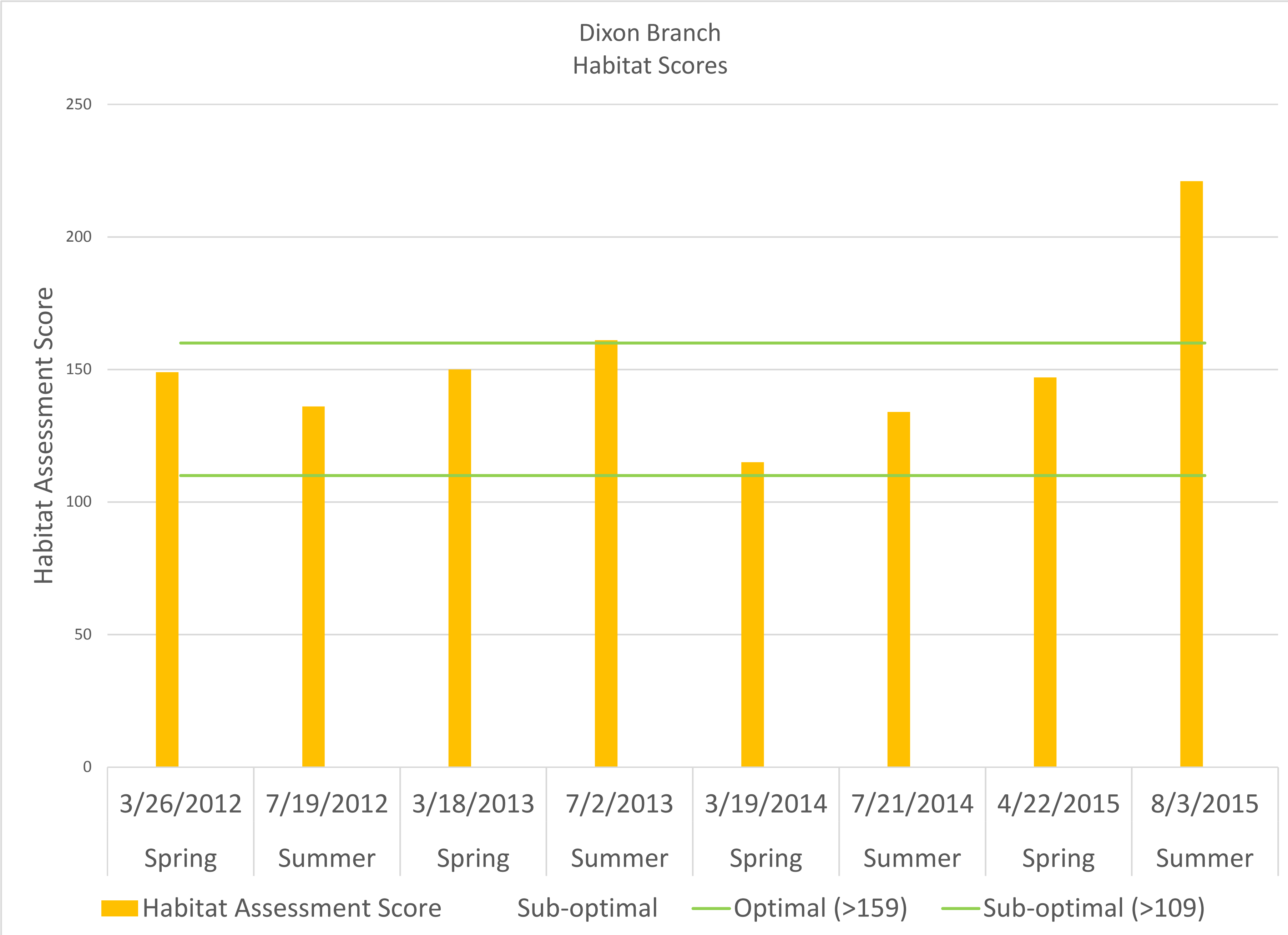
Dixon Branch
E. coli
1000
100
10
1
E. coli (col/100 mL)
2012
2013
2014
2015
2016
Permit Term 3 (Bioassessment)
PCR Geomean
PCR Single Sample

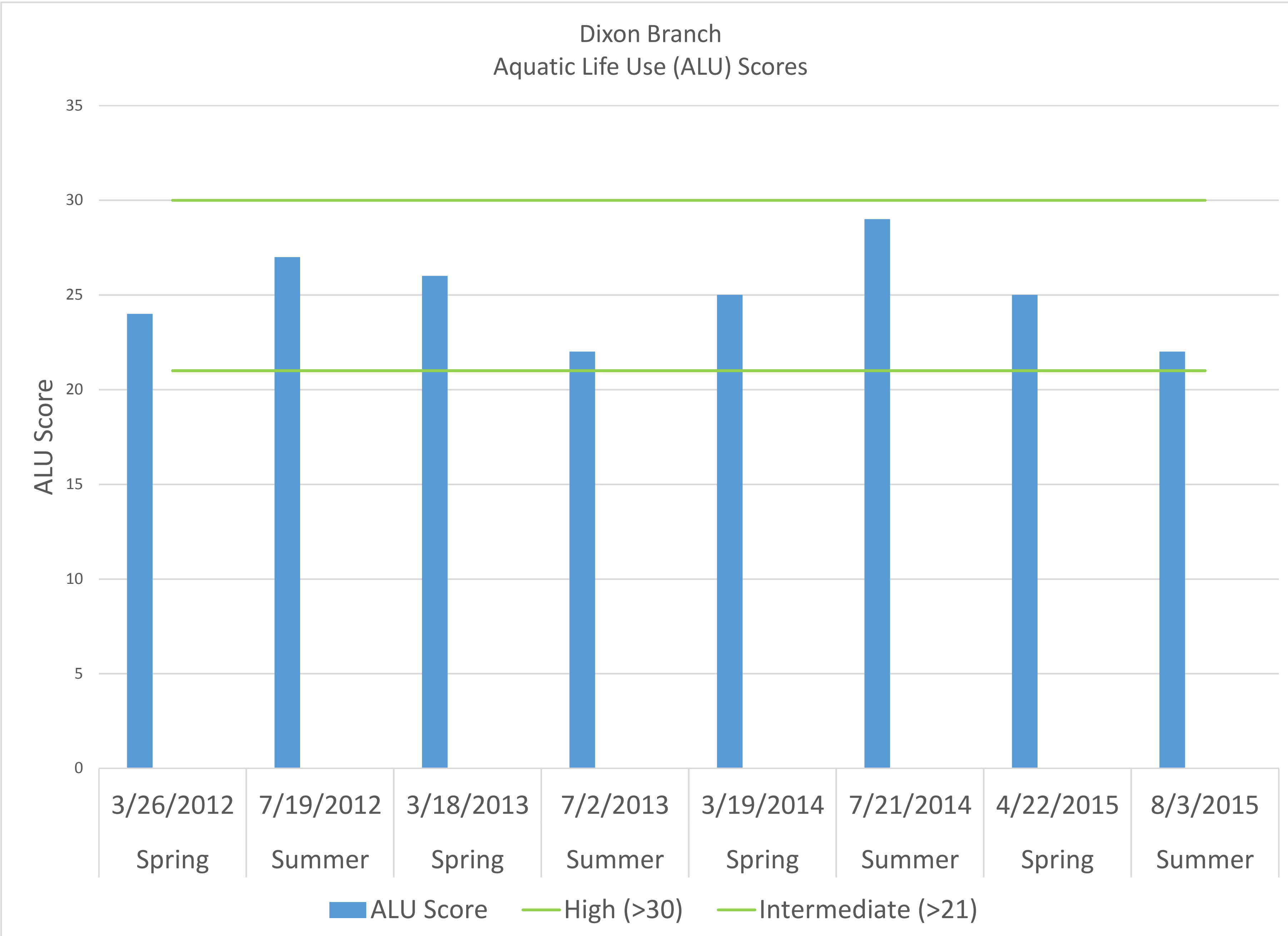

Dixon Branch
Total Coliform
Total Coliform (col/100 mL)
1000
100
10
1
2012
2013
2014
2015
2016
Permit Term 3 (Bioassessment)


Dixon Branch
Dissolved Oxygen (mg/L)
Dissolved Oxygen (mg/L)
0
2
4
6
8
10
12
2012
2013
2014
2015
2016
Permit Term 3 (Bioassessment)
Basin Specific Criterion (>4.5)
Basin Specific Criterion (>3)


Dixon Branch
Ammonia Nitrogen
Ammonia (mg/L)
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
2012
2013
2014
2015
2016
Permit Term 3 (Bioassessment)
TCEQ Screening Criterion


Dixon Branch
Nitrate and Nitrite Nitrogen
Nitrate and Nitrite Nitrogen (mg/L)
10
9
8
7
6
5
4
3
2
1
0
2012
2013
2014
2015
2016
Permit Term 3 (Bioassessment)

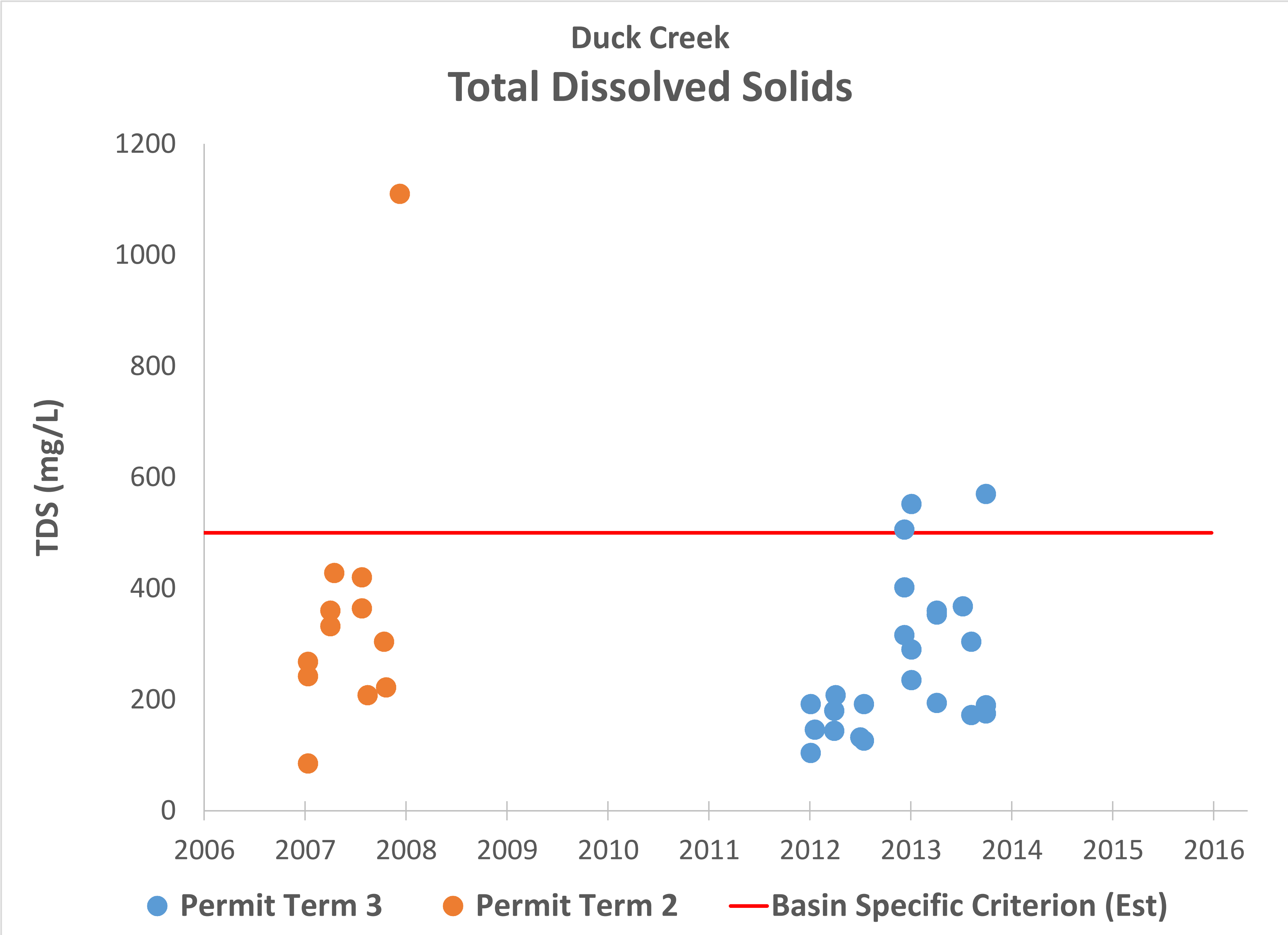

Dixon Branch
Habitat Scores
Habitat Assessment Score
250
200
150
100
50
0
3/26/2012 Spring
7/19/2012 Summer
3/18/2013 Spring
7/2/2013 Summer
3/19/2014 Spring
7/21/2014 Summer
4/22/2015 Spring
8/3/2015 Summer
Habitat Assessment Score
Sub-optimal
Optimal (>159)
Sub-optimal (>109)

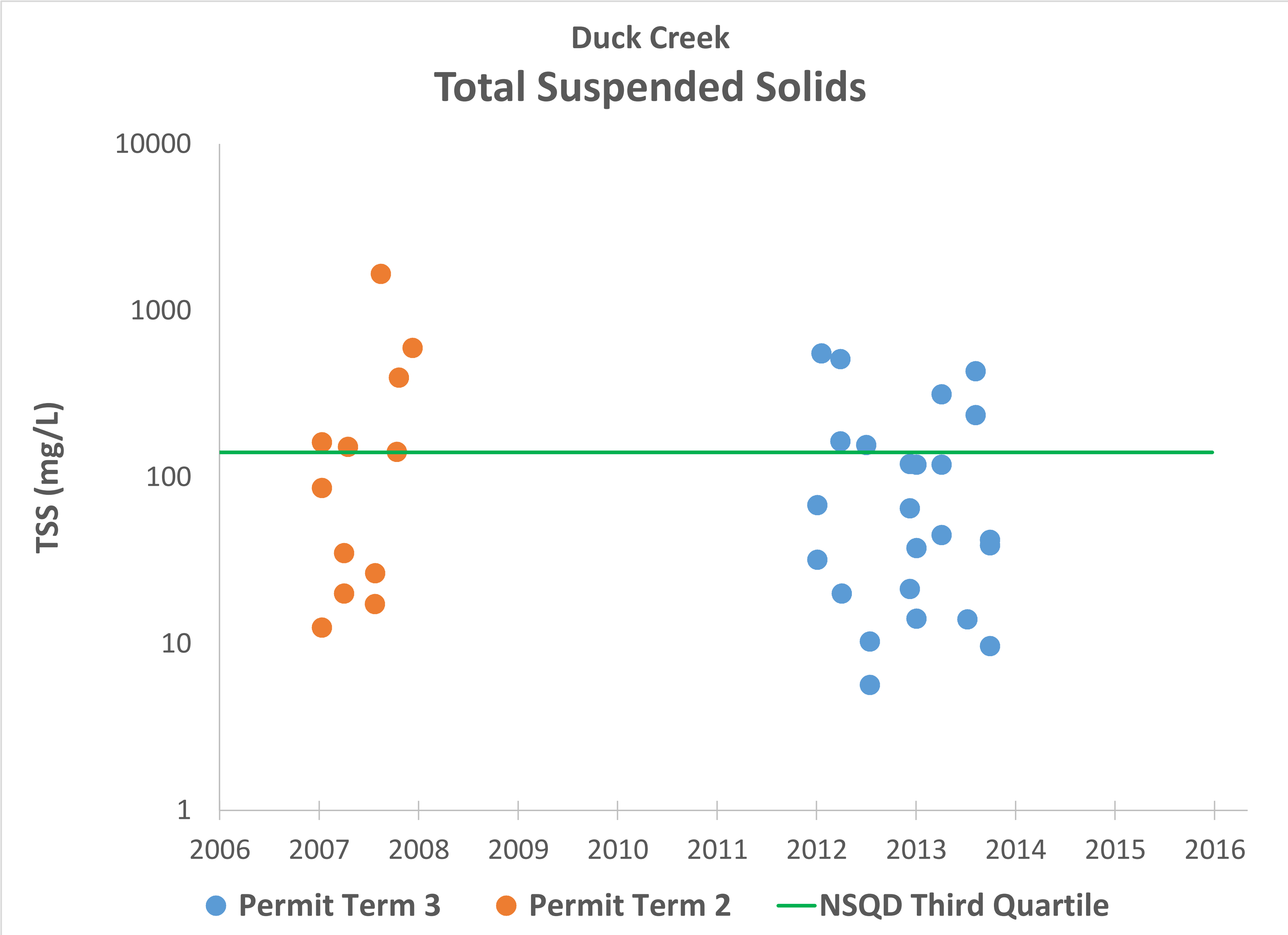


Dixon Branch
Aquatic Life Use (ALU) Scores
ALU Score
35
30
25
20
15
10
5
0
3/26/2012 Spring
7/19/2012 Summer
3/18/2013 Spring
7/2/2013 Summer
3/19/2014 Spring
7/21/2014 Summer
4/22/2015 Spring
8/3/2015 Summer
ALU Score
High (>30)
Intermediate (>21)

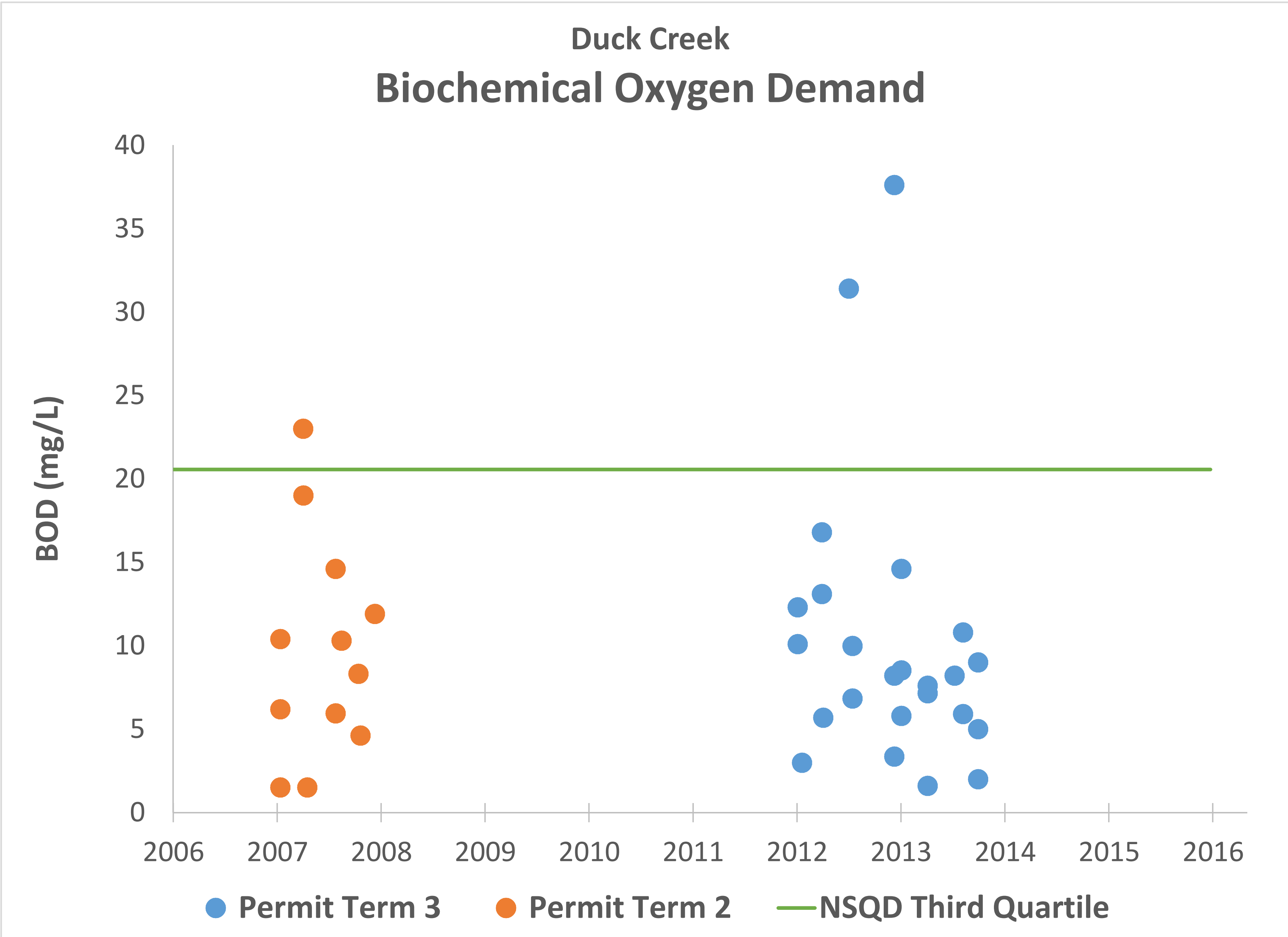
Appendix I

Duck Creek Water Quality
Data Graphs

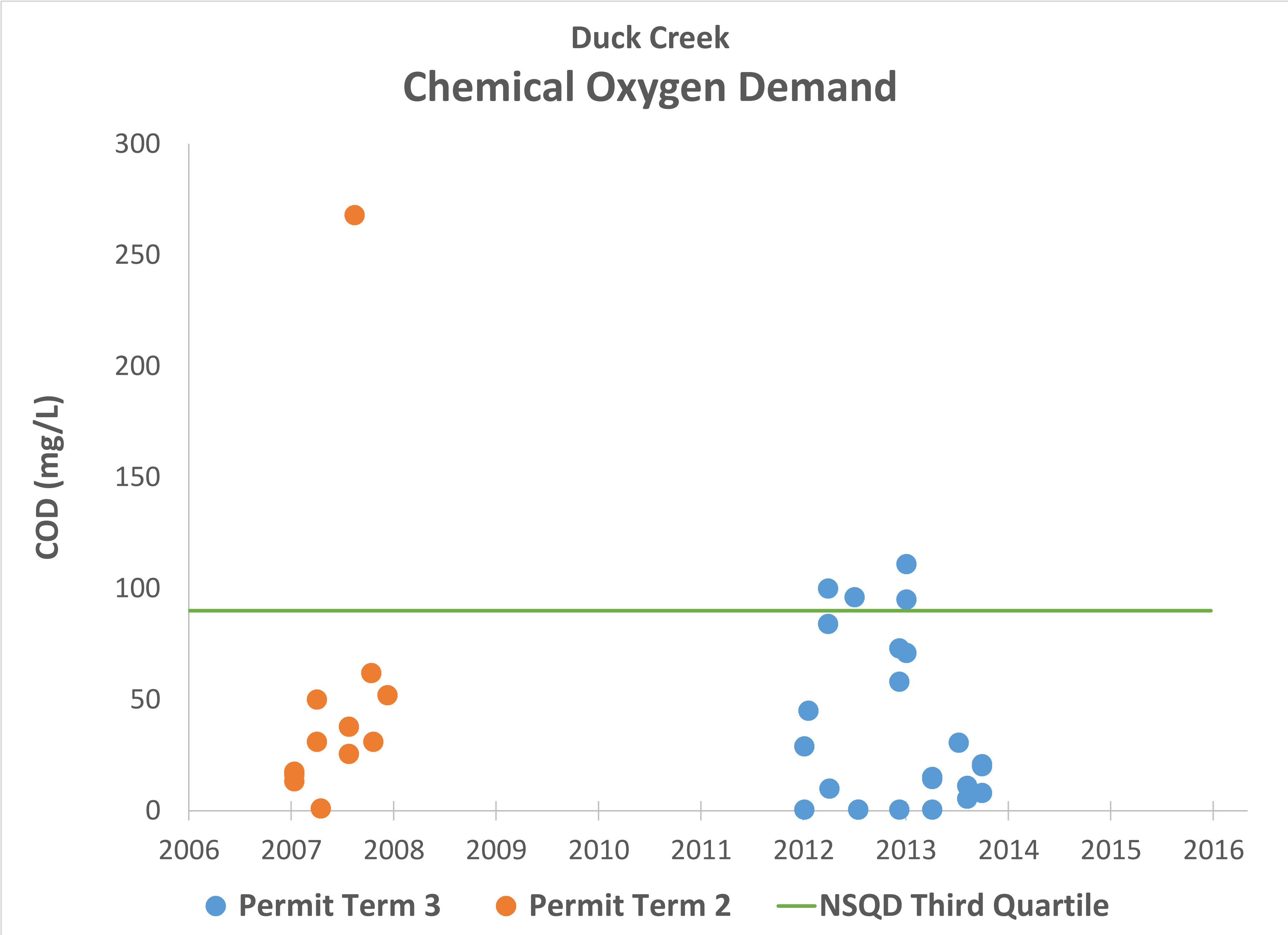

Duck Creek
Total Dissolved Solids
TDS (mg/L)
1200
1000
800
600
400
200
0
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
Permit Term 3
Permit Term 2
Basin Specific Criterion (Est)

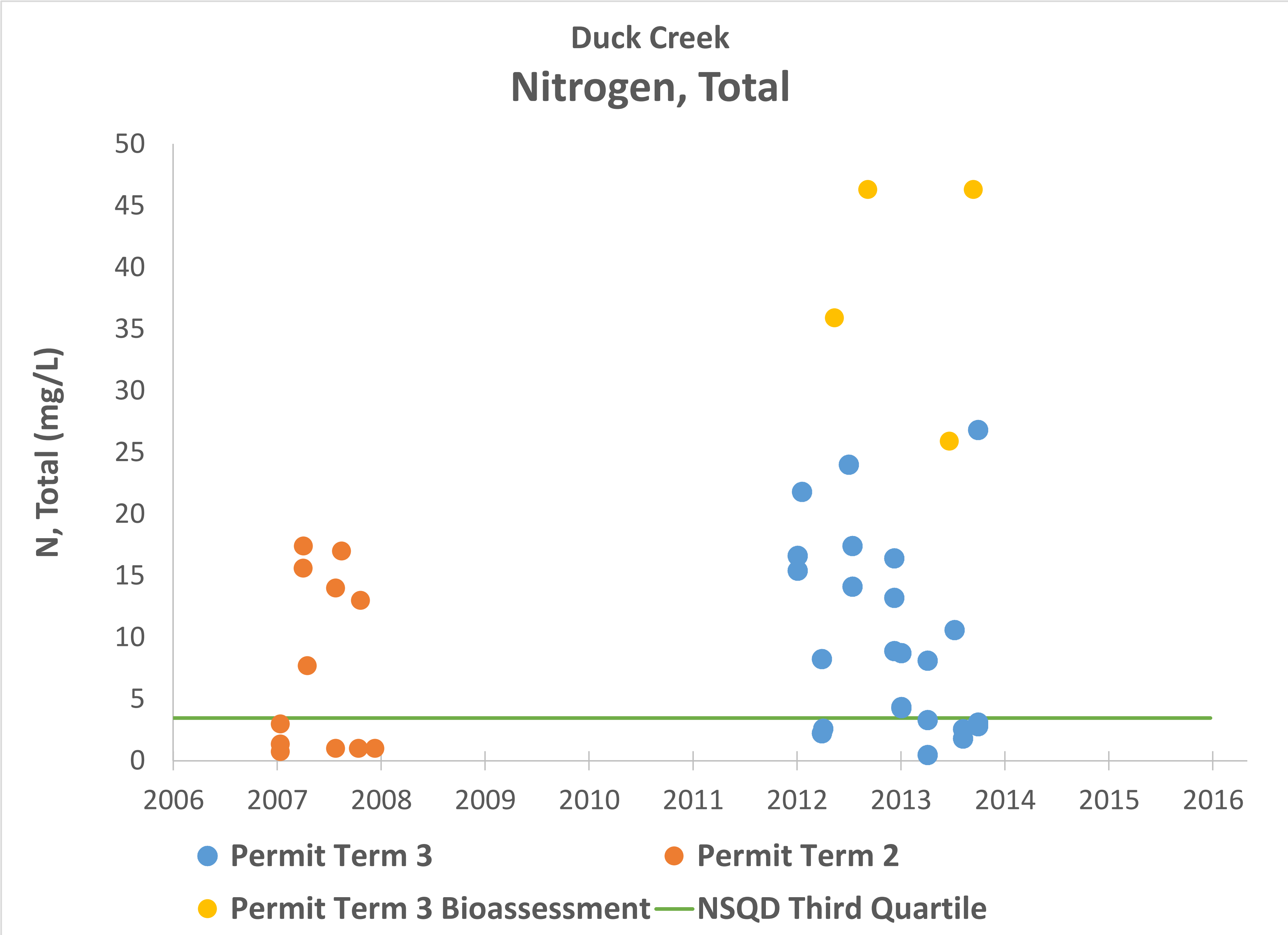


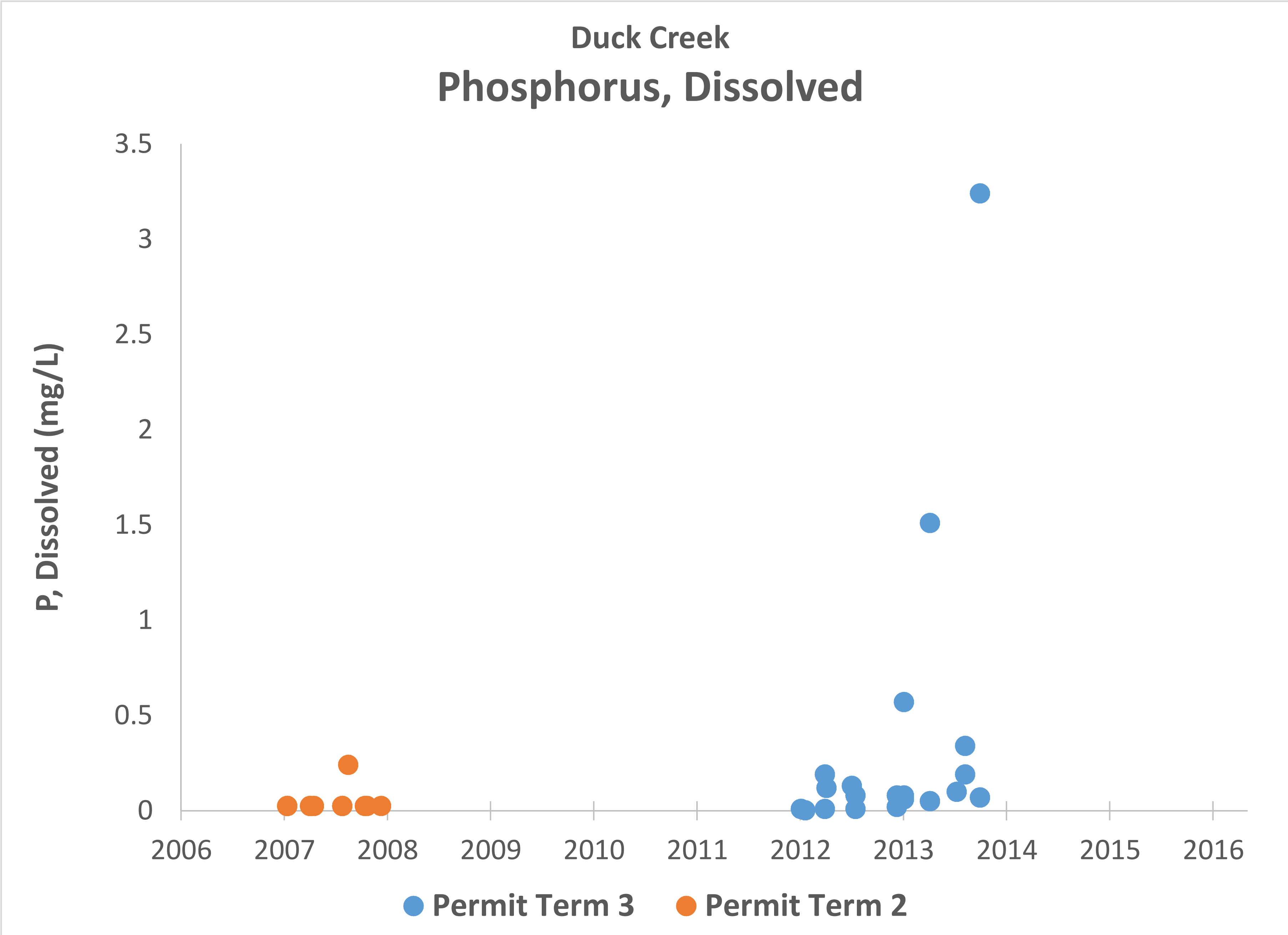
Duck Creek
Total Suspended Solids
TSS (mg/L)
10000
1000
100
10
1
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
Permit Term 3
Permit Term 2
NSQD Third Quartile

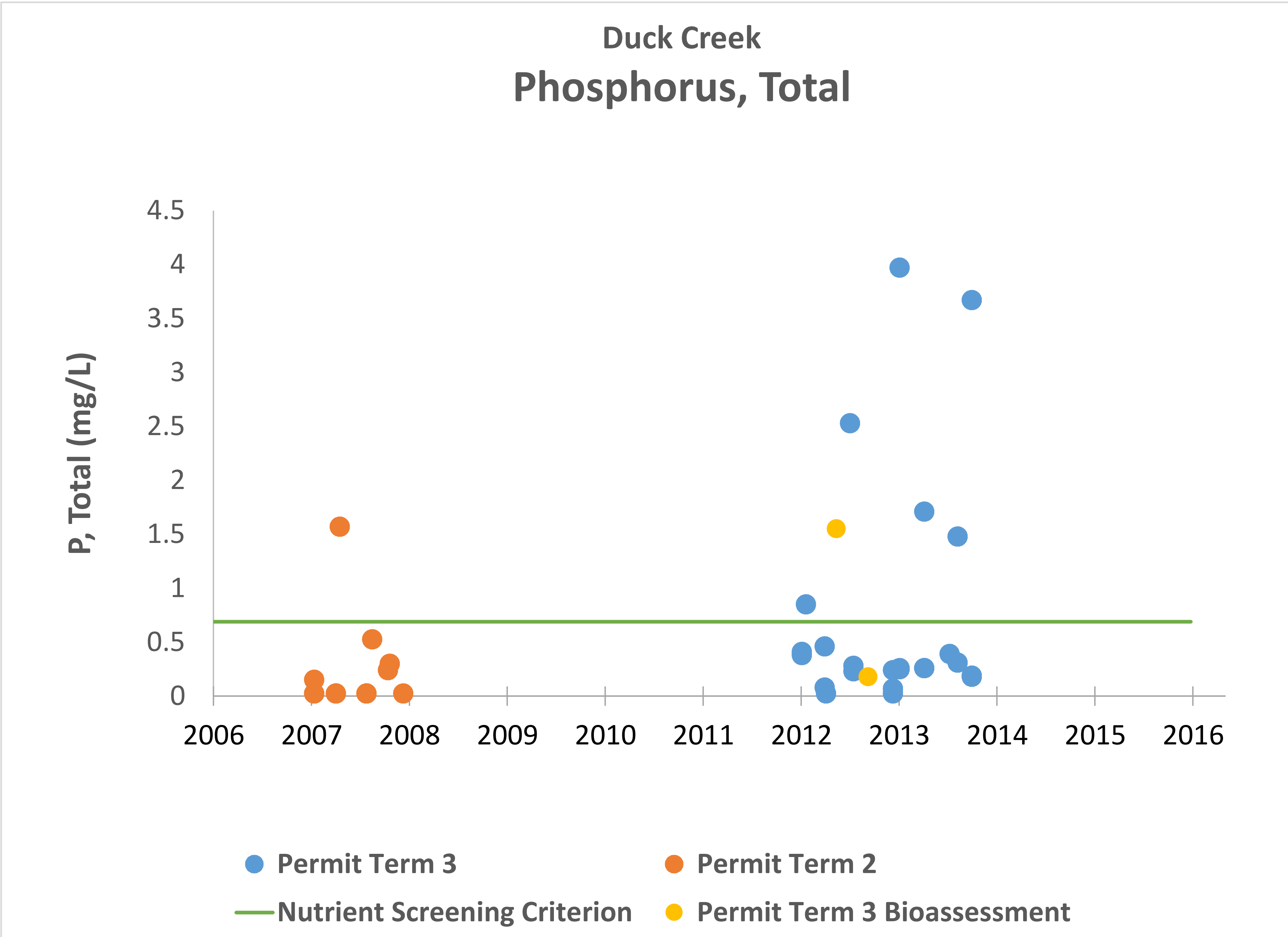


Duck Creek
Biochemical Oxygen Demand
BOD (mg/L)
0
5
10
15
20
25
30
35
40
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
Permit Term 3
Permit Term 2
NSQD Third Quartile

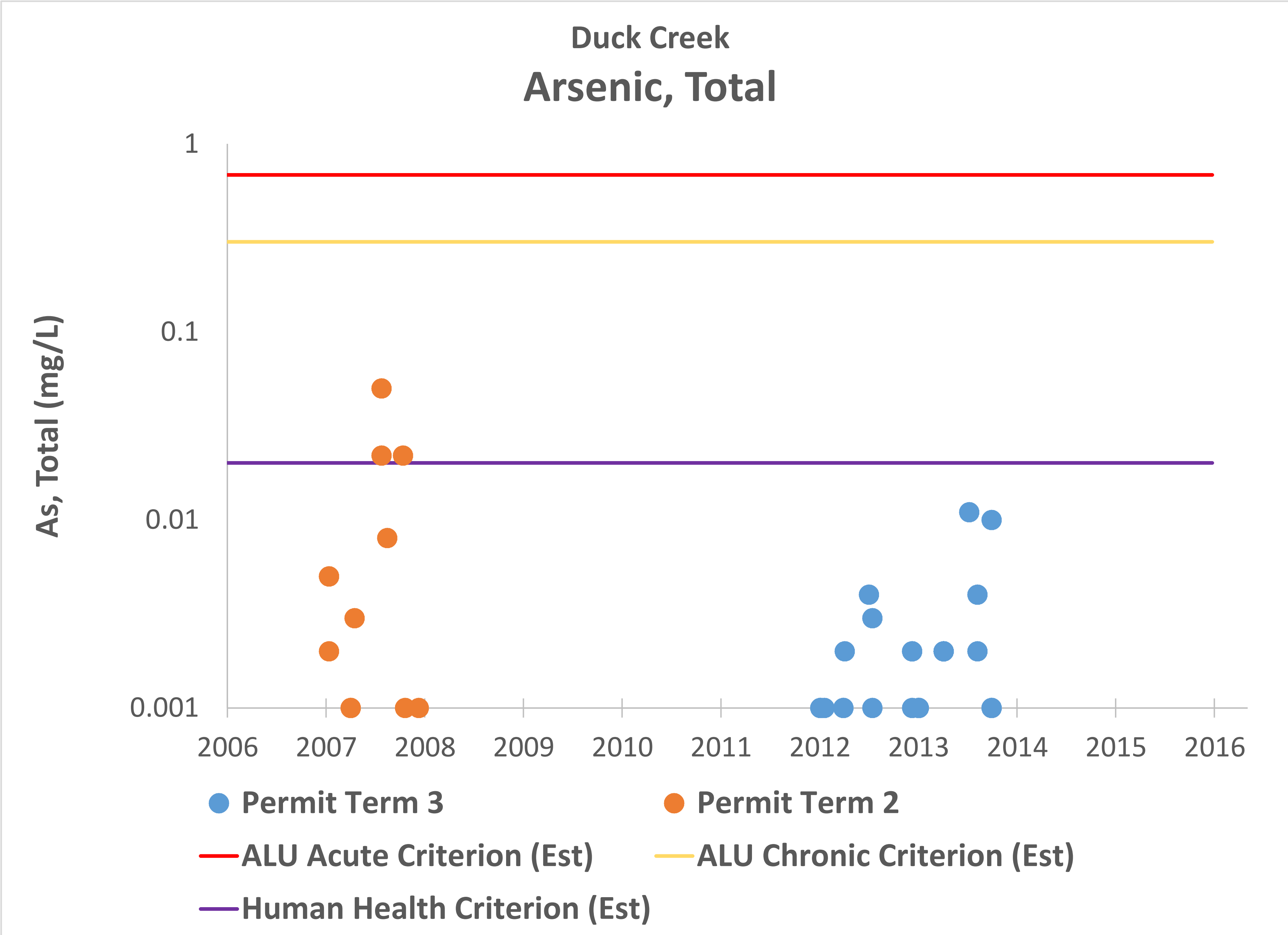

Duck Creek
Chemical Oxygen Demand
COD (mg/L)
300
250
200
150
100
50
0
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
Permit Term 3
Permit Term 2
NSQD Third Quartile


Duck Creek
Nitrogen, Total
N, Total (mg/L)
50
45
40
35
30
25
20
15
10
5
0
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
Permit Term 3
Permit Term 2
Permit Term 3 Bioassessment
NSQD Third Quartile

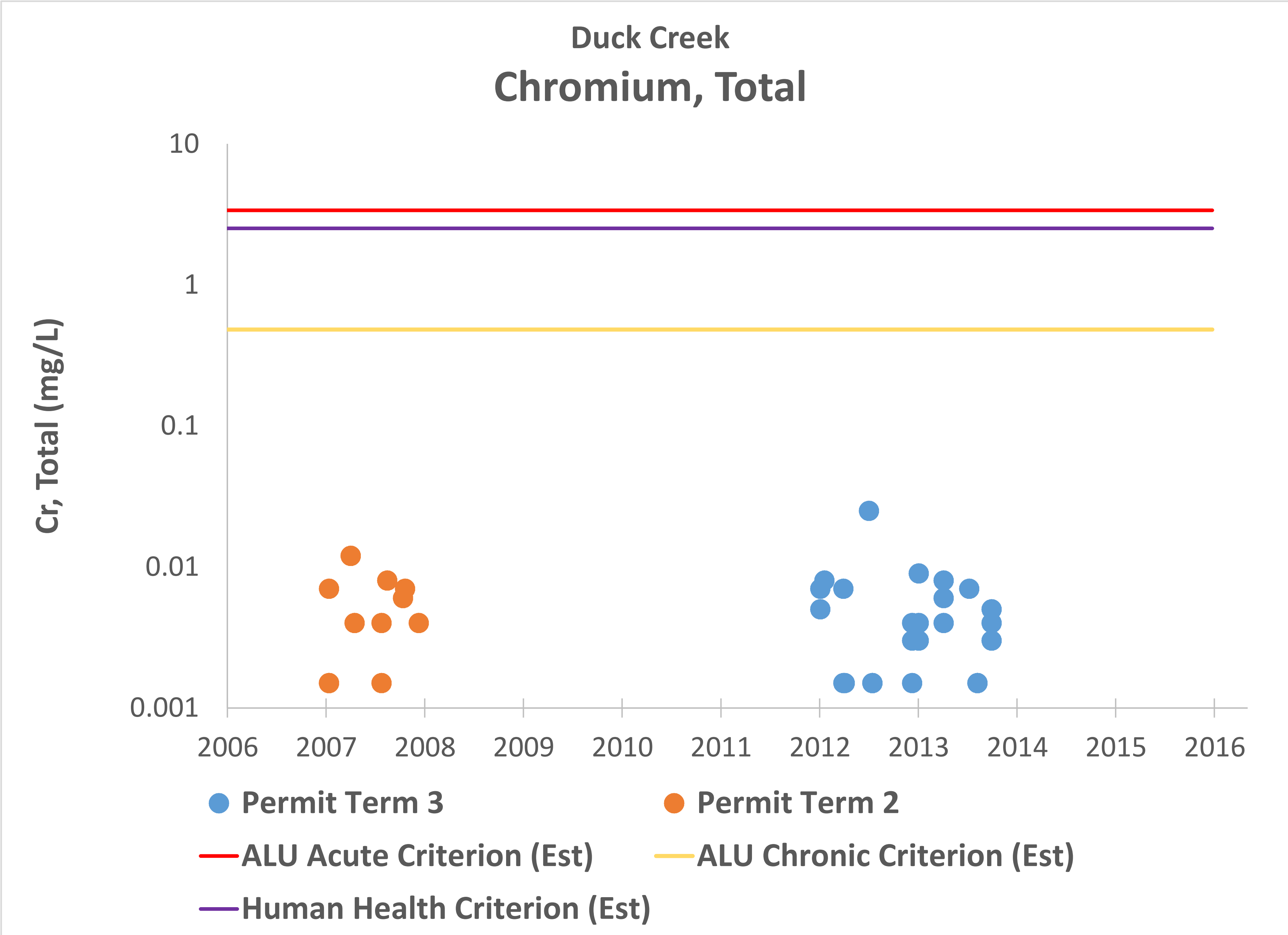

Duck Creek
Phosphorus, Dissolved
P, Dissolved (mg/L)
3.5
3
2.5
2
1.5
1
0.5
0
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
Permit Term 3
Permit Term 2



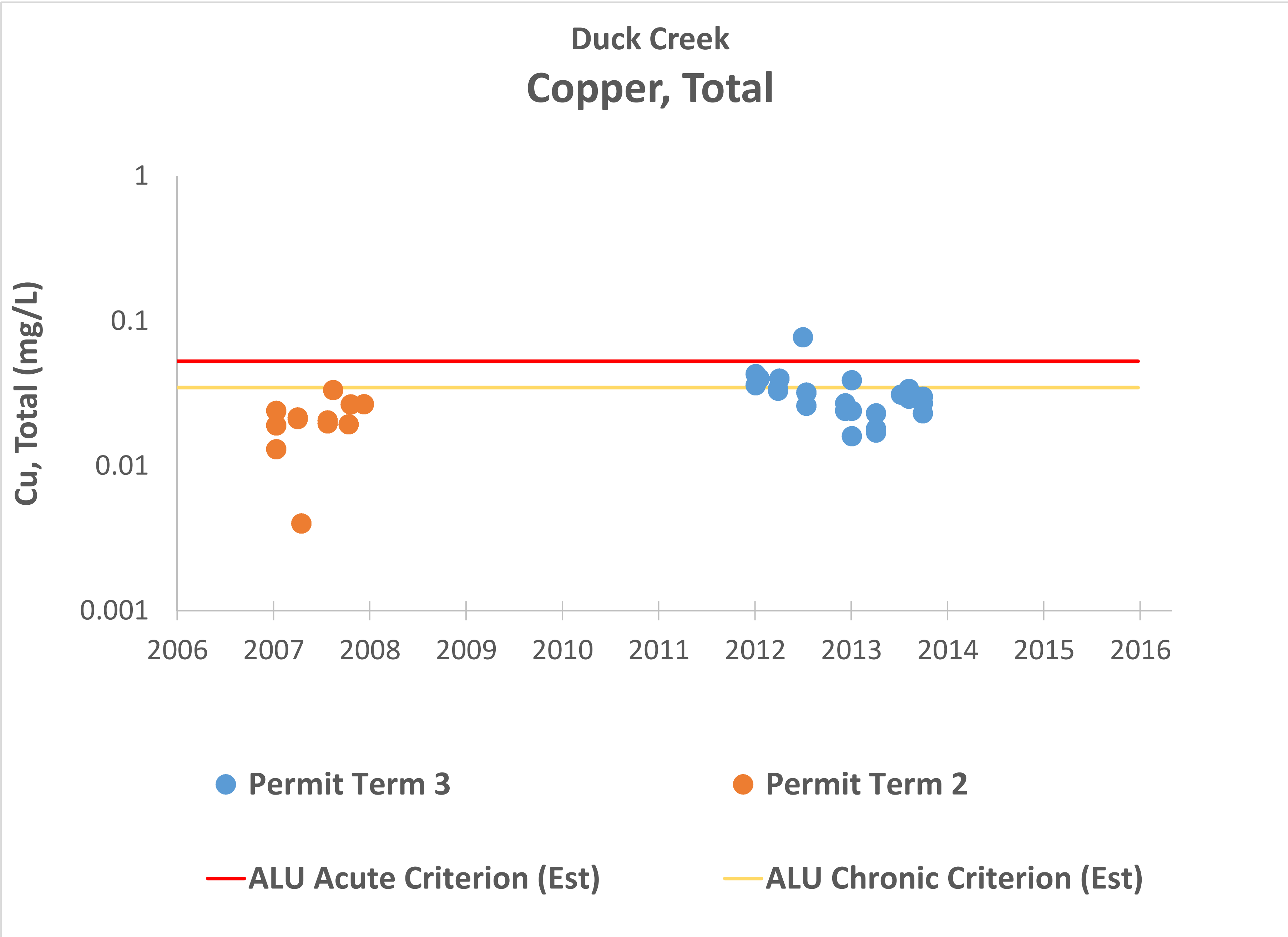
Duck Creek
Phosphorus, Total
P, Total (mg/L)
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
Permit Term 3
Permit Term 2
Nutrient Screening Criterion
Permit Term 3 Bioassessment

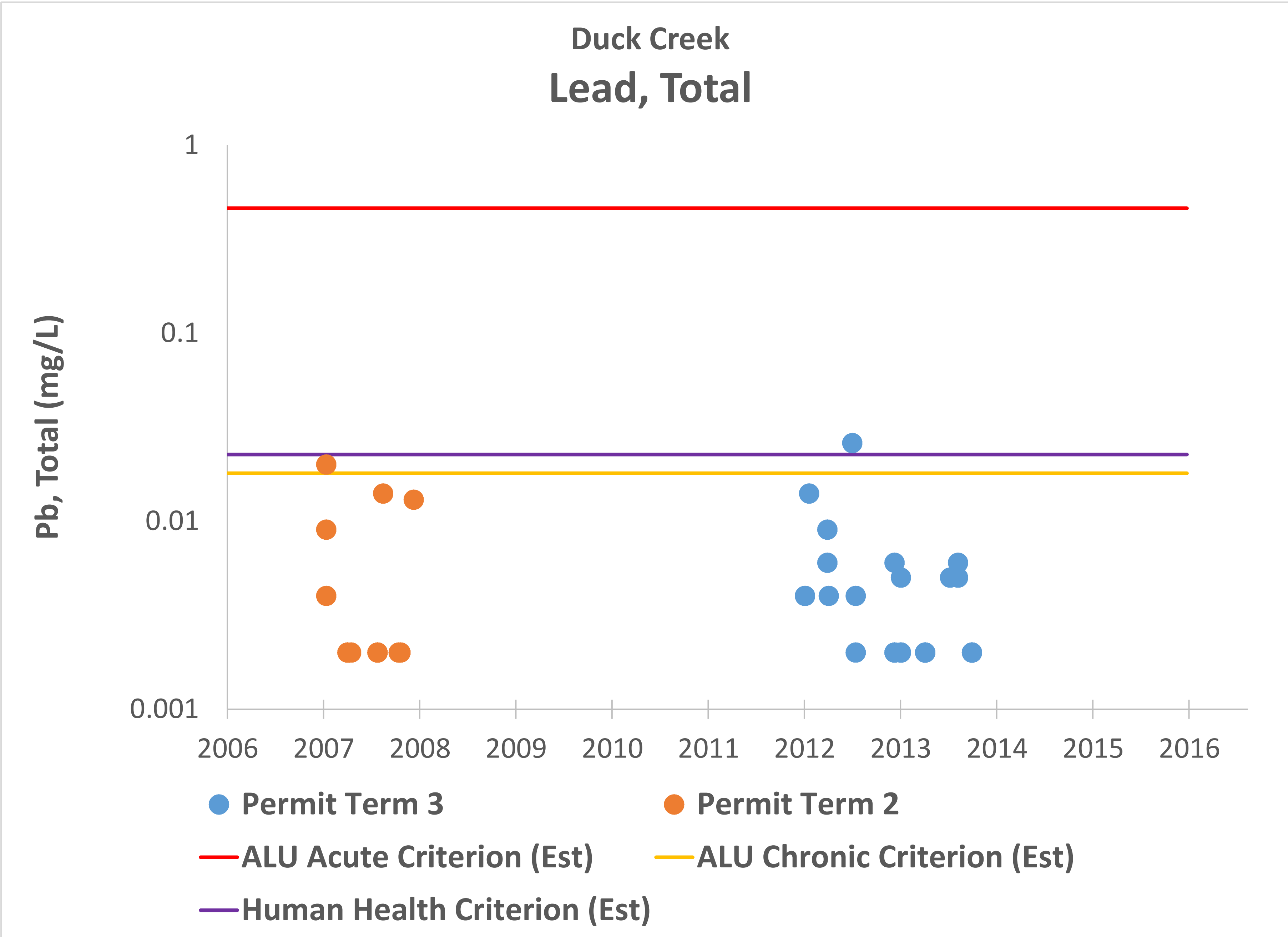


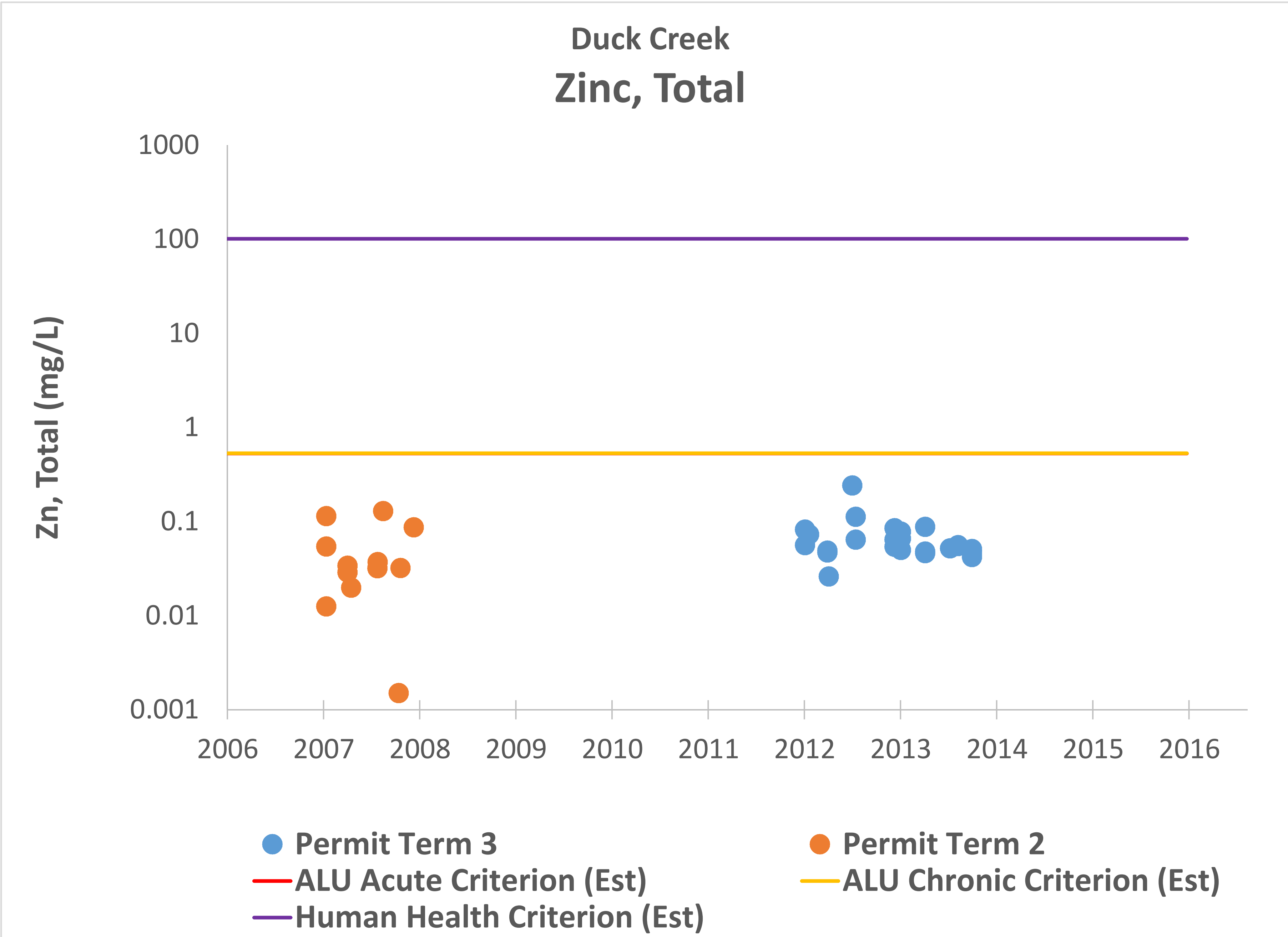
Duck Creek
Arsenic, Total
As, Total (mg/L)
1
0.1
0.01
0.001
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
Permit Term 3
Permit Term 2
ALU Acute Criterion (Est)
ALU Chronic Criterion (Est)
Human Health Criterion (Est)



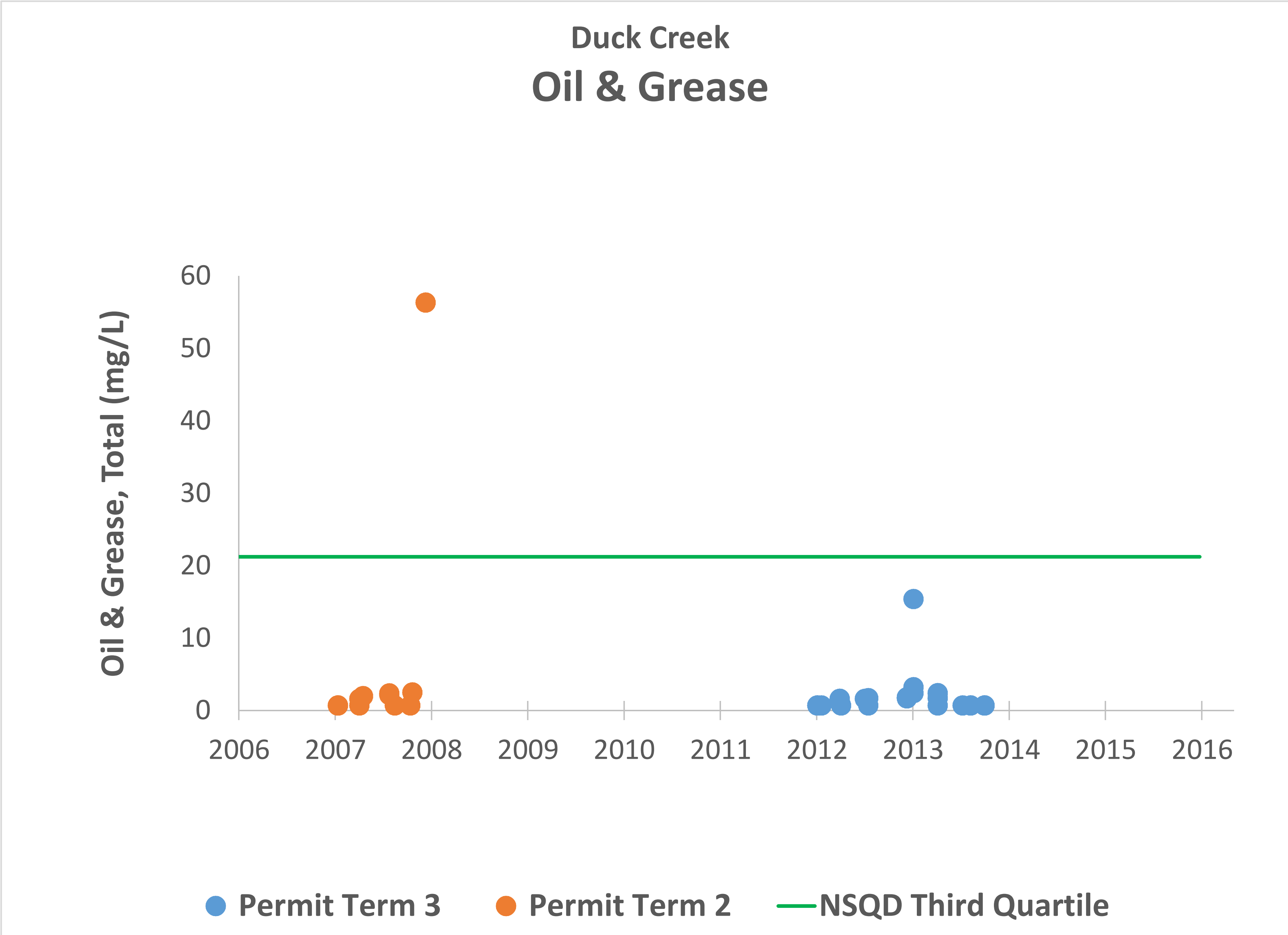
Duck Creek
Chromium, Total
Cr, Total (mg/L)
10
1
0.1
0.01
0.001
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
Permit Term 3
Permit Term 2
ALU Acute Criterion (Est)
ALU Chronic Criterion (Est)
Human Health Criterion (Est)


Duck Creek
Copper, Total
Cu, Total (mg/L)
1
0.1
0.01
0.001
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
Permit Term 3
Permit Term 2
ALU Acute Criterion (Est)
ALU Chronic Criterion (Est)

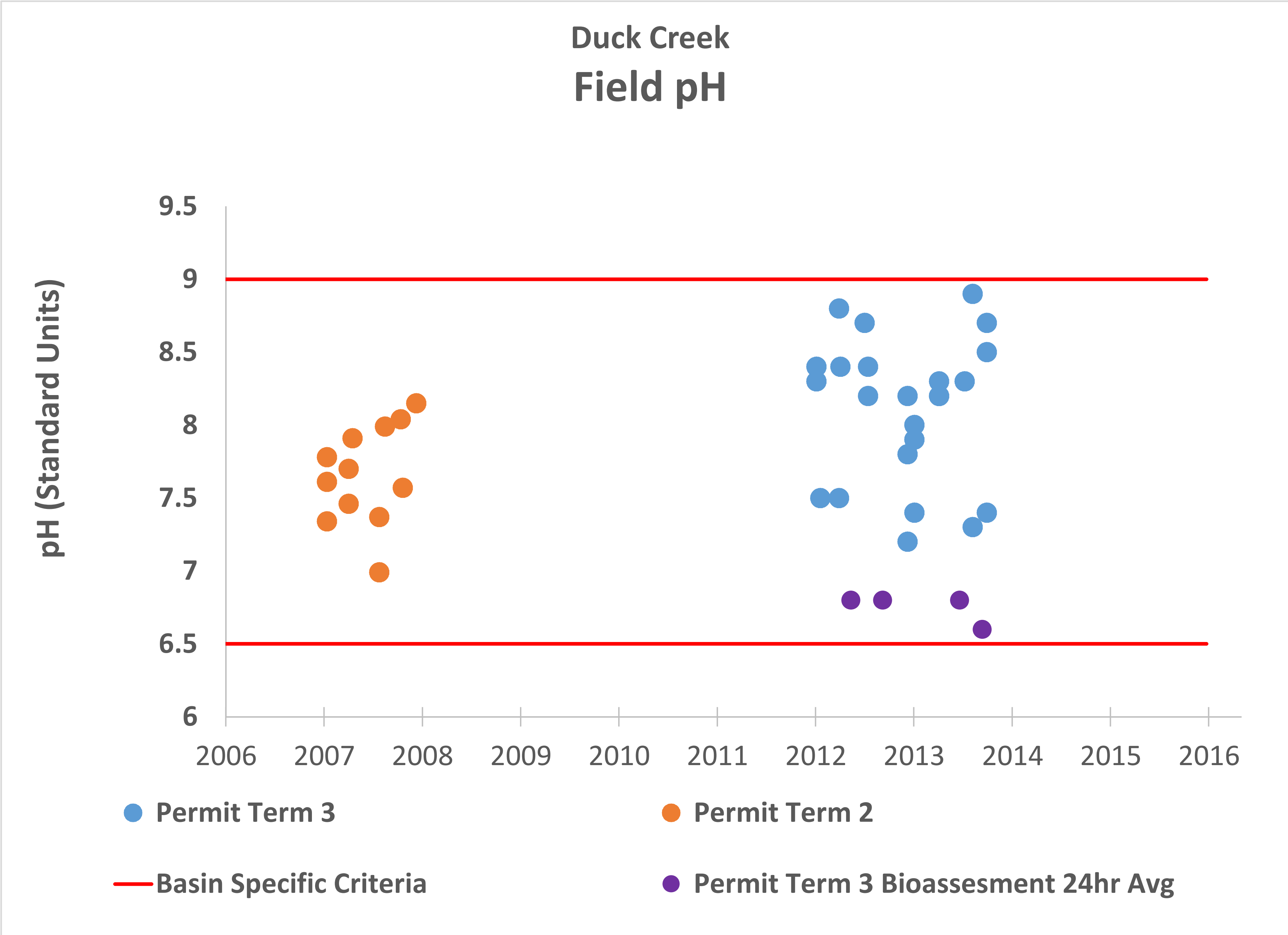

Duck Creek
Lead, Total
Pb, Total (mg/L)
1
0.1
0.01
0.001
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
Permit Term 3
Permit Term 2
ALU Acute Criterion (Est)
ALU Chronic Criterion (Est)
Human Health Criterion (Est)

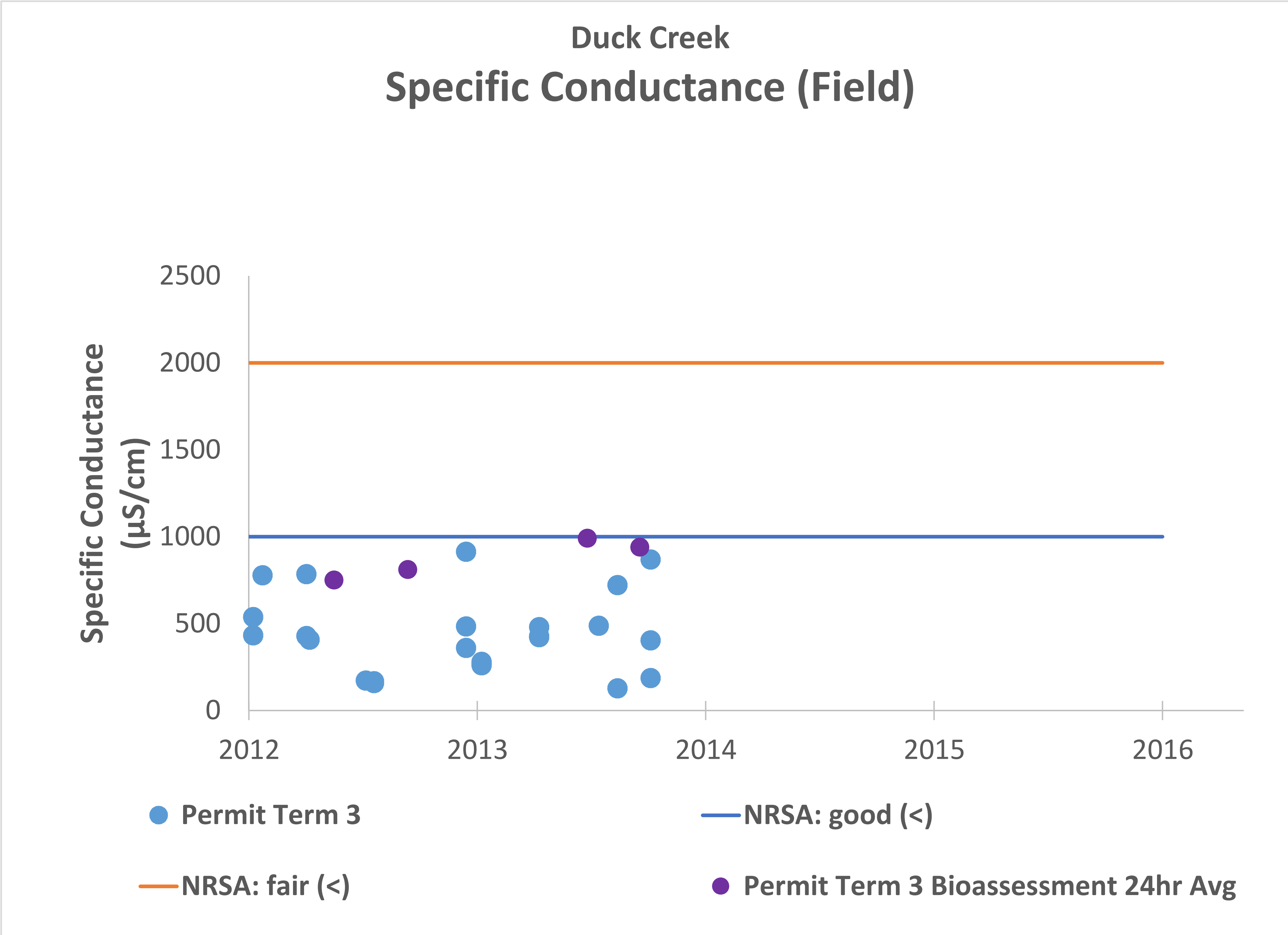


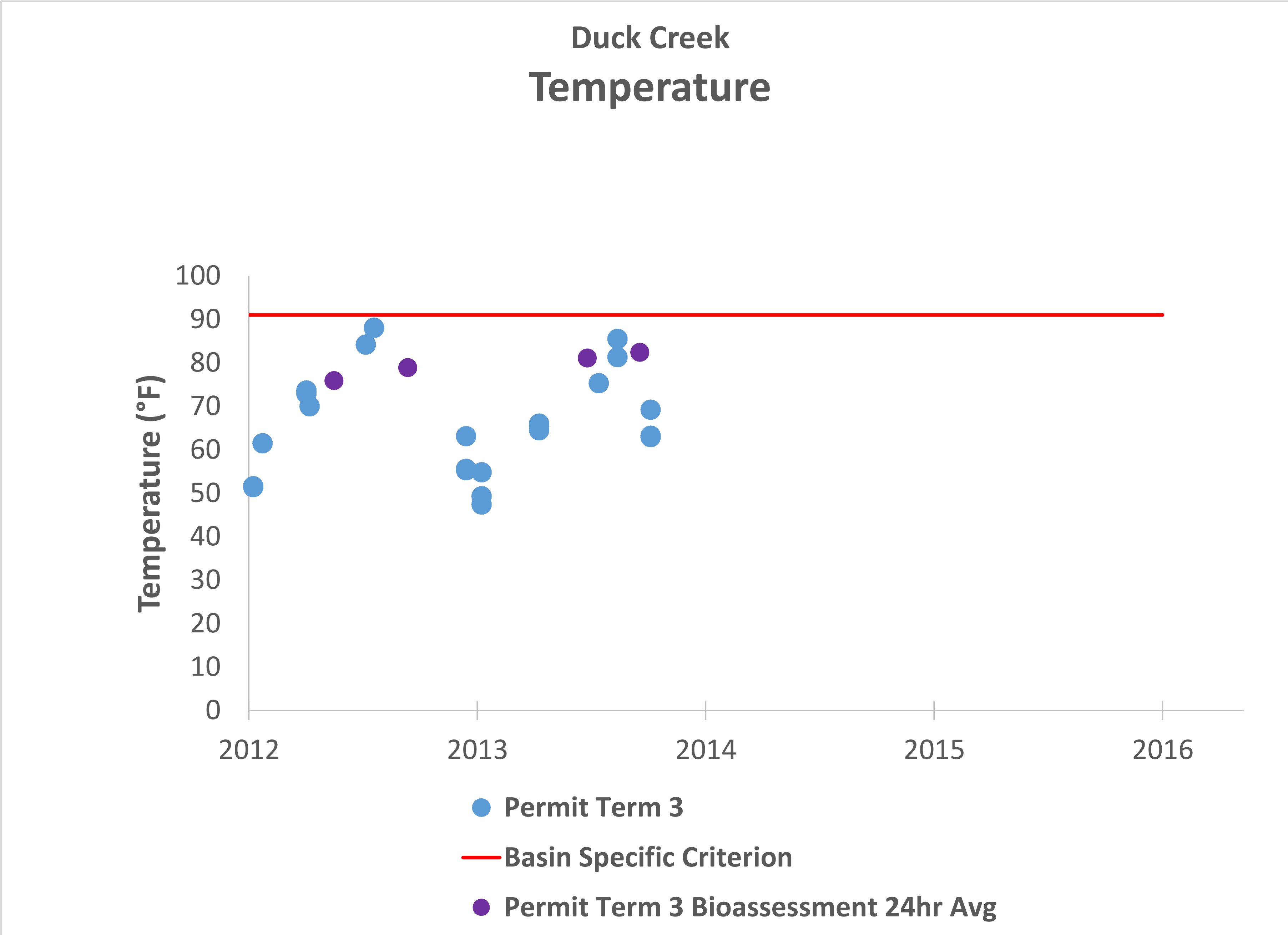
Duck Creek
Zinc, Total
Zn, Total (mg/L)
1000
100
10
1
0.1
0.01
0.001
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
Permit Term 3
Permit Term 2
ALU Acute Criterion (Est)
ALU Chronic Criterion (Est)
Human Health Criterion (Est)

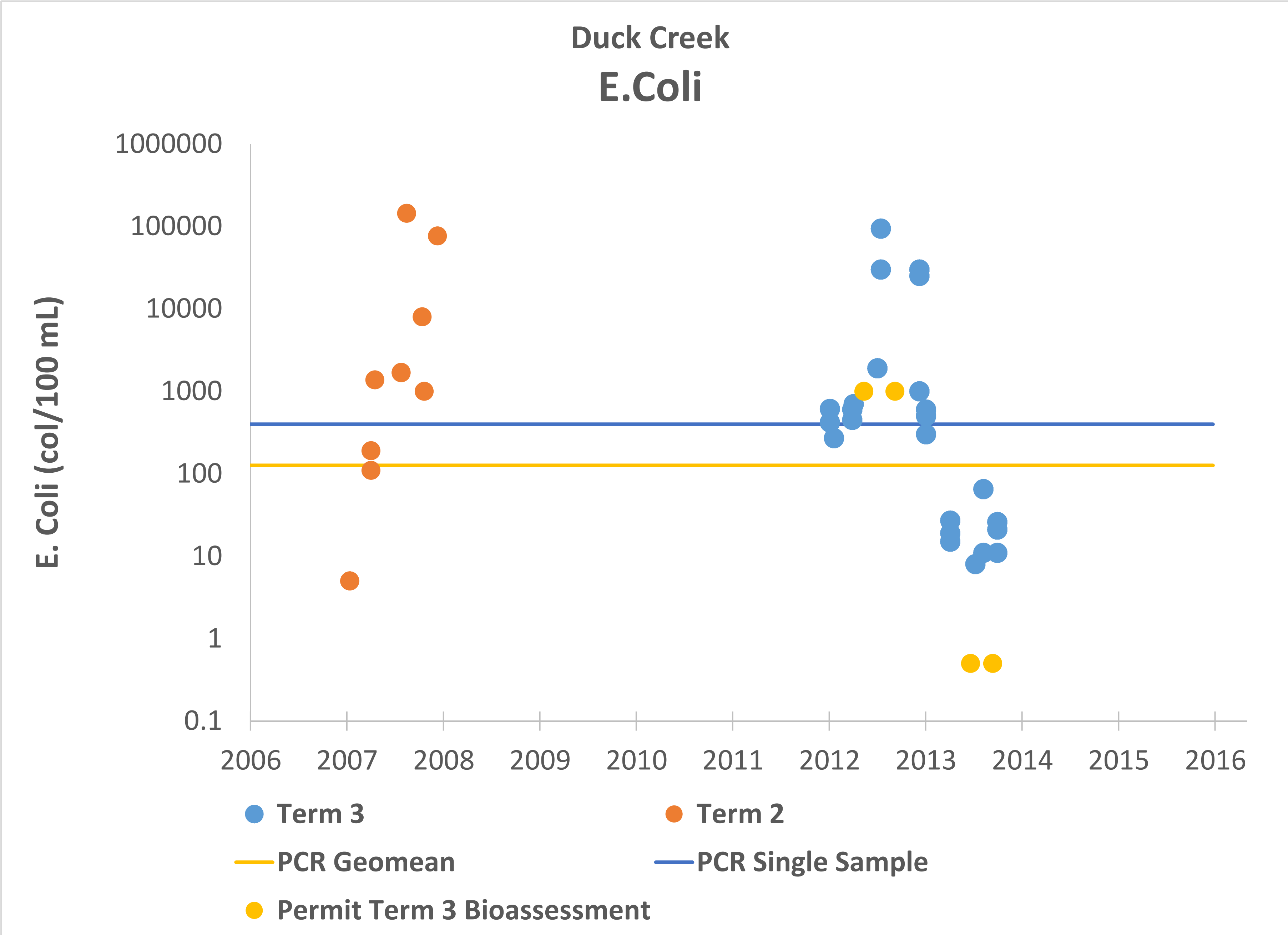


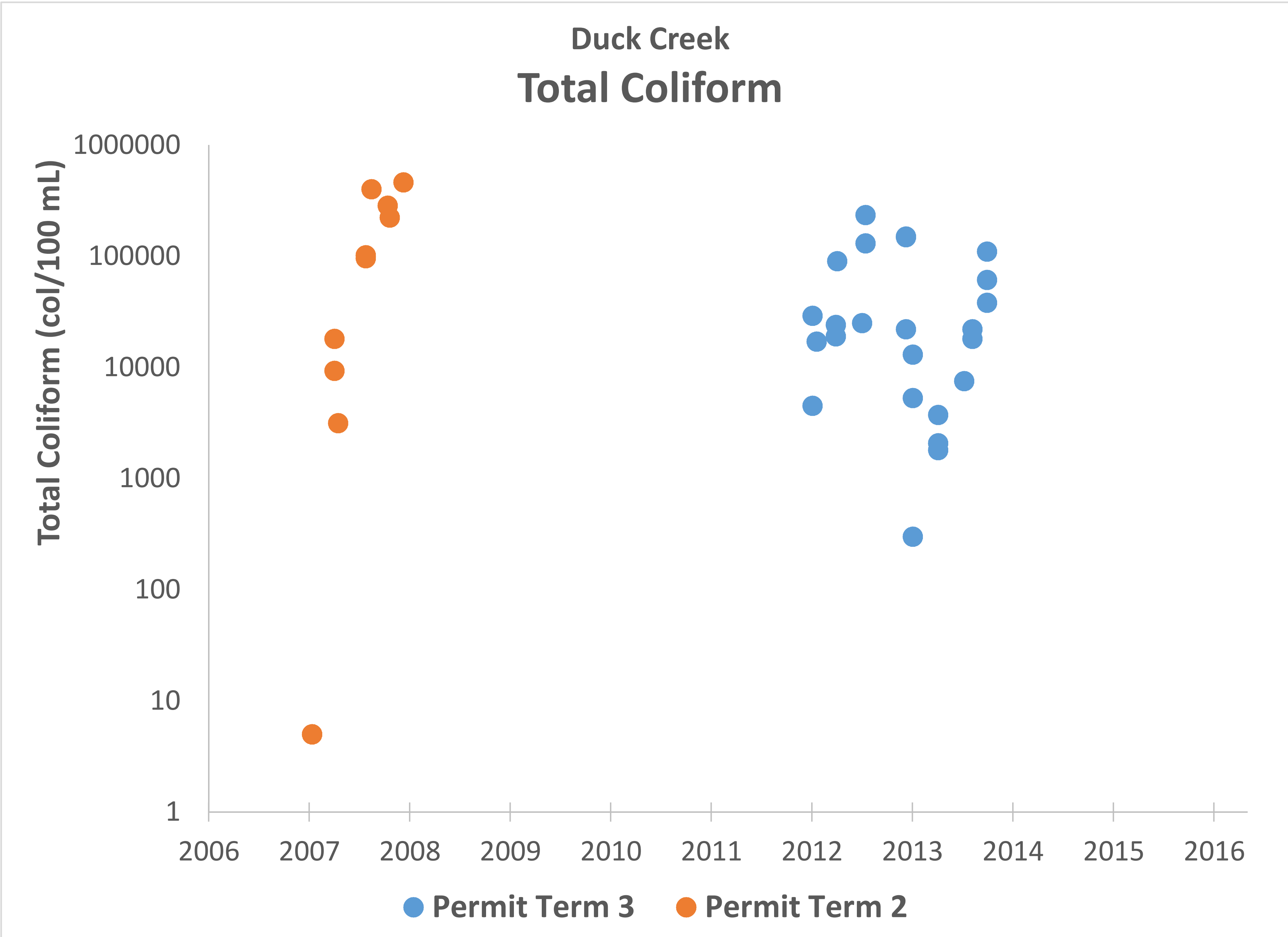
Duck Creek
Oil & Grease
Oil & Grease, Total (mg/L)
60
50
40
30
20
10
0
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
Permit Term 3
Permit Term 2
NSQD Third Quartile


Duck Creek
Field pH
pH (Standard Units)
9.5
9
8.5
8
7.5
7
6.5
6
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
Permit Term 3
Permit Term 2
Basin Specific Criteria
Permit Term 3 Bioassesment 24hr Avg

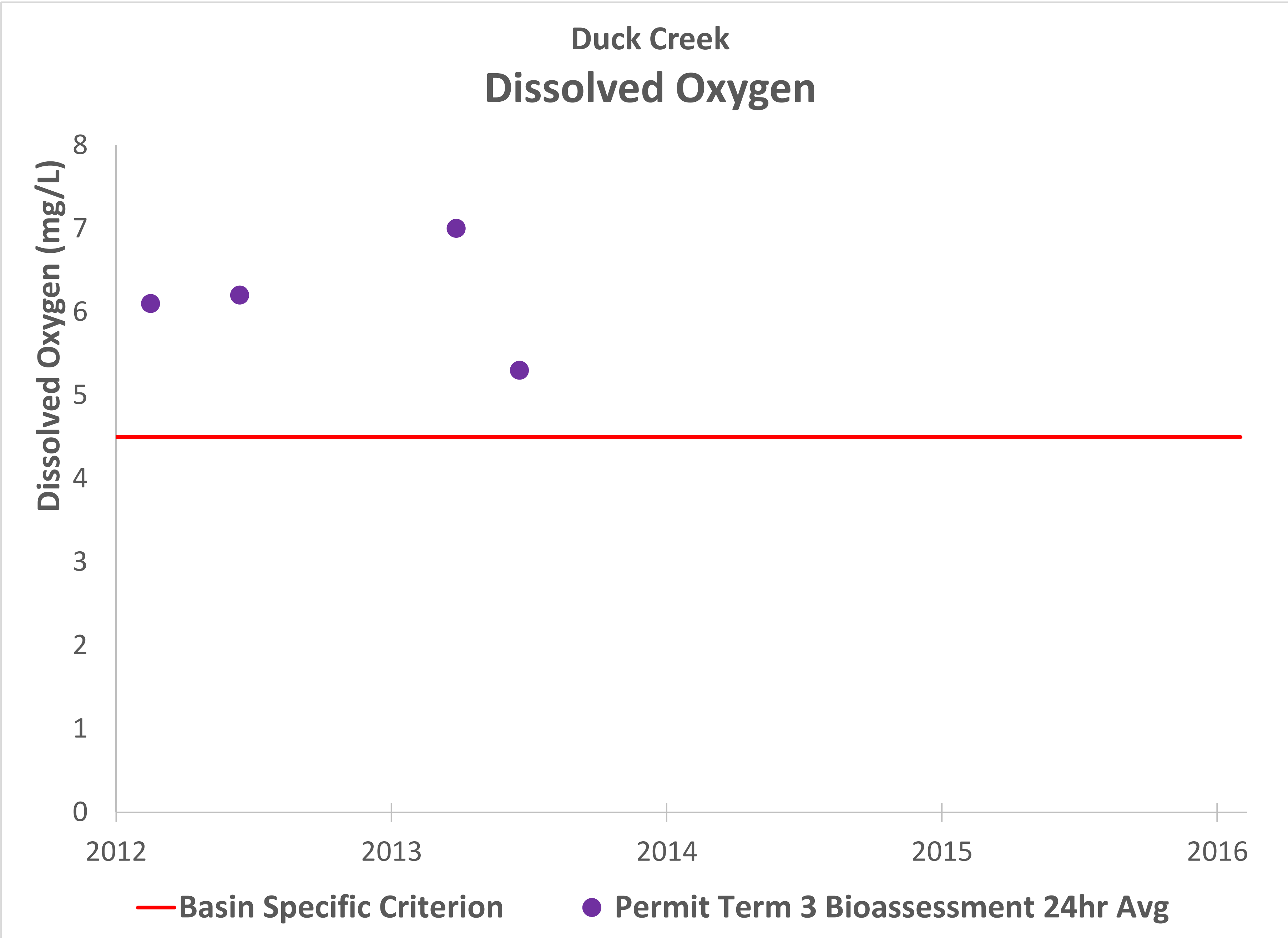

Duck Creek
Specific Conductance (Field)
Specific Conductance (µS/cm)
2500
2000
1500
1000
500
0
2012
2013
2014
2015
2016
Permit Term 3
NRSA: good (<)
NRSA: fair (<)
Permit Term 3 Bioassessment 24hr Avg

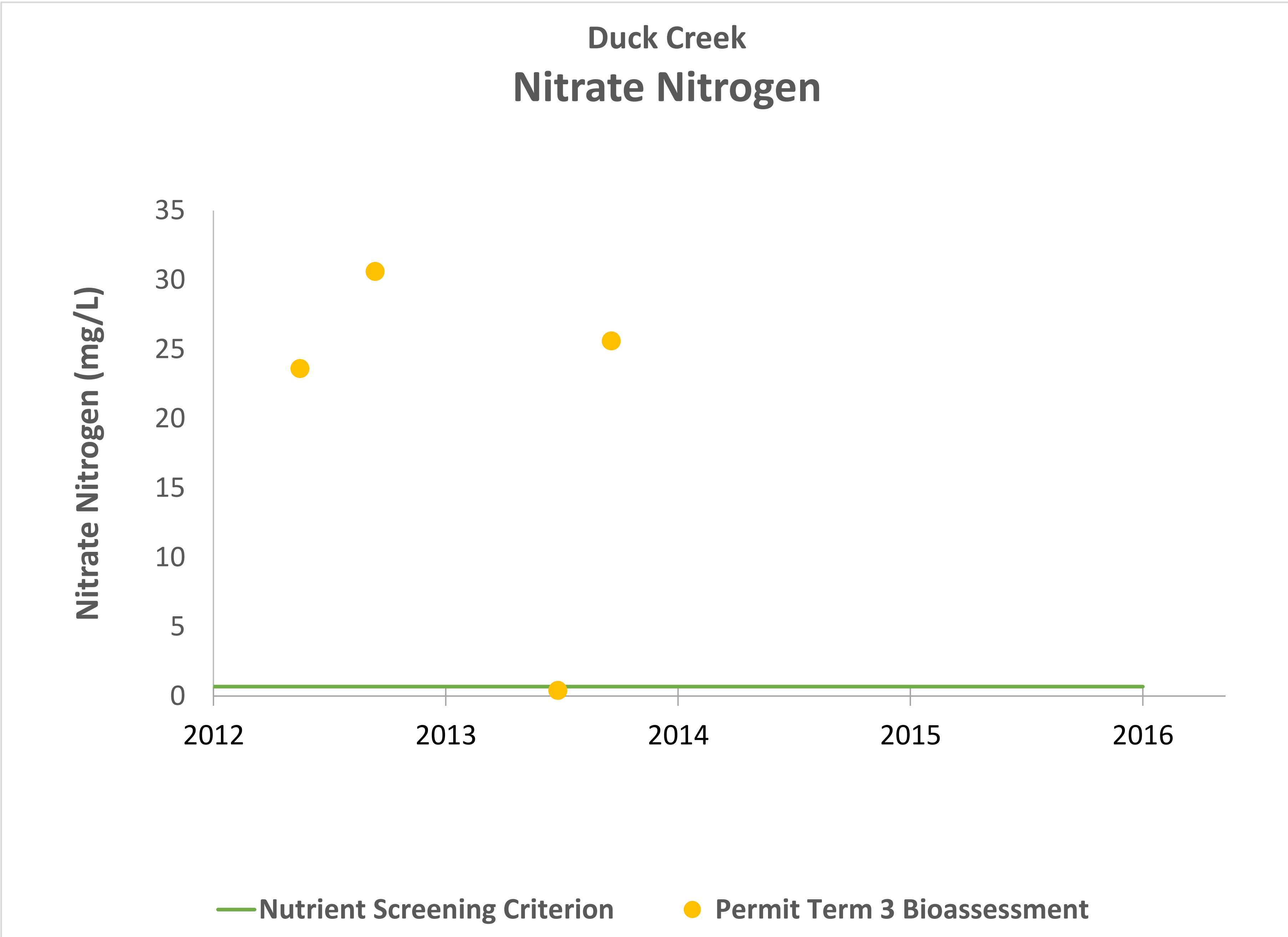

Duck Creek
Temperature
Temperature (°F)
100
90
80
70
60
50
40
30
20
10
0
2012
2013
2014
2015
2016
Permit Term 3
Basin Specific Criterion
Permit Term 3 Bioassessment 24hr Avg

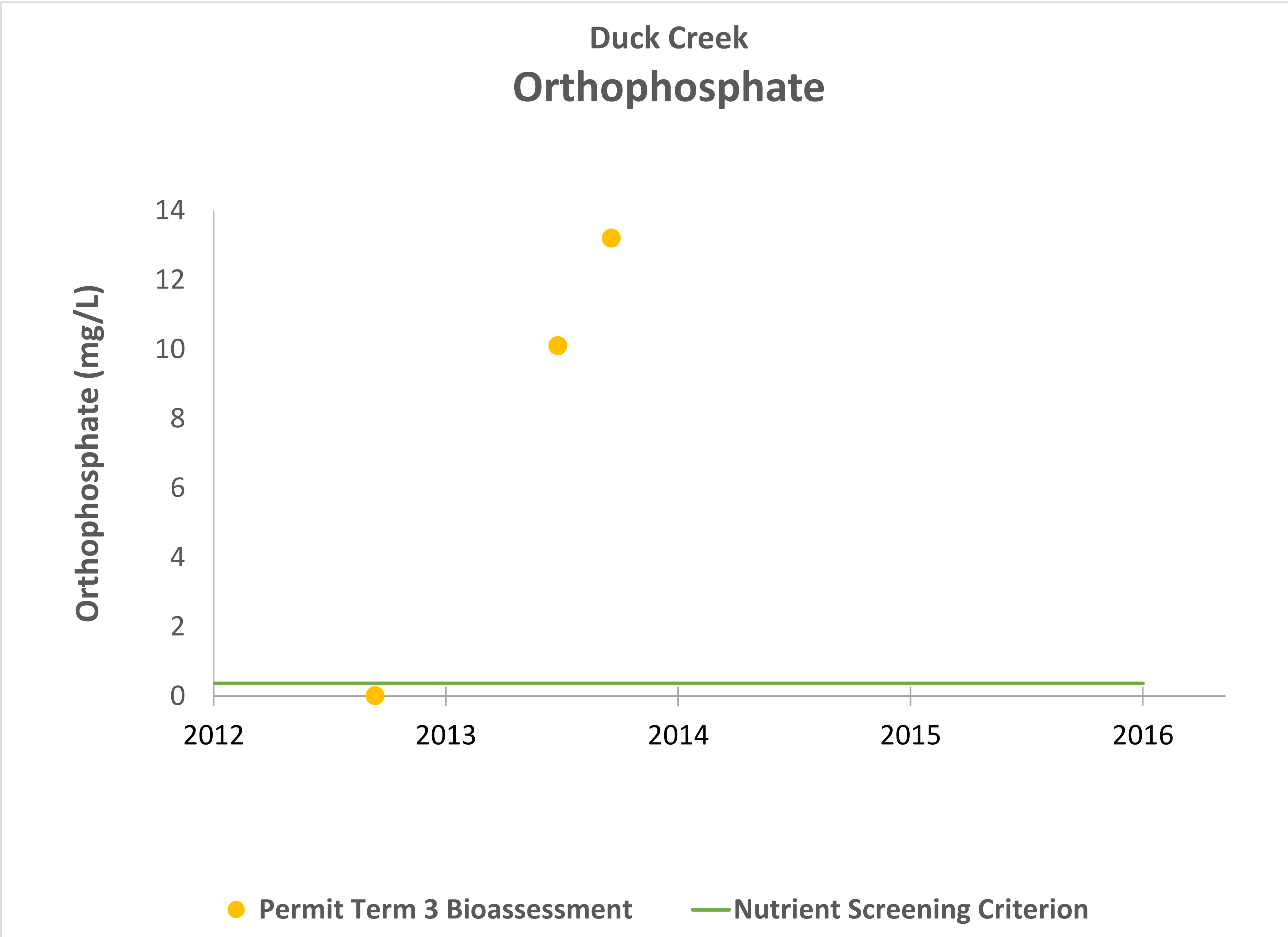

Duck Creek
E.Coli
E. Coli (col/100 mL)
1000000
100000
10000
1000
100
10
1
0.1
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
Term 3
Term 2
PCR Geomean
PCR Single Sample
Permit Term 3 Bioassessment

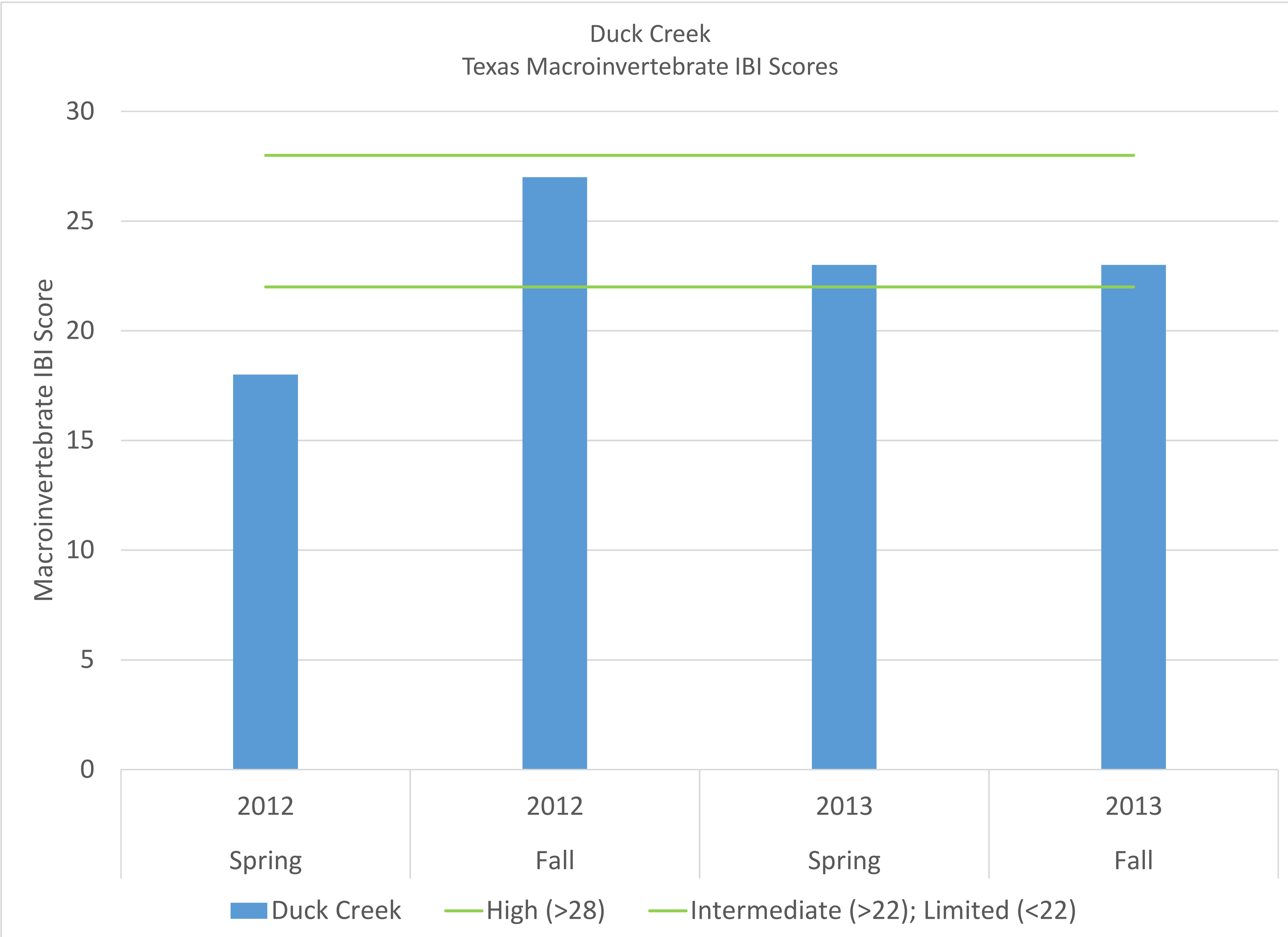


Duck Creek
Total Coliform
Total Coliform (col/100 mL)
1000000
100000
10000
1000
100
10
1
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
Permit Term 3
Permit Term 2

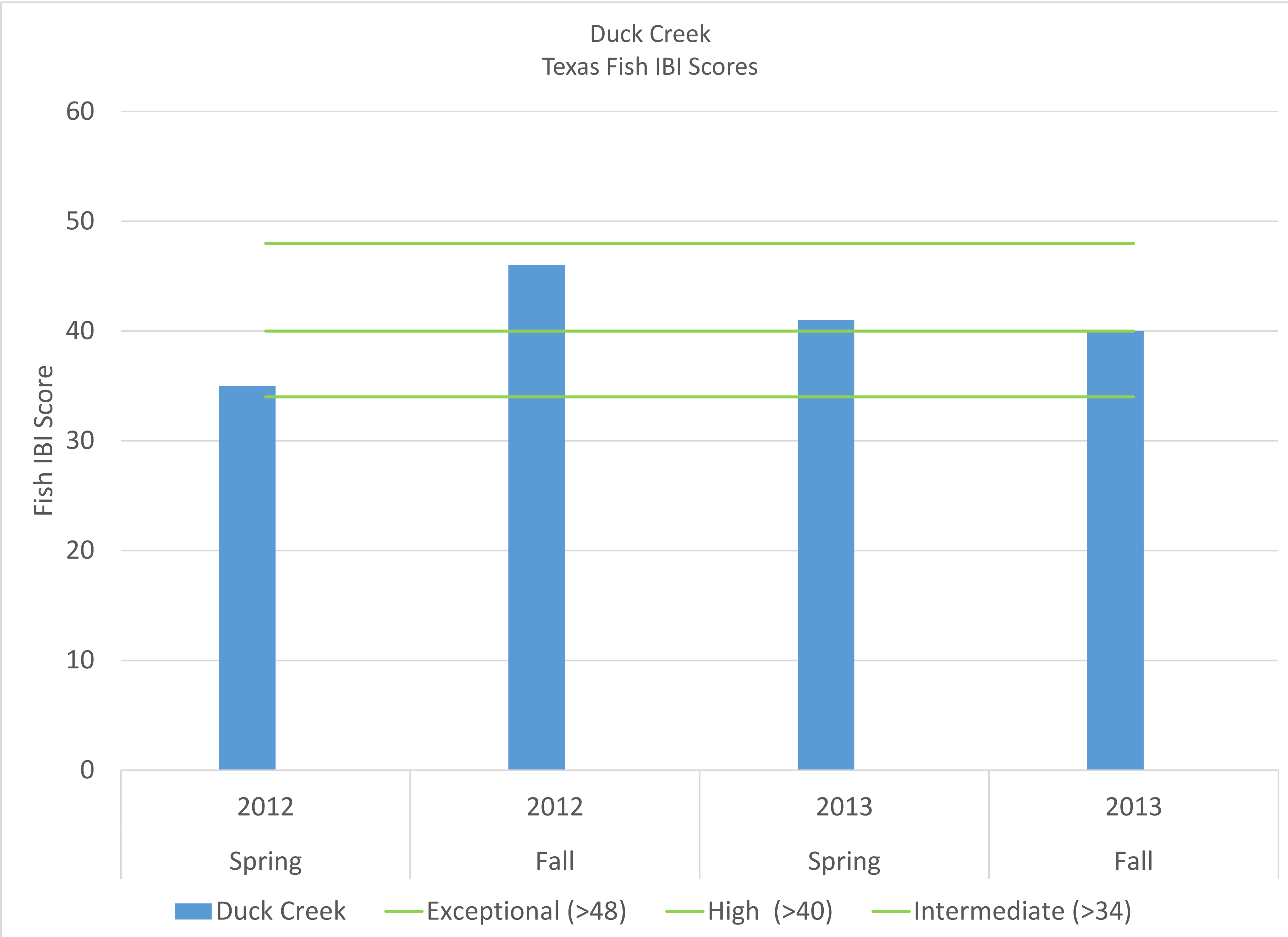

Duck Creek
Dissolved Oxygen
Dissolved Oxygen (mg/L)
0
1
2
3
4
5
6
7
8
2012
2013
2014
2015
2016
Basin Specific Criterion
Permit Term 3 Bioassessment 24hr Avg


Duck Creek
Nitrate Nitrogen
Nitrate Nitrogen (mg/L)
35
30
25
20
15
10
5
0
2012
2013
2014
2015
2016
Nutrient Screening Criterion
Permit Term 3 Bioassessment

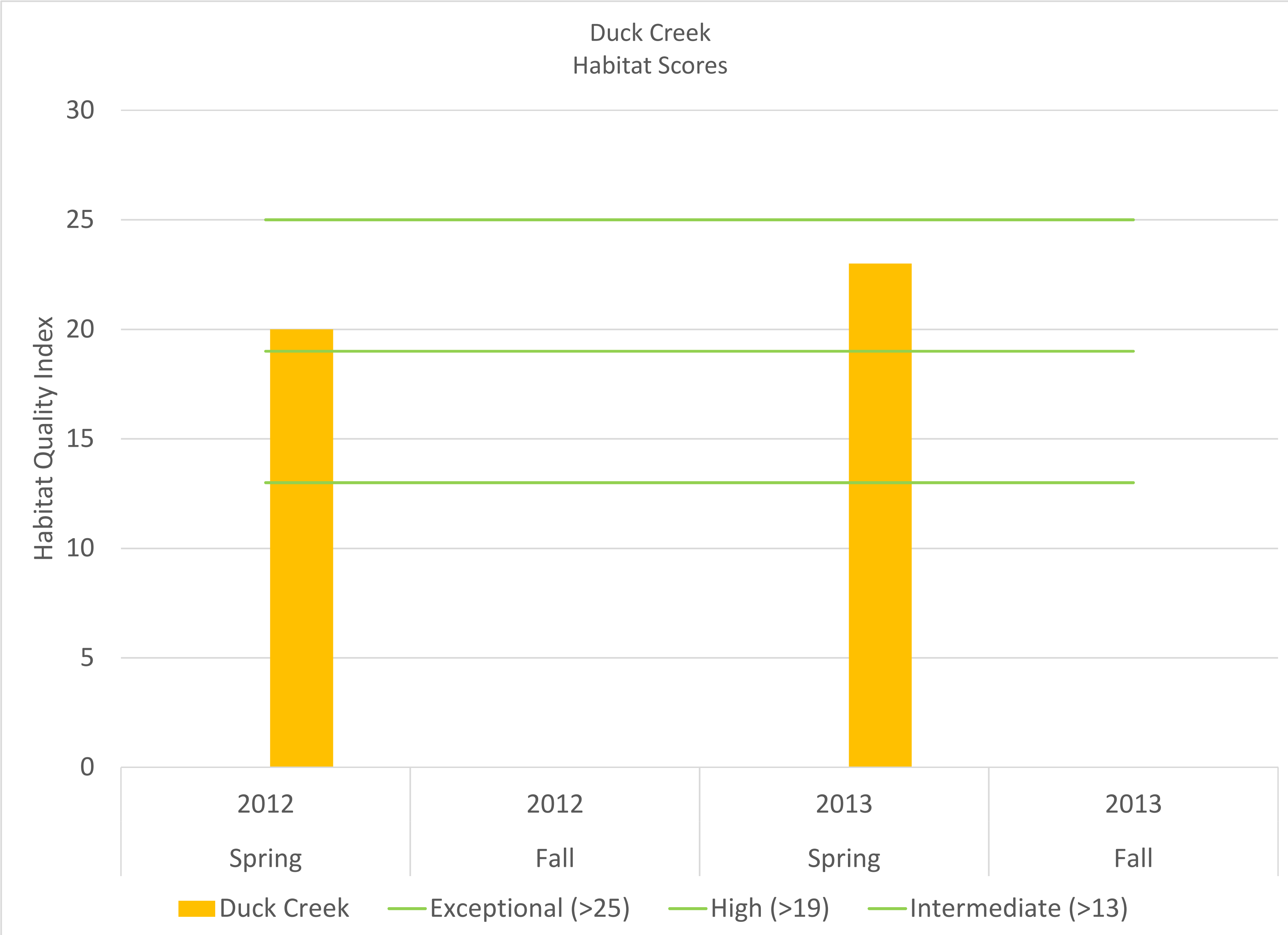

Duck Creek
Orthophosphate
Orthophosphate (mg/L)
14
12
10
8
6
4
2
0
2012
2013
2014
2015
2016
Permit Term 3 Bioassessment
Nutrient Screening Criterion



Duck Creek
Texas Macroinvertebrate IBI Scores
Macroinvertebrate IBI Score
30
25
20
15
10
5
0
2012
Spring
2012
Fall
2013
Spring
2013
Fall
Duck Creek
High (>28)
Intermediate (>22); Limited (<22)

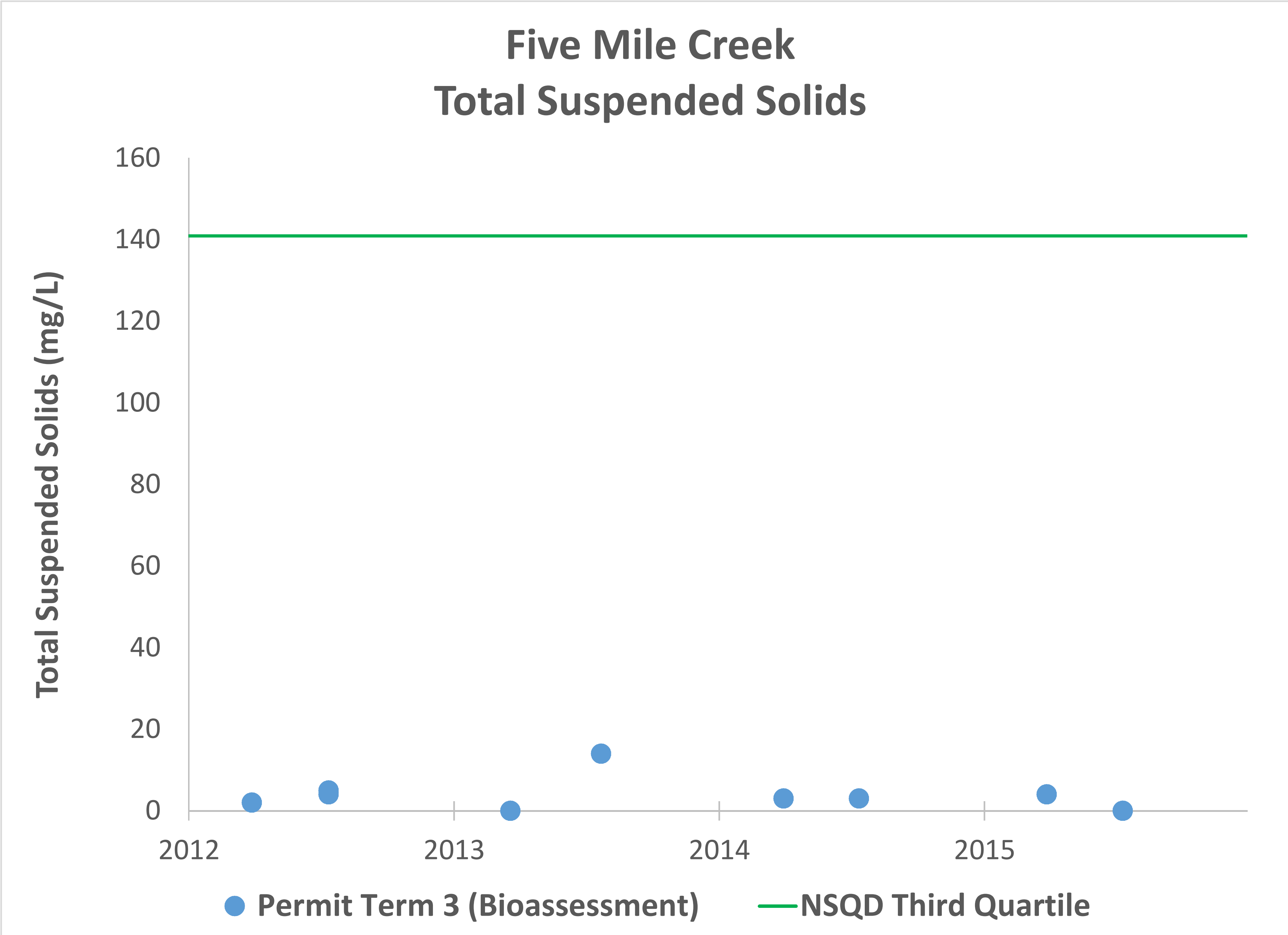


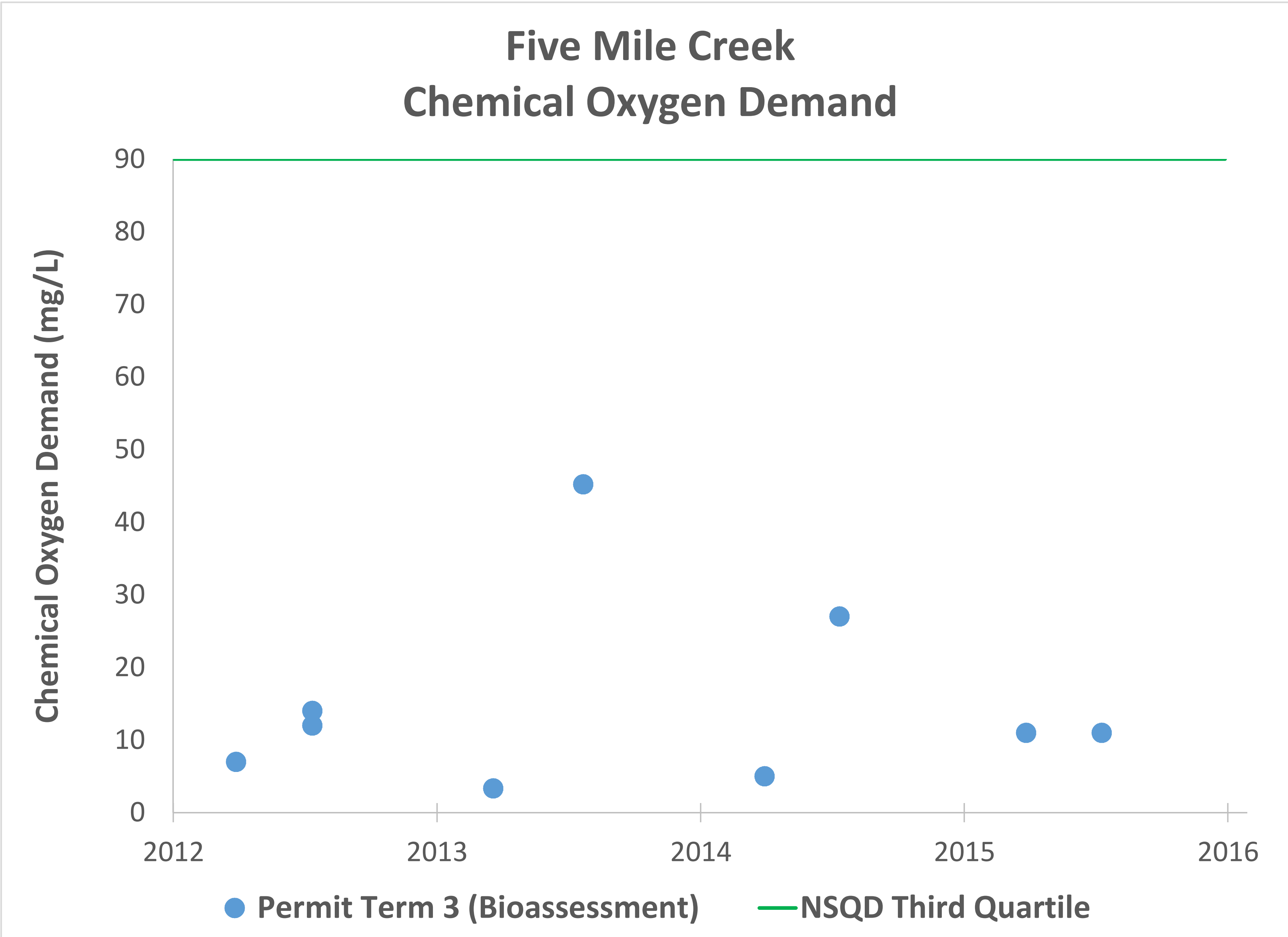
Duck Creek
Texas Fish IBI Scores
Fish IBI Score
60
50
40
30
20
10
0
2012
Spring
2012
Fall
2013
Spring
2013
Fall
Duck Creek
Exceptional (>48)
High (>40)
Intermediate (>34)

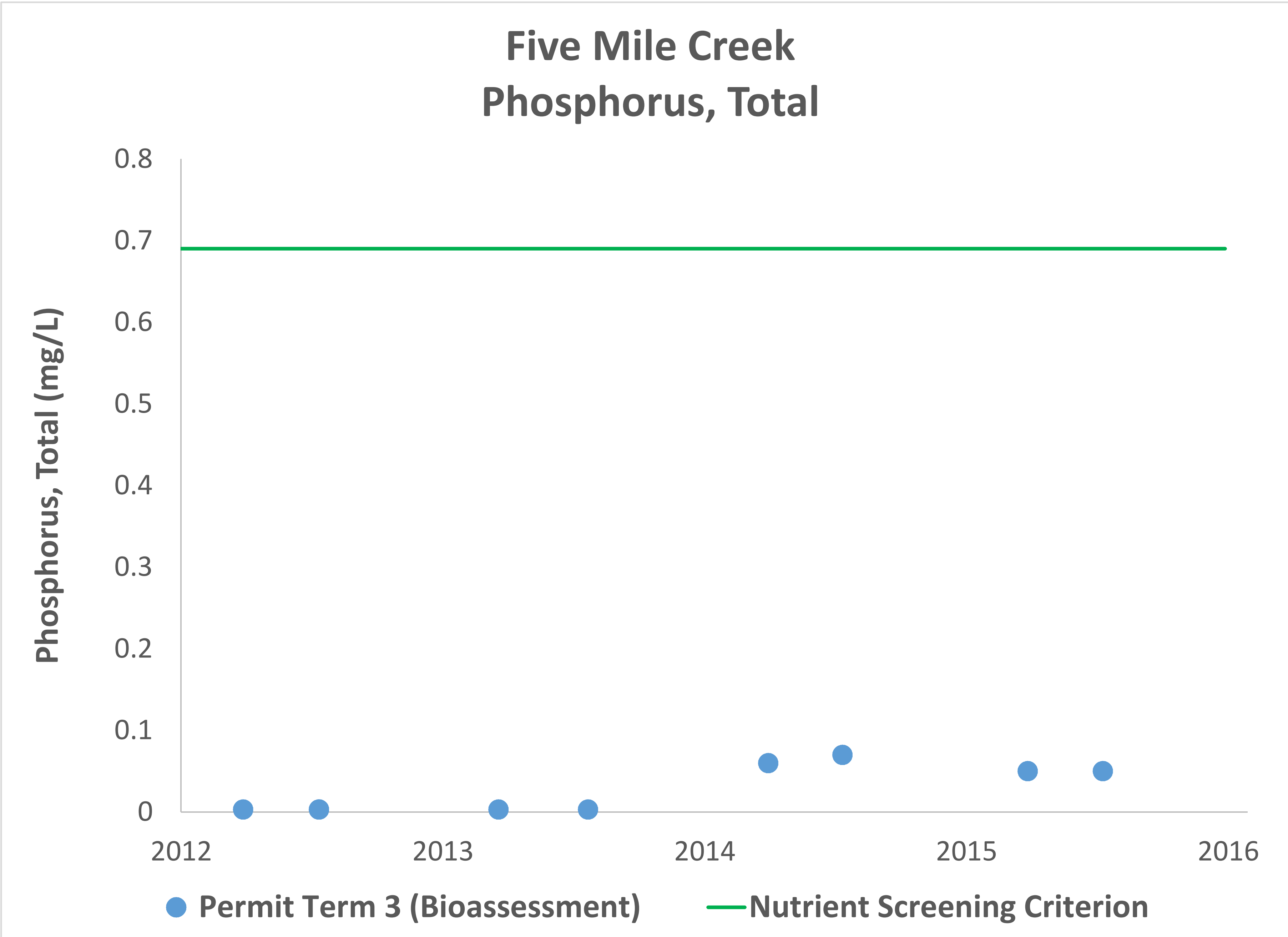

Duck Creek
Habitat Scores
Habitat Quality Index
30
25
20
15
10
5
0
2012
Spring
2012
Fall
2013
Spring
2013
Fall
Duck Creek
Exceptional (>25)
High (>19)
Intermediate (>13)

Appendix J

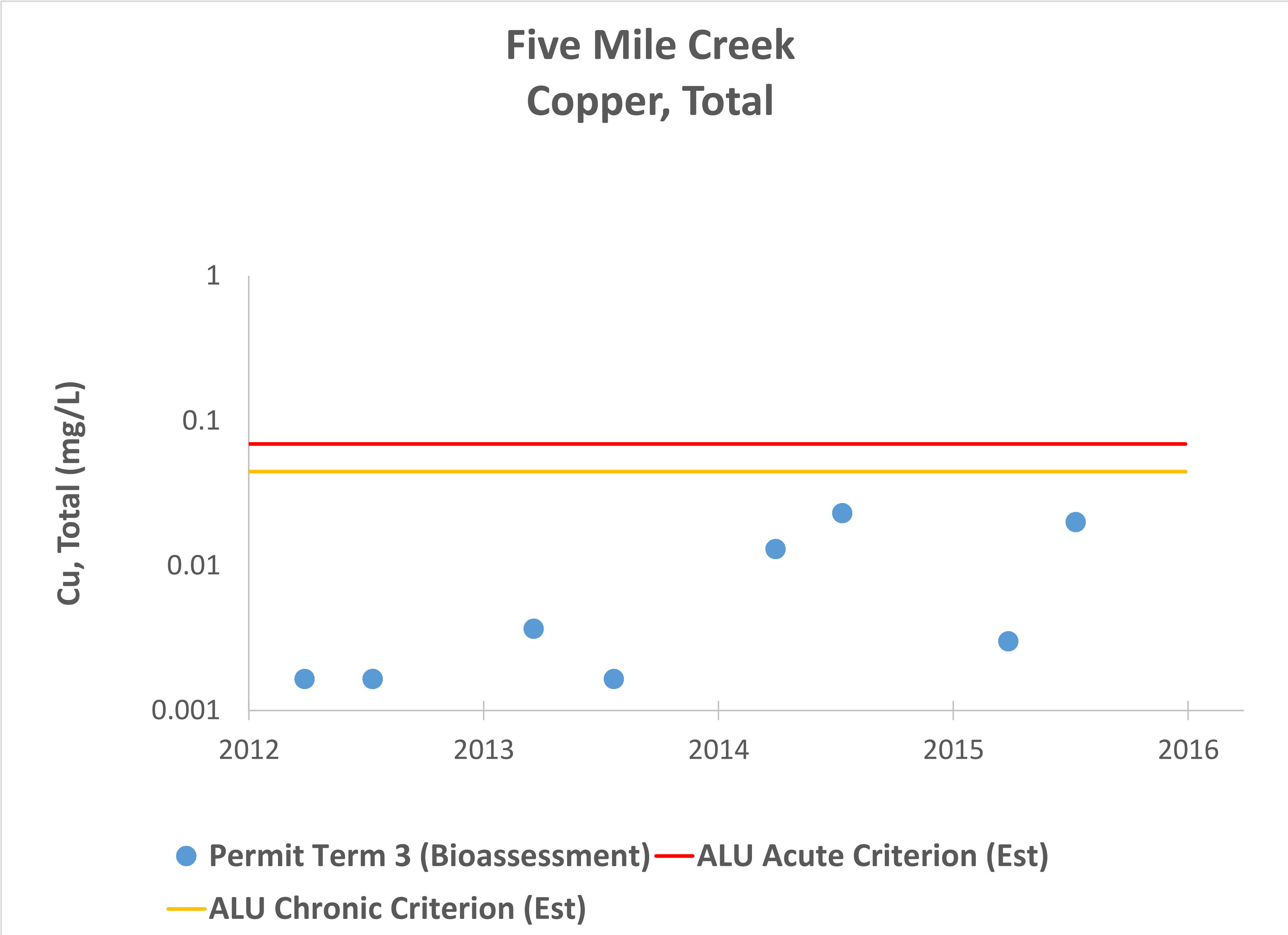
Five Mile Creek Water Quality Data Graphs

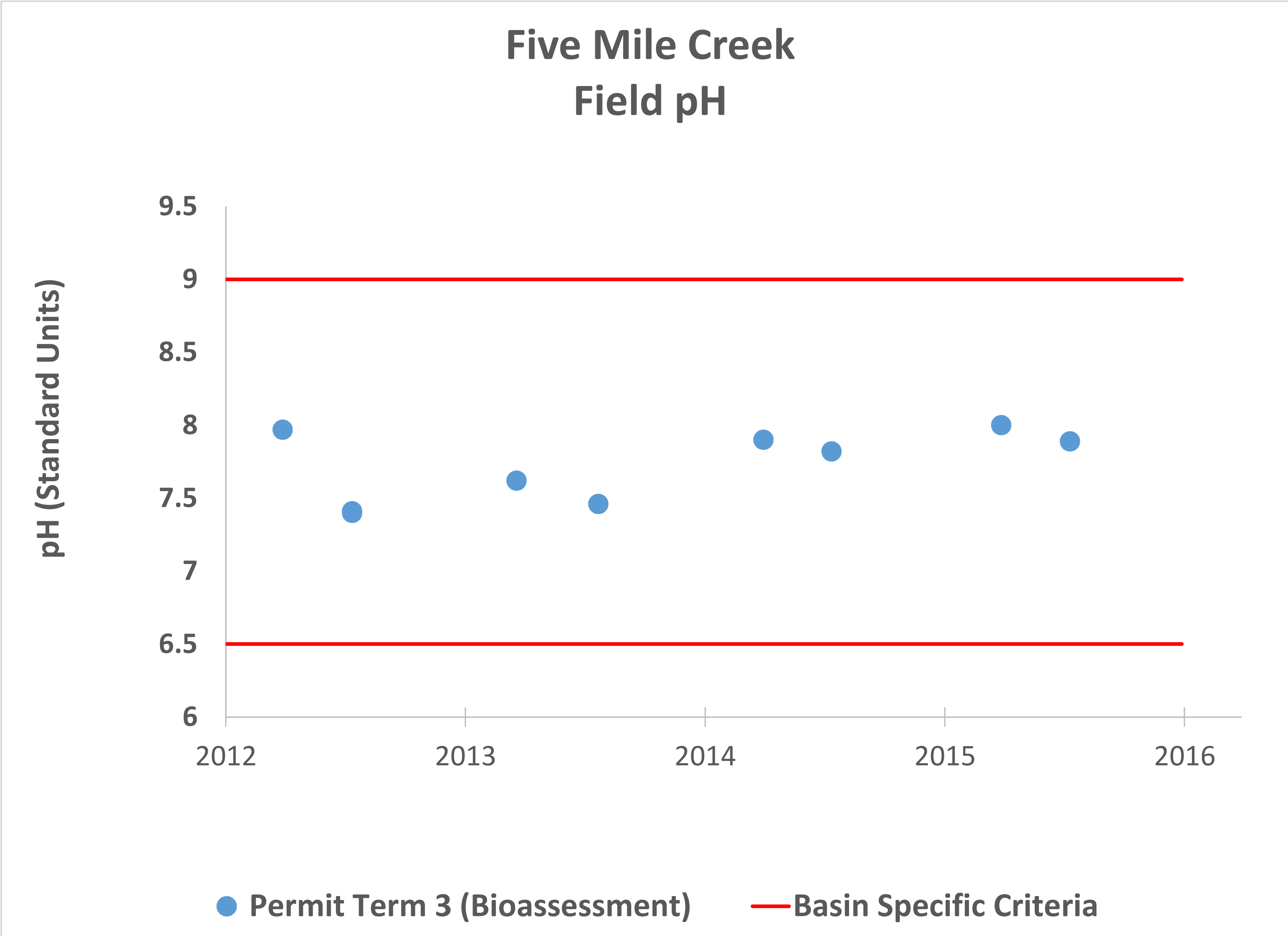

Five Mile Creek
Total Suspended Solids
Total Suspended Solids (mg/L)
160
140
120
100
80
60
40
20
0
2012
2013
2014
2015
Permit Term 3 (Bioassessment)
NSQD Third Quartile

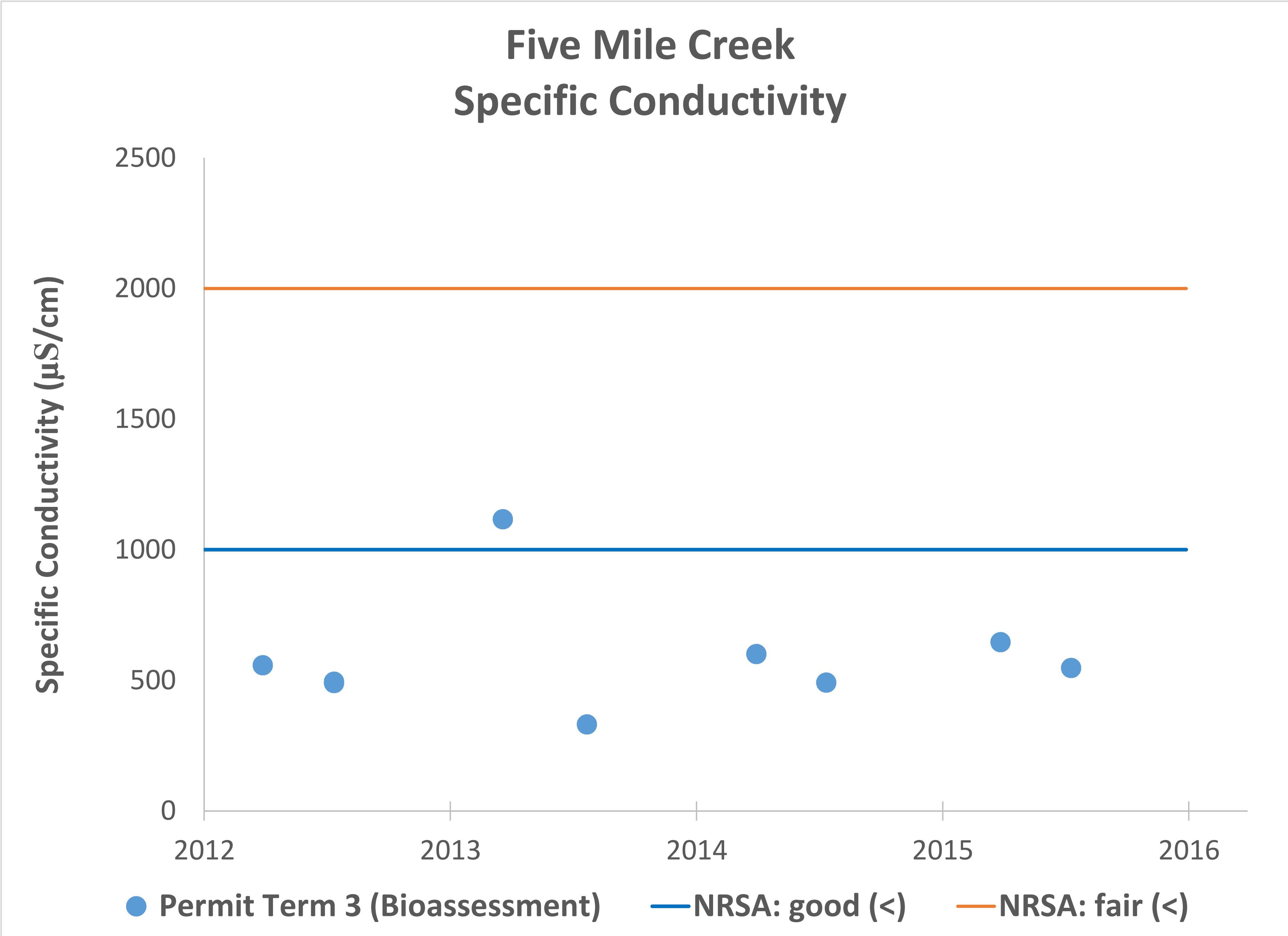

Five Mile Creek
Chemical Oxygen Demand
Chemical Oxygen Demand (mg/L)
0
10
20
30
40
50
60
70
80
90
2012
2013
2014
2015
2016
Permit Term 3 (Bioassessment)
NSQD Third Quartile

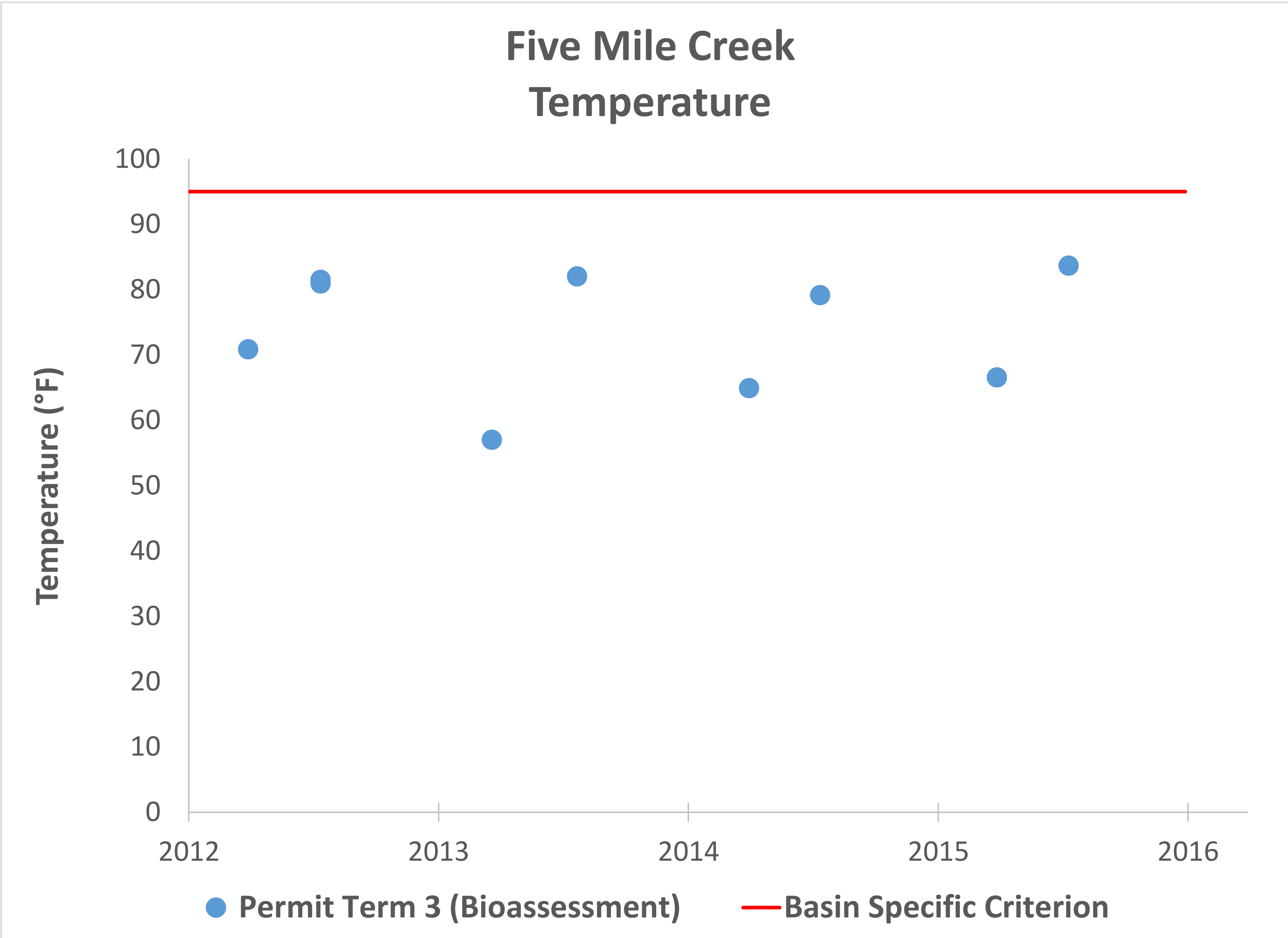


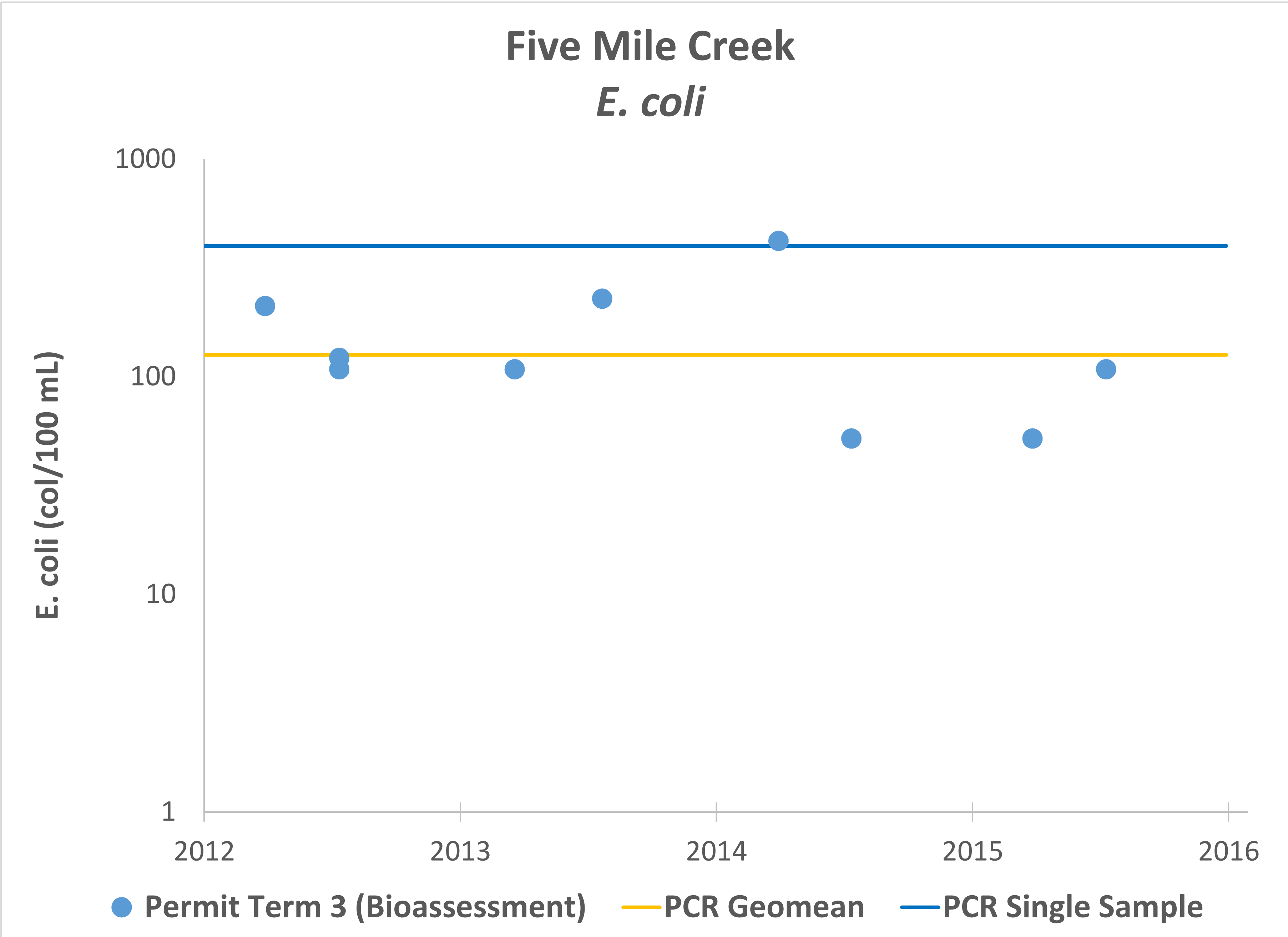
Five Mile Creek
Phosphorus, Total
Phosphorus, Total (mg/L)
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
2012
2013
2014
2015
2016
Permit Term 3 (Bioassessment)
Nutrient Screening Criterion


Five Mile Creek
Copper, Total
Cu, Total (mg/L)
1
0.1
0.01
0.001
2012
2013
2014
2015
2016
Permit Term 3 (Bioassessment)
ALU Acute Criterion (Est)
ALU Chronic Criterion (Est)

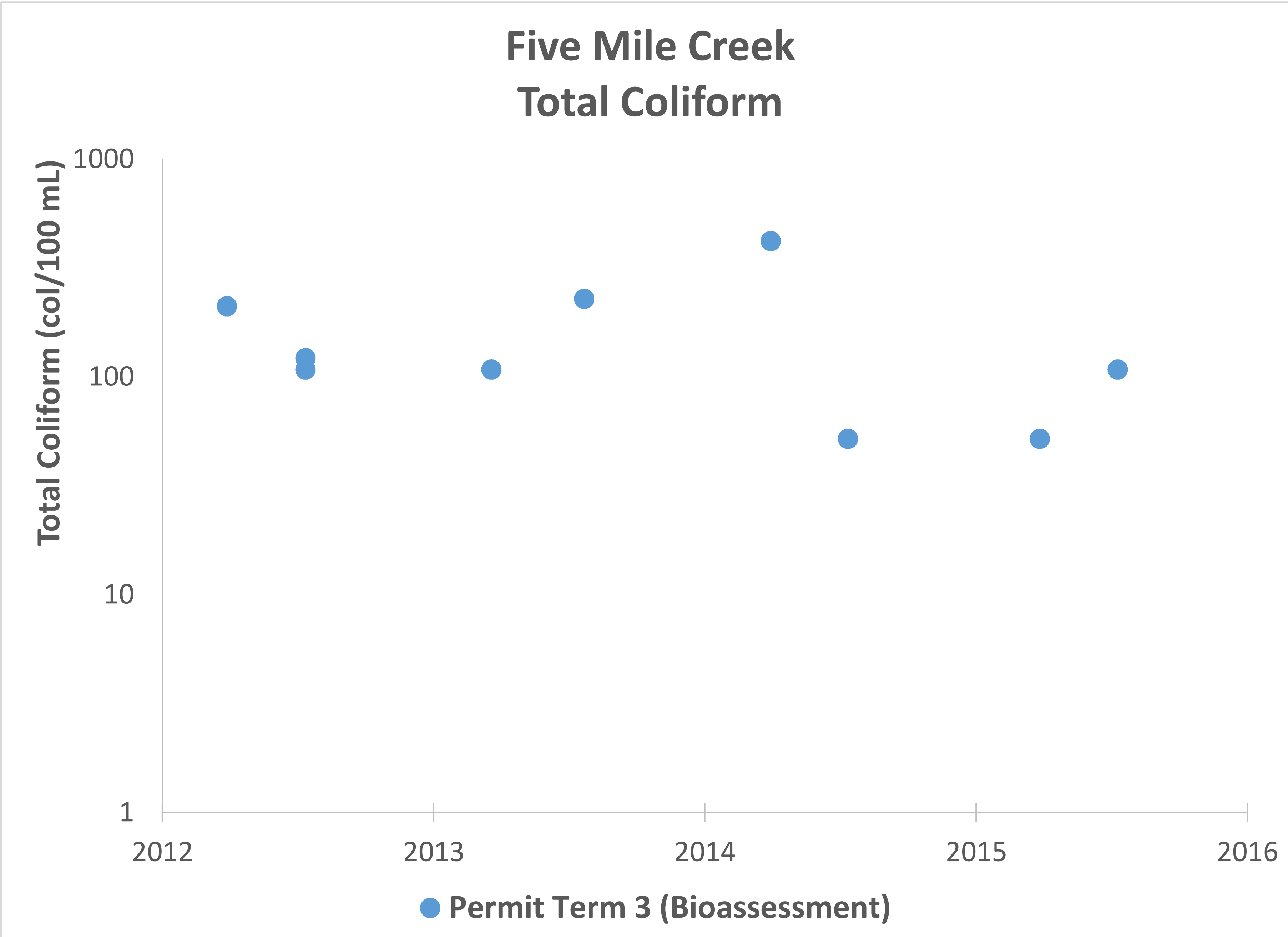

Five Mile Creek
Field pH
pH (Standard Units)
9.5
9
8.5
8
7.5
7
6.5
6
2012
2013
2014
2015
2016
Permit Term 3 (Bioassessment)
Basin Specific Criteria

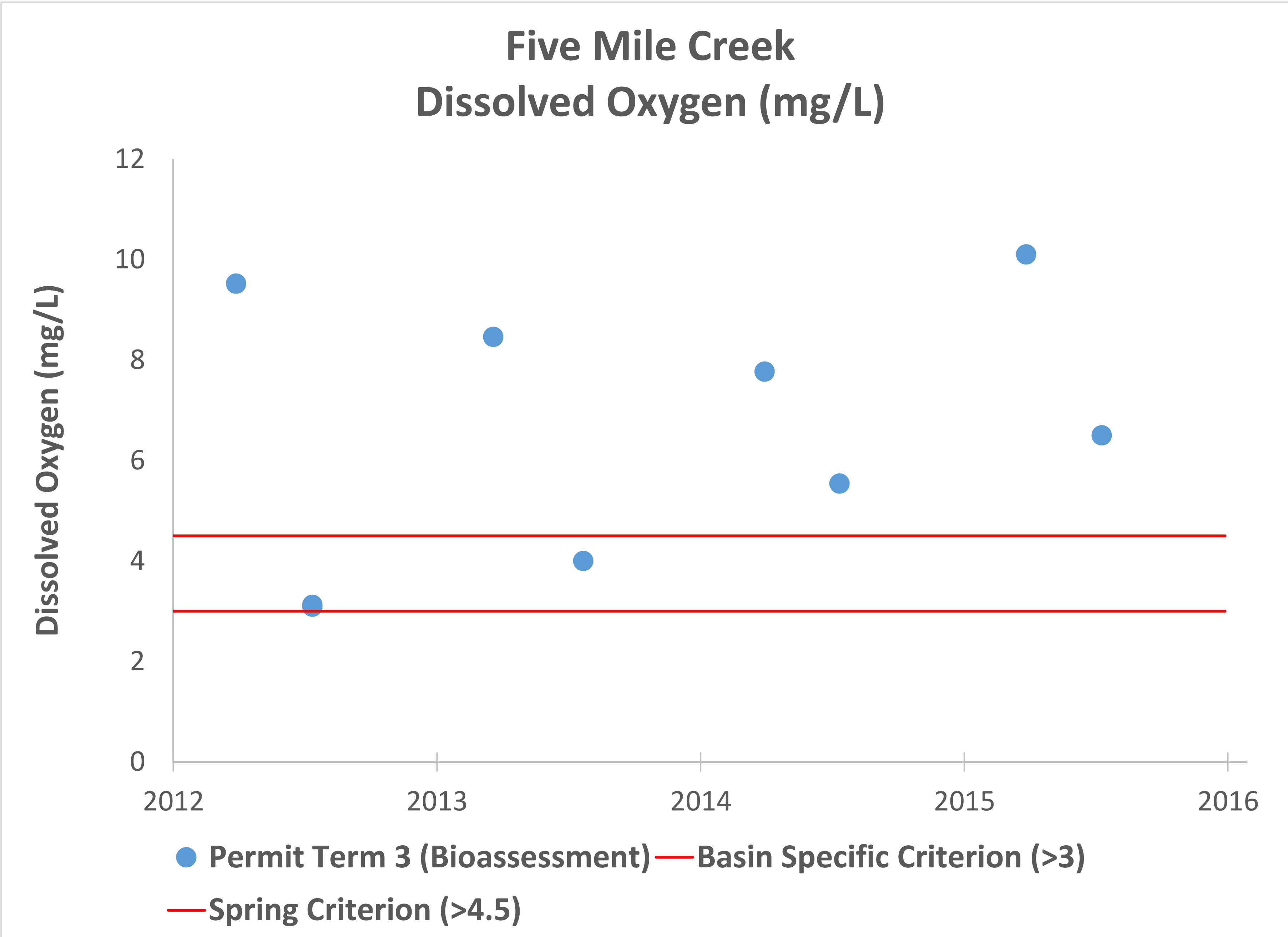

Five Mile Creek
Specific Conductivity
Specific Conductivity (µS/cm)
2500
2000
1500
1000
500
0
2012
2013
2014
2015
2016
Permit Term 3 (Bioassessment)
NRSA: good (<)
NRSA: fair (<)


Five Mile Creek
Temperature
Temperature (°F)
100
90
80
70
60
50
40
30
20
10
0
2012
2013
2014
2015
2016
Permit Term 3 (Bioassessment)
Basin Specific Criterion

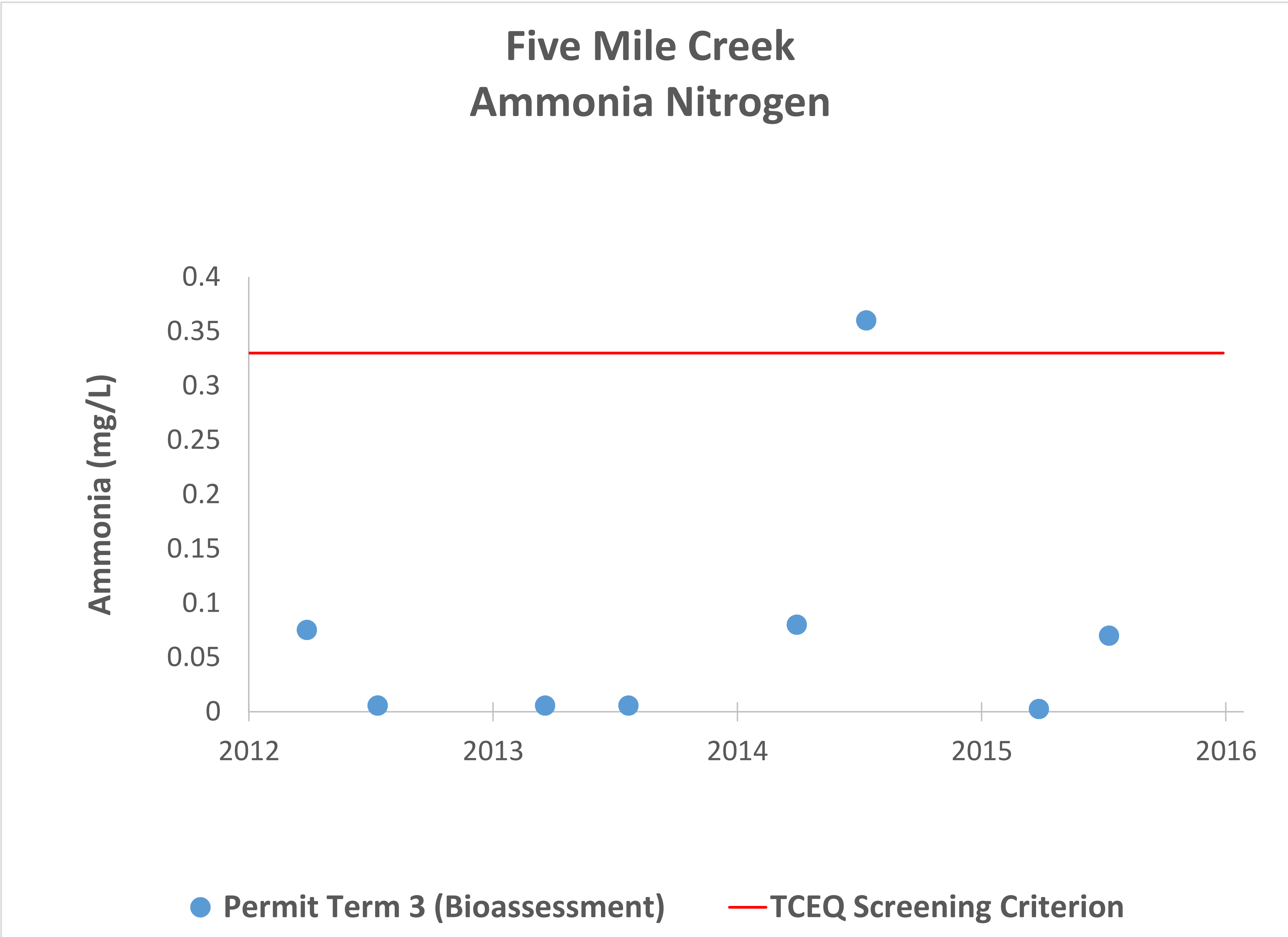


Five Mile Creek
E. coli
1000
100
10
1
E. coli (col/100 mL)
2012
2013
2014
2015
2016
Permit Term 3 (Bioassessment)
PCR Geomean
PCR Single Sample

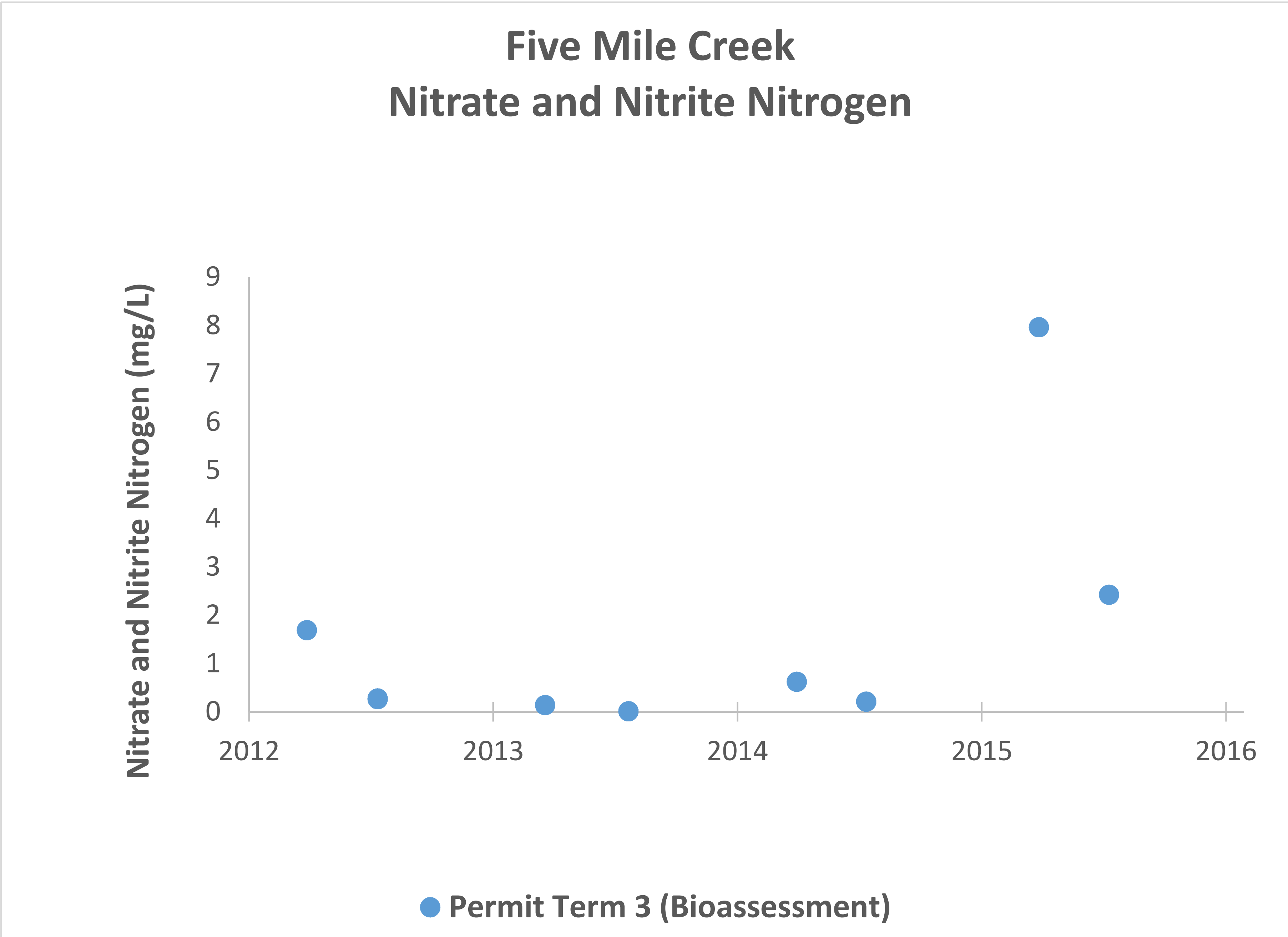

Five Mile Creek
Total Coliform
Total Coliform (col/100 mL)
1000
100
10
1
2012
2013
2014
2015
2016
Permit Term 3 (Bioassessment)

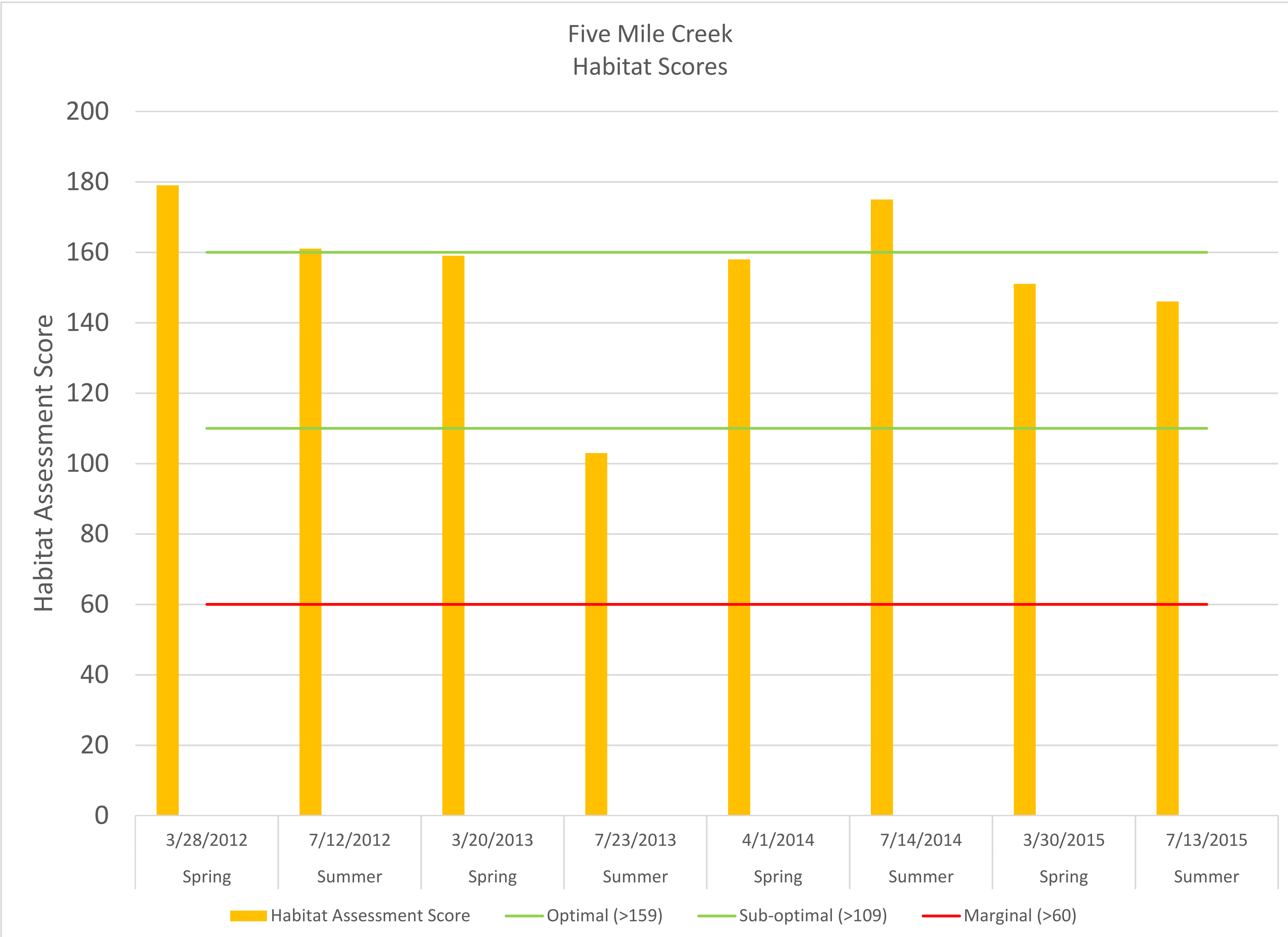


Five Mile Creek
Dissolved Oxygen (mg/L)
Dissolved Oxygen (mg/L)
0
2
4
6
8
10
12
2012
2013
2014
2015
2016
Permit Term 3 (Bioassessment)
Basin Specific Criterion (>3)
Spring Criterion (>4.5)

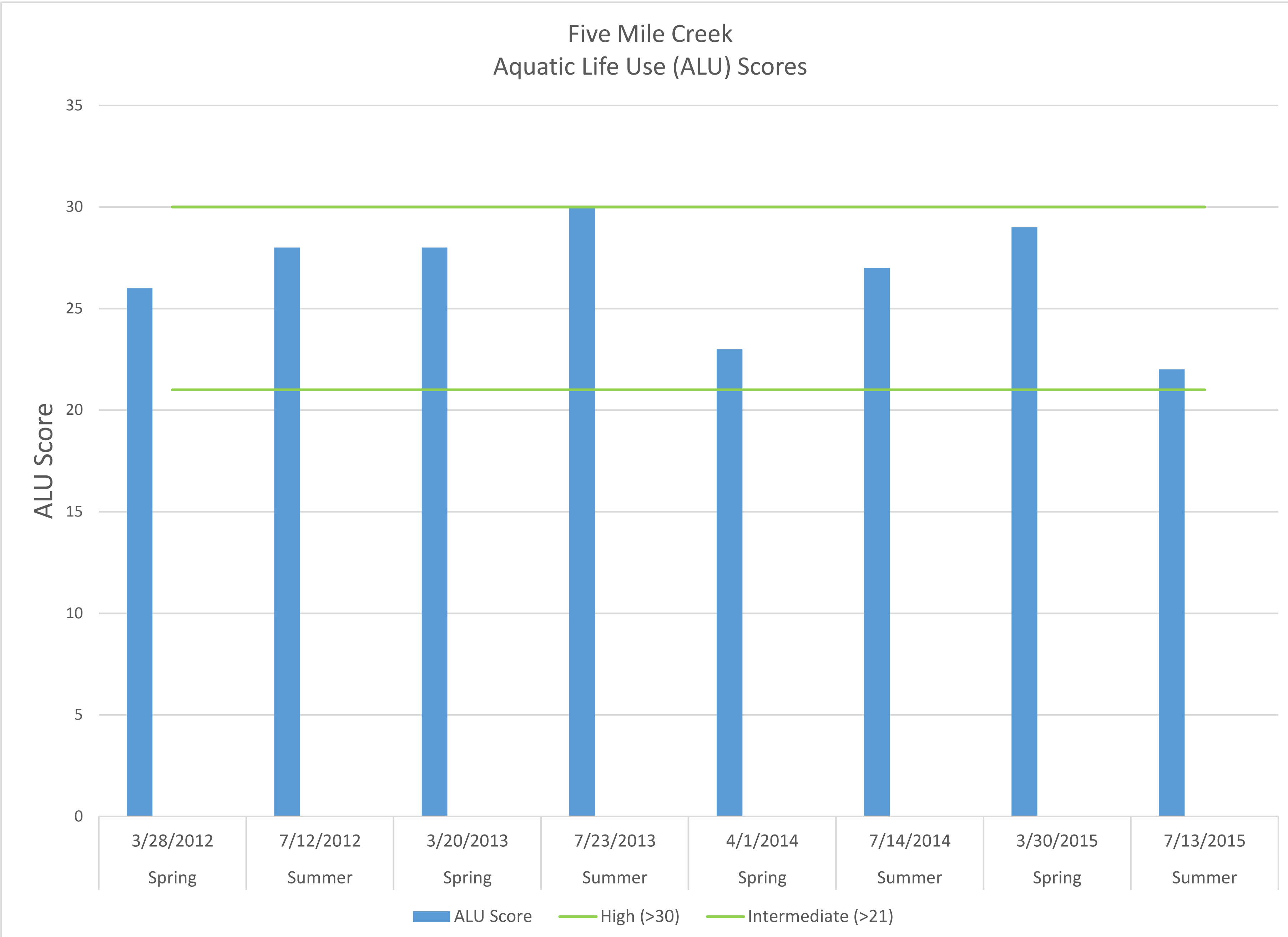


Five Mile Creek
Ammonia Nitrogen
Ammonia (mg/L)
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
2012
2013
2014
2015
2016
Permit Term 3 (Bioassessment)
TCEQ Screening Criterion


Five Mile Creek
Nitrate and Nitrite Nitrogen
Nitrate and Nitrite Nitrogen (mg/L)
9
8
7
6
5
4
3
2
1
0
2012
2013
2014
2015
2016
Permit Term 3 (Bioassessment)

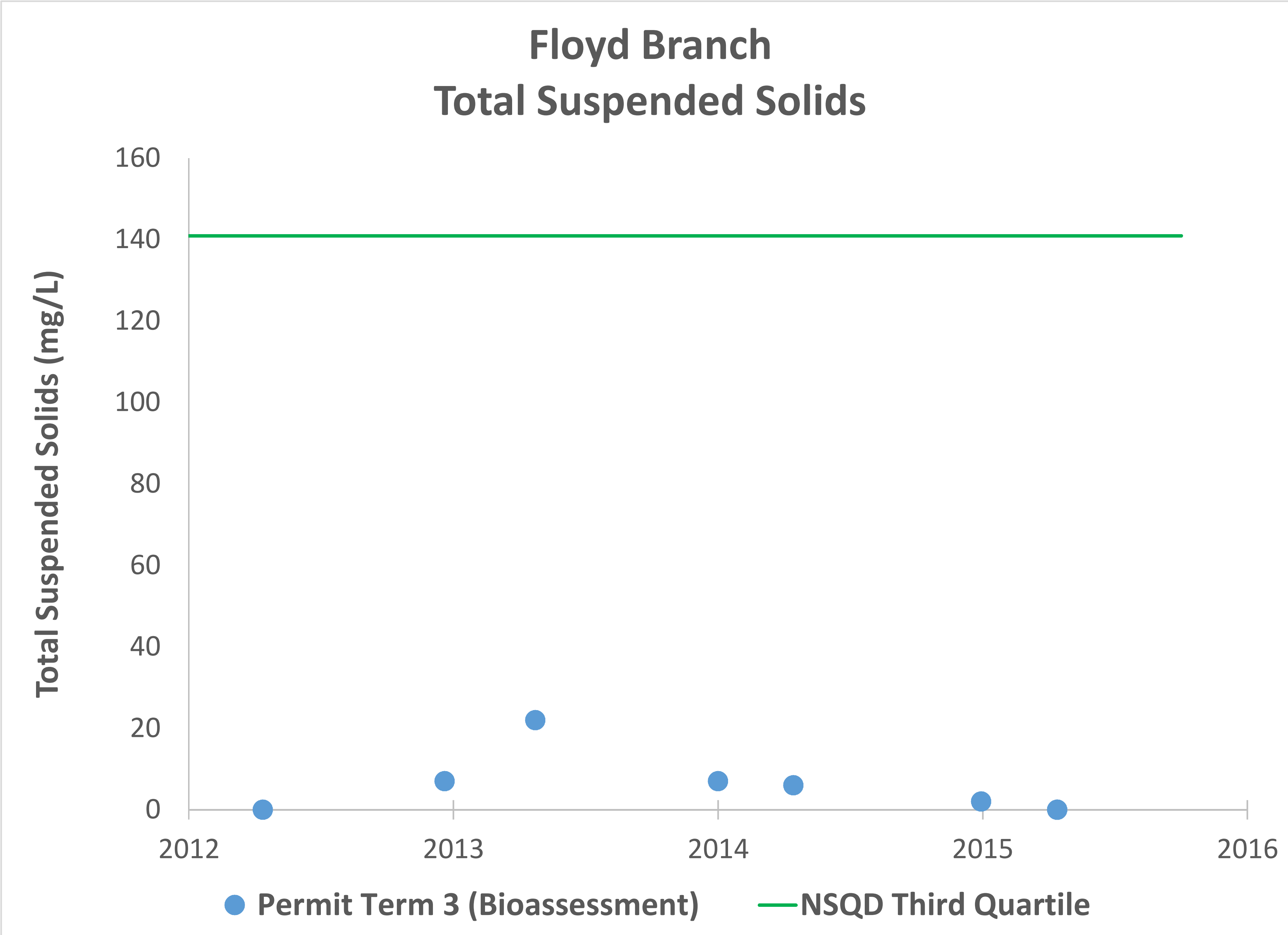


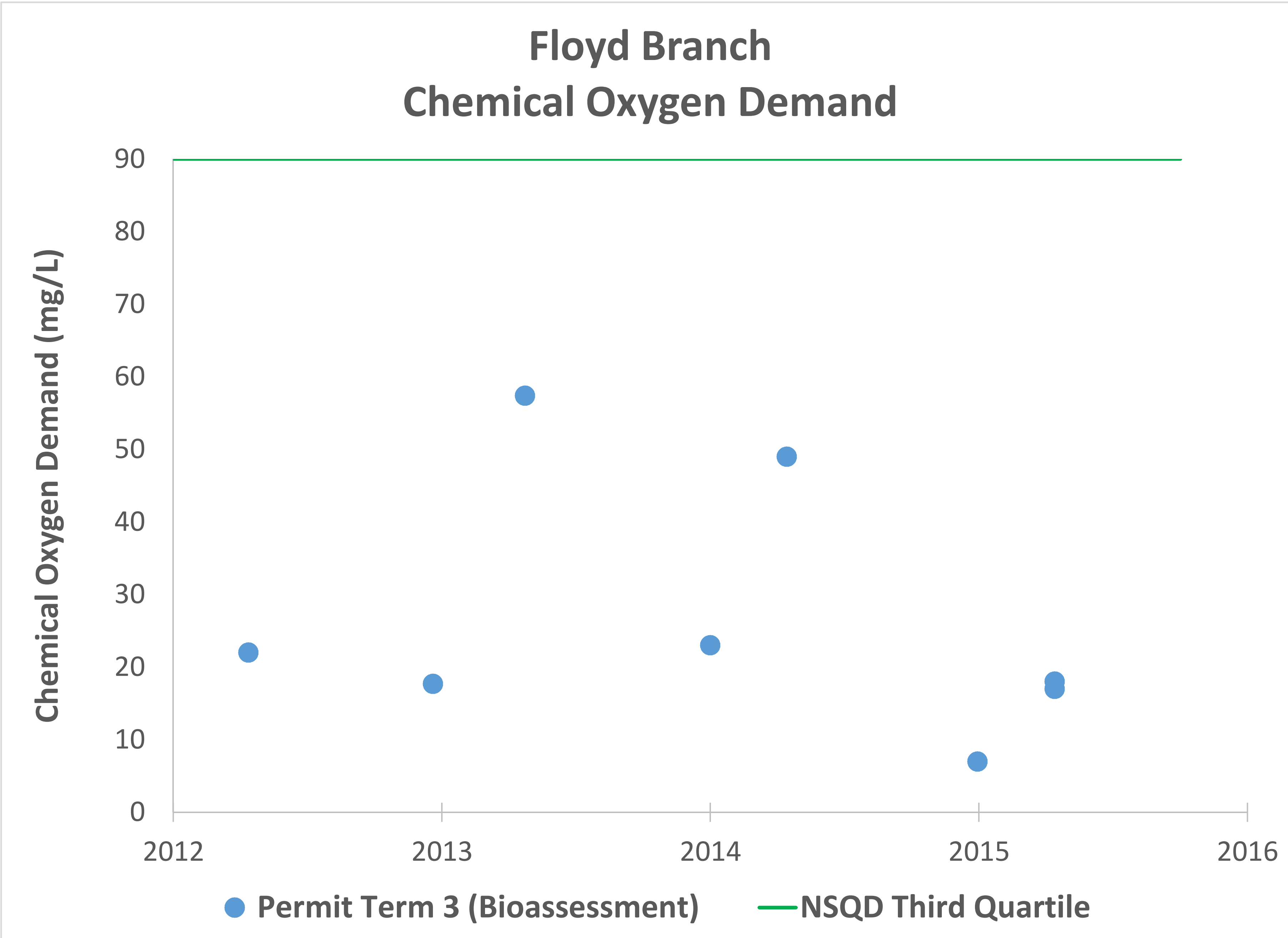
Five Mile Creek
Habitat Scores
Habitat Assessment Score
200
180
160
140
120
100
80
60
40
20
0
3/28/2012
Spring
7/12/2012
Summer
3/20/2013
Spring
7/23/2013
Summer
4/1/2014
Spring
7/14/2014
Summer
3/30/2015
Spring
7/13/2015
Summer
Habitat Assessment Score
Optimal (>159)
Sub-optimal (>109)
Marginal (>60)


Five Mile Creek
Aquatic Life Use (ALU) Scores
ALU Score
35
30
25
20
15
10
5
0
3/28/2012
Spring
7/12/2012
Summer
3/20/2013
Spring
7/23/2013
Summer
4/1/2014
Spring
7/14/2014
Summer
3/30/2015
Spring
7/13/2015
Summer
ALU Score
High (>30)
Intermediate (>21)

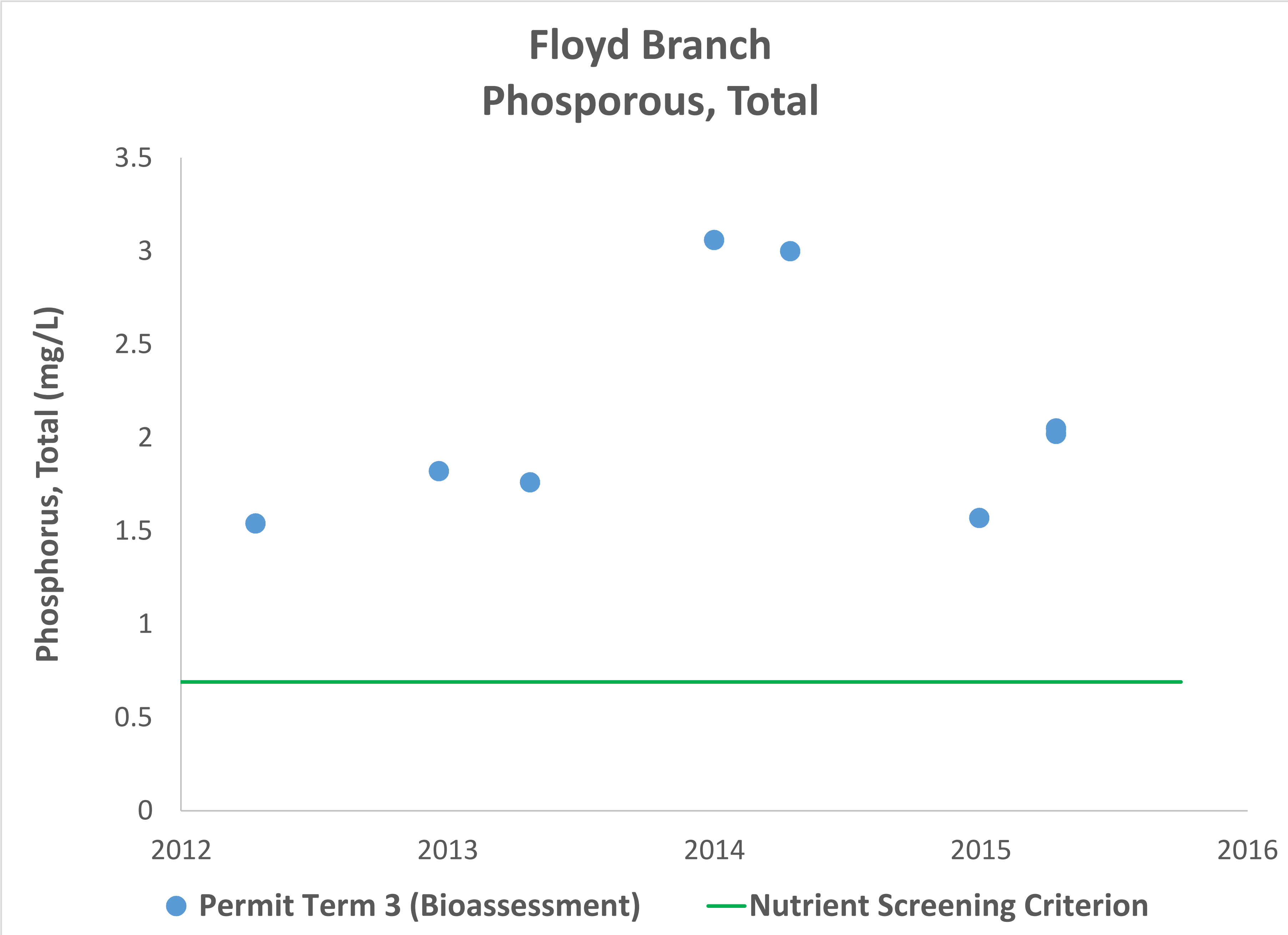
Appendix K

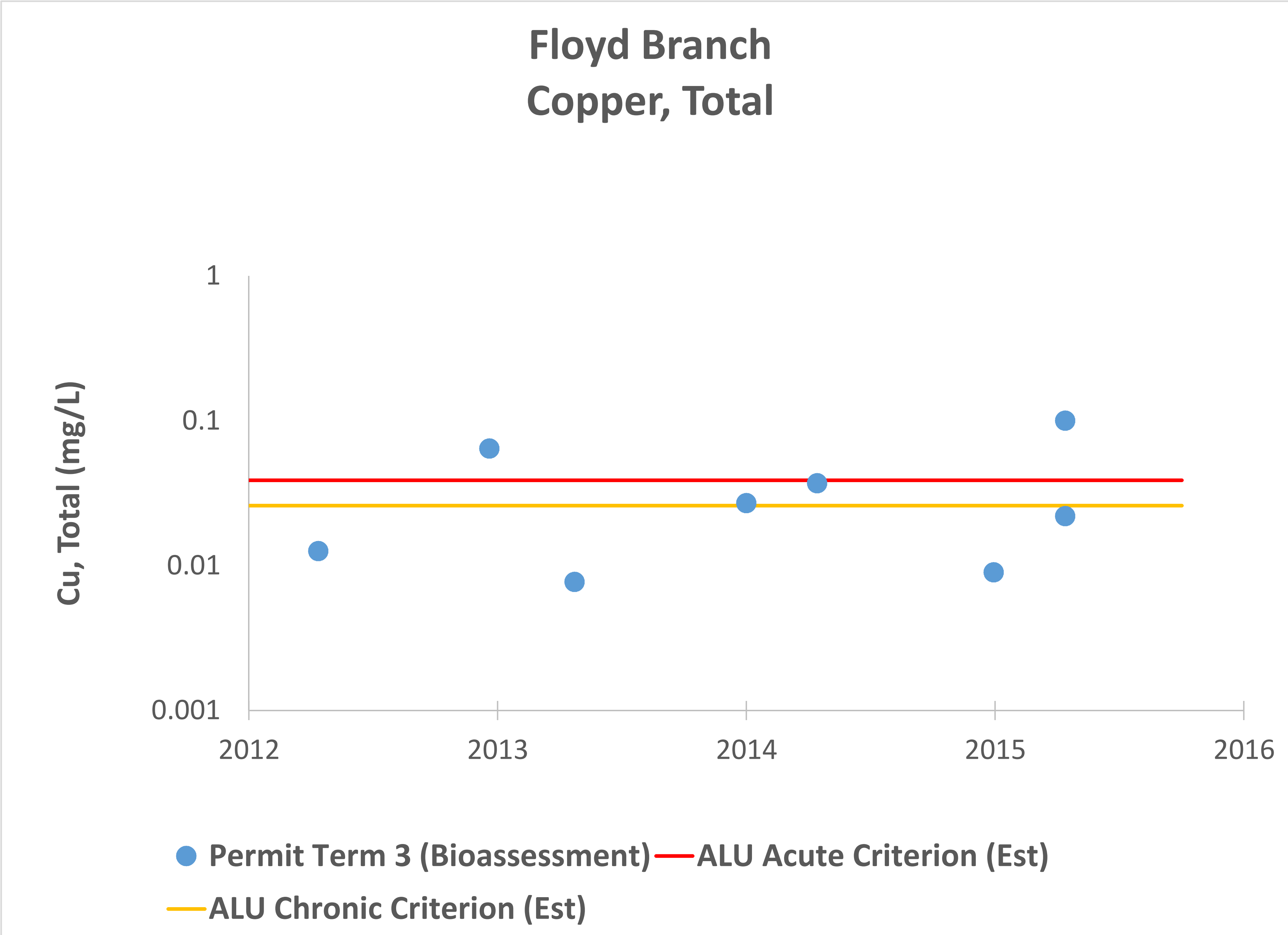
Floyd Branch Water Quality
Data Graphs


Floyd Branch
Total Suspended Solids
Total Suspended Solids (mg/L)
160
140
120
100
80
60
40
20
0
2012
2013
2014
2015
2016
Permit Term 3 (Bioassessment)
NSQD Third Quartile

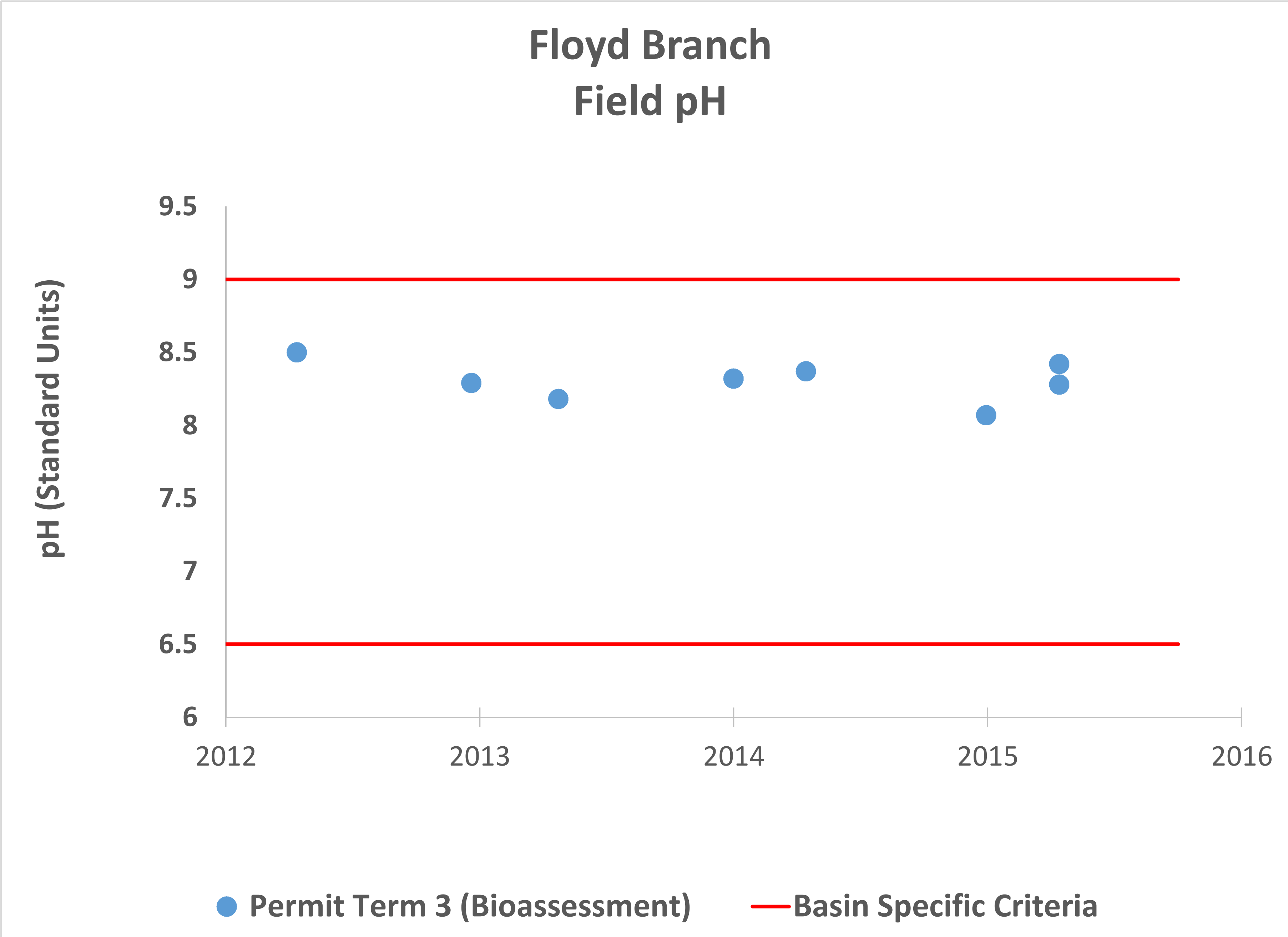


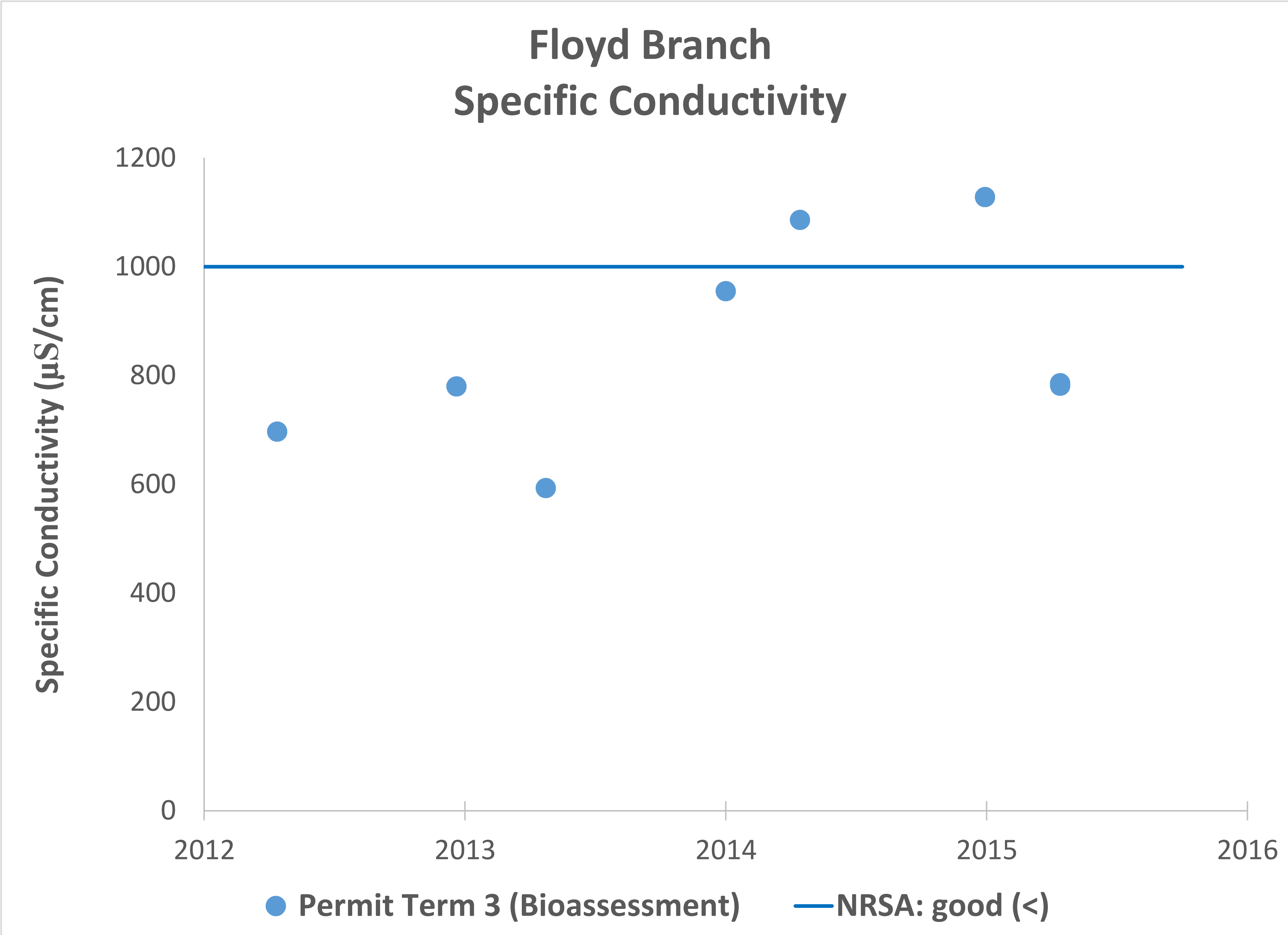
Floyd Branch
Chemical Oxygen Demand
Chemical Oxygen Demand (mg/L)
0
10
20
30
40
50
60
70
80
90
2012
2013
2014
2015
2016
Permit Term 3 (Bioassessment)
NSQD Third Quartile

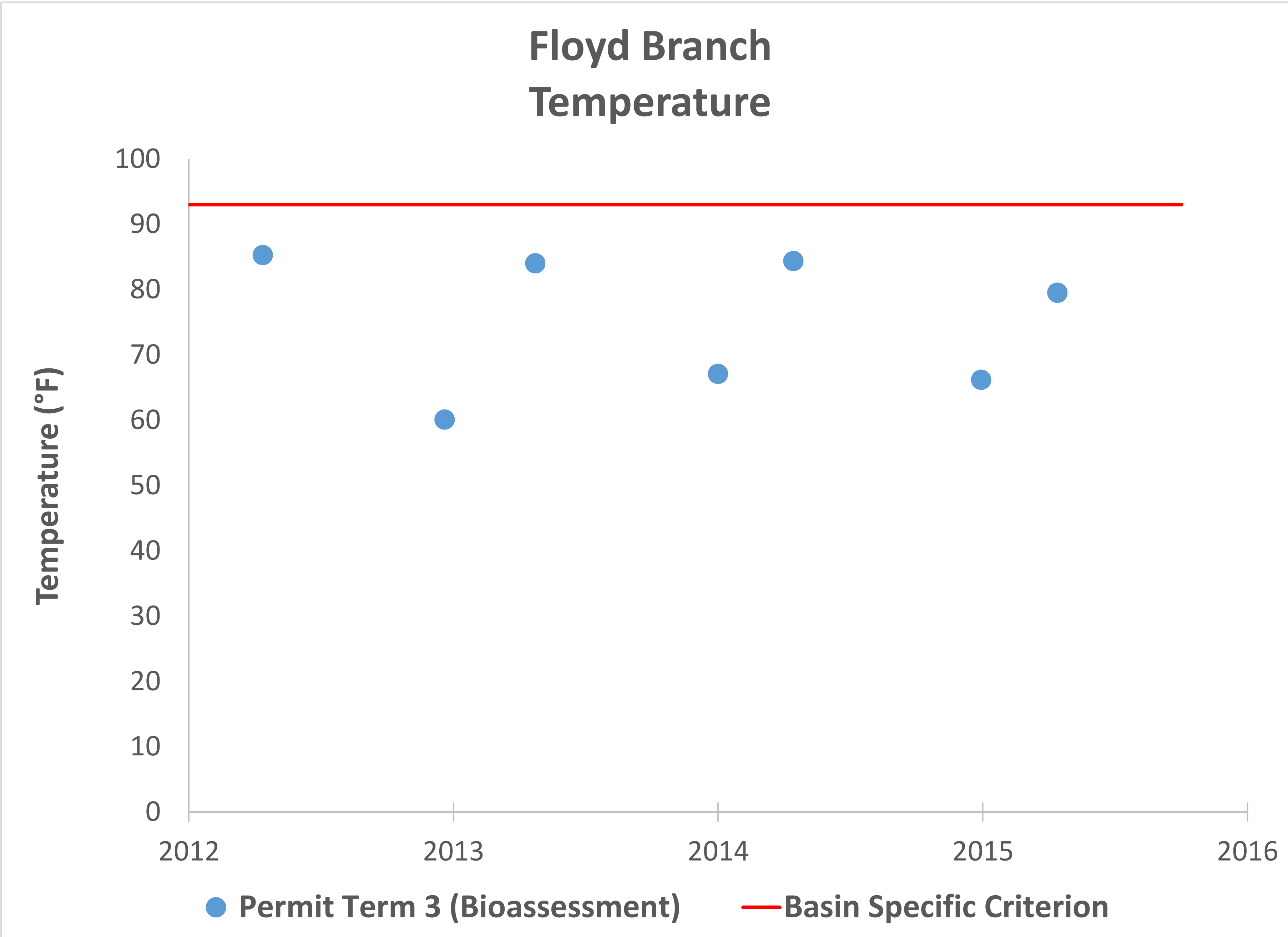

Floyd Branch
Phosporous, Total
Phosphorus, Total (mg/L)
3.5
3
2.5
2
1.5
1
0.5
0
2012
2013
2014
2015
2016
Permit Term 3 (Bioassessment)
Nutrient Screening Criterion



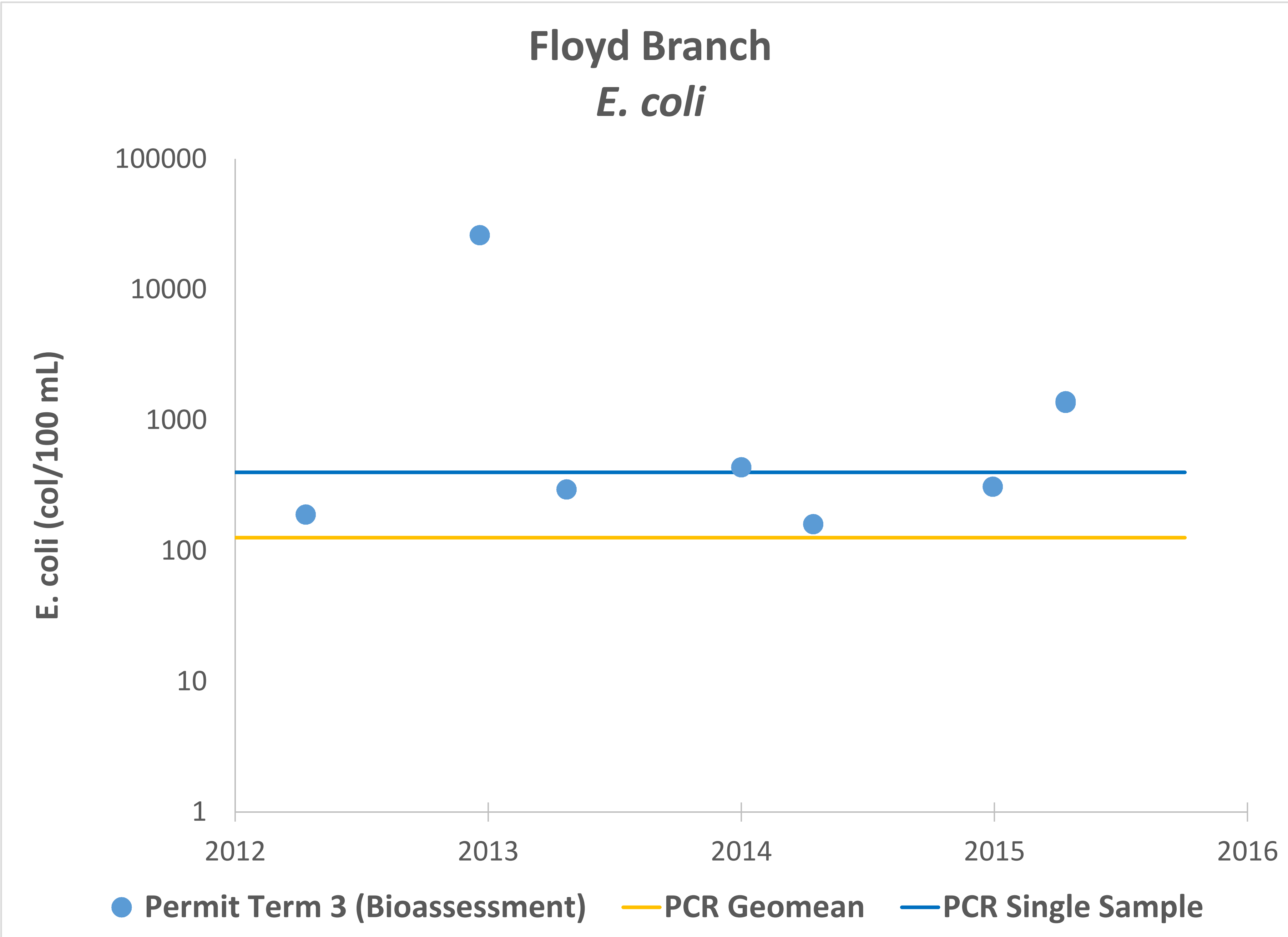
Floyd Branch
Copper, Total
Cu, Total (mg/L)
1
0.1
0.01
0.001
2012
2013
2014
2015
2016
Permit Term 3 (Bioassessment)
ALU Acute Criterion (Est)
ALU Chronic Criterion (Est)

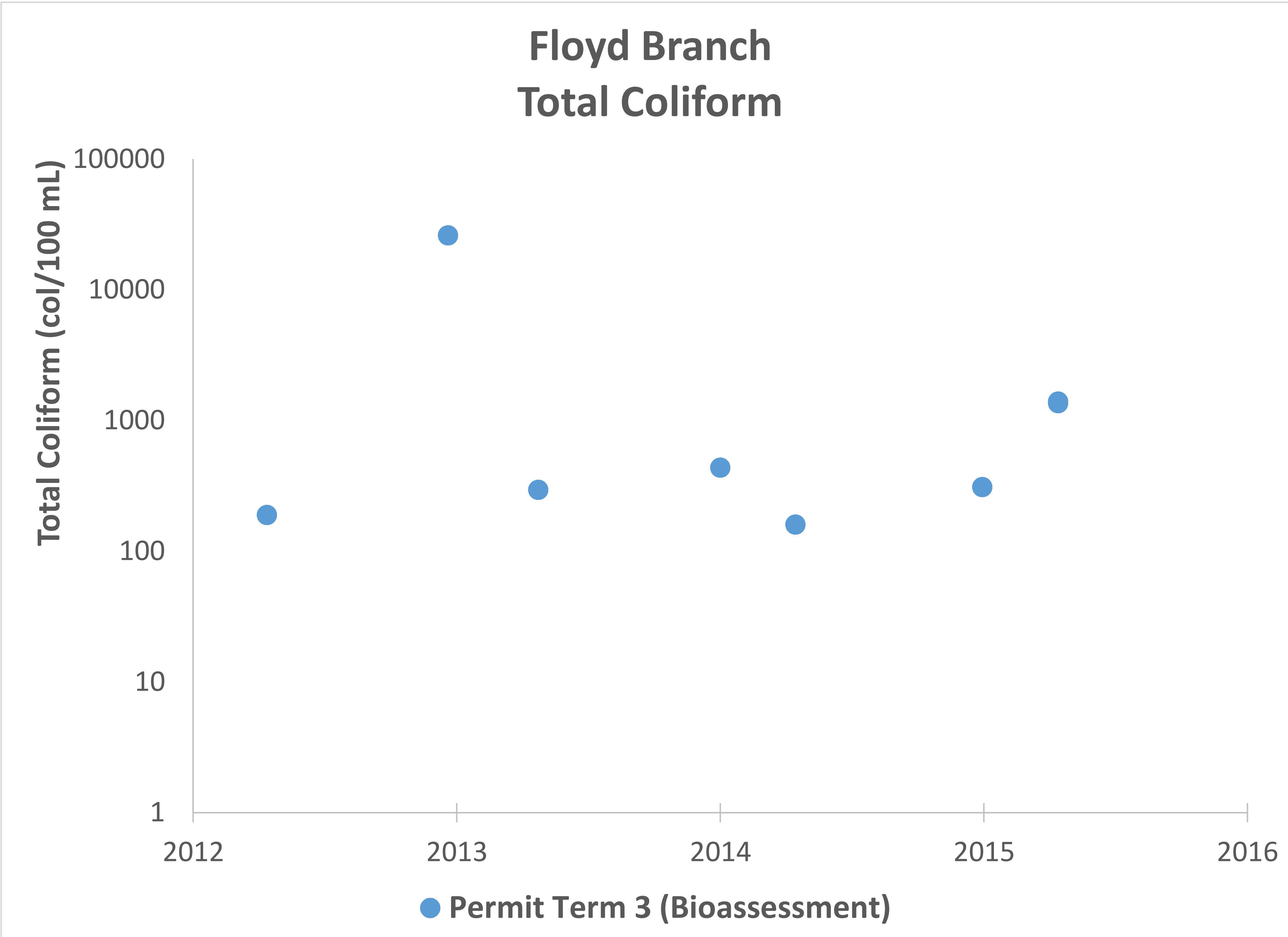

Floyd Branch
Field pH
pH (Standard Units)
9.5
9
8.5
8
7.5
7
6.5
6
2012
2013
2014
2015
2016
Permit Term 3 (Bioassessment)
Basin Specific Criteria

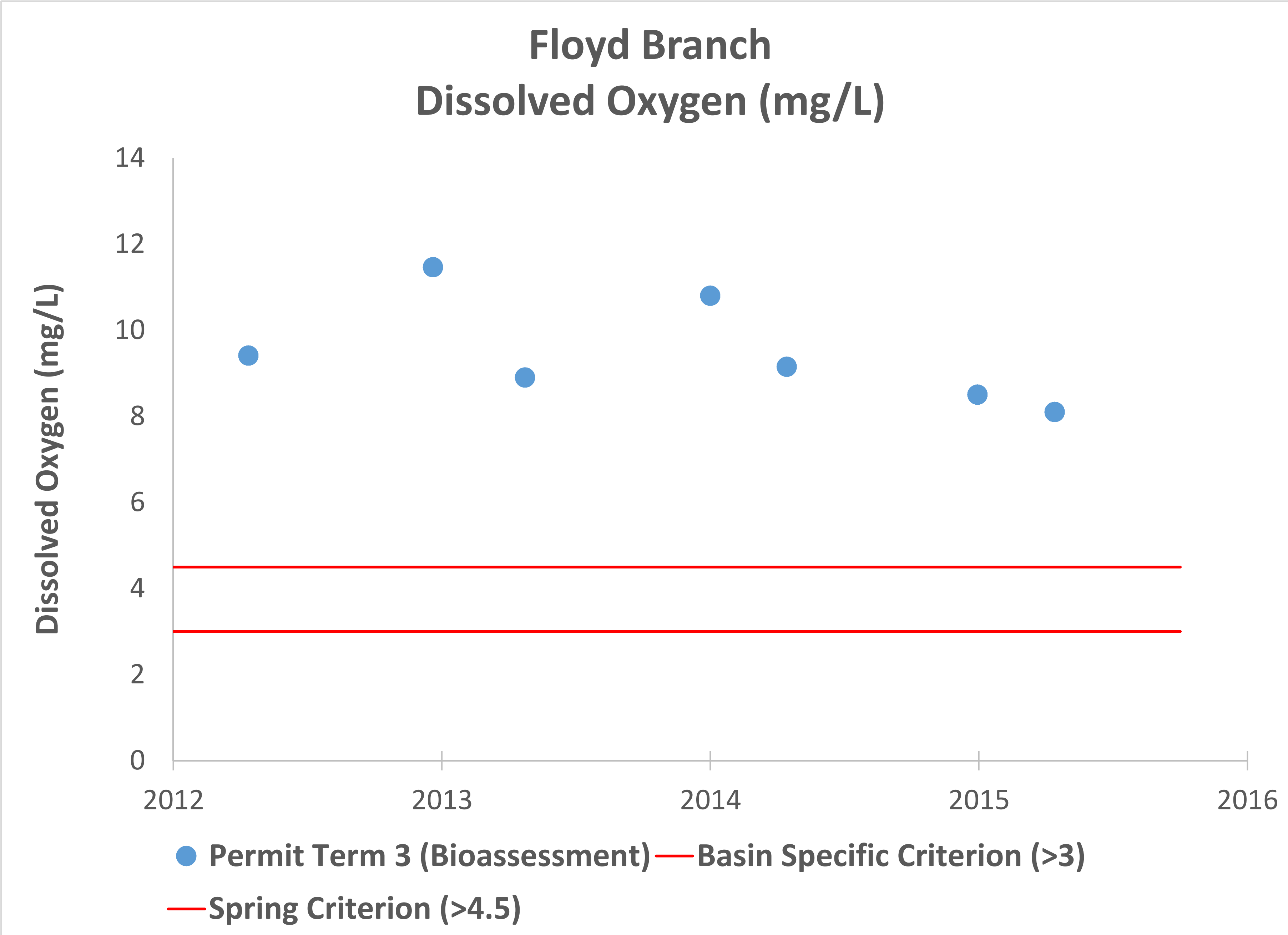

Floyd Branch
Specific Conductivity
Specific Conductivity (µS/cm)
1200
1000
800
600
400
200
0
2012
2013
2014
2015
2016
Permit Term 3 (Bioassessment)
NRSA: good (<)



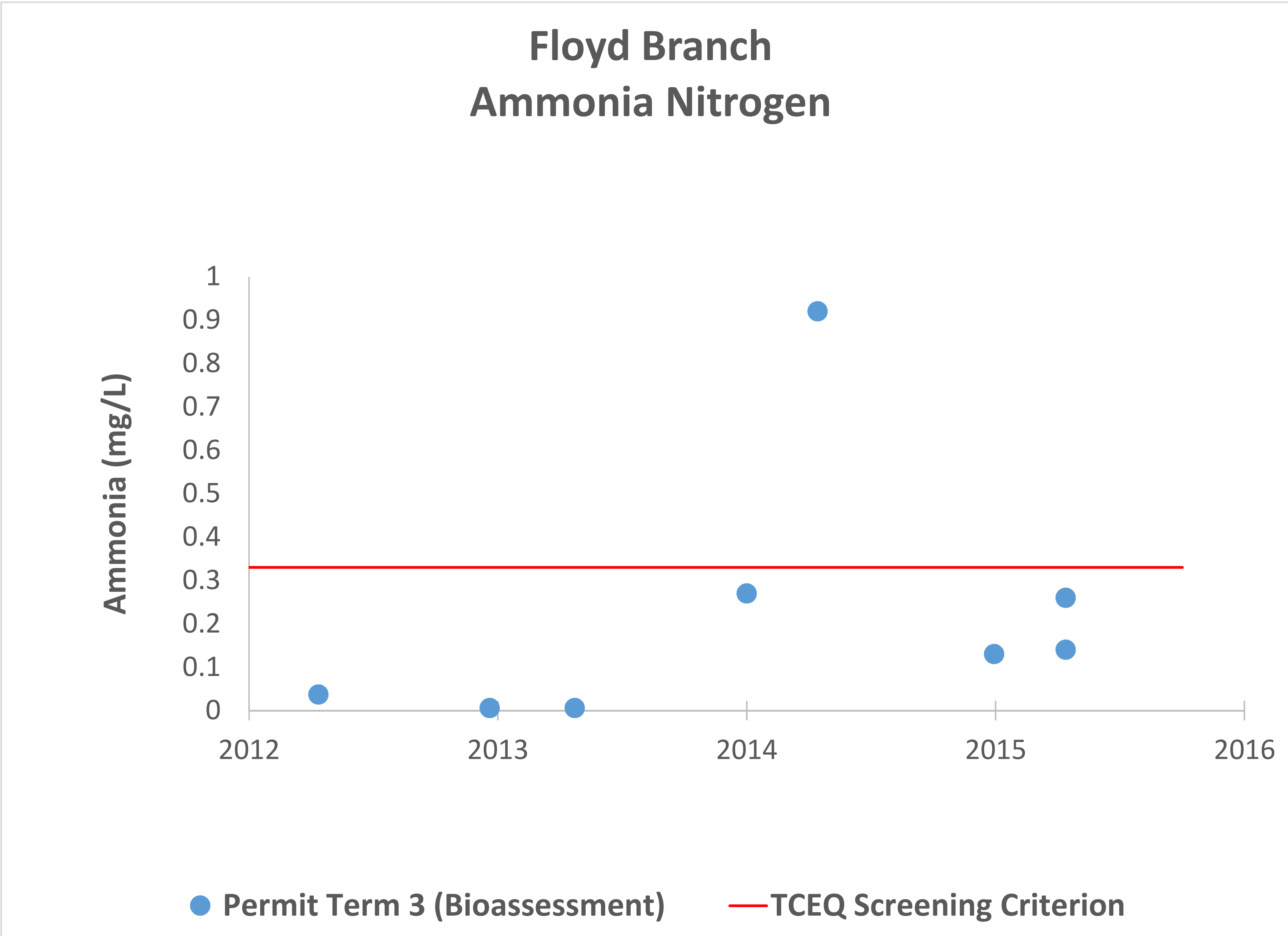
Floyd Branch
Temperature
Temperature (°F)
100
90
80
70
60
50
40
30
20
10
0
2012
2013
2014
2015
2016
Permit Term 3 (Bioassessment)
Basin Specific Criterion

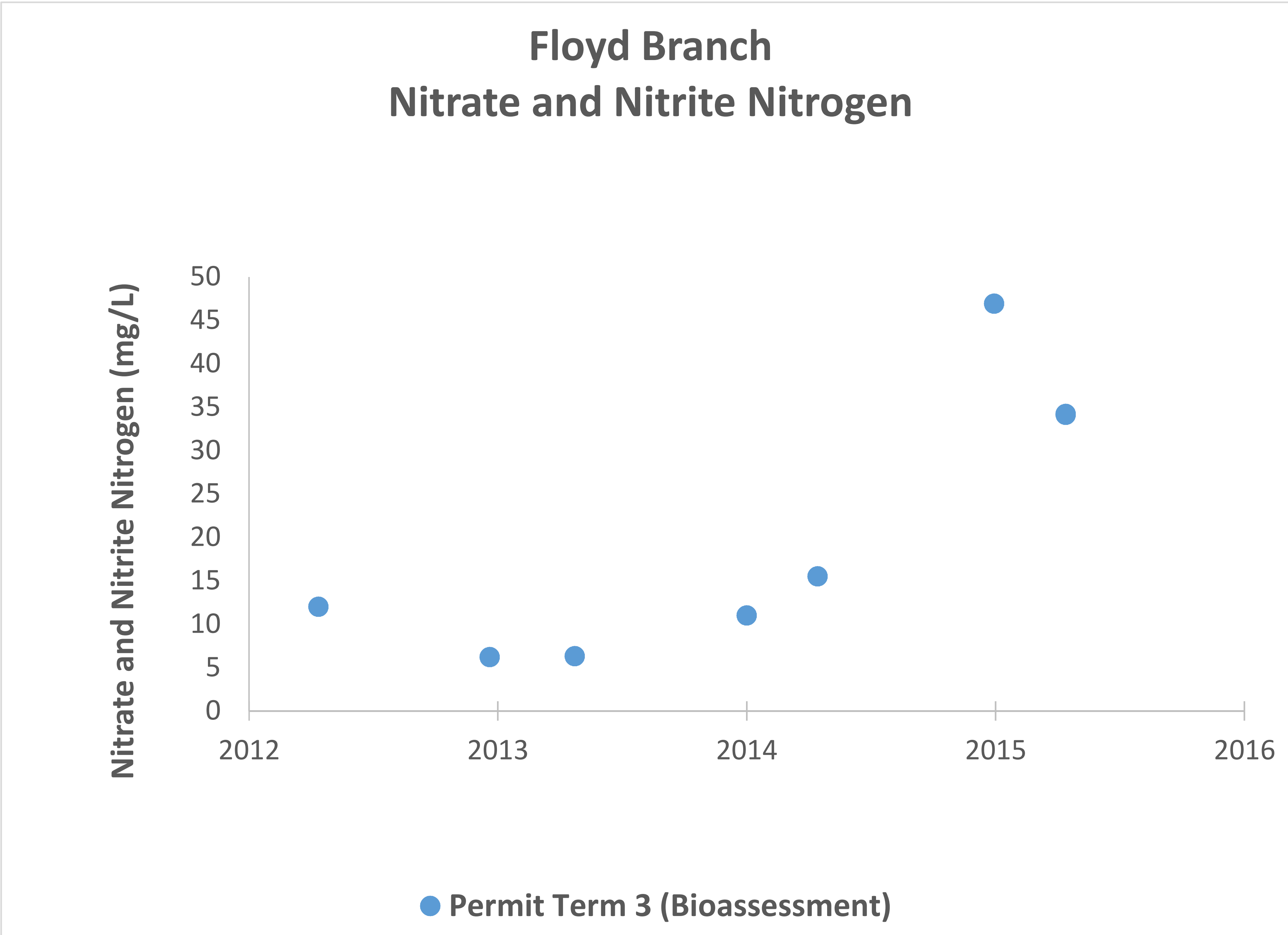

Floyd Branch
E. coli
E. coli (col/100 mL)
100000
10000
1000
100
10
1
2012
2013
2014
2015
2016
Permit Term 3 (Bioassessment)
PCR Geomean
PCR Single Sample

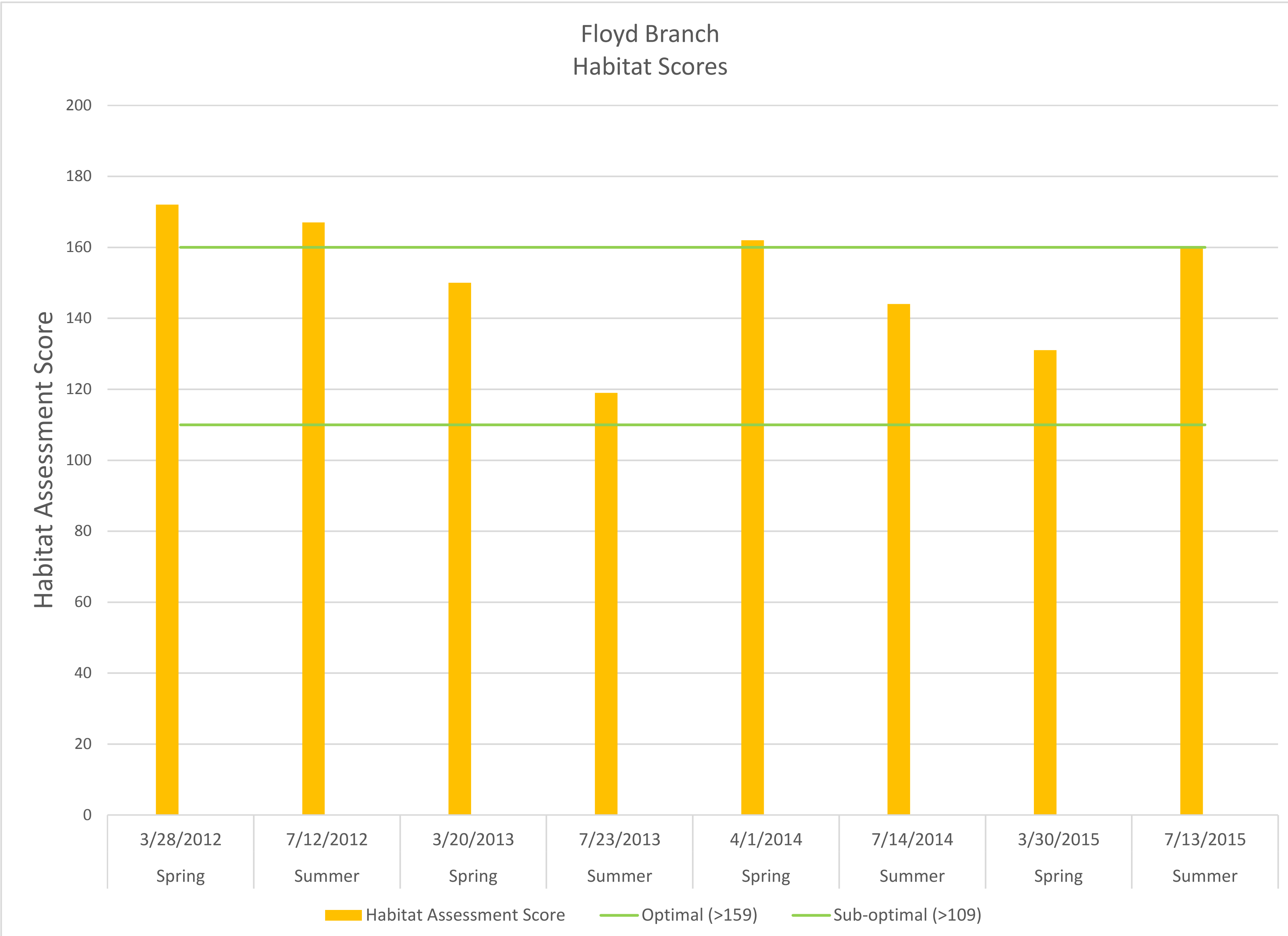

Floyd Branch
Total Coliform
Total Coliform (col/100 mL)
100000
10000
1000
100
10
1
2012
2013
2014
2015
2016
Permit Term 3 (Bioassessment)

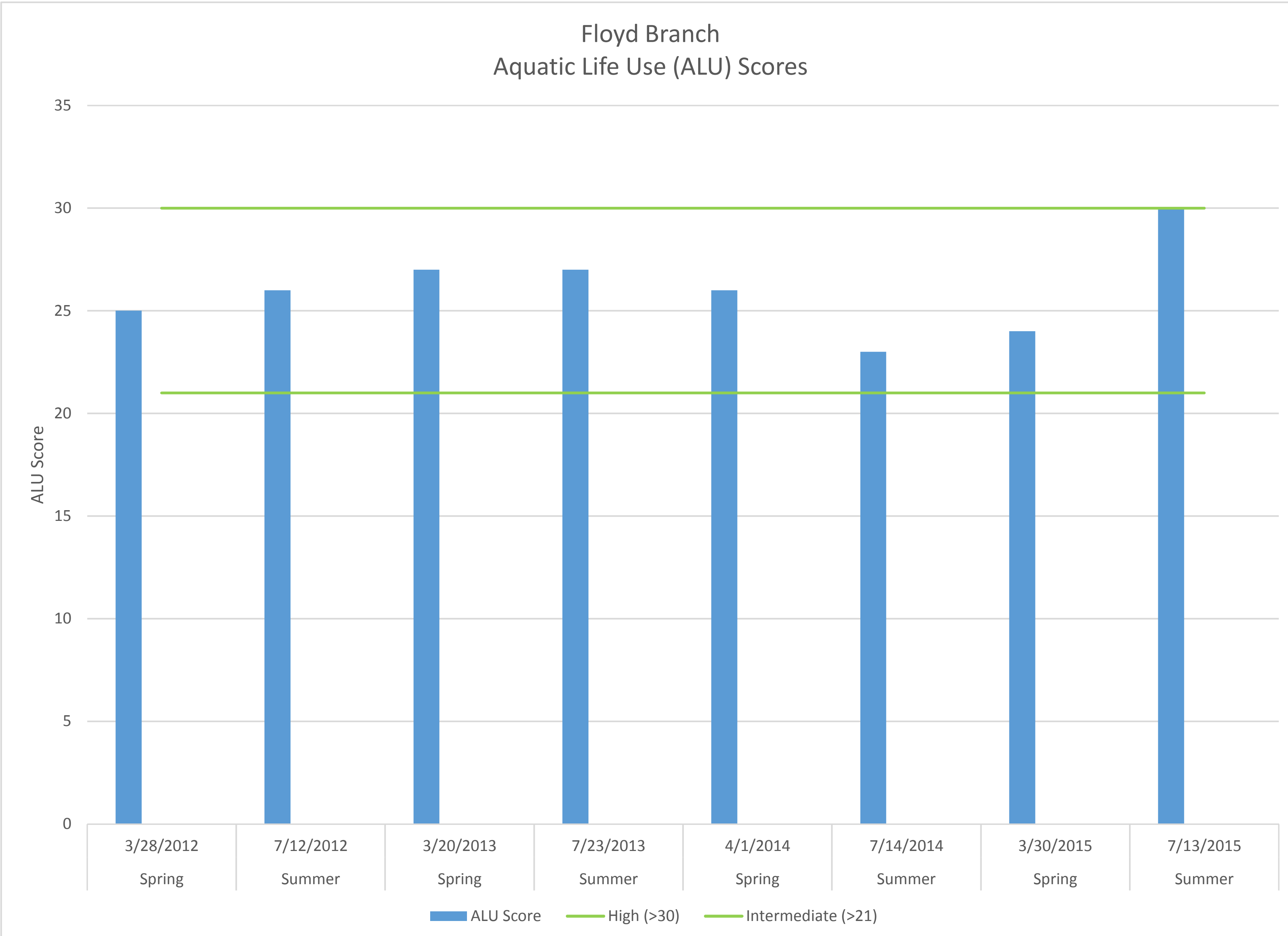


Floyd Branch
Dissolved Oxygen (mg/L)
Dissolved Oxygen (mg/L)
14
12
10
8
6
4
2
0
2012
2013
2014
2015
2016
Permit Term 3 (Bioassessment)
Basin Specific Criterion (>3)
Spring Criterion (>4.5)


Floyd Branch
Ammonia Nitrogen
Ammonia (mg/L)
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
2012
2013
2014
2015
2016
Permit Term 3 (Bioassessment)
TCEQ Screening Criterion

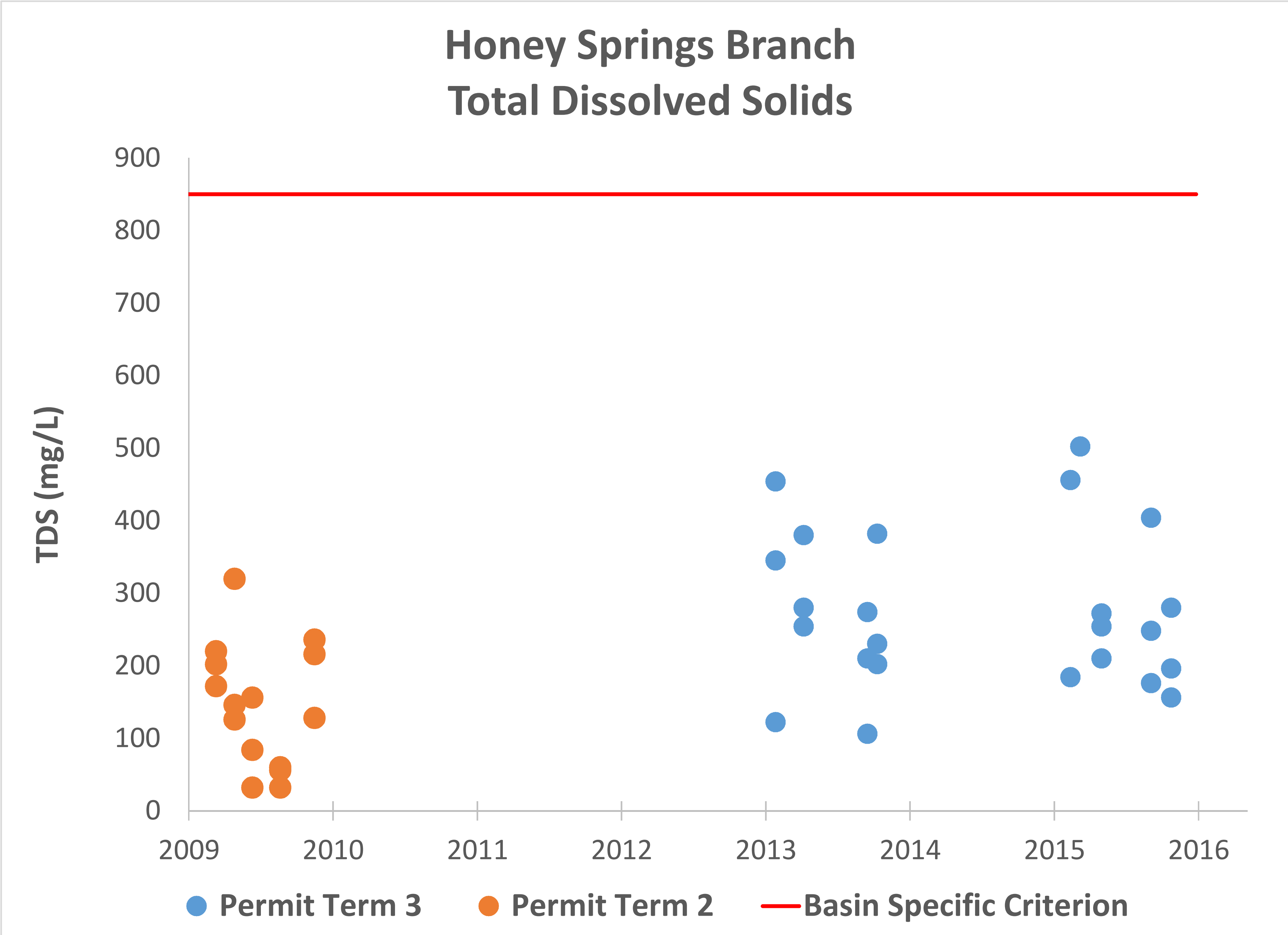

Floyd Branch
Nitrate and Nitrite Nitrogen
Nitrate and Nitrite Nitrogen (mg/L)
50
45
40
35
30
25
20
15
10
5
0
2012
2013
2014
2015
2016
Permit Term 3 (Bioassessment)

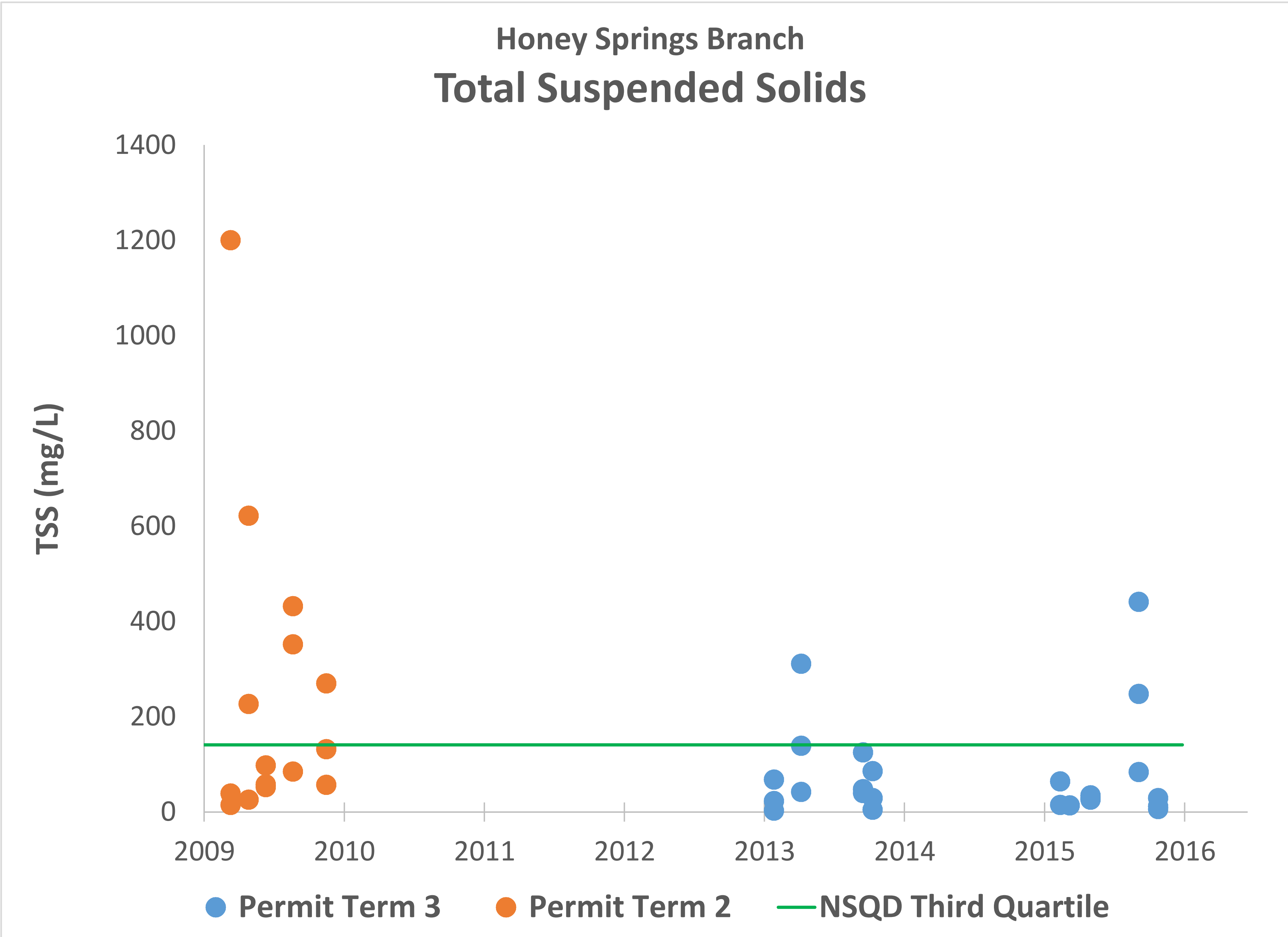

Floyd Branch
Habitat Scores
Habitat Assessment Score
200
180
160
140
120
100
80
60
40
20
0
3/28/2012 Spring
7/12/2012 Summer
3/20/2013 Spring
7/23/2013 Summer
4/1/2014 Spring
7/14/2014 Summer
3/30/2015 Spring
7/13/2015 Summer
Habitat Assessment Score
Optimal (>159)
Sub-optimal (>109)


Floyd Branch
Aquatic Life Use (ALU) Scores
ALU Score
35
30
25
20
15
10
5
0
3/28/2012
Spring
7/12/2012
Summer
3/20/2013
Spring
7/23/2013
Summer
4/1/2014
Spring
7/14/2014
Summer
3/30/2015
Spring
7/13/2015
Summer
ALU Score
High (>30)
Intermediate (>21)

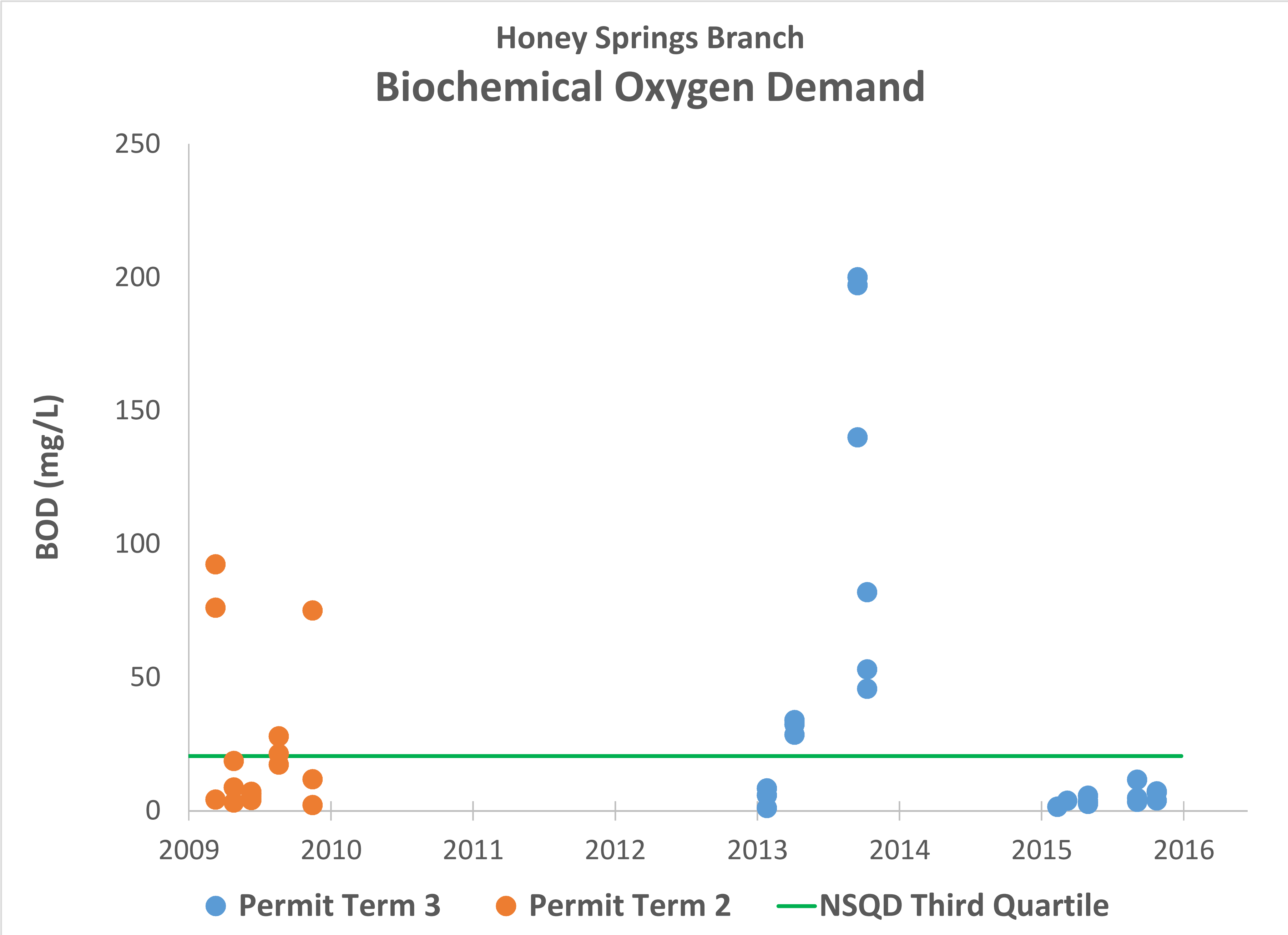
Appendix L

Honey Springs Branch Water Quality Data Graphs

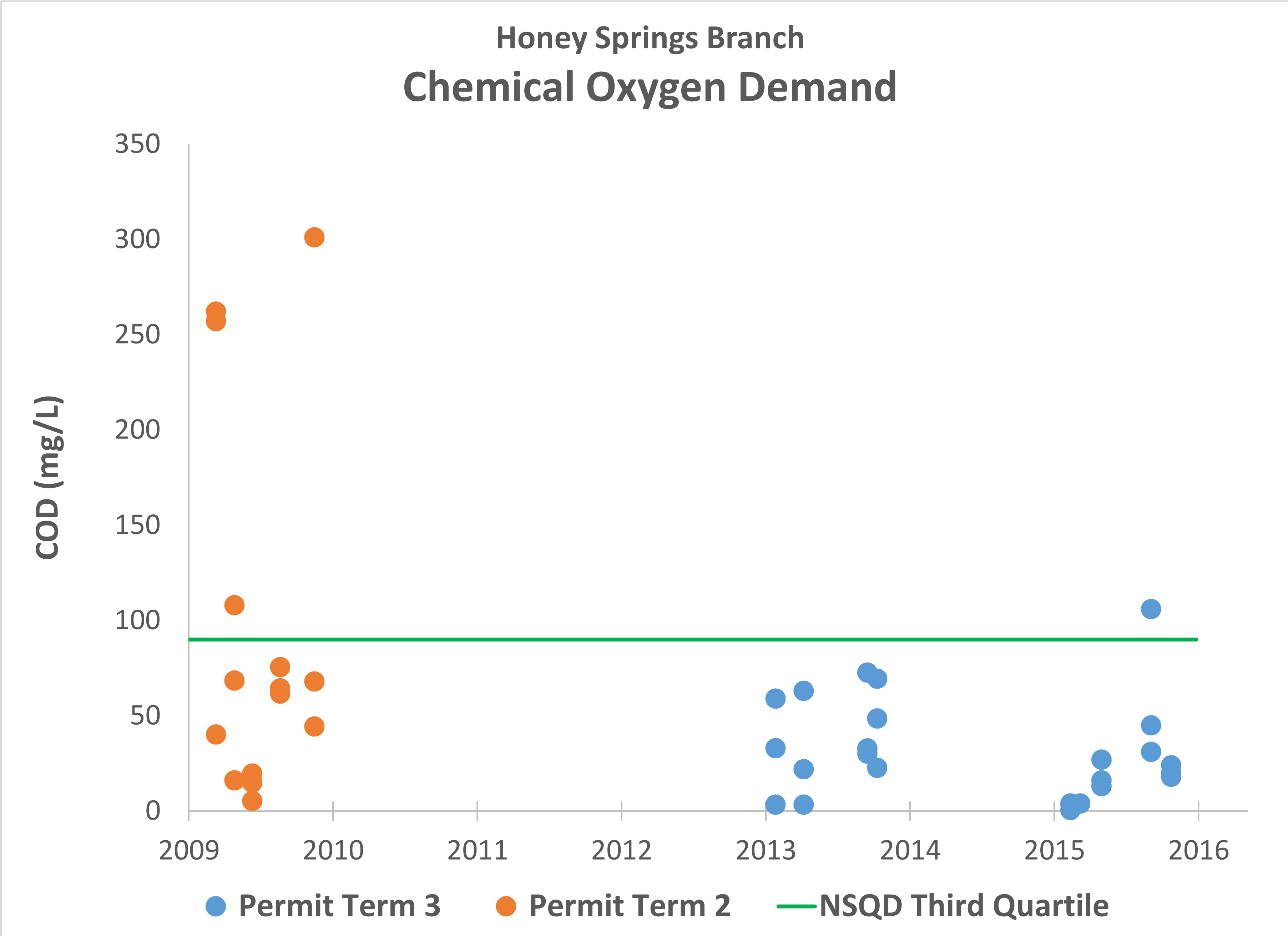

Honey Springs Branch
Total Dissolved Solids
TDS (mg/L)
900
800
700
600
500
400
300
200
100
0
2009
2010
2011
2012
2013
2014
2015
2016
Permit Term 3
Permit Term 2
Basin Specific Criterion



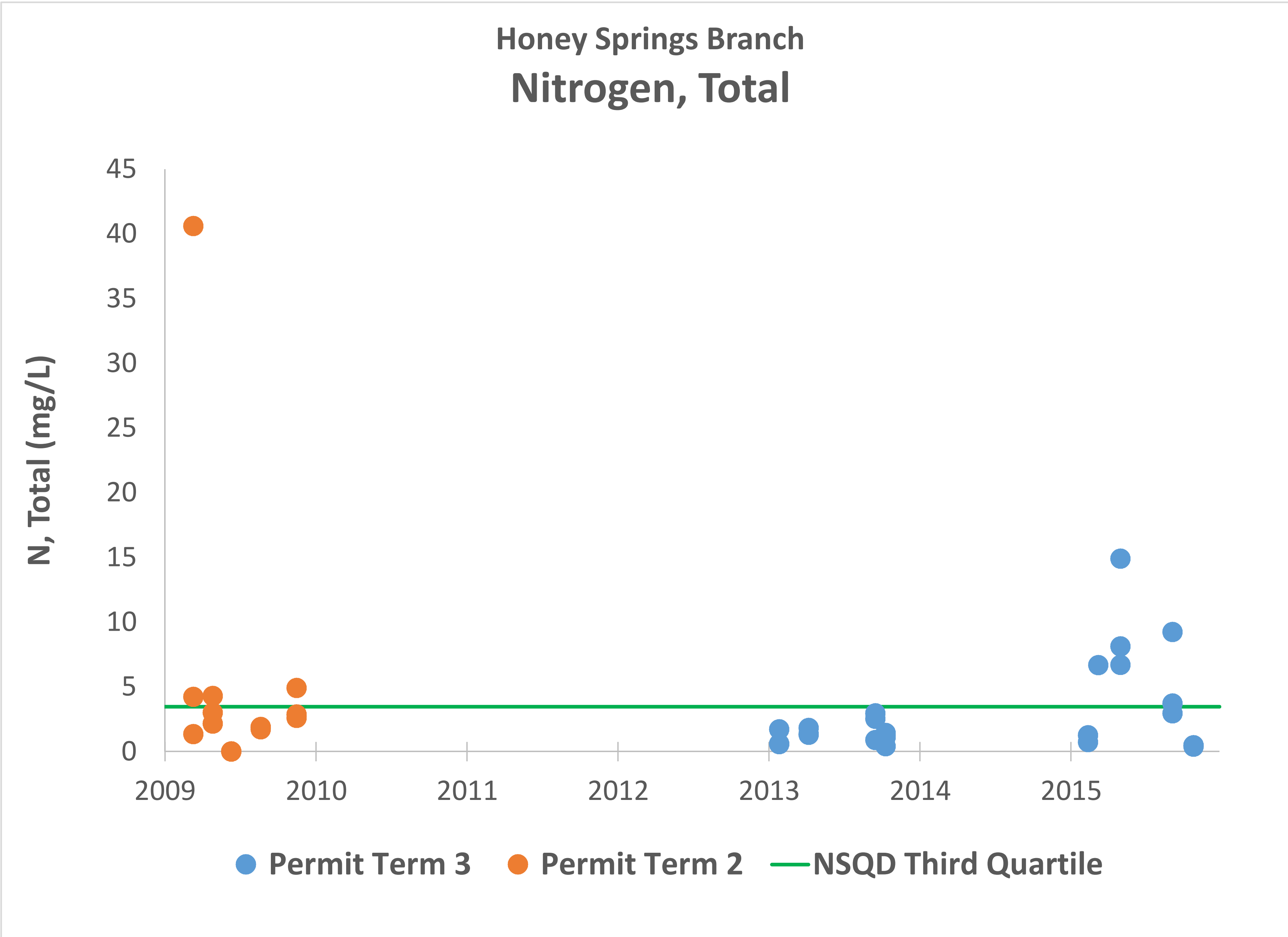
Honey Springs Branch
Total Suspended Solids
TSS (mg/L)
1400
1200
1000
800
600
400
200
0
2009
2010
2011
2012
2013
2014
2015
2016
Permit Term 3
Permit Term 2
NSQD Third Quartile

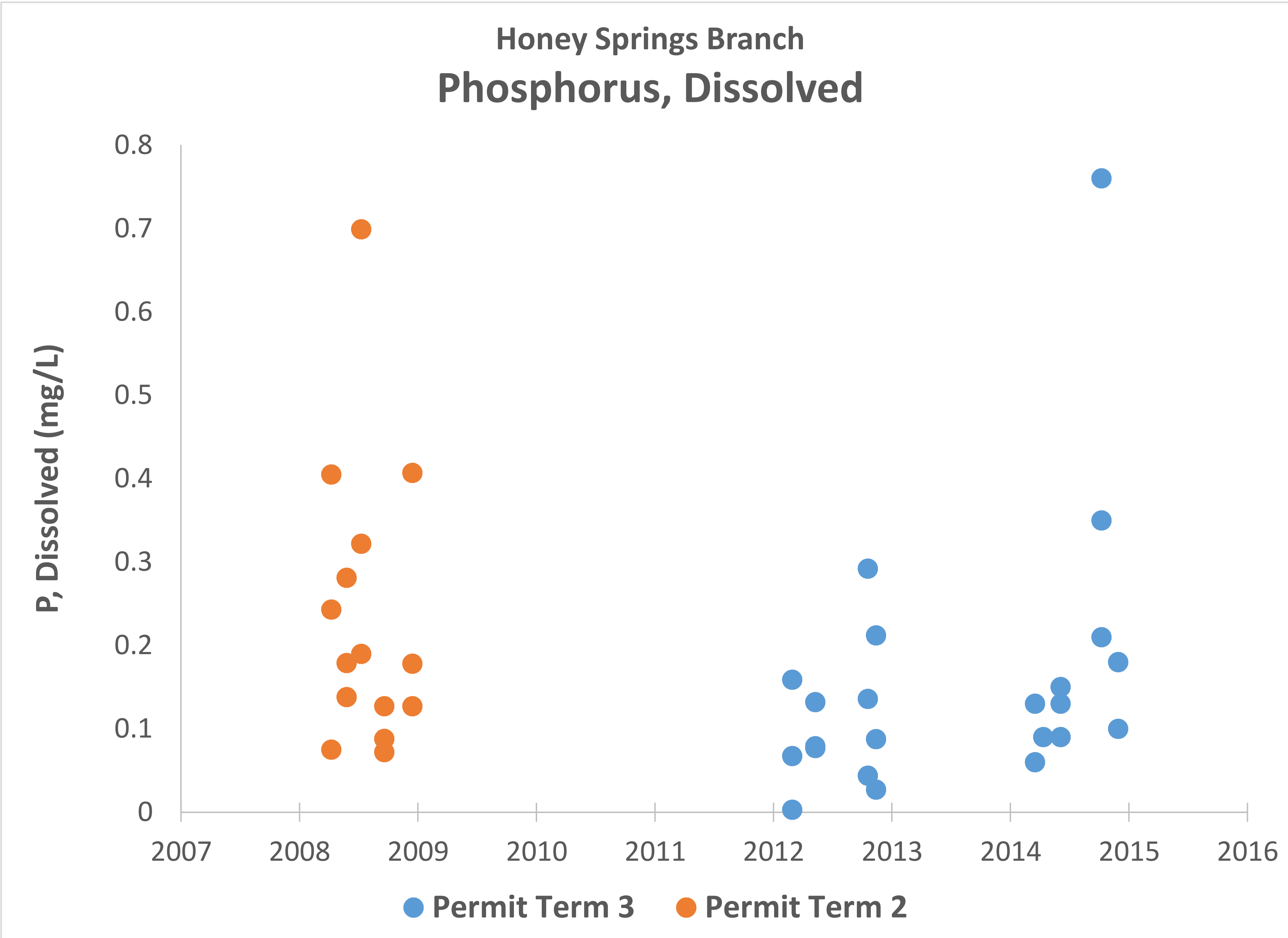


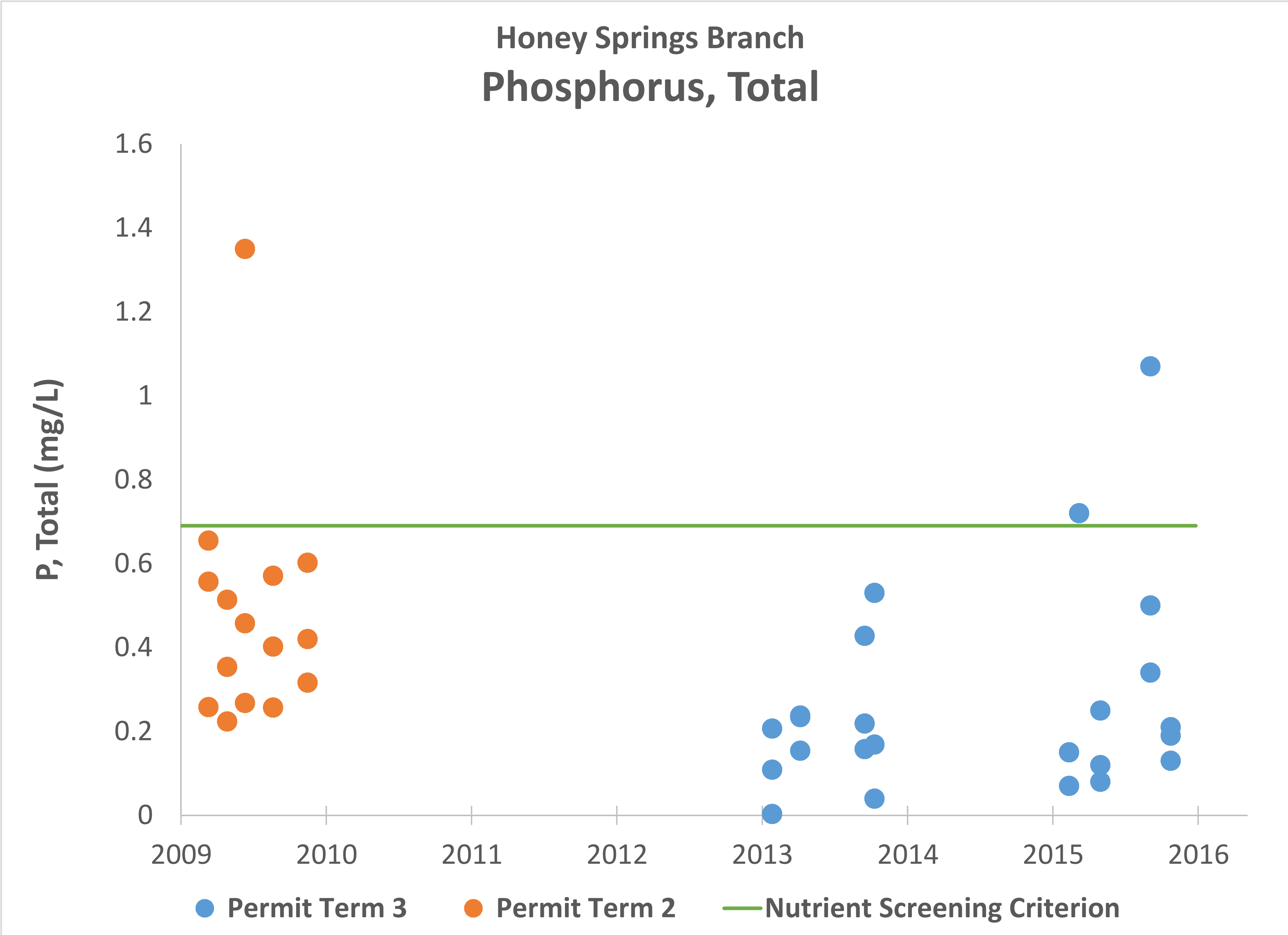
Honey Springs Branch
Biochemical Oxygen Demand
BOD (mg/L)
250
200
150
100
50
0
2009
2010
2011
2012
2013
2014
2015
2016
Permit Term 3
Permit Term 2
NSQD Third Quartile



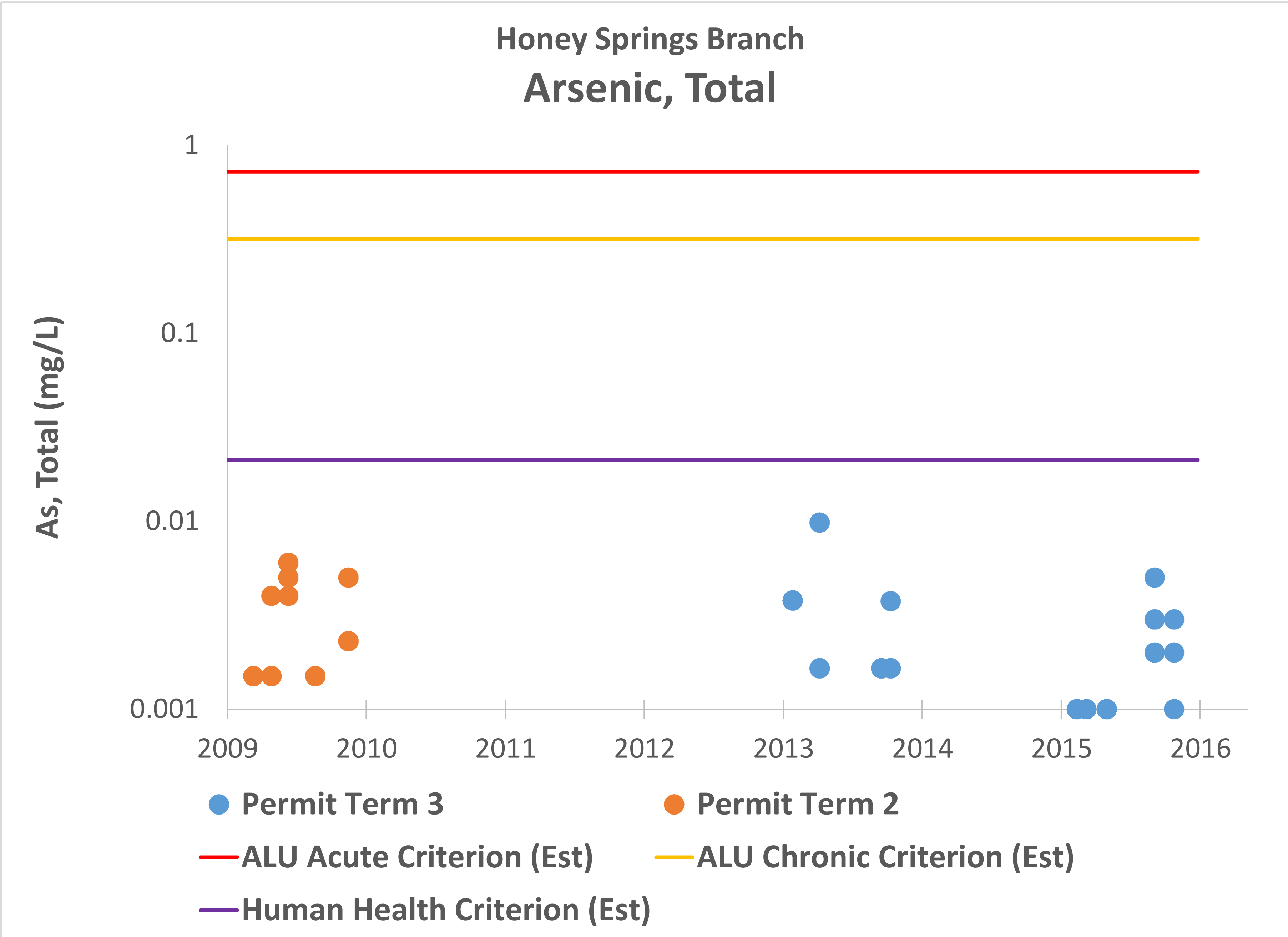
Honey Springs Branch
Chemical Oxygen Demand
COD (mg/L)
350
300
250
200
150
100
50
0
2009
2010
2011
2012
2013
2014
2015
2016
Permit Term 3
Permit Term 2
NSQD Third Quartile


Honey Springs Branch
Nitrogen, Total
N, Total (mg/L)
45
40
35
30
25
20
15
10
5
0
2009
2010
2011
2012
2013
2014
2015
Permit Term 3
Permit Term 2
NSQD Third Quartile

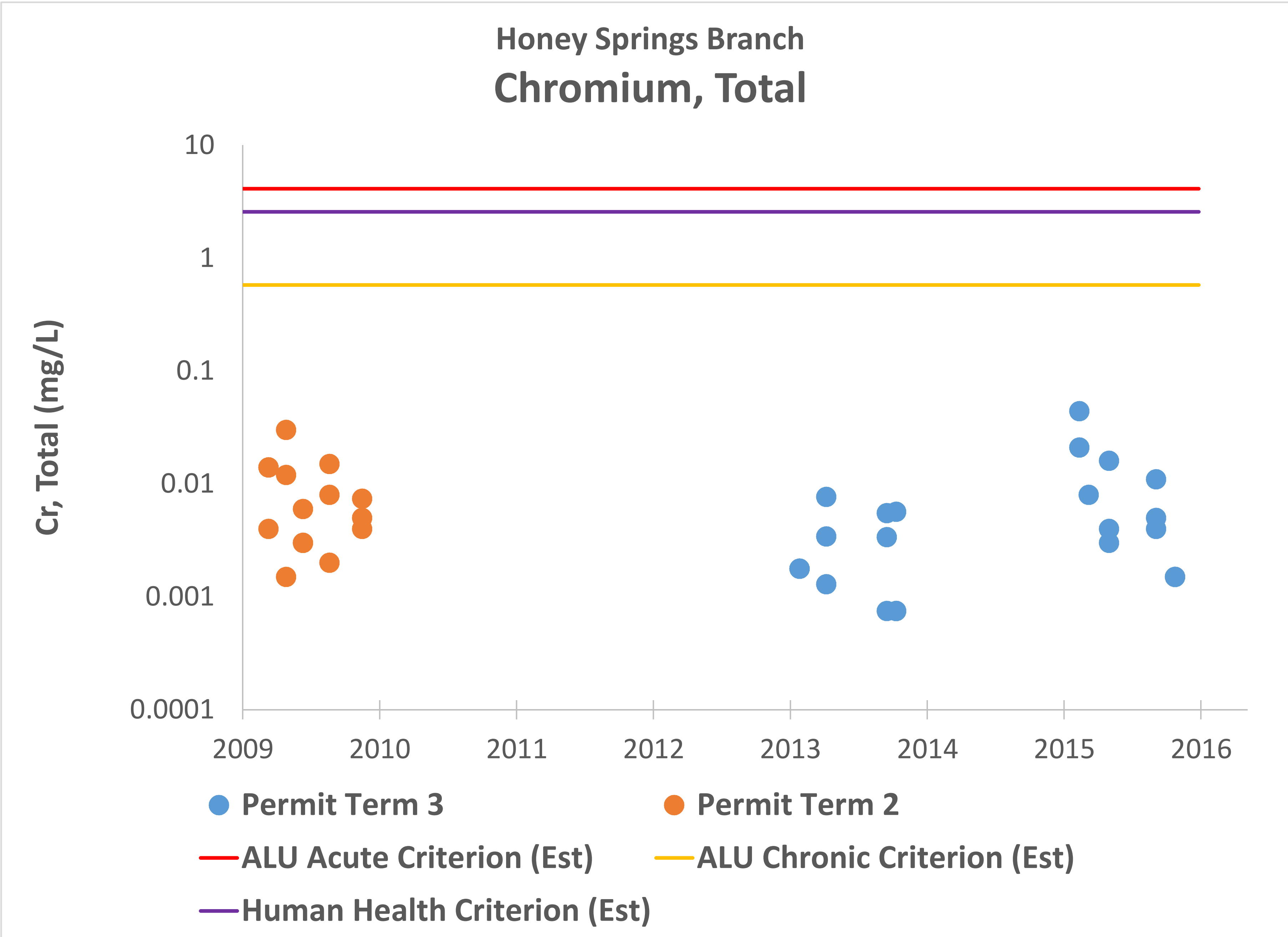

Honey Springs Branch
Phosphorus, Dissolved
P, Dissolved (mg/L)
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
Permit Term 3
Permit Term 2



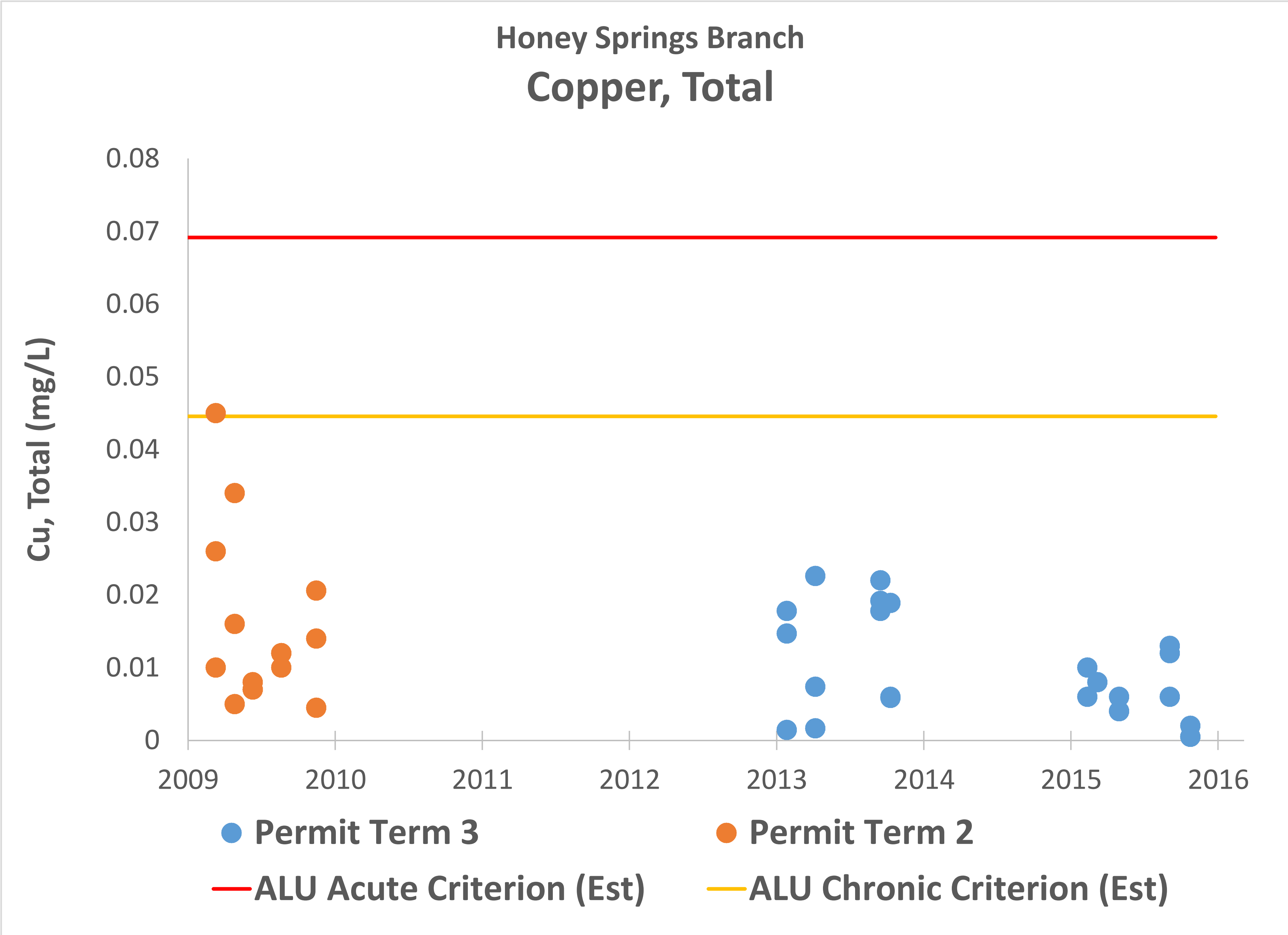
Honey Springs Branch
Phosphorus, Total
P, Total (mg/L)
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
2009
2010
2011
2012
2013
2014
2015
2016
Permit Term 3
Permit Term 2
Nutrient Screening Criterion

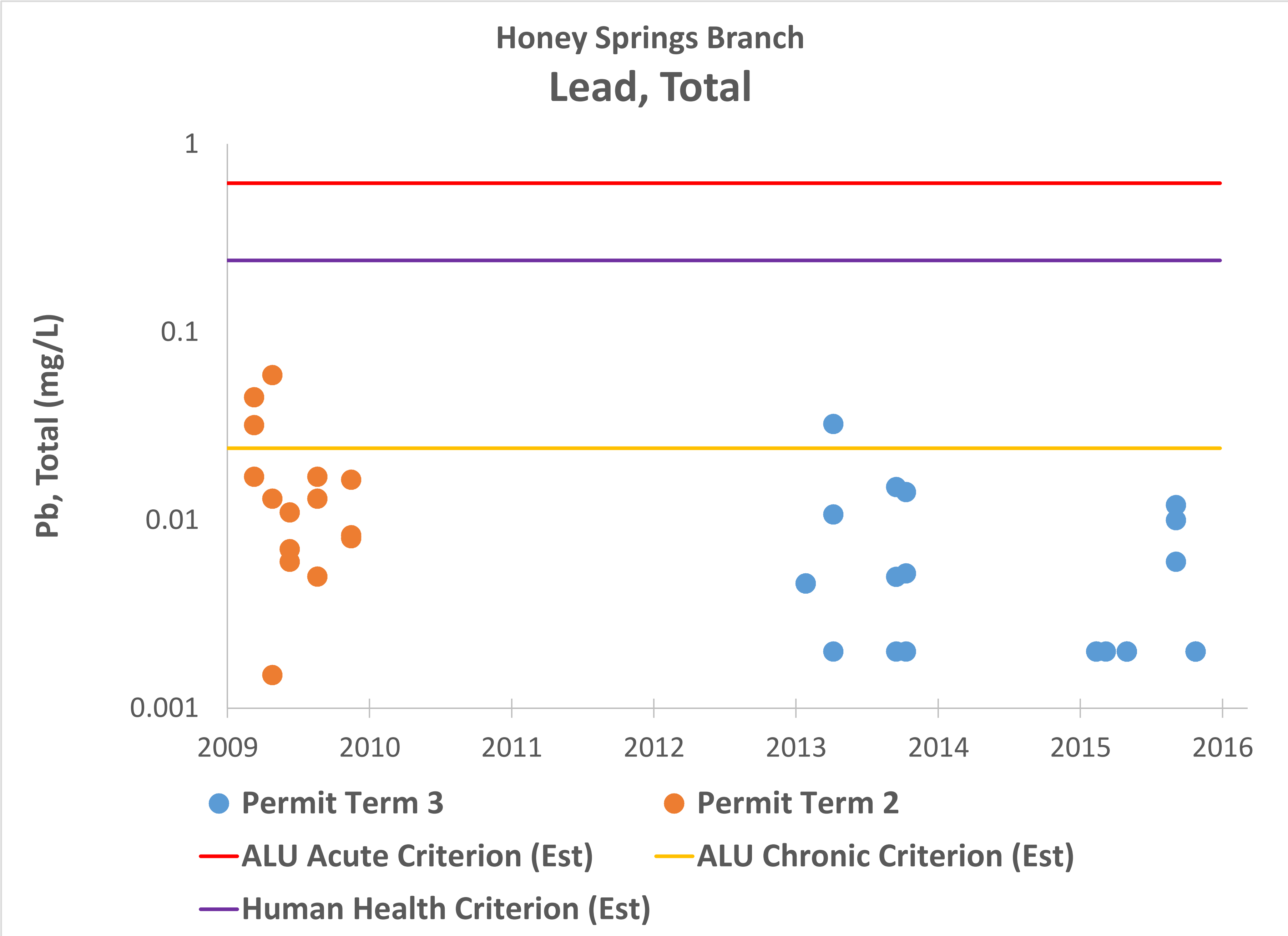


Honey Springs Branch
Arsenic, Total
As, Total (mg/L)
1
0.1
0.01
0.001
2009
2010
2011
2012
2013
2014
2015
2016
Permit Term 3
Permit Term 2
ALU Acute Criterion (Est)
ALU Chronic Criterion (Est)
Human Health Criterion (Est)

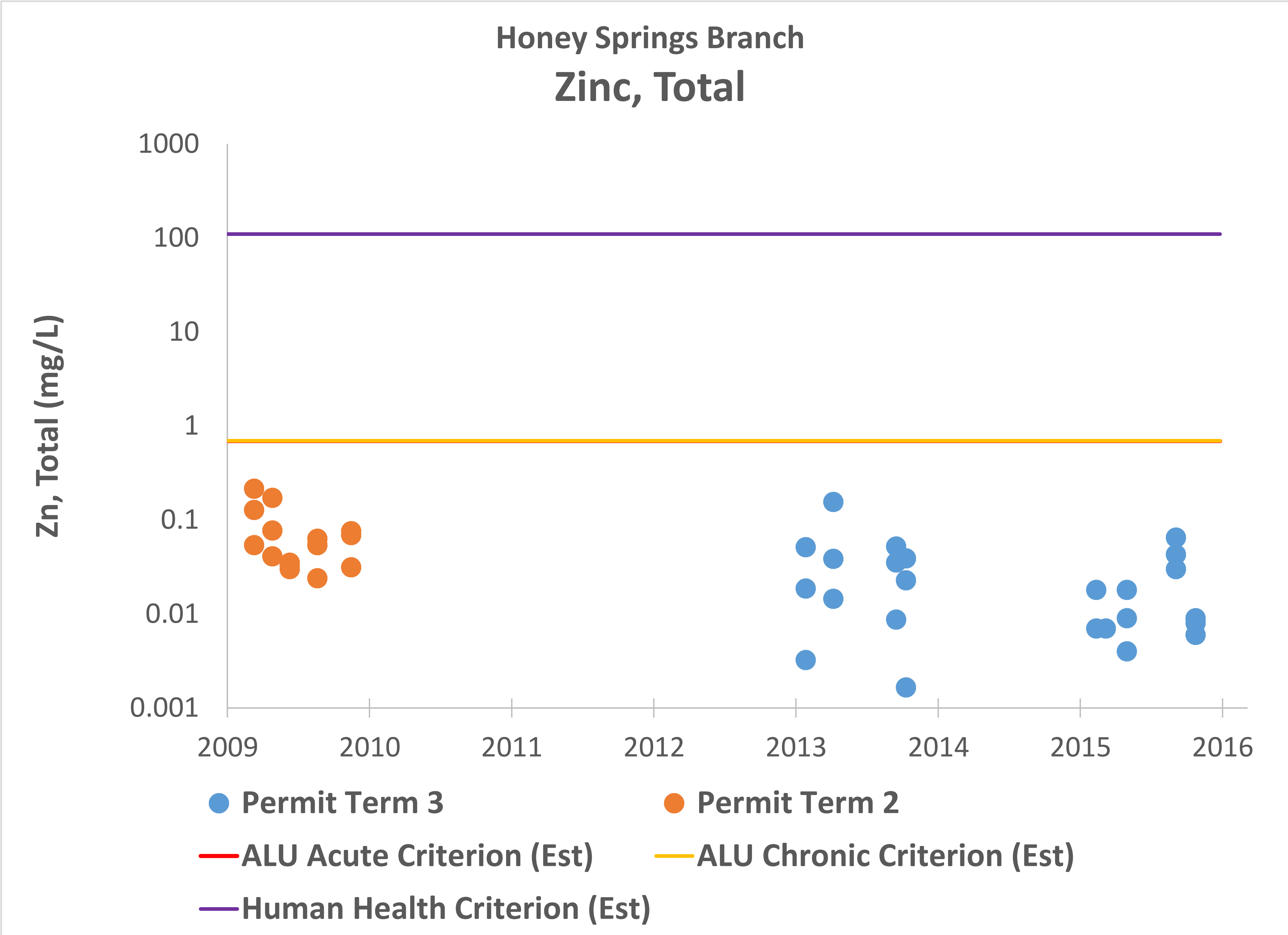


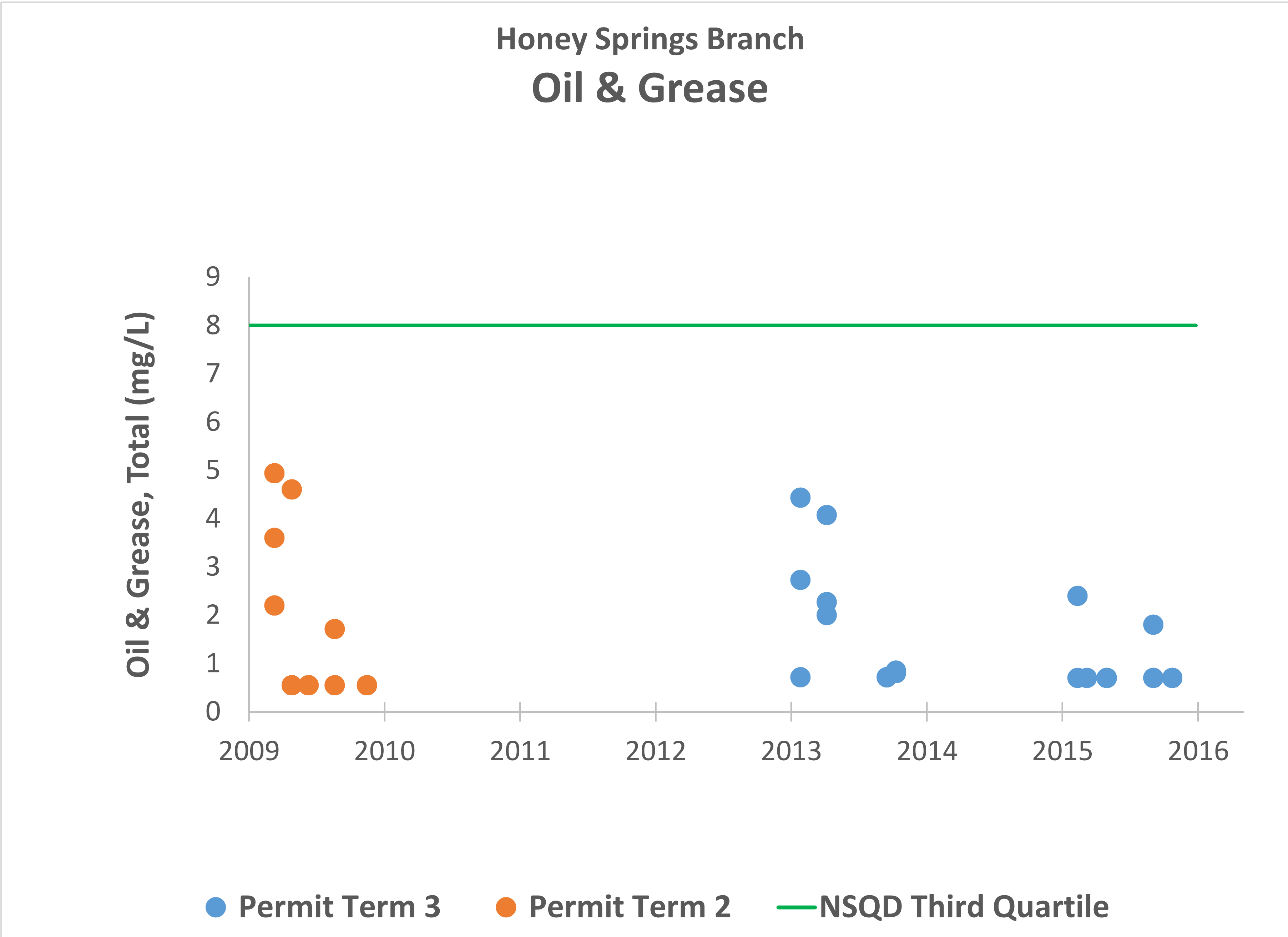
Honey Springs Branch
Chromium, Total
Cr, Total (mg/L)
10
1
0.1
0.01
0.001
0.0001
2009
2010
2011
2012
2013
2014
2015
2016
Permit Term 3
Permit Term 2
ALU Acute Criterion (Est)
ALU Chronic Criterion (Est)
Human Health Criterion (Est)

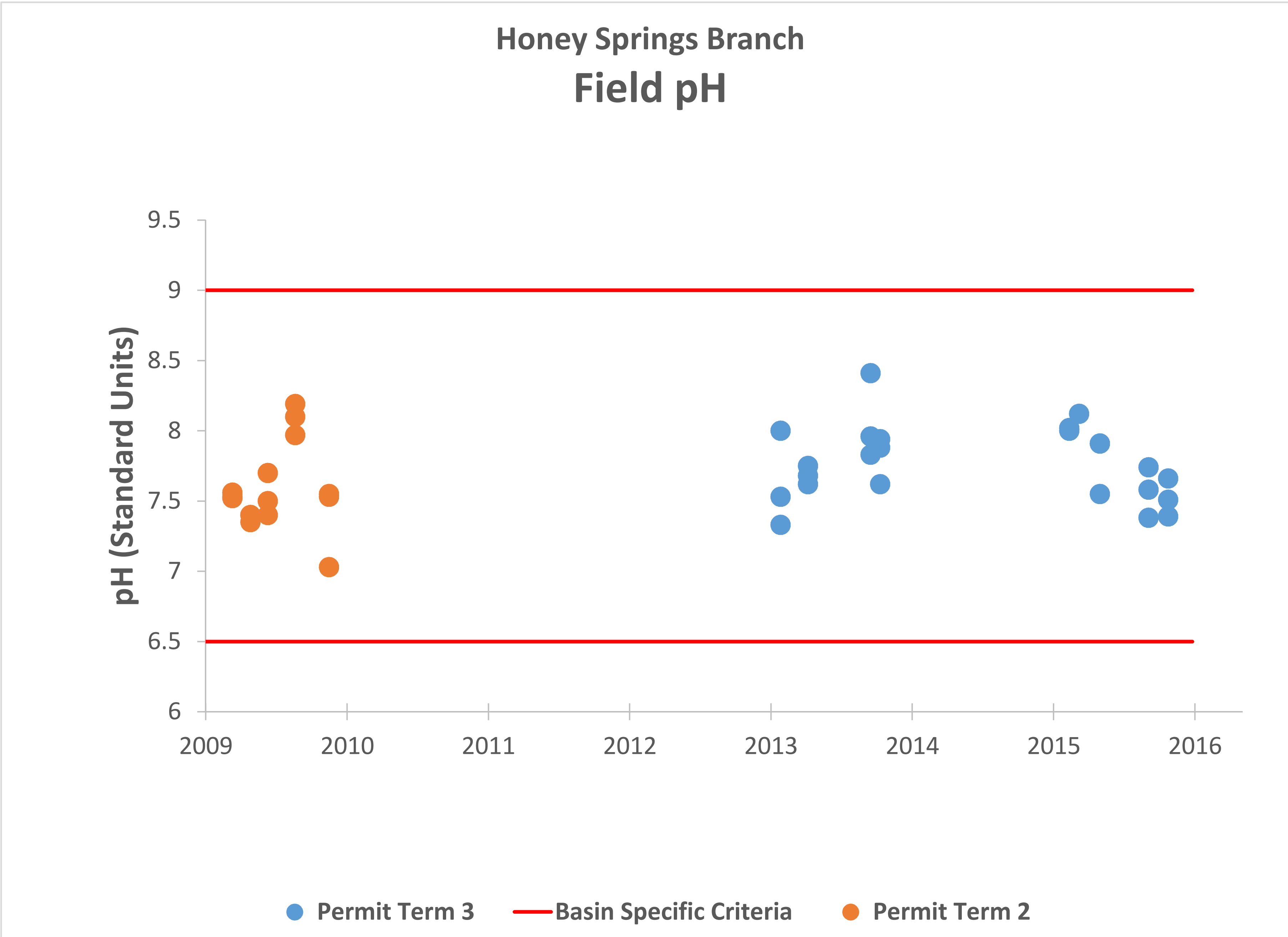

Honey Springs Branch
Copper, Total
Cu, Total (mg/L)
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
2009
2010
2011
2012
2013
2014
2015
2016
Permit Term 3
Permit Term 2
ALU Acute Criterion (Est)
ALU Chronic Criterion (Est)



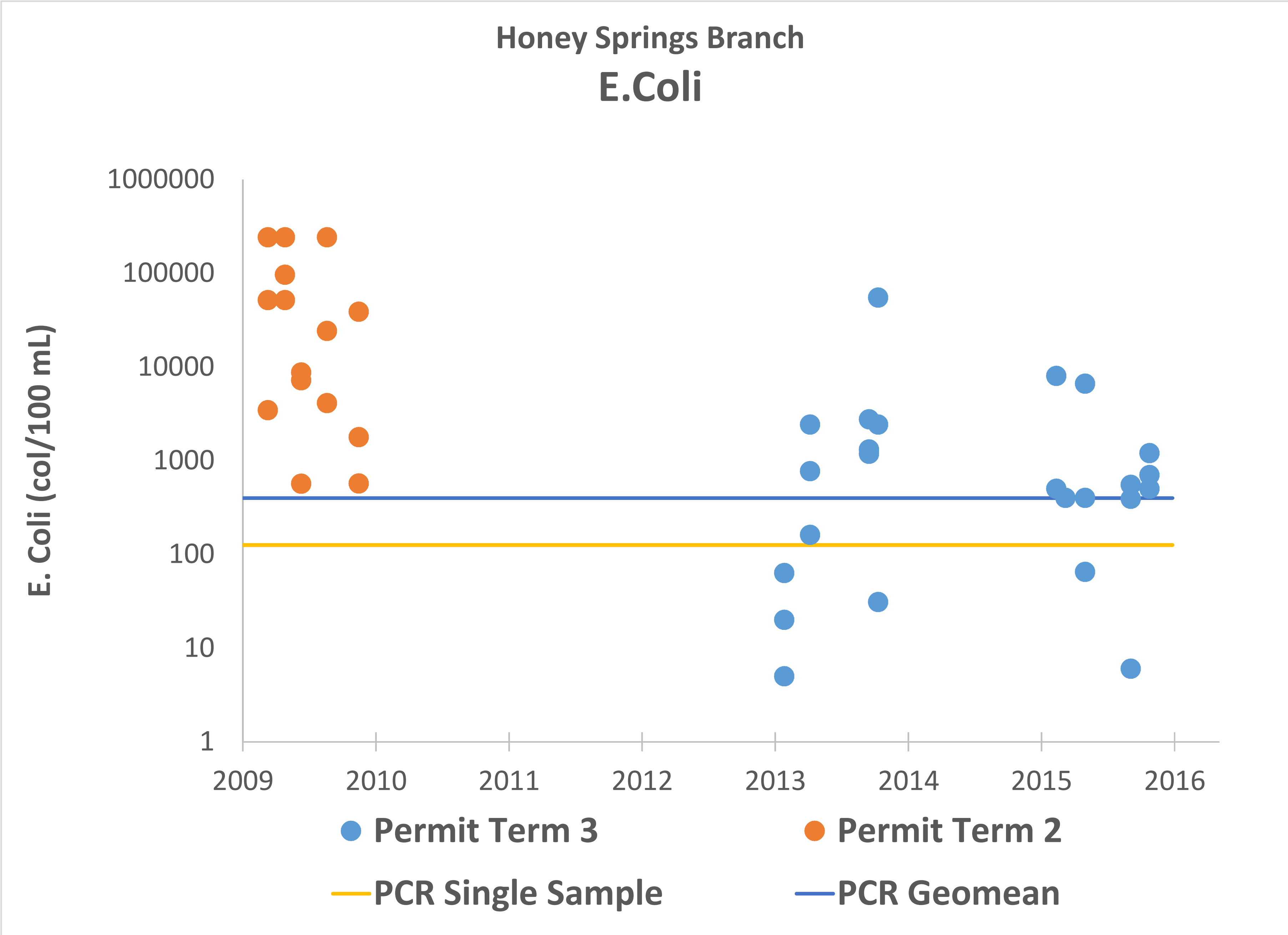
Honey Springs Branch
Lead, Total
Pb, Total (mg/L)
1
0.1
0.01
0.001
2009
2010
2011
2012
2013
2014
2015
2016
Permit Term 3
Permit Term 2
ALU Acute Criterion (Est)
ALU Chronic Criterion (Est)
Human Health Criterion (Est)


Honey Springs Branch
Zinc, Total
Zn, Total (mg/L)
1000
100
10
1
0.1
0.01
0.001
2009
2010
2011
2012
2013
2014
2015
2016
Permit Term 3
Permit Term 2
ALU Acute Criterion (Est)
ALU Chronic Criterion (Est)
Human Health Criterion (Est)


Honey Springs Branch
Oil & Grease
Oil & Grease, Total (mg/L)
0
1
2
3
4
5
6
7
8
9
2009
2010
2011
2012
2013
2014
2015
2016
Permit Term 3
Permit Term 2
NSQD Third Quartile



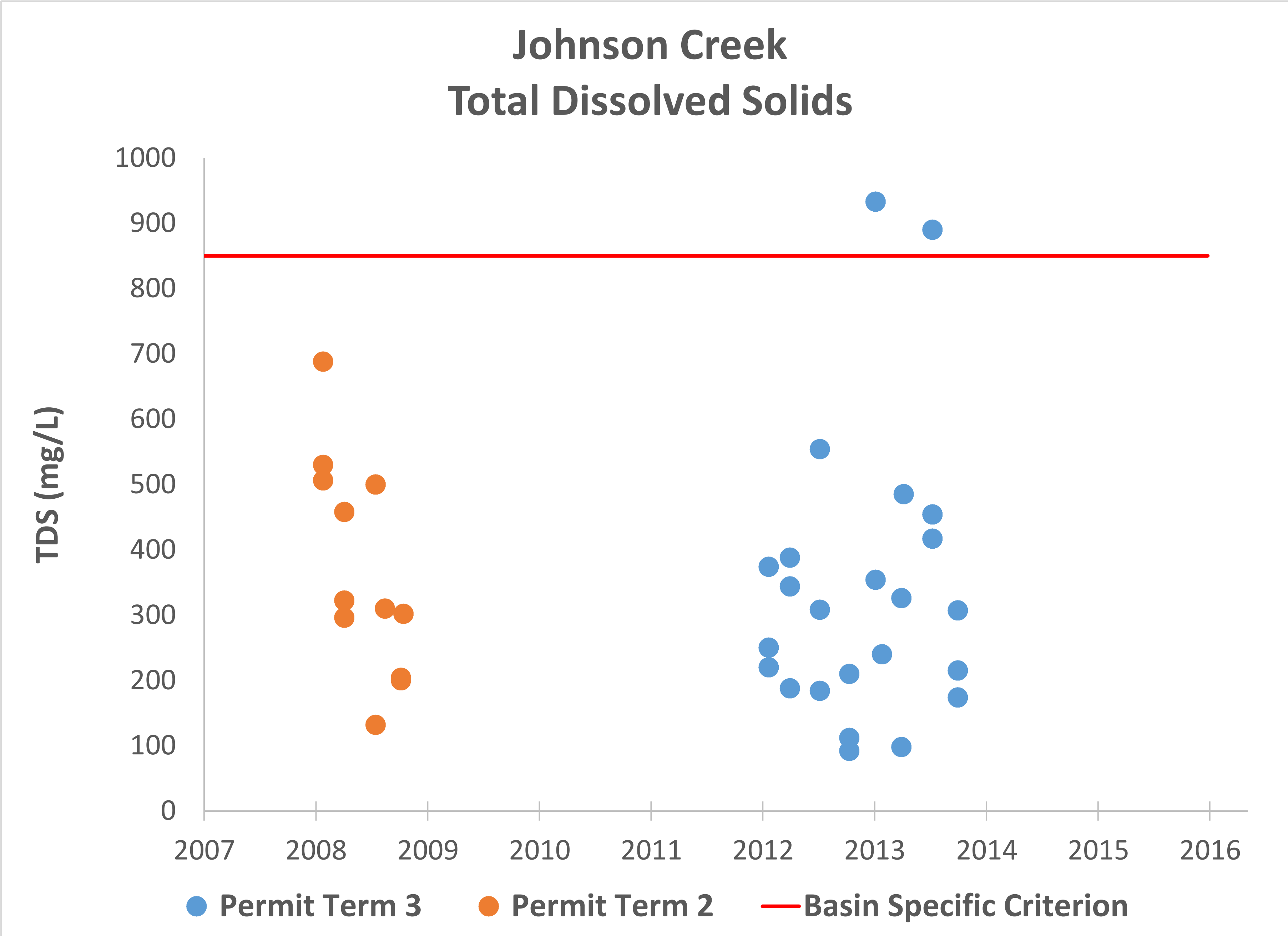
Honey Springs Branch
Field pH
pH (Standard Units)
9.5
9
8.5
8
7.5
7
6.5
6
2009
2010
2011
2012
2013
2014
2015
2016
Permit Term 3
Basin Specific Criteria
Permit Term 2

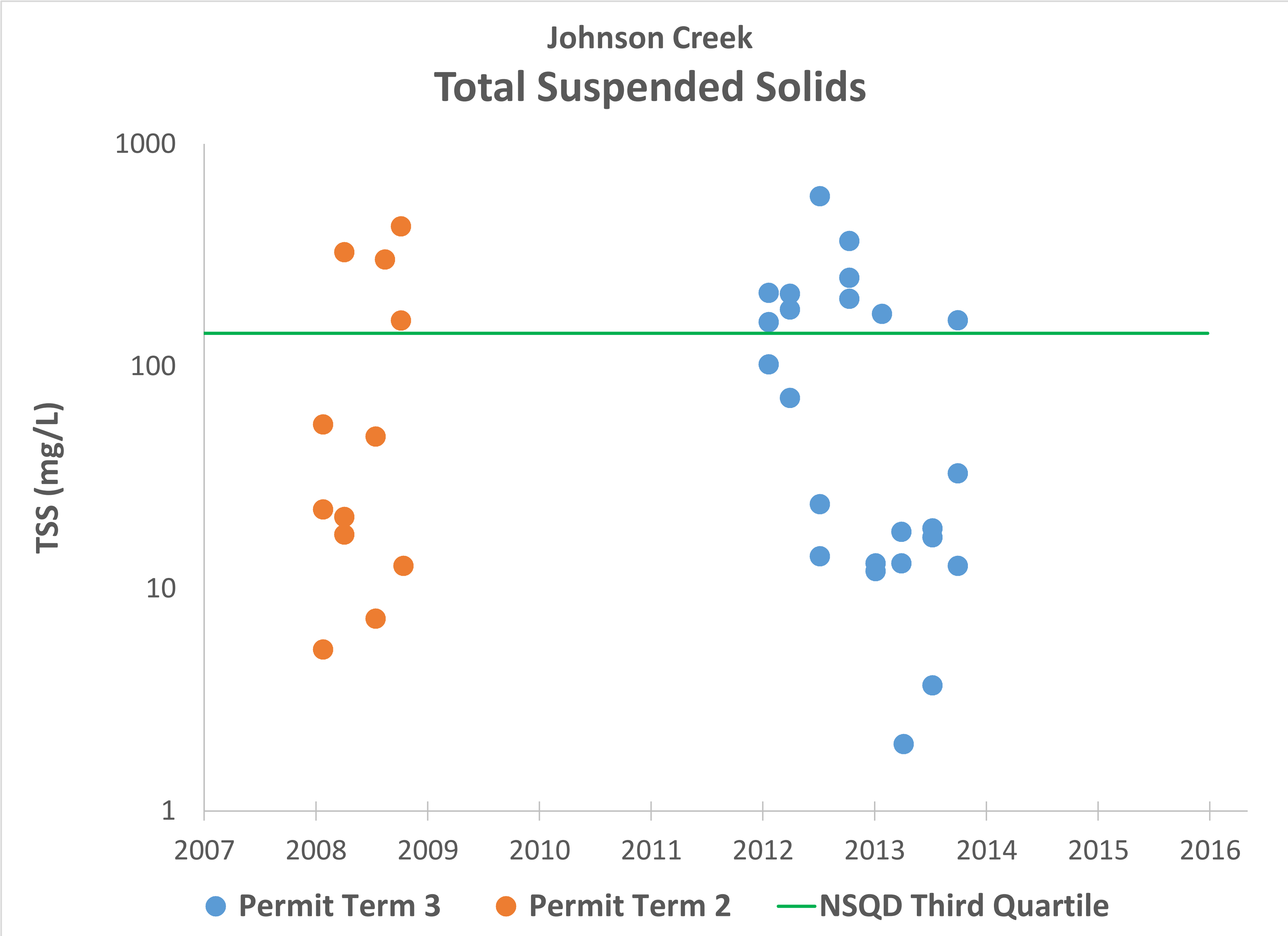


Honey Springs Branch
E.Coli
E. Coli (col/100 mL)
1000000
100000
10000
1000
100
10
1
2009
2010
2011
2012
2013
2014
2015
2016
Permit Term 3
Permit Term 2
PCR Single Sample
PCR Geomean

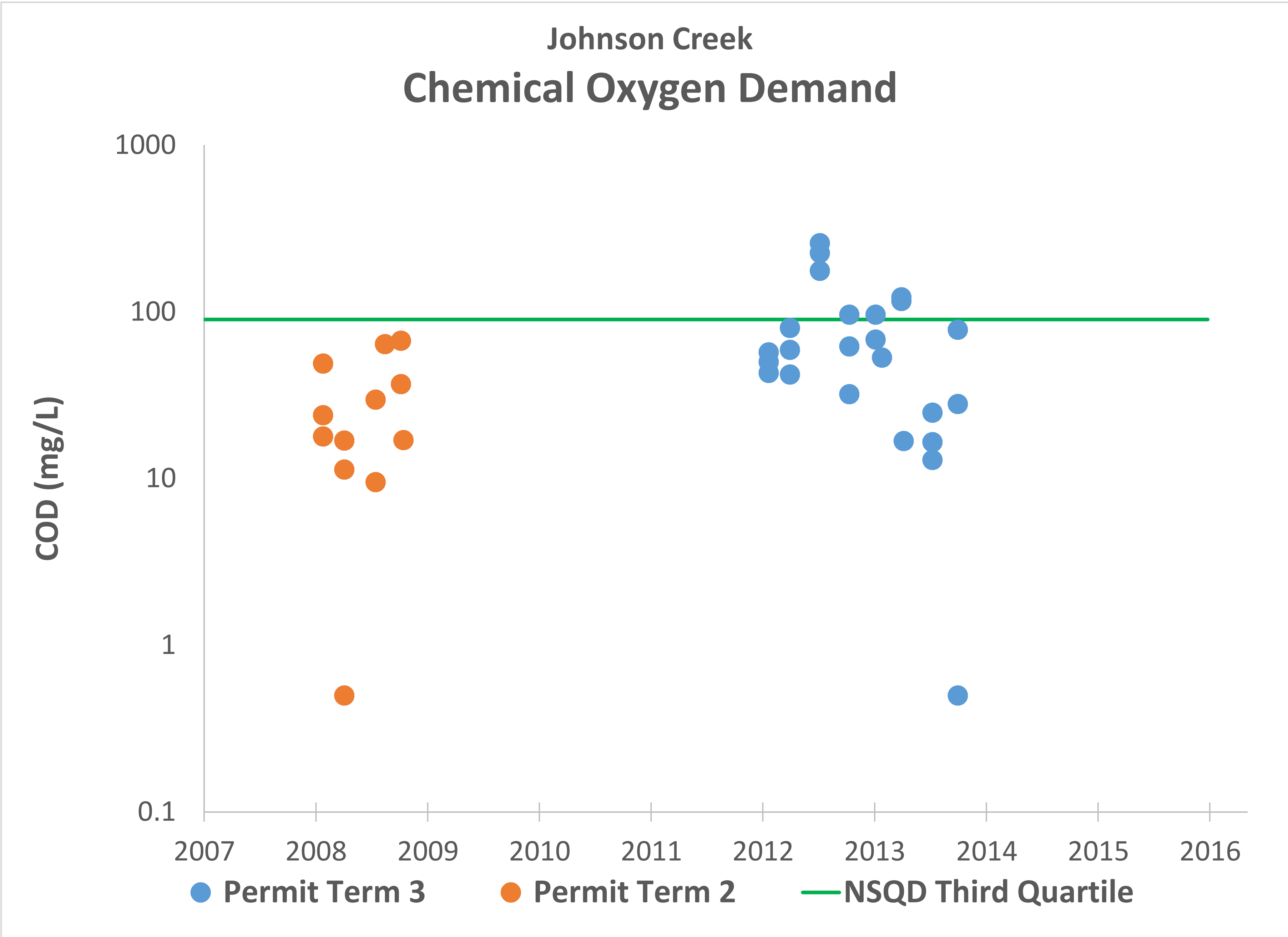
Appendix M

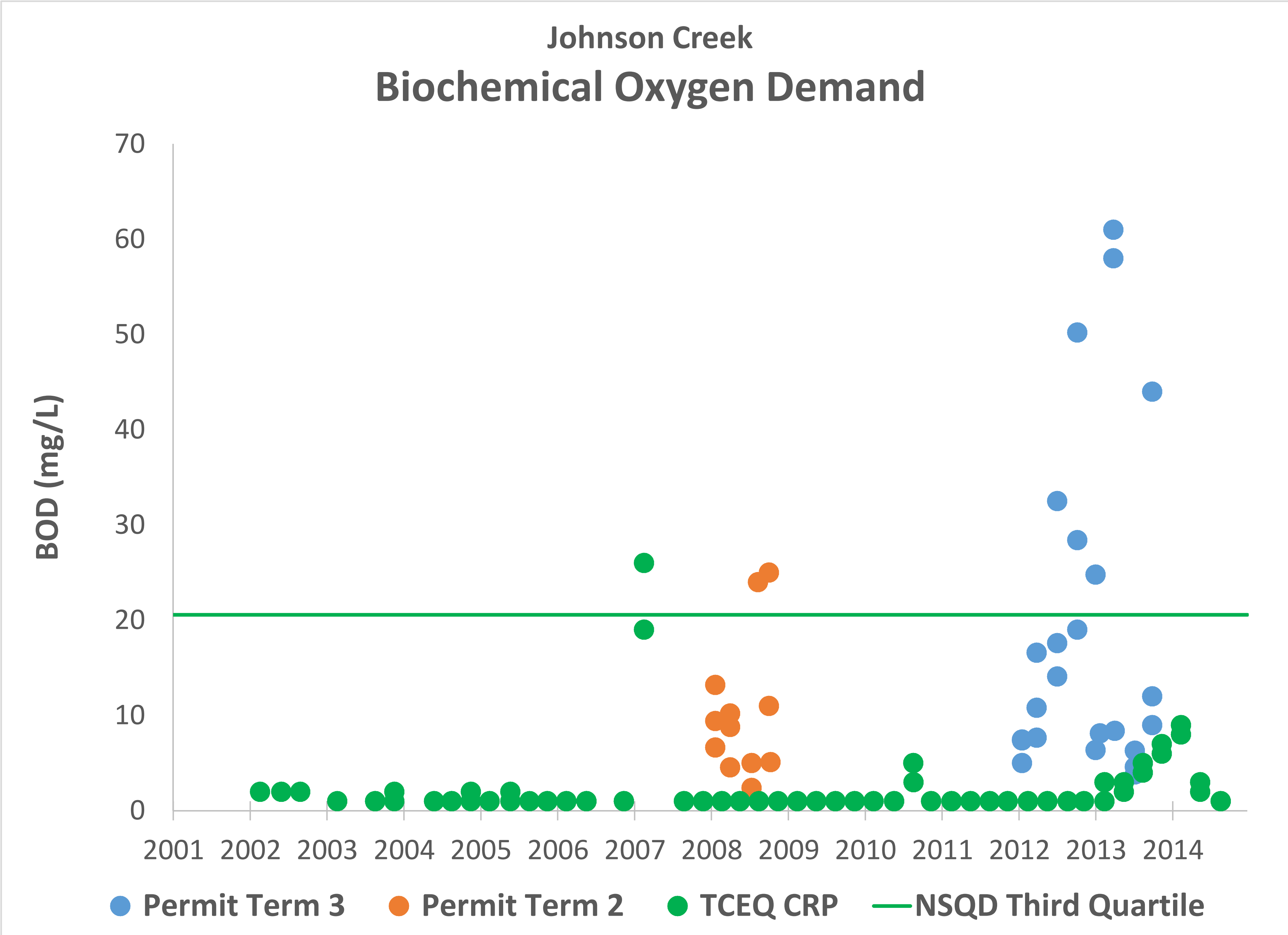
Johnson Creek Water Quality Data Graphs

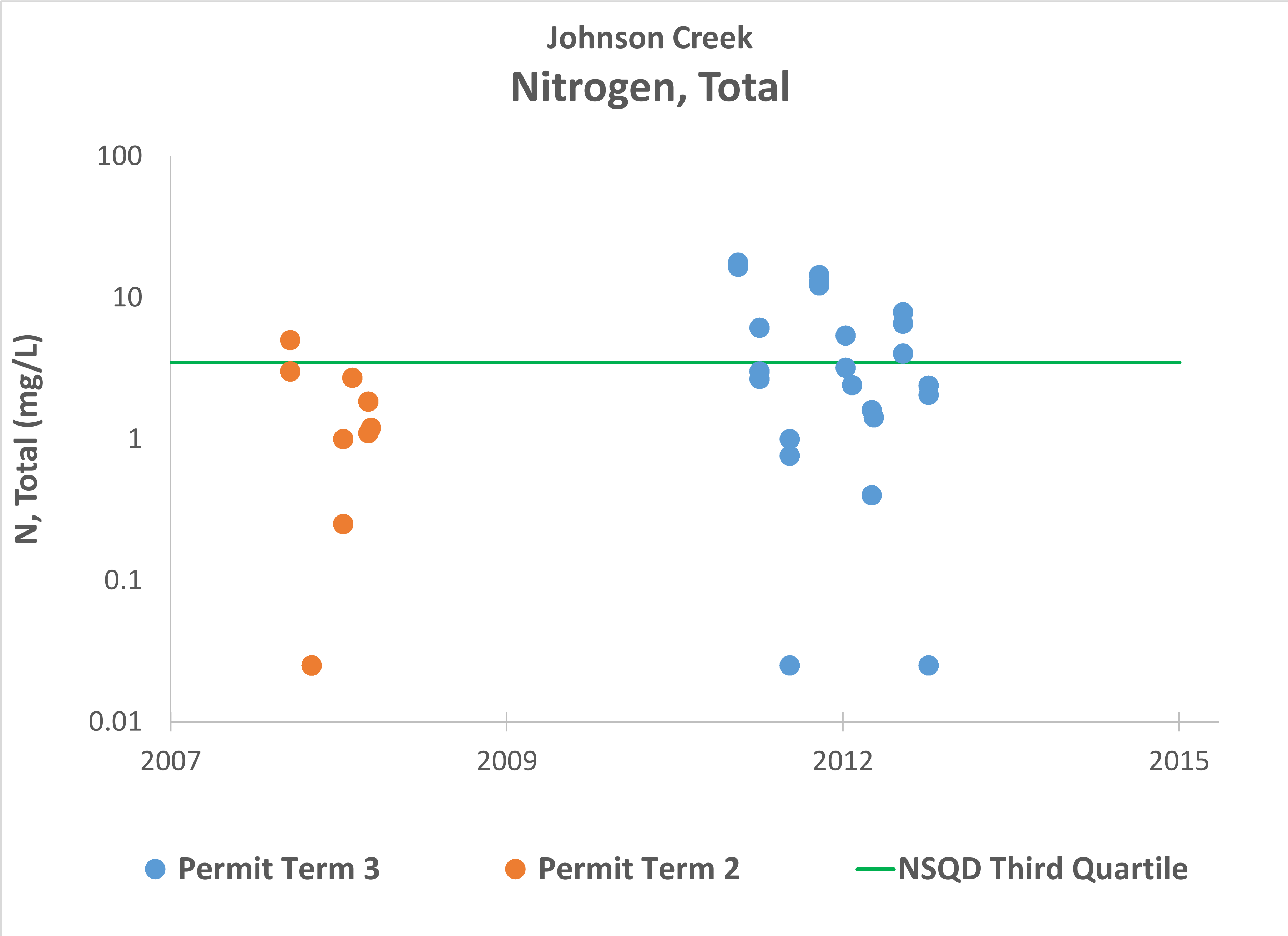

Johnson Creek
Total Dissolved Solids
TDS (mg/L)
0
100
200
300
400
500
600
700
800
900
1000
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
Permit Term 3
Permit Term 2
Basin Specific Criterion



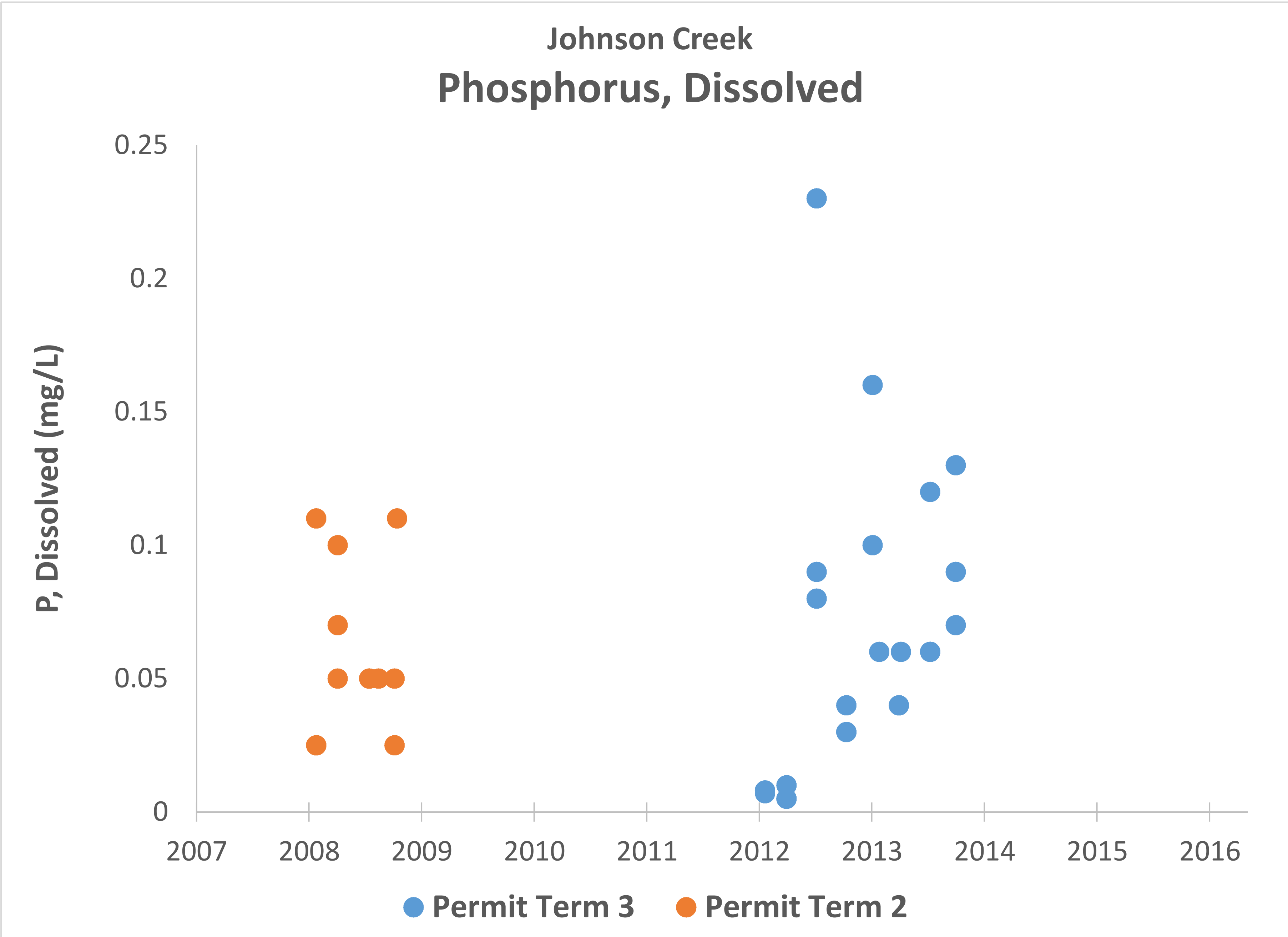
Johnson Creek
Total Suspended Solids
TSS (mg/L)
1000
100
10
1
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
Permit Term 3
Permit Term 2
NSQD Third Quartile

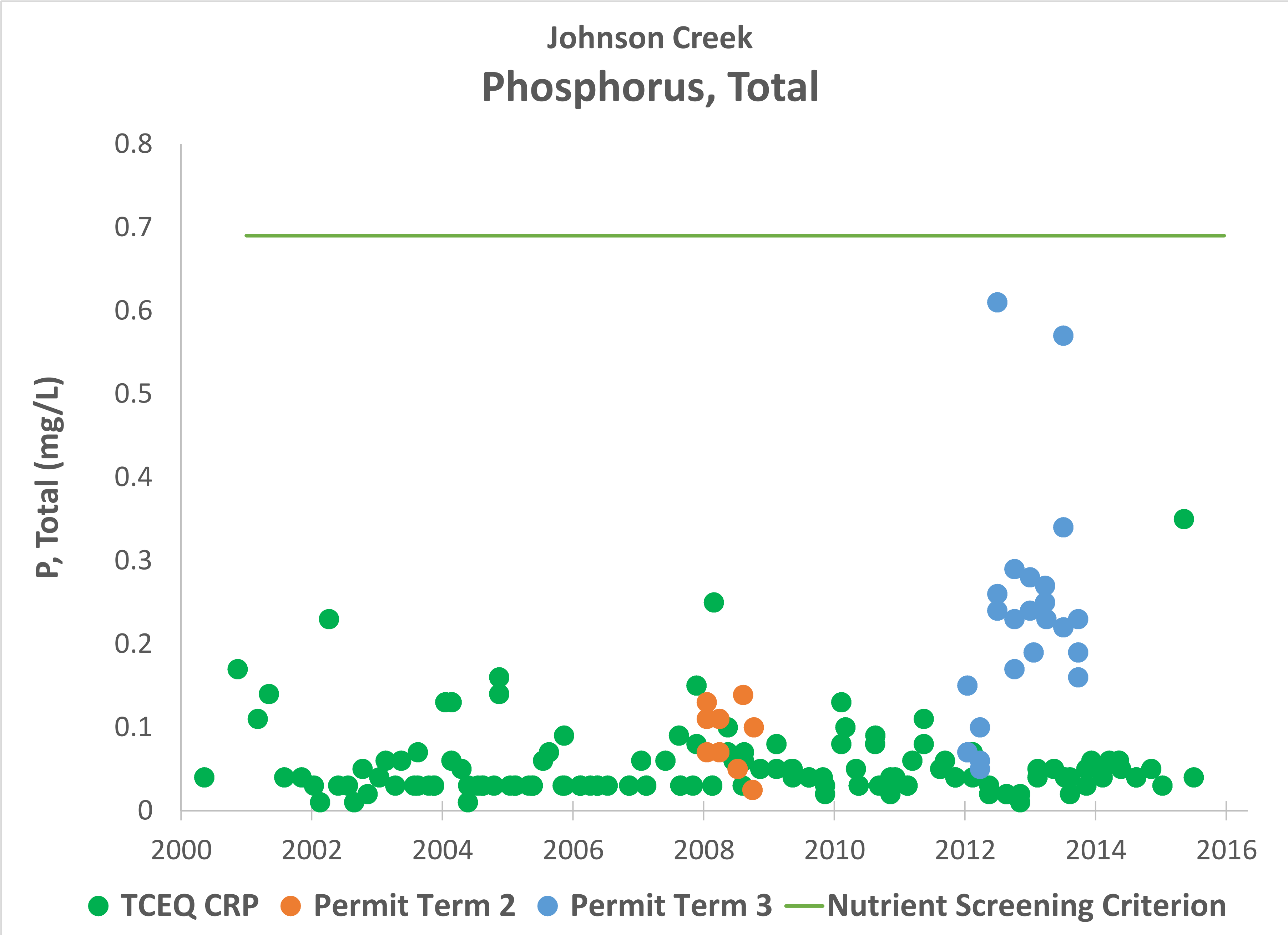

Johnson Creek
Chemical Oxygen Demand
COD (mg/L)
1000
100
10
1
0.1
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
Permit Term 3
Permit Term 2
NSQD Third Quartile

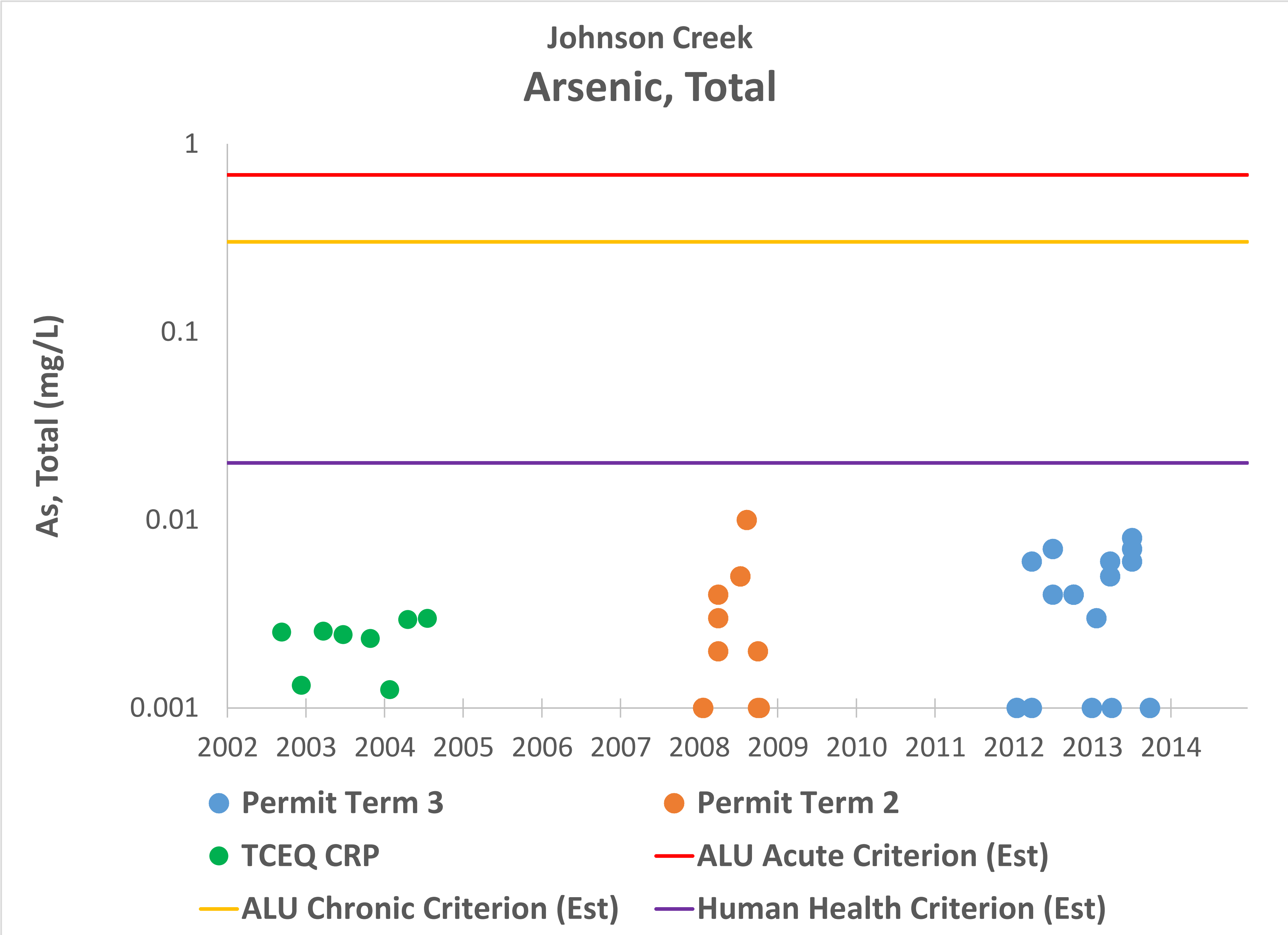

Johnson Creek
Biochemical Oxygen Demand
BOD (mg/L)
70
60
50
40
30
20
10
0
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
Permit Term 3
Permit Term 2
TCEQ CRP
NSQD Third Quartile



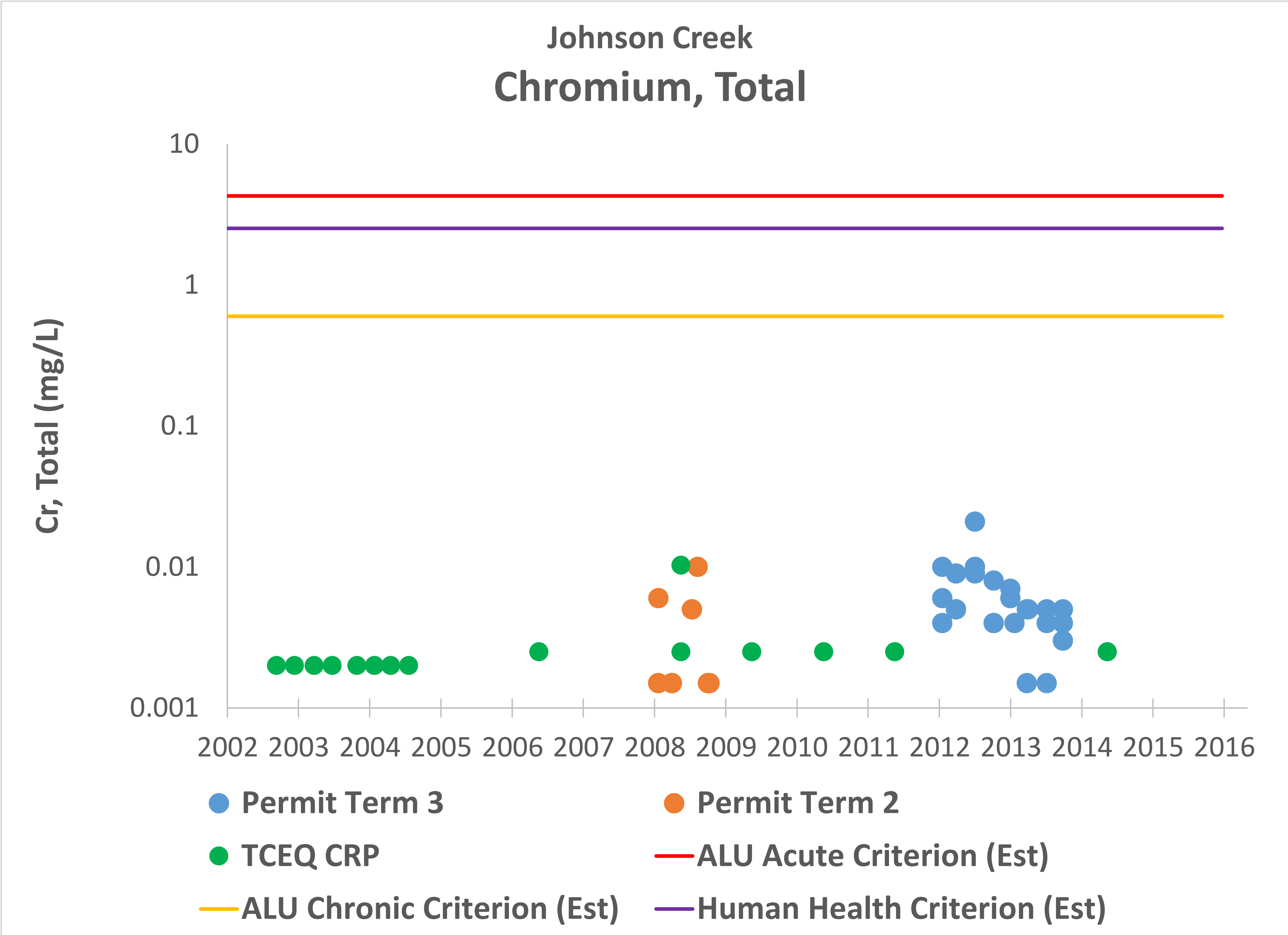
Johnson Creek
Nitrogen, Total
N, Total (mg/L)
100
10
1
0.1
0.01
2007
2009
2012
2015
Permit Term 3
Permit Term 2
NSQD Third Quartile

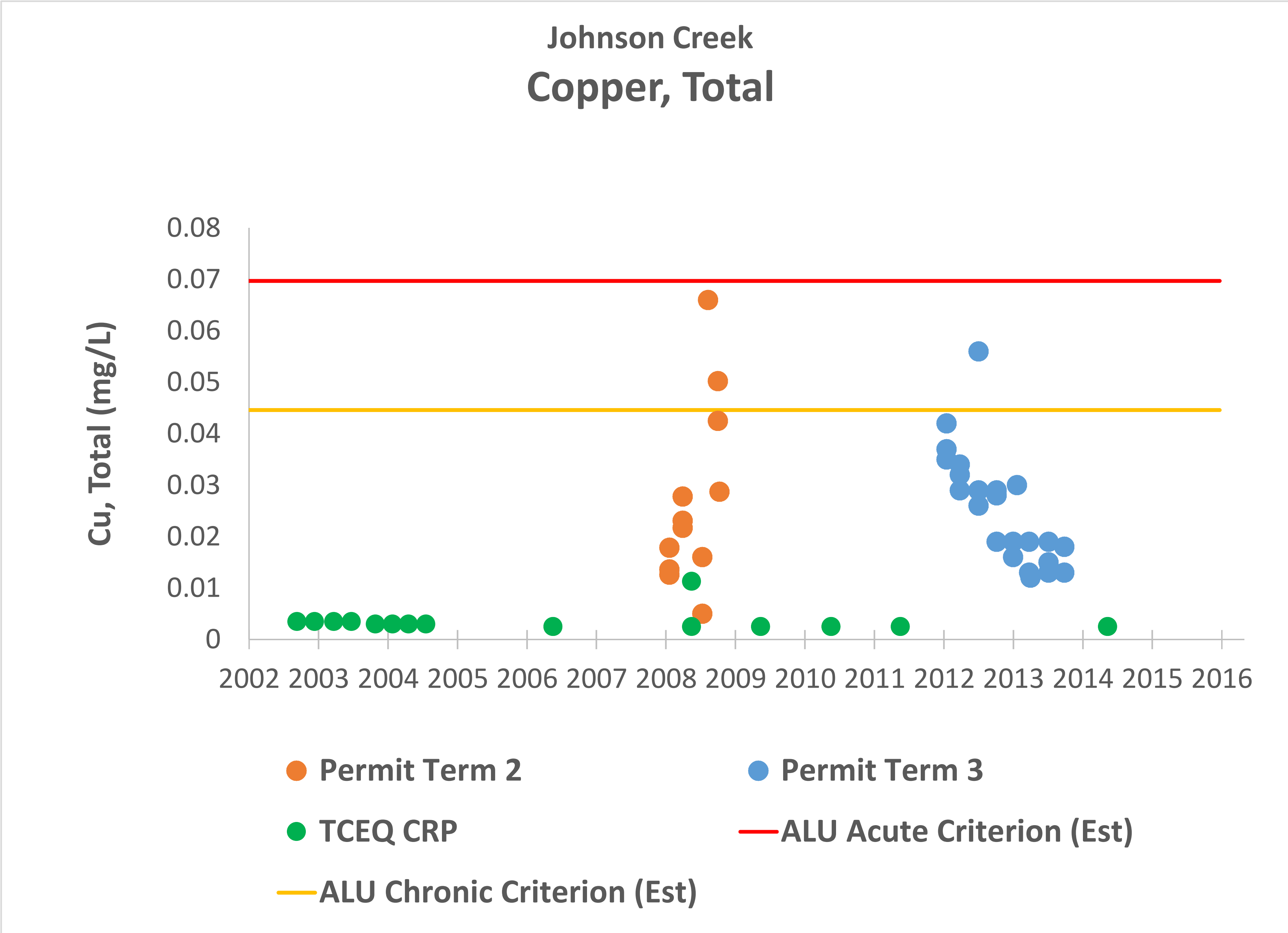

Johnson Creek
Phosphorus, Dissolved
P, Dissolved (mg/L)
0.25
0.2
0.15
0.1
0.05
0
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
Permit Term 3
Permit Term 2

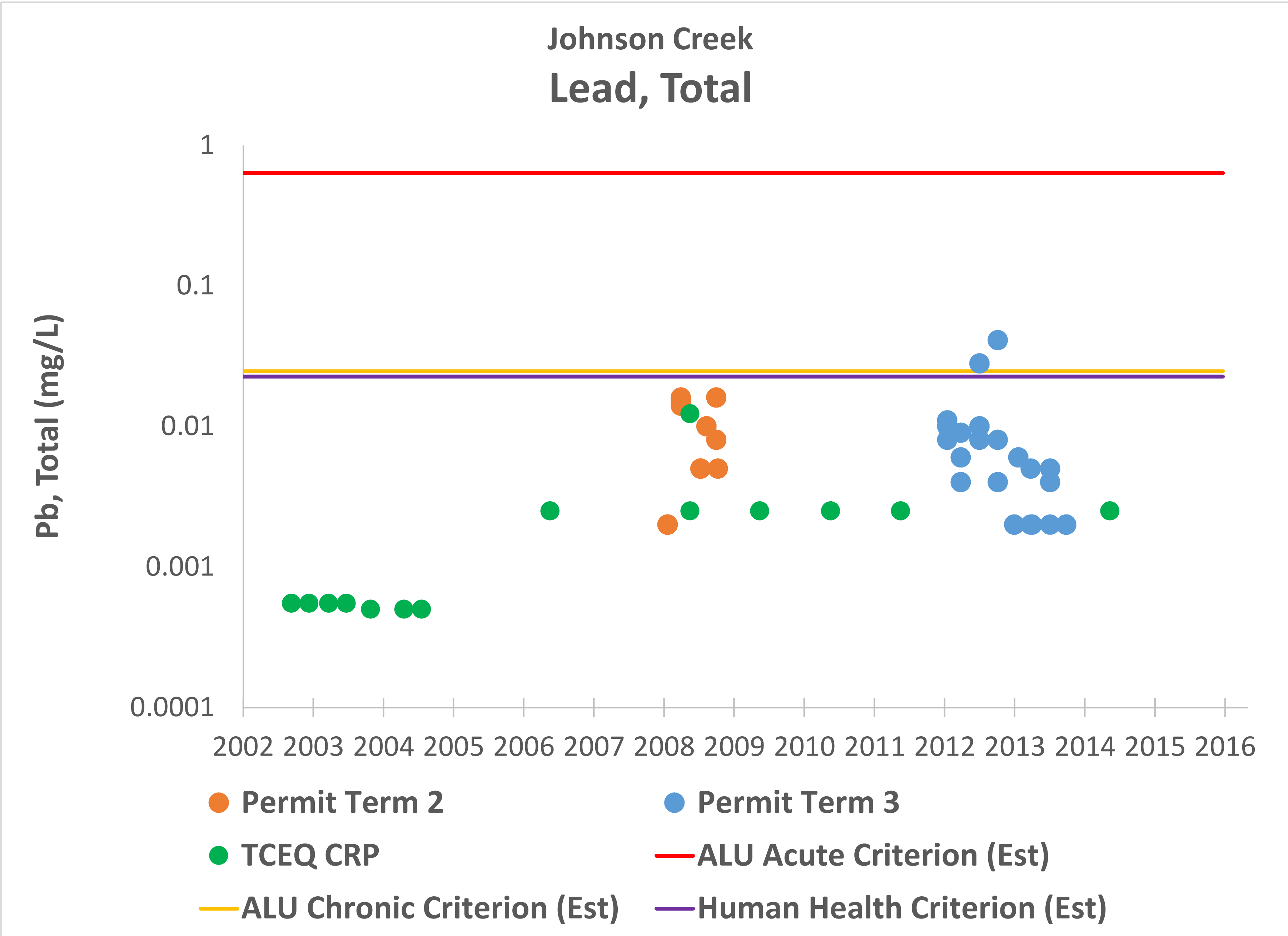

Johnson Creek
Phosphorus, Total
P, Total (mg/L)
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
2000
2002
2004
2006
2008
2010
2012
2014
2016
TCEQ CRP
Permit Term 2
Permit Term 3
Nutrient Screening Criterion

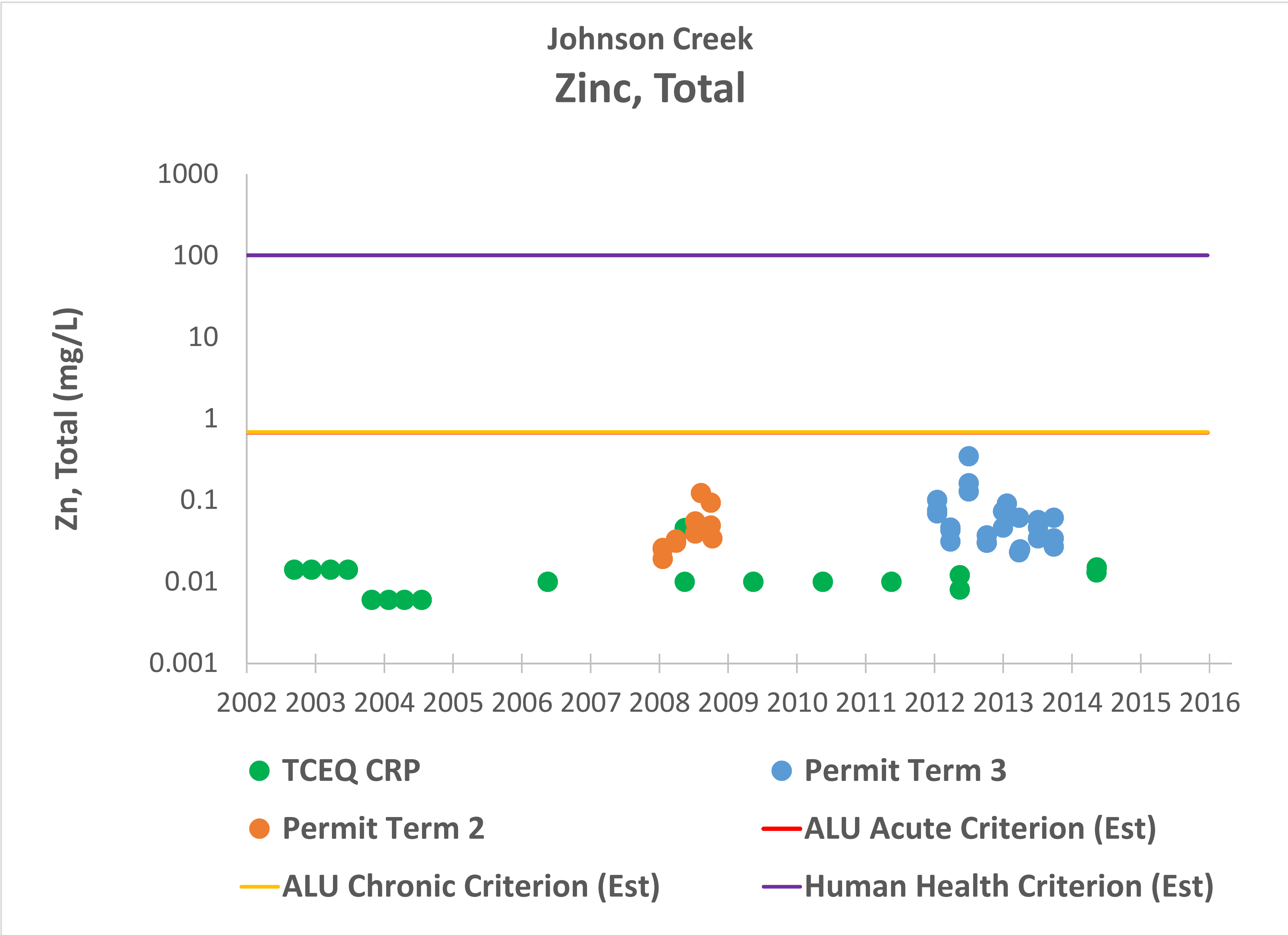


Johnson Creek
Arsenic, Total
As, Total (mg/L)
1
0.1
0.01
0.001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
Permit Term 3
Permit Term 2
TCEQ CRP
ALU Acute Criterion (Est)
ALU Chronic Criterion (Est)
Human Health Criterion (Est)

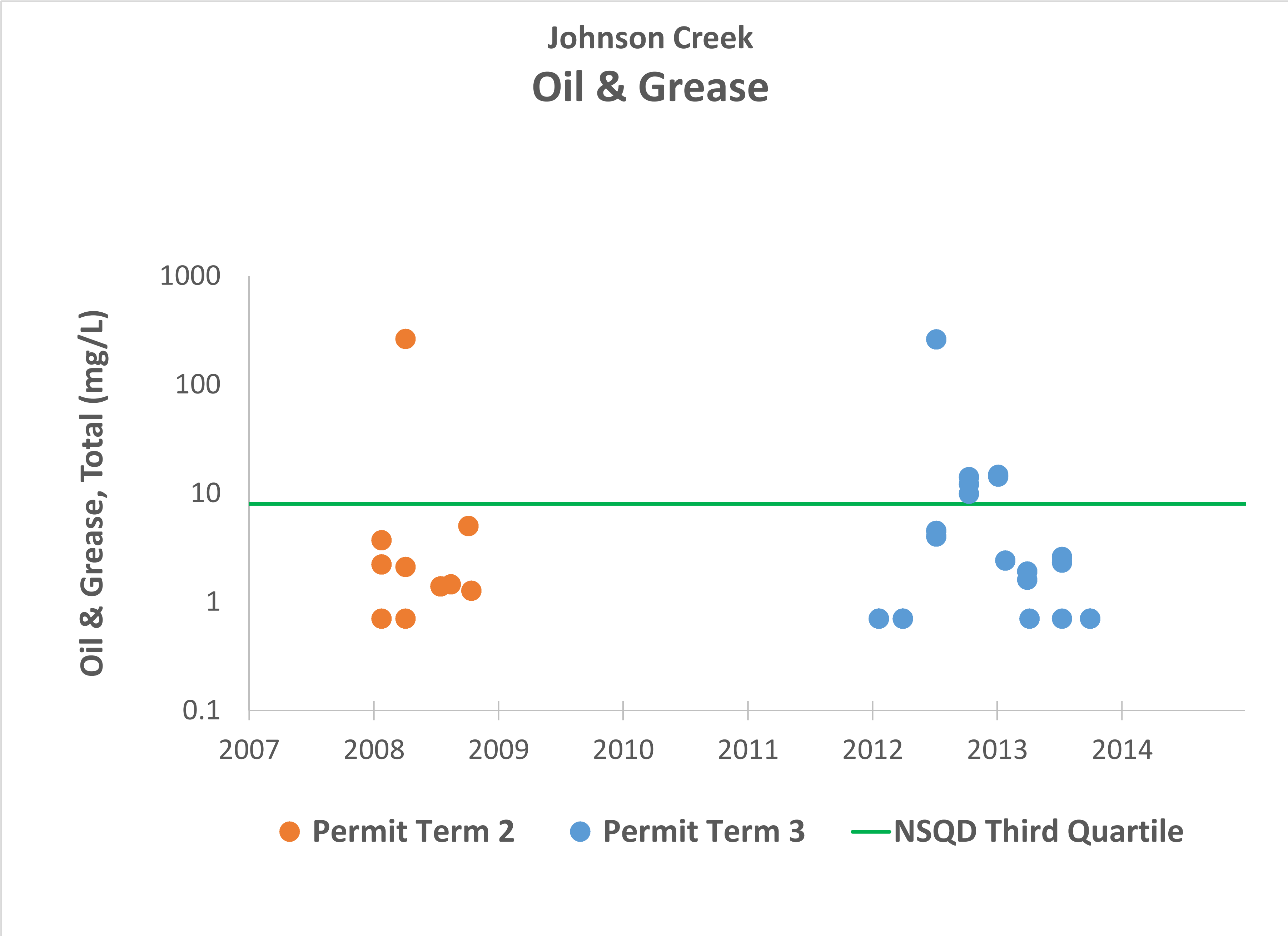

Johnson Creek
Chromium, Total
Cr, Total (mg/L)
10
1
0.1
0.01
0.001
2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016
Permit Term 3
Permit Term 2
TCEQ CRP
ALU Acute Criterion (Est)
ALU Chronic Criterion (Est)
Human Health Criterion (Est)

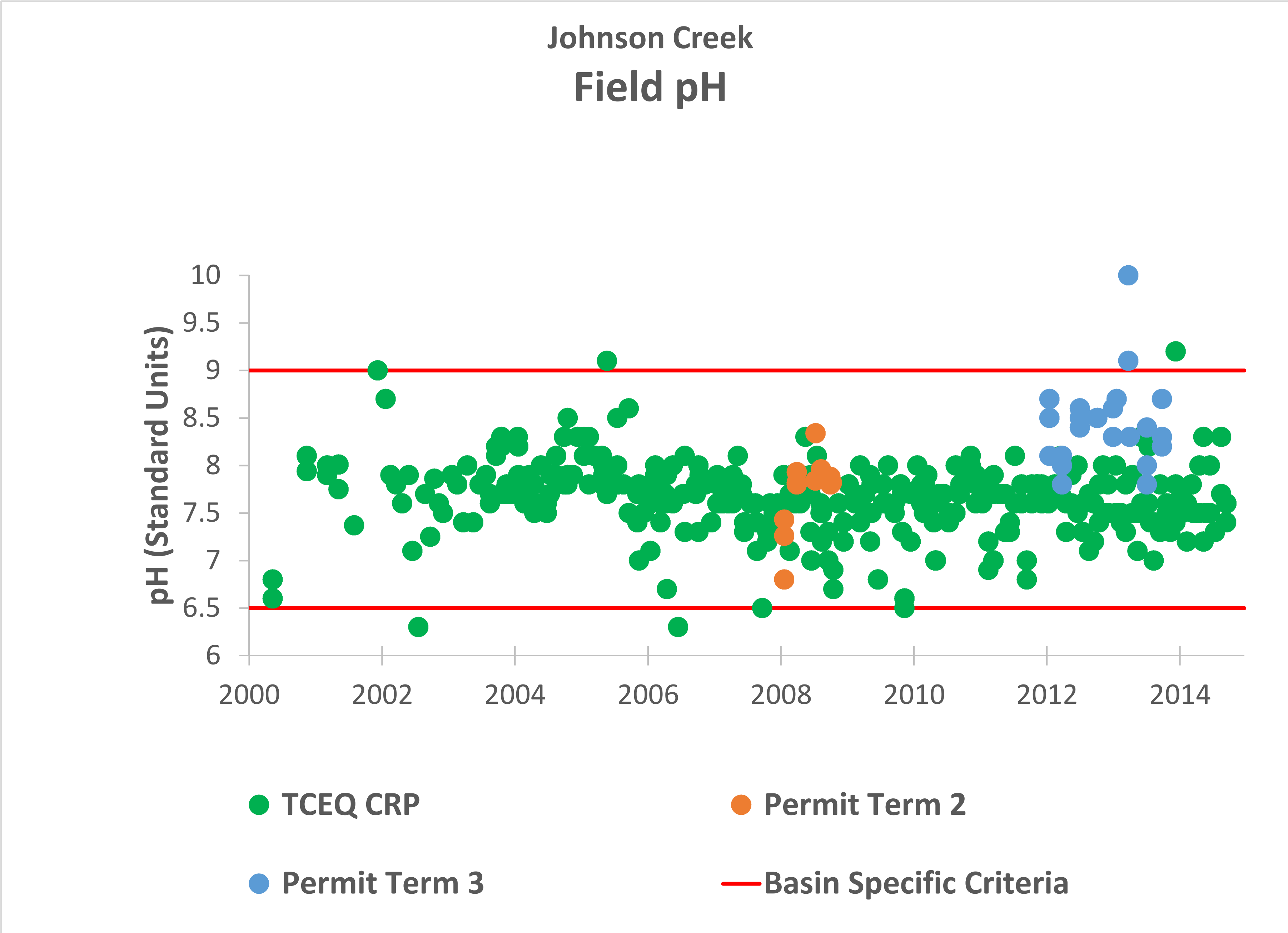

Johnson Creek
Copper, Total
Cu, Total (mg/L)
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016
Permit Term 2
Permit Term 3
TCEQ CRP
ALU Acute Criterion (Est)
ALU Chronic Criterion (Est)


Johnson Creek
Lead, Total
Pb, Total (mg/L)
1
0.1
0.01
0.001
0.0001
2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016
Permit Term 2
Permit Term 3
TCEQ CRP
ALU Acute Criterion (Est)
ALU Chronic Criterion (Est)
Human Health Criterion (Est)

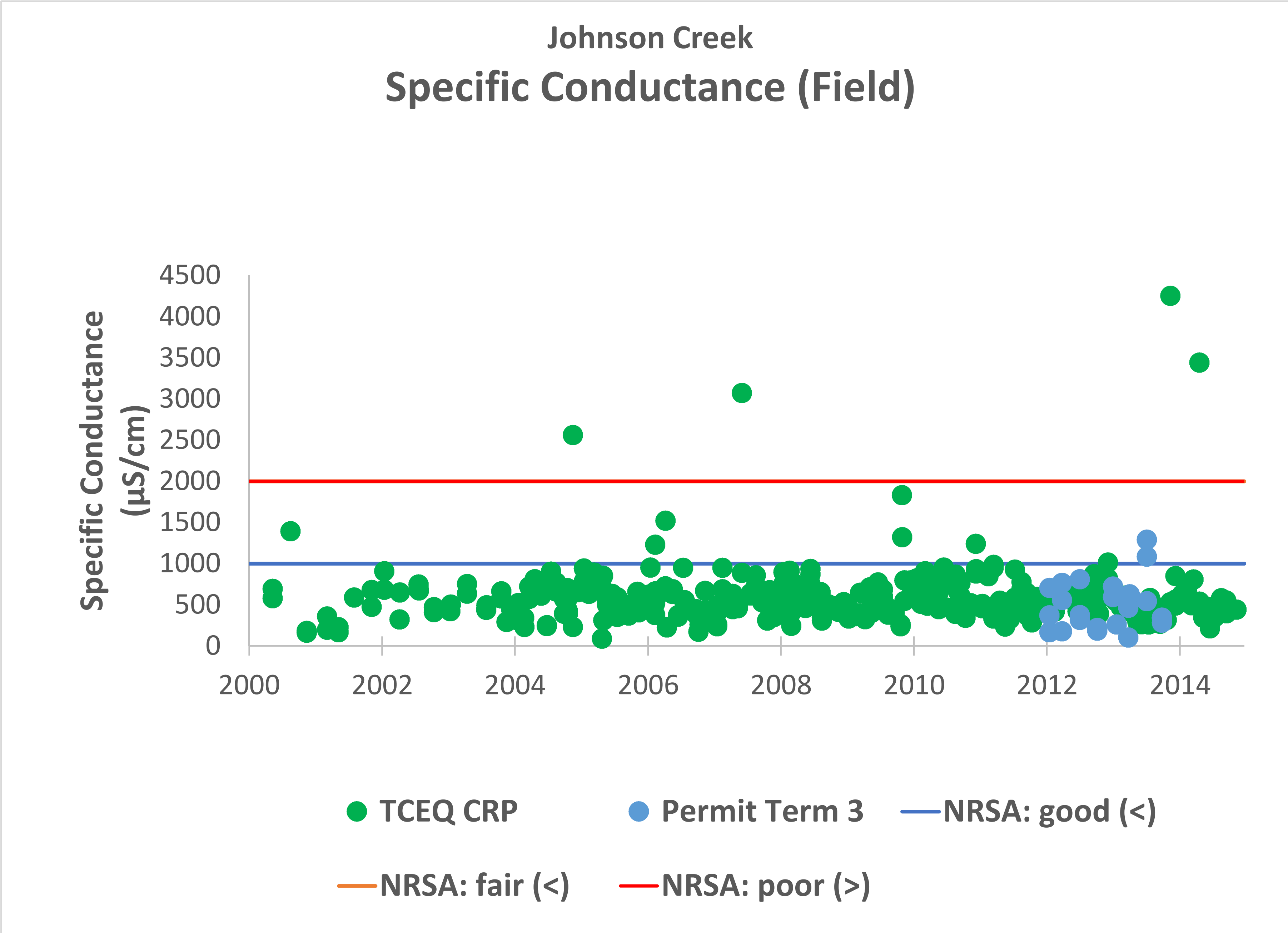


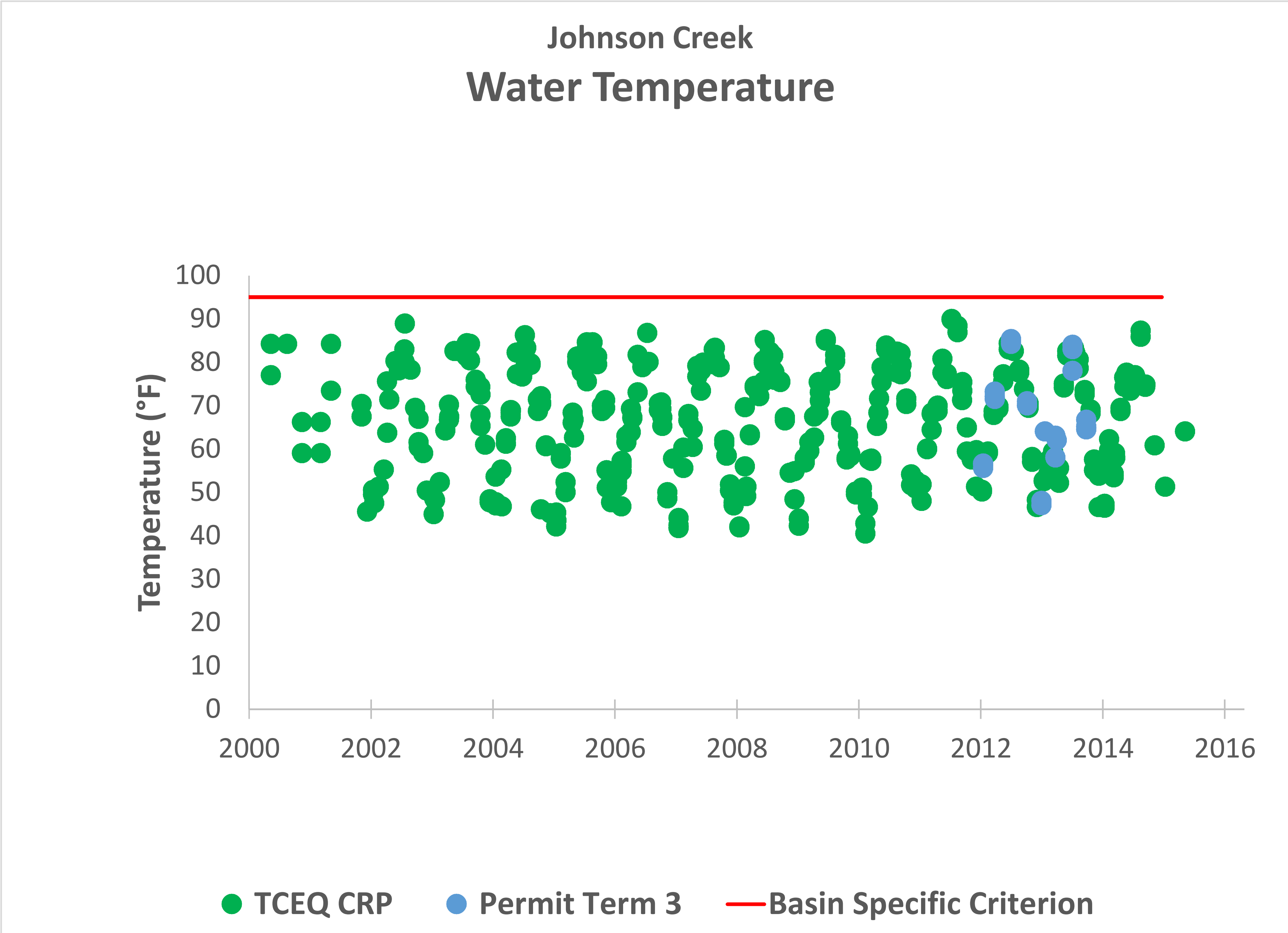
Johnson Creek
Zinc, Total
Zn, Total (mg/L)
1000
100
10
1
0.1
0.01
0.001
2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016
TCEQ CRP
Permit Term 3
Permit Term 2
ALU Acute Criterion (Est)
ALU Chronic Criterion (Est)
Human Health Criterion (Est)


Johnson Creek
Oil & Grease
Oil & Grease, Total (mg/L)
1000
100
10
1
0.1
2007
2008
2009
2010
2011
2012
2013
2014
Permit Term 2
Permit Term 3
NSQD Third Quartile

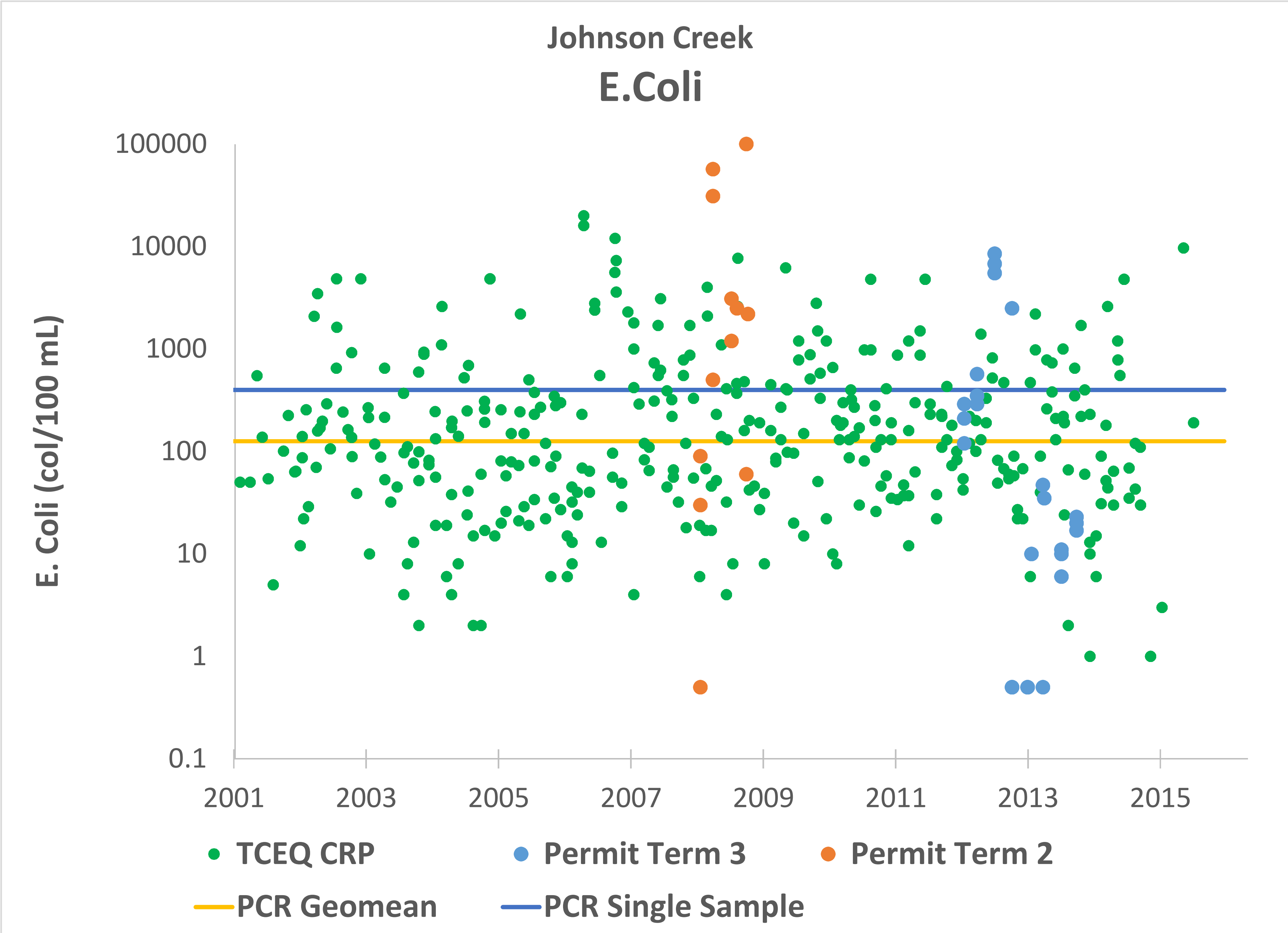


Johnson Creek
Field pH
pH (Standard Units)
10
9.5
9
8.5
8
7.5
7
6.5
6
2000
2002
2004
2006
2008
2010
2012
2014
TCEQ CRP
Permit Term 2
Permit Term 3
Basin Specific Criteria

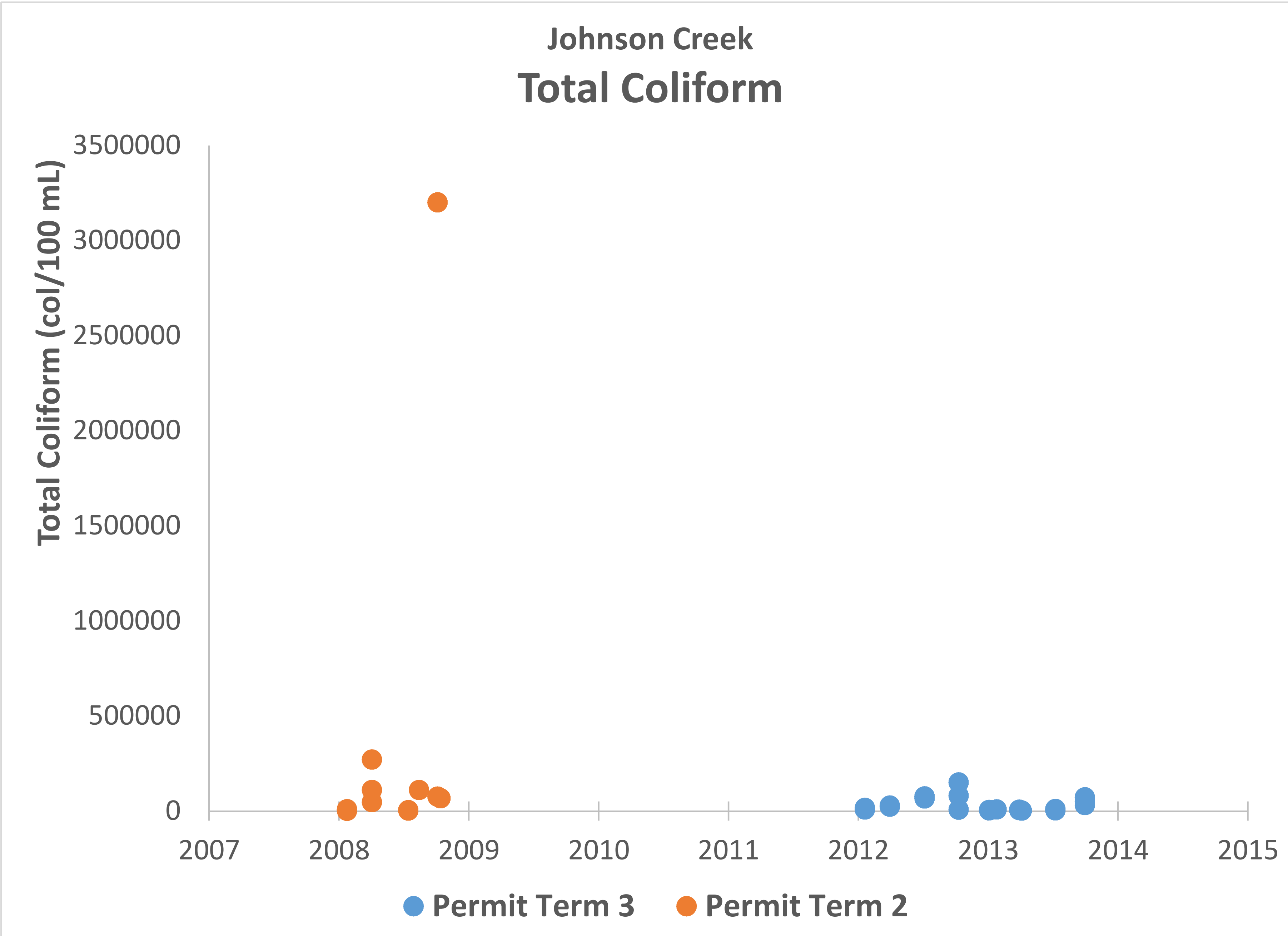

Johnson Creek
Specific Conductance (Field)
Specific Conductance (µS/cm)
4500
4000
3500
3000
2500
2000
1500
1000
500
0
2000
2002
2004
2006
2008
2010
2012
2014
TCEQ CRP
Permit Term 3
NRSA: good (<)
NRSA: fair (<)
NRSA: poor (>)

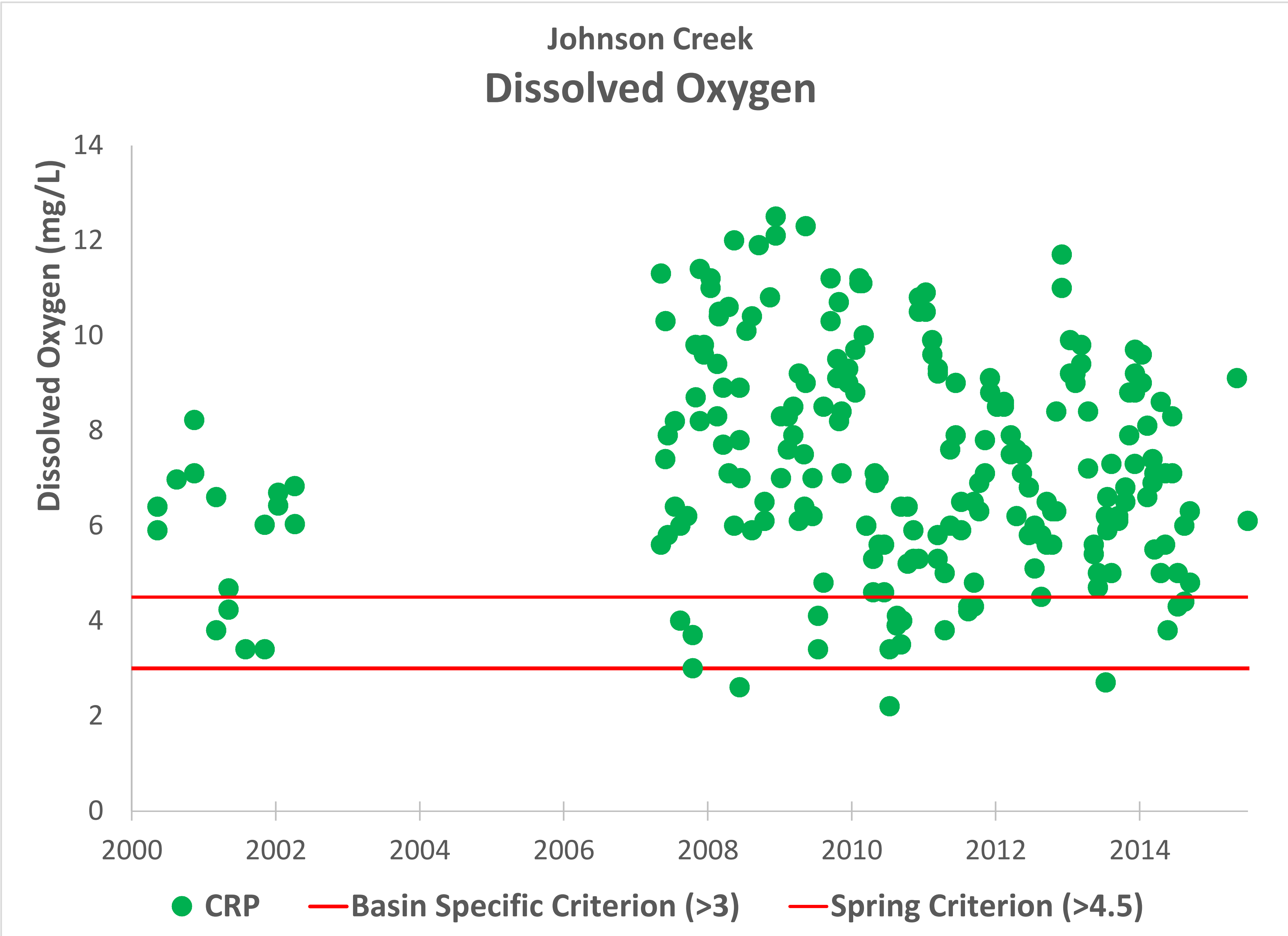


Johnson Creek
Water Temperature
Temperature (°F)
100
90
80
70
60
50
40
30
20
10
0
2000
2002
2004
2006
2008
2010
2012
2014
2016
TCEQ CRP
Permit Term 3
Basin Specific Criterion



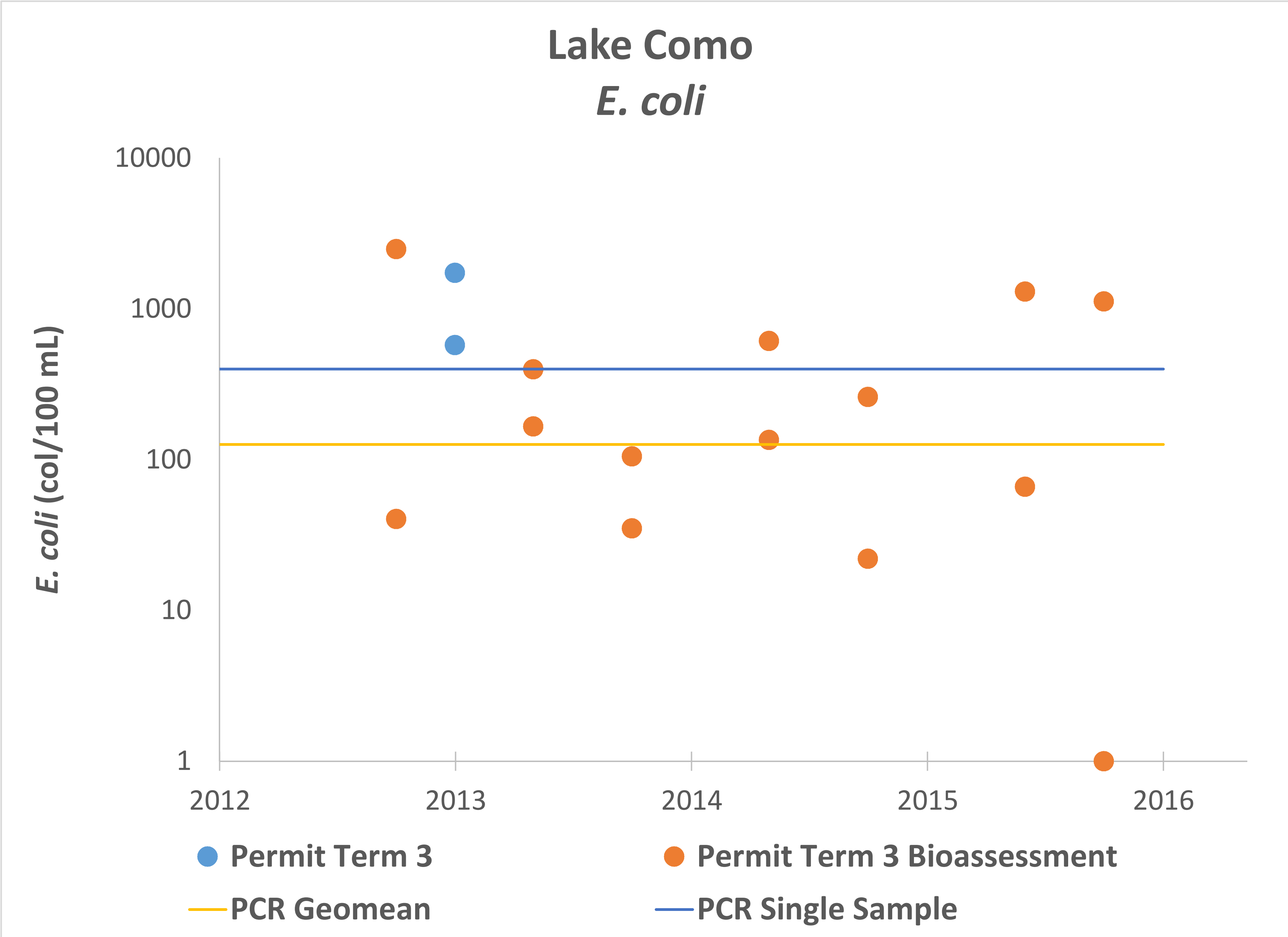
Johnson Creek
E.Coli
E. Coli (col/100 mL)
100000
10000
1000
100
10
1
0.1
2001
2003
2005
2007
2009
2011
2013
2015
TCEQ CRP
Permit Term 3
Permit Term 2
PCR Geomean
PCR Single Sample


Johnson Creek
Total Coliform
Total Coliform (col/100 mL)
3500000
3000000
2500000
2000000
1500000
1000000
500000
0
2007
2008
2009
2010
2011
2012
2013
2014
2015
Permit Term 3
Permit Term 2

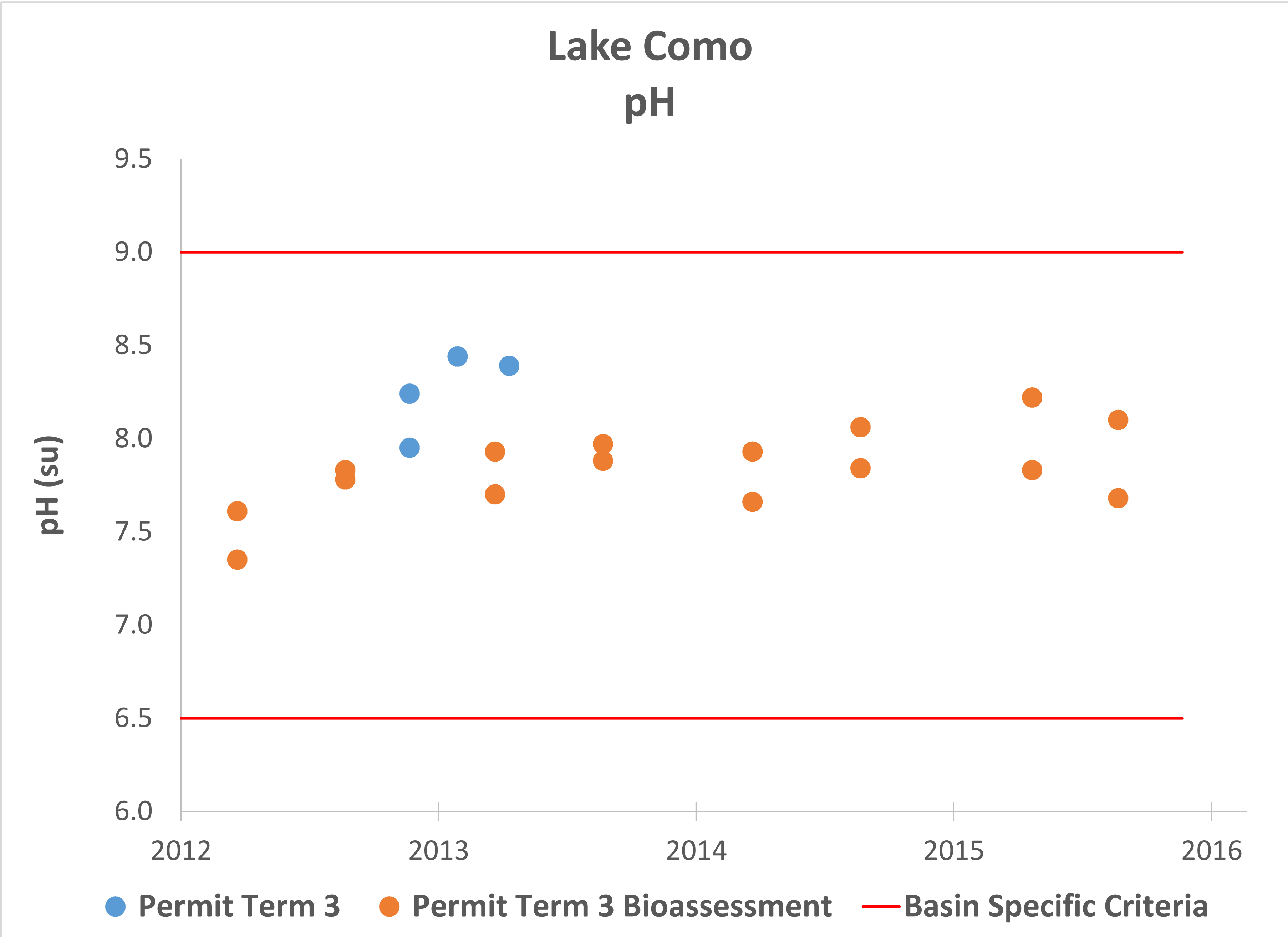

Johnson Creek
Dissolved Oxygen
Dissolved Oxygen (mg/L)
0
2
4
6
8
10
12
14
2000
2002
2004
2006
2008
2010
2012
2014
CRP
Basin Specific Criterion (>3)
Spring Criterion (>4.5)

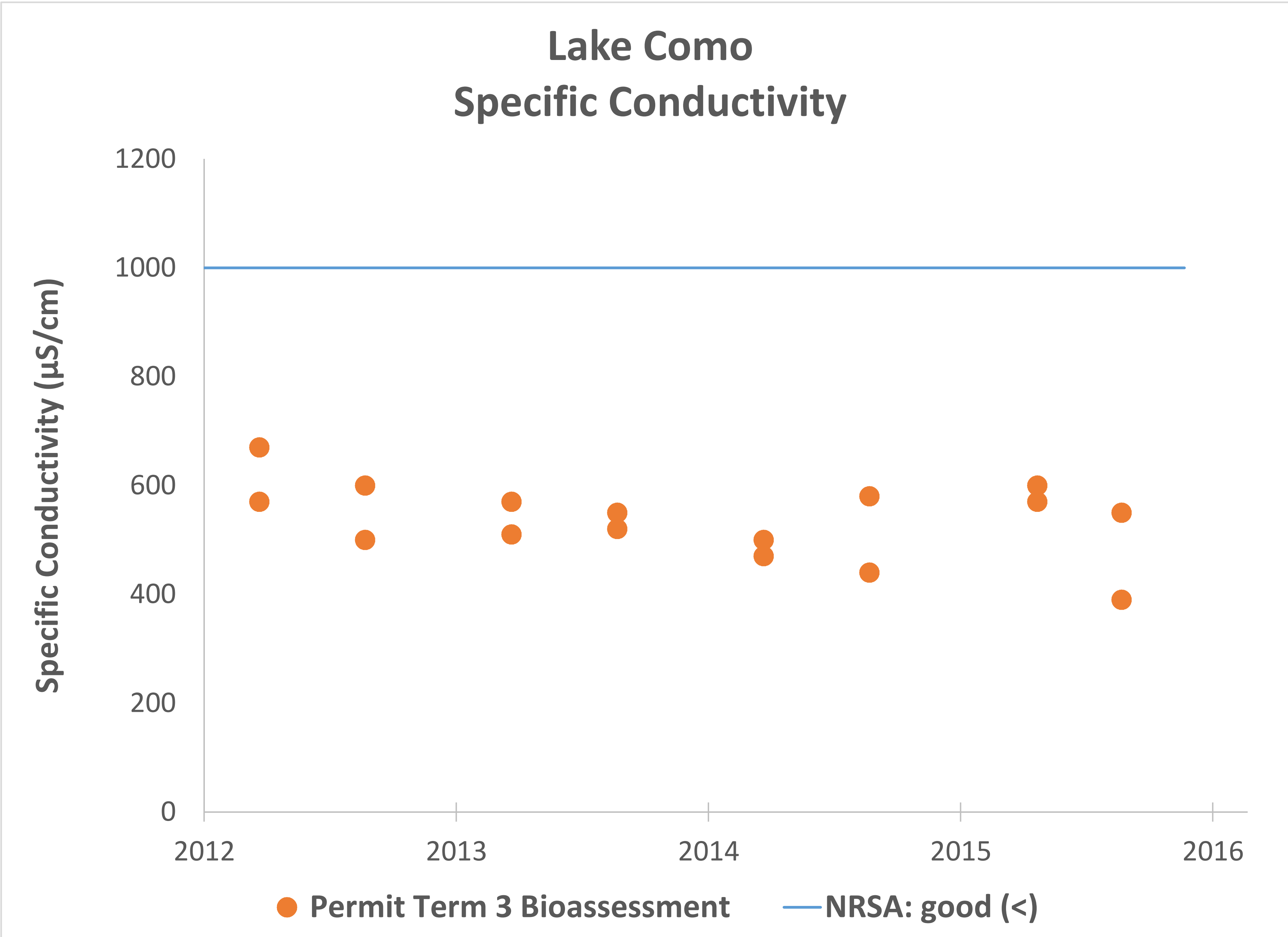
Appendix N

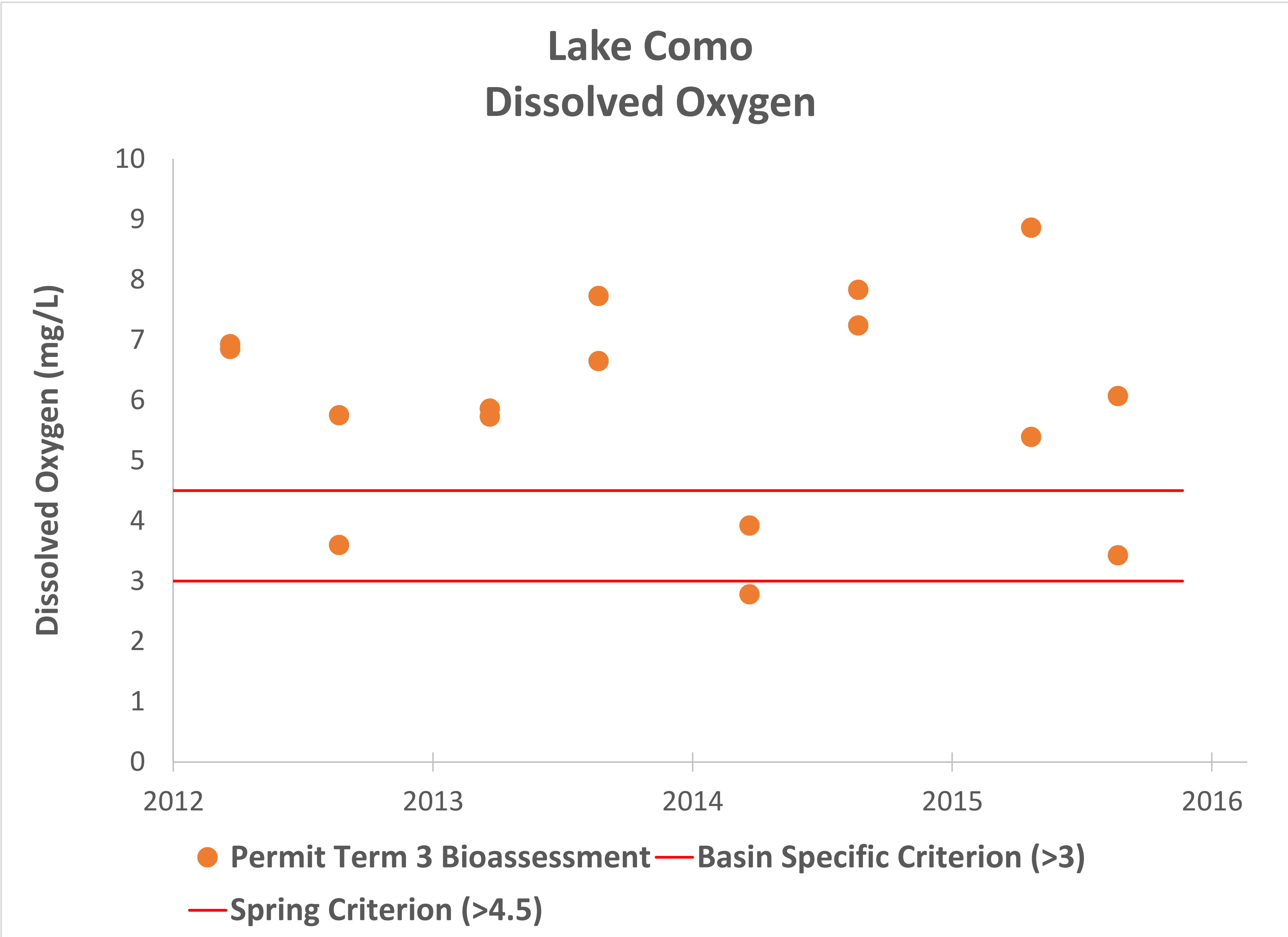
Lake Como – Clear Fork Trinity River Water Quality Data Graphs

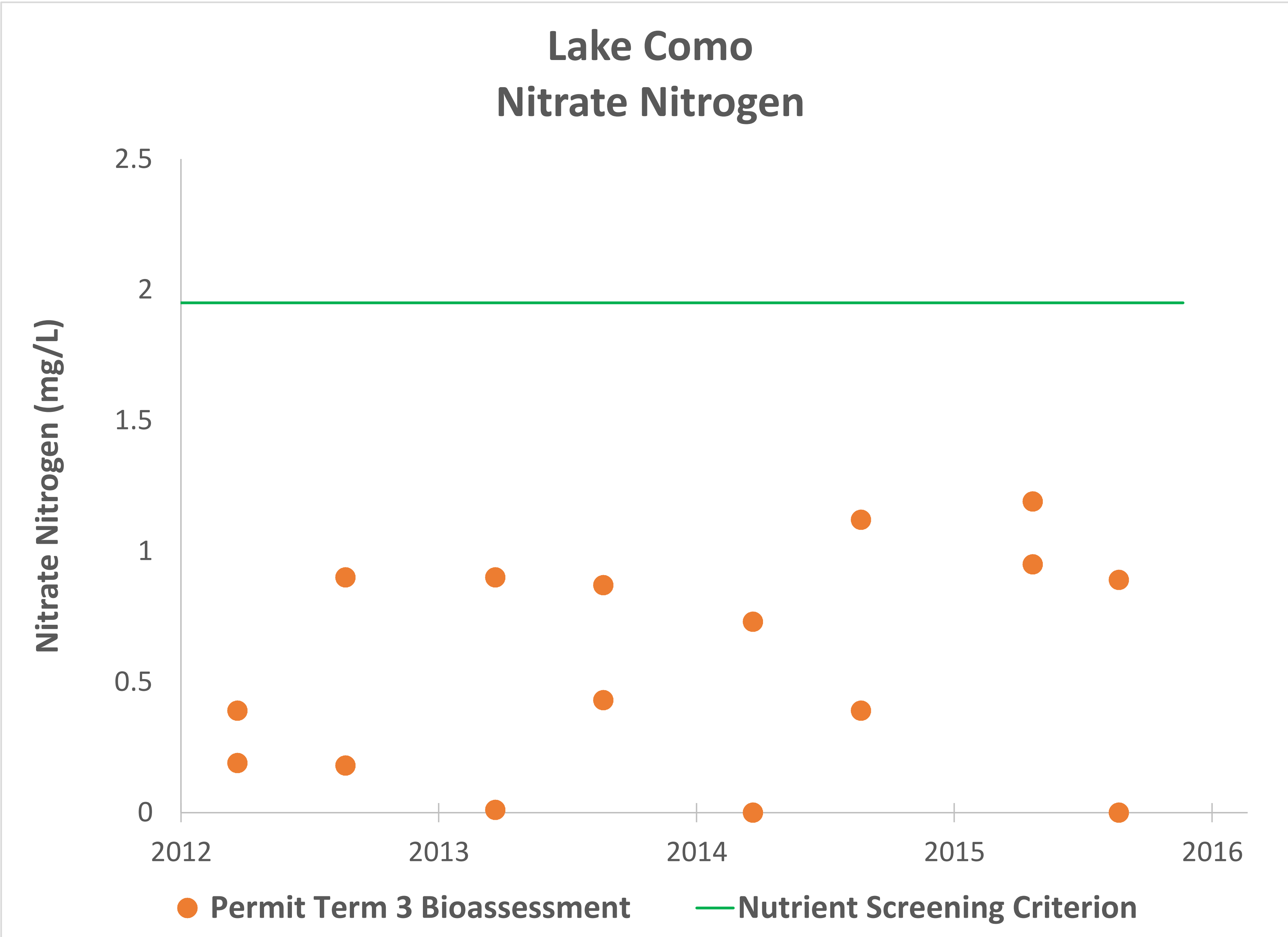


Lake Como
E. coli
10000
1000
100
10
1
E. coli (col/100 mL)
2012
2013
2014
2015
2016
Permit Term 3
Permit Term 3 Bioassessment
PCR Geomean
PCR Single Sample

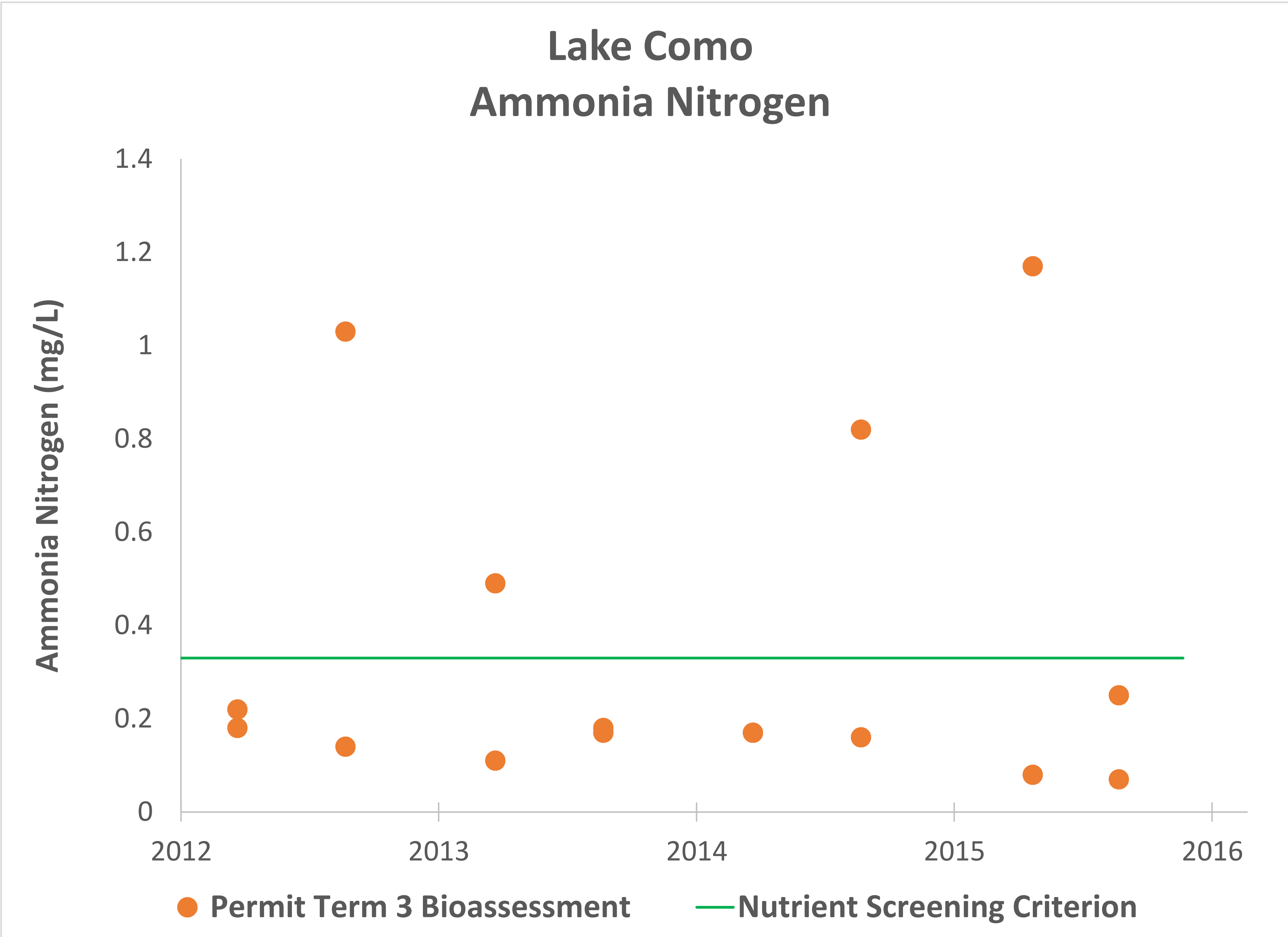

Lake Como
pH
pH (su)
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
2012
2013
2014
2015
2016
Permit Term 3
Permit Term 3 Bioassessment
Basin Specific Criteria


Lake Como
Specific Conductivity
Specific Conductivity (µS/cm)
1200
1000
800
600
400
200
0
2012
2013
2014
2015
2016
Permit Term 3 Bioassessment
NRSA: good (<)

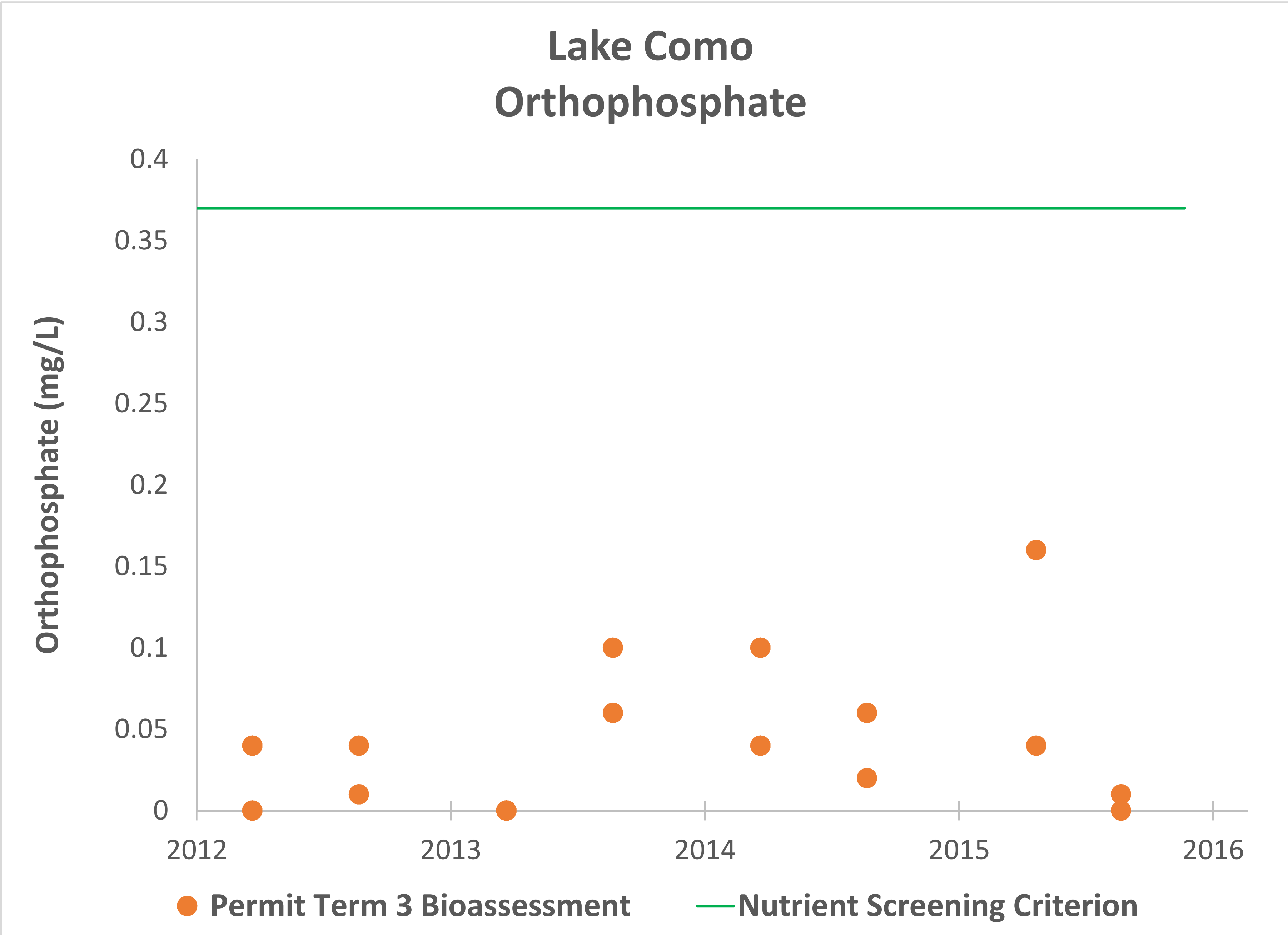

Lake Como
Dissolved Oxygen
Dissolved Oxygen (mg/L)
0
1
2
3
4
5
6
7
8
9
10
2012
2013
2014
2015
2016
Permit Term 3 Bioassessment
Basin Specific Criterion (>3)
Spring Criterion (>4.5)

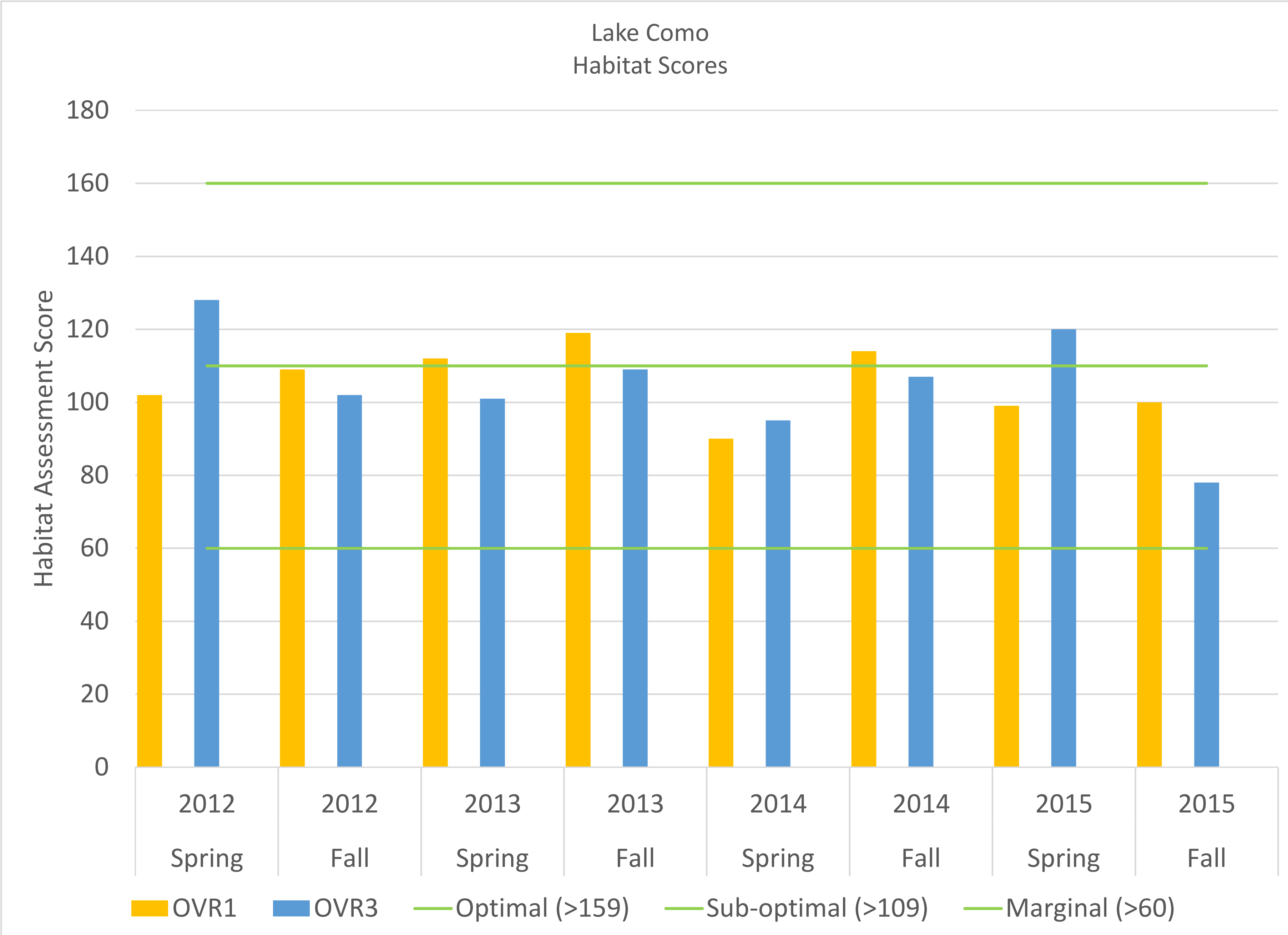


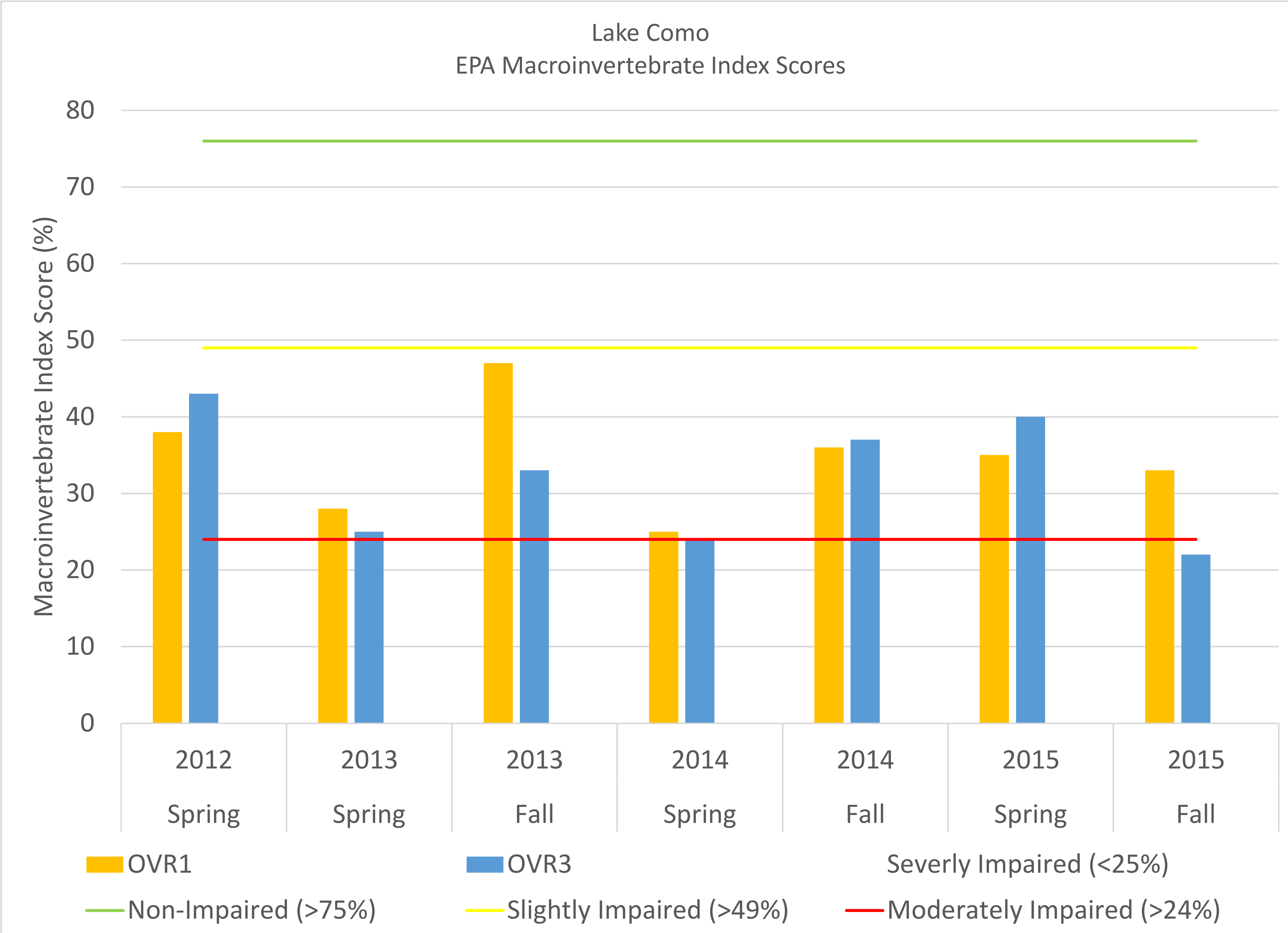
Lake Como
Nitrate Nitrogen
Nitrate Nitrogen (mg/L)
2.5
2
1.5
1
0.5
0
2012
2013
2014
2015
2016
Permit Term 3 Bioassessment
Nutrient Screening Criterion



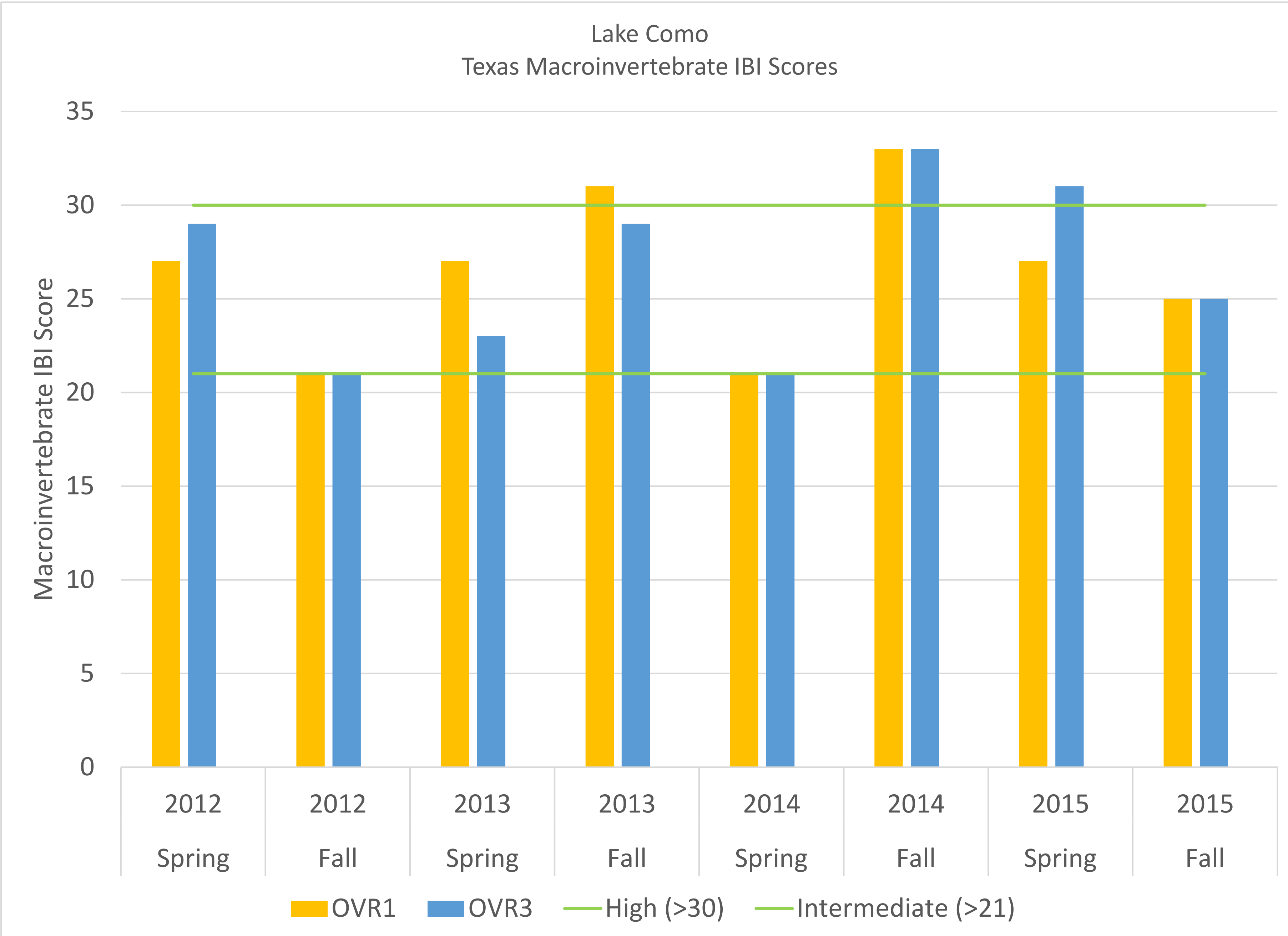
Lake Como
Ammonia Nitrogen
Ammonia Nitrogen (mg/L)
1.4
1.2
1
0.8
0.6
0.4
0.2
0
2012
2013
2014
2015
2016
Permit Term 3 Bioassessment
Nutrient Screening Criterion


Lake Como
Orthophosphate
Orthophosphate (mg/L)
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
2012
2013
2014
2015
2016
Permit Term 3 Bioassessment
Nutrient Screening Criterion


Lake Como
Habitat Scores
180
160
140
120
100
80
60
40
20
0
Habitat Assessment Score
2012 Spring
2012 Fall
2013 Spring
2013 Fall
2014 Spring
2014 Fall
2015 Spring
2015 Fall
OVR1
OVR3
Optimal (>159)
Sub-optimal (>109)
Marginal (>60)

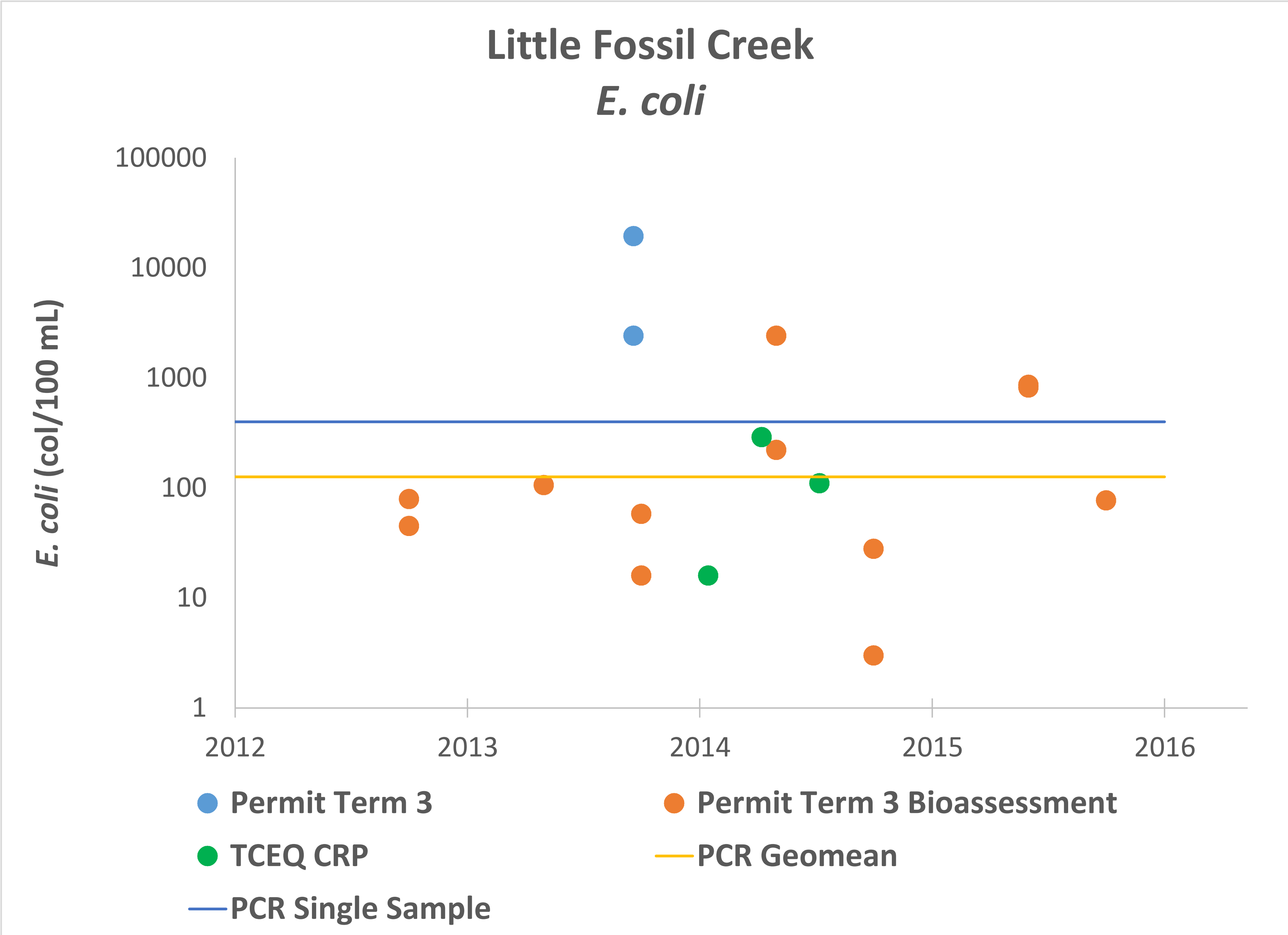


Lake Como
EPA Macroinvertebrate Index Scores
Macroinvertebrate Index Score (%)
80
70
60
50
40
30
20
10
0
2012 Spring
2013 Spring
2013 Fall
2014 Spring
2014 Fall
2015 Spring
2015 Fall
OVR1
OVR3
Severly Impaired (<25%)
Non-Impaired (>75%)
Slightly Impaired (>49%)
Moderately Impaired (>24%)

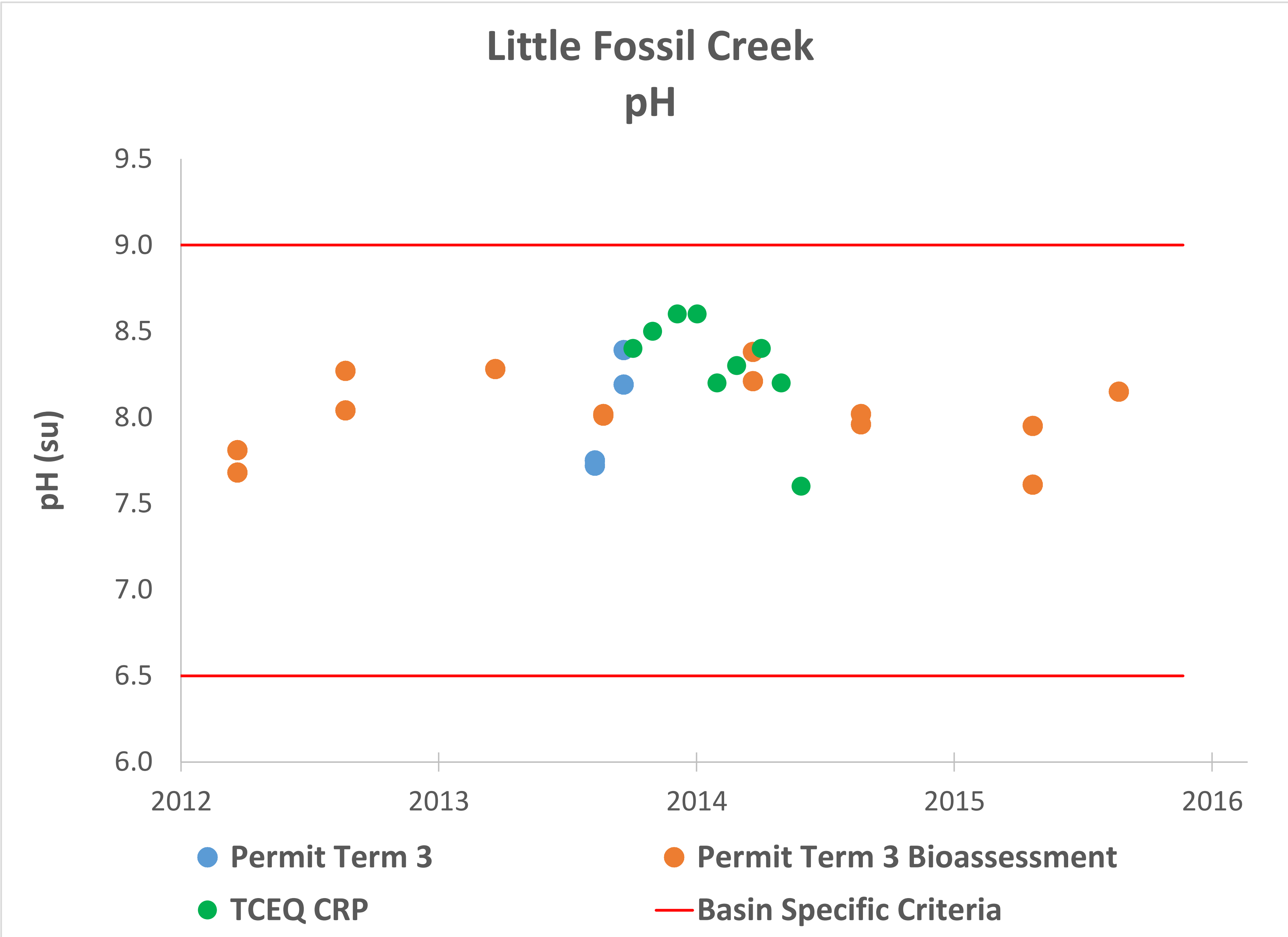

Lake Como
Texas Macroinvertebrate IBI Scores
Macroinvertebrate IBI Score
35
30
25
20
15
10
5
0
2012 Spring
2012 Fall
2013 Spring
2013 Fall
2014 Spring
2014 Fall
2015 Spring
2015 Fall
OVR1
OVR3
High (>30)
Intermediate (>21)

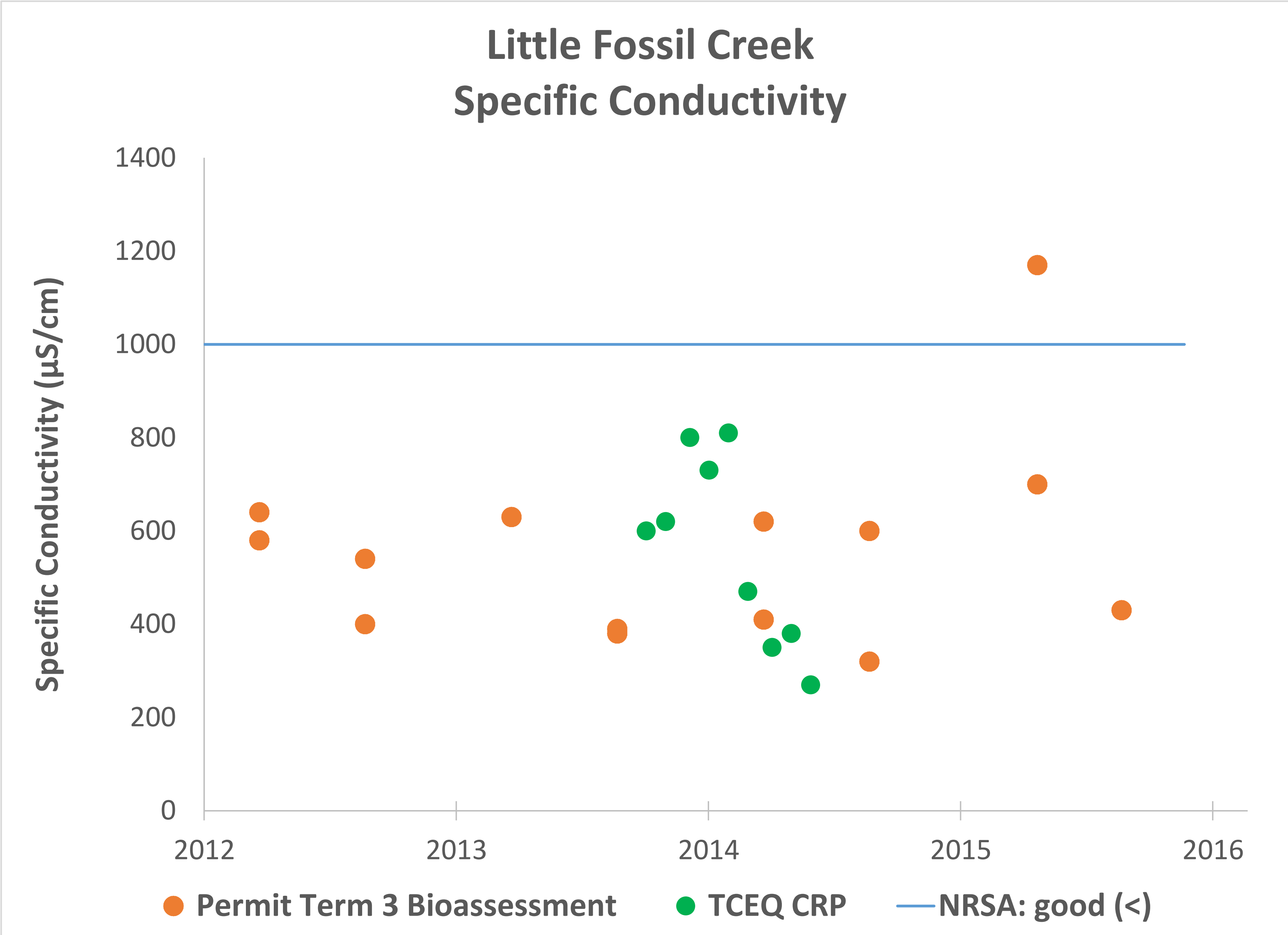
Appendix O

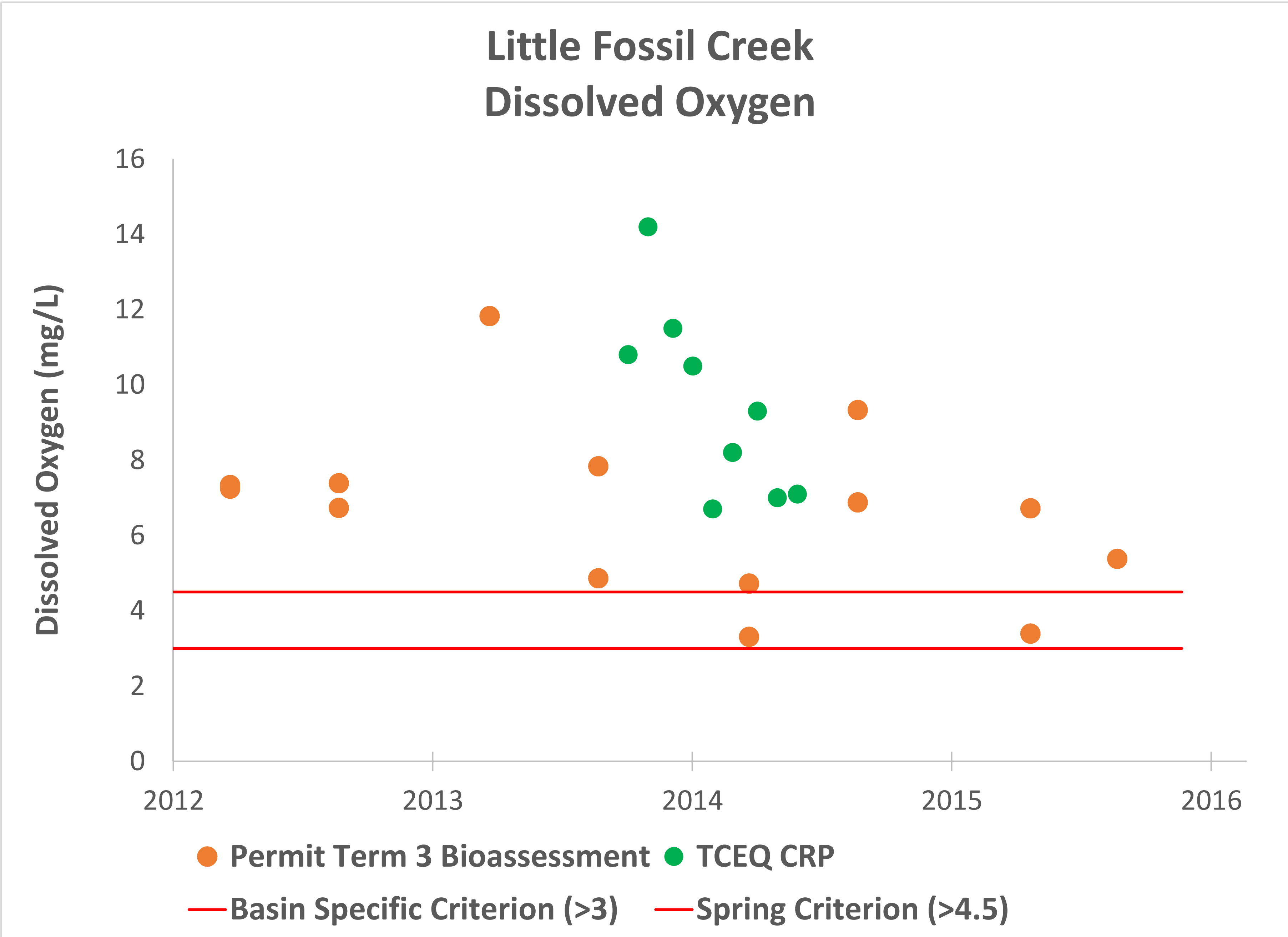
Little Fossil Creek Water Quality Data Graphs

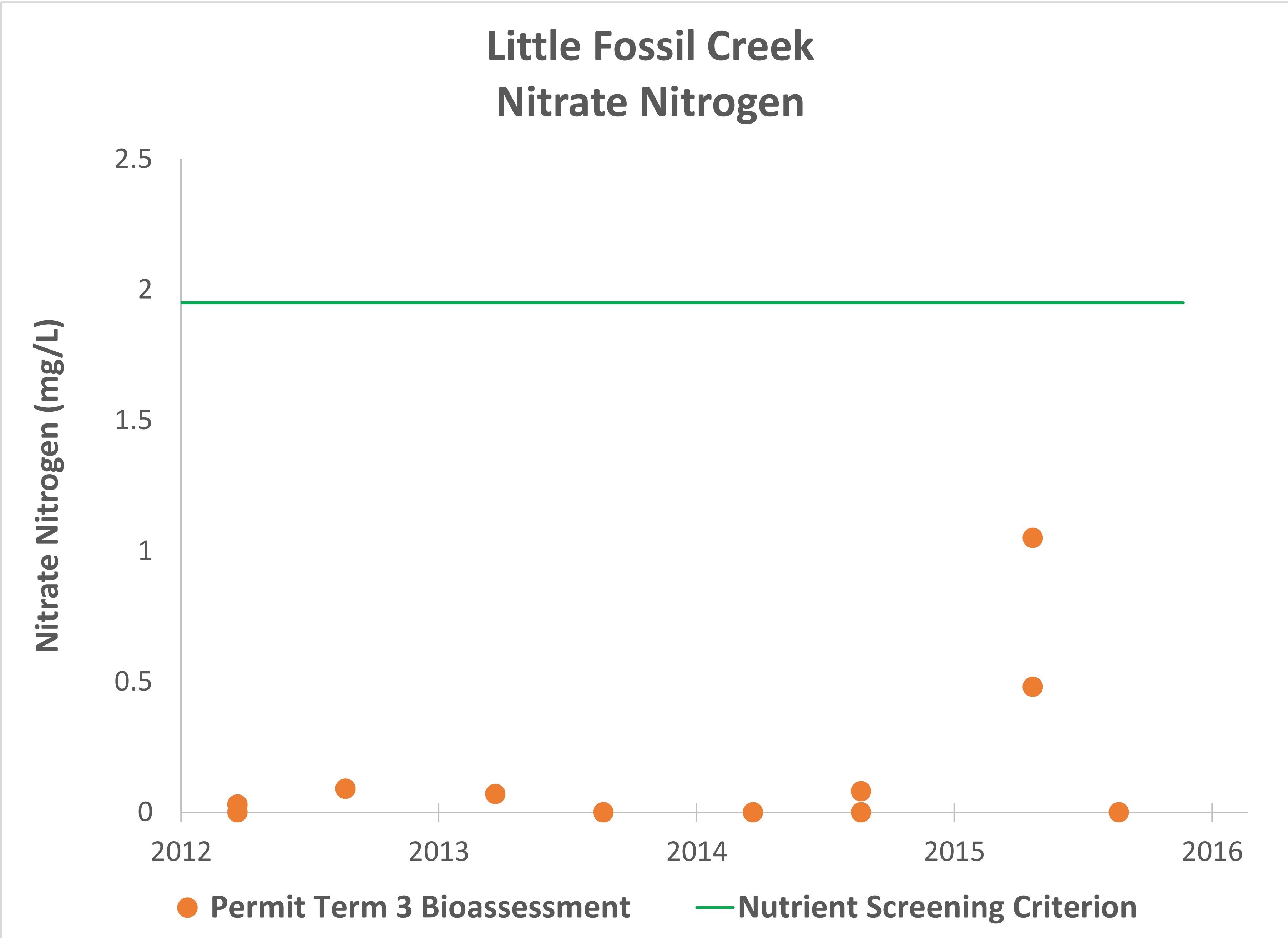


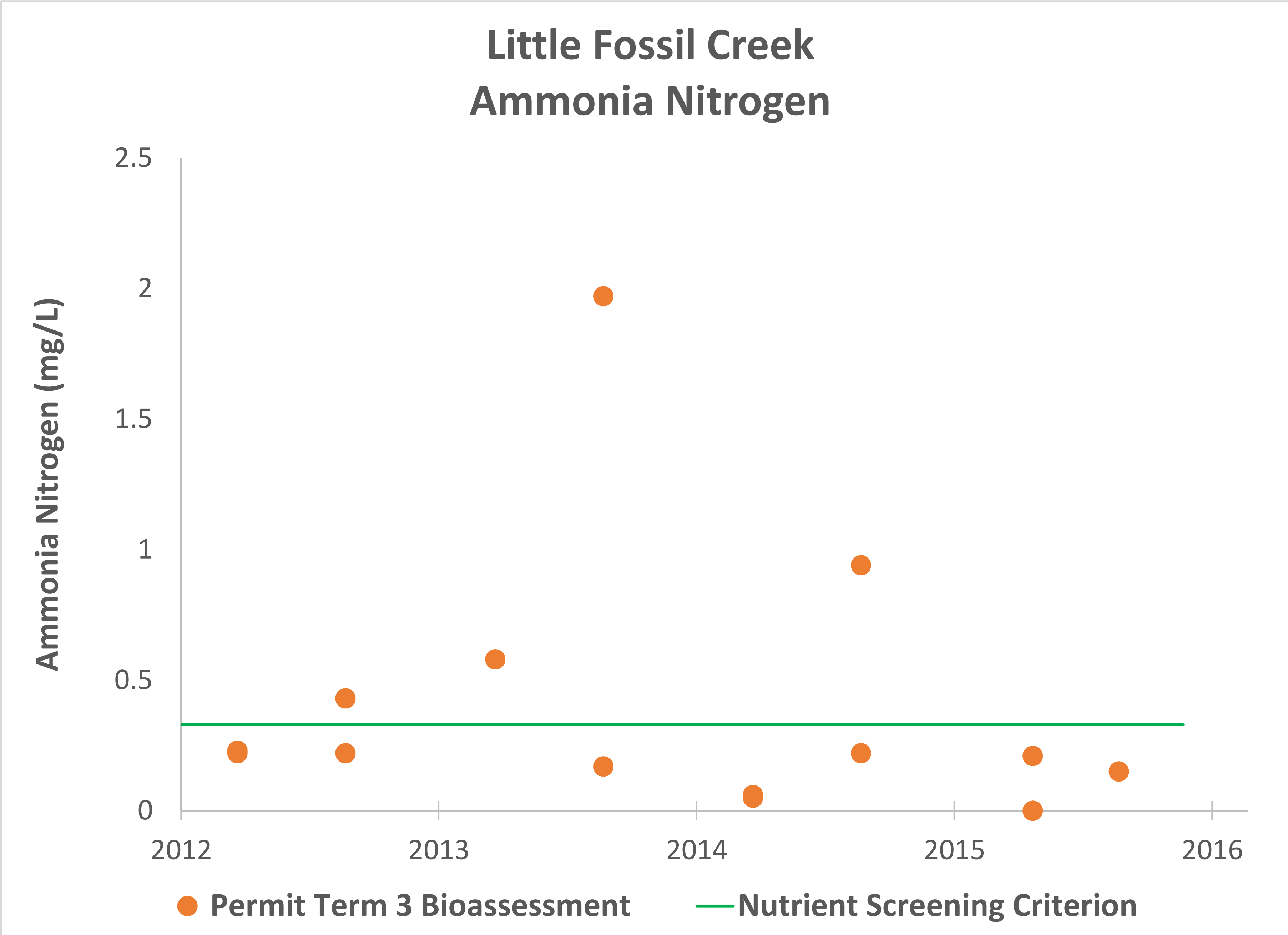
Little Fossil Creek
E. coli
E. coli (col/100 mL)
100000
10000
1000
100
10
1
2012
2013
2014
2015
2016
Permit Term 3
Permit Term 3 Bioassessment
TCEQ CRP
PCR Geomean
PCR Single Sample

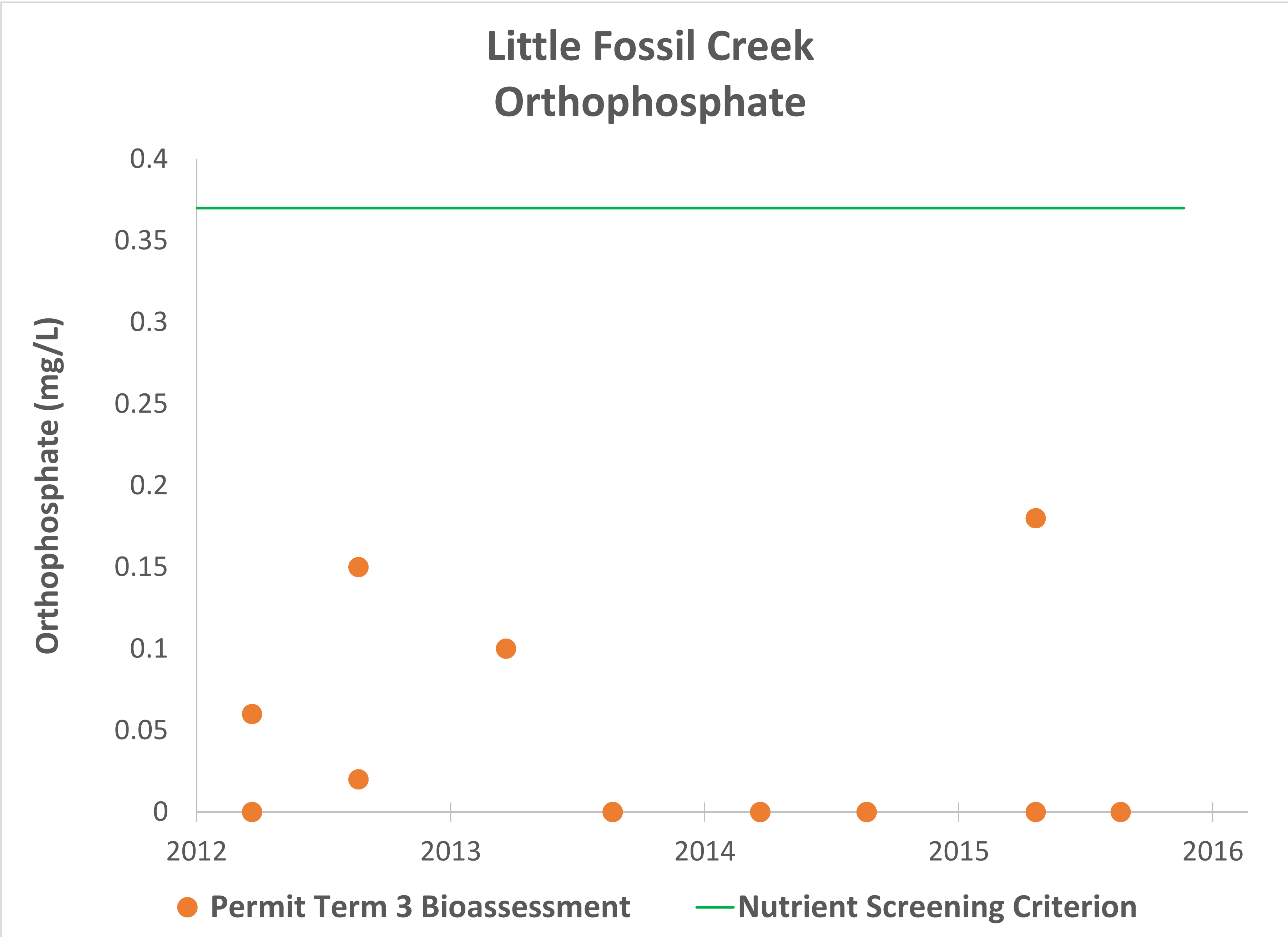

Little Fossil Creek
pH
pH (su)
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
2012
2013
2014
2015
2016
Permit Term 3
Permit Term 3 Bioassessment
TCEQ CRP
Basin Specific Criteria

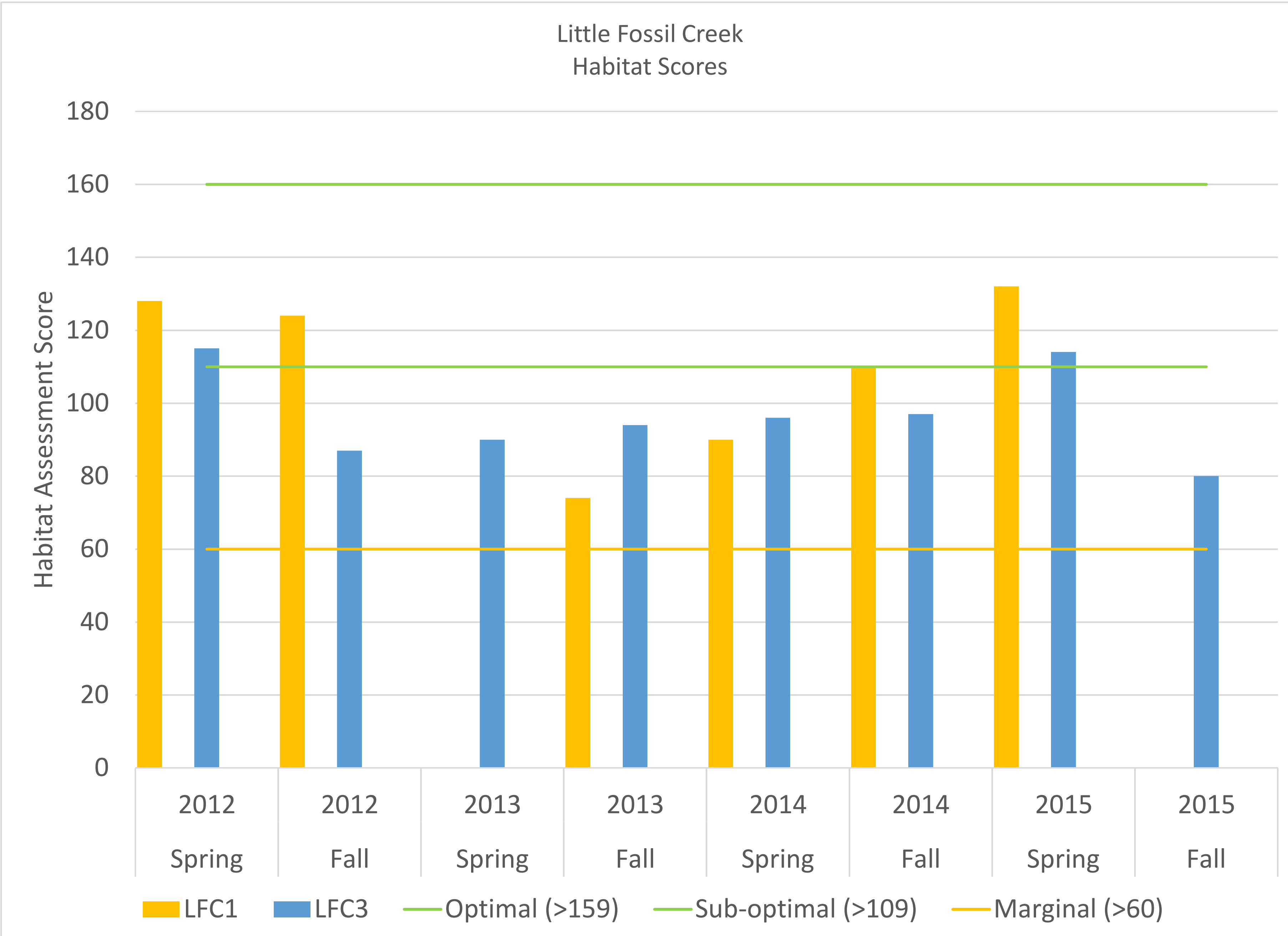

Little Fossil Creek
Specific Conductivity
Specific Conductivity (µS/cm)
1400
1200
1000
800
600
400
200
0
2012
2013
2014
2015
2016
Permit Term 3 Bioassessment
TCEQ CRP
NRSA: good (<)


Little Fossil Creek
Dissolved Oxygen
Dissolved Oxygen (mg/L)
16
14
12
10
8
6
4
2
0
2012
2013
2014
2015
2016
Permit Term 3 Bioassessment
TCEQ CRP
Basin Specific Criterion (>3)
Spring Criterion (>4.5)

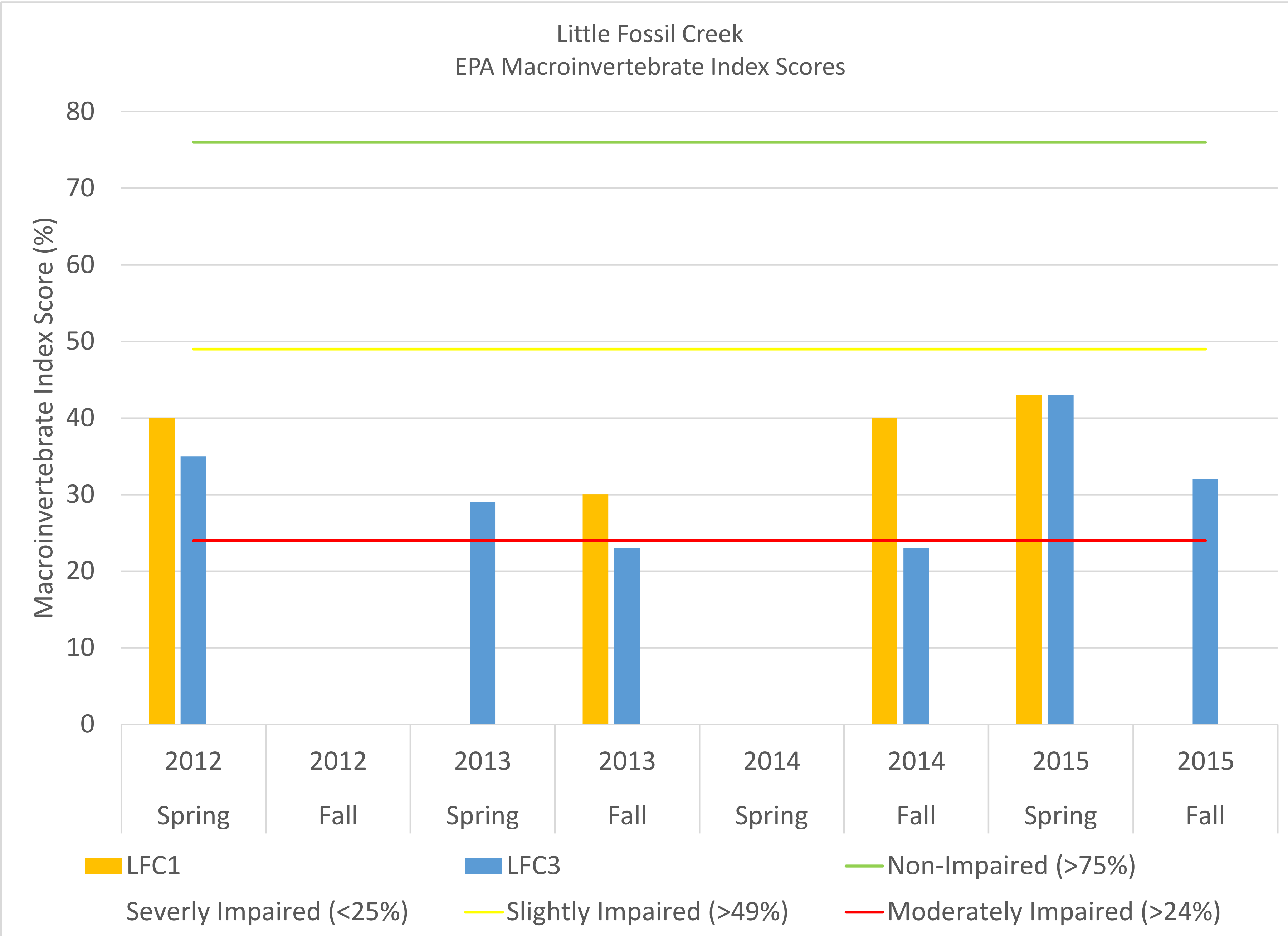

Little Fossil Creek
Nitrate Nitrogen
Nitrate Nitrogen (mg/L)
2.5
2
1.5
1
0.5
0
2012
2013
2014
2015
2016
Permit Term 3 Bioassessment
Nutrient Screening Criterion

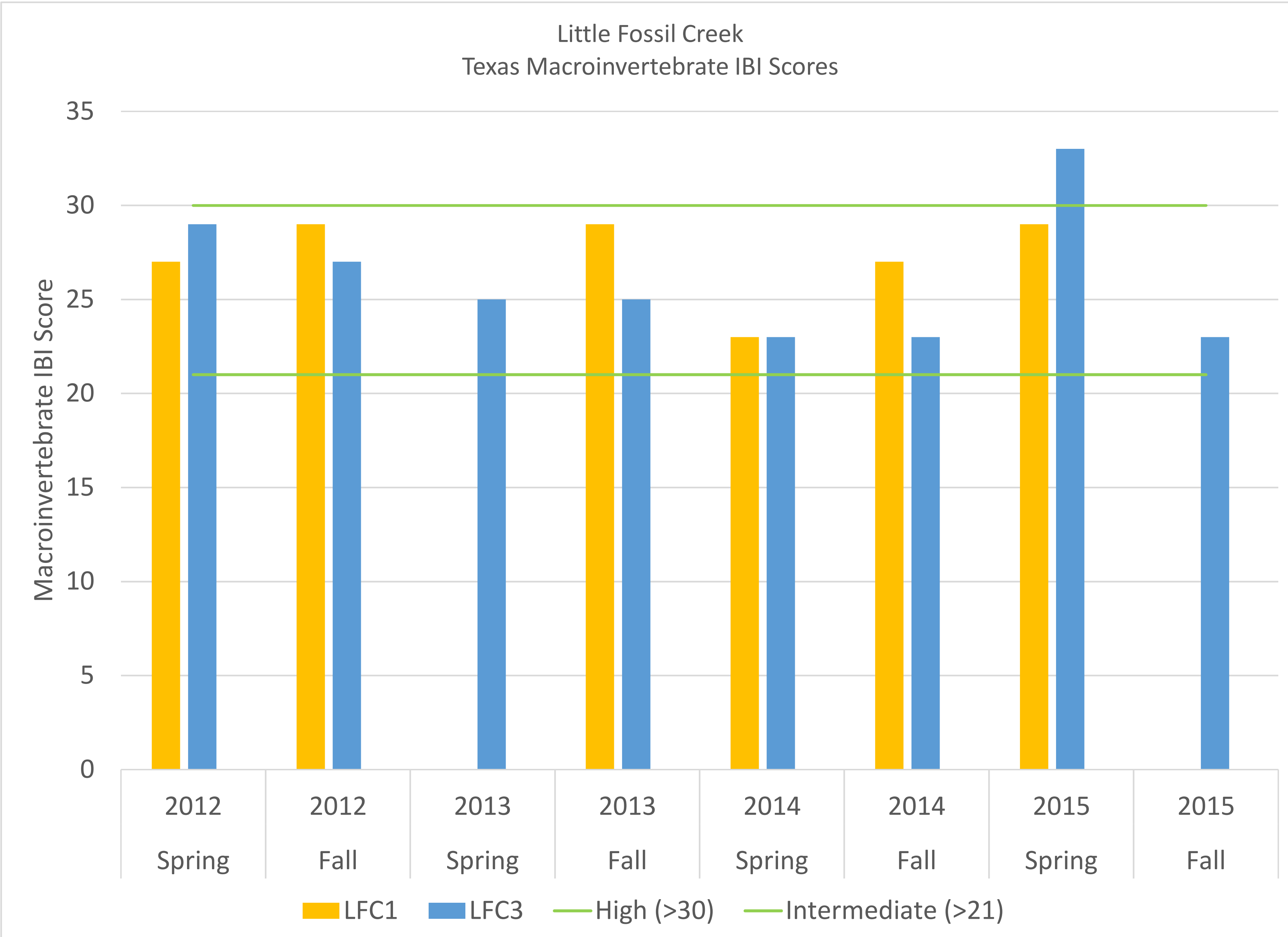

Little Fossil Creek
Ammonia Nitrogen
Ammonia Nitrogen (mg/L)
2.5
2
1.5
1
0.5
0
2012
2013
2014
2015
2016
Permit Term 3 Bioassessment
Nutrient Screening Criterion


Little Fossil Creek
Orthophosphate
Orthophosphate (mg/L)
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
2012
2013
2014
2015
2016
Permit Term 3 Bioassessment
Nutrient Screening Criterion



Little Fossil Creek
Habitat Scores
Habitat Assessment Score
180
160
140
120
100
80
60
40
20
0
2012 Spring
2012 Fall
2013 Spring
2013 Fall
2014 Spring
2014 Fall
2015 Spring
2015 Fall
LFC1
LFC3
Optimal (>159)
Sub-optimal (>109)
Marginal (>60)

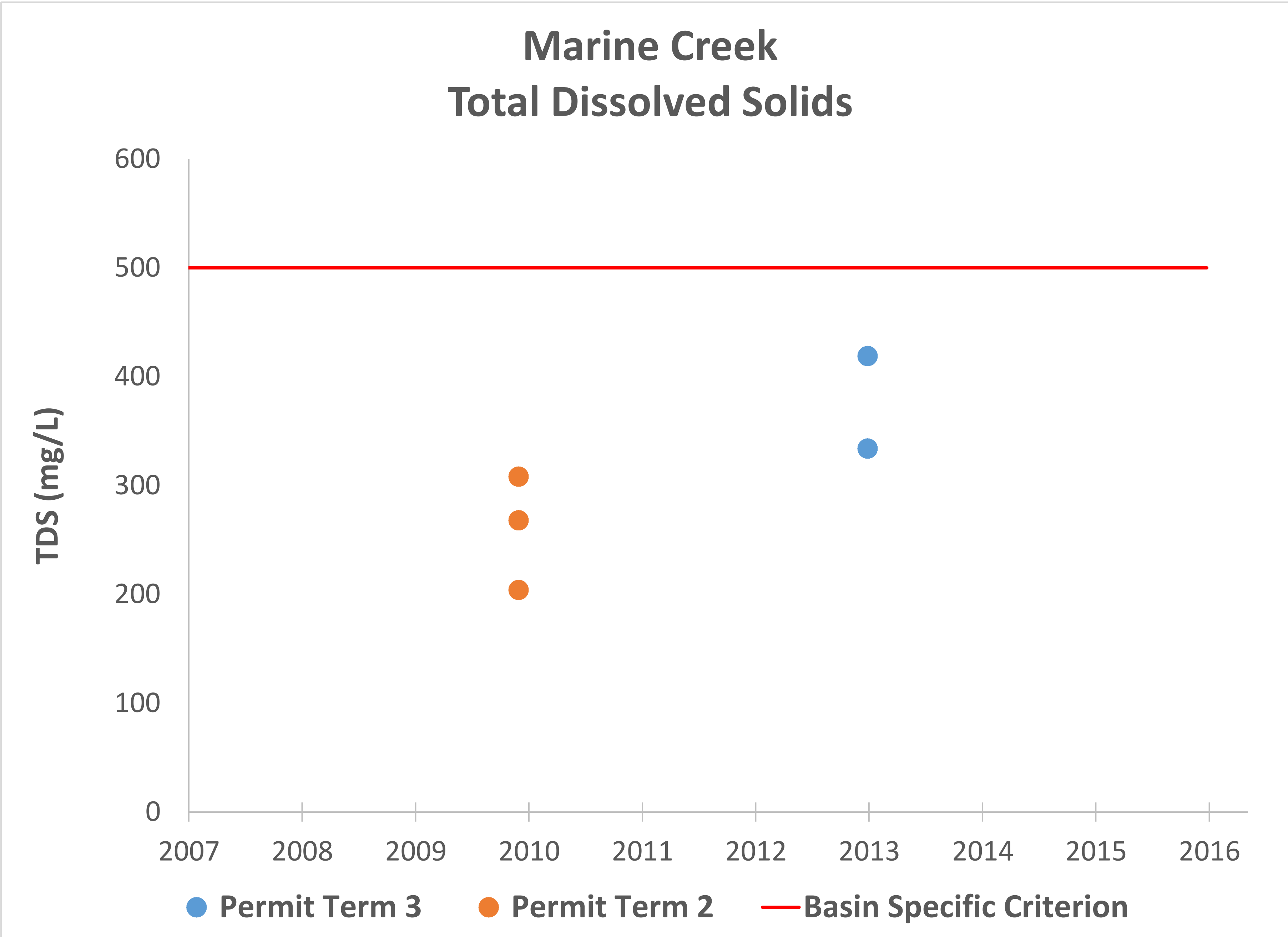

Little Fossil Creek
EPA Macroinvertebrate Index Scores
Macroinvertebrate Index Score (%)
80
70
60
50
40
30
20
10
0
2012 Spring
2012 Fall
2013 Spring
2013 Fall
2014 Spring
2014 Fall
2015 Spring
2015 Fall
LFC1
LFC3
Non-Impaired (>75%)
Severly Impaired (<25%)
Slightly Impaired (>49%)
Moderately Impaired (>24%)



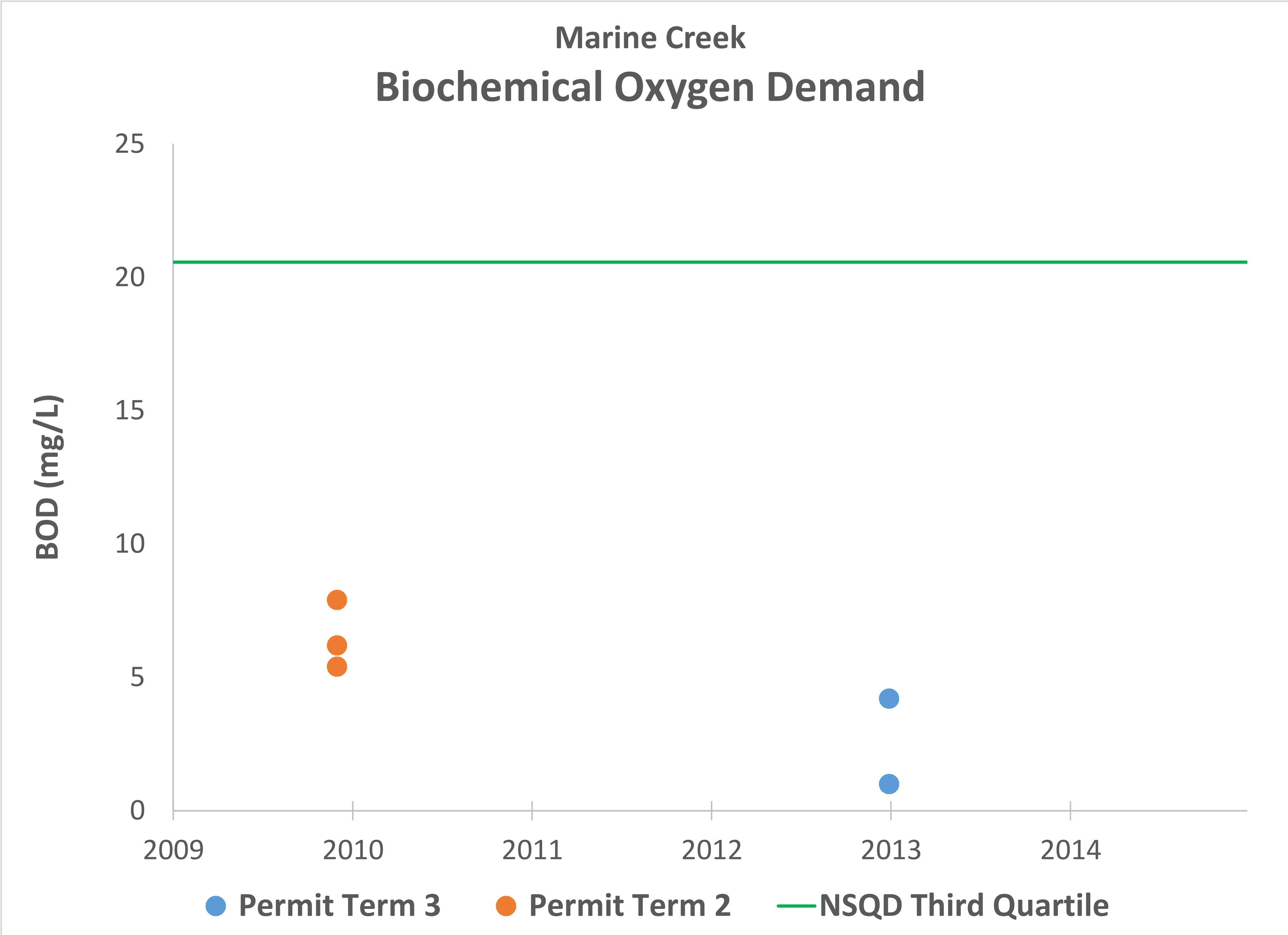
Little Fossil Creek
Texas Macroinvertebrate IBI Scores
Macroinvertebrate IBI Score
35
30
25
20
15
10
5
0
2012 Spring
2012 Fall
2013 Spring
2013 Fall
2014 Spring
2014 Fall
2015 Spring
2015 Fall
LFC1
LFC3
High (>30)
Intermediate (>21)

Appendix P

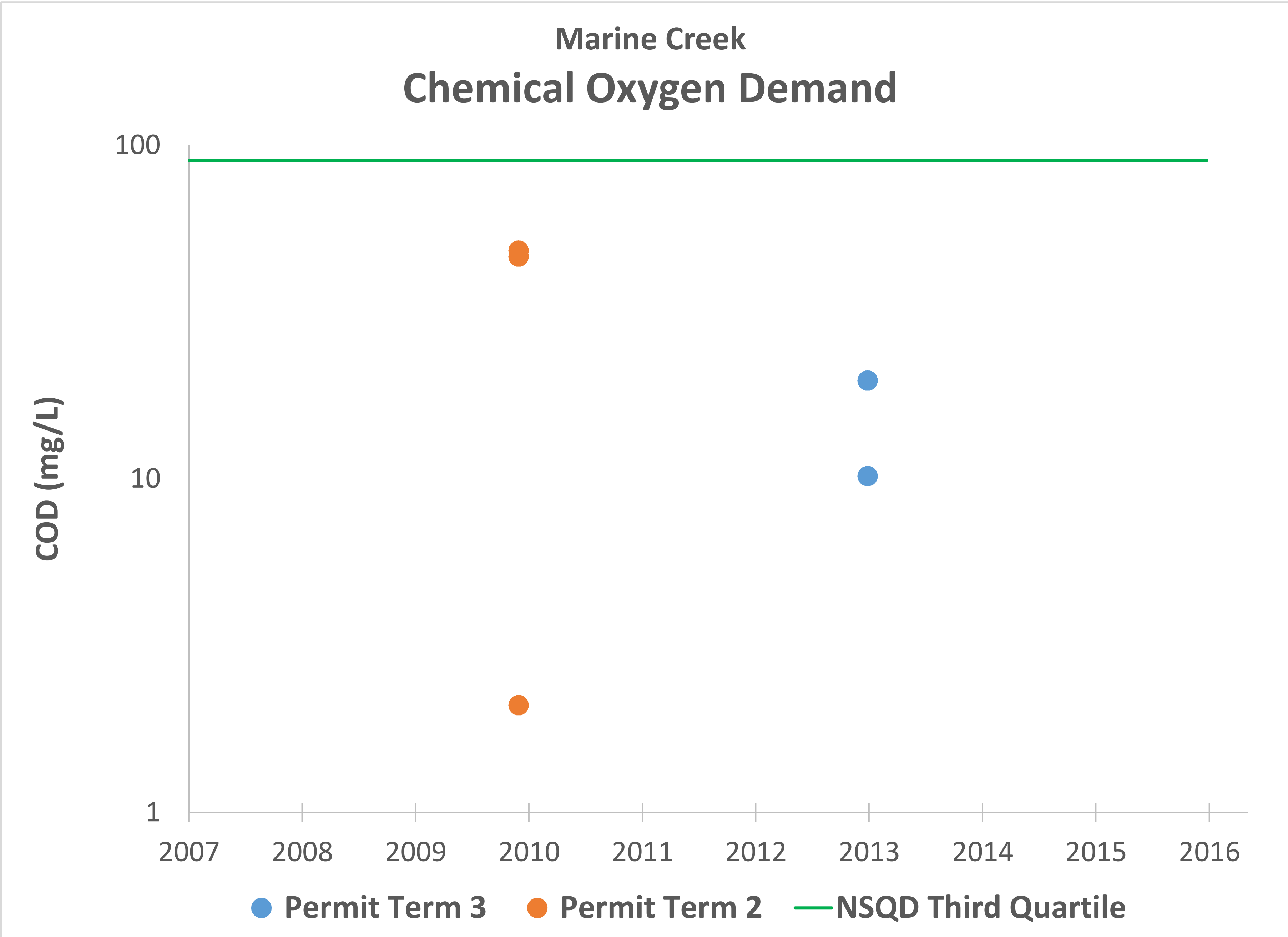
Marine Creek Water Quality Data Graphs


Marine Creek
Total Dissolved Solids
TDS (mg/L)
600
500
400
300
200
100
0
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
Permit Term 3
Permit Term 2
Basin Specific Criterion

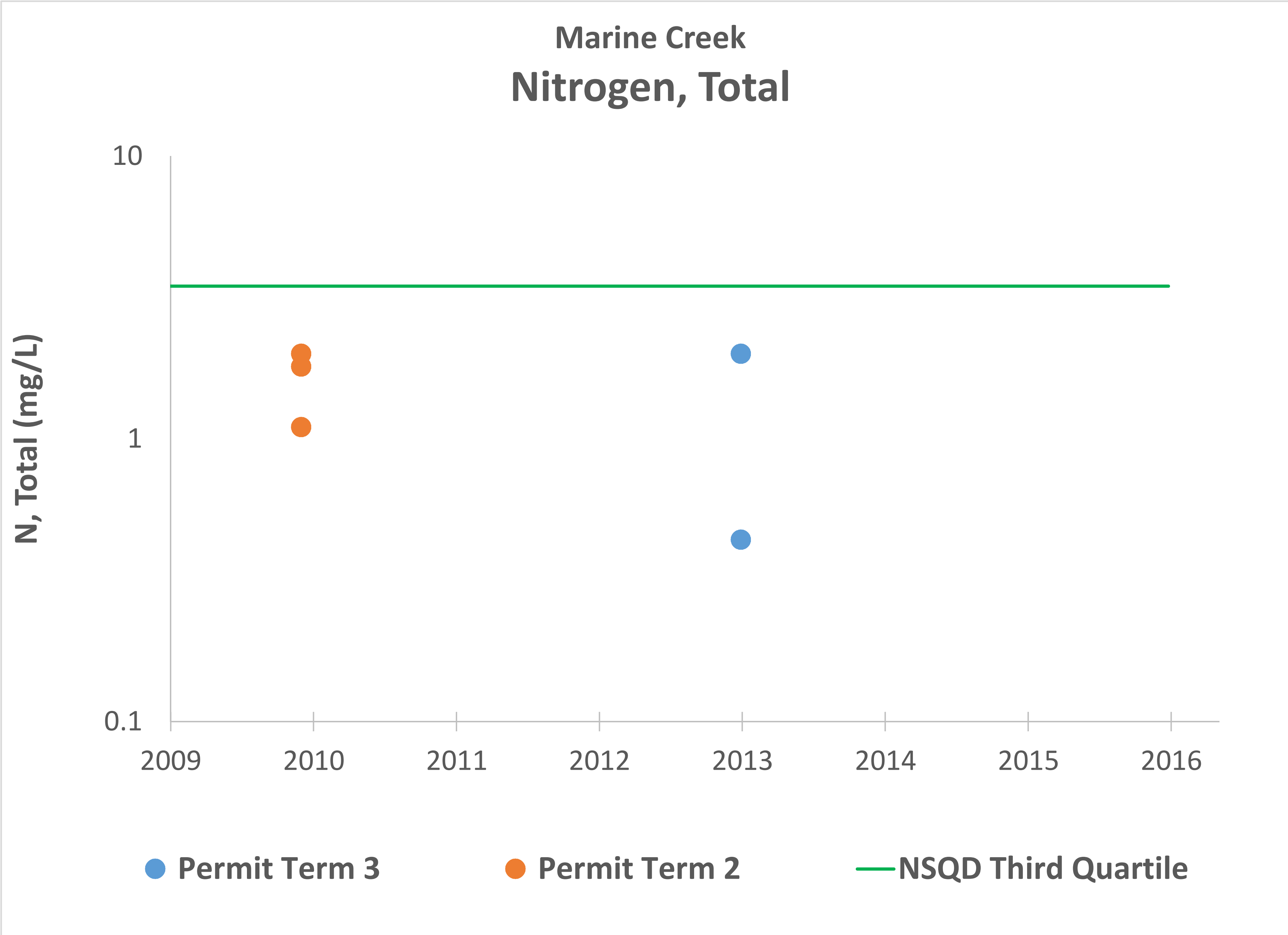

Marine Creek
Total Suspended Solids
TSS (mg/L)
1000
100
10
1
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
Permit Term 3
Permit Term 2
NSQD Third Quartile

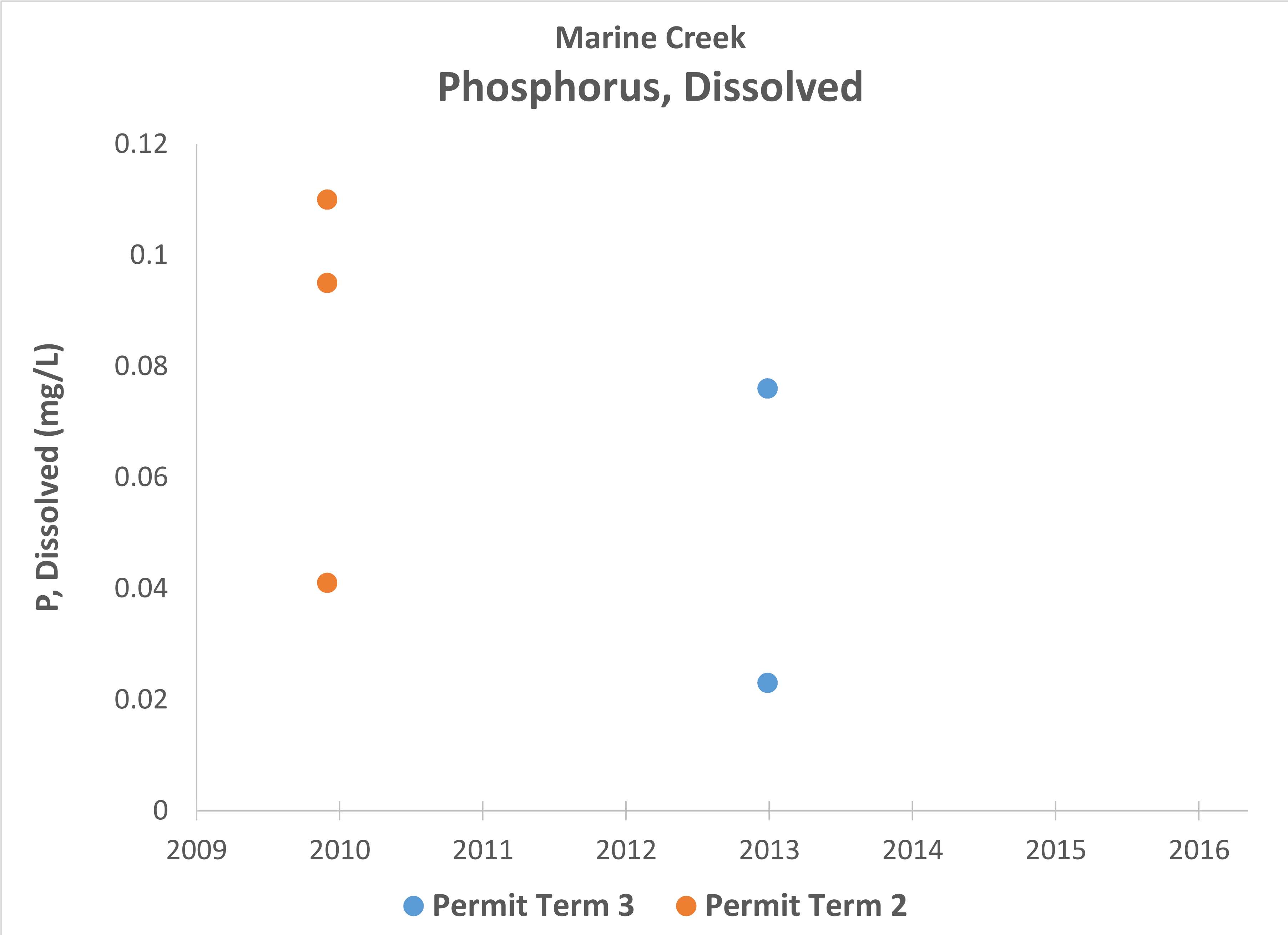


Marine Creek
Biochemical Oxygen Demand
BOD (mg/L)
25
20
15
10
5
0
2009
2010
2011
2012
2013
2014
Permit Term 3
Permit Term 2
NSQD Third Quartile

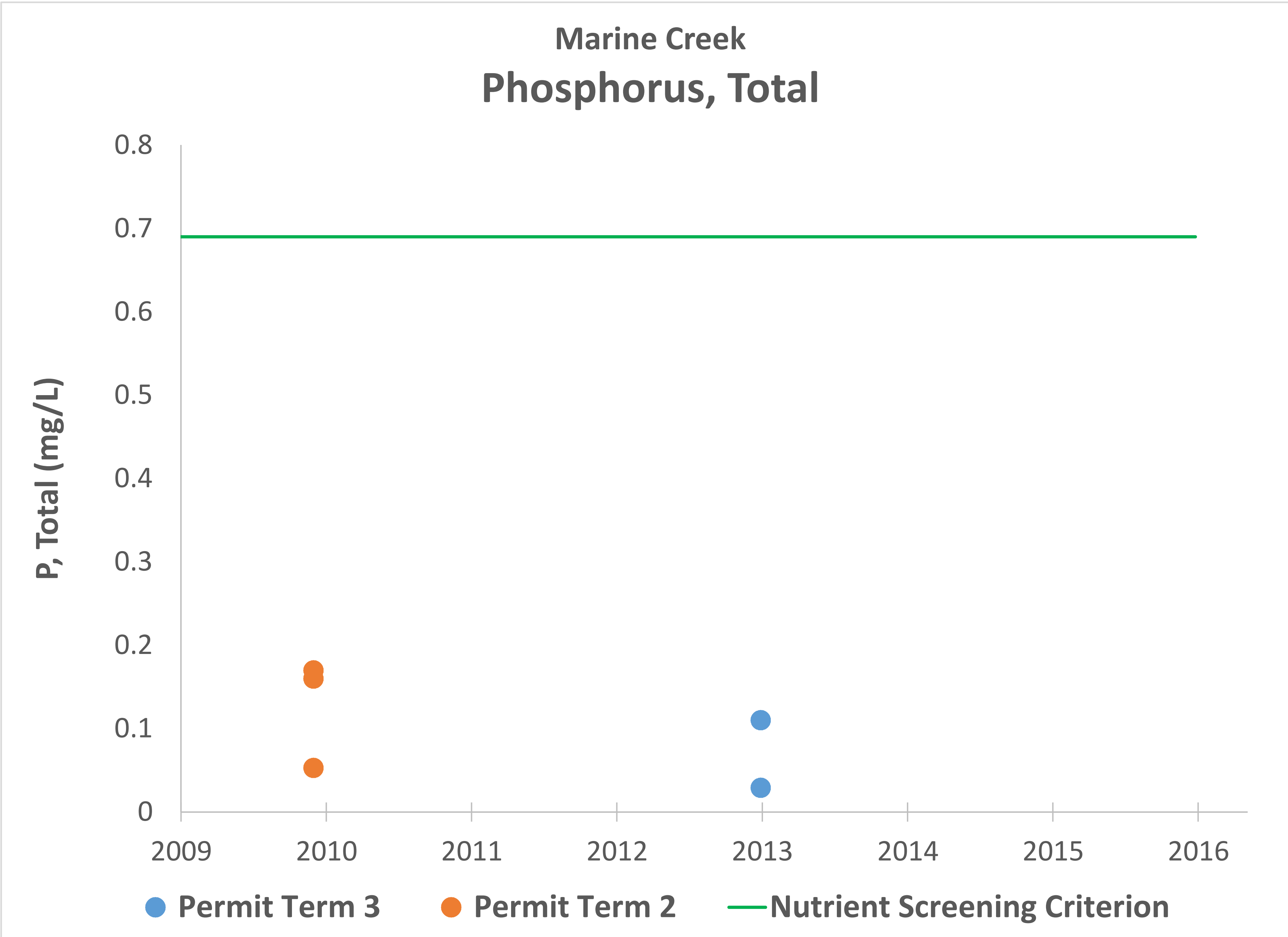


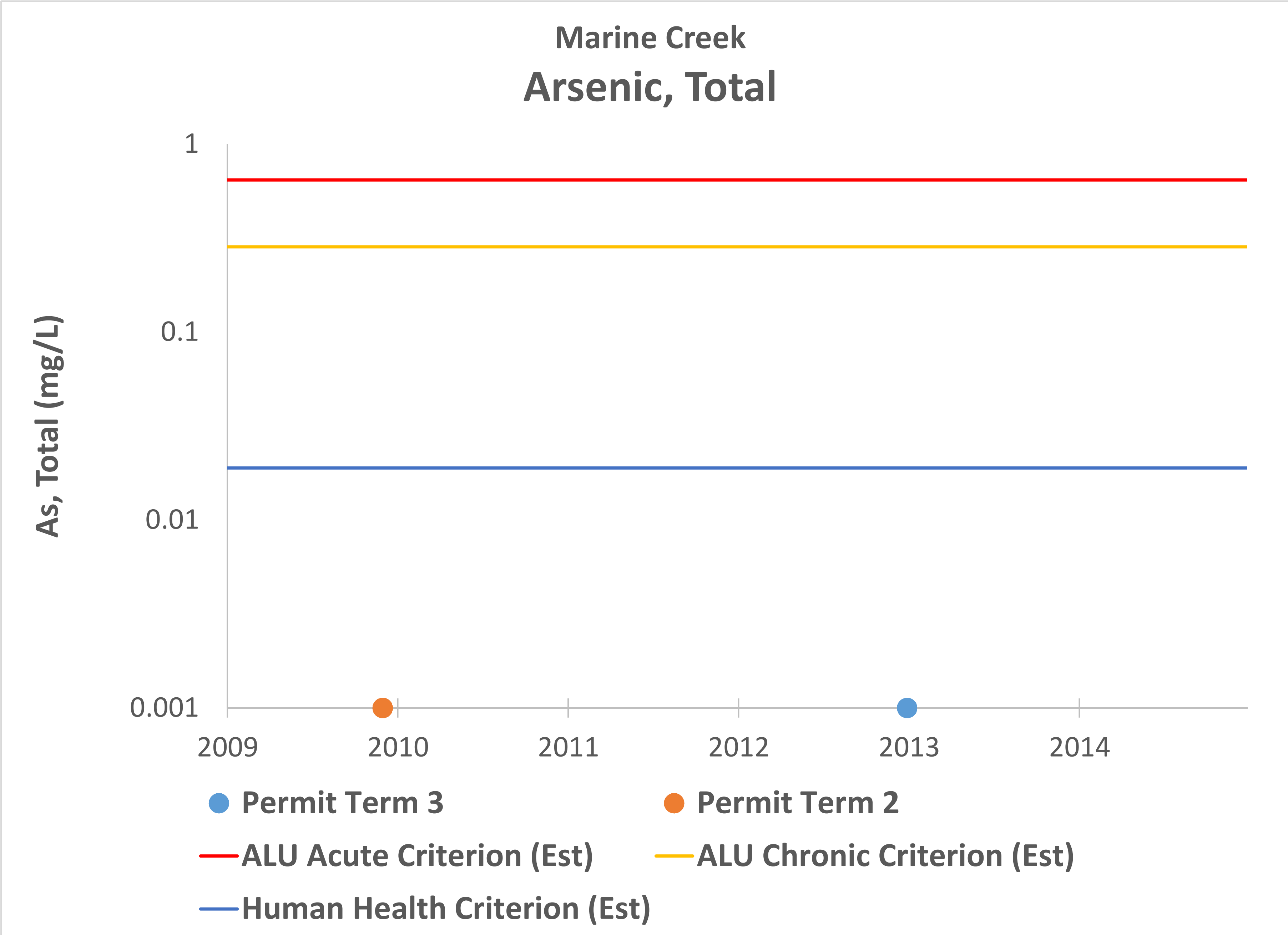
Marine Creek
Chemical Oxygen Demand
COD (mg/L)
100
10
1
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
Permit Term 3
Permit Term 2
NSQD Third Quartile

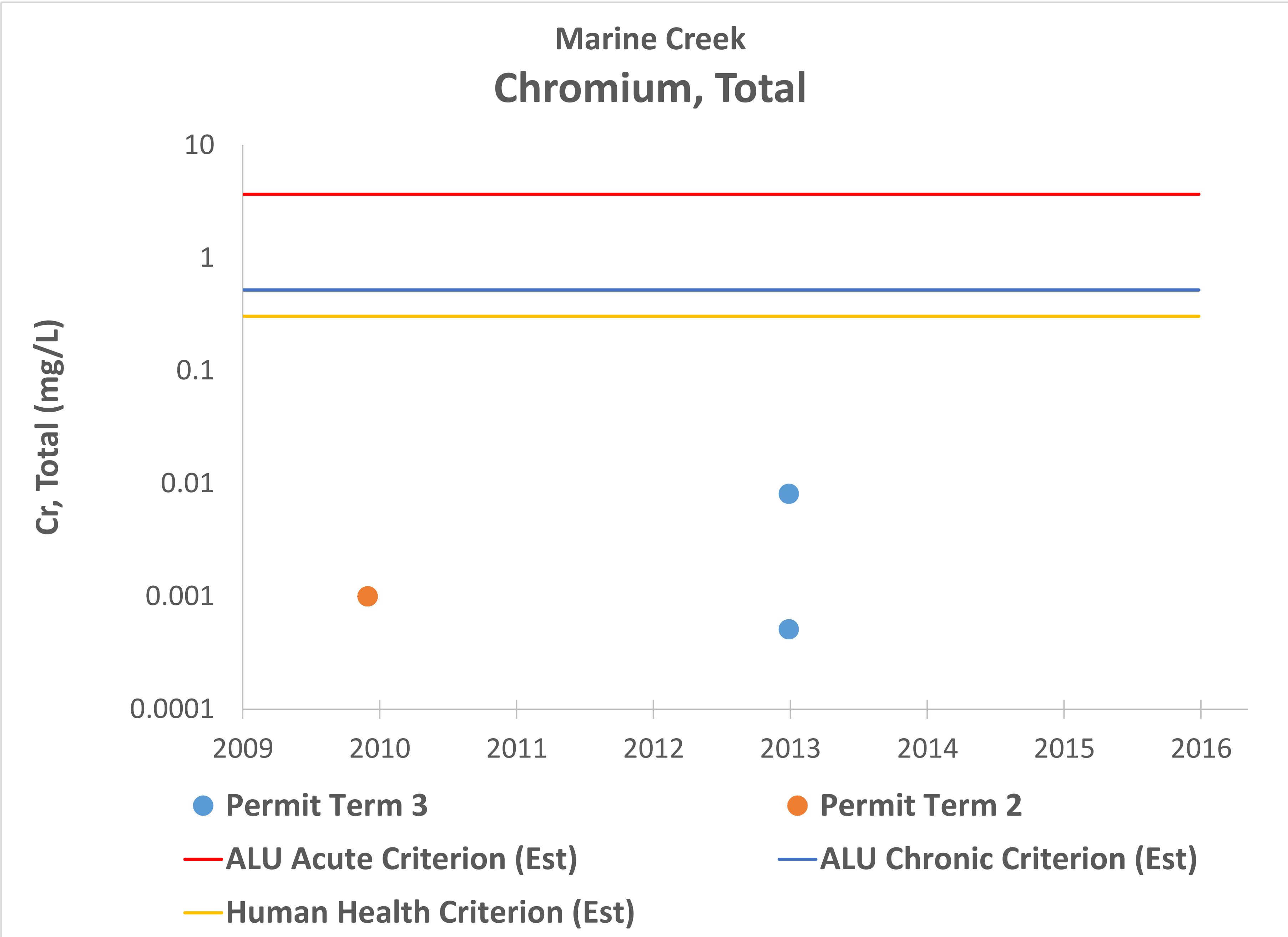

Marine Creek
Nitrogen, Total
N, Total (mg/L)
10
1
0.1
2009
2010
2011
2012
2013
2014
2015
2016
Permit Term 3
Permit Term 2
NSQD Third Quartile

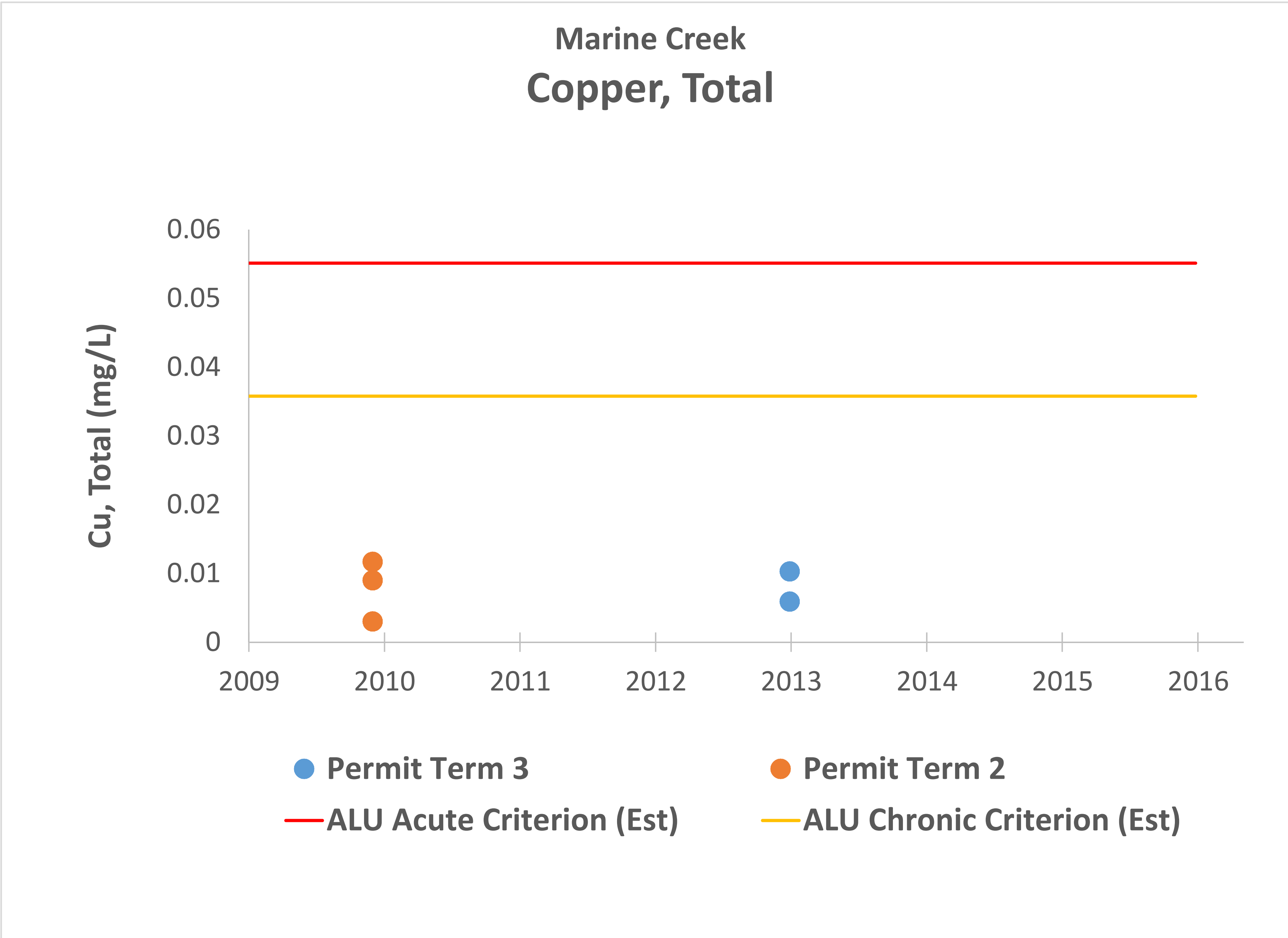


Marine Creek
Phosphorus, Dissolved
P, Dissolved (mg/L)
0.12
0.1
0.08
0.06
0.04
0.02
0
2009
2010
2011
2012
2013
2014
2015
2016
Permit Term 3
Permit Term 2

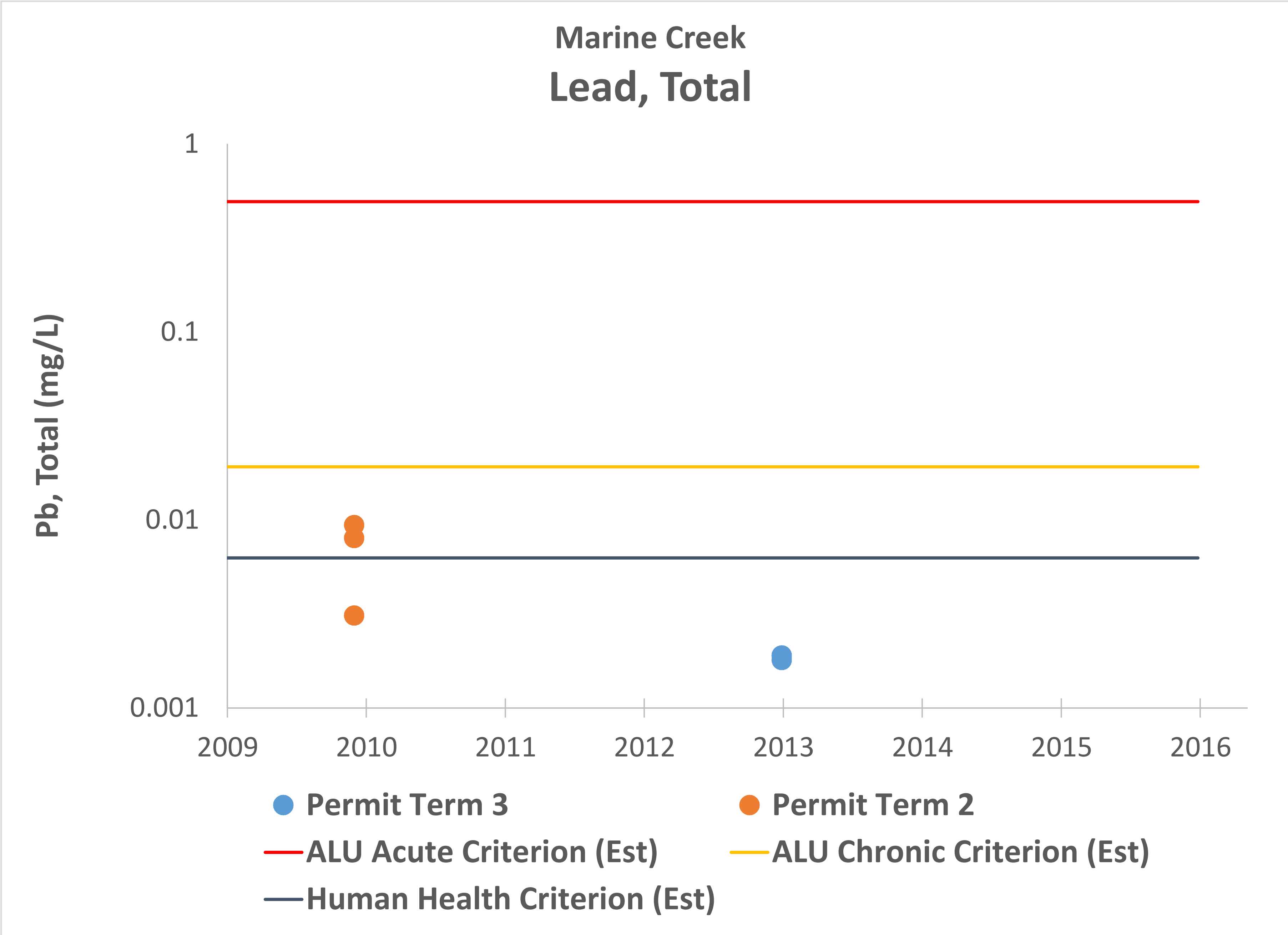

Marine Creek
Phosphorus, Total
P, Total (mg/L)
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
2009
2010
2011
2012
2013
2014
2015
2016
Permit Term 3
Permit Term 2
Nutrient Screening Criterion


Marine Creek
Arsenic, Total
As, Total (mg/L)
1
0.1
0.01
0.001
2009
2010
2011
2012
2013
2014
Permit Term 3
Permit Term 2
ALU Acute Criterion (Est)
ALU Chronic Criterion (Est)
Human Health Criterion (Est)

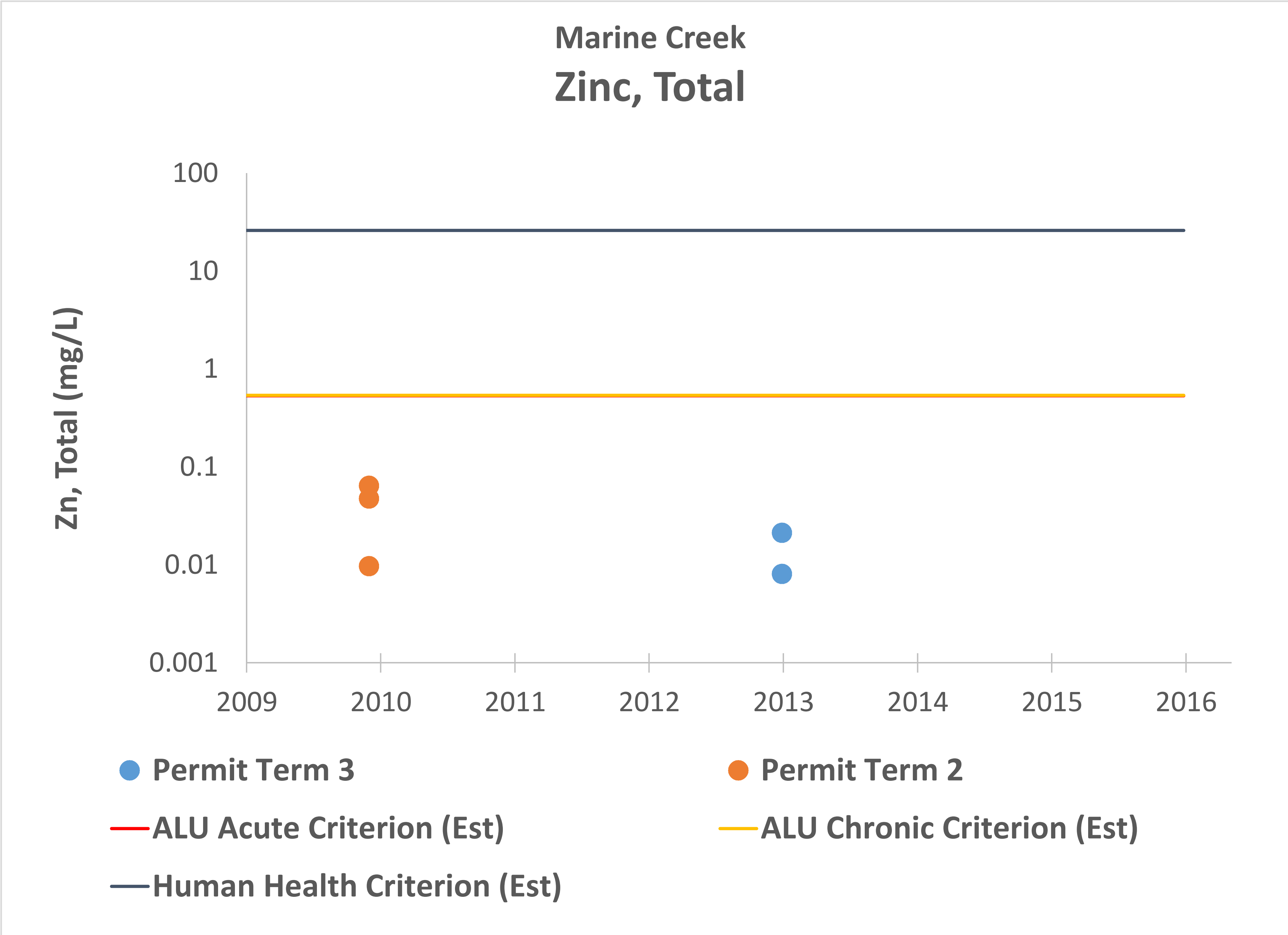

Marine Creek
Chromium, Total
Cr, Total (mg/L)
10
1
0.1
0.01
0.001
0.0001
2009
2010
2011
2012
2013
2014
2015
2016
Permit Term 3
Permit Term 2
ALU Acute Criterion (Est)
ALU Chronic Criterion (Est)
Human Health Criterion (Est)



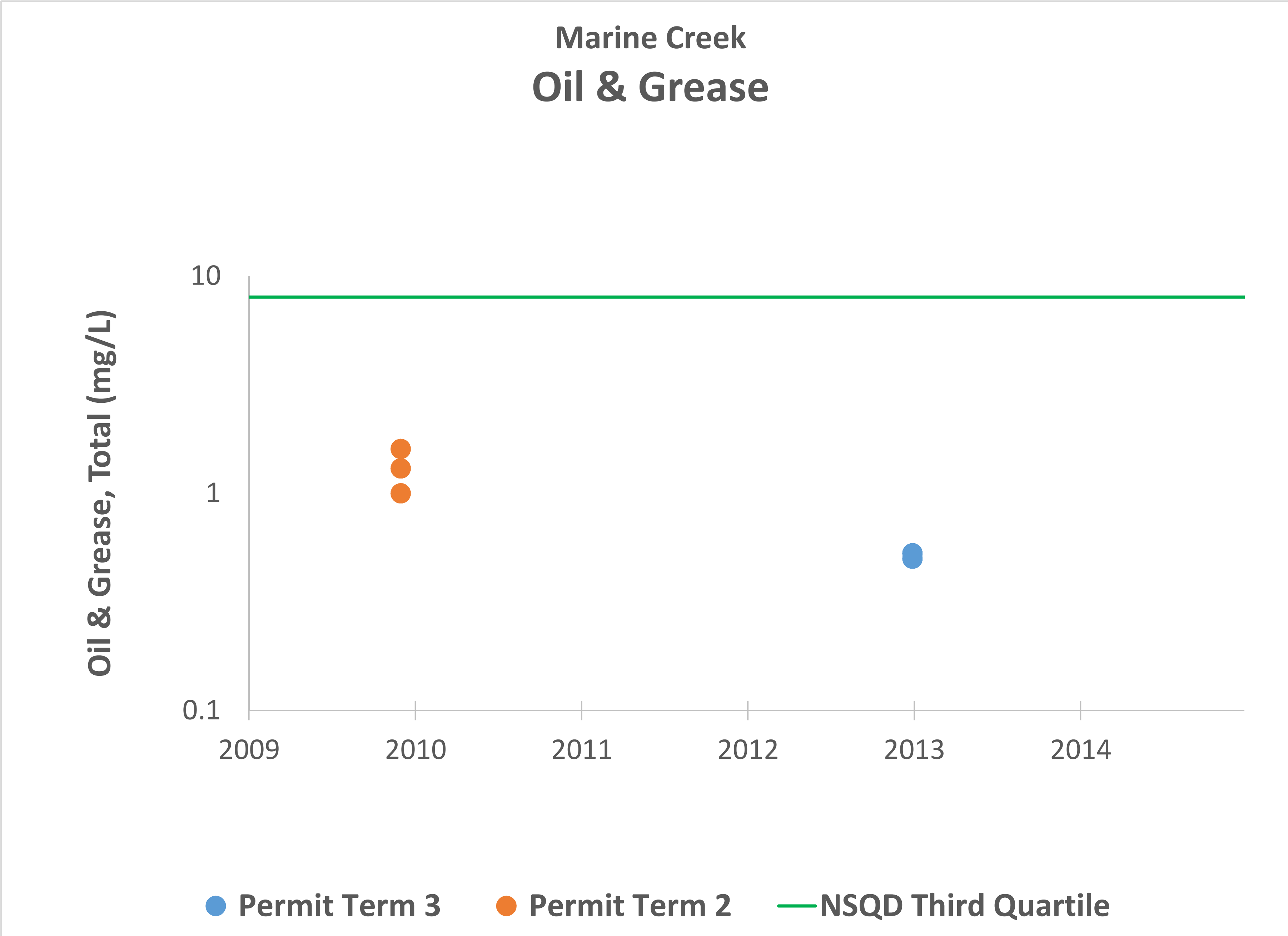
Marine Creek
Copper, Total
Cu, Total (mg/L)
0.06
0.05
0.04
0.03
0.02
0.01
0
2009
2010
2011
2012
2013
2014
2015
2016
Permit Term 3
Permit Term 2
ALU Acute Criterion (Est)
ALU Chronic Criterion (Est)

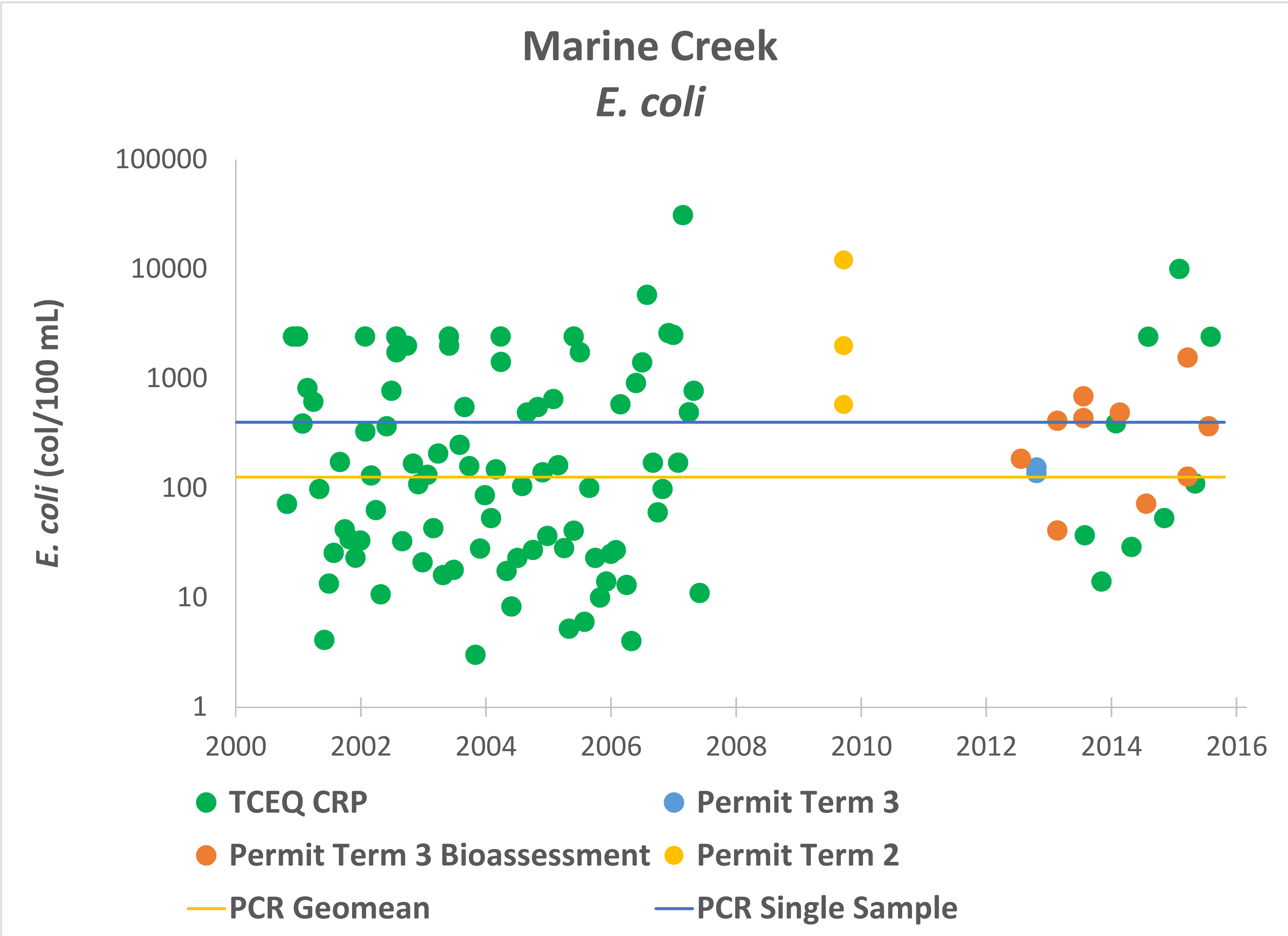


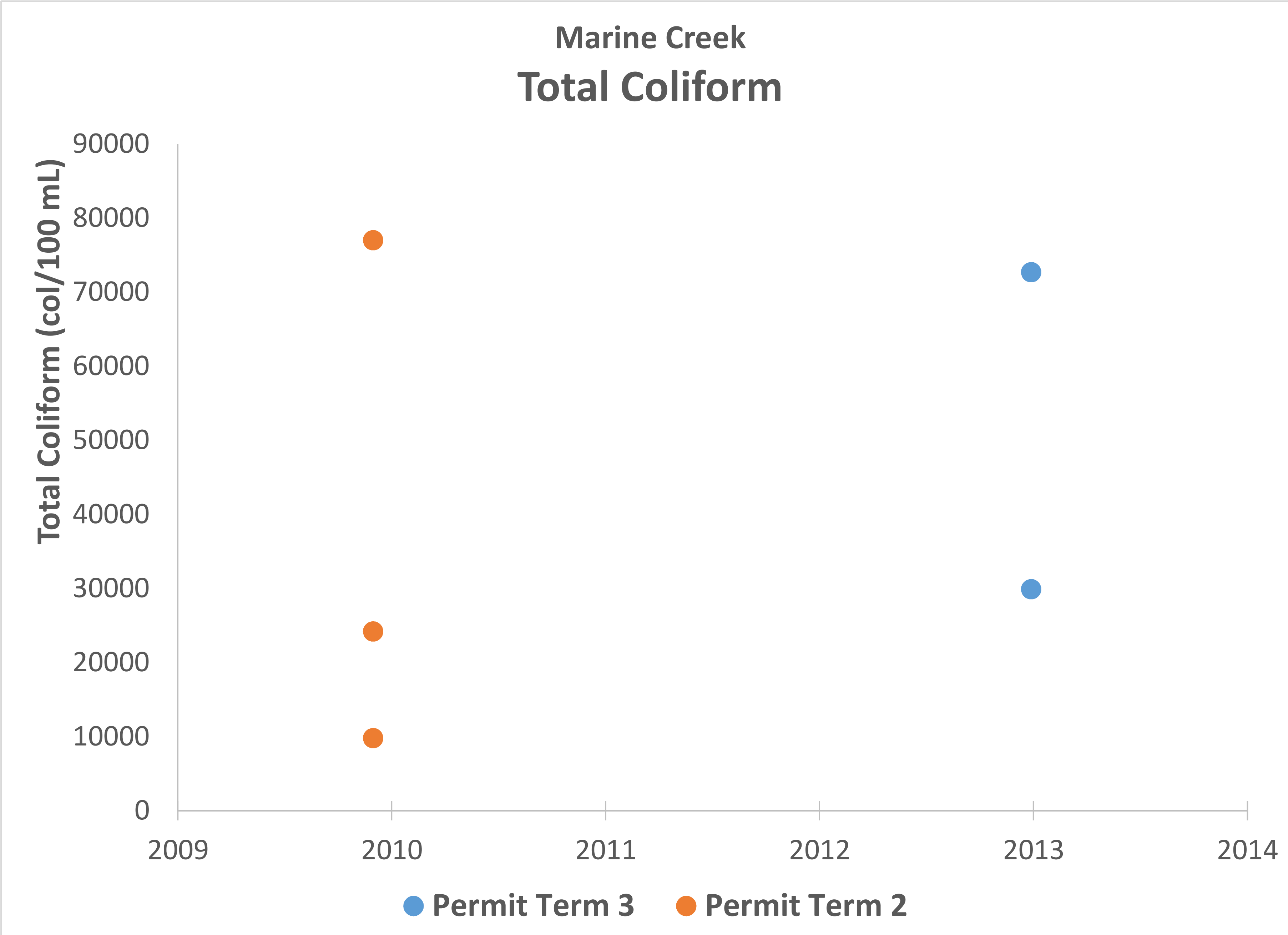
Marine Creek
Lead, Total
Pb, Total (mg/L)
1
0.1
0.01
0.001
2009
2010
2011
2012
2013
2014
2015
2016
Permit Term 3
Permit Term 2
ALU Acute Criterion (Est)
ALU Chronic Criterion (Est)
Human Health Criterion (Est)



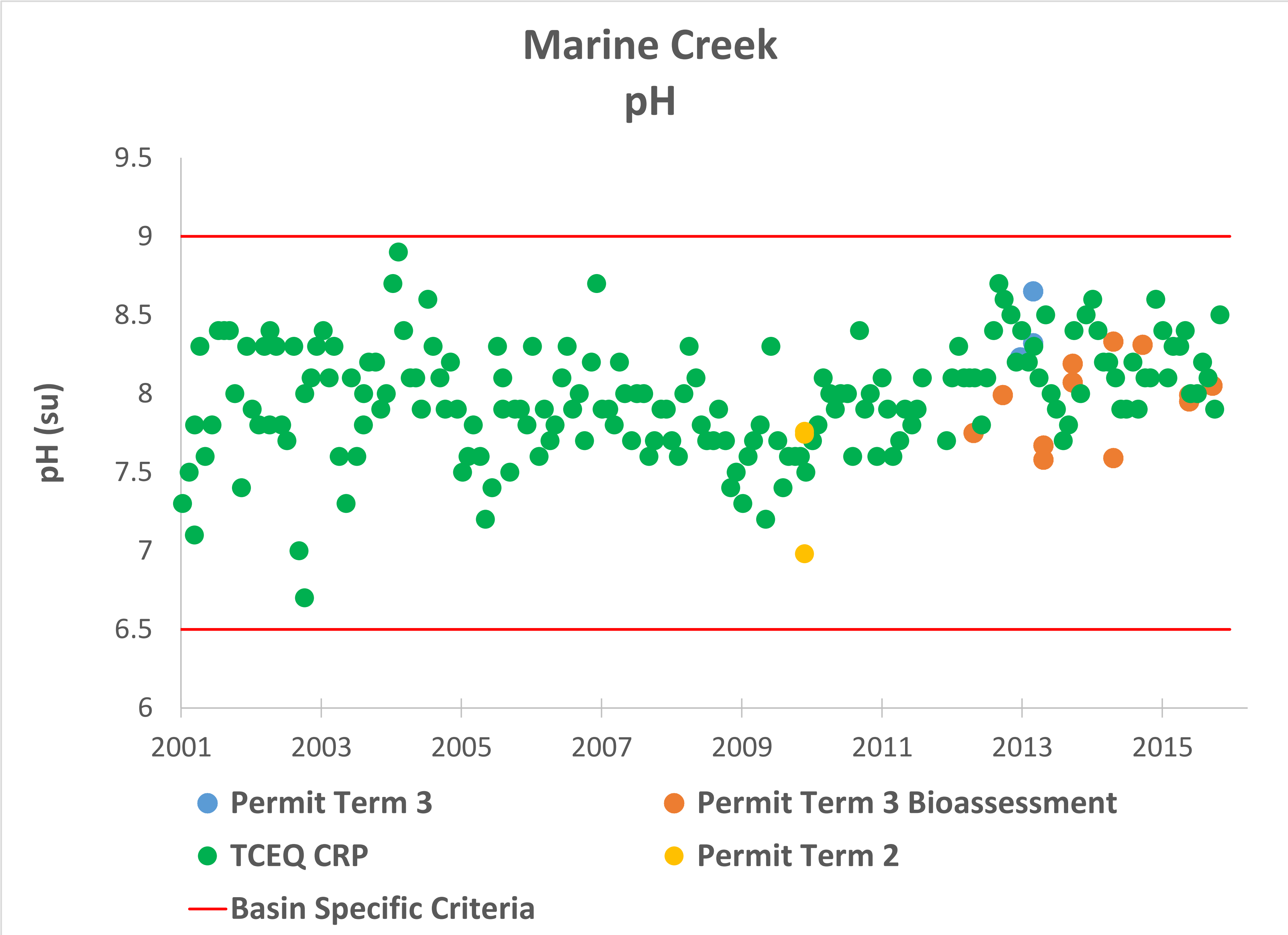
Marine Creek
Zinc, Total
Zn, Total (mg/L)
100
10
1
0.1
0.01
0.001
2009
2010
2011
2012
2013
2014
2015
2016
Permit Term 3
Permit Term 2
ALU Acute Criterion (Est)
ALU Chronic Criterion (Est)
Human Health Criterion (Est)


Marine Creek
Oil & Grease
Oil & Grease, Total (mg/L)
10
1
0.1
2009
2010
2011
2012
2013
2014
Permit Term 3
Permit Term 2
NSQD Third Quartile

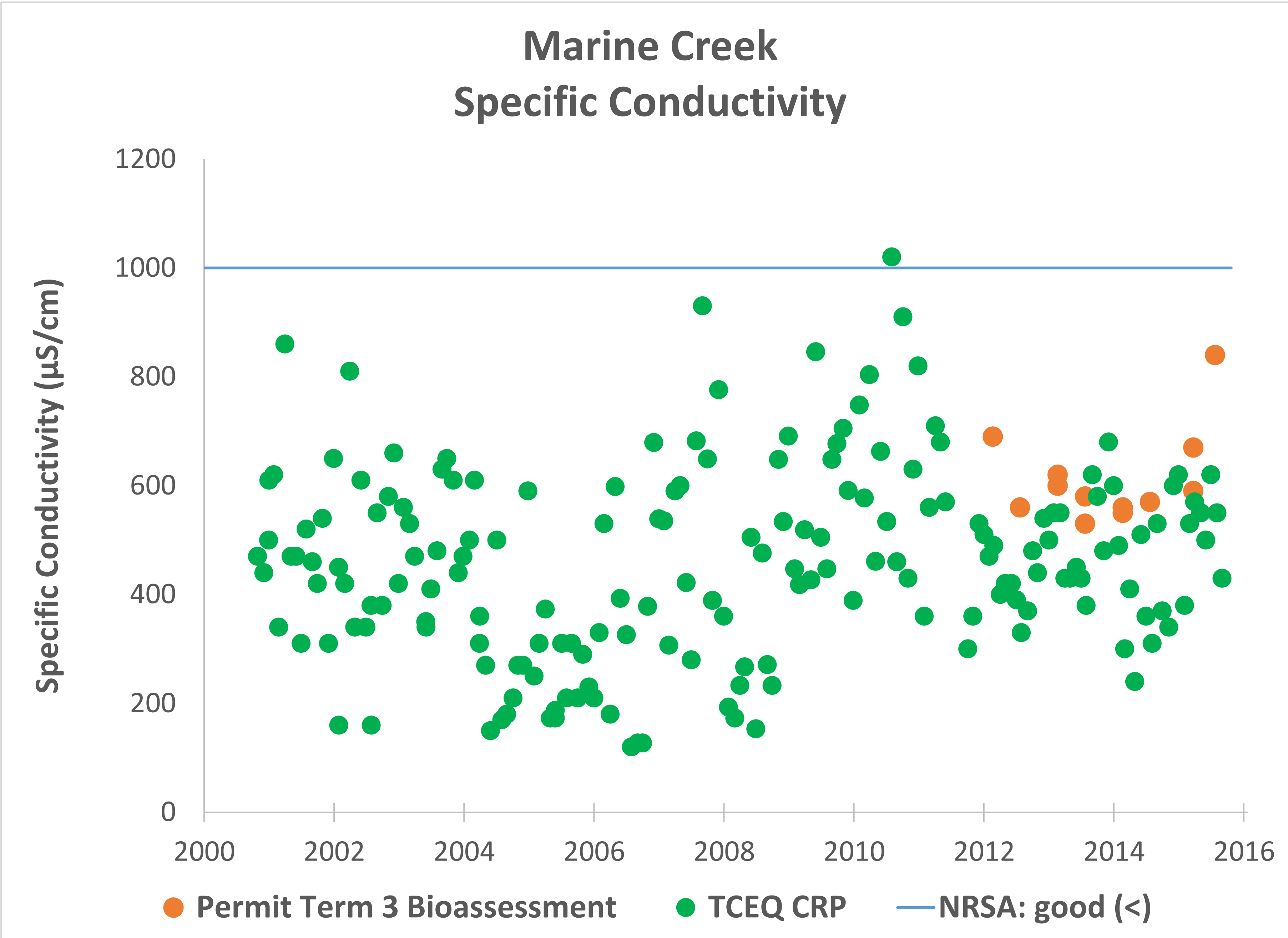

Marine Creek
E. coli
E. coli (col/100 mL)
100000
10000
1000
100
10
1
2000
2002
2004
2006
2008
2010
2012
2014
2016
TCEQ CRP
Permit Term 3
Permit Term 3 Bioassessment
Permit Term 2
PCR Geomean
PCR Single Sample



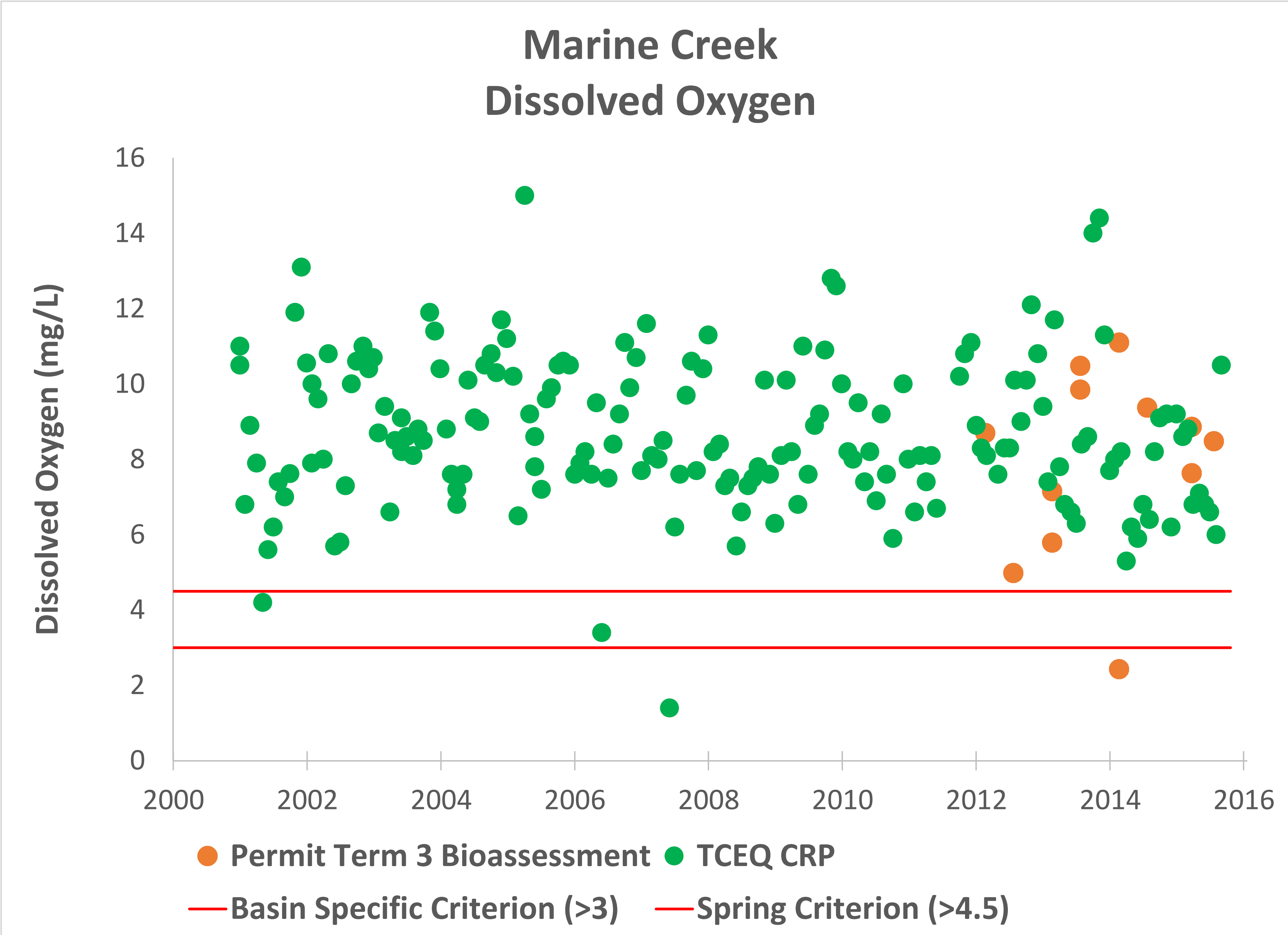
Marine Creek
Total Coliform
Total Coliform (col/100 mL)
90000
80000
70000
60000
50000
40000
30000
20000
10000
0
2009
2010
2011
2012
2013
2014
Permit Term 3
Permit Term 2



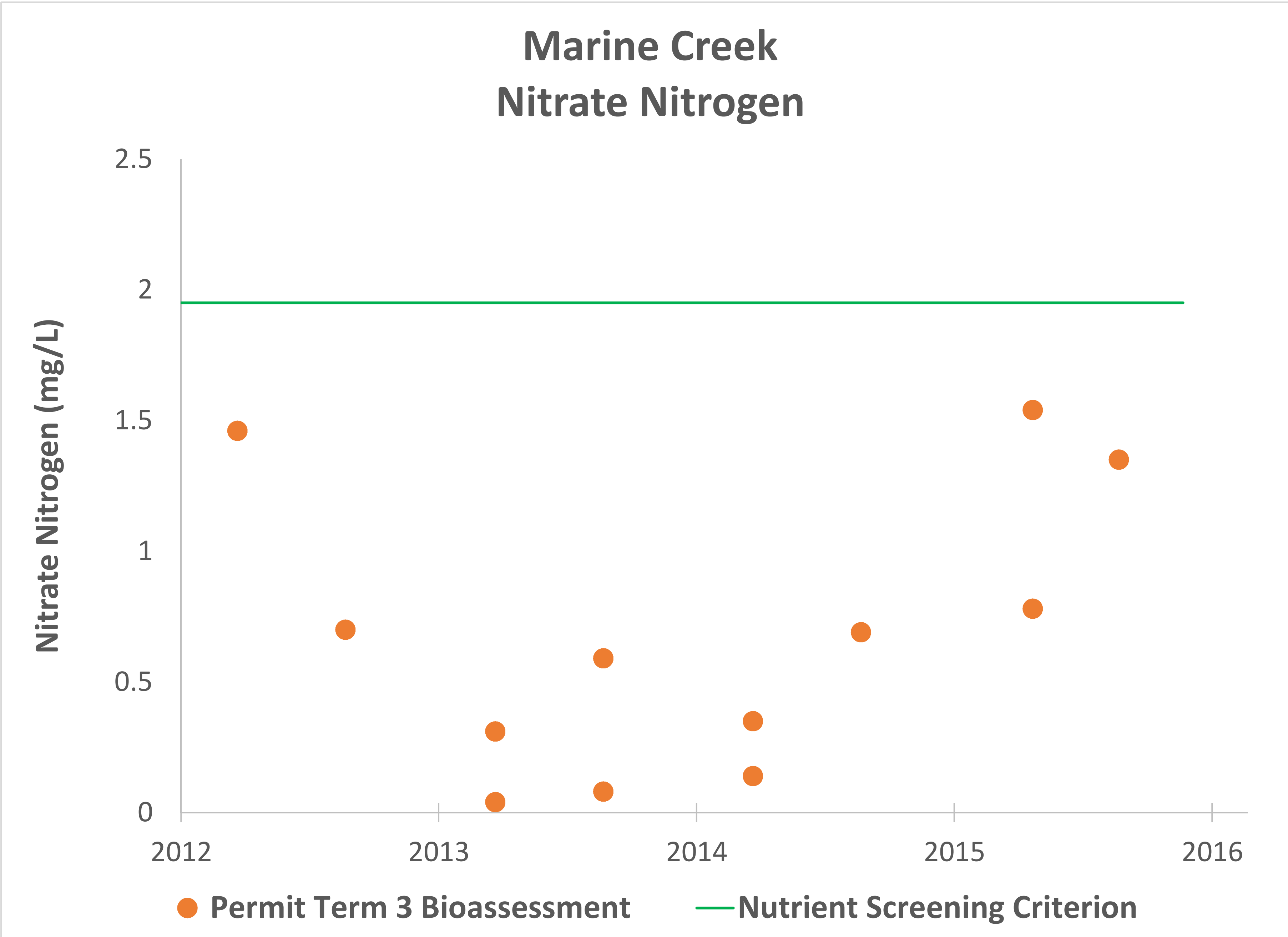
Marine Creek
pH
pH (su)
9.5
9
8.5
8
7.5
7
6.5
6
2001
2003
2005
2007
2009
2011
2013
2015
Permit Term 3
Permit Term 3 Bioassessment
TCEQ CRP
Permit Term 2
Basin Specific Criteria

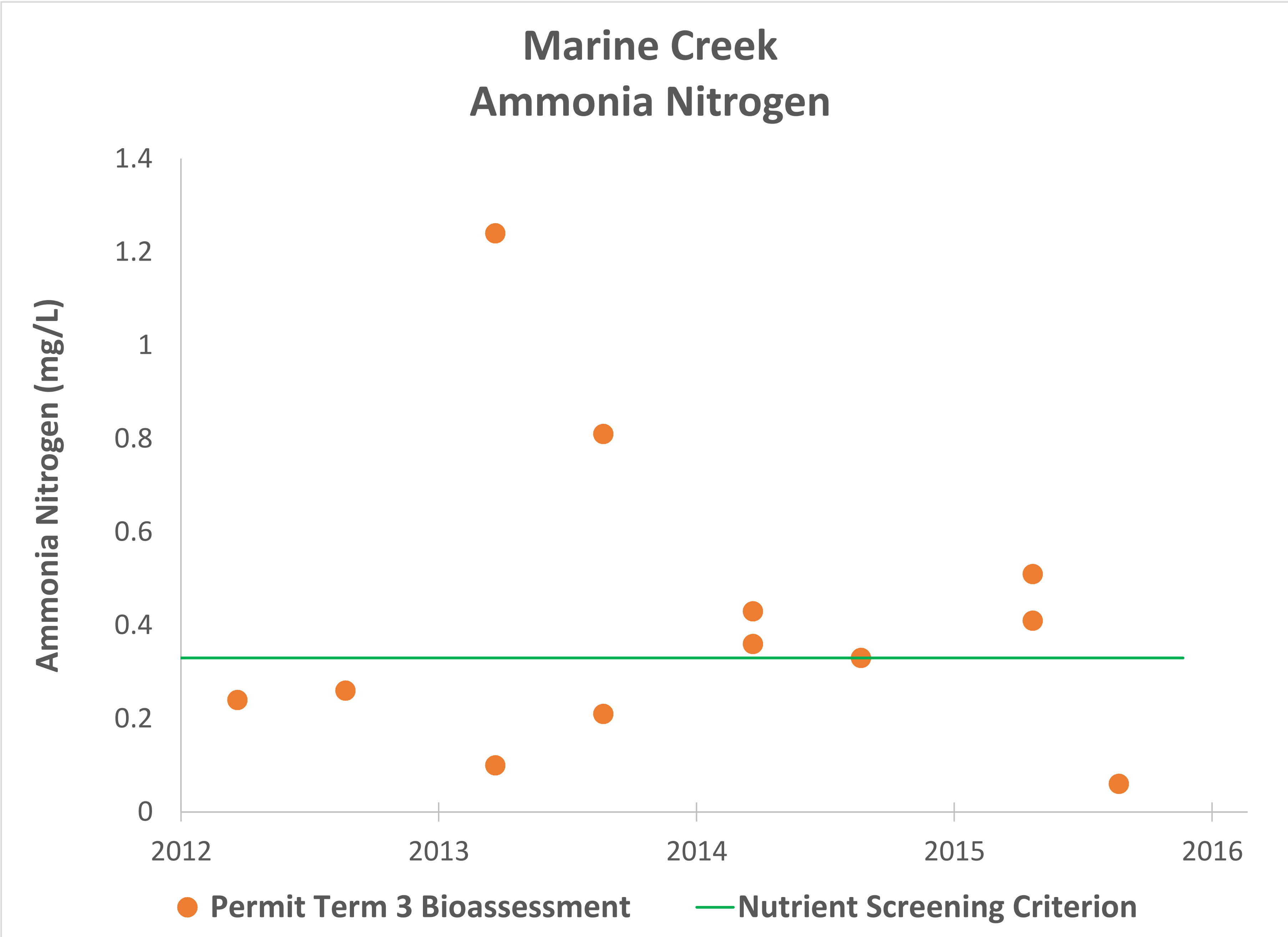


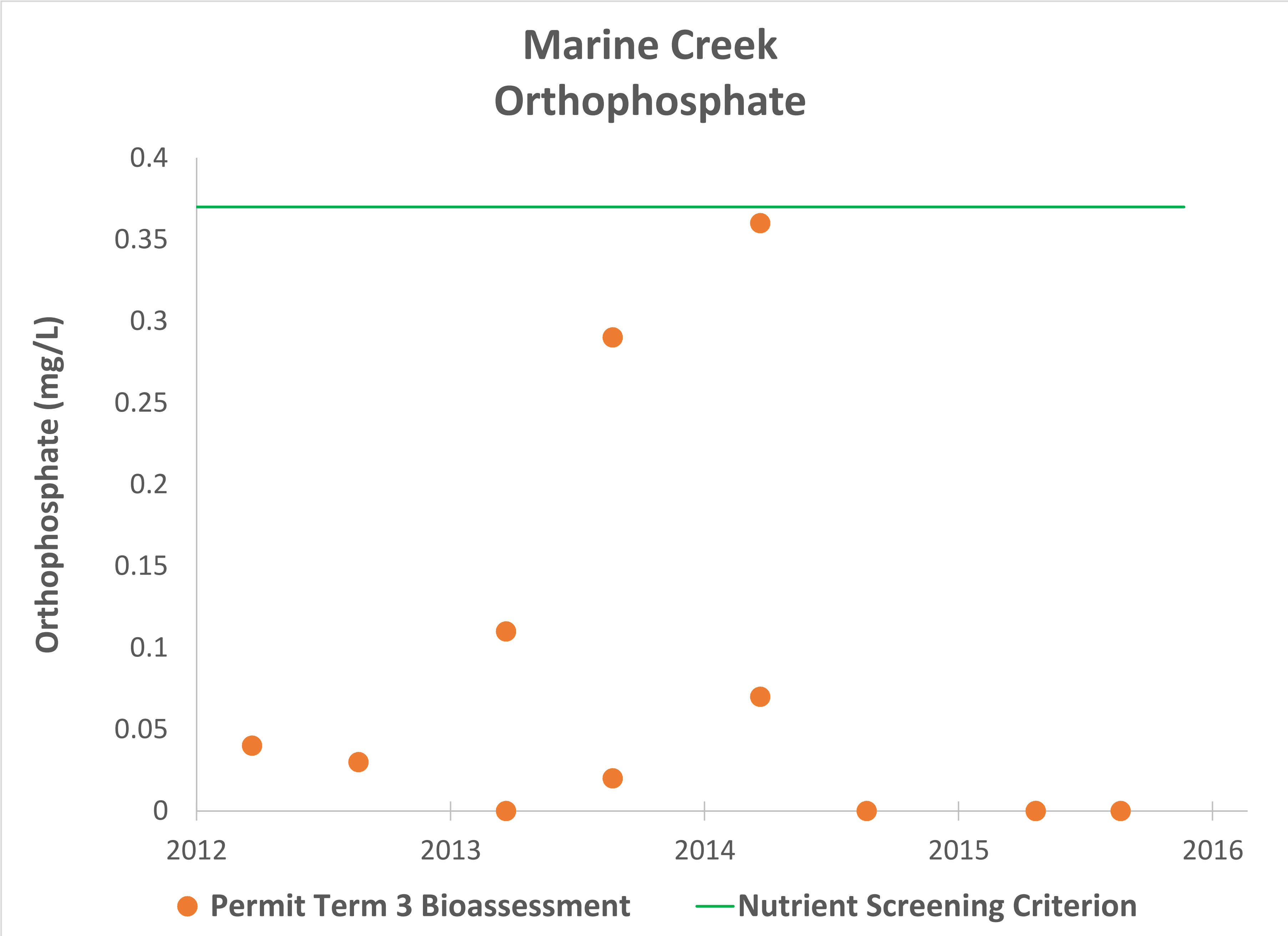
Marine Creek
Specific Conductivity
Specific Conductivity (µS/cm)
1200
1000
800
600
400
200
0
2000
2002
2004
2006
2008
2010
2012
2014
2016
Permit Term 3 Bioassessment
TCEQ CRP
NRSA: good (<)

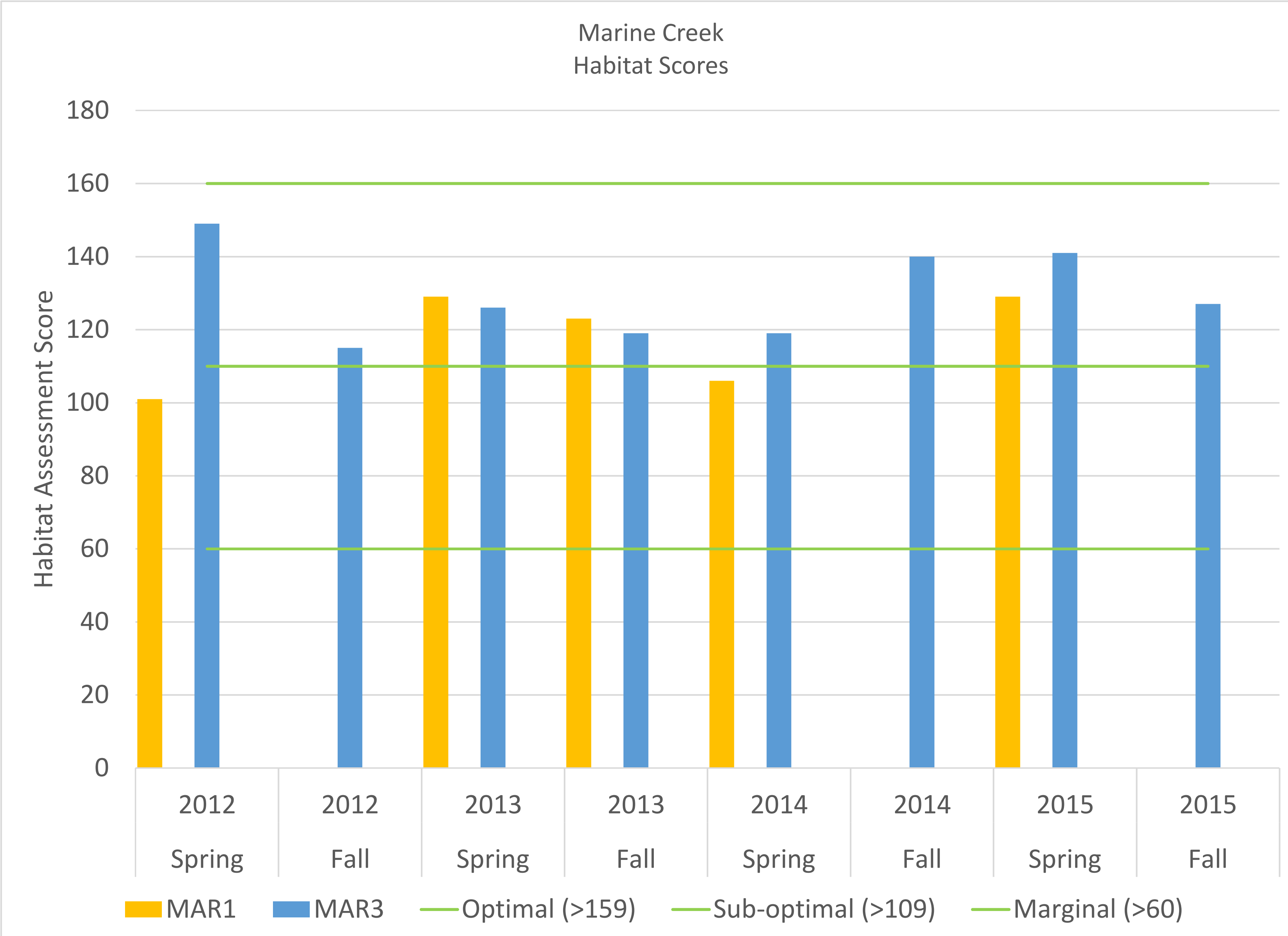


Marine Creek
Dissolved Oxygen
Dissolved Oxygen (mg/L)
0
2
4
6
8
10
12
14
16
2000
2002
2004
2006
2008
2010
2012
2014
2016
Permit Term 3 Bioassessment
TCEQ CRP
Basin Specific Criterion (>3)
Spring Criterion (>4.5)

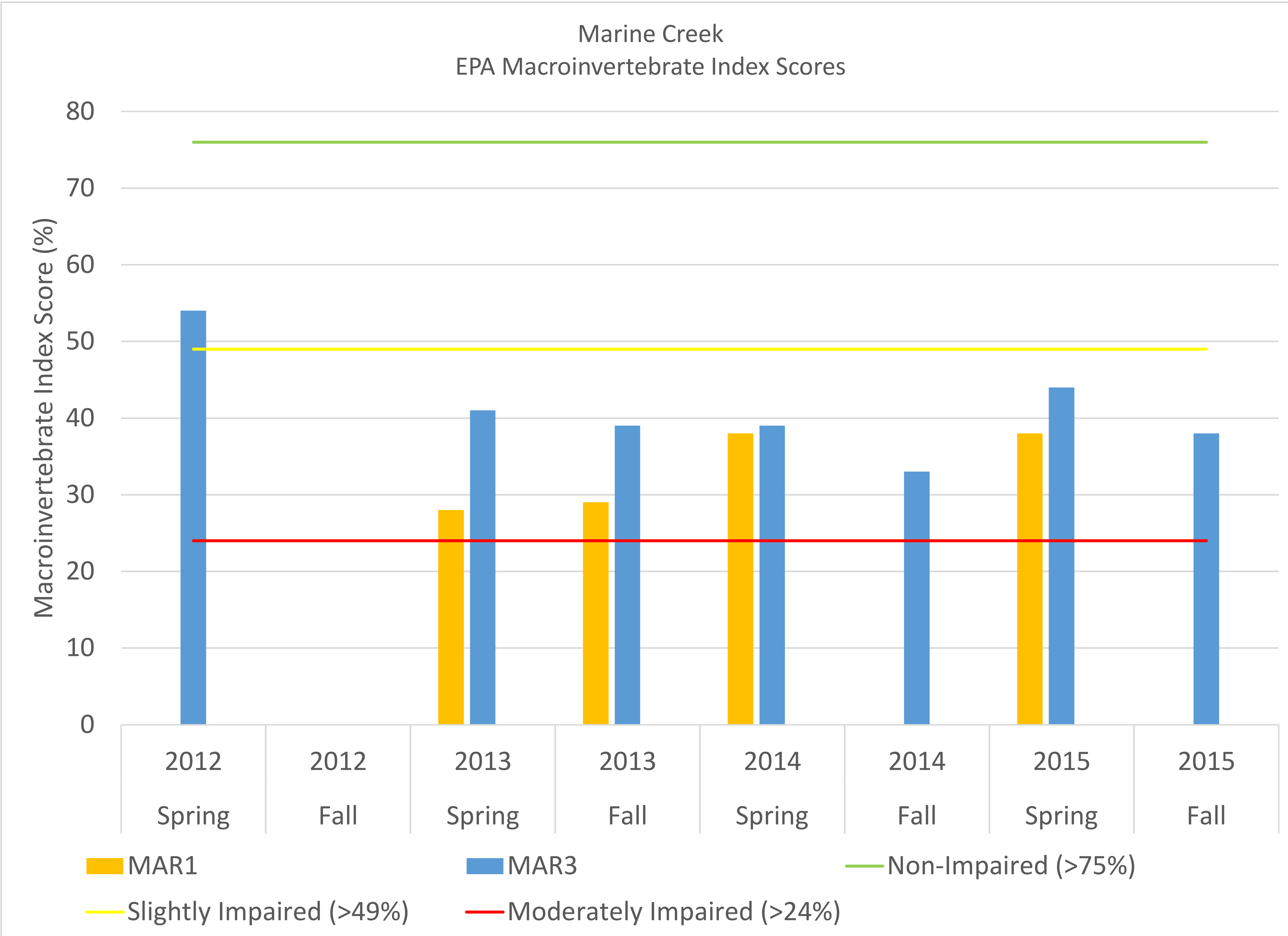

Marine Creek
Nitrate Nitrogen
Nitrate Nitrogen (mg/L)
2.5
2
1.5
1
0.5
0
2012
2013
2014
2015
2016
Permit Term 3 Bioassessment
Nutrient Screening Criterion

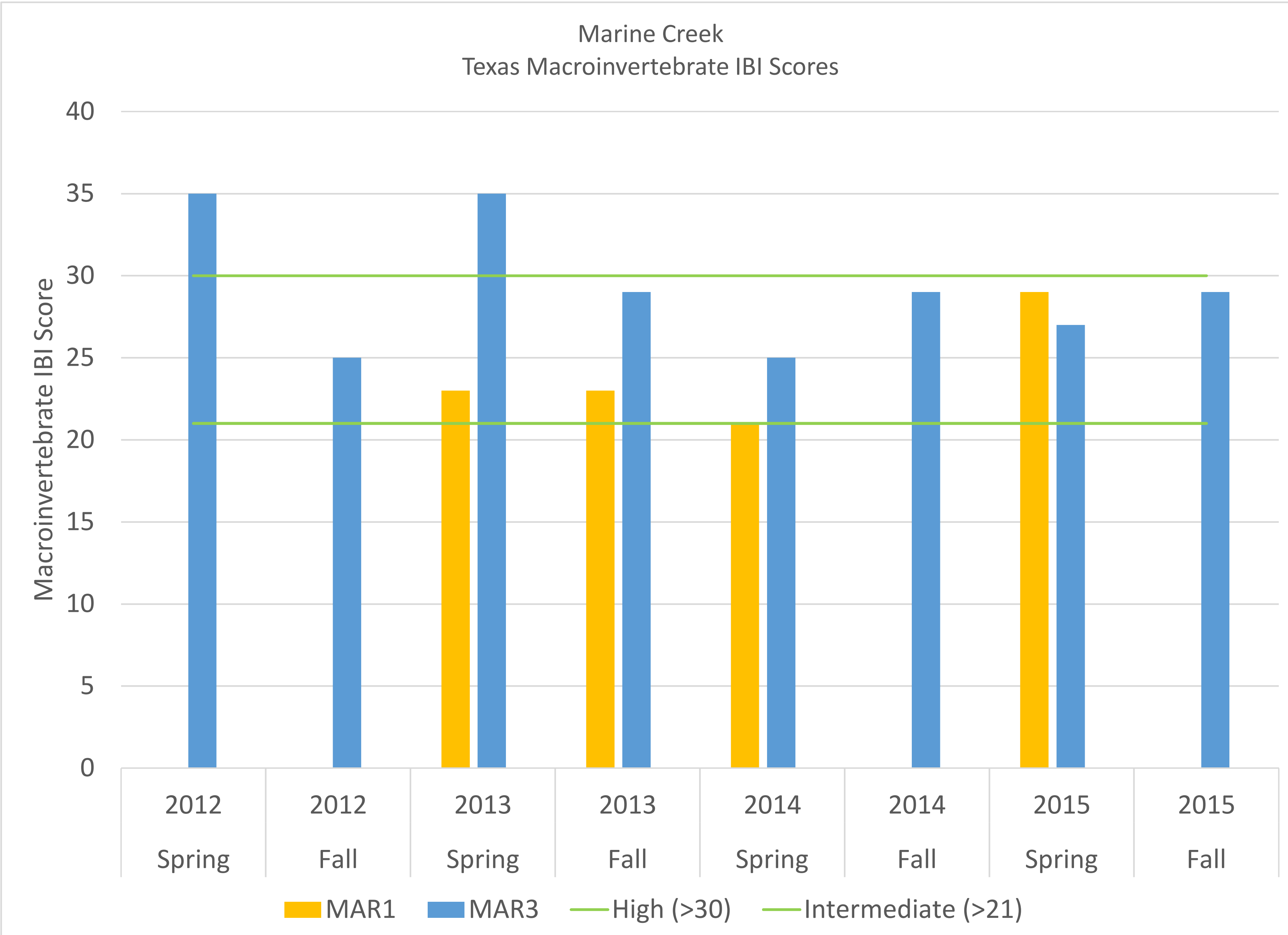

Marine Creek
Ammonia Nitrogen
Ammonia Nitrogen (mg/L)
1.4
1.2
1
0.8
0.6
0.4
0.2
0
2012
2013
2014
2015
2016
Permit Term 3 Bioassessment
Nutrient Screening Criterion


Marine Creek
Orthophosphate
Orthophosphate (mg/L)
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
2012
2013
2014
2015
2016
Permit Term 3 Bioassessment
Nutrient Screening Criterion



Marine Creek
Habitat Scores
Habitat Assessment Score
180
160
140
120
100
80
60
40
20
0
2012 Spring
2012 Fall
2013 Spring
2013 Fall
2014 Spring
2014 Fall
2015 Spring
2015 Fall
MAR1
MAR3
Optimal (>159)
Sub-optimal (>109)
Marginal (>60)

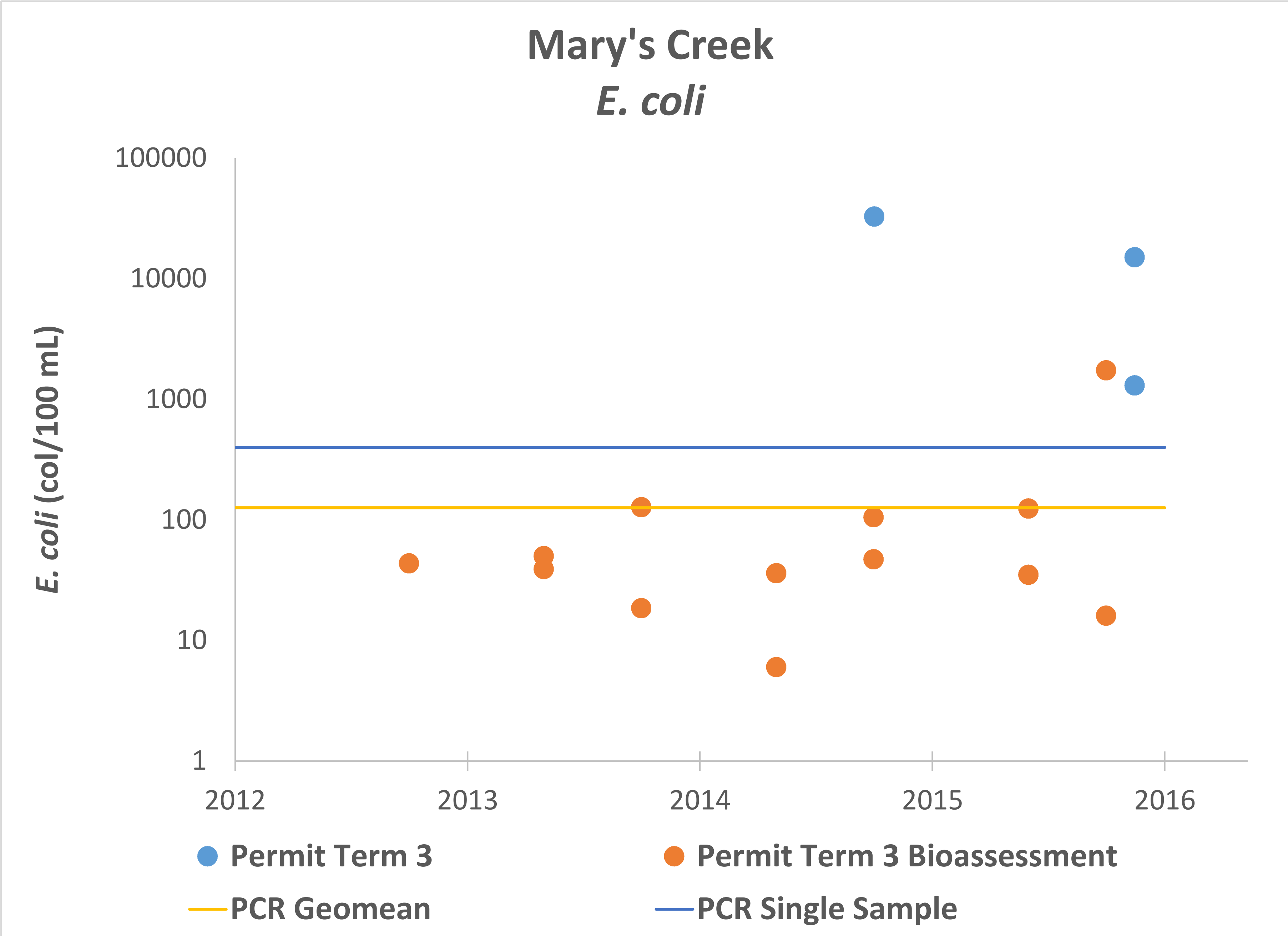

Marine Creek
EPA Macroinvertebrate Index Scores
Macroinvertebrate Index Score (%)
80
70
60
50
40
30
20
10
0
2012 Spring
2012 Fall
2013 Spring
2013 Fall
2014 Spring
2014 Fall
2015 Spring
2015 Fall
MAR1
MAR3
Non-Impaired (>75%)
Slightly Impaired (>49%)
Moderately Impaired (>24%)

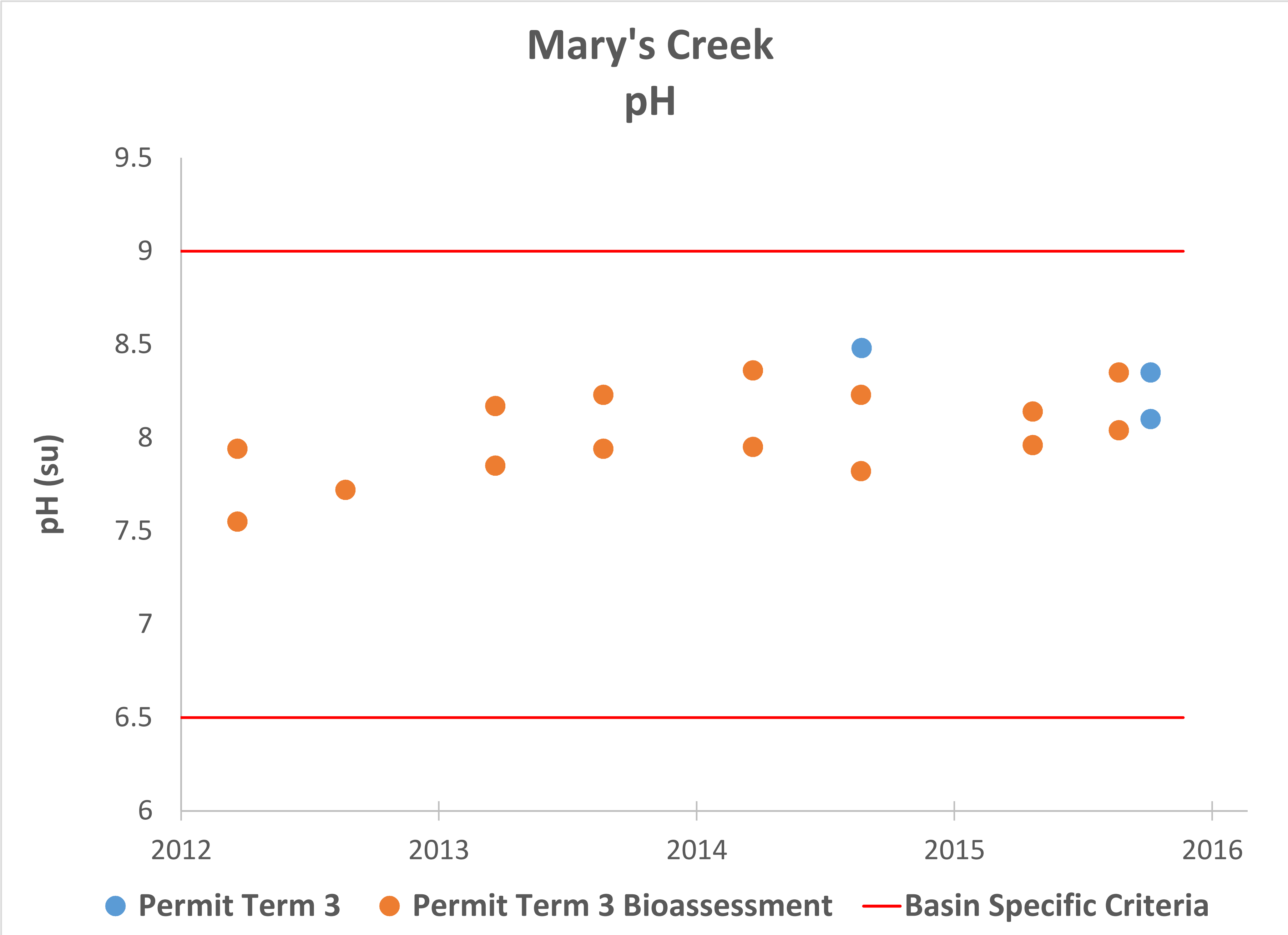


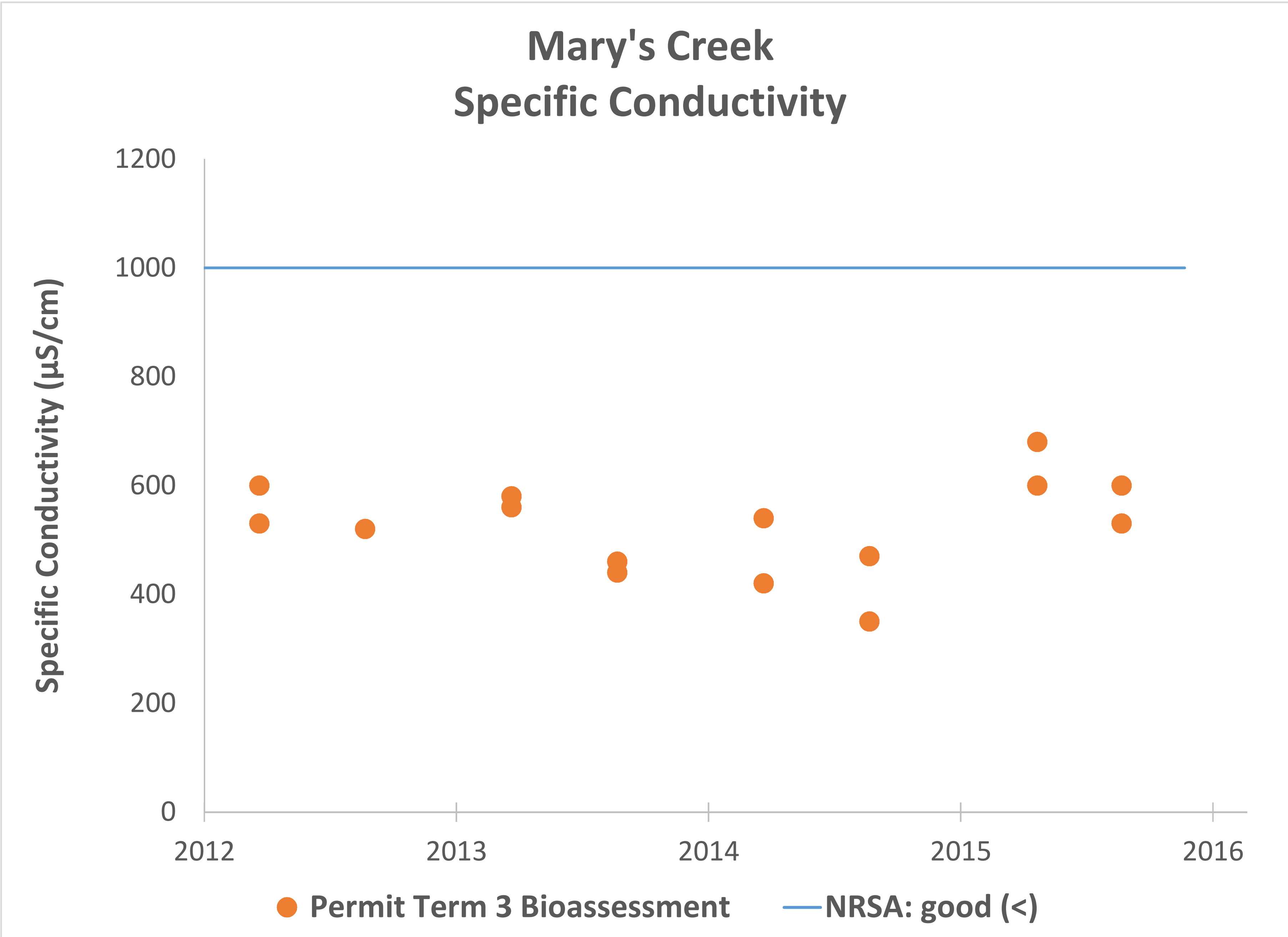
Marine Creek
Texas Macroinvertebrate IBI Scores
Macroinvertebrate IBI Score
40
35
30
25
20
15
10
5
0
2012 Spring
2012 Fall
2013 Spring
2013 Fall
2014 Spring
2014 Fall
2015 Spring
2015 Fall
MAR1
MAR3
High (>30)
Intermediate (>21)

Appendix Q

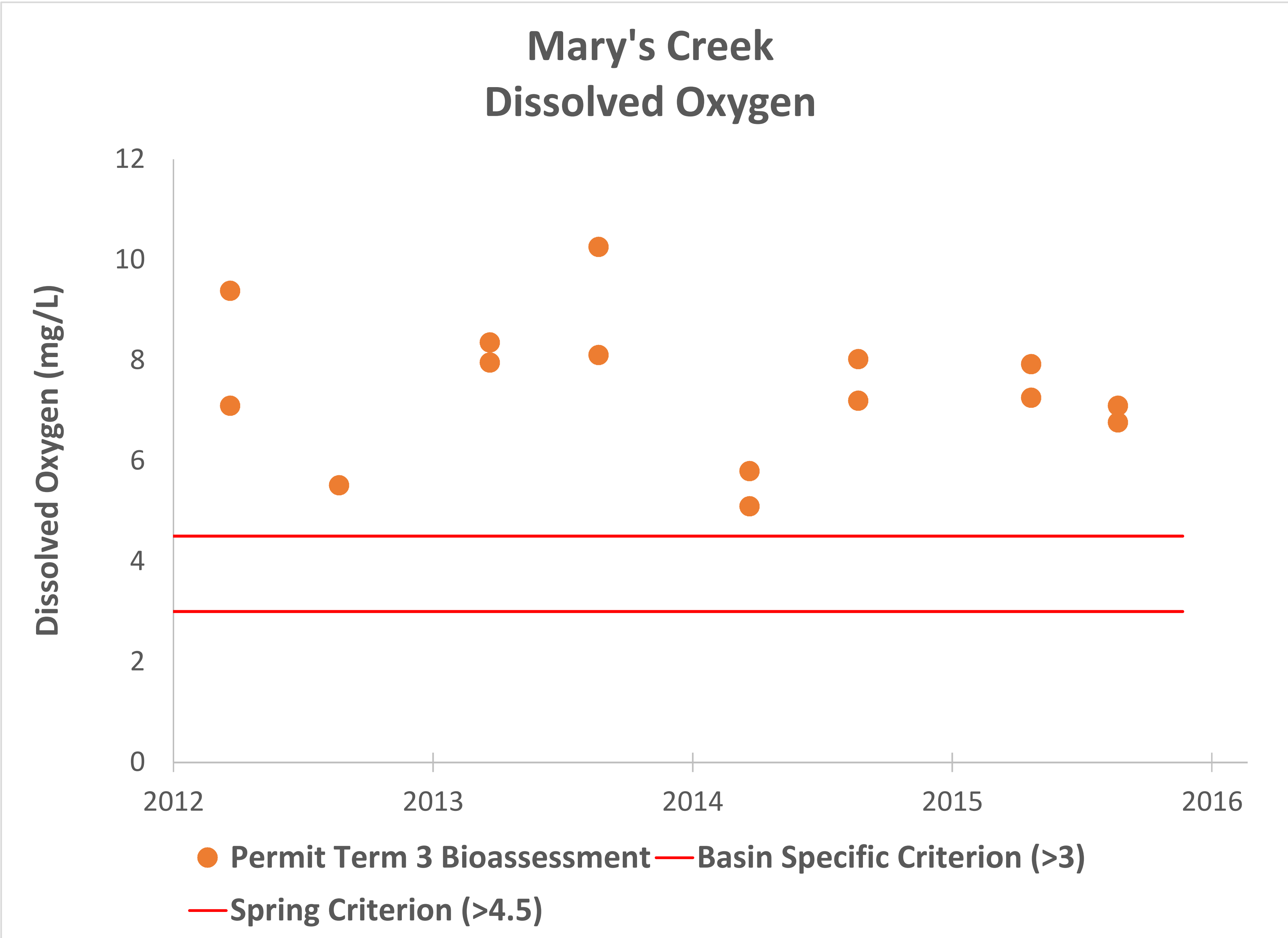
Mary's Creek Water Quality Data Graphs

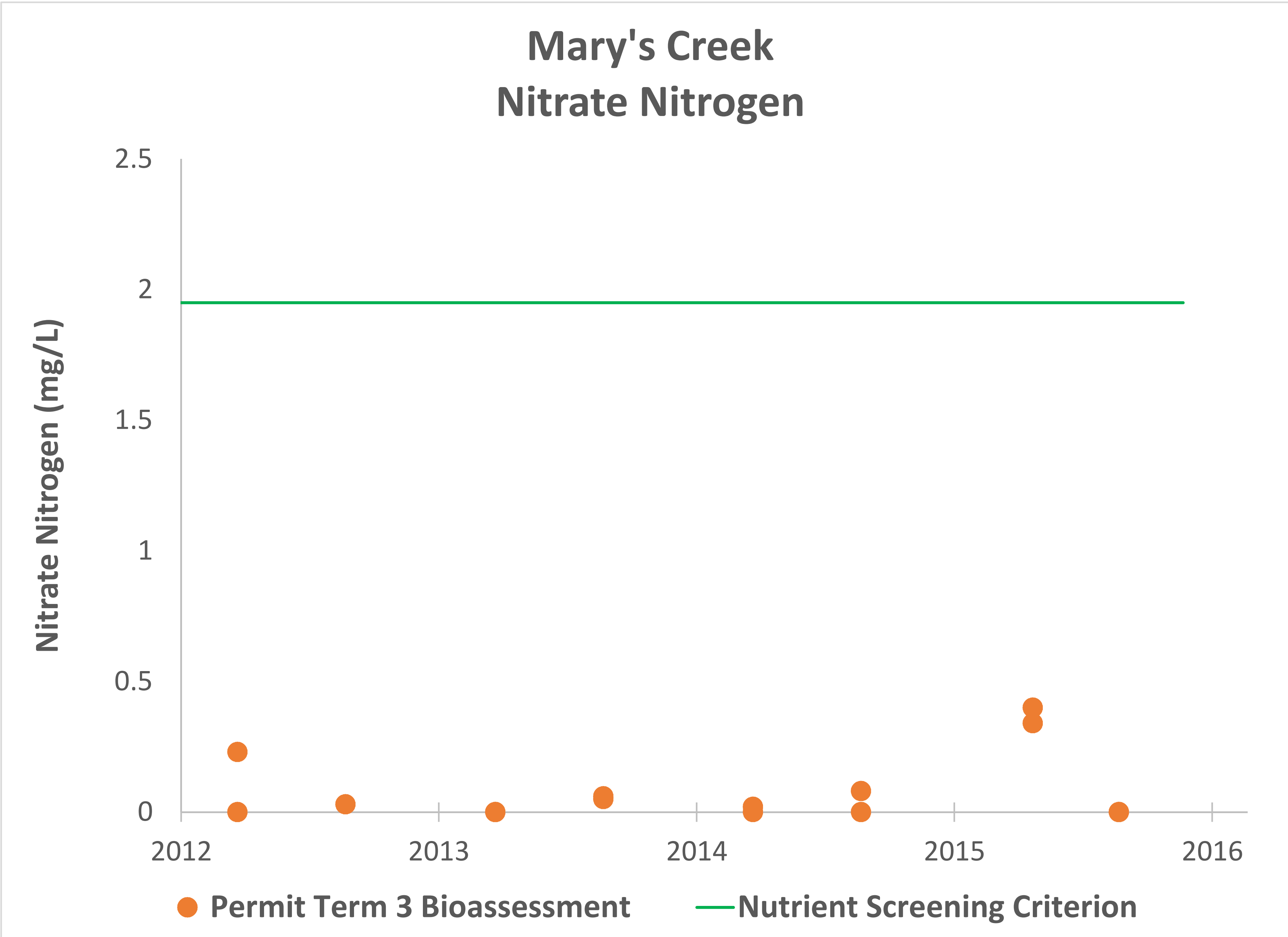

Mary's Creek
E. coli
E. coli (col/100 mL)
100000
10000
1000
100
10
1
2012
2013
2014
2015
2016
Permit Term 3
Permit Term 3 Bioassessment
PCR Geomean
PCR Single Sample


Mary's Creek
pH
9.5
9
8.5
8
7.5
7
6.5
6
pH (su)
2012
2013
2014
2015
2016
Permit Term 3
Permit Term 3 Bioassessment
Basin Specific Criteria

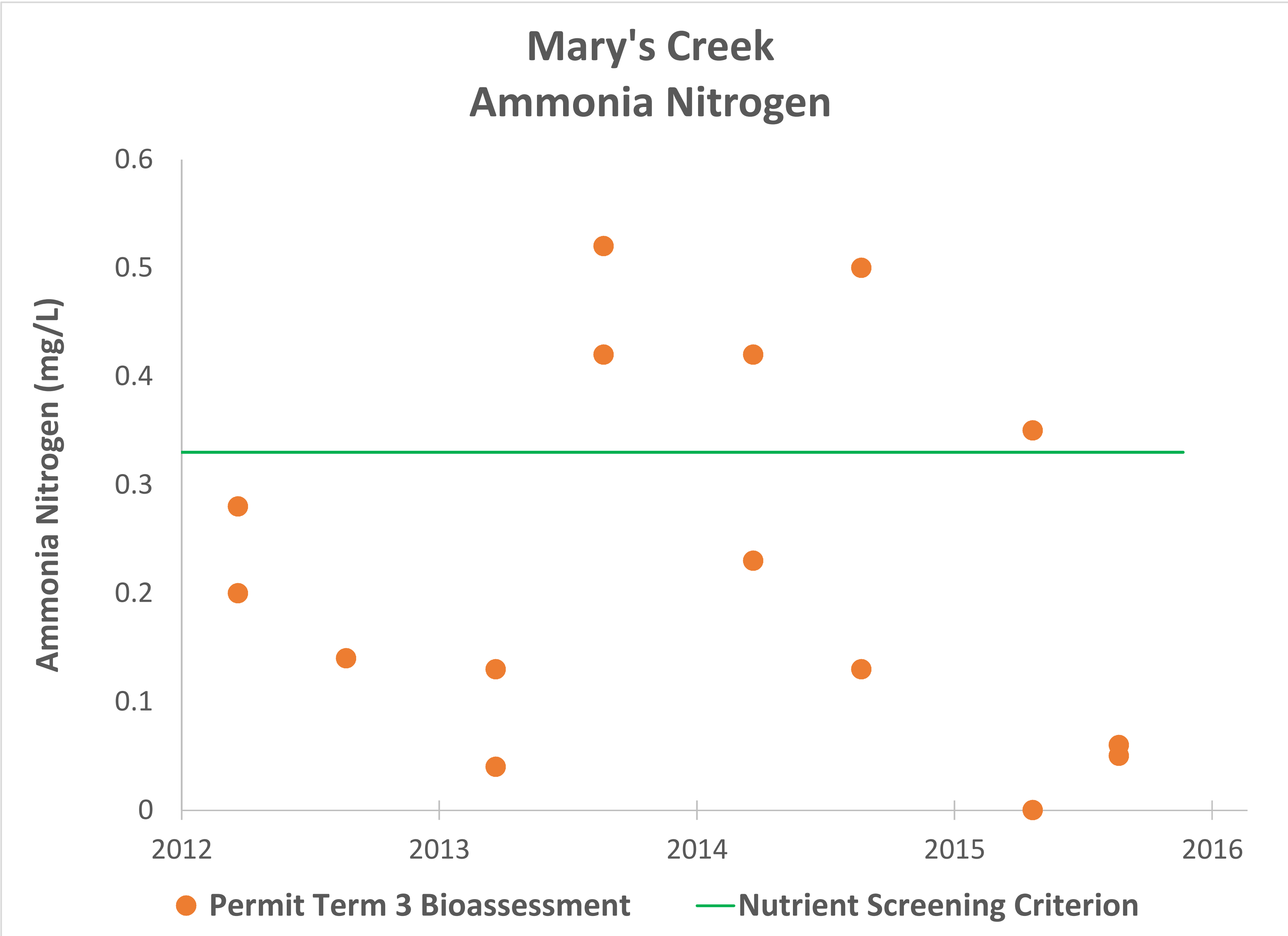


Mary's Creek
Specific Conductivity
Specific Conductivity (µS/cm)
1200
1000
800
600
400
200
0
2012
2013
2014
2015
2016
Permit Term 3 Bioassessment
NRSA: good (<)

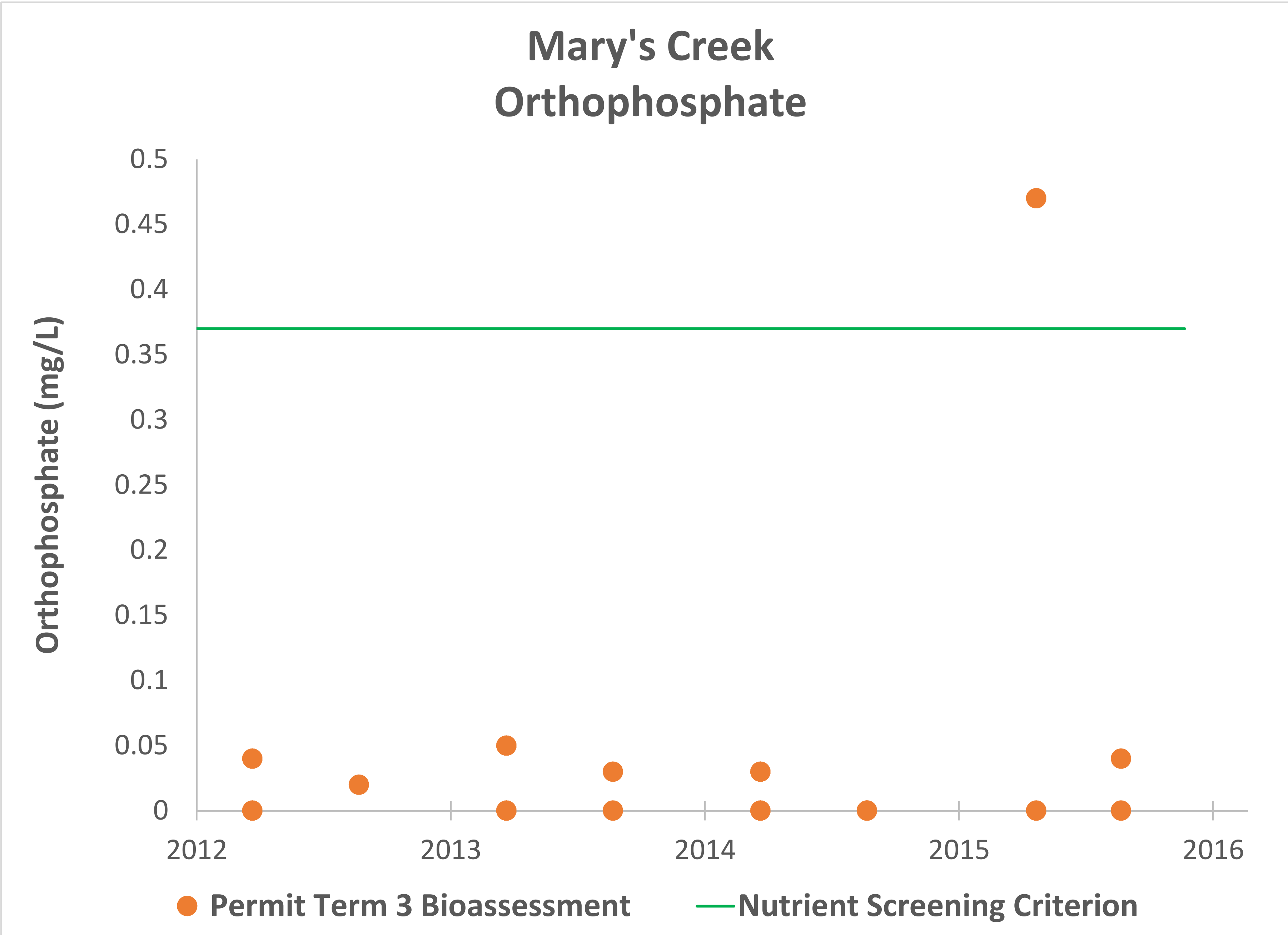

Mary's Creek
Dissolved Oxygen
Dissolved Oxygen (mg/L)
0
2
4
6
8
10
12
2012
2013
2014
2015
2016
Permit Term 3 Bioassessment
Basin Specific Criterion (>3)
Spring Criterion (>4.5)

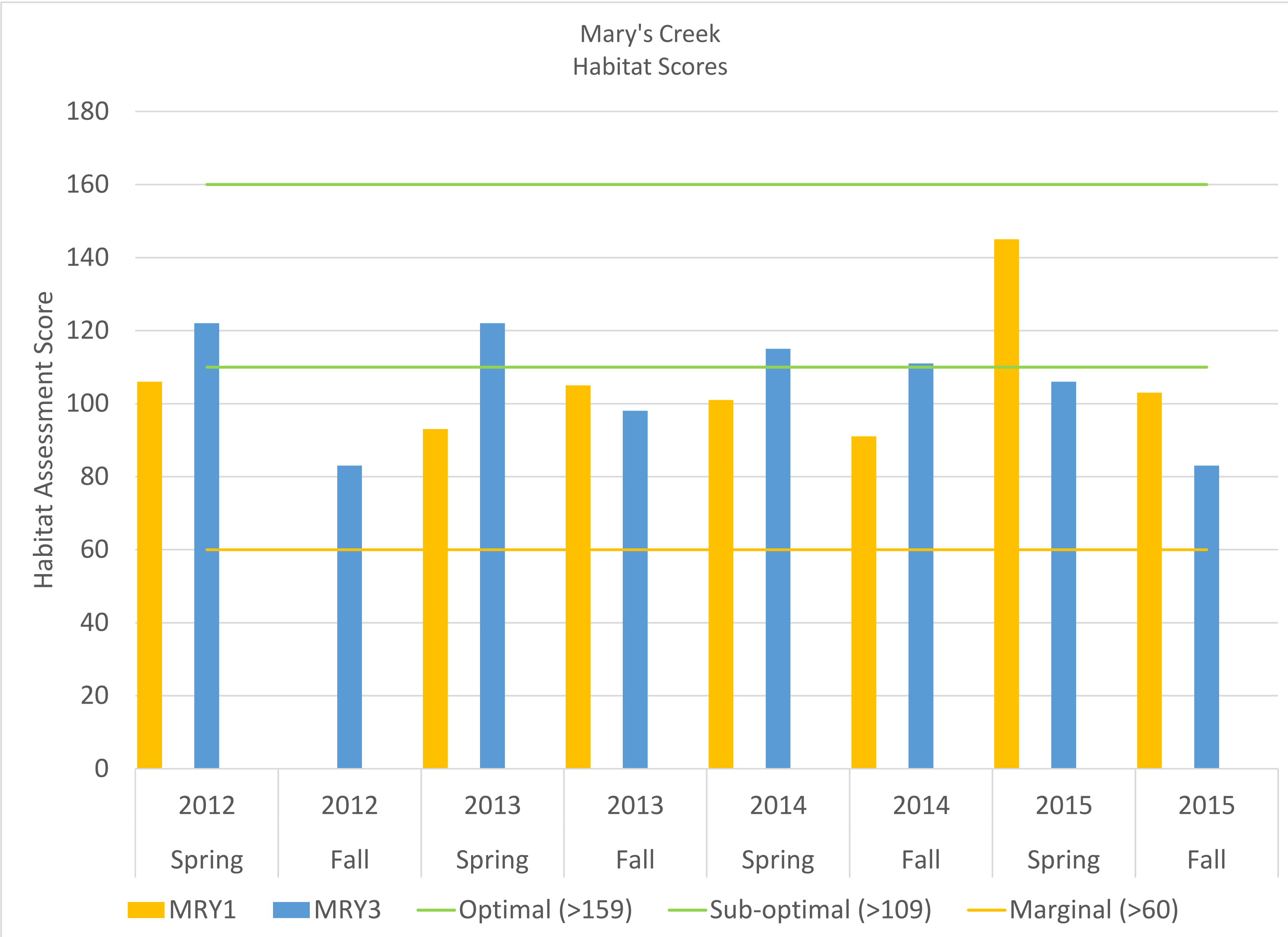


Mary's Creek
Nitrate Nitrogen
Nitrate Nitrogen (mg/L)
2.5
2
1.5
1
0.5
0
2012
2013
2014
2015
2016
Permit Term 3 Bioassessment
Nutrient Screening Criterion

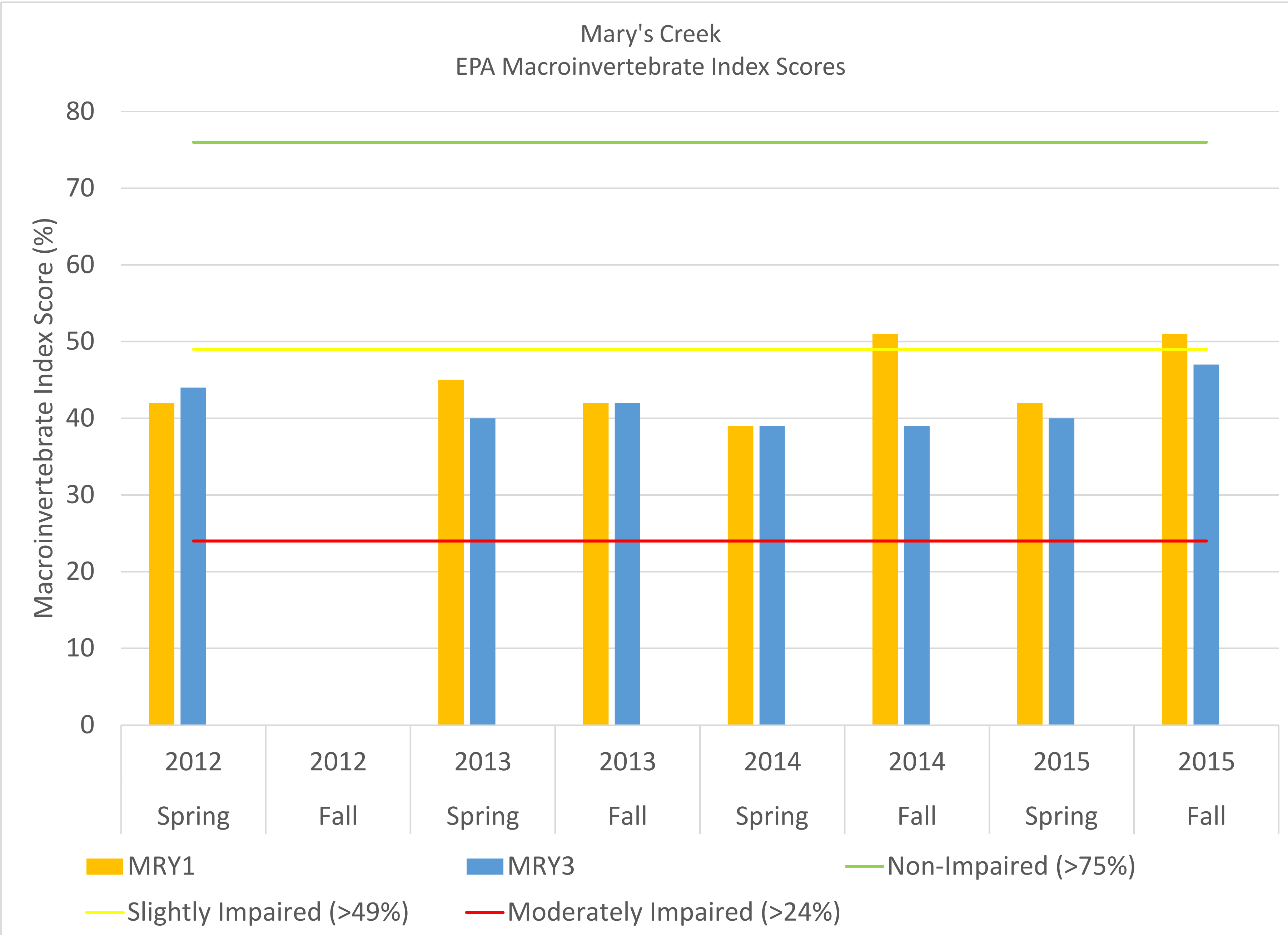


Mary's Creek
Ammonia Nitrogen
Ammonia Nitrogen (mg/L)
0.6
0.5
0.4
0.3
0.2
0.1
0
2012
2013
2014
2015
2016
Permit Term 3 Bioassessment
Nutrient Screening Criterion

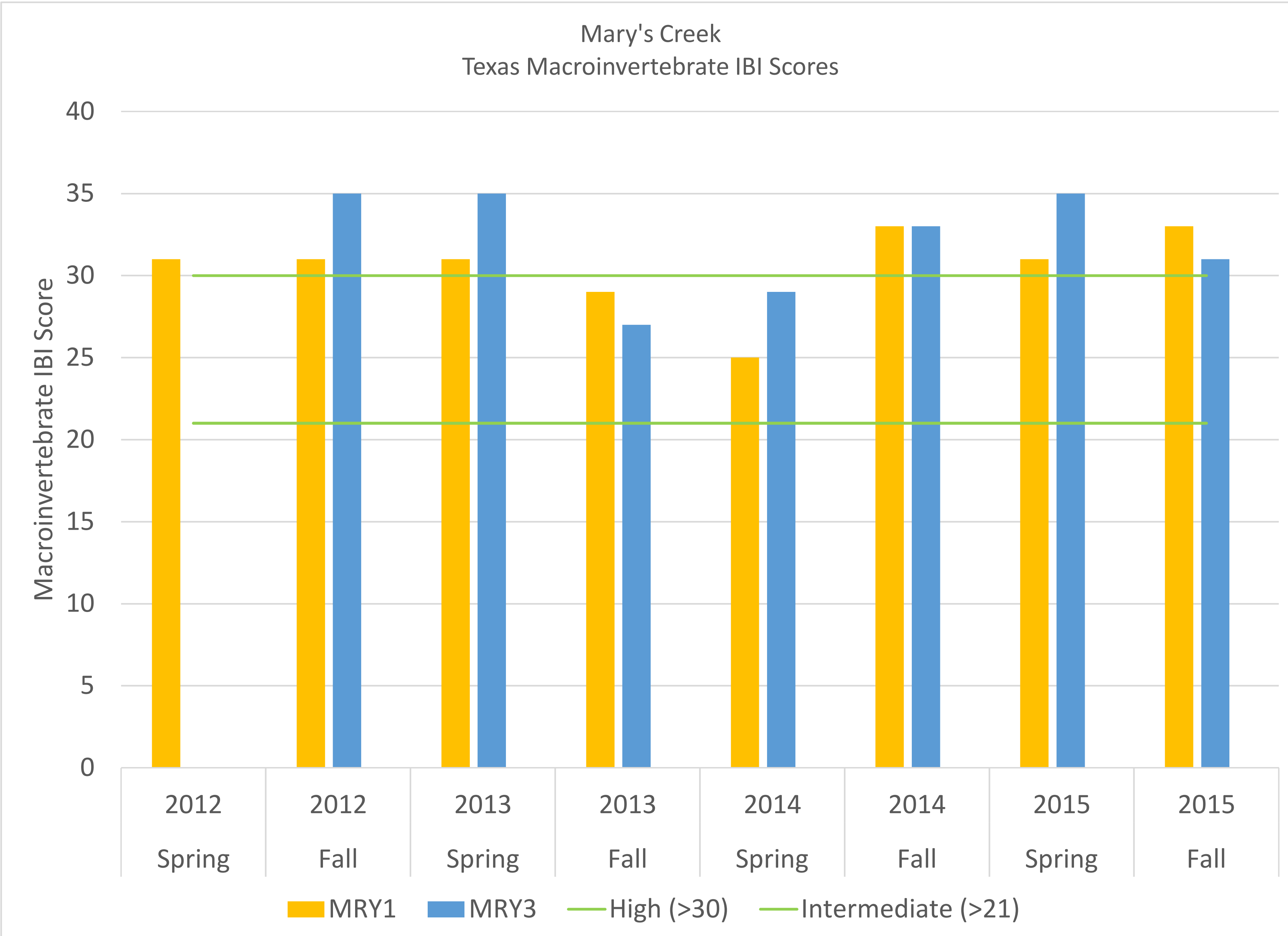

Mary's Creek
Orthophosphate
Orthophosphate (mg/L)
0.5
0.45
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
2012
2013
2014
2015
2016
Permit Term 3 Bioassessment
Nutrient Screening Criterion



Mary's Creek
Habitat Scores
Habitat Assessment Score
180
160
140
120
100
80
60
40
20
0
2012 Spring
2012 Fall
2013 Spring
2013 Fall
2014 Spring
2014 Fall
2015 Spring
2015 Fall
MRY1
MRY3
Optimal (>159)
Sub-optimal (>109)
Marginal (>60)

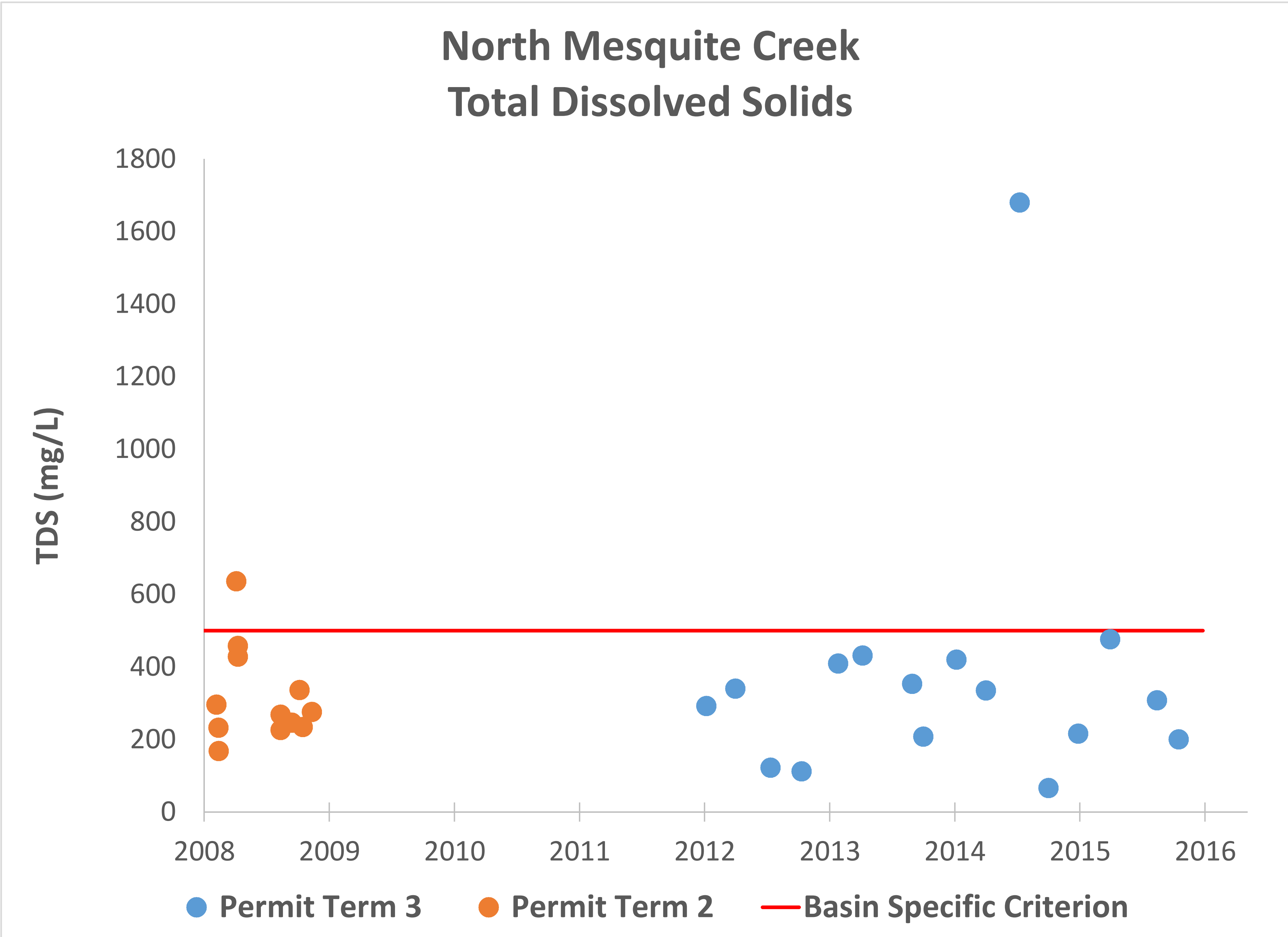


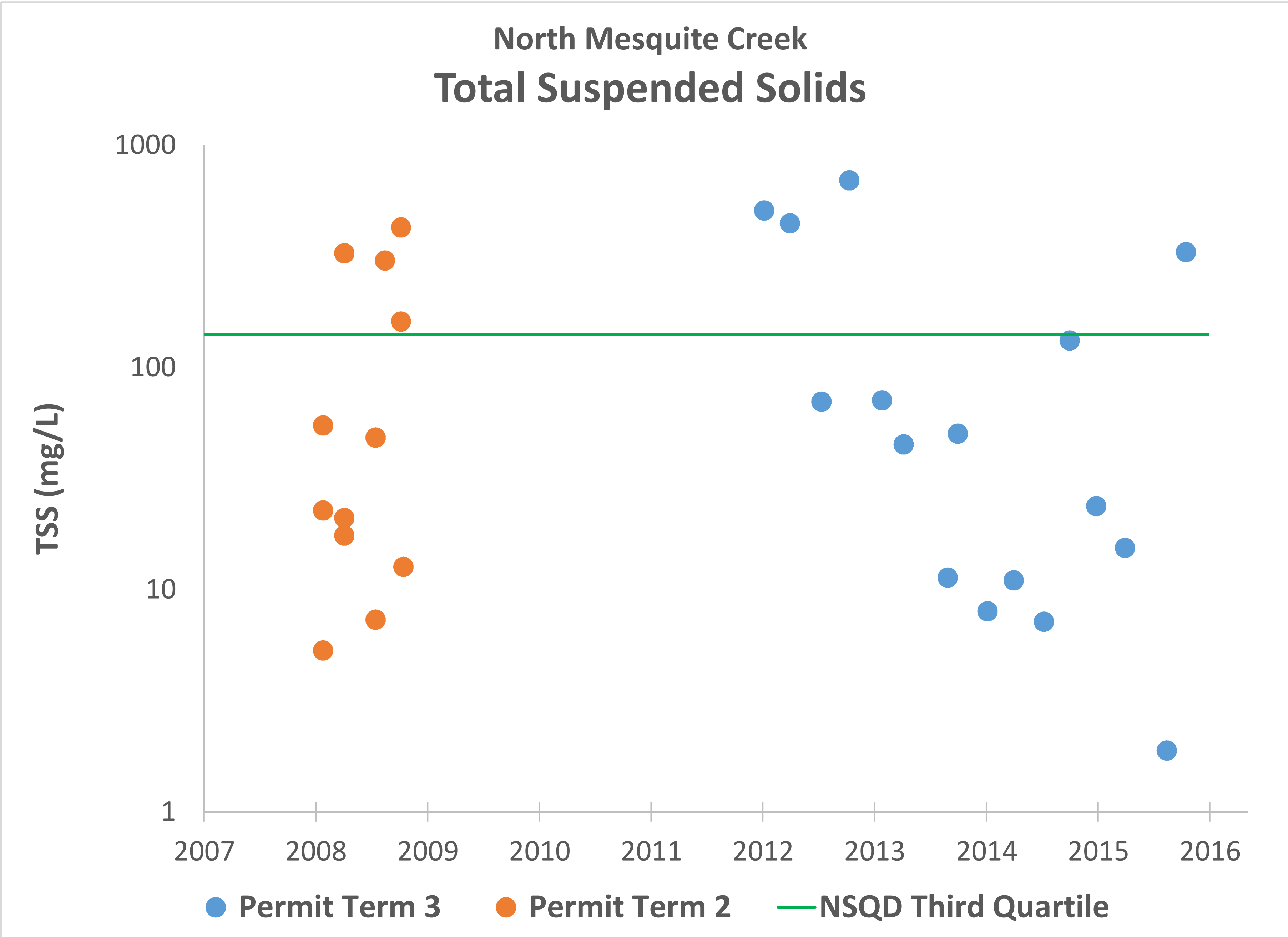
Mary's Creek
EPA Macroinvertebrate Index Scores
Macroinvertebrate Index Score (%)
80
70
60
50
40
30
20
10
0
2012 Spring
2012 Fall
2013 Spring
2013 Fall
2014 Spring
2014 Fall
2015 Spring
2015 Fall
MRY1
MRY3
Non-Impaired (>75%)
Slightly Impaired (>49%)
Moderately Impaired (>24%)

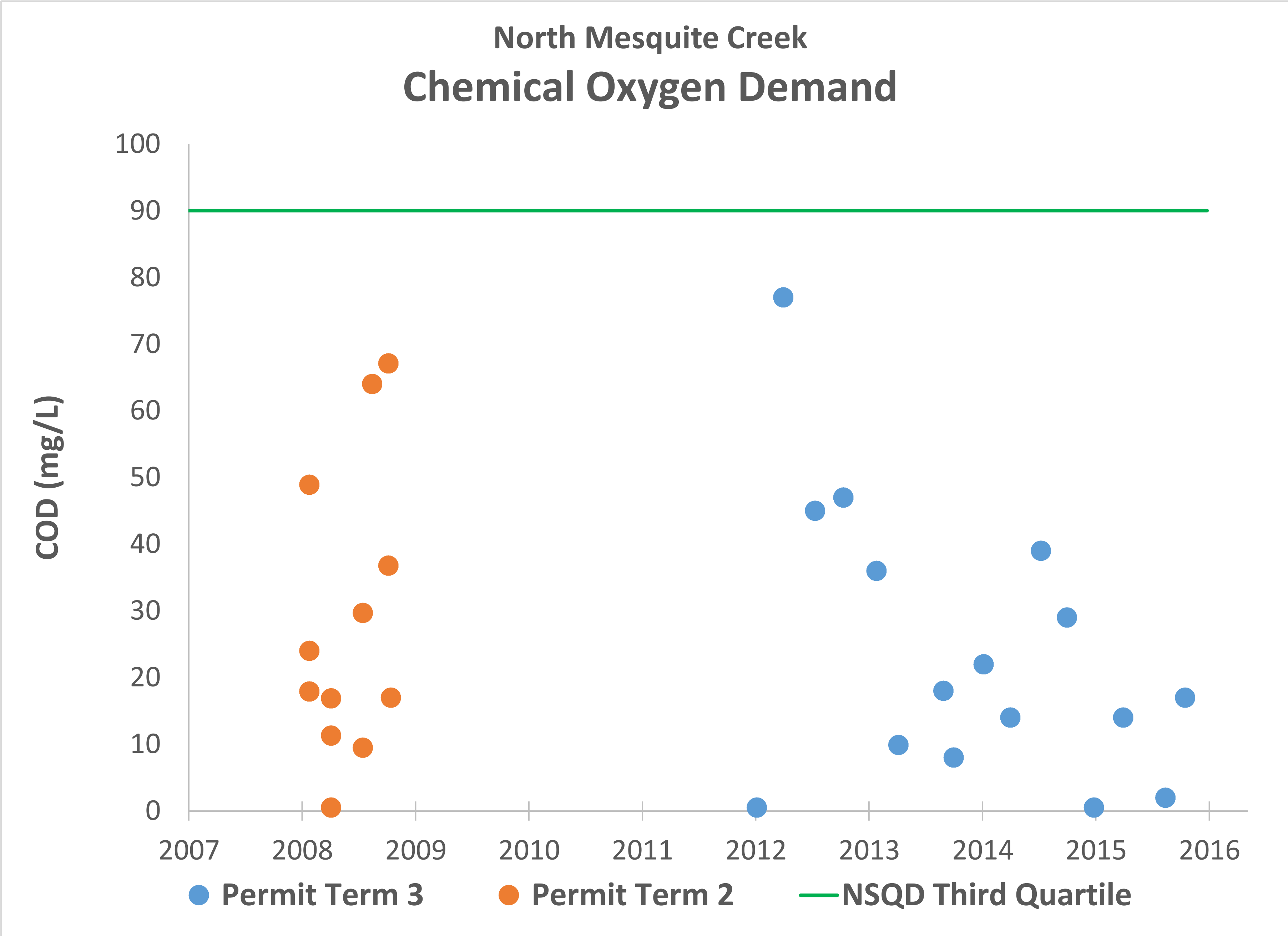

Mary's Creek
Texas Macroinvertebrate IBI Scores
Macroinvertebrate IBI Score
40
35
30
25
20
15
10
5
0
2012 Spring
2012 Fall
2013 Spring
2013 Fall
2014 Spring
2014 Fall
2015 Spring
2015 Fall
MRY1
MRY3
High (>30)
Intermediate (>21)

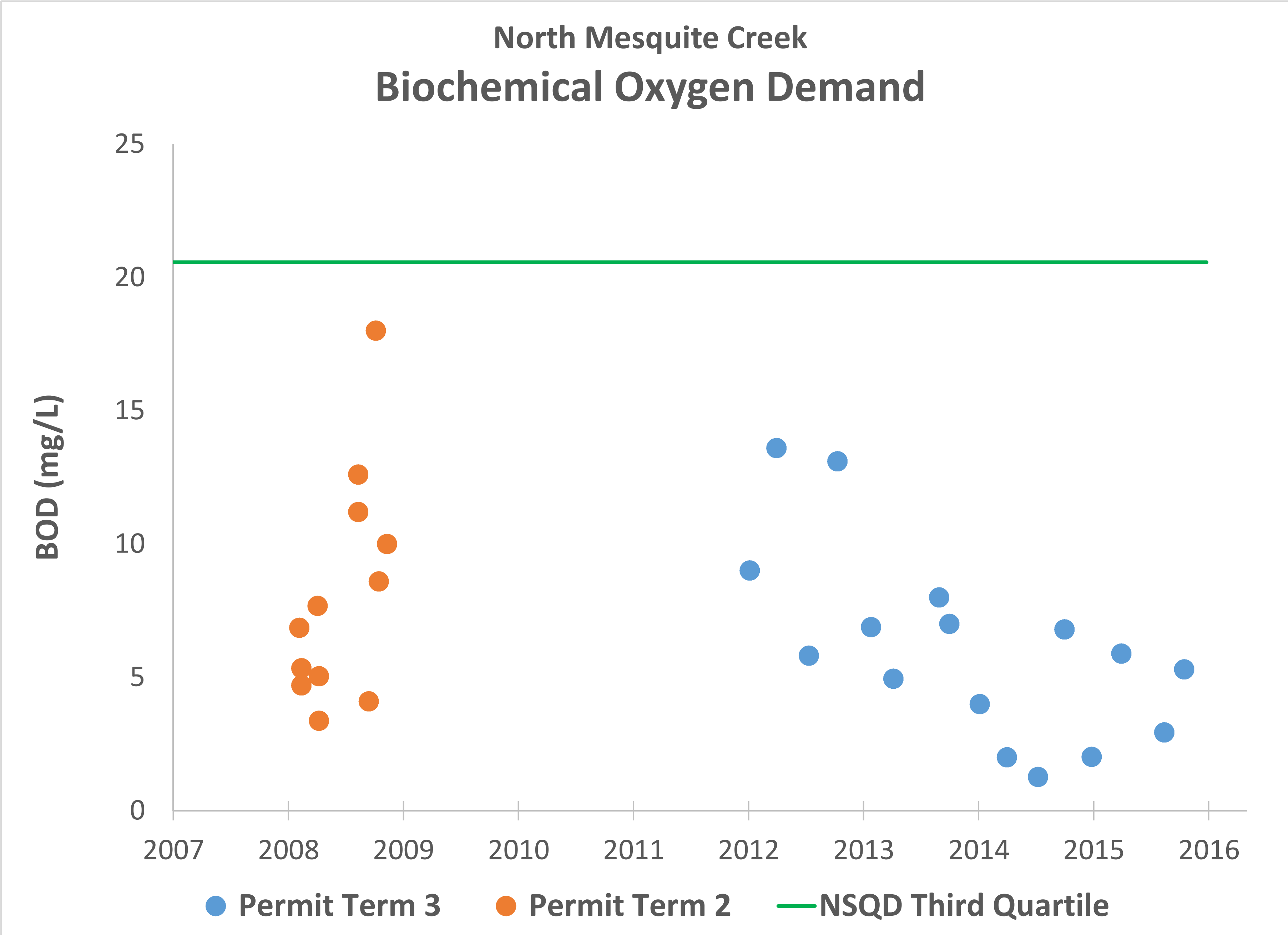
Appendix R

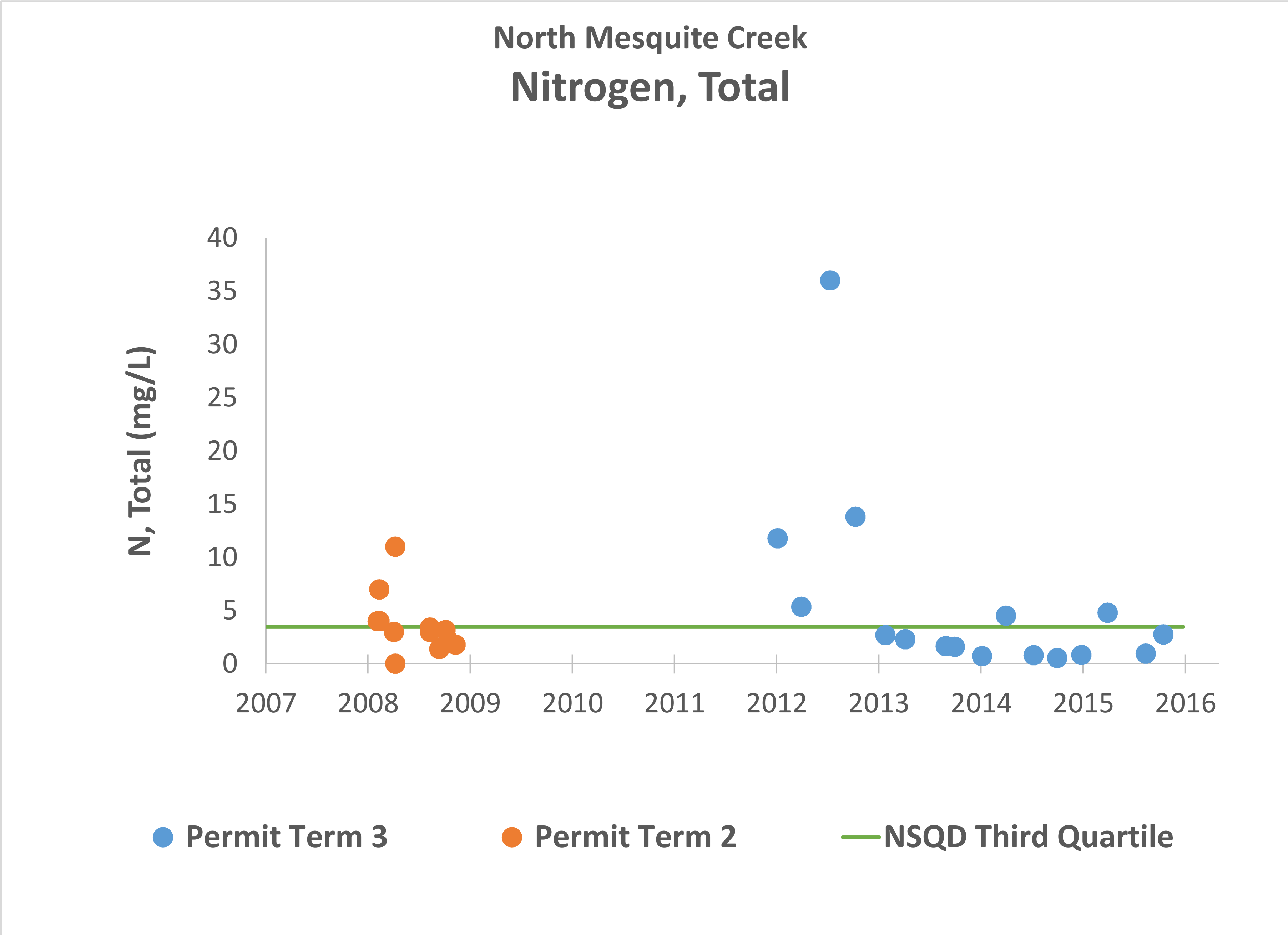
North Mesquite Creek Water Quality Data Graphs

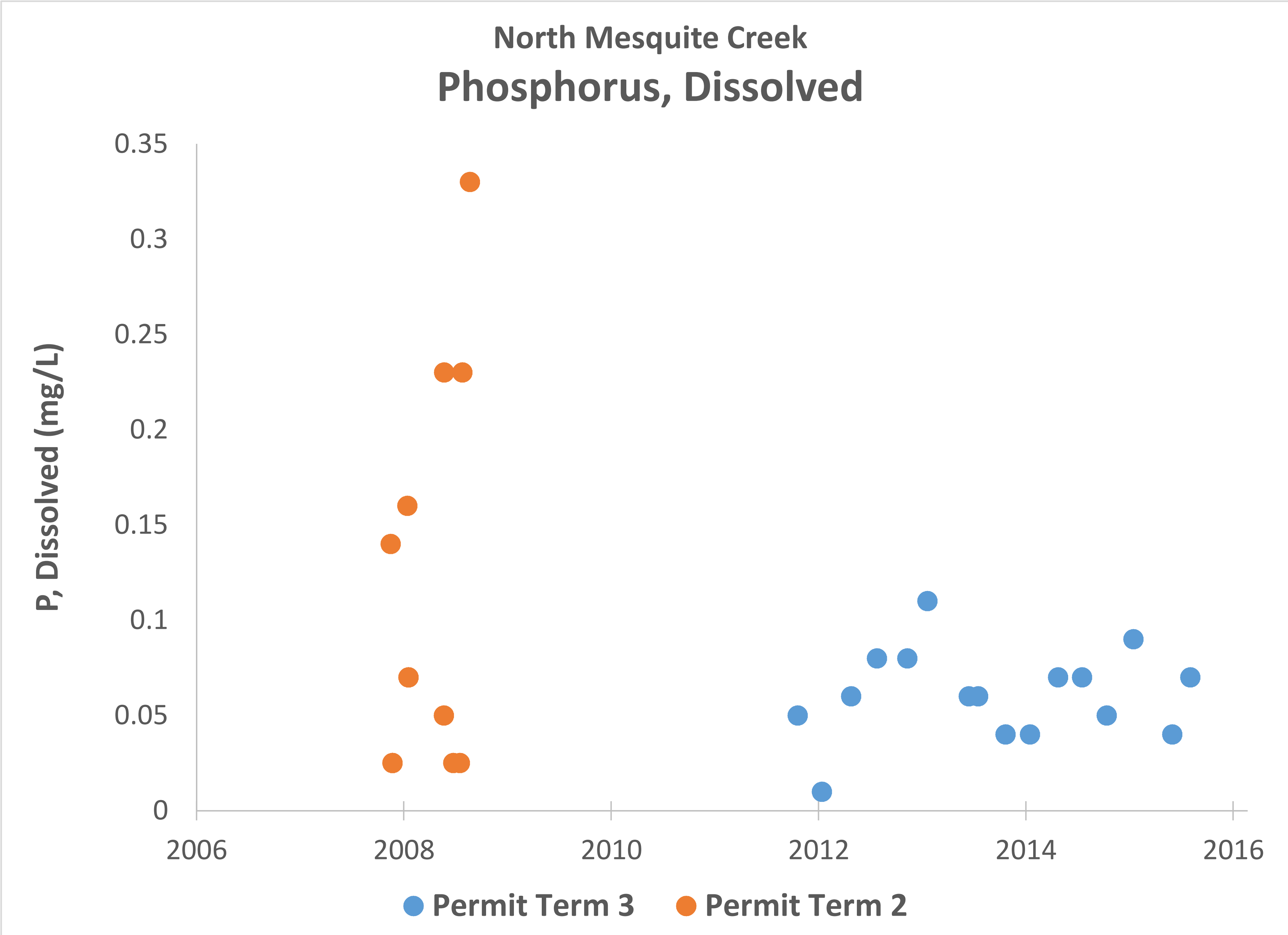

North Mesquite Creek
Total Dissolved Solids
TDS (mg/L)
0
200
400
600
800
1000
1200
1400
1600
1800
2008
2009
2010
2011
2012
2013
2014
2015
2016
Permit Term 3
Permit Term 2
Basin Specific Criterion

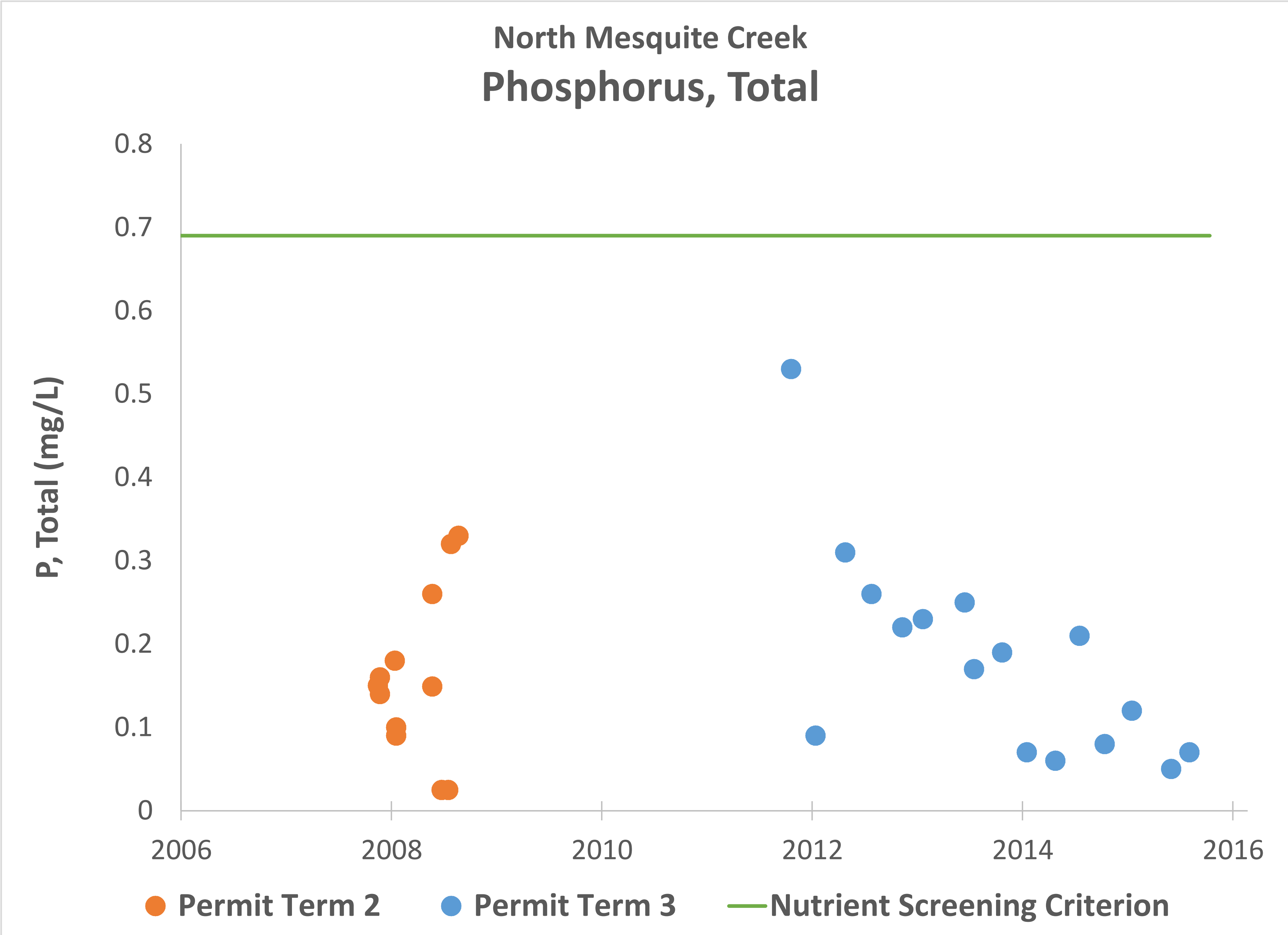

North Mesquite Creek
Total Suspended Solids
TSS (mg/L)
1000
100
10
1
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
Permit Term 3
Permit Term 2
NSQD Third Quartile

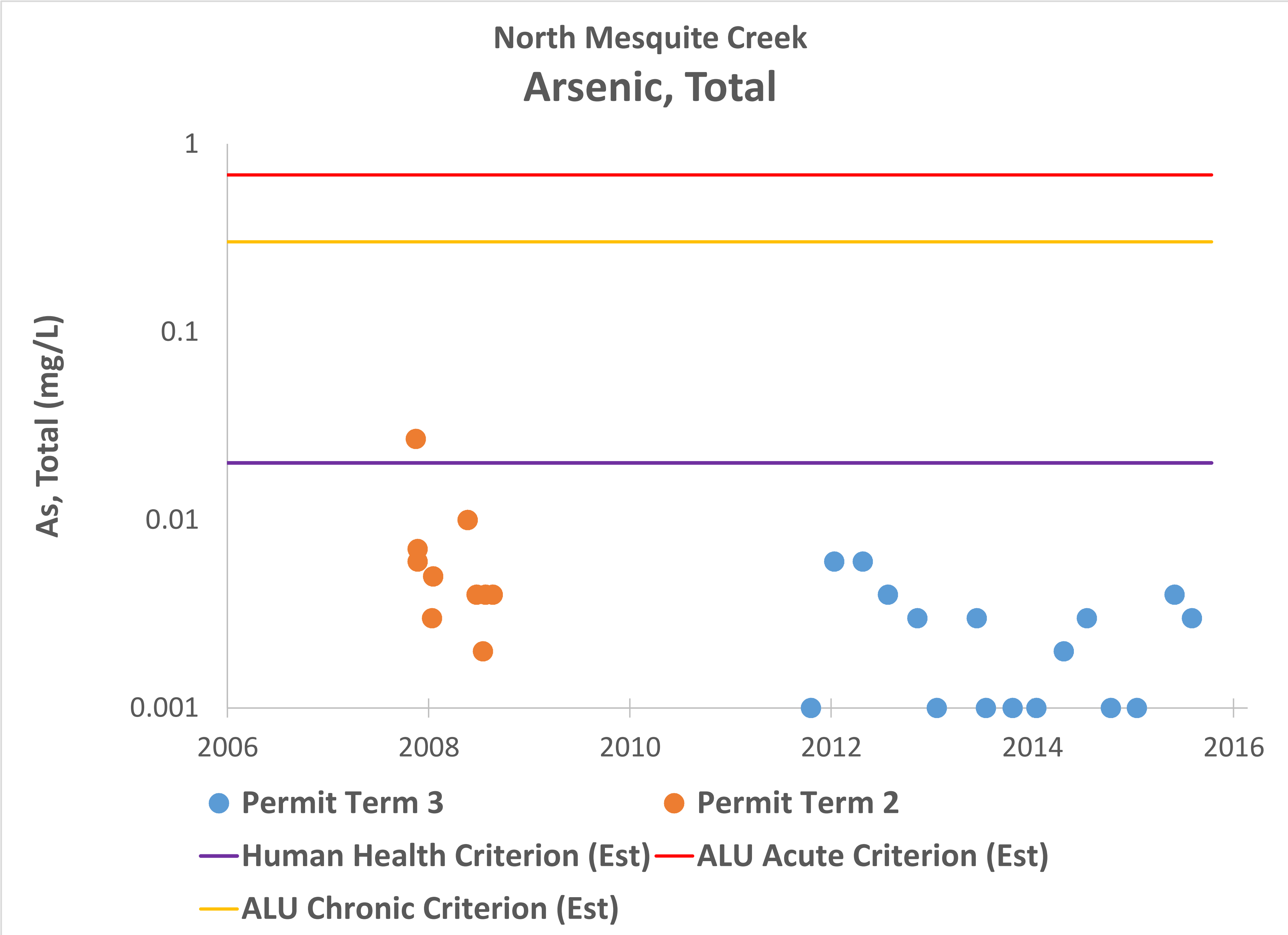

North Mesquite Creek
Chemical Oxygen Demand
COD (mg/L)
100
90
80
70
60
50
40
30
20
10
0
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
Permit Term 3
Permit Term 2
NSQD Third Quartile


North Mesquite Creek
Biochemical Oxygen Demand
BOD (mg/L)
25
20
15
10
5
0
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
Permit Term 3
Permit Term 2
NSQD Third Quartile

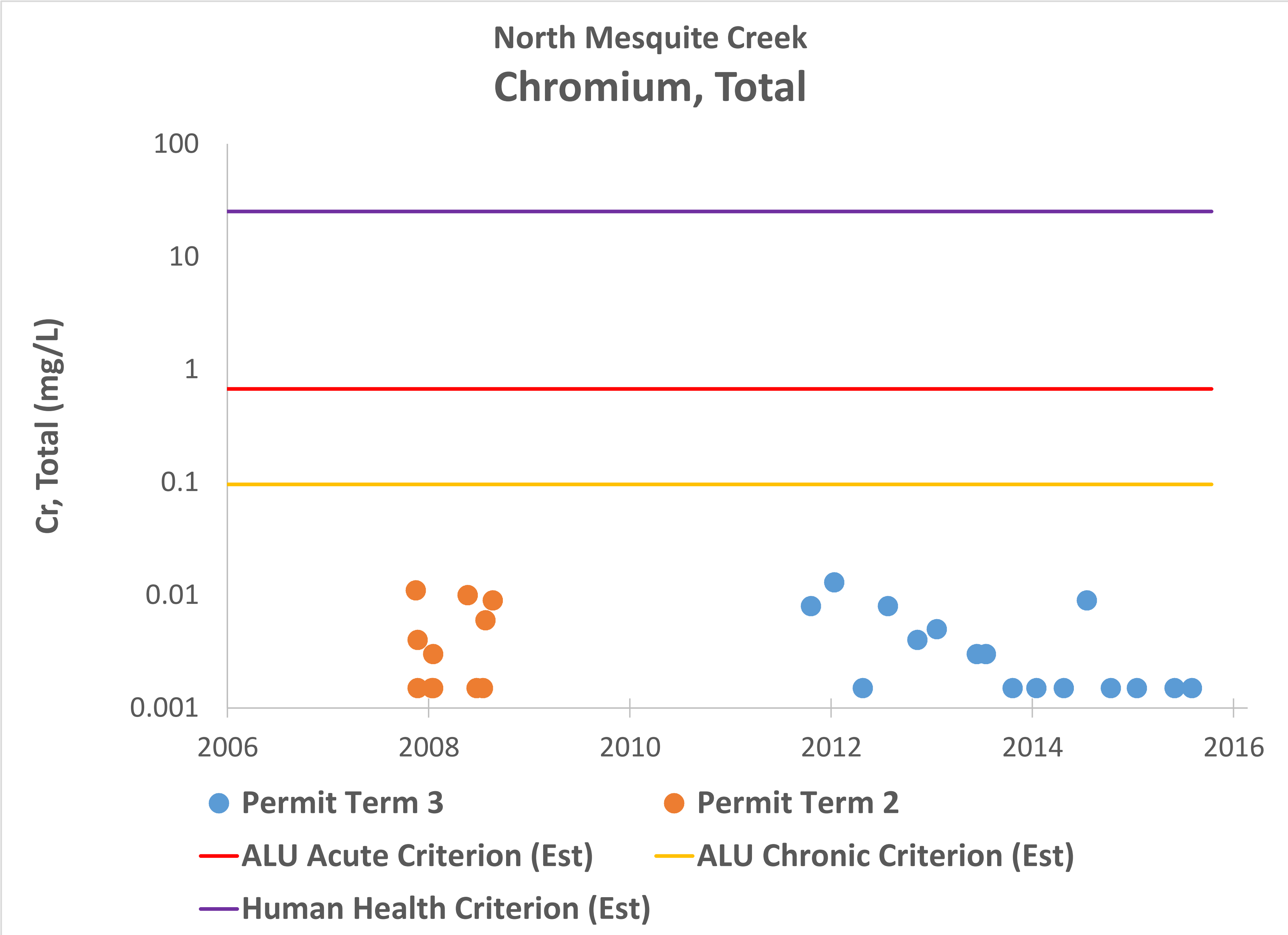

North Mesquite Creek
Nitrogen, Total
N, Total (mg/L)
40
35
30
25
20
15
10
5
0
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
Permit Term 3
Permit Term 2
NSQD Third Quartile

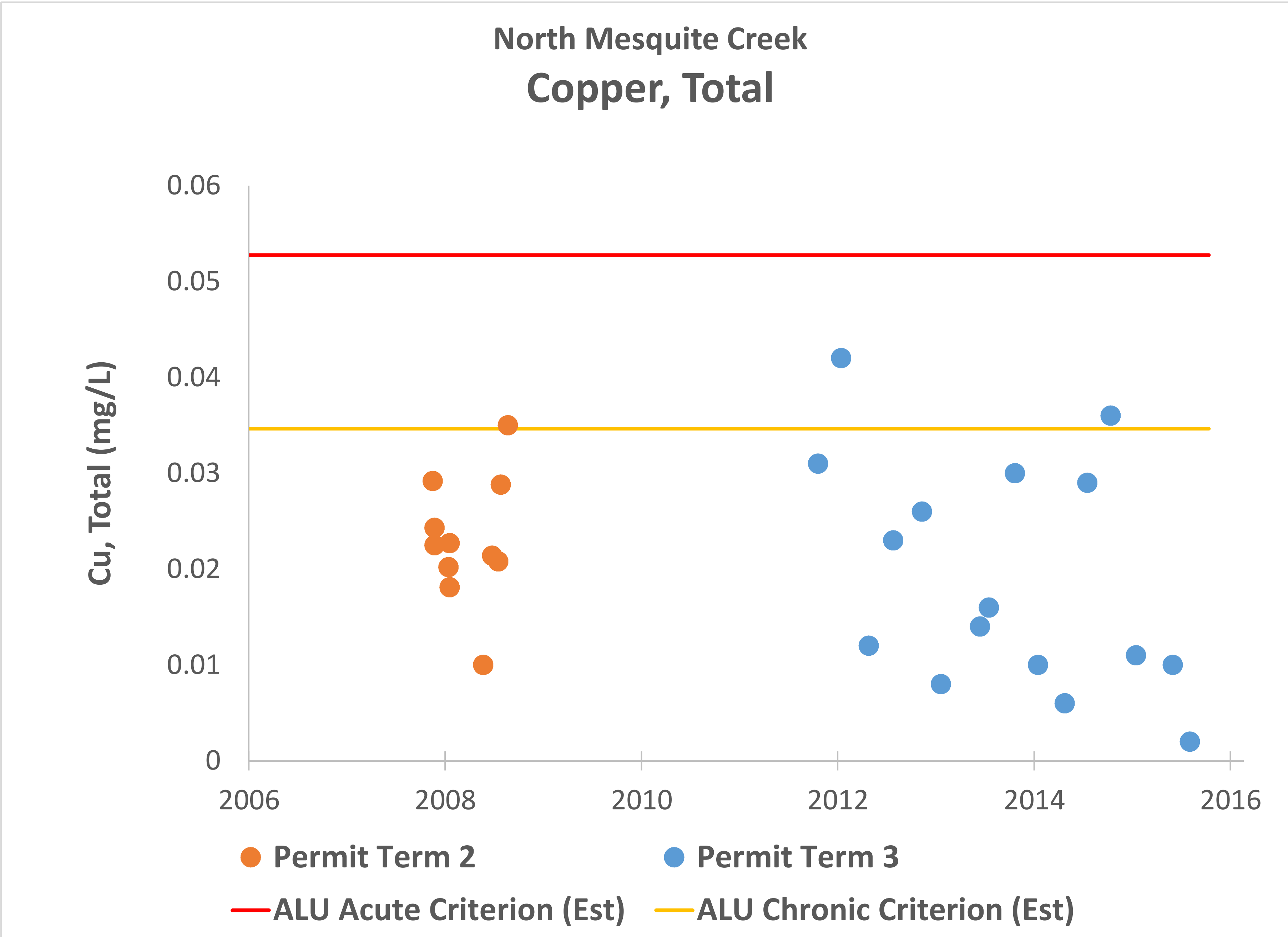

North Mesquite Creek
Phosphorus, Dissolved
P, Dissolved (mg/L)
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
2006
2008
2010
2012
2014
2016
Permit Term 3
Permit Term 2

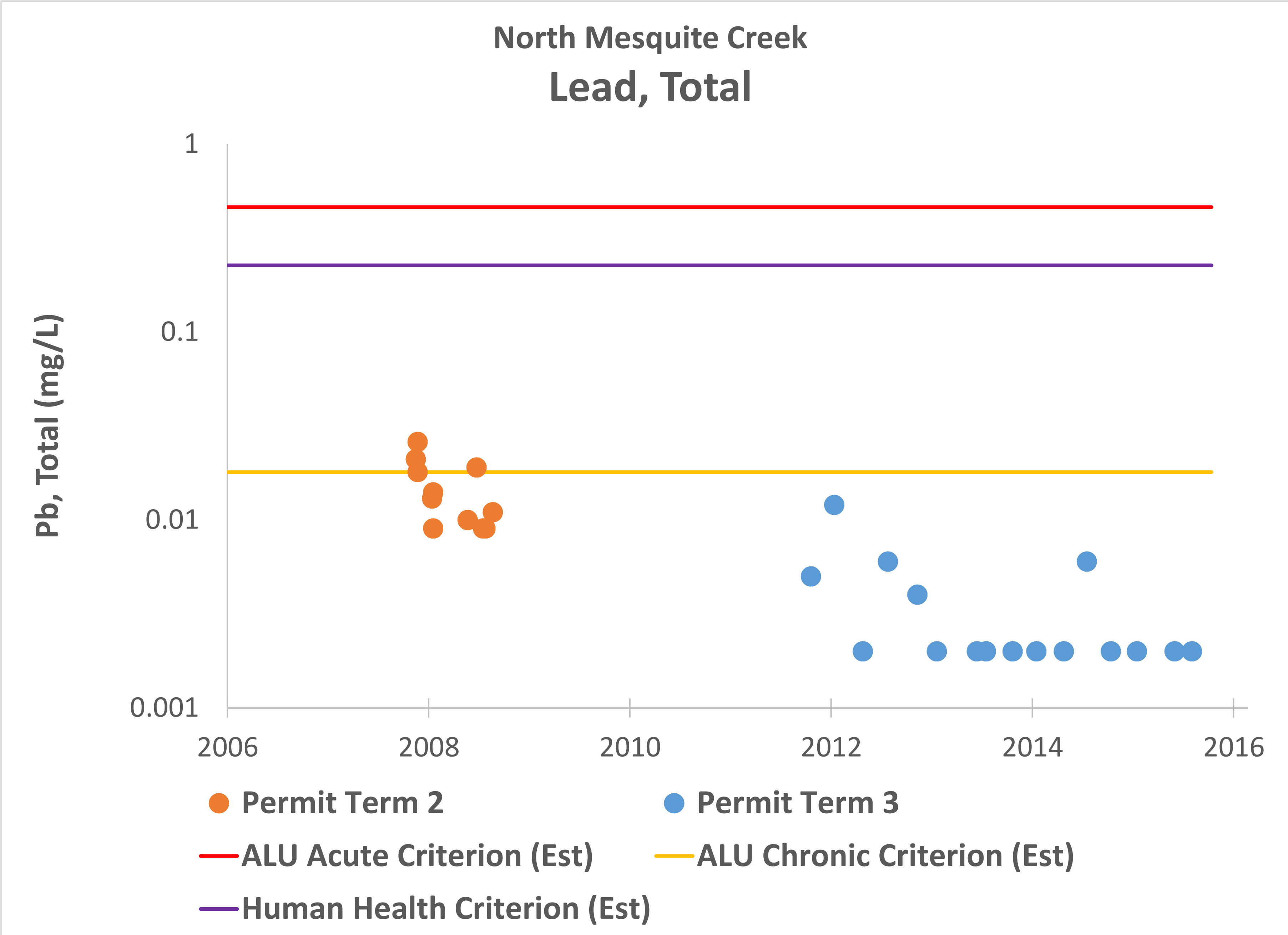

North Mesquite Creek
Phosphorus, Total
P, Total (mg/L)
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
2006
2008
2010
2012
2014
2016
Permit Term 2
Permit Term 3
Nutrient Screening Criterion



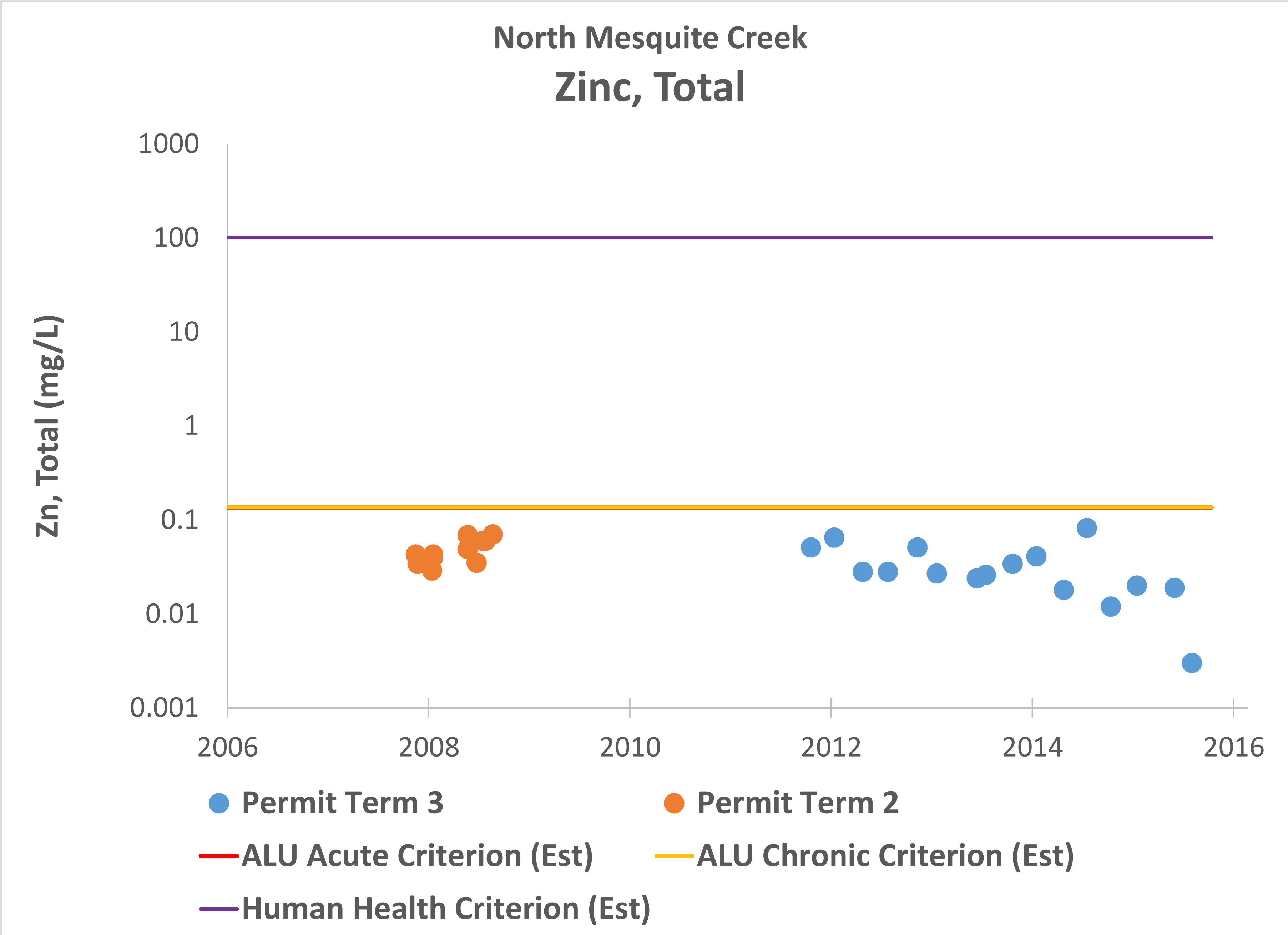
North Mesquite Creek
Arsenic, Total
As, Total (mg/L)
1
0.1
0.01
0.001
2006
2008
2010
2012
2014
2016
Permit Term 3
Permit Term 2
Human Health Criterion (Est)
ALU Acute Criterion (Est)
ALU Chronic Criterion (Est)

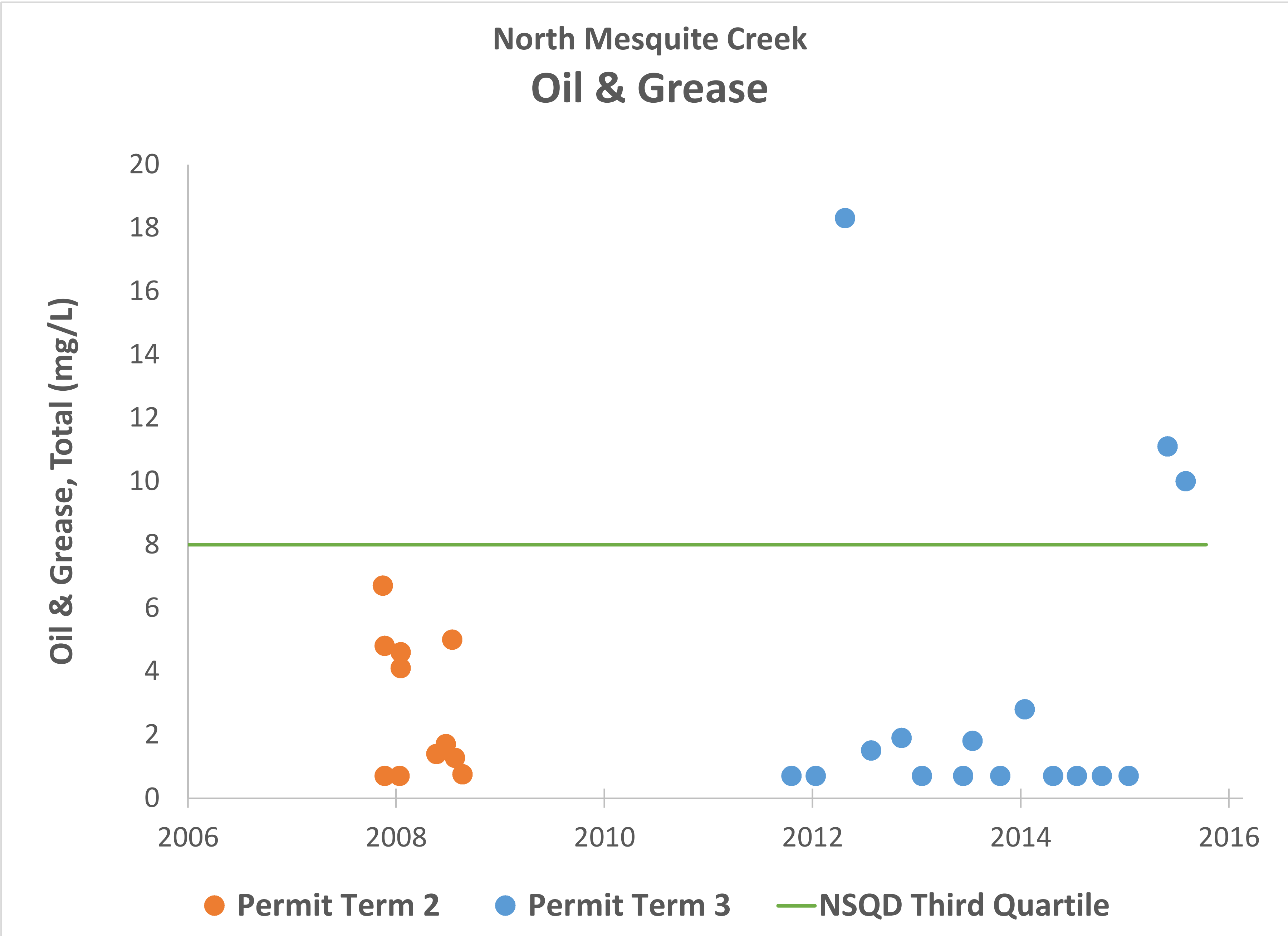

North Mesquite Creek
Chromium, Total
Cr, Total (mg/L)
100
10
1
0.1
0.01
0.001
2006
2008
2010
2012
2014
2016
Permit Term 3
Permit Term 2
ALU Acute Criterion (Est)
ALU Chronic Criterion (Est)
Human Health Criterion (Est)

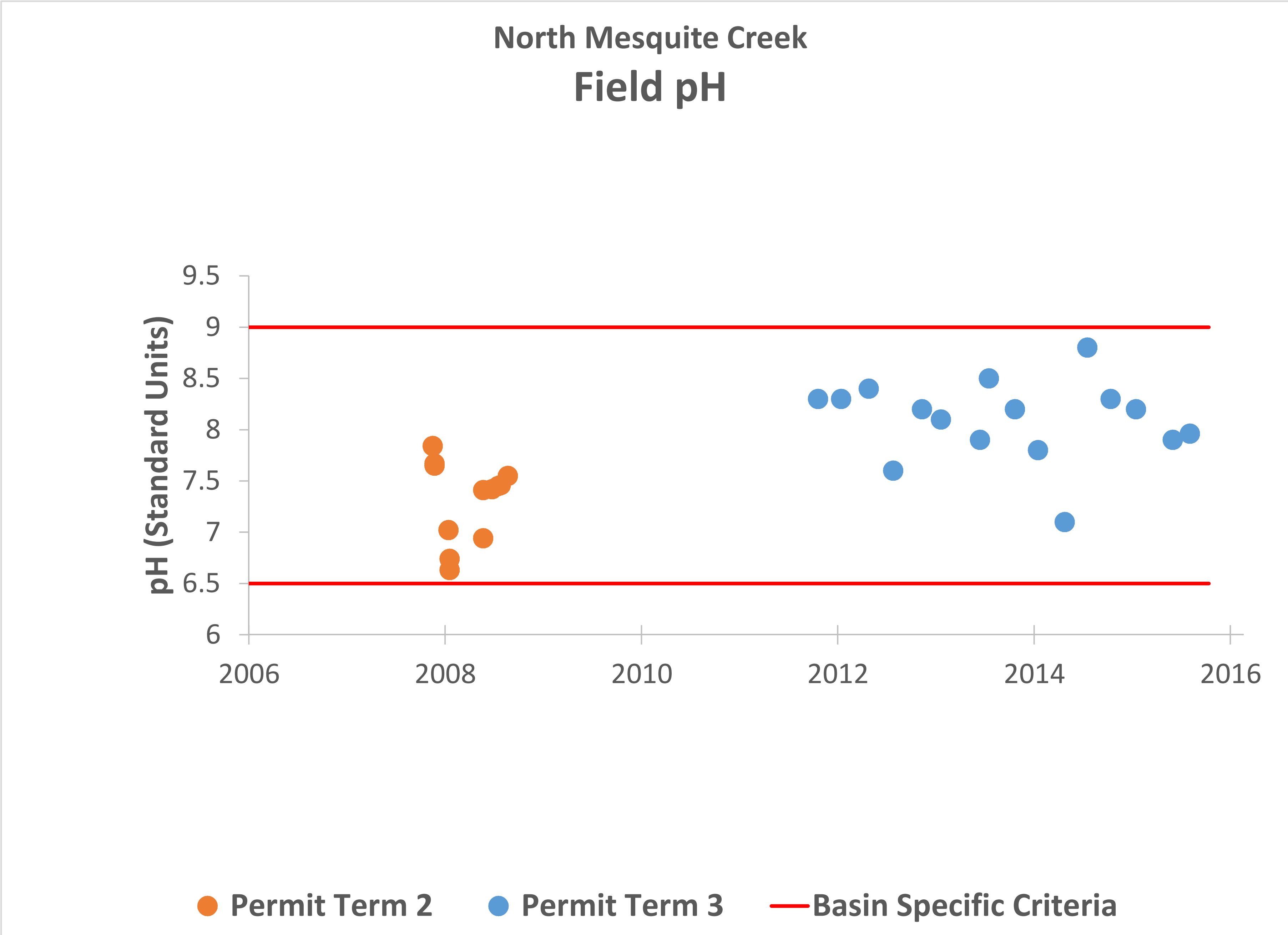

North Mesquite Creek
Copper, Total
Cu, Total (mg/L)
0.06
0.05
0.04
0.03
0.02
0.01
0
2006
2008
2010
2012
2014
2016
Permit Term 2
Permit Term 3
ALU Acute Criterion (Est)
ALU Chronic Criterion (Est)



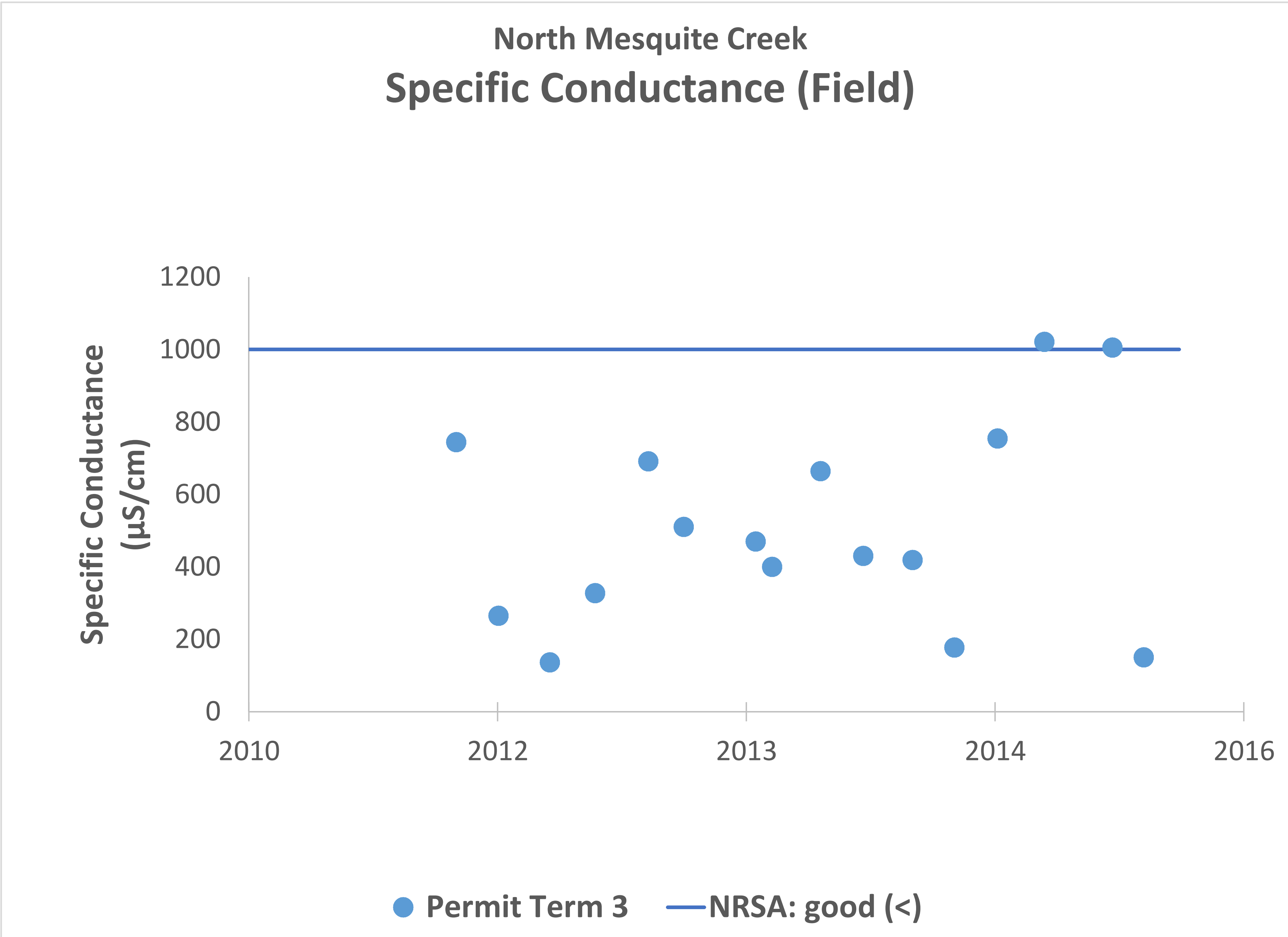
North Mesquite Creek
Lead, Total
Pb, Total (mg/L)
1
0.1
0.01
0.001
2006
2008
2010
2012
2014
2016
Permit Term 2
Permit Term 3
ALU Acute Criterion (Est)
ALU Chronic Criterion (Est)
Human Health Criterion (Est)


North Mesquite Creek
Zinc, Total
Zn, Total (mg/L)
1000
100
10
1
0.1
0.01
0.001
2006
2008
2010
2012
2014
2016
Permit Term 3
Permit Term 2
ALU Acute Criterion (Est)
ALU Chronic Criterion (Est)
Human Health Criterion (Est)

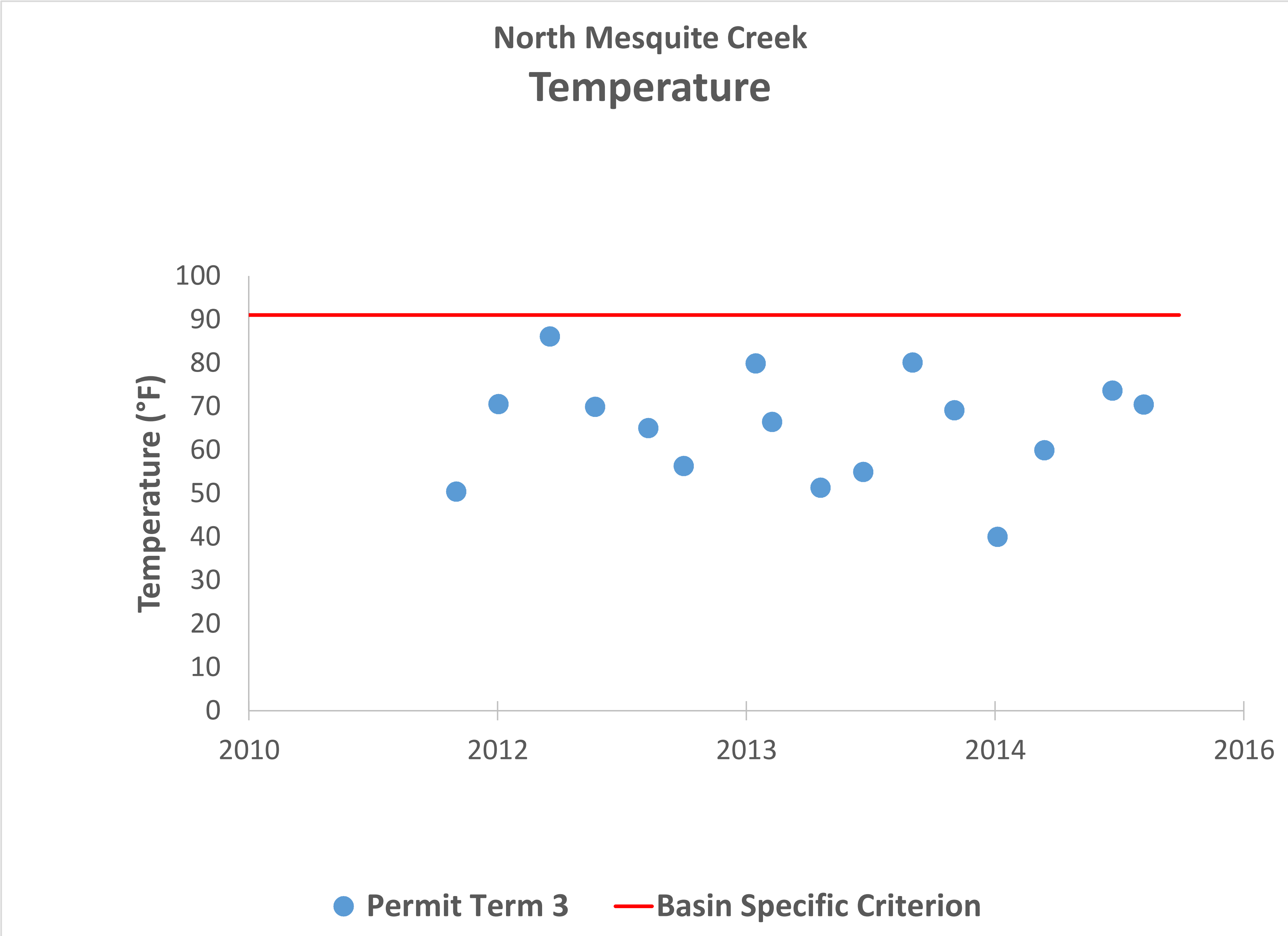

North Mesquite Creek
Oil & Grease
Oil & Grease, Total (mg/L)
20
18
16
14
12
10
8
6
4
2
0
2006
2008
2010
2012
2014
2016
Permit Term 2
Permit Term 3
NSQD Third Quartile

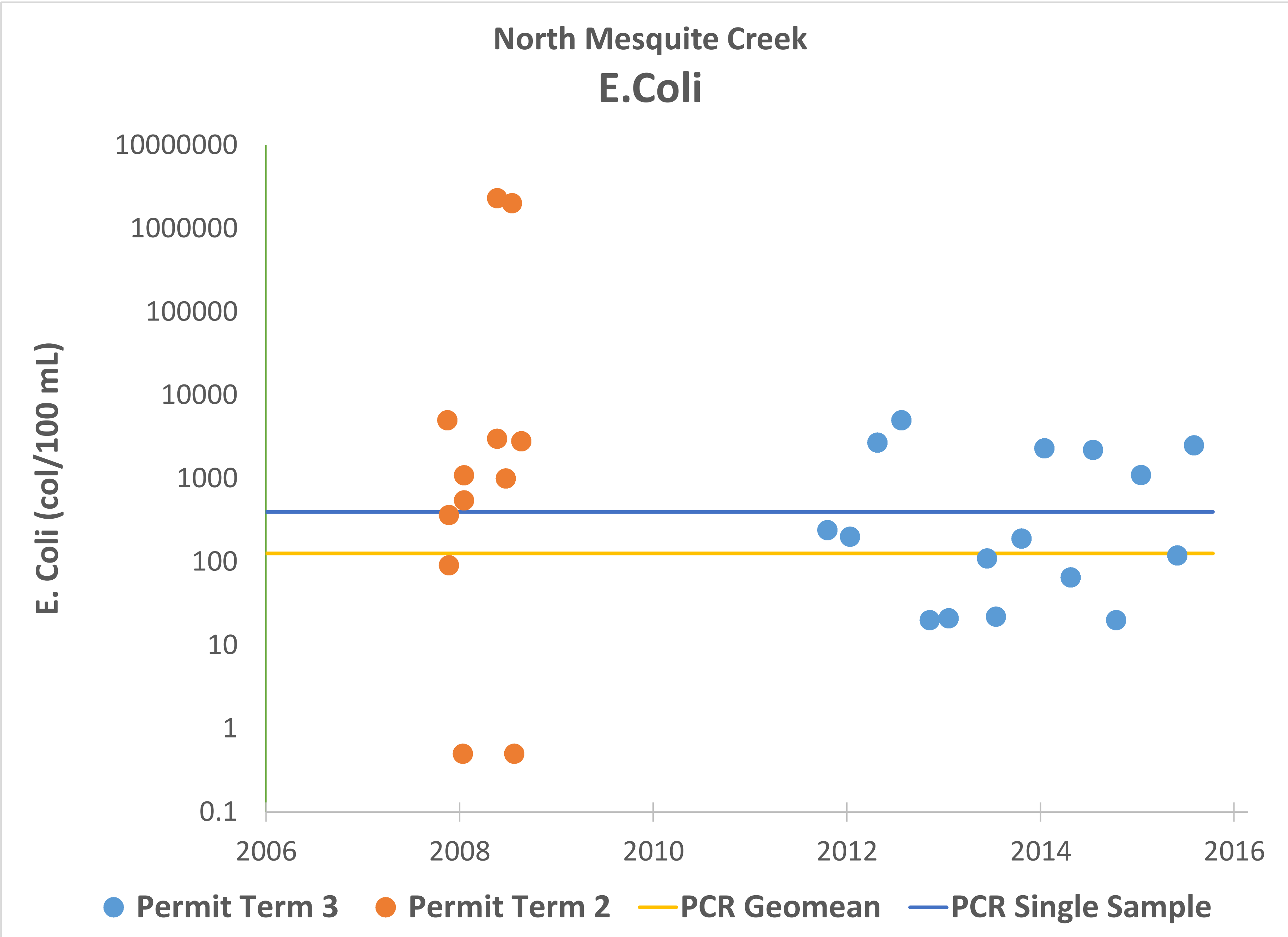


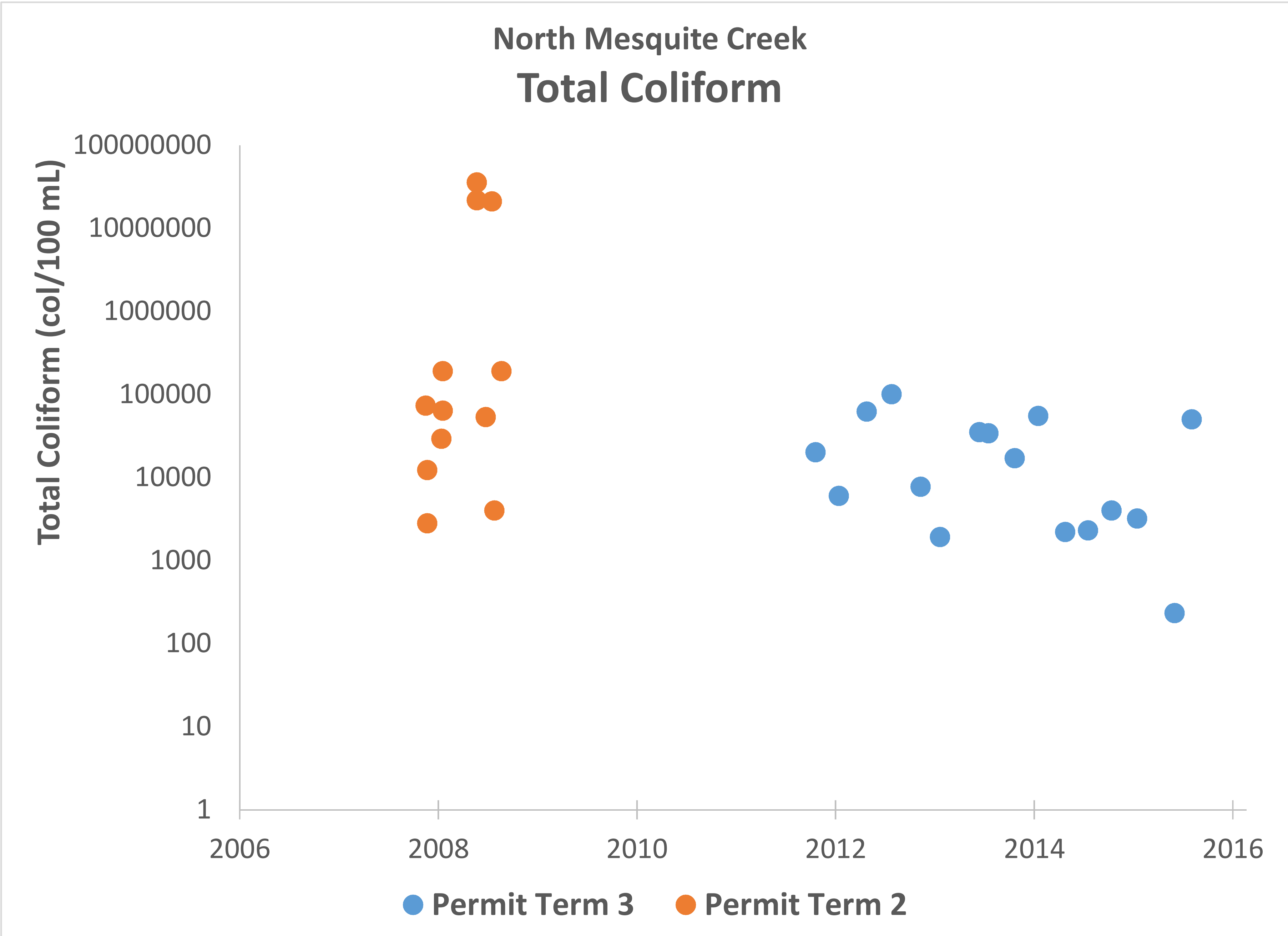
North Mesquite Creek
Field pH
pH (Standard Units)
9.5
9
8.5
8
7.5
7
6.5
6
2006
2008
2010
2012
2014
2016
Permit Term 2
Permit Term 3
Basin Specific Criteria



North Mesquite Creek
Specific Conductance (Field)
Specific Conductance (µS/cm)
1200
1000
800
600
400
200
0
2010
2012
2013
2014
2016
Permit Term 3
NRSA: good (<)

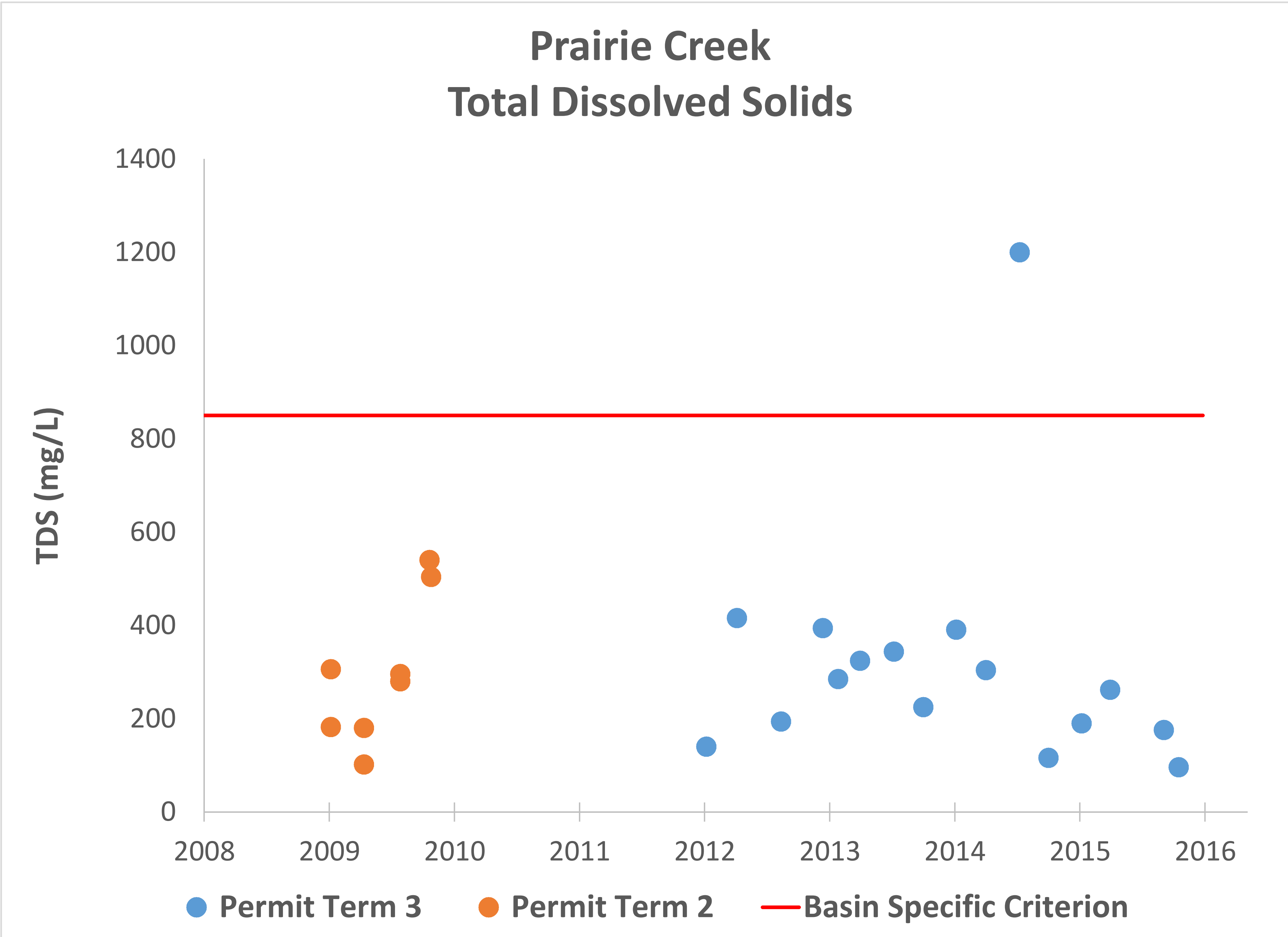

North Mesquite Creek
Temperature
Temperature (°F)
100
90
80
70
60
50
40
30
20
10
0
2010
2012
2013
2014
2016
Permit Term 3
Basin Specific Criterion


North Mesquite Creek
E.Coli
E. Coli (col/100 mL)
10000000
1000000
100000
10000
1000
100
10
1
0.1
2006
2008
2010
2012
2014
2016
Permit Term 3
Permit Term 2
PCR Geomean
PCR Single Sample

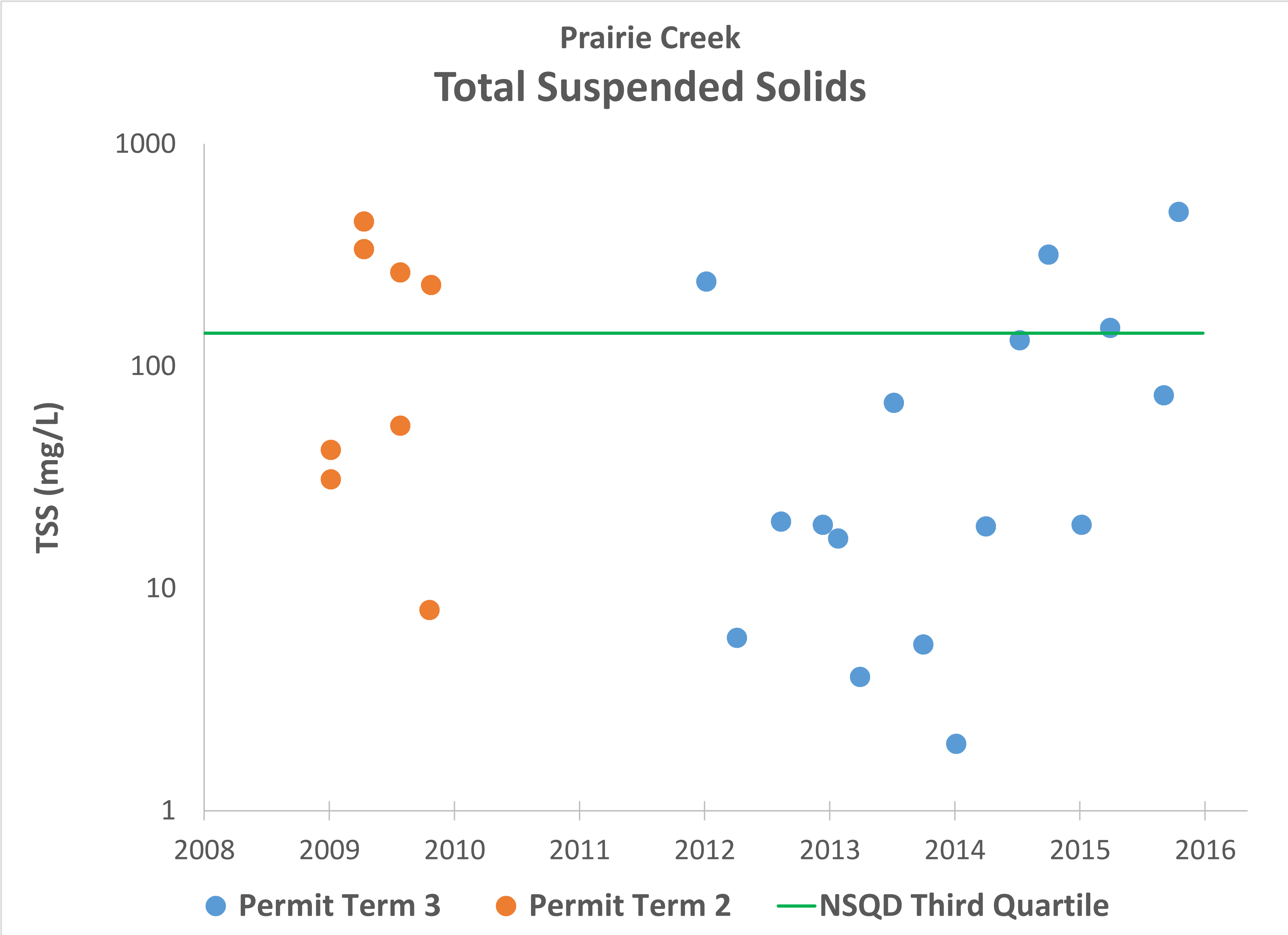

North Mesquite Creek
Total Coliform
Total Coliform (col/100 mL)
100000000
10000000
1000000
100000
10000
1000
100
10
1
2006
2008
2010
2012
2014
2016
Permit Term 3
Permit Term 2

Appendix S

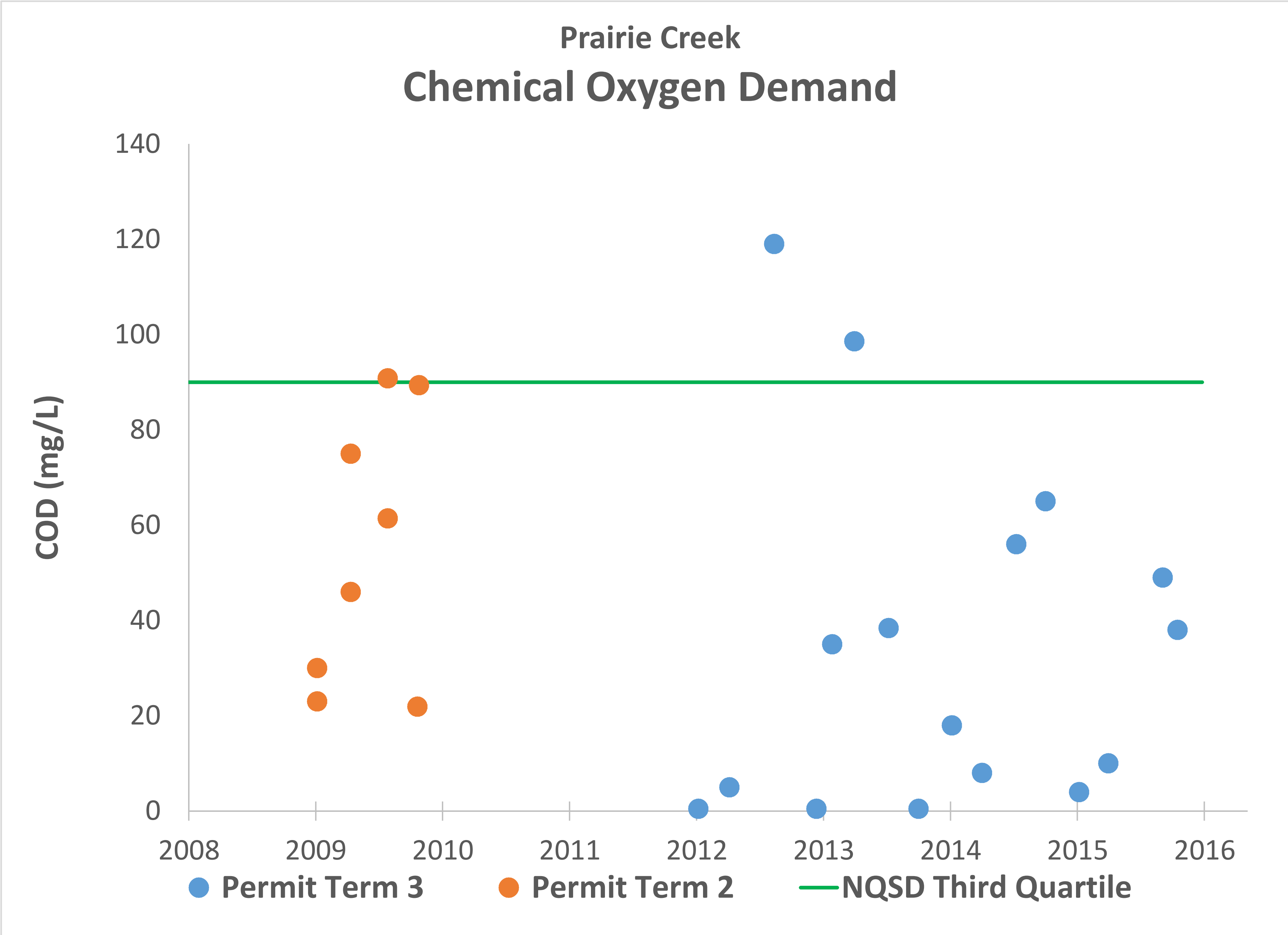
Prairie Creek Water Quality Data Graphs

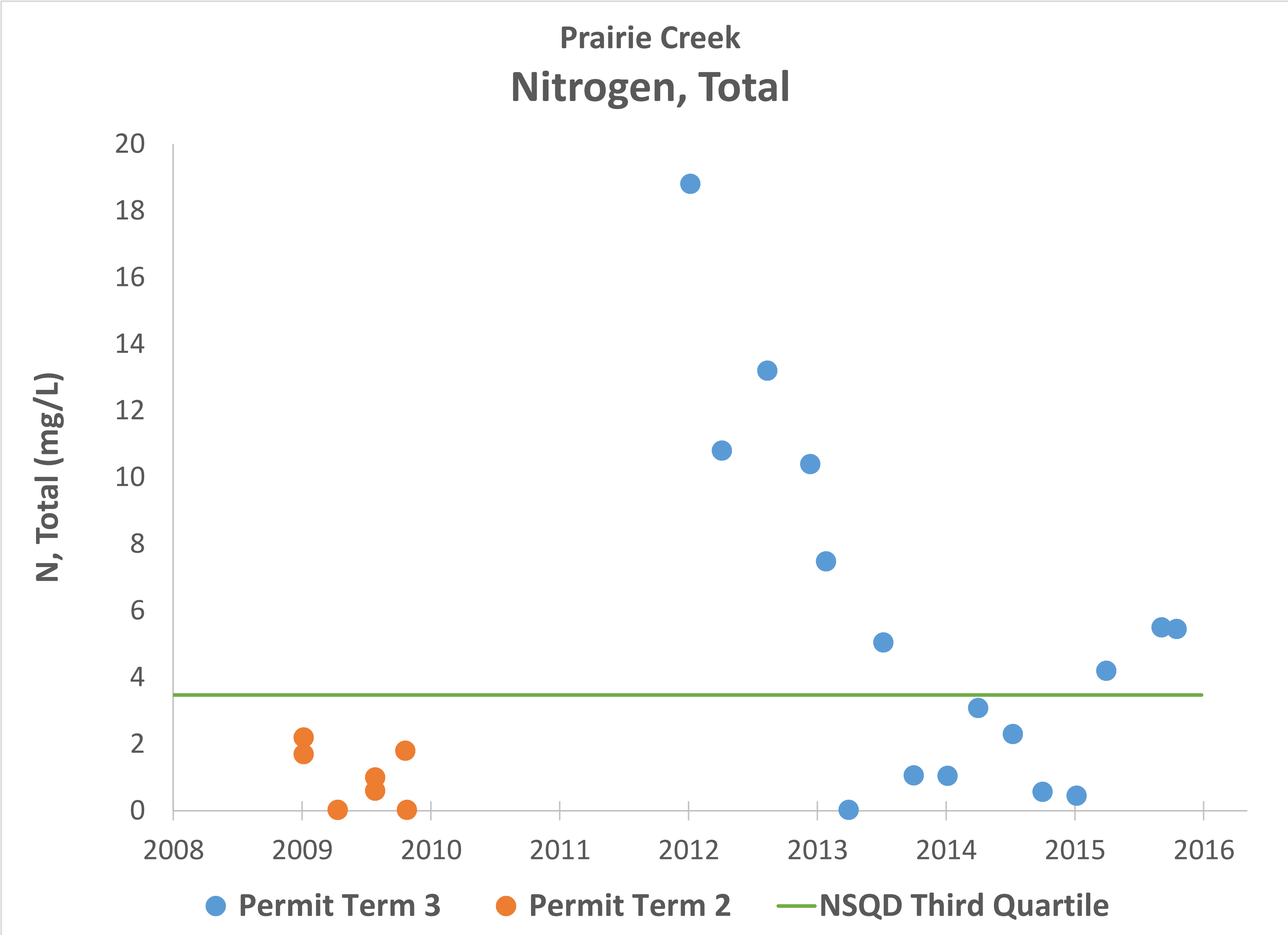


Prairie Creek
Total Dissolved Solids
TDS (mg/L)
1400
1200
1000
800
600
400
200
0
2008
2009
2010
2011
2012
2013
2014
2015
2016
Permit Term 3
Permit Term 2
Basin Specific Criterion

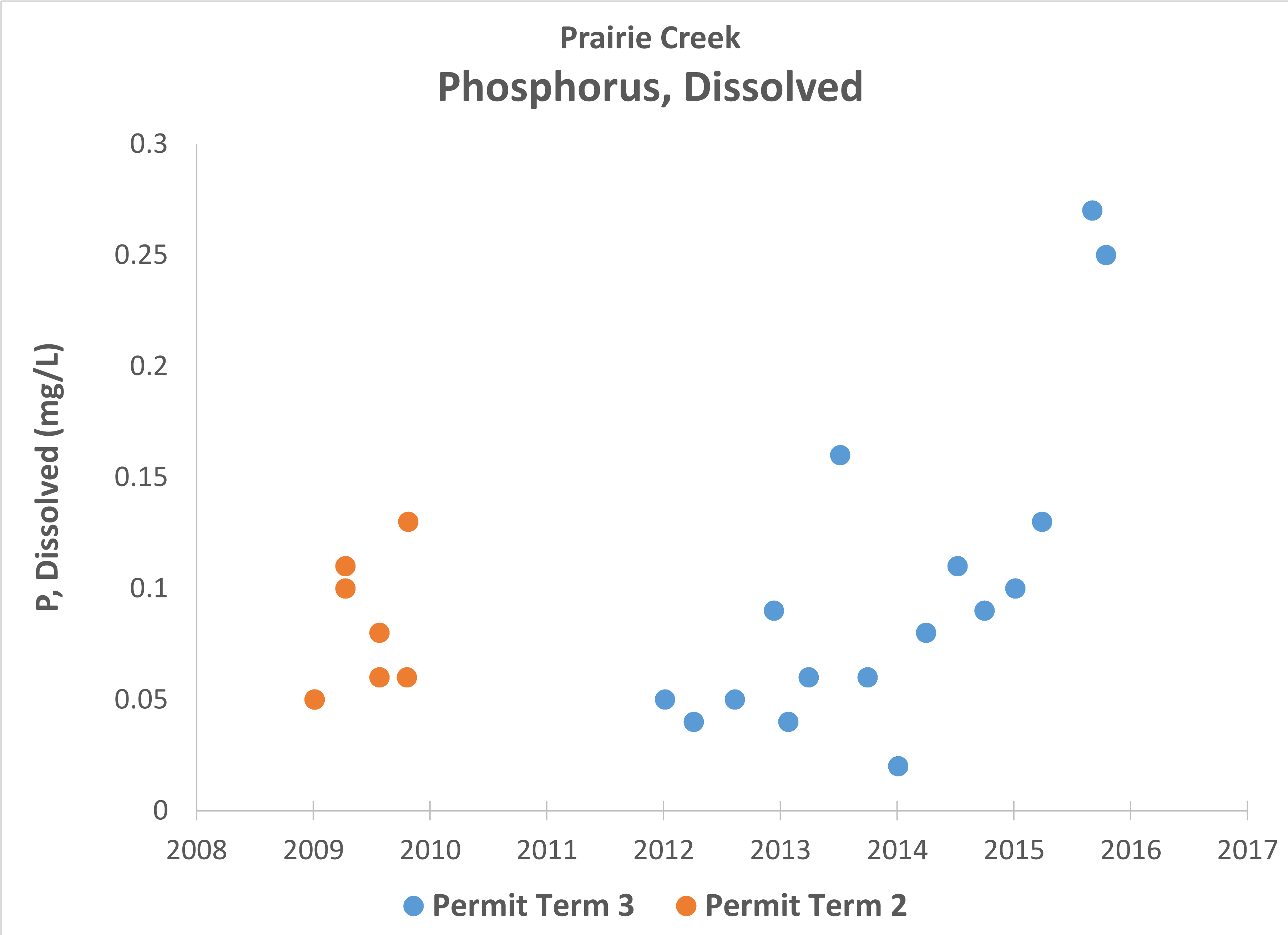


Prairie Creek
Total Suspended Solids
TSS (mg/L)
1000
100
10
1
2008
2009
2010
2011
2012
2013
2014
2015
2016
Permit Term 3
Permit Term 2
NSQD Third Quartile

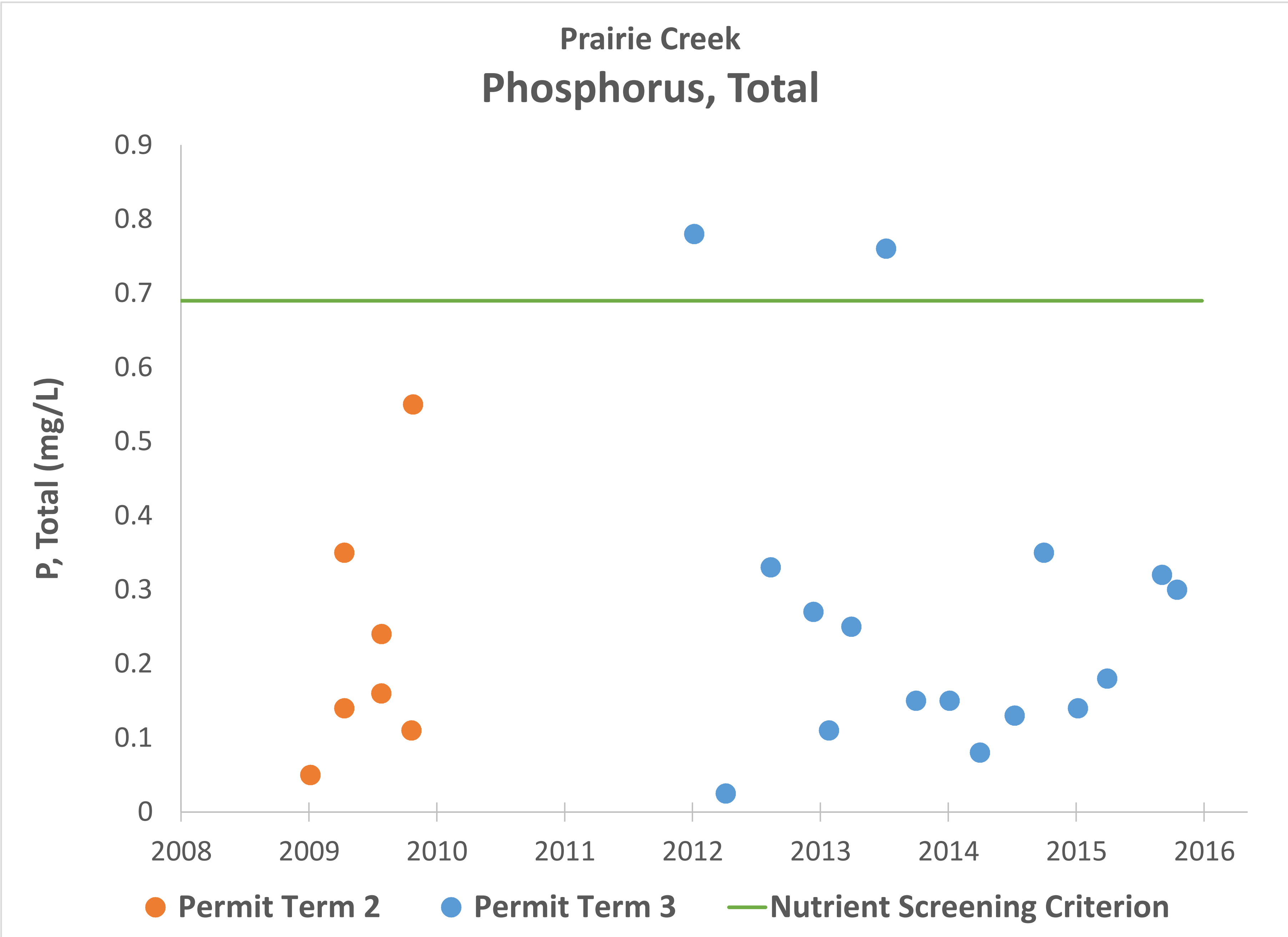

Prairie Creek
Chemical Oxygen Demand
COD (mg/L)
140
120
100
80
60
40
20
0
2008
2009
2010
2011
2012
2013
2014
2015
2016
Permit Term 3
Permit Term 2
NQSD Third Quartile



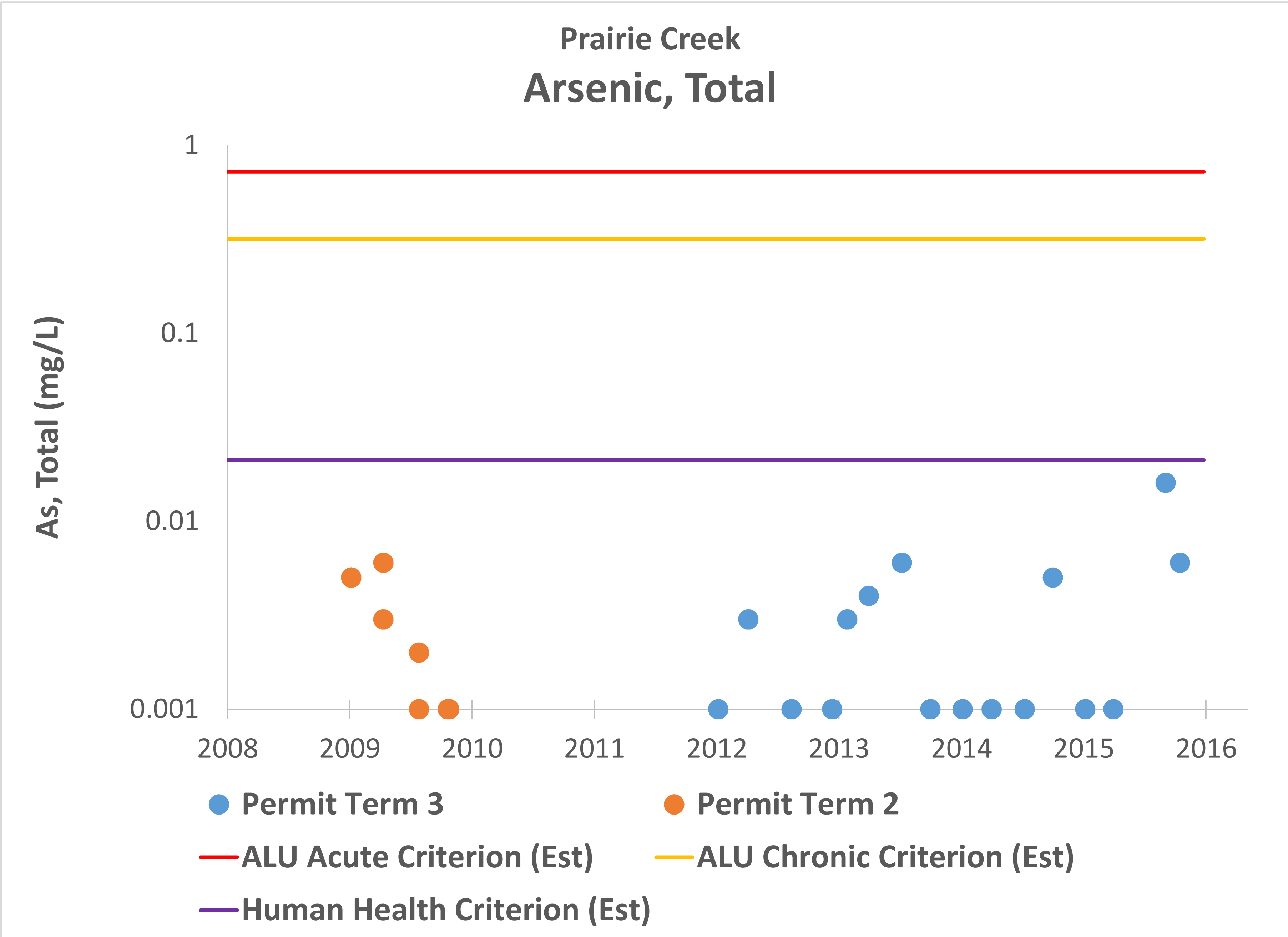
Prairie Creek
Nitrogen, Total
N, Total (mg/L)
20
18
16
14
12
10
8
6
4
2
0
2008
2009
2010
2011
2012
2013
2014
2015
2016
Permit Term 3
Permit Term 2
NSQD Third Quartile



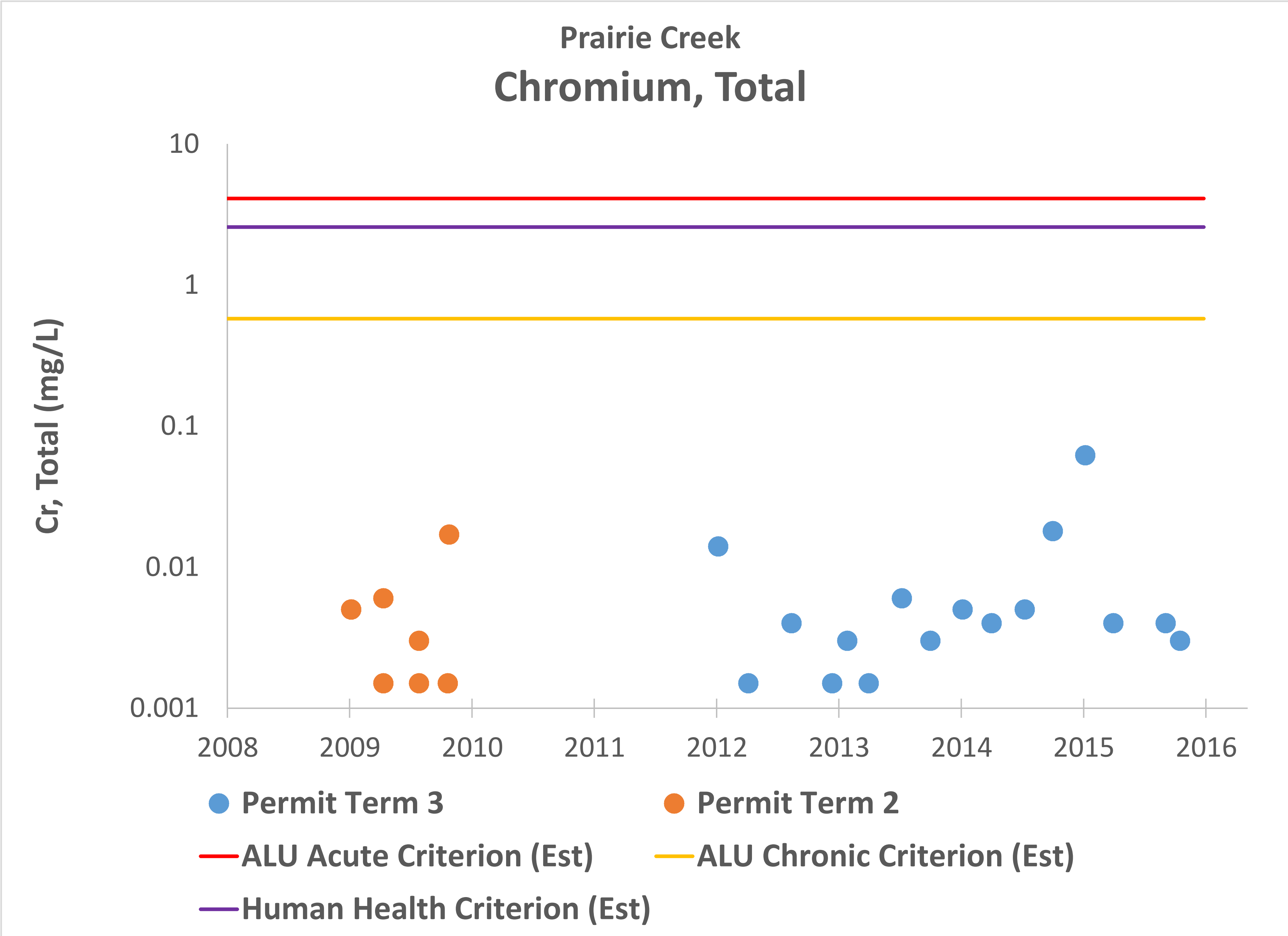
Prairie Creek
Phosphorus, Dissolved
P, Dissolved (mg/L)
0.3
0.25
0.2
0.15
0.1
0.05
0
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
Permit Term 3
Permit Term 2

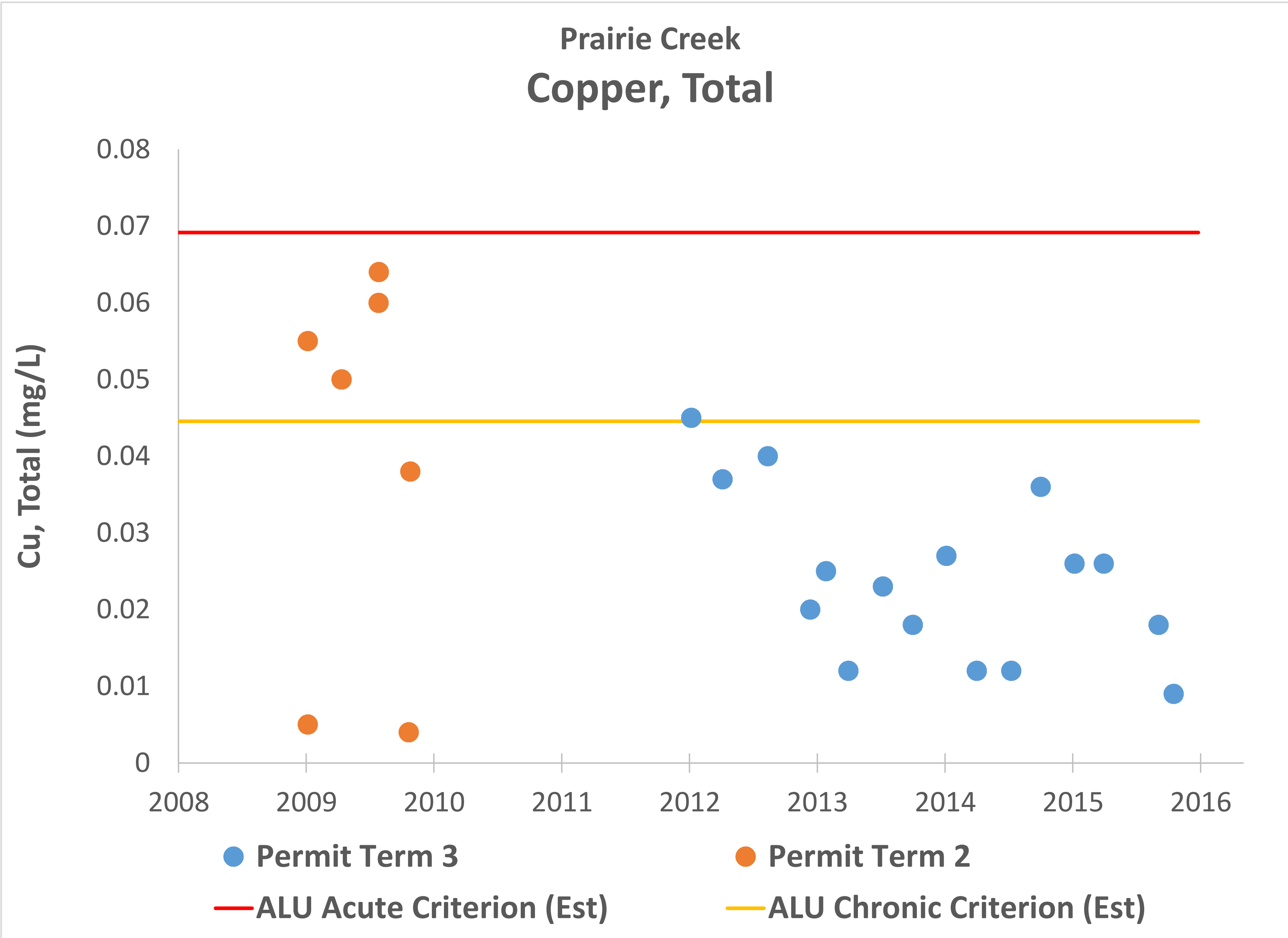


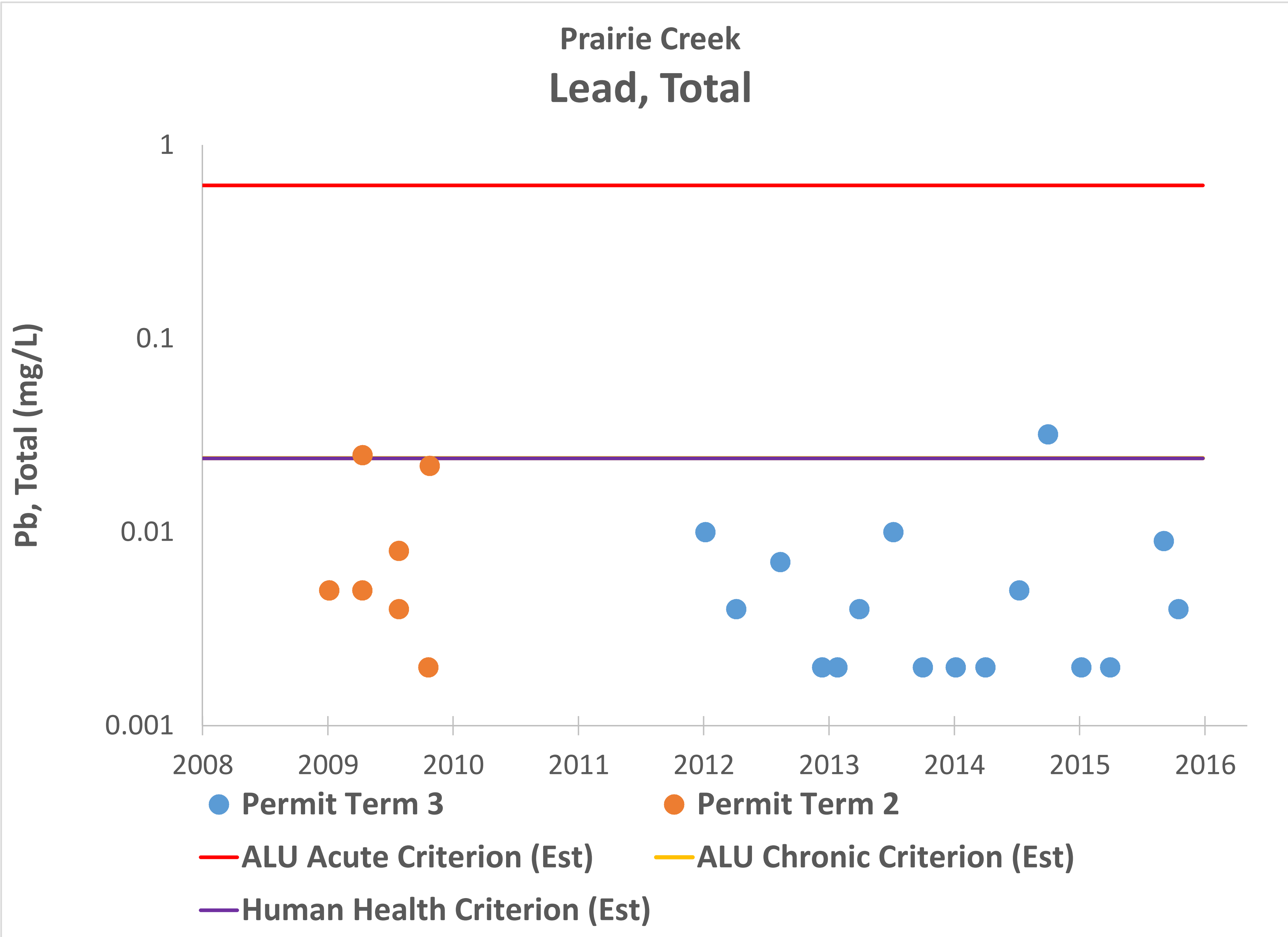
Prairie Creek
Phosphorus, Total
P, Total (mg/L)
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
2008
2009
2010
2011
2012
2013
2014
2015
2016
Permit Term 2
Permit Term 3
Nutrient Screening Criterion



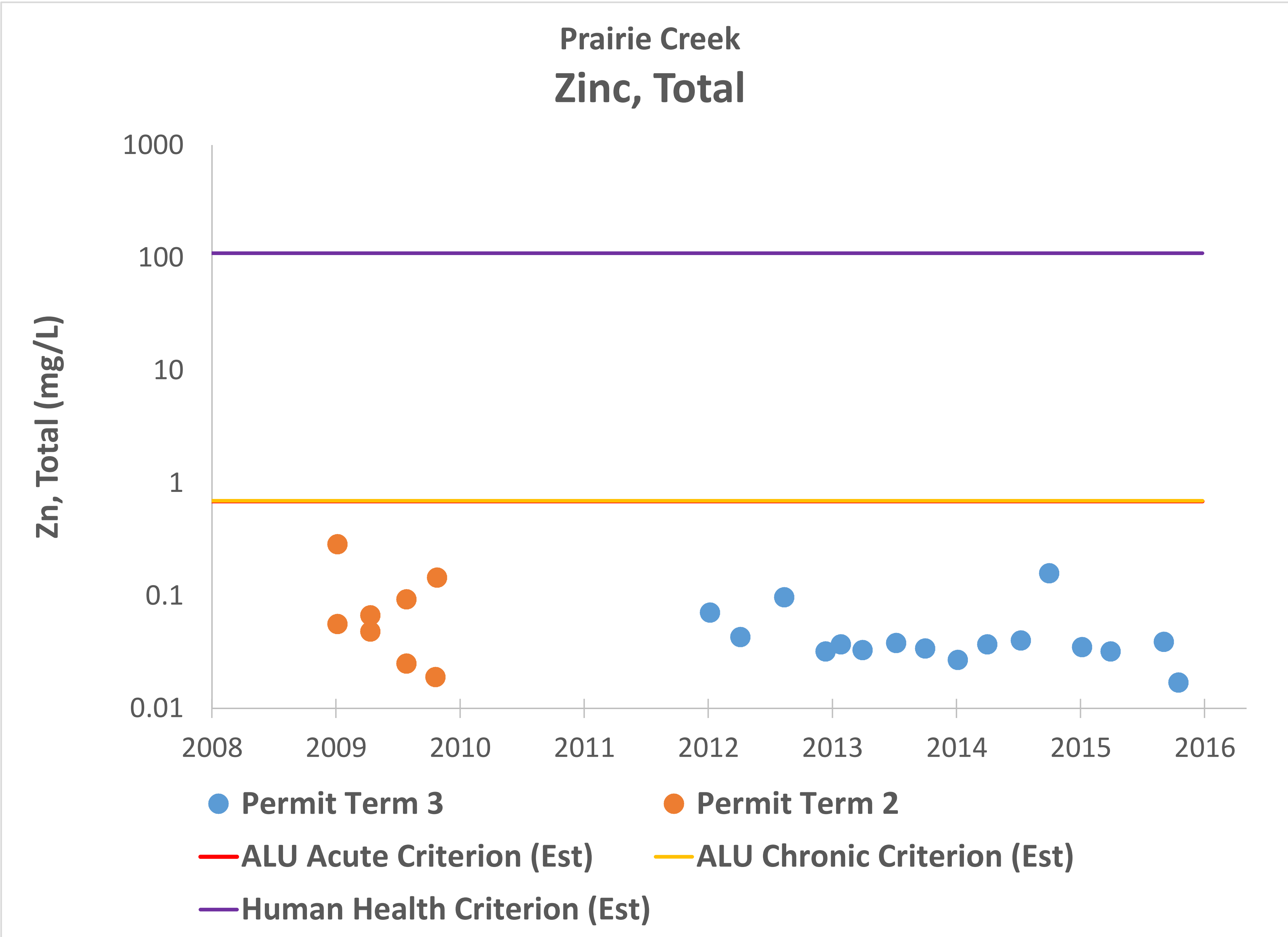
Prairie Creek
Arsenic, Total
As, Total (mg/L)
1
0.1
0.01
0.001
2008
2009
2010
2011
2012
2013
2014
2015
2016
Permit Term 3
Permit Term 2
ALU Acute Criterion (Est)
ALU Chronic Criterion (Est)
Human Health Criterion (Est)


Prairie Creek
Chromium, Total
Cr, Total (mg/L)
10
1
0.1
0.01
0.001
2008
2009
2010
2011
2012
2013
2014
2015
2016
Permit Term 3
Permit Term 2
ALU Acute Criterion (Est)
ALU Chronic Criterion (Est)
Human Health Criterion (Est)

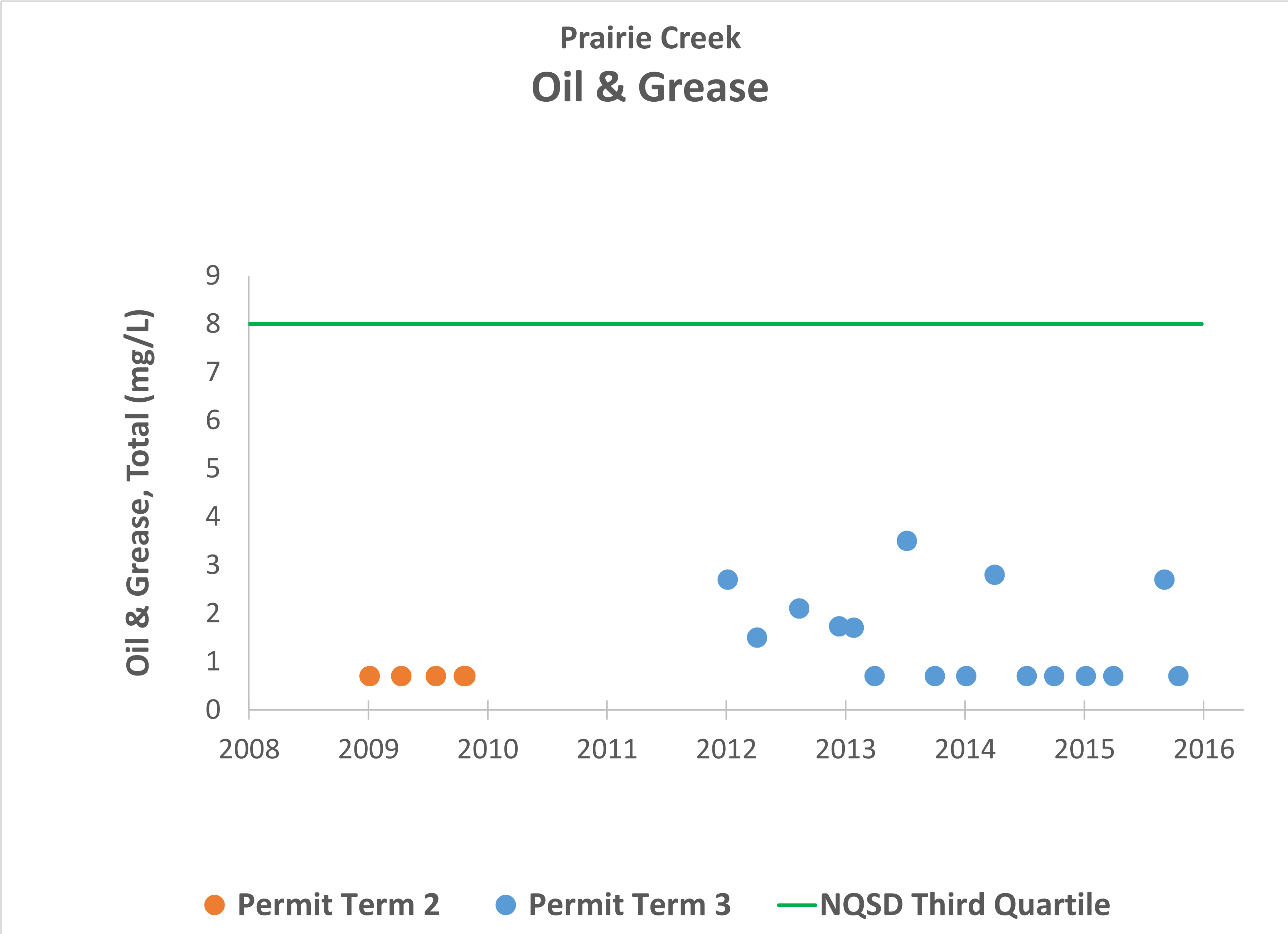

Prairie Creek
Copper, Total
Cu, Total (mg/L)
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
2008
2009
2010
2011
2012
2013
2014
2015
2016
Permit Term 3
Permit Term 2
ALU Acute Criterion (Est)
ALU Chronic Criterion (Est)



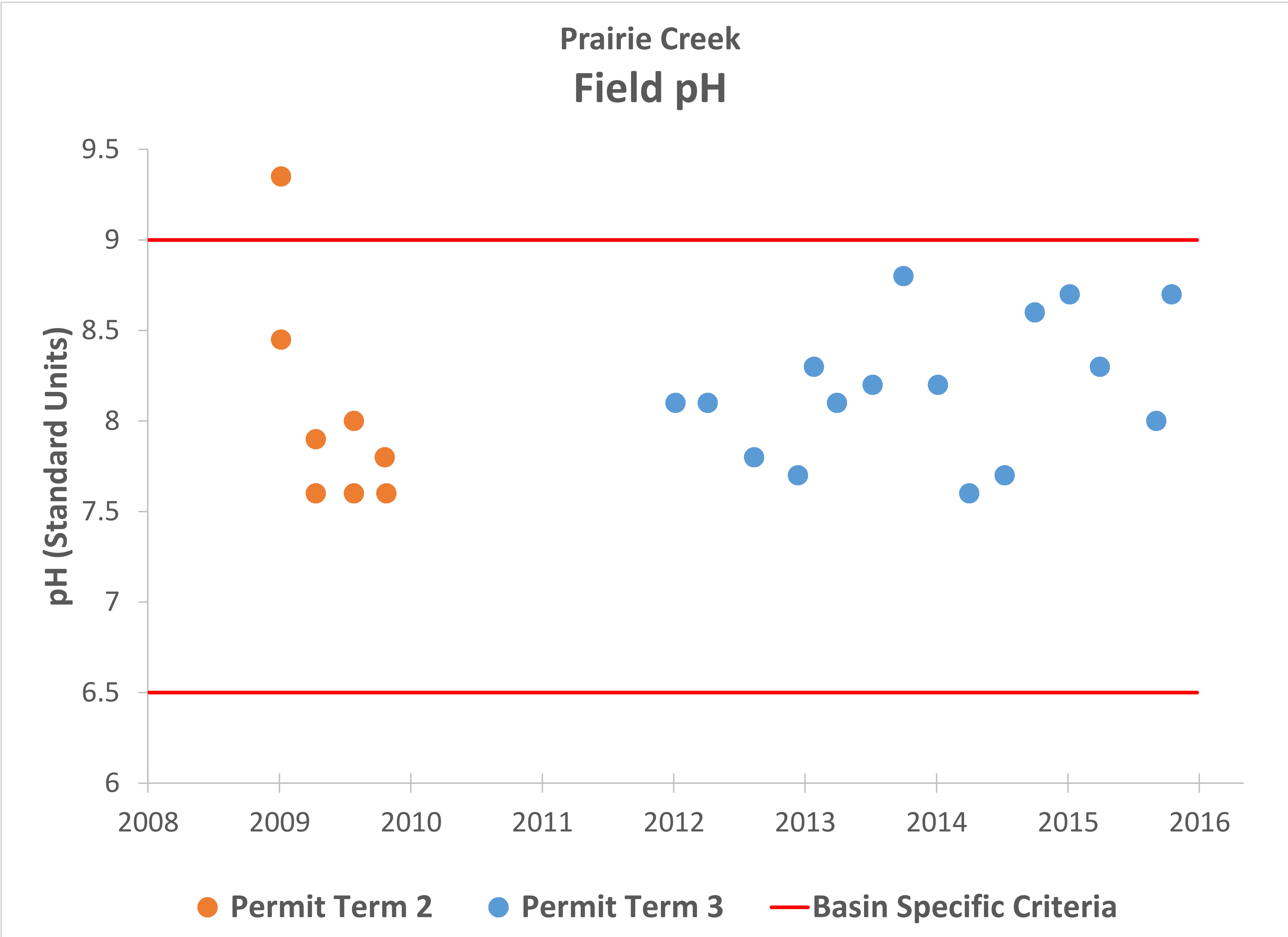
Prairie Creek
Lead, Total
Pb, Total (mg/L)
1
0.1
0.01
0.001
2008
2009
2010
2011
2012
2013
2014
2015
2016
Permit Term 3
Permit Term 2
ALU Acute Criterion (Est)
ALU Chronic Criterion (Est)
Human Health Criterion (Est)

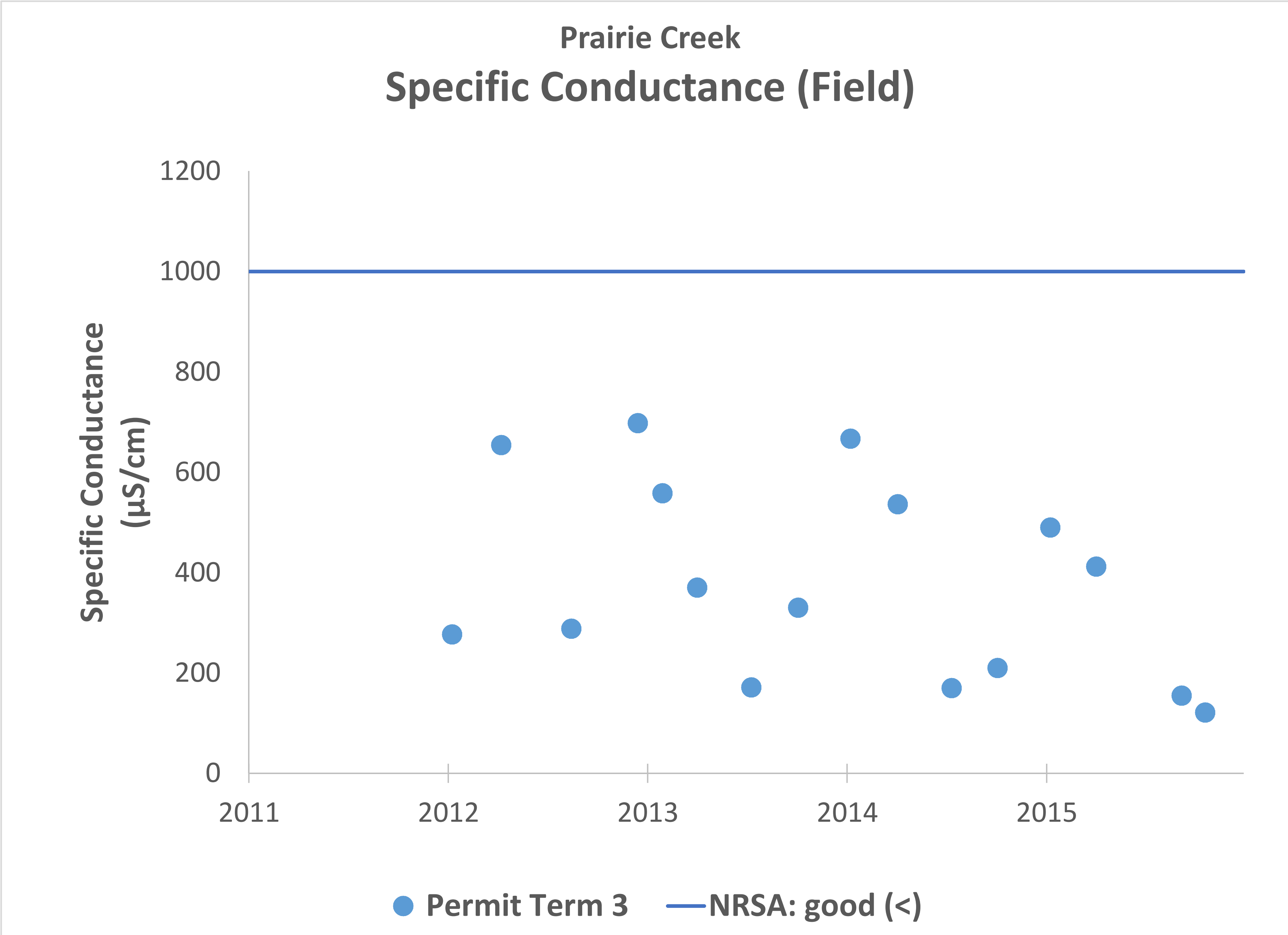


Prairie Creek
Zinc, Total
Zn, Total (mg/L)
1000
100
10
1
0.1
0.01
2008
2009
2010
2011
2012
2013
2014
2015
2016
Permit Term 3
Permit Term 2
ALU Acute Criterion (Est)
ALU Chronic Criterion (Est)
Human Health Criterion (Est)

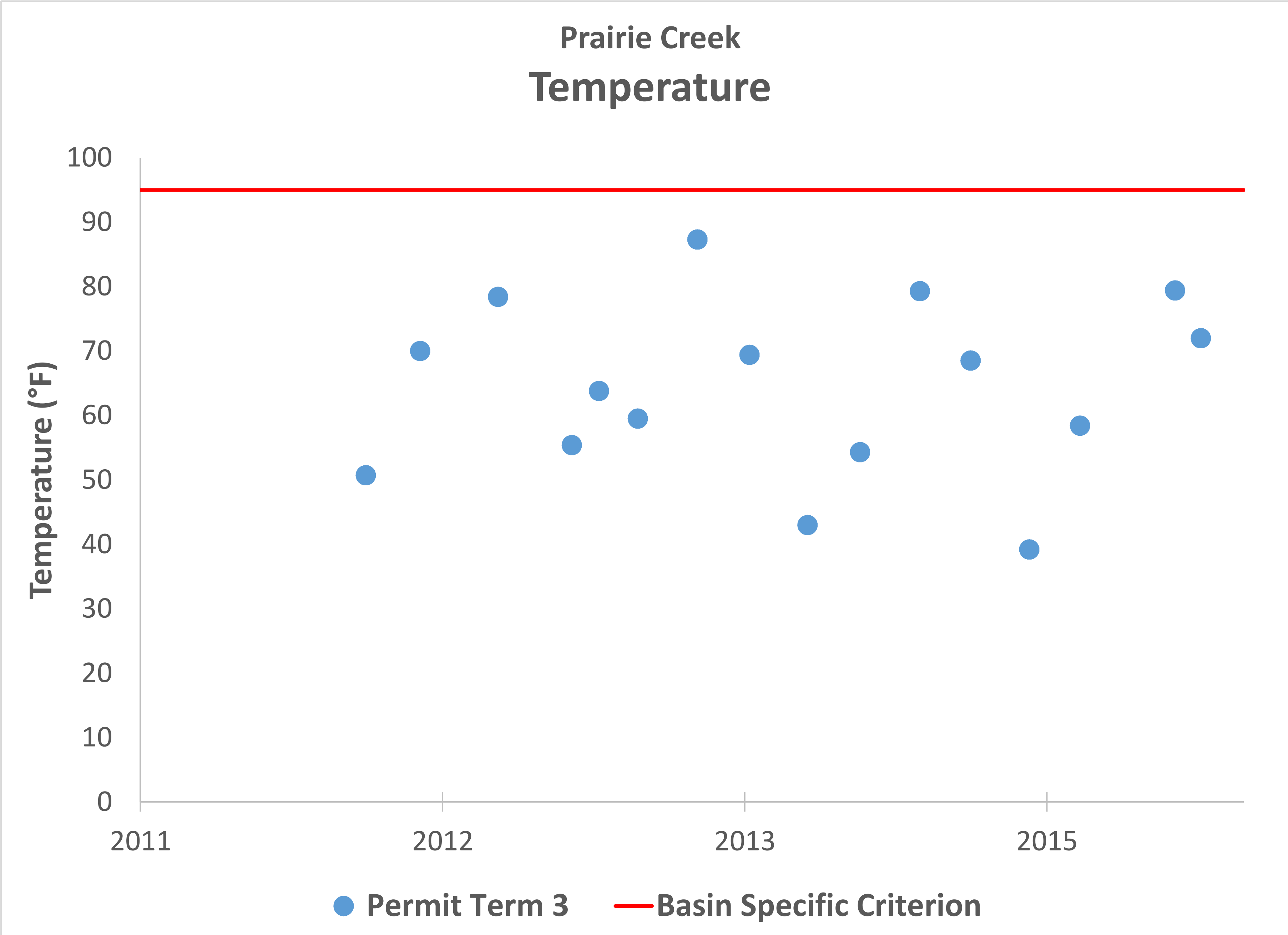


Prairie Creek
Oil & Grease
Oil & Grease, Total (mg/L)
0
1
2
3
4
5
6
7
8
9
2008
2009
2010
2011
2012
2013
2014
2015
2016
Permit Term 2
Permit Term 3
NQSD Third Quartile

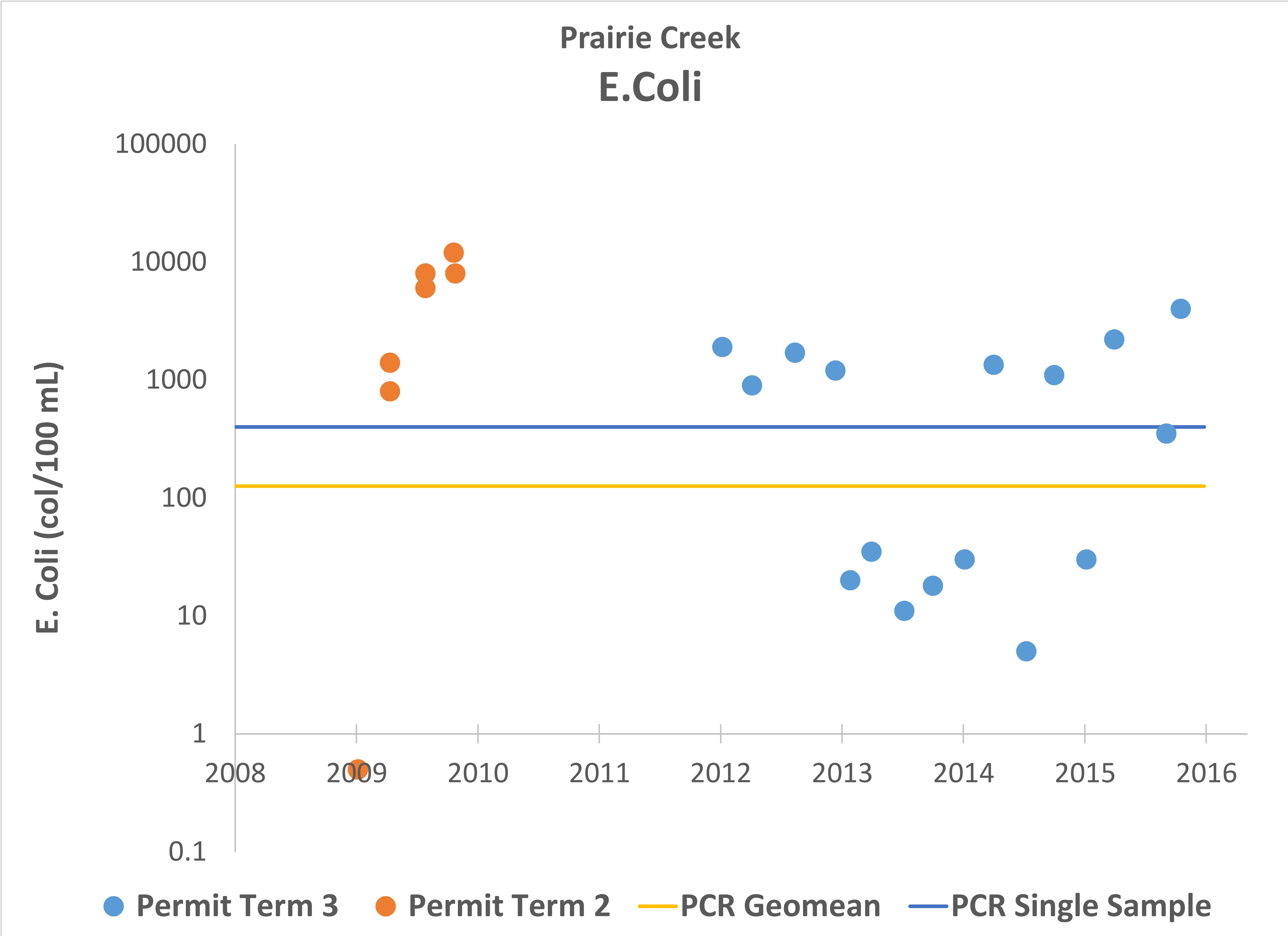

Prairie Creek
Field pH
pH (Standard Units)
9.5
9
8.5
8
7.5
7
6.5
6
2008
2009
2010
2011
2012
2013
2014
2015
2016
Permit Term 2
Permit Term 3
Basin Specific Criteria



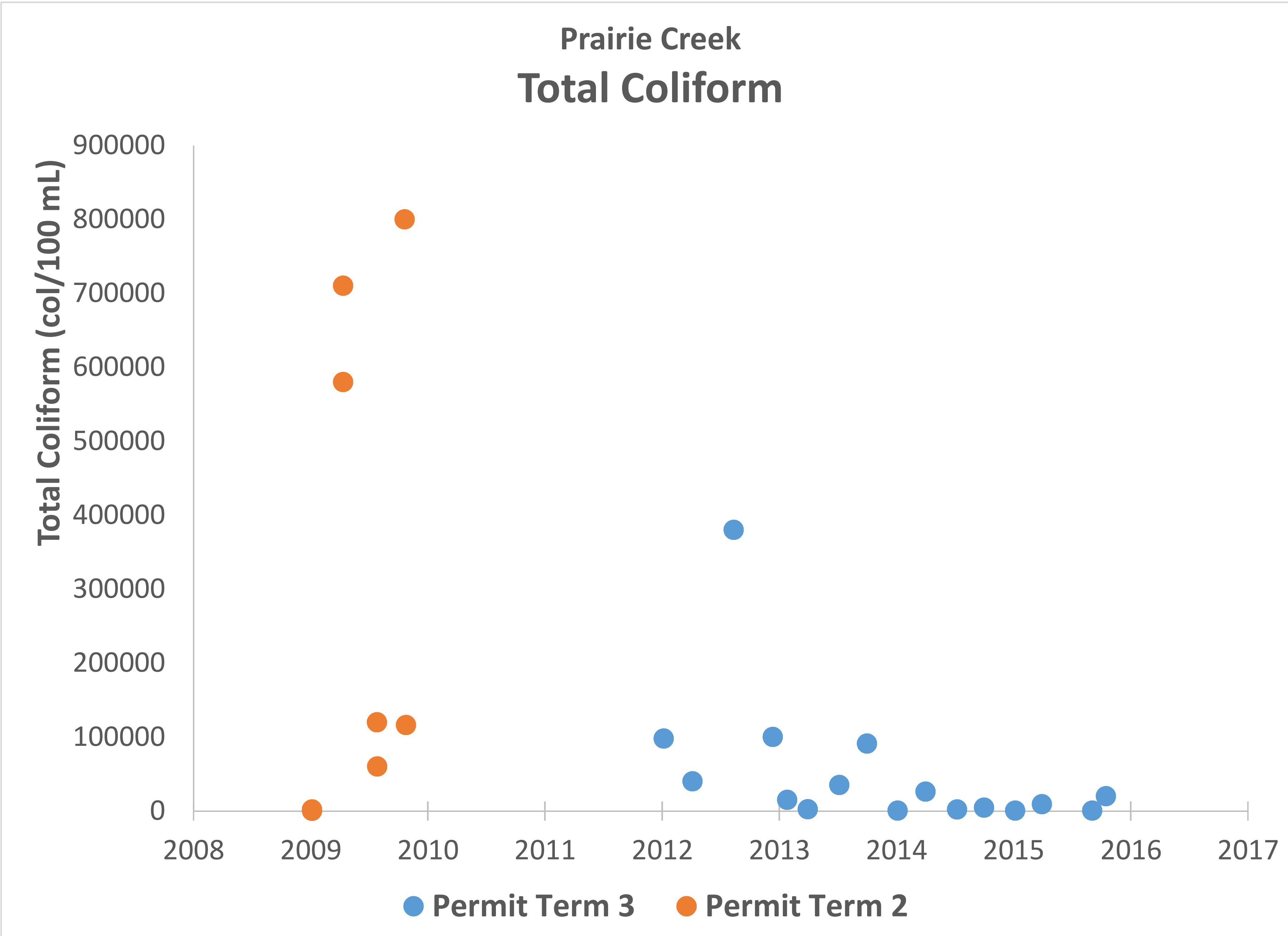
Prairie Creek
Specific Conductance (Field)
Specific Conductance (µS/cm)
1200
1000
800
600
400
200
0
2011
2012
2013
2014
2015
Permit Term 3
NRSA: good (<)



Prairie Creek
Temperature
Temperature (°F)
100
90
80
70
60
50
40
30
20
10
0
2011
2012
2013
2015
Permit Term 3
Basin Specific Criterion

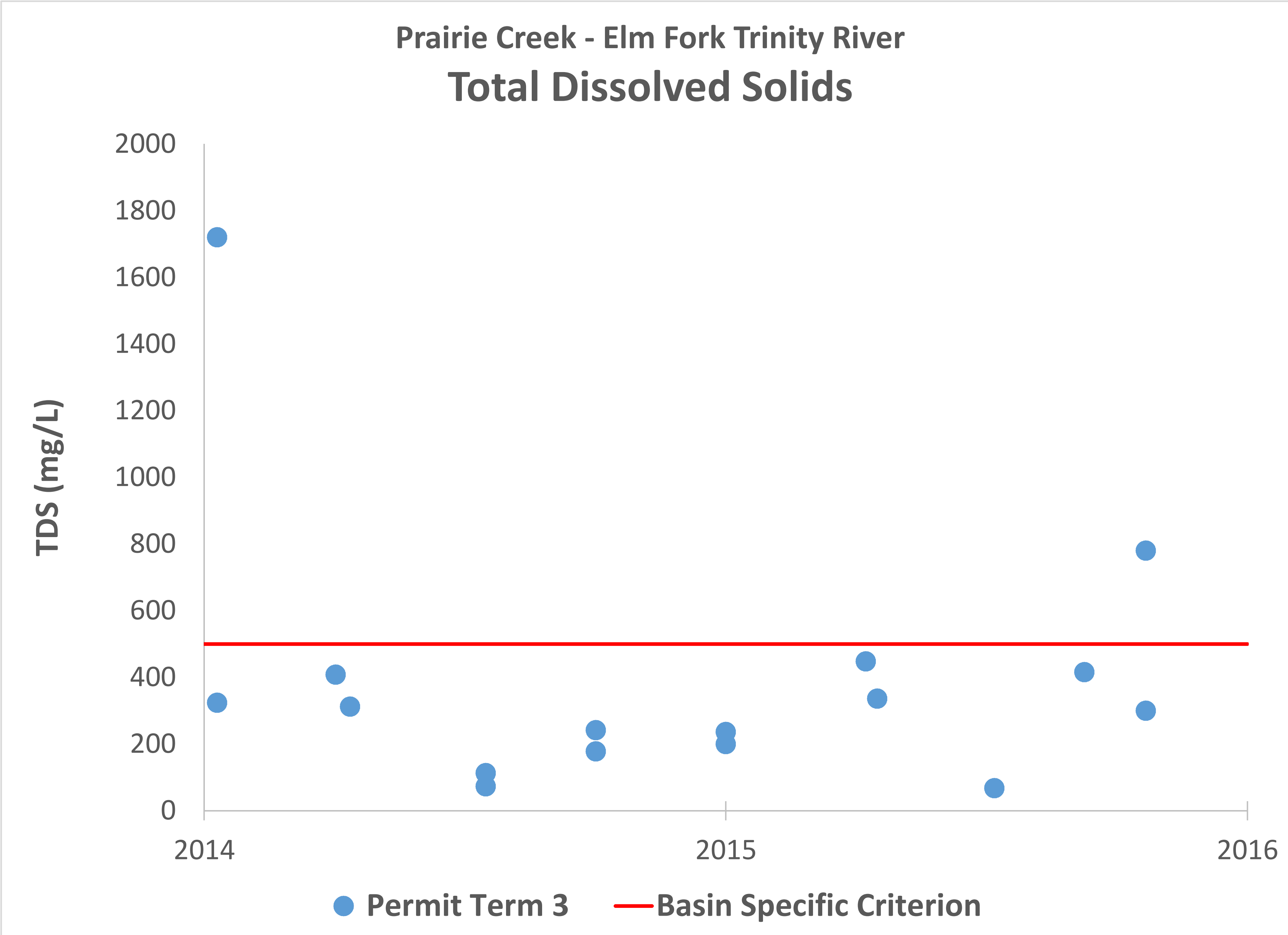


Prairie Creek
E.Coli
E. Coli (col/100 mL)
100000
10000
1000
100
10
1
0.1
2008
2009
2010
2011
2012
2013
2014
2015
2016
Permit Term 3
Permit Term 2
PCR Geomean
PCR Single Sample

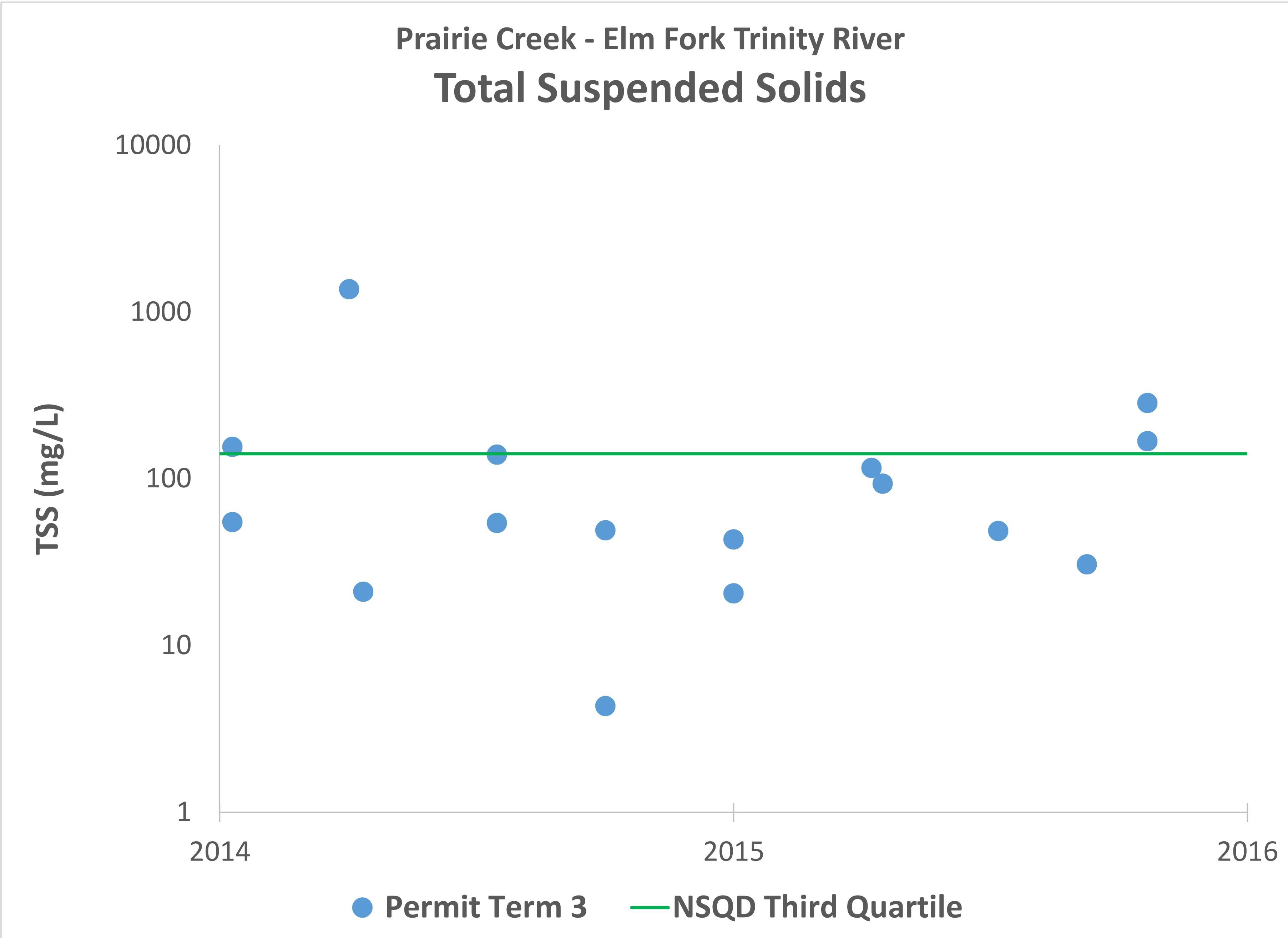

Prairie Creek
Total Coliform
Total Coliform (col/100 mL)
900000
800000
700000
600000
500000
400000
300000
200000
100000
0
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
Permit Term 3
Permit Term 2

Appendix T

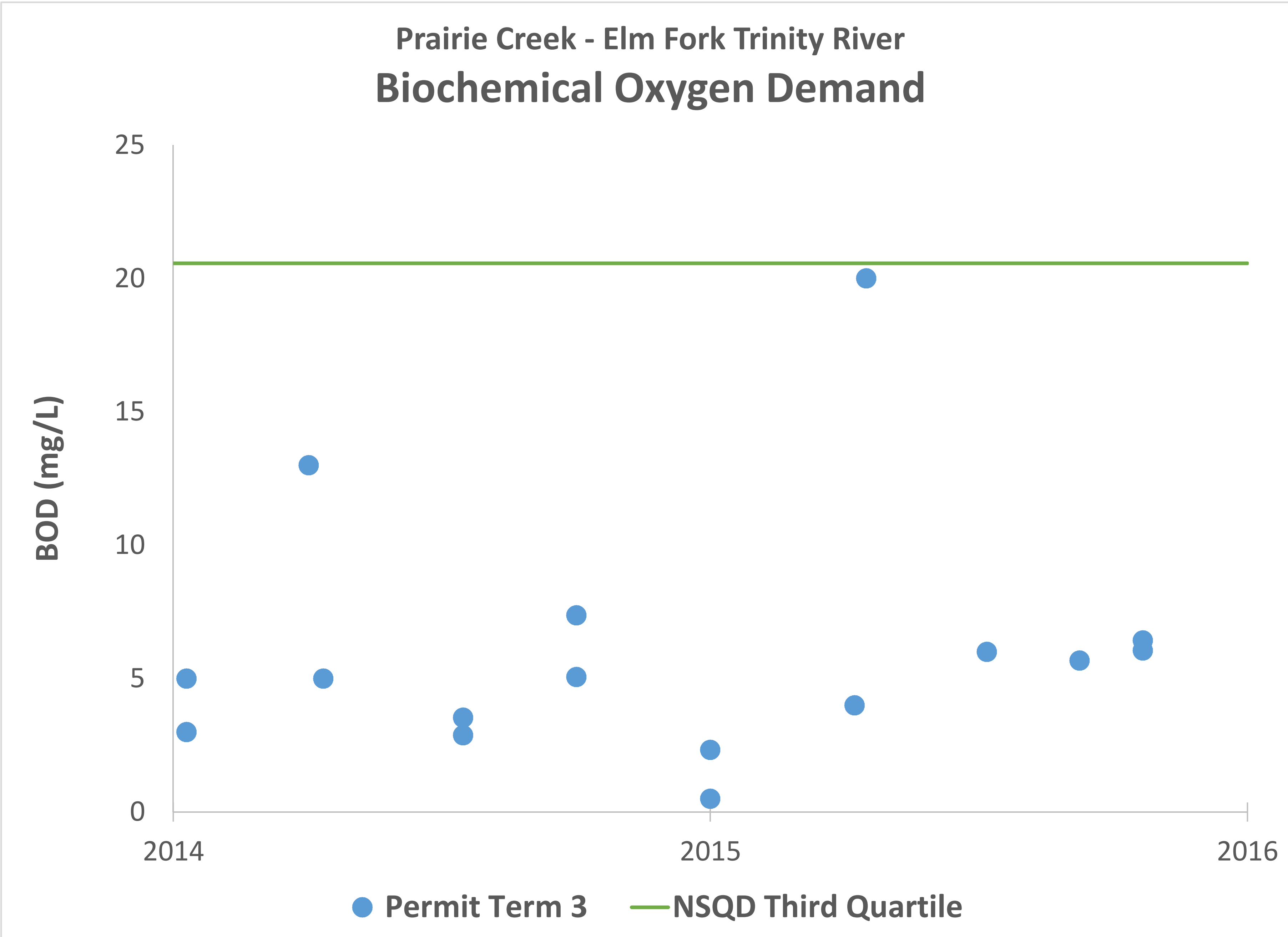
Prairie Creek – Elm Fork Trinity River Water Quality Data Graphs



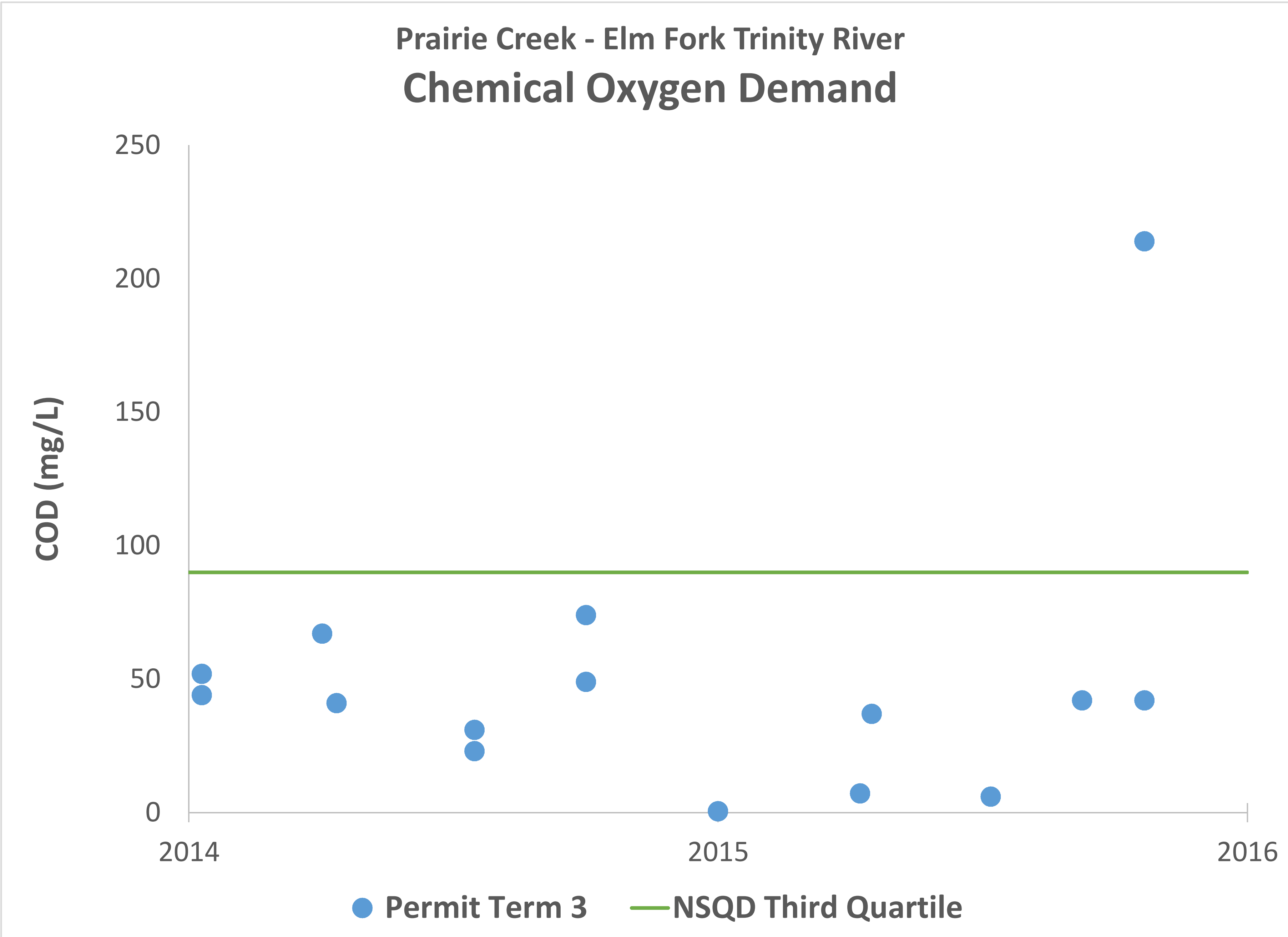
Prairie Creek - Elm Fork Trinity River
Total Dissolved Solids
TDS (mg/L)
2000
1800
1600
1400
1200
1000
800
600
400
200
0
2014
2015
2016
Permit Term 3
Basin Specific Criterion



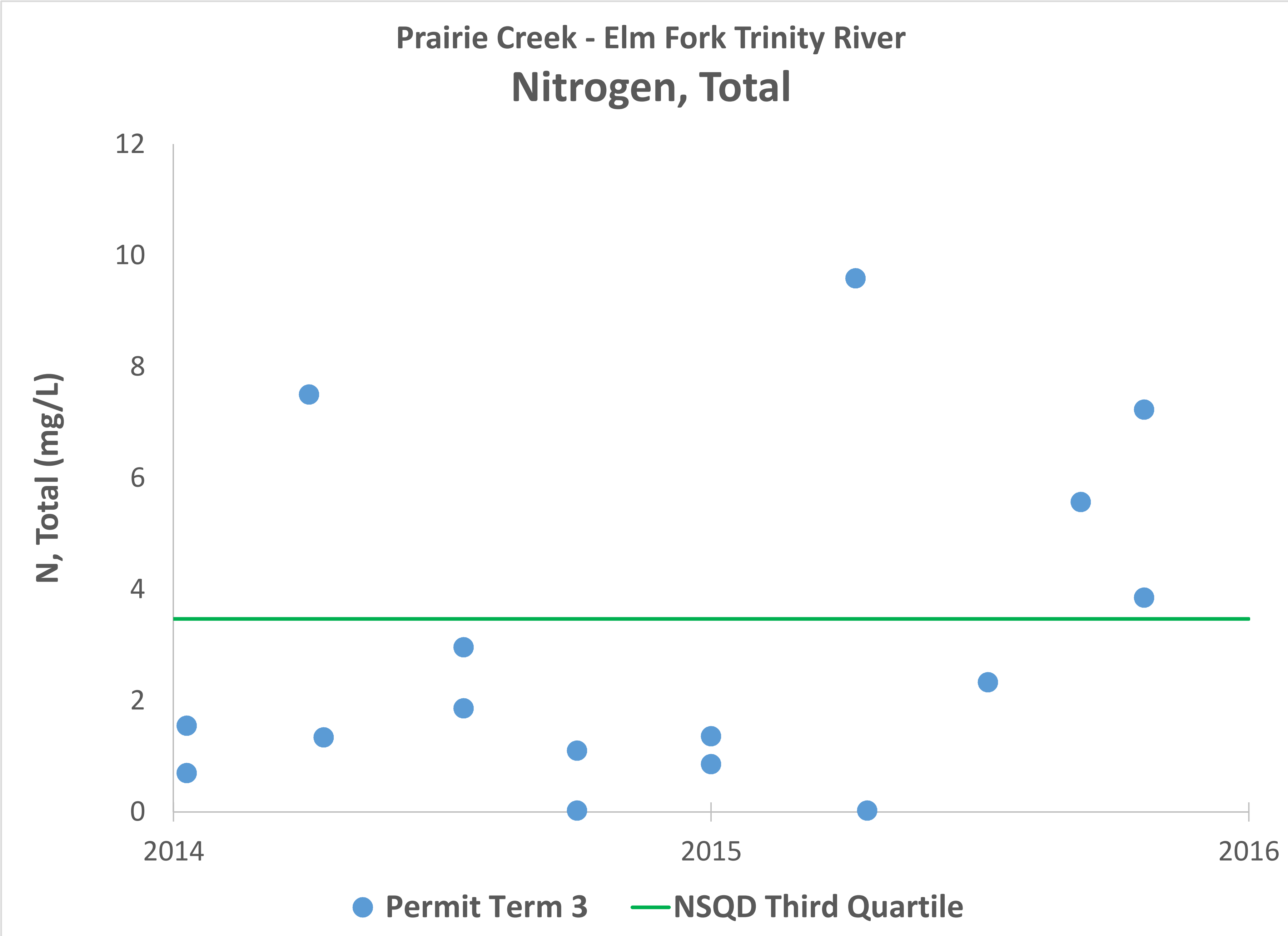
Prairie Creek - Elm Fork Trinity River
Total Suspended Solids
TSS (mg/L)
10000
1000
100
10
1
2014
2015
2016
Permit Term 3
NSQD Third Quartile

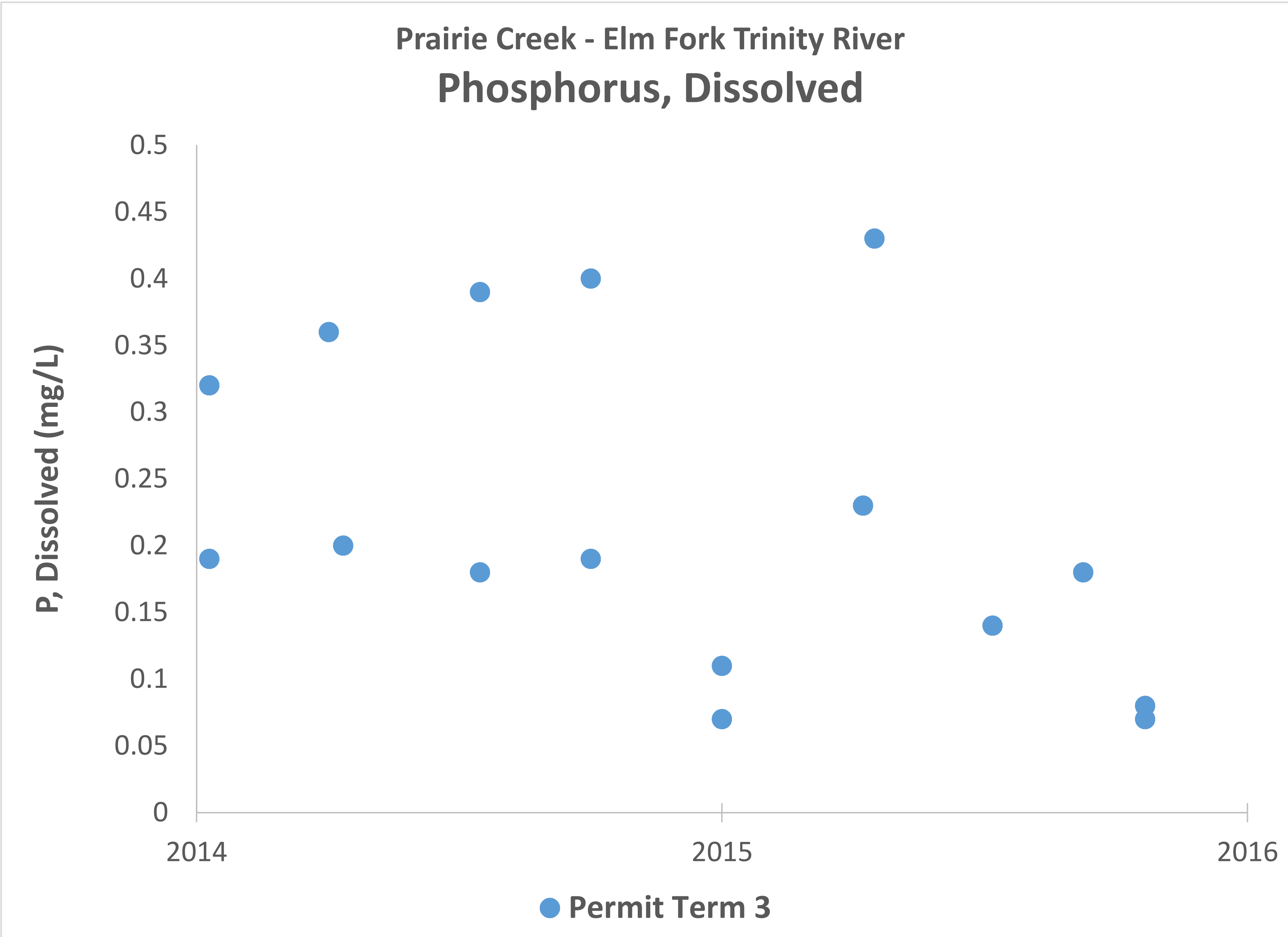


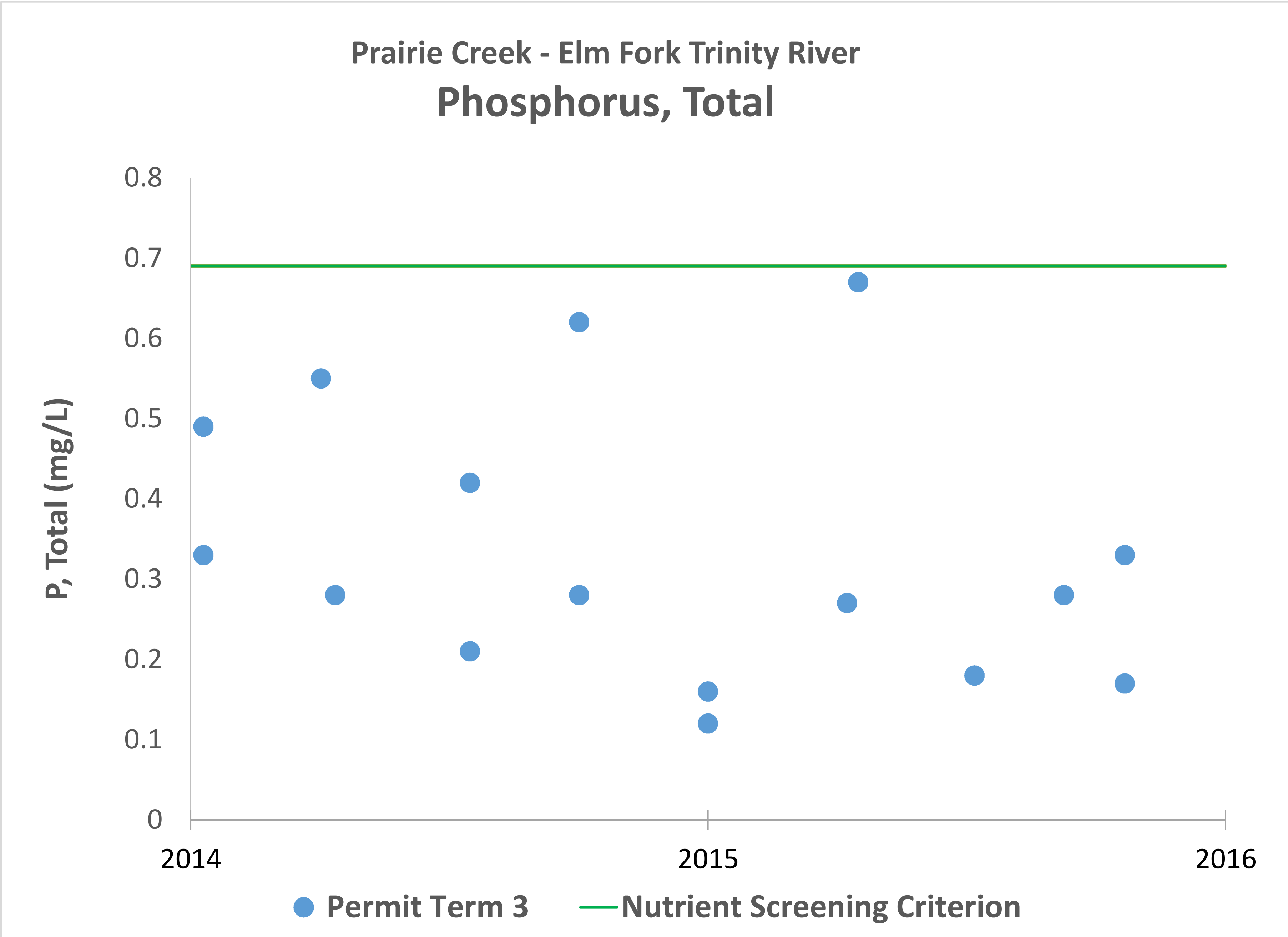
Prairie Creek - Elm Fork Trinity River
Biochemical Oxygen Demand
BOD (mg/L)
25
20
15
10
5
0
2014
2015
2016
Permit Term 3
NSQD Third Quartile

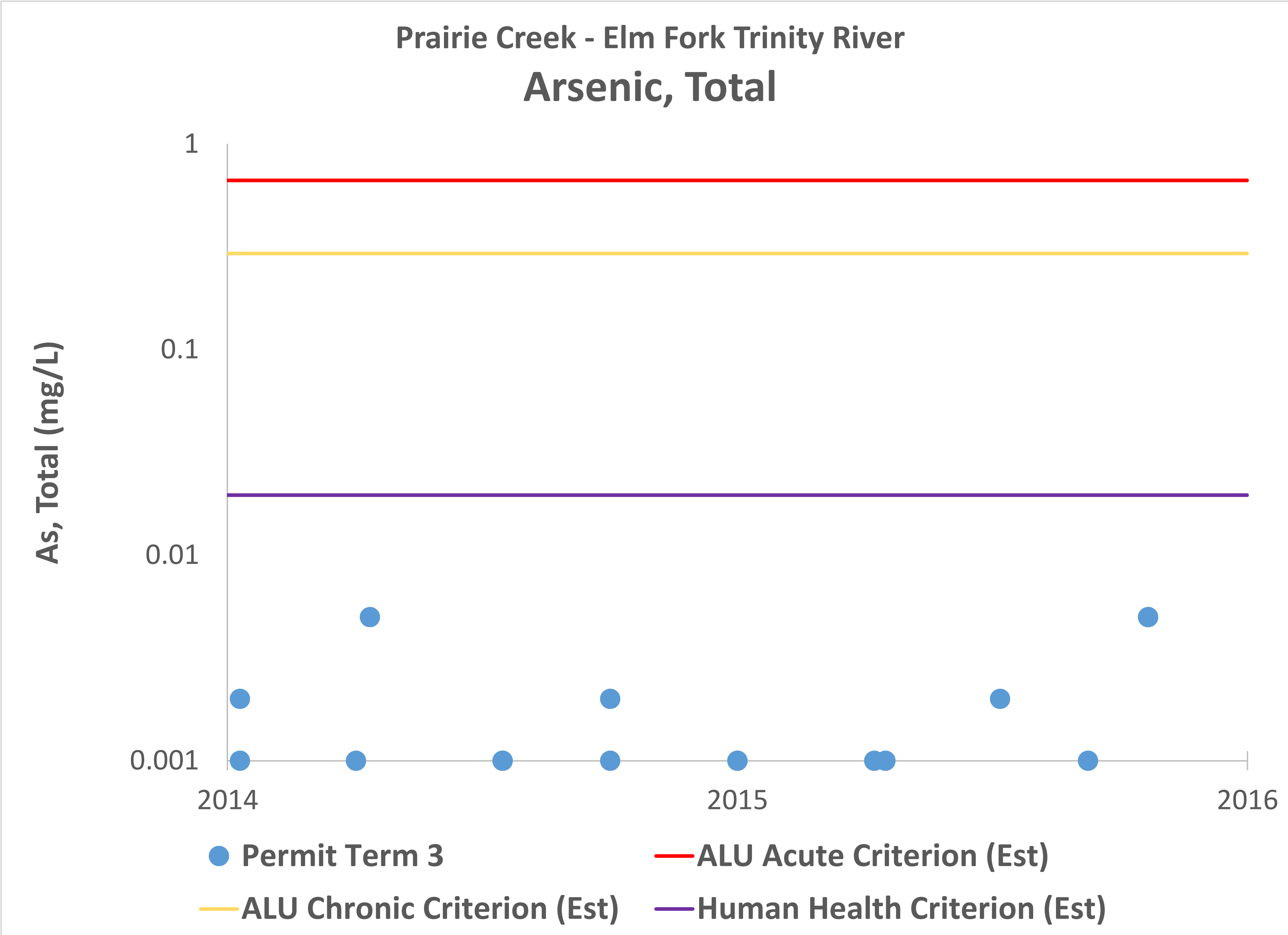


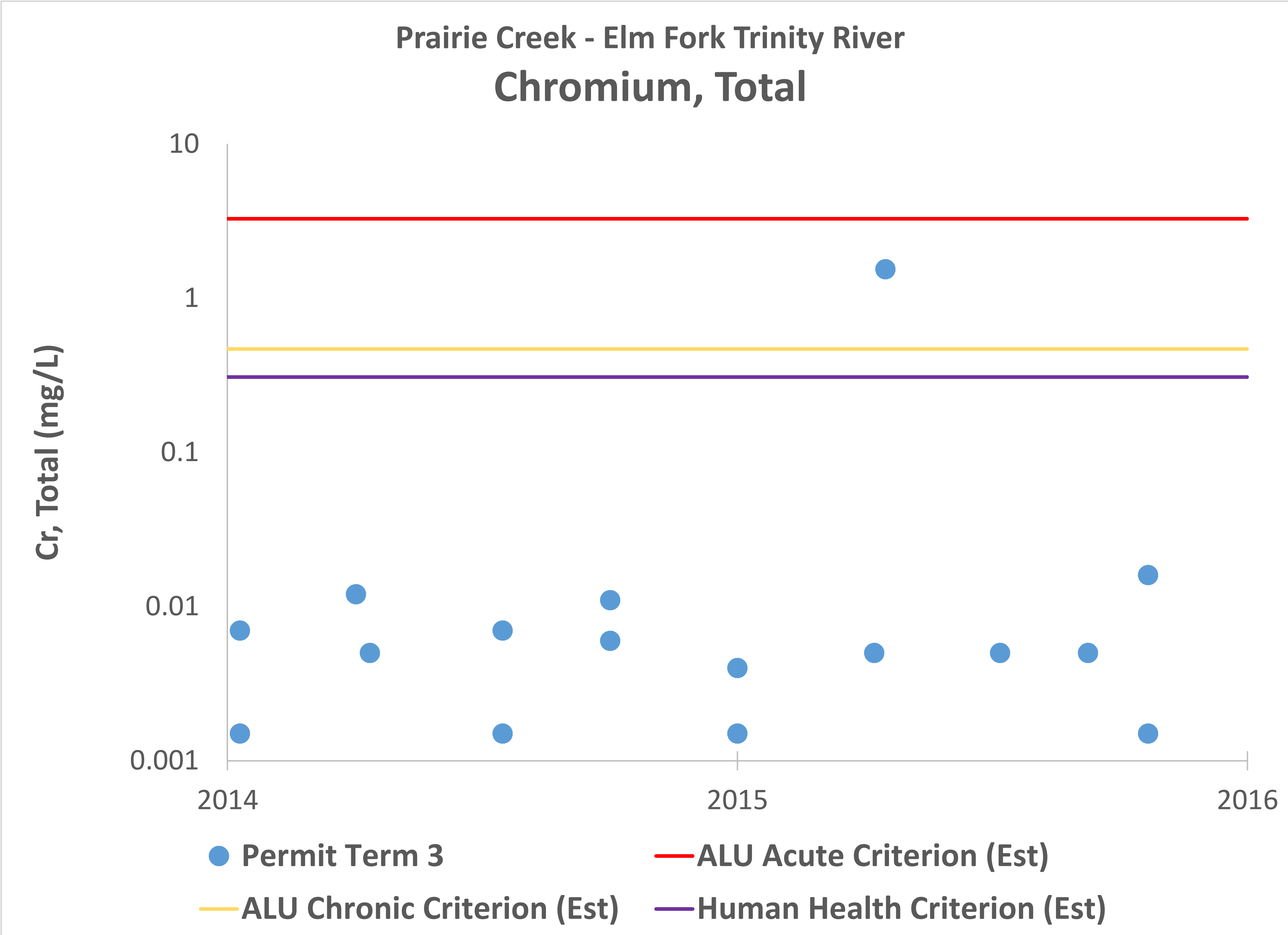
Prairie Creek - Elm Fork Trinity River
Chemical Oxygen Demand
COD (mg/L)
250
200
150
100
50
0
2014
2015
2016
Permit Term 3
NSQD Third Quartile


Prairie Creek - Elm Fork Trinity River
Nitrogen, Total
N, Total (mg/L)
0
2
4
6
8
10
12
2014
2015
2016
Permit Term 3
NSQD Third Quartile

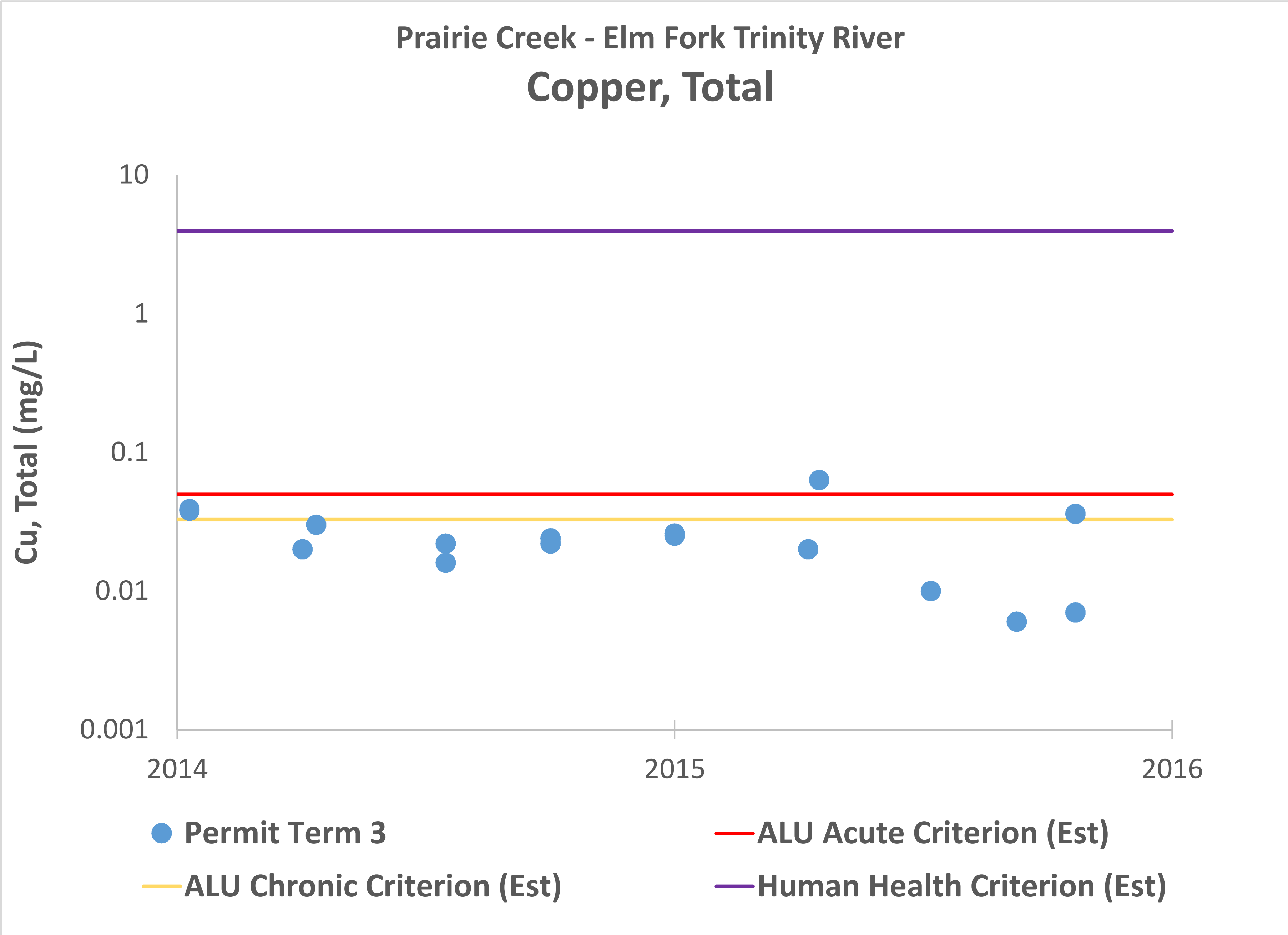

Prairie Creek - Elm Fork Trinity River
Phosphorus, Dissolved
P, Dissolved (mg/L)
0.5
0.45
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
2014
2015
2016
Permit Term 3


Prairie Creek - Elm Fork Trinity River
Phosphorus, Total
P, Total (mg/L)
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
2014
2015
2016
Permit Term 3
Nutrient Screening Criterion

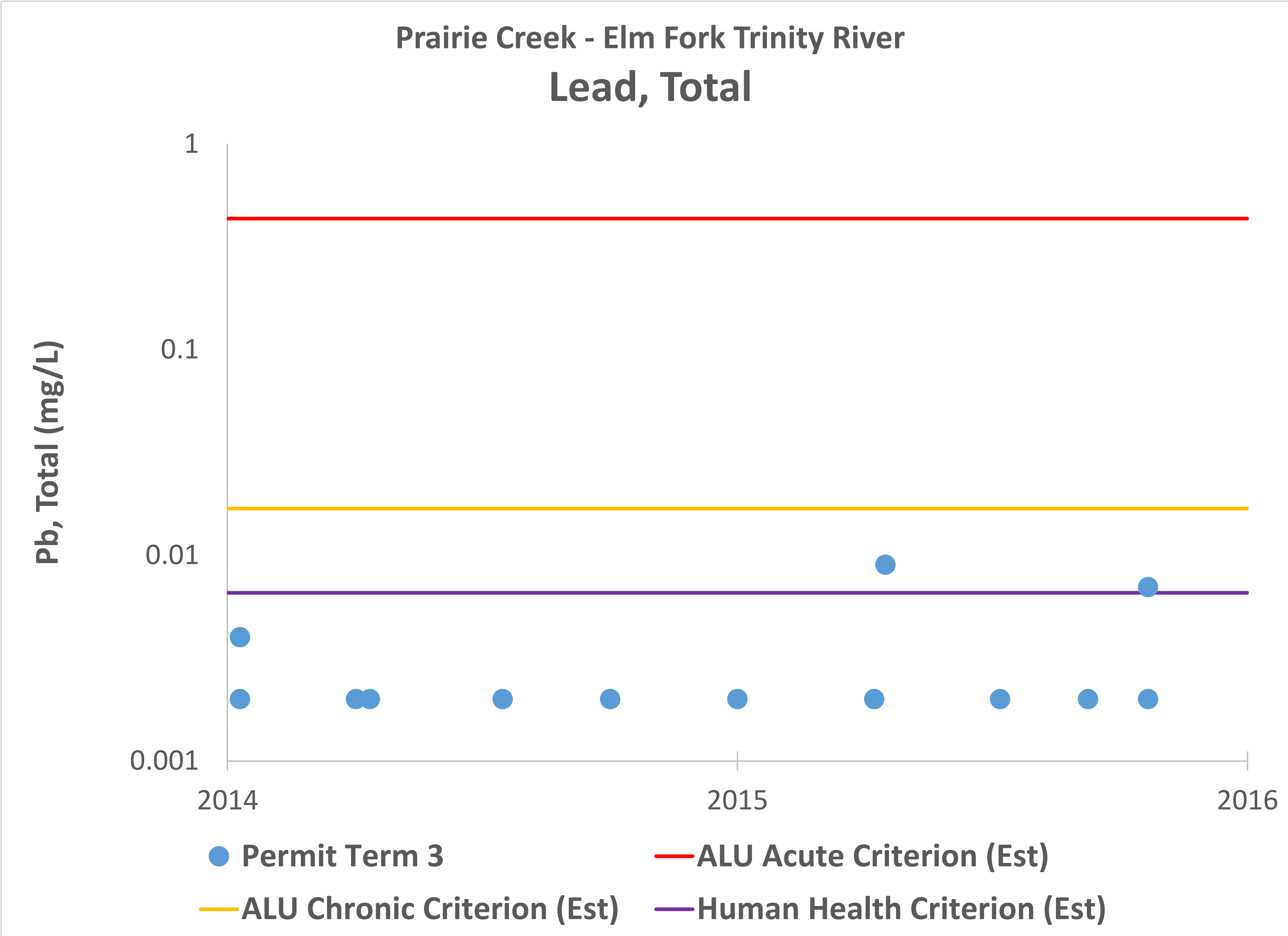

Prairie Creek - Elm Fork Trinity River
Arsenic, Total
As, Total (mg/L)
1
0.1
0.01
0.001
2014
2015
2016
Permit Term 3
ALU Acute Criterion (Est)
ALU Chronic Criterion (Est)
Human Health Criterion (Est)

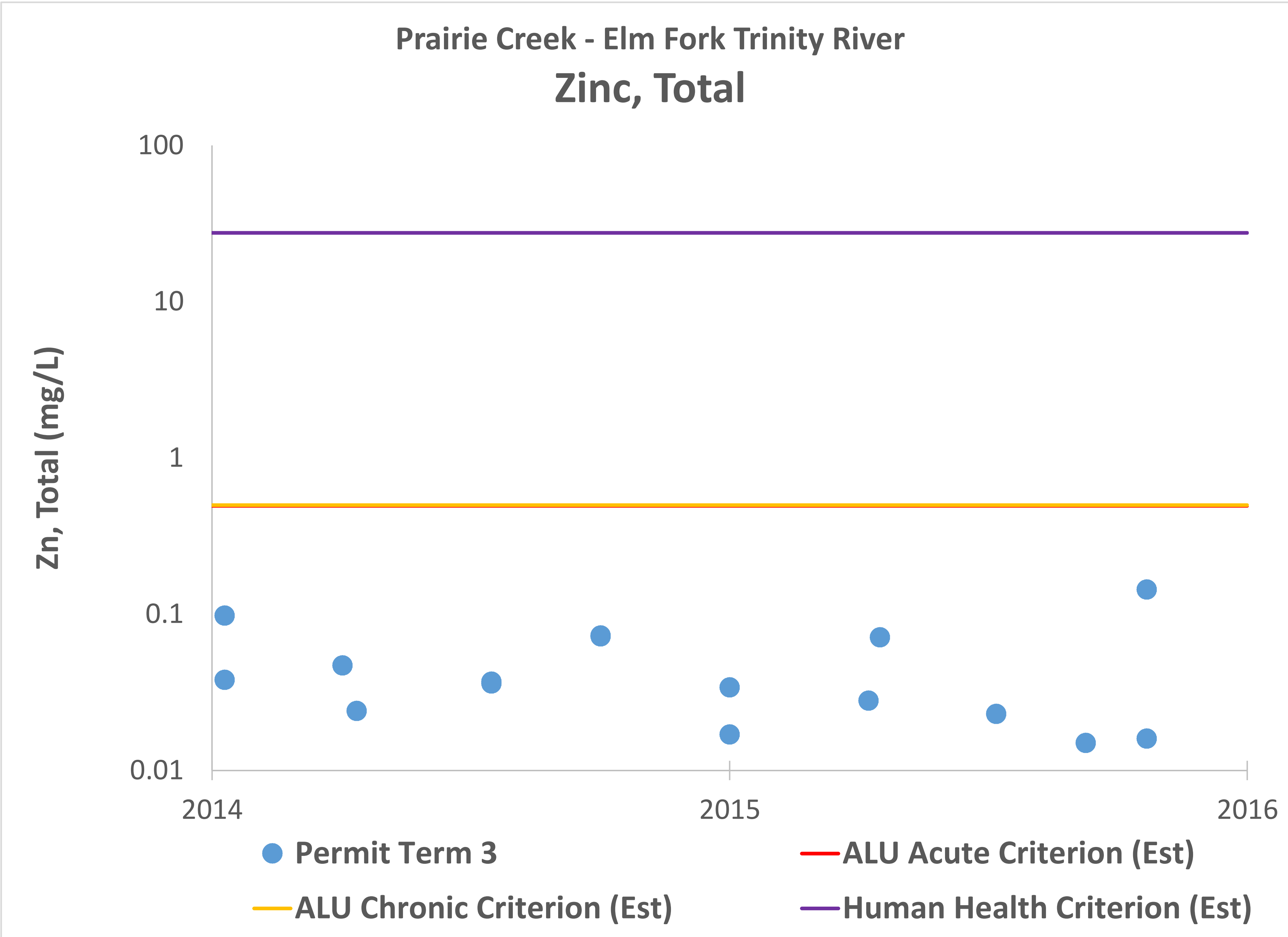


Prairie Creek - Elm Fork Trinity River
Chromium, Total
Cr, Total (mg/L)
10
1
0.1
0.01
0.001
2014
2015
2016
Permit Term 3
ALU Acute Criterion (Est)
ALU Chronic Criterion (Est)
Human Health Criterion (Est)

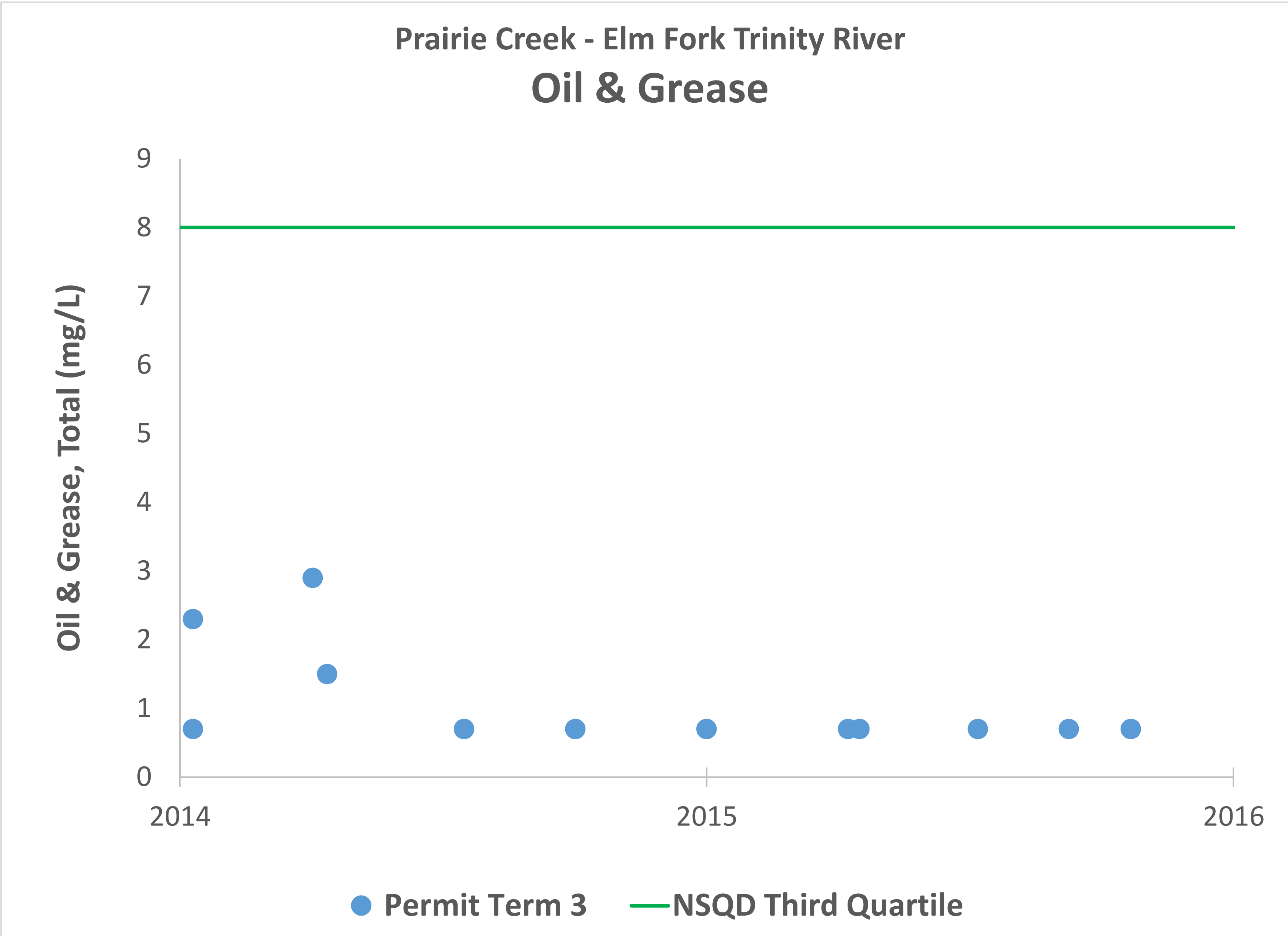


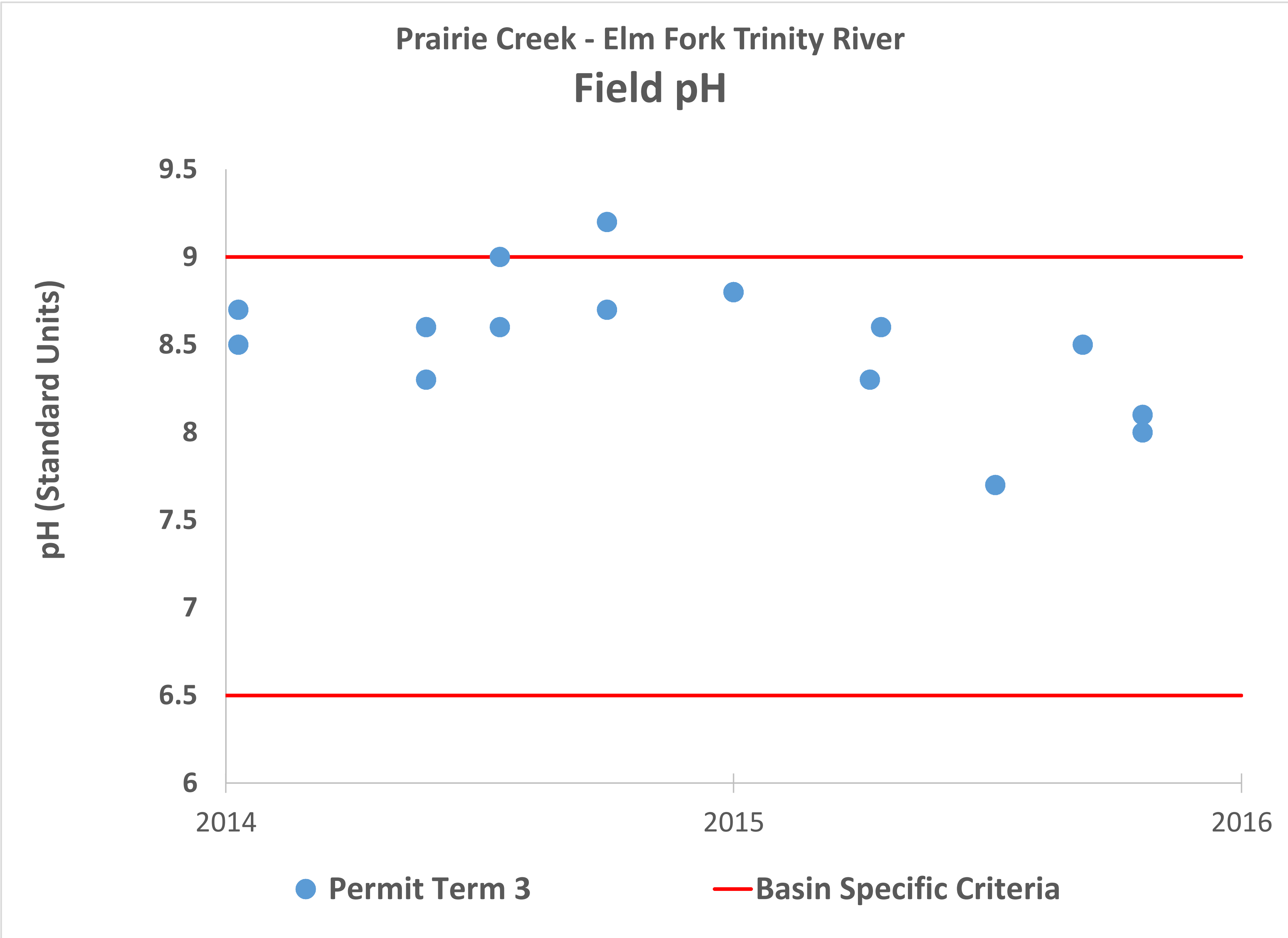
Prairie Creek - Elm Fork Trinity River
Copper, Total
Cu, Total (mg/L)
10
1
0.1
0.01
0.001
2014
2015
2016
Permit Term 3
ALU Acute Criterion (Est)
ALU Chronic Criterion (Est)
Human Health Criterion (Est)

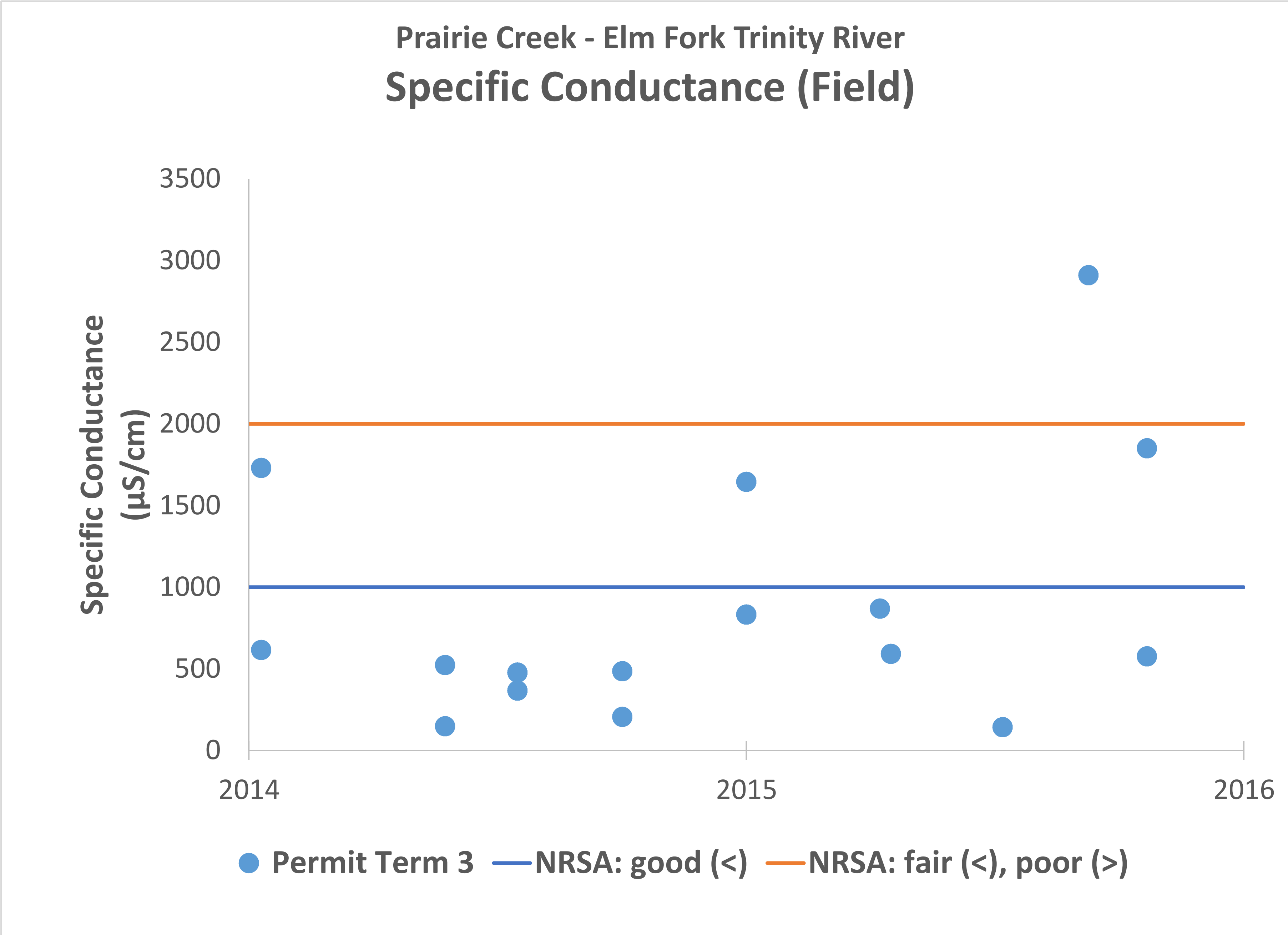

Prairie Creek - Elm Fork Trinity River
Lead, Total
Pb, Total (mg/L)
1
0.1
0.01
0.001
2014
2015
2016
Permit Term 3
ALU Acute Criterion (Est)
ALU Chronic Criterion (Est)
Human Health Criterion (Est)



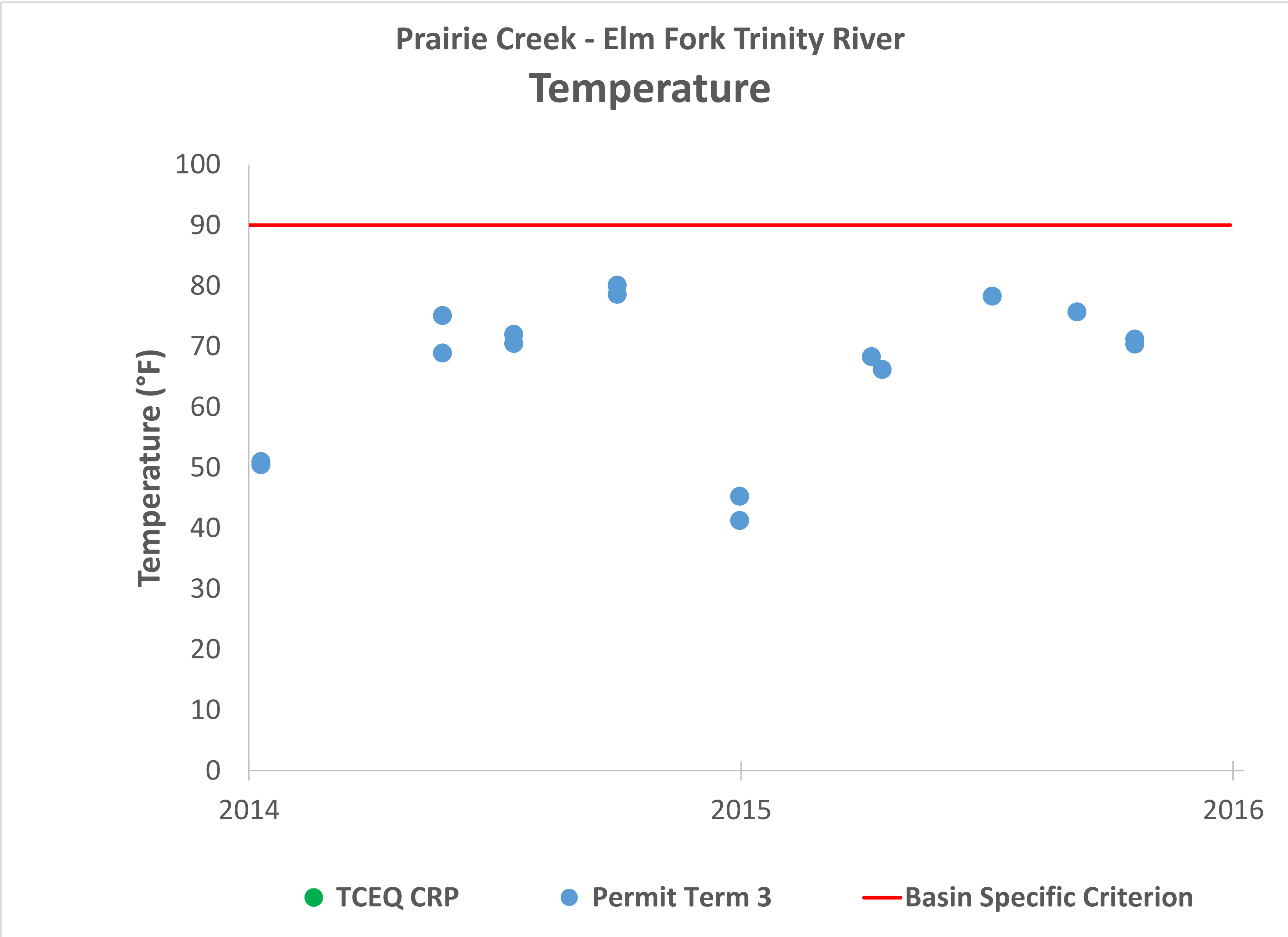
Prairie Creek - Elm Fork Trinity River
Zinc, Total
Zn, Total (mg/L)
100
10
1
0.1
0.01
2014
2015
2016
Permit Term 3
ALU Acute Criterion (Est)
ALU Chronic Criterion (Est)
Human Health Criterion (Est)


Prairie Creek - Elm Fork Trinity River
Oil & Grease
Oil & Grease, Total (mg/L)
0
1
2
3
4
5
6
7
8
9
2014
2015
2016
Permit Term 3
NSQD Third Quartile

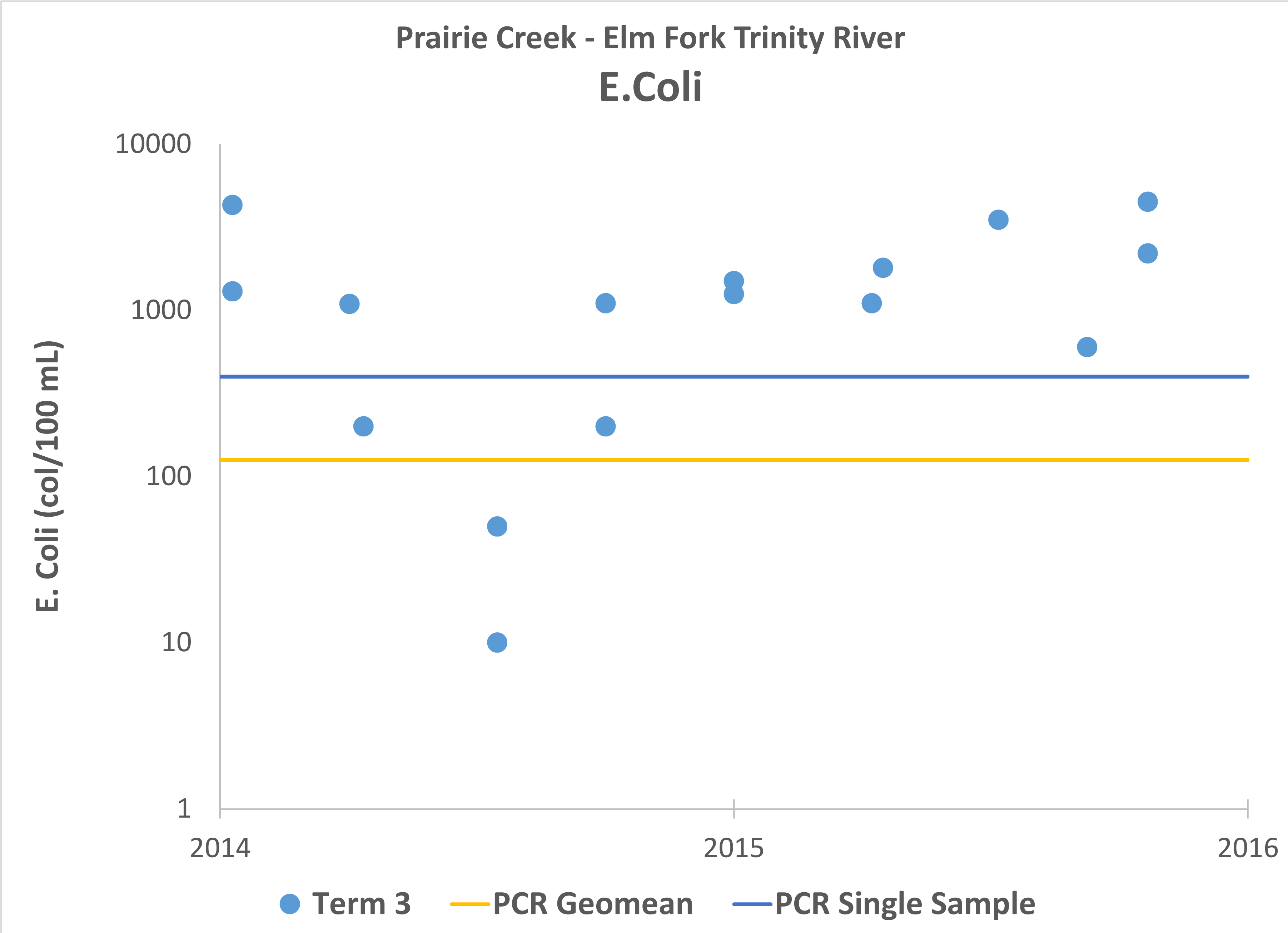

Prairie Creek - Elm Fork Trinity River
Field pH
pH (Standard Units)
9.5
9
8.5
8
7.5
7
6.5
6
2014
2015
2016
Permit Term 3
Basin Specific Criteria



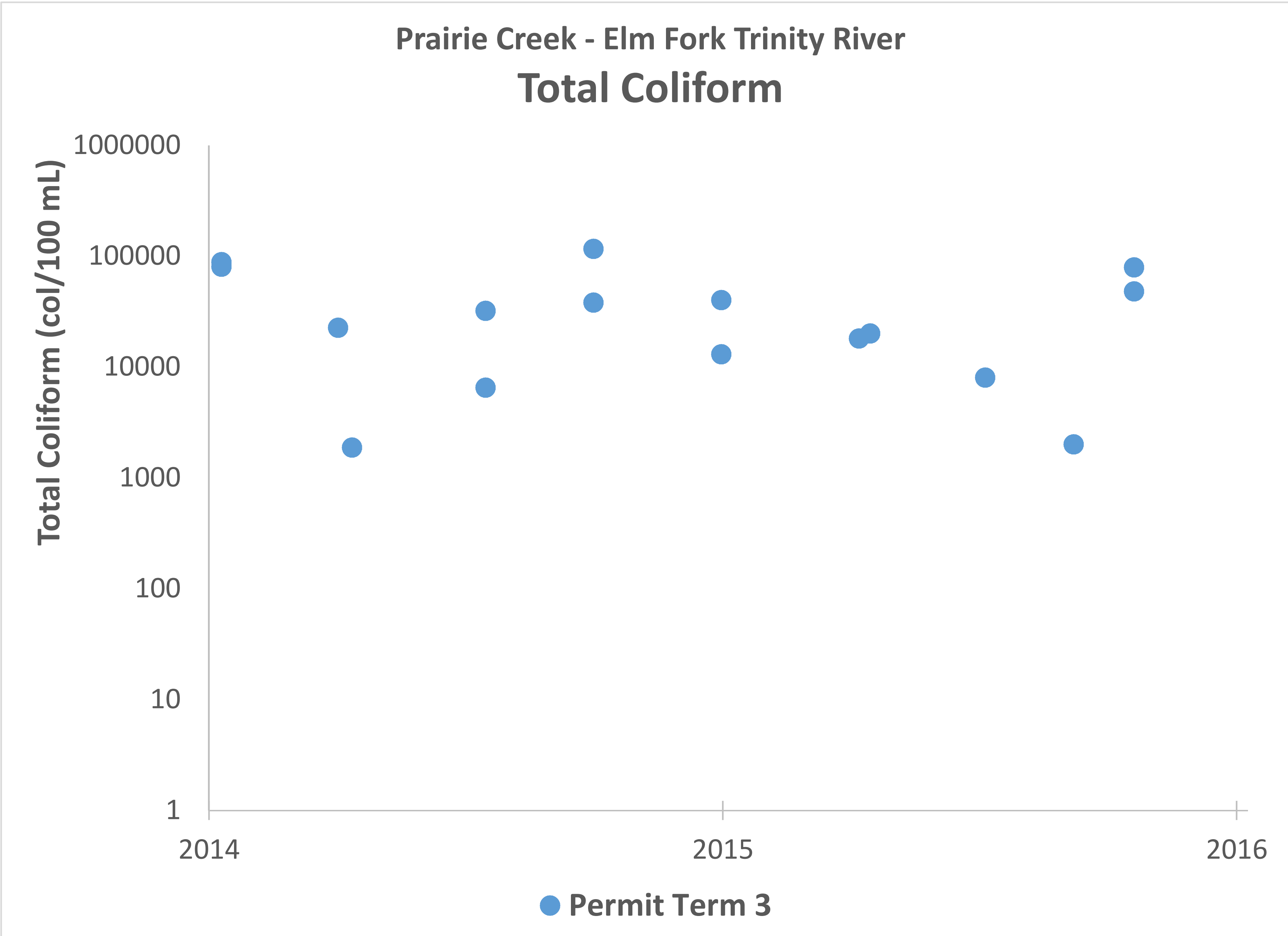
Prairie Creek - Elm Fork Trinity River
Specific Conductance (Field)
Specific Conductance (µS/cm)
3500
3000
2500
2000
1500
1000
500
0
2014
2015
2016
Permit Term 3
NRSA: good (<)
NRSA: fair (<), poor (>)



Prairie Creek - Elm Fork Trinity River
Temperature
Temperature (°F)
100
90
80
70
60
50
40
30
20
10
0
2014
2015
2016
TCEQ CRP
Permit Term 3
Basin Specific Criterion

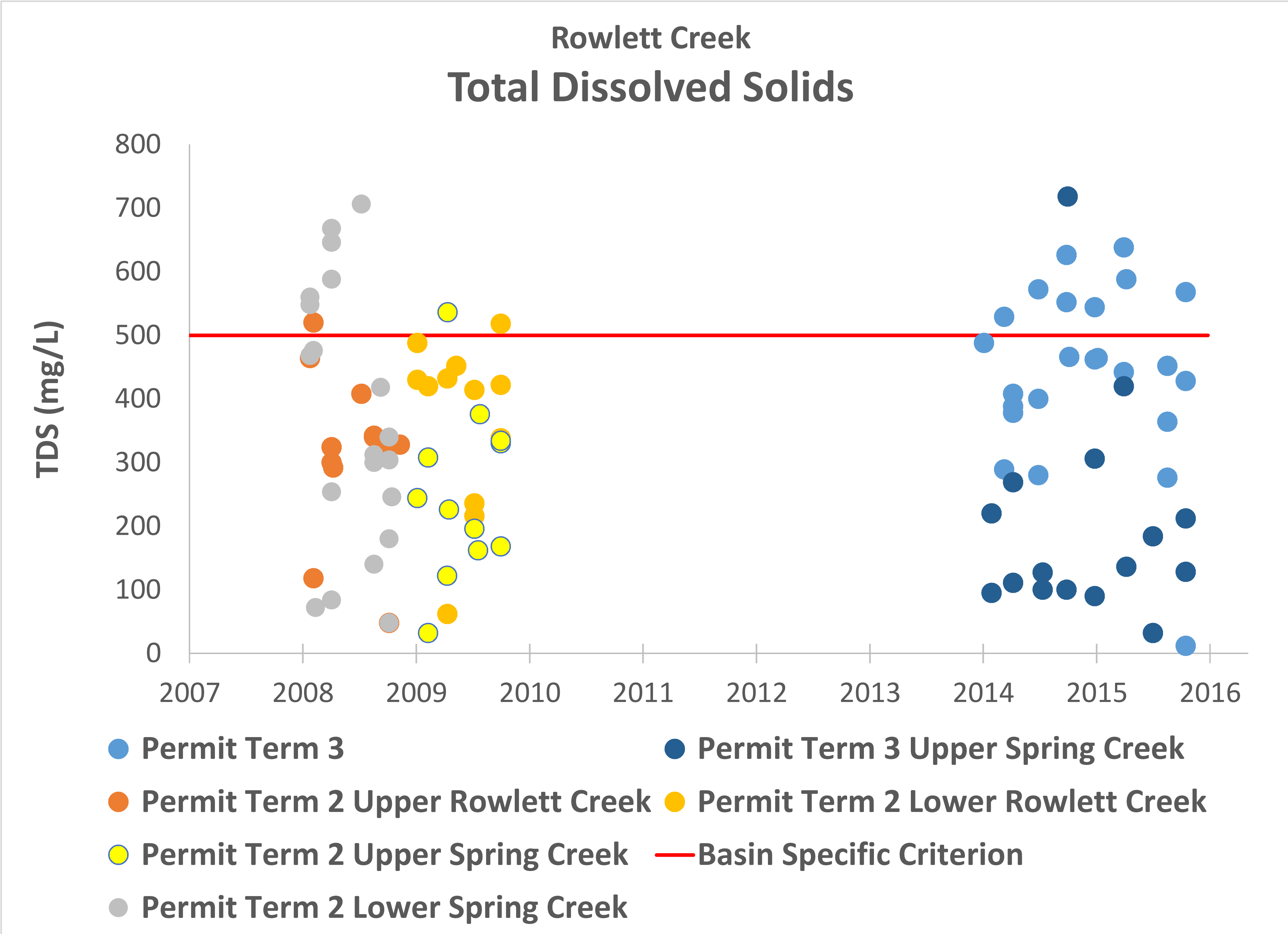


Prairie Creek - Elm Fork Trinity River
E.Coli
E. Coli (col/100 mL)
10000
1000
100
10
1
2014
2015
2016
Term 3
PCR Geomean
PCR Single Sample

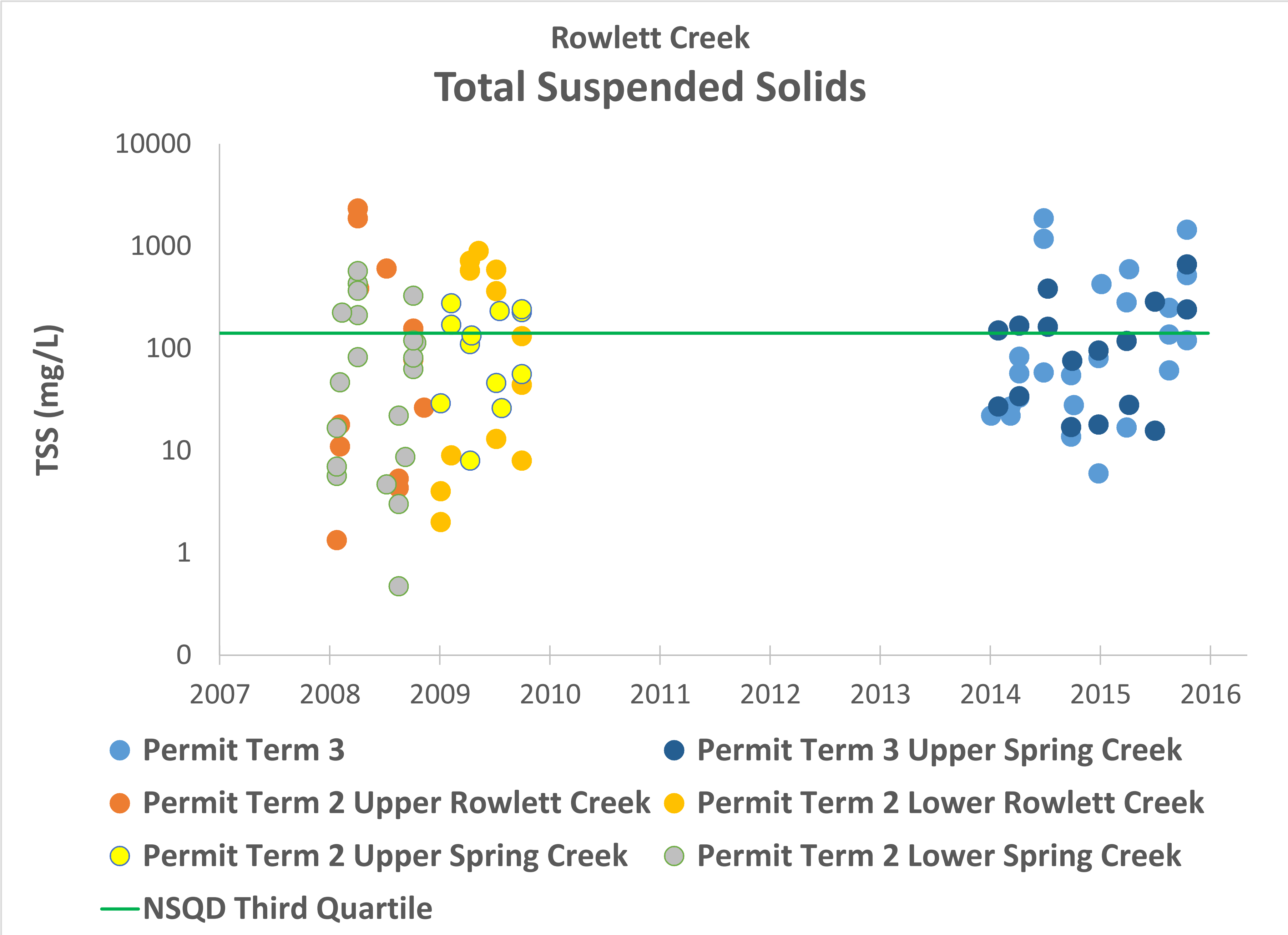

Prairie Creek - Elm Fork Trinity River
Total Coliform
Total Coliform (col/100 mL)
1000000
100000
10000
1000
100
10
1
2014
2015
2016
Permit Term 3

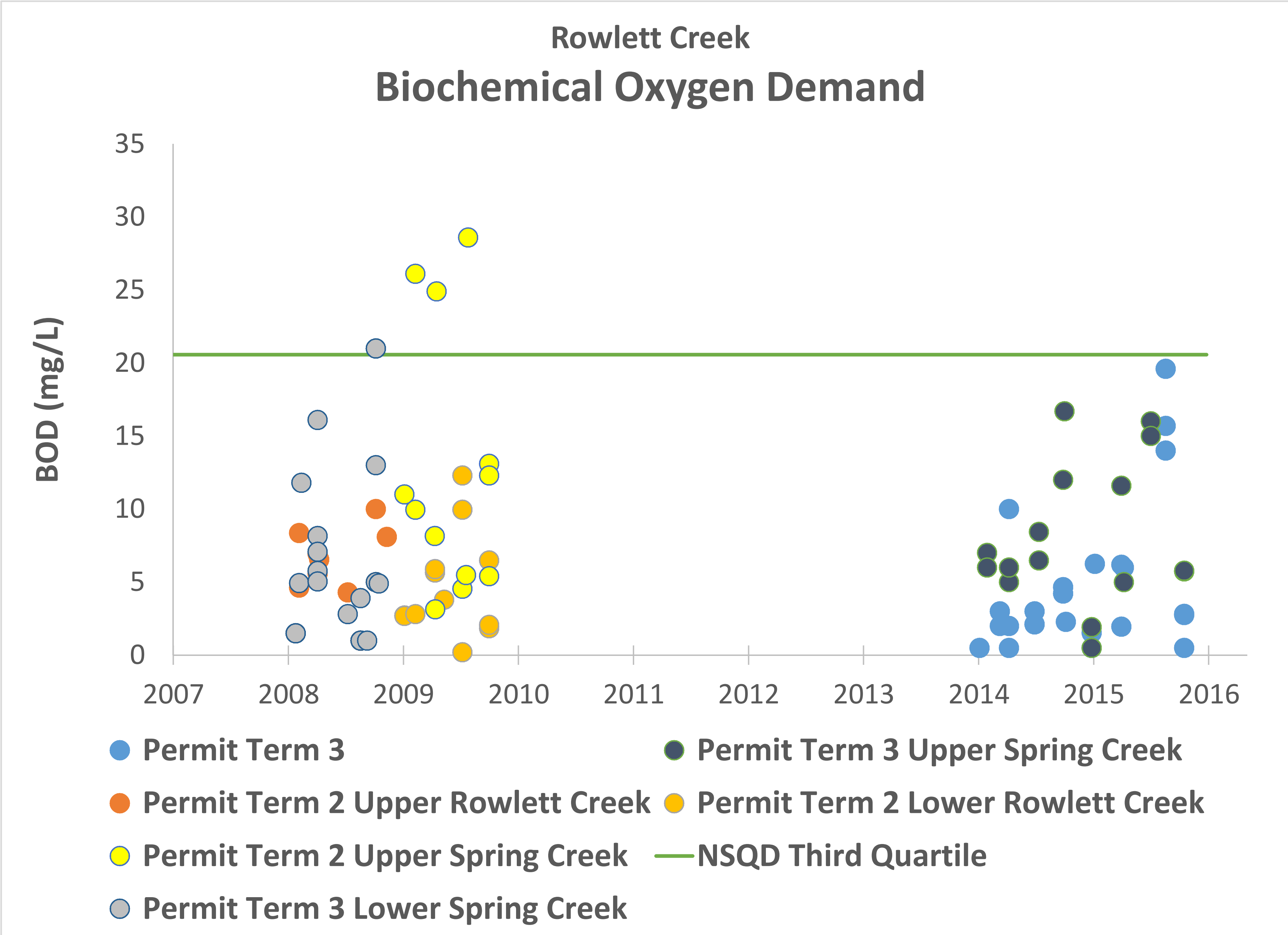
Appendix U

Rowlett Creek Water Quality Data Graphs

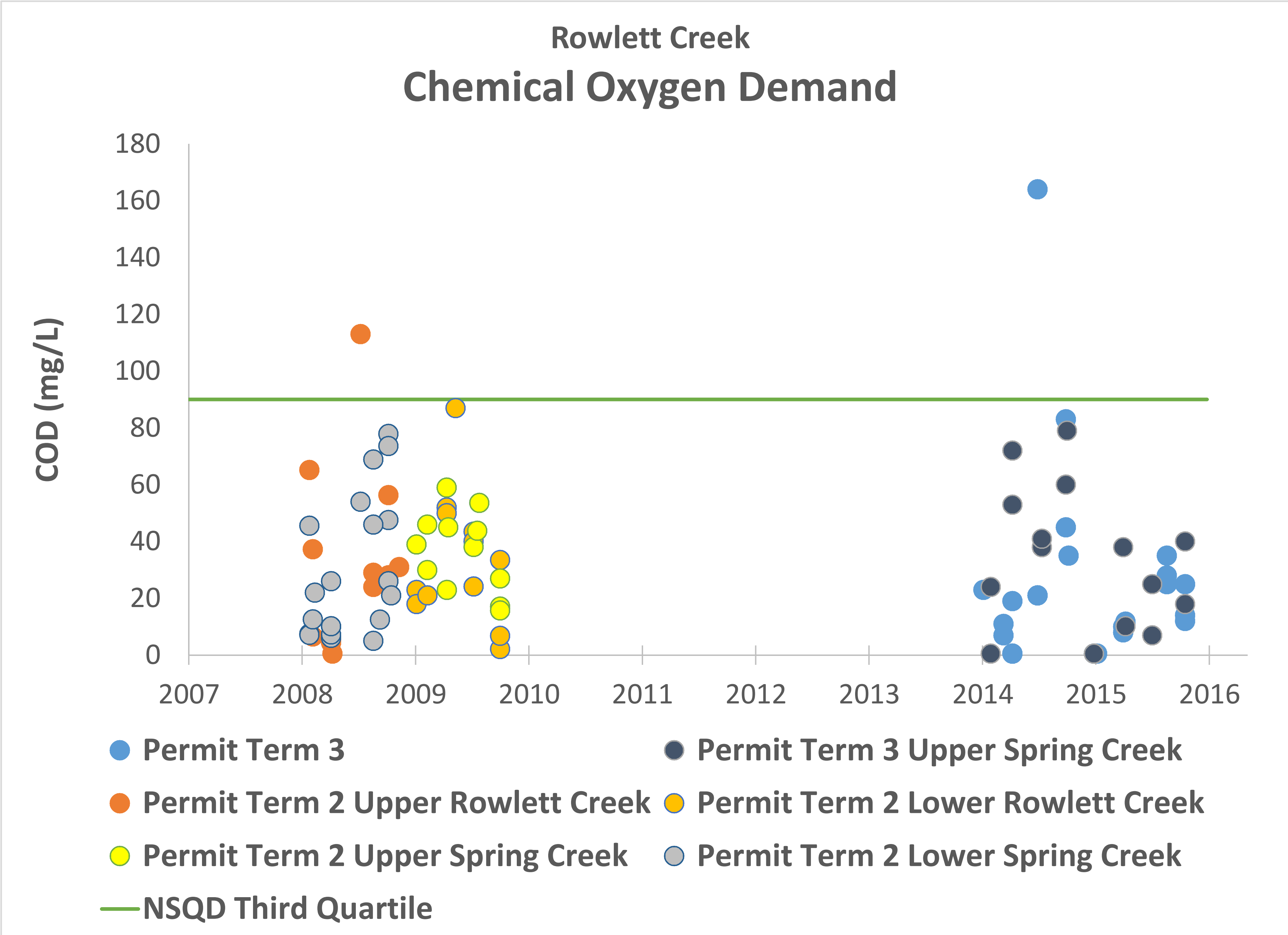


Rowlett Creek
Total Dissolved Solids
TDS (mg/L)
800
700
600
500
400
300
200
100
0
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
Permit Term 3
Permit Term 3 Upper Spring Creek
Permit Term 2 Upper Rowlett Creek
Permit Term 2 Lower Rowlett Creek
Permit Term 2 Upper Spring Creek
Basin Specific Criterion
Permit Term 2 Lower Spring Creek

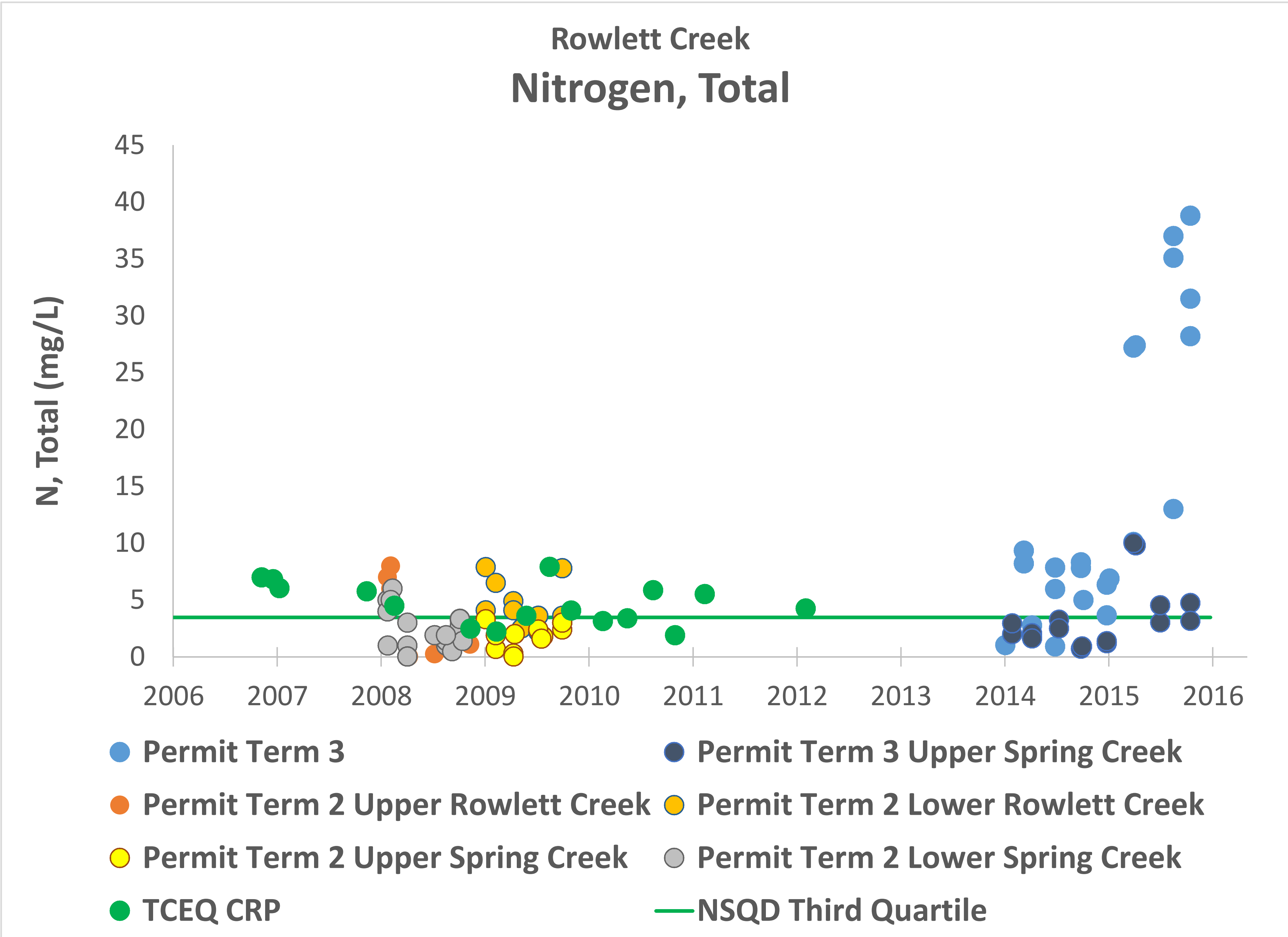

Rowlett Creek
Total Suspended Solids
TSS (mg/L)
10000
1000
100
10
1
0
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
Permit Term 3
Permit Term 3 Upper Spring Creek
Permit Term 2 Upper Rowlett Creek
Permit Term 2 Lower Rowlett Creek
Permit Term 2 Upper Spring Creek
Permit Term 2 Lower Spring Creek
NSQD Third Quartile



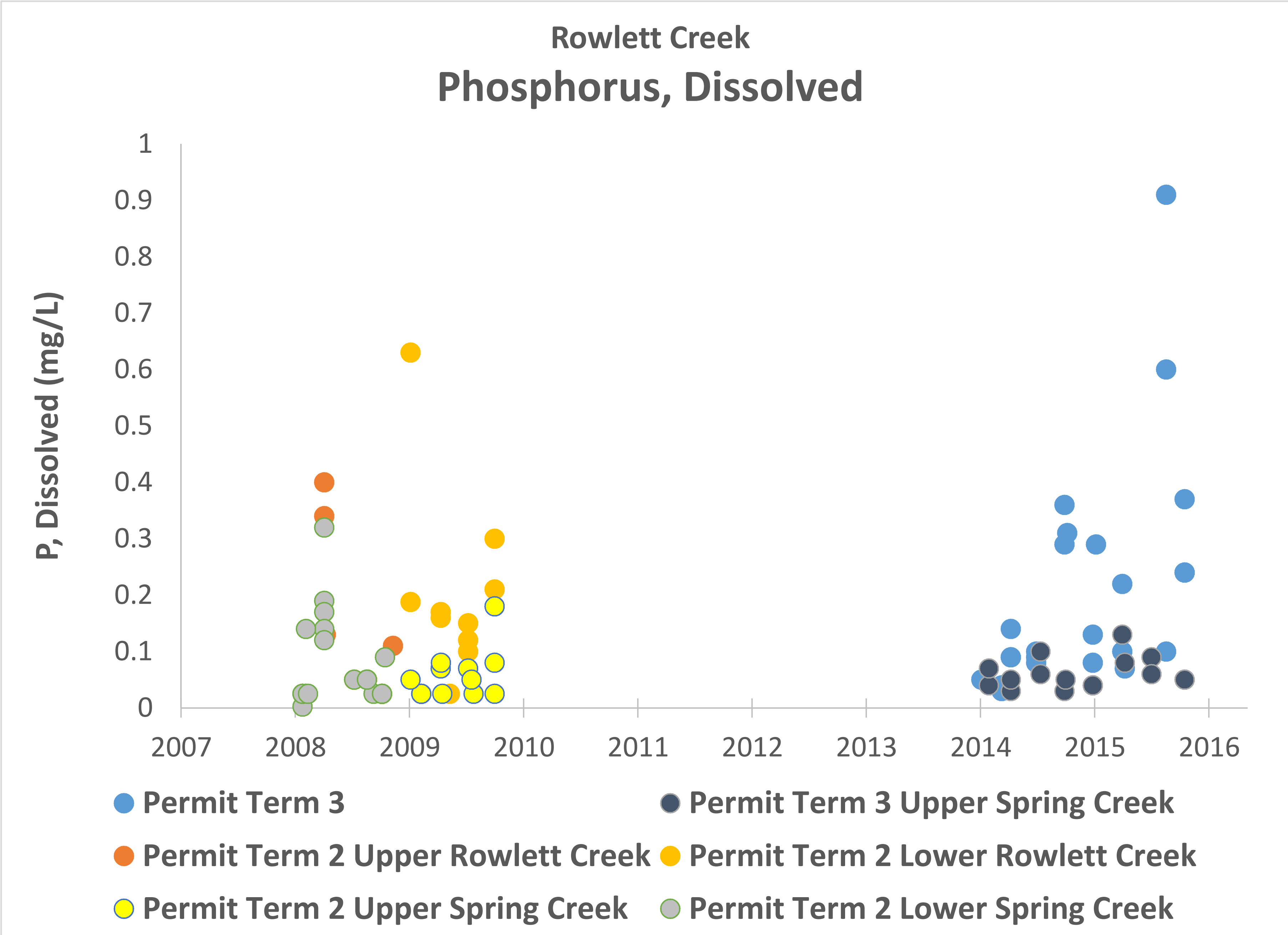
Rowlett Creek
Biochemical Oxygen Demand
BOD (mg/L)
35
30
25
20
15
10
5
0
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
Permit Term 3
Permit Term 3 Upper Spring Creek
Permit Term 2 Upper Rowlett Creek
Permit Term 2 Lower Rowlett Creek
Permit Term 2 Upper Spring Creek
NSQD Third Quartile
Permit Term 3 Lower Spring Creek

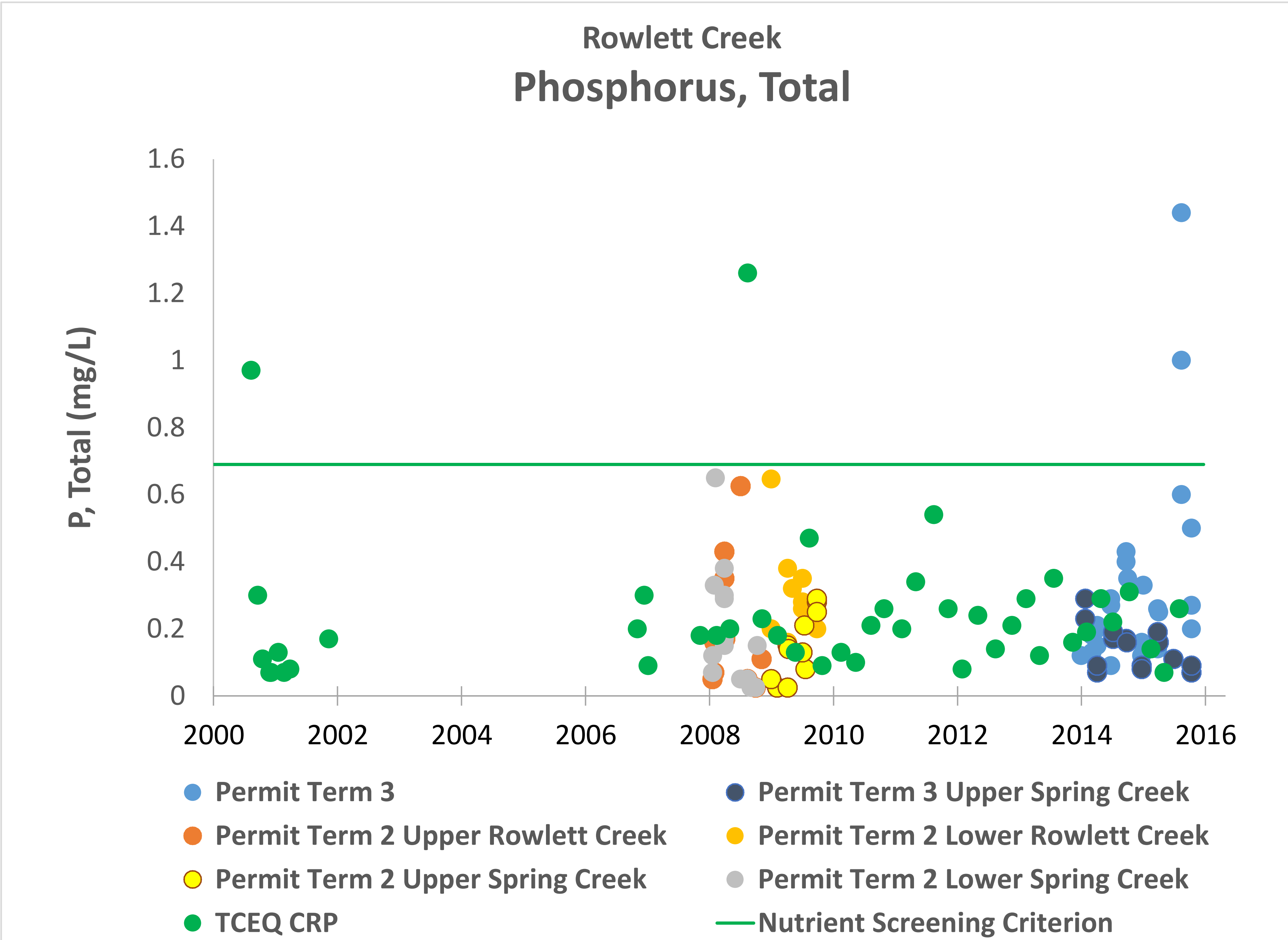


Rowlett Creek
Chemical Oxygen Demand
COD (mg/L)
180
160
140
120
100
80
60
40
20
0
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
Permit Term 3
Permit Term 3 Upper Spring Creek
Permit Term 2 Upper Rowlett Creek
Permit Term 2 Lower Rowlett Creek
Permit Term 2 Upper Spring Creek
Permit Term 2 Lower Spring Creek
NSQD Third Quartile

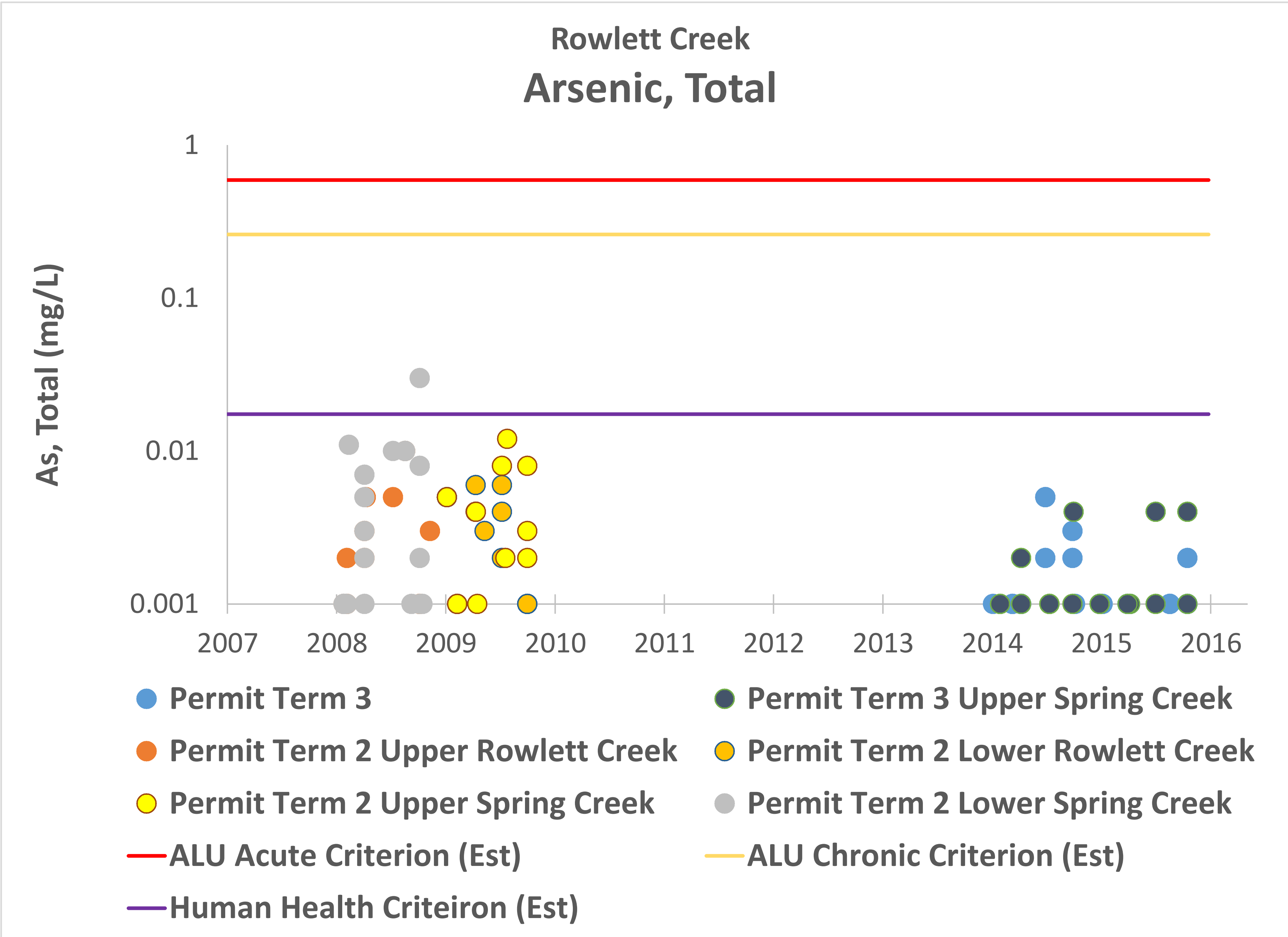


Rowlett Creek
Nitrogen, Total
N, Total (mg/L)
45
40
35
30
25
20
15
10
5
0
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
Permit Term 3
Permit Term 3 Upper Spring Creek
Permit Term 2 Upper Rowlett Creek
Permit Term 2 Lower Rowlett Creek
Permit Term 2 Upper Spring Creek
Permit Term 2 Lower Spring Creek
TCEQ CRP
NSQD Third Quartile

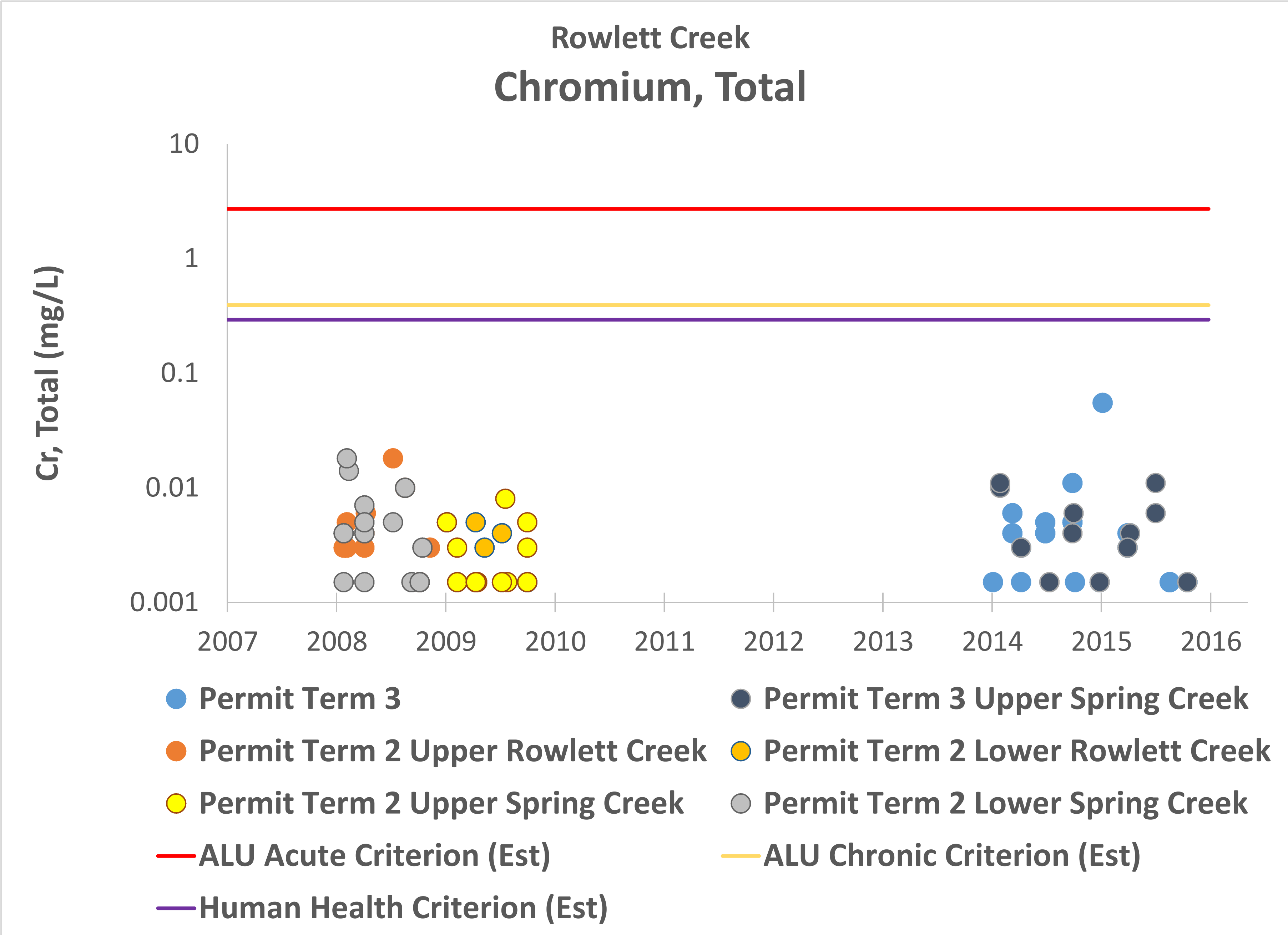

Rowlett Creek
Phosphorus, Dissolved
P, Dissolved (mg/L)
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
Permit Term 3
Permit Term 3 Upper Spring Creek
Permit Term 2 Upper Rowlett Creek
Permit Term 2 Lower Rowlett Creek
Permit Term 2 Upper Spring Creek
Permit Term 2 Lower Spring Creek

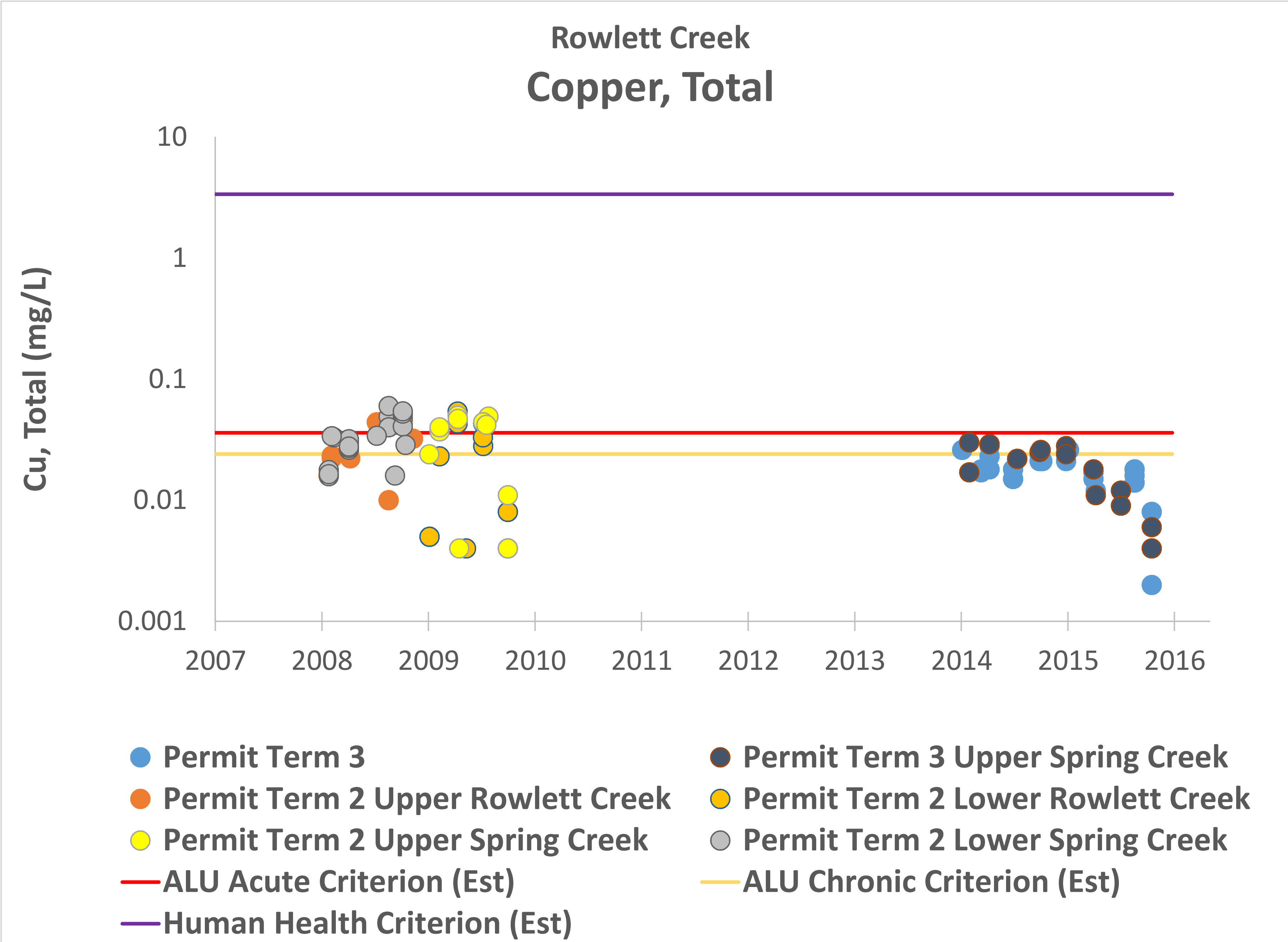


Rowlett Creek
Phosphorus, Total
P, Total (mg/L)
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
2000
2002
2004
2006
2008
2010
2012
2014
2016
Permit Term 3
Permit Term 3 Upper Spring Creek
Permit Term 2 Upper Rowlett Creek
Permit Term 2 Lower Rowlett Creek
Permit Term 2 Upper Spring Creek
Permit Term 2 Lower Spring Creek
TCEQ CRP
Nutrient Screening Criterion

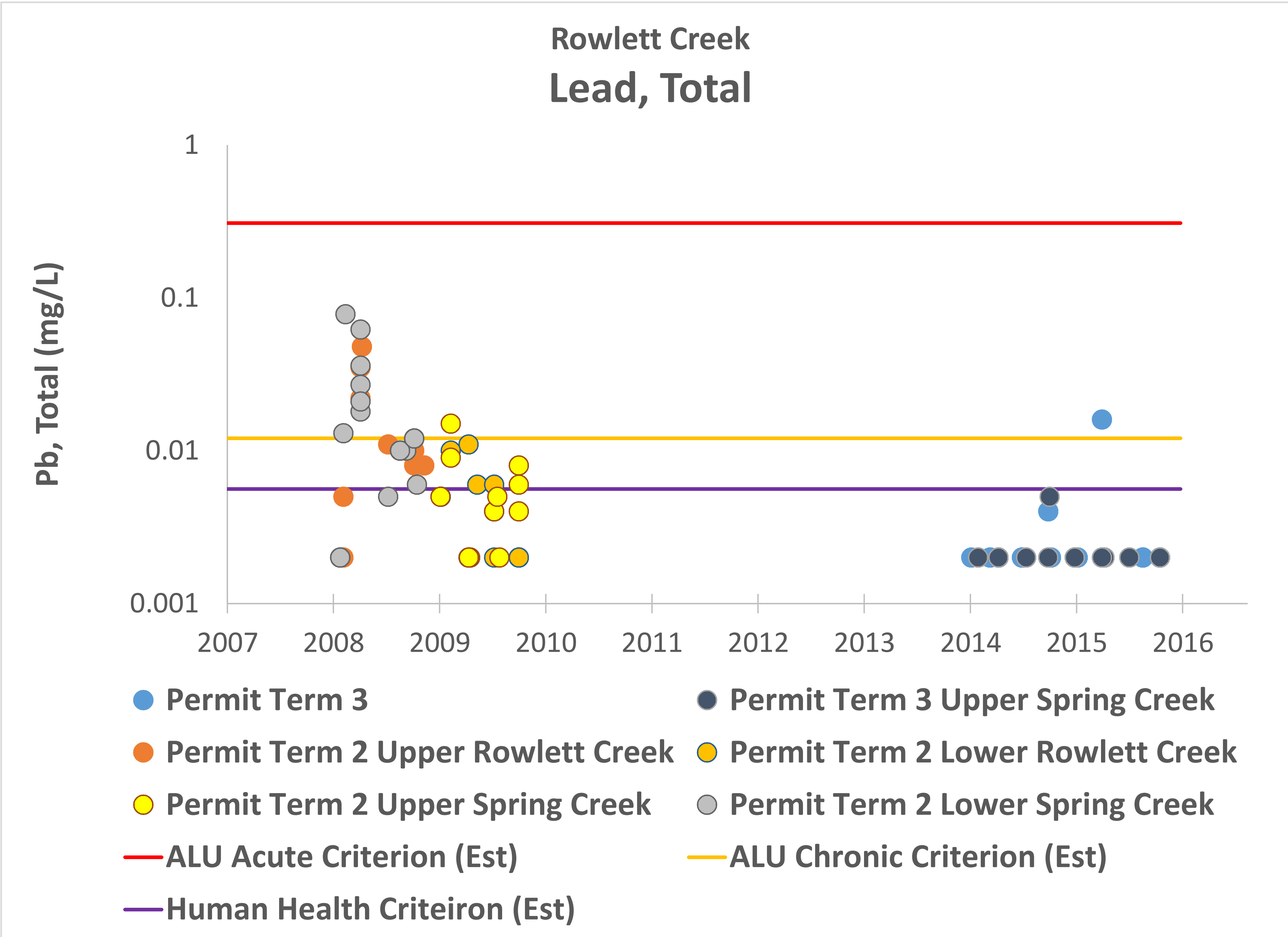


Rowlett Creek
Arsenic, Total
As, Total (mg/L)
1
0.1
0.01
0.001
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
Permit Term 3
Permit Term 3 Upper Spring Creek
Permit Term 2 Upper Rowlett Creek
Permit Term 2 Lower Rowlett Creek
Permit Term 2 Upper Spring Creek
Permit Term 2 Lower Spring Creek
ALU Acute Criterion (Est)
ALU Chronic Criterion (Est)
Human Health Criteiron (Est)

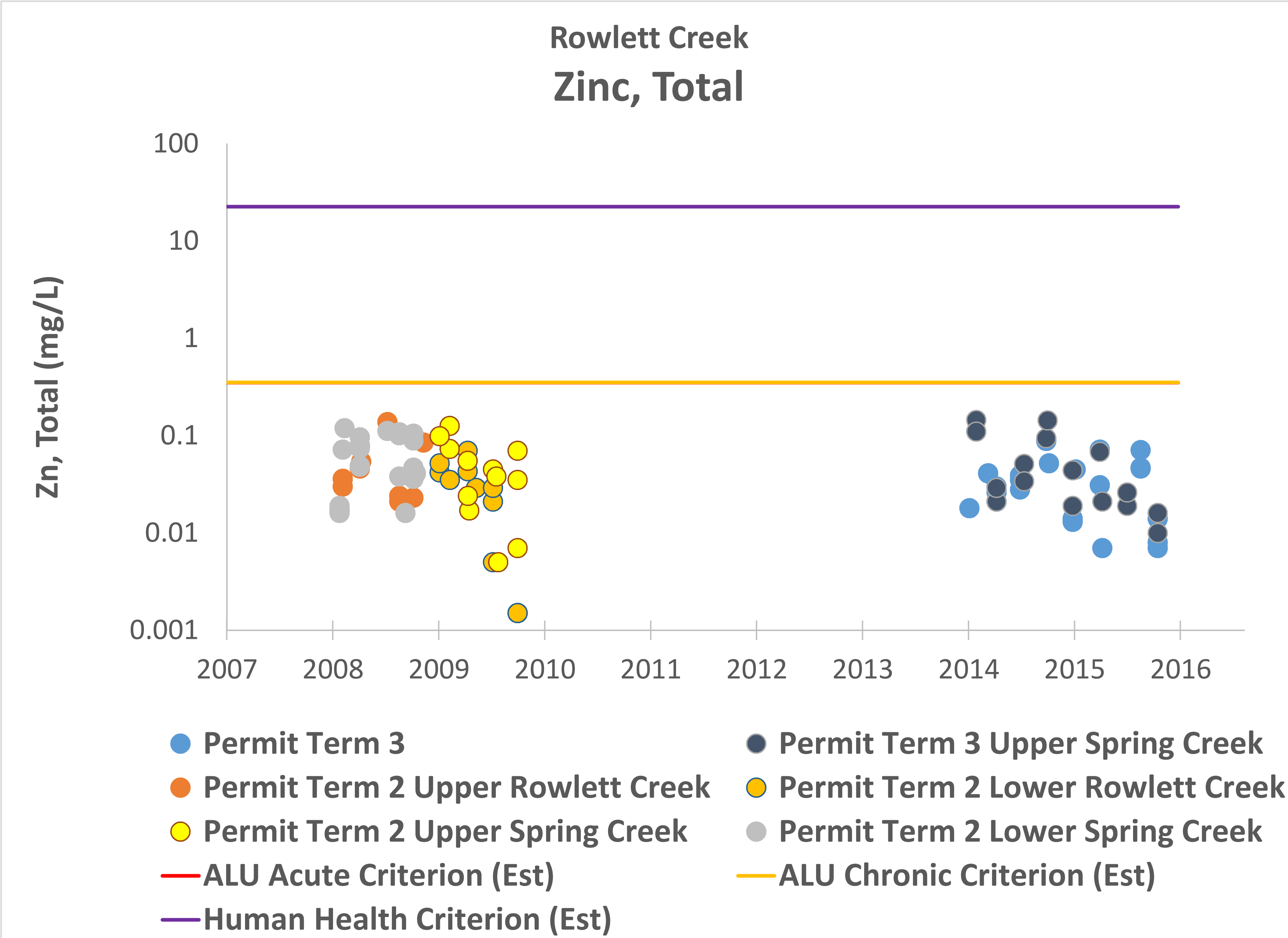

Rowlett Creek
Chromium, Total
Cr, Total (mg/L)
10
1
0.1
0.01
0.001
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
Permit Term 3
Permit Term 3 Upper Spring Creek
Permit Term 2 Upper Rowlett Creek
Permit Term 2 Lower Rowlett Creek
Permit Term 2 Upper Spring Creek
Permit Term 2 Lower Spring Creek
ALU Acute Criterion (Est)
ALU Chronic Criterion (Est)
Human Health Criterion (Est)



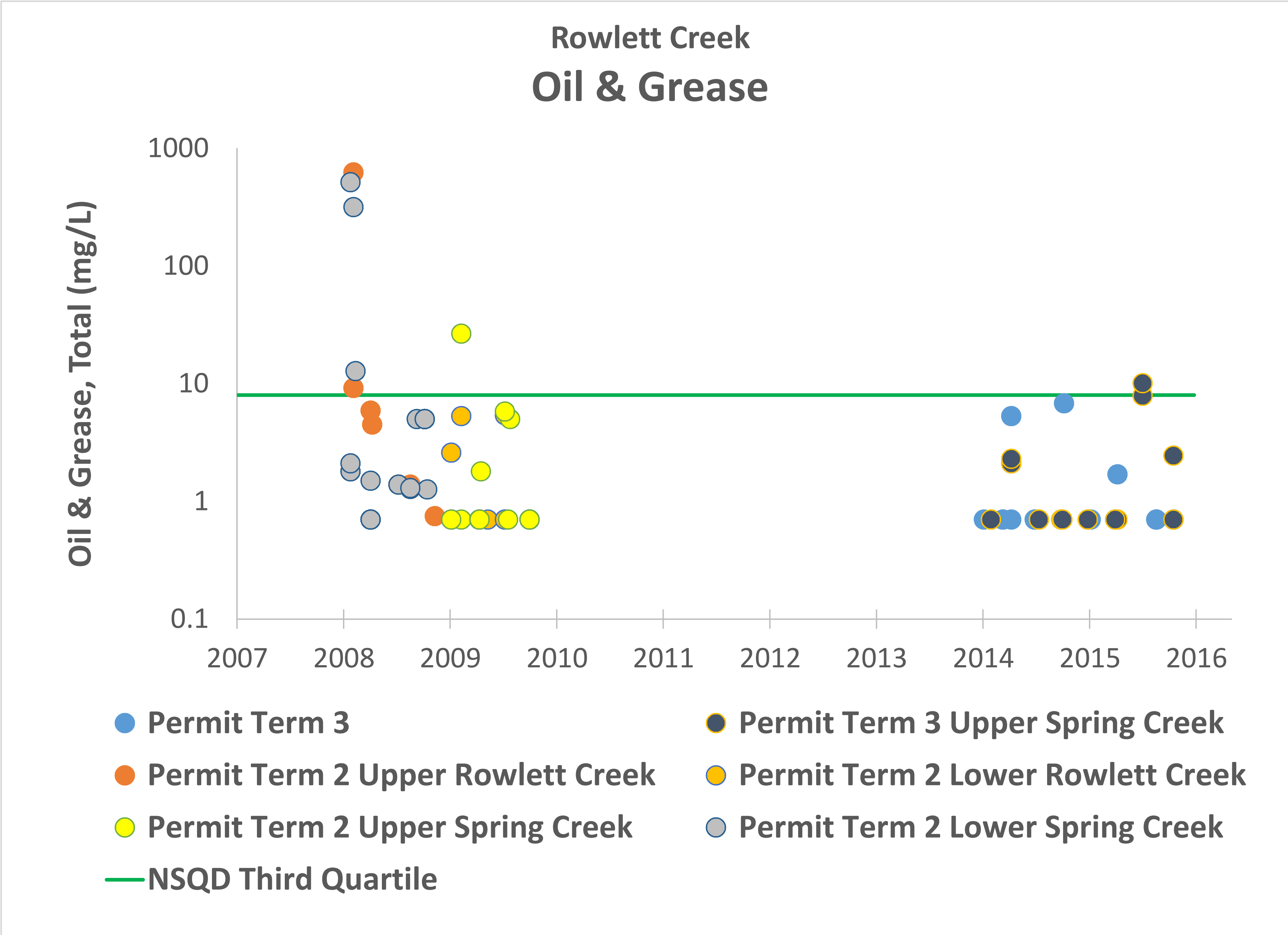
Rowlett Creek
Copper, Total
Cu, Total (mg/L)
10
1
0.1
0.01
0.001
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
Permit Term 3
Permit Term 3 Upper Spring Creek
Permit Term 2 Upper Rowlett Creek
Permit Term 2 Lower Rowlett Creek
Permit Term 2 Upper Spring Creek
Permit Term 2 Lower Spring Creek
ALU Acute Criterion (Est)
ALU Chronic Criterion (Est)
Human Health Criterion (Est)



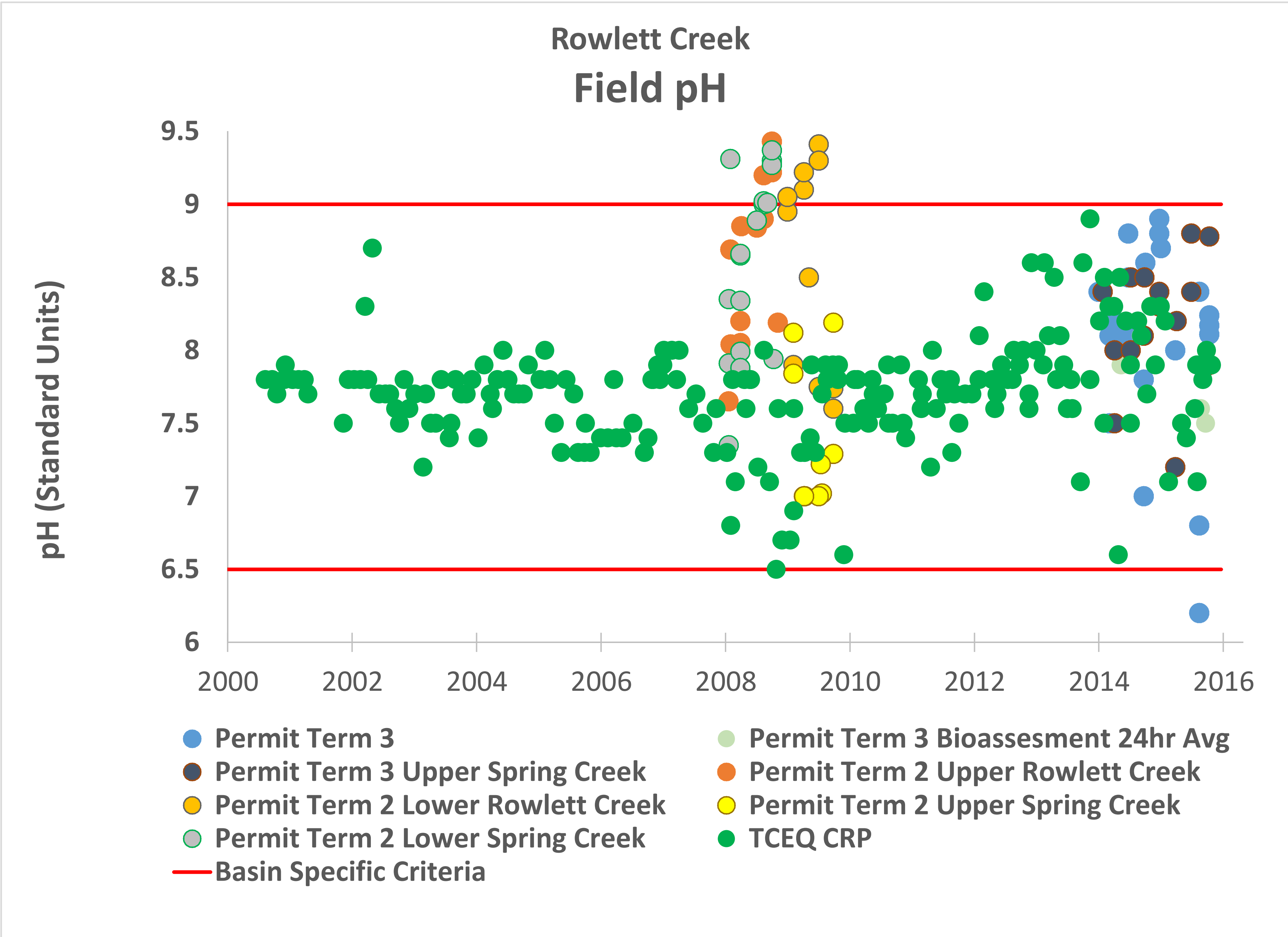
Rowlett Creek
Lead, Total
Pb, Total (mg/L)
1
0.1
0.01
0.001
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
Permit Term 3
Permit Term 3 Upper Spring Creek
Permit Term 2 Upper Rowlett Creek
Permit Term 2 Lower Rowlett Creek
Permit Term 2 Upper Spring Creek
Permit Term 2 Lower Spring Creek
ALU Acute Criterion (Est)
ALU Chronic Criterion (Est)
Human Health Criteiron (Est)

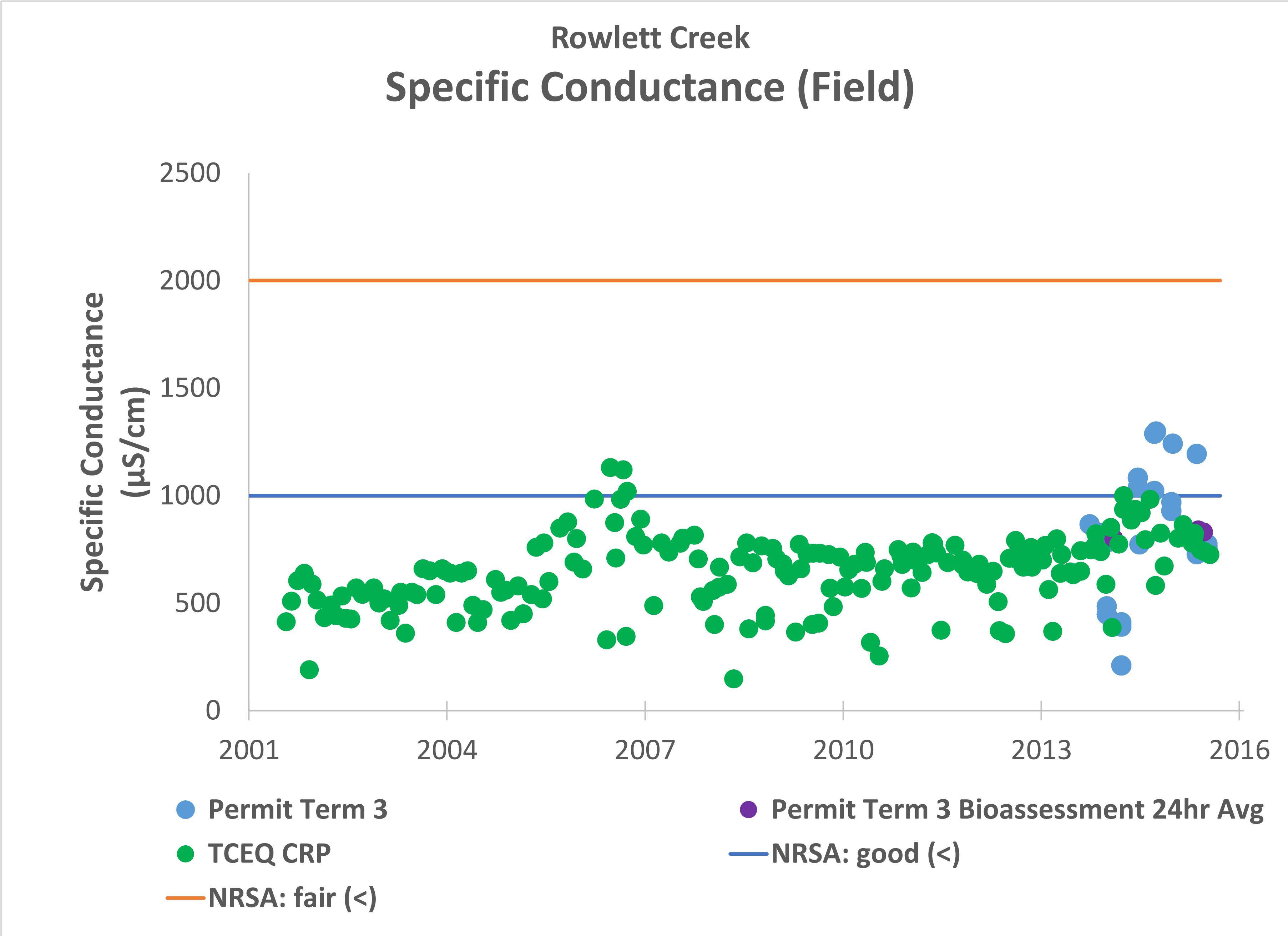


Rowlett Creek
Zinc, Total
Zn, Total (mg/L)
100
10
1
0.1
0.01
0.001
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
Permit Term 3
Permit Term 3 Upper Spring Creek
Permit Term 2 Upper Rowlett Creek
Permit Term 2 Lower Rowlett Creek
Permit Term 2 Upper Spring Creek
Permit Term 2 Lower Spring Creek
ALU Acute Criterion (Est)
ALU Chronic Criterion (Est)
Human Health Criterion (Est)

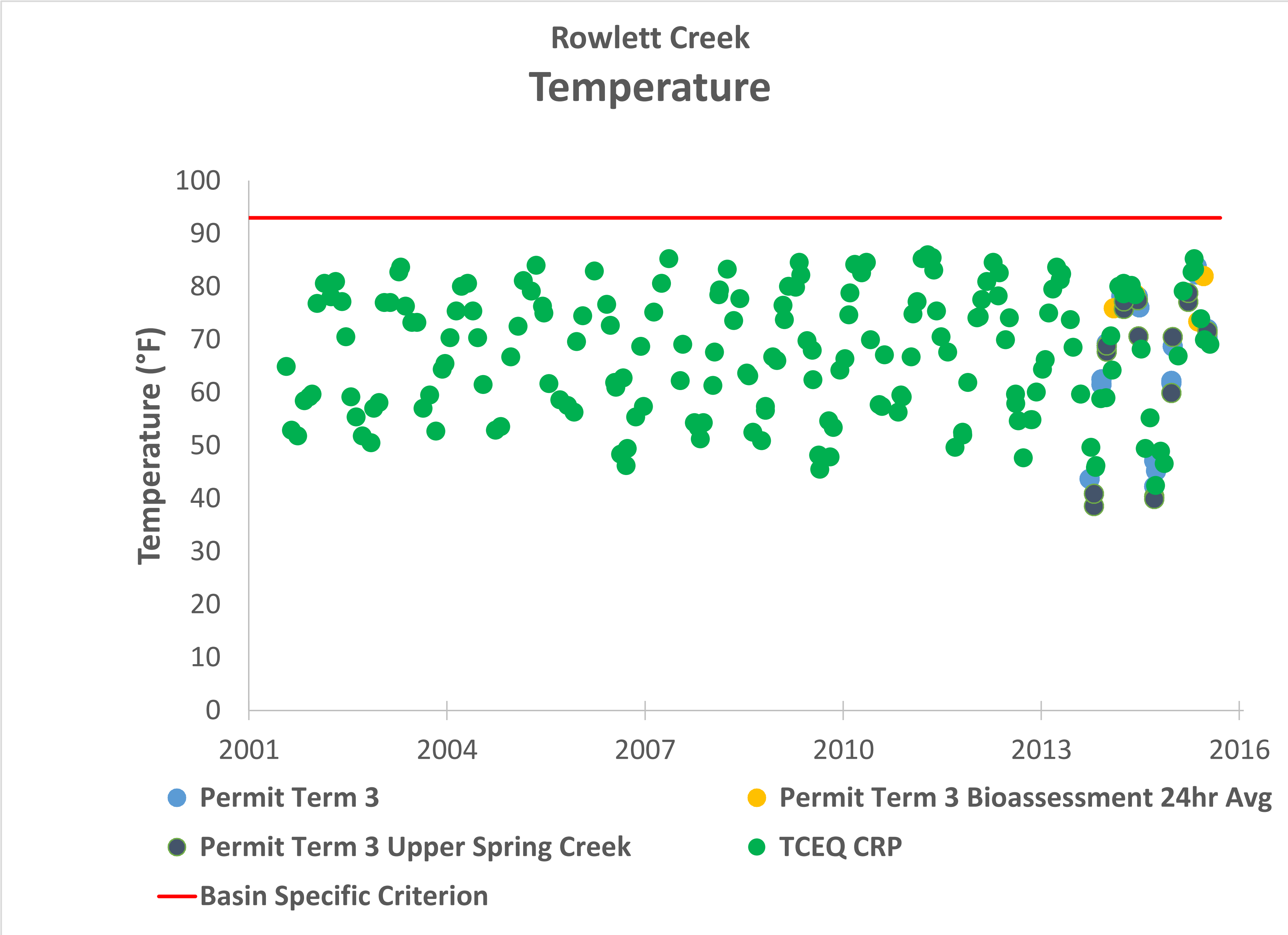


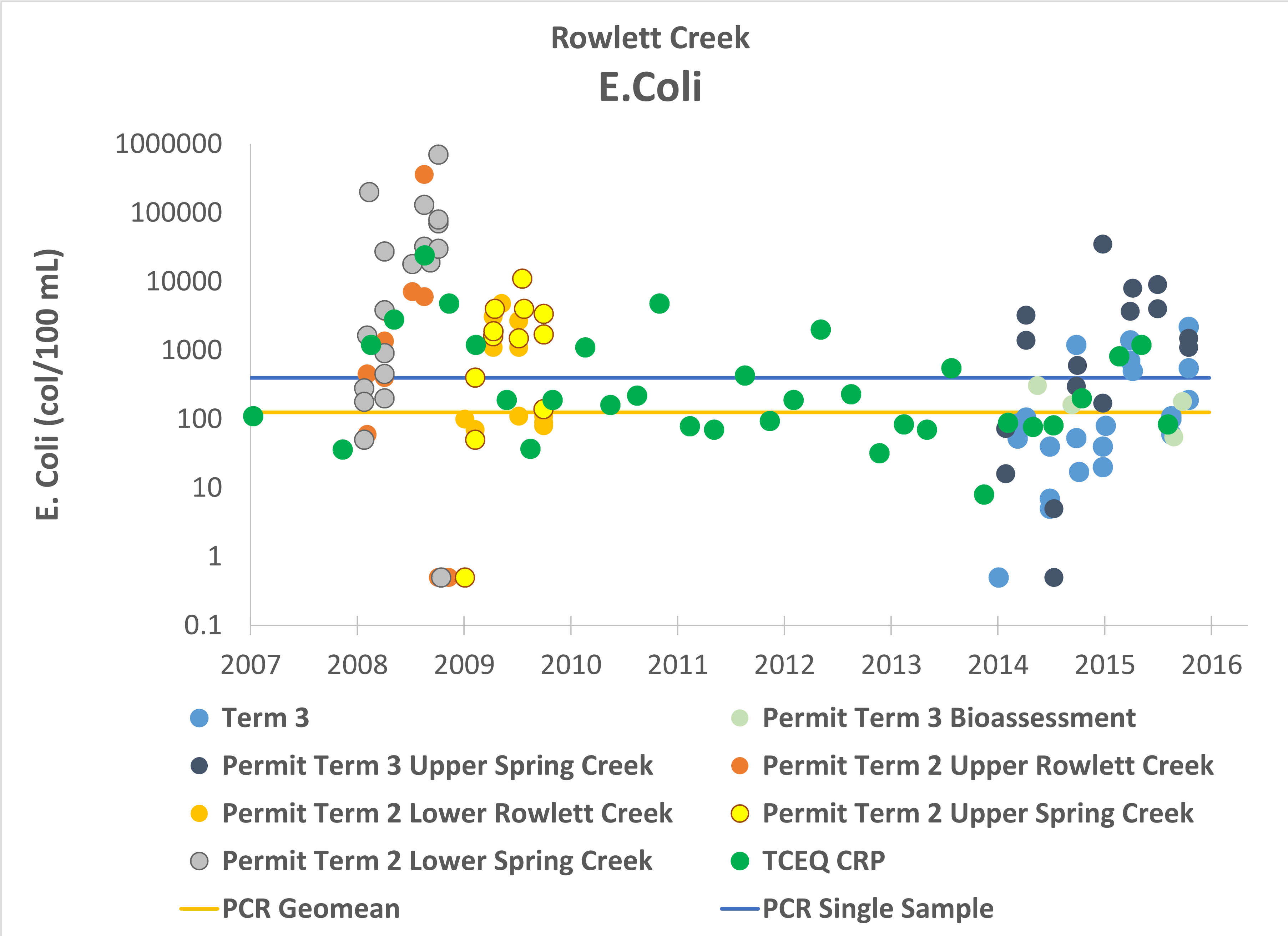
Rowlett Creek
Oil & Grease
Oil & Grease, Total (mg/L)
1000
100
10
1
0.1
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
Permit Term 3
Permit Term 3 Upper Spring Creek
Permit Term 2 Upper Rowlett Creek
Permit Term 2 Lower Rowlett Creek
Permit Term 2 Upper Spring Creek
Permit Term 2 Lower Spring Creek
NSQD Third Quartile


Rowlett Creek
Field pH
pH (Standard Units)
9.5
9
8.5
8
7.5
7
6.5
6
2000
2002
2004
2006
2008
2010
2012
2014
2016
Permit Term 3
Permit Term 3 Bioassesment 24hr Avg
Permit Term 3 Upper Spring Creek
Permit Term 2 Upper Rowlett Creek
Permit Term 2 Lower Rowlett Creek
Permit Term 2 Upper Spring Creek
Permit Term 2 Lower Spring Creek
TCEQ CRP
Basin Specific Criteria

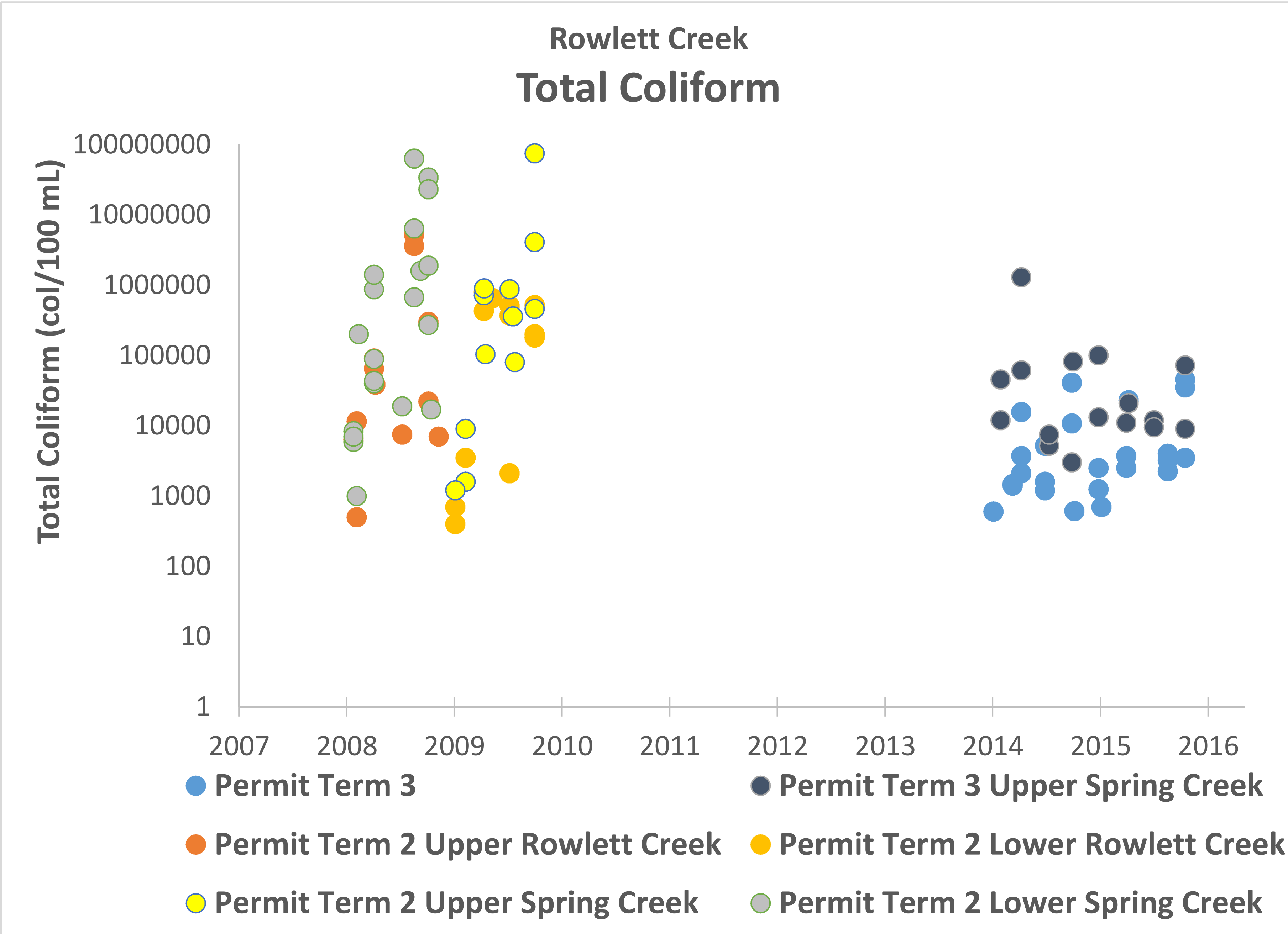


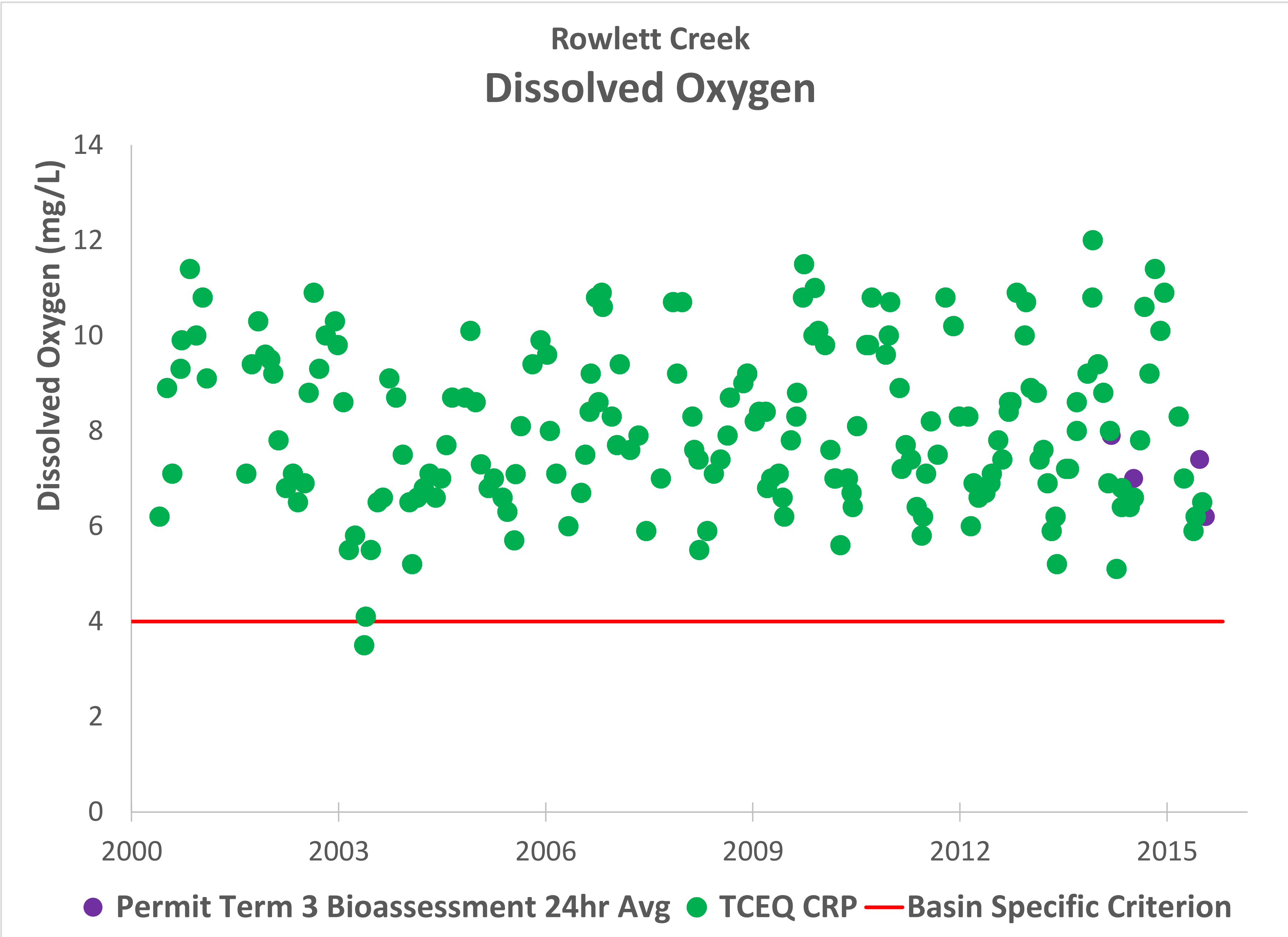
Rowlett Creek
Specific Conductance (Field)
Specific Conductance (µS/cm)
2500
2000
1500
1000
500
0
2001
2004
2007
2010
2013
2016
Permit Term 3
Permit Term 3 Bioassessment 24hr Avg
TCEQ CRP
NRSA: good (<)
NRSA: fair (<)


Rowlett Creek
Temperature
Temperature (°F)
100
90
80
70
60
50
40
30
20
10
0
2001
2004
2007
2010
2013
2016
Permit Term 3
Permit Term 3 Bioassessment 24hr Avg
Permit Term 3 Upper Spring Creek
TCEQ CRP
Basin Specific Criterion

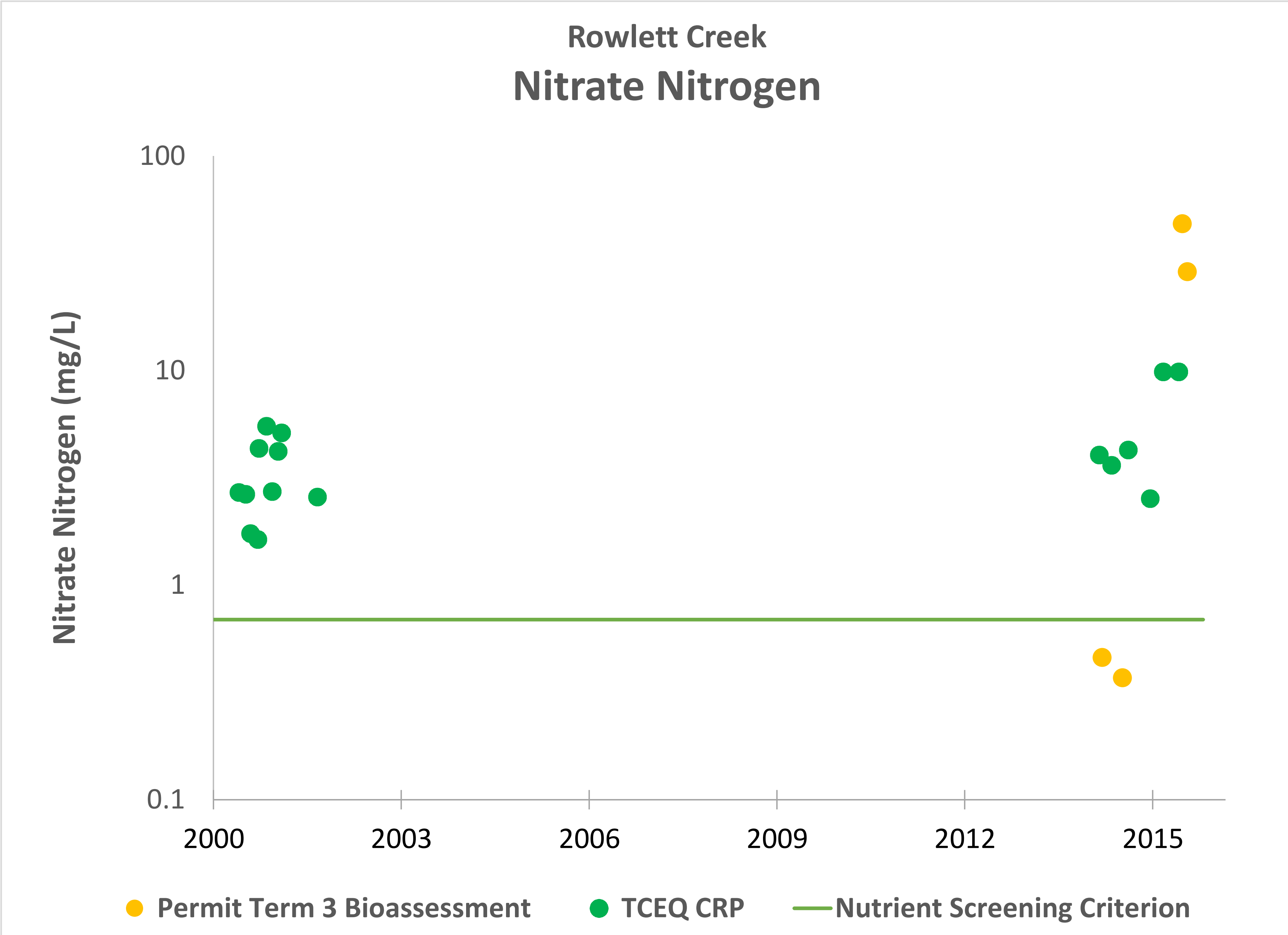


Rowlett Creek
E.Coli
E. Coli (col/100 mL)
1000000
100000
10000
1000
100
10
1
0.1
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
Term 3
Permit Term 3 Bioassessment
Permit Term 3 Upper Spring Creek
Permit Term 2 Upper Rowlett Creek
Permit Term 2 Lower Rowlett Creek
Permit Term 2 Upper Spring Creek
Permit Term 2 Lower Spring Creek
TCEQ CRP
PCR Geomean
PCR Single Sample

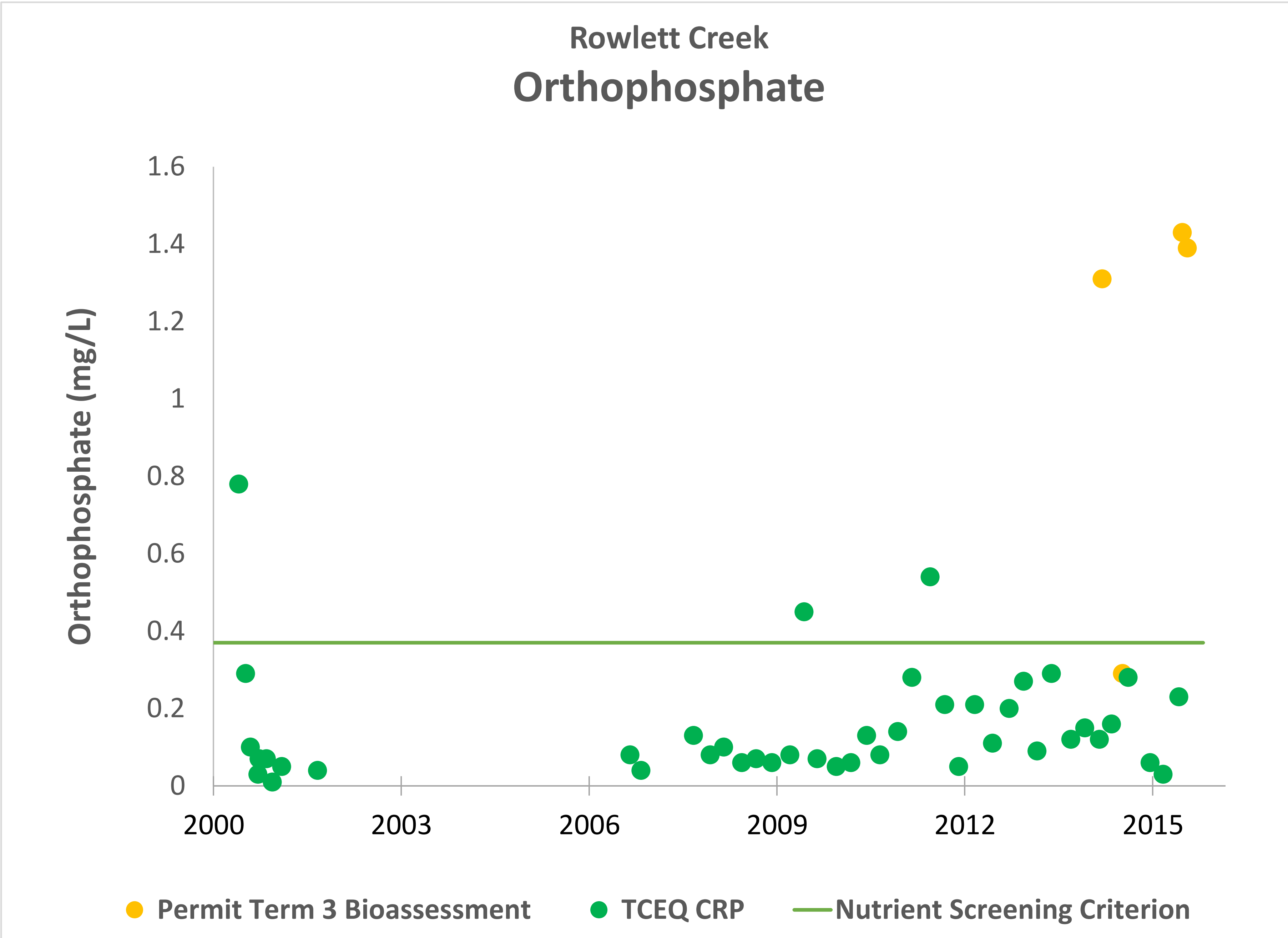

Rowlett Creek
Total Coliform
Total Coliform (col/100 mL)
100000000
10000000
1000000
100000
10000
1000
100
10
1
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
Permit Term 3
Permit Term 3 Upper Spring Creek
Permit Term 2 Upper Rowlett Creek
Permit Term 2 Lower Rowlett Creek
Permit Term 2 Upper Spring Creek
Permit Term 2 Lower Spring Creek



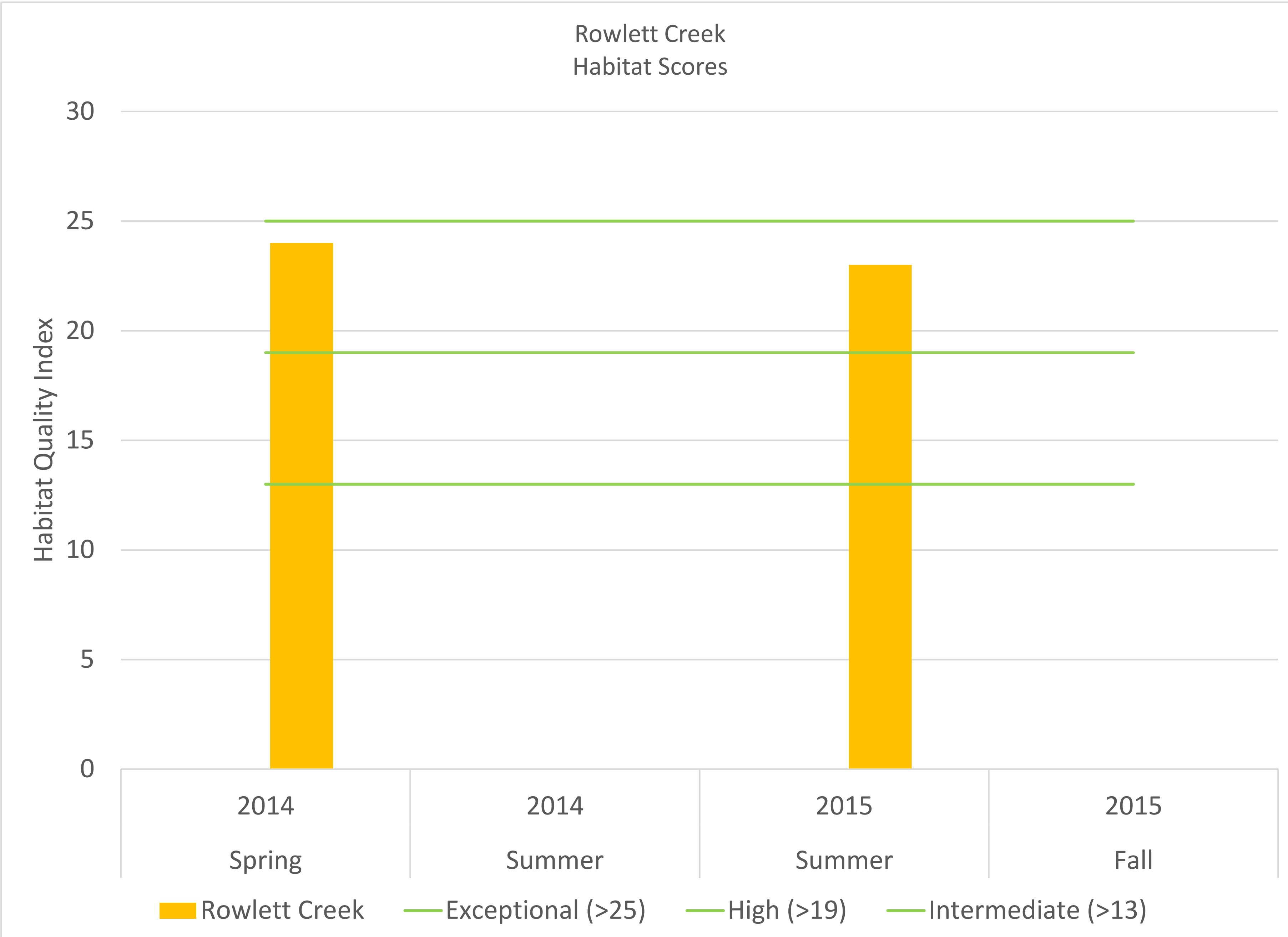
Rowlett Creek
Dissolved Oxygen
Dissolved Oxygen (mg/L)
0
2
4
6
8
10
12
14
2000
2003
2006
2009
2012
2015
Permit Term 3 Bioassessment 24hr Avg
TCEQ CRP
Basin Specific Criterion

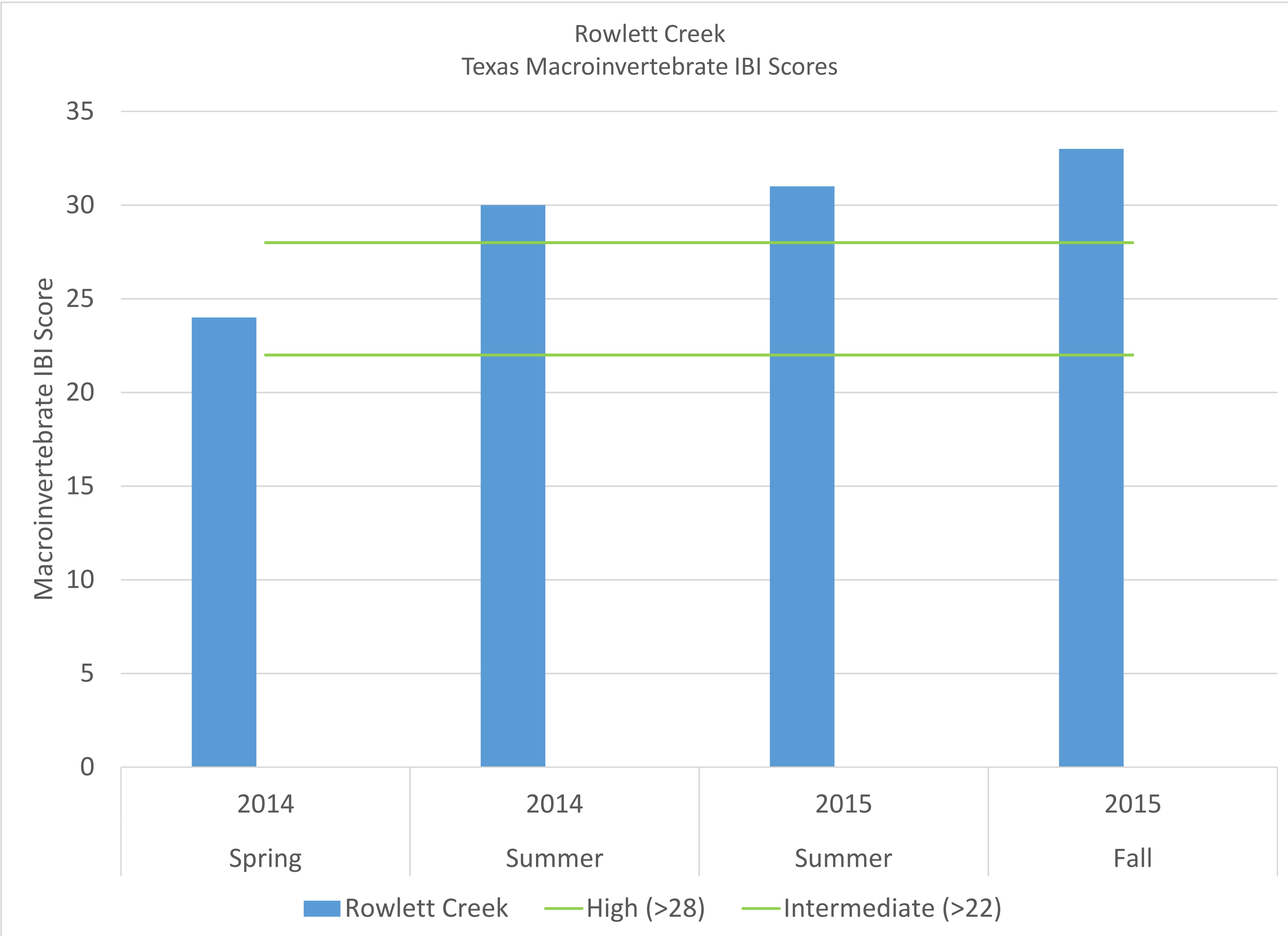


Rowlett Creek
Nitrate Nitrogen
100
10
1
0.1
Nitrate Nitrogen (mg/L)
2000
2003
2006
2009
2012
2015
Permit Term 3 Bioassessment
TCEQ CRP
Nutrient Screening Criterion

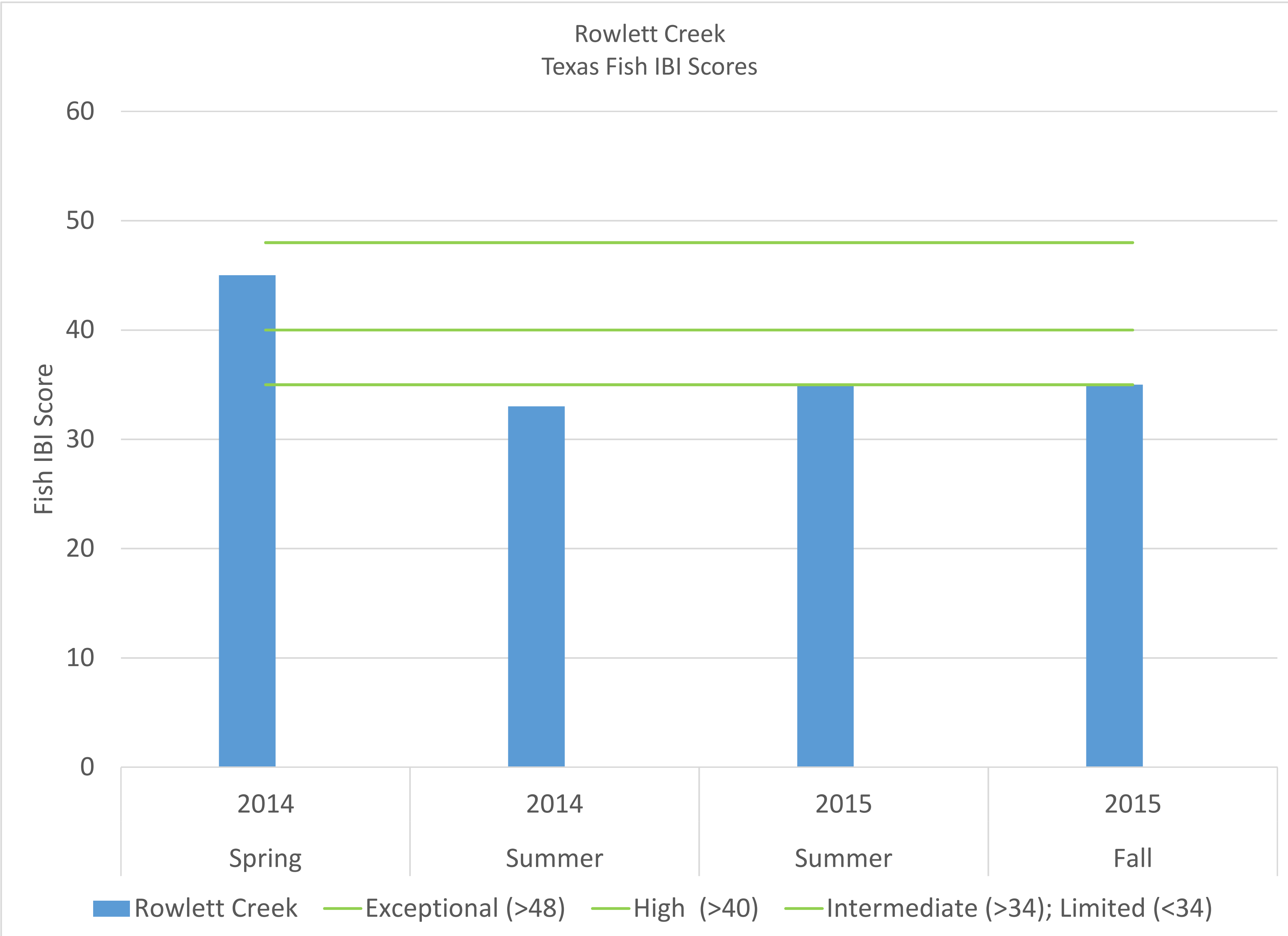


Rowlett Creek
Orthophosphate
Orthophosphate (mg/L)
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
2000
2003
2006
2009
2012
2015
Permit Term 3 Bioassessment
TCEQ CRP
Nutrient Screening Criterion


Rowlett Creek
Habitat Scores
Habitat Quality Index
30
25
20
15
10
5
0
2014
Spring
2014
Summer
2015
Summer
2015
Fall
Rowlett Creek
Exceptional (>25)
High (>19)
Intermediate (>13)

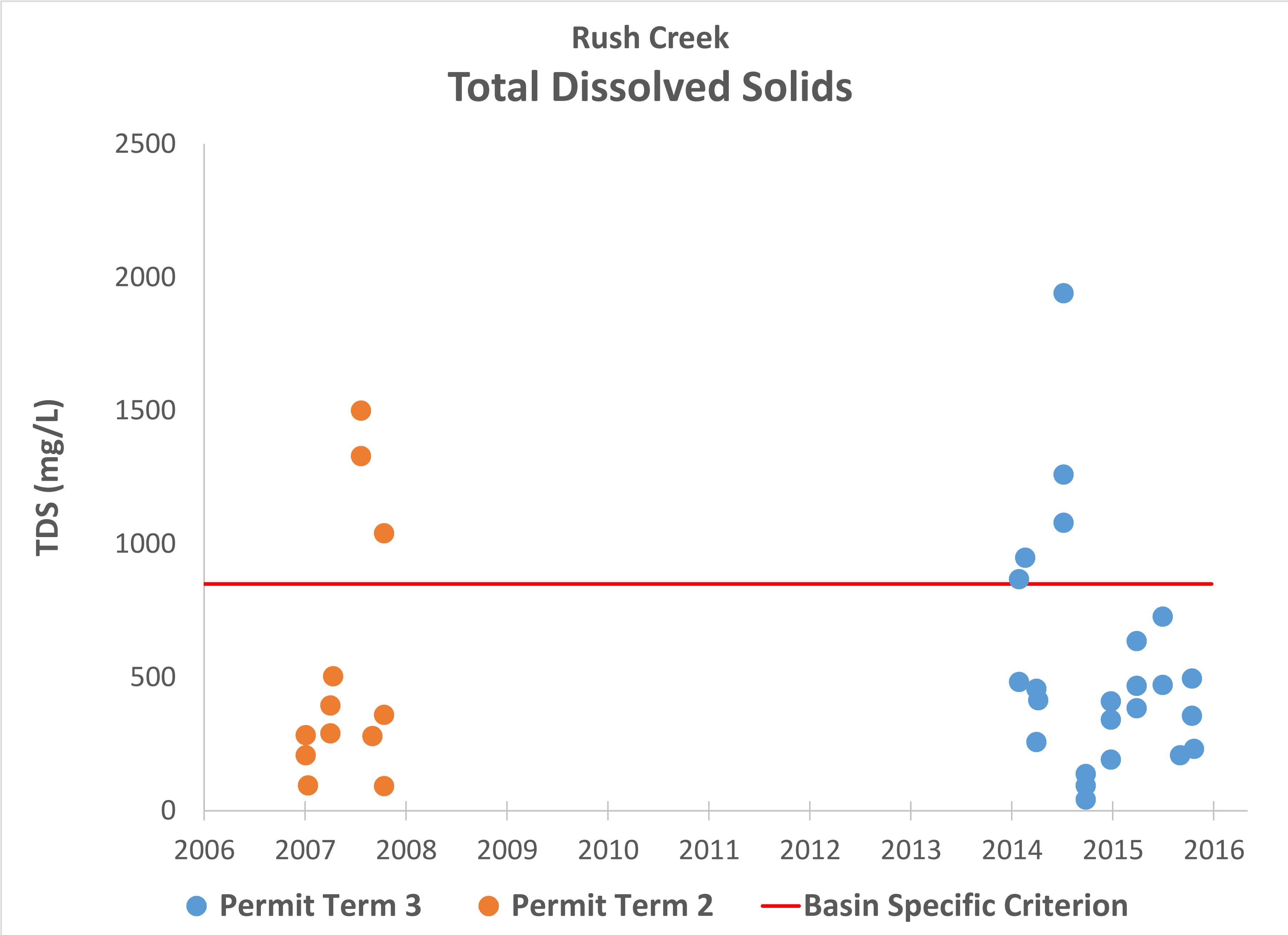


Rowlett Creek
Texas Macroinvertebrate IBI Scores
Macroinvertebrate IBI Score
35
30
25
20
15
10
5
0
2014
Spring
2014
Summer
2015
Summer
2015
Fall
Rowlett Creek
High (>28)
Intermediate (>22)

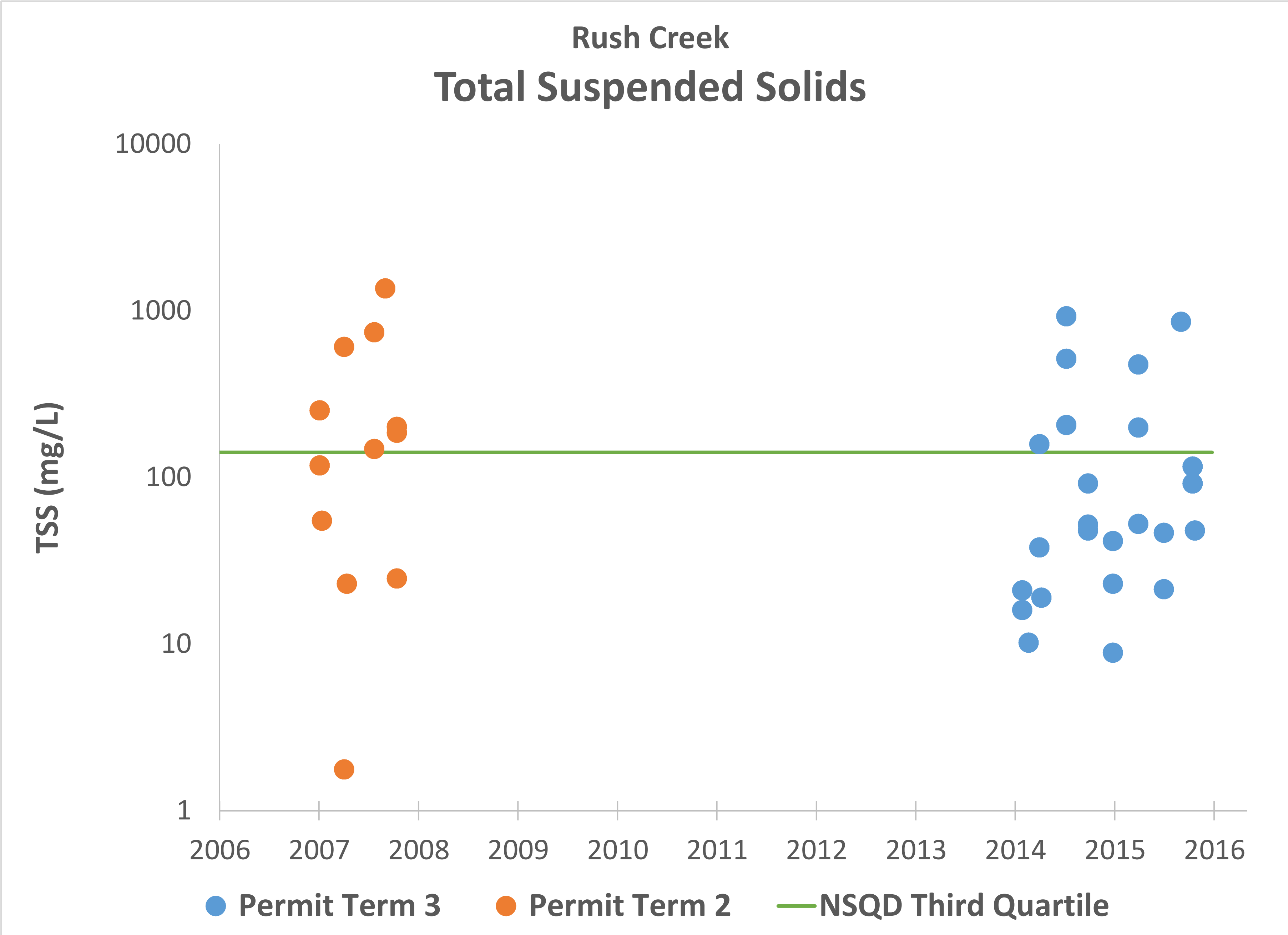

Rowlett Creek
Texas Fish IBI Scores
Fish IBI Score
60
50
40
30
20
10
0
2014
Spring
2014
Summer
2015
Summer
2015
Fall
Rowlett Creek
Exceptional (>48)
High (>40)
Intermediate (>34); Limited (<34)

Appendix V

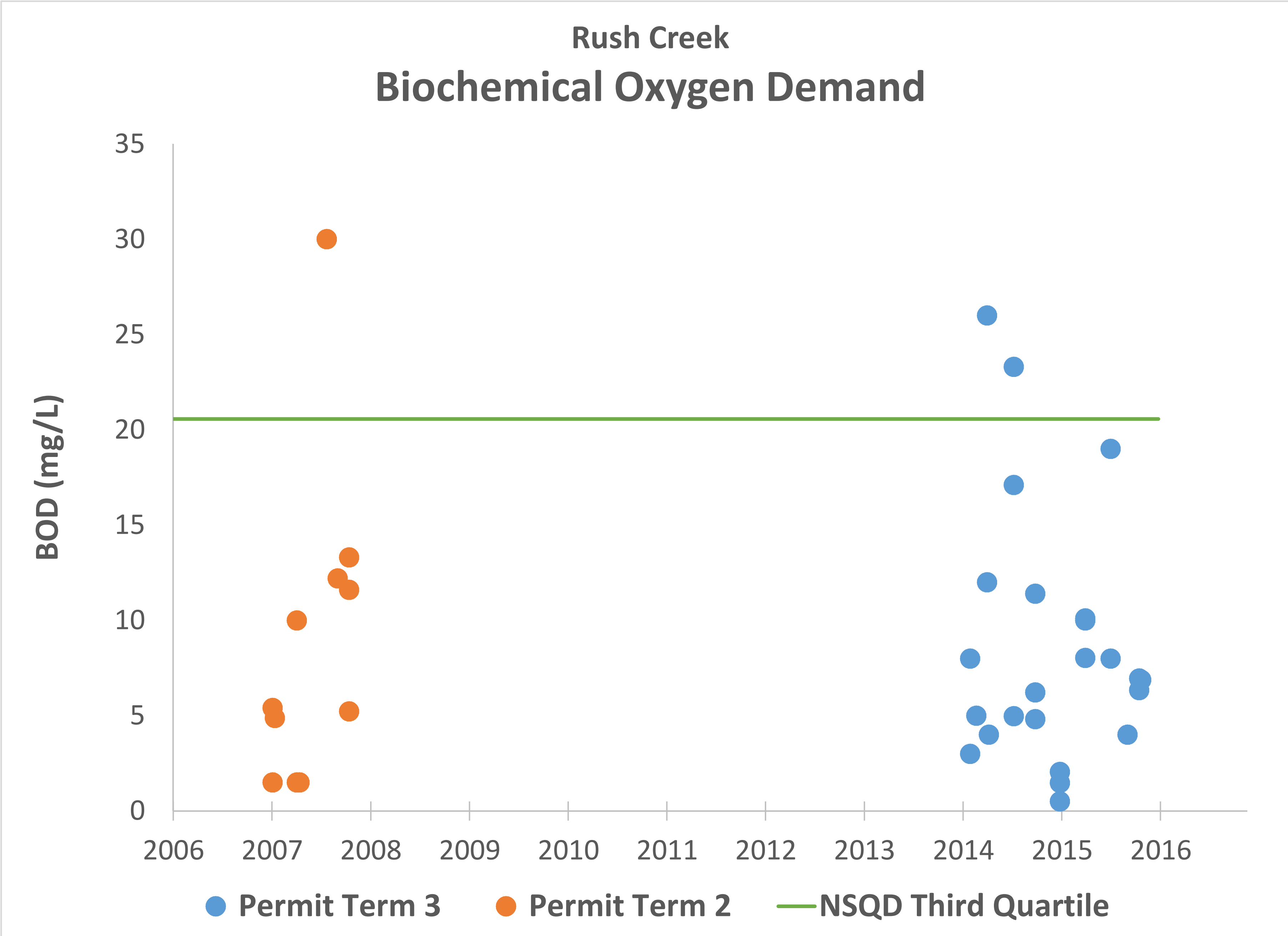
Rush Creek Water Quality
Data Graphs

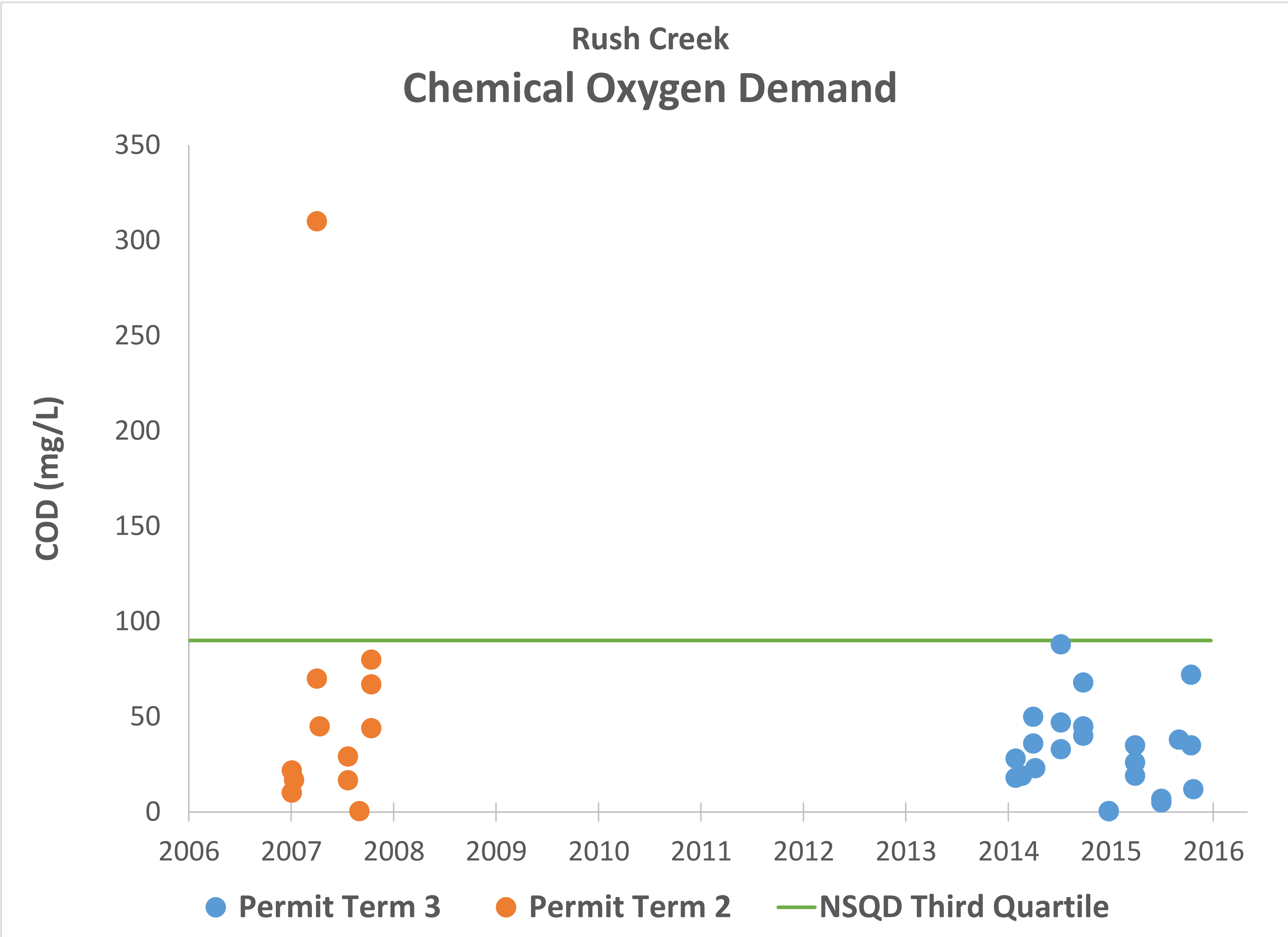


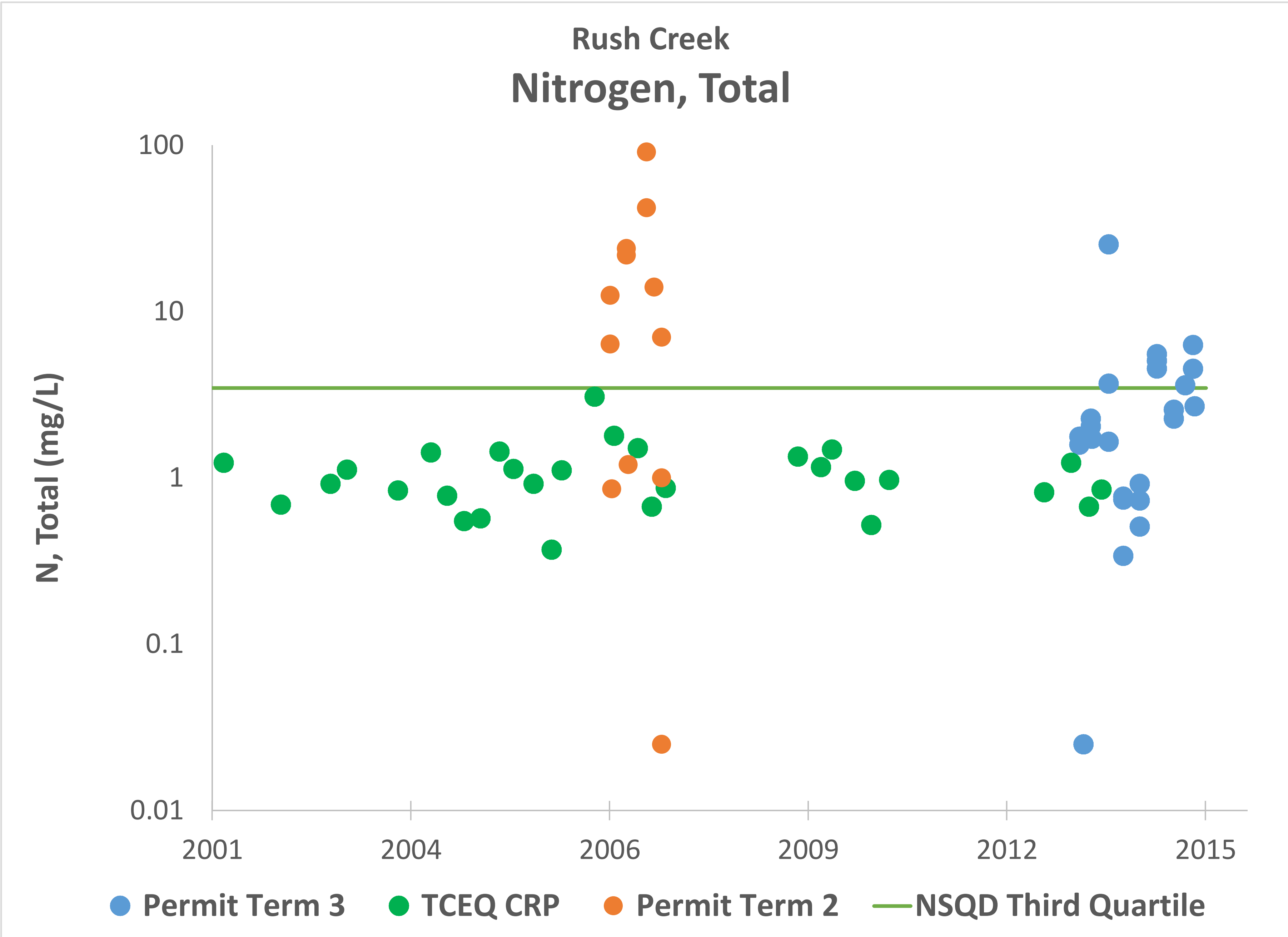
Rush Creek
Total Dissolved Solids
TDS (mg/L)
2500
2000
1500
1000
500
0
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
Permit Term 3
Permit Term 2
Basin Specific Criterion

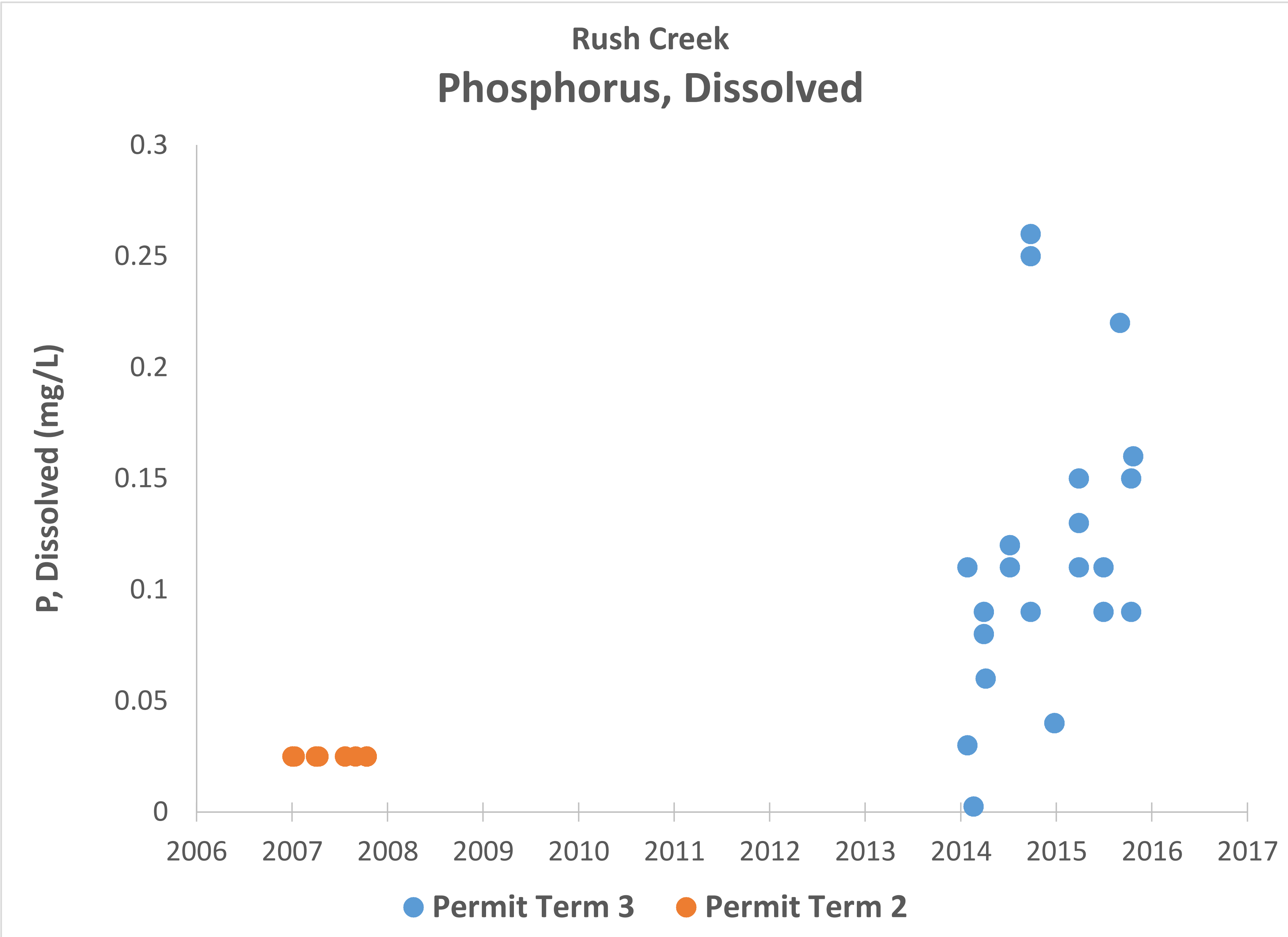


Rush Creek
Total Suspended Solids
TSS (mg/L)
10000
1000
100
10
1
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
Permit Term 3
Permit Term 2
NSQD Third Quartile

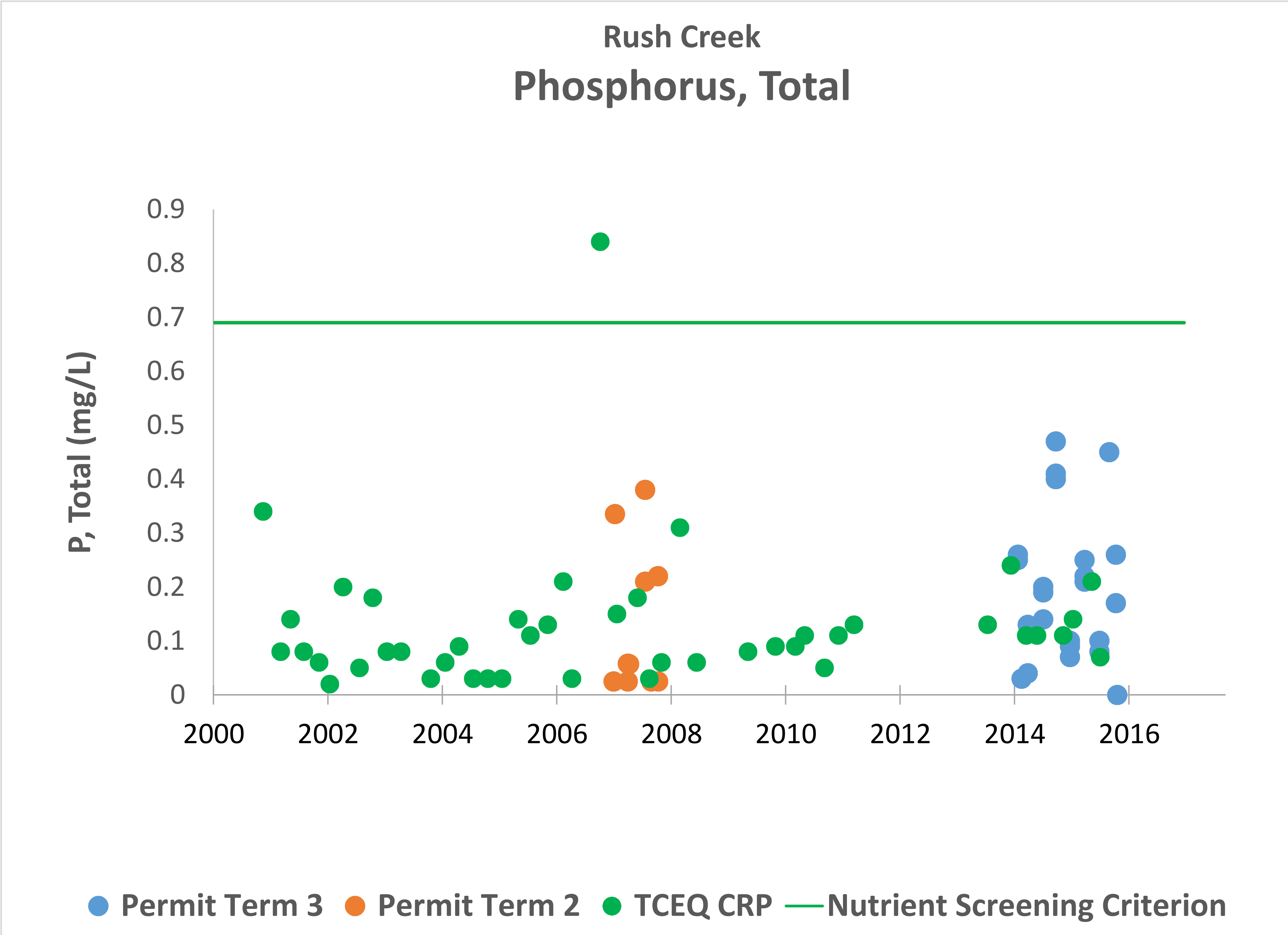

Rush Creek
Biochemical Oxygen Demand
BOD (mg/L)
0
5
10
15
20
25
30
35
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
Permit Term 3
Permit Term 2
NSQD Third Quartile


Rush Creek
Chemical Oxygen Demand
COD (mg/L)
350
300
250
200
150
100
50
0
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
Permit Term 3
Permit Term 2
NSQD Third Quartile

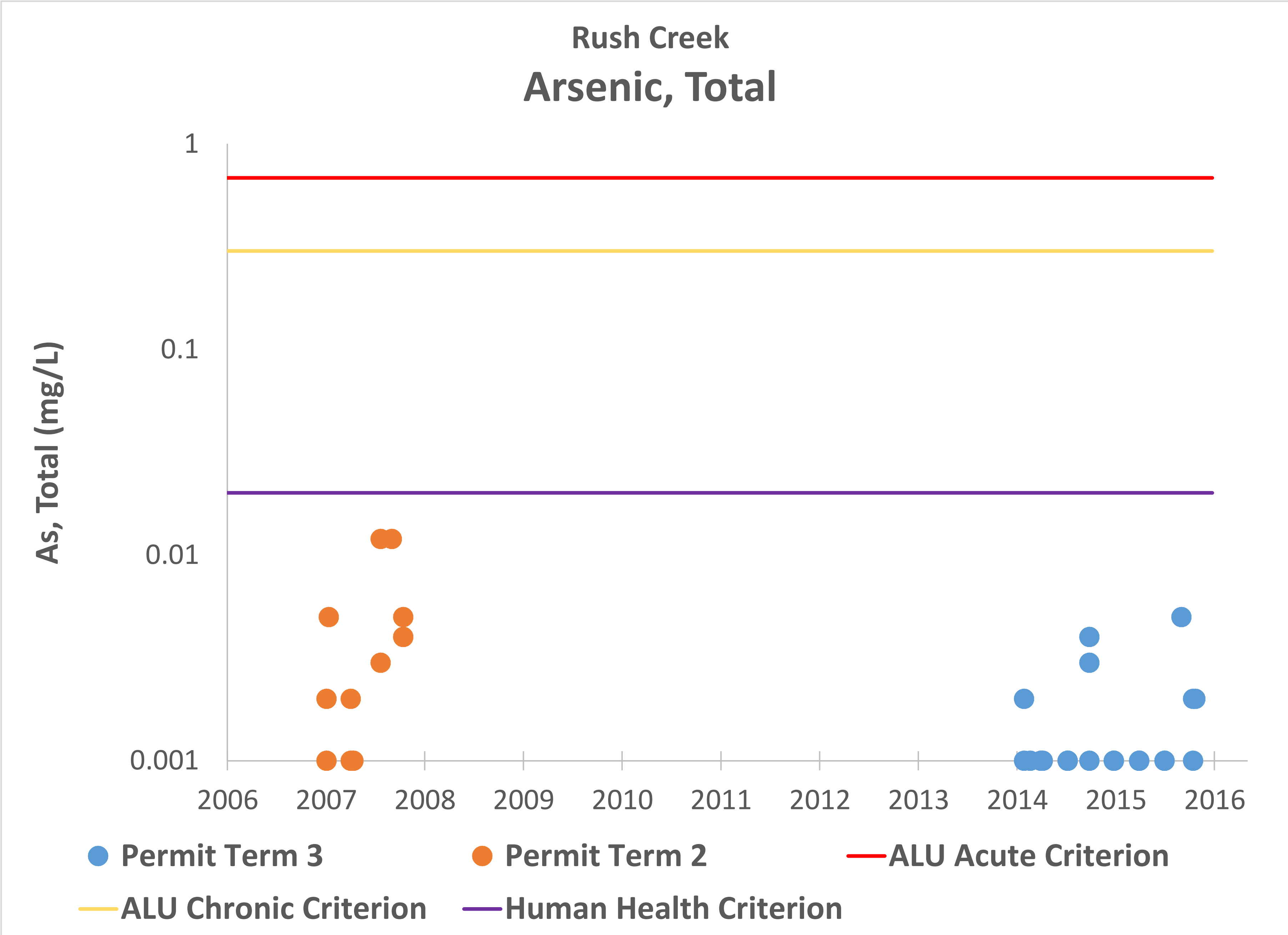

Rush Creek
Nitrogen, Total
N, Total (mg/L)
100
10
1
0.1
0.01
2001
2004
2006
2009
2012
2015
Permit Term 3
TCEQ CRP
Permit Term 2
NSQD Third Quartile

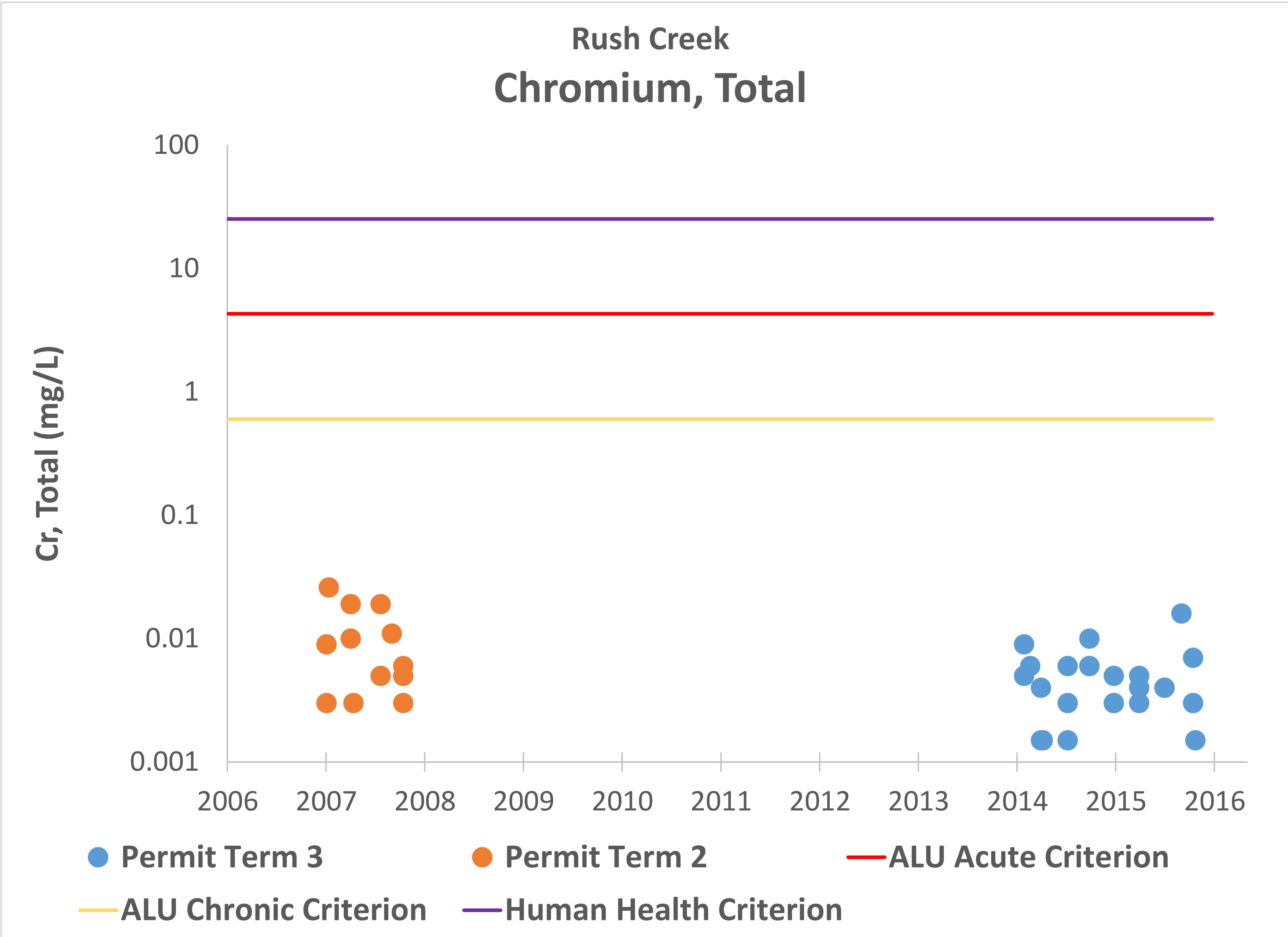


Rush Creek
Phosphorus, Dissolved
P, Dissolved (mg/L)
0.3
0.25
0.2
0.15
0.1
0.05
0
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
Permit Term 3
Permit Term 2

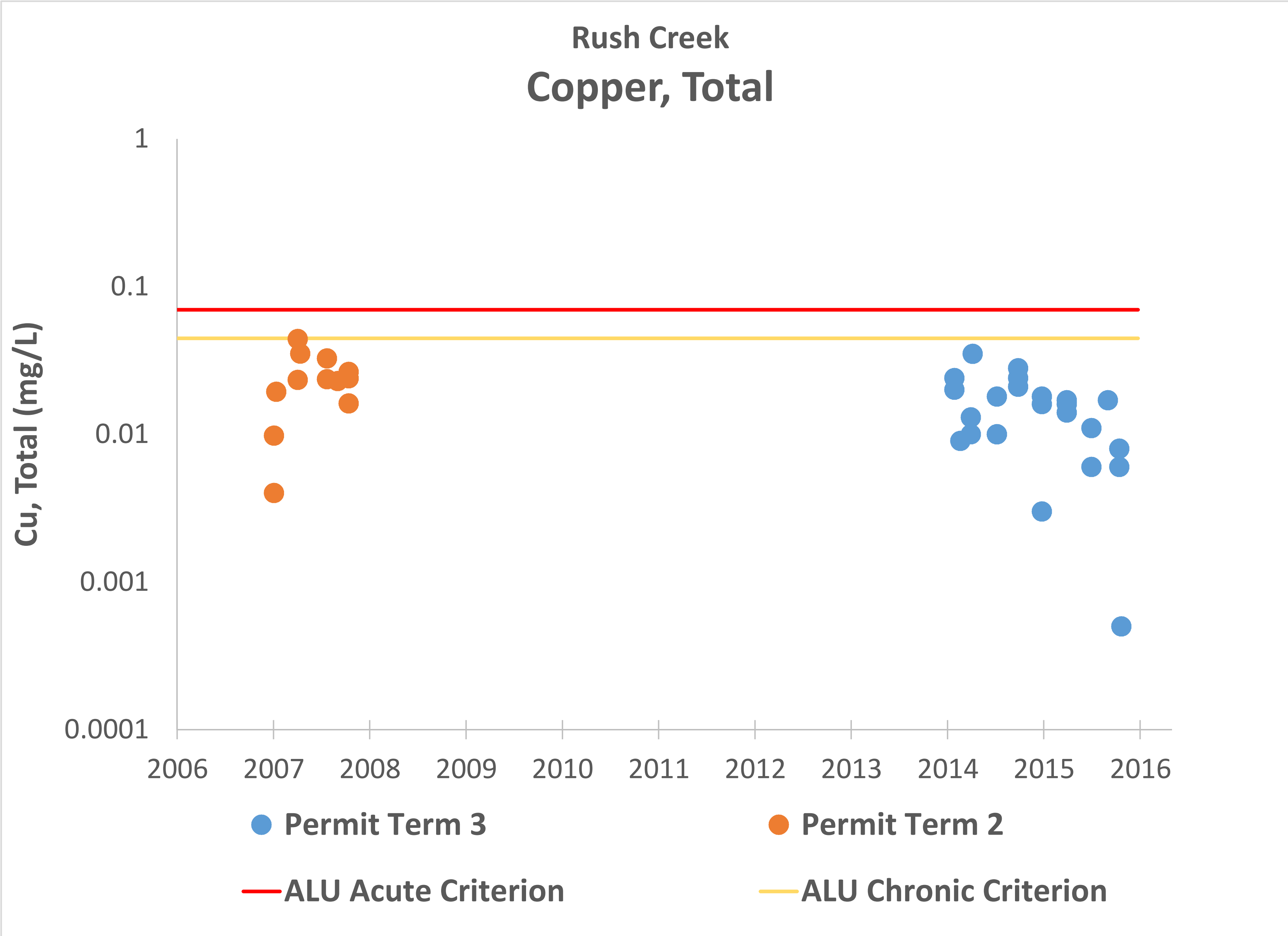


Rush Creek
Phosphorus, Total
P, Total (mg/L)
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
2000
2002
2004
2006
2008
2010
2012
2014
2016
Permit Term 3
Permit Term 2
TCEQ CRP
Nutrient Screening Criterion

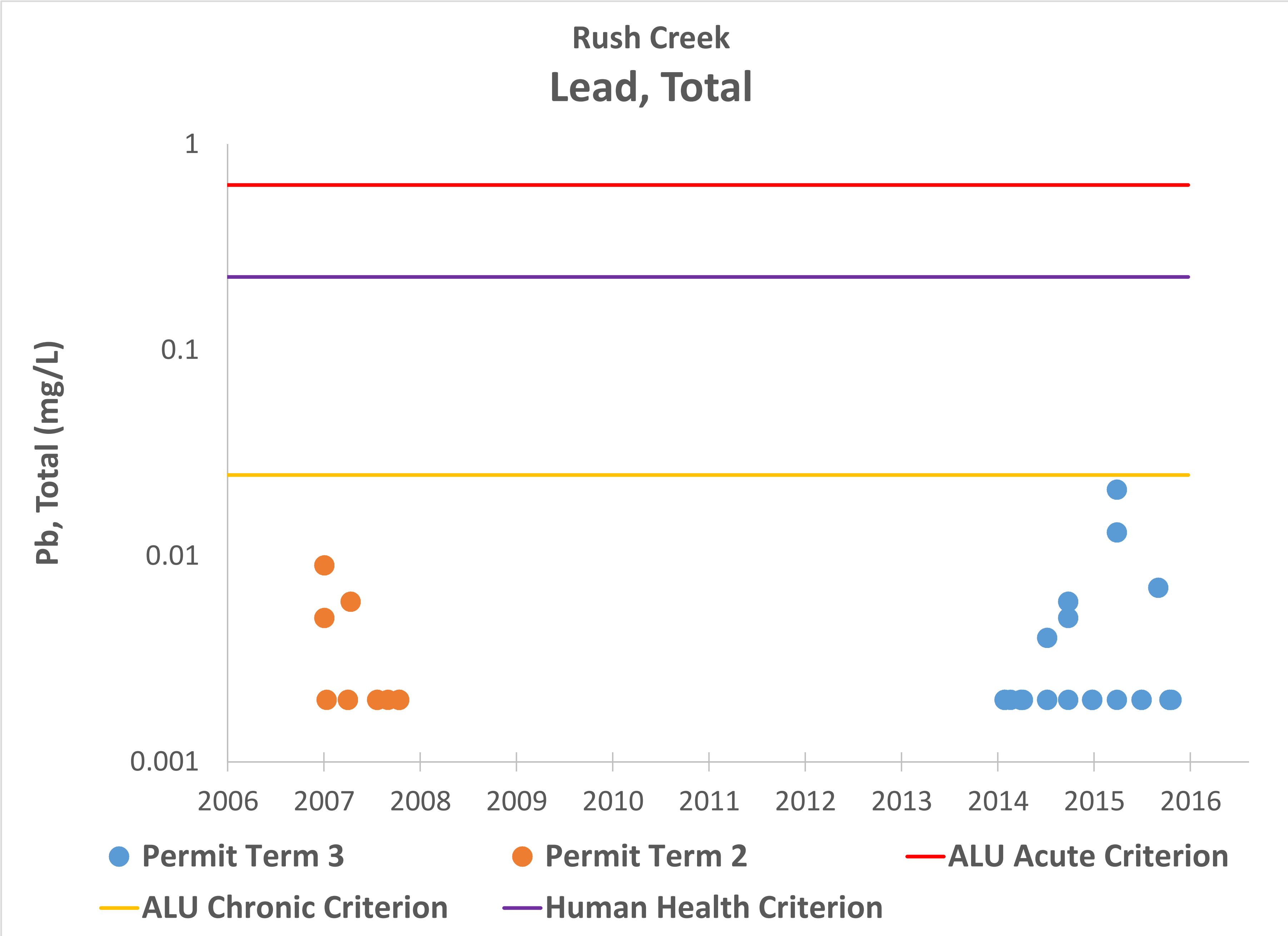

Rush Creek
Arsenic, Total
As, Total (mg/L)
1
0.1
0.01
0.001
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
Permit Term 3
Permit Term 2
ALU Acute Criterion
ALU Chronic Criterion
Human Health Criterion



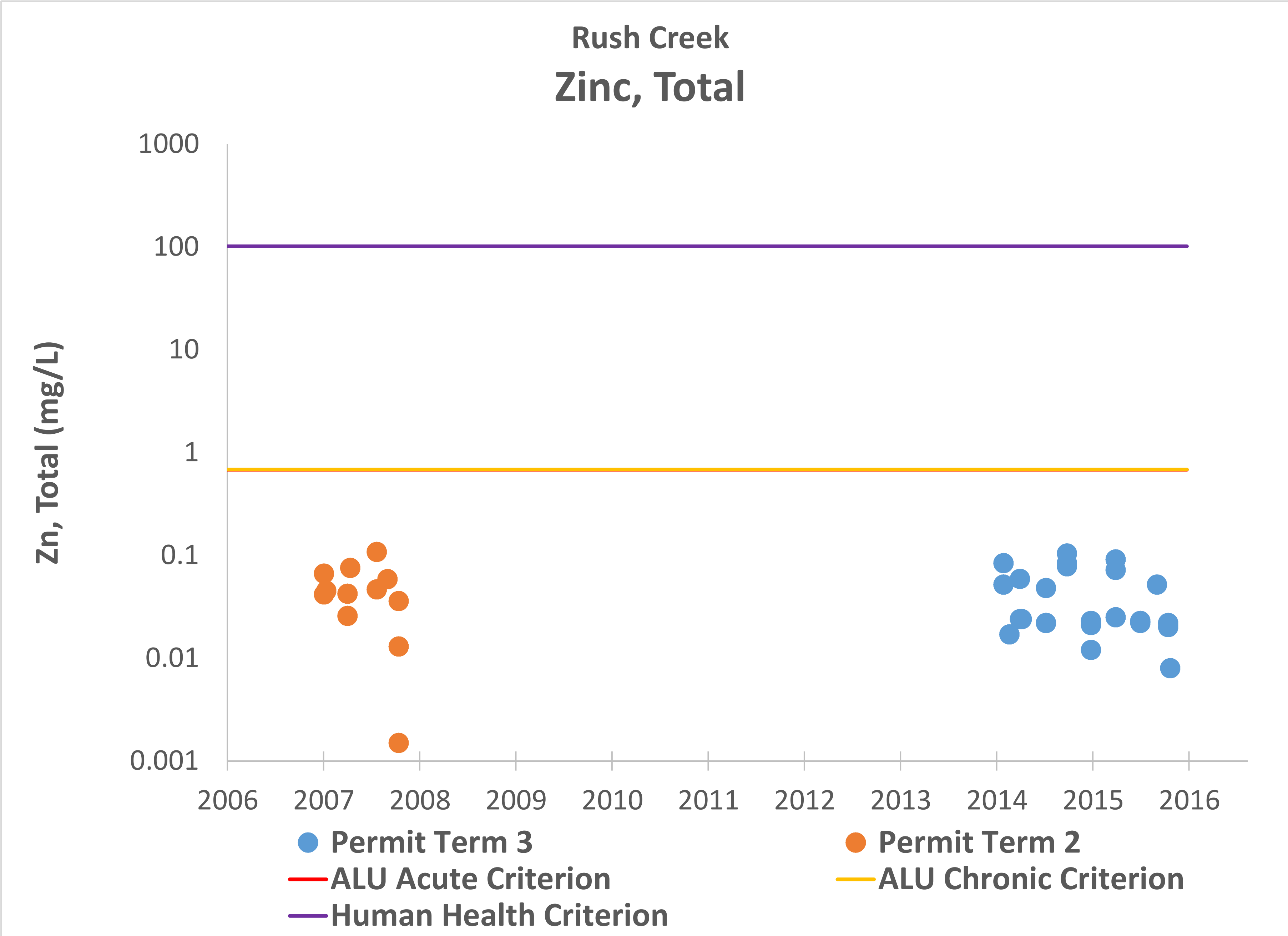
Rush Creek
Chromium, Total
Cr, Total (mg/L)
100
10
1
0.1
0.01
0.001
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
Permit Term 3
Permit Term 2
ALU Acute Criterion
ALU Chronic Criterion
Human Health Criterion

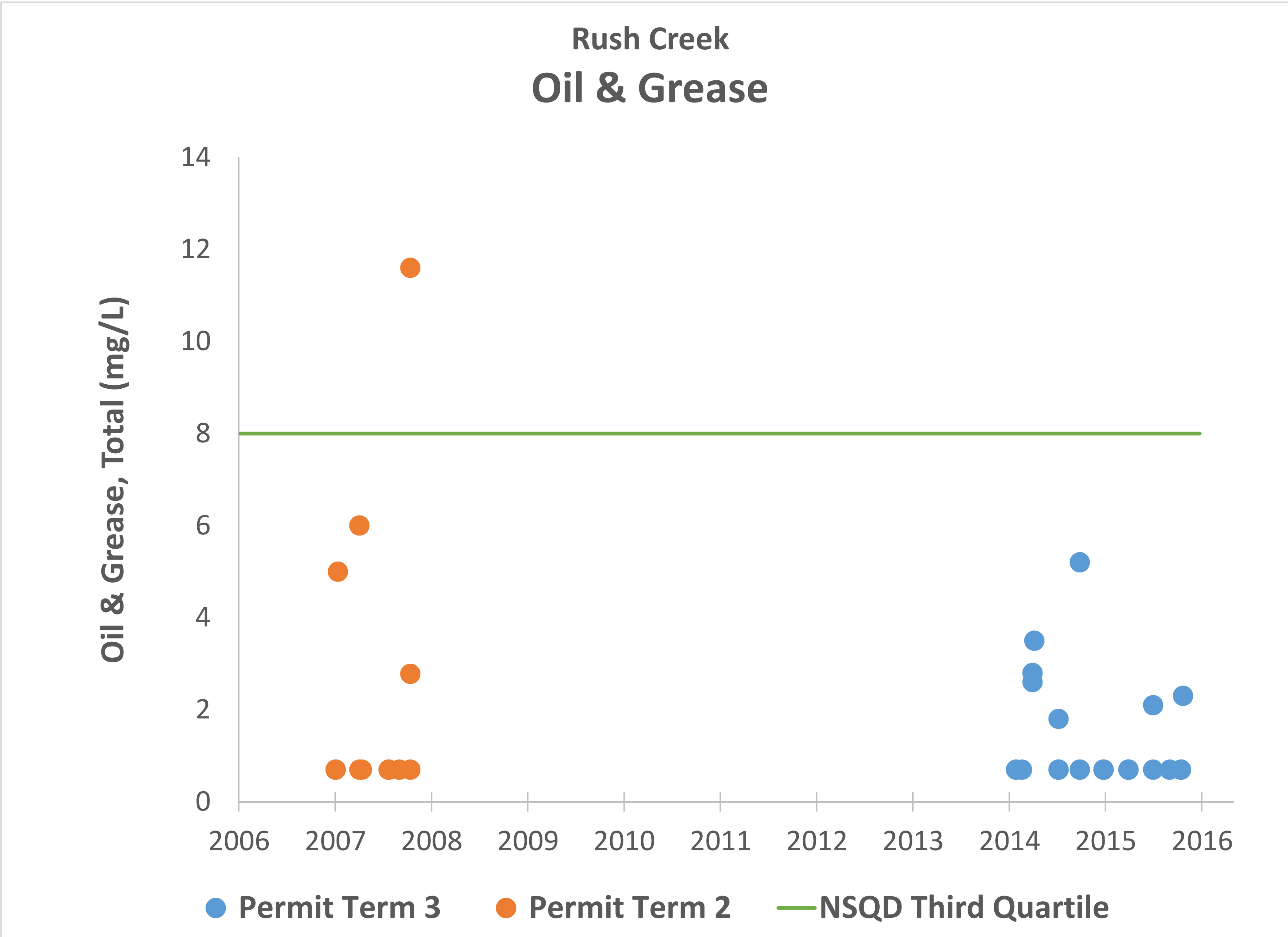


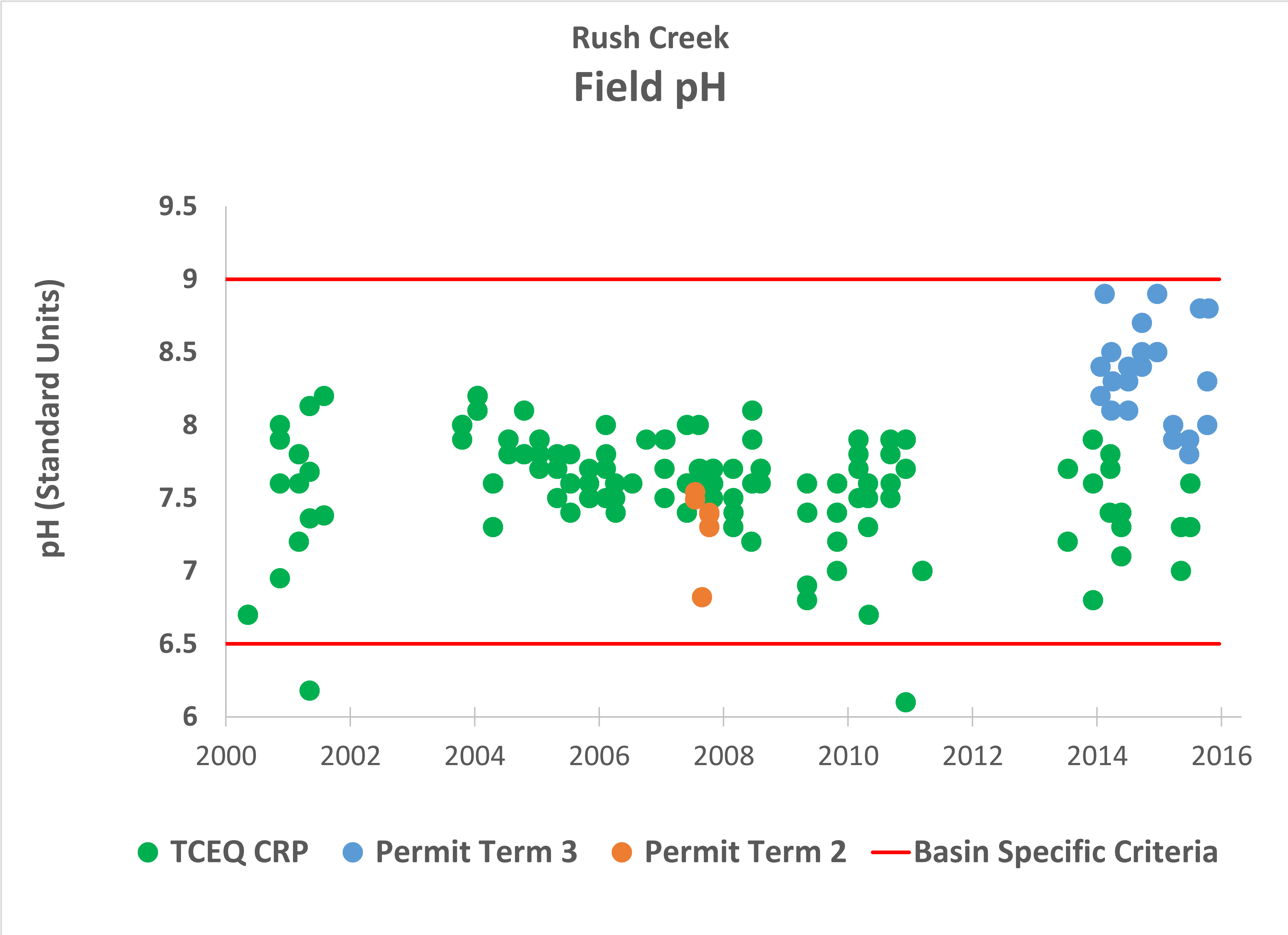
Rush Creek
Copper, Total
Cu, Total (mg/L)
1
0.1
0.01
0.001
0.0001
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
Permit Term 3
Permit Term 2
ALU Acute Criterion
ALU Chronic Criterion



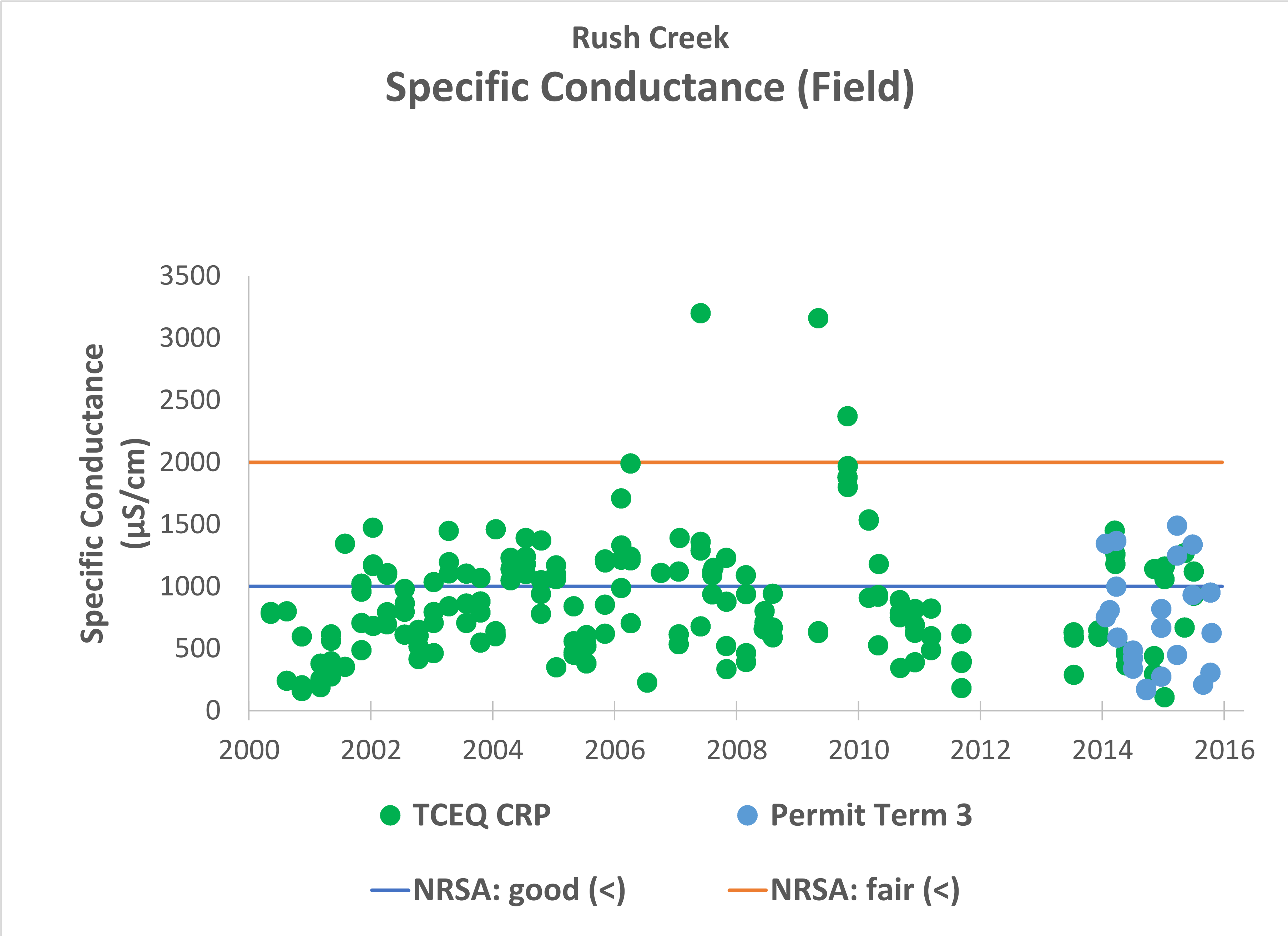
Rush Creek
Lead, Total
Pb, Total (mg/L)
1
0.1
0.01
0.001
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
Permit Term 3
Permit Term 2
ALU Acute Criterion
ALU Chronic Criterion
Human Health Criterion


Rush Creek
Zinc, Total
Zn, Total (mg/L)
1000
100
10
1
0.1
0.01
0.001
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
Permit Term 3
Permit Term 2
ALU Acute Criterion
ALU Chronic Criterion
Human Health Criterion

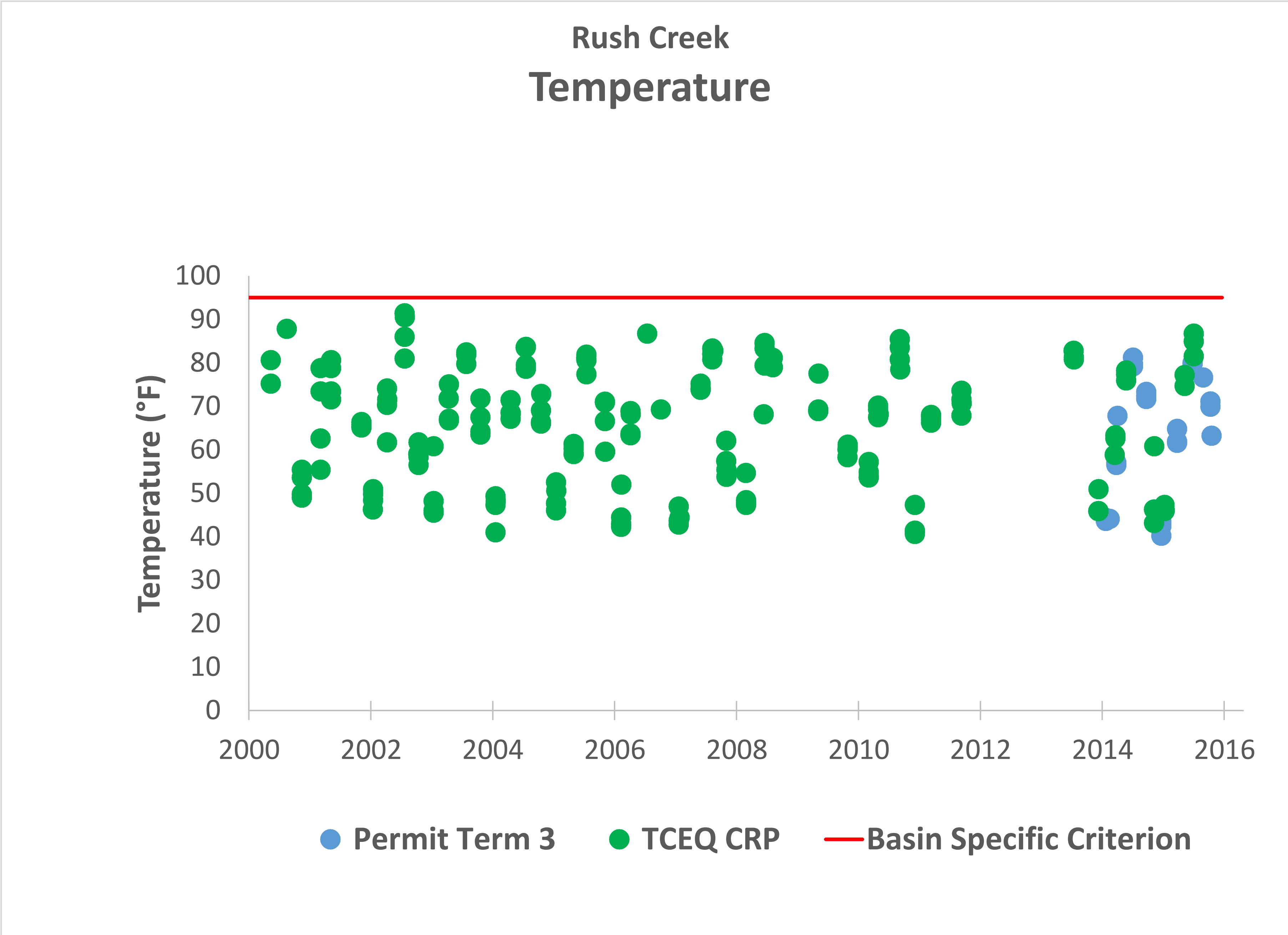

Rush Creek
Oil & Grease
Oil & Grease, Total (mg/L)
0
2
4
6
8
10
12
14
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
Permit Term 3
Permit Term 2
NSQD Third Quartile



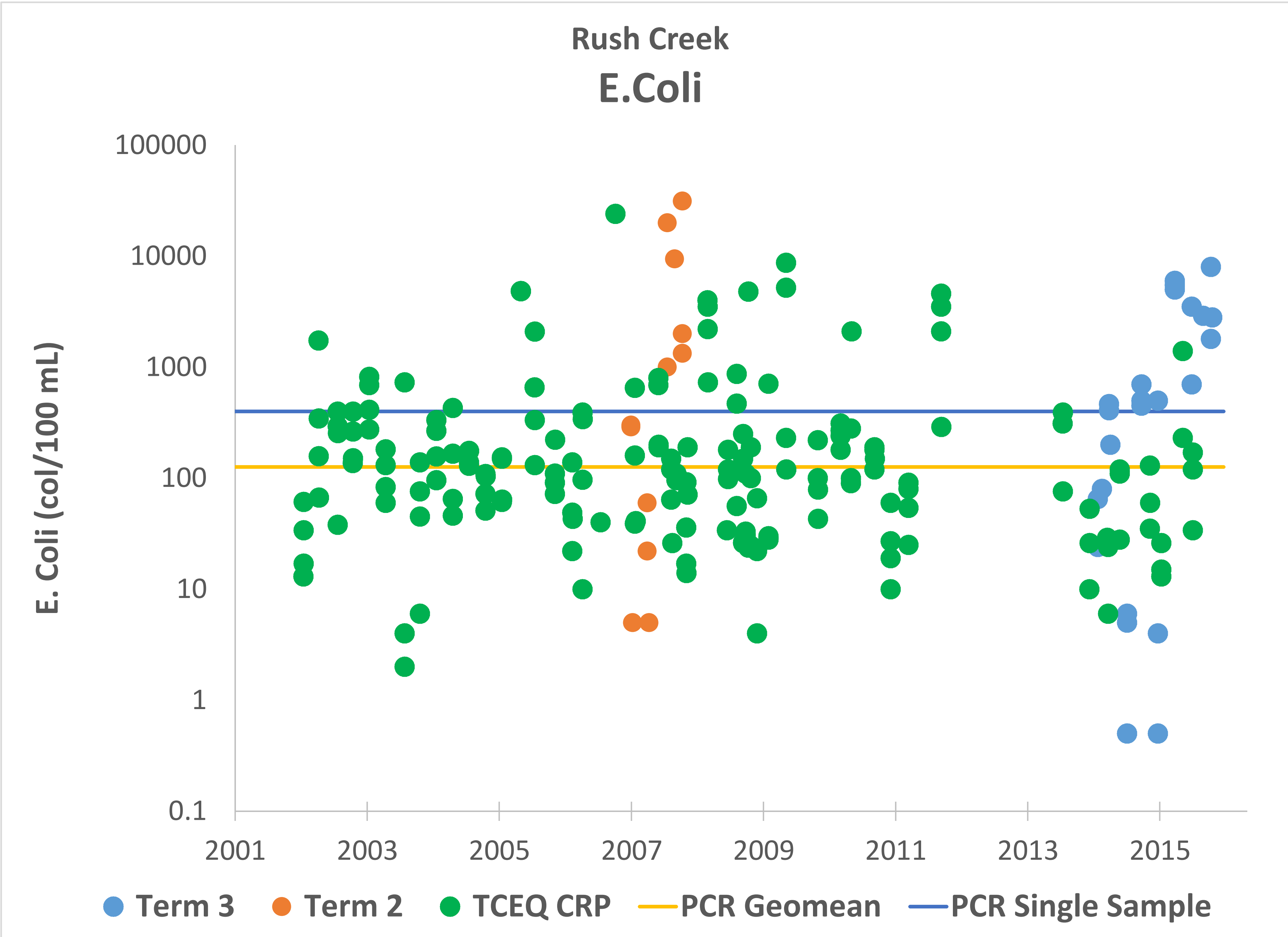
Rush Creek
Field pH
pH (Standard Units)
9.5
9
8.5
8
7.5
7
6.5
6
2000
2002
2004
2006
2008
2010
2012
2014
2016
TCEQ CRP
Permit Term 3
Permit Term 2
Basin Specific Criteria

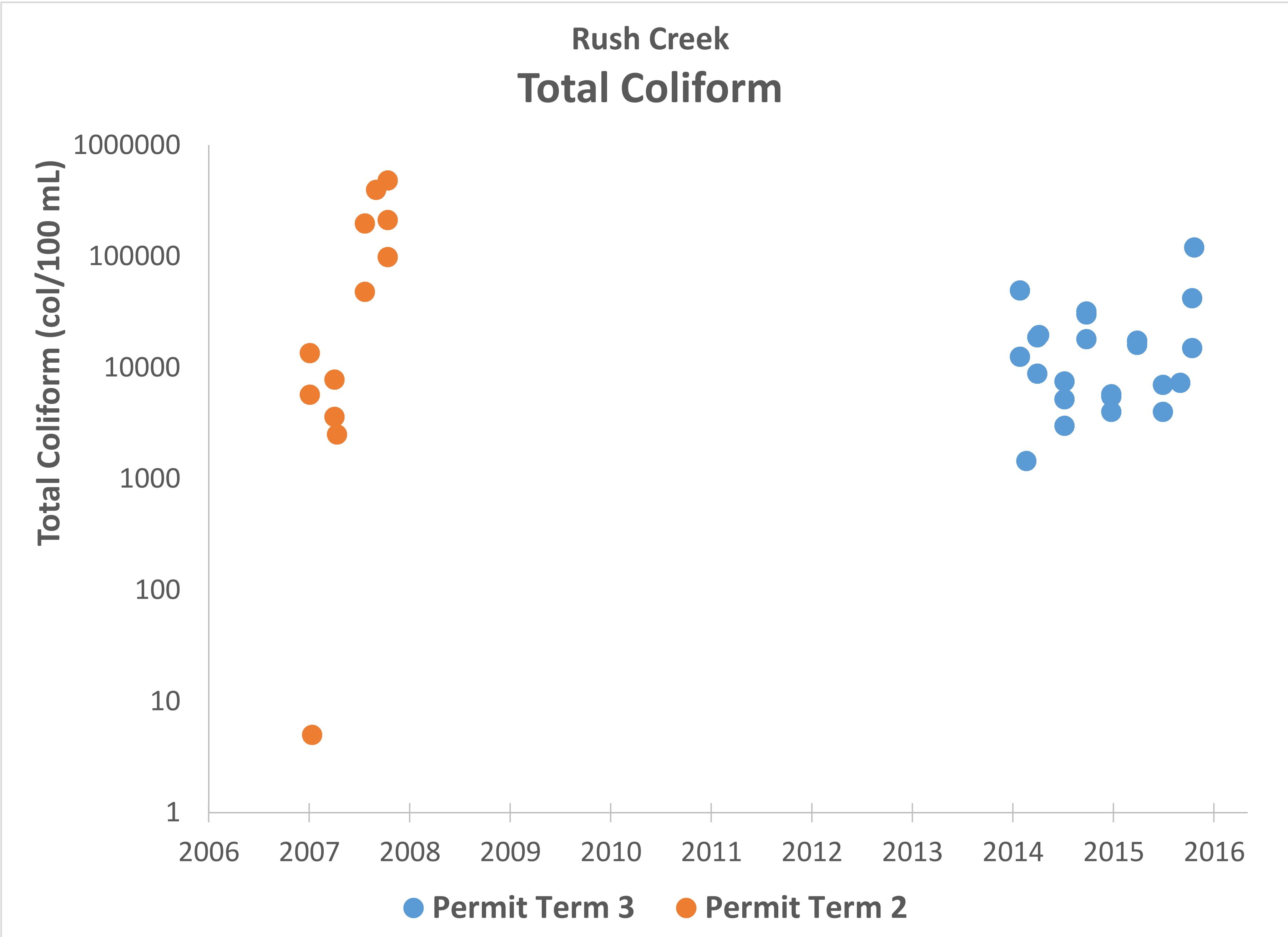


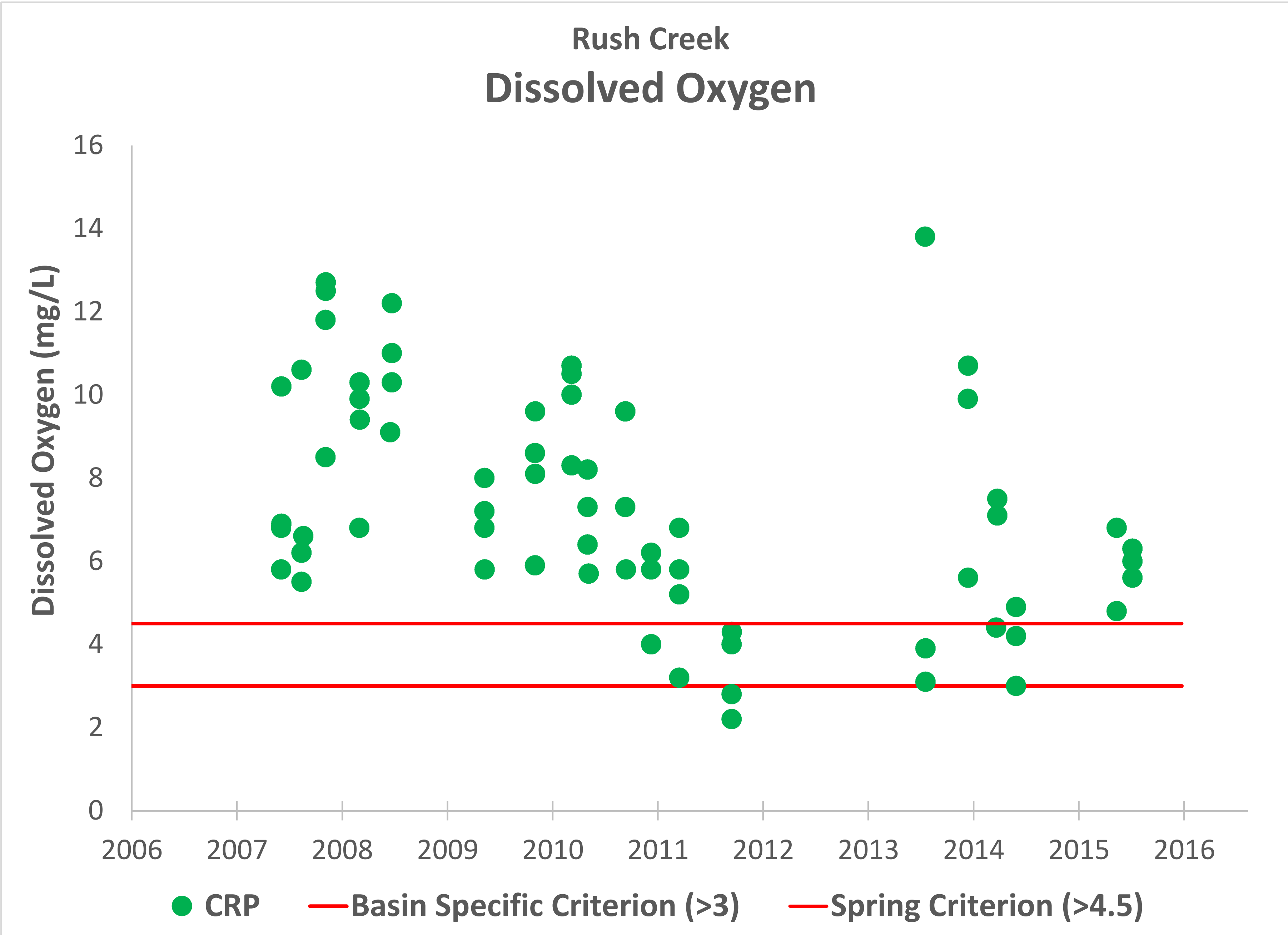
Rush Creek
Specific Conductance (Field)
Specific Conductance (µS/cm)
3500
3000
2500
2000
1500
1000
500
0
2000
2002
2004
2006
2008
2010
2012
2014
2016
TCEQ CRP
Permit Term 3
NRSA: good (<)
NRSA: fair (<)



Rush Creek
Temperature
Temperature (°F)
100
90
80
70
60
50
40
30
20
10
0
2000
2002
2004
2006
2008
2010
2012
2014
2016
Permit Term 3
TCEQ CRP
Basin Specific Criterion


Rush Creek
E.Coli
E. Coli (col/100 mL)
100000
10000
1000
100
10
1
0.1
2001
2003
2005
2007
2009
2011
2013
2015
Term 3
Term 2
TCEQ CRP
PCR Geomean
PCR Single Sample

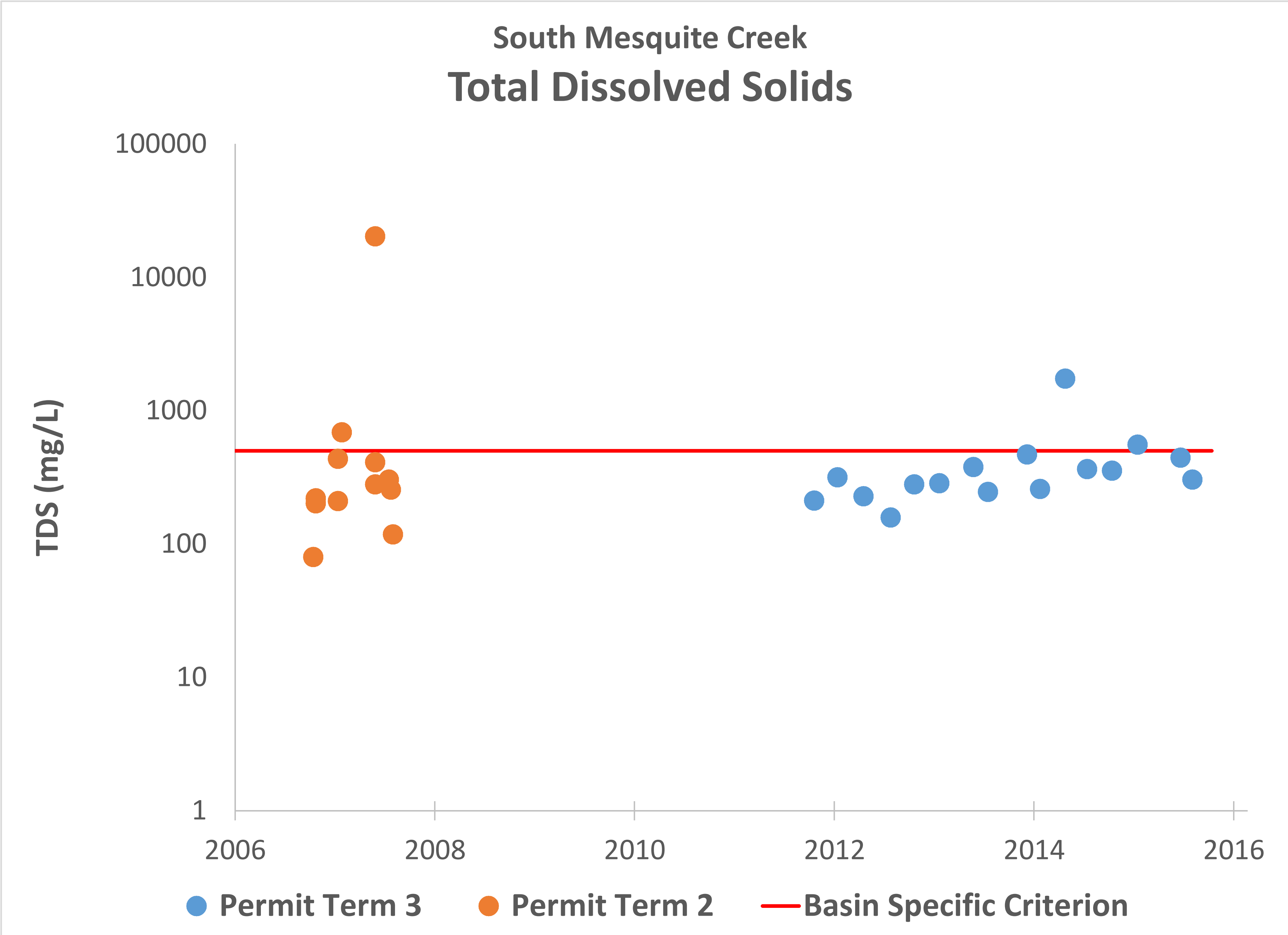

Rush Creek
Total Coliform
Total Coliform (col/100 mL)
1000000
100000
10000
1000
100
10
1
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
Permit Term 3
Permit Term 2

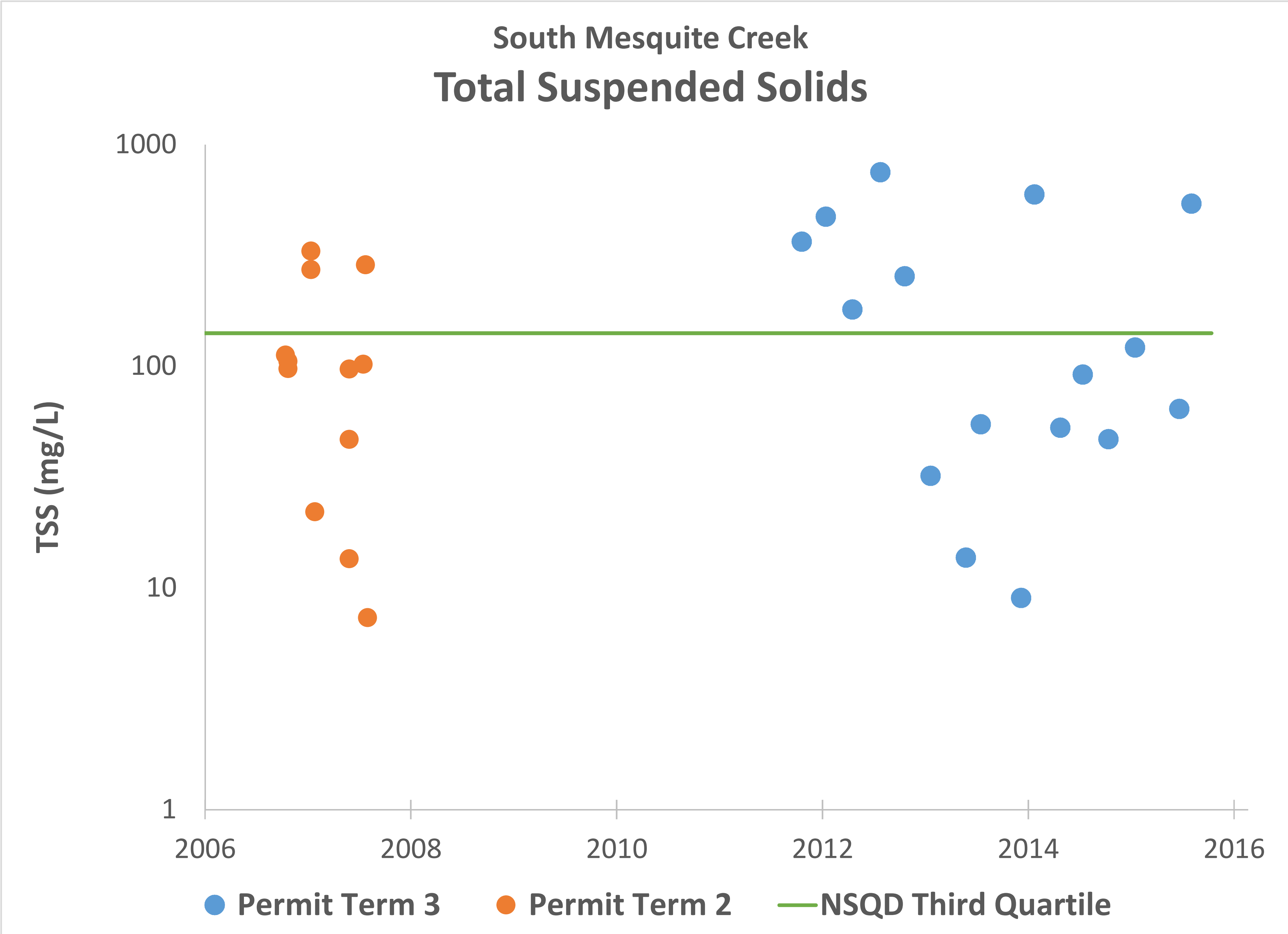


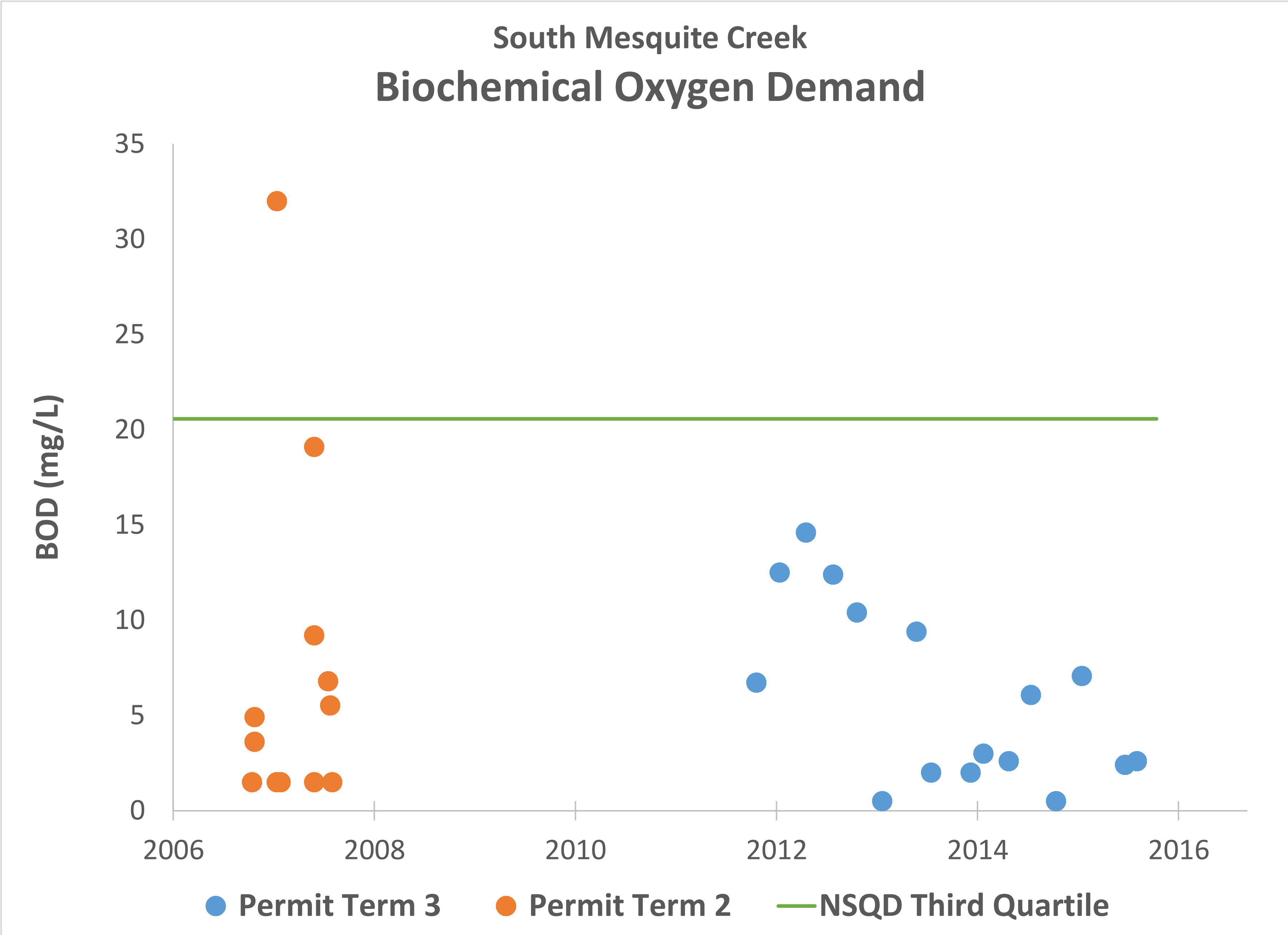
Rush Creek
Dissolved Oxygen
Dissolved Oxygen (mg/L)
0
2
4
6
8
10
12
14
16
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
CRP
Basin Specific Criterion (>3)
Spring Criterion (>4.5)

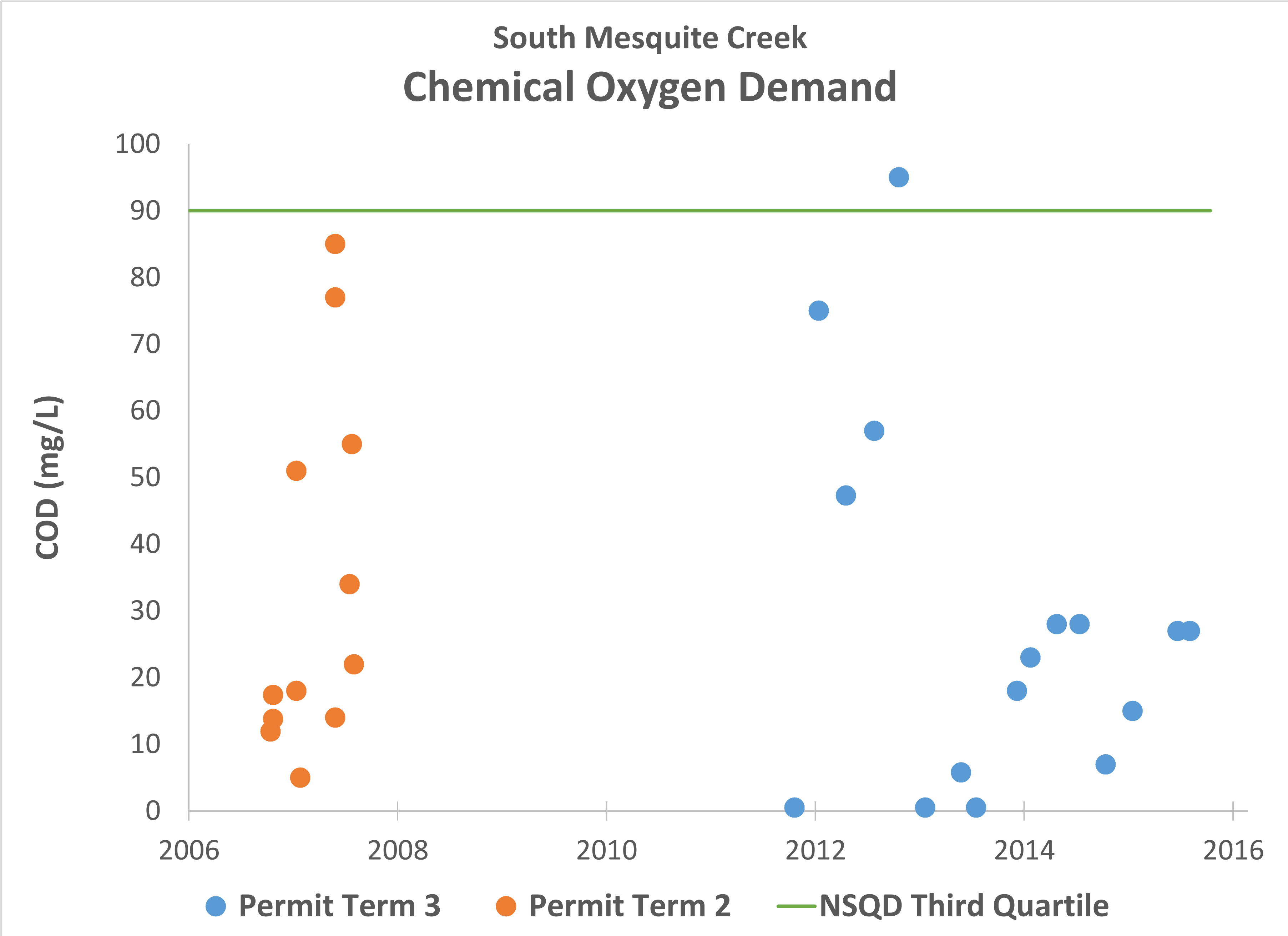
Appendix W

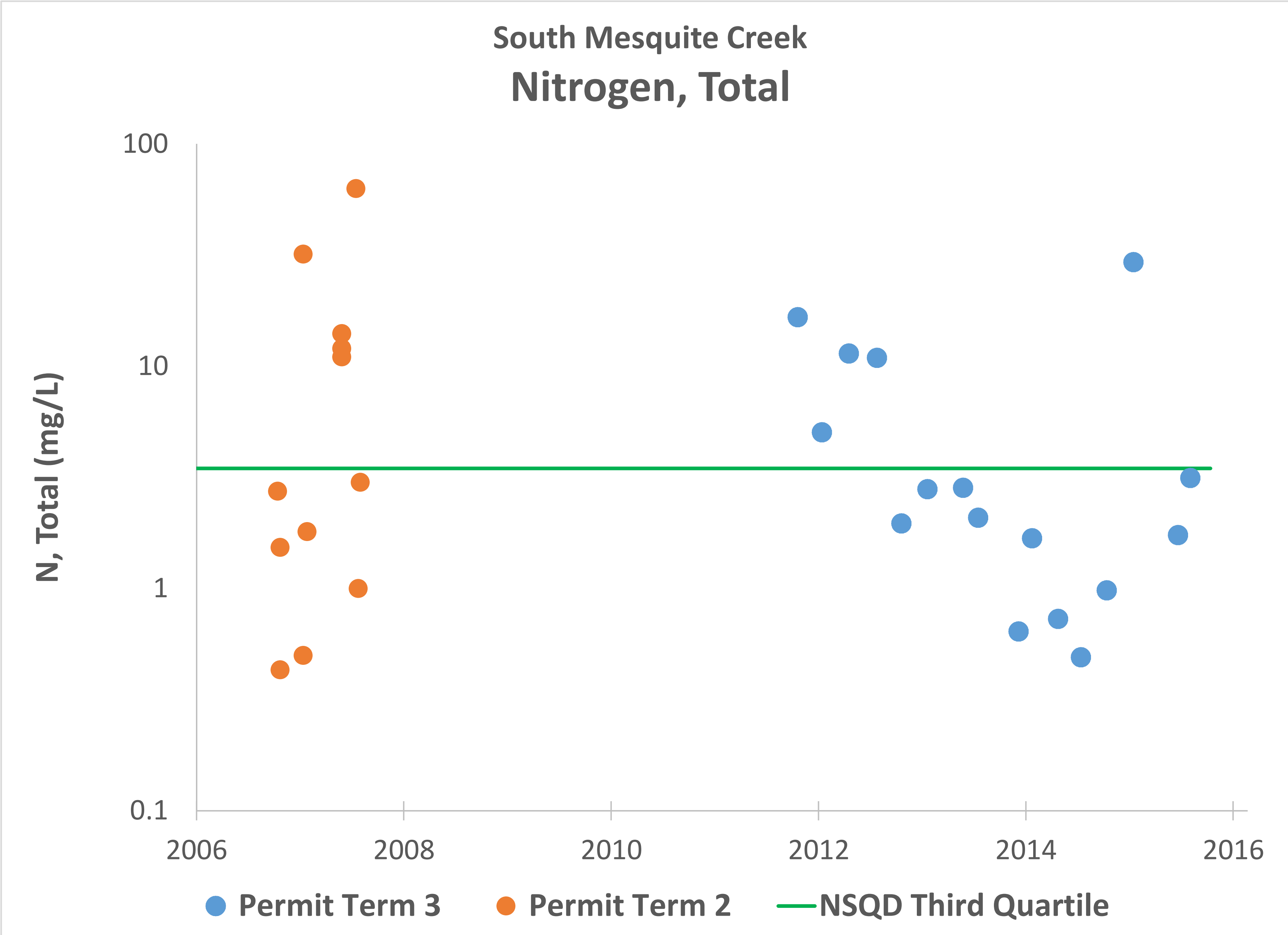
South Mesquite Creek Water Quality
Data Graphs

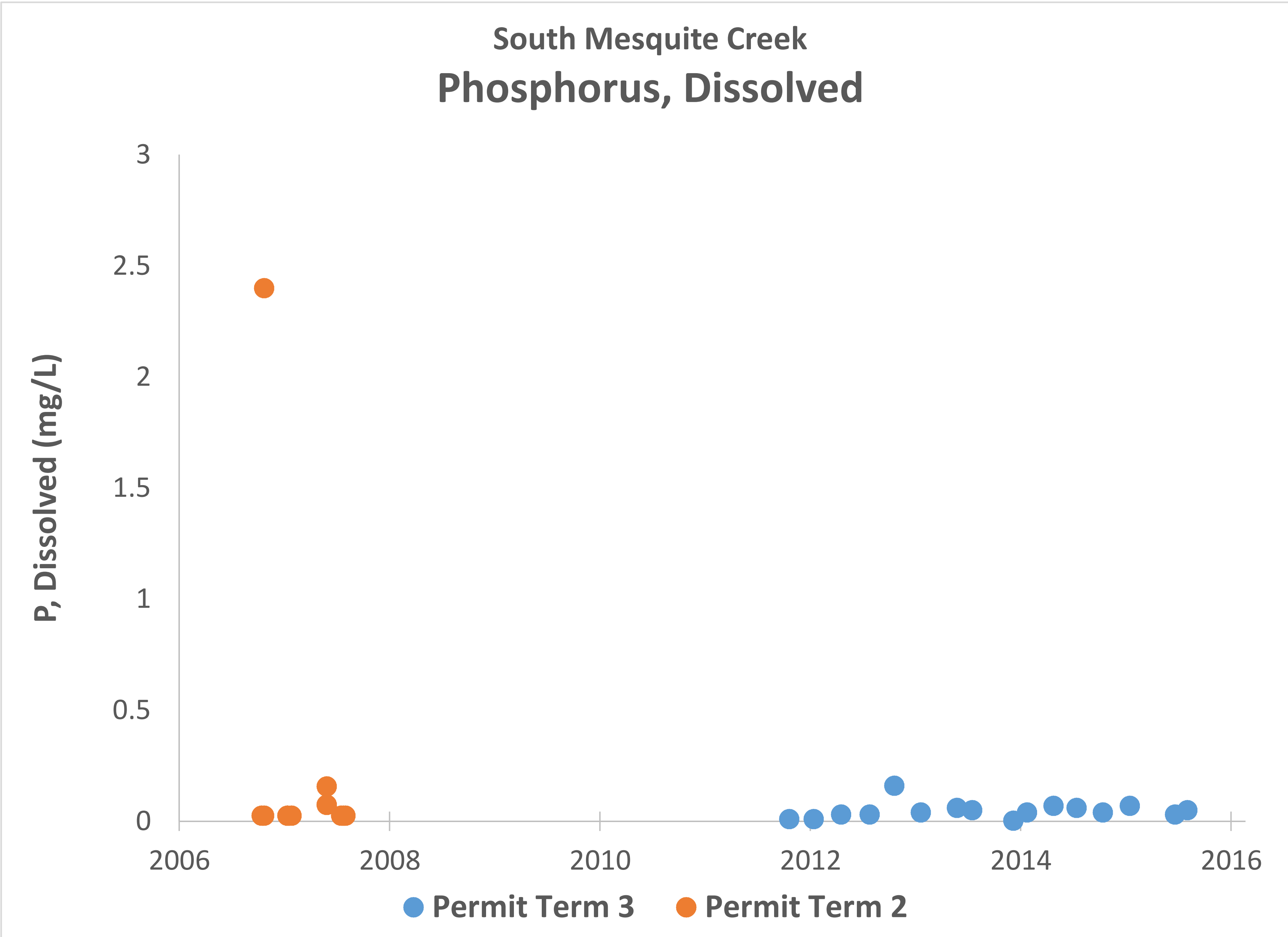

South Mesquite Creek
Total Dissolved Solids
TDS (mg/L)
100000
10000
1000
100
10
1
2006
2008
2010
2012
2014
2016
Permit Term 3
Permit Term 2
Basin Specific Criterion

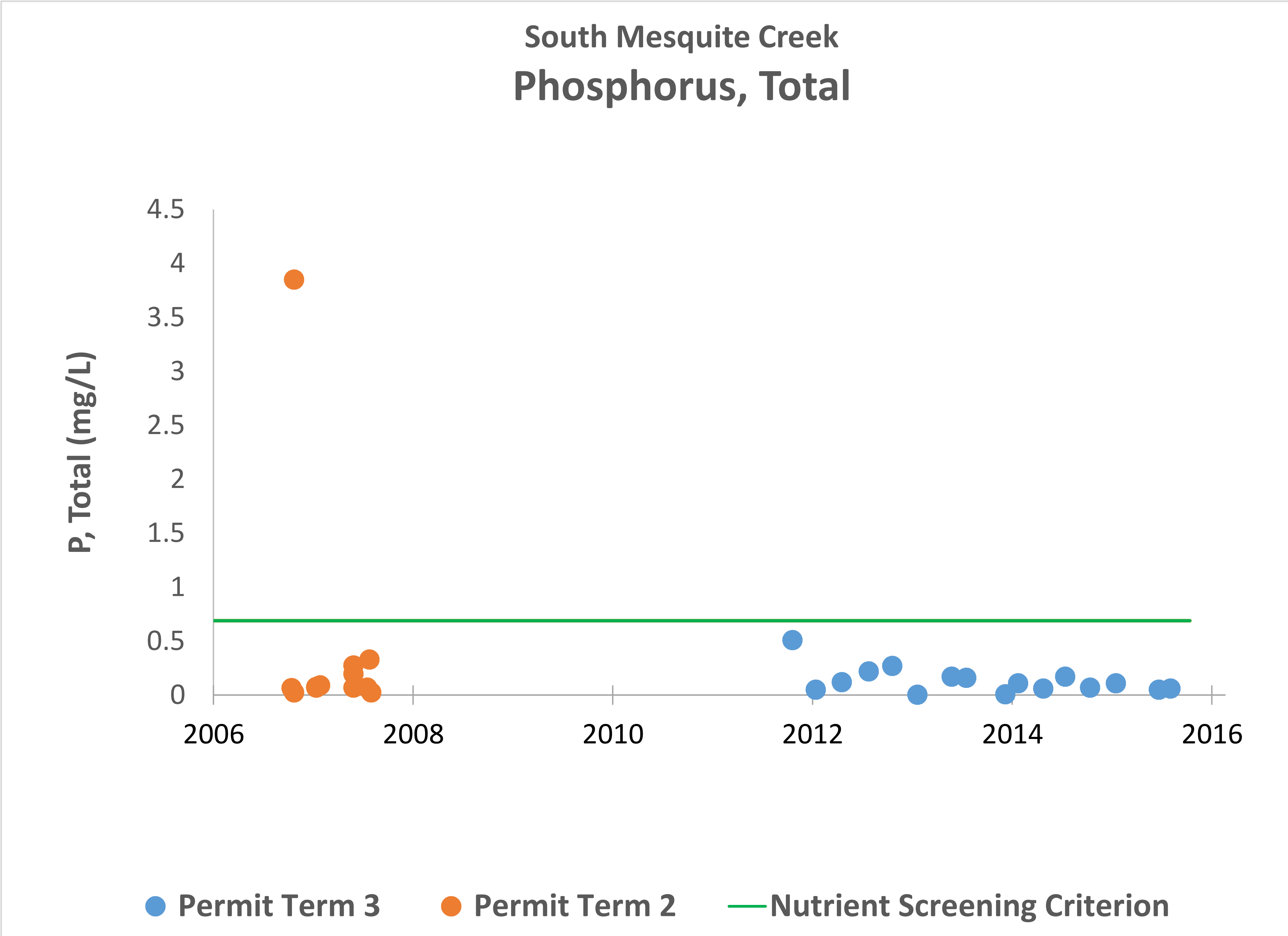

South Mesquite Creek
Total Suspended Solids
TSS (mg/L)
1000
100
10
1
2006
2008
2010
2012
2014
2016
Permit Term 3
Permit Term 2
NSQD Third Quartile

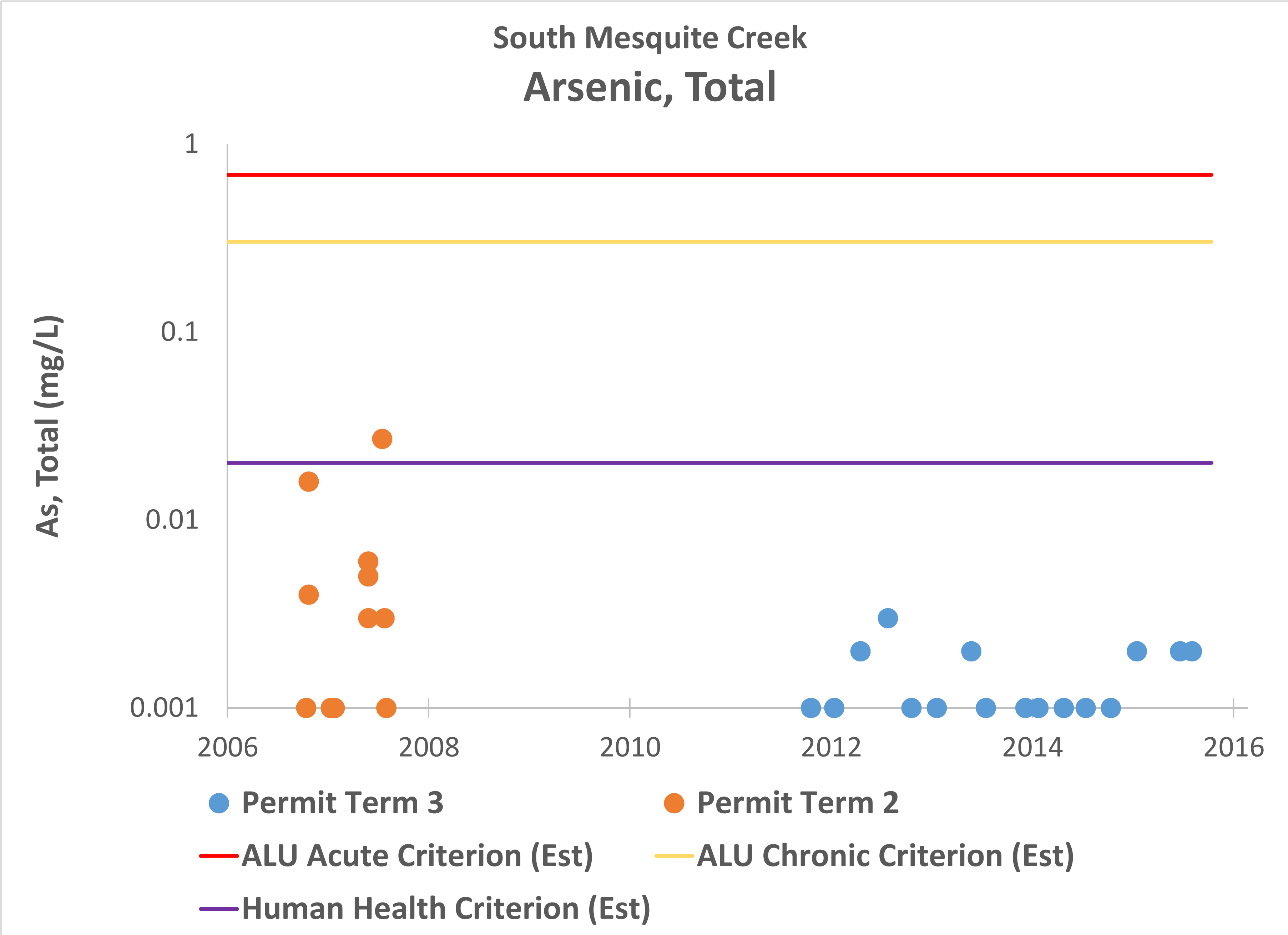

South Mesquite Creek
Biochemical Oxygen Demand
BOD (mg/L)
35
30
25
20
15
10
5
0
2006
2008
2010
2012
2014
2016
Permit Term 3
Permit Term 2
NSQD Third Quartile


South Mesquite Creek
Chemical Oxygen Demand
COD (mg/L)
100
90
80
70
60
50
40
30
20
10
0
2006
2008
2010
2012
2014
2016
Permit Term 3
Permit Term 2
NSQD Third Quartile

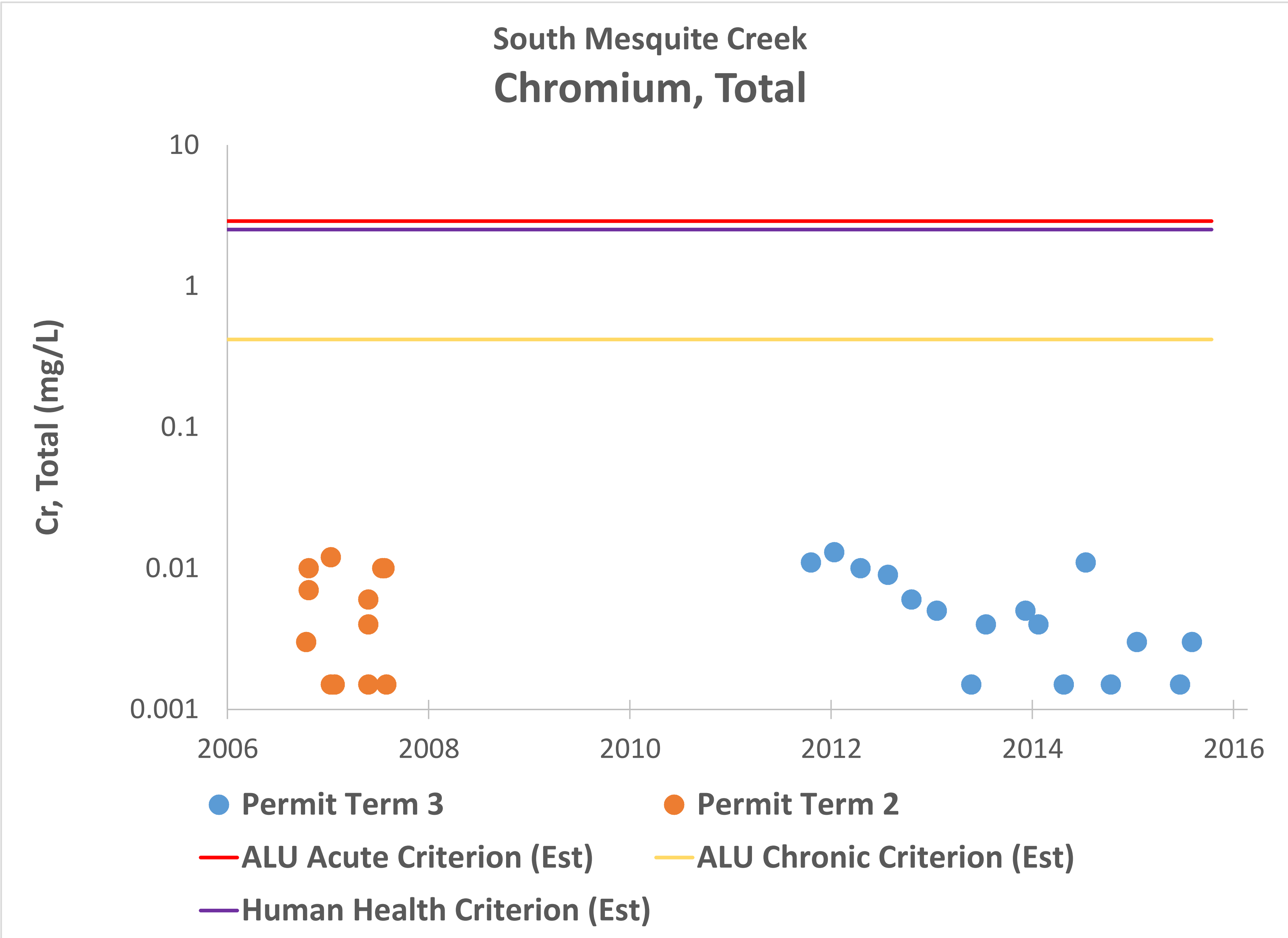

South Mesquite Creek
Nitrogen, Total
N, Total (mg/L)
100
10
1
0.1
2006
2008
2010
2012
2014
2016
Permit Term 3
Permit Term 2
NSQD Third Quartile


South Mesquite Creek
Phosphorus, Dissolved
P, Dissolved (mg/L)
3
2.5
2
1.5
1
0.5
0
2006
2008
2010
2012
2014
2016
Permit Term 3
Permit Term 2

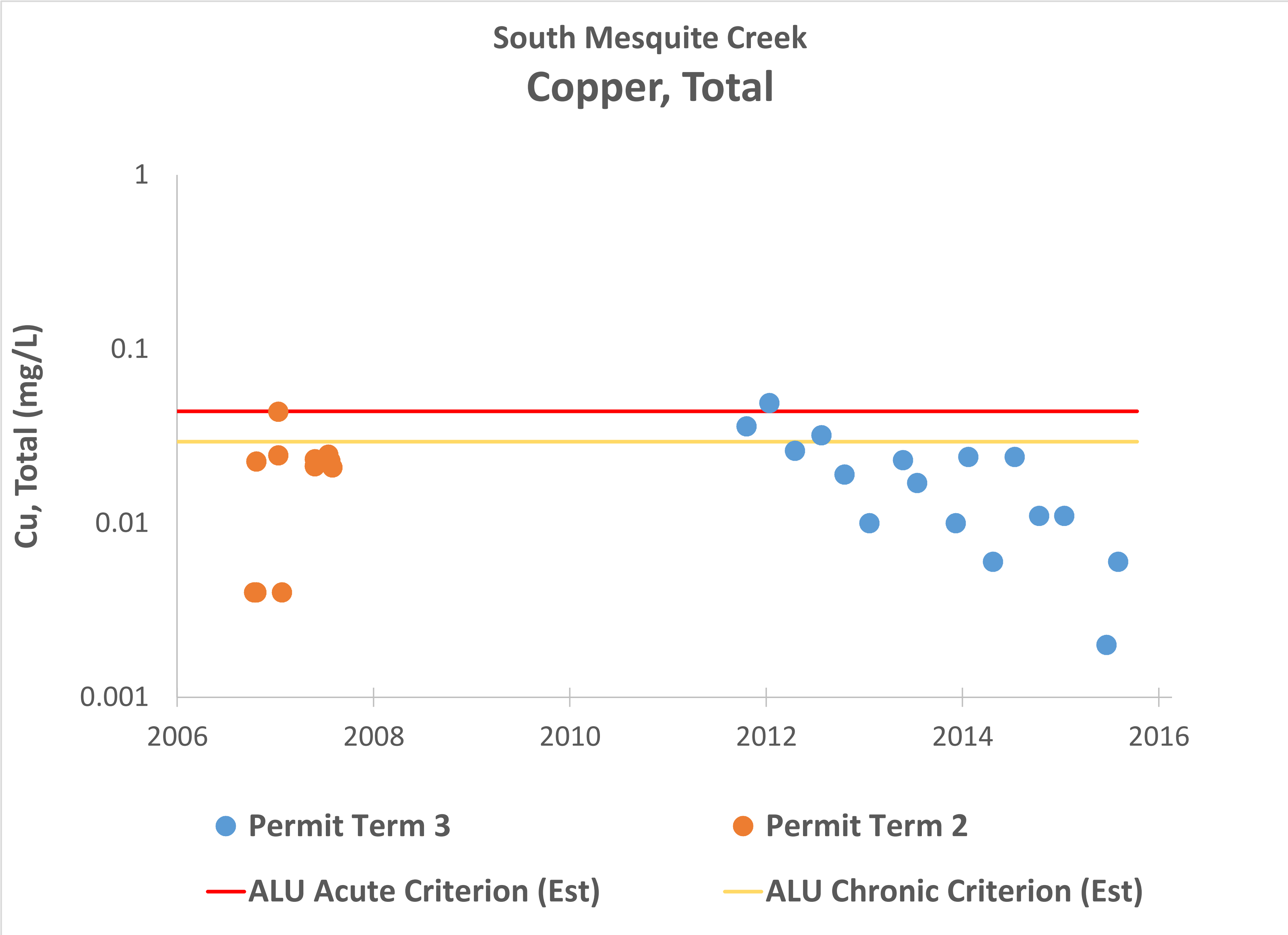

South Mesquite Creek
Phosphorus, Total
P, Total (mg/L)
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
2006
2008
2010
2012
2014
2016
Permit Term 3
Permit Term 2
Nutrient Screening Criterion

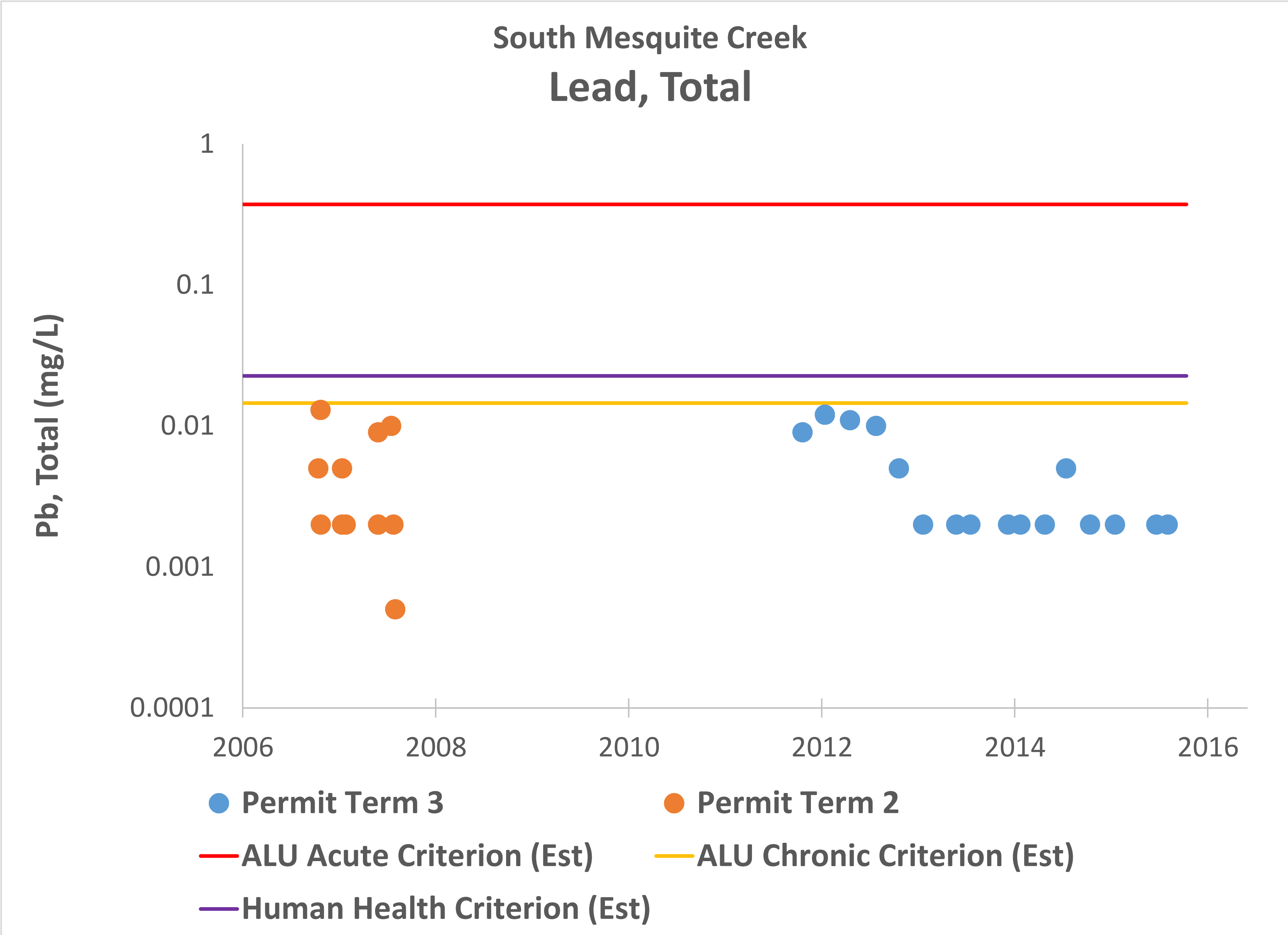


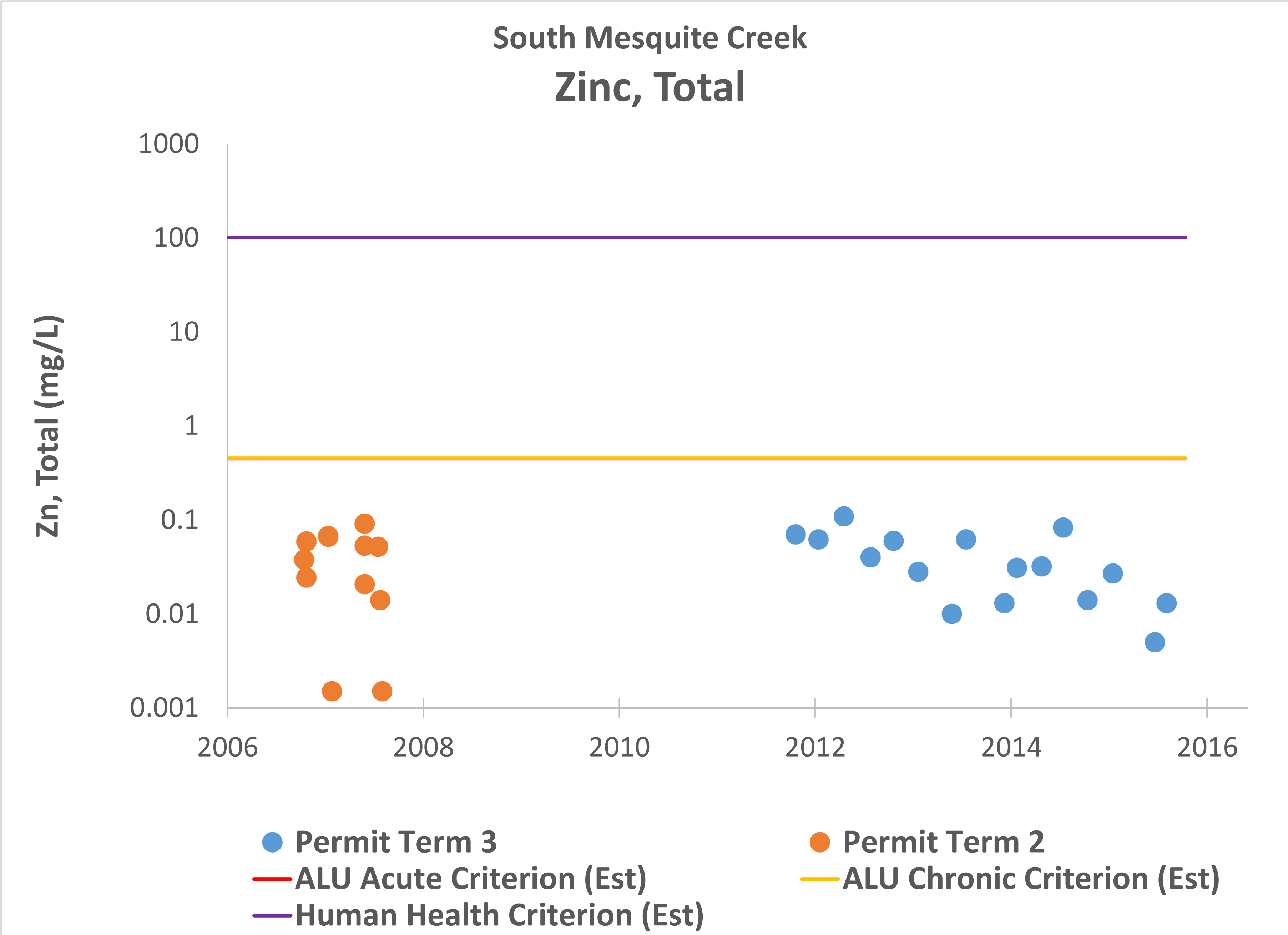
South Mesquite Creek
Arsenic, Total
As, Total (mg/L)
1
0.1
0.01
0.001
2006
2008
2010
2012
2014
2016
Permit Term 3
Permit Term 2
ALU Acute Criterion (Est)
ALU Chronic Criterion (Est)
Human Health Criterion (Est)



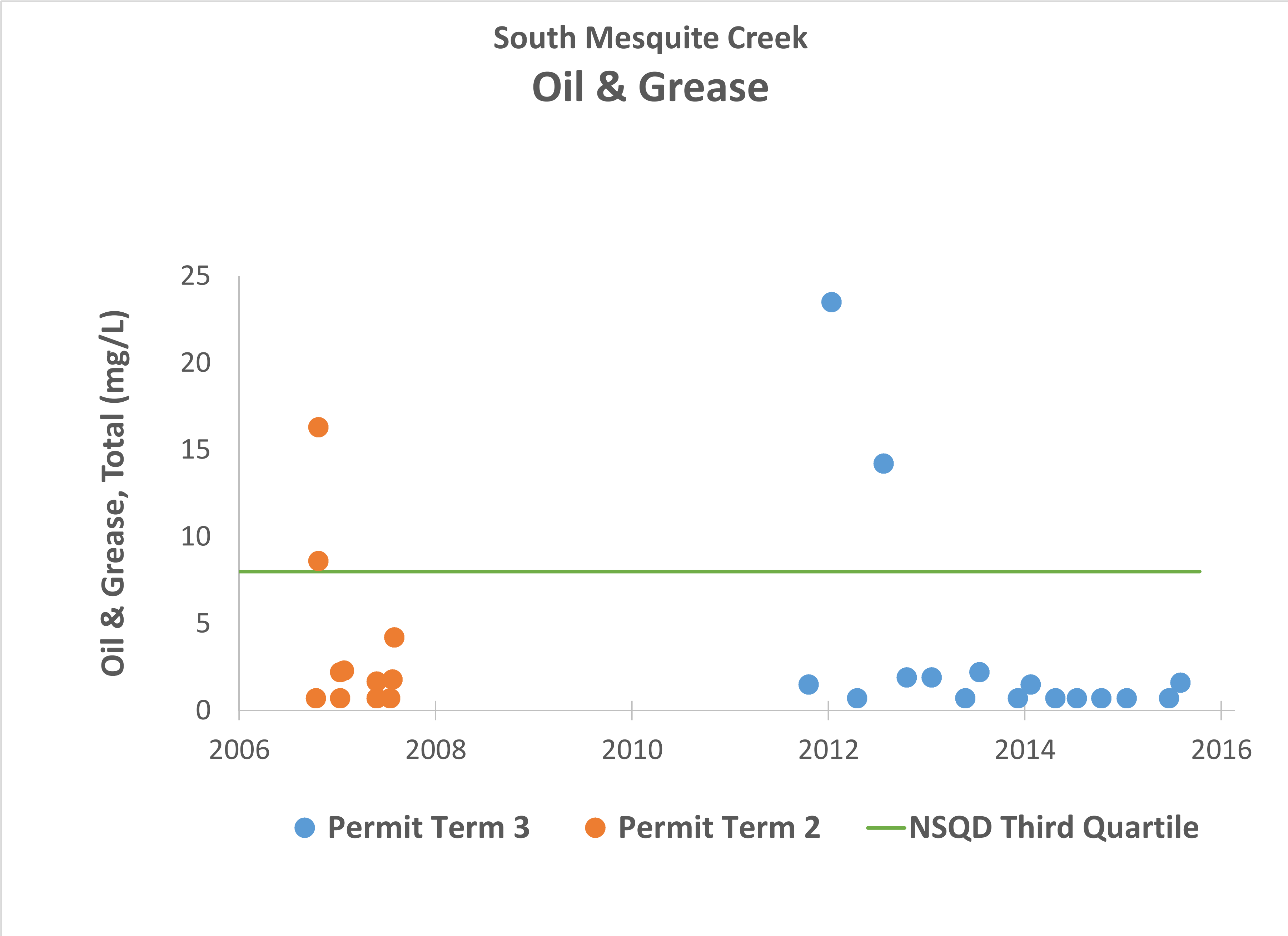
South Mesquite Creek
Chromium, Total
Cr, Total (mg/L)
10
1
0.1
0.01
0.001
2006
2008
2010
2012
2014
2016
Permit Term 3
Permit Term 2
ALU Acute Criterion (Est)
ALU Chronic Criterion (Est)
Human Health Criterion (Est)

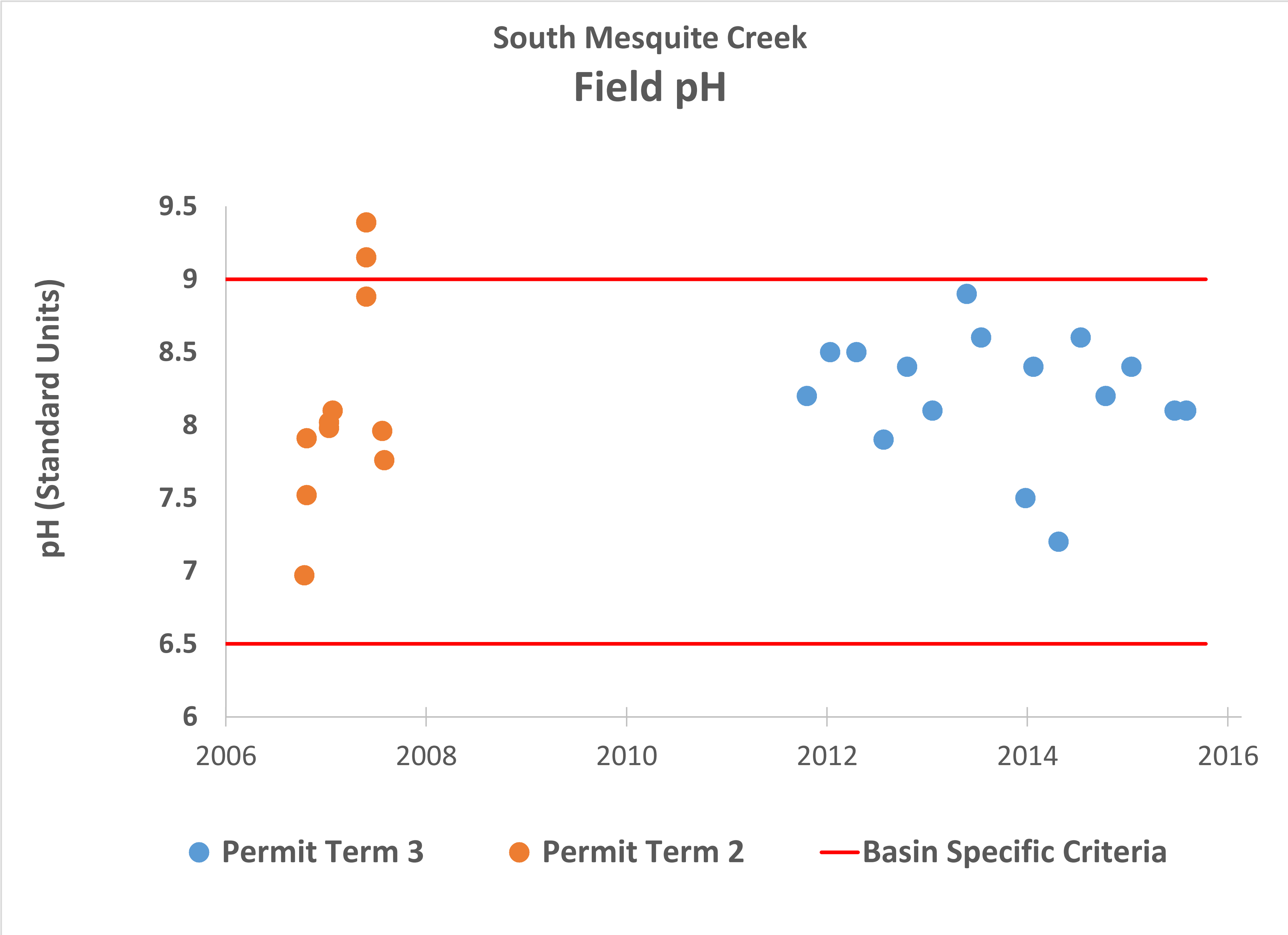

South Mesquite Creek
Copper, Total
Cu, Total (mg/L)
1
0.1
0.01
0.001
2006
2008
2010
2012
2014
2016
Permit Term 3
Permit Term 2
ALU Acute Criterion (Est)
ALU Chronic Criterion (Est)


South Mesquite Creek
Lead, Total
Pb, Total (mg/L)
1
0.1
0.01
0.001
0.0001
2006
2008
2010
2012
2014
2016
Permit Term 3
Permit Term 2
ALU Acute Criterion (Est)
ALU Chronic Criterion (Est)
Human Health Criterion (Est)

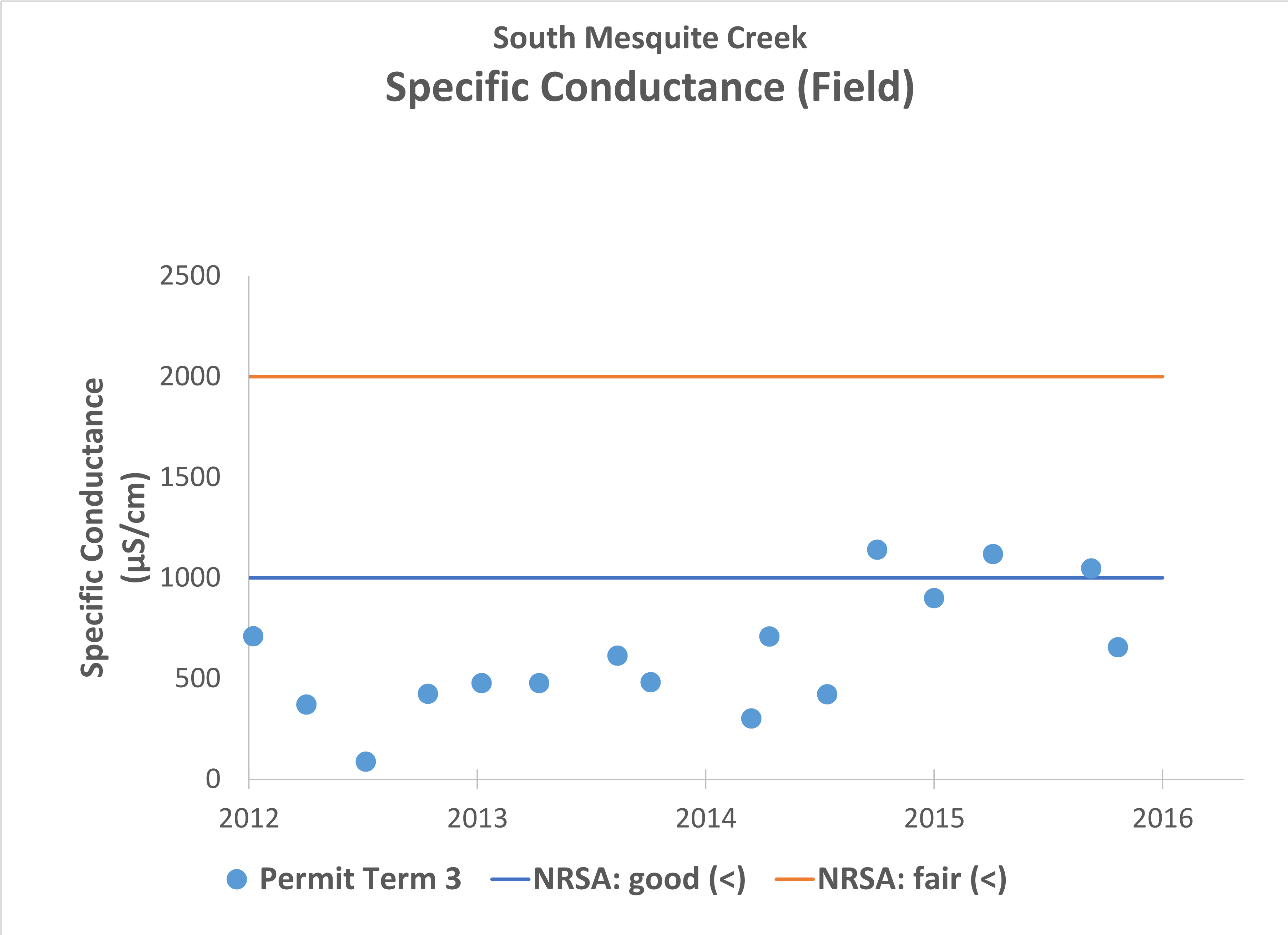


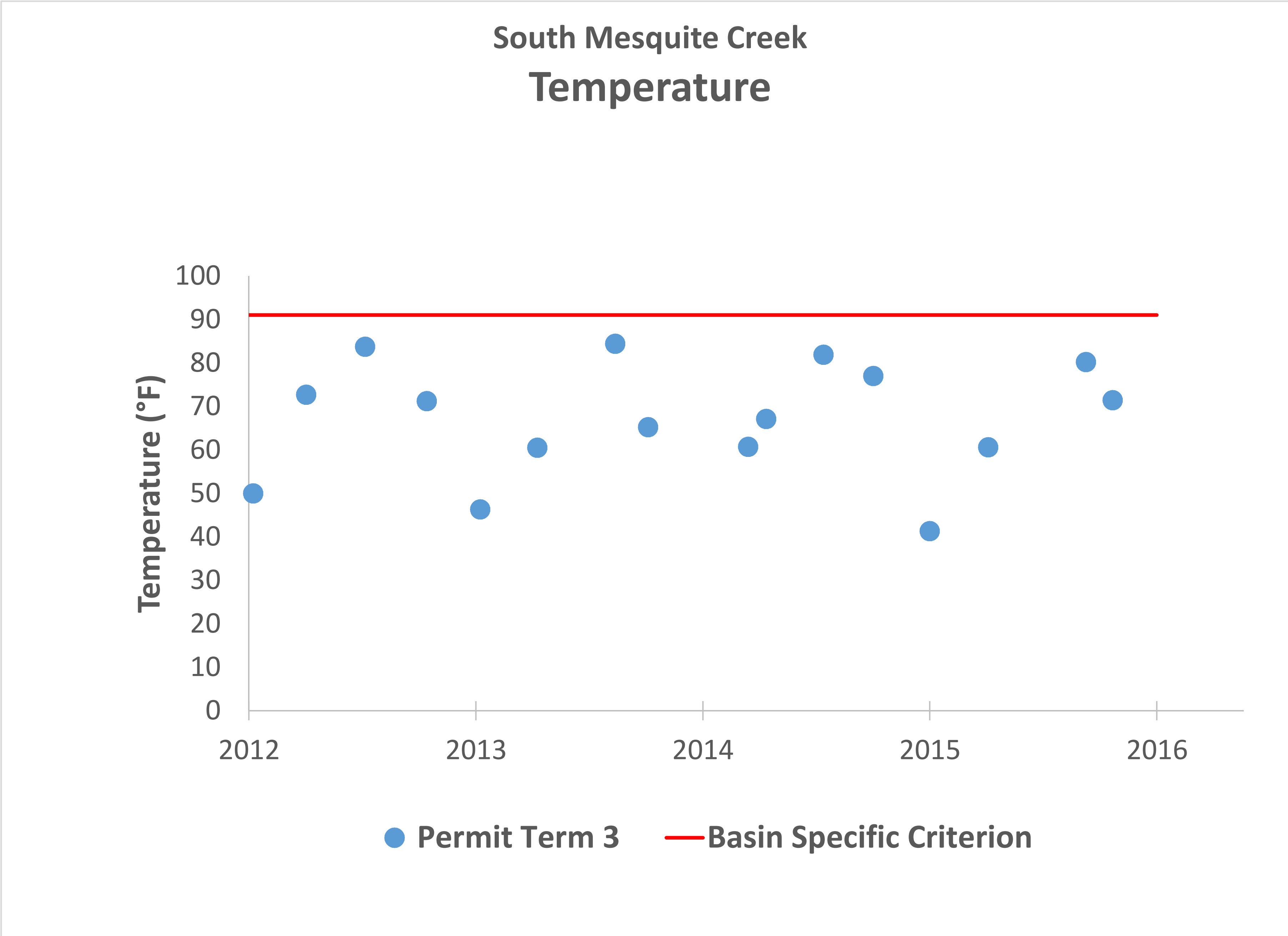
South Mesquite Creek
Zinc, Total
Zn, Total (mg/L)
1000
100
10
1
0.1
0.01
0.001
2006
2008
2010
2012
2014
2016
Permit Term 3
Permit Term 2
ALU Acute Criterion (Est)
ALU Chronic Criterion (Est)
Human Health Criterion (Est)

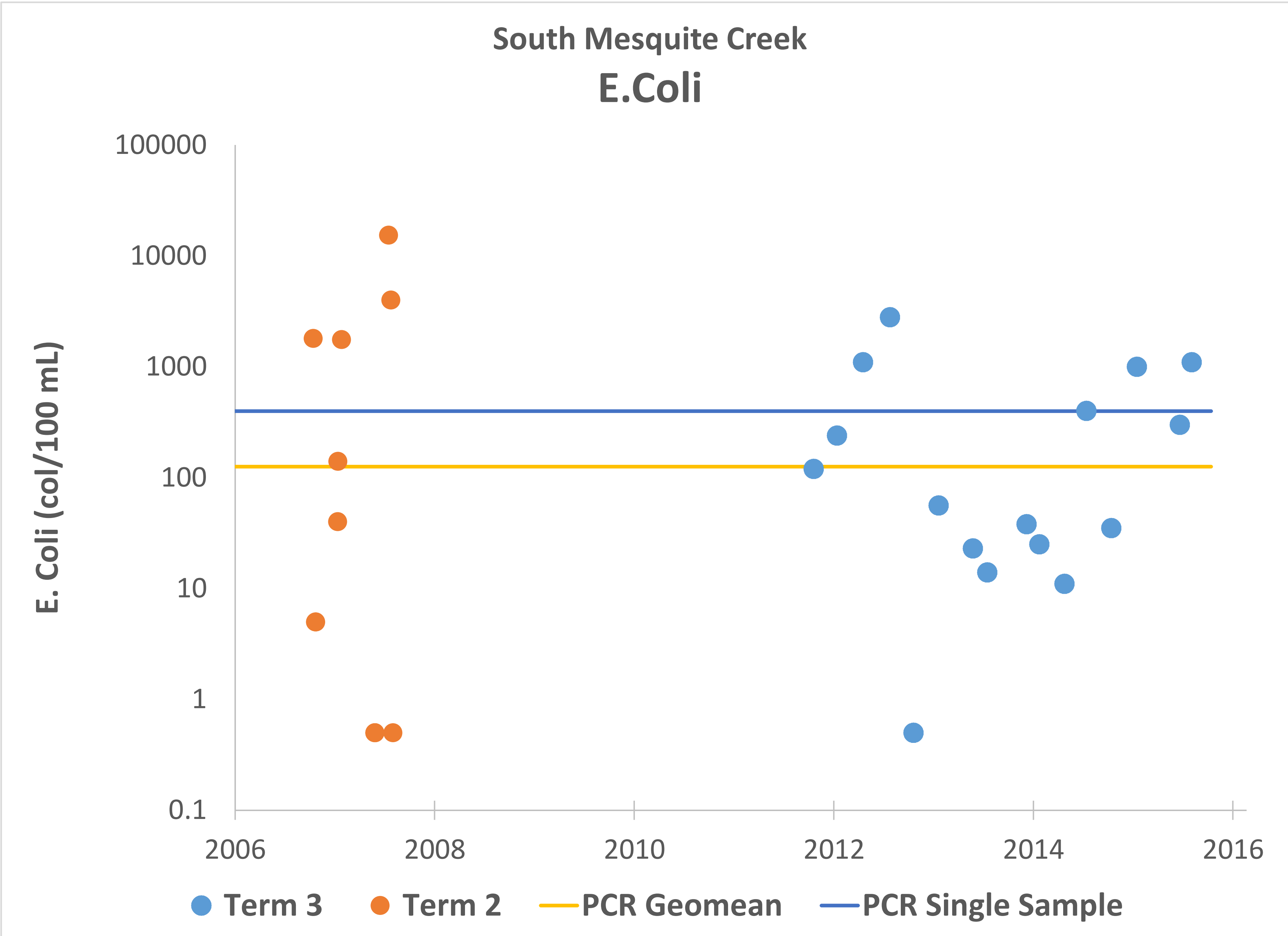

South Mesquite Creek
Oil & Grease
Oil & Grease, Total (mg/L)
25
20
15
10
5
0
2006
2008
2010
2012
2014
2016
Permit Term 3
Permit Term 2
NSQD Third Quartile

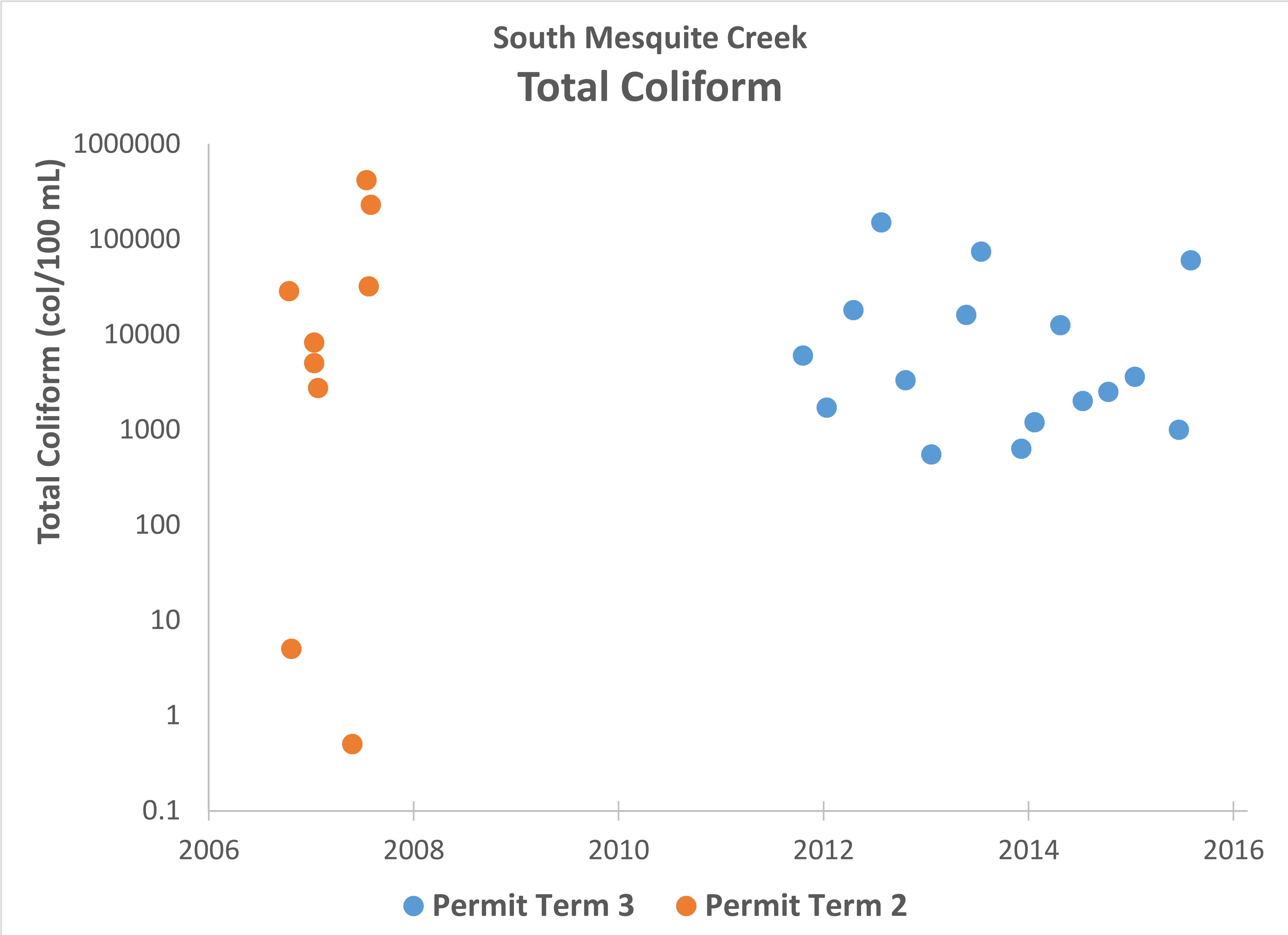


South Mesquite Creek
Field pH
pH (Standard Units)
9.5
9
8.5
8
7.5
7
6.5
6
2006
2008
2010
2012
2014
2016
Permit Term 3
Permit Term 2
Basin Specific Criteria


South Mesquite Creek
Specific Conductance (Field)
Specific Conductance (µS/cm)
2500
2000
1500
1000
500
0
2012
2013
2014
2015
2016
Permit Term 3
NRSA: good (<)
NRSA: fair (<)

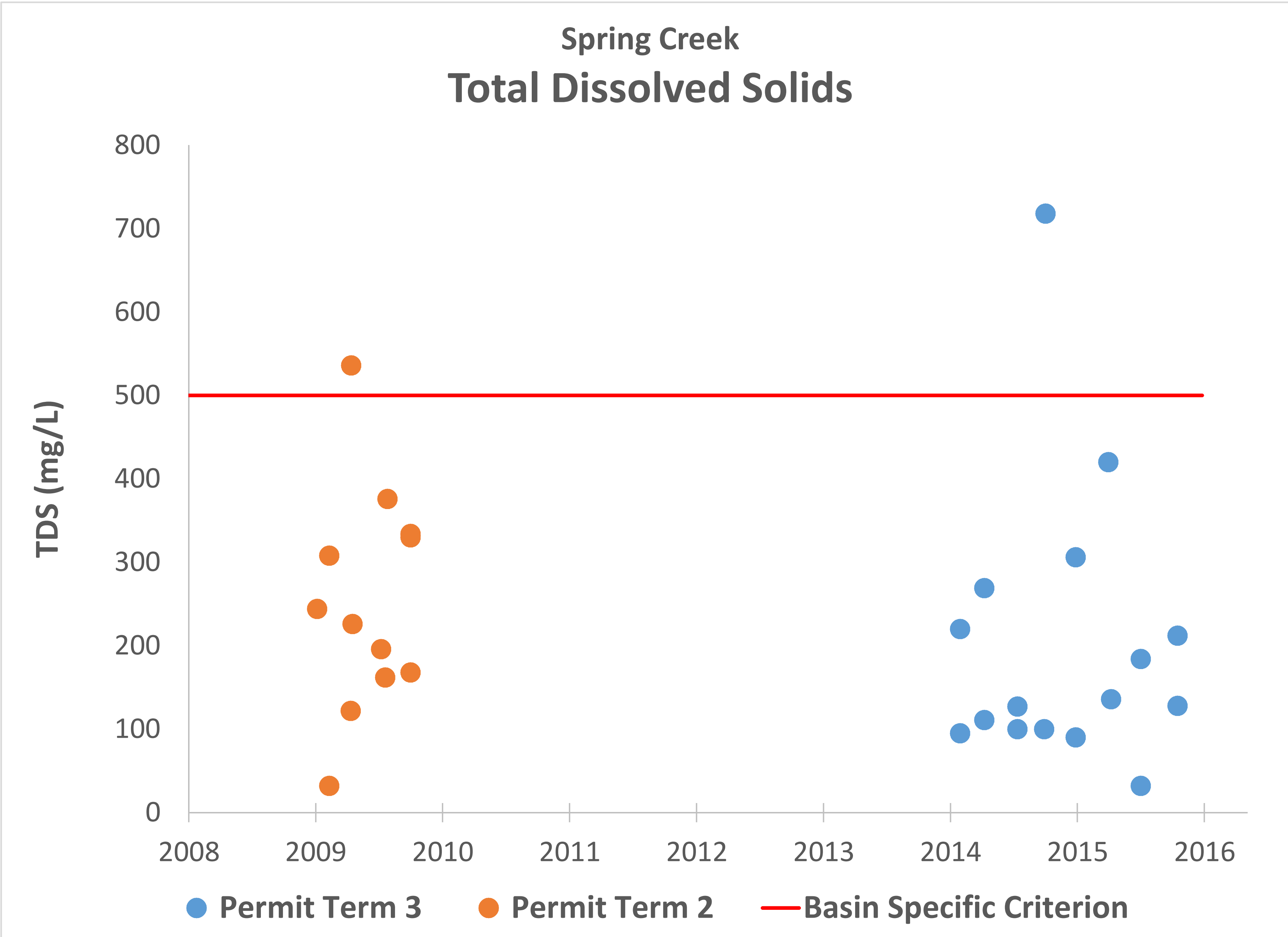

South Mesquite Creek
Temperature
Temperature (°F)
100
90
80
70
60
50
40
30
20
10
0
2012
2013
2014
2015
2016
Permit Term 3
Basin Specific Criterion

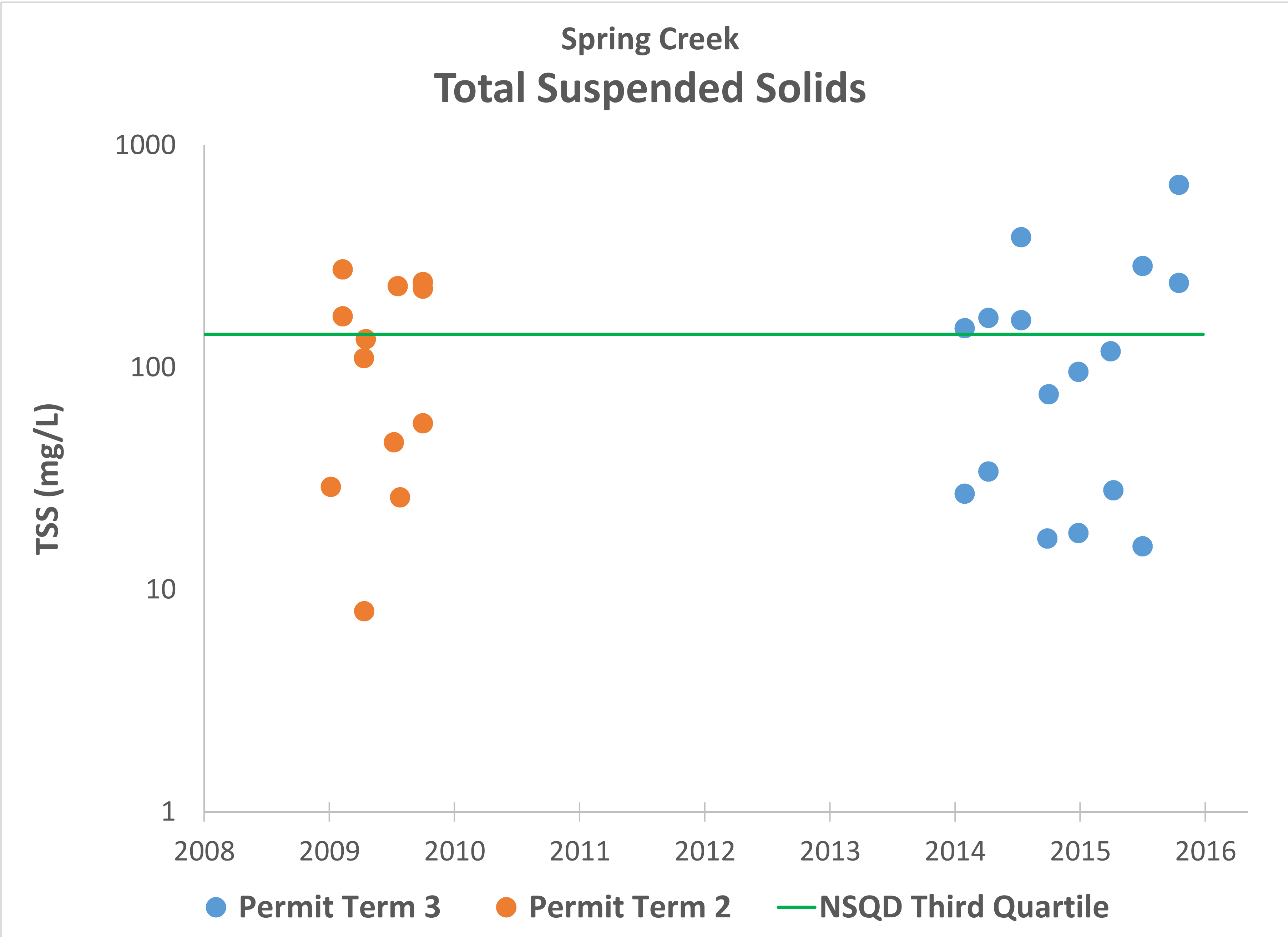

South Mesquite Creek
E.Coli
E. Coli (col/100 mL)
100000
10000
1000
100
10
1
0.1
2006
2008
2010
2012
2014
2016
Term 3
Term 2
PCR Geomean
PCR Single Sample


South Mesquite Creek
Total Coliform
Total Coliform (col/100 mL)
1000000
100000
10000
1000
100
10
1
0.1
2006
2008
2010
2012
2014
2016
Permit Term 3
Permit Term 2

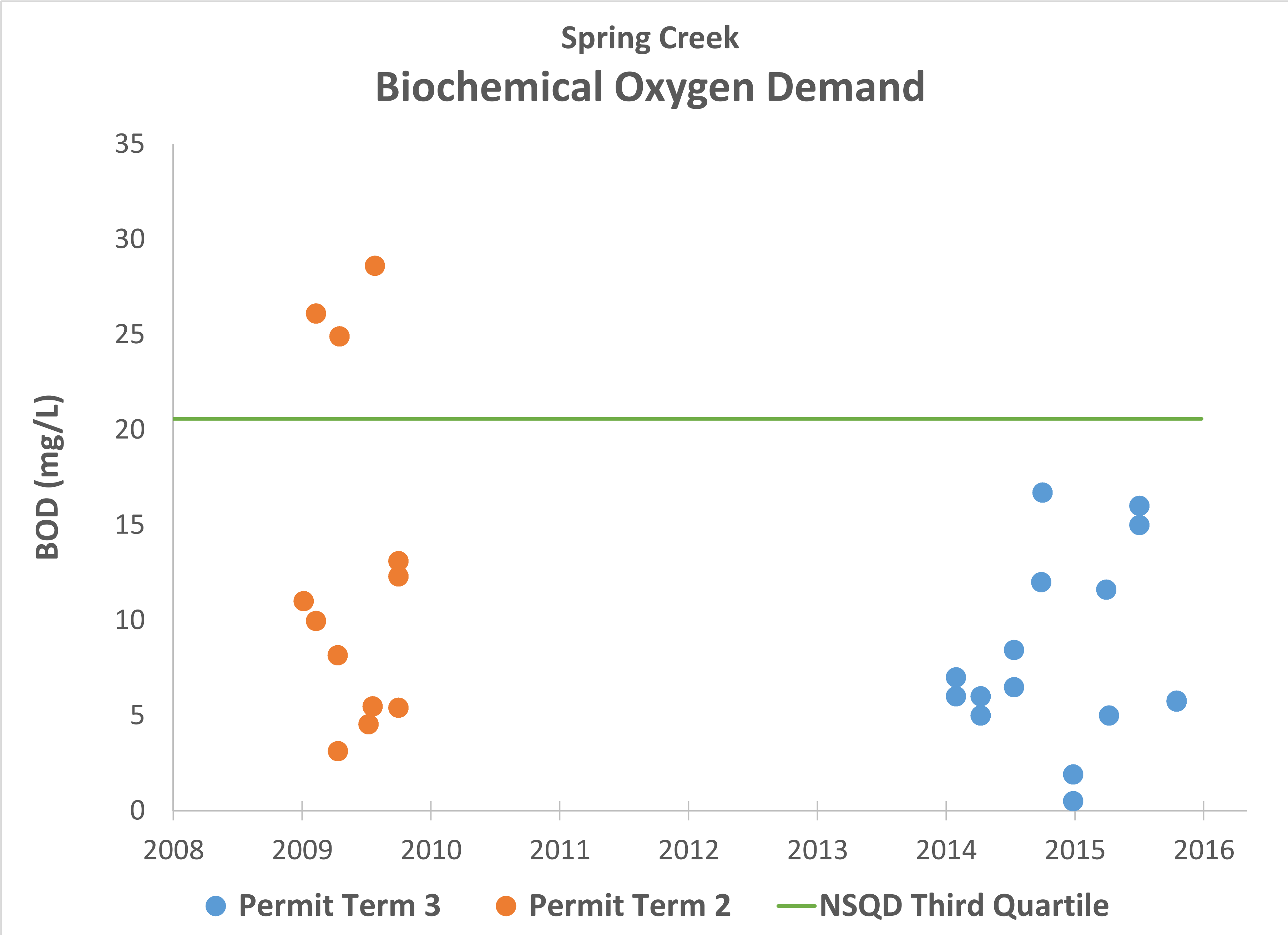
Appendix X

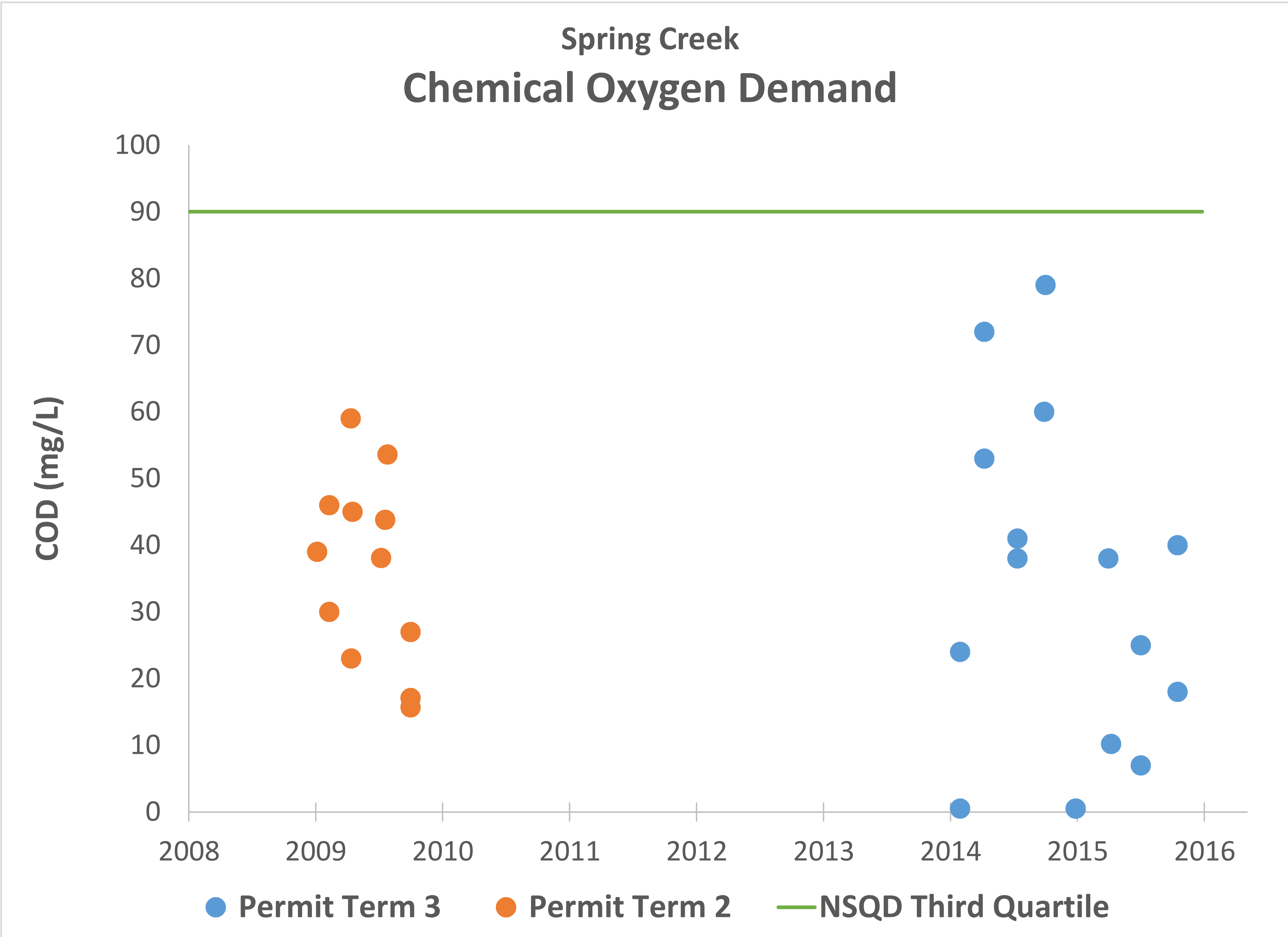
Spring Creek Water Quality
Data Graphs

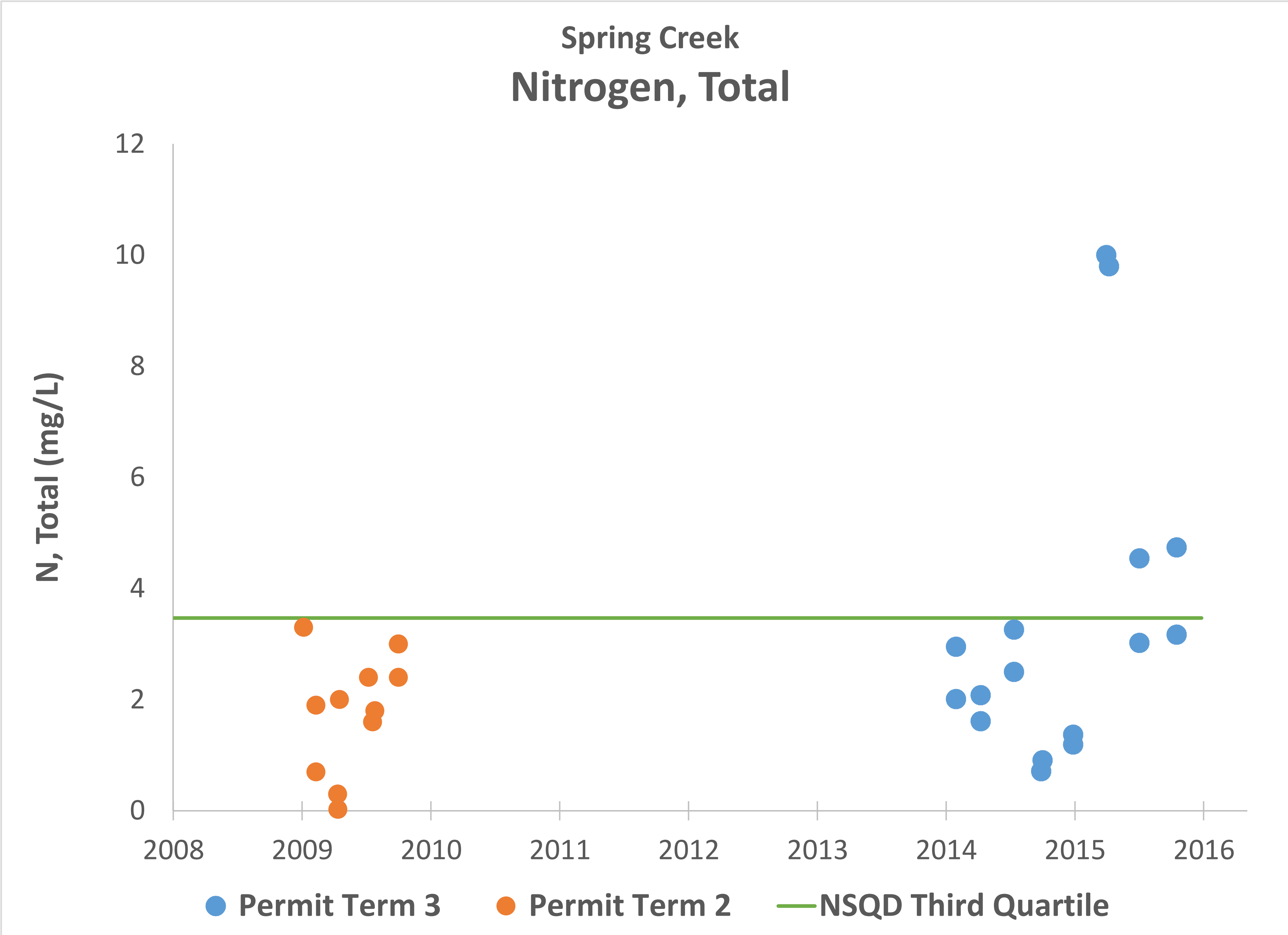

Spring Creek
Total Dissolved Solids
TDS (mg/L)
800
700
600
500
400
300
200
100
0
2008
2009
2010
2011
2012
2013
2014
2015
2016
Permit Term 3
Permit Term 2
Basin Specific Criterion



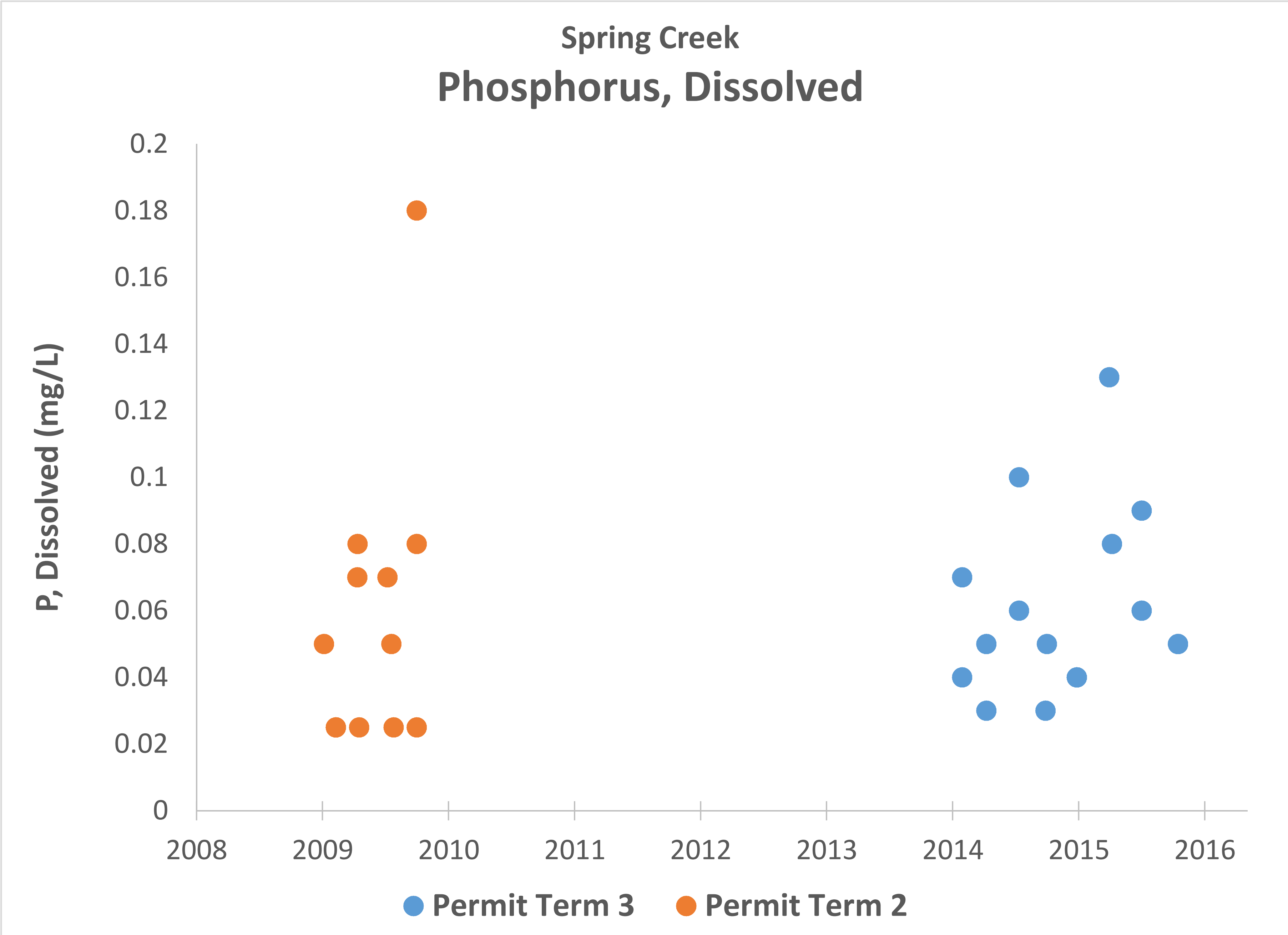
Spring Creek
Total Suspended Solids
TSS (mg/L)
1000
100
10
1
2008
2009
2010
2011
2012
2013
2014
2015
2016
Permit Term 3
Permit Term 2
NSQD Third Quartile


Spring Creek
Biochemical Oxygen Demand
BOD (mg/L)
35
30
25
20
15
10
5
0
2008
2009
2010
2011
2012
2013
2014
2015
2016
Permit Term 3
Permit Term 2
NSQD Third Quartile

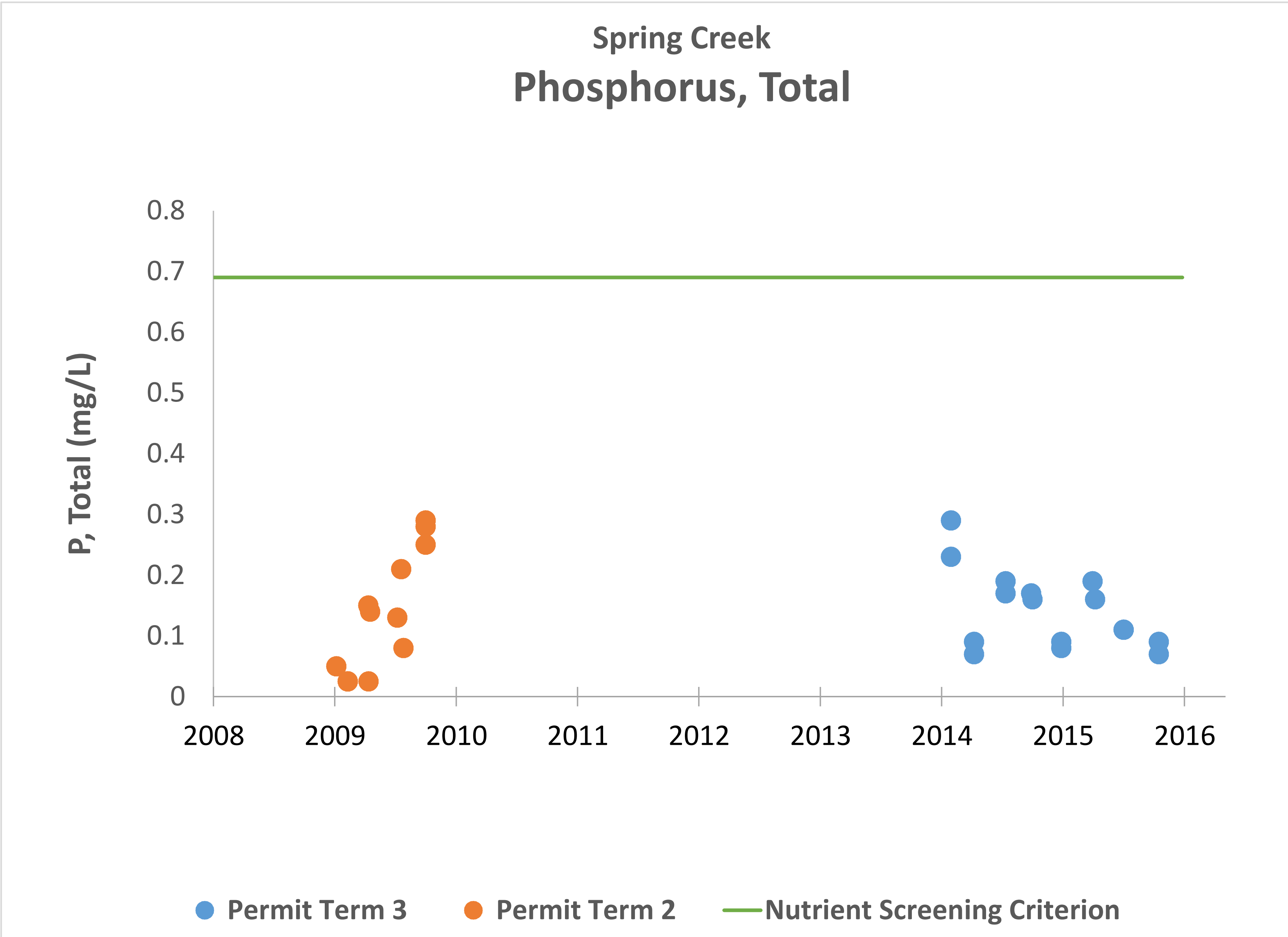

Spring Creek
Chemical Oxygen Demand
COD (mg/L)
100
90
80
70
60
50
40
30
20
10
0
2008
2009
2010
2011
2012
2013
2014
2015
2016
Permit Term 3
Permit Term 2
NSQD Third Quartile

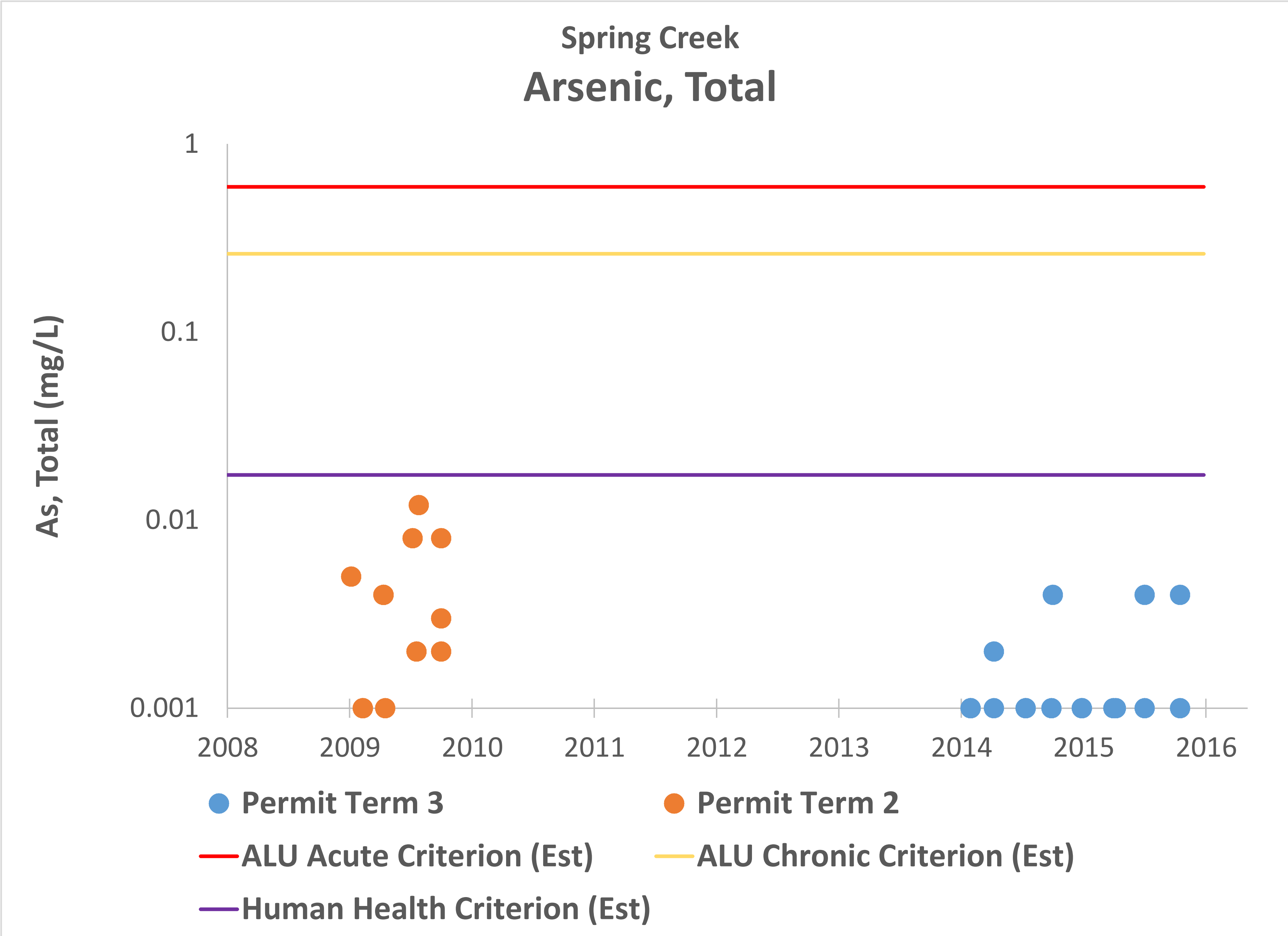


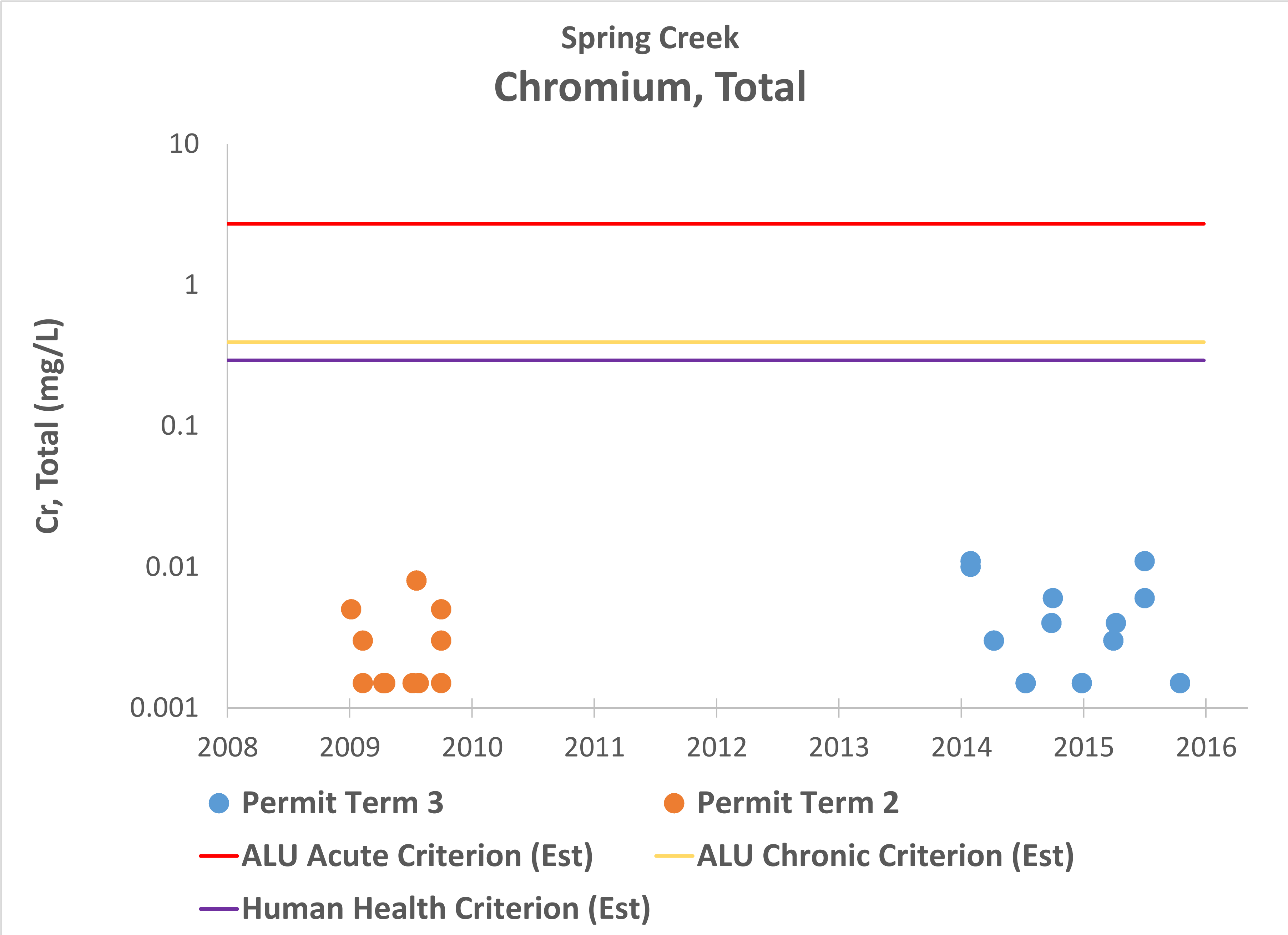
Spring Creek
Nitrogen, Total
N, Total (mg/L)
0
2
4
6
8
10
12
2008
2009
2010
2011
2012
2013
2014
2015
2016
Permit Term 3
Permit Term 2
NSQD Third Quartile



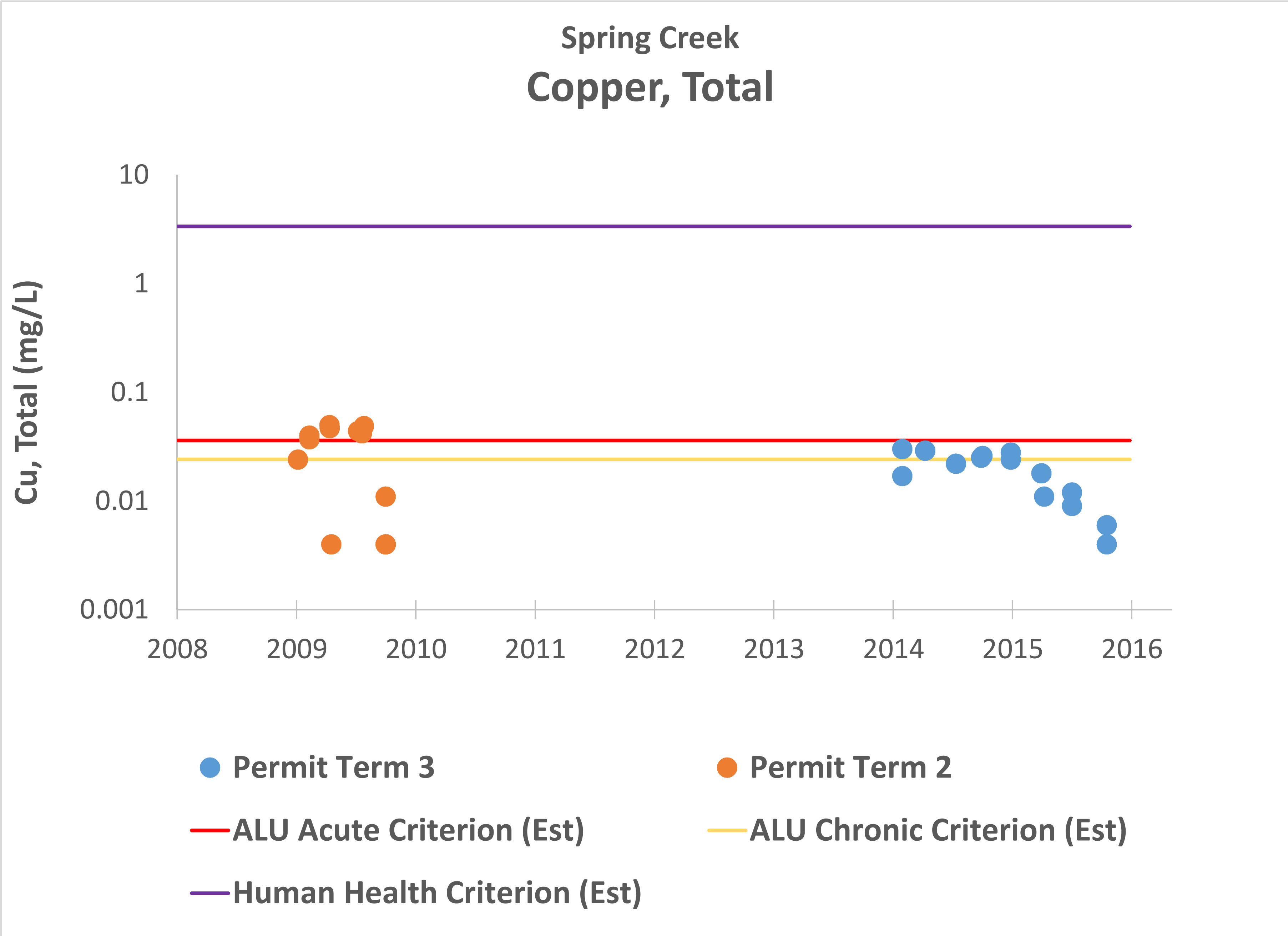
Spring Creek
Phosphorus, Dissolved
P, Dissolved (mg/L)
0.2
0.18
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
2008
2009
2010
2011
2012
2013
2014
2015
2016
Permit Term 3
Permit Term 2


Spring Creek
Phosphorus, Total
P, Total (mg/L)
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
2008
2009
2010
2011
2012
2013
2014
2015
2016
Permit Term 3
Permit Term 2
Nutrient Screening Criterion

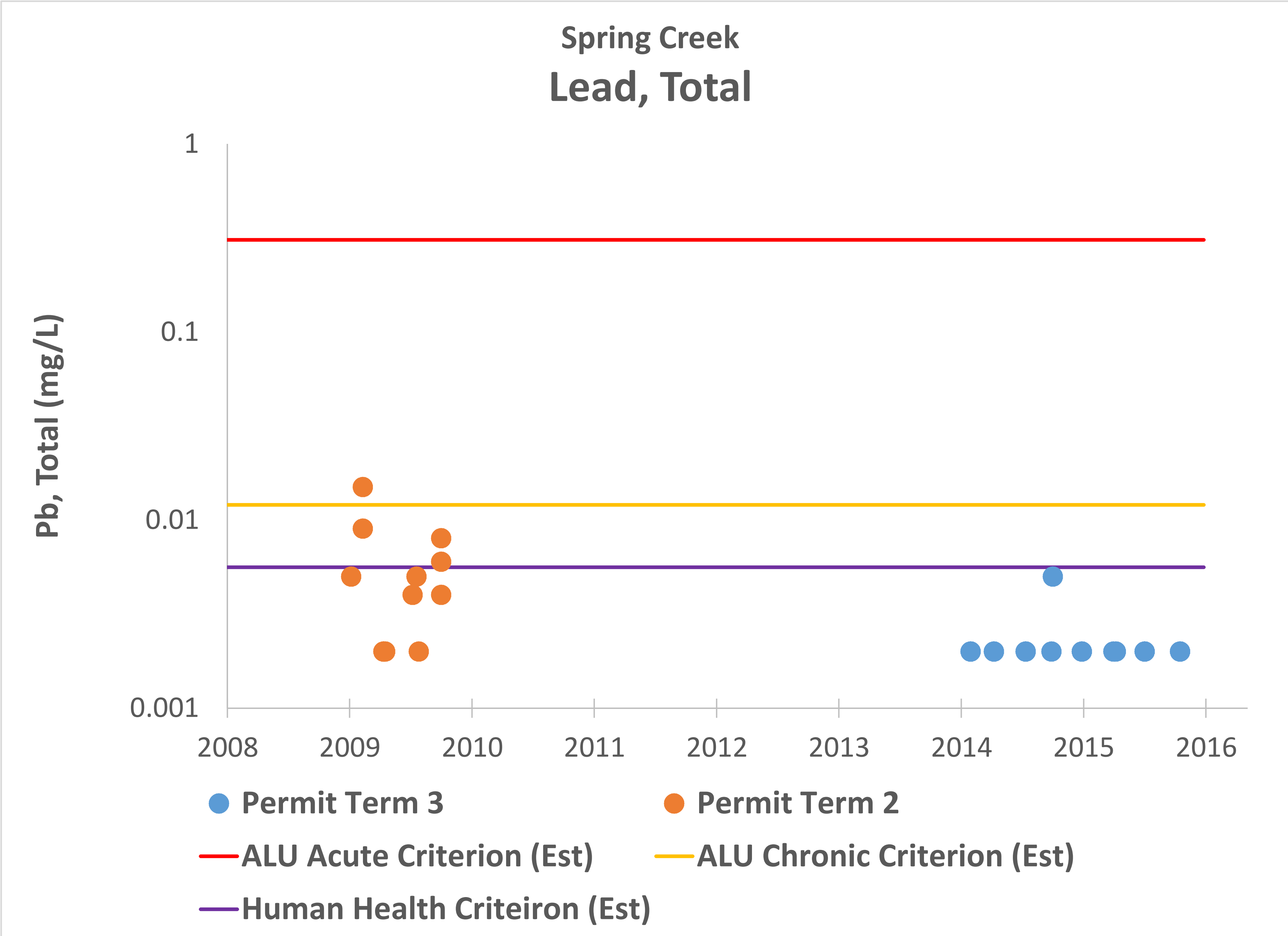

Spring Creek
Arsenic, Total
As, Total (mg/L)
1
0.1
0.01
0.001
2008
2009
2010
2011
2012
2013
2014
2015
2016
Permit Term 3
Permit Term 2
ALU Acute Criterion (Est)
ALU Chronic Criterion (Est)
Human Health Criterion (Est)

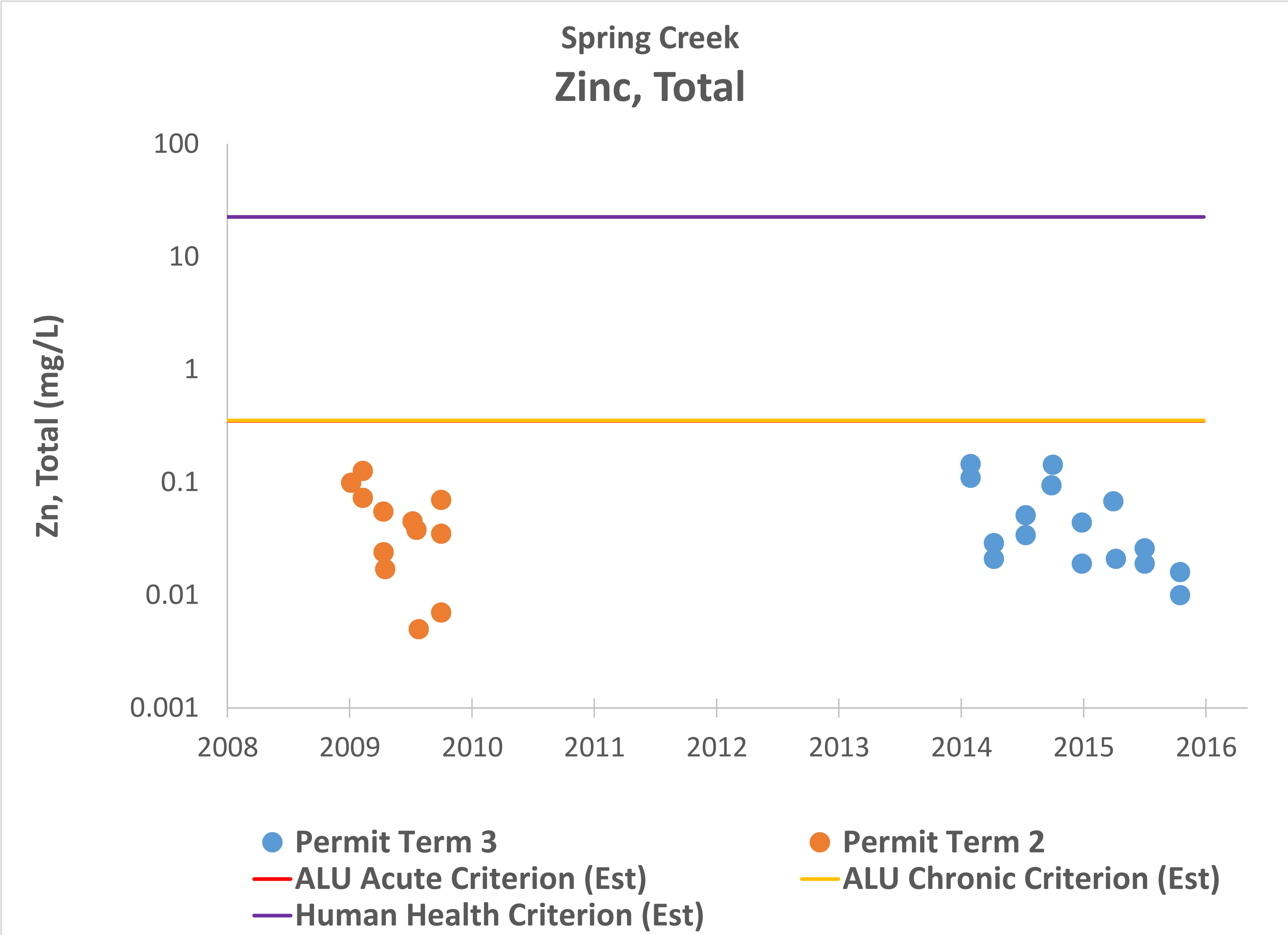


Spring Creek
Chromium, Total
Cr, Total (mg/L)
10
1
0.1
0.01
0.001
2008
2009
2010
2011
2012
2013
2014
2015
2016
Permit Term 3
Permit Term 2
ALU Acute Criterion (Est)
ALU Chronic Criterion (Est)
Human Health Criterion (Est)

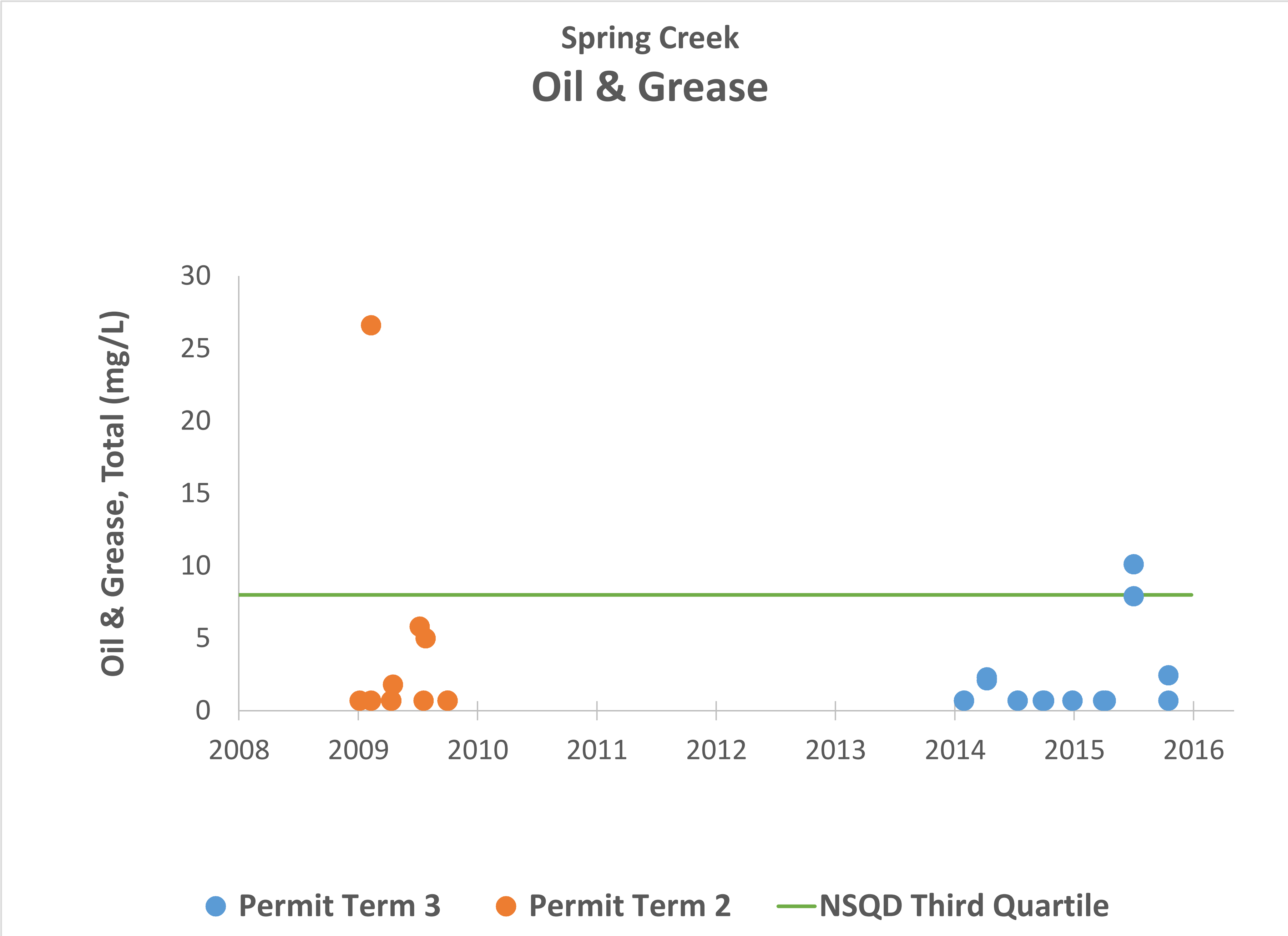


Spring Creek
Copper, Total
Cu, Total (mg/L)
10
1
0.1
0.01
0.001
2008
2009
2010
2011
2012
2013
2014
2015
2016
Permit Term 3
Permit Term 2
ALU Acute Criterion (Est)
ALU Chronic Criterion (Est)
Human Health Criterion (Est)

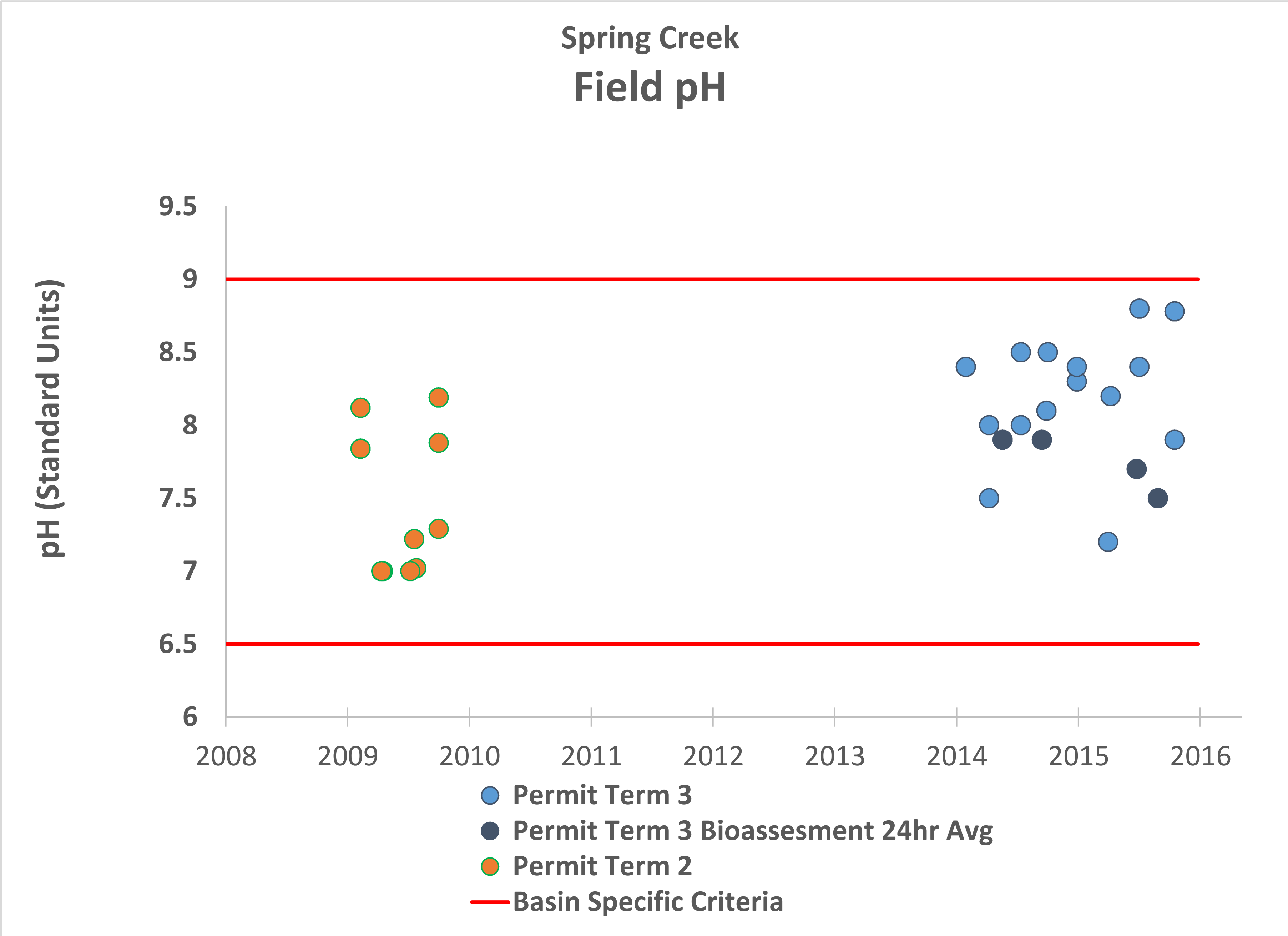

Spring Creek
Lead, Total
Pb, Total (mg/L)
1
0.1
0.01
0.001
2008
2009
2010
2011
2012
2013
2014
2015
2016
Permit Term 3
Permit Term 2
ALU Acute Criterion (Est)
ALU Chronic Criterion (Est)
Human Health Criteiron (Est)

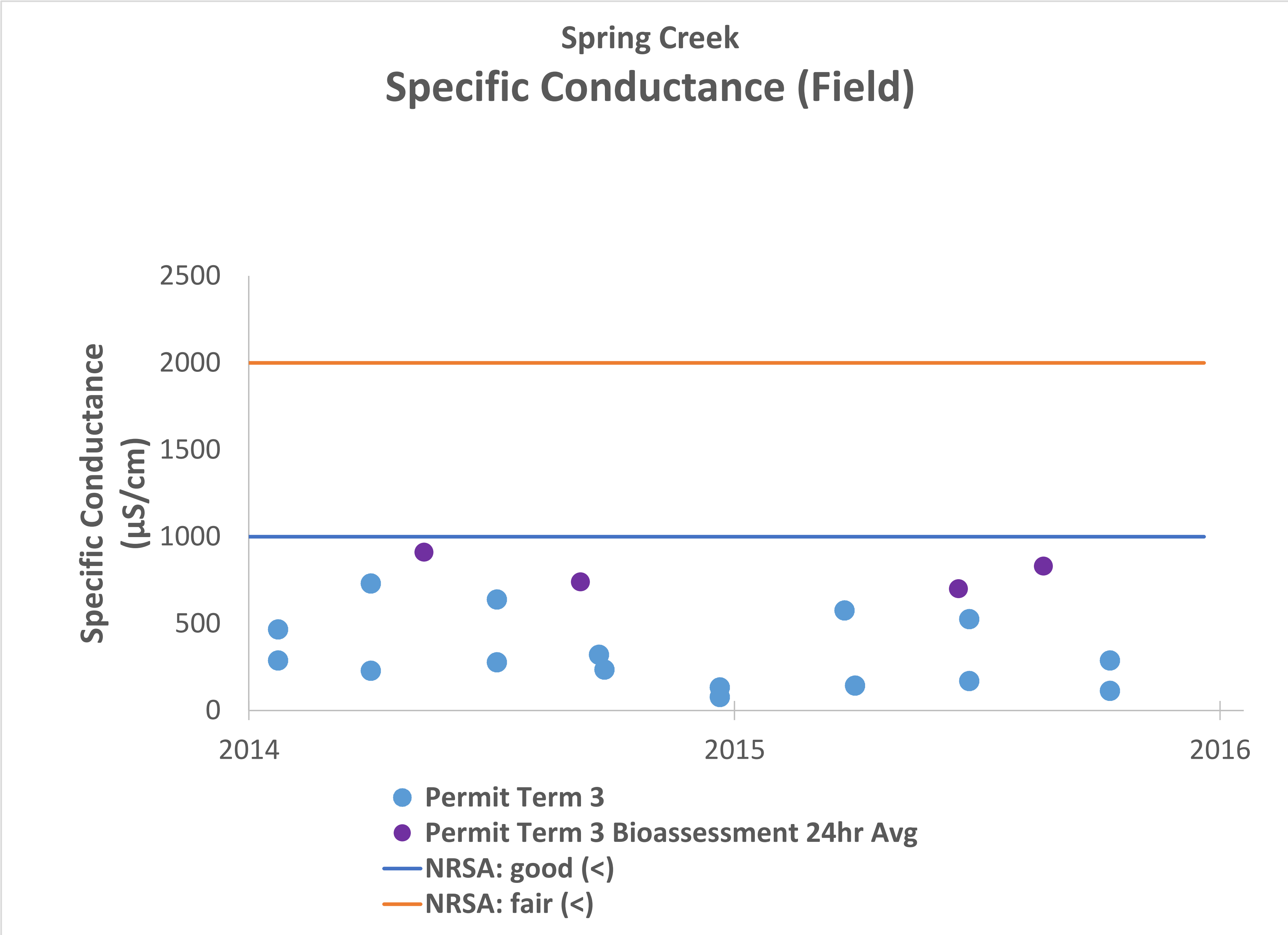


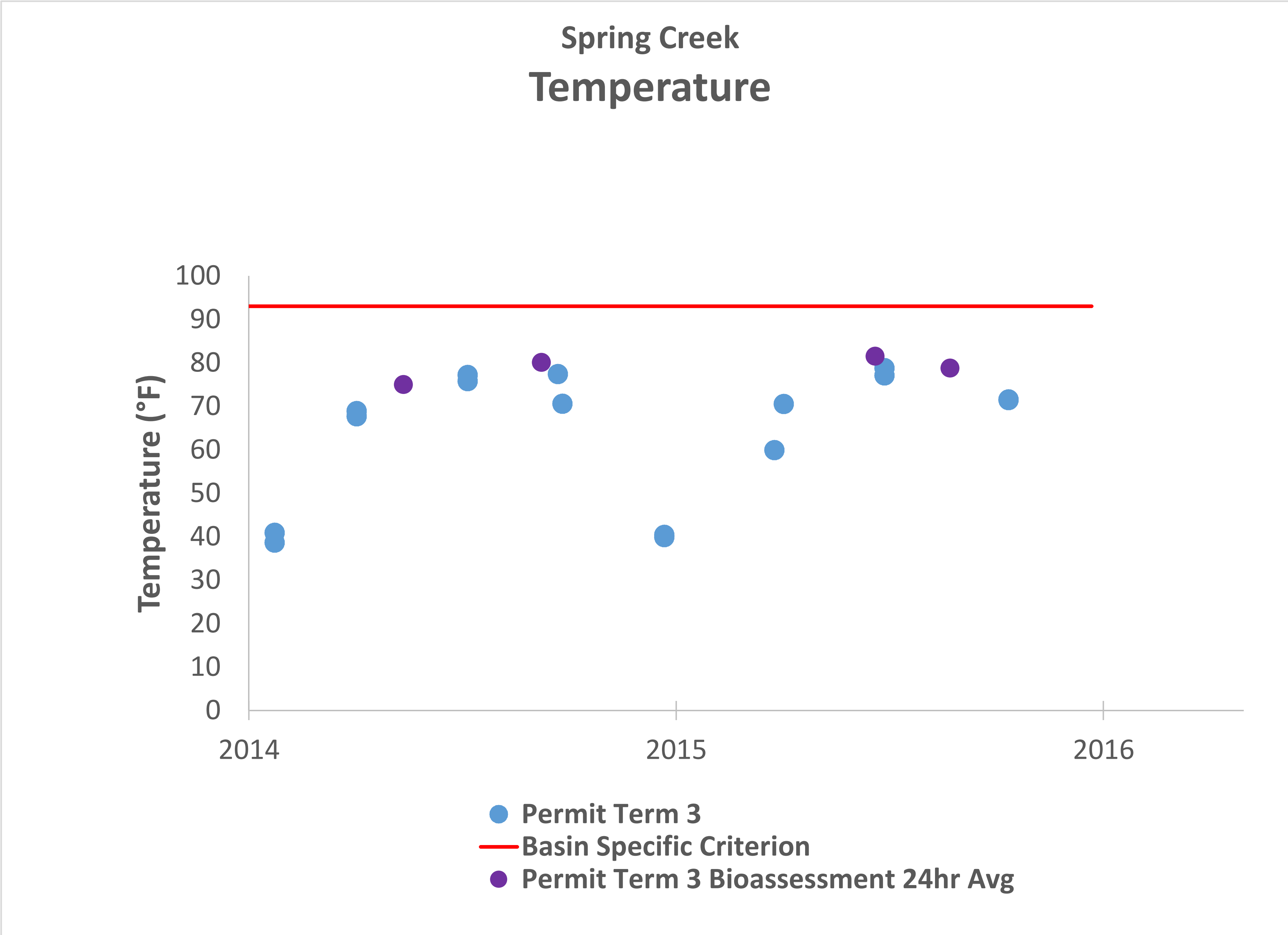
Spring Creek
Zinc, Total
Zn, Total (mg/L)
100
10
1
0.1
0.01
0.001
2008
2009
2010
2011
2012
2013
2014
2015
2016
Permit Term 3
Permit Term 2
ALU Acute Criterion (Est)
ALU Chronic Criterion (Est)
Human Health Criterion (Est)



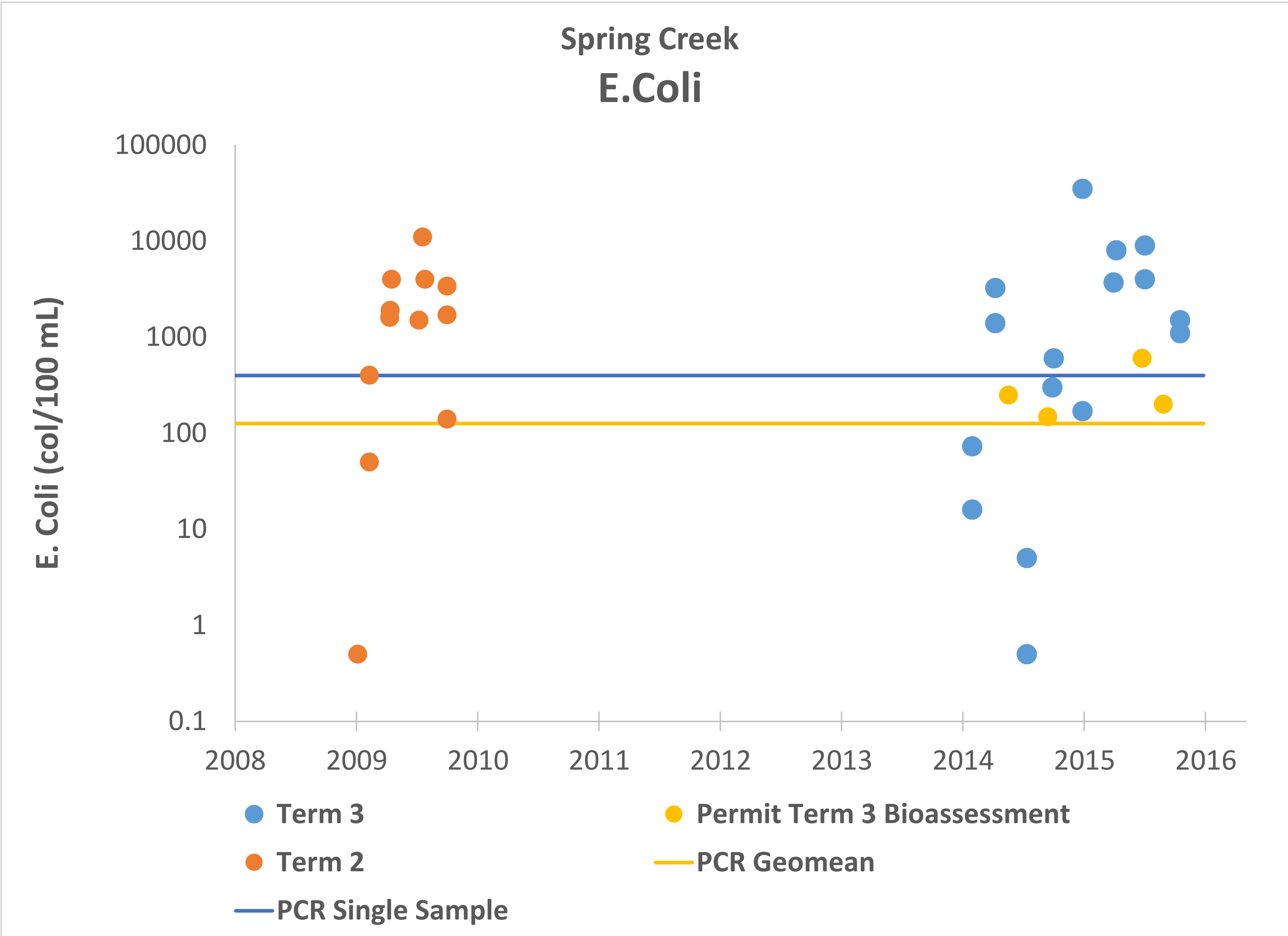
Spring Creek
Oil & Grease
Oil & Grease, Total (mg/L)
30
25
20
15
10
5
0
2008
2009
2010
2011
2012
2013
2014
2015
2016
Permit Term 3
Permit Term 2
NSQD Third Quartile


Spring Creek
Field pH
pH (Standard Units)
9.5
9
8.5
8
7.5
7
6.5
6
2008
2009
2010
2011
2012
2013
2014
2015
2016
Permit Term 3
Permit Term 3 Bioassesment 24hr Avg
Permit Term 2
Basin Specific Criteria

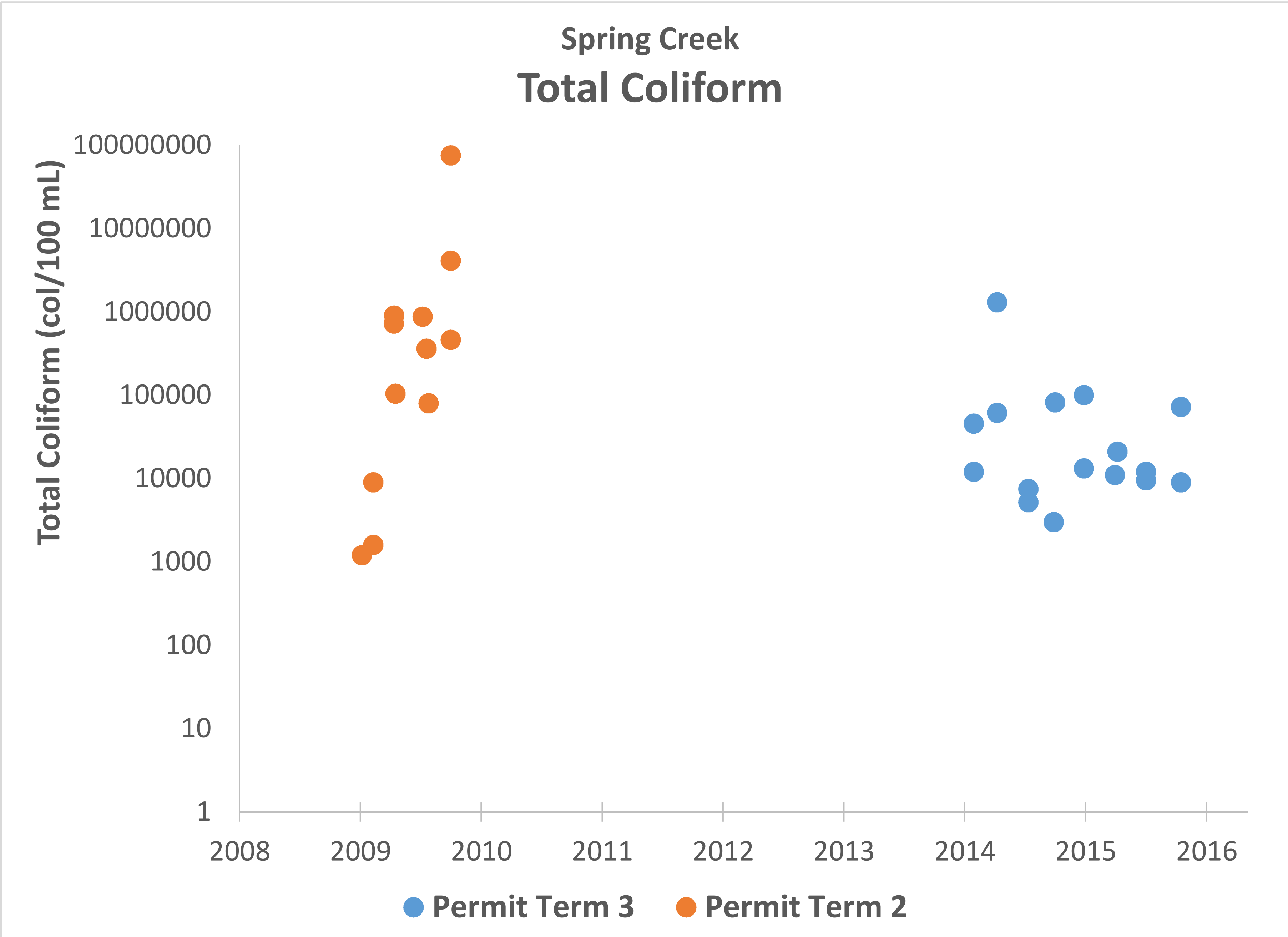

Spring Creek
Specific Conductance (Field)
Specific Conductance (µS/cm)
2500
2000
1500
1000
500
0
2014
2015
2016
Permit Term 3
Permit Term 3 Bioassessment 24hr Avg
NRSA: good (<)
NRSA: fair (<)



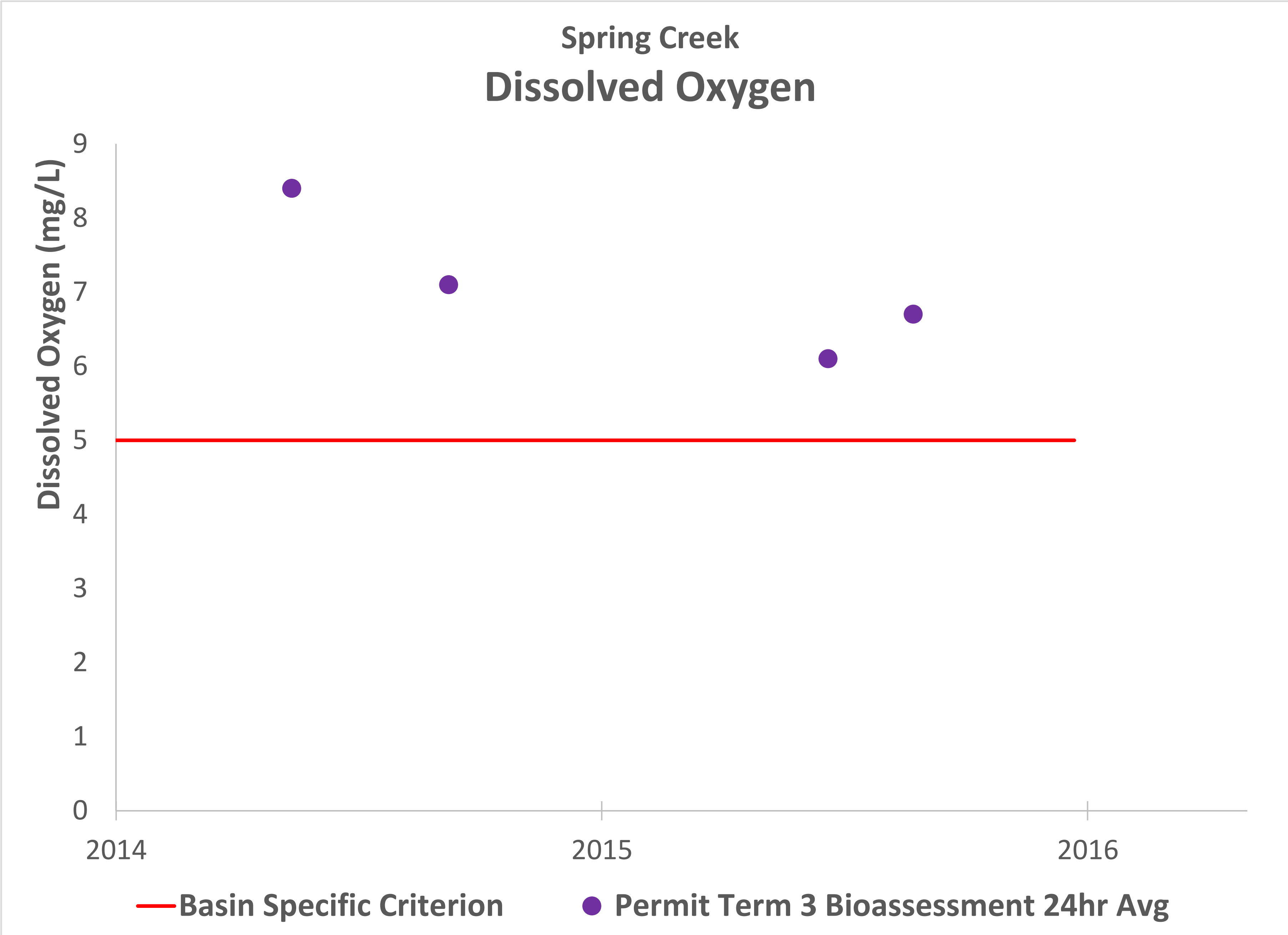
Spring Creek
Temperature
Temperature (°F)
100
90
80
70
60
50
40
30
20
10
0
2014
2015
2016
Permit Term 3
Basin Specific Criterion
Permit Term 3 Bioassessment 24hr Avg

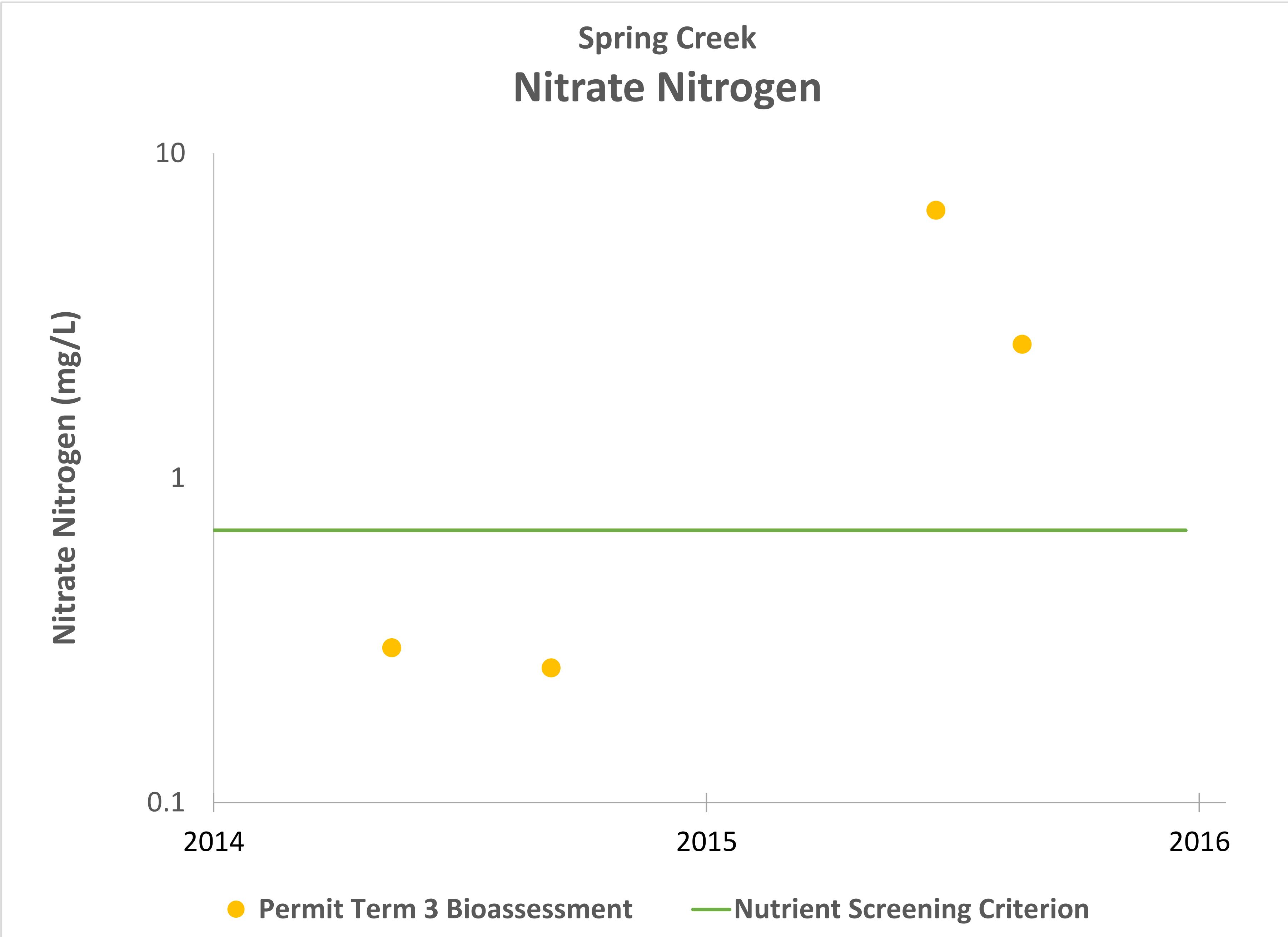


Spring Creek
E.Coli
E. Coli (col/100 mL)
100000
10000
1000
100
10
1
0.1
2008
2009
2010
2011
2012
2013
2014
2015
2016
Term 3
Permit Term 3 Bioassessment
Term 2
PCR Geomean
PCR Single Sample

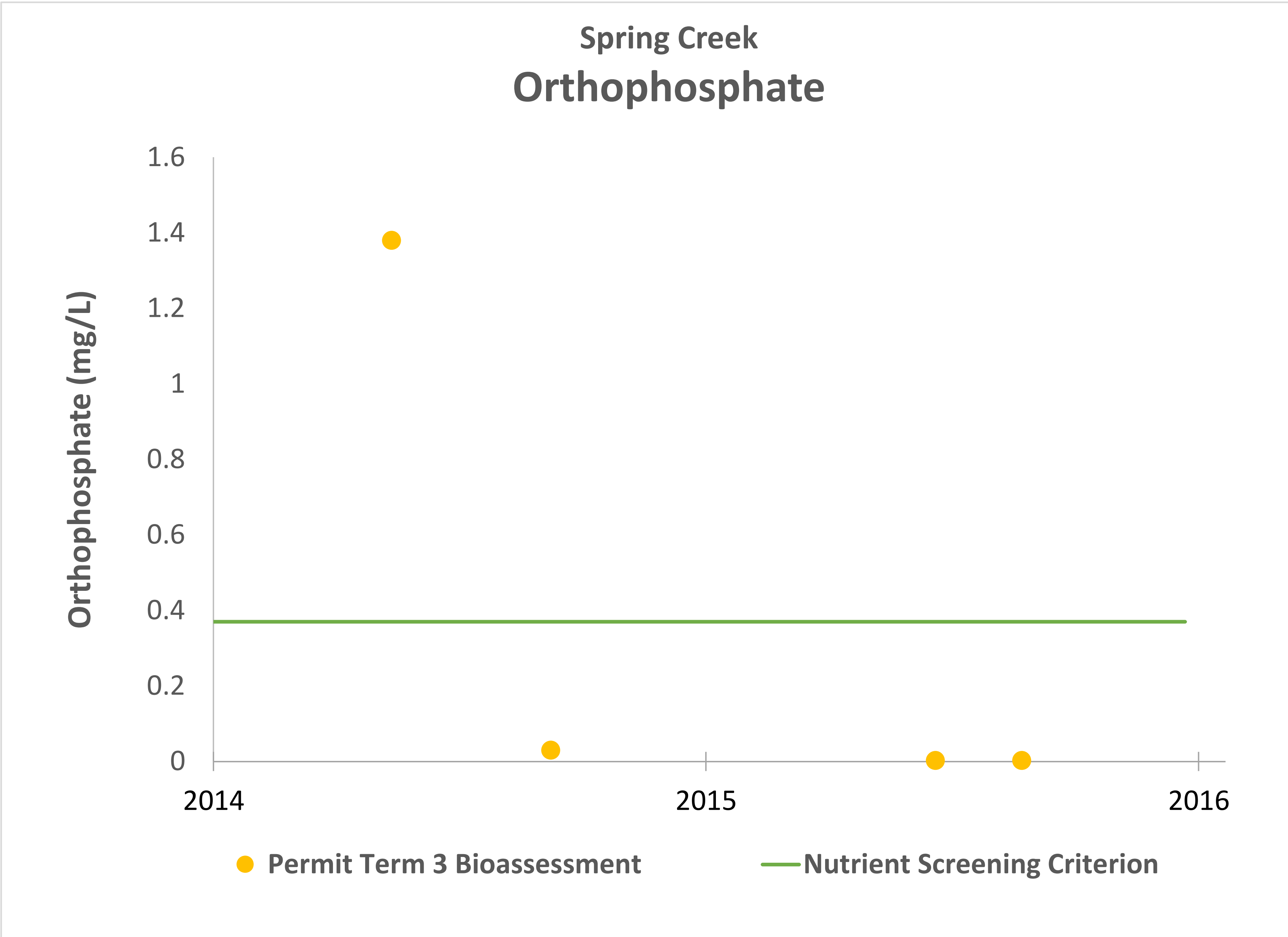


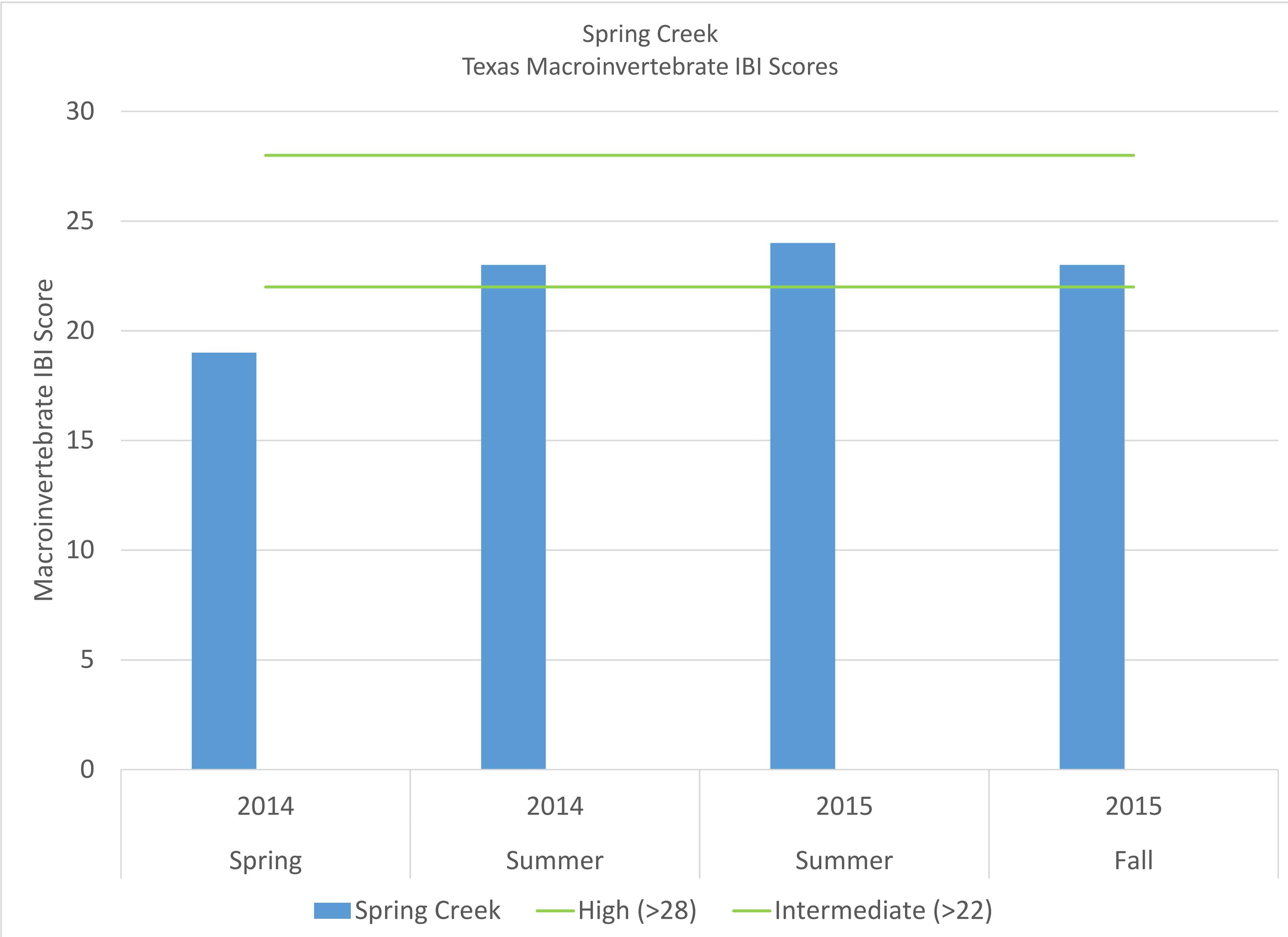
Spring Creek
Total Coliform
Total Coliform (col/100 mL)
100000000
10000000
1000000
100000
10000
1000
100
10
1
2008
2009
2010
2011
2012
2013
2014
2015
2016
Permit Term 3
Permit Term 2

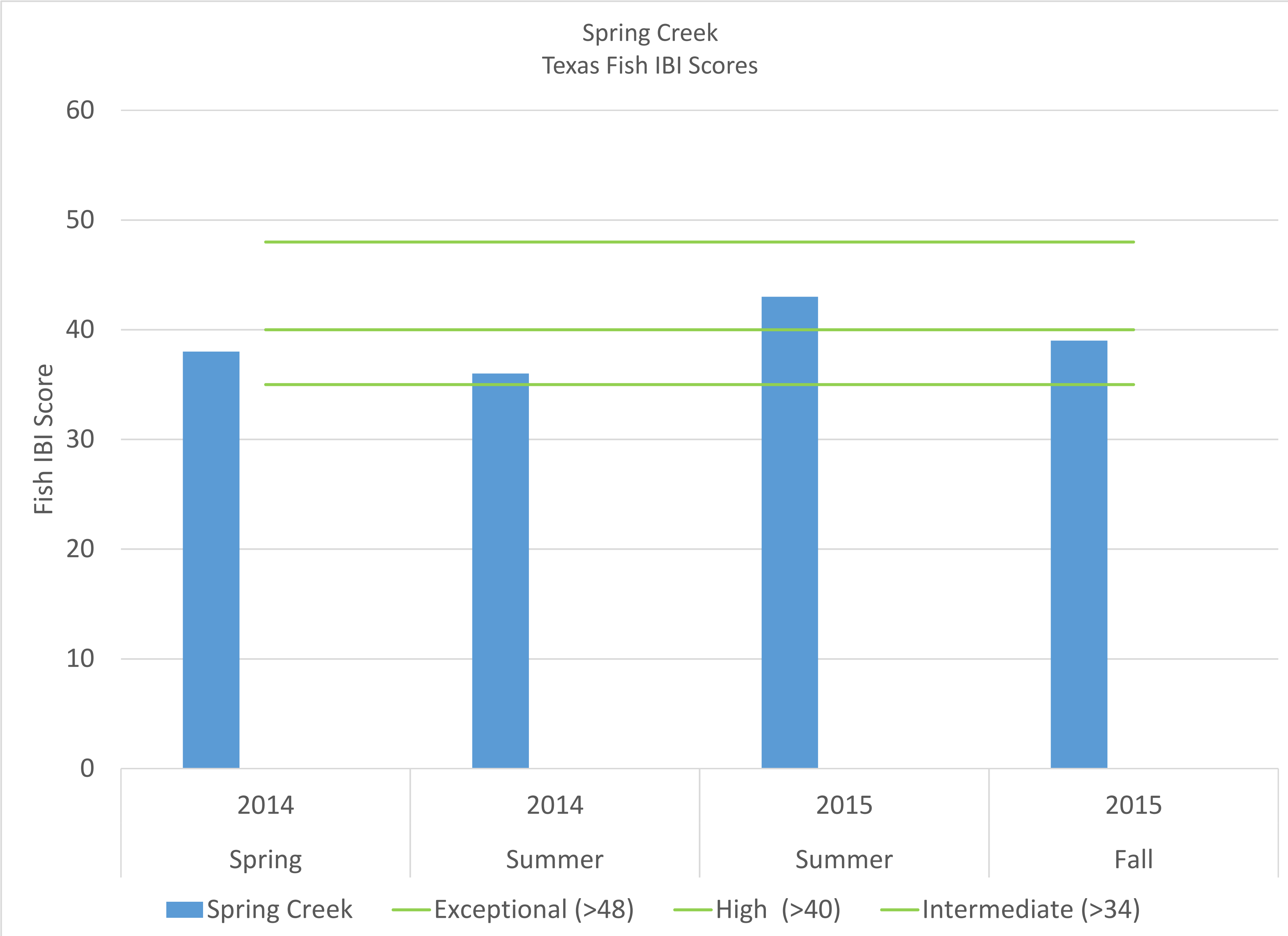

Spring Creek
Dissolved Oxygen
Dissolved Oxygen (mg/L)
9
8
7
6
5
4
3
2
1
0
2014
2015
2016
Basin Specific Criterion
Permit Term 3 Bioassessment 24hr Avg



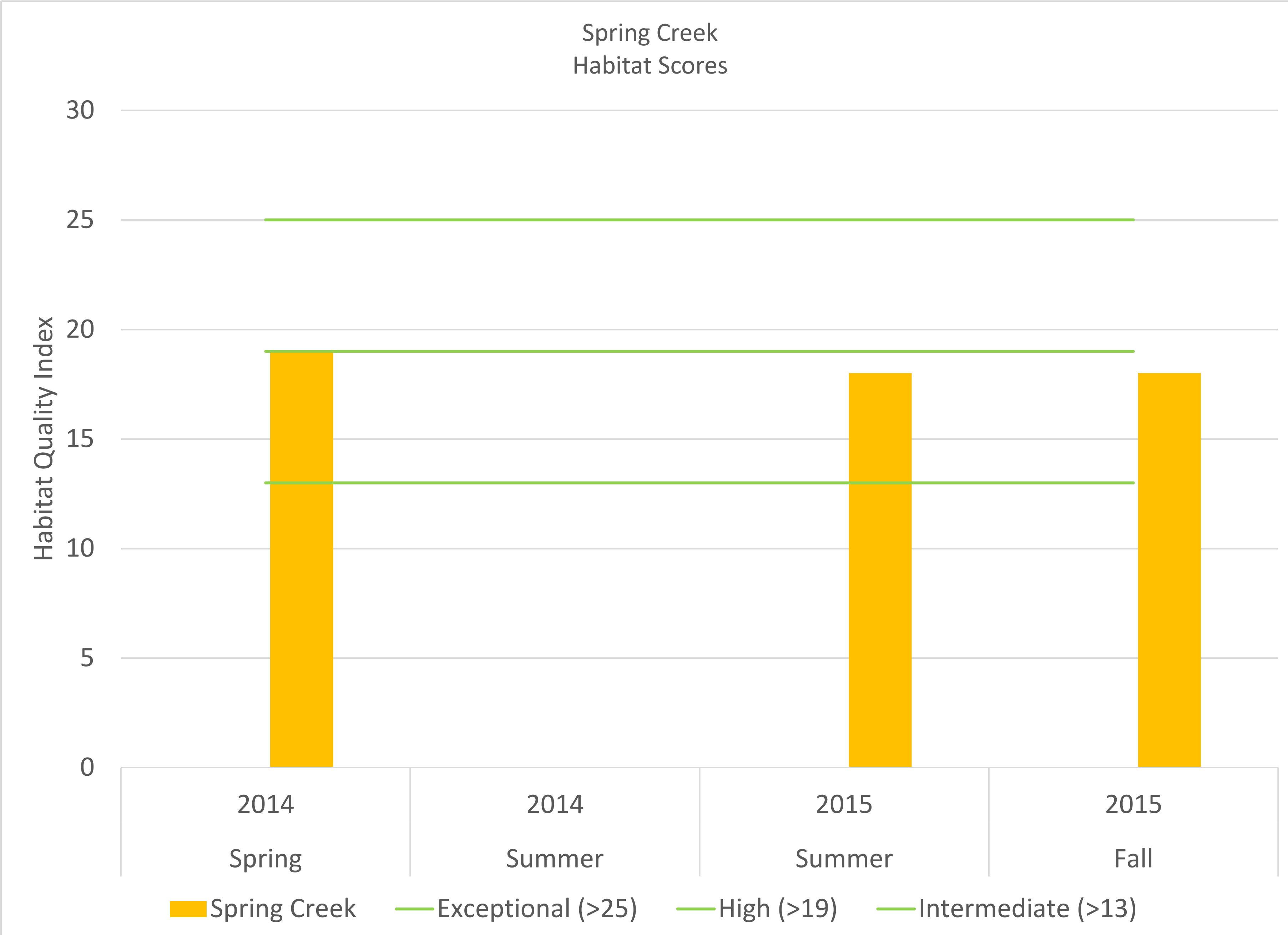
Spring Creek
Nitrate Nitrogen
Nitrate Nitrogen (mg/L)
10
1
0.1
2014
2015
2016
Permit Term 3 Bioassessment
Nutrient Screening Criterion


Spring Creek
Orthophosphate
Orthophosphate (mg/L)
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
2014
2015
2016
Permit Term 3 Bioassessment
Nutrient Screening Criterion


Spring Creek
Texas Macroinvertebrate IBI Scores
Macroinvertebrate IBI Score
30
25
20
15
10
5
0
2014
Spring
2014
Summer
2015
Summer
2015
Fall
Spring Creek
High (>28)
Intermediate (>22)



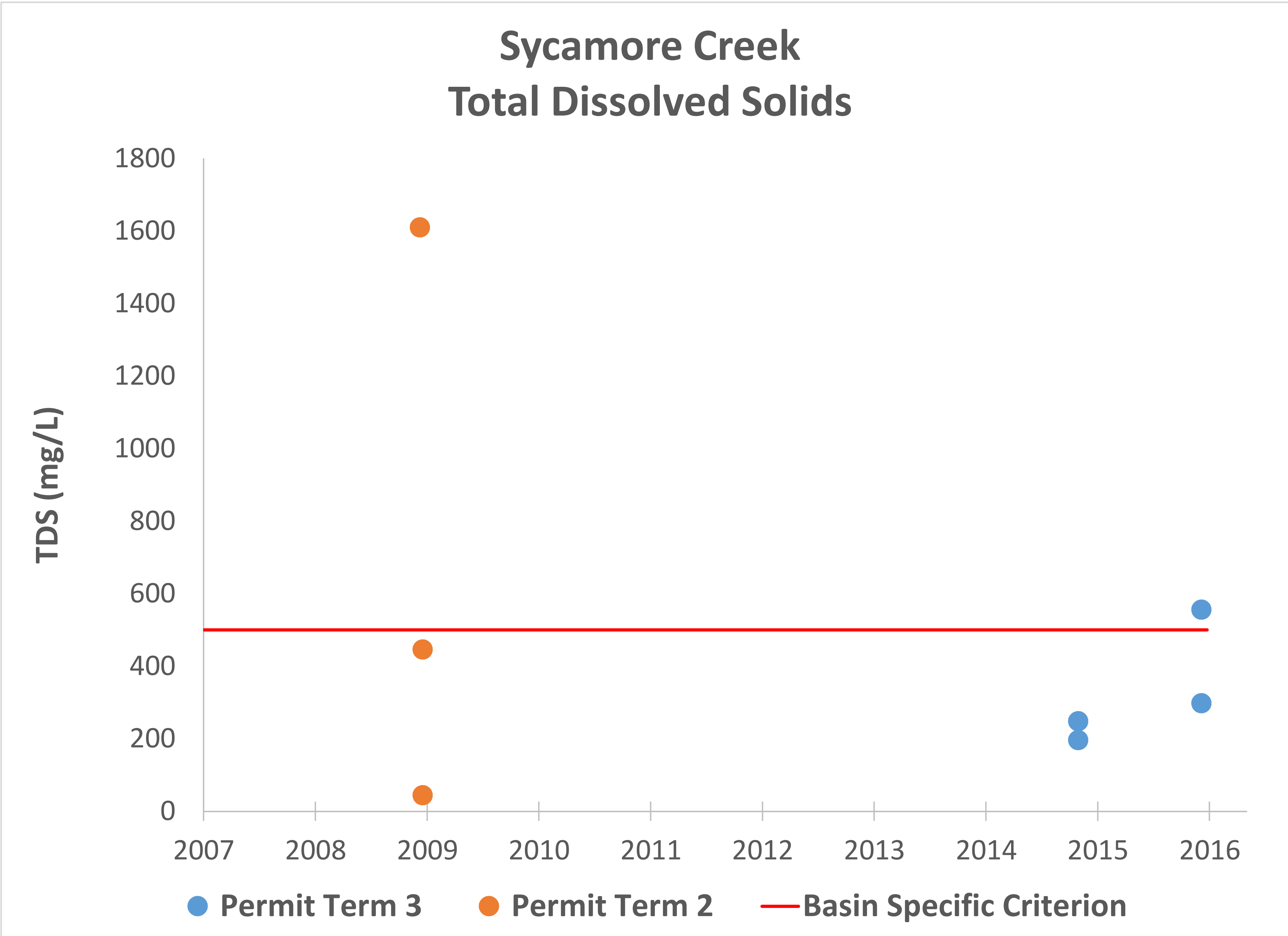
Spring Creek
Texas Fish IBI Scores
60
50
40
30
20
10
0
Fish IBI Score
2014
Spring
2014
Summer
2015
Summer
2015
Fall
Spring Creek
Exceptional (>48)
High (>40)
Intermediate (>34)

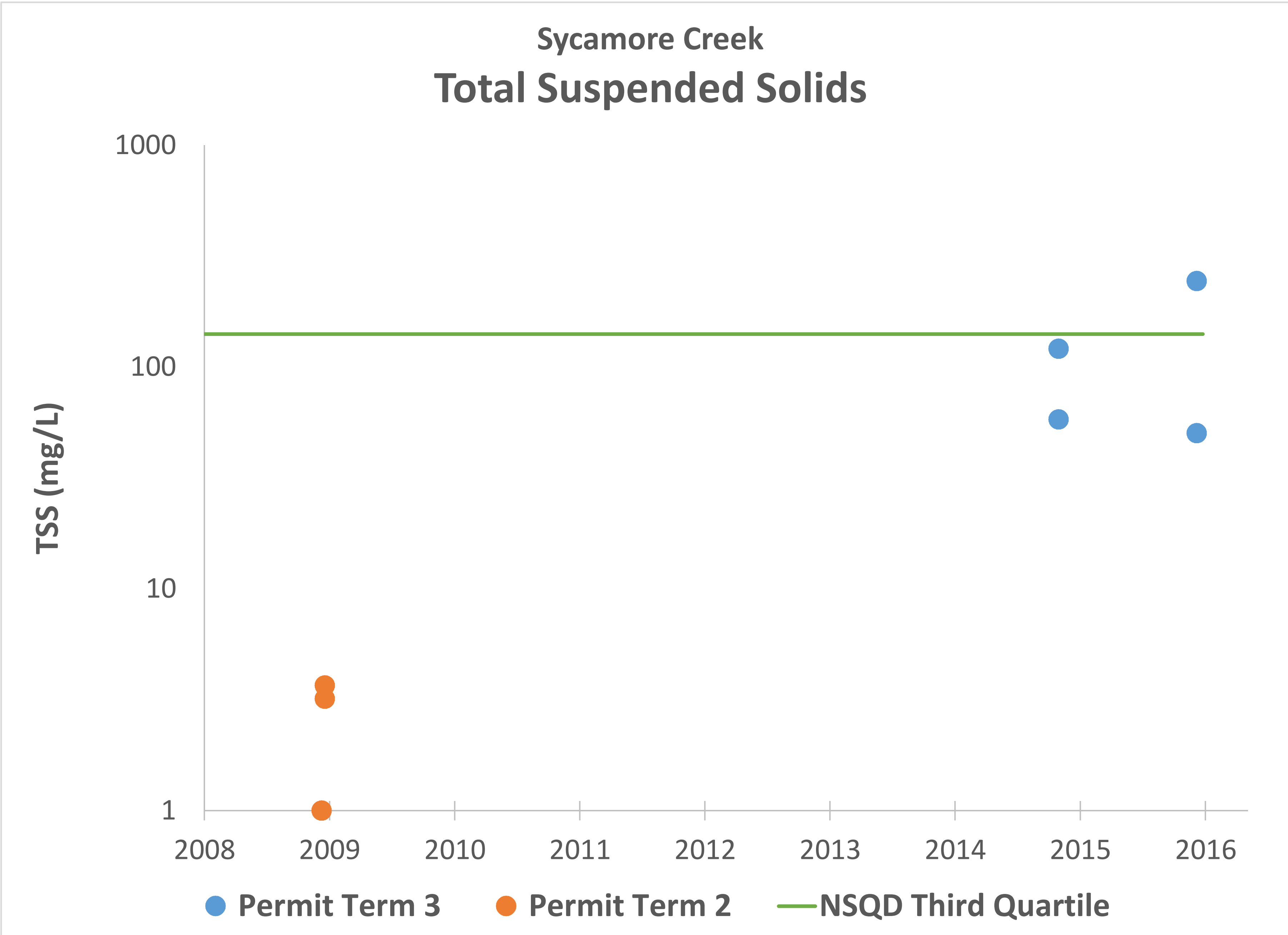


Spring Creek
Habitat Scores
Habitat Quality Index
30
25
20
15
10
5
0
2014
Spring
2014
Summer
2015
Summer
2015
Fall
Spring Creek
Exceptional (>25)
High (>19)
Intermediate (>13)

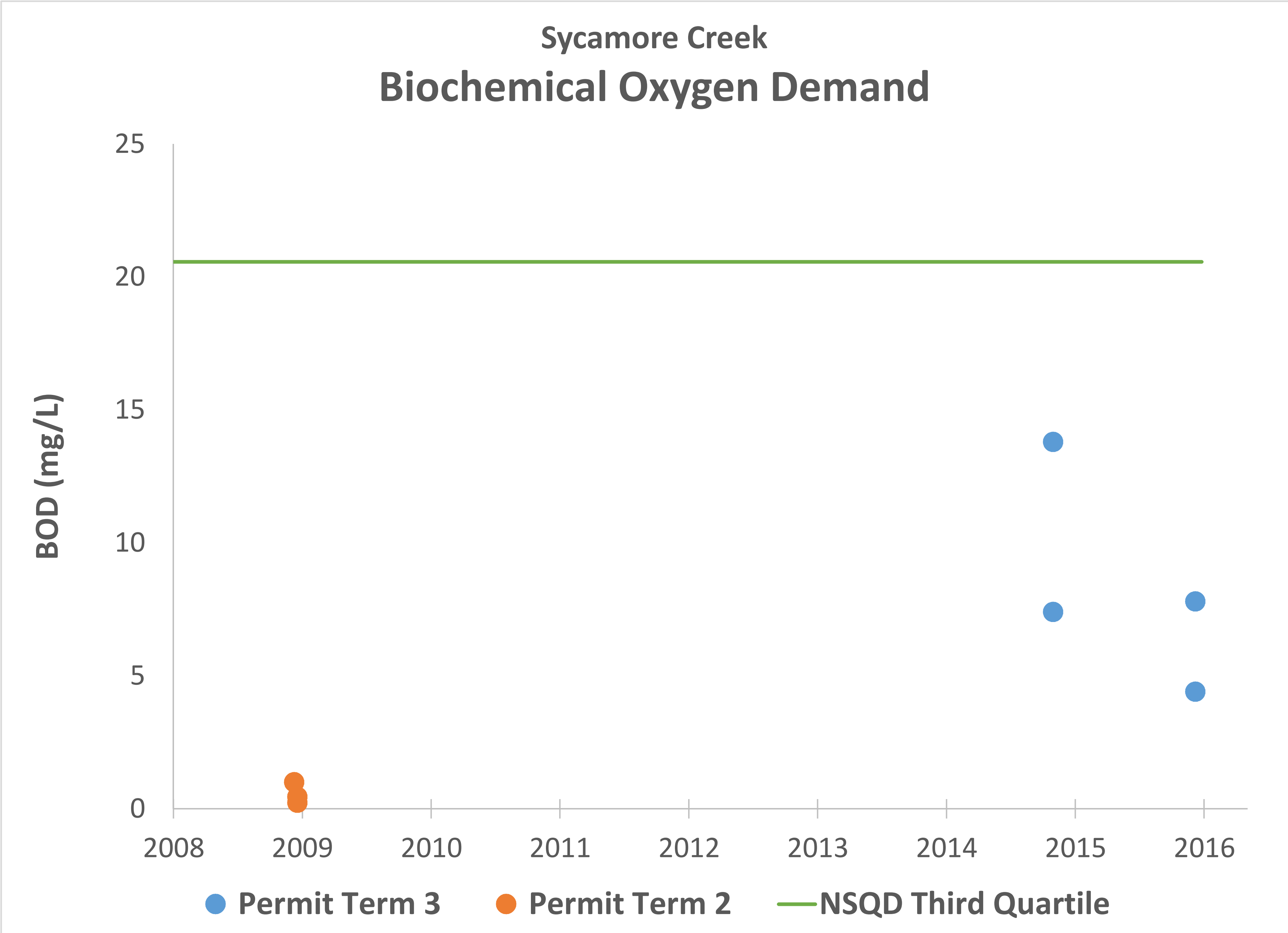
Appendix Y

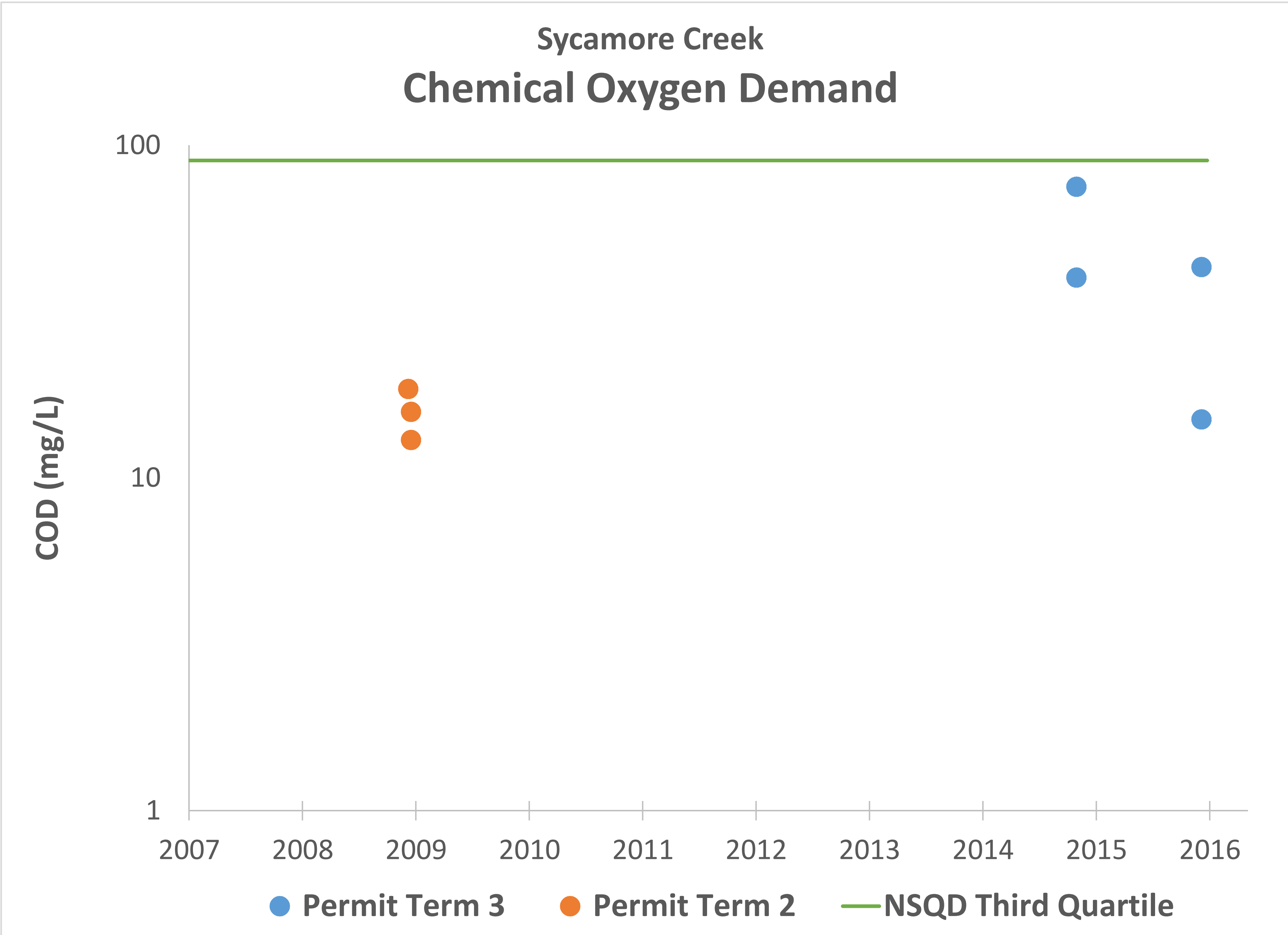
Sycamore Creek Water Quality Data Graphs

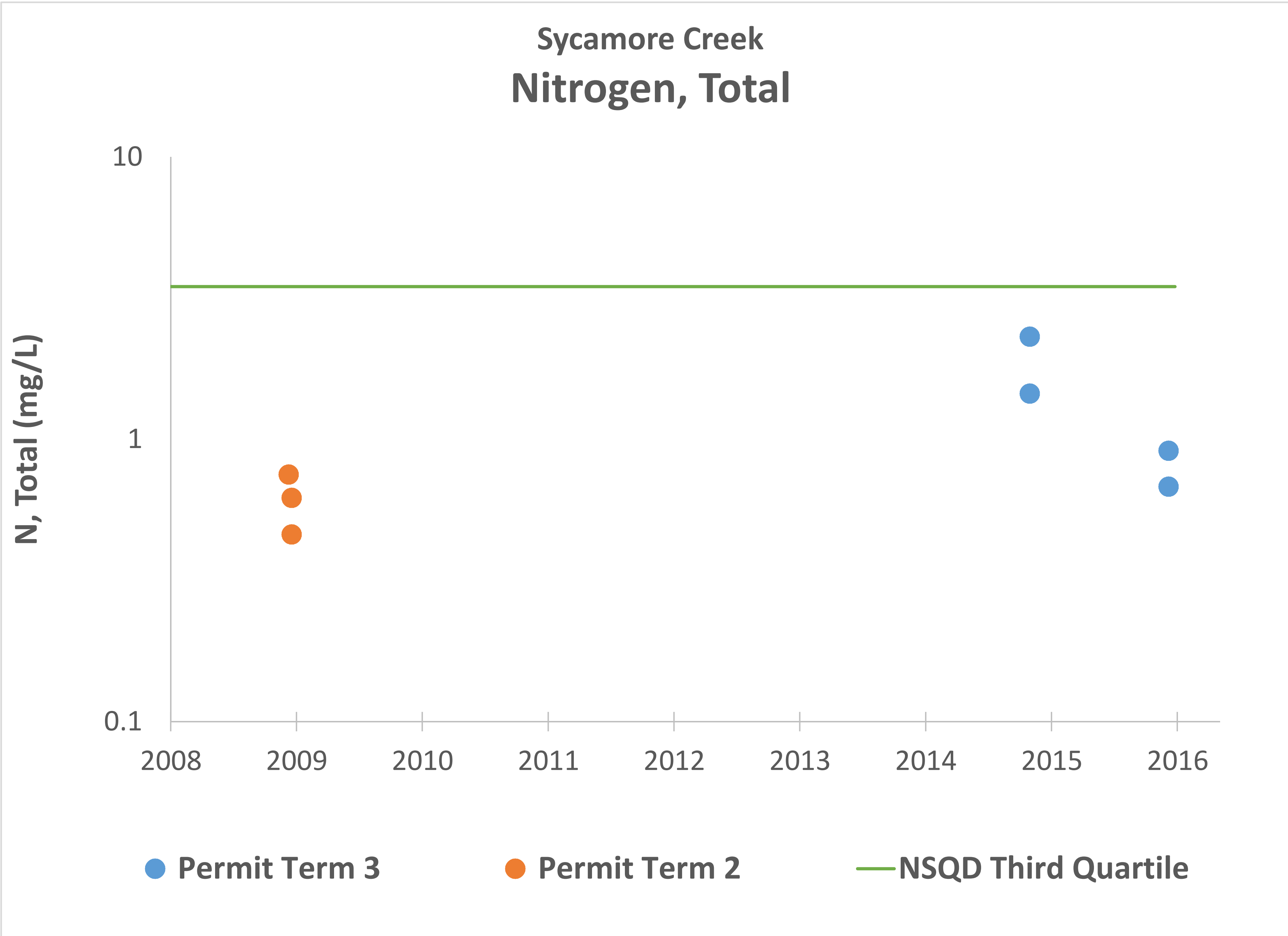

Sycamore Creek
Total Dissolved Solids
TDS (mg/L)
1800
1600
1400
1200
1000
800
600
400
200
0
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
Permit Term 3
Permit Term 2
Basin Specific Criterion

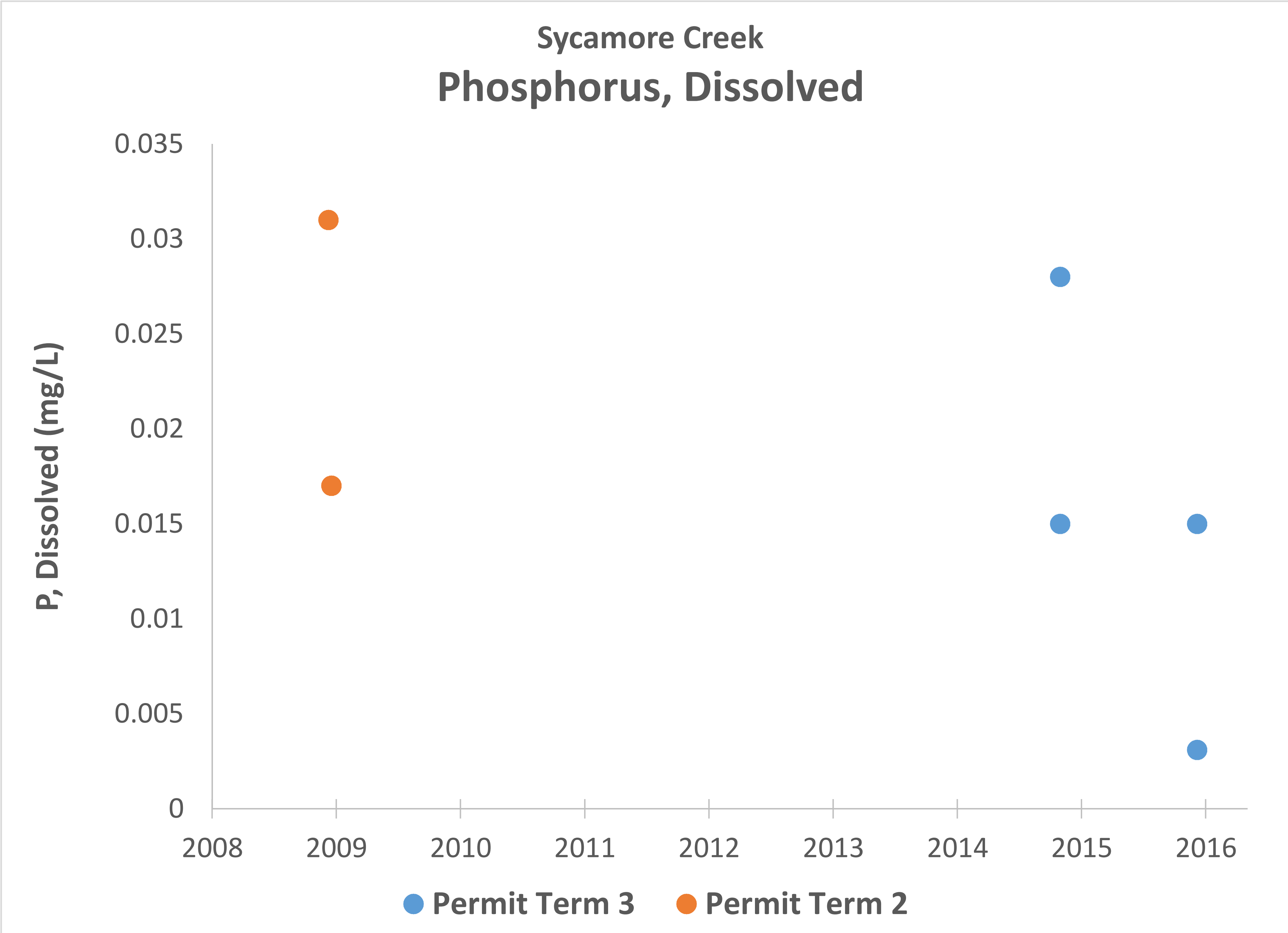


Sycamore Creek
Total Suspended Solids
TSS (mg/L)
1000
100
10
1
2008
2009
2010
2011
2012
2013
2014
2015
2016
Permit Term 3
Permit Term 2
NSQD Third Quartile

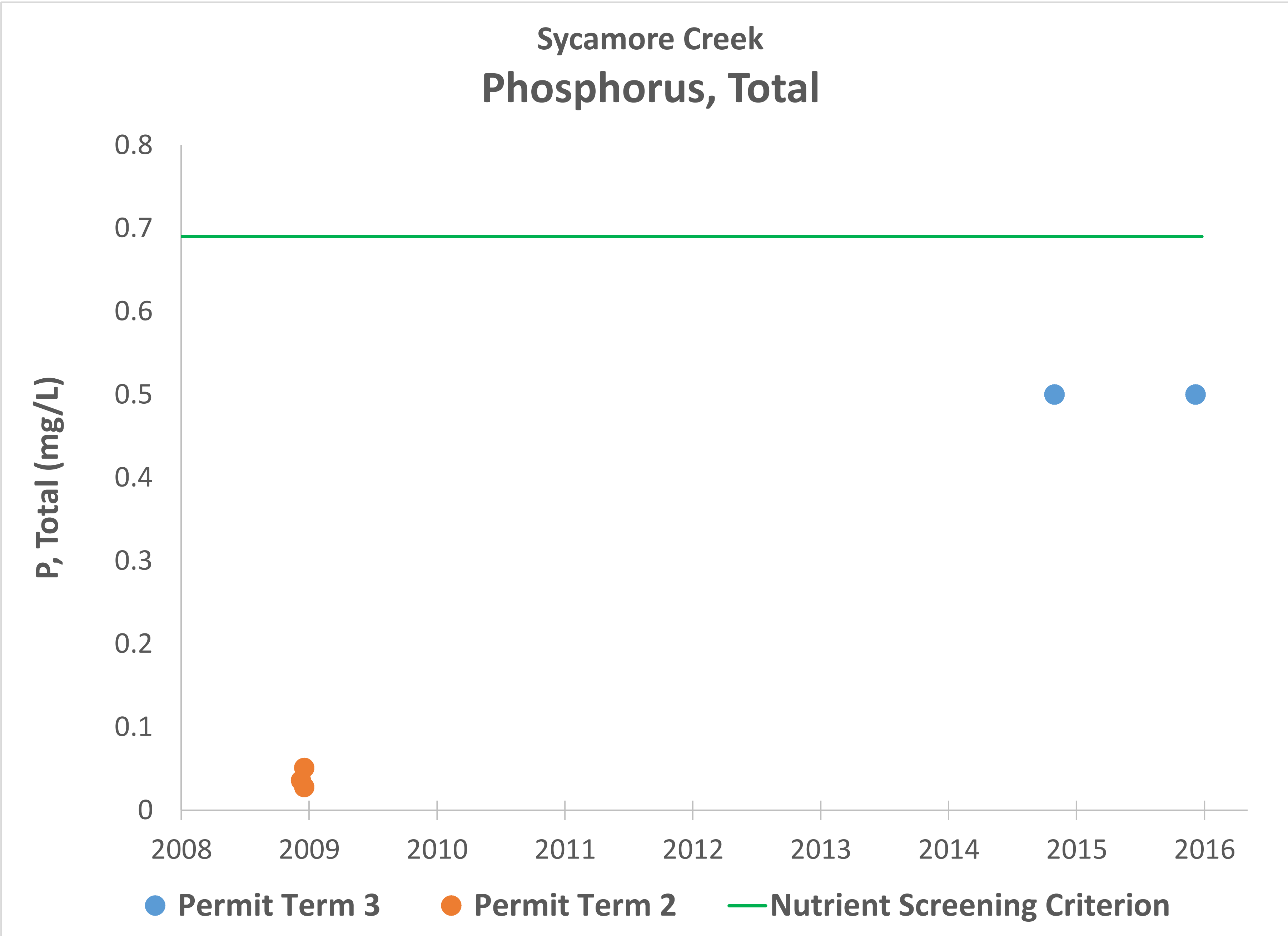

Sycamore Creek
Biochemical Oxygen Demand
BOD (mg/L)
25
20
15
10
5
0
2008
2009
2010
2011
2012
2013
2014
2015
2016
Permit Term 3
Permit Term 2
NSQD Third Quartile


Sycamore Creek
Chemical Oxygen Demand
COD (mg/L)
100
10
1
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
Permit Term 3
Permit Term 2
NSQD Third Quartile

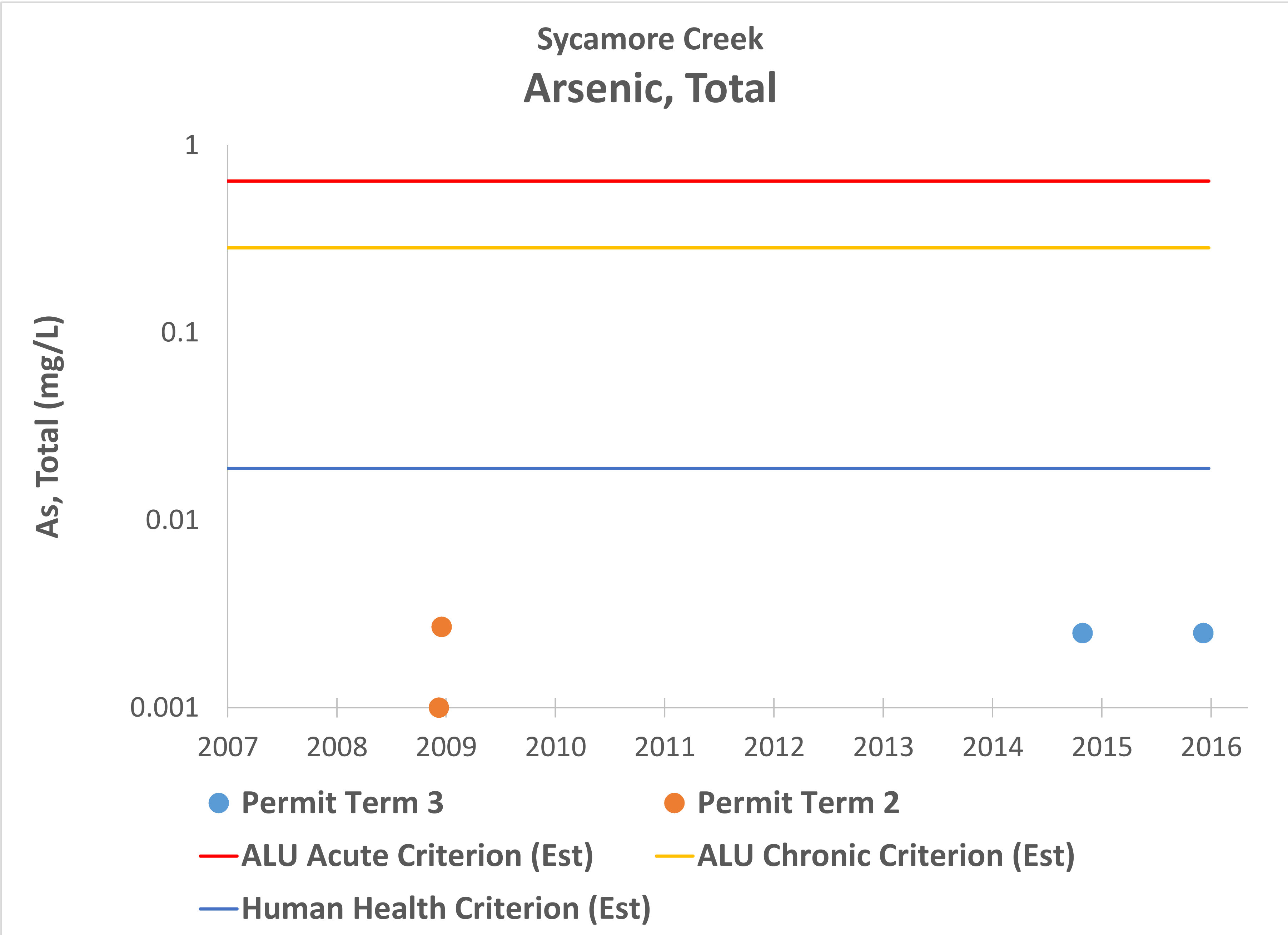

Sycamore Creek
Nitrogen, Total
N, Total (mg/L)
10
1
0.1
2008
2009
2010
2011
2012
2013
2014
2015
2016
Permit Term 3
Permit Term 2
NSQD Third Quartile

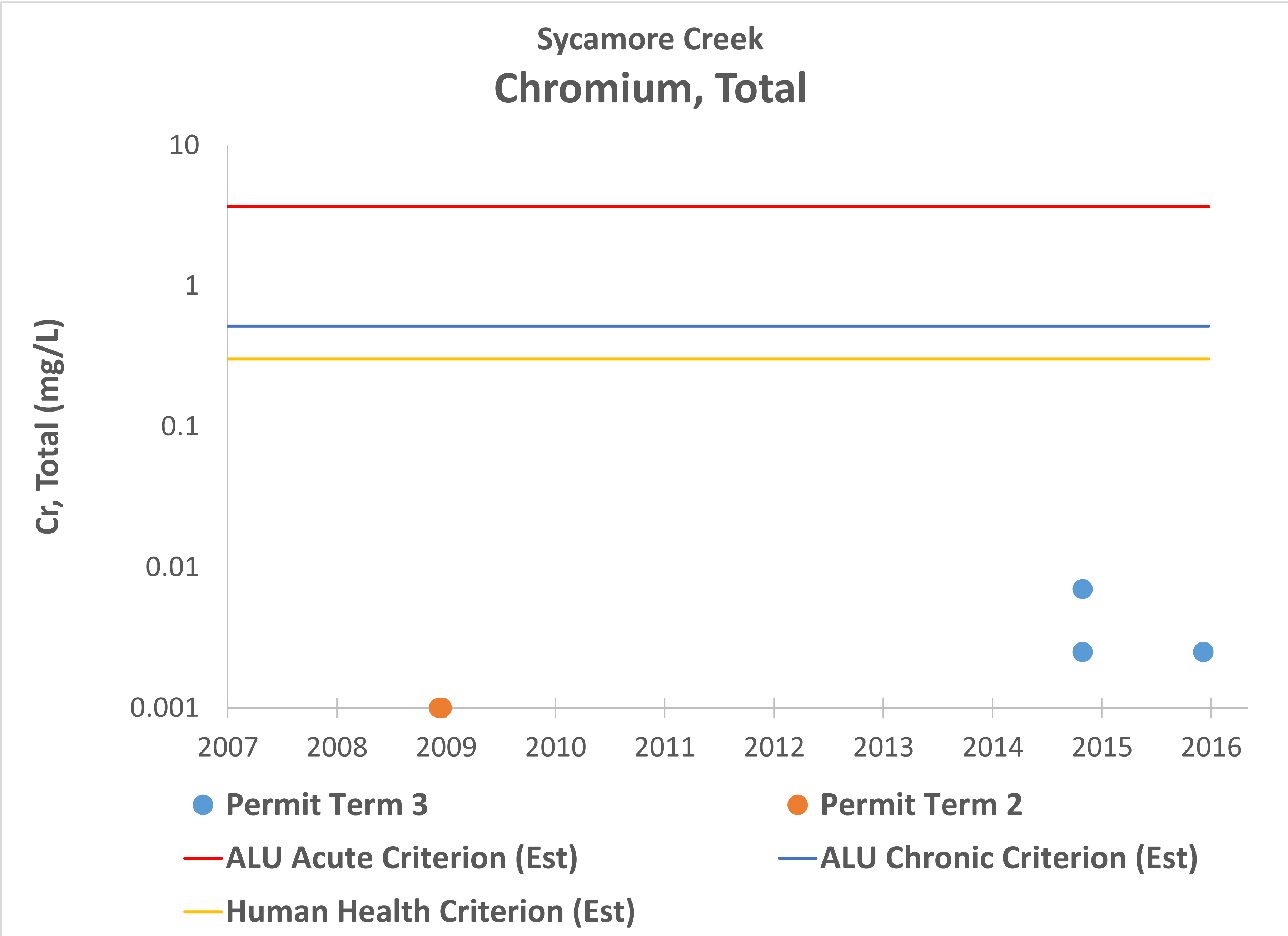


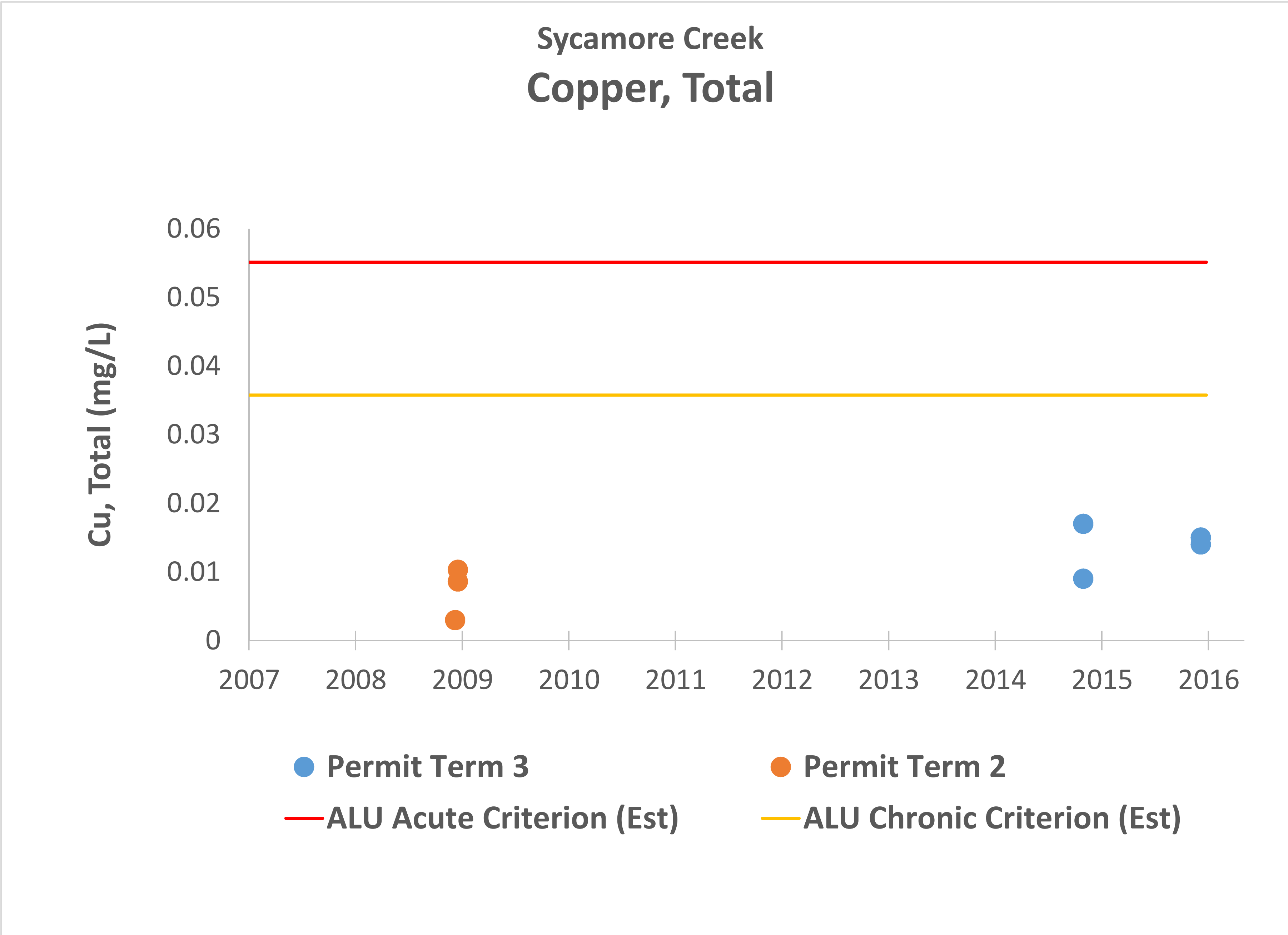
Sycamore Creek
Phosphorus, Dissolved
P, Dissolved (mg/L)
0.035
0.03
0.025
0.02
0.015
0.01
0.005
0
2008
2009
2010
2011
2012
2013
2014
2015
2016
Permit Term 3
Permit Term 2

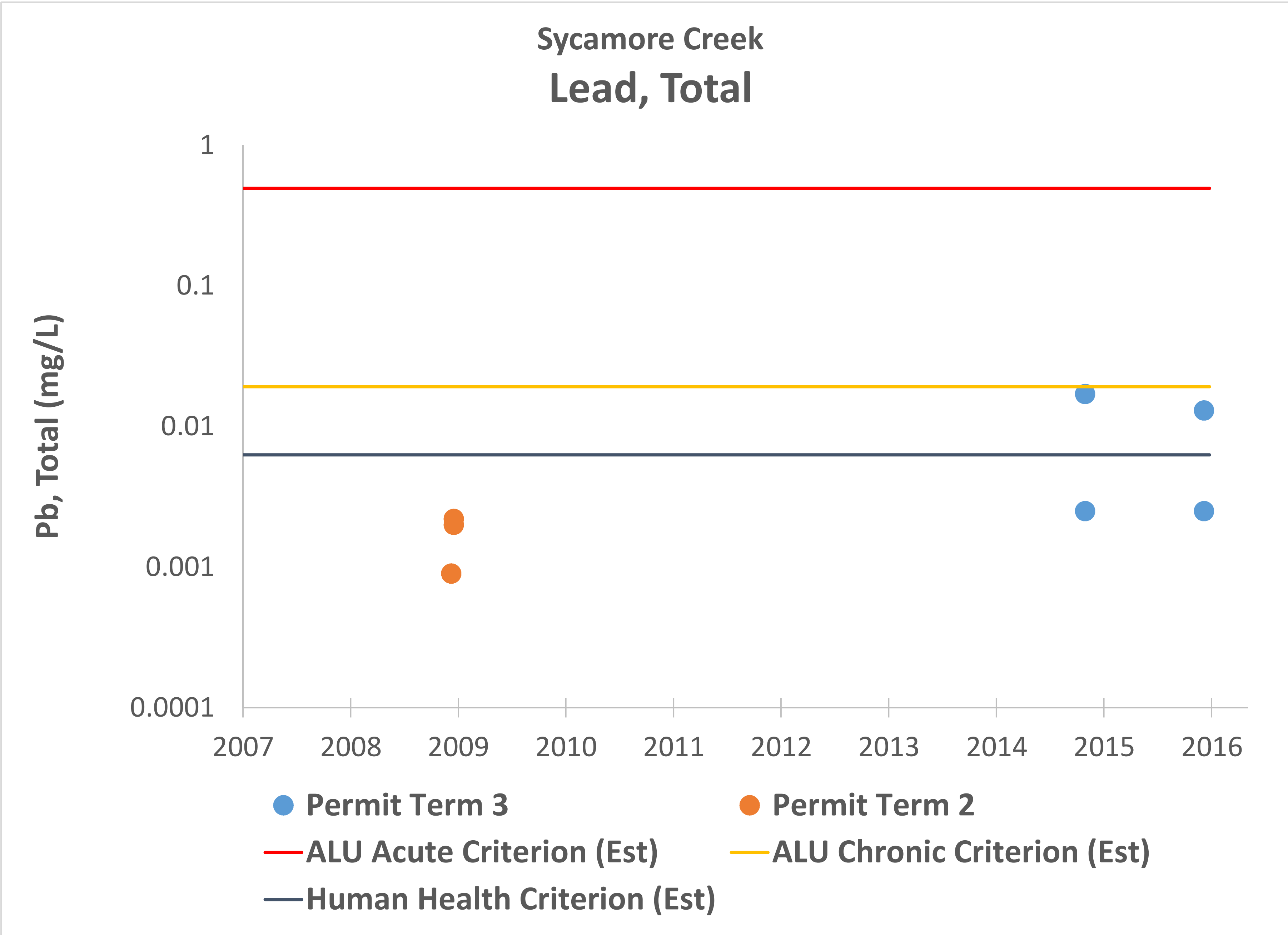


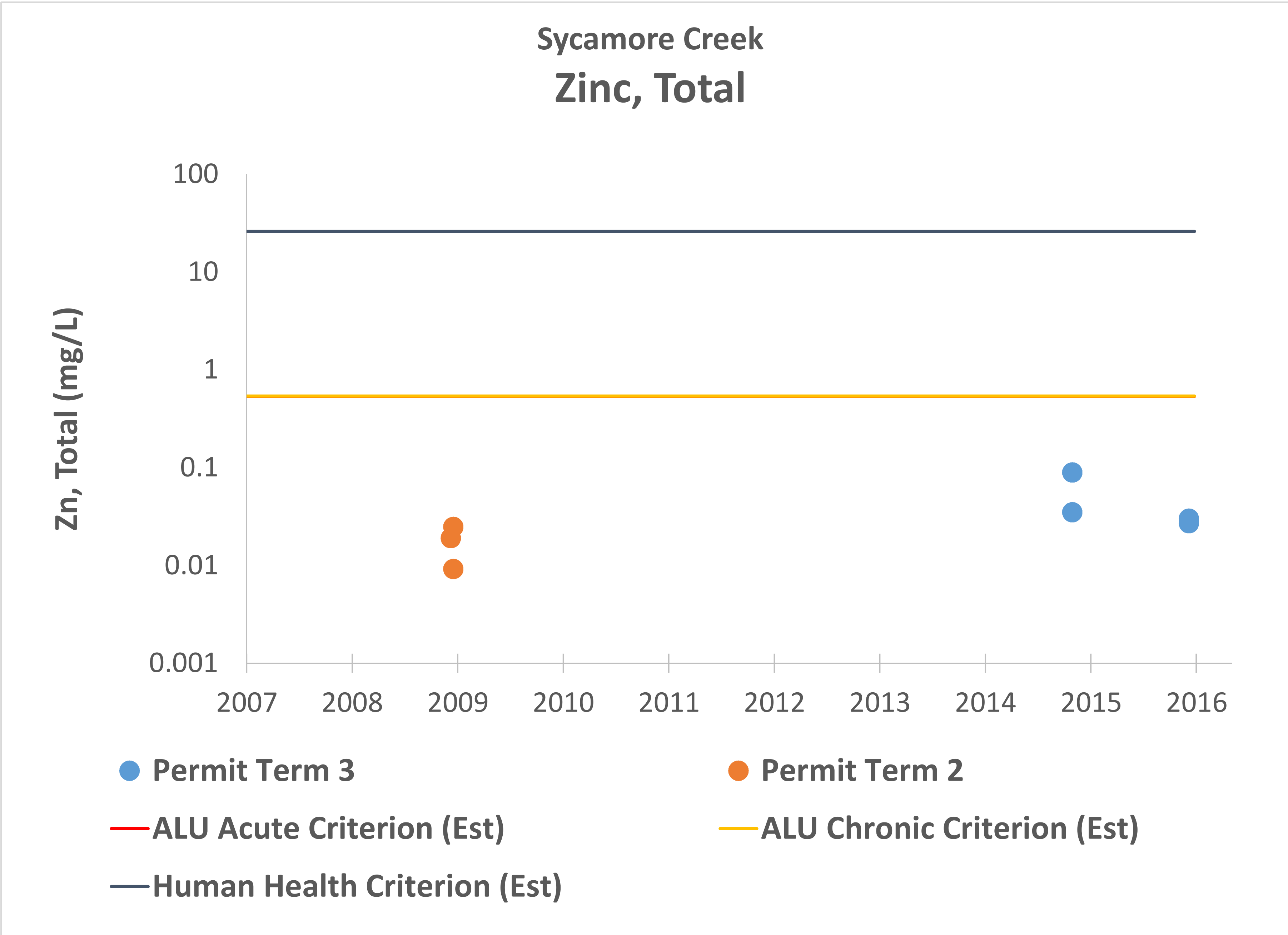
Sycamore Creek
Phosphorus, Total
P, Total (mg/L)
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
2008
2009
2010
2011
2012
2013
2014
2015
2016
Permit Term 3
Permit Term 2
Nutrient Screening Criterion

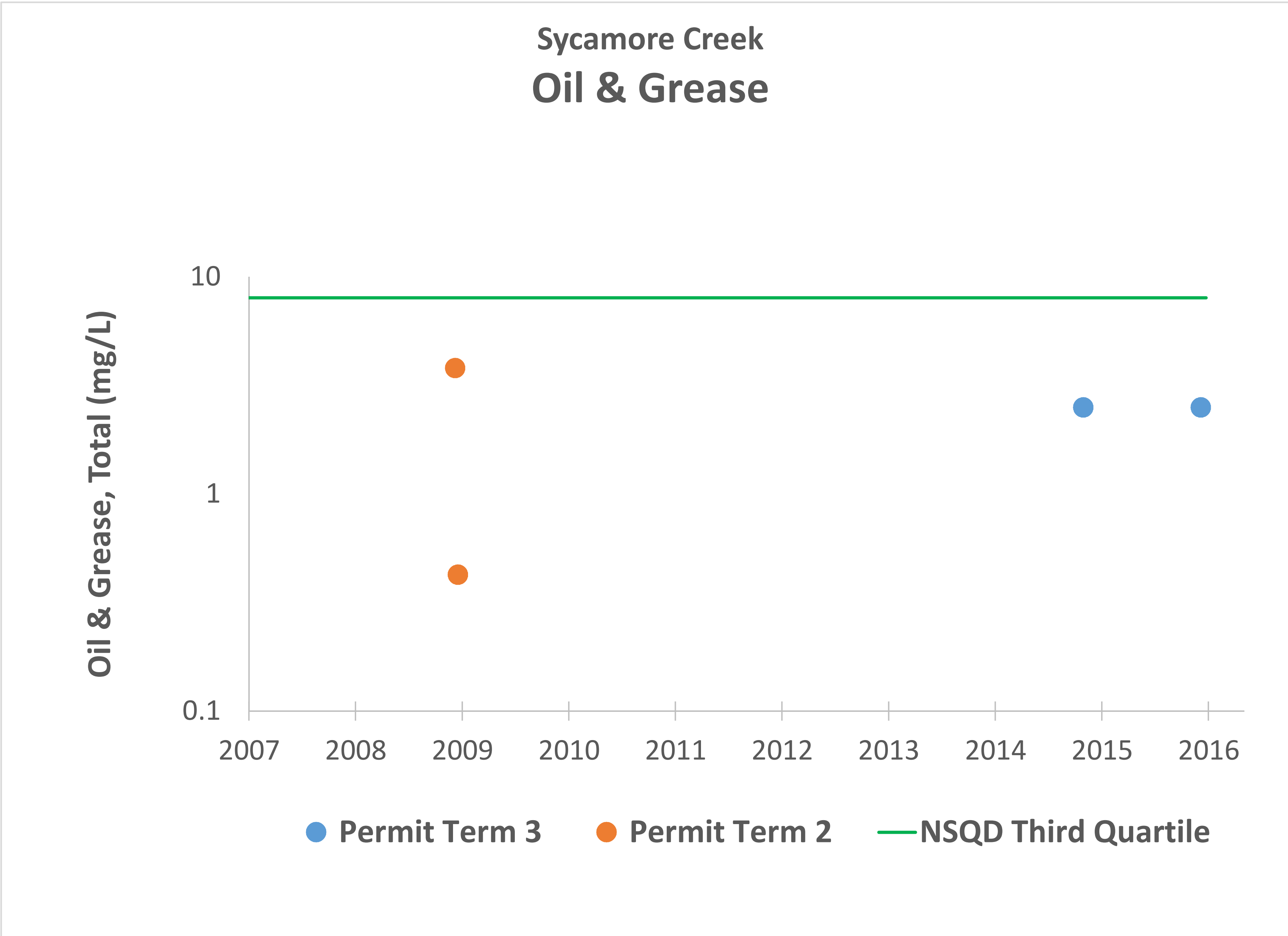

Sycamore Creek
Arsenic, Total
As, Total (mg/L)
1
0.1
0.01
0.001
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
Permit Term 3
Permit Term 2
ALU Acute Criterion (Est)
ALU Chronic Criterion (Est)
Human Health Criterion (Est)

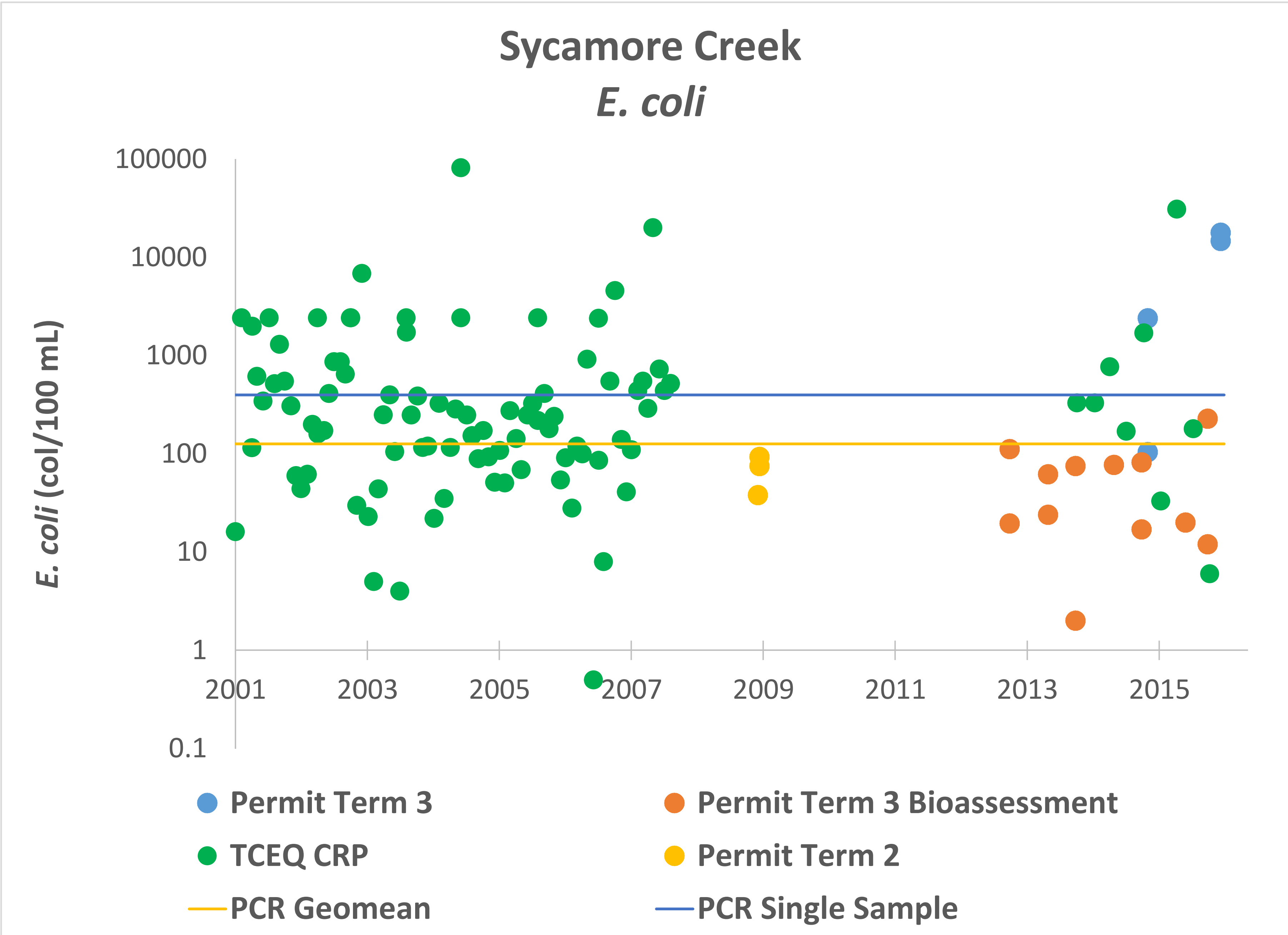

Sycamore Creek
Chromium, Total
Cr, Total (mg/L)
10
1
0.1
0.01
0.001
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
Permit Term 3
Permit Term 2
ALU Acute Criterion (Est)
ALU Chronic Criterion (Est)
Human Health Criterion (Est)

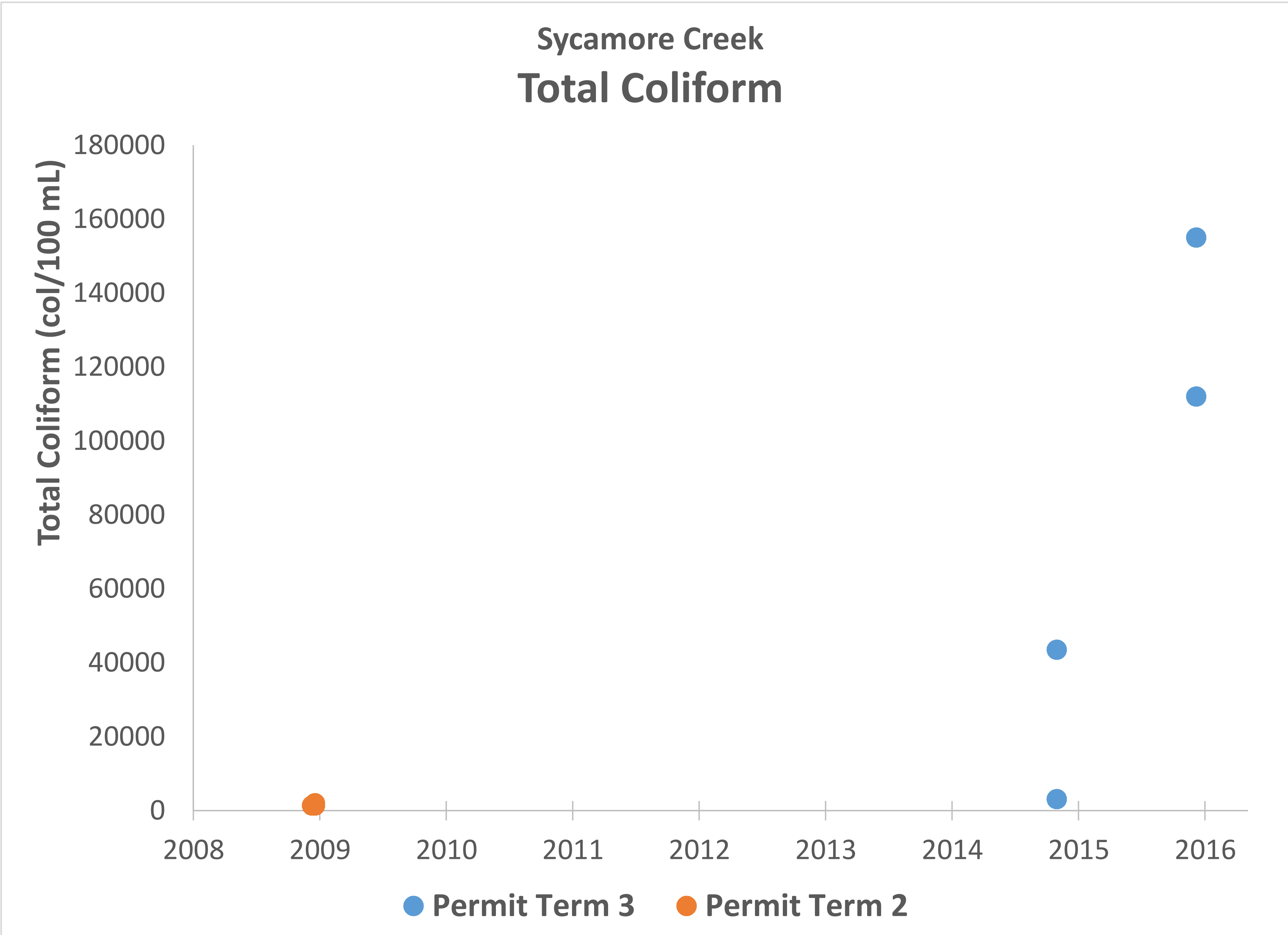

Sycamore Creek
Copper, Total
Cu, Total (mg/L)
0.06
0.05
0.04
0.03
0.02
0.01
0
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
Permit Term 3
Permit Term 2
ALU Acute Criterion (Est)
ALU Chronic Criterion (Est)

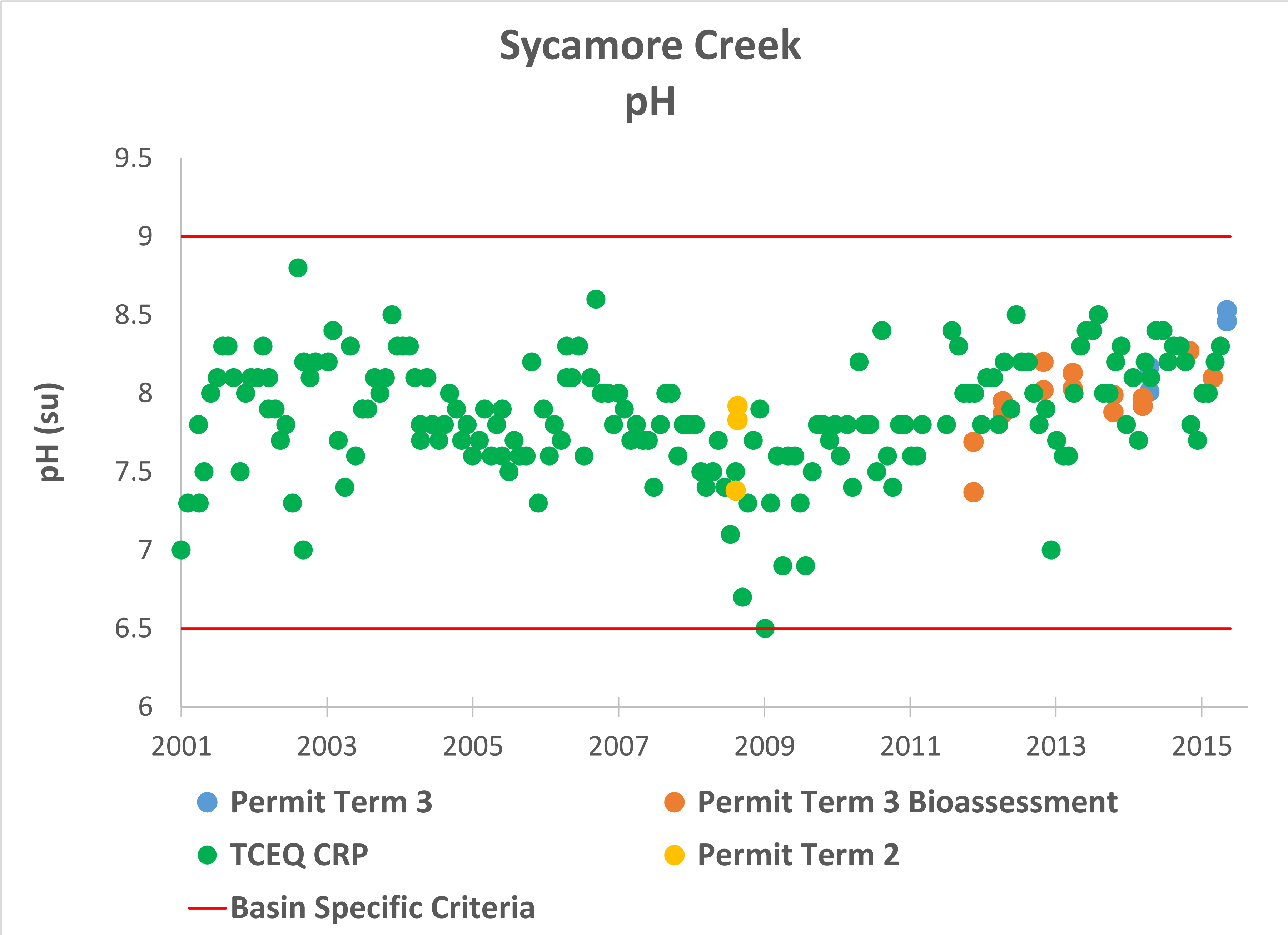

Sycamore Creek
Lead, Total
Pb, Total (mg/L)
1
0.1
0.01
0.001
0.0001
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
Permit Term 3
Permit Term 2
ALU Acute Criterion (Est)
ALU Chronic Criterion (Est)
Human Health Criterion (Est)


Sycamore Creek
Zinc, Total
Zn, Total (mg/L)
100
10
1
0.1
0.01
0.001
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
Permit Term 3
Permit Term 2
ALU Acute Criterion (Est)
ALU Chronic Criterion (Est)
Human Health Criterion (Est)

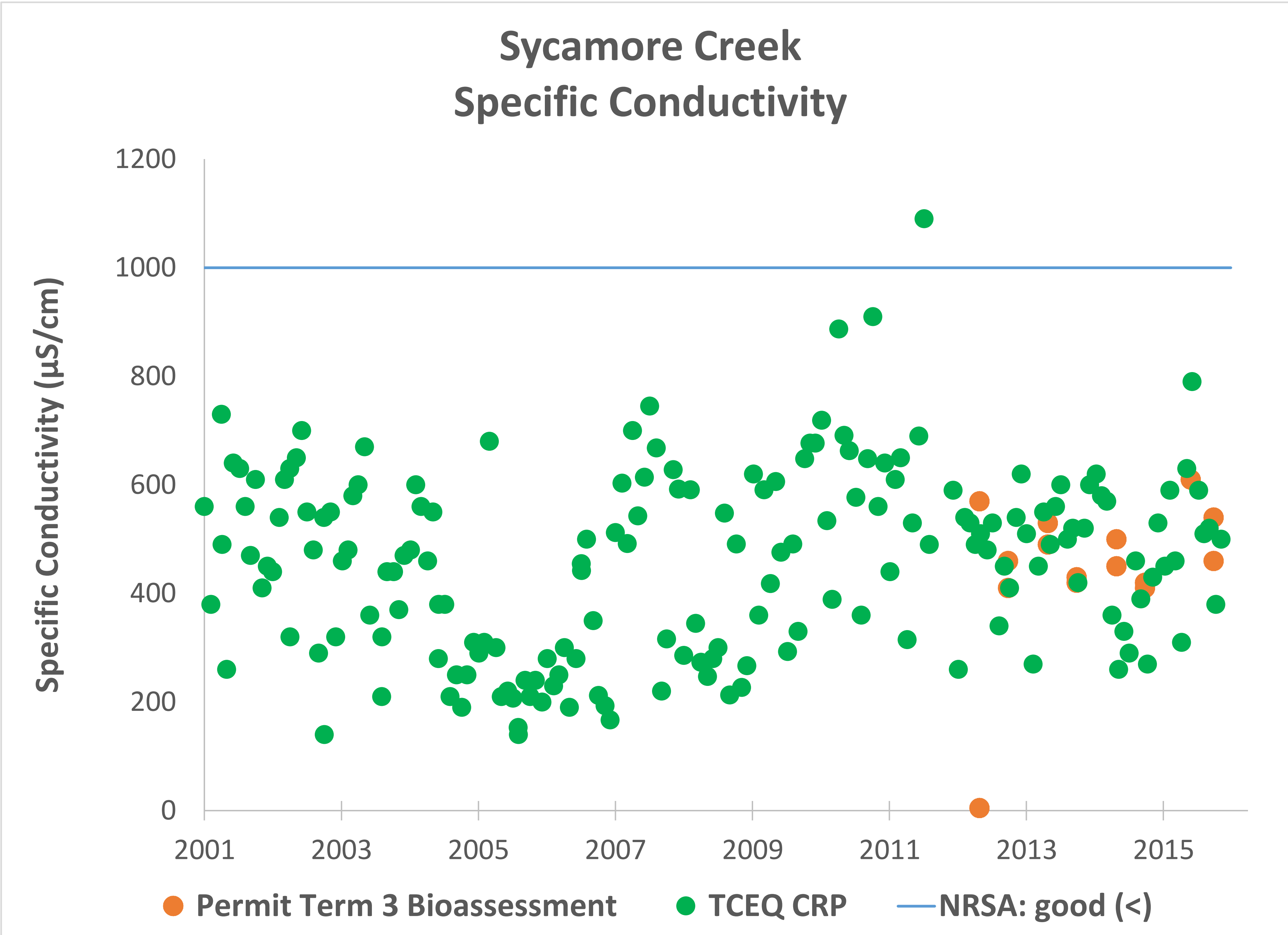

Sycamore Creek
Oil & Grease
Oil & Grease, Total (mg/L)
10
1
0.1
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
Permit Term 3
Permit Term 2
NSQD Third Quartile


Sycamore Creek
E. coli
E. coli (col/100 mL)
100000
10000
1000
100
10
1
0.1
2001
2003
2005
2007
2009
2011
2013
2015
Permit Term 3
Permit Term 3 Bioassessment
TCEQ CRP
Permit Term 2
PCR Geomean
PCR Single Sample

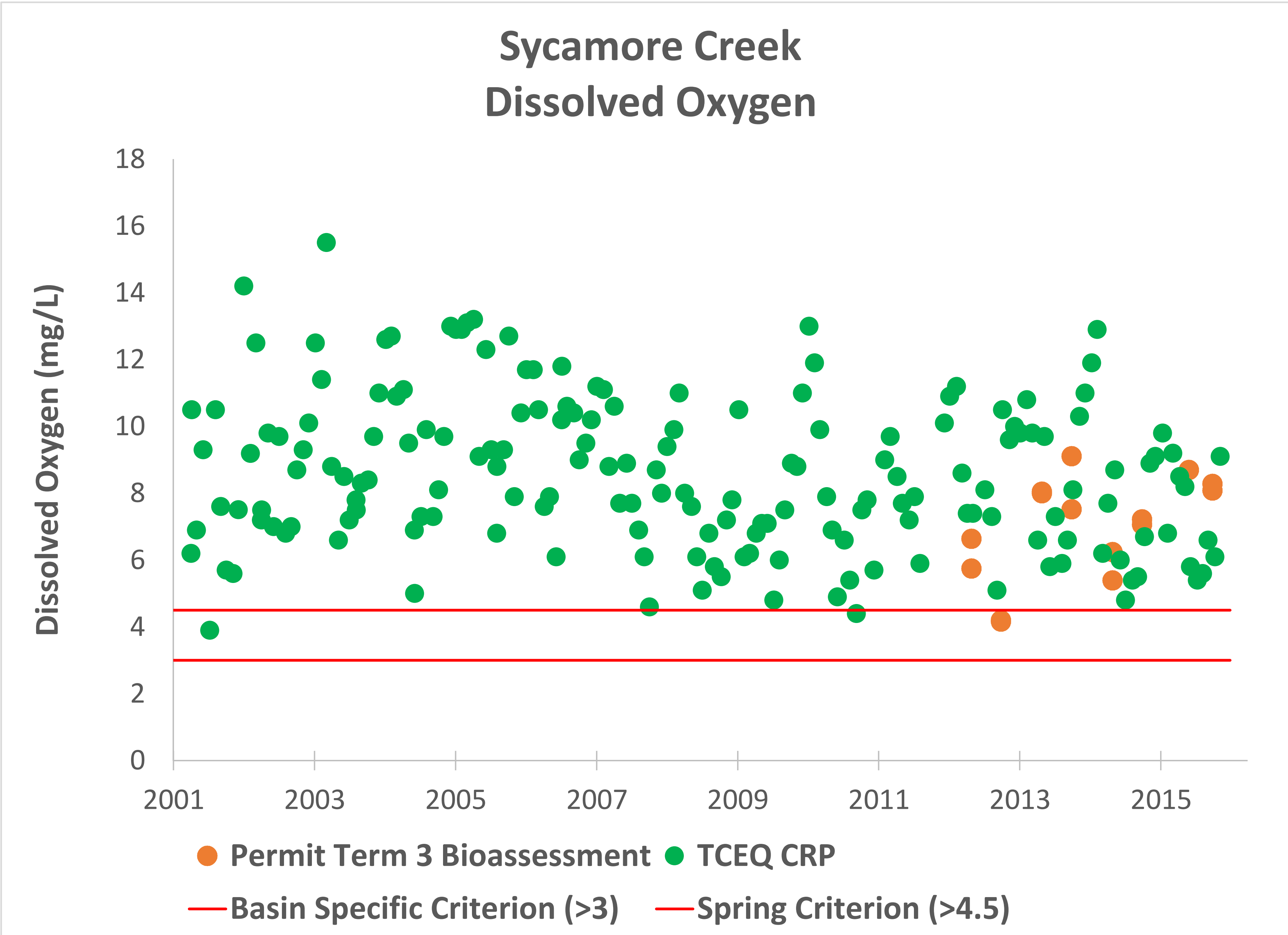

Sycamore Creek
Total Coliform
Total Coliform (col/100 mL)
180000
160000
140000
120000
100000
80000
60000
40000
20000
0
2008
2009
2010
2011
2012
2013
2014
2015
2016
Permit Term 3
Permit Term 2



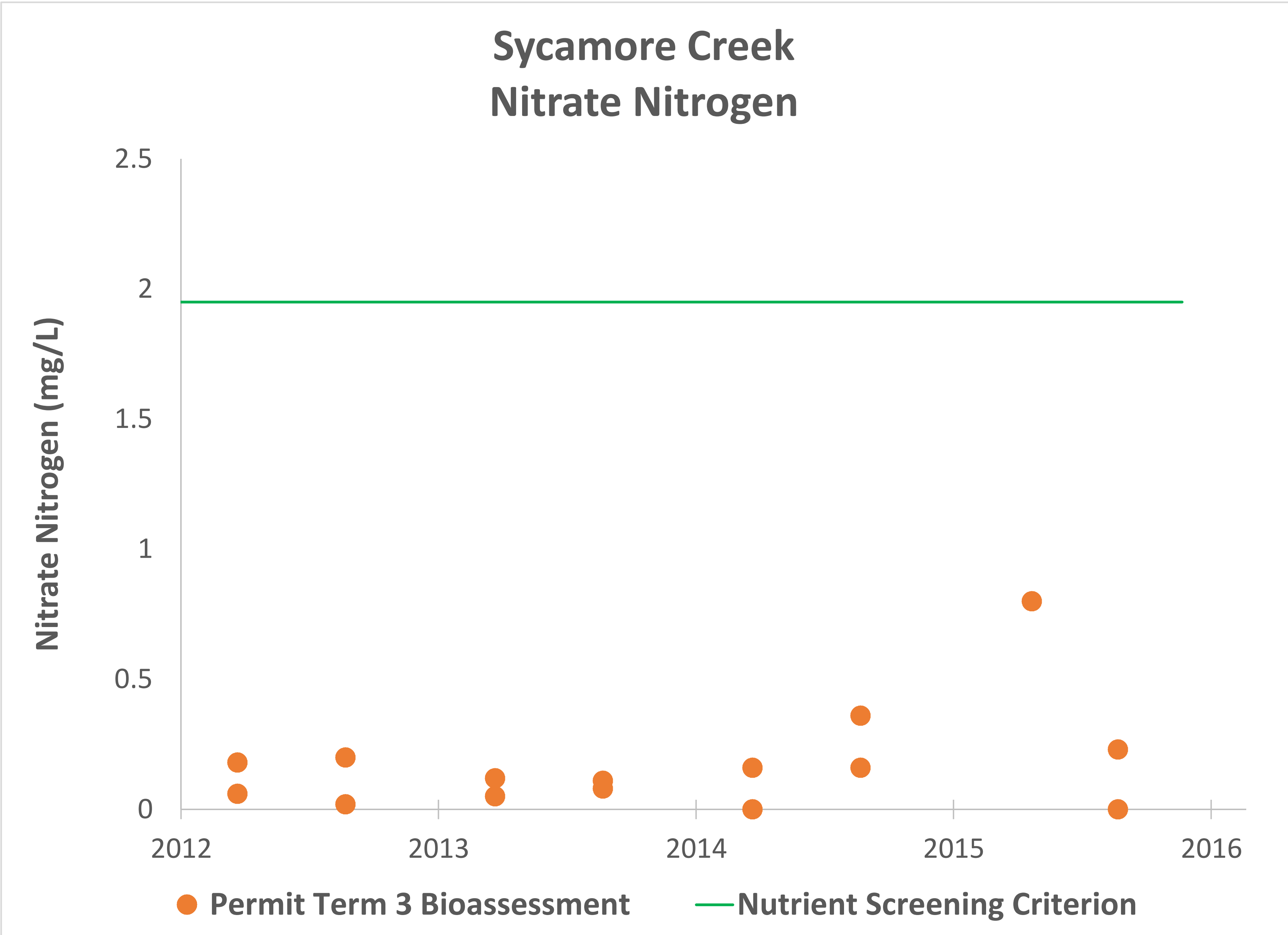
Sycamore Creek
pH
pH (su)
9.5
9
8.5
8
7.5
7
6.5
6
2001
2003
2005
2007
2009
2011
2013
2015
Permit Term 3
Permit Term 3 Bioassessment
TCEQ CRP
Permit Term 2
Basin Specific Criteria

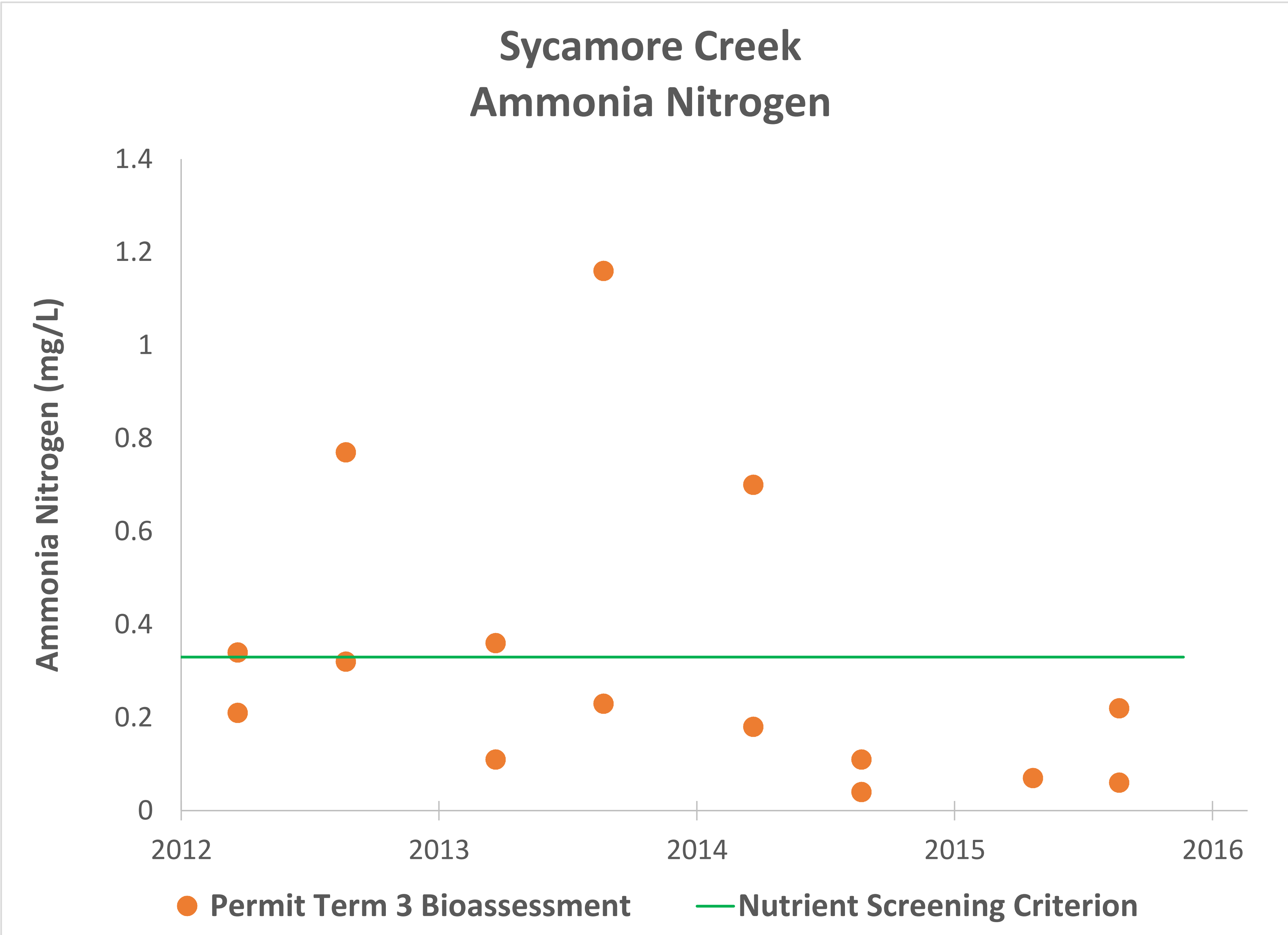


Sycamore Creek
Specific Conductivity
Specific Conductivity (µS/cm)
1200
1000
800
600
400
200
0
2001
2003
2005
2007
2009
2011
2013
2015
Permit Term 3 Bioassessment
TCEQ CRP
NRSA: good (<)

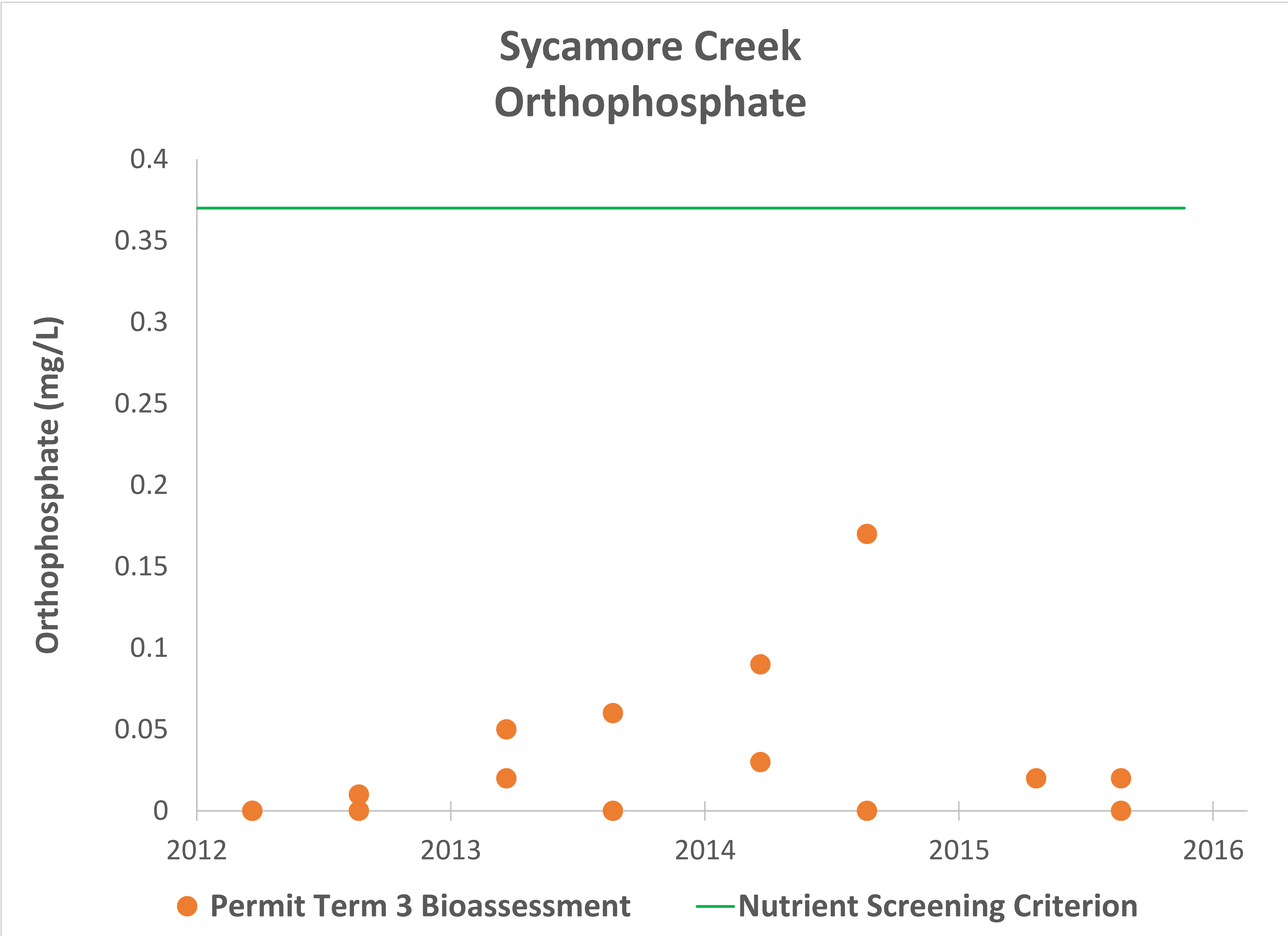


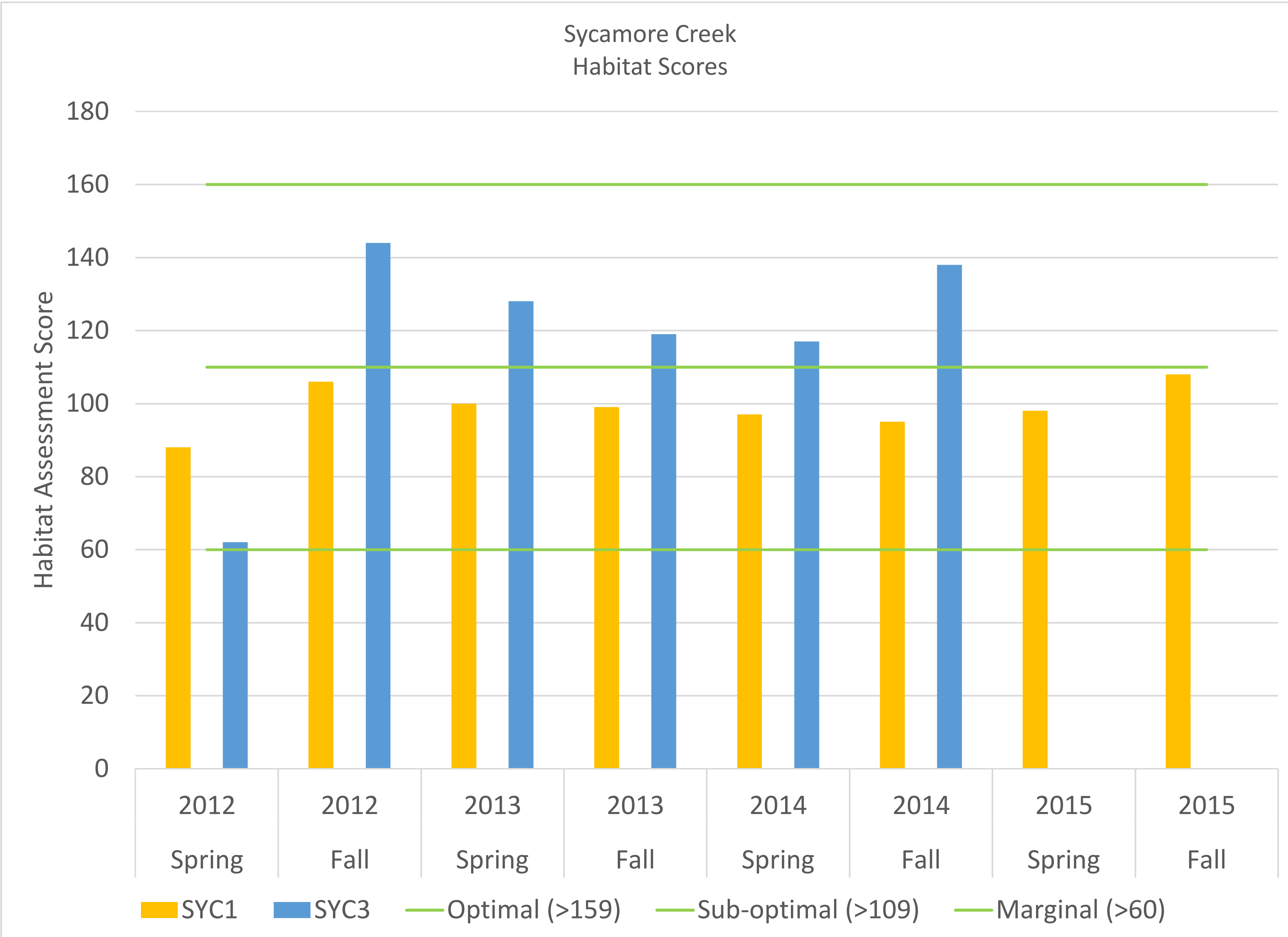
Sycamore Creek
Dissolved Oxygen
Dissolved Oxygen (mg/L)
18
16
14
12
10
8
6
4
2
0
2001
2003
2005
2007
2009
2011
2013
2015
Permit Term 3 Bioassessment
TCEQ CRP
Basin Specific Criterion (>3)
Spring Criterion (>4.5)

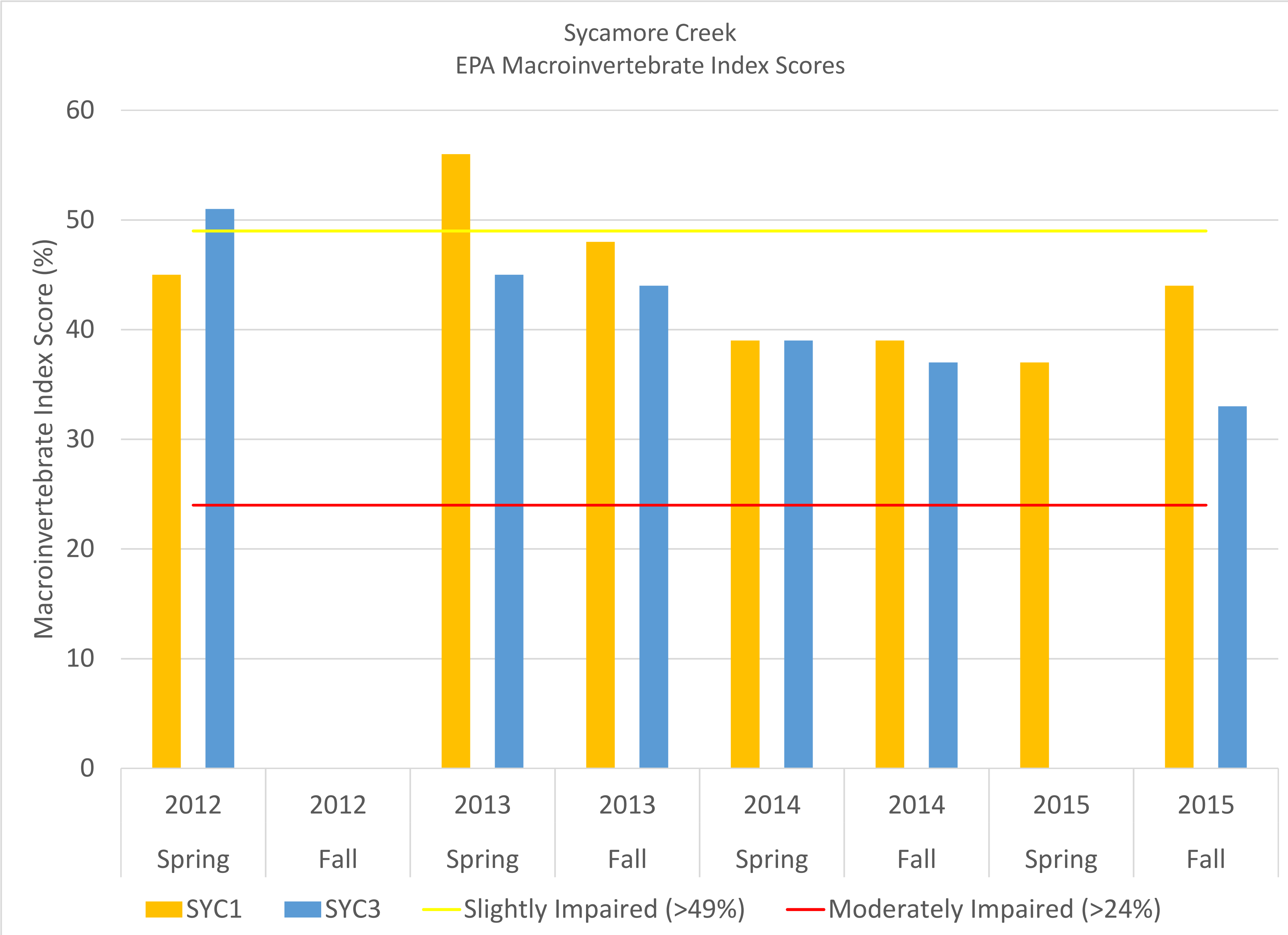

Sycamore Creek
Nitrate Nitrogen
Nitrate Nitrogen (mg/L)
2.5
2
1.5
1
0.5
0
2012
2013
2014
2015
2016
Permit Term 3 Bioassessment
Nutrient Screening Criterion

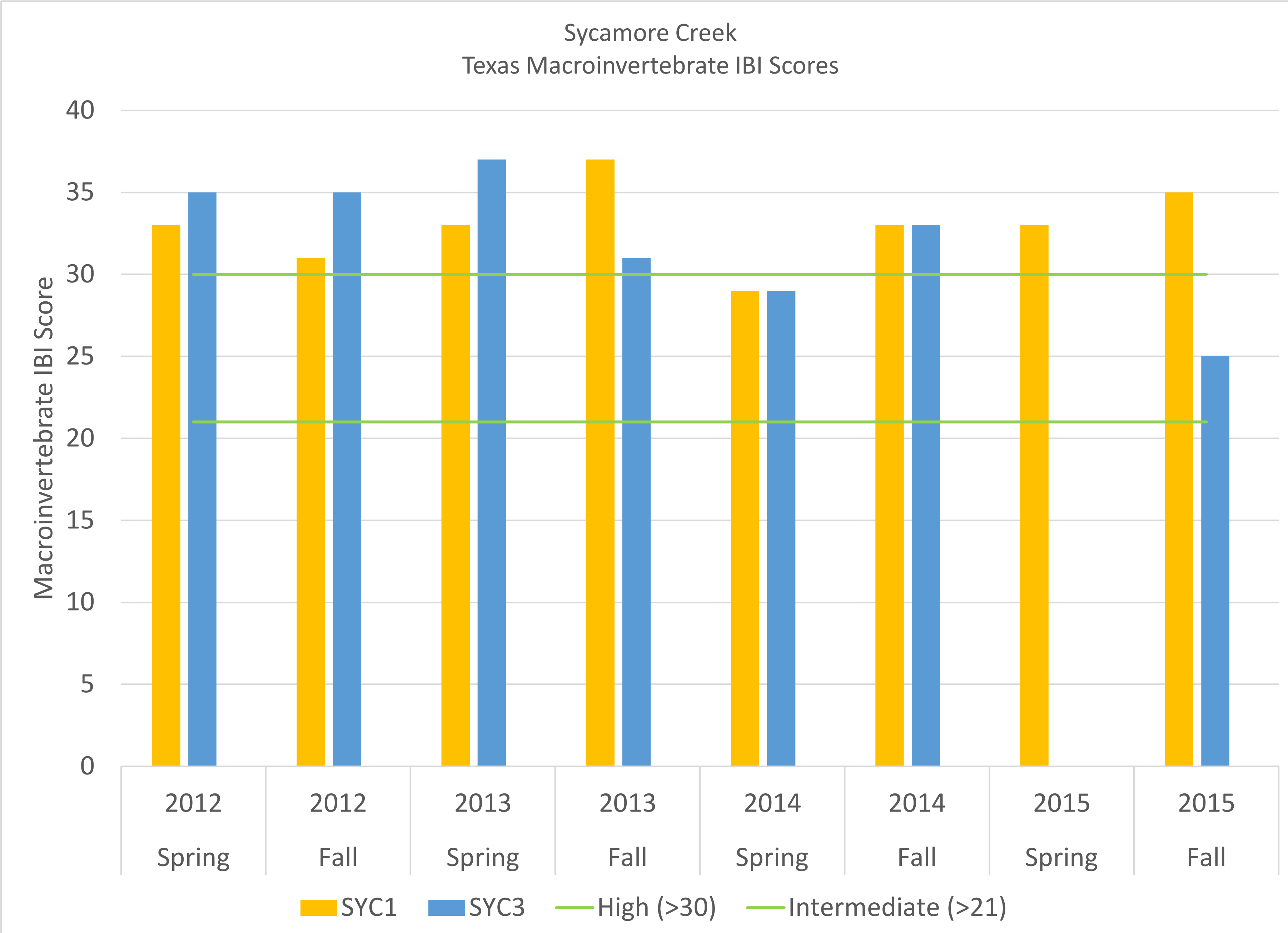


Sycamore Creek
Ammonia Nitrogen
Ammonia Nitrogen (mg/L)
1.4
1.2
1
0.8
0.6
0.4
0.2
0
2012
2013
2014
2015
2016
Permit Term 3 Bioassessment
Nutrient Screening Criterion


Sycamore Creek
Orthophosphate
Orthophosphate (mg/L)
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
2012
2013
2014
2015
2016
Permit Term 3 Bioassessment
Nutrient Screening Criterion

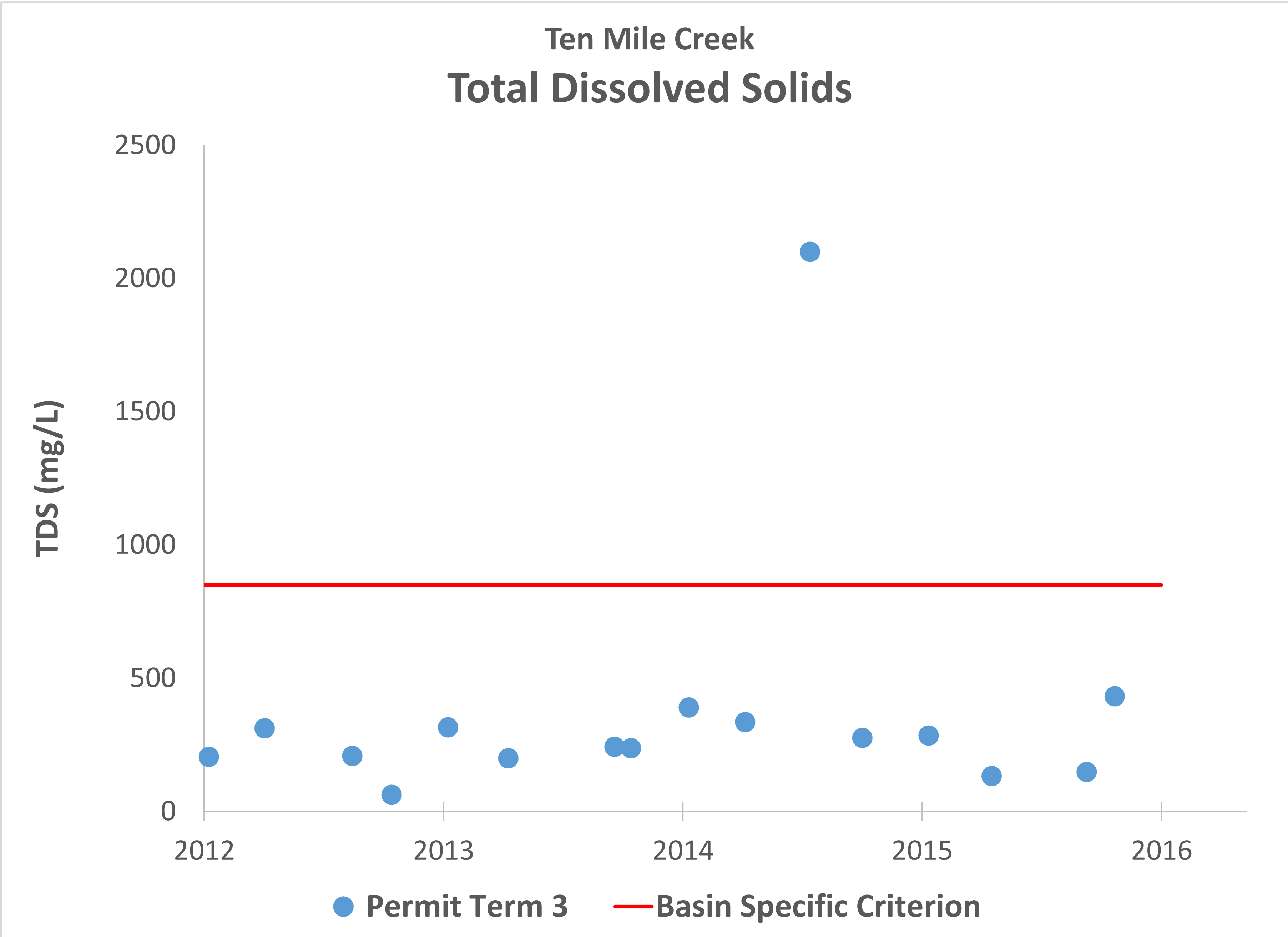

Sycamore Creek
Habitat Scores
Habitat Assessment Score
180
160
140
120
100
80
60
40
20
0
2012 Spring
2012 Fall
2013 Spring
2013 Fall
2014 Spring
2014 Fall
2015 Spring
2015 Fall
SYC1
SYC3
Optimal (>159)
Sub-optimal (>109)
Marginal (>60)

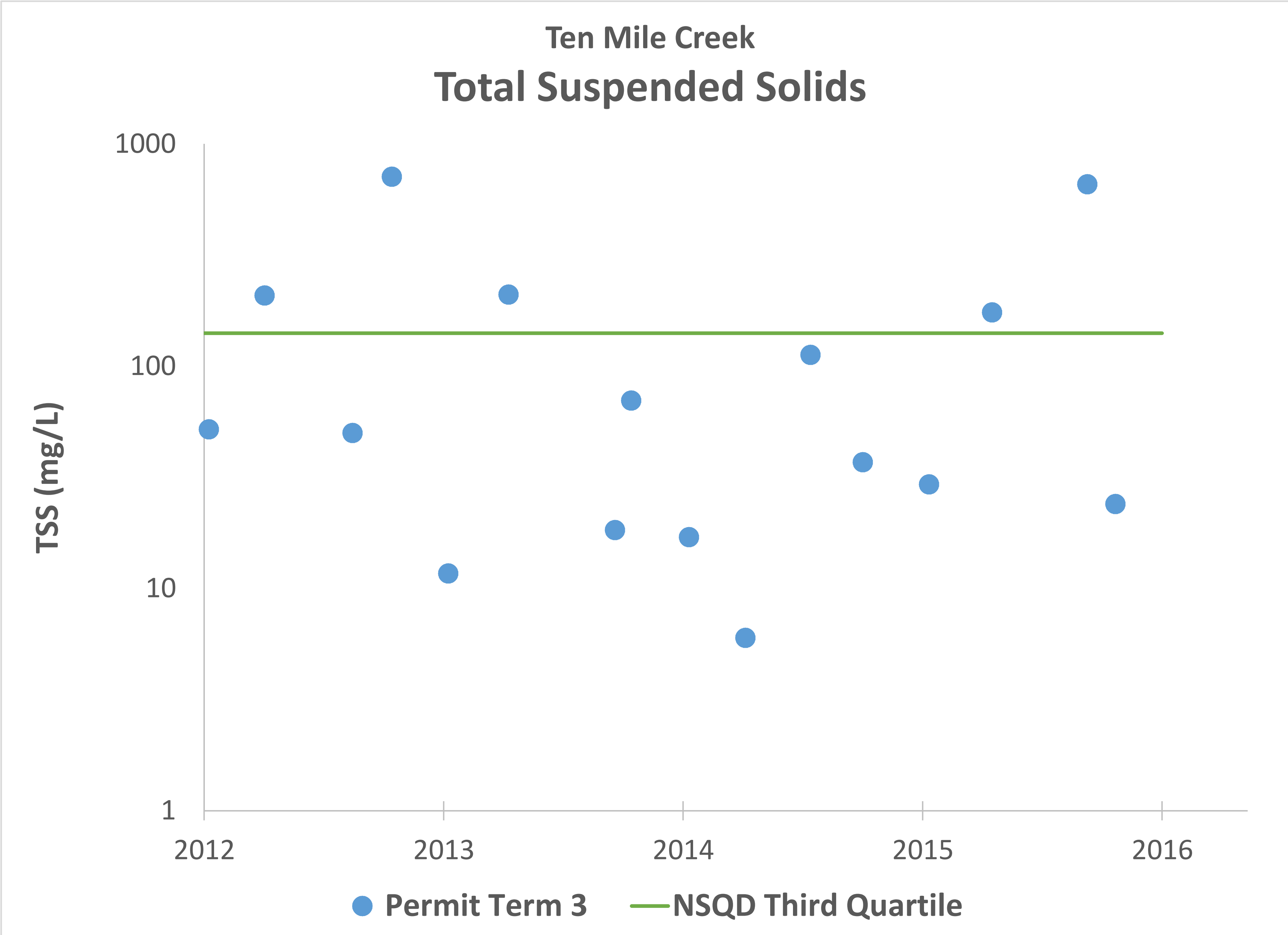

Sycamore Creek
EPA Macroinvertebrate Index Scores
Macroinvertebrate Index Score (%)
60
50
40
30
20
10
0
2012 Spring
2012 Fall
2013 Spring
2013 Fall
2014 Spring
2014 Fall
2015 Spring
2015 Fall
SYC1
SYC3
Slightly Impaired (>49%)
Moderately Impaired (>24%)

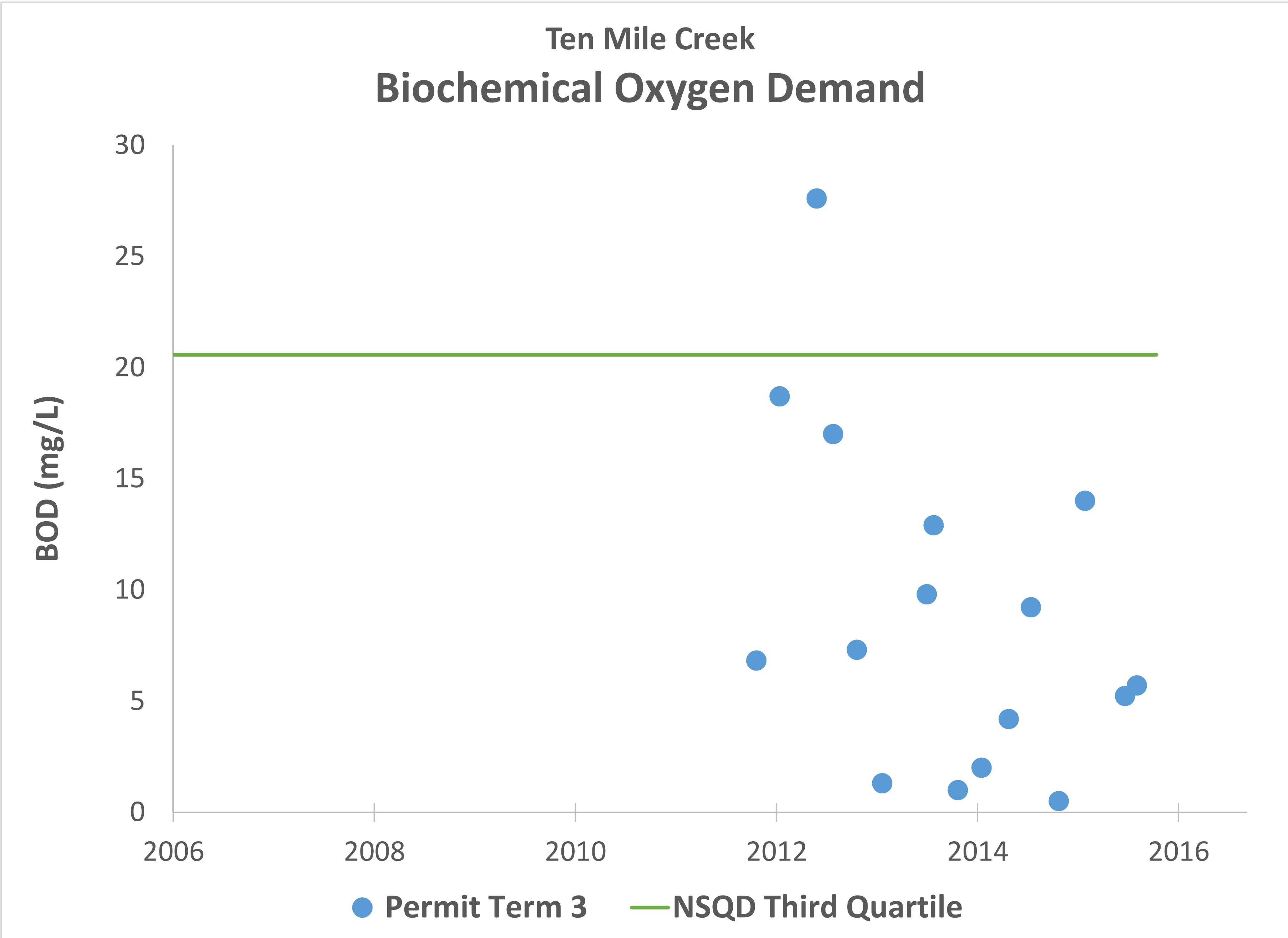

Sycamore Creek
Texas Macroinvertebrate IBI Scores
Macroinvertebrate IBI Score
40
35
30
25
20
15
10
5
0
2012 Spring
2012 Fall
2013 Spring
2013 Fall
2014 Spring
2014 Fall
2015 Spring
2015 Fall
SYC1
SYC3
High (>30)
Intermediate (>21)

Appendix Z

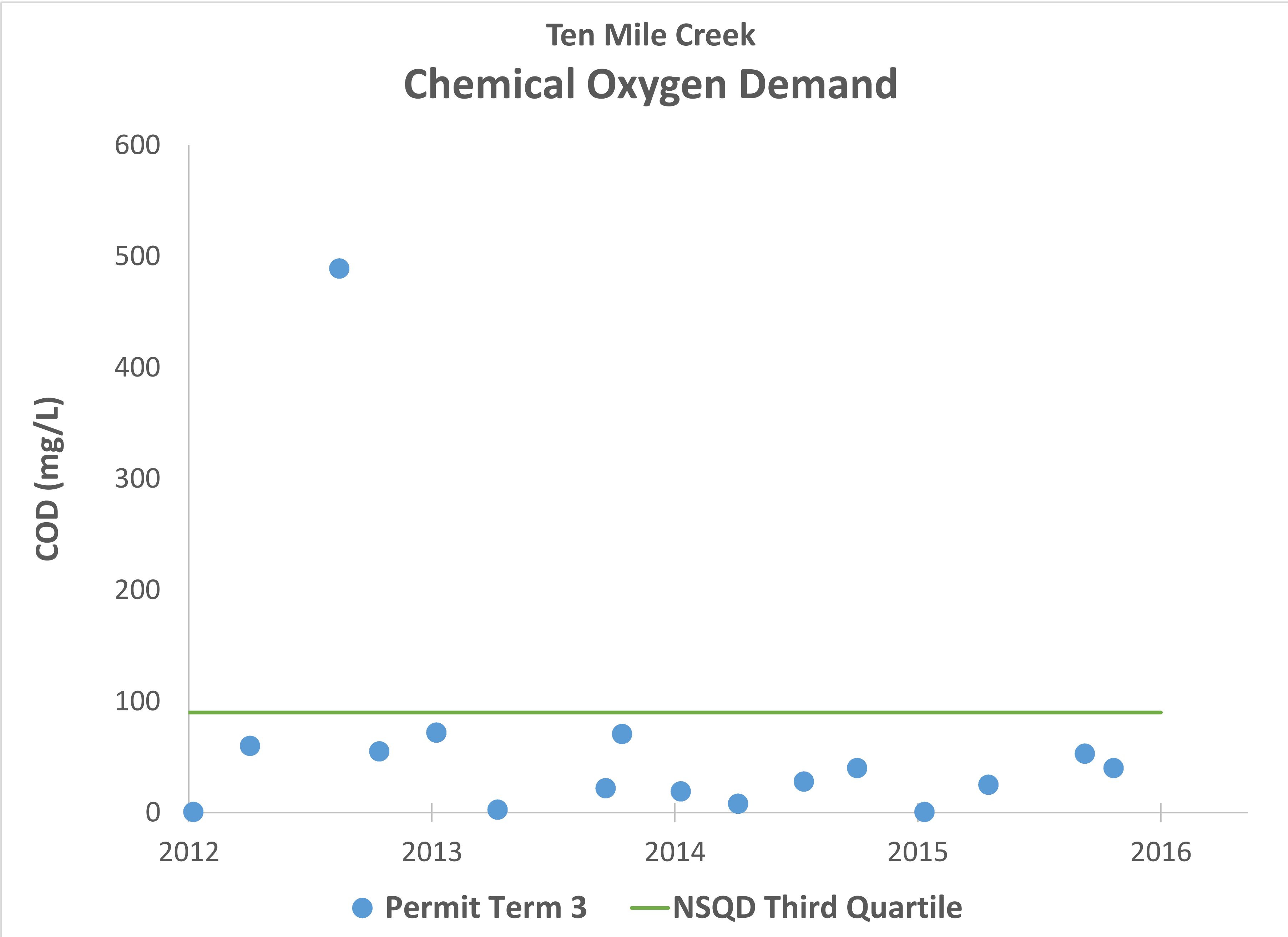
Ten Mile Creek Water Quality Data Graphs


Ten Mile Creek
Total Dissolved Solids
TDS (mg/L)
2500
2000
1500
1000
500
0
2012
2013
2014
2015
2016
Permit Term 3
Basin Specific Criterion

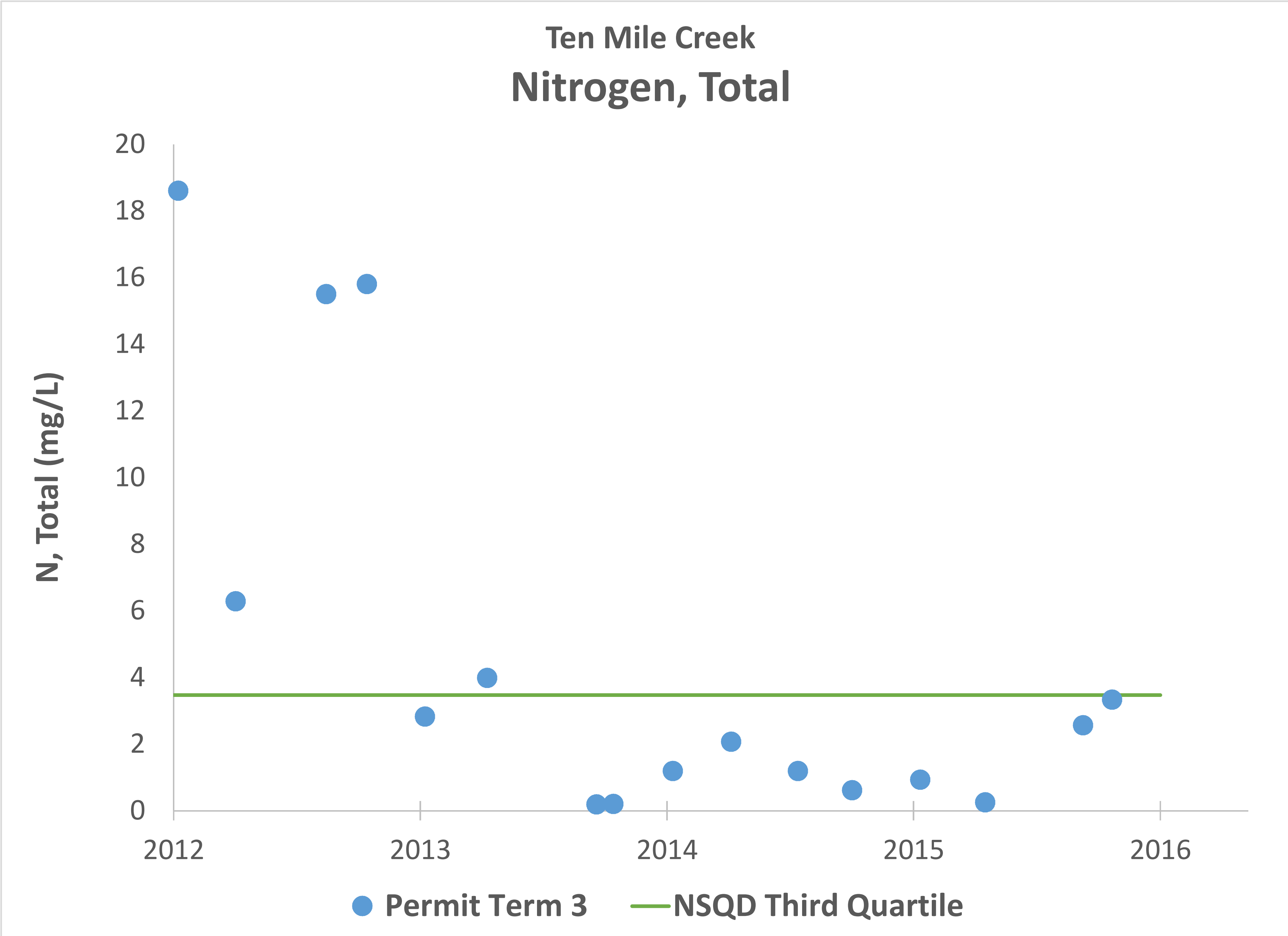

Ten Mile Creek
Total Suspended Solids
TSS (mg/L)
1000
100
10
1
2012
2013
2014
2015
2016
Permit Term 3
NSQD Third Quartile

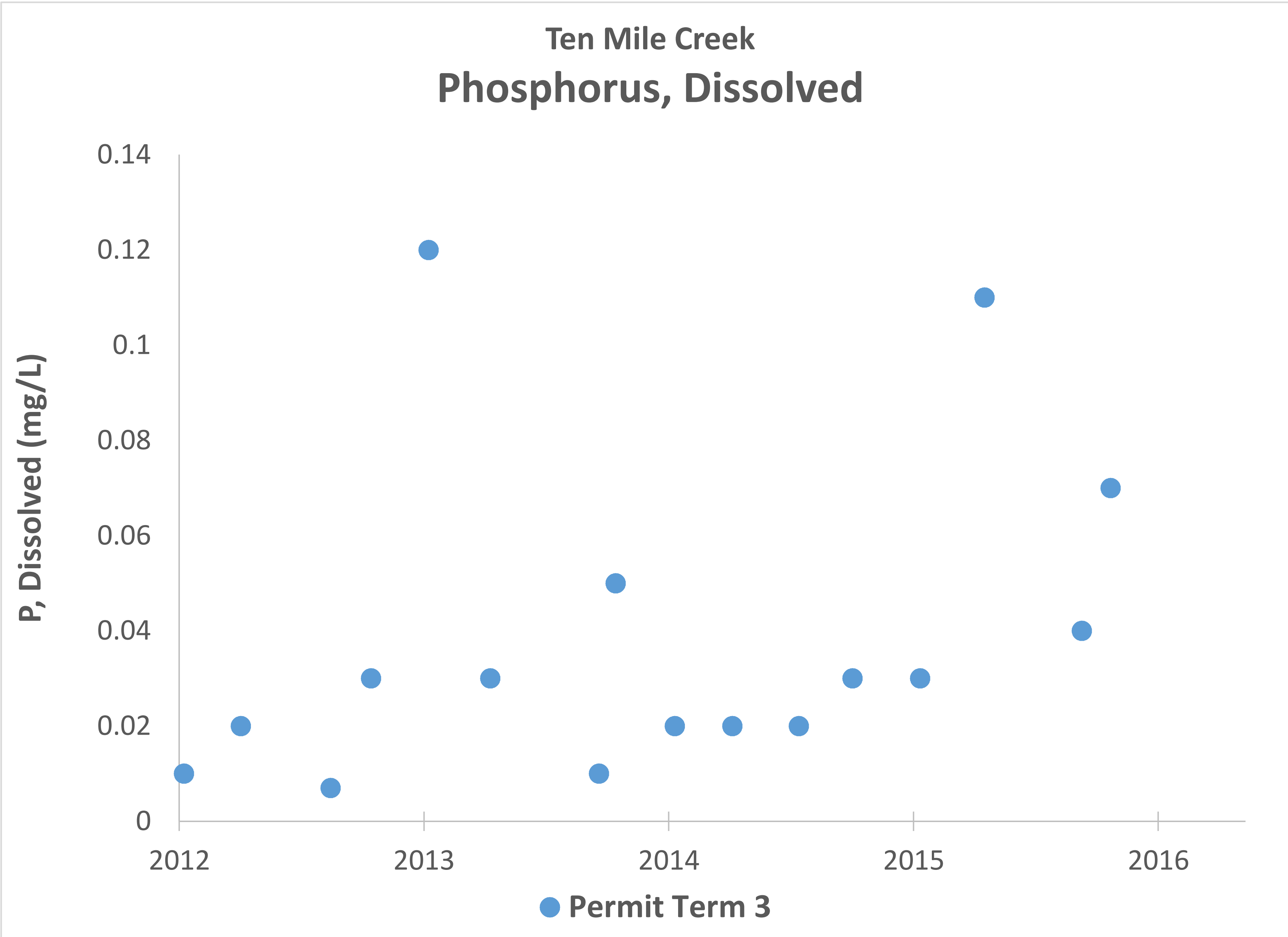


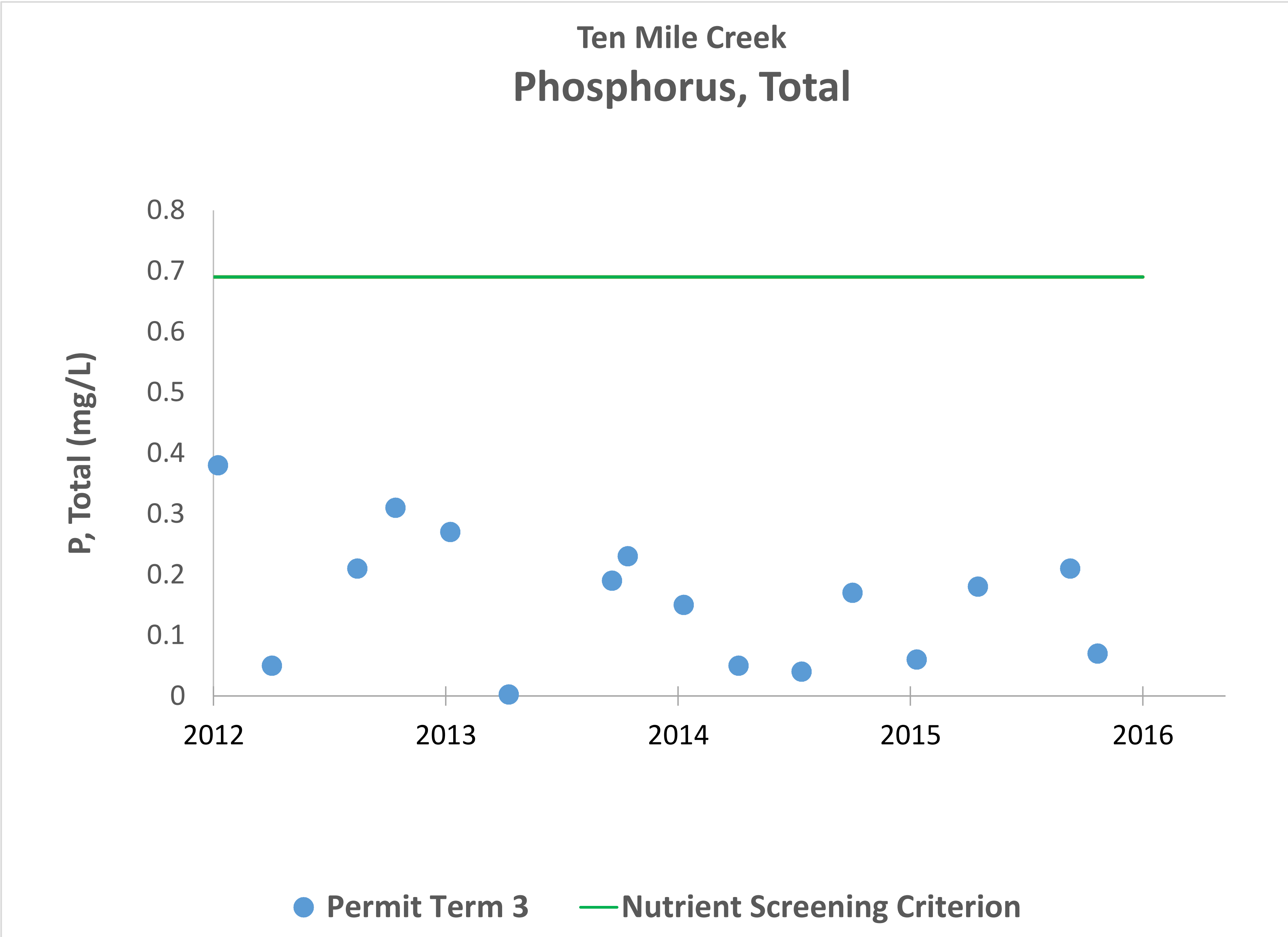
Ten Mile Creek
Biochemical Oxygen Demand
BOD (mg/L)
30
25
20
15
10
5
0
2006
2008
2010
2012
2014
2016
Permit Term 3
NSQD Third Quartile



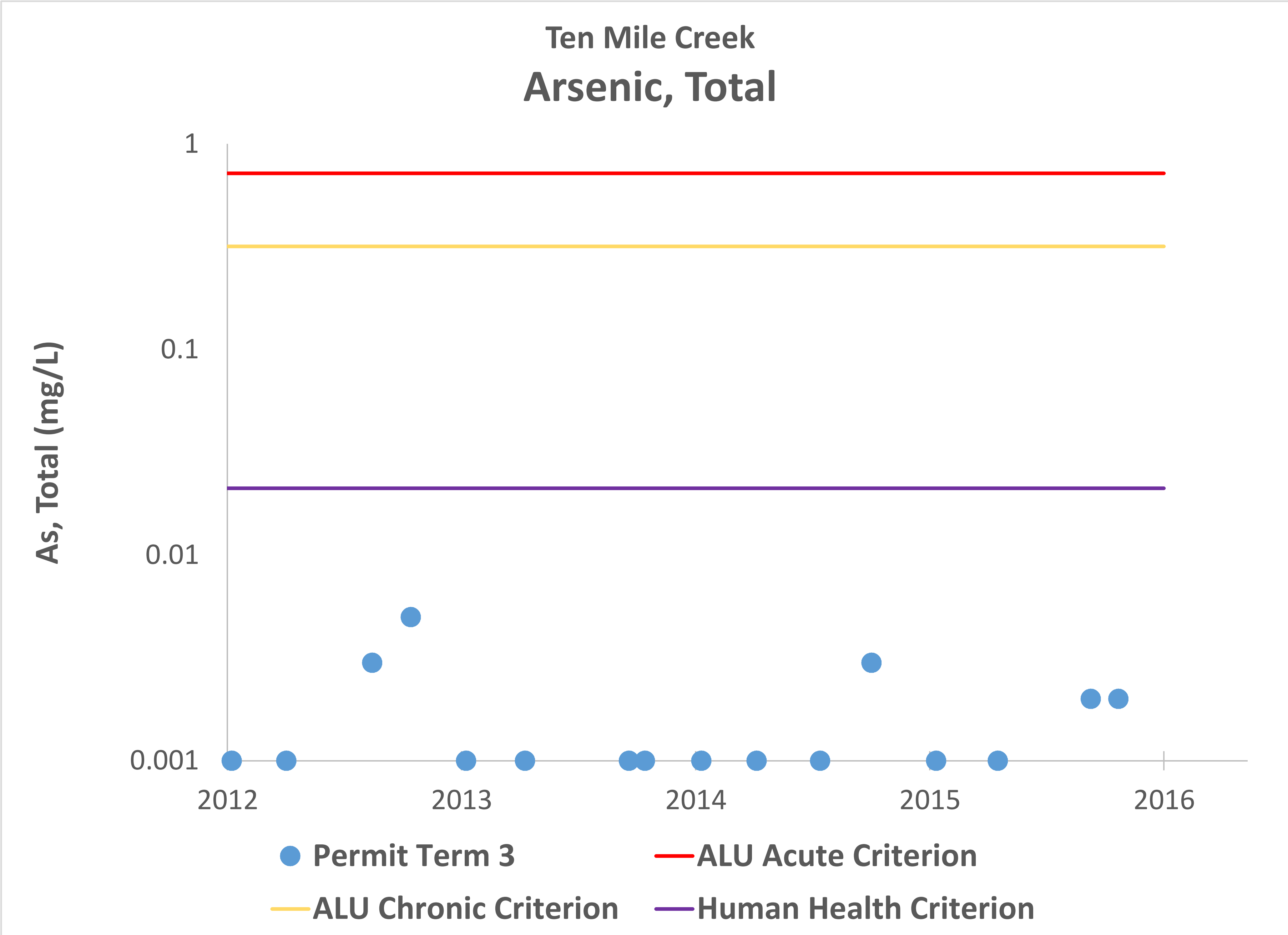
Ten Mile Creek
Chemical Oxygen Demand
COD (mg/L)
600
500
400
300
200
100
0
2012
2013
2014
2015
2016
Permit Term 3
NSQD Third Quartile


Ten Mile Creek
Nitrogen, Total
N, Total (mg/L)
20
18
16
14
12
10
8
6
4
2
0
2012
2013
2014
2015
2016
Permit Term 3
NSQD Third Quartile

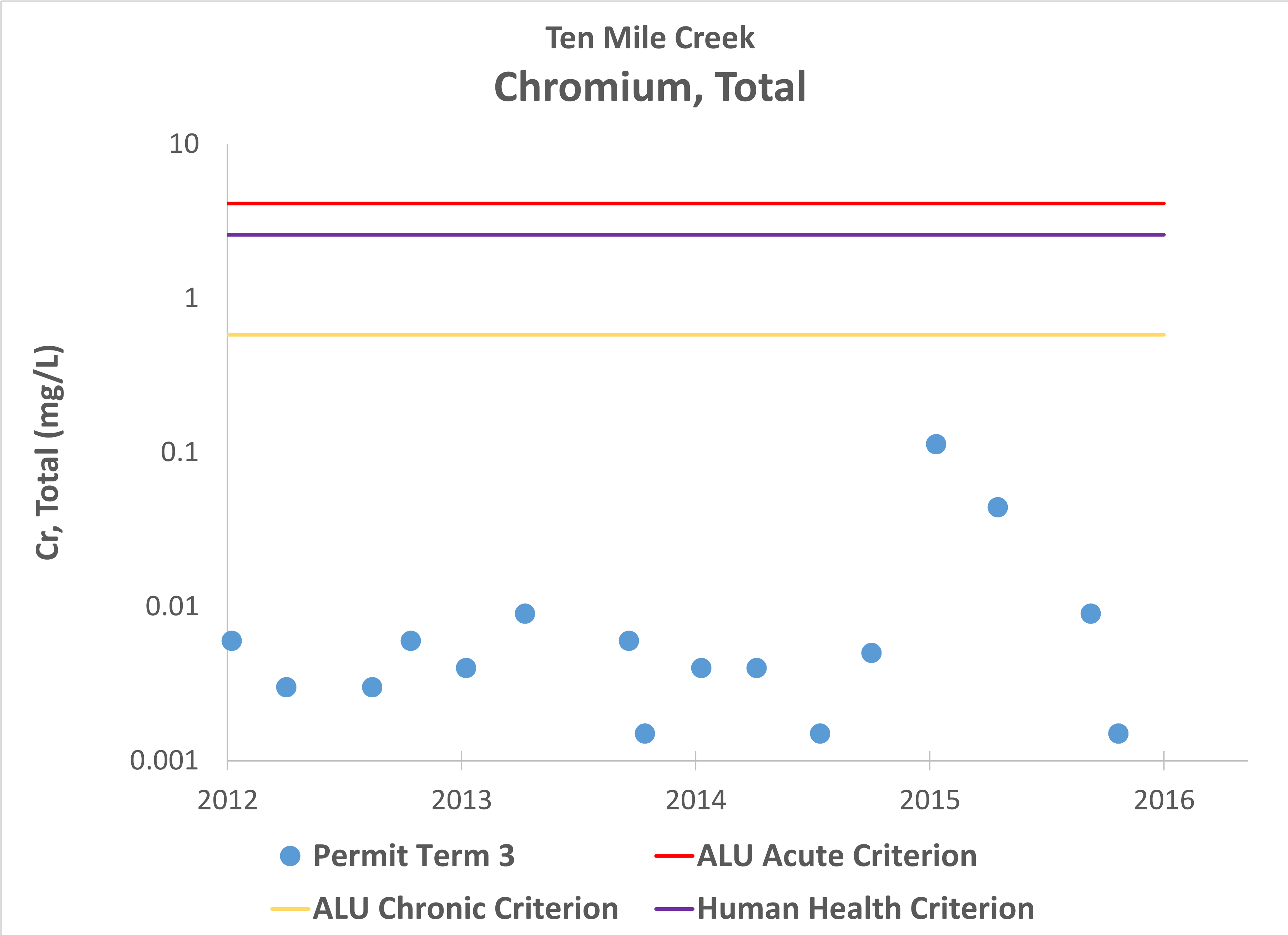

Ten Mile Creek
Phosphorus, Dissolved
P, Dissolved (mg/L)
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
2012
2013
2014
2015
2016
Permit Term 3

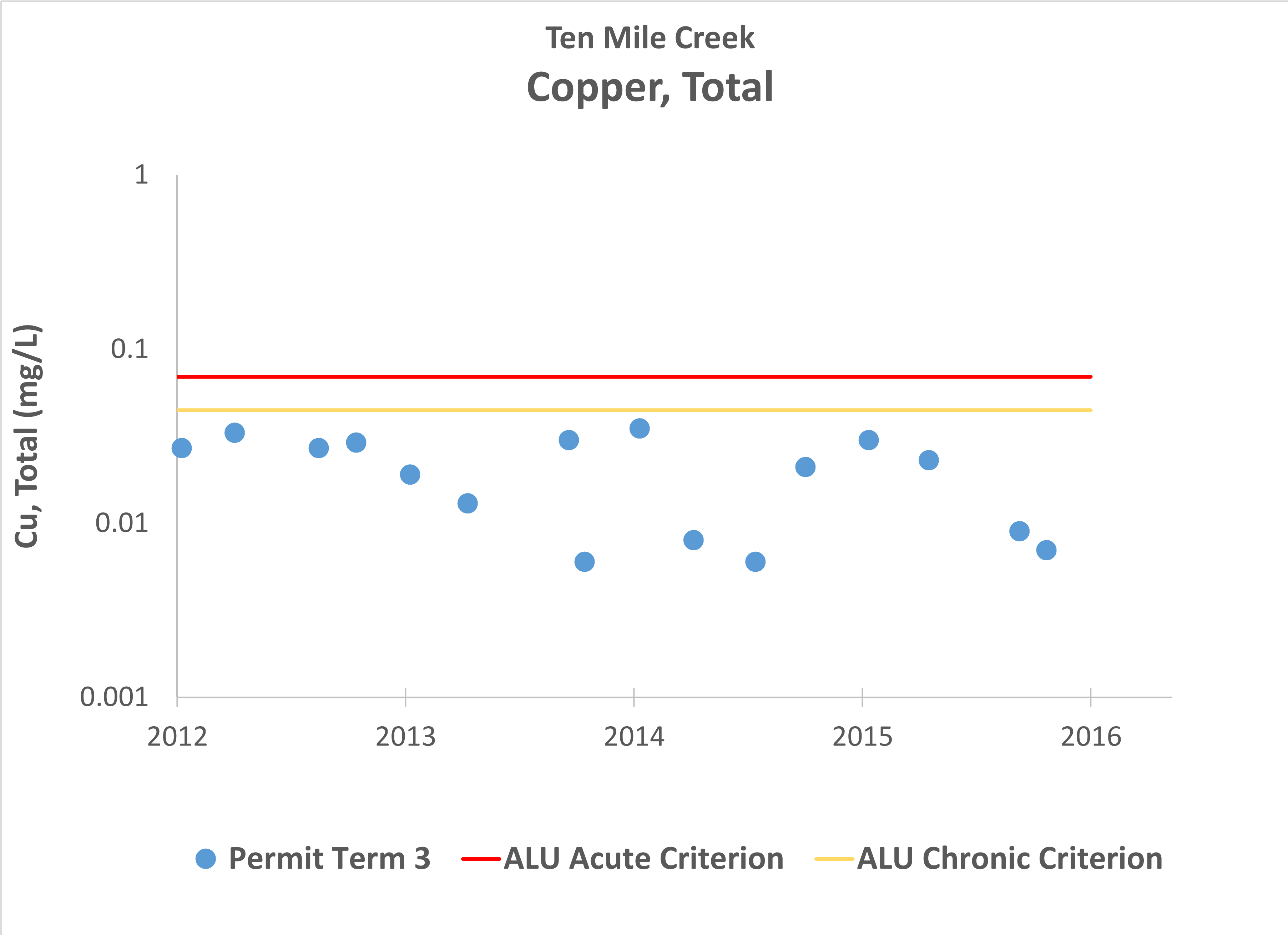


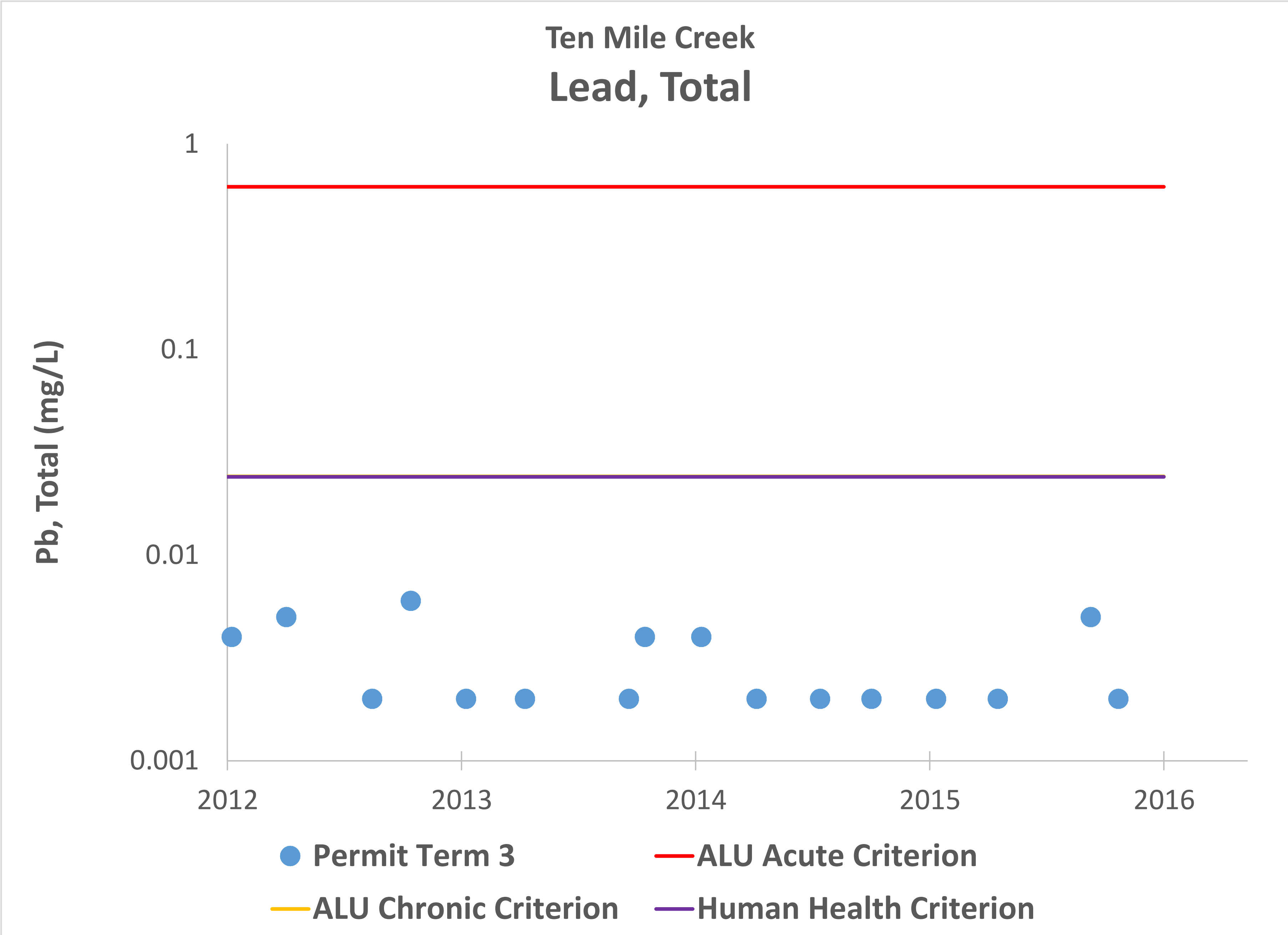
Ten Mile Creek
Phosphorus, Total
P, Total (mg/L)
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
2012
2013
2014
2015
2016
Permit Term 3
Nutrient Screening Criterion



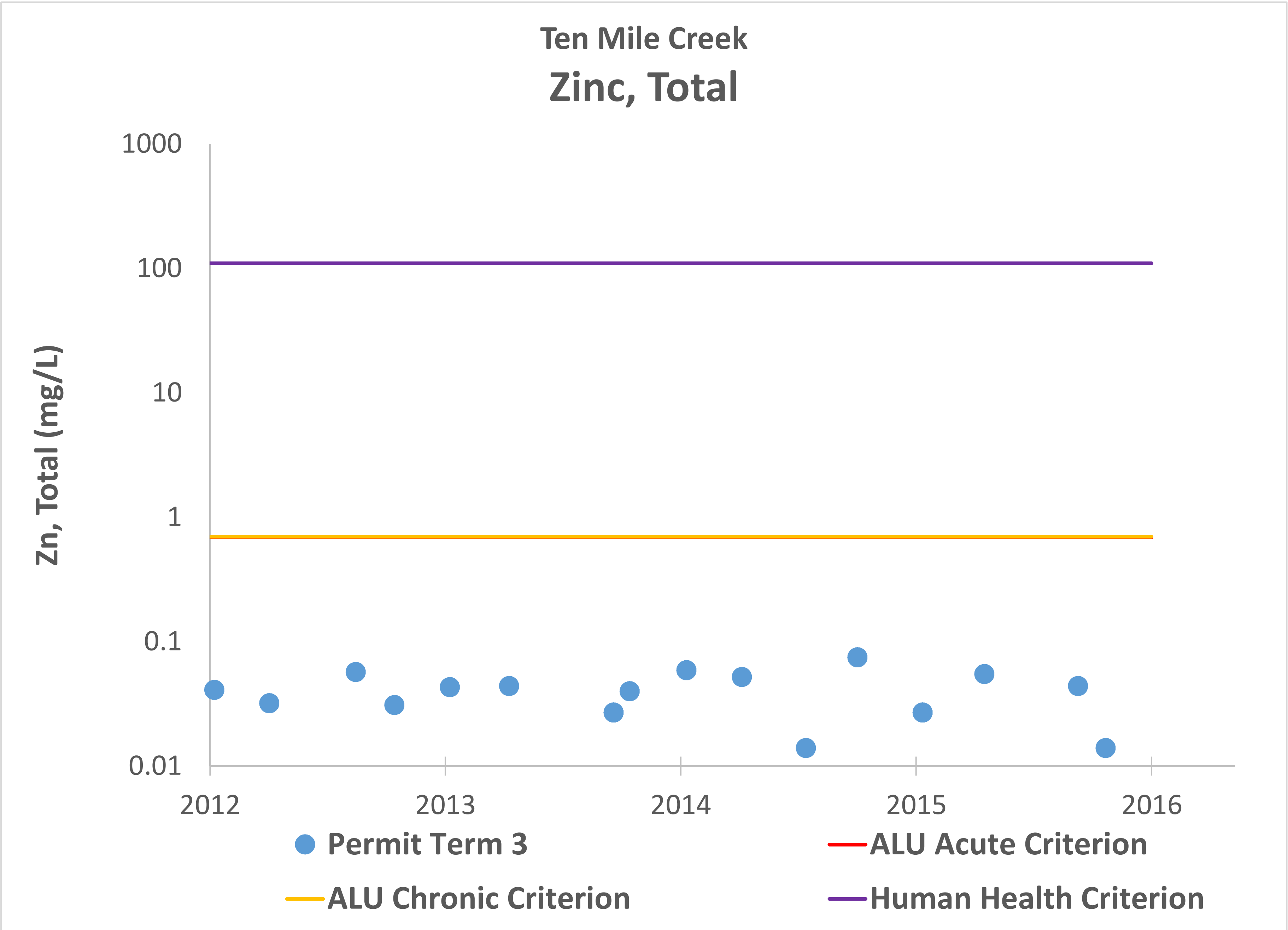
Ten Mile Creek
Arsenic, Total
As, Total (mg/L)
1
0.1
0.01
0.001
2012
2013
2014
2015
2016
Permit Term 3
ALU Acute Criterion
ALU Chronic Criterion
Human Health Criterion

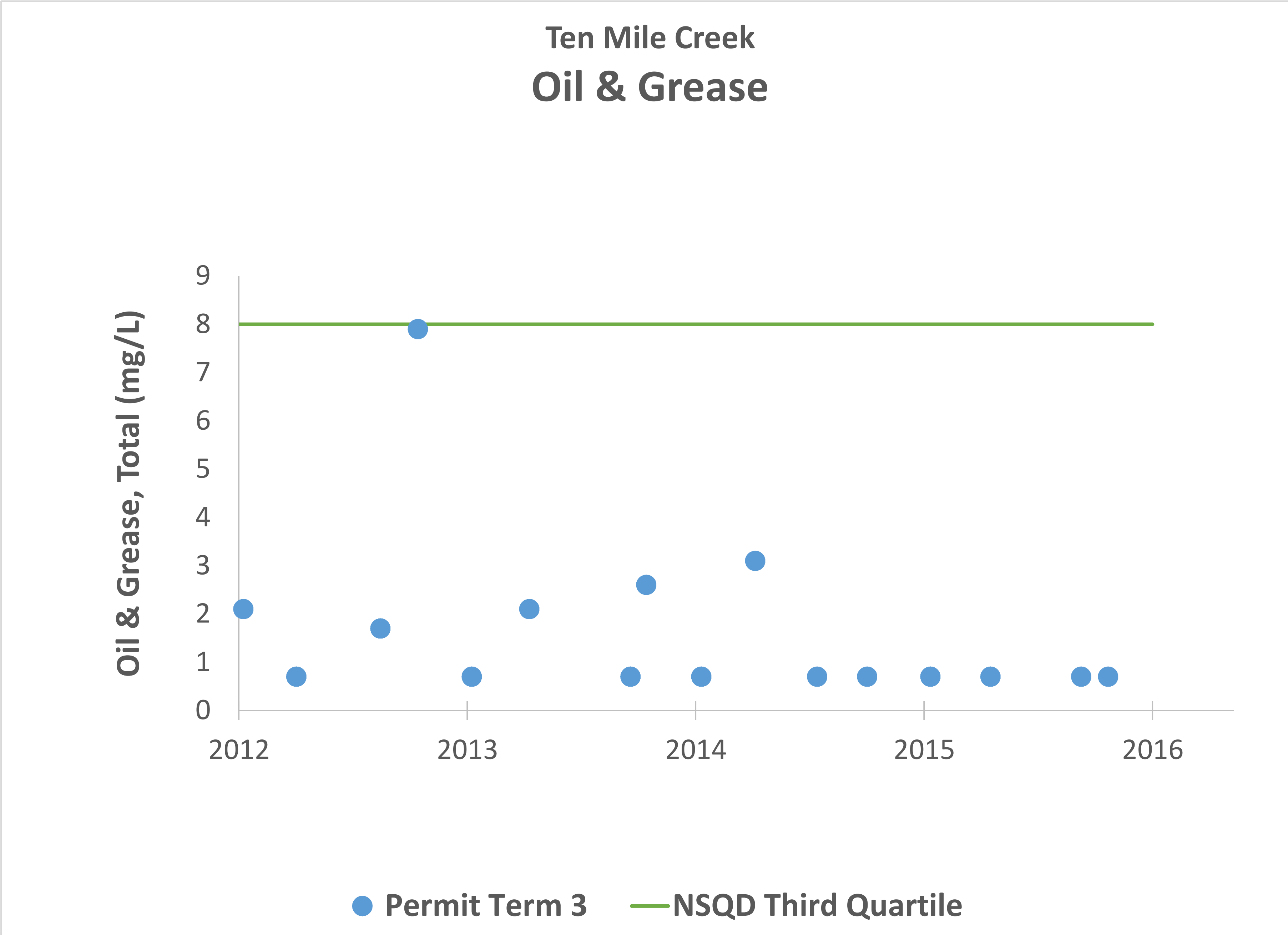

Ten Mile Creek
Chromium, Total
Cr, Total (mg/L)
10
1
0.1
0.01
0.001
2012
2013
2014
2015
2016
Permit Term 3
ALU Acute Criterion
ALU Chronic Criterion
Human Health Criterion


Ten Mile Creek
Copper, Total
Cu, Total (mg/L)
1
0.1
0.01
0.001
2012
2013
2014
2015
2016
Permit Term 3
ALU Acute Criterion
ALU Chronic Criterion

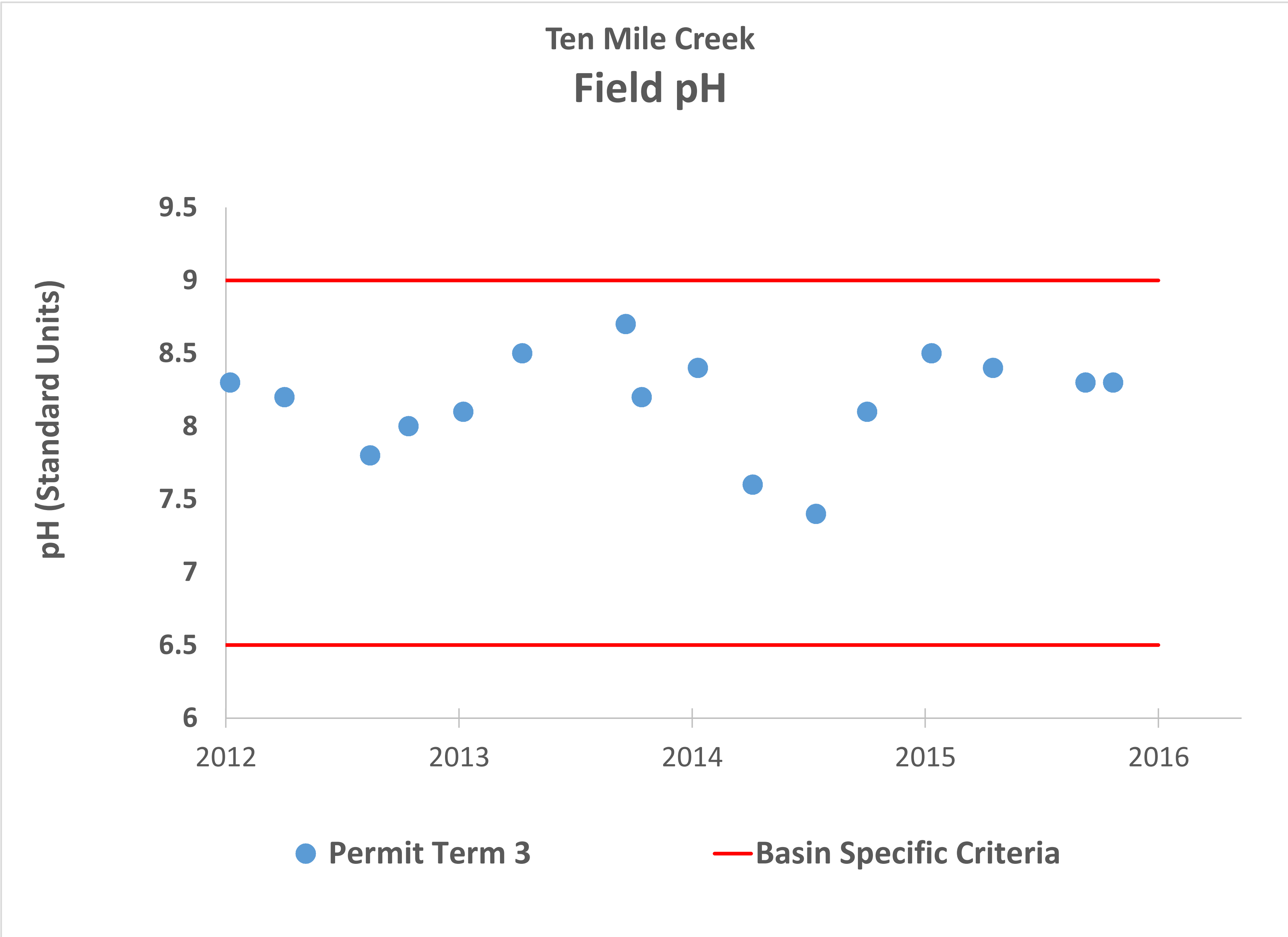


Ten Mile Creek
Lead, Total
Pb, Total (mg/L)
1
0.1
0.01
0.001
2012
2013
2014
2015
2016
Permit Term 3
ALU Acute Criterion
ALU Chronic Criterion
Human Health Criterion

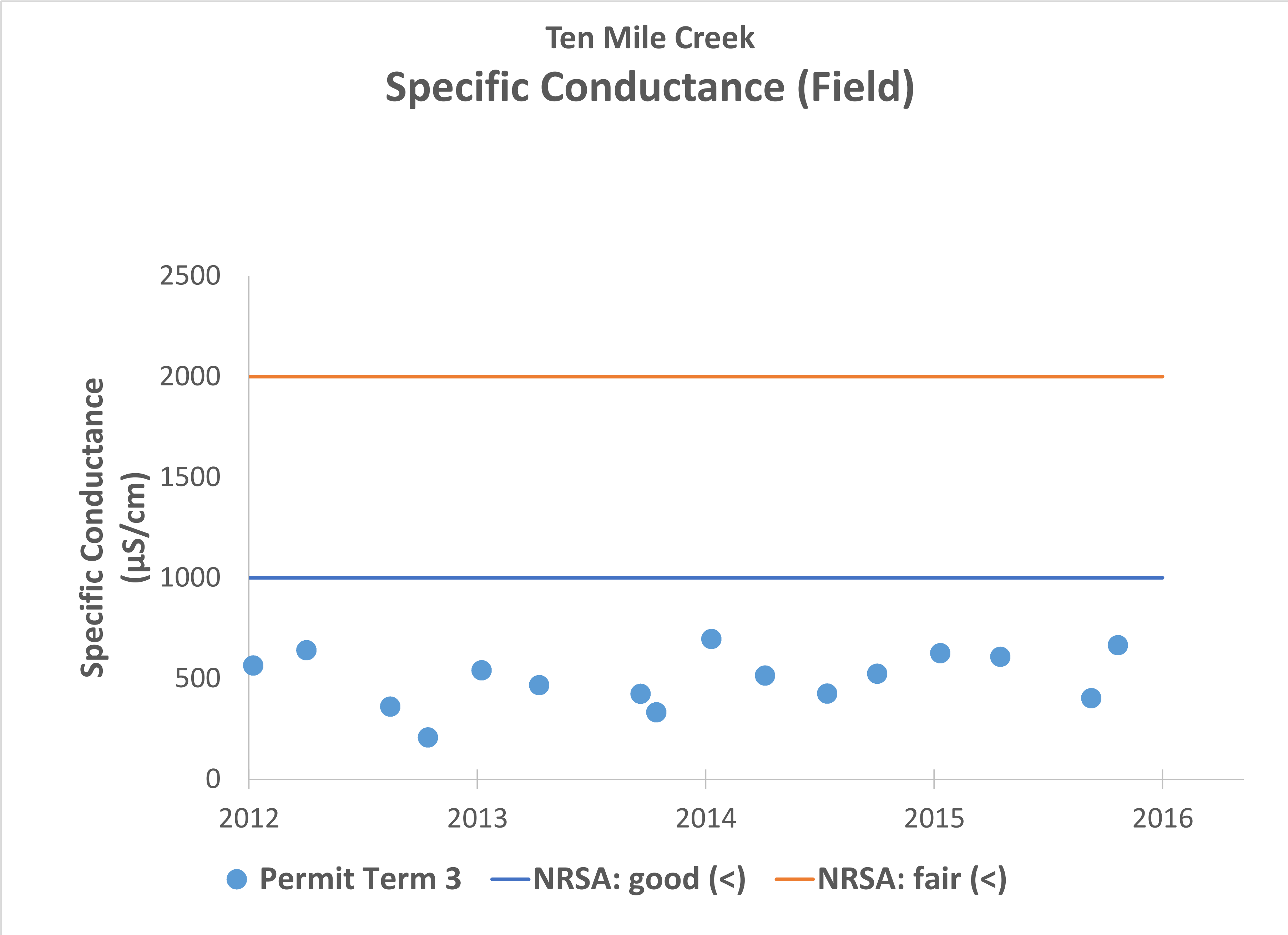

Ten Mile Creek
Zinc, Total
Zn, Total (mg/L)
1000
100
10
1
0.1
0.01
2012
2013
2014
2015
2016
Permit Term 3
ALU Acute Criterion
ALU Chronic Criterion
Human Health Criterion



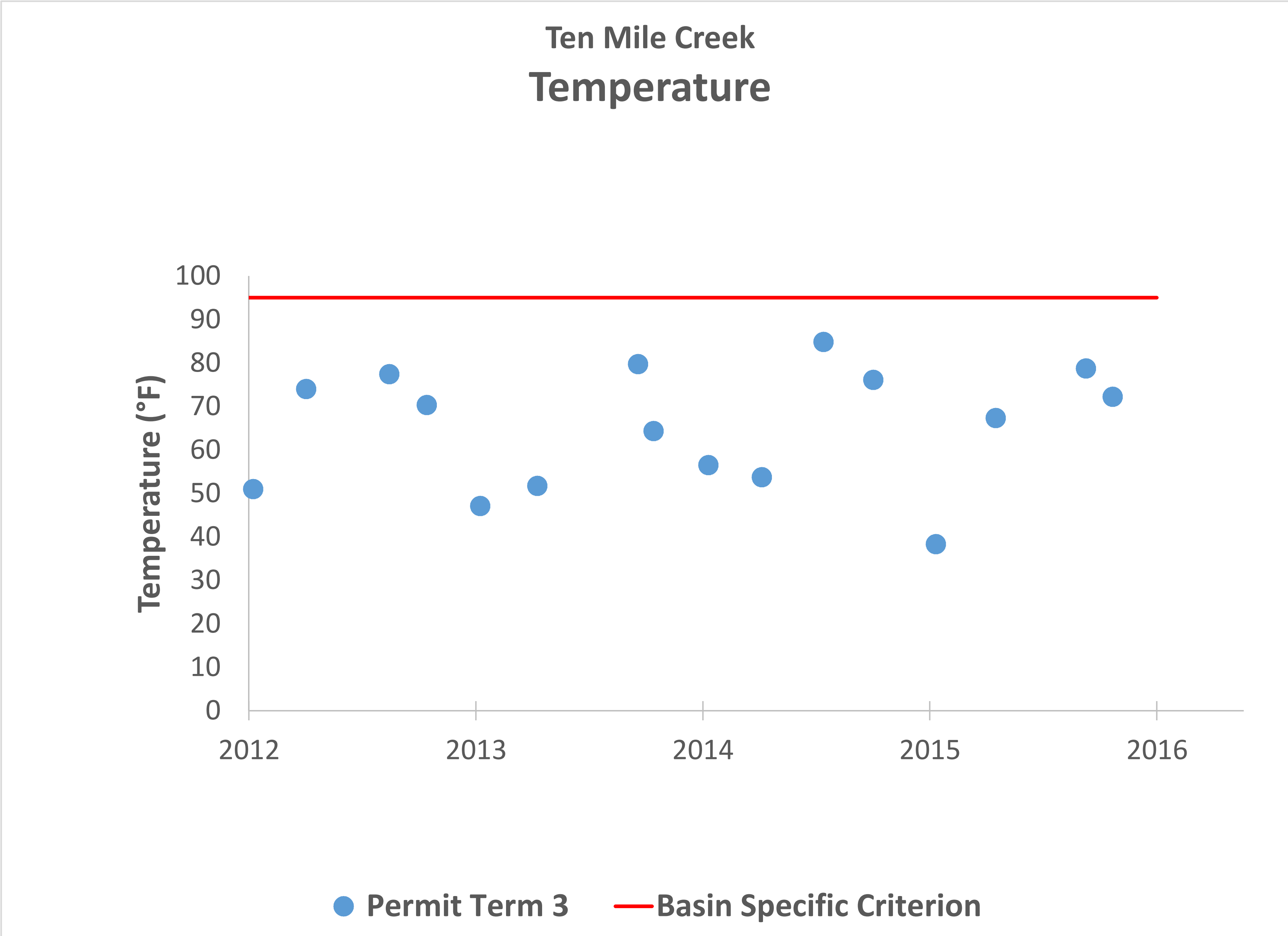
Ten Mile Creek
Oil & Grease
Oil & Grease, Total (mg/L)
0
1
2
3
4
5
6
7
8
9
2012
2013
2014
2015
2016
Permit Term 3
NSQD Third Quartile

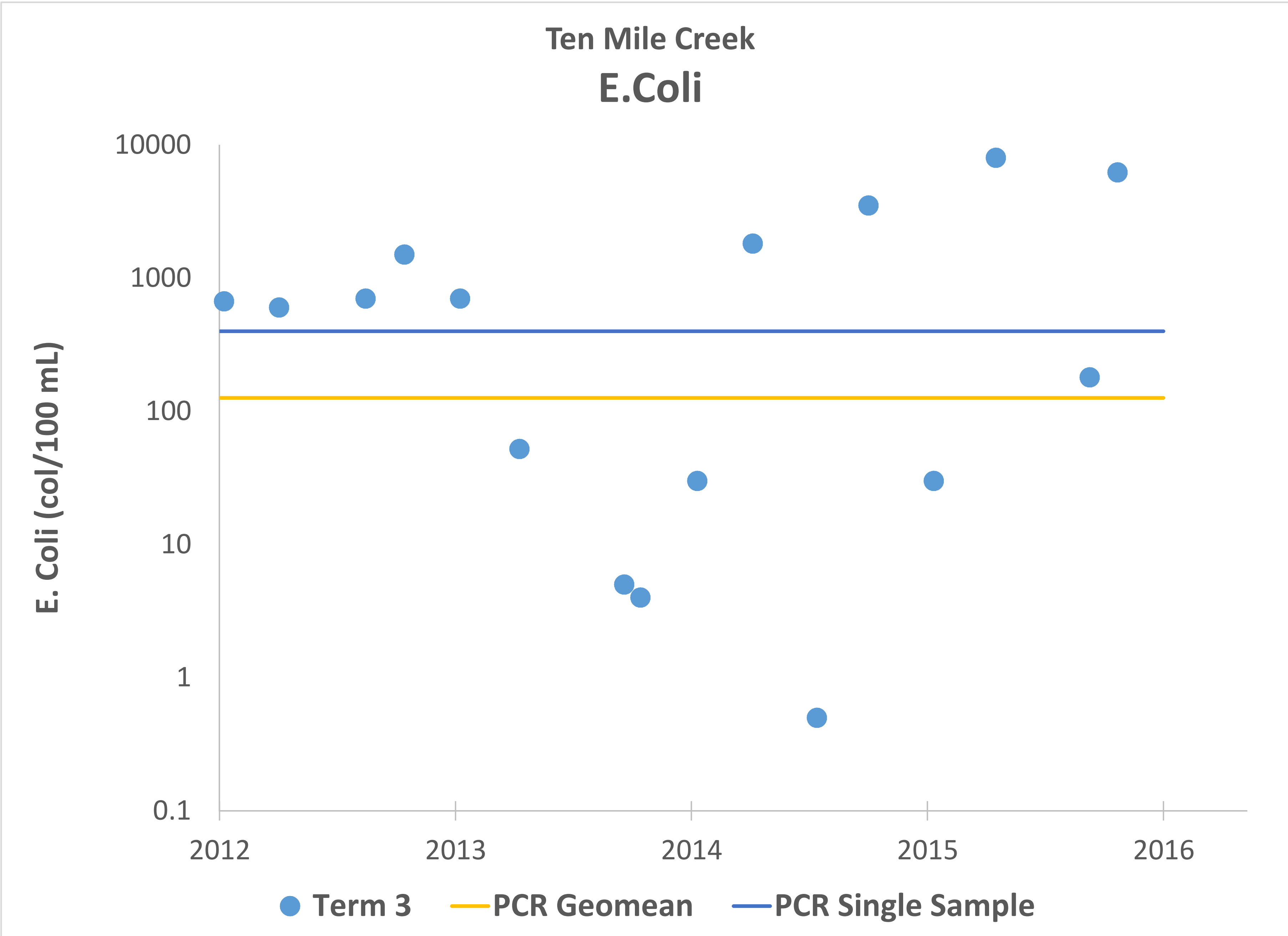


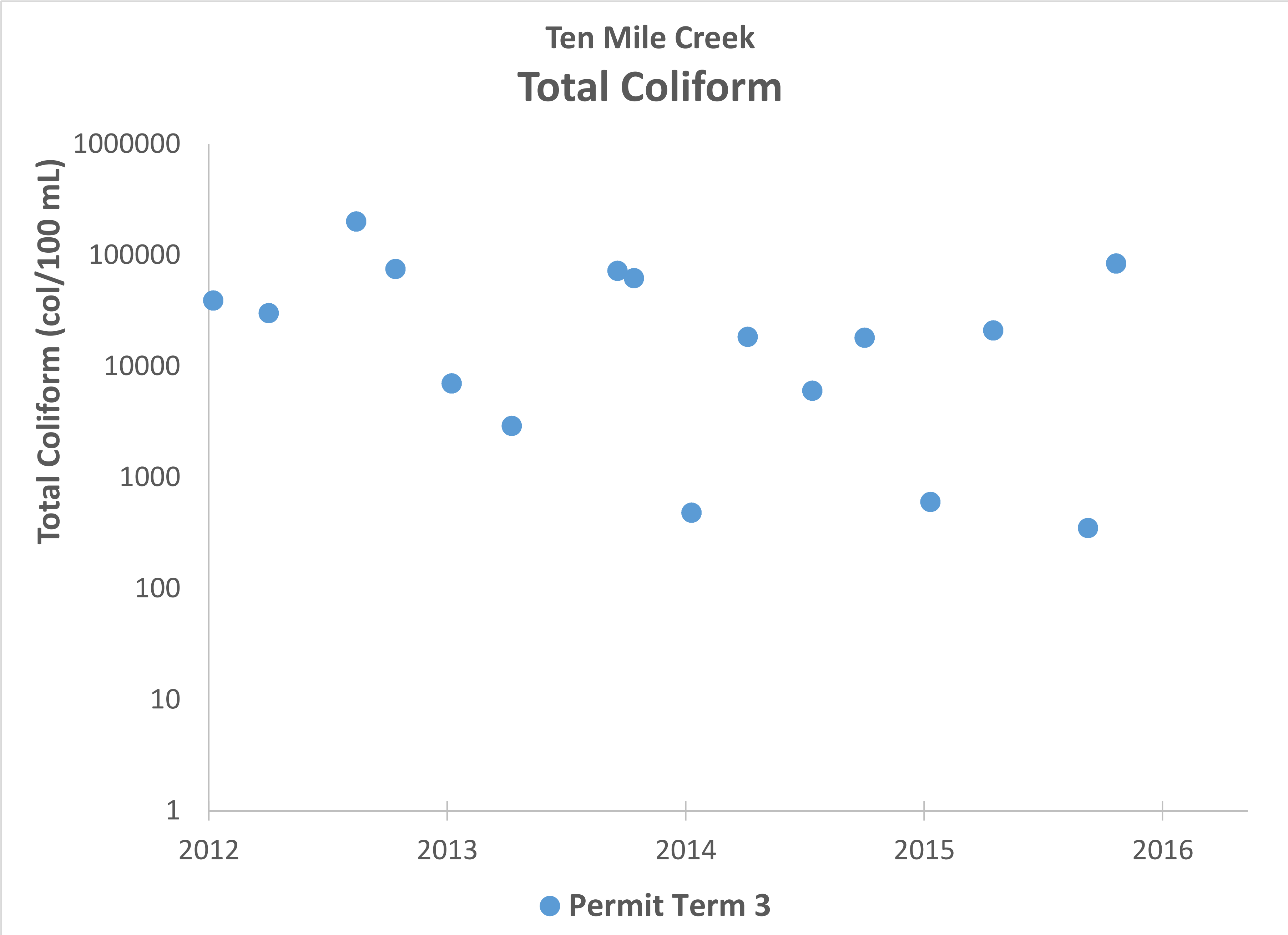
Ten Mile Creek
Field pH
pH (Standard Units)
9.5
9
8.5
8
7.5
7
6.5
6
2012
2013
2014
2015
2016
Permit Term 3
Basin Specific Criteria



Ten Mile Creek
Specific Conductance (Field)
Specific Conductance (µS/cm)
2500
2000
1500
1000
500
0
2012
2013
2014
2015
2016
Permit Term 3
NRSA: good (<)
NRSA: fair (<)


Ten Mile Creek
Temperature
Temperature (°F)
100
90
80
70
60
50
40
30
20
10
0
2012
2013
2014
2015
2016
Permit Term 3
Basin Specific Criterion

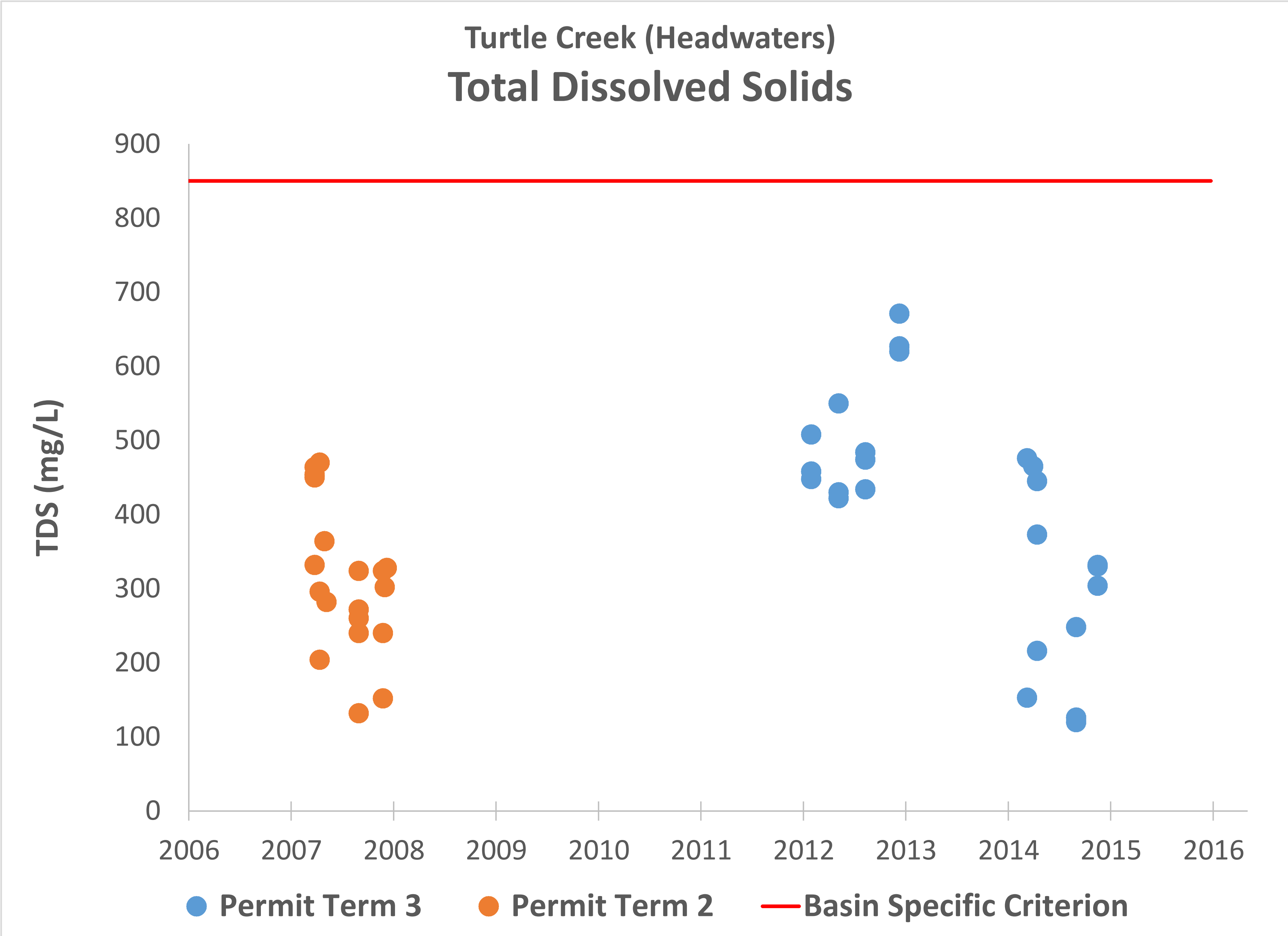

Ten Mile Creek
E.Coli
E. Coli (col/100 mL)
10000
1000
100
10
1
0.1
2012
2013
2014
2015
2016
Term 3
PCR Geomean
PCR Single Sample



Ten Mile Creek
Total Coliform
Total Coliform (col/100 mL)
1000000
100000
10000
1000
100
10
1
2012
2013
2014
2015
2016
Permit Term 3

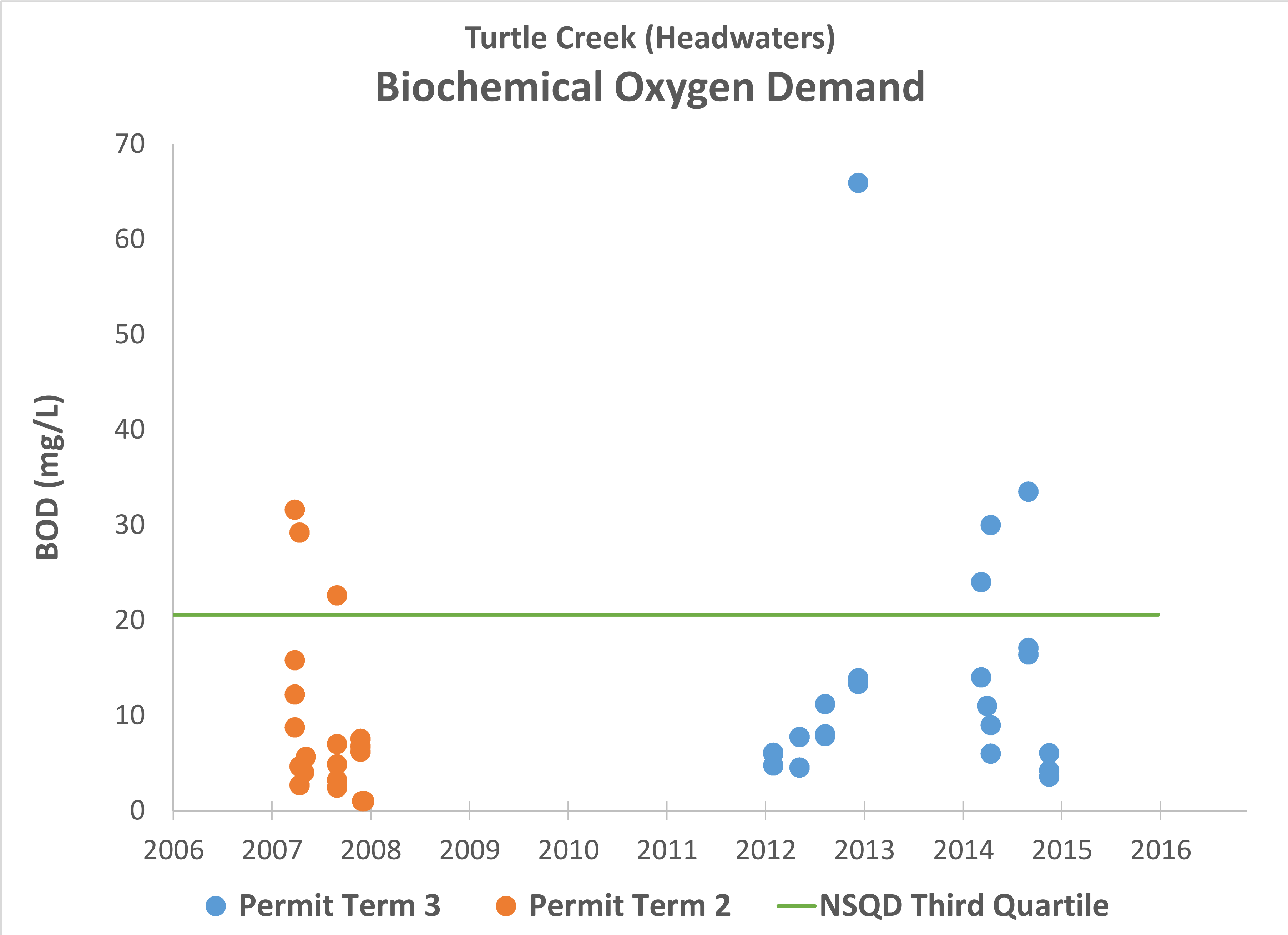
Appendix AA

Turtle Creek Water Quality
Data Graphs

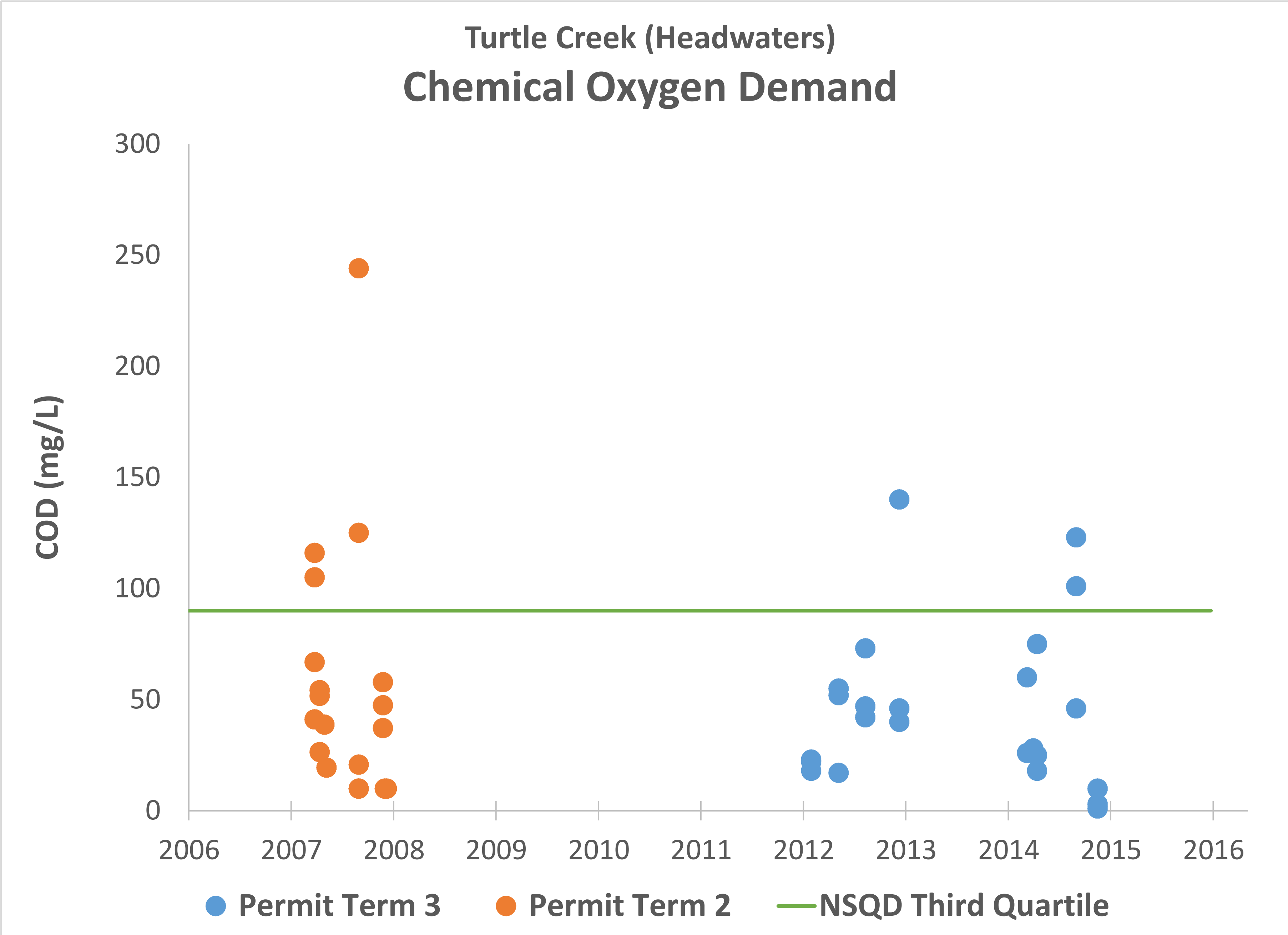


Turtle Creek (Headwaters)
Total Dissolved Solids
TDS (mg/L)
0
100
200
300
400
500
600
700
800
900
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
Permit Term 3
Permit Term 2
Basin Specific Criterion

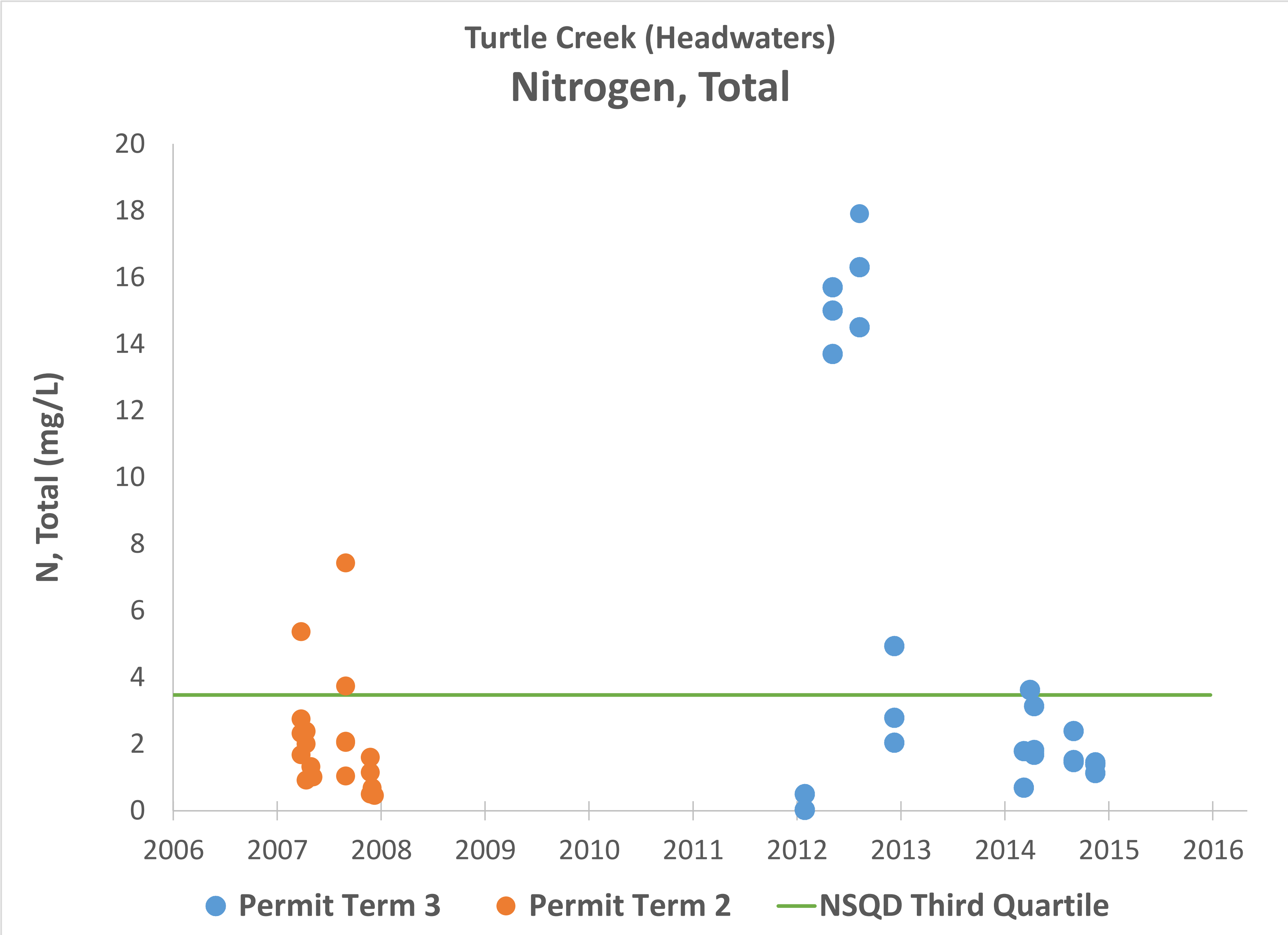
Turtle Creek (Headwaters)
Total Suspended Solids
TSS (mg/L)
10000
1000
100
10
1
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
Permit Term 3
Permit Term 2
NSQD Third Quartile

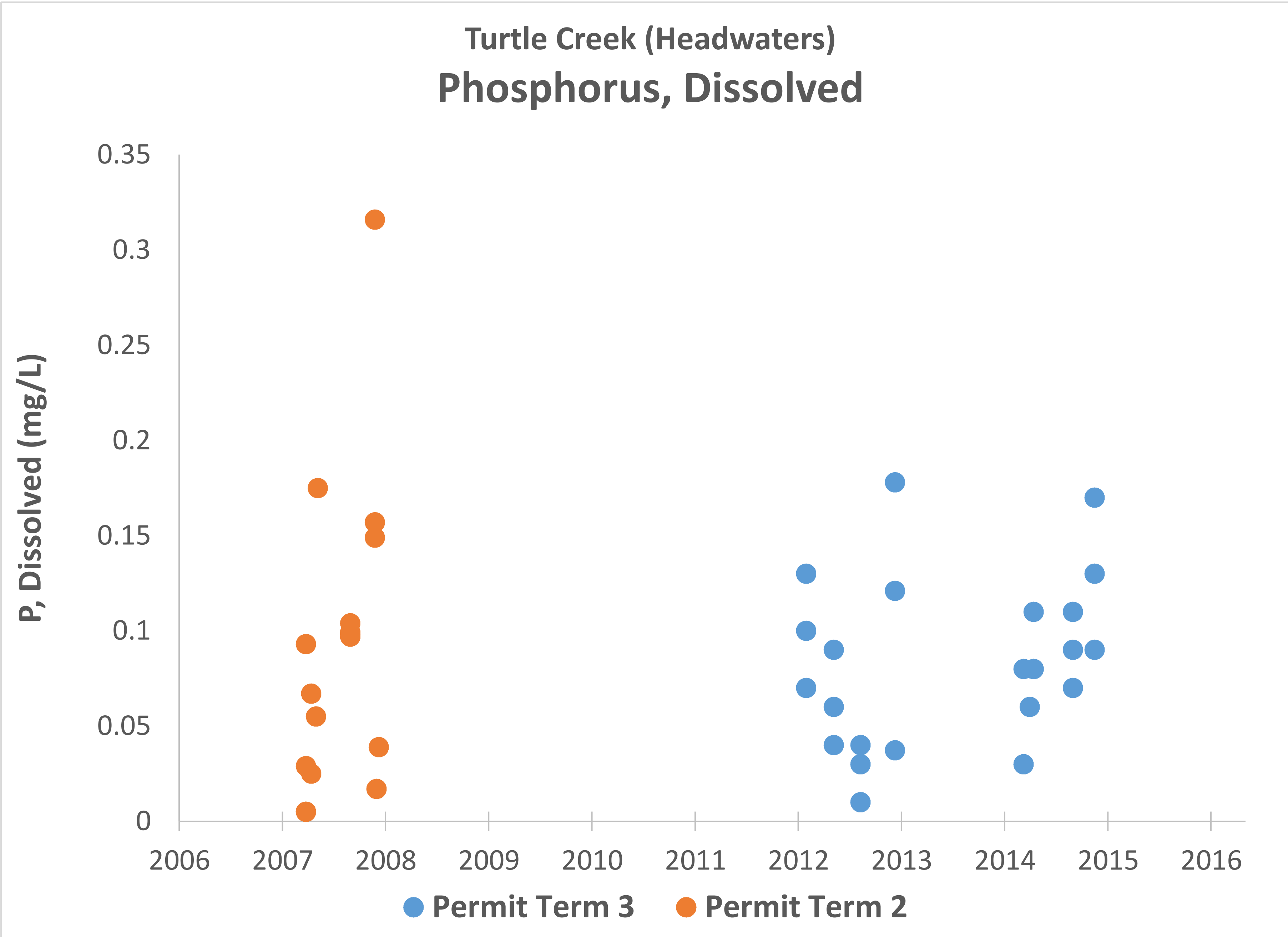


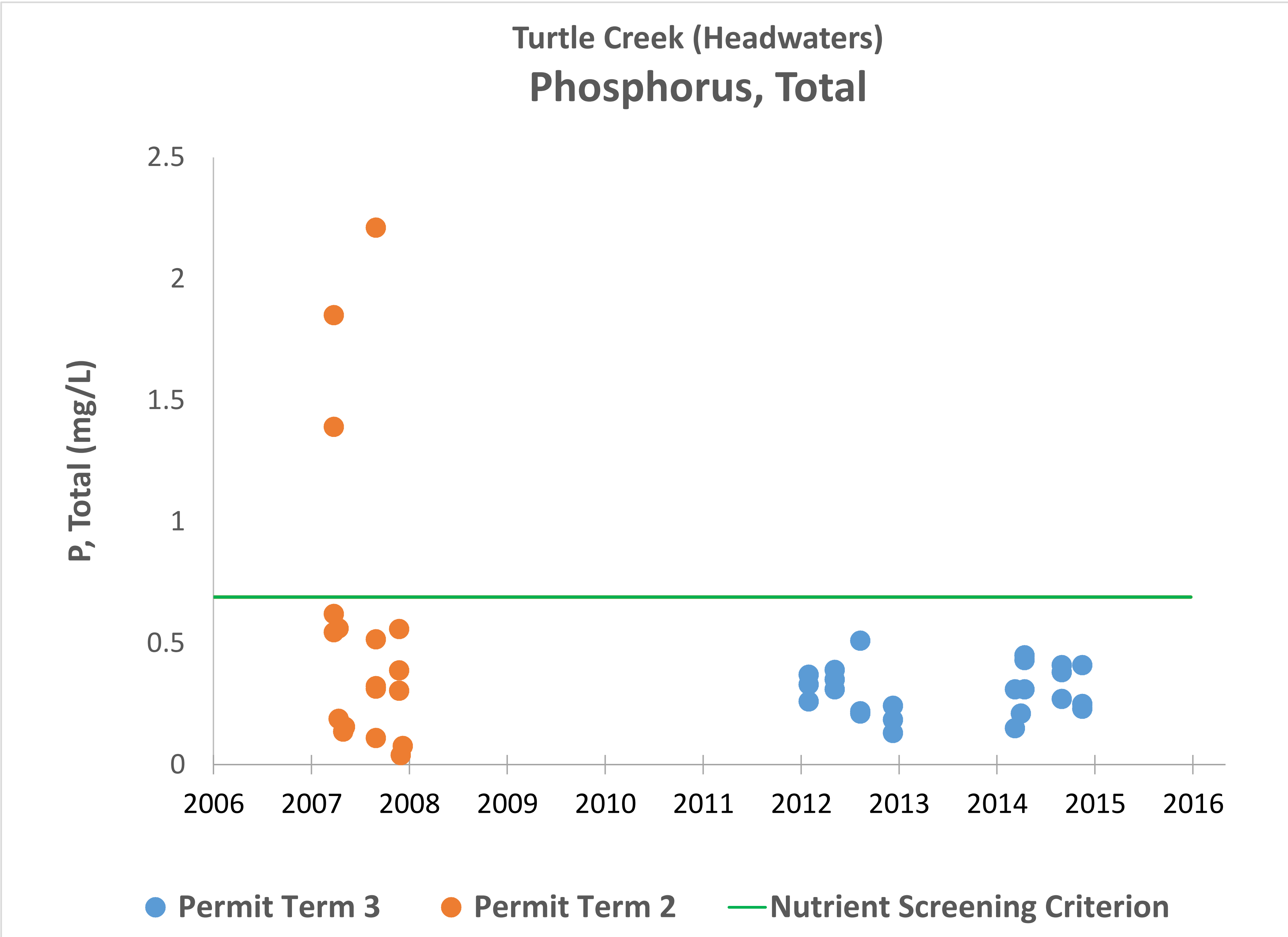
Turtle Creek (Headwaters)
Biochemical Oxygen Demand
BOD (mg/L)
70
60
50
40
30
20
10
0
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
Permit Term 3
Permit Term 2
NSQD Third Quartile

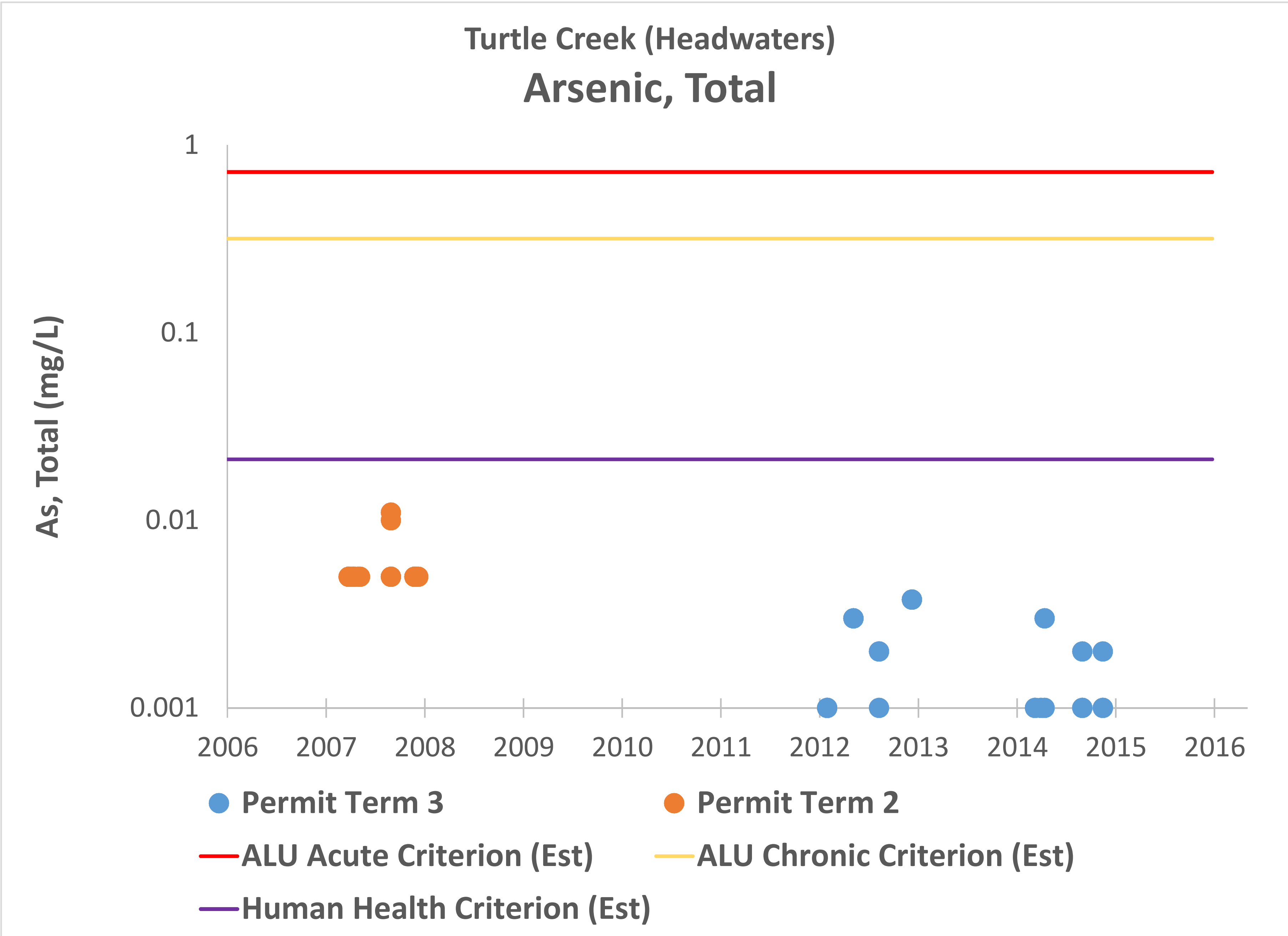


Turtle Creek (Headwaters)
Chemical Oxygen Demand
COD (mg/L)
300
250
200
150
100
50
0
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
Permit Term 3
Permit Term 2
NSQD Third Quartile

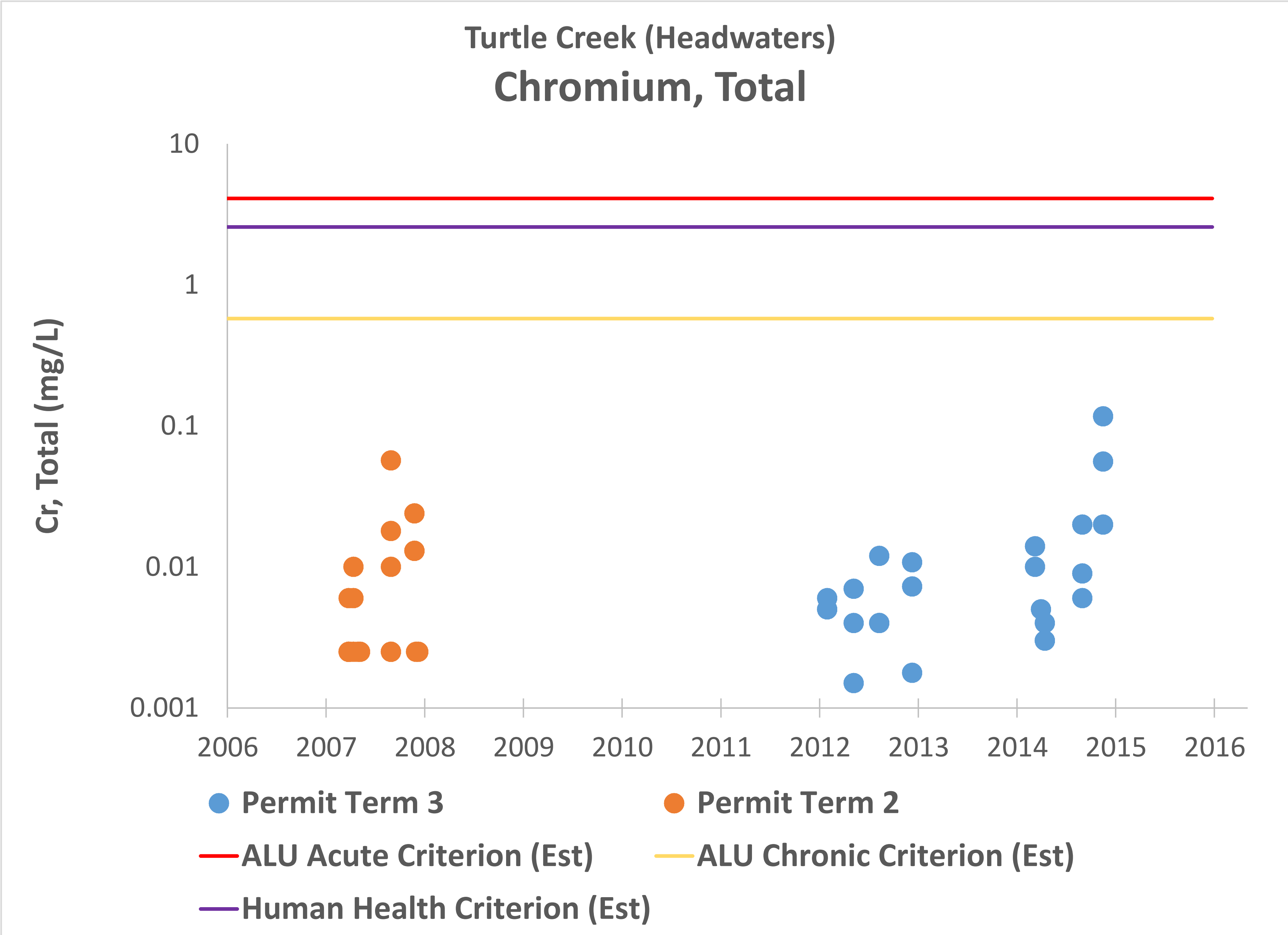

Turtle Creek (Headwaters)
Nitrogen, Total
N, Total (mg/L)
20
18
16
14
12
10
8
6
4
2
0
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
Permit Term 3
Permit Term 2
NSQD Third Quartile


Turtle Creek (Headwaters)
Phosphorus, Dissolved
P, Dissolved (mg/L)
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
Permit Term 3
Permit Term 2

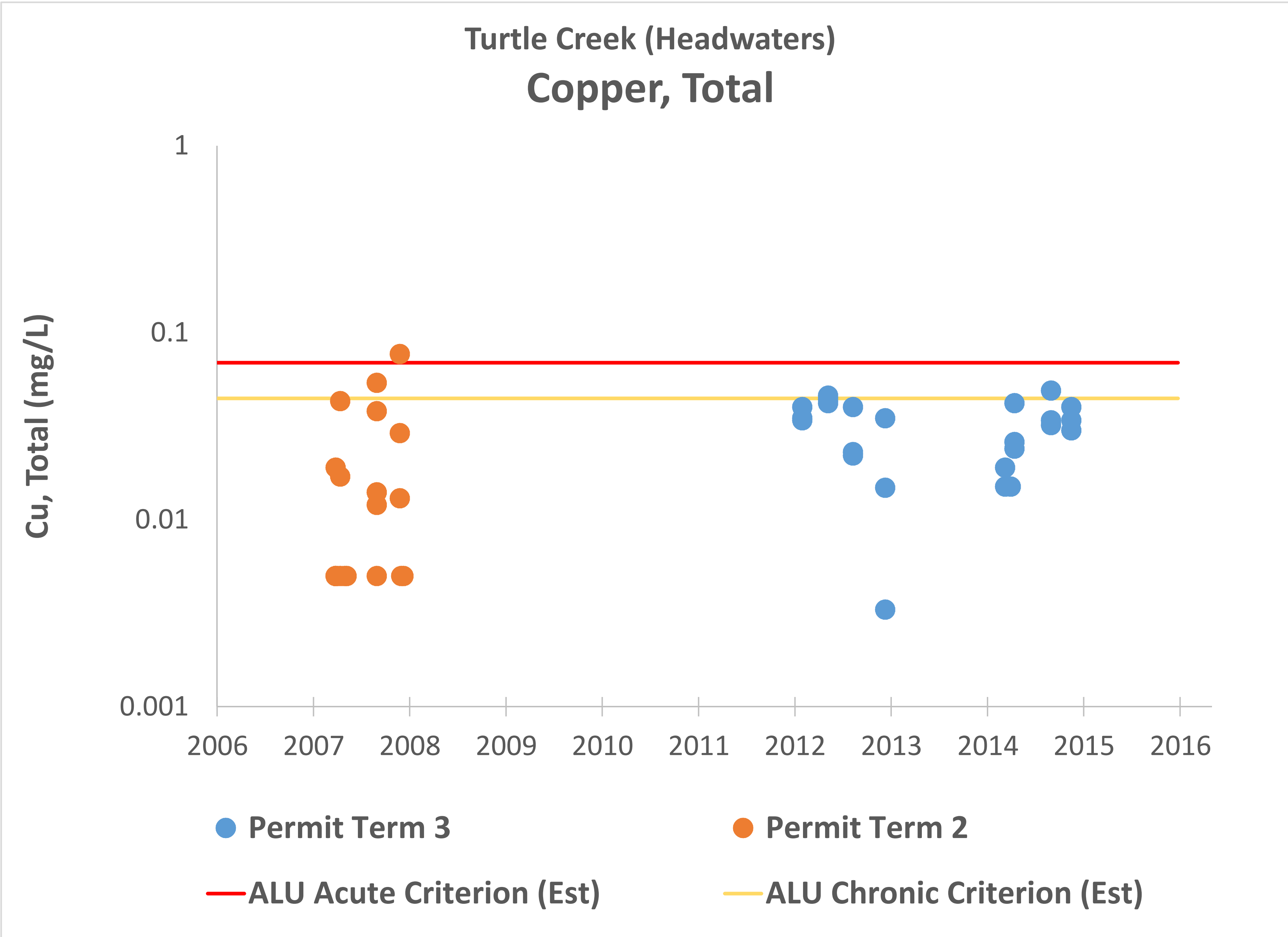

Turtle Creek (Headwaters)
Phosphorus, Total
P, Total (mg/L)
2.5
2
1.5
1
0.5
0
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
Permit Term 3
Permit Term 2
Nutrient Screening Criterion



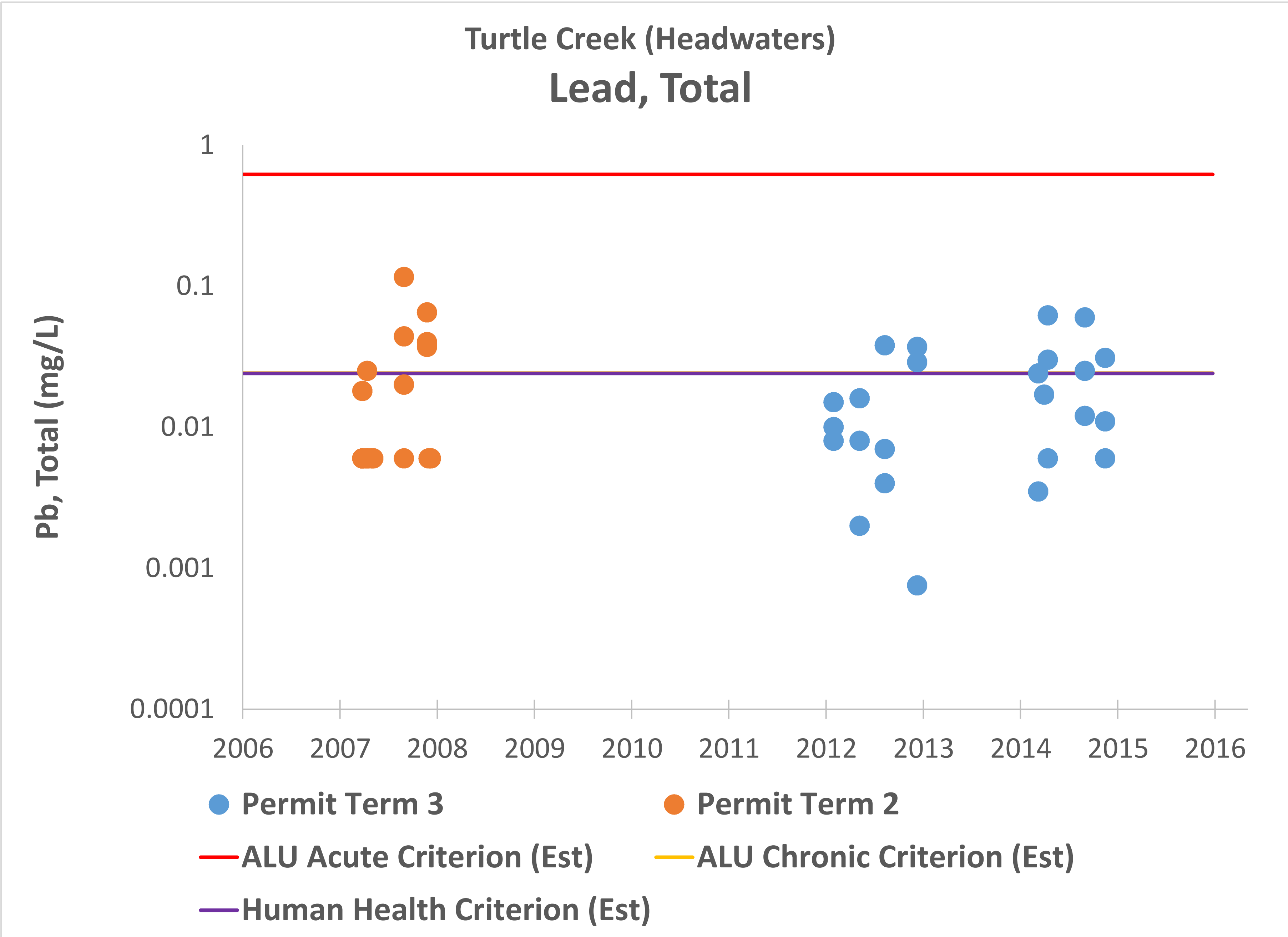
Turtle Creek (Headwaters)
Arsenic, Total
As, Total (mg/L)
1
0.1
0.01
0.001
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
Permit Term 3
Permit Term 2
ALU Acute Criterion (Est)
ALU Chronic Criterion (Est)
Human Health Criterion (Est)

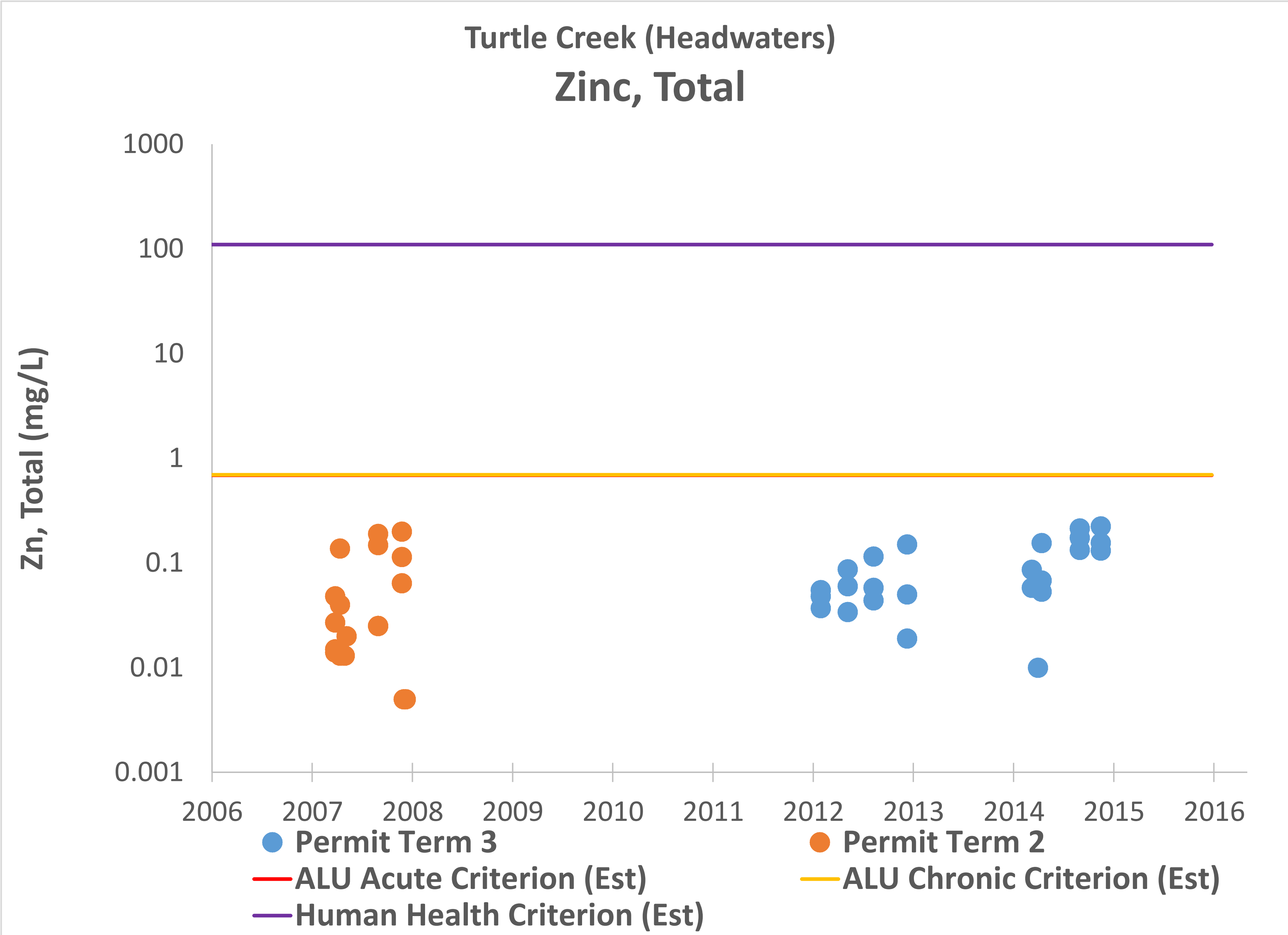


Turtle Creek (Headwaters)
Chromium, Total
Cr, Total (mg/L)
10
1
0.1
0.01
0.001
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
Permit Term 3
Permit Term 2
ALU Acute Criterion (Est)
ALU Chronic Criterion (Est)
Human Health Criterion (Est)

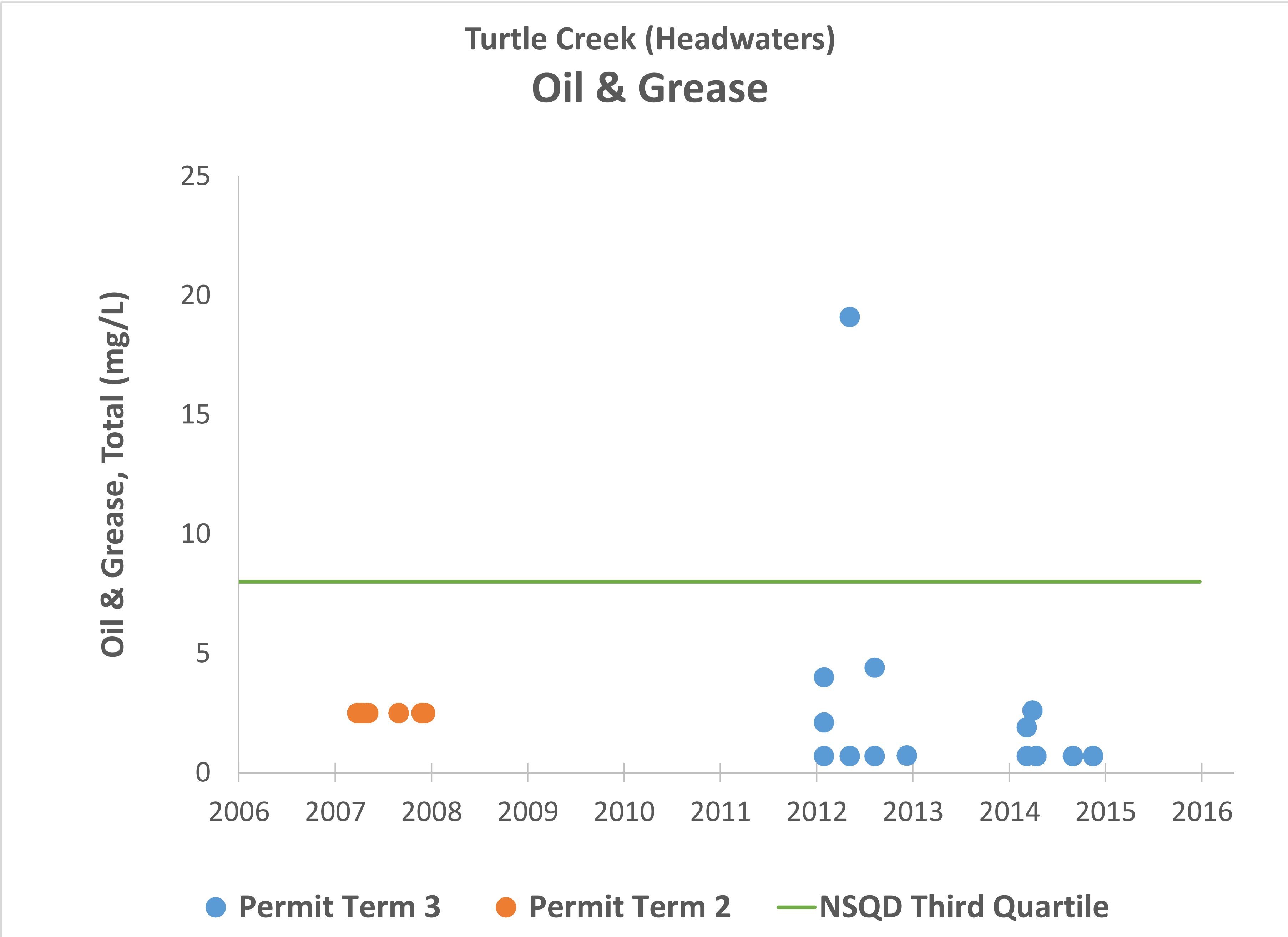


Turtle Creek (Headwaters)
Copper, Total
Cu, Total (mg/L)
1
0.1
0.01
0.001
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
Permit Term 3
Permit Term 2
ALU Acute Criterion (Est)
ALU Chronic Criterion (Est)

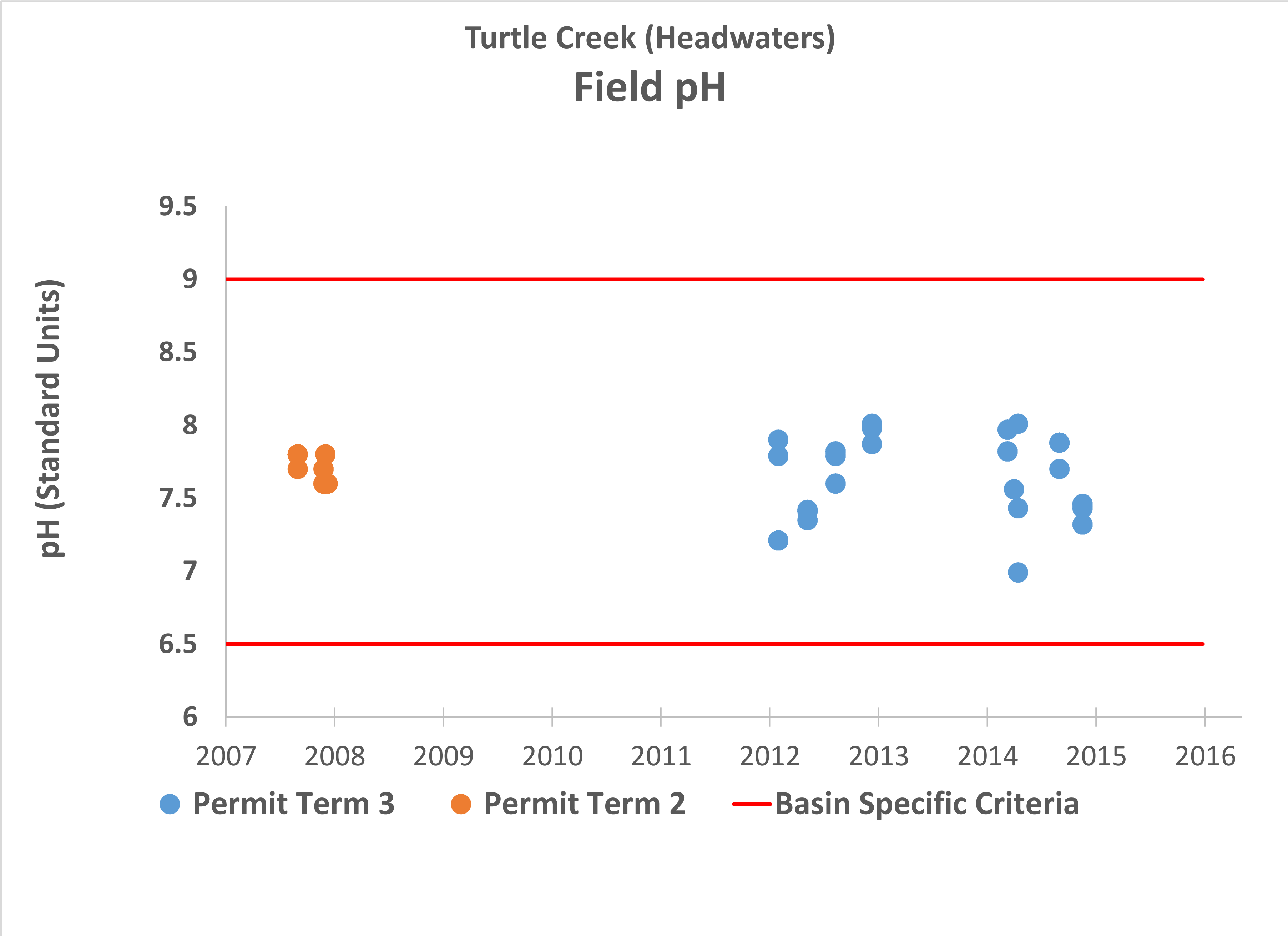

Turtle Creek (Headwaters)
Lead, Total
Pb, Total (mg/L)
1
0.1
0.01
0.001
0.0001
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
Permit Term 3
Permit Term 2
ALU Acute Criterion (Est)
ALU Chronic Criterion (Est)
Human Health Criterion (Est)



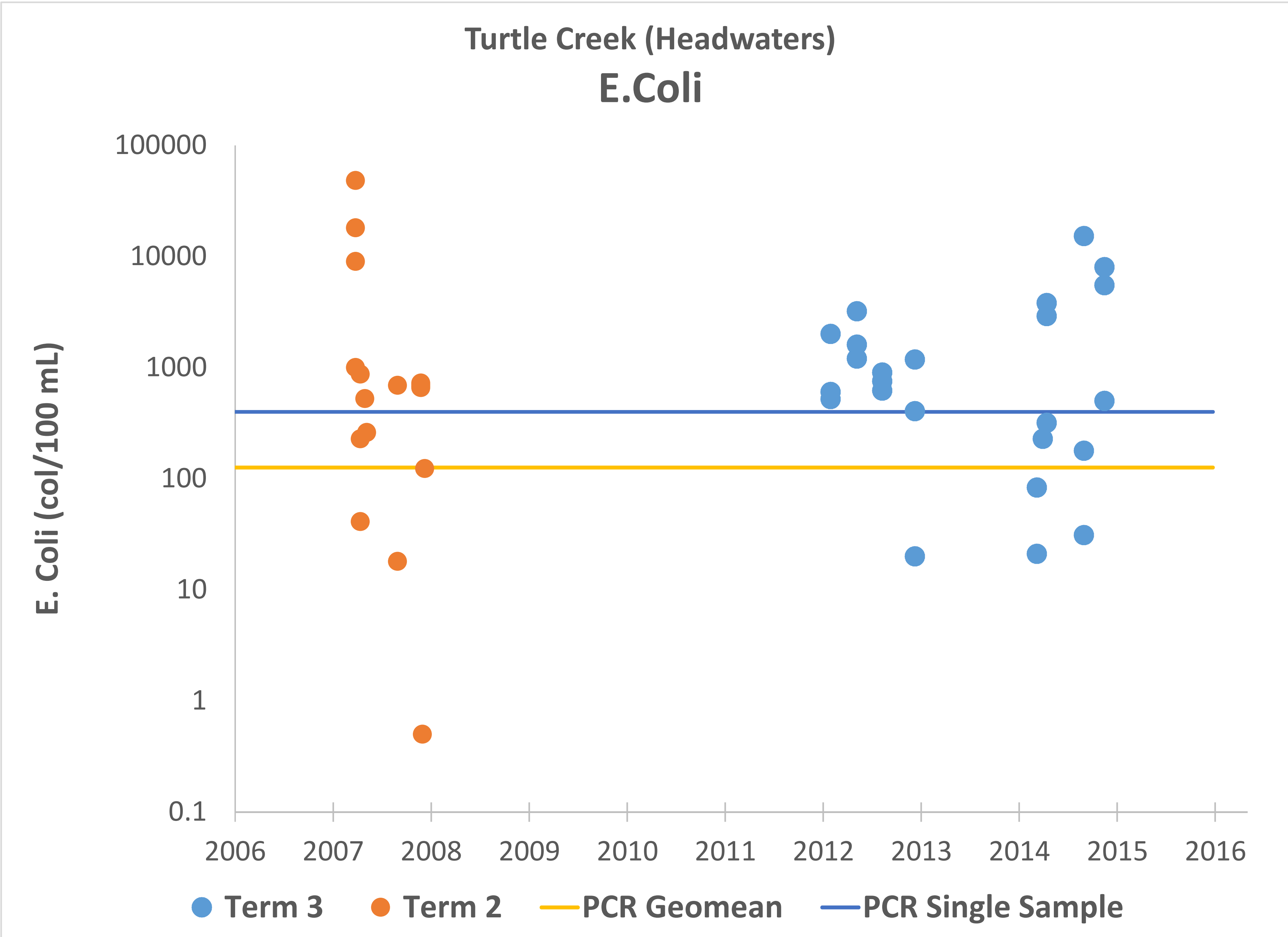
Turtle Creek (Headwaters)
Zinc, Total
Zn, Total (mg/L)
1000
100
10
1
0.1
0.01
0.001
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
Permit Term 3
Permit Term 2
ALU Acute Criterion (Est)
ALU Chronic Criterion (Est)
Human Health Criterion (Est)



Turtle Creek (Headwaters)
Oil & Grease
Oil & Grease, Total (mg/L)
0
5
10
15
20
25
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
Permit Term 3
Permit Term 2
NSQD Third Quartile



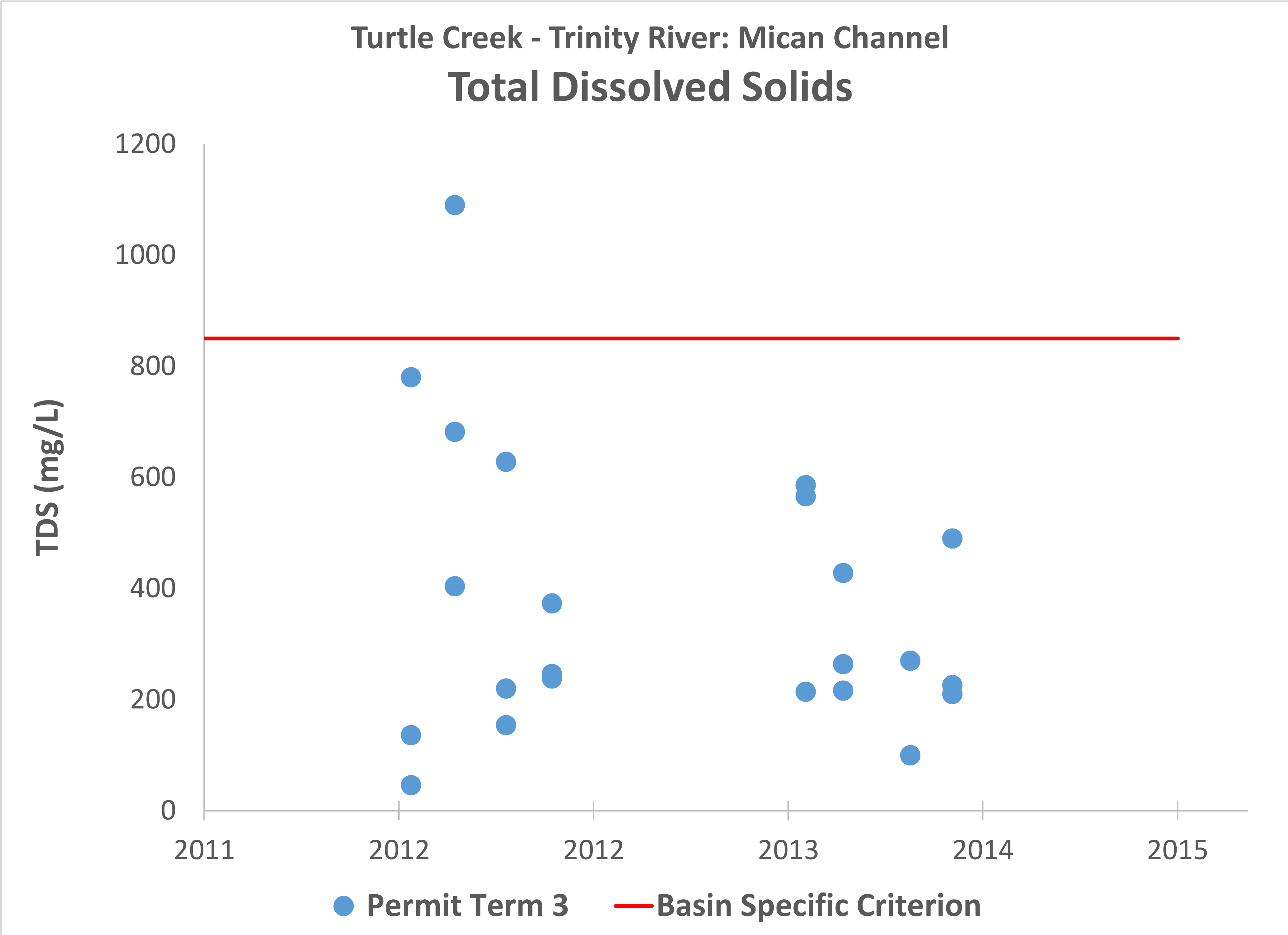
Turtle Creek (Headwaters)
Field pH
pH (Standard Units)
9.5
9
8.5
8
7.5
7
6.5
6
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
Permit Term 3
Permit Term 2
Basin Specific Criteria



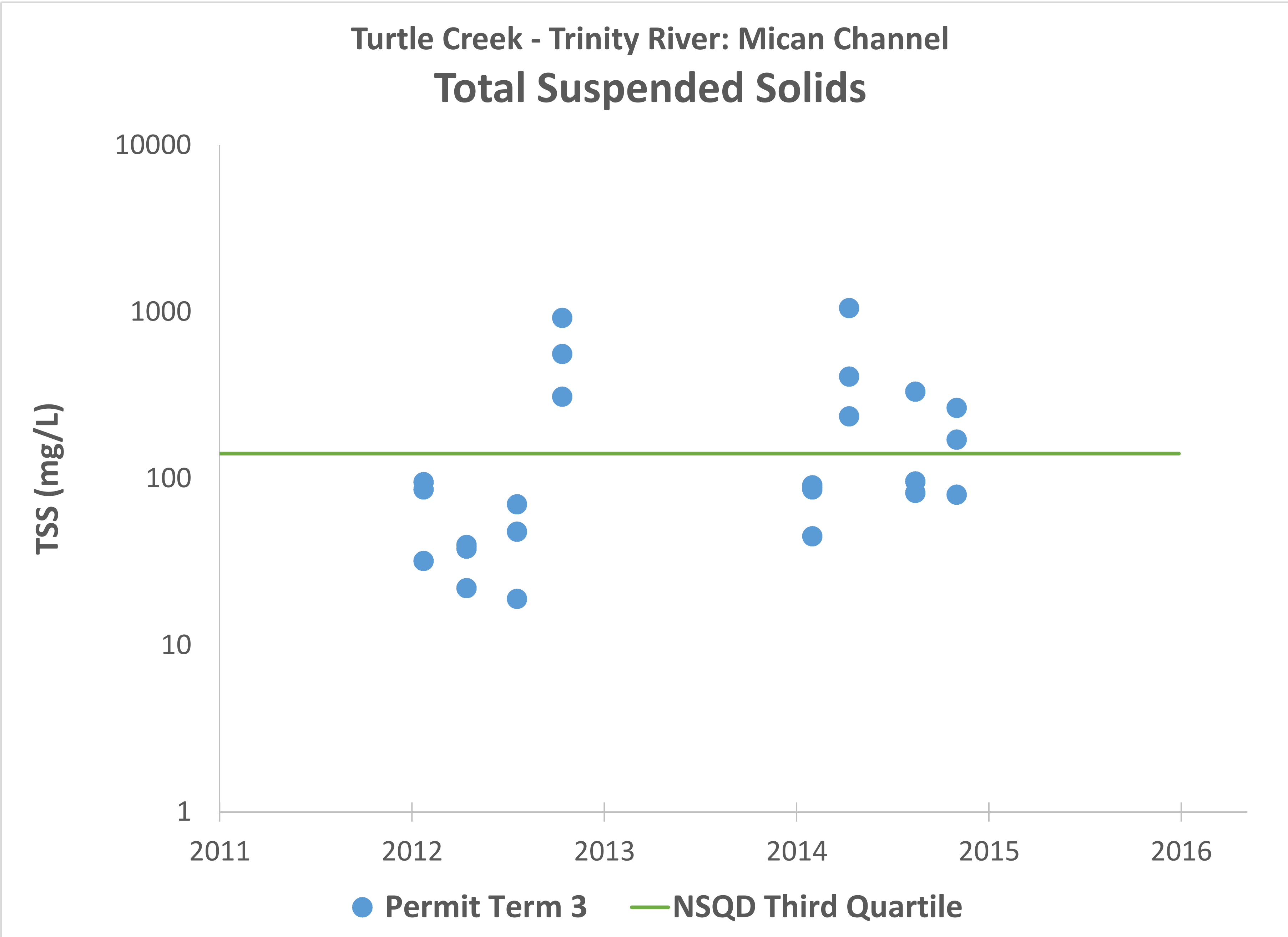
Turtle Creek (Headwaters)
E.Coli
E. Coli (col/100 mL)
100000
10000
1000
100
10
1
0.1
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
Term 3
Term 2
PCR Geomean
PCR Single Sample

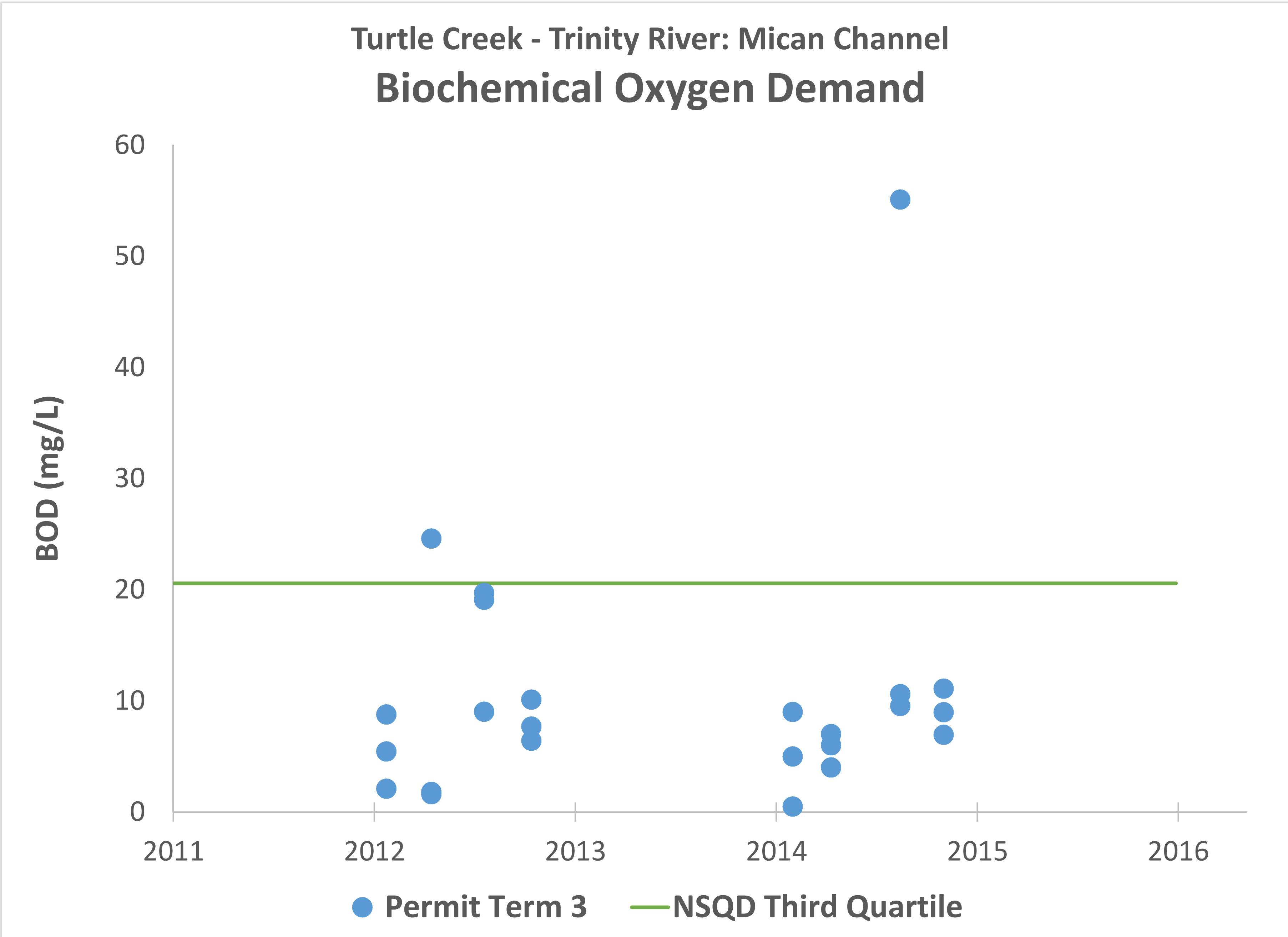
Appendix AB

Turtle Creek – Trinity River Water Quality Data Graphs

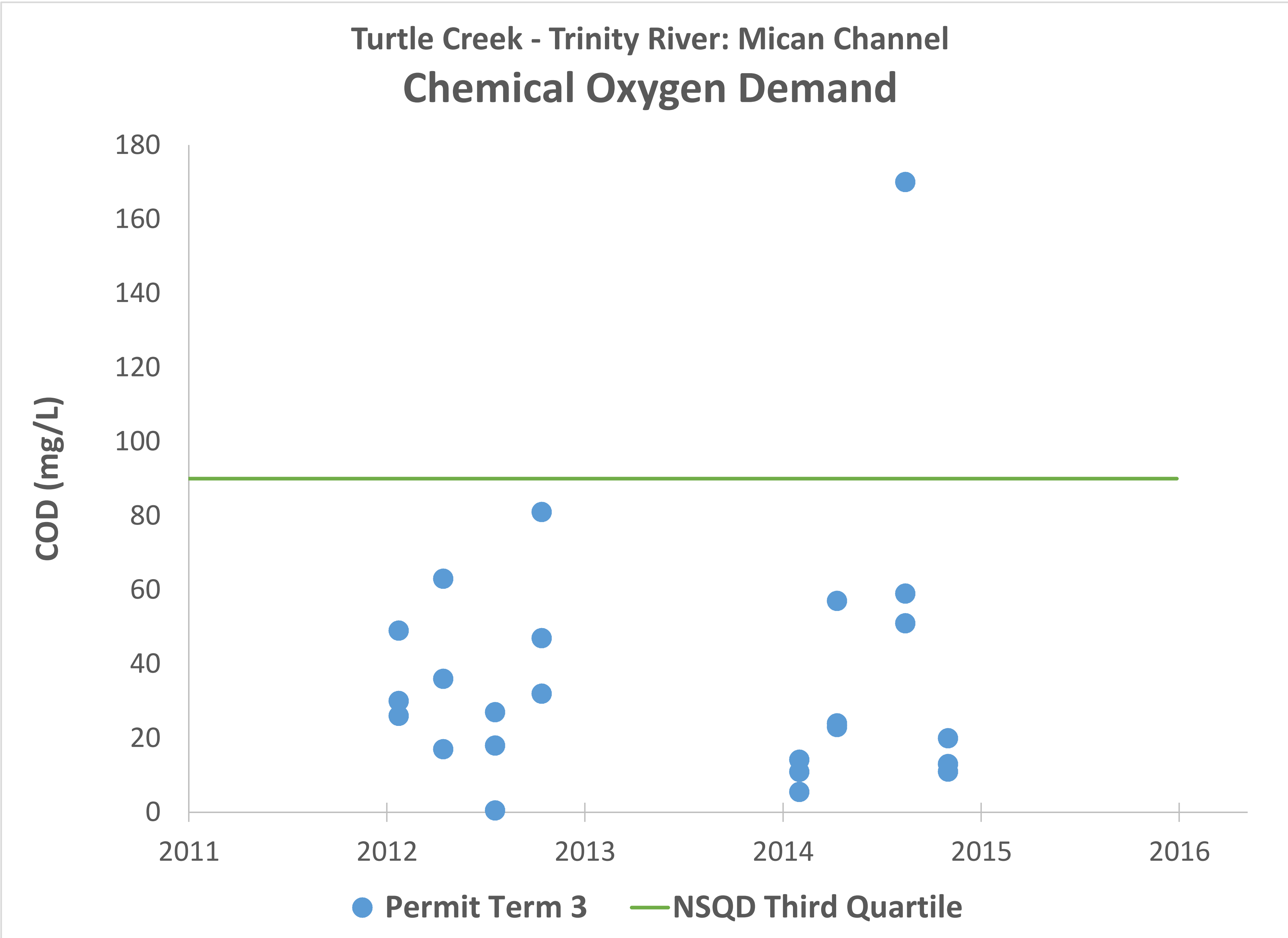


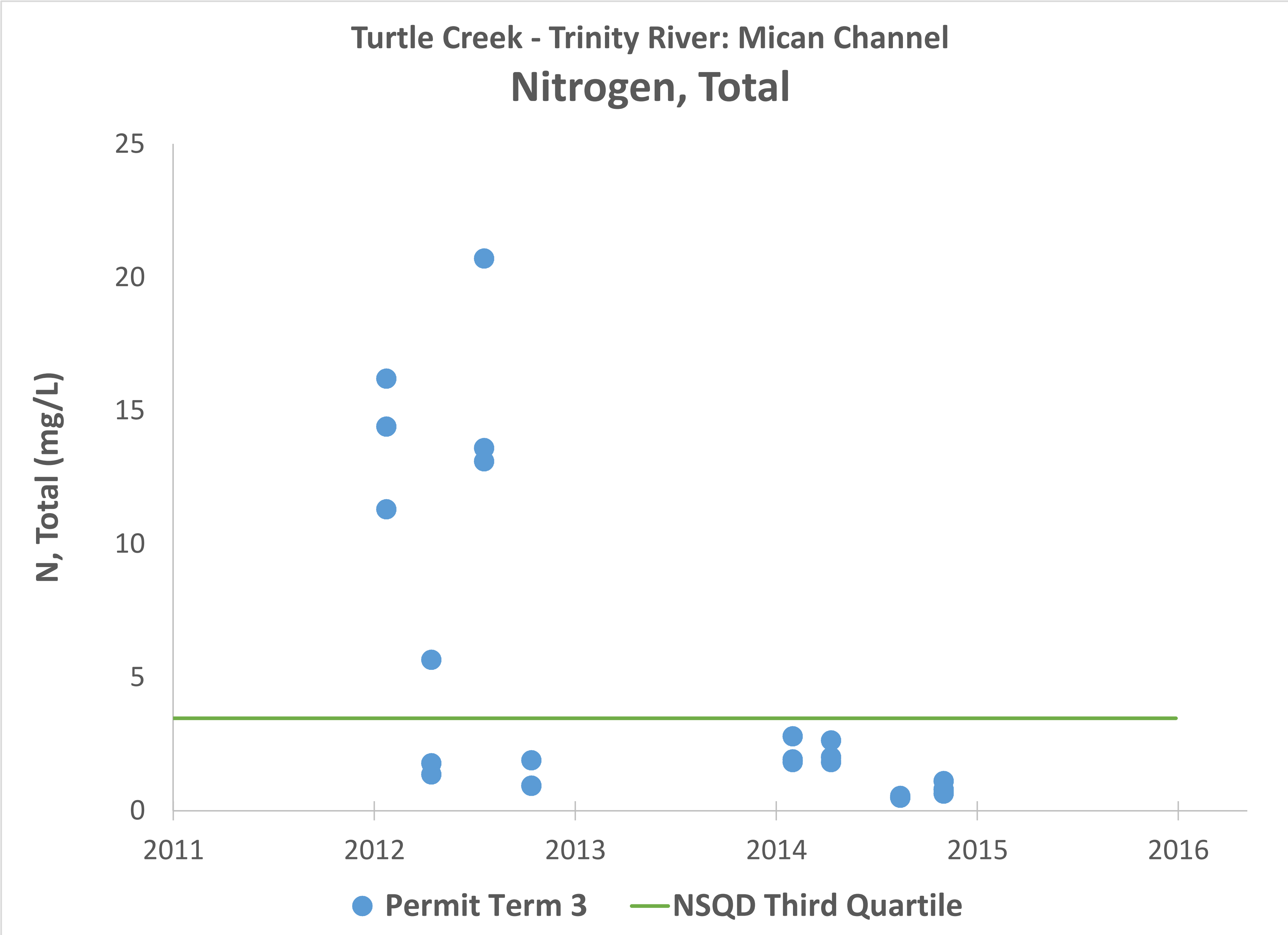
Turtle Creek - Trinity River: Mican Channel
Total Dissolved Solids
TDS (mg/L)
1200
1000
800
600
400
200
0
2011
2012
2012
2013
2014
2015
Permit Term 3
Basin Specific Criterion


Turtle Creek - Trinity River: Mican Channel
Total Suspended Solids
TSS (mg/L)
10000
1000
100
10
1
2011
2012
2013
2014
2015
2016
Permit Term 3
NSQD Third Quartile

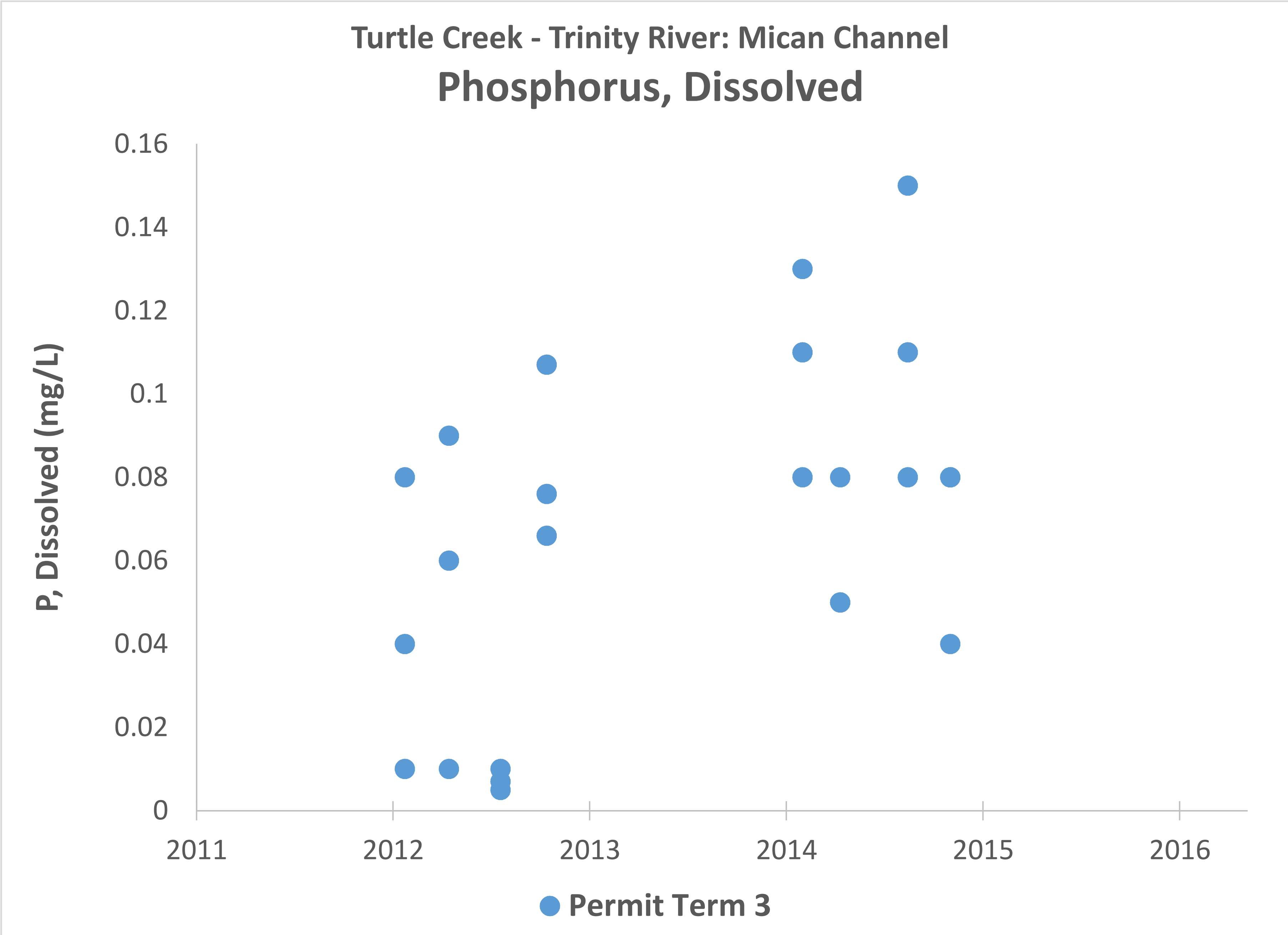


Turtle Creek - Trinity River: Mican Channel
Biochemical Oxygen Demand
BOD (mg/L)
60
50
40
30
20
10
0
2011
2012
2013
2014
2015
2016
Permit Term 3
NSQD Third Quartile

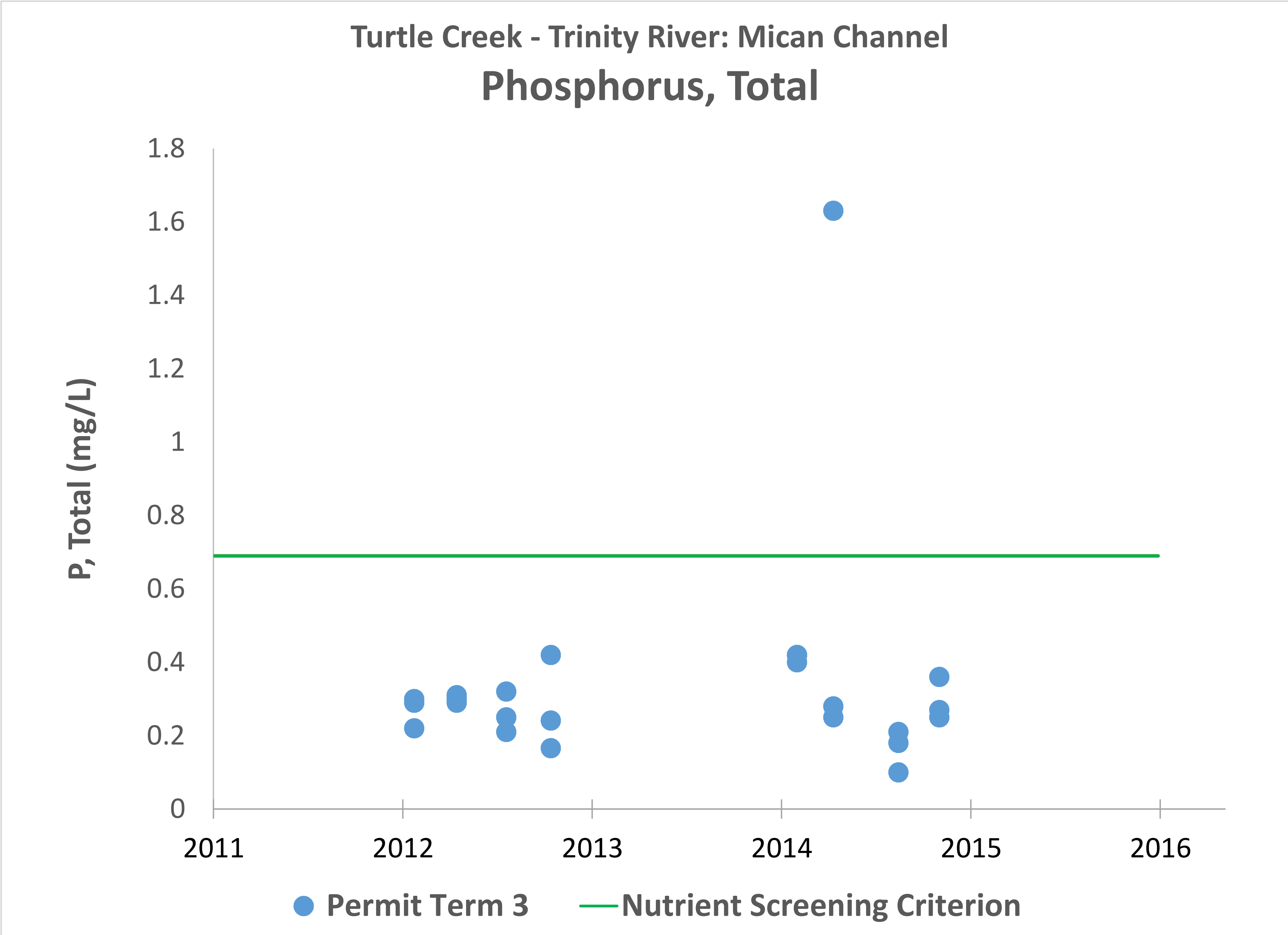

Turtle Creek - Trinity River: Mican Channel
Chemical Oxygen Demand
COD (mg/L)
180
160
140
120
100
80
60
40
20
0
2011
2012
2013
2014
2015
2016
Permit Term 3
NSQD Third Quartile

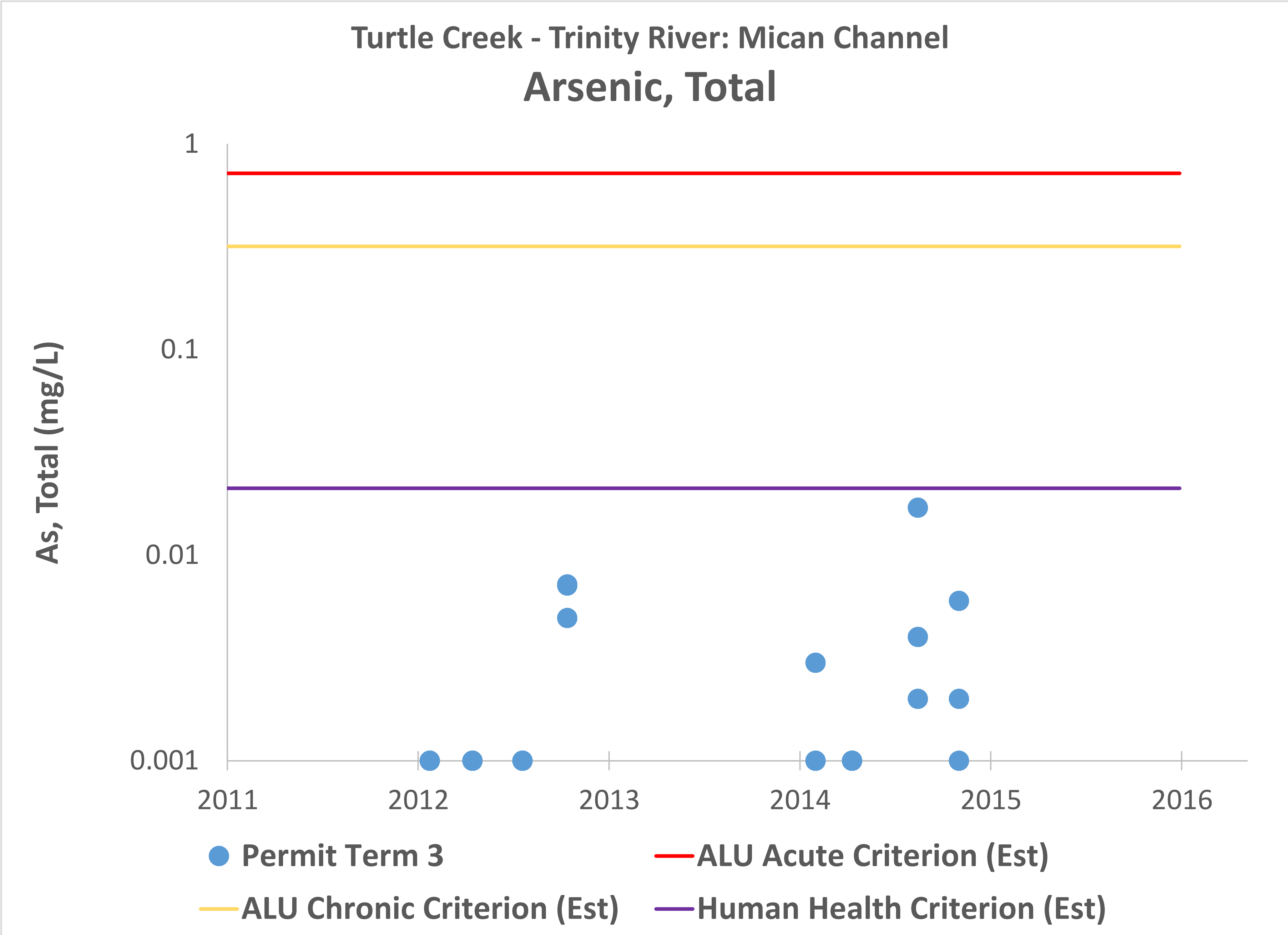


Turtle Creek - Trinity River: Mican Channel
Nitrogen, Total
N, Total (mg/L)
25
20
15
10
5
0
2011
2012
2013
2014
2015
2016
Permit Term 3
NSQD Third Quartile

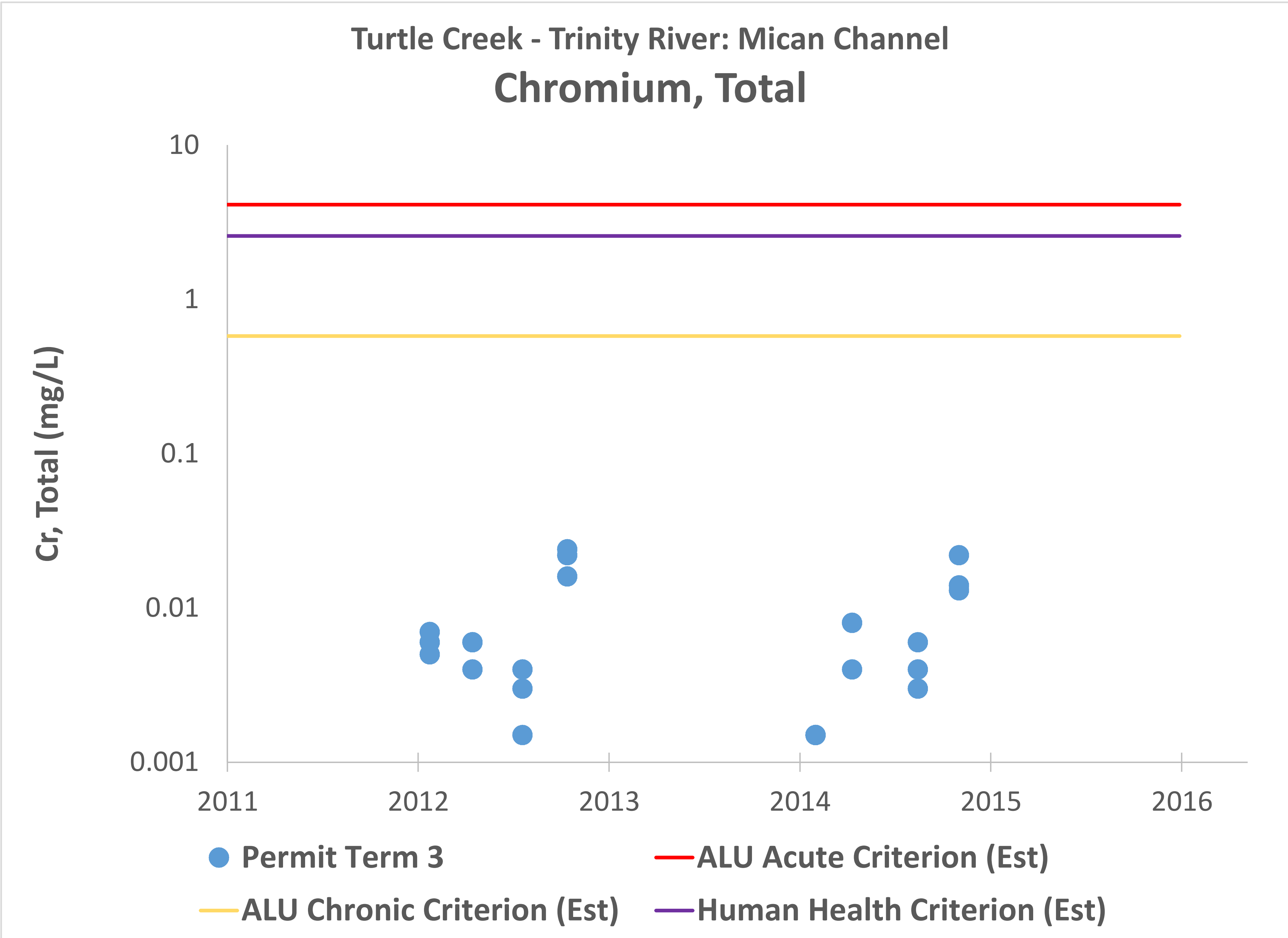


Turtle Creek - Trinity River: Mican Channel
Phosphorus, Dissolved
P, Dissolved (mg/L)
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
2011
2012
2013
2014
2015
2016
Permit Term 3

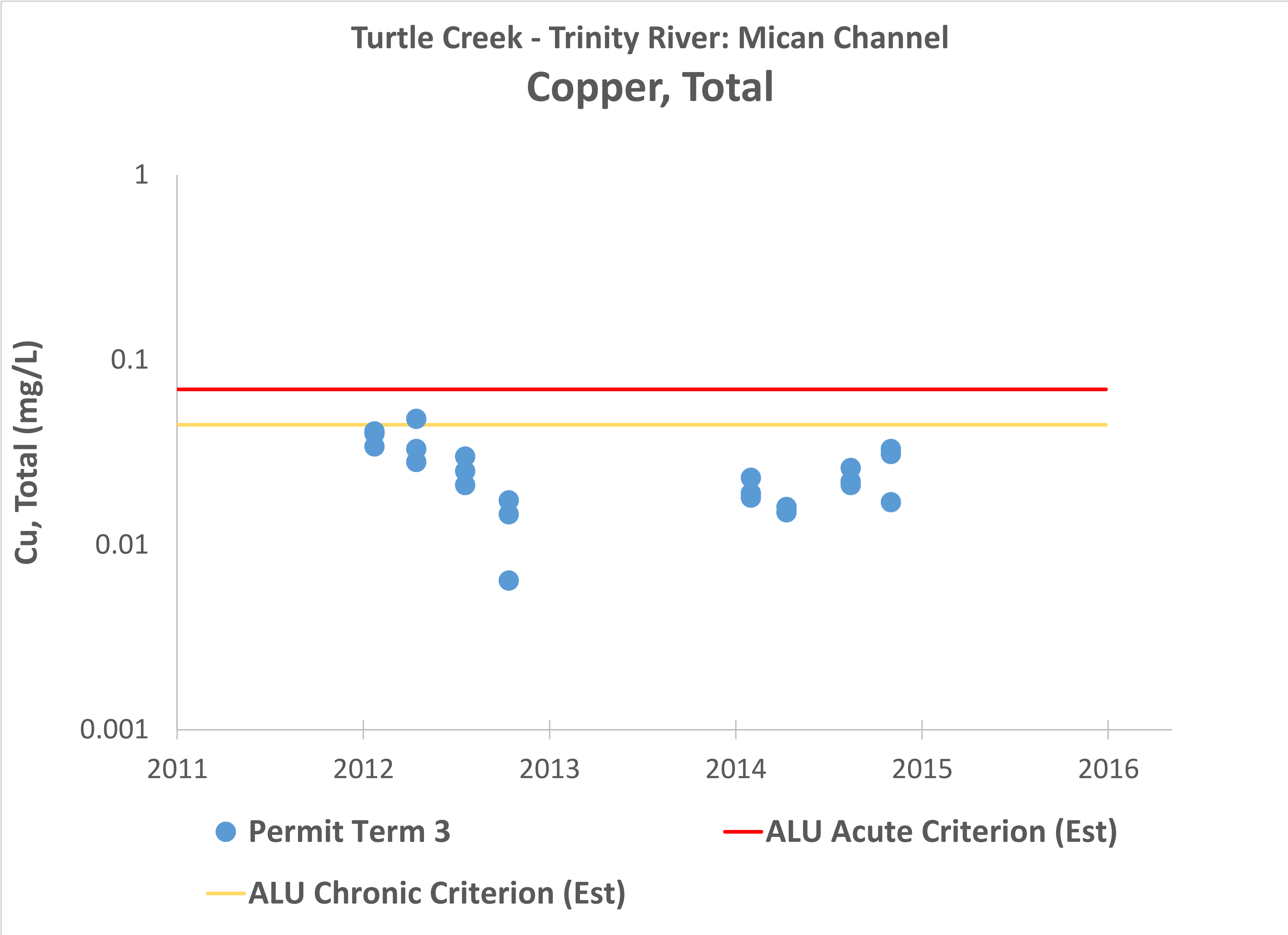

Turtle Creek - Trinity River: Mican Channel
Phosphorus, Total
P, Total (mg/L)
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
2011
2012
2013
2014
2015
2016
Permit Term 3
Nutrient Screening Criterion

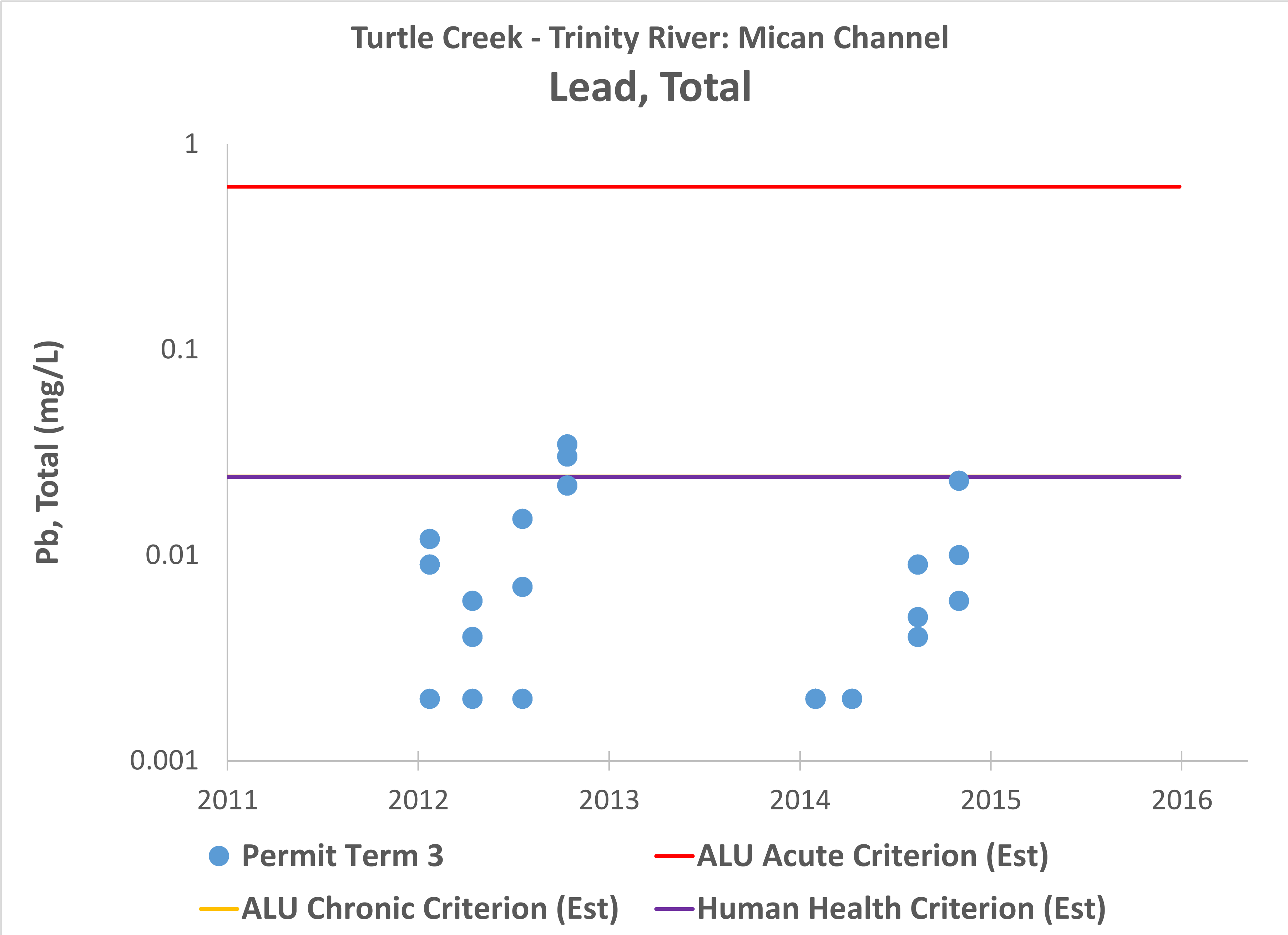


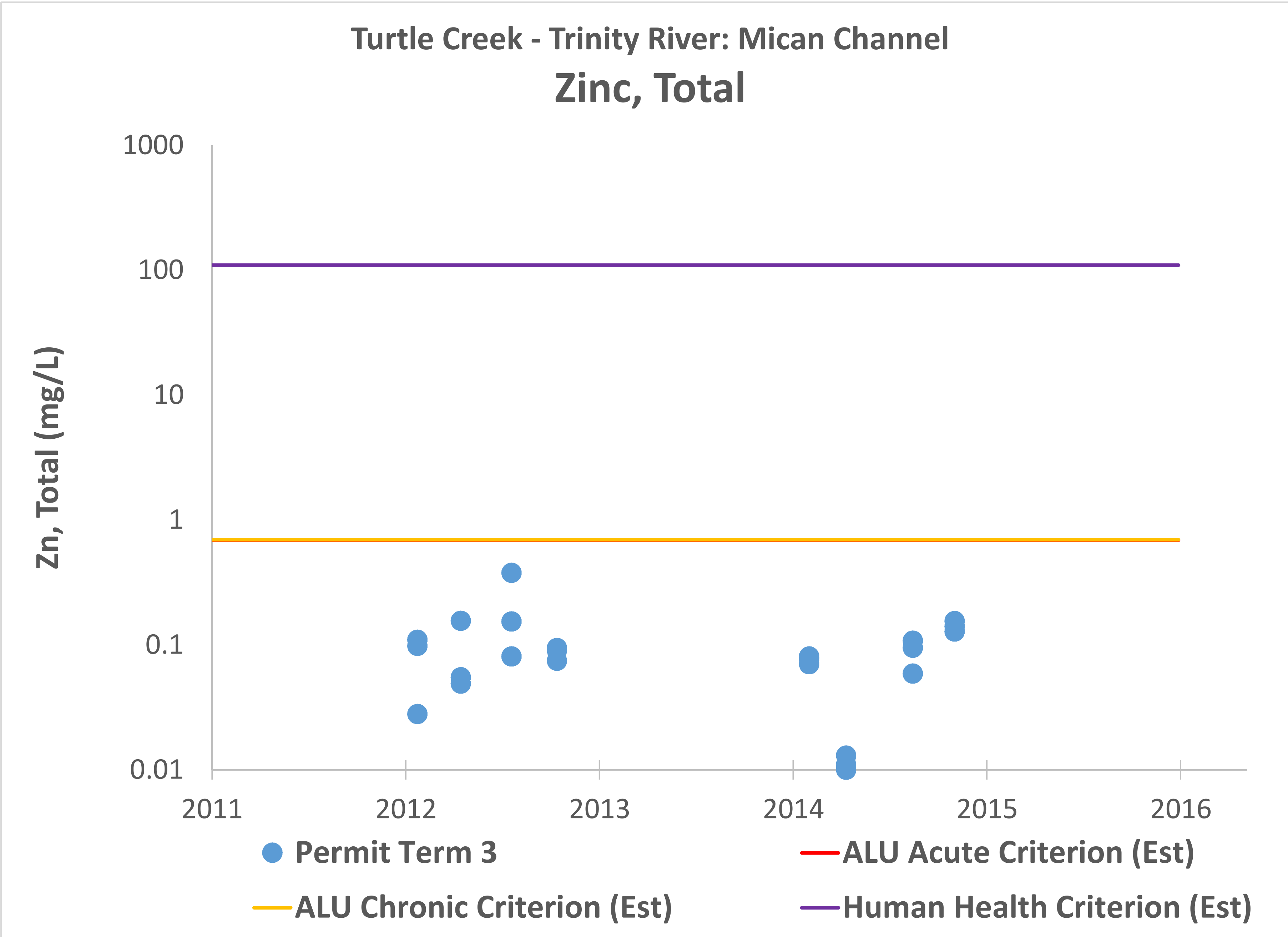
Turtle Creek - Trinity River: Mican Channel
Arsenic, Total
As, Total (mg/L)
1
0.1
0.01
0.001
2011
2012
2013
2014
2015
2016
Permit Term 3
ALU Acute Criterion (Est)
ALU Chronic Criterion (Est)
Human Health Criterion (Est)



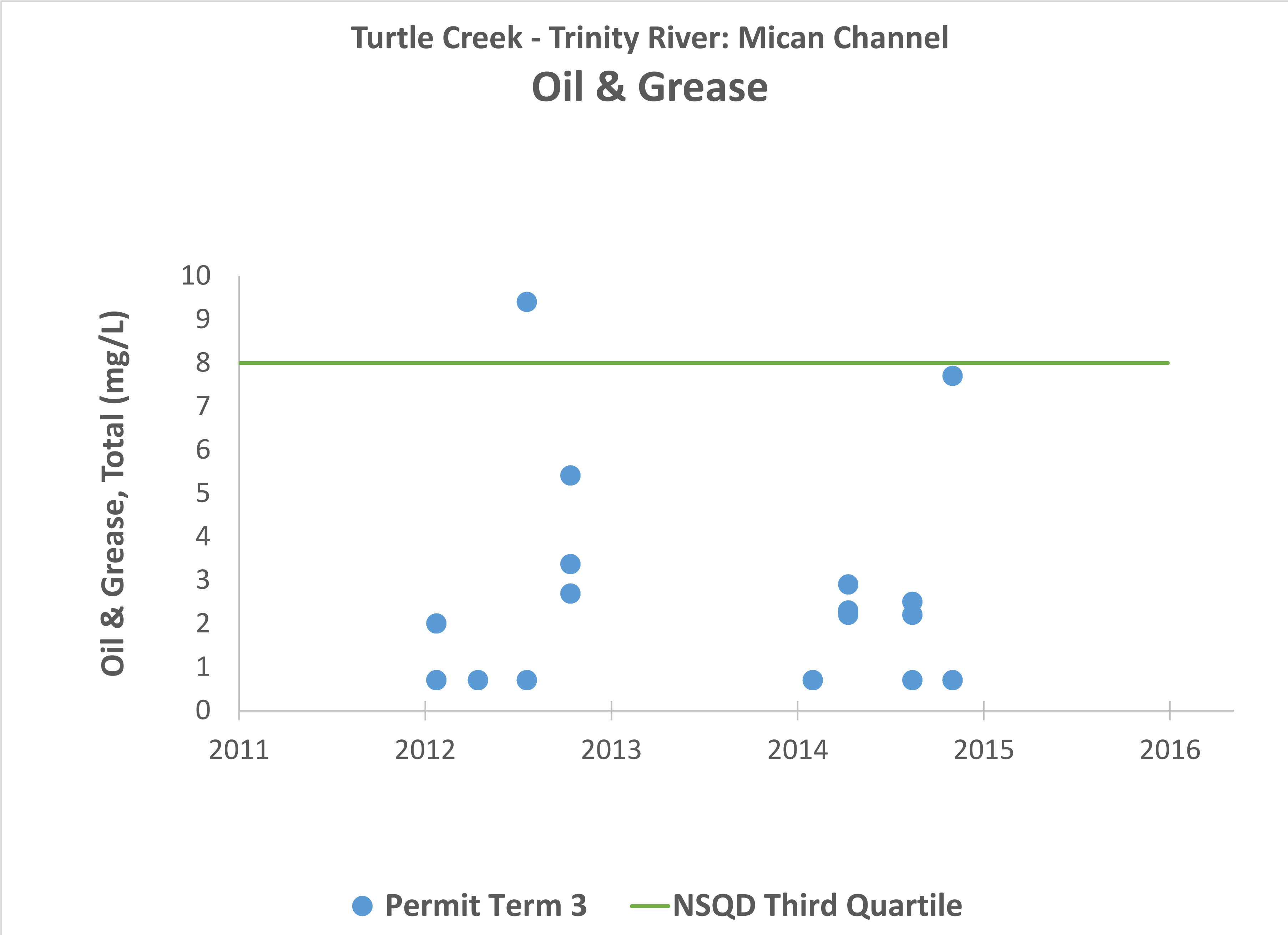
Turtle Creek - Trinity River: Mican Channel
Chromium, Total
Cr, Total (mg/L)
10
1
0.1
0.01
0.001
2011
2012
2013
2014
2015
2016
Permit Term 3
ALU Acute Criterion (Est)
ALU Chronic Criterion (Est)
Human Health Criterion (Est)

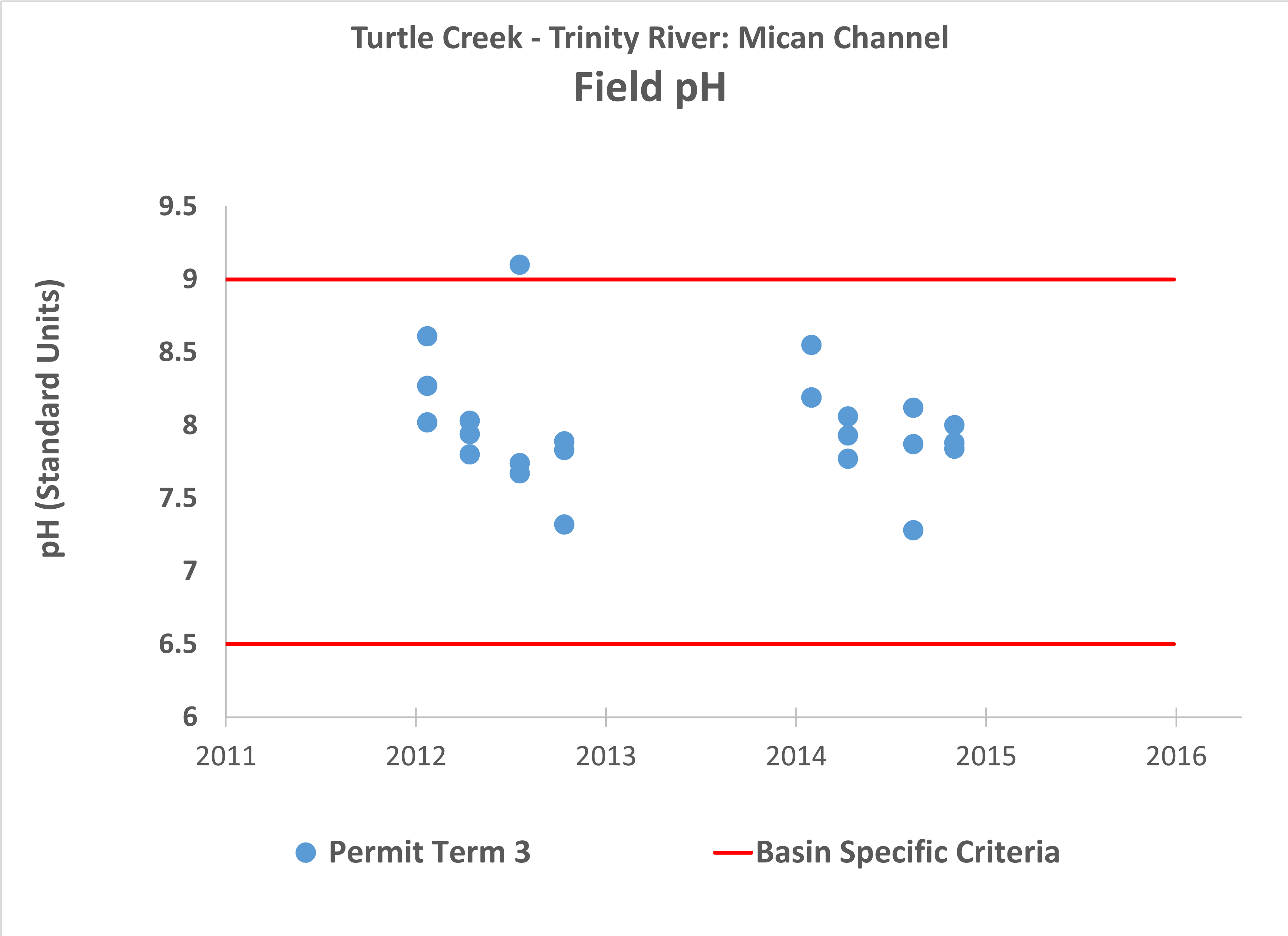

Turtle Creek - Trinity River: Mican Channel
Copper, Total
Cu, Total (mg/L)
1
0.1
0.01
0.001
2011
2012
2013
2014
2015
2016
Permit Term 3
ALU Acute Criterion (Est)
ALU Chronic Criterion (Est)

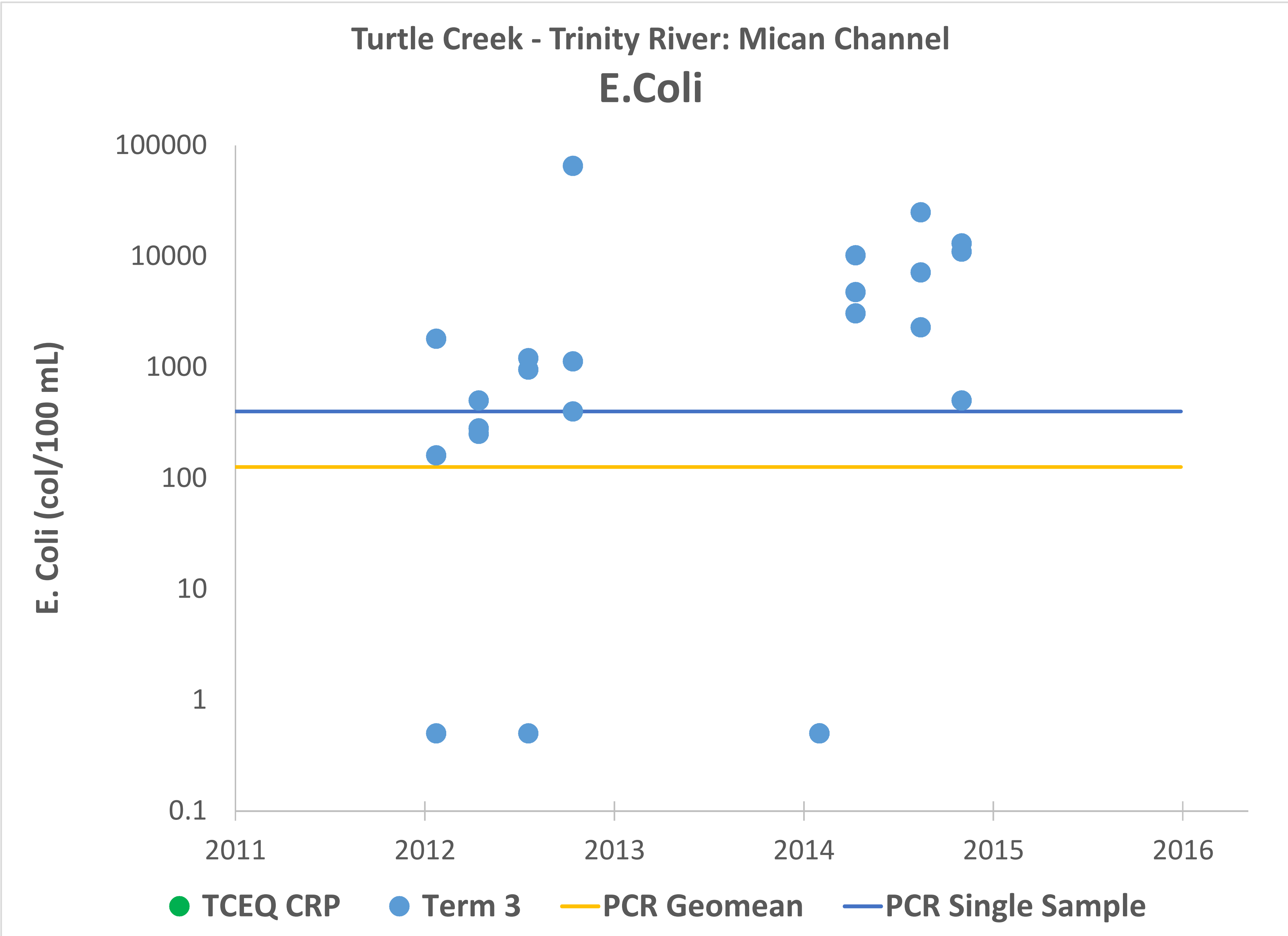

Turtle Creek - Trinity River: Mican Channel
Lead, Total
Pb, Total (mg/L)
1
0.1
0.01
0.001
2011
2012
2013
2014
2015
2016
Permit Term 3
ALU Acute Criterion (Est)
ALU Chronic Criterion (Est)
Human Health Criterion (Est)



Turtle Creek - Trinity River: Mican Channel
Zinc, Total
Zn, Total (mg/L)
1000
100
10
1
0.1
0.01
2011
2012
2013
2014
2015
2016
Permit Term 3
ALU Acute Criterion (Est)
ALU Chronic Criterion (Est)
Human Health Criterion (Est)


Turtle Creek - Trinity River: Mican Channel
Oil & Grease
Oil & Grease, Total (mg/L)
10
9
8
7
6
5
4
3
2
1
0
2011
2012
2013
2014
2015
2016
Permit Term 3
NSQD Third Quartile

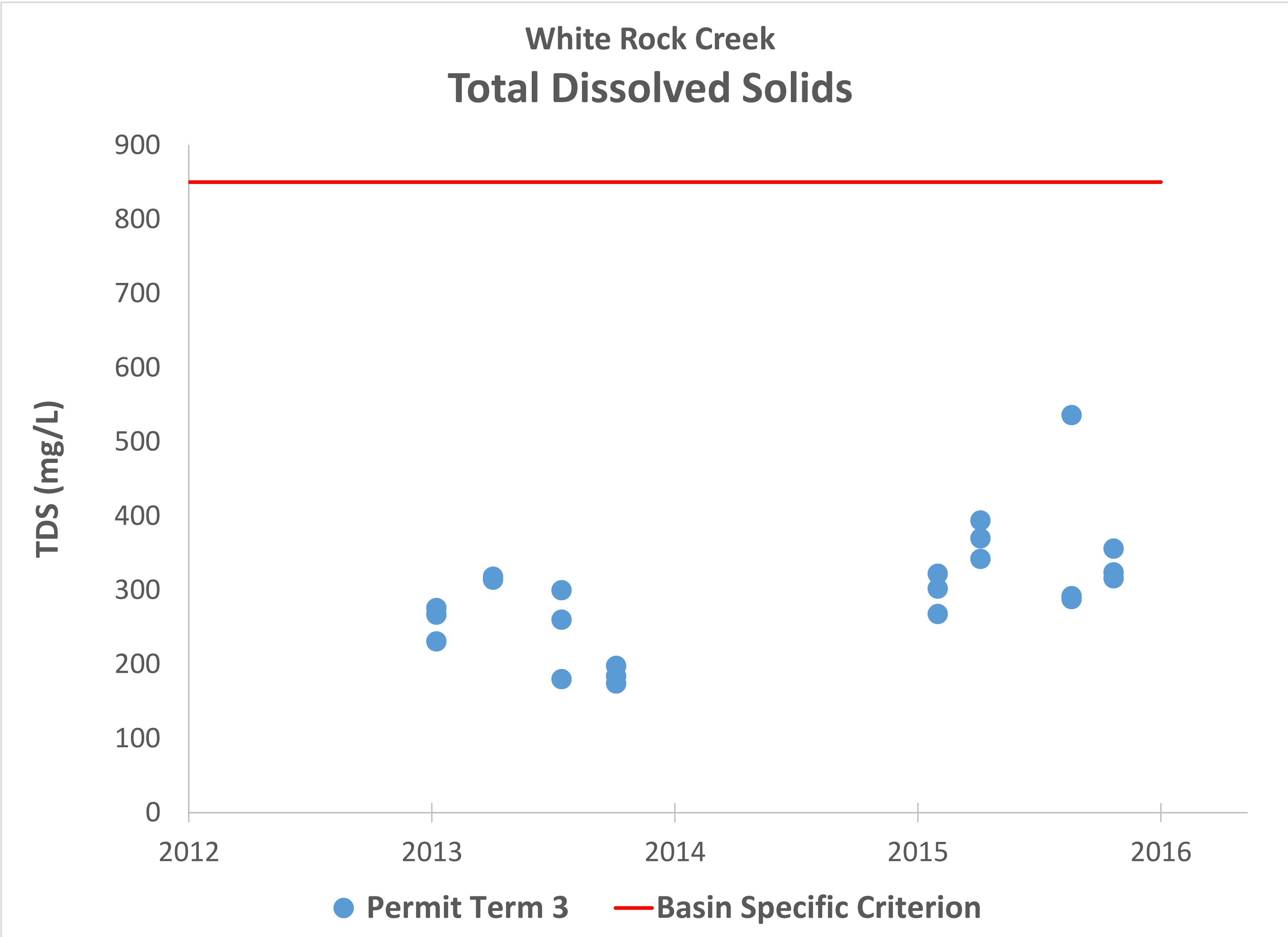

Turtle Creek - Trinity River: Mican Channel
Field pH
pH (Standard Units)
9.5
9
8.5
8
7.5
7
6.5
6
2011
2012
2013
2014
2015
2016
Permit Term 3
Basin Specific Criteria

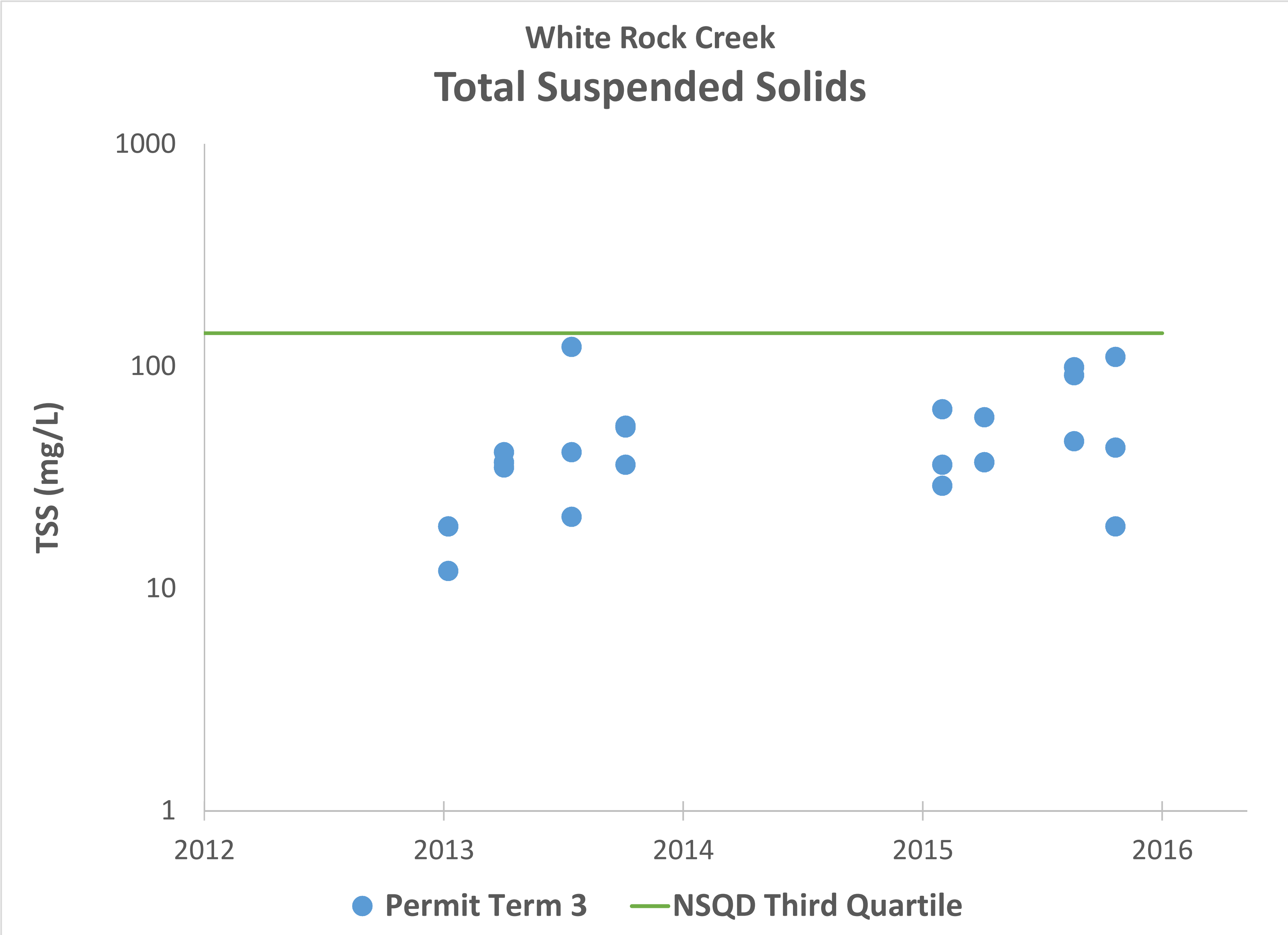


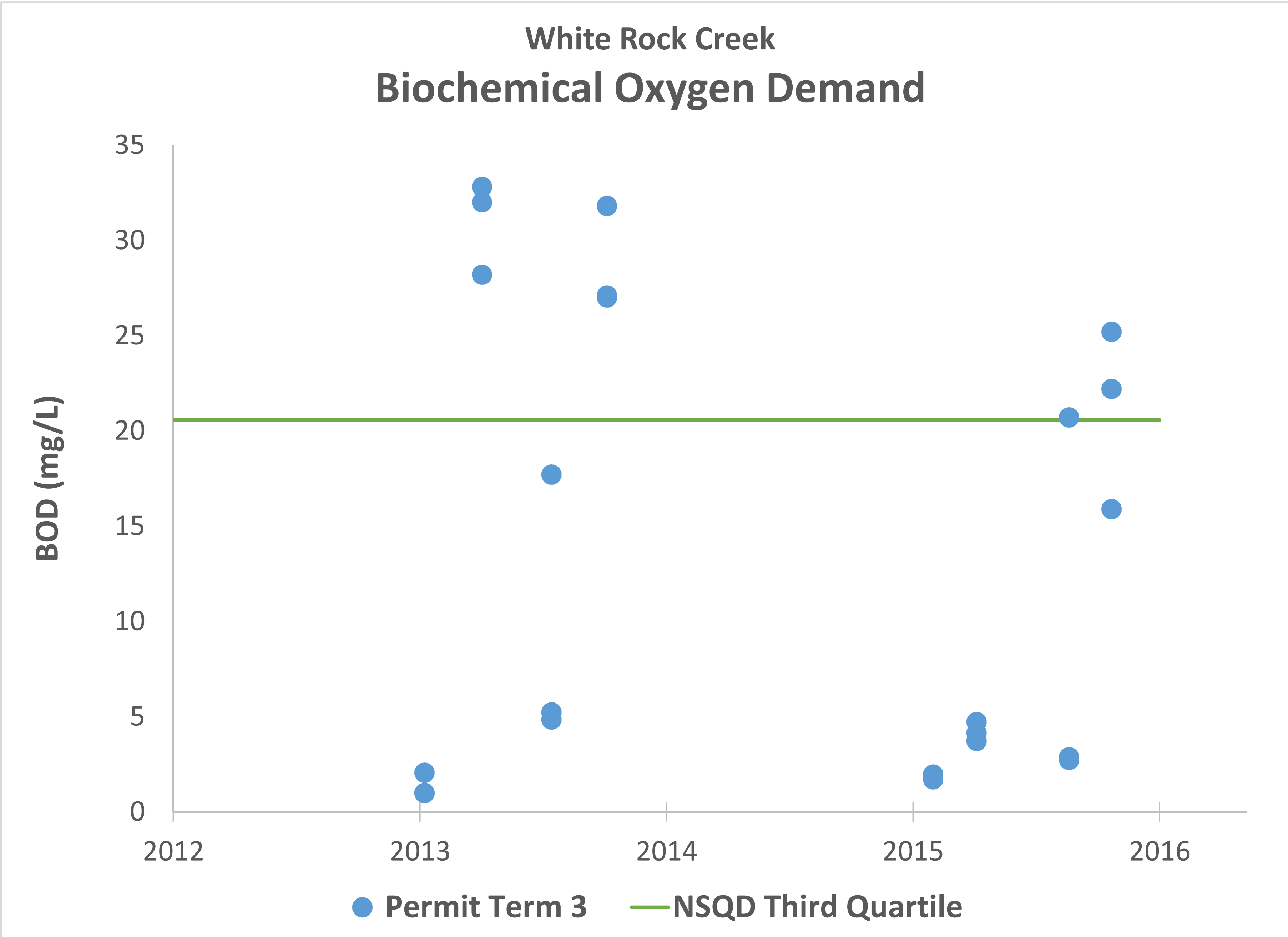
Turtle Creek - Trinity River: Mican Channel
E.Coli
E. Coli (col/100 mL)
100000
10000
1000
100
10
1
0.1
2011
2012
2013
2014
2015
2016
TCEQ CRP
Term 3
PCR Geomean
PCR Single Sample

Appendix AC

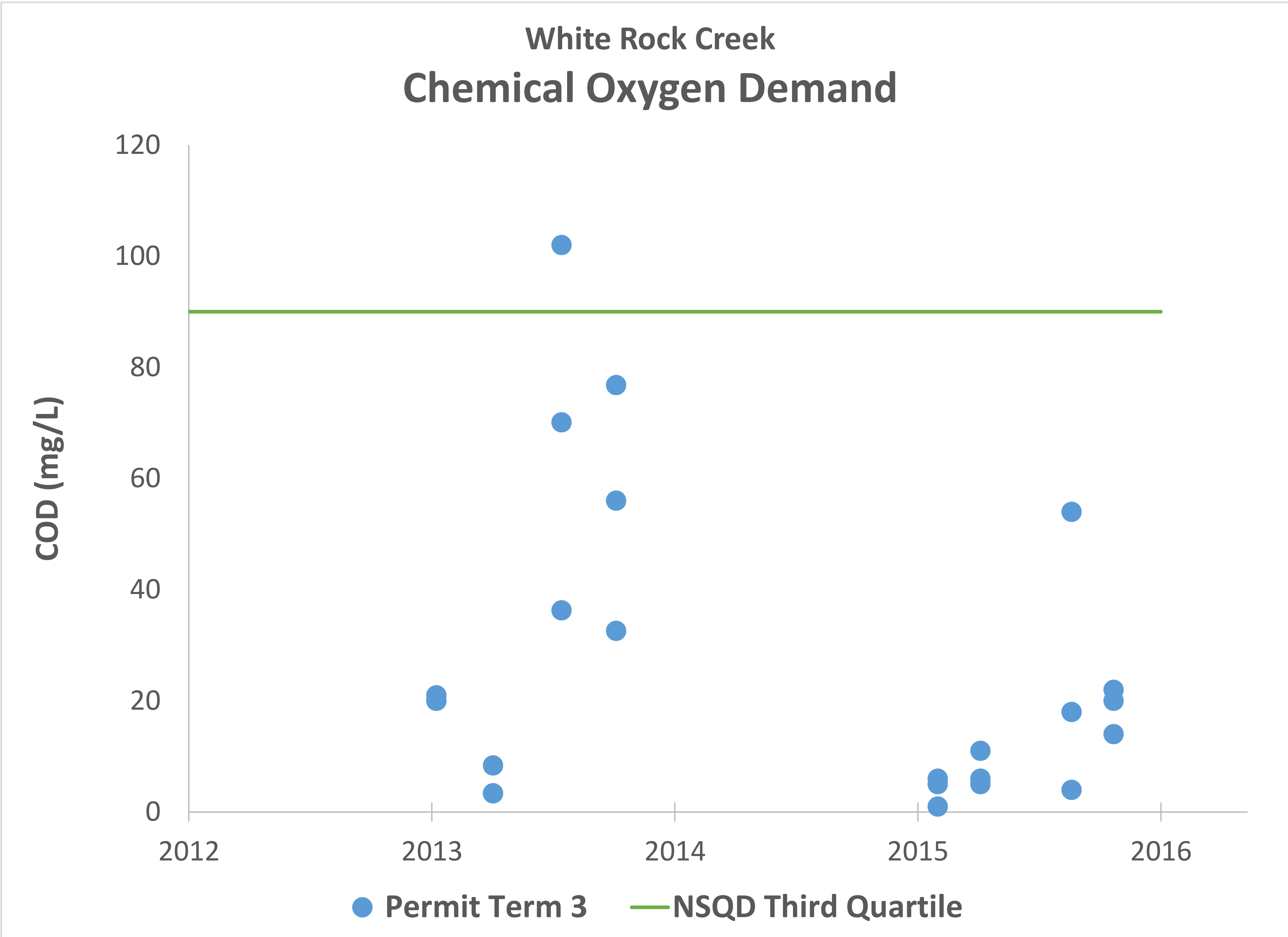
White Rock Creek Water Quality
Data Graphs

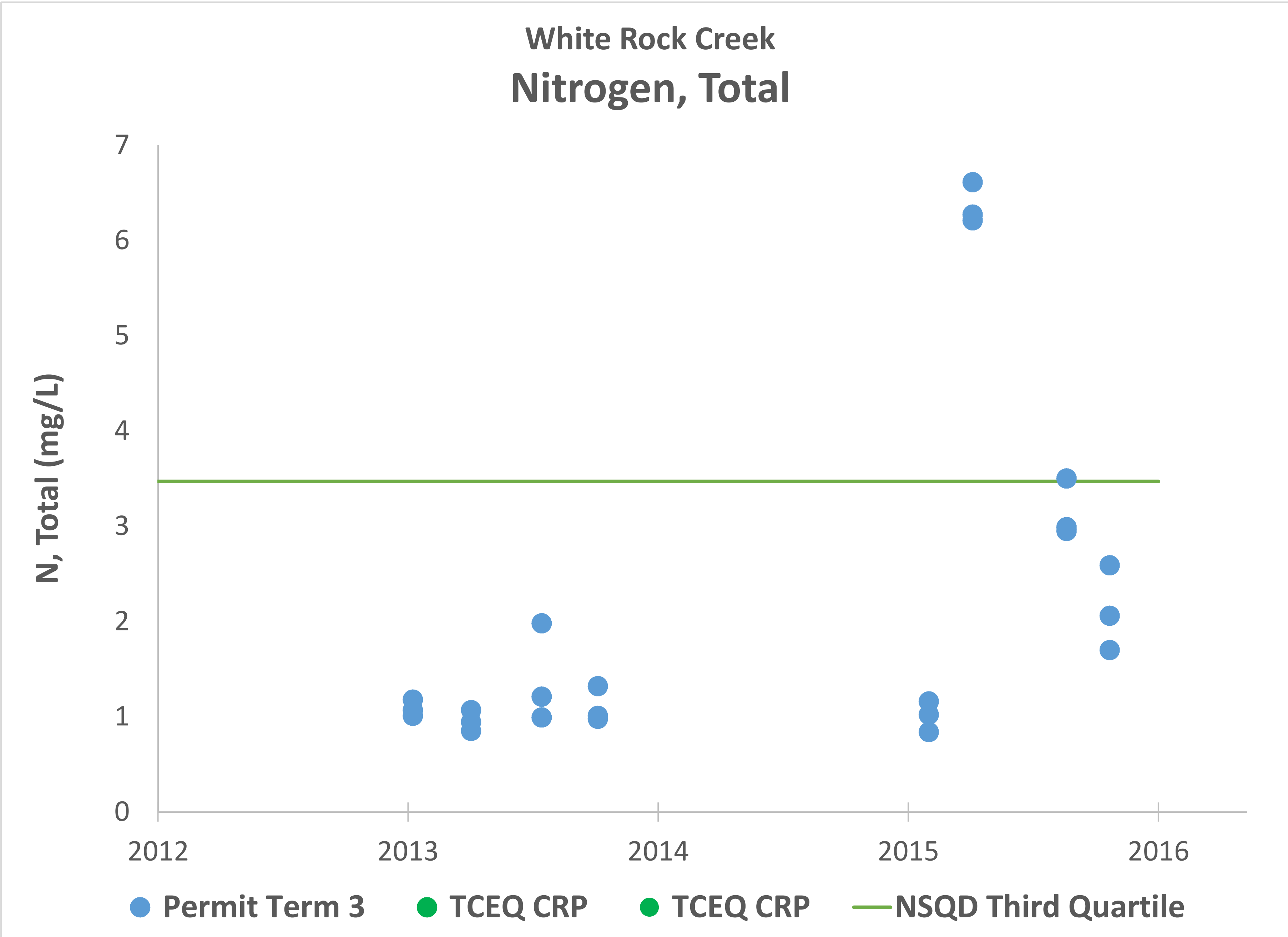

White Rock Creek
Total Dissolved Solids
TDS (mg/L)
900
800
700
600
500
400
300
200
100
0
2012
2013
2014
2015
2016
Permit Term 3
Basin Specific Criterion


White Rock Creek
Total Suspended Solids
1000
100
10
1
TSS (mg/L)
2012
2013
2014
2015
2016
Permit Term 3
NSQD Third Quartile

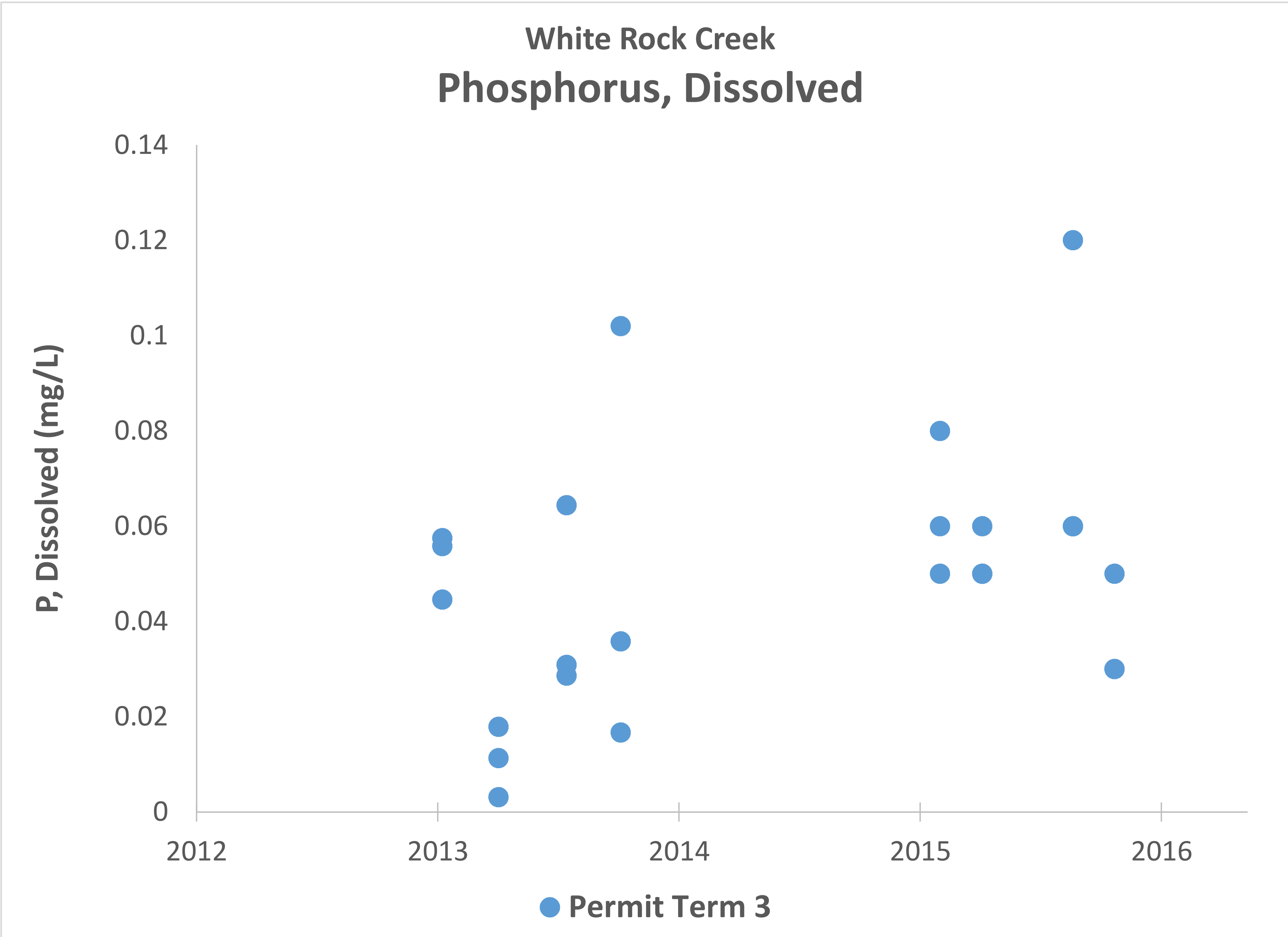


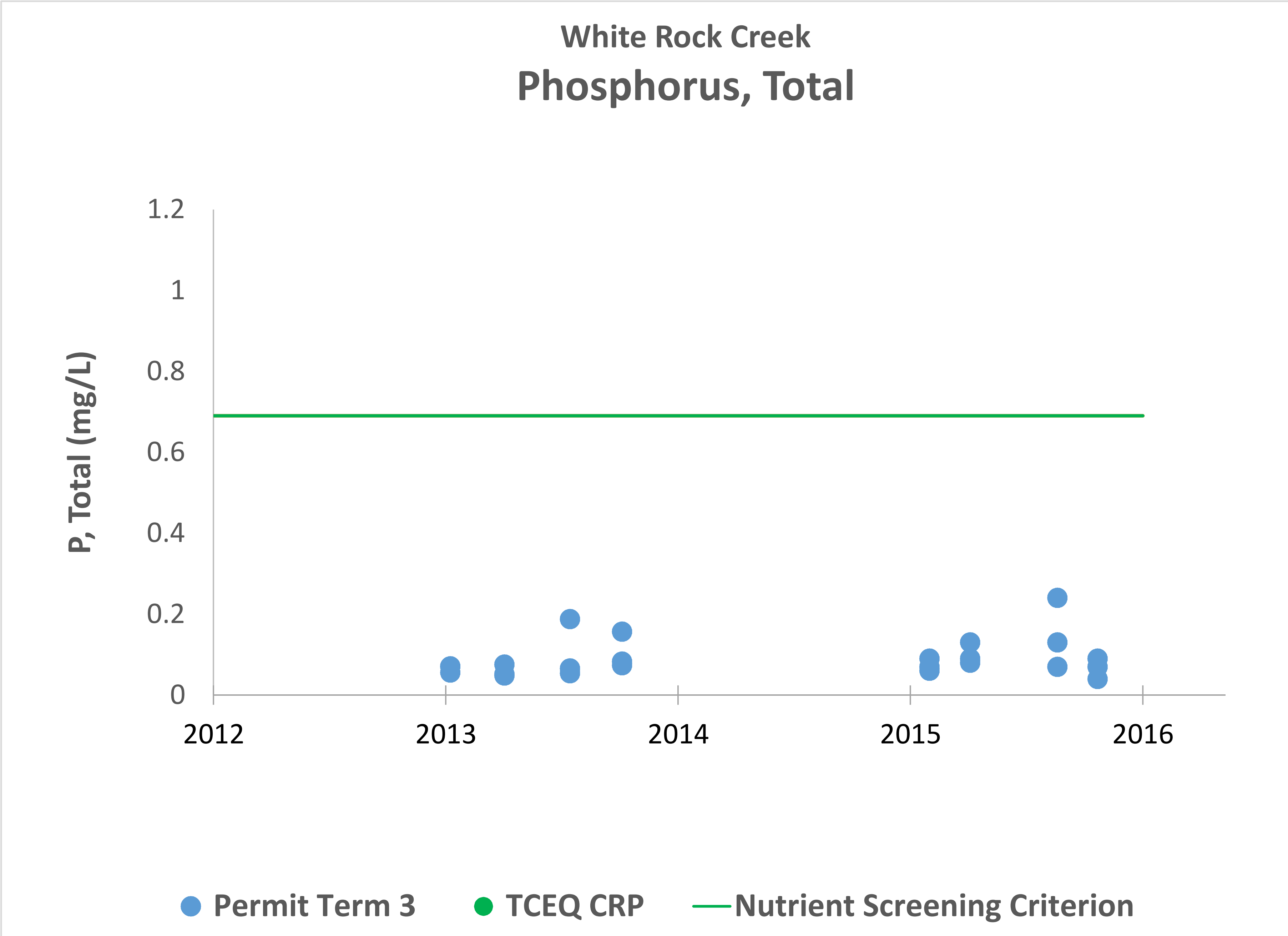
White Rock Creek
Biochemical Oxygen Demand
BOD (mg/L)
35
30
25
20
15
10
5
0
2012
2013
2014
2015
2016
Permit Term 3
NSQD Third Quartile

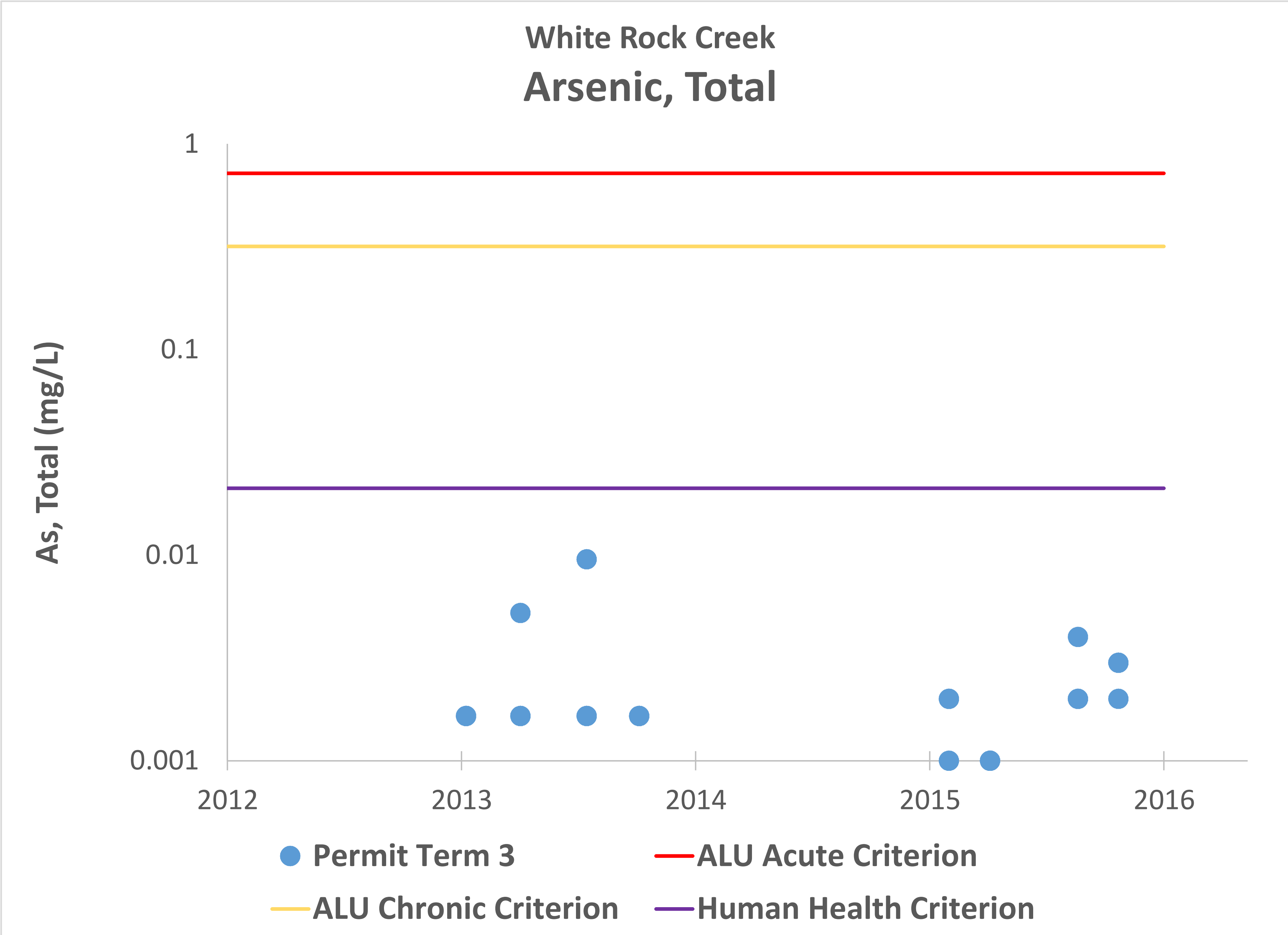

White Rock Creek
Chemical Oxygen Demand
COD (mg/L)
120
100
80
60
40
20
0
2012
2013
2014
2015
2016
Permit Term 3
NSQD Third Quartile

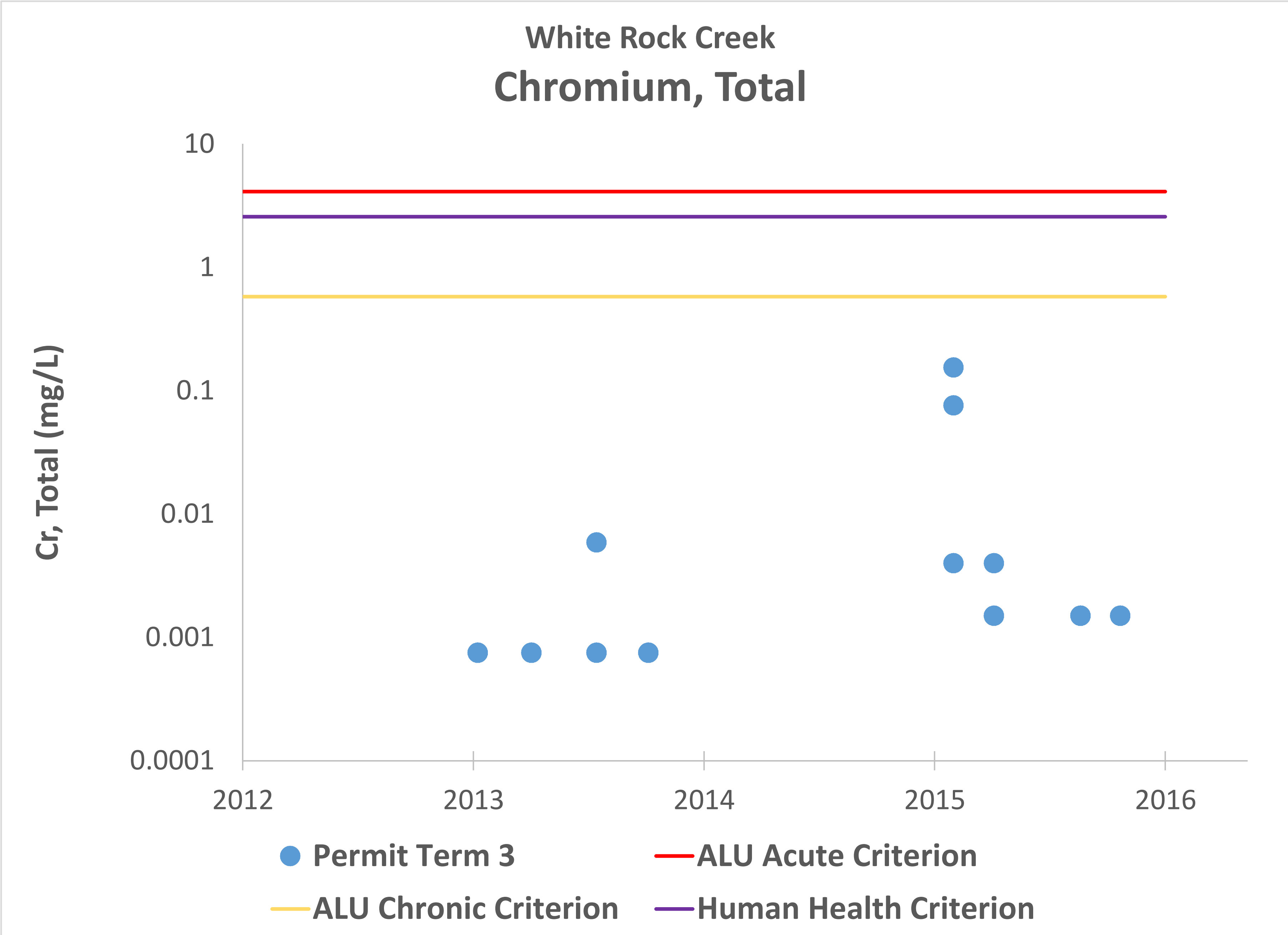


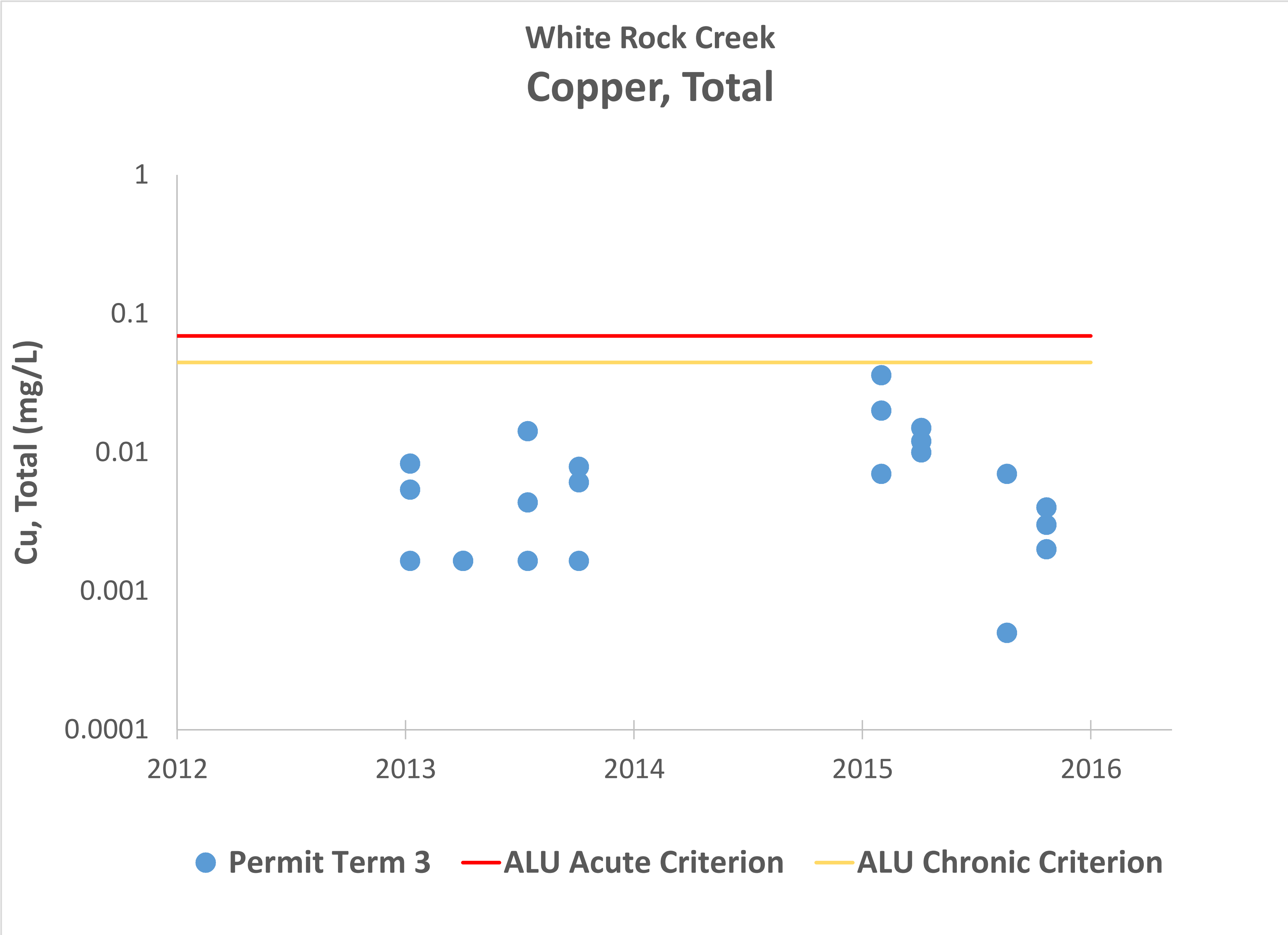
White Rock Creek
Nitrogen, Total
N, Total (mg/L)
0
1
2
3
4
5
6
7
2012
2013
2014
2015
2016
Permit Term 3
TCEQ CRP
TCEQ CRP
NSQD Third Quartile

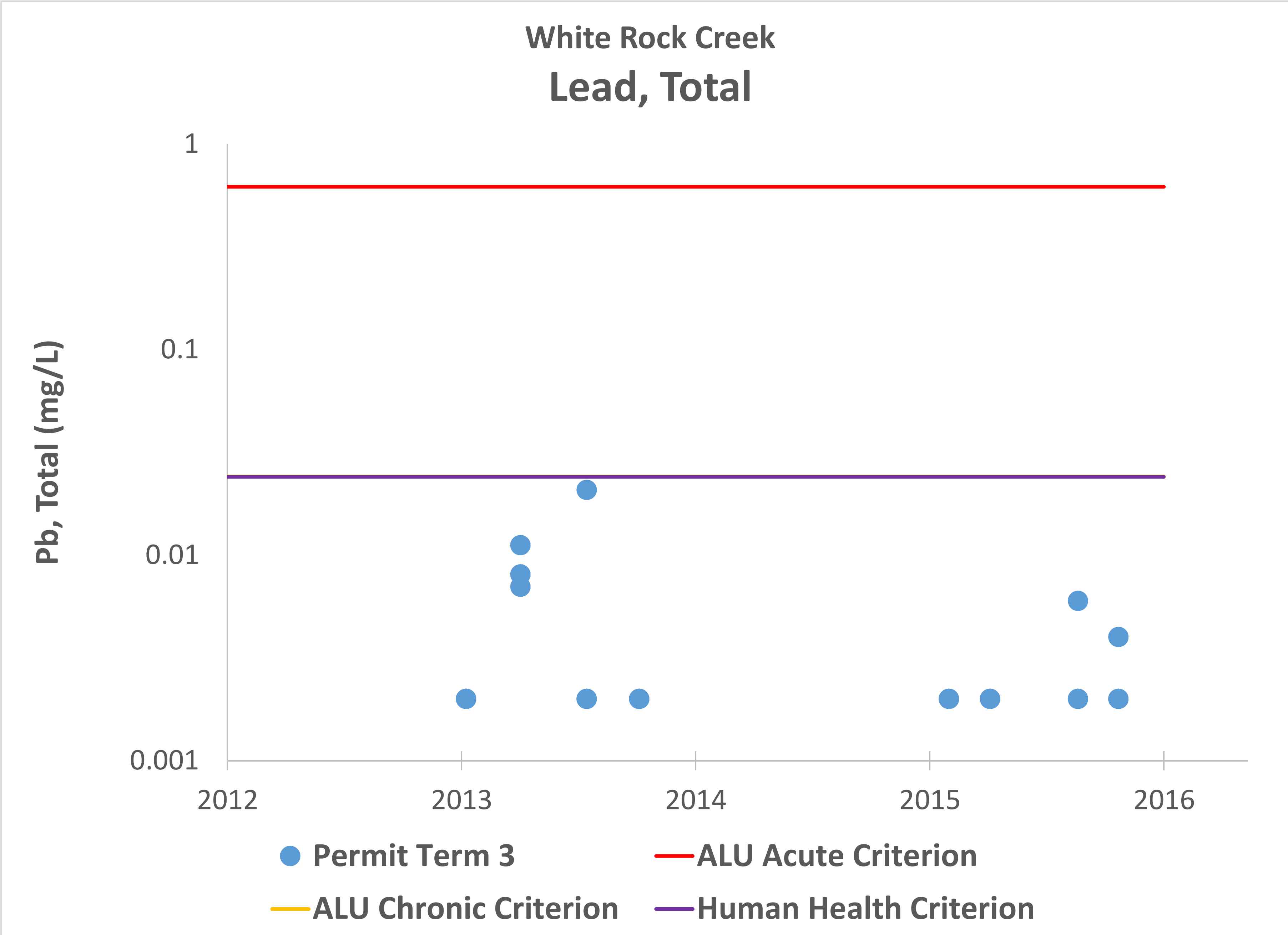

White Rock Creek
Phosphorus, Dissolved
P, Dissolved (mg/L)
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
2012
2013
2014
2015
2016
Permit Term 3

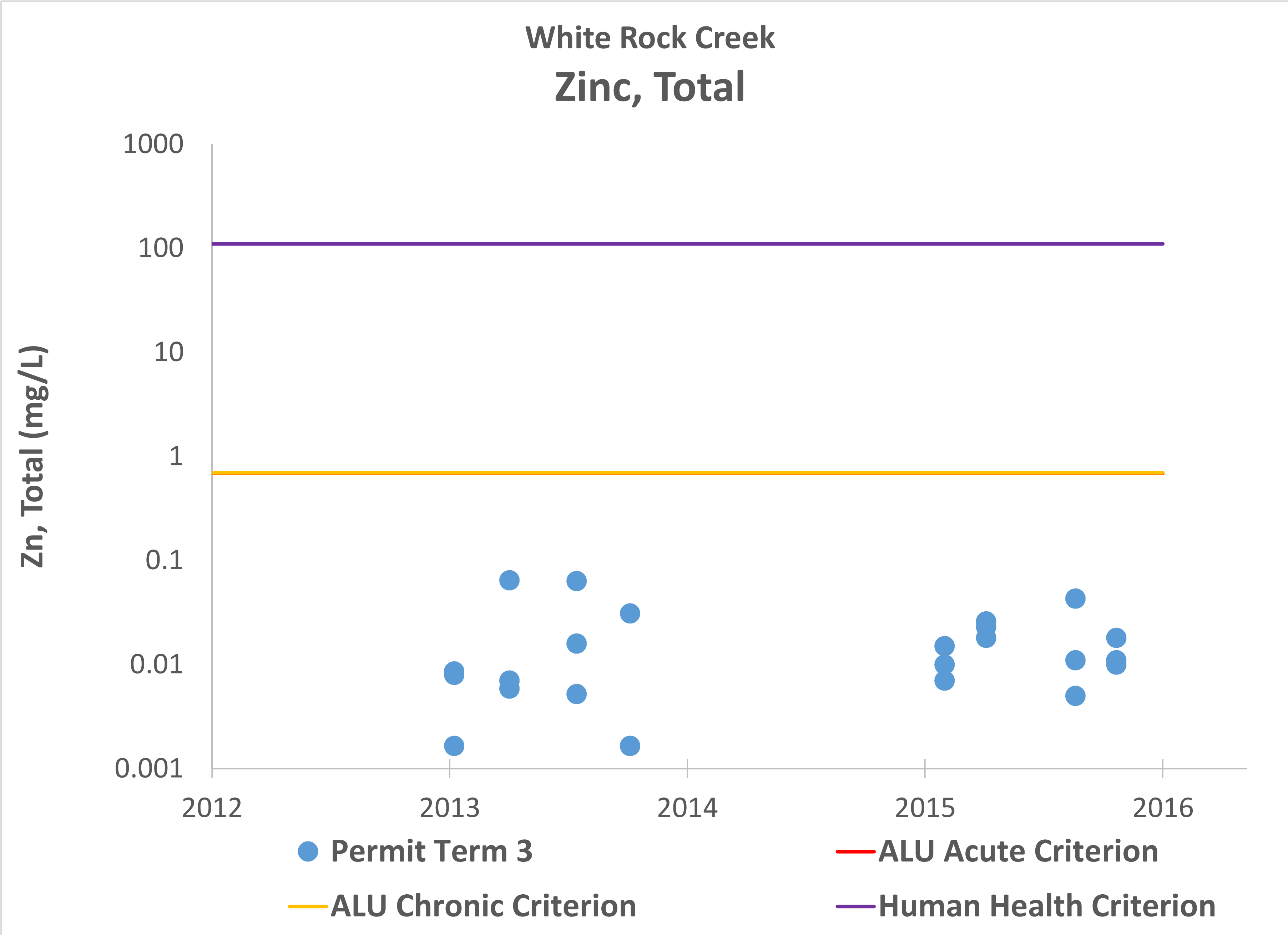

White Rock Creek
Phosphorus, Total
P, Total (mg/L)
1.2
1
0.8
0.6
0.4
0.2
0
2012
2013
2014
2015
2016
Permit Term 3
TCEQ CRP
Nutrient Screening Criterion


White Rock Creek
Arsenic, Total
As, Total (mg/L)
1
0.1
0.01
0.001
2012
2013
2014
2015
2016
Permit Term 3
ALU Acute Criterion
ALU Chronic Criterion
Human Health Criterion

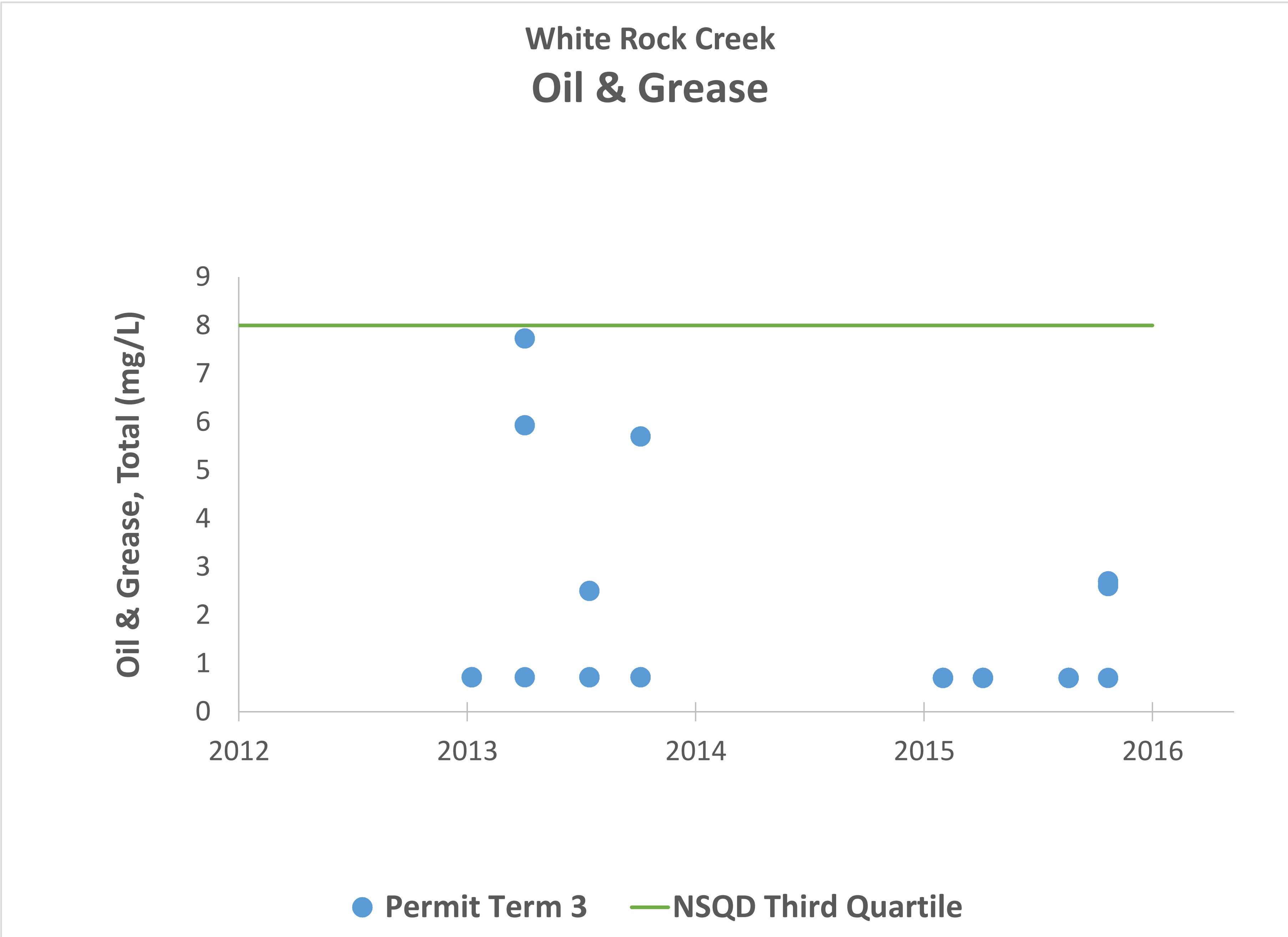

White Rock Creek
Chromium, Total
Cr, Total (mg/L)
10
1
0.1
0.01
0.001
0.0001
2012
2013
2014
2015
2016
Permit Term 3
ALU Acute Criterion
ALU Chronic Criterion
Human Health Criterion


White Rock Creek
Copper, Total
Cu, Total (mg/L)
1
0.1
0.01
0.001
0.0001
2012
2013
2014
2015
2016
Permit Term 3
ALU Acute Criterion
ALU Chronic Criterion

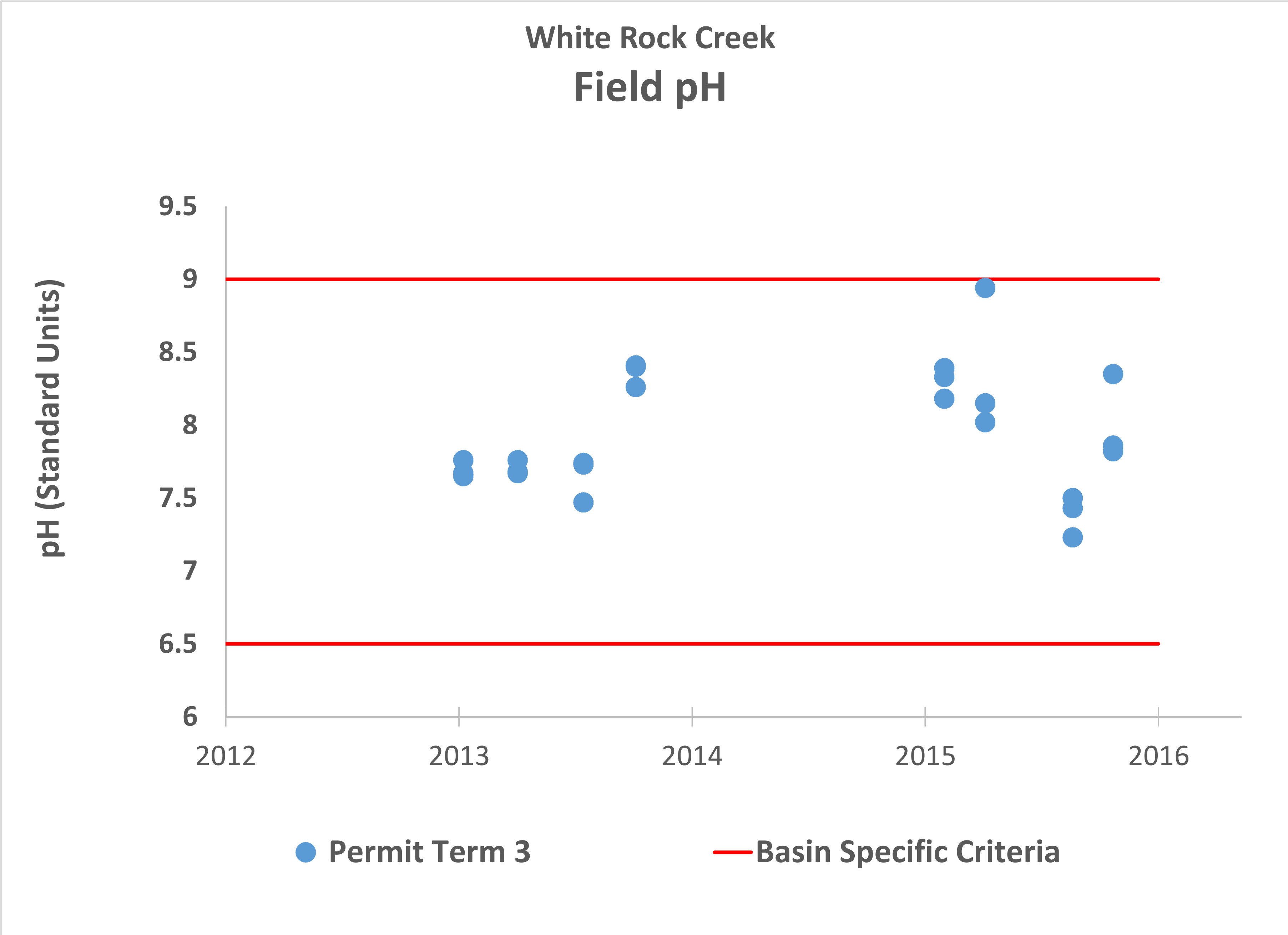

White Rock Creek
Lead, Total
Pb, Total (mg/L)
1
0.1
0.01
0.001
2012
2013
2014
2015
2016
Permit Term 3
ALU Acute Criterion
ALU Chronic Criterion
Human Health Criterion



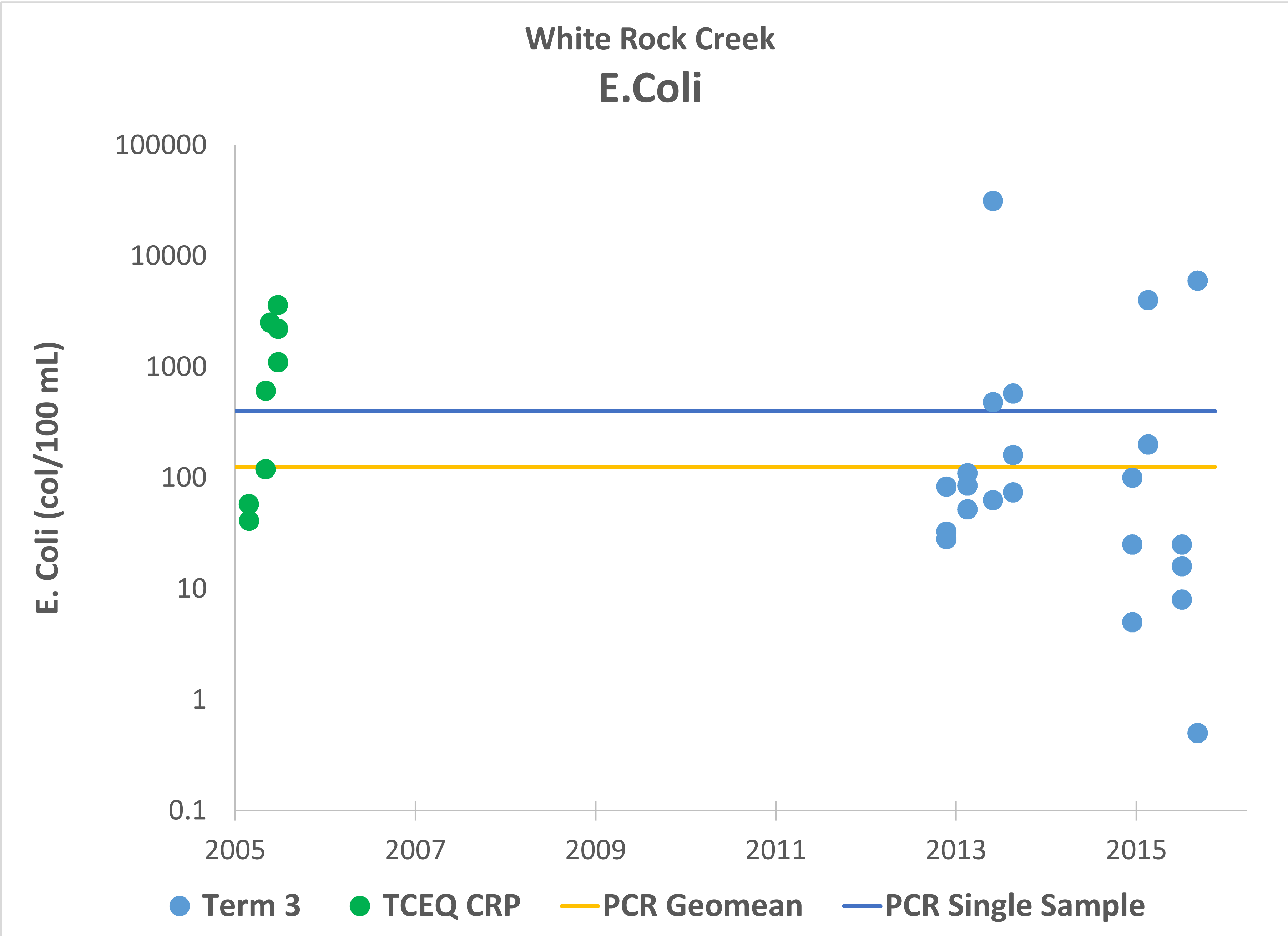
White Rock Creek
Zinc, Total
Zn, Total (mg/L)
1000
100
10
1
0.1
0.01
0.001
2012
2013
2014
2015
2016
Permit Term 3
ALU Acute Criterion
ALU Chronic Criterion
Human Health Criterion



White Rock Creek
Oil & Grease
Oil & Grease, Total (mg/L)
0
1
2
3
4
5
6
7
8
9
2012
2013
2014
2015
2016
Permit Term 3
NSQD Third Quartile

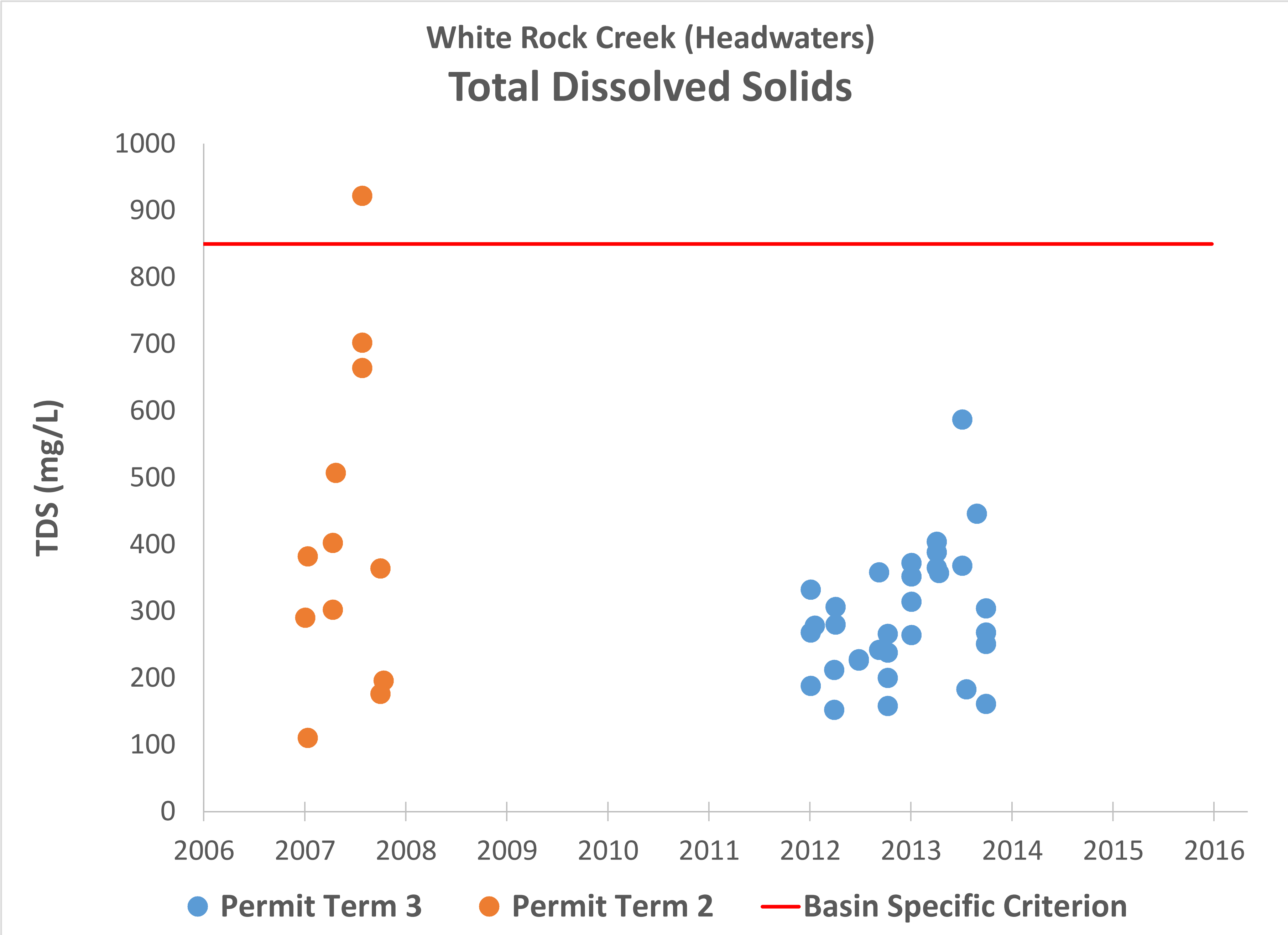


White Rock Creek
Field pH
pH (Standard Units)
9.5
9
8.5
8
7.5
7
6.5
6
2012
2013
2014
2015
2016
Permit Term 3
Basin Specific Criteria

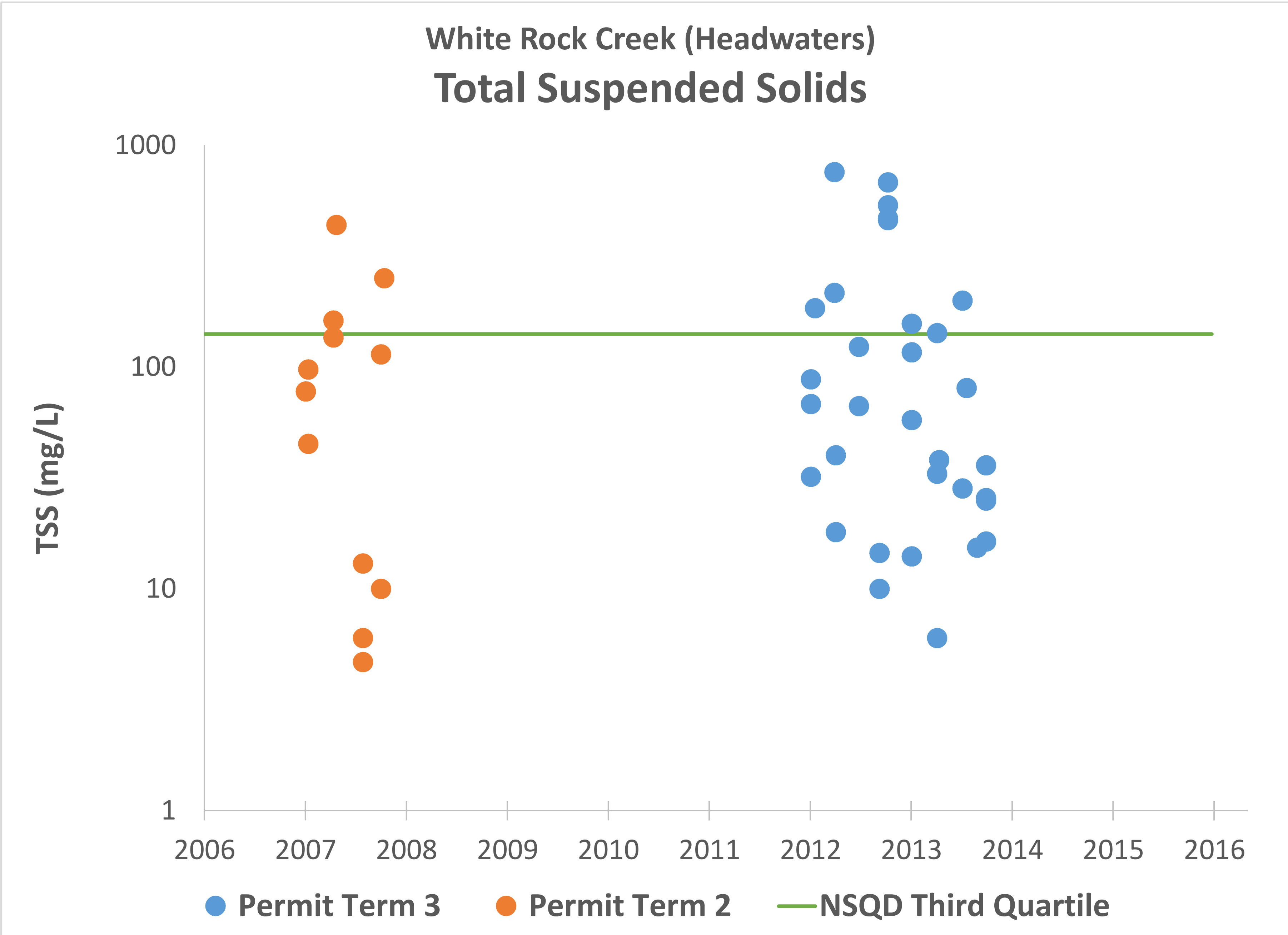

White Rock Creek
E.Coli
E. Coli (col/100 mL)
100000
10000
1000
100
10
1
0.1
2005
2007
2009
2011
2013
2015
Term 3
TCEQ CRP
PCR Geomean
PCR Single Sample

Appendix AD

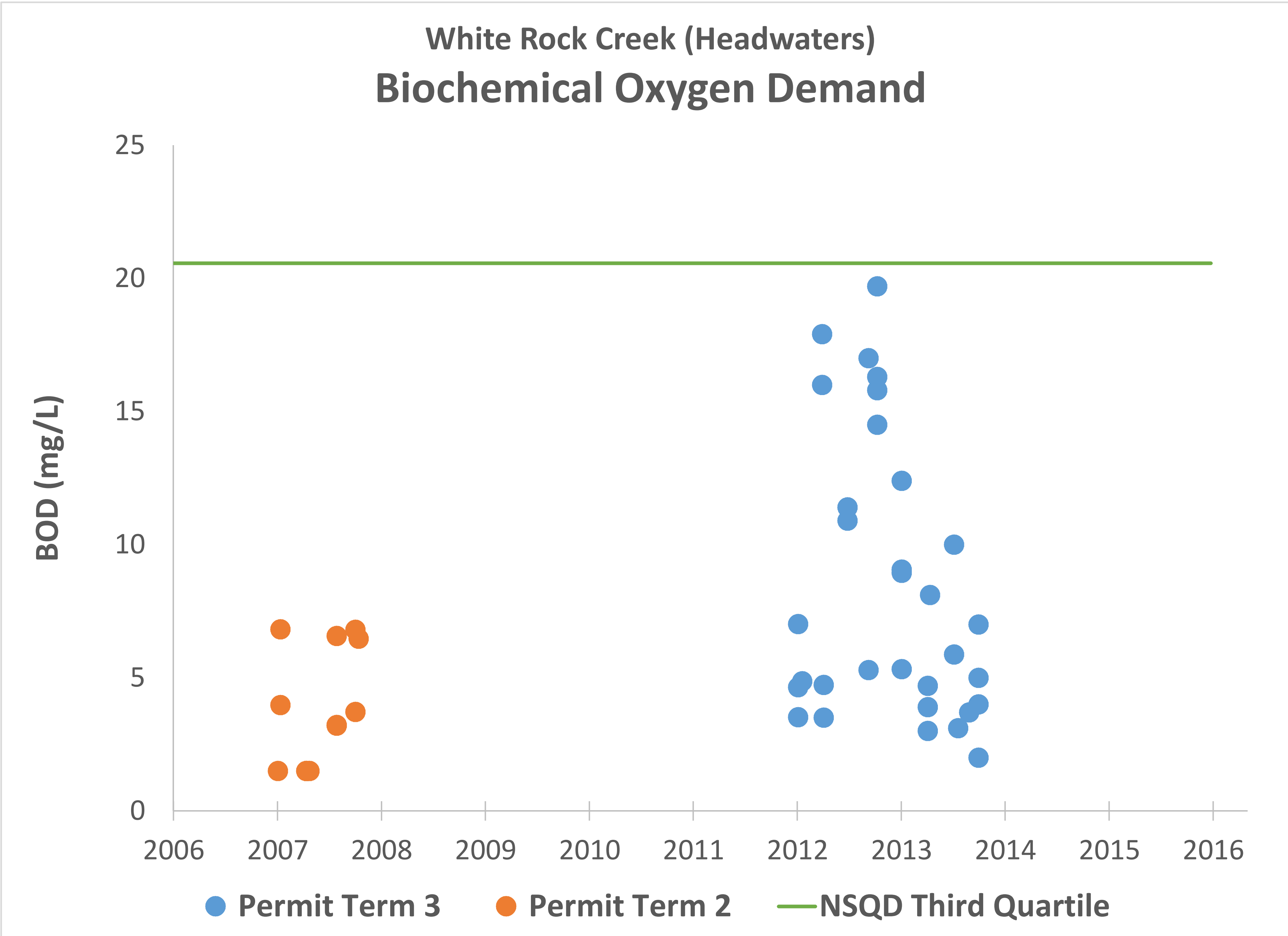
White Rock Creek (Headwaters) Water Quality Data Graphs



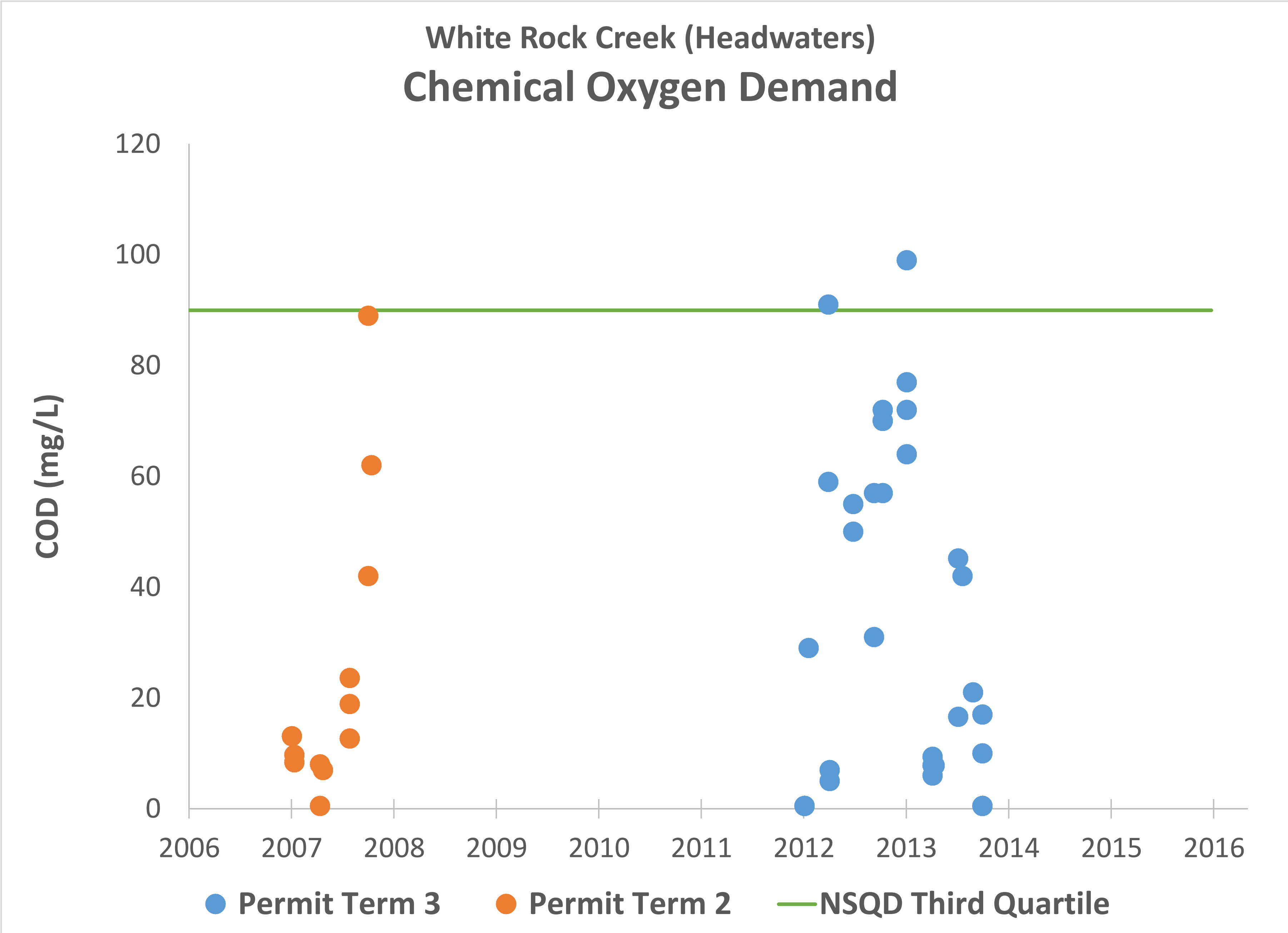
White Rock Creek (Headwaters)
Total Dissolved Solids
TDS (mg/L)
1000
900
800
700
600
500
400
300
200
100
0
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
Permit Term 3
Permit Term 2
Basin Specific Criterion

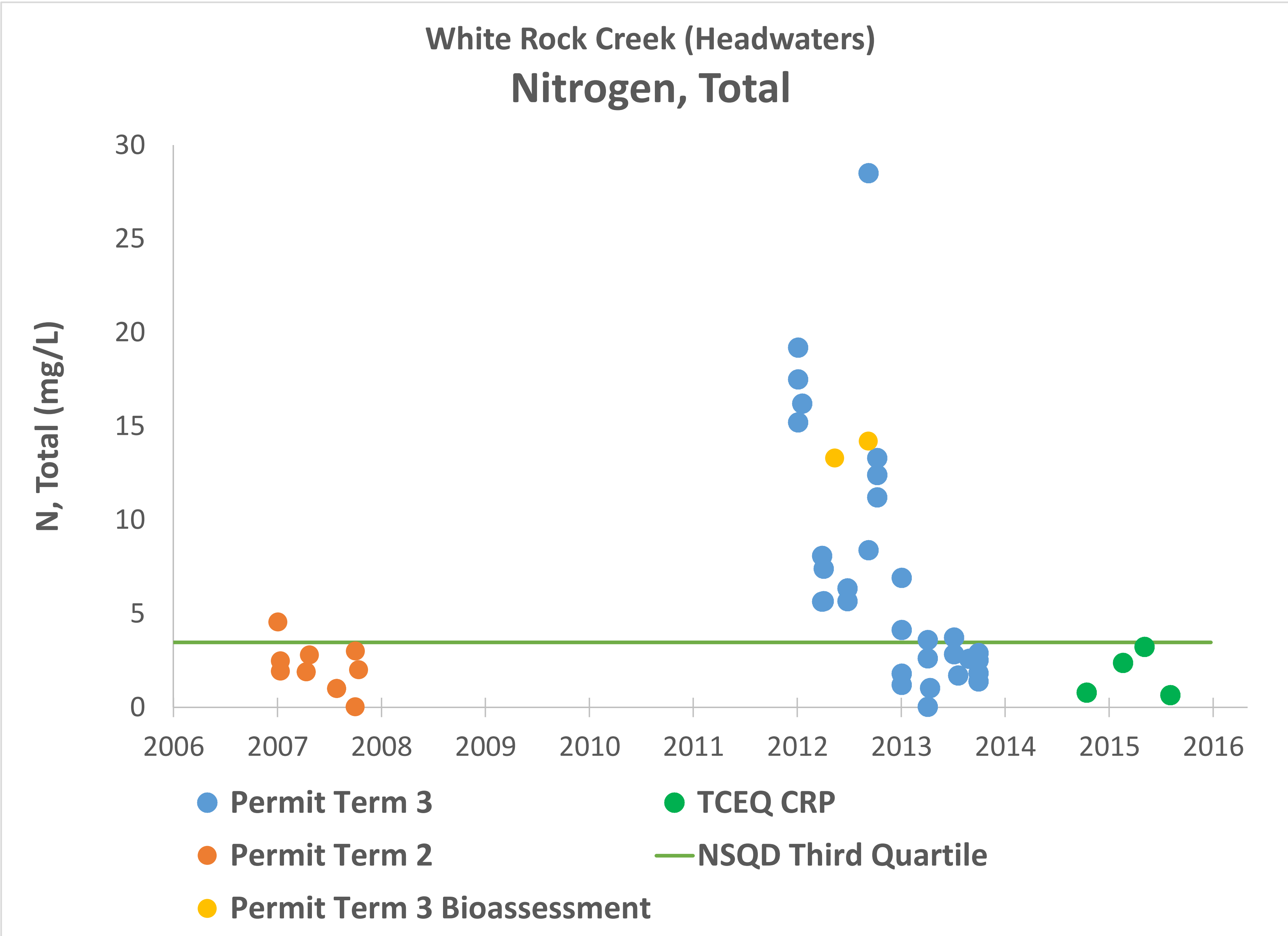


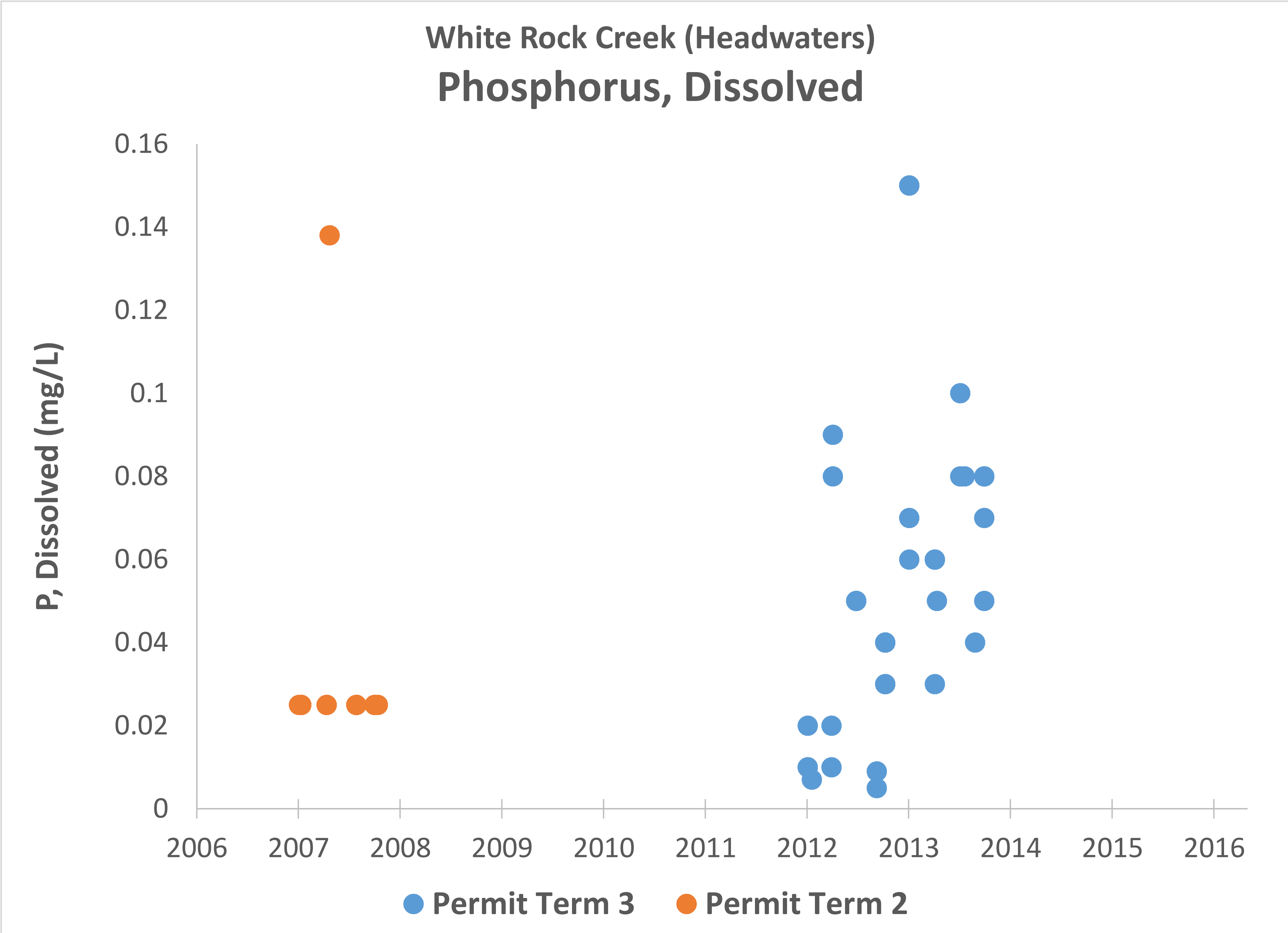
White Rock Creek (Headwaters)
Total Suspended Solids
TSS (mg/L)
1000
100
10
1
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
Permit Term 3
Permit Term 2
NSQD Third Quartile



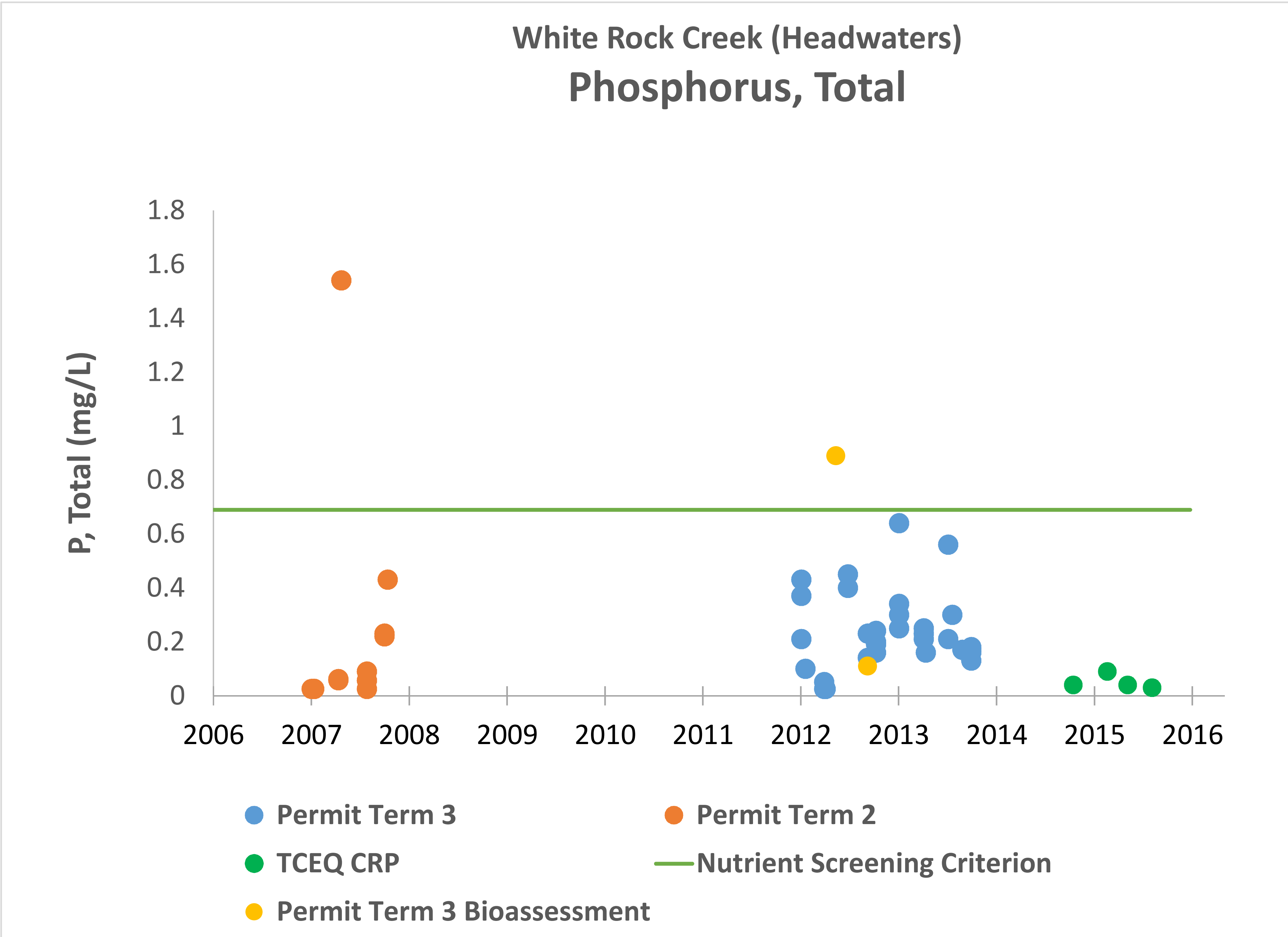
White Rock Creek (Headwaters)
Biochemical Oxygen Demand
BOD (mg/L)
25
20
15
10
5
0
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
Permit Term 3
Permit Term 2
NSQD Third Quartile

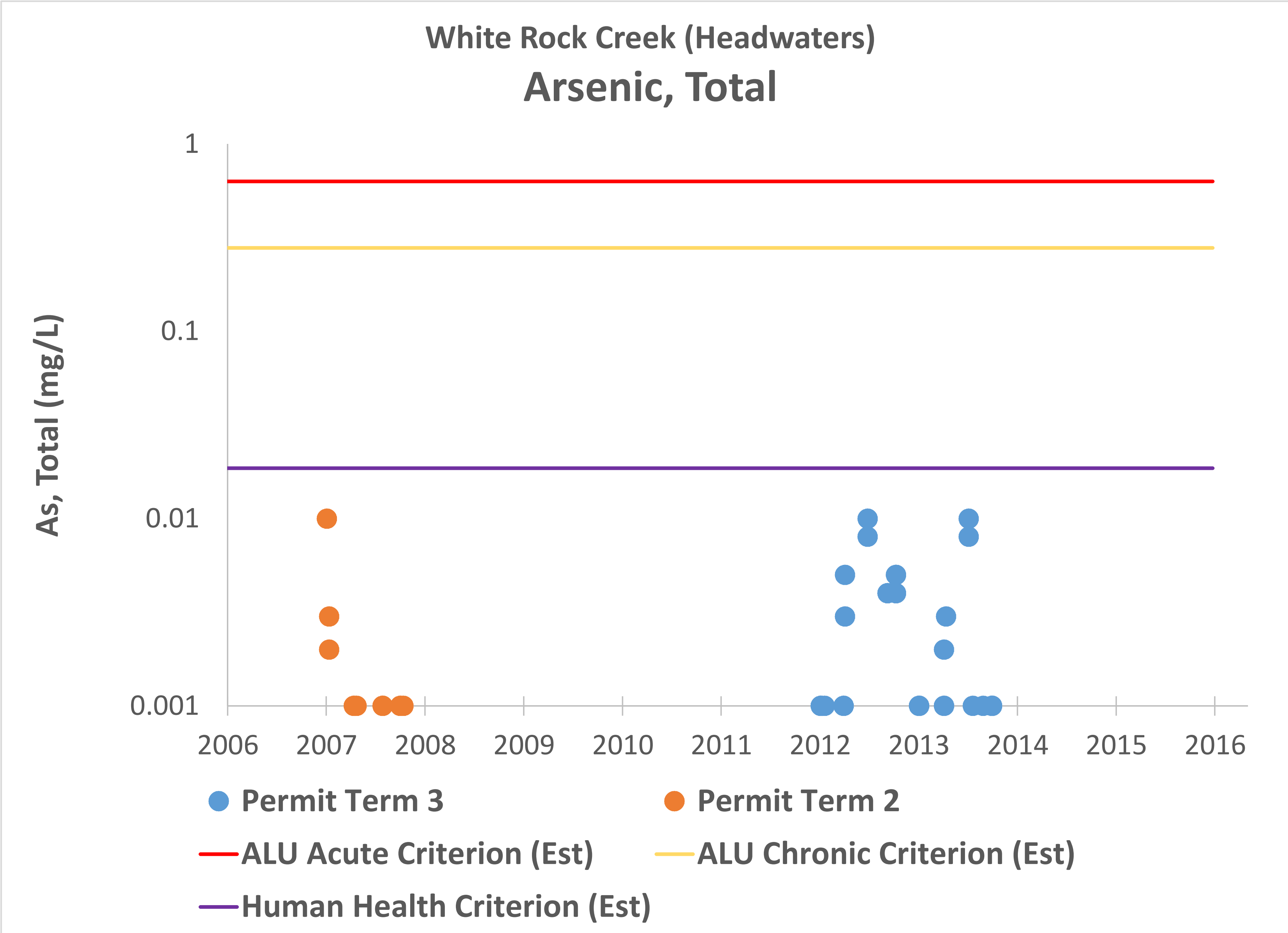

White Rock Creek (Headwaters)
Chemical Oxygen Demand
COD (mg/L)
120
100
80
60
40
20
0
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
Permit Term 3
Permit Term 2
NSQD Third Quartile


White Rock Creek (Headwaters)
Nitrogen, Total
N, Total (mg/L)
30
25
20
15
10
5
0
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
Permit Term 3
Permit Term 2
Permit Term 3 Bioassessment
TCEQ CRP
NSQD Third Quartile

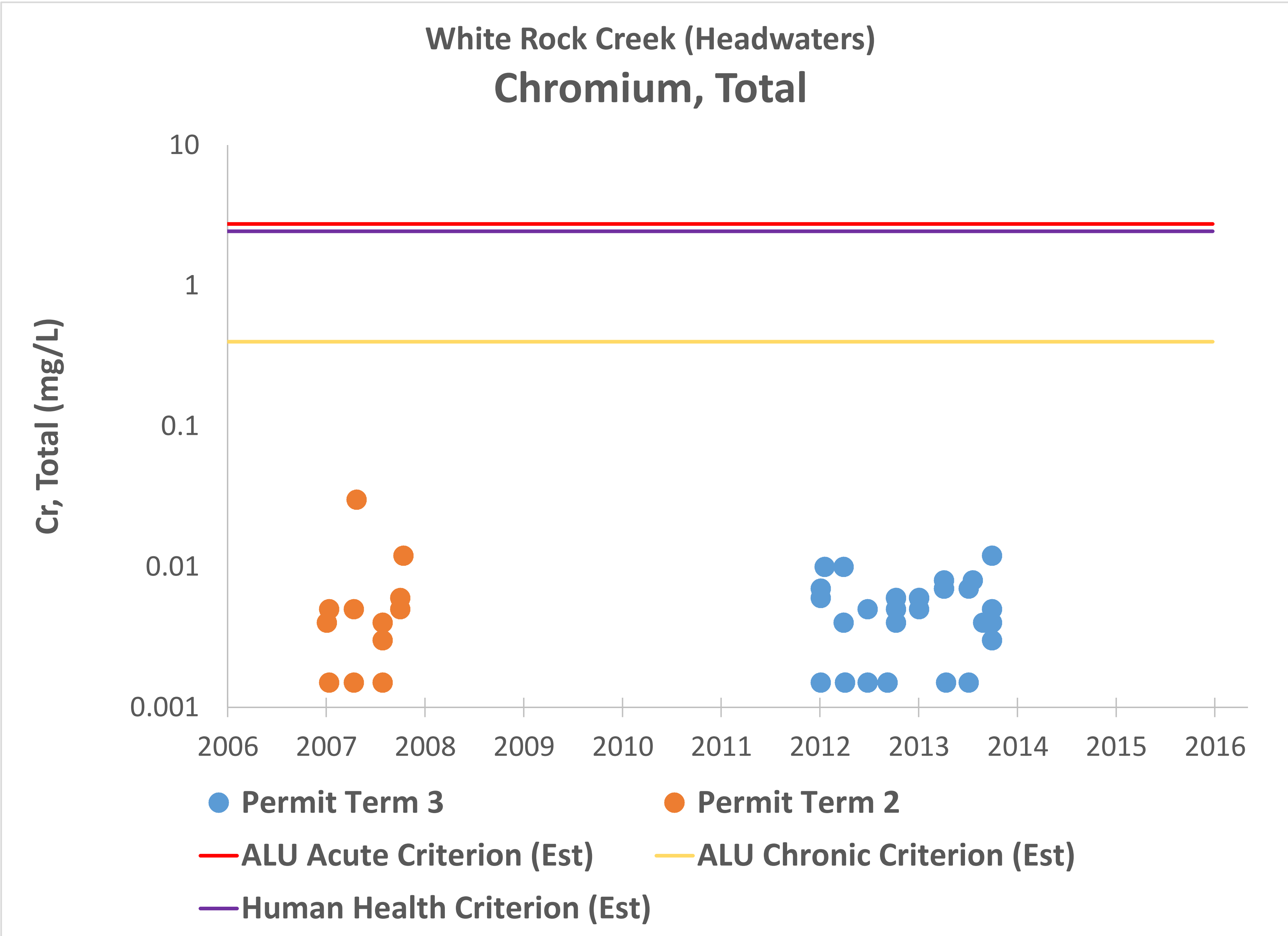


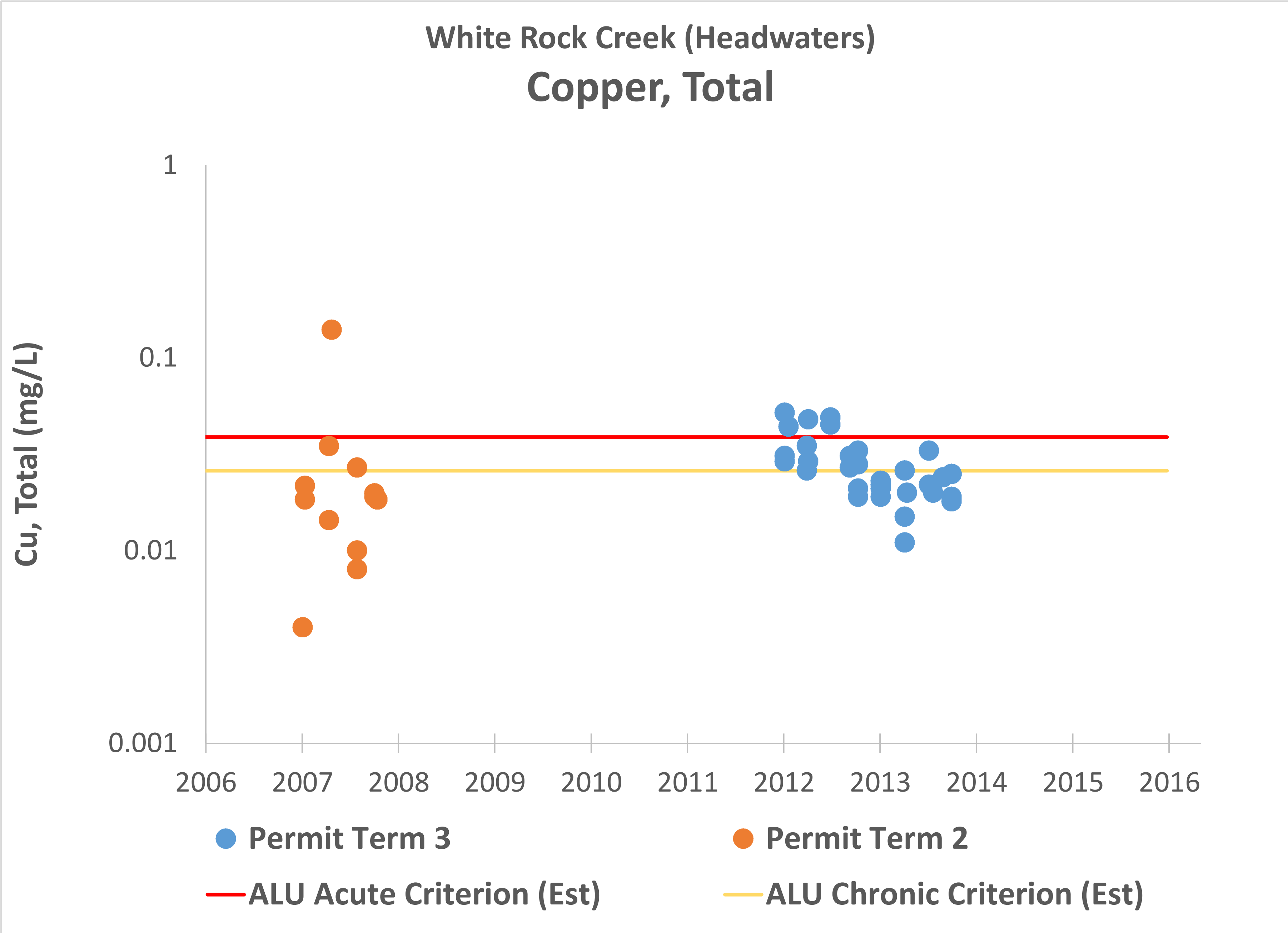
White Rock Creek (Headwaters)
Phosphorus, Dissolved
P, Dissolved (mg/L)
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
Permit Term 3
Permit Term 2

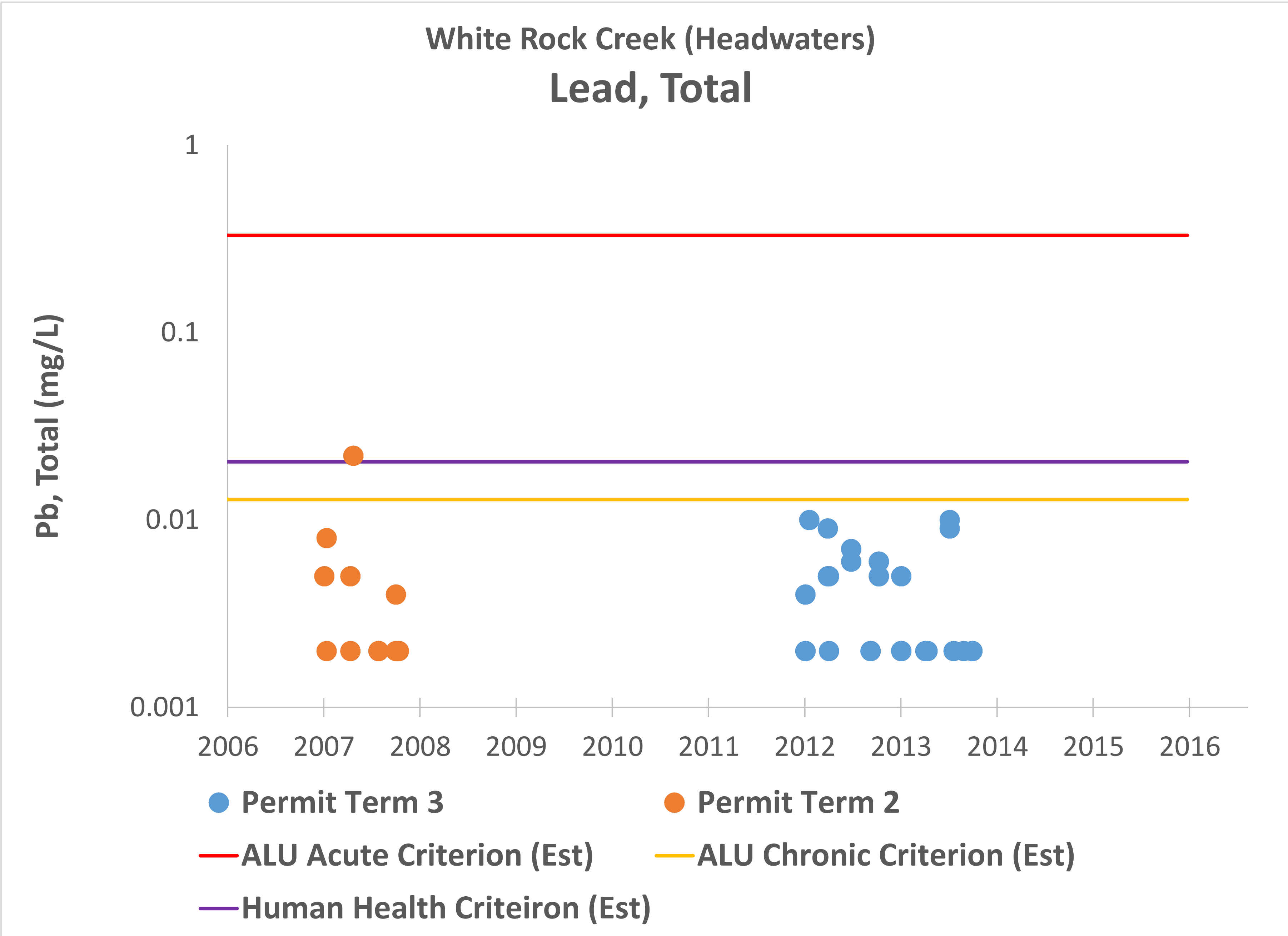

White Rock Creek (Headwaters)
Phosphorus, Total
P, Total (mg/L)
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
Permit Term 3
Permit Term 2
TCEQ CRP
Nutrient Screening Criterion
Permit Term 3 Bioassessment

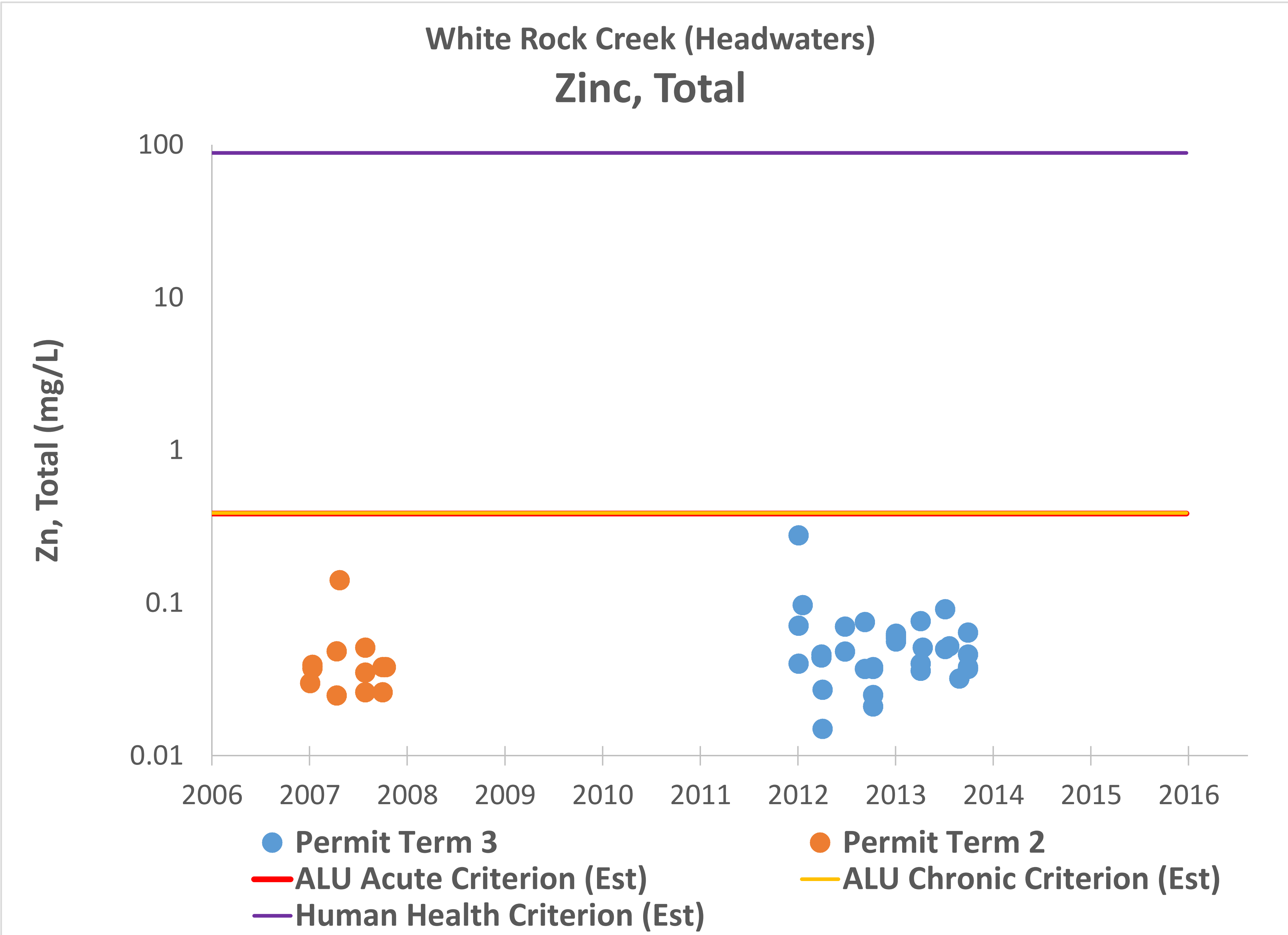


White Rock Creek (Headwaters)
Arsenic, Total
As, Total (mg/L)
1
0.1
0.01
0.001
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
Permit Term 3
Permit Term 2
ALU Acute Criterion (Est)
ALU Chronic Criterion (Est)
Human Health Criterion (Est)

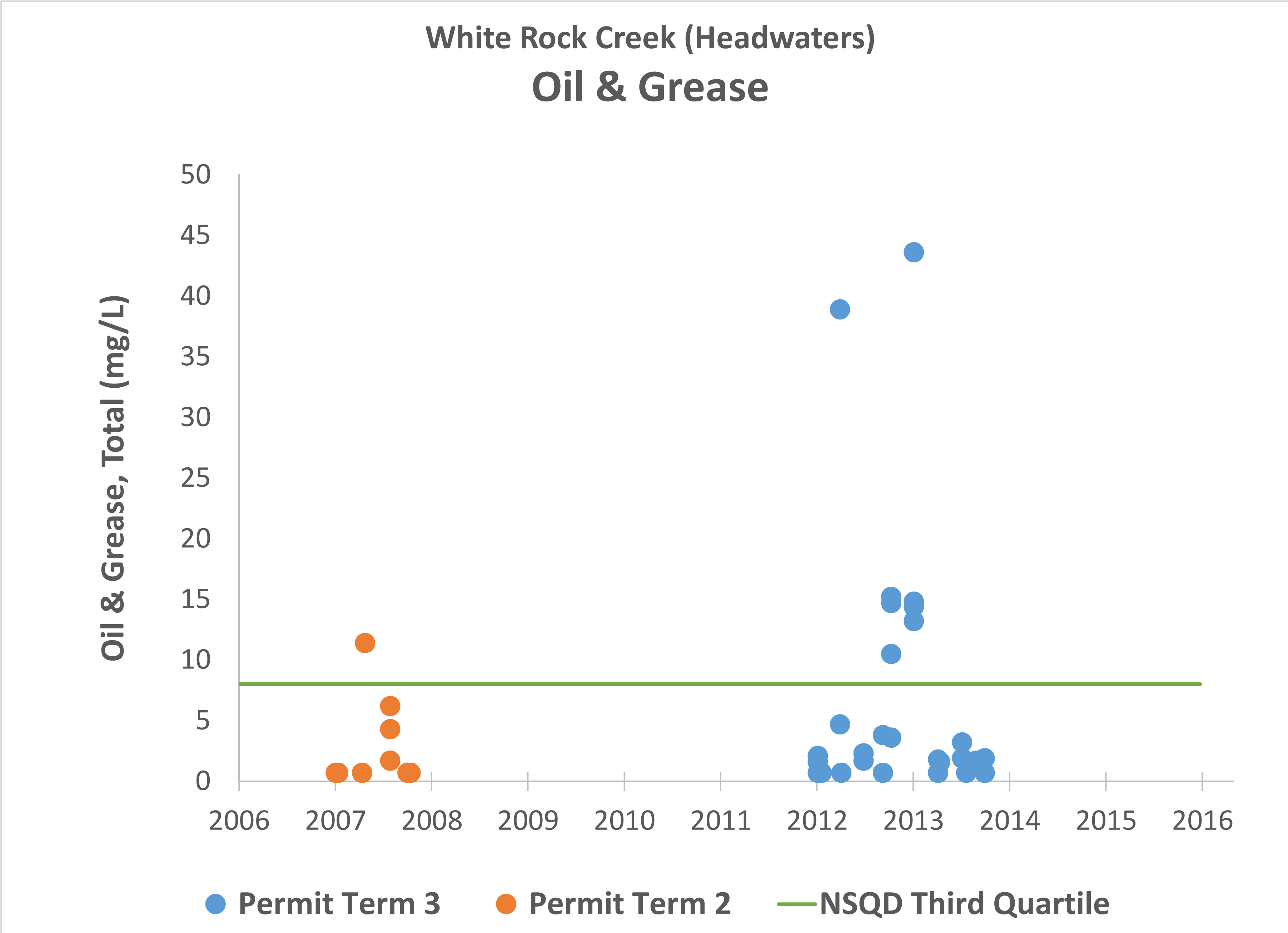

White Rock Creek (Headwaters)
Chromium, Total
Cr, Total (mg/L)
10
1
0.1
0.01
0.001
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
Permit Term 3
Permit Term 2
ALU Acute Criterion (Est)
ALU Chronic Criterion (Est)
Human Health Criterion (Est)

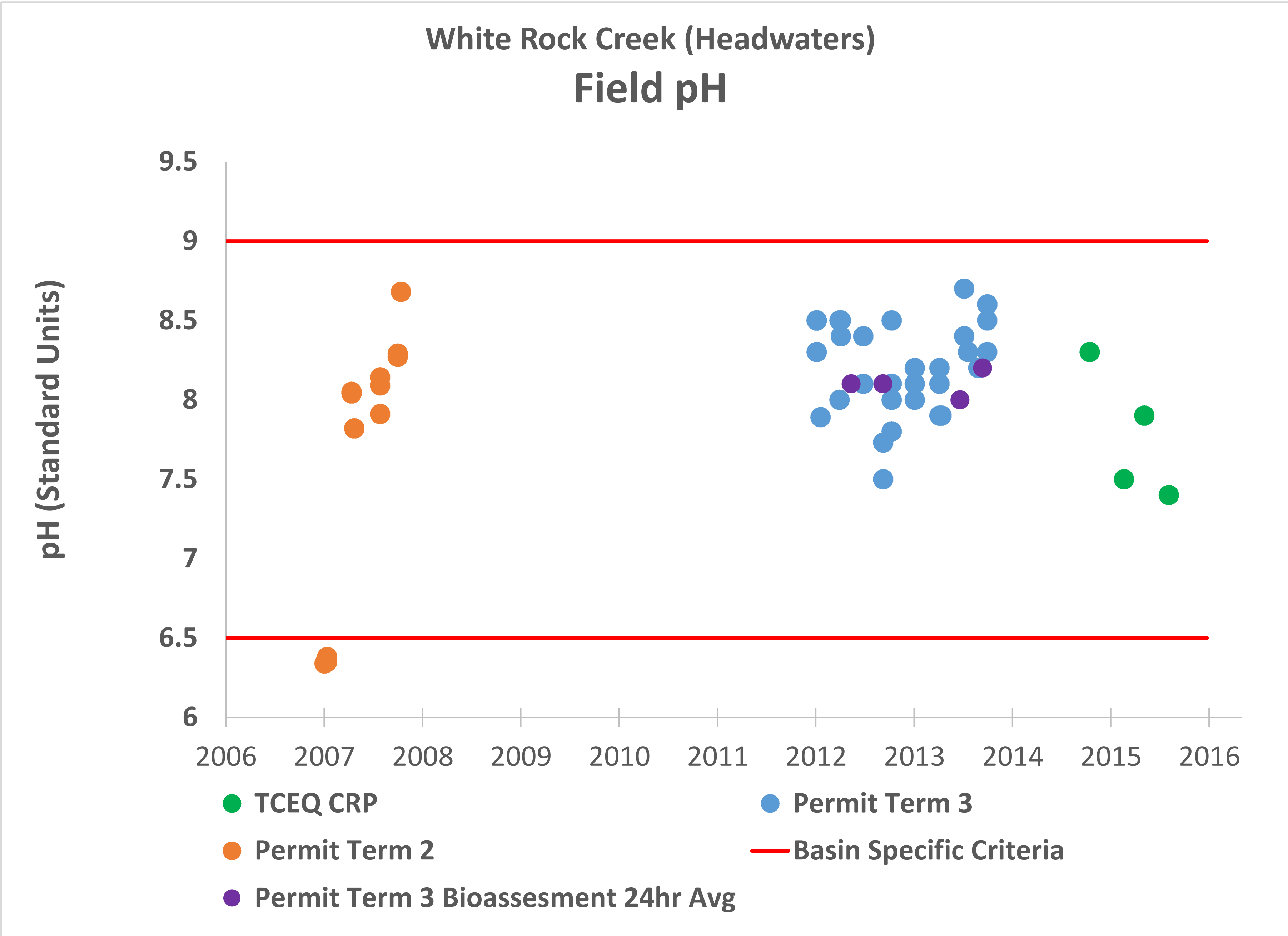

White Rock Creek (Headwaters)
Copper, Total
Cu, Total (mg/L)
1
0.1
0.01
0.001
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
Permit Term 3
Permit Term 2
ALU Acute Criterion (Est)
ALU Chronic Criterion (Est)

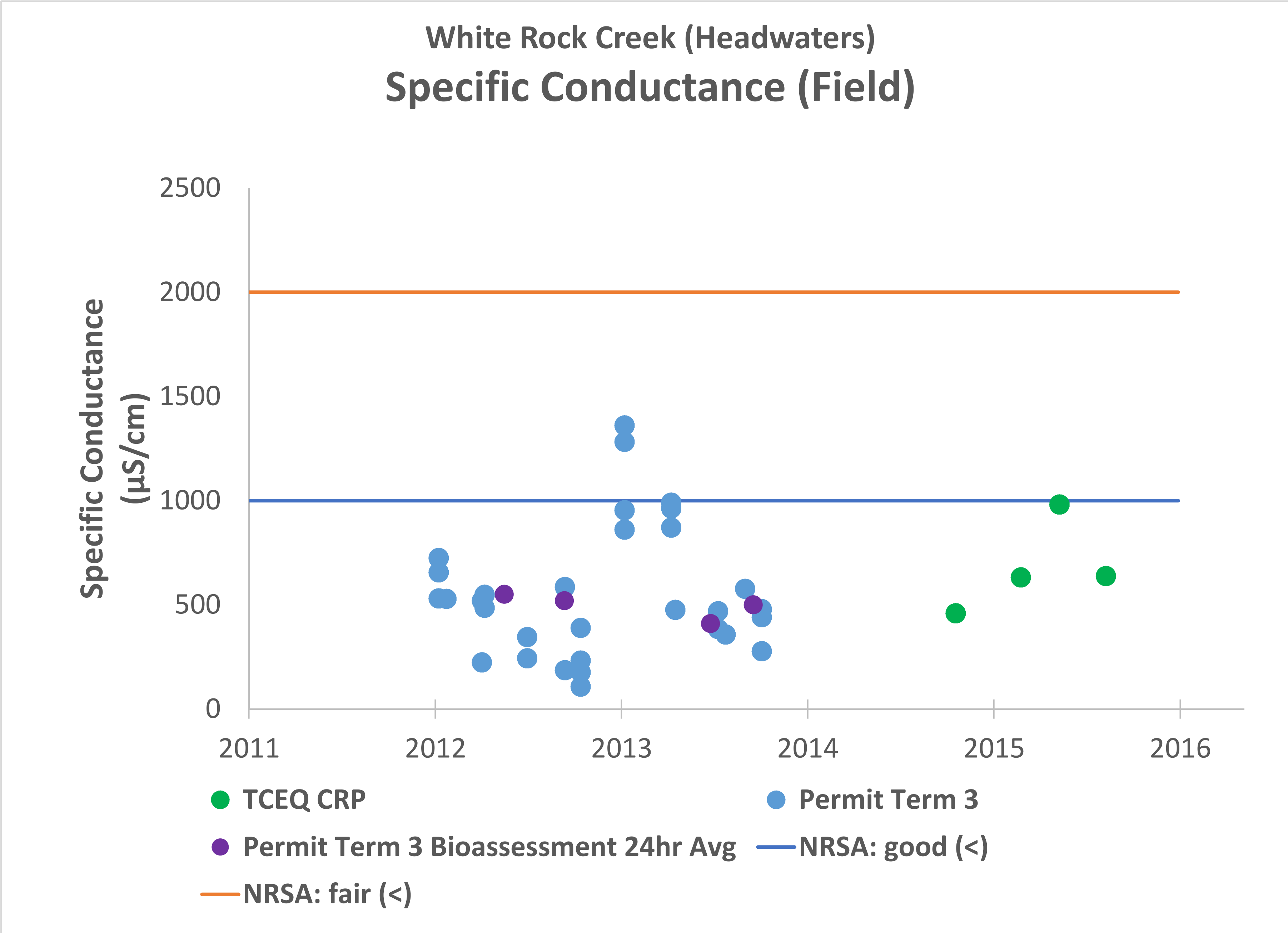

White Rock Creek (Headwaters)
Lead, Total
Pb, Total (mg/L)
1
0.1
0.01
0.001
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
Permit Term 3
Permit Term 2
ALU Acute Criterion (Est)
ALU Chronic Criterion (Est)
Human Health Criteiron (Est)



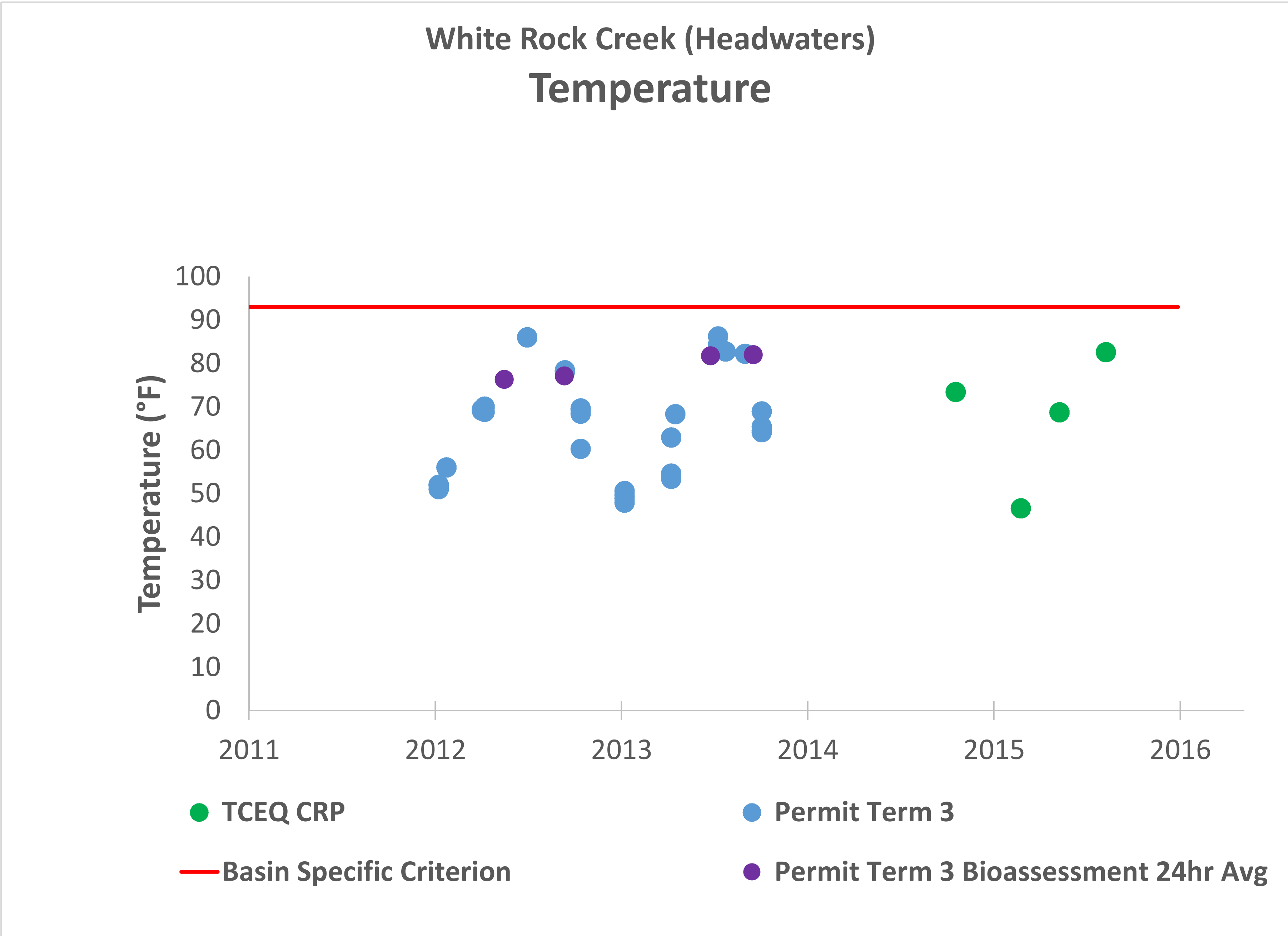
White Rock Creek (Headwaters)
Zinc, Total
Zn, Total (mg/L)
100
10
1
0.1
0.01
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
Permit Term 3
Permit Term 2
ALU Acute Criterion (Est)
ALU Chronic Criterion (Est)
Human Health Criterion (Est)

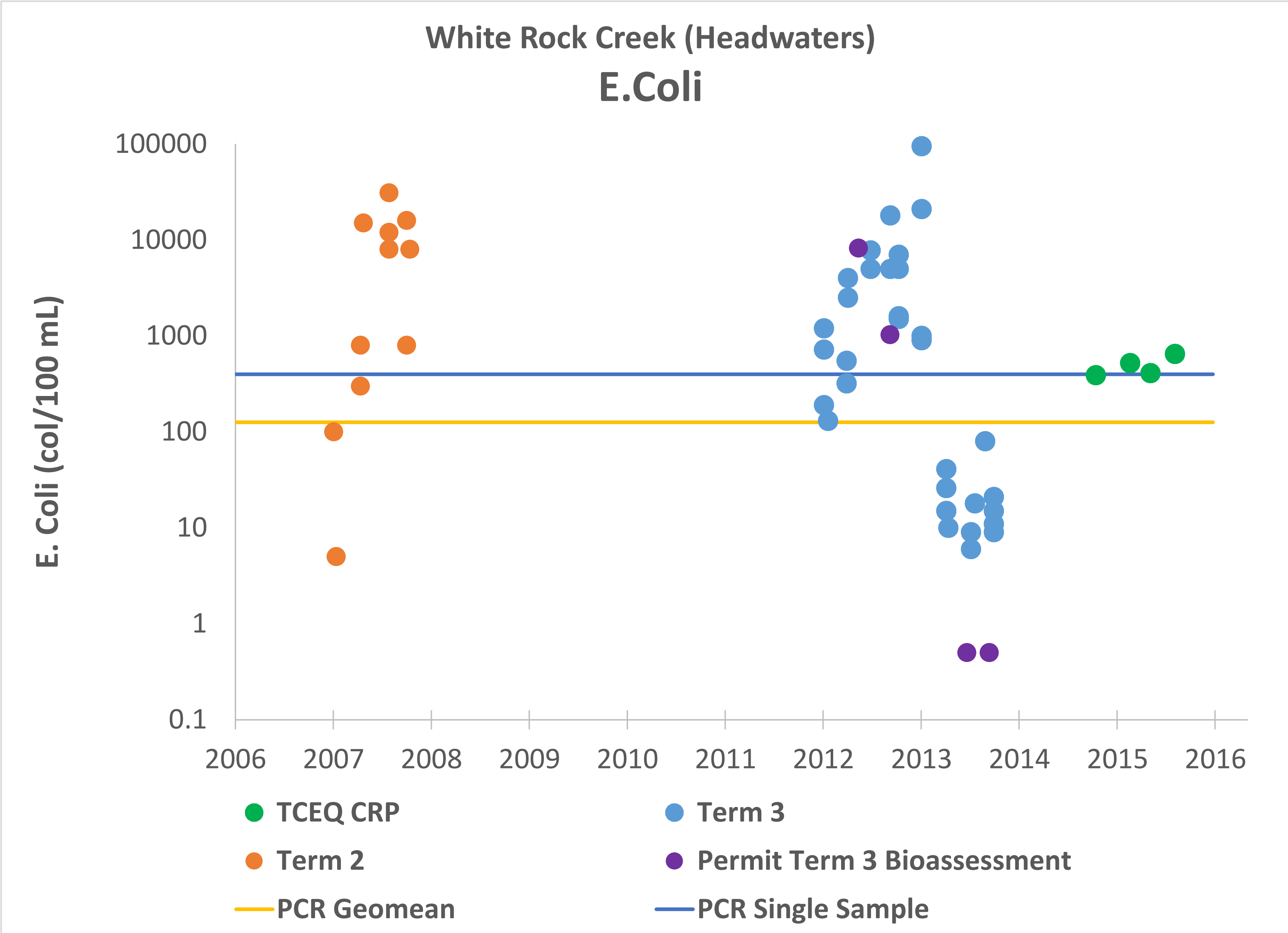

White Rock Creek (Headwaters)
Oil & Grease
Oil & Grease, Total (mg/L)
0
5
10
15
20
25
30
35
40
45
50
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
Permit Term 3
Permit Term 2
NSQD Third Quartile


White Rock Creek (Headwaters)
Field pH
pH (Standard Units)
9.5
9
8.5
8
7.5
7
6.5
6
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
TCEQ CRP
Permit Term 3
Permit Term 2
Basin Specific Criteria
Permit Term 3 Bioassesment 24hr Avg

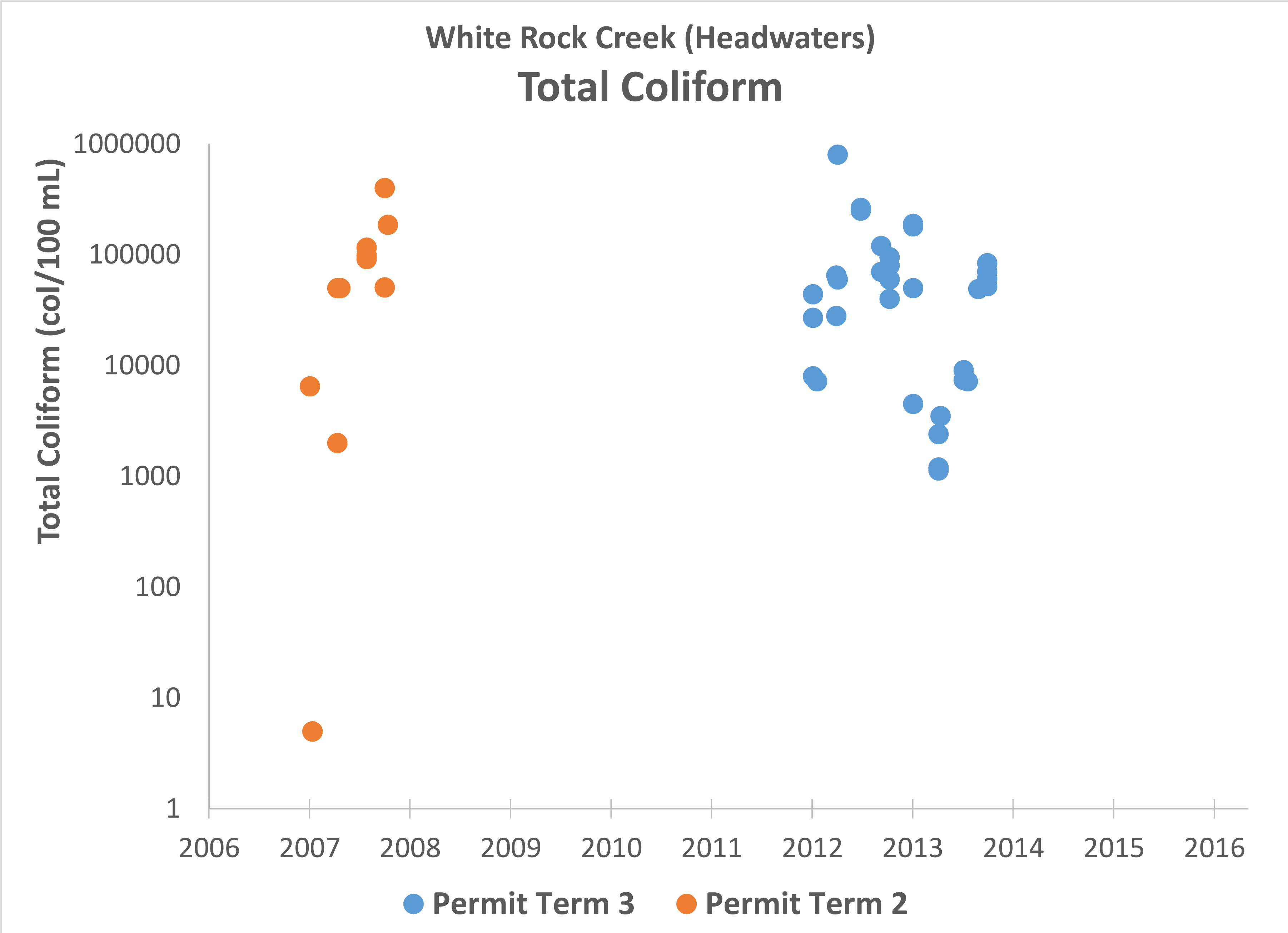


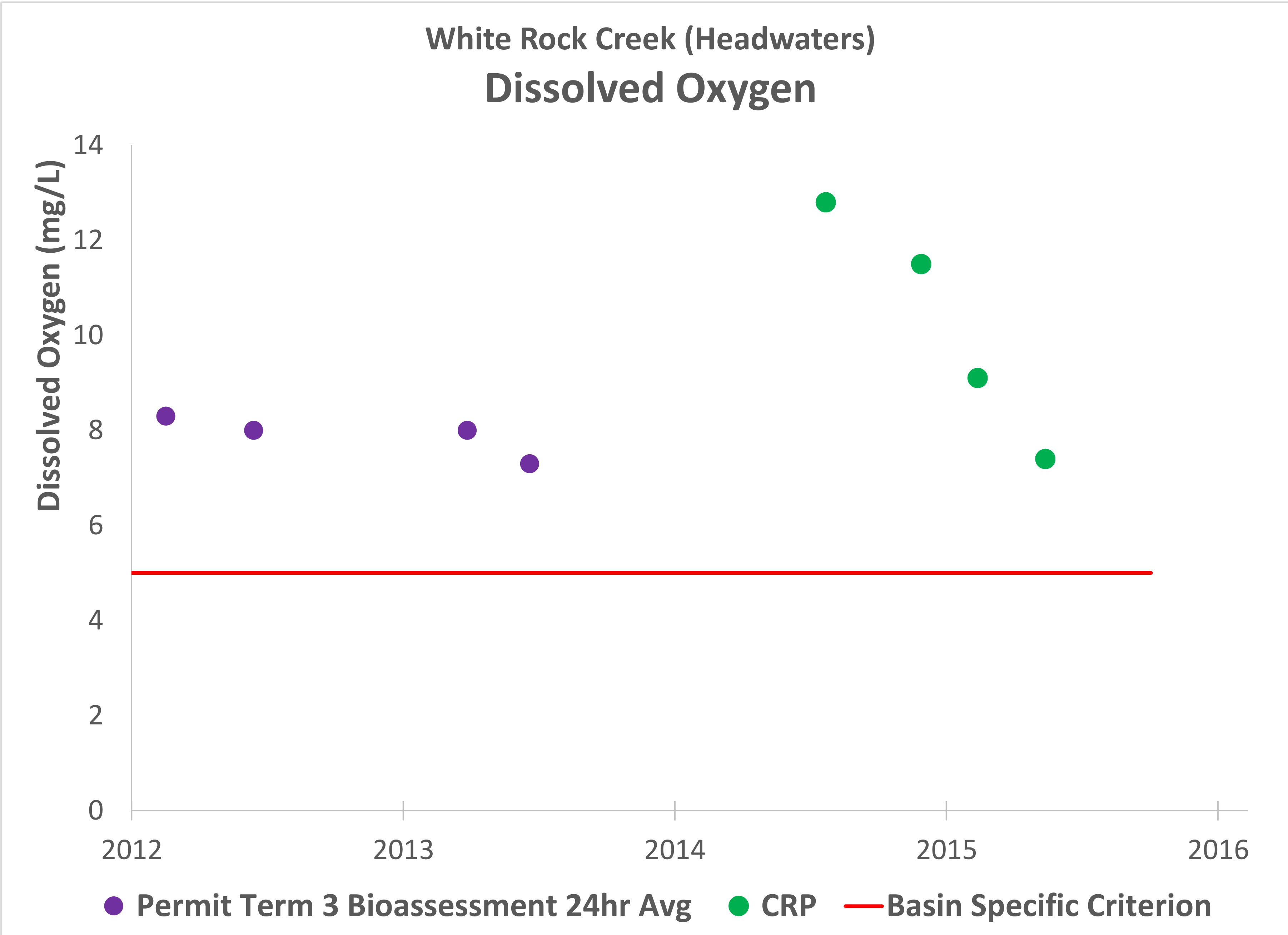
White Rock Creek (Headwaters)
Specific Conductance (Field)
Specific Conductance (µS/cm)
2500
2000
1500
1000
500
0
2011
2012
2013
2014
2015
2016
TCEQ CRP
Permit Term 3
Permit Term 3 Bioassessment 24hr Avg
NRSA: good (<)
NRSA: fair (<)

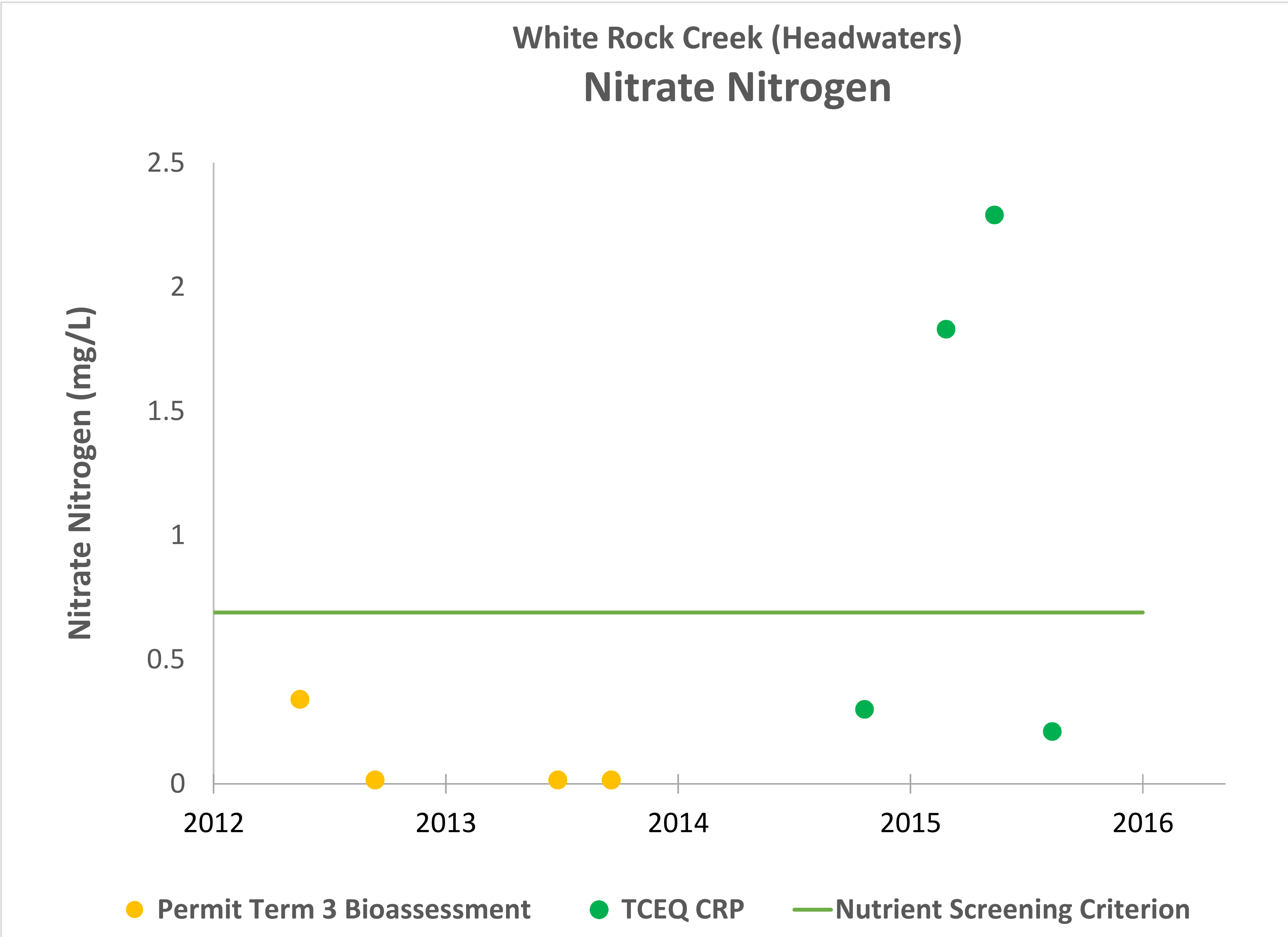

White Rock Creek (Headwaters)
Temperature
Temperature (°F)
100
90
80
70
60
50
40
30
20
10
0
2011
2012
2013
2014
2015
2016
TCEQ CRP
Permit Term 3
Basin Specific Criterion
Permit Term 3 Bioassessment 24hr Avg

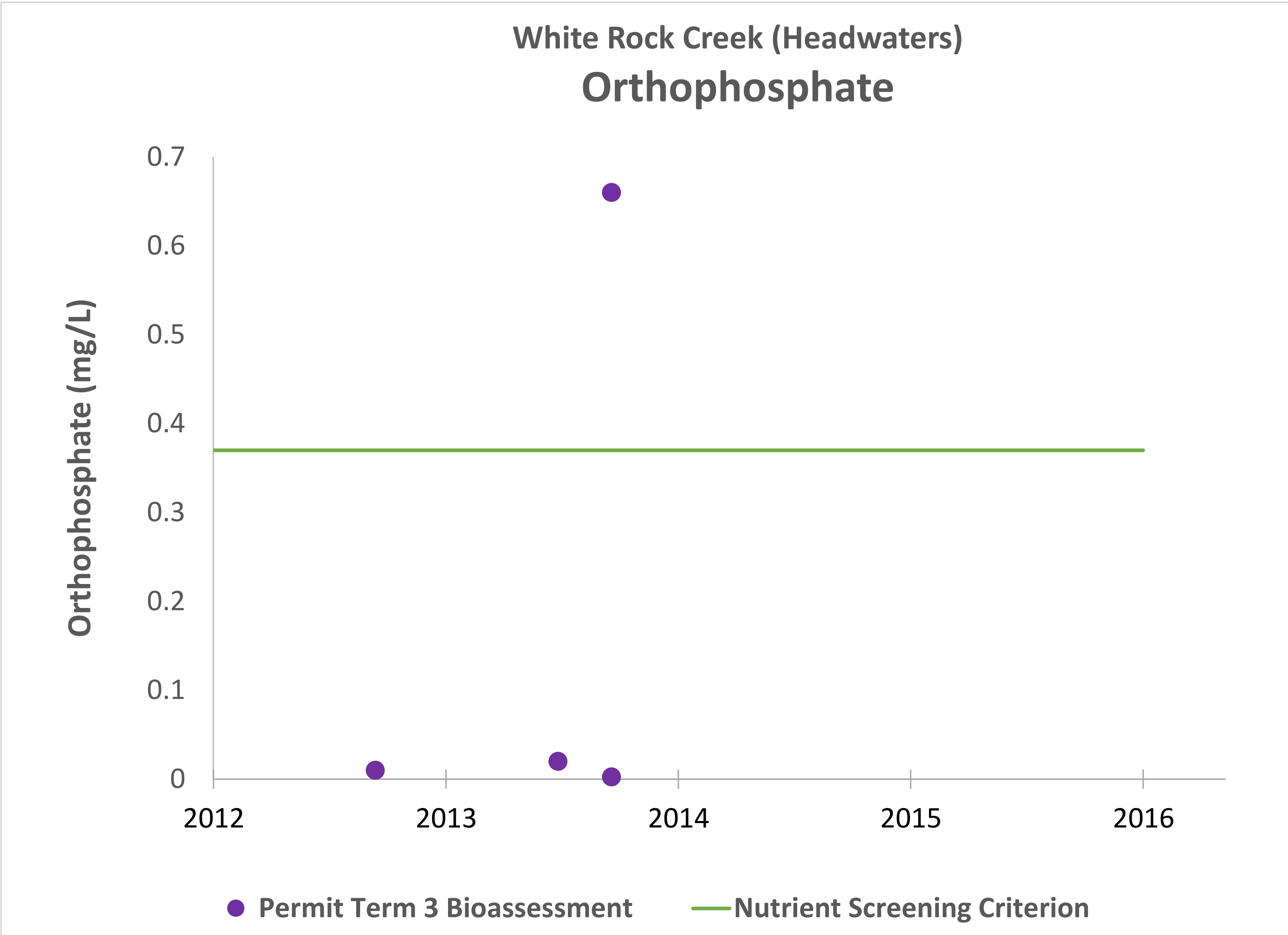


White Rock Creek (Headwaters)
E.Coli
E. Coli (col/100 mL)
100000
10000
1000
100
10
1
0.1
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
TCEQ CRP
Term 3
Term 2
Permit Term 3 Bioassessment
PCR Geomean
PCR Single Sample

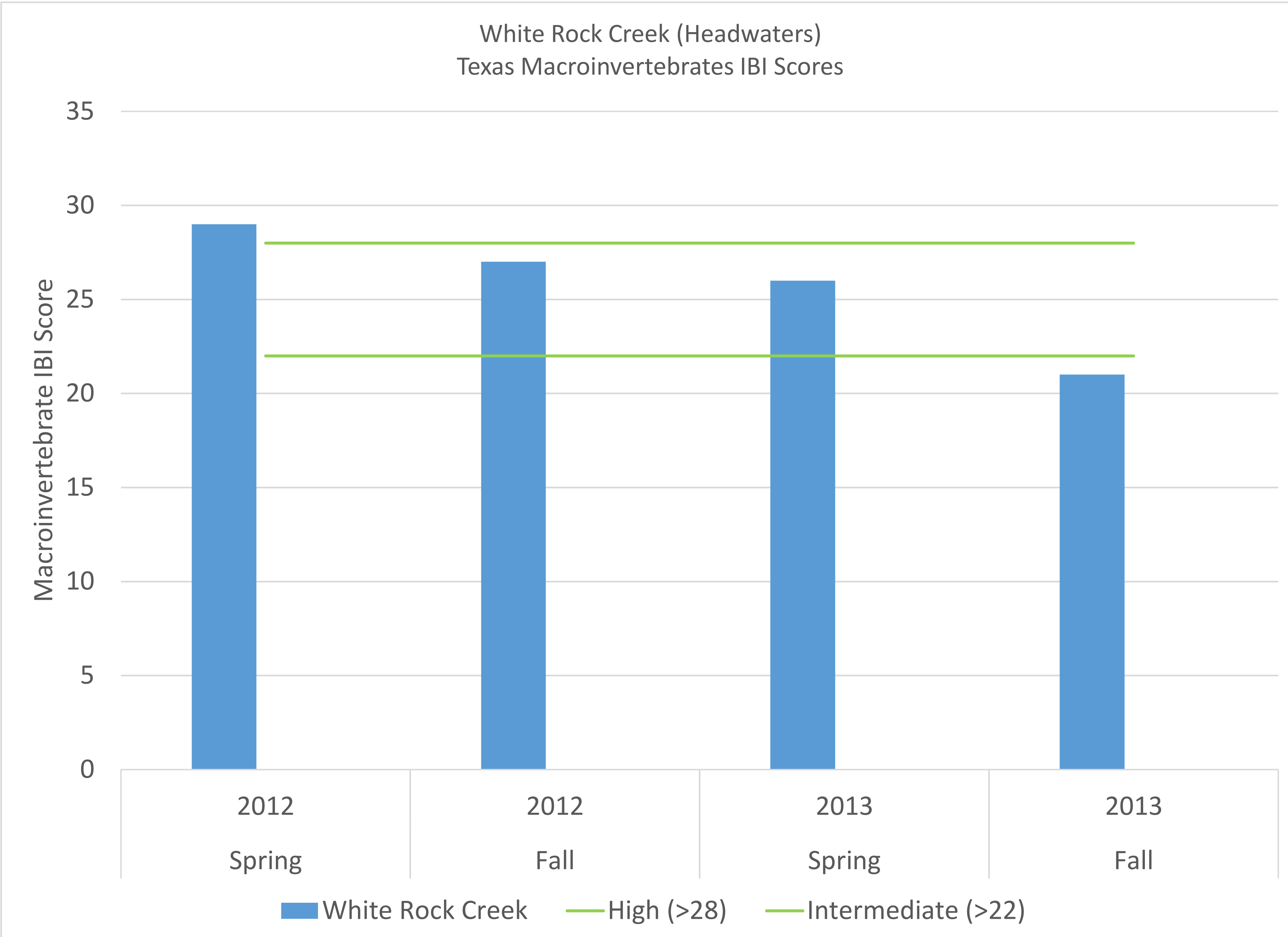

White Rock Creek (Headwaters)
Total Coliform
Total Coliform (col/100 mL)
1000000
100000
10000
1000
100
10
1
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
Permit Term 3
Permit Term 2

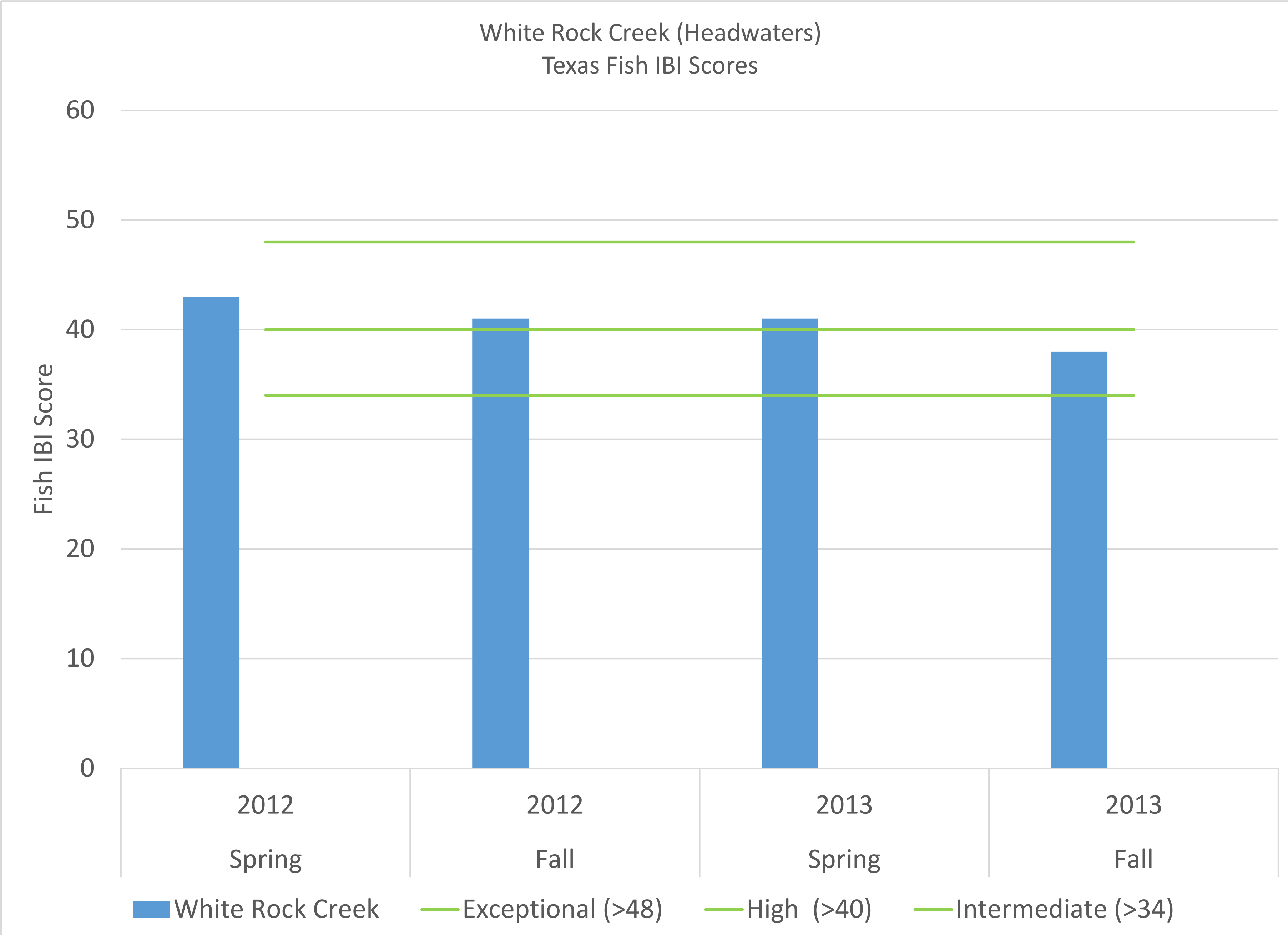

White Rock Creek (Headwaters)
Dissolved Oxygen
Dissolved Oxygen (mg/L)
14
12
10
8
6
4
2
0
2012
2013
2014
2015
2016
Permit Term 3 Bioassessment 24hr Avg
CRP
Basin Specific Criterion

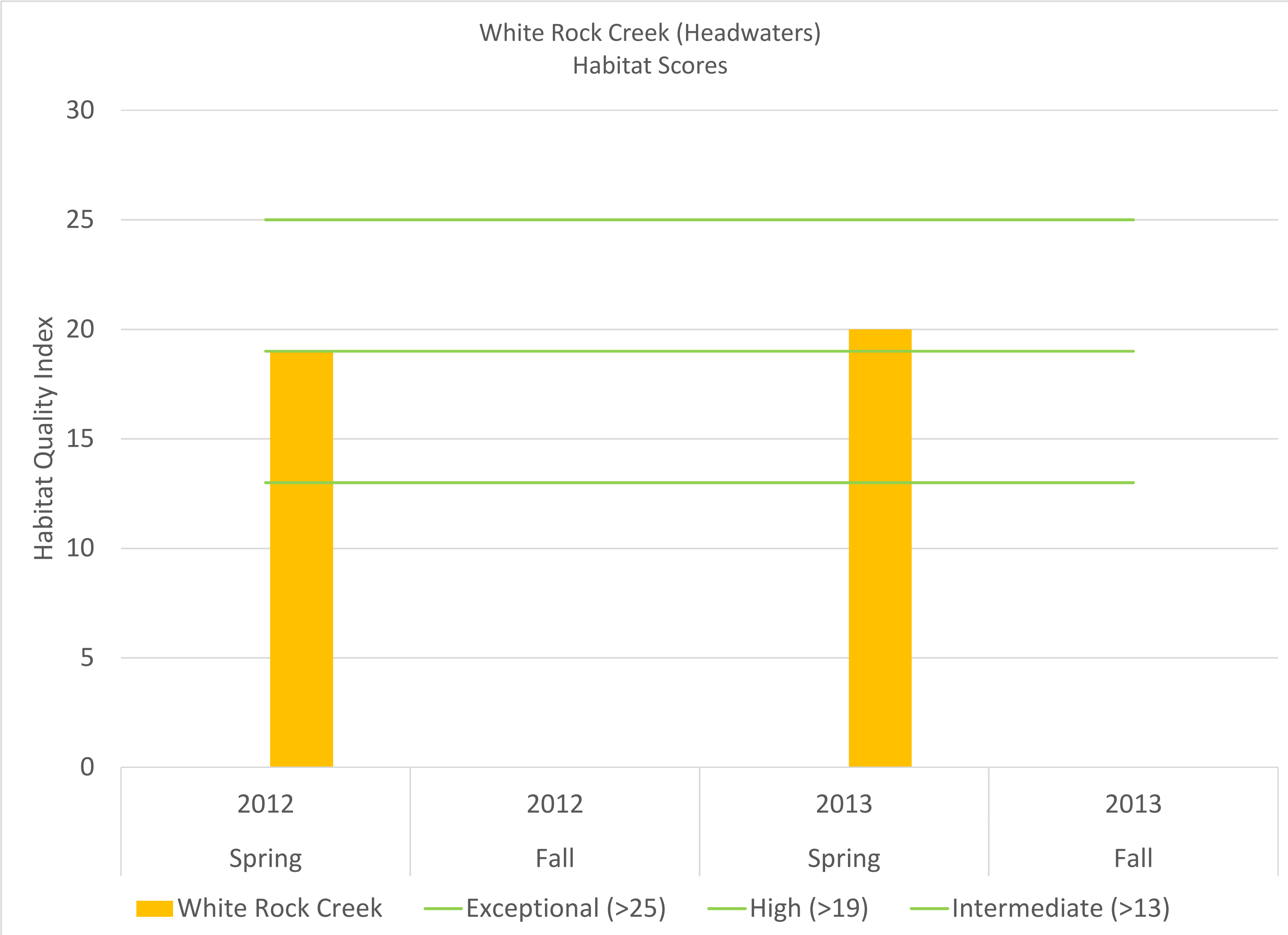

White Rock Creek (Headwaters)
Nitrate Nitrogen
Nitrate Nitrogen (mg/L)
2.5
2
1.5
1
0.5
0
2012
2013
2014
2015
2016
Permit Term 3 Bioassessment
TCEQ CRP
Nutrient Screening Criterion



White Rock Creek (Headwaters)
Orthophosphate
Orthophosphate (mg/L)
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
2012
2013
2014
2015
2016
Permit Term 3 Bioassessment
Nutrient Screening Criterion


White Rock Creek (Headwaters)
Texas Macroinvertebrates IBI Scores
Macroinvertebrate IBI Score
35
30
25
20
15
10
5
0
2012
Spring
2012
Fall
2013
Spring
2013
Fall
White Rock Creek
High (>28)
Intermediate (>22)

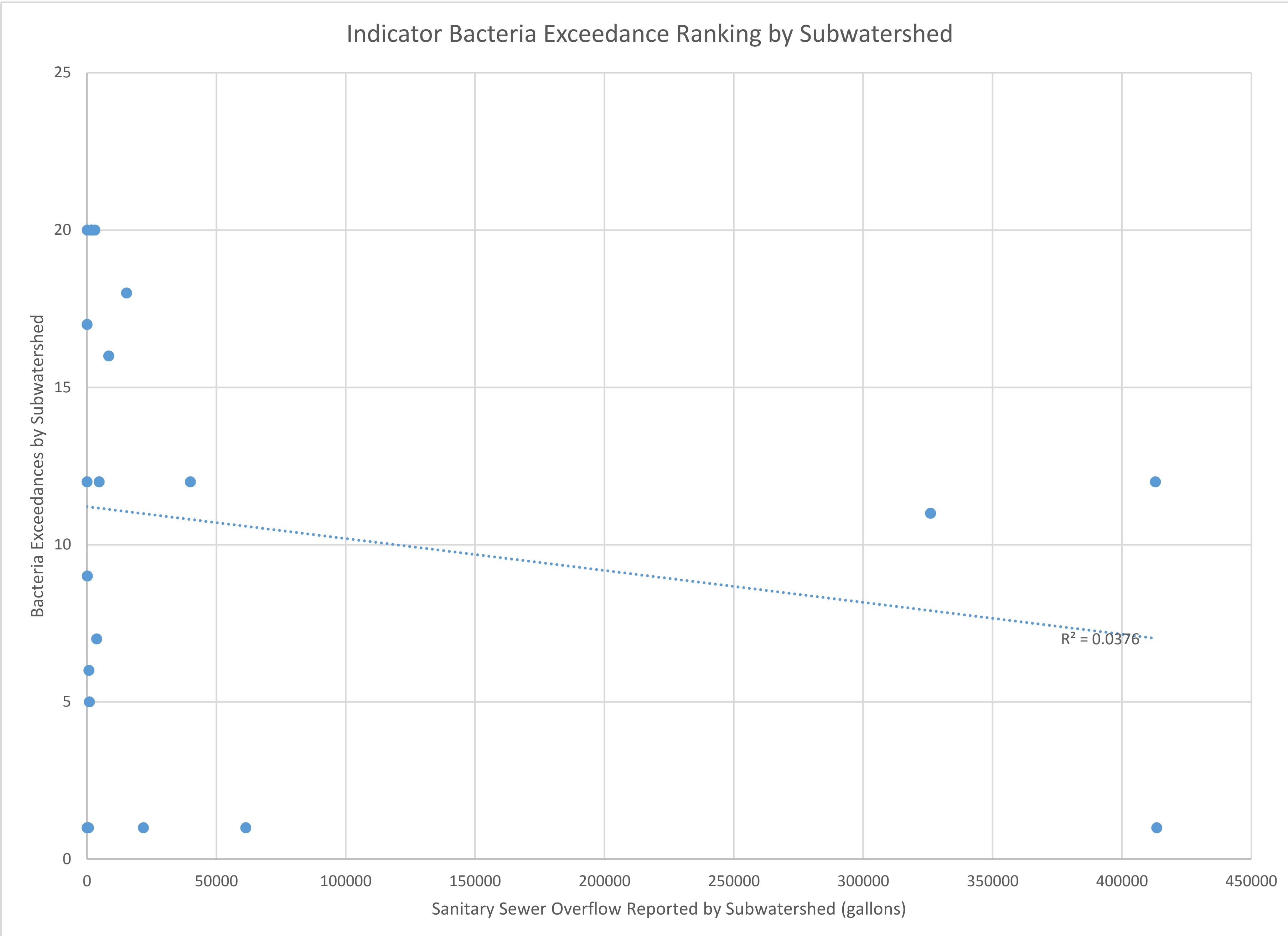

White Rock Creek (Headwaters)
Texas Fish IBI Scores
Fish IBI Score
60
50
40
30
20
10
0
2012
Spring
2012
Fall
2013
Spring
2013
Fall
White Rock Creek
Exceptional (>48)
High (>40)
Intermediate (>34)



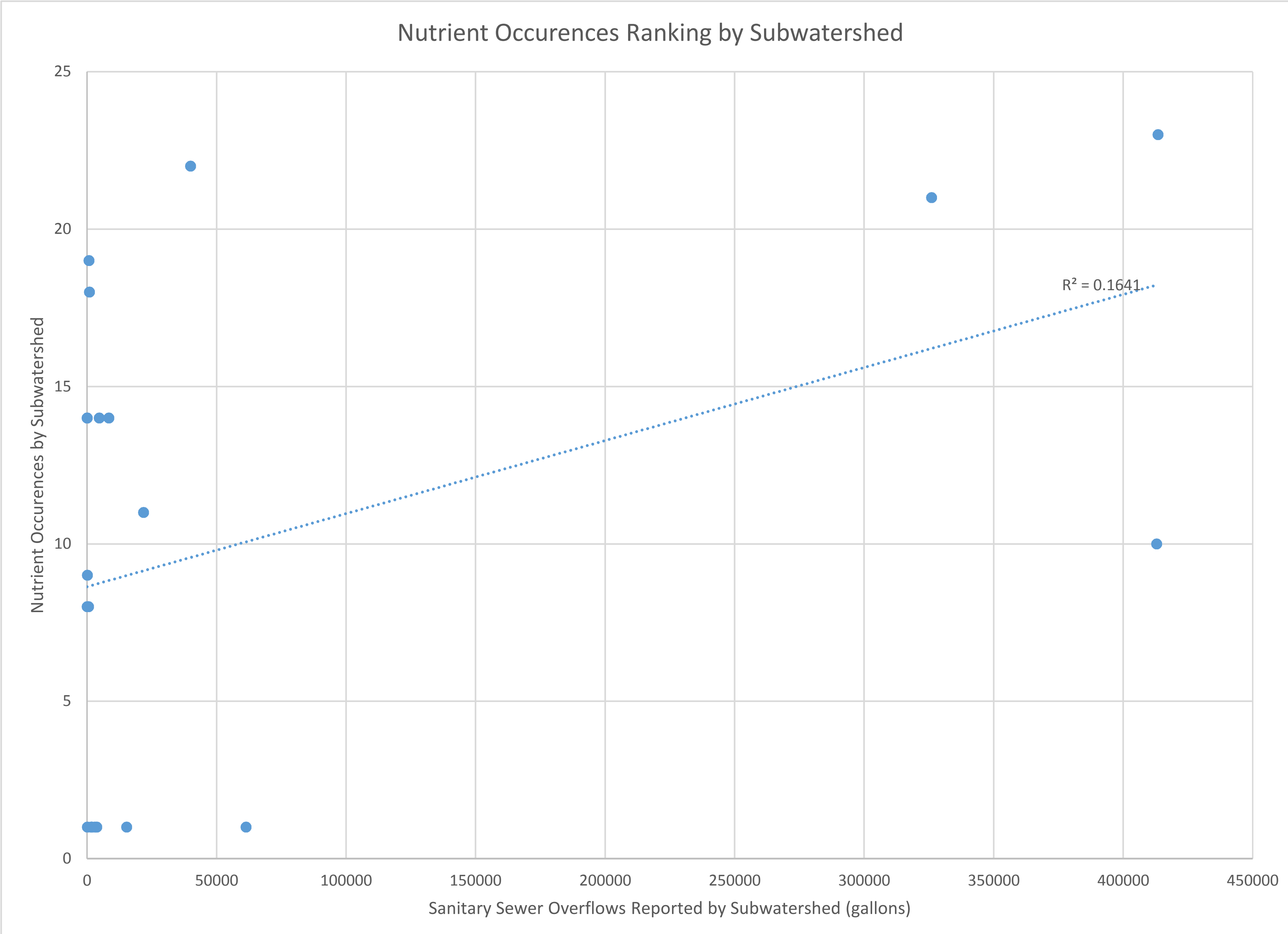
White Rock Creek (Headwaters)
Habitat Scores
Habitat Quality Index
30
25
20
15
10
5
0
2012 Spring
2012 Fall
2013 Spring
2013 Fall
White Rock Creek
Exceptional (>25)
High (>19)
Intermediate (>13)

Appendix AE

Sanitary Sewer Overflow Analysis



Indicator Bacteria Exceedance Ranking by Subwatershed
Bacteria Exceedances by Subwatershed
25
20
15
10
5
0
0
50000
100000
150000
200000
250000
300000
350000
400000
450000
Sanitary Sewer Overflow Reported by Subwatershed (gallons)
R² = 0.0376


Nutrient Occurences Ranking by Subwatershed
Nutrient Occurences by Subwatershed
Sanitary Sewer Overflows Reported by Subwatershed (gallons)
$R^2 = 0.1641$
0
5
10
15
20
25
0
50000
100000
150000
200000
250000
300000
350000
400000
450000

Appendix AF

Annual Load Tables

2012

Watershed	Drainage Area (acres)	Rainfall (in)	Avg. Slope (%)	Coefficient 1	Coefficient 2	Flow Estimation Method	Annual Flow Equation	Annual Flow	Comments
Prairie Creek	NA	28.38	NA	NA		Historical Regression	Mean Annual Flow (acre ft) = 293.52 * Annual Rainfall (in) - 2830.6	5499.4976	USGS 08057445 station was discontinued on 9/30/2011; Rain gage: Mesquite Metropolitan Airport (53970)
Headwaters White Rock Creek	15317	NA	NA	NA		Interpolation	Mean Annual Flow (acre ft) = 0.36 * Mean Annual Flow at White Rk Ck at Greenville Ave	19883.47136	USGS 08057200
Headwaters Ten Mile Creek	6733	33.91	NA	NA		Historical Regression	Mean Annual Flow (acre ft) = 264 * Annual Rainfall (in) - 4622	4330.24	Rain gage: Dallas Executive Airport (03971)
Johnson Creek	9089.43	31.25	3.166	-209.5798549	9.718797812	Reference Watershed	Mean Annual Flow (acre ft) = Annual Rainfall (in) * (10 * % Imp - 210)	15625	Rain gage: Arlington Municipal Airport (53907)
Delaware Creek	4662.22	31.5	1.167	-129.7489761	4.985037457	Reference Watershed	Mean Annual Flow (acre ft) = Annual Rainfall (in) * (5 * % Imp - 130)	7402.5	Rain gage: Dallas Love Field Airport (13960)
North Mesquite Creek	6266.45	28.38	3.016	-146.7330089	6.700352858	Reference Watershed	Mean Annual Flow (acre ft) = Annual Rainfall (in) * (7 * % Imp - 146)	10756.02	Rain gage: Mesquite Metropolitan Airport (53970)
Duck Creek	14589	28.38	NA	NA		Historical Regression	Mean Annual Flow (acre ft) = 796 * Annual Rainfall (in) - 13089	9501.48	Rain gage: Mesquite Metropolitan Airport (53970)
South Mesquite Creek	12560	28.38	NA	NA		Historical Regression	Mean Annual Flow (acre ft) = 790 * Annual Rainfall (in) - 13801	8619.2	Rain gage: Mesquite Metropolitan Airport (53970)

Data Sources:

Drainage areas for all watersheds are provided in the corresponding NCTCOG annual reports

Coefficient 1 and 2 were derived to allow for % Imp to be incorporated into the Annual Flow equation. For the full % runoff equation see the Reference Flows tab. The % runoff is being converted here to acre feet using the watershed DA and annual precipitation (as a variable

See Annual Flow Procedures word document located at J:\SC\PROJECTS\100024283 NCTCOG FY1\WR\Data Analysis\Flow Estimation for an explanation of the flow estimation methods

2012

Permitted Entity	Annual Flow (litre)	TDS(lb)	TSS(lb)	BOD (lb)	COD (lb)	Nitrogen Total (lb)	Phosphorus Dissolved (lb)	Phosphorus Total (lb)	Arsenic Total (lb)	Chromium Total (lb)	Copper Total (lb)	Lead Total (lb)	Zinc Total (lb)	Oil and Grease (lb)	E. coli (billion Col.)	Total coliforms (billion Col.)
City of Arlington	19273153711	11415538	8409399	767468	4178143	367429	1923	8144	163	336	1402	520	3888	1108270	4036441	89780774
City of Garland	11719903009	5701519	3721339	340971	1074633	346333	1475	12122	58	159	939	192	2054	40414	18063301	87166779
City of Irving	9130849302	3762456	3001181	513714	1659616	231420	975	4410	66	130	692	216	2427	77573	3191647	68863205
City of Mesquite(S.M.Creek)	10631626654	5355694	10342231	270832	1056490	257472	469	5274	53	252	838	246	1647	237901	1132268	46699420
City of Mesquite (N.M.Creek)	13267355314	6332454	12547912	303607	1243091	489559	1462	8702	132	234	790	197	1258	165258	2699907	62356570
City of Mesquite Total		11688148	22890143	574438	2299581	747030	1931	13975	184	486	1628	444	2904	403159	3832175	109055990
City of Plano	24525900792	13057857	15320678	594700	2318243	559555	1636	9124	210	291	1784	331	4339	176403	12247622	180326686
North Texas Tollway Authority	24525900792	12015511	8967597	511140	1880428	662595	1556	11835	198	228	1700	234	1959	480620	5602806	389961823
TxDOT-Dallas(Prairie Creek)	6783530405	4277122	1066775	154522	471082	198901	860	5346	34	90	531	93	909	30022	966653	104805545
TxDOT-Dallas(H.T.M.Creek)	5341272392	2313860	3008607	206422	1781025	165385	197	2797	35	53	341	56	474	38564	463355	45934943
TxDOT-Dallas Total		6590982	4075382.29	360944	2252106	364286	1057	8143	69	143	872	149	1382	68586	1430008	150740487

S.M. Creek = South Mesquite Creek
N.M.Creek = North Mesquite Creek
H.T.M.Creek = Headwaters Ten Mile Creek

2012

Watershed	Annual Flow (litre)	TDS(lb)	TSS(lb)	BOD (lb)	COD (lb)	Nitrogen Total (lb)	Phosphorus Dissolved (lb)	Phosphorus Total (lb)	Arsenic Total (lb)	Chromium Total (lb)	Copper Total (lb)	Lead Total (lb)	Zinc Total (lb)	Oil and Grease (lb)	E. coli (billion Col.)	Total coliforms (billion Col.)
Johnson Creek	19273153711	11415538	8409399	767468	4178143	367429	1923	8144	163	336	1402	520	3888	1108270	4036441	89780774
Duck Creek	11719903009	5701519	3721339	340971	1074633	346333	1475	12122	58	159	939	192	2054	40414	18063301	87166779
Delaware Creek	9130849302	3762456	3001181	513714	1659616	231420	975	4410	66	130	692	216	2427	77573	3191647	68863205
South Mesquite Creek	10631626654	5355694	10342231	270832	1056490	257472	469	5274	53	252	838	246	1647	237901	1132268	46699420
North Mesquite Creek	13267355314	6332454	12547912	303607	1243091	489559	1462	8702	132	234	790	197	1258	165258	2699907	62356570
Headwaters White Rock Creek (Plano)	24525900792	13057857	15320678	594700	2318243	559555	1636	9124	210	291	1784	331	4339	176403	12247622	180326686
Headwaters White Rock Creek (NTTA)	24525900792	12015511	8967597	511140	1880428	662595	1556	11835	198	228	1700	234	1959	480620	5602806	389961823
Headwaters White Rock Creek (Average)		12536684	12144137	552920	2099335	611075	1596	10480	204	259	1742	283	3149	328512	8925214	285144254
Prairie Creek	6783530405	4277122	1066775	154522	471082	198901	860	5346	34	90	531	93	909	30022	966653	104805545
Headwaters Ten Mile Creek	5341272392	2313860	3008607	206422	1781025	165385	197	2797	35	53	341	56	474	38564	463355	45934943

2013

Watershed	Drainage Area (acres)	Rainfall (in)	Avg. Slope (%)	Coefficient 1	Coefficient 2	Flow Estimation Method	Annual Flow Equation	Annual Flow	Comments
Prairie Creek	NA	26.82	NA	NA		Historical Regression	Mean Annual Flow (acre ft) = 293.52 * Annual Rainfall (in) - 2830.6	5041.6064	Rain gage: Dallas executive airport
Headwaters White Rock Creek	15317	NA	NA	NA		Interpolation	Mean Annual Flow (acre ft) = 0.36 * Mean Annual Flow at White Rk Ck at Greenville Ave	14578.77819	USGS discharge data for white rock creek
Headwaters Ten Mile Creek	6733	26.82	NA	NA		Historical Regression	Mean Annual Flow (acre ft) = 264 * Annual Rainfall (in) - 4622	2458.48	Rain gage: Dallas executive airport
Johnson Creek	9089.43	25.95	3.166	-209.5798549	9.718797812	Reference Watershed	Mean Annual Flow (acre ft) = Annual Rainfall (in) * (10 * % Imp - 210)	13052.85	Rain gage: Airlington municipal airport
Delaware Creek	4662.22	28.95	1.167	-129.7489761	4.985037457	Reference Watershed	Mean Annual Flow (acre ft) = Annual Rainfall (in) * (5 * % Imp - 130)	6875.625	Rain gage: Love field airport
North Mesquite Creek	6266.45	26.82	3.016	-146.7330089	6.700352858	Reference Watershed	Mean Annual Flow (acre ft) = Annual Rainfall (in) * (7 * % Imp - 146)	10333.746	Rain gage: Dallas executive airport
Duck Creek	14589	28.95	NA	NA		Historical Regression	Mean Annual Flow (acre ft) = 796 * Annual Rainfall (in) - 13089	9955.2	Rain gage: Love field airport
South Mesquite Creek	12560	26.82	NA	NA		Historical Regression	Mean Annual Flow (acre ft) = 790 * Annual Rainfall (in) - 13801	7386.8	Rain gage: Dallas executive airport

Data Sources:
Drainage areas for all watersheds are provided in the corresponding NCTCOG annual reports
Coefficient 1 and 2 were derived to allow for % Imp to be incorporated into the Annual Flow equation.
For the full % runoff equation see the Reference Flows tab. The % runoff is being converted here to acre feet using the watershed DA and annual precipitation (as a variable).
See Annual Flow Procedures word document located at J:\SC\PROJECTS\100024283 NCTCOG FY1\WR\Data Analysis\Flow Estimation for an explanation of the flow estimation methods.
NOAA airport precipitation data: http://cdo.ncdc.noaa.gov/qclcd/QCLCD
USGS monitoring station: http://nwis.waterdata.usgs.gov/nwis/annual/?search_site_no=08057200&agency_cd=USGS&referred_module=sw&format=sites_selection_links

2013

Permitted Entity	Annual Flow (litre)	Annual Load															
		TDS(lb)	TSS(lb)	BOD (lb)	COD (lb)	Nitrogen Total (lb)	Phosphorus Dissolved (lb)	Phosphorus Total (lb)	Carbaryl (lb)	Arsenic Total (lb)	Chromium Total (lb)	Copper Total (lb)	Lead Total (lb)	Zinc Total (lb)	Oil and Grease (lb)	E. coli (billion Col.)	Total coliforms (billion Col.)
City of Arlington	16100453403	14473111	1524158	728832	1872364	110271	2928	9377	2.1	77	172	674	154	1997	210604	26493	26974968
City of Garland	12279558389	8489176	3208719	208106	991260	173416	14280	29170	2.1	120	126	747	113	1532	113700	164034	28927570
City of Irving	8480958559	3793958	1529004	459871	1285115	61763	3194	7946	2.1	61	140	482	87	1294	88578	2643444	31361171
City of Mesquite(S.M.Creek)	9111483637	5970913	1779423	145967	681625	48611	1557	4017	2.1	40	100	395	80	1225	41179	21412	21377818
City of Mesquite (N.M.Creek)	12746488004	9842343	1248102	188487	505114	58169	2178	6112	2.1	70	98	590	112	946	51987	55129	25050036
City of Mesquite Total		15813256	3027524	334454	1186739	106780	3735	10129	4.3	110	199	985	193	2171	93165	76541	46427854
City of Plano	17982658110	14445489	3010509	235340	1192310	111996	3419	10407	2.4	143	188	923	206	2316	607553	4940735	43906908
North Texas Tollway Authority	17982658110	12235305	1893325	240940	1269617	102736	2577	10704	2.4	79	278	872	159	2079	305263	21619875	129724648
TxDOT-Dallas(Prairie Creek)	6218729926	4037540	324614	239853	592949	62105	1097	4353	2.4	34	41	302	82	487	21250	13059	22295701
TxDOT-Dallas(H.T.M.Creek)	3032490428	1659658	518121	52330	279451	15599	351	1538	2.4	13	23	123	27	245	13371	57693	10909384
TxDOT-Dallas Total		5697197	842734.774	292183	872400	77705	1448	5891	4.8	48	65	424	109	732	34621	70752	33205085.8

S.M. Creek = South Mesquite Creek
N.M.Creek = North Mesquite Creek
H.T.M.Creek = Headwaters Ten Mile Creek

2013

Watershed	Annual Flow (litre)	Annual Load															
		TDS(lb)	TSS(lb)	BOD (lb)	COD (lb)	Nitrogen Total (lb)	Phosphorus Dissolved (lb)	Phosphorus Total (lb)	Carbaryl (lb)	Arsenic Total (lb)	Chromium Total (lb)	Copper Total (lb)	Lead Total (lb)	Zinc Total (lb)	Oil and Grease (lb)	E. coli (billion Col.)	Total coliforms (billion Col.)
Johnson Creek	16100453403	14473111	1524158	728832	1872364	110271	2928	9377	2.1	77	172	674	154	1997	210604	26493	26974968
Duck Creek	12279558389	8489176	3208719	208106	991260	173416	14280	29170	2.1	120	126	747	113	1532	113700	164034	28927570
Delaware Creek	8480958559	3793958	1529004	459871	1285115	61763	3194	7946	2.1	61	140	482	87	1294	88578	2643444	31361171
South Mesquite Creek	9111483637	5970913	1779423	145967	681625	48611	1557	4017	2.1	40	100	395	80	1225	41179	21412	21377818
North Mesquite Creek	12746488004	9842343	1248102	188487	505114	58169	2178	6112	2.1	70	98	590	112	946	51987	55129	25050036
Headwaters White Rock Creek (Plano)	17982658110	14445489	3010509	235340	1192310	111996	3419	10407	2.1	143	188	923	206	2316	607553	4940735	43906908
Headwaters White Rock Creek (NTTA)	17982658110	12235305	1893325	240940	1269617	102736	2577	10704	2.1	79	278	872	159	2079	305263	21619875	129724648
Headwaters White Rock Creek (Average)		13340397	2451917	238140	1230964	107366	2998	10555	2.1	111	233	898	182	2197	456408	13280305	86815778
Prairie Creek	6218729926	4037540	324614	239853	592949	62105	1097	4353	0.8	34	41	302	82	487	21250	13059	22295701
Headwaters Ten Mile Creek	3032490428	1659658	518121	52330	279451	15599	351	1538	0.8	13	23	123	27	245	13371	57693	10909384

2014

Watershed	Drainage Area (acres)	Rainfall (in)	Avg. Slope (%)	Coefficient 1	Coefficient 2	Flow Estimation Method	Annual Flow Equation	Annual Flow	Comments
Rush Creek	18291	18.88	3.558	-404.9	19.6	Reference Watershed	Mean Annual Flow (acre ft) = Annual Rainfall (in) * (19.6 * % Imp - 404.9)	15288.56522	Rain Gage: Arlington Municipal Airport
Rowlett Creek	83962	NA	NA	NA	NA	Interpolation	Mean Annual Flow (acre ft) = 1.09 * Mean Annual Flow @ Rowlett Ck nr Saschse, TX	70370.00365	USGS monitoring station mean annual flow http://waterdata.usgs.gov/nwis/
Cottonwood Branch-Hackberry Creek	2868	21.32	2.626	-69.9	3.1	Reference Watershed	Mean Annual Flow (acre ft) = Annual Rainfall (in) * (3.1 * % Imp - 69.9)	4479.87328	Rain Gage: Dallas International Airport
South Mesquite Creek	9965	19.71	NA	NA	NA	Historical Regression	Mean Annual Flow (acre ft) = 790 * Annual Rainfall (in) - 13801	1769.9	Rain gage: Dallas Executive Airport
North Mesquite Creek	6257	19.71	1.407	-146.7	6.7	Reference Watershed	Mean Annual Flow (acre ft) = Annual Rainfall (in) * (6.7 * % Imp - 146.7)	3246.882503	Rain gage: Dallas Executive Airport
Pittman-Spring Creek	5590	NA	NA	NA	NA	Interpolation	Mean Annual Flow (acre ft) = 0.073 * Mean Annual Flow @ Rowlett Ck nr Saschse, TX	4712.853455	USGS monitoring station mean annual flow http://waterdata.usgs.gov/nwis/
Prairie-Elf Fork Trinity River	1264	21.32	1.86	-33.1	1.4	Reference Watershed	Mean Annual Flow (acre ft) = Annual Rainfall (in) * (1.4 * % Imp - 33.1)	819.46618	Rain Gage: Dallas International Airport
Prairie Creek	6004	19.71	NA	NA	NA	Historical Regression	Mean Annual Flow (acre ft) = 263.95 * Annual Rainfall (in) - 1204.3	3998.1545	Rain gage: Dallas Executive Airport
Headwaters Ten Mile Creek	6734	19.71	NA	NA	NA	Historical Regression	Mean Annual Flow (acre ft) = 264 * Annual Rainfall (in) - 4621.6	578.84	Rain gage: Dallas Executive Airport

2014

Permitted Entity	Annual Flow (litre)															
		TDS(lb)	TSS(lb)	BOD (lb)	COD (lb)	Nitrogen Total (lb)	Phosphorus Dissolved (lb)	Phosphorus Total (lb)	Arsenic Total (lb)	Chromium Total (lb)	Copper Total (lb)	Lead Total (lb)	Zinc Total (lb)	Oil and Grease (lb)	E. coli (billion Col.)	Total coliforms (billion Col.)
City of Arlington	18858167554	27373486	6685353	888209	1191289	140869	6946	5335	139	398	586	3478	28936	1849036	12769337	43730519
City of Garland	86800121582	61046885	53646852	3017262	4610330	646476	30139	29023	686	1611	3030	4274	157537	37214213	38260192	174974578
City of Irving	5525842336	6604517	1361044	191840	297105	15482	1381	1787	52	119	199	408	4729	1600344	4564254	23954987
City of Mesquite(S.M.Creek)	2183139509	3079686	796242	42835	83613	3742	343	286	20	43	56	114	1776	1376864	113196	4820918
City of Mesquite (N.M.Creek)	4004970603	5666241	72776	103009	166787	13553	795	839	33	84	115	207	3296	403060	486103	10833445
City of Mesquite Total	6188110112	8745927	869018	145844	250400	17295	1138	1125	54	127	171	322	5072	1779925	6941513	120165363
City of Plano	5813219152	1625479	1529408	285040	369448	23213	1089	1858	35	135	253	418	5110	905117	7427616	1309988087
North Texas Tollway Authority	1010796627	836662	502856	43292	72186	4596	708	669	9	23	48	47	858	195793	2033596	4749102
TxDOT-Dallas(Prairie Creek)	4931650969	6013207	575979	199860	224432	17722	1522	1142	65	136	226	465	4088	586018	736665	14765363
TxDOT-Dallas(H.T.M.Creek)	713988628	1126239	56949	18570	21883	1763	91	118	4	13	21	34	600	208524	354192	1550783
TxDOT-Dallas Total	5645639598	7139447	632929	218430	246315	19485	1613	1260	70	148	246	499	4688	794541	1090857	16316146

2014

Watershed	Annual Flow (litre)	TDS(lb)	TSS(lb)	BOD (lb)	COD (lb)	Nitrogen Total (lb)	Phosphorus Dissolved (lb)	Phosphorus Total (lb)	Arsenic Total (lb)	Chromium Total (lb)	Copper Total (lb)	Lead Total (lb)	Zinc Total (lb)	Oil and Grease (lb)	E. coli (billion Col.)	Total coliforms (billion Col.)
Rush Creek	18858167554	27373486	6685353	888209	1191289	140869	6946	5335	139	398	586	3478	28936	1849036	12769337	43730519
Rowlett Creek	86800121582	61046885	53646852	3017262	4610330	646476	30139	29023	686	1611	3030	4274	157537	37214213	38260192	174974578
Cottonwood Branch-Hackberry Creek	5525842336	6604517	1361044	191840	297105	15482	1381	1787	52	119	199	408	4729	1600344	4564254	23954987
South Mesquite Creek	2183139509	3079686	796242	42835	83613	3742	343	286	20	43	56	114	1776	1376864	113196	4820918
North Mesquite Creek	4004970603	5666241	72776	103009	166787	13553	795	839	33	84	115	207	3296	403060	486103	10833445
Pittman-Spring Creek	5813219152	1625479	1529408	285040	369448	23213	1089	1858	35	135	253	418	5110	905117	6520979	112885449
Prairie-Elf Fork Trinity River	1010796652	836662	502856	43292	72186	4596	708	669	9	23	48	47	858	195793	2033597	4749102
Prairie Creek	4931650969	6013207	575979	199860	224432	17722	1522	1142	65	136	226	465	4088	586018	736665	14765363
Headwaters Ten Mile Creek	713988628	1126239	56949	18570	21883	1763	91	118	4	13	21	34	600	208524	354192	1550783

2015

Watershed	Drainage Area (acres)	Rainfall (in)	Avg. Slope (%)	Coefficient 1	Coefficient 2	Flow Estimation Method	Annual Flow Equation	Annual Flow	Comments
Rush Creek	18291	63.12	3.558	-404.9	19.6	Reference Watershed	Mean Annual Flow (acre ft) = Annual Rainfall (in) * (19.6 * % Imp - 404.9)	50941.19669	Rain Gage: Arlington Municipal Airport
Rowlett Creek	83962	NA	NA	NA	NA	Interpolation	Mean Annual Flow (acre ft) = 1.09 * Mean Annual Flow @ Rowlett Ck nr Saschse, TX	304241.8162	USGS monitoring station mean annual flow http://waterdata.usgs.gov/nwis/inventory?agency_code=USGS&site_no=08061540
Cottonwood Branch-Hackberry Creek	2868	68.01	2.626	-69.9	3.1	Reference Watershed	Mean Annual Flow (acre ft) = Annual Rainfall (in) * (3.1 * % Imp - 69.9)	14240.41834	Rain Gage: Dallas International Airport
South Mesquite Creek	9965	63.81	NA	NA	NA	Historical Regression	Mean Annual Flow (acre ft) = 790 * Annual Rainfall (in) - 13801	36608.9	Rain gage: Dallas Executive Airport
North Mesquite Creek	6257	63.81	1.407	-170.6	6.7	Reference Watershed	Mean Annual Flow (acre ft) = Annual Rainfall (in) * (6.7 * % Imp - 170.6)	8957.069221	Rain gage: Dallas Executive Airport
Pittman-Spring Creek	5590	NA	NA	NA	NA	Interpolation	Mean Annual Flow (acre ft) = 0.073 * Mean Annual Flow @ Rowlett Ck nr Saschse, TX	20375.82806	USGS monitoring station mean annual flow http://waterdata.usgs.gov/nwis/inventory?agency_code=USGS&site_no=08061540
Prairie-Elm Fork Trinity River	1264	68.01	1.86	-33.1	1.4	Reference Watershed	Mean Annual Flow (acre ft) = Annual Rainfall (in) * (1.4 * % Imp - 33.1)	4663.302029	Rain Gage: Dallas International Airport
Prairie Creek	6004	63.81	NA	NA	NA	Historical Regression	Mean Annual Flow (acre ft) = 263.95 * Annual Rainfall (in) - 1204.3	15638.3495	Rain gage: Dallas Executive Airport
Headwaters Ten Mile Creek	6733	63.81	NA	NA	NA	Historical Regression	Mean Annual Flow (acre ft) = 264 * Annual Rainfall (in) - 4621.6	12221.24	Rain gage: Dallas Executive Airport

2015

Permitted Entity	Annual Flow (litre)	Annual Load															
		TDS(lb)	TSS(lb)	BOD (lb)	COD (lb)	Nitrogen Total (lb)	Phosphorus Dissolved (lb)	Phosphorus Total (lb)	Carbaryl (lb)	Arsenic Total (lb)	Chromium Total (lb)	Copper Total (lb)	Lead Total (lb)	Zinc Total (lb)	Oil and Grease (lb)	E. coli (billion Col.)	Total coliforms (billion Col.)
City of Arlington	62835041024	56841889	22854041	967605	2909049	453211	15353	25050	7.4	300	675	1530	820	4514	196245	19219668	136849483
City of Garland	375276755289	361131786	271492782	5396983	11844681	18282038	230964	363338	43.7	1517	5895	12272	3723	25854	1034169	18607472	396073342
City of Irving	17565297420	12830703	4447407	381016	780943	139408	3840	5957	2.0	77	119	642	142	942	127145	5074468	25103738
City of Mesquite(S.M.Creek)	45156413332	41264233	19214001	325534	1891485	877549	4729	7218	5.5	199	299	747	348	1468	144350	2748897	75749883
City of Mesquite (N.M.Creek)	11048382224	5236812	2336288	92923	183897	87443	1461	2192	1.3	67	70	359	85	335	145535	1032748	15863267
City of Mesquite Total	56204795556	46501045	21550289	418457	2075382	964992	6190	9410	6.8	266	369	1106	434	1803	289885	43888920	174024098
City of Plano	25133213886	10444537	10142352	429556	971037	262014	3740	6233	2.9	132	229	776	194	1545	185273	44921667	189887365
North Texas Tollway Authority	5752098368	4413014	1274924	81619	555114	48886	2077	3456	0.7	35	2501	306	60	552	15534	1182775	16393480
TxDOT-Dallas(Prairie Creek)	19289620116	7697187	7834652	215606	1073779	165851	7974	9994	2.4	276	776	840	223	1308	65915	3173143	14418991
TxDOT-Dallas(H.T.M.Creek)	15074677602	8275175	7360336	215437	988701	60818	2077	4320	1.8	66	1392	573	125	1163	40711	5430653	39929052
TxDOT-Dallas Total	34364297718	15972362	15194988	431043	2062480	226669	10051	14314	4.1	343	2168	1413	348	2471	106626	8603795	54348043

S.M. Creek = South Mesquite Creek
N.M.Creek = North Mesquite Creek
H.T.M.Creek = Headwaters Ten Mile Creek

2015

Watershed	Annual Flow (litre)	Annual Load															
		TDS(lb)	TSS(lb)	BOD (lb)	COD (lb)	Nitrogen Total (lb)	Phosphorus Dissolved (lb)	Phosphorus Total (lb)	Carbaryl (lb)	Arsenic Total (lb)	Chromium Total (lb)	Copper Total (lb)	Lead Total (lb)	Zinc Total (lb)	Oil and Grease (lb)	E. coli (billion Col.)	Total coliforms (billion Col.)
Rush Creek	62835041024	56841889	22854041	967605	2909049	453211	15353	25050	7.4	300	675	1530	820	4514	196245	19219668	136849483
Rowlett Creek	375276755289	361131786	271492782	5396983	11844681	18282038	230964	363338	43.7	1517	5895	12272	3723	25854	1034169	18607472	396073342
Cottonwood Branch-Hackberry Creek	17565297420	12830703	4447407	381016	780943	139408	3840	5957	2.0	77	119	642	142	942	127145	5074468	25103738
South Mesquite Creek	45156413332	41264233	19214001	325534	1891485	877549	4729	7218	5.5	199	299	747	348	1468	144350	2748897	75749883
North Mesquite Creek	11048382224	5236812	2336288	92923	183897	87443	1461	2192	1.3	67	70	359	85	335	145535	1032748	15863267
Pittman-Spring Creek	25133213886	10444537	10142352	429556	971037	262014	3740	6233	2.9	132	229	776	194	1545	185273	19625898	77818713
Prairie-Elf Fork Trinity River	5752098368	4413014	1274924	81619	555114	48886	2077	3456	0.7	35	2501	306	60	552	15534	1182775	16393480
Prairie Creek	19289620116	7697187	7834652	215606	1073779	165851	7974	9994	2.4	276	776	840	223	1308	65915	3173143	14418991
Headwaters Ten Mile Creek	15074677602	8275175	7360336	215437	988701	60818	2077	4320	1.8	66	1392	573	125	1163	40711	5430653	39929052

City of Dallas Load Estimation

Watershed	Area (acres)	Impervious(acres)	Impervious (%)		
Five Mile Creek Trinity River	30,302	4,541	15%		15%
Headwaters Turtle Creek	21,887	8,563	39%		
Turtle Creek-Trinity River	22,353	6,248	28%		
White Rock Creek_White Rock Lake	22,712	6,785	30%		30%
	97254	**26137**	26.9		
	24,314				

City of Dallas Load Estimation

Sample Dates	Sample ID	Event	Duration (hrs)	Rainfall Total (Inches)	Antecedent Dry Period (hrs)	Total Volume of Discharge Sampled (gal)
8/20/2015	WRC-100-3	3	2	0.45	1248	4
8/20/2015	WRC-200-3	3	2	0.45	1248	4
8/20/2015	WRC-300-3	3	2	0.45	1248	4
4/5/2015	WRC-100-2	2	6	0.92	689	4
4/5/2015	WRC-200-2	2	6	0.92	689	4
4/5/2015	WRC-300-2	2	6	0.92	689	4
1/31/2015	WRC-100-1	1	8	0.52	225	4
1/31/2015	WRC-200-1	1	8	0.52	225	4
1/31/2015	WRC-300-1	1	8	0.52	225	4
Average for Season			5.33	0.63	242.21	4

Watershed	Area (acres)	(sq ft)	Volume of rain (ft3)	vol (gal)	vol MG
FMC-TR	30,302	1319955120			
Headwater TC	21,887	953397720			
TC-TR	22,353	973696680			
WRC-WRL	22,712	989334720			
Average Area	24,314	1,059,096,060	51940072.59	388538724.8	388.5387248

Factor to multi conc to get load in lbs per event = 3235.362

Acre	Sq Feet
1	43560
inches	feet
1	0.083333333
cu foot	gallon
1	7.48051948
gallon	Liters
1	3.785

1gal=8.327 lbs

Load (pounds) = 0.226*R*C*A
R = Runoff (inches)
C = Concentration (mg/L)
A = Area (acres)

R = P*Rv*(H/D)
P = Rainfall
Rv = Runoff Coefficient
H = # of hours sample collect = time for composite = 1
D = Duration of Storm (hr)

City of Dallas Load Estimation

Sample Dates	Sample ID	Event	Duration (hrs)	Rainfall Total (Inches)	Antecedent Dry Period (hrs)	Total Volume of Discharge Sampled (gal)
9/9/2015	FMC-100-3	3	4.5	0.92	480	4
9/9/2015	FMC-200-3	3	4.5	0.92	480	4
9/9/2015	FMC-300-3	3	4.5	0.92	480	4
5/6/2015	FMC-100-2	2	2.5	0.16	197	4
5/6/2015	FMC-200-2	2	2.5	0.16	197	4
5/6/2015	FMC-300-2	2	2.5	0.16	197	4
3/13/2015	FMC-100-1	1	2.5	0.2	87	4
2/16/2015	FMC-200-1	1	3	0.12	363	4
2/16/2015	FMC-300-1	1	3	0.12	363	4
			3.278	0.409	316	4

Watershed	Area (acres)	(sq ft)	Volume of rain (ft3)	vol (gal)	vol MG		
FMC-TR	30,302	1319955120					
Headwater TC	21,887	953397720					
TC-TR	22,353	973696680					
WRC-WRL	22,712	989334720					
Average Area	24,314	1,059,096,060	44976248.35	336445701.9	336.4457019		
						Factor to multi conc to get load in lbs per event =	2801.583

Acre	Sq Feet
1	43560
inches	feet
1	0.083333333
cu foot	gallon
1	7.48051948
gallon	Liters
1	3.785

1gal=8.327 lbs

Load (pounds) = 0.226*R*C*A
R = Runoff (inches)
C = Concentration (mg/L)
A = Area (acres)

R = P*Rv*(H/D)
P = Rainfall
Rv = Runoff Coefficient
H = # of hours sample collect = time for composite = 1
D = Duration of Storm (hr)

City of Dallas Load Estimation

TestName	Units	Minimum	Maximum	Mean	Median	Standard Deviation	WRC-100-1 1/31/15	WRC-200-1 1/31/15	WRC-300-11/31/15	WRC-100-2 4/5/15	WRC-200-2 4/5/15	WRC-300-2 4/5/15	WRC-100-3 8/20/15	WRC-200-3 8/20/15	WRC-300-3 8/20/15
TDS, Total Dissolved Solids	mg/L	268	536	**346**	46	82.06095296	302	322	268	370	394	342	536	292	288
TSS. Total Suspended Solids	mg/L	29	99	**55.33**	3.305	25.23390576	29	36	64	37	59	37	46	91	99
BOD, 5 Day Biochemical Oxygen Demand	mg/L	1.9	20.7	**5.35**	6	6.283492546	1.9	1..71	1.97	4.72	4.15	3.73	2.88	20.7	2.73
COD, Chemical Oxygen Demand	mg/L	1	54	**12.22**	2.99	16.414763	1	6	5	5	6	11	18	54	4
Nitrogen Total	mg/L	0.84	6.61	**3.51**	0.06	2.343955584	1.16	0.84	1.02	6.61	6.21	6.27	2.95	3.5	2.99
Phosphorus Dissolved	mg/L	0.05	0.12	**0.0675**	0.09	0.023145502	0.08	0.06	0..05	0.05	0.05	0.06	0.06	0.12	0.06
Total Phosphorus (as P)	mg/L	0.06	0.24	**0.1067**	0.002	0.055901699	0.09	0.07	0.06	0.13	0.08	0.09	0.07	0.24	0.13
Arsenic, As	mg/L	0.002	0.004	**0.0022**	0.003	0.000666667	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.004
Chromium, Cr	mg/L	0.003	0.154	**0.0281**	0.01	0.052982177	0.154	0.076	0.004	0.003	0.003	0.004	0.003	0.003	0.003
Copper, Cu	mg/L	0.001	0.036	**0.0121**	0.004	0.010867894	0.02	0.007	0.036	0.012	0.015	0.01	0.001	0.007	0.001
Lead, Pb	mg/L	0.004	0.006	**0.0042**	0.015	0.000666667	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.006	0.004
Zinc, Zn	mg/L	0.005	0.043	**0.0176**	1.4	0.011854441	0.015	0.007	0.01	0.018	0.023	0.026	0.005	0.043	0.011
Oil & Grease, Total Recovered	mg/L	1.4	1.4	**1.4**	25	2.35514E-16	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4
E. coli	MPN	5	4000	**508.78**	#NUM!	1311.578322	100	25	5	4000	200	200	25	8	16

City of Dallas Load Estimation

TestName	Units	Minimum	Maximum	Mean	Median	Standard Deviation	FMC-100-1 3/13/15	FMC-200-1 2/16/15	FMC-300-1 2/16/15	FMC-100-2 5/6/15	FMC-200-2 5/6/15	FMC-300-2 5/6/15	FMC-100-3 9/9/15	FMC-200-3 9/9/15	FMC-300-3 9/9/15
TDS, Total Dissolved Solids	mg/L	176	1084	**401**	35	280.2873526	502	1084	456	254	272	210	248	176	404
TSS. Total Suspended Solids	mg/L	14	441	**106.22**	3.61	145.2375449	14	64	15	35	29	26	441	84	248
BOD, 5 Day Biochemical Oxygen Demand	mg/L	1.49	11.6	**4.249**	16	3.074558686	3.76	1.49	1.51	5.61	3.61	2.54	11.6	4.76	3.36
COD, Chemical Oxygen Demand	mg/L	1	106	**27.44**	6.68	32.84475267	4	1	4	27	13	16	106	45	31
Nitrogen Total	mg/L	0.72	14.9	**6.029**	0.13	4.471589327	6.68	1.26	0.72	14.9	8.12	6.69	9.23	3.71	2.95
Phosphorus Dissolved	mg/L	0.06	0.76	**0.2189**	0.25	0.220535963	0.09	0.13	0.06	0.15	0.13	0.09	0.76	0.35	0.21
Total Phosphorus (as P)	mg/L	0.07	1.07	**0.3667**	0.002	0.340881211	0.72	0.15	0.07	0.25	0.12	0.08	1.07	0.5	0.34
Arsenic, As	mg/L	0.002	0.005	**0.0024**	0.008	0.001013794	0.002	0.002	0.002	0.002	0.002	0.002	0.005	0.002	0.003
Chromium, Cr	mg/L	0.003	0.044	**0.0129**	0.006	0.013176157	0.008	0.044	0.021	0.016	0.004	0.003	0.011	0.004	0.005
Copper, Cu	mg/L	0.004	0.013	**0.0077**	0.004	0.003316625	0.008	0.006	0.01	0.006	0.004	0.004	0.013	0.006	0.012
Lead, Pb	mg/L	0.004	0.012	**0.0058**	0.018	0.003073181	0.004	0.004	0.004	0.004	0.004	0.004	0.01	0.006	0.012
Zinc, Zn	mg/L	0.004	0.065	**0.0223**	1.4	0.020396078	0.007	0.018	0.007	0.018	0.009	0.004	0.043	0.03	0.065
Oil & Grease, Total Recovered	mg/L	1.4	1.8	**1.44**	400	0.133333333	1.4	1.4	1.4	1.4	1.4	1.4	1.8	1.4	1.4
E. coli	MPN	6	8000	**1879**	#NUM!	3098.650755	400	8000	500	400	6600	65	550	390	6

City of Dallas Load Estimation

TestName	Units	Water Quality Standard	WRC Mean	**WRC Load (lbs)**	FMC Mean	**FMC Load (lbs)**
Duration of Storm Event	hr		5.33		3.278	
Rainfall	in		0.63		0.409	
Antecedent Dry Period	hr		242.21		316	
Total Volume of Discharge Sampled	gal		4		4	
Total Dissolved Solids (TDS)	mg/L		346	**21,789,668**	401	**20,609,815**
Total Suspended Solids (TSS)	mg/L		55.33	**3,484,458**	106.22	**5,459,288**
BOD	mg/L		5.35	**336,921**	4.249	**218,382**
COD	mg/L		12.22	**769,566**	27.44	**1,410,308**
Total Nitrogen	mg/L		3.51	**221,045**	6.029	**309,867**
Phosphorus Dissolved	mg/L		0.0675	**4,251**	0.2189	**11,251**
Total Phosphorus (as P)	mg/L		0.1067	**6,720**	0.3667	**18,847**
Arsenic (As)	mg/L		0.0022	**139**	0.0024	**123**
Chromium (Cr)	MPN		0.0281	**1,770**	0.0129	**663**
Copper (Cu)	mg/L		0.0121	**763**	0.0077	**396**
Lead (Pb)	mg/L		0.0042	**264**	0.0058	**298**
Zinc (Zn)	mg/L		0.0176	**1,108**	0.0223	**1,146**
Oil & Grease, Total Recovered	mg/L		1.4	**88,166**	1.44	**74,010**
E. coli	MPN		508.78	**422**	1,879	**1,098**

Load (pounds) = 0.226*R*C*A 0.226*P*Rv*(H/D)*C*A
R = Runoff (inches)
C = Concentration (mg/L)
A = Area (acres)

R = P*Rv*(H/D)
P = Rainfall
Rv = Runoff Coefficient 0.3
H = # of hours sample collect = time for composite = 1
D = Duration of Storm (hr)

Chemical Loading

Load (pounds) = 0.226*R*C*A = 0.226*P*Rv*(H/D)*C*A = X*C	WRC Acres	FMC Acres
Rv = Runoff Coefficient	0.3	0.15
H = # of hours sample collect	1	1
A = Area (acres)	22,712	30,302
X =0.226*P*Rv*(H/D)*C*A	62975.9188	51396.04769

Bacteria Loading

Load (pounds) = 1.03*(10-3)*R*C*A = 0.00103*P*Rv*(H/D)*C*A = X*C

C = Bacteria Concentration (#/100ml)		
Rv = Runoff Coefficient	0.3	0.15
H = # of hours sample collect	1	1
A = Area (acres)	22,712	30,302
X =0.00103*P*Rv*(H/D)*A	0.82952065	0.584136221

R = P*Rv*(H/D)
P = Rainfall
Rv = Runoff Coefficient 0.3
H = # of hours sample collect = time for composite = 1
D = Duration of Storm (hr)

City of Dallas Load Estimation

TestName	Units	Minimum	Maximum	Mean	Median	Standard Deviation	WRC-100-1 1/31/15	WRC-200-1 1/31/15	WRC-300-11/31/15	WRC-100-2 4/5/15	WRC-200-2 4/5/15	WRC-300-2 4/5/15	WRC-100-3 8/20/15	WRC-200-3 8/20/15	WRC-300-3 8/20/15	FMC-100-1 3/13/15	FMC-200-1 2/16/15	FMC-300-1 2/16/15	FMC-100-2 5/6/15	FMC-200-2 5/6/15	FMC-300-2 5/6/15	FMC-100-3 9/9/15	FMC-200-3 9/9/15	FMC-300-3 9/9/15
TDS, Total Dissolved Solids	mg/L	176	1084	373.3333333	41.5	202.31135	302	322	268	370	394	342	536	292	288	502	1084	456	254	272	210	248	176	404
TSS. Total Suspended Solids	mg/L	14	441	80.77777778	3.61	104.4591423	29	36	64	37	59	37	46	91	99	14	64	15	35	29	26	441	84	248
BOD, 5 Day Biochemical Oxygen Demand	mg/L	1.49	20.7	4.765882353	8.5	4.724345271	1.9	1..71	1.97	4.72	4.15	3.73	2.88	20.7	2.73	3.76	1.49	1.51	5.61	3.61	2.54	11.6	4.76	3.36
COD, Chemical Oxygen Demand	mg/L	1	106	19.83333333	3.605	26.37790965	1	6	5	5	6	11	18	54	4	4	1	4	27	13	16	106	45	31
Nitrogen Total	mg/L	0.72	14.9	4.767222222	0.09	3.698698985	1.16	0.84	1.02	6.61	6.21	6.27	2.95	3.5	2.99	6.68	1.26	0.72	14.9	8.12	6.69	9.23	3.71	2.95
Phosphorus Dissolved	mg/L	0.05	0.76	0.147647059	0.125	0.174983192	0.08	0.06	0..05	0.05	0.05	0.06	0.06	0.12	0.06	0.09	0.13	0.06	0.15	0.13	0.09	0.76	0.35	0.21
Total Phosphorus (as P)	mg/L	0.06	1.07	0.236666667	0.002	0.272115892	0.09	0.07	0.06	0.13	0.08	0.09	0.07	0.24	0.13	0.72	0.15	0.07	0.25	0.12	0.08	1.07	0.5	0.34
Arsenic, As	mg/L	0.002	0.005	0.002333333	0.004	0.000840168	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.004	0.002	0.002	0.002	0.002	0.002	0.002	0.005	0.002	0.003
Chromium, Cr	mg/L	0.003	0.154	0.0205	0.0075	0.038262637	0.154	0.076	0.004	0.003	0.003	0.004	0.003	0.003	0.003	0.008	0.044	0.021	0.016	0.004	0.003	0.011	0.004	0.005
Copper, Cu	mg/L	0.001	0.036	0.009888889	0.004	0.008123234	0.02	0.007	0.036	0.012	0.015	0.01	0.001	0.007	0.001	0.008	0.006	0.01	0.006	0.004	0.004	0.013	0.006	0.012
Lead, Pb	mg/L	0.004	0.012	0.005	0.0165	0.002300895	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.006	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.01	0.006	0.012
Zinc, Zn	mg/L	0.004	0.065	0.019944444	1.4	0.016368809	0.015	0.007	0.01	0.018	0.023	0.026	0.005	0.043	0.011	0.007	0.018	0.007	0.018	0.009	0.004	0.043	0.03	0.065
Oil & Grease, Total Recovered	mg/L	1.4	1.8	1.422222222	200	0.094280904	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.8	1.4	1.4
E. coli	MPN	5	8000	1193.888889	#NUM!	2413.488856	100	25	5	4000	200	200	25	8	16	400	8000	500	400	6600	65	550	390	6