Technical Memorandum BCWA

Date: February 5, 2020
To: Bear Creek Watershed Association
From: Russell N. Clayshulte, Manager
Re: BCWA TM 2019.02 UBCW Summary

Contents

Sampling Program

Bear Creek Watershed Association maintains four water quality sampling stations at Summit Lake and upper Bear Creek (UBCW), Mt Evans Wilderness, Clear Creek County Colorado. The Association selected sampling Site 36 (Summit Lake near the outfall culverts), Upper Bear Creek Site 37 downstream of ponds #1 and #2 on the mainstem of Bear Creek.

Figure 1 UBCW Sampling Stations

Historical Investigation

In 2005, the Colorado Water Quality Control Division staff requested that the BCWA begin to look upstream of Evergreen Lake to determine potential causes for low macroinvertebrate scores at the Keys-on-the-Green site. It was suggested that temperature and nutrients were causing potential impairment. In 2006, the BCWA established a monitoring site on upper Bear Creek at the Clear Creek County line. Initial data showed elevated total ammonia concentrations coming from unknown upstream sources.

As such, the BCWA in 2007 established a monitoring site above the Singing River Ranch on Bear Creek where there were no apparent anthropogenic sources. The expected condition at this site was low nutrients, which was not the case. There were elevated concentrations of total phosphorus and nitrate-nitrogen above expected conditions for both the 2007 and 2008 data collection seasons. After consultation with WQCD staff, they suggested the BCWA take a sample at and below Summit Lake to establish the most upstream "background" conditions. Based on the EPA Rocky Mountain Alpine ecoregion II data sets, there should be extremely low levels of phosphorus (e.g., 0-5 ug/l) and nitrogen (e.g., 0-50 ug/l) at the Summit Lake sites.

In 2009, the BCWA established sites 36 and 37 at Summit Lake. The phosphorus and nitrogen data in 2009 exceeded the expected conditions for an ecoregion II environment. The BCWA was particularly surprised by the high total ammonia concentrations. This data resulted in the BCWA conducting a more detailed investigation of the site. The BCWA also researched fens, atmospheric depositions and other natural causes. The BCWA made observations of the periphyton coverage on hard substrate within Bear Creek down to site 37. These observations showed an excess of periphyton beyond normal expectations, which strongly suggested nutrient enrichment (Figure 2). It was field observations that help suggest the origin of pollutants came from the vicinity of the parking lot and wastewater holding vaults. Association observations suggest that one origin of the pollutants was the new/old toilet vaults at the Summit Lake parking lot

Figure 2 Excessive periphyton growth on hard substrate in Bear Creek

The preliminary data analyses from just visually tracing high algal productivity in the fen ponds showed extremely elevated nutrients, that were higher than found anywhere else in the watershed (Figure 3). In 2013, measurements from only a single estimated emergent point of the plume had a seasonal average total phosphorus of 1,801 ug/l (maximum 4,112 ug/l), with a conservative estimate of 129 pounds/month discharged into upper Bear Creek (potentially over 400 pounds in the warm season). That is potentially more total phosphorus discharged into Bear Creek than 10 out of 16 wastewater treatment plants discharge in an entire year. Denver Parks and Recreation in 2013 repaired the new vaults and the 2014 water quality data suggests this helped resolve part of the nutrient loading.

Figure 3 Excessive red algal growth typical in fen ponds along the suspected pollutant plume flow

In 2014, the nutrient loading from the plume monitoring site declined with a peak measured total Phosphorus concentration of 735 ug/l and an estimated total phosphorus load of 52 pounds during the monitoring season. The total nitrogen load estimate was also reduced at 46 pounds. These declining load values were encouraging and suggested that the leaking problem from the wastewater vaults may be resolved. However, nutrient loading remains a concern.

The new state interim Total Phosphorus standard for cold-water streams is 110 ug/l and the concentration measured in the plume exceeds 4,112 ug/l. The Association measured nearly 3,108 ug/l of Total Nitrogen and the new state interim Total Nitrogen Standard for cold-water streams is 1,250 ug/l. While these measured results aren't technically a standards violation currently, they are indicative of a significant pollution problem degrading the aquatic biota and habitat. This nutrient loading contributed to excessive (100% coverage) attached algal growth (periphyton) on rock substrate in Bear Creek. The Association has also documented fish kills that appear attributable to the pollution plume. The Association provides the City and County of Denver, Colorado Department of Parks and Wildlife, Colorado Water Quality Control Division, State Forest Service and National Forest Service technical memorandums with data results and conclusions. Denver has committed to additional characterizations of the water quality problem(s) and is working towards mitigation of any problem(s) associated with the Denver Mountain Park Facilities.

2019 Monitoring Data Sites 36, 37 and 63

Table 1 Site 36, 37 and 63 Field Data and Observations

	6/21/2019	7/18/2019	8/14/2019	9/12/2019	10/3/2019
	Site 36 Bear Creek				
Time	9:15	10:00	10:00	10:50	10:30
Water Temperature C	0.40	5.60	9.10	6.50	1.2
Air Temperature C	9.2	10.6	16.6	0.5	5.6
pH	8.16	8.08	8.59	7.12	1:26
Specific Conductance ms/cm	20.8	22.7	22.5	23.6	24.9
Dissolved Oxygen mg/l	9.57	8.61	8.72	8.91	9.45
	Site 37 Bear Creek				
Time	9:40	10:20	10:25	10:30	10:00
Water Temperature C	2.30	6.10	7.40	4.20	0.1
Air Temperature C	8.6	9.2	12.8	1.9	19:12
pH	7.92	7.75	7.70	7.01	7.44
Specific Conductance ms/cm	21.1	22.3	23.3	25.0	27.4
Dissolved Oxygen mg/l	9.07	8.82	8.20	9.26	10.21
	Site 63 Bottom Fen				
Time	9:25	10:05	10:06	10:10	10:12
Water Temperature C	3.6	9.8	7.6	4.2	0.1
Air Temperature C	10.1	9.1	10.8	1.9	6.9
pH	8.0	7.6	8.1	7.4	7.0
Specific Conductance ms/cm	29.1	47.9	47.4	41.5	57.9
Dissolved Oxygen mg/l	4.6	5.5	3.6	5.1	2.5

	Estimated Flow cfs				
site 36 through Culverts	2.46	4.72	3.28	0.26	0.83
site 37 - Bear Creek	4.83	4.48	3.42	0.95	0.38
Site 63 - Bottom Fen	0.02	0.01	0.21	0.230	0.01
	Periphyton Coverage				
site 36 - within Summit lake	1%	2%	3%	1%	3%
site 37 - Bear Creek	15%	10%	8%	20%	80%
	Fish Present				
site 36 - within Summit lake	0	1	1	1	1
site 37 - Bear Creek	0	5	2	3	0

Table 2 Site 36, 37 and 63 Nutrient Data

Site	Parameter	6/21/2019	7/18/2019	8/14/2019	9/12/2019	10/3/2019	Average
BCWA Segment Sample Sites							
36 - Outlet Summit Lake	Total Nitrogen, ug/l	288	944	319	237	424	**442**
	Phosphorus, total, ug/l	11	255	14	6	49	**67**
37 - Upper Bear Creek	Total Nitrogen, ug/l	335	345	244	262	300	**297**
	Phosphorus, total, ug/l	18	17	6	6	11	**12**
Site 63 - Bottom Fen	Total Nitrogen, ug/l	215	228	478	4581	479	**1196**
	Phosphorus, total, ug/l	46	203	409	4709	316	**1137**

Table 3 Site 36 and 37 Flow Estimates and Nutrient Load Estimates

	June	July	August	Sep	Oct	Season Totals
site 36 through Culverts	142	290	202	15	51	650
site 37 - Bear Creek	287	275	210	57	23	829
Site 63 - Bottom Fen	1.0	0.8	12.7	14.1	0.6	29
Total Phosphorus, Pounds/month						
site 36 through Culverts	4.27	201.47	7.69	2.06	9.31	215
site 37 - Bear Creek	14.08	12.75	3.43	1.69	0.74	32
Site 63 - Bottom Fen	0.12	0.46	14.18	12.17	1.84	27
Total Nitrogen, Pounds/month						
site 36 through Culverts	111.7	745.8	175.1	17.9	61.5	1,051
site 37 - Bear Creek	262.1	258.7	139.7	46.2	18.9	707
Site 63 - Bottom Fen	0.6	0.5	16.6	18.4	1.9	36

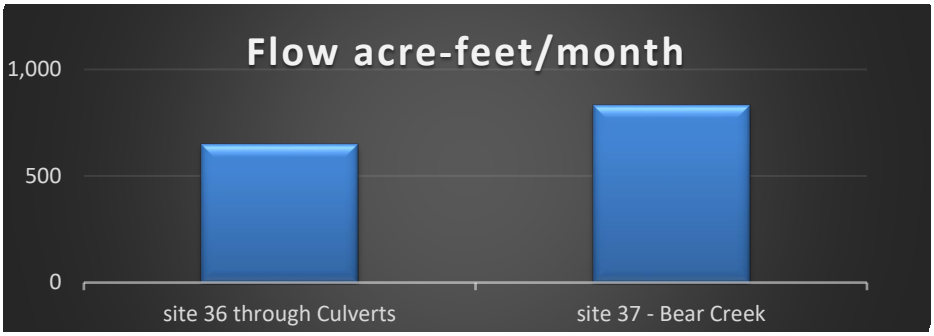

Figure 4 Monthly estimated flows

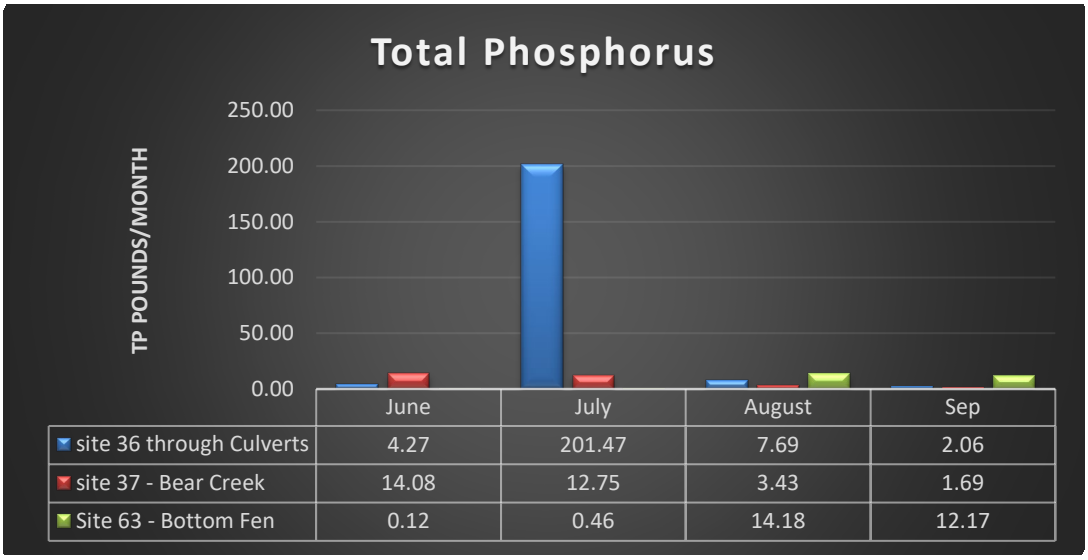

Figure 5 Total Phosphorus Loading

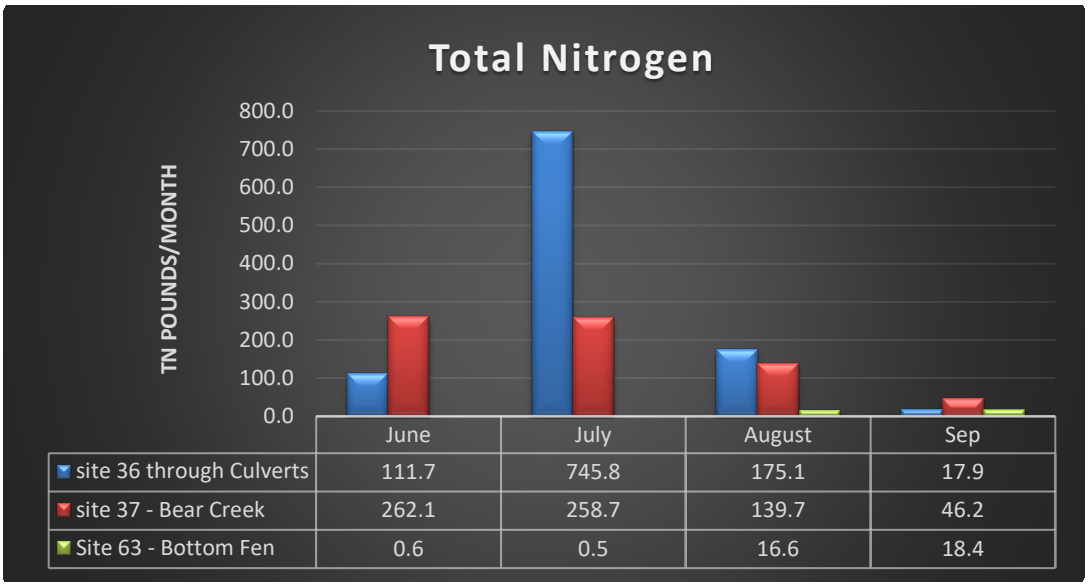

Figure 6 Total Nitrogen Loading

Status of Pollutant Plume

The BCWA is still confident that pollutant plume continues to diminish, albeit slowly. This nutrient loading data suggests the leaking vaults were a nutrient source (particularly phosphorus) and the repair of those wastewater vaults was generally successful in reducing nutrient loading. There continues to be a total phosphorus loading associated in general with the fen complex down-gradient flow from the parking lot area. There appears to be a longer-term legacy problem with nutrient loading associated with long-term visitation to the area.

Although the fen plume monitoring site continues to produce an elevated phosphorus loading, this load is not reflected in the concentrations and load measured at site 37. This indicates that algal productivity is consuming much of the nutrient load prior to this monitoring site (Figure 7). Most of the recent algal grow appears to be several species of green algae. There does continue to be a potential problematic bluegreen algae that may be associated with the observed fish kills. Almost all of this algal mat material will die over the winter and flush downstream in the spring runoff. As such, the nutrient load gets flushed downstream as organic matter.

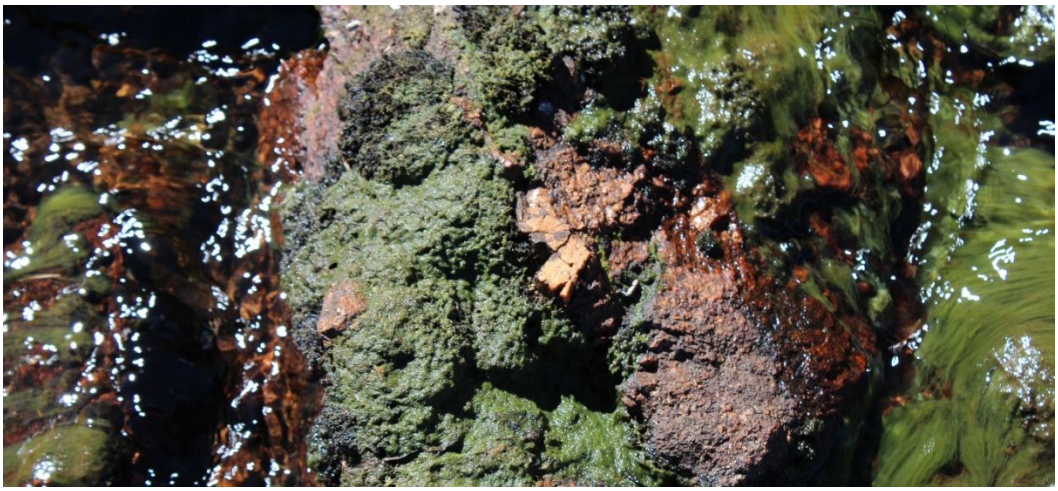

Figure 7 Algal growth in Bear Creek upstream of site 37

Fen Complex Study

A type of tributary wetland in the watershed is called a fen. In the Mt. Evans portion of the watershed, these wetland fens are an important and unique wetland type. They are ancient ecosystems 8,000 to 12,000 years old. They "provide important headwater quality functions," including carbon storage, water storage, wildlife habitat, and biodiversity. Fens, are peat-forming wetlands that receive nutrients from sources other than precipitation:

usually from upslope sources through drainage from surrounding mineral soils and from groundwater movement (*BCWA Fact Sheet 49 Wetlands, Fens and WQ BCW).*

In 2014, the Association conducted a special survey of three Fen ponds to establish background or expected conditions on "non-polluted" Fen Ponds (*BCWA Fact Sheet 52 Mt Evans Fen WQ*). The Association selected three Fen pond sizes to establish backgrounds: a small Fen (25 square feet, about 1-foot-deep), medium Fen (85 square feet, about 2 feet deep), and a larger Fen (125 square feet, about 4 feet deep). There were no indications of any anthropogenic influences on these Fen ponds. The Fen ponds were sampled on September 17, 2014, with an expectation that this would show the season low nutrient conditions. The results for total nitrogen and total phosphorus were much higher than suspected. The median total phosphorus for this limited special survey was 165 ug/l. The preliminary data strongly suggests the chemistry and nutrient dynamics in the Fen complex is more complicated than predicted. As such, the Association began a five-year special study to establish the background or expected nutrient conditions for the Fen complex.

The Association summarized evidence in the Regulation #38 Rulemaking Hearing for South Platte Basin Standards that suggests fen wetlands have background phosphorus levels that exceed Table Value Standards (TVS) even though streams in the same segment do not have elevated phosphorus levels (*Fact Sheet 53 BCR 2015 Regulation 38 Update*). It is not yet known what background level would be appropriate or if it varies among these fens. The Colorado Water Quality Commission applauds the efforts of BCWA to obtain data that improves our understanding of existing conditions. Site-specific standards are needed for all, or part, of Segment 7 for which phosphorus standards are required, but there is uncertainty about the habitat type or the geographic scope of applicability for site-specific standards (or conversely for the TVS). Resolving the uncertainty will require additional sampling to obtain representative data. Delaying the effective date by five years gives BCWA, time to collect additional data and propose site-specific phosphorus and Total Nitrogen standards as appropriate for the Fen complex. Total Phosphorus standards were delayed until an effective date of 12/31/2020.

In 2016, the Association established a control fen located on the south side of Bear Creek. This site has no visible human impact. All the fens on the north side of Bear Creek have varying degrees of anthropogenic degradation. The Association continued the fen study in 2019.

Table 4 Site 76 and 95 2019 Field Data

	6/21/2019	7/18/2019	8/15/2019	9/12/2019
	Site 76 North Fen			
Time	9:45	10:20	10:40	dry
Water Temperature C	2.50	8.10	7.40	
Air Temperature C	8.6	9.8	12.8	
pH	7.57	7.84	7.79	
Specific Conductance ms/cm	18.2	23.4	24.4	
Dissolved Oxygen mg/l	5.71	7.85	6.18	
	Site 95 South Control Fen			
Time	10:00	10:40	10:06	10:40
Water Temperature C	4.40	7.80	7.60	4.70
Air Temperature C	8.5	15.3	10.8	4.6
pH	7.62	7.72	7.74	6.85
Specific Conductance ms/cm	12.6	6.9	28.6	35.9
Dissolved Oxygen mg/l	7.64	5.91	6.06	5.06

Table 5 2019 Nutrient Data

Site	Parameter	6/8/2018	7/13/2018	8/10/2018	9/13/2018	Average
BCWA Segment Sample Sites						
76 - North Fen	Total Nitrogen, ug/l	866	549	365		**593**
	Phosphorus, total, ug/l	30	34	15		**26**
95 South Control Fen	Total Nitrogen, ug/l	386	114	90	26	**154**
	Phosphorus, total, ug/l	14	115	9	16	**39**

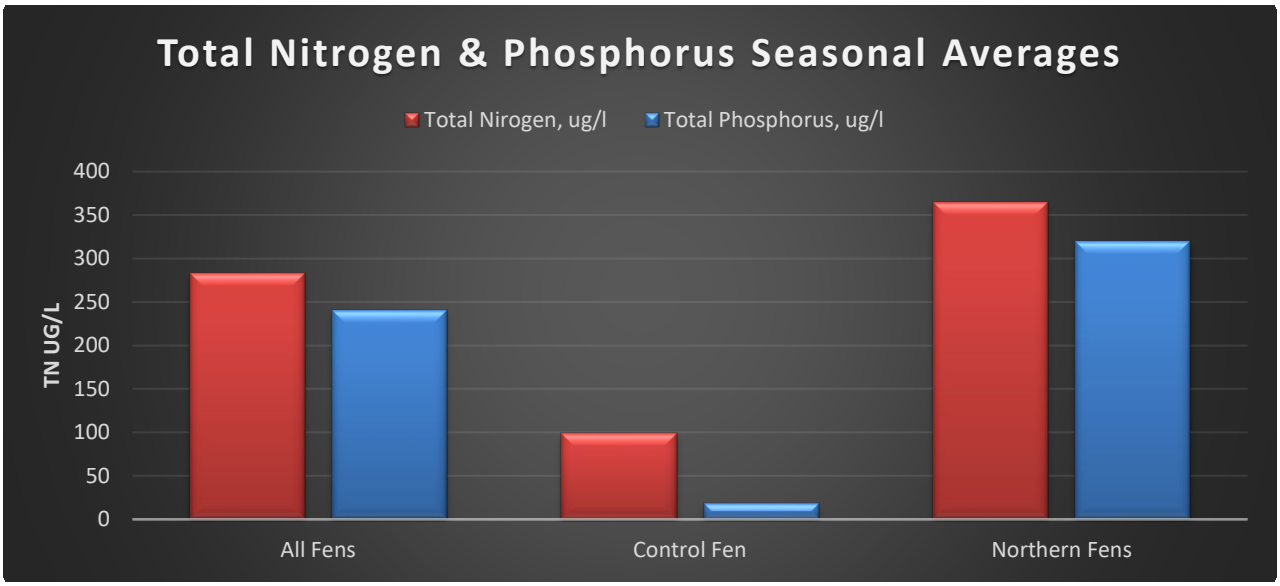

Figure 8 Nitrogen and Phosphorus Trends