

Memorandum

To: Rick Goncalves, Chairman, CCBWQA TAC
CC: Chuck Reid, Manager, CCBWQA
From: William P. Ruzzo, P.E.
Date: May 25, 2011
Re: Cherry Creek Stream Reclamation at 12-Mile Park – Water Quality Benefits and Costs

Presented in this memorandum is a more detailed evaluation of the water quality benefits and costs for the Cherry Creek Stream Reclamation at 12-Mile Park project (12-Mile Park). The 12-Mile Park project consists of approximately 3,000 feet along the outside bend of Cherry Creek adjacent to the existing dog park (see Figure 1).

BACKGROUND

Water quality benefits and costs for the 12-Mile Project were first evaluated for the 2008 5-year capital improvement program (CIP) based on master planning level estimates for projects costs. Since then, the Authority initiated alternative investigations and preliminary design for the 12-Mile Project resulting in updated information on stream reclamation needs and cost projections¹. Also, a breach in the right bank of Cherry Creek resulted in stream flows being diverted away from the main channel resulting in sediment deposition in the wetlands and other environmental damages that were not considered in the 2008 water quality evaluation.

In addition, Cherry Creek State Park (CCSP) has been developing a plan to upgrade the off-leash dog area (DOLA) adjacent to and part of the 12-Mile Park project. CCSP projections conservatively estimated the number of dog visits per year to be 450,000. Because the CCSP and the Authority project are overlapping in area, water quality impact, and benefits, the two projects are integral. This updated information provides the basis for preparing a more detailed evaluation of water quality costs and benefits for the 12-Mile Park project.

¹ CH2MHill April 2011. *Cherry Creek at 12-Mile Park Draft Alternatives Evaluation Report.*

OVERVIEW OF WATER QUALITY BENEFITS

Water quality benefits from the combined 12-Mile Park and DOLA projects (combined projects) fall into one of two categories, stream reclamation or recreation management.

Stream Reclamation. Stream reclamation benefits and evaluation procedures have been documented in the Authority's Stream Reclamation Interim Report². Benefits include reductions in sediment and other pollutant loads and concentrations, including phosphorus and nitrogen. These benefits are supported by Authority data, literature research, and quantitative analysis. Procedures used by the Authority to quantify phosphorus reduction benefits are also provided in the Interim Report and were used herein to quantify benefits of the 12-Mile Park project.

The CH2M Hill stream reclamation plan also addresses the dispersed runoff from the DOLA by including a bioswale along the top of the east bank of Cherry Creek. This BMP is intended to capture minor storm events from the DOLA and provide filtration and infiltration treatment of the runoff.

Because of the breach that occurred in the right bank of Cherry Creek, the 12-Mile Park project also includes repairs and restoration of Cherry Creek and the damaged wetland area. The primary benefit of the breach repair that's not included in overall stream reclamation is the removal of deposited sediment and vegetative restoration of the damaged area. The benefits of sediment removal have been quantified in this memo using procedures documented in the Interim Report.

Recreation Management. The CCSP DOLA project includes extensive improvements, relative to water quality, such as perimeter fencing, controlled access to Cherry Creek, and waste management practices. Quantification of water quality benefits for perimeter fencing and controlled access to Cherry Creek is assumed to be part of the overall stream reclamation benefits. Benefits of waste management practices, however, have been quantified in this memorandum.

In addition to management of the dog use area, the overall CCSP project includes modifications to the horse boarding area, which is adjacent to the DOLA area on the west and south. The principal modification to the horse area, relative to water quality, will be an updated manure management plan, whose benefits have been quantified in this memorandum.

QUANTIFICATION OF WATER QUALITY BENEFITS

Calculations were performed to quantify the water quality benefits associated with stream reclamation and recreation management activities discussed above. The

² CCBWQA Technical Advisory Committee, April 12, 2011 (final draft). *Stream Reclamation, Water Quality Benefit Evaluation – Interim Report.*

calculations, assumptions, and variables used in the analysis are provided within the appendix to this memorandum. A summary of the calculations is presented below.

Stream Reclamation. Calculations (sheet 1) were made following the guidelines in the Interim Report, except that the interest rate used for this analysis was 4%³. The results show that over the life of the project, the phosphorus reduction for stream stabilization alone is 51-lbs per year and the life-time unit cost is \$1,520 per pound of phosphorus.

Calculations for the breach area benefits (sheet 2) were based solely on the phosphorus content of eroded sediment from the wetlands area using data gathered as part of the reclamation project design. The benefits (i.e.: phosphorus load in the sediment) was spread out over the assumed project life of 35-years, resulting in an additional 37 lbs per year of phosphorus reduction.

Calculations for the bio-swale benefits are discussed under the Dog Use Area Improvements and the Waste Management Plan for Horse Boarding Area, but are considered part of the stream reclamation benefits because the 12-Mile Park project includes a bioswale. The reported⁴ effectiveness of bio-swales to immobilize phosphorus varies widely (i.e.: 30 to 80%). For conservatism, bio-swale effectiveness was assumed to be 30% for phosphorus immobilization.

Dog Use Area Improvements. Calculations (sheet 3) of benefits associated with management of the dog wastes are based on values generated by CCSP using traffic counts, visitor surveys, and DOLA pass sales. Their analysis of the DOLA area use shows that about 450,000 dog-visits per year occur generating four cubic yards of waste per week. Since dog waste contain around 10% of phosphates per pound, the DOLA generates over 25,000 pounds of phosphorus per year which could reach Cherry Creek if not managed properly⁵. The CCSP dog waste management plan is anticipated to be 90% efficient in removal of waste and phosphorus, resulting in a net water quality by reducing almost 23,000 pounds of phosphorus per year.

For the stream reclamation component (sheet 3), it is conservatively estimated that 10% of the dog wastes will not be removed through waste management, but would still be treated before discharging into Cherry Creek by including bioswale in the stream reclamation plan along the creek bank adjacent to the DOLA. The assumed efficiency of the bio-swale is 30%, which is conservatively low. This BMP can

³ At the Boards request, the Authority is investigating the appropriate discount rates to be used in evaluation of Authority CIP projects. The value used has not been approved by the Board but is believed to be a reasonable rate for this analysis.

⁴ Oregon Department of Environmental Quality January 2003. *Biofilters (Bioswales, Vegetative buffers, & Constructed Wetlands for Storm Water Discharge Pollution Removal*.

⁵ The amount of phosphorus in dog waste used in this analysis is approximately 0.6 lbs/year/dog. Lake Tahoe investigation (<http://www.4swep.org/resources/LakeTahoeReport/064.html>) suggest the value could be as high as 2 lbs/year/dog.

effectively prevent about 780 lbs/year of phosphates from dog wastes from entering Cherry Creek.

Waste Management Plan for Horse Boarding Area. Calculations (sheet 4) of benefits associated with an effective horse manure management plan are based on the pending renewal of the concessionaire lease for the facility. Based on an internet literature search, the amount of manure waste per 1,000-pound horse and the phosphorus content were determined. The number of horses and the rental season were approximated from discussions with CCSP staff. The horse boarding area is estimated to generate over 232,000 pounds of phosphorus per year.

For the stream reclamation component, it is conservatively estimated that 10% of the manure wastes will not be removed through waste management, but would still be treated before discharging into Cherry Creek by including bio-swale in the stream reclamation plan along the creek bank adjacent to the DOLA. The assumed efficiency of the bio-swale is 30%, which is conservatively low. This BMP can effectively prevent about 21 pounds/year of phosphates from manure wastes from entering Cherry Creek.

The potential impacts of storm runoff from dog waste and horse manure on phosphorus concentrations in Cherry Creek were also estimated for the loads that are not otherwise removed through waste management practices (sheet 5). The estimated annual phosphorus load from these sources is 2,670 pounds and the mean annual flow in Cherry Creek at 12-Mile Park project is estimated to be 15,000 acre feet. This converts to a concentration of 0.065 mg/l. When compared to the mean annual phosphorus concentration in Cherry Creek (i.e.: 0.210 mg/l), the potential impacts are apparent. Phosphorus from dog waste and horse manure could contribute to the degradation of water quality in Cherry Creek Reservoir.

WATER QUALITY COST/BENEFITS

The final step in the analysis was a comparison of project costs and benefits, as measured by the reduction in phosphorus through project construction. Cost and benefits are compared separately for the Authority's stream reclamation work and the CCSP recreation management work.

Stream Reclamation. Table 1 below shows the benefits of stream reclamation individual components and Table 2 compares the cost and benefits for the total stream reclamation work that also includes benefits of breach repairs and sediment removal, and the bio-swale to treat storm runoff from dog waste and manure wastes.

Table 1 – Average Annual Phosphorus Reduction Benefits for Components of Stream Reclamation

Reclamation Component	Phosphorus Reduction	Units
Bed/Bank stabilization annual P load Reduction	51	lbs P/year
Breach Repair average annual P load reduction	37	lbs P/year
Bioswale treatment of Dog Wastes	780	lbs P/year
Bioswale treatment of Manure Wastes	21	lbs P/year
Total	889	lbs P/year

Table 2 – Stream Reclamation Benefit Cost Analysis – Complete Project

Item	Cherry Creek Stream Reclamation @ 12-Mile Park
Project Length (mi) =	0.57
Project Capital Costs ¹ =	\$ 1,451,000
Project Cost per mile =	\$ 2,554,000
Stream Reclamation Water Quality Benefits (lbs/mi/yr) =	90
Total Phosphorus reduction benefits (lbs/yr) ³ =	889
Capital Recovery Factor (4% 35-years) =	0.0538
Annualized Capital Cost =	\$ 78,100
Annual O&M Cost(2.5%) ² =	\$ 36,275
Project Annual Unit Cost (\$/lb) =	\$ 129
Baseline Project Life (yr) =	35
Project Life Time Costs =	\$ 2,720,625
Project Life Time Water Quality Benefits (lb) =	31118
Project Life Time Unit Costs (\$/lb) =	\$ 87

NOTES:

1. CH2M Hill February 2011. Draft Alternatives Evaluation Report
2. Ruzzo August 25, 2004. CCBWQA - Long-Term Capital Budget Projections
3. Includes benefits of sediment removal and of bio-swale treatment of dog and horse manure wastes.

Without the repairs to the breach area, sediment removal, and bio-swales to treat dog and horse manure wastes, the Project Life Time Unit Costs would be \$1,520/pound of phosphorus (see appendix sheet 1). Adding the benefits of repairing the breach area to the benefits of stream reclamation, the results show that over the life of the project, the phosphorus reduction is 889-lbs per year and the life-time unit cost is \$87 per pound of phosphorus. These additional benefits represent over a ten-fold reduction in cost per pound of phosphorus.

Recreation Management. Table 3 below shows the costs and benefits, as measured by the reduction in phosphates, associated with the recreational modifications for the DOLA and the horse concession. The analysis suggests that the waste management

practices for the DOLA and horse concession could be as low as two dollars per pound of phosphorus removed.

Table 3 – Recreation Management Cost and Benefits.

Item	Recreation Management
Project Capital Costs ¹ =	\$ 1,100,000
Capital Recovery Factor (4% 35-years) =	0.0538
Annualized Capital Cost =	\$ 59,200
Annual O&M Cost(2.5%) ² =	\$ 27,500
Baseline Project Life (yr) =	35
Project Life Time Costs =	\$ 2,062,500
DOLA Dog waste management benefits (lbs P/year)=	22950
Horse manure waste management benefits (lbs P/year) =	628
Project Annual Water Quality Benefits (lbs/yr) =	23578
Project Life Time Water Quality Benefits (lb) =	825221
Project Annual Unit Cost (\$/lb) =	\$ 4
Project Life Time Unit Costs (\$/lb) =	\$ 2

NOTES:

1. Cost estimate by CCSP
2. Ruzzo August 25, 2004. *CCBWQA - Long-Term Capital Budget Projections*

CONCLUSIONS

The Authority uses the cost per pound of phosphorus immobilized as a metric to compare capital projects and to assess the water quality benefits. The Authority's contribution to projects is sometimes limited to a cost of \$600 per pound of phosphorus when partnering with other agencies or local government.

The analysis presented herein suggests that when concentrated nutrient (phosphorus) sources are addressed, along with stream reclamation, the water quality benefits are significantly increased, and can reduce cost per pound to values below \$100 per pound. This supports the Authority's approach of also addressing local sources of nutrients, when partnering with others on stream reclamation projects.



Figure 2. Cherry Creek State Park Preferred Alternative

**Cherry Creek State Park
Dog Off-Leash Area Project**

CHERRY CREEK BASIN WATER QUALITY AUTHORITY
 CHERRY CREEK STREAM RECLAMATION AT 12-MILE PARK
 EVALUATION OF COST AND BENEFITS

**PHOSPHORUS LOADS FROM STREAM RECLAMATION
 AND ESTIMATED WATER QUALITY BENEFITS**

Item	Cherry Creek Stream Reclamation @ 12-mile Park
Project Length (mi) =	0.57
Project Capital Costs ¹ =	\$ 1,451,000
Project Cost per mile =	\$ 2,554,000
Stream Reclamation Water Quality Benefits (lbs/mi/yr) =	90
Project Annual Water Quality Benefits (lbs/yr) =	51
Capital Recovery Factor (4% 35-years) =	0.0538
Annualized Capital Cost =	\$ 78,100
Annual O&M Cost(2.5%) ² =	\$ 36,275
Project Annual Unit Cost (\$/lb) =	\$ 2,237
Baseline Project Life (yr) =	35
Project Life Time Costs =	\$ 2,720,625
Project Life Time Water Quality Benefits (lb) =	1790
Project Life Time Unit Costs (\$/lb) =	\$ 1,520

NOTES:

1. CH2M Hill February 2011. Draft Alternatives Evaluation Report
2. Ruzzo August 25, 2004. CCBWQA - Long-Term Capital Budget Projections

**CHERRY CREEK BASIN WATER QUALITY AUTHORITY
 CHERRY CREEK STREAM RECLAMATION AT 12-MILE PARK
 EVALUATION OF COST AND BENEFITS
 PHOSPHORUS LOADS FROM BREACH AREA DAMAGE AND ESTIMATED
 REPAIR BENEFITS**

ASSUMPTIONS:

Volume of material deposited in wetland pond ¹ =	2000	cy
Volume of other sediment deposits =	unknown	cy
Phosphorus content in sediment ¹ =	0.6	lbs/ton
Sediment density =	80	pcf

LOAD CALCULATIONS

Single event load =	1296	lbs P
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PHOSPHORUS REDUCTION BENEFIT

Since the sediment in the wetland pond will be removed from CCSP to balance imported materials then the phosphorus load reduction is a one-time benefit spread over the life of the project.

Project life assumption =	35	years
Average annual P load reduction =	37	lbs P/year

Add this amount to the estimated amount for stream reclamation to identify benefits of breach repair

NOTES:

1. CH2M Hill February 2011. Draft Alternatives Evaluation Report
2. Ruzzo August 25, 2004. CCBWQA - Long-Term Capital Budget Projections

**CHERRY CREEK BASIN WATER QUALITY AUTHORITY
 CHERRY CREEK STREAM RECLAMATION AT 12-MILE PARK
 EVALUATION OF COST AND BENEFITS
 PHOSPHATE LOADS FROM DOLA AND ESTIMATED BMP BENEFITS**

DOG USE INFORMATION

	Quantity	Unit	Source
Dogs use at DOLA areas =	450,000	#dogs/year	CCSP ¹
Waste produced =	4	cy/week	CCSP ¹

ASSUMPTIONS:

Dog waste, Phosphate =	10%	% Phosphate/lb	http://www.soil.ncsu.edu/publications/Soilfacts/AG-439-18/
Waste production =	0.2	lbs/dog/day	http://www.poopbutler.com/pooper-scooper-health.htm
Waste density =	45.0	pcf	Assumed similar to horses, dry
Season =	365	days/year	CCSP Manager

LOAD CALCULATIONS

Waste production =	4900	lbs/week
Waste production =	254800	lbs/year
Phosphates produced =	25500	lbs/year

NOTES: 1. Values generated using traffic counters, visitor surveys and DOLA pass sales.

CCSP WASTE MANAGEMENT PLAN BENEFITS

Dog waste management effectiveness =	90%	percent reduction per year	Assumption vetted by CCSP personnel
Average annual P load reduction =	22950	lbs/year	

AUTHORITY STREAM RECLAMATION PLAN

Phosphates in storm runoff =	2600	lbs/year	
Effectiveness of bio-swale areas =	30%	percent reduction per year	http://www.deq.state.or.us/wq/stormwater/docs/nwr/biofilters.pdf
Water Quality Benefits =	780	lbs P/year reduction	

CHERRY CREEK BASIN WATER QUALITY AUTHORITY
 CHERRY CREEK STREAM RECLAMATION AT 12-MILE PARK
 EVALUATION OF COST AND BENEFITS

PHOSPHATE LOADS FROM HORSE CONCESSION AND ESTIMATED BMP BENEFITS

HORSE USE INFORMATION

	Quantity	Unit	Source
Horses boarded/rented =	50		Estimate, CCSP Manager

ASSUMPTIONS:

Horse waste, Phosphate =	6	lbs Phosphate/ton	http://www.soil.ncsu.edu/publications/Soilfacts/AG-439-18/
Waste production =	31.0	lbs/day/1000lb horse	http://pubs.cas.psu.edu/freepubs/pdfs/ub035.pdf
Waste density =	63.0	pcf	http://pubs.cas.psu.edu/freepubs/pdfs/ub035.pdf
Season =	150	days/year	CCSP manager

LOAD CALCULATIONS

Waste production =	1550	lbs waste/day
Waste production =	232500	lbs waste/year
Phosphates produced =	698	lbs/year

NOTES: 1. Values generated using traffic counters, visitor surveys and DOLA pass sales.

CCSP WASTE MANAGEMENT PLAN BENEFITS

Waste management effectiveness =	90%	percent reduction per year	Assumption vetted by CCSP personnel
Average annual P load reduction =	628	lbs/year	

AUTHORITY STREAM RECLAMATION PLAN

Phosphates in storm runoff =	70	lbs/year	
Effectiveness of bio-swale areas =	30%	percent reduction per year	http://www.deq.state.or.us/wq/stormwater/docs/nwr/biofilters.pdf
Water Quality Benefits =	21	lbs P/year reduction	

CHERRY CREEK BASIN WATER QUALITY AUTHORITY
 CHERRY CREEK STREAM RECLAMATION AT 12-MILE PARK
 EVALUATION OF COST AND BENEFITS
PHOSPHATE CONCENTRATION DUE TO DOG AND HORSE WASTE

ITEM	QUANTITY	UNITS
Loads		
Annual Dog Waste P loads (not otherwise removed in dumpsters)	2600	lbs/year
Horse manue Waste P loads (not otherwise removed by concessionaire)	70	lbs/year
Total Phosphorus loads from recreation areas	2670	lbs/year
Runoff Volume		
Mean annual inflow to Reservoir ¹	16080	af
Watershed area at dam	386	sq.mi
Watershed area at 12-Mile Park	360	sq.mi
Adjusted mean annual inflow to Reservoir	15000	af
Unit load from dog and horse waste	0.18	lbs/af
Unit load from dog and horse waste	0.065	mg/l
Flow weighted mean annual phosphorus conc ¹ .	0.210	mg/l

NOTES:

1. CCBWQA 2011. *2010 Annual Report on Activities*