

MEMORANDUM

Date: December 9, 2012

To: *Bear Creek Watershed Association*

From: Russell N. Clayshulte, Manager

Re: **Technical Memorandum 2012.02 - Sampling Program Summit Lake/ Denver Mountain Parks and National Forest Service lands and 2012 Water Quality Data and Observations**



Problem

Bear Creek Watershed Association established two sampling stations at Summit Lake and upper Bear Creek, Mt Evans Wilderness, Clear Creek County Colorado. The Association selected sampling Site 36 (Summit Lake at outfall) and Upper Bear Creek Site 37 to monitor assumed high quality “background” conditions. However, past monitoring data showed atypical water quality results. The station data suggested there is a pollution source causing elevated nutrient loads, low pH conditions and reduced dissolved oxygen. Association observations suggested the pollution plume originated from the old toilet vaults area in the Summit Lake parking area and effecting data results from sites 36 and 37.

The limited 2011 water quality data suggested a nutrient pollution source in the area, but no site-specific monitoring was done to trace the potential pollutant source. The possible points of enriched nutrient water were photographed where they discharge into the small pond below Summit Lake (Figure 1) within the Bear Creek upper drainage. The discharge zone appeared to be about 25 feet across.



Figure 1 Growth in suspected flow plume into Bear Creek below Summit Lake

There was 90% to 100% periphyton coverage of the cobble substrate recorded for about ¼ mile of Bear Creek below the second pond on September 9, 2011 (Figure 2). At the BCWA site 36 sampling point in Summit Lake at the outfall pipes, the periphyton coverage was about 10%.

The BCWA produced a photographic record of the algal growth on September 9, 2011, which included the suspected discharge point into Bear Creek. The data in Tables 1 and 2 suggested nutrient loading was occurring, as indicated by the nitrate data.



Figure 2 Bear Creek below Summit Lake with about 90% periphyton coverage and thick blue-black algae, September 9, 2011. Site elevation is about 12,000 feet. Several areas were noted with 100% periphyton coverage on cobble substrate. Once the algal matting established all fish in stream disappeared.

Table 1 2011 Field Data

Site	Location	Date	Time	pH	Temp °C	DO(mg/l)	SC (ms/cm)	Flow (cfs)
Segments 7 and 8								
Site 36	Summit Lake outfall (Mount Evans Wilderness) (Segment 8)	7/8/2011	1:21	6.53	11.8	7.17	0.02	4.26
		7/16/2011	2:00	5.88	9.54	8.22	0.019	2.51
		8/11/2011	9:48	8.29	9.9	8.32	0.029	2.9
		9/9/2011	9:27	8.89	6.1	6.75	0.028	1.5
Site 37	Bear Creek, Mainstem from Lake 1/4 mile downstream (Segment 7)	7/8/2011	1:55	6.99	12.11	7.41	0.18	5.67
		7/16/2011	2:55	7.63	11.15	7.02	0.019	2.9
		8/11/2011	10:01	7.45	9.7	8.05	0.024	3.2
		9/9/2011	9:54	7.52	5.62	7.43	0.025	4.5

Table 2 2011 Chemistry

	7/18/2011				8/11/2011				9/8/2011			
	NO3-NO2 Ug/l	TN Ug/l	Ammonia Ug/l	T Phos Ug/l	NO3-NO2 Ug/l	TN Ug/l	Ammonia Ug/l	T Phos Ug/l	NO3-NO2 Ug/l	TN Ug/l	Ammonia Ug/l	T Phos Ug/l
Site 36	2	192	9	5	9	214	11	3	37	97	35	7
Site 37	16	239	9	13	37	254	14	5	103	161	22	11

2012 BCWA Sample Sites

In June 2012, the Association began a special study effort to document the extent and magnitude of the potential pollution plume. The Association walked the area to identify potential problem areas. The Association concluded that the source area was in the vicinity of the parking lot. The Association originally assumed the problem was related to the past waste disposal practice of using pit privies. There are a large number of wetland or bog ponds that occur between the parking lot and upper Bear Creek. The Association noted that some of these ponds in a drainage fall-line had much more algal productivity than those ponds nearer Summit Lake and well downstream from the parking lot. This suggested that the pollution plume was surfacing in-part in some of the ponds. The special sampling program at Summit Lake established four new BCWA sampling sites:

1. BCWA Site 60 – North shore of Summit Lake. This is an area where no apparent drainage comes from the parking area and, as such, this site was selected as the control site. There is less than 5% periphyton coverage of the hard substrate at this site and water clarity is very good and easily exceeds 5 meters. Numerous active and healthy fish were seen at this site.
2. BCWA Site 61 top of plume (Figure 3) across from the Summit Lake parking lot in a pond about 5X10-feet with a May depth of 20” and moderate orange algal growth covering 80% of pond substrate. In July pond depth was shallow. By August 2012 the orange algal growth about 6 inches thick and the pond had more water from surround drainage and rainfall. In September the red orange algal matting was about 12 inches thick with very little Dissolved Oxygen.
3. BCWA Site 62 middle of plume about ½-way to point of discharge into lower pond (Figure 4) about 8X20-feet with a May depth of 20” and moderate orange algal growth covering 75% of pond substrate. In July pond depth very shallow, area drying out with red-orange algal growth. By August sampling much more water (as seen in Figure 4) with 18” depth and very extensive red algal growth. Noted dead moths and other insects. In September the pond was about 16 inches deep with reduced red and green algal growth, and appeared to have gotten some rain/snow input (dilution).
4. BCWA Site 63 bottom of plume at discharge point into lower pond (Figure 5) with dispersed flow zone about 20-feet wide, area contains red algae covering about 95% of substrate. There are about 6 places where plume flow appears to enter the first pond below Summit Lake (See Figure 6). There is one major marshy area inflow point that enters Bear Creek above the first pond, but this discharge appears to be more surface runoff that originates east of the park area. The Association only selected the middle pond within the “groundwater” discharge zone. In early June this site had the most flow. Smaller flows were observed in July and August. This flow path also has the thickest algal growth and the most algal growth in the adjacent first pond. However there are other nutrient loading points from the in-flow zone. In September the plume runoff had reduced flow at the monitoring site, but the inflow zone was noted to be about 25 meters across and 14 separate inflow zones were noted.

Additionally the monitoring program used BCWA Site 36 in Summit Lake at the discharge pipes and the Site 37 upper Bear Creek data. There is no apparent nutrient loading observed in Summit Lake at the discharge culverts. In May the lake was still mostly frozen with some open water along shoreline. There was no algal covering of substrate within Summit Lake. In 2011 and 2012,

the periphyton coverage of hard substrate at the culvert pipes within Summit Lake is at maximum only about 5%, which is the expected condition.

Figures 6 and 7 shown sampling area and suspected plume origin. Historic practice left septic waste on site in a pit privy or vault. The parking lot now has relatively new “water tight” waste vaults, which are periodically pumped and hauled to the Metropolitan Wastewater Reclamation plant in Denver, according to information provided to the Association.



Figure 3 BCWA Site 61



Figure 4 BCWA Site 62



Figure 5 BCWA Site 63

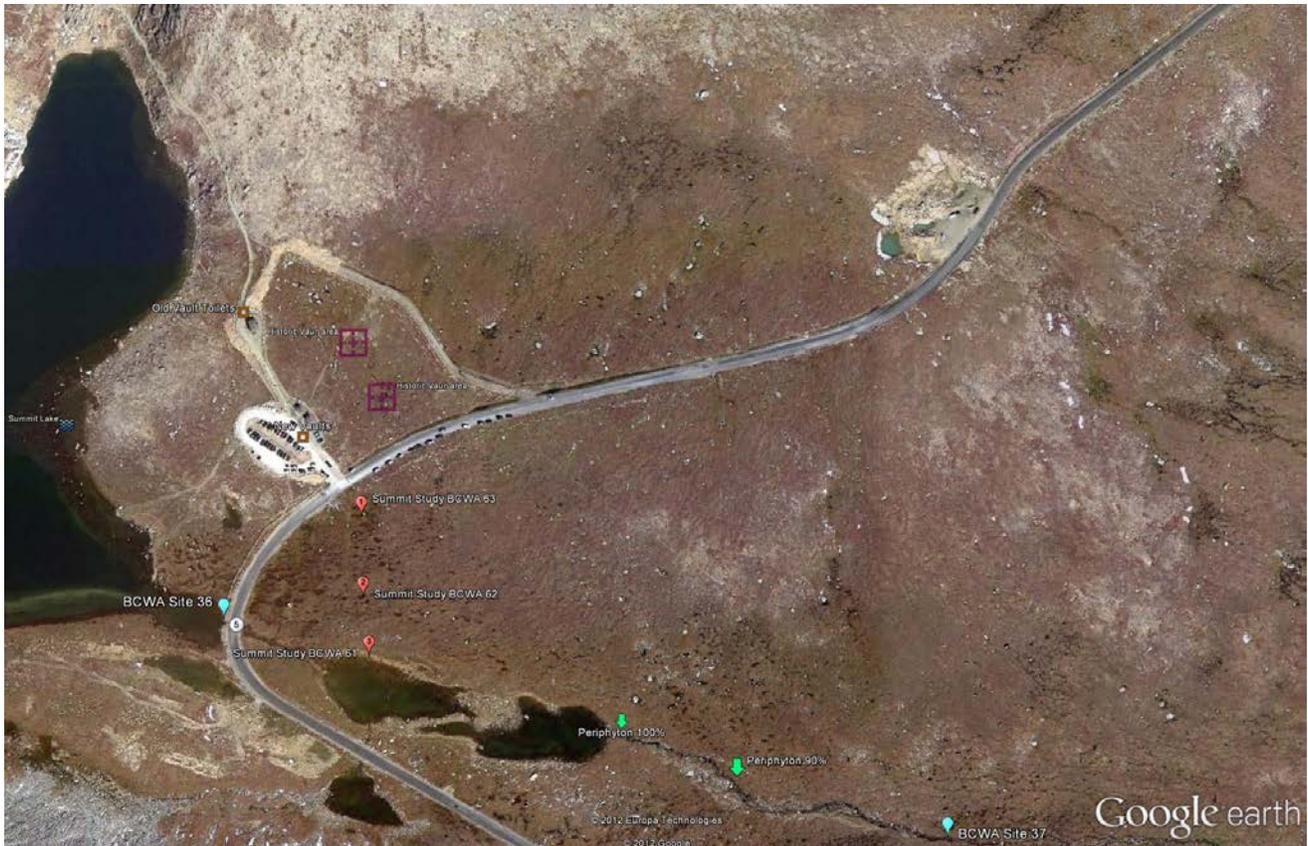


Figure 6 General Summit lake Parking area and suspected plume path



Figure 7 Note heavy car presence at parking lot and on road

Mt. Evans Visitation and Potential Wastewater Generation

Nicole Malandri (Recreation Fee Manager, Clear Creek Ranger District) provided the Association with some rough numbers of visitors to Mount Evans. Sales data and number of passes sold/issued was used to determine visitation numbers. In order to approximate the total number of visitors multipliers are used for each type of pass sold. A personal pass represents one person, while a 2.9 people per vehicle multiplier are used for the other passes, except for medium vehicles which are multiplied by 15 people and a large vehicle is 40 people.

So these numbers are not exact, but provide a good estimate about visitation.

Year	Total Visitors
2004	110,513
2005	115,000
2006	111,200
2007	125,400
2008	120,900
2009	127,632
2010	168,944
2011	168,479

Potential Wastewater Generation - Assuming minimal liquid waste generation of 1/2 cup/person, there was about 7,000 gallons of urine discharged into vaults in 2011. The original practice at the summit parking area was to allow a pit privy to fill, and then simply dig a new site. The past practice could have resulted in over 225,000 gallons of concentrated waste product (assuming an average long-term visitation of 35,000) left on site and slowly discharging into upper Bear Creek.

Association membership were informed that the new “concert” vaults don’t leak. However, at the beginning of the 2012 season (opening day) Association members observed vault tanks held considerable liquid and solid waste. The vaults were not emptied at the end of the 2011 season and the waste product froze in the vaults.

2012 Site Visitation Notes

6/26/2012 – Informed that there were at least 3 old vault privies with waste left on site into the late 1980’s or early 1990’s. No 2012 pumping of vaults, yet content appeared less than seen on 5/25/20. Flow from vault area rapidly drying. Elevation difference 20-30 feet. Red algal mats forming in pools at bottom of plume. Greenback Cutthroats observed from 14 to 24”, count in Bear Creek above plume estimated at 17 fish. Fish observed down to site 37 ranging in size from 10-18 inches (> 50 fish).

7/13/2012 – All 4 vaults contain very little liquid, mostly solids. Vaults are over ½ full of solids and not they don’t appear to be pumpable. Few fish (saw 2 fish) remain below pipes (upper pond) and none in stream. A 14-15 inch cutthroat was scared through the pipes and traveled downstream toward the first pond. This fish died very quickly (3-4 minutes) in stream adjacent to plume and floated belly-up into the first pond. Heavy algal matting in upper Bear Creek, including blue-black algae at 90% coverage.

8/10/2012 – Western men’s and women’s vaults remain over ½ full with solids and very little liquid waste; while the 2-western vaults have more liquid content. Marshy area south of parking lot much wetter than last sampling with most ponds mostly full. Replicated sampling ponds from 7/13/2012 sampling. Definite increase in orange algal matting with thick bottom deposits. Difficult to trace plume flow path or pinpoint source origin. However, there is drainage from parking lot area (Figure 9). No live fish observed below summit lake culverts down to site 37. Large dead fish at plume mouth (Figure 10). The blue-black algal growth in upper Bear Creek below second pond was about 95% cover of substrate with long green filamentous algae common (Figure 11). At BCWA Site 37, the periphyton coverage had decreased to about 20-25% (Figure 12). BCWA Site 60 in Summit Lake had no periphyton cover of substrate (Figure 13).

9/6/2012 – The vaults were closed for the year and the women’s vault had been pumped clean. The men’s vault was still filled with mostly solids and little visible liquid waste. The Association was informed that the women’s vault would undergo a leak test, which was simply to fill the vault with water and hand measure the water level. The snow fall that occurred from the day before monitoring had mostly melted and the runoff from this event had generated new surface flow into sites 61 and 62. Figure 14 shows the very thick orange algal that covers the pond to about 12 inches and clumped on the surface. Fish were observed in Summit Lake at both sites 60 and 36. These fish were healthy and not stressed. There were no fish observed in Bear Creek below the Summit Lake culverts. . In September the plume runoff was reduced to about 2-3 gallons per minute at the monitoring site, but the inflow zone was noted to be about 25 meters across and with a minimum of 14 separate inflow point/zones were noted. As such, the inflow plume was about 0.5 cfs. The algal growth had extended 3-4 meters into the bigger Bear Creek Pond. Figure 15 shows the plume inflow points into the upper bear Creek pond.



Figure 8 **Dead Fish in Bear Creek**



Figure 9 **Summit Parking Lot and Suspected Flow Plume Origin**



Figure 10 Large Dead Fish 8-10-12



Figure 11 95% periphyton cover of substrate



Figure 12 BCWA Site 37



Figure 13 BCWA Site 60 in Summit Lake had 0% periphyton coverage in August 2012



Figure 14 Orange algal growth in site 61 pond September 2012



Figure 15 Inflow points into Upper Bear Creek September 2012

2012 Special Study Data

The Association feels confident that the lower extent of the suspected pollution plume has been identified. However the middle and upper flow paths are not so clearly delineated. Water in the plume flow can have a low pH and low dissolved oxygen (Table 3). Nutrient data for the suspected plume demonstrates a significant pollution problem with extremely high total phosphorus and total nitrogen loading into upper Bear Creek (Table 4). The total phosphorus concentration measured at Site 63 are the highest recorded for any water in the watershed. The 2012 monitoring problem clearly shows a significant pollution plume is associated with current and past waste disposal/ management practices at the parking lot. The nutrient loading data clearly demonstrates that the current vault system is a part of the nutrient loading. The low dissolved oxygen, low pH and excessive ammonia-nitrogen are probably contributing to the observed fish kills.

There is massive nutrient loading and deleterious effects to aquatic life associated with the suspected pollution plume. The new state interim Total Phosphorus standard for cold water streams is 110 ug/l and the concentration measured in the plume exceeds 1,825 ug/l. The Association measured nearly 2,366 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 at this time, they are indicative of a significant pollution problem degrading the aquatic biota and habitat. This nutrient loading is causing excessive (100% coverage) attached algal growth (periphyton) on rock substrate in Bear Creek. The Association has also documented fish kills that appears to be directly attributable to the pollution plume

The Association had assumed that the increased nutrients seen in 2011 at the upper Bear Creek monitoring site 37 were caused by historic waste management practices when pit privies were used for human waste disposal (from 1927 thru 1990 approximately). However observations made in 2012 suggest the new vault toilets are leaking and adding to the pollution plume. The Association believes it is imperative from a water quality perspective to immediately address the possibility that the vault toilets are causing a significant nutrient loading problem in upper Bear Creek.

The Association strongly believes it is necessary to install several lysimeters adjacent to the vaults and along the suspected flow path for additional water quality testing. There needs to be further study to determine the extent, concentration and movement of the plume to understand and minimize future fish kills and environmental effects associated with the pollution plume. The low pH, low dissolved oxygen and elevated ammonia-nitrogen associated with the pollution plume are likely contributing to or directly producing the fish kills and degrading habitat.

The Association is willing to work with Denver Mountain Parks and National Forest Service to address this problem and find a suitable mitigation plan to address the water quality impairment problem. Unfortunately, the Association has reviewed no communication back from any of the following local or regulatory agencies that were alerted to this problem in August 2012.

Arthur Gilkison, Denver Mountain Parks
Lauri Dannemiller, **Manager Denver Parks and Recreation**
Dick Parachini, Colorado Water Quality Control Division
Paul Winkle, Colorado Parks and Wildlife
Jamie Anthony, Colorado Parks and Wildlife
Nicole Malandri, Clear Creek Ranger District

Table 3 Special Study Field Data

	5/25/2012	6/25/2012	7/12/2012	8/9/2012	9/6/2012
Site 36 Outlets					
Time	10:30	9:47	9:38	9:39	10:00
Temperature C	2.3	8.4	10.3	10.8	7.3
pH	7.24	6.93	7.57	9.42	7.83
Specific Conductance ms/cm	0.022	0.021	0.021	0.023	0.02
Dissolved Oxygen mg/l	10.92	7.77	11.34	6.8	7.21
Site 37 Bear Creek					
Time			9:58	9:47	9:45
Temperature C			10.4	11.1	6.8
pH			6.9	8.25	7.37
Specific Conductance ms/cm			0.021	0.02	0.021
Dissolved Oxygen mg/l			10.52	6.92	8.05
Site 60 North Shore					
Time		9:27	10:30	10:23	10:33
Temperature C		9	10.2	10.8	8.9
pH		7.43	6.65	7.12	7.95
Specific Conductance ms/cm		0.021	0.02	0.019	0.02
Dissolved Oxygen mg/l		7.51	9.77	5.7	6.7
Site 61 Top Plume					
Time	10:25	10:01	10:38	10:10	9:25
Temperature C	2.3	14.1	8.6	7.1	6.3
pH	7.01	7.21	5.94	6.44	8.26
Specific Conductance ms/cm	0.024	0.037	0.051	0.067	0.068
Dissolved Oxygen mg/l	11.73	5.75	6.2	3.05	3.38
Site 62 Middle Plume					
Time	10:15	10:30	10:16	10:05	9:30
Temperature C	3.3	14	8.6	8.5	4.9
pH	7.17	6.89	5.64	7.02	8.25
Specific Conductance ms/cm	0.034	0.061	0.026	0.042	0.024
Dissolved Oxygen mg/l	7.64	5.07	5.95	4.09	6.5
Site 63 Bottom Plume					
Time	10:10	10:35	10:11	10:00	9:35
Temperature C	0.9	13.4	8.5	8.5	5.9
pH	7.67	6.42	5.96	7.12	7.56
Specific Conductance ms/cm	0.073	0.058	0.036	0.034	0.043
Dissolved Oxygen mg/l	6.41	8.1	2.72	2.11	0.91

Table 4 2012 Chemistry

Site	Parameter	5/25/2012	6/25/2012	7/12/2012	8/9/2012	9/6/2012	Average
36 - Outlet Summit Lake	Nitrate/Nitrite as N, dissolved	33	6	3	24	141	41
36 - Outlet Summit Lake	Phosphorus, total	15	12	13	4	10	11
36 - Outlet Summit Lake	Total Nitrogen	461	209	254	178	190	258
36 - Outlet Summit Lake	Nitrogen, ammonia	23	14	25	21	24	21
37 - Upper Bear Creek	Nitrate/Nitrite as N, dissolved			33	52	65	50
37 - Upper Bear Creek	Phosphorus, total			9	8	7	8
37 - Upper Bear Creek	Nitrogen, ammonia			25	14	30	23
60 - Summit Lake North Shore	Nitrate/Nitrite as N, dissolved		6	2	23	63	24
60 - Summit Lake North Shore	Phosphorus, total		11	13	11	6	10
60 - Summit Lake North Shore	Total Nitrogen		190	293	244	81	202
60 - Summit Lake North Shore	Nitrogen, ammonia		7	15	15	26	16
61 -Top of Plume	Nitrate/Nitrite as N, dissolved	32	5	4	8	5	11
61 -Top of Plume	Phosphorus, total	45	70	28	17	11	34
61 -Top of Plume	Total Nitrogen	474	813	407	266	34	399
61 -Top of Plume	Nitrogen, ammonia	29	14	28	3	17	18
62 - Est Middle Plume	Nitrate/Nitrite as N, dissolved	19	6	5	11	6	9
62 - Est Middle Plume	Phosphorus, total	73	67	12	10	7	34
62 - Est Middle Plume	Total Nitrogen	887	1,117	416	373	108	580
62 - Est Middle Plume	Nitrogen, ammonia	28	13	29	12	19	20
63- Est Bottom Plume	Nitrate/Nitrite as N, dissolved	10	6	10	9	4	8
63- Est Bottom Plume	Phosphorus, total	156	532	620	1,826	518	730
63- Est Bottom Plume	Total Nitrogen	830	1,979	416	2,366	777	1,274
63- Est Bottom Plume	Nitrogen, ammonia	27	18	29	5	22	20