FINAL REPORT

OWEB GRANT # 215-2046
Umpqua Basin Collaborative Monitoring

November 5, 2018

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Table of Contents

List of Tables

List of Graphs

List of Maps

List of Photos

Project Overview

This report updates the monitoring results of PUR's previous OWEB reports, OWEB Grant #209-2052, #212-2062, and #214-2046. Rather than report only the new monitoring, we have added it to the previously reported data to display a longer dataset which now, in certain areas, comprises 13 years of monitoring data. The South Umpqua Reference Run includes some of this long-term data as well as the addition of new reference sites from the Lookingglass/Olalla Watershed which completed three years of monitoring under our previous OWEB Grant. Three years of new monitoring is reported for the Lower South Umpqua Fifth Field Watershed which was collected entirely under grant #215-2046. All water quality data was collected by PUR's volunteer monitoring participants assisting PUR's Monitoring Coordinator and/or PUR's Assistant Monitoring Coordinator.

The objectives of water quality monitoring were to:

- Gather data on temperature, turbidity, conductivity, dissolved oxygen, pH, total coliform and *E. coli* bacteria that will lead to scientifically-based understanding of current and changing watershed conditions;
- Provide current water quality information to PUR's project planning team to support restoration planning;
- Collect and provide water quality data to complement others' work;
- Collect and provide data where none is currently being gathered;
- Gather data where future restoration efforts may be planned so that "pre" water quality parameters can be recorded;
- Provide "A" quality data to the ODEQ's AWQMS-Water Quality Monitoring Database

Monitoring Methods

Representativeness of Data:

Though our data will be compared from site to site, month to month and year to year, it must be stated that, except for the continuous temperature data, all water quality data are from grab sampling. As much as was possible, sampling runs were conducted at the same time of day and in the same direction, upstream or downstream, as previous runs. By taking monthly measurements it was possible to get some indication of annual changes, but even these monthly changes can be greatly affected by diurnal changes. Streamflow, pH, dissolved oxygen, trace elements, nutrients suspended particles as well as temperature are known to vary greatly over the course of a 24-hour period. Many of these changes are because of the sun either directly or indirectly – weather changes, seasonal changes, photosynthesis, rainfall, snowmelt, and streamflow. Other changes can be caused by human influence, such as the release of effluent from waste water treatment plants, release of water from reservoirs and irrigation withdrawals. "The amplitude of the diel changes can be as large as changes occurring on annual timescales" (Nimick, Gammons, & and Parker, 2011). Certainly, it would have been ideal to deploy data loggers for all water quality parameters and monitor 24 hours a day. With only one multi-parameter probe available, this would have severely limited the number of sites that could be monitored. Thus, we settled for grab sampling and report the data for what it is; a snap shot of water quality conditions at a particular place at a specific time. Data exceeding ODEQ standards is reported but conditions producing these exceedances may very well have occurred far more often than just at the time of our grab sampling.

Water Quality Parameters

Monitoring of all parameters followed standard methods as described in *Oregon Plan for Salmon and Watersheds Water Quality Monitoring Technical Guide Book*, *The EPA Guide to Volunteer Monitoring, YSI Product Training Manual* and the manufacturers' equipment manual recommendations and is approved by ODEQ under our Quality Assurance Project Plans. In 2007 PUR purchased a YSI Sonde multi-parameter device with funds received by the Council that were dedicated to improvement of water quality. DEQ uses Sondes for some of their data collection and approved its use in our *Quality Assurance Project Plan, 2008 Addendum.* Parameters and methods used are listed in Table 1.

Parameter	**Method**
E. coli & total coliform	IDEXX Colilert method, manufacturer's protocol
Turbidity	Nephelometric, Hach 2100P, following manufacturer protocols
Field Turbidity	YSI Optical wiping turbidity sensor in EXO2 Sonde datalogger, following manufacturer's protocols
Dissolved Oxygen	Hach kit Modified Winkler Method, manufacturer protocols
Dissolved Oxygen	YSI Dissolved Oxygen 550A Meter following manufacturer's protocols
Dissolved Oxygen	YSI ROX Optical Dissolved Oxygen Sensor in EXO2 Sonde datalogger, following manufacturer's protocols
Temperature	NIST thermometer and Sonde thermometer
Continuous Temperature	Onset Data Loggers
Conductivity	YSI Conductivity Meter Model 30 following manufacturer's protocols
Conductivity	YSI Conductivity Sensor in EXO2 Sonde datalogger, following manufacturer's protocols
pH	Orion pH probe and meter
pH	YSI Low Ionic Water pH sensor Combination pH and Gel Reference, manufacturer protocols

Table 1. Parameters monitored, and methods used in PUR's water quality monitoring

Parameter	Precision	Accuracy	Measurement Range
Temperature	±1.0°C	±0.5°	-5 to 35°C
pH	±0.3 SU	±0.2 SU	0 to 14 SU
Turbidity	±5% of Std. Value	±5% of Std. Value	0 to 1000 NTU
Conductivity	±10% of Std. Value	±7% of Std. Value	0 to 4999 μS/cm
Dissolved Oxygen	±0.3 mg/l	0.2 mg/l	1 to 14.6 mg/l
E. coli	±0.6 log		0 to >2420 MPN
Photo Points		± 3 feet	

Table 2. Precision and accuracy of water quality parameters measured

Precision: Duplicate sample results were used to determine the precision of water quality measurements for each sampling event. Differences between duplicate values were compared against precision requirements outlined in the DEQ Data Quality Matrix to assign data precision classifications.

Accuracy: Accuracy for pH, turbidity, and conductivity were determined by measuring standards before and after each sampling event. Deviations from standards were compared to accuracy ranges defined in the Data Quality Matrix to assign an accuracy classification for samples collected for each parameter. Temperatures were obtained with a NIST traceable thermometer that is calibrated by Oregon DEQ annually.

Split Samples: Split samples were conducted with the Oregon DEQ at least twice a year to further assess quality assurance.

Representativeness: Site selections were carefully chosen stream reaches that did not have contributing factors such as pond outflow or beaver dams upstream of collection sites. Samples were, when possible, collected from the center of the stream channel where the water is well mixed and, thus, most representative of the stream conditions.

Comparability: We hoped to insure comparability with similar projects by following standardized sampling protocols and procedures developed by state agencies. We also performed split samples at least twice a year ensure that our techniques produced results comparable to those of Oregon DEQ.

Turbidity Overview:

Turbidity in a stream appears cloudy to the human eye due to suspended particles. These particles could be silt or clay from sediment runoff but could also be from microscopic organisms. Measuring turbidity is easy with a light source and a detector such is supplied in the HACH kit and the YSI optical sensor used by PUR. These devises measure the amount of light scattered by the particles in the water which is then picked up by a detector. The result is expressed in nephelometric turbidity units or NTUs. High turbidity levels are a problem for both public and private drinking water systems. Furthermore, fish may experience trouble breathing if particles get into their gills. Fish and other aquatic creatures have trouble feeding due to diminished vision. Fish eggs and fry may suffocate if fine particles are deposited into the gravels where they are developing. Migrating salmon will choose to avoid waters with high turbidity and may even stop their migration until the waters clear. Several researchers have reported that turbidity levels in the 60-70 NTU range will disrupt the feeding behaviors of juvenile coho. Fry that have newly emerged are even more susceptible and have demonstrated reduced growth and a tendency to emigrate from streams with levels of 25-50 NTU. "Effects on salmonids will differ based on their developmental stage. Suspended sediments may affect salmonids by altering their physiology, behavior, and habitat, all of which may lead to physiological stress and reduced survival rates" (Bash, 2001).

The result of turbidity can even affect stream temperature. The deposition of fines has been shown to decrease streambed connectivity and reduce the exchange of ground water and surface water across the stream bed. "Sediment may alter the dynamics of heating, cooling, and temperature buffering. The two-way exchange between the stream channel and the hyporheic zone is perhaps the most important buffer to high stream temperatures" (Poole and Berman 2001 referenced by Bash, 2001).

Interpreting the results of turbidity data is more difficult than collecting it. Natural background levels can differ by unique individual watershed processes and historical changes to the watershed. For examples, headwater streams tend to be less turbid than mainstems. Grab sample monitoring makes it more difficult to draw conclusions because it is only a single moment in time and does not give a complete picture over space and time. DEQ standards for turbidity are currently under revision. As DEQ reports, "The current turbidity standard is outdated and inadequate to fully protect Oregon's waters from potential effects from turbidity. The current provisions, adopted in 1976, require no more than a ten percent increase over natural background turbidity levels. At low natural turbidity levels that are prevalent in Oregon waters much of the year, a ten percent increase is within the error range of measurement and does not correspond with an impact on beneficial uses. In addition, the expression of the standard has made it challenging to implement across all of DEQ's water quality programs" (Appendix B) (Turbidity Rulemaking Fact Sheet, 2010). Appendix C: British Columbia Turbidity and Suspended Sediment Standards has been included to provide specific levels that experts view of concern for various beneficial uses.

For this report we provide the percentage of grab sample readings at an individual site that exceed 10 NTU. This serves only as an indicator of sites that could use further investigation to determine if stream improvement projects might contribute to more favorable conditions for salmonids and other aquatic organisms.

The Oregon Watershed Assessment Manual recommends using 50 NTUs as the turbidity evaluation criteria for watershed assessments. At this level, turbidity interferes with sight-feeding aquatic organisms and provides an indication of the biological effect of suspended sediment. Seven out of 454 (1.5%) South Umpqua River turbidity samples exceeded 50 NTUs.61 Additional monitoring is necessary to determine if turbidity levels are of concern in tributaries.

pH Overview:

The negative logarithm of the hydrogen ion concentration of a solution is defined as pH with the scale from 0 to 14. This scale indicates the acidity or alkalinity of a solution, with pH 7.0 being neutral. As you climb the scale from 7 the solution becomes more basic or caustic. From 7 down the scale to 0 it becomes more acidic. In a logarithmic scale, each whole unit of incremental change is equal to a ten-fold increase or decrease in acidity or alkalinity. See Appendix D for a scale indicating the pH of common products.

The equipment used to measure pH consists of a meter and an electrode. The electrode measures the amount of positive hydrogen ions in the water by running a very low electric current through the water. The electrode placed in the stream then develops an electrical potential that is proportional to the pH of the solution. A reference electrode is needed to complete the circuit and provide a stable reference potential. The voltage is then passed to the meter, amplified, and converted to the pH scale. Because temperature influences the electrical potential of pH electrodes, pH probes must be equipped with a thermometer and automatic temperature compensation. Inaccuracy can be a problem when measuring low ionic strength waters common in the Umpqua. Ions need to be present in order to pass the low electric current. PUR purchased a special pH probe from YSI that is made to work in low ionic strength streams. This not only increases the accuracy, but also reduces the time for the equipment to become stable when moved from one stream to the next.

The following is DEQ's pH criteria for the Umpqua Basin, a summarization from the 303(d) Listing criteria at http://www.deq.state.or.us/wq/assessment/docs/methodology0406.pdf

Parameter	Criteria	Assessment Method	Data Requirements
pH	$6.5 \leq pH \leq 8.5$ Estuarine and fresh waters	Greater than 10 percent of the samples are outside the range of the appropriate criterion and a minimum of at least two samples outside the range of the appropriate criterion for the time period of interest.	A minimum of 5 representative data points available per site collected on separate days for each time period of interest. Time periods are Summer: June 1 through September 30; Fall-Winter-Spring (FWS): October 1 to May 31

Table 3. DEQ pH criteria for the Umpqua Basin

Evaluating grab sample pH data is difficult. As with other parameters, grab samples provide only a momentary snap-shot. Levels of pH cycle daily and seasonally. Photosynthesis of aquatic plants during the day takes the sun's energy and consume carbon dioxide (an acid) producing a base - hydroxide. Therefore, during the day, pH levels become more basic (rise). At night the reverse occurs, and plants respire releasing carbon dioxide making the waters more acid; peaking just before dawn. During summer there can be increased plant growth and nutrients that greatly increase this diurnal affect. Increasing acidity can have additional affects because it acts as a solvent and may leach toxic metals from sediments and substrate depending on local conditions. An unexplained change in pH might be an indication of contamination of the water by possible toxic materials from a spill or urban runoff and should be investigated.

Streams tend to have a narrow range of pH values that typically fall between 6 and 9. The level of the pH in freshwater streams is important for all forms of wildlife and humans. Aquatic organisms generally prefer a pH range between 6.5 and 8.5 and suffer when the pH lies outside this range. It is important to have safe pH ranges for juvenile development. "Chronic effects from low pH can occur at levels that are not toxic to adult fish but that impair reproduction including altered spawning behavior, reduced egg viability, decreased hatchability and reduced survival of the early life stages" (Carter, 2008). Persistent high pH levels can be harmful to salmonids by reducing their activity and feeding levels. Extremely low or high levels can even cause death.

Dissolved Oxygen Overview:

Oxygen is as necessary to aquatic life as it is to life on land. The amount of oxygen found in water is called dissolved oxygen (DO). Many factors influence how much oxygen water can contain as well as how it gets there. Temperature (oxygen is more soluble at colder temperatures), atmospheric pressure (increasing altitude results in less pressure and therefore less ability of water to hold dissolved oxygen), and salinity (increasing salt concentration results in lower DO) all affect DO. Turbulent water can increase DO as does photosynthesis of aquatic plants during the day. At night, aquatic plant respiration consumes the DO. Decomposition of organic matter also uses up dissolved oxygen. Once again grab sampling can only provide a snap-shot of that moment in time of day, season of year, and current stream condition.

Appendix E contains DEQ's flow chart depicting the evaluation process to determine which dissolved oxygen criteria would apply to any particular water body. Though not as thorough, it easier to understand in the following summarization from the 303(d) Listing criteria at http://www.deq.state.or.us/wq/assessment/docs/methodology0406.pdf

Parameter	Criteria	Assessment Method	Data Requirements
Dissolved Oxygen	*Spawning*: DO ≥ 11.0 mg/l or 95 % saturation; *Cold-water:* ≥ 8.0 mg/l or 90% as an absolute minimum; *Cool-water*: ≥ 6.5 mg/l; *Warm-water*: 5.5 mg/l.	For 10 or more samples greater than 10 percent of the samples may not exceed the appropriate criterion and a minimum of at least two exceedances of the criterion for the time period of interest. For 5 to 9 samples in the time period of interest, there may be no exceedances of the appropriate criteria.	A minimum of 5 representative data points available per site collected on separate days per applicable time period. Applicable time periods and fish use available on DEQ's Water Quality Standards web page.

Table 4. DEQ Dissolved Oxygen criteria for the Umpqua Basin

Dissolved oxygen is critical at all life stages of salmonids but, as is indicated in the criteria during time of spawning, there is the greatest need for high DO for survival of the eggs placed in the gravel. Without 11.0 mg/l DO egg development will be impaired or stopped altogether. Reduced DO concentrations can adversely affect swimming performance of migrating salmonids. Sustained swimming speed dropped sharply when DO fell to 6.5-7.0 mg/l (Bjornn T. a., 1991 pg.85).

Conductivity Overview:

Conductivity is a measure of water's ability to conduct an electric current. It is measured in units of current called microsiemens (µS) per centimeter (cm) or µS/cm. Conductivity increases with the number of dissolved ions present in water and with increasing temperature. Conductivity probes come with a built-in temperature probe and software that corrects the reading for the effect of temperature, normalizing conductivity to 25°C. This is then called specific conductance. Conductivity varies 2% with each 1°C change in temperature. Conductivity is affected by the natural local conditions/geology. Because it is a measure of the ions dissolved in the water, conductivity increase in areas with soils that will dissolve easily such as clay soils. Increases in conductivity may be an indication of human influences, such as leaking septic systems or spills of substances containing salts (ionic compounds, not just sodium chloride) that reach the streams. There are many types of soluble salts that increase conductivity when they are dissolved in water. Examples include potassium chloride, calcium chloride, and magnesium chloride. Acids and bases will also increase the conductivity of a solution. Organic compounds have a very low ability to conduct current, so substances like oil, and sugar have a very low conductivity.

There are no established standards for conductivity; however, "Conductivity is useful as a general measure of stream water quality. Each stream tends to have a relatively constant range of conductivity that, once established, can be used as a baseline for comparison with regular conductivity measurements. Significant changes in conductivity could then be an indicator that a discharge or some other source of pollution has entered a stream." "Studies in inland fresh waters indicate that streams supporting good mixed fisheries have a range between 150 and 500 uS/cm" (EPA, 2012).

E. coli Overview:

E. coli is monitored as an indicator species of bacteria. It would be extremely difficult and expensive to monitor for many of the organisms that carry disease. Therefore only *E. coli* was chosen for monitoring because its presence is an indication of fecal contamination and a warning that other pathogens may also be present. It can also be an indicator that best management practices of livestock are not being observed, of failing septic systems, of a large concentration of warm-blooded wildlife contaminating the water, or of a malfunctioning or overloaded wastewater treatment plant.

E. coli is easily measured with EPA approval by using the protocol and supplies from IDEXX Laboratories, Inc. A sample is collected in a sterile 100 milliliter (ml) bottle, kept on ice, and returned to a laboratory for analysis. The results are expressed in terms of a most probable number (MPN) of *E. coli* organisms in a 100 ml sample. The standard is a little difficult to comprehend, but a level greater than or equal to 126 MPN/100 ml determined five times in a 30-day period could cause a stream to be listed. A single reading greater than 406 MPN/100 ml could also trigger a listing.

The 303(d) Listing criteria for *E. coli* by Oregon Department of Environmental Quality listed at http://www.deq.state.or.us/wq/assessment/docs/methodology0406.pdf is shown below. The national Environmental Protection Agency uses a more conservative, lower criteria of 235 MPN/100 ml. In this report we will indicate both the 406 and the 235 criteria for comparison. The 235 MPN/100 ml criteria will be used as an indicator for evaluating streams in need of further investigation.

There are many possible sources of E. coli and other fecal bacteria in water. These can be divided into "point sources" and "non-point sources." The legal definition of a point source is one for which there is an operational permit, such as the outlet for a wastewater treatment plant. Stream contamination can also come from non-point sources, or ones for which there is no operational permit, such as animal waste. Although septic systems require an installation permit, there is no annual operational permit. These sources are considered non-point even if a single failing septic field adjacent to a stream is causing high fecal bacteria levels. Upland areas with concentrated fecal waste can be non-point sources that contribute significantly to bacteria levels because bacteria are washed down into streams during rain events.
According to the Oregon Water Quality Standards, a stream is considered water quality-limited for bacteria when one of two events occurs: 1) 10% of two or more samples taken from the same stream have *E. coli* concentrations exceeding 406 bacteria per 100 ml of water; and 2) the average *E. coli* concentration of five samples taken within a 30-day period exceeds 126 bacteria per 100 ml of water.

Bacteria taken from various locations along the South Umpqua River within the Lower South Umpqua Watershed. Twenty out of 130 samples (15%) exceed 126 bacteria per 100 ml. Five samples (3.8%) exceed 406 bacteria per 100 ml. The South Umpqua River from the mouth to stream mile 15.9 (the confluence with Roberts Creek) is 303(d) listed for fecal coliform in the fall, winter, and spring. From stream mile 15.9 to 57.7 (the confluence with Days Creek), the South Umpqua River is 303(d) listed all year.[59] Additional monitoring is necessary to determine if Lower South Umpqua Watershed tributaries have water quality-limiting levels of bacteria. (Geyer, South Umpqua Watershed Assessment and Action Plan, 2003)

Temperature Overview:

Stream temperature is an important factor affecting all aquatic organisms including fish. For salmonids (salmon and trout), which are coldwater fish, healthy growth is supported by water temperatures ranging from 40-66°F, outside this range they generally don't grow in size and extreme temperatures can be lethal (The Oregon Plan for Salmon and Watersheds, 1999, pp. 6-1). These temperature extremes can affect every life stage of the salmonids (Bjornn & Reiser, 1991, pp. 106, 112). Temperature and dissolved oxygen (DO) are inversely proportional, therefore, as stream temperature increases the amount of DO available decreases (The Oregon Plan for Salmon and Watersheds, 1999, pp. 6-1). Decreases in DO may metabolically stress salmonids and increase the likelihood of disease (The Oregon Plan for Salmon and Watersheds, 1999, pp. 6-1). As water temperature increases to stressful levels, salmonids seek cold water refugia (The Oregon Plan for Salmon and Watersheds, 1999, pp. 6-1) and (Nielsen, Lisle, & Ozaki, 1994). Extremely high-water temperatures can be lethal to coldwater fish. One study found the upper lethal limits for steelhead was 75.0°F and for cutthroat trout was 73.0°F (Bell, 1990, p. 11.4). The upper lethal limit for young coho salmon and Chinook salmon acclimated to 70°F was 78.8°F, measured as 50% mortality after 16.7 hours (Brett, 1952, pp. 282-3). Many of our monitoring sites exceeded these potentially lethal temperatures for steelhead and cutthroat and some even exceeded the higher lethal temperatures for coho and Chinook. However, unlike in these lab studies, in natural streams there is diurnal temperature fluctuation associated with night cooling, so these high stream temperatures are not sustained.

The driving factors for stream temperature are stream characteristics, such as flow and surface area, and radiant energy; the most important source being solar radiation. Solar radiation is reduced by shading and cloud cover and increased by solar input, which is often reflected by higher air temperatures. Streams in the Umpqua basin have been anthropogenically altered by removal of riparian vegetation, water withdrawals, and altered stream characteristics.

Since cloud cover and air temperatures vary daily and annually, there is also annual variability in stream temperatures and in seven-day average maximum (7DAM) stream temperatures. Stream temperature increases as it flows downstream due to decreased shading as the stream widens and increased surface area (Murphy & Meehan, 1991, pp. 35-36). In addition, stream temperatures may increase lower in the watershed due to a decreasing portion of cooler ground water inflow and increasing air temperature at lower elevations. The Umpqua Basin Stream Characterization project continuously monitored 269 stream temperature sites in the Umpqua basin from 1998 to 2001 and found a relationship between the sites distance to the drainage divide and the 7DAM stream temperature (Smith, K., 2003, p. 3).

Continuous Temperature:

Continuous summer temperatures were monitored from 2014-2017 using the protocol in the Water Quality Monitoring Technical Guide Book (The Oregon Plan for Salmon and Watersheds, 1999, pp. 6-1 to 6-12). Sites varied by year, with the number of years monitored varying from one to six years depending on the site. Onset water temperature recorders (Tidbit, Hobo, or Tidbit v2 models) were placed in streams in late spring or early summer and retrieved late summer or fall depending on flows and logistical concerns. Water temperature recorders were tied to rocks to prevent movement of the devices and hidden in the streams. Careful site selection was made to ensure there would be flow and good mixing (not stagnant) at the site in late summer when flows are the lowest to ensure the site would be representative of the stream at that location.

Prior to stream placement of water temperature recorders, pre-deployment accuracy checks were performed on all devices according to established protocols (The Oregon Plan for Salmon and Watersheds, 1999, pp. 6-5 to 6-7) and later modified by DEQ in 2010. Water temperature recorders are placed in warm and ice water baths comparing temperatures to National Institute of Standards and Technology (NIST) certified VWR Traceable Digital Thermometers that are inspected annually for accuracy by the DEQ Lab. Post-deployment accuracy checks are completed after retrieval of the water temperature recorders using the same method. Field accuracy checks are also conducted comparing NIST certified VWR Traceable Digital Thermometer temperatures to that of the water temperature recorders, when possible, at the time of deployment, mid-season, and at the time of retrieval. Care is taken to check the temperature with the digital thermometer near the location of the water temperature recorder.

Representativeness of Data:

Though our data will be compared from site to site, month to month and year to year, it must be stated that, except for the continuous temperature data, all water quality data are from grab sampling. As much as was possible, sampling runs were conducted at the same time of day and in the same direction, upstream or downstream, as previous runs. By taking monthly measurements it was possible to get some indication of annual changes, but even these monthly changes can be greatly affected by diurnal changes. Streamflow, pH, dissolved oxygen, trace elements, nutrients suspended particles as well as temperature are known to vary greatly over the course of a 24-hour period. Many of these changes are due to the effect of the sun either directly or indirectly – weather changes, seasonal changes, photosynthesis, rainfall, snowmelt, and streamflow. Other changes can be caused by human influence, such as the release of effluent from waste water treatment plants, release of water from reservoirs and irrigation withdrawals. “The amplitude of the diel changes can be as large as changes occurring on annual timescales” (Nimick, Gammons, & and Parker, 2011). Certainly, it would have been ideal to deploy data loggers for all water quality parameters and monitor 24 hours a day. With only one multi-parameter probe available, this would have severely limited the number of sites that could be monitored. Thus, we settled for grab sampling and report the data for what it is; a snap shot of water quality conditions at a particular place at a specific time. Data exceeding ODEQ standards is reported but conditions producing these exceedances may very well have occurred far more often than just at the time of our grab sampling.

Water Quality Data Analysis

Grab Sample Reporting:

All grab sample data was entered into ODEQ's Volunteer Water Quality Grab Sample Data Submittal Excel Spreadsheet which is available for download from their website (www.deq.state.or.us/lab/wqm/volmonresources.htm). (Soon to be directly uploaded into ODEQ's AWQMS database, not currently a requirement)

"The workbook contains two required worksheets. 1) **Worksheet1: Project Information-** This required worksheet includes specific project information needed to add the data into the DEQ LASAR database. 2) **Worksheet 2 Raw Data-** This worksheet contains all the fields needed to describe monitoring stations and result values in LASAR. The first six rows describe the monitoring location. The date and time define when the site was visited. The remaining rows are for entering the raw data results and all the information needed to describe each result in LASAR--including data quality. Each parameter has a family of 6 or 7 columns containing information needed for upload to LASAR: result value, duplicate value, precision, accuracy (not for all parameters), data quality level, method and parameter comment" (DEQ, 2010).

Only data which ranked as "A" or "B" quality was included for analysis in this report. (See Appendix H) Most data was "A"; in only a few cases was the data rated "B." Graphs were produced to compare individual sites and temporal changes. Box plots were used to summarize individual sites over the course of the period of record. (See Appendix J: Interpreting a Box Plot for help in understanding box plots.) For this report we did not discard any "outliers"; the data was carefully reviewed, and notes recorded at the time of sampling considered. It was felt that particularly low or high values were real and denoted a natural occurrence that was indicative of the watershed. Scatter plots were used to display sites' values over time and compared to DEQ standard criteria. Site values were summarized and presented in a table, when there was enough data to warrant doing so, by percent of measurements exceeding the parameter's standard criteria. For this report two time periods were used: 1. May 16 - October 14 and 2. October 15 through May15. This differs from the often-used Summer (June, July, August) and Fall/Winter/Spring (September through May) that others have employed. The weather conditions in the study area seem to lend themselves to this division as the month of September lends itself to inclusion as a summer month far better than skewing the Fall/Winter/Spring grouping with the warm September conditions.

Continuous Temperature:

All continuous temperature data collected were downloaded from the water temperature recorders with Onset's Boxcar or HOBOware Pro software and summarized using Microsoft Excel software and ESRI ArcGIS. Continuous temperature data was compared to ODEQ temperature criteria for continuous summer temperature (ODEQ, 2011, p. 46) and Figure 320A & 320B (ODEQ, 2003) (See Appendix K and Appendix L), using ODEQ's Temperature macro (for Microsoft Excel software) modified by Kent Smith for Excel 2007/2010 and for ODEQ's current temperature criteria (ODEQ, 2011, p. 46). All pre-deployment accuracy checks, post-deployment accuracy checks, and field audits were compiled on ODEQ's ExampleContinuousSample.xls workbooks (ODEQ, 2009) and submitted to the ODEQ lab. All data except one site were A quality (+/- 5°C) as per DEQ criteria (DEQ, 2010). The one site that was not A quality will be discussed in the appropriate result section.

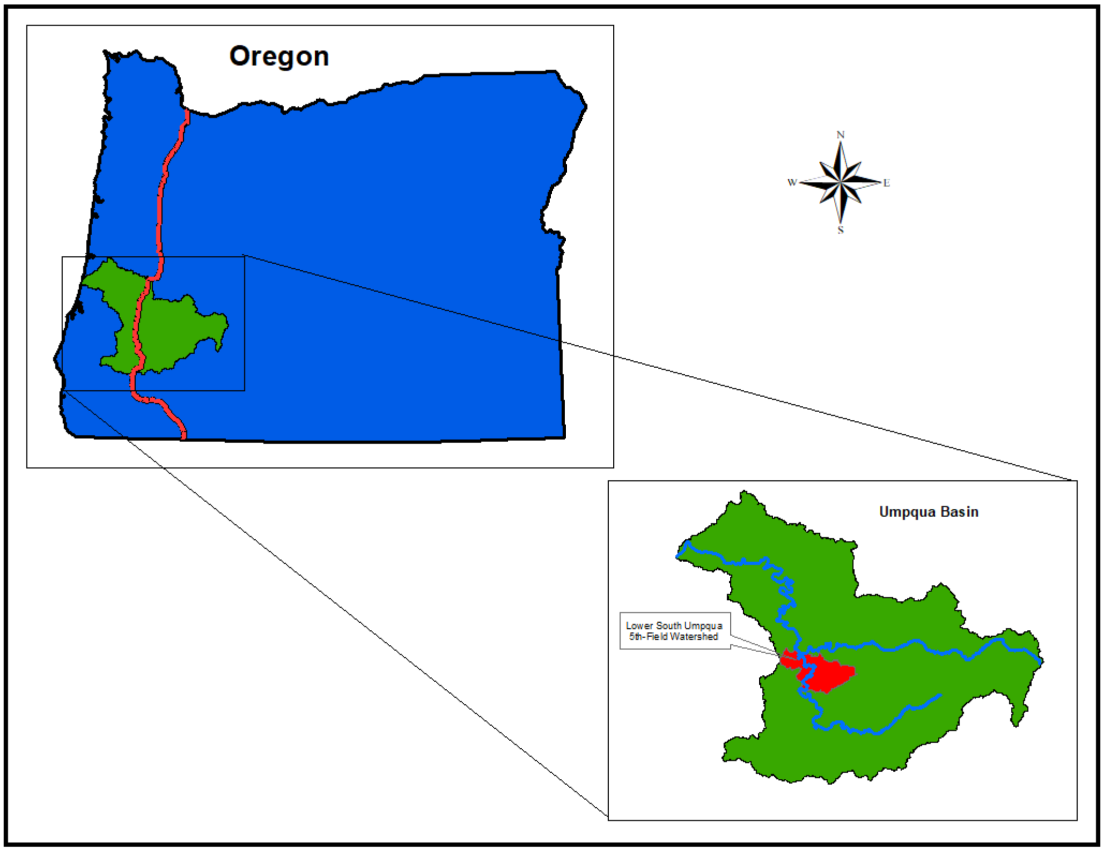
In the analysis, degrees Fahrenheit were chosen as the unit of temperature instead of degrees Celsius because PUR works with partners that use Fahrenheit as the standard of measure. For ease of communication to the public, and greater understanding, degrees Fahrenheit were chosen as the unit of measure.

Data was compared to that collected from a previous PUR large scale basin wide temperature study, Umpqua Basin Stream Temperature Characterization (Dammann, D.M., 2017).

Water Quality Monitoring Results

Lower South Umpqua Watershed

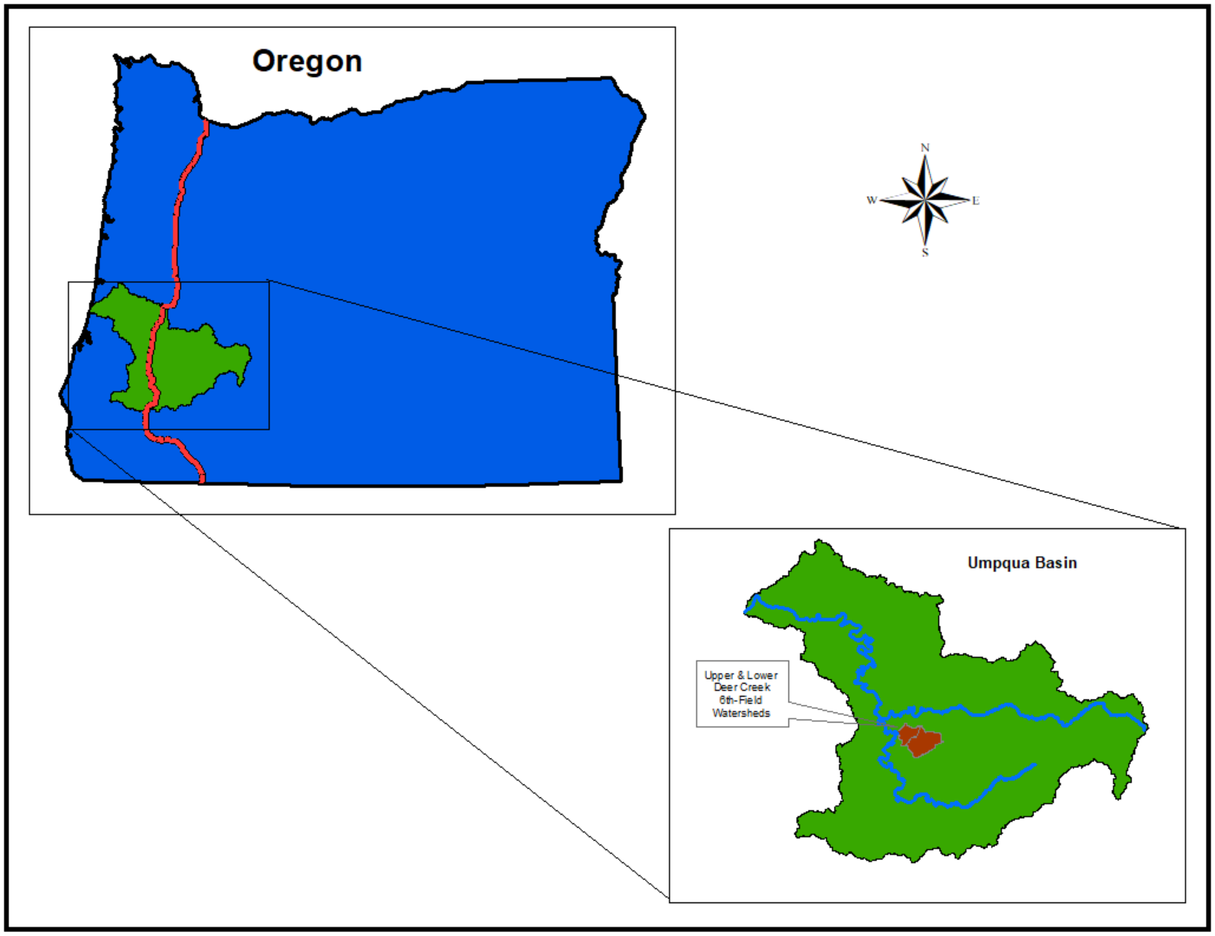
Area Description, Background & Monitoring Sites



Map 1. Lower South Umpqua Fifth-Field Watershed Area Map

The Lower South Umpqua fifth-field watershed is located in central Douglas County, Oregon, and includes the cities of Roseburg, and Winston. It is approximately 153,509 acres. PUR's Watershed Assessments report this region in two Assessments: The Deer Creek Watershed Assessment and Action Plan, consisting of two sixth-field watersheds, Lower Deer Creek HUC 171003021303 and Upper Deer Creek HUC 171003021302; and the Lower South Umpqua Watershed Assessment and Action Plan, consisting of three sixth-field watersheds, Newton Creek-South Umpqua River HUC 171003021305, Roberts Creek HUC 171003021301 and Champagne Creek HUC 171003021304. For the purposes of the general description they will be discussed separated by the Watershed Assessment and Action Plan areas. Data will be presented for the entire Lower South Umpqua fifth-field watershed, including all 5 sixth-fields.

Upper and Lower Deer Creek Sixth-Field Watersheds



Map 2. Upper and Lower Deer Creek Sixth-Field Area Map

Deer Creek, a tributary to the South Umpqua River, flows generally east to west and enters the South Umpqua in the center of Roseburg. The Deer Creek Watershed is 43, 090 acres in size and comprises two main tributaries: North Fork Deer Creek and South Fork Deer Creek which meet near Dixonville and then continues 5 miles on to the mouth in Roseburg. Lane Mountain at 3,468 feet above sea level is the highest point and the mouth at 420-foot elevation is the lowest. The topography is hilly to mountainous. Stream gradients average 4.5% in the tributaries and only 0.5% for the mainstem.

93.7% of the land is privately owned, with 6.06% BLM, 0.18% Douglas County, and O.02% State owned. The landscape in the lower regions is a mosaic of agriculture uses such as pasturelands, crop land and orchards intermixed with urban areas and rural residential development. In the mountains areas coniferous forests exist and forestry dominates the land use. In 2002 there were over 250 homes and dwellings within 300 feet of Deer Creek and its tributaries, all using on individual septic systems accept for 100 homes from the Library to the end of Douglas Street that are on a municipal sewage system.

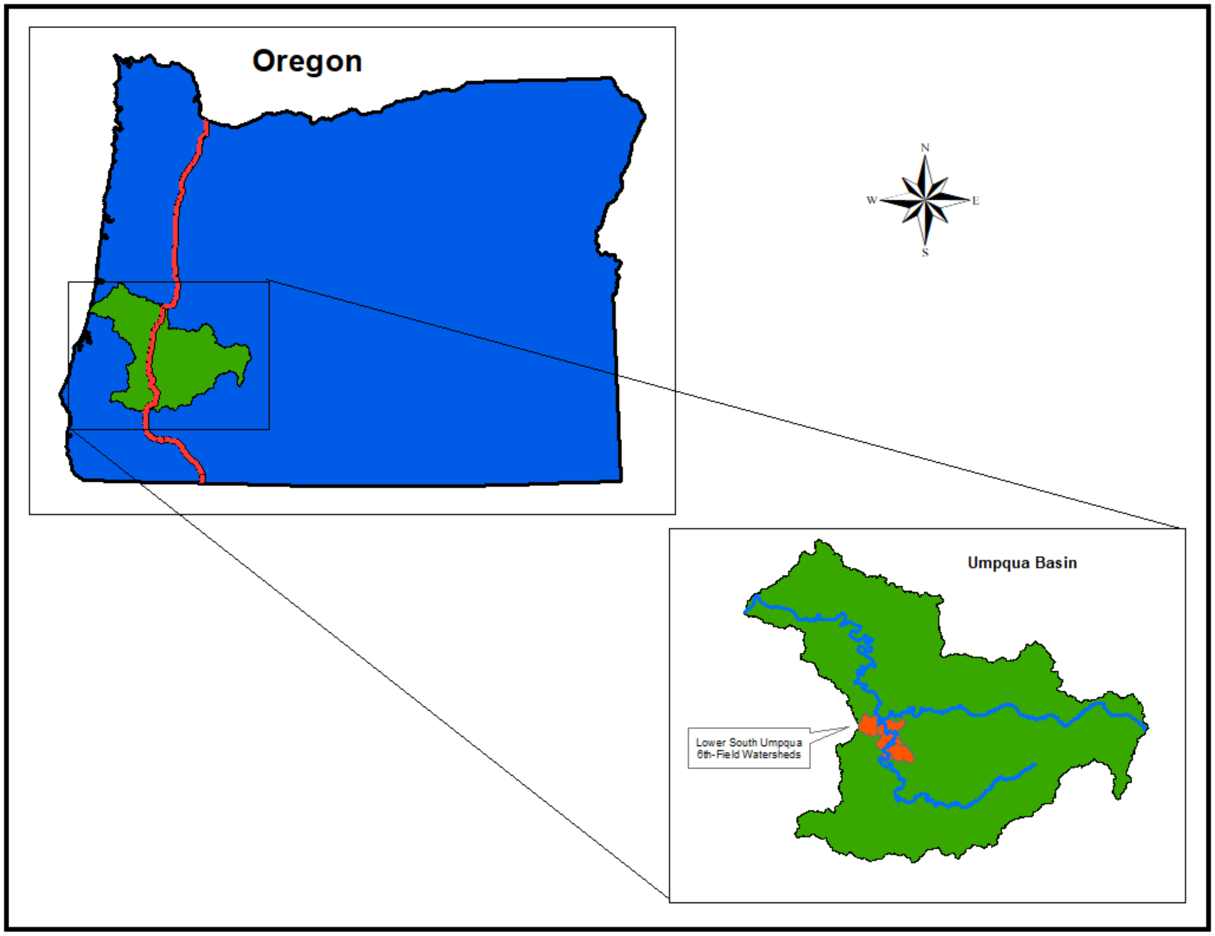
The land has dramatically changed since the 1840's when settlers from the east came to this area. Within a decade the scattered oak and prairie grassland were turned into farms with fencing. Five dairies appeared along South Fork Deer Creek. Many turkey farms existed in the 1930's and 40's. Prune orchards were plentiful. In the 50's and 50's there were about 15 sawmills in the South Fork Deer Creek Watershed. Landowners rerouted the creeks to suit their farming needs. When native plants and trees were removed from the riparian areas due to grazing, logging, flooding and other events, the opportunistic Himalayan blackberry took over, preventing native plants, shrubs and even trees from establishing themselves again. This plant has invaded most of the watershed riparian areas creating a monoculture in many areas.

Both anadromous and resident fish species are found in the Deer Creek Watershed. Coho salmon, winter steelhead trout, fall Chinook, cutthroat trout and Pacific lamprey use this watershed in addition to dace and sculpin and other smaller native fish.

The Umpqua Basin Fish Access Team surveyed the culverts in the Deer Creek Watersheds in 2003 as part of the basin wide culvert surveys. Only one culvert in these watersheds ranked in the top 75 culverts out of 2800 culverts surveyed. It is on a tributary where it goes under Highway 138 and not so important for fish use.

Photo 1.**Deer Creek below Fowler Street Bridge 9/7/17**

Newton Creek-South Umpqua River, Champagne and Roberts Creeks Sixth-Field Watersheds



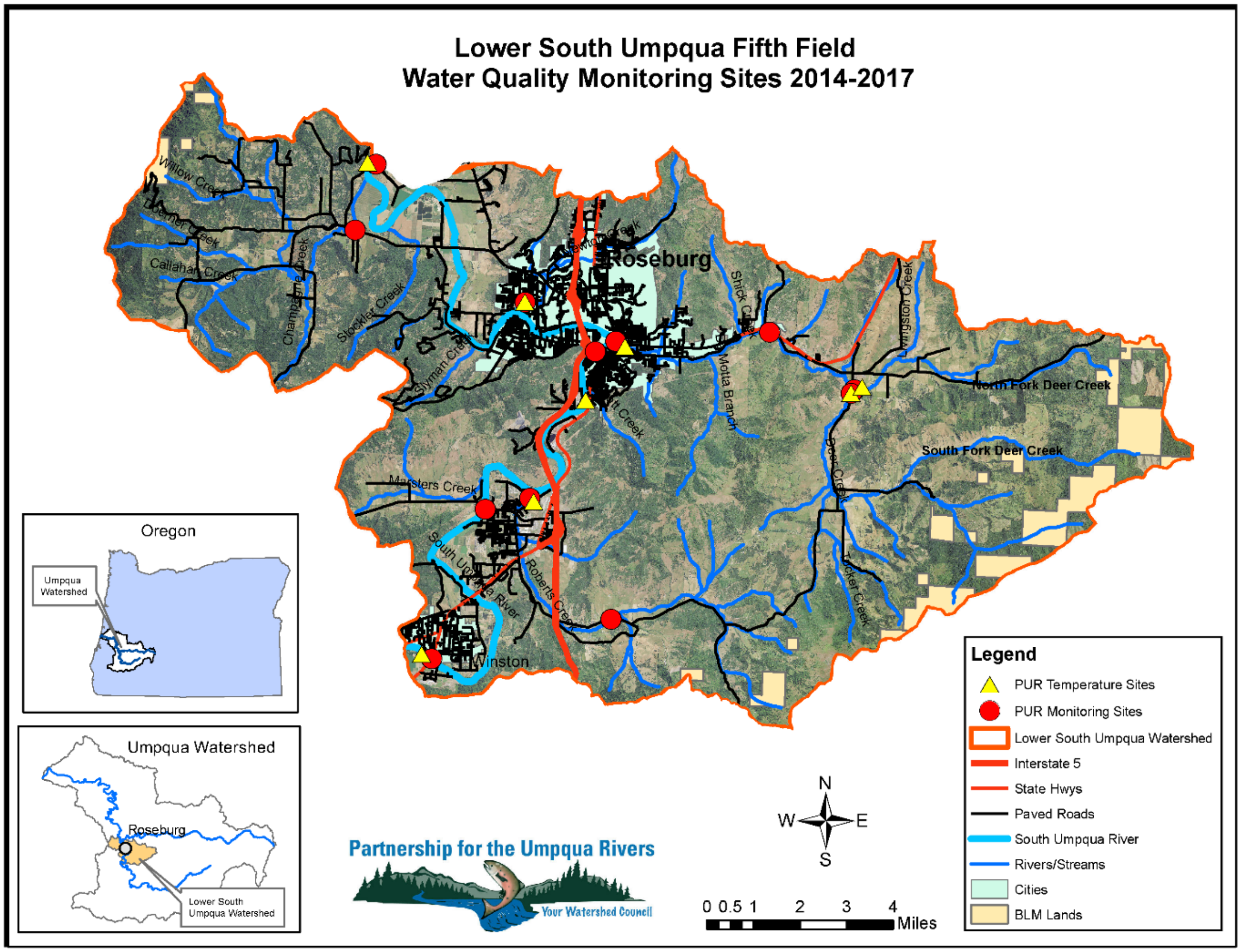
Map 3. Newton Creek-South Umpqua River, Roberts and Champagne Sixth-Field Watersheds Area Map

	Site ID	River/Stream	Location	Latitude	Longitude	Township, Range, Section
1	SU14	South Umpqua River	at Oak Ave. Bridge	43.211603	-123.350197	T27S R6W S24
2	SU14a	South Umpqua	At Templin Boat Ramp	43.207294	-123.356775	T27S R6W S25
3	DC1	Deer Creek	At Fowler Street Bridge	43.2124	-123.34	T27S R5W S19
4	DC2	Deer Creek	Off road near 5155 N Umpqua Hwy	43.218931	-123.277820	T27S R5W S23
5	NDC1	North Fork Deer Creek	At Dixonville Road Bridge	43.201780	-123.241418	T27S R5W S24
6	SDC1	South Fork Deer Creek	At private property Rd. Bridge 18276 Dixonville Rd.	43.201254	-123.241941	T28S R5W S1
7	RC2	Roberts Creek	Bridge on Roberts Creek Road before upper split with Glengary Loop Road	43.1279	-123.341	T28S R5W S18
8	SU12	South Umpqua River	HWY 99 Bridge between Thompson and East Dye Rd. Winston	43.11333	-123.416998	T28S R6W S21
9	SU13	South Umpqua River	At Happy Valley Road Bridge	43.1608	-123.396	T28S R6W S3
10	RC1	Robert Creek	At Carnes Rd Bridge	43.159683	- 123.382092	T28S R6W S2
11	NC1	Newton Creek	Near mouth, Jefferson Street Bridge	43.2255	-123.382	T27S R6W S14
12	SU15	South Umpqua River	At Singleton Park	43.2667	-123.447	T26S R6W S31
13	CC1	Champagne Creek	Melrose Road Bridge past Melrose School	43.2459	-123.455	T27S R6W S6

Table 5. Monitoring Sites in the Lower South Umpqua Watershed 2015-2017.

	Site ID	River/Stream	Location	Latitude	Longitude	Township, Range, Section
1	DC1	Deer Creek	Fowler Street Bridge	43.2124	-123.34	T27S R5W S19
2	NDC1	North Fork Deer Creek	At Dixonville Road Bridge	43.201780	-123.241418	T27S R5W S24
3	SDC1	South Fork Deer Creek	Bridge 18276 Dixonville Rd.	43.201254	-123.241941	T28S R5W S1
4	SU12	South Umpqua River	HWY 99 Bridge between Thompson and East Dye Rd. Winston	43.11333	-123.416998	T28S R6W S21
5	RC1	Robert Creek	At Carnes Rd Bridge	43.159683	- 123.382092	T28S R6W S2
6	NC1	Newton Creek	Near mouth, Jefferson Street Bridge	43.2255	-123.382	T27S R6W S14
7	SU15	South Umpqua River	At Singleton Park	43.2667	-123.447	T26S R6W S31
8	SU12.5	South Umpqua River	At Douglas County Fairgrounds boat ramp	43.211603	-123.350197	T27S R6W S24

Table 6. Temperature Recorder Sites in the Lower South Umpqua Watershed 2015-2017.



Map 4. Lower South Umpqua Watershed monitoring sites.

RESULTS – Lower South Umpqua Watershed

Turbidity

Turbidity levels in the Lower South Umpqua Watershed generally follow most watersheds in the Umpqua Basin where it is common to have elevated levels during the winter months coinciding with periods of elevated rain and stream flow. Graph 1 displays three years of monitoring data summarized by month. This clearly indicates that the extreme levels of turbidity occur during the winter months. Graph 2 also displays this trend. Roberts Creek exhibits the most occurrences of high turbidity at both sites as well as the highest level of all sites at upper Roberts Creek. Graph 3 and 4 indicate that all the high turbidity levels were outliers when plotted as box and whiskers. They are however, real events correlating to storm events. The tributaries, as might be expected, were generally worse than the South Umpqua. These are summarized in Table 7 and Table 8 indicating a trend in summer vs winter levels.

Thanks to the Oregon Water Resources Department (OWRD) through OWEB Grant #217-2054 we obtained the summer flow data for Deer Creek at Fowler Street and compared that to our grab sample turbidity. Graph 4 indicates that increases in summer flow did not produce significant turbidity increases. However, Graph 5 with one winter flow obtained from stream gage data indicates that it corresponds to a large turbidity spike.

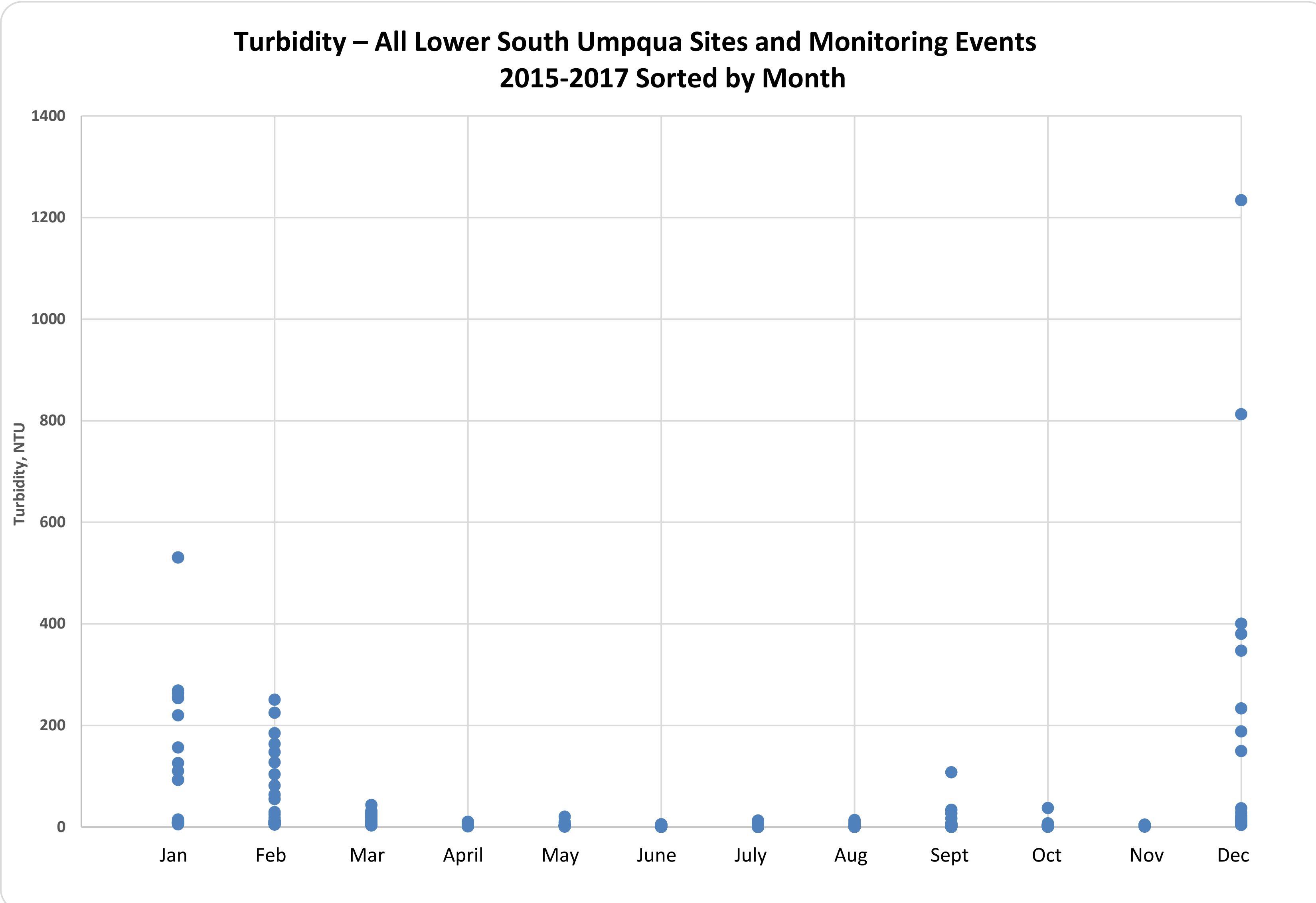
The elevation of turbidity on 9/7/2017 on lower Roberts Creek of 108 NTU as well as a call from DEQ telling us that reports had been made to them that Roberts Creek near Carnes Road was looking terrible, flagged a concern as to what was occurring. The PUR Monitoring Team went and hiked Roberts Creek in the area above Carnes Road. We were able to determine that there was no flow in Roberts Creek above the confluence with a side channel behind the Shop Smart. The small tributary was the source of the turbid water that came from a culvert under Highway 42 and came out behind the McDonald's. The water was coming from a ditch alongside highway 42 between the highway and McDonalds that disappeared into a culvert going under Roberts Creek Road heading toward the Chevron Station. We were unable to determine the source of the water. Further investigation should be undertaken to see if this tributary is affecting water quality in winter as well. This information was passed on to DEQ to investigate.

This water source is what triggered the red (extreme concern) that is displayed in Table 8 for the summer in lower Roberts Creek. For the winter data it is apparent that the site on upper Roberts Creek is contributing to the turbidity problem.

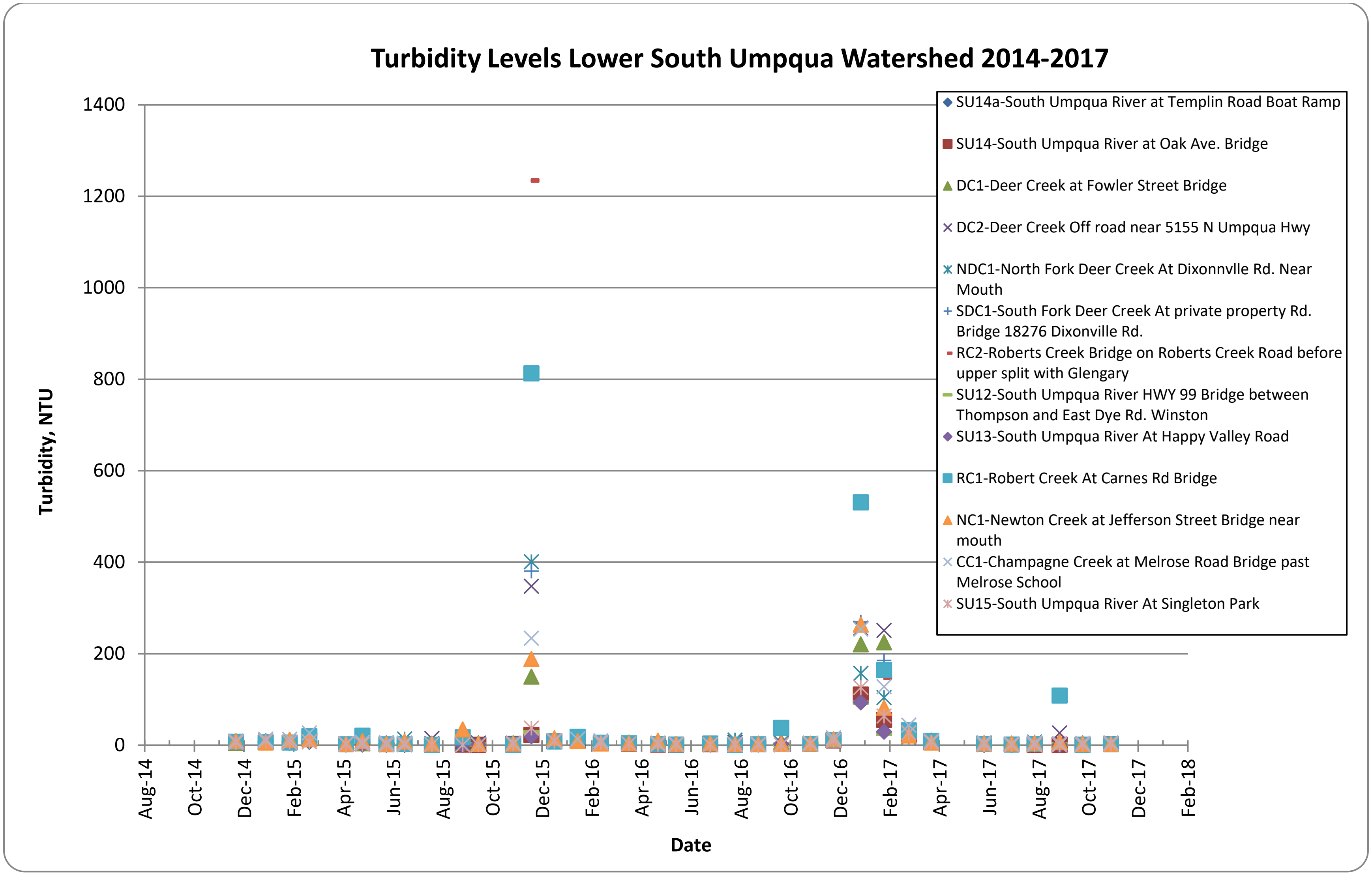
Photo 2. **Tributary flowing into Roberts Creek August 2017.**

Black arrow indicates tributary flow, red arrow indicates Roberts Creek Stream bed. Area at start of red arrow is dry.

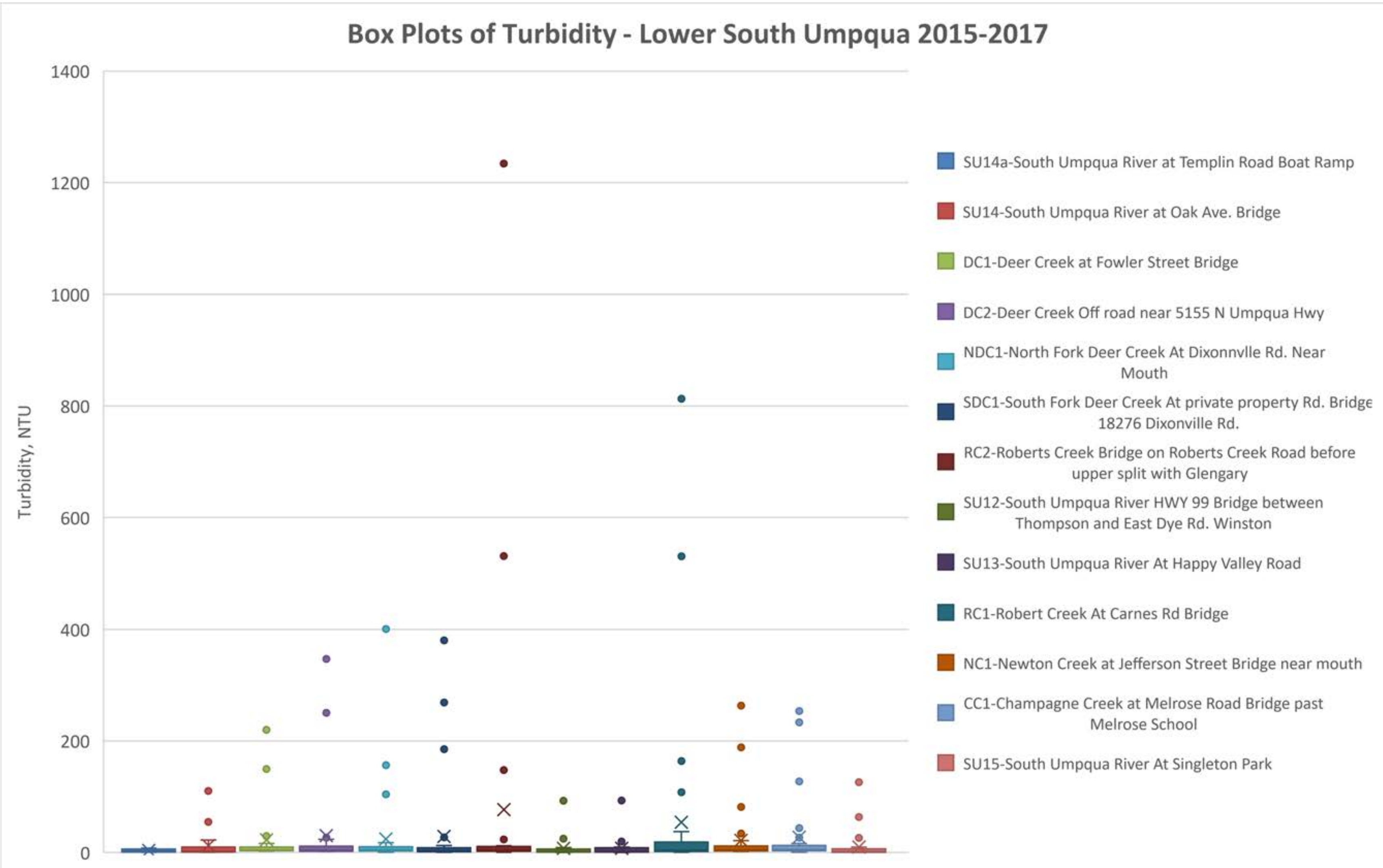
Photo 3. **Drainage between Highway 42 and McDonalds.**



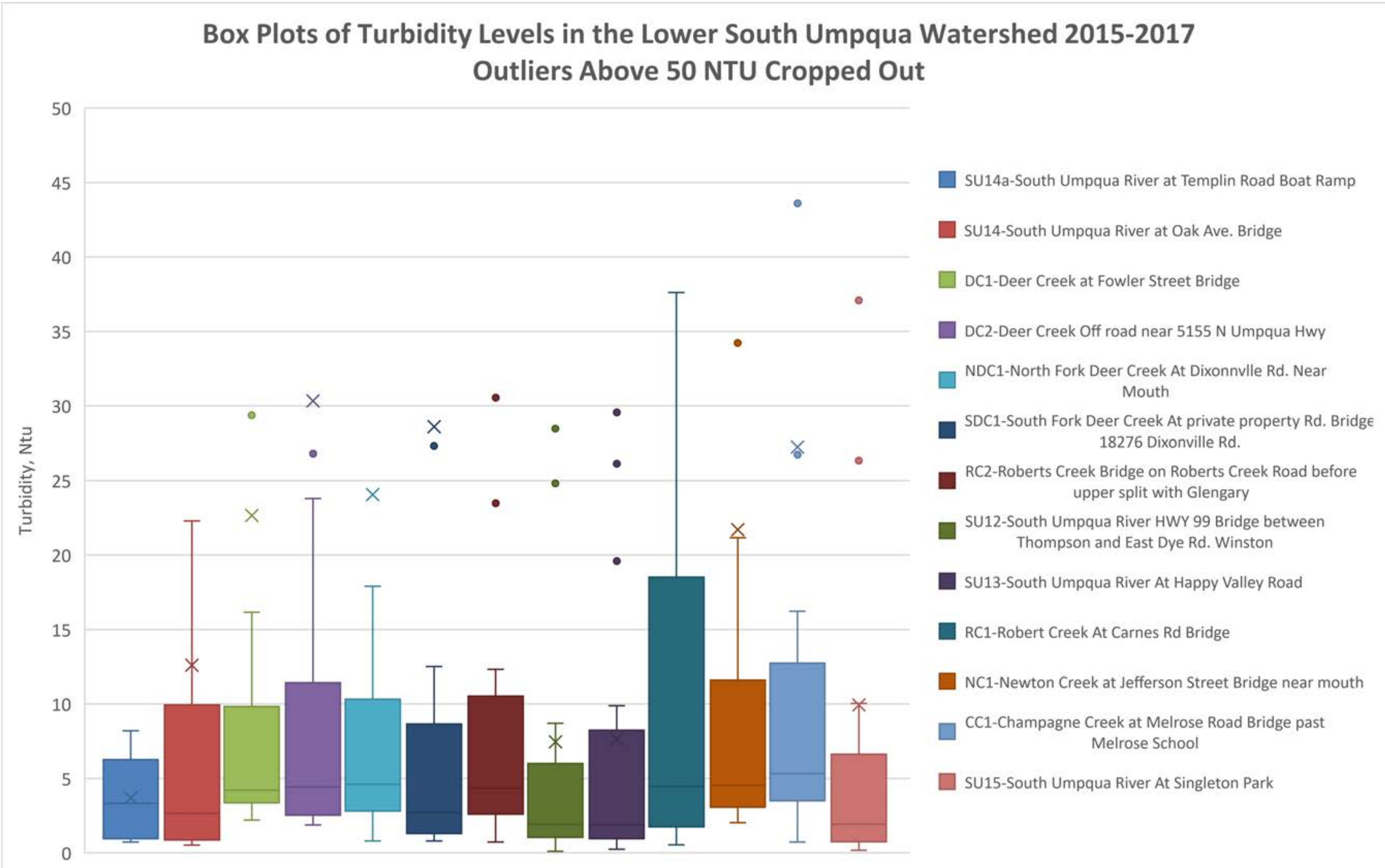
Graph 1. Turbidity levels Lower South Umpqua Watershed 2015-2017 all sites all data sorted by month.



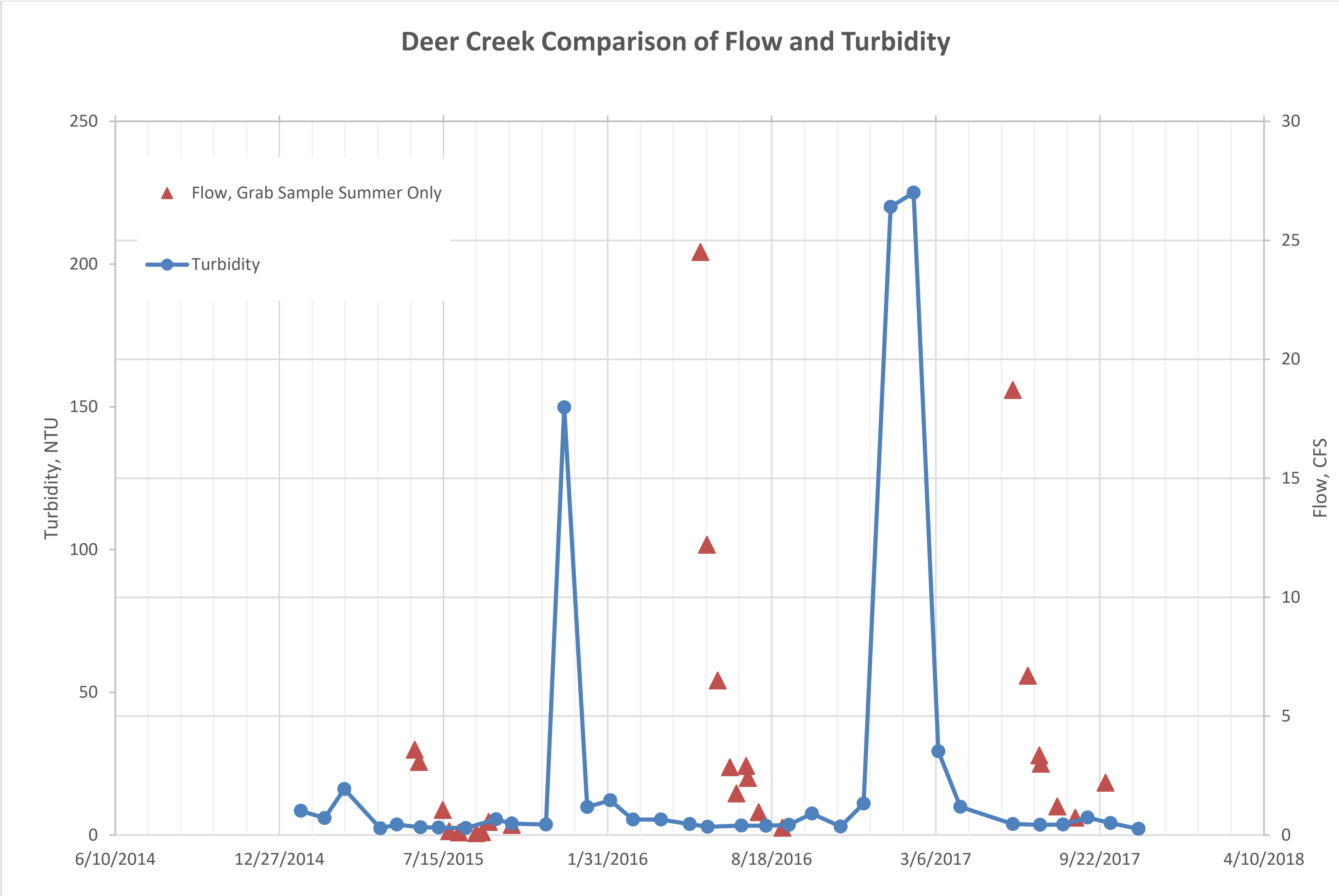
Graph 2. Turbidity Levels Lower South Umpqua Watershed 2015-2017 by site and date.



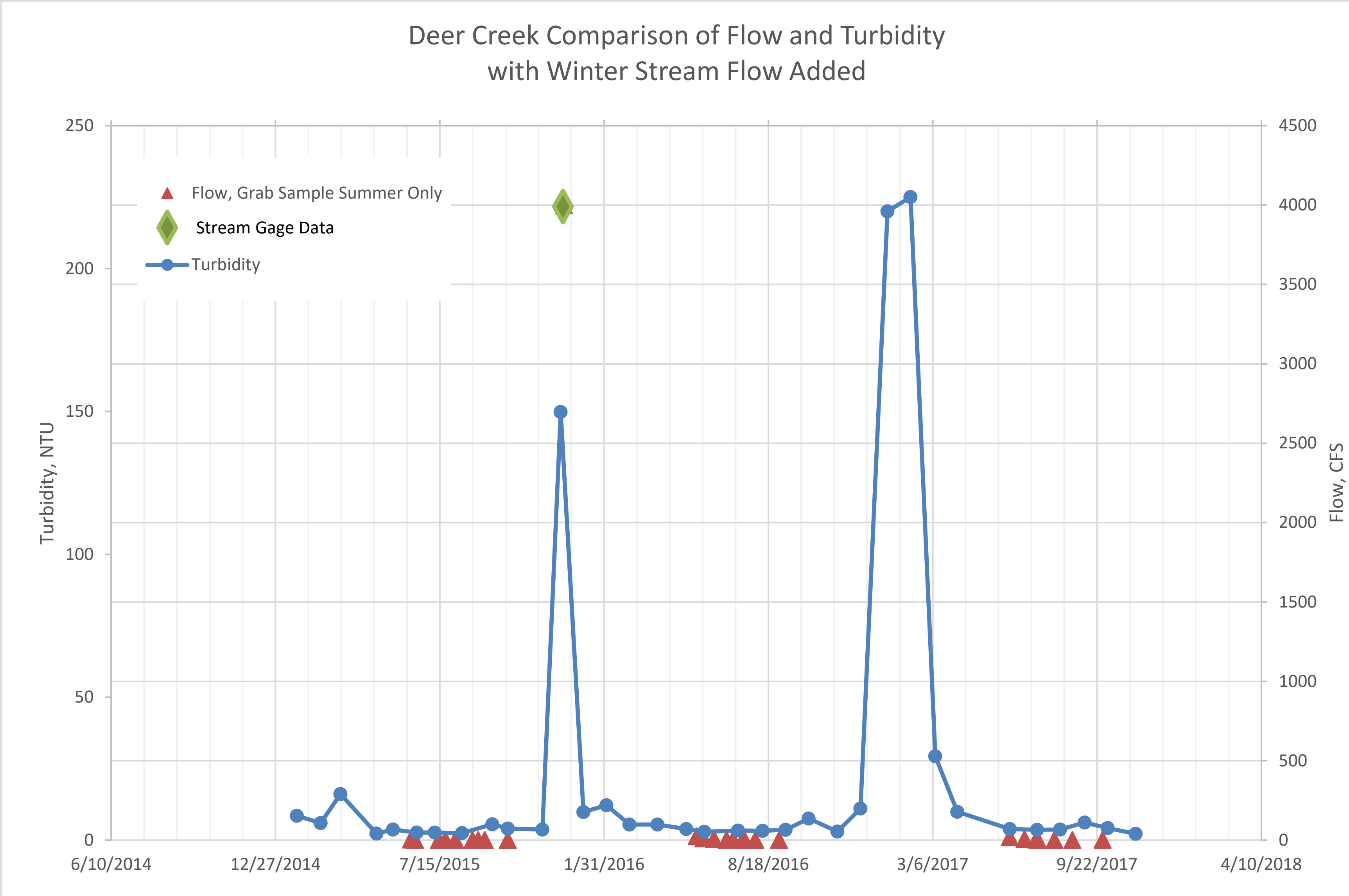
Graph 3. Box Plots of Turbidity levels at sites in the Lower South Umpqua monitored for 2015-2017.



Graph 4. Graph 4. Box Plots of Turbidity Levels for Lower South Umpqua Watershed Sites 2014-2017. Turbidity axis cropped to 50 NTU to expand box and whiskers for clarity.



Graph 5. Comparison of flow and turbidity for Deer Creek at Fowler Street Bridge. Flow collected by the Oregon Water Resources Department (OWRD) under an OWEB Grant was taken for summer months only.



Graph 6. Deer Creek at Fowler Street Bridge, comparison of summer flow from OWRD and one winter stream gage flow for 12/13/15.

Lower South Umpqua River Fifth Field	10 NTU or Greater		Total
Station ID - Site Description	Count	% of Samples	# of Samples
SU14-South Umpqua River at Oak Ave. Bridge*	5	17%	30
DC1-Deer Creek at Fowler Street Bridge	7	20%	35
DC2-Deer Creek Off road near 5155 N Umpqua Hwy	9	26%	35
NDC1-North Fork Deer Creek At Dixonnvlle Rd. Near Mouth	10	29%	35
SDC1-South Fork Deer Creek At private property Rd. Bridge 18276 Dixonville Rd.	5	15%	34
RC2-Roberts Creek Bridge on Roberts Creek Road before upper split with Glengary	8	30%	27
SU12-South Umpqua River HWY 99 Bridge between Thompson and East Dye Rd. Winston	4	11%	35
SU13-South Umpqua River At Happy Valley Road	4	11%	35
RC1-Robert Creek At Carnes Rd Bridge	11	32%	34
NC1-Newton Creek at Jefferson Street Bridge near mouth	9	26%	35
CC1-Champagne Creek at Melrose Road Bridge past Melrose School	10	32%	31
SU15-South Umpqua River At Singleton Park	5	15%	34

*Added SU14a-South Umpqua River at Templin Road Boat Ramp to Oak Ave. Bridge data because they are so close to each other.

Table 7. Summary by site of turbidity levels equal to or exceeding 10 NTUs.

Turbidity Levels, Summer and Winter, Lower South Umpqua Sites 2015-2017

SITE	Summer (May 1 - Sept.30)			Winter (Oct 1-April 30)		
	Total # Samples	# > 10 NTU	% > 10 NTU	Total # Samples	# > 10 NTU	% > 10 NTU
SU14-South Umpqua River at Oak Ave. Bridge*	11	0	0%	19	5	26%
DC1-Deer Creek at Fowler Street Bridge	14	0	0%	21	7	33%
DC2-Deer Creek Off road near 5155 N Umpqua Hwy	14	2	14%	21	7	33%
NDC1-North Fork Deer Creek at Dixonville Rd. Near Mouth	13	2	15%	22	7	32%
SDC1-South Fork Deer Creek Bridge 18276 Dixonville Rd.	14	0	0%	21	5	24%
RC2-Roberts Creek Bridge on Roberts Creek	7	0	0%	20	8	40%
SU12-South Umpqua River HWY 99 Bridge	14	0	0%	21	3	14%
SU13-South Umpqua River at Happy Valley Road	14	0	0%	21	4	19%
RC1-Robert Creek at Carnes Rd Bridge	14	3	21%	20	8	40%
NC1-Newton Creek at Jefferson Street Bridge near mouth	14	1	7%	21	7	33%
CC1-Champagne Creek at Melrose Road Bridge past Melrose School	12	0	0%	19	10	53%
SU15-South Umpqua River at Singleton Park	14	0	0%	20	5	25%

*Added SU14a-South Umpqua River at Templin Road Boat Ramp to Oak Ave. Bridge data because they are so close.

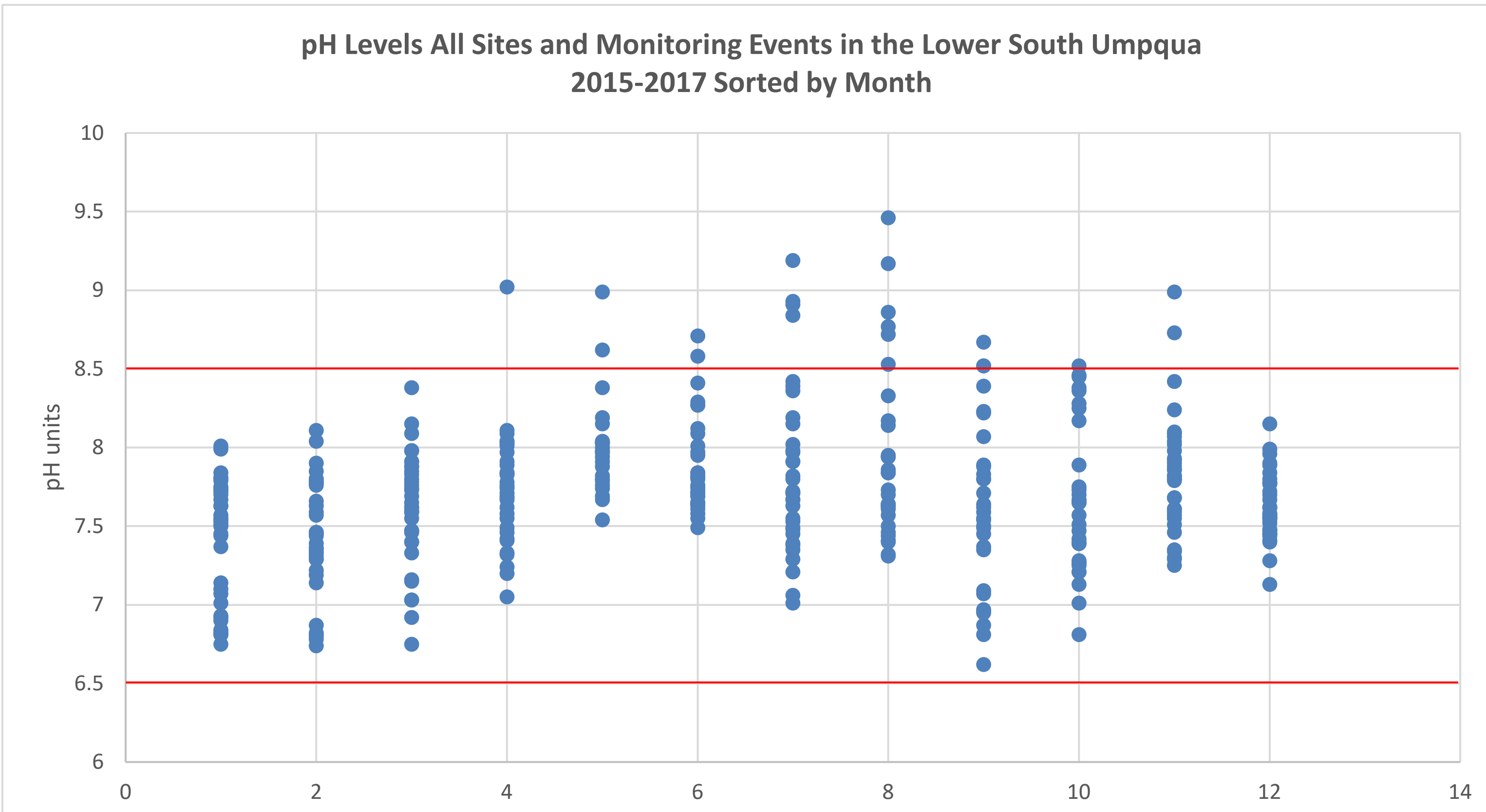
Color Key:	Level of Concern	Color Key Evaluation Criteria
	No Concern	< 10 NTU
	Low Concern	Between 1 % and 9% of samples ≥10NTU
	High Concern	Between 10% and 20% ≥10 NTU
	Extreme Concern	20% or more ≥10 NTU

Table 8. Turbidity levels summer and winter Lower South Umpqua Watershed sites 2015-2017 with Color Key ratings.

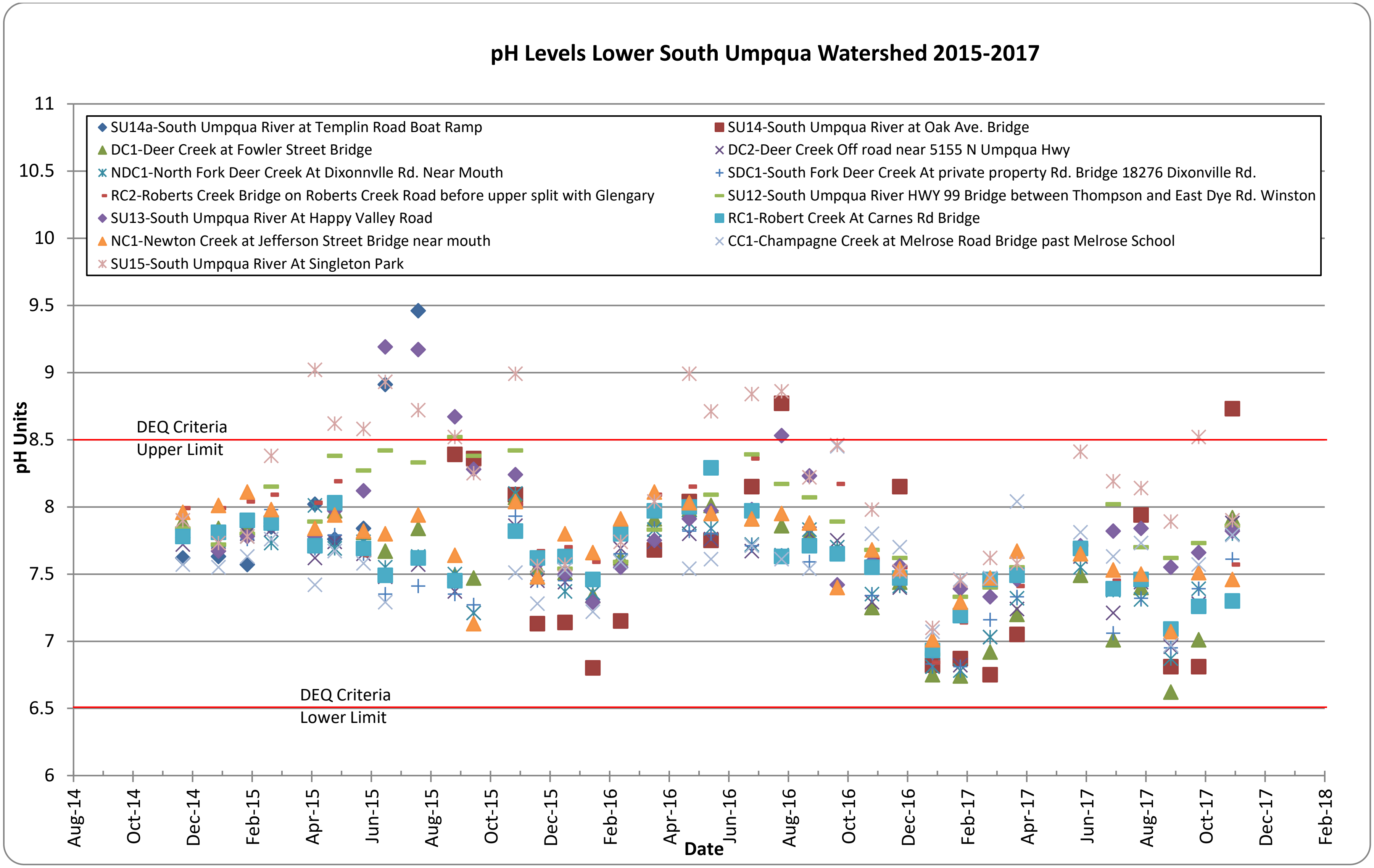
RESULTS – Lower South Umpqua Watershed 2015-2017

pH

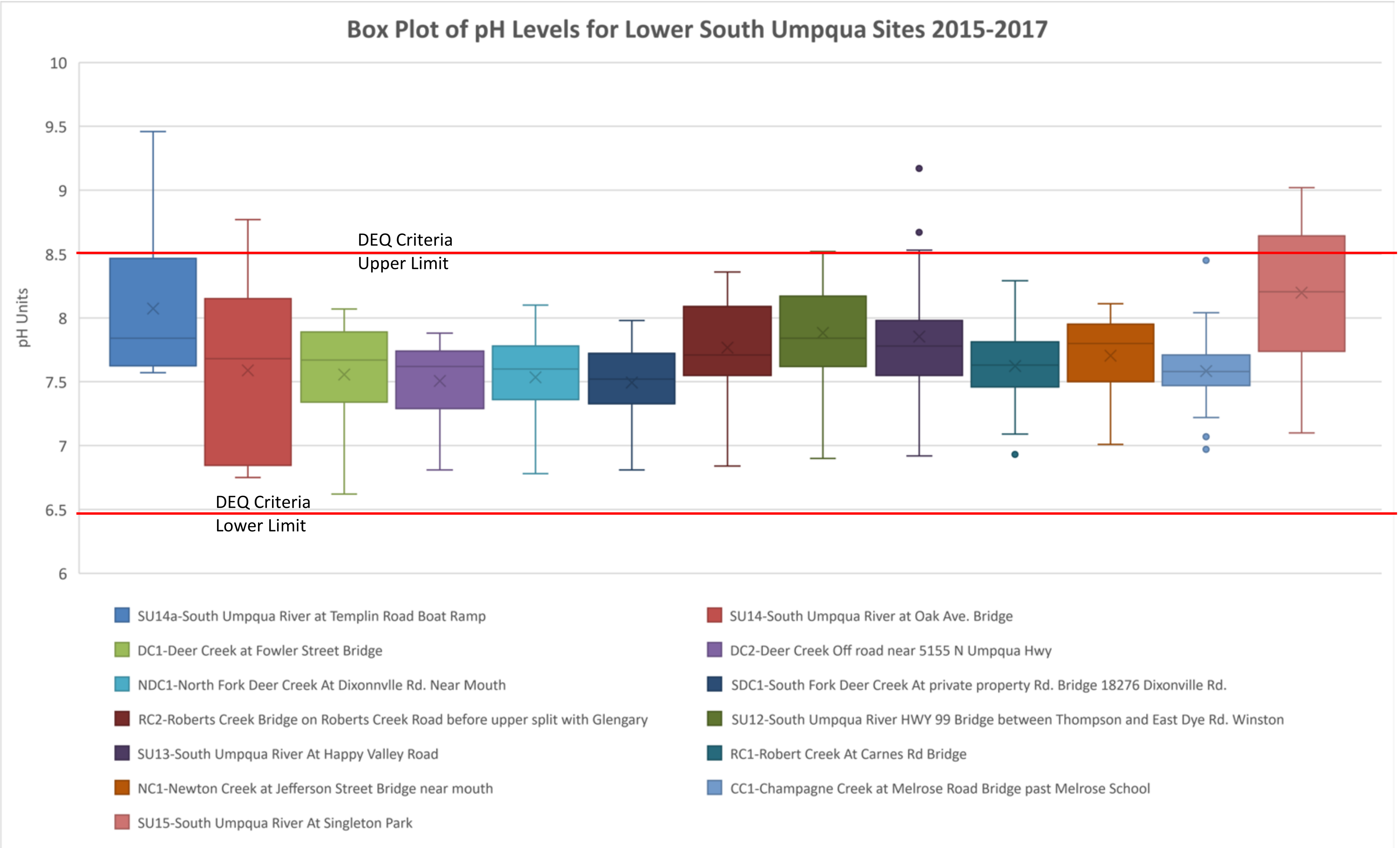
PH values were measured year-round for three years and no sites fell below DEQ's lower standard criteria of 6.5. Graph 6 indicates that late spring through early fall there were several exceedances above the 8.5 pH DEQ upper exceedance criteria. From Graph 7 and 8 it is easy to see that these occurred at five sites: SU14a-South Umpqua River at Templin Road Boat Ramp, SU14-South Umpqua River at Oak Ave. Bridge, SU13-South Umpqua River at Happy Valley Road, SU15-South Umpqua River at Singleton Park, and RC1-Robert Creek at Carnes Rd Bridge. RC2-Roberts Creek Bridge on Roberts Creek Road before upper split with Glengary and SU12-South Umpqua River HWY 99 Bridge, Winston were designated yellow (Moderate Concern) Rating because of exceedances of 8.25 which likely may have exceeded 8.5 if we had been able to conduct continuous pH measurements throughout the day.



Graph 7. pH levels Lower South Umpqua Watershed 2015-2017 all sites, all data sorted by month.



Graph 8. pH levels Lower South Umpqua Watershed 2015-2017 monitoring sites.



Graph 9. Box and Whisker plots of pH levels for Lower South Umpqua sites 2015-2017

SITE	Upper pH RATING	Lower pH RATING
SU14a-South Umpqua River at Templin Road Boat Ramp	Red	Blue
SU14-South Umpqua River at Oak Ave. Bridge	Red	Blue
DC1-Deer Creek at Fowler Street Bridge	Blue	Blue
DC2-Deer Creek Off road near 5155 N Umpqua Hwy	Blue	Blue
NDC1-North Fork Deer Creek at Dixonville Rd. Near Mouth	Blue	Blue
SDC1-South Fork Deer Creek At private property Rd. Bridge 18276 Dixonville Rd.	Blue	Blue
RC2-Roberts Creek Bridge on Roberts Creek Road before upper split with Glengary	Yellow	Blue
SU12-South Umpqua River HWY 99 Bridge, Winston	Yellow	Blue
SU13-South Umpqua River at Happy Valley Road	Red	Blue
RC1-Robert Creek at Carnes Rd Bridge	Red	Blue
NC1-Newton Creek at Jefferson Street Bridge near mouth	Blue	Blue
CC1-Champagne Creek at Melrose Road Bridge past Melrose School	Blue	Blue
SU15-South Umpqua River at Singleton Park	Red	Blue

Rating	**Color**	**Upper pH Criteria**	**Lower pH Criteria**
No Concern	Blue	None above 8.25	None below 6.75
Low Concern	Green	1 ≥ 8.25	1 ≤ 6.75
Moderate Concern	Yellow	2 or more ≥ 8.25 or 1 ≥ 8.5	2 ≤ 6.75 or 1 ≤ 6.5
Extreme Concern	Red	2 or more ≥ 8.5	2 or more ≤ 6.5

Table 9. PH levels high and low, Lower South Umpqua Watershed sites 2015-2017 with Color Key ratings.

RESULTS – Lower South Umpqua Watershed 2015-2017

Dissolved Oxygen

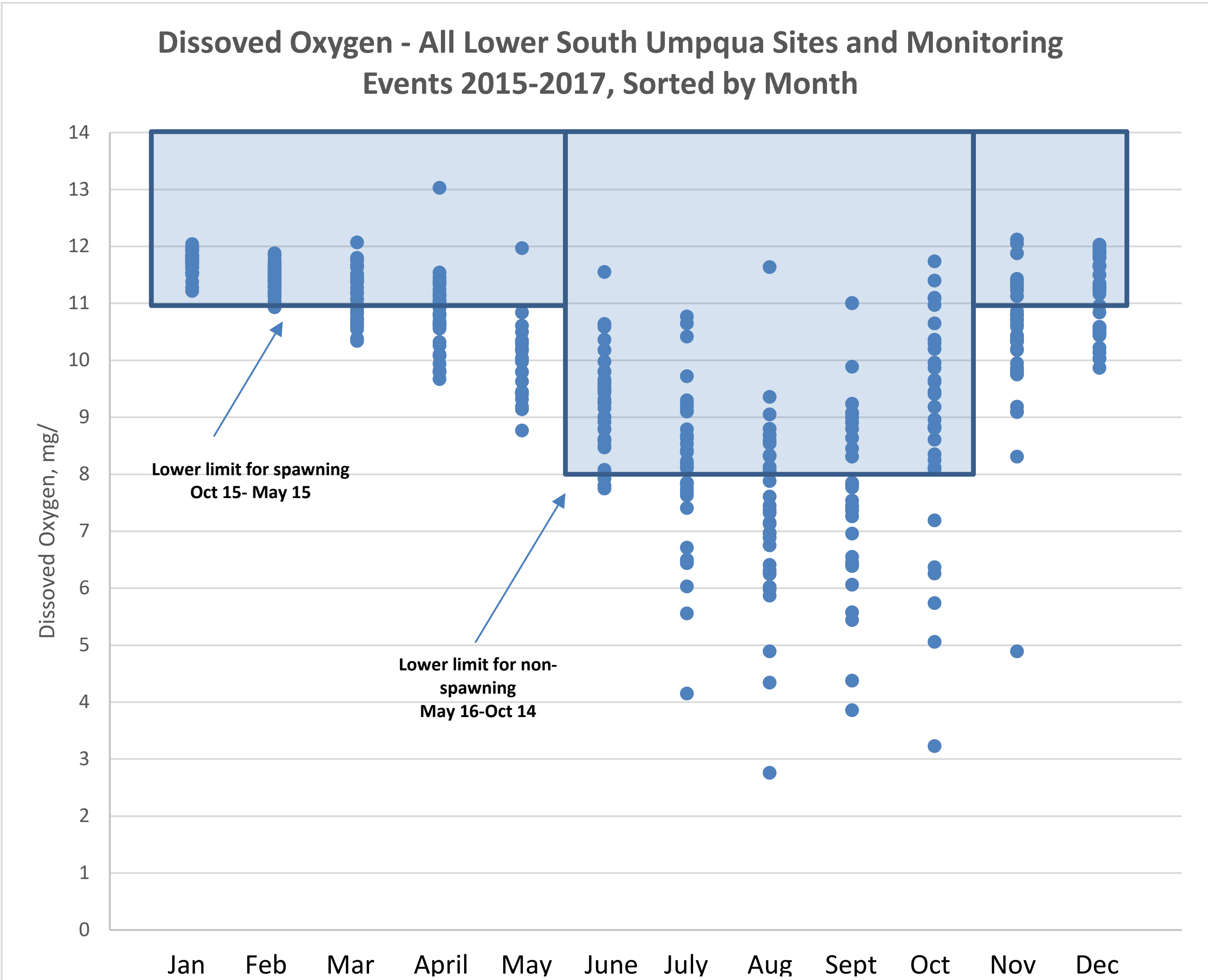
In Graph 9, dissolved oxygen for Lower South Umpqua Watershed 2015-2017 all sites, all data sorted by month, it is apparent that only January has no exceedances of the DEQ dissolved oxygen criteria for spawning and February comes very close to having none. All other months have exceedances for either spawning or non-spawning criteria.

For the non-spawning season of May 16-October 15 for these watersheds, only three sites adhered to DEQ minimum criteria of 8 mg/l at the times we monitored. These were: RC2-Roberts Creek Bridge on Roberts Creek Road before upper split with Glengary, SU12-South Umpqua River HWY 99 Bridge, Winston and SU15-South Umpqua River at Singleton Park.

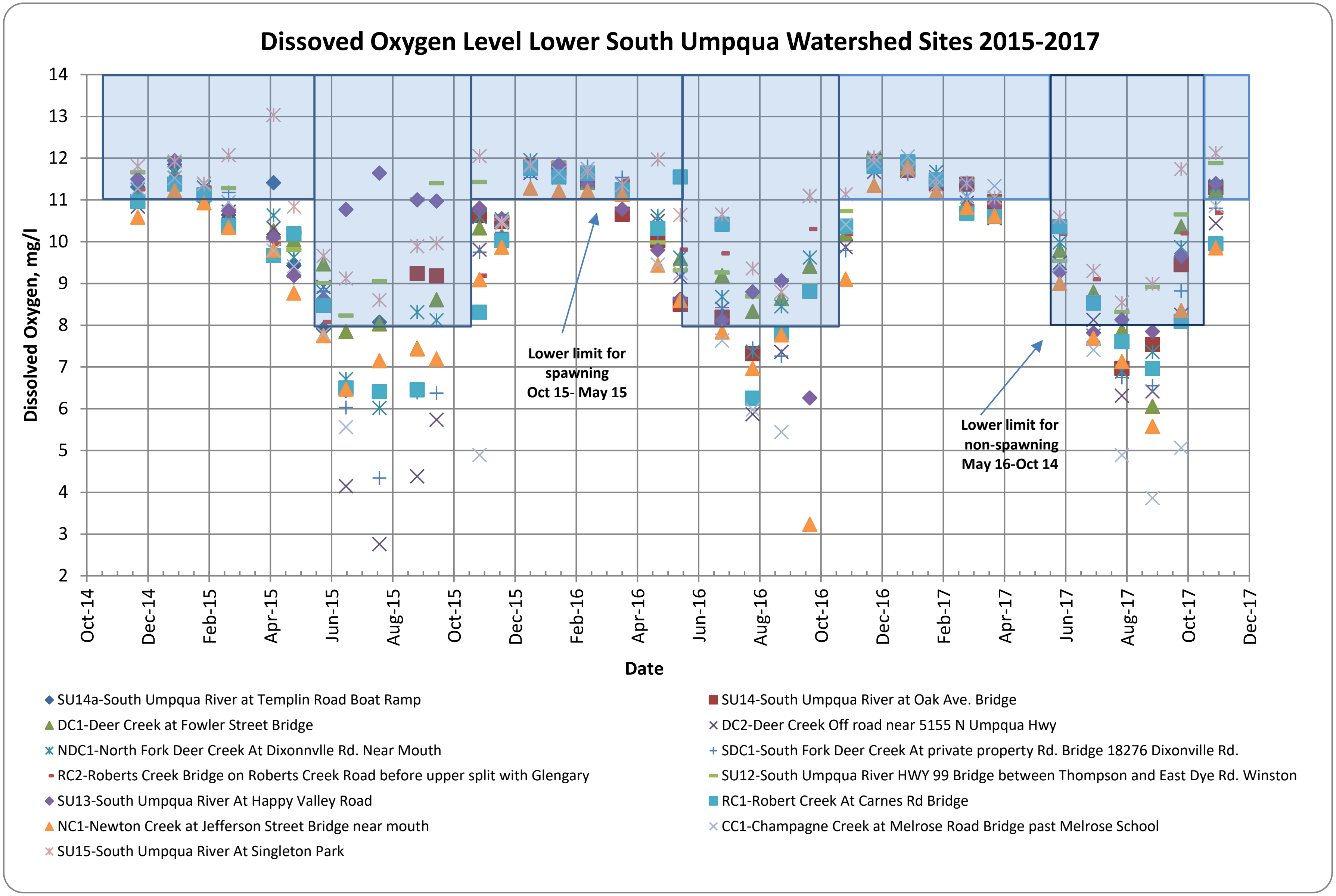
For the spawning season (October 16-May 15) criteria none of our sites consistently fell within the 11 mg/l dissolved oxygen criteria. Many sites failed to meet criteria 40% of the times sampled. This is one of the cases where grab sample monitoring may not have captured the lowest dissolved oxygen value but certainly was sufficient to indicate failing streams.

Graph 10 displays some interesting data which observation at the time of collection helps explain. DC2 - Deer Creek off road near 5155 n Umpqua Hwy every summer became an extremely low flow pool with some water coming in from a small culvert under the Hwy. Champagne Creek becomes just a pool during summer at the site we monitor. Roberts Creek in summer goes mostly dry with some isolated pools and the only flow is from that unknown source of water flowing in from the unnamed tributary discussed in the section on turbidity. Newton Creek, though not going dry, has very low summer flow which may be coming from city drains. All three years of the study were very dry summers with little to no summer rain (See Appendix M). Even the South Umpqua at Happy Valley Road fell to 6.26 mg/l in early October 2016 when it appeared as a flat lake with little flow.

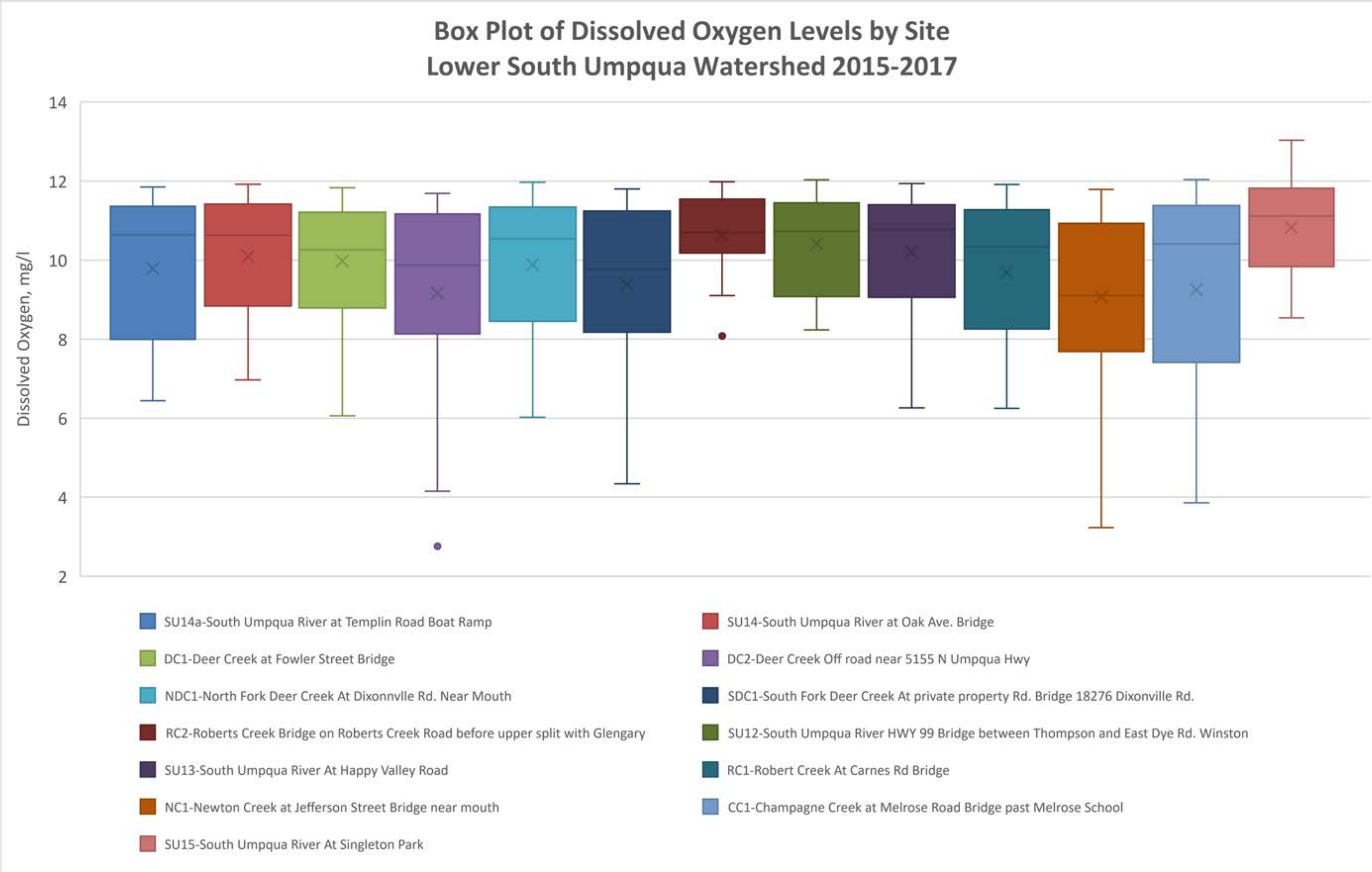
Photo 4. **South Umpqua at Happy Valley Rd, 10/6/16.**



Graph 10. Dissolved Oxygen for Lower South Umpqua Watershed 2015-2017 all sites all data sorted by month.



Graph 11. Dissolved oxygen levels of sites in the Lower South Umpqua Watershed 2015-2017 compared for spawning and non-spawning DEQ criteria.



Graph 12. Box Plot of Dissolved oxygen levels of sites in Lower South Umpqua Watershed 2015-2017.

	Non-spawning Season May 16-October 15				Spawning Season October 16-May 15			
	Total # Samples	# Below Minimum D.O. Criteria of 8 mg/l	% Below Minimum D.O. Criteria of 8 mg/l	Rating	Total # Samples	# Below Minimum D.O. Criteria of 11 mg/l	% Below Minimum D.O. Criteria of 11 mg/l	Rating
SU14a-South Umpqua River at Templin Road Boat Ramp	4	2	50%	Extreme Concern	5	1	20%	Extreme Concern
SU14-South Umpqua River at Oak Ave. Bridge	7	3	43%	Extreme Concern	14	6	43%	Extreme Concern
DC1-Deer Creek at Fowler Street Bridge	15	4	31%	Extreme Concern	20	9	45%	Extreme Concern
DC2-Deer Creek Off road near 5155 N Umpqua Hwy	16	8	50%	Extreme Concern	19	10	53%	Extreme Concern
NDC1-North Fork Deer Creek at Dixonville Rd. Near Mouth	16	6	38%	Extreme Concern	19	7	37%	Extreme Concern
SDC1-South Fork Deer Creek at private property Rd. Bridge	17	8	47%	Extreme Concern	17	7	41%	Extreme Concern
RC2-Roberts Creek Bridge on Roberts Creek Road before upper split with Glengary	8	0	0%	No Concern	19	9	47%	Extreme Concern
SU12-South Umpqua River HWY 99 Bridge, Winston	16	0	0%	No Concern	19	4	21%	Extreme Concern
SU13-South Umpqua River at Happy Valley Road	16	3	19%	High Concern	19	8	42%	Extreme Concern
RC1-Robert Creek at Carnes Rd Bridge	15	7	47%	Extreme Concern	18	10	56%	Extreme Concern
NC1-Newton Creek at Jefferson Street Bridge near mouth	16	12	75%	Extreme Concern	19	11	58%	Extreme Concern
CC1-Champagne Creek at Melrose Road Bridge	13	9	69%	Extreme Concern	18	7	39%	Extreme Concern
SU15-South Umpqua River at Singleton Park	14	0	0%	No Concern	20	3	15%	High Concern

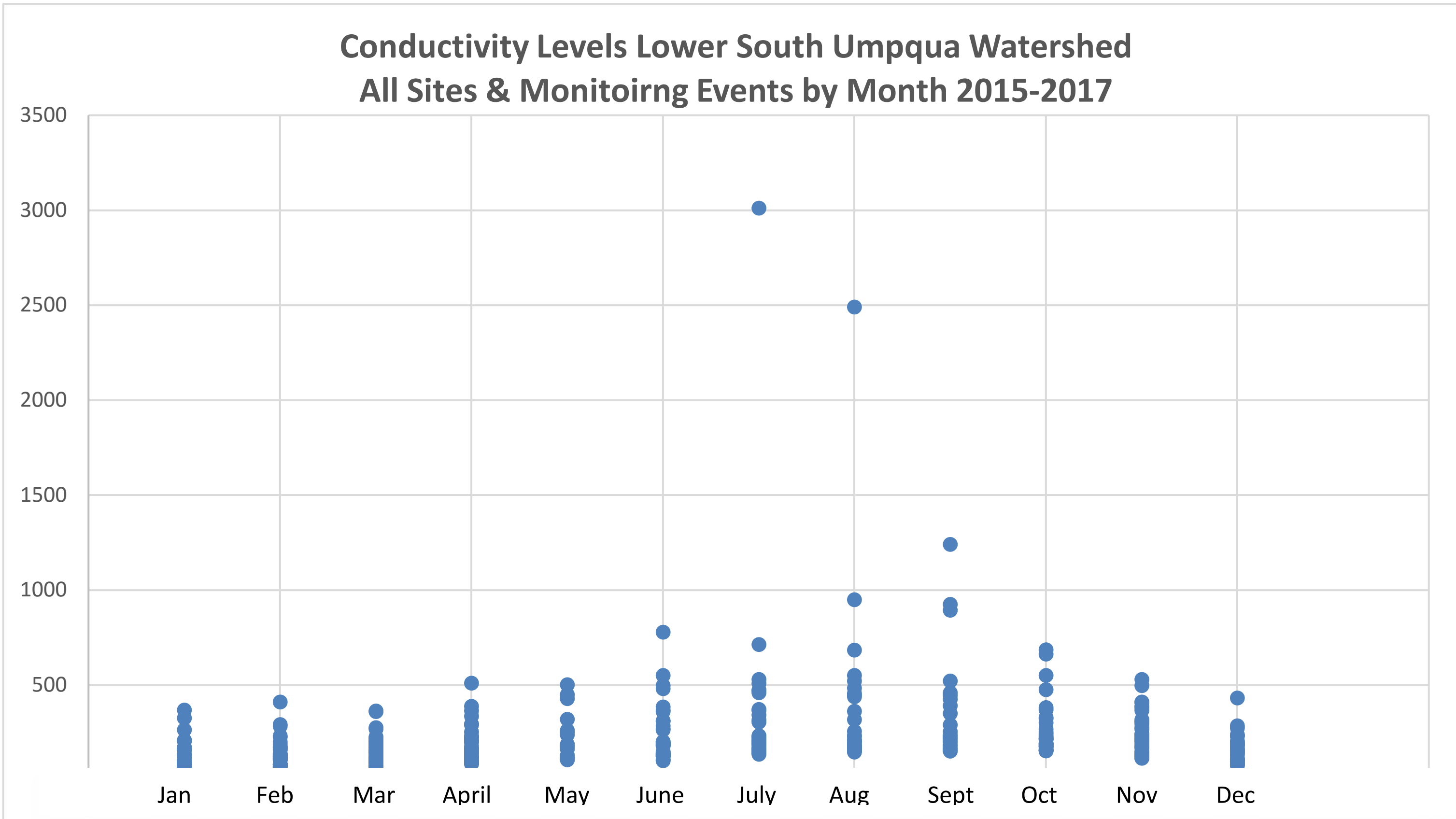
Color Key:	**Level of Concern**	**Color Key Evaluation Criteria**
(blue)	No Concern	0% (No Exceedances)
(green)	Low Concern	≥1% ≤9% Exceedances
(yellow)	High Concern	≥10% ≤19% Exceedances
(red)	Extreme Concern	≥20% Exceedances

Table 10. Rating of Lower South Umpqua Watershed 2015-2017 Sites for stream dissolved oxygen levels compared to Spawning Season and Non-Spawning Season DEQ Criteria with Color Key

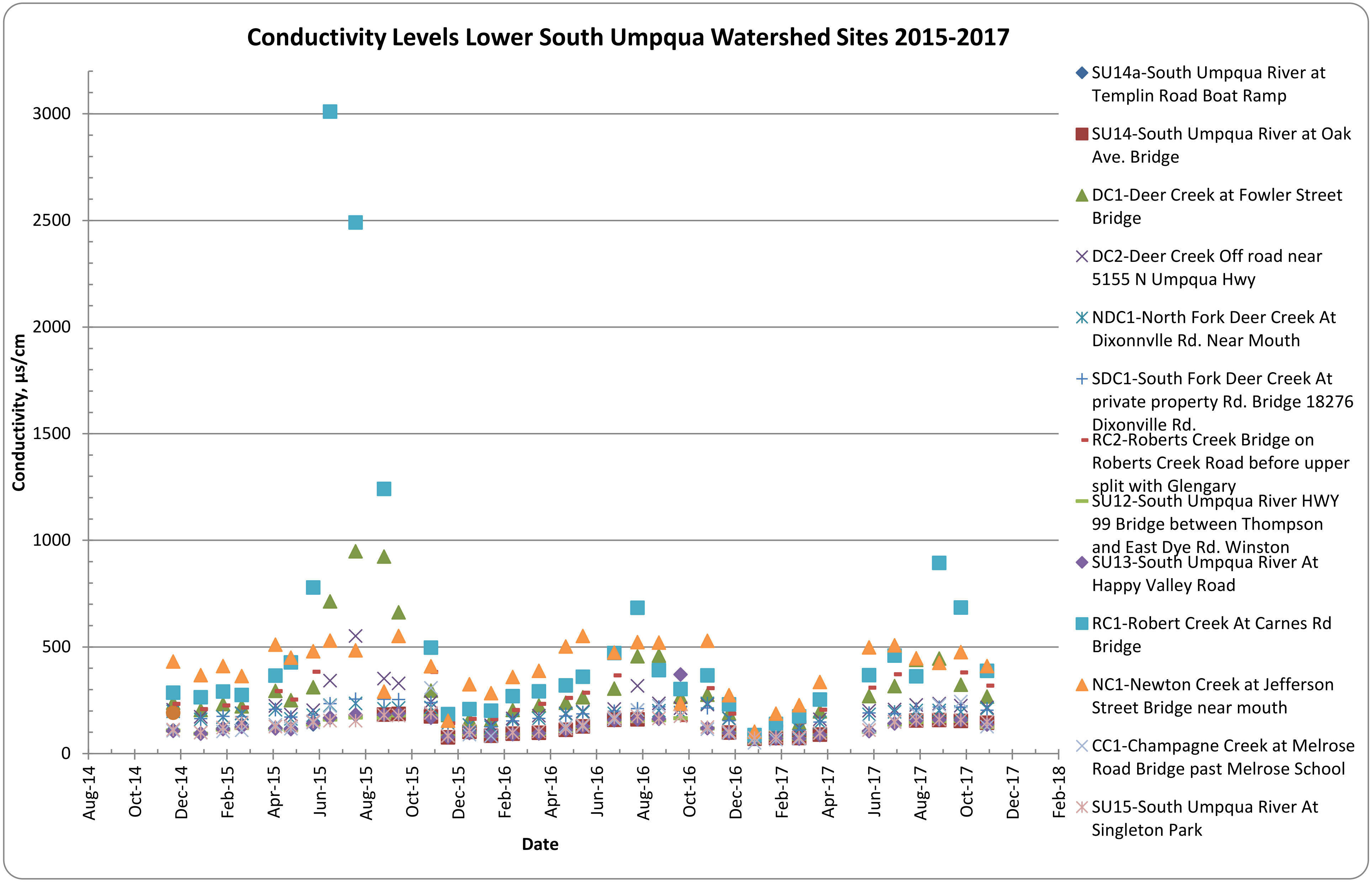
RESULTS – Lower South Umpqua Watershed 2015-2017

Conductivity

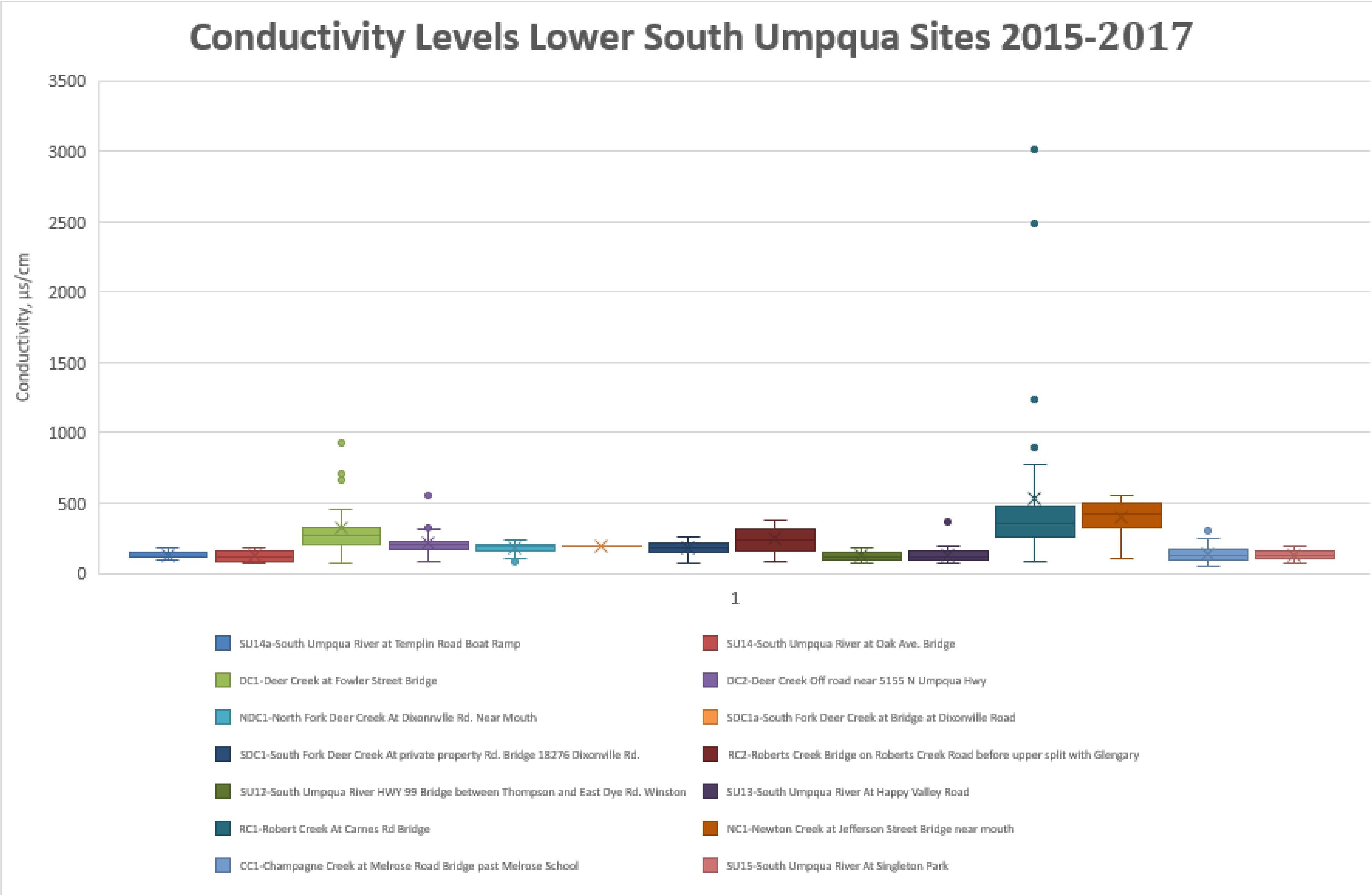
Most conductivity levels in the Lower South Umpqua monitoring area were within normal ranges for the Umpqua Basin, with only three exceeding 500 us/cm. Two of these three: DC1- Deer Creek at Fowler Street and NC1 - Newton Creek near the mouth had outliers during summer months when the flows where low and the small streams tend to concentrate salts as they dry up and are also both streams that flow through potions of Roseburg that might be contributing some urban runoff. Graph 16 indicates that the higher conductivity occurs in Deer Creek at the lowest summer flows. RC1 – Roberts Creek at Carnes Road is very suspicious and not Roberts Creek flow itself but the summer flow from an unnamed tributary with an unknown water source as described in the turbidity section.



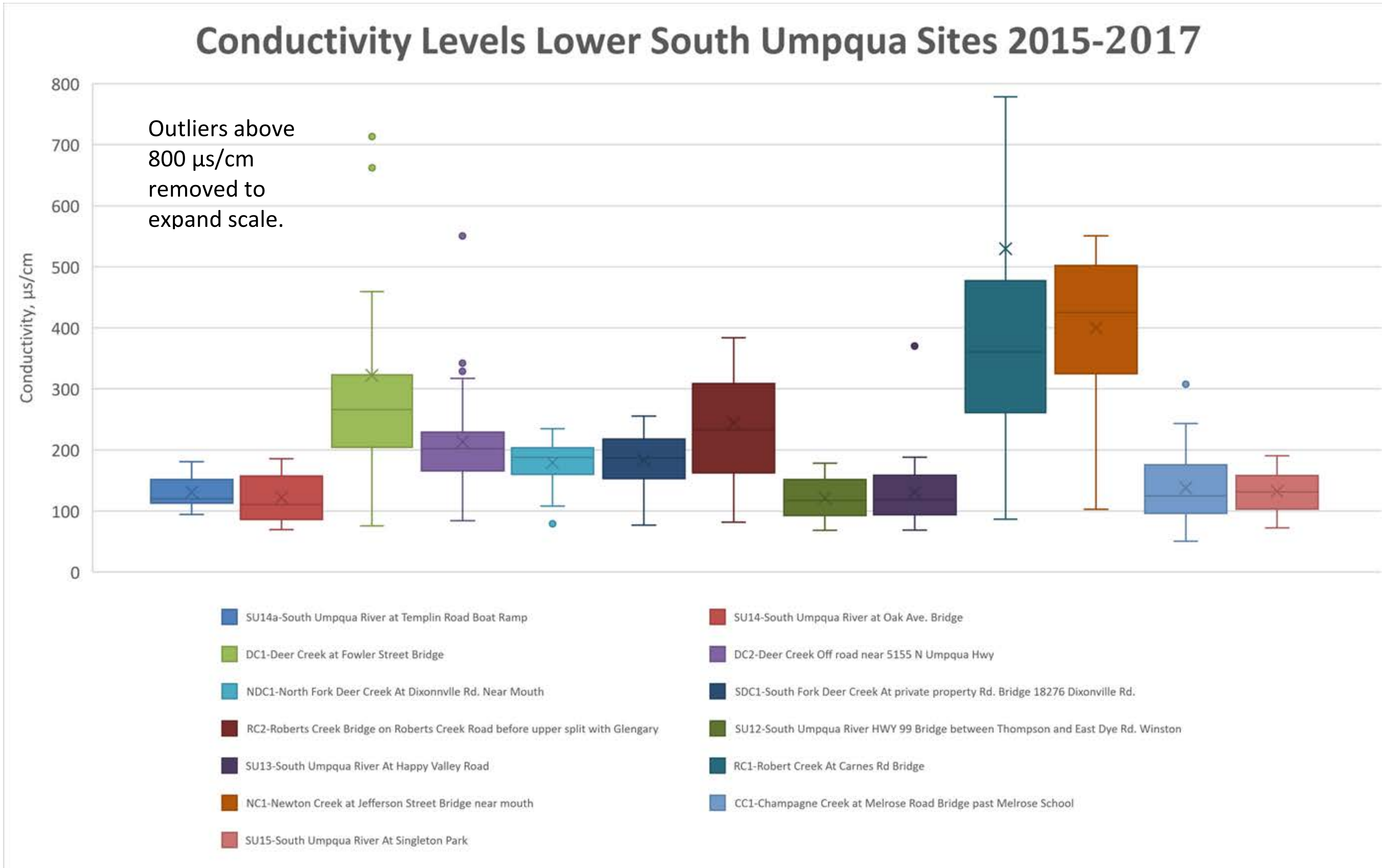
Graph 13. Conductivity levels all Lower South Umpqua Watershed sites and events from 2015-2017 displayed by month.



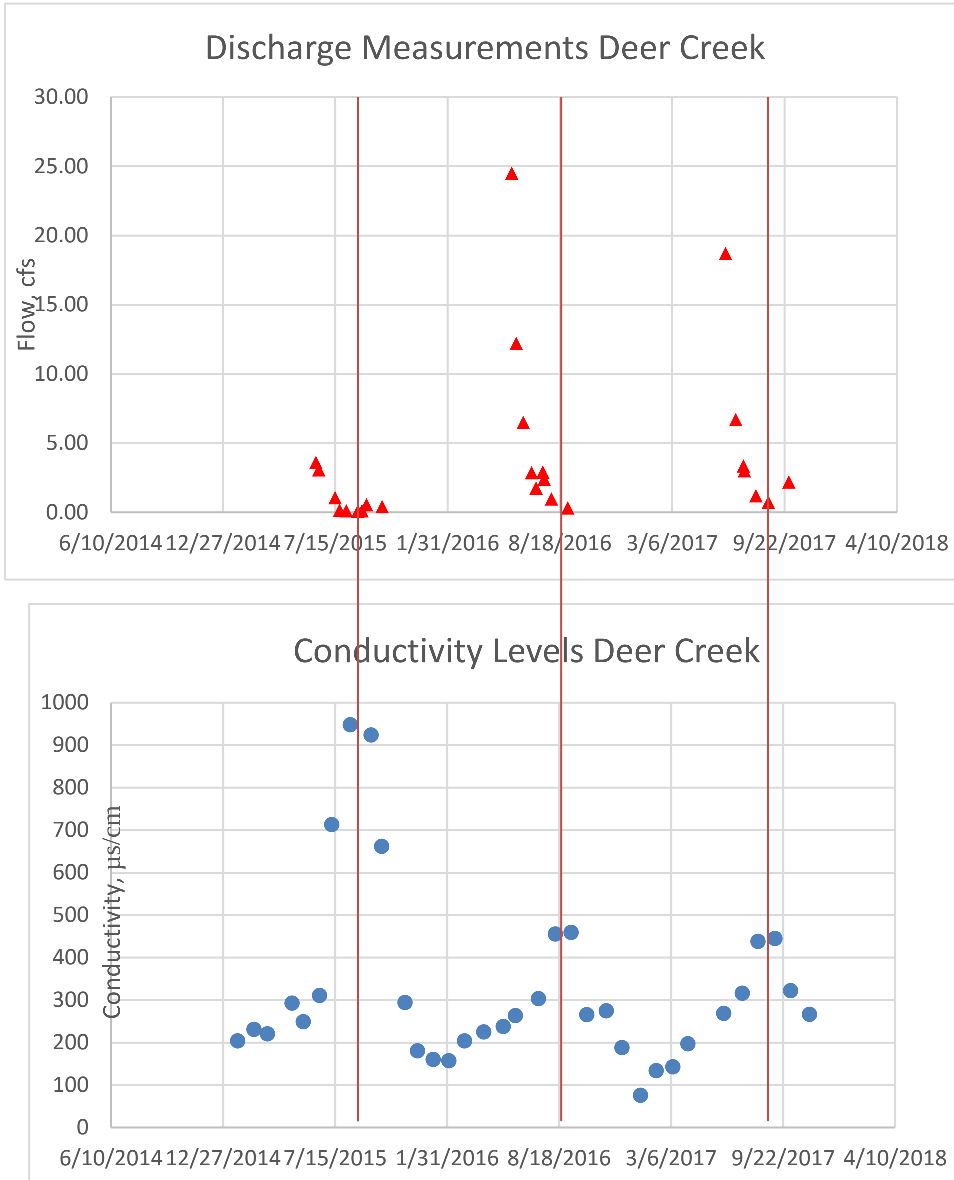
Graph 14. Conductivity Lower South Umpqua Watershed 2015-2017.



Graph 15. Box Plots of conductivity levels at Lower South Umpqua Watershed sites 2015-2017.



Graph 16. Box Plots of conductivity levels at Lower South Umpqua Watershed sites 2015-2017. Outliers cropped outliers above 800 µs/cm to expand graph.



Graph 17. Composite graph of flow and conductivity of Deer Creek at Fowler Street.

Conductivity Level Rating Lower South Umpqua Watershed Monitoring Sites 2015-2017

SITE	Rating
SU14a-South Umpqua River at Templin Road Boat Ramp	Blue
SU14-South Umpqua River at Oak Ave. Bridge	Blue
DC1-Deer Creek at Fowler Street Bridge	Yellow
DC2-Deer Creek Off road near 5155 N Umpqua Hwy	Blue
NDC1-North Fork Deer Creek at Dixonville Rd. Near Mouth	Blue
SDC1-South Fork Deer Creek at private property Rd. Bridge	Blue
RC2-Roberts Creek Bridge on Roberts Creek Road before upper split with Glengary	Blue
SU12-South Umpqua River HWY 99 Bridge, Winston	Blue
SU13-South Umpqua River at Happy Valley Road	Blue
RC1-Robert Creek at Carnes Rd Bridge	Yellow
NC1-Newton Creek at Jefferson Street Bridge near mouth	Yellow
CC1-Champagne Creek at Melrose Road Bridge	Blue
SU15-South Umpqua River at Singleton Park	Blue

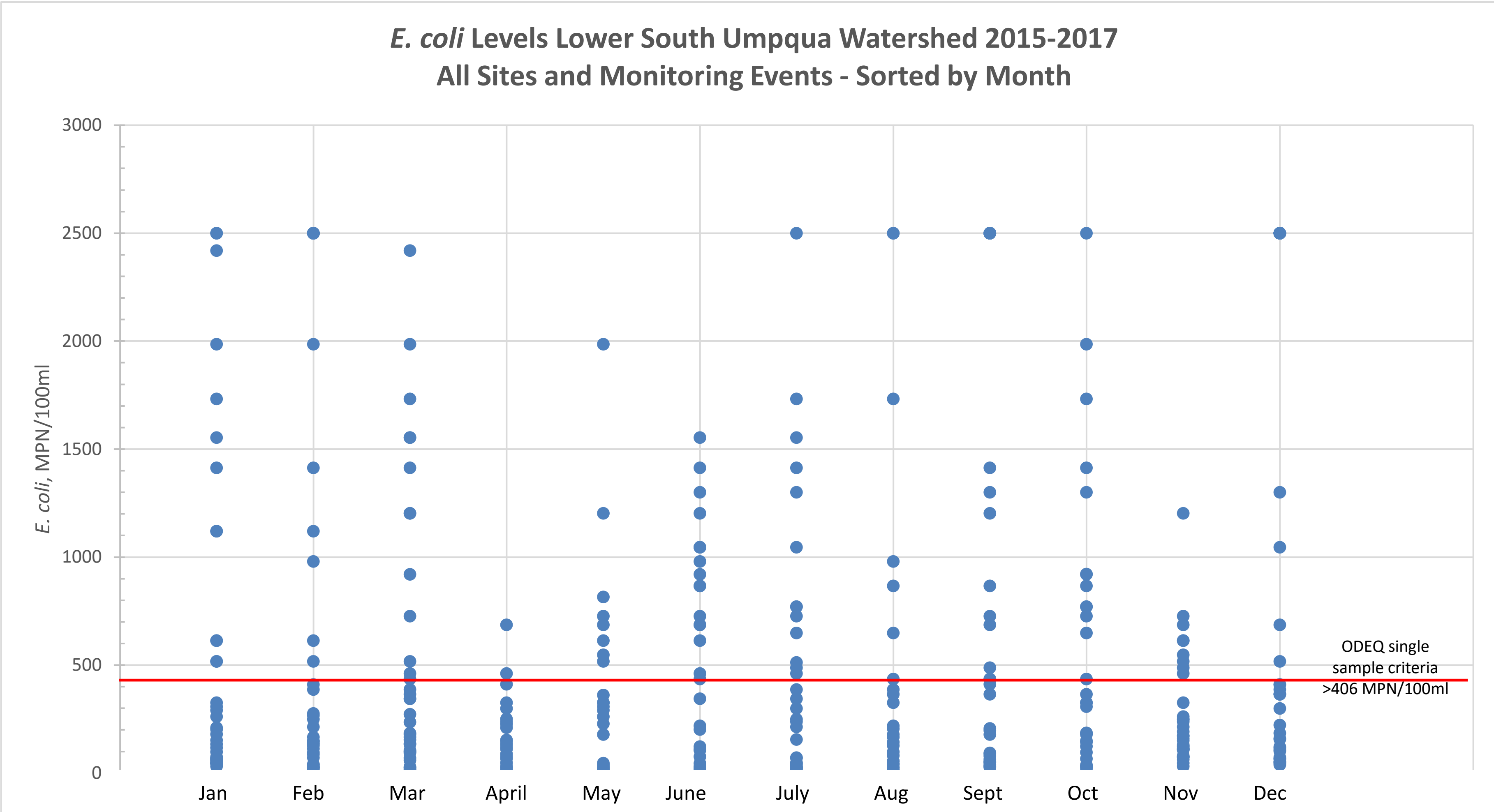
Rating	Color	Conductivity Level
No Concern	Blue	<500 uS/cm
Concern	Yellow	>500 uS/cm

Table 11. Conductivity levels rating Lower South Umpqua monitoring sites 2015-2017

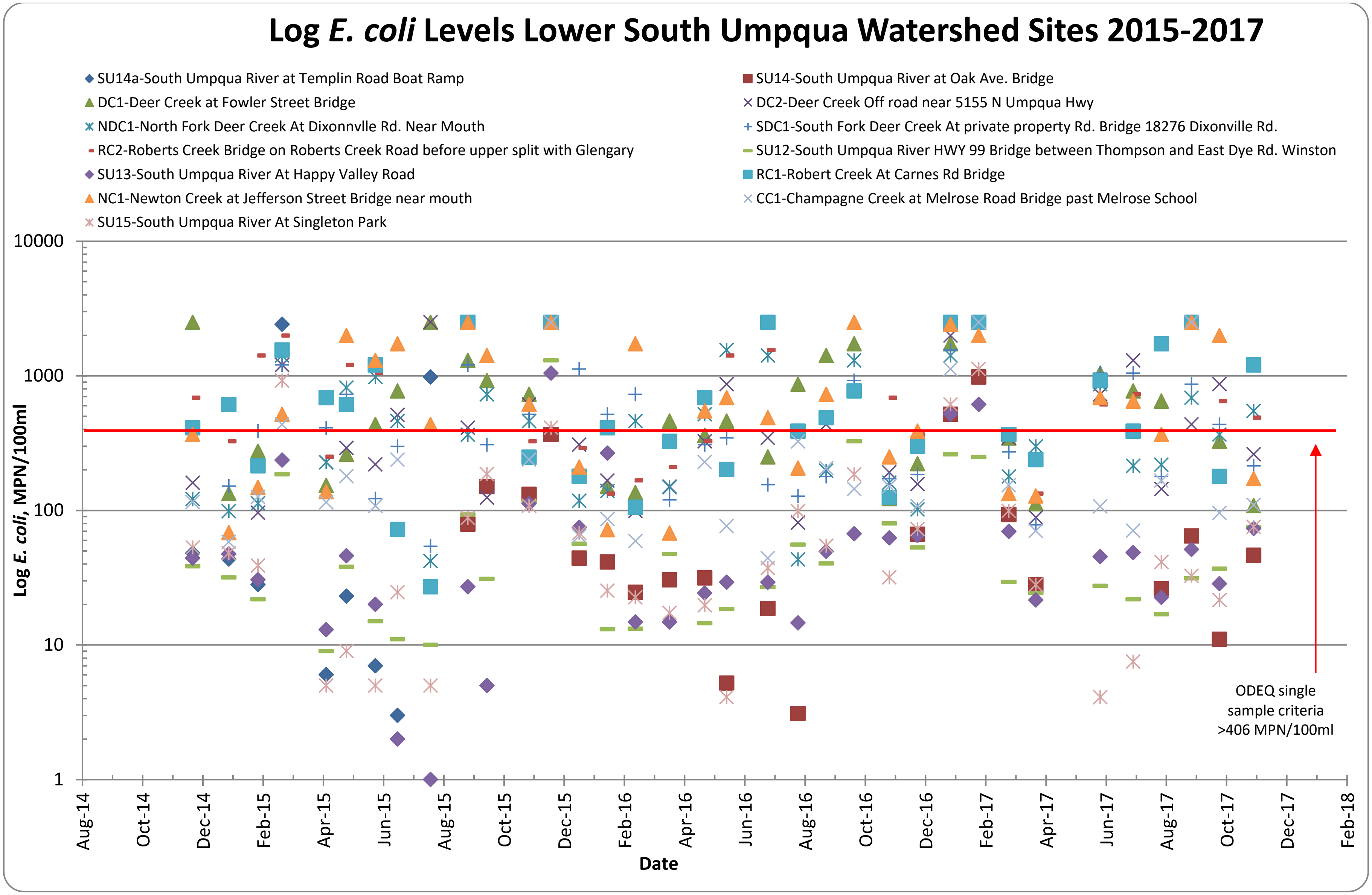
RESULTS Lower South Umpqua Watershed 2015-2017

E. coli Bacteria

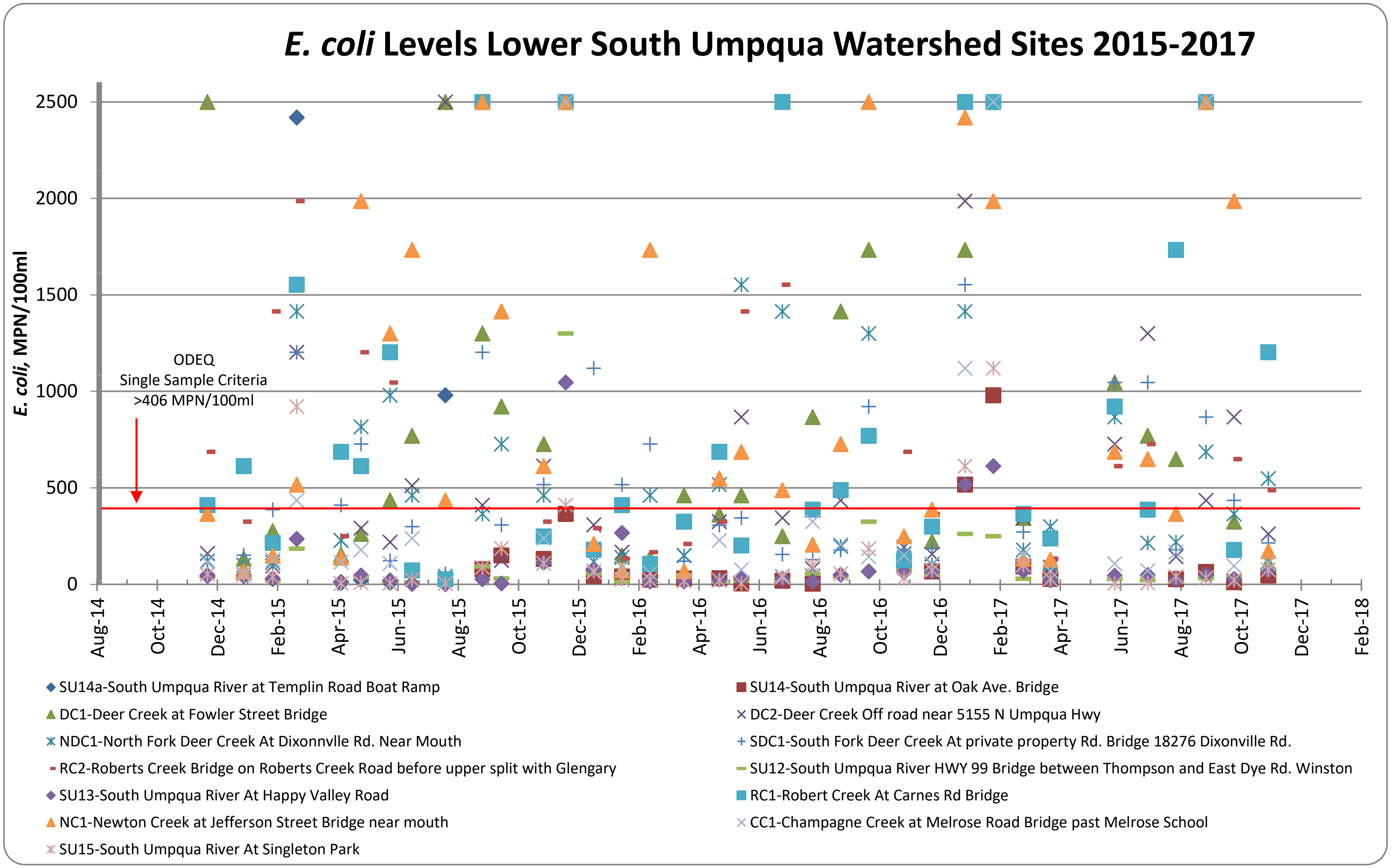
Graph 17 of all data sorted by month shows that exceedances of the DEQ single sample criteria for *E. coli* (406 MPN/100ml) occurred in all months of the year. There were no exceedances of DEQ criteria during the summer only at four sample sites in the 5^{th} field watershed all of which were in the South Umpqua River: SU14-South Umpqua River at Oak Ave. Bridge, SU12-South Umpqua River HWY 99 Bridge, Winston, SU13-South Umpqua River at Happy Valley Road, and SU15-South Umpqua River at Singleton Park. Clearly the tributaries are the main source of *E. coli* in this region.
Four creeks having extremely high levels are shown in Graph 21 to display the maximum of the upper quartile for each over the limit of our assay >2419.6. These four creeks also have over half of the collected samples exceeding ODEQ criteria as the Graph 20 and Table 12 show. These creeks are DC1 - Deer Creel at Fowler Street, NC1 – Newton Creek near the mouth, and RC1 & RC2 – Roberts Creek both higher and lower in its watershed.



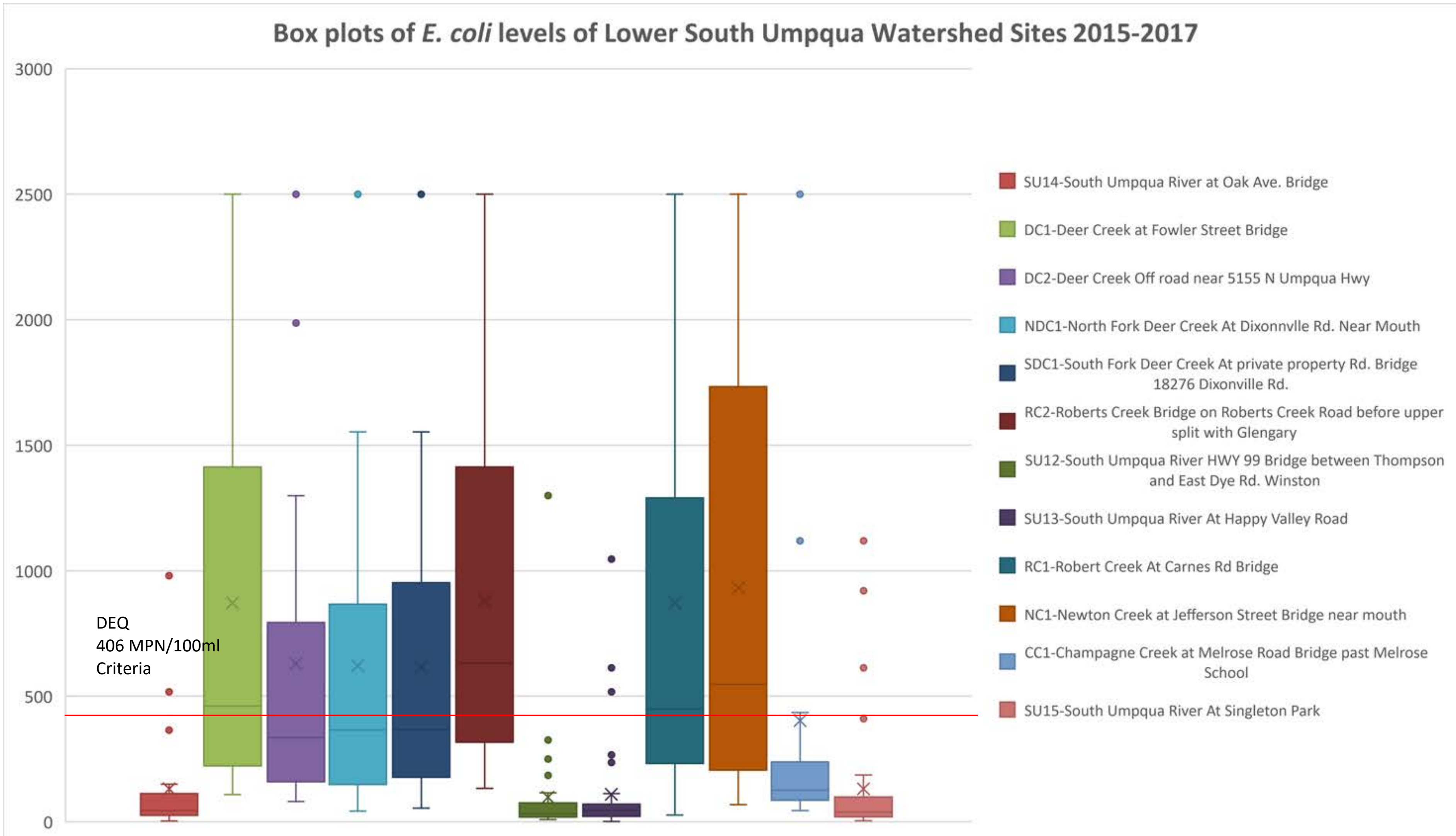
Graph 18. *E. coli* levels all Lower South Umpqua Watershed sites and monitoring events 2015-2017 sorted by month. Values of ≥2419.6, the limit of the assay without dilution, are displayed as 2500.



Graph 19. Log *E. coli* levels Lower South Umpqua Watershed Sites 2015-2017. Values ≥2419.6, the limit of the assay, are displayed at Log 2500.



Graph 20. *E. coli* levels Lower South Umpqua Watershed Sites 2015-2017. Values ≥2419.6, the limit of the assay, are displayed at 2500.



Graph 21. Box plots of *E. coli* levels of Lower South Umpqua Watershed sites 2015-2017. Values ≥2419.6, the limit of the assay, are displayed at 2500.

Lower South Umpqua Sites	Greater than 406 MPN/100ml		Total
Station ID - Site Description	Count	% of Samples	# of Samples
SU14a-South Umpqua River at Templin Road Boat Ramp	2	22%	9
SU14-South Umpqua River at Oak Ave. Bridge	2	10%	21
DC1-Deer Creek at Fowler Street Bridge	20	57%	35
DC2-Deer Creek Off road near 5155 N Umpqua Hwy	15	44%	34
NDC1-North Fork Deer Creek At Dixonnvlle Rd. Near Mouth	17	49%	35
SDC1-South Fork Deer Creek At private property Rd. Bridge 18276 Dixonville Rd.	16	47%	34
RC2-Roberts Creek Bridge on Roberts Creek Road before upper split with Glengary	15	58%	26
SU12-South Umpqua River HWY 99 Bridge between Thompson and East Dye Rd. Winston	1	3%	35
SU13-South Umpqua River At Happy Valley Road	3	9%	35
RC1-Robert Creek At Carnes Rd Bridge	19	56%	34
NC1-Newton Creek at Jefferson Street Bridge near mouth	21	60%	35
CC1-Champagne Creek at Melrose Road Bridge past Melrose School	5	16%	31
SU15-South Umpqua River At Singleton Park	4	11%	35

Table 12. *E. coli* exceedances by site the Lower South Umpqua Watershed based ODEQ single sample criteria.

Rating of Lower South Umpqua Watershed Sites for *E. coli*, Summer and Winter

SITE	Summer (May1 – Sept 30)				Winter (Oct 1 – April 30)			
	Total # Sumer Samples	# Above ODEQ Criteria (406 MPN/100ml)	% Above ODEQ Criteria (406 MPN/100ml)	ODEQ Rating	Total # Winter Samples	# Above ODEQ Criteria (406 MPN/100 ml)	% Above ODEQ Criteria (406 MPN/100 ml)	ODEQ Rating
SU14a-South Umpqua River at Templin Road Boat Ramp	4	1	25%		5	1	20%	
SU14-South Umpqua River at Oak Ave. Bridge	7	0	0%		14	2	14%	
DC1-Deer Creek at Fowler Street Bridge	13	10	77%		21	9	43%	
DC2-Deer Creek Off road near 5155 N Umpqua Hwy	14	8	57%		20	7	35%	
NDC1-North Fork Deer Creek at Dixonnvlle Rd. Near Mouth	14	8	57%		21	8	38%	
SDC1-South Fork Deer Creek at private property Rd. Bridge	14	5	36%		20	11	55%	
RC2-Roberts Creek Bridge on Roberts Creek Road before upper split with Glengary	7	6	86%		19	9	47%	
SU12-South Umpqua River HWY 99 Bridge, Winston	14	0	0%		21	1	5%	
SU13-South Umpqua River at Happy Valley Road	13	0	0%		22	3	14%	
RC1-Robert Creek at Carnes Rd Bridge	14	9	64%		20	10	50%	
NC1-Newton Creek at Jefferson Street Bridge near mouth	14	12	86%		21	9	43%	
CC1-Champagne Creek at Melrose Road Bridge	12	1	8%		19	4	21%	
SU15-South Umpqua River at Singleton Park	14	0	0%		21	4	19%	

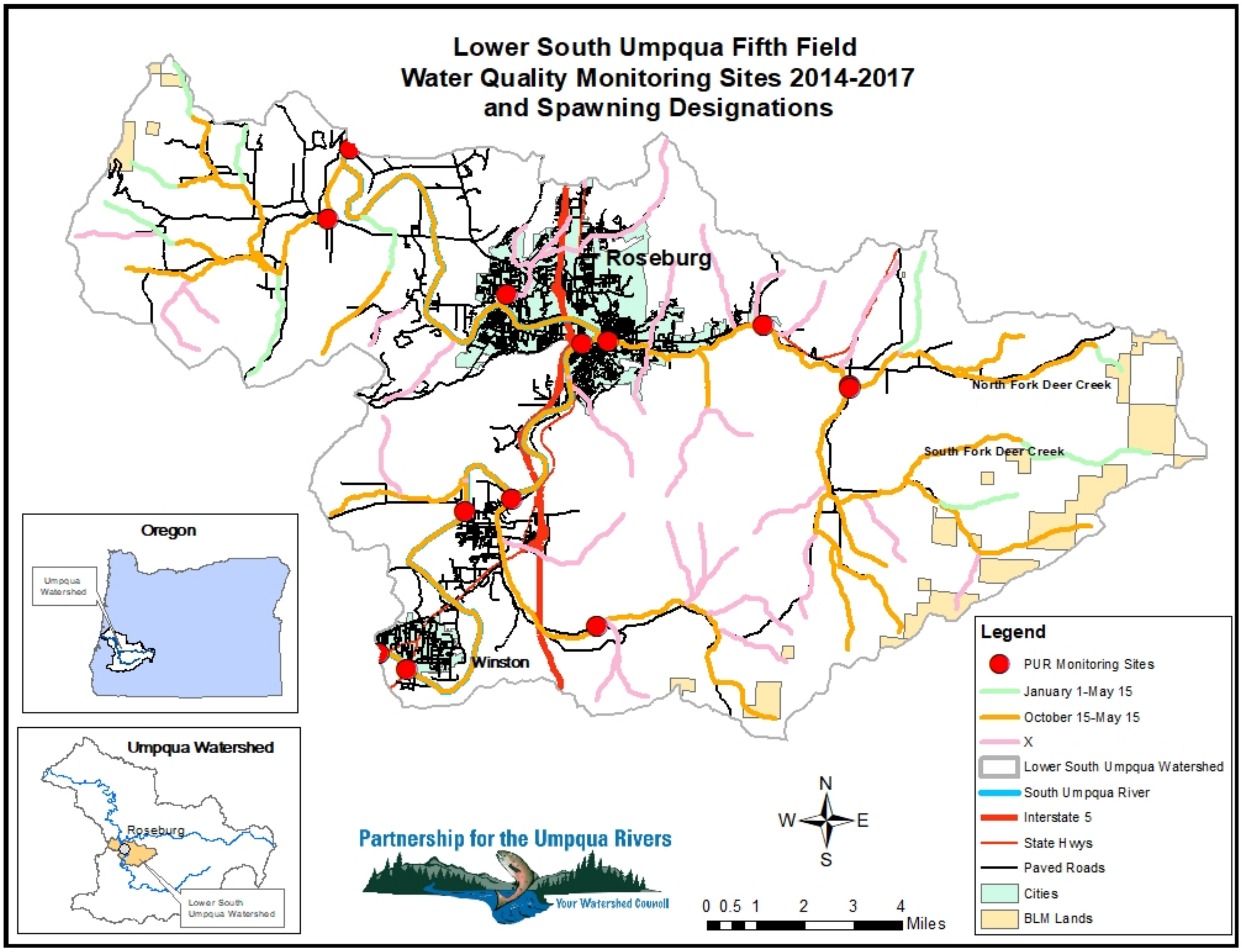
Rating	Color	ODEQ Criteria
No Concern (below standard criteria)		≤406
Concern (exceeds standard criteria)		>406

Table 13. Rating of all Lower South Umpqua Watershed Sites for *E. coli*, Summer and Winter, ODEQ criteria.

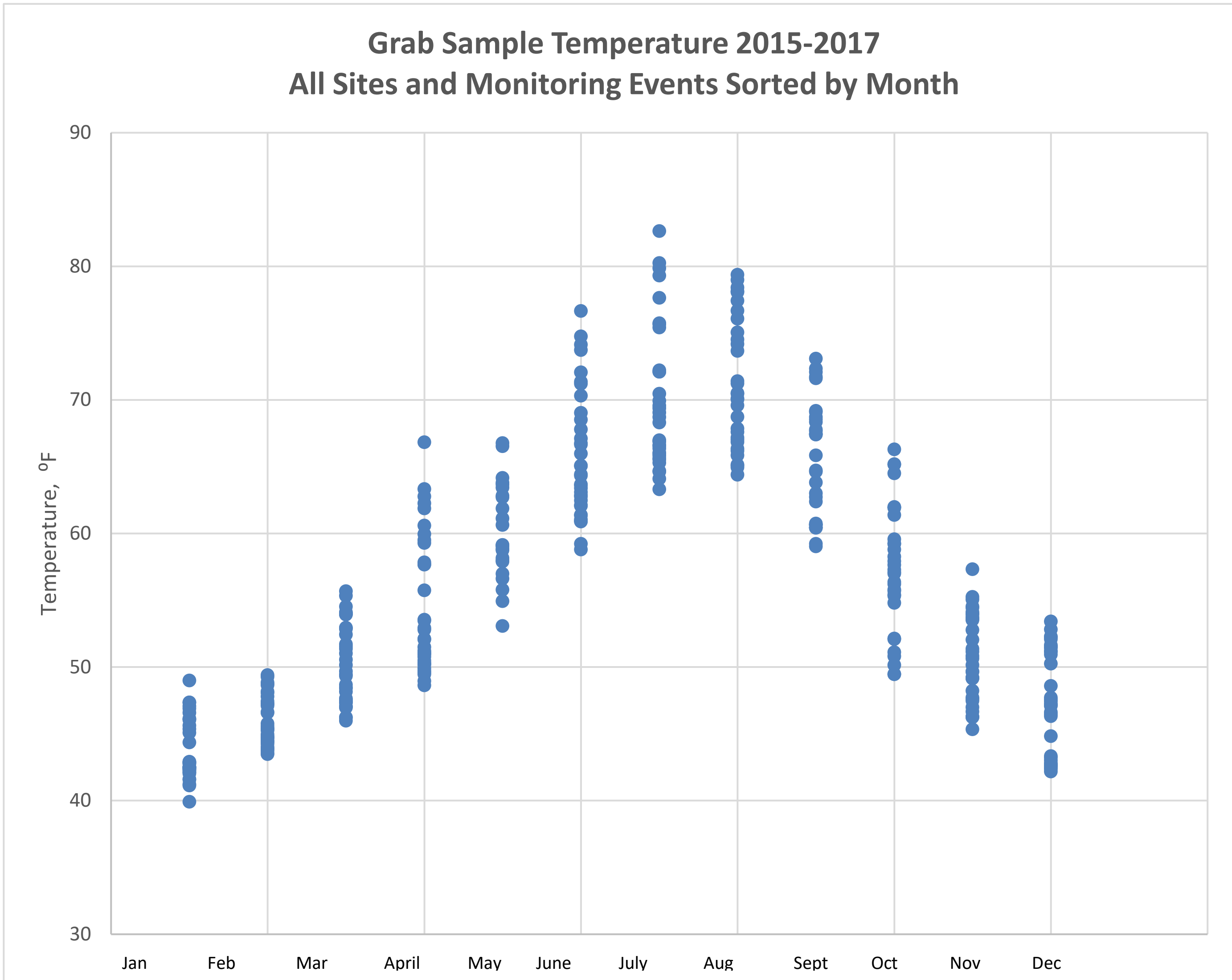
RESULTS Lower South Umpqua Watershed

Grab Sample Temperature Monitoring

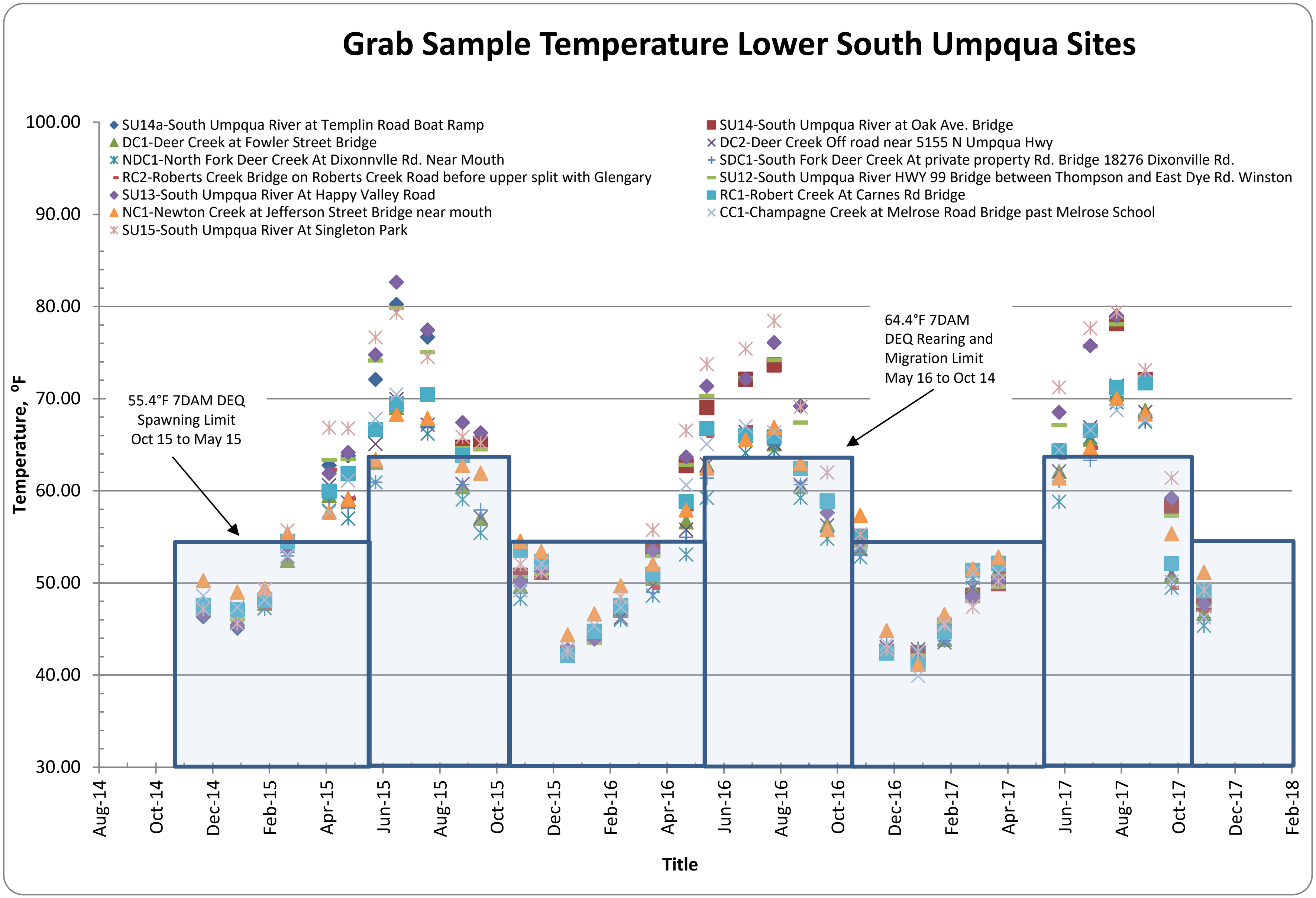
Temperature was recorded at each of our grab sample monitoring events, and though this would not allow evaluation for DEQ temperature criteria because continuous temperature recording could only provide the 7DMA. It is included here for evaluation and stream rating to provide additional information for planning restoration sites. As it turned out every monitoring site in this area exceeded both “Rearing and Migration” criteria of 64.4°F for May 16 – October 14 and “Spawning” criteria October 15 to May 15 for the creeks monitored as designated to this criteria on Map 5. Therefore, the summary table (Table 14) designated every stream monitored in need of improvement for failing to meet both criteria.



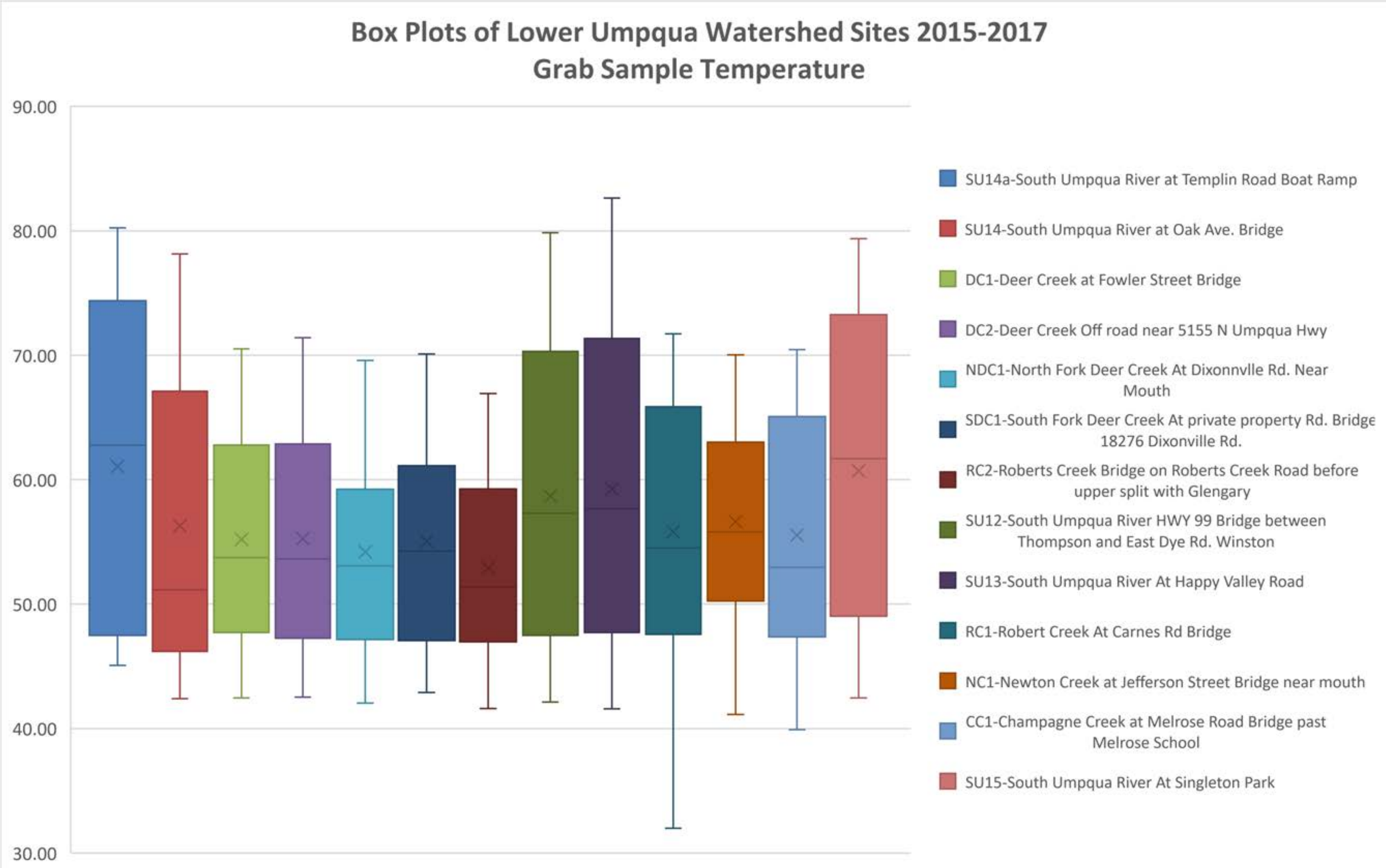
Map 5. Lower South Umpqua Monitoring Sites and Spawning Designations



Graph 22. Grab sample temperature data all events and sites sorted by month South Umpqua Watershed 2015-2017.



Graph 23. Grab sample temperature results for all Lower South Umpqua sites 2015-2017.



Graph 24. Box and whisker plots of grab sample temperatures for each site in Lower South Umpqua Watershed.

Temperature Ratings Lower South Umpqua Grab Sample Monitoring Sites 2015-2017

SITE	Rating based on Spawning Criteria 55.4°F 7DAM Oct 15-May 15	Rating based on Rearing and Migration Criteria 64.4°F 7DAM May 16-Oct 14
SU14a-South Umpqua River at Templin Road Boat Ramp		
SU14-South Umpqua River at Oak Ave. Bridge		
DC1-Deer Creek at Fowler Street Bridge		
DC2-Deer Creek Off road near 5155 N Umpqua Hwy		
NDC1-North Fork Deer Creek at Dixonville Rd. Near Mouth		
SDC1-South Fork Deer Creek at private property Rd. Bridge		
RC2-Roberts Creek Bridge on Roberts Creek Road before upper split with Glengary		
SU12-South Umpqua River HWY 99 Bridge, Winston		
SU13-South Umpqua River at Happy Valley Road		
RC1-Robert Creek at Carnes Rd Bridge		
NC1-Newton Creek at Jefferson Street Bridge near mouth		
CC1-Champagne Creek at Melrose Road Bridge		
SU15-South Umpqua River at Singleton Park		

Rating	Grab Sample Temperatures 7DAM Spawning Oct 15 to May 15	Grab Sample Temperatures 7DAM Rearing and Migration May 16- Oct 14	Color
Good	<55.4° F	<64.4° F	
Needs Improvement	>55.4° F	>64.4° F	

Table 14. Table Temperature Ratings Lower South Umpqua Grab Sample Monitoring Sites 2015-2017

RESULTS Lower South Umpqua Watershed

Continuous Temperature Monitoring

PUR has run a continuous temperature logger at DC1- Deer Creek at Fowler Street for the three years of this study: 2015, 2016, and 2017. The summary data is displayed in **Table 15 and 16**. All three years the 7DAM well exceeded the 64.4°F 7DAM Rearing and Migration Criteria required for creeks in this area. In 2017 it exceeded 64.4°F by 15.7°F! For the three years there were 84, 109 and 95 days respectively during which the temperature exceeded 64°F. The 7DAM agreed with our grab sample data which designated this creek into the red – needing improvement, as did all of the other sites where we had temperature loggers for two years. (The second year at Singleton Park at the mouth of the South Umpqua our logger was stolen.) However, in 2016 the 7DAM was 85°F with the maximum temperature during that week of 87.5°F and the low that week of 76.6°F.

In Graph 25 the 2017 Deer Creek sites were clipped to correspond with the time range monitored in 1999 (Graph 24) which was extracted from the Deer Creek Assessment produced by PUR when it was the Umpqua Basin Watershed Council. The comparing years: Deer Creek in 1999 peeked around 73.5°F while in 2017 clipped to this time period showed a peak of 78.4°F; South Fork Deer Creek in 1999 peaked around 72°F and in 2017 near 76°F; North Fork Deer Creek 1999 peaked at 70°F and 2017 at74°F. Appendix F: Annual 7 Day Average Maximum Stream Temperature for Umpqua Basin Stream Characterization Project Reference Sites from 1998-2017 (Dammann, D.M., 2017, p. 7), though not monitoring Deer Creek does indicate that one of the nearest watersheds to Deer Creek displayed a 2.5°F. Thus, Deer Creek may be warming more than Myrtle Creek since Deer Creek evidenced almost a 5°F increase from 1999.

The set of graphs included in Graph 26 show daily temperature fluctuations for the summers of 2015, 2016, and 2017 at the Fowler Creek site on Deer Creek. Different weather patterns are likely responsible for the differences in timing of peaks and valleys between years.

Site Name	Site	Start Date	Stop Date	Seasonal Maximum		Seasonal Minimum		Seasonal Max ΔT		7-Day averages			
	ID			Date	Value	Date	Value	Date	Value	Date	Max	Min	Δ T
Lower South Umpqua Run													
Deer Creek at Fowler Street Bridge	DC1	6/24/2015	10/4/2015	7/3/2015	81.9	9/28/2015	52.9	7/29/2015	12.1	6/30/2015	80.1	71	9.5
Deer Creek at Fowler Street Bridge	DC1	6/2/2016	10/5/2016	8/19/2016	78.6	10/3/2016	55.2	8/19/2016	10.7	7/29/2016	76	67	8.9
Deer Creek at Fowler Street Bridge	DC1	6/8/2017	10/4/2017	8/3/2017	80.1	10/4/2017	51.2	8/2/2017	10.7	8/6/2017	78.1	70	8.6
North Fork Deer Creek at Dixonville Rd.	NDC1	6/2/2016	10/5/2016	6/5/2016	74.9	10/3/2016	53.5	6/3/2016	10.1	6/5/2016	72.2	64	7.8
North Fork Deer Creek at Dixonville Rd.	NDC1	6/8/2017	10/4/2017	8/10/2017	75.2	10/4/2017	49.8	6/24/2017	10.8	8/7/2017	73.9	69	5
South Fork Deer Creek Dixonville Rd.	SDC1	6/2/2016	10/5/2016	8/19/2016	76.7	10/3/2016	55.1	8/19/2016	10.9	8/17/2016	75	65	9.6
South Fork Deer Creek Dixonville Rd.	SDC1	6/8/2017	10/4/2017	8/3/2017	77.6	10/4/2017	52	8/3/2017	9.9	8/6/2017	76.5	68	8.1
South Umpqua River HWY 99 Winston*	SU12	6/30/2016	10/5/2016	7/29/2016	85.4	10/5/2016	58.3	8/11/2016	9.8	7/29/2016	83.3	75	8.7
South Umpqua River HWY 99 Winston*	SU12	6/28/2017	10/4/2017	8/3/2017	85.2	10/4/2017	56.1	8/2/2017	9.3	8/6/2017	83.6	76	7.5
Roberts Creek at Carnes Rd. Bridge	RC1	6/2/2016	10/5/2016	7/29/2016	78.7	10/3/2016	55.3	7/2/2016	13.6	7/27/2016	76.4	66	10
Roberts Creek at Carnes Rd. Bridge	RC1	6/8/2017	10/4/2017	8/3/2017	82	10/4/2017	49.6	8/2/2017	15.1	8/1/2017	79.5	66	14
South Umpqua at Douglas Fairgrounds	SU13.5	6/30/2016	10/5/2016	8/19/2016	86.3	10/5/2016	60.3	8/1/2016	10.9	7/29/2016	84.3	75	8.9
South Umpqua at Douglas Fairgrounds	SU13.5	7/12/2017	10/4/2017	8/3/2017	86.8	10/4/2017	59	8/3/2017	8.5	8/5/2017	85.3	78	7.6
Newton Creek near mouth	NC1	6/2/2016	10/2/2016	8/9/2016	74.5	10/1/2016	56.6	8/9/2016	10.3	8/12/2016	72.1	67	5.3
Newton Creek near mouth	NC1	6/8/2017	10/4/2017	8/4/2017	73	10/4/2017	54.2	6/24/2017					
South Umpqua at Singleton Park	SU15	6/30/2016	10/5/2016	8/19/2016	87.5	10/3/2016	59.8	8/19/2016	10.9	8/17/2016	85	76	9.2

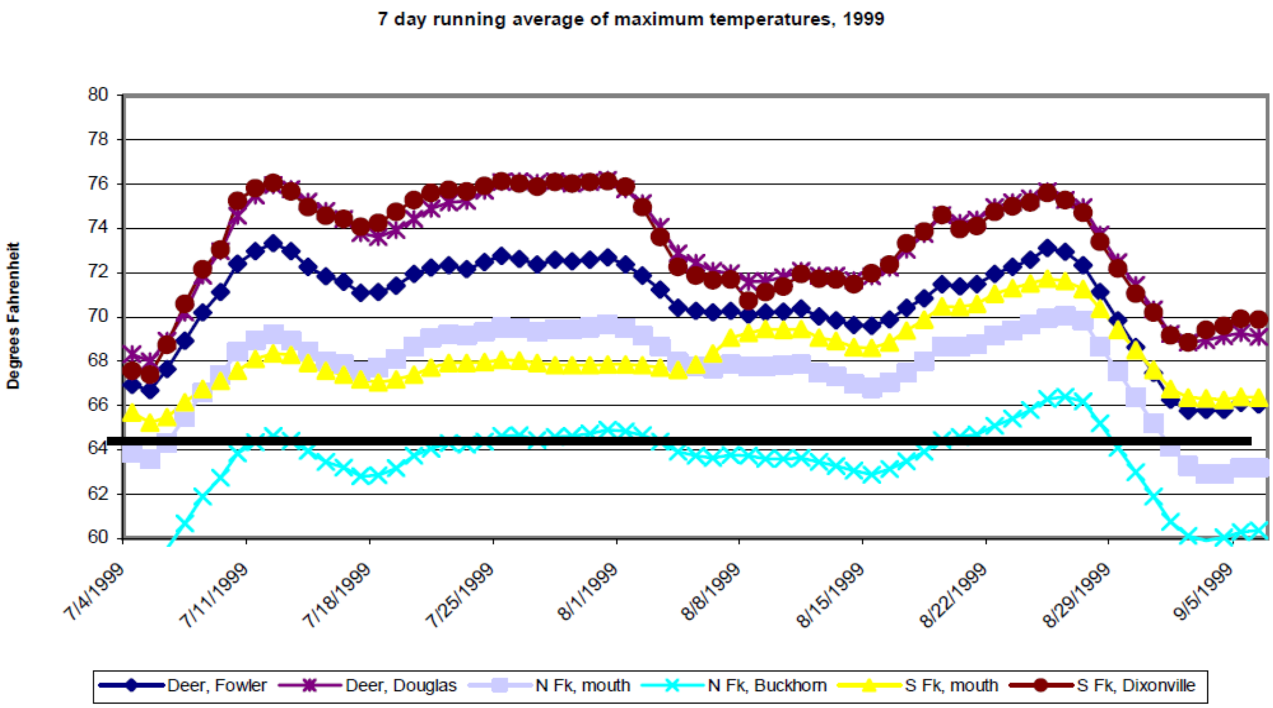
Table 15. Lower South Umpqua continuous temperature logger summary.

Site Name	Site	Days >	Days >	Days >	Hours >	Hours >	Hours >	Warmest day of 7-day max		
	ID	55 F	64 F	70 F	55 F	64 F	70 F	Date	Max	Min
Lower South Umpqua Run										
Deer Creek at Fowler Street Bridge	DC1	103	84	66	2450	1752	728.5	7/3/2015	81.9	70.5
Deer Creek at Fowler Street Bridge	DC1	126	109	69	3023.5	2101	741.5	7/29/2016	78.3	69.3
Deer Creek at Fowler Street Bridge	DC1	119	95	82	2813.5	2078	927.5	8/3/2017	80.1	69.4
North Fork Deer Creek at Dixonville Rd.	NDC1	126	88	26	2978.5	1515	175	6/5/2016	74.9	66.3
North Fork Deer Creek at Dixonville Rd.	NDC1	118	89	44	2719	1768	447	8/10/2017	75.2	70.8
South Fork Deer Creek Dixonville Rd.	SDC1	126	108	59	3023.5	1866	395	8/19/2016	76.7	65.8
South Fork Deer Creek Dixonville Rd.	SDC1	119	93	69	2809.5	1999	510	8/3/2017	77.6	67.8
South Umpqua River HWY 99 Winston*	SU12	98	94	86	2351.5	2161	1697	7/29/2016	85.4	76.1
South Umpqua River HWY 99 Winston*	SU12	99	93	80	2375.5	2090	1816	8/3/2017	85.2	76.1
Roberts Creek at Carnes Rd. Bridge	RC1	126	108	66	3023.5	1918	623.5	7/29/2016	78.7	68.6
Roberts Creek at Carnes Rd. Bridge	RC1	119	96	74	2791	1904	720	8/3/2017	82	67.4
South Umpqua at Douglas Fairgrounds	SU13.5	98	95	90	2351.5	2232	1811	7/29/2016	85.8	77
South Umpqua at Douglas Fairgrounds	SU13.5	85	84	69	2039.5	1835	1568	8/3/2017	86.8	78.3
Newton Creek near mouth	NC1	123	107	23	2951.5	1953	204	8/9/2016	74.5	64.2
Newton Creek near mouth	NC1	119	94	16	2846.5	1921	175	8/3/2017	73	68.4
South Umpqua at Singleton Park	SU15	98	95	90	2351.5	2210	1827.5	8/19/2016	87.5	76.6

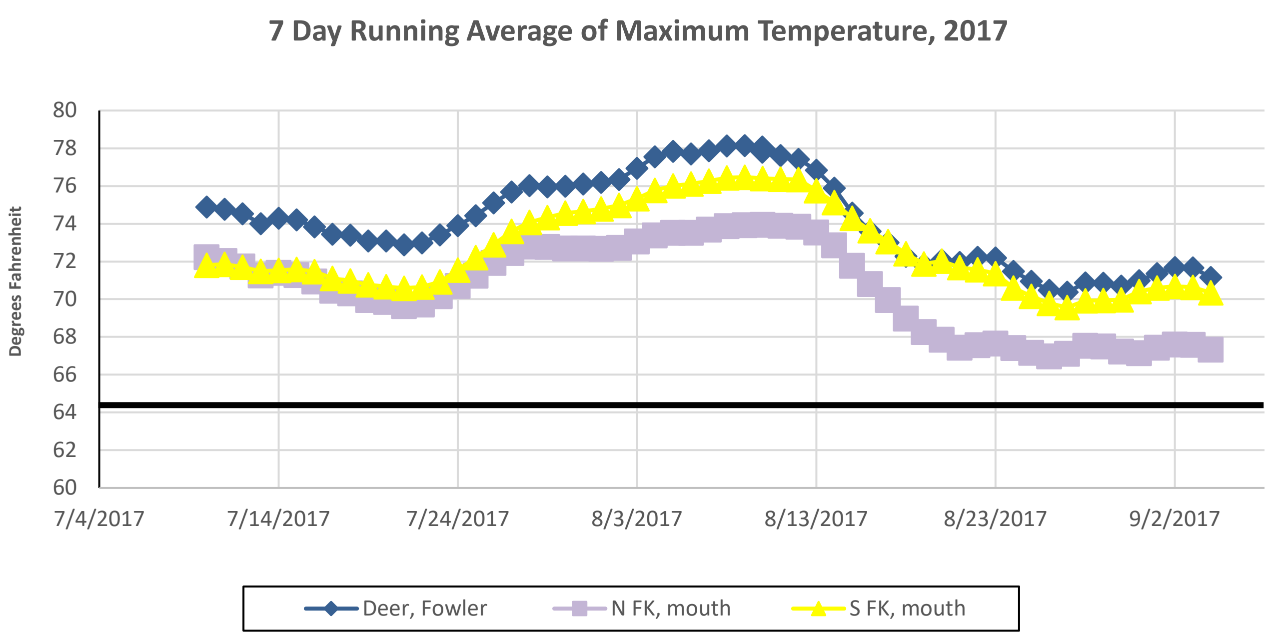
Table 16. Continued for Lower South Umpqua continuous temperature logger summary.

7 Day Running Average of Maximum Temperature

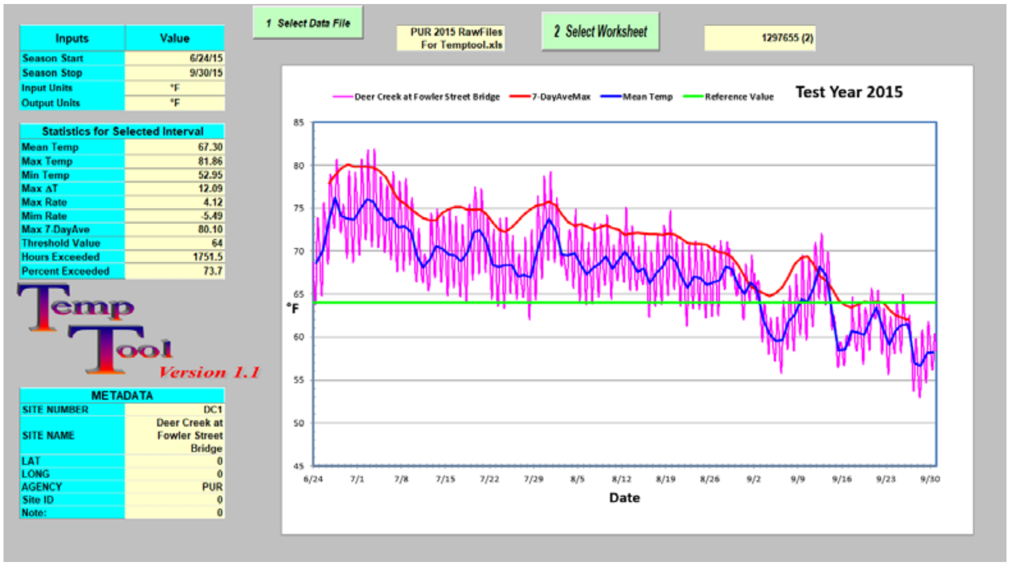
(Information from Deer Creek Watershed Assessment and Action Plan, Umpqua Basin Watershed Council, 2002)

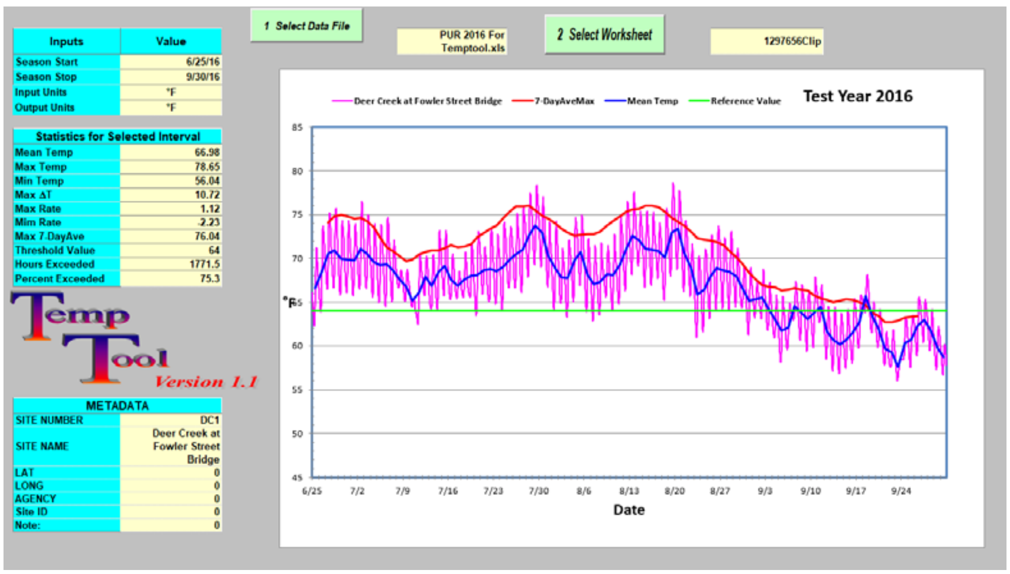


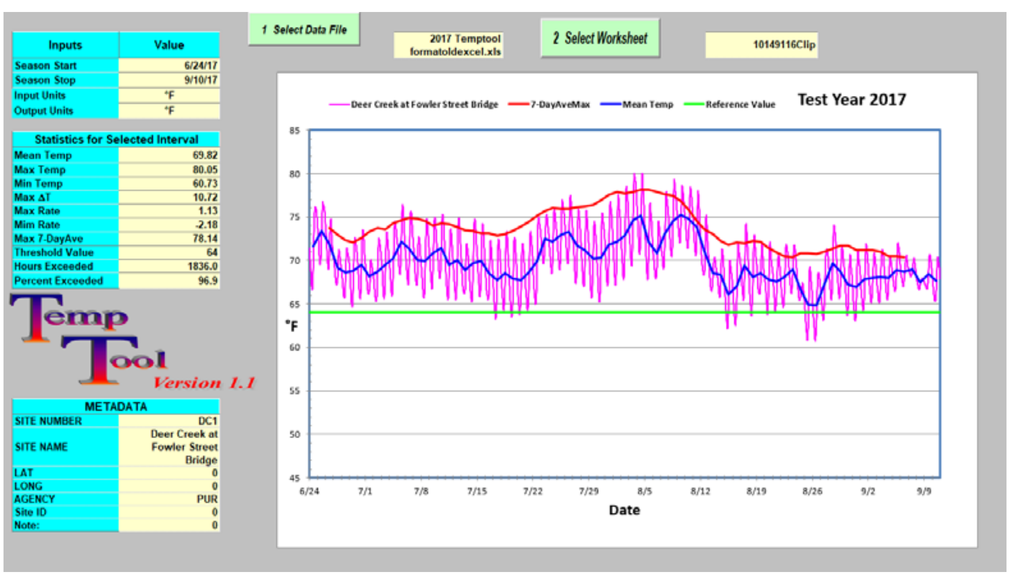
Graph 25. Data from 1999 from Deer Creek Watershed Assessment.



Graph 26. Plot 7-Day Average Running Max for three of the sites that were monitored in 1999 above.







Graph 27. Summer temperature data for 2015, 2016, & 2017 for Deer Creek at Fowler Street Bridge.

RESULTS Lower South Umpqua Watershed 2015-2017

Summary

Table 16 displays the ranking for sites and parameters in the Lower South Umpqua Watershed. A quick glance at the chart indicates that turbidity, dissolved oxygen, *E. coli*, and temperature all failed badly at meeting criteria at all sites. PH, at least, had six sites that fell within the DEQ criteria range, at least for the times that monitoring was carried out.

The worst site was R1 – Roberts Creek at Carnes Road, followed closely by U14 – South Umpqua at Oak Street Bridge.

Summary Rating for Lower South Umpqua Monitoring Sites 2015-2017 – Six Water Quality Parameters

	Turbidity	pH	Dissolved Oxygen	Conductivity	*E. coli* ≥406 MPN/100ml Criteria	Temperature 2010 Criteria
SU14-South Umpqua River at Oak Ave. Bridge	Red	Red	Red	Blue	Red	Red
DC1-Deer Creek at Fowler Street Bridge	Red	Blue	Red	Blue	Red	Red
DC2-Deer Creek Off road near 5155 N Umpqua Hwy	Red	Blue	Red	Blue	Red	Red
NDC1-North Fork Deer Creek at Dixonnvlle Rd. Near Mouth	Red	Blue	Red	Blue	Red	Red
SDC1-South Fork Deer Creek at private property Rd. Bridge	Red	Blue	Red	Blue	Red	Red
RC2-Roberts Creek Bridge on Roberts Creek Road	Red	Yellow	Red	Blue	Red	Red
SU12-South Umpqua River HWY 99 Bridge, Winston	Yellow	Yellow	Red	Blue	Red	Red
SU13-South Umpqua River at Happy Valley Road	Yellow	Red	Red	Blue	Red	Red
RC1-Robert Creek at Carnes Rd Bridge	Red	Red	Red	Yellow	Red	Red
NC1-Newton Creek at Jefferson Street Bridge near mouth	Red	Blue	Red	Yellow	Red	Red
CC1-Champagne Creek at Melrose Road Bridge	Red	Blue	Red	Blue	Red	Red
SU15-South Umpqua River at Singleton Park	Red	Red	Yellow	Blue	Red	Red

Table 17. Rating summary of Lower South Umpqua monitoring sites. See individual parameter's summary for the criteria used in establishing the color.

South Umpqua Reference Run

Area Description, Background & Monitoring Sites

PUR's strategy for water quality monitoring is to monitor fifth field by fifth-field for 3 years of intensive monitoring of a fifth-field at many locations. After three years the next fifth-field will be chosen and monitored intensively. As fifth-fields are complete the intensively monitored phase a few representative sites are selected to maintain as reference sites.

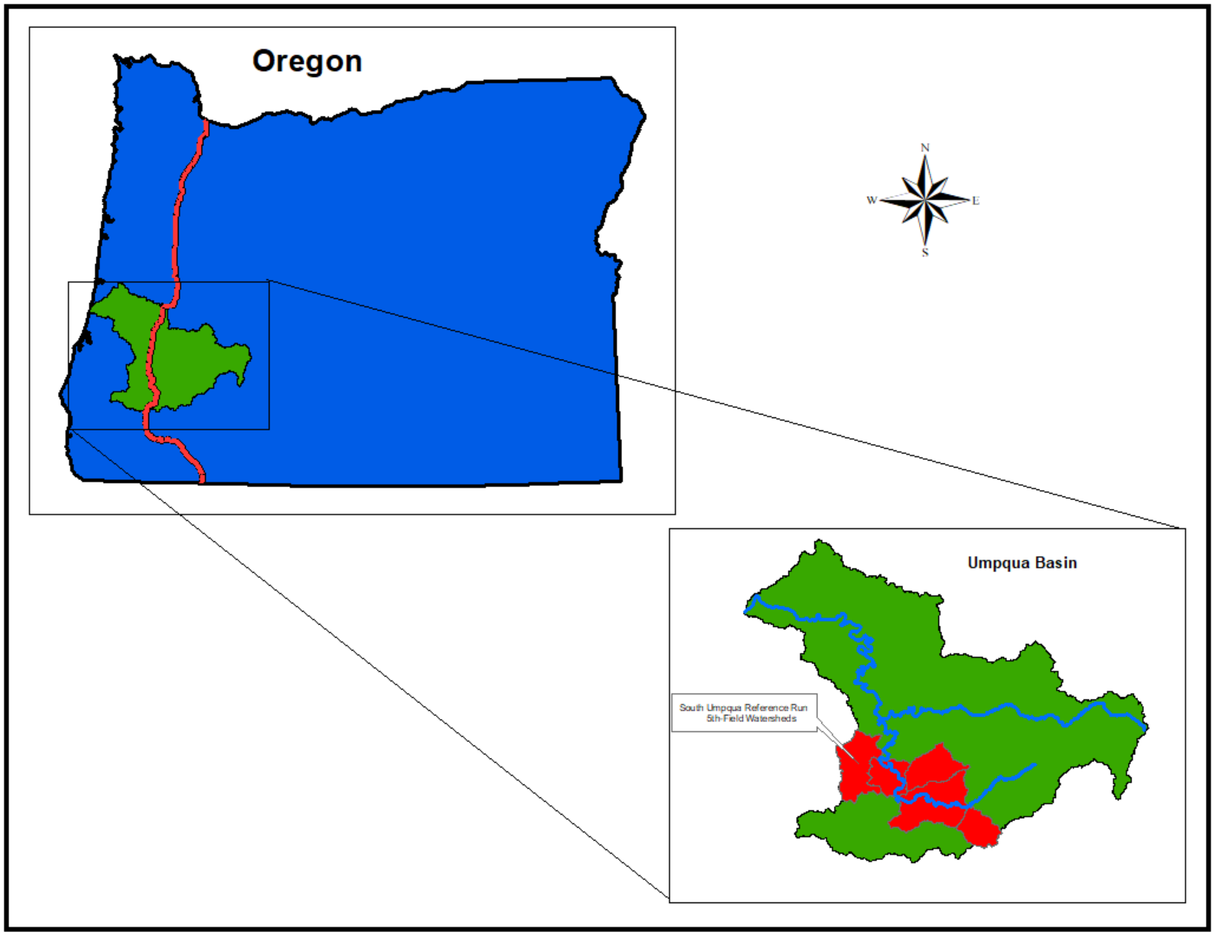
The "South Umpqua Reference Run" was established by the Monitoring Committee in January of 2015 to maintain a few long-term sites in several fifth-field watersheds that have been intensively monitored for three or more years in a majority of the South Umpqua fifth field watersheds. Map 6 displays the three fifth-field watersheds that were incorporated into our first reference run.

The description of these watersheds and the report on three years of data collection can be found in PUR's Final Report, January 31, 2017 for OWEB Grants #212-2062 and 214-2016 available on PUR's website: www.umpquarivers.org as well as on OGMS (OWEB Grant Management System).

When reference sites are selected the previously collected data is included into the reference data set to better track long term changes. For consistency of data collection techniques, only data where a Sonde was used were used in this analysis. Therefore, several sites are being reported back to 2010.

Photos 5-10 give an indication of the varying conditions occurring at some of the reference sites at different times of the year.

All data will be presented as box plot graphs including outliers to compare from year to year. Individual monitoring event data has been provided to ODEQ and will eventually be available at their new online data storage system - AWQMS (Ambient Water Quality Monitoring System). Anyone wishing to obtain the raw data may contact Joe Carnes at the Partnership for the Umpqua Rivers.



Map 6. South Umpqua Reference Run area map

Photo 5.
Elk Creek merging with the South Umpqua 1/17/17.

Photo 6.
Elk Creek at mouth 8/23/17.

Photo 7.
Lookingglass Creek at Hwy 42 Bridge West of Olalla Rd. 7/18/17.

Photo 8.
Morgan Creek at Dairy Loop Road Bridge. 9/21/17

Photo 9. **South Umpqua River at Brockway Road 1/20/16**

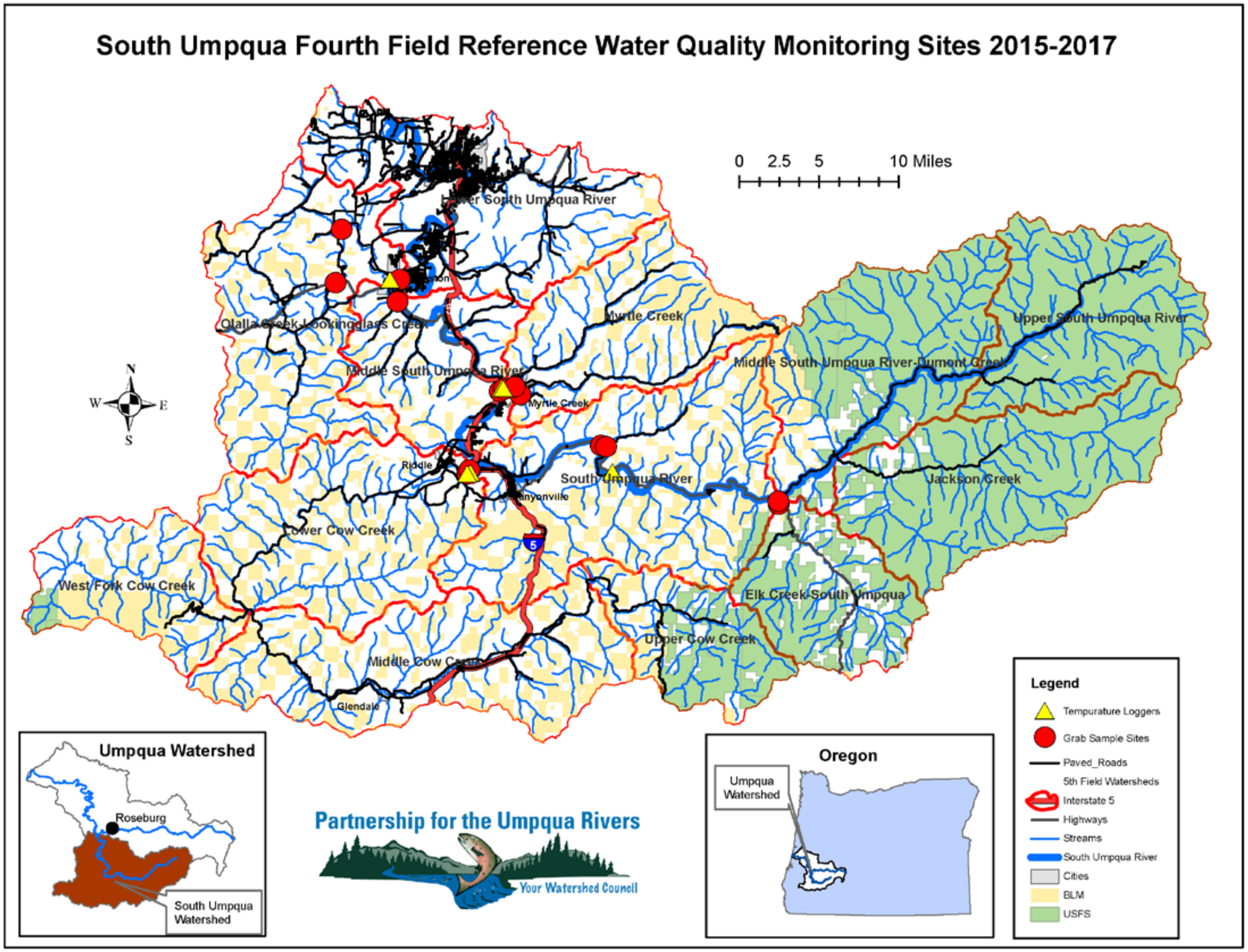
Photo 10. **South Umpqua River at Brockway Road 7/18/17.**

	Site ID	River/Stream	Location	Latitude	Longitude	Township, Range, Section
1	SU1	South Umpqua River	Above Elk Creek	42.92716	-122.95144	T30S R2W S33
2	E1	Elk Creek	Near Mouth	42.833983	-122.84921	T30S R2W S33
3	SU2	South Umpqua River	At Hwy 1 bridge	42.9728	-123.172	T30S R4W S9
4	DC4	Days Creek	At Hwy 1 bridge	42.9724	-123.166	T30S R4W S10
5	COC1	Cow Creek	Near Mouth	42.9428	-123.3367	T30S R5W S19
6	SU6	South Umpqua River	At Lawson Bar	42.947	-123.334	T30S R5W S19
7	SU8	South Umpqua River	Near Myrtle Creek Water Plant	43.0227	-123.297	T29S R5W S28
8	MC1	Myrtle Creek	At mouth	43.0229	-123.296	T29S R5W S28
9	SM1	South Myrtle Creek	At Neil Lane Bridge	43.016972	-123.274371	T29S R5 S27
10	NM1a	North Myrtle Creek	At Evergreen Park Near Mouth	43.0233	-123.2832	T29S R5 S27
11	SU11	South Umpqua River	At Brockway Road	43.0978	-123.43	T28S R6W S32
12	LG3	Lookingglass Creek	At Hwy 42 Bridge West of Olalla Rd.	43.113333	-123.50773	T28S R7W S27
13	MG2	Morgan Creek	At lower Dairy Loop Rd. Bridge	43.1615	-123.50326	T28S R7W S2
14	LG1	Lookingglass Creek	At Hwy 42 Bridge Winston Near Mouth	43.1177	-123.4283	T28S R6W S20

Table 18. South Umpqua Reference Water Quality Monitoring Sites.

	Site ID	River/Stream	Location	Latitude	Longitude	Township, Range, Section
1	SU1a	South Umpqua	Private Property at 3280 Shivley Rd.	42.9484	-123.158	T30S R4W S22
	COC1	Cow Creek	Near Mouth	42.9428	-123.3367	T30S R5W S19
2	SU6	South Umpqua	Upstream Lawson Bar	42.947	-123.334	T30S R5W S19
3	SU8	South Umpqua	Below Myrtle Creek Water Plant	43.0227	-123.297	T29S R5W S28
4	MC1	Myrtle Creek	At mouth	43.0229	-123.296	T29S R5W S28
5	LG1	Lookingglass Creek	At Brockway Rd. Bridge Winston Near Mouth	43.117365	-123.440747	T28S R6W S20

Table 19. South Umpqua Reference Temperature Recorder Monitoring Sites.



Map 7. South Umpqua Reference Run water quality monitoring sites.

SU1 - South Umpqua above Elk Creek at Bridge

Year	Monthly Samples	Months
2010	12	Full Year
2012	6	July- December
2013	9	January-August
2015	12	Full Year
2016	12	Full Year
2017	12	Full Year

Table 20. Number of monitoring events per year included in graphs that follow for South Umpqua above Elk Creek site.

Flow

USGS has a stream gage at this exact spot on the South Umpqua at Tiller. The graph of the discharge data from 2010 through 2017 is included here in Graph 34 and the mean flow per water year displayed in Table 21. They can be used for comparison to water quality parameters. 2015 had the lowest flow during the period studied and there has been a slight increase in recorded low flow (less low) from 2015 to 2016 and to 2017.

Turbidity

The South Umpqua river at Tiller has some elevated turbidity levels from 2010 thru 2017. During our grab sampling the highest level detected was 20 NTU which is quite good compared to other parts of the Umpqua Basin. Photo 12 shows how the river appears at 12.3 NTU. In our January 31, 2017 Report we indicated that only 11% of our samples from 2008-2013 were greater than 10 NTU. It is apparent from Graph 28 that this has even decreased when comparing the upper quartiles above the 10 NTU line of 2015-2017 to 2010-2013.

pH

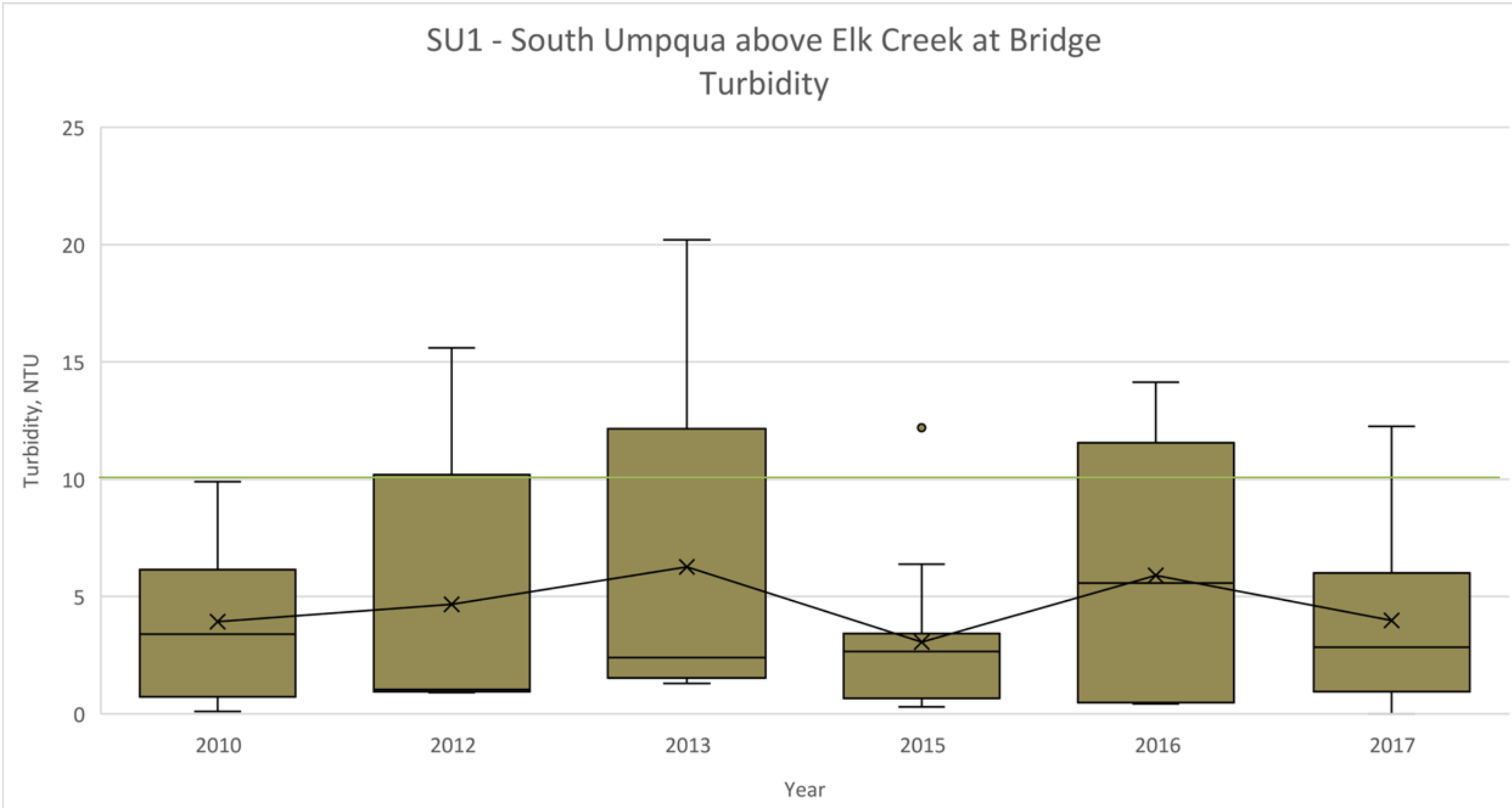
In general, the pH levels at this site are good compared to many other areas in the Umpqua. With grab sampling only two sampling events exceeded the upper DEQ recommended limit of 8.5 and those were in 2010 and 2013. The box plot graph does indicate and interesting trend in that the pH values for 2015, 2016, and 2017 showing a downward trend in pH both at the high and low end of the range. Median and mean values show a slight decrease for each year. Graphs 30, 31, and 32 were created to see if it could be determined if this might be due to algae. Algae alone does not appear to be the cause as many of the low pH levels are occurring during winter in the middle of the day. Time of sampling was ruled out in Graph 33 where pH vs Time of day were plotted to see if there was a similar trend. Considering temperature as another influencing possibility was ruled out as an increase in temperature from 0 degrees Celsius to 10 degrees Celsius results in a 0.2 drop in ph. If you decrease the temperature the opposite will happen: the pH level will increase very slightly. So, it is unlikely that temperature is accounting for this change. Graph 30 indicates that both summer and winter pH values are trending downward with some in 2017 approaching the lower limit line of 6.5 recommended by DEQ. The trend lines were added, and R-Squared values displayed. Interestingly when all data was include (Graph 31) vs only 2015-2017 (Graph 32) a stronger R-Squared was obtained with a steeper downward trend. Not enough data, nor 24-hour data is available to make any reliable conclusions. This site should be carefully monitored for possible future ongoing changes. If safe and affordable it would be a good site for continuous monitoring of pH.

Dissolved Oxygen
The South Umpqua above Elk Creek at Tiller, had no exceedances of the DEQ dissolved oxygen criteria for the non-spawning criteria (see Graphs 35 and 36). Only two failed to reach the spawning criteria of 11 mg/l during the period of 10/16 thru 5/15. These are marked on Graph 36 and only occurred in 2015. One was within 15 days of the beginning of the season and the other within 12 days of the end of the season. The two events touching the upper line are within the reproducibility of the instrument of being at 11. There appears to be some variability from year to year but within the limits. Years 2016 and 2017 are trending upward toward better dissolved oxygen content of the water.

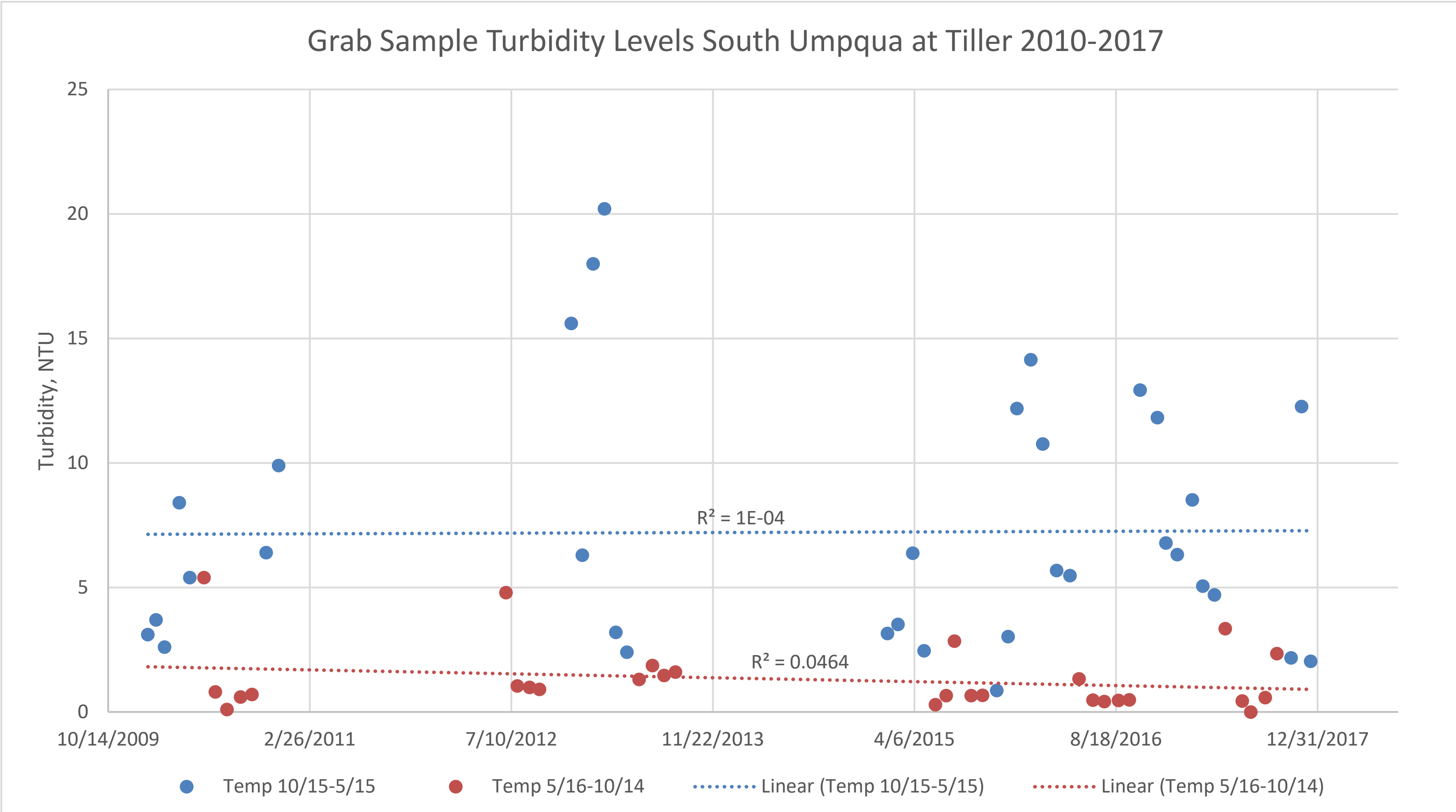
Conductivity
Conductivity levels for the South Umpqua at Tiller were within normal ranges for the Umpqua Basin, and none even exceeded 160 µS/cm. The conductivity did show a slight downward trend from 2015 thru 2017. It might be of interest to continue to watch this in future years to see if it is coinciding with the downward trend in pH for those years.

E. coli
E. coli levels were not high at this site with none ever exceeding 250 MPN/100ml, let alone 406 MPN/100ml or greater, the one time reading that would list a stream. Only three were above the 126 MPN/100ml which DEQ criteria indicates would have to have been measured 5 times in one month to also list a stream for *E. coli.*

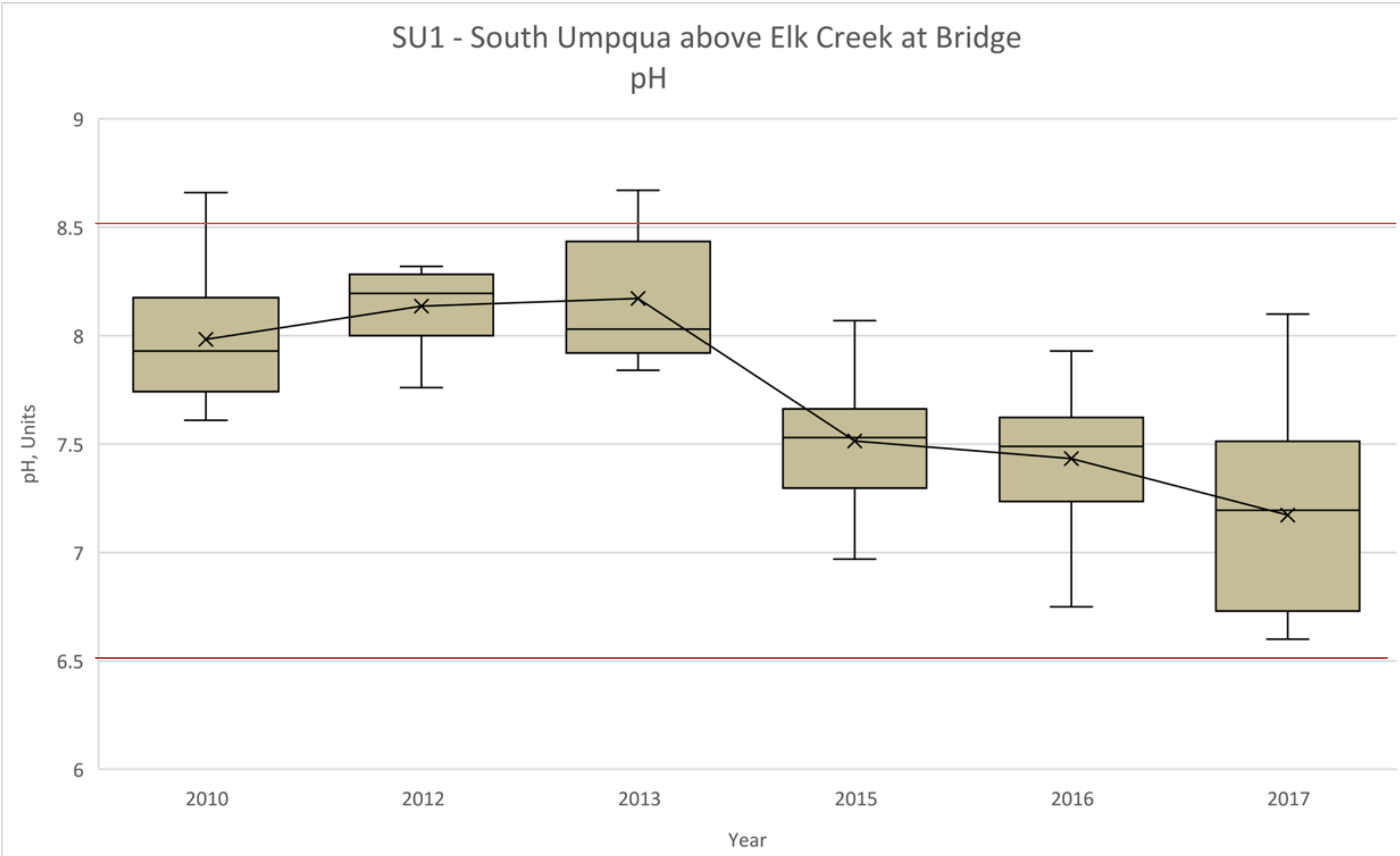
Temperature
PUR has partnered with the USFS Tiller Ranger District in the monitoring of the Elk Creek/Tiller area since 2008 with PUR collecting the grab sample water quality parameters and the Forest Service providing the data from their continuous summer temperature monitoring sites. For this study, we are adding only the South Umpqua at Tiller and Elk Creek at the mouth for reference sites. The South Umpqua River at Tiller is a designated area for Core Cold Water which must meet the criteria of 7DAM <60.8^{o} F. Appendix K shows which streams need to meet this criterion. Unfortunately, this site fared very poorly for temperature. Our grab sample data alone was indicative that there was no way these waters would meet the 7DAM of <60.8^{o} F. The Forest Service's continuous temperature data confirmed this with a 2016 7DAM of 82.4^{o} F and a corresponding low at the same time of 77.4^{o} F!
Though this site failed badly at meeting the Core Cold Water criteria, during the spawning time of year it appeared from our grab sample data to meet the Spawning Criteria of ≤55.4^{o} F. A close viewing of Appendix L however, indicates that this small section of the river is not considered a spawning area.



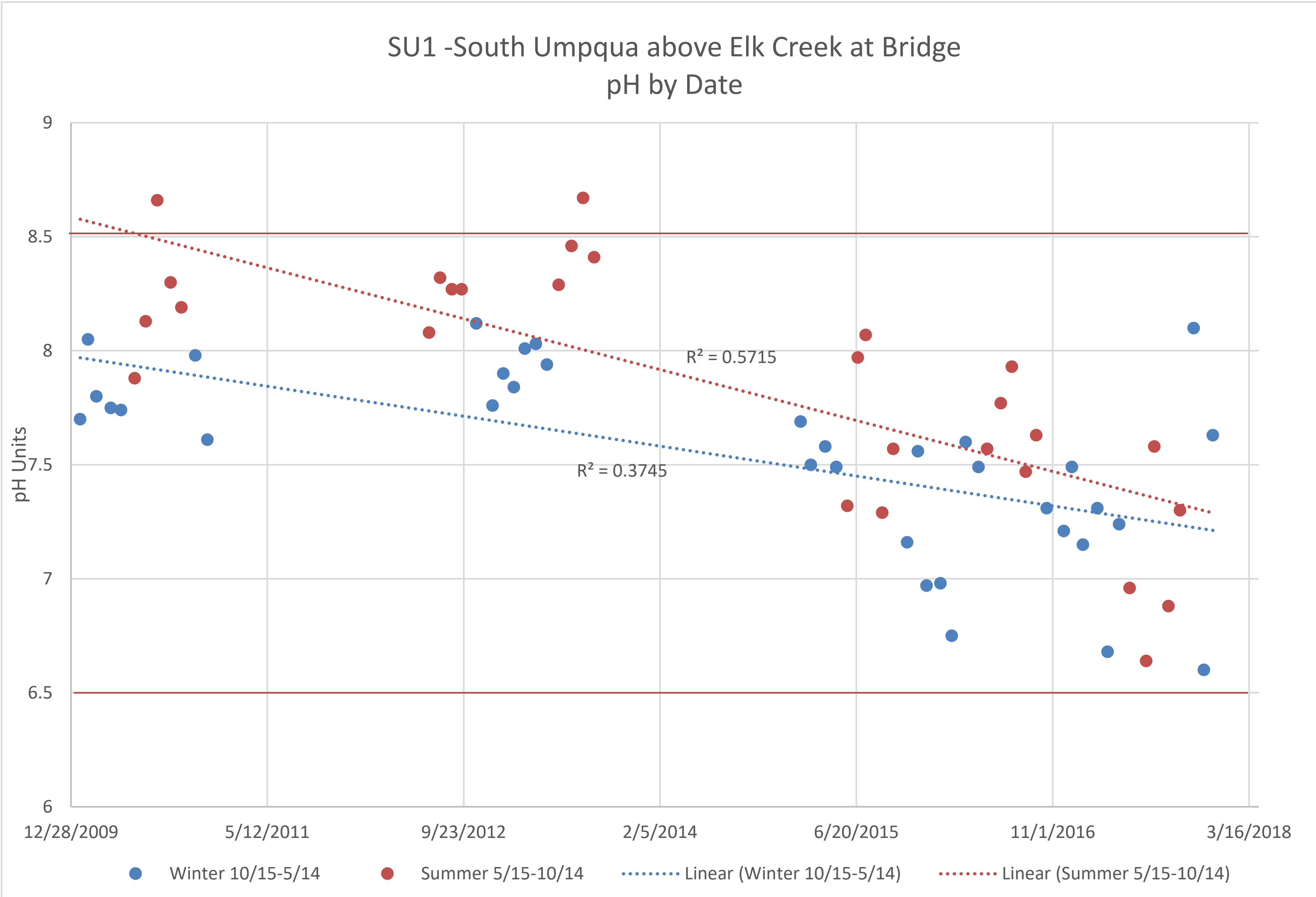
Graph 28. Box plots by year of turbidity levels of the South Umpqua above Elk Creek.



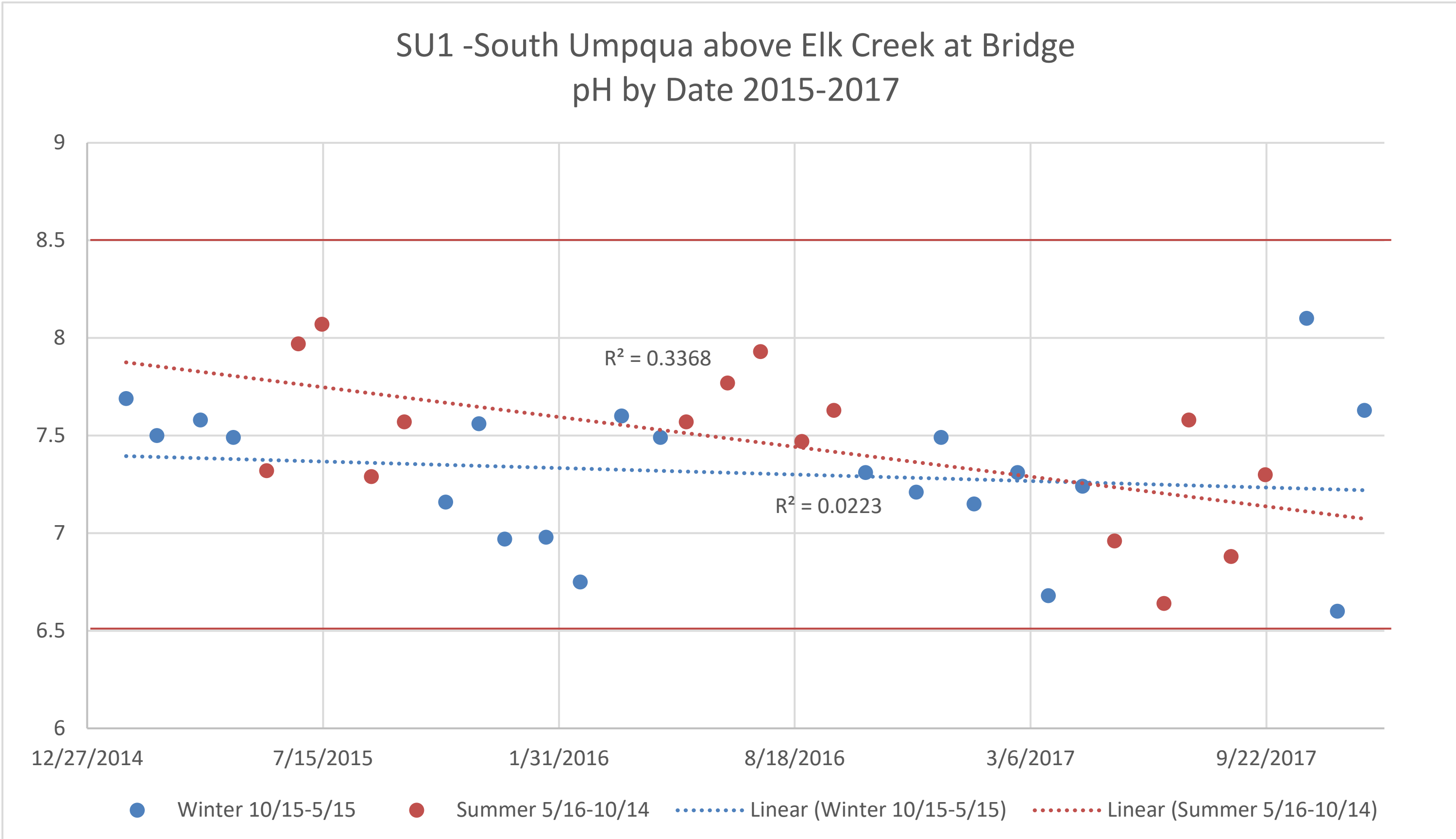
Graph 29. Grab sample turbidity levels South Umpqua at Tiller 2010-2017 summer and winter separated.



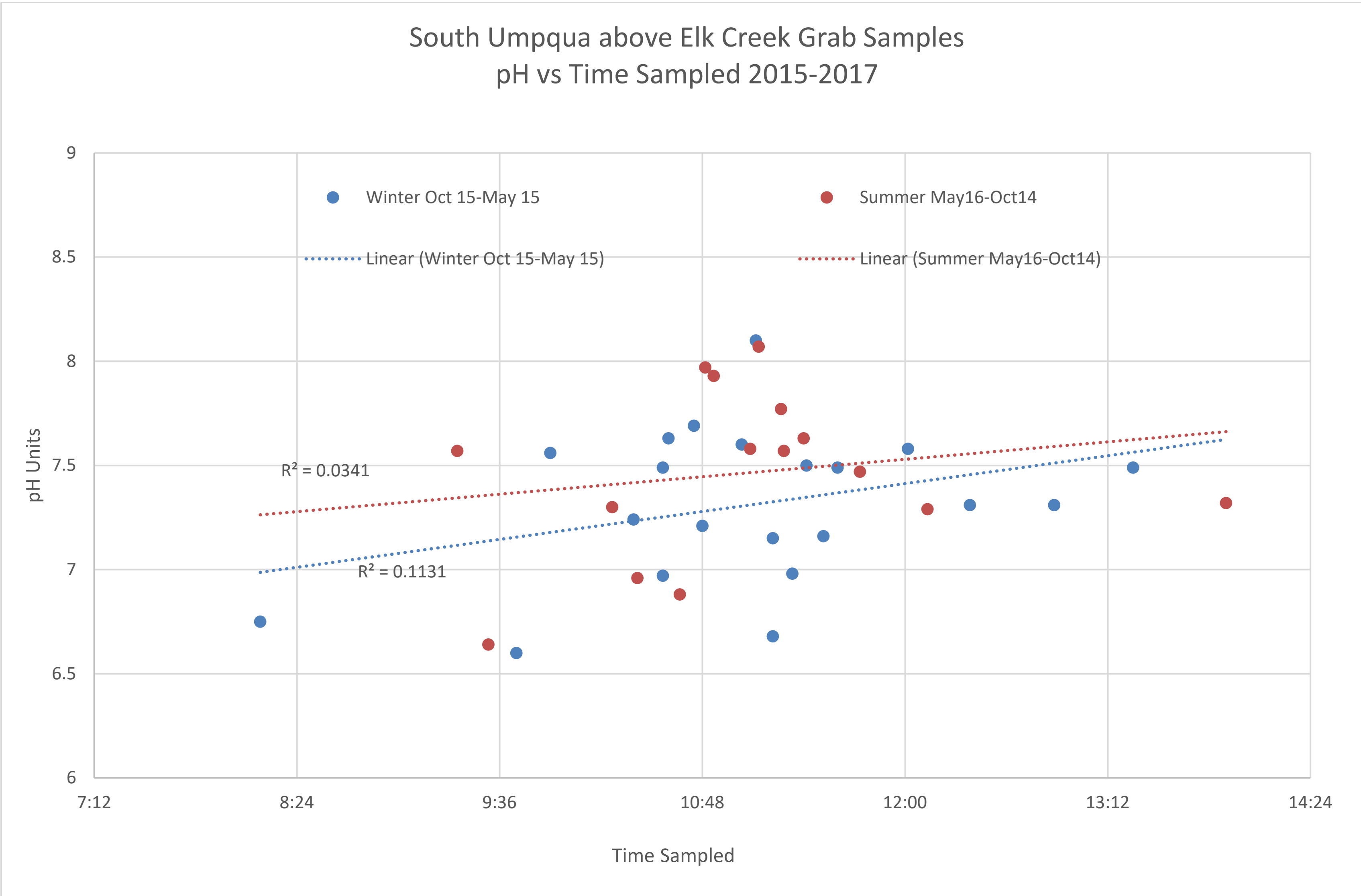
Graph 30. Box plots by year of pH grab sample levels of the South Umpqua above Elk Creek.



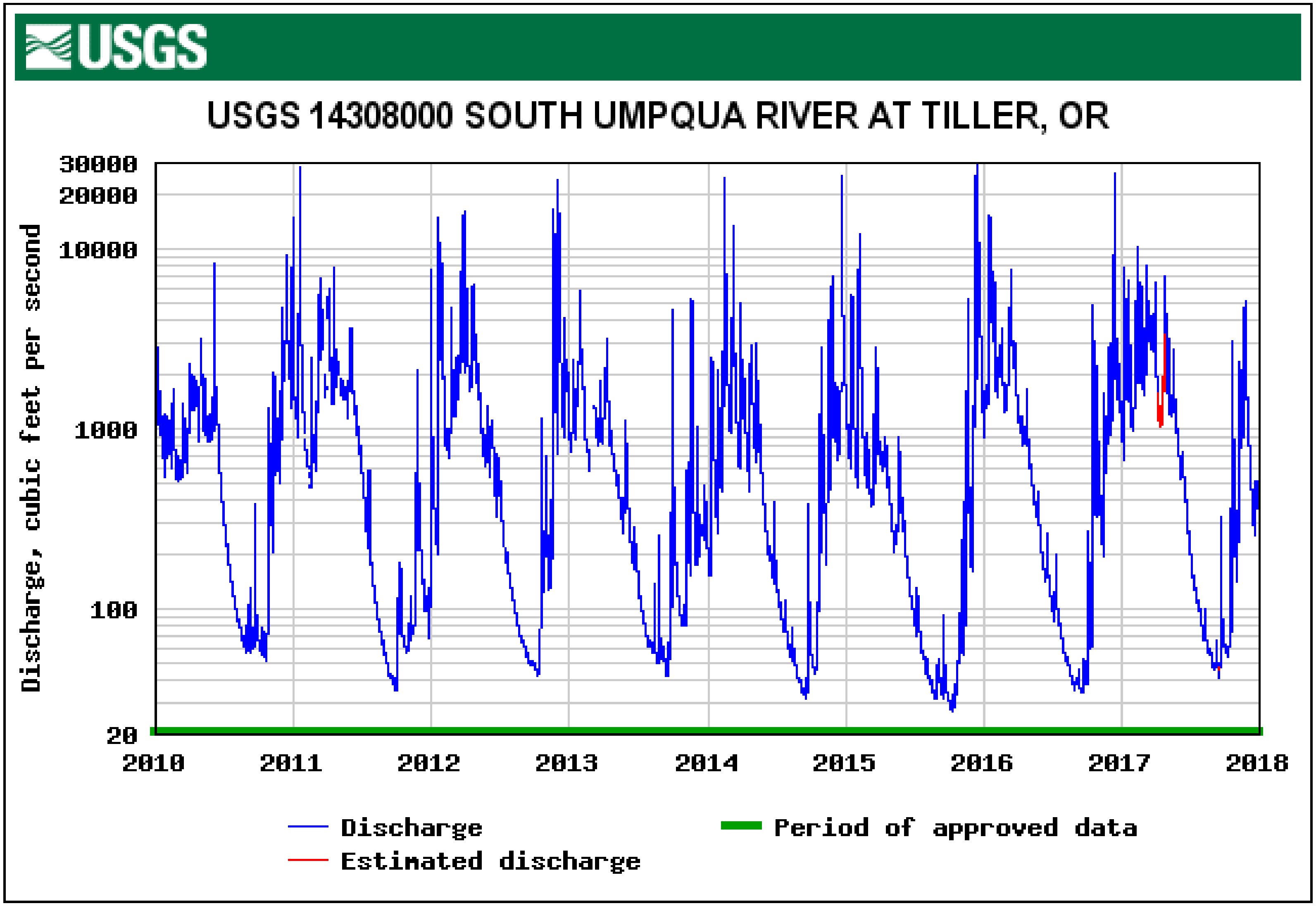
Graph 31. pH at South Umpqua above Elk Creek 2010-2017 indicating dates between to10/15 and 5/15 compared to period 5-16 and 10/14 when algae appears to be most active.



Graph 32. SU1 -South Umpqua above Elk Creek at Bridge pH summer and winter separated 2015-2017.



Graph 33. Grab sample data at South Umpqua above Elk Creek at Tiller for years 2015-2017 pH levels plotted against time of collection separated by winter and summer.



Graph 34. Stream discharge data from 2010-2017 from USGS gage at Tiller on the South Umpqua River.

Douglas County, Oregon Hydrologic Unit Code 17100302 Latitude 42°55'50", Longitude 122°56'50" NAD27 Drainage area 449 square miles Gage datum 991.8 feet above NGVD29	**Output formats** HTML table of all data Tab-separated data Reselect output format

Water Year	00060, Discharge, cubic feet per second
Period-of-record for statistical calculation restricted by user	
2010	715.1
2011	1,470
2012	1,132
2013	919.3
2014	822.7
2015	862.1
2016	1,250
2017	1,443
** No Incomplete data have been used for statistical calculation	

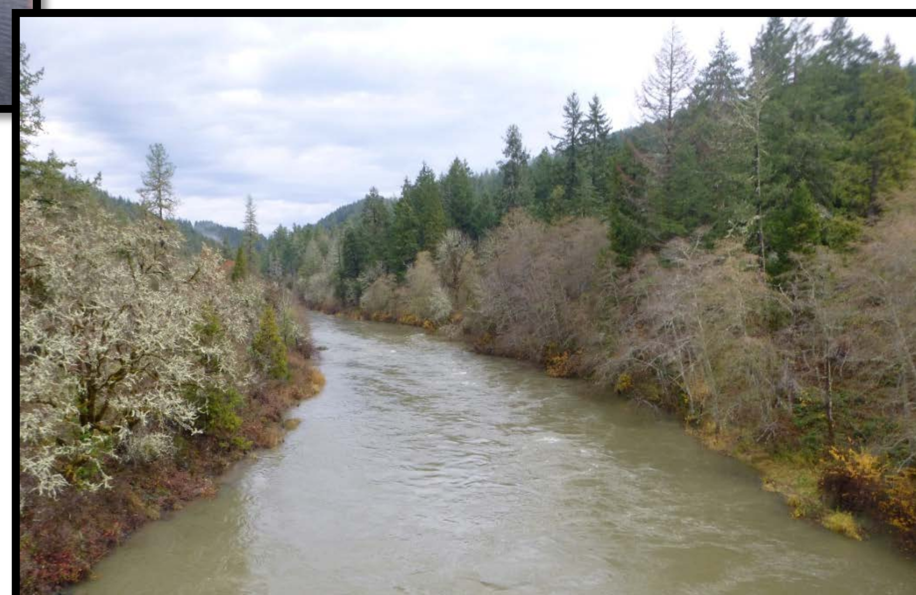
Table 21. USGS data summary of discharge values 2010-2017 water years.

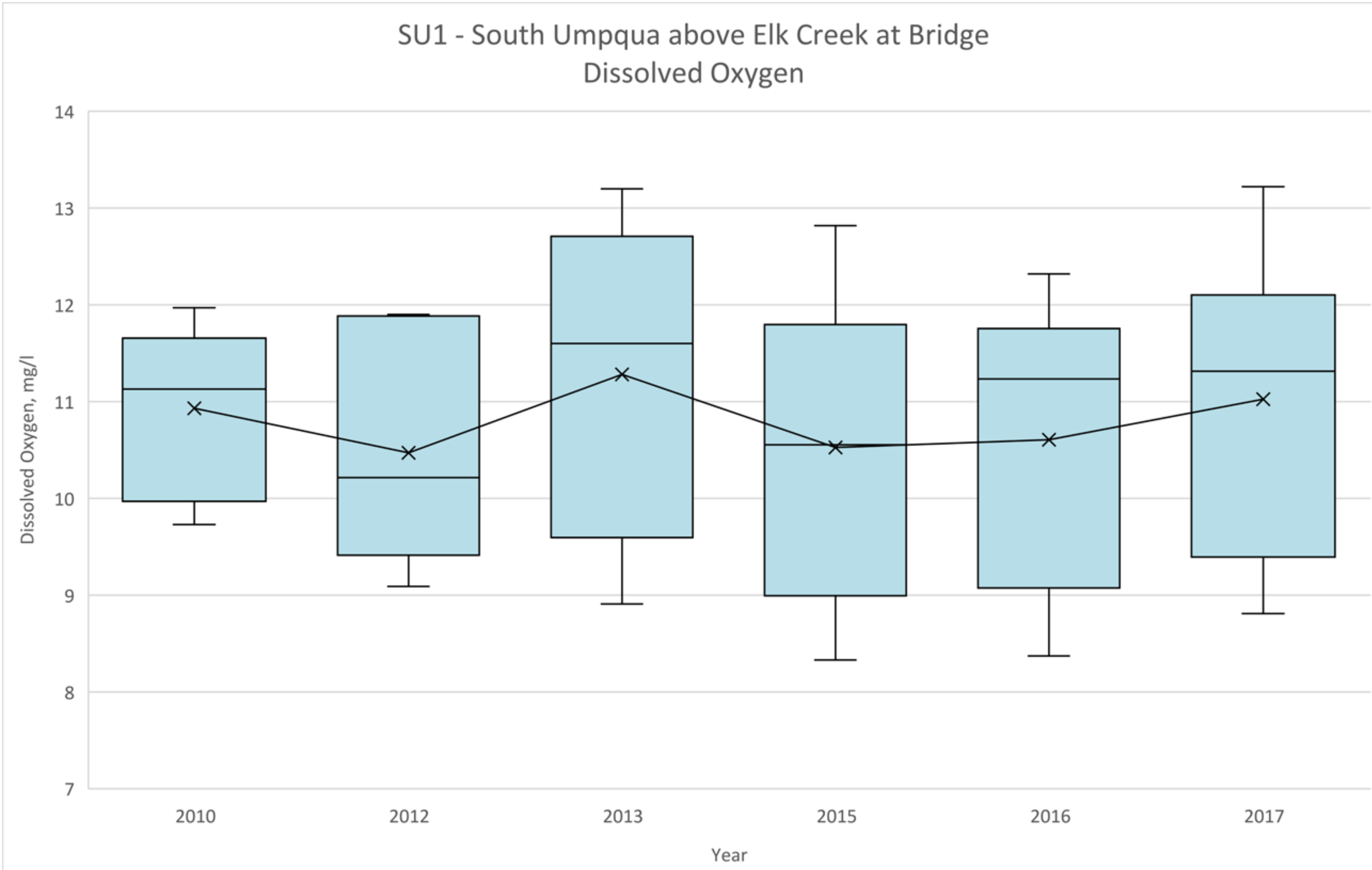
Photo 11. **SU1 -South Umpqua looking downstream from bridge at Tiller on 7/24/13.**

Difficult to see because of the reflection but there is a lot of algae present which, if it is not dying off, during the day sunlight encourages oxygen production from CO2 cleavage resulting in lower pH. At night oxygen is consumed through respiration and then returns to a reducing environment increasing alkalinity, which increases pH.

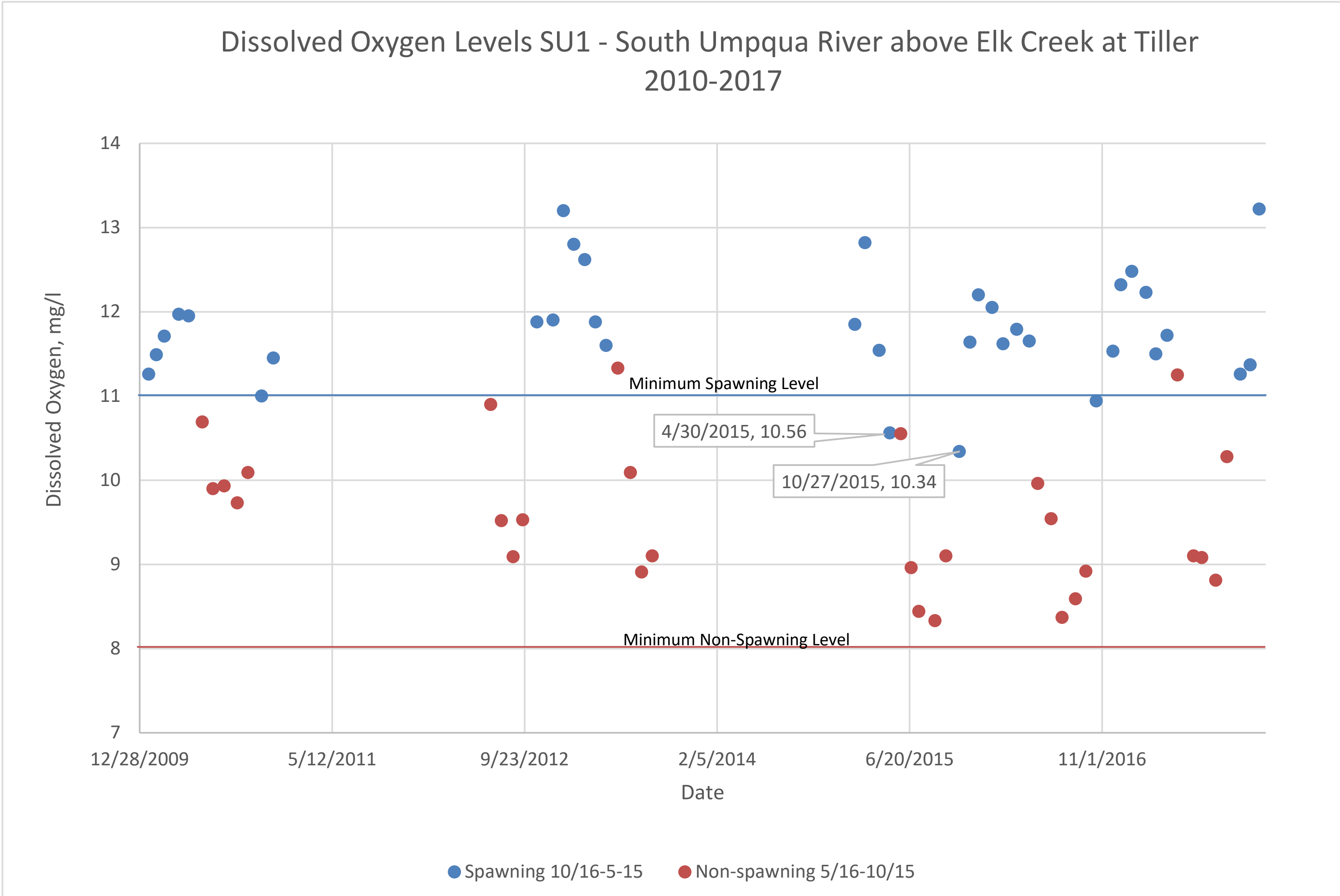
Photo 12. **High flows. SU1 -South Umpqua looking upstream from bridge at Tiller on 11/21/17.**

The turbidity currently was 12.3 for comparison to Graph 28.

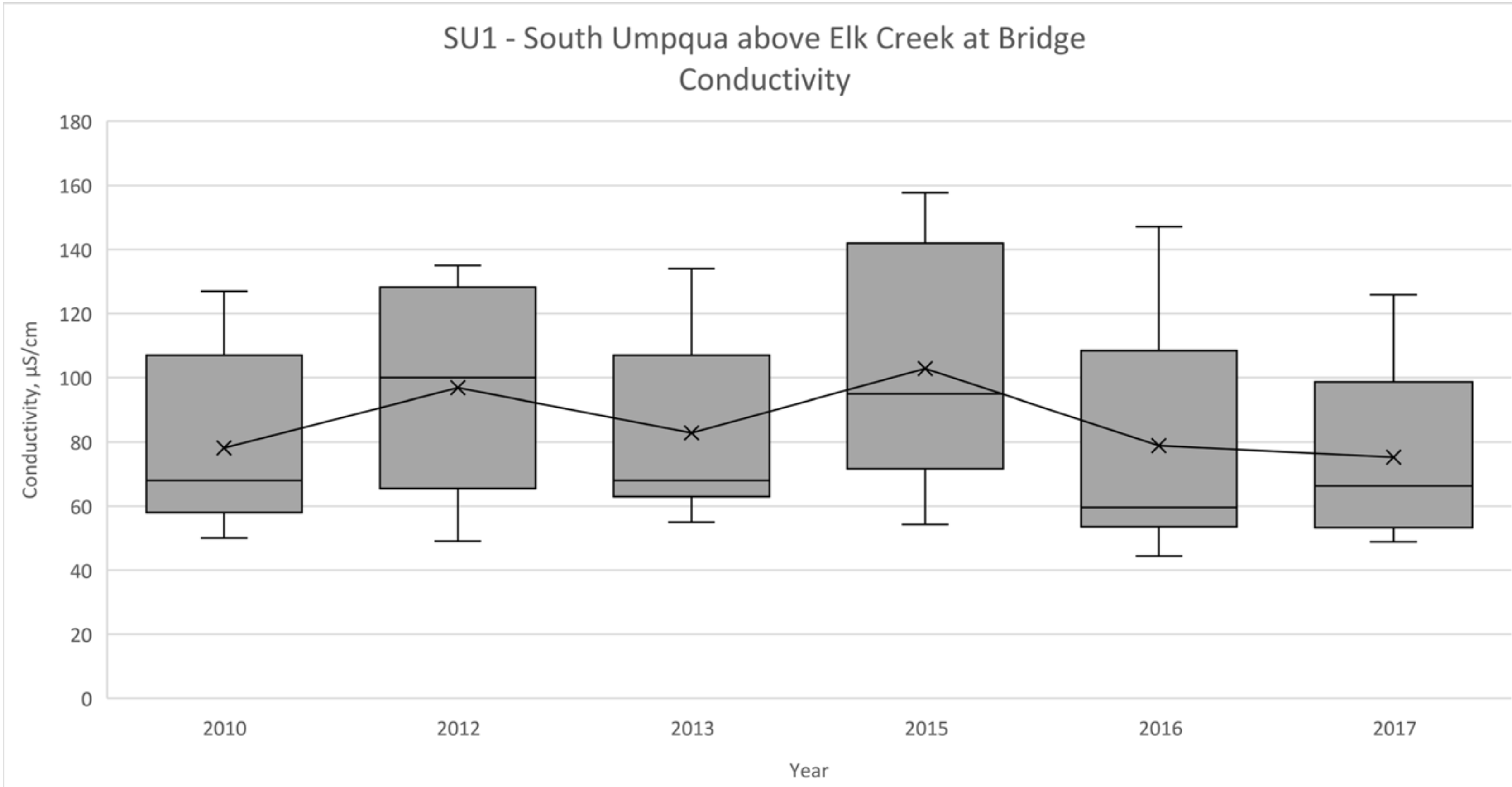




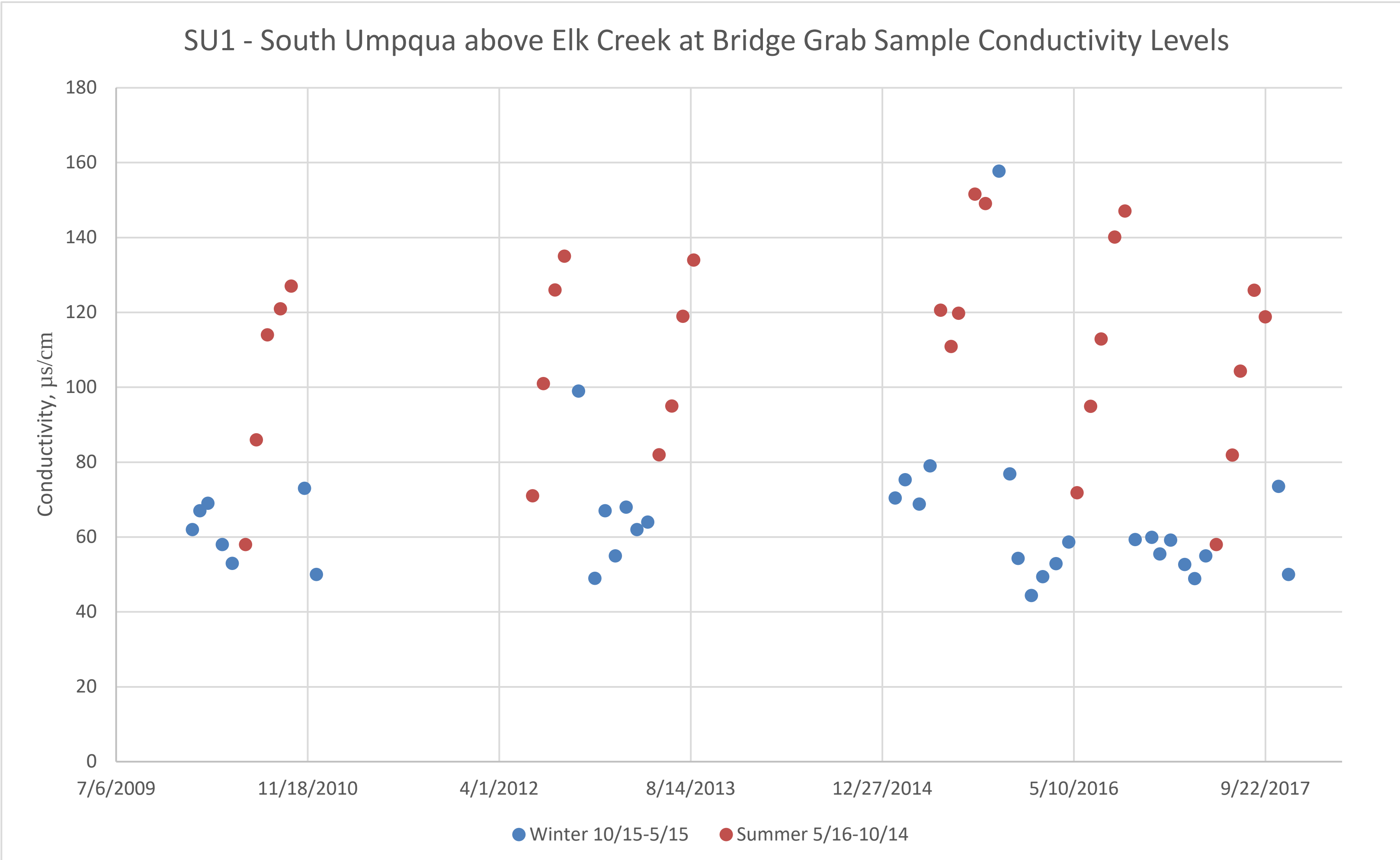
Graph 35. Box plots by year of dissolved oxygen levels of the South Umpqua above Elk Creek.



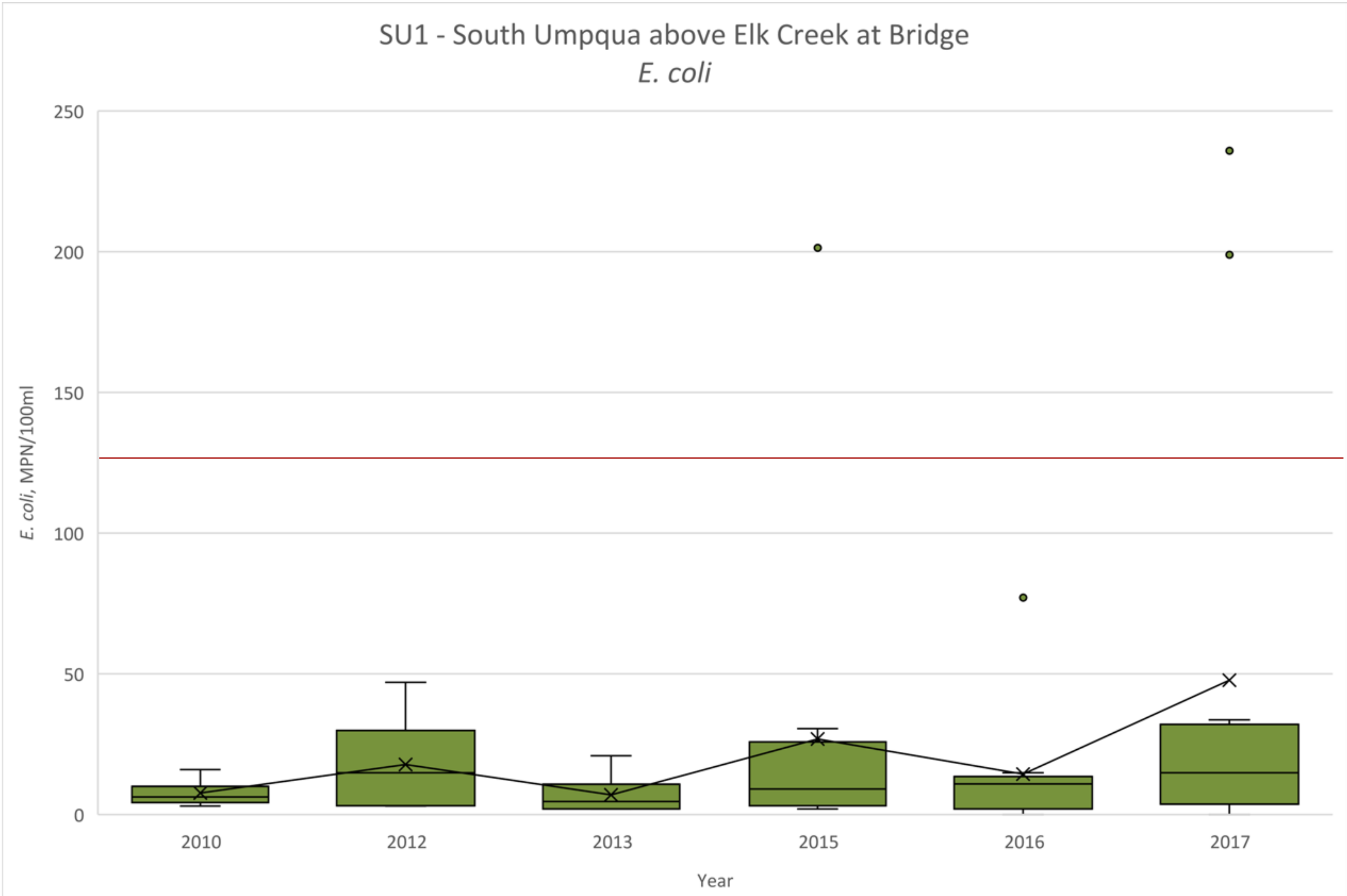
Graph 36. Dissolved Oxygen levels 2010-2017 for each monitoring event for the SU1 - South Umpqua River at Tiller, displayed comparing meeting spawning or non-spawning criteria.



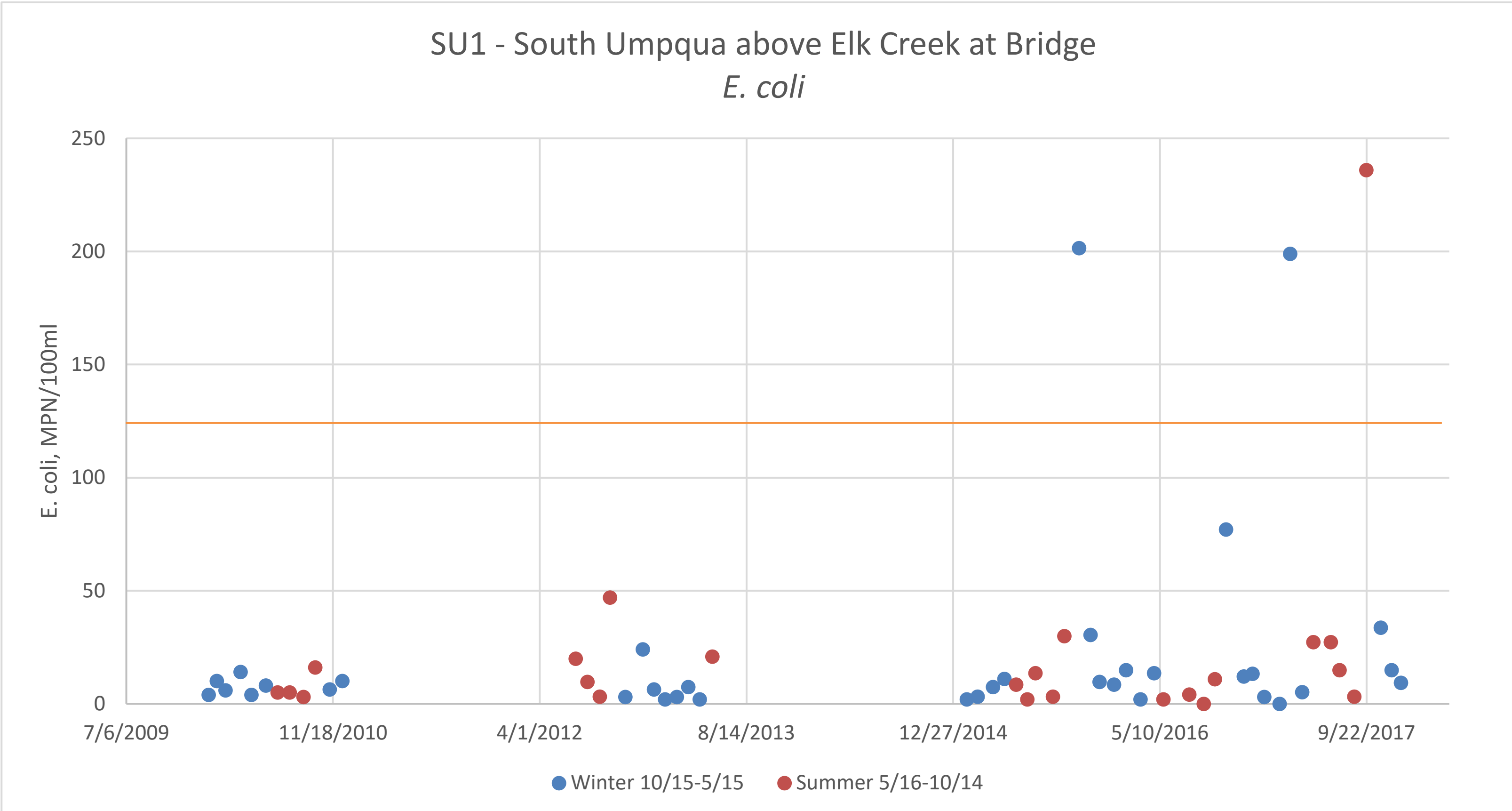
Graph 37. Box plots by year of conductivity levels of the South Umpqua above Elk Creek.



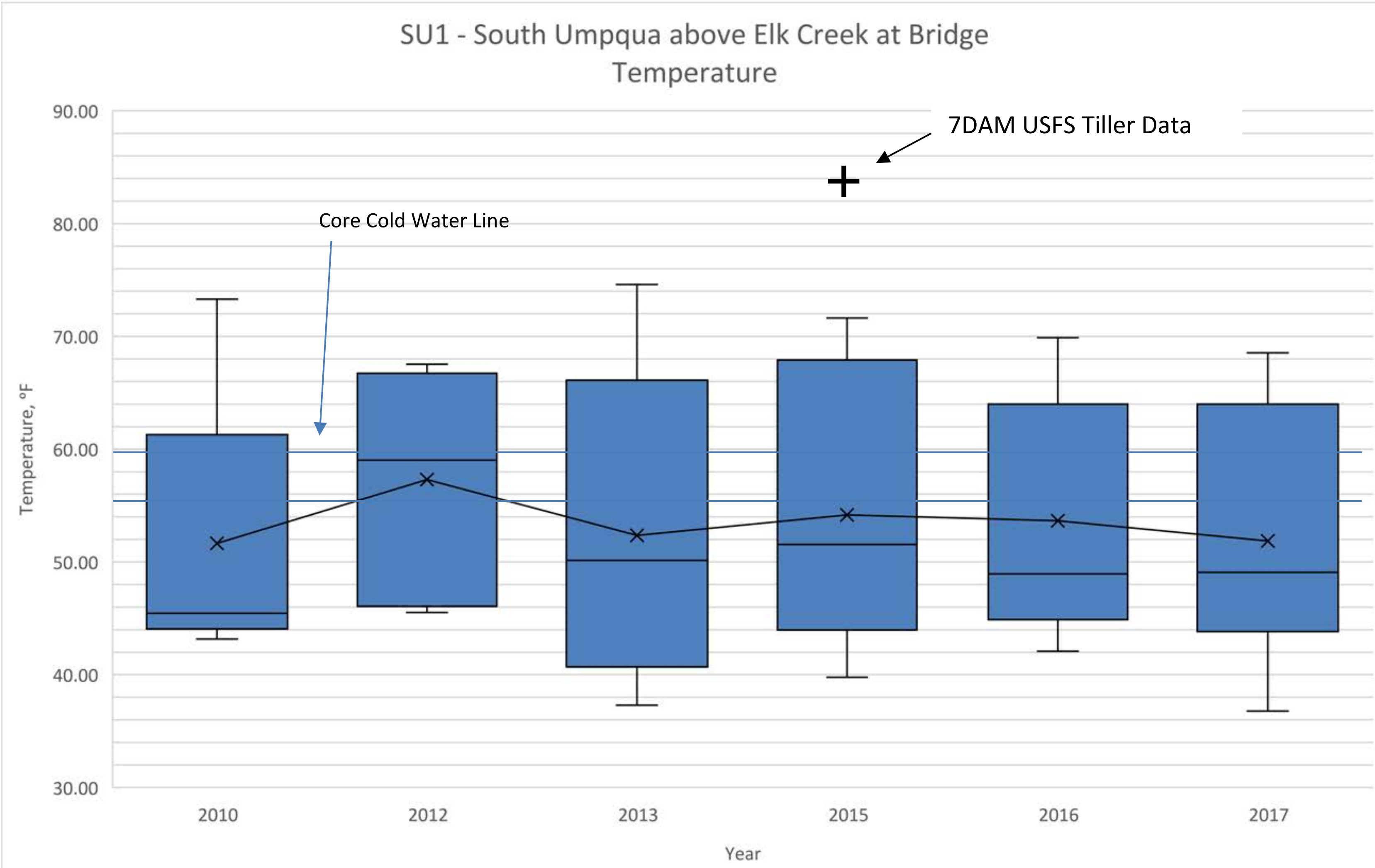
Graph 38. SU1 - South Umpqua above Elk Creek at Bridge grab sample conductivity levels.



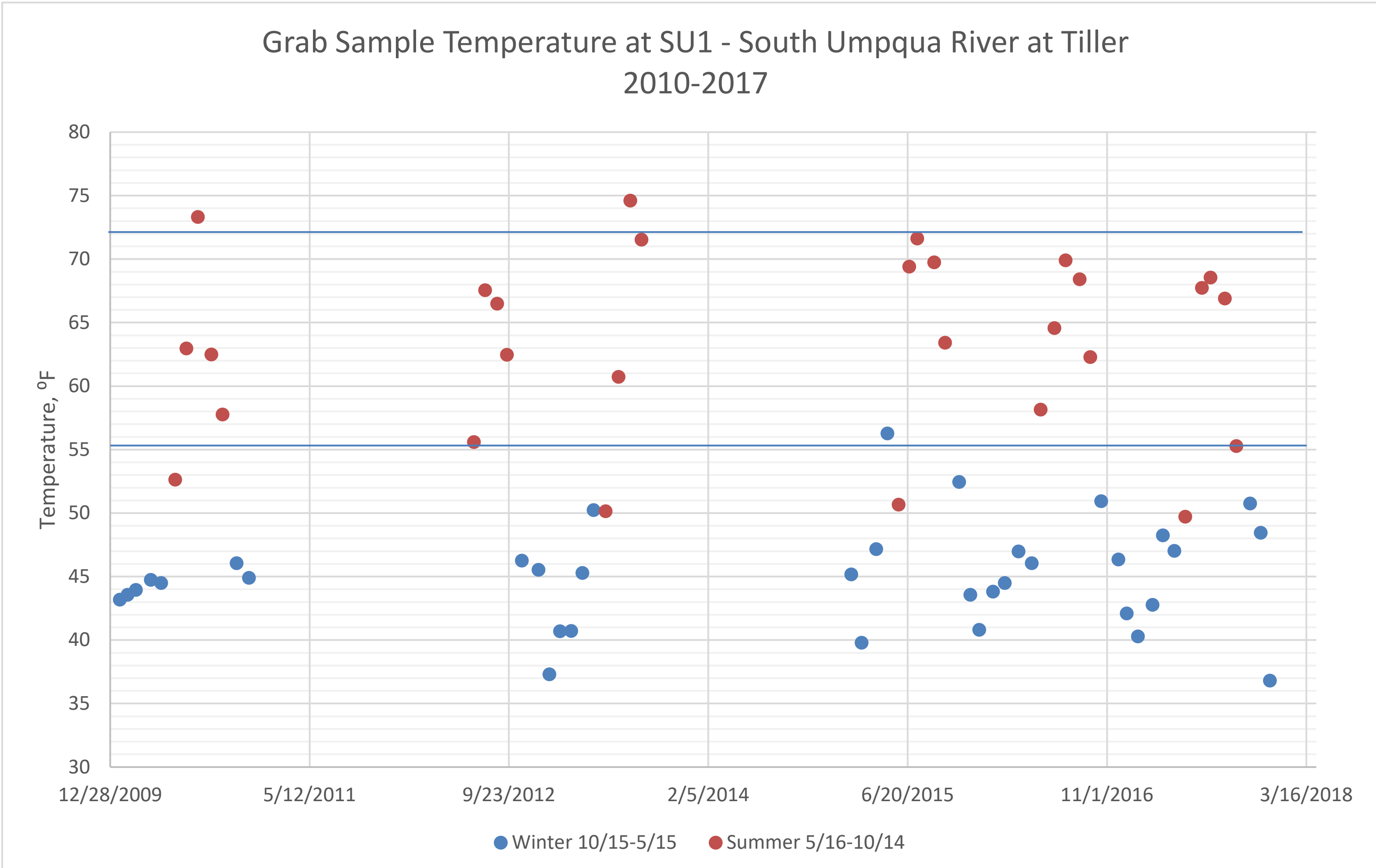
Graph 39. Box plots by year of *E. coli* levels of the South Umpqua above Elk Creek.



Graph 40. SU1 - South Umpqua above Elk Creek at Bridge E. coli levels 2010-2017.



Graph 41. Box plots by year of temperature levels of the South Umpqua above Elk Creek. The continuous temperature data was provided by USFS Tiller Data – Amy Rusk.



Graph 42. Grab sample temperature from 2010 thru 2017 at the South Umpqua River at Tiller summer and winter separated.

Site Name	Start Date	Stop date	Seasonal Maximum Date	Value	Seasonal Minimum Date	Value	Seasonal Max ΔT Date	Value	7-Day averages Date	Maximum	Minimum	ΔT
South Umpqua at Tiller above Elk Creek 2015	06/02/15	09/27/15	07/02/15	83.1	09/18/15	58.5	07/29/15	9.0	07/04/15	82.4	77.4	5.0

Site Name	Days > 55 F	Days > 64 F	Days > 70 F	Hours > 55 F	Hours > 64 F	Hours > 70 F	Warmest day of 7-day max Date	Maximum	Minimum	Agency
South Umpqua at Tiller above Elk Creek 2015	118	111	91	2831.5	2379.0	1645.0	07/02/15	83.1	77.8	UNF-TLRD

Table 22. USFS, Tiller continuous temperature data summary of the South Umpqua at Tiller.

E1 - Elk Creek (Tiller) Near Mouth

Year	Monthly Samples	Months
2009	8	Spread over year
2010	12	Full Year
2013	9	January-August
2015	12	Full Year
2016	12	Full Year
2017	12	Full Year

Table 23. Number of monitoring events per year included in graphs that follow for Elk Creek site.

Flow
USGS has a stream gage several miles upstream of the mouth of Elk Creek. The chart of the discharge data from 2009 through 2017 is included here in Graph 58. It isn't useful for summer time referencing as the gage always goes dry during summer. However, winter high flows might be of use even though it is a long way from the mouth and several tributaries enter Elk Creek downstream of the gage.

Turbidity
Turbidity is a major issue in Elk Creek as is evident in Photo 5 which shows a plume of turbid water merging with the South Umpqua River. In our January 31, 2017 Report we indicated that 21% of our samples from 2008-2013 were greater than 10 NTU. For 2015-2017 addition, 57% of the samples were greater than 10 NTU, but none exceeded 35 NTU. Graph 44 clearly shows that all the higher levels occurred during winter, and therefore during spawning.

pH
In general, the pH levels at this site are good compared to many other areas in the Umpqua (see Graphs 45). With grab sampling only one sampling event exceeded the upper DEQ recommended limit of 8.5 and that was in the summer of 2010. The box plot graph does indicate and interesting trend in that the pH values for 2015, 2016, and 2017 show a downward trend in pH both at the high and low end of the range as we saw at the South Umpqua at Tiller site just above the Mouth of Elk Creek. Median values show a slight decrease for each year and the Mean decrease is quite dramatic. Graph 46 was created to see if it could be determined if this might be due to algae. Algae alone does not appear to be the cause as many of the low pH levels are occurring during winter in the middle of the day. Considering temperature as another influencing possibility was ruled out as an increase in temperature from 0 degrees Celsius to 10 degrees Celsius results in a 0.2 drop in pH. If you decrease the temperature the opposite will happen: the pH level will increase very slightly. So, it is unlikely that temperature is accounting for this change. Graph 47 indicates that both summer and winter pH values are trending downward with some in 2017 approaching the lower limit line of 6.5 recommended by DEQ. The trend lines were added only out of curiosity. Not enough data, nor 24-hour data is available

to make any reliable result. This site should be carefully monitored for possible future ongoing changes. If safe and affordable it would be a good site for continuous monitoring of pH.

Dissolved Oxygen

The mouth of Elk Creek at Tiller, had no exceedances of the DEQ dissolved oxygen criteria for the non-spawning criteria (see Graphs 49, 50 and 51). Five failed to make the spawning criteria of 11 mg/l during the period of 10/16 thru 5/15. They are all within 0.4 mg/l of meeting criteria and, as the Sonde DO probe has an accuracy of ±.2, they are very near meeting criteria.

Conductivity

Conductivity levels for the mouth of Elk Creek were within normal ranges for the Umpqua Basin, and none even exceeded 350 us/cm. The conductivity did show a slight downward trend from 2015 thru 2017. With Elk Creek going very close to dry at this site during the summer, the increasing summer conductivity levels are likely due to concentration of salts and minerals in the water, increasing the conductivity which then drops again in the winter months.

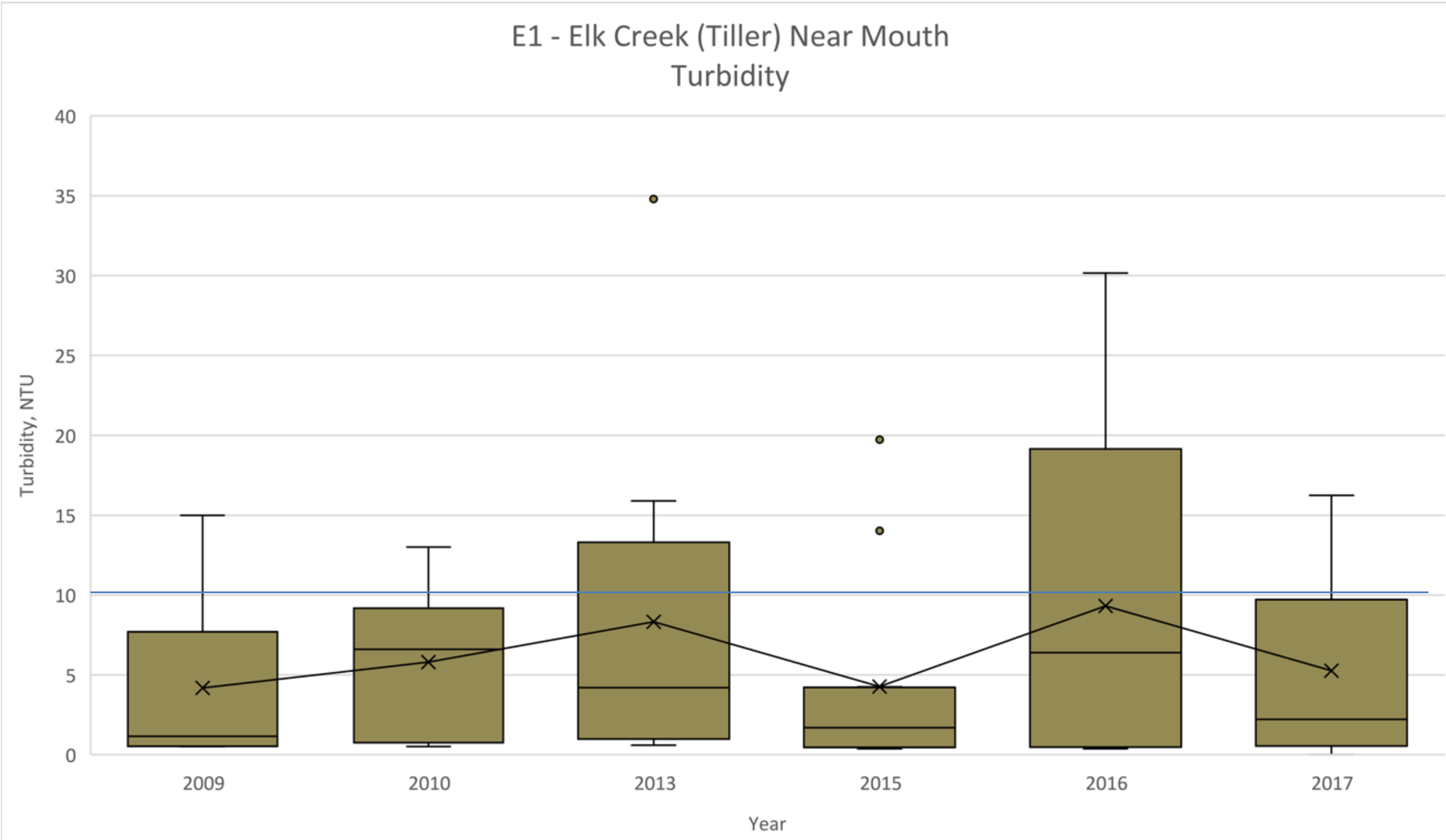
E. coli

E. coli levels were generally not terrible at this site with none ever exceeding the one time reading at 406 MPN/ml or greater would list a stream (Graph 55 and 56). All but 6 samples (4 summer and 2 winter) were below 126 MPN/100 ml DEQ criteria indicates that a site would have to have been measured 5 times in one month to list a site with values of >126 up to 405. There might be a slight trend of higher values appearing in the more recent years and should be watched.

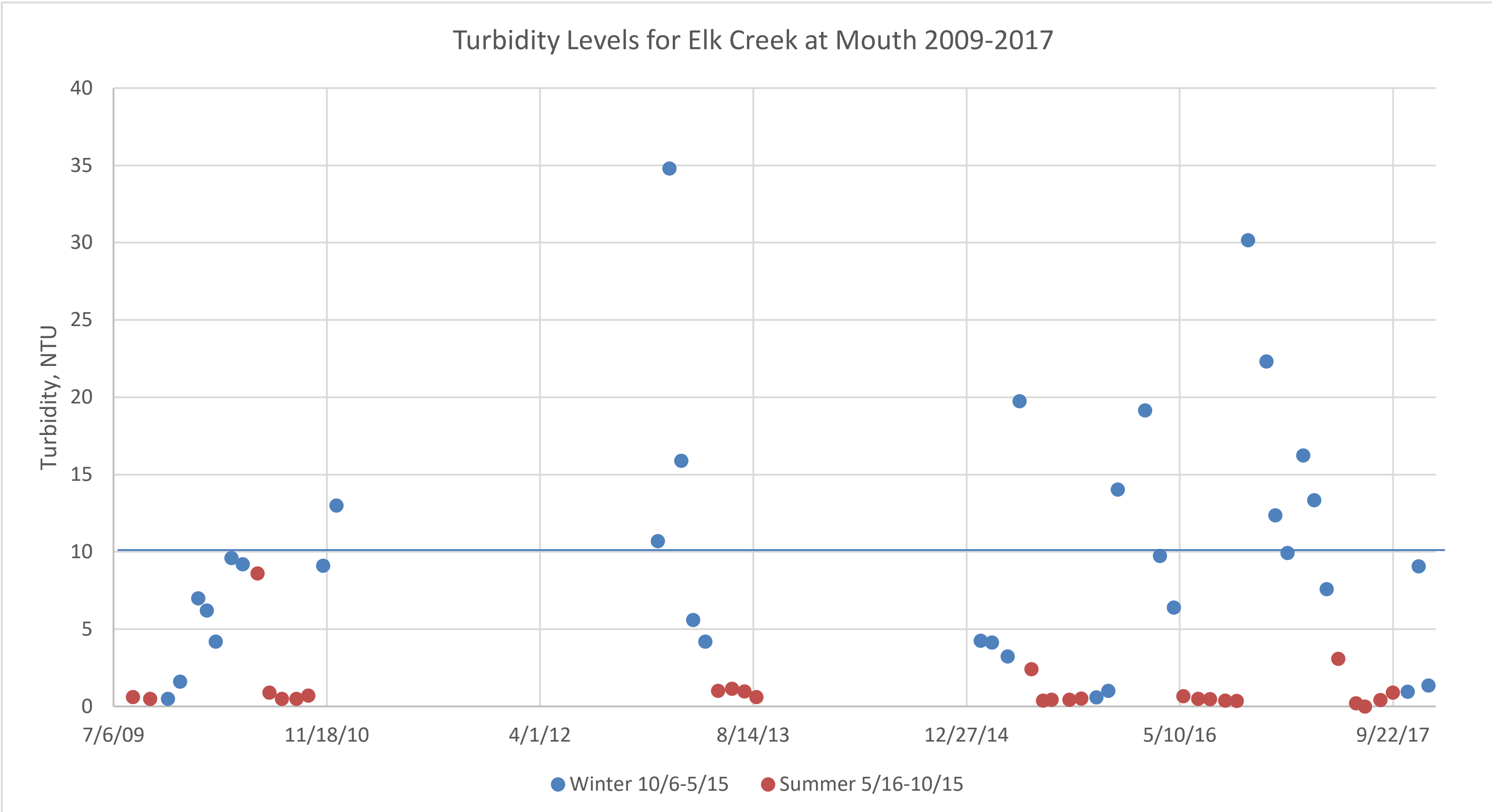
Temperature

PUR has partnered with the USFS Tiller Ranger District in the monitoring of the Elk Creek/Tiller area since 2008 with PUR collecting the grab sample water quality parameters and the Forest Service providing the data from their continuous summer temperature monitoring sites. For this study, we are adding only the South Umpqua at Tiller and Elk Creek at the mouth for reference sites. The mouth of Elk Creek at Tiller is a designated area for Core Cold Water which must meet the criteria of 7DAM <60.8^{o} F. Appendix K shows which streams need to meet this criterion.

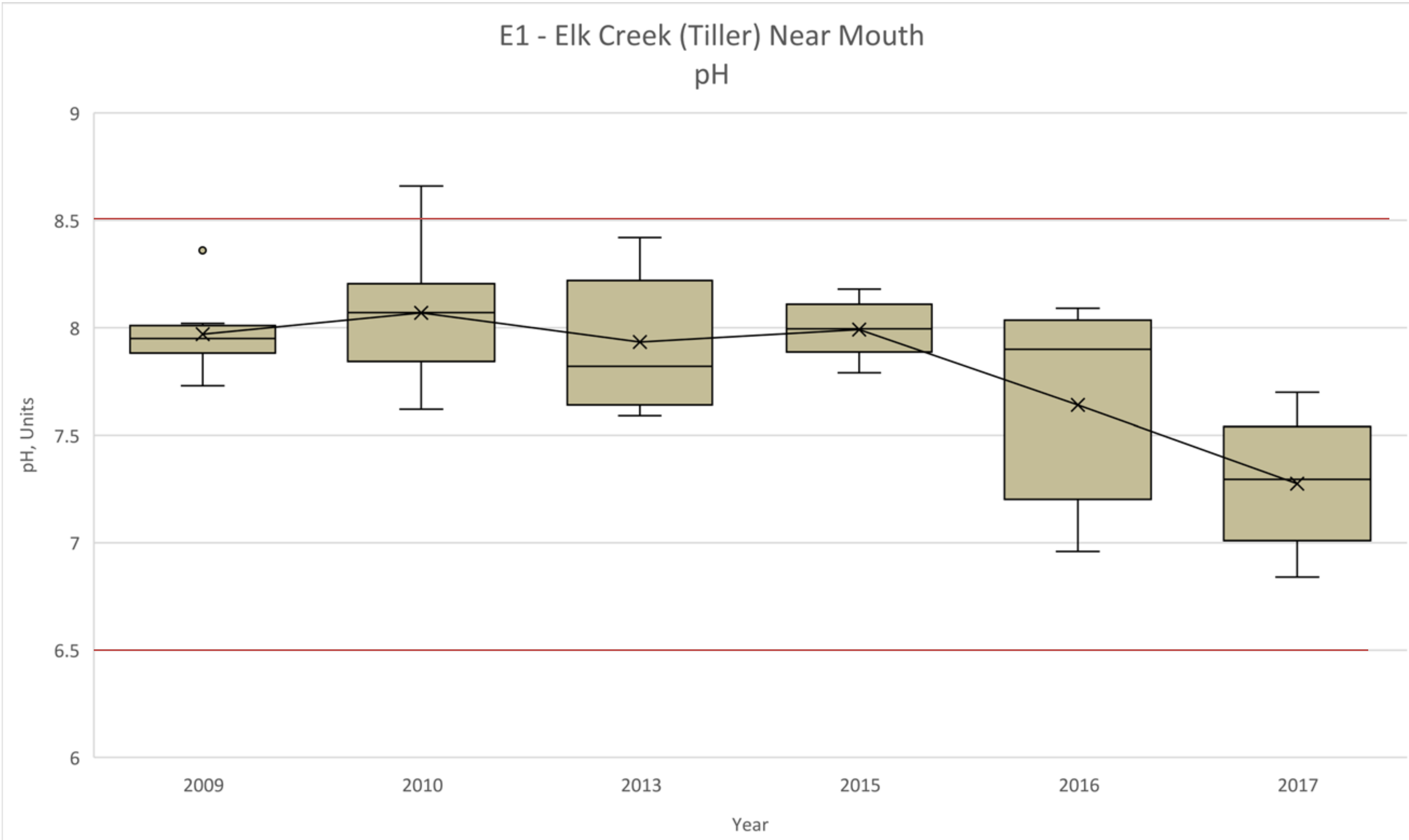
Unfortunately, this site fared very poorly for temperature. Our grab sample data alone was indicative that there was no way these waters would meet the 7DAM. The Forest Service's continuous temperature data confirmed this with a 2015 7DAM of 77.5^{o} F, 2016 of 73.2^{o} F and 2017 of 72.8^{o} F (See Table 22 for the full summary). Though this site failed badly at meeting the Core Cold Water criteria, during the spawning time of year it appeared from our grab sample data to meet the Spawning Criteria of ≤55.4^{o} F with no samples exceeding this temperature. See Graphs 56 and 57. No trends are apparent at this time.



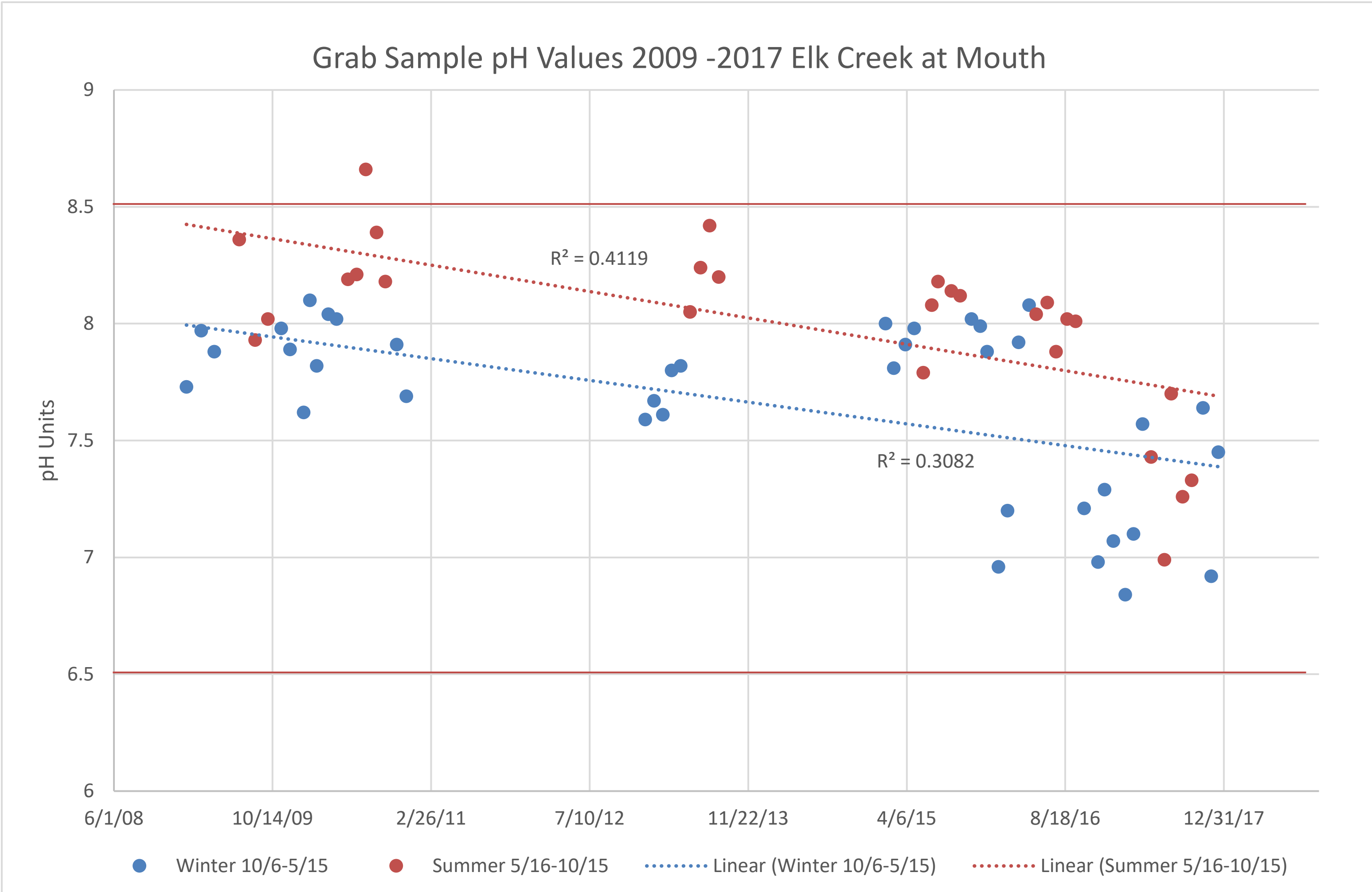
Graph 43. Box plots by year of turbidity levels of Elk Creek near the mouth.



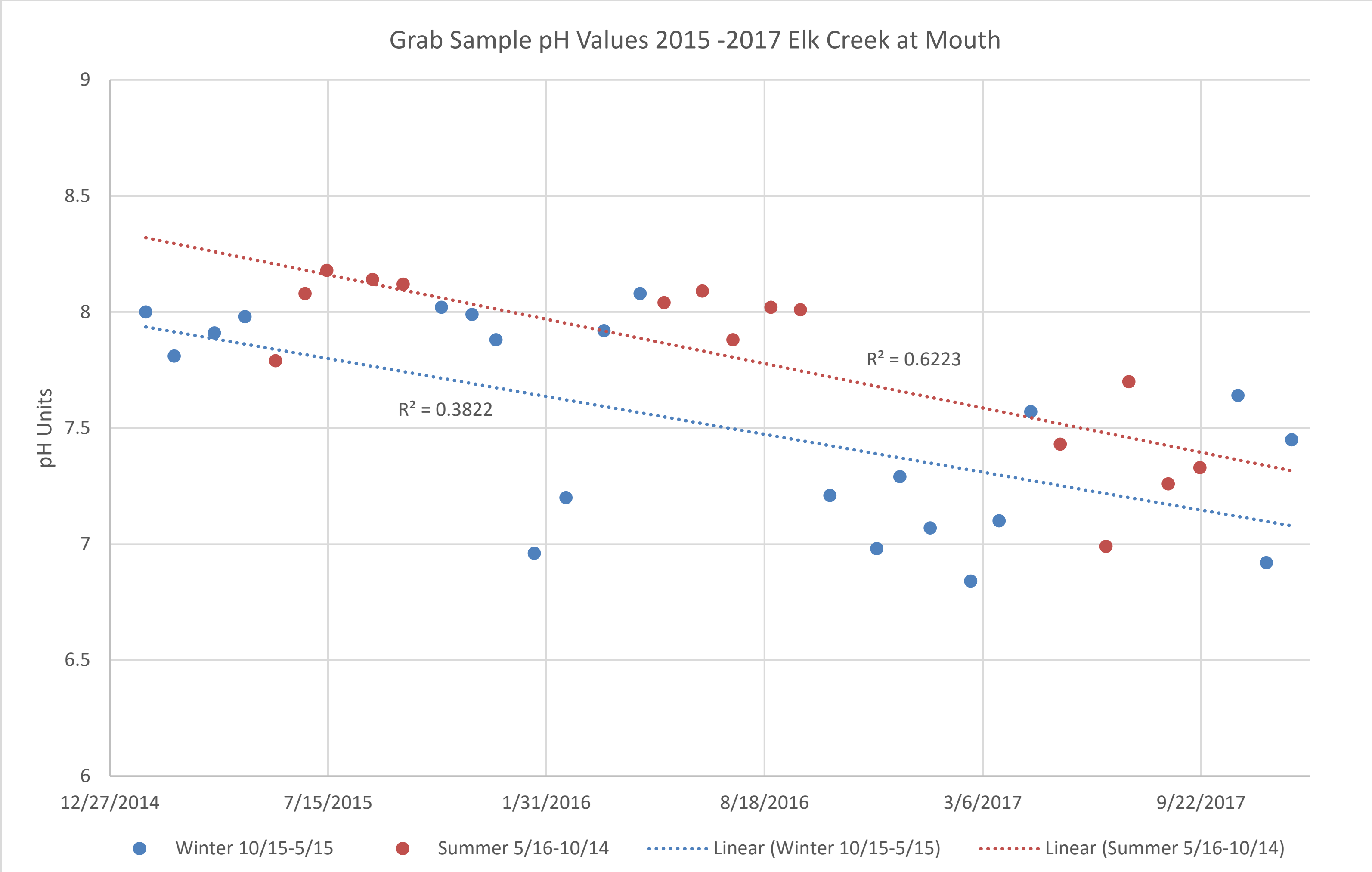
Graph 44. Grab sample turbidity levels for Elk Creek at the mouth from 2009 through 2017 summer and winter separated.



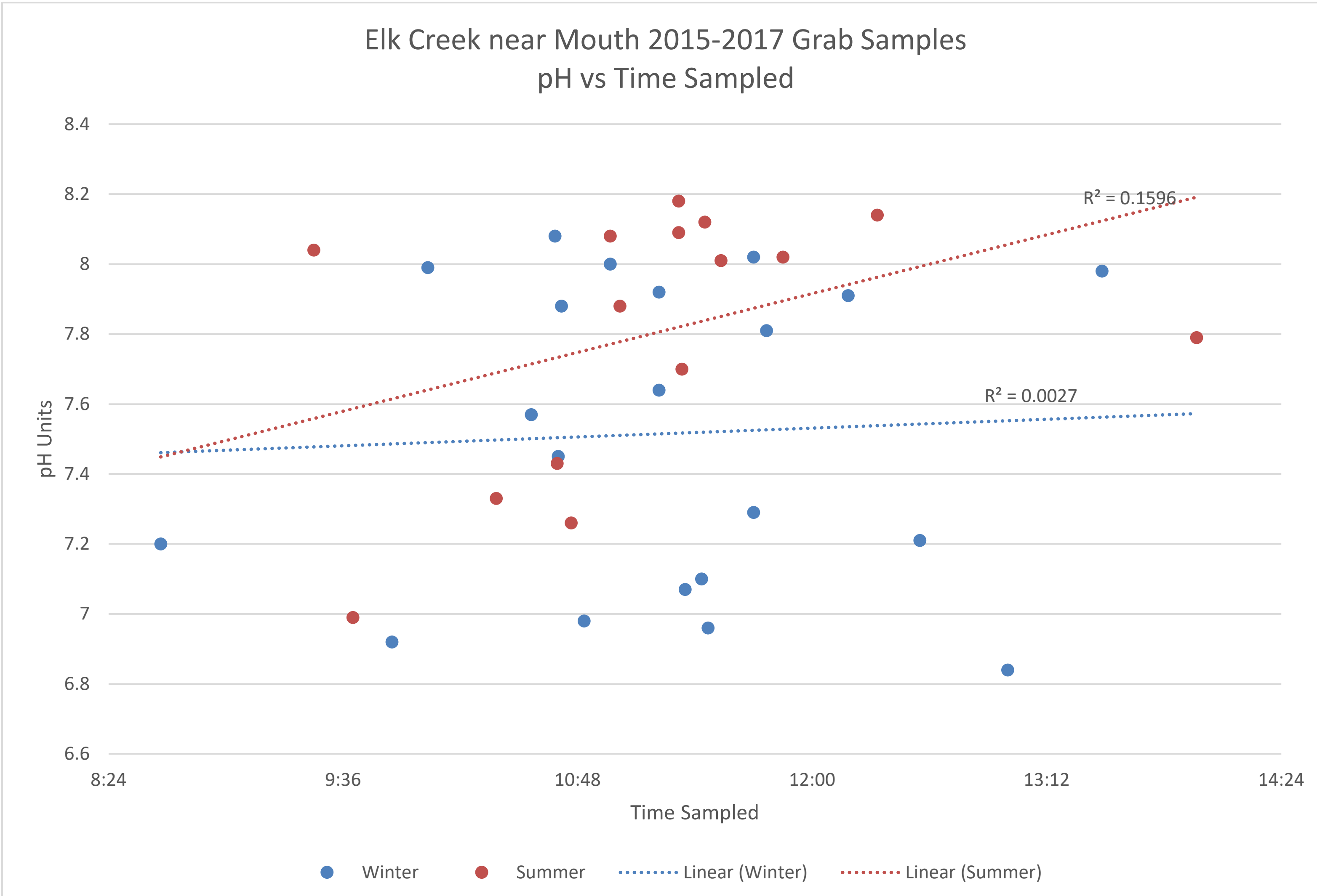
Graph 45. Box plots by year of pH levels of Elk Creek near the mouth.



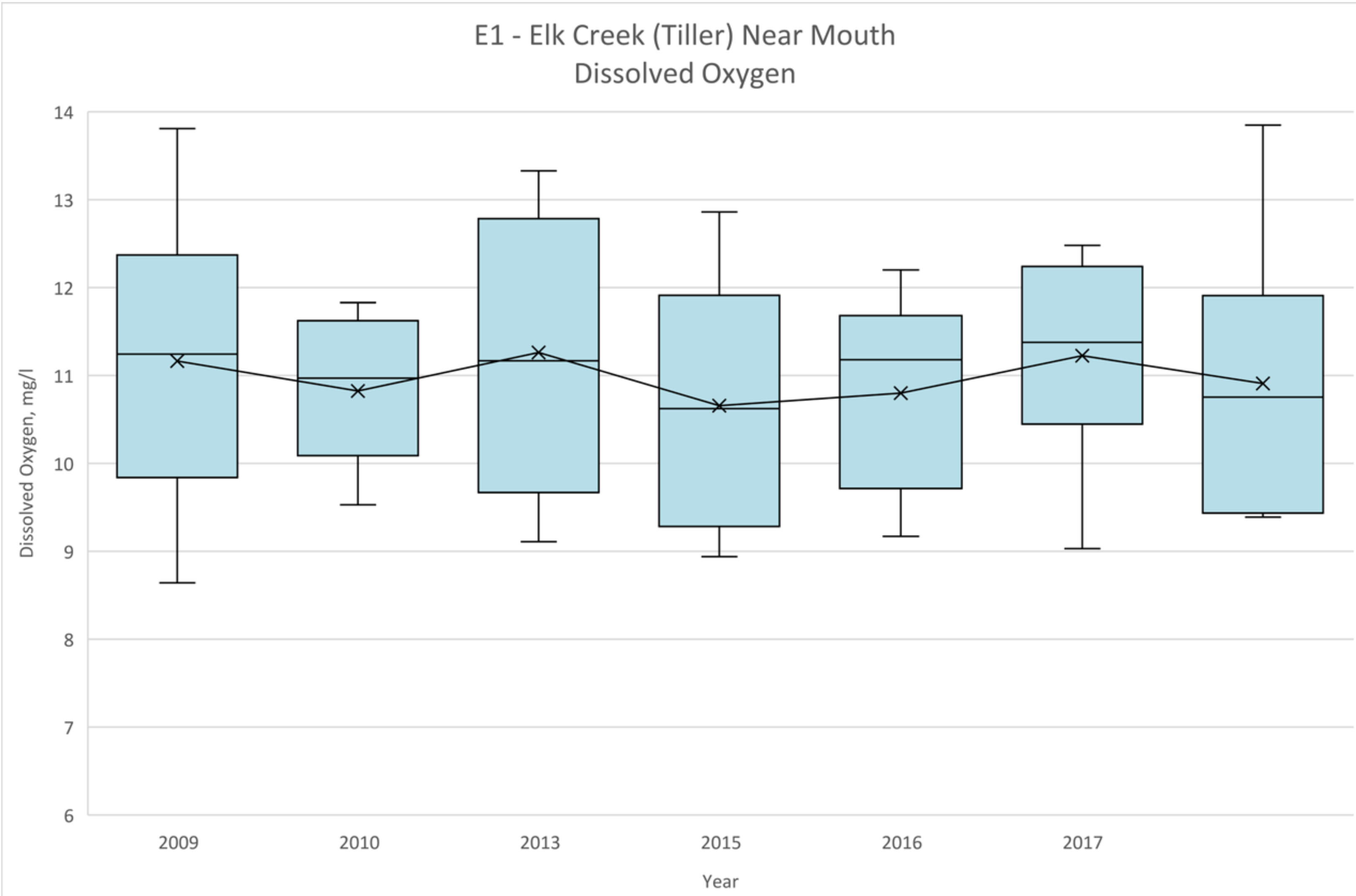
Graph 46. Grab sample pH at Elk Creek at the mouth 20089-2017 summer and winter separated.



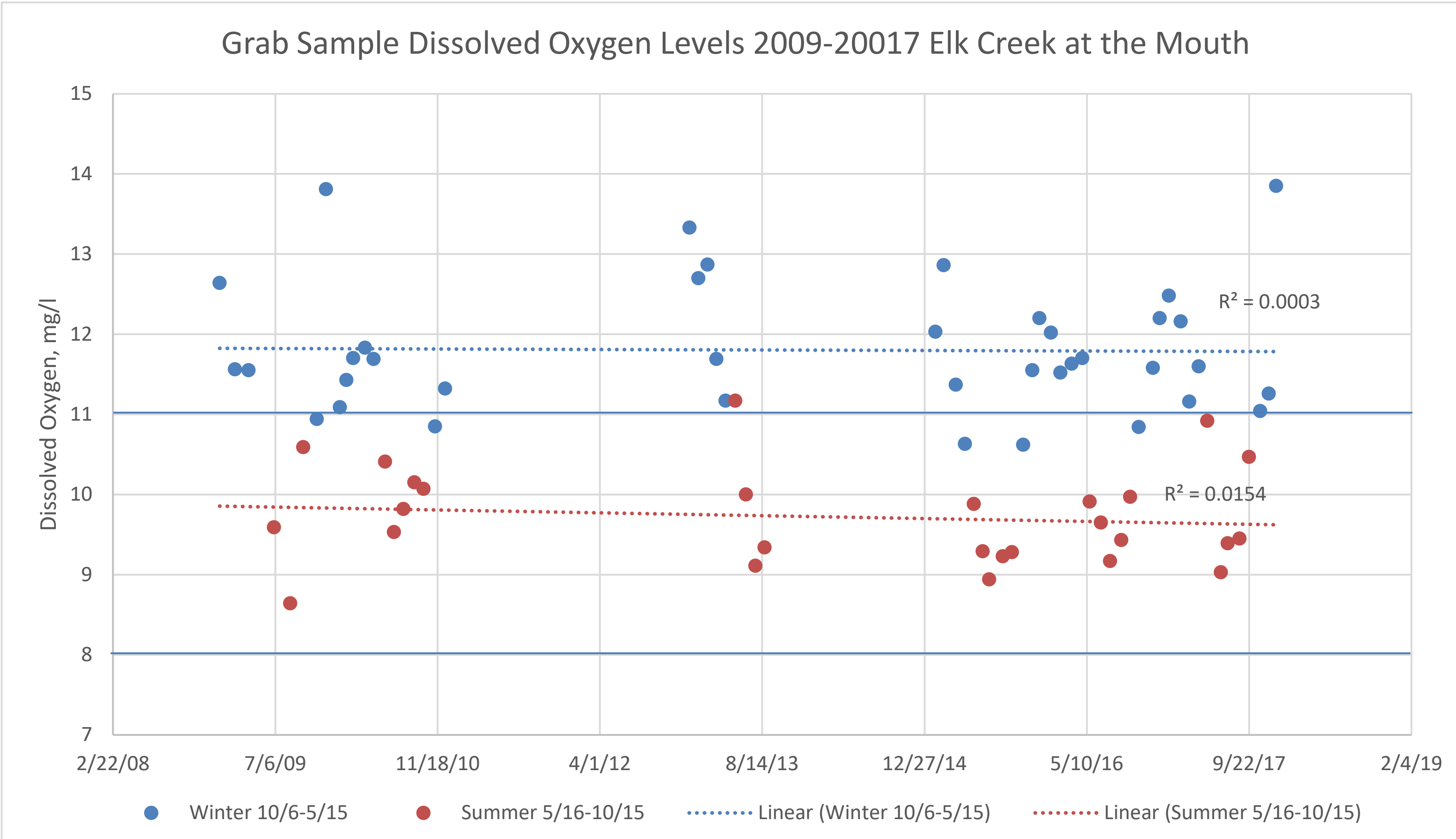
Graph 47. Grab Sample pH Values 2015 -2017 Elk Creek at mouth summer and winter separated.



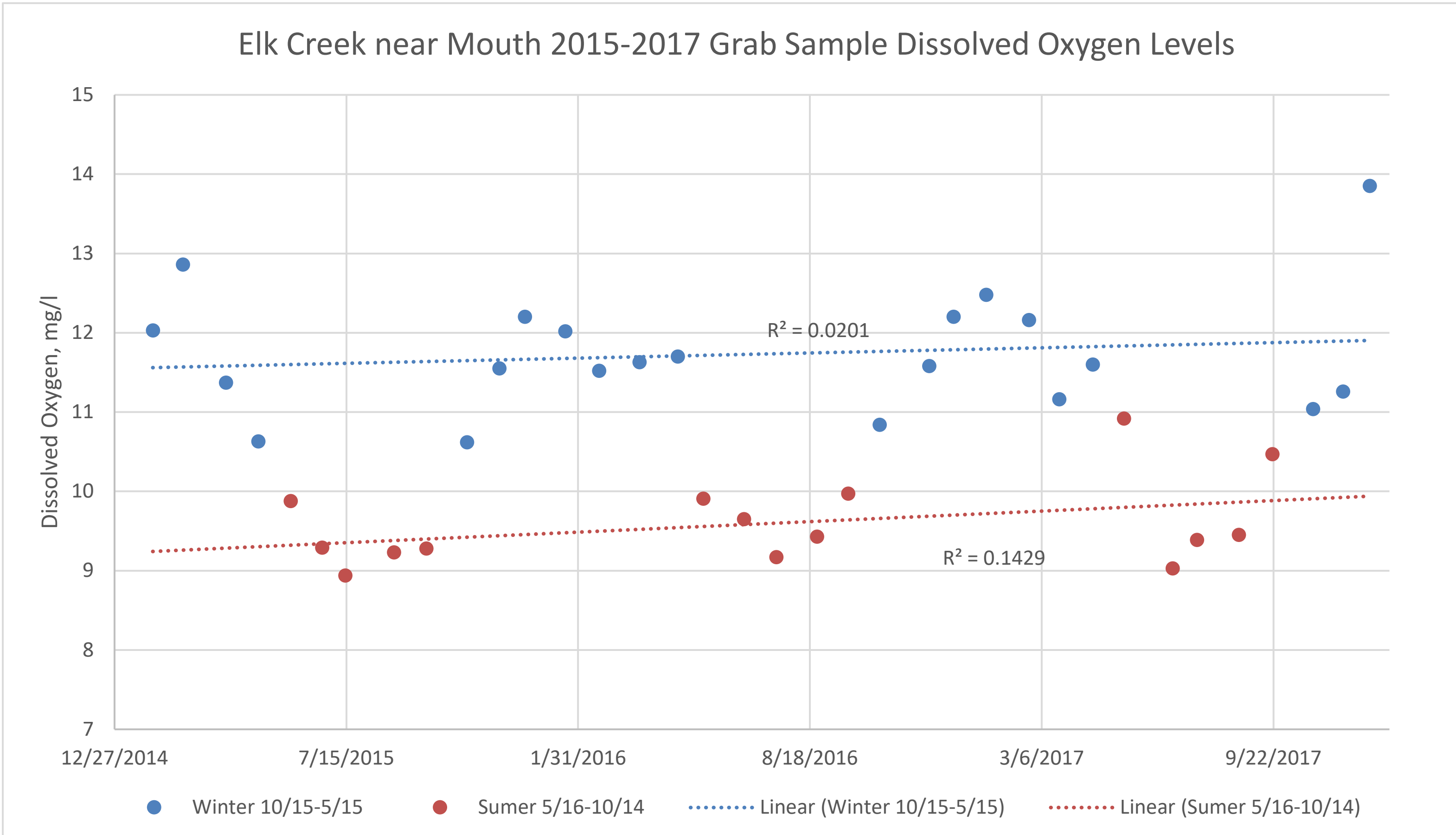
Graph 48. Grab sample pH values plotted against time sampled for Elk Creek near mouth 2015-2017.



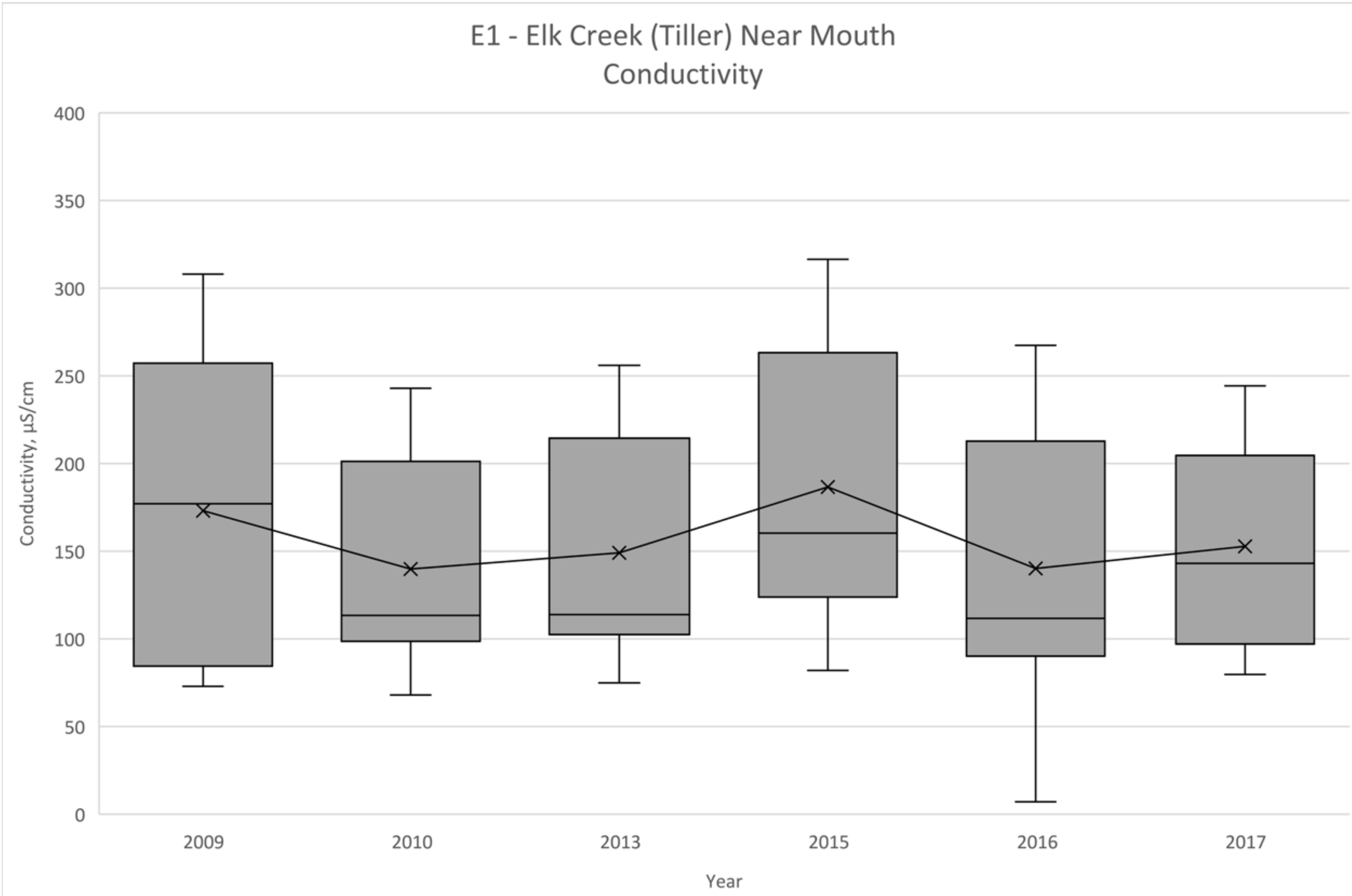
Graph 49. Box plots by year of dissolved oxygen levels of Elk Creek near the mouth.



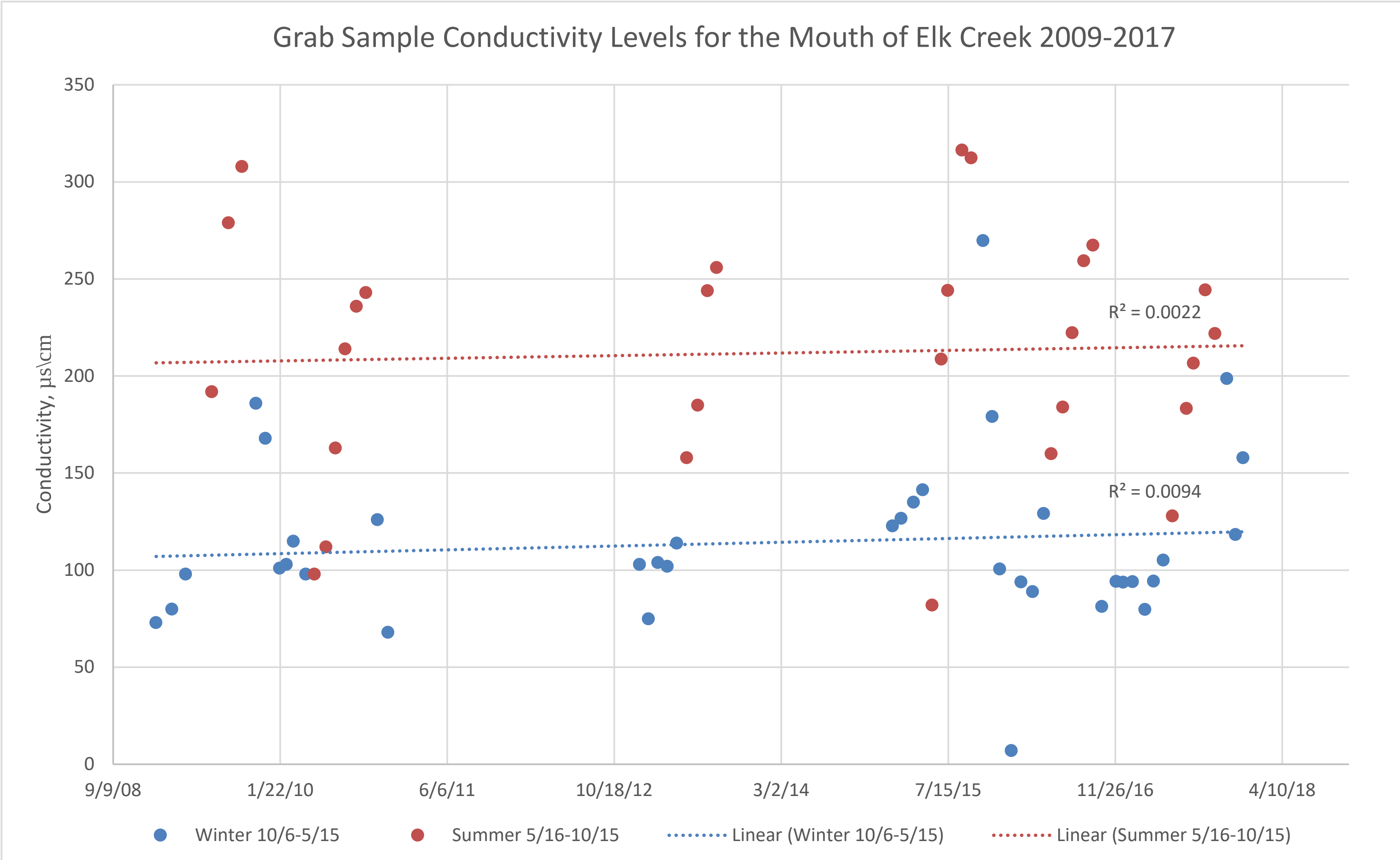
Graph 50. Dissolved Oxygen levels 2009-2017 for each monitoring event for Elk Creek at the mouth, displayed comparing meeting winter (spawning) or summer (non-spawning) criteria summer and winter separated.



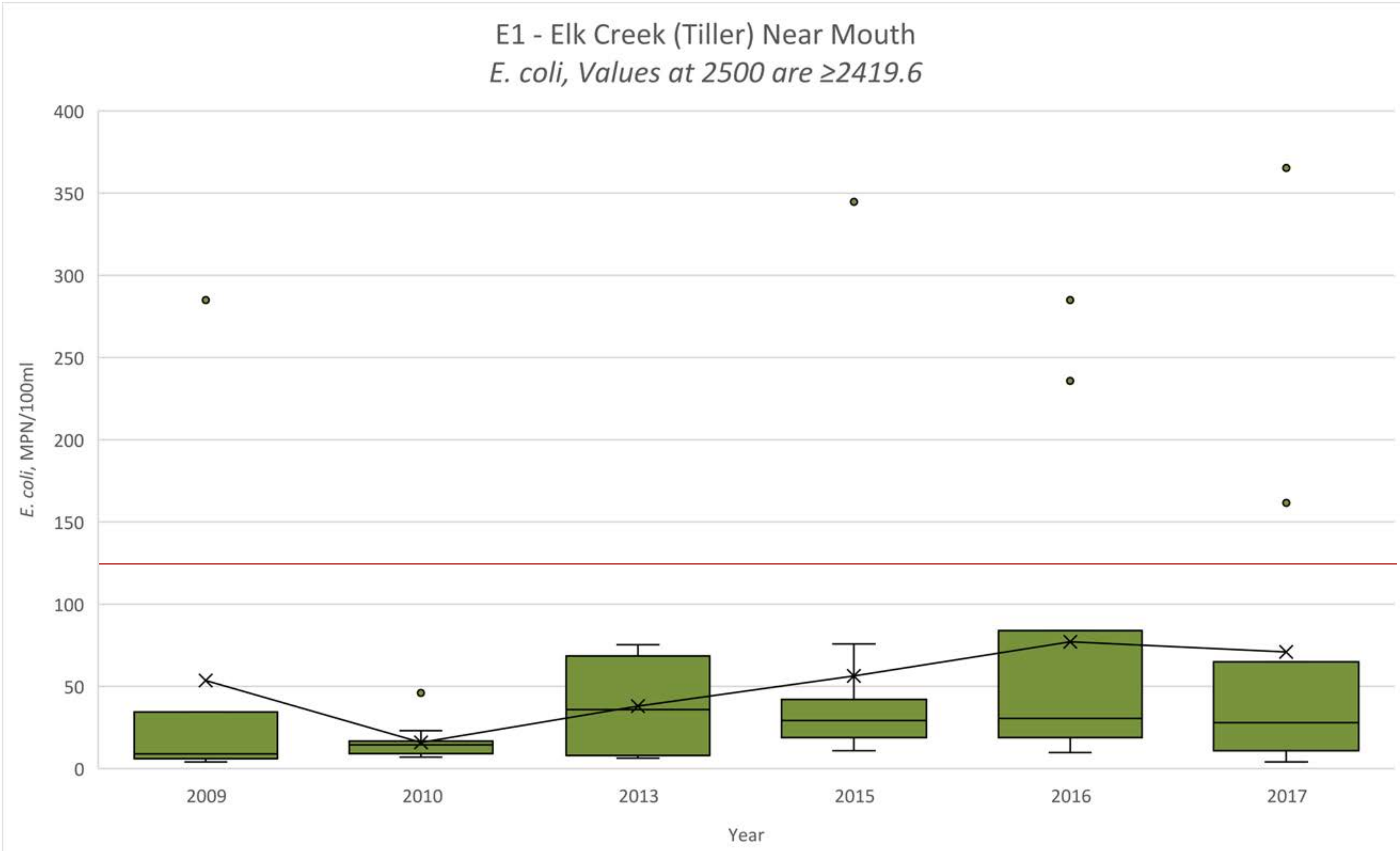
Graph 51. Elk Creek near Mouth 2015-2017 grab sample dissolved oxygen levels.



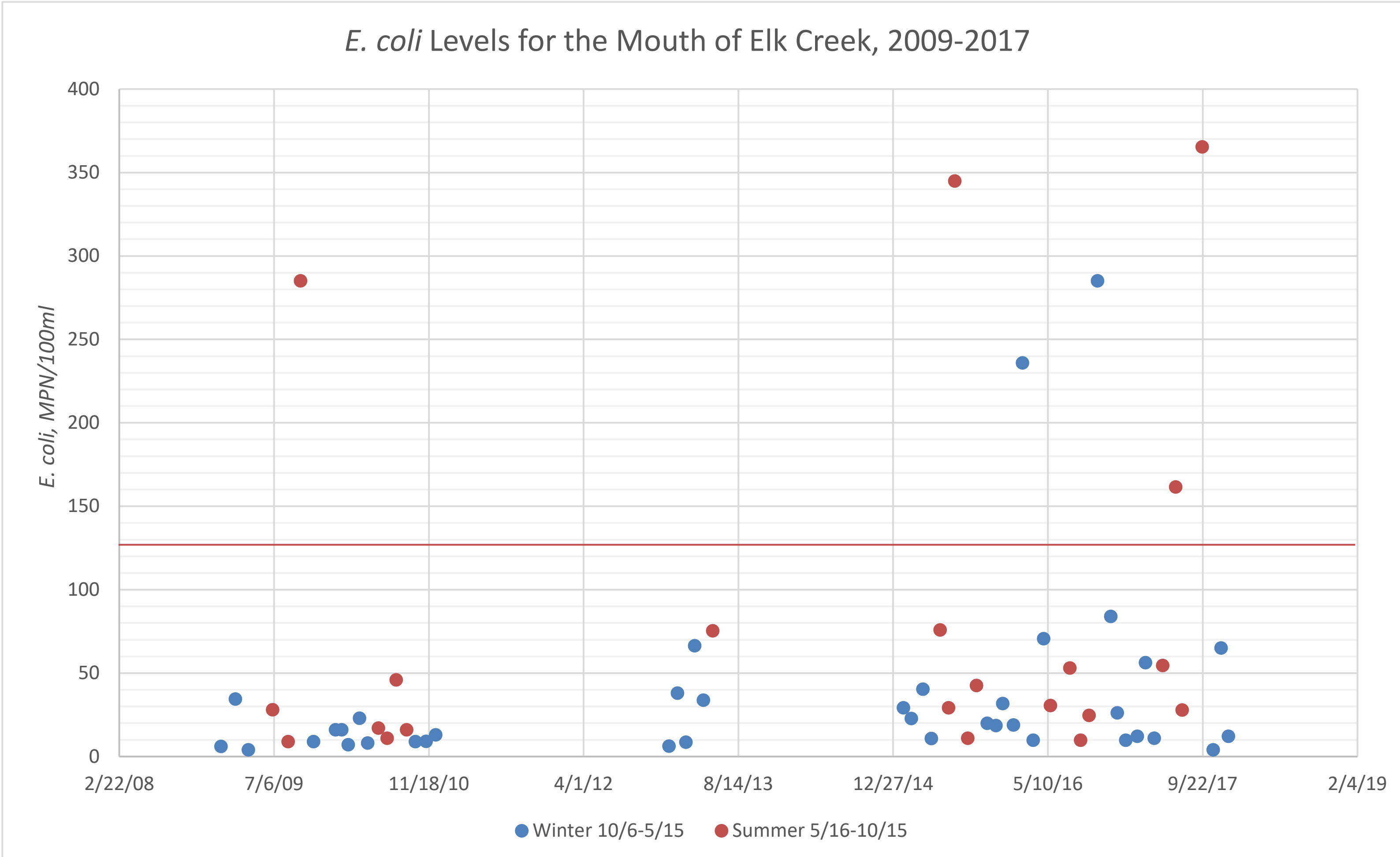
Graph 52. Box plots by year of conductivity levels of Elk Creek near the mouth.



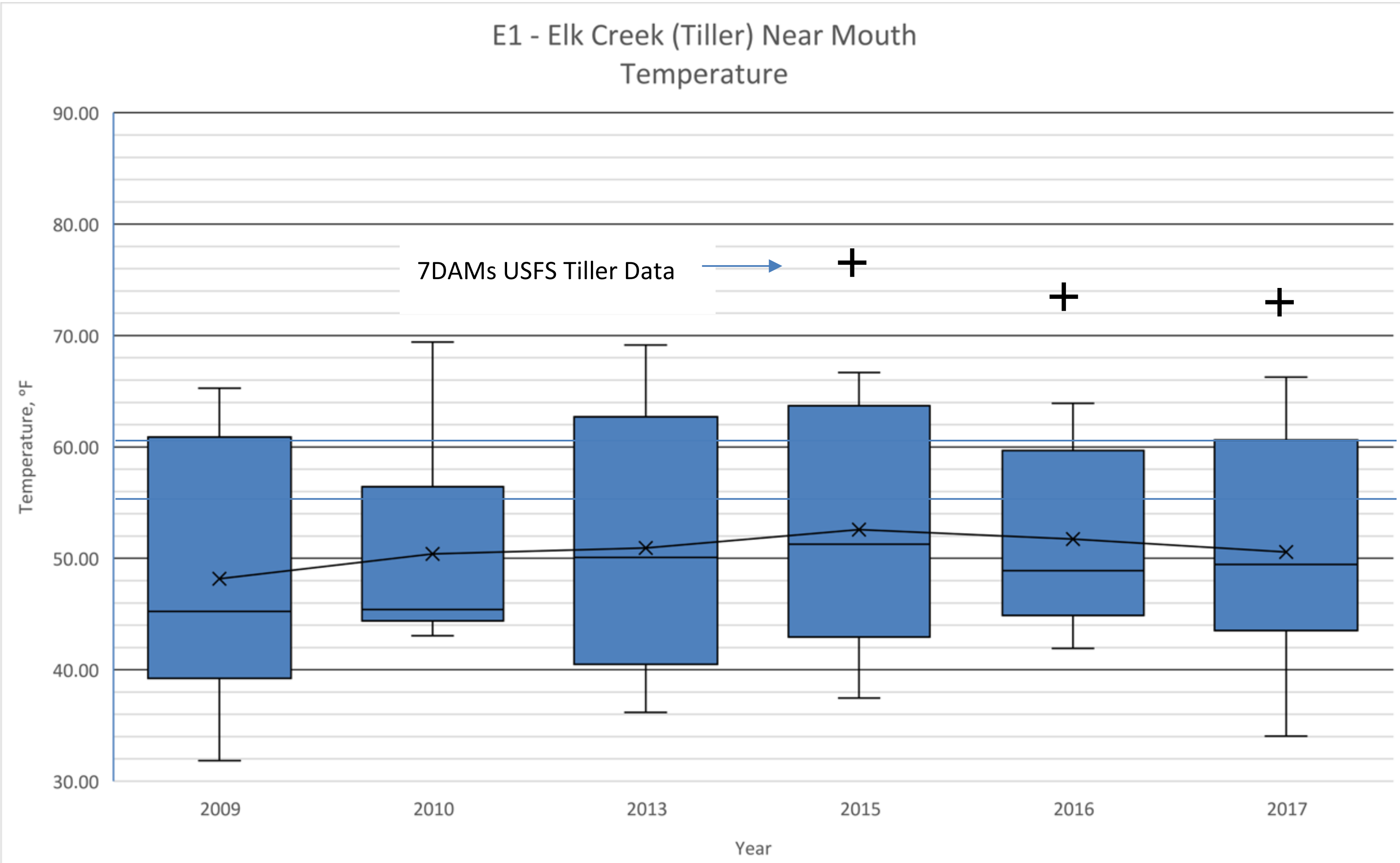
Graph 53. Grab sample conductivity levels from 2008 through 2017 at the mouth of Elk Creek summer and winter separated.



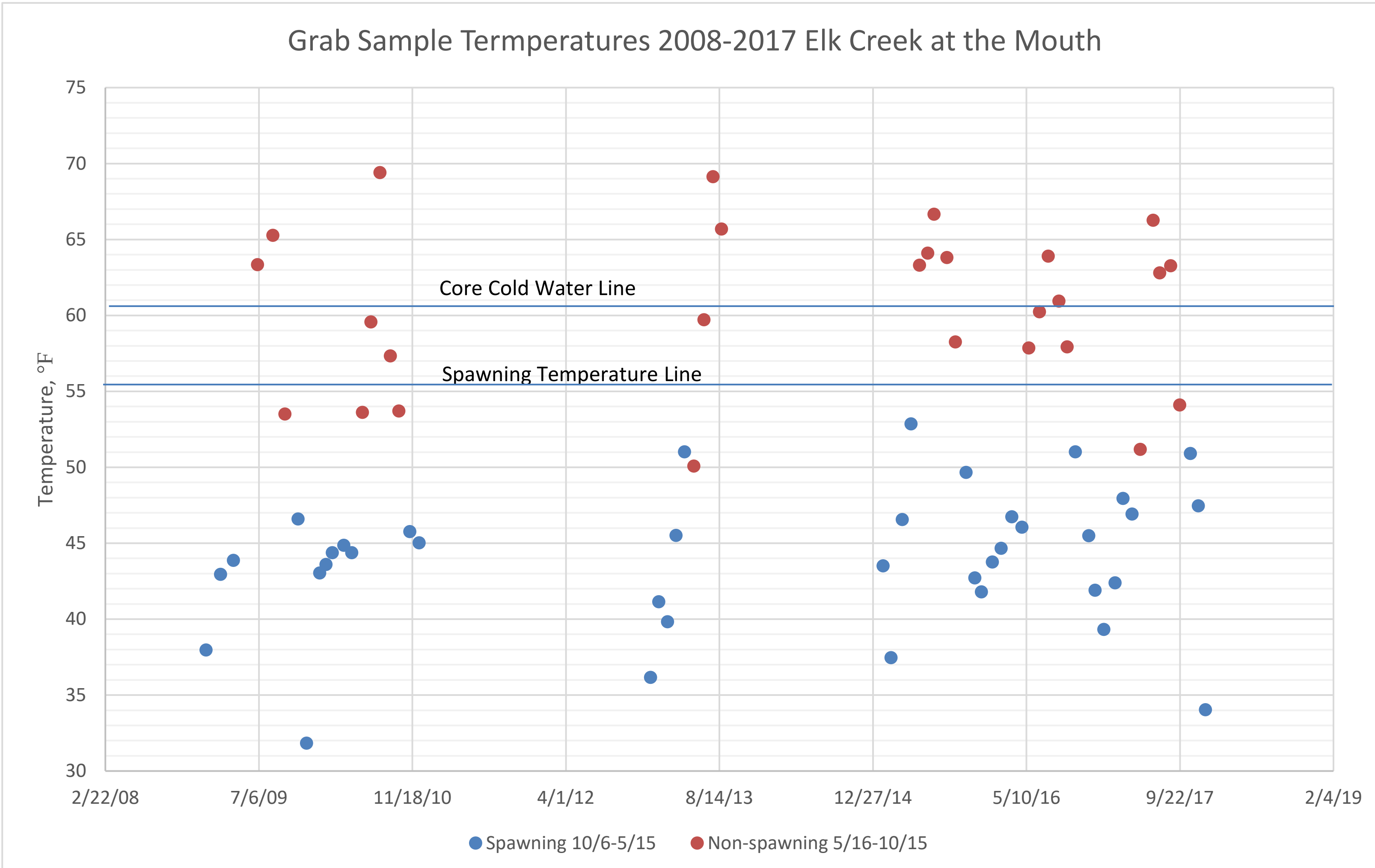
Graph 54. Box plots by year of *E. coli* levels of Elk Creek near the mouth.



Graph 55. *E. coli* Levels for the Mouth of Elk Creek, 2009-2017 summer and winter separated.



Graph 56. Box plots by year of grab sample temperature levels of Elk Creek near the mouth. 7DAM values supplied by USFS Tiller Data, Amy Rusk.

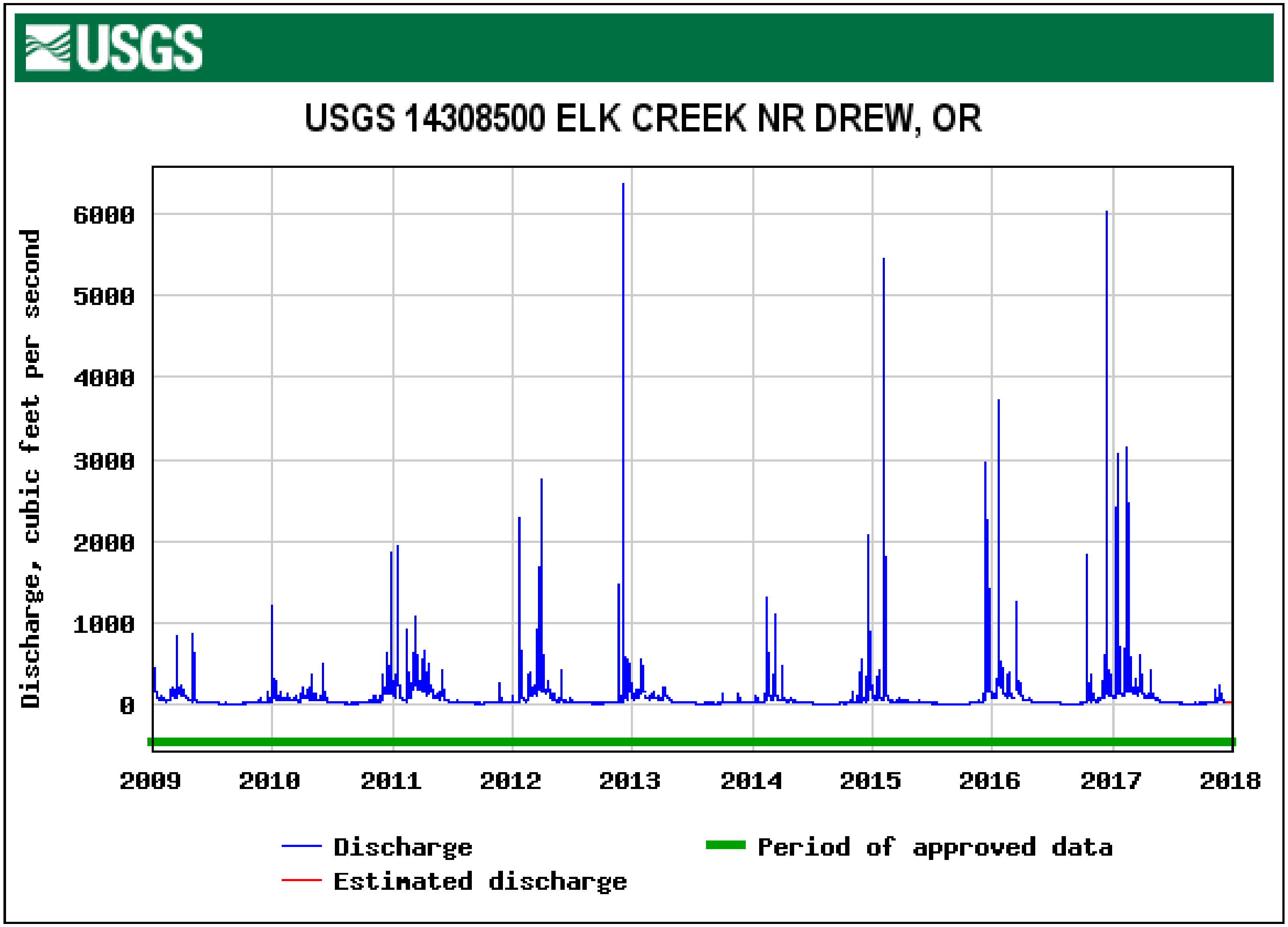


Graph 57. Grab sample temperature levels for Elk Creek at the mouth 2008-2017. This site needs to meet the Core Cold Water Criteria of less than 60.8°F and the Spawning Criteria of 55.4°F summer and winter separated.

Site Name	Start Date	Stop date	Seasonal Maximum		Seasonal Minimum		Seasonal Max ΔT		7-Day averages			
			Date	Value	Date	Value	Date	Value	Date	Max	Min	Δ T
Elk Creek at Tiller 2015	6/2/2015	9/27/2015	7/2/2015	78.4	9/6/2015	54.5	6/5/2015	8.9	7/4/2015	77.5	70.4	7.1
Elk Creek at Tiller 2016	06/15/16	10/06/16	07/29/16	75.6	09/15/16	52.7	09/28/16	14.3	07/28/16	73.7	66.1	7.6
Elk Creek at Tiller 2017	06/10/17	09/29/17	09/27/17	95.4	09/28/17	47.4	09/27/17	44.6	08/09/17	72.8	68.4	4.3

Site Name	Days >	Days >	Days >	Hours >	Hours >	Hours >	Warmest 7-day max			Agency
	55 F	64 F	70 F	55 F	64 F	70 F	Date	Maximum	Minimum	
Elk Creek at Tiller 2015	118	92	45	2826	1767	486.5	7/2/2015	78.4	70.8	UNF-TLRD
Elk Creek at Tiller 2016	114	84	39	2672.5	1491.5	175.5	07/29/16	75.6	67.7	UNF-TLRD
Elk Creek at Tiller 2017	110	99	47	2575.5	1893.0	372.5	08/08/17	73.5	68.8	UNF-TLRD

Table 24. Table 22. USFS, Tiller continuous temperature data summary of Elk Creek at Tiller.



Graph 58. Stream discharge data from 2009-2017 from USGS gage at Elk Creek near Drew. This gage is many miles upstream of the mouth of Elk Creek but is included for general reference purposes.

DC4 - Days Creek at Hwy 1 Bridge

Year	Monthly Samples	Months
2015	12	Full Year
2016	12	Full Year
2017	12	Full Year

Table 25. Number of monitoring events per year included in graphs that follow for Days Creek site.

Days Creek was determined to be an excellent reference site from past data we had collected at 13 sites along the creek and tributaries. We chose to begin monitoring the mouth of Days Creek even though this would be a new site. The lowest site we had monitored in the past was above Woods Creek. Therefore, all the data for this report is new data and will not be compared to past data.

Turbidity
Turbidity levels in Days Creek rise above 10 NTU in winter only (See Graph 60). The levels are high enough during spawning to be of concern for egg survival. Graph 60 gives no indication of trends on this short data set.

pH
The pH levels in Days Creek all fall within the DEQ Criteria of no higher than 8.5 and no lower than 6.5. (See Graphs 61 and 62.) Graph 62 displays an indication of pH trending lower between 2015 and 2017. This same trend has been evident at the South Umpqua River at Tiller and Elk Creek at the mouth. Graph 53 displays the trend lines for summer and winter data.
More years need to be monitored to see if this continues.

Dissolved Oxygen
Days Creek needs to meet the Non-spawning DO level of at least 8.0 mg/l and the Spawning Criteria of at least 11 mg/l. All samples were above 8mg/l. Two samples in 2015, and one in 2016 were below the Spawning level. Two in 2017 were within equipment accuracy of meeting 11. Graph 63 looks as if the dissolved oxygen levels were increasing over the three years. Looking at Graph 64 it is apparent that the summer samples were influencing this trend when all samples were analyzed with a box plot. Continued monitoring will be interesting to see if this is true and what might be triggering it that might be used in other locations. PUR did do a project two years ago that fenced livestock out of Days Creek for two miles just above and below Woods Creek. Also, further up Days Creek have been several significant restoration efforts by PUR and BLM.

Conductivity
Conductivity levels Days Creek were within normal ranges for the Umpqua Basin, and none even exceeded 350 µS/cm. The conductivity did show increased levels during summer months

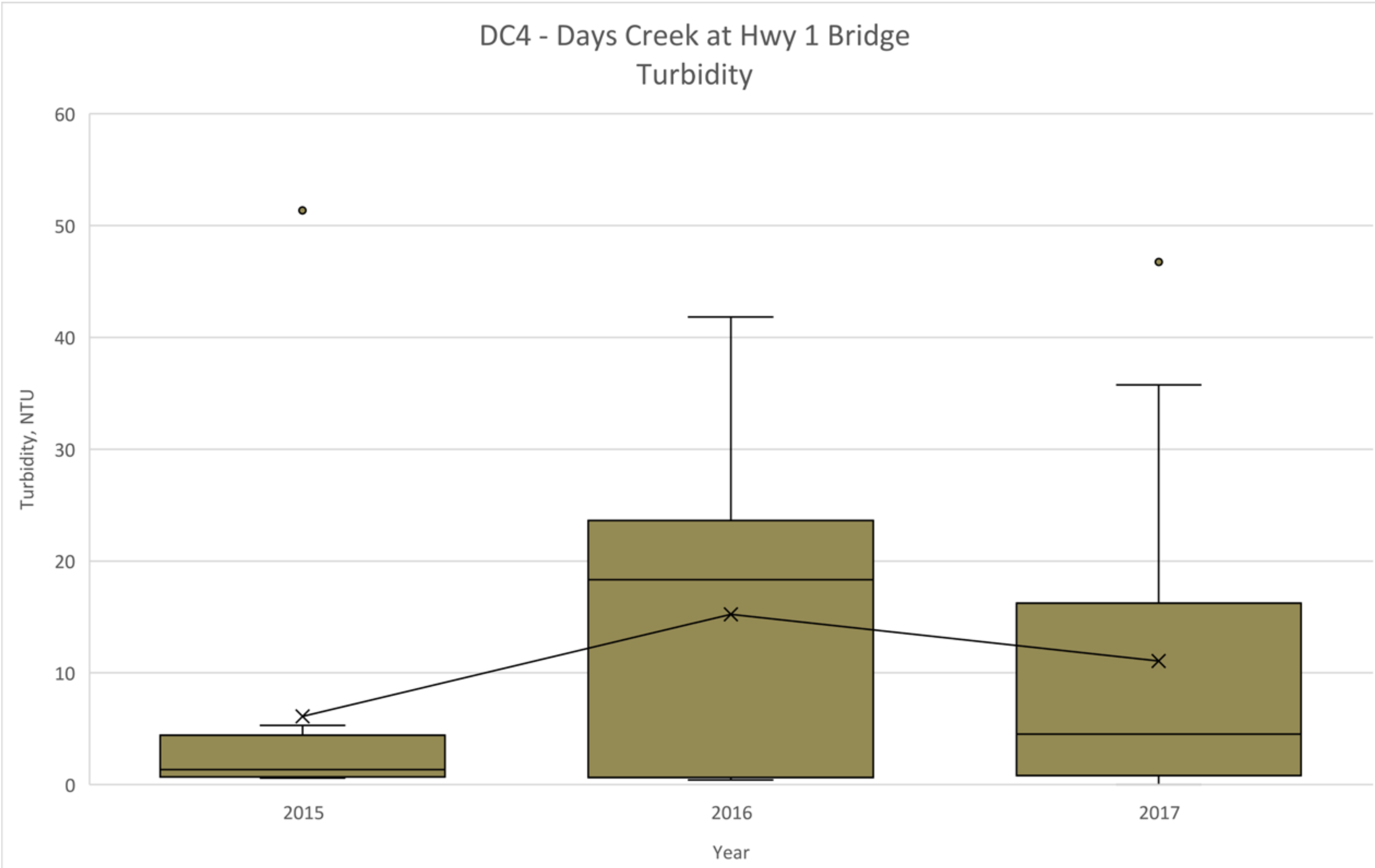
when the Creek flow gets very low. (See Graph 66.) Both Graph 65 and 66 show no trend over these three years.

E. coli

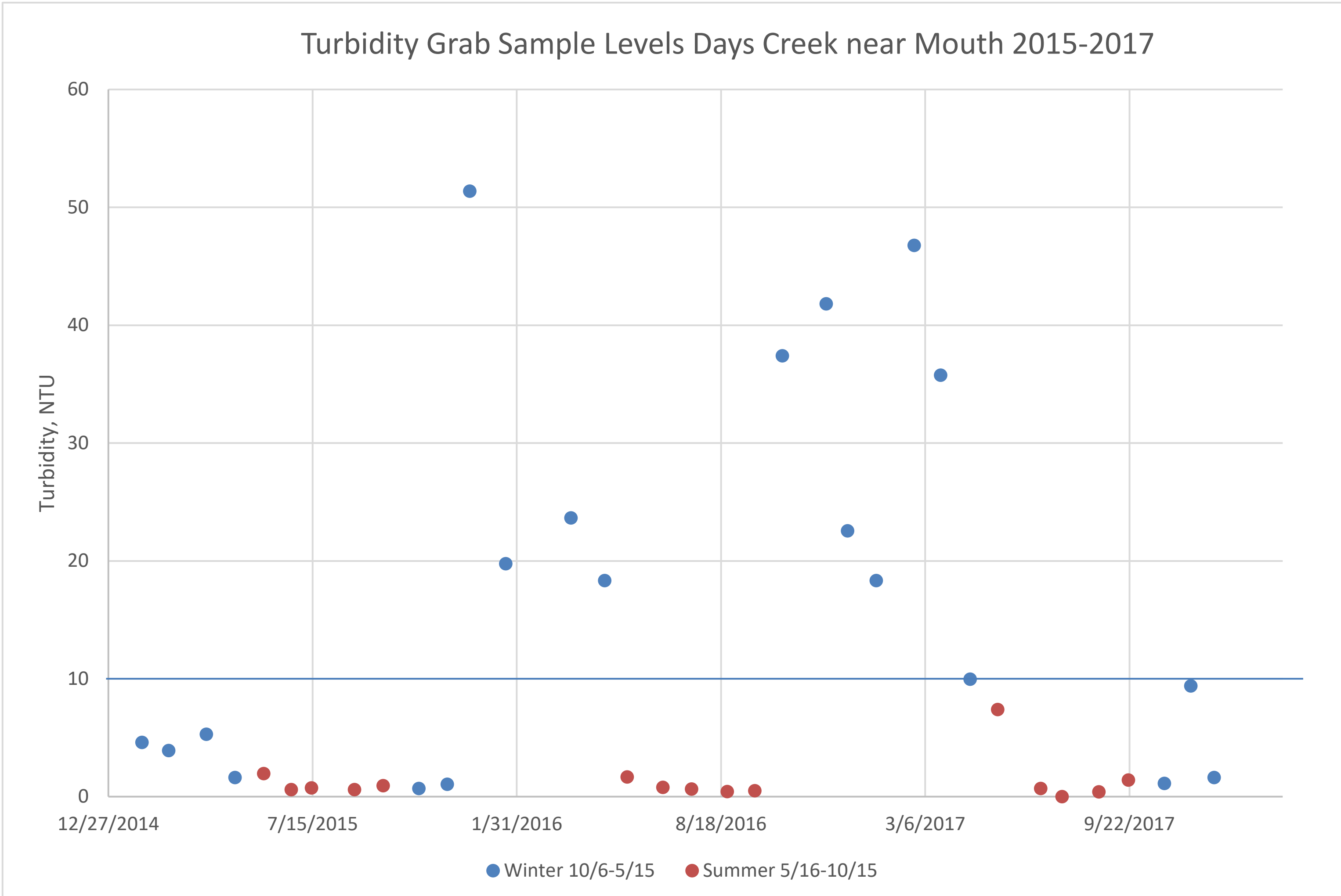
Four *E. coli* levels, two in summer and two in winter, exceeded the one time reading at 406 MPN/ml or greater that lists a stream (Graph68). Below 406 MPN/100ml on Graph 67 and 68 it is clear there are many high levels (≥126) of *E. coli* that if the site had been monitored 5 times in one month might also have listed the creek. No trends are currently apparent.

Temperature

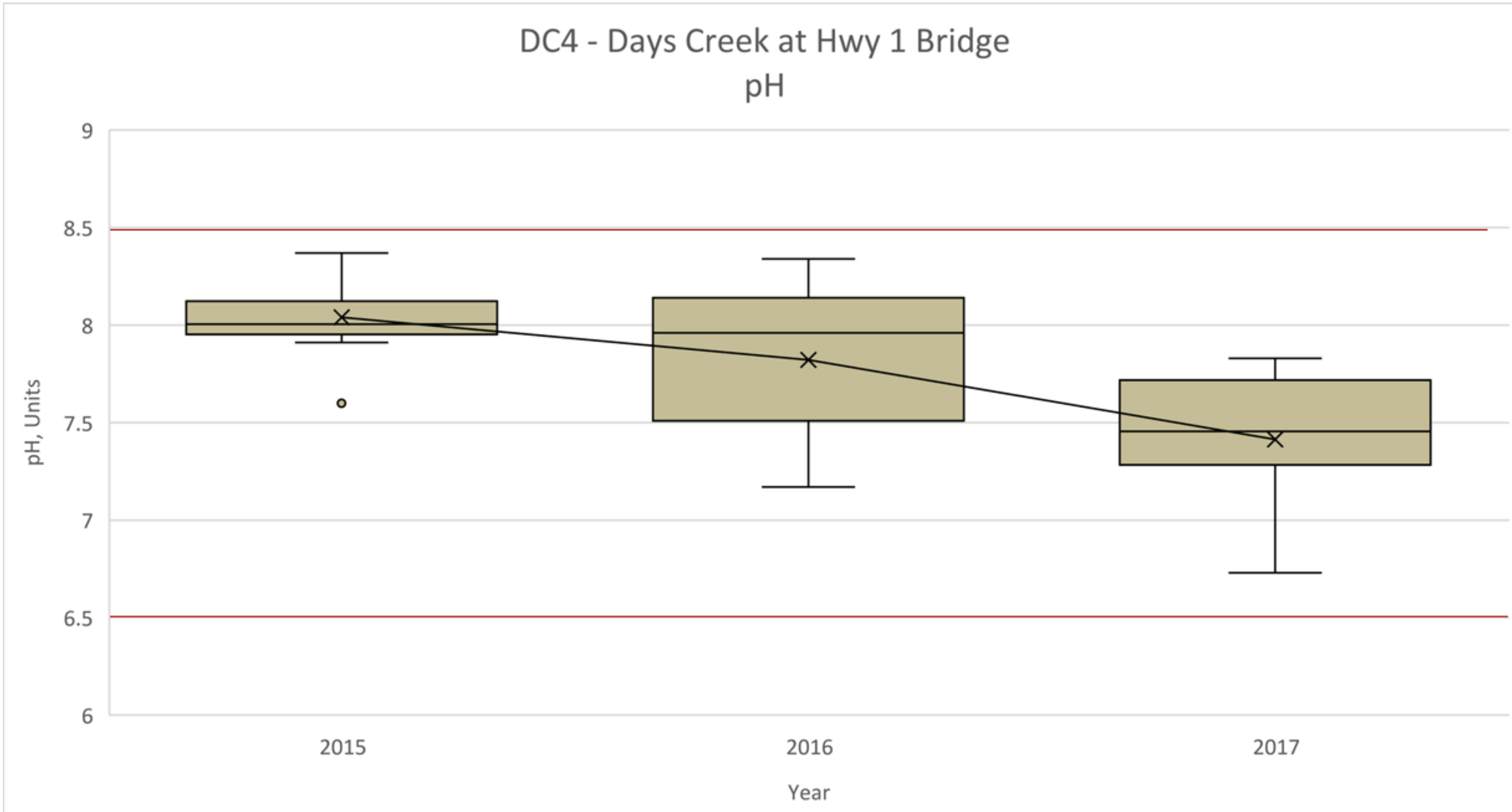
Days Creek does not fall in the Core Cold Water area (Appendix L) and therefore should meet the 64.4°F Rearing and Migration Criteria (Oct 15- May 14) and the Spawning limit of 55.4°F (May 16-Oct 14). We were not able to perform continuous temperature recording at this site so may have missed highs that occurred at other times of the day or on other days than our grab sampling. Our data however, indicated only two events in 2015 that exceeded 64.4°F and none in the other two years. All sampling during Spawning season fell below the 55.4°F. Trends are not evident.



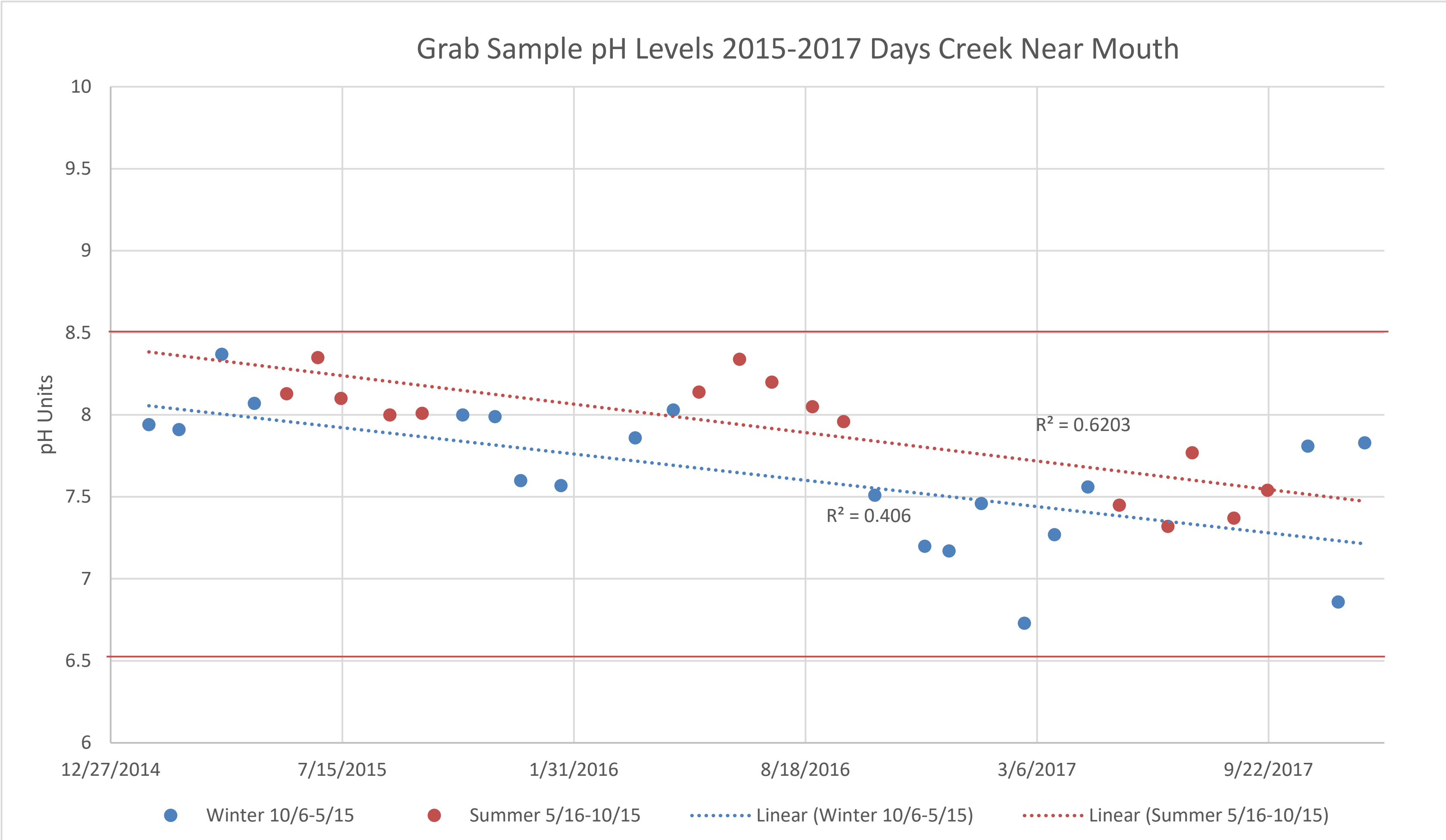
Graph 59. Box plots by year of grab sample turbidity levels of Days Creek near the mouth.



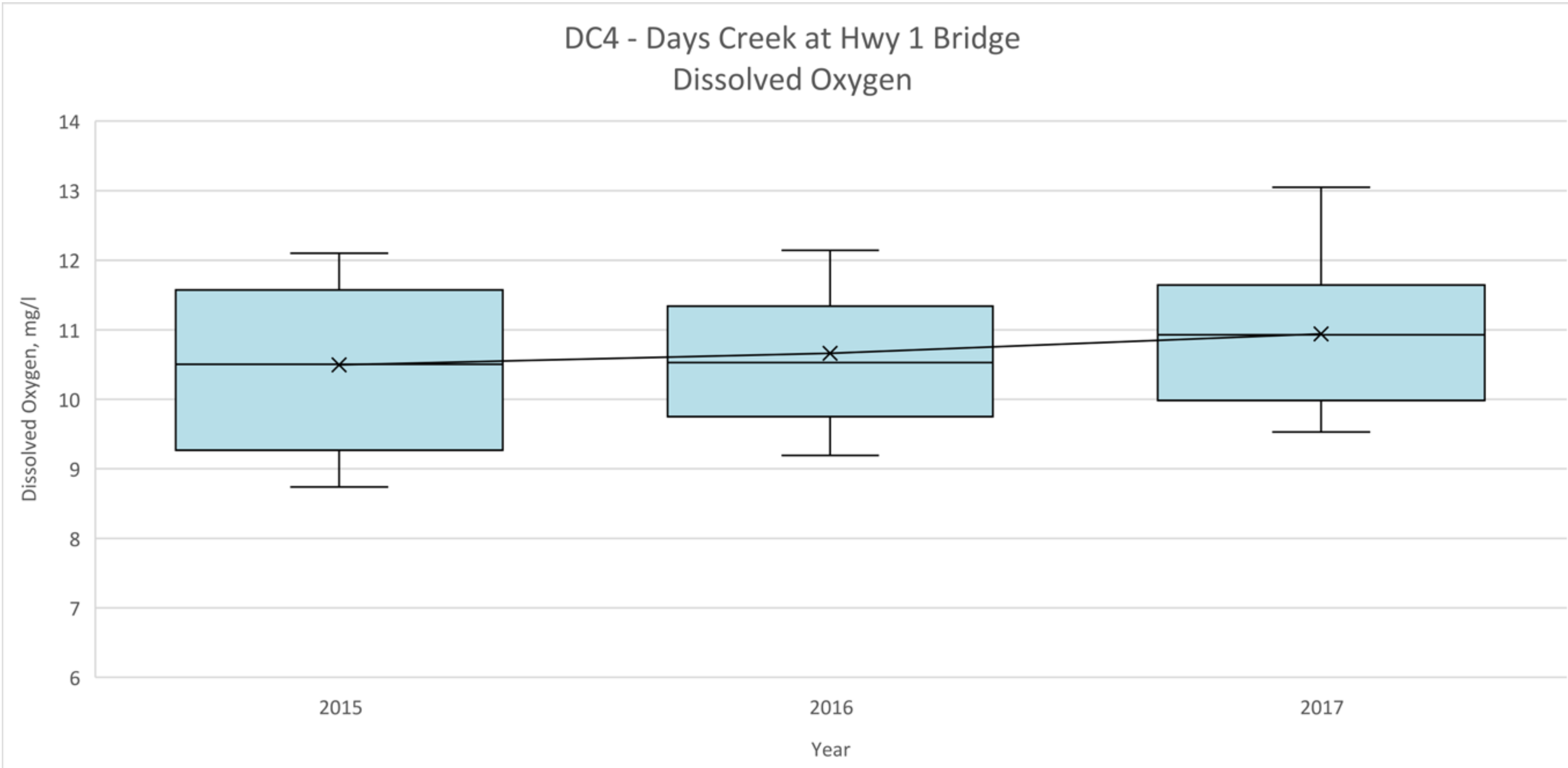
Graph 60. Turbidity grab samples for Days Creek near the mouth 2015-2017 summer and winter separated.



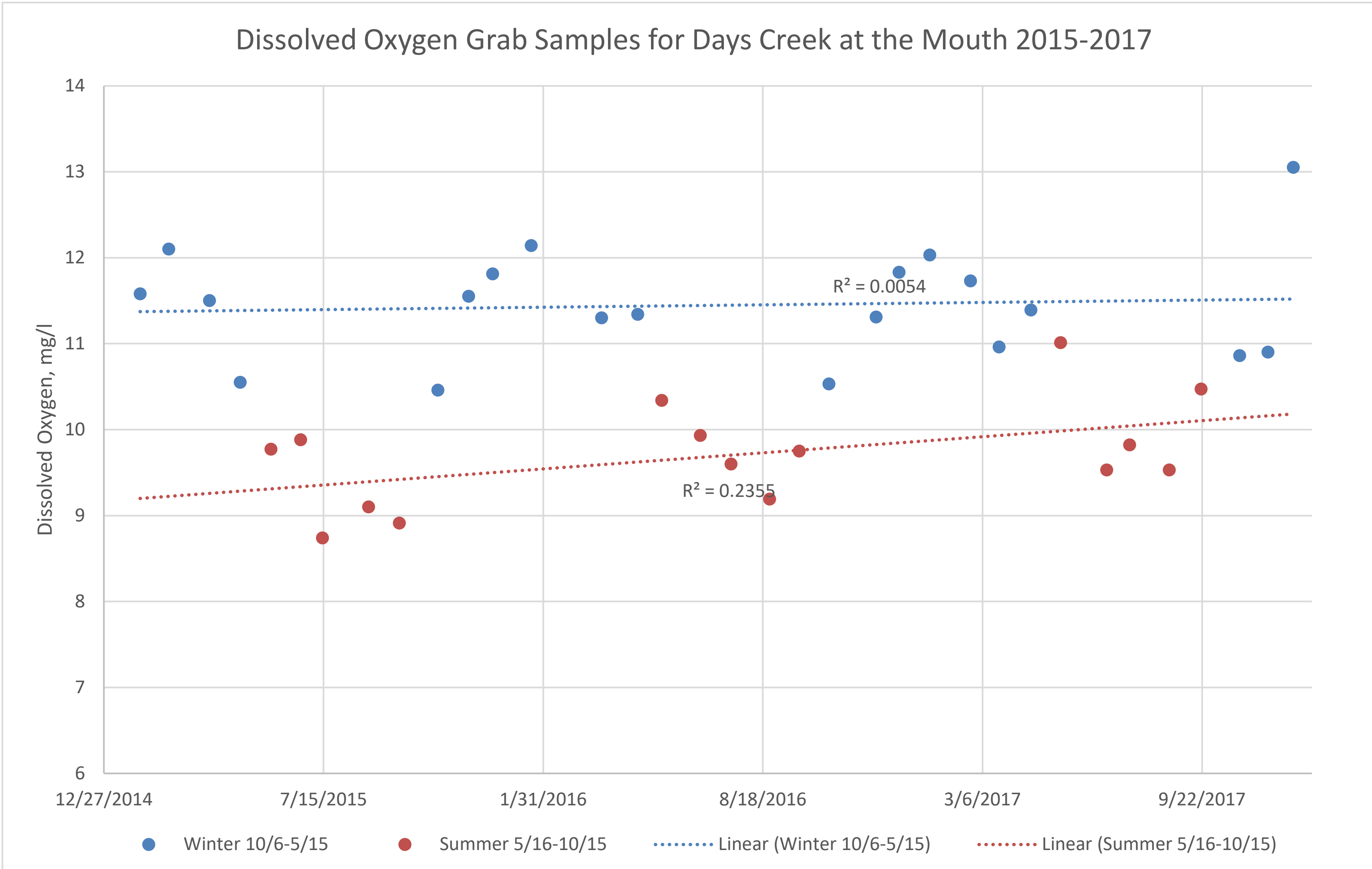
Graph 61. Box plots by year of grab sample pH levels of Days Creek near the mouth.



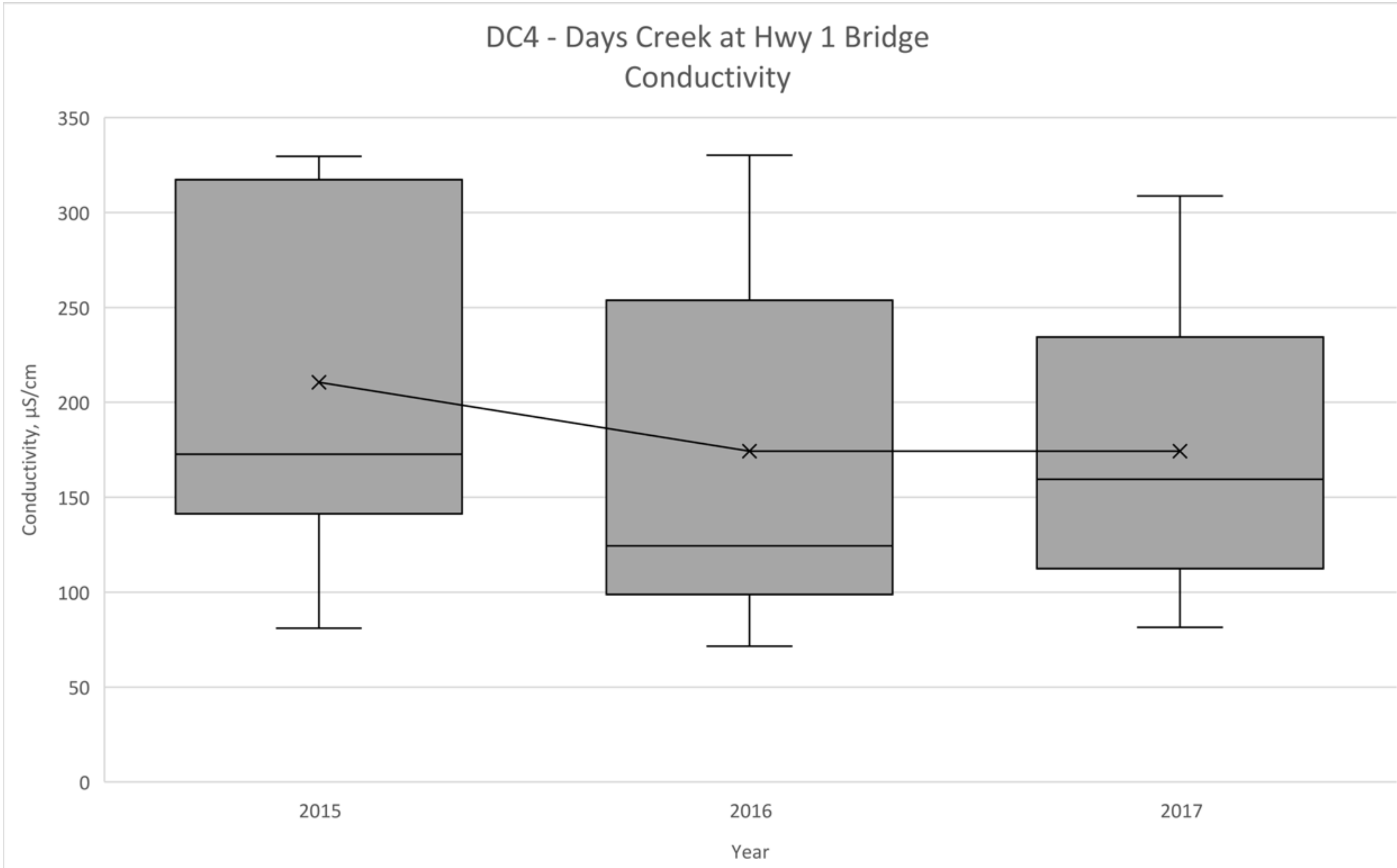
Graph 62. Grab Sample pH Levels 2015-2017 Days Creek near the mouth with summer and winter separated.



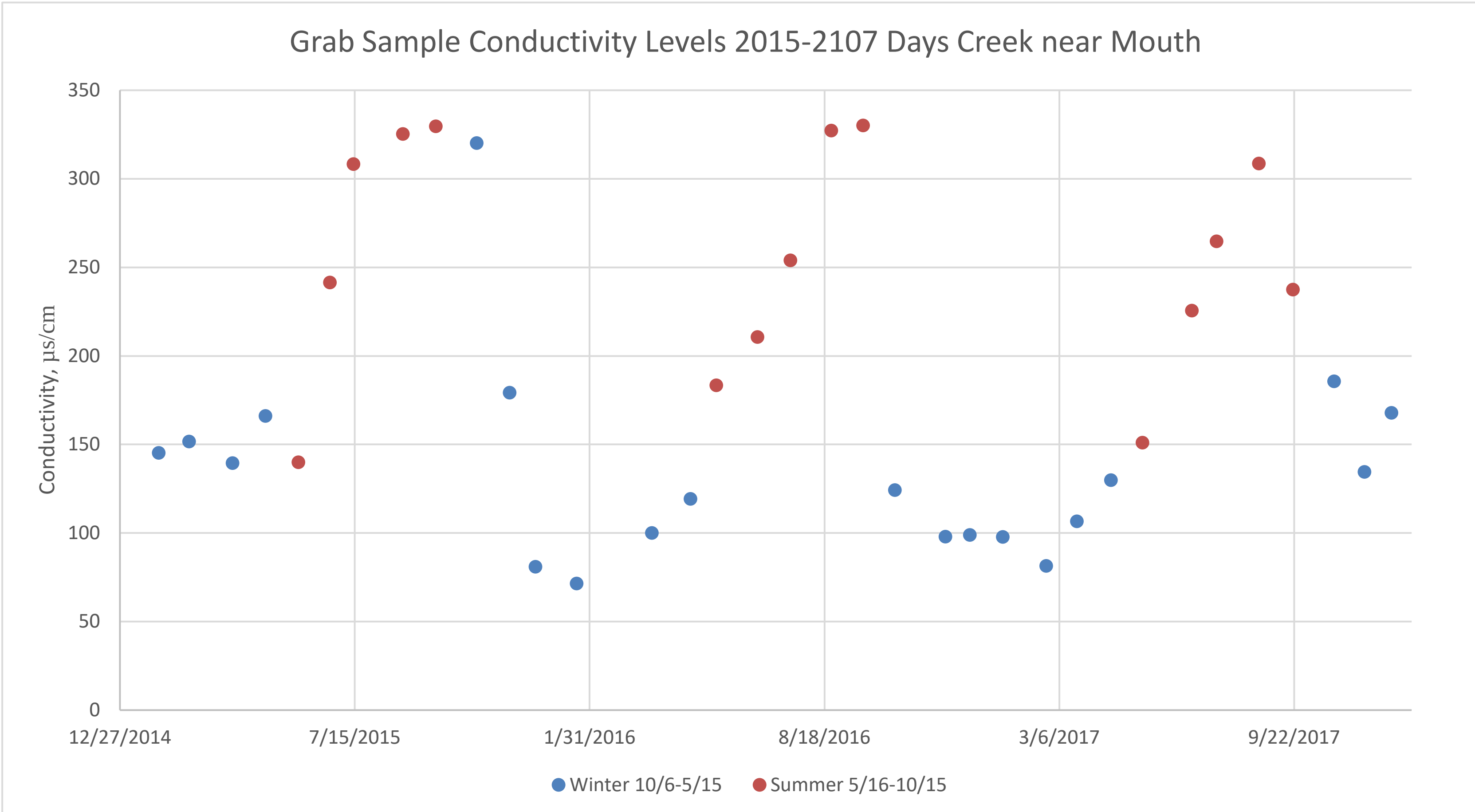
Graph 63. Box plots by year of grab sample dissolved oxygen levels of Days Creek near the mouth.



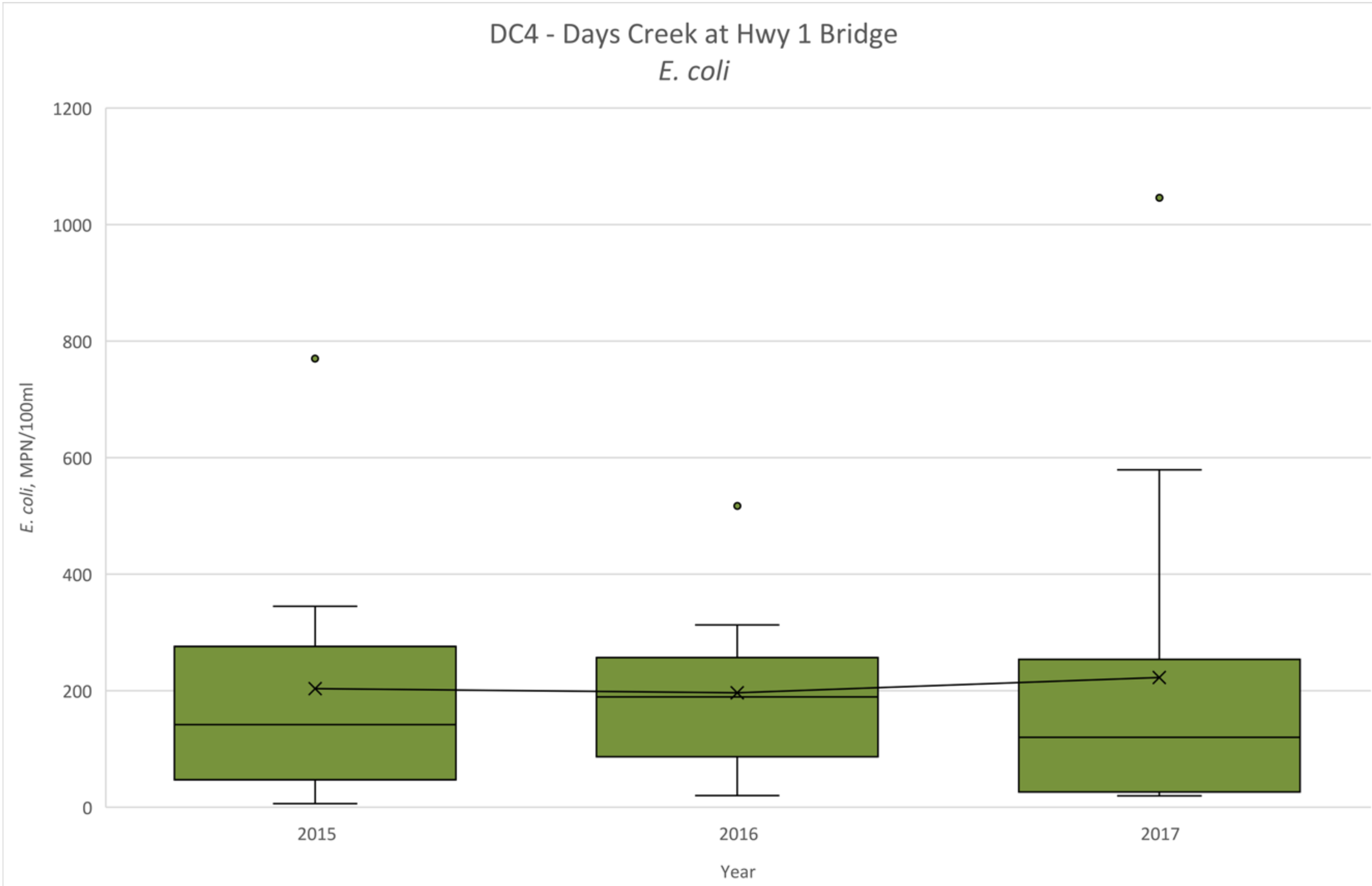
Graph 64. Dissolved Oxygen grab samples for Days Creek at the mouth 2015-2017 summer and winter separated.



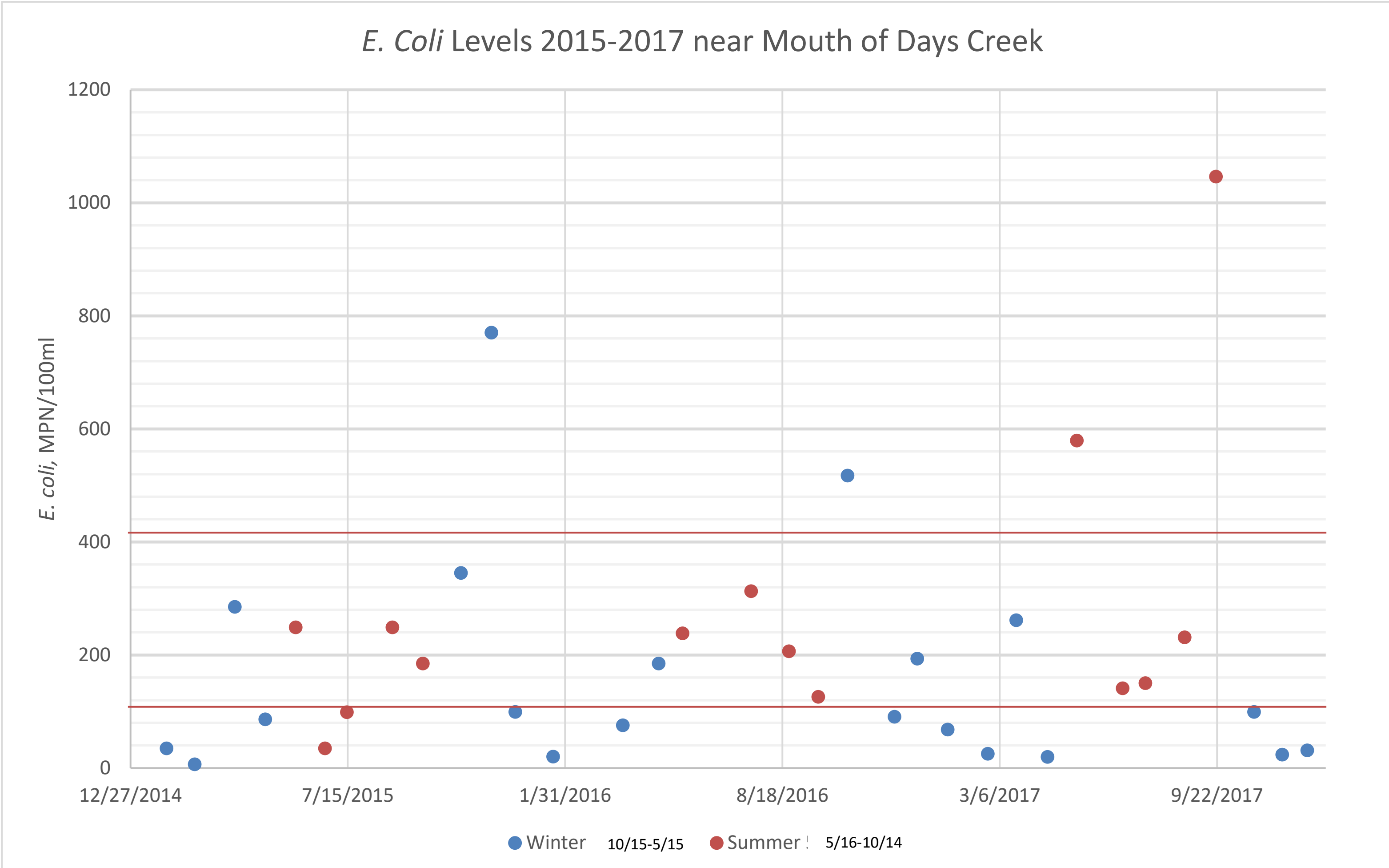
Graph 65. Box plots by year of grab sample conductivity levels of Days Creek near the mouth.



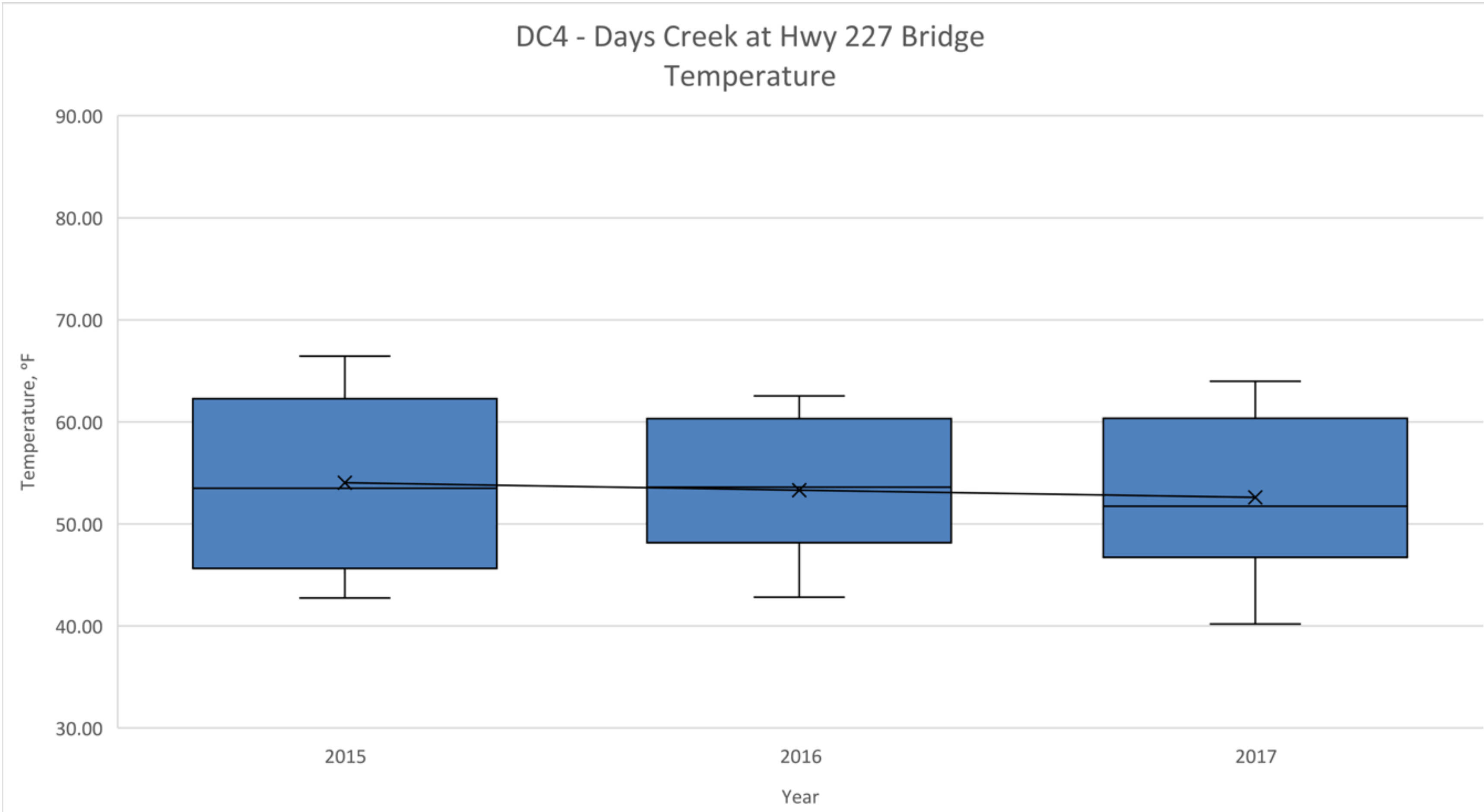
Graph 66. Grab sample conductivity levels 2015-2107 Days Creek near mouth summer and winter separated.



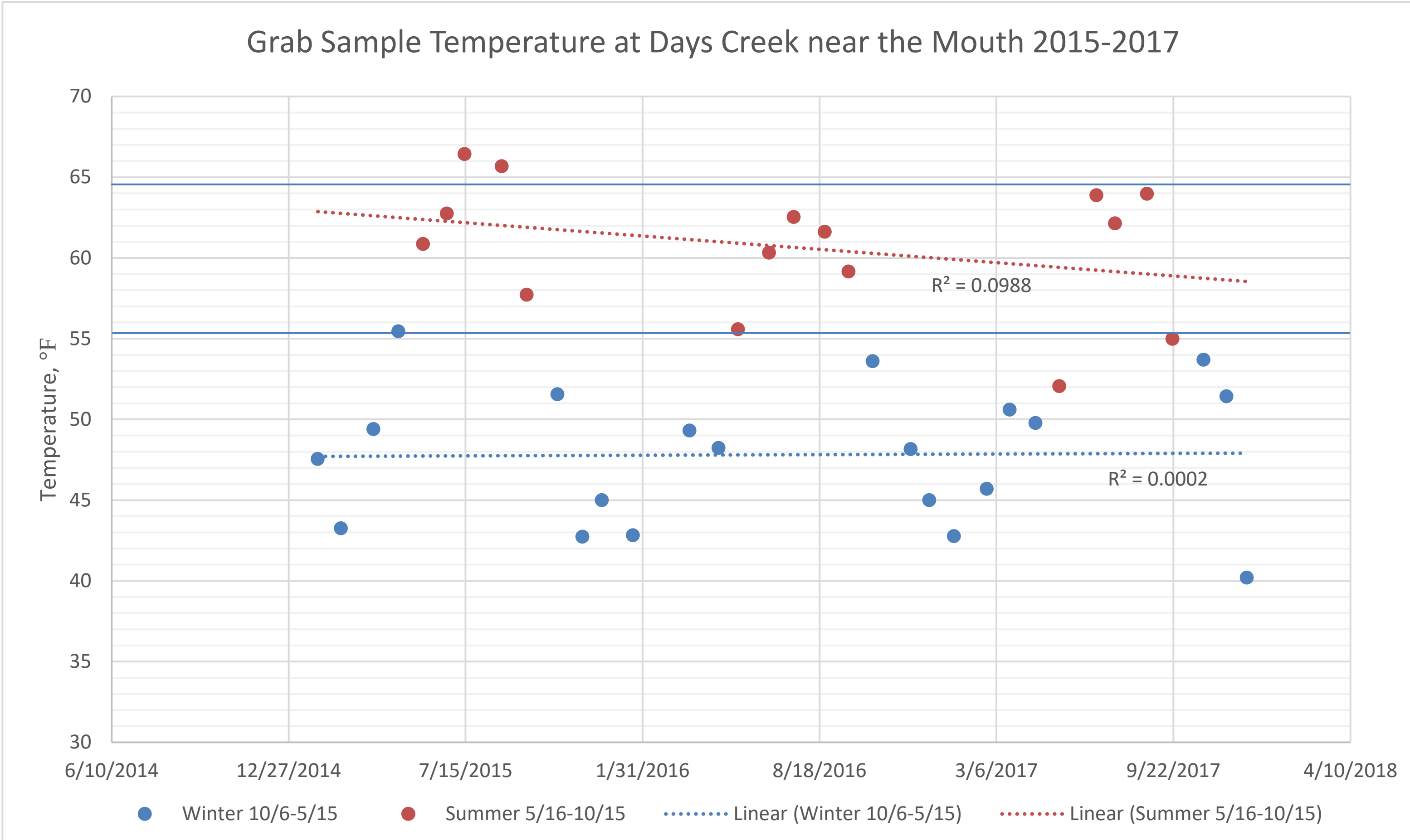
Graph 67. Box plots by year of grab sample *E. coli* levels of Days Creek near the mouth.



Graph 68. *E. coli* Levels 2015-2017 near mouth of Days Creek summer and winter separated.



Graph 69. Box plots by year of grab sample temperature levels of Days Creek near the mouth.



Graph 70. Grab sample temperature at Days Creek near the mouth 2015-2017 summer and winter separated.

SU2 - South Umpqua at Hwy 1 Bridge Days Creek

Year	Monthly Samples	Months
2010	12	Full Year
2012	11	Full Year
2013	15	Full Year, 3 July
2014	13	Jan-Aug
2015	12	Full Year
2016	12	Full Year
2017	12	Full Year

Table 26. Number of monitoring events per year included in graphs that follow for the South Umpqua at Days Creek site.

Turbidity

The South Umpqua river at Days Creek has winter turbidity issues from 2010 thru 2017. These generally coincided with rain events (See Appendix M for rain records.) During our grab sampling the highest level detected was 74 NTU. (See Graphs 71, 72, and 73.) No levels were detected above 10 NTU during summer months. The highest levels occurred in 2016 but no trend is evident.

pH

The pH grab sample levels between 2010 and 2017 at this site were all within the DEQ Criteria for pH (see Graphs 74 and 75). The box plot graph does indicate an interesting trend in that the pH values for 2015, 2016, and 2017 showing a downward trend in pH both at the high and low end of the of plots. Trend lines were added to Graph 75. Not enough data, nor 24-hour data is available to make any reliable result. However, the summer and the winter trends were downward which weighted the box plot data. Summer levels are high and, though not reaching the DEQ Upper Limit, should be watched to make sure this site is not getting worse. Graph 76 was produced to see if pH plotted against sampling time might show a similar trend. It showed an opposite slope indicating variation in time sampled was not responsible for the downward trend of pH.

Dissolved Oxygen

The South Umpqua River at Days Creek, had no exceedances of the DEQ dissolved oxygen criteria for the non-spawning criteria (see Graphs 77 and 78). In 2015 two monitoring events came very close to falling below 8 mg/l. (Note that this was a drought year and the river was quite low.) Six exceeded the spawning criteria of 11 mg/l during the period of 10/16 thru 5/15. All of these stayed above 10 mg/l.

Conductivity

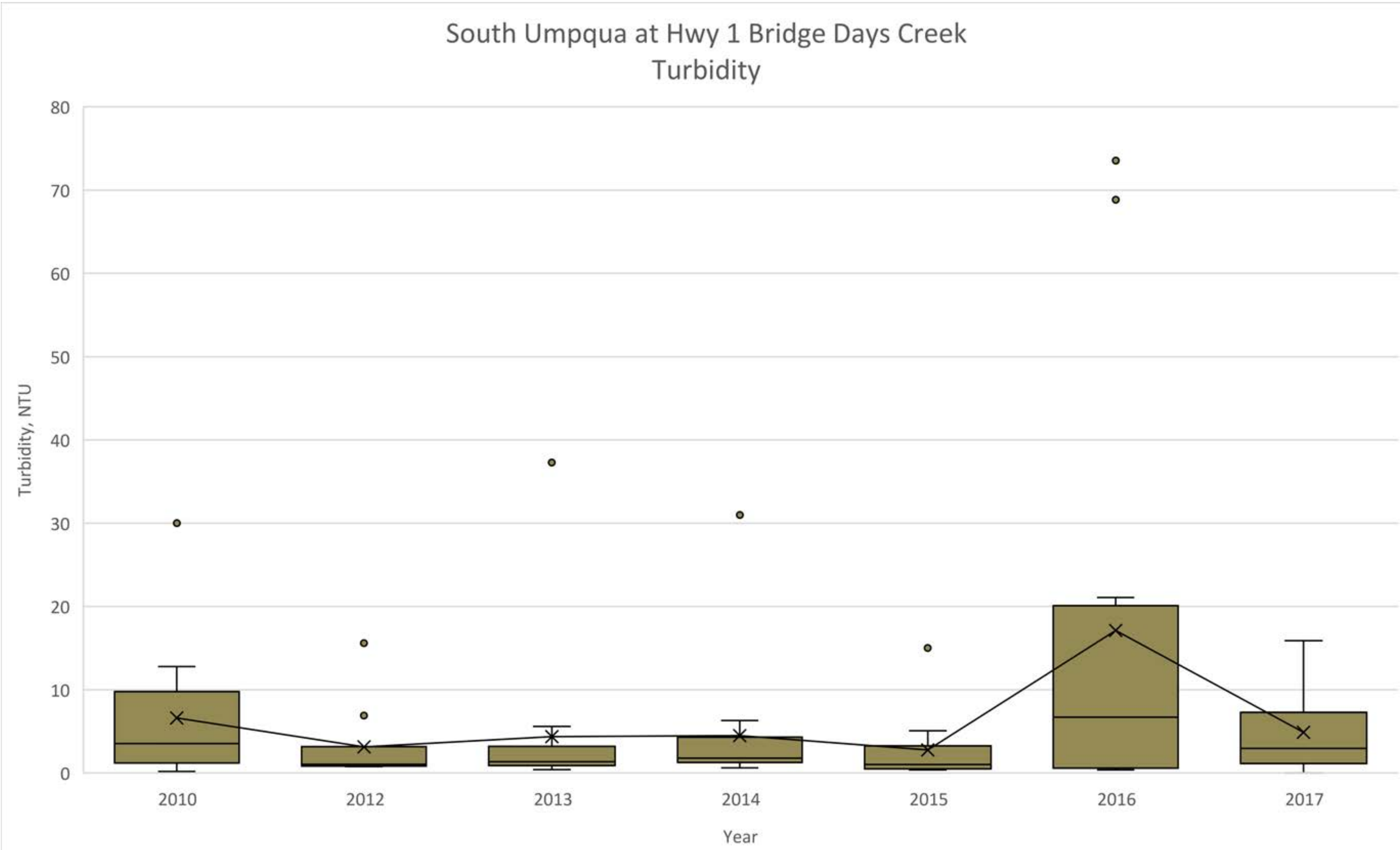
Conductivity levels for the South Umpqua River at Days Creek were within normal ranges for the Umpqua Basin, and none even exceeded 190 µS/cm. The conductivity did show a slight downward trend from 2015 thru 2017. It might be on interest to continue to watch this in future years to see if it is coinciding with the downward trend in pH for those years. Graph 80 indicates that the higher levels occurred during summer.

E. coli

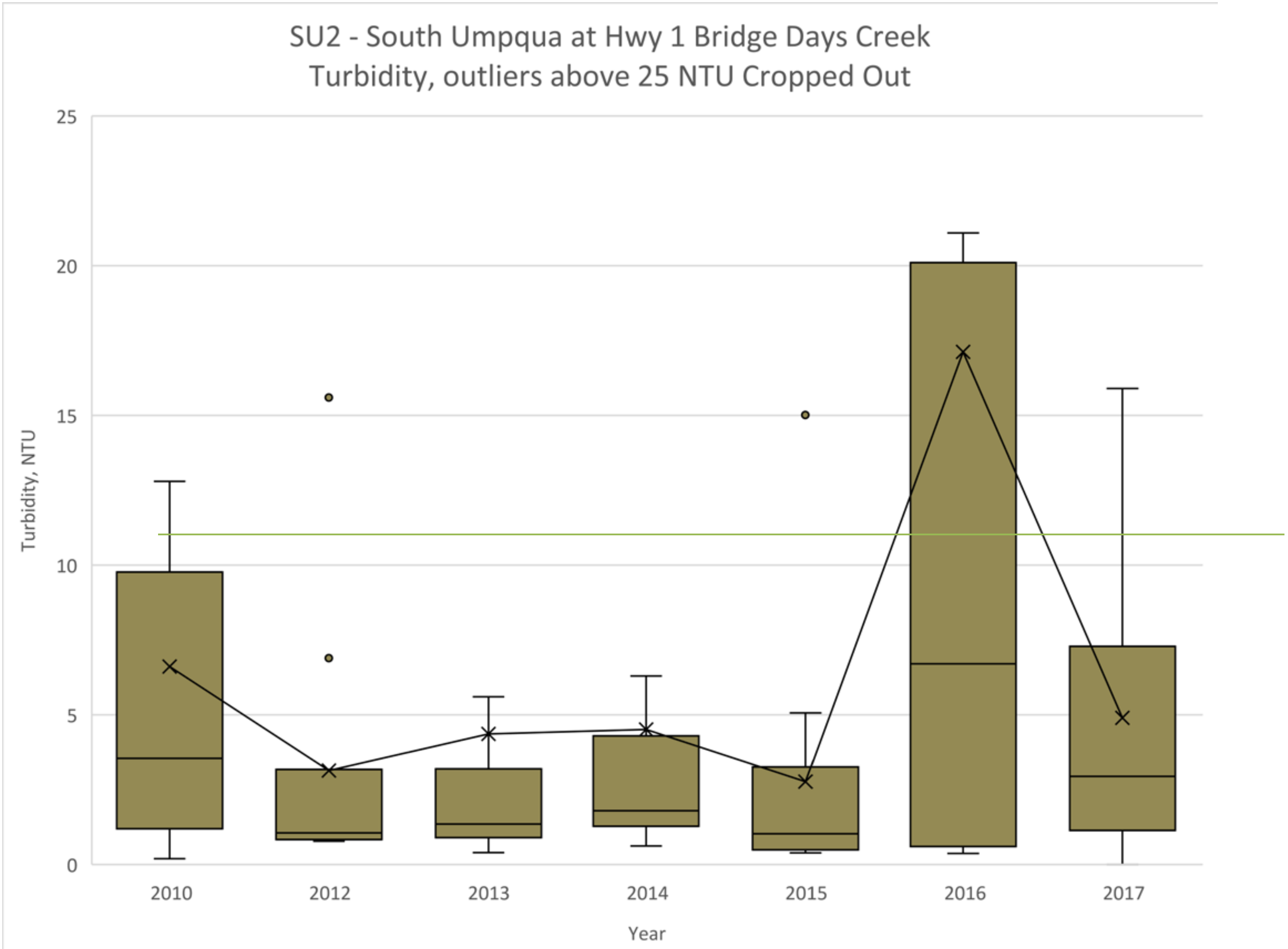
E. coli levels were generally not bad at this site with none ever exceeding 250 MPN/100ml. Many were below the 126 MPN/100ml which DEQ criteria indicates would have to have been measured 5 times in one month to have listed it. One time reading at 406 MPN/ml or greater would list a stream. Of the four outliers shown on Graph 81, three occurred in the fall and the other one in the spring.

Temperature

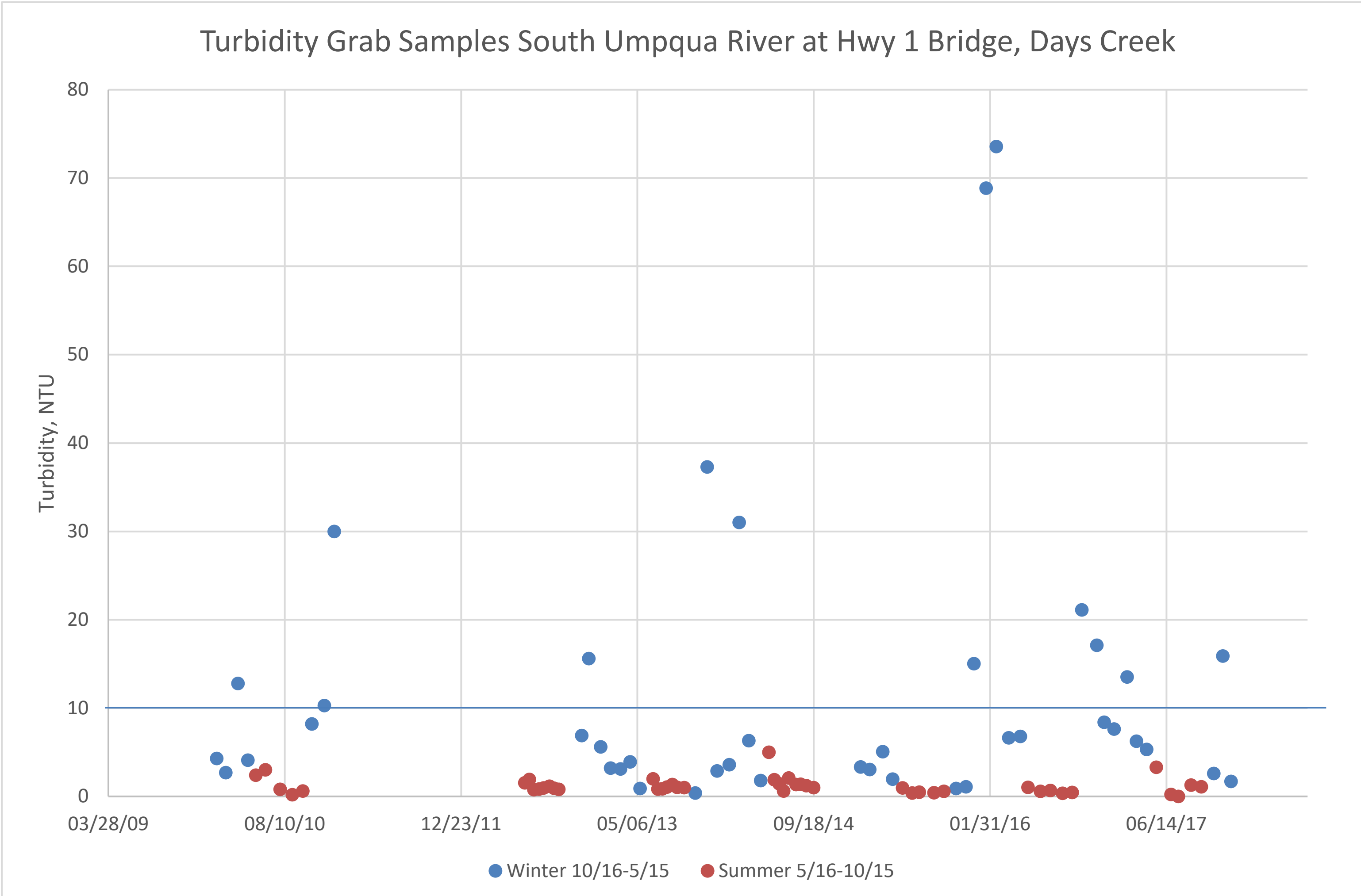
This part of the South Umpqua River does not fall in the Core Cold Water area (Appendix L) and therefore should meet the 64.4°F Rearing and Migration Criteria (Oct 15- May 14) and the Spawning limit of 55.4°F (May 16-Oct 14). Our data indicated (Graphs 83 and 84) only one event fell above Spawning Season Criteria of 55.4°F. This occurred in 2015. Our grab sampling data, as well as our three years of continuous summer temperature monitoring, show clearly that this site does not meet the Rearing and Migration Criteria of 64.4°F. The three years of data logger results were from 2012 – 7DAM was 82.3°F, 2013 was 82.9°F, and 2015 was 85.9°F. Though trend lines were drawn on Graph 75 for summer and winter temperatures, there was acceptable no trend.



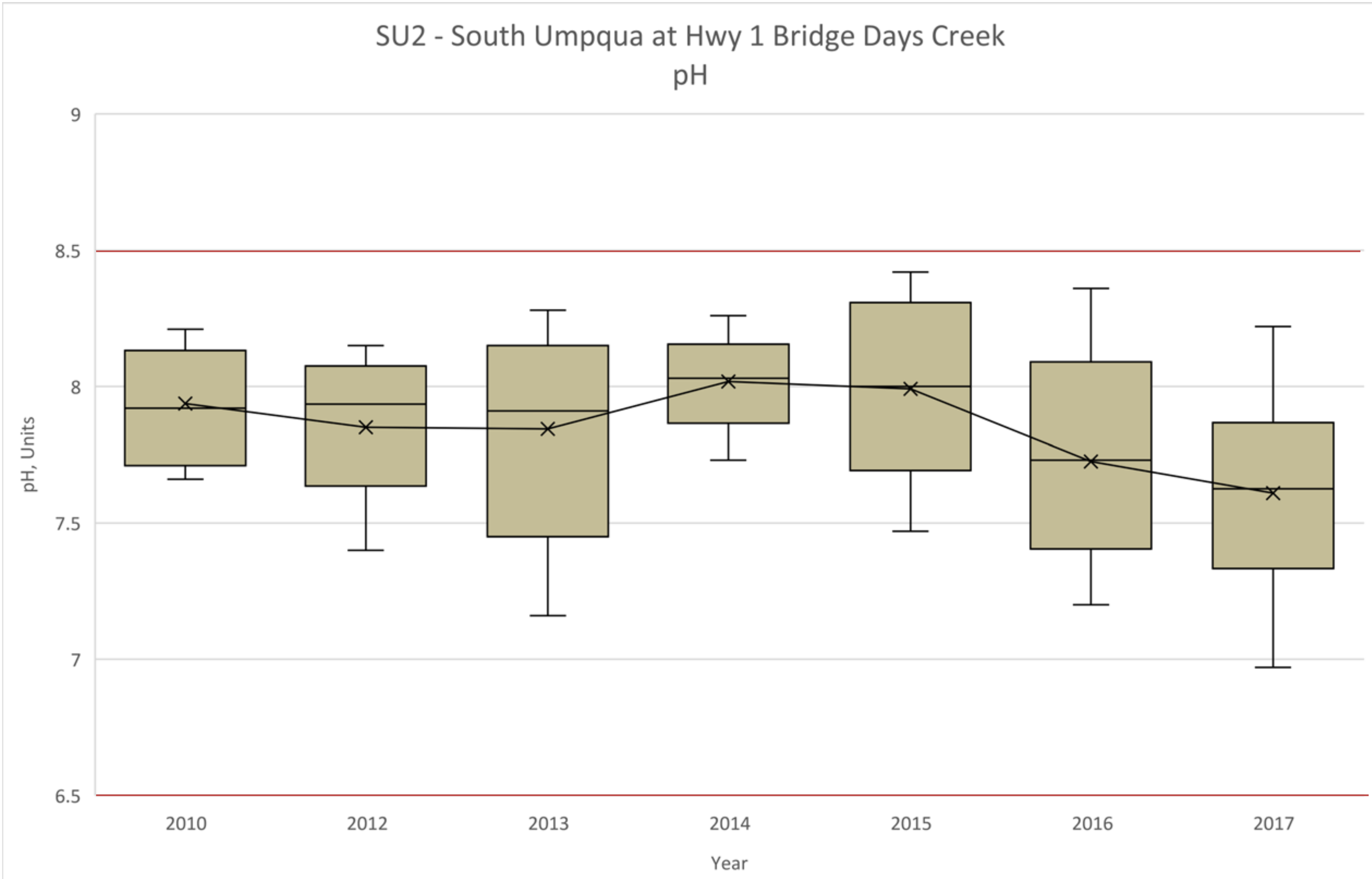
Graph 71. Box plots by year of grab sample turbidity levels of the South Umpqua at Days Creek.



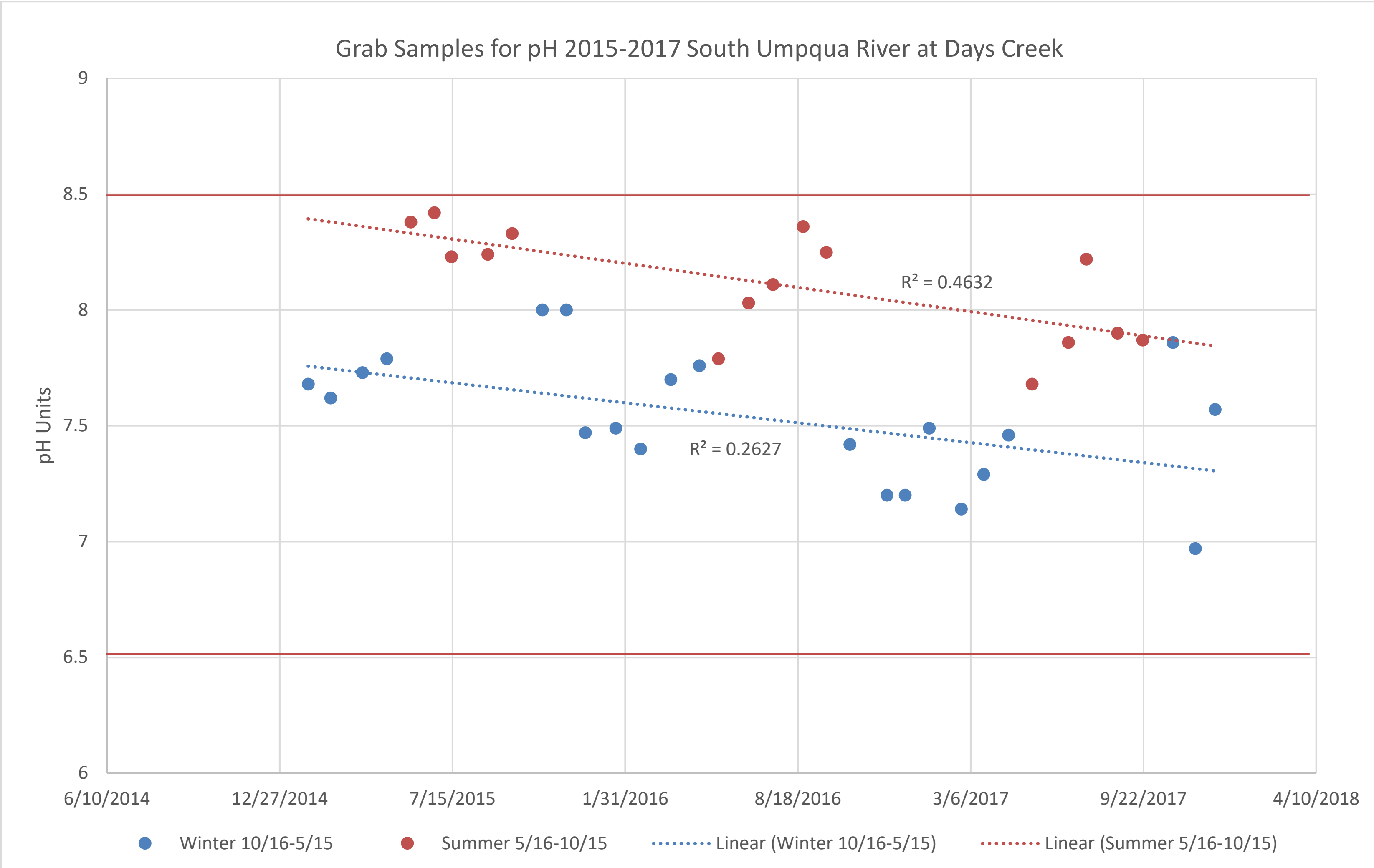
Graph 72. Box plots by year of grab sample turbidity levels of the South Umpqua at Days Creek. Outliers above 25 NTU where dropped to expand the box plots for clarity.



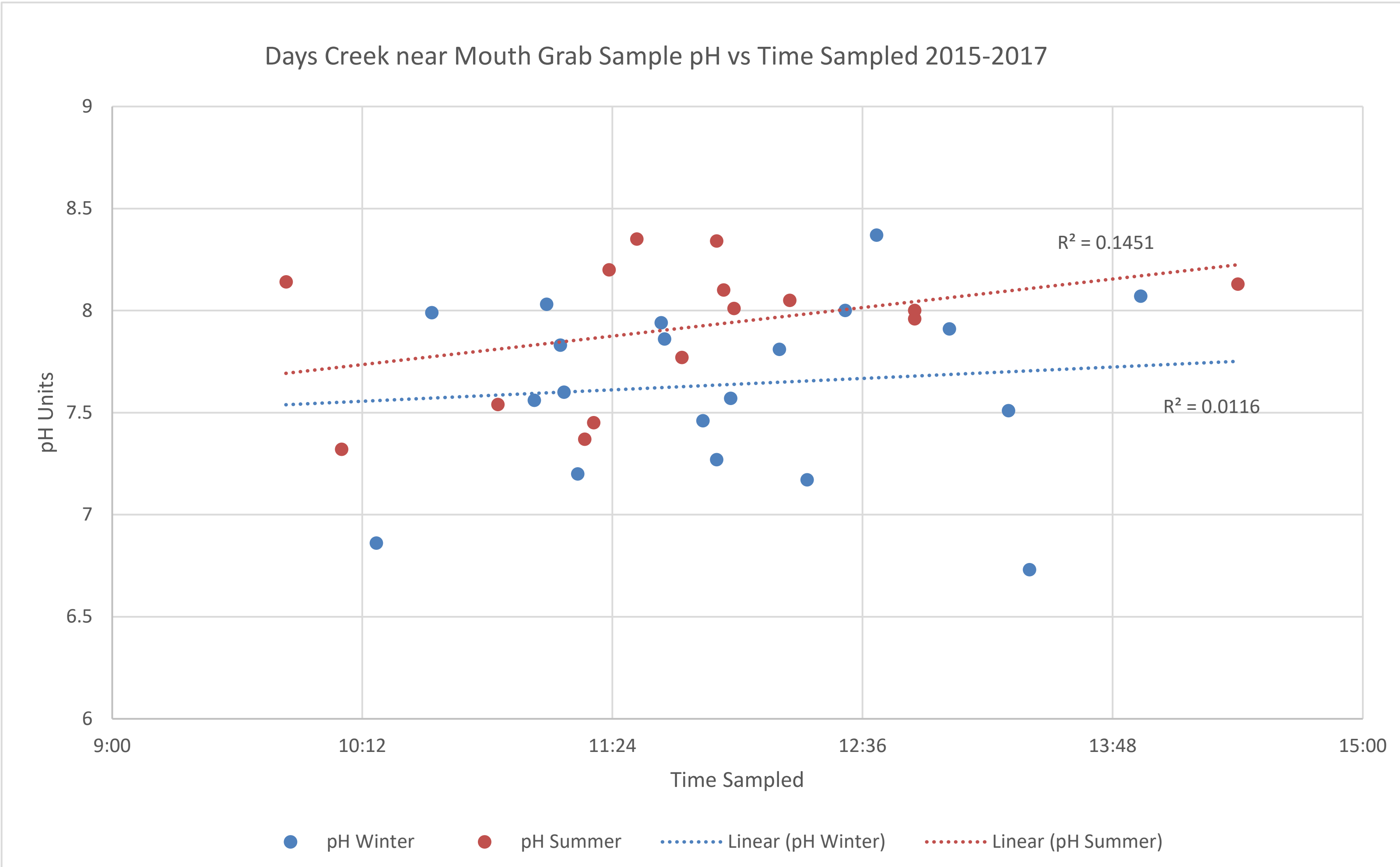
Graph 73. South Umpqua River at Hwy 1 bridge, Days Creek grab samples for turbidity summer and winter separated.



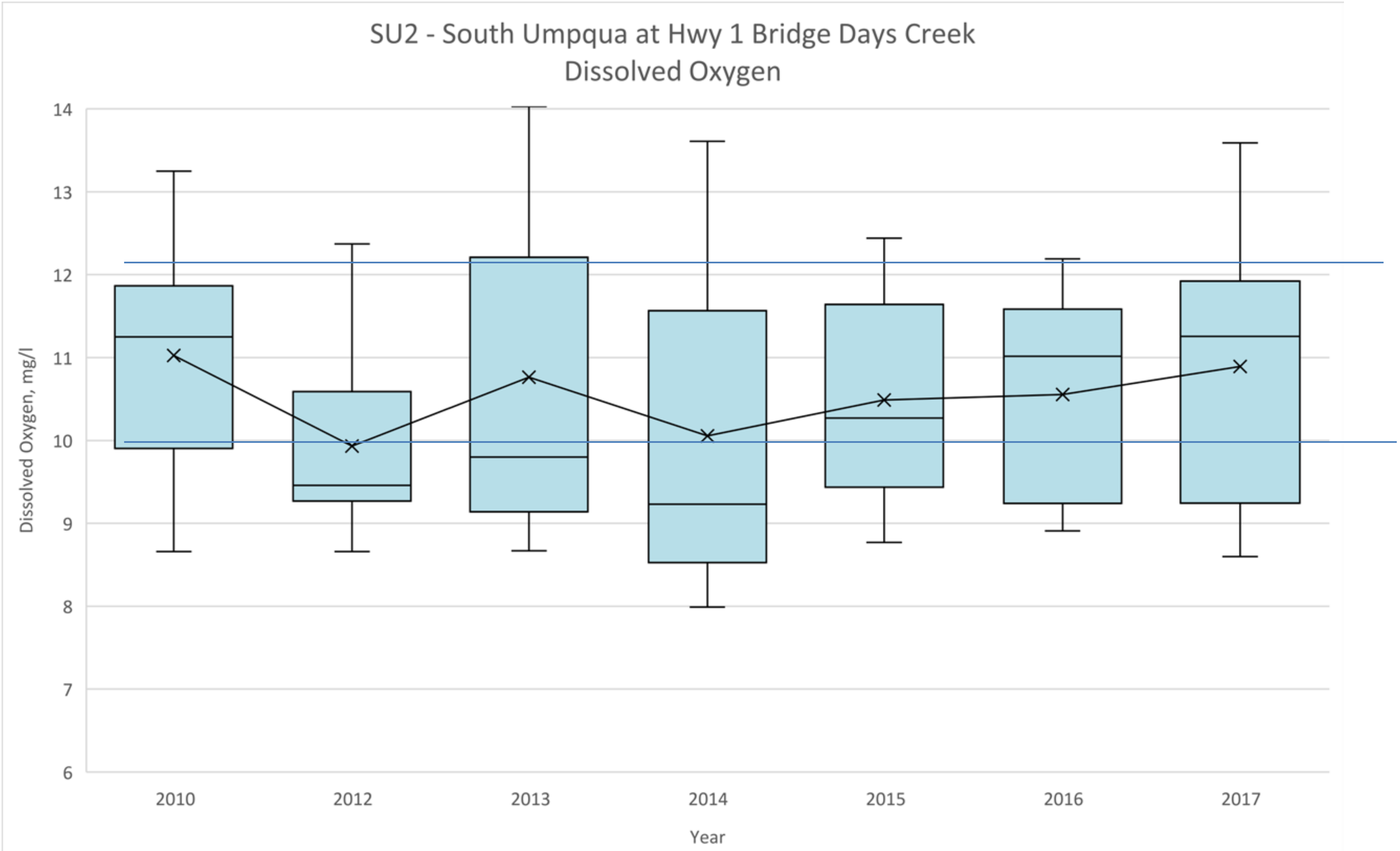
Graph 74. Box plots by year of grab sample pH levels of the South Umpqua at Days Creek.



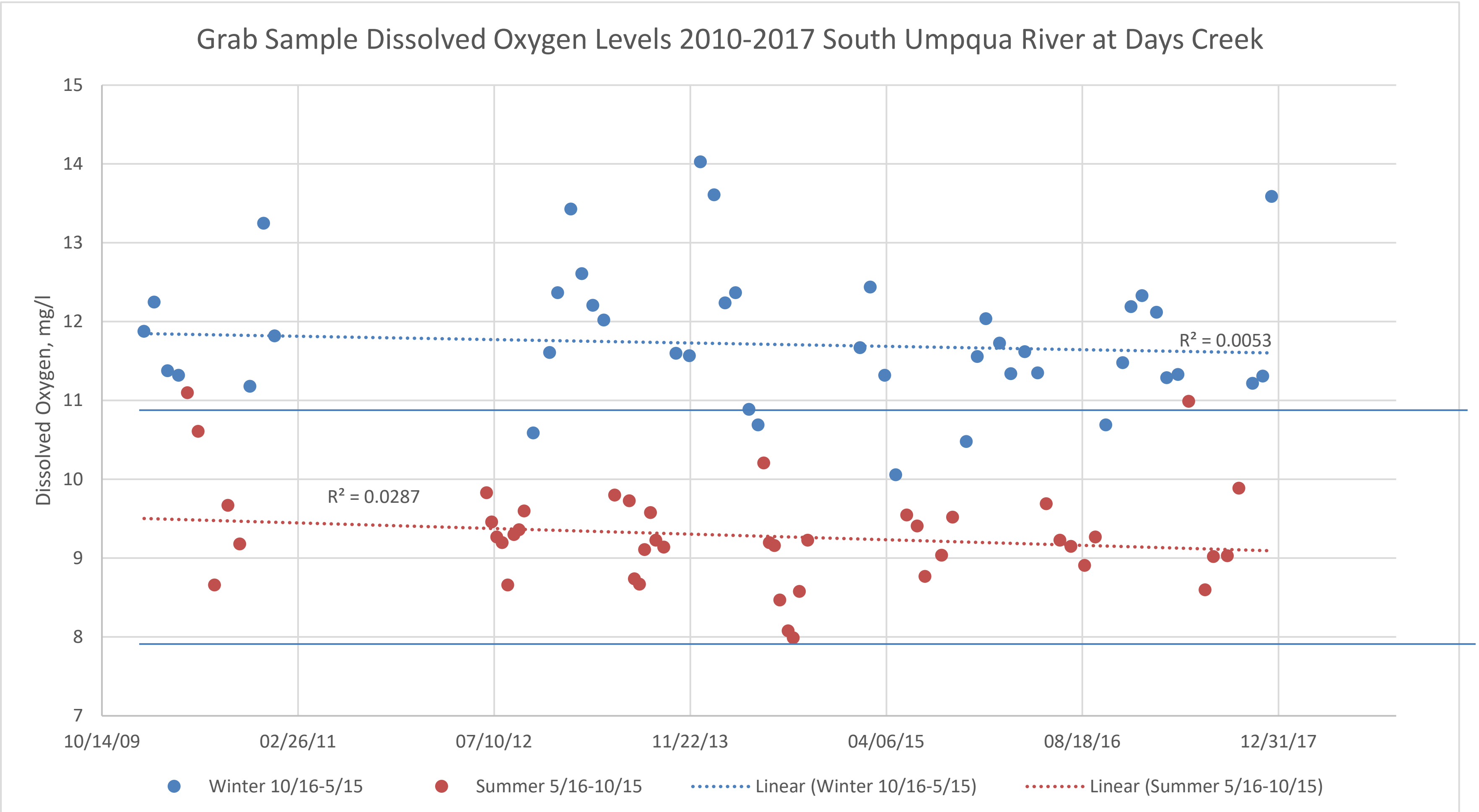
Graph 75. Grab Samples for pH 2015-2017 South Umpqua River at Days Creek, summer and winter separated.



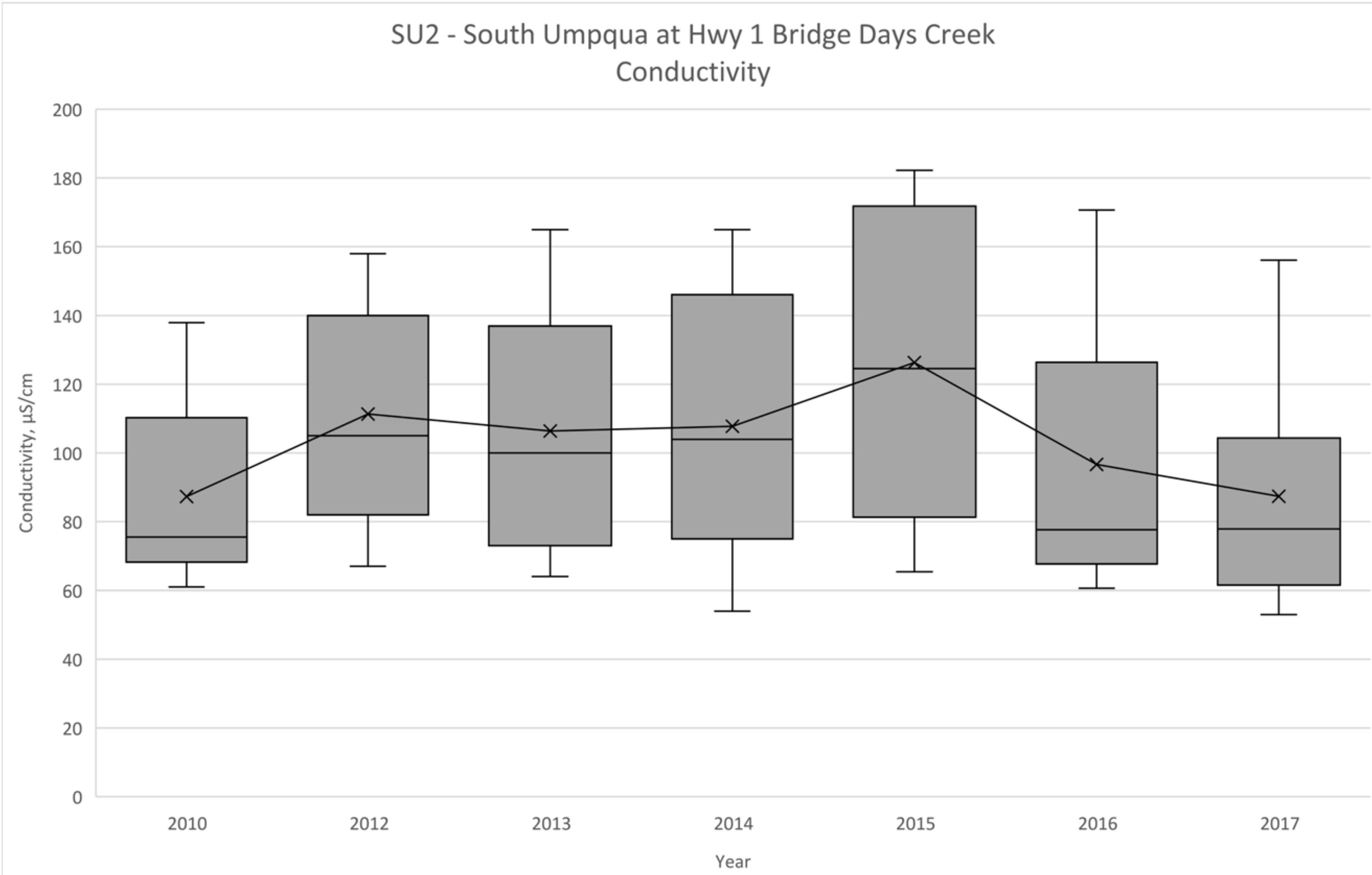
Graph 76. Days Creek near mouth grab sample pH vs time sampled 2015-2017.



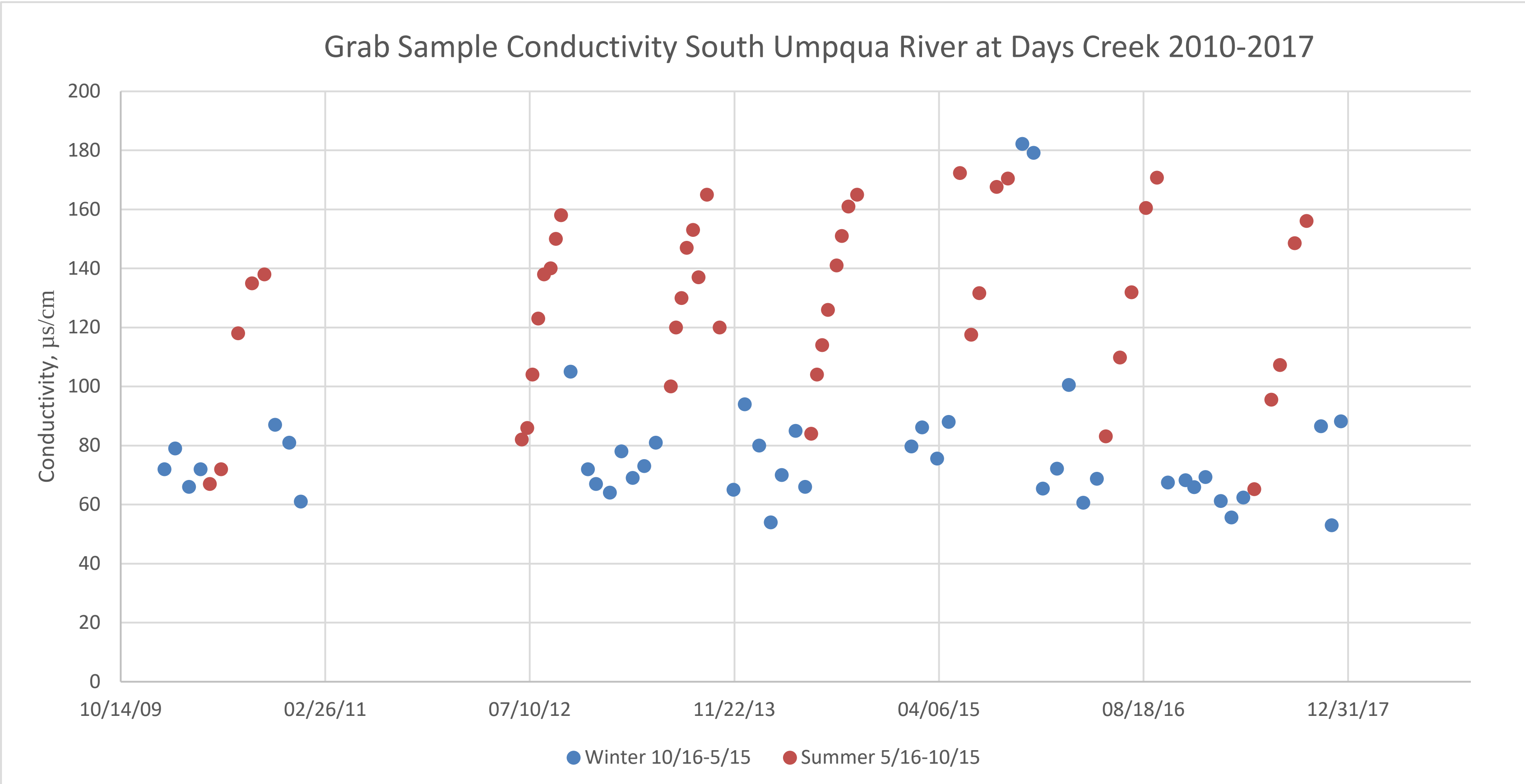
Graph 77. Box plots by year of grab sample dissolved oxygen levels of the South Umpqua at Days Creek.



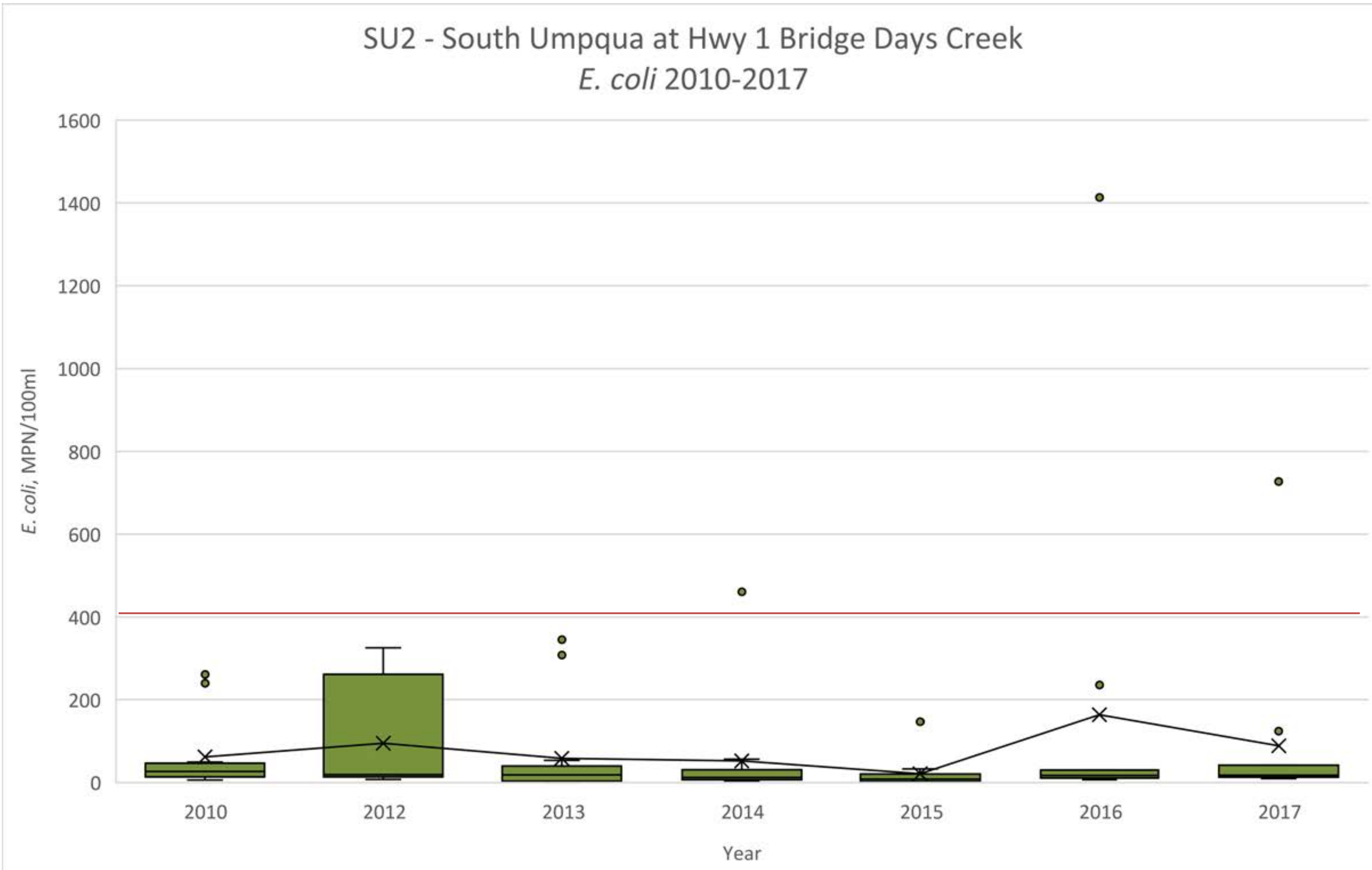
Graph 78. Grab sample dissolved oxygen levels 2010-2017 South Umpqua River at Days Creek summer and winter separated.



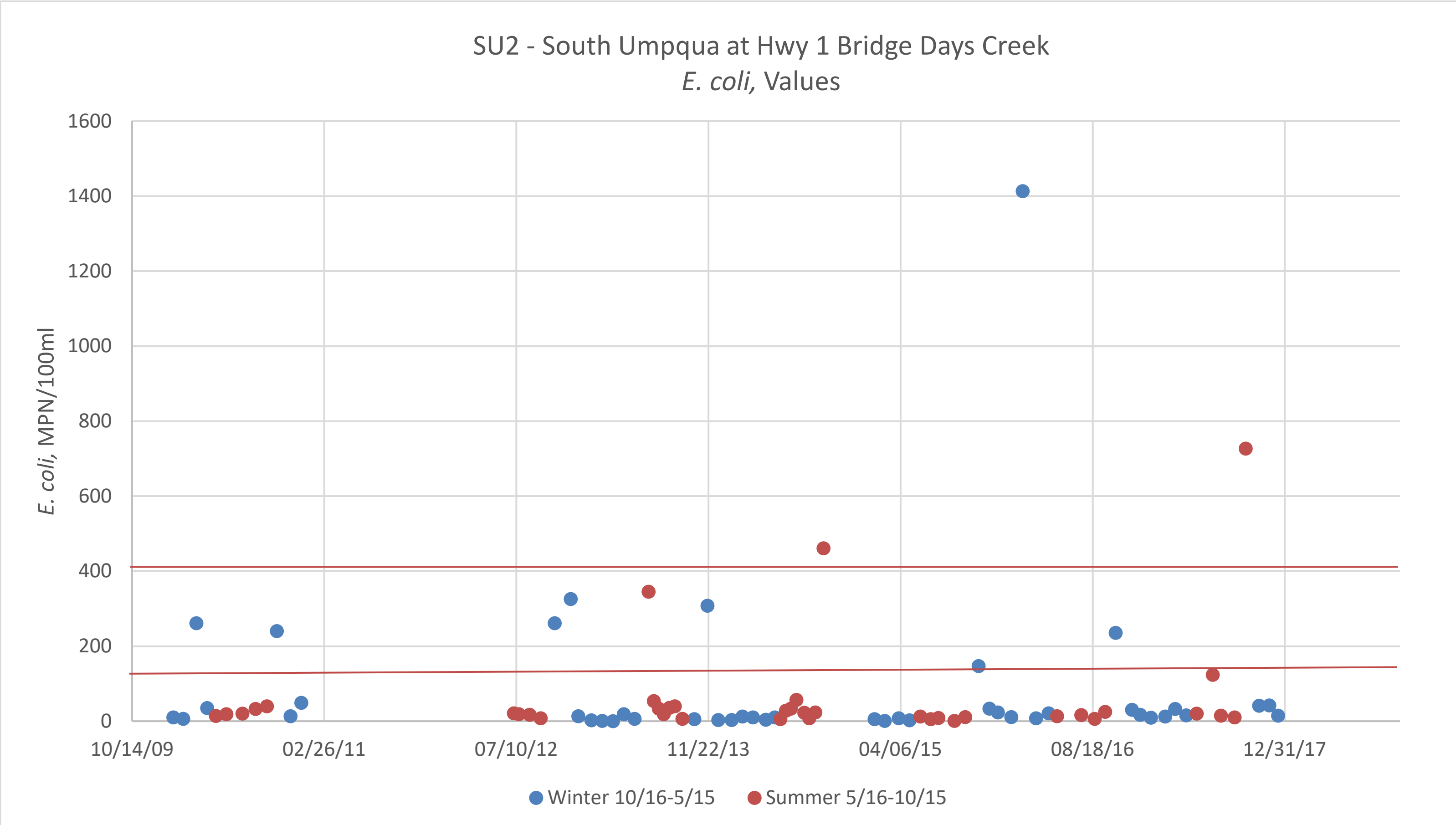
Graph 79. Box plots by year of grab sample conductivity levels of the South Umpqua at Days Creek.



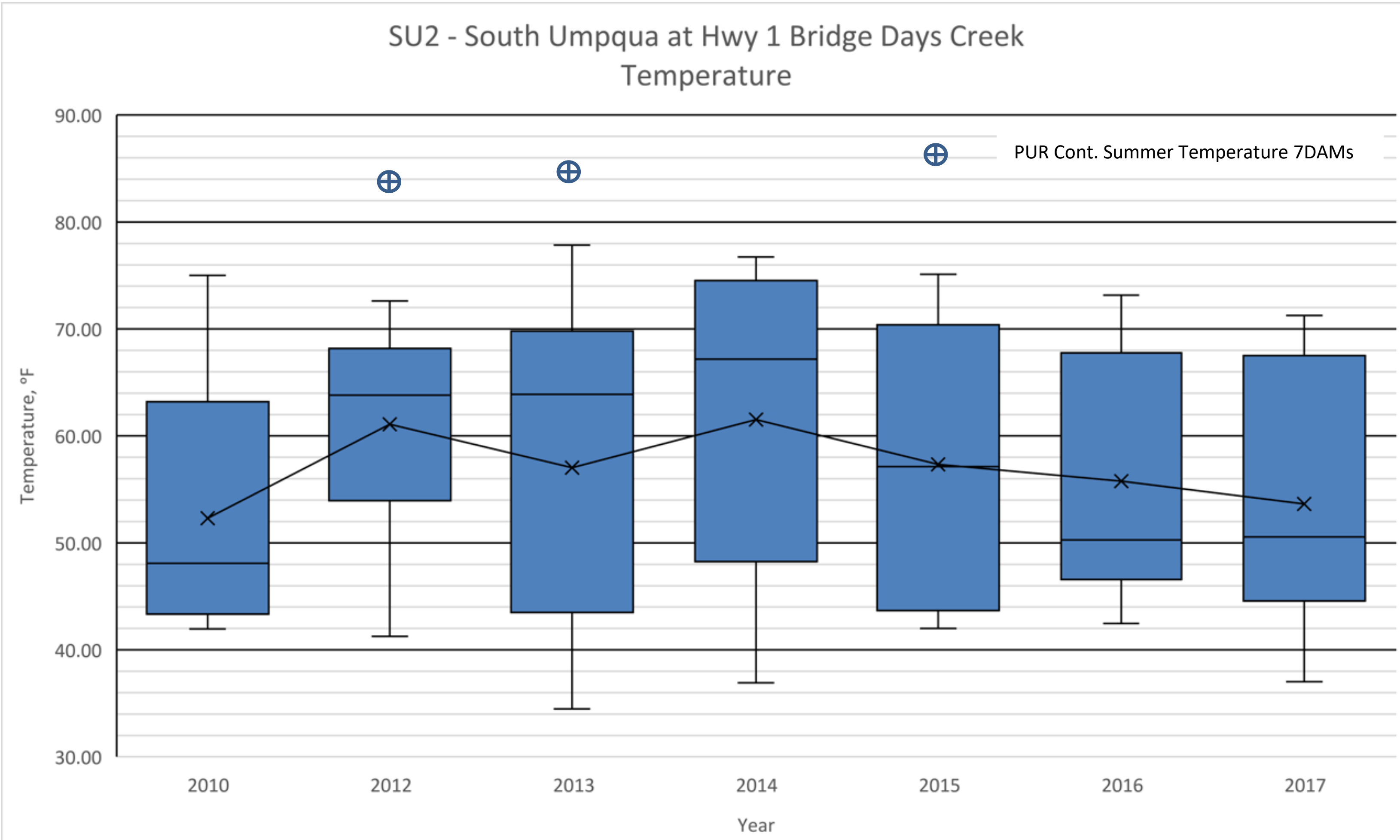
Graph 80. Grab sample conductivity South Umpqua River at Days Creek 2010-2017 summer and winter separated .



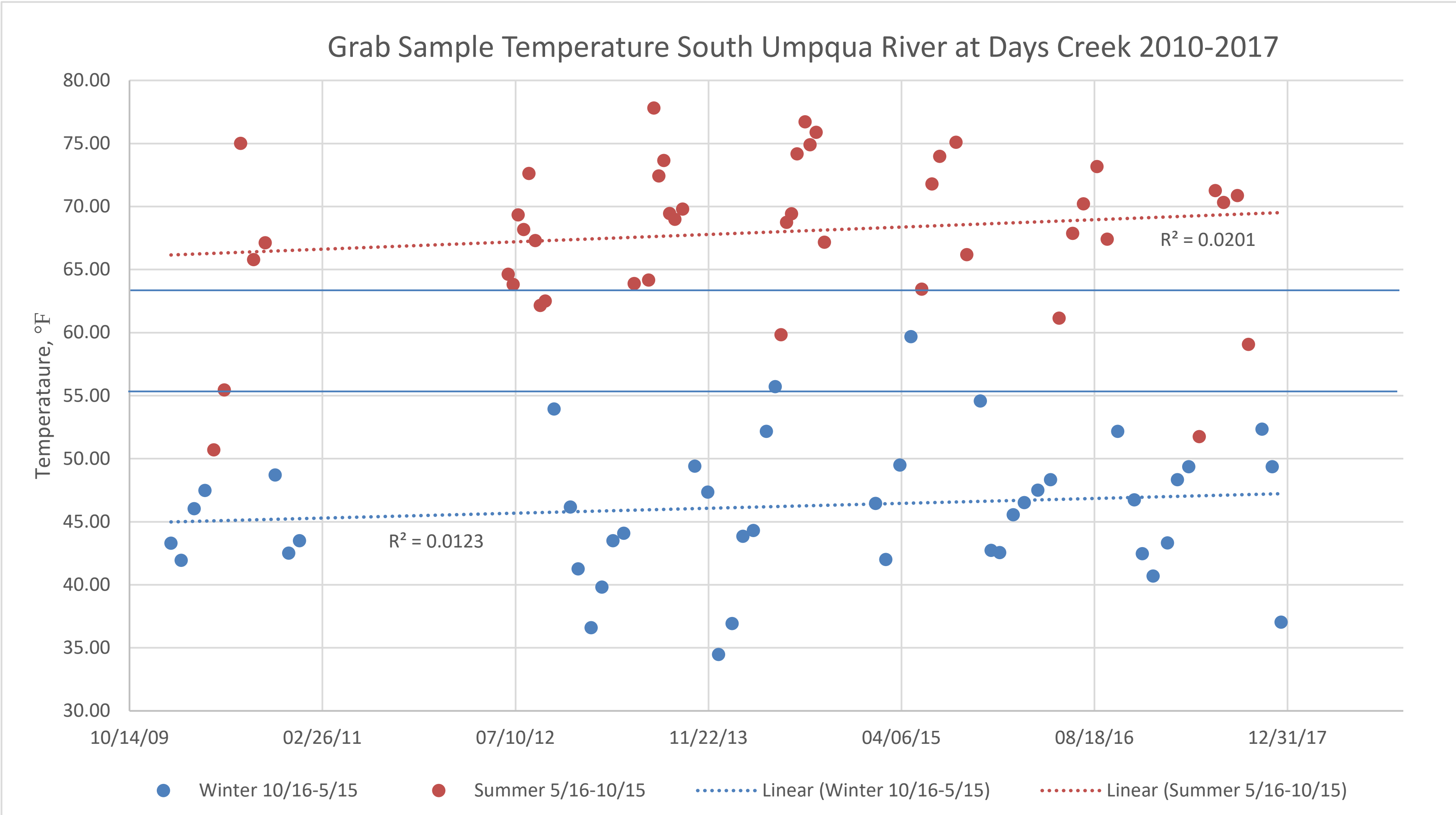
Graph 81. Box plots by year of grab sample *E. coli* levels of the South Umpqua at Days Creek.



Graph 82. E. coli, Values SU2 - South Umpqua at Hwy 1 Bridge Days Creek Summer and Winter Separated.



Graph 83. Box plots of South Umpqua at Days Creek 2010-2017 with PUR continuous data shown for 3 summers.



Graph 84. SU2 - South Umpqua at Hwy 1 bridge at Days Creek temperature grab samples 2010-2017 summer and winter separated.

COC1 - Cow Creek Near Mouth at Yokum Road Bridge

Year	Monthly Samples	Months
2010	12	Full Year
2012	11	Full Year
2013	12	Jan-Aug, 3 July
2015	12	Full Year
2016	12	Full Year
2017	12	Full Year

Table 27. Number of monitoring events per year included in graphs that follow for Cow Creek site.

Flow

USGS has a stream gage near our monitoring spite on Cow Creek near Riddle. The chart of the discharge data from 2010 through 2017 is included here in Graph 101. It can be used for comparison to water quality parameters. 2014 and 2015 had the lowest flow during the period studied and there has been a slight increase in recorded low flow from 2015 to 2016 and to 2017.

Turbidity

Cow Creek near the mouth was sampled 2010 thru 2017. During our grab sampling, the highest level detected was 110.9 NTU which occurred in 2012. Photo 13 shows how the river appears at 110.9 NTU. There were 12 exceedances of 10 NTU but none occurred during the summer and the others were spread over the years, most likely correlated to rain events. No trend is evident.

Photo 13. **Cow Creek looking upstream 11/29/12, 110.9NTU.**

pH

With grab sampling seven events exceeded the upper DEQ recommended limit of 8.5. Six of the exceedances were in summer, likely due to algal photosynthesis during the day. Only one in occurred in winter. No pH levels were measured below 7.0. The box plot graph does again, as it has at the four previous sites, indicate and interesting trend in that the pH values for 2015, 2016, and 2017 showing a downward trend in pH both at the high and low end of the range. Median and mean values show a slight decrease for each year. Graph 90 indicates that both summer and winter pH values are trending downward. Not enough data, nor 24-hour data is available to make any reliable result. However, by 2017 no sampling events exceeded the higher or the lower DEQ criteria. This site should be carefully monitored for possible future ongoing changes.

Dissolved Oxygen

Graphs 91 and 92 display the dissolved oxygen grab sample data for Cow Creek near the mouth. No levels were detected below the lower limit of 8, in fact, the lowest measured was 8.9 which occurred in August of 2015. Eleven measurements did fall below the spawning criteria of eleven, though none were below ten. No trend is apparent.

Conductivity

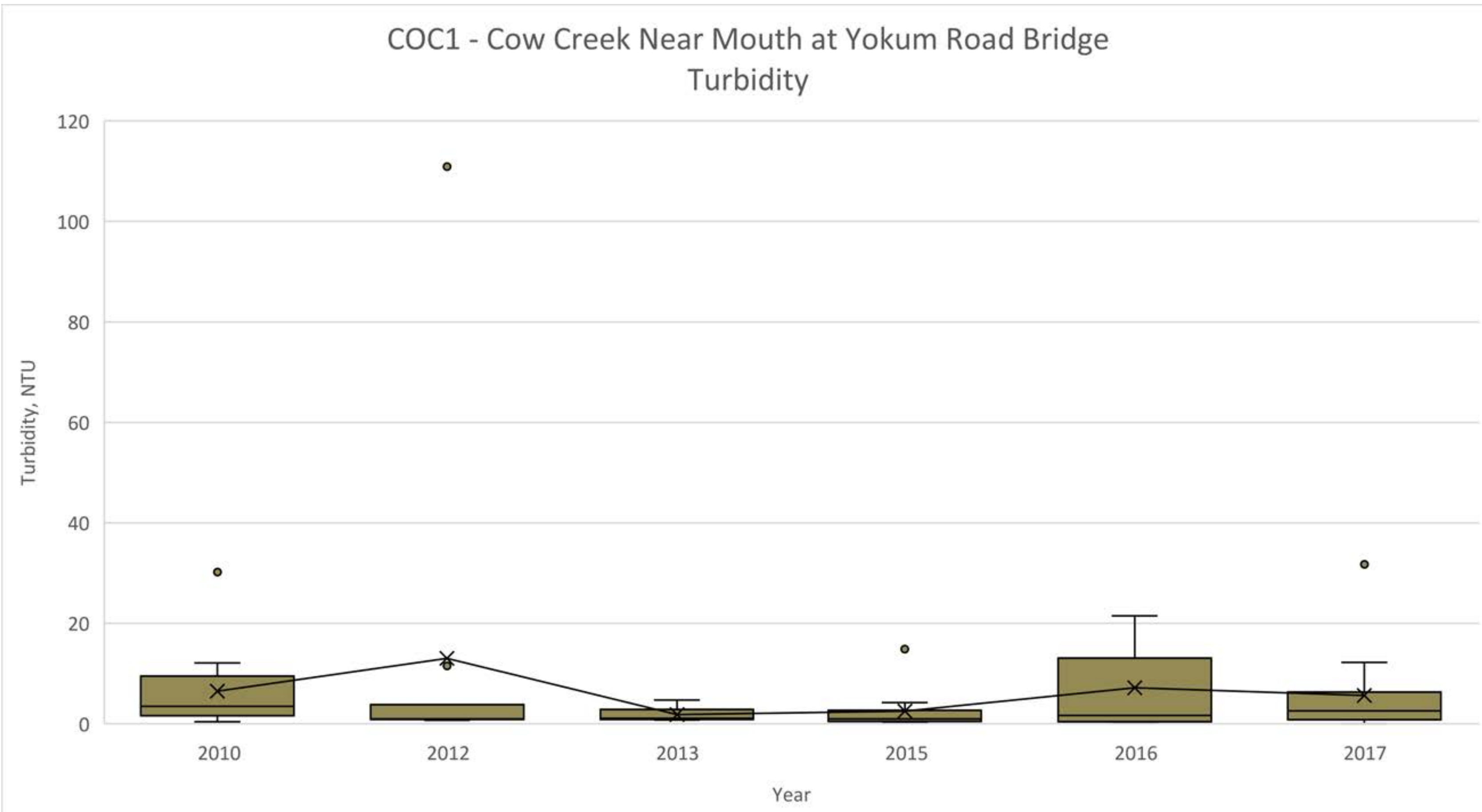
Graphs 93 and 94 display the conductivity grab sample data. All are within normal ranges for the Umpqua basin. No trend is evident, and variation was between 50 and 160 with the higher readings occurring during the summer.

E. coli

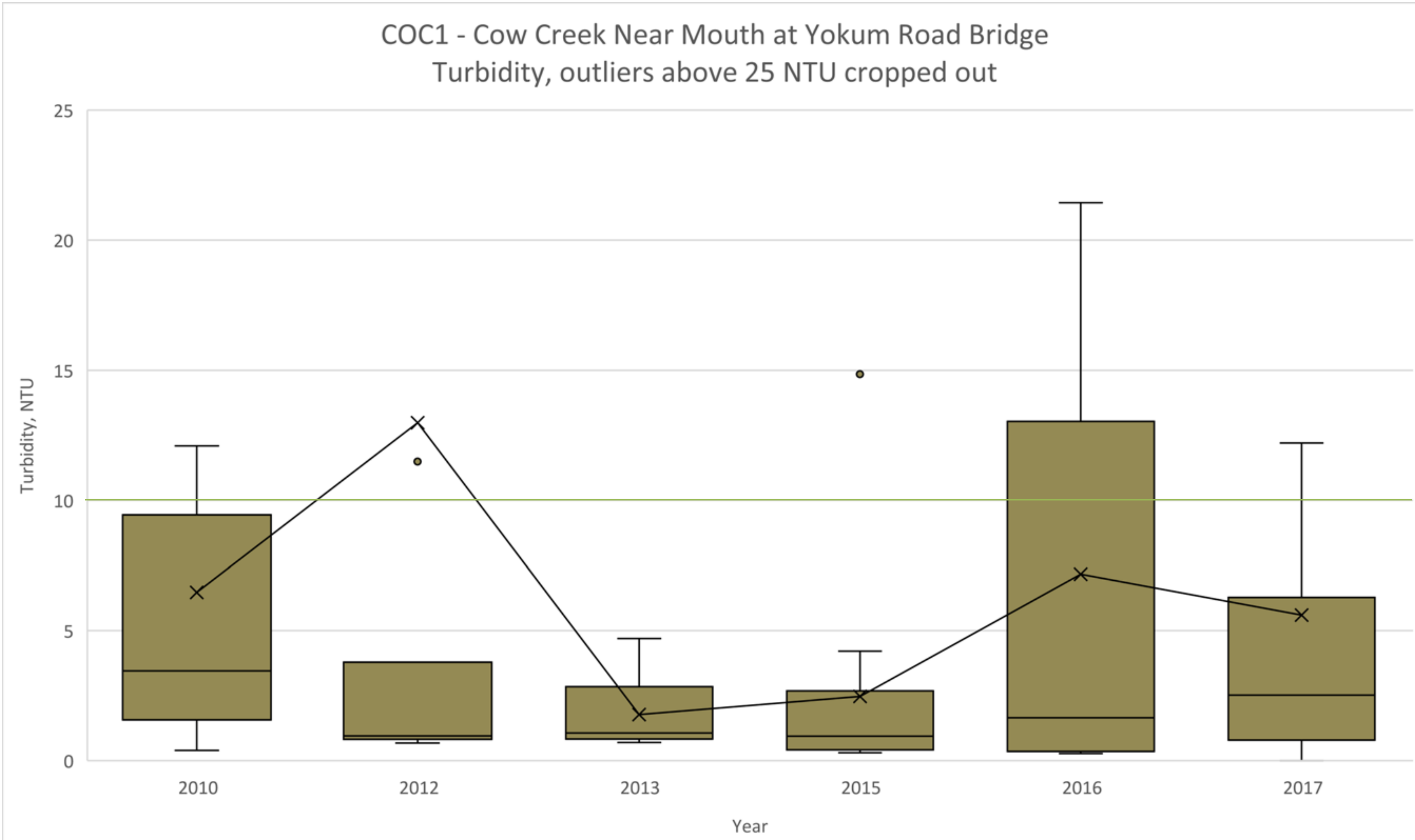
E. coli levels are displayed in graphs 95 through 98. Four outliers occurred high enough to list this section of Cow Creek. Three occurred in winter and one in summer. Only two additional samples were above the 126 MPN/100ml which DEQ criteria indicates would have to have been measured 5 times in one month to have listed it. One time reading at 406 MPN/ml or greater would list a stream. No trend is evident.

Temperature

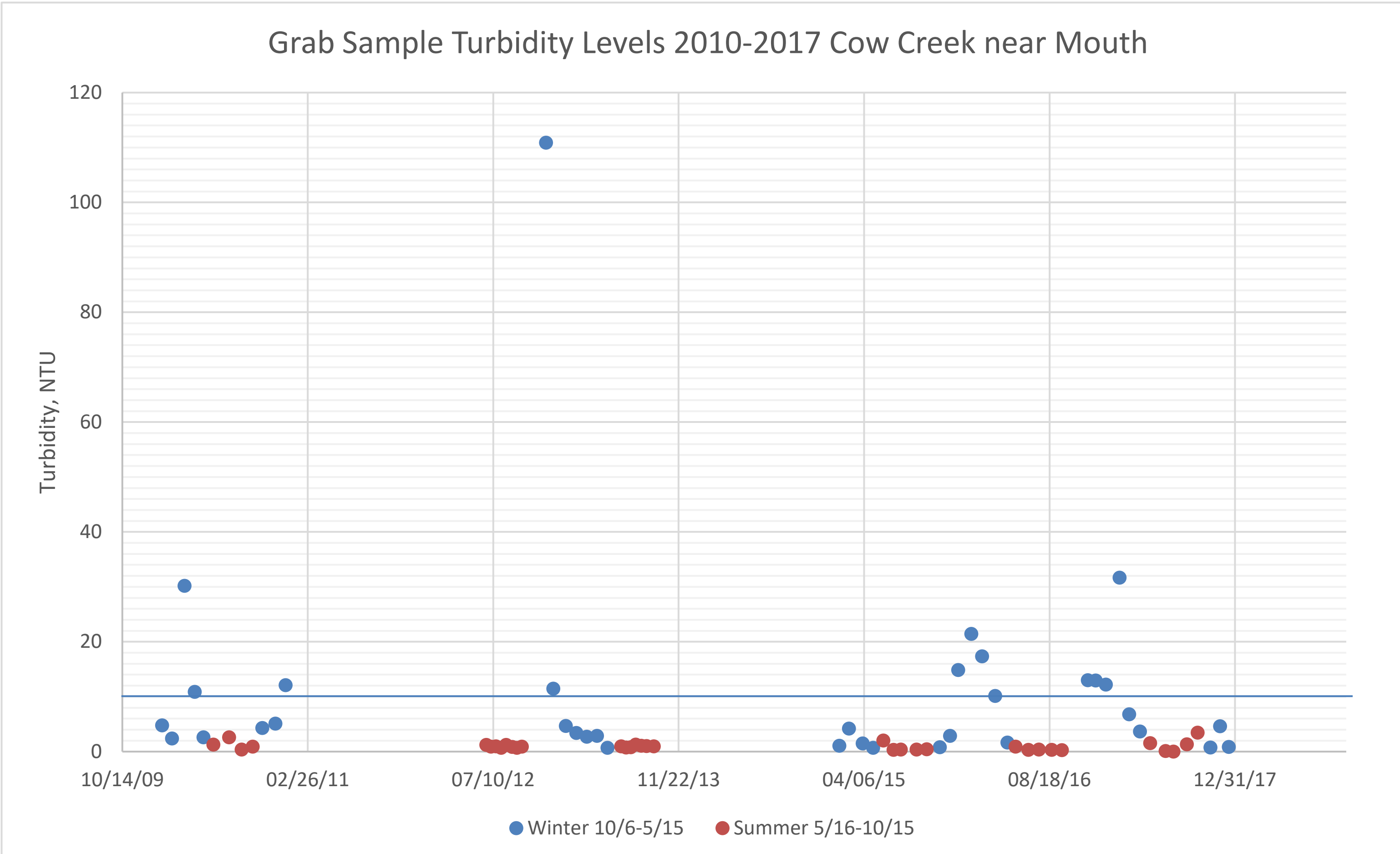
Graphs 99 and 100 display the temperature data for the mouth of Cow Creek. Very high stream summer temperatures were consistently detected for the summer months, with most exceeding 64.4°F in all years monitored. The winter temperature, however, almost all fell below the 55.4°F spawning criteria with only one in late April of 2015 exceeding it. No trend is evident.



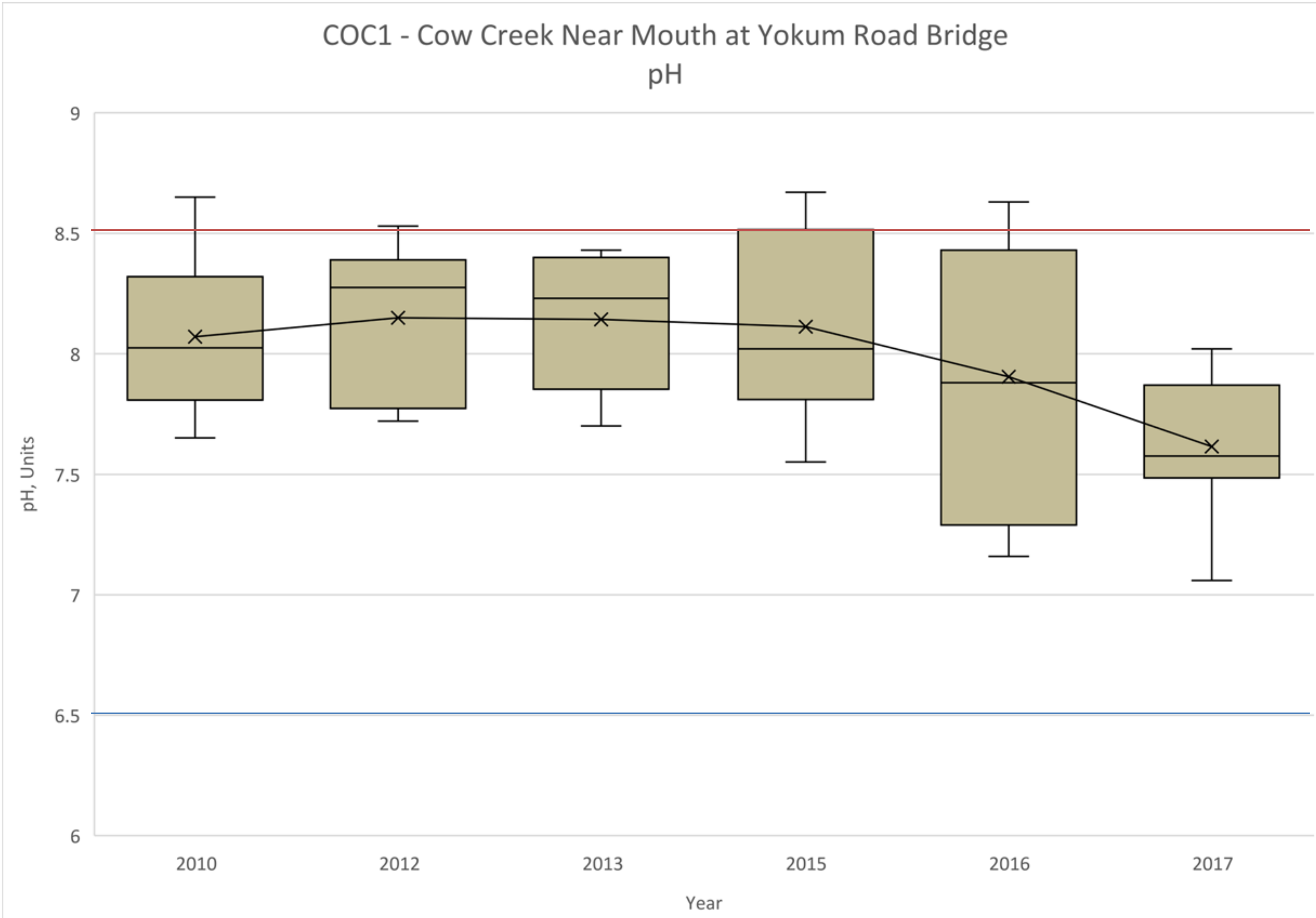
Graph 85. Box plots by year of grab sample turbidity levels of Cow Creek near mouth.



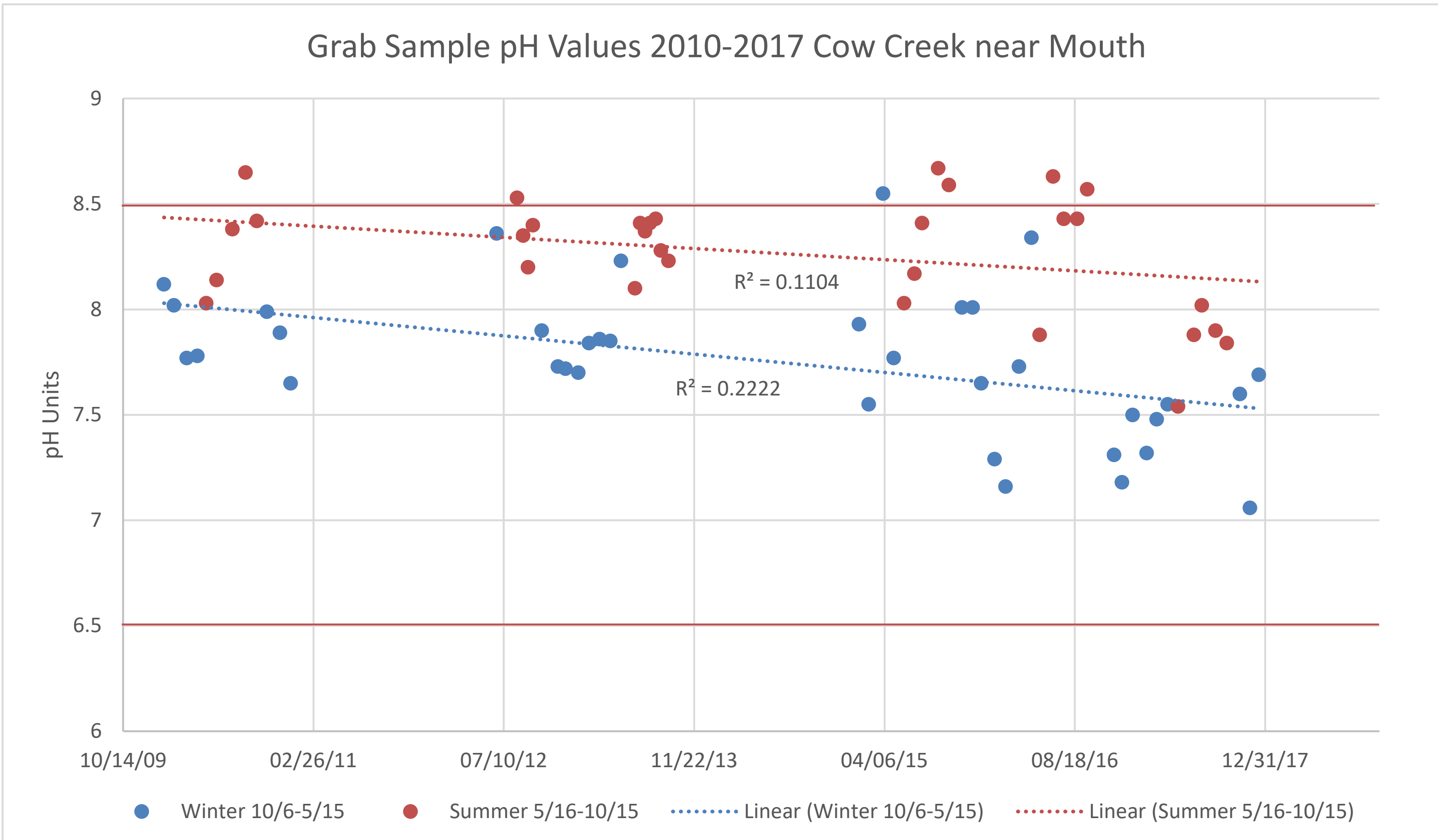
Graph 86. Box plots by year of grab sample turbidity levels of Cow Creek near mouth with outliers greater than 25 NTU removed.



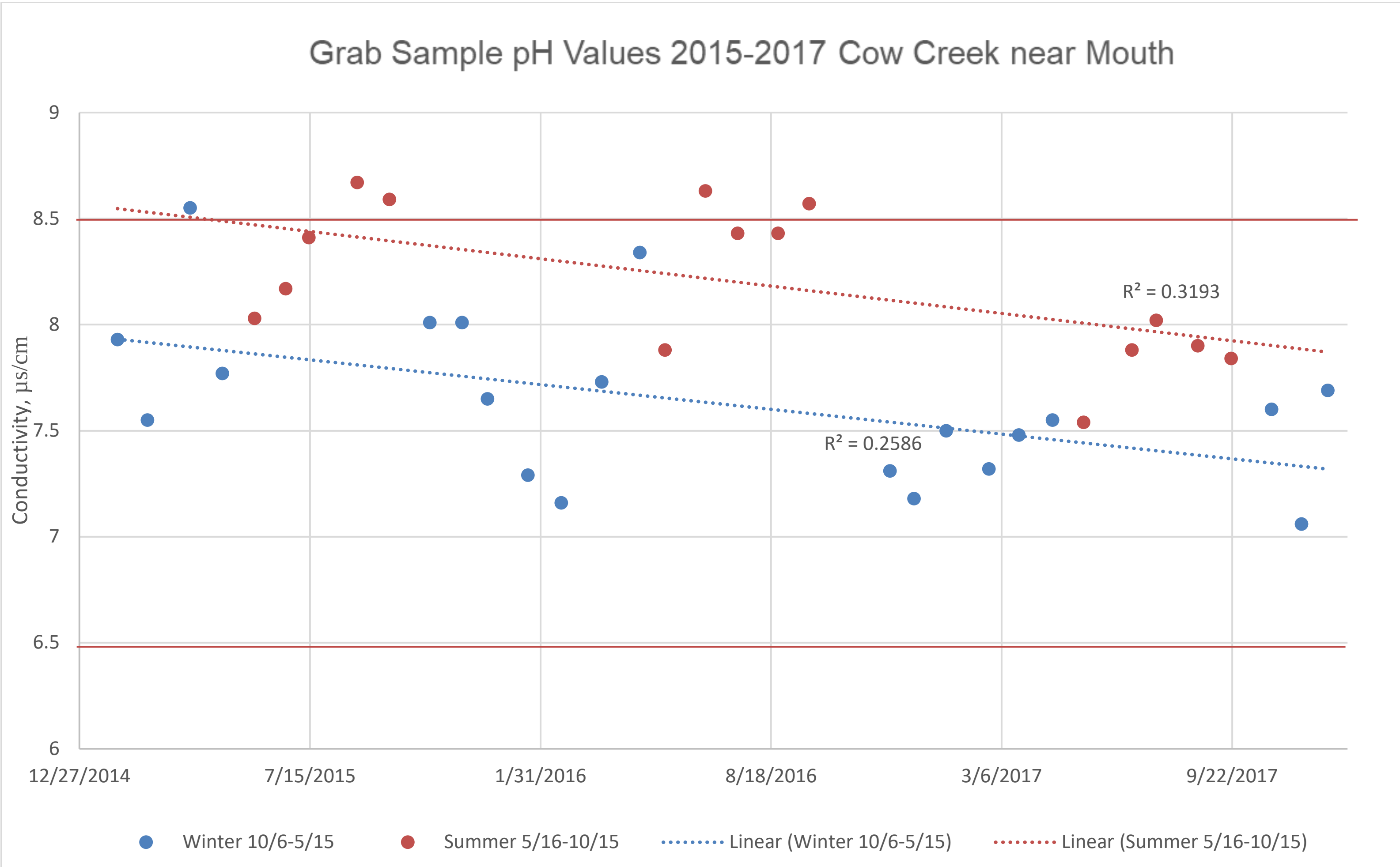
Graph 87. Grab sample turbidity Levels 2010-2017 Cow Creek near the mouth summer and winter separated.



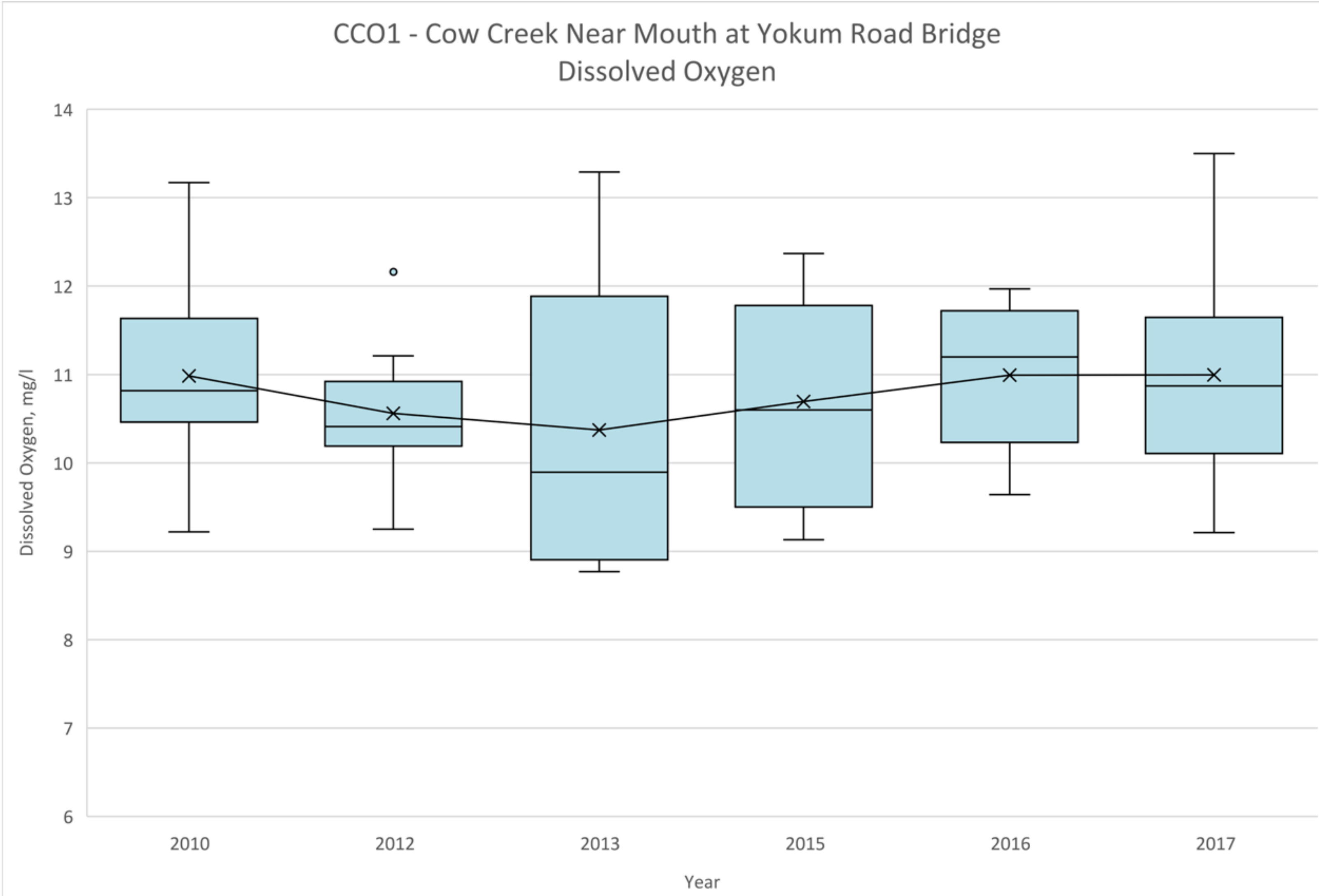
Graph 88. Box plots by year of grab sample pH levels of Cow Creek near mouth.



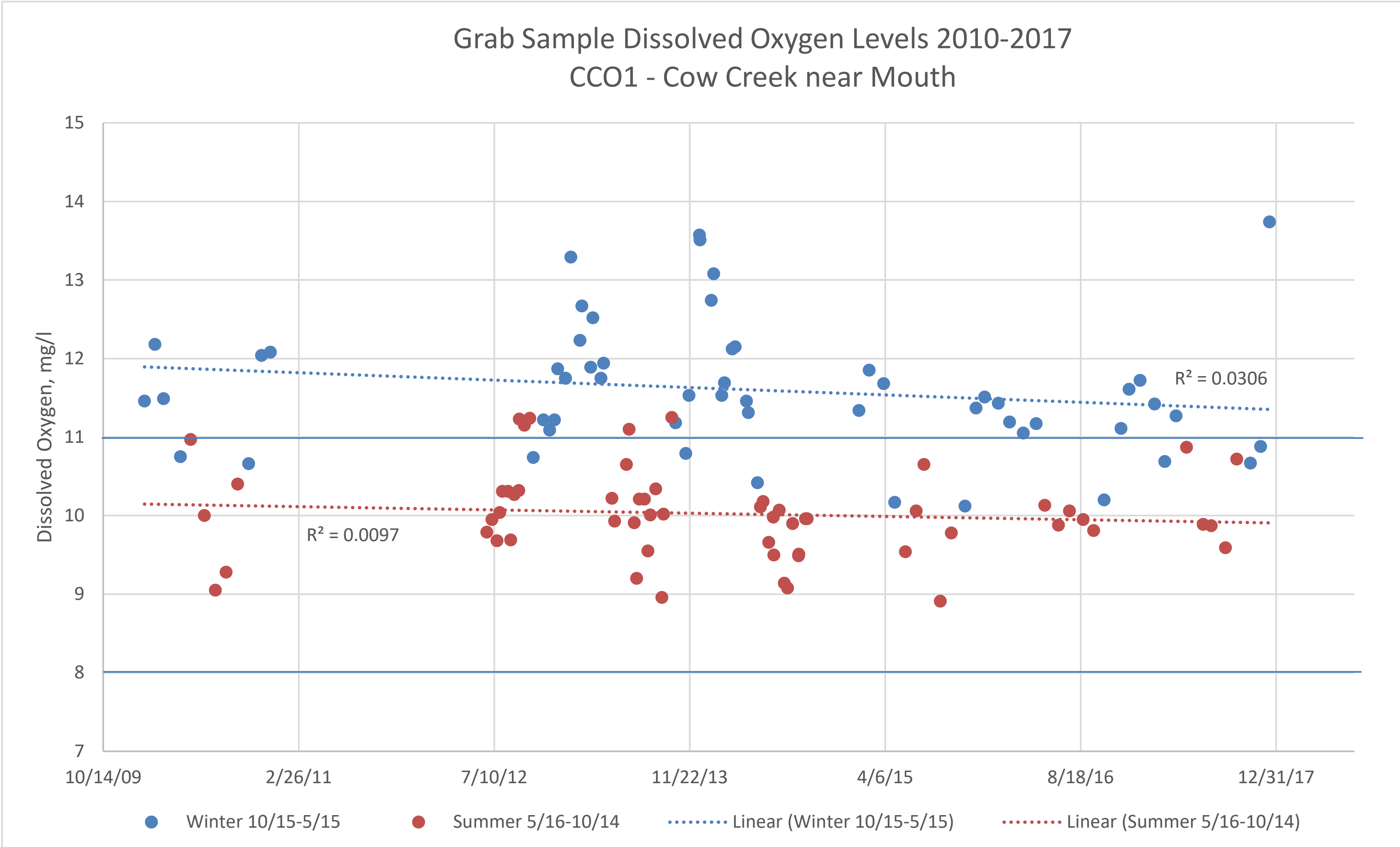
Graph 89. Grab sample pH Values 2001-2017 Cow Creek near mouth summer and winter separated.



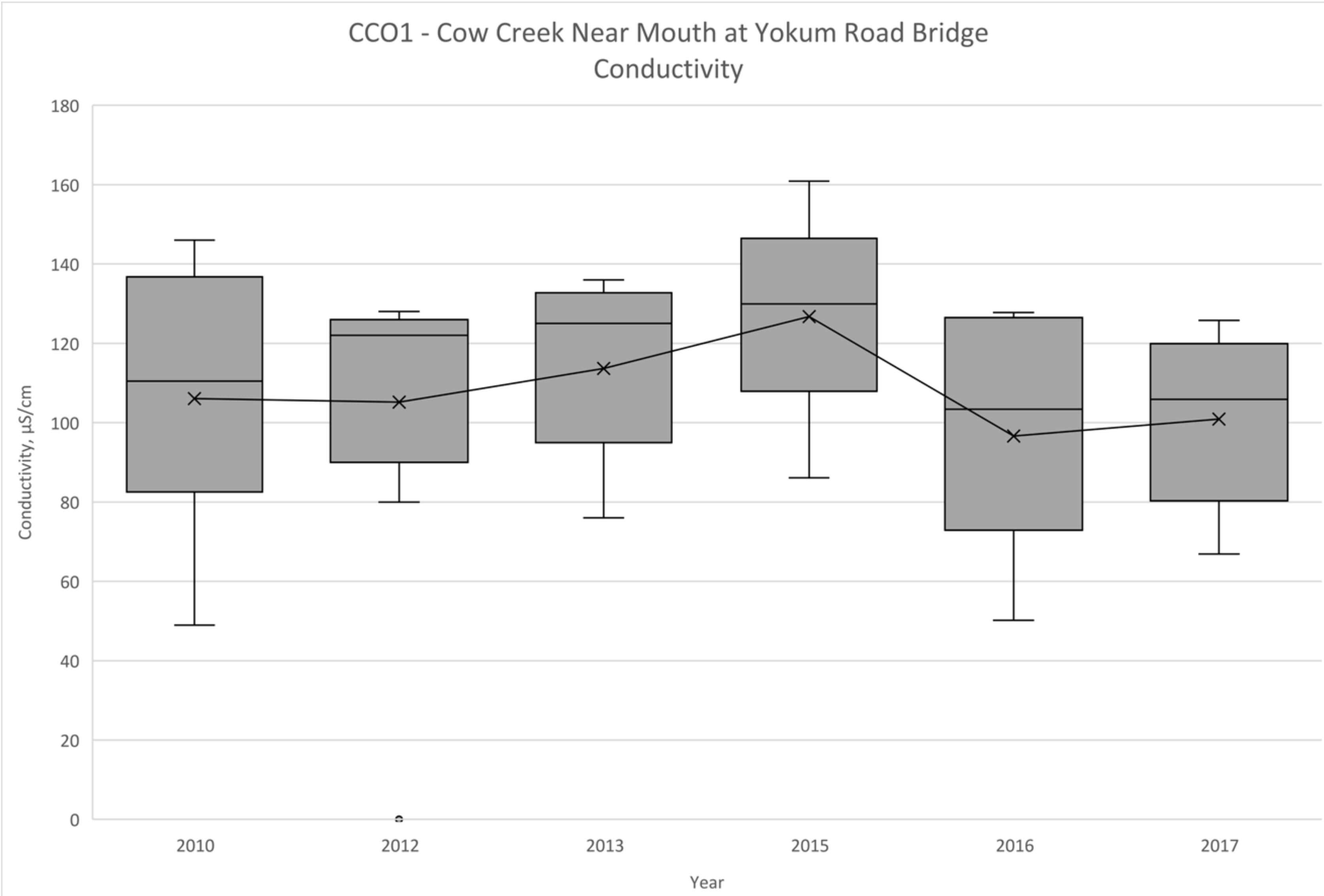
Graph 90. Grab Sample pH Values 2015-2017 Cow Creek near mouth summer and winter separated.



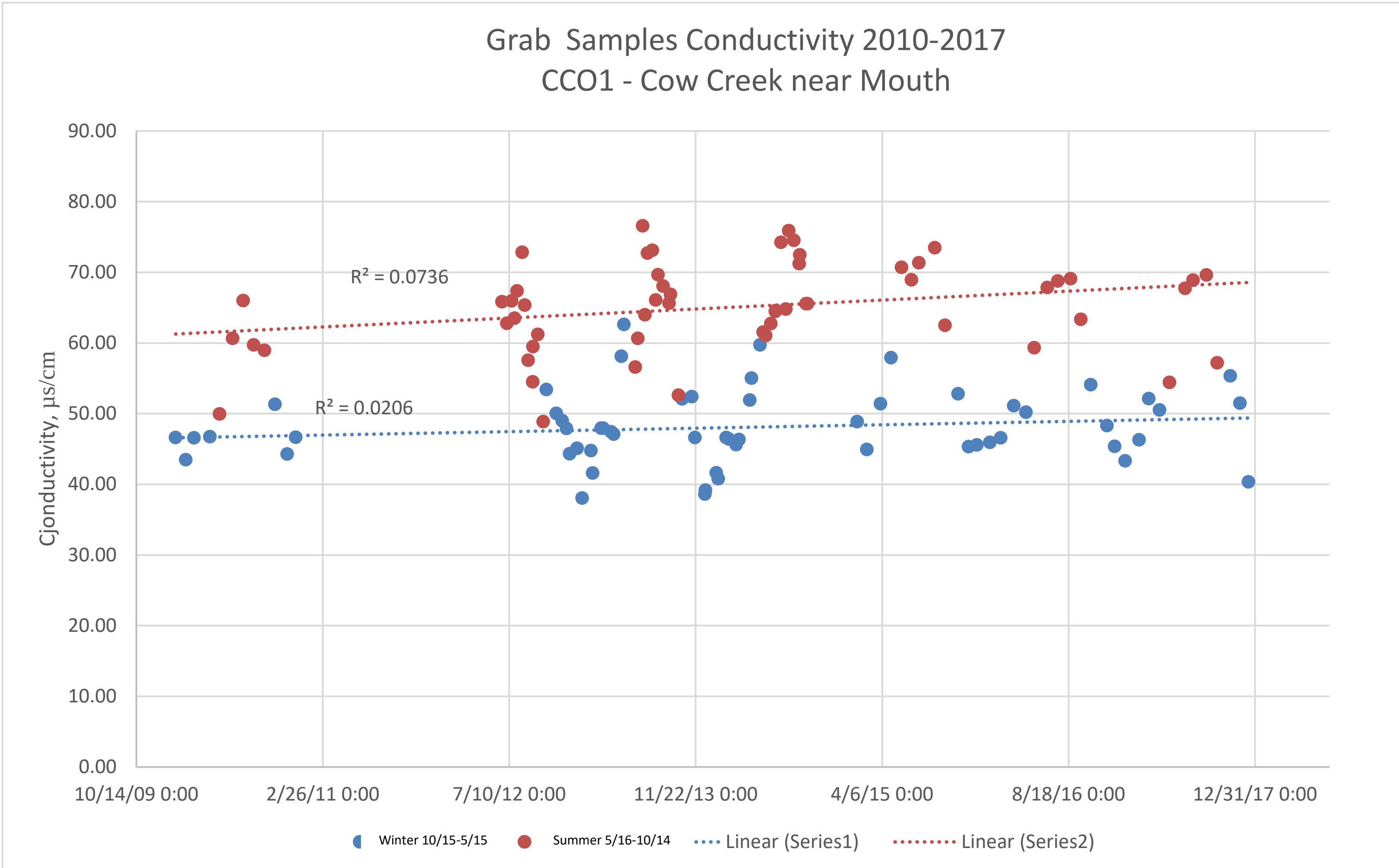
Graph 91. Box plots by year of grab sample dissolved oxygen levels of Cow Creek near mouth.



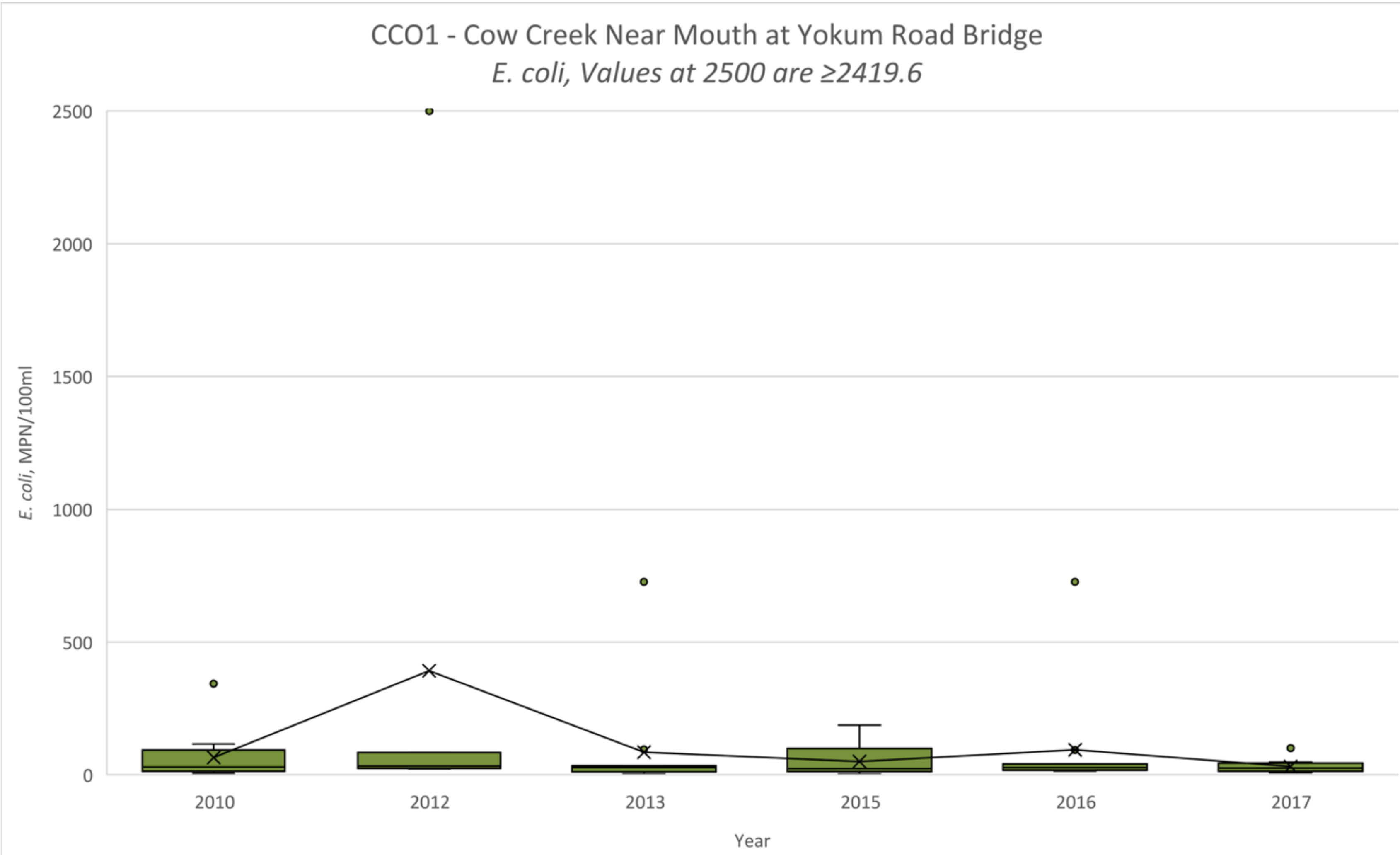
Graph 92. CCO1 - Cow Creek near Mouth Grab Sample Dissolved Oxygen Levels 2010-2017 summer and winter separated.



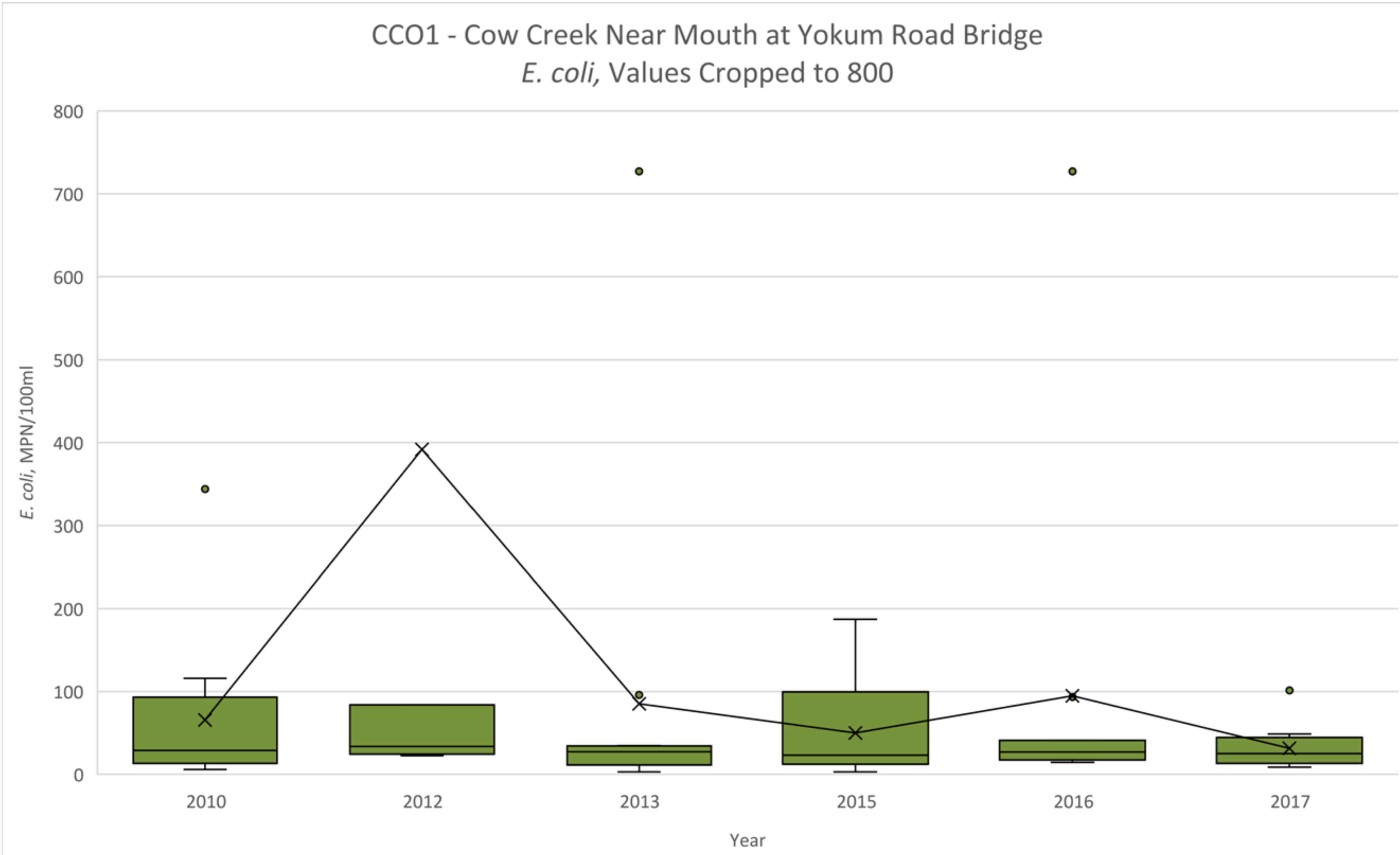
Graph 93. Box plots by year of grab sample conductivity levels of Cow Creek near mouth.



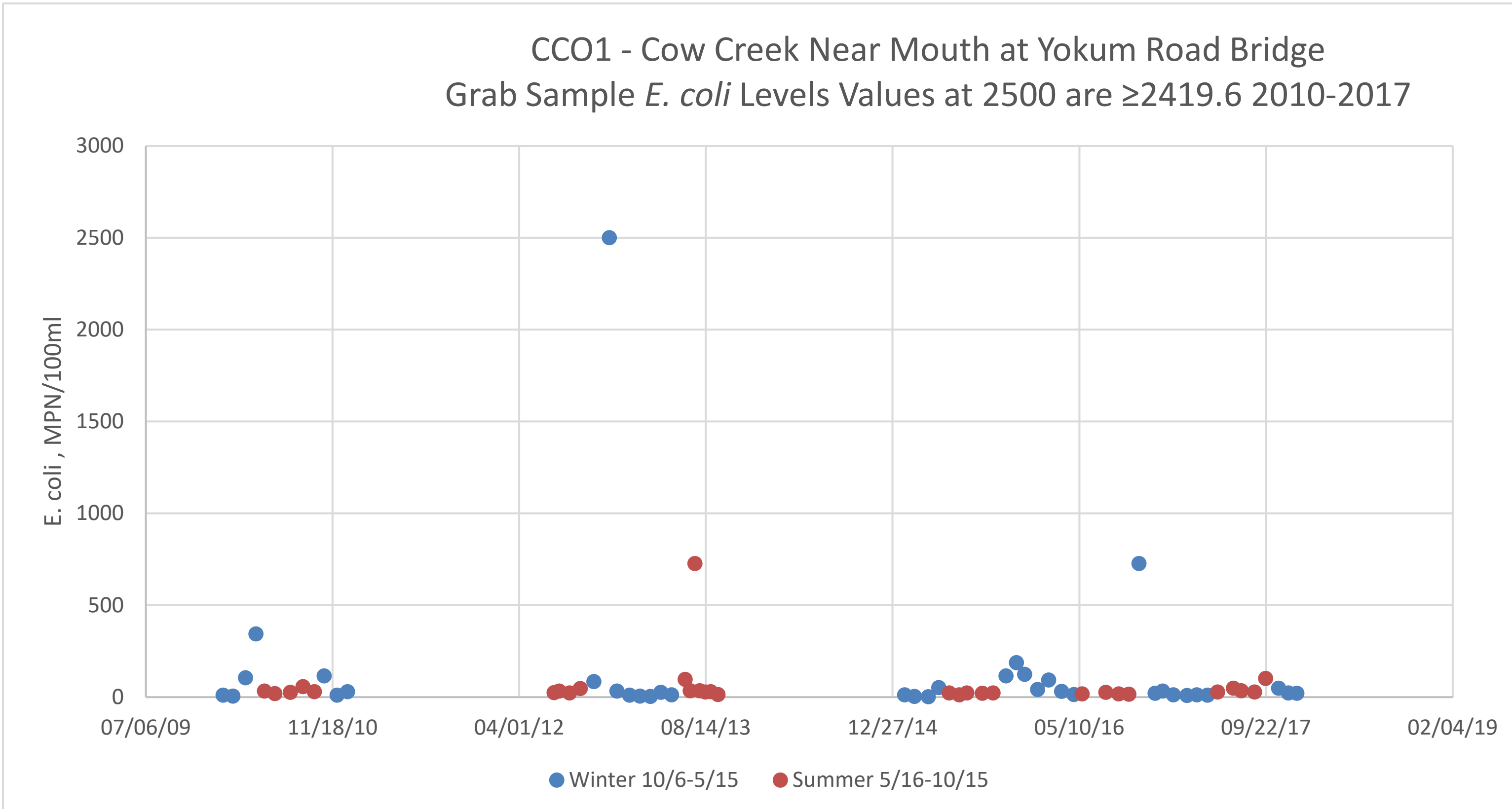
Graph 94. CCO1 - Cow Creek near mouth grab samples conductivity 2010-2017 summer and winter separated.



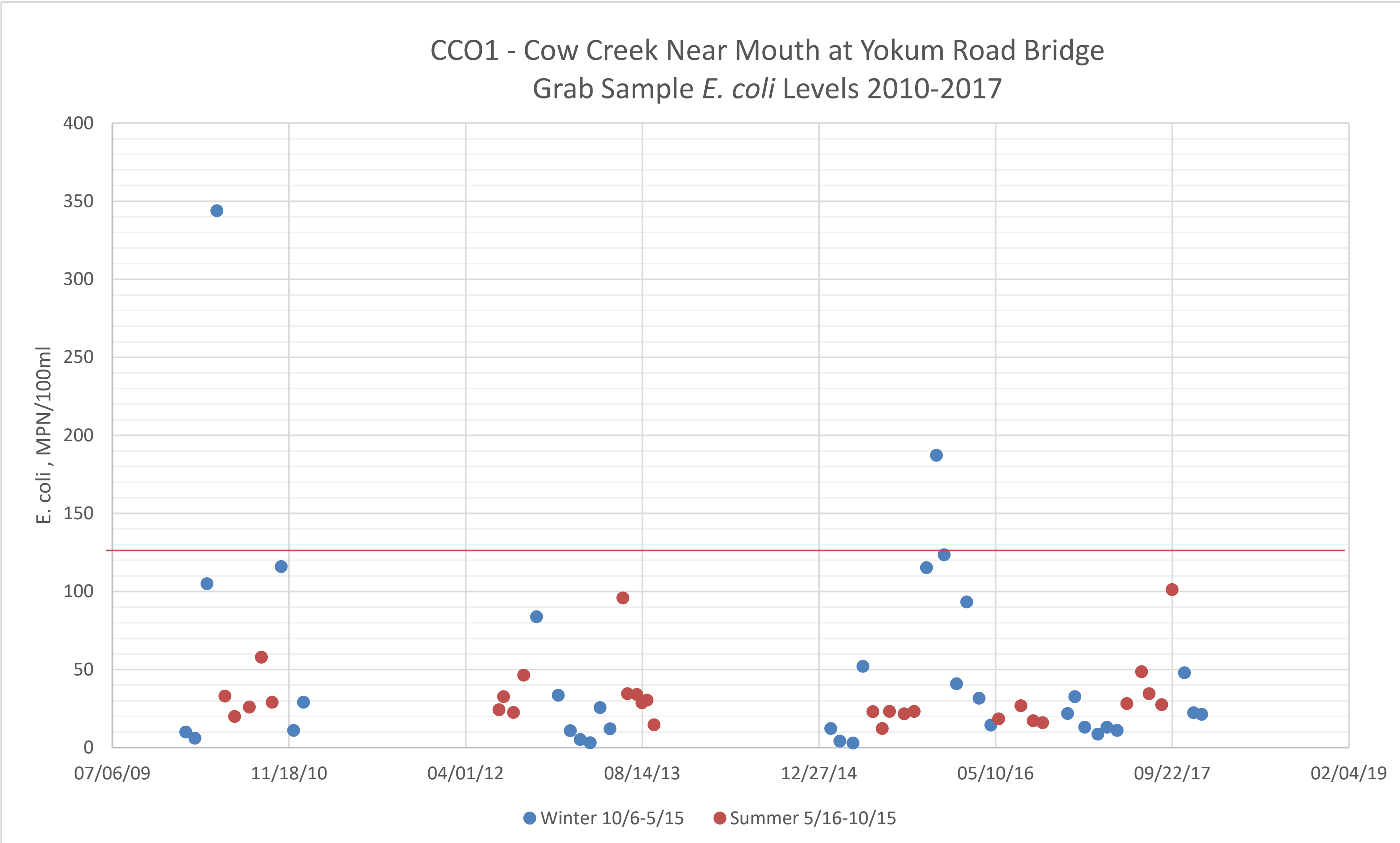
Graph 95. Box plots by year of grab sample *E. coli* levels of Cow Creek near mouth.



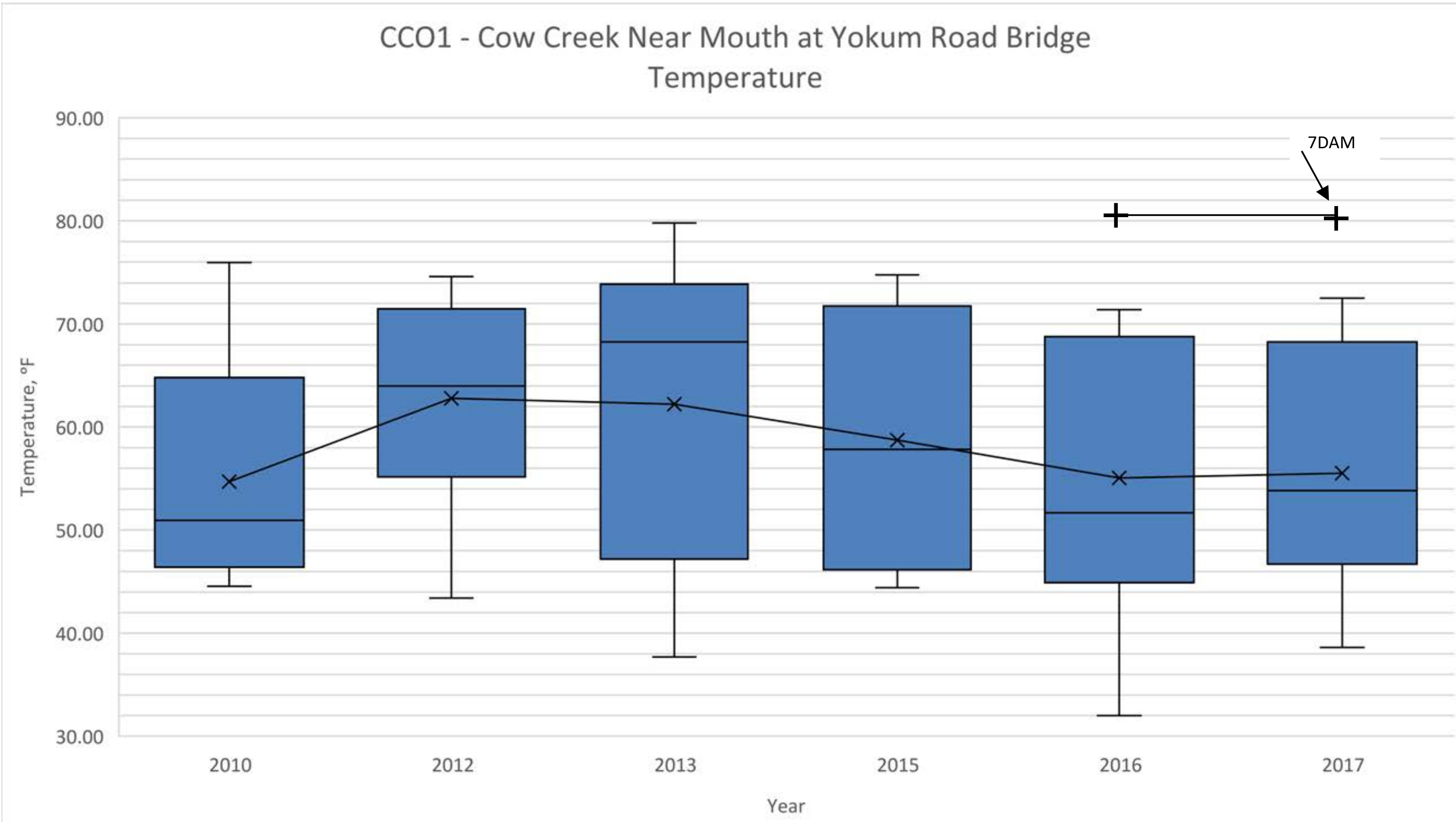
Graph 96. Box plots by year of grab sample *E. coli* levels of Cow Creek near mouth with outliers greater than 800 removed.



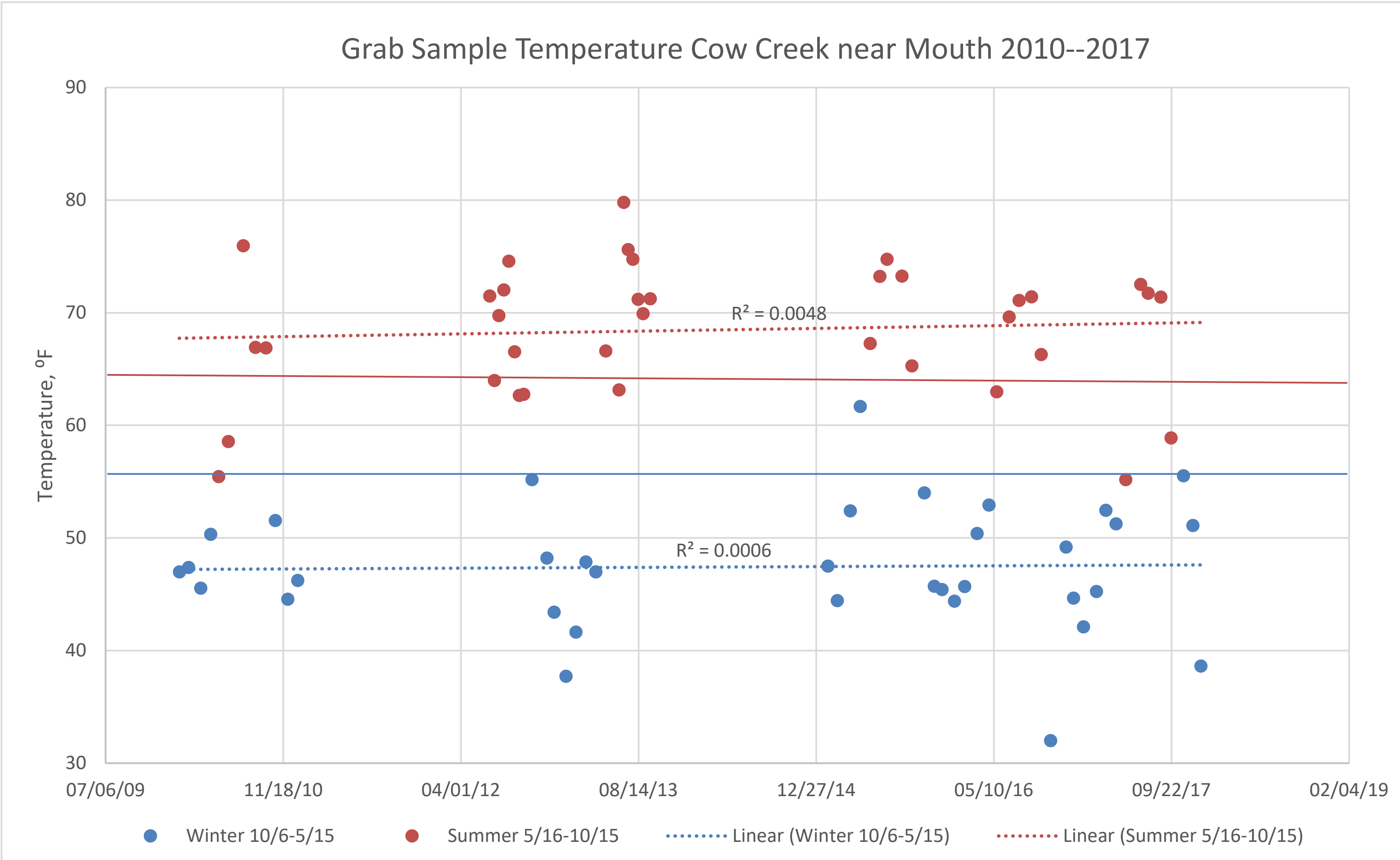
Graph 97. CCO1 - Cow Creek Near Mouth at Yokum Road Bridge grab sample *E. coli* levels 2010-2017 summer and winter separated.



Graph 98. CCO1 - Cow Creek Near Mouth at Yokum Road Bridge Grab Sample *E. coli* levels 2010-2017 summer and winter separated.



Graph 99. Box plots by year of grab sample temperature levels of Cow Creek near mouth.



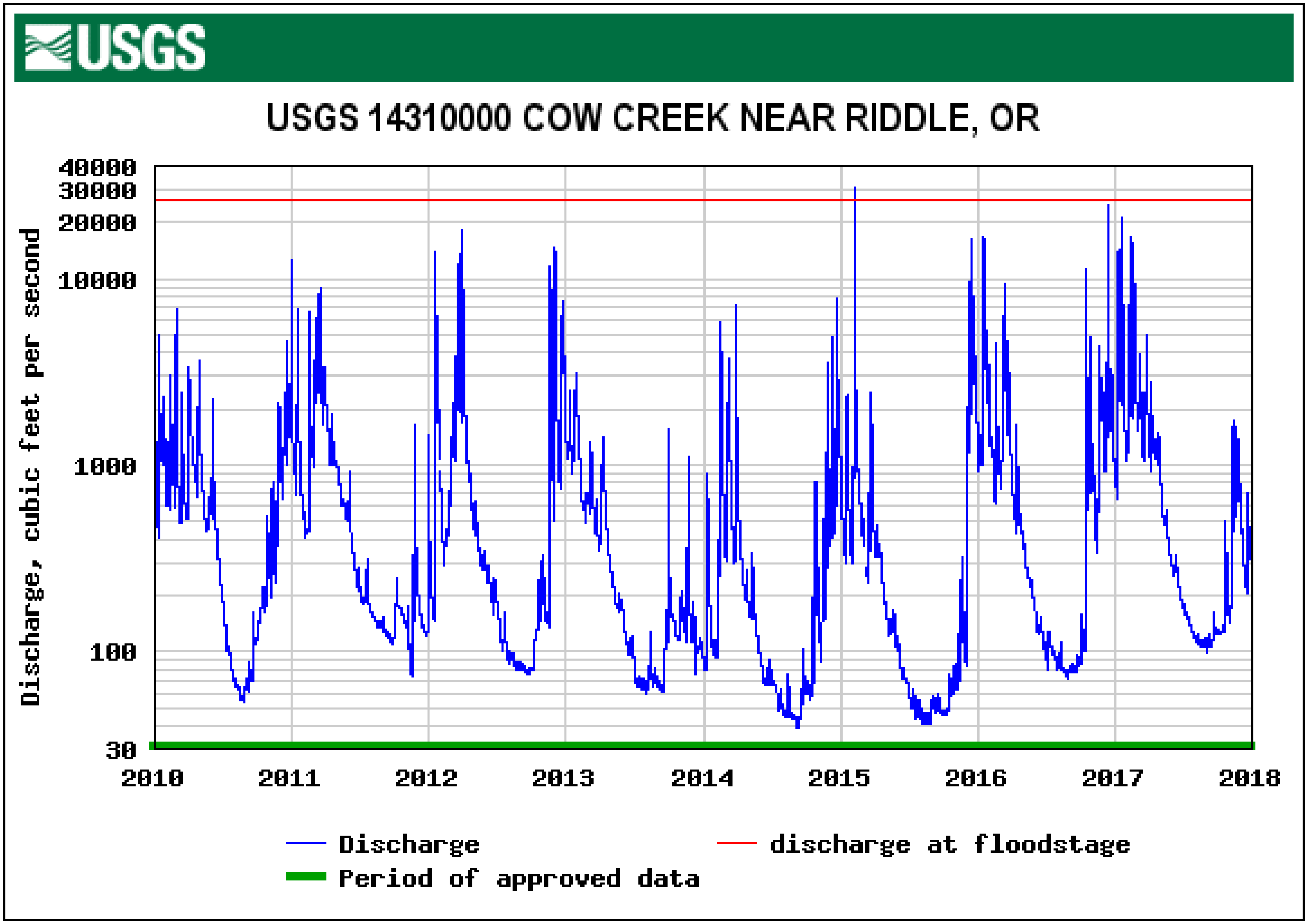
Graph 100. Grab Sample Temperature Cow Creek near the mouth 2010—2017 summer and winter separated.

Site Name	Site	Start Date	Stop Date	Seasonal Maximum		Seasonal Minimum		Seasonal Max ΔT		7-Day averages			
	ID			Date	Value	Date	Value	Date	Value	Date	Max	Min	Δ T
South Umpqua Reference Run													
Cow Creek at Yokum Rd Bridge	COC1	6/23/2016	9/17/2016	7/29/2016	81.7	9/14/2016	59.9	6/26/2016	10.4	7/28/2016	80.2	72.7	7.5
Cow Creek at Yokum Rd Bridge	COC1	6/28/2017	9/20/2017	8/3/2017	81.8	9/19/2017	59.2	7/14/2017	9.8	8/2/2017	80.1	72.1	8

Table 28. Continuous temperature data summary for the Cow Creek at Yokum Road bridge.

Site Name	Site	Days >	Days >	Days >	Hours >	Hours >	Hours >	Warmest day of 7-day max		
	ID	55 F	64 F	70 F	55 F	64 F	70 F	Date	Max	Min
South Umpqua Reference Run										
Cow Creek at Yokum Rd Bridge	*COC1*	87	87	73	2087.5	1985.5	1405	7/29/2016	81.7	73.8
Cow Creek at Yokum Rd Bridge	*COC1*	85	81	73	2039.5	1926.5	1362.5	8/3/2017	81.8	73.2

Table 29. Continuous temperature data summary for the Cow Creek at Yokum Road bridge.



Graph 101. Stream discharge data from 2010-2017 from USGS gage at Tiller on the South Umpqua River.

SU6 - South Umpqua at Lawson Bar above Cow Creek

Year	Monthly Samples	Months
2012	11	Full Year
2013	12	Jan-Aug, 3 July
2015	12	Full Year
2016	12	Full Year
2017	12	Full Year

Table 30. Number of monitoring events per year included in graphs that follow for South Umpqua at Lawson Bar above Cow Creek.

Turbidity

The South Umpqua above Lawson was sampled 2012 thru 2017 (Graphs 102-104.) During our grab sampling, the highest level detected was 65 NTU which occurred in 2012 This was the only occurrence that fell above 50 NTU which "The Oregon Watershed Assessment Manual recommends using 50 NTUs as the turbidity evaluation criteria for watershed assessments. At this level, turbidity interferes with sight-feeding aquatic organisms and provides an indication of the biological effect of suspended sediment." There were 10 exceedances of 10 NTU but none occurred during the summer and the others were spread over the years, most likely correlated to rain events. No trend is evident.

pH

With grab sampling six events exceeded the upper DEQ recommended limit of 8.5 all six of the exceedances were in summer, likely due to algal photosynthesis during the day. No pH levels were measured below 7.0. The box plot graph does again, as it has for many previous sites, indicate and interesting trend in that the pH values for 2015, 2016, and 2017 showing a downward trend in pH both at the high and low end of the range. Median and mean values show a slight decrease for each year. Graph 90 indicates that both summer and winter pH values are trending downward. Not enough data, nor 24-hour data is available to make any reliable result. However, by 2017 no sampling events exceeded the higher or the lower DEQ criteria. This site should be carefully monitored for possible future ongoing changes.

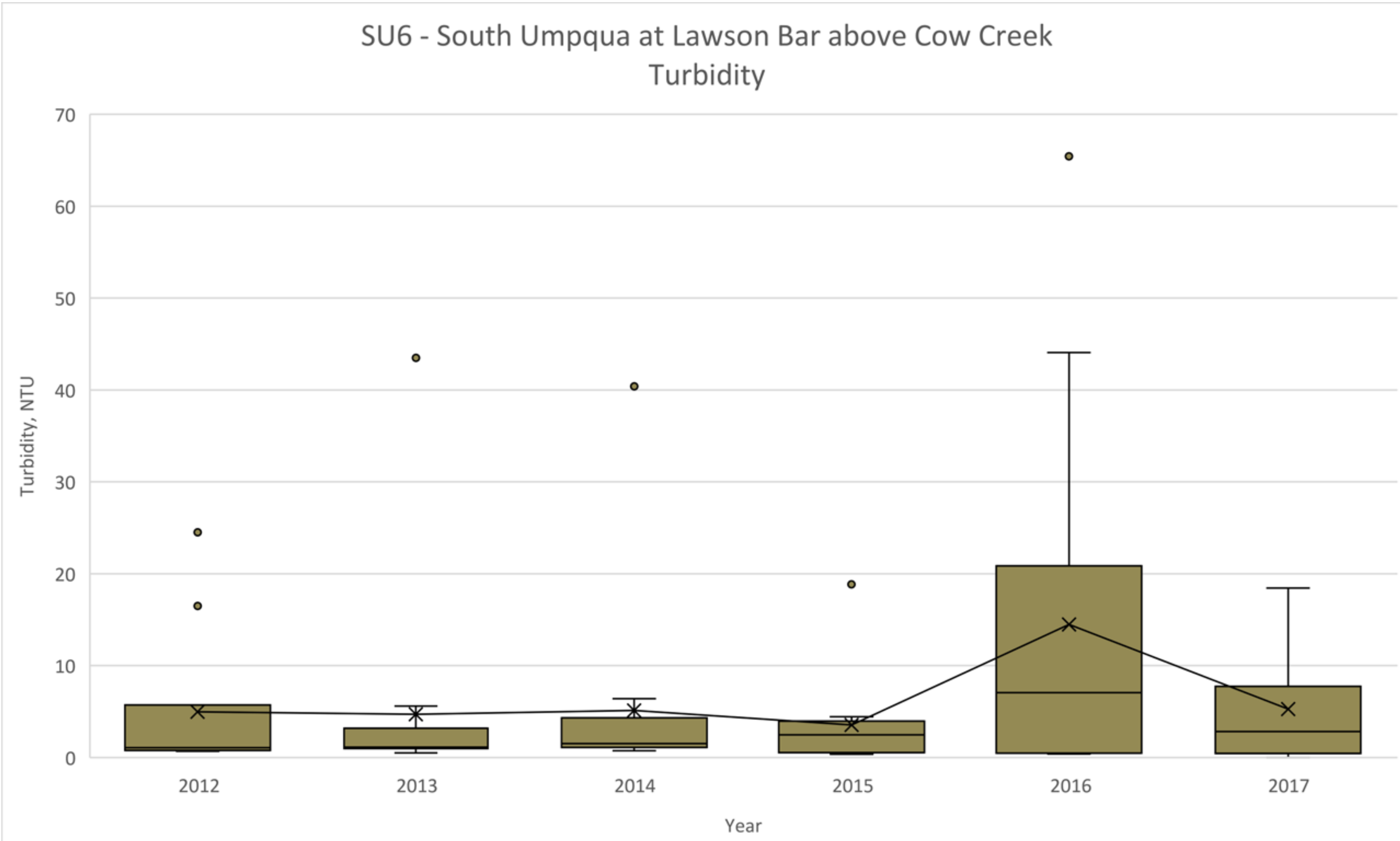
Dissolved Oxygen

Graphs 108 and 109 display the dissolved oxygen grab sample data for the South Umpqua at Lawson Bar. No levels were detected below the lower limit of 8. Only four measurements did fall below the spawning criteria of eleven, though none were below ten. All summer dissolved oxygen levels were within the acceptable range. No trend is apparent.

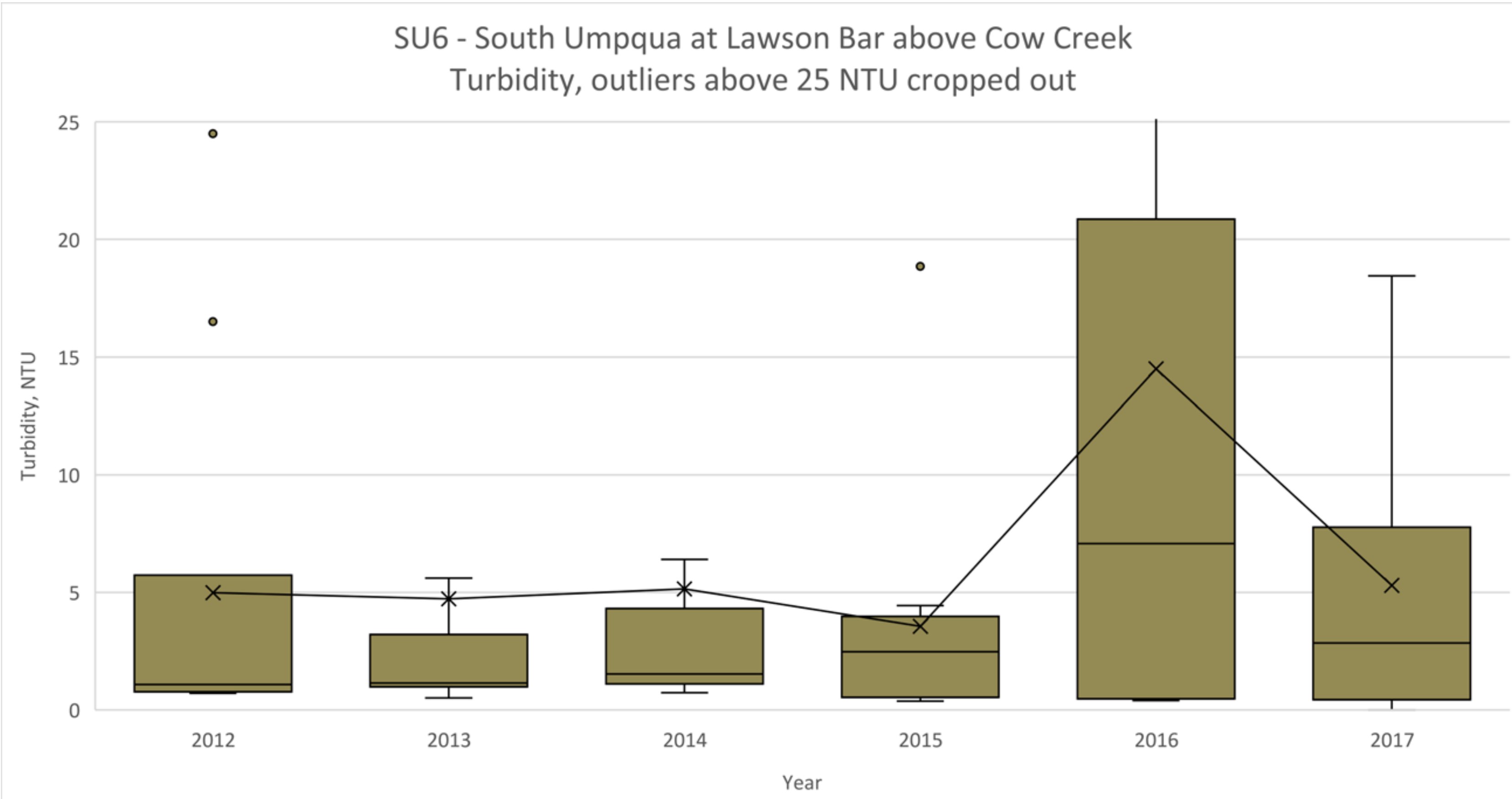
Conductivity
Graphs 110 and 111 display the conductivity grab sample data. All are within normal ranges for the Umpqua basin. No trend is evident, and variation was between 50 and 200 with the higher readings occurring during the summer.

E. coli
E. coli levels are displayed in graphs 112 through 114. Five outliers occurred high enough to list this section of the South Umpqua River. Four occurred in winter and one in summer. Of the rest of the samples only one winter sample exceeded the 126 MPN/100ml which DEQ criteria indicates would have to have been measured 5 times in one month to have listed it. One time reading at 406 MPN/ml or greater would list a stream. No trend is evident.

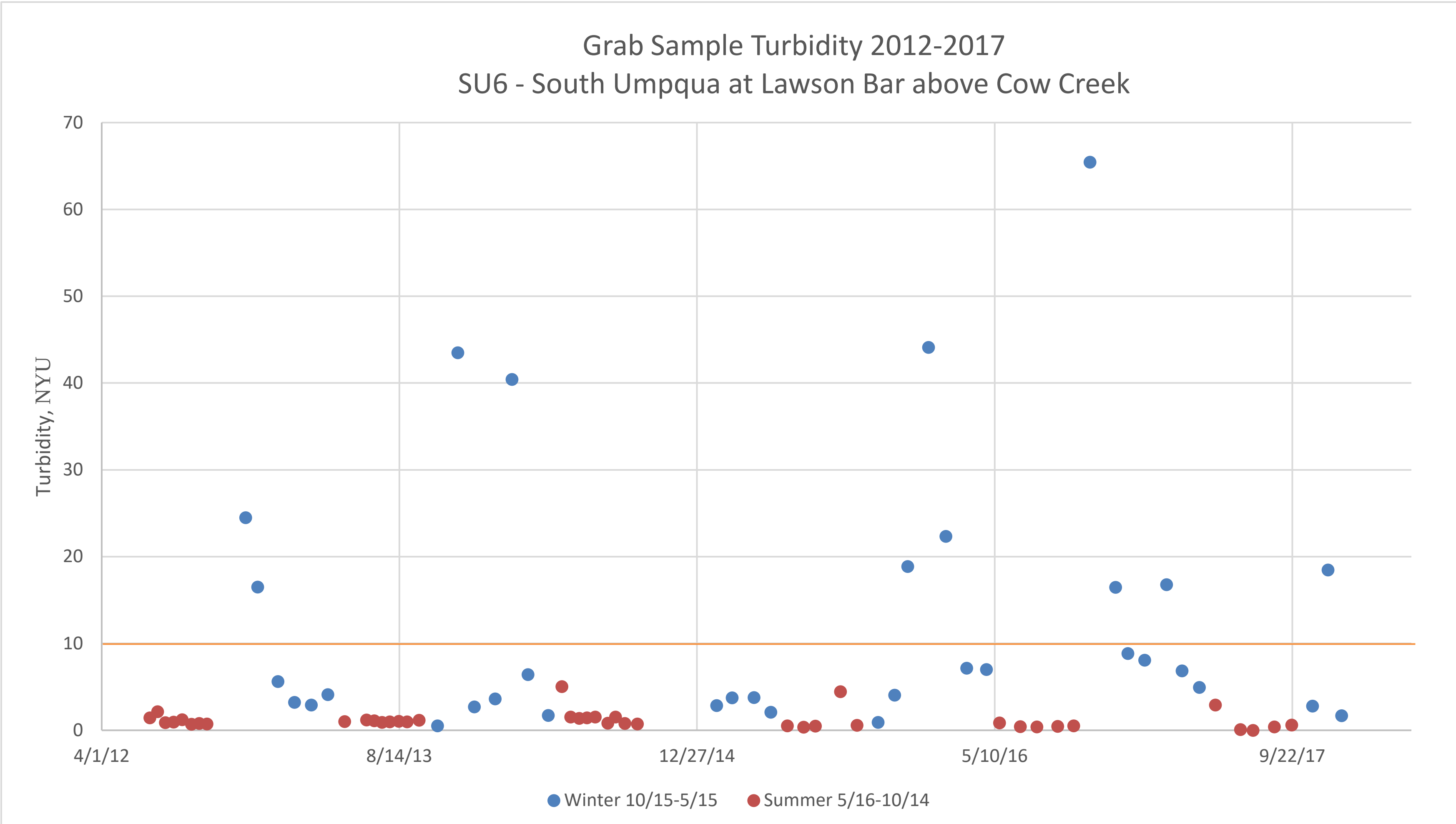
Temperature
Graphs 115, 116 and Table 31 display the temperature data for the South Umpqua River at Lawson Bar. Having consistently placed summer data loggers at this site we have six years of continuous data which showed that the 7DAM was always above 80°F and lists this stretch of the river for temperature. Even our grab sample temperature data was an indicator of this problem. The winter temperatures mostly all fell below the 55.4°F spawning criteria with only four exceeding it. No trend is evident.



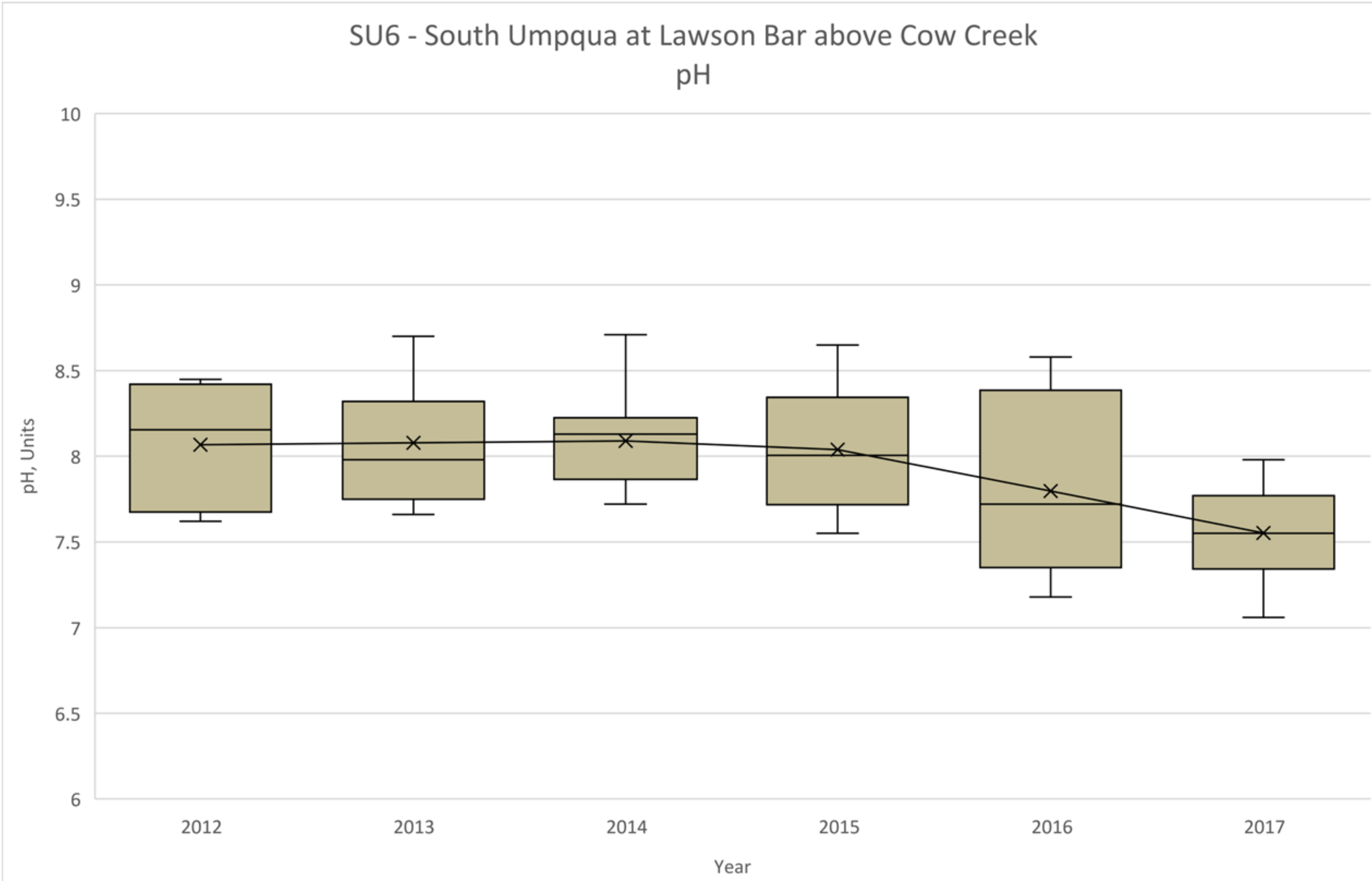
Graph 102. Box plots by year of grab sample turbidity levels of the South Umpqua River at Lawson Bar above Cow Creek.



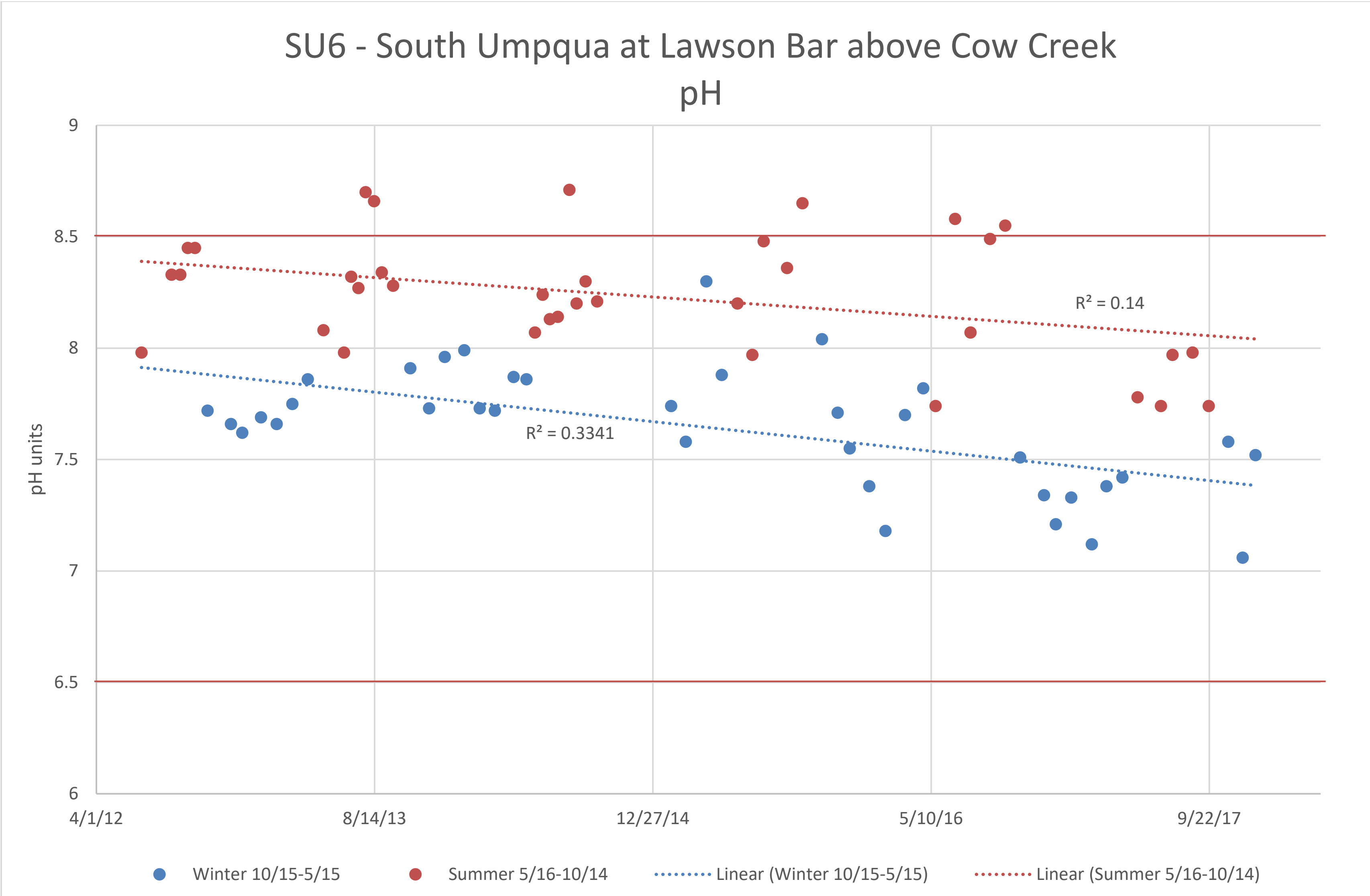
Graph 103. Box plots by year of grab sample turbidity levels of the South Umpqua River at Lawson Bar above Cow Creek with outliers above 25 NTU cropped out.



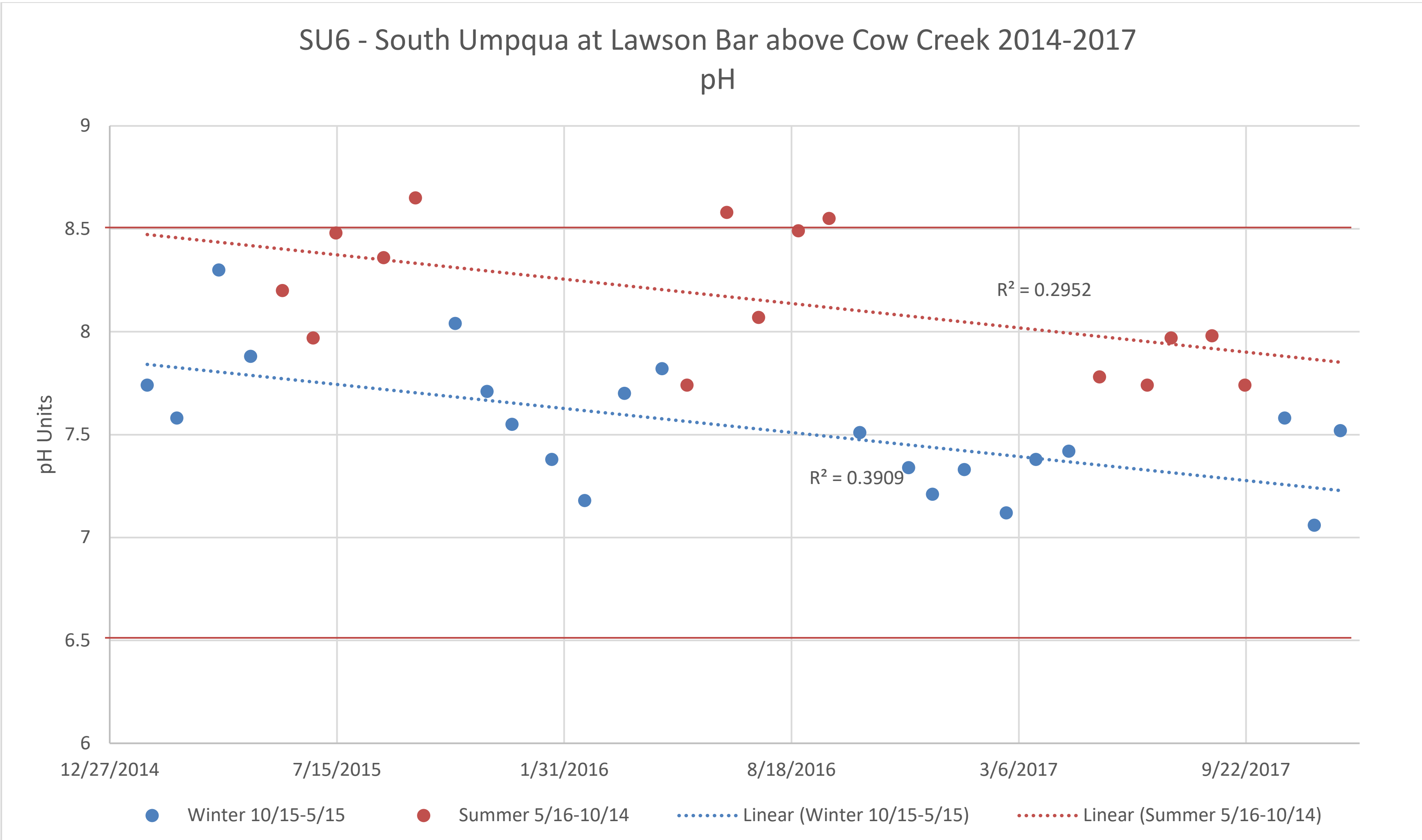
Graph 104. SU6 - South Umpqua at Lawson Bar above Cow Creek grab sample turbidity 2012-2017 summer and winter separated.



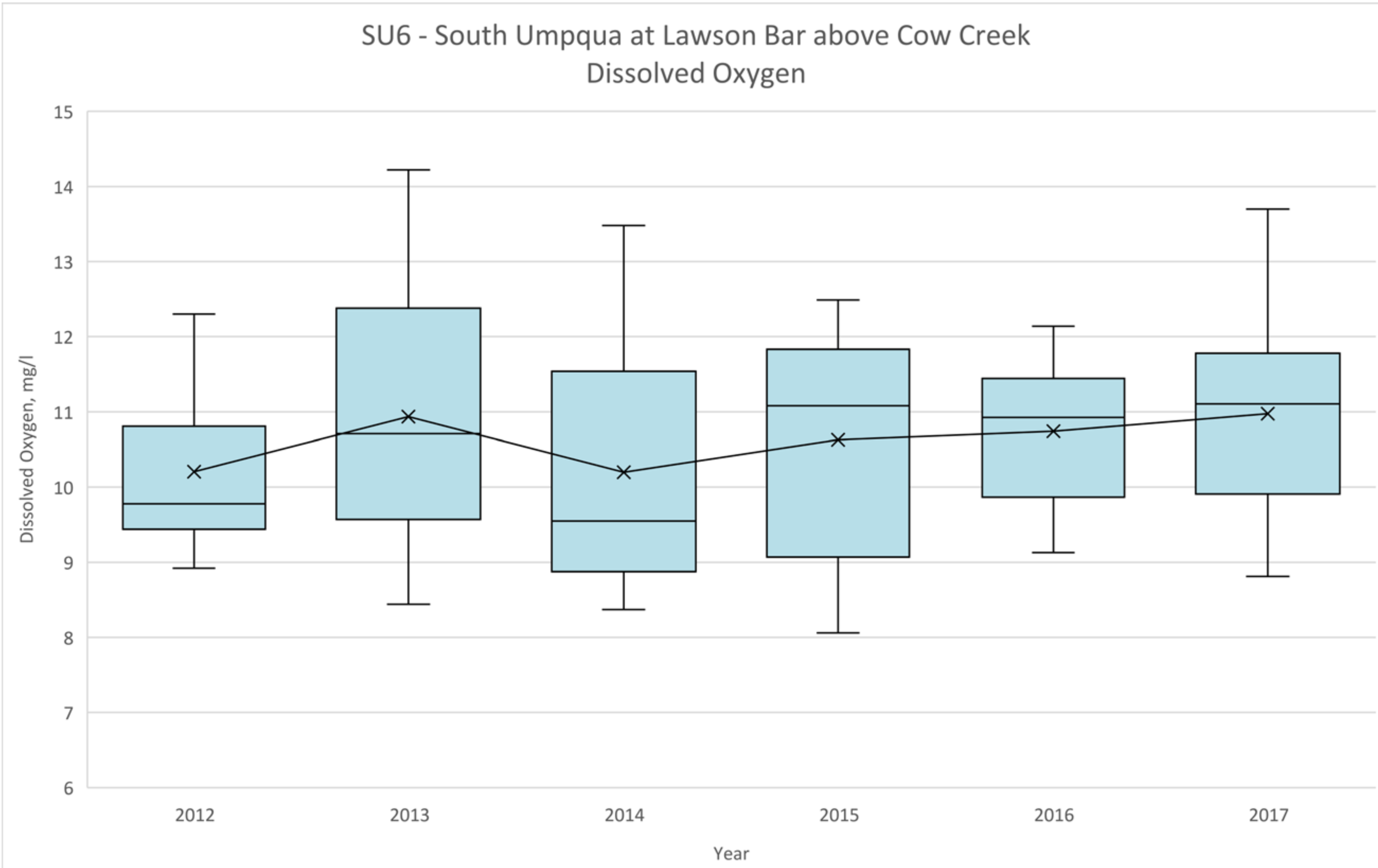
Graph 105. Box plots by year of grab sample pH levels of the South Umpqua River at Lawson Bar above Cow Creek.



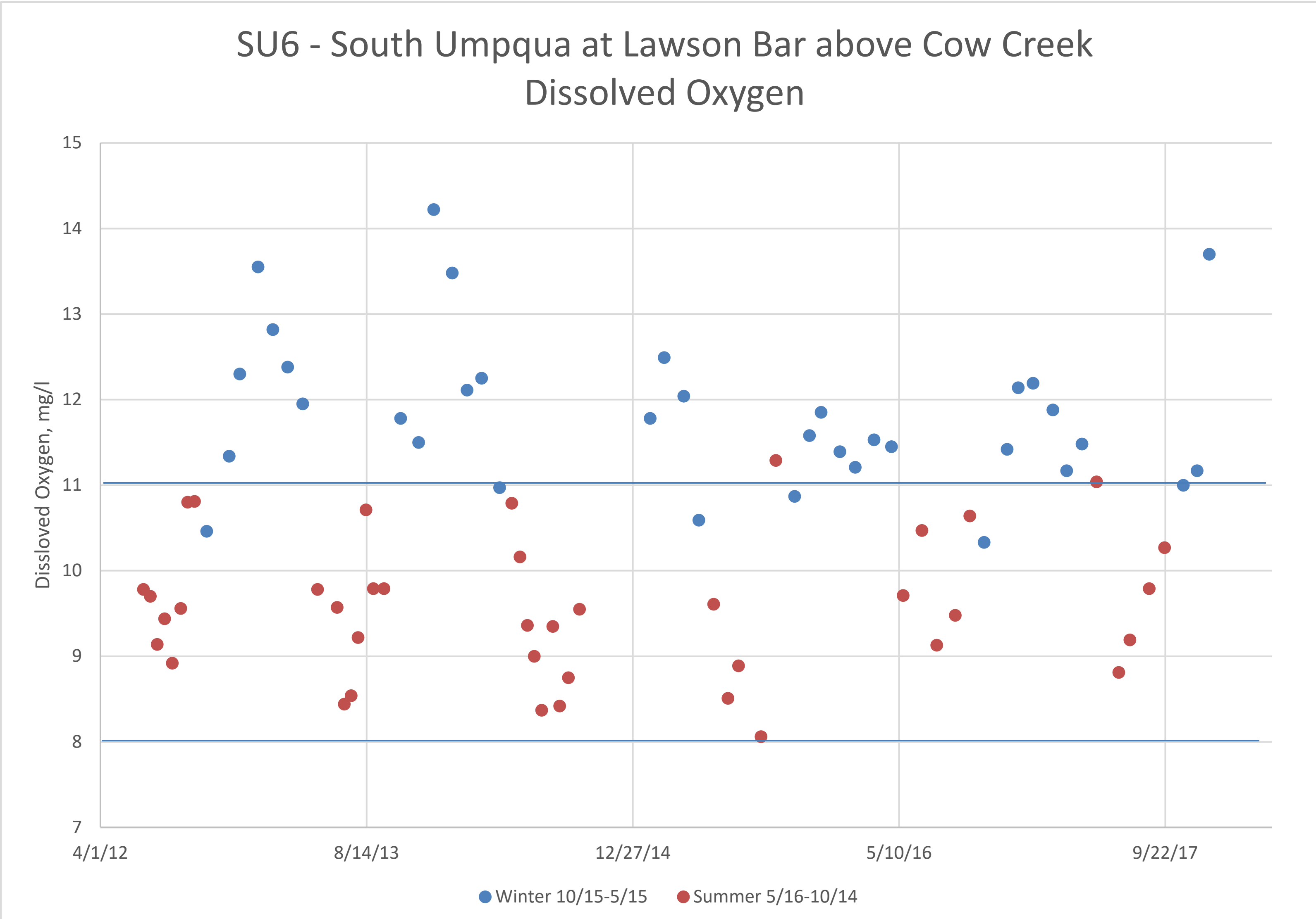
Graph 106. SU6 - South Umpqua at Lawson Bar above Cow Creek 2012-2017 pH summer and winter separated.



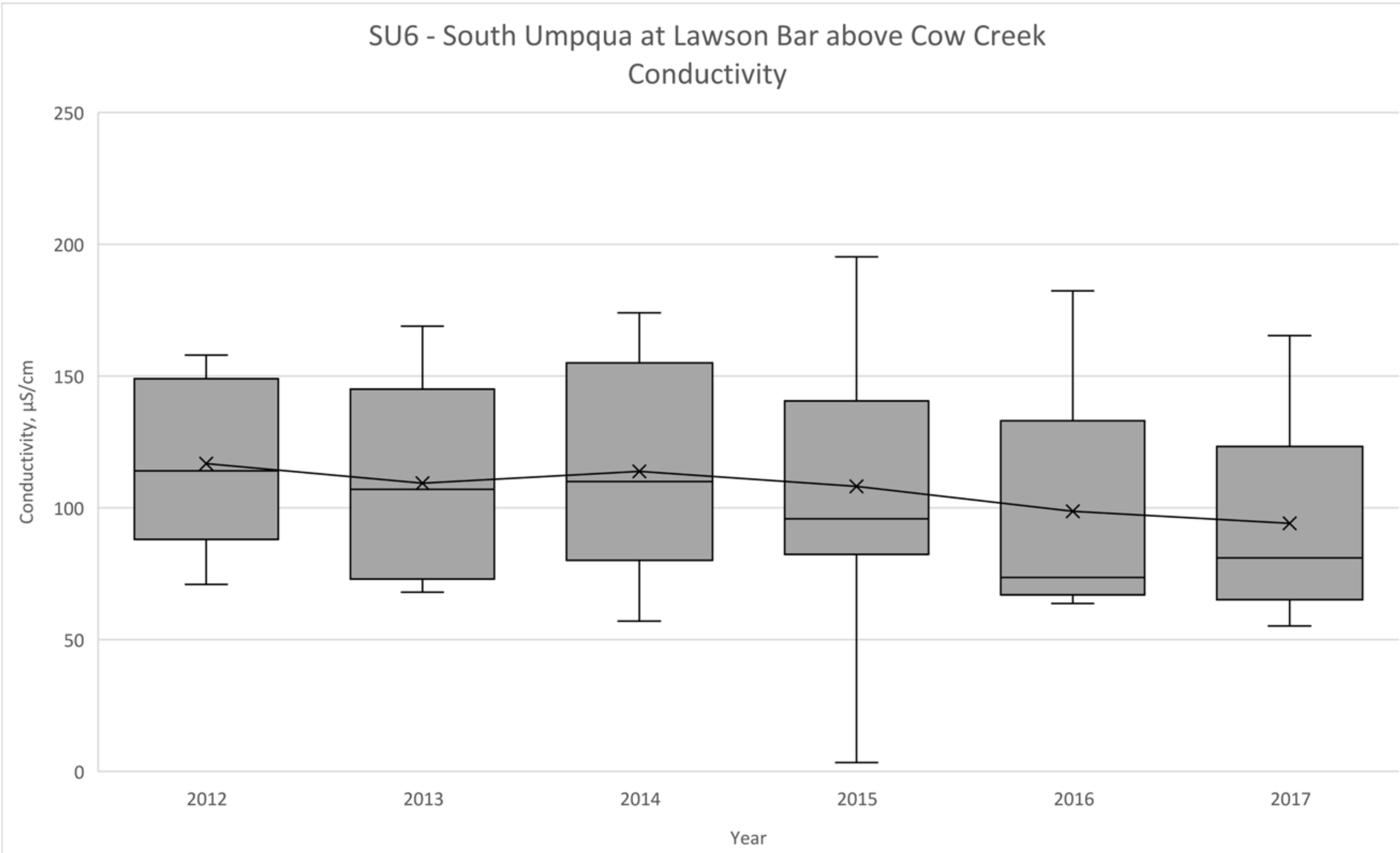
Graph 107. SU6 - South Umpqua at Lawson Bar above Cow Creek 2014-2017 pH summer and winter separated.



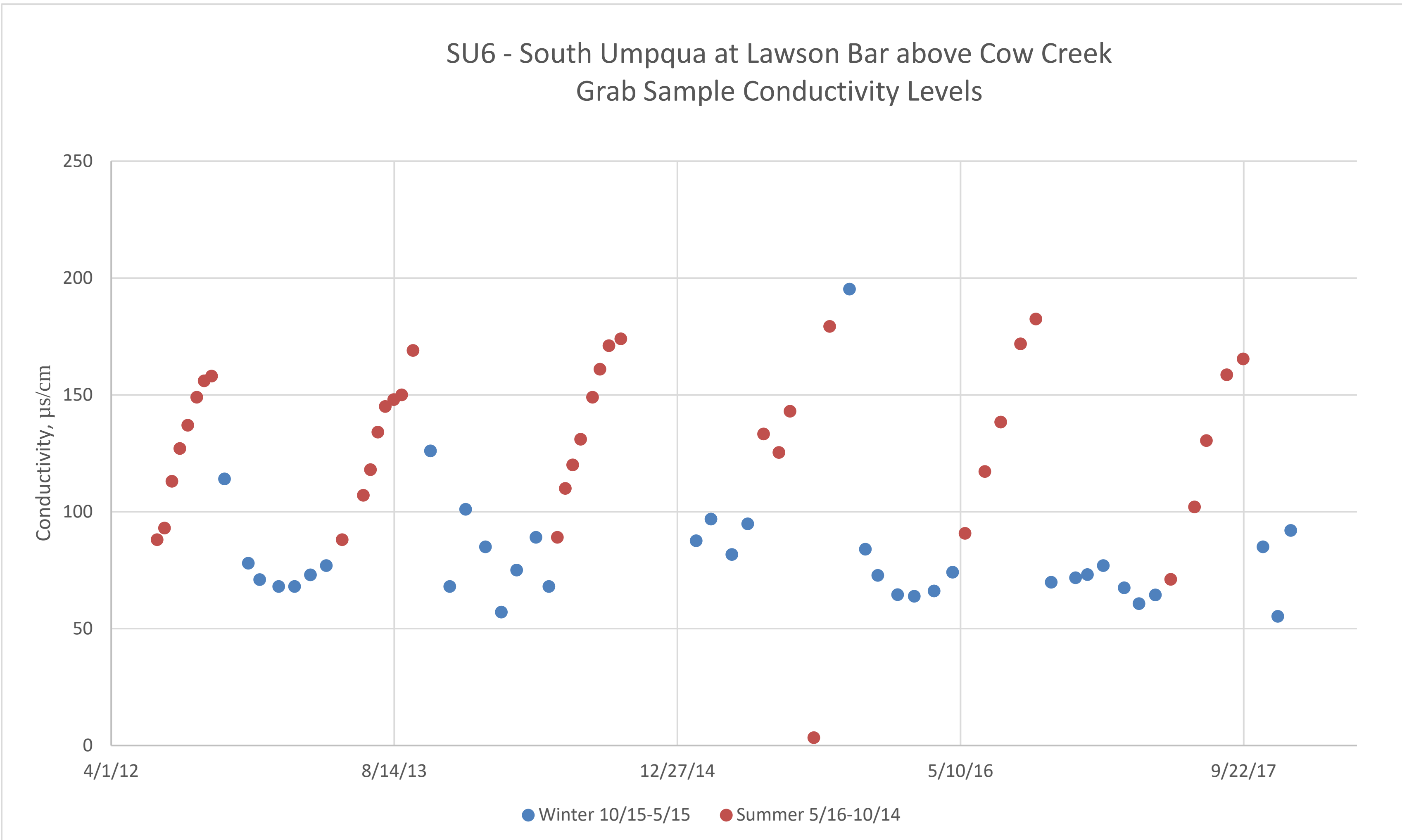
Graph 108. Box plots by year of grab sample dissolved oxygen levels of the South Umpqua River at Lawson Bar above Cow Creek.



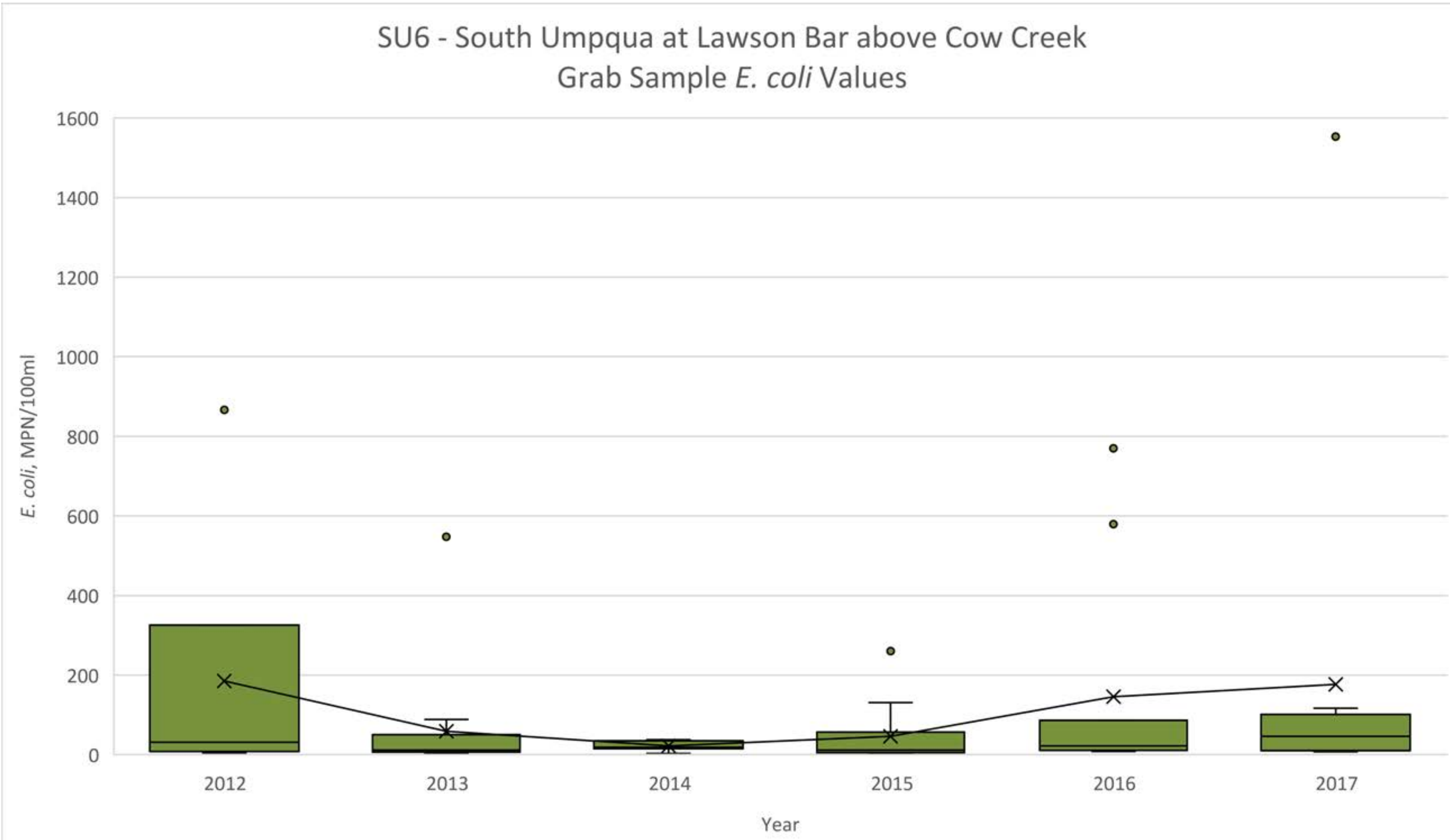
Graph 109. SU6 - South Umpqua at Lawson Bar above Cow Creek Dissolved Oxygen summer and winter separated.



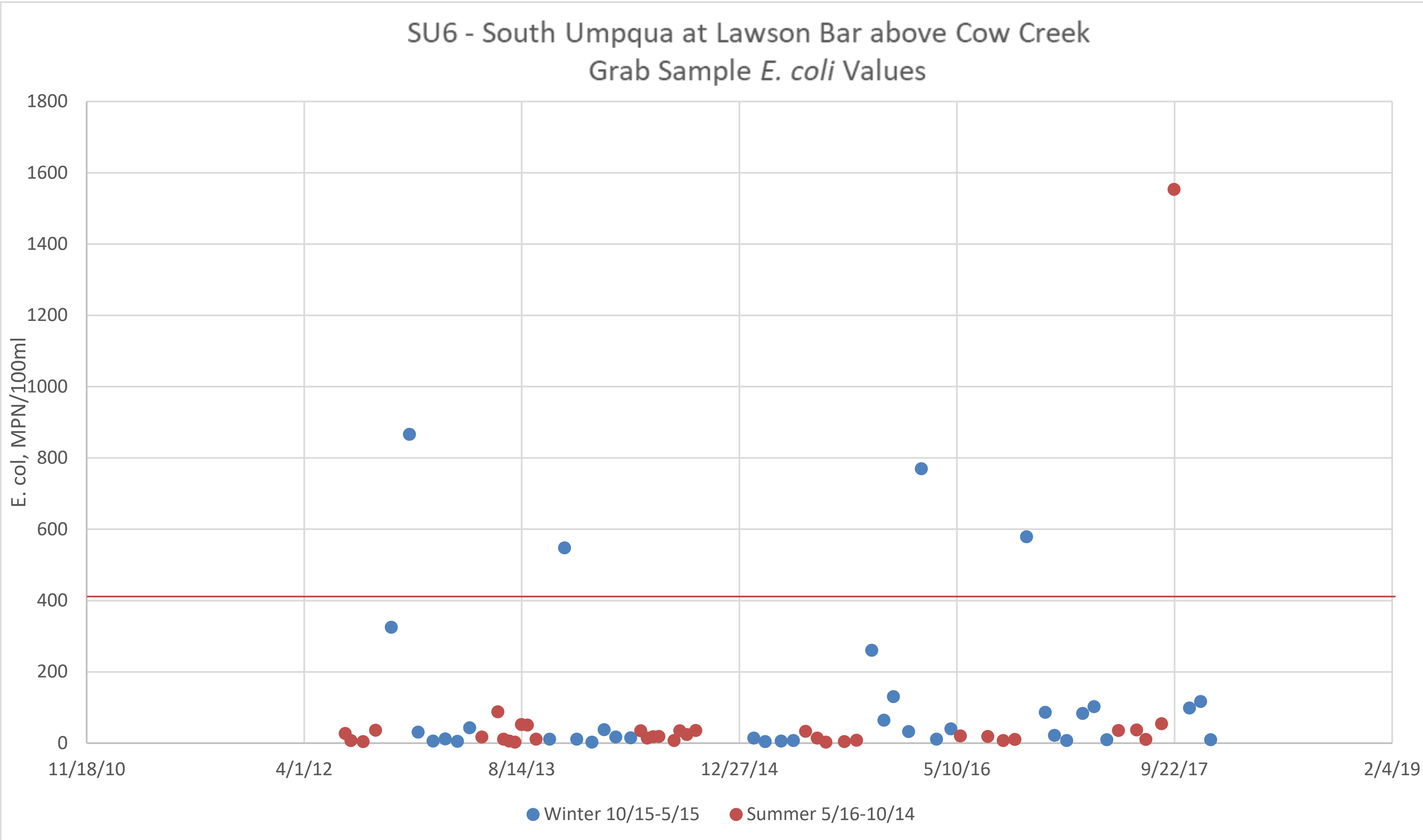
Graph 110. Box plots by year of grab sample conductivity levels of the South Umpqua River at Lawson Bar above Cow Creek.



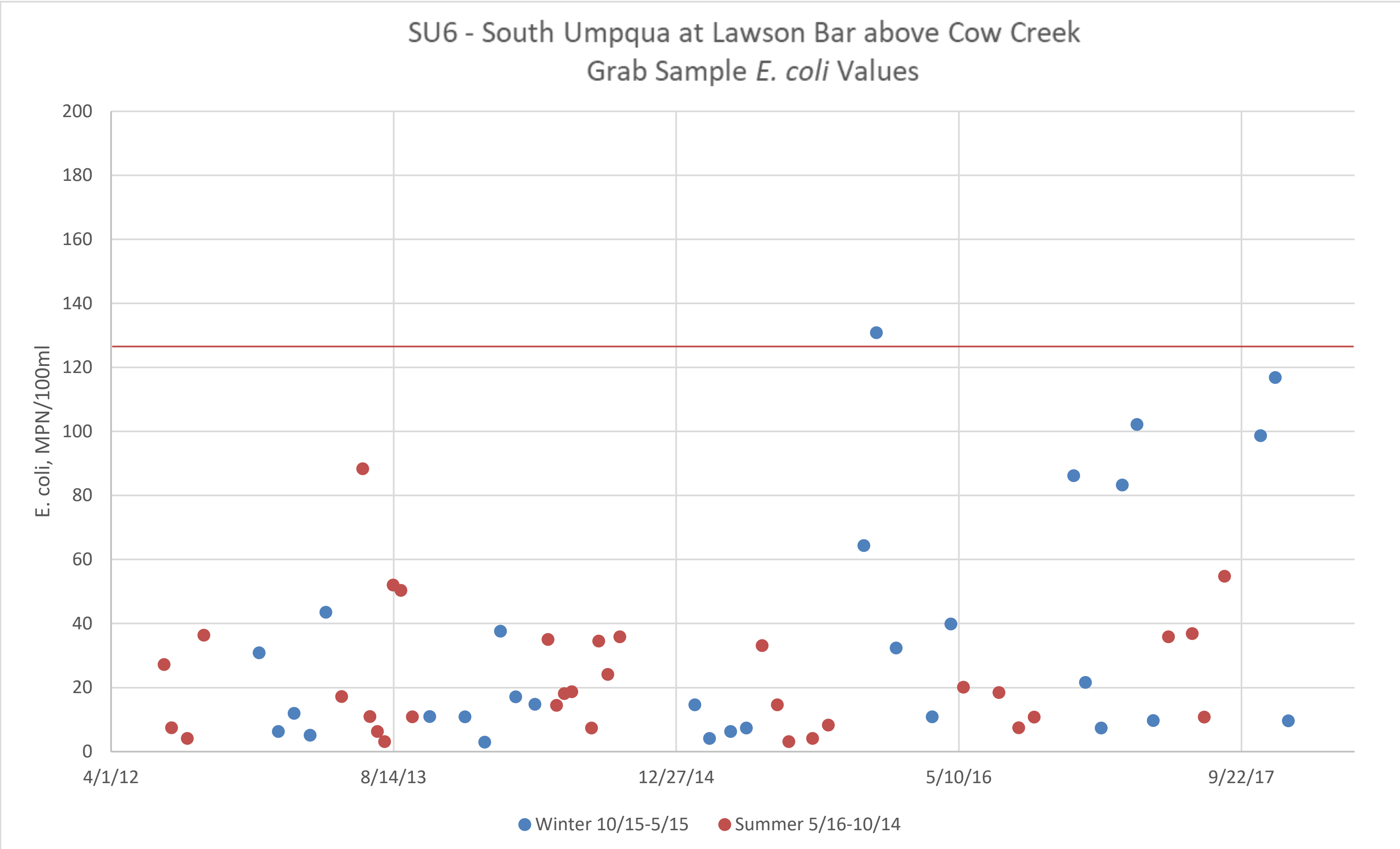
Graph 111. SU6 - South Umpqua at Lawson Bar above Cow Creek Grab Sample Conductivity Levels summer and winter separated.



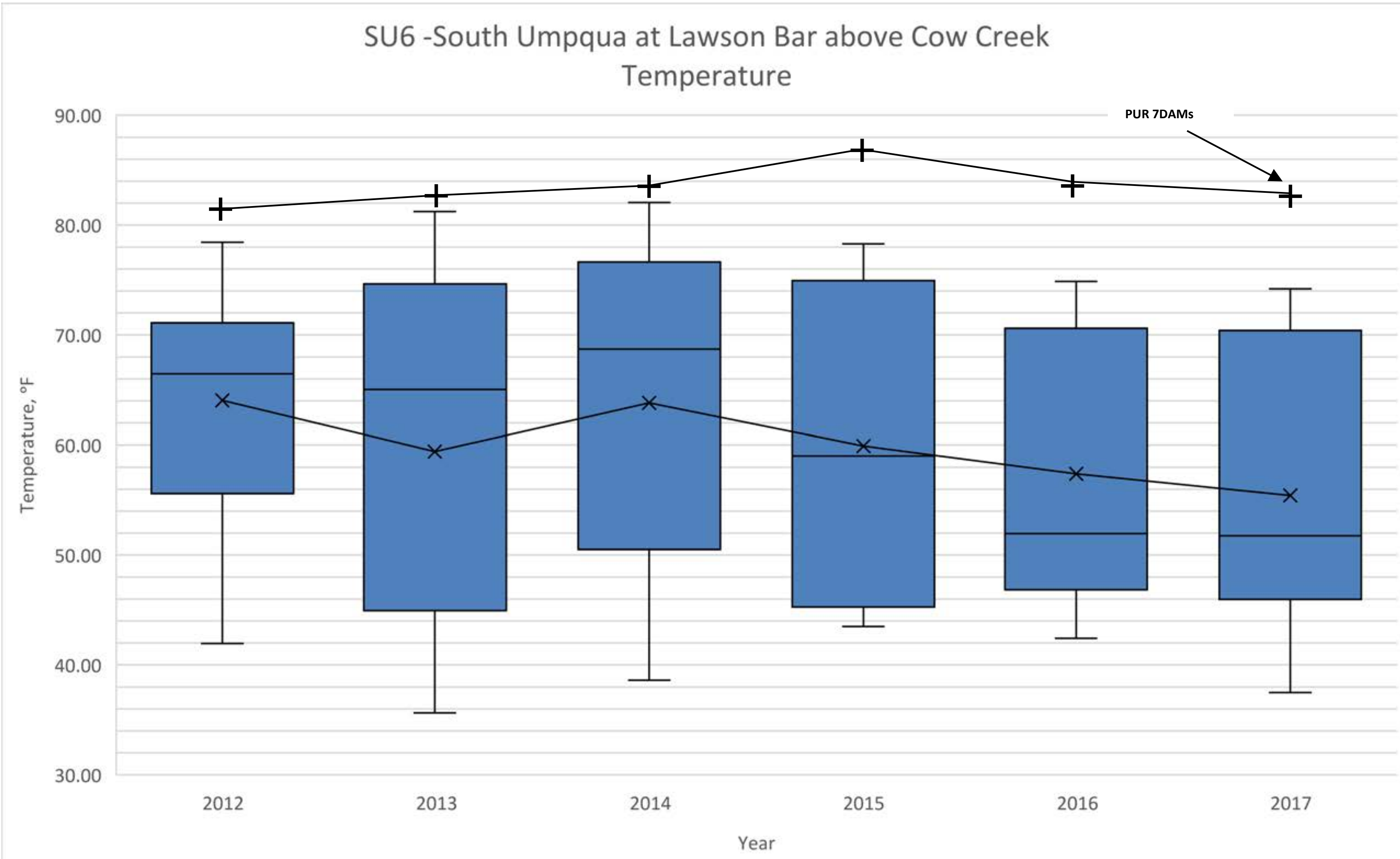
Graph 112. Box plots by year of grab sample *E. coli* levels of the South Umpqua River at Lawson Bar above Cow Creek.



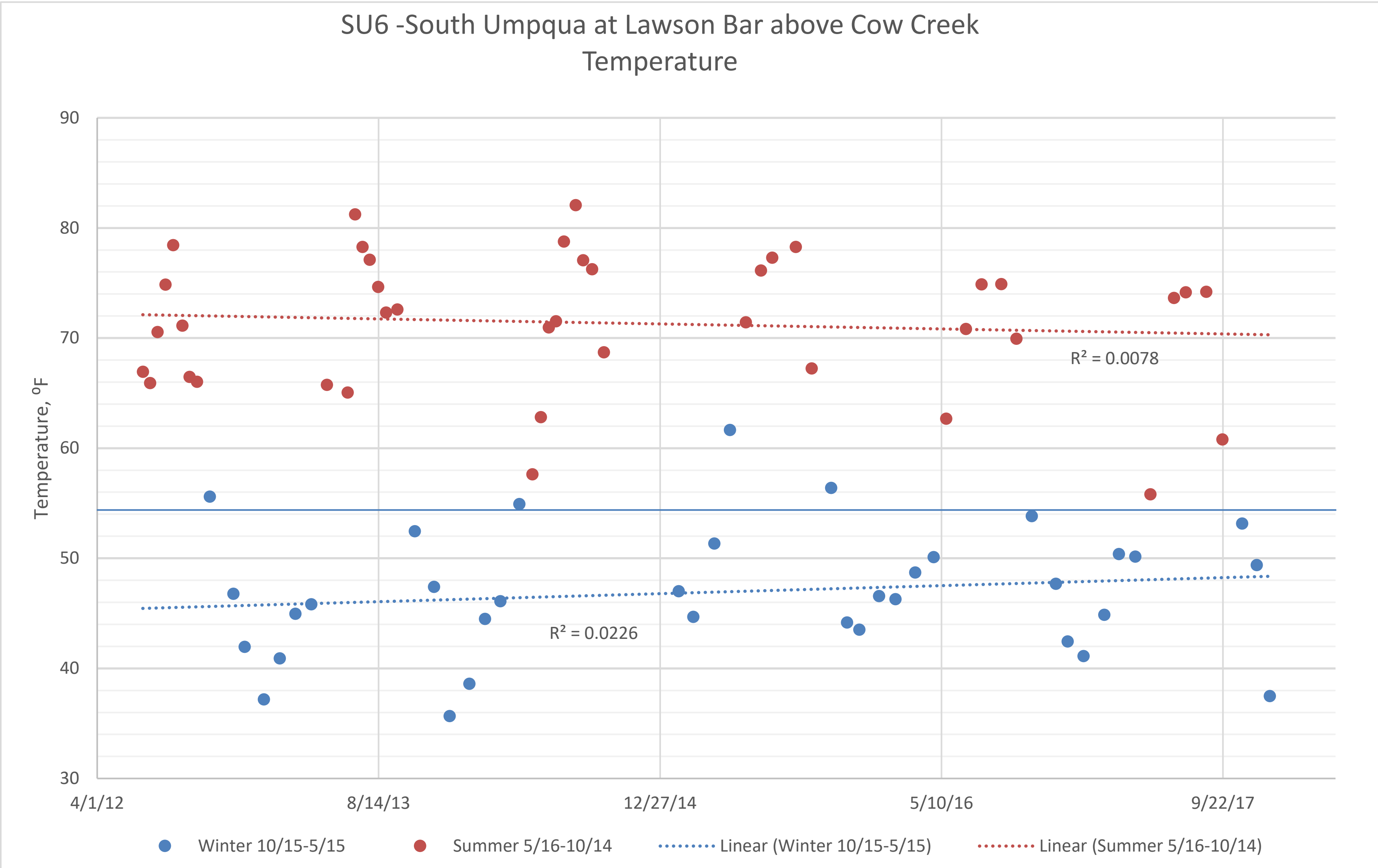
Graph 113. SU6 - South Umpqua at Lawson Bar above Cow Creek grab sample *E. coli* values summer and winter separated.



Graph 114. SU6 - South Umpqua at Lawson Bar above Cow Creek Grab Sample *E. coli* values clipped to 200 max summer and winter separated.



Graph 115. Box plots by year of grab sample temperature levels of the South Umpqua River at Lawson Bar above Cow Creek.



Graph 116. SU6 -South Umpqua at Lawson Bar above Cow Creek temperature summer and winter separated.

Site Name	Site	Start Date	Stop Date	Seasonal Maximum		Seasonal Minimum		Seasonal Max ΔT		7-Day averages			
	ID			Date	Value	Date	Value	Date	Value	Date	Max	Min	Δ T
South Umpqua Reference Run													
South Umpqua Upstream of Lawson Bar	SU6	07/18/12	09/24/12	08/17/12	82.8	09/12/12	63.4	07/25/12	8.1	08/16/12	81.2	76.5	4.7
South Umpqua Upstream of Lawson Bar	SU6	06/21/13	09/24/13	07/03/13	84.4	09/24/13	62.9	06/28/13	8.4	07/24/13	83.1	77.3	5.8
South Umpqua Upstream of Lawson Bar	SU6	06/13/14	09/17/14	07/30/14	84.7	06/18/14	61.4	06/18/14	8.7	07/31/14	83.4	77.6	5.8
South Umpqua Upstream of Lawson Bar	SU6	6/24/2015	9/22/2015	7/2/2015	87.4	9/17/2015	61.5	9/22/2015	15	7/4/2015	86.5	80.7	5.8
South Umpqua Upstream of Lawson Bar	SU6	6/23/2016	9/14/2016	8/20/2016	85.3	9/14/2016	63.5	8/19/2016	9.5	8/17/2016	83.7	75.8	7.9
South Umpqua Upstream of Lawson Bar	SU6	6/28/2017	9/20/2017	8/4/2017	83.9	9/20/2017	62.1	7/6/2017	7.5	8/6/2017	82.4	77.6	4.8

Site Name	*Site*	Days >	Days >	Days >	Hours >	Hours >	Hours >	Warmest day of 7-day max		
	ID	55 F	64 F	70 F	55 F	64 F	70 F	Date	Max	Min
South Umpqua Reference Run										
South Umpqua Upstream of Lawson Bar	*SU6*	69	69	66	1655.5	1651.0	1209.5	08/17/12	82.8	78.1
South Umpqua Upstream of Lawson Bar	*SU6*	96	95	88	2303.5	2254.0	1978.0	07/25/13	84.0	77.3
South Umpqua Upstream of Lawson Bar	*SU6*	97	97	92	2327.5	2299.5	1954.0	07/30/14	84.7	78.5
South Umpqua Upstream of Lawson Bar	*SU6*	91	91	84	2183.5	2124.5	1852.5	7/2/2015	87.4	81.3
South Umpqua Upstream of Lawson Bar	*SU6*	84	84	83	2015.5	2011	1763	8/20/2016	85.3	77
South Umpqua Upstream of Lawson Bar	*SU6*	85	84	80	2039.5	1976.5	1840.5	8/4/2017	83.9	79.2

Table 31. Continuous temperature data summary for South Umpqua upstream of Lawson Bar.

SU8 - South Umpqua near Myrtle Creek Treatment Plant above Myrtle Creek

Year	Monthly Samples	Months
2010	12	Full Year
2012	11	Jun-Dec, 3 July
2013	15	Full Year, 3 July
2014	13	Jan-Aug, 3 July
2015	12	Full Year
2016	12	Full Year
2017	12	Full Year

Table 32. Number of monitoring events per year included in graphs that follow for

Turbidity
The South Umpqua near Myrtle Creek water treatment plant was sampled 2010 thru 2017 (Graphs 117-119.) During our grab sampling, the highest level detected was 76 NTU which occurred in February 2015. This was the only occurrence that fell above 50 NTU which "The Oregon Watershed Assessment Manual recommends using 50 NTUs as the turbidity evaluation criteria for watershed assessments. At this level, turbidity interferes with sight-feeding aquatic organisms and provides an indication of the biological effect of suspended sediment." There were 11 exceedances of 10 NTU spread over the years, but none occurred during the summer. No trend is evident.

pH
With grab sampling, 14 events exceeded the upper DEQ recommended limit of 8.5 all 14 of the exceedances were in summer, likely due to algal photosynthesis during the day. No pH levels were measured below 7.0. The box plot graph does again, as it has for many previous sites, indicate and interesting trend in that the pH values for 2015, 2016, 2017 and even 2014 (greater R-Squared values are obtained if 2014 is included) for this site, showing a downward trend in pH for the median and mean values for each year. Graph 123 indicates that both summer and winter pH values are trending downward. Not enough data, nor 24-hour data is available to make any reliable result. However, by 2017 no sampling events exceeded the higher or the lower DEQ criteria. This site should be carefully monitored for possible future ongoing changes.

Dissolved Oxygen

Graphs 124 and 125 display the dissolved oxygen grab sample data for the South Umpqua at Myrtle Creek. No levels were detected below the lower limit of 8. Eight measurements did fall below the spawning criteria of eleven, though none were below ten. All summer dissolved oxygen levels were within the acceptable range. No trend is apparent.

Conductivity

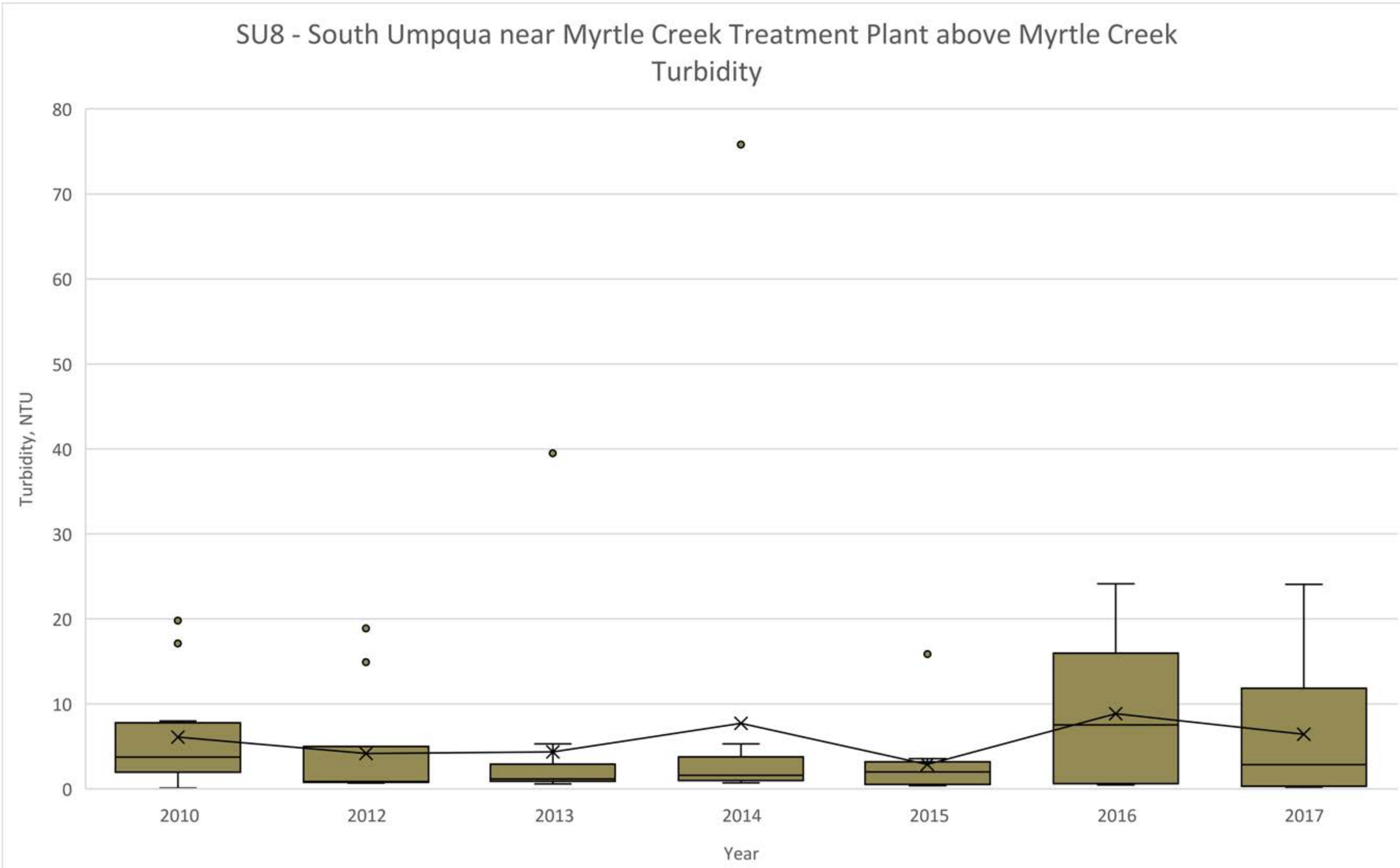
Graphs 126 and 127 display the conductivity grab sample data. All are within normal ranges for the Umpqua basin. No trend is evident, and variation was between 50 and 180 with the higher readings occurring during the summer.

E. coli

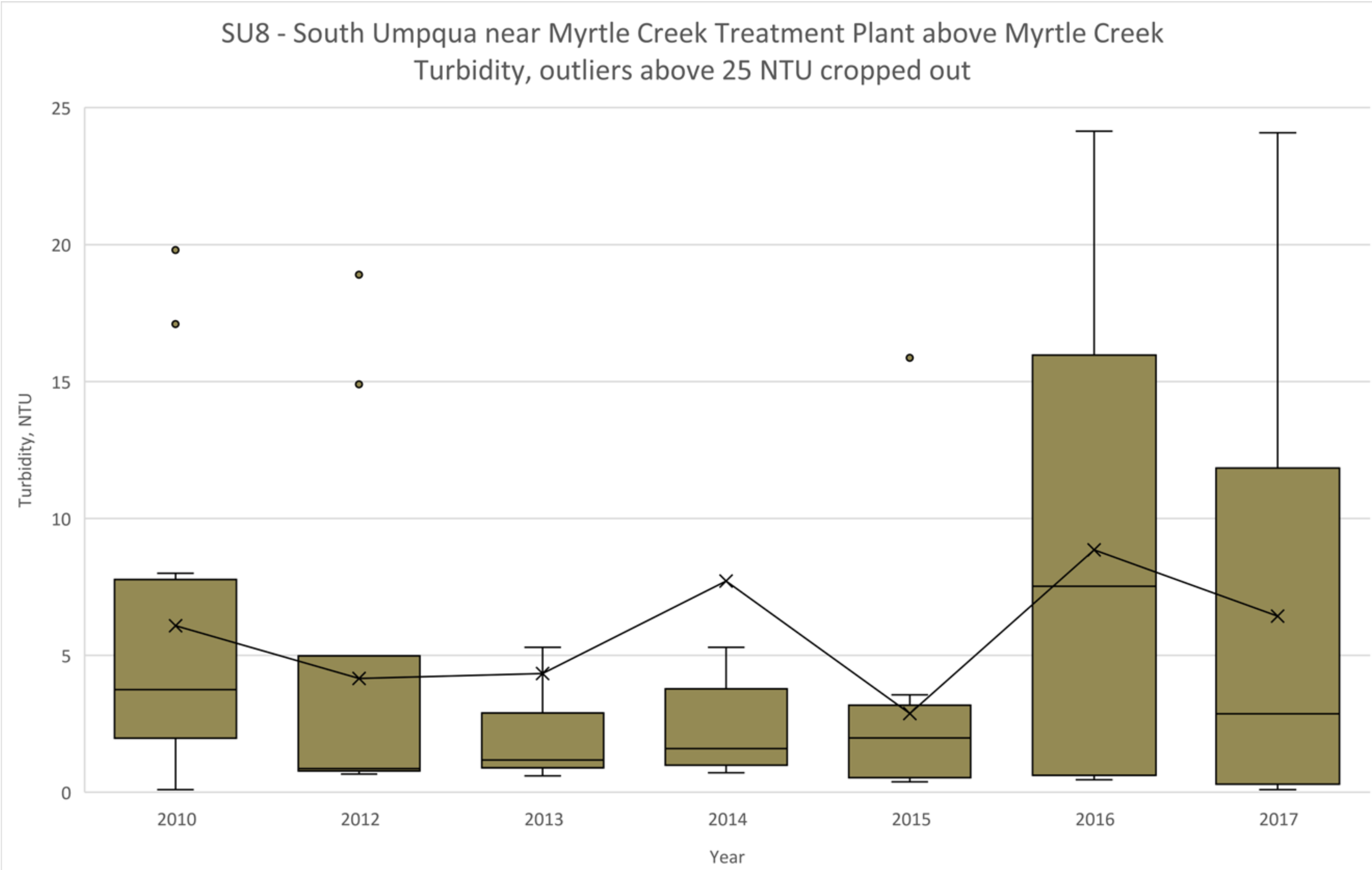
E. coli levels are displayed in graphs 128 through 130. Eight outliers occurred high enough to list this section of the South Umpqua River. Six occurred in winter and two in summer. Eight samples, both summer and winter, were above the 126 MPN/100ml which DEQ criteria indicates would have to have been measured 5 times in one month to have listed it. One time reading at 406 MPN/ml or greater would list a stream. No trend is evident.

Temperature

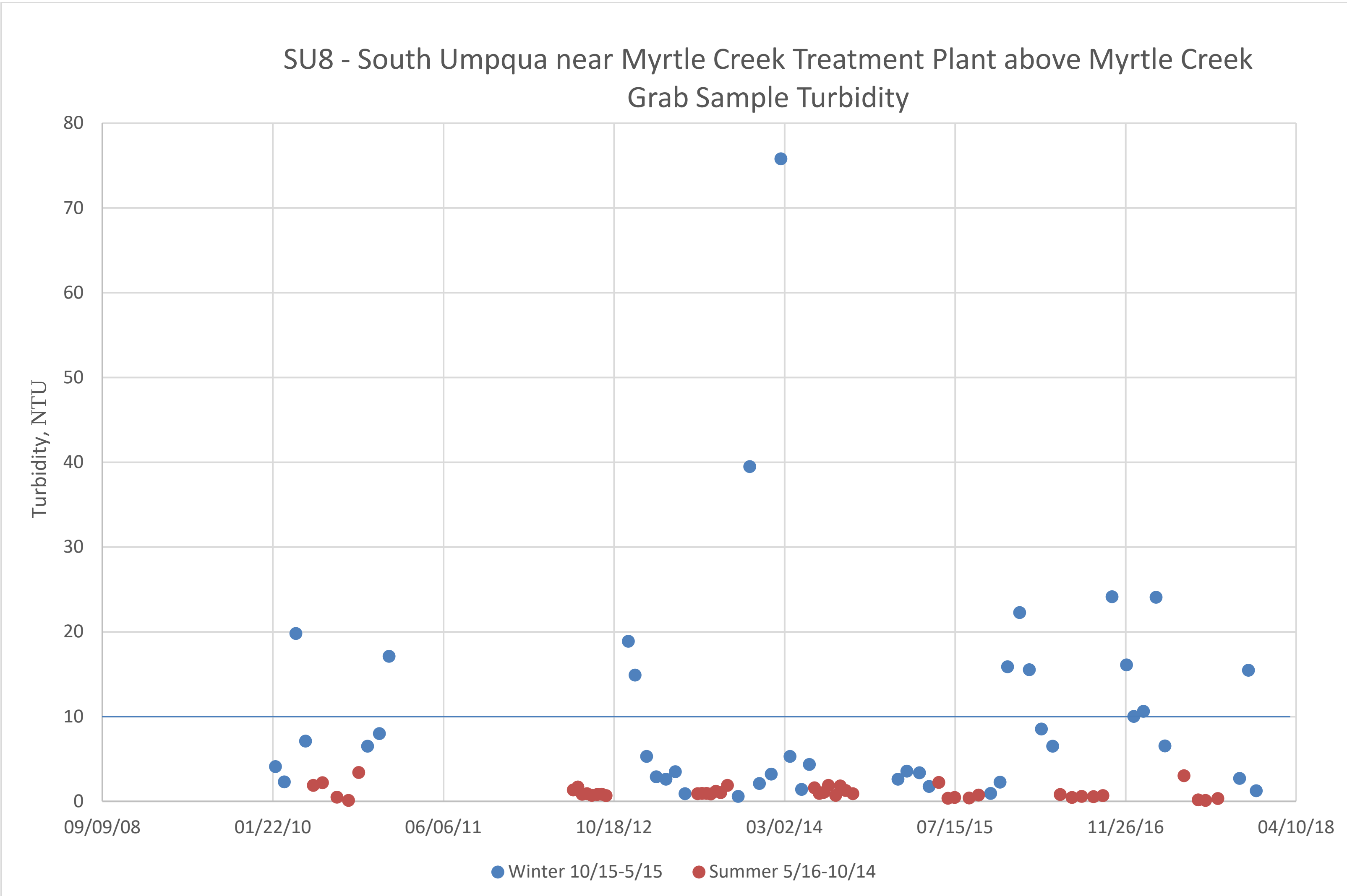
Graphs 130, 131 and Table 33 display the temperature data for the South Umpqua River at Myrtle Creek. We placed summer data loggers at this site for three years of continuous data which showed that the 7DAM was always above 80°F and lists this stretch of the river for temperature. Even our grab sample temperature data was an indicator of this problem. The winter temperatures mostly all fell below the 55.4°F spawning criteria with five exceeding it. No trend is evident.



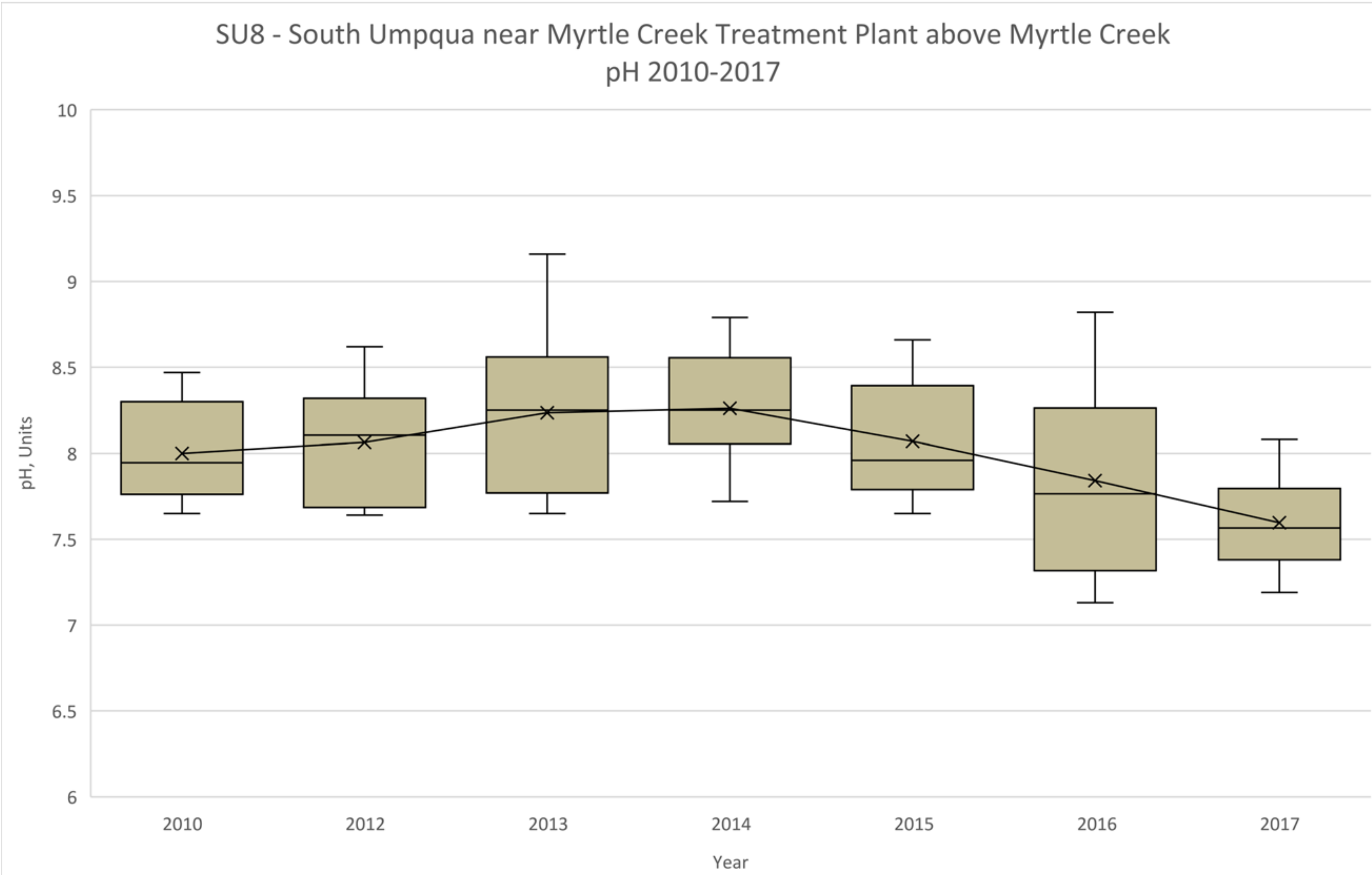
Graph 117. Box plots by year of grab sample turbidity levels of the South Umpqua River above Myrtle Creek.



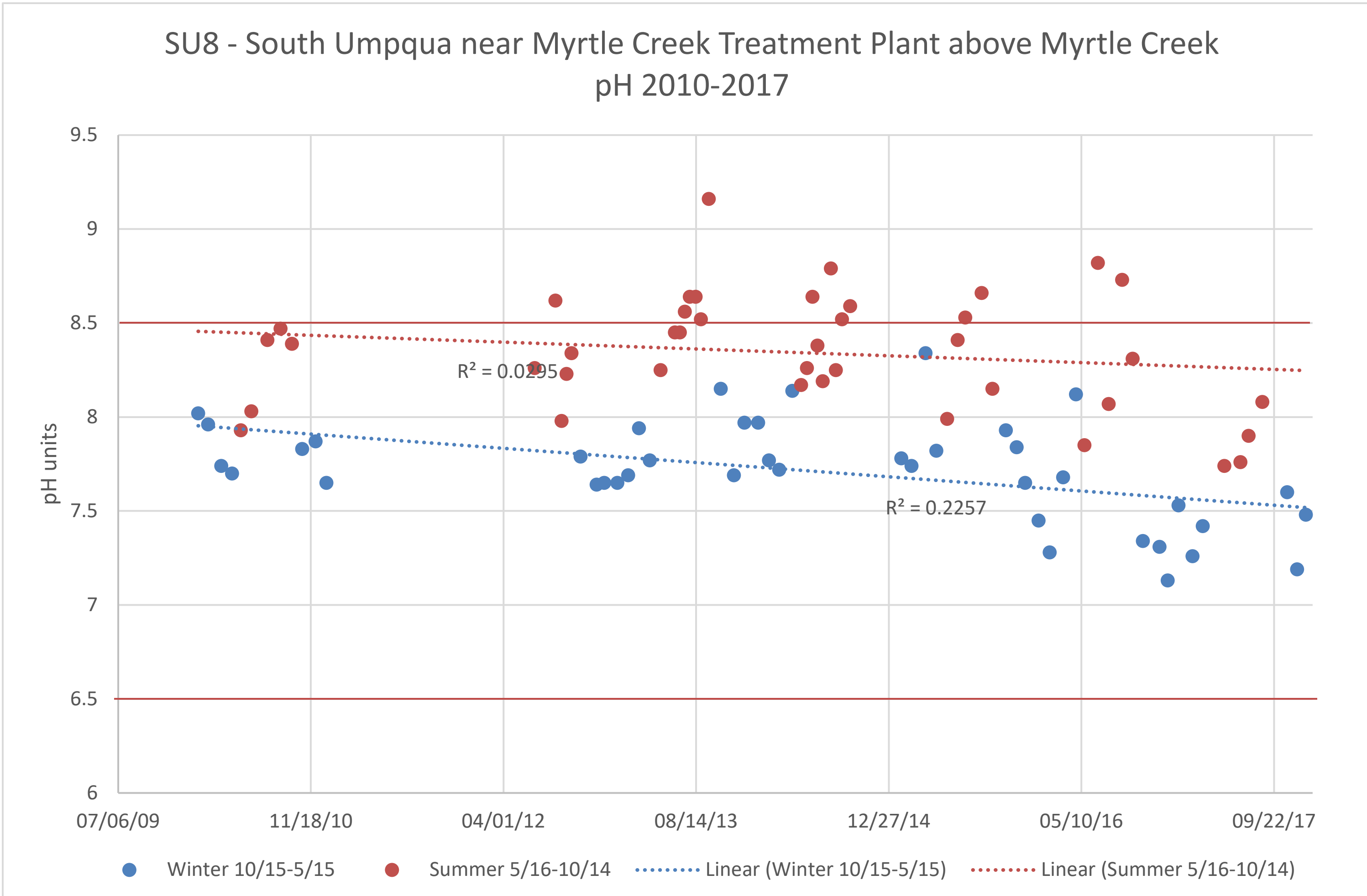
Graph 118. Box plots by year of grab sample turbidity levels of the South Umpqua River above Myrtle Creek outliers above 25 NTU removed.



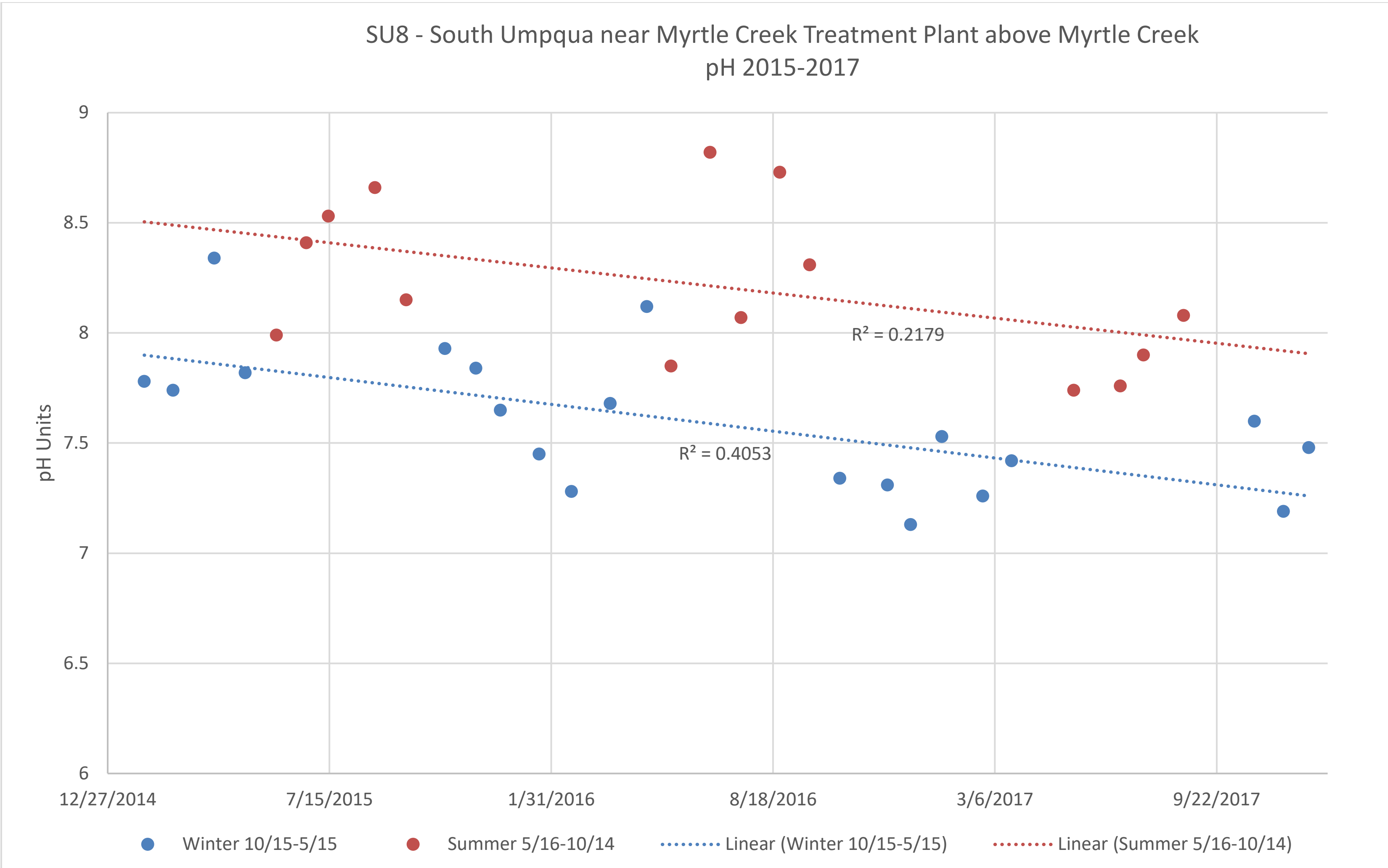
Graph 119. SU8 - South Umpqua near Myrtle Creek Treatment Plant above Myrtle Creek grab sample turbidity summer and winter separated.



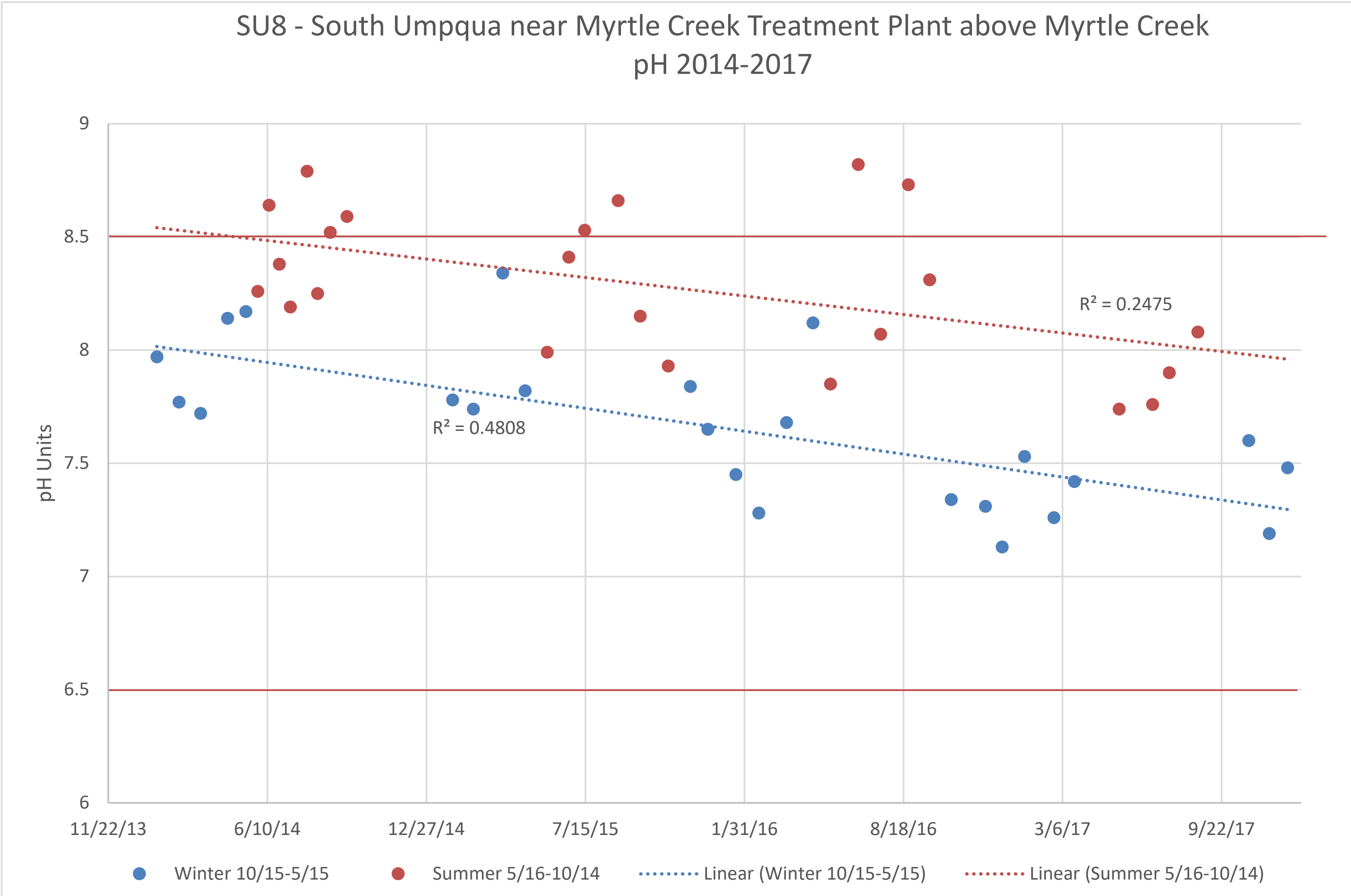
Graph 120. Box plots by year of grab sample pH levels of the South Umpqua River above Myrtle Creek.



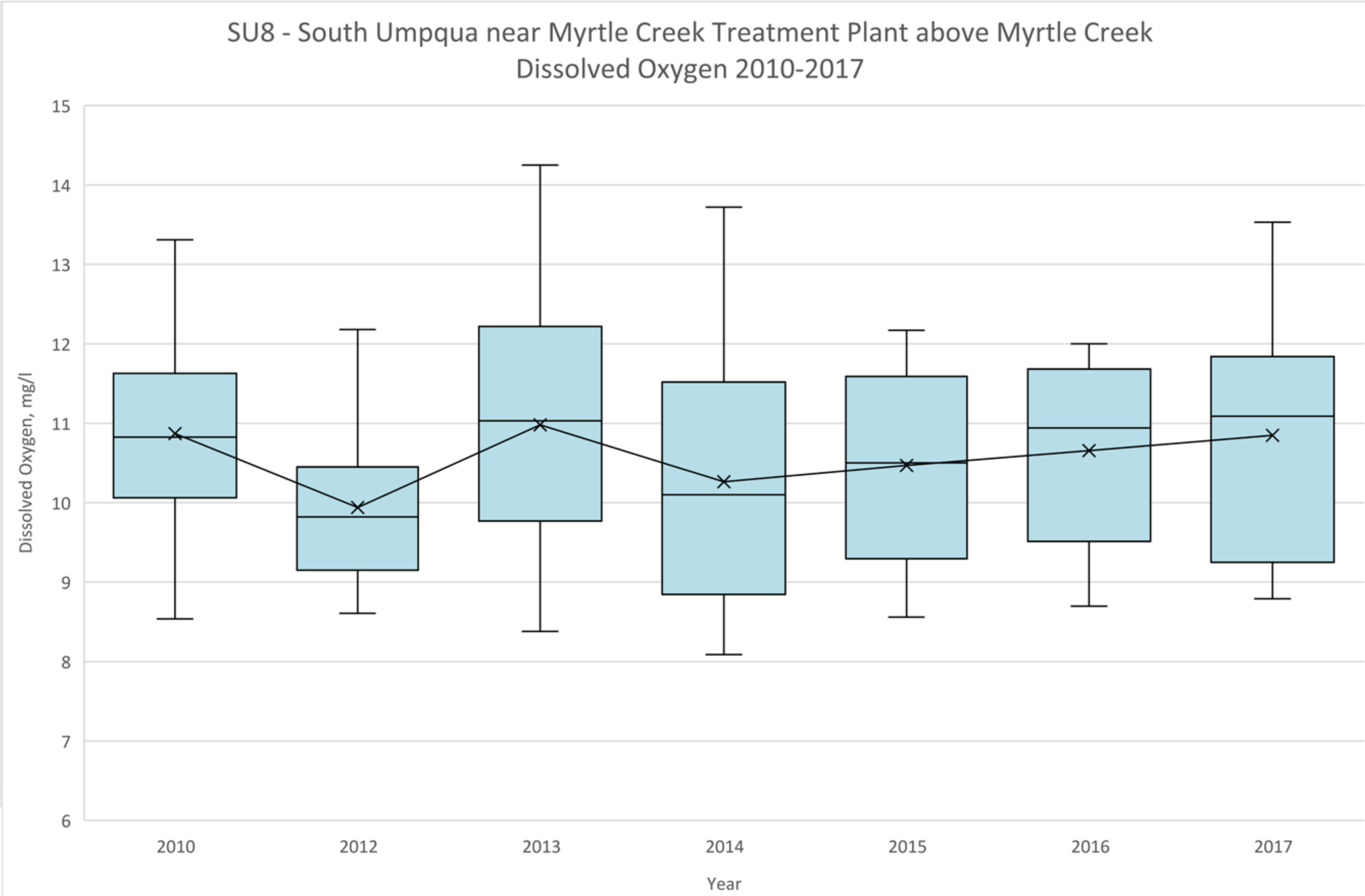
Graph 121. SU8 - South Umpqua near Myrtle Creek Treatment Plant above Myrtle Creek pH 2010-2017 summer and winter separated.



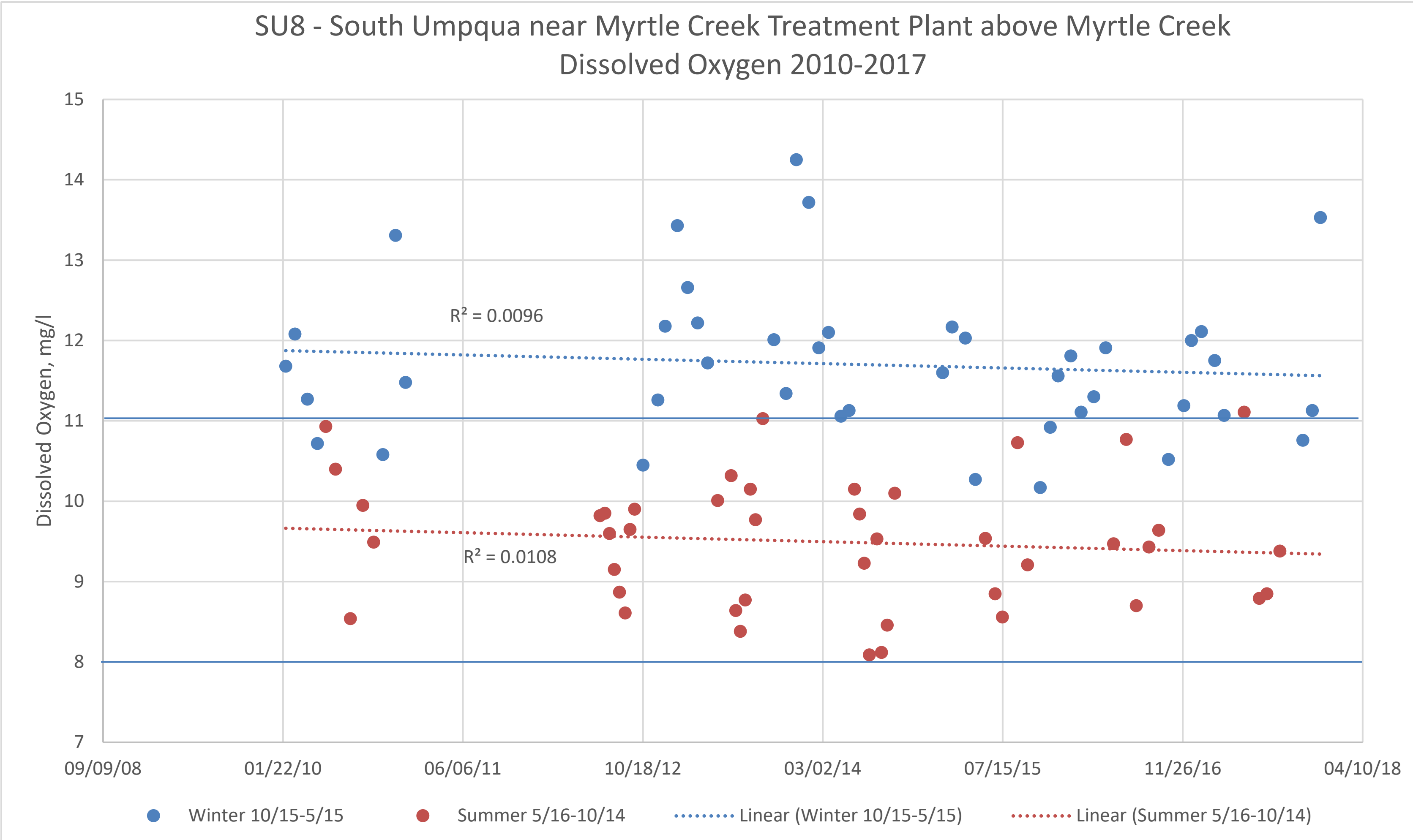
Graph 122. SU8 -South Umpqua near Myrtle Creek Treatment Plant above Myrtle Creek pH 2015-2017 summer and winter separated.



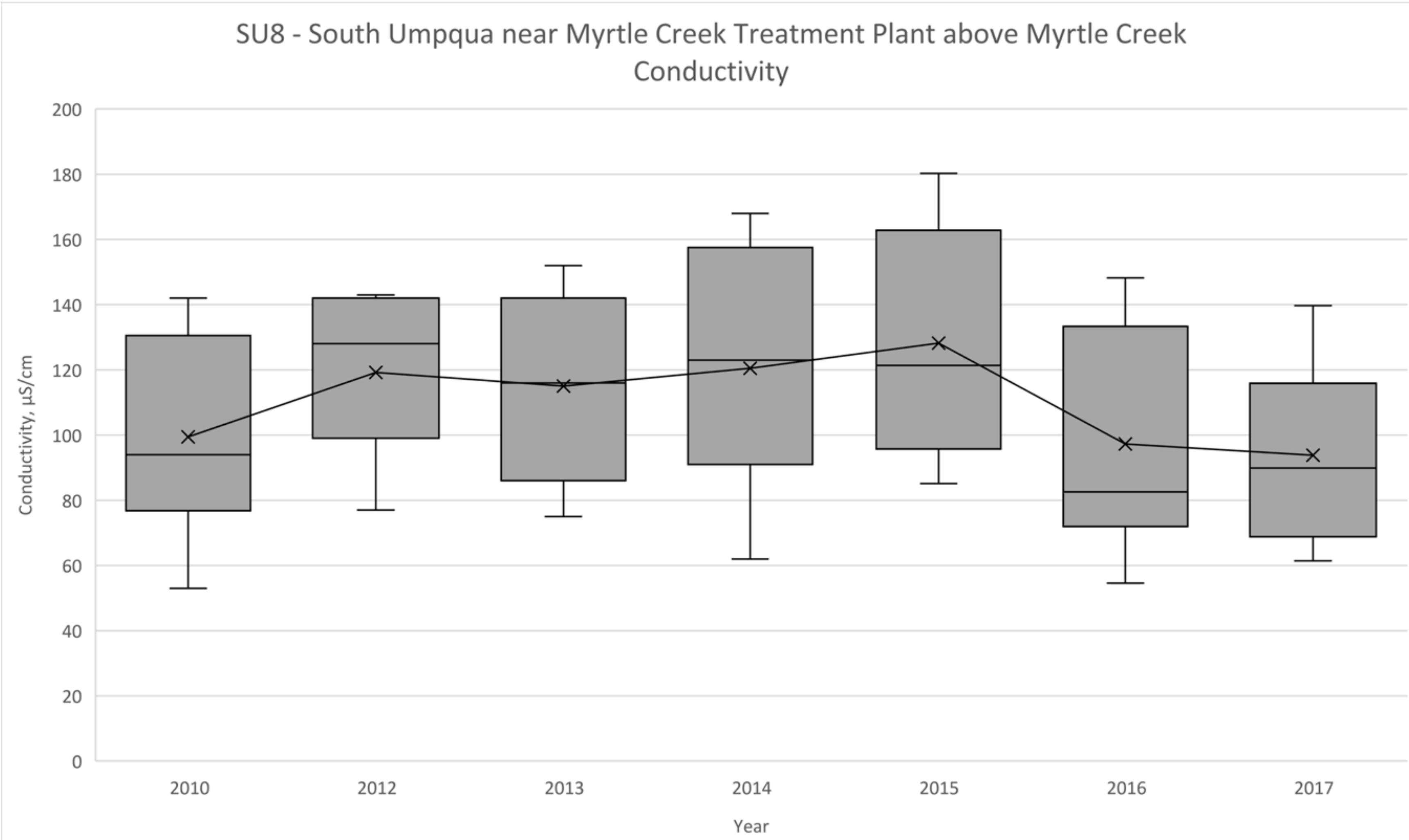
Graph 123. South Umpqua near Myrtle Creek treatment plan above Mouth of Myrtle Creek, grab sample pH 2014-20167.



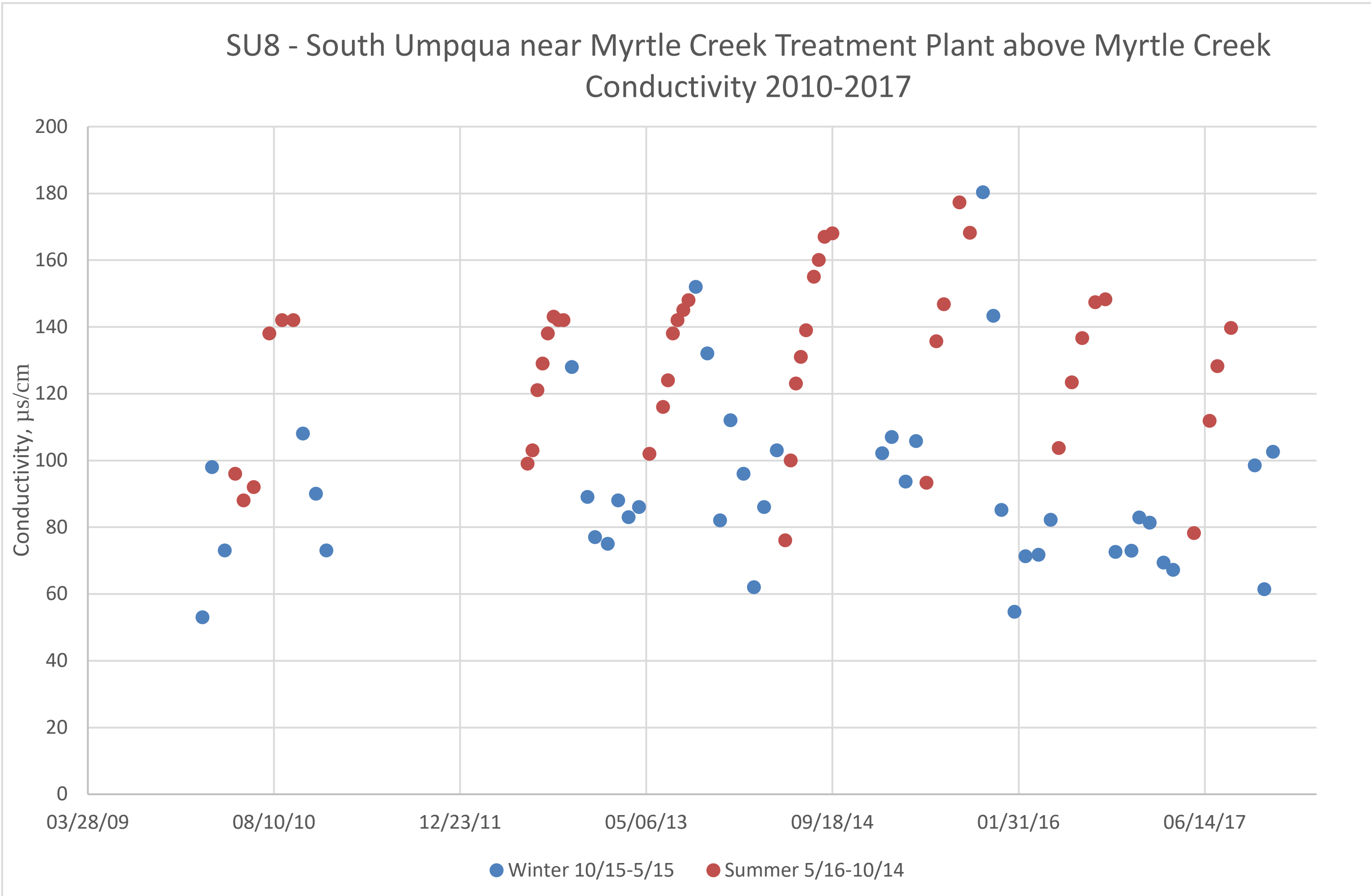
Graph 124. Box plots by year of grab sample dissolved oxygen levels of the South Umpqua River above Myrtle Creek.



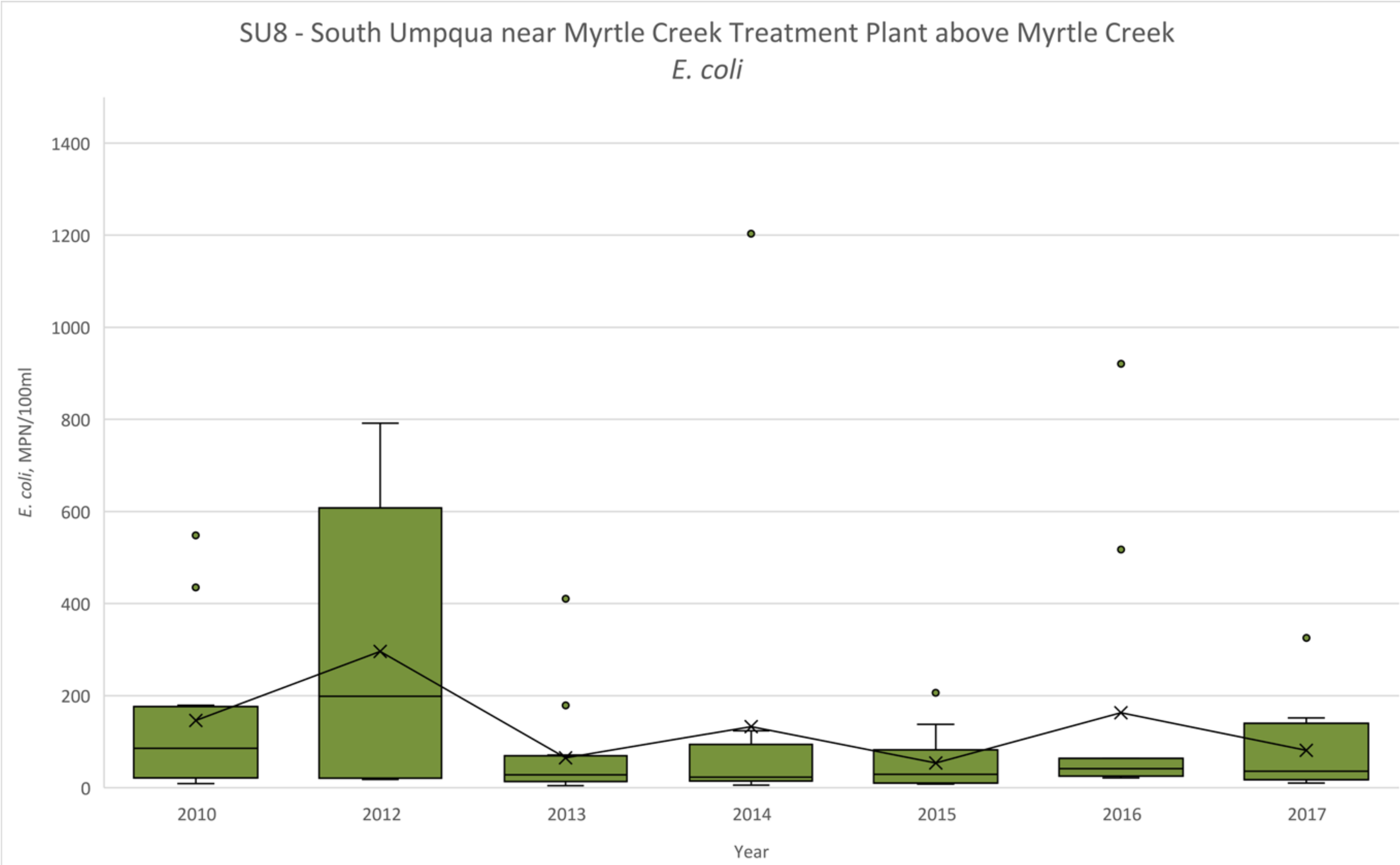
Graph 125. SU8 - South Umpqua near Myrtle Creek treatment plant above Myrtle Creek dissolved oxygen 2010-2017 summer and winter separated.



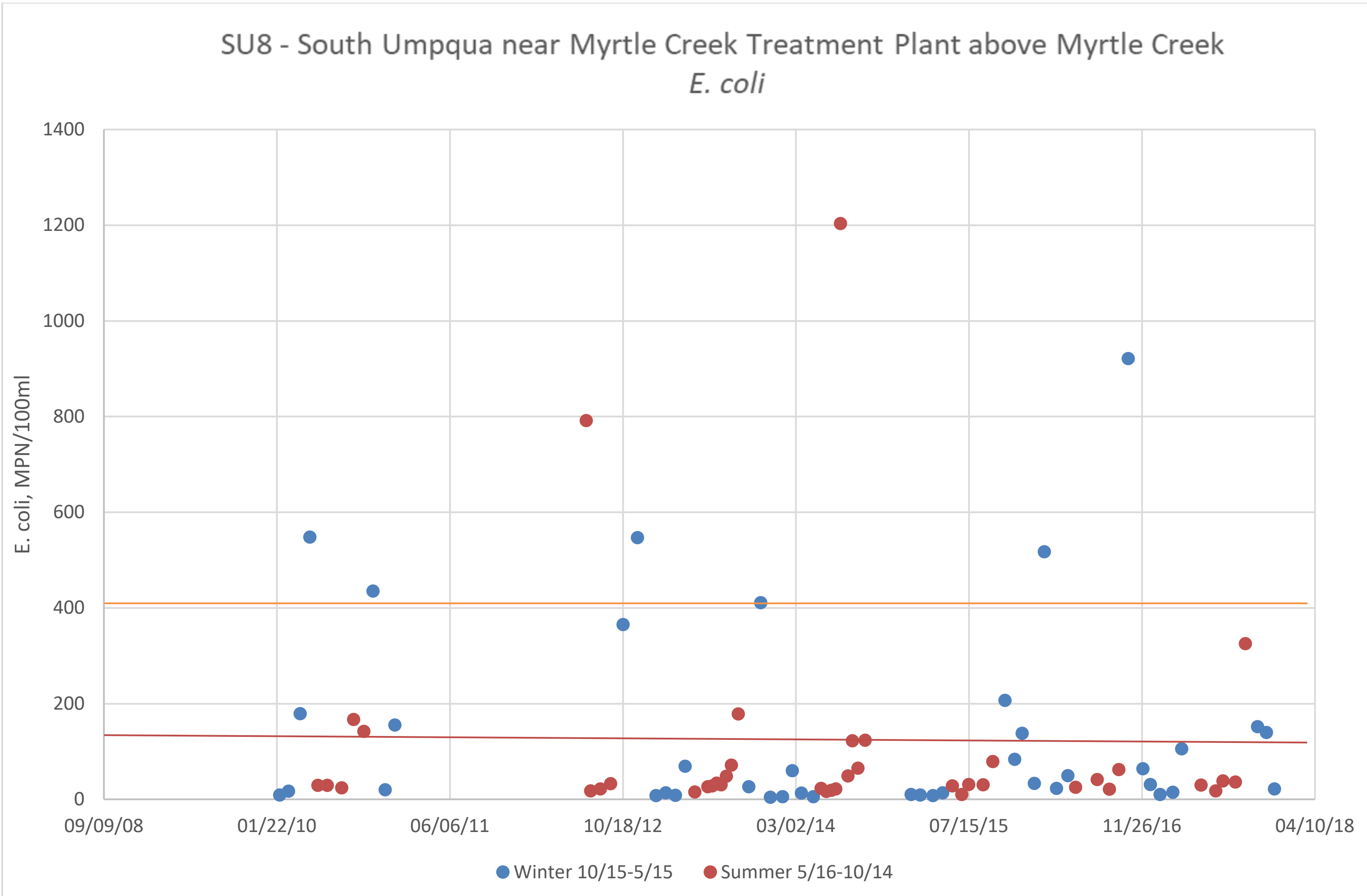
Graph 126. Box plots by year of grab sample conductivity levels of the South Umpqua River above Myrtle Creek.



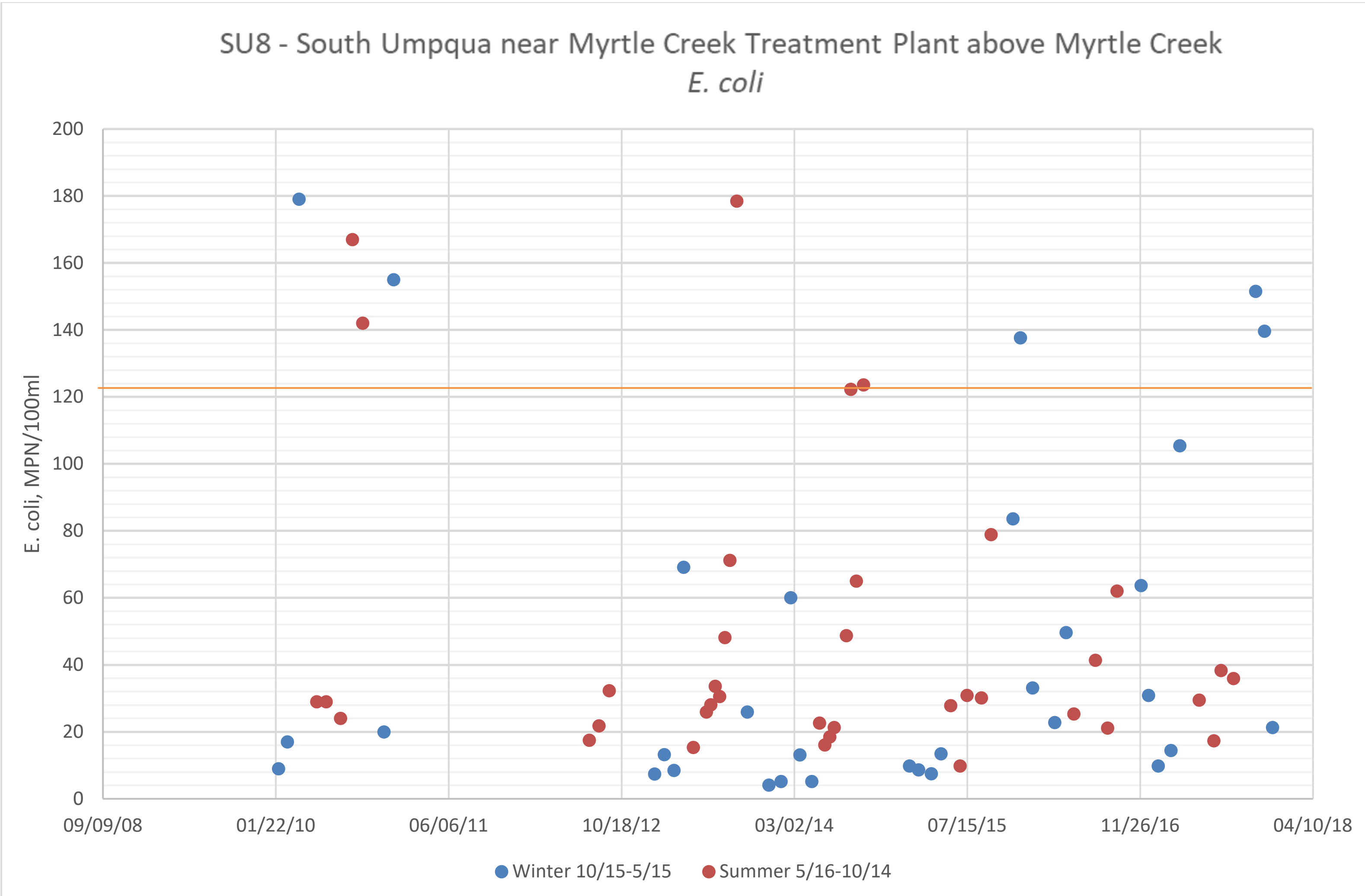
Graph 127. SU8 - South Umpqua near Myrtle Creek Treatment Plant above Myrtle Creek Conductivity 2010-2017 summer and winter separated.



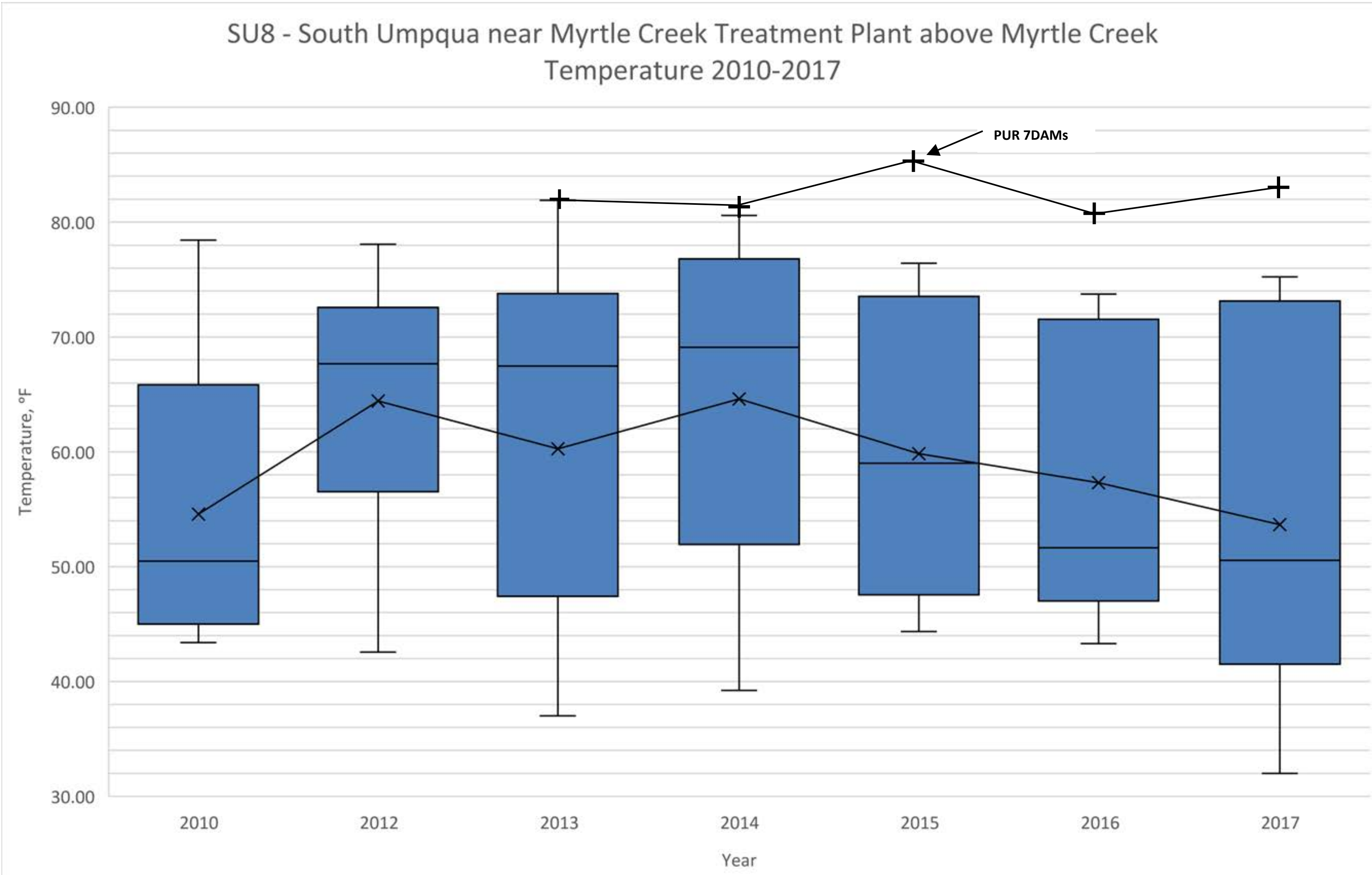
Graph 128. Box plots by year of grab sample *e. coli* levels of the South Umpqua River above Myrtle Creek.



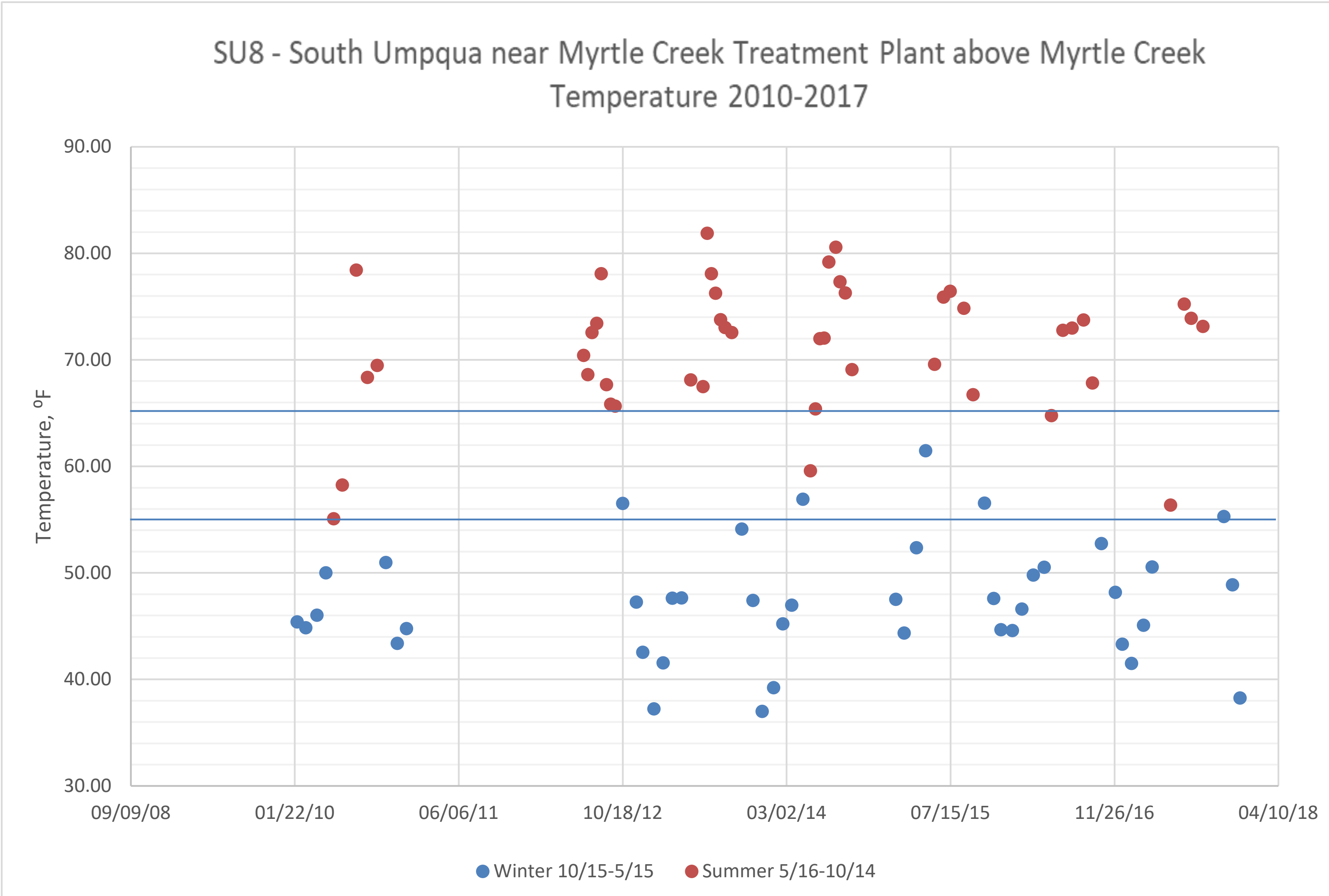
Graph 129. SU8 - South Umpqua near Myrtle Creek Treatment Plant above Myrtle Creek *E. coli* summer and winter separated.



Graph 130. SU8 - South Umpqua near Myrtle Creek Treatment Plant above Myrtle Creek *E. coli* summer and winter separated.



Graph 131. Box plots by year of grab sample temperature levels of the South Umpqua River above Myrtle Creek.

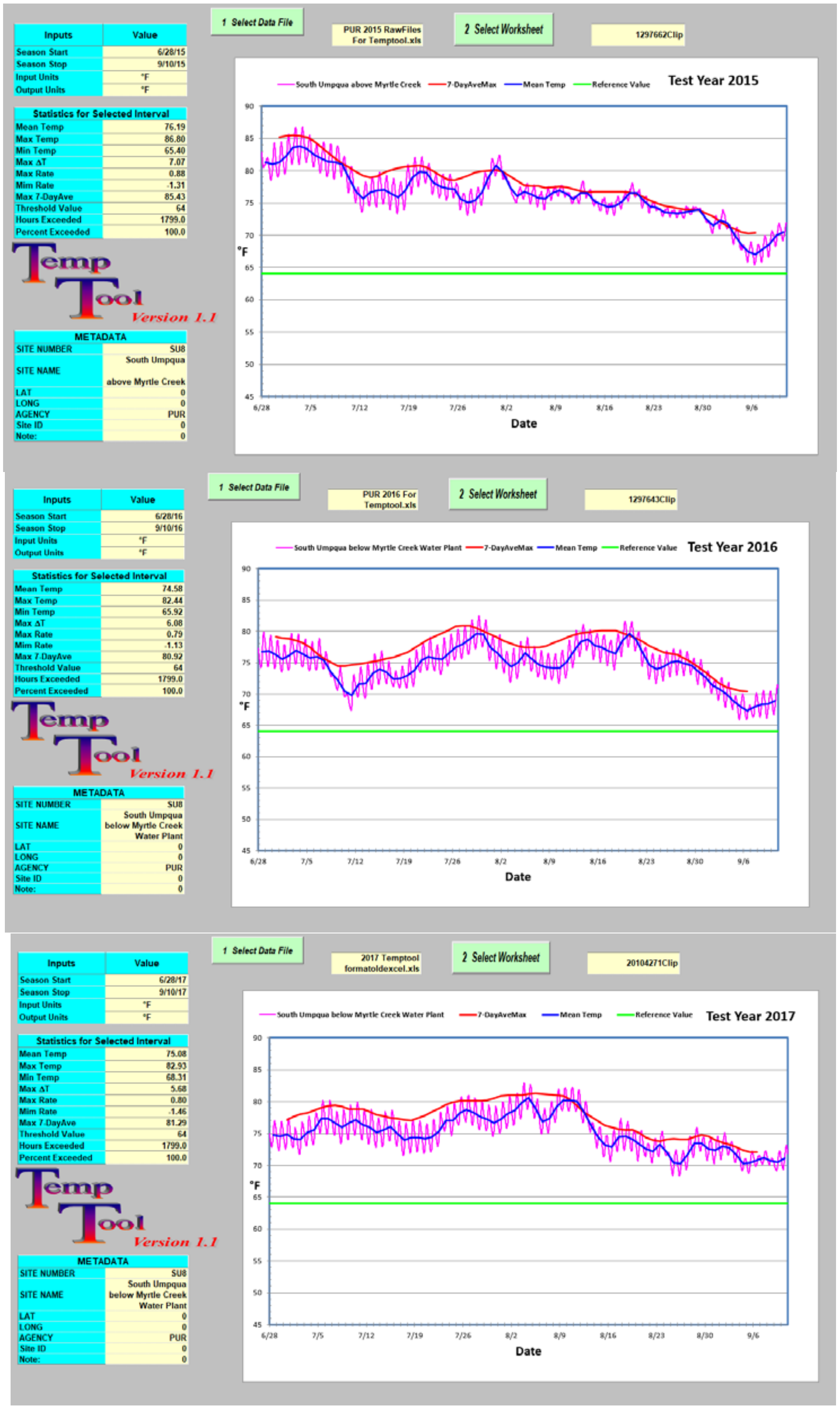


Graph 131. SU8 - South Umpqua near Myrtle Creek Treatment Plant above Myrtle Creek Temperature 2010-2017 summer and winter separated.

Site Name	*Site*	Start Date	Stop Date	Seasonal Maximum		Seasonal Minimum		Seasonal Max ΔT		7-Day averages			
	ID			Date	Value	Date	Value	Date	Value	Date	Max	Min	Δ T
South Umpqua Reference Run													
South Umpqua above Myrtle Creek	SU8	6/24/2015	9/22/2015	7/3/2015	86.8	9/18/2015	62.8	9/22/2015	16.3	7/3/2015	85.4	80.3	5.2
South Umpqua above Myrtle Creek	SU8	6/23/2016	9/19/2016	7/29/2016	82.4	9/14/2016	64	6/26/2016	7	7/28/2016	80.9	76	5
South Umpqua above Myrtle Creek	SU8	6/28/2017	9/20/2017	8/3/2017	82.9	9/20/2017	61.6	8/3/2017	5.7	8/6/2017	81.3	77	4.3

Site Name	*Site*	Days >	Days >	Days >	Hours >	Hours >	Hours >	Warmest day of 7-day max		
	ID	55 F	64 F	70 F	55 F	64 F	70 F	Date	Max	Min
South Umpqua Reference Run										
South Umpqua above Myrtle Creek	*SU8*	91	91	81	2183.5	2135	1842	7/3/2015	86.8	81
South Umpqua above Myrtle Creek	*SU8*	89	89	82	2135.5	2135.5	1709	7/29/2016	82.4	77.2
South Umpqua above Myrtle Creek	*SU8*	85	83	79	2039.5	1978.5	1805.5	8/3/2017	82.9	77.2

Table 33. Continuous temperature data summary for the Cow Creek above Myrtle Creek.



Graph 132. Set of summer daily water temperature data for 2015, 2016 & 2017 for the South Umpqua above Myrtle Creek.

MC1 - Myrtle Creek Near Mouth

Year	Monthly Samples	Months
2010	12	Full Year
2012	17	Jun-Dec, 3 July
2013	28	Full Year, 2X month
2014	22	Jan-Sept, 2X month
2015	12	Full Year
2016	12	Full Year
2017	12	Full Year

Table 34. Number of monitoring events per year included in graphs that follow for Myrtle Creek near the mouth.

Turbidity
Myrtle Creek near the mouth was sampled 2010 thru 2017 (Graphs 133-135.) During our grab sampling, the highest level detected was 131 NTU which occurred in February 2014. Eight occurrences fell above 50 NTU which "The Oregon Watershed Assessment Manual recommends using 50 NTUs as the turbidity evaluation criteria for watershed assessments. At this level, turbidity interferes with sight-feeding aquatic organisms and provides an indication of the biological effect of suspended sediment." There were numerous exceedances of 10 NTU spread over the years, but only one occurred during the summer. No trend is evident. This site needs watching/restoration for high turbidity levels.

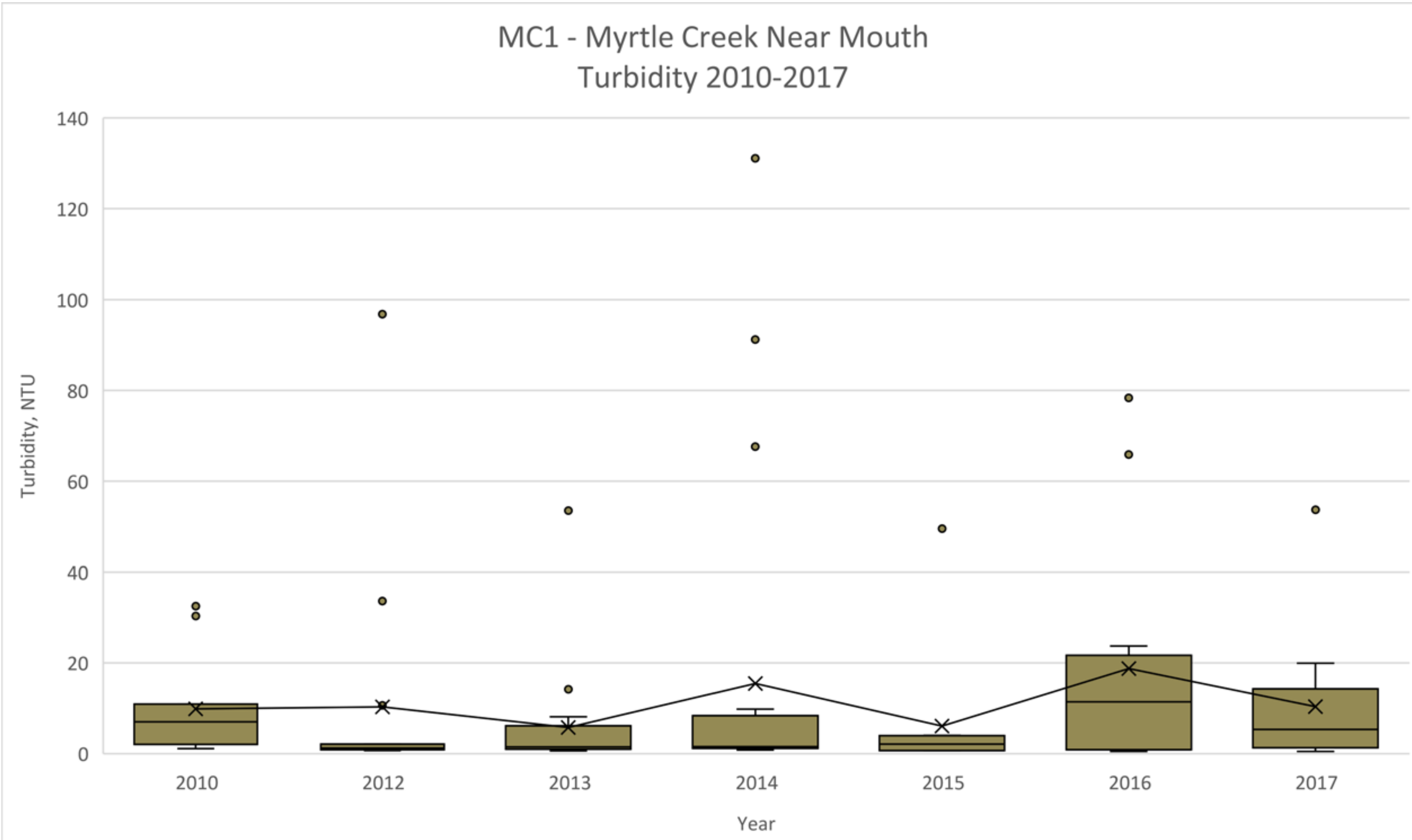
pH
With grab sampling, five events exceeded the upper DEQ recommended limit of 8.5 all five of the exceedances were in summer, likely due to algal photosynthesis during the day. No pH levels were measured below 7.0. The box plot graph (136) does again, as it has for many previous sites, indicate and interesting trend in that the pH values for 2015, 2016, 2017 showing a downward trend in pH for the median and mean values for each year. Graph 138 indicates that both summer and winter pH values are trending downward from 2015-2017 with none exceeding either the upper or lower criteria. This site should be carefully monitored for possible future ongoing changes.

Dissolved Oxygen
Graphs 139 and 140 display the dissolved oxygen grab sample data for Myrtle Creek near the mouth. No levels were detected below the lower limit of eight. Eleven winter measurements did fall below the spawning criteria of eleven, though none were below ten. All summer dissolved oxygen levels were within the acceptable range. No trend is apparent.

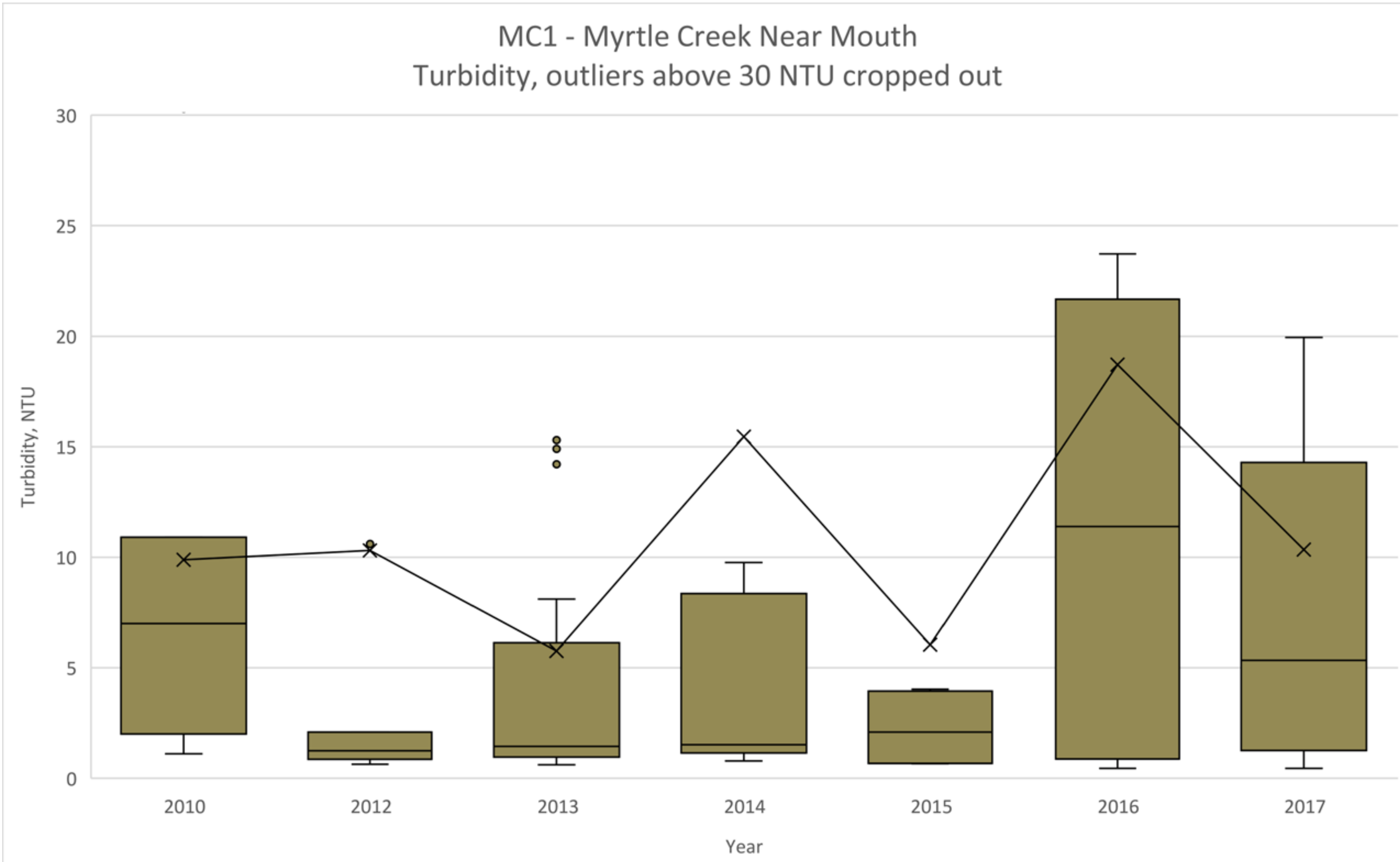
Conductivity
Graphs 141 and 142 display the conductivity grab sample data. All are within normal ranges for the Umpqua basin. No trend is evident, and variation was between 50 and 300 with the higher readings mostly occurring during the summer.

E. coli
E. coli levels are displayed in graphs 143 through 145**.** 31 sampling events occurred high enough to list this section of the South Umpqua River. 24 occurred in winter and seven in summer. Also, many samples, both summer and winter, were above the 126 MPN/100ml which DEQ criteria indicates would have to have been measured 5 times in one month to have listed it. One time reading at 406 MPN/ml or greater would list a stream. No trend is evident. Myrtle Creek needs attention paid to this *E. coli* problem.

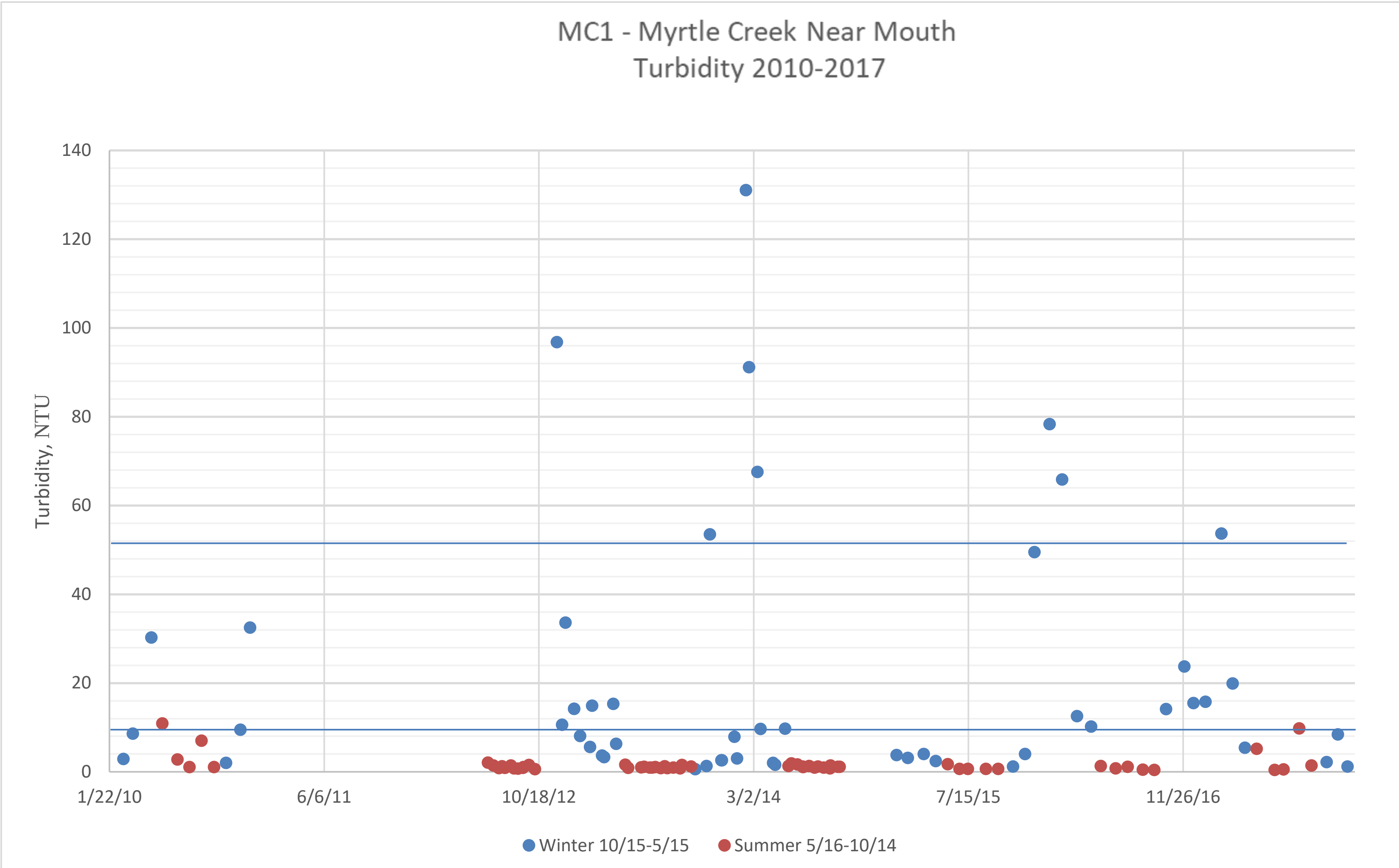
Temperature
Graphs 146, 147 and Table 35 display the temperature data for the South Umpqua River at Myrtle Creek. We placed summer data loggers at this site for three years of continuous data which showed that the 7DAM was always above 75°F and lists this stretch of the creek for temperature. Even our grab sample temperature data was an indicator of this problem. The winter temperatures mostly all fell below the 55.4°F spawning criteria with only four exceeding it and these were in May very near the 15^{th} (two occurred on the 14^{th} of May. No trend is evident.



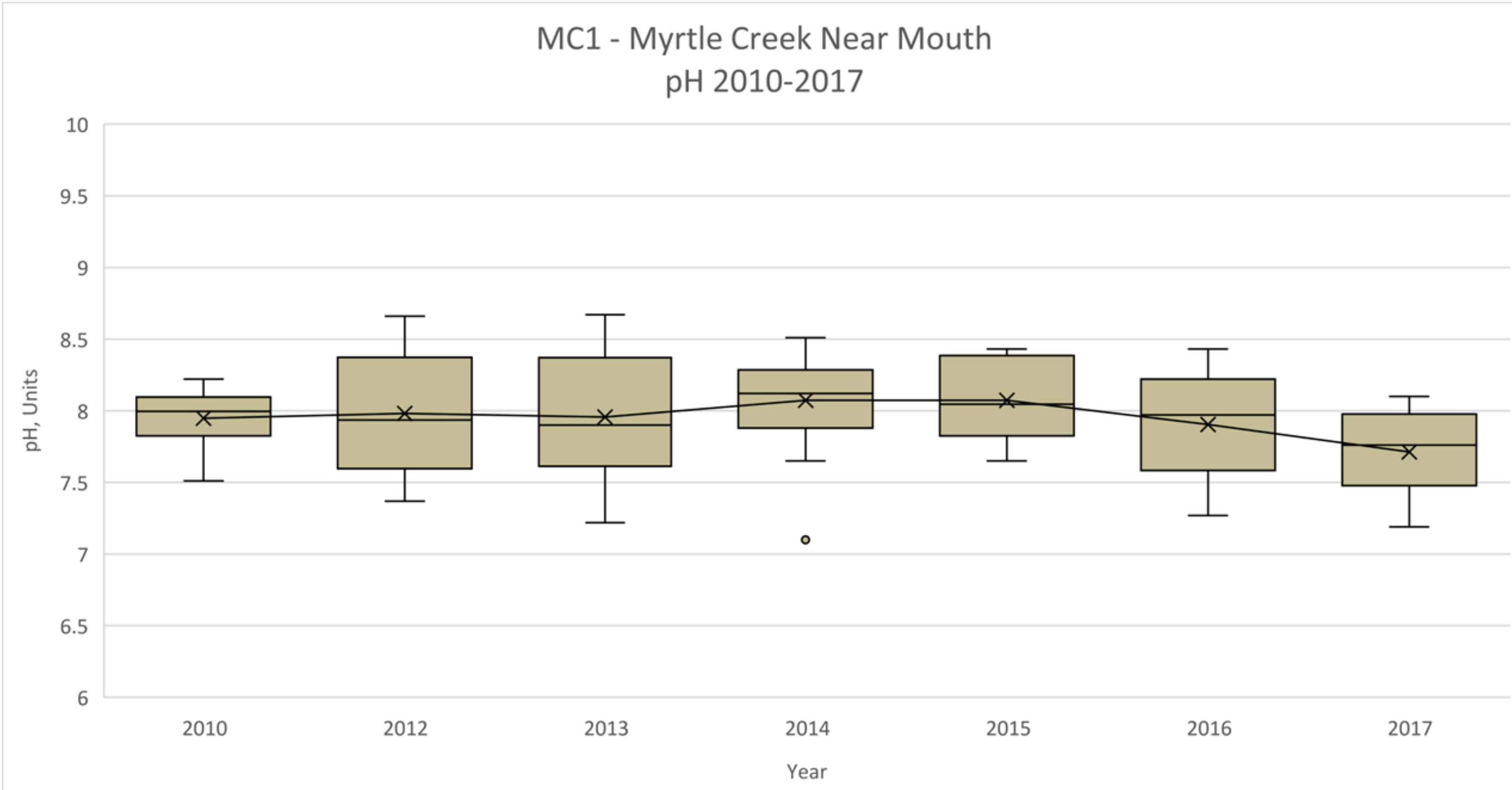
Graph 133. Box plots by year of grab sample turbidity levels of Myrtle Creek near mouth.



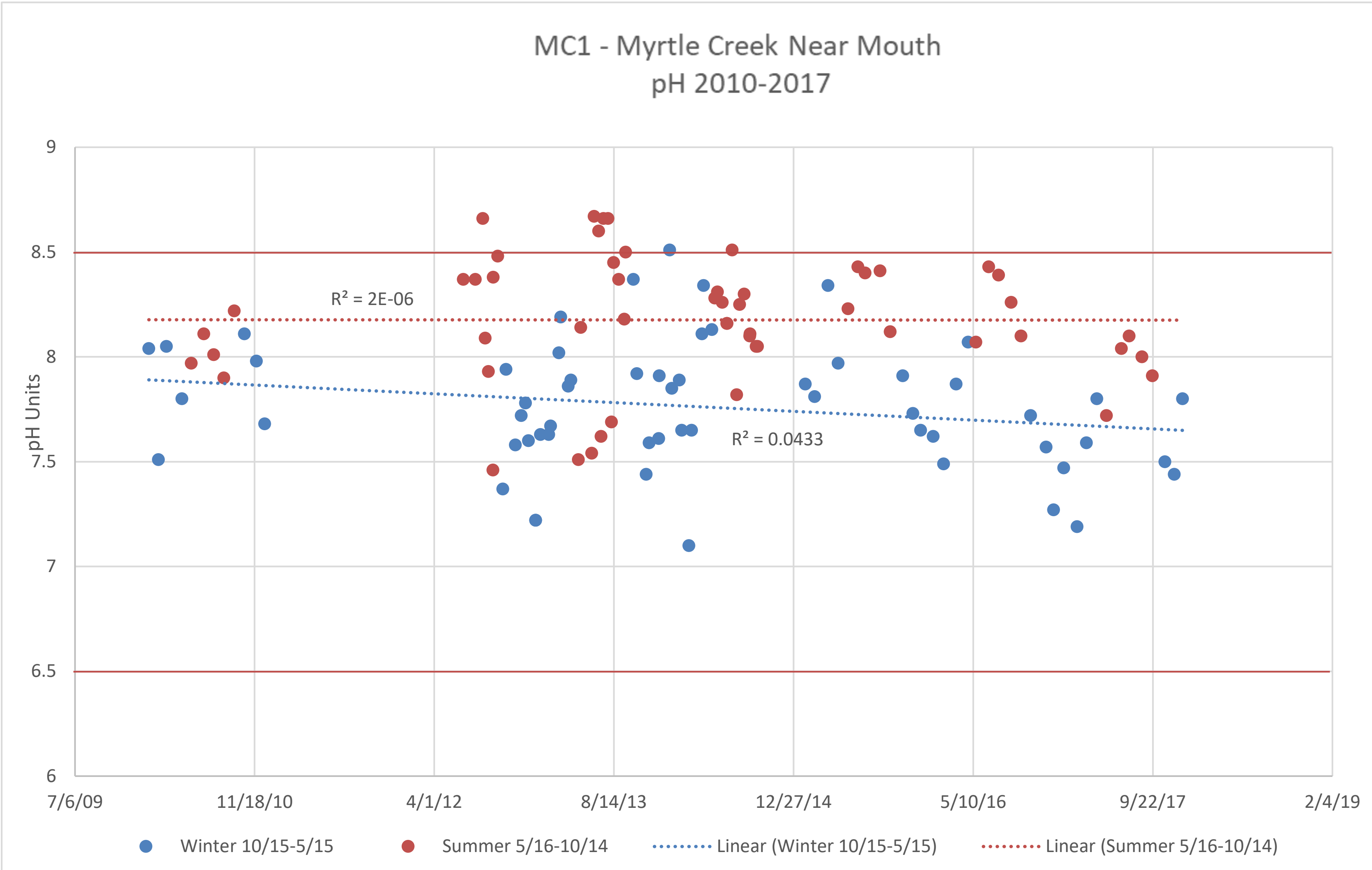
Graph 134. Box plots by year of grab sample turbidity levels of Myrtle Creek near mouth outliers above 30 NTU removed.



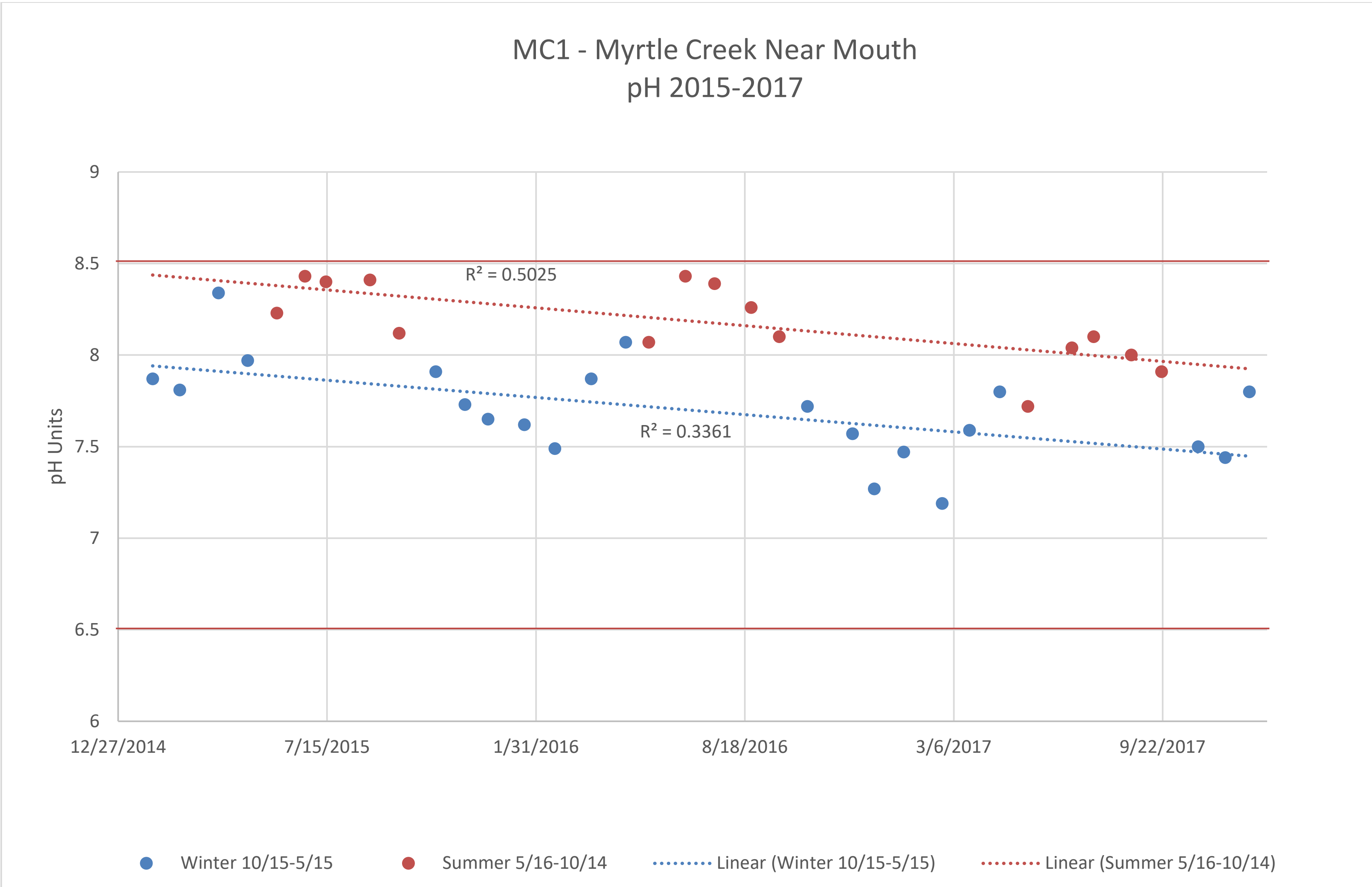
Graph 135. MC1 - Myrtle Creek near mouth turbidity grab sample 2010-2017.



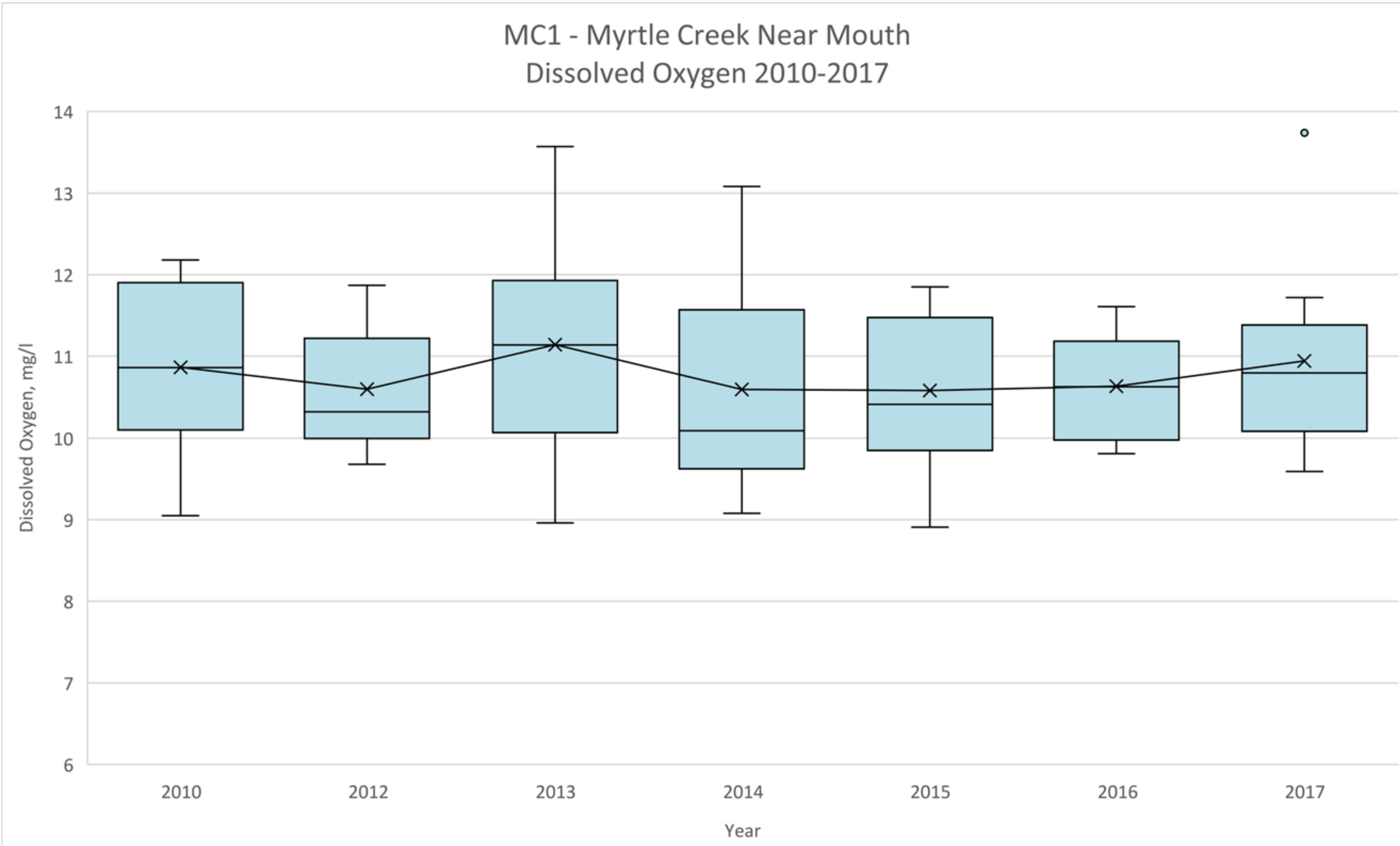
Graph 136. Box plots by year of grab sample pH levels of Myrtle Creek near mouth.



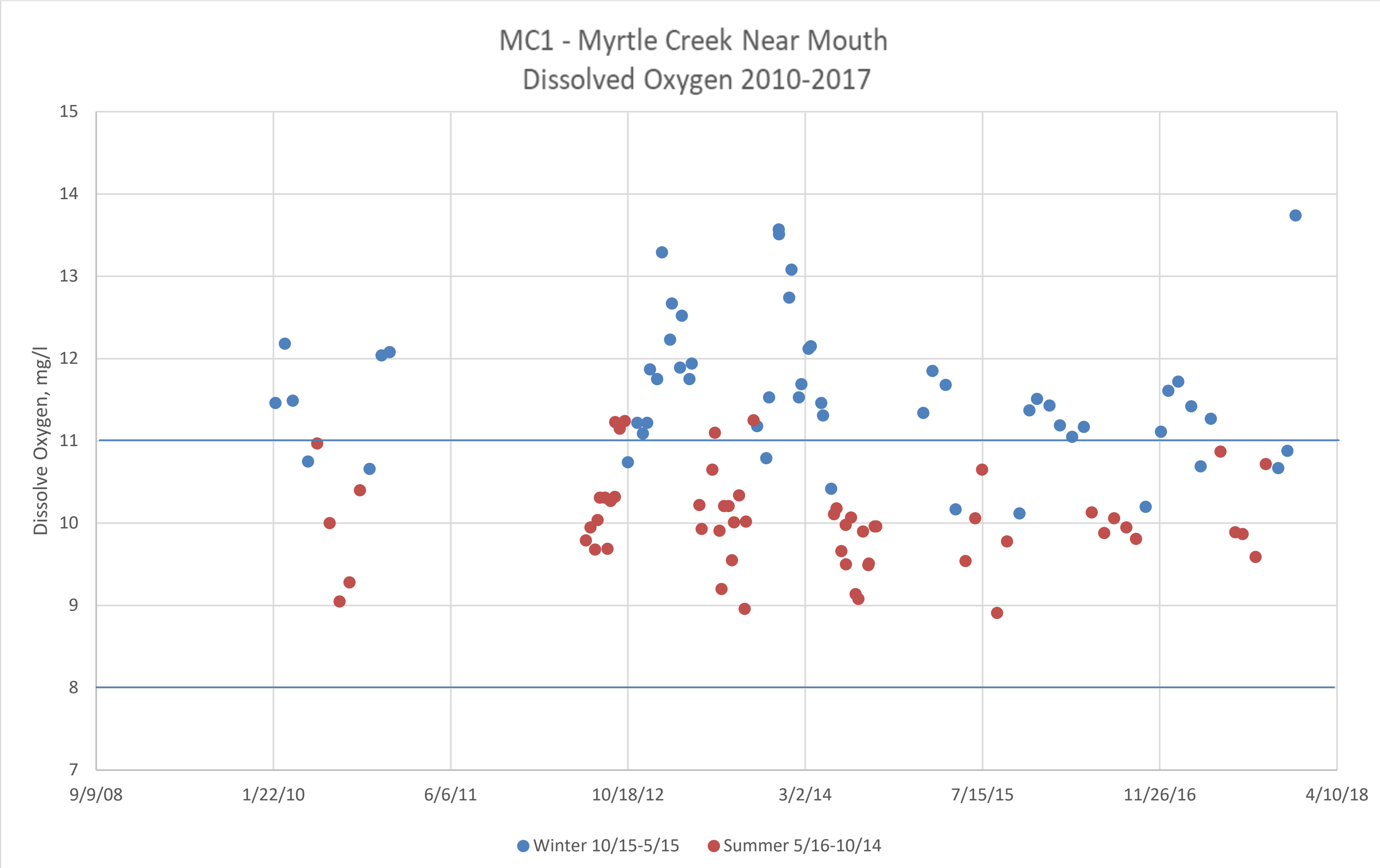
Graph 137. MC1 - Myrtle Creek Near Mouth pH 2010-2017 summer and winter separated.



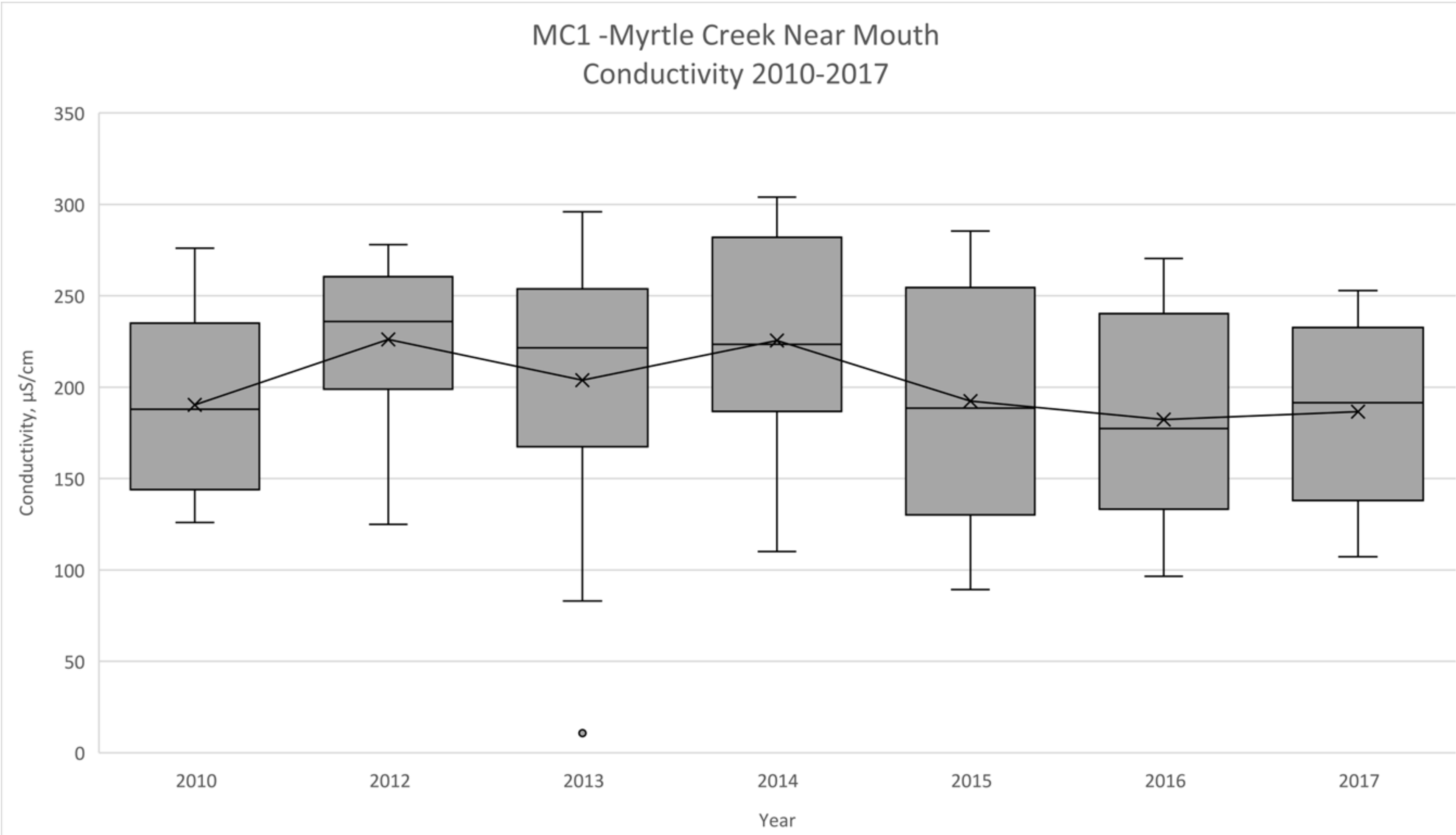
Graph 138. MC1 - Myrtle Creek Near Mouth pH 2015-2017 summer and winter separated.



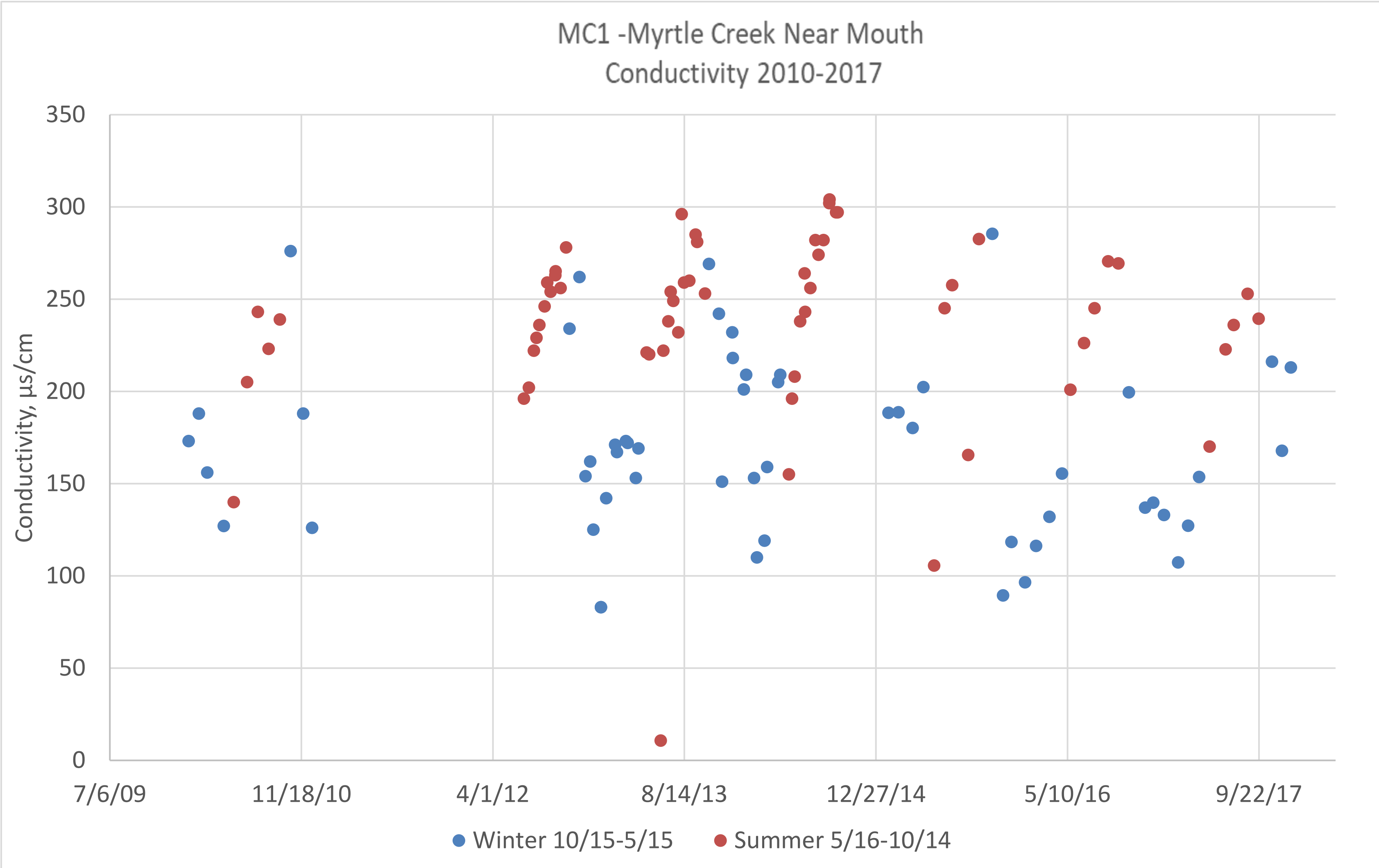
Graph 139. Box plots by year of grab sample dissolved oxygen levels of Myrtle Creek near mouth.



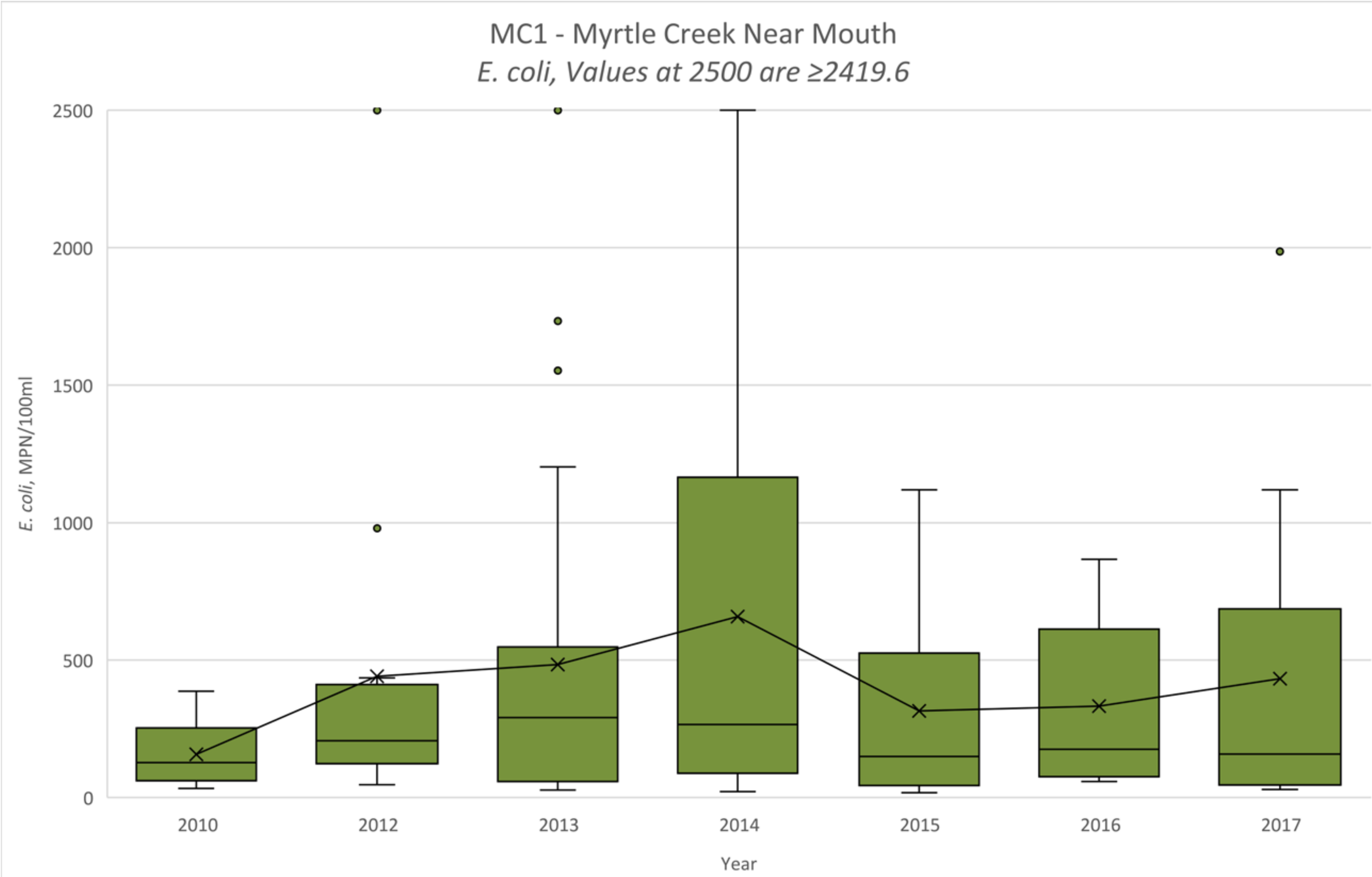
Graph 140. MC1 - Myrtle Creek Near Mouth Dissolved Oxygen 2010-2017



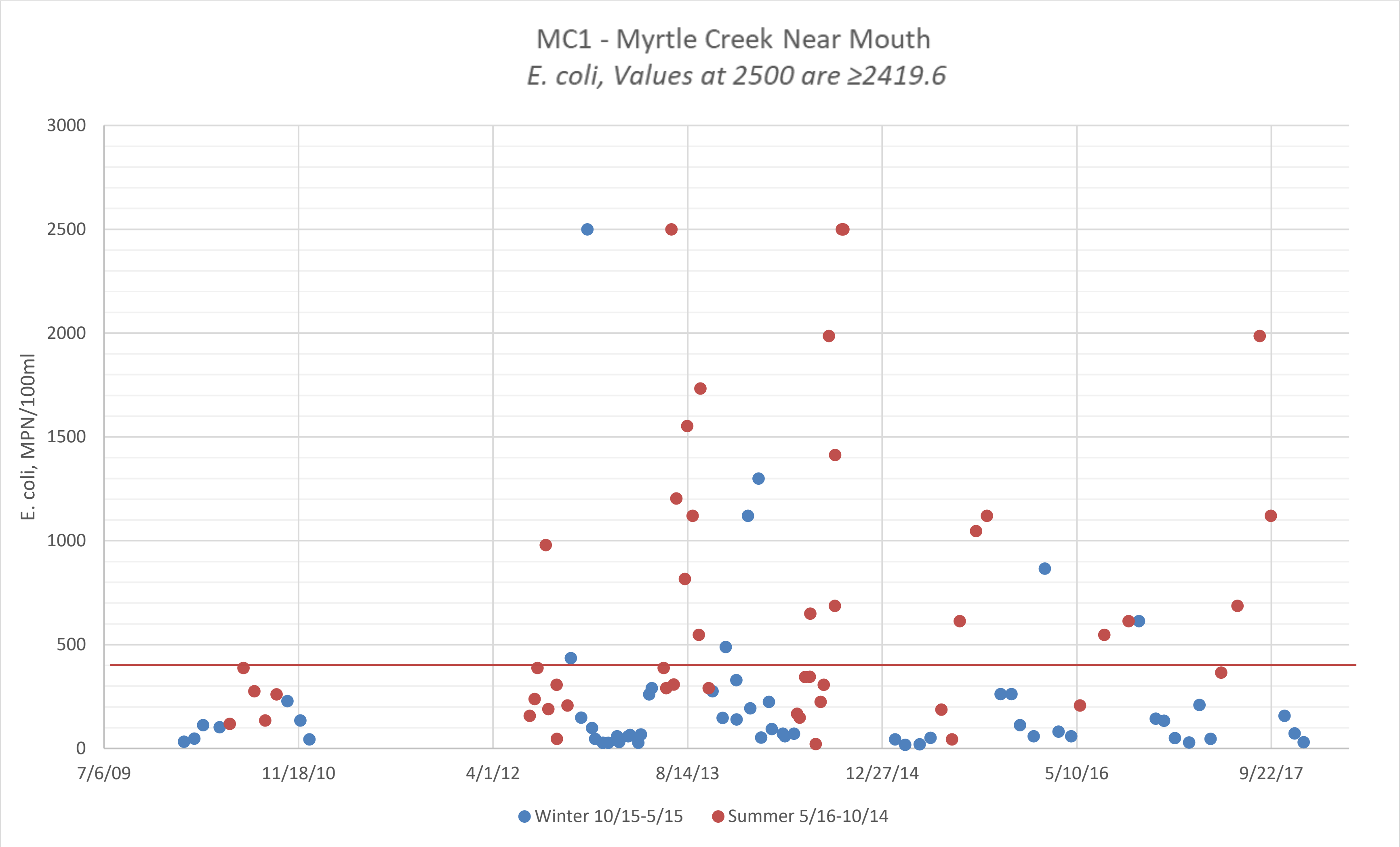
Graph 141. Box plots by year of grab sample conductivity levels of Myrtle Creek near mouth.



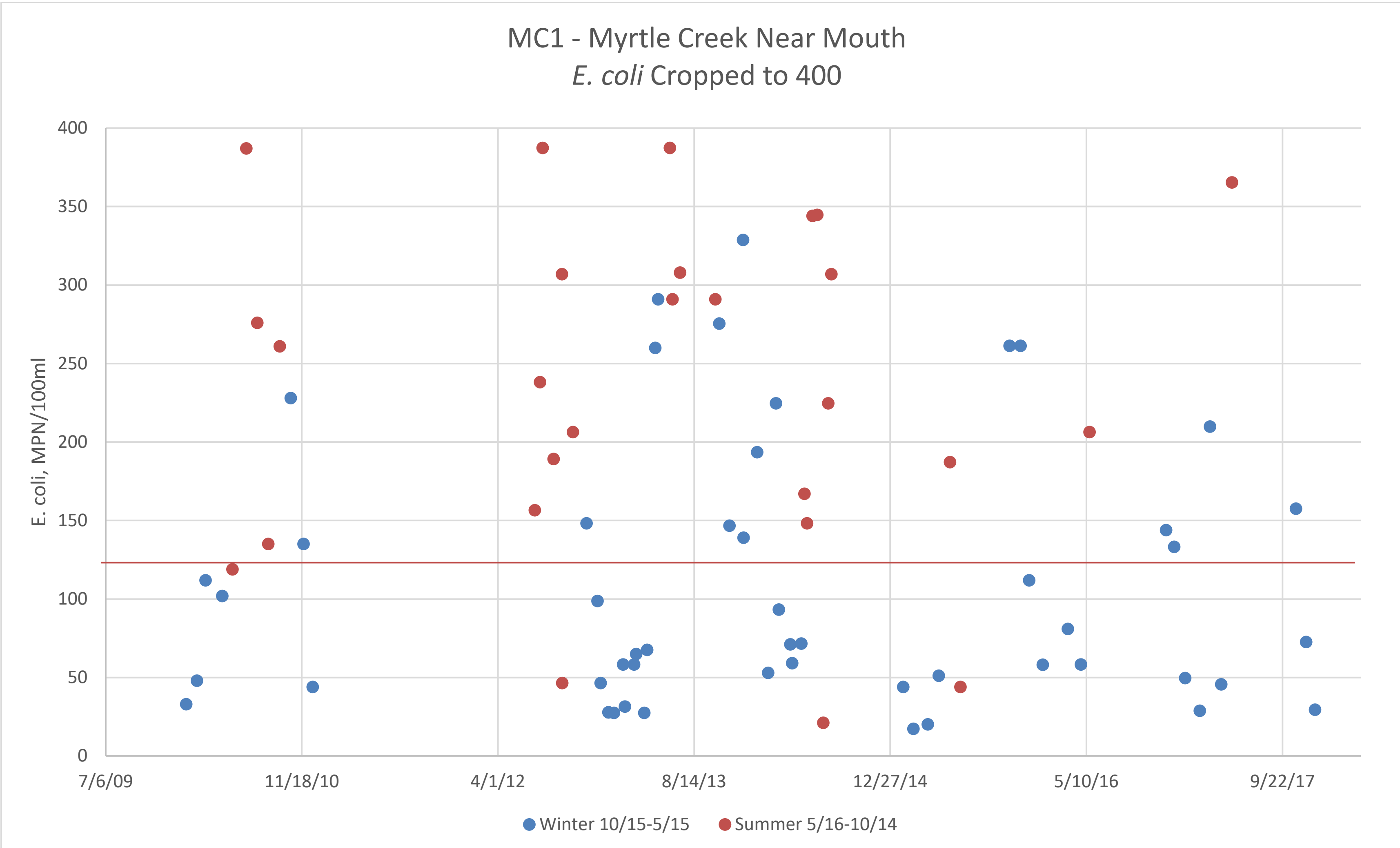
Graph 142. MC1 -Myrtle Creek Near Mouth Conductivity 2010-2017 Summer and Winter Separated



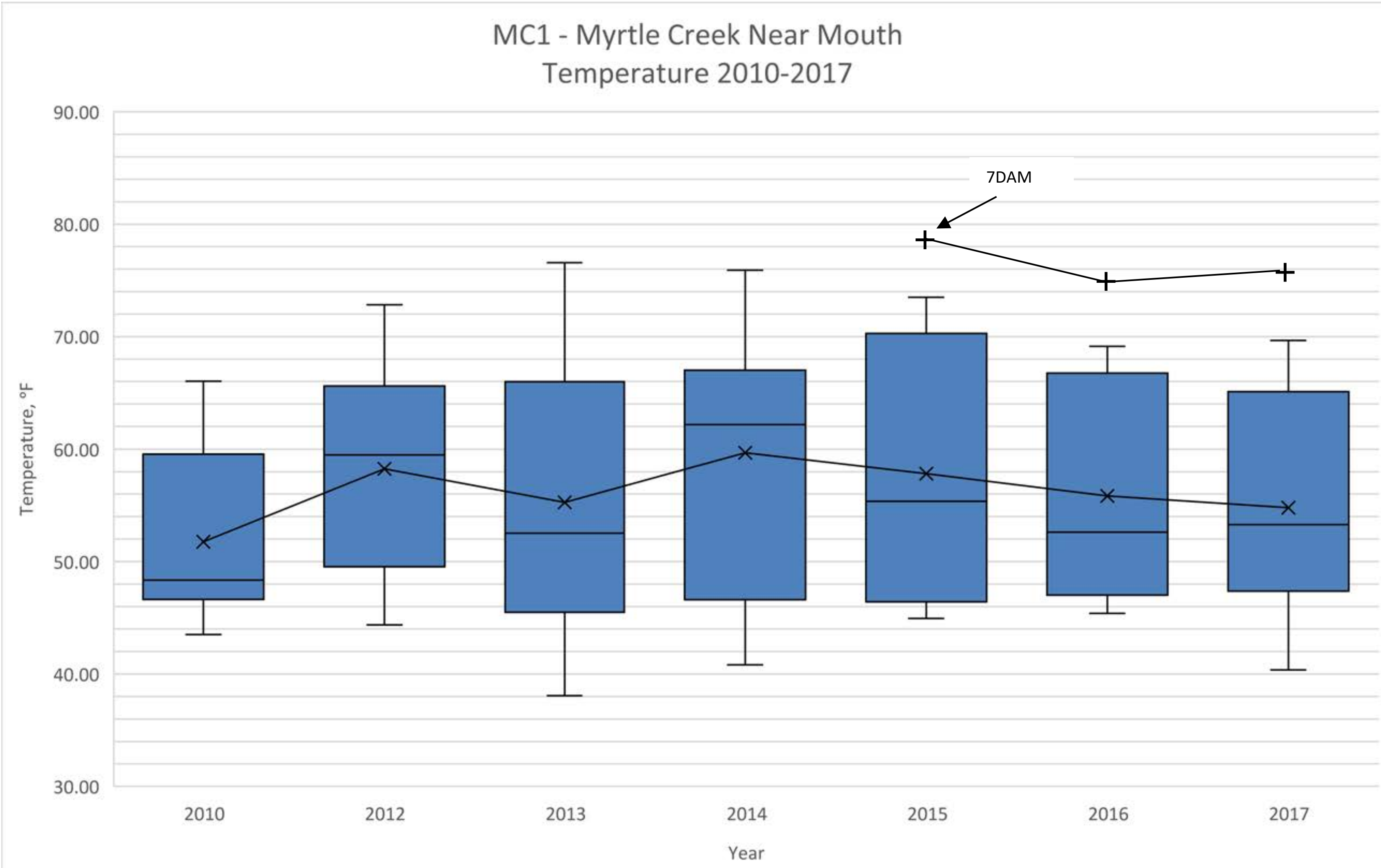
Graph 143. Box plots by year of grab sample turbidity *E. coli* levels of Myrtle Creek near mouth.



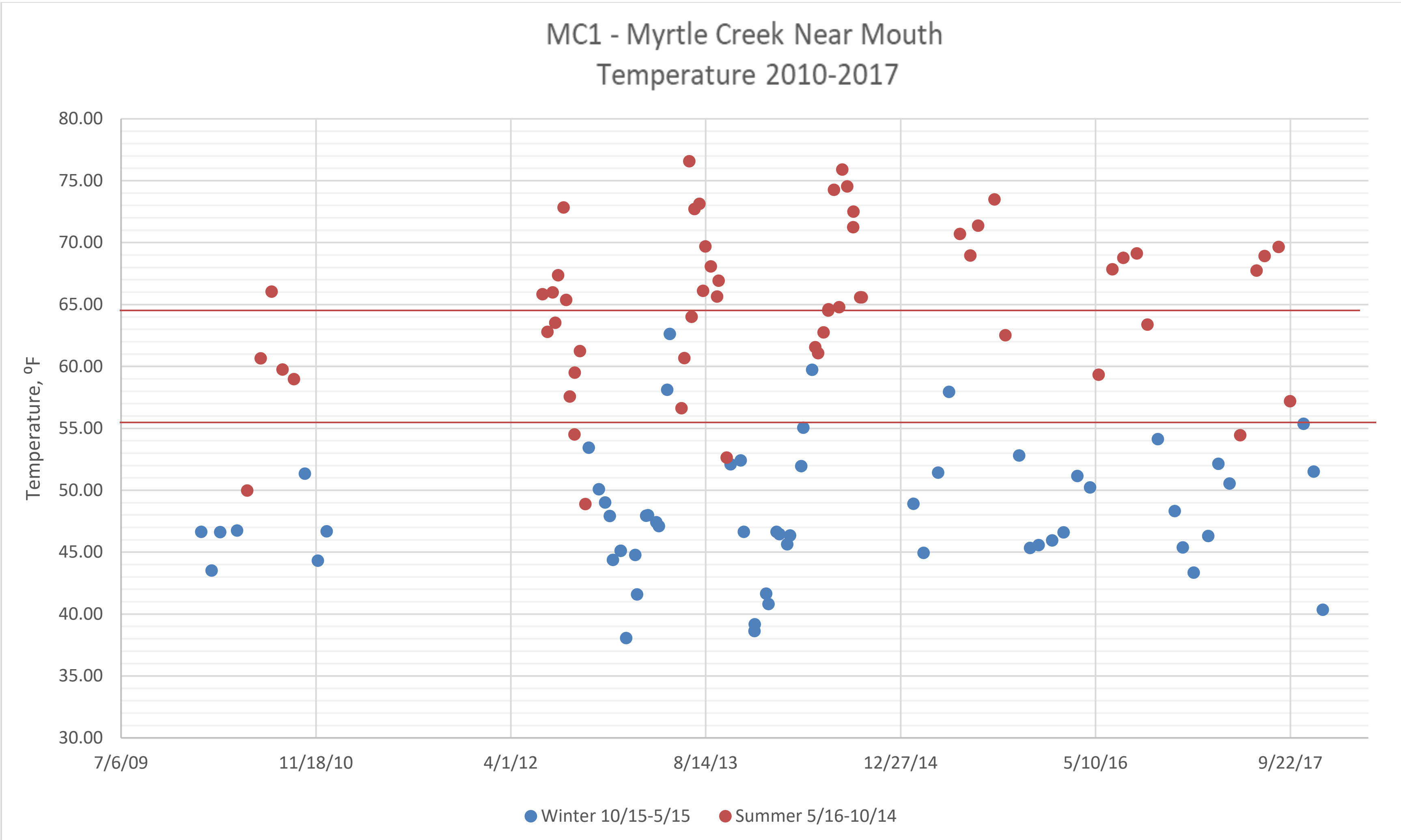
Graph 144. MC1 - Myrtle Creek Near Mouth E. coli, Values at 2500 are ≥2419.6 summer and winter separated.



Graph 145. MC1 - Myrtle Creek Near Mouth E. coli, Values Cropped to 400, summer and winter separated.



Graph 146. Box plots by year of grab sample temperature levels of Myrtle Creek near mouth.



Graph 147. MC1 - Myrtle Creek Near Mouth Temperature 2010-2017 summer and winter separated.

Site Name	Site	Start Date	Stop Date	Seasonal Maximum		Seasonal Minimum		Seasonal Max ΔT		7-Day averages			
	ID			Date	Value	Date	Value	Date	Value	Date	Max	Min	Δ T
South Umpqua Reference Run													
Myrtle Creek near mouth	MC1	6/24/2015	9/22/2015	7/2/2015	79.7	9/6/2015	55	9/22/2015	19.9	7/4/2015	78.6	69.6	9
Myrtle Creek near mouth	MC1	6/23/2016	9/19/2016	7/29/2016	76.9	9/14/2016	57.7	7/2/2016	10.4	7/28/2016	74.9	66.3	8.6
Myrtle Creek near mouth	MC1	6/28/2017	9/20/2017	8/3/2017	77.6	9/16/2017	56.9	8/3/2017	10	8/6/2017	75.9	68	7.9

Site Name	Site	Days >	Days >	Days >	Hours >	Hours >	Hours >	Warmest day of 7-day max		
	ID	55 F	64 F	70 F	55 F	64 F	70 F	Date	Max	Min
South Umpqua Reference Run										
Myrtle Creek near mouth	*MC1*	91	82	67	2183	1728.5	760	7/2/2015	79.7	70.4
Myrtle Creek near mouth	*MC1*	89	79	50	2135.5	1553	433.5	7/29/2016	76.9	67.5
Myrtle Creek near mouth	*MC1*	85	79	54	2039.5	1696.5	540	8/3/2017	77.6	67.6

Table 35. Continuous temperature data summary for Myrtle Creek near the mouth.

SM1 – South Myrtle Creek Near Mouth

Year	Monthly Samples	Months
2006	9	
2009	8	
2010	12	Full Year
2012	17	Jun-Dec, 3 July
2013	28	Full Year, 2X month
2014	22	Jan-Sept, 2X month
2015	12	Full Year
2016	12	Full Year
2017	12	Full Year

Table 36. Number of monitoring events per year included in graphs that follow for South Myrtle near mouth.

Turbidity

South Myrtle Creek near the mouth was sampled 2006 thru 2017 (Graphs 148-149.) During our grab sampling, the highest level detected was 128 NTU which occurred in January 2006. Only one other occurrence fell above 50 NTU which "The Oregon Watershed Assessment Manual recommends using 50 NTUs as the turbidity evaluation criteria for watershed assessments. At this level, turbidity interferes with sight-feeding aquatic organisms and provides an indication of the biological effect of suspended sediment." There were numerous exceedances of 10 NTU spread over the years, but only one of these occurred during the summer. No trend is evident.

pH

With grab sampling, no events exceeded the upper DEQ recommended limit of 8.5 or fell below the lower exceedance. No pH levels were measured below 7.0. The box plot graph (150) does again, as it has for many previous sites, what appears to show a downward trend in pH values for 2015, 2016, 2017 showing a downward trend in pH for the mean values only for each year. Graph 152 shows both summer and winter pH values are not indicating a R-Squared any greater than .22 from 2015-2017. Grab sampling for pH at this site indicates no cause for concern.

Dissolved Oxygen

Graphs 153 and 154 display the dissolved oxygen grab sample data for South Myrtle Creek near the mouth. No levels were detected below the lower limit of eight. Ten winter measurements did fall below the spawning criteria of eleven, though none were below ten. All summer dissolved oxygen levels were within the acceptable range. No trend is apparent.

Conductivity

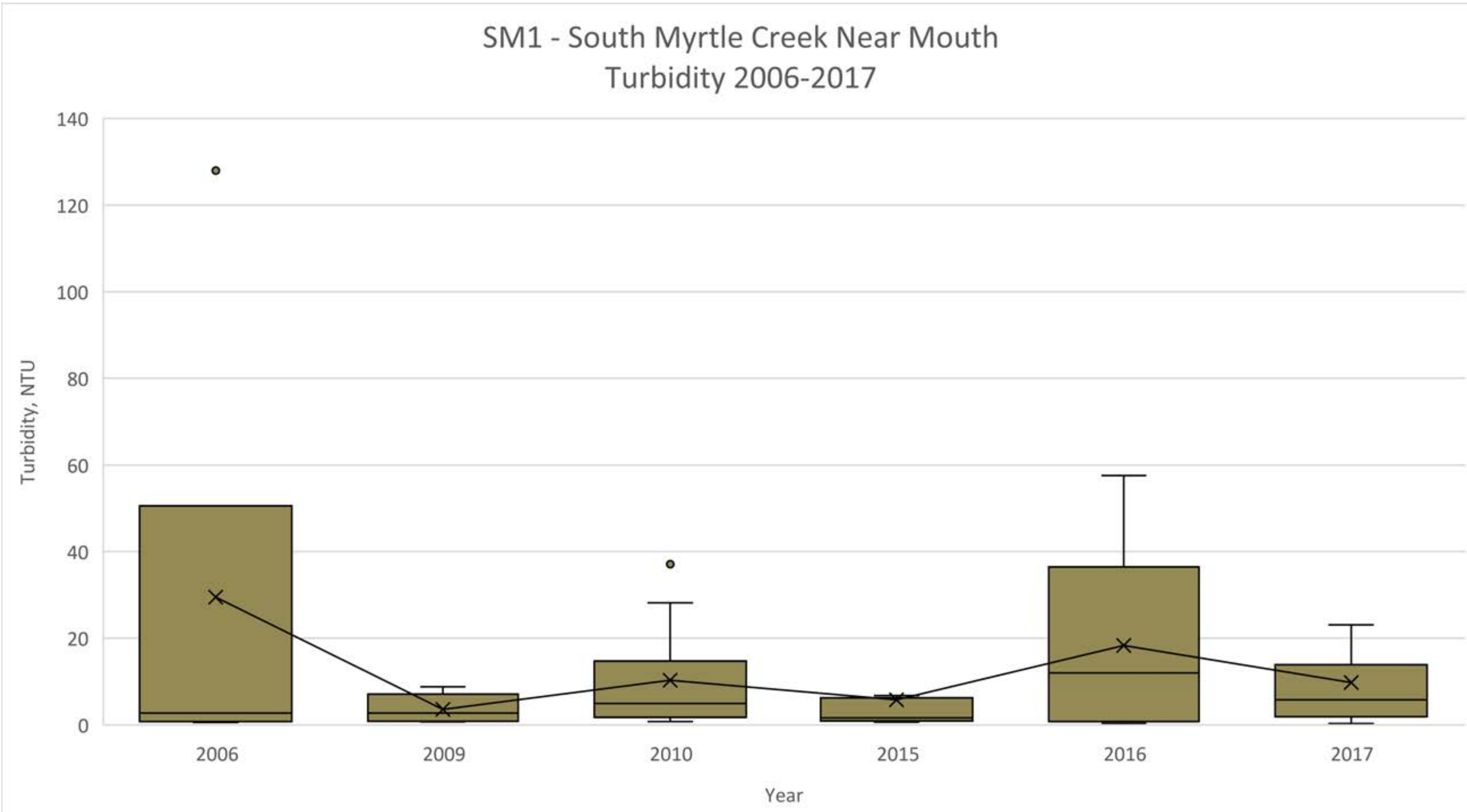
Graphs 155 and 156 display the conductivity grab sample data. All are within normal ranges for the Umpqua basin. No trend is evident, and variation was between 50 and 368 with the higher readings mostly occurring during the summer as flows decrease.

E. coli

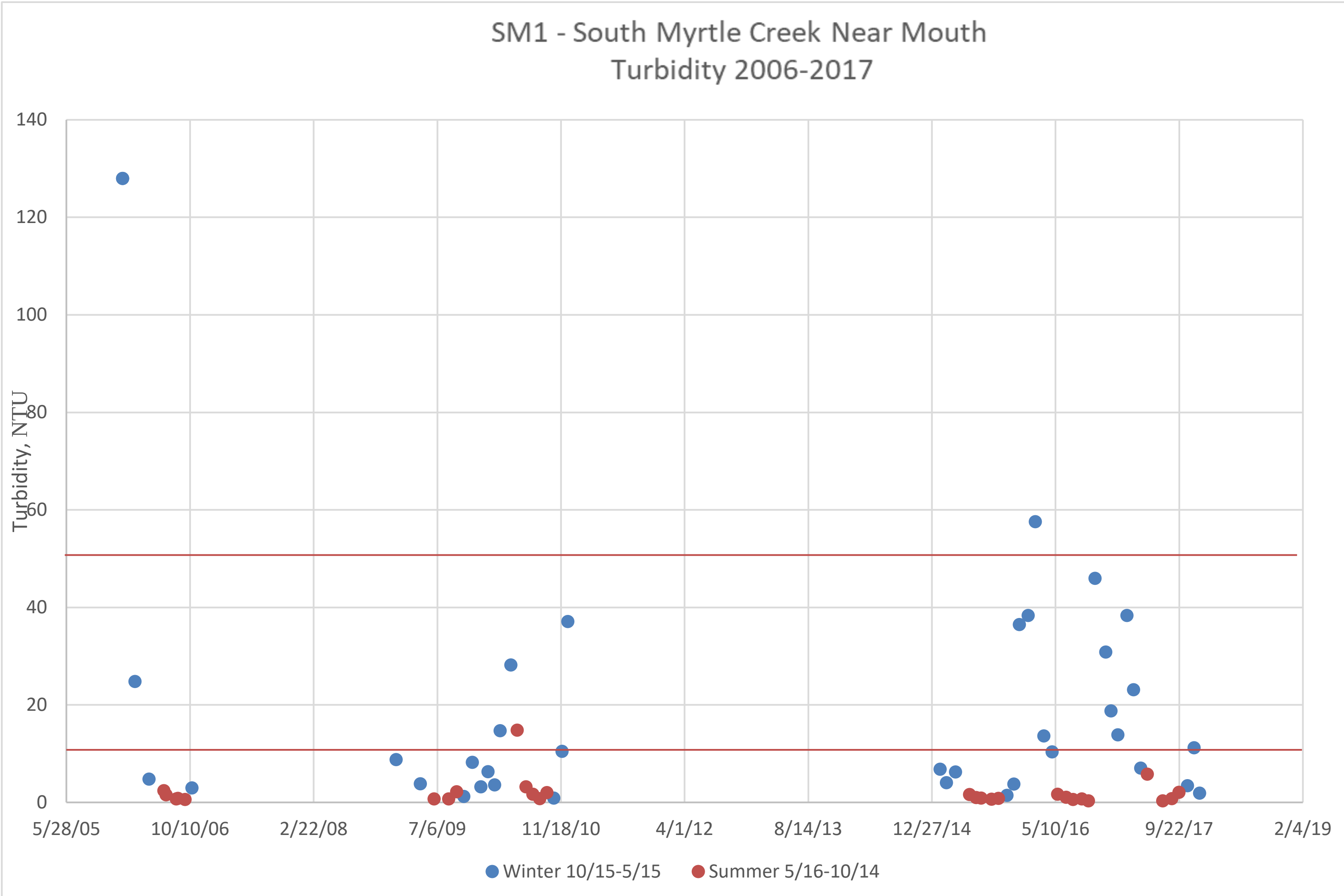
E. coli levels are displayed in graphs 157 and 158**.** Thirteen sampling events occurred high enough to list this section of South Myrtle Creek. Three occurred in winter and ten in summer. Also, many samples, both summer and winter, were above the 126 MPN/100ml which DEQ criteria indicates would have to have been measured 5 times in one month to have listed it. One time reading at 406 MPN/ml or greater would list a stream. No trend is evident. South Myrtle Creek needs attention paid to this *E. coli* problem.

Temperature

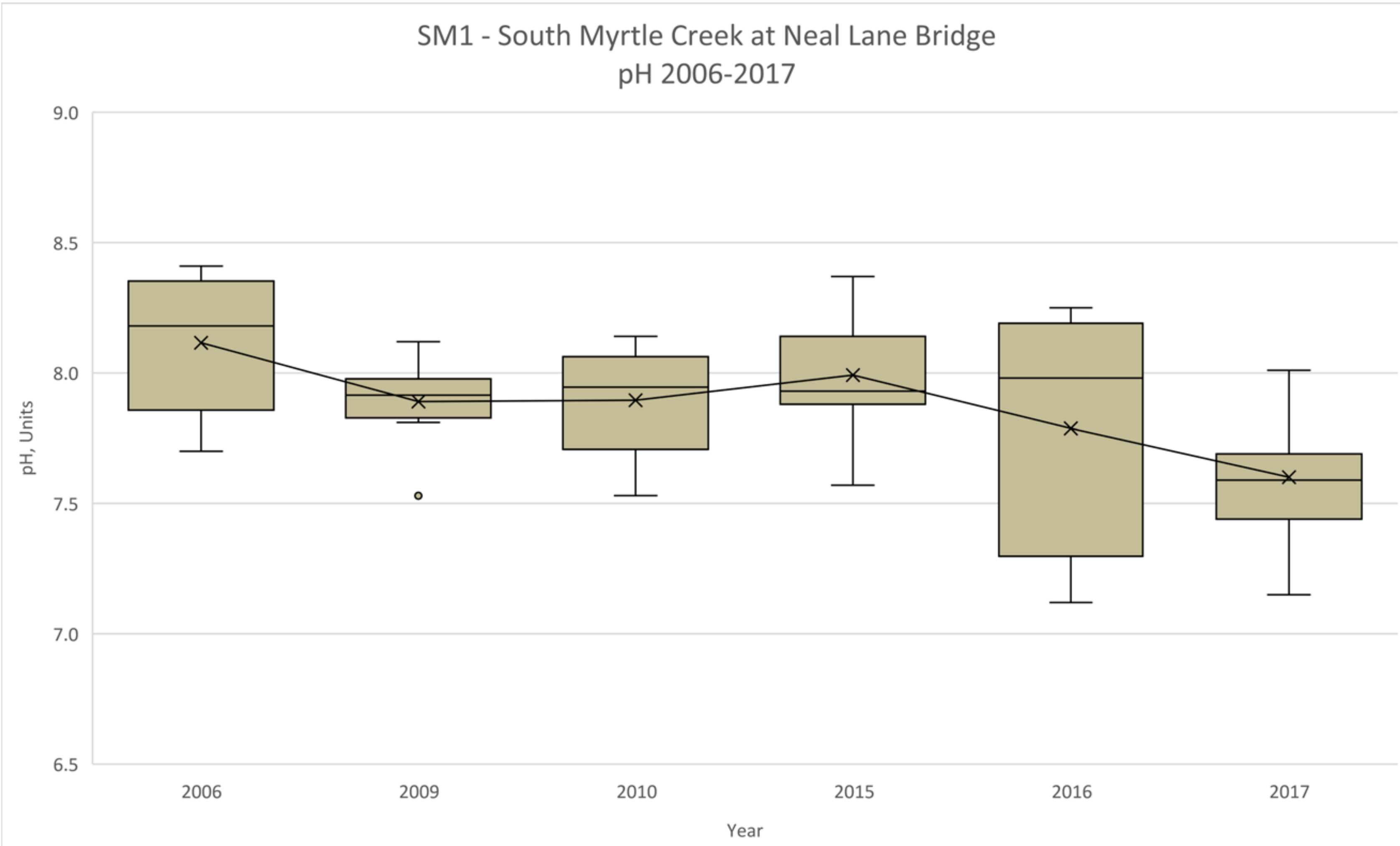
Graphs 159 and 160 display the temperature data for the South Myrtle Creek. The winter temperatures were good with all falling below the 55.4°F spawning criteria. Summer temperature had 12 exceedances of the 64.4°F criteria and 15 meeting the criteria. No trend is evident.



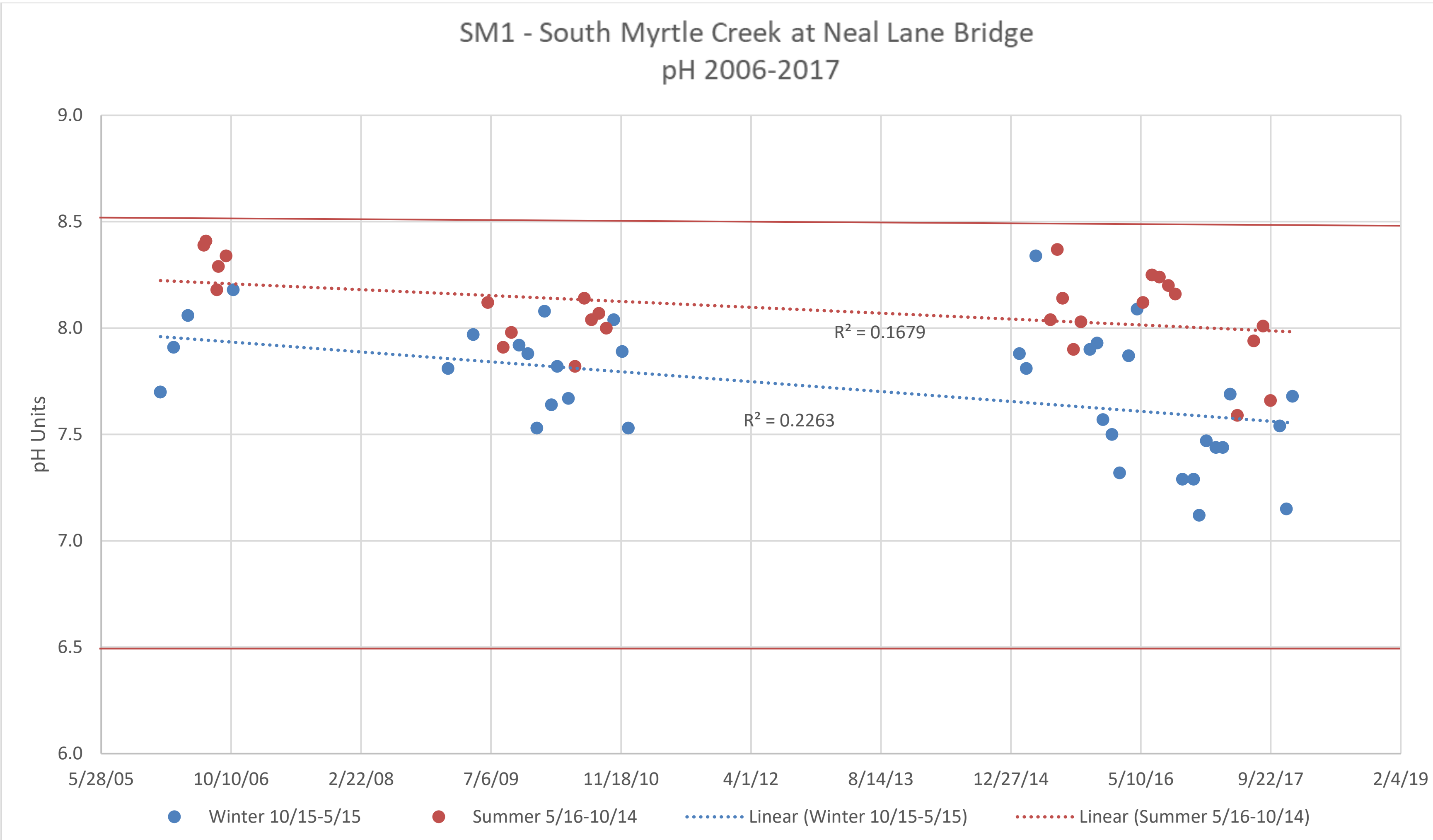
Graph 148. Box plots by year of grab sample turbidity levels of South Myrtle Creek near mouth.



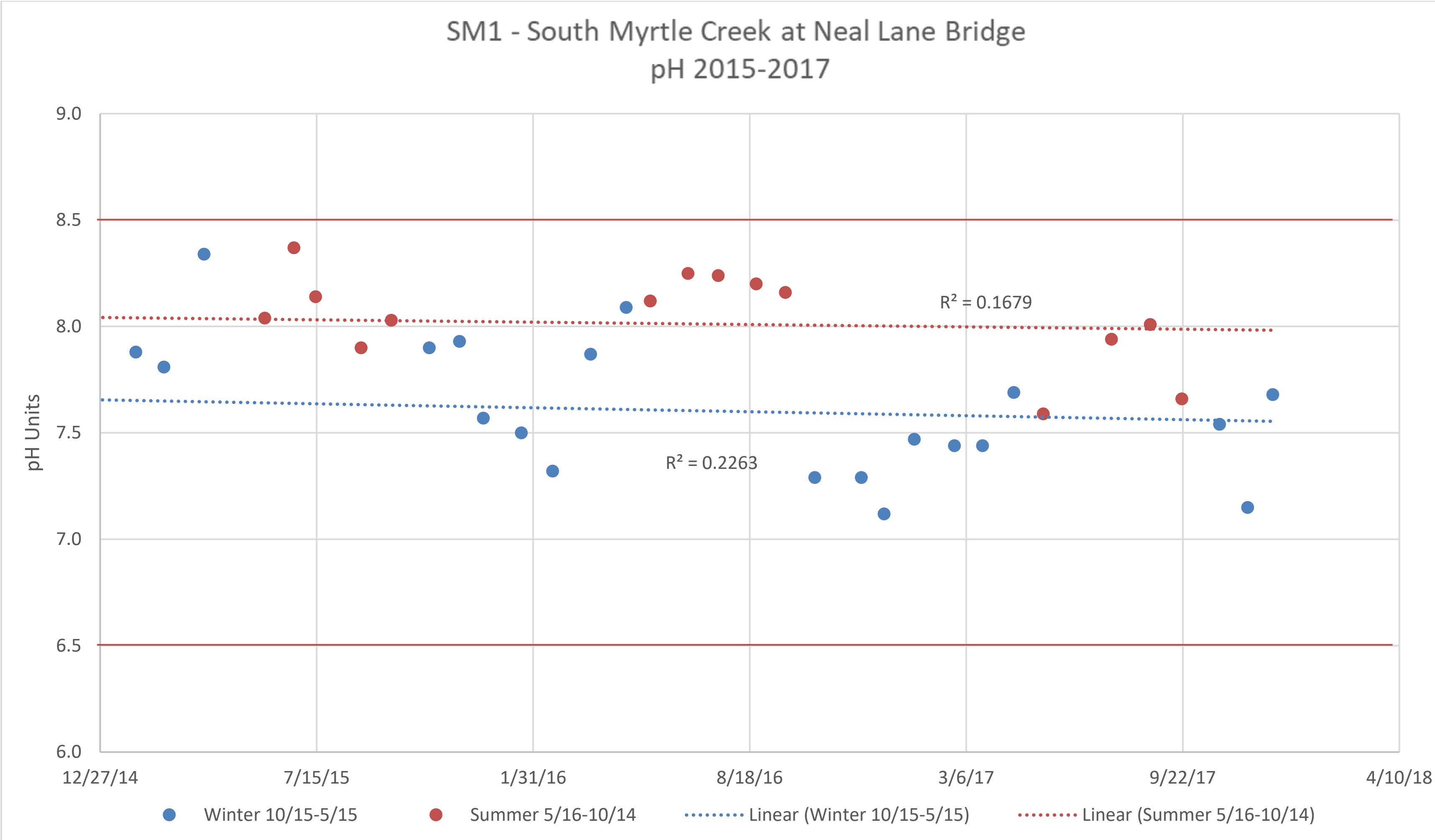
Graph 149. SM1 - South Myrtle Creek Near Mouth Turbidity 2006-2017 summer and winter separated.



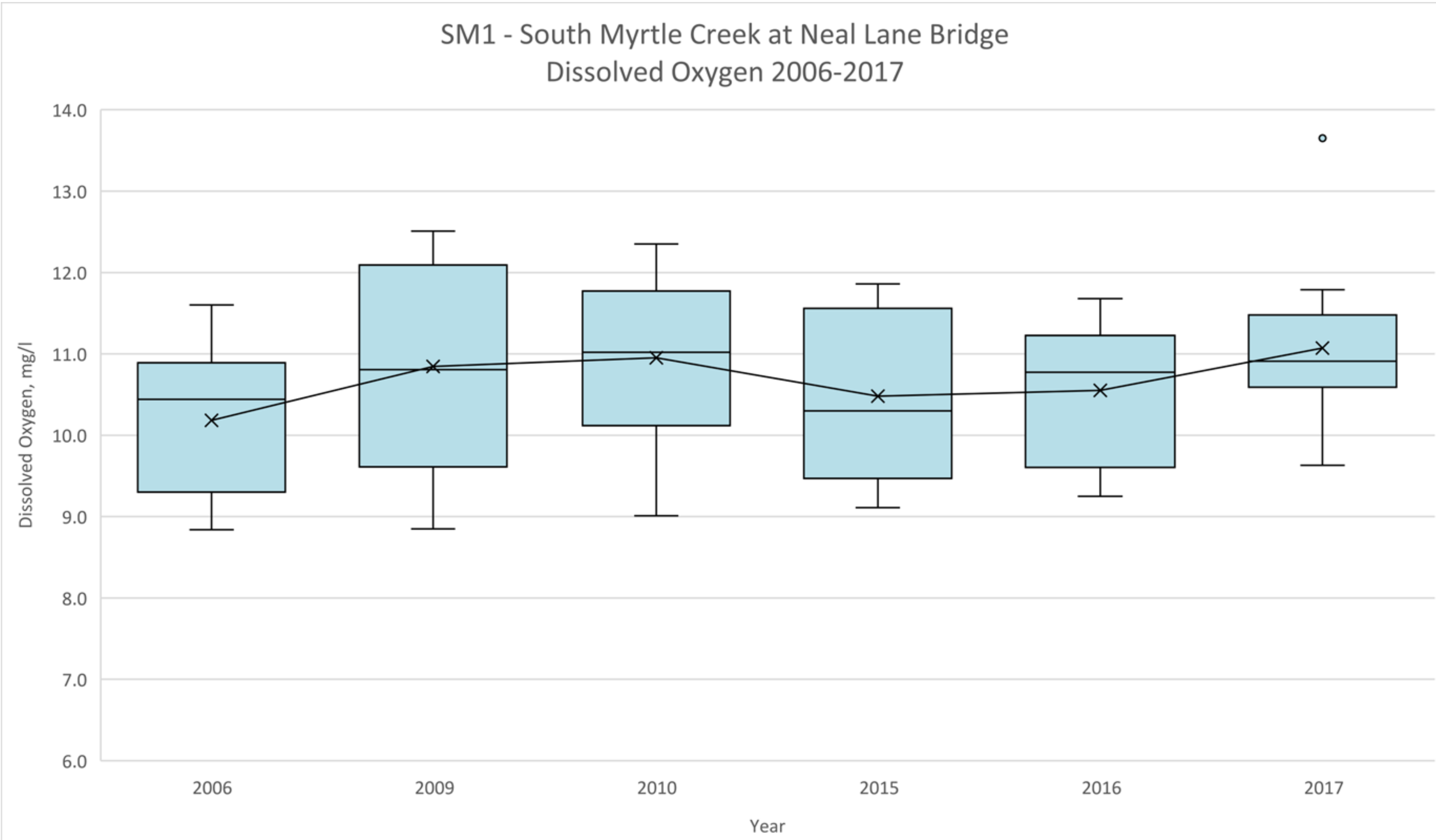
Graph 150. Box plots by year of grab sample pH levels of South Myrtle Creek near mouth.



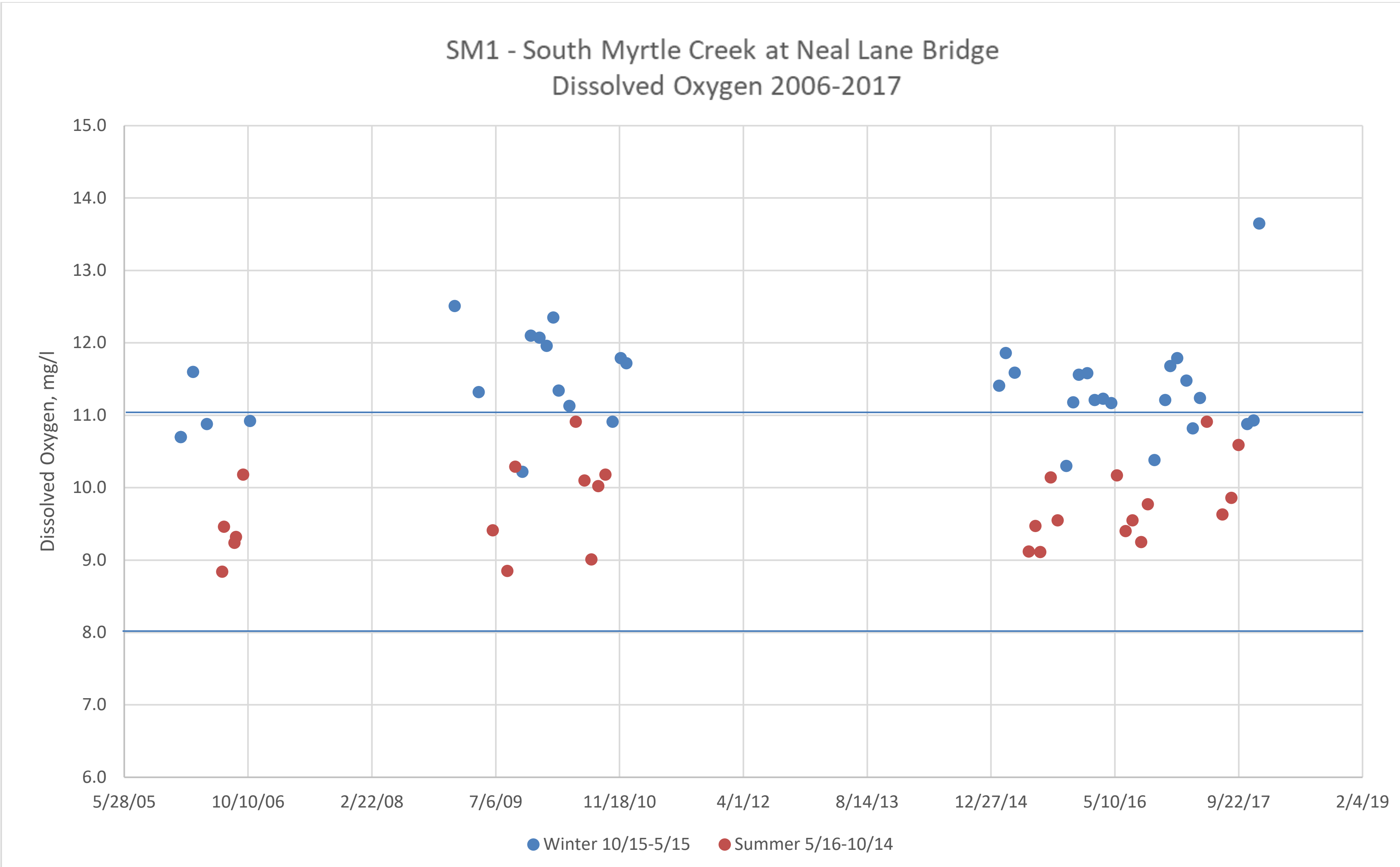
Graph 151. SM1 - South Myrtle Creek at Neal Lane Bridge pH 2006-2017 summer and winter separated.



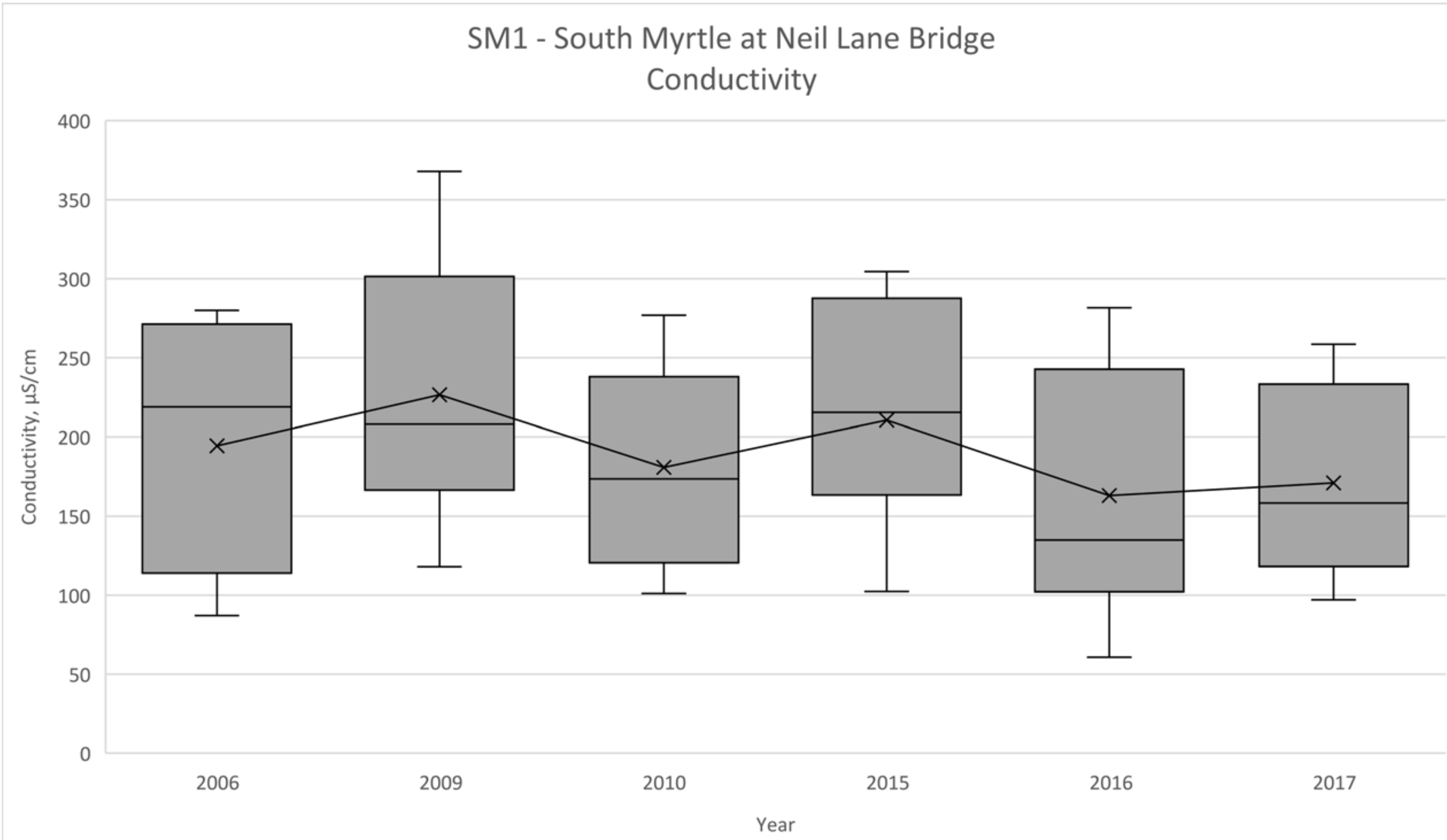
Graph 152. M1 - South Myrtle Creek at Neal Lane Bridge pH 2014-2017 summer and winter separated.



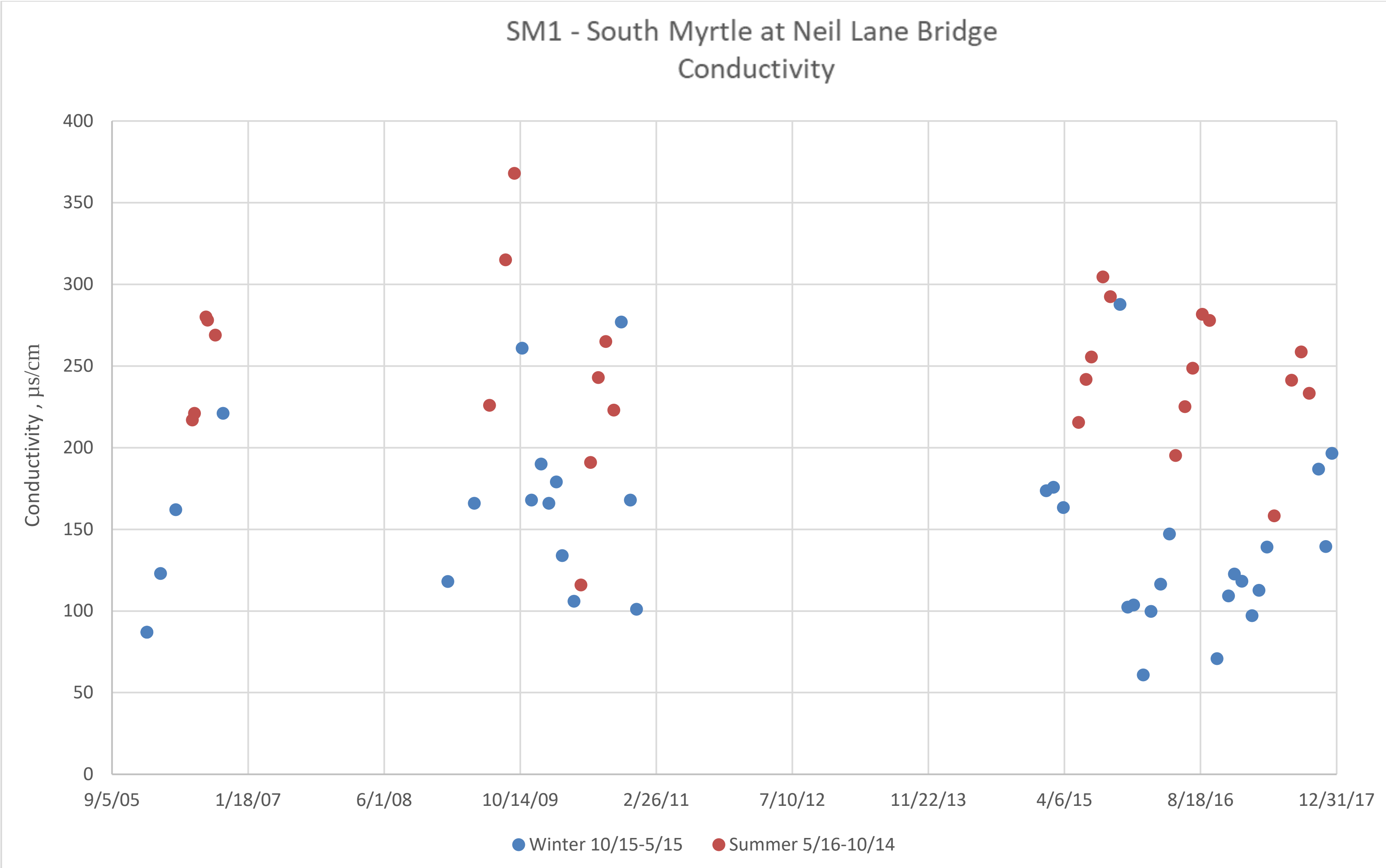
Graph 153. Box plots by year of grab sample dissolved oxygen levels of South Myrtle Creek near mouth.



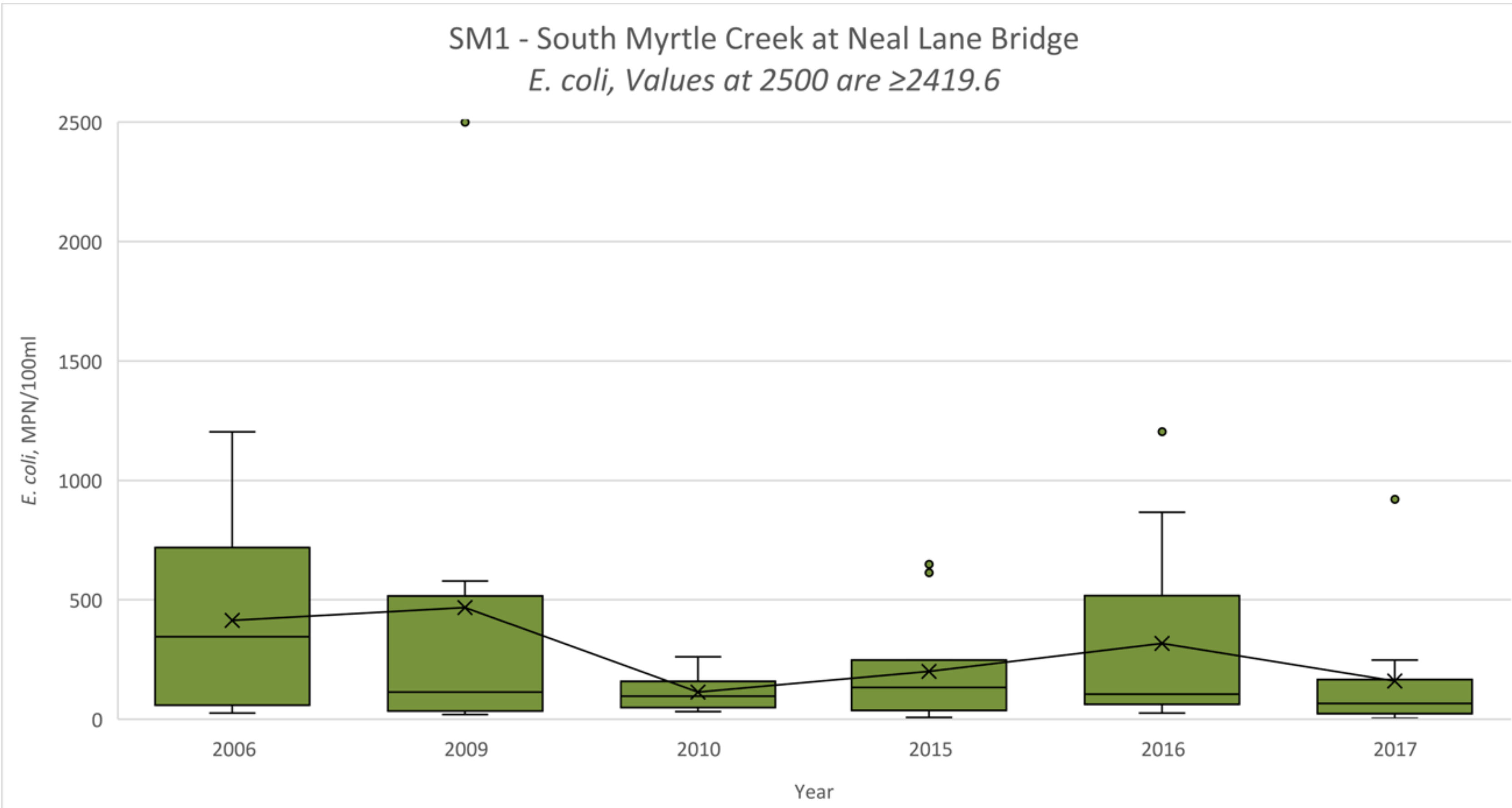
Graph 154. SM1 - South Myrtle Creek at Neal Lane Bridge dissolved oxygen 2006-2017 summer and winter separated.



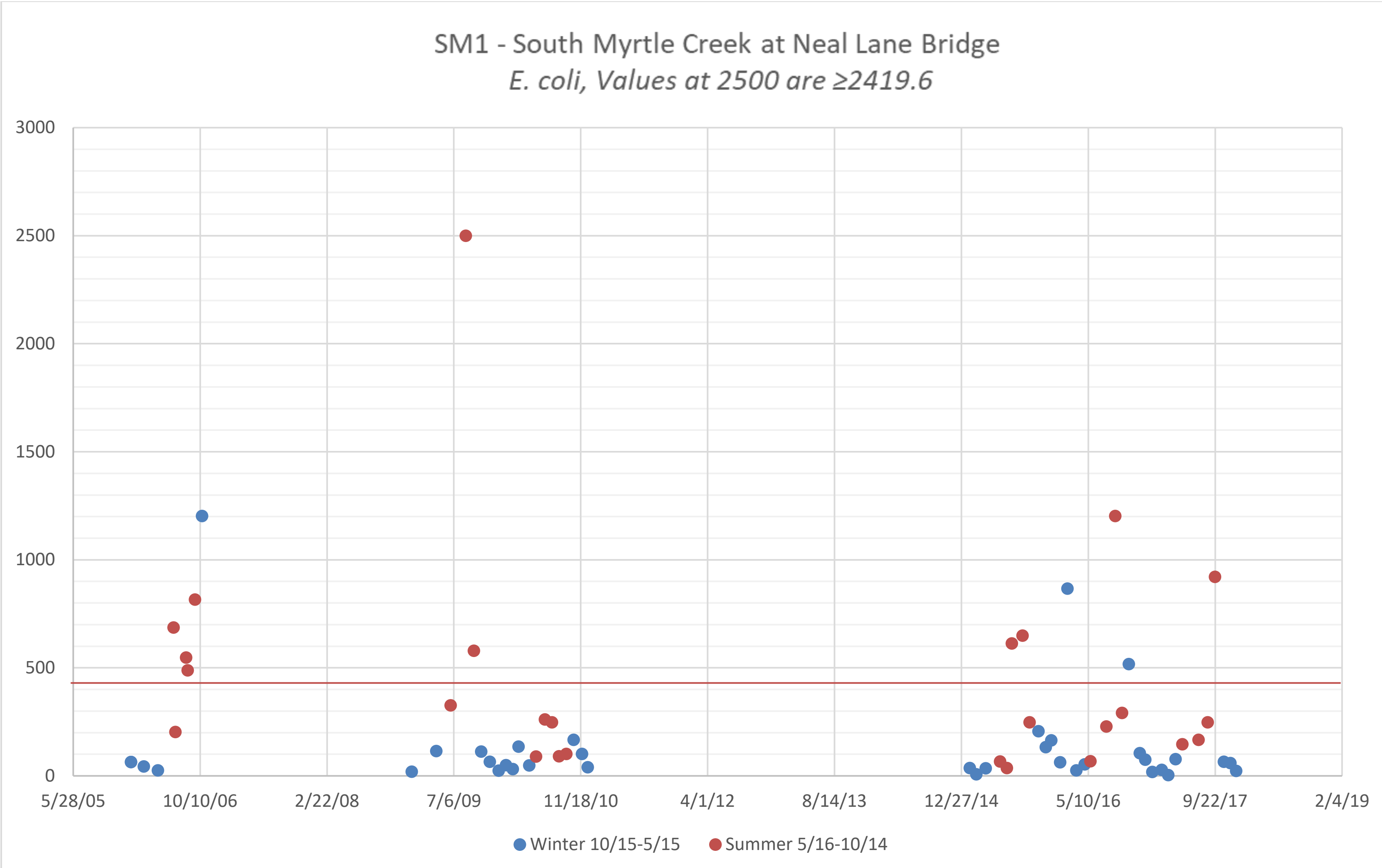
Graph 155. Box plots by year of grab sample conductivity levels of South Myrtle Creek near mouth.



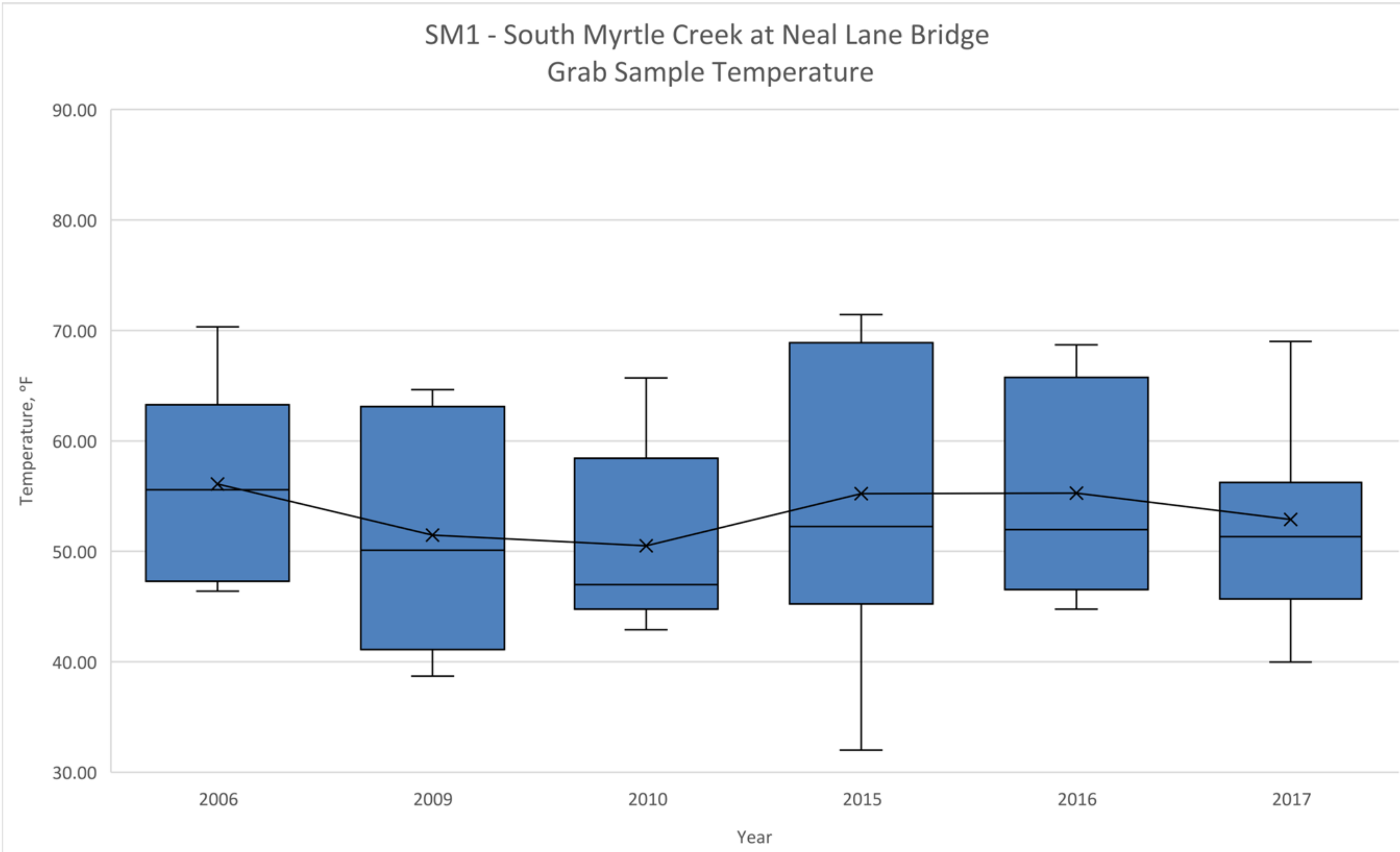
Graph 156. SM1 - South Myrtle at Neil Lane Bridge conductivity grab samples 2006-2017 summer and winter separated.



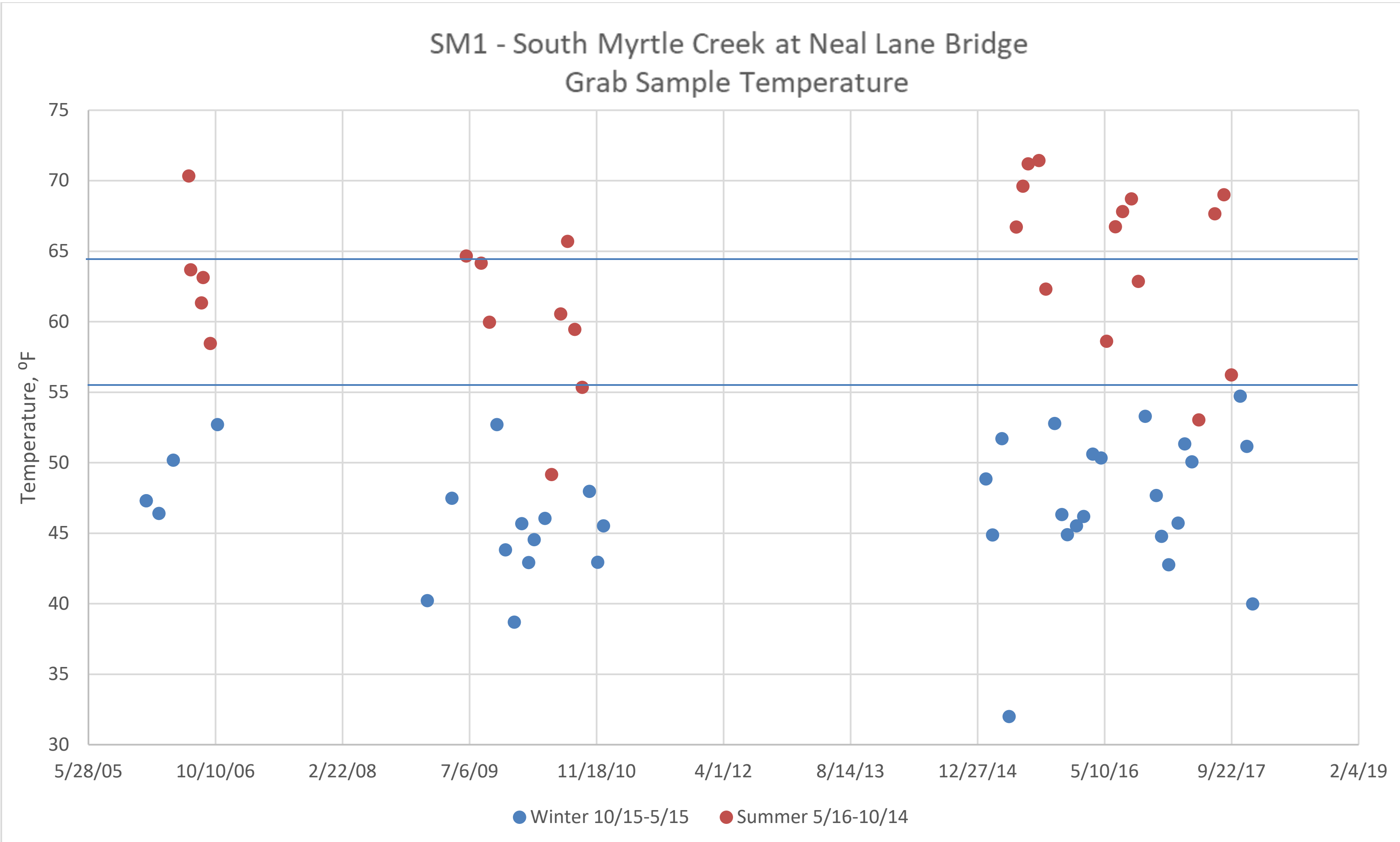
Graph 157. Box plots by year of grab sample *E. coli* levels of South Myrtle Creek near mouth.



Graph 158. SM1 - South Myrtle Creek at Neal Lane Bridge E. coli, Values at 2500 are ≥2419.6 Summer and Winter Separated



Graph 159. Box plots by year of grab sample temperature levels of South Myrtle Creek near mouth.



Graph 160. SM1 - South Myrtle Creek at Neal Lane Bridge Grab Sample Temperature summer and winter separated.

NM1 - North Myrtle Creek at Evergreen Park near Mouth

Year	Monthly Samples	Months
2010	12	Full Year
2013	12	Full Year
2014	9	Jan-Sept
2015	12	Full Year
2016	12	Full Year
2017	12	Full Year

Table 37. Number of monitoring events per year included in graphs that follow for North Myrtle near mouth.

Turbidity

North Myrtle Creek near the mouth was sampled 2010 thru 2017 (Graphs 161-163). During our grab sampling, the highest level detected was 98 NTU which occurred in February 2014. Only four other occurrences fell above 50 NTU which "The Oregon Watershed Assessment Manual recommends using 50 NTUs as the turbidity evaluation criteria for watershed assessments. At this level, turbidity interferes with sight-feeding aquatic organisms and provides an indication of the biological effect of suspended sediment." There were numerous exceedances of 10 NTU spread over the years, but none of these occurred during the summer. No trend is evident.

pH

With grab sampling, no events exceeded the upper DEQ recommended limit of 8.5 or fell below the lower exceedance of 6.5. No pH levels were measured below 7.0. The box plot (Graph 164) does again, as it has for many previous sites, what appears to show a downward trend in pH values for 2015, 2016, 2017 showing a downward trend in pH for the mean and median values. Graph 166 shows both summer and winter pH values are indicating a R-Squared 0.4826 and 0.2869 from 2015-2017. Grab sampling for pH at this site indicates no cause for concern.

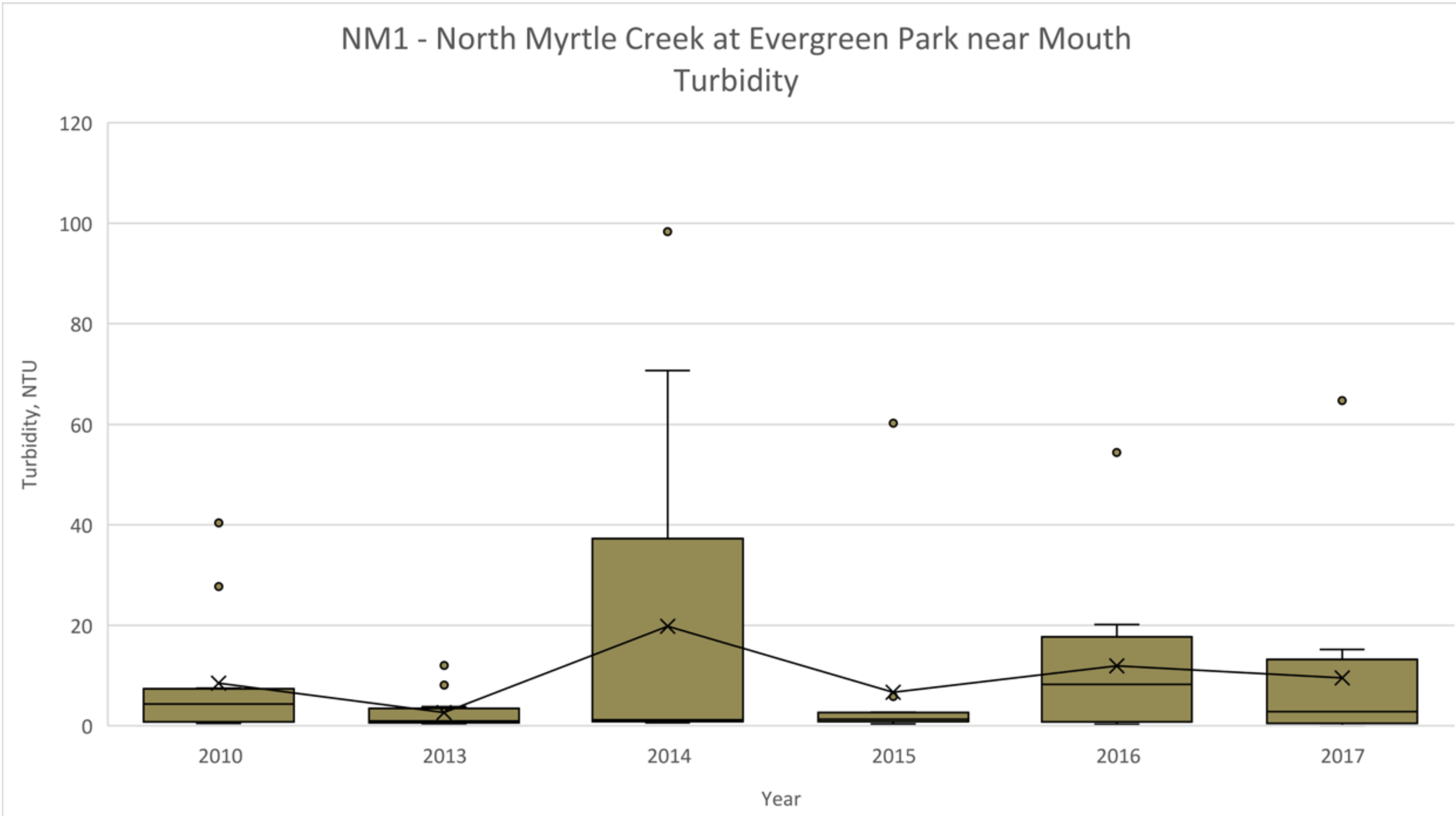
Dissolved Oxygen

Graphs 167 and 168 display the dissolved oxygen grab sample data for North Myrtle Creek near the mouth. One summer sample of 6.7 was detected below the lower limit of eight in August of 2013. A second summer sample fell right at 8.1 in August 2014. Nine winter measurements fell below the spawning criteria of eleven, none fell below 10. All summer dissolved oxygen levels were within the acceptable range. No trend is apparent.

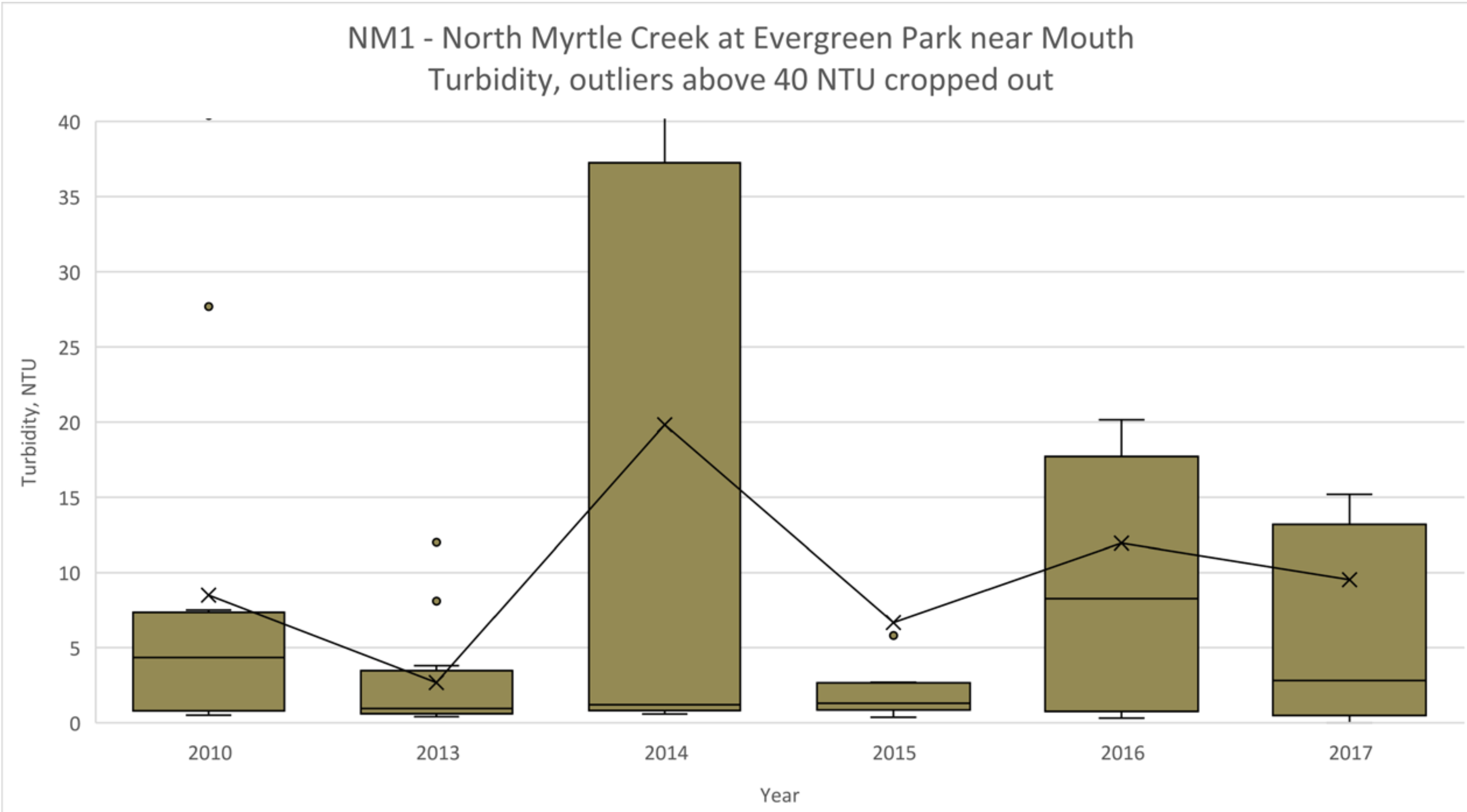
Conductivity
Graphs 169 and 170 display the conductivity grab sample data. All are within normal ranges for the Umpqua basin. No trend is evident, and variation was between 10 and 331 with the higher readings mostly occurring during the summer as flows decrease.

E. coli
E. coli levels are displayed in graphs 171, 172 and 173**.** Seventeen sampling events occurred high enough to list this section of North Myrtle Creek. Thirteen occurred in winter and four in summer. Also, many samples, both summer and winter, were above the 126 MPN/100ml which DEQ criteria indicates would have to have been measured 5 times in one month to have listed it. One time reading at 406 MPN/ml or greater would list a stream. No trend is evident. North Myrtle Creek needs attention paid to this *E. coli* problem.

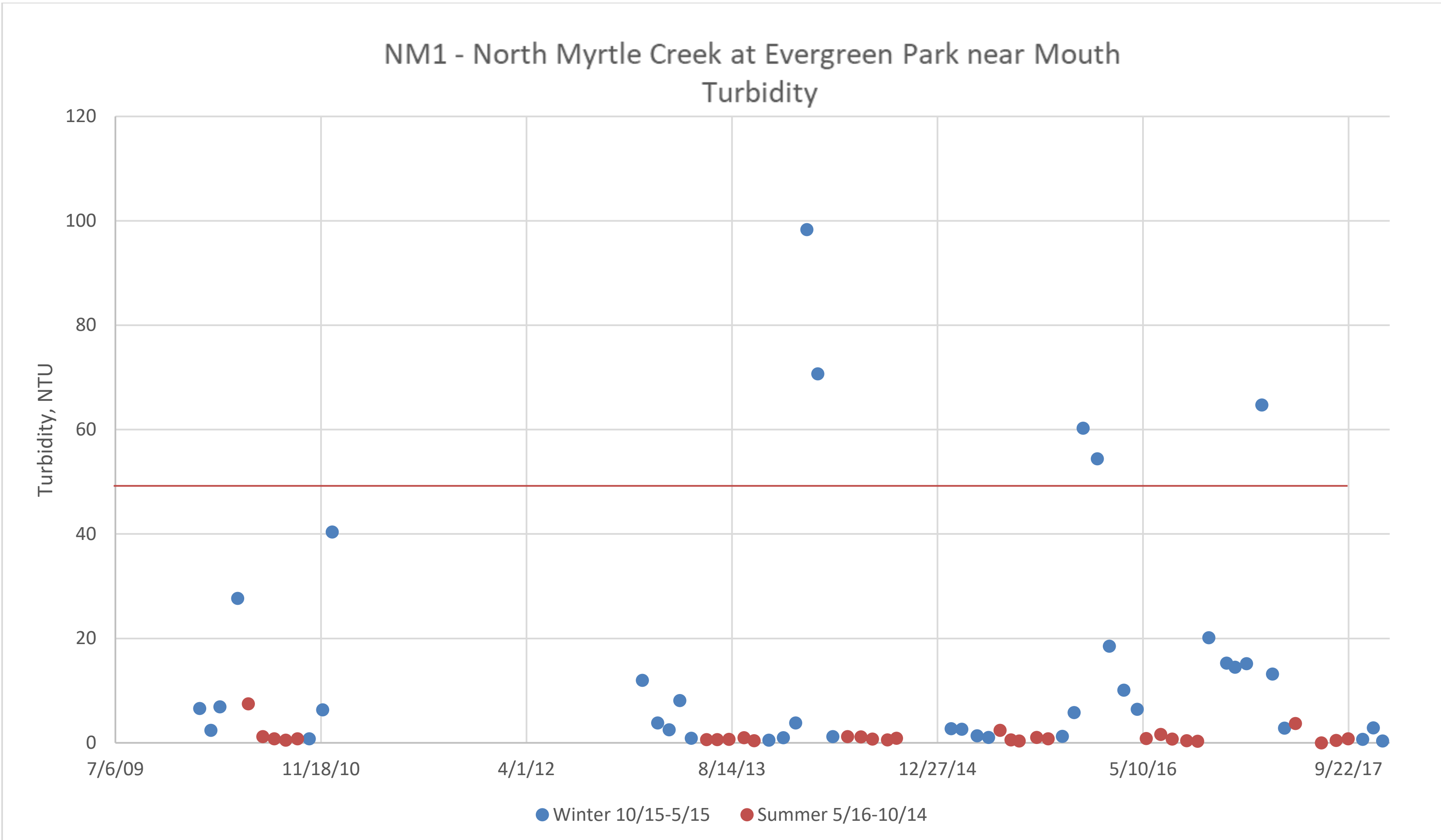
Temperature
Graphs 174 and 175 display the temperature data for the North Myrtle Creek. The continuous temperature data provided under PUR's Reference Temperature Study Graphed on Graph 174 and data in Table 38 show that all years fail to meet the 7DAM 64.4°F criteria since all years were above at lease72.4°F. The winter temperatures were generally good with all but two falling below the 55.4°F spawning criteria. Summer temperature had 14 exceedances of the 64.4°F criteria and 16 meeting the criteria. No trend is evident.



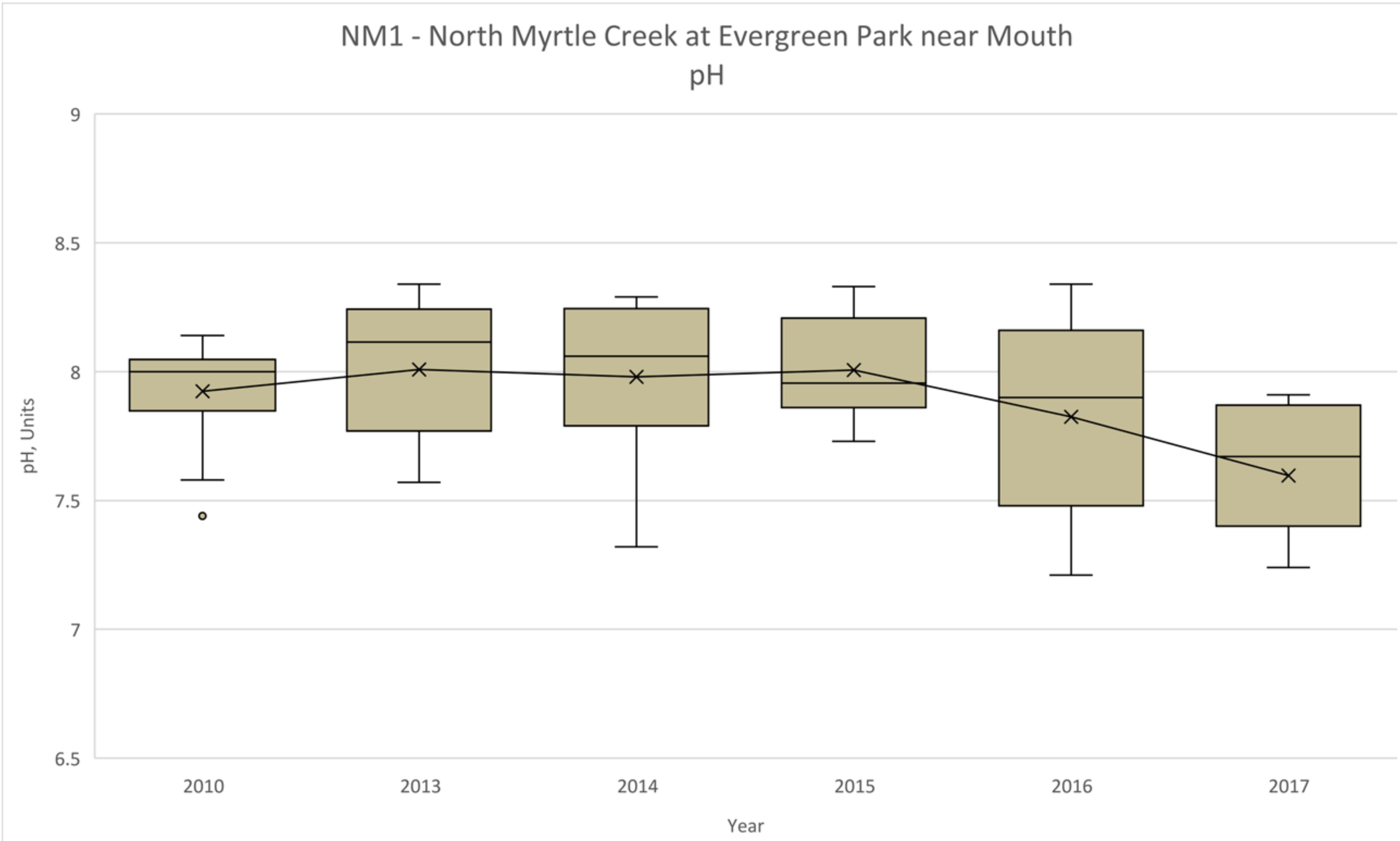
Graph 161. Box plots by year of grab sample turbidity levels of North Myrtle Creek near mouth



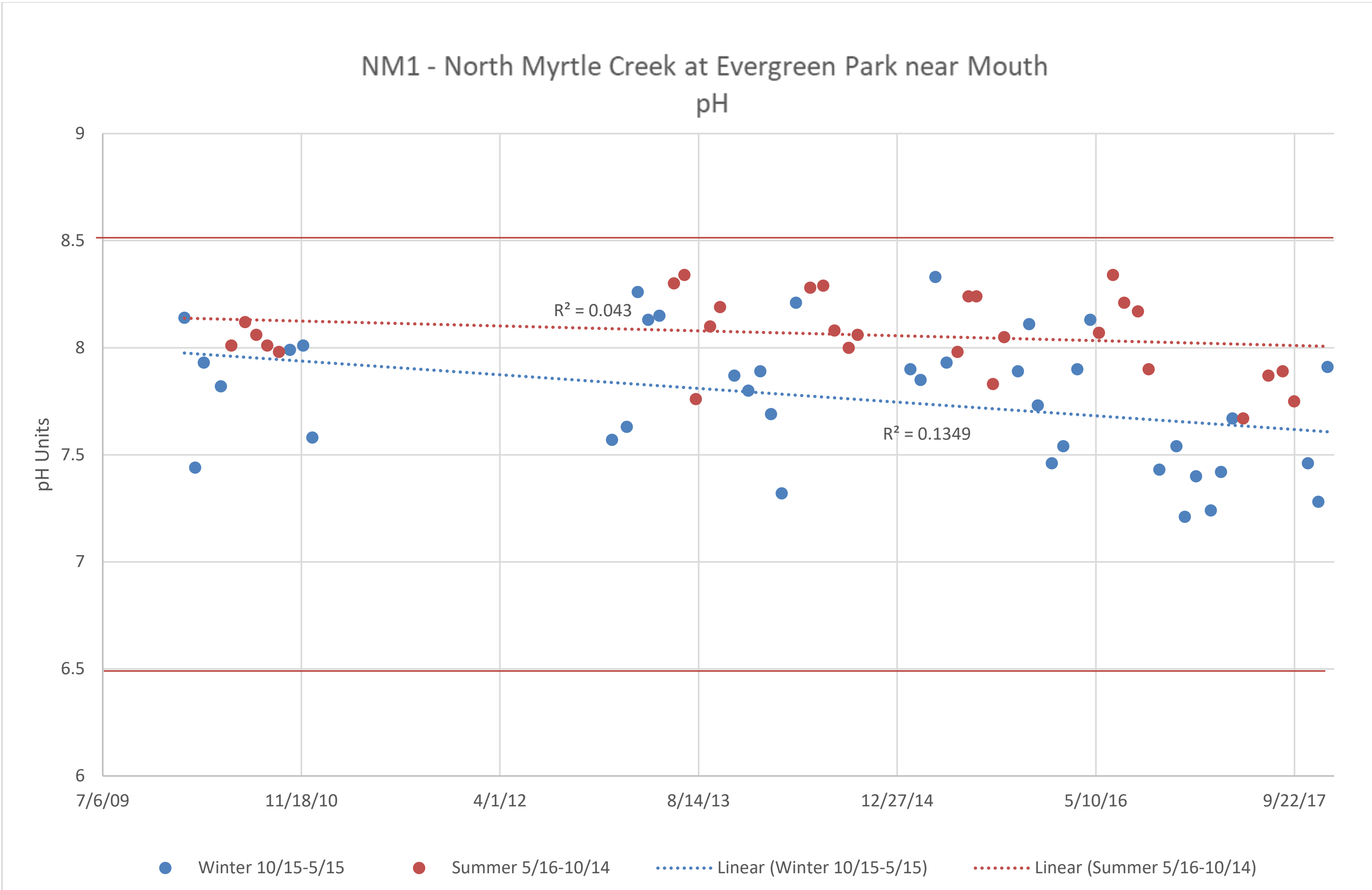
Graph 162. Box plots by year of grab sample turbidity levels of North Myrtle Creek near mouth outliers above 40 NTU cropped out.



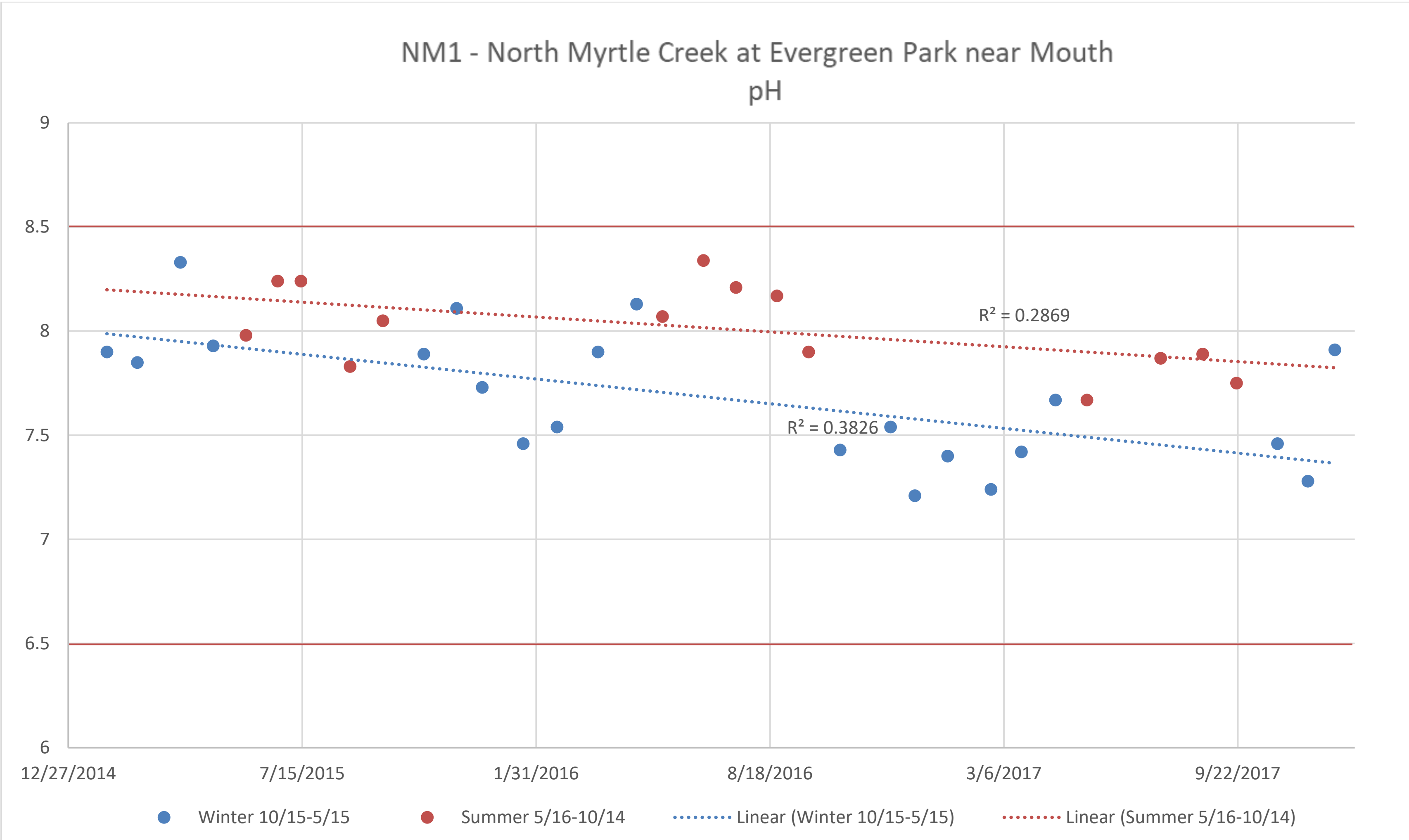
Graph 163. NM1 - North Myrtle Creek at Evergreen Park near Mouth Turbidity summer and winter separated.



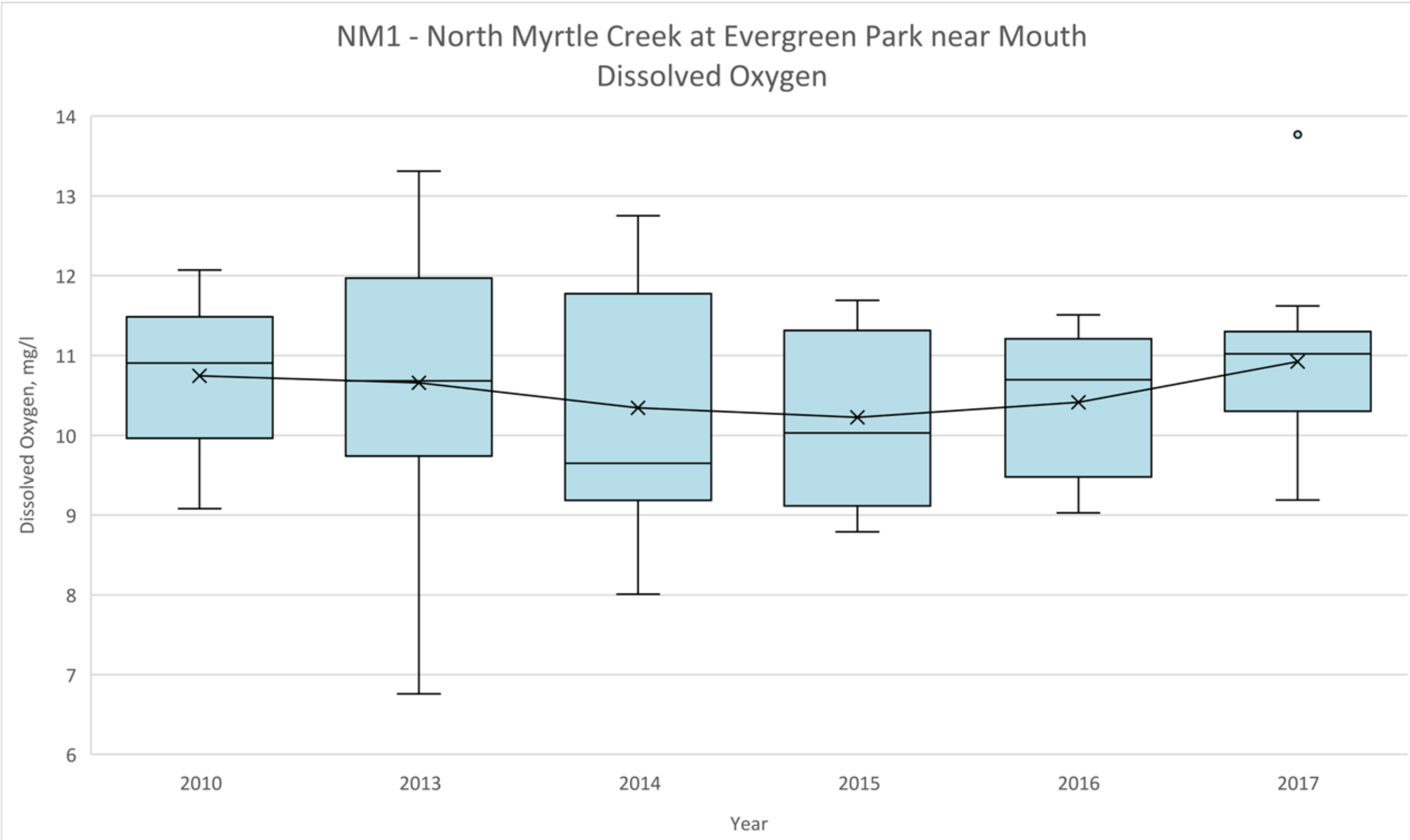
Graph 164. Box plots by year of grab sample pH levels of North Myrtle Creek near mouth.



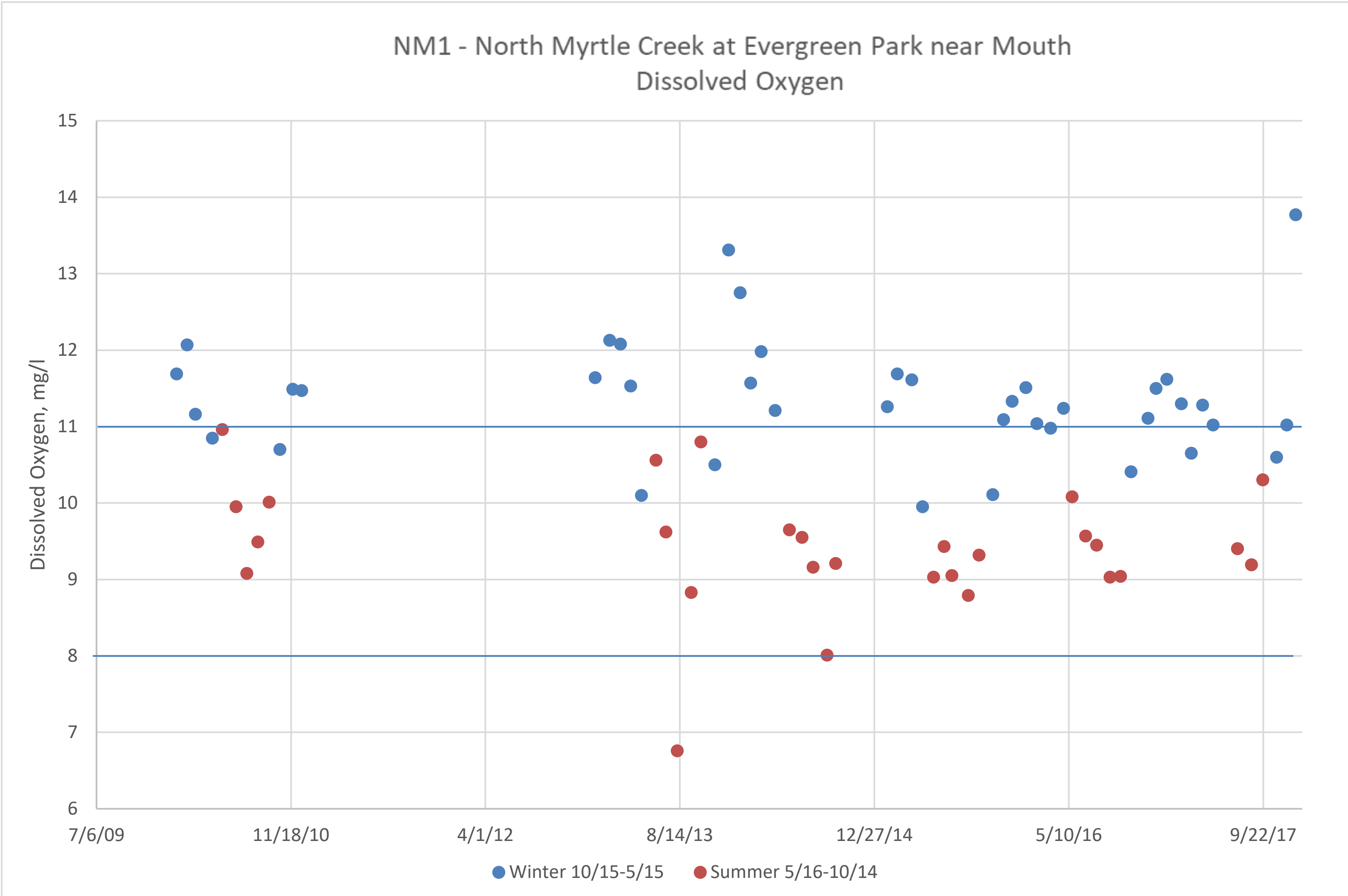
Graph 165. NM1 - North Myrtle Creek at Evergreen Park near Mouth pH summer and winter separated 2009-2017.



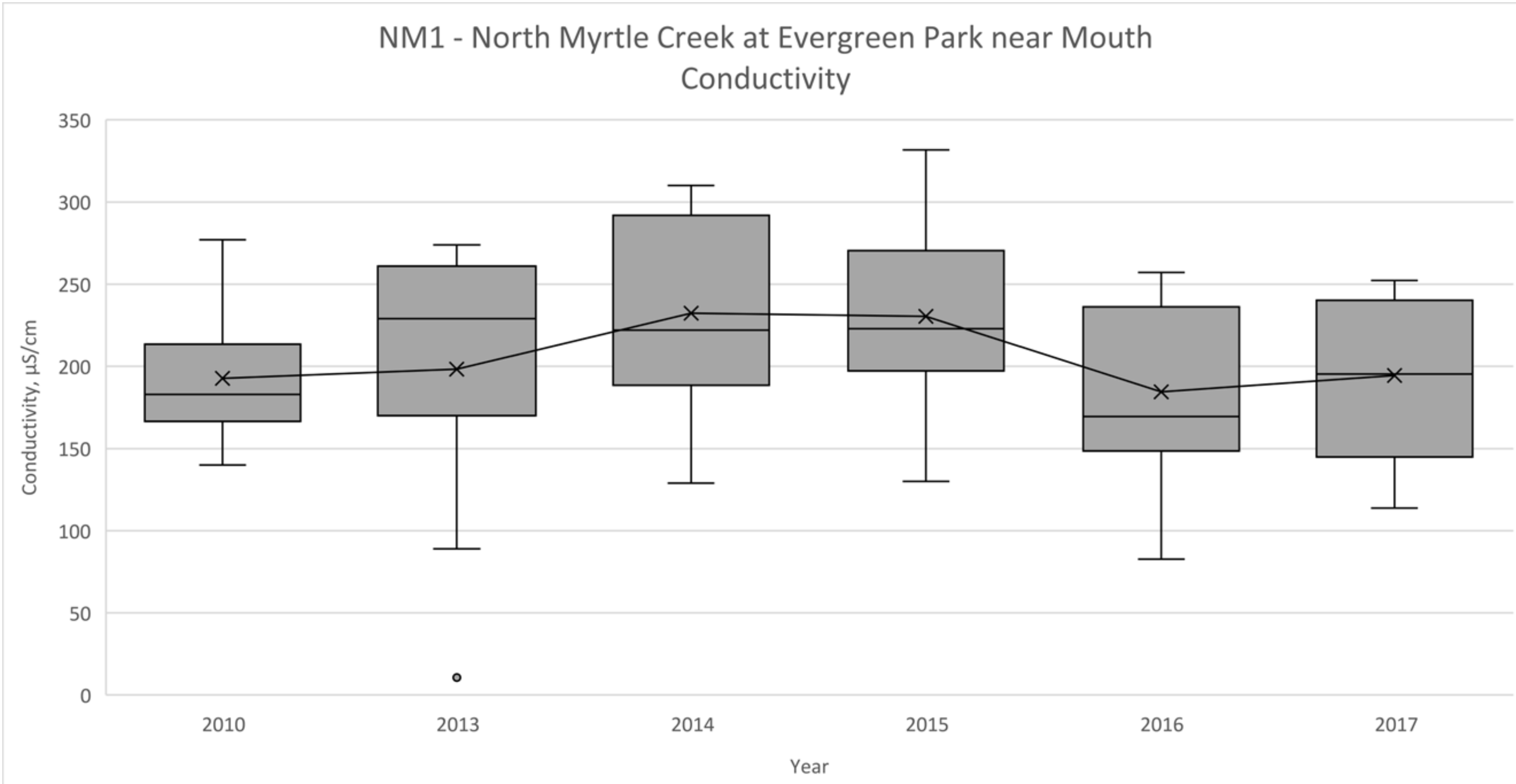
Graph 166. NM1 - North Myrtle Creek at Evergreen Park near Mouth pH summer and winter separated 2015-2017.



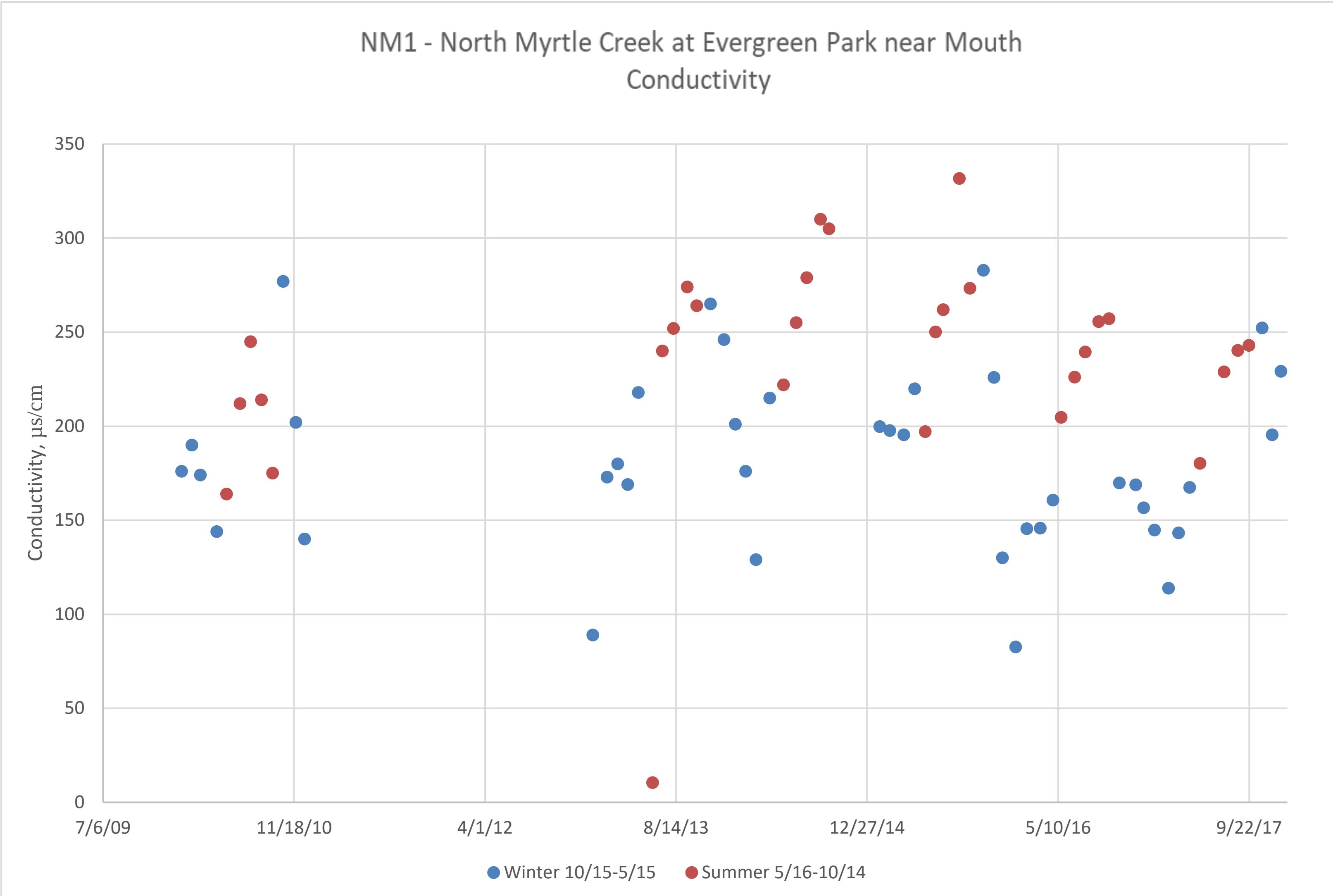
Graph 167. Box plots by year of grab sample dissolve oxygen levels of North Myrtle Creek near mouth.



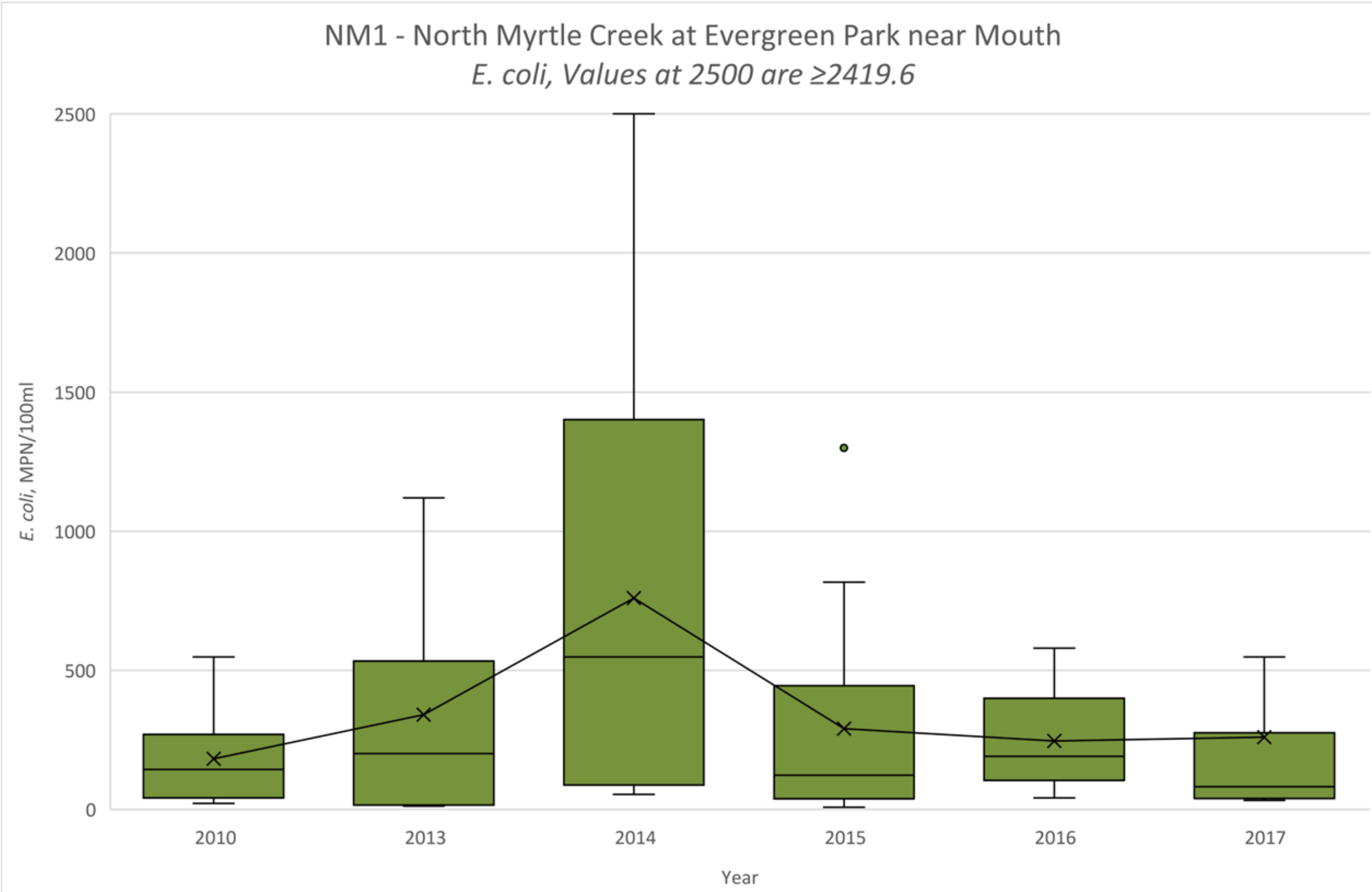
Graph 168. Dissolved oxygen grab samples North Myrtle Creek at Evergreen Park near mouth 2010-2017.



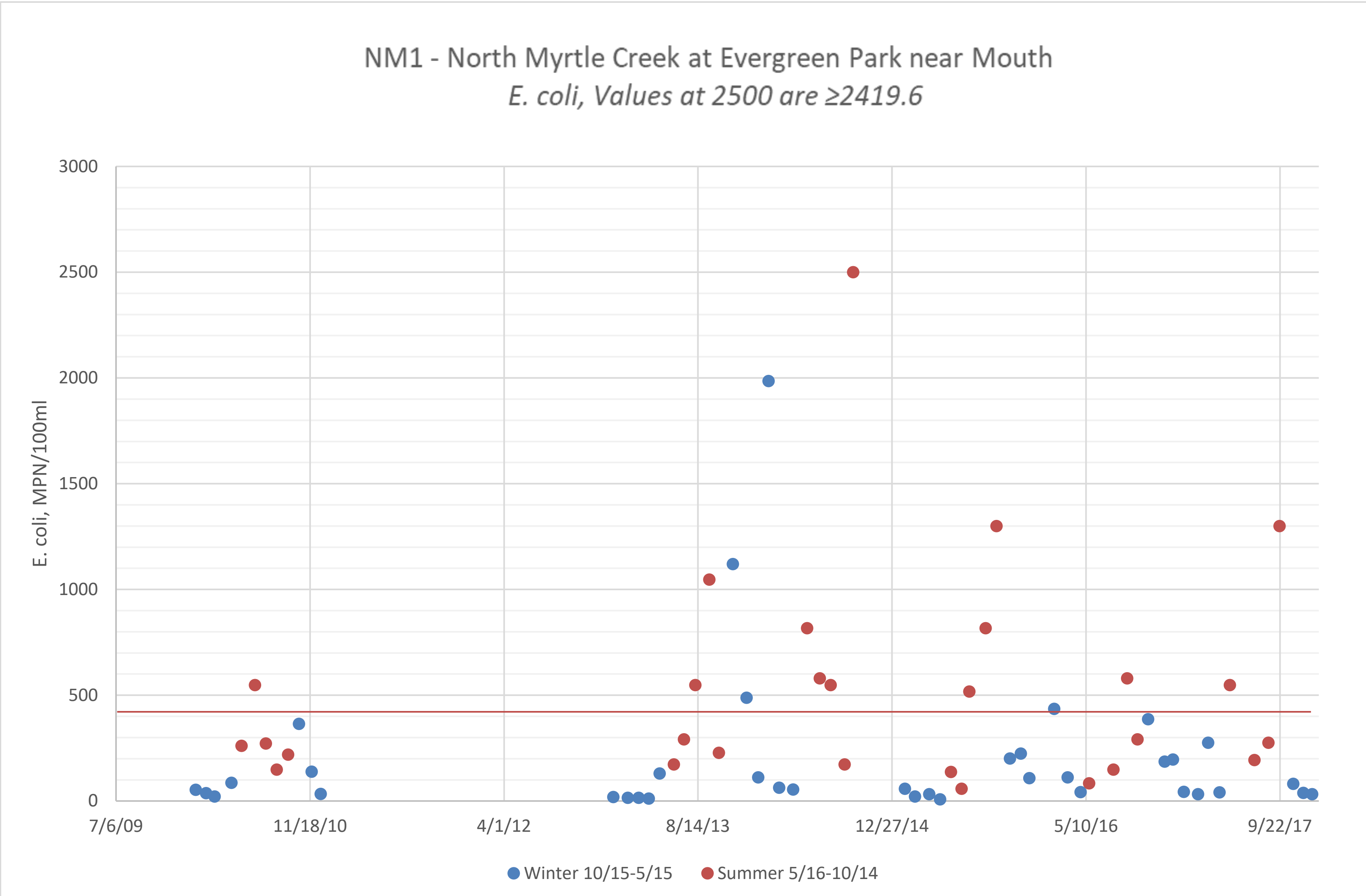
Graph 169. NM1 – Box Plots North Myrtle Creek at Evergreen Park near mouth grab sample conductivity.



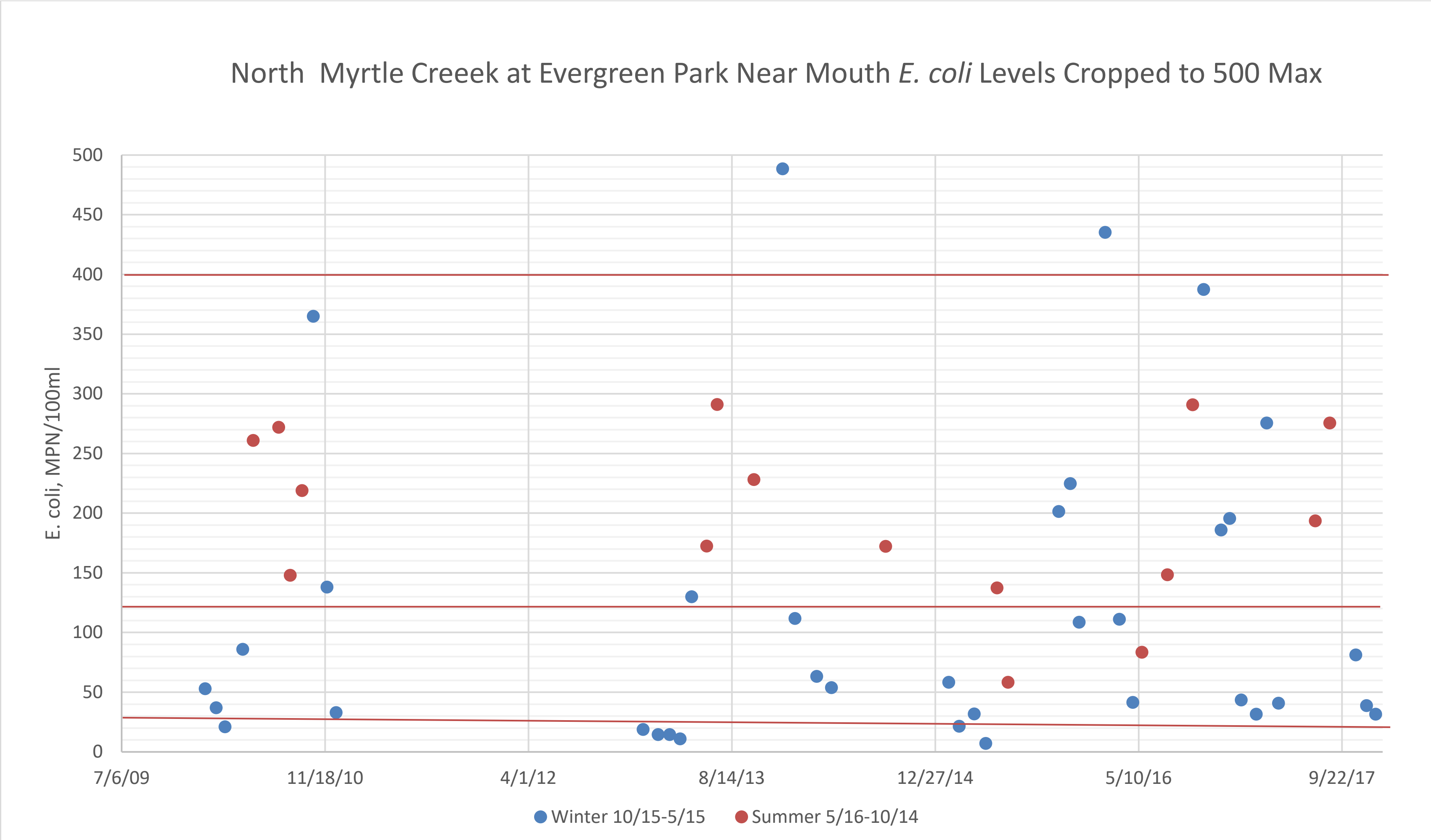
Graph 170. - North Myrtle Creek at Evergreen Park near mouth conductivity grab samples.



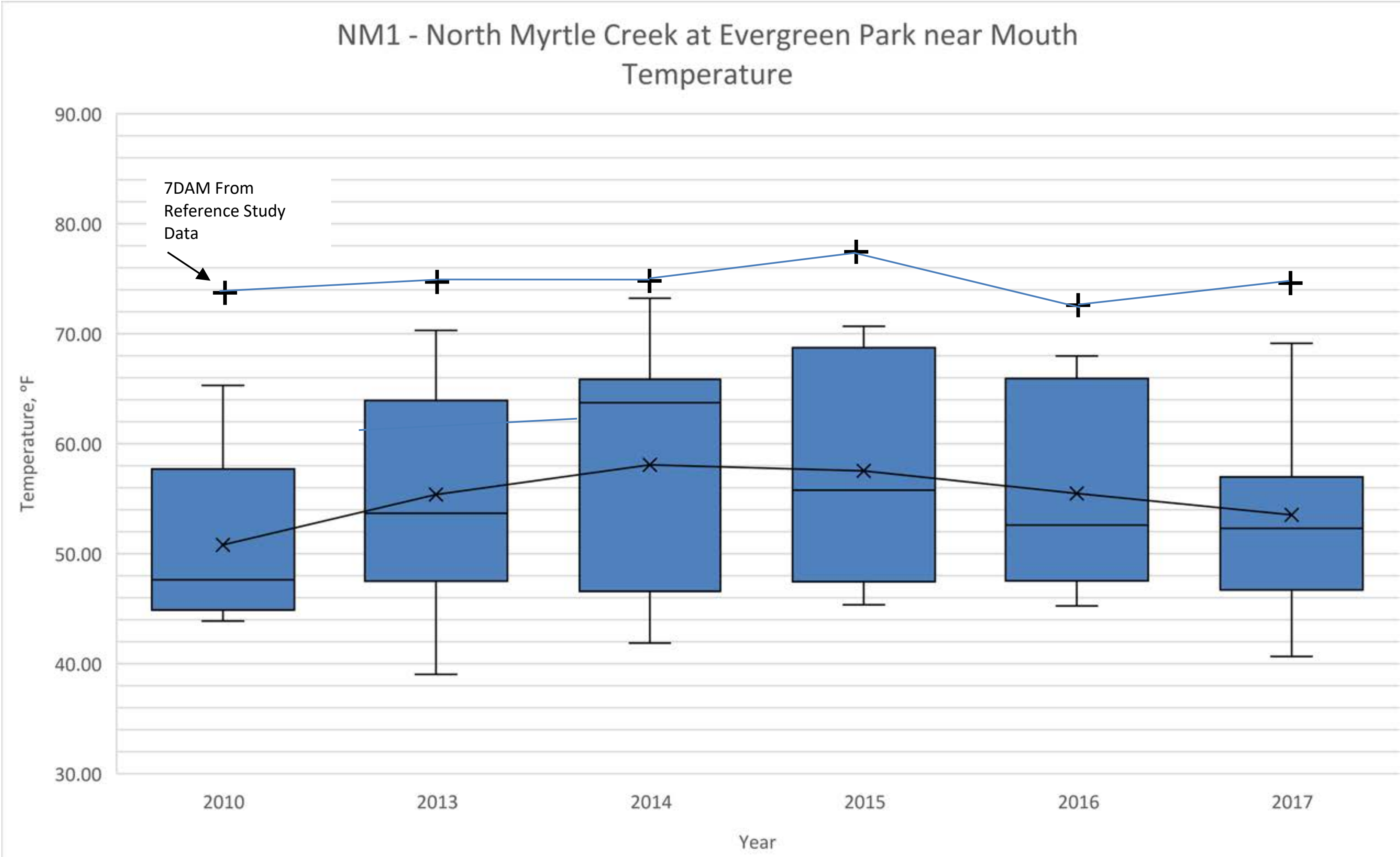
Graph 171. Box plots by year of grab sample *E. coli* levels of North Myrtle Creek near mouth.



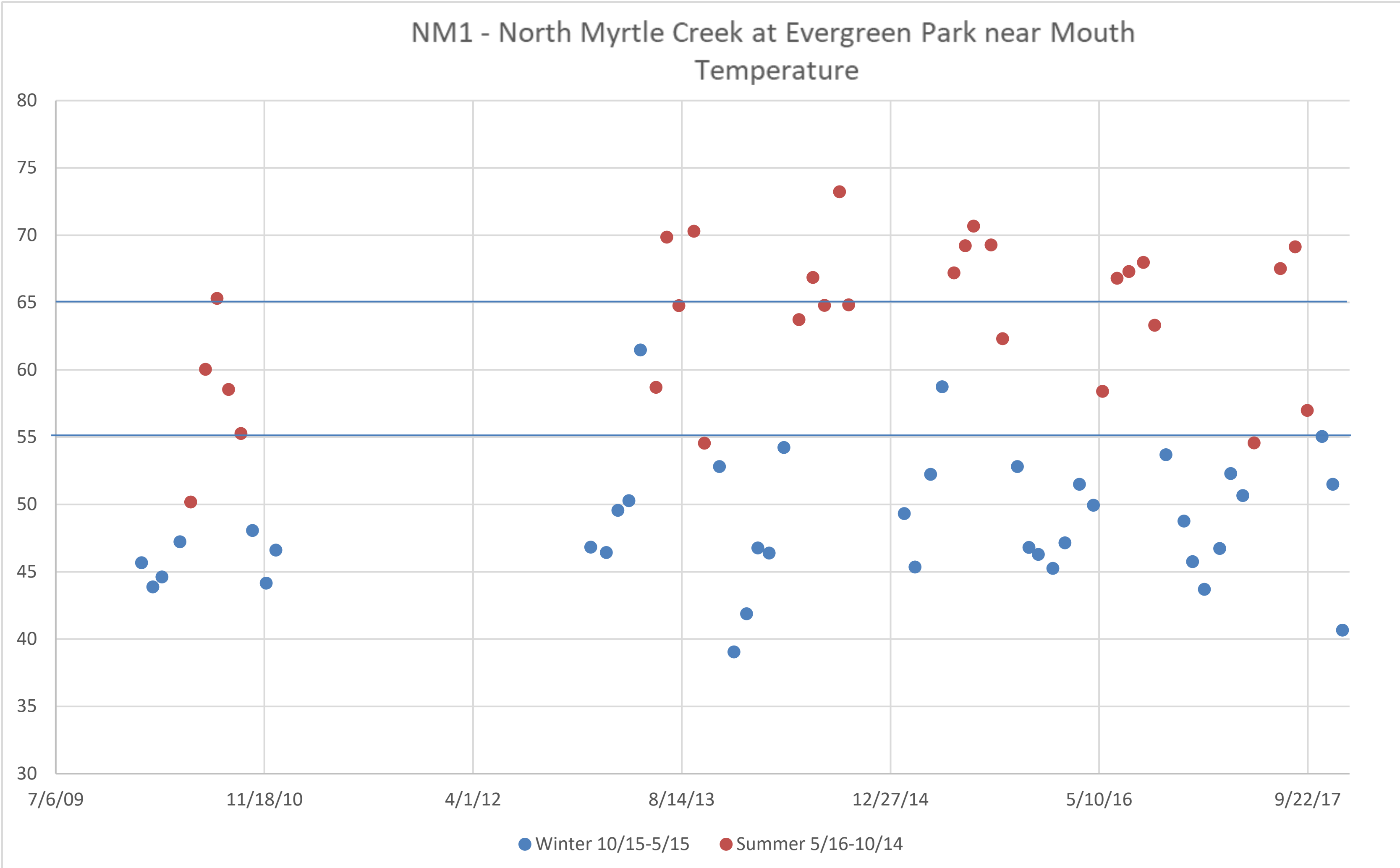
Graph 172. NM1 - North Myrtle Creek at Evergreen Park near Mouth *E. coli,* Values at 2500 are ≥2419.6 Summer and Winter Seperated.



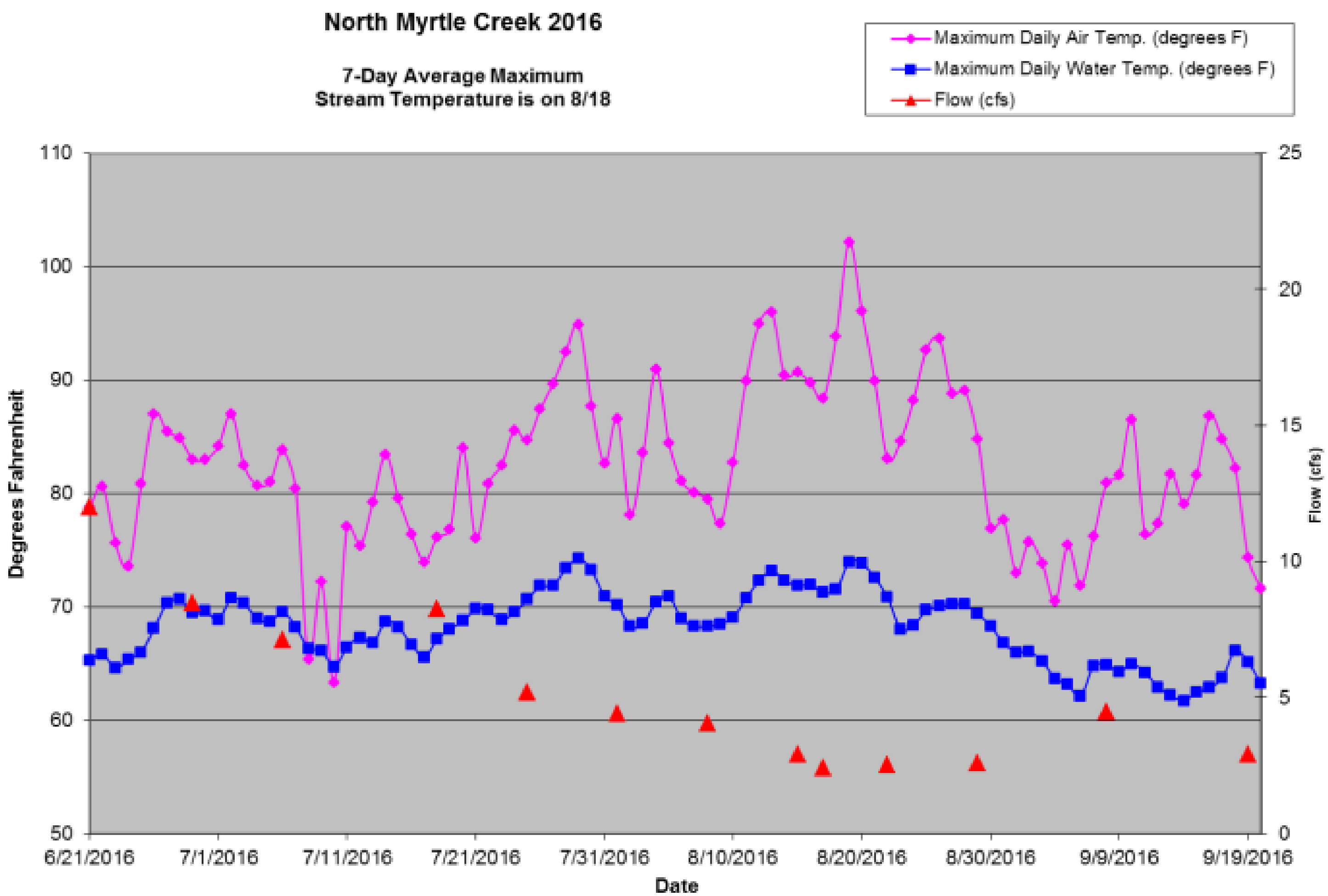
Graph 173. NM1 - North Myrtle Creek at Evergreen Park near Mouth *E. coli* cropped to 500 max.



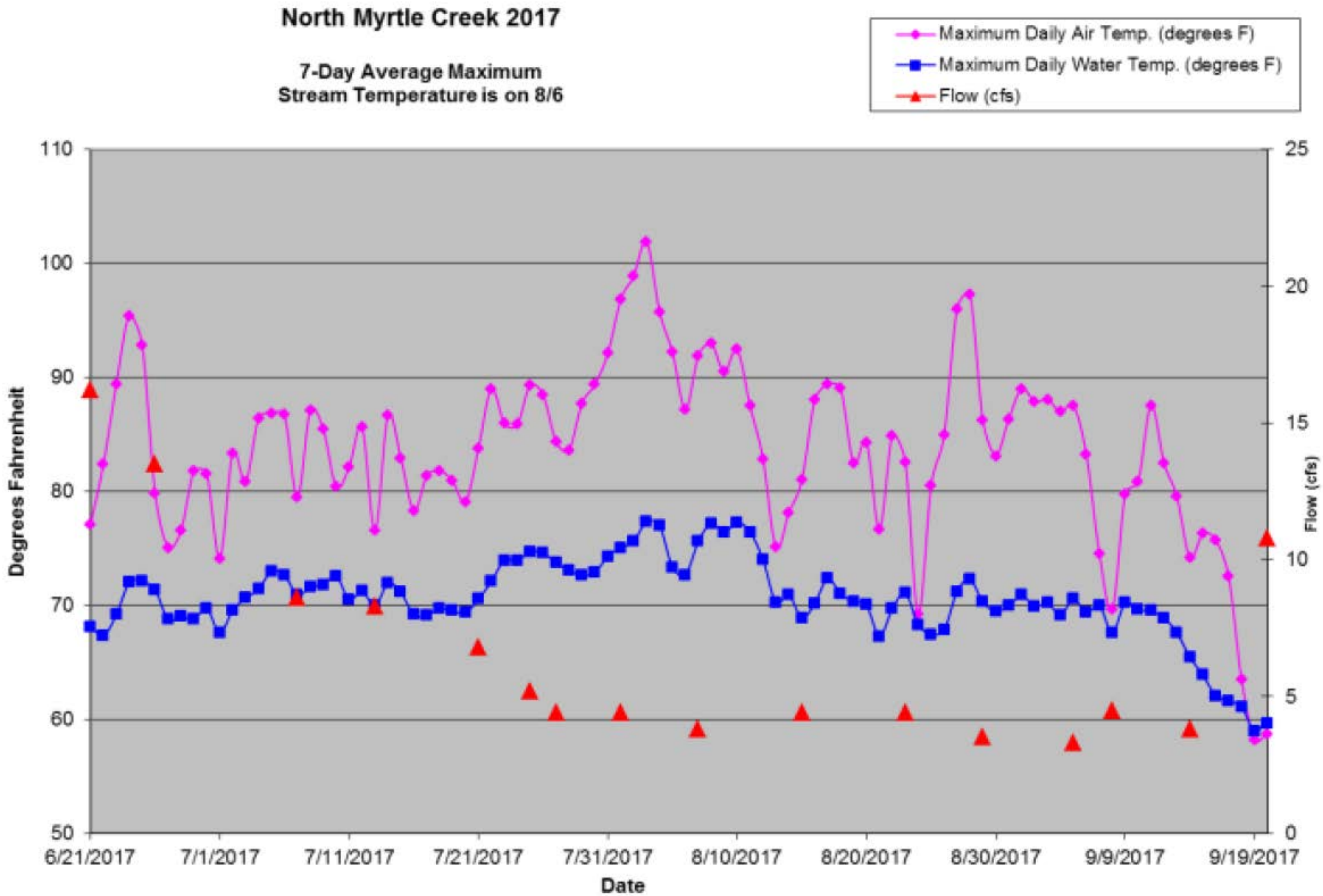
Graph 174. Box plots by year of grab sample temperature levels of North Myrtle Creek near mouth.



Graph 175. NM1 - North Myrtle Creek at Evergreen Park near the mouth Temperature summer and winter separated.



Graph 176. North Myrtle Creek 7-Day moving Maximum stream temperatures, air temperatures and flow for summer 2016 from the Umpqua Basin Stream Temperature Characterization- Reference Site 2017 Update.



Graph 177. North Myrtle Creek 7-Day moving Maximum stream temperatures, air temperatures and flow for summer 2017 from the Umpqua Basin Stream Temperature Characterization- Reference Site 2017 Update.

Data from Umpqua Basin Stream Temperature Characterization Reference Site 2017 Update

Site Name	Start Date	Stop date	Seasonal Maximum		Seasonal Minimum		Seasonal Max ΔT		7-Day average		
			Date	Value	Date	Value	Date	Value	Date	Max	Min
N Myrtle @ mouth	06/21/10	09/25/10	08/16/10	75.0	06/21/10	54.4	08/25/10	10.8	08/15/10	73.5	64.6
N Myrtle @ mouth	06/14/13	09/21/13	07/25/13	76.3	06/14/13	54.3	07/22/13	10.7	07/24/13	74.7	65.7
N Myrtle @ mouth	06/17/14	10/02/14	08/02/14	76.4	10/02/14	54.2	08/06/14	9.9	08/01/14	74.4	67.6
N Myrtle @ mouth	06/07/15	09/21/15	06/27/15	78.2	09/06/15	56.4	06/17/15	9.8	06/30/15	77.0	69.5
N Myrtle @ mouth	06/05/16	09/24/16	07/29/16	74.3	06/15/16	55.1	06/20/16	7.6	08/18/16	72.4	66.6
N Myrtle @ mouth	06/05/17	09/22/17	08/03/17	77.4	06/14/17	53.5	08/03/17	10.3	08/06/17	75.6	67.4

Table 38. Continuous temperature data summary for North Myrtle Creek near the mouth. Data from the Umpqua Basin Stream Temperature Characterization Reference Site 2017 Update.

SU11 - South Umpqua at Brockway Road Bridge

Year	Monthly Samples	Months
2012	11	June-Dec, duplicates
2013	12	Jan-Sept, duplicates
2014	9	May-Sept
2015	11	Full Year
2016	12	Full Year
2017	12	Full Year

Table 39. Number of monitoring events per year included in graphs that follow for the South Umpqua at Brockway Road bridge.

Turbidity

The South Umpqua River at Brockway Road bridge was sampled 2012 thru 2017 (Graphs 178-180). During our grab sampling, the highest level detected was 63.6 NTU which occurred in November 2012. Only two other occurrences fell above 50 NTU which "The Oregon Watershed Assessment Manual recommends using 50 NTUs as the turbidity evaluation criteria for watershed assessments. At this level, turbidity interferes with sight-feeding aquatic organisms and provides an indication of the biological effect of suspended sediment." There were eight exceedances of 10 NTU. but none of these occurred during the summer. No trend is evident.

pH

With grab sampling, no events exceeded the upper DEQ recommended limit of 8.5 or fell below the lower exceedance of 6.5. No pH levels were measured below 7.0. The box plot (Graph 164) does again, as it has for many previous sites, what appears to show a downward trend in pH values for 2015, 2016, 2017 showing a downward trend in pH for the mean and median values. Graph 182 shows summer and winter pH values are indicating a R-Squared 0.1445 and 0.2869 from 2015-2017. These do not show high correlation to indicate a downward trend. Grab sampling for pH at this site indicates some concern for high summer pH values.

Dissolved Oxygen

Graphs 185 and 186 display the dissolved oxygen grab sample data for the South Umpqua River at Brockway Road bridge. Only one summer sample of 6.1 was detected below the lower limit of eight in August of 2015. Nine winter measurements fell below the spawning criteria of eleven. No trend is apparent.

Conductivity

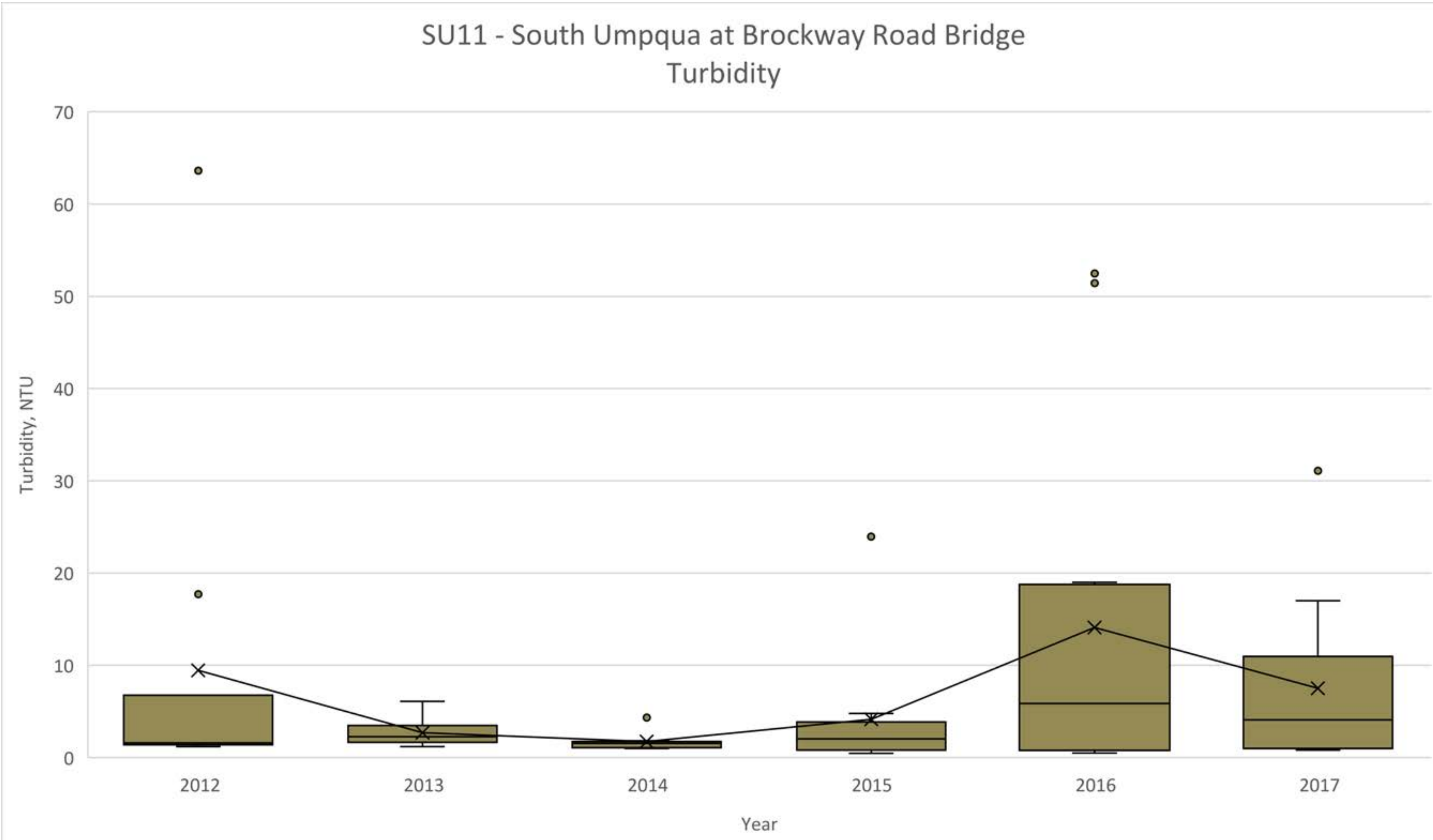
Graphs 187 and 188 display the conductivity grab sample data. All are within normal ranges for the Umpqua basin. No trend is evident, and variation was between 64 and 272 with the higher readings mostly occurring during the summer as flows decrease.

E. coli

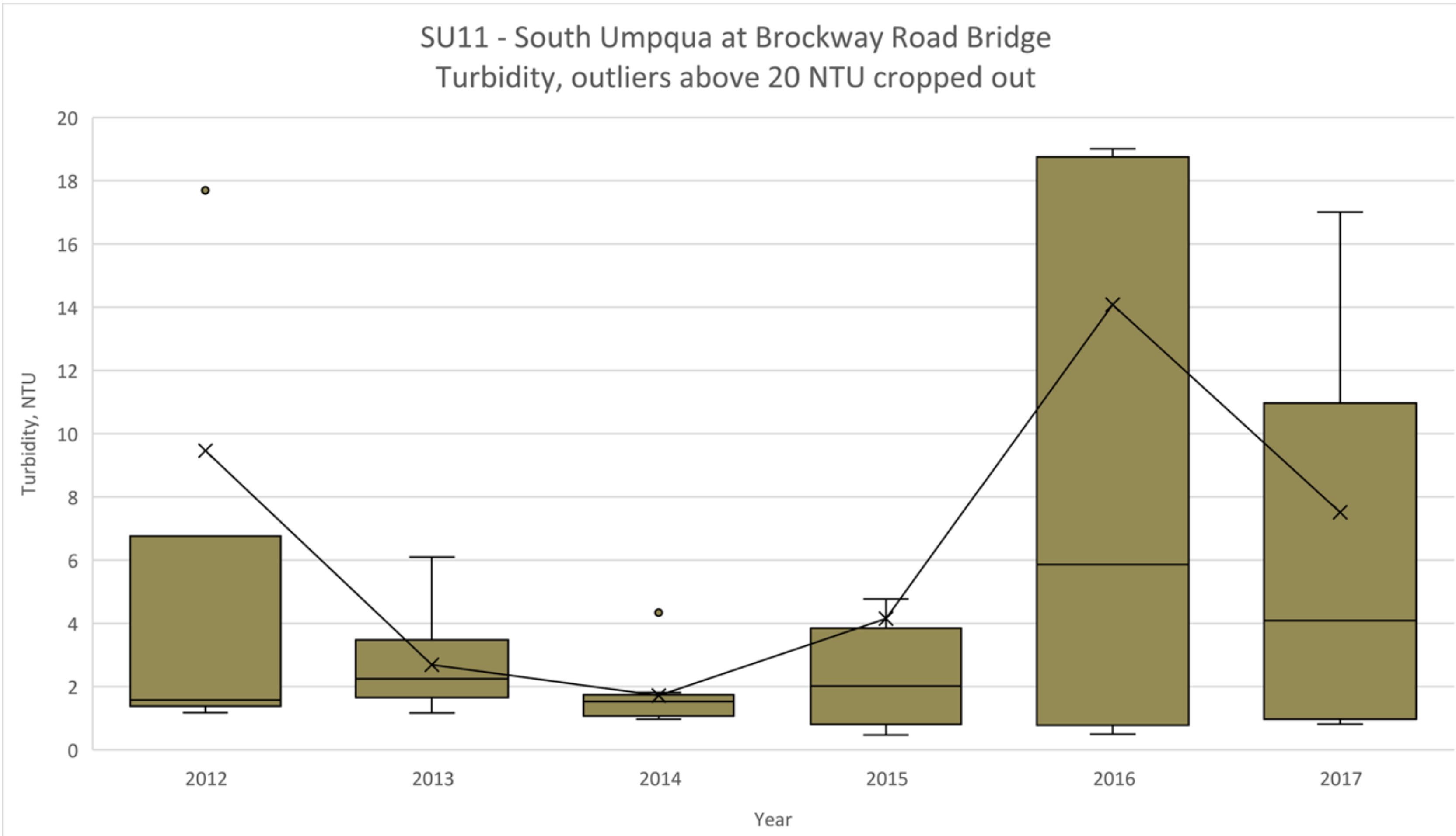
E. coli levels are displayed in graphs 189, 190 and 191**.** Two sampling events produced very high levels of *E. coli* which would list this section the South Umpqua River at Brockway Road bridge. Both occurred in winter. All others were below the 406 MPN/100ml single sample listing criteria.

Temperature

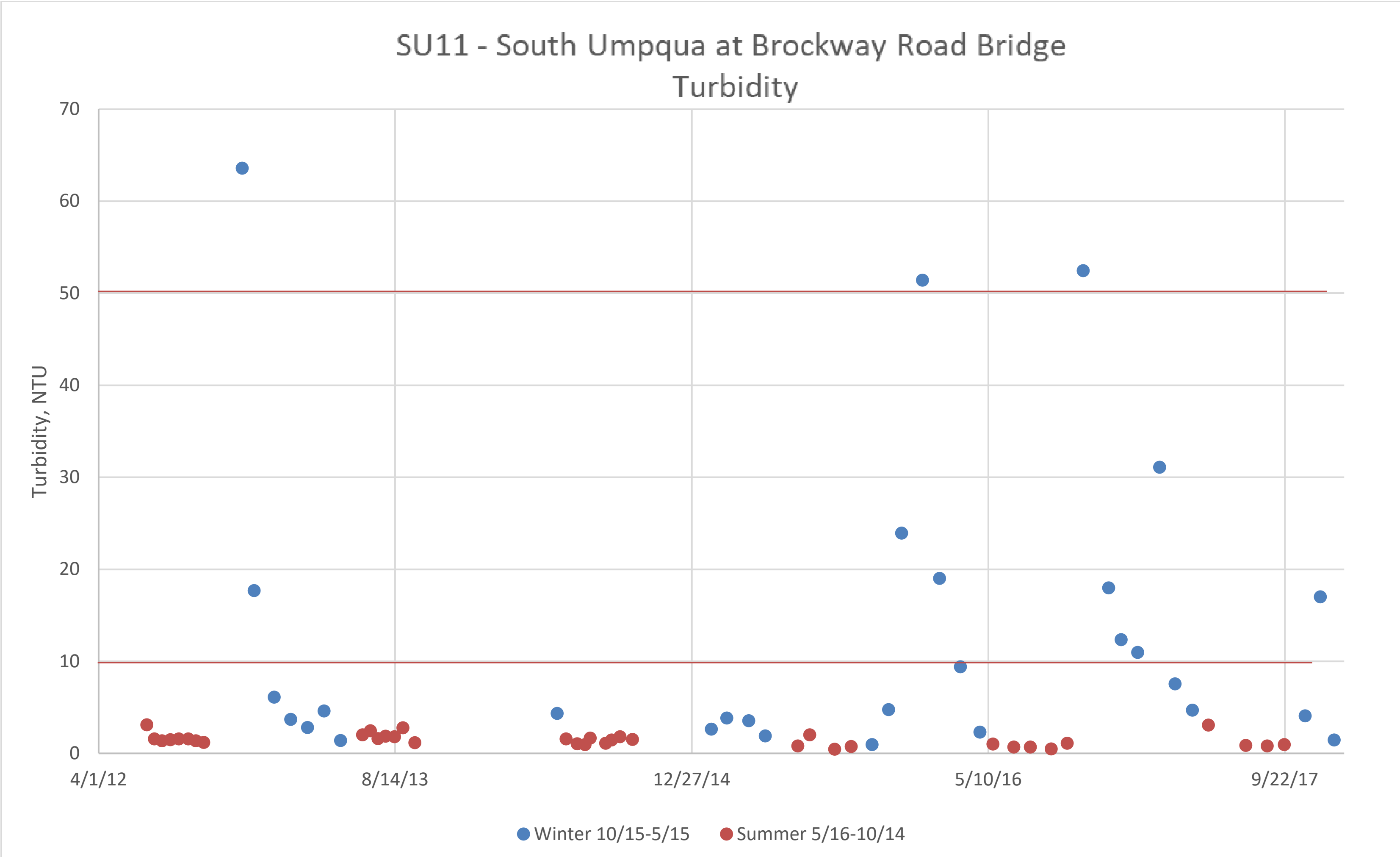
Graphs 192 and 193 display the temperature data for the South Umpqua River at Brockway Road bridge. The winter temperatures were generally good with all but five falling below the 55.4°F spawning criteria; these were all on the fringes of the date range. Summer temperatures however, almost all exceeded the 64.4°F criteria with only three meeting it. No trend is evident.



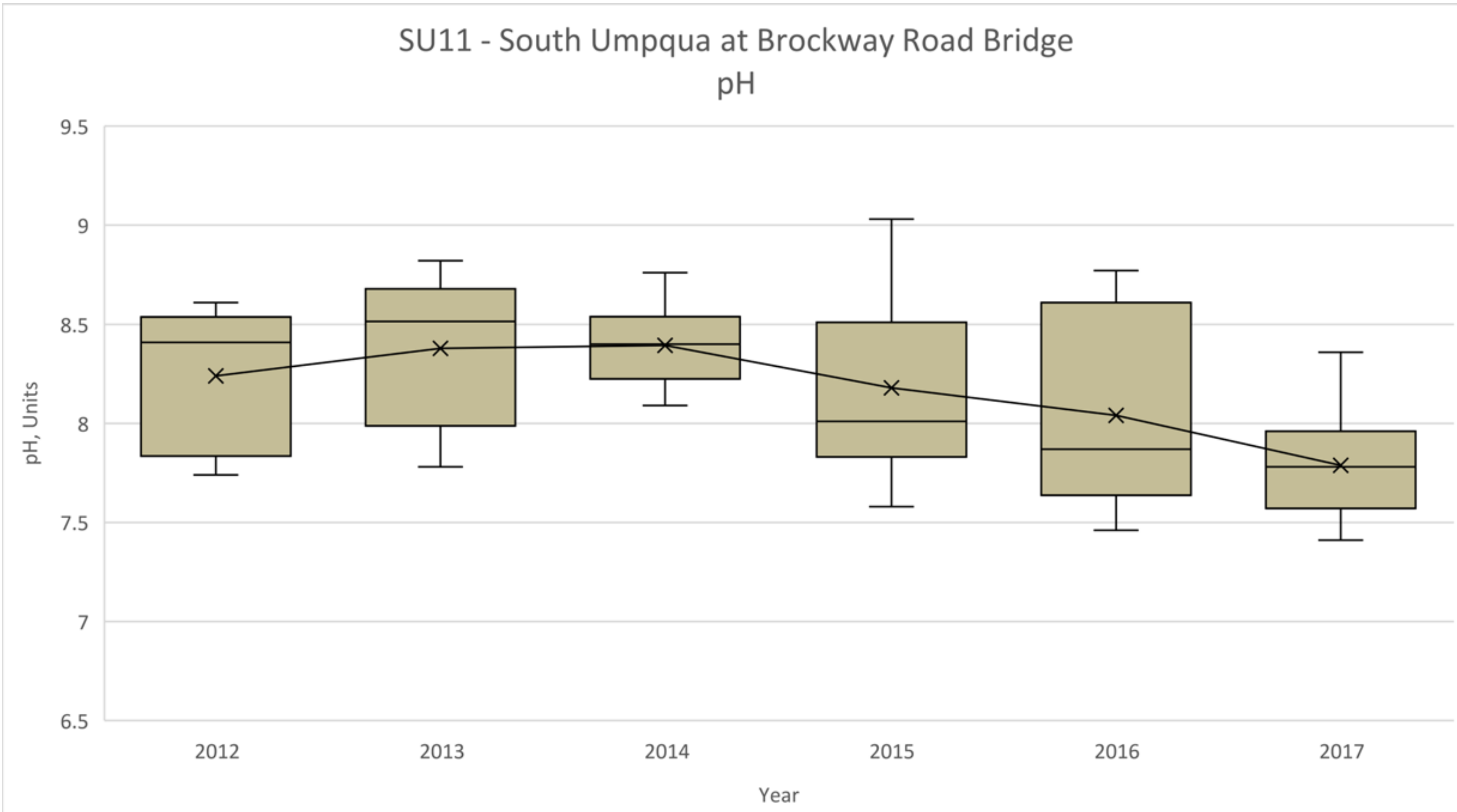
Graph 178. Box plots by year of grab sample turbidity levels of South Umpqua at Brockway bridge.



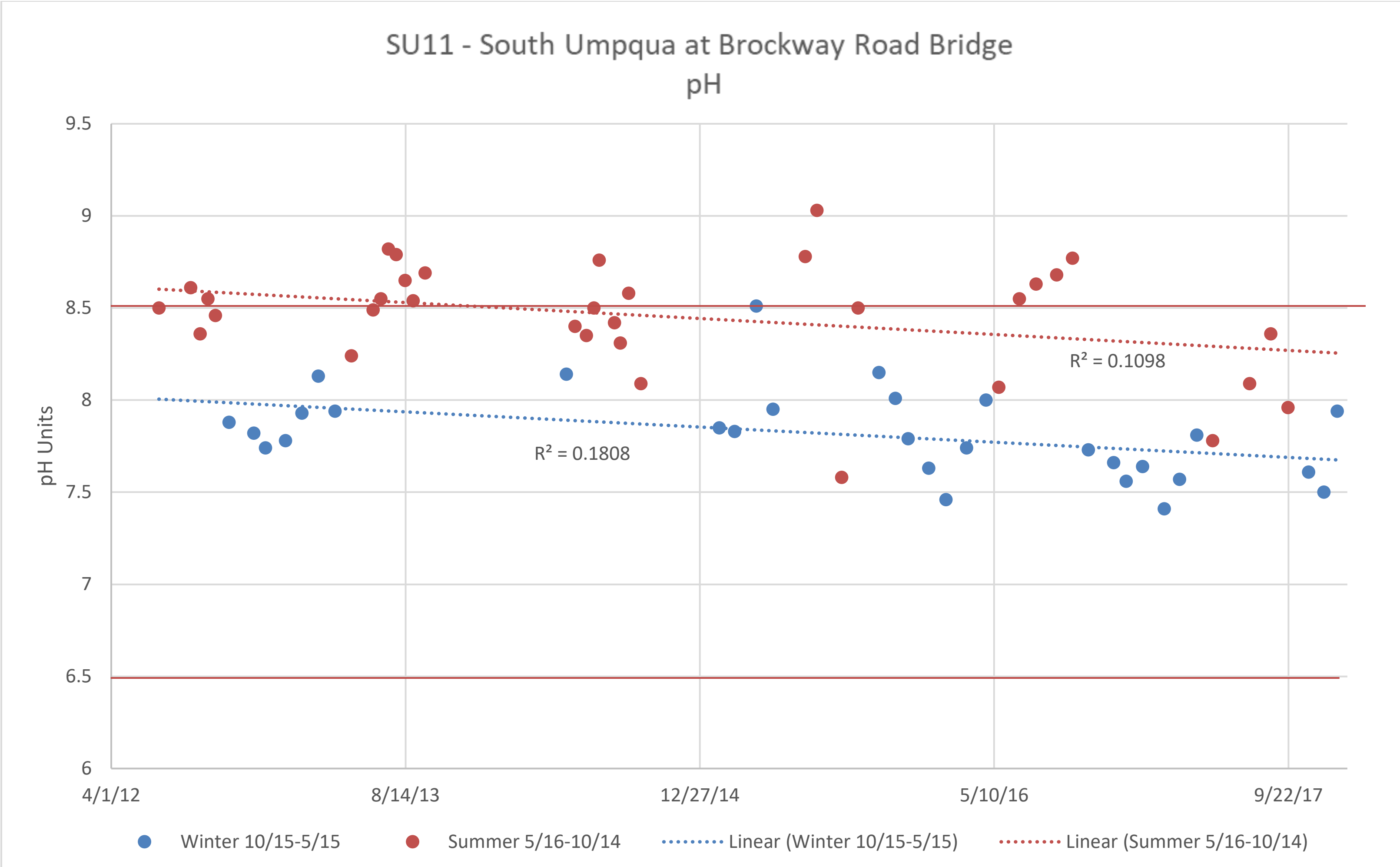
Graph 179. Box plots by year of grab sample turbidity levels of South Umpqua at Brockway bridge with outliers above 20 NTU removed.



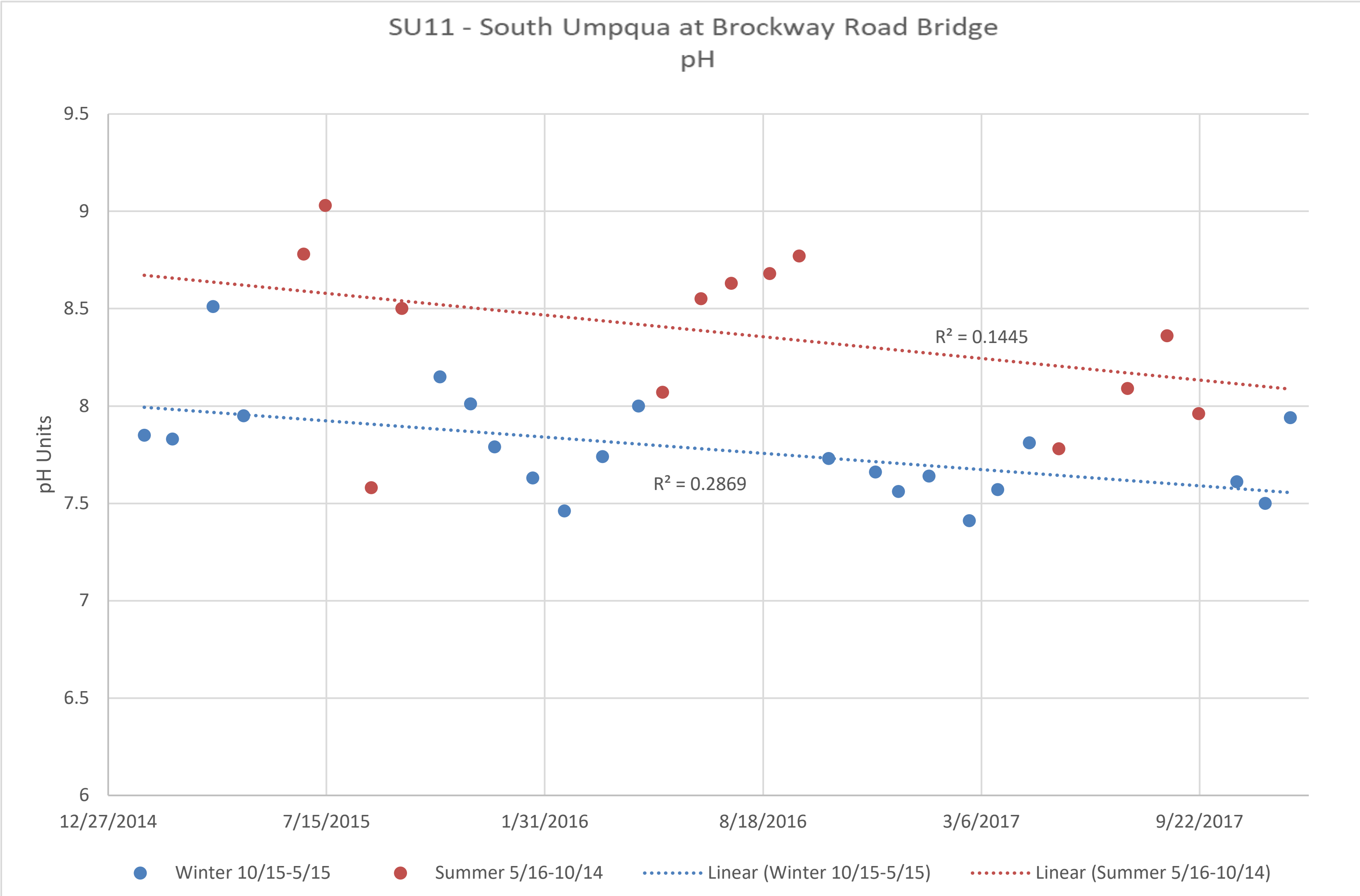
Graph 180. SU11 - South Umpqua at Brockway Road Bridge turbidity summer and winter separated.



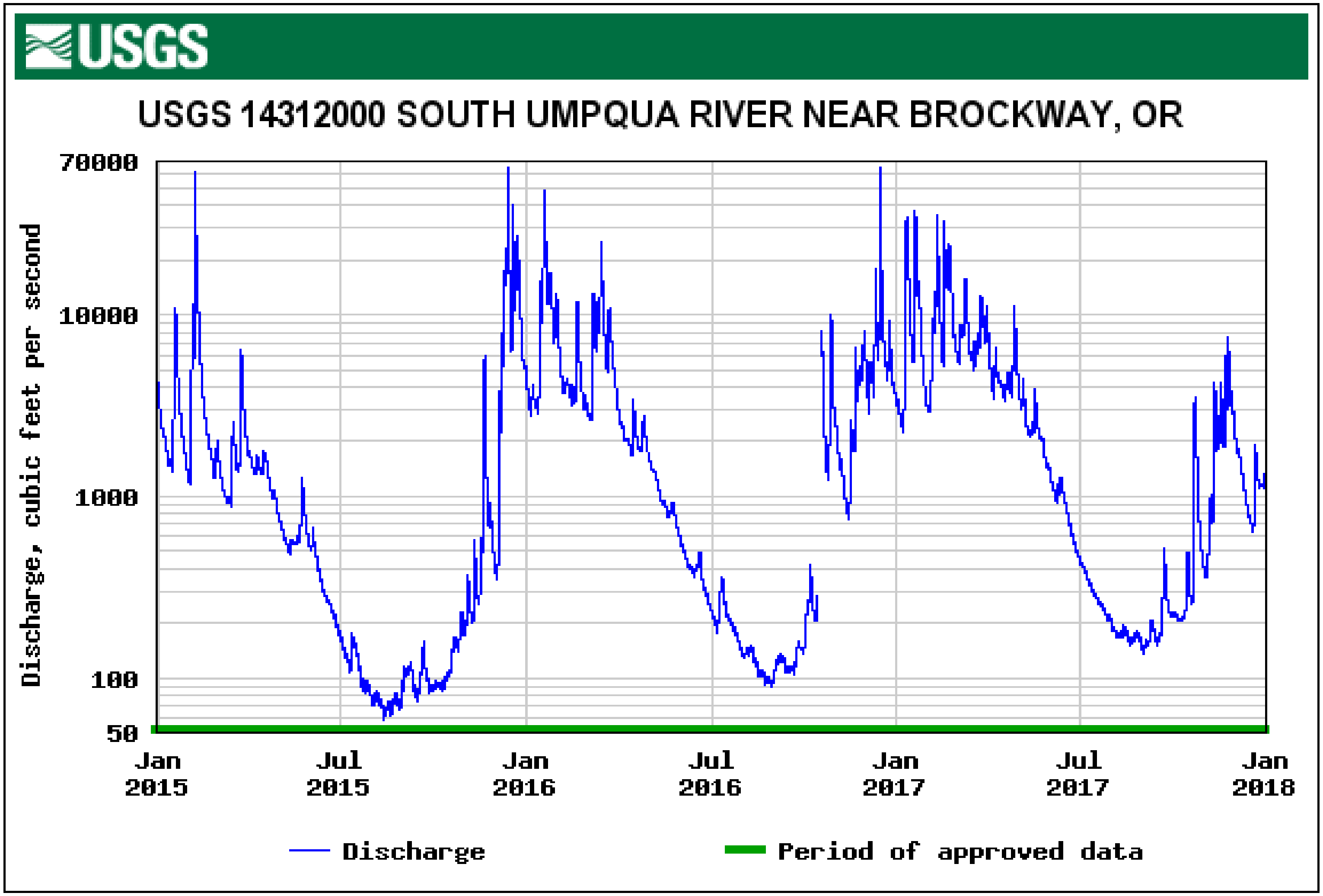
Graph 181. Box plots by year of grab sample pH levels of South Umpqua at Brockway bridge.



Graph 182. SU11 - South Umpqua at Brockway Road Bridge pH grab samples 2012-2017.



Graph 183. SU11 - South Umpqua at Brockway Road Bridge pH 2015-2017.



Graph 184. USGS South Umpqua River Near Brockway, Or Stream Gage.

USGS Surface-Water Annual Statistics for the Nation

The statistics generated from this site are based on approved daily-mean data and may not match those published by the USGS in official publications. The user is responsible for assessment and use of statistics from this site. For more details on why the statistics may not match, click here.

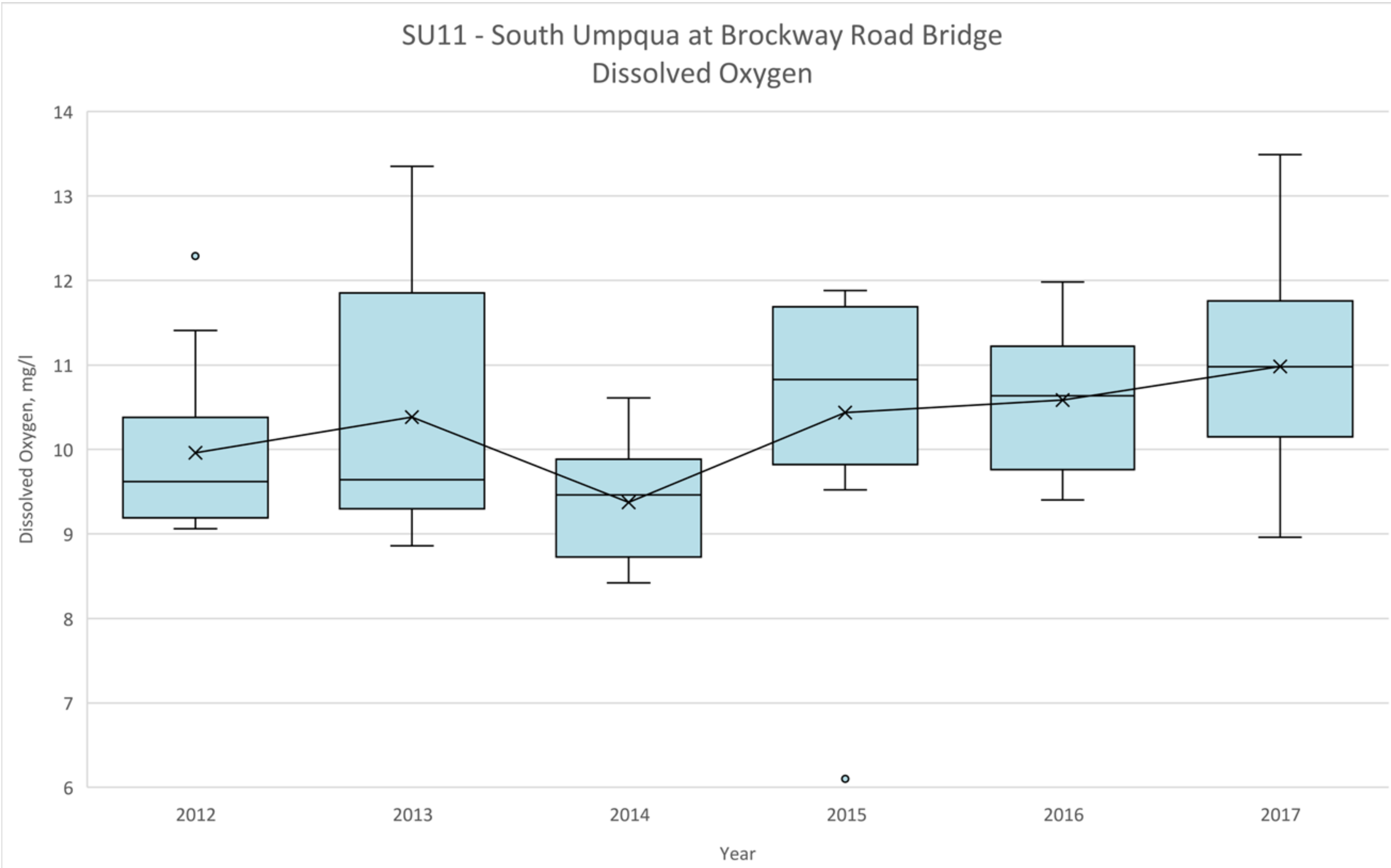
USGS 14312000 SOUTH UMPQUA RIVER NEAR BROCKWAY, OR

Available data for this site Water-Year Summary GO

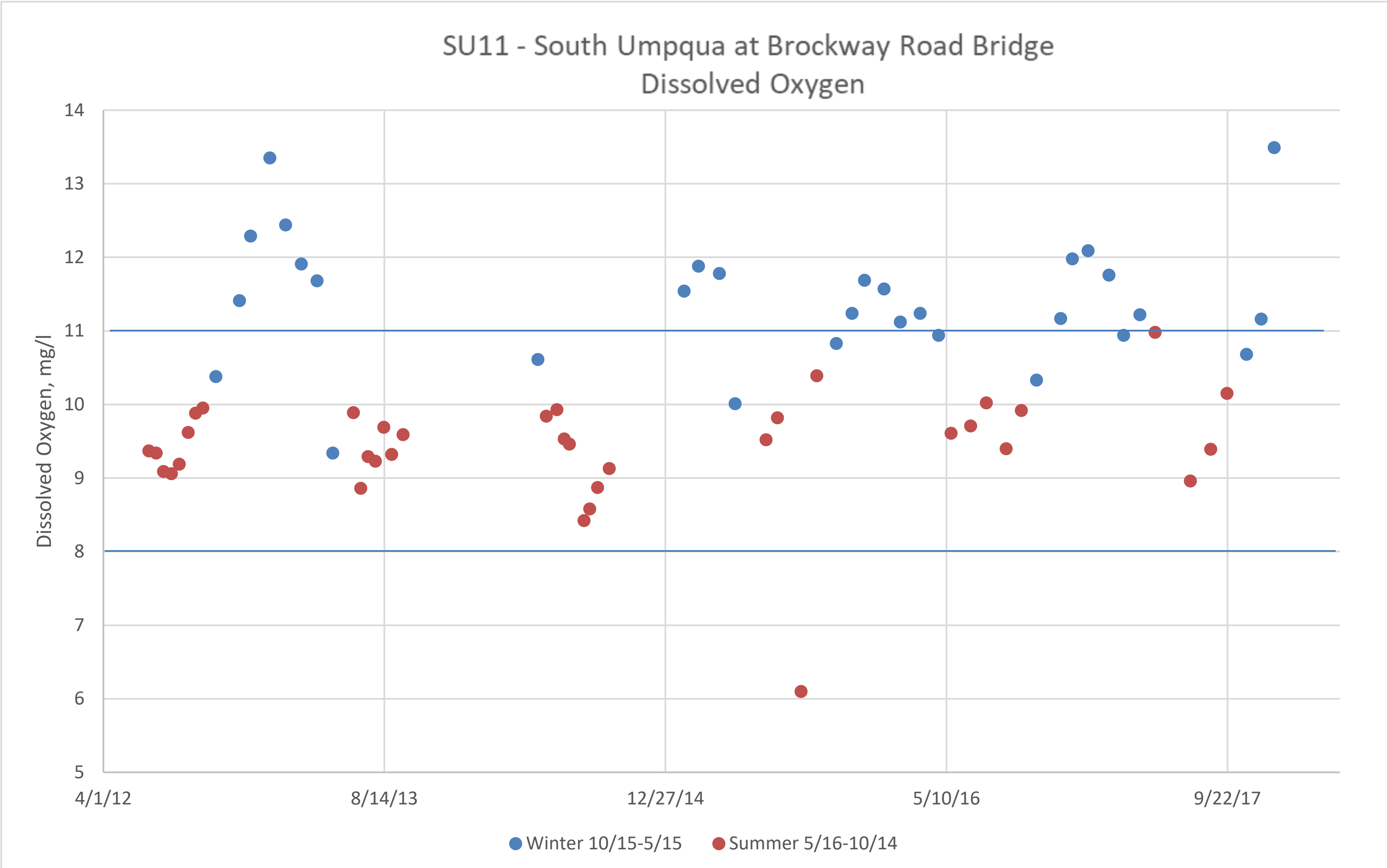
Douglas County, Oregon Hydrologic Unit Code 17100302 Latitude 43°08'00", Longitude 123°23'50" NAD27 Drainage area 1,670 square miles Gage datum 462.52 feet above NGVD29	**Output formats** HTML table of all data Tab-separated data Reselect output format

Water Year	00060, Discharge, cubic feet per second
Period-of-record for statistical calculation restricted by user	
2010	1,883
2011	3,560
2012	2,780
2013	2,445
2014	1,494
2015	1,971
2016	3,337
2017	4,321
** No Incomplete data have been used for statistical calculation	

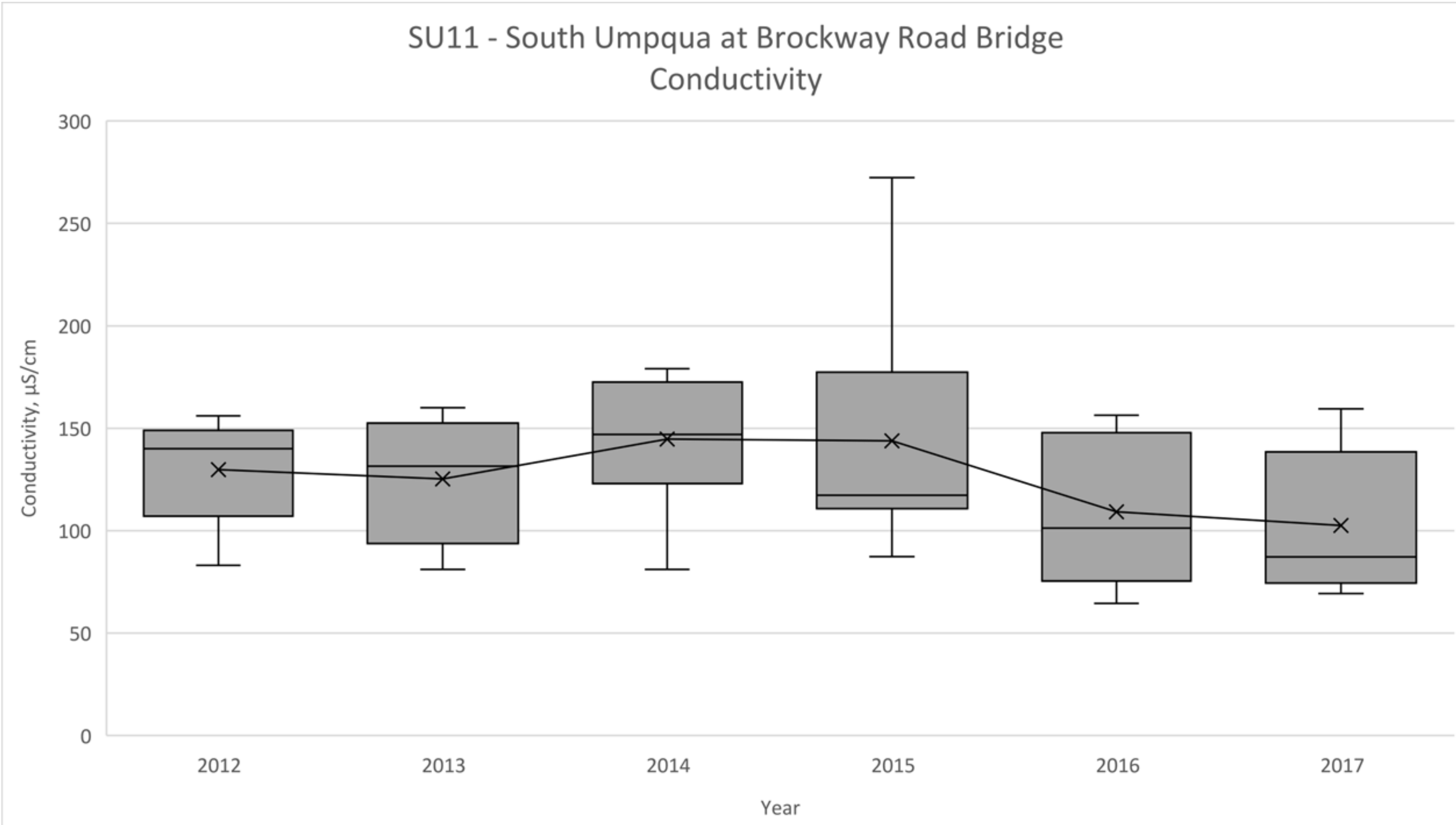
Table 40. USGS Stream Gage data for the South Umpqua River 2010-2017 at Brockway, Oregon.



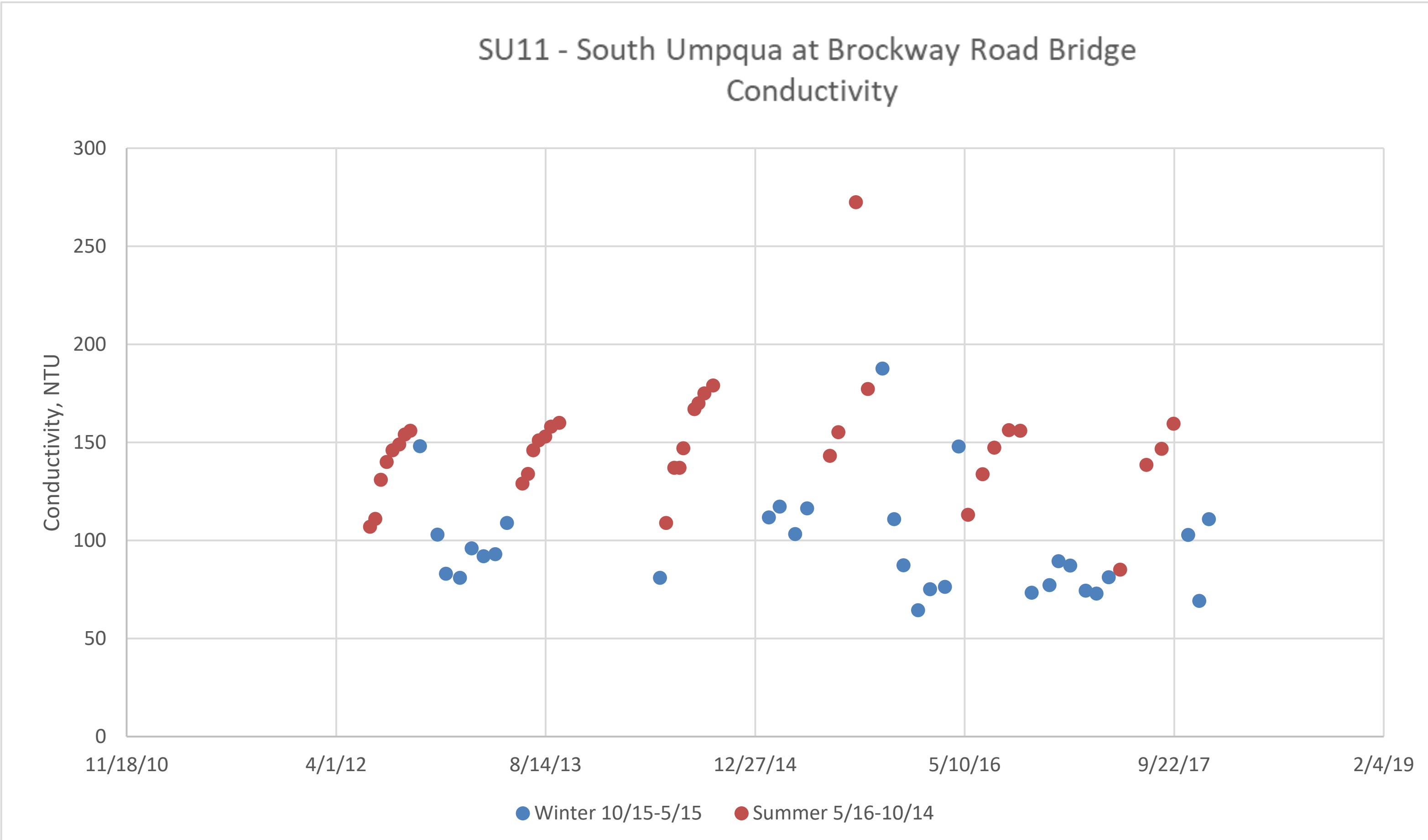
Graph 185. Box plots by year of grab sample dissolved oxygen levels of South Umpqua at Brockway bridge.



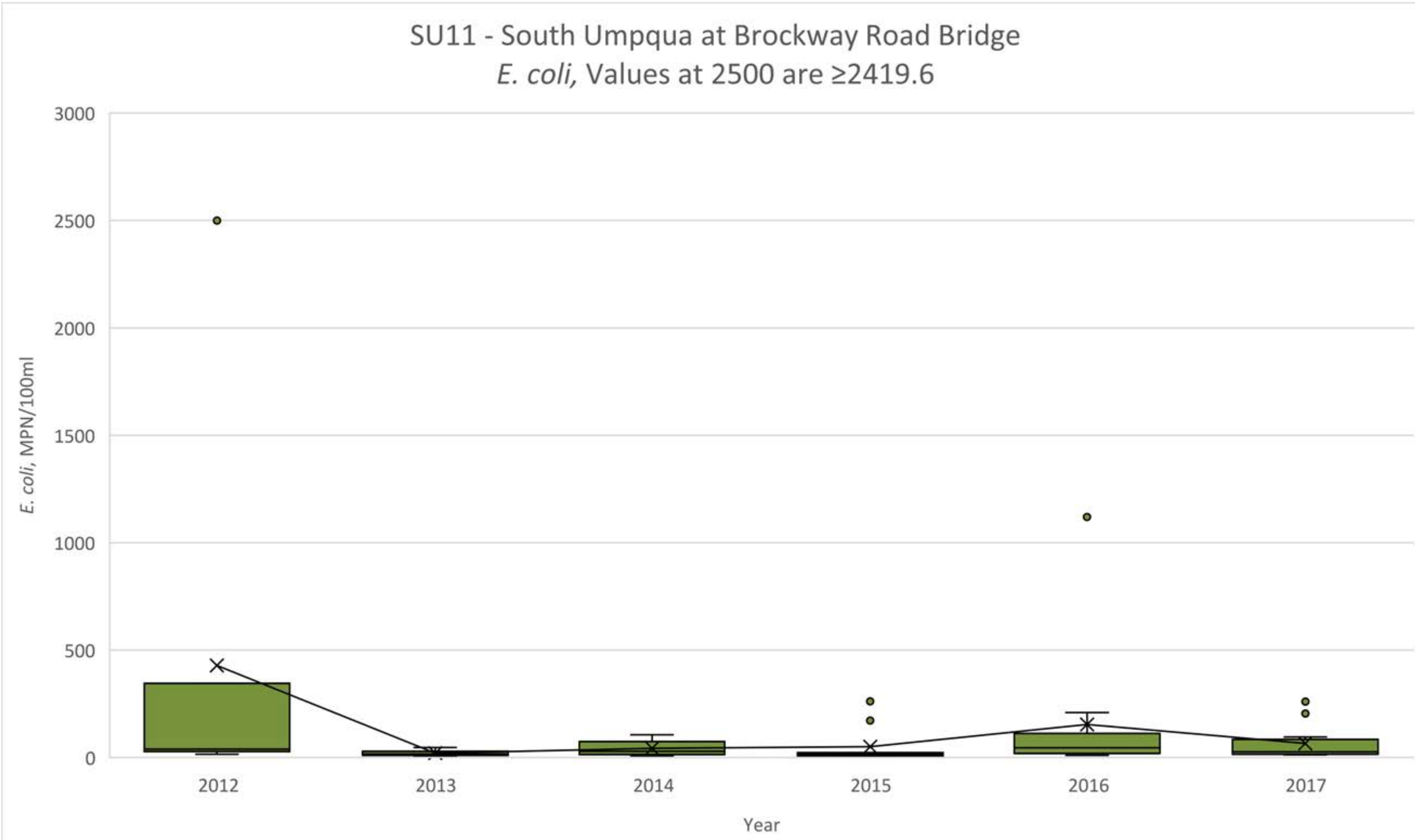
Graph 186. SU11 - South Umpqua at Brockway Road Bridge Dissolved Oxygen summer and winter separated.



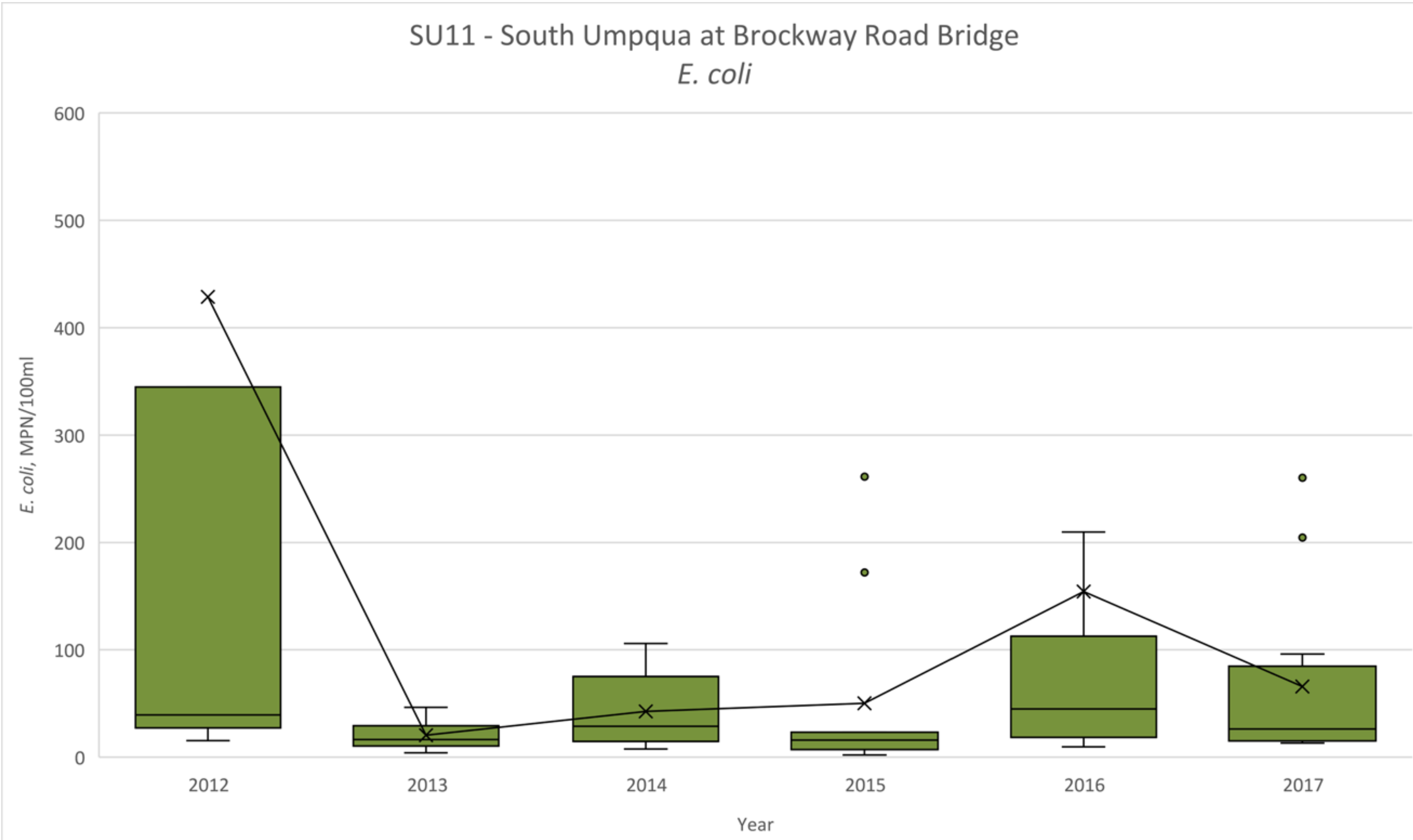
Graph 187. Box plots by year of grab sample conductivity levels of South Umpqua at Brockway bridge.



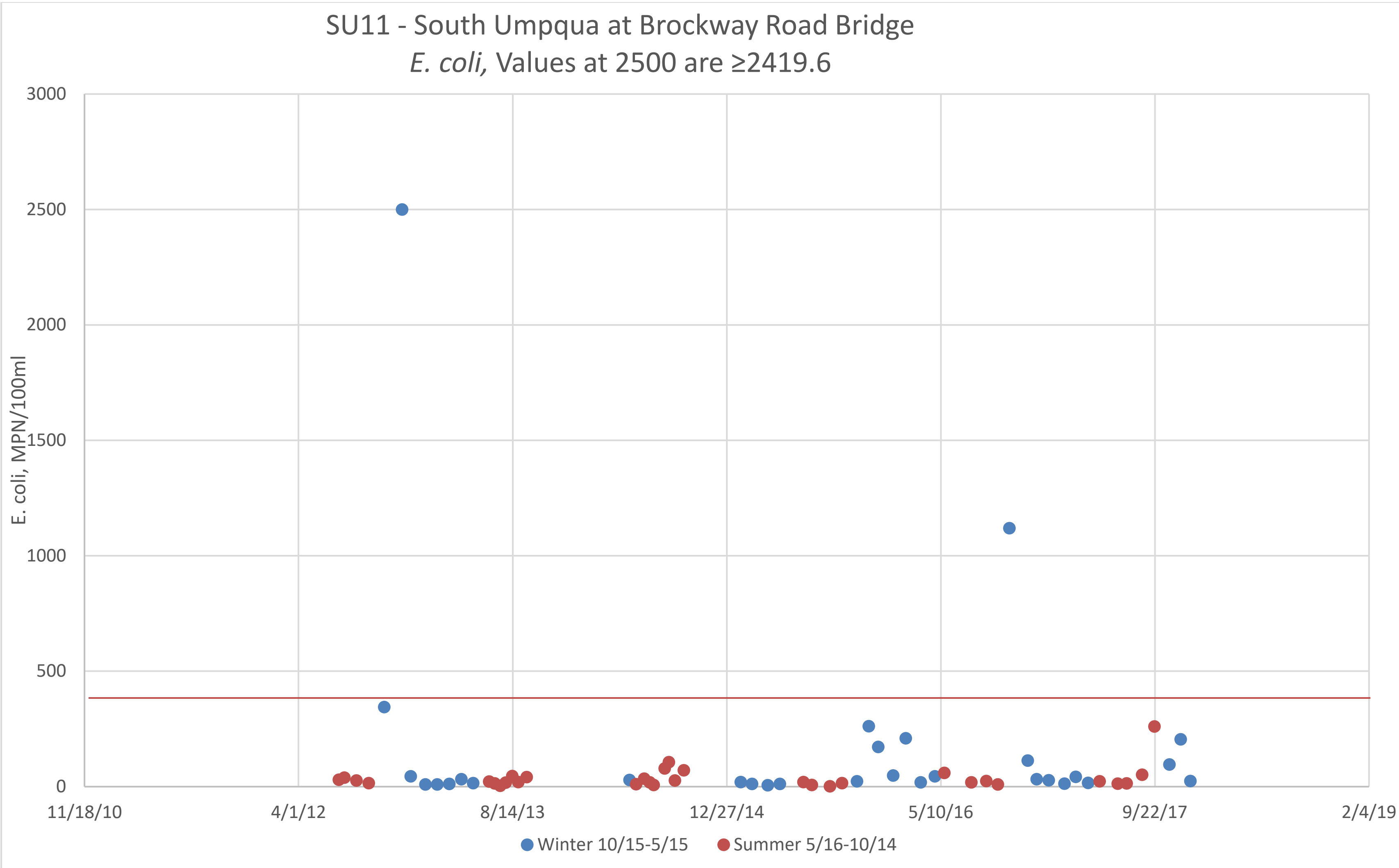
Graph 188. SU11 - South Umpqua at Brockway Road Bridge conductivity summer and winter separated.



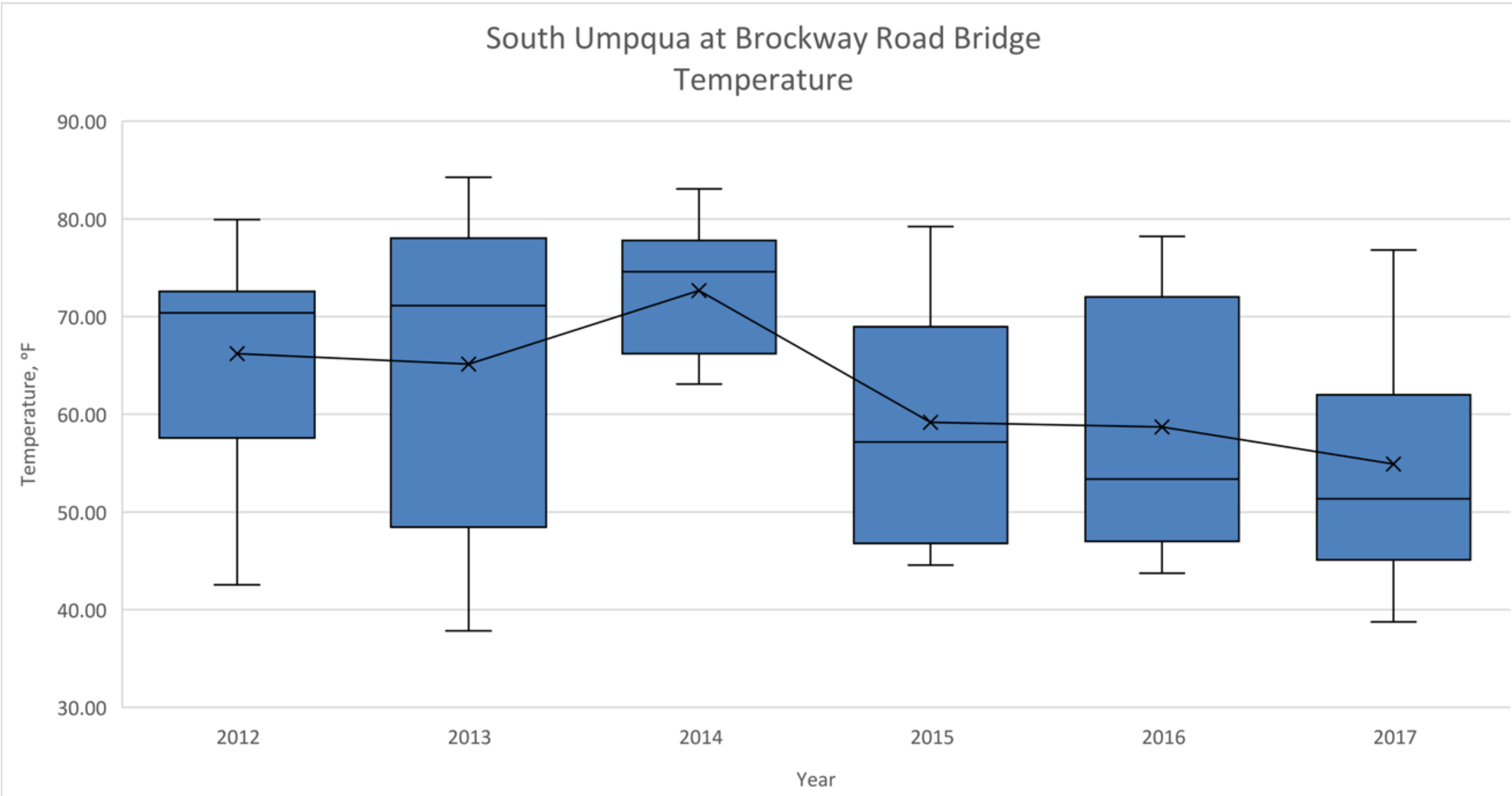
Graph 189. Box plots by year of grab sample *E. coli* levels of South Umpqua at Brockway bridge.



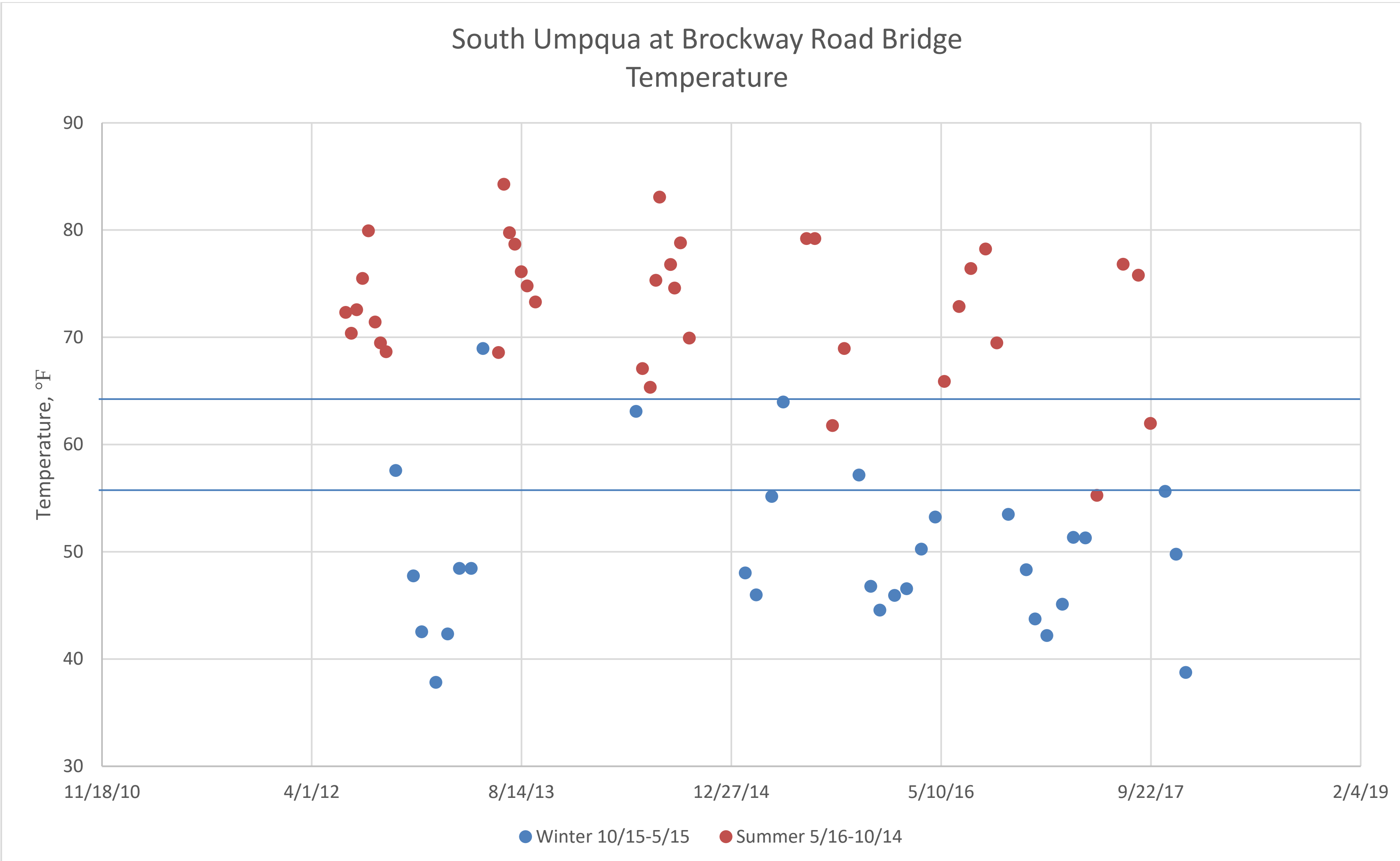
Graph 190. Box plots by year of grab sample *E. coli* levels of South Umpqua at Brockway bridge with outliers over 600 removed.



Graph 191. SU11 grab sample temperature levels of South Umpqua at Brockway bridge.



Graph 192. Box Plots of Grab Sample Temperature at Brockway Road Bridge 2012-2017



Graph 193. SU11 - South Umpqua at Brockway Road Bridge grab sample temperatures 2012-2017.

LG3 - Lookingglass Creek at Hwy 42 Bridge West of Olalla Road

Year	Monthly Samples	Months
2012	6	June-Dec
2013	12	Full Year
2014	12	Full Year
2015	12	Full Year
2016	12	Full Year
2017	12	Full Year

Table 41. Number of monitoring events per year included in graphs that follow for Lookingglass Creek at Highway 42 bridge.

Turbidity

Lookingglass Creek at Highway 42 bridge was sampled 2012 thru 2017 (Graphs 194-195). During our grab sampling, the highest level detected was 45 NTU with none going over 50 NTU which "The Oregon Watershed Assessment Manual recommends using 50 NTUs as the turbidity evaluation criteria for watershed assessments. At this level, turbidity interferes with sight-feeding aquatic organisms and provides an indication of the biological effect of suspended sediment." There were many samples exceeding 10 NTU occurring in both winter and summer. Graph 195 shows that there is a slight downward trend of summer turbidity and a slight upward trend in winter turbidity. It should be noted that Lookingglass Creek is influenced by the output from Ben Irving Reservoir which contributes a great deal of dissolved clay into Berry Creek which feeds into Olalla Creek and into Lookingglass Creek.

pH

With grab sampling, one event exceeded the upper DEQ recommended limit of 8.5, none fell below the lower exceedance of 6.5. No pH levels were measured below 7.0. The box plot (Graph 196) does not show a downward trend in pH values for 2015, 2016, 2017. Graph 197 shows summer and winter pH values for 2015-2017. These do not show any correlation to indicate a downward trend. The pH values were good at this site except for the one outlier at 8.66.

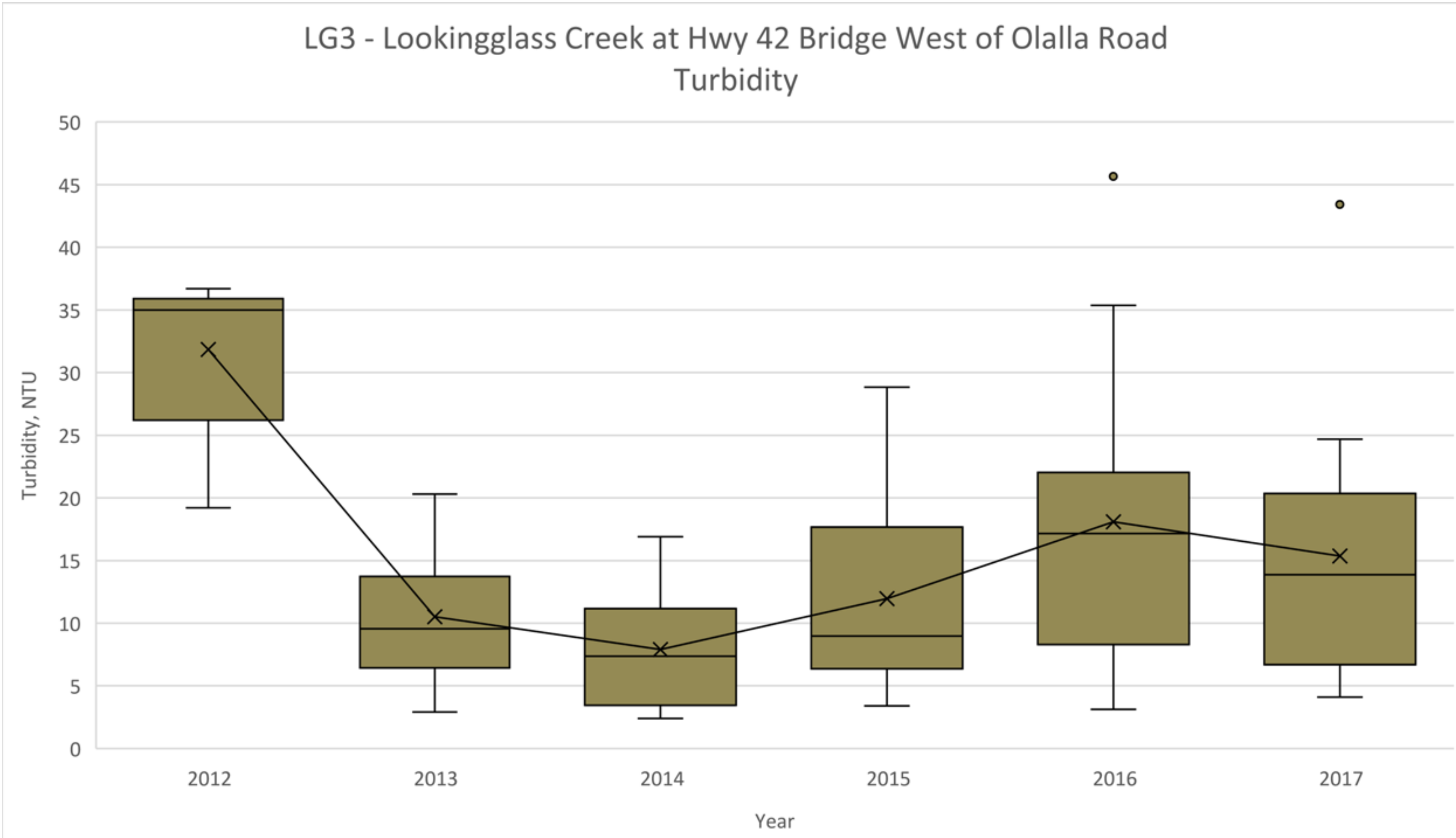
Dissolved Oxygen

Graphs 198 and 199 display the dissolved oxygen grab sample data for LG3 - Lookingglass Creek at Hwy 42 Bridge West of Olalla Road. Only one summer grab sample of 7.6 was detected below the lower limit of eight in July of 2014. However, eighteen winter measurements fell below the spawning criteria of eleven. No trend is apparent.

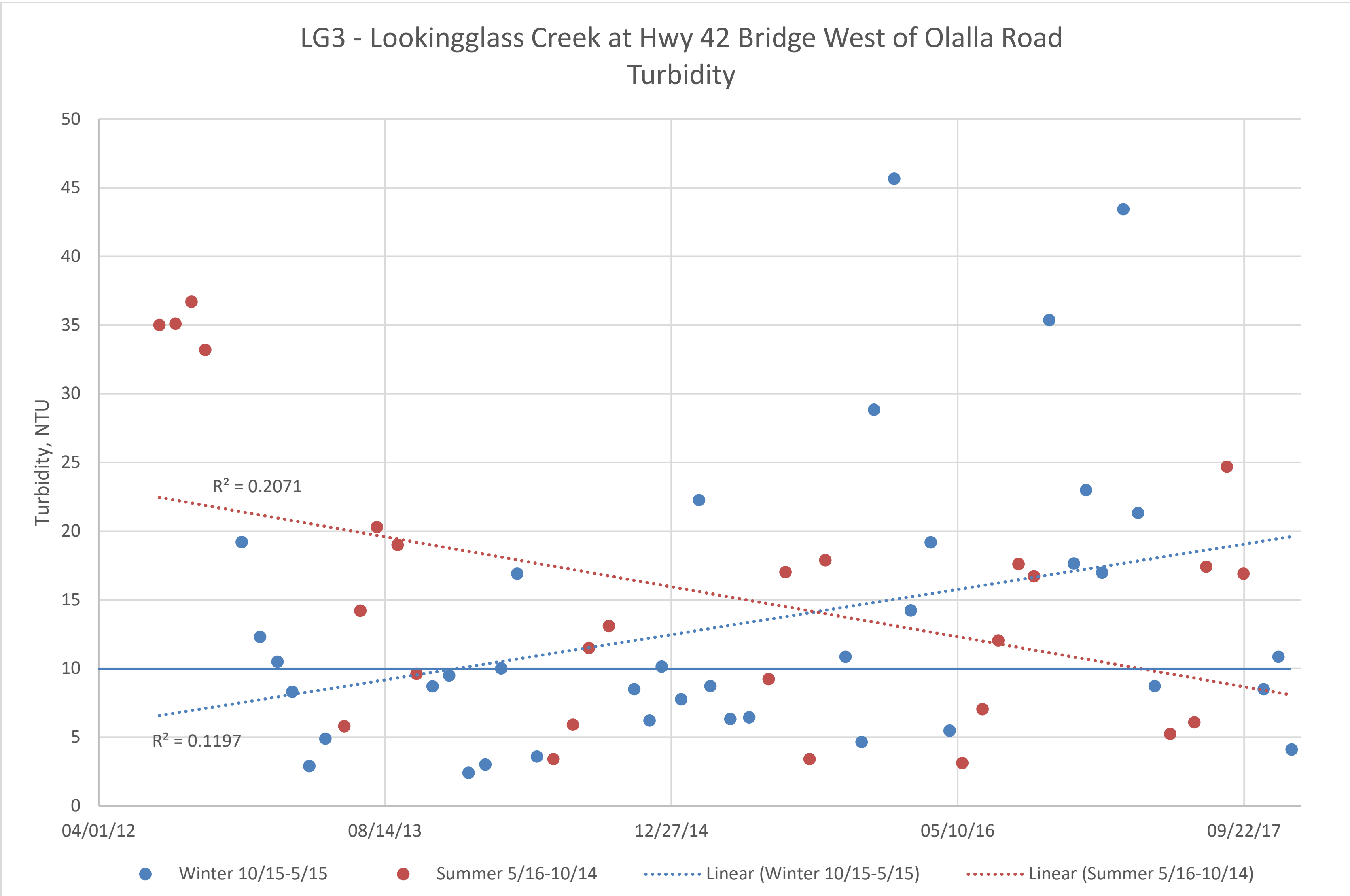
Conductivity
Graphs 200 and 201 display the conductivity grab sample data. All are within normal ranges for the Umpqua basin. No trend is evident, and variation was between 65.9 and 128 with a single outlier at 173. At this site there was not a significant increase during the summer months contrary to many sites in the Umpqua basin.

E. coli
E. coli levels are displayed in graphs 202, 203 and 204**.** Fifteen sampling events produced high levels of *E. coli* which would list this section of Lookingglass Creek at Hwy 42 Bridge West of Olalla Road. These occurred in summer and winter. All others were below the 406 MPN/100ml single sample listing criteria, though 17 might have produced listings if sampled 5 times within a month because they fell between 126 and 406 MPN/100ml (see Graph 204).

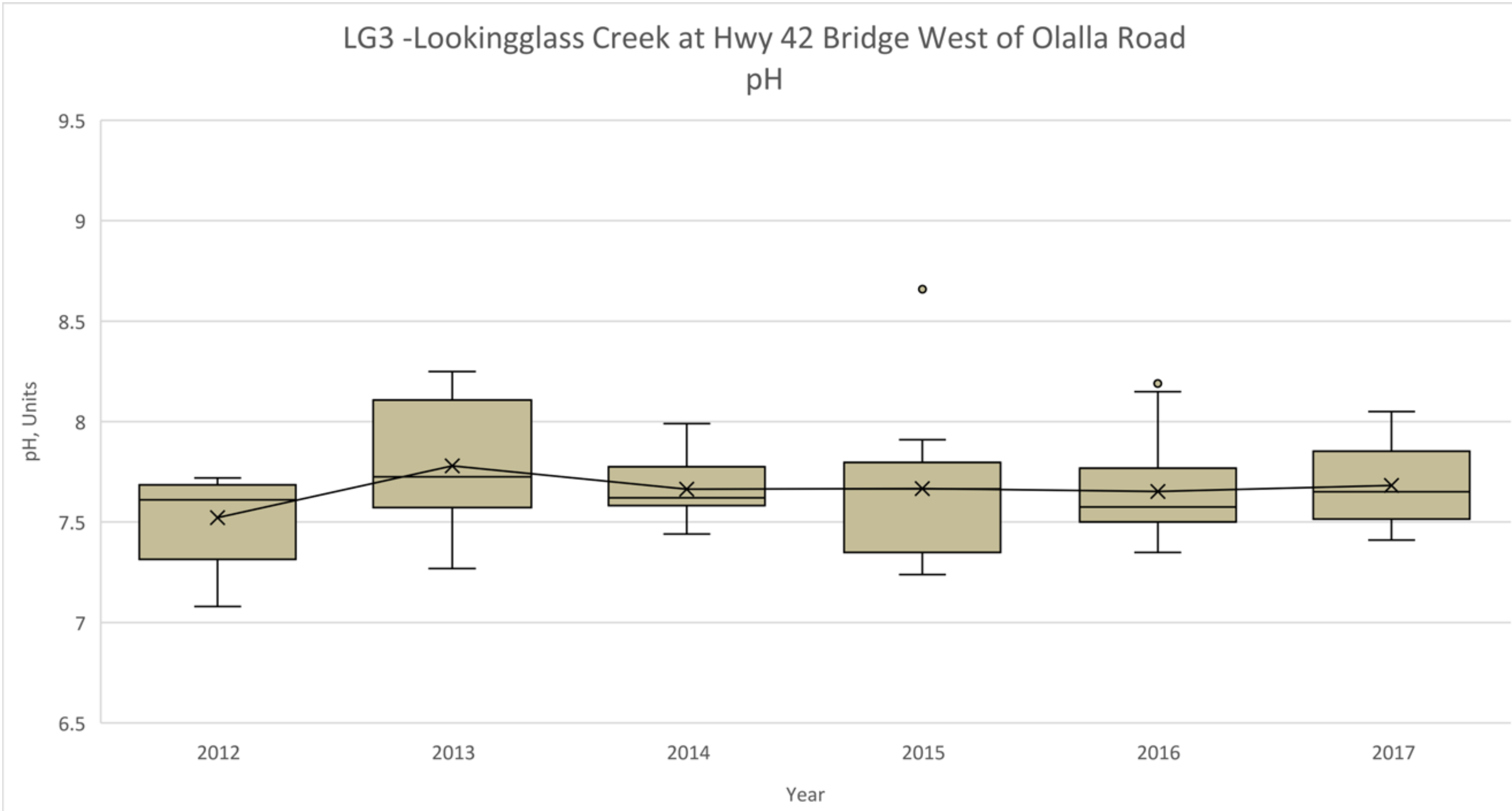
Temperature
Graphs 205 and 206 display the temperature data for Lookingglass Creek at Hwy 42 Bridge West of Olalla Road. The winter temperatures were very good with only one failing and that was at 56.6 with the spawning criteria being below the 55.4°F. Summer temperatures however, had eleven exceedances of the 64.4°F criteria with fifteen meeting it. No trend is evident.



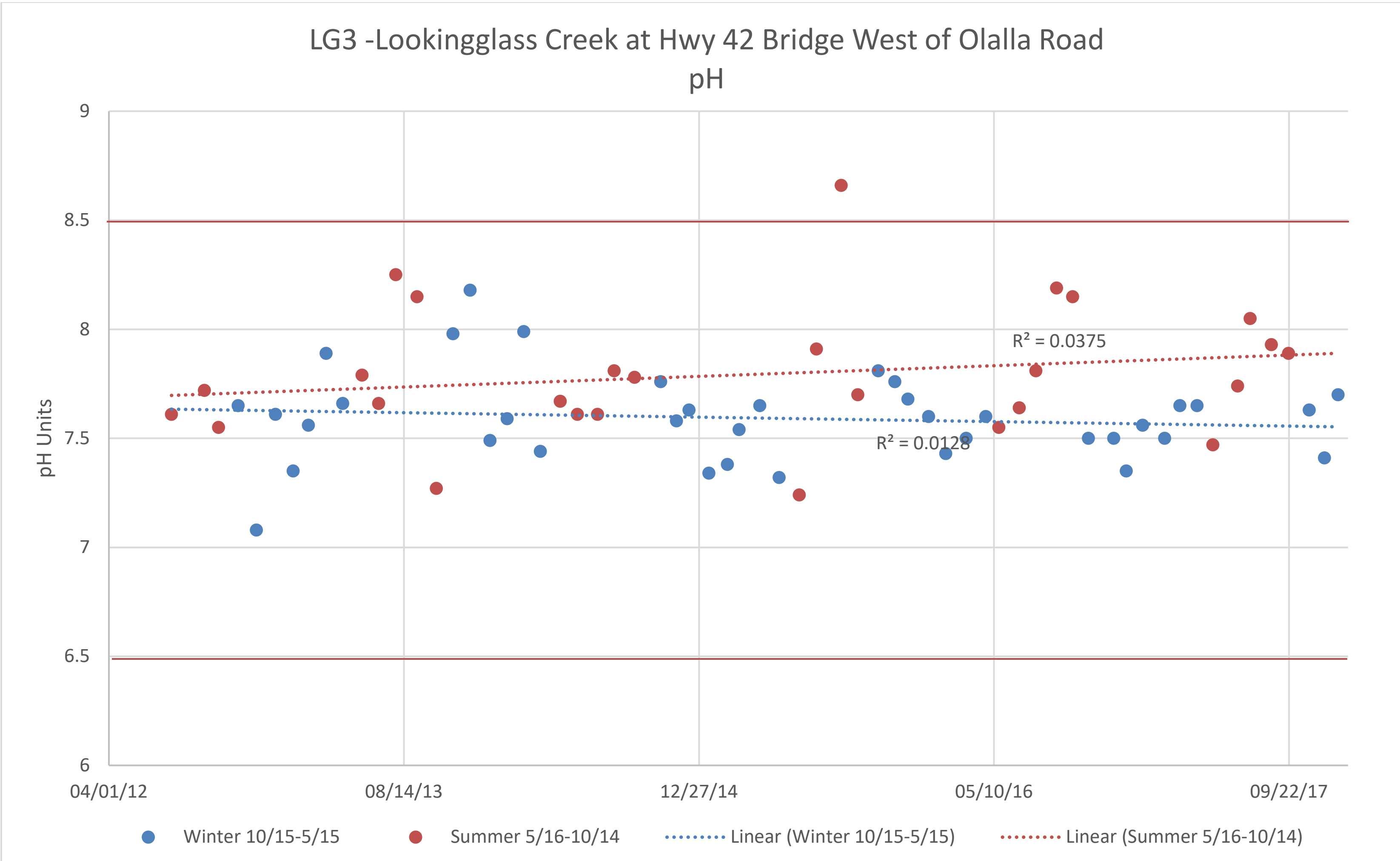
Graph 194. Box plots by year of grab sample turbidity levels for Lookingglass Creek at Hwy 42 Bridge West of Olalla Road.



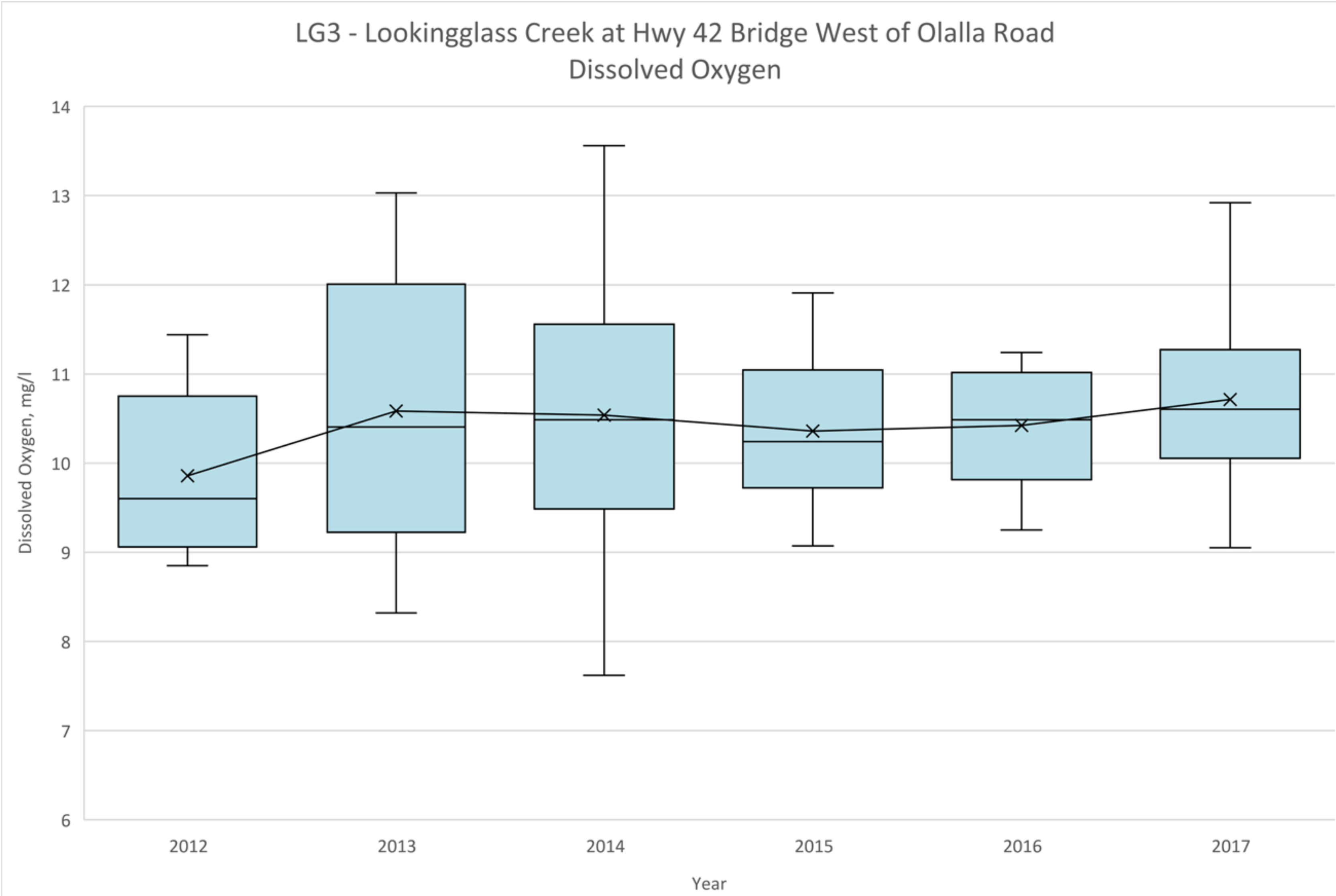
Graph 195. LG3 - Lookingglass Creek at Hwy 42 Bridge West of Olalla Road turbidity.



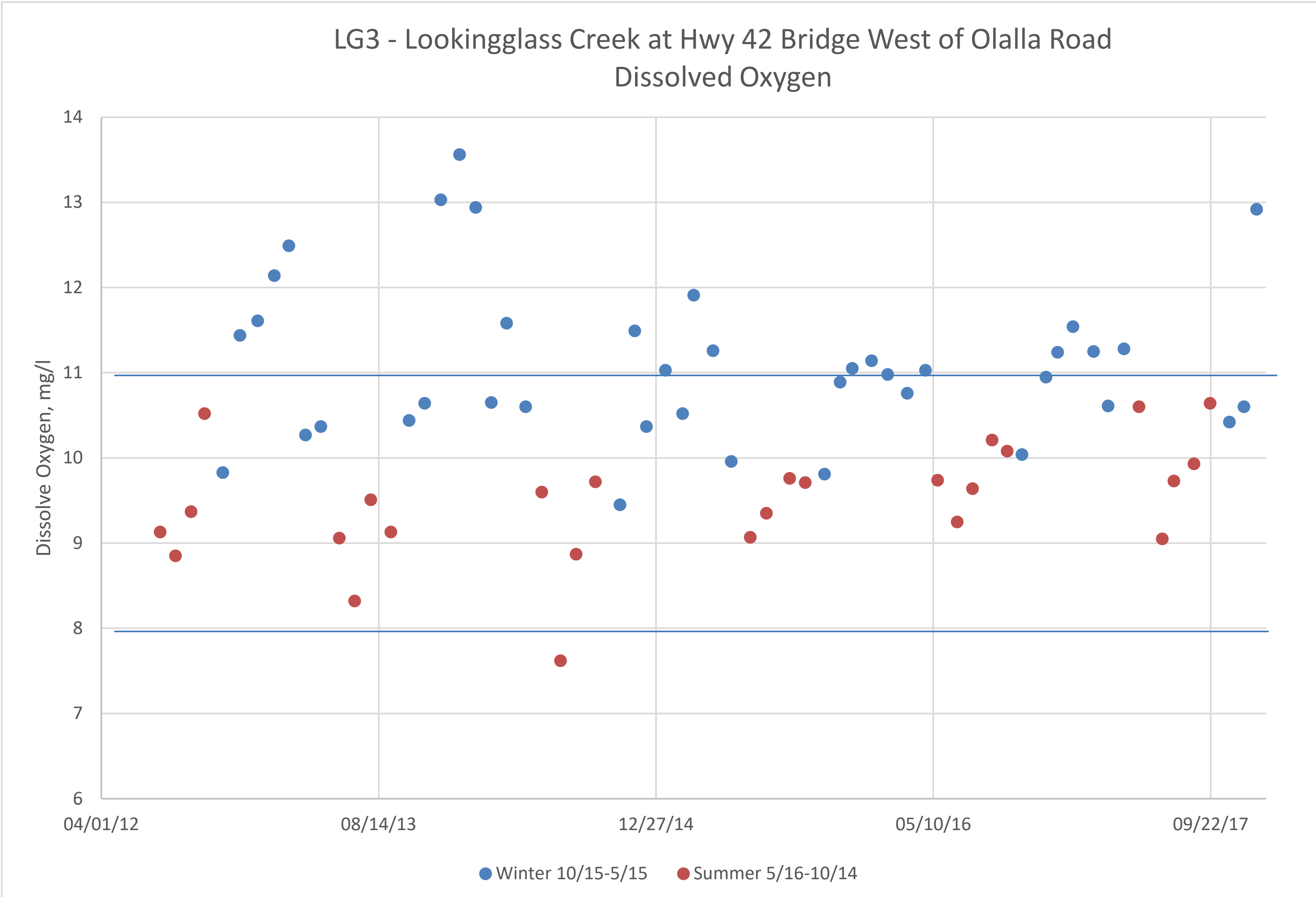
Graph 196. Box plots by year of grab sample pH levels for Lookingglass Creek at Hwy 42 Bridge West of Olalla Road.



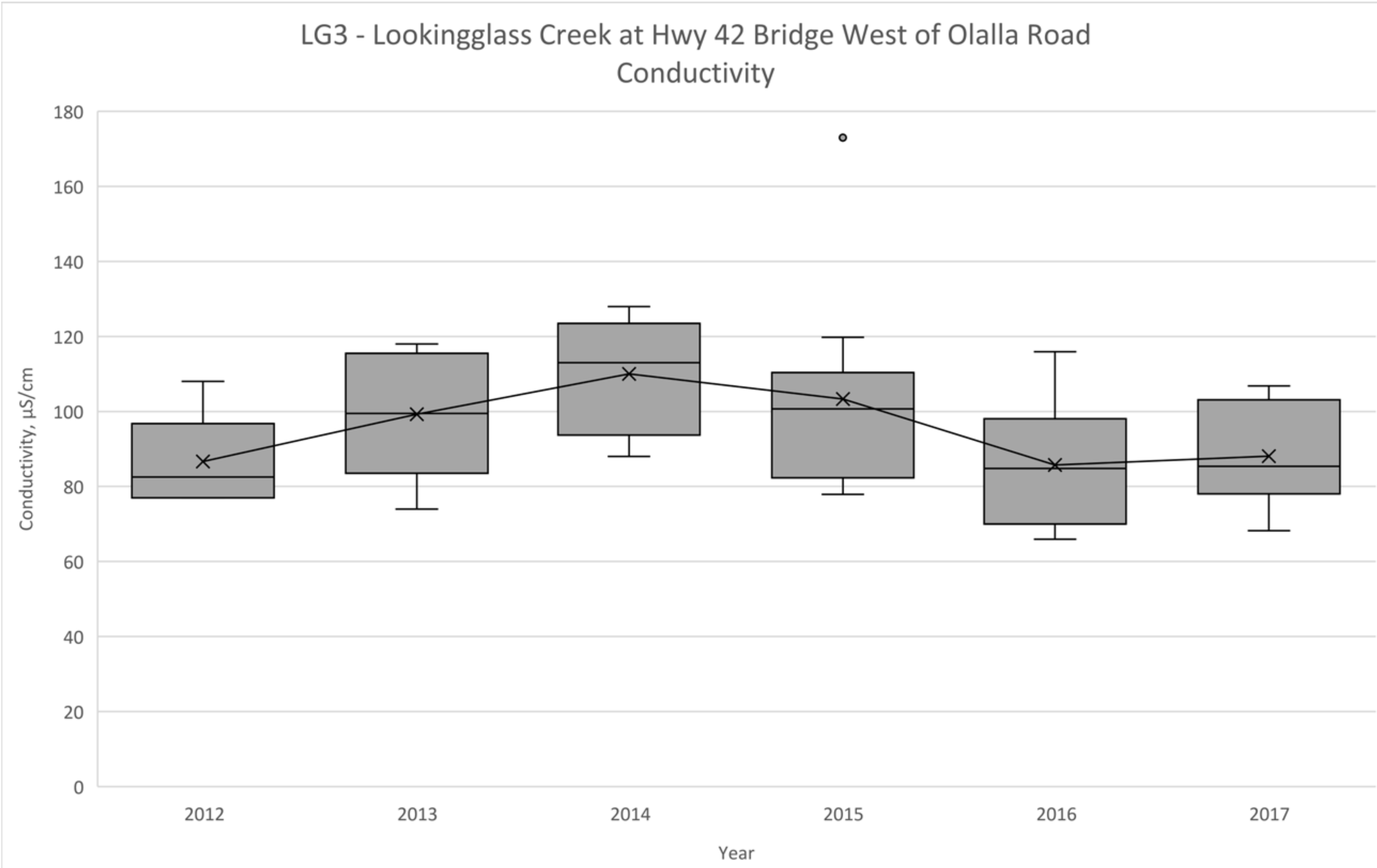
Graph 197. LG3 -Lookingglass Creek at Hwy 42 Bridge West of Olalla Road pH 2012-2017.



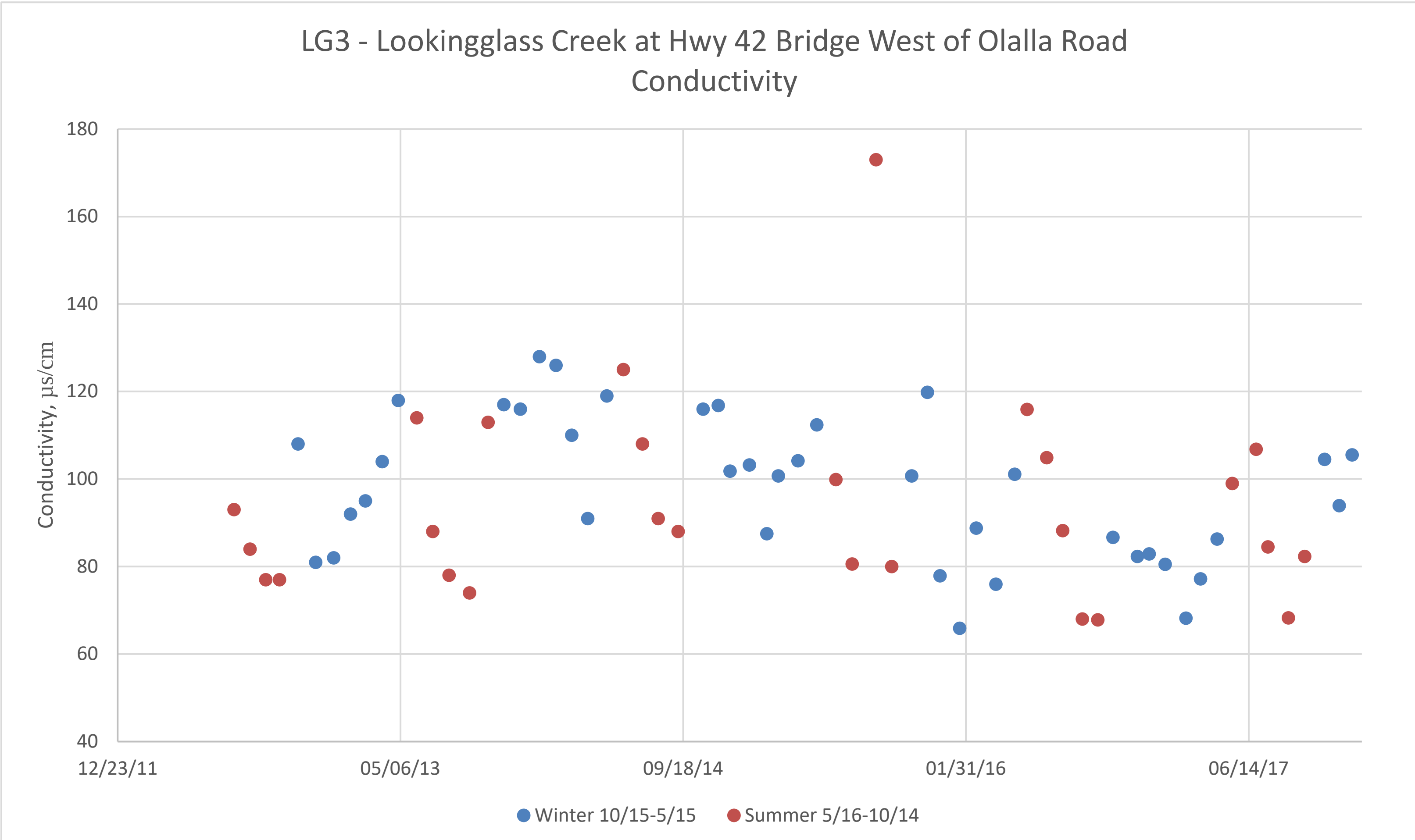
Graph 198. Box plots by year of grab sample dissolved oxygen levels for Lookingglass Creek at Hwy 42 Bridge West of Olalla Road.



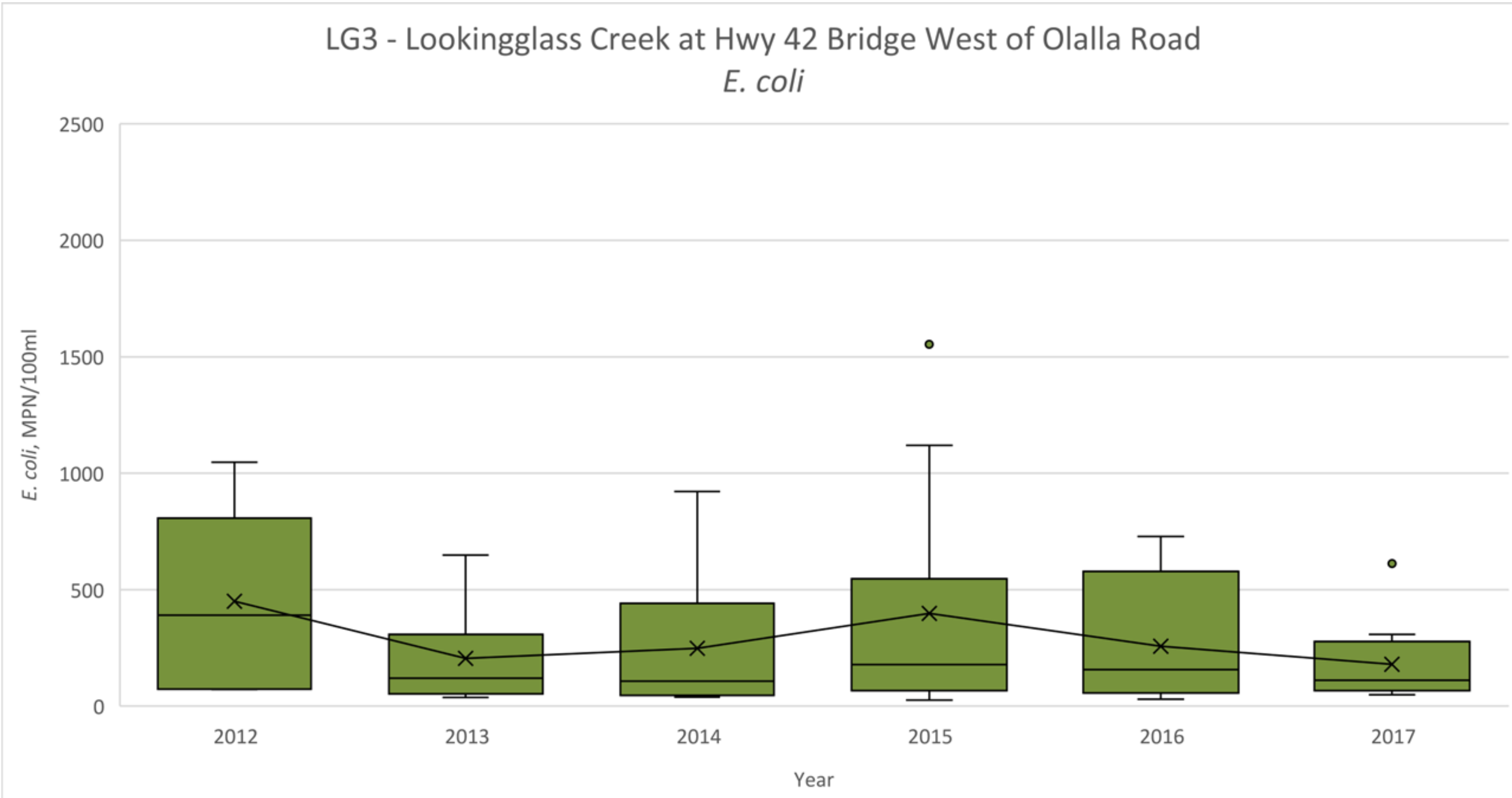
Graph 199. LG3 - Lookingglass Creek at Hwy 42 Bridge West of Olalla Road Dissolved Oxygen.



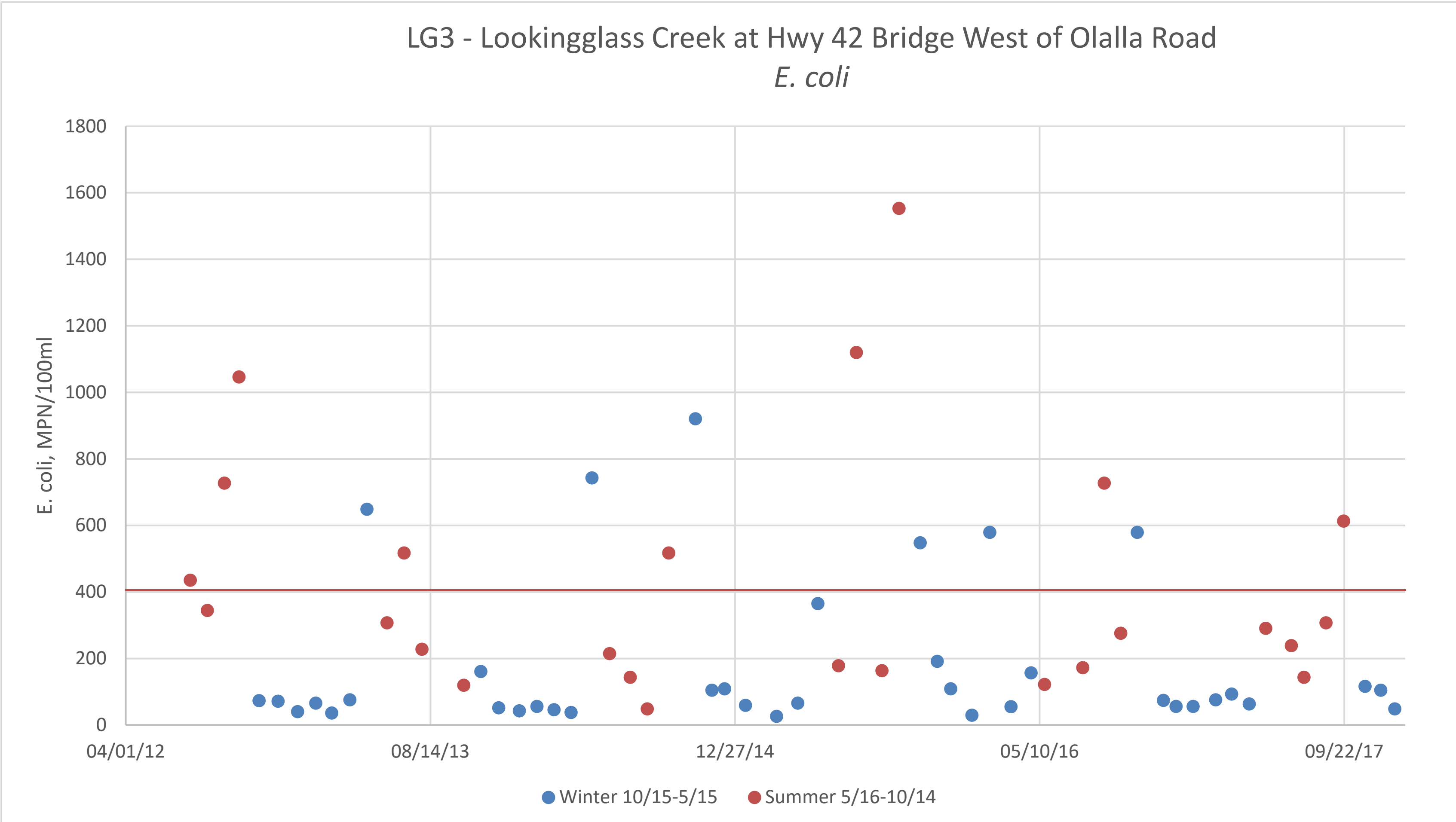
Graph 200. Box plots by year of grab sample conductivity levels for Lookingglass Creek at Hwy 42 Bridge West of Olalla Road.



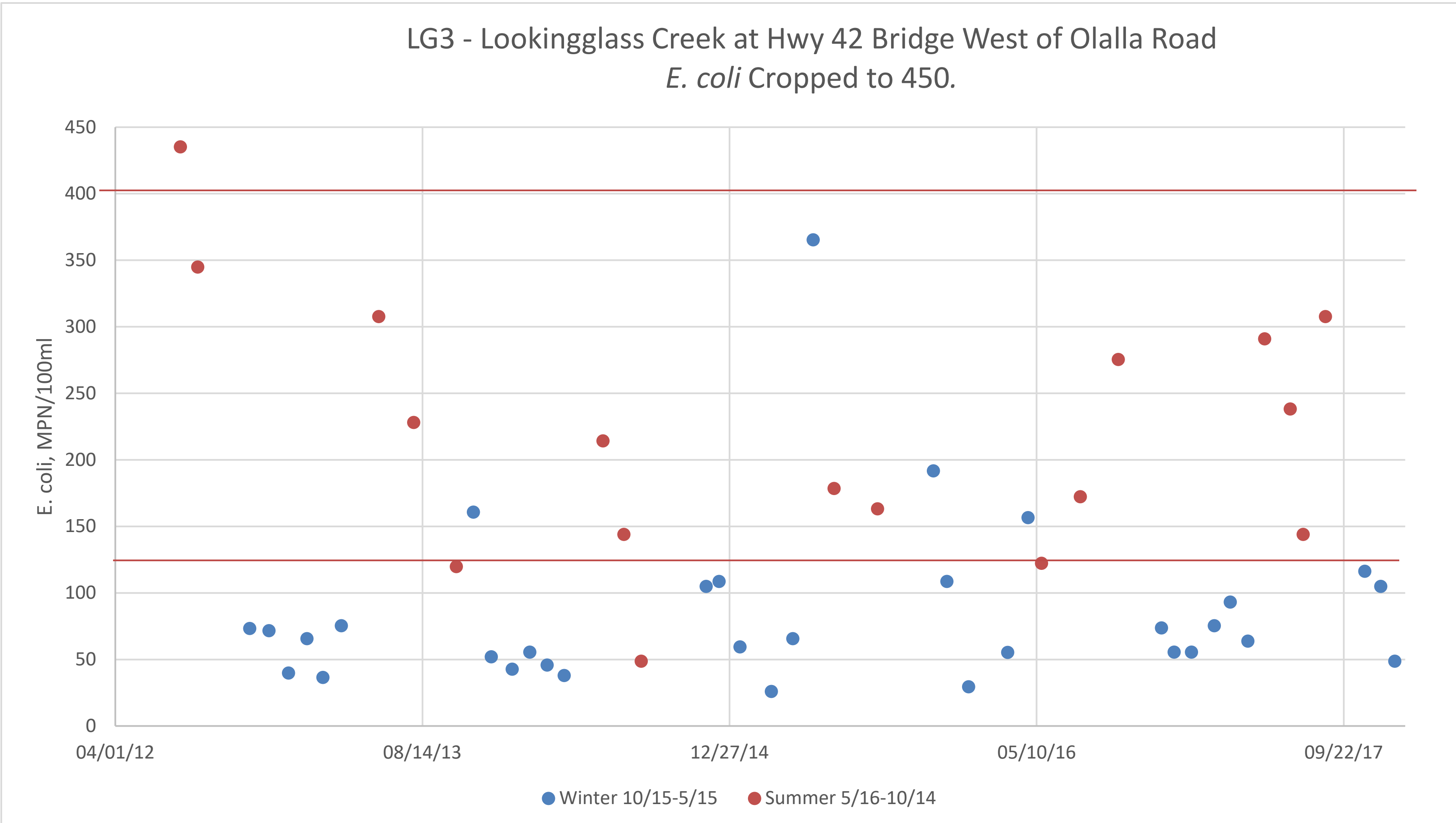
Graph 201. LG3 - Lookingglass Creek at Hwy 42 Bridge West of Olalla Road Conductivity



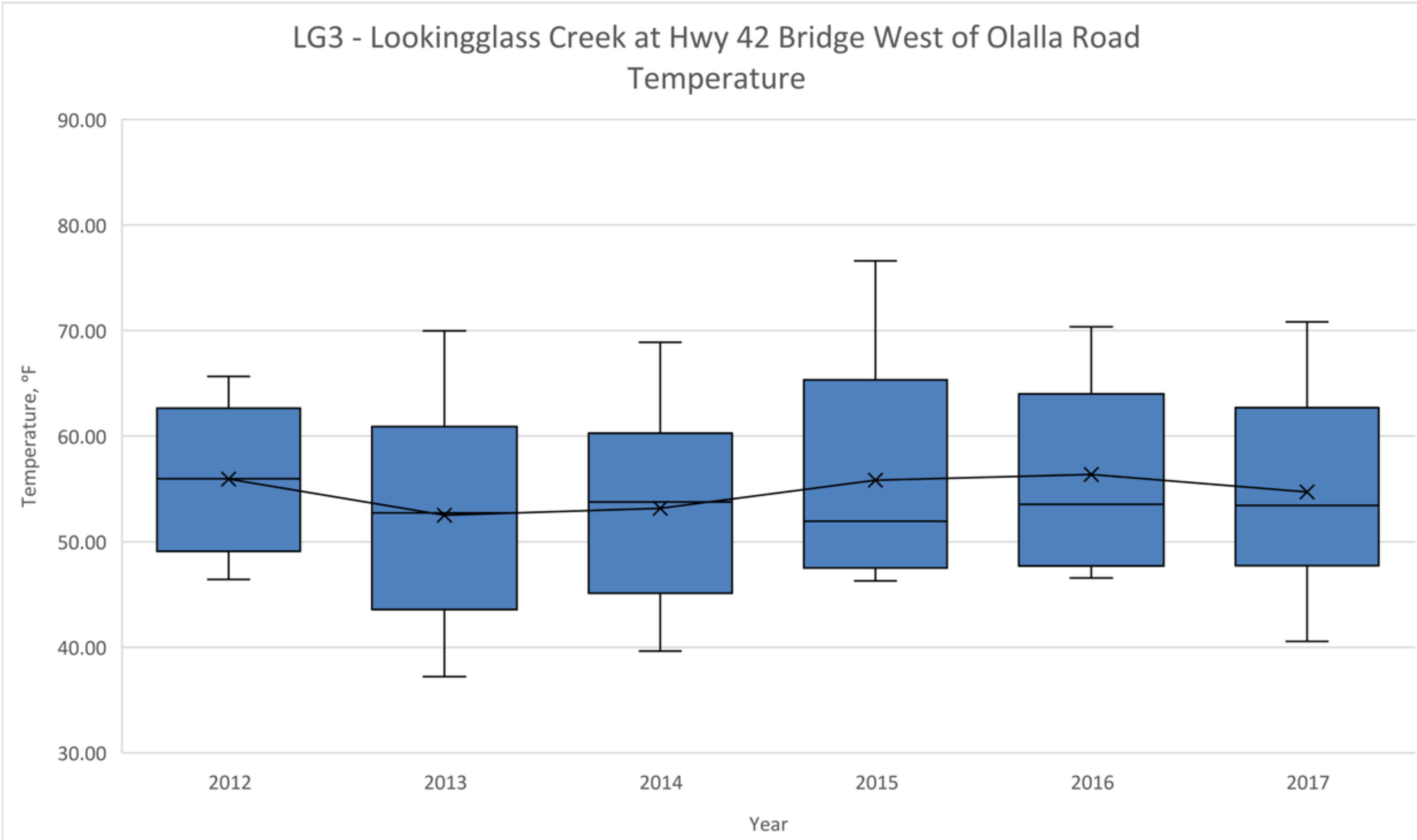
Graph 202. Box plots by year of grab sample *E. coli* levels for Lookingglass Creek at Hwy 42 Bridge West of Olalla Road.



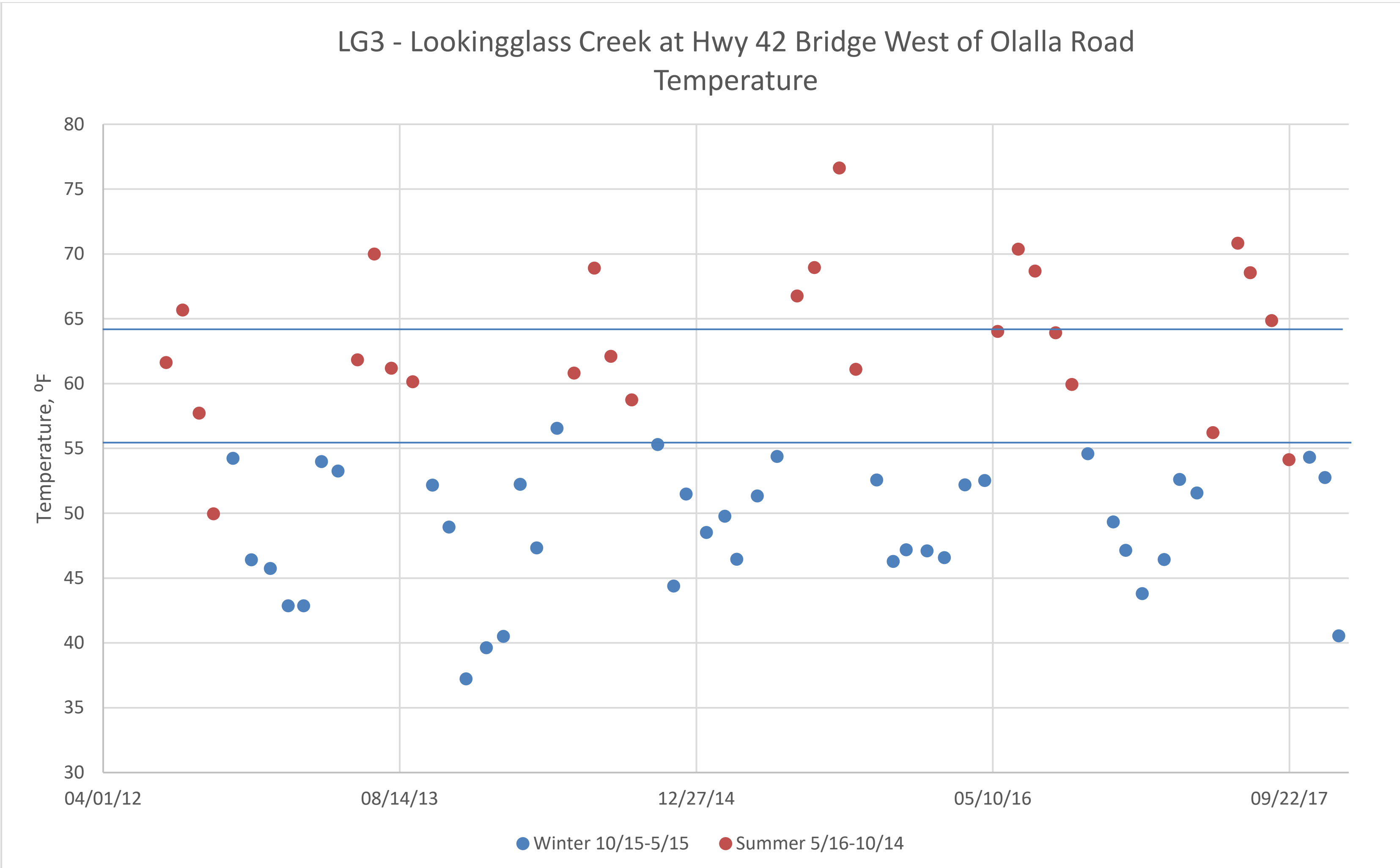
Graph 203. LG3 - Lookingglass Creek at Hwy 42 Bridge West of Olalla Road *E. coli*



Graph 204. LG3 - Lookingglass Creek at Hwy 42 Bridge West of Olalla Road *E. coli* cropped to 450.



Graph 205. Box plots by year of grab sample temperature levels for Lookingglass Creek at Hwy 42 Bridge West of Olalla Road.



Graph 206. LG3 - Lookingglass Creek at Hwy 42 Bridge West of Olalla Road temperature grab samples 2012-2017.

MG2 - Morgan Creek at Lower Dairy Loop Road Bridge

Year	Monthly Samples	Months
2014	12	Full Year
2015	12	Full Year
2016	12	Full Year
2017	12	Full Year

Table 42. Number of monitoring events per year included in graphs that follow for Morgan Creek at Lower Dairy Loop Road Bridge.

Turbidity

MG2 - Morgan Creek at Lower Dairy Loop Road Bridge was sampled 2014 thru 2017 (Graphs 207-208). During our grab sampling, the highest level detected was 40 NTU with none going over 50 NTU which "The Oregon Watershed Assessment Manual recommends using 50 NTUs as the turbidity evaluation criteria for watershed assessments. At this level, turbidity interferes with sight-feeding aquatic organisms and provides an indication of the biological effect of suspended sediment." There were many samples exceeding 10 NTU occurring in winter only. Graph 208 shows that there is no trend of summer turbidity and a slight upward trend in winter turbidity.

pH

With grab sampling, no events exceeded the upper DEQ recommended limit of 8.5, and none fell below the lower exceedance of 6.5. No pH levels were measured below 7.0. pH looks very steady at this site and well with in the DEQ recommended range.

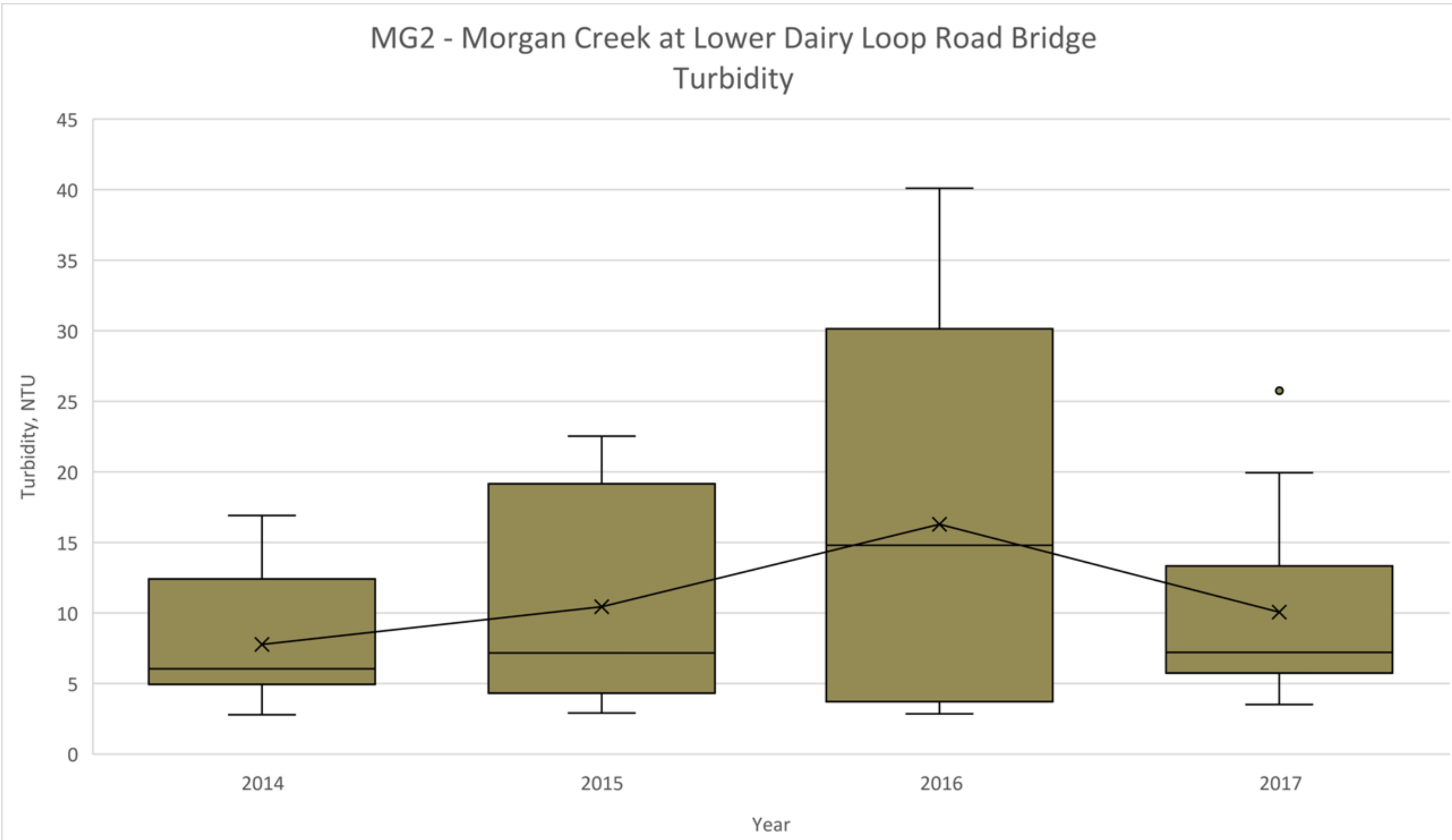
Dissolved Oxygen

Graphs 211 and 212 display the dissolved oxygen grab sample data for Morgan Creek at Lower Dairy Loop Road Bridge. Dissolved oxygen is a problem at this site with failure to meet both spawning and non-spawning times. No trend is apparent.

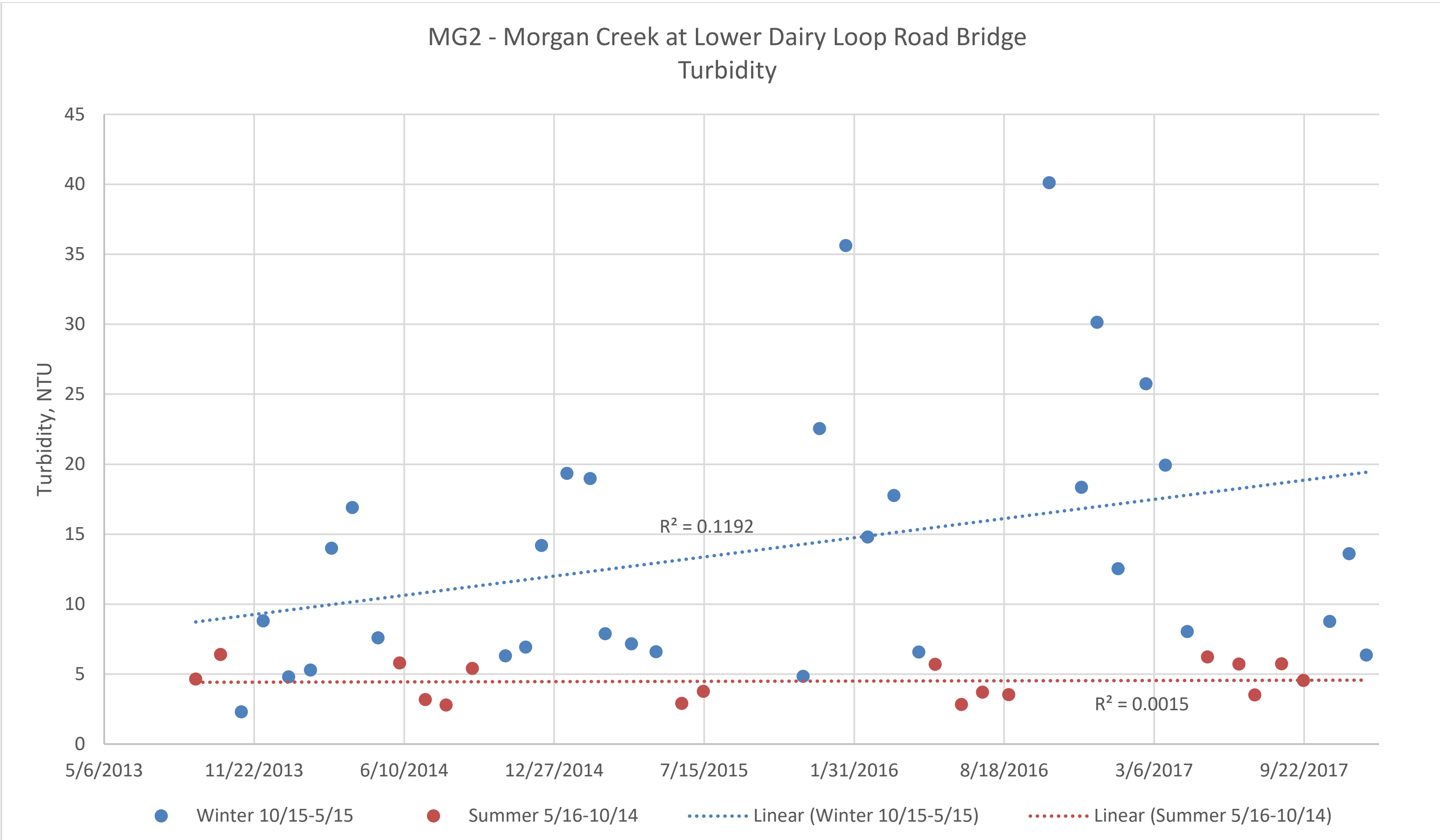
Conductivity
Graphs 213 and 214 display the conductivity grab sample data. All are within normal ranges for the Umpqua basin. No trend is evident, and variation was between 57 and 371. At this site most of the higher levels were during the summer months.

E. coli
E. coli levels are displayed in graphs 215 and 216**.** Ten sampling events produced high levels of *E. coli* during the winter months which would list this section of Morgan Creek at Lower Dairy Loop Road Bridge. All others were below the 406 MPN/100ml single sample listing criteria, though eleven might have produced listings if sampled 5 times within a month as their levels between 126 and 406 MPN/100ml (see Graph 204).

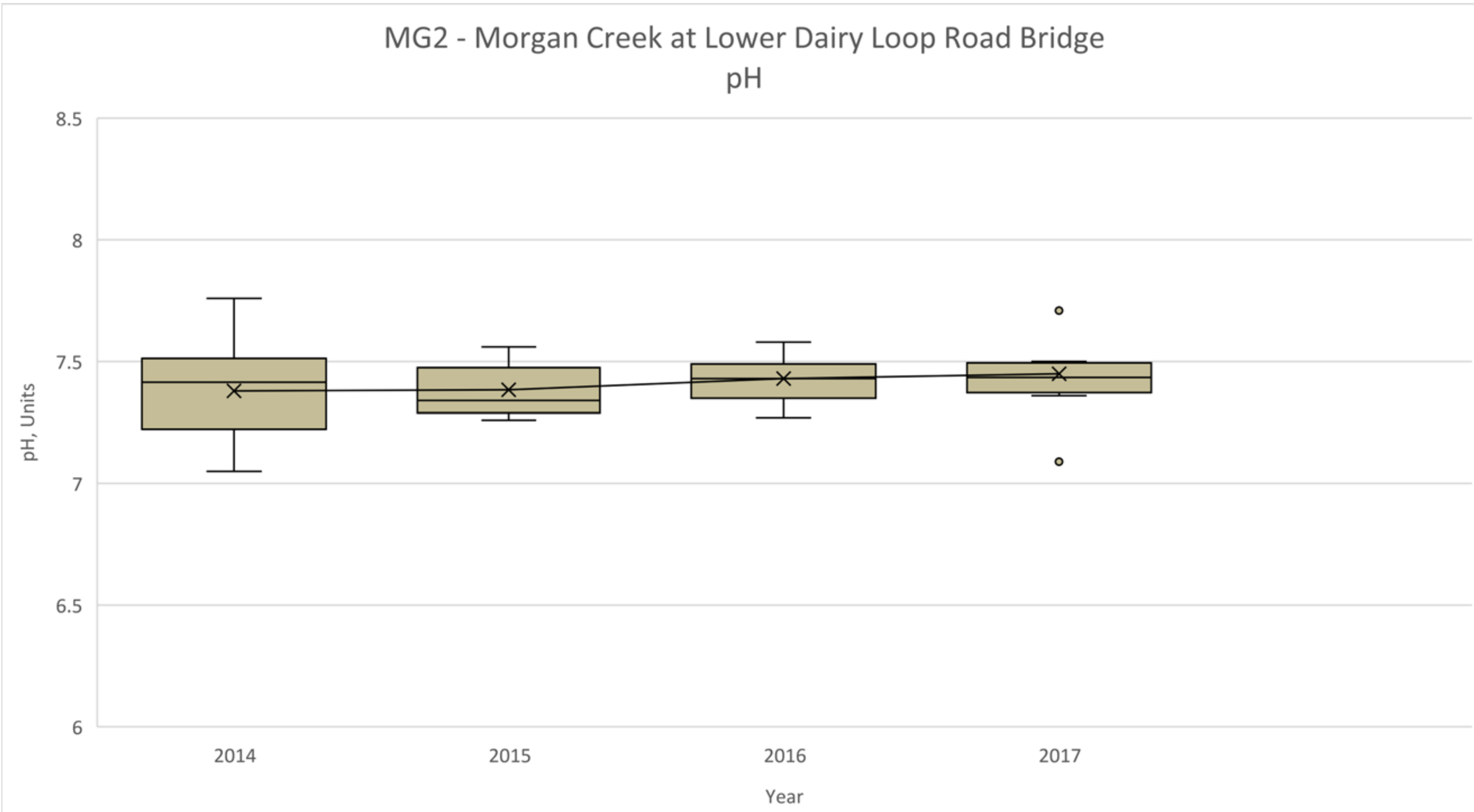
Temperature
Graphs 217 and 2018 display the temperature data for Morgan Creek at Lower Dairy Loop Road Bridge. The winter temperatures were good with only three failing and those were right at the edge of the spawning criteria dates. Summer temperatures however, had ten exceedances of the 64.4°F criteria with seven meeting it. No trend is evident.



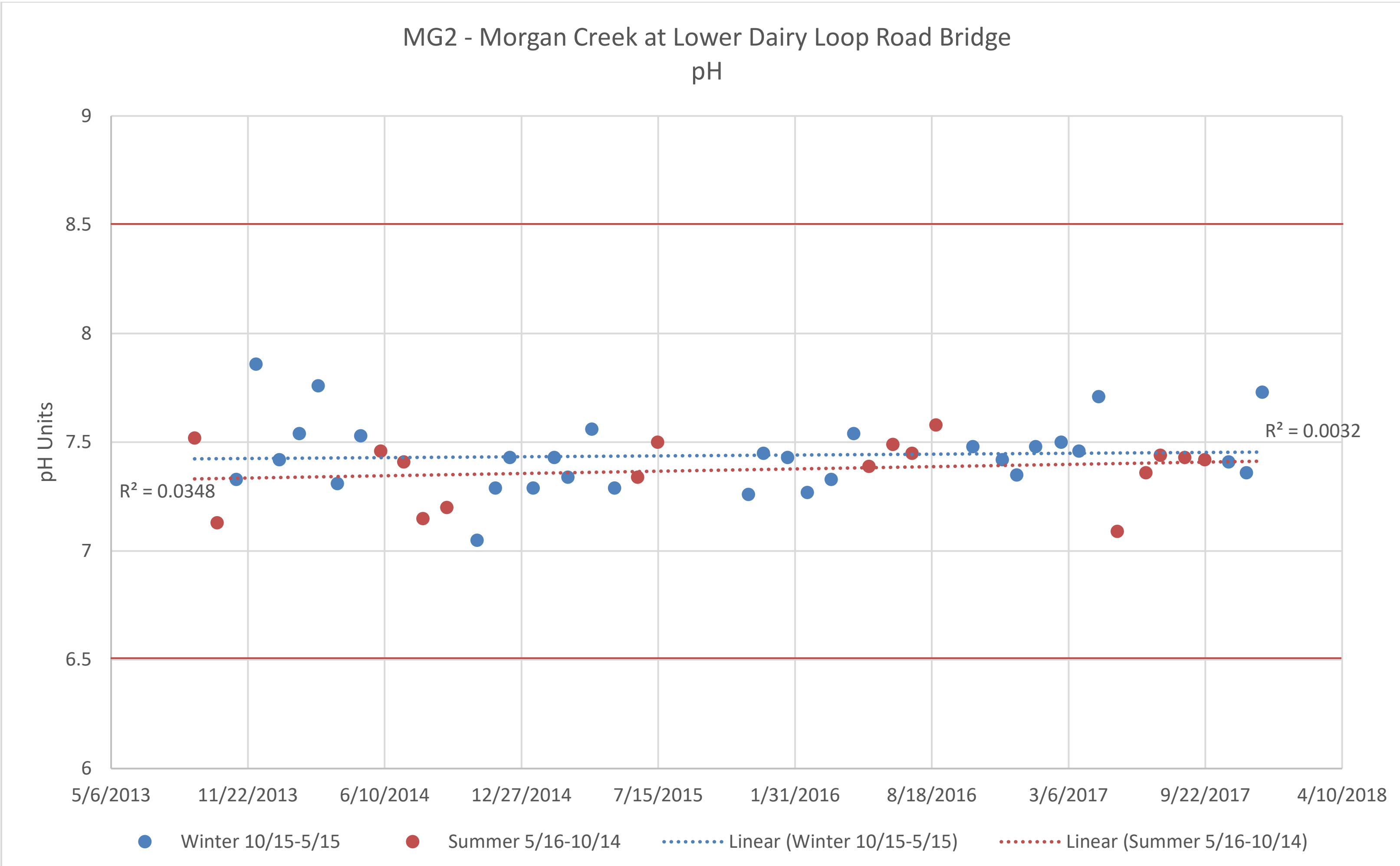
Graph 207. Box plots by year of grab sample turbidity levels Morgan Creek at Lower Dairy Loop Road bridge.



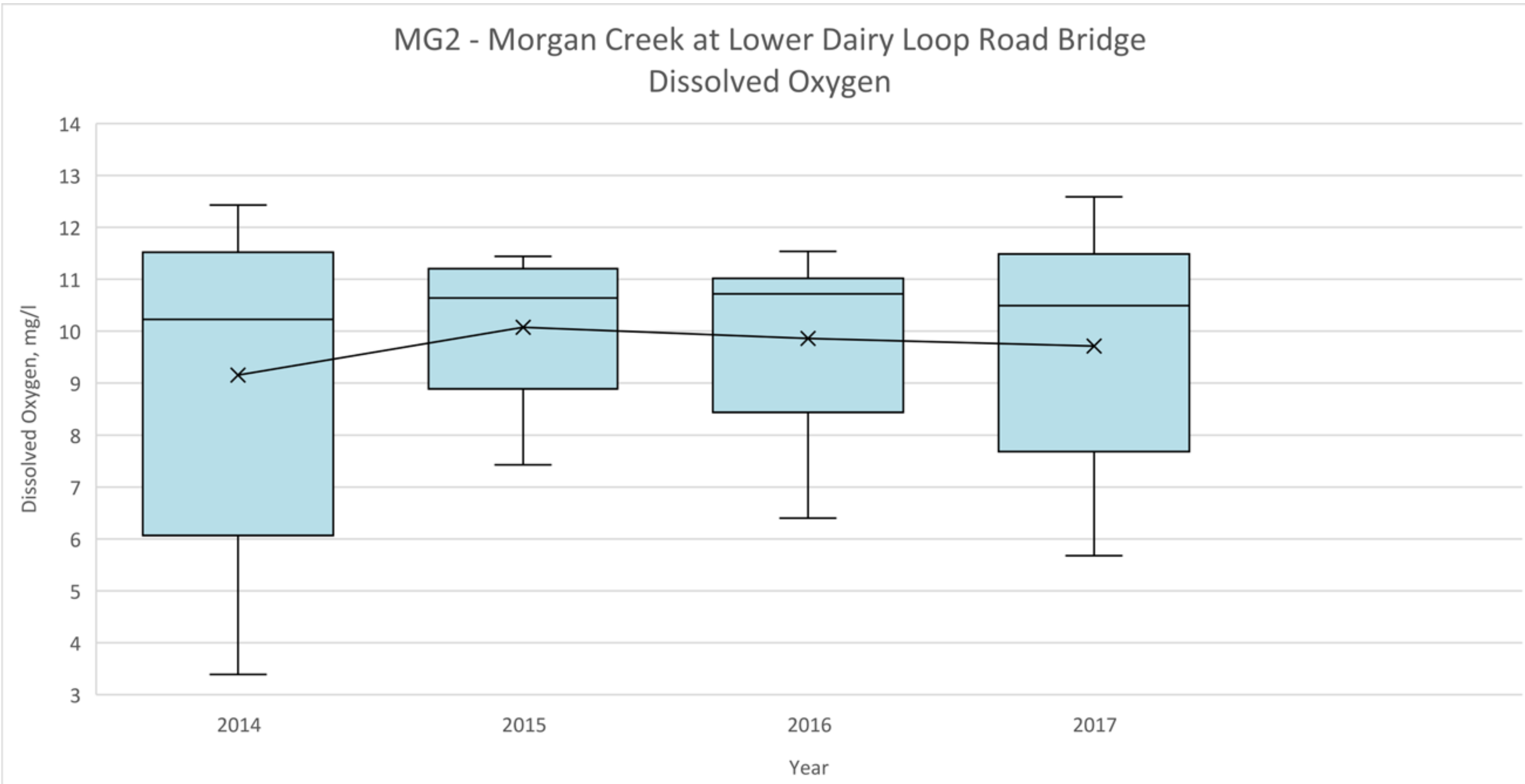
Graph 208. MG2 - Morgan Creek at Lower Dairy Loop Road Bridge grab sample turbidity 2014-2017.



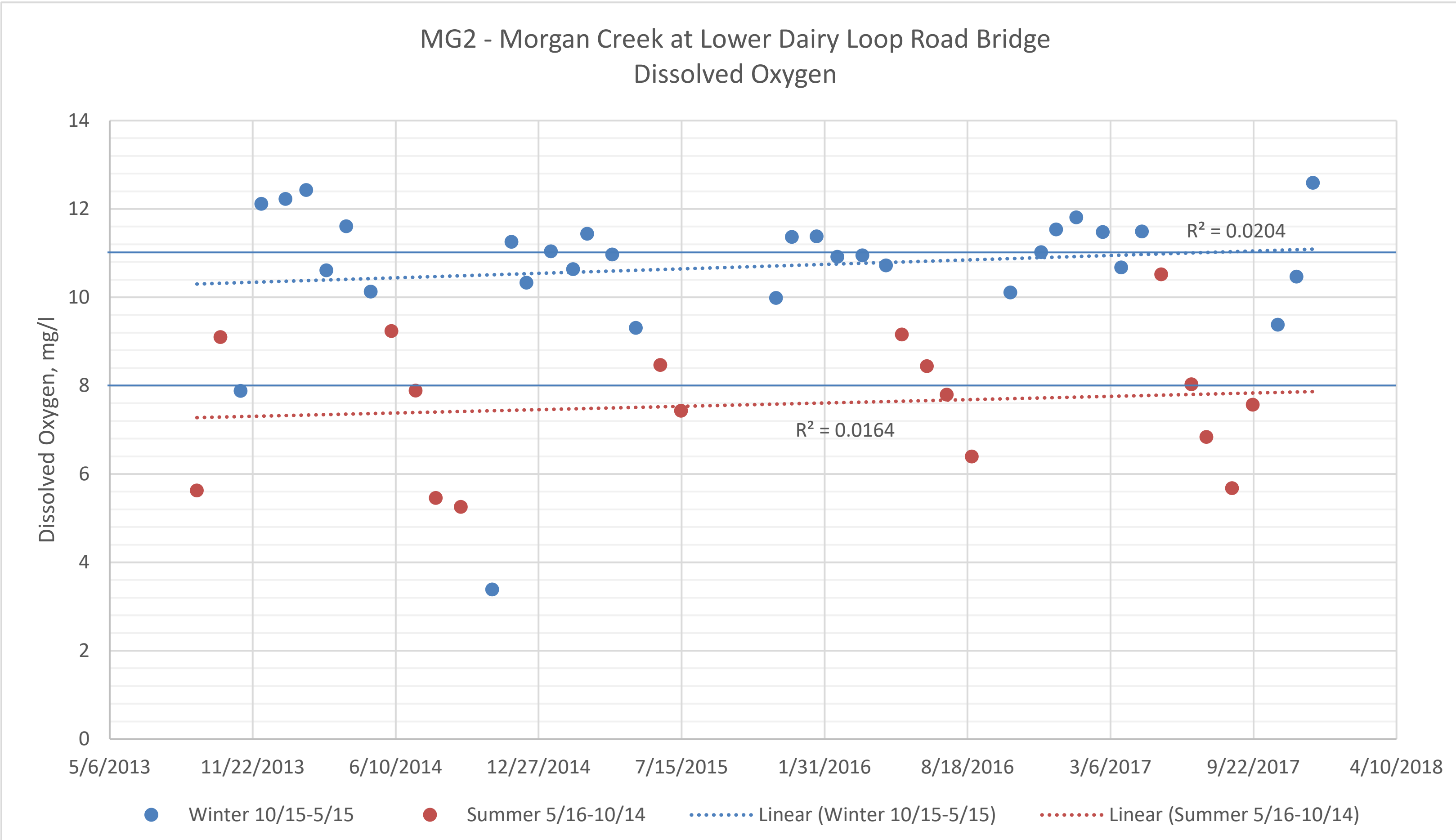
Graph 209. Box plots by year of grab sample pH levels Morgan Creek at Lower Dairy Loop Road bridge.



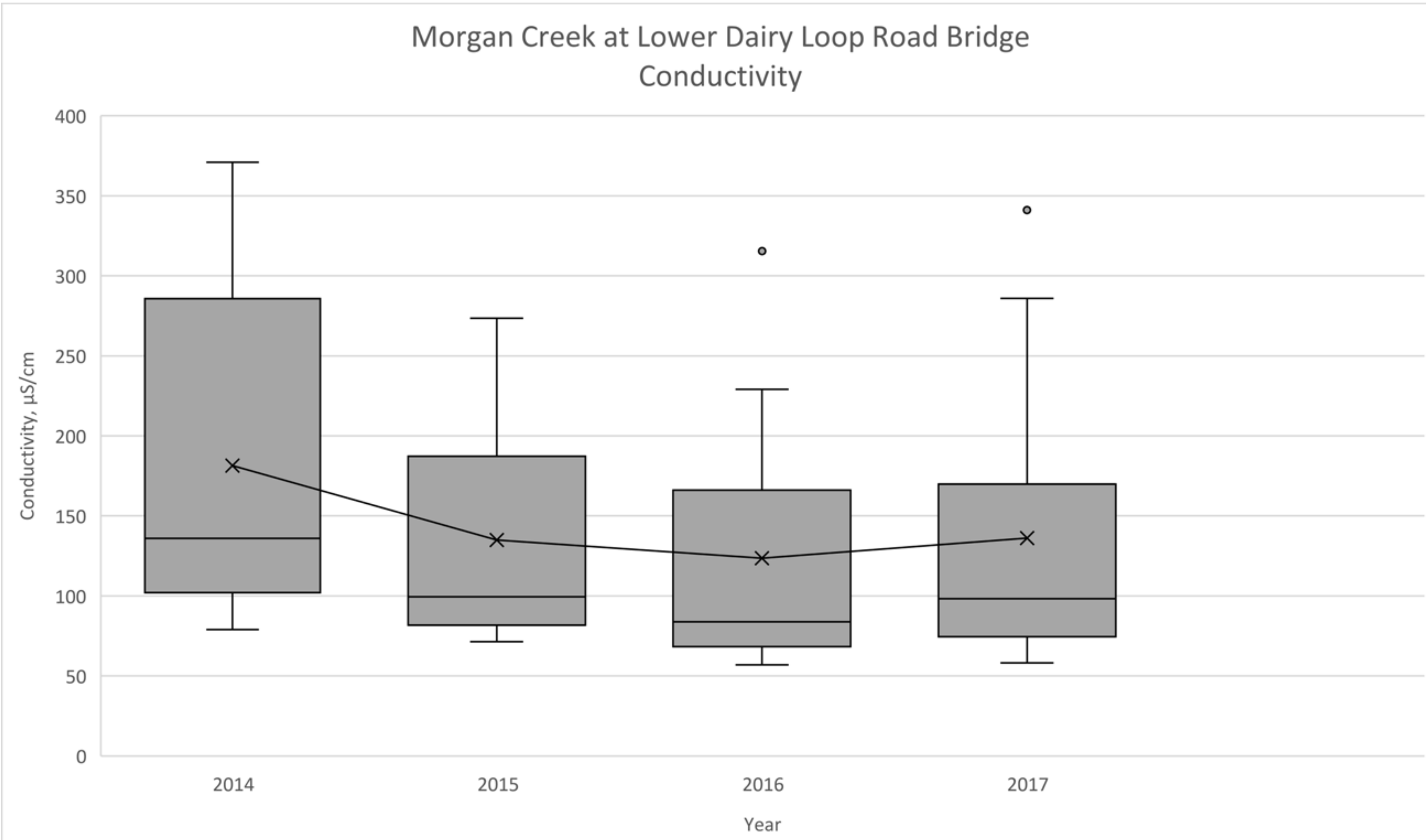
Graph 210. MG2 - Morgan Creek at Lower Dairy Loop Road Bridge pH grab sampling 2013-2017.



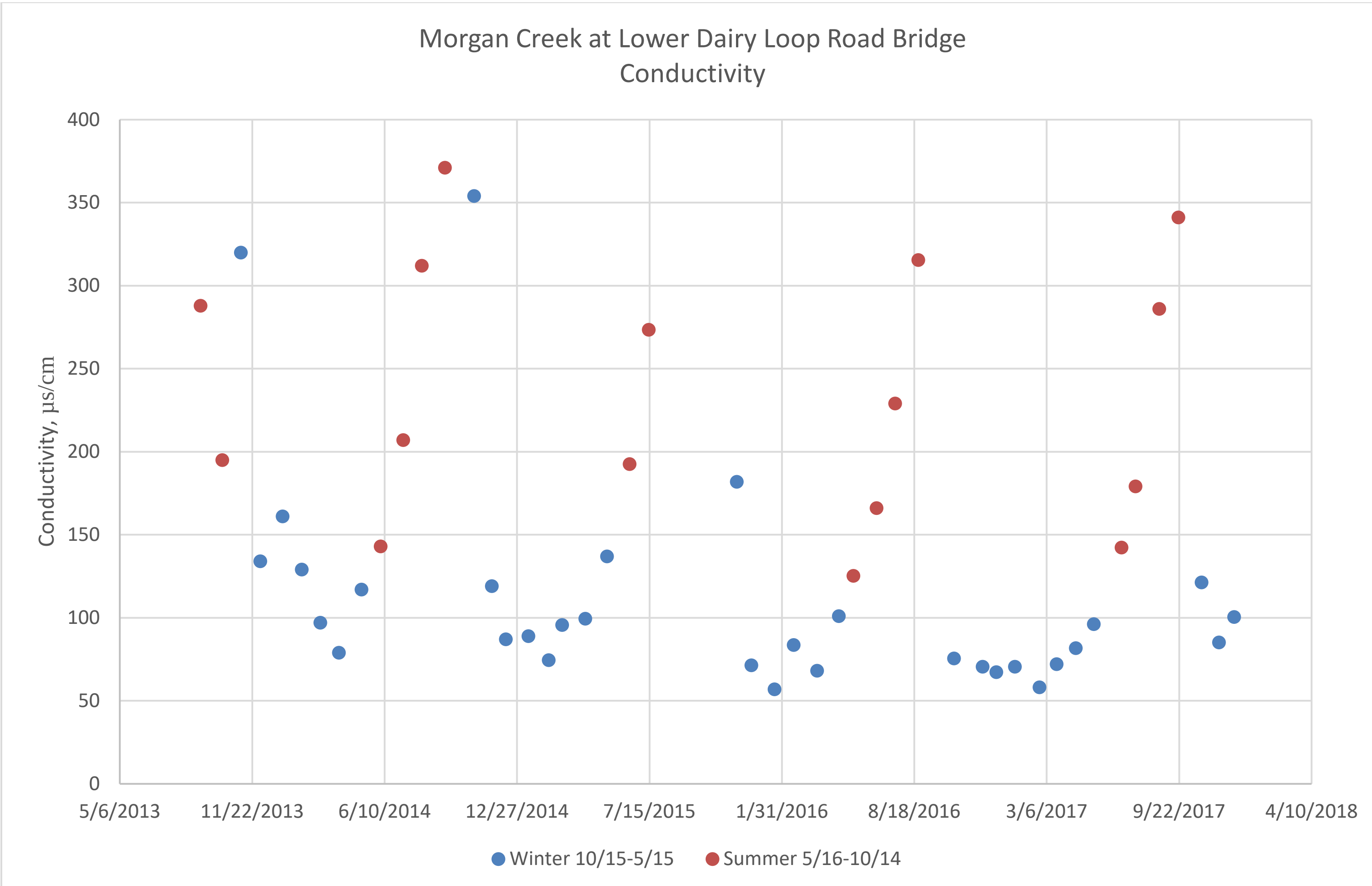
Graph 211. Box plots by year of grab sample dissolved oxygen levels Morgan Creek at Lower Dairy Loop Road bridge.



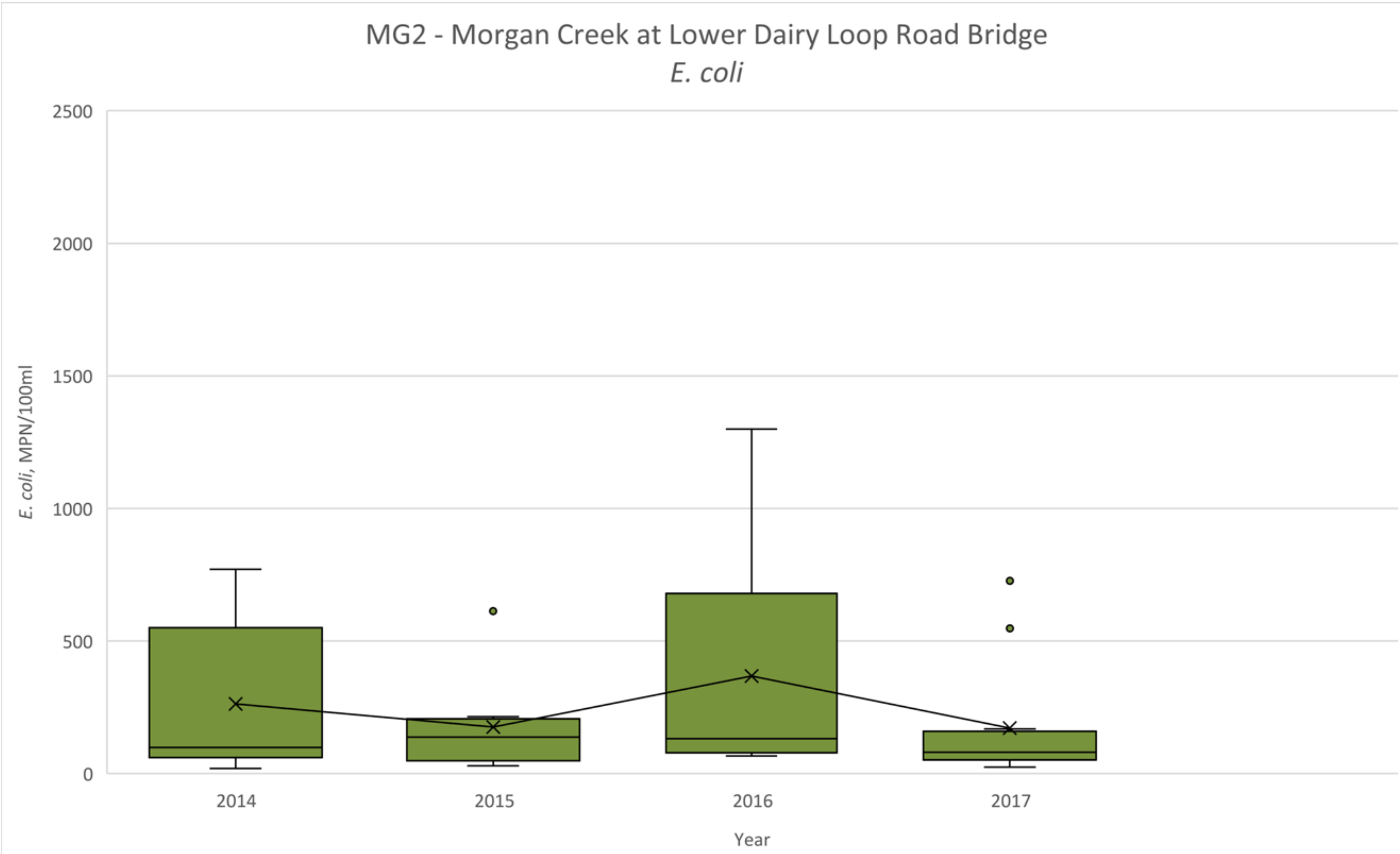
Graph 212. MG2 - Morgan Creek at Lower Dairy Loop Road Bridge Dissolved Oxygen.



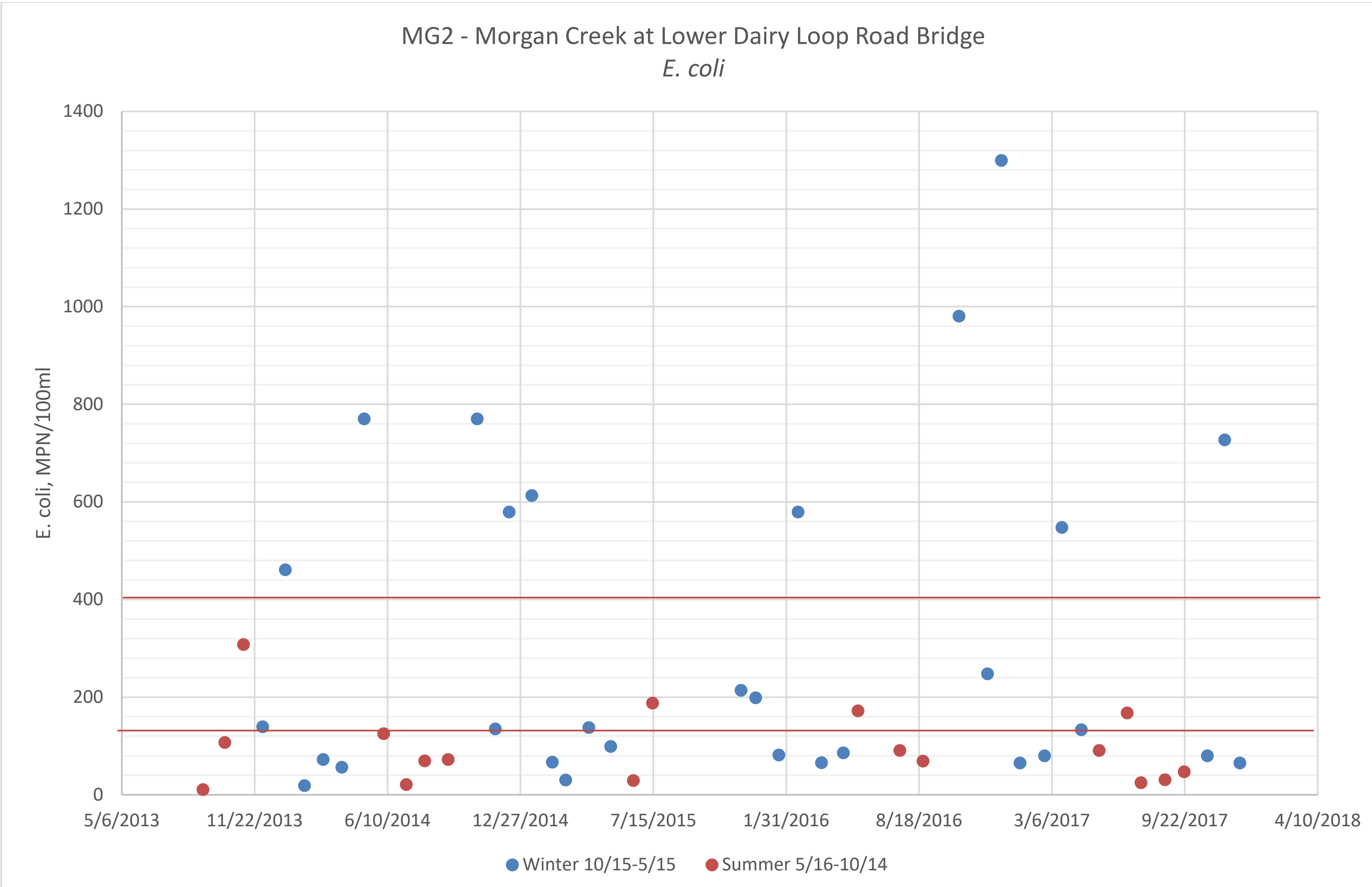
Graph 213. Box plots by year of grab sample conductivity levels Morgan Creek at Lower Dairy Loop Road bridge.



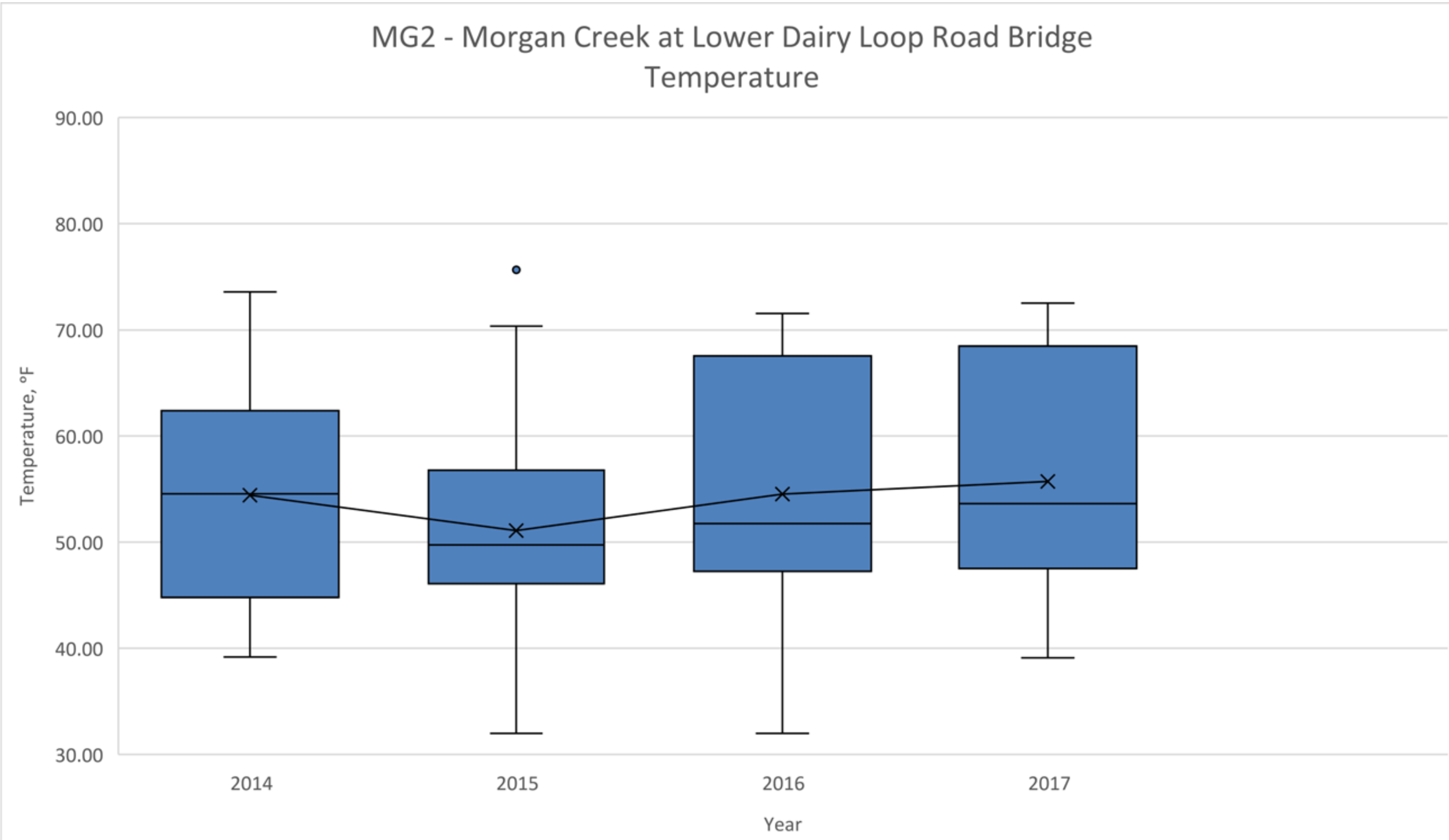
Graph 214. Morgan Creek at Lower Dairy Loop Road Bridge grab sample conductivity 2014-2017.



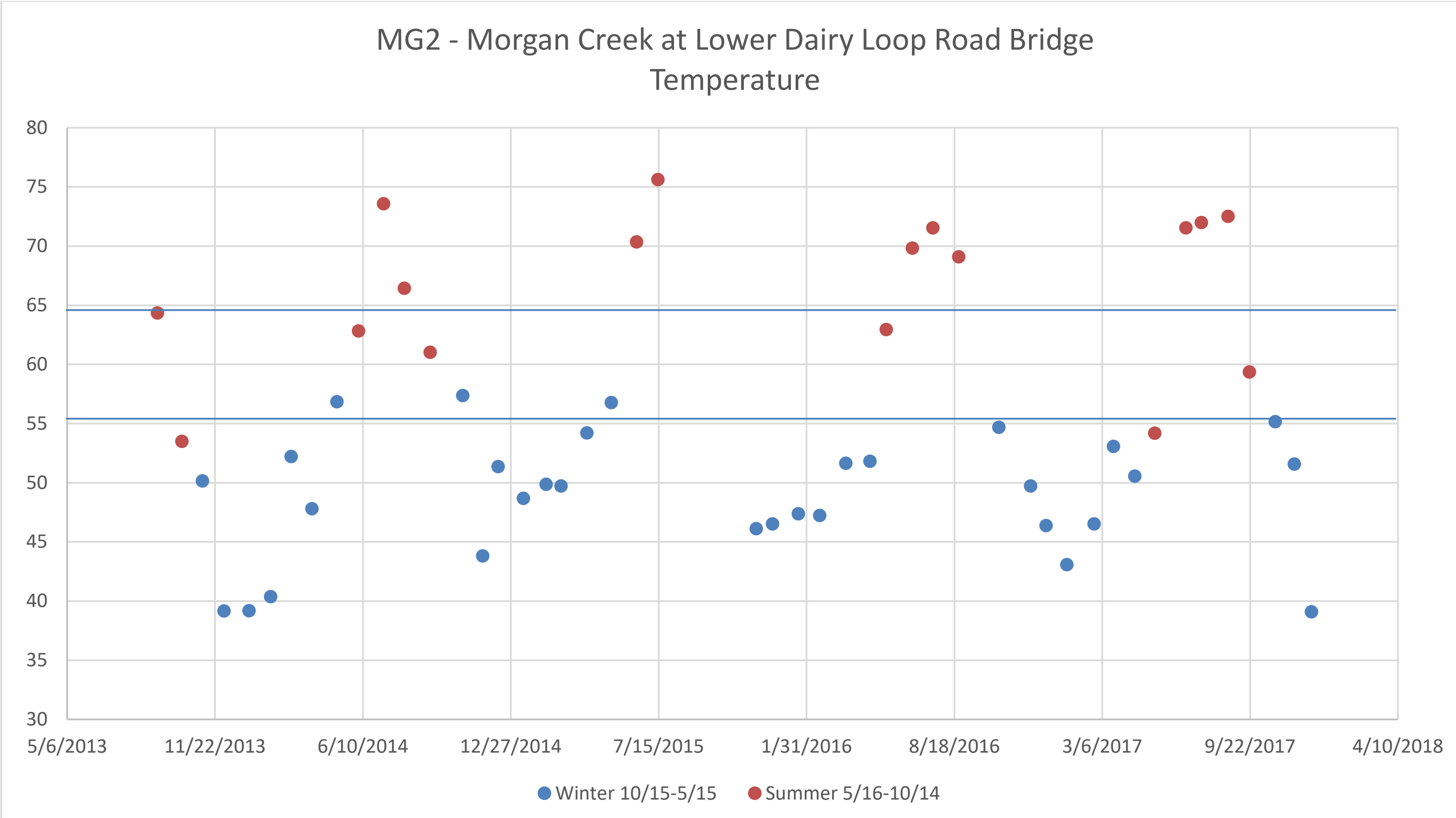
Graph 215. Box plots by year of grab sample *E. coli* levels Morgan Creek at Lower Dairy Loop Road bridge.



Graph 216. MG2 - Morgan Creek at Lower Dairy Loop Road Bridge E. coli



Graph 217. Box plots by year of grab sample temperature levels Morgan Creek at Lower Dairy Loop Road bridge.



Graph 218. MG2 - Morgan Creek at Lower Dairy Loop Road Bridge grab sample temperature 2014-2017.

LG1 - Lookingglass Creek at Hwy 42 Bridge near Mouth

Year	Monthly Samples	Months
2010	11	Feb-Dec
2012	12	June-Dec, Duplicates
2013	22	Full Year, Duplicates
2014	24	Full Year, Duplicates
2015	12	Full Year
2016	12	Full Year
2017	12	Full Year

Table 43. Number of monitoring events per year included in graphs that follow Lookingglass Creek near mouth.

Turbidity
LG1 - Lookingglass Creek at Hwy 42 Bridge near Mouth was sampled 2014 thru 2017 (Graphs 220-221). During our grab sampling, the highest level detected was 138 and 88 NTU the rest not going over 50 NTU which "The Oregon Watershed Assessment Manual recommends using 50 NTUs as the turbidity evaluation criteria for watershed assessments. At this level, turbidity interferes with sight-feeding aquatic organisms and provides an indication of the biological effect of suspended sediment." There were many samples exceeding 10 NTU occurring mostly in winter only, and a number in summer and winter staying below the 10 NTU. Graph 221 shows that there is no trend of summer or winter turbidity levels.

pH
With grab sampling, two events exceeded the upper DEQ recommended limit of 8.5 by very little, and none fell below the lower exceedance of 6.5. No pH levels were measured below 7.0. No trend is apparent.

Dissolved Oxygen
Graphs 224 and 225 display the dissolved oxygen grab sample data for Lookingglass Creek at Hwy 42 Bridge near the mouth. Dissolved oxygen levels approach the lower summer level with two falling below 8 mg/l. Many also fall below the winter spawning level, making dissolved oxygen of great concern at this site. No trend is apparent.

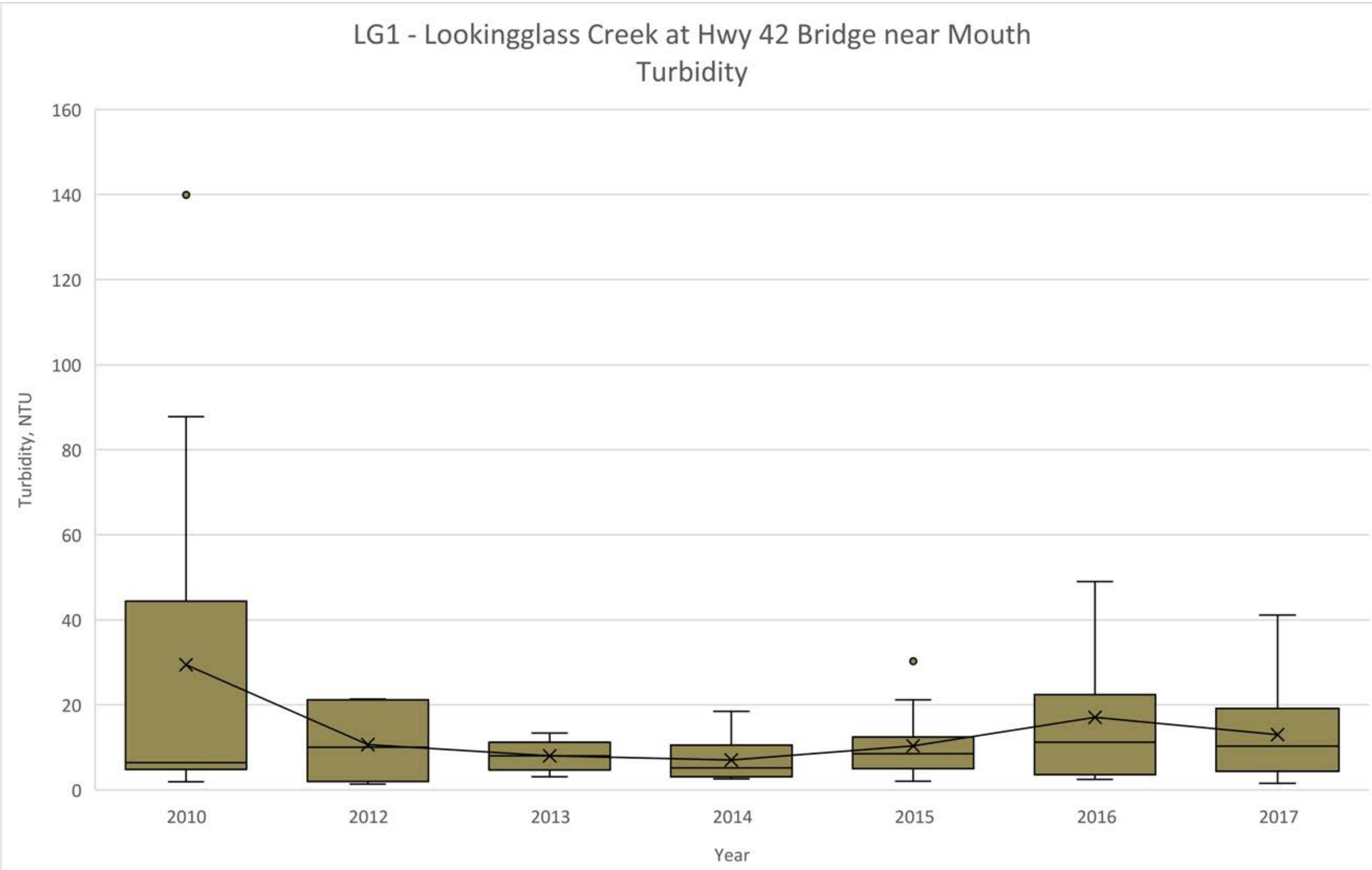
Conductivity
Graphs 226 and 227 display the conductivity grab sample data. All are within normal ranges for the Umpqua basin. No trend is evident, and variation was between 68 and 155. Levels intermix between summer and winter. No trend is evident.

E. coli

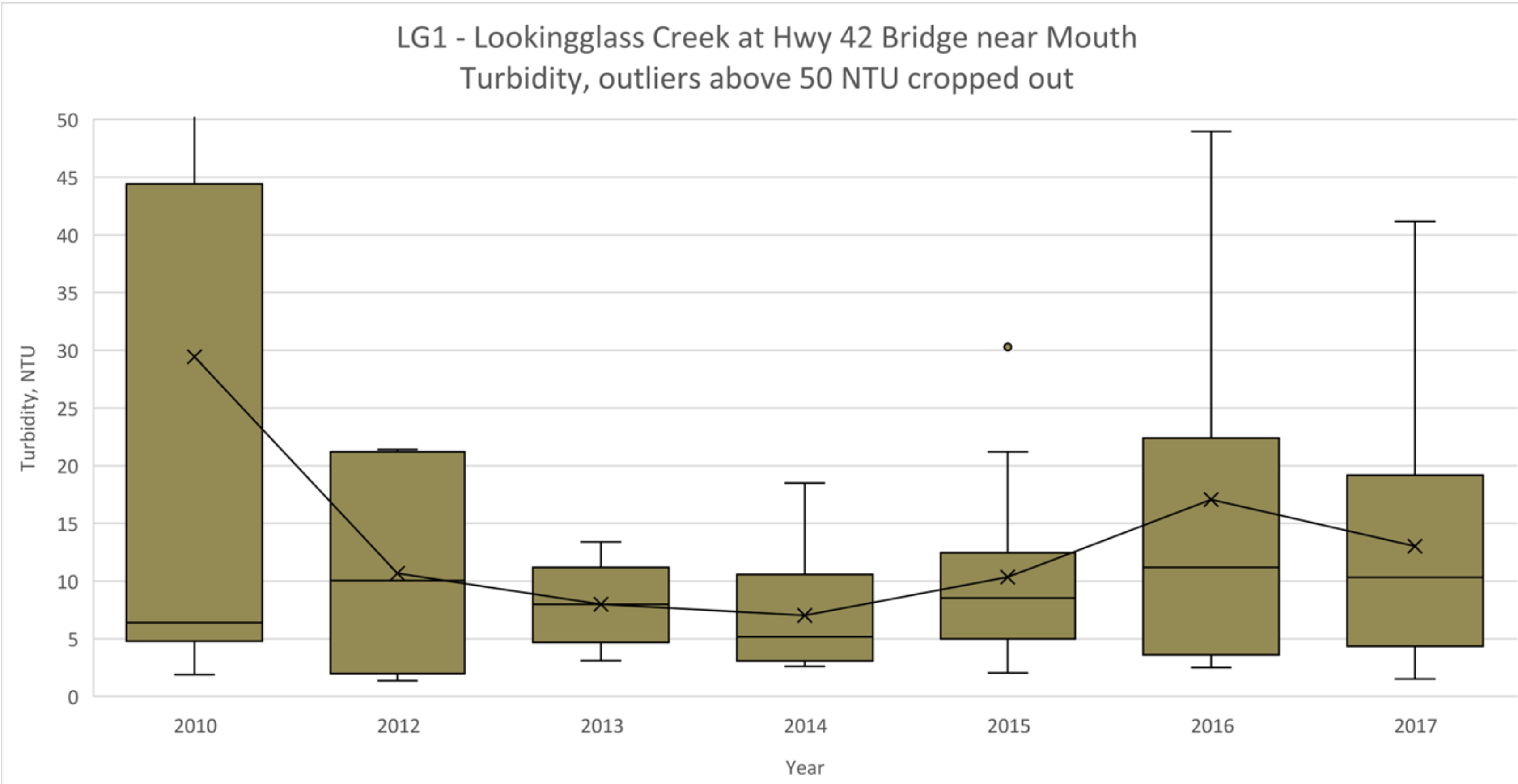
E. coli levels are displayed in graphs 228 and 229**.** Six sampling events produced high levels of *E. coli* during the winter months which would list this section of Lookingglass Creek at Hwy 42 Bridge near the mouth. All others were below the 406 MPN/100ml single sample listing criteria, though many would have produced listings if sampled 5 times within a month as all, but three sampling event produced levels between 126 and 406 MPN/100ml (see Graph 230).

Temperature

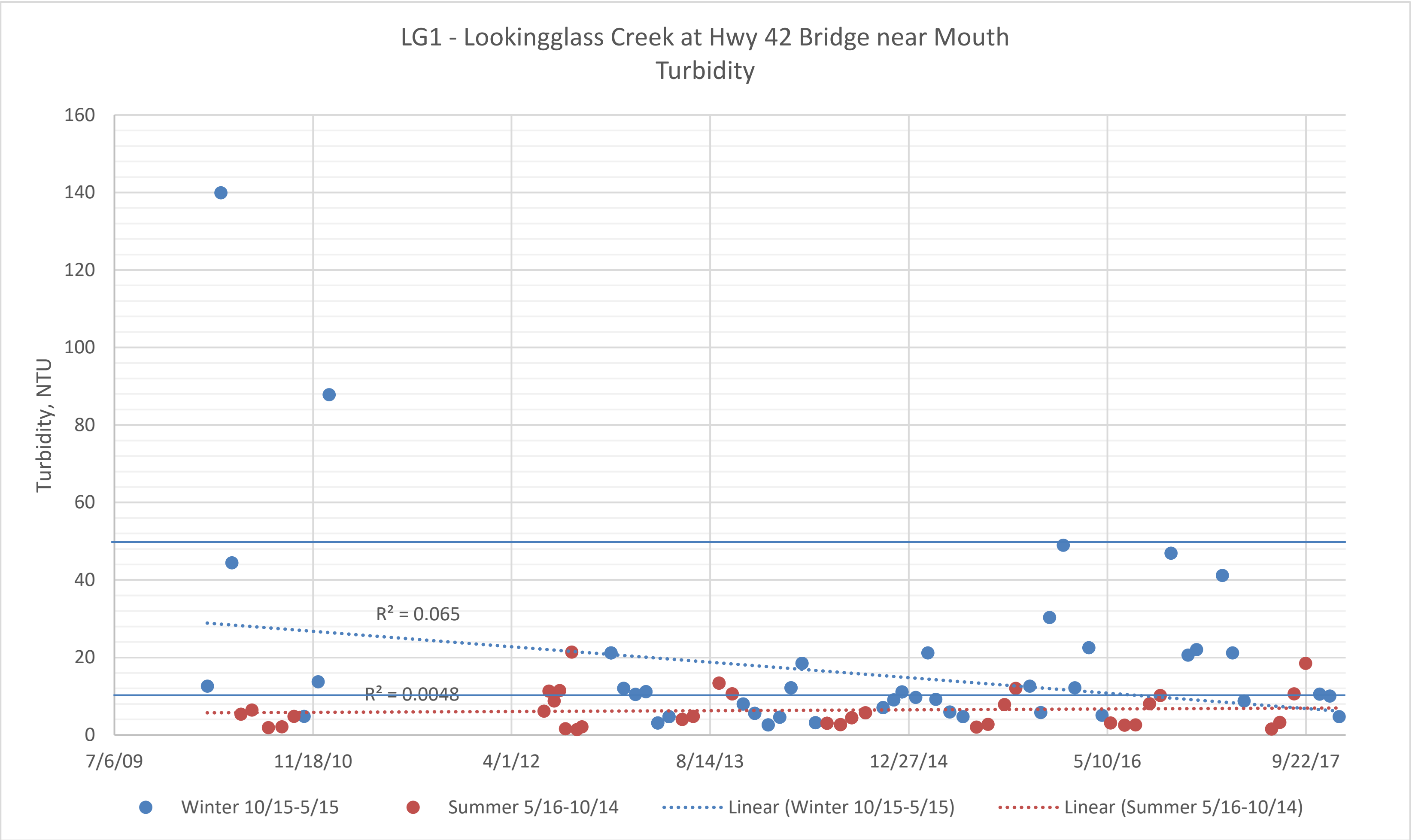
Graphs 217 and 2018 display the temperature data for LG1 - Lookingglass Creek at Hwy 42 Bridge near the mouth. The winter and summer temperatures both failed to meet criteria at numerous sampling events. At least many more winter spawning criteria were met then were not met. With summer samplings almost all did not meet criteria making summer temperature a concern for this area. No trend is evident.



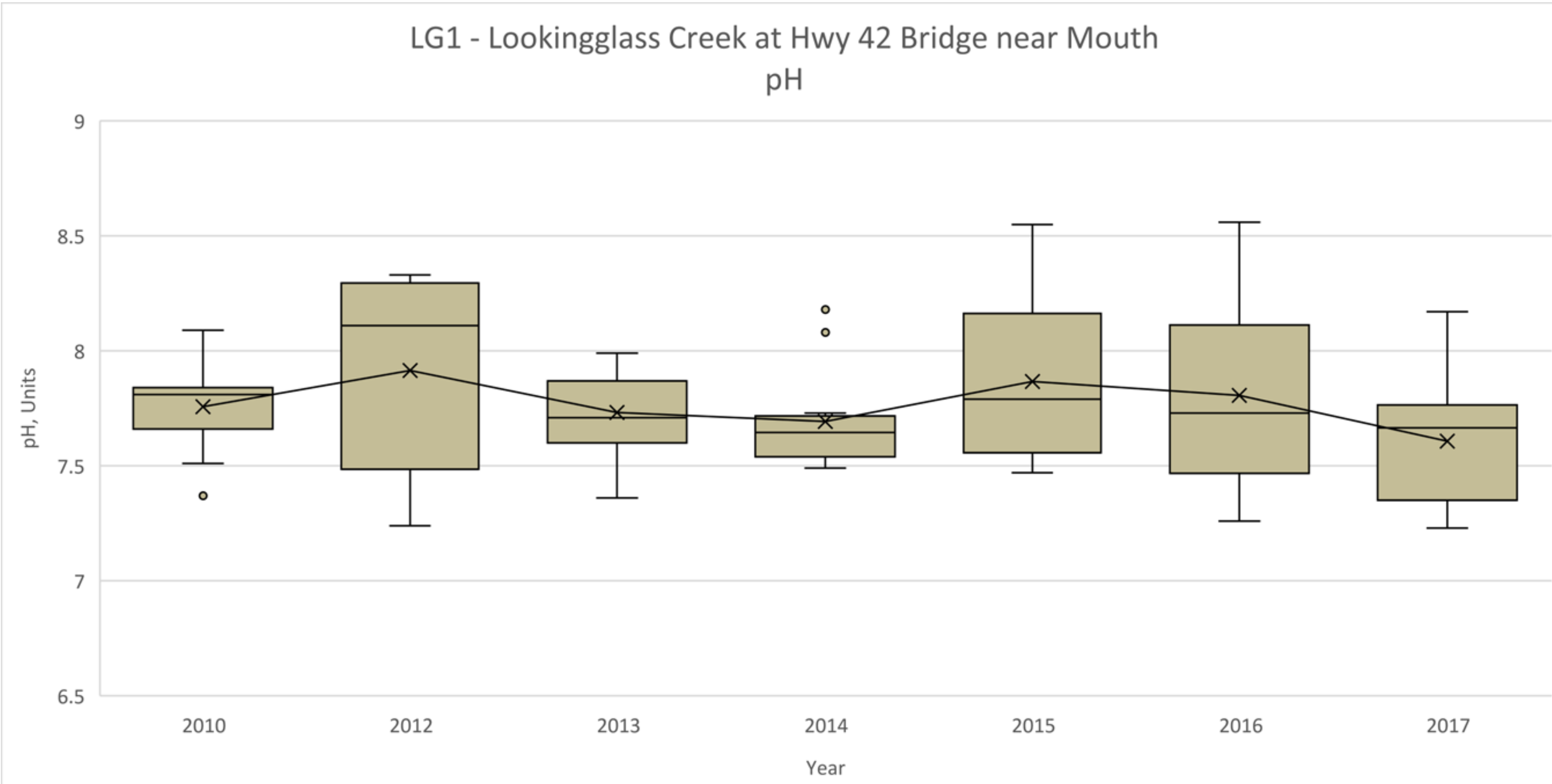
Graph 219. Box plots by year of grab sample turbidity levels Lookingglass Creek at Hwy 42 Bridge near mouth.



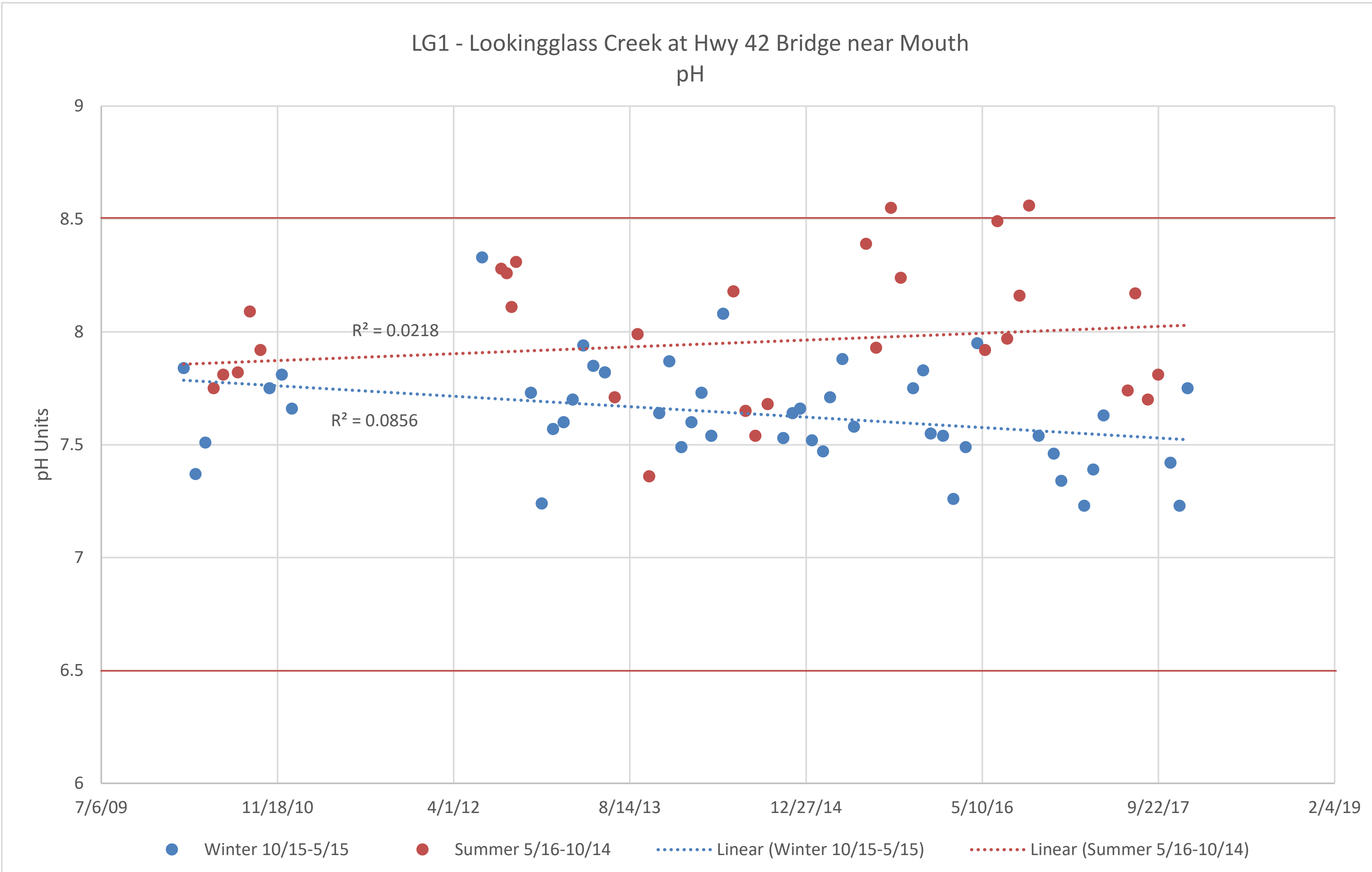
Graph 220. Box plots by year of grab sample turbidity levels Lookingglass Creek at Hwy 42 Bridge near mouth with outliers above 50 NTU removed for display.



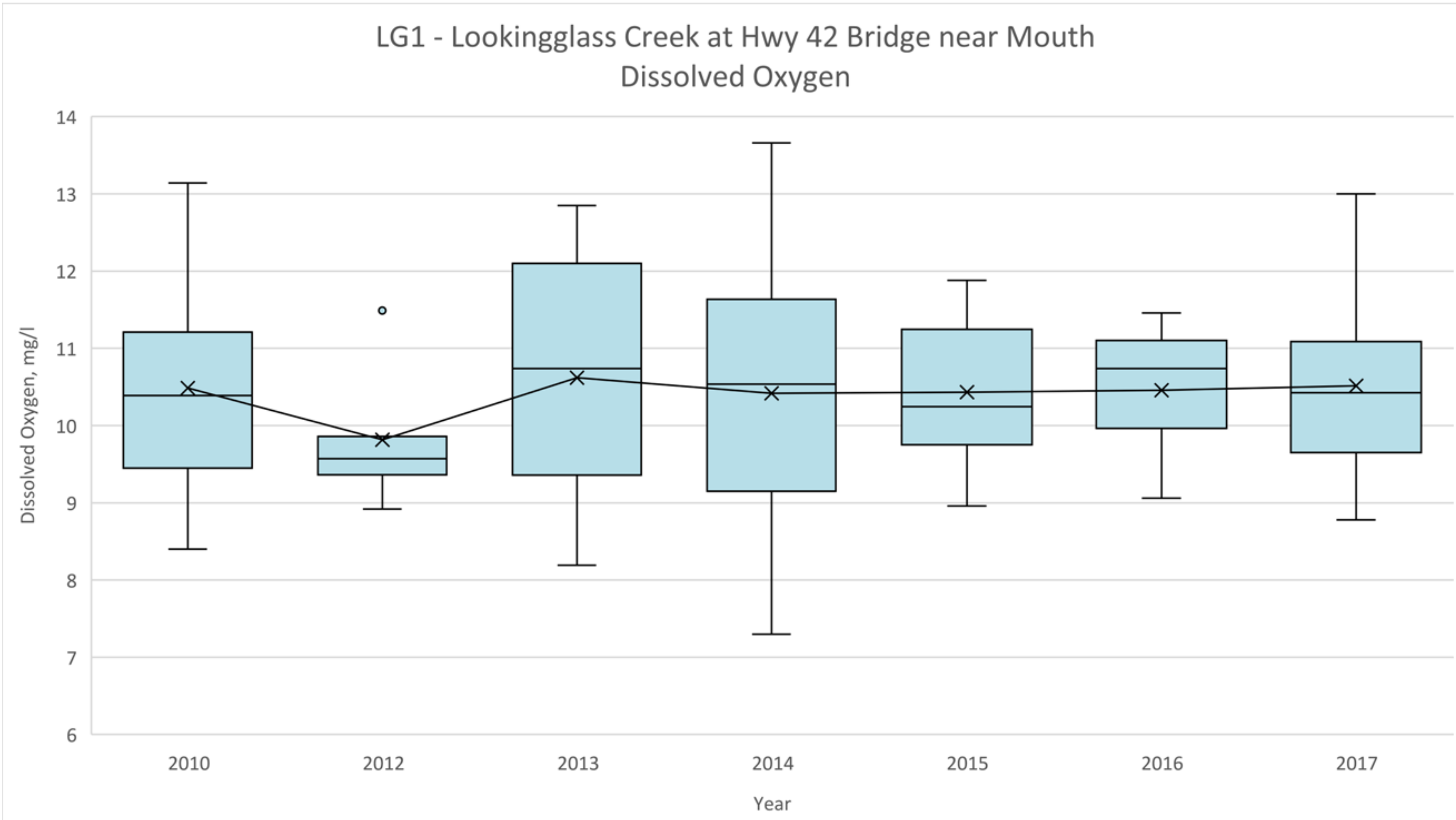
Graph 221. LG1 - Lookingglass Creek at Hwy 42 Bridge near mouth turbidity 2010-2017.



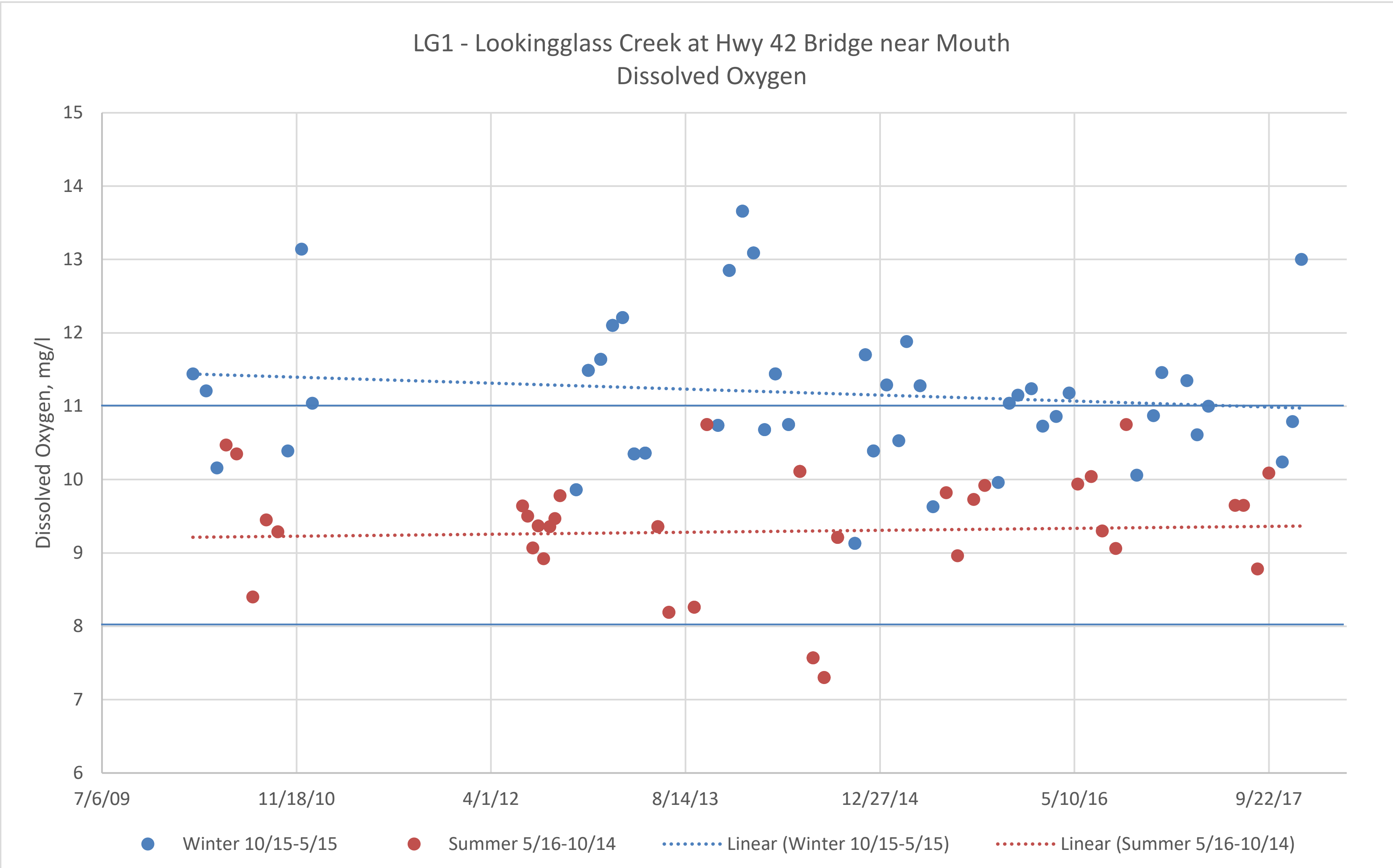
Graph 222. Box plots by year of grab sample pH levels Lookingglass Creek at Hwy 42 Bridge near mouth.



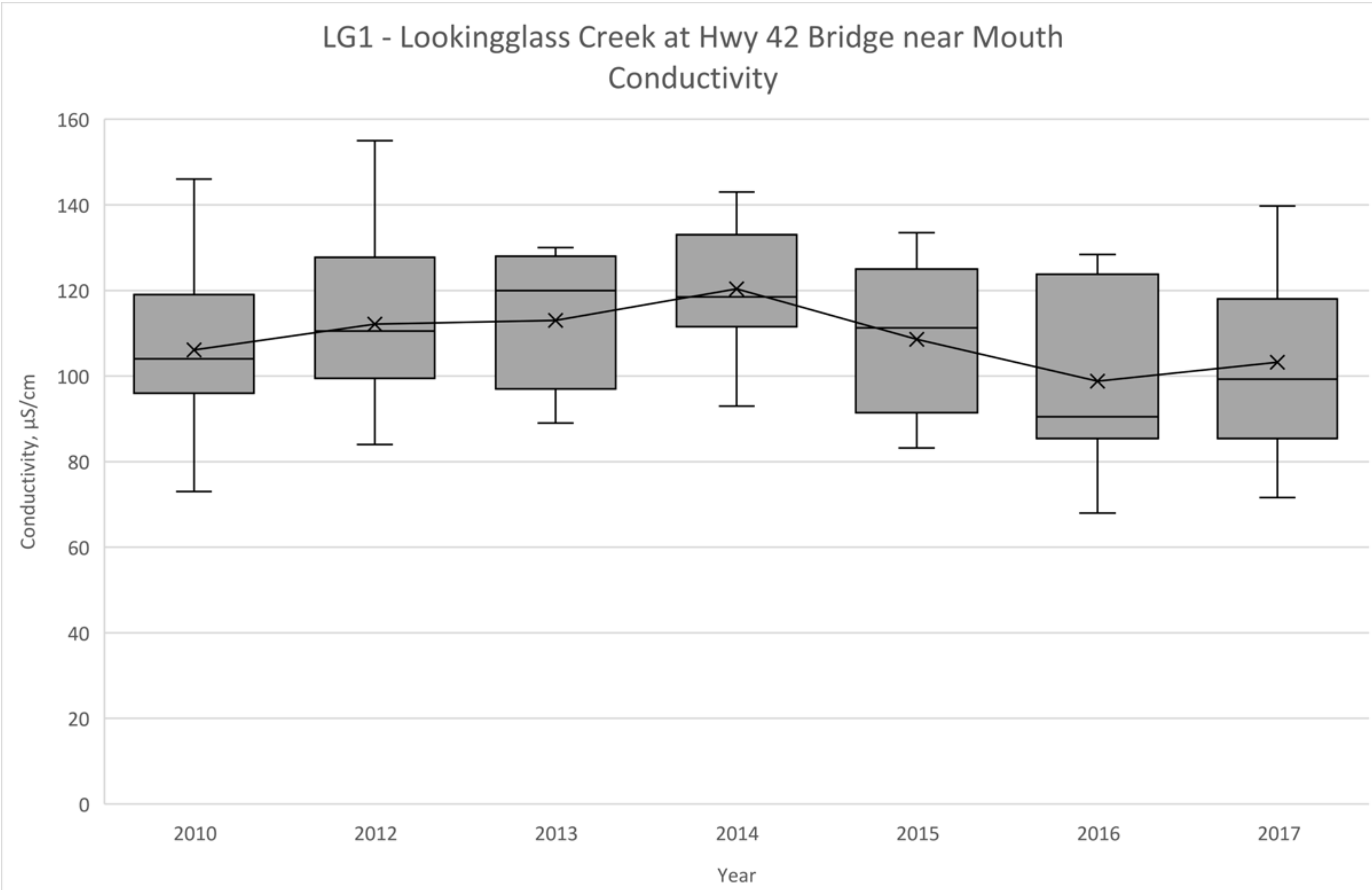
Graph 223. LG1 - Lookingglass Creek at Hwy 42 Bridge near mouth pH grab samples 2010-2017



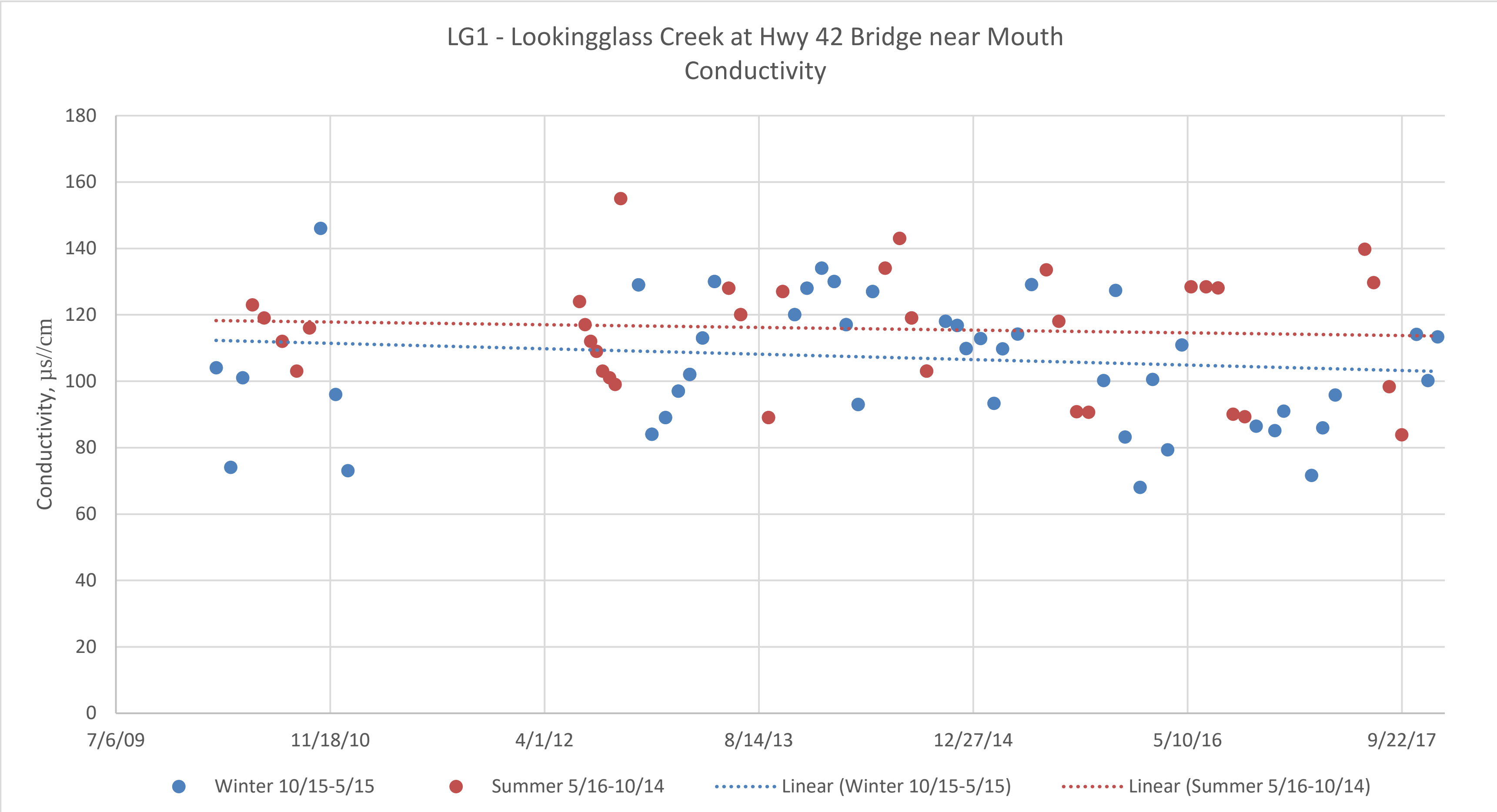
Graph 224. Box plots by year of grab sample dissolved oxygen levels Lookingglass Creek at Hwy 42 Bridge near mouth.



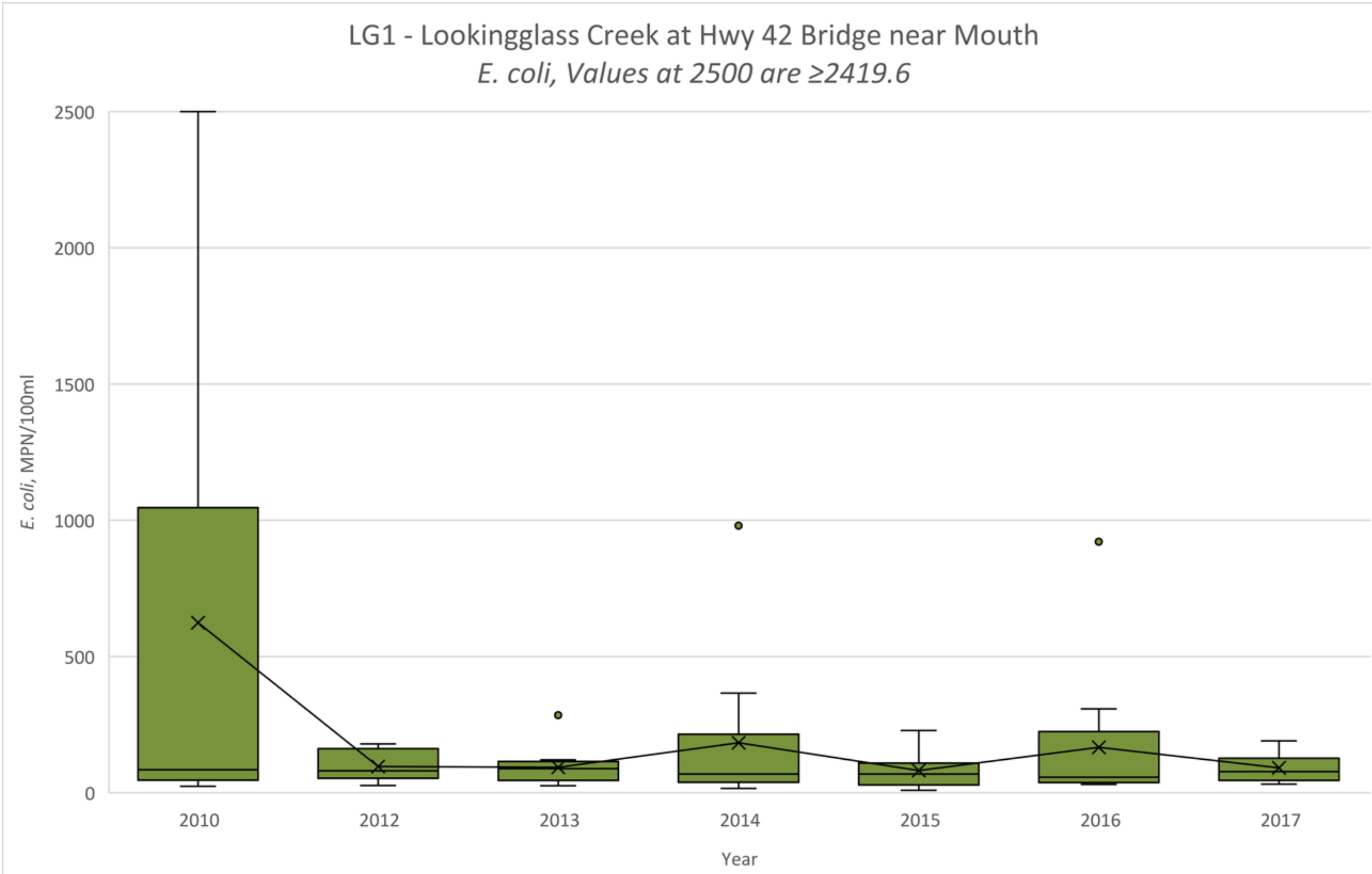
Graph 225. LG1 - Lookingglass Creek at Hwy 42 Bridge near mouth dissolved oxygen grab samples 2010-2017.



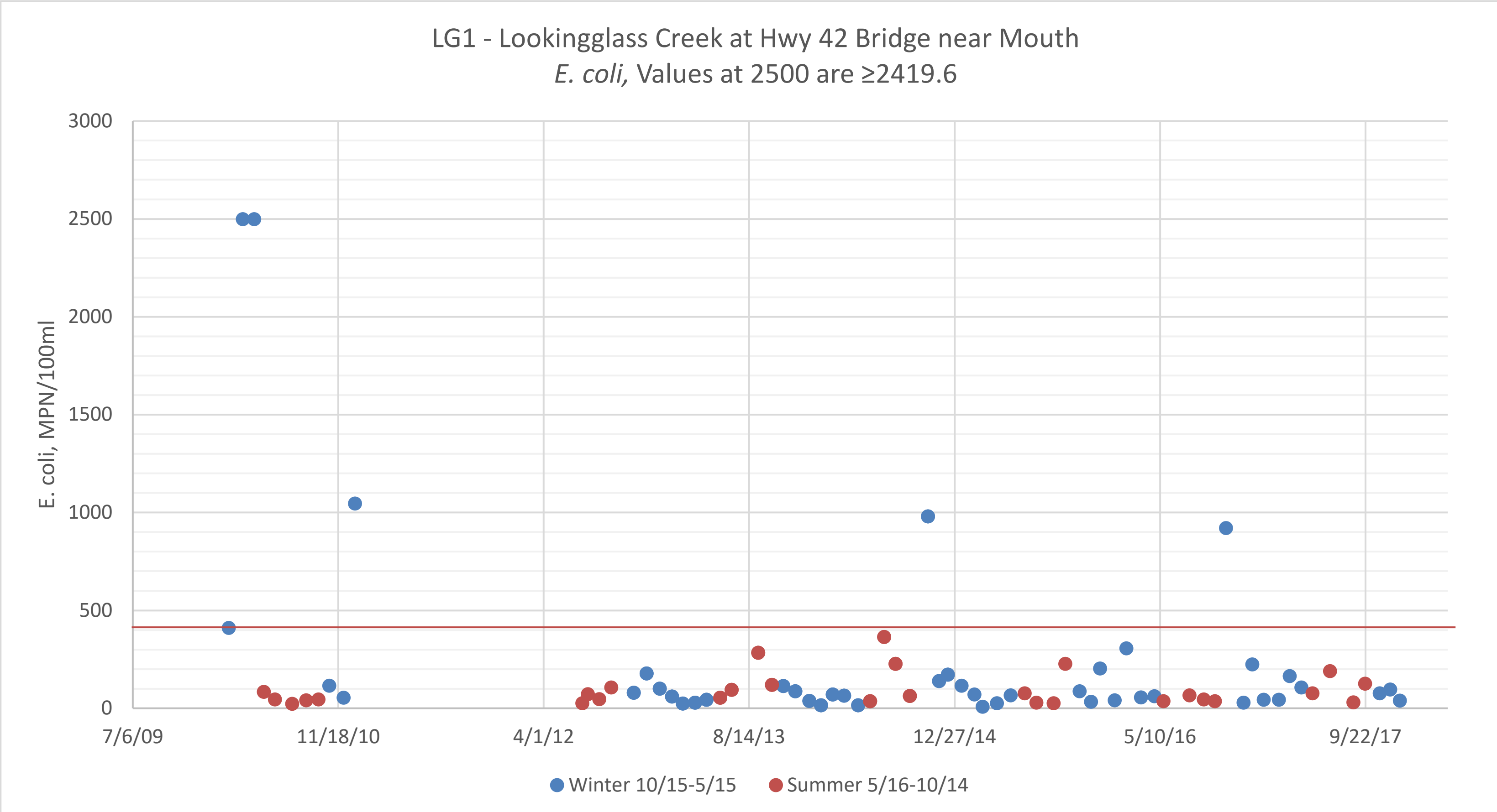
Graph 226. Grab sample conductivity levels LC1-Lookingglass Creek at Hwy 42 Bridge near the mouth.



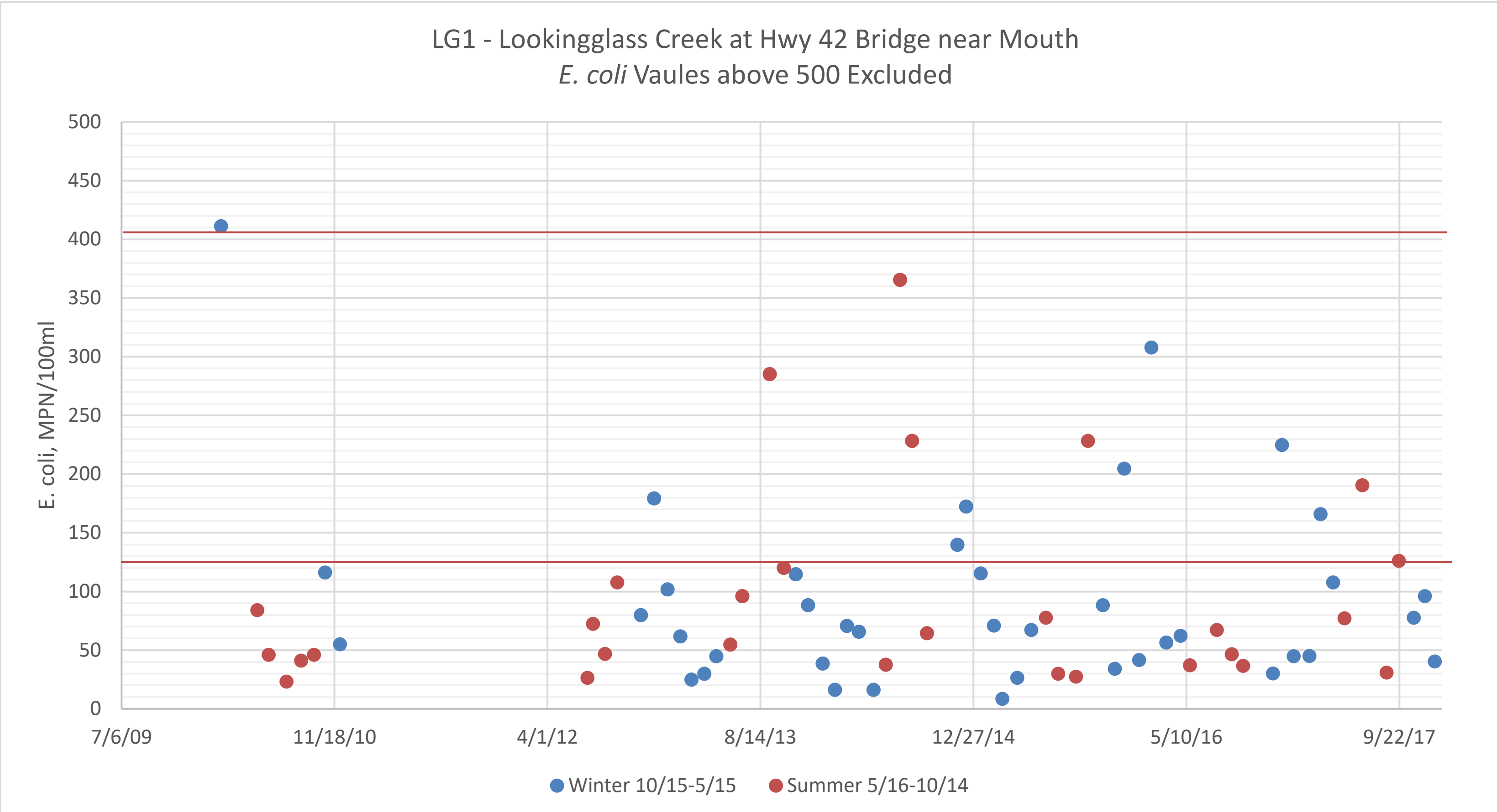
Graph 227. Box plots by year of grab sample conductivity levels Lookingglass Creek at Hwy 42 Bridge near mouth.

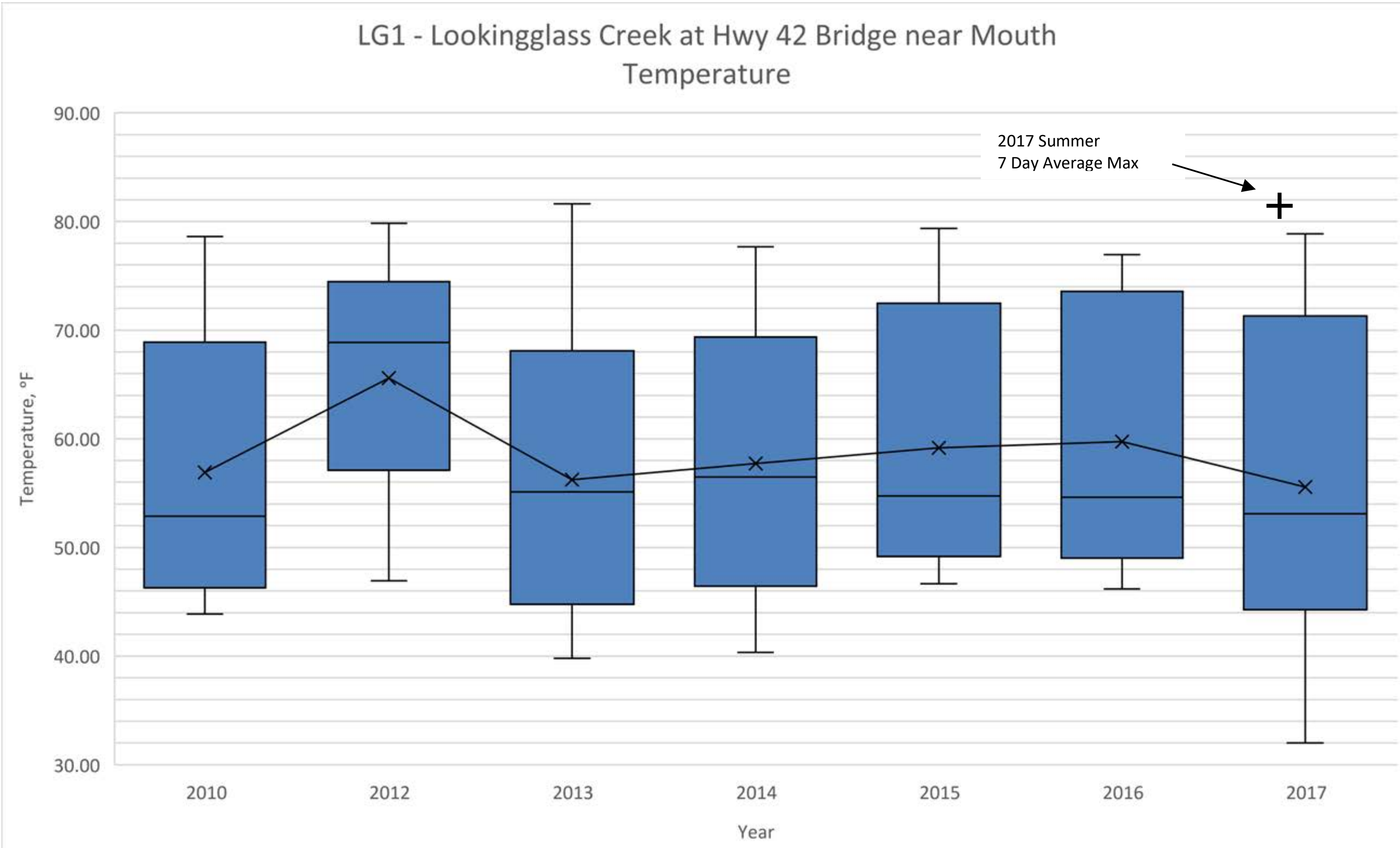


Graph 228. Box plots by year of grab sample *E. coli* levels Lookingglass Creek at Hwy 42 Bridge near mouth.



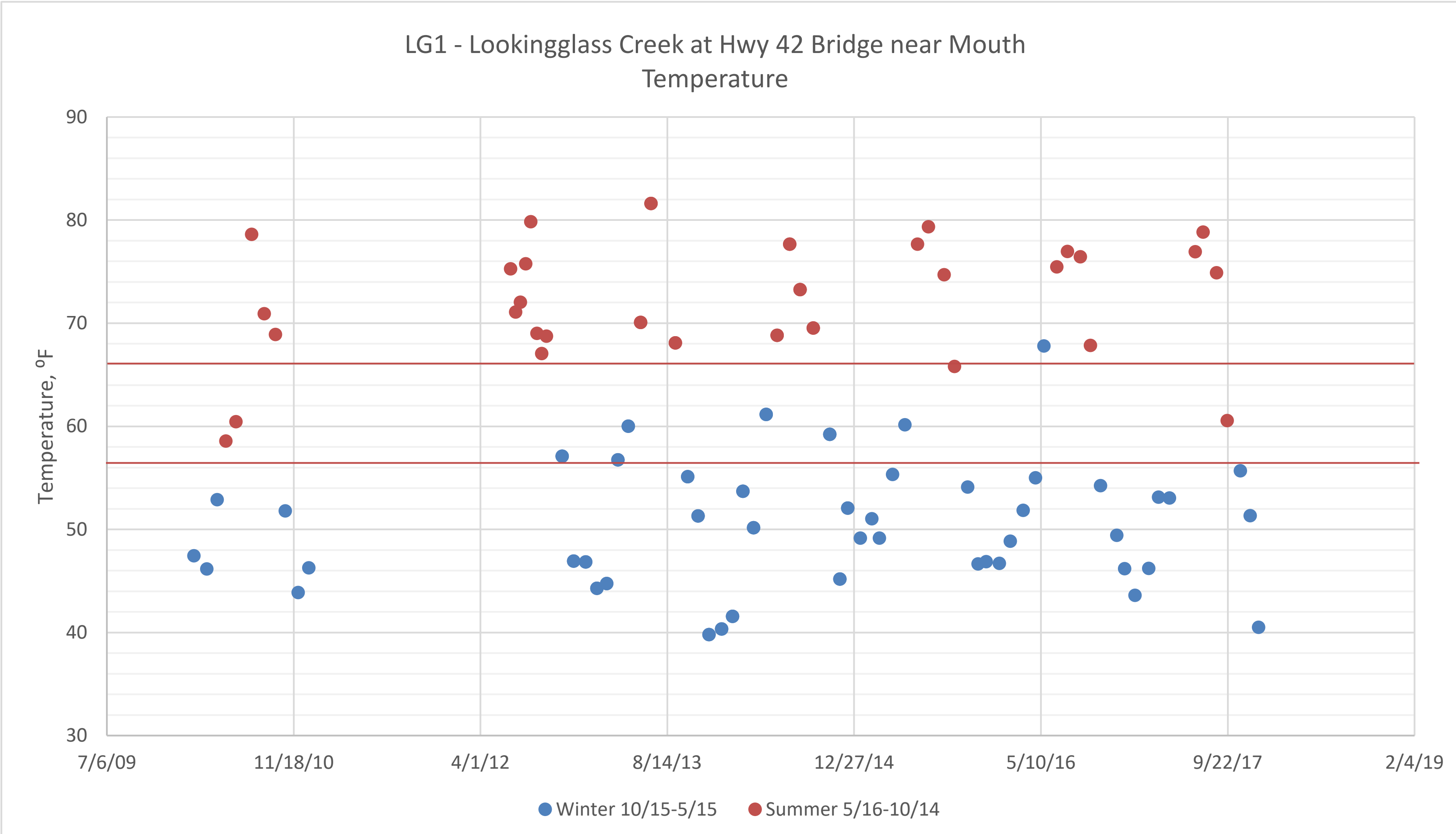
Graph 229. LG1 - Lookingglass Creek at Hwy 42 Bridge near Mouth E. coli, Values at 2500 are ≥2419.6.


LG1 - Lookingglass Creek at Hwy 42 Bridge near Mouth
E. coli Vaules above 500 Excluded
E. coli, MPN/100ml
500
450
400
350
300
250
200
150
100
50
0
7/6/09
11/18/10
4/1/12
8/14/13
12/27/14
5/10/16
9/22/17
Winter 10/15-5/15
Summer 5/16-10/14



Graph 230. LG1 - Lookingglass Creek at Hwy 42 Bridge near mouth *E. coli* values above 500 excluded.

Graph 231. Box plots by year of grab sample temperature levels Lookingglass Creek at Hwy 42 Bridge near mouth.



Graph 232. LG1 - Lookingglass Creek at Hwy 42 Bridge near mouth grab sample temperature2010-2017.

Site Name	*Site*	Start Date	Stop Date	Seasonal Maximum		Seasonal Minimum		Seasonal Max ΔT		7-Day averages			
	ID			Date	Value	Date	Value	Date	Value	Date	Max	Min	Δ T
South Umpqua Reference Run													
Lookingglass Creek at Brockway Rd. Bridge	LG1a	6/28/2017	9/20/2017	7/27/2017	84.4	9/20/2017	60.9	8/1/2017	11.4	8/1/2017	82.9	73.2	9.6

Site Name	*Site*	Days >	Days >	Days >	Hours >	Hours >	Hours >	Warmest day of 7-day max		
	ID	55 F	64 F	70 F	55 F	64 F	70 F	Date	Max	Min
South Umpqua Reference Run										
Lookingglass Creek at Brockway Rd. Bridge	*LG1a*	85	83	79	2039.5	1943	1579.5	8/1/2017	84.2	72.8

Table 44. Continuous temperature data summary for Lookingglass Creek at Brockway Rd. Bridge

ACRONYMS

- ODEQ: Oregon Department of Environmental Quality
- DO: Dissolved Oxygen
- EPA: Environmental Protection Agency
- NTU: Nephelometric Turbidity Units
- OWEB: Oregon Watershed Enhancement Board
- PUR: Partnership for the Umpqua Rivers
- QAPP: Quality Assurance Project Plan
- RAC: Secure Rural Schools and Self-Determination Act of 2000 (Public law 110-343)
- UBWC: Umpqua Basin Watershed Council
- OGMS: OWEB Grant Management System
- AWQMS: Ambient Water Quality Monitoring System

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ACKNOWLEDGEMENTS

PUR gratefully acknowledges funding assistance from the Oregon Watershed Enhancement Board. We also wish to thank DEQ ‘s Volunteer Monitoring Coordinator, Steve Hanson, for help with training, advice, equipment and supplies. This work could not have been possible without our many volunteers who gave their time and energy to monitor no matter the weather conditions. Special thanks go Mary Ann Hansen, and David Swartzlander. Thank you to Amy Rusk, Hydrologist for the Tiller Ranger District of the USFS for providing the continuous temperature logger data for Elk Creek and the South Umpqua at Tiller.

Appendix

Appendix A: Designated Beneficial Uses for the Umpqua Basin

Table 320A

Designated Beneficial Uses
Umpqua Basin
(340-41-0320)

Beneficial Uses	Umpqua R. Estuary to Head of Tidewater & Adjacent Marine Waters	Umpqua R. Main from Head of Tidewater to Confluence of N. & S. Umpqua Rivers	North Umpqua River Main Stem	South Umpqua River Main Stem	All Other Tributaries to Umpqua, North & South Umpqua Rivers
Public Domestic Water Supply[1]		X	X	X	X
Private Domestic Water Supply[1]		X	X	X	X
Industrial Water Supply	X	X	X	X	X
Irrigation		X	X	X	X
Livestock Watering		X	X	X	X
Fish & Aquatic Life[2]	X	X	X	X	X
Wildlife & Hunting	X	X	X	X	X
Fishing	X	X	X	X	X
Boating	X	X	X	X	X
Water Contact Recreation	X	X	X	X	X
Aesthetic Quality	X	X	X	X	X
Hydro Power			X	X	X
Commercial Navigation & Transportation	X				

[1] With adequate pretreatment (filtration & disinfection) and natural quality to meet drinking water standards.

[2] See also Figures 320A and 320B for fish use designations for this basin.

Table produced November, 2003

Appendix B: ODEQ Current Turbidity Rule

Turbidity Rule (OAR 340-041-0036) (Water Quality Standards, 2010)

Turbidity (Nephelometric Turbidity Units, NTU): No more than a ten percent cumulative increase in natural stream turbidities may be allowed, as measured relative to a control point immediately upstream of the turbidity causing activity. However, limited duration activities necessary to address an emergency or to accommodate essential dredging, construction or other legitimate activities and which cause the standard to be exceeded may be authorized provided all practicable turbidity control techniques have been applied and one of the following has been granted:

1. Emergency activities: Approval coordinated by the Department with the Oregon Department of Fish and Wildlife under conditions they may prescribe to accommodate response to emergencies or to protect public health and welfare;
2. Dredging, Construction or other Legitimate Activities: Permit or certification authorized under terms of section 401 or 404 (Permits and Licenses, Federal Water Pollution Control Act) or OAR 14l-085-0100 et seq. (Removal and Fill Permits, Division of State Lands), with limitations and conditions governing the activity set forth in the permit or certificate.

Appendix C: British Columbia Turbidity and Suspended Sediment Standards

Taken from Bash, 2001, p. 70.

Appendix D: pH Scale

Appendix E: Dissolved Oxygen Evaluation Flow Chart

Flow Chart illustrating the evaluation process for dissolved oxygen data collected from Oregon water bodies (Assessment Methodology for Oregon's 2004/2006 Integreated Report on Water Quality Status – ODEQ Water Quality Division)

Appendix F: Annual 7 Day Average Maximum Stream Temperature for Umpqua Basin Stream Characterization Project Reference Sites from 1998-2017 (Dammann, D.M., 2017, p. 7).

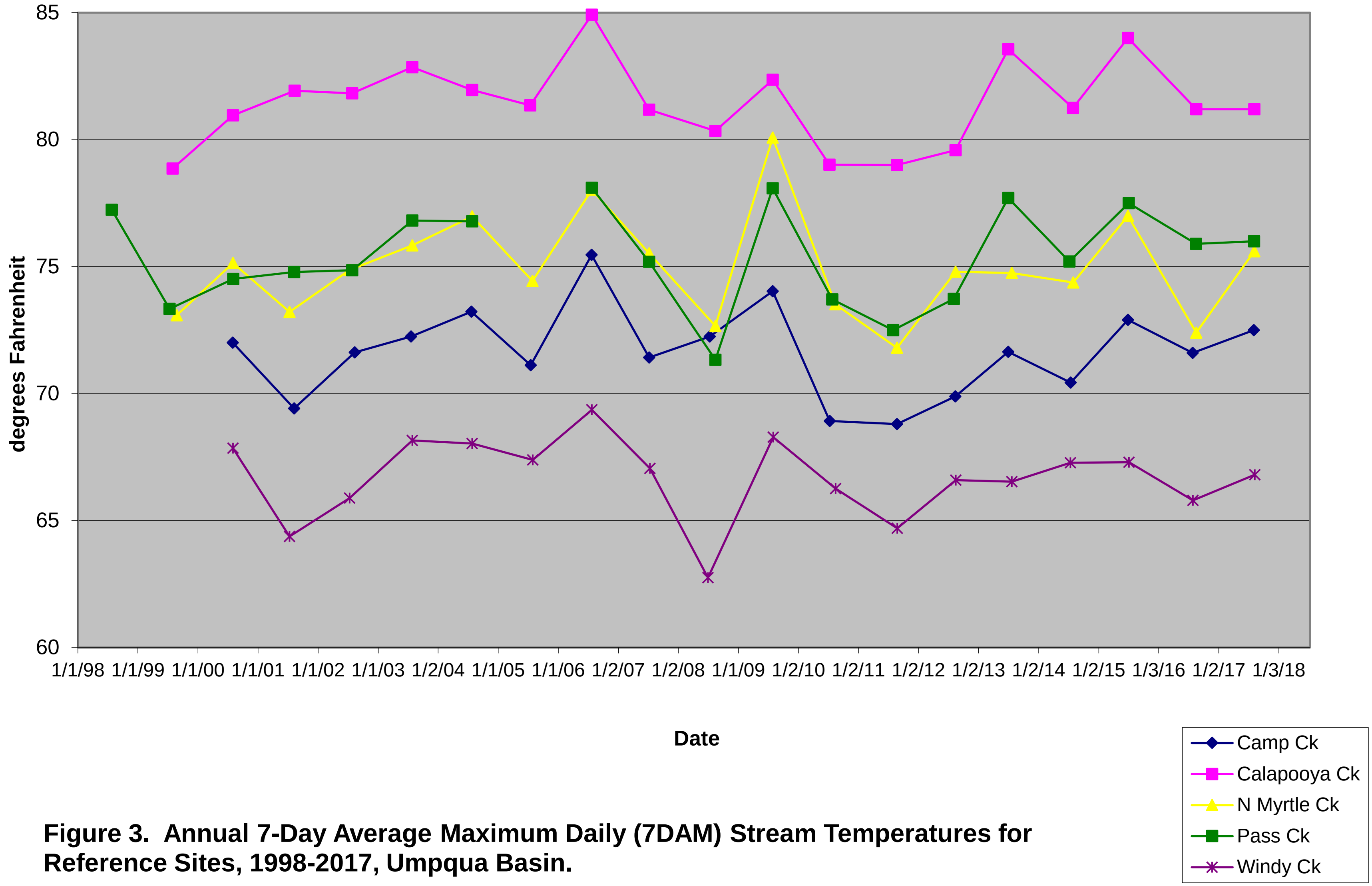


Figure 3. Annual 7-Day Average Maximum Daily (7DAM) Stream Temperatures for Reference Sites, 1998-2017, Umpqua Basin.

Appendix G: Reference Stream Temperature Summer 7DAM 1999-2015, North Myrtle Creek at the mouth

		Seasonal Maximum		Seasonal Minimum		Seasonal Max ΔT		7-Day averages				Days >	Days >	Days >	Hours >	Hours >	Hours >			
Start Date	Stop Date	Date	Value	Date	Value	Date	Value	Date	Max	Min	Δ T	55 F	64 F	70 F	55 F	64 F	70 F	Date of warmest day of 7-day max	Max	Min
07/01/99	09/13/99	08/28/99	74.3	09/11/99	54.7	08/16/99	11.3	08/25/99	73.1	64.9	8.2	75	72	40	1797.0	1092.0	271.5	08/24/99	74.3	64.6
06/30/00	09/15/00	07/30/00	77.3	09/10/00	55.6	07/20/00	11.1	08/01/00	75.1	65.5	9.7	78	69	30	1871.5	1146.0	229.5	07/30/00	77.3	67.3
06/19/01	09/11/01	07/09/01	75.5	09/06/01	55.6	06/20/01	12.5	07/11/01	73.2	64.3	8.9	85	81	37	2039.5	1339.0	212.0	07/09/01	75.5	63.9
06/23/02	09/19/02	07/10/02	77.8	09/08/02	54.7	06/25/02	12.0	07/12/02	74.9	65.7	9.2	89	83	35	2135.0	1402.5	325.5	07/10/02	77.8	66.1
06/27/03	09/15/03	07/21/03	77.8	09/14/03	57.0	06/28/03	11.8	07/28/03	75.8	66.2	9.6	81	80	62	1943.5	1604.5	570.5	07/30/03	77.5	68.1
06/24/04	09/16/04	07/24/04	78.6	09/07/04	57.4	07/23/04	11.7	07/26/04	77.0	67.2	9.8	85	84	59	2039.5	1574.0	603.0	07/24/04	78.6	68.9
06/28/05	09/19/05	07/18/05	76.0	09/19/05	54.3	07/26/05	11.0	07/29/05	74.4	65.2	9.2	84	74	47	2009.5	1337.5	404.5	07/29/05	75.6	66.6
06/22/06	09/23/06	07/24/06	81.0	09/23/06	53.7	06/24/06	11.6	07/25/06	78.0	68.9	9.1	94	94	94	2255.5	2255.5	2255.5	07/24/06	81.0	72.0
06/24/07	10/06/07	07/11/07	77.5	09/25/07	49.2	08/29/07	11.9	07/08/07	75.5	65.8	9.7	105	105	105	2519.5	2519.5	2519.5	07/11/07	77.5	70.5
06/02/08	09/23/08	08/16/08	74.6	06/02/08	51.8	07/13/08	9.4	08/15/08	72.7	67.1	5.5	114	114	114	2735.5	2735.5	2735.5	08/16/08	74.6	69.1
06/08/09	10/03/09	07/28/09	81.5	10/02/09	50.7	08/20/09	12.2	07/30/09	80.1	70.3	9.8	118	118	118	2831.5	2831.5	2831.5	07/28/09	81.5	70.8
06/21/10	09/25/10	08/16/10	75.0	06/21/10	54.4	08/25/10	10.8	08/15/10	73.5	64.6	9.0	97	97	97	2327.5	2327.5	2327.5	08/16/10	75.0	65.5
06/21/11	09/25/11	08/25/11	73.5	09/01/11	54.9	06/21/11	9.5	08/25/11	71.8	64.5	7.2	97	97	97	2327.5	2327.5	2327.5	08/25/11	73.5	67.1
06/17/12	10/12/12	08/16/12	76.6	10/05/12	46.5	09/03/12	18.2	08/15/12	74.8	65.6	9.2	118	118	118	2831.5	2831.5	2831.5	08/16/12	76.6	67.7
06/14/13	09/21/13	07/25/13	76.3	06/14/13	54.3	07/22/13	10.7	07/24/13	74.7	65.7	9.0	100	90	52	2395.0	1795.5	396.5	07/25/13	76.3	66.7
06/17/14	10/02/14	08/02/14	76.4	10/02/14	54.2	08/06/14	9.9	08/01/14	74.4	67.6	6.8	108	99	55	2581.0	1858.5	548.0	08/02/14	76.4	68.0
06/07/15	09/21/15	06/27/15	78.2	09/06/15	56.4	06/17/15	9.8	06/30/15	77.0	69.5	7.5	107	95	58	2567.5	2030.0	588.5	06/27/15	78.2	70.3

North Myrtle Creek at Mouth

Appendix H: Oregon DEQ Data Quality Matrix

Data Validation Criteria for Water Quality Parameters Measured in the Field

Quality Level	Quality Assurance Plan	Water Temperature Methods	pH Methods	Dissolved Oxygen Methods	Turbidity Methods	Conductivity Methods	Bacteria Methods	Data Uses
A+	DEQ QAPP approved by DEQ QA Officer	Thermometer Accuracy checked with NIST standards A ≤ ± 0.5°C P ≤ ± 0.5°C	Calibrated pH electrode A ≤ ± 0.2 S.U. P ≤ ± 0.3 S.U.	Winkler titration or calibrated Oxygen meter A ≤ ± 0.2 mgL^{-1} P ≤ ± 0.3 mgL^{-1}	Nephelometric Turbidity meter A ≤ ± 5% Standard value P ≤ ± 5% (± 1 NTU if NTU < 20)	Meter with temp correction to 25°C A ≤ ± 7% of standard value P ≤ ± 10%	DEQ Approved Methods Absolute difference between log-transformed values P ≤ 0.6 log	Regulatory, permitting, compliance (e.g., 303(d) and 305(b) assessments)
A	External QAPP	External Data Thermometer Accuracy checked with NIST standards A ≤ ± 0.5°C P ≤ ± 0.5°C	External Data Calibrated pH electrode A ≤ ± 0.2 S.U. P ≤ ± 0.3 S.U.	External Data Winkler titration or calibrated Oxygen meter A ≤ ± 0.2 mgL^{-1} P ≤ ± 0.3 mgL^{-1}	External Data Nephelometric Turbidity meter A ≤ ± 5% Standard value P ≤ ± 5% (± 1 NTU if NTU <20)	External Data Meter with temp correction to 25°C A ≤ ± 7% of standard value P ≤ ± 10%	External Data DEQ Approved Methods Absolute difference between log-transformed values P ≤ 0.6 log	Regulatory, permitting, compliance (e.g., 303(d) and 305(b) assessments)
B	Minimum Data Acceptance Criteria Met	Thermometer Accuracy checked with NIST standards A ≤ ± 1.0°C P ≤ ± 2.0°C	Any Method A ≤ ± 0.5 S.U. P ≤ ± 0.5 S.U.	Winkler titration or calibrated Oxygen meter A ≤ ± 1 mgL^{-1} P ≤ ± 1 mgL^{-1}	Any Method A ≤ ± 30% P ≤ ± 30%	Meter with temp correction to 25°C A ≤ ± 10% of standard value P ≤ ± 15%	DEQ Approved Methods Absolute difference between log-transformed values P ≤ 0.8 log	Regulatory, permitting, compliance (e.g., 303(d) and 305(b) assessments) with professional judgment
C		A > ± 1.0°C P > ± 2.0°C	A > ± 0.5 S.U. P > ± 0.5 S.U.	A > ± 2 mgL^{-1} P > ± 2 mgL^{-1}	A > 30% P > 30%	A > ± 10% P > ± 15%	Absolute difference between log-transformed values P > 0.8 log	Void data. Not used for 303(d) and 305(b) assessments
D		Missing Data	Missing Data	Missing Data	Missing Data	Missing Data	Missing Data	Missing Data
E	No QAPP provided	No Precision Checks	Any Method No Precision Checks	Any Method No Precision Checks or A ≤ ± 2 mgL^{-1} P ≤ ± 2 mgL^{-1}	Any Method No precision checks	Meter without routine calibration No precision checks	Any Method No precision checks	Informational purposes only
F	See accompanying notes							

Appendix I: Oregon DEQ Data Quality Matrix

Data Validation Criteria for Water Quality Parameters Measured in the Field

Notes:

QA definitions of Data Quality Levels

- **A+** – Data of known Quality; collected by DEQ; meets QC limits established in the QAPP.
- **A** – Data of known Quality; submitted by entities outside of DEQ; meets QC limits established in a *DEQ-approved* QAPP.
- **B** – Data of known *but lesser* Quality; data may not meet established QC but is within marginal acceptance criteria; or data value may be accurate, however controls used to measure Data Quality Objective elements failed (e.g., batch failed to meet blank QC limit); the data may be useful in limited situations or in supporting other, higher quality data.

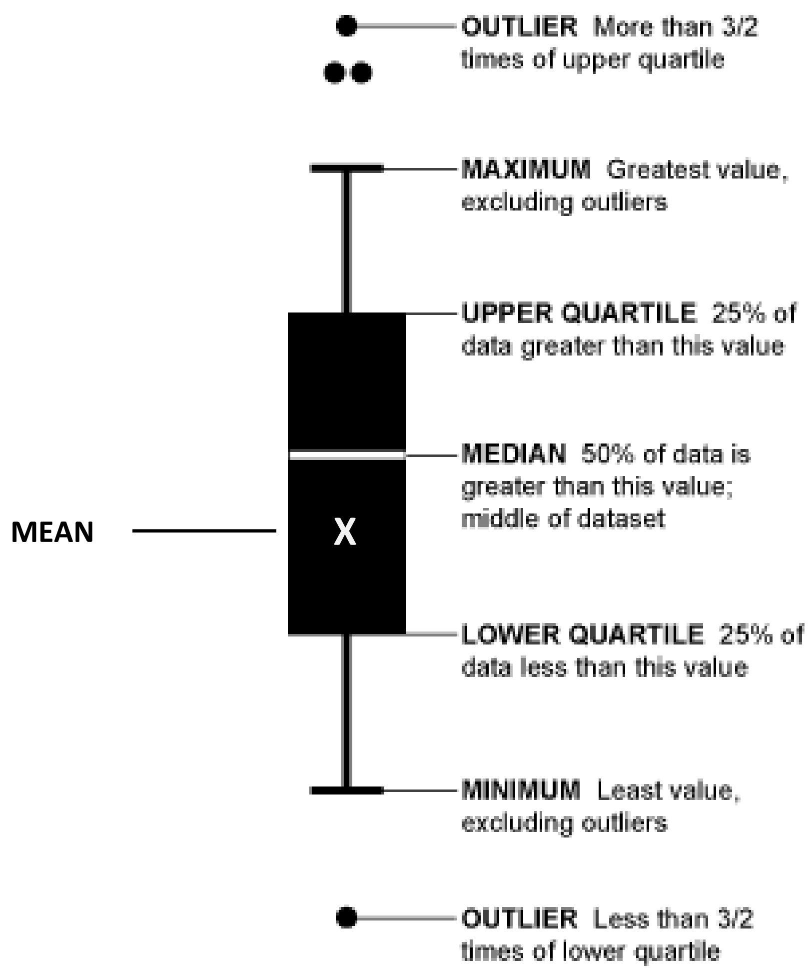
Note: Statistics for **turbidity, conductivity,** and **bacteria** are concentration-dependent; thus low-concentration B level data may be considered acceptable for all uses.

- **C** – Data of unacceptable Quality; data are typically discarded (Void) in response to analytical failure. **Note:** There may be rare instances where there may be field data that may still meet DQOs as determined by the Project Officer. In these cases a result should be entered instead of “Void” however the grade must remain at C. There must also be a comment in the final report that explains the qualification.
- **D** – Incomplete data; no sample collected or no reportable results, typically due to sampling failure.
- **E** – Data of unknown quality or known to be of poor quality; no QA information is available, data could be valid, however, no evidence is available to prove either way. Data is provided for Educational Use Only.
- **F** – Exceptional Event; "A" quality data (data is of known quality), but not representative of sampling conditions as required by the project plan.(e.g., a continuous water quality monitor intended to collect background environmental conditions collects a sample impacted by a fire that created anomalous conditions to the environment).

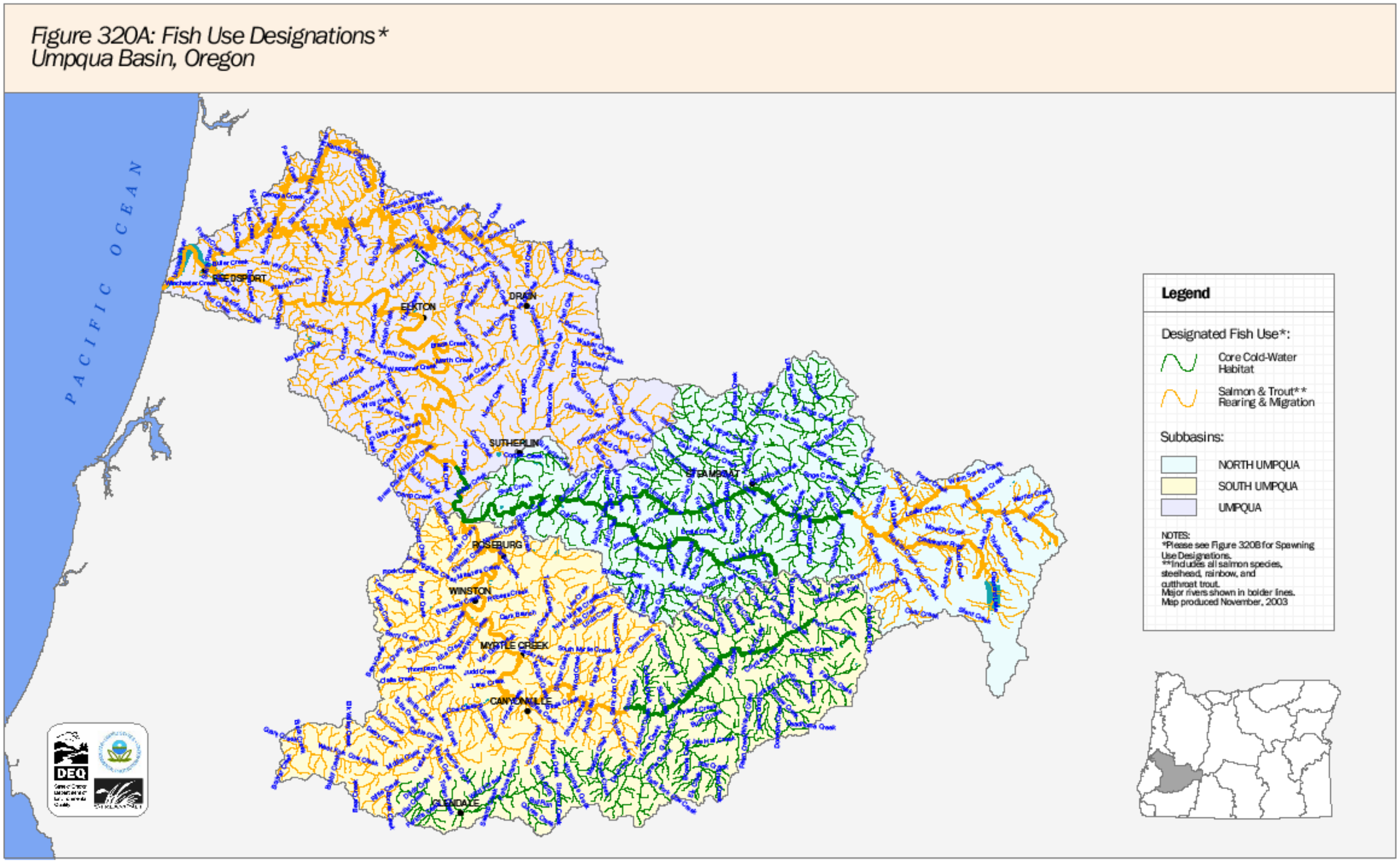
Data Quality Level Grading Criteria:

- **A** = Accuracy as determined by comparison with standards, e.g., during equipment calibration or pre- and post-deployment checks
- **P** = Precision as determined by replicate measurements, e.g., during field duplicates, field audits, or split sample

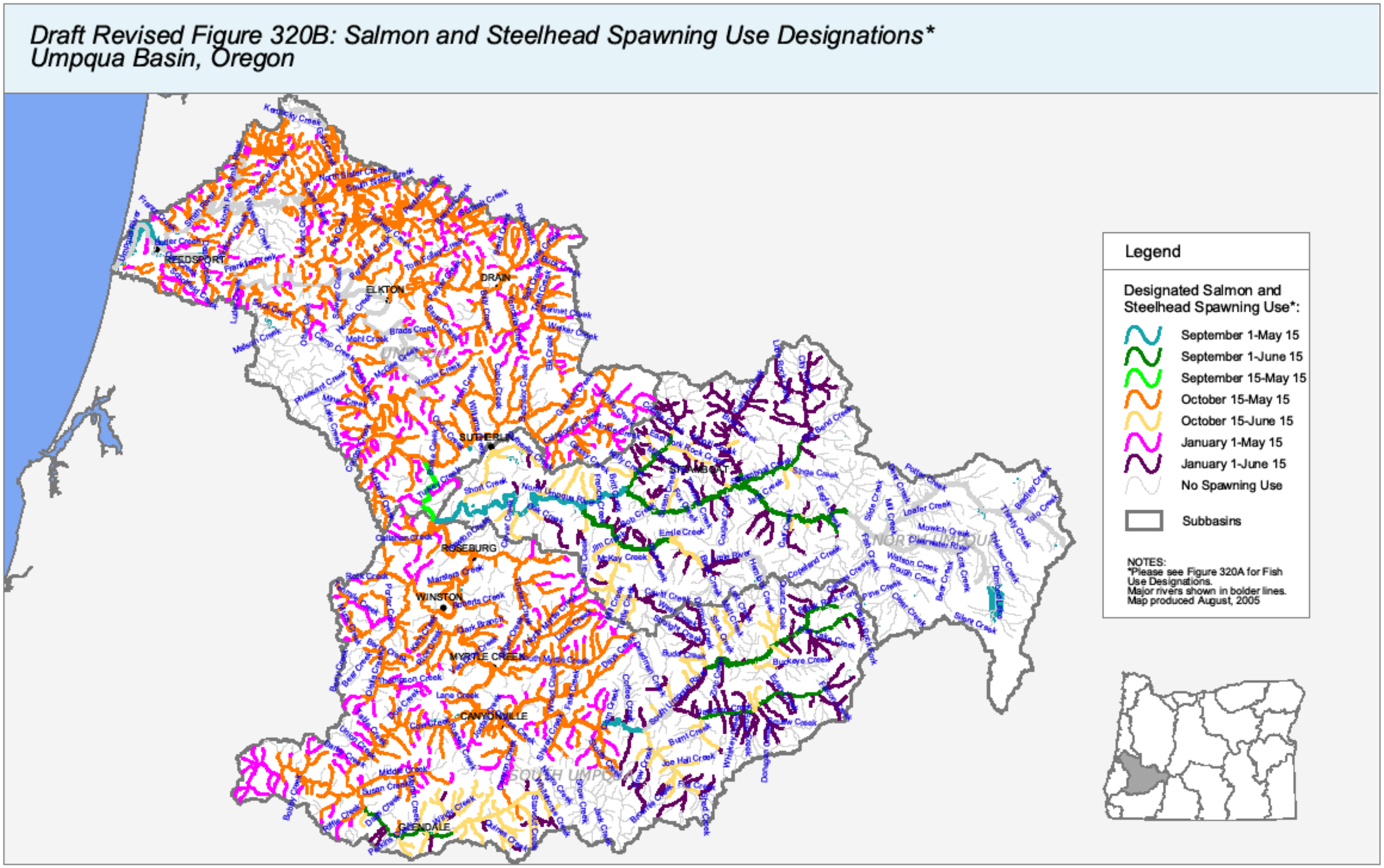
Appendix J: Interpreting a Box Plot



Appendix K: Umpqua Basin Fish Use Designations from ODEQ 2003



Appendix L: Umpqua Basin Salmon and Steelhead Spawning Use Designations from ODEQ 2003



Appendix M: Precipitation Data from NOAA gathered at Roseburg Regional Airport

2014

Day	Jan		Feb		Mar		Apr		May		Jun		Jul		Aug		Sep		Oct		Nov		Dec	
1	0	2014	0	2014	0.08	2014	0	2014	0	2014	0	2014	0	2014	0	2014	0	2014	0	2014	0.1	2014	0.38	2014
2	0	2014	0.01	2014	0.02	2014	0	2014	0	2014	0	2014	0	2014	0	2014	0	2014	0	2014	0	2014	0.01	2014
3	0.02	2014	0.1	2014	0.35	2014	0.01	2014	T	2014	0	2014	0	2014	0	2014	0	2014	0	2014	0.06	2014	0.21	2014
4	0	2014	0.01	2014	T	2014	0.06	2014	0.1	2014	0	2014	0	2014	0	2014	0	2014	0	2014	0.07	2014	0.03	2014
5	0	2014	0	2014	0.2	2014	0.06	2014	0.1	2014	0	2014	0	2014	0	2014	0	2014	0	2014	0	2014	0.32	2014
6	0.12	2014	0.24	2014	0.44	2014	T	2014	0.01	2014	0	2014	0	2014	0	2014	0	2014	0	2014	0.11	2014	0.01	2014
7	0.07	2014	0.36	2014	T	2014	0	2014	0	2014	0	2014	0	2014	0	2014	0	2014	0	2014	0	2014	0	2014
8	0.17	2014	0.34	2014	0.13	2014	0	2014	0.34	2014	0	2014	0	2014	0	2014	0	2014	0	2014	0	2014	0	2014
9	0.04	2014	0.04	2014	0.89	2014	T	2014	0.25	2014	0	2014	0	2014	0	2014	0	2014	0	2014	T	2014	0.21	2014
10	T	2014	0.02	2014	0.17	2014	0	2014	0.17	2014	0	2014	0	2014	0	2014	0	2014	0	2014	0	2014	0.39	2014
11	0.82	2014	0.1	2014	0	2014	0	2014	0	2014	0	2014	T	2014	0	2014	0	2014	0.01	2014	0	2014	0.41	2014
12	0.04	2014	0.92	2014	0	2014	0	2014	0	2014	0	2014	0	2014	0.03	2014	0	2014	0	2014	0.01	2014	0.03	2014
13	0	2014	0.35	2014	0	2014	0	2014	0	2014	0.06	2014	0	2014	T	2014	0	2014	0	2014	0.62	2014	0	2014
14	0	2014	1.42	2014	0.03	2014	0	2014	0	2014	0	2014	0	2014	0	2014	0	2014	0.48	2014	0.77	2014	0.05	2014
15	0	2014	0.36	2014	0	2014	0	2014	0	2014	0	2014	0	2014	0	2014	0	2014	0.57	2014	0	2014	0.07	2014
16	0	2014	0.09	2014	0.36	2014	0	2014	0	2014	0.06	2014	0	2014	0	2014	0	2014	0	2014	0	2014	T	2014
17	0	2014	0.4	2014	0.1	2014	0.16	2014	0.21	2014	T	2014	0	2014	0	2014	T	2014	0.05	2014	0	2014	0.13	2014
18	0	2014	0.68	2014	0	2014	0	2014	0.04	2014	0	2014	0	2014	0	2014	0.09	2014	0	2014	T	2014	0.18	2014
19	0	2014	0.06	2014	0	2014	0.01	2014	0.06	2014	0	2014	0	2014	0	2014	0	2014	0	2014	0.17	2014	0.28	2014
20	0	2014	0.02	2014	T	2014	0	2014	0	2014	0	2014	0	2014	0	2014	0	2014	0.41	2014	0.03	2014	1.02	2014
21	0	2014	0	2014	0	2014	0.12	2014	0	2014	0	2014	0.02	2014	0	2014	0	2014	0.03	2014	0.41	2014	0.4	2014
22	0	2014	0	2014	0	2014	0.15	2014	0	2014	0	2014	T	2014	0	2014	0	2014	0.78	2014	0.49	2014	0.13	2014
23	0	2014	0.01	2014	0	2014	0.32	2014	0.01	2014	T	2014	0.18	2014	0	2014	T	2014	0.18	2014	0	2014	0.02	2014
24	0	2014	0	2014	0	2014	0.28	2014	0	2014	0	2014	0	2014	0	2014	1.37	2014	0.16	2014	0	2014	0.7	2014
25	0	2014	0	2014	0.09	2014	0.09	2014	T	2014	0.77	2014	0	2014	0	2014	0.01	2014	0.49	2014	0.01	2014	0.13	2014
26	0	2014	T	2014	0.38	2014	0.07	2014	0	2014	0.04	2014	0	2014	0	2014	0	2014	0.14	2014	0	2014	0	2014
27	0.01	2014	0.15	2014	0.26	2014	0.27	2014	0	2014	0.03	2014	0	2014	0	2014	0	2014	T	2014	1.1	2014	0.09	2014
28	0.29	2014	0.01	2014	1.25	2014	0	2014	0.16	2014	0	2014	0	2014	0	2014	0	2014	0.07	2014	0.81	2014	0.15	2014
29	0.06	2014	M	M	0.16	2014	0	2014	0	2014	0	2014	0	2014	0	2014	0.05	2014	0.02	2014	0.05	2014	0.18	2014
30	0.02	2014	-	-	0.05	2014	0	2014	0	2014	0	2014	0	2014	T	2014	T	2014	0.24	2014	0	2014	0	2014
31	0.1	2014	-	-	T	2014	-	-	0	2014	-	-	0	2014	0	2014	-	-	0.31	2014	-	-	0	2014

Annual Rainfall = 32.45

2015

Day	Jan		Feb		Mar		Apr		May		Jun		Jul		Aug		Sep		Oct		Nov		Dec	
1	0	2015	0.13	2015	0	2015	0.03	2015	0	2015	0.24	2015	0	2015	T	2015	0	2015	0	2015	0.15	2015	0.27	2015
2	0	2015	0.34	2015	0.03	2015	0	2015	0	2015	T	2015	0	2015	T	2015	0.08	2015	0	2015	0.06	2015	0.14	2015
3	0	2015	0.88	2015	T	2015	0.04	2015	0	2015	0	2015	0	2015	0	2015	0	2015	0.03	2015	0.02	2015	0.56	2015
4	T	2015	0	2015	0	2015	0	2015	0	2015	0	2015	0	2015	0	2015	0.01	2015	0	2015	0	2015	0.53	2015
5	0	2015	0.07	2015	0	2015	0.08	2015	0	2015	0	2015	0	2015	0	2015	0	2015	0	2015	T	2015	0.03	2015
6	0	2015	1.89	2015	0	2015	0.13	2015	T	2015	0	2015	0	2015	0	2015	0	2015	0	2015	0	2015	0.78	2015
7	0	2015	0.6	2015	0	2015	0.21	2015	0	2015	0	2015	0	2015	0	2015	0	2015	0	2015	0.31	2015	0.73	2015
8	0	2015	0.21	2015	0	2015	0	2015	0	2015	0	2015	0	2015	0	2015	0	2015	0	2015	0.4	2015	0.03	2015
9	0	2015	0.19	2015	0	2015	0	2015	0	2015	T	2015	T	2015	0	2015	0	2015	0	2015	0.06	2015	1.35	2015
10	0	2015	0	2015	T	2015	0	2015	0	2015	0	2015	0	2015	0	2015	0	2015	0.07	2015	0	2015	1.2	2015
11	T	2015	0	2015	0.37	2015	0.11	2015	0.03	2015	0	2015	0	2015	0	2015	0	2015	0	2015	0.05	2015	0.65	2015
12	0.17	2015	0	2015	0	2015	0	2015	0.11	2015	0	2015	0.01	2015	0	2015	0	2015	0	2015	0	2015	1.49	2015
13	0	2015	0	2015	T	2015	0.09	2015	T	2015	0	2015	0	2015	0	2015	0	2015	0	2015	0	2015	1.43	2015
14	0	2015	0	2015	0.64	2015	0.12	2015	T	2015	0	2015	0	2015	0.01	2015	0	2015	0	2015	0	2015	0.25	2015
15	0.4	2015	0	2015	0.15	2015	0	2015	T	2015	0	2015	0	2015	0	2015	T	2015	0	2015	0.92	2015	0	2015
16	0.07	2015	0	2015	0	2015	0	2015	T	2015	0	2015	0	2015	0	2015	0.08	2015	0.05	2015	0.08	2015	0.2	2015
17	0.72	2015	0	2015	T	2015	0	2015	0	2015	0	2015	0	2015	0	2015	0.2	2015	0.15	2015	0.11	2015	0.88	2015
18	0.02	2015	0	2015	0	2015	0	2015	0	2015	0	2015	0	2015	0	2015	0	2015	0	2015	0.09	2015	0.49	2015
19	0	2015	0	2015	0	2015	0	2015	T	2015	0	2015	0	2015	0	2015	0	2015	0.33	2015	0.36	2015	0.03	2015
20	0	2015	0	2015	0.34	2015	0	2015	0.01	2015	0	2015	0	2015	0	2015	0	2015	0	2015	0	2015	0.24	2015
21	0	2015	0	2015	0.05	2015	0	2015	0.03	2015	0	2015	0	2015	0	2015	T	2015	0	2015	0	2015	0.91	2015
22	T	2015	0	2015	0.43	2015	0	2015	T	2015	0	2015	0	2015	0	2015	0	2015	0	2015	0	2015	0.21	2015
23	T	2015	0	2015	0.78	2015	0.1	2015	0	2015	0	2015	0	2015	0	2015	0	2015	0	2015	0.15	2015	0.92	2015
24	0	2015	0	2015	0.01	2015	T	2015	0	2015	0	2015	0	2015	0	2015	0	2015	0	2015	0.57	2015	0.22	2015
25	0	2015	0	2015	0	2015	0.03	2015	0	2015	T	2015	0	2015	0	2015	0	2015	0.38	2015	0	2015	0.01	2015
26	0	2015	0.28	2015	0	2015	0	2015	0	2015	0	2015	0	2015	0	2015	T	2015	T	2015	0	2015	0	2015
27	0	2015	0.21	2015	T	2015	0	2015	0	2015	0	2015	0	2015	0	2015	0	2015	0.03	2015	0	2015	0.18	2015
28	0	2015	0	2015	0	2015	0	2015	0	2015	0	2015	0	2015	0	2015	0	2015	0.24	2015	0	2015	0.12	2015
29	0	2015	M	M	0	2015	0	2015	0	2015	0	2015	0	2015	0.05	2015	0	2015	0.02	2015	0	2015	0.32	2015
30	0	2015	-	-	0	2015	0	2015	0	2015	0	2015	0	2015	0.17	2015	0	2015	0.01	2015	0.02	2015	0.02	2015
31	0	2015	-	-	0.28	2015	-	-	0.04	2015	-	-	0	2015	0	2015	-	-	0.34	2015	-	-	0	201

Annual Rainfall = 30.46

2016

Day	Jan		Feb		March		April		May		June		July		Aug		Sept		Oct		Nov		Dec	
1	0	2016	T	2016	0.05	2016	0	2016	0	2016	0	2016	0	2016	0	2016	0	2016	0.26	2016	T	2016	0.05	2016
2	0	2016	0.2	2016	0.05	2016	0	2016	0.05	2016	0	2016	0	2016	0	2016	0.02	2016	0.61	2016	T	2016	0.02	2016
3	0.09	2016	0.06	2016	0	2016	0.07	2016	0.31	2016	0	2016	0	2016	0	2016	0	2016	0.06	2016	T	2016	0	2016
4	0.07	2016	T	2016	T	2016	0.07	2016	0.06	2016	0	2016	0	2016	0	2016	0	2016	0.1	2016	0	2016	0.35	2016
5	0.11	2016	0.11	2016	0.89	2016	0	2016	0	2016	0	2016	0	2016	0	2016	0	2016	0.38	2016	0.5	2016	0.05	2016
6	0.05	2016	0.02	2016	0.17	2016	0	2016	0	2016	0	2016	0	2016	0	2016	0.01	2016	0.01	2016	0	2016	0.18	2016
7	T	2016	0	2016	0.09	2016	0	2016	0	2016	0	2016	0.2	2016	0	2016	0	2016	0.03	2016	0	2016	0	2016
8	0.08	2016	0	2016	0.05	2016	0	2016	T	2016	0	2016	0.52	2016	0	2016	0	2016	0	2016	0	2016	0.17	2016
9	0.14	2016	0	2016	0.42	2016	0	2016	0	2016	T	2016	T	2016	0	2016	0	2016	0	2016	0	2016	0.8	2016
10	0	2016	0	2016	0.26	2016	0	2016	0	2016	0.03	2016	0.05	2016	0	2016	0	2016	0.1	2016	0	2016	0.13	2016
11	0.05	2016	0.02	2016	0.08	2016	0	2016	0	2016	0	2016	0	2016	0	2016	0	2016	0	2016	0.03	2016	0.19	2016
12	0.16	2016	0.15	2016	0.56	2016	T	2016	0	2016	0	2016	0	2016	0	2016	0	2016	0.03	2016	T	2016	0.05	2016
13	0.63	2016	0.06	2016	0.53	2016	0.19	2016	T	2016	0	2016	0	2016	0	2016	0	2016	1.5	2016	0.01	2016	0.01	2016
14	0.41	2016	0.06	2016	0.4	2016	0.91	2016	0.21	2016	0.42	2016	0	2016	0	2016	0	2016	0.53	2016	0.51	2016	2.88	2016
15	0.14	2016	0	2016	0.01	2016	0.01	2016	0.01	2016	0.23	2016	0	2016	0	2016	0	2016	0.81	2016	0.1	2016	0.04	2016
16	0.26	2016	0	2016	0	2016	0	2016	0	2016	0.01	2016	0	2016	0	2016	0	2016	1.35	2016	0.26	2016	0	2016
17	1.41	2016	0.09	2016	0	2016	0	2016	0	2016	0.11	2016	0	2016	0	2016	0	2016	0.51	2016	T	2016	0	2016
18	0.23	2016	0.7	2016	T	2016	0	2016	T	2016	0.06	2016	T	2016	0	2016	0	2016	0.19	2016	0.02	2016	0	2016
19	0.89	2016	0.69	2016	T	2016	0	2016	0.1	2016	0	2016	0	2016	0	2016	0	2016	0	2016	0.06	2016	0.04	2016
20	0	2016	0	2016	0.16	2016	0.01	2016	T	2016	0	2016	0	2016	0	2016	0	2016	0.07	2016	1	2016	0.17	2016
21	0.18	2016	0.02	2016	0.77	2016	0.25	2016	0.01	2016	0	2016	0	2016	0	2016	0	2016	0.16	2016	0.12	2016	0	2016
22	0.44	2016	0	2016	0.35	2016	0.21	2016	0.09	2016	0	2016	0	2016	0	2016	T	2016	T	2016	0.25	2016	0.01	2016
23	0.2	2016	0	2016	T	2016	0.1	2016	0.01	2016	0	2016	0	2016	0	2016	0.04	2016	T	2016	0.09	2016	0.7	2016
24	0.15	2016	T	2016	0.06	2016	0.34	2016	0	2016	0	2016	0	2016	0	2016	T	2016	0.34	2016	0.01	2016	0.03	2016
25	T	2016	0	2016	T	2016	0	2016	0	2016	0	2016	0	2016	0	2016	0	2016	0.37	2016	0.11	2016	0	2016
26	T	2016	0.37	2016	0.25	2016	0.02	2016	0	2016	0	2016	0	2016	0	2016	0	2016	0.31	2016	0.34	2016	0.04	2016
27	T	2016	T	2016	0.06	2016	0.1	2016	0	2016	0	2016	0	2016	0	2016	0	2016	0.93	2016	0.09	2016	0.11	2016
28	0.36	2016	0.01	2016	0.03	2016	0	2016	0	2016	0	2016	0	2016	0	2016	0	2016	0	2016	0.19	2016	0.01	2016
29	0.22	2016	0.05	2016	0	2016	0.04	2016	0	2016	0	2016	0	2016	0	2016	0	2016	0.17	2016	0.07	2016	0	2016
30	0.27	2016	-	-	0	2016	0	2016	0	2016	0	2016	0	2016	0	2016	0	2016	0.05	2016	0.18	2016	0.05	2016
31	0.07	2016	-	-	0	2016	-	-	0	2016	-	-	0	2016	0	2016	-	-	0.02	2016	-	-	0.01	20

Total Rainfall = 38.25

2017

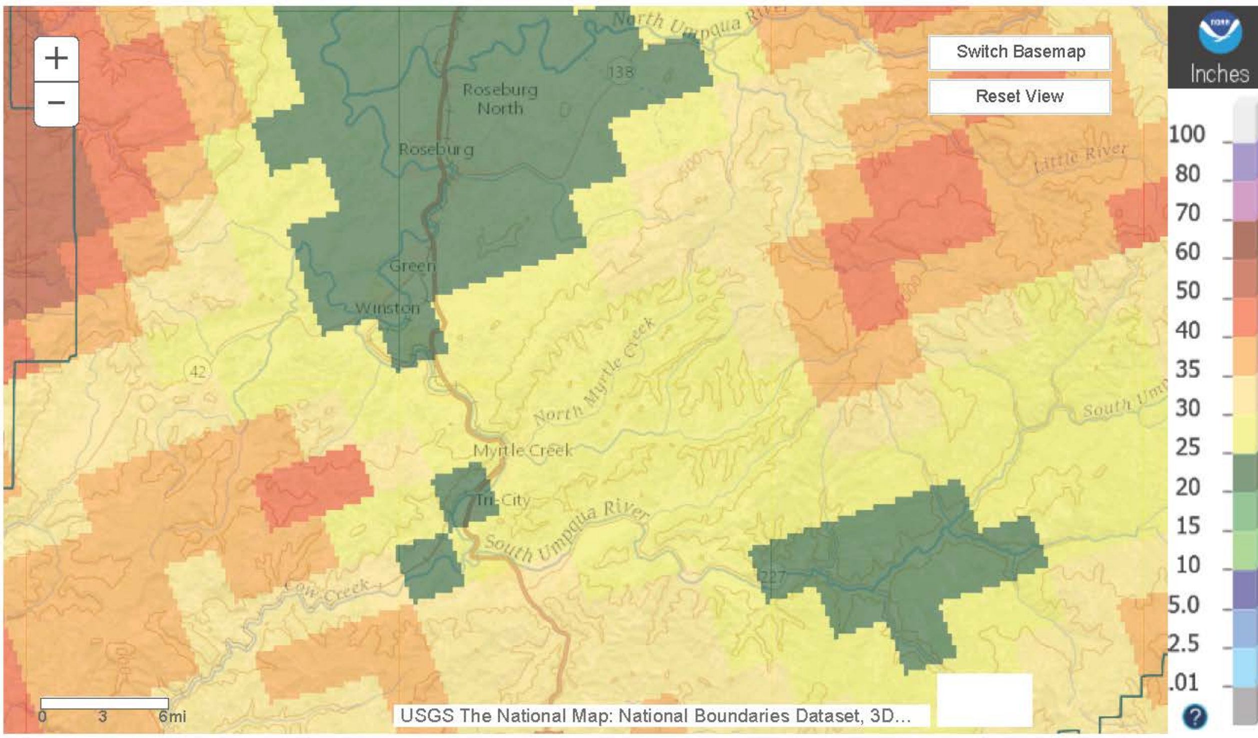
Day	Jan		Feb		Mar		Apr		May		Jun		Jul		Aug		Sep		Oct		Nov		Dec	
1	0.35	2017	0.01	2017	0	2017	0	2017	T	2017	0.02	2017	0	2017	0	2017	0	2017	0.08	2017	0	2017	T	2017
2	T	2017	T	2017	0	2017	0	2017	T	2017	0	2017	0	2017	0	2017	0	2017	T	2017	0.15	2017	0.18	2017
3	0.07	2017	0.5	2017	0.25	2017	0	2017	0	2017	0	2017	0	2017	0	2017	0	2017	0	2017	0.17	2017	0.12	2017
4	0.05	2017	0.38	2017	0.29	2017	0	2017	0.11	2017	0	2017	0	2017	0	2017	0	2017	0	2017	T	2017	0	2017
5	0	2017	0.1	2017	0.38	2017	0	2017	0.12	2017	0	2017	0	2017	0	2017	0	2017	0	2017	0.39	2017	0	2017
6	0	2017	0.02	2017	0.3	2017	0.06	2017	T	2017	0	2017	0	2017	0	2017	0.05	2017	0	2017	0.02	2017	0	2017
7	0.6	2017	0.72	2017	0.33	2017	0.28	2017	0	2017	0.11	2017	0	2017	0	2017	0.06	2017	T	2017	T	2017	T	2017
8	0.77	2017	0.23	2017	0.11	2017	0.09	2017	0	2017	0.25	2017	0	2017	0	2017	0	2017	0	2017	0.16	2017	T	2017
9	0.85	2017	0.66	2017	0.13	2017	0.16	2017	0	2017	0.12	2017	0	2017	T	2017	0	2017	0	2017	0.65	2017	T	2017
10	0.95	2017	0.14	2017	0	2017	0.05	2017	0	2017	0.25	2017	0	2017	0	2017	0	2017	0.03	2017	0.18	2017	0.01	2017
11	0.08	2017	T	2017	0.01	2017	0.11	2017	0.19	2017	0.02	2017	0	2017	0	2017	0	2017	0.22	2017	0	2017	T	2017
12	0	2017	0	2017	0	2017	0.09	2017	0.12	2017	0.02	2017	0	2017	0	2017	0	2017	0.09	2017	0.05	2017	T	2017
13	0	2017	0	2017	T	2017	0.03	2017	0.24	2017	0	2017	0	2017	T	2017	0	2017	0.01	2017	0.33	2017	0	2017
14	0	2017	0.01	2017	0	2017	0.05	2017	0	2017	T	2017	0	2017	0	2017	T	2017	0	2017	T	2017	0	2017
15	0	2017	0.82	2017	0.18	2017	0	2017	0.08	2017	0.04	2017	0	2017	0	2017	0	2017	0	2017	0.51	2017	0.02	2017
16	0	2017	0.99	2017	0.01	2017	0.2	2017	0.27	2017	0	2017	0	2017	0	2017	0	2017	0	2017	0.16	2017	T	2017
17	0.11	2017	0.09	2017	0.02	2017	0.42	2017	0.01	2017	0	2017	0	2017	0	2017	T	2017	0	2017	0.04	2017	0	2017
18	0.92	2017	0.23	2017	0.42	2017	0.02	2017	0	2017	0	2017	0	2017	0	2017	0.11	2017	0	2017	T	2017	0	2017
19	0.04	2017	0.59	2017	0.02	2017	0.23	2017	0	2017	0	2017	0	2017	0	2017	0.08	2017	0.29	2017	0.01	2017	0.66	2017
20	0.03	2017	0.92	2017	0.18	2017	0.14	2017	0	2017	0	2017	0	2017	0	2017	0.46	2017	0.76	2017	0.23	2017	0.16	2017
21	0.29	2017	0.47	2017	0.26	2017	0	2017	0	2017	0	2017	0	2017	0	2017	T	2017	0.67	2017	0.03	2017	T	2017
22	0.35	2017	0.67	2017	0.08	2017	0.02	2017	0	2017	0	2017	0	2017	0	2017	0	2017	0.77	2017	0.09	2017	0	2017
23	0	2017	T	2017	0.26	2017	0.15	2017	0	2017	0	2017	0	2017	0	2017	0	2017	0	2017	0.32	2017	0	2017
24	0	2017	0.06	2017	0.61	2017	0.21	2017	0	2017	0	2017	0	2017	0	2017	0	2017	0	2017	0.06	2017	T	2017
25	T	2017	0	2017	0.07	2017	0.05	2017	0	2017	0	2017	0	2017	0	2017	0	2017	0	2017	0.02	2017	T	2017
26	0.01	2017	0.56	2017	0.36	2017	0.63	2017	0	2017	0	2017	0	2017	0	2017	0	2017	0	2017	0.29	2017	0.01	2017
27	0	2017	0.04	2017	0.1	2017	0.07	2017	0	2017	0	2017	0	2017	0	2017	0	2017	0	2017	T	2017	0.05	2017
28	0	2017	0.05	2017	0.01	2017	0	2017	0	2017	0	2017	0	2017	0	2017	0	2017	0	2017	0.18	2017	T	2017
29	0	2017	M	M	0.5	2017	0	2017	T	2017	0	2017	0	2017	0	2017	0.16	2017	0	2017	0	2017	0.19	2017
30	0	2017	-	-	0.1	2017	T	2017	0	2017	0	2017	0	2017	0	2017	T	2017	0	2017	0.01	2017	0	2017
31	T	2017	-	-	0	2017	-	-	0	2017	-	-	0	2017	0	2017	-	-	T	2017	-	-	0	2017

Annual Rainfall = 33.03

Appendix N: Observed Precipitation Data Maps from NOAA

10/17/2018 https://water.weather.gov/precip/print.php?product=observed

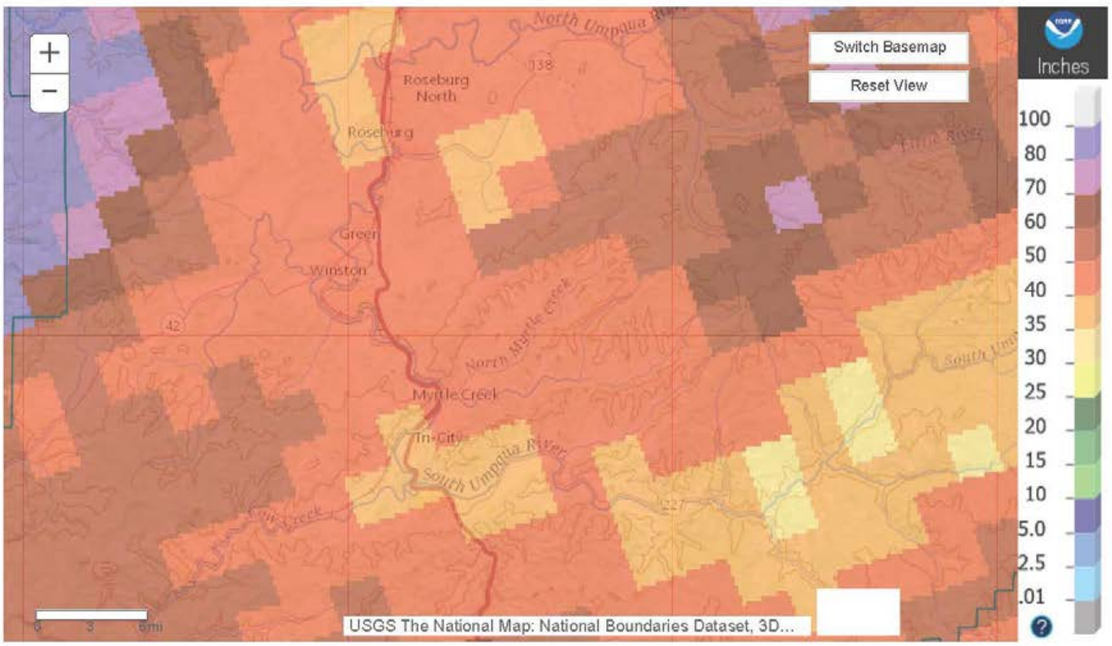
Observed Precipitation



Displaying 2009 Annual Observed Precipitation
Valid on: January 01, 2010 12:00 UTC
What is UTC time? Map Help

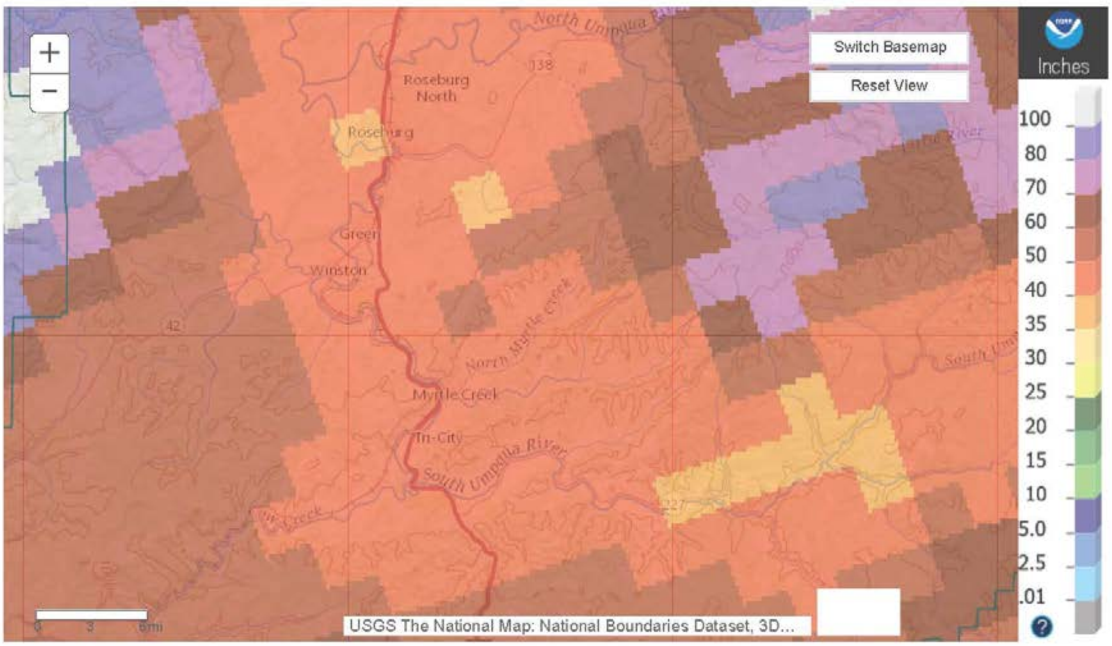
https://water.weather.gov/precip/print.php?product=observed

Observed Precipitation



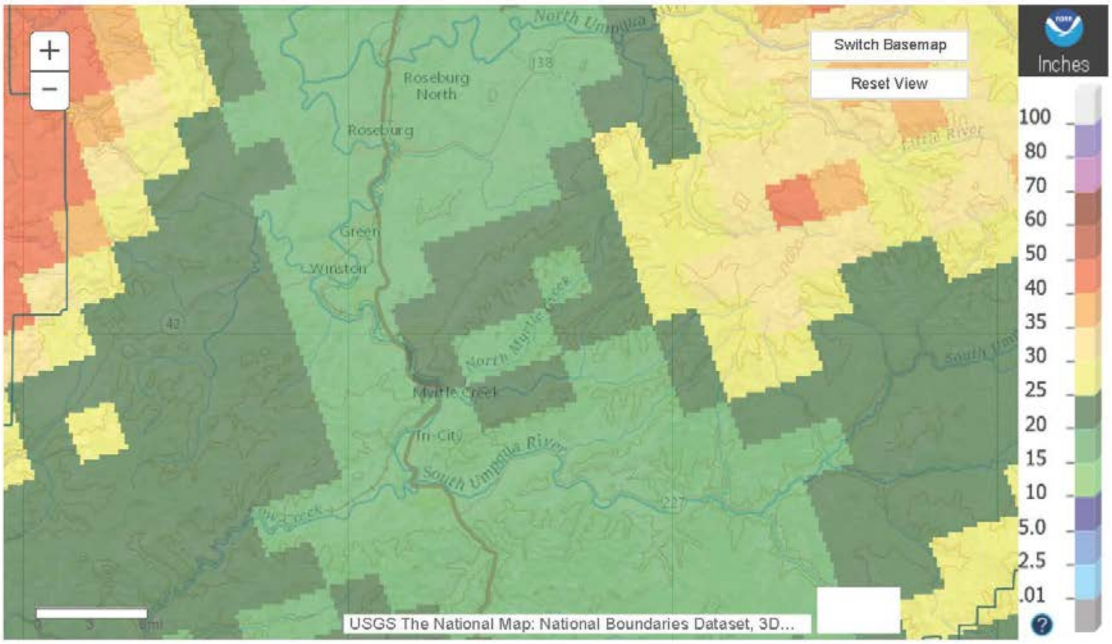
Displaying 2010 Annual Observed Precipitation
Valid on: January 01, 2011 12:00 UTC
What is UTC time? Map Help

Observed Precipitation



Displaying 2012 Annual Observed Precipitation
Valid on: January 01, 2013 12:00 UTC
What is UTC time? Map Help

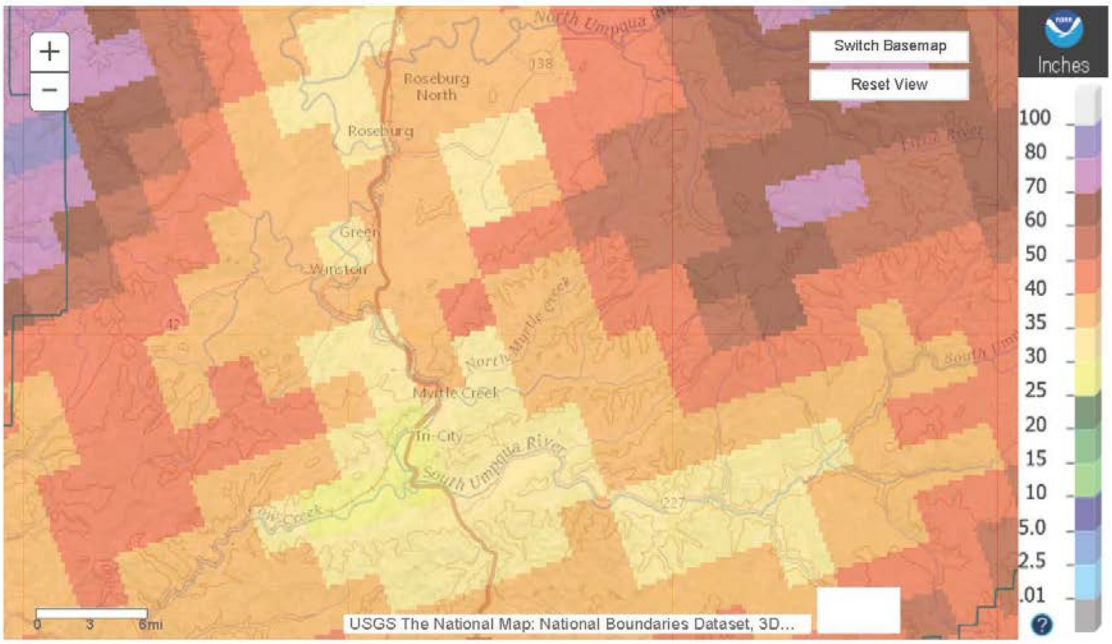
Observed Precipitation



Displaying 2013 Annual Observed Precipitation
Valid on: January 01, 2014 12:00 UTC
What is UTC time? Map Help

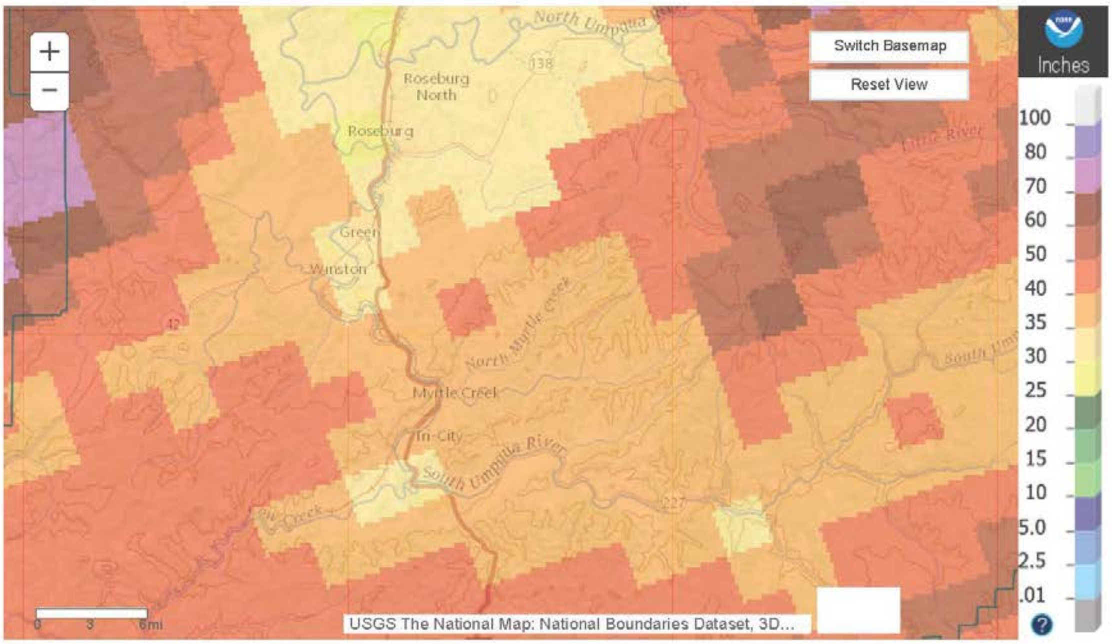
Observed Precipitation

USA.gov



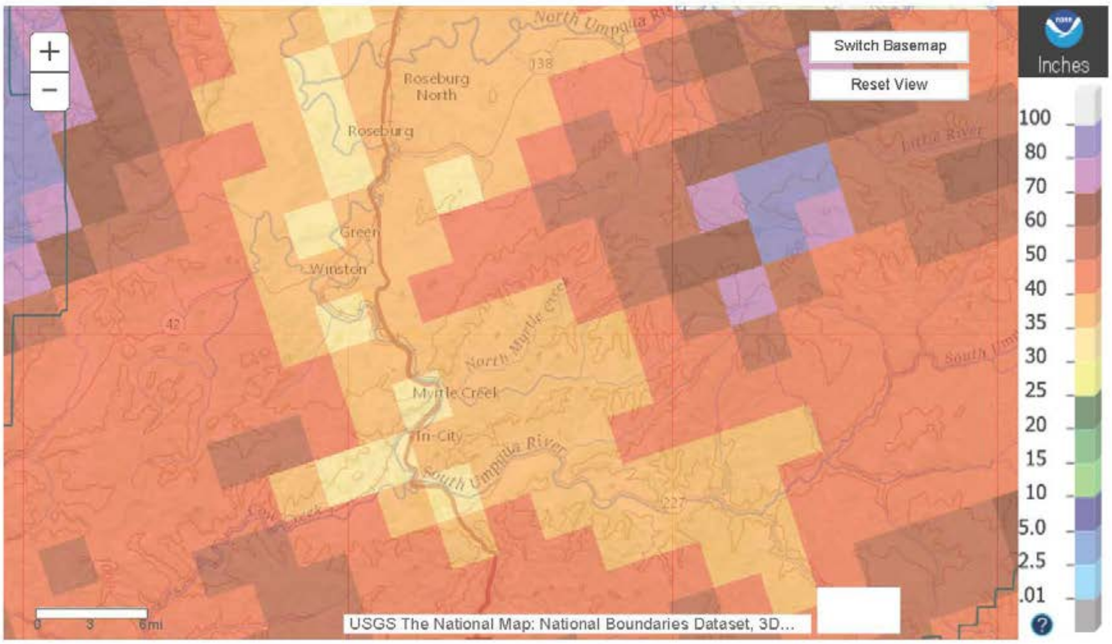
Displaying 2014 Annual Observed Precipitation
Valid on: January 01, 2015 12:00 UTC
What is UTC time? Map Help

Observed Precipitation



Displaying 2015 Annual Observed Precipitation
Valid on: January 01, 2016 12:00 UTC
What is UTC time? Map Help

Observed Precipitation



Displaying 2017 Annual Observed Precipitation
Valid on: January 01, 2018 12:00 UTC
What is UTC time? Map Help