

A HISTORICAL VIEW: TRANSMOUNTAIN DIVERSION DEVELOPMENT IN COLORADO

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ABSTRACT

As the headwaters for seven major rivers, water resources in Colorado have been diverted for use for over 150 years. Transbasin diversions have been developed to move water from one river basin to another, including transmountain diversions, which move water over the continental divide. Transmountain diversions have historically been developed to provide water for irrigated agriculture and municipal purposes. This paper briefly discusses the development of each of Colorado's 30 transmountain diversions between the Colorado, South Platte, Arkansas and Rio Grande river basins, and provides a summary of diversions for recent years.

INTRODUCTION

Many people in the Colorado water community have traditionally divided transbasin diversions into two categories: transmountain diversions, which move water from one side of the continental divide to the other, and transbasin, where water is moved between basins that ultimately drain to the same ocean. In addition to surface water diversions, there are also geological formations that allow wells located in one basin to pump water native to another.

BACKGROUND

Based on the 2000 Census and the Colorado State Engineer's records, the front range of Colorado (the east slope, excluding the North Platte and Rio Grande basins) has 89% of the state's population but only 16% of the state's water (USCB, 2000; SEO, 2000). Because the front range and the eastern plains of Colorado are in a semi-arid environment, transmountain diversions, diversions from one side of the continental divide to the other, have been constructed to move water to the eastern slope to help satisfy the region's demand for water.

As a prior appropriation state, water users who first put water to a beneficial use and obtained a water right have the right to do so over users who started using water later in time. The right to divert water from one basin to another is administered under the prior-appropriation system, like other water rights. The oldest surface water diversion in continuous use in Colorado is the San Luis Peoples Ditch in the San Luis Valley, with a priority date of April 1852. The first transmountain diversion recorded in Colorado was constructed 8 years later in 1860, to provide water for

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mining near the town of Fairplay. The East and West Hoosier ditches diverted water from the headwaters of the Blue River into the Middle Fork of the South Platte River. Since 1860, 30 ditches and tunnels have been constructed to move water over the continental divide for irrigation, domestic, commercial and industrial uses.

TRANSMOUNTAIN DIVERSION PROJECTS

Broadly speaking, the development of transmountain diversions in Colorado has occurred in two waves, with a group of projects developed around the 1930's to provide supplemental water for irrigation, and another set of projects constructed in the 1960's and 1970's to provide water for municipal purposes. Many projects originally built to provide irrigation water have been changed, at least in part, to municipal and other non-agricultural uses.

Figure 1 shows the location of the active transmountain diversions in Colorado. Table 1 shows the 1990-1999 10-year average diversion, and the year 2000 diversion for each of the projects. Following these are descriptions of Colorado's transmountain projects, arranged by basin, and listed in order, from north to south.

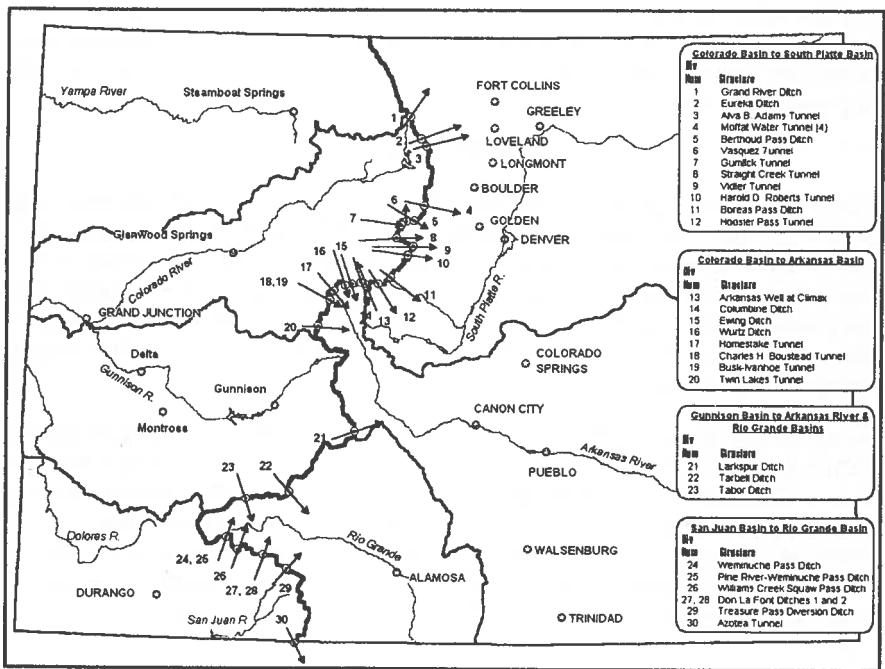


Figure 1. Transmountain Diversions in Colorado.

Table 1. Summary of Transmountain Diversions.

Diversion Number	Structure	Quantity Diverted Water Year (Oct 1 - Sep 30)			Principal Owner / Contact
		1985 (1) (AF)	10-year mean 1990-1999 (AF)	2000 (3) (AF)	
1	Grand River Ditch	20,831	20,460	18,559	Water Supply and Storage Co.
2	Eureka Ditch	0	128	0	City of Loveland
3	Alva B. Adams Tunnel	285,200	205,718	247,735	Northern Colorado Water Conservancy District
4	Moffat Water Tunnel (4)	77,545	44,318	51,726	City of Denver
6	Gumlick Tunnel		2,340	2,781	City of Denver
7	Berthoud Pass Ditch	567	950	0	City of Northglenn
8	Straight Creek Tunnel	409	323	370	Adolph Coors Company
9	Vidler Tunnel	369	643	332	Vidler Water Company
10	Harold D. Roberts Tunnel	299	61,789	93,645	City of Denver
11	Boreas Pass Ditch	40	139	111	City of Englewood
12	Hoosier Pass Tunnel	7,400	9,939	10,770	City of Colorado Springs
13	Arkansas Well at Climax	0	230	0	Vall Associates
14	Columbine Ditch	1,809	1,773	1,720	Pueblo Board of Water Works
15	Ewing Ditch	1,359	1,057	1,030	Pueblo Board of Water Works
16	Wurtz Ditch	3,832	2,762	2,080	Pueblo Board of Water Works
17	Charles H. Boustead Tunnel	71,797	59,740	44,830	US Bureau of Reclamation
18	Homestake Tunnel		23,048	26,914	Cities of Aurora / Colorado Springs
19	Busk-Ivanhoe Tunnel	8,268	4,740	5,210	Pueblo Board of Water Works, Aurora
20	Twin Lakes Tunnel	8,016	38,452	42,117	Twin Lakes Reservoir and Canal Co.
21	Larkspur Ditch	329	31	0	Catlin Canal Company
22	Tarbell Ditch	172	419	630	Private Individuals (3)
23	Tabor Ditch	1,435	495	495	Colorado Division of Wildlife
24	Weminuche Pass Ditch	2,088	1,099	0	Colorado Division of Wildlife
25	Pine River-Weminuche Pass Ditch	873	491	203	San Luis Valley Conservation District
26	Williams Creek Squaw Pass Ditch	253	359	230	Navajo Development Company
27, 28	Don La Font Ditches 1 and 2	447	201	10	Colorado Division of Wildlife
29	Treasure Pass Diversion Ditch	613	123	70	Private Individual
30	Azotea Tunnel	91,790	96,189	40,506	US Bureau of Reclamation
TOTAL		751,279	577,954	592,074	

Notes:

1. U.S. Geological Survey. Estimated Use of Water in Colorado, 1985, Water-Resources Investigation Report 88-4101. 1985.
2. Based on Irrigation year, Nov 1 - Oct 31
3. All year 2000 data should be considered preliminary.
4. Does not include Gumlick / Vasquez diversions.

Colorado Basin into the South Platte Basin

Grand River Ditch: The Grand River Ditch diverts from numerous streams tributary to the North Fork of the Colorado River and delivers the water over La Poudre Pass into Long Draw Creek, a tributary of the Cache la Poudre River. The ditch is 14.2 miles long and is located entirely within Rocky Mountain National Park. The ditch is owned by the Water Supply and Storage Co. and the water is used as a supplemental irrigation supply. The ditch has an appropriation date of September 1, 1890, and a decreed capacity of 524.6 cubic feet per second. The Grand River Ditch generally diverts from late May or early June until late September. Flows are measured through a 10-foot Parshall Flume, equipped with telemetry.

Long term average diversions are about 18,530 acre-feet per year. The water year 1990-1999 average annual diversions were 20,460 acre-feet. The year 2000 diversion was 18,559 acre-feet (CDSS, 2000, Seivers, 2000).

Eureka Ditch: The Eureka Ditch was a small ditch which diverted water from the headwaters of Tonahutu Creek, tributary of the North Fork of the Colorado River

approximately one mile north of Grand Lake, owned by the City of Loveland. The 0.8 mile long ditch had an estimated capacity of 0.85 cubic feet per second. The ditch collected surface runoff from the southwest side of Sprague Pass and conveyed it over into the headwaters of Spruce Creek, tributary of the Big Thompson River. The ditch was located entirely within Rocky Mountain National Park. Because the 11,700 foot elevation of the ditch made it difficult to maintain, the City exchanged the ditch for shares of the Colorado-Big Thompson project owned by the U.S. Park Service in 1995. The Park Service removed the diversion and backfilled the ditch. Water previously captured by the ditch now continues to flow westward and is used for instream flow purposes.

The annual diversion has ranged between 0 and 260 acre-feet per year, with an average annual diversion of 34 acre-feet. The 1990-1992 average annual yield was 128 acre-feet, with no diversions since 1992 (CDSS, 2000; Howard, 2000).

Alva B. Adams Tunnel: The 13.1-mile Alva B. Adams Tunnel transports water west to east 3,800 feet beneath the Continental Divide, a tunnel second in length only to the Roberts Tunnel. The Adams Tunnel is part of the Colorado - Big Thompson (CBT) project, which is owned by the U.S. Bureau of Reclamation and managed by the Northern Colorado Water Conservancy District. The project furnishes supplemental irrigation water to approximately 720,000 acres, domestic water to more than 400,000 people in the South Platte River Basin, and generates hydroelectric power. The project also conveys water from the Windy Gap Project from the west to east slope.

The tunnel passes under Rocky Mountain National Park, which receives both electricity and water from the project. The west portal is at an elevation of 8340 feet, the east portal is at an elevation of 8240 feet, and the tunnel passes under Andrews Pass nearly 3700 feet below the ground surface. Excavation from the east portal lasted 37½ months and averaged 1,146 feet per month, while west portal contractors worked 31 months and averaged 833 feet per month. The tunnel holed through on June 10, 1944, with a difference in alignment of less than one inch.

The 9-foot, 9-inch tunnel was lined with a one-foot thick concrete ring. A 69-Kilovolt transmission line, encased in a pipe running along the roof of the tunnel, connects east and west slope power facilities. The tunnel has a capacity of 550 cubic feet per second. The 1990-1999 average annual delivery was 205,718 acre-feet, with a 2000 delivery of 247,735 acre-feet (U.S.B.R., 2000).

Moffat Water Tunnel: The Moffat Tunnel is owned by the Denver Water Board and delivers water from the Williams Fork and Moffat collection systems in the Colorado River basin, under the Continental Divide into South Boulder Creek to Gross Reservoir. The tunnel was originally the pilot bore for the Moffat Railroad Tunnel, and is located 75 feet south of, and parallel to, the railroad tunnel. The west portal is near the Winter Park Ski Area at an elevation of 9,091 feet.

The circular tunnel is fully lined, 10.5 feet in diameter, 6.1 miles long, and designed

to operate under pressure. The tunnel has a capacity of 1,280 cubic feet per second. The pioneer bore was completed in 1927. The tunnel was enlarged and partially lined in 1935-36. The first western slope water flowed east on June 10, 1936. Lining the tunnel was completed 1958.

Deliveries through the Moffat Tunnel include water from the Williams Fork collection system, which has already flowed through the Gumlick and Vasquez tunnels. The tunnel also conveys an average of 2300 acre-feet of water from the City of Englewood's Ranch Creek and Meadow Creek collection systems, which was completed in the 1940's.

The 1990-1999 mean annual diversion through the Moffat Tunnel (excluding water from the Gumlick/Vasquez tunnels) was 44,318 acre-feet. The year 2000 diversion was 51,726 acre-feet (DWB, 2000; Lewellen, 2001; Wood, 2001).

Berthoud Pass Ditch: The Berthoud Pass Ditch is owned by the Cities of Northglenn and Golden, which each receive approximately half its yield. The ditch diverts water from the headwaters of the Fraser River and delivers it into the headwaters of the West Fork of Clear Creek. The diversion includes a ditch that collects surface runoff, and a short tunnel that carries the water under the parking lot for the Berthoud Pass Ski Area. The ditch is 3.5 miles long and diverts water from the northwest side of Berthoud Pass above 11,300 feet in elevation.

The ditch has an appropriation date of June 30, 1902, a decreed capacity of 53.4 cubic feet per second, and was originally used for irrigation. Northglenn and Golden purchased the ditch from FRICO in the mid-1980's, and the water is now used for municipal purposes. The Berthoud Pass Ditch typically diverts during June and July.

The 1990-1999 average annual yield was 950 acre-feet, though the ditch did not divert in 1999 or 2000 due to a collapse in the tunnel. With repairs to the tunnel complete, the ditch is expected to divert water in 2001 (CDSS, 2000; Moore, 2000).

Vasquez Tunnel: The Vasquez Tunnel was constructed by Denver to convey water from the east portal of the Gumlick Tunnel in Clear Creek, north under the continental divide to the Fraser River basin. The Gumlick and Vasquez tunnels are connected by a short conduit. The Vasquez Tunnel conveys water from the Williams Fork collection system to the Moffat Tunnel, thence to South Boulder Creek.

The southern, or east slope, portal is located at an elevation of 10,310 feet, and the north, or west slope, portal is located at 10,210 feet. The tunnel is 3.4 miles long, with a 7 foot, horseshoe cross section. The tunnel has a capacity of 550 cubic feet per second and was completed in 1958.

The 1990-1999 mean annual diversions through the Vasquez Tunnel were 2070 acre-feet, with the diversions being equal to those of the Gumlick Tunnel in 7 of the last 10 years. The 2000 diversion was 2781 acre-feet, the same as the Gumlick Tunnel.

Gumlick Tunnel: The Gumlick Tunnel (a.k.a. the Jones Pass Tunnel) is owned by the Denver Water Board. It carries water diverted by the Williams Fork collection system on the west slope to the West Fork of Clear Creek, which is tributary to the South Platte. The tunnel was originally completed in 1940, with lining and other improvements undertaken in 1957-1958. The tunnel is 2.9 miles long, fully lined, with a 7-foot horseshoe shaped cross-section. Water is diverted at the west portal at an elevation of 10,313 feet, to the east portal at 10,000 feet, 11 miles west of the town of Empire. The tunnel has a capacity of 550 cubic feet per second.

The Williams Fork collection system diverts water from Steelman Creek at an elevation of 10,480 feet and Bobtail Creek at 10,313 feet. Originally, water carried through the Gumlick Tunnel was delivered to Clear Creek. After the completion of the Vasquez Tunnel in 1958, water has typically been re-diverted from Clear Creek back to the west slope to the Fraser River basin, though in 3 years of the last 11 water delivered through the Gumlick was allowed to flow down Clear Creek.

The water year 1990-1999 annual average diversion through the tunnel was 2340 acre-feet, with a year 2000 diversion of 2781 acre-feet.

Straight Creek Tunnel: The Straight Creek Tunnel is located approximately 60 miles west of Denver, and carries west-bound Interstate 70 under the continental divide. The tunnel was renamed the Dwight D. Eisenhower Memorial Bore in 1972. The tunnel is the highest vehicular tunnel in the world, with an elevation of 11,013 feet at the East Portal and 11,158 feet at the West Portal. The tunnel is operated by the Colorado Department of Transportation. Construction on Straight Creek Tunnel took 5 years, with the tunnel opening to traffic on March 8, 1973.

Water from the Straight Creek Tunnel comes from two sources; a transmountain diversion that is piped under the continental divide for industrial use at the tunnel, and tunnel seepage. Water from both sources is discharged into Clear Creek, and the Adolph Coors Company holds a decree for the right to use the water discharged from the tunnel. The decree was filed by Coors while the tunnel was under construction.

Water used at the tunnel is diverted from Straight Creek via an infiltration gallery and stored in an underground reservoir near the west portal of the tunnel. The water is then piped through the tunnel, with taps for fire fighting and other non-potable uses. A water treatment plant located at the east portal treats the water to potable standards. Drainage for tunnel seepage is provided beneath the roadway. Wastewater from the potable system, drainage from non-potable uses and tunnel seepage all flow to the east portal, where it is treated and then discharged into Clear Creek.

The 1990-1999 annual average delivery to Clear Creek was 316 acre-feet, with a 2000 yield of 370 acre feet. Water from the Straight Creek Tunnel diversion is used for augmentation purposes by the Adolph Coors Company or others to which it leases the water. (CDOT, 2000; Vaught, 2000).

Vidler Tunnel: The Vidler Tunnel is owned by the City of Golden. The water is used

primarily for augmentation and municipal purposes in the Clear Creek basin, though some of the water has been purchased for augmentation purposes in Summit County. The Vidler Tunnel diverts water from the headwaters of Peru Creek, a tributary of the Blue River, under Argentine Pass and into the headwaters of Leavenworth Creek, a tributary of Clear Creek. The water used in Summit County stays in the Blue River basin and so is not transbasin in nature. The majority of the diversions occur during the months of June, July and August.

Rees Vidler bought the Horseshoe Tunnel (a.k.a. Good Luck Tunnel) in 1902, intending to extend the tunnel under the continental divide to connect the railroads at Silver Plume and Keystone. Financing to complete the tunnel was never found, and the mining claims overlaying the Vidler tunnel reverted to Clear Creek and Summit counties due to unpaid taxes. In 1952, Herbert Young began buying the claims in the Vidler Claims Group, all but one of which were purchased for back taxes. In 1956 the Vidler Tunnel was presented as an alternative for a highway tunnel under the continental divide, but was rejected because the grade was too great for automobile traffic. Young then purchased an option on water rights located above the confluence of Soda Creek and the Snake River. In 1967 financing was found and in 1968 the 1.4 mile long tunnel was completed. The first water flowed through the tunnel in 1969, and the collection system, which diverts water above an elevation of 11,000 feet, was completed in 1970. The tunnel is decreed for 31.5 cubic feet per second.

The 1990-1999 water year average annual diversion was 643 acre-feet, and the 2000 water year diversion was 332 acre-feet (Vidler, 2000; CDSS, 2000; Hydrosphere, 1999; Young, 1991; Burcher, 2001).

Harold D. Roberts Tunnel: At 23.3 miles, the Roberts Tunnel is the longest major tunnel water delivery tunnel in the world, approximately as long as the tunnel under the English Channel. Construction on the pilot bore began on September 17, 1942, and was completed in 1962. The west portal lies opposite Dillon Dam on the bottom of Dillon Reservoir. The east portal is near the town of Grant. The bore has two horizontal bends and a maximum overburden of 4465 feet.

The fully lined tunnel is 10.25 feet in diameter, designed to operate under pressure, and has a capacity of 1020 cubic feet per second. The tunnel flows by gravity, with the west portal at an elevation of 8,845 feet, 174 feet higher than the eastern portal. The first water flowed through the tunnel on July 17, 1964. The tunnel cost an average \$25 per inch to construct. The tunnel has an outside diameter of sixteen feet, with a quarter-inch steel plate lining that was inserted in two, 30-foot long pieces. Grout was pumped in to fill the space between the rock walls and liner.

Diversions through the Roberts Tunnel can occur year-round, with the highest deliveries typically occurring in July and August. The 1990-1999 average annual delivery was 61,789 acre-feet, and the 2000 diversion was 93,645 acre-feet (DWB, 2000; USNet1b, 2000; Lewellen, 2000).

Boreas Pass Ditch: The Boreas Pass Ditch diverts water from the headwaters of

Indiana Creek, a tributary of the Blue River, and delivers it into the headwaters of North Tarryall Creek, a tributary of the South Platte River. The ditch is owned by the City of Englewood, which uses the water for municipal purposes.

The 0.8 mile long ditch diverts water from the northwest side of the summit of Boreas Pass, at approximately 11,500 feet above sea level. The ditch has a total decreed right to 16 cubic feet per second, with an appropriation date of January 1, 1910, and was originally appropriated to irrigate land in South Park. The ditch generally diverts during the months of June and July. In 1990 Englewood rehabilitated the ditch, which included putting the ditch in pipe where it crosses a talus slope to eliminate high seepage losses.

The 1990-1999 annual diversions, including the non-diversion years, averaged 139 acre-feet, with 111 acre-feet diverted in 2000. With a recent annual demand of between 6000 and 7000 acre-feet, the ditch typically provides between 2 and 3 percent of the City's annual supply (CDSS, 2000; McCormick, 2000; Wood, 2000).

East Hoosier and West Hoosier Ditches: The Hoosier Ditches were the first recorded transmountain diversion constructed in Colorado, and were used to provide supplemental water for hydro-mining near Fairplay. The ditches divert water from the headwaters of the Blue River into the Middle Fork of the South Platte River. The east East Hoosier Ditch is 1.8 miles long, while the west East Hoosier Ditch is 1.3 miles long. Hoosier Pass, the lowest point on the diversions, is at an elevation of 11,540 feet. The East Hoosier Ditch is decreed for a total of 60 cubic feet per second, and the West Hoosier Ditch is decreed for 17 cubic feet per second, both with an appropriation date of August 5, 1929. The City of Colorado Springs obtained the rights to the Hoosier ditches and now diverts the water through the Hoosier Pass Tunnel as part of the Continental-Hoosier Diversion System (Radosevich, 1976).

Hoosier Pass Tunnel: The Continental-Hoosier Diversion System (a.k.a. the Blue River Project) is located southwest of Breckenridge, Colorado, and is owned by the City of Colorado Springs which developed the project as a source of municipal water. Water is diverted from the Blue River and its tributaries on the west slope to the Middle Fork of the South Platte River on the east slope. Water taken through the Hoosier Tunnel is delivered to Montgomery Reservoir, which is located in the headwaters of the Middle Fork of the South Platte River above Fairplay.

The Hoosier Pass Tunnel is an unlined tunnel, approximately 10 feet in diameter and 1.5 miles long. The tunnel was completed in 1951 and has a capacity of approximately 500 cubic feet per second. Montgomery Reservoir has a capacity of 4900 acre-feet, a spillway elevation of 10,861 feet and was completed in 1957. The reservoir is also decreed to store water from the South Platte basin.

Water from both the Blue River and the Middle Fork of the South Platte River is conveyed 70 miles across South Park to Colorado Springs via the 30-inch Montgomery Pipeline.

The 1990-1999 average annual yield from the Blue River portion of the project was 9939 acre-feet, while diversions from the South Platte were 1401 acre-feet. The 2000 diversions for the Blue River and South Platte are 1401 and 386 acre-feet respectively (CDSS, 2000; USGS, 1985).

Arkansas Basin to the Colorado Basin

Arkansas Well: The Arkansas Well (a portion of the Stevens and Leiter Ditch) is owned by the Climax Molybdenum Mine, and is the only transmountain diversion in Colorado that diverts water from the east slope to the west slope (except for the Vasquez Tunnel, whose water is eventually re-diverted to the east slope). The original 38 cubic feet per second right to the Stevens and Leiter Ditch was used by the Leadville Water Company for municipal use and for the smelters in Leadville. In 1964, 5.4 cubic feet per second was changed to industrial use at the Climax Mine, which diverted the water at the Arkansas Well, a sump located in the headwaters of the Arkansas River. Diversions from the well have been used for domestic, industrial and commercial purposes, and have averaged about 300 acre-feet per year. Diversions occur year-round, and the Arkansas Well has an annual pumping limit of 786 acre-feet per year.

The 1990-1999 average annual diversion by the Arkansas Well was 230 acre-feet, with no delivery in the year 2000 (CDSS, 2000; Gelvin, 2000; Thompson, 2000).

Colorado Basin to the Arkansas Basin

Columbine Ditch: The Columbine Ditch diverts water from the headwaters of the East Fork of the Eagle River and delivers it into the headwaters of Chalk Creek. The ditch was built in 1931 as a supplemental source of irrigation water, and purchased by the South Side Water Works of Pueblo (which became part of the Pueblo Board of Water Works) in 1953. In 1993, the Board changed the decreed use of the Columbine Ditch from agricultural to municipal and other beneficial uses. The Pueblo Board of Water Works uses the water for municipal purposes or leases it out to others for use as a supplemental irrigation supply or for augmentation.

The ditch is located 13 miles north of Leadville and diverts water over an unnamed pass approximately 2 miles southwest of the Climax Molybdenum Mine, crossing the continental divide at an elevation of 11,500 feet. The ditch is approximately 2 miles long, 3 to 5 feet deep, and 15 feet wide at the top.

The ditch has an appropriation date of June 21, 1930, for 60 cubic feet per second. The ditch may divert between April 28 and October 21 of each year, and may divert a maximum of 3148 acre-feet in any one year. The majority of the diversions through the Columbine Ditch occur during the months of May through August.

The average annual diversion through the Columbine Ditch for 1990-1999 was 1773 acre-feet, while the 2000 diversion was 1720 acre-feet (CDSS, 2000; Ward, 2000).

Ewing Ditch: The Ewing Ditch (a.k.a. the Ewing Placer Ditch) diverts water from

the headwaters of Piney Creek, a tributary of the Eagle River, over Tennessee Pass at an elevation of 10,500 feet, and into the headwaters of Tennessee Creek, a tributary of the Arkansas River. The ditch is approximately 1.5 miles long, and was constructed in 1880, making it the oldest transbasin diversion into the Arkansas basin, and the oldest diversion still in use. Constructed as a source of supplemental irrigation water, the ditch is approximately one mile long and intercepts runoff from a drainage area of 2,400 acres.

The Ewing Ditch, the Clear Creek Dam and Reservoir were purchased by the Pueblo Board of Water Works from the Otero Canal Company in 1955. In 1993, the Board changed the decreed use of the Ewing Ditch from agricultural to municipal and other beneficial uses. The Board uses the water for municipal purposes or leases it to other water users as a supplemental irrigation water supply or for augmentation purposes.

The Ewing Ditch has an appropriation date of June 1, 1906, for 18.5 cubic feet per second, with an estimated capacity of 19.6 cubic feet per second. The ditch may divert water between April 18 and October 28, and may divert a maximum of 2402 acre-feet in any one year. The 1990-1999 average annual diversion through the Ewing Ditch averaged 1057 acre-feet, with a 2000 diversion of 1030 acre-feet. (CDSS, 2000; USGS, 1985).

Wurtz Ditch and Wurtz Extension Ditch: The Warren Wurtz and the Wurtz Extension ditches divert water from approximately 9.2 square miles in the headwaters of the South Fork of the Eagle River and deliver it into the headwaters of Tennessee Creek, a tributary of the Arkansas River. The ditch is 6 to 8 feet deep, 20 feet wide at the top and 6 miles long. The Wurtz Extension Ditch is another 6.5 miles long and empties into the Wurtz ditch at Bennett Creek. The Wurtz Ditch was originally constructed in 1929 to provide "irrigation of land for agricultural purposes in the Valley of the Arkansas River." The North Side Water Works of Pueblo (which became part of the Pueblo Board of Water Works) purchased the Wurtz Ditch in 1938. In 1953, the Board extended the ditch to intercept Rule and Yoder creeks.

In 1993, the Board changed the decreed use of the Wurtz Ditch from agricultural to municipal and other beneficial uses. The Board uses the water for municipal purposes or leases it to other water users as a supplemental irrigation water supply or for augmentation purposes.

The Wurtz Ditch has an appropriation date of June 8, 1929, for 85.0 cubic feet per second; the decree for the Extension is dated 1953 and is for 100 cubic feet per second. The ditch may divert between April 18 and October 28, and may divert up to 4083 acre-feet in any one year. The average annual yield for the 1990-1999 period was 2762 acre-feet, while the 2000 yield was 2080 acre-feet (CDSS, 2000; USGS, 1985; Ward, 2000).

Homestake Tunnel: The Homestake Project diverts water from the headwaters of the Eagle River, northwest of Leadville. The project is a joint venture of the Cities of Colorado Springs and Aurora and was built to provide water for municipal purposes.

Water is diverted from several tributaries of Homestake Creek and routed to Homestake Reservoir. Diversions then pass from the reservoir through the Homestake Tunnel to Lake Fork, above Turquoise Reservoir. Water moves from Turquoise to Twin Lakes Reservoir through the Mt. Elbert conduit and power plant, then through the Otero Pump Station and the Homestake Pipeline to Aurora and Colorado Springs.

Homestake Reservoir was completed in 1967 and has a total capacity of 43,300 acre-feet, with a spillway elevation of 10,260 feet. The Homestake Tunnel was completed in 1965 and is 5.5 miles long. The west portal is in the bottom of Homestake Reservoir at an elevation of 10,280 feet. The east portal is at an elevation of 9,960 feet, and the tunnel has a maximum cover of 1,600 feet.

The 1990-1999 average annual yield of the project was 23,048 acre-feet, while the 2000 yield was 26,914 acre-feet (USGS, 1985; Colorado Springs Utilities, 1994).

Charles H. Boustead Tunnel: The Charles H. Boustead Tunnel (a.k.a. Divide Tunnel) transports water from the Fryingpan River under the Continental Divide to the head of Turquoise Reservoir in the Arkansas River Basin. The tunnel is part of the Fryingpan-Arkansas Project, a multipurpose water development constructed by the U.S. Bureau of Reclamation. Diversions from the west slope are made from an elevation 10,002 feet.

The Boustead Tunnel is approximately 5.4 miles long, is horseshoe shaped with a diameter of 10.5 feet, has a maximum overburden of approximately 2000 feet, and a decreed capacity of 945 cubic feet per second. Construction on the tunnel began in 1965 and was complete in 1971. The primary purpose of the project is to provide supplemental water for irrigation and municipal use, though the project also generates electrical power. The tunnel can divert an annual average of 69,200 acre-feet, plus up to 3000 acre-feet of water to be exchanged with the Twin Lakes Reservoir and Canal Company.

The 1990-1999 average annual delivery through the tunnel was 59,740 acre-feet. The water year 2000 diversion was 44,830 acre-feet (CDSS, 2000; USGS, 1985, Simpson, 2000).

Busk-Ivanhoe Tunnel: The Busk-Ivanhoe Tunnel (a.k.a. the Carlton Tunnel) was originally built as a railroad tunnel. The tunnel diverts water from the headwaters of Ivanhoe Creek, a tributary of the Fryingpan River and delivers it to Turquoise Reservoir, in the headwaters of the Arkansas River. The 1.3-mile long tunnel delivers the water to Busk Creek, which is tributary to Turquoise Reservoir.

In 1888 surveys were made for a tunnel from Busk to Ivanhoe creeks. Tunneling crews met in October 1893, and the first train passed through the tunnel on December 13, 1893. The Busk-Ivanhoe tunnel was originally 21 feet high, 15 feet wide, and cost \$1.25 million to construct. It took workers, who were paid \$7.00 per day, 236 days to complete. The west portal of the tunnel is at an elevation of 10,280

feet, the east at 10,800 feet, and the tunnel has a maximum overburden of 1220 feet.

By 1900, most of the railroad traffic was from silver mines of the Cripple Creek region and coal mines from Glenwood Springs. Because the price of silver slumped in the early 1900s, the railroad was sold to a group of private investors from Colorado Springs in 1917. The Busk-Ivanhoe Tunnel was renamed Carlton Tunnel and used for automobile traffic. Recognizing the tunnel as a way to convey additional water to the Arkansas basin, a half-pipe was installed on one side of the tunnel. In 1942 use of the tunnel as a roadway ceased when the State discontinued maintenance of the road. In 1945, the tunnel caved in. The tunnel was purchased in 1949 by the Highline Canal Company and restored at the cost of \$50,000. The High Line Canal Company used the tunnel to convey supplemental water for irrigation east of Pueblo.

The Pueblo Board of Water Works purchased half of the Busk-Ivanhoe Water System from the High Line Canal Company in 1971. The High Line Canal Company retained ownership of the remaining half of the Busk-Ivanhoe system until 1988, when it sold 95 percent of its remaining half to the City of Aurora. In 2000 Aurora bought the remaining shares of the company.

The capacity of the Busk-Ivanhoe Tunnel is currently limited to about 60 cfs through a 30-concrete pipe lying on the floor of the tunnel. In order to offset some of the lost capacity, the Pueblo Board of Water Works contracted with the U.S. Bureau of Reclamation to take deliveries of a portion of the yield of the Busk-Ivanhoe System through the Boustead Tunnel.

The tunnel has an appropriation date of June 27, 1921 and may divert between March 24 and November 25. The tunnel and west slope ditches have a total decreed capacity of 180 cubic feet per second and may divert a maximum of 10,082 acre-feet in any one year. The Busk-Ivanhoe Company has a contract for 10,000 acre-feet of storage space in with the U.S.B.R. in Turquoise Reservoir; but because the contract was originally with the Highline Canal Company, the Bureau asserts that the space may only be used to store irrigation water. Because both municipalities have changed the water from agricultural to municipal use, the Bureau has not allowed water from the system to be stored in the account.

The majority of the diversions are made during the snowmelt runoff months, sometimes extending into October. The 1990-1999 average annual yield was 4740 acre-feet, and the 2000 yield was 5210 acre-feet (Abbott, 1985; Colorado Railroad, 2000; CDSS, 2000; Hancock, 1990; Ward, 2000).

Twin Lakes Tunnel: The Twin Lakes collection and delivery system was constructed in the 1930's to serve land irrigated by the Colorado Canal in Crowley County in the Arkansas basin. The collection system is located in the headwaters of the Roaring Fork River. Water is diverted into Grizzly Reservoir, which is located in Lincoln Gulch. Grizzly has an active capacity of 570 acre-feet, but normally fluctuates less than 400 acre-feet. From Grizzly Reservoir, the water flows under the

continental divide through the Twin Lakes (a.k.a. Independence Pass) Tunnel into North Fork Lake Creek. The water is stored in 54,452 acre-feet of storage space owned by the Twin Lakes Reservoir and Canal Company in Twin Lakes Reservoir. The Company also holds water rights for water native to the Arkansas river basin. Diversions through the Twin Lakes Tunnel began on May 24, 1935.

Fifty-four percent of the Twin Lakes Reservoir and Canal Company is owned by the City of Colorado Springs, with the remaining shares held by the Pueblo Board of Water Works, Pueblo West, The City of Aurora, and a dozen smaller users.

The Twin Lakes Tunnel is circular, concrete lined and 8.5 feet in diameter. The tunnel is about 4 miles long and has a capacity of 625 cubic feet per second. The western portal of the Twin Lakes tunnel is at an elevation of 10,520 feet, the eastern portal is at 10,460 feet, and the tunnel has a maximum overburden of 2630 feet.

The Twin Lakes Tunnel is "as straight as a rifle barrel," and when the tunnel is shut down you can stand downstream of the gates at the western portal and see the pinprick of light of the eastern portal, 4 miles away. During the winter when snow closes the road between the caretaker's house and the town of Aspen, and the only flow in the tunnel is what leaks past the closed gates, the caretakers can open an access door and drive through the tunnel to get their groceries and mail at Leadville.

Flows through the tunnel are measured in a 12-foot Parshall flume at the tunnel's east portal, which is fitted with satellite telemetry. The 1990-1999 average annual yield of the west slope portion of Twin Lakes project was 38,785 acre-feet, with a yield of 42,117 acre-feet in water year 2000 (Abbott, 1985; Ringle, 2000).

Gunnison Basin to the Arkansas Basin

Larkspur Ditch: The Larkspur Ditch was constructed by the Catlin Canal Company to provide supplemental water for irrigation under the Catlin Canal, east of Pueblo. The ditch was built in 1939, and diverts water from Hurry Creek, from the north of the west side of Marshall Pass, approximately 3 miles west of Poncha Pass. The ditch crosses Marshall Pass at an elevation of 10,900 feet, and delivers water to Poncha Creek, a tributary of the South Arkansas River. The ditch is 1.5 miles long, with a conditional right to extend it another 1.5 miles. Diversions are measured in a 4-foot Parshall flume. The ditch generally runs all summer, from June 1 through September. The ditch can divert a maximum of 7 to 8 cubic feet per second, but typically flows at 3 to 4 cubic feet per second.

The canal company anticipates the ditch delivering an average of 200 acre-feet per year. The 1990-1999 average annual water year diversions were 31 acre-feet. There were no diversions in the year 2000 because the ditch was out of priority for all but 3 or 4 days.

Gunnison Basin to the Rio Grande Basin

Tarbell Ditch: The Tarbell Ditch (a.k.a. Cochetopa Transmountain Ditch) diverts

water from Lake Fork of Cochetopa Creek in the Gunnison River basin, to Lake Fork Creek, tributary to the Middle Fork of Saguache Creek, in the Rio Grande basin. Flows in the ditch are measured with a 2.5 foot Parshall flume. The ditch is approximately 0.7 miles long and diverts water from Lake Fork at an elevation of 11,190 feet, over an unnamed pass at an elevation of approximately 11,180 feet. The ditch is equipped with satellite telemetry.

The decree was applied for on February 1, 1905, and the first water was delivered in 1917 and was used for supplemental irrigation near Saguache. The ditch typically runs from the third week in June through the end of August. The ditch is decreed for 25 cubic feet per second. The ditch is currently owned by three individuals, with 2/5, 2/5, 1/5 ownership, all of whom use the water for irrigation.

The water year 1990-1999 average annual diversion was 419 acre-feet, with a year 2000 diversion of 630 acre-feet in 89 days (Lovato, 2000).

Tabor Ditch: The Tabor Ditch is owned by the Colorado Division of Wildlife. The ditch diverts water from tributaries of Cebolla Creek, in the headwaters of the Gunnison basin, over Spring Creek Pass into Big Spring Creek, tributary to North Clear Creek. The ditch was originally constructed to provide supplemental irrigation water, but was changed by the Division of Wildlife to include augmentation, wildlife habitat, reservoir conservation pool, and refill rights.

The ditch is open, approximately 0.5 miles long, 5 feet wide at the bottom and 3 feet deep. The ditch has an appropriation date of 1910 for 24.41 cubic feet per second, with a second enlargement right for 15.21 cubic feet per second. The ditch is approximately 3/8 of a mile long, with an estimated capacity of 30 cubic feet per second. Flows are measured in a 3-foot Parshall flume fitted with a data logger and satellite telemetry.

The 1990-1999 average annual yield was 1435 acre-feet, while the diversion for the water year 2000 was 495 acre-feet. Because the ditch is fairly senior, it is typically in priority when there is a demand for water in the Rio Grande basin (Johnson, 2000).

San Juan Basin to the Rio Grande Basin

Weminuche Pass Ditch: The Weminuche Pass Ditch (a.k.a. Raber Lohr Ditch) diverts water from the headwaters of the Los Pinos River, a tributary of the San Juan, into Weminuche Creek, a tributary of the Rio Grande. The ditch is owned by the Colorado Division of Wildlife, which uses the water for irrigation in conjunction with various wildlife programs. The ditch, with an appropriation date of 1934, was originally constructed to supply supplemental water for irrigation and was purchased by the Division of Wildlife in the early 1980's. There have been four filings on the ditch, for a total of 40 cubic feet per second. Diversions typically begin around the beginning of June and continue until mid-July. The ditch is approximately 1.5 miles long, open, with a 10-foot wide bottom, and a depth of 3 to 4 feet.

The average annual diversion for water years 1990-1999 was 1088 acre-feet, which included no diversions in 1993-1996, when the ditch was shut down for repairs. There was also no diversion in water year 2000, because the call in the San Juan basin curtailed diversions through the ditch by the time there was demand for the water in the Rio Grande basin (Baer, 2000; Johnson, 2000; Riverside, 2000).

Pine River - Weminuche Pass Ditch: The Pine River - Weminuche Pass Ditch (a.k.a. Fuchs Ditch) diverts from the headwaters of the Los Pinos River into Weminuche Creek, a short distance from the Weminuche Pass Ditch. The ditch was constructed in 1934, is approximately 1.3 miles long, is decreed for 6 cubic feet per second, and has a physical capacity estimated at 25 cubic feet per second. The original decree was to provide supplemental irrigation water for 320 acres in the San Luis Valley.

The ditch is owned one quarter each by two different individuals and half by the San Luis Valley Water Conservancy District. Currently the ditch is used both for irrigation and for augmenting out of priority uses in the San Luis Valley. Flows are measured in a 3-foot Parshall flume fitted with satellite telemetry where the ditch crosses the continental divide.

The ditch begins diverting around the beginning of June and is typically out of priority by mid-July. The highest flows typically occur right after the ditch is turned on, and ditch diversions are administered from the satellite data. Average annual diversions are approximately 450 acre-feet per year. The 1990-1999 average annual yield was 491 acre-feet. The water year 2000 diversion was 203 acre-feet, and was limited because the ditch was called out of priority. (Baer, 2000; Riverside, 2000).

Williams Creek - Squaw Pass Ditch: The Williams Creek - Squaw Pass Diversion diverts water from the headwaters of Williams Creek, a tributary of the Piedra River, and delivers it into the headwaters of Squaw Creek. The ditch has an appropriation date of September 9, 1937, as a supplemental supply of irrigation water for 600 acres in the San Luis Valley.

The ditch was purchased in 1978 by the Navajo Development Company, which has converted part of the right to augmentation uses. While sales of the right for augmentation purposes have resulted in the ditch being owned by numerous individuals, the majority of the water is still used for irrigation purposes by ranchers and farmers in the area around the town of Creede. The majority of the water is diverted during the months of June and July.

The ditch is approximately 0.1 miles long, and flows through the ditch are measured in a 2-foot Parshall flume which is fitted with satellite telemetry. The ditch is decreed for 10 cubic feet per second, with an estimated capacity of 12 cubic feet per second.

The 1990-1999 average annual yield was 359 acre-feet. The water year 2000 yield was 230 acre-feet, when diversions stopped due to a lack of water physically available. Typically 35 to 40 acre-feet per year are used for augmentation purposes, with the remainder being used for irrigation (Baer, 2000; Riverside, 2000).

Don La Font Ditches 1 and 2: The Don Lafont Ditches No. 1 and No. 2 divert from the headwaters of the East Fork of the Piedra River, over Piedra Pass and into tributaries of the Rio Grande. The ditches are owned and operated by the Colorado Division of Wildlife. The majority of the water is diverted during the runoff months, typically from June 1 through mid July. Typically diversions are curtailed because of insufficient stream flow rather than the river call. Both ditches have an appropriation year of 1940. The Don Lafont #1 has a decreed capacity of 4 cubic feet per second with an estimated capacity of 10 cubic feet per second. The Don Lafont #2 has an original filing for 6 cubic feet per second, an enlargement for an additional 6 cubic feet per second, and an estimated capacity of 12 cubic feet per second.

The ditches are decreed for irrigation use. The Division of Wildlife works with irrigators, and delivers water from the ditches to irrigators in exchange for the irrigators leaving water in reservoirs for wildlife purposes.

Both ditches are approximately 0.5 miles long. Because of the high elevation of the ditches, snow and ice accumulation in the ditches delayed the initiation of diversions. To begin diverting earlier in the season, both ditches were put into corrugated pipe in the 1980's. Because the ditches are located inside a wilderness area, a special use permit had to be obtained to use construction equipment to install the pipe, and a helicopter was used to lift a backhoe in and out of the site. Flows from Don La Font No. 1 and No. 2 are measured in 9-inch and 1.5-foot Parshall flumes, respectively, and equipped with satellite telemetry.

The average annual combined diversion has been approximately 225 acre-feet. The water year 1990-1999 average annual yield was 201 acre-feet, with a year 2000 diversion of 10 acre-feet. The 2000 diversion was limited by insufficient flows (Riverside, 2000; Johnson, 2000).

Treasure Pass Diversion Ditch: The Treasure Pass Diversion Ditch diverts water from Treasure Creek, a tributary of Wolf Creek, a tributary of the West Fork of the San Juan River. The ditch crosses the continental divide at Wolf Creek Pass, and delivers water into the South Fork of the Rio Grande. The ditch was built in 1922 to provide supplemental irrigation water for 800 acres in the San Luis Valley. The ditch is decreed for 7 cubic feet per second and has an estimated capacity of 15 cubic feet per second. The headgate is approximately a half mile southwest of the highway at the top of Wolf Creek Pass.

The ditch is owned by a private individual and is used to irrigate approximately 300 acres in the San Luis Valley. The structure typically diverts during the runoff months of June and July. Flows are measured in a 2-foot Parshall flume, and are recorded with a graphical recorder.

The water year 1990-1999 average annual diversion was 123 acre-feet. The water year 2000 diversion was 70 acre-feet. The 2000 diversions were limited in duration because of insufficient flows, and in quantity because ditch maintenance had not been completed (Baer, 2000; Riverside, 2000).

Azotea Tunnel: The San Juan Chama Project was developed by the U.S. Bureau of Reclamation as part of the Colorado River Storage Project. The project diverts water from tributaries of the San Juan River in the Colorado River basin in Colorado for delivery to the Rio Grande basin in New Mexico. The Project provides an average annual diversion of about 110,000 acre-feet of water from tributaries of the San Juan River for municipal, domestic, and industrial uses, as well as supplemental irrigation water and incidental recreation and fish and wildlife benefits.

Surveys for diverting San Juan River Basin waters into the Rio Chama began in 1933. Construction of Azotea Tunnel began on April 22, 1964, and was completed on November 11, 1970. The Azotea Tunnel is 12.8 miles long, has a capacity of 950 cfs, and carries the water from the Navajo River, tributary to the San Juan, to Azotea Creek in the Rio Grande basin.

As the project was a federal undertaking, there are no state water rights associated with the project. The average annual diversion for water years 1990-1999 was 91,790 acre-feet, and the water year 2000 yield was 96,189 acre-feet (USBRb, 2000).

SUMMARY

Transmountain diversions in Colorado have been developed to divert water from an area with unappropriated water to areas that were deemed to be water short. Generally speaking, water projects built in the first half of the 1900's were developed to provide supplemental water for agricultural purposes, while projects constructed in the second half were wholly or at least in part for municipal purposes. Combined with the fact that several of the projects originally developed for irrigation purposes have been purchased and converted to municipal use, the majority of the water diverted across the continental divide is now used for municipal purposes.

Excluding the Arkansas Well, the total amount of water diverted from the west side of the continental divide to the east averaged 577,724 acre-feet for the 1990-1999 period, and was 591,742 acre-feet in 2000.

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