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1.0 SOUTH PLATTE RIVER NEAR DENVER, COLORADO

1.1 STUDY AREA OVERVIEW

1.1.1 Study Area Description

The South Platte River originates in the Rocky Mountains and flows east and northeast through forest and mountain rangeland to approximately 20 miles from Denver where it enters the plains and flows into the Chatfield Reservoir. The river then flows through mainly urban areas and into the City of Denver. Land use upstream of Denver is approximately 48 percent forest, 35 percent rangeland, 6 percent agriculture, 5 percent urban, and 6 percent other. However, most of the water from the forested headwaters is used as the municipal water supply for Denver and is removed from reservoirs upstream of Chatfield Reservoir. Land use downstream of the reservoir is mainly urban (Litke and Kimbrough 1998). The primary sources of water for this river are snowmelt in the mountains and rainfall on the plains. Groundwater also contributes substantially to the South Platte River in the plains (Dennehy et al. 1998). The South Platte River has its highest flows in the late spring and early summer because of snowmelt in the Rockies. Summer thunderstorms add to the flow, occasionally causing flooding (Silkensen 1992).

The primary sources of water for this river are snowmelt in the mountains and rainfall. Groundwater also contributes substantially to the South Platte River in the plains (Dennehy et al. 1998). The South Platte has its highest flows in the late spring and early summer because of snowmelt in the Rockies. Summer thunderstorms add to the flow, occasionally causing flooding (Silkensen 1992).

The South Platte River historically was an intermittent river but today is perennial, due in part to human influence. Irrigation return flows, water storage, and transbasin water diversion have all played a part in altering the water flow (Silkensen 1992). Explorers in 1820 described the confluence of the north and south forks of the South Platte River as shallow with barren and wooded areas along the banks. Trees were more abundant closer to the mountains. In 1842, explorers again found that the quantity and lushness of the vegetation increased with proximity to the mountains. It is probable that vegetation decreased downstream because, during periods of drought, the water sunk into an aquifer below the surface, leaving the riverbed dry. In the summer of 1842, the South Platte River was reported to be completely dry (Silkensen 1992).

Following the discovery of gold on Dry Creek in 1858, gold-seekers traveled through the South Platte Valley to reach the Denver area. Timber along the river was probably used for firewood. A few years later, the South Platte River was described as narrow and muddy, and devoid of any trees (Silkensen 1992).

The early mining camps near Denver necessitated development of irrigation for agriculture in the early 1860s. As farmers irrigated, it became apparent in the early 1880s that there was an increase in the volume of water in the river channels at and below the irrigated land. The flow on the South Platte River was much more uniform because the irrigating canals reduced the flow

during the flood season and through seepage, the water percolated through the soil, and returned to the river years later (Silkensen 1992).

Construction of reservoirs along the South Platte River began in 1879 to meet increased water demands. Much of the land along the river already was being farmed, so investors bought higher bench land above the river's floodplain. More canals were constructed or enlarged to supply water to these lands. Eventually, water demand outstripped the supply. As a result, storage reservoirs were constructed to capture the surplus flows on the South Platte River each spring as the mountain snowpack melted. The reservoirs not only stored spring runoff, but they contributed return flow through seepage. Water diversions also have contributed to the flow of the South Platte River. The first trans-basin diversion was created in 1860 near Fairplay for gold prospectors to wash mining ore. Although this diversion was short-lived, 11 trans-basin water diversions into the South Platte River Basin were in place by 1922 (Silkensen 1992).

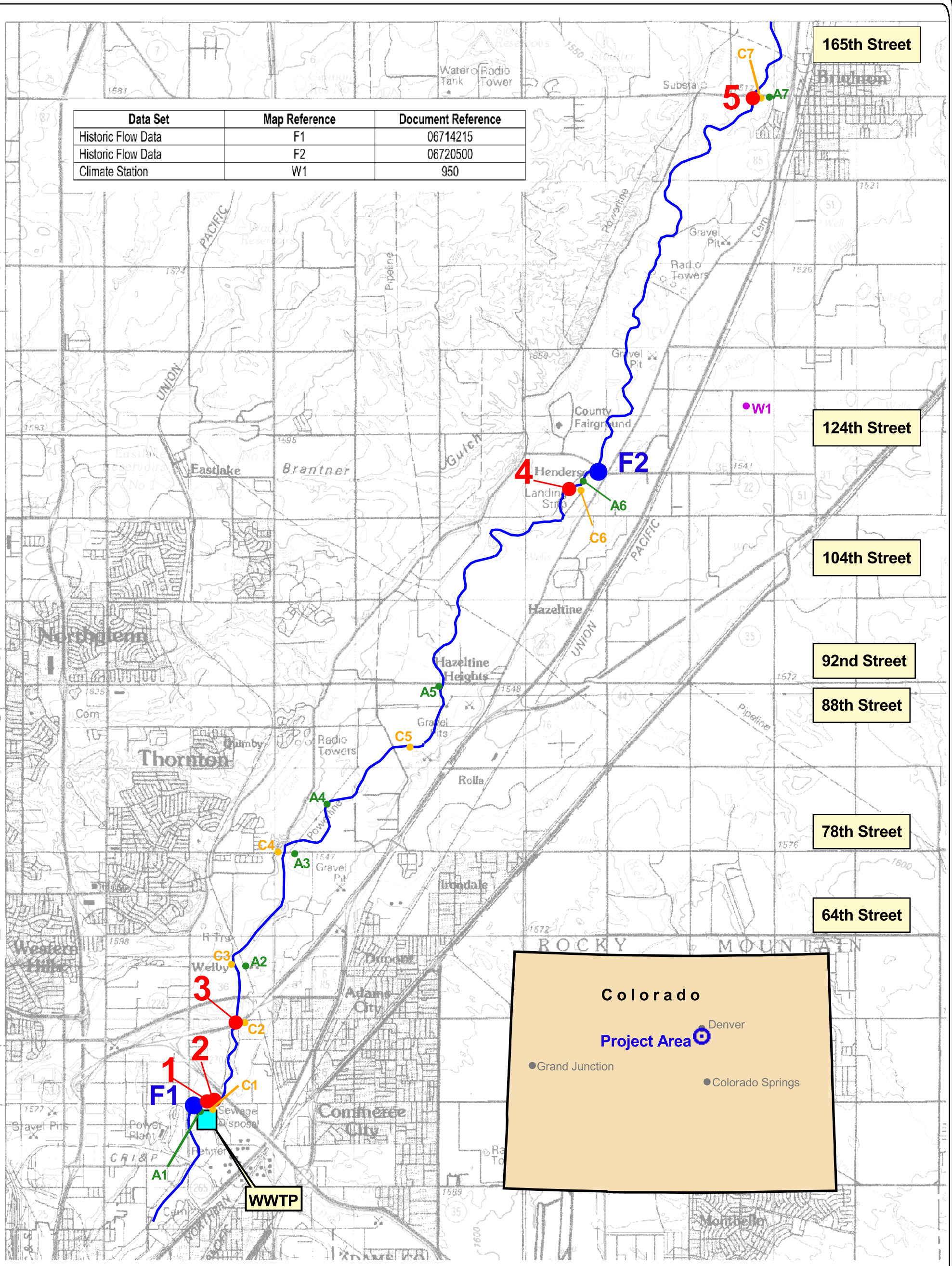
All of these human influences have changed the river's channel formation and sedimentation. The regulated flow has allowed riparian vegetation to stabilize the river channel, forcing it to become narrower and less sinuous. This, in turn, has restricted the river's lateral movement, prohibiting water dispersion during flooding. Irrigation return flows have contributed to the pollution of the river water (Silkensen 1992). Water quality in the South Platte River has been degraded by mining wastes, municipal wastewater, industrial discharges, agricultural return flows, and stormwater runoff.

Figure C-6-1 shows the locations of the site reconnaissance sites (red numbers 1 through 5) and the locations of historical data. Table C-6-1 describes each data point.

Table C-6-1
Historical Data Locations for the South Platte River near Denver, Colorado

Data Label	Data Summary	Reference
A1	Invertebrate and fish data	MWRD, CDM et al. 1994a
06714215	Historical flow data	USGS
C1	Historical Chemical Data	MWRD
C2	Historical Chemical Data	MWRD
C3	Historical Chemical Data	MWRD
A2	Invertebrate (78th Ave.) and fish (72nd Ave.) data	MWRD, CDM et al. 1994a
A3	Invertebrates and fish data	MWRD, CDM et al. 1993, 1994b
C4	Historical Chemical Data	MWRD
A4	Invertebrate data	MWRD
C5	Historical Chemical Data	MWRD
A5	Invertebrate and fish data	MWRD, CDM et al. 1993, 1994a,b
C6	Historical Chemical Data	MWRD
A6	Invertebrate and fish data	MWRD, CDM et al. 1993, 1994a,b
06720500	Historical flow data	USGS
950	Historical precipitation and temperature data	NCDC
C7	Historical Chemical Data	MWRD
A7	Invertebrate and fish data	MWRD, CDM et al. 1994b

MWRD Denver Metro Wastewater Reclamation District
CDM – Camp Dresser & McKee
USGS – U.S. Geological Survey
NCDC – National Climatic Data Center



Data Set	Map Reference	Document Reference
Historic Flow Data	F1	06714215
Historic Flow Data	F2	06720500
Climate Station	W1	950

Arid West Water Quality Research Project Habitat Characterization Study
South Platte River Near Denver, Colorado

Legend

- Stream Study Area
- Reconnaissance Data (1 - 5)
- Historic Flow Data (F1 - F2)
- Historic Chemical Data (C1 - C7)
- Historic Aquatic Data (A1 - A7)
- Climate Station (W1)
- Wastewater Treatment Plant (WWTP)

1 0 1 2

Scale in Miles

Source: US Geological Survey 30x60 Minute Quadrangle Map
Denver East, Colorado(1981)

N

URS

Figure C-6-1

X:\PimaCounty\WQRP\Projects\Denver.apr

1.1.2 Ecoregion Description

Denver and the South Platte River are located in Ecoregion 25, Western High Plains (Omernick and Bailey 1997). Ecoregion 25 occupies a large area from eastern Wyoming and western Nebraska south to west Texas and southeastern New Mexico, including most of northeastern Colorado. The South Platte River itself receives runoff from a large, high-elevation watershed that lies in Ecoregion 21, Southern Rocky Mountains. Ecoregion 25 is dominated by relatively smooth plains with little relief and has semi-arid climatic conditions, with hot summers and cold winters. Shortgrass prairies dominate natural vegetation in this ecoregion. Dominant land uses in this region include grazing, cropland, and irrigated agriculture. However, most of the watershed investigated by this project has been extensively urbanized, producing abundant managed storm water runoff. Some characteristic plant species of this region include sideoats grama and buffalograss. Some of the vertebrate wildlife species that are characteristic of Ecoregion 25 include swift fox, black-tailed prairie dog, hispid pocket mouse, bison, mountain plover, upland sandpiper, horned lark, lark bunting, Great Plains toad, prairie lined racerunner, plains hognose snake, and prairie rattlesnake (URS 2000).

1.2 WATER QUALITY STANDARDS

The section of the South Platte River mainstem from the Burlington Ditch diversion in Denver to a point immediately below the confluence with Big Dry Creek has the following designated uses:

- **Class 2 - Warm Water Aquatic Life**. These are waters that are not capable of sustaining a wide variety of cold or warmwater biota, including sensitive species, due to physical habitat, water flows or levels, or uncorrectable water quality conditions that result in substantial impairment of the abundance and diversity of species.

- **Class 2 - Secondary Contact.** These surface waters are suitable or intended to become suitable for recreational uses on or about the water, which are not included in the primary contact subcategory, including but not limited to fishing and other streamside or lakeside recreation.

- **Domestic Water Supply.** These surface waters are suitable or intended to become suitable for potable water supplies. After receiving standard treatment (defined as coagulation, flocculation, sedimentation, filtration, and disinfection with chlorine or its equivalent), these waters will meet Colorado drinking water regulations and any revisions, amendments, or supplements thereto.

- **Agriculture.** These surface waters are suitable or intended to become suitable for irrigation of crops usually grown in Colorado and which are not hazardous as drinking water for livestock.

Table C-6-2 shows the water quality standards for constituents of concern for the South Platte River near Denver.

Table C-6-2
Water Quality Standards for Constituents of Concern for the South Platte River Near Denver, Colorado

Constituent of Concern	Criteria to protect uses
Ammonia (un-ionized)	0.1 mg/L (chronic) Formula (acute)
Arsenic	50 µg/L total recoverable (acute)
Beryllium	
Cadmium	9.9 µg/L dissolved (acute)* 1.1 µg/L dissolved (chronic)*
Chlorine	0.019 mg/L (acute) 0.011 mg/L (chronic)
Copper	17.7 µg/L dissolved (acute)* 11.8 µg/L dissolved (chronic)*
DDT	
Mercury	2.4 µg/L dissolved (acute) 0.4 µg/L dissolved (chronic)
PCBs	
Selenium	10 µg/L total recoverable (chronic)
Fecal Coliform Bacteria	2,000 cfu/100 mL
pH	6.5-9.0
Temperature	
Turbidity	
Dissolved Oxygen	5.0 mg/L 7-day average (April 1 through July 31) 2.0 mg/L 1-day instantaneous (August 1 through March 31) 4.5 mg/L 30-day average (August 1 through March 31)
Total Dissolved Solids	
Nutrients	
Salinity	

* Criteria calculated via formula based on hardness of 100 mg/L as $CaCO_3$
mg/L – milligram(s) per liter
µg/L – microgram(s) per liter
cfu – colony forming unit

1.3 WASTEWATER TREATMENT PLANTS DISCHARGING TO THE STUDY AREA

The Denver Metro Wastewater Reclamation District (MWRD) is a single-purpose special government formed in 1961 to provide wastewater collection and treatment service to a portion of the Denver metropolitan area. MWRD provides service to 55 local cities and sanitation districts, encompassing approximately 1.3 million people and a service area of some 380 square miles. The Central Plant (Denver Metro Wastewater Treatment Plant [WWTP]) is the largest wastewater treatment facility between the Mississippi River and the West Coast, discharging effluent to the South Platte River and the Burlington Ditch.

1.3.1 National Pollutant Discharge Elimination System Discharge Permits

A summary of selected National Pollutant Discharge Elimination System (NPDES) permit parameters for the Denver Metro WWTP discharges to the South Platte River are provided in **Table C-6-3** This expired on August 31, 1997. A draft permit likely will be developed after the state of Colorado completes its triennial review of South Platte River standards in late 2000 or early 2001.

Table C-6-3
Summary of Selected NPDES Permit Parameters for Denver Metro WWTP

Parameter	Units	Limit Type	Value
$CBOD_5$	mg/L	30-day average 7-day average	17 25
Total Suspended Solids	mg/L	30-day average 7-day average	30 45
Fecal Coliform Bacteria	#/100 mL	30-day average 7-day average	2,000 4,000
Total Residual Chlorine	mg/L	30-day average Daily maximum	0.011 0.019
pH	S.U.	Maximum Minimum	9 6.5
Whole Effluent Toxicity (WET) Testing		Required/Not Required	Required
Total Ammonia	mg/L as N	30-day average	Varies monthly from 10 - 15
Nitrite	mg/L as N	30-day average	1
Nitrate + Nitrite	mg/L as N	30-day average	10
Dissolved Oxygen	mg/L	Daily minimum	Varies seasonally from 4.5 - 5
S.U. – Standard Unit(s)			

Effluent flows are also limited in the permit, varying monthly from 177.8 million gallons per day (mgd) in December to 227.0 mgd in May. Additional requirements and constraints are detailed in the permit, included in **Appendix L**.

1.3.2 Effluent Quality

EPA's Permit Compliance System (PCS) was queried to obtain historical data on effluent quality as reported by the WWTP of interest. This system is a holding of Discharge Monitoring Reports that are submitted to EPA by state NPDES programs. Table C-6-4 a shows a summary of the discharge monitoring data for the Denver Metro WWTP.

Table C-6-4
Summary of Selected PCS Parameters for the Denver Metro WWTP

Parameter	Units	Average Reporting Concentrations		Number of Measurements	Period of Record
$CBOD_5$	mg/L	Minimum Average Maximum	0 7.8 35	70 294 294	1989-2000
Dissolved Oxygen	mg/L	Minimum Average Maximum	4.8 6.7 8.4	157 51 63	1989-2000
Fecal Coliform Bacteria	#/100 mL	Minimum Average Maximum	27 362 13,000	71 251 251	1989-2000
pH	S.U.	Minimum Average Maximum	6.3 7.8	250 250	1989-2000

Table C-6-4
Summary of Selected PCS Parameters for the Denver Metro WWTP

Parameter	Units	Average Reporting Concentrations		Number of Measurements	Period of Record
Temperature	°C	Minimum	10	179	1989-2000
		Average	18.5	51	
		Maximum	26	179	
Nitrite plus Nitrate Total 1 Det. (as N)	mg/L	Minimum			1989-2000
		Average	4.3	134	
		Maximum	7.8	134	
Total Nitrate Nitrogen (as N)	mg/L	Minimum	0	44	1989-1992
		Average	2.8	44	
		Maximum	20	44	
Total Nitrite Nitrogen (as N)	mg/L	Minimum	0	48	1989-2000
		Average	0.2	175	
		Maximum	1.59	175	
Total Ammonia Nitrogen	mg/L	Minimum	3.8	51	1989-1999
		Average	9	179	
		Maximum	30	179	
Total Arsenic (as AS)	µg/L	Minimum			1989-2000
		Average	<0.04	173	
		Maximum	7.3	173	
Potentially Dissolved Cadmium	µg/L	Minimum			1990-2000
		Average	<0.15	148	
		Maximum	2.06	148	
Total Recoverable Cadmium	µg/L	Minimum			1989-1990
		Average	0.2	28	
		Maximum	2.3	28	
Total Cadmium (as CD)	mg/L	Minimum	0	3	1989
		Average	0	3	
		Maximum	0	3	
Potentially Dissolved Copper	µg/L	Minimum			1990-2000
		Average	7.4	148	
		Maximum	36.3	148	
Total Recoverable Copper	µg/L	Minimum	3	23	1989-1990
		Average	8.9	28	
		Maximum	23	28	
Total Copper (as CU)	mg/L	Minimum	4	3	1989
		Average	8.3	3	
		Maximum	15	3	
Potentially Dissolved Mercury	µg/L	Minimum			1990-2000
		Average	<0.019	148	
		Maximum	0.92	148	
Total Mercury (as HG)	µg/L	Minimum			1989-1992
		Average	14.49	29	
		Maximum	2,079	29	
Total Selenium (as SE)	µg/L	Minimum			1989-2000
		Average	0.83	175	
		Maximum	7.6	175	
Total Residual Chlorine	mg/L	Minimum			1989-2000
		Average	<0.005	116	
		Maximum	0.5	201	

Table C-6-4
Summary of Selected PCS Parameters for the Denver Metro WWTP

Parameter	Units	Average Reporting Concentrations		Number of Measurements	Period of Record
Total Suspended Solids	mg/L	Minimum			1989-2000
		Average	16.3	298	
		Maximum	91	298	

1.3.3 WWTP Processes

Effluent from the Denver Metro WWTP is discharged to either the South Platte River or the Burlington Ditch, which serves agricultural irrigators and other users. Other WWTPs discharging to the South Platte River in the Denver Metro area include Centennial, Littleton/Englewood, Adams County, and Brighton. The Denver Metro WWTP was first constructed in 1966 with a capacity of 117 mgd. Major modifications to the plant, which now includes the original "North Complex" and the newer "South Complex," have included the following:

- 1966: Chlorination added.
- 1975 to 1976: South Complex added, bringing total capacity to 170 mgd.
- 1987: New primary clarifiers added to North Complex, replacing clarification capacity at an abandoned upstream plant that previously provided pretreatment for the Central Plant.
- 1988: Dechlorination added to both the North Complex and South Complex.
- 1990 to 1991: Nitrification and denitrification added to the North Complex, and various upgrades to the South Complex.

The total capacity of the Denver Metro WWTP is now rated at 185 mgd. Liquid train unit processes in place at the two complexes include the following:

- North Complex
  - bar screens
  - grit removal
  - primary clarification
  - secondary treatment in aeration basins (air-based) with nitrification and denitrification
  - secondary clarification

- chlorination and dechlorination

- South Complex
  - bar screens
  - grit removal
  - primary clarification
  - secondary treatment in aeration basins (pure oxygen) without nitrification or denitrification
  - secondary clarification
  - chlorination and dechlorination

MWRD is preparing to initiate a significant master planning effort, which will guide the nature of future treatment facilities at the Denver Metro WWTP and perhaps additional sites. Plans for reuse of effluent from the Denver Metro WWTP for industrial and irrigation-related uses are in place, with expected reuse of up to 13.6 mgd upon completion of the second phase of construction.

1.3.4 WWTP Flows to Receiving Water and Reuse

MWRD is authorized to discharge treated effluent into the South Platte River, and may divert effluent to the Burlington Ditch for irrigation purposes. Daily flow data for the effluent produced by the Denver Metro WWTP are available in electronic format for 1997 through the present. In 1999, the North Complex discharged an average of 85.9 mgd. The South Complex discharged an average of 62.2 mgd, for a combined total average of 148 mgd.

1.4 PHYSICAL DATA OVERVIEW

This section summarizes available historic hydrologic and geomorphology data. A summary of the geomorphology site reconnaissance effort is also included.

1.4.1 Hydrologic Data and Geomorphology Summary

Near Denver, the South Platte River has a mean velocity of approximately 1 foot per second and a mean gradient of 18.9 feet per mile. The stream is highly channelized in this region with a sinuosity of approximately 1 (low) and an average channel width of 122 feet. The predominant substrate is sand. The river has been straightened and realigned in places and grade control and bank protection measures exist through much of the reach (CDM 1994).

The Denver Metro WWTP discharges to the South Platte River in Denver. Streamflow statistics indicate that mean monthly streamflow above the WWTP outfall ranges from 63 cubic feet per second (cfs) (December) to 798 cfs (May) and mean monthly streamflow below the WWTP ranges from 186 cfs (December) to 1,066 cfs (June). During the winter months, the river upstream of the WWTP is typically completely diverted for irrigation purposes. Mean monthly flows for these two points, as well as the gaged period of records (PORs), are presented on **Figure C-6-2**. Table C-6-5 summarizes the hydrologic and hydraulic data availability for the study area.

Table C-6-5
Available Hydrologic and Hydraulic Data for the South Platte River at Denver, Colorado

Gage ID	Gage Name	Average Daily Flow POR	Annual Peak Daily Flow POR	Partial Duration Peak Daily Flow POR	Stage-Discharge Relationship Availability
06714215 (upstream)	South Platte at 64th Ave. Commerce City, CO	1982 - 1998	1982 - 1996	NA	1983 - 2000
06720500 (downstream)	South Platte River at Henderson, CO	1926 - 1998	1926 - 1996	NA	1983 - 2000

Hydrologic controls upstream of Denver include the Chatfield Reservoir; four headwater reservoirs (Antero, Spinney Mountain, Eleven Mile, and Cheeseman); and various agricultural, industrial, and municipal withdrawals and return flows.

Air temperature and precipitation data were recorded in Brighton at NCDC station number 950 (refer to **Figure C-6-1**) from 1973 through 1998. The estimated average annual precipitation is 14.5 inches in this region. The estimated average temperature in this area is 50°F. Table C-6-6 presents the average monthly precipitation and temperature.

Table C-6-6
Average Monthly Precipitation and Temperature for the South Platte near Denver, Colorado

Month	Precipitation (Inches)	Temperature (°F)
January	0.5	30
February	0.4	33
March	1.3	40
April	1.6	48
May	2.4	58
June	1.8	67
July	1.6	73
August	1.5	71
September	1.0	63
October	0.9	51
November	0.9	37
December	0.5	30

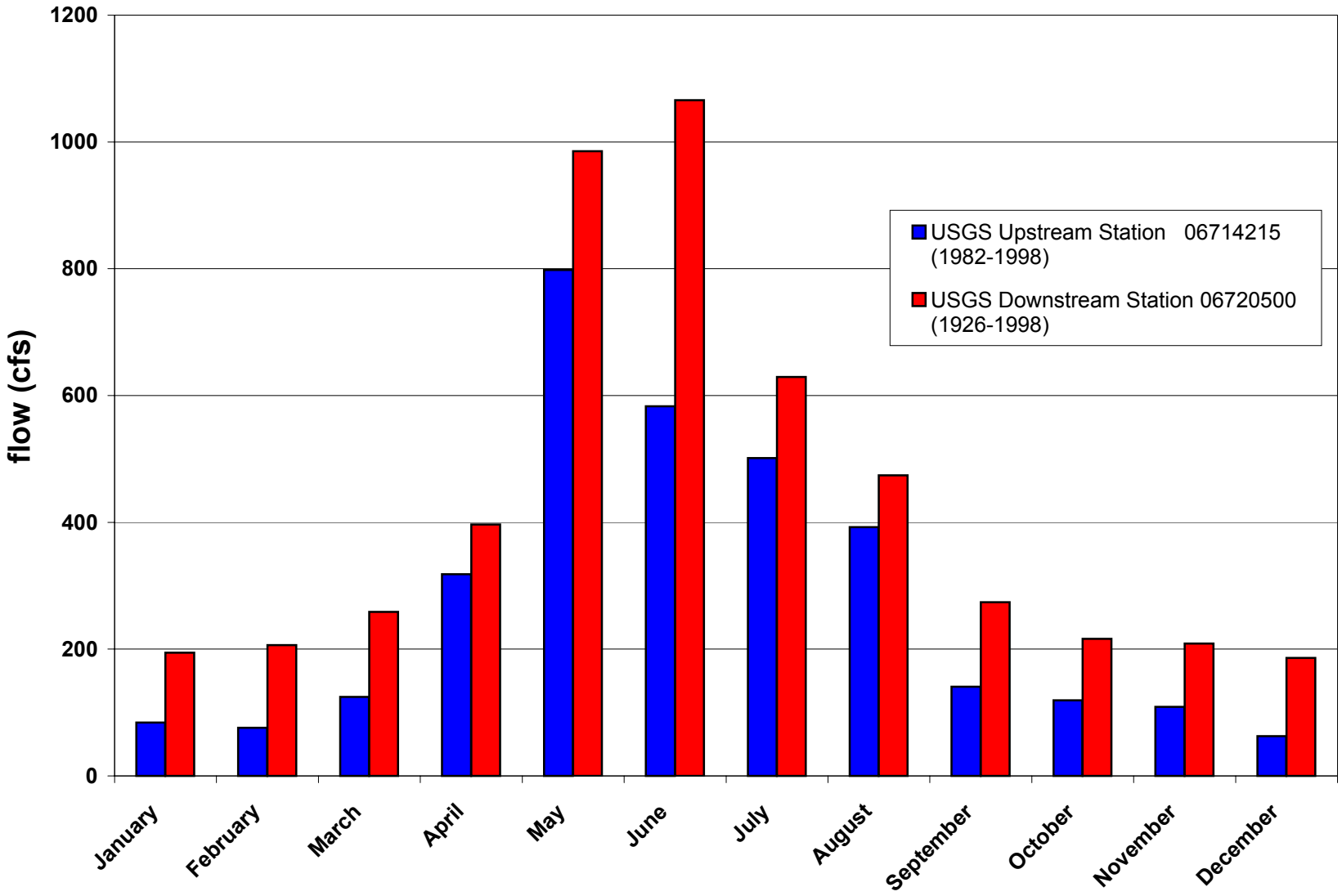


Figure C-6-2
WQRP Habitat Characterization Study
Mean Monthly Streamflow South Platte River
Metro Wastewater Reclamation District

1.4.2 Geomorphological Site Reconnaissance Summary

The South Platte River upstream of the Denver Metro WWTP, in Commerce City, Colorado drains an area of approximately 3,861 square miles. The semi-arid climate northeast of Denver is one of warm summers, cool to cold winters, and mean annual precipitation of approximately 14.2 inches; owing to snowfall in the Rocky Mountains, basinwide mean annual precipitation may be greater than 19.7 inches. Roughly the upper 70 percent of the South Platte River drainage basin above Commerce City is in the southern section of the Rocky Mountains Physiographic Province. The remainder of the basin, plus additions to drainage-basin area between Sites 1 and 5 (described below; near Brighton, Colorado), lies in the western part of the Great Plains Physiographic Province, which is characterized by stream-dissected plains underlain generally by a veneer of wind-deposited fine sand and silt resting on Cretaceous- and Tertiary-age rocks; Quaternary alluvium underlies most bottomland surfaces along stream channels.

A site visit was conducted in April 2000 to collect data at the following five sites within the study area (all shown on **Figure C-6-1**):

- Site 1 – Immediately upstream of Denver Metro WWTP discharge. The site is often dry, but it was flowing on the day of the site reconnaissance.
- Site 2 – Immediately downstream of the Denver Metro WWTP discharge.
- Site 3 – Near 72nd Avenue, upstream of the confluence of Clear Creek and the South Platte River.
- Site 4 – Upstream of the 124th Avenue Bridge crossing.
- Site 5 – Upstream of the 160th Avenue Bridge crossing.

Data on the South Platte River observed during the reconnaissance visit are presented below and in Table C-6-7.

Table C-6-7
Morphometric Data from South Platte River Near Denver, Colorado

	Site 1	**Site 2**	**Site 3**	**Site 4**	**Site 5**
Site description	**Upstream of Denver Metro WWTP**	**Downstream of Denver Metro WWTP**	**At Interstate 76**	**124th Street, Henderson, CO**	**Colorado Highway 7 Bridge**
Discharge (cfs)	32.8	282.5	317.8	353.2	423.8
Bedload texture	Sand and fine gravel	Gravel and cobbles	Sand		
Channel texture	Coarse sand and cobbles		Gravel	Gravel	Gravel
Bank texture	Medium sand	Medium sand	Cobbles	Silt w/medium sand	Sand
Sinuosity	1.00	1.16	1.16	1.33	1.21
Channel gradient	0.0020	0.0019	0.0019	0.0019	0.0014

Table C-6-7
Morphometric Data from South Platte River Near Denver, Colorado

	Site 1	Site 2	Site 3	Site 4	Site 5
Site description	**Upstream of Denver Metro WWTP**	**Downstream of Denver Metro WWTP**	**At Interstate 76**	**124th Street, Henderson, CO**	**Colorado Highway 7 Bridge**
Channel width (ft)	147.6	131.2	180.5	262.5	262.5
Channel depth (ft)					
Channel incision (ft)		4.3		4.9	6.6
Floodplain width (ft)			213.3	32.8	16.4
Floodplain bank height (ft)			16.4	8.2	13.1
Channel vegetation					Herbs
Floodplain vegetation	Elms and willows		Grasses	Grass, willow, elms, few cottonwood	Grass, willow
Terrace vegetation					

[1] Constructed channel

1.4.2.1 Reach Streamflow

Streamflow in the South Platte River immediately above the Denver Metro WWTP is perennial and highly regulated by upstream reservoirs and urban water use. Base flow averages 7.1 to 10.6 cfs, and snowmelt inputs (mostly in May and June), depending on storage needs for upstream reservoirs and diversions, may vary from base flow to 3,531.5 cfs or more. In the snowmelt season of the 2000 water year, the peak daily mean discharge was 773.4 cfs on May 18. Mean discharge at a USGS gage near Site 1 for April 20, 2000 (the day of the site visits), was 32.8 cfs and contributions to streamflow by effluent additions, immediately downstream, ranged from 41.0 cfs (reported for 5 a.m.) to 282.5 cfs (estimated at about 11 a.m.). Estimated discharges at Sites 3 (0.9 mile downstream, 656.2 feet above the mouth of Clear Creek), 4 (near 124th Street, Henderson, Colorado), and 5 (at Colorado Highway 7 bridge, Brighton), respectively, were 317.8, 353.2, and 423.8 cfs. Although these discharges clearly may include estimation error, they strongly suggest that during low flow, with discharges of April 20, 2000 serving as an example, additions by tributaries such as Sand Creek and Clear Creek and of wastewater, irrigation returns, and possibly groundwater seepage, increase discharge of the South Platte River between Commerce City and Brighton. Farther downstream, at the USGS gage for South Platte River near Kersey, Colorado (drainage-basin area approximately 9,614 square miles), mean discharge on April 20, 2000, was 289.6 cfs.

1.4.2.2 Site 1 and 2 Field Observations

From the Denver Metro WWTP near Sites 1 and 2, sewage effluent enters a highly altered channel of the South Platte River that has a bed mostly of coarse sand and cobbles; less than 10 percent of the bed material appears to be fine sand, silt, or clay. Where exposed, sediment forming the banks is largely medium sand with small amounts of finer sediment sizes. Sinuosity, reflecting local, modified conditions, is 1.00 at Site 1 and 1.16 at Site 2. Channel gradients above and below the WWTP input are, respectively, 0.0020 and 0.0019 but, owing to channelization and grade control, signify imposed conditions. Channel widths at Sites 1 and 2 are 147.6 and

131.2 feet, respectively. The smaller width at Site 2 may be due to extensive bank protection (riprap); at Site 1 bank protection is much less pronounced and, with grade-control structures, has proven poorly effective at preventing bed and bank erosion.

True floodplain and pre-development floodplain (now low terrace) areas are restricted to the channel incision at Sites 1 and 2. At both sites the channel incision is bounded by levees on a high terrace that protect the treatment plant and agricultural lands from flooding. At Site 1 floodplain is not apparent but at Site 2 it is approximately 4.3 feet higher than the thalweg. Channel vegetation is absent at both sites although algae are abundant on bed material. On other surfaces within the channel incision grasses and trees (especially elms and willows) are common.

Modification of unprotected channel and other bottomland features by recent floods at Sites 1 and 2 has been significant. The levees that form the upper banks along the river reach prevent most floods from spilling onto the terrace but also concentrate flood flows within the levees, thereby increasing the potential for within-channel damage. This concentration of flood flow probably has the effect also of increasing damage to riparian-zone vegetation at Sites 1 and 2.

Sediment transport is moderate, much being suspended or as bed load of sand and fine gravel. Inputs of all sediment sizes finer than medium cobbles are available from upstream and from tributaries and, therefore, bed forms as ripples and bars at Site 1 are common. Sediment-free wastewater inputs have caused a small amount of channel cutting, and a tendency for this incision has extended upstream as well toward Site 1. High turbulence and velocity of effluent inputs at Site 2 have caused bed material to remain mostly in the gravel and cobble sizes.

1.4.2.3 Site 3 Field Observations

The South Platte River at Site 3, approximately 0.9 mile downstream from the effluent outflow and immediately below bridges of Interstate 76, has a channel gradient of 0.0019 and a sinuosity of 1.16. The area of floodplain within the channel incision is small, adding only approximately 32.8 feet to the 180.5-foot-wide channel; the alluvial terrace cut by the river channel is approximately 16.4 feet higher than floodplain level. Vegetation on the limited area of floodplain is largely grasses, herbs, elm seedlings, and a few willows. Algae are abundant on bed material of the channel, the median size of which is 1.2-inch gravel. Maximum sediment size of bed material is 8.4-inch cobbles in a sand and silt matrix. Bank material is dominated by fine sand with coarser sizes up to 0.2-inch gravel. The right bank exhibits erosion by recent high water, whereas the bank on the left side of the channel is greatly disturbed by a road exposing bed sediment up to 2.4 inches in diameter.

Bed load derived from upstream sources is substantial, largely sand forming long, narrow sand dunes at in-channel discharges and gravel bars during higher discharges. The thalweg is well defined but appears to be quite active; channel islands are absent except as gravel bars related to bridge supports. Bed material is derived both from upstream sources of the South Platte River and from Clear Creek, which enters the river from the left at the lower end of the Site 3 reach but through meandering of recent millennia has supplied coarse sediment to all parts of the reach.

1.4.2.4 Site 4 Field Observations

Channel width near 124th Street at Henderson (Site 4) is 262.5 feet, including the right third that is poorly defined owing to extensive disturbance and erosion. A narrow strip of floodplain, approximately 4.9 feet above the thalweg, lines the left side of the channel incision, whereas an alluvial terrace approximately 8.2 feet higher than the thalweg forms the right bank of the channel. Site 4 is a reach with considerable disturbance by nearby and upstream sand and gravel mining and bank erosion by recent flooding on both sides. The downstream end of the reach is defined by cement riprap on the right bank that limits meander movement. The channel gradient is 0.0019 and the sinuosity is 1.33, which may be artificially high owing to thalweg re-positioning and gravel bars derived from gravel-mining activities.

Unlike most other channels that convey wastewater effluent, the South Platte River at Site 4 does not appear to have degraded its channel significantly. Likely reasons are (1) the sand and gravel mines as close as 0.3 mile upstream that destabilize bottomland alluvium and thus provide copious supplies of bed material to the channel, and (2) a series of grade-control dams, the nearest being 1.9 and 4.4 miles upstream, that during flood flows prevent extensive bed erosion but accentuate bank erosion. Bed material ranges from silt to 2-inch cobbles, with gravel the dominant size. Undisturbed bank material is mostly silt with smaller amounts of fine to medium sand. Pool-riffle sequences formed by sand and gravel bed load are poorly developed, but longitudinal, rippled sand dunes are significant. Much algae occur on recently immobile bed sediment; on the small area of floodplain on the left are thick grasses, coyote willow, scattered elms, and, at the lower end of the reach, cottonwoods.

1.4.2.5 Site 5 Field Observations

Channel width below the Colorado Highway 7 bridge at Brighton (Site 5) is 80 meters. Floodplain on the left is absent and a narrow strip of approximately 16.4 feet and occupied by a bicycle path may represent floodplain on the right. The possible floodplain is 6.6 feet above the thalweg and the terrace level on both sides is 13.1 feet higher. Channel gradient is 0.0014 and the sinuosity is 1.21. The median size of bed material is 0.4-inch gravel; less than 1.6-inch-millimeters gravel. Bank material on the right is dominated by fine sand and the left bank is stabilized by riprap. Channel vegetation is limited to sparse herbs on bars. Managed vegetation on the likely floodplain includes thick grasses, coyote willow, and cocklebur.

The channel at Site 5 is active and sand moving as bed load in the deepest part of the stream is substantial. Bed forms include ripples, dunes, and bars, and slumps and other failures are numerous, averaging approximately one per 16.4 feet of bank. Channel degradation of at least 1.5 meters is documented near the left by marks on bridge supports constructed in 1965 whereas bed-elevation reduction has probably been less than a meter along the right side of the channel during the same period. Upstream from the Brighton Site 0.9 to 1.9 miles are a number of pits for sand and gravel mining. Although grade-control dams also have been installed along the river, the extraction of alluvium has likely been greater than the rate of replenishment, and net bed-level reduction with local channel widening has occurred. It appears possible that the effects on channel morphology of the South Platte River between Sites 4 and 5 by sand and gravel mining have been much greater than the effects of recent floods and wastewater discharge.

The geomorphic effects of wastewater contributions to the channel of the South Platte River downstream from Commerce City have been less pronounced than they have been along the Santa Cruz River. Probable reasons for the lesser influence are other inputs of wastewater and water and sediment by tributaries of perennial discharge, channel and lowland modifications such as grade-control dams and sand and gravel operations, and perennial discharge that increases in the downstream direction. If transmission loss occurs along the study reach, it is not extensive and is less than compensating inputs of water. At high flow rates water may be lost to bank storage, but impermeable shale underlies the alluvium along most or all of the river corridor, thereby minimizing the potential for channel abstractions.

1.5 PHYSICAL ANALYSIS

1.5.1 Climate Assessment

Air temperature and precipitation data were recorded in Brighton at NCDC station number 950 (refer to **Figure C-6-1**) from 1973 through 1998. The estimated average annual precipitation is 14.5 inches in this region. The estimated average temperature in this area is 50°F, the minimum daily temperature is -26°F, and the maximum daily temperature is 103°F. Table C-6-8 presents the average monthly precipitation and the maximum daily precipitation. **Table C-6-9** presents the minimum, mean, and maximum temperature.

Table C-6-8
Mean Monthly Precipitation and Maximum Daily Precipitation
Near Denver, Colorado

NCDC Station 0950 (1973-1998)		
Month	**Mean Monthly Precipitation (Inches)**	**Maximum Daily Precipitation (Inches)**
January	0.5	0.66
February	0.4	0.60
March	1.3	2.12
April	1.6	2.26
May	2.4	2.73
June	1.8	2.40
July	1.6	2.25
August	1.5	1.89
September	1.0	1.36
October	0.9	1.82
November	0.9	1.17
December	0.5	1.37
Annual Precipitation Total (inches)	14.5	

Table C-6-9
Mean, Maximum, and Minimum Monthly Temperature
Near Denver, Colorado

NCDC Station 0950 (1973-1998)			
Month	**Minimum Temperature (°F)**	**Mean Temperature (°F)**	**Maximum Temperature (°F)**
January	-22	28.0	74.0
February	-24	33.0	77.0
March	-8	40.5	82.0
April	-8	48.3	90.0
May	22	57.8	94.0
June	34	67.5	102.0
July	44	72.5	103.0
August	41	70.5	101.0
September	19	62.5	97.0
October	0	50.9	90.0
November	-14	36.9	81.0
December	-26	29.8	74.0
Min/Mean/Max	-26	50	103

1.5.2 Flow Assessment

Figure C-6-3 presents the mean daily flow versus time for the Denver Metro WWTP and USGS gages upstream and downstream of the WWTP. The mean daily flow in the South Platte River is presented on **Figure C-6-4**.

The mean monthly streamflow upstream and downstream of Denver Metro WWTP and the mean monthly WWTP discharge are plotted on **Figure C-6-5**. The upstream flow varies from less than 100 cfs during December, January, and February to a peak of 800 cfs in May. The downstream varies from a low flow of 200 cfs during December and January to a peak flow of more than 1,000 cfs during June. The peak upstream flow pattern is consistent with the peak rainfall observed at the climate station near Denver (NCDC 0950). The peaks in the South Platte River are due to snowmelt.

Log Pearson Type III flood frequency analysis was performed on both the upstream and downstream gages of the South Platte River (**Figure C-6-6**). Results of this analysis for a range of flood events is presented in Table C-6-10. The drainage area for the upstream gage is 3,884 square miles compared to 4,713 square miles for the downstream gage.

Table C-6-10
Flood Frequency Analysis for the South Platte River Near Denver, Colorado

USGS Gage	2-year Flood (cfs)	10-year Flood (cfs)	50-year Flood (cfs)	100-year Flood (cfs)
06714215 (upstream of WWTP)	7,500	12,000	17,500	20,000
06720500 (downstream of WWTP)	6,000	12,500	23,000	29,000

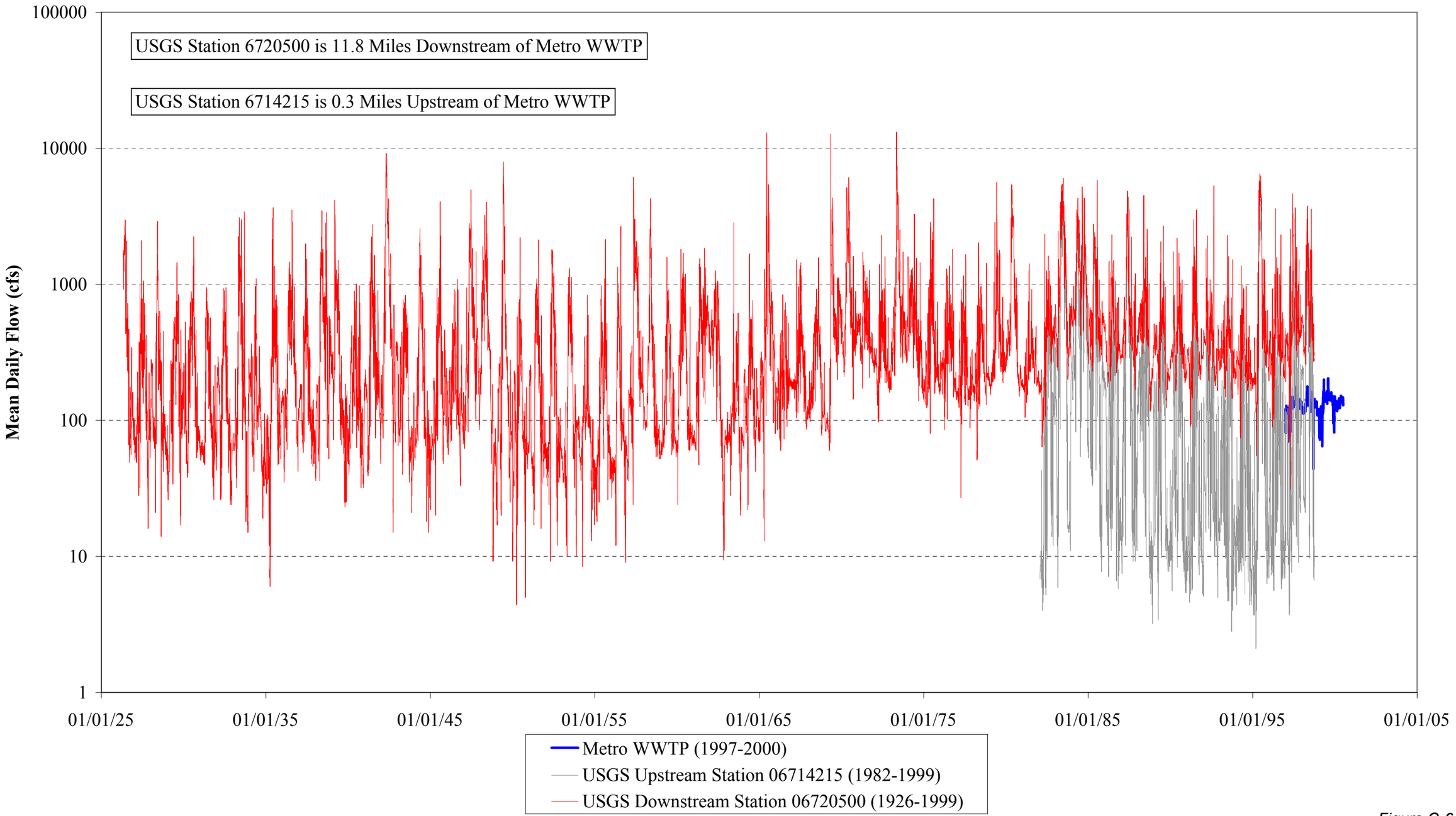


Figure C-6-3
Mean Daily Flow Values
South Platte River Near Denver, Colorado

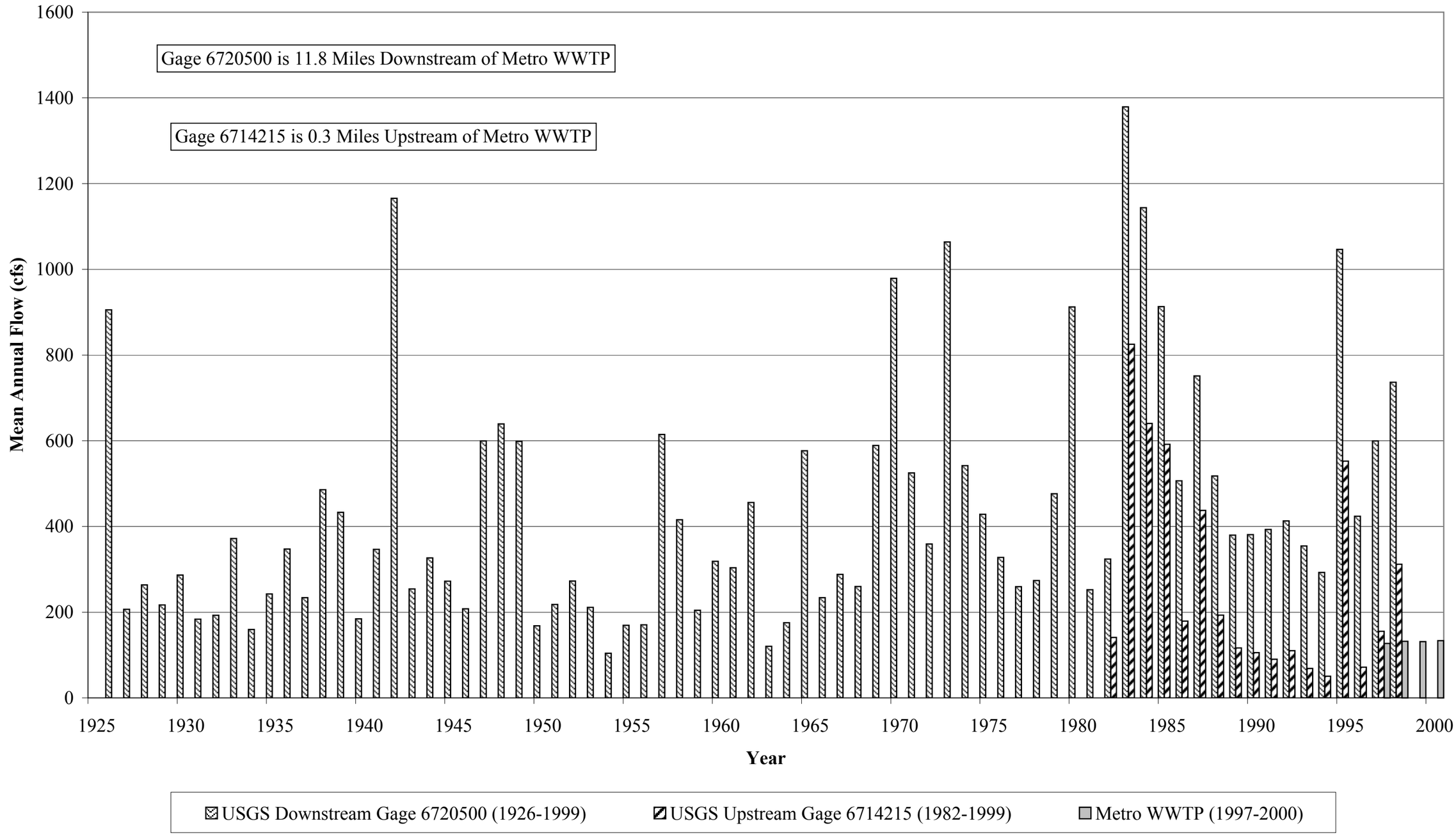


Figure C-6-4
Mean Annual Flow Values
South Platte River Near Denver, Colorado

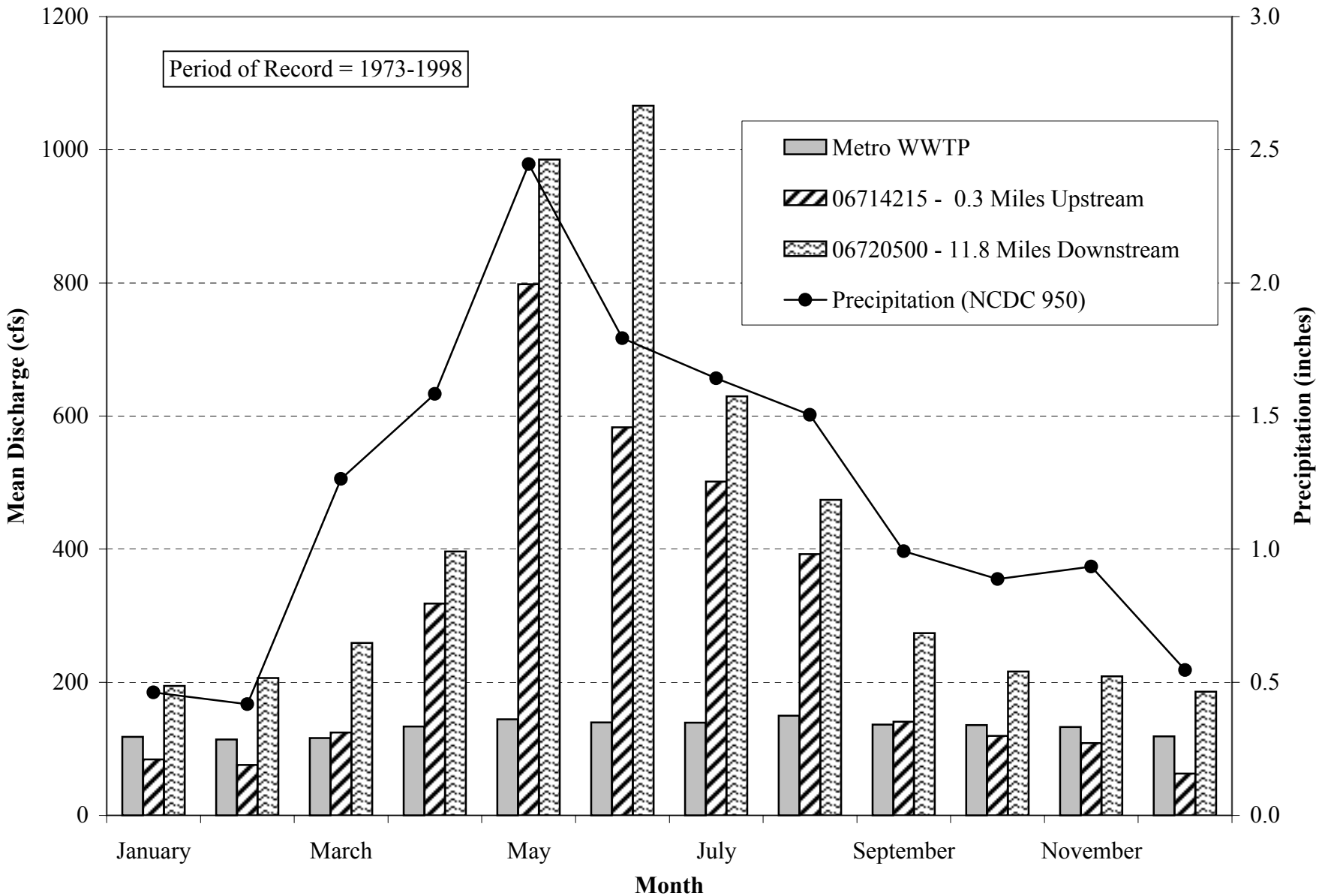


Figure C-6-5
Mean Monthly Flow Values
South Platte River Near Denver, Colorado

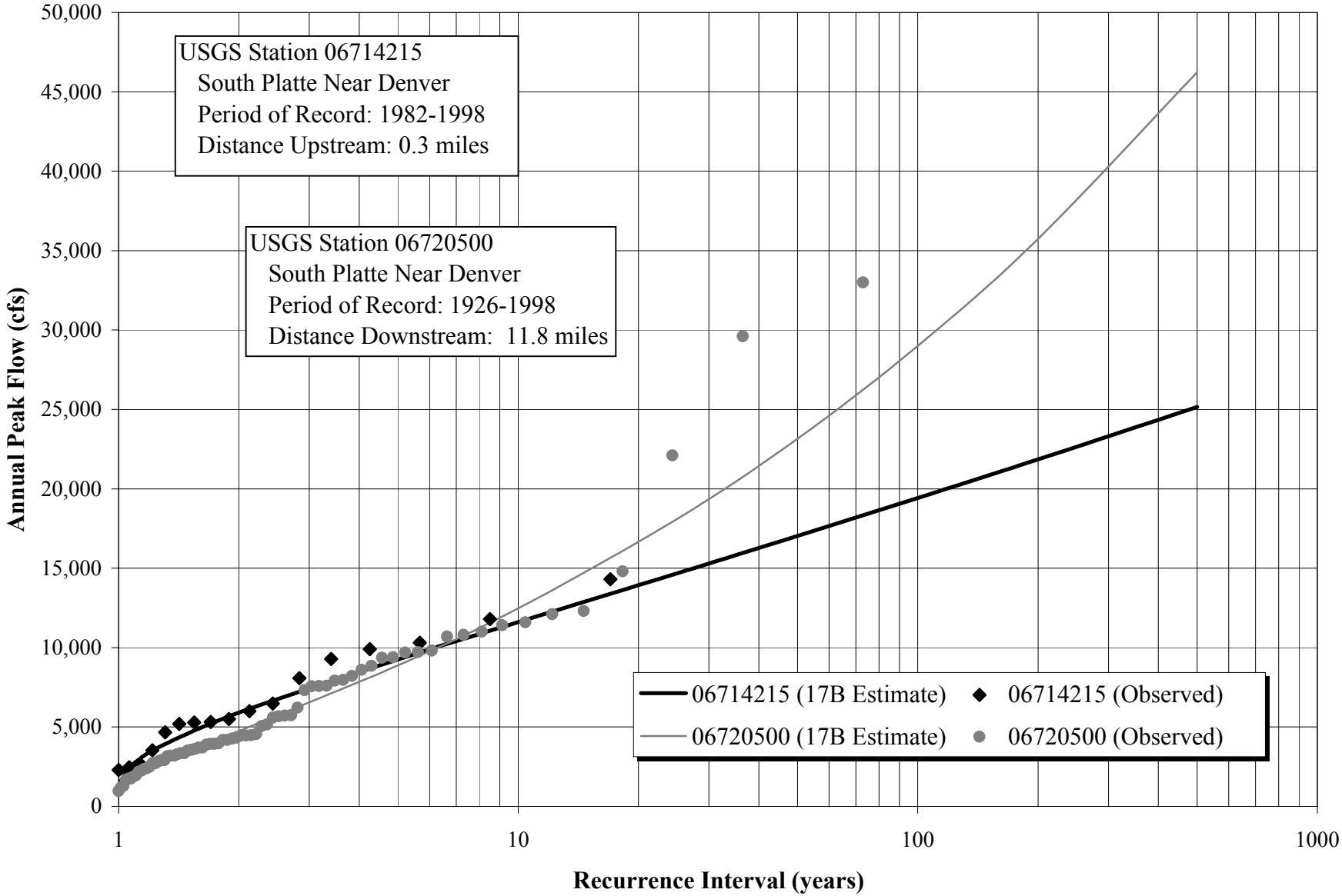


Figure C-6-6
Annual Peak Flow Frequency Analysis
Sount Platte River Near Denver, Colorado

Log Pearson Type III low flow frequency analysis was completed using a low-flow duration of 1 day, 7 days, and 30 days for the upstream and downstream gages of the South Platte (**Figures C-6-7 and C-6-8**). Results of this analysis for a range of low-flow events and duration periods is presented in Table C-6-11.

Table C-6-11
Low Flow Frequency Analysis for the South Platte River Near Denver, Colorado

USGS Gage	3-year low flow (1-day duration) (cfs)	3-year low flow (7-day duration) (cfs)	3-year low flow (30-day duration) (cfs)	10-year low flow (1-day duration) (cfs)	10-year low flow (7-day duration) (cfs)	10-year low flow (30-day duration) (cfs)
06714215 (upstream of WWTP)	3	5	9	2	4	6
06720500 (downstream of WWTP	30	40	65	11	18	35

In addition to flood frequency and low flow frequency analysis, flow duration curves were used to establish the percent of time that mean daily flows occur. The flow was analyzed on a daily, 7-day, and 30-day duration of occurrence. **Figures C-6-9, C-6-10, and C-6-11** show the duration frequency curves for USGS upstream of the Denver Metro WWTP (USGS 06714215). These curves show the percent of time that a given flow occurs. In recent decades (1991-1998), **Figures C-6-9, C-6-10, and C-6-11** show that upstream of the Denver Metro WWTP, flow occurs less frequently than in earlier decades. For example, on **Figure C-6-9,** a flow of 200 cfs or more occurred 45 percent of the time during 1983 through 1990 and 20 percent of the time during 1991 through 1998. This may indicate that upstream uses of the water resource have increased over time.

Figures C-6-12, C-6-13, and C-6-14 show the frequency duration curves for the USGS gages downstream of the Denver Metro WWTP (USGS 06720500). **Figures C-6-14, C-6-15, C-6-16, and C-6-17** show the frequency duration curves for upstream and downstream of the WWTPs for recent history and also include frequency duration for the Denver Metro WWTP.

1.5.3 Depth and Velocity

The project team used stage discharge relationship data provided from USGS to establish power equations relating discharge, velocity, and depth for USGS gage 06714215 (upstream of WWTP) and 06720500 (downstream of WWTP). From these relationships and the maximum mean daily flow for each gage, the maximum velocity to occur upstream and downstream of the WWTP is shown in **Table C-6-12**. Velocities and depths that occur 50 percent and 80 percent of the time or more are also presented in **Table C-6-12**.

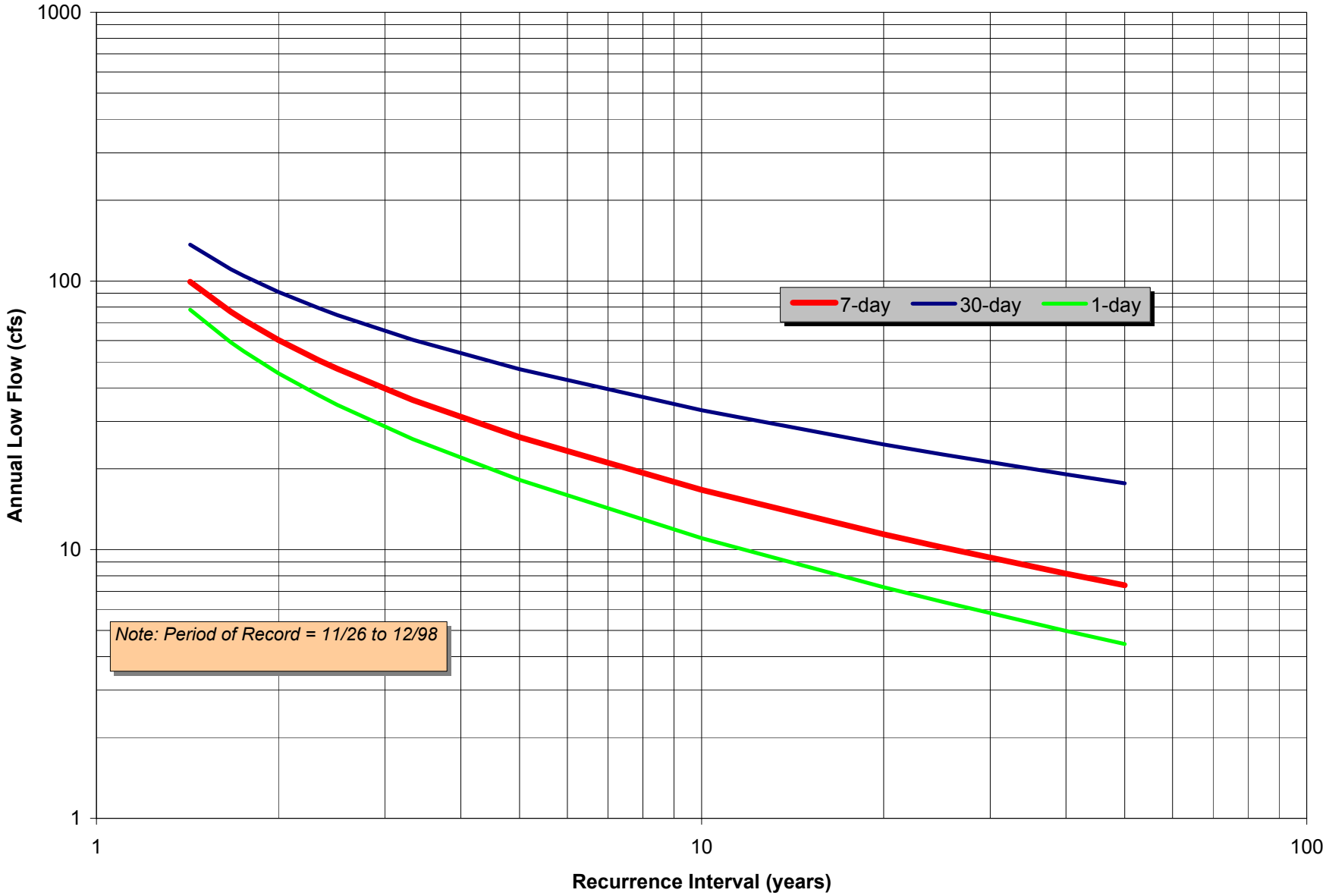


Figure C-6-7
Low Flow Duration-Frequency Analysis
Gage 06720500 Downstream of Metro WWTP
South Platte River Near Denver, Colorado

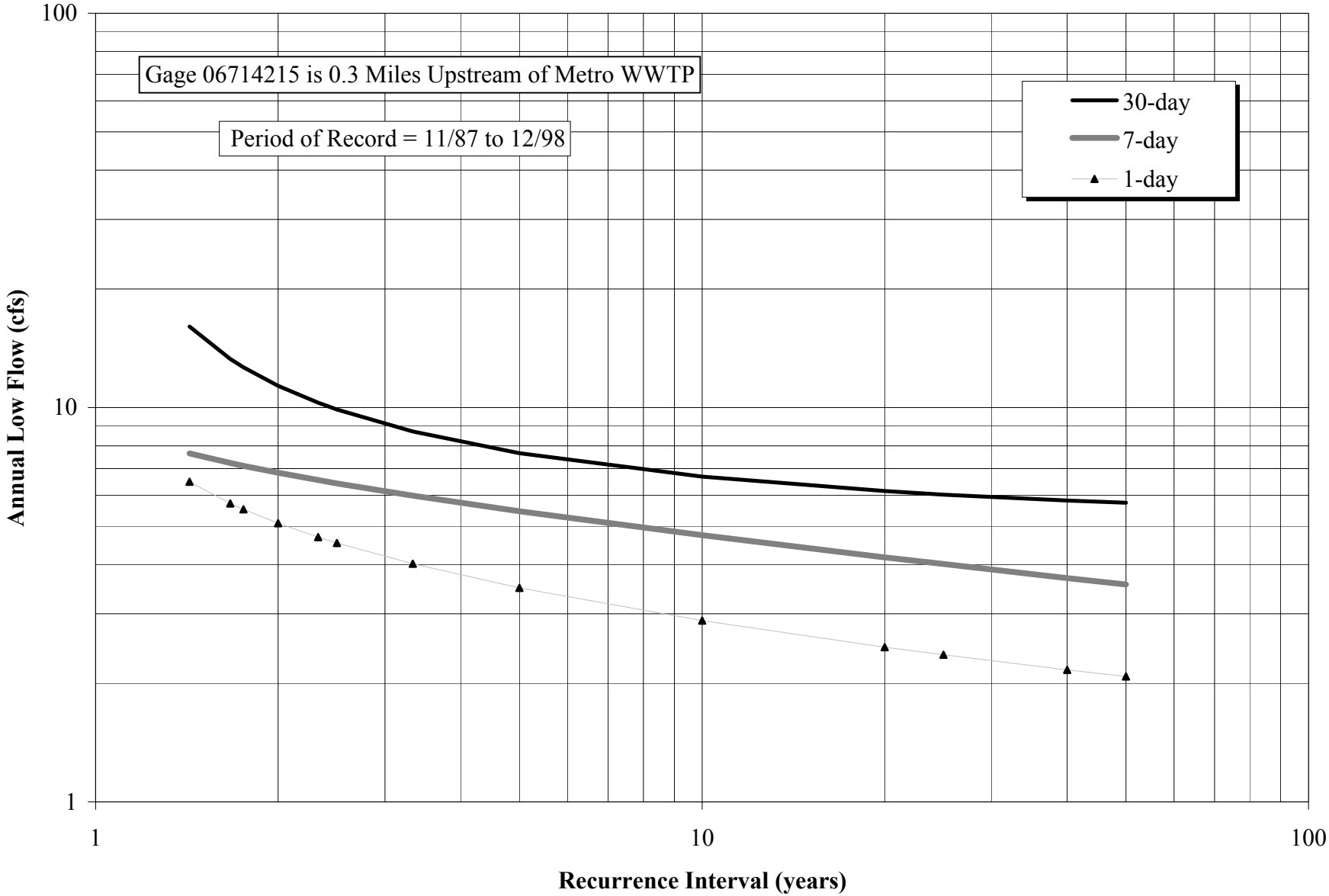


Figure C-6-8
Low Flow Duration-Frequency Analysis
USGS Station 06714215
South Platte River Near Denver, Colorado

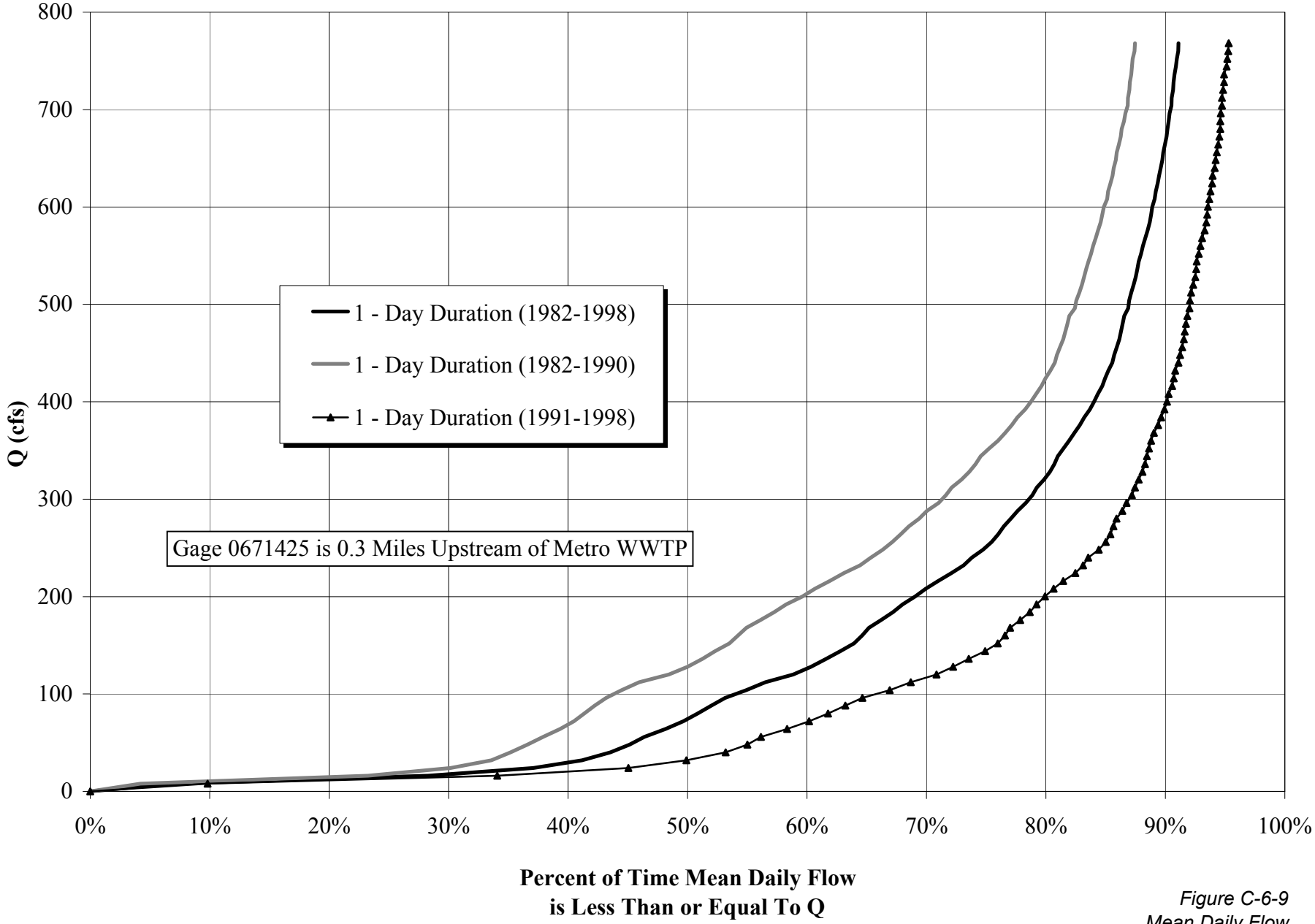


Figure C-6-9
Mean Daily Flow
Cumulative Frequency Distribution
USGS Station 06714215
South Platte River Near Denver, Colorado

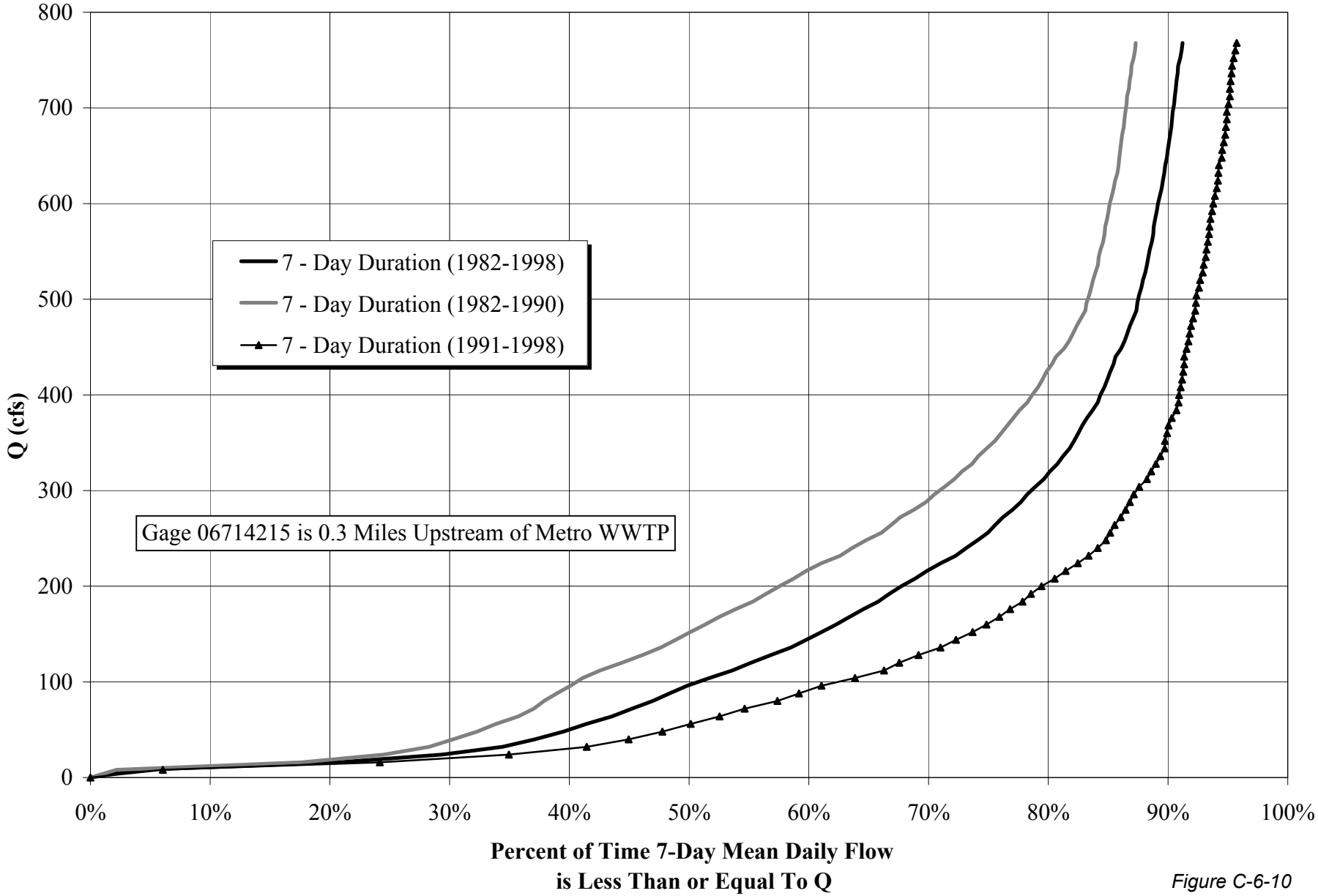


Figure C-6-10
7-Day Mean Daily Flow
Cumulative Frequency Distribution
USGS Station 06714215
South Platte River Near Denver, Colorado

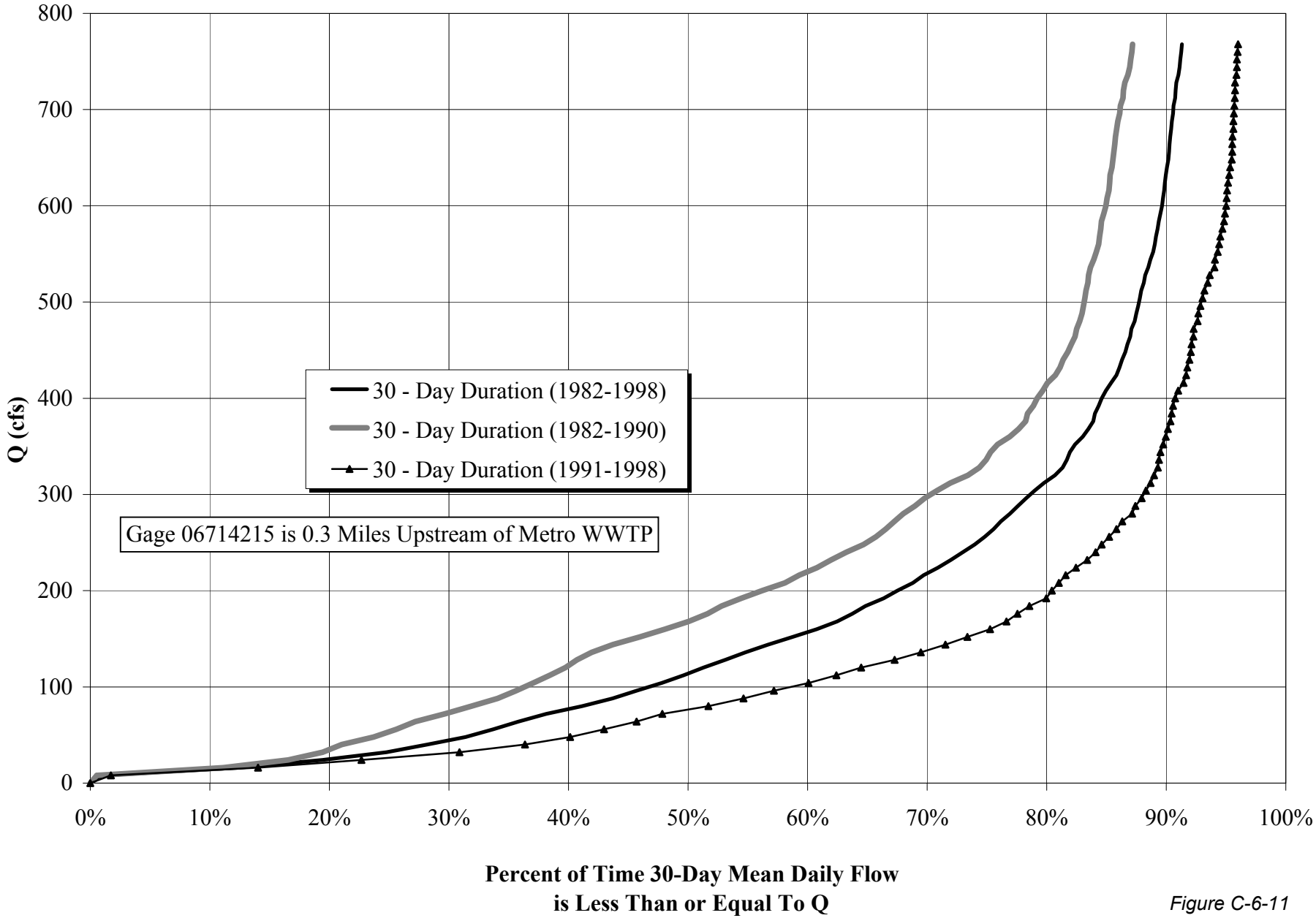


Figure C-6-11
30-Day Mean Daily Flow
Cumulative Frequency Distribution
USGS Station 06714215
South Platte River Near Denver, Colorado

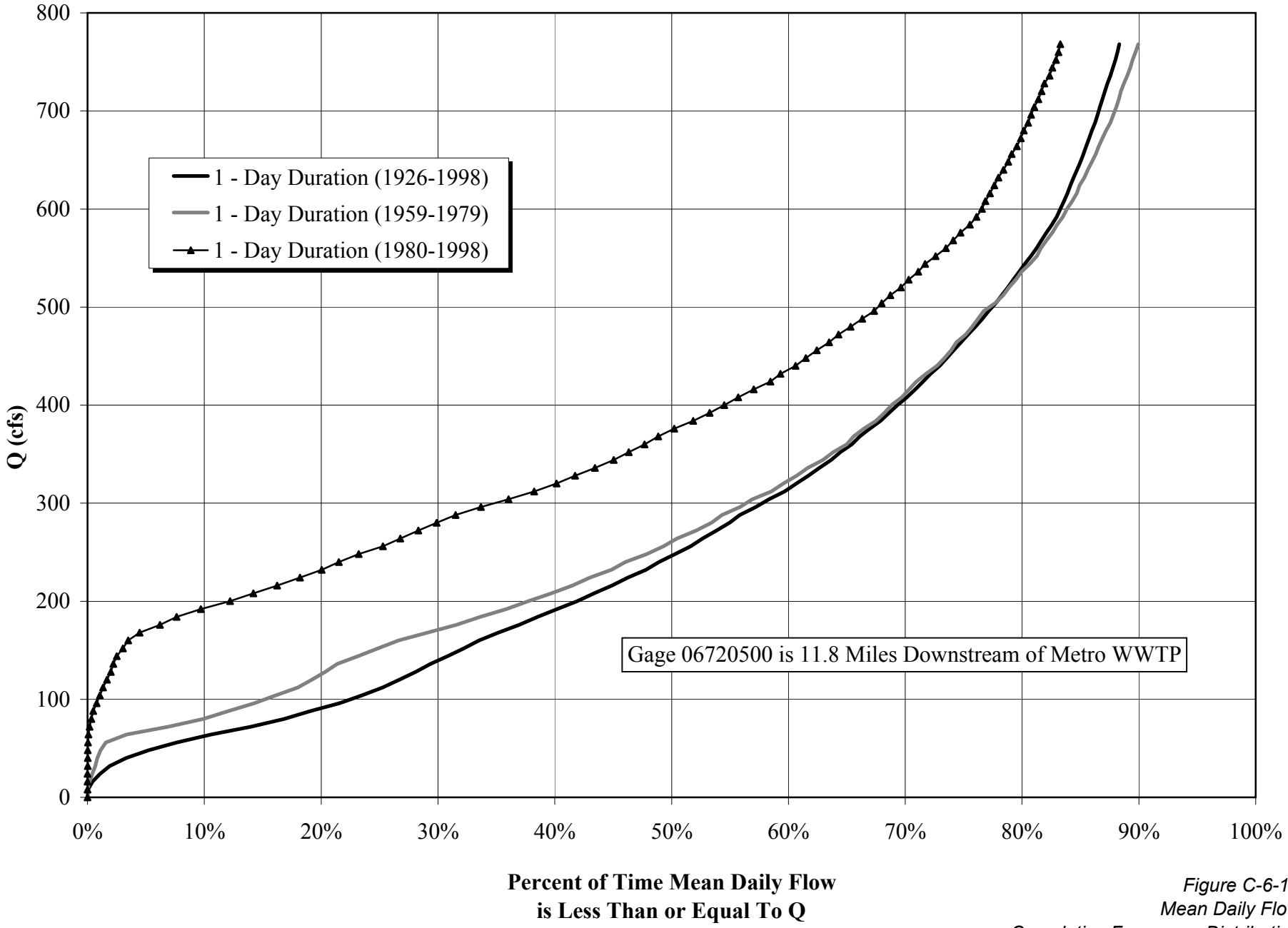


Figure C-6-12
Mean Daily Flow
Cumulative Frequency Distribution
USGS Station 06720500
South Platte River Near Denver, Colorado

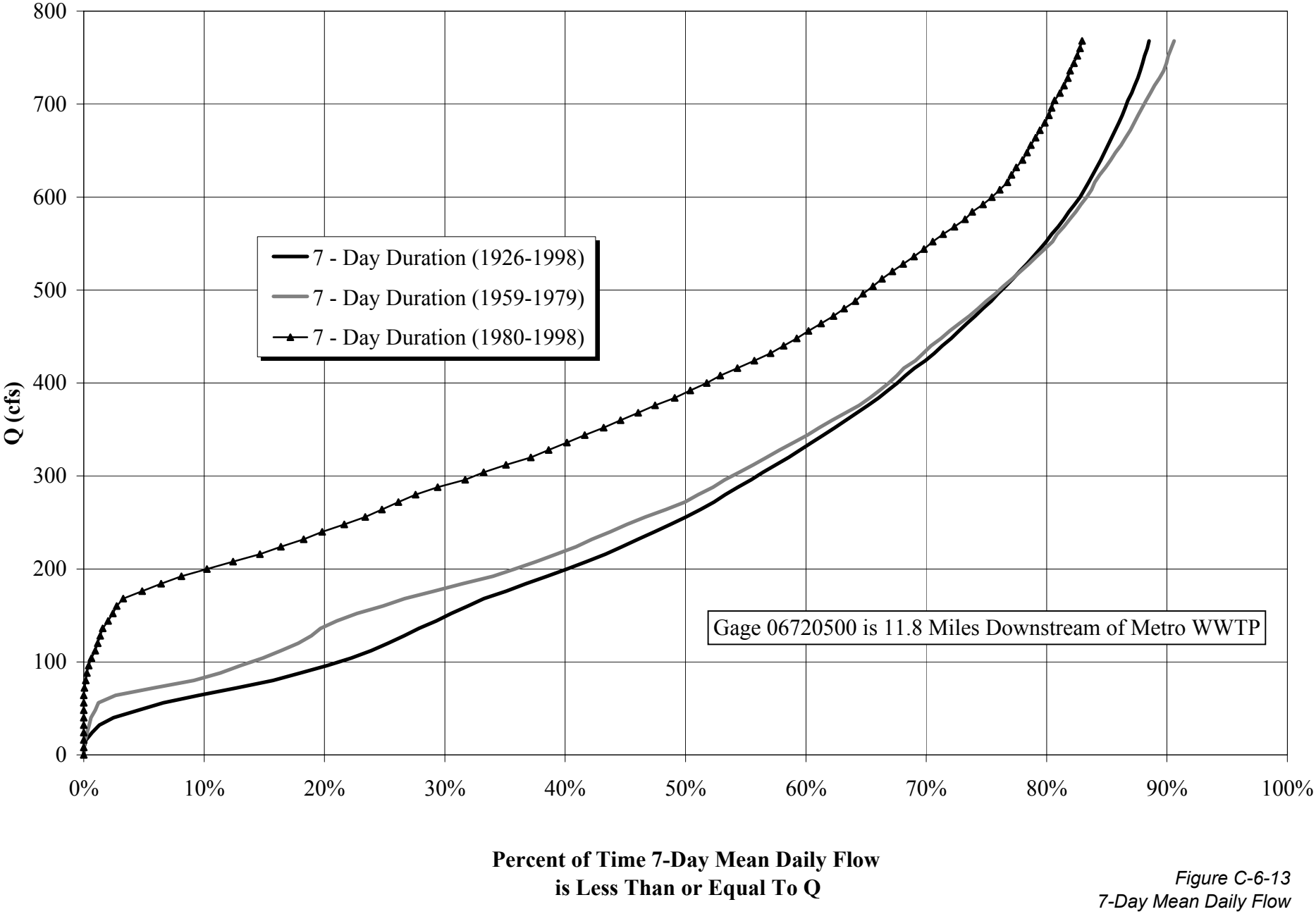


Figure C-6-13
7-Day Mean Daily Flow
Cumulative Frequency Distribution
USGS Station 06720500
South Platte River Near Denver, Colorado

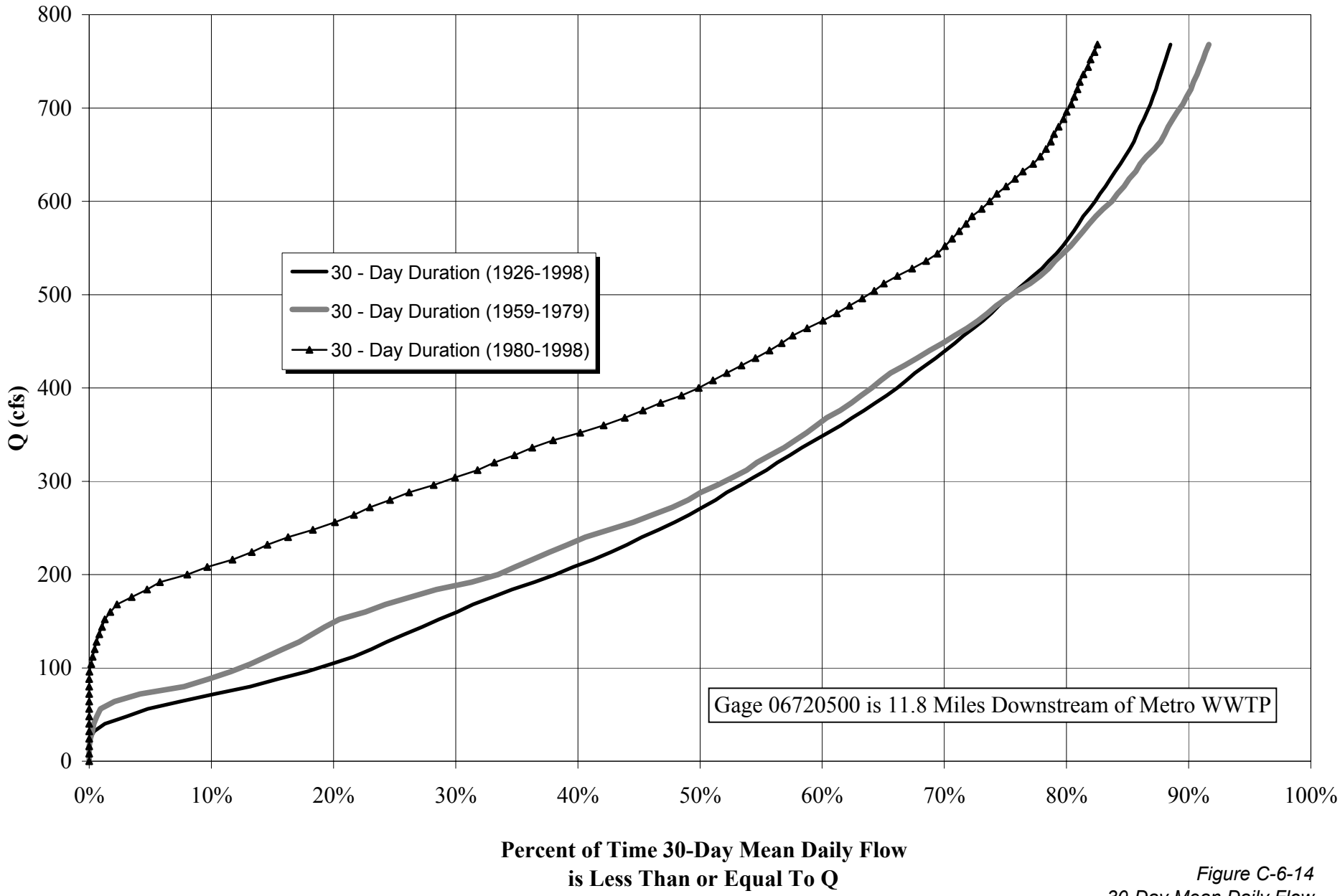


Figure C-6-14
30-Day Mean Daily Flow
Cumulative Frequency Distribution
USGS Station 06720500
South Platte River Near Denver, Colorado

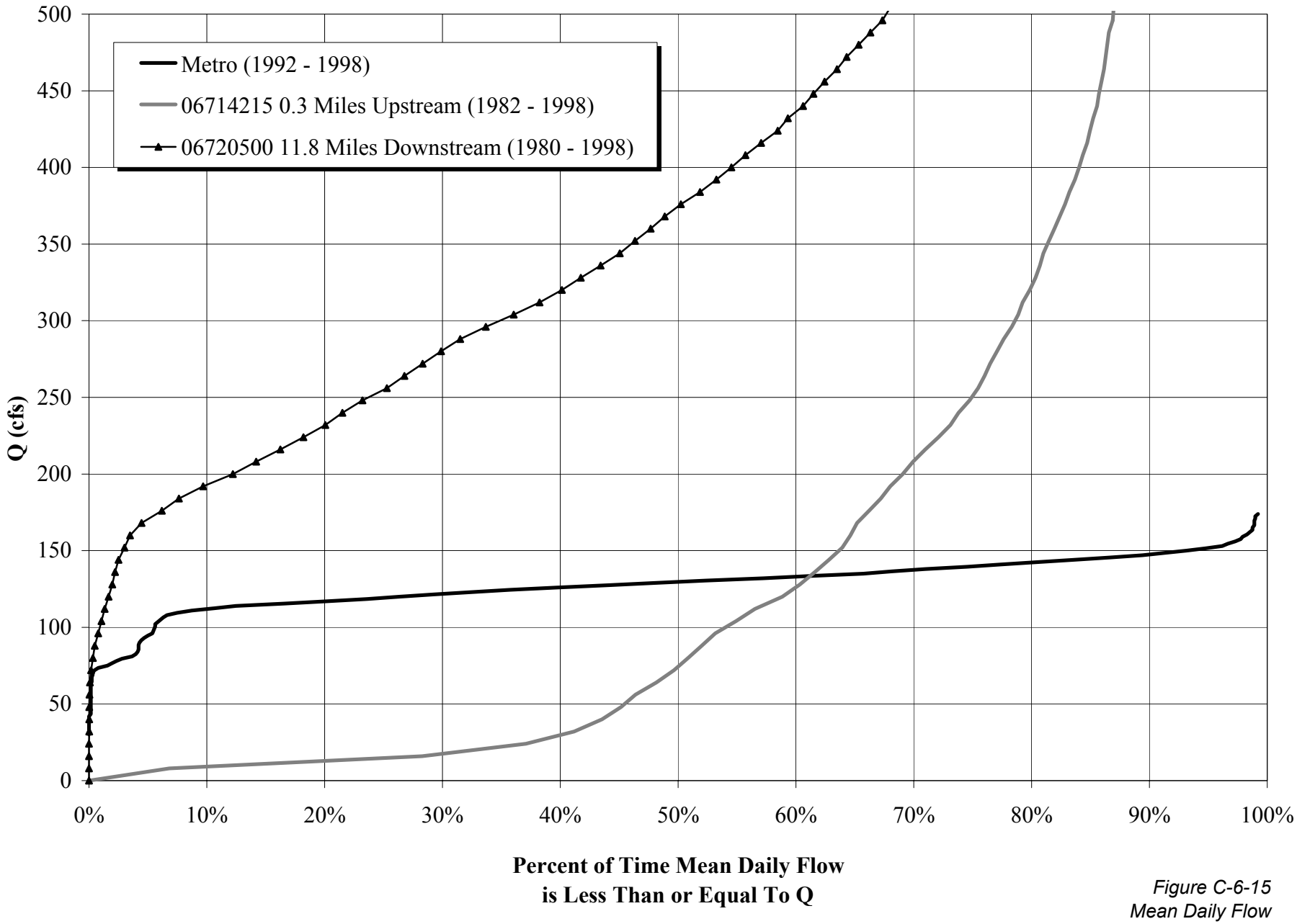


Figure C-6-15
Mean Daily Flow
Cumulative Frequency Distribution
Metro WWTP and Upstream/Downstream Gages
South Platte River Near Denver, Colorado

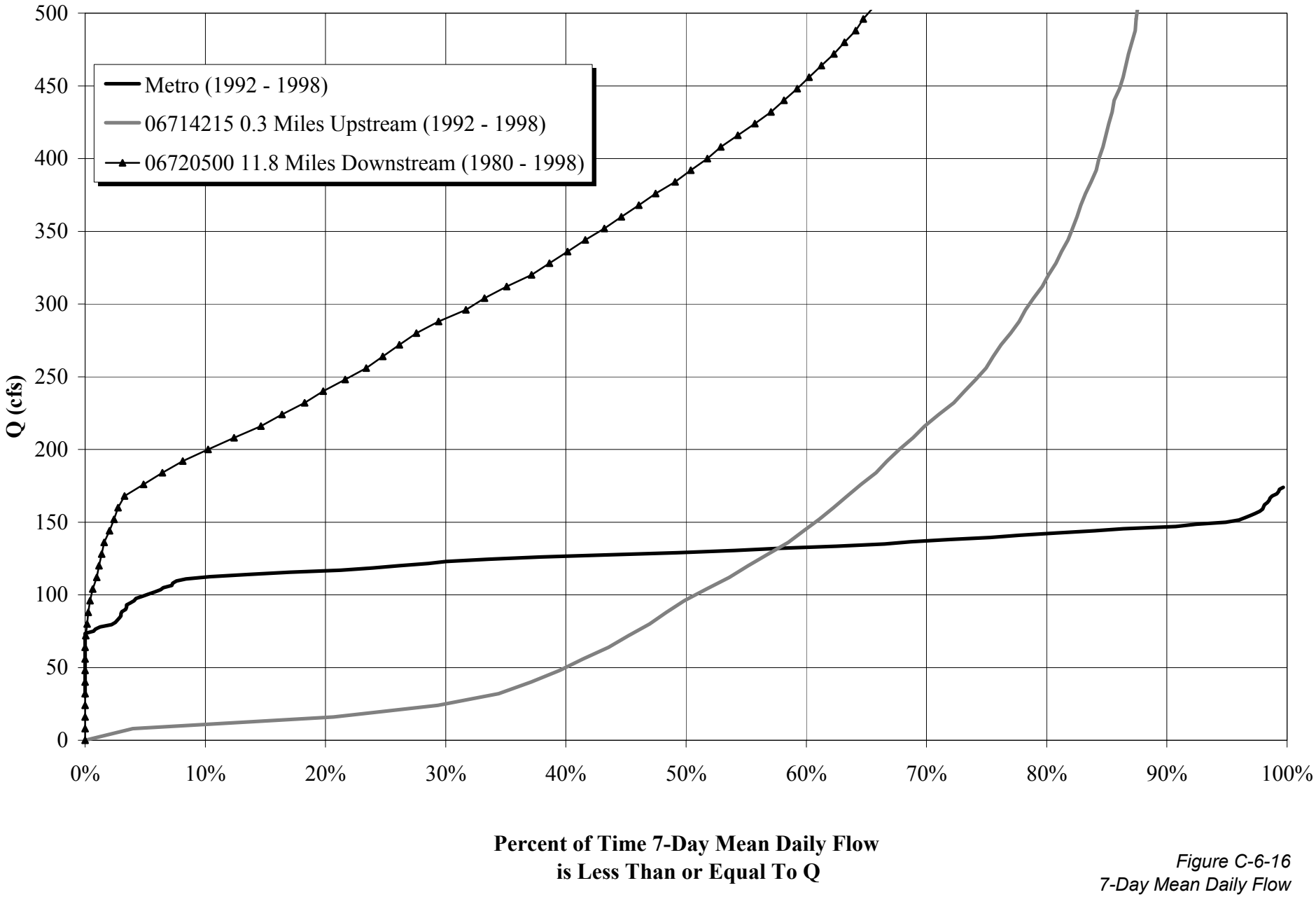


Figure C-6-16
7-Day Mean Daily Flow
Cumulative Frequency Distribution
Metro WWTP and Upstream/Downstream Gages
South Platte River Near Denver, Colorado

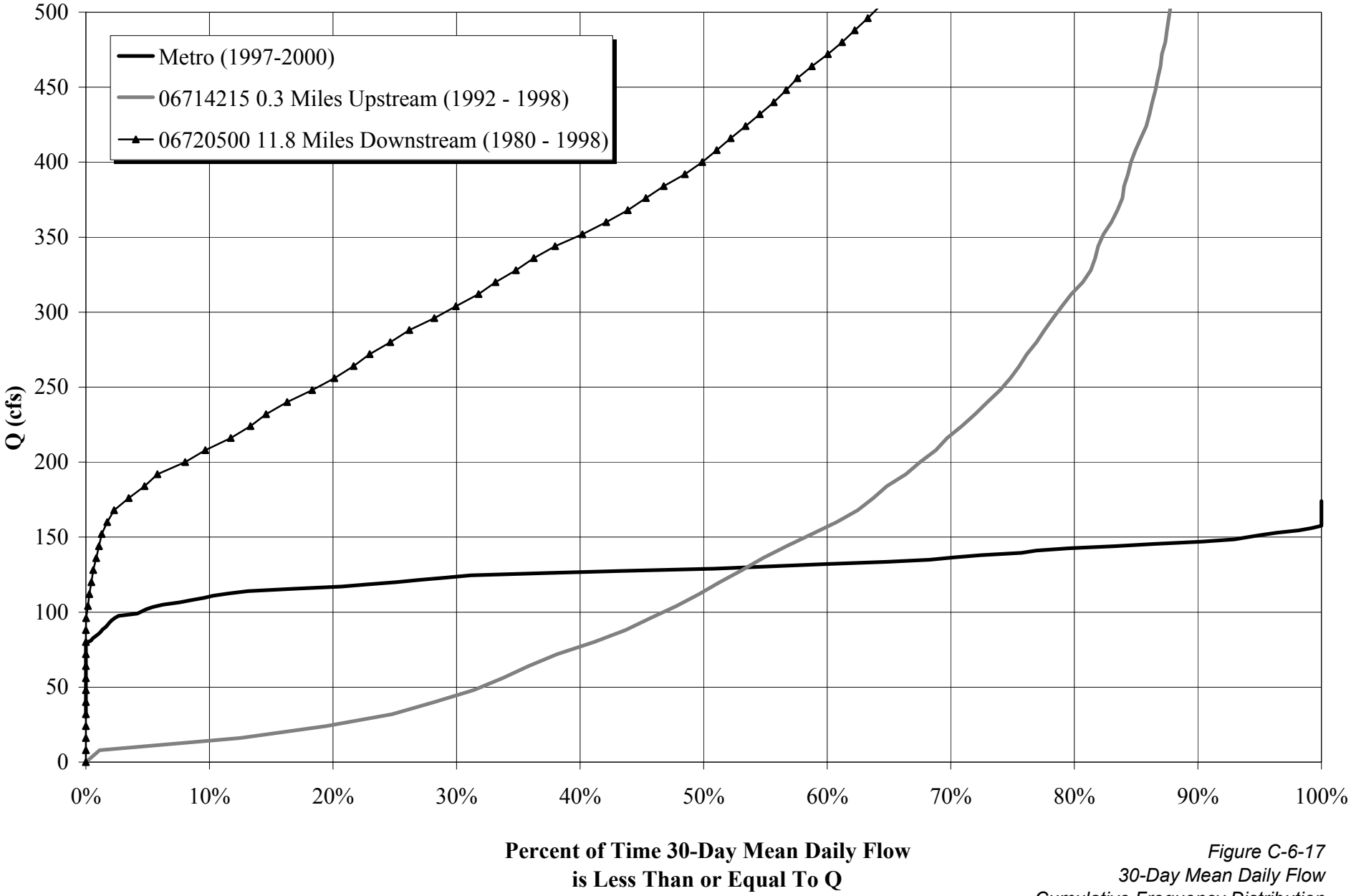


Figure C-6-17
30-Day Mean Daily Flow
Cumulative Frequency Distribution
Metro WWTP and Upstream/Downstream Gages
South Platte River Near Denver, Colorado

Table C-6-12
Velocities and Depths of the South Platte River Near Denver, Colorado

Gage	Max Velocity	Velocity and depth that occur 50% of time or more	Velocity and depth that occur 80% of time or more
06714215 (upstream of WWTPs)	7 ft/s	1.2 ft/s and 1 ft	0.9 ft/s and 0.6 ft
06720500 (downstream of WWTPs)	10 ft/s	1.6 ft/s and 1.4 ft	1.9 ft/s and 1.7 ft

Using the classification provided by Novotny and Olem (1997) the South Platte River near Denver could be categorized as a fast and shallow stream system.

1.6 CHEMICAL DATA OVERVIEW

This study area was included in the South Platte River Basin National Water Quality Assessment (NAWQA) report. In the vicinity of the Denver Metro WWTP, there were two basic fixed sites used in the NAWQA report: one upstream from the WWTP (South Platte River at Denver), and one downstream from the WWTP (South Platte River at Henderson). These two basic fixed sites were sampled a total of 41 times between April 1993 and September 1995 for major ions, nutrients, organic carbon, suspended sediment, and physical parameters (Dennehy et al. 1998).

During the NAWQA study, a point-source nutrient synoptic study also was complete in the area of the Denver Metro WWTP. This synoptic study included multiple stations along the South Platte River and its tributaries. During the synoptic study, all locations were sampled for nitrogen and phosphorous species at least once. In addition to the point-source nutrient synoptic study, a trace element synoptic study was completed in the Denver area. Again, multiple sampling locations were used along the South Platte River and its tributaries. The major objective of this study was to determine the trace element loading from Clear Creek to the South Platte River. This synoptic study was completed twice over the study period.

The major findings from this NAWQA study were that the South Platte River in the vicinity of Denver ranked among the highest (25th percentile) of the NAWQA study units completed between 1992 and 1995 for nutrients in the water, pesticides in the water, trace elements in the sediments, and semi-volatile organic compounds in the sediments.

MWRD conducted field studies designed to determine the relationship between fish species and low dissolved oxygen (DO) content of the South Platte River between the Burlington Ditch and the confluence with Big Dry Creek. The studies were divided into two phases: (1) to determine if significant relationships exist between low DO concentrations and the diversity and density of fish in the pools, and if methods used are appropriate; and (2) to determine fish occurrence and density, as well as collect more data to supplement Phase 1 fieldwork.

The Phase 1 study fieldwork was completed during September 1992 over a 7-day period. Field parameters were measured on an hourly basis at five locations for the 7-day period. This was completed upstream and downstream from the four pools included in the study (two 88th Avenue pools, the Brantner pool, and the Fulton pool). Ambient toxicity testing also was completed at these four pools plus a reference pool (McDonalds). For the ambient toxicity testing, samples were collected daily during the time of lowest DO (usually 0100 to 0700 hours) and analyzed for alkalinity, hardness, pH, conductivity, and ammonia. Upstream and downstream from all of the pools used in the study, a run and a riffle were monitored for DO concentrations.

During the Phase 2 study, the same five areas as in Phase 1 were studied, as well as two additional areas (one near Brighton and one near Platteville, Colorado). Five of these areas were within Segment 15 of the South Platte River, and two were within reference segments (one upstream from Segment 15 and one downstream from Segment 15). The Phase 2 study included sampling from three separate studies completed within Segment 15. CDM completed the first study over a 13-day period in August 1993, in which field parameters were measured on an hourly basis for a 48-hour period during fish sampling within pools and manual measurements were collected in the early morning hours from the runs and riffles surrounding the pools. MWRD completed the second study over two 48-hour periods in July and September 1993, in which a water quality study was completed. During their study, 11 locations were sampled 10 times in each 48-hour period for DO, pH, temperature, biochecmical oxygen demand (BOD), CBOD, alkalinity, and nitrogen species. The EPA Region IV Ecological Services Division completed the third study, in which five reaches orresponding to the Phase 2 study reaches were monitored for a 24-hour period in late August/early September for temperature and DO (CDM et al. 1994).

USGS (Blakely et al. 1983) conducted a study of a large summer storm within the Denver area and its impact, with respect to loading, to the South Platte River. A total of nine stations were sampled during this study. Three of the stations were on the South Platte River, and six of the stations were at the mouths of tributaries to the South Platte River. All of the stations were sampled for total suspended sediment, chemical oxygen demand, total organic carbon, selected nutrients, and selected trace elements. Each station was sampled between six and eight times during the storm (once during pre-storm baseflow, twice during increasing flow, once or twice at peak flow, twice during decreasing flow, and once post-storm as close to pre-storm baseflow as possible). The major finding of this study was that a substantial portion of the loading in the South Platte River was from resuspension or scouring of the bottom material, rather than from the tributaries or direct runoff.

USGS (Dennehy et al. 1995) conducted a review of the data available, and subsequently used as a historical reference for the South Platte River Basin NAWQA Report. It includes a listing of the agencies and entities contacted that may have produced reports on the South Platte River Basin, as well as a brief discussion on the quality of the data collected. The major findings of this report were that nutrient concentrations increased slightly downstream from Littleton, Colorado; and, in urban areas total organic nitrogen and ammonia dominated the nitrogen species. USGS also found that there was limited data within the South Platte River Basin on suspended sediment and pesticides.

USGS (McMahon et al. 1995) also conducted a study to determine the quality and quantity of groundwater discharging to the South Platte River below Denver. The results were used to determine if groundwater was partially responsible for the low DO concentrations present in the South Platte River. Grab samples were collected from three surface water sites (McKay Road, Henderson, and Road 8). The grab samples were analyzed for field parameters, major ions, nutrients, iron, and manganese. They were collected from August 1992 through January 1993, May 1993, and July 1993. Field parameters also were measured at 30 surface locations within the study reach. Sediments were sampled at the same three surface water sites listed above. The sediments were analyzed for percent less than 0.079-inch, percent organic matter in the less than 0.079-inch size fraction, and for rates of microbial denitrification. The major findings of this report were as follows:

1. During low-flow conditions, groundwater discharges to the South Platte River; conversely, during high-flow conditions, recharge occurs.

2. The groundwater in the area has a lower pH and DO concentration than the surface water; thus, during discharge, pH and DO may be lowered in the surface water due to mixing with the groundwater.

3. Groundwater may contribute ammonia and phosphorus to the upstream section of the reach, and nitrite + nitrate to the downstream section of the reach; however, the extent of contribution is difficult to determine due to the widespread distribution of sources and sinks for nutrients along the South Platte River (specifically within the alluvial material directly underlying the river and the bed sediments within the river).

As part of the NAWQA program a study was completed to determine the major sources and loading of nutrients to the South Platte River in different seasons corresponding to irrigation and low flow. Five synoptic studies, in which a total of 41 sites were used, were completed along the South Platte River. The synoptic studies were completed in April, May, June, and August 1994, and January 1995. The samples collected were analyzed for field parameters and nutrients. The major findings of this synoptic study were that there was not much change between the five synoptic sampling times, and that the composition of nitrogen species changed from equal portions of ammonia and nitrite + nitrate near Henderson to nearly all nitrite + nitrate near Kersey (Litke 1996).

Water quality data that will be examined in this data analysis phase of this project was collected from USGS and MWRD. Water quality data for station 06714215 (upstream) were retrieved from EPA's *STORET* database and USGS' National Water Information System (NWIS) database. Data also were obtained directly from MWRD. The POR at each station a summary of the data available for each parameter category is shown in Table C-6-13.

Table C-6-13
Summary of Records Available for the South Platte River Near Denver, Colorado

Constituent Group	06714215 (upstream)		South Platte River at MWRD Sites	
	POR	Description	POR	Description
Physical Parameters	2/82 - 12/92	Data available for specific conductivity and water temperature.	1/88 - 12/98	Biweekly sampling; substantial amounts of data for all parameters.
Nutrients	3/94 - 9/99	Minimal data available.	1/88 - 12/98	Biweekly sampling; substantial amounts of data for all parameters.
Trace Elements		None Available	1/88 - 12/98	Biweekly sampling; substantial amounts of data for all parameters.
Major Ions		None Available	1/88 - 12/98	Biweekly sampling; substantial amounts of data for all parameters.
Organics		None Available		None Available
Sediments		None Available		None Available
Biological Parameters		None Available		None Available
Radiological		None Available		None Available
Isotopical		None Available		None Available

Station 06714215 (upstream) was sampled for physical parameters and nutrients only. Substantial amounts of data were available for the physical parameters. The POR for this station is December 1982 though September 1999.

As part of the requirements for their NPDES discharge permit, MWRD conducted biweekly sampling at the following sites along the South Platte River: 64th Avenue, upstream of the confluence of Clear Creek, 78th Avenue, 88th Avenue, at McKay Road, at 124th Avenue, and 160th Avenue. The sites were sampled for physical parameters, nutrients, and trace elements. The POR for the site upstream of the confluence of Clear Creek is January 1992 through December 1998. The POR for all other sites is January 1988 through December 1998.

Although the upstream station chosen has limited amounts of data available, there is a substantial amount of water quality data from the MWRD and from the historic reports.

1.7 CHEMICAL ANALYSIS

Eleven stations were used in the chemical analysis of this study area. One station (06714215) was located upstream from the Denver Metro WWTP, and 10 stations were located downstream from the WWTP (000009, SP-64, SC, SPR-CC, SP-78, SP-88, SP-MCKAY, 06720500, SP-124, and SP-160). Table C-6-14 contains a brief description of the chemical data available at these stations. A more thorough summary of the data available is located in **Appendix R**.

Table C-6-14
Brief Summary of the Data Available for the South Platte Study Area

Station	POR	Average Number of Measurements								
		Physical	Nutrients	Major Ions	Trace Elements	Organics	Biological	Sediments	Radiological	Isotopical
06714215 (upstream)	2/82 - 3/99	114	2	–	–	–	–	–	–	–
000009 (downstream)	6/63 - 4/93	1087	987	80	399	157	295	–	6	–
SP-64 (downstream)	1/88 - 2/00	322	322	–	260	–	–	–	–	–
SC (downstream)	11/98 - 2/00	31	31	–	–	–	–	–	–	–
SPR-CC (downstream)	2/95 - 2/00	84	84	–	75	–	–	–	–	–
SP-78 (downstream)	1/88 - 2/00	314	314	–	257	–	–	–	–	–
SP-88 (downstream)	1/88 - 2/00	104	104	–	88	–	–	–	–	–
SP-MCKAY (downstream)	4/88 - 11/98	292	292	–	248	–	–	–	–	–
06720500 (downstream)	10/54 - 9/99	160	37	31	25	2	33	2	–	–
SP-124 (downstream)	1/88 - 2/00	311	311	–	258	–	–	–	–	–
SP-160 (downstream)	1/88 - 11/98	317	317	–	257	–	–	–	–	–

Table C-6-15 contains a summary of the data quality assessment for the South Platte study area. Overall, the data quality was rated as good.

Table C-6-15
Data Quality Assessment for South Platte River Near Denver, Colorado

Station ID	Major Ion Charge Balance	Specific Conductance versus TDS	Measured TDS versus Calculated TDS	Anions or Cations to Specific Conductivity
06714215 (upstream)	–	–	–	–
000009 (downstream)	OVERALL: Poor (n=4) Good:0 Marginal:0 Poor:4	OVERALL: Good (n=1063) Good:844 Marginal:160 Poor:59	OVERALL: Marginal (n=4) Good:2 Marginal:0 Poor:2	OVERALL: Poor (n=6) Good:0 Marginal:0 Poor:6
SP-64 (downstream)	–	–	–	–
SC (downstream)	–	–	–	–
SPR-CC (downstream)	–	–	–	–
SP-78 (downstream)	–	–	–	–
SP-88 (downstream)	–	–	–	–
SP-MCKAY (downstream)	–	–	–	–

Table C-6-15
Data Quality Assessment for South Platte River
Near Denver, Colorado

Station ID	Major Ion Charge Balance	Specific Conductance versus TDS	Measured TDS versus Calculated TDS	Anions or Cations to Specific Conductivity
06720500 (downstream)	–	OVERALL: Good (n=71) Good:71 Marginal:0 Poor:0	–	–
SP-124 (downstream)	–	–	–	–
SP-160 (downstream)	–	–	–	–

Only 2 of the 11 stations (000009 and 06720500) had the necessary analyses completed to be able to assess the quality of the data.

For station 000009, all four assessment methods could be completed. One method (specific conductivity versus total dissolved solids [TDS]) indicated that the data quality was good, based on 1,063 sets of measurements. One method (measured TDS versus calculated TDS) indicated that the data quality was marginal, based on four sets of measurements. The remaining two methods (major ion charge balance and anions/cations to specific conductivity) indicated that the quality of the data collected at this station was poor, based on four and six sets of measurements, respectively.

For station 06720500, only one of the four assessment methods (specific conductivity versus TDS) could be completed. This method indicated that the quality of the data collected at this station was good, based on 71 sets of measurements.

A Piper diagram showing the distribution of cations and anions for this study area was not created because there were no complete sets of cations and anions measured at any of the sites.

1.8 AQUATIC HABITAT AND SPECIES OVERVIEW

This section provides an overview of the historic records regarding aquatic life and habitat in the South Platte River near Denver and provides a summary of the site reconnaissance effort.

1.8.1 Historical Data Summary

Historical records on fish species resident in the South Platte River date back to at least the late 1800s; occasional fish studies were carried out until the early 1980s (**Appendix M**). Beginning in the mid-1980s and continuing until the late 1990s, MWRD or its contractors have conducted a variety of fish surveys (**Appendix M**). Macroinvertebrate data are limited, collected only by MWRD from the late 1980s through 1993 (**Appendix M**). [Note: MWRD has collected

macroinvertebrates samples since 1993, but these samples have not been analyzed.] No historical algae data were identified. The following is a summary of the identified historical records containing aquatic biology information:

- Jordan (1891) and Ellis (1914) provided early records of fish populations in the South Platte River in what is now the Denver metropolitan area. The information from these records was obtained from a summary prepared by CDM (1994a).

- Li (1968), Johnson (1972), and Propst (1982) conducted fish surveys in the South Platte River as part of either a master's thesis or a doctoral dissertation, and Goettl (1982) gathered fish data to determine the potential of establishing a sport fishery in the South Platte River. The information from these records was obtained from a summary prepared by CDM (1994a).

- The Colorado Division of Wildlife (CDOW) gathers fish data on surface waters in the state of Colorado. CDM (1994a) reports a summary of data collected 1989 through 1990.

- MWRD has collected fish survey data on the South Platte River above and below its point of discharge to the river since the mid-1980s. The record of these unpublished data ranges from 1986 until 1998.

- CDM et al. (1993, 1994a, 1994b) collected and/or reviewed fish data as part of a series of scientific studies conducted on the South Platte River below the Denver Metro WWTP discharge. The purpose of these studies was to develop a site-specific DO standard in a segment of the river downstream of the discharge.

1.8.2 Site Reconnaissance Summary

Appendix N reports the habitat scoring results using the Rapid Bioassessment Protocol (RBP) Habitat Assessment Method and the habitat scoring results using the Project Habitat Assessment Method. **Appendix N** also summarizes the results of the macroinvertebrate sampling as well as provides descriptive information gathered from each sample site.

1.8.2.1 Evaluation of Aquatic Habitat Quality

Site 1 – Reference Reach Upstream of the Denver Metro WWTP Outfall. Instream habitat quality rates fairly high for this reach of the South Platte River. Substrates vary from gravel to cobble and there is a mix of pool, run, and riffle habitats. Dense growths of filamentous algae were present; emergent and submergent macrophytes were absent. The river channel has been somewhat modified along this reach, especially the left bank. Riparian vegetation is severely impacted on the left bank and moderately impacted on the right bank. The large channel width precludes any portion of the reach from being shaded.

South Platte River Site 1 – Upstream.

Site 2 – Downstream of the Denver Metro WWTP Outfall. Habitat quality declines significantly between Sites 1 and 2, which is the result of increased channel modifications, loss of riparian vegetation, and poor instream habitat diversity. The continuous high volume discharge at this location results in a flow regime composed exclusively of a deep run. Substrates change from the gravel/cobble present at Site 1 to a sandy bottom substrate at Site 2. Filamentous algae were limited, likely because of substrate limitations and water depth; some submergent macrophytes were present.

South Platte Site 2 – Downstream.

Denver Metro WWTP Outfall

Site 3 – South Platte River Upstream of the Clear Creek Confluence. Habitat quality at Site 3 increases somewhat from Site 2 primarily because of improved instream habitat quality. Some improvement in channel morphology and riparian habitat also occurs and the width of the channel increases markedly from Site 2. Run habitat continues to dominate, but some riffles are present; pool habitat remains absent. The substrate is comprised of gravel and cobble; dense growths of filamentous algae were again present covering more than 90 percent of the stream bottom.

Denver Site 3 – Downstream.

South Platte Site 3 – Upstream.

Site 4 – South Platte River Upstream of the 124th Avenue Bridge. Habitat quality is the best at Site 4. Individual habitat scores increase for factors related to instream habitat diversity and channel morphology. The South Platte River at this location appears to have been allowed to flow somewhat naturally without channelization. Run habitat is again dominant, but both pool and riffle habitats are present as well. Substrates are primarily composed of cobble material. Dense filamentous algae were also present covering 80 to 90 percent of the substrate surface, but other aquatic plants were absent.

South Platte Site 4 – Upstream.

South Platte Site 5 – Upstream.

Site 5 – South Platte River Upstream of the 160th Avenue Bridge. Habitat quality declines somewhat from Site 4, primarily because of the reduced habitat diversity and increased levels of fine sediments, which results in increased embeddedness. Cobble and sand are the dominant particle sizes. The density of filamentous algae declined markedly from Site 4, covering less than 25 percent of the substrate at Site 5.

1.8.2.2 Comparison of Results of Habitat Scoring Methods

Both scoring methods rate Site 2 as the site with the poorest habitat quality and Site 4 as the site with the best habitat quality. Although there is agreement on the extremes, there are some differences between the scoring methods. In general, the overall pattern is the same for both methods, but the degree of differences between sites varied somewhat. For example, Site 5 is given a higher score than Site 1 with the RBP Habitat Assessment Method, but given a lower score than Site 1 with the Project Habitat Assessment Method.

1.8.2.3 Evaluation of Macroinvertebrate Community

The results of the April 20, 2000 macroinvertebrate sampling are documented in **Appendix N**. The macroinvertebrate sampling was conducted as a screening-level assessment only. The identification of aquatic organisms was limited to field recognition; no organisms were taken to a laboratory for complete identification. Consequently, many of the organisms observed could only be identified to the class or order level and comparisons with the results of historical data collection efforts are limited. Following is a brief description of the results of the screening level macroinvertebrate sampling at each site.

Site 1 – Reference Reach Upstream of the Denver Metro WWTP Outfall. Taxa richness was limited to nine taxa at the reference site. Two of these taxa were part of the Ephemeroptera, Plecoptera, Trichoptera (EPT) taxa (baetid mayflies and hydropsychid caddisflies). Oligochaete worms and chironomid midges were dominant, constituting more than 90 percent of the macroinvertebrates at this site. Other taxa included Cladocera, blackflies, leeches, flatworms, and mites.

Site 2 – Downstream of the Denver Metro WWTP Outfall. The number of taxa declined to six at Site 2; no EPT taxa were collected. Total abundance also declined markedly at Site 2, the result of limited habitat available for colonization. Oligochaete worms were the dominant taxon, but chironomid and ceratopogonid midges were abundant as well.

Site 3 – South Platte River Upstream of the Clear Creek Confluence. Taxa richness declined from six at Site 2 to only five at Site 3, but the abundance of invertebrates recovered for the most part from the decline at Site 2. No EPT taxa were collected. More than 95 percent of all

organisms collected were oligochaete worms. Chironomid midges made up most of the rest of the organisms.

Site 4 – South Platte River Upstream of 124th Avenue Bridge. Taxa richness increased to eight at Site 4, but oligochaete worms continued to constitute more than 90 percent of all organisms collected. One EPT taxon (baetid mayflies) was collected at this site. Other common taxa included blackflies, cladoceran zooplankton, and chironomid midges.

Site 5 – South Platte River Upstream of 160th Avenue Bridge. Taxa richness was seven at this site. One EPT taxon (Hydropsychid caddisfly) was collected. Oligochaetes were no longer dominant. Instead, ceratopogonid midges were the dominant taxon. Chironomid midges, cladoceran zooplankton, and blackflies were also commonly collected.

1.8.2.4 Summary of Changes Downstream of Outfall

The number of taxa was limited at all five sites with not much difference found between the reference site and Sites 4 and 5. There was a slight increase in EPT taxa above the point of discharge. Invertebrate abundance declined markedly below the discharge but increased again downstream. This change very likely was the result of limited instream habitat for invertebrates immediately below the point of discharge. With the exception of Site 5, oligochaete worms dominated the benthic community, even above the wastewater discharge.

1.9 AQUATIC BIOLOGY ANALYSIS

1.9.1 Analysis of Available Data

1.9.1.1 Macroinvertebrates

1.9.1.1.1 Comparability of Methods

There is little similarity between the site reconnaissance and MWRD sample collection methods (Table C-6-16). MWRD used a Surber sampler to collect three replicate quantitative samples from each site on each date. The number of organisms of each taxon found in each replicate were summed to yield a total number per sample. Final organism counts were converted into numbers of animals per square meter. The site reconnaissance samples were qualitative samples collected with a kicknet. Numbers of organisms cannot be converted to a per-square-meter basis, but it is likely that approximately 1 square meter of substrate was kicked.

Table C-6-16
Comparison of Invertebrate Collection and Identification Methods

Invertebrate Study	Sample Period	Sample Method	Sample Processing	Reported Taxonomic Identification
MWRD (1988 - 1993)	Fall season 1988 - 1993	Three replicates collected from each site with Surber sampler.	Unknown	Lowest taxonomic level practical for both insects and non-insects.

Table C-6-16
Comparison of Invertebrate Collection and Identification Methods

Invertebrate Study	Sample Period	Sample Method	Sample Processing	Reported Taxonomic Identification
Site Reconnaissance	June 2000	D-frame kick net with 500 micron mesh; Three 1-minute kick nets from variety of habitat types.	Field counted; subsampled as necessary (see text for details)	Field identification to lowest practical level – typically, family for insects; order or class for non-insects

1.9.1.1.2 Comparability of Data Sets

The following is a description of relevant sites sampled by MWRD, between 1988 and 1993, and the site reconnaissance effort:

- MWRD (2000) – Data collected regularly at five sites during the fall season each year from 1988 to 1993:
  - 64th Avenue – Site A1 on **Figure C-6-1**. Upstream of the Denver Metro WWTP discharge. Near location of Reconnaissance Site 1.
  - 78th Avenue – Site A2 on **Figure C-6-1**. Downstream of the Denver Metro WWTP discharge. Downstream of Reconnaissance Site 3.
  - 88th/92nd Avenue - Site A3/A4 on **Figure C-6-1**. Samples collected from 88th and 92nd Avenue sites were combined for analysis.
  - 124th Avenue - Site A6 on **Figure C-6-1**. Same location as Reconnaissance Site 4.
  - 160th Avenue – Site A7 on **Figure C-6-1**. Same location as Reconnaissance Site 5.

Site Reconnaissance – Data collected from five sites in April 2000 (all shown on **Figure C-6-1**):

- Site 1 – Immediately upstream of Denver Metro WWTP discharge. The site is often dry, but it was flowing on the day of the site reconnaissance. Near Denver Metro 64th Avenue site.
- Site 2 – Immediately downstream of the Denver Metro WWTP discharge.
- Site 3 – Near 72nd Avenue, upstream of the confluence of Clear Creek and the South Platte River.
- Site 4 – Upstream of the 124th Avenue Bridge crossing. Same location as MWRD 124th Avenue site.

- Site 5 – Upstream of the 160th Avenue Bridge crossing. Same location as MWRD 160th Avenue site.

The MWRD data set represents a consistent annual sampling at a variety of sites upstream and downstream of the WWTP discharge. Although there is only one sample event per year, the consistency of the sample effort provides a data set useful for temporal as well as spatial analyses. In contrast, the reconnaissance study represents a single sample event or very brief snapshot in time since sampling was conducted only once at each site. While the site reconnaissance and MWRD data sets may not be directly comparable because of method differences, to the degree possible the site reconnaissance data will be evaluated in the context of the historical data.

1.9.2 Data Analysis Results

1.9.2.1 Macroinvertebrates

Four aquatic biological measures were used to compare data results: total number of taxa; Hilsenhoff Biotic Index (HBI) values; percent EPT taxa; and relative abundance of major taxonomic groups: Oligochaetes (segmented worms); Diptera (flies); Other [primarily Crustacea, Gastropoda (snails), Odonata (dragonflies and damselflies), Hemiptera (true bugs) and Coleoptera (beetles)].

1.9.2.1.1 Effect of Varying Levels of Taxonomic Identification

The MWRD data were evaluated at two levels of taxonomic identification to evaluate if reducing the level of identification to the family/order level had much of an impact on temporal and longitudinal patterns. The results of this analysis help determine the relevance of the site reconnaissance results to the historical MWRD data.

Viewing the MWRD results with all taxonomic information shows that the number of taxa at a given site and year is somewhat variable between 1988 and 1993 (**Figure C-6-18**). For example, at 64th Avenue, above the WWTP discharge, the number of taxa varied between 11 and 24 (1990 and 1993) and 21 in 1989 and 1991, respectively. Downstream of the WWTP discharge, 78th Avenue shows marked increase in taxa richness between 1988 and 1991 before dropping again to a fairly uniform number of taxa in 1992 and 1993 (**Figure C-6-18**).

If the MWRD data are converted so that taxonomic identification is limited to the family/order level (same as that used by the site reconnaissance effort), the temporal and longitudinal patterns are somewhat similar to the results obtained at higher levels of taxonomic resolution (compare **Figures C-6-18 and C-6-19**). The primary difference between the results is that between-year variability is somewhat dampened, but that is to be expected at lower levels of taxonomic resolution.

A similar comparison was conducted using HBI values (compare **Figures C-6-20 and C-6-21**). Overall results are the same longitudinally (i.e., with the exception of 64th Avenue, most site HBI scores vary between 6.00 and 7.00). At 64th Avenue, the HBI scores are lower, typically around

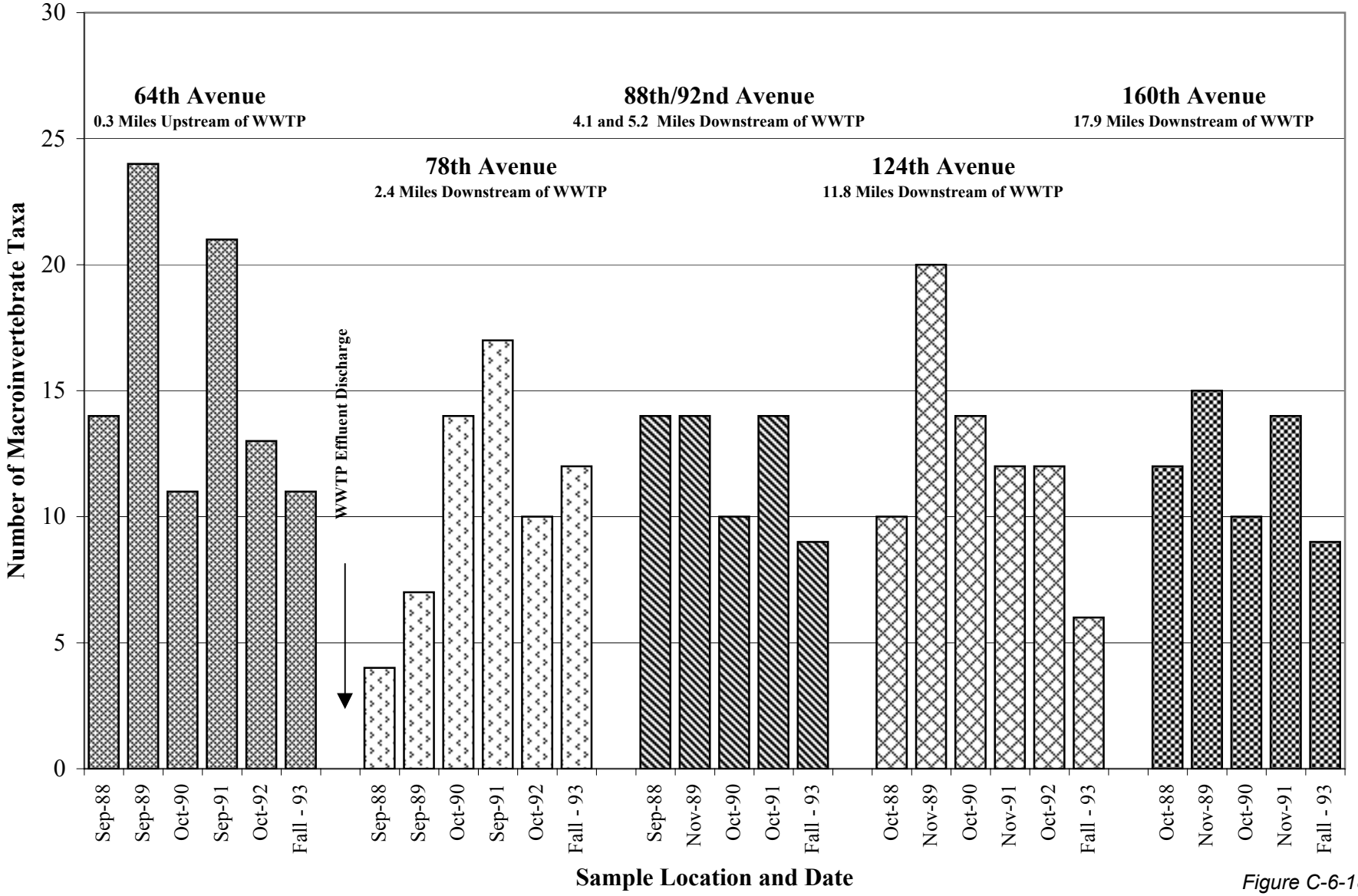


Figure C-6-18
Number of Macroinvertebrate Taxa
Denver Metro Data, 1988-1993
(Taxa Identified to Lowest Practical Level)
South Platte River Near Denver, Colorado

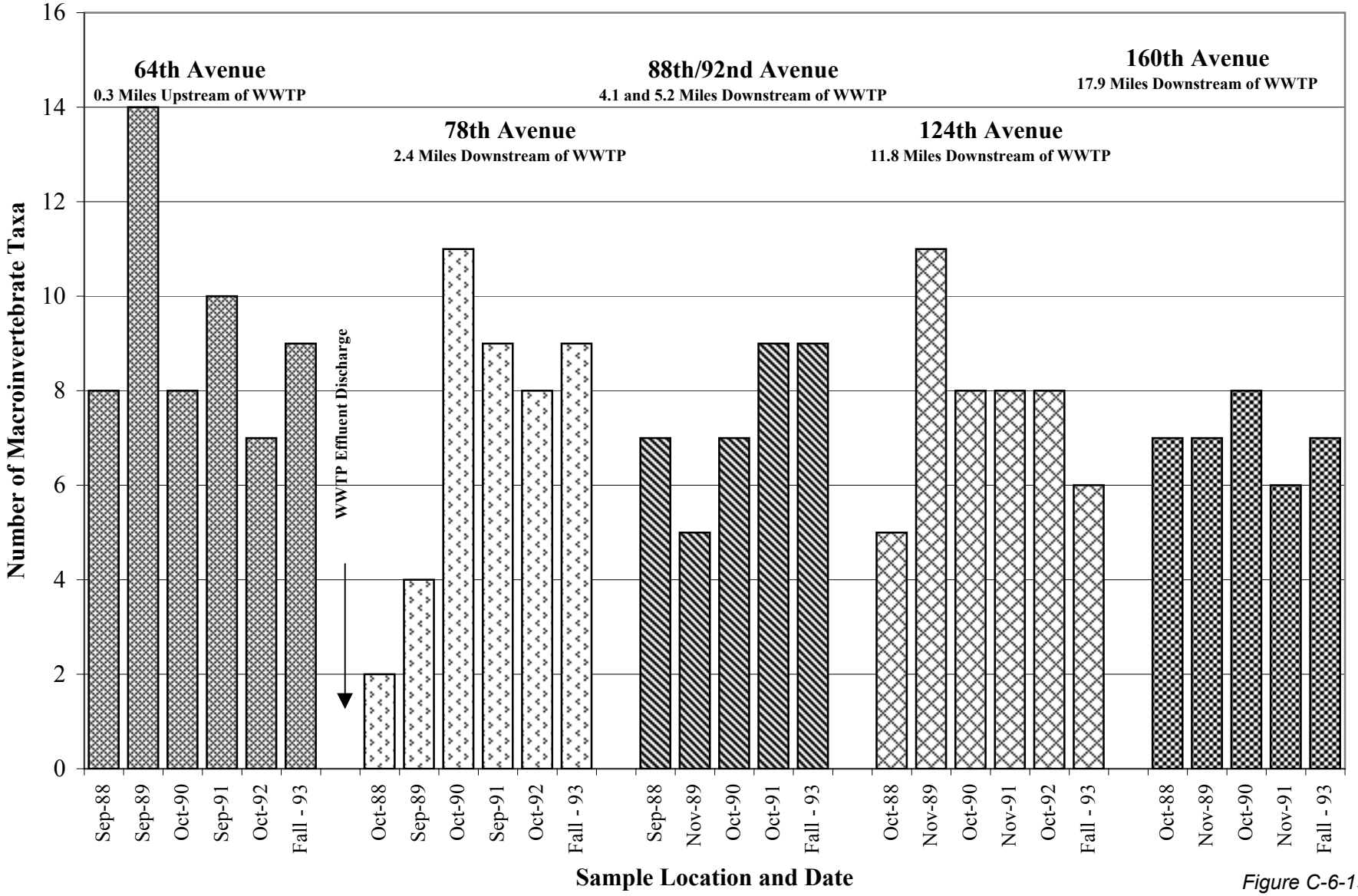


Figure C-6-19
Number of Macroinvertebrate Taxa
Denver Metro Data, 1988-1993
(Taxa Identified to Family/Order Level)
South Platte River Near Denver, Colorado

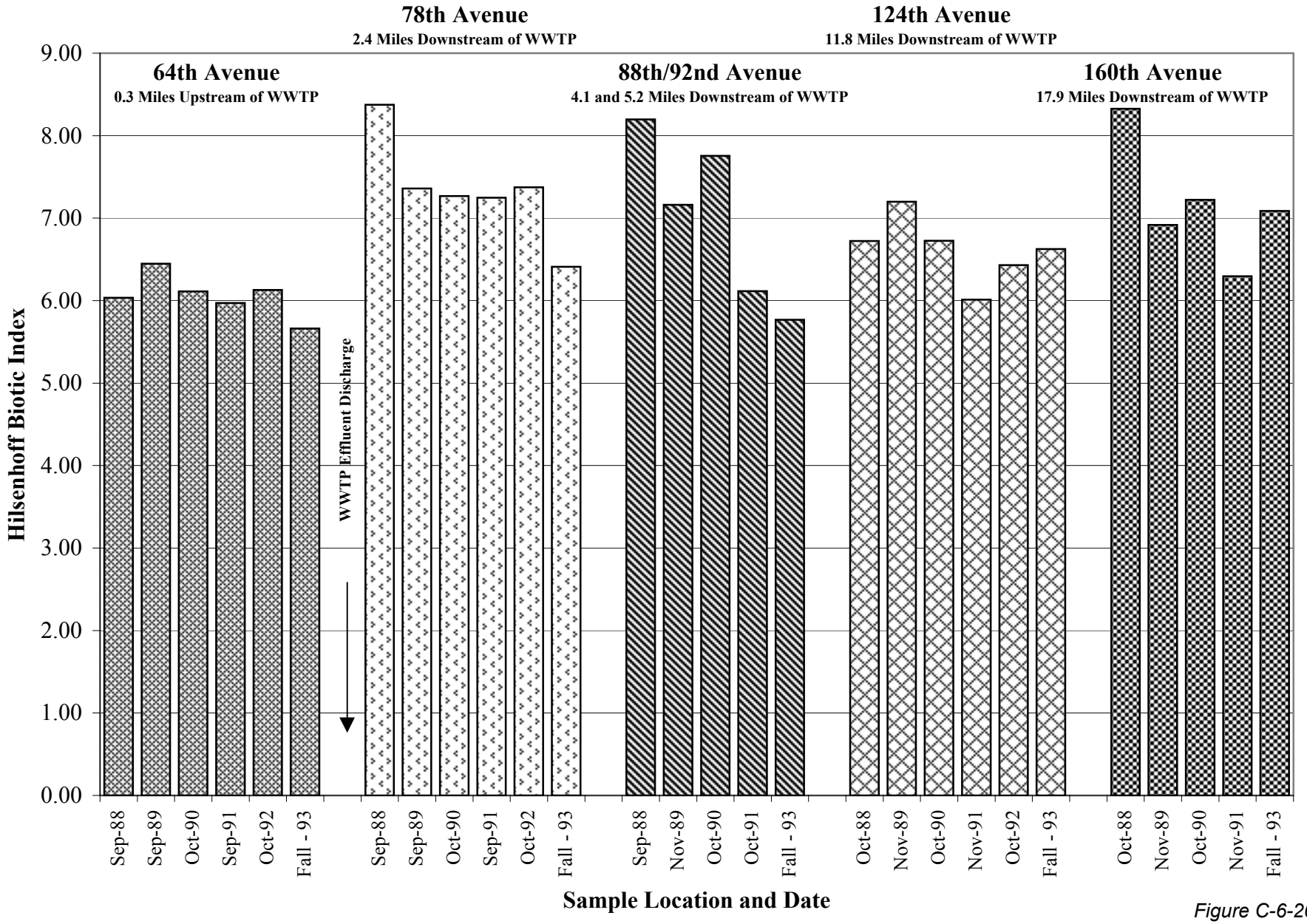


Figure C-6-20
Hilsenhoff Biotic Index
Denver Metro Data, 1988-1993
(Taxa Identified to the Lowest Possible Level)
South Platte River Near Denver, Colorado

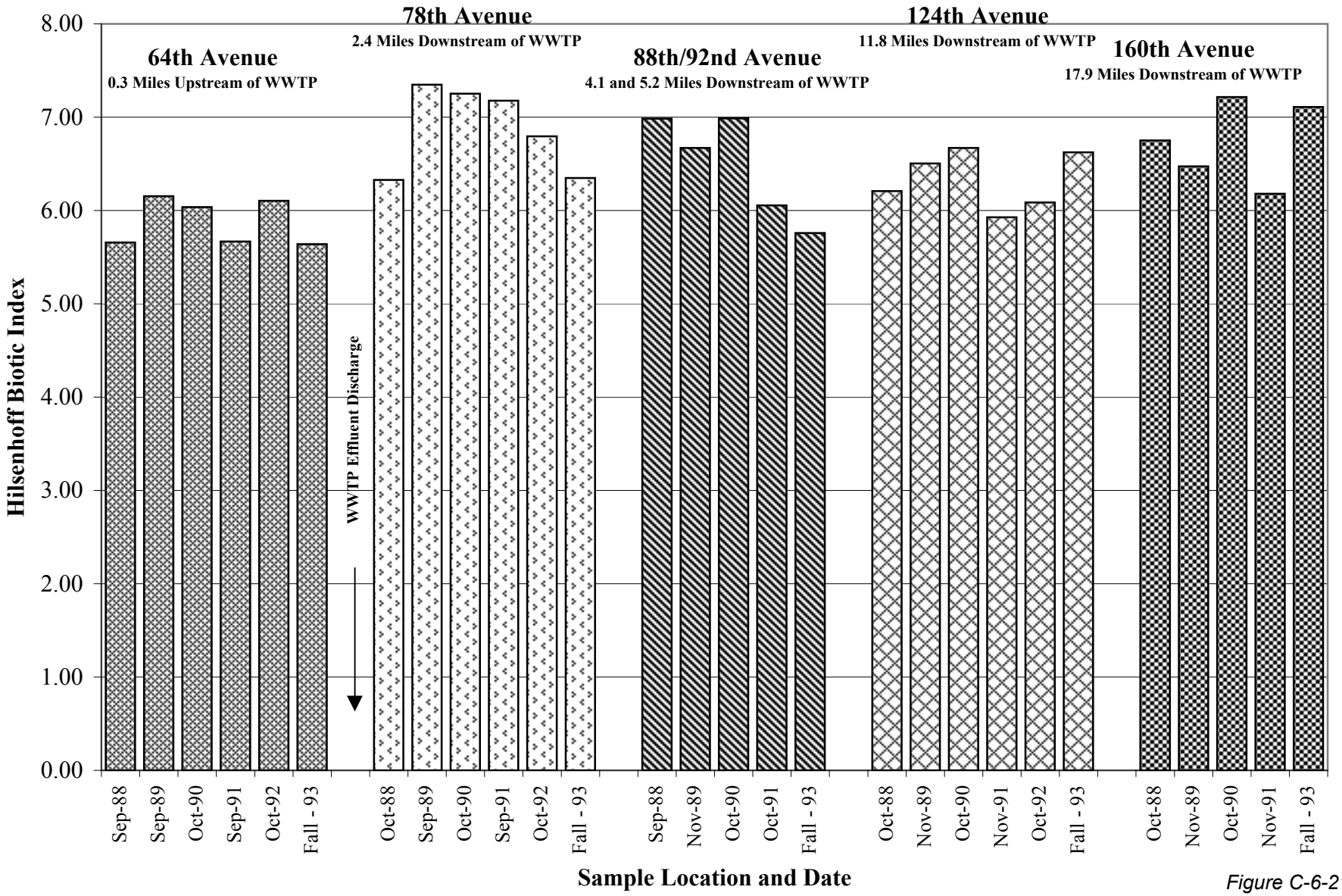


Figure C-6-21
Hilsenhoff Biotic Index
Denver Metro Data, 1988-1993
(Taxa Identified to Family/Order Level)
South Platte River Near Denver, Colorado

6.00 or less. While longitudinally the results are generally the same at different levels of taxonomic resolution, there is a notable temporal difference. Typically, at the highest taxonomic resolution the 1988 scores for 78th, 88th/92nd, and 160th avenues are notably higher than subsequent years. However, at the family/ order level, this distinction is generally lost. The cause of this difference is loss of taxonomic resolution. At the family/order level, the tolerance values used for chironomid midges and Oligochaete worms was a single number, 6 and 7.5, respectively. However, at the genus level tolerance values can range from 0 to 10 for chironomid midges and Oligochaetes. Based on the genera and species reported in the MWRD data, tolerance values were typically between 8 and 10 for Oligochaetes and chironomid midges. If these higher values were used, HBI scores would be elevated.

1.9.2.1.2 Longitudinal Patterns in Macroinvertebrate Community Structure

Sample methods vary among studies. As a consequence, only overall patterns can be discussed, not specific results (e.g. 12 taxa versus 15 taxa at a given site). Also, all historical data sets as well as site reconnaissance data represent points in time rather than a time series. Thus, it can only be assumed that the longitudinal patterns observed on the day of sampling consistently occur during all months or seasons of the year.

Number of Families/Orders. The number of families/orders does not follow any consistent longitudinal pattern (**Figure C-6-22**). Typically, if all sites were similar in terms of habitat, one would expect to find a pattern of higher taxonomic richness upstream of the WWTP, a decrease in richness immediately downstream of the discharge, and then increased richness with increasing distance downstream of the discharge. **Figure C-6-22** illustrates the lack of consistent patterns, especially regarding the expectation of higher richness upstream of the WWTP facility. For example, in 1988, 1989, and 2000 the upstream site (64th Avenue) has greater taxonomic richness than the site sampled below the discharge. However, in all other years the site below the discharge either has higher richness than the upstream site or similar richness. [Note: a review of **Figure C-6-18**, which includes all the taxa, shows the same inconsistency.] These results suggest that factors other than water quality or in addition to water quality limit taxonomic richness. For example, some of the variability at 64th Avenue may be a result of flow variation upstream of the WWTP.

HBI Values. Longitudinal patterns of HBI values show that in most years the HBI value rises below the WWTP discharge, and then declines with distance downstream of the discharge (**Figure C-6-23**). This is the expected pattern associated with the addition of stressors associated with wastewater effluent. However, exceptions to this pattern are evident in 1993 and 2000. In 1993, HBI values increased with distance downstream of the discharge; in 2000, HBI values increased until Site 5. Because of the gap in the data set between 1993 and 2000, it is unknown whether the trend observed in 1993 and 2000 is typical or a deviation from earlier trends.

Percent EPT Taxa. With two exceptions observed at the 64th Avenue site, the percent EPT taxa (mostly baetid mayflies and hydropsychid caddisflies) is low throughout this reach of river (**Figure C-6-24**). The percentage appears to have increased some from 1991 to 1993, but the

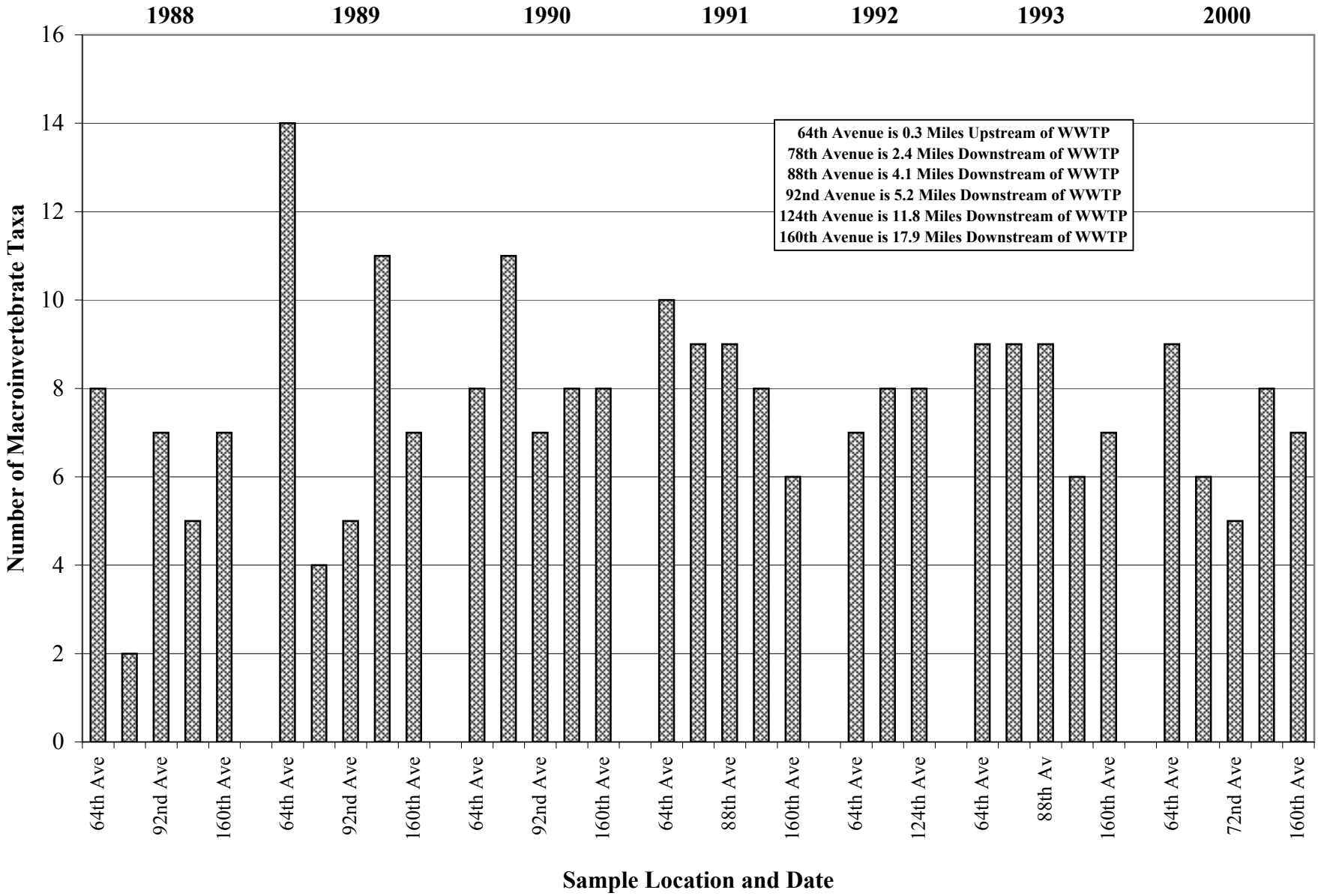


Figure C-6-22
Number of Macroinvertebrate Taxa
Denver Metro Data 1988-1993 vs. Site Reconnaissance 2000
(Taxa Identified to Family/Order Level)
South Platte River Near Denver, Colorado

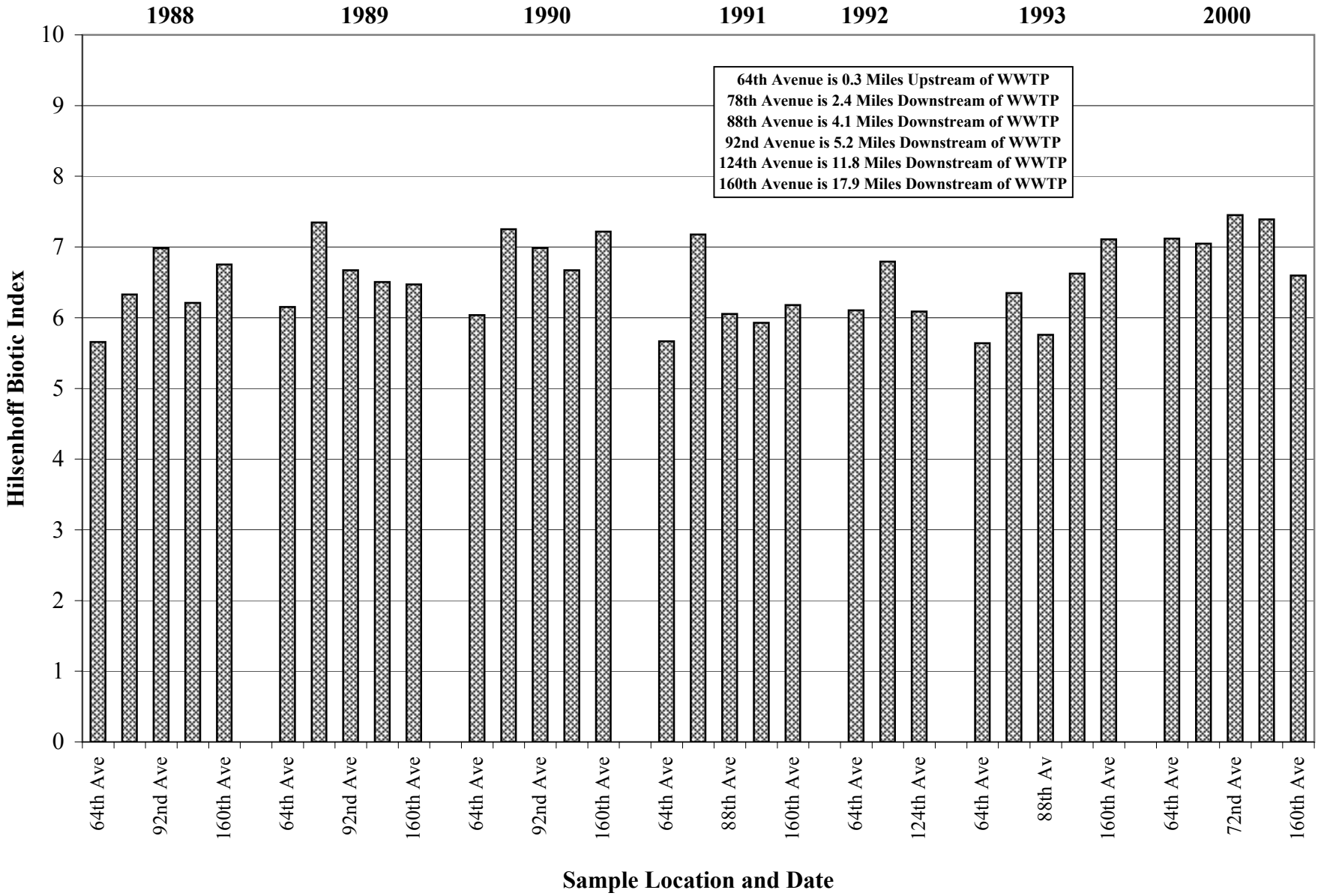


Figure C-6-23
Hilsenhoff Biiotic Index
Denver Metor Data 1988-1993 vs. Site Reconnaissance 2000
(Taxa Identified to Family/Order Level)
South Platte River Near Denver, Colorado

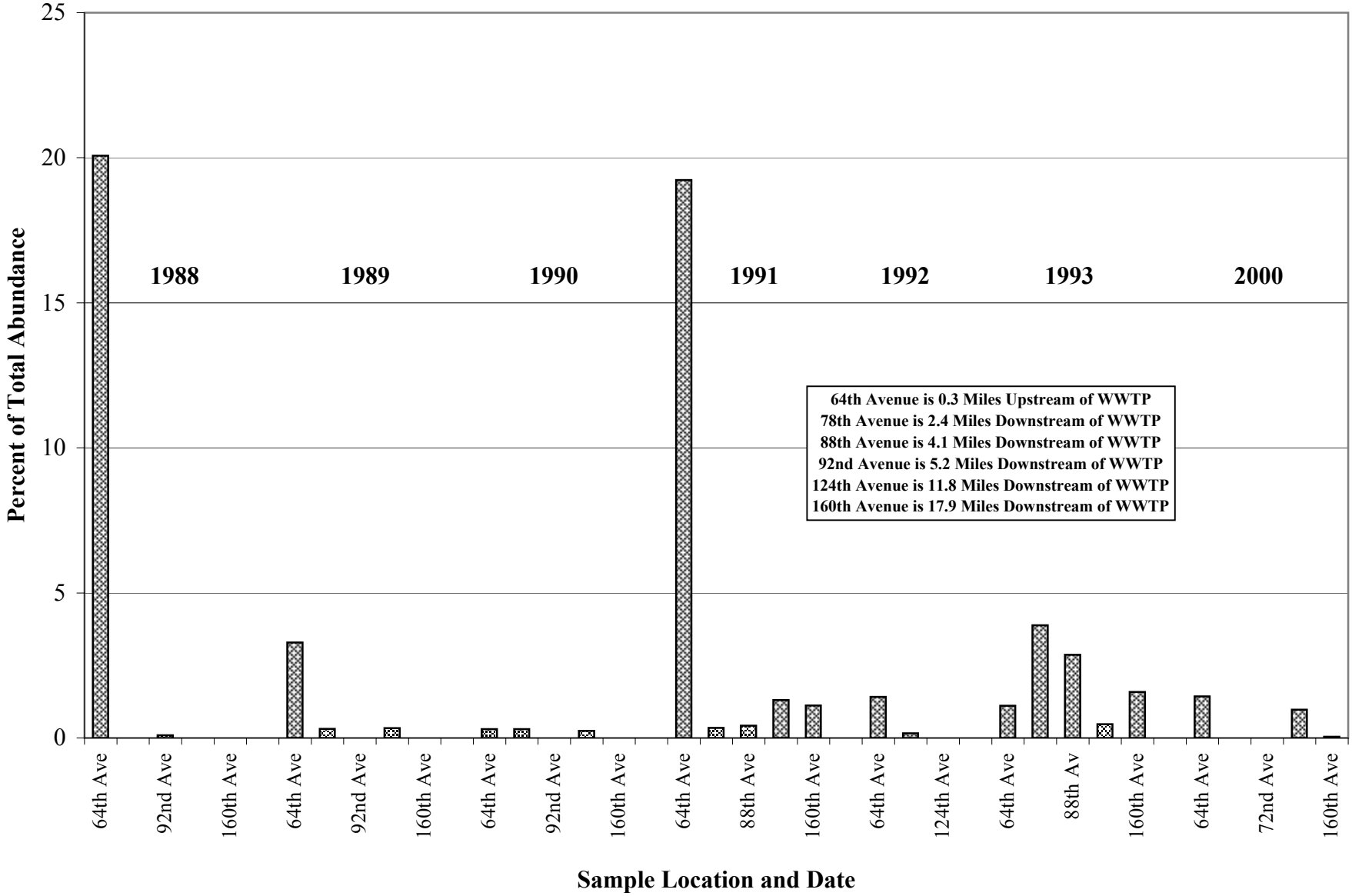


FIgure C-6-24
Percent Mayflies, Stoneflies and Caddisflies (EPT Taxa)
Denver Metro Data 1988-1993 vs. Site Reconnaissance 2000
South Platte River Near Denver, Colorado

overall percentage of these organisms within the aquatic community remains small (less than 5 percent).

Relative Abundance. Abundance of macroinvertebrates is variable from year to year; 1991 appears to have been an unusual year with relatively high densities of macroinvertebrates at most sites (**Figure C-6-25**). Oligochaete worms and chironomid midges typically dominate the composition of the aquatic community at any given site/year (**Figure C-6-26**). However, from year to year it appears that sites shift from a dominance of either worms or midges. During the 2000 site reconnaissance survey, oligochaete worms were considerably more abundant than the chironomid midges.

1.9.2.2 Fish Community

Considerable variability exists in the numbers of fish species present at a given site from year to year (**Figure C-6-27**). For example, at 124th Avenue, the number of species has varied between three and nine. The 64th Avenue site, upstream of the WWTP, appears to have the most stable number of species as well as the most species in a given year. However, farther upstream at 31st Avenue, the number of species is not all that different from sites downstream of the discharge.

Longitudinal patterns are evident in the data record (**Figure C-6-28**). From year to year, typically fewer species of fish are collected at the site immediately downstream of the WWTP discharge than are collected upstream of the discharge. This pattern was observed in 10 of 11 years. However, species richness tends to increase with increased distance downstream of the effluent discharge. Fish abundance is typically higher upstream of the WWTP. However, this increased abundance is restricted to the upstream 64th Avenue site. Abundance at the other upstream site, 31st Avenue, is typically as low or lower than sites downstream of the discharge.

1.9.2.3 Habitat Quality

The Project and RBP Habitat Assessment Methods scored all sites similarly (**Figure C-6-29**). The best habitat scores were obtained at Sites 1 and 4, above the WWTP discharge and at 124th Avenue, respectively. Habitat scores were lowest below the WWTP discharge at Reconnaissance Site 2. This site is located in an area with significant channel alteration and little to no riparian zone. Downstream of Site 2 habitat scores improve until Site 5, which scored a little lower than Site 4.

A linear regression between RBP and Project habitat scores found a significant, positive relationship (r2 = 0.9181) (**Figure C-6-30**). An analysis of the factors contributing to variability in habitat quality scores showed that variability in instream habitat factors had the most influence on between-site scores (**Figures C-6-31 and C-6-32**). Riparian zone and channel alteration factors generally scored poorly at all sites, although there was some improvement in these factors at the farthest downstream sites.

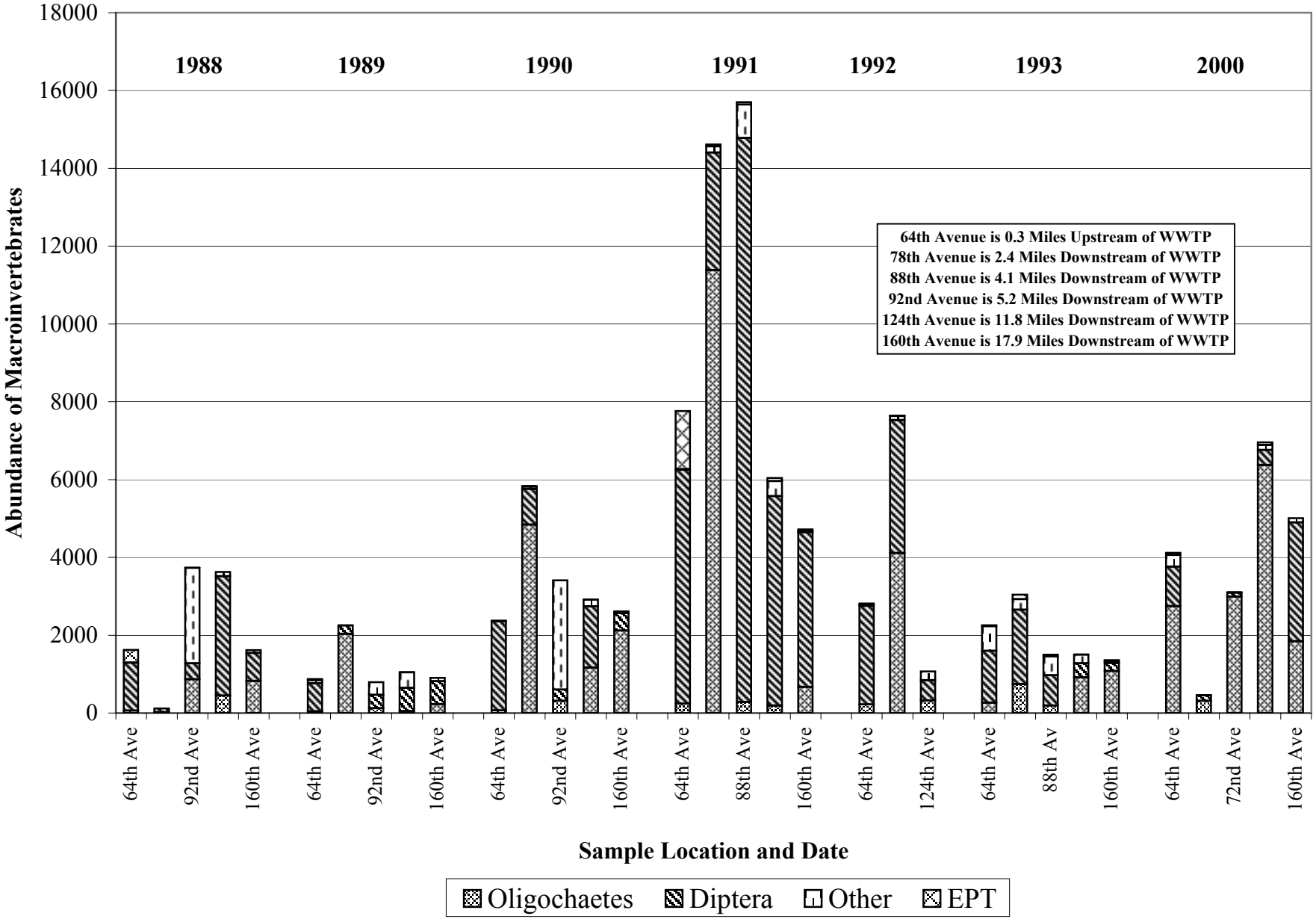


Figure C-6-25
Abundance of Major Macroinvertebrate Groups
Denver Metro Data 1988-1993 vs. Site Reconnaissance 2000
South Platte River Near Denver, Colorado

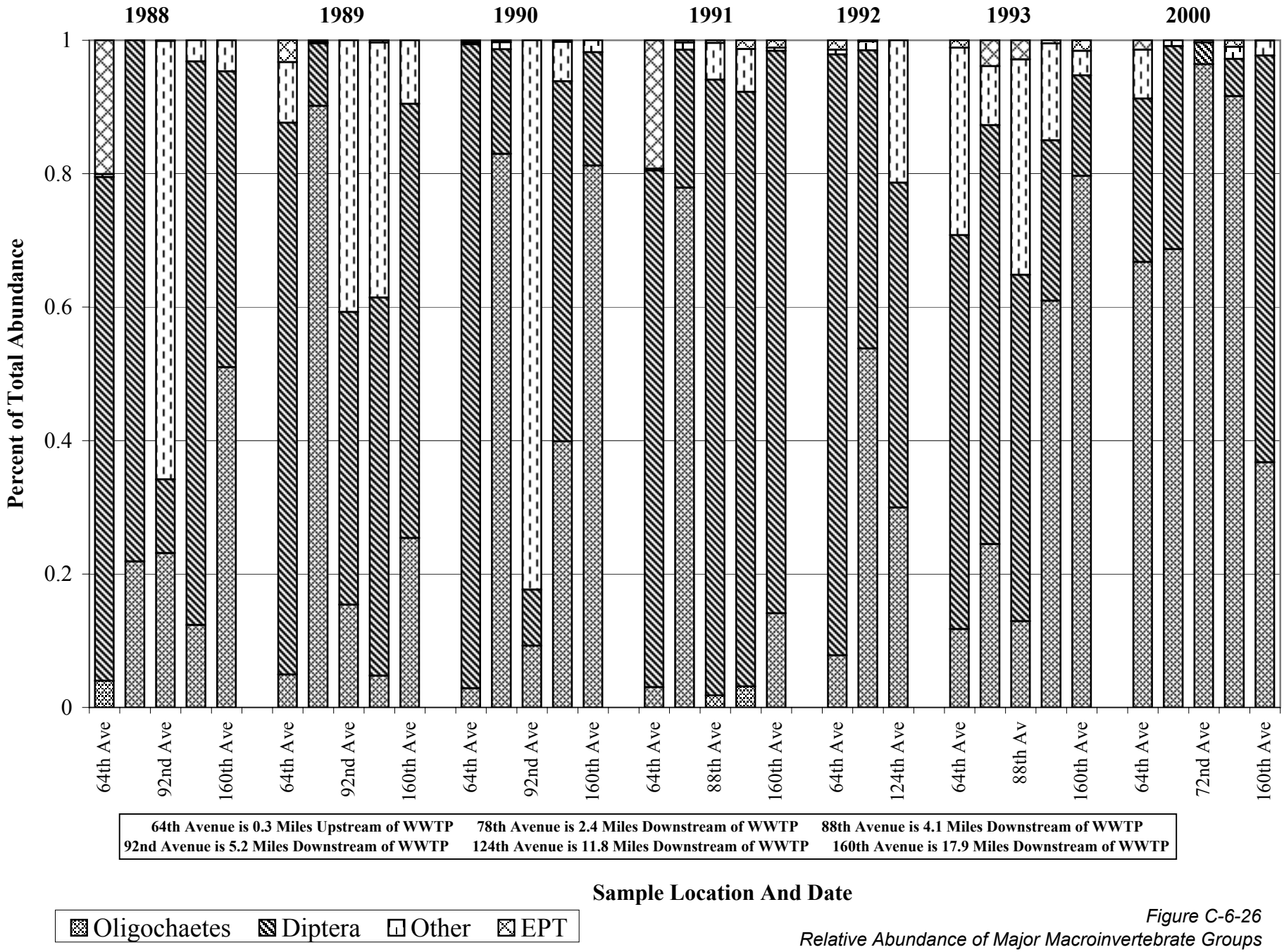


Figure C-6-26
Relative Abundance of Major Macroinvertebrate Groups
Denver metro Data 1988-1993 vs. Site Reconnaissance 2000
South Platte River Near Denver, Colorado

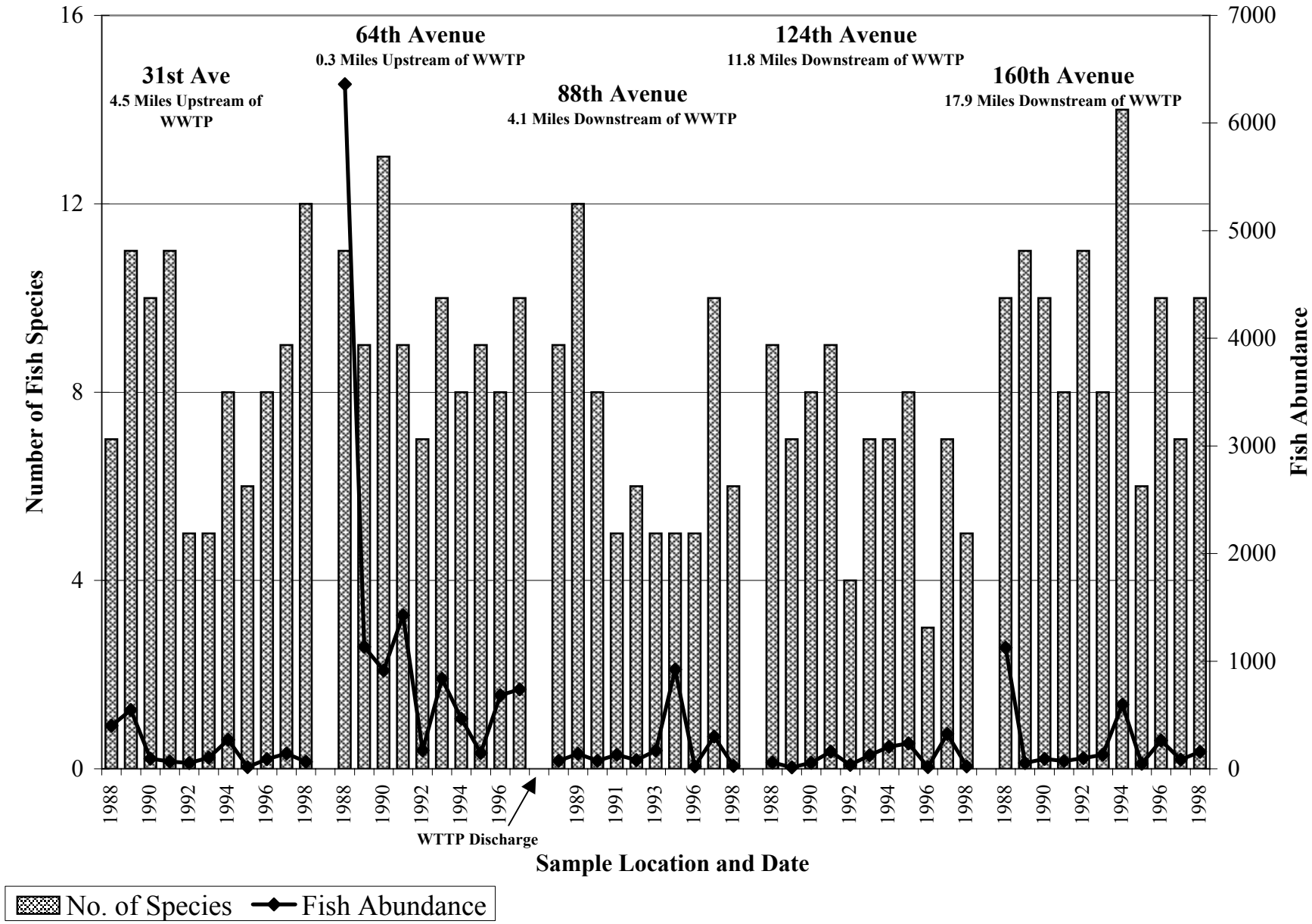


Figure C-6-27
Annual Variation in Fish Abundance and Species Richness
Denver Metro Data 1988-1998
South Platte River Near Denver, Colorado

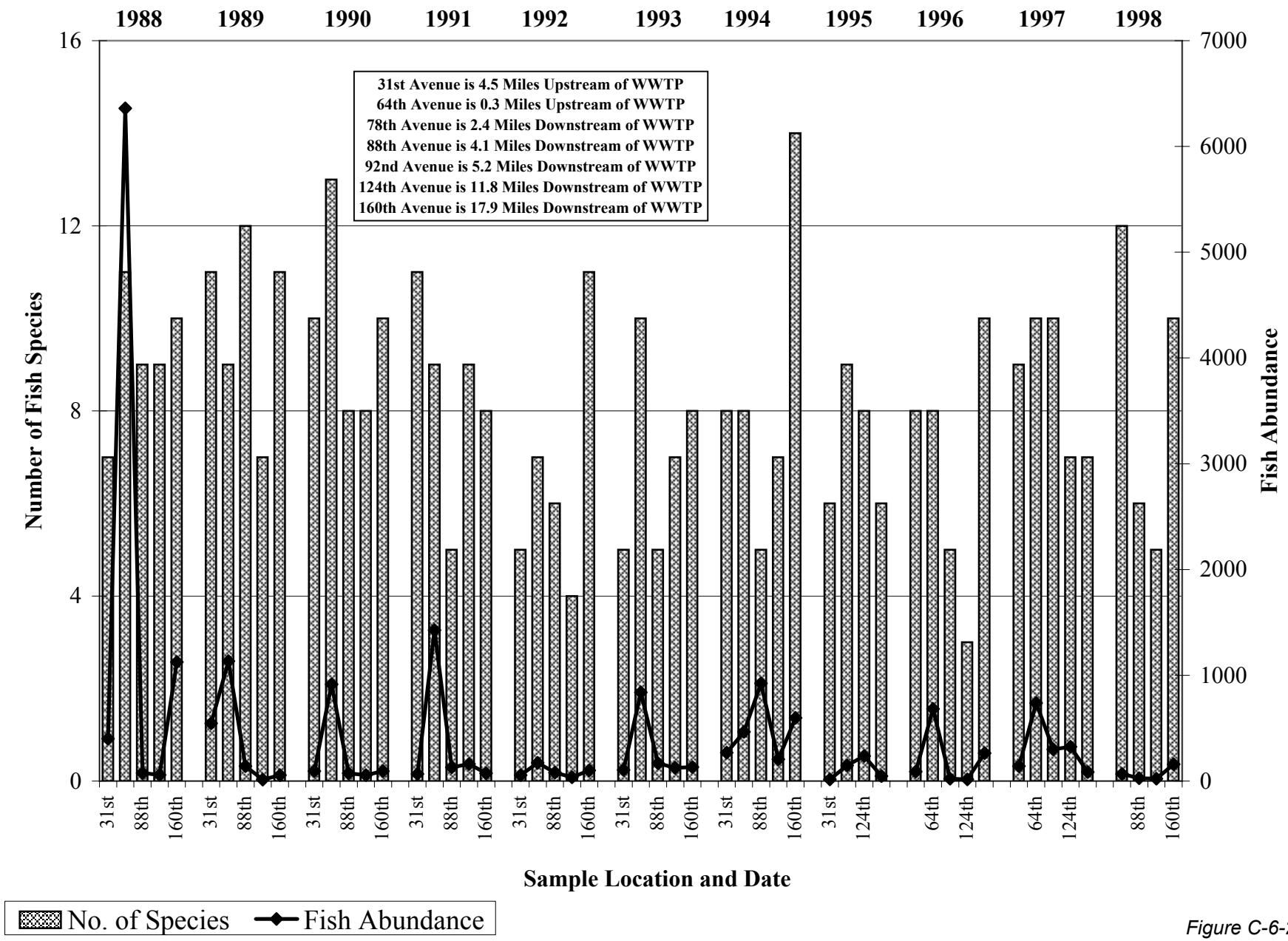


Figure C-6-28
Logitudinal Variation in Fish Abundance and Species Richness
Denver Metro Data 1988-1998
South Platte River Near Denver, Colorado

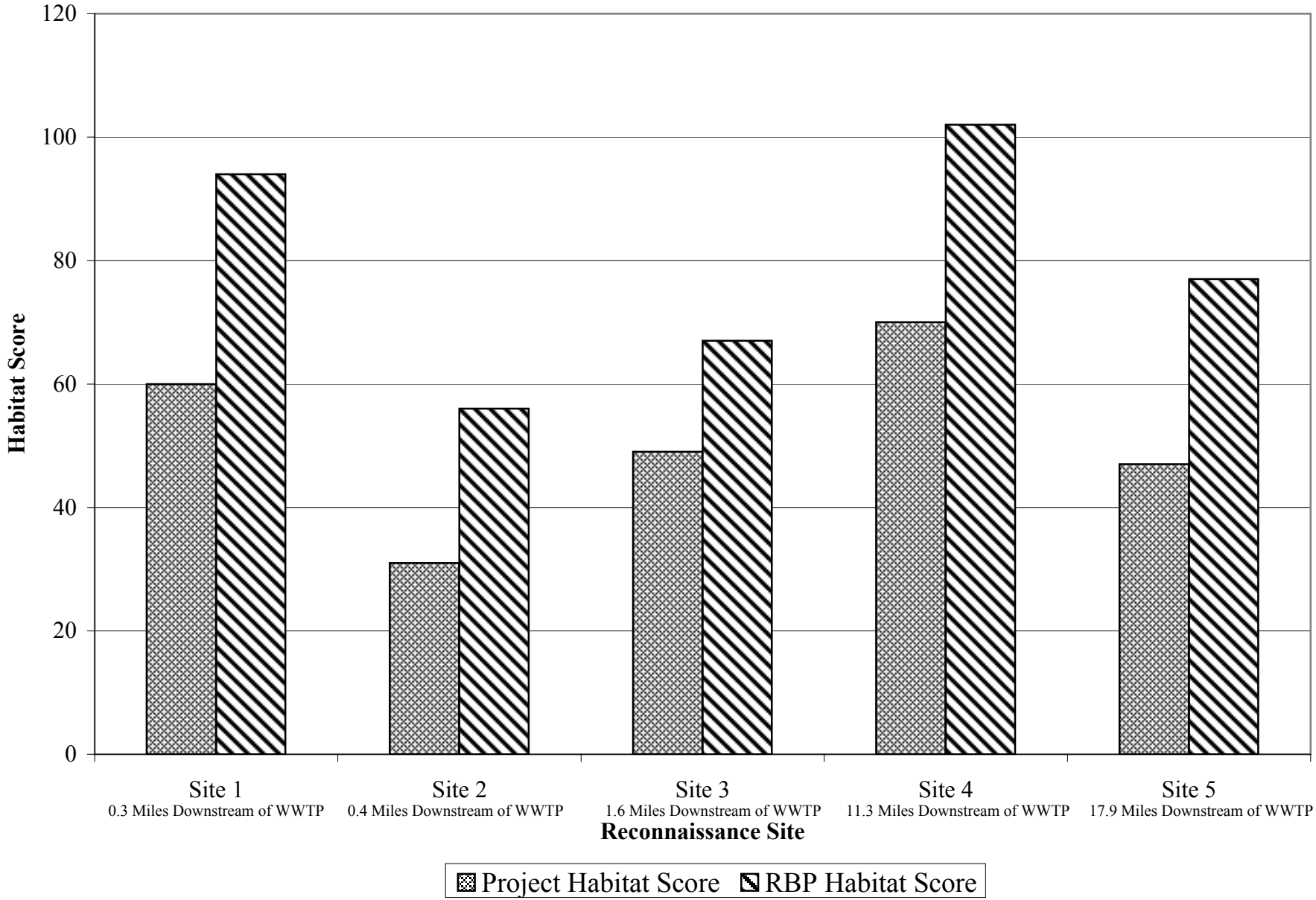


Figure C-6-29
Project Habitat vs. RBP Habitat Scores
South Platte River Near Denver, Colorado

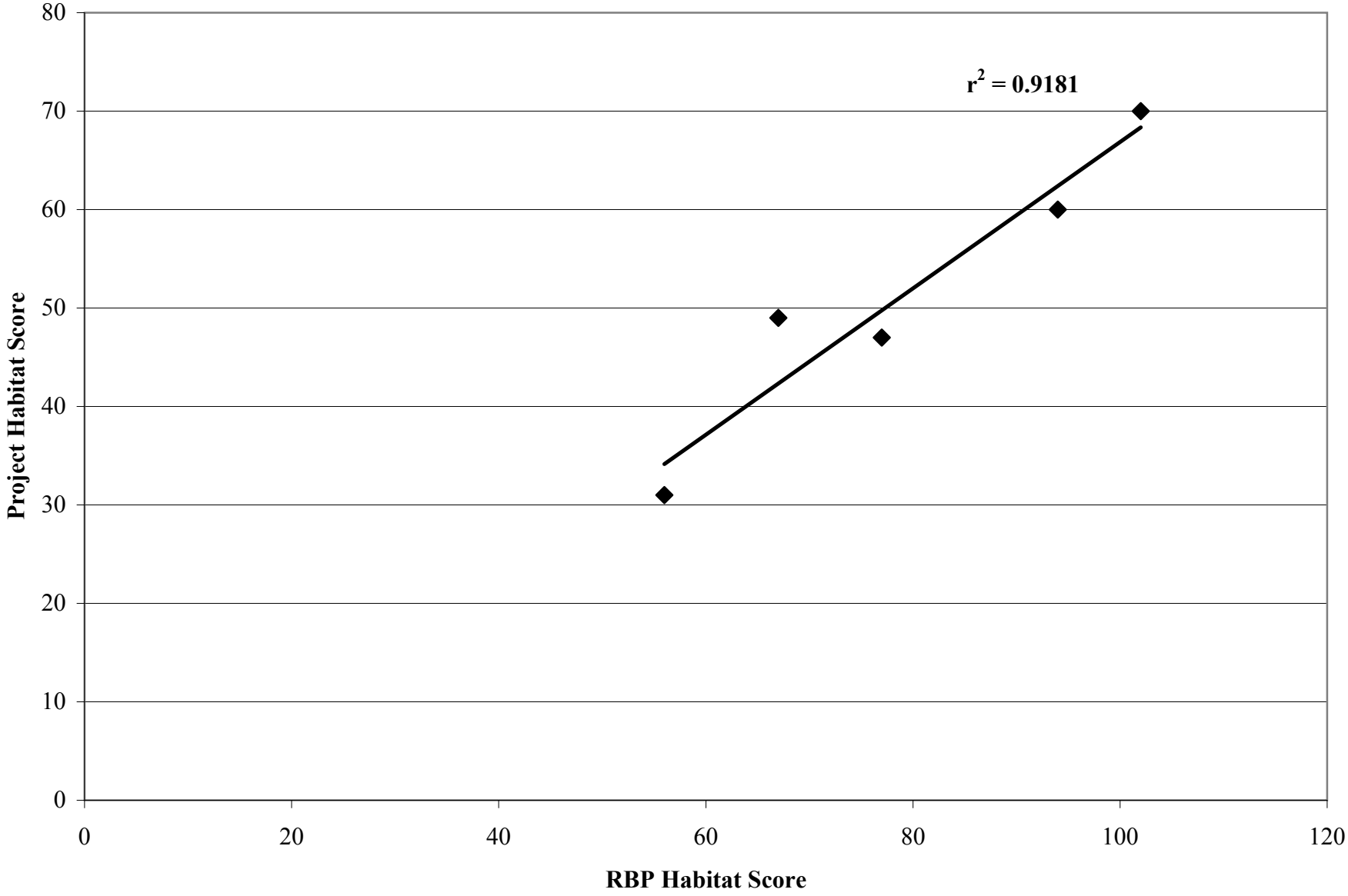


Figure C-6-30
Linear Regression: RBP vs. Project Habitat Scores
South Platte River Near Denver, Colorado

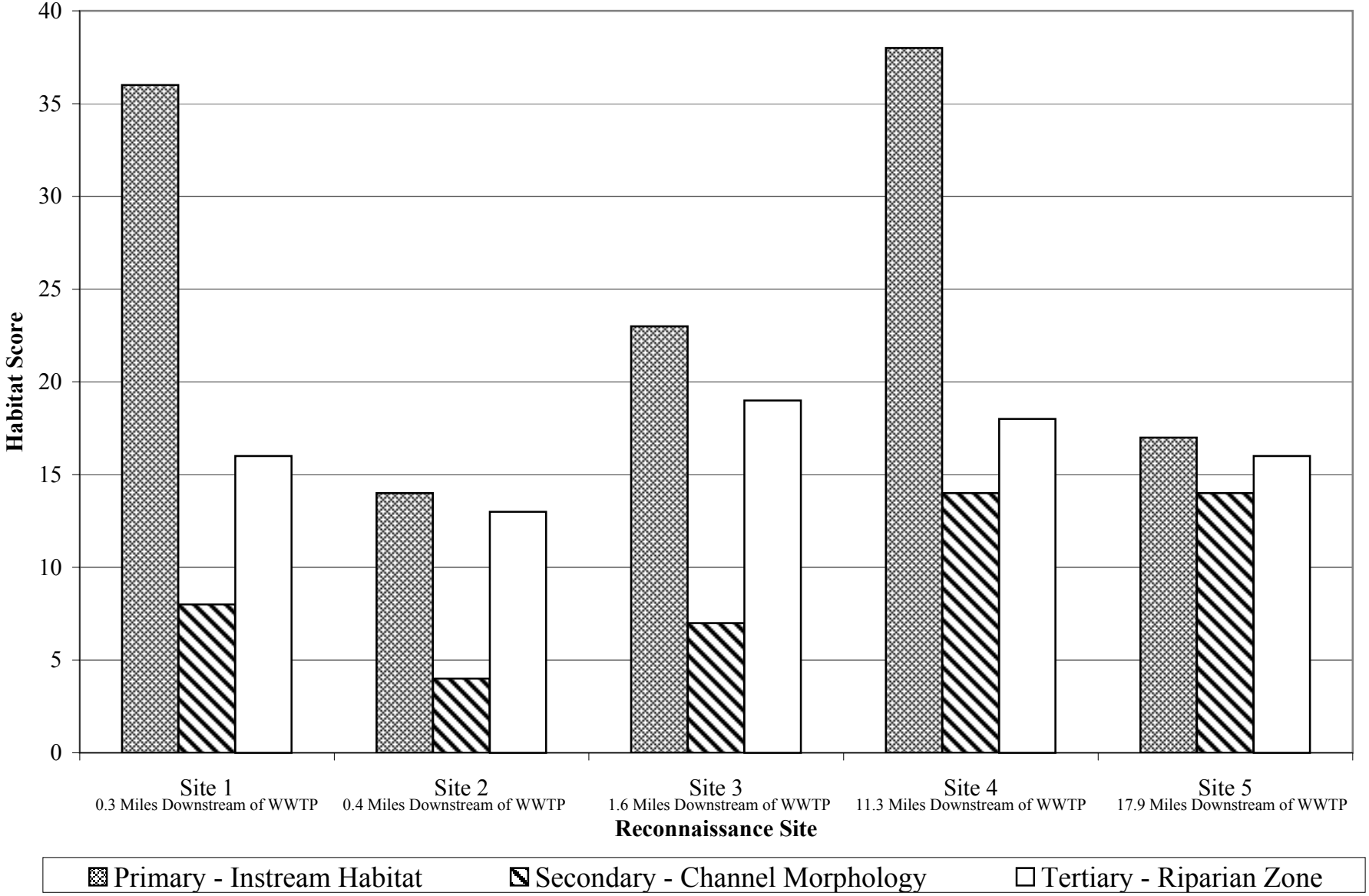


Figure C-6-31
Project Habitat Scores:
Comparison Among Primary, Secondary and Tertiary Factors
South Platte River Near Denver, Colorado

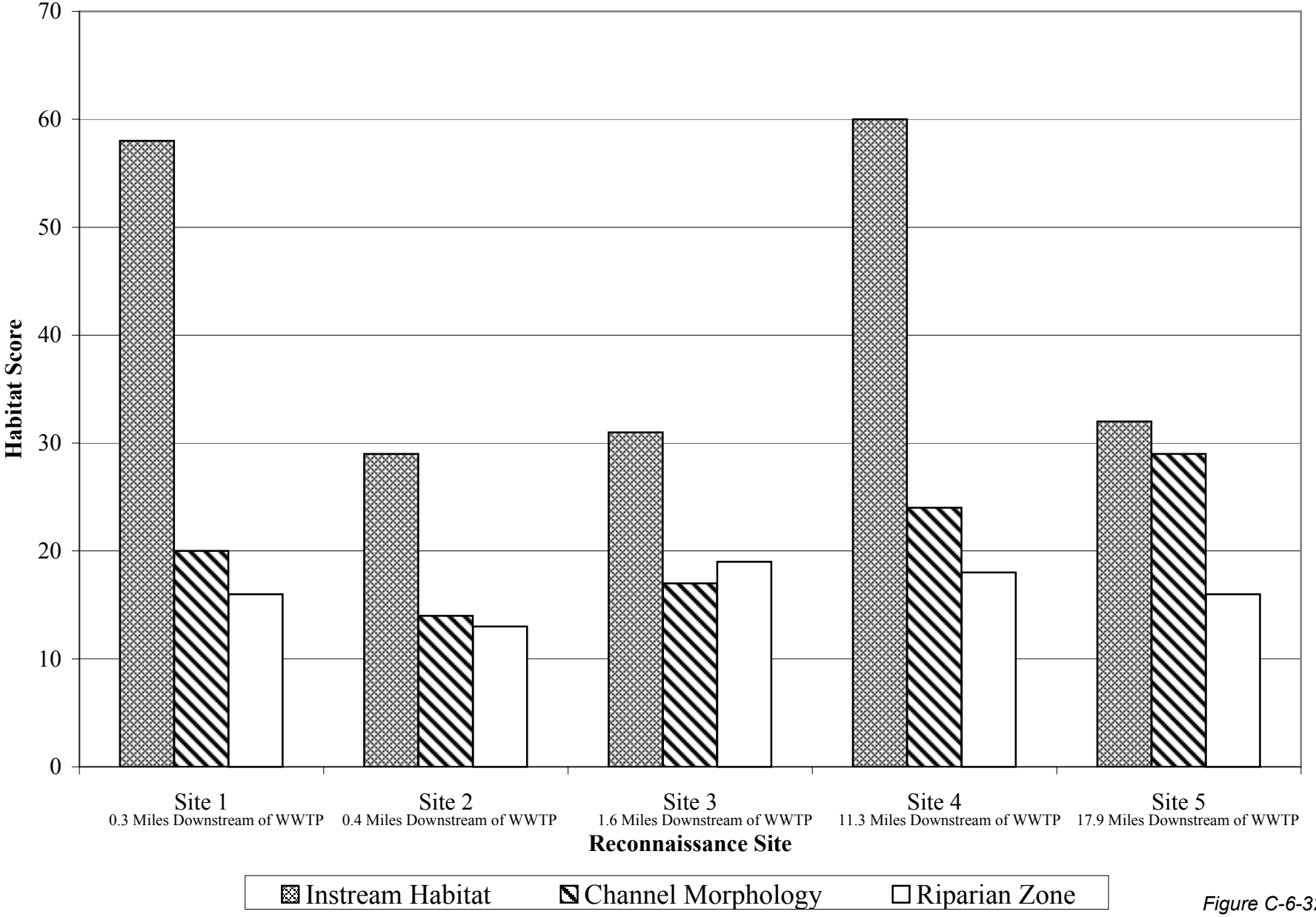


Figure C-6-32
RBP Habitat Scores:
Comparison Among Instream Habitat,
Channel Morphology and Riparian Zone Factors
South Platte River Near Denver, Colorado

1.10 TERRESTRIAL HABITAT AND SPECIES OVERVIEW

This section provides a summary of historic terrestrial species and habitat data near Denver, Colorado. A summary of the site reconnaissance is also provided. **Appendix O** contains a list of species that could occur near Denver and a list of species observed during site reconnaissance efforts.

1.10.1 Historical Data Summary

In the early and mid-1800s, explorers described the area around the confluence of the north and south forks of the South Platte River as barren and wooded. They reported that the quantity of trees and vegetation increased towards the mountains. After the gold rush in 1859, the South Platte River was described by travelers as desolate, probably due to the heavy use of the corridor by gold-seekers. As the area around Denver was developed and irrigation, reservoir construction, and trans-basin diversions were implemented, a more regulated flow in the South Platte River allowed riparian vegetation along the river to increase (Silkensen 1992).

Some species have declined in numbers as a result of human influences. Ute ladies' tresses are found in relatively low-elevation riparian meadows three general areas in the western United States, including the Front Range of Colorado. The Ute orchid is found in moist soils in wet meadows near springs, lakes, or perennial streams where the vegetation is relatively open. It was federally listed as a threatened species in 1992. The Ute orchid is believed to be extirpated from most of its historical range because of alterations of stream hydrography and hydrology (USGS 2000a).

The greenback cutthroat trout was once found in the headwaters of the South Platte River. It was restricted to mountainous and foothill areas because the lower river reaches were too warm and turbid. Populations were greatly reduced because of competition and hybridization with other species of trout and loss or degradation of habitat from mining, logging, grazing, and irrigation projects. This trout was federally listed as threatened in 1978. However, it is believed that genetically pure populations of greenback cutthroat trout were extinct by 1930 (USGS 2000a).

The Pawnee mountain skipper occurs in the South Platte River drainage system along the Front Range of the Rocky Mountains. This butterfly is found in mountainous areas characterized by canyons with steep slopes and narrow valleys. Skippers are usually found in dry, open ponderosa pine woodlands on outcroppings of Pike's Peak granite where soils are thin, unstable, and susceptible to water erosion. Two essential habitat components are blue grama and prairie gayfeather. This butterfly's habitat and range have been limited or destroyed by construction of an existing dam and reservoir and several other types of development. It was federally listed as a threatened species in 1987 (USGS 2000a).

Although human settlement has had many negative effects on the ecology of the South Platte River Basin, it also has been beneficial to some species of wildlife that are dependent upon riparian areas. Gravel pit ponds, irrigation ponds, lakes, and reservoirs provide important habitat

for waterfowl and shore birds. Groves of willow and eastern cottonwood create gallery forests along watercourses and provide important wildlife habitat (EPA 1977).

Looking upstream on the South Platte River just upstream from the Denver Metro WWTP outfall. Riparian vegetation along this reach of the South Platte is strongly dominated by Siberian elm with some box elder. Herbaceous species here included cheat grass, yellow sweet clover, dandelion, hemlock, and several mustards.

A study on habitat selection by wintering waterfowl on the South Platte River, downstream from the Denver Metro WWTP, was conducted in January and February of 1993. Nineteen species of waterfowl were observed in the study area. Species that constituted more than 5 percent of the population were, in order of abundance, northern shoveler, gadwall, mallard, northern pintail, green-winged teal, ring-necked duck, common goldeneye, and American wigeon (Johnson et al. 1993).

Koch (1994) conducted vegetation studies on the lower South Platte River just west of Fort Morgan in northeastern Colorado. In a 1992 vegetation survey, she identified 41 plant species within the 7.4-acre study parcel. Exotic species were the most common, constituting more than half of the species encountered and 60.2 percent of relative vegetative cover. Native facultative forbs and grasses had a relative cover of 34.6 percent, and obligate riparian species had a relative cover of 5.3 percent. The three species that were far more common than any other were whitetop (*Cardaria chalepensis*), common ragweed, and cockelbur. In 1993, Koch identified 28 species in a vegetation survey. The same three species were dominant. There were three woody species present in the study area: sandbar willow, eastern cottonwood, and Russian olive, but Russian olive was not found in 1993 (Koch 1994).

1.11 TERRESTRIAL BIOLOGY ANALYSIS

1.11.1 Site 1 – Reference Reach Upstream of the Denver Metro WWTP Outfall

Immediately upstream of the Denver Metro WWTP, the width of riparian vegetation is 50 feet on the left bank and 115 feet on the right bank. Trees at this site are almost entirely Siberian elm with few box elder. Herbaceous plants include milkweed, thistle, carrot, heron's bill, mallow, sweet clover, dock, and *Sisymbrium* sp. Knapweed, an invasive plant, is present at this site. The only grass at this site is a brome species. One the left bank there is moderate canopy cover of large trees and sparse cover of small trees. Understory cover is sparse, and there is a moderate amount of ground cover. There is moderate amount of bare dirt of duff. Large trees on the right bank are sparse, and small trees have heavy canopy cover. There is moderate understory and ground cover and a moderate amount of bare dirt or duff. Special habitat features at this site are snags and dead and down trees.

There are many human influences at this location. Buildings and a lawn are present on the right bank. A paved recreational path and roads are on both banks. There is an outlet pipe on the left bank at the upstream end of the study reach, and there is trash on the right bank. The surrounding area is disturbed.

Using the riparian classification system, Site 1 is described as a forested, deciduous, Siberian elm community. The riparian vegetation score is low because of low species diversity, low to moderate percent cover in all vegetative layers, and potential habitat for few threatened, endangered, or sensitive plant species. The score for other habitat characteristics is high because of high contrast with adjacent vegetation, some special habitat features, and a wide riparian zone. The wildlife score is low because relatively few species were observed during the site visit, the lists of potential vertebrate species include relatively few species, and there is potential habitat for very few threatened, endangered, or sensitive species. The score for disturbance characteristics is low because of invasive species and moderate to high levels of other human-caused disturbances.

1.11.2 Site 2 – Downstream of the Denver Metro WWTP Outfall

There is virtually no riparian vegetation on the left bank of the South Platte River at the wastewater treatment plant outfall. The right bank has a riparian band 0 to 100 feet wide. Siberian elm and willow trees are abundant at this site. Indian bean is present but rare. Herbaceous plants include amaranth, milkweed, *Conyza* sp., dandelion, cocklebur, mullein, and teasel. The only grass at this site is cheat grass.

The only vegetation on the left side of the river is a sparse canopy cover of large trees and sparse ground cover. The ground cover is largely a result of hydro-seeding on the left bank. The right bank has a sparse cover of large trees and moderate canopy cover of small trees. Understory cover is sparse, and ground cover is heavy on the right bank. There is a moderate amount of bare dirt or duff.

Looking downstream on the South Platte River over the outfall from the Denver Metro WWTP. There is little riparian vegetation on the riprapped left bank. The right bank supports some Siberian elm, willow, catalpa, and teasel.

The adjacent non-riparian vegetation is open fields and disturbed areas. There is riprap on both banks. There are buildings and the outfall from the WWTP on the right bank. A paved recreational path and a park are on the left bank, and roads are on both banks.

Using the riparian classification system, this site is described as a forested, deciduous, willow/elm community. The riparian vegetation score is low because of low species diversity and low percent cover in all vegetative layers. The score for other habitat characteristics is low because of discontinuous habitat, moderate contrast with adjacent vegetation, and a relatively narrow riparian zone. The wildlife score is high because several species were observed during the site visit, and there is potential habitat for several threatened, endangered, or sensitive species. The score for disturbance characteristics is relatively low because of some invasive species and moderate levels of human-caused disturbances.

1.11.3 Site 3 - South Platte River Upstream of the Clear Creek Confluence

The width of the riparian band is approximately 50 to 100 feet on the left bank of the river and 50 feet on the right bank. Siberian elm and willow are the common tree species here. Eastern cottonwood is uncommon at this location. Common herbaceous plants include milkweed, carrot, heron's bill, bladder pod, mallow (*Malva parvifolia*), and teasel. Cheat grass is the only grass present at this site.

Canopy cover of trees is sparse on the left bank. Understory and ground cover is sparse as well. There is a moderate amount of bare dirt or duff on the left bank. On the right bank, canopy cover of large trees is sparse, and canopy cover of small trees is moderate. Understory and ground cover are both moderate. There is a moderate amount of bare dirt or duff as well.

There is riprap on the right bank. Roads and paved recreational trail are present on both sides of the river. A park is located on the left bank at this site. Adjacent non-riparian vegetation is disturbed. Special habitat features include dead and down trees, snags, and the Interstate 76 bridge. There are hundreds of swallow nests under the bridge.

Using the riparian classification system, this site is described as a forested, deciduous, willow/elm community. The riparian vegetation score is low because of relatively low species diversity and low percent cover in all vegetative layers. The score for other habitat characteristics is moderate because of discontinuous habitat, moderate contrast with adjacent vegetation, and a moderately wide riparian zone. The wildlife score is relatively high because several species were observed during the site visit and there is potential habitat for several threatened, endangered, or sensitive species. The score for disturbance characteristics is moderate because of relatively few invasive species and moderate levels of other disturbances.

1.11.4 Site 4 – South Platte River Upstream of the 124th Avenue Bridge

At this location, the width of the riparian band is approximately 150 feet on the left bank and 200 feet on the right bank. Eastern cottonwood and willow are the common trees at this location. Elm is present but uncommon. Herbaceous plants include carrot, sunflower, dock, *Sisymbrium* sp., dandelion, cocklebur, and shepherd's purse. Grasses include timothy (*Phleum* sp.) and cheat grass.

Cottonwood, willow, and Siberian elm are the dominant tree species at Site 4 near 124th Street on the South Platte River. Many portions of the riverbank in this area have been riprapped and support little riparian vegetation. The common green forb growing on the exposed cobble in this photograph is water speedwell. Also common on the cobble is annual bluegrass.

Canopy and understory cover are sparse on the left bank. Ground cover is moderate. Barren areas are heavy on this side of the river. Large trees are virtually absent from the right bank, and canopy cover of small trees is moderate. Understory cover and ground cover are moderate. Special habitat features here include dead and down trees, eroded banks, and decay cavities. Adjacent non-riparian vegetation is re-seeded bare dirt with artificially planted trees.

The South Platte River looking downstream from Site 3 at Interstate 76 and Clear Creek. The dominant perennial species along the river here is Siberian elm with occasional individuals of cottonwood and willow. Some sedges, rushes, and other wetland plants are present locally along the river bank.

Riprap is present on both sides of the river at this site. Roads, pavement, and buildings are located on the right bank. A road, pipe outlet, field, and sand and gravel mine are on the left bank.

Using the riparian classification system, this site is described as a forested, deciduous, willow/cottonwood community. The riparian vegetation score is low because of low species diversity and low percent cover in all vegetative layers. The score for other habitat characteristics is high because of several special habitat features and a very wide riparian zone. The wildlife score is relatively high because several species were observed during the site visit and there is potential habitat for several threatened, endangered, or sensitive species. The score for disturbance characteristics is relatively low because of moderate to high levels of human-caused disturbances in the riparian zone and adjacent areas.

1.11.5 Site 5 – South Platte River Upstream of the 60th Avenue Bridge

The riparian band at this site is 100 feet wide on the left bank and 50 feet on the right side. Common trees at this location are eastern cottonwood and willow. Elm is uncommon, and salt cedar is rare. Herbaceous plants include heron's bill, sunflower, bladder pod, *Sisymbrium* sp., dandelion, cocklebur, mullein, and teasel. Grama and western wheatgrass are present, but were probably planted.

There is a moderate canopy cover of large trees and a sparse cover of small trees on the left bank. Understory and ground cover are moderate. Bare dirt or duff is sparse. On the right bank, canopy and understory cover are sparse. There is moderate ground cover. Bare dirt or duff is sparse. The adjacent non-riparian vegetation is short grass prairie and highly disturbed areas. The only special habitat feature here is dead and downed trees.

Looking upstream from the 160th Avenue Bridge on the South Platte River. The large floodplain trees at left center are all cottonwoods.

There is riprap on both banks of the river. There are buildings on the left bank and sidewalks and roads on both side of the river. The right side of the river is used as a pasture. Horses graze on the left bank.

Using the riparian classification system, this site is described as a forested, deciduous, willow/cottonwood community. The riparian vegetation score is low because of low species diversity and low percent cover in all vegetative layers. The score for other habitat characteristics is moderate because of moderate habitat continuity, moderate contrast with adjacent vegetation, few special habitat types or features, and a relatively wide riparian zone. The wildlife score is relatively high because several species were observed during the site visit and there is potential habitat for several threatened,

endangered, or sensitive species. The score for disturbance characteristics is low because of invasive species, moderate grazing, and moderate levels of other disturbances in the riparian zone and adjacent areas.