Bear Creek Watershed Association

Bear Creek Watershed and the Flood of September 2013 – The Water Quality Connection

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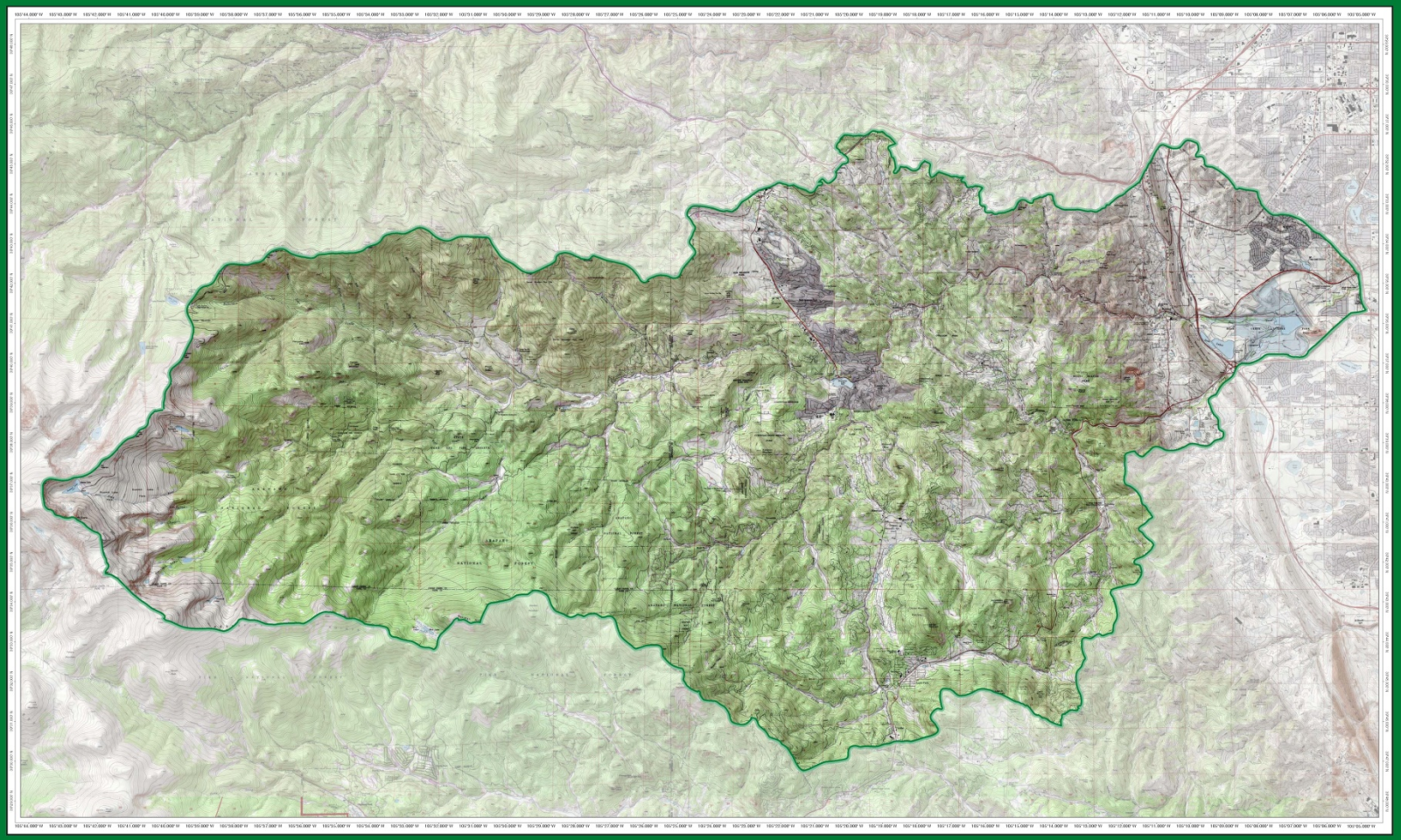
The Bear Creek Watershed Association protects & restores water & environmental quality within the Bear Creek Watershed from the effects of land use.

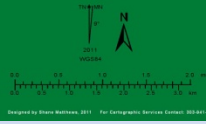
Mt. Evans

Evergreen

Morrison

Bear Creek Watershed 2011





Bear Creek Watershed Association
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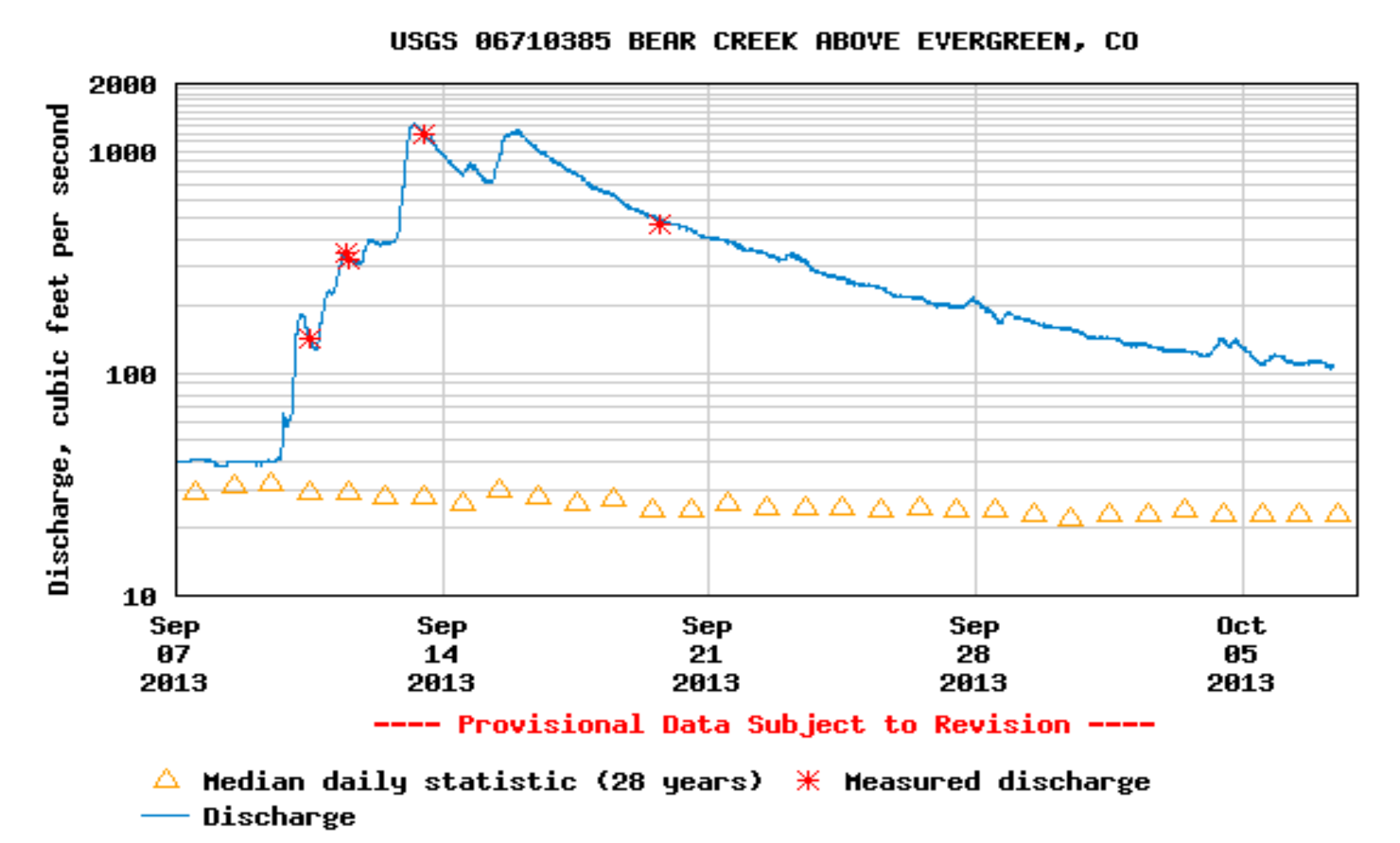
In September 2013, the Bear Creek Reservoir became a major flood control structure that prevented downstream damage.



Bear Creek @ 50 cfs

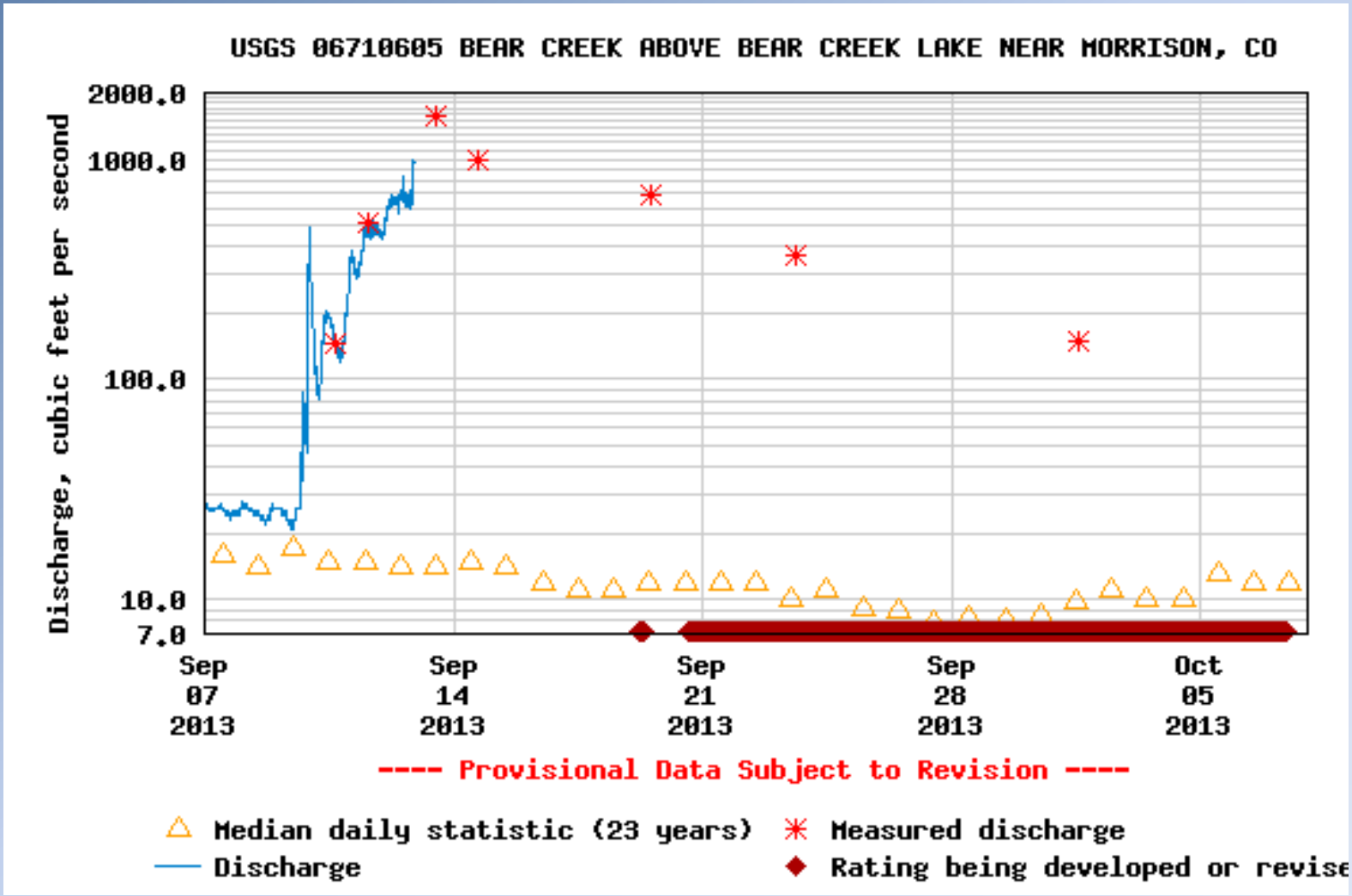
Bear Creek O'Fallon @ 300 cfs

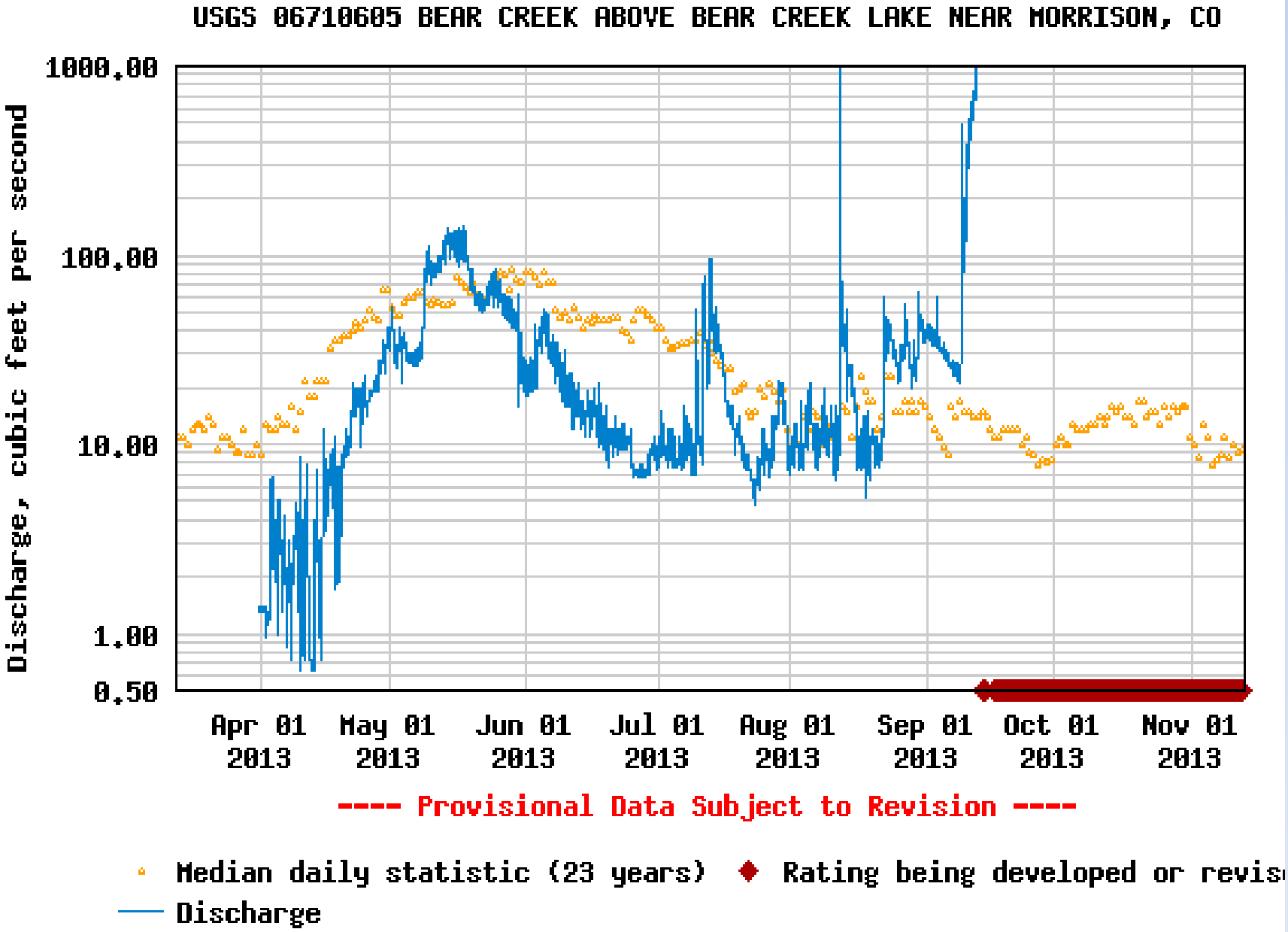
After Flood at 100 cfs

Bear Creek Park @ 500 cfs

Lower Bear Creek

Bear Creek peak stage (UDFCD) was 3,200 cfs in Morrison exceeded 3,600 cfs in the Park. Likely 50-year event

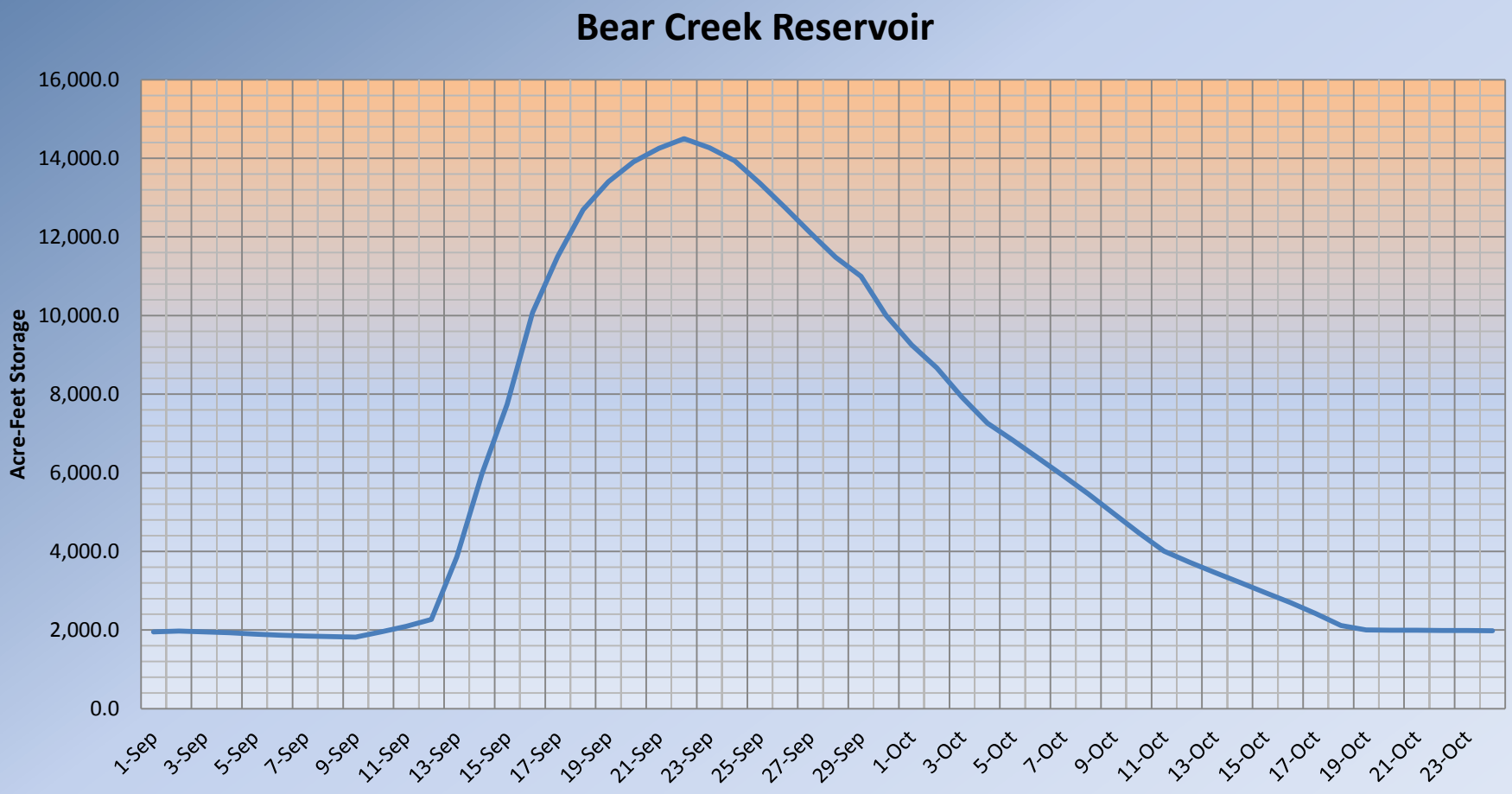



USGS 06710605 BEAR CREEK ABOVE BEAR CREEK LAKE NEAR MORRISON, CO
Discharge, cubic feet per second
1000.00
100.00
10.00
1.00
0.50
Apr 01 2013
May 01 2013
Jun 01 2013
Jul 01 2013
Aug 01 2013
Sep 01 2013
Oct 01 2013
Nov 01 2013
---- Provisional Data Subject to Revision ----
Median daily statistic (23 years)
Rating being developed or revis
Discharge

High water marks show stream width increased 3x-10x and depth up to 8’

Bear Creek Reservoir

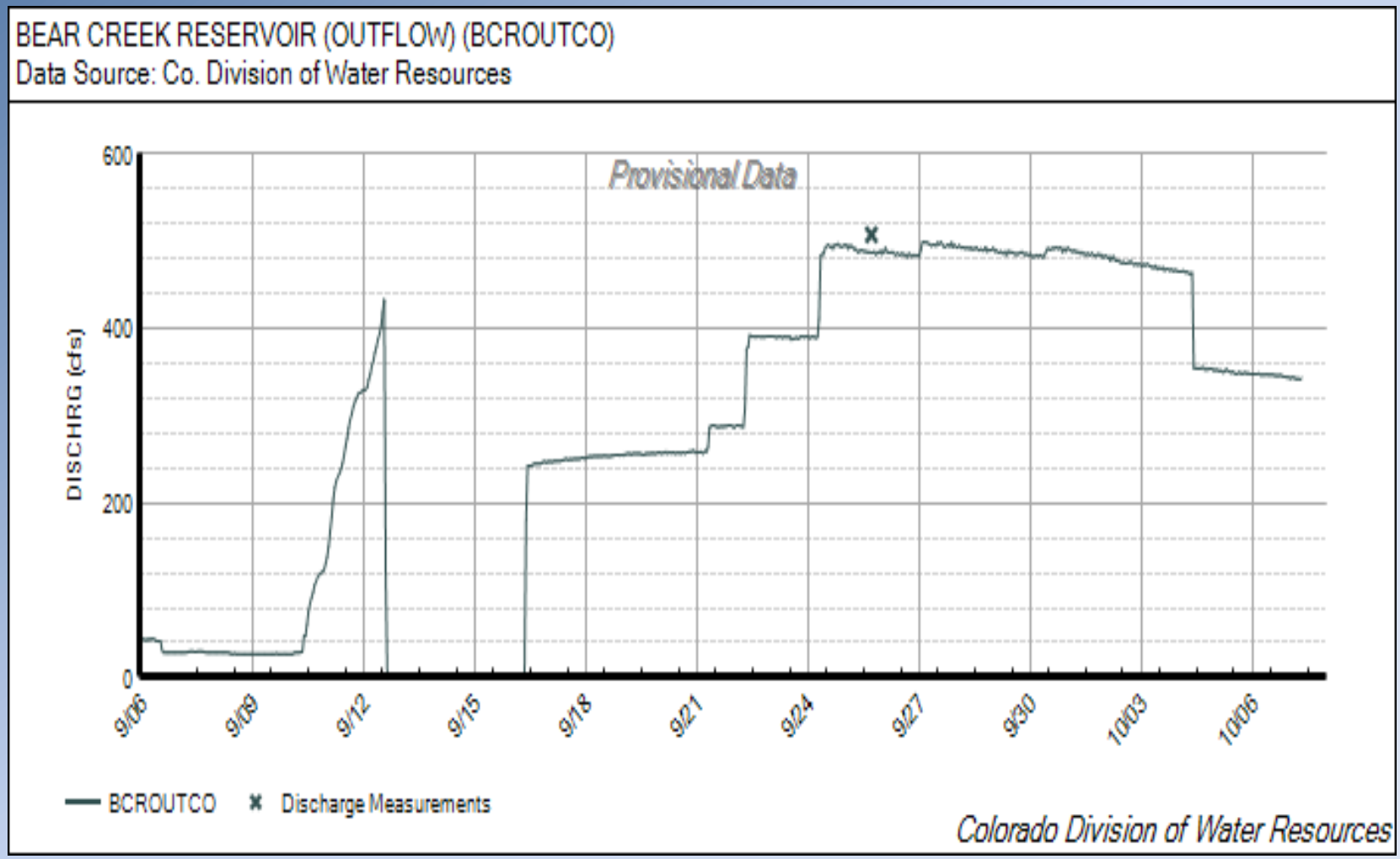
Normal pool rose from 1,817 acre-feet to about 15,000 acre-feet (5 trillion gallons) on September 22, 2013



Bear Creek Reservoir

Lower Bear Creek

U.S. Army Corps of Engineers shut the outflow gates on Bear Creek Reservoir on September 13, 2013



High Water Mark

BCR

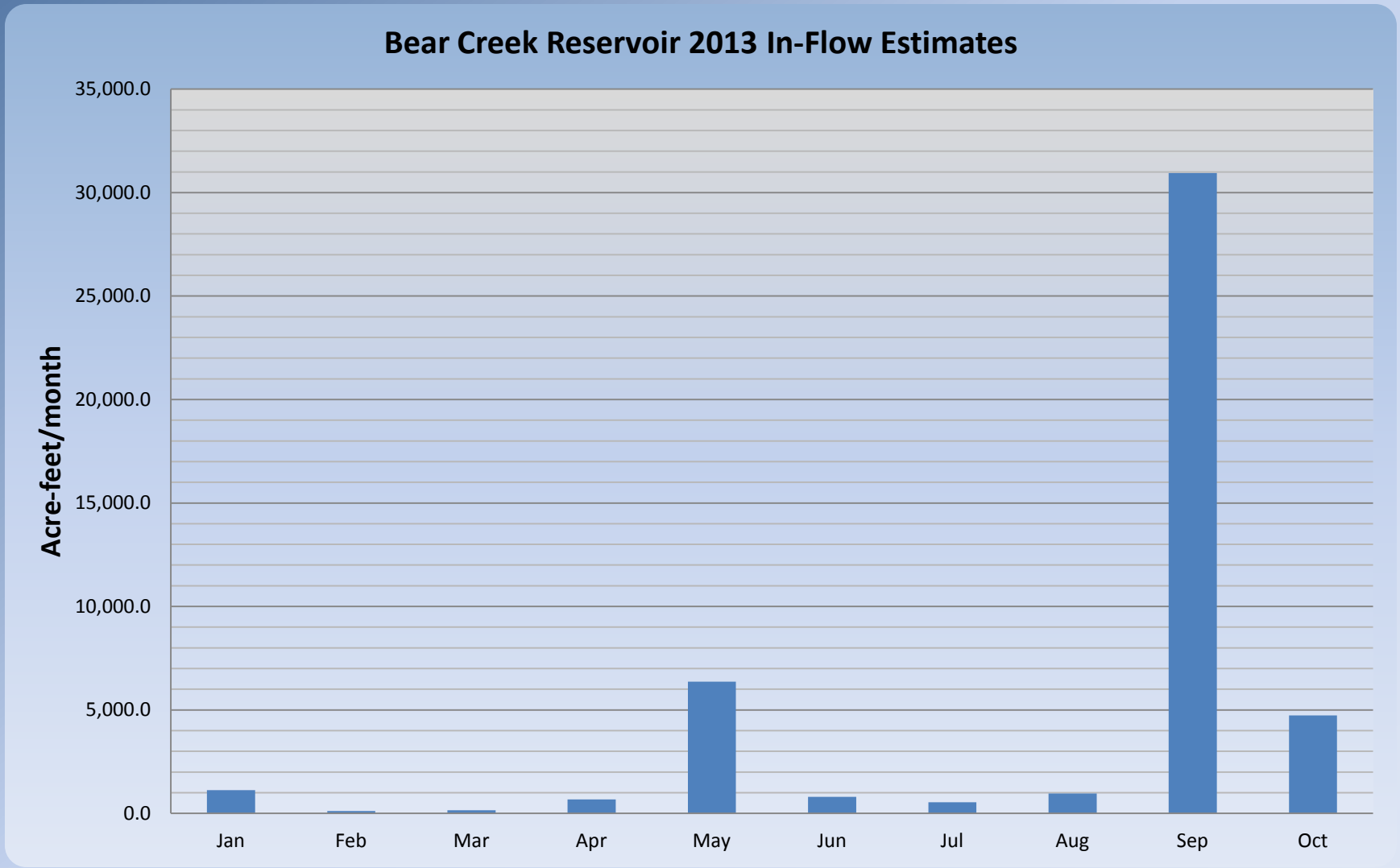
@ 14,000 ac-feet

25.75 meters

Secchi 0.50 meters

TSS – 24.7 mg/l

Changed Annual Hydrology



Lots of mud

and Organics

Bear Creek Watershed Association Surface Water Monitoring Program Version 2013.01

Water quality monitoring program

- 68 Sites (some monitored since 1991)
  - 5 Bear Creek Reservoir monitoring profiles
  - Evergreen Lake and Genesee Reservoir profiles

Year round temperature monitoring of Bear Creek and Turkey Creek

- >2,150,000 measurements

Monitor total phosphorus, dissolved phosphorus, nitrate+nitrite, total ammonia, total nitrogen, TIN, oxygen, specific conductance, temp, carbon, pH, bacteria, phytoplankton, zooplankton, chlorophyll, Secchi, TSS

Special Studies

- Fishery surveys at 14 sites
- Macroinvertebrate collections
- Habitat
- Flow studies
- BMP Effectiveness
- Stormwater data collection
- E. Coli
- Septic Systems Contributions
- Lake Sediments

Stream/ Watershed/ Wastewater Treatment Facilities	
Field Data	Laboratory Analyses
Temperature (discrete field probe)	Nitrate/Nitrite as N, dissolved
Temperature (continuous data loggers, 1/2-2m)	Total Ammonia
Dissolved Oxygen	Total Phosphorus
Specific Conductivity	Total Nitrogen
pH	E. coli, select sites
Flow	BCR Sediment study (TP)
Macroinvertebrates	BCR Sediment study (Organics)
Habitat	BCR Sediment Study (Grain Size)
Periphyton Coverage (Qualitative)	
Reservoirs (BCR and Evergreen)	
Field Data	Laboratory Analyses
Temperature (field probe, 1/2-m intervals in central pool)	Nitrate+Nitrite-Nitrogen
Temperature (continuous data loggers, 1/2-2m)	Total Nitrogen
Dissolved Oxygen (field probe, 1/2-m intervals in central pool)	Total Inorganic Nitrogen (Calculation)
	Total Phosphorus
Specific Conductivity (field probe, 1/2-m intervals in central pool)	Total Dissolved Phosphorus
pH (field probe, 1/2-m intervals in central pool)	Chlorophyll
Total depth	Residue, Non-Filterable (TSS)
Secchi Reading	BCR Phytoplankton (July, August, September only; six sample sets)
Wastewater Treatment Facilities	
Field Data	Laboratory Analyses
Daily average effluent discharge	Total Nitrogen
Temperature (continuous data loggers, Effluent)	Nitrate+Nitrite-Nitrogen
	Ammonia-Nitrogen
	Total Inorganic Nitrogen (Calculation = NO2+NO3+NH4)
	Total Phosphorus

Site ID	Site Location by Stream Segment	2013			Reference Site	Sample Months
		Data Logger	Manual Flows	Chemistry		
Segment 1a						
WWTF Site 1	Singing River Ranch			**x**		
Site 58	Bear Creek above Singing River Ranch	x	x	x	R	May-Nov
Site 1b ETU	Williams Bridge	x				
Site 2a	Golden Willow Bridge	x	x	x	R	May-Nov
Site 2b ETU	Below Golden Willow at mile marker 3.5	x				
Site 3a	Above Evergreen Lake at CDOW Site	x	USGS gauge	x		May-Nov
Segment 1b						
Site 15a	Bear Creek within Bear Creek Park	x	USGS gauge	x	R	Jan-Dec
Site 24	Morrison WWTF	x		x		March-Nov

Damages

- Flooding upper Bear
- >10 major stream breeches
- Sediment infilling Evergreen Lake
- Damaged >50 bridges and roads/ driveways
- Flooded and exposed sewer mains
- Heavy damage to recreation facilities Bear Creek Park
- Lost gaging station
- Lost temperature probes
- Lost stream gauges
- Massive stream erosion
- Breeched most side fish ponds

Did the flood cause an ecological reset?

- Altered stream channels, heavy scouring
- Changed stream embeddedness
- Massive sediment movement - boulders to silt-clay
- Deposition in reservoirs and lakes
- Displaced fish populations
- Impacts to macroinvertebrates
- Removed periphyton from substrate
- Altered stream chemistry
- Flushing nutrients from alluvial areas
- Destroyed or removed wetlands

Looked at water quality

Site	Description	Total Nitrogen	NO2+NO3	Ammonia	Total Phosphorus
Segments 7 and 8					
Site 36	Summit Lake (Segment 8)	345	165	16	6
Site 65	Bear Creek Mainstem Between Pond #1 & #2	283	167	14	8
Site 37	Bear Creek Mainstem (Segment 7)	338	169	169	6
Segment 3					
Site 25	Vance Creek (Mt. Evans Wilderness)	260	37	16	23
Segment 1a					
Site 58	Bear Creek above Singing River Ranch	274	121	2	16
Site 2a	Golden Willow Bridge	323	94	9	20
Site 3a	Above Evergreen Lake at CDOW Site	414	122	19	26
Segment 1d					
Site 4a	Evergreen Lake Profile Station, 1.5m	401	106	22	26
Site 4e	Evergreen Lake Profile Station, 4.5m	382	106	21	31
Segment 1e					
Site 5	CDOW downtown Little Bear site	**347**	130	6	**22**
Site 8a	Bear Creek Cabins at CDOW Site	**376**	146	14	**25**
Site 9	O'Fallon Park, west end at CDOW Site	**384**	159	21	**25**
Site 12	Lair o' the Bear Park, at CDOW site	**410**	179	16	**29**
Site 13a	Below Idledale, Shady Lane CDOW site	**454**	178	18	**28**
Site 14a	Morrison Park west end at CDOW Site	**456**	185	10	**29**
Segment 4a					
Site 34	Mt Vernon Drainage, Morrison	1938	1415	13	30
Segment 5					
Site 50	Cub Creek, Upstream Cub Creek Park	615	375	21	48
Site 35	Cub Creek @ Brookforest Inn	385	221	12	26
site 32	Troublesome Mouth	**1635**	632	44	**137**
Site 64	Troublesome at Culvert above West Jeff	902	175	11	86
Site 18	South Turkey Creek Aspen Park Metropolitan District	555	17	14	18
Site 16a	Turkey Creek within Bear Creek Park	712	323	31	57
Segment 6b					
Site 19	North Turkey Creek Flying J Ranch Bridge	692	245	12	34
Segment 1b					
Site 15a	Bear Creek within Bear Creek Park	610	207	27	50
Segment 1c					
Site 40a	Bear Creek Reservoir 1/2m	968	209	49	166
Segment 2					
Site 45	Lower Bear Creek, concrete trace/ weir	635	215	62	61

EGL Quality

Evergreen Lake 9/24/2013			
Site	**Parameter**	**Result**	**Units**
4a	Total Nitrogen	401	µg/L
4a	Nitrate/Nitrite as N, dissolved	106	µg/L
4a	Nitrogen, ammonia	22	µg/L
4a	Phosphorus, total	26	µg/L
4a	Total Dissolved Phosphorus	8	µg/L
4a	Residue, Non-Filterable (TSS)	7.6	mg/L
4a	Chlorophyll a	0.3	µg/L
4a	Chlorophyll a	0.3	µg/L
4e	Total Nitrogen	382	µg/L
4e	Nitrate/Nitrite as N, dissolved	106	µg/L
4e	Nitrogen, ammonia	21	µg/L
4e	Phosphorus, total	31	µg/L
4e	Total Dissolved Phosphorus	8	µg/L
4e	Residue, Non-Filterable (TSS)	12.8	mg/L

Evergreen Lake September > 20,650 ac-ft
TP(res) pounds >1,650
TN(res) pounds >22,550

EGL is a direct use water supply

High Turbidity

Bear Creek Park

BCR Input/ Output Quality

Site	Parameter		5-Aug	9-Sep	23-Sep
Turkey Creek Inflow					
16a	Total Nitrogen	µg/L	**1049**	**962**	**712**
16a	Nitrate/Nitrite as N, dissolved	µg/L	**557**	**851**	**323**
16a	Nitrogen, ammonia	µg/L	**53**	**53**	**31**
16a	Phosphorus, total	µg/L	**28**	**11**	**57**
16a	Total Dissolved Phosphorus	µg/L	**7**	**2**	**15**
16a	Residue, Non-Filterable (TSS)	mg/L	**16.4**	**20.2**	**20.4**
Bear Creek Inflow					
15a	Total Nitrogen	µg/L	**1078**	**592**	**610**
15a	Nitrate/Nitrite as N, dissolved	µg/L	**327**	**415**	**207**
15a	Nitrogen, ammonia	µg/L	**206**	**43**	**27**
15a	Phosphorus, total	µg/L	**68**	**49**	**50**
15a	Total Dissolved Phosphorus	µg/L	**28**	**15**	**13**
15a	Residue, Non-Filterable (TSS)	mg/L	**14.5**	**13.0**	**17.6**
Lower Bear Creek Reservoir Outflow					
45	Total Nitrogen	µg/L	**2241**	**607**	**635**
45	Nitrate/Nitrite as N, dissolved	µg/L	**29**	**80**	**215**
45	Nitrogen, ammonia	µg/L	**56**	**66**	**62**
45	Phosphorus, total	µg/L	**259**	**120**	**61**
45	Total Dissolved Phosphorus	µg/L	**83**	**51**	**25**
45	Residue, Non-Filterable (TSS)	mg/L	**15.4**	**18.0**	**10.4**

BCR Inflow September > 31,000 ac-ft
TP(res) pounds >14,000
TN (res) pounds > 82,000

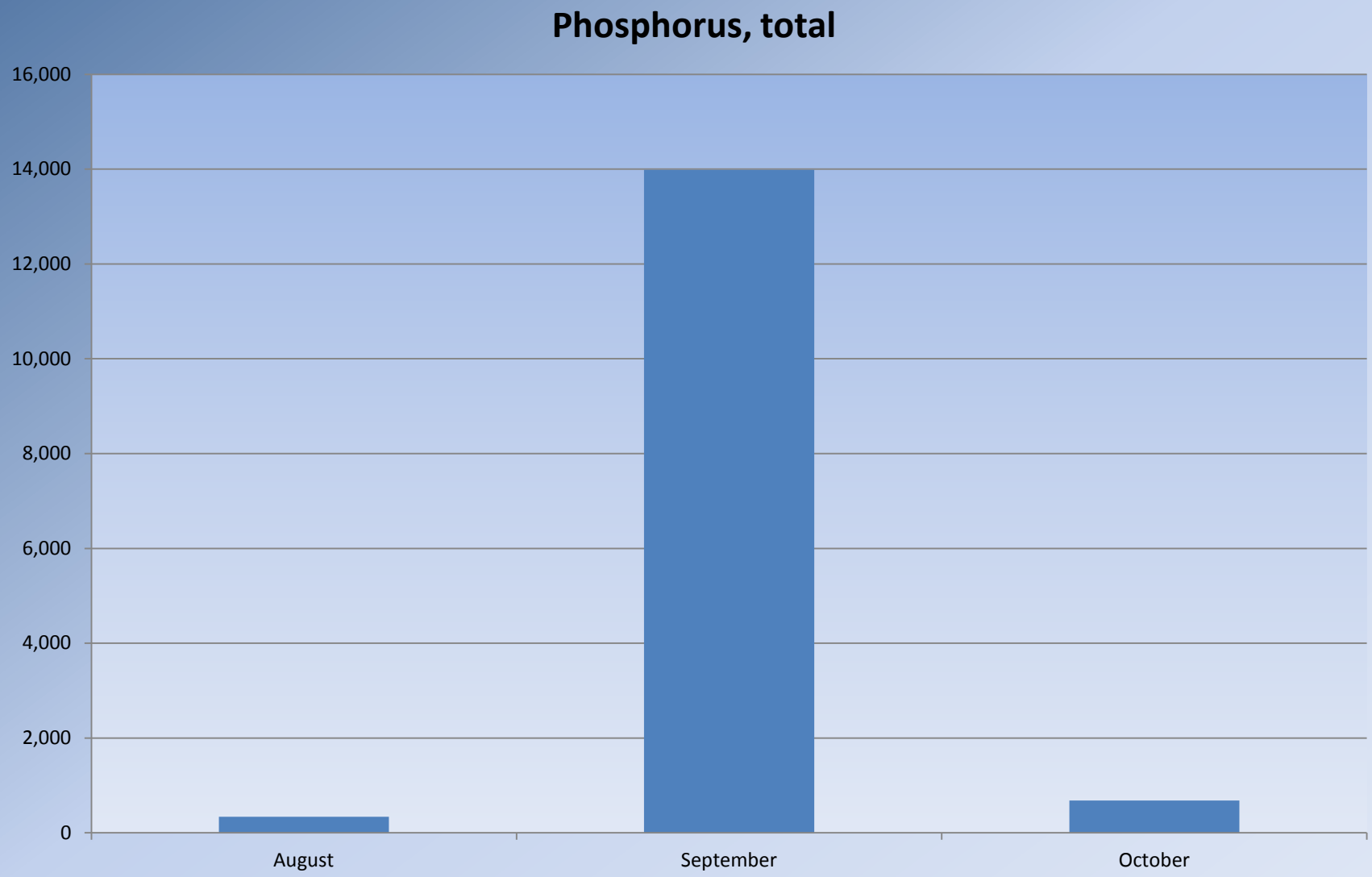
BCR Quality

			5-Aug	9-Sep	23-Sep	11-Oct
Bear Creek Reservoir (-1/2m)						
40a	Total Nitrogen	µg/L	**1272**	**864**	**968**	**715**
40a	Nitrate/Nitrite as N, dissolved	µg/L	**36**	**75**	**209**	**173**
40a	Nitrogen, ammonia	µg/L	**149**	**57**	**49**	**34**
40a	Phosphorus, total	µg/L	**128**	**138**	**166**	**53**
40a	Total Dissolved Phosphorus	µg/L	**88**	**60**	**30**	**26**
40a	Residue, Non-Filterable (TSS)	mg/L	**7.0**	**14.8**	**6.6**	**10.2**
40a	Chlorophyll a	µg/L	**25.1**	**56.0**	**4.7**	**12.4**
40a	Chlorophyll a	µg/L	**28.0**	**52.5**	**4.4**	**12.1**
Bear Creek Reservoir (-10m)						
40b	Total Nitrogen	µg/L	**978**	**453**	**676**	**723**
40b	Nitrate/Nitrite as N, dissolved	µg/L	**38**	**88**	**228**	**168**
40b	Nitrogen, ammonia	µg/L	**181**	**115**	**54**	**34**
40b	Phosphorus, total	µg/L	**123**	**112**	**60**	**52**
40b	Total Dissolved Phosphorus	µg/L	**97**	**48**	**29**	**16**
40b	Residue, Non-Filterable (TSS)	mg/L	**9.6**	**23.0**	**4.6**	**39.8**
Bear Creek reservoir (-20m)						
40c	Total Nitrogen	µg/L			**601**	**757**
40c	Nitrate/Nitrite as N, dissolved	µg/L			**203**	**169**
40c	Nitrogen, ammonia	µg/L			**65**	**42**
40c	Phosphorus, total	µg/L			**57**	**132**
40c	Total Dissolved Phosphorus	µg/L			**23**	**16**
40c	Residue, Non-Filterable (TSS)	mg/L			**7.2**	**7.7**

BCR Load Estimates

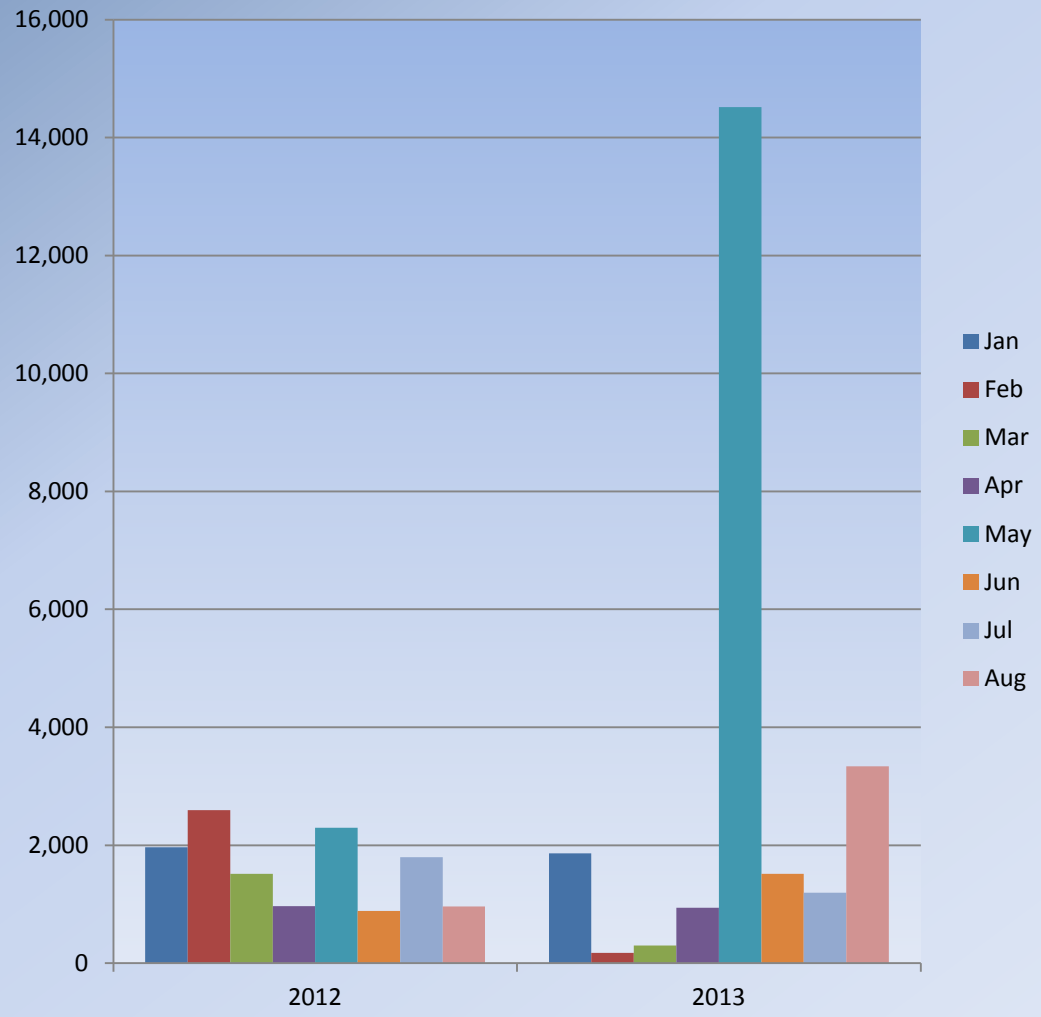
	Estimated Pounds		
	August	September	October
Total Nitrogen	3,340	81,560	9,229
Nitrate/Nitrite as N, dissolved	95	17,610	2,233
Nitrogen, ammonia	391	5,814	439
Phosphorus, total	336	13,986	684
Total Dissolved Phosphorus	231	2,528	335
Residue, Non-Filterable (TSS)	18,400	1,720,000	156,200

Total Phosphorus Load BCR

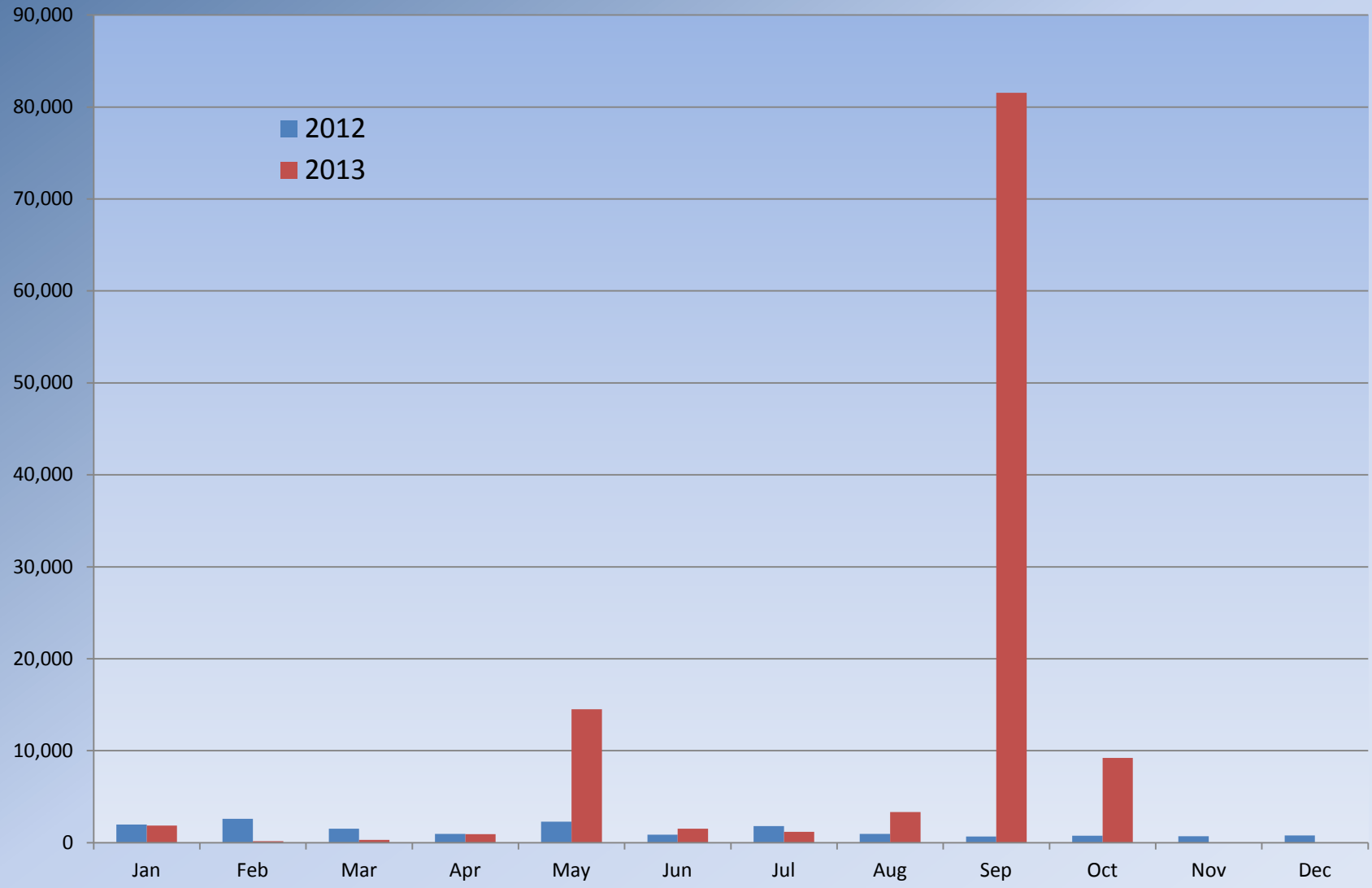


Total Nitrogen BCR

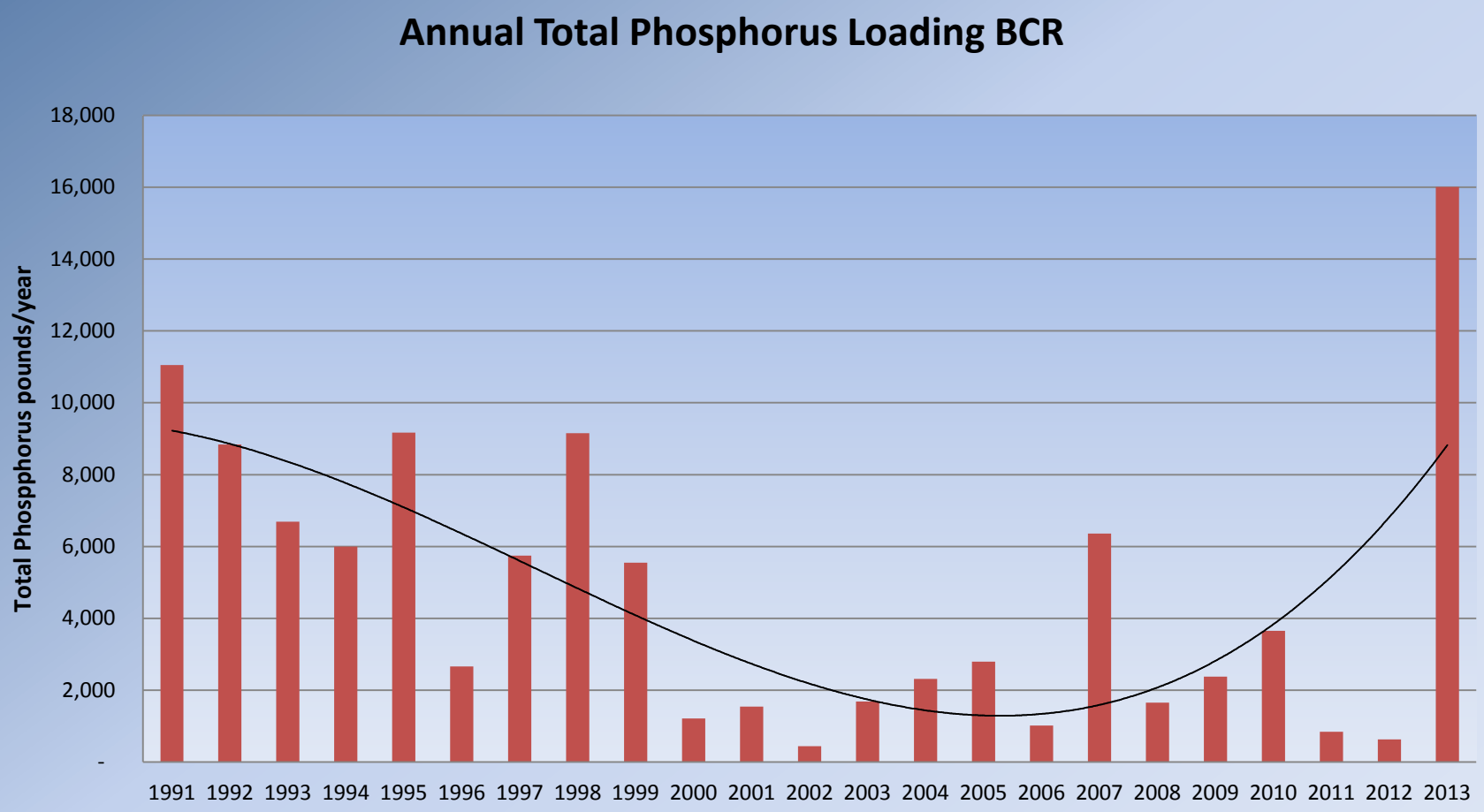
	Total Nitrogen Total Load Pounds/Month	
	2012	2013
Jan	1,965	1,860
Feb	2,596	177
Mar	1,514	302
Apr	968	940
May	2,299	14,514
Jun	884	1,516
Jul	1,797	1,195
Aug	961	3,340
Sep	677	81,560
Oct	760	9,228
Nov	693	
Dec	773	
Total	15,887	114,633



Total Nitrogen Pounds/ Month



Total Phosphorus Annual Load BCR



Nutrient Retention BCR

	Estimated Pounds Retained			
	Reservoir	Outflow	Retained	
Total Nitrogen	81,560	53,501	28,059	34%
Nitrate/Nitrite as N, dissolved	17,610	14,239	3,371	19%
Nitrogen, ammonia	5,814	4,128	1,686	29%
Phosphorus, total	13,986	5,139	8,847	63%
Total Dissolved Phosphorus	2,528	1,937	591	23%
Residue, Non-Filterable (TSS)	1,720,000	362,380	1,357,620	79%

Adapt Management Program

- New internal nutrient load
- New baseline surveys for fishery, macroinvertebrates, habitat, pebble counts, stream flows, tributaries, reservoir sediments
- Determine changes to Coyote Gulch trade project and baseline removal efficiency
- Modify monitoring program, temperature probes, field stream gauges

Expectations BCR

- Algal blooms
- Dissolved Oxygen problems
- High organic decay
- Odor problems
- Nutrient internal load increases
- Difficultly meeting standards
- Modify management strategies
- Repair aeration system
- Replace station buoy
- More of same in future