TECHNICAL MEMORANDUM BCWA

Date: **February 3, 2015**
To: ***Bear Creek Watershed Association***
From: Russell N. Clayshulte, Manager

Re: **TM 2014.04 –Coyote Gulch Data Summary/ Record and Association Trade Credit**

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The Association coordinates with the City of Lakewood a sampling program on Coyote Gulch in the Bear Creek Park (Figure 1). The monitoring is done at two sampling sites: above the restoration project (Upper Coyote), and at the discharge into the reservoir (Lower Coyote) (Figure 2). Beginning in 2013, the Association incorporated the nutrient sampling into the Association monitoring program as part of the P2 Supplemental Monitoring Program. The Association reduced the monitoring frequency to bi-monthly. Nutrient analyses are done at the Association's contract laboratory GEI Consultants Inc. The Association collects the chemistry data for total phosphorus, total nitrogen, ammonia-nitrogen and nitrate-nitrogen (Table 1). The Association takes bi- monthly flow measurements to determine nutrient loading. The Association also collects data for temperature, pH, specific conductance and Dissolved Oxygen. Data results are incorporated into the Association monthly and annual data summaries (Tables 2, 3, and 4). The Association has pre-construction and post-construction loading data. This monitoring project has established a total phosphorus trade credit for use of the Association membership.

Figure 1 Coyote Gulch Discharges into Bear Creek Reservoir

In September 2013, the reservoir became a major flood control structure. The rains began in earnest on September 9, 2013 in the upper watershed. The U.S. Army Corps of Engineers shut the outflow gates on Bear Creek Reservoir on September 13, 2013. The pool rose from 1,817 acre-feet to about 15,000 acre-feet (5 trillion gallons) on September 22, 2013. The surface area was about 500 acres or 70% of surface acre capacity. Although Bear Creek Reservoir returned to normal pool by the end of October, the water quality in the reservoir may be altered for years to come. The entire Coyote Gulch project site was submerged. The site was underwater for about 30-days. Figure 3 shows the Coyote Gulch drainage with the water level just about the Upper Coyote sampling point. The project site was cover by fine muds from 1-4 mm thick (Figure 4). Analyses of these muds show a considerable amount of nutrients. This flooding event may affect the project. There was some vegetation dye-off due to the submergence.

Figure 2 **Coyote Gulch Sample Sites**

Figure 3 **Flooded Coyote Gulch**

Figure 4 **Fine muds coat surfaces in Coyote Gulch**

Table 1 Laboratory Methods and Detection Limits

Analyte	Method	Minimum Detection limit
Total Phosphorus	QC 10-115-01-4-U	2 µg/L
Total Dissolved Phosphorus	QuickChem 10-115-01-4-U, with manual digestion	2 µg/L
Total Nitrogen	Standard Methods 4500-N B, with manual digestion	2 ug/l
Nitrate+Nitrite	QC 10-107-04-1-B	2 µg/L
Total Ammonia	QuickChem 10-107-06-3-D	3 ug/l

Table 2 2014 Field Data for Coyote Gulch

Collected by the City of Lakewood and Bear Creek Watershed Association

Segment	Site	Location	Date	Time	pH	Temp °C	DO(mg/l)	SC (ms/cm)	Flow (cfs)	Est Periphyton Coverage %	Water Clarity
Segment 4a	Site 47a	Upper Coyote	2/10/2014	12:51	7.91	0.00	10.65	1.880	0.30	0%	c
			4/21/2014	11:38	7.93	10.50	10.21	1.420	0.20	50%	c
			6/16/2014	9:35	7.78	11.70	9.00	1.340	0.25	25%	c
			8/18/2014	11:44	7.96	15.80	6.39	1.023	0.29	5%	c
			10/20/2014	12:30	7.70	9.20	10.66	1.311	0.39	25%	c
			12/8/2014	12:03	7.64	0.40	13.50	1.445	0.40	10%	c
	Site 47b	Lower Coyote	2/10/2014	1:00	8.19	0.10	12.97	1.870	0.30	0%	c
			4/21/2014	11:50	8.25	13.10	11.78	1.400	0.14	50%	c
			6/16/2014	9:40	8.10	13.20	10.47	1.320	0.35	10%	c
			8/18/2014	11:55	8.40	16.40	7.46	1.104	0.29	35%	c
			10/20/2014	12:40	8.04	10.60	12.21	1.230	0.35	100%	c
			12/8/2014	12:10	7.99	0.70	13.80	1.431	0.17	30%	c

Table 3 2014 Nutrient Data for Coyote Gulch

Collected by Bear Creek Watershed Association

Segment	Site	Location	Date	Total Nitrogen	Nitrogen, ammonia	Nitrate Nitrite	Phosphorus, total
Segment 4a	Site 47a	Upper Coyote	2/10/2014	2,762	17	2,186	25
			4/21/2014	737	27	314	43
			6/16/2014	1,222	20	806	83
			8/18/2014	1,017	13	485	97
			10/20/2014	1,722	11	1,170	38
			12/8/2014	2,774	19	2,323	24
	Site 47b	Lower Coyote	2/10/2014	2,732	14	2,111	23
			4/21/2014	684	34	199	51
			6/16/2014	1,024	28	596	63
			8/18/2014	856	21	330	85
			10/20/2014	1,410	5	874	44
			12/8/2014	2,696	15	2,246	17

Table 4 2014 Nutrient Loading foe Coyote Gulch

Loading Pounds/Period

Location	Date	Flow Estimate	Total Nitrogen	Nitrogen, ammonia	Nitrate/Nitrite	Phosphorus, total
Upper Coyote	Jan-Feb	35.8	269.3	1.7	213.2	2.4
	Mar-Apr	23.6	47.3	1.7	20.1	2.8
	May-Jun	29.7	99.0	1.6	65.3	6.7
	Jul-Aug	34.5	95.6	1.2	45.6	9.1
	Sep-Oct	45.8	214.8	1.4	145.9	4.7
	Nov-Dec	47.1	355.9	2.4	298.0	3.1
Lower Coyote	Jan-Feb	35.7	265.5	1.4	205.2	2.2
	Mar-Apr	16.9	31.5	1.6	9.2	2.4
	May-Jun	42.3	118.1	3.2	68.7	7.3
	Jul-Aug	35.7	83.1	2.0	32.0	8.3
	Sep-Oct	42.3	162.6	0.6	100.8	5.1
	Nov-Dec	20.6	151.0	0.8	125.8	1.0

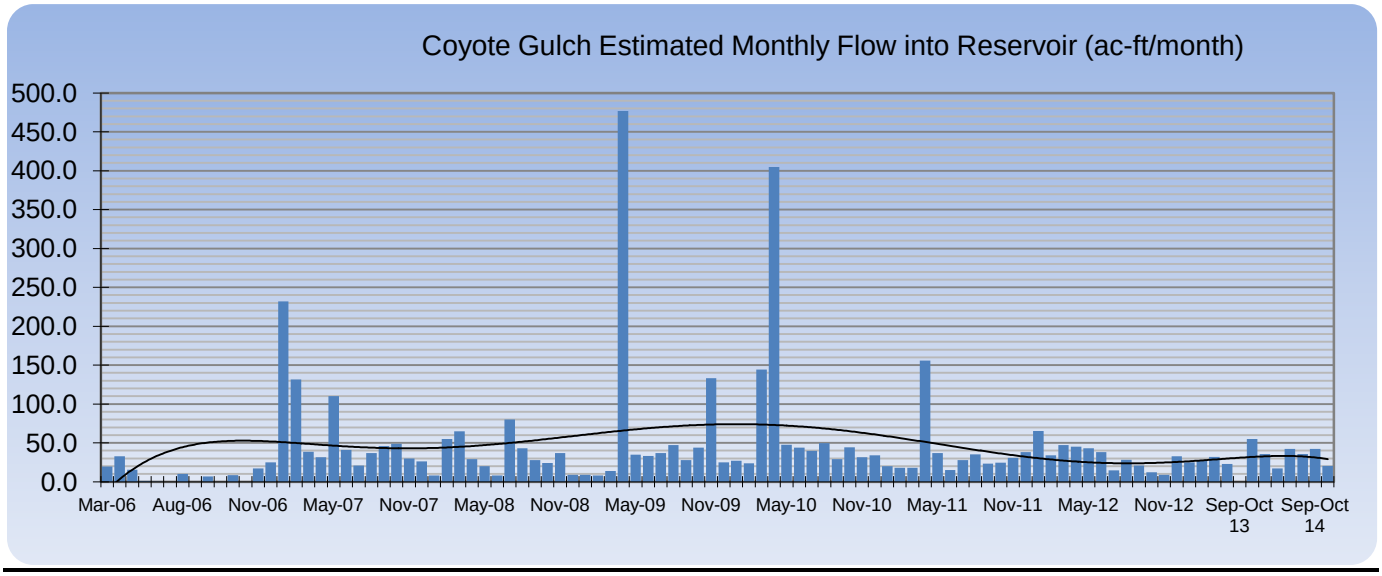

Figure 5 Coyote Gulch Estimated Monthly Flow Summary

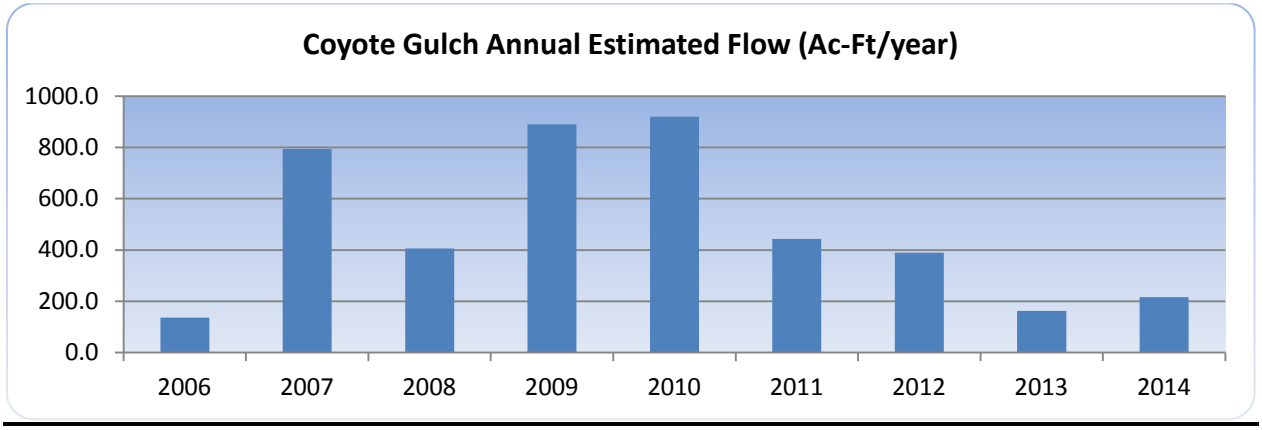

Figure 6 Annual Estimated Flows from Coyote Gulch into Bear Creek Reservoir

Table 5 Average and total pounds per month at monitoring sites as base load (all data)

		Average Loading Pounds By Year			
		Reservoir		Above Project	
		Nitrate	T Phos	Nitrate	T Phos
Pre-construction	**2006-2007**	200.7	20.0		
Post-Construction	**2007-2008**	128.7	4.4	160.9	5.2
	2009*	142.0	6.7	185.9	8.9
	2010*	203.7	8.1	222.3	8.5
	2011*	103.0	6.1	163.9	7.0
	2012	106.6	2.7	104.4	4.8
	2013	80.6	4.6	78.8	4.7
	2014	90.3	4.4	131.4	4.8
		Loading Pounds After Stable			
		Reservoir		**Above Project**	
		Nitrate	**T. Phos**	**Nitrate**	**T Phos**
	Total Pounds	**9,607**	**600**	**11,461**	**690**
	Average	**163**	**10**	**194**	**12**
	Median	**90**	**4**	**120**	**5**

2009*/2010*/2011 average loadings per year excludes April storm loadings

Table 6 Annual Available Total Phosphorus Trade Pounds

Total Phosphorus Trade Pounds				
	Total Base Flow		Trade Ration Pounds	
	Monthly	Annual	Monthly	Annual
Average	5.3	63.5	7.3	**88.0**
Median	4.6	55.2	7.7	**92.2**
Monthly TRP=PC Base Load-TBF Monthly Pounds/2				
The base trade ratio is 2:1 for Association Trade Projects				
Base Flows Exclude April Storm Loadings				
Annual Trade Pounds Available = 81.8 pounds Total Phosphorus				

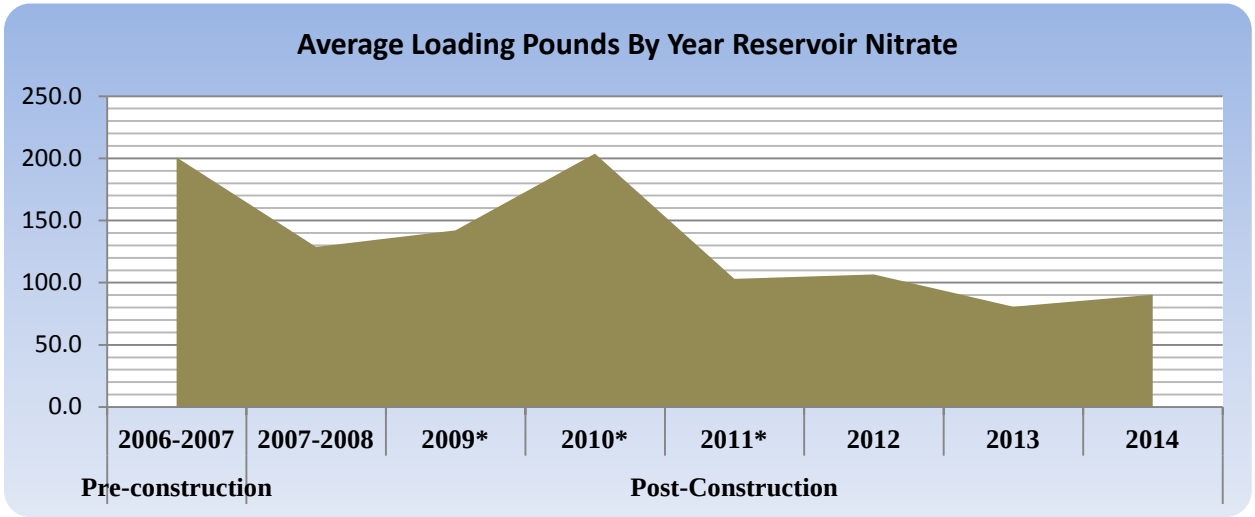

Figure 7 Average Annual Pounds of Nitrate Reaching Reservoir

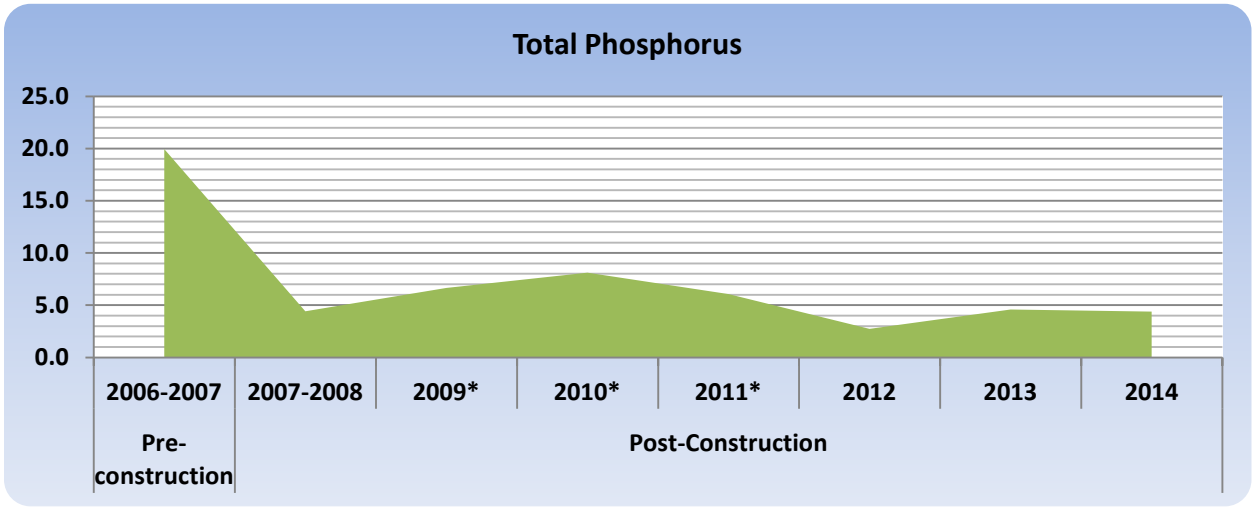

Figure 8 Average Annual Pounds of Total Phosphorus Reaching Reservoir

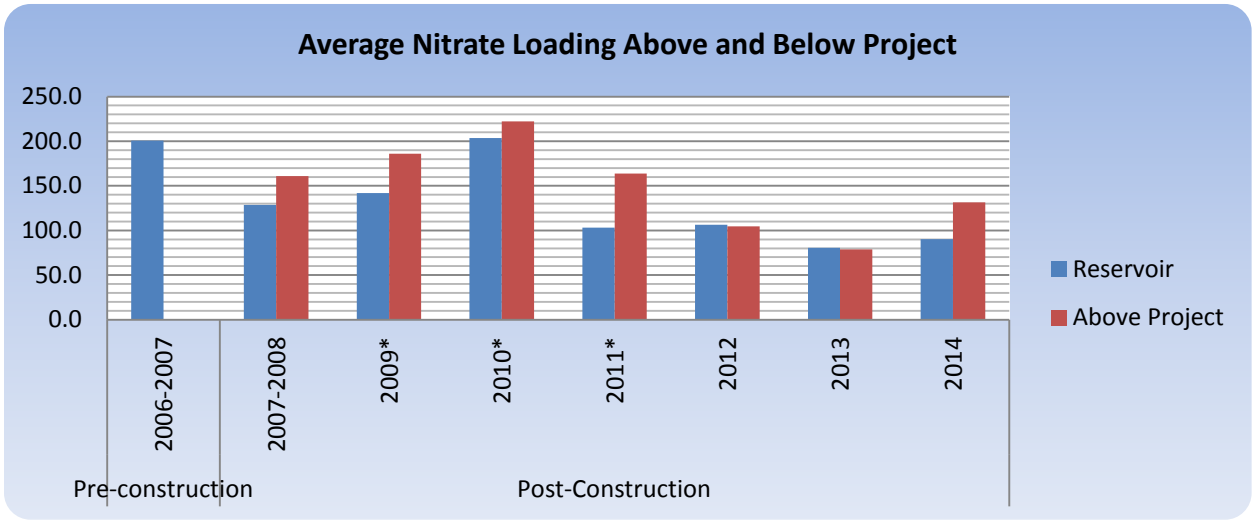

Figure 9 Average Nitrate Loading Above and Below Project

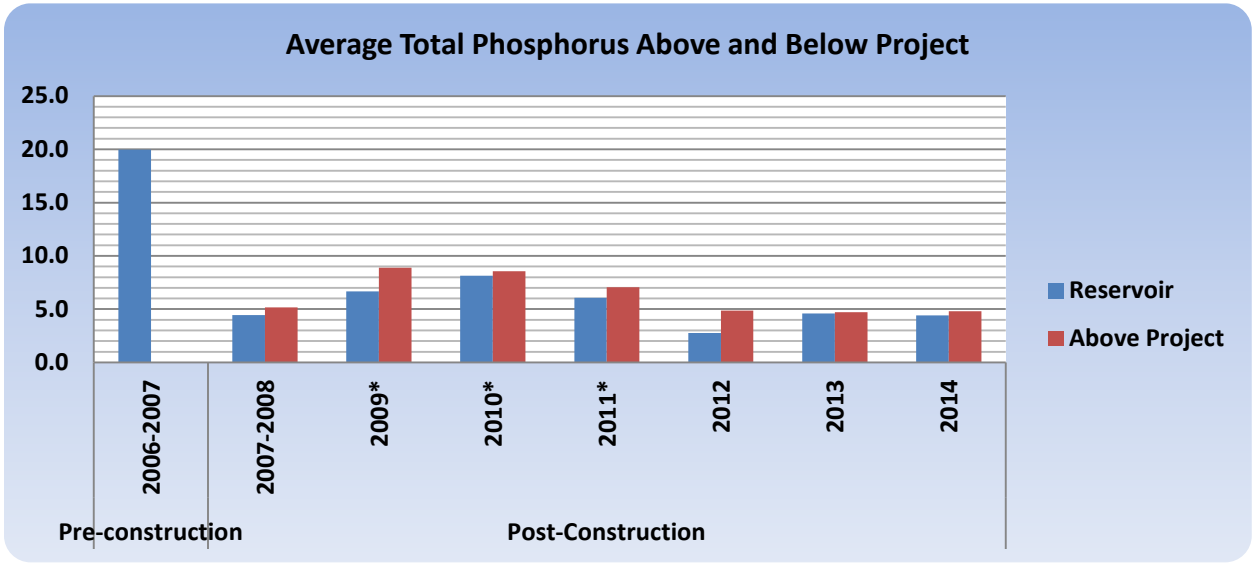

Figure 10 Average Total Phosphorus Above and Below Project

Figure 11 Coyote Gulch Pre-Construction

Figure 12 Coyote Gulch During Construction

Figure 13 New Stone Check Dam Installed

Figure 14 Coyote Gulch Construction Completion without vegetation

Figure 15 Check Dam from Figure 15 with Vegetation

Figure 16 Coyote Gulch as Stabilized in Fall 2009

Figure 17 Lower Coyote April 2010 with Storm Flows

Figure 18 October 2013 after submergence at Upper Coyote (See debris line)

Figure 19 November 2013

Figure 20 Rock drop structures not affected by submergence (November 2013)

Figure 21 Trees submerged in 50-feet water (November 2013)

Figure 22 April 21, 2014. Large amount of organic matter in drainage area.

Figure 23 Most Trees Survived the Flooding