M E M O R A N D U M

Date: **January 25, 2014**
To: ***Bear Creek Watershed Association***
From: Russell N. Clayshulte, Manager

Re: **Technical Report 2013.03 – 2013 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 2013 Field Data for Coyote Gulch

Collected by the City of Lakewood and Bear Creek Watershed Association

Location	Date	Time	pH	Temp °C	DO(mg/l)	SC (ms/cm)	Flow (cfs)	Est Periphyton Coverage %	Water Clarity
Upper Coyote	2/19/2013	12:43	8.28	0.00	8.44	1.390	0.17	0%	c
	4/22/2013	10:00	8.09	5.30	11.50	1.350	0.49	20%	c
	6/17/2013	12:58	8.34	14.70	9.06	0.740	0.39	10%	c
	8/26/2013	1:27	8.22	19.06	7.17	1.129	0.13	5%	c
	11/18/2013	12:07	8.11	0.02	12.24	1.410	0.21	5%	c
Lower Coyote	2/19/2013	12:55	8.57	0.30	13.78	1.320	0.21	5%	c
	4/22/2013	10:10	8.20	6.60	11.42	1.350	0.23	15%	c
	6/17/2013	13:00	8.27	14.70	10.34	0.730	0.27	25%	c
	8/26/2013	1:35	8.56	22.00	7.51	1.115	0.19	5%	sm
	11/18/2013	12:18	8.28	3.80	13.00	1.370	0.46	5%	c

Table 3 2013 Nutrient Data for Coyote Gulch
Collected by Bear Creek Watershed Association

Location	Date	Total Nitrogen ug/l	Nitrogen, ammonia ug/l	Nitrate/Nitrite ug/l	Phosphorus, total ug/l
Upper Coyote	2/19/2013	1898	36	1756	30
	4/22/2013	1214	14	800	37
	6/17/2013	982	41	465	87
	8/26/2013	1199	45	305	103
	11/18/2013	2010	35	1640	31
Lower Coyote	2/19/2013	1667	28	1513	15
	4/22/2013	1066	14	660	12
	6/17/2013	1192	47	427	123
	8/26/2013	1023	64	149	89
	11/18/2013	1875	55	1421	38

Table 4 2013 Nutrient Loading foe Coyote Gulch

			Loading Pounds/Period			
Location	Date	Flow Estimate	Total Nitrogen	Nitrogen, ammonia	Nitrate/Nitrite	Phosphorus, total
Upper Coyote	Jan-Feb	19.8	102.1	1.9	94.4	1.6
	Mar-Apr	58.8	194.3	2.2	128.0	5.9
	May-Jun	45.9	122.8	5.1	58.2	10.9
	Jul-Aug	15.3	50.1	1.9	12.7	4.3
	Sep-Oct	Flooded				
	Nov-Dec	24.4	110.7	1.9	100.5	1.0
Lower Coyote	Jan-Feb	25.1	114.0	1.9	103.4	1.0
	Mar-Apr	27.8	80.8	1.1	50.0	0.9
	May-Jun	32.1	104.3	4.1	37.4	10.8
	Jul-Aug	23.0	64.0	4.0	9.3	5.6
	Sep-Oct	Flooded				
	Nov-Dec	55.0	280.6	8.2	212.7	5.7

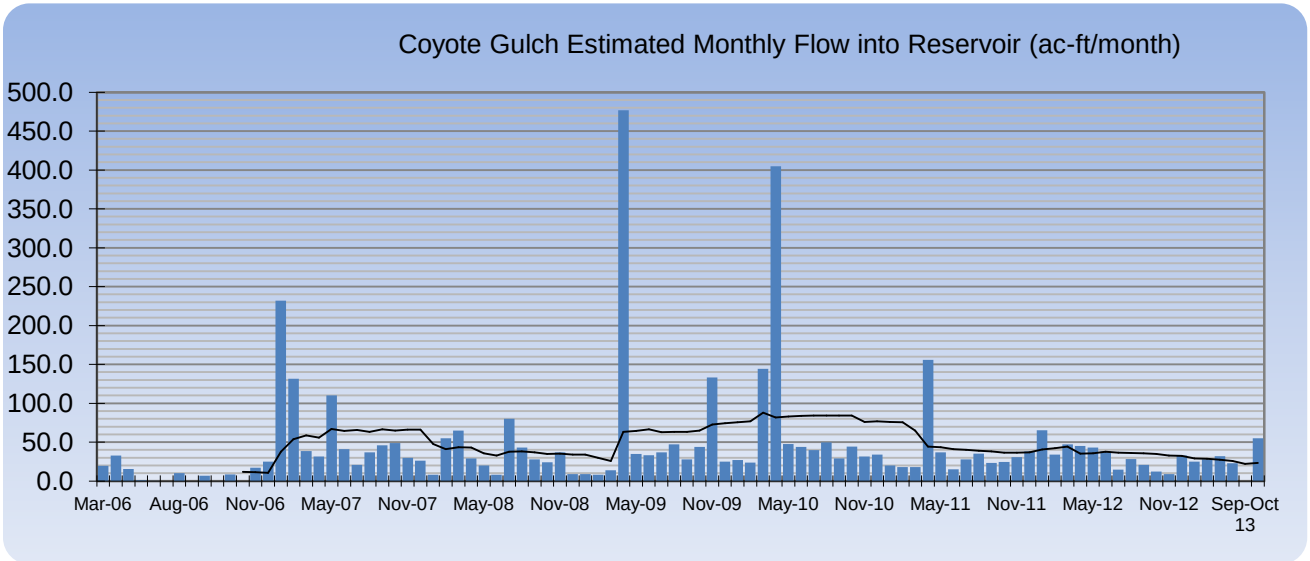

Figure 5 Coyote Gulch Estimated Monthly Flow Summary

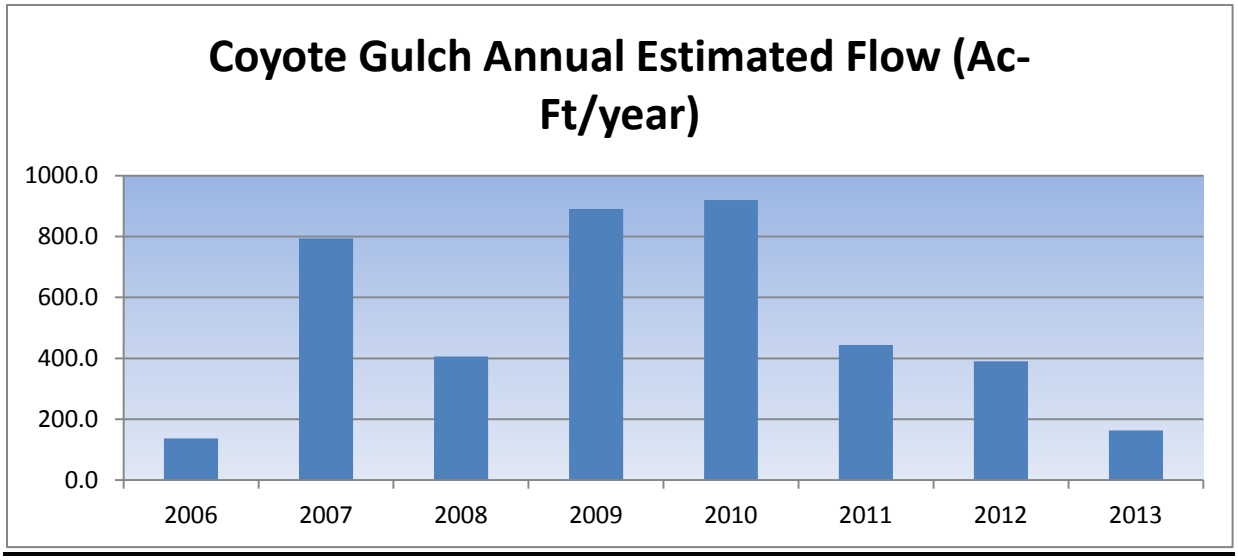

Figure 6 **Annual Estimated Flows from Coyote Gulch into Bear Creek Reservoir**

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
		Loading Pounds After Stable			
		Reservoir		**Above Project**	
		Nitrate	**T. Phos**	**Nitrate**	**T Phos**
	Total Pounds	**9,065**	**574**	**10,672**	**661**
	Average	**156**	**10**	**184**	**11**
	Median	**89**	**4**	**119**	**4**

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	5.4	65.3	7.3	**87.1**
Median	5.3	64.1	7.3	**87.7**
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 Phosphors				

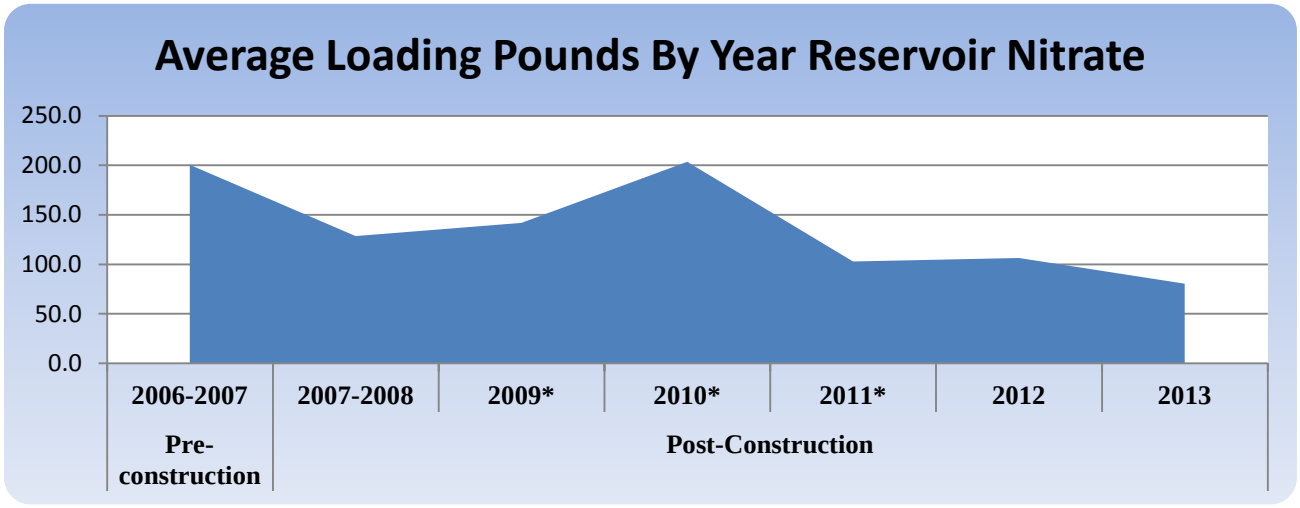

Figure 7 Average Annual Pounds of Nitrate Reaching Reservoir

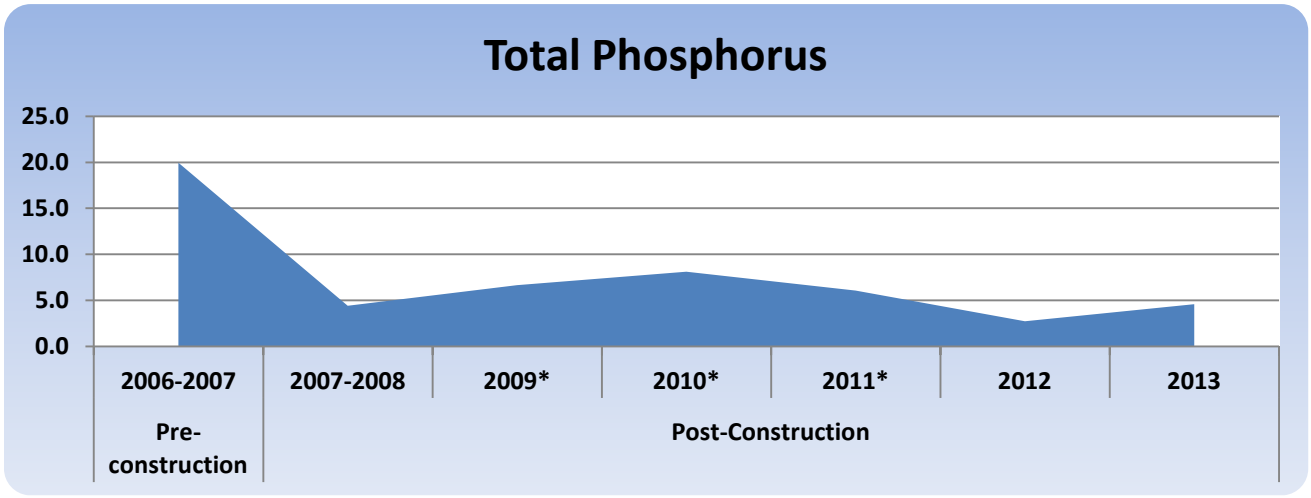

Figure 8 Average Annual Pounds of Total Phosphorus Reaching Reservoir

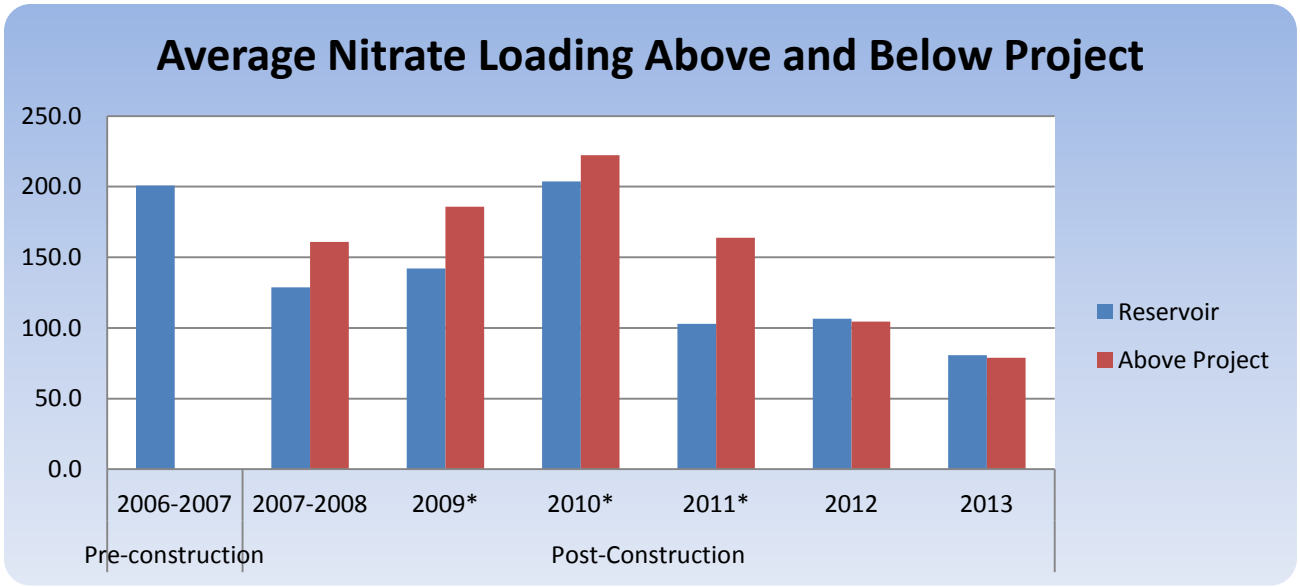

Figure 9 Average Nitrate Loading Above and Below Project

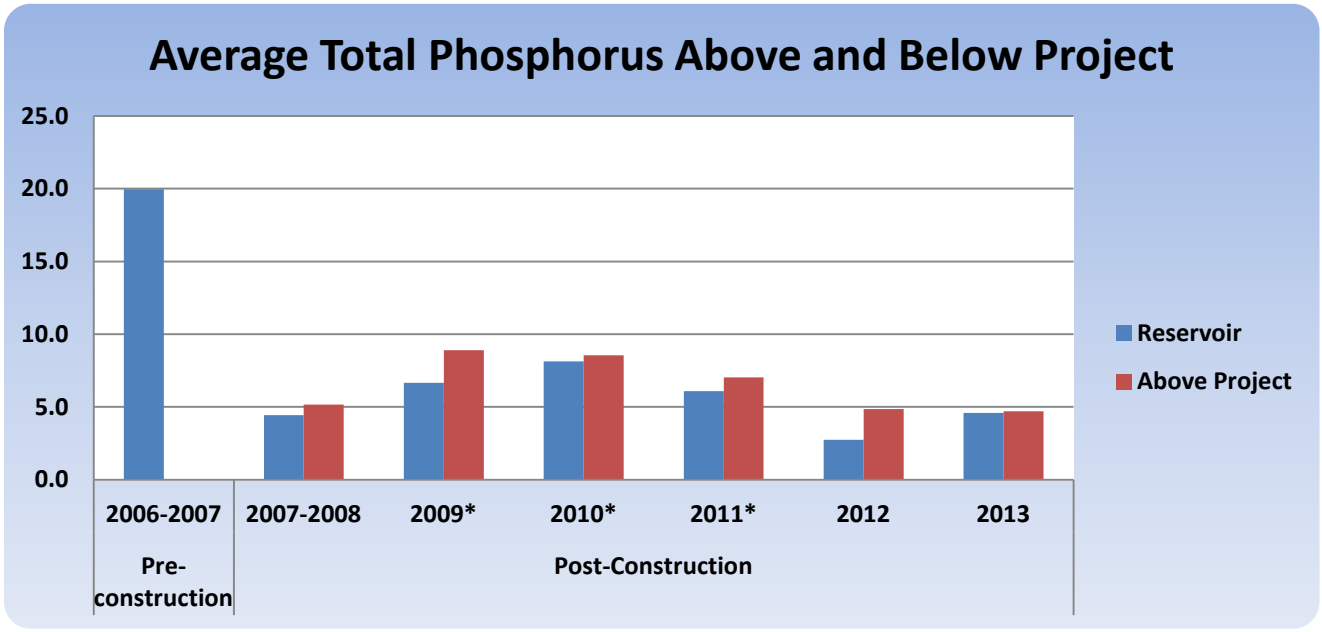

Figure 10 Average Total Phosphorus Above and Below Project

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)