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**Bureau of Reclamation**

and

**Colorado Springs Utilities**

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**Southern Delivery System  
Environmental Impact  
Statement**

**Review of Cost Estimates for Current  
Water Development Projects in the  
Front Range**

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**November 2004**



**MWH**

**Colorado Springs, Colorado**

**In Association With**  
ERO Resources Corporation  
BBC Research & Consulting  
Chadwick Ecological Consultants, Inc.  
Western Cultural Resource Management, Inc.

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## 1.0 Introduction

The objective of this report is to investigate possible cost thresholds for use in screening Southern Delivery System (SDS) Environmental Impact Statement (EIS) alternatives based on the cost of other major water development projects in the Front Range. Five recent water supply studies for Front Range water providers were reviewed to determine the capital and operations costs of their short-list of project alternatives. The value of Colorado-Big Thompson Project units, which are bought and sold as commodities, was also reviewed. The projects reviewed include:

- Windy Gap Firming Project Alternative Plan Formulation Report, prepared by Boyle Engineering Corporation and EDAW for the Northern Colorado Water Conservancy District, February 2003.
- Northern Integrated Supply Project (NISP) Phase II Alternative Evaluation, prepared by MWH Americas, Inc. for the Northern Colorado Water Conservancy District, January 2004.
- Draft Report – Moffat Collection System Project Screen No. 1, prepared by MWH in association with HDR, Inc. for Denver Water, April 2004.
- Rueter-Hess Reservoir Final Environmental Impact Study, prepared by URS for U.S. Army Corps of Engineers (USACE), 2004
- Cost of Colorado Big Thompson Project Units
- Colorado River Return Project Reconnaissance Study Summary Report, prepared by Boyle Engineering Corporation for Colorado Water Conservation Board, 2003

Reports for each project included a varying degree of detail regarding cost estimates. Readily available information as possible was gathered for each project and summarized in this memo. Some reports discuss firm yield, while others discuss average annual yield, or simply storage capacity. Where possible, the unit costs are discussed in each of the three forms for comparison among projects. Costs of reservoirs only are discussed in Section 8.0.

## 2.0 Windy Gap Firing Project

The purpose of the Windy Gap Firing Project is to enhance the reliability of raw water deliveries from the existing Windy Gap Project to project participants. The initial alternatives investigation was based on a need for 110,000 acre-foot (ac-ft) of storage. For the Windy Gap Firing Project, firm yield was that which could be supplied in every year through a repeat of historic hydrology from 1950 to 1996.

The Windy Gap Firing Project short list included 7 plans consisting of 6 different reservoir locations. Table 1 presents the storage and the cost data for each plan. Since many plans include multiple storage locations, the total storage unit cost is based on a weighted average of costs for each element. Conveyance costs reflect the estimated capital costs for pipelines and pump stations and a 30 percent contingency for construction and 30 percent allowance for design and administrative costs. The operations costs were based on the estimated power consumption of the pump stations (the cost of power is based on Xcel's standard primary rates for commercial operations). For the purposes of this report, an additional fixed O&M cost was added as 0.5 percent of the storage and conveyance cost of the project. Present worth of annual costs was determined using 5 percent interest over 50 years. The Windy Gap Firing Project delivers raw water; no treatment facilities are included.

**Table 1. Windy Gap Firing Project Storage Capacity and Cost Estimates.**

	Plan 1	Plan 2	Plan 3	Plan 4	Plan 5	Plan 6	Plan 7
Lower Chimney Hollow <sup>1</sup>							
Storage (acre-feet)	110,000	84,000	110,000	44,500			
Storage Unit Cost (\$/ac-ft)	\$1,810	\$1,870	\$1,810	\$2,070			
Cactus Hill <sup>1</sup>					111,000 \$820		
Little Thompson <sup>1</sup>						110,000 \$1,180	
Rawhide North <sup>1</sup>			13,000 \$3,200				13,000 \$3,200
Jasper North <sup>2</sup>				79,000 \$1,350			79,000 \$1,350
Jasper North A <sup>2</sup>		36,500 \$2,030					
Total Storage (ac-ft)	110,000	120,500	123,000	123,500	111,000	110,000	92,000
Total Storage Unit Cost (\$/ac-ft)	\$1,800	\$1,900	\$2,000	\$1,600	\$800	\$1,200	\$1,600
Firm Yield (ac-ft)	24,500	28,500	21,500	28,500	12,000	24,500	19,000
Firm Yield Capital Unit Cost (\$/ac-ft)	\$8,100	\$8,100	\$11,200	\$7,000	\$7,600	\$5,300	\$7,800
Total Storage Cost (\$M)	\$199	\$231	\$241	\$199	\$91	\$130	\$148
Total Conveyance Cost (\$M)	\$3	\$20	\$3	\$16	\$98	\$63	\$11
Annual Power Present Worth (\$M)	\$0.73	\$20.08	\$0.73	\$21.91	\$32.86	\$32.86	\$16.43
Annual O&M Present Worth (\$M)	\$18.44	\$22.91	\$22.27	\$19.63	\$17.25	\$17.62	\$14.51
Total Cost (\$M)	\$221	\$294	\$267	\$257	\$239	\$243	\$190
Firm Yield Unit Cost <sup>3</sup> (\$/ac-ft)	\$9,000	\$10,300	\$12,400	\$9,000	\$19,900	\$9,900	\$10,000

<sup>1</sup> Cost determined from cost estimate curves created by developing estimates for at least three capacities at each location and best fitting a curve to the data points

<sup>2</sup> Cost based on preliminary dam layout and reservoir capacity for each plan unless otherwise noted

<sup>3</sup> Total Cost divided by Firm Yield

Firm yield unit costs for the Windy Gap Firming Project varied from \$9,000 to \$20,000 per ac-ft including the present worth of annual costs. The unit cost per acre-foot of storage is discussed in 8.0.

The cost estimates listed above are from the Windy Gap Firming Study Feasibility Report. An EIS is currently underway, which could result in other alternatives and updated cost estimates.

### 3.0 Northern Integrated Supply Project

The NISP is a collaborative project among 13 water providers and the Northern Colorado Water Conservancy District. The project objectives are to provide 34,400 ac-ft of new firm annual supply and 17,000 ac-ft of firming storage. Firm yield is defined for the project as the yield that could be delivered in every year of the 50-year planning period. Firming storage would be used by project participants to store and provide reliability to existing water rights. The NISP project provides raw water only; no treatment facilities are included.

There were six reservoir locations considered in the NISP short-list of alternatives. Each of the reservoirs was considered in one or more of 19 alternatives. Unit cost curves for different storage volumes were developed for each reservoir location. The unit costs in the Poudre Basin ranged from about \$900 to \$1,900 per ac-ft of storage (see Figure 1). The unit costs in the South Platte Basin ranged from about \$800 to \$2,300 per ac-ft of storage for generally smaller reservoirs (see Figure 2).

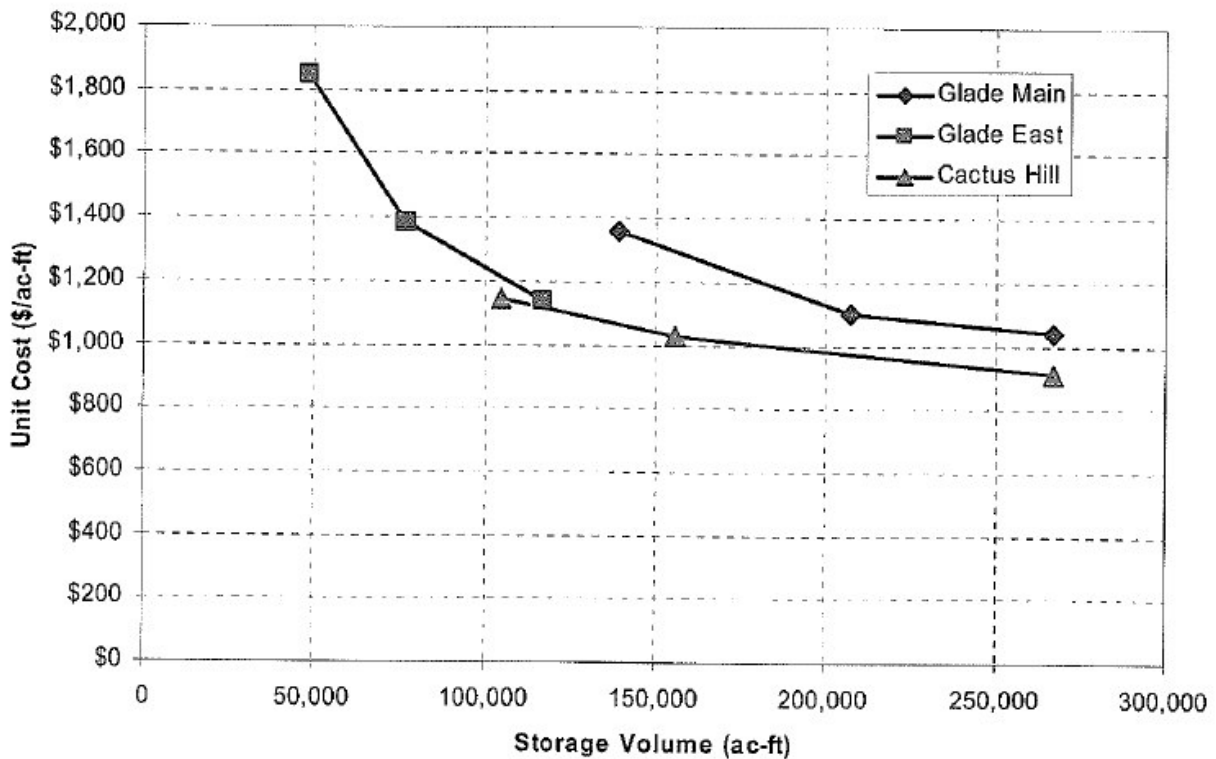
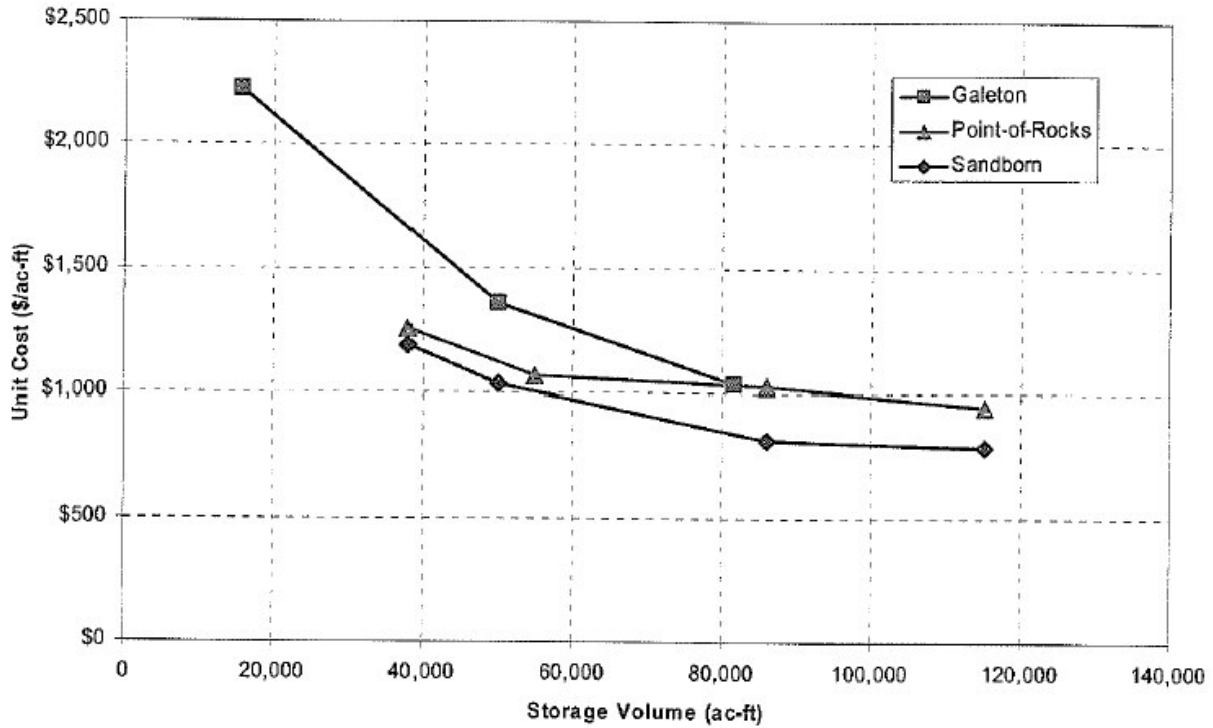


Figure 1. Poudre Basin Reservoir Unit Cost Curves.



**Figure 2. Lower South Platte Basin Reservoir Unit Cost Curves.**

Total screening-level capital costs were developed for 19 alternatives based on the major construction items but did not include pumping or O&M costs. Screening level costs are summarized in Table 2. Each project has a total firm yield of 34,400 ac-ft. The firm yield unit costs for the 19 alternatives varied from \$9,100 to \$15,700 per ac-ft.

**Table 2. Screening-level Capital Costs and Yield Unit Costs for NISP Alternatives.**

<b>Alternative Name</b>	<b>Firm Yield (ac-ft)</b>	<b>Capital Cost – Yield (\$ million)</b>	<b>Firm Yield Unit Cost (\$/ac-ft)</b>
Glade Reservoir and SPWCP (Blended)	34,400	\$312	\$9,100
Glade Reservoir (Maximized) and SPWCP	34,400	\$385	\$11,200
Glade Reservoir and SPWCP (Maximized)	34,400	\$309	\$9,000
Glade Reservoir, SPWCP and Dry-year Leases (Blended)	34,400	\$394	\$11,500
Glade Reservoir, SPWCP (Maximized) and Dry-year Leases	34,400	\$318	\$9,200
Glade Reservoir, SPWCP and Dry-year Leases (Yield Balanced) <sup>1</sup>	34,400	\$330	\$9,600
Glade Reservoir (Maximized) and Sanborn Reservoir (Direct Delivery)	34,400	\$525	\$15,300
Glade Reservoir and Sanborn Reservoir (Balanced, Direct Delivery)	34,400	\$420	\$12,200
Glade Reservoir and Point-of-Rocks Reservoir (Balanced, Direct Delivery)	34,400	\$432	\$12,600
Glade Reservoir and Sanborn Reservoir (Blended, Pipeline to Poudre)	34,400	\$482	\$14,000
Glade Reservoir (Maximized), Improved Irrigation Efficiencies	34,400	\$482	\$14,000
Cactus Hill and SPWCP (Blended)	34,400	\$328	\$9,500
Cactus Hill (Maximized) and SPWCP	34,400	\$393	\$11,400
Cactus Hill and SPWCP (Maximized)	34,400	\$329	\$9,600
Cactus Hill (Maximized) and Sanborn (Direct Delivery)	34,400	\$539	\$15,700
Cactus Hill (Maximized) and Point-of-Rocks (Direct Delivery)	34,400	\$504	\$14,700
Cactus Hill and Sanborn (Balanced, Direct Delivery)	34,400	\$525	\$15,300
Cactus Hill and Point-of-Rocks (Balanced, Direct Delivery)	34,400	\$527	\$15,300
Cactus Hill (Maximized), Improved Irrigation Efficiencies and Dry-Year Leases	34,400	\$539	\$15,700

Note: SPWCP = South Platte Water Conservation Project

\* Closest to proposed project

The proposed project was a 177,000 ac-ft Glade Reservoir and a 20,000 ac-ft Galeton Reservoir. Feasibility level cost estimates for the proposed project are shown in Table 3. The total cost before environmental mitigation including all capital and annual costs is about \$440 million. The feasibility level yield unit cost for the NISP proposed project including all capital and annual costs but not environmental mitigation is \$12,800 per ac-ft. Scaling up the lowest and highest screening level capital costs to be comparable to the proposed project total project costs (a factor of 1.3) results in a firm yield unit cost ranging from \$12,000 to \$21,000 per ac-ft. The unit cost per acre-foot of storage is discussed in Section 8.0.

**Table 3. Detailed Cost Estimate for NISP Proposed Project.**

<b>Description</b>	<b>Total Construction Cost</b>	<b>Total Right-of-Way and Water Rights Cost</b>	<b>Present Worth Annual O&amp;M<sup>1</sup></b>	<b>Present Worth Annual Energy Cost<sup>1</sup></b>
Glade Reservoir	\$182.9	\$0.0	\$14.8	\$0.0
Glade Pump Station	\$33.1	\$0.0	\$2.7	\$6.6
Glade Forebay	\$2.9	\$0.0	\$0.2	\$0.0
Glade-Horsetooth Pipeline	\$13.4	\$0.0	\$1.1	\$0.0
Poudre Valley Canal Upgrades	\$19.0	\$0.0	\$1.5	\$7.1
Right-of-way Acquisition	\$0.0	\$10.0	\$0.0	\$0.0
<b>Subtotal</b>	<b>\$251.3</b>	<b>\$10.0</b>	<b>\$20.3</b>	<b>\$13.7</b>
Galeton Reservoir	\$27.3	\$0.0	\$2.2	\$0.0
Riverside Pump Station	\$7.6	\$0.0	\$0.6	\$11.3
Riverside Forebay	\$1.1	\$0.0	\$0.1	\$0.0
SPWCP Pipeline & Pump Stations	\$58.1	\$0.0	\$4.7	\$1.1
SPWCP right-of-way Acquisition	\$0.0	\$2.0	\$0.0	\$0.0
First Use Water Rights	\$0.0	\$10.0	\$0.0	\$0.0
Annual Water Rights Payment	\$0.0	\$0.0	\$18.3	\$0.0
<b>Subtotal</b>	<b>\$94.1</b>	<b>\$12.0</b>	<b>\$25.9</b>	<b>\$12.4</b>
Platte River Environmental Mitigation	\$0.0	\$0.0	\$5.5	\$0.0
<b>Grand Total</b>	<b>\$345.4</b>	<b>\$22.0</b>	<b>\$51.7</b>	<b>\$26.1</b>

<sup>1</sup> Present worth of annual costs were determined using 5 percent interest over 50 years. Fixed O&M costs were determined as 0.5 percent of the overall construction cost of the project. The cost of power was assumed to be \$0.05 per kilowatt-hr.

## **4.0 Moffat Collection System Project**

Cost estimates developed for this project have not been made public at this point. The final report is expected to be ready for release in early 2005. Colorado Springs could make a request to Denver Water to view the information prior to release.

## 5.0 Colorado-Big Thompson Project Units

The Colorado-Big Thompson Project (C-BT) is a Reclamation water supply project in northern Colorado. C-BT provides raw water to agricultural and municipal users in the area bounded approximately by Boulder, Fort Collins, and Greeley. The Northern Colorado Water Conservancy District is the local sponsor for this federal water project.

C-BT water is allocated in shares, or units, to project participants. Acquisition of C-BT units via transfer from agricultural owners has historically been one of the primary means of securing new yield for many of the municipalities in the rapidly growing northern Front Range area. Units are considered a commodity, and may be transferred from one owner to another without initiating a Colorado Water Court case. This has made the C-BT market one of the most active water markets in the region.

The price of C-BT units varies continuously in response to supply-and-demand forces in the marketplace. Units have typically sold for \$10,000 to \$15,000 per unit.

The amount of water associated with a C-BT unit is established annually by the Northern Colorado Water Conservancy District Board, which sets a quota for C-BT water deliveries per unit owned. C-BT is considered a supplemental water supply, and is designed to be used more heavily in dry years when local supplies are insufficient to meet demands. Historically the C-BT quota has varied from 0.5 ac-ft/unit to 1.0 ac-ft/unit. The quota includes both an annual yield component and a carryover storage component. The average yield per unit is about 0.7 ac-ft, and the firm yield is about 0.6 ac-ft.

Based on the C-BT unit price and the firm yield quota, the cost of acquiring C-BT units for firm yield is in the range of \$17,000/ac-ft to \$25,000/ac-ft. On an average yield basis the cost ranges from \$14,000/ac-ft to \$21,000/ac-ft.

## 6.0 Rueter-Hess Reservoir Project

The purpose of the Rueter-Hess Reservoir project is to capture and store seasonal high flows in Cherry Creek to better use Parker Water and Sanitation District's junior water rights and to capture advanced wastewater treatment return flows. The project provides raw water to the District's system; no water treatment facilities are included.

The Rueter-Hess EIS discusses five final reservoir locations and two alternative sizes for the Rueter-Hess Reservoir. Costs for the second level screening were based on embankment, spillway, and outlet works construction. The project sizes and costs are summarized in Table 4. Unfortunately, the EIS did not include the capacities of reservoirs that were eliminated in screening, so it is not possible to calculate their unit costs. The EIS does not have a firm yield estimate for any of the alternatives; an estimate of average annual yield is only available for the two Rueter-Hess Reservoir sizes considered.

**Table 4. Rueter-Hess Reservoir Second Level Screening Cost and Storage Summary.**

Project	Total Storage <sup>1</sup> (ac-ft)	Average Annual Yield (ac-ft)	Storage Capital Cost (\$ million)	Avg. Annual Yield Unit Cost (\$/ac-ft)
Rueter-Hess (16,200 ac-ft)	16,200	4,136	\$42.7	\$10,300
Scott Road	N/A	N/A	\$29.9	N/A
Bridge Canyon	N/A	N/A	\$22.8	N/A
Confluence	N/A	N/A	\$24.0	N/A
Lower Lake Gulch	N/A	N/A	\$45.6	N/A
Rueter-Hess (11,200 ac-ft)	11,200	3,471	\$37.7	\$10,900

<sup>1</sup> Includes active and inactive storage  
N/A = not available

Table 5 provides detailed cost estimates for all elements the final two alternatives. O&M and power costs were estimated for this report and converted to present worth. Average annual yield unit cost based on the total project cost estimates ranges from \$12,800 to \$14,200 per ac-ft. These costs do include a chlorination station, but do not include O&M costs and power costs.

**Table 5. Reuter-Hess EIS Alternatives Detailed Cost Estimates (\$ million).**

	<b>16,200 ac-ft Rueter-Hess Alternative</b>	<b>11,200 ac-ft Rueter-Hess Alternative</b>
Dam and Reservoir	\$35.0	\$31.5
Diversion Structure	\$4.3	\$4.3
Pump/Chlorination Station	\$4.2	\$4.2
Access Road	\$0.7	\$0.7
Reservoir Delivery Pipeline	\$5.6	\$5.6
O&M Present Worth <sup>1</sup>	\$2.5	\$2.3
Power Present Worth <sup>2</sup>	\$1.8	\$1.7
<b>Subtotal</b>	\$54.1	\$50.3
<b>Avg. Annual Yield Unit Cost (\$/ac-ft)</b>	<b>\$13,100</b>	<b>\$14,500</b>
Wellfield and Facilities	\$49.6	\$52.7
<b>Total</b>	<b>\$103.7</b>	<b>\$103.0</b>

<sup>1</sup> O&M costs are based on 0.05 percent of the capital cost per year.

<sup>2</sup> Power costs were estimated based on an average pumping rate of 35 cfs (78 cfs pump station capacity) and a head of 250 feet to achieve the annual water delivered to the reservoir (includes diversions, pumping, and water treatment return flows).

Note: Annual costs were converted to present worth based on 5 percent interest of 50 years.

## 7.0 Colorado River Return Project

The Colorado River Return Project (CRRP, also known as the Big Straw Project) was formulated to capture Colorado's share of Colorado River flows near the State line and deliver them to water users on the Front Range. The CRRP includes a diversion from the Colorado River near the Colorado-Utah border, a small regulating reservoir, a pipeline to Dillon Reservoir, and a series of pump stations. The least expensive CRRP alternatives for three sizing options in terms of total project cost (capital cost plus present value of O&M costs) are listed in Table 6. Average annual yields are provided for each project size, but these are only estimates. Detailed hydrologic analyses were not performed for the CRRP Reconnaissance Study. Although firm yield estimates are not available, it is believed by the CRRP project team that the 250,000 ac-ft and 500,000 ac-ft yields could be delivered in nearly every year of operation, and that 750,000 ac-ft could be delivered in many years.

The CRRP was determined to be infeasible by the State of Colorado based on technical and cost factors, and is no longer under consideration.

**Table 6. Colorado River Return Project Average Annual Yield and Costs.**

<b>Average Annual Yield (ac-ft)</b>	<b>Total Cost (\$ billion)</b>	<b>Average Annual Unit Cost (\$/ac-ft)</b>
250,000	\$8.1	\$32,400
500,000	\$13.4	\$26,800
750,000	\$18.3	\$24,400

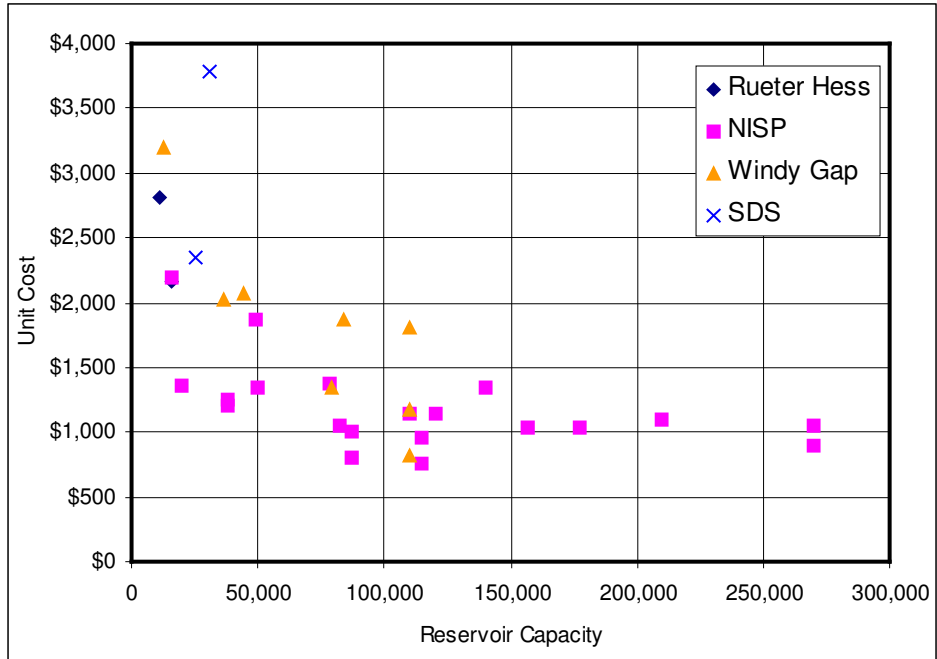
Source: Colorado River Return Reconnaissance Study Summary Report, CWCB (by Boyle, et al), Nov. 14, 2003.

## 8.0 Reservoir Cost Analysis

Costs for dam and reservoir construction alone are discussed in this section for use in reservoir site cost analysis. The short-listed reservoirs considered in the previously discussed studies, their capacities, costs, and unit costs are summarized in Table 7 and Figure 3. Reservoir unit costs range from \$750 to \$3,800 per ac-ft of storage.

**Table 7. Front Range Reservoir Unit Costs.**

Site	Capacity (ac-ft)	Dam and Reservoir Cost (\$ million)	Storage Unit Cost (\$/ac-ft)
<b>Rueter Hess</b>			
Rueter Hess (small)	11,200	\$32	\$2,813
Rueter Hess (preferred)	16,200	\$35	\$2,160
<b>NISP</b>			
Glade Reservoir (preferred)	177,000	\$183	\$1,033
Glade Reservoir (large)	270,000	\$284	\$1,050
Glade Reservoir (medium)	210,000	\$231	\$1,100
Glade Reservoir (small)	140,000	\$189	\$1,350
Galeton Reservoir (preferred)	20,000	\$27	\$1,365
Galeton Reservoir (large)	82,000	\$86	\$1,050
Galeton Reservoir (medium)	50,000	\$68	\$1,350
Galeton Reservoir (small)	16,000	\$35	\$2,200
Glade East (large)	120,000	\$138	\$1,150
Glade East (medium)	78,000	\$108	\$1,380
Glade East (small)	49,000	\$92	\$1,870
Cactus Hill (large)	270,000	\$243	\$900
Cactus Hill (medium)	157,000	\$162	\$1,030
Cactus Hill (small)	110,000	\$127	\$1,150
Point-of-Rocks (large)	115,000	\$109	\$950
Point-of-Rocks (medium)	87,000	\$87	\$1,000
Point-of-Rocks (small)	38,000	\$48	\$1,250
Sandborn (large)	115,000	\$86	\$750
Sandborn (medium)	87,000	\$70	\$800
Sandborn (small)	38,000	\$46	\$1,200
<b>Windy Gap</b>			
Lower Chimney Hollow	110,000	\$199	\$1,810
Lower Chimney Hollow (medium)	84,000	\$157	\$1,870
Lower Chimney Hollow (small)	44,500	\$92	\$2,070
Cactus Hill	110,000	\$90	\$820
Little Thompson	110,000	\$130	\$1,180
Rawhide North	13,000	\$42	\$3,200
Jasper North	79,000	\$107	\$1,350
Jasper North A	36,500	\$74	\$2,030
<b>SDS</b>			
Jimmy Camp Creek	30,500	\$116	\$3,790
Williams Creek	25,000	\$59	\$2,343



**Figure 3. Front Range Reservoir Unit Costs.**

## 9.0 Summary

The range of unit costs expressed on the basis of total project costs (capital and O&M costs) for Front Range raw water development projects is summarized in Table 8 along with notes on how cost estimates were determined. In some cases unit costs are based on firm annual yield provided by the project, and in other cases unit costs are based on average annual yield. None of the project costs include water treatment associated with producing finished water for delivery to customers.

**Table 8. Summary of Yield Unit Cost Ranges for Front Range Water Development Projects.**

Project	Firm Yield Unit Cost Range (\$/ac-ft)	Average Annual Yield Unit Cost Range (\$/ac-ft)	Notes on Cost Estimates	Project Status
Windy Gap Firming Project	9,000 – 20,000	N/A	Includes storage & conveyance construction, O&M, and power	EIS in progress
Northern Integrated Supply Project	12,000 – 21,000	N/A	Includes storage & conveyance construction, O&M, and power	EIS in progress
Moffat Collection System	N/A	N/A		EIS in progress
Rueter-Hess Reservoir	N/A	13,100 – 14,500	Includes storage & conveyance construction, O&M and power, chlorination station	NEPA permitting completed; under construction
Colorado-Big Thompson	17,000 – 25,000	14,000 – 21,000	Based on market price of C-BT units	Existing
Colorado River Return Project	N/A	24,400 – 32,400	Includes capital plus O&M and power	Infeasible

Based on this review of similar Front Range water development projects, the upper limit on unit cost of firm annual yield for short-listed alternatives is about \$25,000/ac-ft, and the upper limit on unit cost of average annual yield is about \$21,000/ac-ft.

The unit cost of reservoir storage alone considered in other Front Range water projects has ranged from \$750 to \$3,800 per ac-ft.