Appendix B

Embro Pond Water Quality Assessment
Updated October 13, 2016

CONTENTS

FIGURES

1 Purpose and Background

Embro Pond is located just north of the community of Embro and is located within the larger Mud Creek subwatershed on the Middle Thames River. The Embro Pond is on the upper portion of the Youngsville Drain and has an upstream drainage area of 665 hectares. The Youngsville Drain is a potential coldwater stream system. The purpose of this study was to initiate monitoring in 2015 to give a general assessment of water quality conditions in the pond and immediately upstream and downstream. This monitoring gives us a snapshot of water quality and is limited to the conditions of 5 sampling occasions from April to October in 2015 with past monitoring from 1986 to 1994 being evaluated as well.

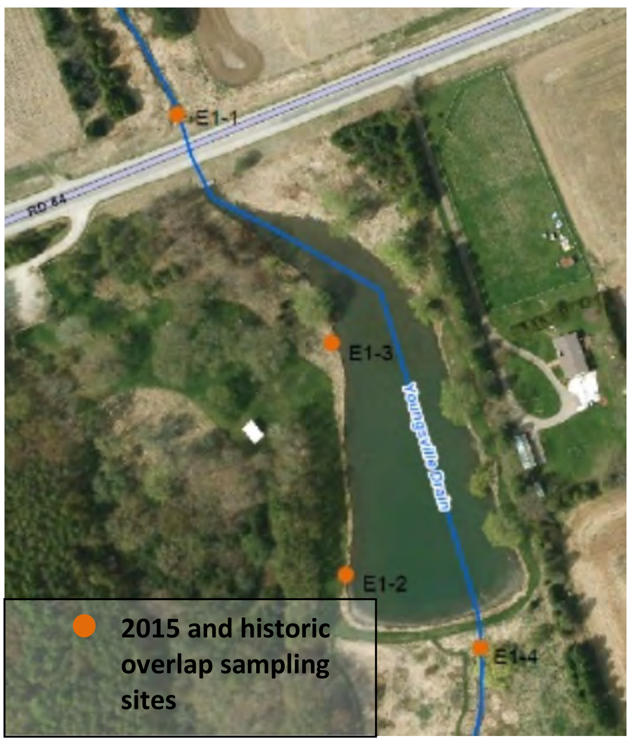


Figure 1 Embro Pond Water Quality Sampling Sites 2015

As part of an evaluation of water quality in Embro Pond, 5 samples were taken in 2015 at 4 locations, one upstream, 2 in pond, and one downstream (see Map 1). Embro Pond was part of a past targeted watershed study and remediation work, with water monitoring occurring from 1986 to 1994. This data was included in the evaluation of the results (see figures in Appendix). Three of the five samples were taken during low flow conditions. The dry conditions in the summer and fall of 2015 resulted in minimal opportunity to monitor runoff conditions. There was some variation in flow based on minimal rain but only one date had rain with full runoff conditions (June 1) and one date had rain with partial runoff conditions (October 9). Samples were analysed at ALS Laboratories in London. Samples were analyzed for Nitrate, Nitrite, Total Kjeldahl Nitrogen, Total Phosphorus, Orthophosphate, *E. coli*, Chloride, and Suspended Solids. Field measurements were taken with a YSI multi-parameter meter for Dissolved Oxygen, pH, Conductivity, and Temperature. Continuous temperature measurements were taken from June 1 to September 23 using a datalogger recording in half hour intervals.

2 Results: Water Chemistry and Bacteria

Results are provided for 7 parameters which are related to land use activities. Pond samples were combined for analysis.

2.1 Temperature

Fate and Behaviour: Water temperature in the river system varies with seasonal changes and also throughout the day, warming in the daytime and cooling in the evening and overnight. Water temperature can have an effect on water quality and the water's ability to hold dissolved oxygen. As water warms, it has a reduced ability to retain oxygen. Optimizing cooler temperatures is desired to maintain oxygen levels and reduce excess algae growth. This can help to support diverse and healthy fish communities.

Sources: Water temperatures can be cooled by groundwater inputs, stream shading, and natural deeper channel flow. Water temperatures can be warmed by widened channelized streams, ponding, and reduced shading and tree cover.

Standards: There is no standard for temperature but the Ministry of Environment and Climate Change states that the natural thermal regime of any body of water shall not be altered so as to impair the quality of the natural environment. In particular, the diversity, distribution and abundance of plant and animal life shall not be significantly changed.

Monitoring Results:

- Stream temperature data for June, July and August 2015 were taken during periods in which monthly air temperature averages were similar to historical monthly air temperature averages (ref. Environment Canada - London Airport) . The September 2015 air temperature average was higher than historical September air temperature averages, which may have kept the water temperature higher than normal.

- The temperatures upstream are consistently cooler than downstream temperatures indicating the pond has a warming effect.

- The difference in temperature from upstream to downstream ranges from 0 to over 7C, with an average difference of 2.5C change.

- For both upstream and downstream, the stream temperature shows a diurnal pattern with daytime highs and nighttime lows but upstream has a wider range of diurnal temperatures with approximately 6C change from day time highs to night time lows. The downstream temperatures remained warmer with less diurnal change of 2-3C, and with the range becoming smaller as the summer progressed likely as a result of the pond holding the heat through the night.

- The historic monitoring from 1986 to 1994 shows a similar pattern where upstream temperatures are cooler than the pond and downstream temperatures. Historic monitoring shows variation which can be related to cooler or warmer temperatures and the months in which the sampling took place.

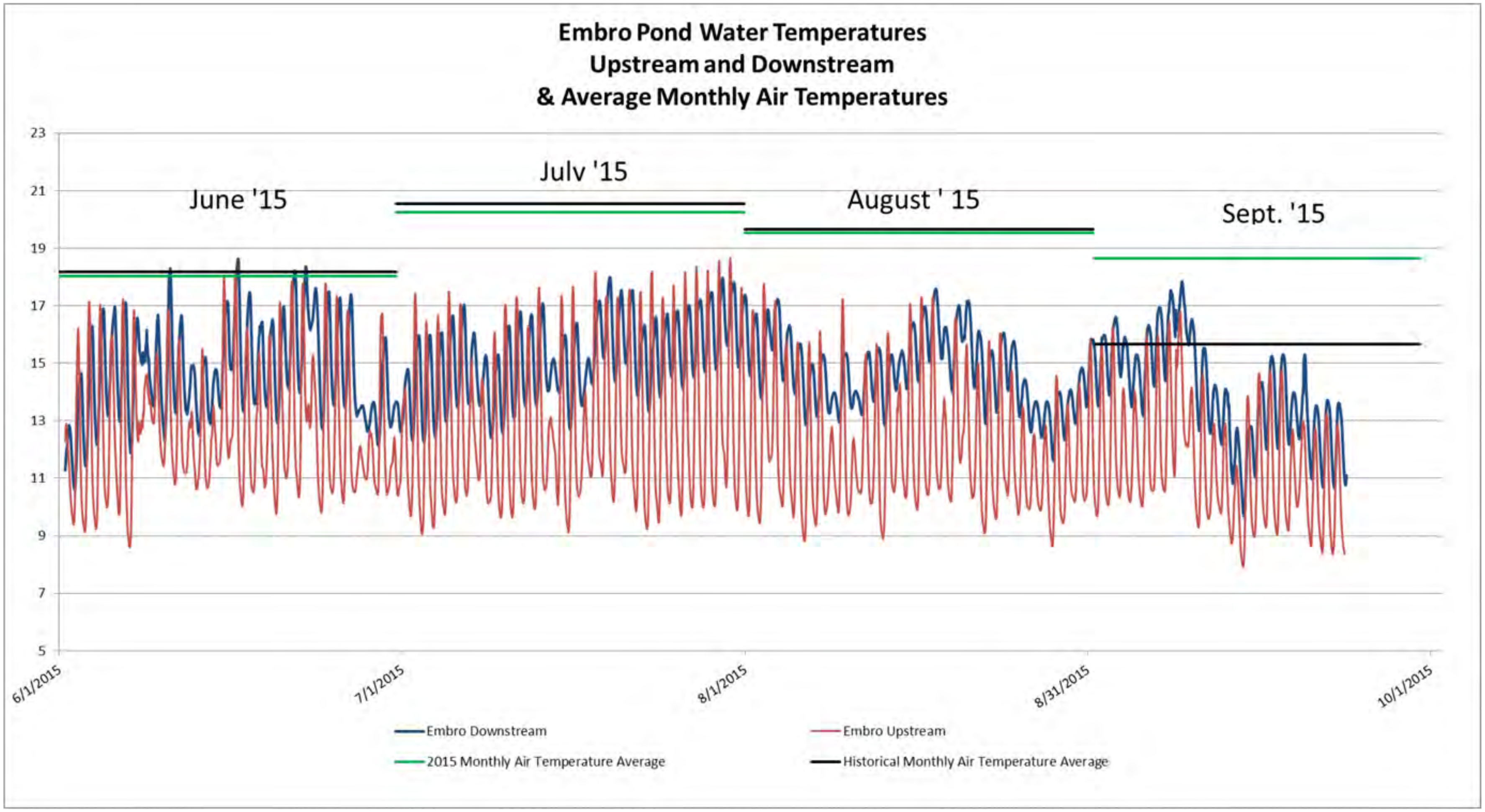
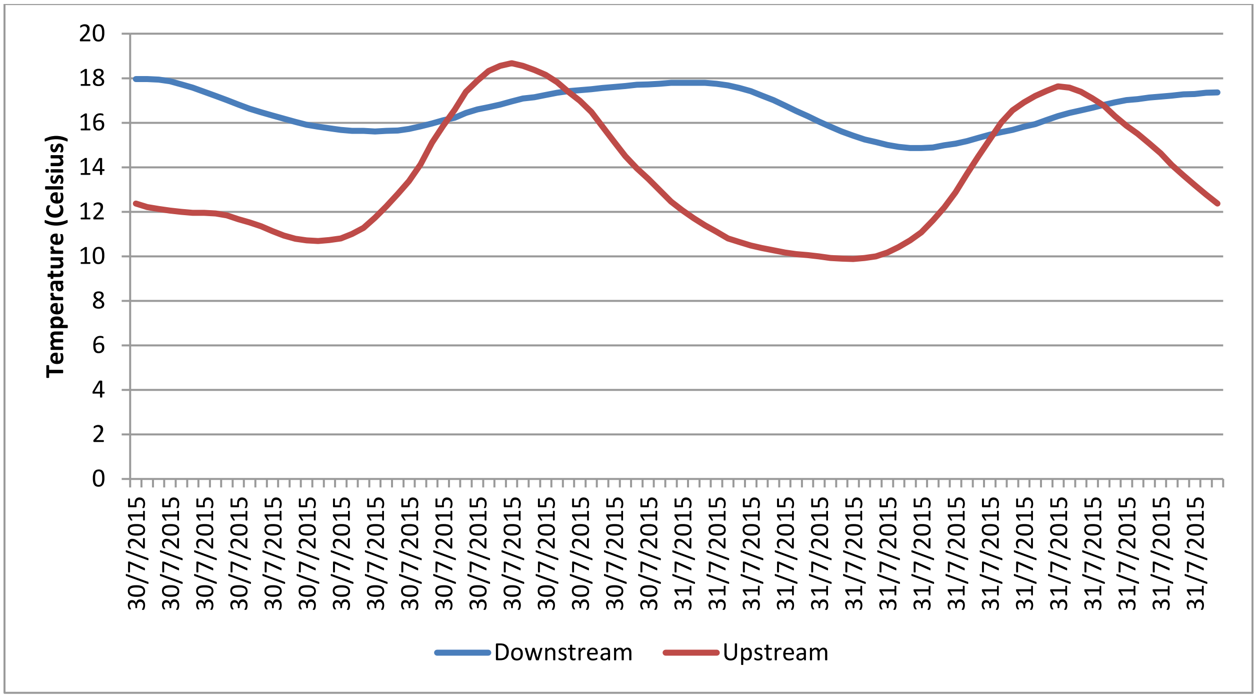


Figure 2 Embro Dam Temperature Upstream and Downstream

Figure 3 Embro Pond Temperature July 30 - 31, 2015



2.2 E. coli Bacteria

Fate and behavior: *Escherichia coli* (*E. coli*) are a type of fecal bacteria found in human and animal waste. Their presence in water indicates fecal contamination. *E. coli* are a strong indicator for the presence of other pathogens found in human and animal waste.

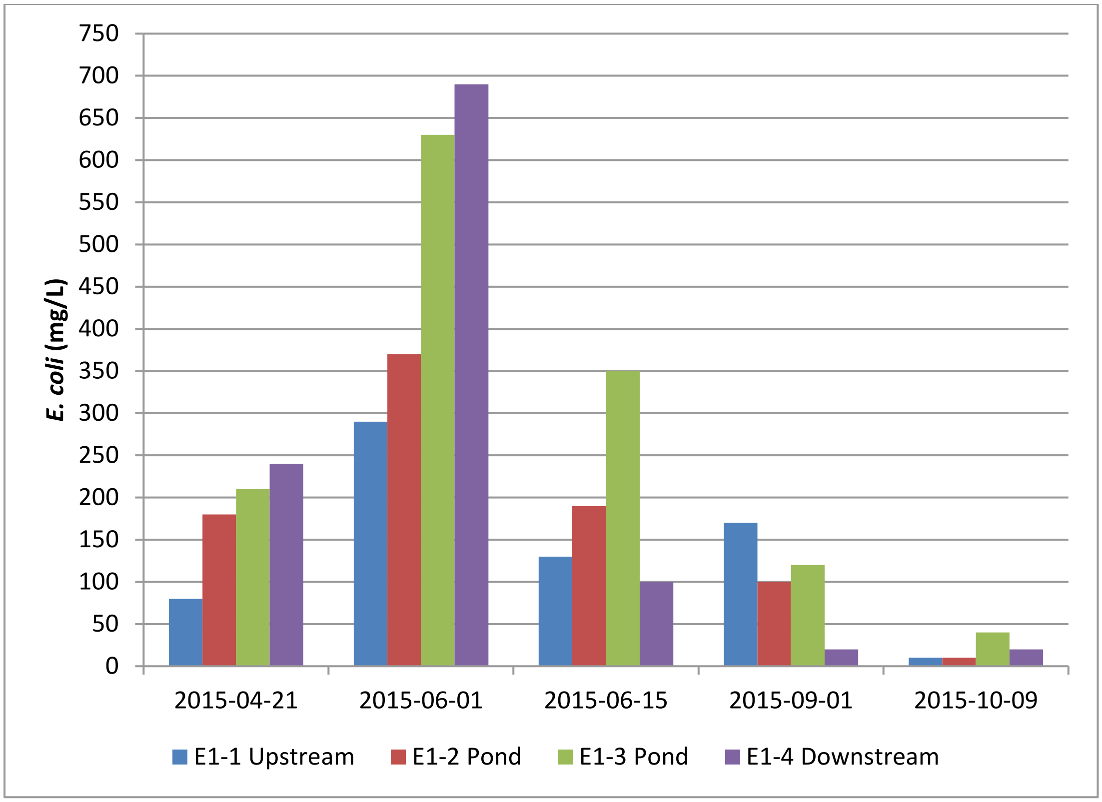
Sources: Potential sources of fecal bacteria include upstream runoff from biosolids/sewage, livestock or wildlife waste, faulty private septic systems, and other stormwater runoff.

Standards: The Provincial Water Quality Objective (PWQO) for recreational waters is 100 E. coli/100 mL. This guideline is used as a target for comparison, recognizing that Embro Pond is not monitored as recreational water.

Monitoring Results:

- Concentrations of *E. coli* bacteria are similar to *E. coli* levels in area streams with fairly low numbers at three of the 5 sampling dates.
- The June 1 rain event shows higher *E. coli* levels as expected.
- 2015 upstream *E. coli* levels are fairly comparable to historic data and lower than many of the years. 2015 pond and downstream data is slightly higher than most of the historic data.

Figure 4 2015 E. Coli



2.3 Total Phosphorus and Orthophosphate

Fate and Behavior: Phosphorus is not directly toxic to aquatic life, but elevated concentrations can lead to undesirable changes in a watercourse including excess plant growth, reduced oxygen levels, reduced biodiversity, and harmful algae. Orthophosphate, which is a form of phosphorus most biologically available to plants, was also measured.

Sources: Phosphorus sources can include commercial fertilizers, animal waste, and domestic and industrial wastewater including soaps and cleaning products. Phosphorus binds to soil and is readily transported to streams with eroding soil.

Standards: Ontario has an interim Provincial Water Quality Objective (PWQO) of 30 *u*g/L of total phosphorus to prevent the nuisance growth of algae.

Monitoring Results:

- For most dates and locations in 2015, concentrations of total phosphorus were low and close to the Provincial Objective. Two dates (April 21 and September 1) for one of the pond sites had quite high phosphorus levels with no obvious explanation.
- Historic and 2015 upstream phosphorus levels are low with the majority of the data close to objective levels. Historic median levels of phosphorus improved from 1986 to 1994 in the pond and remain at similar levels in 2015. Historic downstream levels have been higher than upstream and pond levels.
- Orthophosphate levels are also low with some samples below the detection limit for 2015. Only the June 1st rain event showed higher orthophosphate levels as expected. The lowest numbers are in the mid to late summer and early fall when plant uptake of this more biologically available form of phosphorus is at its peak.
- Historic and 2015 upstream orthophosphate levels are low with the majority of the data close to objective levels. Historic median levels of orthophosphate improved from 1986 to 1994 in the pond and remain at similar levels in 2015. Historic downstream levels have been higher than upstream levels.

Figure 5   2015 Total Phosphorus

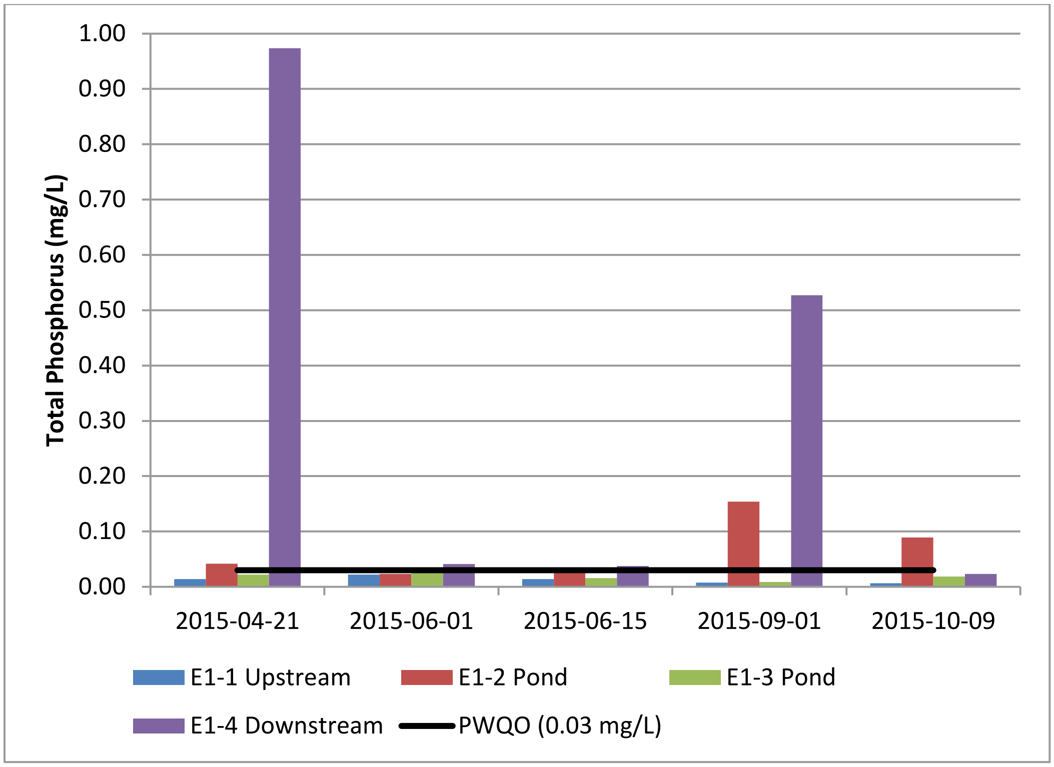
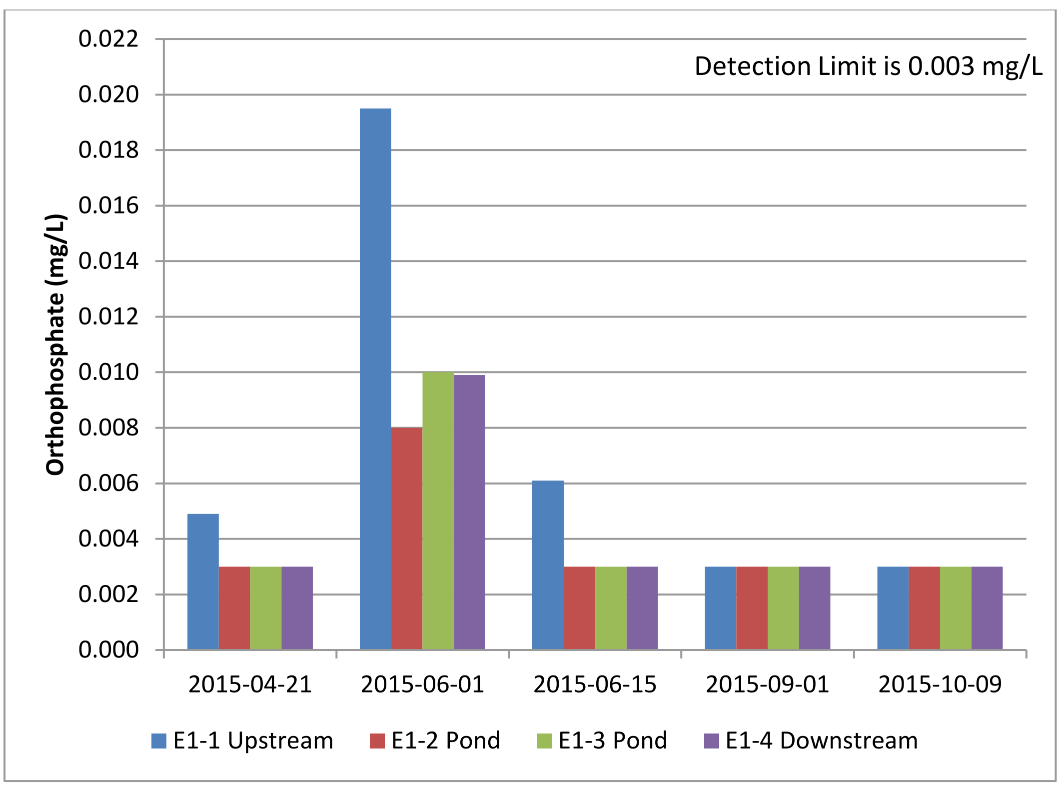


Figure 6   2015 Orthophosphate



2.4 Nitrate

Fate and Behaviour: Nitrate is a nutrient that does not adsorb to sediment and moves readily through surface runoff to streams and through soil into groundwater. Elevated levels in a watercourse can be toxic to aquatic organisms, especially amphibians.

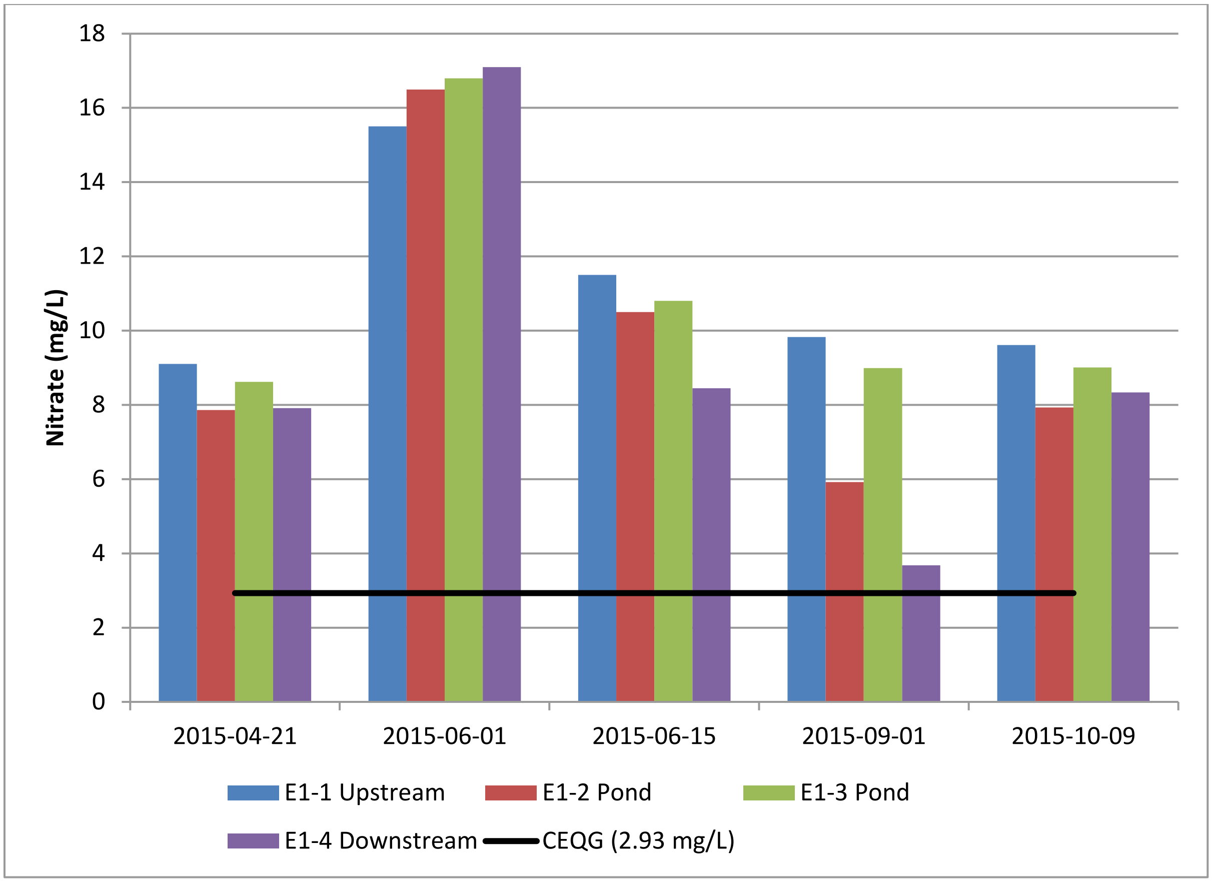
Sources: Nitrate sources can include sewage/animal waste, commercial fertilizers, septic systems, atmospheric deposition and natural decomposition of organic wastes.

Standards: Ontario does not have a Provincial Water Quality Objective for aquatic life but the Canadian Environmental Quality Guideline (CEQG) to protect aquatic life from direct toxicity to nitrate is 2.93 mg/L.

Monitoring Results:

- For 2015 the nitrate levels are consistently above the aquatic life guideline and in range similar to the Middle Thames watershed which is somewhat higher than other Upper Thames streams.
- Nitrates were higher during the rain event sample in 2015 which is to be expected for a water soluble nutrient.
- Historic data was consistently above aquatic guidelines and in a similar range to 2015 nitrate levels.

Figure 7 2015 Nitrate



2.5 Chloride

Fate and Behaviour: Chloride moves easily with water and persists in the river system. Nearly all chloride added to the environment will eventually migrate to surface water or groundwater. Chloride can be toxic to aquatic organisms at high concentrations, and affects growth and reproduction at lower concentrations.

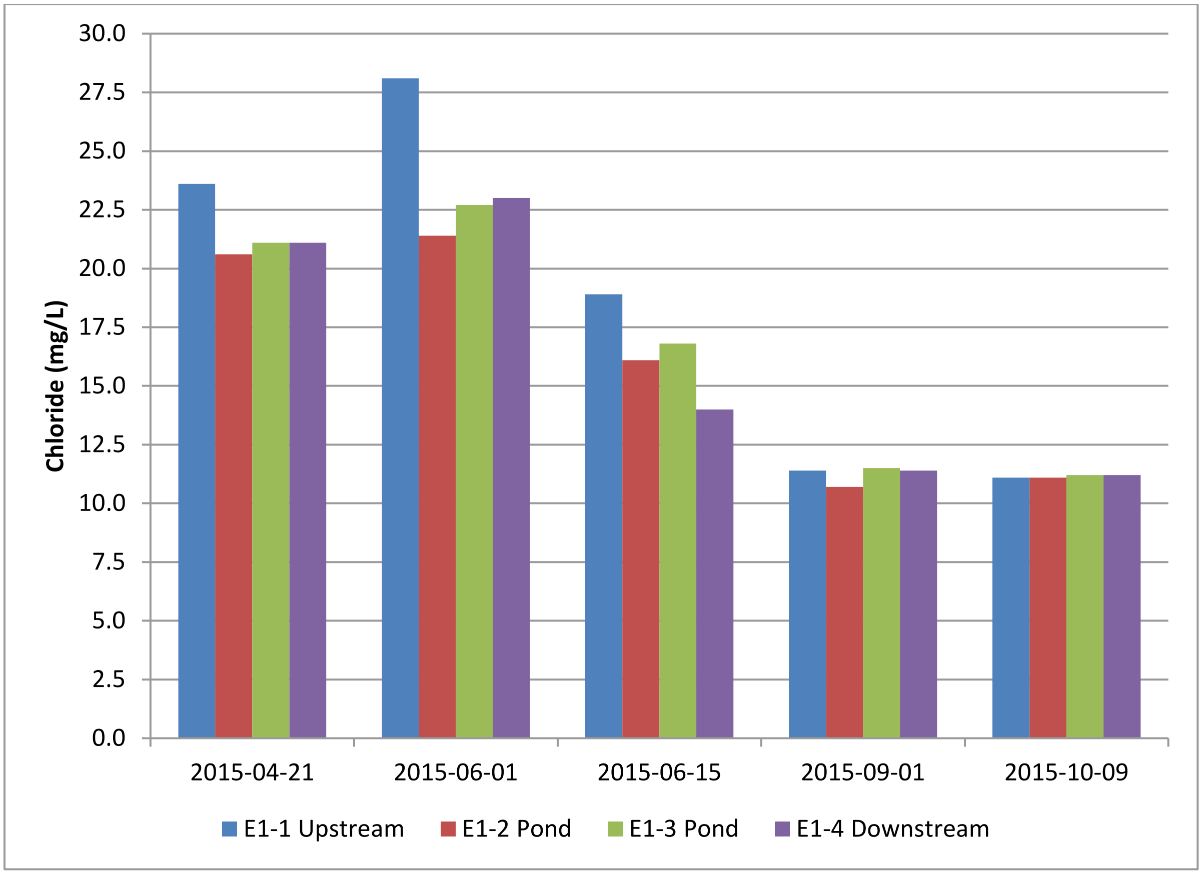
Sources: The highest loadings of chloride are typically associated with the application and storage of road salt (e.g., calcium chloride). Urban streams tend to have the highest chloride concentrations.

Standards: Ontario does not have a Provincial Water Quality Objective for aquatic life.
A Canadian Environmental Quality Guideline (CEQG) for the long-term exposure of toxicity for sensitive aquatic species is 120 mg/L.

Monitoring Results:

- All samples are well below the guideline for chloride for both 2015 and historic samples and fall within a similar range.
- April to June had somewhat higher levels than samples later in the season but still very low compared to the guideline.
- The timing of sampling for this study did not provide data for winter or early spring runoff when chloride levels would be expected to be higher as a result of road salt runoff.

Figure 8 2015 Chloride



2.6 Suspended Solids

Fate and Behaviour: Suspended solids consist of silt, clay, and fine particles of organic and inorganic matter. These particles can be carriers of phosphorus, metals, and other contaminants. Suspended solids can be detrimental to aquatic organisms including fish.

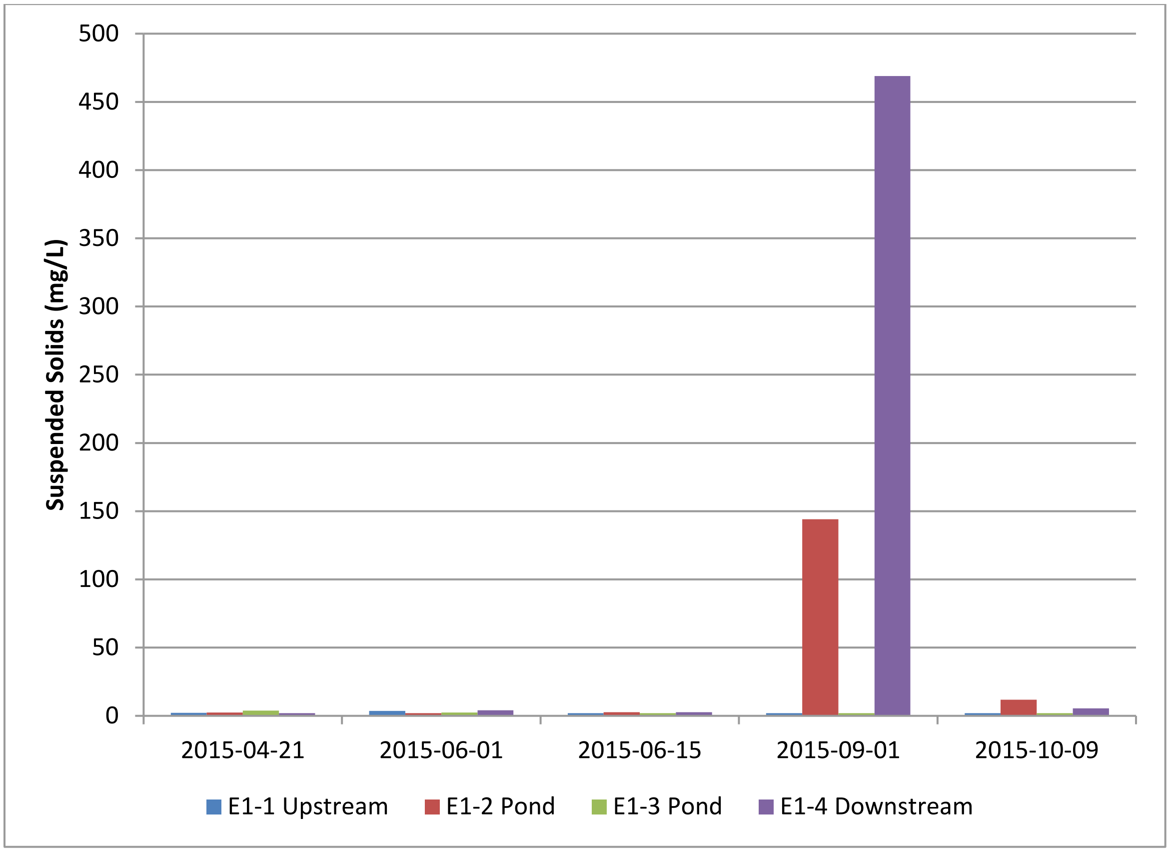
Sources: Soil erosion is the most common source of suspended solids to a watercourse. This can be from cultivated land, construction, development, eroded stream banks or natural erosion of stream beds.

Standards: There is no established standard for suspended solids. However, turbid water is undesirable for healthy aquatic life, recreation, and aesthetics.

Monitoring Results:

- Suspended solid levels are fairly low and similar to other sites across the Upper Thames watershed.
- For most dates and locations in 2015, concentrations of suspended solids were low with the exception of September 1st for the two pond locations had quite high suspended solids levels with no obvious explanation. The phosphorus levels were also high for these sites on this date.
- Historic and 2015 suspended solids levels were all typically below 30 mg/L with median levels between 10 to 15 mg/L.

Figure 9 2015 Suspended Solids



2.7 Dissolved Oxygen

Dissolved oxygen is important for fish and other aquatic life. Dissolved oxygen levels below 4 mg/L can have an adverse effect on fish communities. Cooler water temperatures help to retain dissolved oxygen in water. Water flowing through natural stream channels with rock/riffles improves oxygen levels. Stagnant areas and decaying vegetation reduce oxygen levels.

Results: Spot field measurements were taken for dissolved oxygen using the YSI meter. This limited data gives a general indication of oxygen conditions at the time of sampling recognizing dissolved oxygen levels vary throughout the day. Readings upstream and downstream were similar and showed good oxygen levels, ranging from 7mg/l to 12 mg/l. The pond also had good readings with a range of 8 to 15 mg/L except September 1 when the readings were 1 mg/L and 5mg/L. This could be due to warm temperatures and vegetation die-off.

2.8 Metals

A suite of metals, including copper, lead, zinc and iron was tested in each sample as part of standard laboratory tests on two sample dates (April 21 and June 1). Metals are long lasting in the environment where they tend to accumulate in streambed sediments. Metals can bio-accumulate in fish and wildlife and can be toxic to aquatic life at elevated levels. Metals tend to be low in non-urban areas and are typically very low across the Upper Thames watershed.

Results: All sample results on both dates showed very low to non-existent metals in the samples. Only one pond site on April 21st had levels of iron just above the Provincial objective for aquatic life.

3 Discussion

- In general, the water quality in the Youngsville Drain where it was sampled upstream, downstream and in Embro Pond showed levels typical of the Middle Thames watershed and other Upper Thames streams for 2015. The headwaters of this area include some healthy riparian areas with groundwater discharge creating this potential coldwater stream.

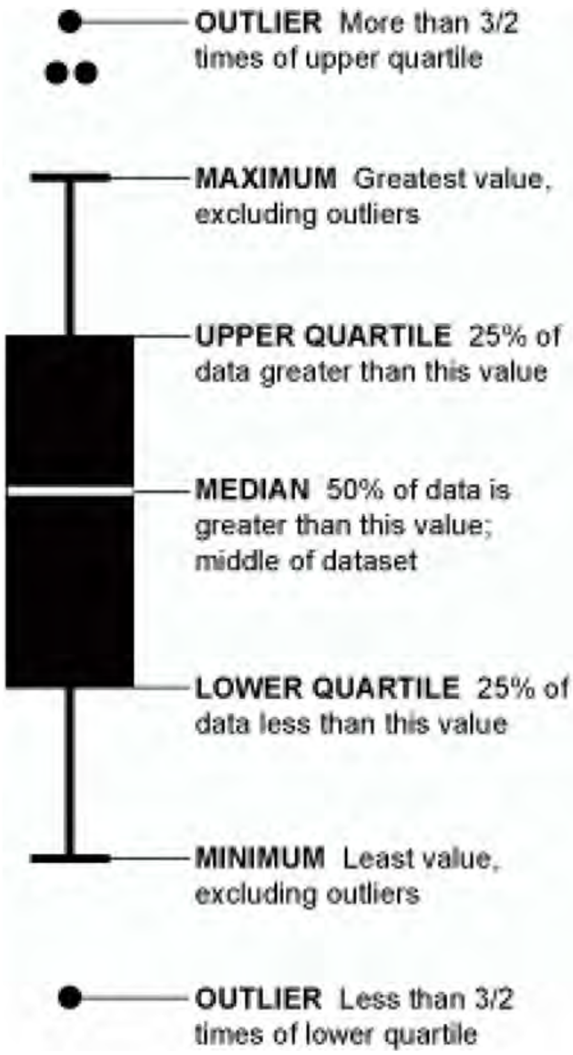
- Most parameters showed similar results to the historic data with *E. coli* showing some improvement. Most parameters had relatively low levels with the exception of nitrate which was consistently above the guideline both historically and in 2015.

- Temperature differences are apparent between upstream and downstream of the pond based on continuous measurements and show a greater difference as the summer progressed, likely as a result of the warming effect of the pond.

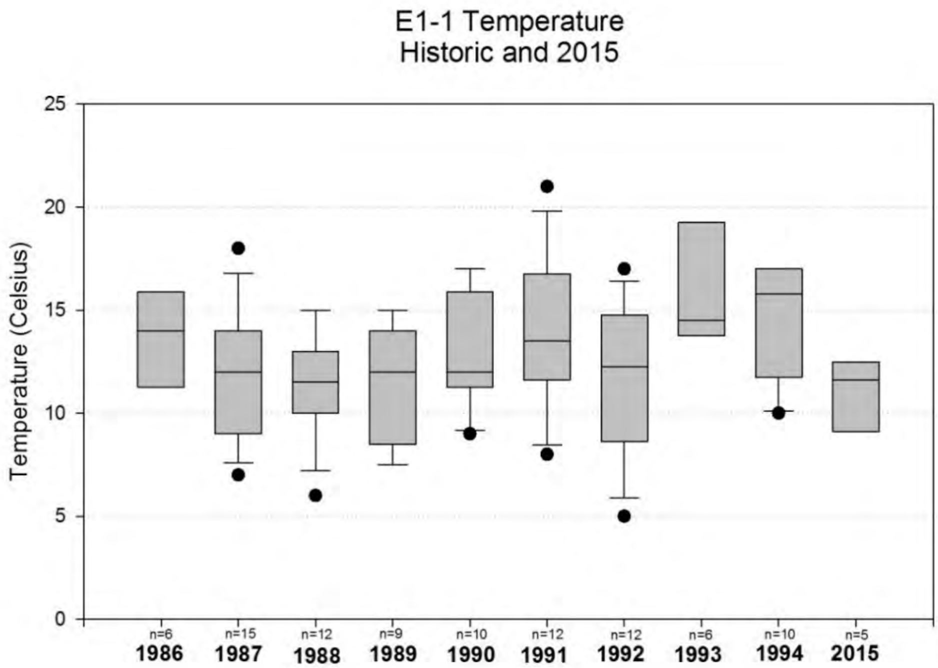
- Ponds can act as a settling basin for sediment and associated contaminants such as phosphorus, and these can accumulate in the bottom sediments. These contaminants can be resuspended when disturbed such as during more extreme flow conditions. Sampling of the bottom sediments would give an indication of any accumulation.

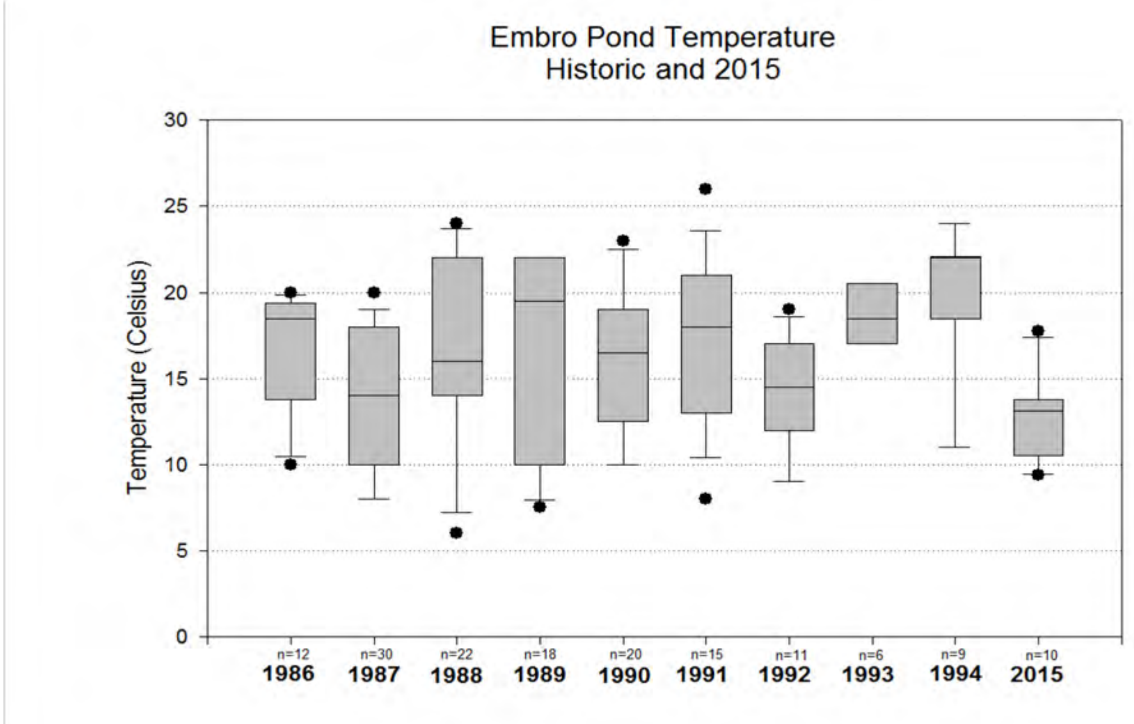
4 Appendix: Historical and 2015 Boxplots

How to Read a Boxplot

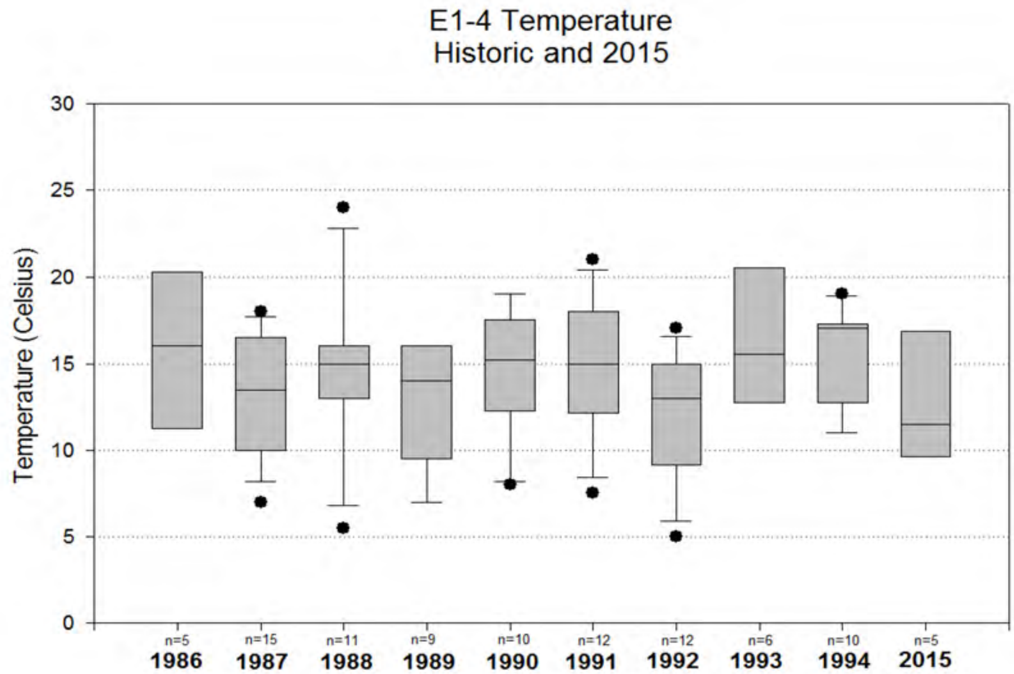


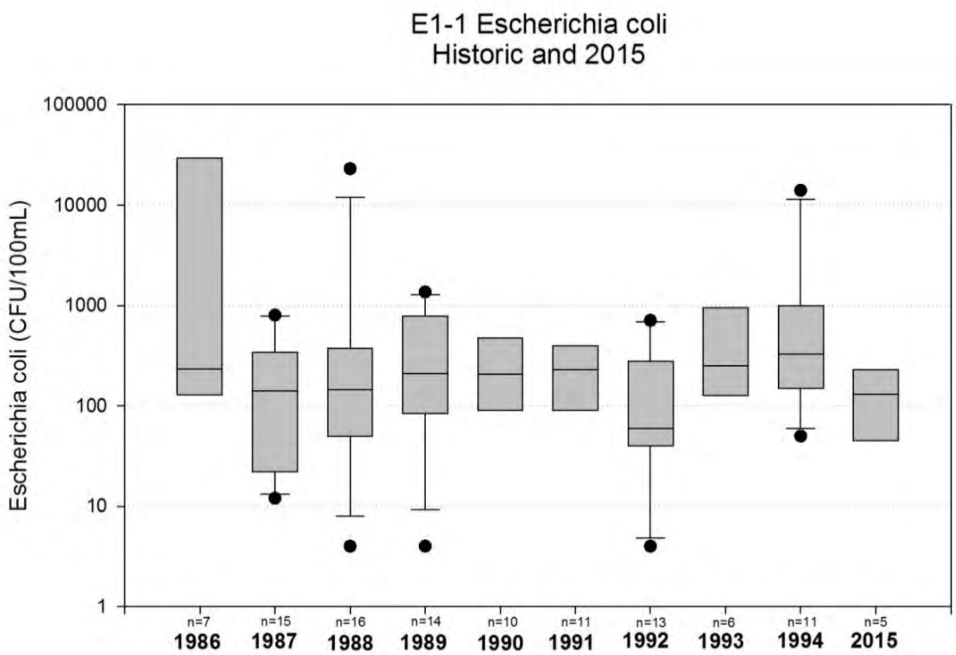
5 Temperature



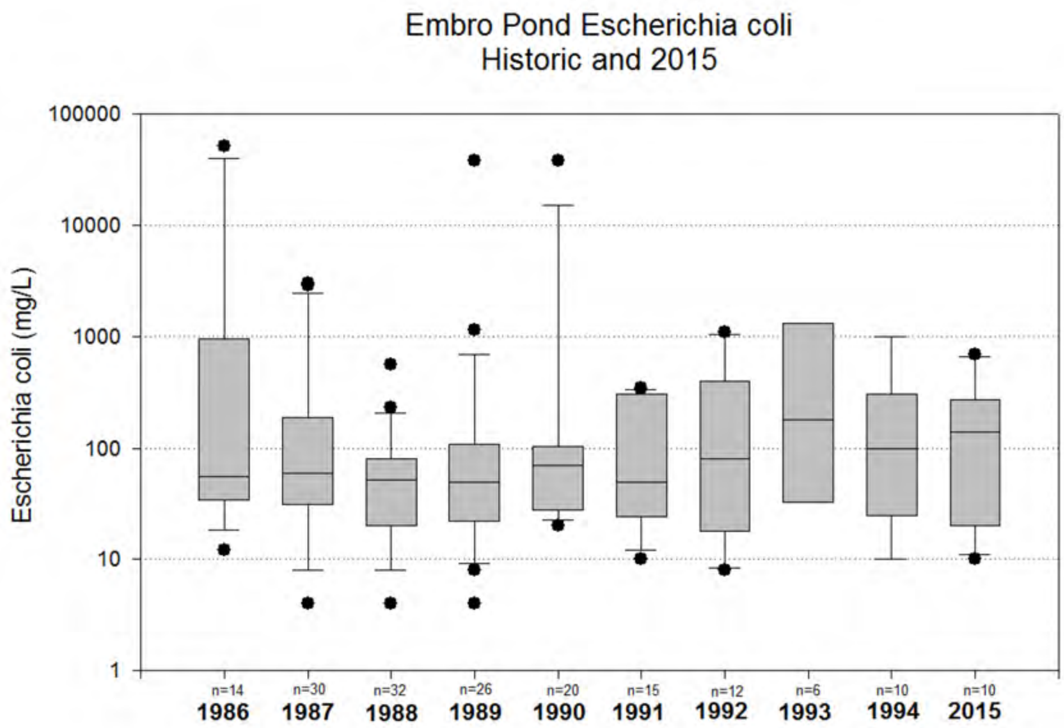


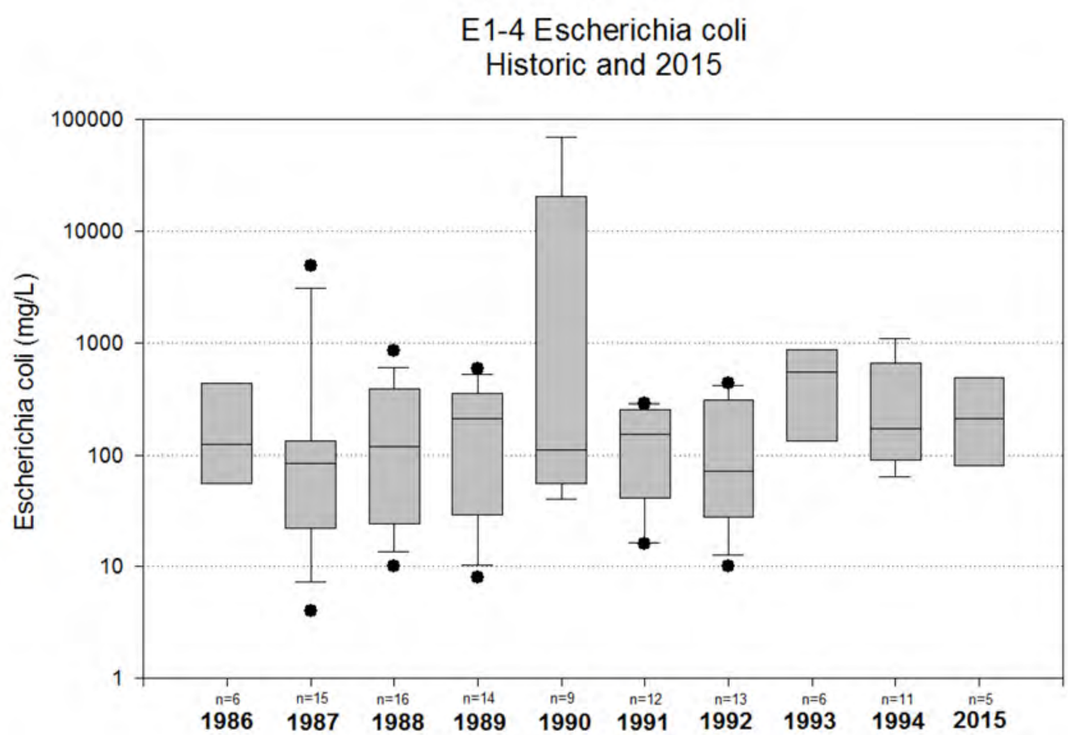
6 E. Coli



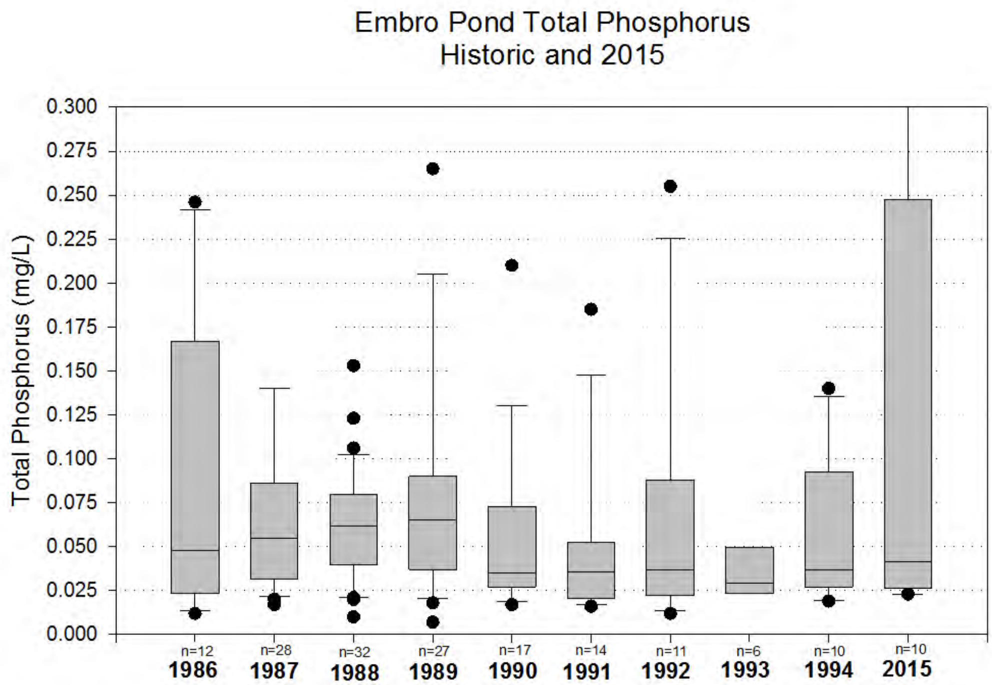


E. Coli

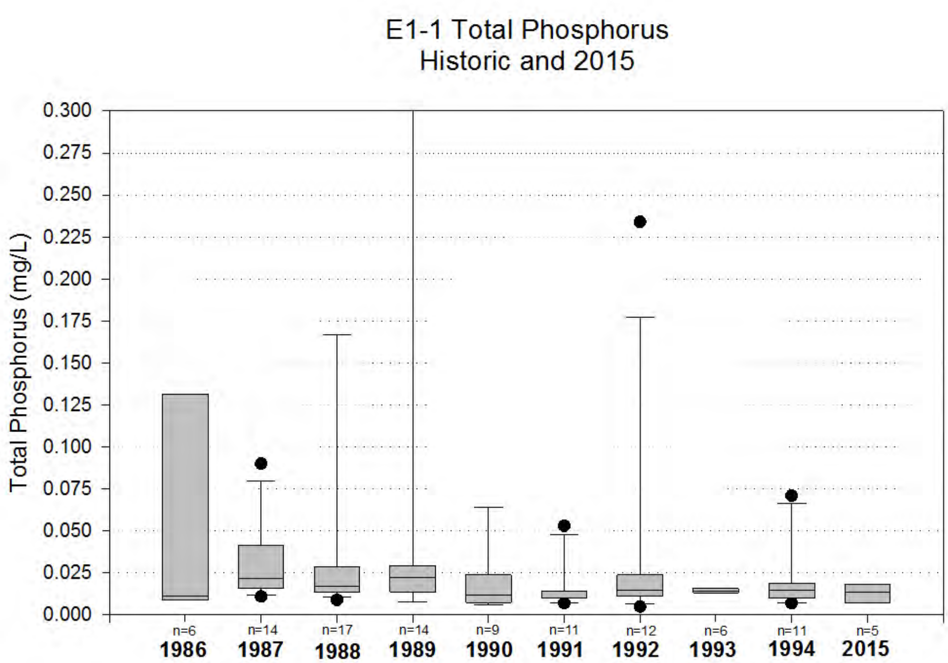

Embro Pond Escherichia coli
Historic and 2015
Escherichia coli (mg/L)
100000
10000
1000
100
10
1
n=14
n=30
n=32
n=26
n=20
n=15
n=12
n=6
n=10
n=10
1986
1987
1988
1989
1990
1991
1992
1993
1994
2015

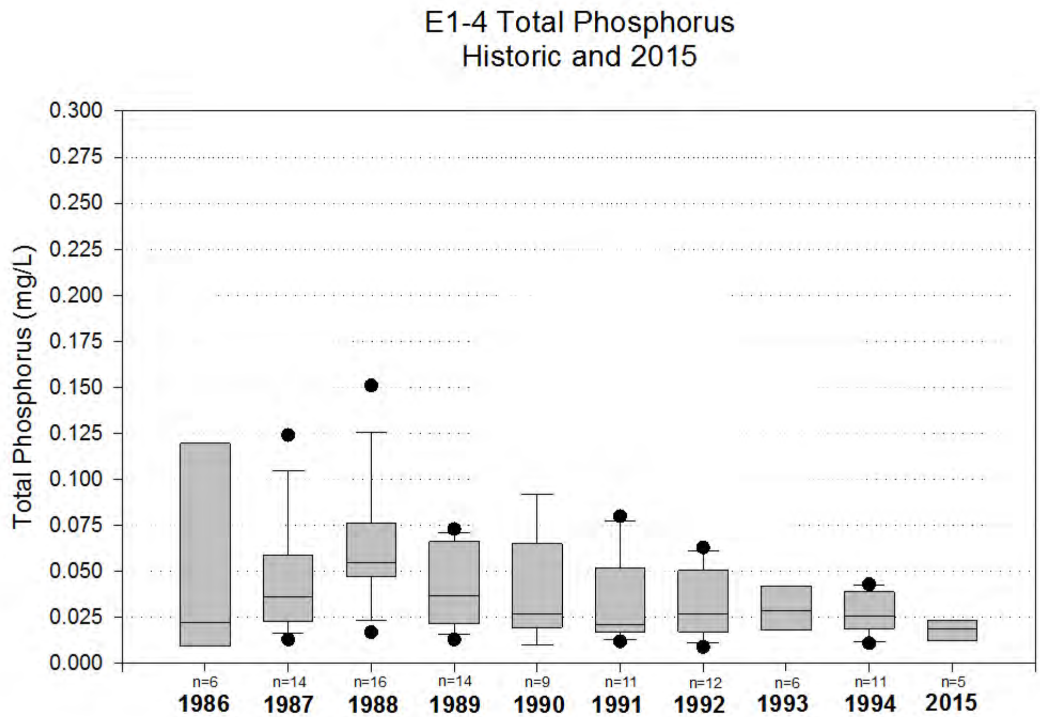

E1-4 Escherichia coli
Historic and 2015
Escherichia coli (mg/L)
100000
10000
1000
100
10
1
n=6
n=15
n=16
n=14
n=9
n=12
n=13
n=6
n=11
n=5
1986
1987
1988
1989
1990
1991
1992
1993
1994
2015

7 Total Phosphorus



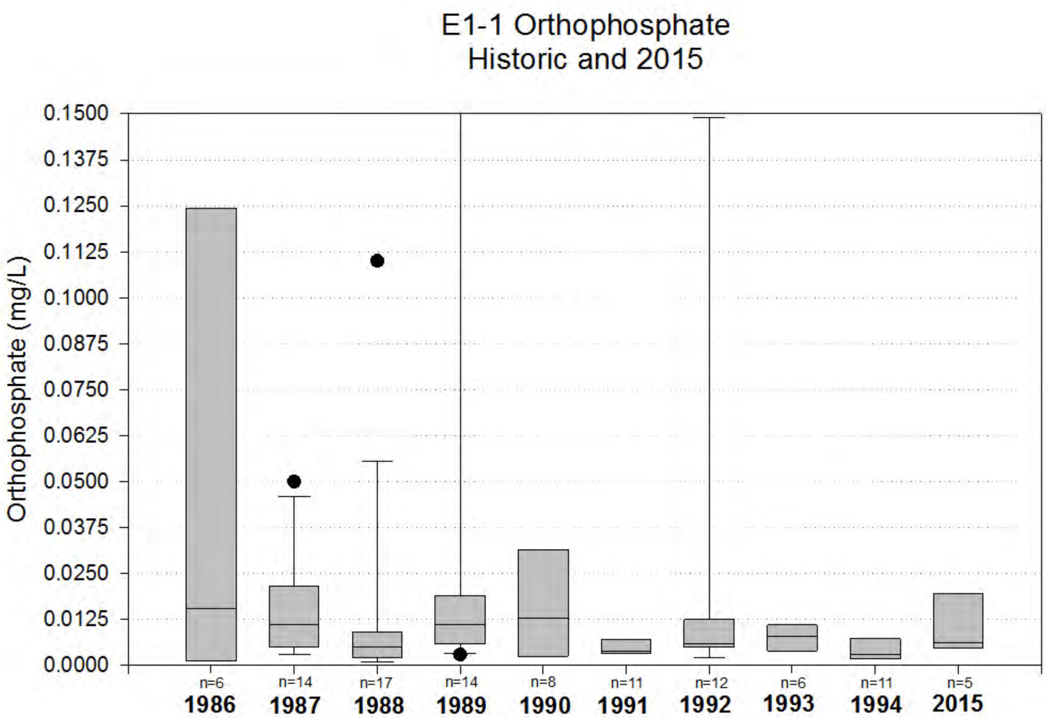
The scales of these graphs were adjusted according to the majority of the data for better visual comparison of results and several outliers are not shown on these graphs.

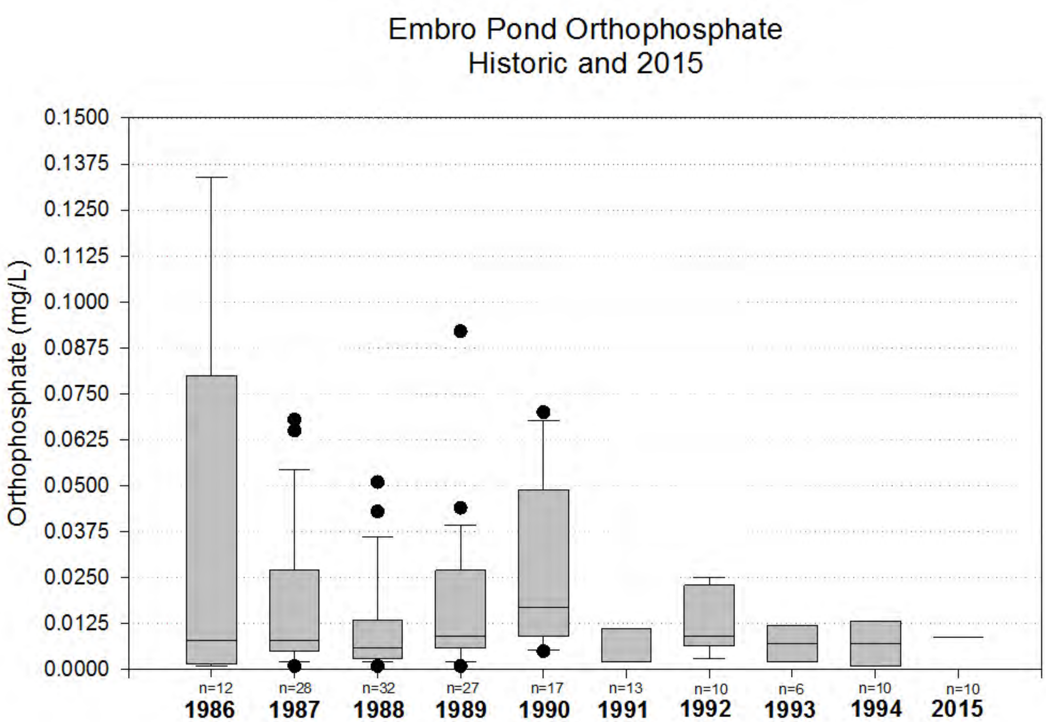


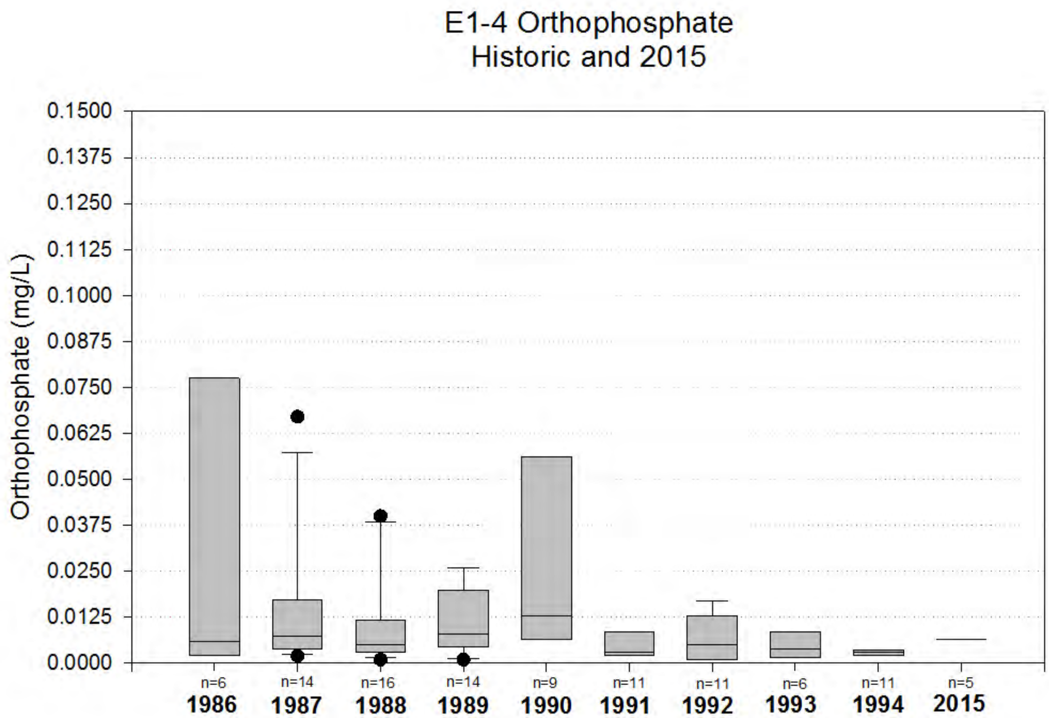

E1-4 Total Phosphorus
Historic and 2015
Total Phosphorus (mg/L)
0.300
0.275
0.250
0.225
0.200
0.175
0.150
0.125
0.100
0.075
0.050
0.025
0.000
n=6
1986
n=14
1987
n=16
1988
n=14
1989
n=9
1990
n=11
1991
n=12
1992
n=6
1993
n=11
1994
n=5
2015

8 Orthophosphate

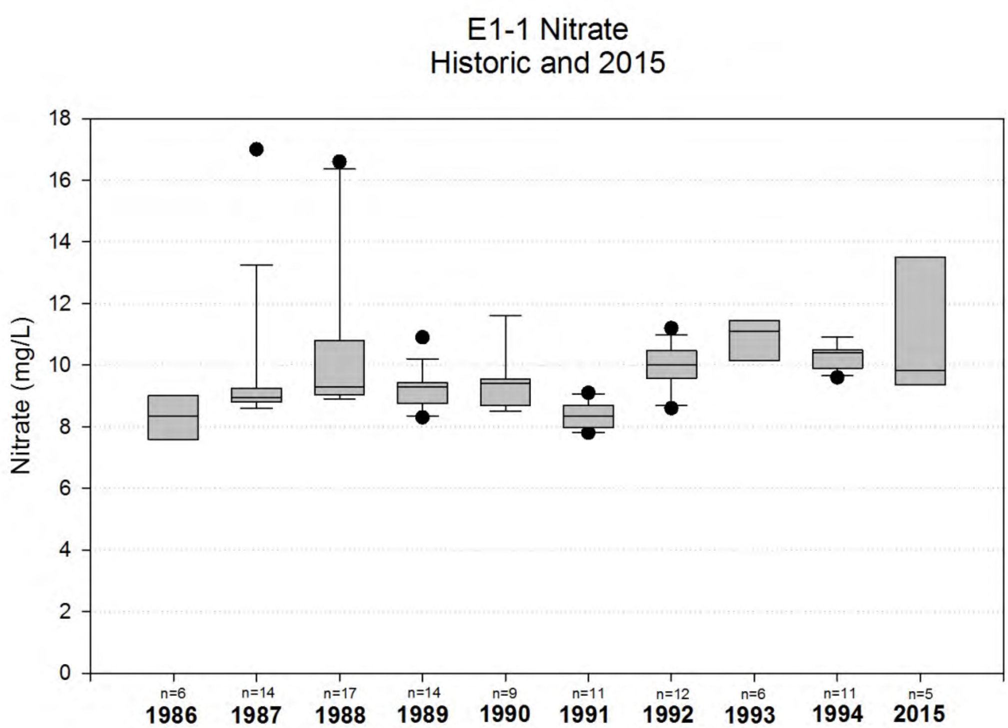
The scale of this graph was adjusted according to the majority of the data for better visual comparison of results and several outliers are not shown on the graph.

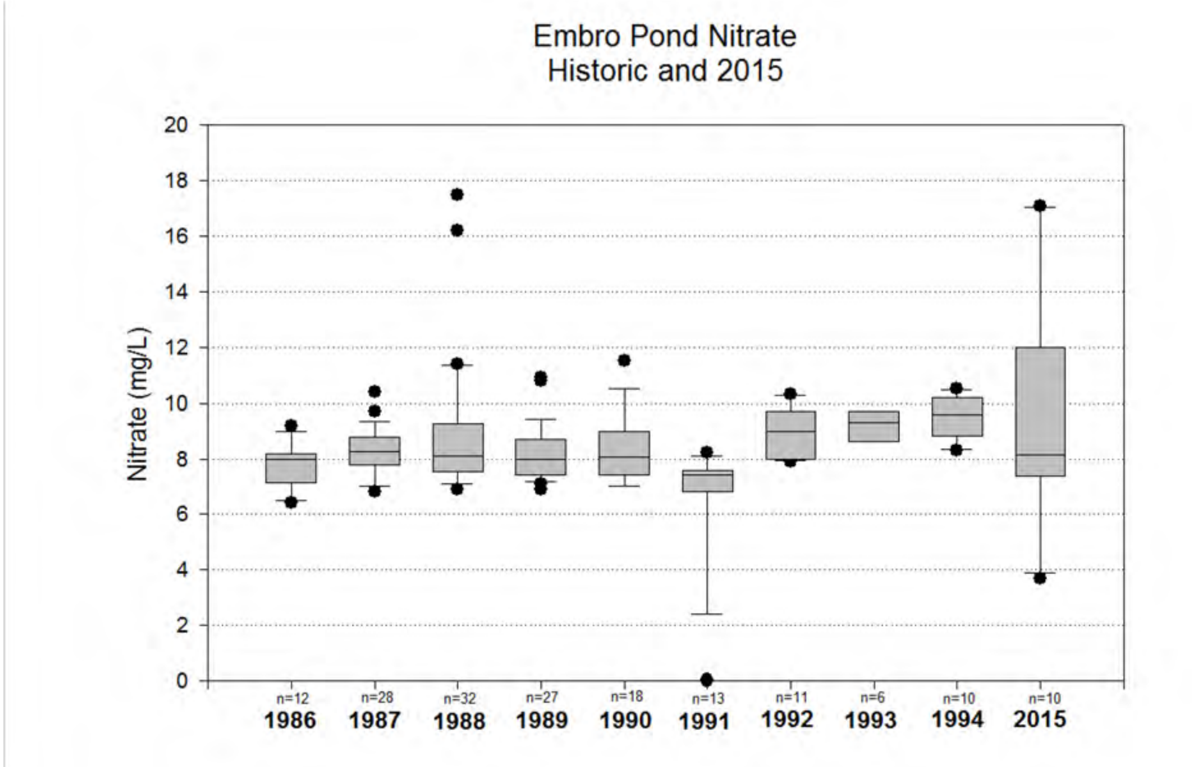


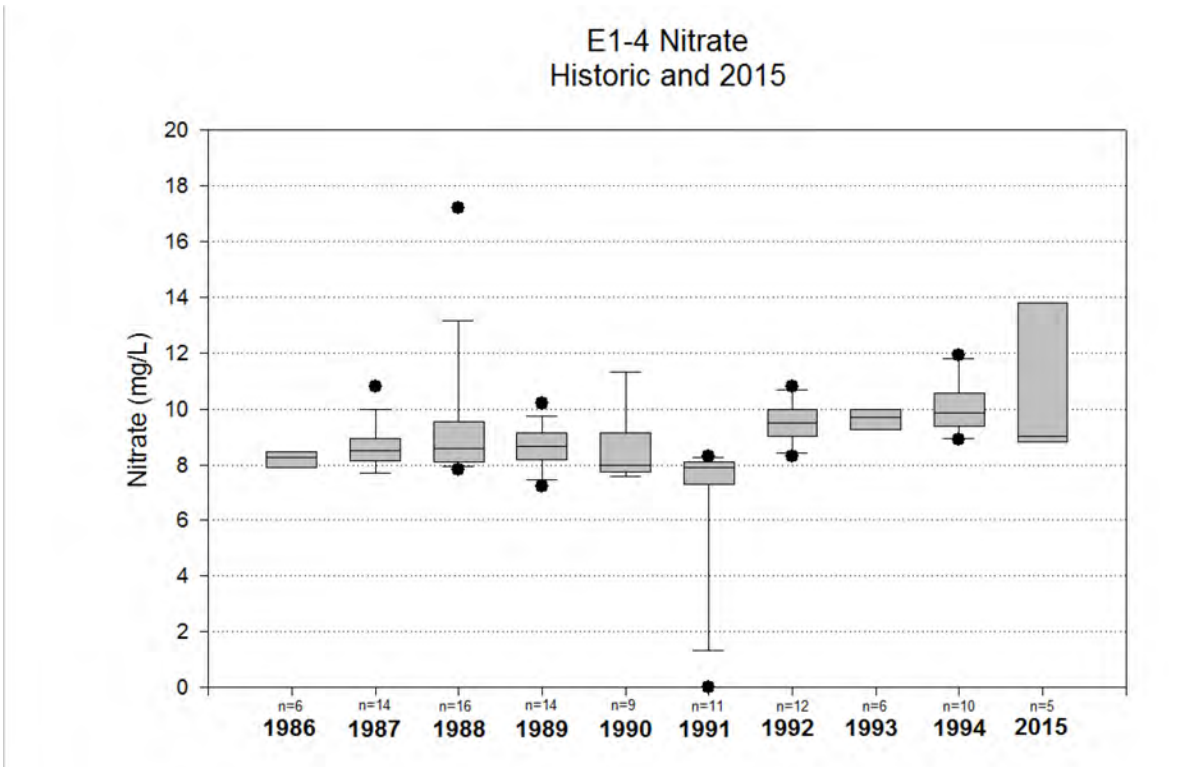



E1-4 Orthophosphate
Historic and 2015
Orthophosphate (mg/L)
0.1500
0.1375
0.1250
0.1125
0.1000
0.0875
0.0750
0.0625
0.0500
0.0375
0.0250
0.0125
0.0000
n=6
1986
n=14
1987
n=16
1988
n=14
1989
n=9
1990
n=11
1991
n=11
1992
n=6
1993
n=11
1994
n=5
2015

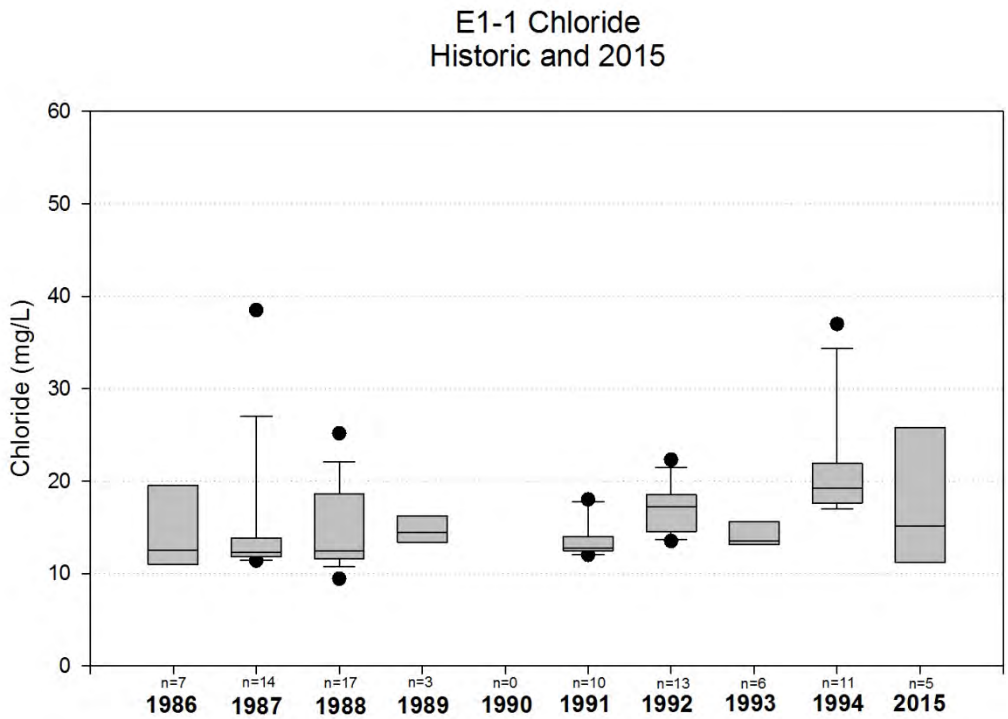
9 Nitrate

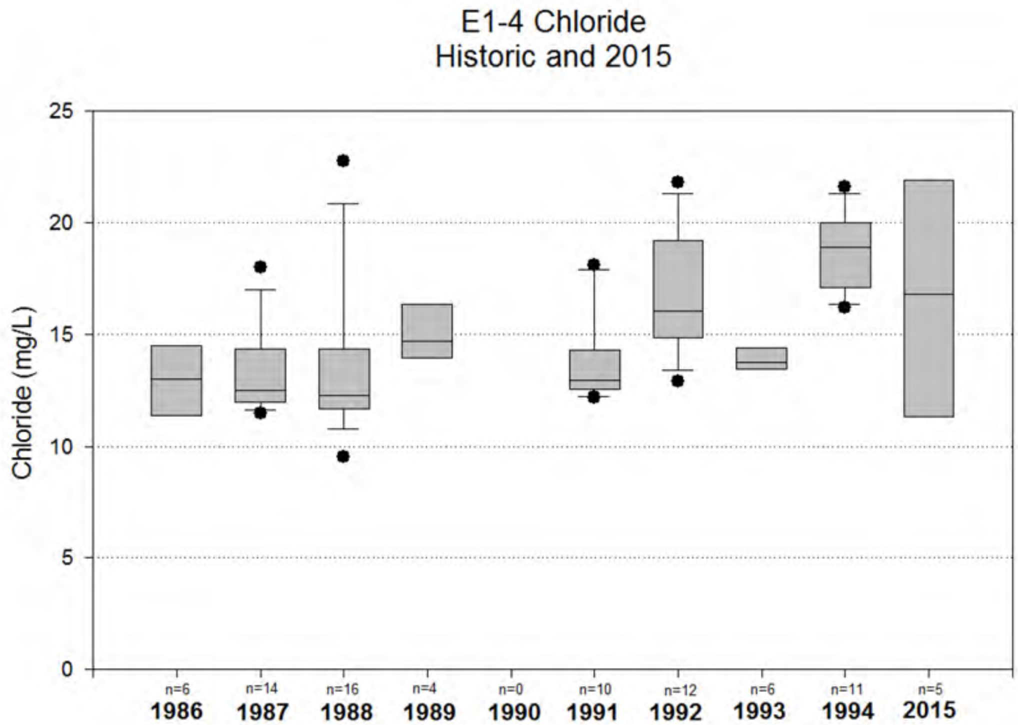

E1-1 Nitrate
Historic and 2015
Nitrate (mg/L)
18
16
14
12
10
8
6
4
2
0
n=6
1986
n=14
1987
n=17
1988
n=14
1989
n=9
1990
n=11
1991
n=12
1992
n=6
1993
n=11
1994
n=5
2015

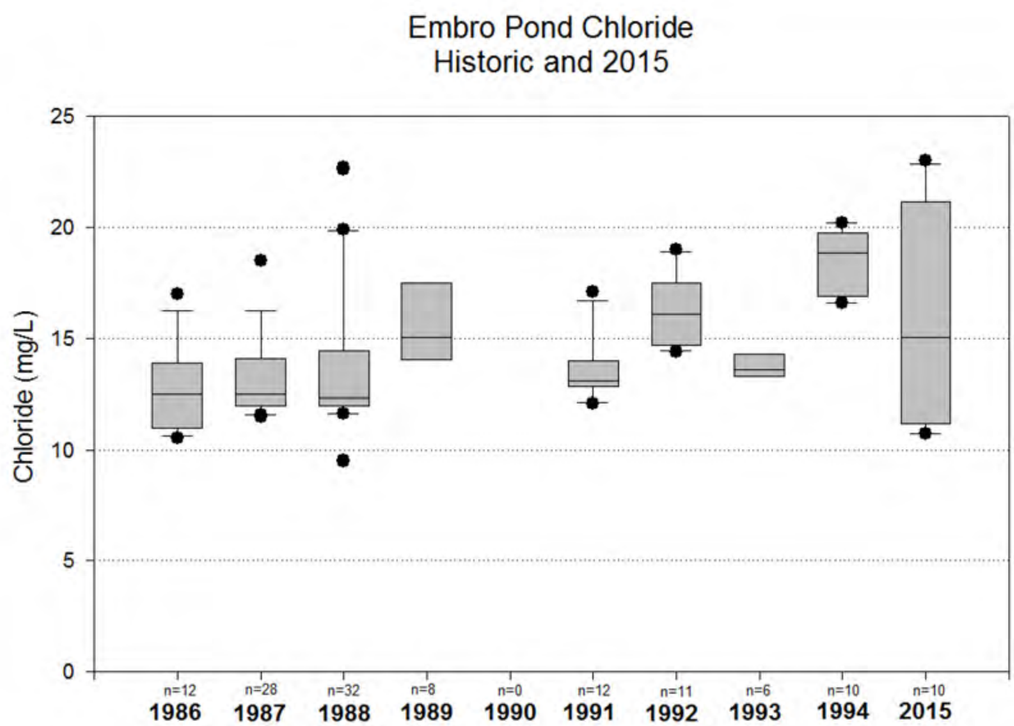

Embro Pond Nitrate
Historic and 2015
Nitrate (mg/L)
0
2
4
6
8
10
12
14
16
18
20
n=12
n=28
n=32
n=27
n=18
n=13
n=11
n=6
n=10
n=10
1986
1987
1988
1989
1990
1991
1992
1993
1994
2015


E1-4 Nitrate
Historic and 2015
Nitrate (mg/L)
0
2
4
6
8
10
12
14
16
18
20
n=6
n=14
n=16
n=14
n=9
n=11
n=12
n=6
n=10
n=5
1986
1987
1988
1989
1990
1991
1992
1993
1994
2015

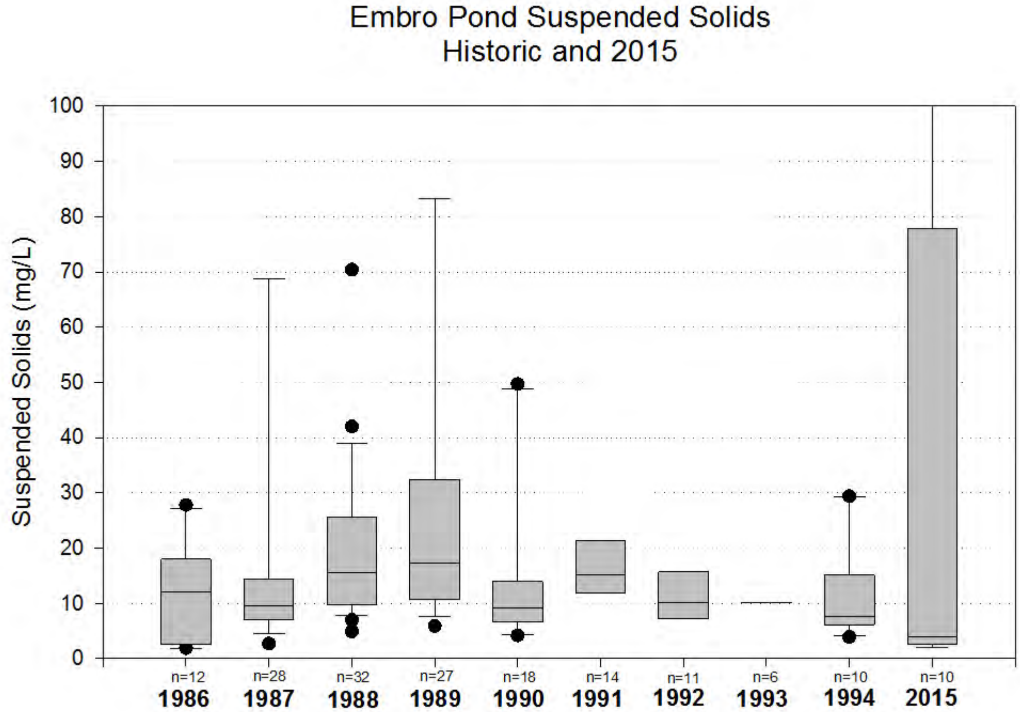
10 Chloride

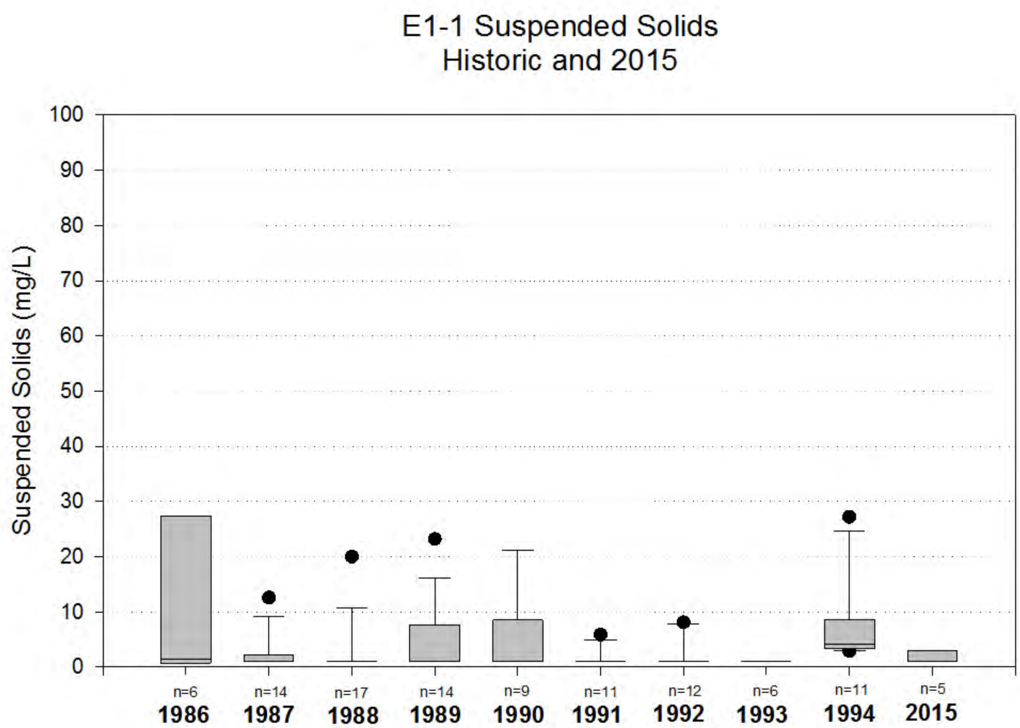

E1-1 Chloride
Historic and 2015
Chloride (mg/L)
0
10
20
30
40
50
60
n=7
n=14
n=17
n=3
n=0
n=10
n=13
n=6
n=11
n=5
1986
1987
1988
1989
1990
1991
1992
1993
1994
2015

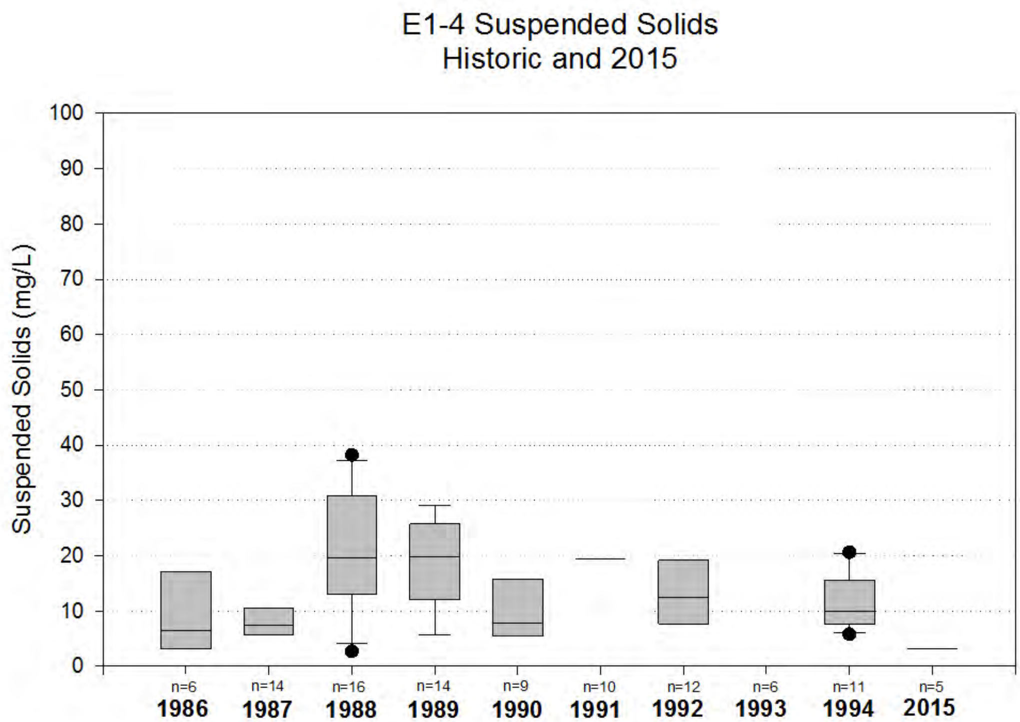

E1-4 Chloride
Historic and 2015
Chloride (mg/L)
0
5
10
15
20
25
n=6
n=14
n=16
n=4
n=0
n=10
n=12
n=6
n=11
n=5
1986
1987
1988
1989
1990
1991
1992
1993
1994
2015


Embro Pond Chloride
Historic and 2015
Chloride (mg/L)
0
5
10
15
20
25
n=12
n=28
n=32
n=8
n=0
n=12
n=11
n=6
n=10
n=10
1986
1987
1988
1989
1990
1991
1992
1993
1994
2015

11 Suspended Solids






E1-4 Suspended Solids
Historic and 2015
Suspended Solids (mg/L)
100
90
80
70
60
50
40
30
20
10
0
n=6
n=14
n=16
n=14
n=9
n=10
n=12
n=6
n=11
n=5
1986
1987
1988
1989
1990
1991
1992
1993
1994
2015