South Platte River Recreation & Habitat Improvements:

Grant Frontier Park to Overland Pond Park Reach

FINAL PRELIMINARY DESIGN REPORT

Prepared for the Colorado Water Conservation Board

(Contract No. C150493)

DECEMBER 2012

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The Greenway Foundation, Since 1974

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Acronyms

AASHTO	American Association of State Highway and Transportation Officials
ADA	Americans with Disabilities Act
BFE	Base Flood Elevation
BFEs	Base Flood Elevations
BMP	best management practice
CCA	chromated copper arsenate
CDOT	Colorado Department of Transportation
CDOW	Colorado Division of Wildlife
CDPHE	Colorado Department of Public Health and Environment
cfs	cubic feet per second
CPDS	Colorado Pollution Discharge System
CWCB	Colorado Water Conservation Board
DPR	Department of Parks and Recreation
EPA	U.S. Environmental Protection Agency
FEMA	Federal Emergency Management Agency
FFE	Finished Floor Elevation
FHAD	Flood Hazard Area Delineation
FIF	Fishing is Fun
FIRMs	Flood Insurance Rate Maps
FIS	Flood Insurance Study
fps	feet per second
GIS	geographical information system
GOCO	Great Outdoors Colorado
GPS	global positioning system
HSI	Habitat Suitability Index
MWRD	Metro Wastewater Reclamation District
NAVD	North American Vertical Datum
NFIP	National Flood Insurance Program
NGS	National Geodetic Survey
NGVD	National Geodetic Vertical Datum
NPDES	National Pollutant Discharge Elimination System
NWPs	nationwide general permits
OHWM	Ordinary High Water Mark
RINO	River North
RISO	River South
River	South Platte River
RVIP	River Vision Implementation Plan
SHPO	State Historic Preservation Office
SWMP	Stormwater Management Plan
TMDL	Total Maximum Daily Load
UBC	United Building Code
UDFCD	Urban Drainage and Flood Control District
USACE	U.S. Army Corps of Engineers
USDA	U.S. Department of Agriculture
USDCM	Urban Storm Drainage Criteria Manual

USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey
WSELs	water surface elevations
WSRA	Water Supply Reserve Account
WWTP	Wastewater Treatment Plant

Section 1
Introduction

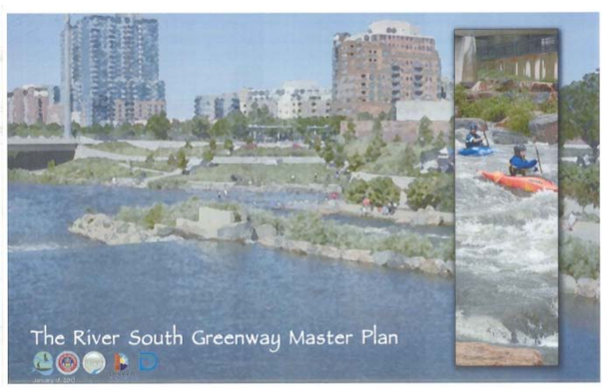
1.1 Background

The South Platte River (River) flows through the metropolitan Denver area and is classified as an urban river (Urban Drainage and Flood Control District [UDFCD] 1985). An urban river is characterized as a straight, narrow, and relatively deep channel with steep protected channel banks to prevent lateral channel migration and a developed floodplain. The River has been channelized, straightened, and deepened to increase its conveyance capacity and decrease adjacent floodprone areas allowing more land to be developed while reducing the amount of riparian vegetation and habitat. The current flow regime is highly regulated due to the two upstream flood control and water supply reservoirs—Chatfield and Bear Creek.

Compared to a natural river of similar morphology and broad plain physical setting, the South Platte River through Denver is narrow and incised. As a result of this man-made morphology, the River's banks have been armored to prohibit lateral migration and stabilize the channel location. Without adequate bank armoring, the channel could laterally migrate and/or downcut, which accelerate stream bank erosion, lowering of water tables, and downstream sedimentation.

This existing urban river has lost most of the natural aquatic habitat, resulting in little or no structural diversity of the stream bed, which leaves this urban reach with steep, narrow banks that provide limited support for terrestrial or aquatic vegetation and wildlife. In addition to negative ecosystem impacts, there is limited recreational use in this reach primarily because of perceived poor water quality due to upstream treated wastewater and urban stormwater inflows, existing grade control structures, and limited access points.

Since the 1970s, the Greenway Foundation, a nonprofit organization, has continuously strived to implement environmental and recreational improvements along the South Platte River Greenway. Over the last 4 years, significant effort has been completed to further progress the envisioned plan for the South Platte River Greenway through three community-based, multi-stakeholder visional documents—the South Platte River Vision Implementation Plan (RVIP) (March 2011), the River South (RISO) Greenway Master Plan (January 2010), and the River North (RINO) Greenway Master Plan (April 2009). The master plans envision enhanced recreation habitat, water quality, and river access along the South Platte River. These improvements are considered nonconsumptive in that they have no impact on water rights in the River, and is in agreement with the Metro Basin Needs Assessment Report (Colorado Water Conservation Board [CWCB] 2011).



The South Platte RVIP identified priority projects to enhance nonconsumptive aspects along the South Platter River corridor such as boating, fishing, and tubing, as well as address river access, habitat, and water quality concerns through multi-purpose improvements.

Improvements along the South Platte River between West Dartmouth Avenue and Alameda Avenue were divided into two reaches:

1. West Dartmouth Avenue to West Mississippi Avenue (Instream, Grant-Frontier Park, Pasquinel's Park, and Overland Pond Park)

2. West Mississippi Avenue to Alameda Avenue (Vanderbilt Park and Johnson-Habitat Park)

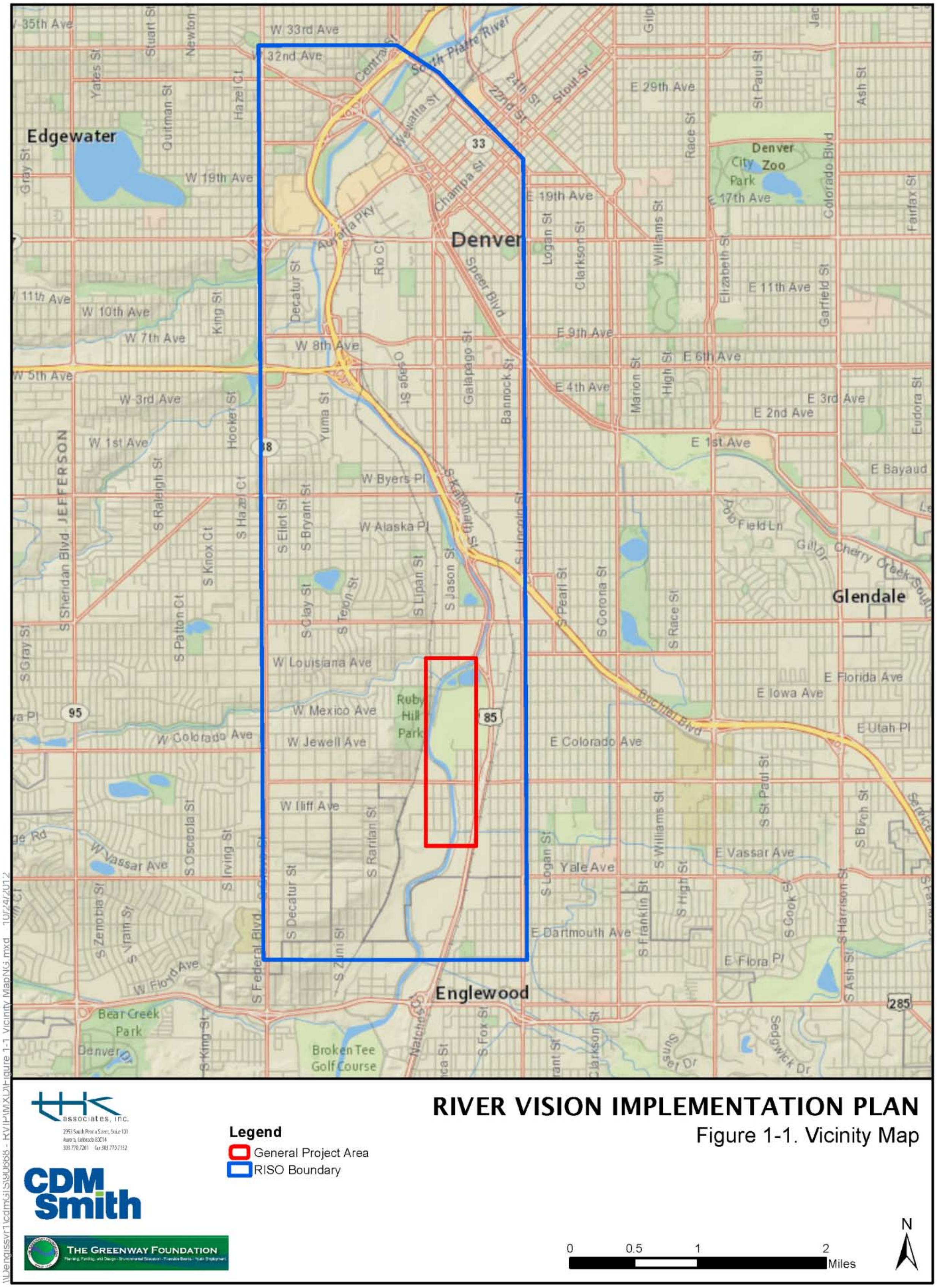
Based on statewide and Denver needs identified by the Metro Basin Roundtable (CWCB 2011), the Greenway Foundation applied for a Water Supply Reserve Account (WSRA) grant from the CWCB to take the improvements envisioned for the South Platte River Greenway between West Dartmouth Avenue and West Mississippi Avenue from conceptual design to preliminary design. The Greenway Foundation was awarded a WSRA grant in 2012 (Contract No. C150493) with support from the City and County of Denver Parks and Recreation Department.

This preliminary design report documents proposed improvements to a portion of Reach One, including Grant-Frontier Park, Pasquinel's Landing Park, and Overland Pond Park. The proposed project reach, from the south side of Grant Frontier Park (Wesley Avenue) to Santa Fe Drive (south bound), will be improved in a manner that simulates the natural condition within the constraints described in Section 1.4 below.

In this developed reach of the South Platte River, restoring fully natural conditions is not feasible; however, channel bank modifications including recontouring and modification of an existing grade control structure will be designed to improve habitat and recreational functionality, channel stability, and water quality. Where possible, an effort will be made to reconnect the river channel to the floodplain either by creating flood storage areas at a lower elevation or by using open space adjacent to the channel to provide additional river-edge habitat. In addition to providing recreation and habitat benefits, the design includes multi-use river access facilities to provide safe and enjoyable boating and fishing experiences through the length of the project reach as well as improvements to the existing park facilities.

1.2 Project Area Description

The project area is within the South Platte River corridor between Wesley Avenue at the upstream end and Santa Fe Drive at the downstream end (see **Figure 1-1**), a distance of approximately 2 miles. The project reach includes three existing river front parks: Grant-Frontier Park (right descending overbank), Pasquinel's Landing Park (right descending overbank), and Overland Pond Park and Overland Municipal Golf Course (right descending overbank), The channel within the project reach is approximately 150 feet wide with depths varying between one-foot at low flows and up to 15 feet during extreme flooding conditions. The channel banks are steep (1V:2H) and armored with riprap revetments.



RIVER VISION IMPLEMENTATION PLAN

Figure 1-1. Vicinity Map

The overbank areas along the reach include industrial, residential, and park properties. Three major storm drain outfall directly into the South Platte River within the project area: 1) Harvard Gulch, 2) Evans/Asbury, and 3) Evans outfalls. Additionally, the Sanderson Gulch outfall occurs downstream of West Florida Avenue.

1.3 Project Goals and Objectives

As defined in the RISO greenway plan and RVIP, the goals of this project include:

1. Simulate natural conditions to the best extent possible
2. Maintain or improve channel flood capacity.
3. Enhance water quality.
4. Improve wildlife habitat, both aquatic and terrestrial.
5. Provide maintenance and emergency access to the river.
6. Provide a world class trail and recreational experience along the river.
7. Facilitate a comprehensive design process, including all stakeholders and reviewing agencies.

To meet these goals, the following objectives were developed:

- Create wetland/backwater areas in Grant-Frontier and Pasquinel's Landing parks for water quality, habitat, and recreation.
- Improve environmental education through interpretive trails and an environmental playground.
- Install instream improvements to increase the diversity and quality of habitat in a manner that appears and functions naturally and improves water quality.
- Remove invasive vegetation and re-introduce native species.
- Improve park and river access through trail realignments and boat launches (including access for canoes, kayaks, and rafts) that are Americans with Disabilities Act (ADA) compliant.
- Utilize stormwater quality Best Management Practices (BMPs) to the maximum extent possible.
- Hold regular stakeholder meetings with the City and County of Denver, UDFCD, and Colorado Division of Wildlife (CDOW), as well as public outreach meetings with local neighborhood associations, Trout Unlimited, and interested general public.

Additionally, project area landscapes should comply with the objectives necessary for Natural Area designation by City and County of Denver, which includes the following:

- Provide or could provide protection for a sustainable natural ecosystem, wildlife habitat, native plant species and communities, geological formations, water corridors or wetlands
- Serve as an example of a rare or unique native condition in an urban setting in need of ecological preservation

- Serve as an outdoor classroom or laboratory for scientific study or other educational opportunities for the public
- Function as an area of biological diversity, natural beauty, and inspiration that meets aesthetic needs and that enriches the meaning and enjoyment of human life

The project goals and objectives directly support the RISO Greenway Master Plan and RVIP mission to initiate an ongoing, collaborative effort between citizens, property owners, City and County of Denver agencies, UDFCD, the Greenway Foundation, and additional public and private organizations committed to a healthy South Platte River. This approach allows the City and County of Denver and the Greenway Foundation will continue their historic partnership, in cooperation with RISO funding partners, in championing the South Platte River and its tributaries in areas proximate to the River.

1.4 Constraints and Opportunities

The project reach is extensively constrained by urban development that has expanded from downtown Denver into neighboring suburban areas along the South Platte River. Many constraints exist because of urban development such as regulated flows due to flood control facilities and water supply reservoirs; water quality issues associated with urban stormwater runoff and treated wastewater effluent; and adjacent utilities and public facilities including roads, pipelines and water diversions,

The river channel gradient plays an essential role in channel stability, sediment transport, and conveyance capacity in the project reach. Removal of the Florida Avenue grade control structure would create a significant opportunity to add additional boat and fish friendly grade control structures that mimic natural riverine features such as riffles and enhance fishing, boating, and tubing as well as improve aquatic habitat. Constraints regarding hydrology, main channel geometry, bed material, water quality, utilities, and roads will need to be addressed by the project elements.

1.5 Project Approach

With the goals and objectives as a guide, a preliminary design approach was developed that includes the following tasks:

1. Data collection and site reconnaissance to identify existing site conditions.
2. Develop a concept site plan based on existing conditions, constraints, and opportunities.
3. Determine design criteria for individual project elements.
4. Refine the concept site plan based on design criteria.
5. Perform quantitative analysis on project elements, including hydraulic and sediment transport modeling.
6. Develop preliminary design drawings.

Performed in parallel with the above technical tasks are key outreach activities including agency coordination and identification of permits required for the project.

1.6 Report Organization

This report provides a summary of existing conditions as well as describes technical issues such as specific habitat criteria, river hydraulics, and floodplain impacts. A description of the project elements and design criteria for each element is presented as the basis of design for the proposed improvements. The elements combined with the design criteria were used to develop the preliminary design. The report also identifies permit requirements and potential constructability issues.

This report is organized into the following seven sections:

- **Section 1: Introduction**.
- **Section 2: Existing Conditions** – Summarizes project area biological resources, vegetation, jurisdictional wetlands, hydrology, geomorphology, hydraulics, property ownership, utilities within the project area, river access areas, recreation, and subsurface characteristics.
- **Section 3: Project Elements** – Presents all of the proposed project elements and provides a basis for their inclusion in the project.
- **Section 4: Design Considerations and Analyses** – Identifies the design criteria, describes the modeling and analysis process, and summarizes results.
- **Section 5: Preliminary Design Development and Recommendations** – Describes the development of the preliminary design and provides recommendations on outstanding issues to address during final design.
- **Section 6: Project Implementation** – Includes regulatory and agency requirements, potential constructability issues and construction constraints, and project costs and funding.
- **Section 7: References** – Lists references used throughout the report.
- **Appendices** – Preliminary Design Drawings, Wetland Delineation Report; Geotechnical Engineering Report, Hydrology Data.

Section 2
Existing Conditions

2.1 Introduction

Existing conditions were documented and evaluated using a variety of reports, drawings, surveys, and site investigations. This section describes the existing infrastructure, recreational features, vegetation, wetlands, threatened and endangered species, and geomorphic, hydrologic, hydraulic, and habitat characteristics of the project area, including the adjacent parks and river channel.

2.2 Biological Resources

This section summarizes the results of previous studies and recent investigations conducted to identify and evaluate riverine biological resources (both aquatic and riparian) and the potential presence of sensitive species in the vicinity of the project area.

2.2.1 Aquatic Habitat

Aquatic and riparian habitat was previously investigated along the South Platte River during RISO (Greenway Foundation 2010) and summarized for the project area. The following subsections describe the habitat structure identified in the project area.

2.2.1.1 Habitat Survey

Existing habitat characteristics were identified through field reconnaissance, geographical information system (GIS) mapping, hydraulic modeling, and fish sampling data. Notes, sketches, photographs, and global positioning system (GPS) data were recorded for significant channel features, including grade control structures, riffles, major outfalls, and channel bars. Much of the project area geometry contains minimal variations in channel structure with even bottoms and a constant longitudinal slope.

Many native and non-native fish species have been identified in the project area over the last 30 years. CDOW has been compiling fish sampling data for native and non-native fish species throughout Colorado. The CDOW database contains fish sampling data along the South Platte River in the Denver Metro area. Based on this sampling, the following fish have been identified within the project reach:

- Common Shinner (*Luxilus cornutus*) - Native
- White Sucker (*Catostomus commersonii*) - Native
- Longnose Sucker (*Catostomus catostomus*) - Native
- Longnose Dace (*Rhinichthys cataractae*) - Native
- Green Sunfish (*Lepomis cyanellus*) - Native
- Black Bullhead (*Ameiurus melas*) - Native
- Creek Chub (*Semotilus atromaculatus*) - Native
- Channel Catfish (*Lctalurus punctatus*) – Native
- Largemouth Bass (*Micropterus salmoides*) – Non-native
- Common Carp (*Cyprinus carpio*) – Non-native

2.2.1.2 Habitat Suitability

A habitat suitability analysis was completed for the project area during RISO. This analysis was used to summarize the existing habitat suitability for the project area based on the Habitat Suitability Index (HSI) information from the U.S. Fish and Wildlife Service (USFWS 1983, 1982). The HSI habitat preferences used includes velocity, depth, gradient, and channel structures (see **Table 2-1**).

Seasonal hydrologic discharges were used in the existing conditions hydraulic model, described in Section 2.6, to identify suitable RISO habitat areas. These model results indicate that median spring (March to May) and summer (June to July) flows resulted in the longest reaches of existing habitat for sampled fish listed in Section 2.2.1.1. Reaches that contained two or more preferred habitat occurrences of sampled fish were considered to have existing habitat. Under the worst conditions, during the winter season, when flows are lowest, numerous areas along the project reach contain poor or no suitable habitat due to either limited preferred flow or velocity, as shown in **Figure 2-1**.

2.2.2 Riparian Habitat

The project area riparian zone, comprised of mixed deciduous vegetation, is the product of the densely urbanized lands adjacent to the project area and the straight, incised river channel. Riparian vegetation is dominated by plains cottonwood and willows, as well as non-native, introduced species as described in Section 2.2.3. Occasionally, the riverbank flattens out into benches or bars that support pockets of willow scrub-shrub communities. The riparian habitat, a narrow (typically 20 to 50 feet wide) vegetated strip, is affected by encroachment of upland species, and typical of a confined urban river corridor (see Section 2.3 - Wetlands Delineation). Species that are listed on the Colorado noxious, invasive, or exotic pest plant weed lists have been identified throughout in the project area (see Section 2.2.3.2).

2.2.3 Vegetation

The banks and overbank within the project area are overgrown with vegetation that can make the river inaccessible to people. The majority of vegetation is invasive species with a few mature plains cottonwood (*Populus deltoids subsp. Monilifera*) and willow stands such as Peachleaf willows (*Salix amygdaloides*) and Crack willows (*Salix Fragilis*) scattered along each side of the project reach. Introduced, non-native species also exist and relate more to park environments. They are described in Section 2.2.3.2.

Table 2-1 Summary of Preferred Habitat Characteristics for Selected Fish Species

Fish Species	Common Shiner	White Sucker	Longnose Sucker	Longnose Dace	Largemouth Bass	Green Sunfish	Black Bullhead	Creek Chub	Channel Catfish
Predominant substrate preference	Sand and Gravel	Very coarse sand (1 to 2 mm)	Gravel and rock (1 - 20 cm)		Gravel (0.2 - 6.4 cm)	Pebbles and gravel (0.2 - 5.0 cm)	Fine dominant (> 50%)		Rubble dominant with gravel and boulders present, aquatic vegetation abundant
Average Current Velocity (ft/sec)	0.5						0.5		
Average Current Velocity during summer and spring (ft/sec)				1.0 – 2.0	0-0.3 (Adult, Juvenile)* 0-0.1 (Fry)	0-0.5 (Adult, Juvenile)* 0-0.1 (Fry)	0-0.2	0.5 – 1.0 (Adult, Juvenile)	0.5 (in cover areas)
Average riffle Velocity during spawning (ft/sec)		1.0 – 2.0*	1.0 -3.0*					0.5 – 2.0*	
Average nesting depth (in)						2 – 12*			
Average Depth (ft)					10 – 50*				
Average riffle depth (ft)		0.5 – 1.0*	0.3 – 0.6*	0.75 – 1.0*					
Max Depth (m)								1.0 – 2.0*	
Average water fluctuation during growing season (m)					-2 - 0.5				
Percent shade (%)		50	25 - 80			25	20	75 - 100	40
Stream Gradient (ft/ft)		0.002 – 0.008			0.001	0.002		0.007 – 0.013	
Spawning Location			Inlet streams						

*Characteristics were generated from the HSI ranges for optimum fish habitat and will be used as "preferred habitat" for comparison with the hydraulic model. See Section 2.6.

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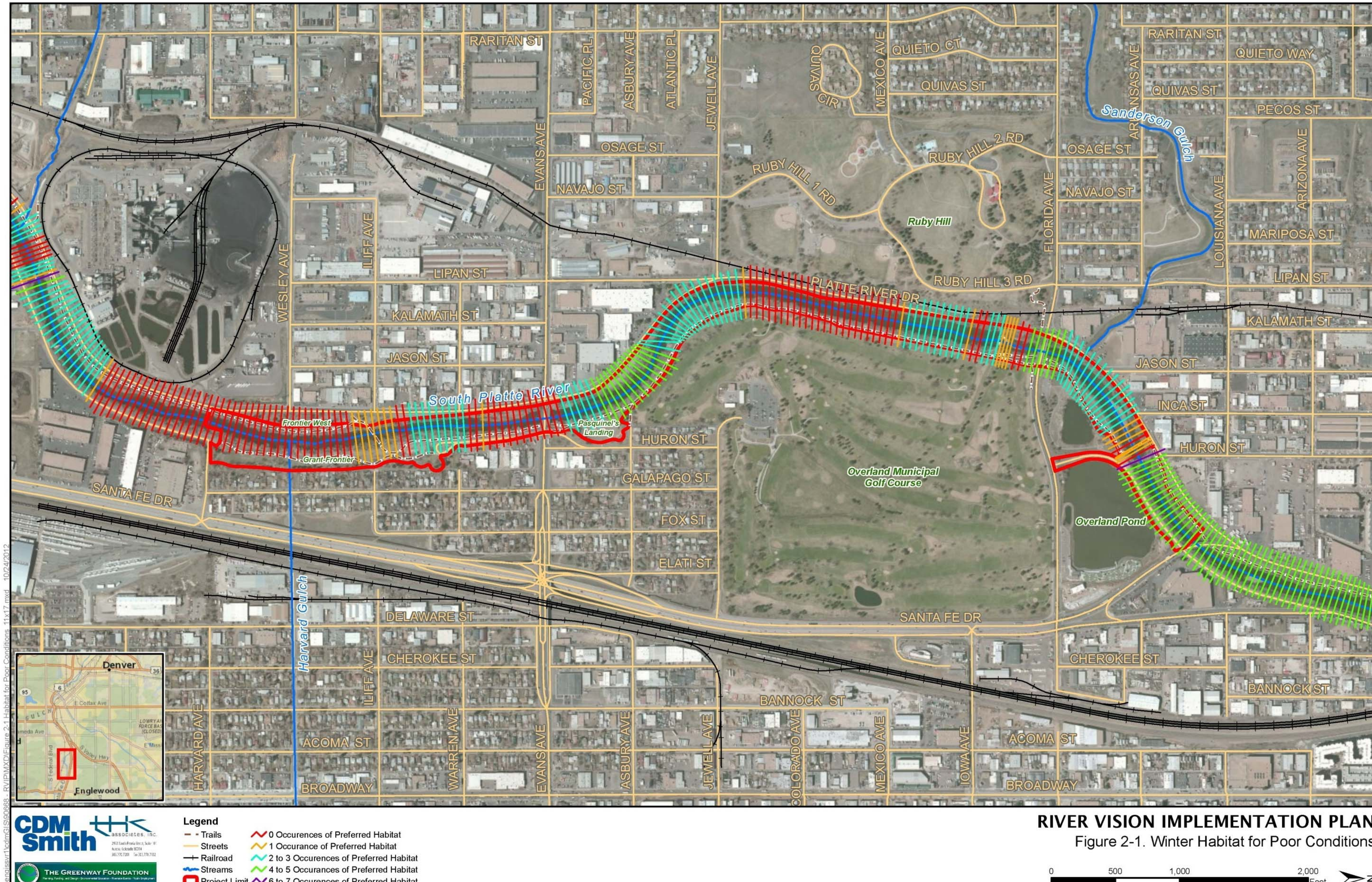

RIVER VISION IMPLEMENTATION PLAN
Figure 2-1. Winter Habitat for Poor Conditions

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2.2.3.1 Native Vegetation

Native vegetation only occurs in a few areas along the South Platte River because of the invasive species dominance. Native plant species common to this area include:

- Box elder (*Acer negundo*),
- Peachlead willow (*Salix amygdaloides*)
- Plains cottonwood (*Populus deltoids subsp. Monilifera*)
- Chokecherry (*Prunus virginiana subsp. Melanocarpa*)
- Golden currant (*Ribes aureum*)
- Hawthorne (*Crataegus sp*.)
- Rabbitbrush (*Chrysothamnus nauseosa*)
- Sandbar willow (*Salix exigua*)
- Snowberry (*Symphoricarpos occidentalis*)
- Woods' rose (*Rosa woodsii*)
- Arctic rush (*Juncus arcticus*)
- Blue grama (*Bouteloua gradcilis*)
- Buffalograss (*Buchloe dactyloides*)
- Emory's sedge (*Carex emoryi*)
- Switchgrass (*Panicum virgatum*)
- Western wheatgrass (*Pascopyrum smithii*)
- Goldenrod (*Solidago missouriensis*)
- Indian hemp (*Apocynum cannabium*)
- Sand-verbena (*Abronia fragrans*)
- Showy milkweed (*Asclepias speciosa*)
- Wild licorice (*Glycyrrhiza lepidota*)

Figure 2-2 shows two examples of cottonwoods along the river edge. **Figure 2-3** displays cottonwoods located in Grant-Frontier Park.

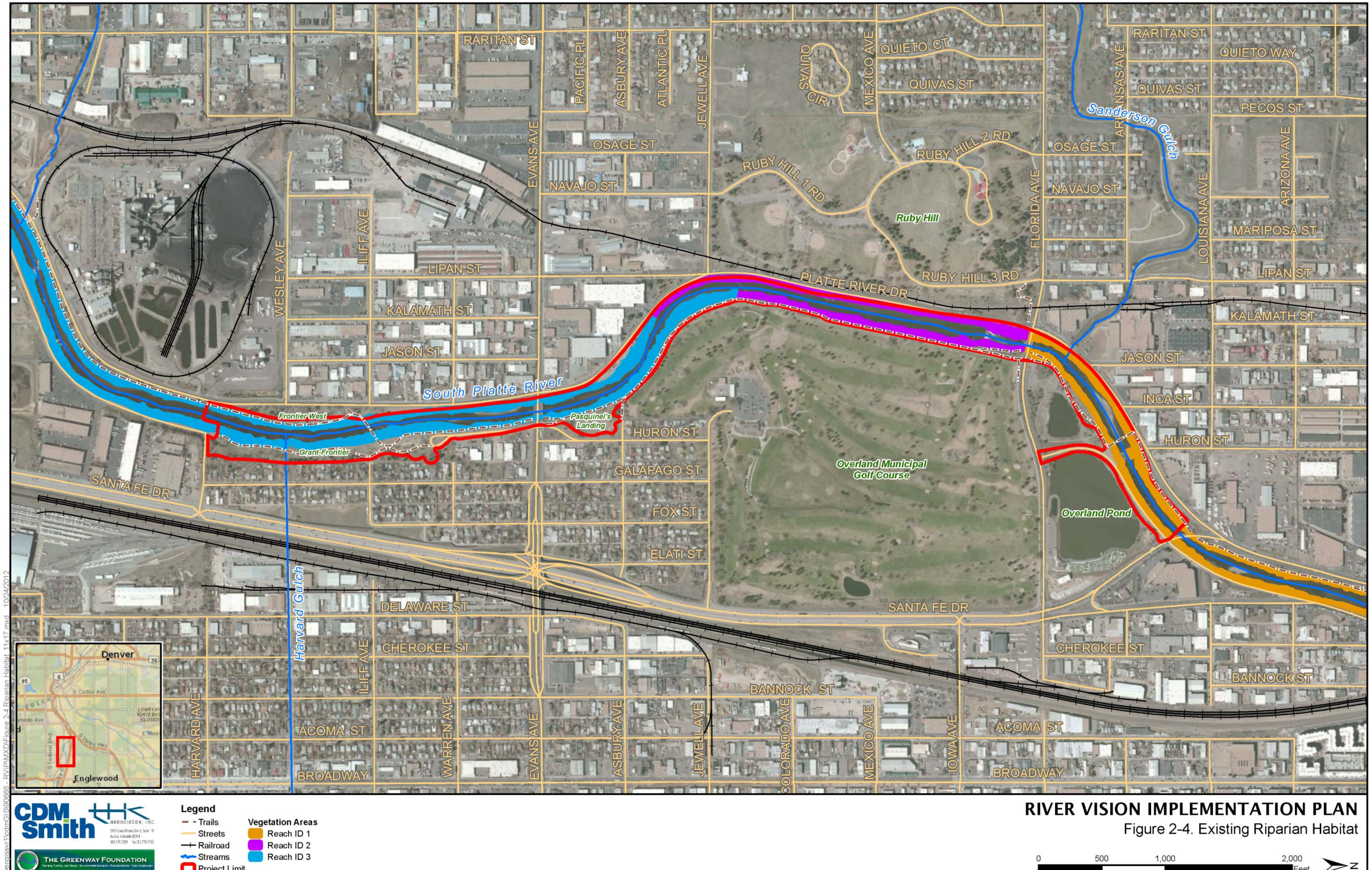
The location, type, and quality of riparian vegetation were also identified through field reconnaissance completed during the RISO study. Vegetation mapping was conducted at a relatively coarse planning level of detail; areas of each bank were grouped together based on general vegetation composition, density, or age class. Data collected included:

- Locations where vegetation communities change
- Dominant species in both the over and understory
- Approximate cover of both the over and understory

Figure 2-2. Native Cottonwoods at river edge.

Figure 2-3. Large Cottonwoods and Evergreens in Grant-Frontier Park. Evergreen trees in these photographs are non-native introduced species.

Three habitat areas were identified along the project reach and shown in **Figure 2-4.**



RIVER VISION IMPLEMENTATION PLAN

Figure 2-4. Existing Riparian Habitat

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1. ID 1(Santa Fe Drive to West Florida Avenue) – High quality vegetation due to high percent of canopy cover and older age class canopy. The overstory is mixed deciduous with cottonwood, alder, elm, and willow. The trees in this reach appear to be an older age class than those in previous habitat segments. Overstory cover ranges from 35 to 100 percent and is typically 20 to 50 feet wide along the bank. The understory is a similar mixture of grasses and forbs found in earlier habitat segments. Understory cover is essentially 100 percent.

2. ID 2 (West Florida Avenue upstream for approximately 1/2-mile on the right bank and 2/3-mile on the left bank) – Medium quality vegetation due to lower percent of canopy cover and younger age class canopy. The over and understory species composition remains essentially unchanged from ID 1 except the age of vegetation appears to be younger. Additionally, the overall cover is thinner.

3. ID 3 (upstream of Evens Avenue to West Dartmouth Avenue) – High quality vegetation similar in canopy, age and composition as ID 1.

Vegetation communities designated as low quality exhibit extensive urban upland species intermingling, a young canopy without significant percentage of cover, or significant distribution, whereas high quality communities exhibit significant willow scrub-shrub, high percentage of canopy cover, and/or older canopy.

2.2.3.2 Invasive Vegetation

Numerous species of invasive tree, shrub, and noxious weed species exist in the project area. The most common invasive tree species are the Siberian Elm (*Ulmus pumilus*) and Chinese Elm (*Ulmus parvifolia*). They are prevalent in low lying areas and adjacent to water. The areas along the east bank of the river adjacent to the Overland Golf Course have dense stands of these elms. These elms propagate by wind dispersed seeds that spread rapidly and often displaces native vegetation. Several other invasive tree species identified along this reach include Crack Willow (*Salix Fragilis*) and Russian Olive (*Elaeagnus angustifolia*). Invasive shrub varieties found along the South Platte River in the project area include tamarisk/saltcedar (*Tamarix*) and buckthorn (*Ceanothus velutinus*).

In addition to invasive shrubs, there are numerous noxious weeds that exist including Canadian Thistle (*Cirsium arvensis*), Bindweed (*Convolvus ariensis*), Leafy Spurge (*Euphorbia esula*), Diffuse Knapweed (*Centaurea diffusa*), Hoary Cress (*Lepidium draba*), Yellow and Dalmatian Toadflax (*Linaria vulgaris*), Purple Loosestrife (*Lythrum salicaria*), Musk Thistle (*Carduss nutans*), and Scotch Thistle (*Onopordum acanthium*). Herbicides and the timing of their application are critical to eradicating noxious weeds. The City and County of Denver's Natural Resource Division is currently eradicating these species along Grant-Frontier and Overland Pond Park.

Several areas have been planted with non-native plant materials that have subsequently spread along the South Platte River corridor. The plants are commonly trees that are typically found in park environments and include ash (*Fraxinus*), hawthorn (*Crataegus*), crabapple (*Malus coronaria*), pine (*Pinus*), and Sruce (Picea) trees. These plants are not indicative of the native plants of the South Platte River.

Existing herbaceous invasive species eradication in the project area is being actively addressed by City and County of Denver Natural Resource Division.

2.2.4 Threatened and Endangered Species

Habitat for threatened and endangered species can potentially occur within the project area. ERO Resources Corporation (ERO) assessed the project area for potential habitat for species listed as threatened or endangered under the Endangered Species Act (ESA). The U.S. Fish and Wildlife Service (USFWS) lists several threatened and endangered species with potential habitat in the City and County of Denver or with potential to be affected by projects within the City and County of Denver (USFWS 2010). **Table 2-2** lists those federally threatened, endangered, and candidate species.

Table 2-2. Federally Threatened, Endangered, and Candidate Species Potentially Found in Denver County or Potentially Affected Projects in Denver County

Common Name	Scientific Name	Status*	Habitat	Suitable Habitat Present
Mammals				
Preble's meadow jumping mouse	*Zapus hudsonius preblei*	T	Shrub riparian/wet meadows	No, within the Denver Block Clearance Zone.
Birds				
Interior least tern†	*Sterna antillarum athalassos*	E	Sandy/pebble beaches on lakes, reservoirs, and rivers	No habitat, no depletions to the South Platte River.
Piping plover†	*Charadrius melodus*	T	Sandy lakeshore beaches, river sandbars	No habitat, no depletions to the South Platte River.
Whooping crane†	*Grus americana*	E	Mudflats around reservoirs and in agricultural areas	No habitat, no depletions to the South Platte River.
Fish				
Pallid sturgeon†	*Scaphirhynchus albus*	E	Mesic to wet tallgrass prairies and meadows	No habitat, no depletions to the South Platte River.
Plants				
Ute ladies'-tresses orchid	*Spiranthes diluvialis*	T	Moist to wet alluvial meadows, floodplains of perennial streams, and around springs and lakes below 6,500 feet	No, located in SPR Block Clearance Zone.
Western prairie fringed orchid†	*Platanthera praeclara*	T	Moist to wet alluvial meadows, floodplains of perennial streams, and around springs and lakes below 6,500 feet	No habitat, no depletions to the South Platte River.

Notes: *T = Federally Threatened Species, E = Federally Endangered Species, C = Federal Candidate Species.
**Water depletions in the South Platte River may affect the species and/or critical habitat in downstream reaches in other counties or states.

The interior least tern, piping plover, whooping crane, pallid sturgeon, and western prairie fringed orchid are species that are affected by continued or ongoing water depletions to the Platte River system. There is no suitable habitat present for the species and this project would not result in any depletions to the South Platte River. Because of the lack of habitat and depletions, the proposed project would not affect these species.

The project area is within an area designated by USFWS as the Preble's Denver metro block clearance zone and the ULTO South Platte River block clearance zone. The species are assumed to be absent in these zones. Because the project occurs within the block clearance zones, the proposed project would not affect Preble's or ULTO.

2.3 Wetlands Delineation

2.3.1 Field Investigation

On June 21 and 24, 2012, ERO performed a site investigation to identify jurisdictional wetland extents within the project area. This delineation was conducted in conformance with the *Regional Supplement to the Corps of Engineers Wetland Delineation Manual: Great Plains Regional, Version 2.0* (U.S. Army Corps of Engineers [USACE] 2010). Jurisdictional wetlands were identified based on three indicators: 1) hydrophytic vegetation, 2) hydric soils, and 3) wetland hydrology. A field investigation report is provided in Appendix A.

2.3.2 Wetland Mapping

Based on the ERO report, wetlands occur sporadically along the river banks in the project area with typical widths ranging from 1 to 3 feet and wider areas along the riparian terraces and bars (see **Figure 2-5**). These areas include sandbar willow (*Saliz exigua*) wetlands with an understory of Emory's sedge (*Carex emoryi*) and reed canarygrass (*Phalaris arundinacea*) and herbaceous wetlands dominated by Emory's sedge, red canarygrass, and Arctic rush (*Juncus articus*). Sandbar willows were also found in association with upland vegetation that includes smooth brome and other grasses. **Table 2-3** summarizes the varying wetland areas delineated by ERO.

Table 2-3. Summary of Wetland Types Delineated by ERO*

Wetland Type	Area (acres)
Freshwater Pond	37
Riverine	152
Freshwater Forested/Shrub Wetland	3
Freshwater Emergent Wetland	0.3
Other	2
Total	194

*Delineated by ERO

The Overland Golf Course pond is lined with boulders and for the most part does not contain wetlands except near the southwest corner on a low terrace dominated by Emory's sedge (see adjacent photograph), and along the eastern shore dominated by sandbar willow with little understory.

The ordinary high water mark (OHWM) in the study area varies depending on the location. At Florida Avenue, the OHWM is approximately 5,229.0 feet while at Evans Avenue it is approximately 5,239.0 feet. The OHWM at the Harvard Gulch outfall is approximately 5,248.0 feet.

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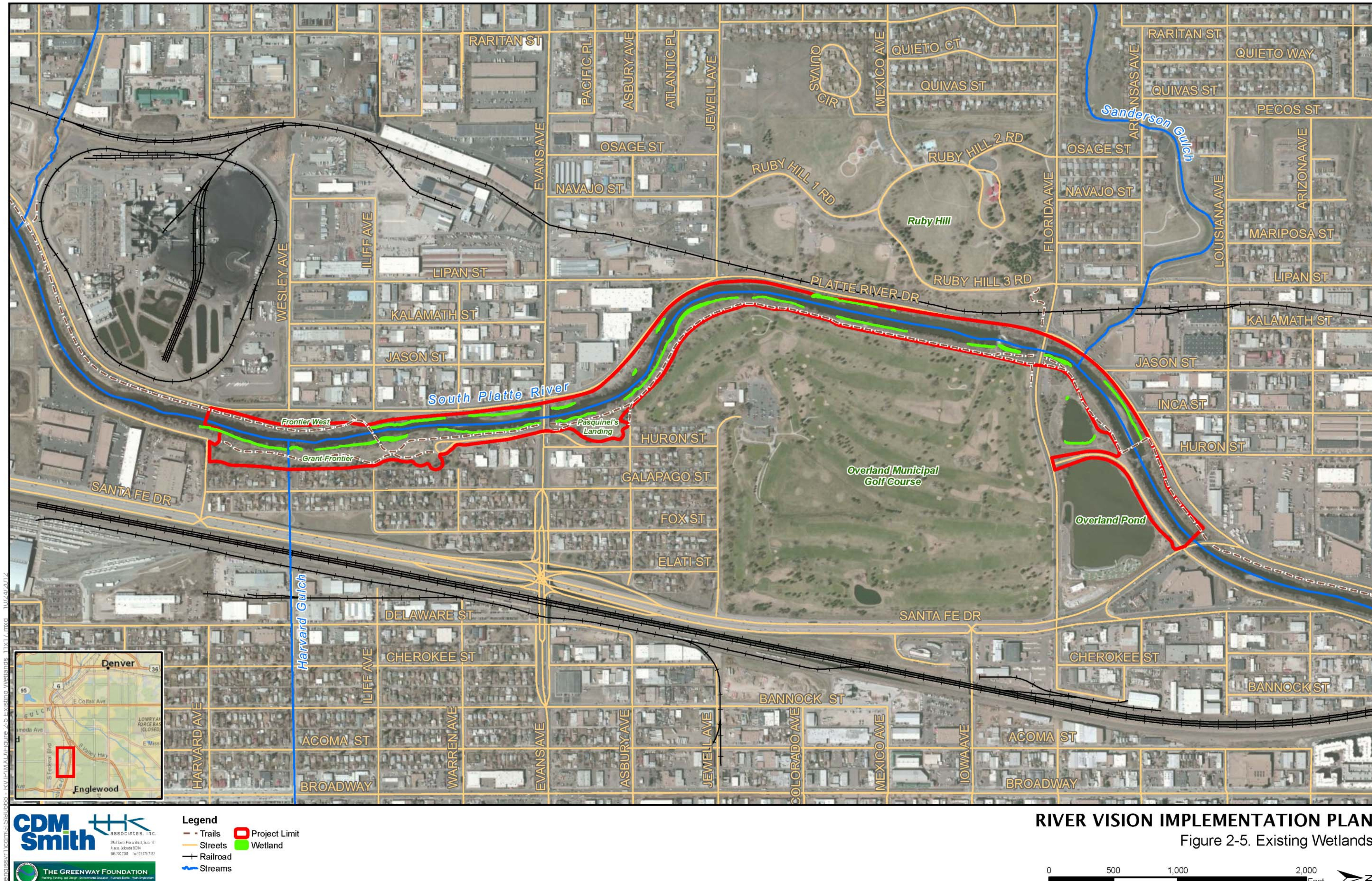

RIVER VISION IMPLEMENTATION PLAN

Figure 2-5. Existing Wetlands

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2.4 Hydrology

Historically, the South Platte River flowed perennially through the Denver metropolitan area, supported substantial growth of native cottonwoods and willows, and carried abundant water that supported early irrigation projects. As the Denver Metro area developed, the River's flow regime has become highly regulated due to effluent discharges, reservoir releases, water storage, and diversions. Low-flows are dominated by regulated reservoir releases from Chatfield Reservoir and Littleton/ Englewood Wastewater Treatment Plant (WWTP) effluent discharge.

2.4.1 Precipitation

Average annual precipitation, as determined from the nearest Utah Climate Center gage (Stapleton, Colorado gage #52223; at elevation 5,228 feet above mean sea level) is 15.0 inches with most falling during March through August for a period of record of 15 years from 1997 to 2011. Mean monthly temperatures range from 24.0 degrees Fahrenheit in January to 63.0 degrees Fahrenheit in July. Localized severe weather is not uncommon in the form of convective events that can occur at any time, but most typically in the late spring and early summer.

2.4.2 Flow Data

High flow events in the Denver metropolitan area are often associated with a combination of stalled frontal precipitation and snowmelt runoff or high intensity thunderstorms. The South Platte River typically exhibits its highest flow during the late spring and early summer that is, in large part, a function of snowmelt runoff. This characteristic flow usually abates by late June, but can last until late August or early September, depending on the depth of snow pack in the watershed and/or the amount of spring and summer rainfall.

There are two U.S. Geological Survey (USGS) river gages that measure flows along the South Platte River through Denver, one of which is located within project reach, as shown in **Figure 2-6**. From upstream to downstream, they are:

- Gage 06711565, "South Platte River at Englewood, Colorado," between Dartmouth Avenue and Harvard Gulch in Englewood
- Gage 06714000, "South Platte River at Denver, Colorado," just upstream of 20th Street below the confluence with Cherry Creek

Detailed data from both of these gages, including gage information, summary statistics, and hydrographs for the periods of record, are presented in Appendix B (USGS 2009 http://www.usgs.gov/). There was another gage (Gage 06711590) that measured discharge just downstream of Florida Avenue in Denver.

Figure 2-6 and **Table 2-4** show the period of record for each gage's daily flow data and the average monthly hydrographs for each USGS gage, respectively. The two gages with extended periods of record (06711565 and 06714000) recorded low flows in the winter (December through February) and highest flows in spring (March through May).

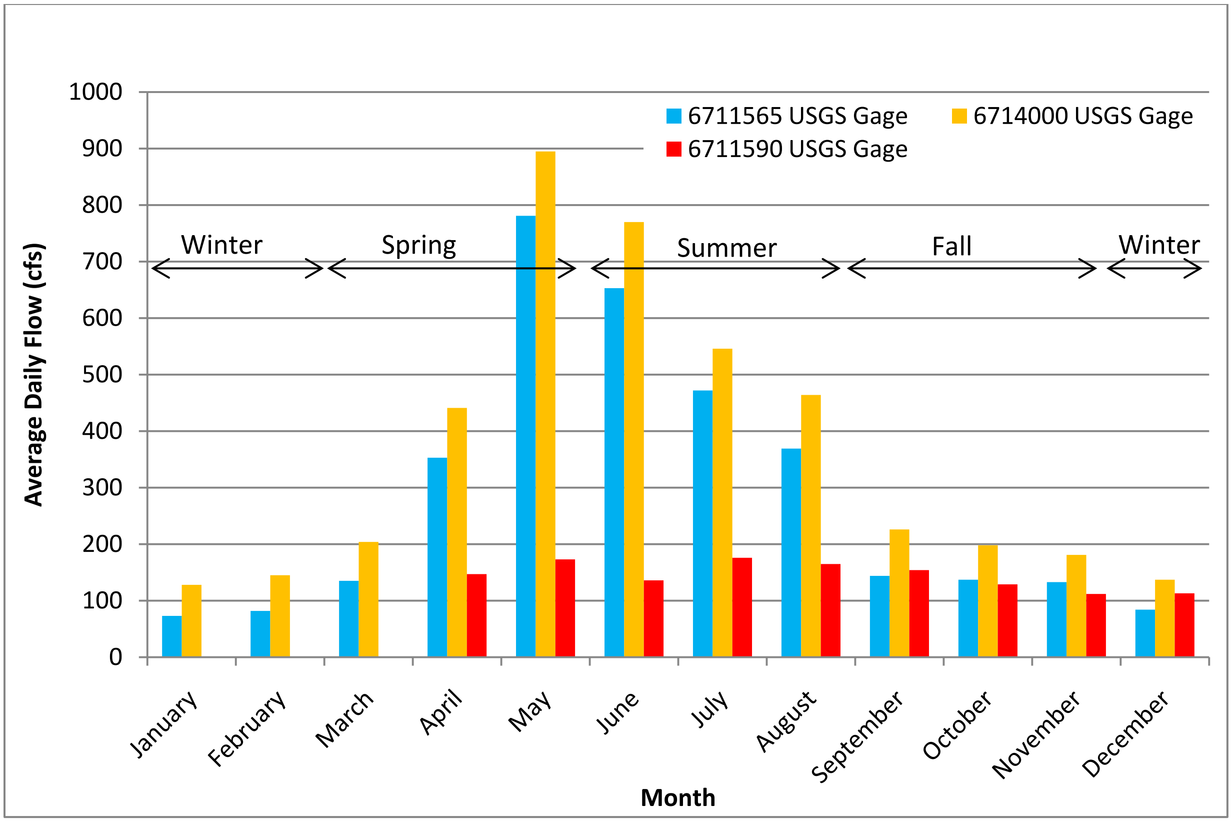


Figure 2-6. Average Daily USGS Gage Peak Flows

Table 2-4. USGS South Platte River Gages, Period of Record of Daily Discharge Data

Gage ID	Location	Period of Record - Daily Discharge Data
06711565	Upstream of Harvard Gulch	2/1/1983 - present
06711590	Upstream of Florida Ave	3/18/1981 - 12/31/1981
06714000	Upstream of 20th Ave	8/11/1942 – present

The South Platte River base flow typically varies between 80 and 400 cubic feet per second (cfs) as measured at the USGS Gage Station located on the South Platte River at Englewood, Colorado (Gage ID 6711565). Base flow varies diurnally as a function of releases from Chatfield and Littleton/Englewood WWTP. Flows are typically highest in May and June, coinciding with runoff associated with the melting of mountain snowpack and/or frontal storm systems. In these months, average daily flows range from 400 cfs to 750 cfs, but can rise as high as 4,000 cfs.

2.4.3 Hydrologic Characterization

Three hydrologic conditions were analyzed for this analysis—low flow, seasonal flow, and extreme flow. Low flow rates were used to assess aquatic habitat for existing and proposed conditions, seasonal flow rates were used to assess the improvements under channel forming conditions, and extreme flow rates were used to understand how these improvement impact regulatory base flood elevations.

2.4.3.1 Low Flows

Low flow rates are particularly critical for aquatic habitat because they may not sufficiently inundate habitat areas or provide sufficient flow depths, and can potentially result in high water temperature and low water quality. Both gages with significant periods of record show that January and February of 2003 had the lowest average monthly flows on record: in 2003 gage 06711565 averaged 21.8 cfs in January and 21.5 cfs in February compared to average January and February flows for gaged period of record of 73 cfs and 82 cfs, respectively. USGS gage 06714000 recorded 62.3 cfs in 2003 for January and February, compared to average January and February flows for gaged period of record of 128 and 145 cfs, respectively.

2.4.3.2 Seasonal Flows

Seasonal flow rates were also used to characterize existing habitat conditions and as an indicator of the channel-forming discharge. Average monthly flows from the South Platte River Gage 06711565 were considered representative of the seasonal flows (see Table 2-4).

2.4.3.3 Flood Flows

The Flood Insurance Study (FIS) [FEMA 2005] discharge profiles show that high flows upstream of the project area are limited by Chatfield Reservoir; a portion of the storage in Chatfield is reserved for flood control. The maximum release from Chatfield is about 5,000 cfs. However, there are several tributaries between Chatfield and the upstream limit of the project area that are also regulated by flood control facilities, including Big Dry Creek, Bear Creek, and Little Dry Creek. The FIS indicates 10-year flows of 6,500 cfs at Evans Avenue. One hundred-year flows for the same location is 16,500 cfs. The FIS discharge profile is included in Appendix C.

2.5 Geomorphology

The South Platte River through the Denver metropolitan area has been straightened and realigned to accommodate urban development. As a result of channel incision, the river within the project reach has largely abandoned its natural floodplain resulting in higher energy flows. Channel incision is a direct consequence of channelization, encroachment, confinement, and urbanization. Numerous infrastructure, commercial, residential, agricultural, flood control, and water supply activities in the South Platte River corridor have affected the morphology of the river resulting in an aquatic environment substantially different from what existed prior to when development activities began around 1850.

The channel is dominated by steep banks, runs, and glides; a morphology that is common to channelized urban rivers. A run is defined as a low-gradient section of river with little turbulence and a defined channel thalweg. Glides are also defined as low-gradient reaches with little turbulence, but glides do not have a definite thalweg (flat-bottomed channel section). There are long stretches of channel bed with little transverse or longitudinal channel variation (i.e., sections with flat bottom and constant slope) due to grade control structures within, upstream, and downstream of the project reach.

The river has two existing grade control structures within the project area—upstream of West Florida Avenue (see adjacent photograph) and downstream of the pedestrian bridge adjacent to Overland Pond Park. The grade control structure downstream of the pedestrian bridge consists of concrete and grouted boulders with a boat chute located in the middle of the channel. This structure has approximately 3 feet of drop and protects a large sewer pipe crossing. It was determined by the project team that this structure is passable by boaters and tubers and is not a safety hazard; therefore, no improvements would be made to this structure and it was not evaluated any further.

The grade control structure upstream of West Florida Avenue was constructed in mid-1970s by UDFCD and The Greenway Foundation. No record drawings exist to describe its actual construction date or when it was modified to include the boat chute. However, stories of the structures past (Shoemaker 2012) suggest that the boat chute was added in the 1980s. Today, there is an 8-foot drop and the boat chute is nearly impossible to safely pass except under high flow conditions. The structure is also not passable by fish migrating upstream except under high flow conditions.

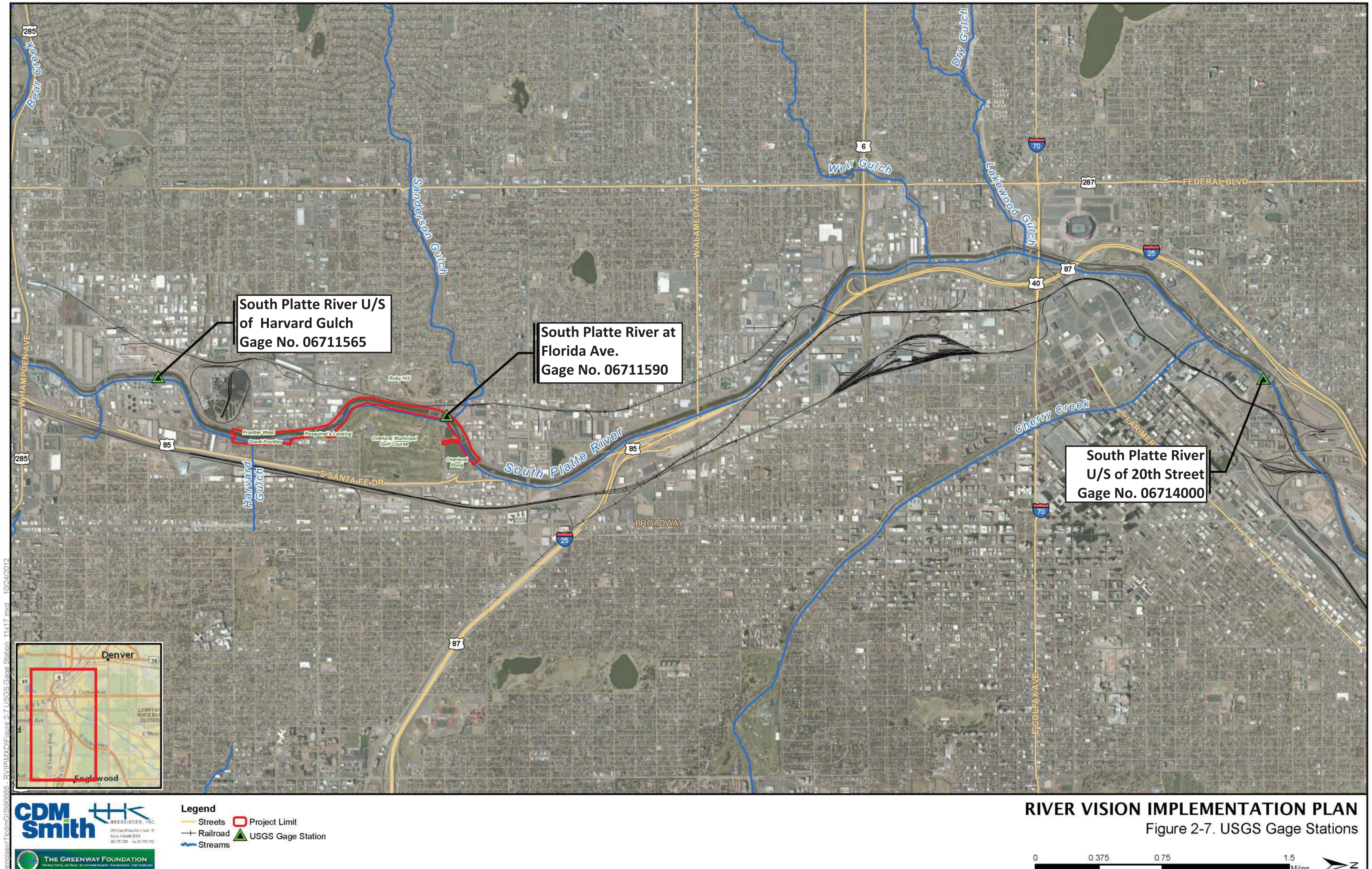
In-channel features are presented in **Figure 2-7**.

2.5.1 Overview

The South Platte River was examined within the project reach to characterize the existing channel geomorphology. The channel geomorphology (including planform, bedform, valley slope, and substrate) used to classify this reach was also used to develop recommended channel enhancements included as part of the proposed improvements described in Section 3 and Section 5.

In 1983, UDFCD began a program of monitoring geomorphic changes in the South Platte River bed and banks, including annual surveys of cross-sections at a number of fixed locations along the river. Since that time, UDFCD has developed a total of 55 permanently marked cross-sections, none of which are located directly within the project reach, but seven are located within the downtown Denver area, which has similar channel and floodplain characteristics as our project reach.

UDFCD cross-section locations are shown in **Figure 2-8**. In 1983, 1996, and 2008, UDFCD published reports summarizing the geomorphic assessments at the surveyed cross-sections (UDFCD 1996). The 2008 UDFCD report states that the South Platte River through the Denver metropolitan area has remained stable since the 1983 UDFCD report, neither substantially degrading nor aggrading or exhibiting bank erosion.


South Platte River U/S
of Harvard Gulch
Gage No. 06711565
South Platte River at
Florida Ave.
Gage No. 06711590
South Platte River
U/S of 20th Street
Gage No. 06714000
South Platte River
Cherry Creek
Harvard Gulch
Sanderson Gulch
Weir Gulch
Lakewood Gulch
Dry Gulch
Bear Creek
FEDERAL BLVD
W ALAMEDA AVE
S SANTA FE DR
BROADWAY
E COLFAX AVE
LARIMER
W HAMPDEN AVE
Denver
Englewood
Legend
Streets
Railroad
Streams
Project Limit
USGS Gage Station
RIVER VISION IMPLEMENTATION PLAN
Figure 2-7. USGS Gage Stations
0
0.375
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1.5
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N
THE GREENWAY FOUNDATION

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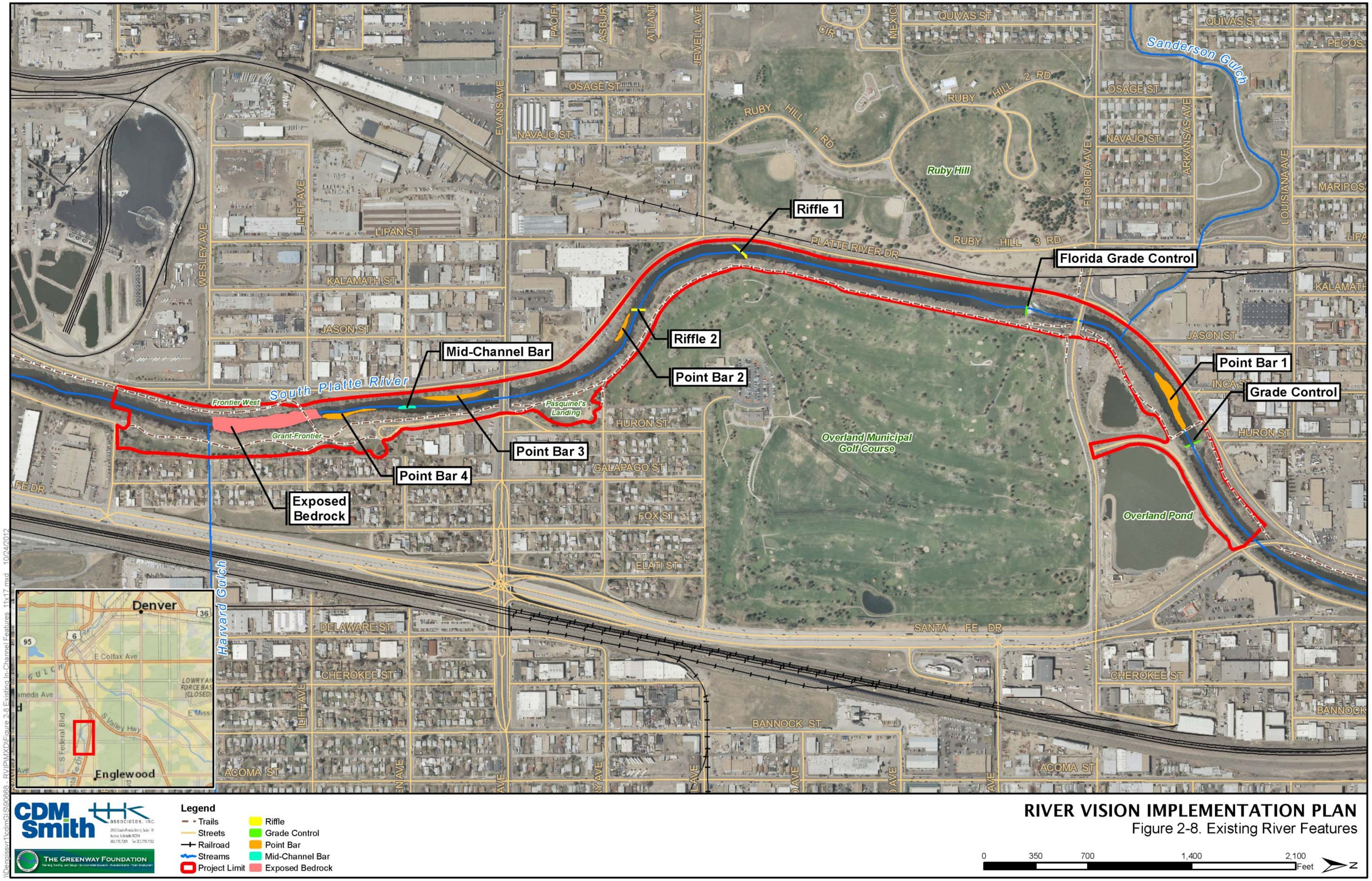

RIVER VISION IMPLEMENTATION PLAN

Figure 2-8. Existing River Features

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UDFCD has classified the South Platte River within their jurisdiction as rural, suburban, urban, or engineered. According to the report, in 1983 the Metro reaches were characterized as containing both suburban and urban reaches, whereas the 1996 report characterizes all seven surveyed cross-sections within the study reach as urban river reaches. The characteristics of urban river reaches are described as follows:

- The river has been straightened and realigned; sinuosity is approximately 1.1
- The river's flood channel is narrow and relatively deep compared to the rural river
- Except during periods of extreme low flows, there are few exposed bars
- There is relatively little riparian vegetation
- The river is bounded by very high-valued lands containing impervious development
- Anthropogenic impacts are ubiquitous

South Platte River cross-sections surveyed in 1998 and 2007 were obtained from the UDFCD and compared to identify changes in geometry in the reach of the River through Denver. The maximum river bed degradation measured was 1.3 feet and the maximum river bed aggradation measured was 1.6 feet. Overall, river channel geometry has remained relatively stable throughout Denver.

2.5.2 Historical Bed Profiles and Planform

UDFCD – Cross-sections located upstream and downstream of the project reach were compared to assess low-flow channel lateral migration. UDFCD surveyed information for cross-sections at 40.5 and Station 41 in 1998, 1999, 2004, 2005, and 2007. These sections are shown in **Figure 2-9**, verifying the steep slopes and lack of horizontal migration in the River though the project area. Minor lateral migration does occur in the channel.

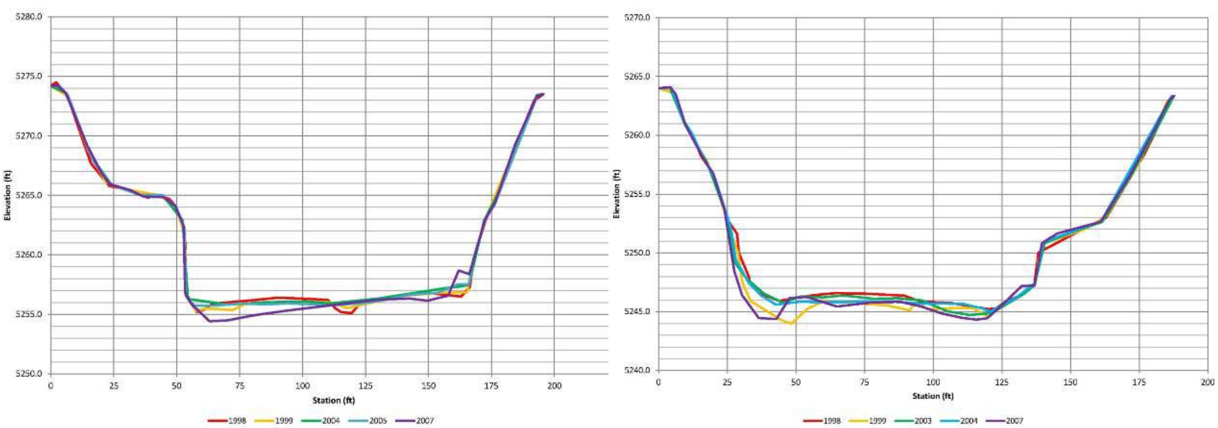


Figure 2-9. Surveyed Cross-section 41 (left) and 40.5 (right) geometry over time.

Based on the UDFCD geomorphic assessment, the channel bed has not significantly degraded for the cross-sections located in Metro reaches indicating a stable bed.

2.5.2.1 Riffles

There are two existing riffles within the project reach.

- Riffle 1 is located approximately 200 feet downstream of Jewell Avenue. This 60-foot long riffle consists of riprap and small boulders (approx. 1- to 2-foot diameter). This riffle was most likely constructed to protect the river from flows coming from the outlet of a storm drain.
- Riffle 2 is located approximately 700 feet upstream of Jewell Avenue. This 90-foot long riffle consists of broken concrete, riprap, and small boulders (approx. 1- to 2-foot diameter).

2.5.2.2 Bars

Several channel bars (point and mid-channel) form naturally throughout the project reach; however, the locations and shapes change when the flow in the river comes up. Three existing point bars were identified in the spring and summer of 2012 that, according to historical photographs, have remained along the river over approximately the past 10 years.

- Point Bar 1 – located adjacent to Overland Pond, upstream of the existing pedestrian bridge. This 400-foot long point bar forms upstream of an existing grade control structure on the west bank.
- Point Bar 2 – located just upstream of Riffle 2. This 200-foot long point bar forms on the inner bank of a bend.
- Point Bar 3 – located just upstream of Evans Avenue. This 400-foot long point bar forms due to the river widening to accommodate the Evans Avenue bridge.
- Point Bar 4 – located downstream of the pedestrian bridge, adjacent to the Grant-Frontier Park. This approximately 200-foot long bar forms due to the pedestrian bridge pushing flow towards the west bank and away from the east bank.

One mid-channel bar also exists upstream of Bar 2, adjacent to Warren Avenue. This bar forms because the thalweg is on the west side of the river and then shifts to the east side as the river widens to accommodate the Evans Avenue bridge.

2.5.3 Channel Classification

The Rosgen stream classification system was analyzed for two surveyed cross-sections: one at Grant-Frontier Park and one downstream of Riffle 2. The Rosgen stream classification is a commonly used method for conceptually characterizing streams based on entrenchment ratio, the width-to-depth ratio, sinuosity, slope, and channel material. This classification allows for better conceptual understanding and prediction of the behavior of a river. It should be noted, however, that the Rosgen system is typically used for rural, unconfined streams and has a more limited use in an urbanized environment due to numerous constraints placed on the river channel (Rosgen 1997). Therefore, engineering analysis was also used during the preliminary design to quantify the forces that form the channel morphology (see Section 4).

Identification of the Rosgen Level II stream classification is based on the following parameters—entrenchment ratio, width/depth ratio, sinuosity, channel slope, and channel material. Rosgen stream classification is founded on the concept of bankfull flow. The bankfull flow is the flow rate that has the most significant channel forming impact; bankfull flow moves the most sediment over a long period of time. The bankfull flow is typically equal to the 1.5- to 2-year recurrence interval event for a stable channel, and the bankfull width is the width of the channel at bankfull flow. The entrenchment ratio is defined as the flood-prone width divided by the bankfull width. The flood prone width is two times the bankfull width, and is used to describe the degree of vertical containment of the channel.

The surveyed cross-sections were classified as type F5 (entrenched) or B5c (moderately entrenched), which is a typical classification for urbanized streams. The entrenchment ratio for these cross-sections is 1.4, which is a boundary value between Type F and Bc. The detailed Rosgen stream classification calculations are included in Appendix D.

The Rosgen F5 classification designation indicates that the river is incised or significantly entrenched (entrenchment ratio less than 1.4), with a moderate to high width-to-depth ratio (ratio greater than 12), moderate sinuosity (greater than 1.2), and shallow slopes (less than 0.02); channel bed material is primarily sand. The project reach exhibits a sinuosity of approximately 1.2 (valley length = 7,000 feet and channel length = 8,400 feet). A sinuosity between 1.0 and 1.05 is considered straight, between 1.06 and 1.3 is considered low, and between 1.31 and 3.0 is considered meandering. This value may indicate that the channel will have tendency to migrate laterally and reform meanders. This tendency has been addressed in the past through bank armoring.

2.5.4 Sediment Transport

The South Platte River bed material consists of claystone, cobble, gravel, and sand. Chunks of concrete rubble or riprap on the channel bed are common throughout the project area. In areas where bedrock is exposed, degradation occurs very slowly. Sediment supply along the project reach is minimal over the last decade due to the flood-control dams and grade control structures that create constant hydrologic regimes minimizing degradation or aggradation and erosion.

However, there has been sedimentation upstream of the Florida Avenue grade control structure, as shown in **Figure 2-10**.

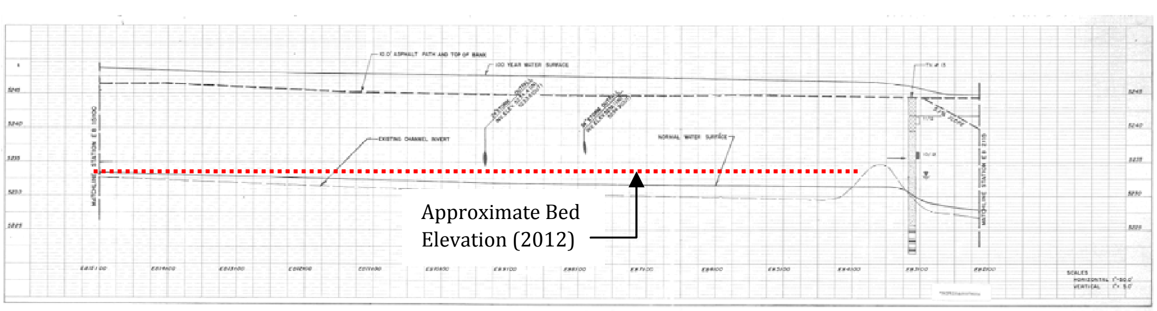


Figure 2-10. Approximate Bed Elevation Change Upstream of Florida Avenue GCS.

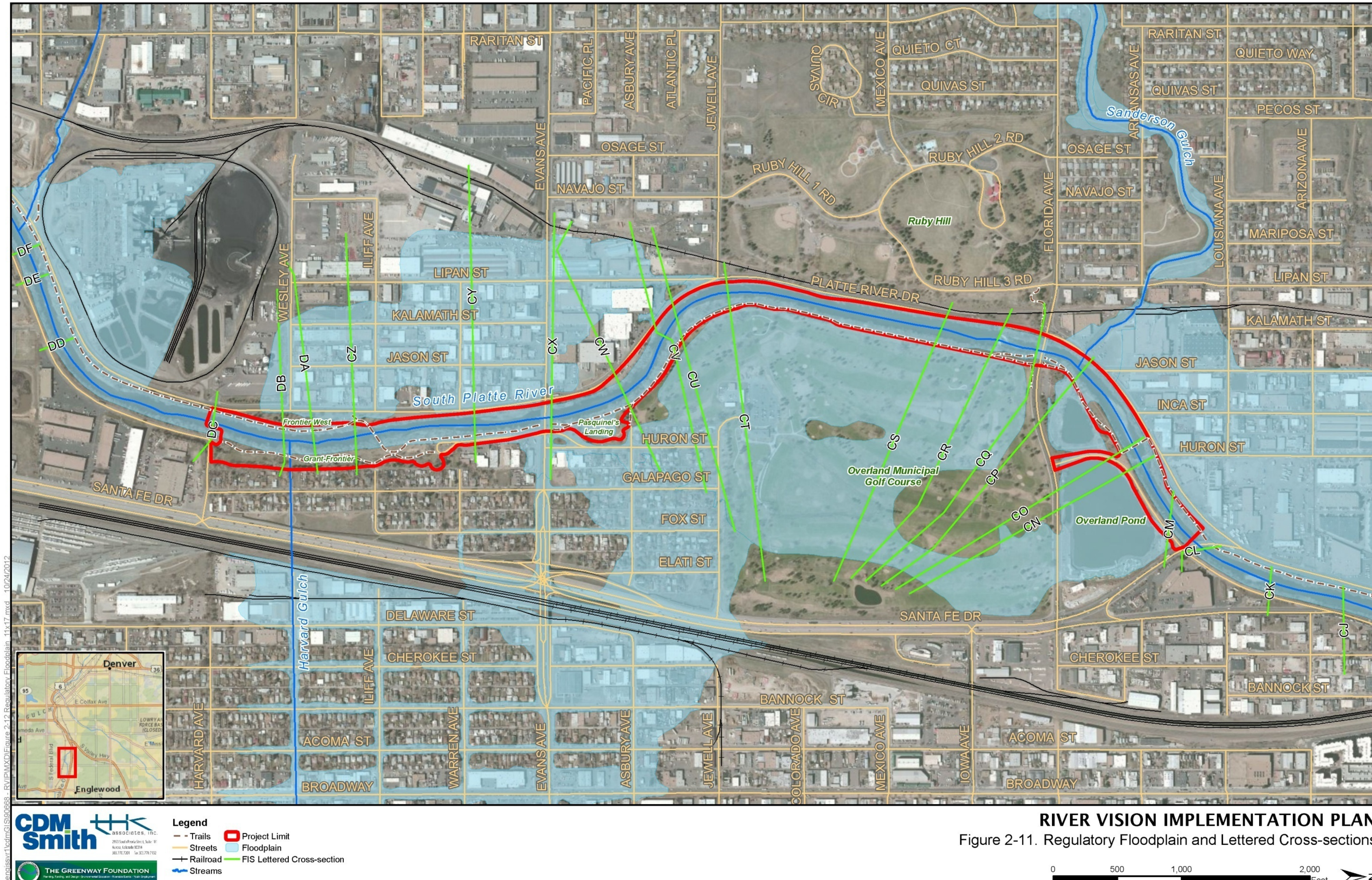
2.6 Hydraulic Conditions

2.6.1 Overview

The South Platter River along the project reach is located in the City and County of Denver, which is part of the National Flood Insurance Program (NFIP). NFIP is regulated by FEMA by requiring flood insurance for structures located within the 100-year floodplain (or regulatory floodplain). The regulatory floodplain is developed through engineering analysis using hydraulic models to delineate the floodplain. This model is referred to as the effective hydraulic model. CDM Smith followed FEMA guidelines to update and revise the regulatory hydraulic model developed for the South Platte River. The current regulatory floodplain for the project area is shown in **Figure 2-11**. **Table 2-5** summarizes depths and velocities located throughout the project reach at the same locations as the lettered FIS cross-sections used for the regulatory hydraulic model (see Figure 2-11 for cross-section locations).

Table 2-5. Velocity and Depth for Low Flow Hydraulic Model at FIS Lettered Cross-sections

FIS XS Letter	Flow (cfs)	Velocity (cfs)	Depth (ft)
DD	16,500	0.45	0.88
DC	16,500	1.4	0.71
DB	16,500	1.39	0.71
DA	16,500	1.4	0.71
CZ	16,500	1.74	0.58
CY	16,500	1.23	0.79
Evans Ave			
CX	16,500	1.23	0.77
CW	16,500	0.64	1.37
CV	17,300	0.69	1.25
CU	17,300	0.78	1.19
CT	17,300	0.99	0.99
CS	17,300	0.87	1.02
CR	17,300	4.07	0.19
CQ	17,300	0.75	1.31
Florida Ave			
CP	17,750	0.81	1.17
CO	18,000	1.52	0.64
CN	18,000	0.54	1.61



RIVER VISION IMPLEMENTATION PLAN
Figure 2-11. Regulatory Floodplain and Lettered Cross-sections

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2.6.2 Effective Hydraulic Model

The effective regulatory hydraulic model ("Regulatory Model") was obtained from UDFCD, which served as the basis for this analysis. The regulatory model was in HEC-2 format and used the National Geodetic Vertical Datum of 1929 (NGVD 29). The HEC-2 model was converted into HEC-RAS format and the elevations changed to NAVD88. The datum shift (i.e., NGVD 29 to NAVD 88) of the project reach is +3.01 feet. Therefore, 3.01 feet was added into the calculated water surface elevations (WSELs) of the regulatory and duplicate effective models. This converted mode, termed the "Duplicate Effective Model", was rerun using the HEC-RAS v 4.1.0. The duplicate effective model is defined as a copy of the hydraulic analysis used in the regulatory model.

Converting the regulatory HEC-2 model into HEC-RAS involved minor model revisions due to different computation methods and inputs between the models such as distance between upstream cross-section and bridge deck. However, most of the channel characteristics such as roughness, bank stations, cross-section geometry, ineffective flow, blocked obstructions, and contraction and expansion coefficients directly imported from the regulatory HEC-2 model. Additionally, flow data, flow change locations, and specified flow regime were also directly imported from the regulatory model. After the model was converted, it was simplified to remove cross-sections upstream and downstream of the project area. All cross-sections above RS 1520 (FIS Lettered XS "DD"), located at 3,900 feet upstream of Evans Avenue bridge, and below RS 1340 ("CN"), located at 1,600 feet downstream of Florida Avenue bridge were removed. Because the model was simplified, a known depth boundary condition was added based on the regulatory WSEL at RS 1330.

Per the NFIP regulations, if an alternative hydraulic model (i.e., the HEC-RAS model) is used instead of the effective FIS model (i.e., HEC-2 model); the new model must be calibrated to reproduce the profiles of the regulatory model within 0.5 feet. As shown in **Table 2-6**, the maximum difference in WSEL between the regulatory and duplicate effective models is 0.47 feet. **Table 2-7** summarizes the depth and velocities located in the project area at the lettered FIS cross-sections.

Table 2-6. Comparison of 100-year Water Surface Elevations

FIS XS Letter	RS of Regulatory & Duplicate Models	RS of Corrected Effective Model	Discharge (cfs)	WSEL (ft)* Regulatory (a)	WSEL (ft)* Duplicate Effective (b)	WSEL (ft)* Corrected Effective (c)	Change in WSEL (b) - (a)	Change in WSEL (c) - (b)	Change in WSEL (c) - (a)
DD	1520						0		
DC	1510	10500.99	16,500	5258.51	5258.72	5257.9	0.21	-0.82	-0.61
DB	1500	10013.7	16,500	5258.07	5258.38	5257.18	0.31	-1.2	-0.89
DA	1490	9778.496	16,500	5257.96	5258.29	5256.98	0.33	-1.31	-0.98
CZ	1480	9439.483	16,500	5257.59	5257.94	5256.36	0.35	-1.58	-1.23
CY	1470	8511.66	16,500	5257.28	5257.75	5255.35	0.47	-2.4	-1.93
Evans Ave	1460.5	7971.48							
CX	1460	7911.48	16,500	5254.64	5254.71	5253.94	0.07	-0.77	-0.7
CW	1450	7336.291	16,500	5253.05	5253.13	5252.8	0.08	-0.33	-0.25
CV	1440	6799.778	17,300	5252.09	5252.19	5252.16	0.1	-0.03	0.07
CU	1430	6617.758	17,300	5252.09	5251.92	5252.01	-0.17	0.09	-0.08
CT	1420	6112.113	17,300	5250.78	5250.82	5250.92	0.04	0.1	0.14
CS	1410	4429.585	17,300	5248.8	5248.64	5247.2	-0.16	-1.44	-1.6
CR	1400	3961.024	17,300	5245.8	5245.14	5243.89	-0.66	-1.25	-1.91
CQ	1381	3649.83	17,300	5245.6	5245.67	5244.84	0.07	-0.83	-0.76
Florida Ave	1380.5	3624.8							
CP	1370	3244.58	17,750	5243.8	5243.81	5243.2	0.01	-0.61	-0.6
CO	1360	2547.62	18,000	5242.2	5241.96	5242.21	-0.24	0.25	0.01
CN	1340		18,000	5242.07	5242.07		0.00		

*referenced to NAVD 88

Table 2-7. Velocity and Depth for Effective Hydraulic Model at FIS Lettered Cross-sections

FIS XS Letter	Velocity (cfs)	Depth (ft)
DD	9.07	12.57
DC	9.32	11.9
DB	7.14	14.49
DA	6.46	15.1
CZ	6.24	15.45
CY	4.37	17.05
Evan Ave		
CX	6.4	14.1
CW	10.1	13.24
CV	9.04	12.71
CU	8.97	13.45
CT	9.73	12.46
CS	8.94	11.37
CR	10.84	11.03
CQ	7.83	16.51
Florida Ave		
CP	5.43	15.61
CO	7.77	14.81
CN	6.59	17.09

2.6.3 Corrective Effective Model

The Corrected Effective Model is defined as the model that corrects any error in the duplicated effective model, adds any additional cross-sections to the duplicate effective model, or incorporates more detailed topographic information than that used in the regulatory model. The regulatory HEC-2 model obtained from the UDFCD was coded in 1982. Therefore, the corrected effective model was developed to update the geometry data of the duplicate effective model. The following steps were used to revise the duplicate effective model and develop the corrected effective model:

1. The duplicate effective model was georefferenced using HEC-GeoRAS. Best available elevation data, 2-foot contours provided by City and County of Denver, was used for the conversion.

2. Main channel cross-sections were surveyed along the study reach and added into the updated georefferenced model.

Once the corrected-effective model was updated based on new survey information; the model was reviewed for continuity. In review of the profile, several areas between Evans Avenue and Florida Avenue contained abrupt changes in WSEL. After further review, these abrupt WSEL changes occurred between cross-sections where overbank flow was either an active or in-active part of the floodplain (See **Figure 2-12**).

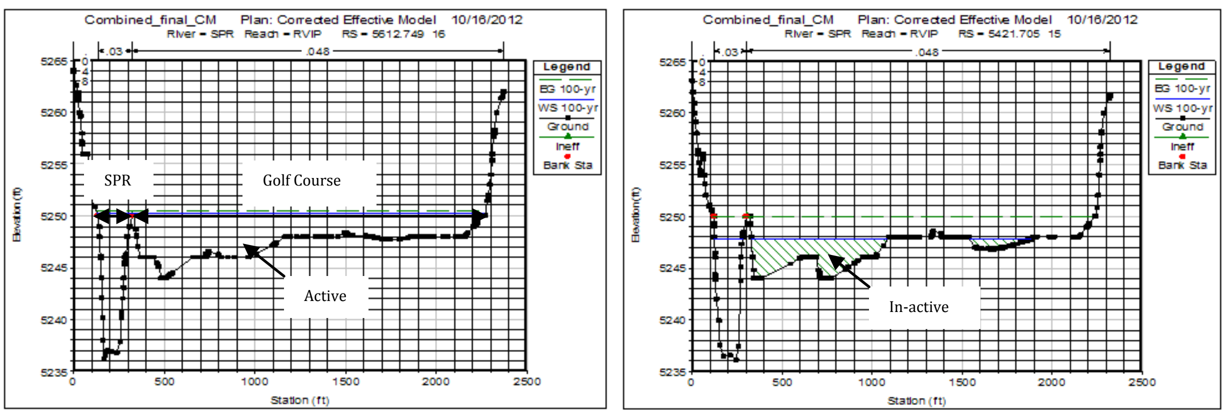


Figure 2-12. South Platte River Water Surface Elevations at Station 56+12 (left) and 54+21 (right).

These hydraulic results are caused by varying channel capacity of the SPR and limitations of 1-dimensional hydraulic modeling. Therefore, in order to accurately model this area, a split flow reach was added to the right overbank directly downstream of Evans Avenue.

The overflow reach was developed based on the following geometry and modeling assumptions:

1. Overflow reach was delineated based on the 2-foot contours to estimate an approximate flow path for the 100-year overtopping flow.

2. Bank stations were estimated based on cross-section geometry to contain the major flowpath within the cross-section. Bank stations are only approximate because no delineated channel exists in this overbank area.

3. Manning's roughness values from the duplicate-effective model were used for the overflow reach (roughness value is 0.048). The roughness value was applied to the right, left, and

main channel for all cross-sections except the first three cross-sections to account for street flow (n=0.015) and residential flow (n=0.055).

4. Overflow discharge was calculated using the optimized lateral weir feature in HEC-RAS. This feature calculates the overtopping flow using the broad crested weir equation based on a constant overtopping depth. The overtopping depth is optimized using an optimization tool in HEC-RAS that follows set minimum tolerances. The lateral weir tailwater was setup to automatically discharge into the overflow reach at the appropriate adjacent cross-section.

Table 2-6 presents the comparison of 100-year WSELs of the regulatory, duplicate effective, and corrected effective models at FIS lettered cross-sections. The WSELs calculated by the corrected effective model are less than those calculated by the duplicate effective model at all cross-sections with the exception of cross-sections CO, CU, and CT (0.2-. 0.1-, 0.1-foot increase, respectively). **Table 2-8** summarizes the depths and velocities under the 100-year flow conditions during the corrective-effective hydraulic analysis

Table 2-8. 100-year Velocity and Depth for Corrective Effective Hydraulic Model at FIS Lettered Cross-sections

FIS XS Letter	Velocity (cfs)	Depth (ft)
DD		
DC		
DB	8.66	13.2
DA	7.79	13.91
CZ	8.39	14.13
CY	8.03	16.82
Evans Ave		
CX	6.4	14.1
CW	10.1	13.24
CV	9.04	12.71
CU	8.97	13.45
CT	9.73	12.46
CS	8.94	11.37
CR	10.84	11.03
CQ	7.83	16.51
Florida Ave		
CP	5.43	15.61
CO	7.77	14.81
CN	6.59	17.09

2.6.4 Low Flow Model

An existing conditions low-flow hydraulic model was developed in HEC-RAS for the RISO Greenway Master Plan Report to estimate the quality of existing aquatic habitat for target fish species within the reach (CDM Smith 2010). The model geometry and input parameters were prepared based on 2-foot topographic data provided by City and County of Denver, and the UDFCD annual surveyed cross-sections discussed previously. The model was developed to determine existing aquatic habitat as discussed in Section 2.2. In addition to identifying existing aquatic habitat, the hydraulic model analyzed extreme low flow conditions to identify aquatic habitat during worst case scenario flows in the South Platte River.

2.7 Water Quality

Water quality declines with increased urban activities in the Denver metropolitan area and poor water quality adversely impacts the aquatic habitat and recreational uses of the South Platte River. The water quality of the South Platte River in the project reach is affected by both point and nonpoint source loading from the surrounding watersheds. The drainage basins that contribute to the water quality of the project area include South Platte River, Bear Creek, Harvard Gulch, and Sanderson Gulch. Additionally, there are a number of point sources authorized to discharge treated effluent within the watershed under the National Pollutant Discharge Elimination System (NPDES) such as Englewood WWTP and Metro WWTP.

Section 303(d) of the Clean Water Act requires states to assess water quality every 2 years. Water bodies that do not meet the state's water quality standards are 303(d) listed as water quality limited waters. These waters are then targeted for Total Maximum Daily Load (TMDL) development, which determines load reductions needed to meet water quality standards. Segment 14 of the South Platte River was placed on the 1998 Colorado 303(d) list of water quality limited water bodies for *E. coli* and the 2002 303(d) list for nitrate. *E. coli* is an indicator organism for pathogenic bacteria and is primarily an urban wet-weather/stormwater concern. Nitrate is primarily a dry-weather flow concern associated with treated wastewater effluent point source discharges.

As a result of these listings, TMDLs were developed for both parameters. Because stormwater sources are likely contributing significant loads of *E. coli*, the TMDL for *E. coli* discussed BMP implementation to reduce loading to meet instream water quality standards. Treated wastewater effluent is the main source of nitrate in the project reach and waste loads have been allocated to the Littleton/Englewood WWTP. The TMDL reports are available at http://www.cdphe.state.co.us/wq/Assessment/TMDL/southplatte.html.

In addition to the 303(d) listings for nitrate and *E. coli*, trash has been a concern for recreational users. Recreational users such as paddlers, swimmers, fishers, joggers, and walkers have documented the presence of trash and the perceived impairment of the South Platte River.

2.8 River Access

2.8.1 Overall River Access

Each side of the River has steep grades with dense stands of trees and shrubs, limiting access, as shown in **Figure 2-13**. However, there are a few existing locations where river access is provided, which should be enhanced to make the River accessible. The locations that exist today include Grant-Frontier Park (south of the existing pedestrian bridge), along trails adjacent to Overland Golf Course Area, and within the Overland Pond Park. Neither of these access points is compliant with the Americans with Disability Act.

Figure 2-13. Dense strands of trees and shrubs line each bank of the South Platte River in the Grant-Frontier and Overland Park area.

2.8.1.1 Grant-Frontier Park, South of the Existing Pedestrian Bridge

A large sand/gravel bar exists on the east side of the River, as shown in **Figure 2-14**, just north of the existing pedestrian bridge that crosses the River in Grant-Frontier Park. Recreational enthusiasts, including gold panners/dredgers, and fishermen use this access point. Organized activities with the South Platte River Environmental Education program (SPREE) brings school children down to the River at this location. Access is afforded by a steep natural trail at the base of the slope that has existing retaining wall and large tree stands. This access point is adjacent to a channel bar.

Figure 2-14. Existing trail that accesses the river at Grant-Frontier Park

2.8.1.2 Overland Golf Course Area

Figure 2-15. Existing natural trail between the Regional Concrete Trail and the South Platte River trail

Several social trails exist between the South Platte River Regional Trail and the River (see **Figure 2-15)**. These trails wind between the trees and riparian vegetation and eventually return to the Regional Trail. Access to the River is fairly limited in the golf course area because of dense stands of cattails.

2.8.1.3 Overland Park Area

With recent clearing operations, the River is accessible in this area by traversing steep slopes or social trails in a few locations.

2.8.2 Existing Boat Launch

The only boat launch that exists is at the Florida Avenue grade control structure, just south of Florida Avenue on the east bank (see **Figure 2-16**). The trail access and portage for the boat chute is located on the east bank of the river making it difficult to put a boat in and safely utilize the boat chute. There is no formal connection between the boat chute and an accessible boat take out area. During low flows, it is difficult to safely put in or take out at this boat launch.

Figure 2-16. Existing trail and boat launch at Florida grade control structure

2.8.3 Existing Overlooks

There are several overlook areas existing in this reach located on the east bank of the river upstream of West Florida Avenue (see **Figure 2-17)**. They are located in the dense stands of invasive species and are in varying degrees of disrepair. Photographs shown in **Figure 2-18** display the configuration and condition of these overlook areas.

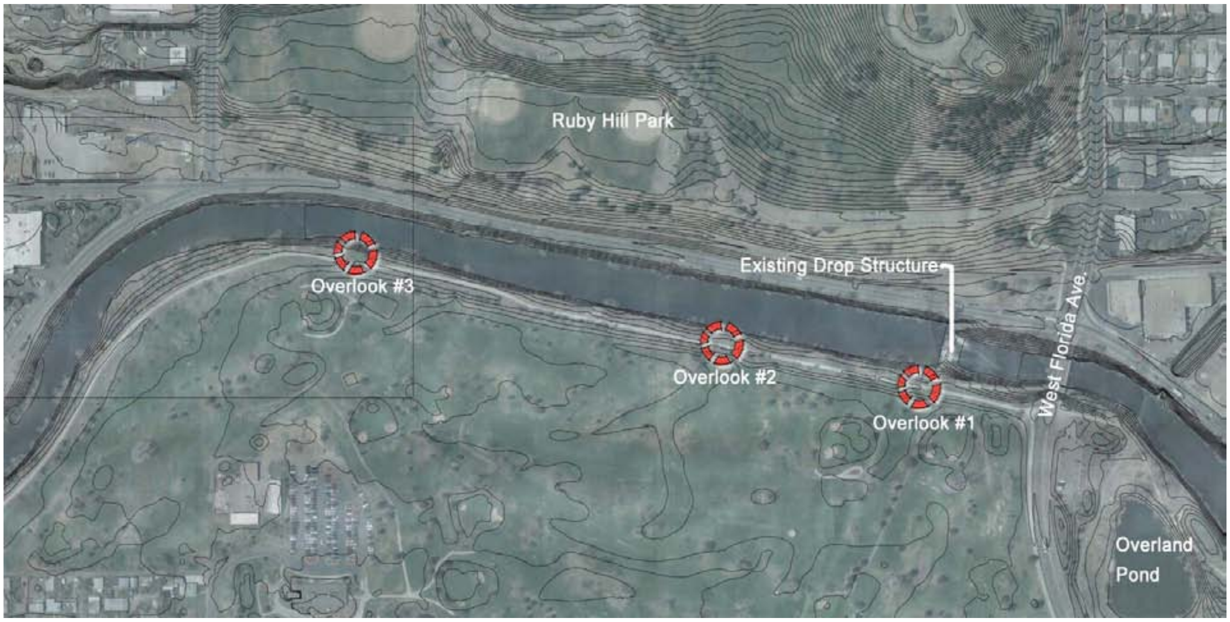


Figure 2-17. Existing overlook areas in plan view

Figure 2-18. Existing overlook areas 1 and 2 (left to right)

2.9 Recreation

The South Platte River is known for recreational activities on and adjacent to the river. Major recreational facilities along the river include Confluence Park and the South Platte River Regional Trail. These are commonly used for boating, fishing, wildlife viewing, swimming, biking, jogging, and commuting. Similar to Confluence Park, the Greenway Foundation foresees this project reach as another opportunity to enhance the river corridor, changing it into a multi-purpose area by increasing river access, improving water quality, enhancing aquatic diversity, and promoting river awareness.

2.9.1 River Recreation

Although boating, fishing, and wildlife viewing are popular activities along the river, they are limited in the project reach for reasons already described in this section.

2.9.1.1 Boating

Boating—including kayaking, canoeing, and rafting—and tubing are popular recreational uses of the River. However, most of these activities occur upstream and downstream of the project reach due to limited river access, unsafe channel conditions, and poor water quality.

River flow also impacts the recreational boating opportunities along the project reach. Summertime flows in combination with low gradients result in slow moving Class I (black) water, punctuated with several short Class II-III whitewater drops that require skillful maneuvering. Whereas at high levels, 1,500 cfs and above, the Florida Avenue grade control structure and Overland Park grade control structure can be rated as Class III+ or Class IV, requiring the ability to execute a series of technical moves, offering little or no opportunity for scouting, portaging or escape.

2.9.1.2 Fishing

Colorado Trout Unlimited believes the urban river is a great amenity that enables communities to do what they love in their own backyard (http://www.cotrout.org/). Over the past 30 years, the Greenway Foundation has provided access points to the river that allow for fishing, specifically near Overland Golf Course off of Florida Avenue, and near Habitat Park. However, because of the poor aquatic habitat, the fishing is marginal.

2.9.1.3 Wildlife Viewing

The banks of the river provide habitat for a variety of wildlife that live and migrate along the river. The river provides a place for urban residents to learn, watch, and experience the natural environment and wildlife in their neighborhoods. Bird watching and other wildlife viewing is an important recreational activity along the river at Grant-Frontier Park, Pasquinel's Landing Park, and Overland Pond Park, in addition to many of the other parks along the South Platte River.

2.9.2 Trails

The project area contains several different types of trails including regional, local, and social, unsanctioned trails.

2.9.2.1 Regional Trails

The South Platte River Regional Trail runs 30 miles from Chatfield Reservoir to 104th Avenue in Adams County, including this project reach (see **Figure 2-19)**.

Figure 2-19. 8-foot wide regional trail at West Florida Avenue

2.9.2.2 Local Trails

Several paved local trails exist in the Overland Pond area and the southern portion of Grant-Frontier Park. See **Figure 2-20** for photograph of a typical local trail in the project area.

Figure 2-20. 8-foot wide local trail near Grant-Frontier Park

2.9.2.3 Social Trails

This reach of the South Platte River has numerous social, non-sanctioned trails that vary in width and character. These can be narrow trails that go into a wooded area that receives little usage or a wider trail that can access the river and experiences high usages shown in **Figure 2-21**.

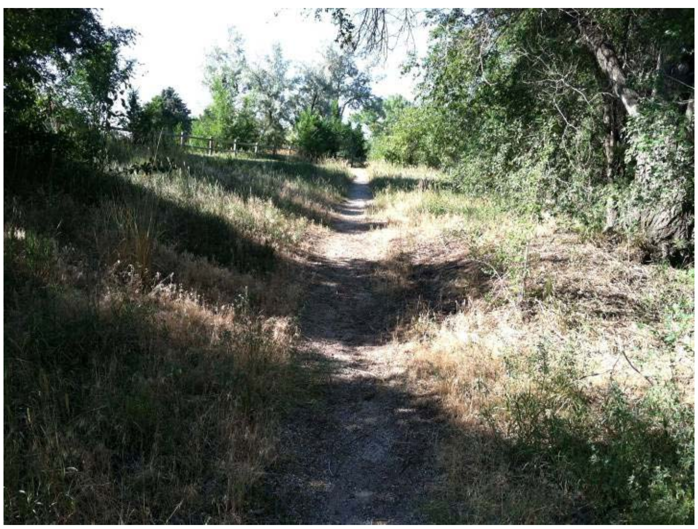


Figure 2-21. Existing natural trail along Overland Golf Course

2.9.3 Bridges

Within the limits of the project area there are two existing pedestrian bridges that cross the South Platte River at Grant-Frontier Park and at Overland Pond. **Figure 2-22** shows the bridge crossing at Grant-Frontier Park and at Overland Pond. These bridges are connected to the regional trail, provide local access and are frequently used by commuters, local residents and recreational runners, bikers and fisherman.

Figure 2-22a. Pedestrian bridge located by Grant-Frontier Park

Figure 2-22b. Pedestrian bridge located by Overland Pond

2.9.4 Park Facilities

Three existing park facilities are located in the project area: Grant-Frontier Park, Pasquinel's Landing Park, and Overland Pond Park.

2.9.4.1 Grant-Frontier Park

Grant-Frontier Park contains an existing playground, camping grounds, parking lot, open space, and restroom enclosure; see **Figure 2-23** for photographs of the existing features. This park is located along the South Platter River and adjacent to a residential neighborhood. The park is bisected by the Harvard Gulch outall structure.

Few residents frequent the park; however, the occasional dog walkers, picnickers, and children are seen enjoying the park. Grant-Frontier Park acts as one of the few river access points along the South Platte River, although there is no boat put-ins located near the facility.


Existing Playground Area


Existing Miners Camp (utilized by SPREE)


Existing Port-o-let enclosure

Existing Interpretive Signage


Open Play Areas (Irrigated Bluegrass)


Existing Parking Area/Access Drive

Figure 2-23. Existing features at Grant-Frontier Park

2.9.4.2 Pasquinel's Landing Park

Pasquinel's Landing Park contains an existing playground, existing site amenities, open space, and interpretive signs; (see **Figure 2-24)**. Pasquinel's Landing Park is located along the river directly downstream of West Evans Avenue. The park contains a large area of open space that needs continual maintenance by the City and County of Denver. The existing playground facility is older with minimal playground equipment. The park is also connected to the regional trail along the river that is used to access the park.

Existing Playground Area

Open Play Areas (Irrigated Bluegrass)

Existing Site Amenities (Benches, trash receptacles, water fountains etc.)

Interpretive Signs

Figure 2-24. Existing features at Pasquinel's Landing Park

2.9.4.3 Overland Pond Park

Overland Pond Park is a seven-acre City and County of Denver park along the river adjacent to the Overland Golf Course. The park includes Overland Pond, which is a 1.5 acre pond that has a maximum depth of seven feet. Fish species in the pond include bluegill (*Lepomis macrochirus*), common carp (*Cyprinus carpio*), crappie (*Pomoxis*), bullhead (*Ameiurus*), and largemouth bass (*Micropterus salmoides*).

The park was recently improved to remove invasive vegetation, including cheatgrass (*Bromus*) and Chinese elm (*Ulmus parvifolia*). The improvements, which were funded by a grant from the U.S. Fish and Wildlife Service, opened up the riparian zone adjacent to the river. Stone steps were installed down to the river to allow access for curious children and fly-fishermen. The improvements can serve as a model for potential opportunities at the other parks within the project area.

2.10 Property Ownership and Easements

Land use within the project area includes industrial, commercial, residential, and park land as shown in **Figure 2-25**. The river corridor through the project reach is owned by the City and County of Denver, who are participating stakeholders for this project. The four major park and recreational areas along the project reach include Grant-Frontier Park, Pasquinel's Park, Overland Municipal Golf Course, and Overland Pond Park. See **Figure 2-26** for a project area property ownership map.

2.11 Infrastructure and Utilities

The project reach is confined by existing infrastructure, with storm drains, sewers, and water distribution systems located along the river corridor, as shown in **Figure 2-27**.

2.11.1 Water and Sewer Systems

Based on available information provided by Denver and the Metro Wastewater Reclamation District (MWRD) and a site survey, the gravity sanitary sewers and water pipes adjacent to the river have been identified, as shown in Figure 2-26. A majority of the project reach contains adjacent sanitary sewer systems ranging between 24-inch and 48-inch diameter pipes and a few pipes less than 24-inch in diameter. There is approximately 10 to 15 feet of cover between the top of the sewers and the ground elevation, on average; the depth of cover ranges from 1-foot to 23 feet.

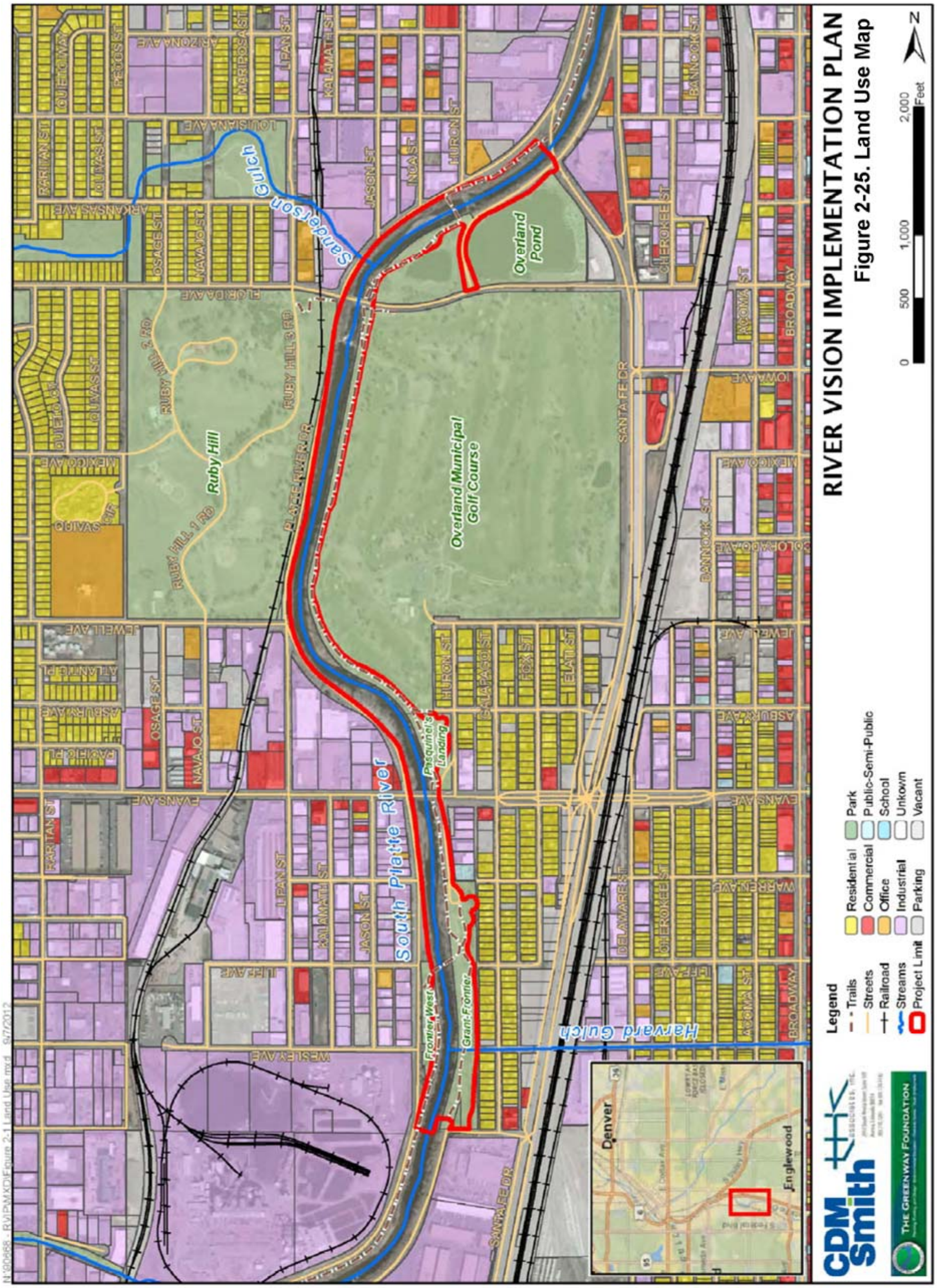
There are no Denver Water pipes within the project area.

2.11.2 Storm Drain System

Twelve storm drains outfall into the river, including the Asbury outfall, Sanderson Gulch outfall, and Harvard Gulch outfall. The Harvard Gulch outfall is a pressure outfall that is located in the southern portion of Grant-Frontier Park discharging Harvard Gulch stormwater.

2.11.3 Irrigation Diversion

An existing pump station is located on the west bank of the river south of Florida Avenue. The station is owned by the City and County of Denver and pumps water from the river to Overland Pond, which is an irrigation holding pond for Overland Golf Course and Aqua Golf. Currently, Denver has a decreed water right of 2.1 AF/day of river water for irrigation. The existing station consists of a 35 HP vertical turbine wet pit pump mounted on top of a circular concrete wet well in the river (see adjacent photograph). There is also an associated building on the west bank that contains the electrical and control equipment.


RIVER VISION IMPLEMENTATION PLAN
Figure 2-25. Land Use Map
Legend
Trails
Streets
Railroad
Streams
Project Limit
Residential
Commercial
Office
Industrial
Parking
Park
Public-Semi-Public
School
Unkown
Vacant
0
500
1,000
2,000
Feet
N
South Platte River
Sanderson Gulch
Harvard Gulch
Ruby Hill
Overland Municipal Golf Course
Overland Pond
Pasquinel's Landing
Frontier West
Grant-Frontier
PLATTE RIVER DR
SANTA FE DR
BROADWAY
EVANS AVE
JEWELL AVE
FLORIDA AVE
MEXICO AVE
IOWA AVE
ASBURY AVE
WESLEY AVE
Denver
Englewood
THE GREENWAY FOUNDATION

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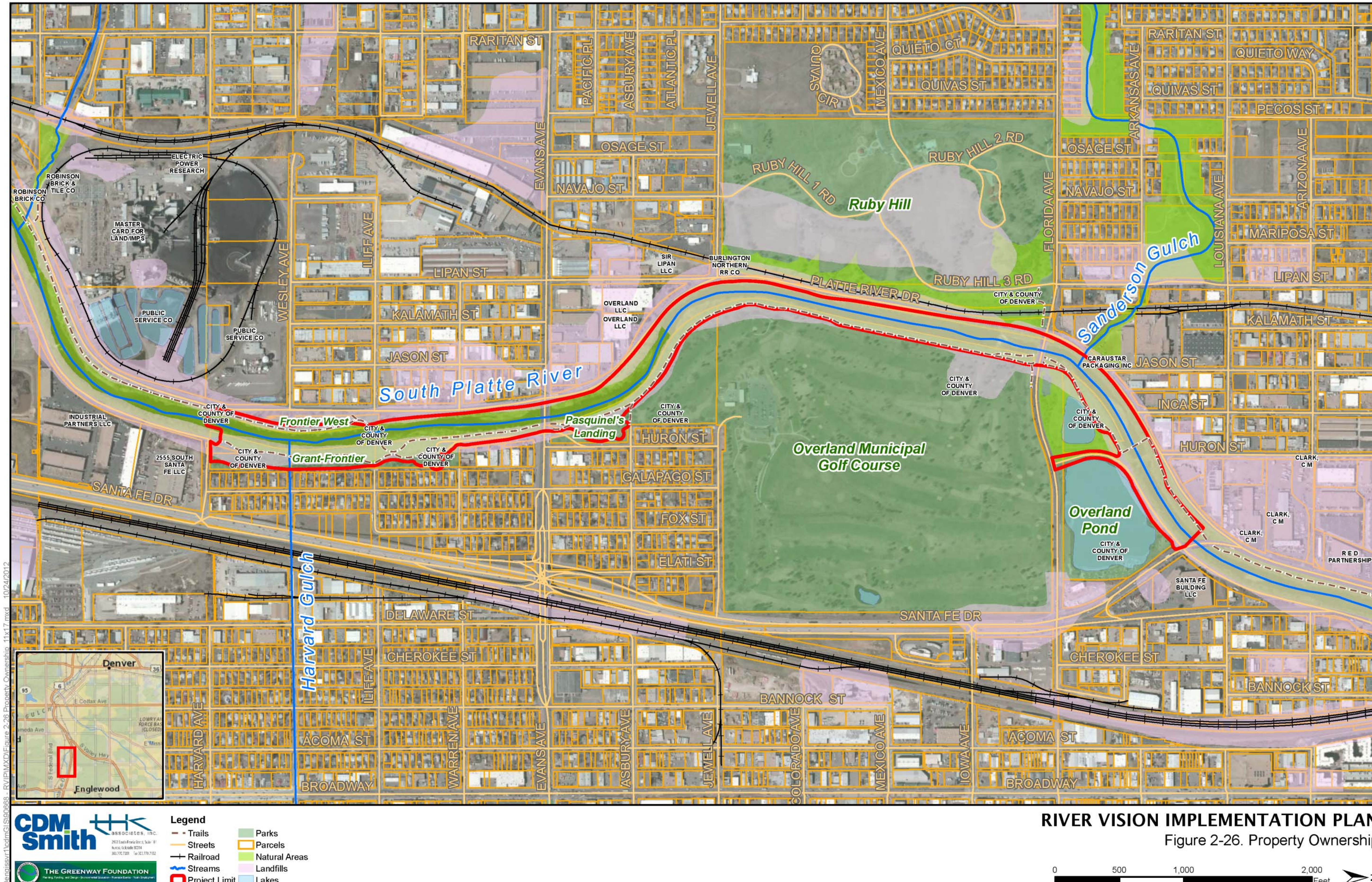

RIVER VISION IMPLEMENTATION PLAN

Figure 2-26. Property Ownership

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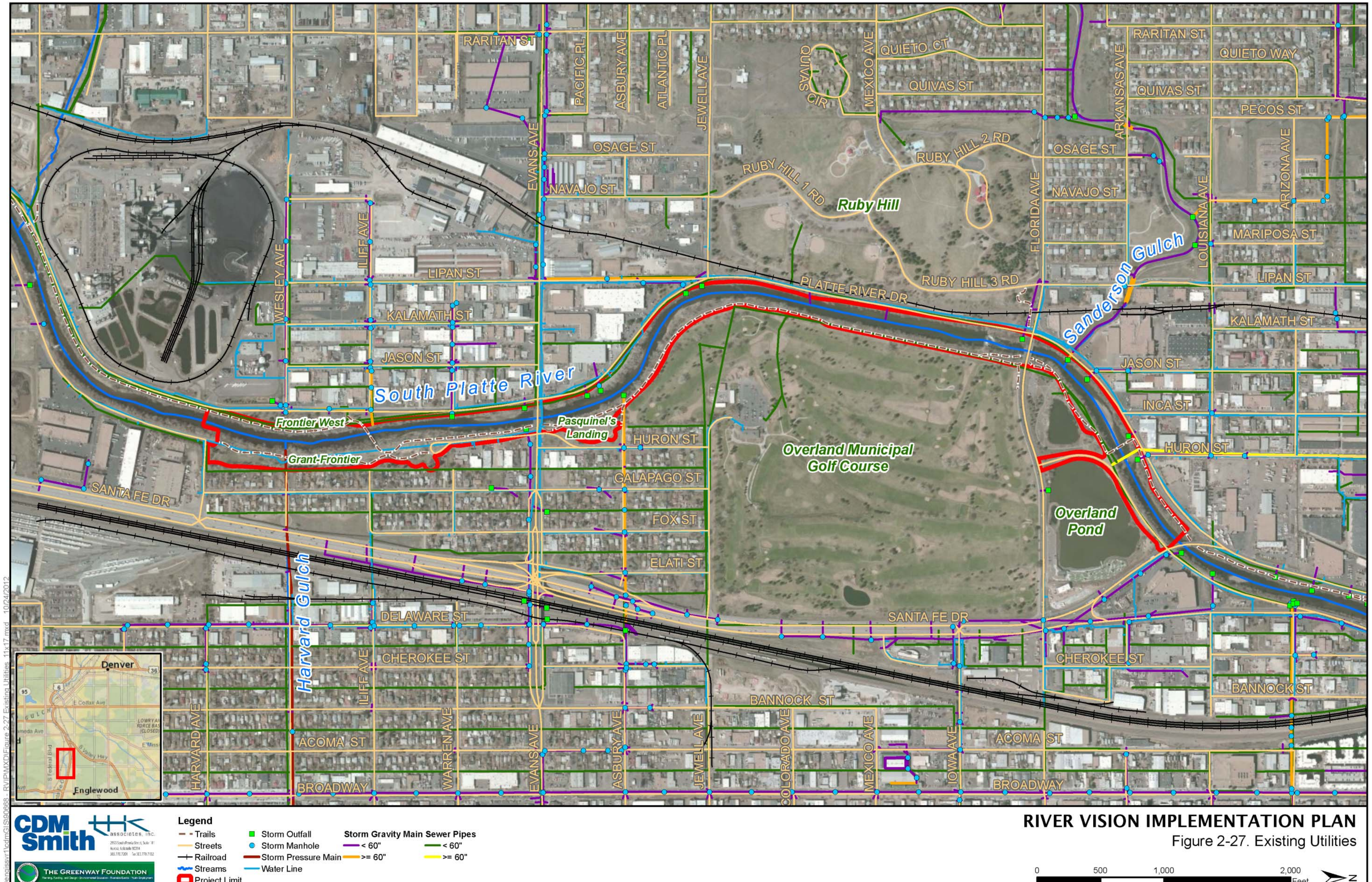

RIVER VISION IMPLEMENTATION PLAN
Figure 2-27. Existing Utilities

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The existing wet well is located upstream of a grade control structure in the river, which provides the constant head for the wet well.

2.11.4 Dry Utilities

Overhead cable, electric, and/or telephone lines also exist within the project area but only at the two major road crossings; Florida Avenue and Evans Avenue. However, maps were not available from the servicing entity for these utilities. Further utility locates will be required during final design phase to identify any additional dry utilities, especially gas lines, as well as define the specific elevations of these utilities.

2.12 Subsurface Characteristics

A geotechnical engineering analysis for the project area has been performed that includes subsurface borings and river sediment sampling. Appendix E contains the geotechnical engineering analysis.

2.12.1 Geotechnical Investigation

Four borings and three sediment sampling locations were conducted for the analysis at the following locations:

- Boring 1 (Florida drop structure): 8 feet of fill over very hard bedrock, Max depth 20 feet
- Boring 2 (Pasquinel's Landing): 1 foot of fill over poorly- to well-graded sand to max depth of 20 feet, groundwater at the time of drilling at 9 feet
- Boring 3 (Grant-Frontier Park): 3 feet of fill over 5 feet of poorly- to well-graded sand over very hard bedrock, max depth 20 feet
- Boring 4 (Harvard Gulch outfall): 5 feet of fill over very hard bedrock, max depth 20 feet
- Sediment Sample 1 (Florida drop structure): 3 feet of poorly-graded sand over 1 foot of clayey sand over poorly-graded sand to max depth of 7 feet
- Sediment Sample 2 (500 feet south of Florida drop structure): 3 feet of poorly-graded sand over 1 foot of clayey sand, max depth of 4 feet
- Sediment Sample 3 (1,000 feet south of Florida drop structure): Poorly-graded sand to max depth of 3 feet

Laboratory testing was performed on selected soil and bedrock samples obtained from borings to determine in-situ soil moisture content and dry density, Atterberg limits, swell-consolidation characteristics, and gradation. Detailed results are summarized in Appendix E.

2.12.2 Geology

Based on the analysis, the subsurface conditions encountered in the borings consist of overburden fills and natural soils extending to relatively shallow bedrock or to the full depth explored. The fill ranged from silty to clayey gravel to clayey sand with occasional sandy lean clay and isolated debris and organic material.

The natural overburden soils generally consisted of poorly- to well-graded sand alluvium containing variable silt and gravel, occasional silty sand lenses, and isolated organic material. Based on sampler penetration resistance, the alluvial sands ranged from medium dense to dense. The bedrock is predominantly claystone containing varying amounts of sand and lenses and zones of sandstone. As described above, it is very hard. It is also relatively dry. It appears to be similar to, and may consist of, the "Denver Blue" bedrock, which can be extremely hard for a soft sedimentary rock and difficult to excavate. The Florida Avenue grade control structure is likely founded directly on the bedrock.

2.12.3 Groundwater

Groundwater is generally close to the river water surface elevation. Groundwater was encountered in one boring during drilling at a depth of about 9 feet. However, stabilized groundwater levels were measured 12 days after drilling in all four borings at depths ranging from 6 to 16.5 feet.

2.12.4 Landfill Evaluation

Pinyon Environmental, Inc. (Pinyon) completed a limited landfill investigation of the Pasquinel's Landing Park. A potential historical landfill has been identified at the park; however, the limits and composition of potential fill material have not been evaluated. Potential improvements at the park could include site grading that would remove significant quantities of earth that could lead to uncovering potential landfill materials. This would potentially lead to costly materials management issues, as well as worker health and safety problems.

Pinyon's investigation evaluated subsurface soils in key areas where construction could occur, and to characterize these soils for waste disposal purposes. In addition, soils were evaluated for potential landfill materials and the presence of asbestos-containing materials (ACMs).

A total of nine test pits were proposed in order to evaluate areas within the anticipated area of improvements. Test pits TP-1 through TP-3 were closest to the river, and test pits TP-4 through TP-6 were stepped out from the river east of the South Platte River Trail (Figure 2). Another three test pits were initially planned, further east of test pits TP-4 through TP-6; however, given the presence of native soils in test pits TP-4 through TP-6 (discussed below), only six of the proposed test pits were completed to avoid disturbance to the park.

No evidence of municipal solid waste, demolition debris (other than concrete block and small red brick fragments), or potential asbestos containing material was observed. Slightly elevated PID readings were noted in test pit TP-2; however, no obvious evidence of contamination (e.g., staining, strong odors, etc.) was observed during sample collection. A sample was collected from test pit TP-2 from the four to six foot layer and submitted for the laboratory analyses as described above. No other elevated PID readings were noted during field screening activities nor were any visible or olfactory evidence of contamination observed in any excavated soils.

Based on the results of this investigation (Pinyon 2012), no evidence of potential environmental conditions that would preclude redevelopment activities at Pasquinel's Landing Park was observed in the test pits completed on the site.

2.13 Cultural Resources

Historically, the South Platte River has played a significant role in the State of Colorado's cultural resources. The South Platte River greatly influenced the Native American settlers to settle in the State of Colorado because of the easy access to water and the abundant supply of timber. In the 1850s, the discovery of gold sparked the development of the mining industry in Colorado, which created more travel and settlement along the South Platte River. And in 1869, the Union Pacific Railroad was completed, providing another way of travel along the South Platte River.

To date, the U.S. Department of Interior National Park Service and State Historic Preservation Office (SHPO) have not identified any historical sites along the project area. If a site is uncovered unexpectedly during construction, the contractor would have to comply with Section 106 of the National Historic Preservation Act and notify the U.S. Department of Interior National Park Service and SHPO.

Section 3
Project Elements

3.1 Introduction

This "River Vision" project was initiated to implement RISO Greenway Master Plan recommendations along the South Platte River and includes the design of multi-purpose improvements to enhance recreation, river access, habitat, vegetation, water quality, and advance river awareness and environmental education. The overall vision for the project area including the Grant-Frontier/ Pasquinel's Landing/Overland Pond Park complex is to create a new recreational destination for the residents of south Denver. Improvements will provide habitat and recreational opportunities within the South Platte River and adjacent park areas as well as enhance the water quality in the river. The intent of the project is to make the area more inviting to both humans and wildlife.

Specifically, the project will increase the visibility, accessibility, and attractiveness of the river; construct emergent benches within the channel banks to create wetland features; construct in-channel aquatic habitat structures to improve fish habitat for recreational fishing; and modify existing grade control structures to enhance recreational boating opportunities. An enhanced ecosystem, coupled with the densely populated surrounding area, will provide unlimited recreational and environmental education opportunities for Colorado citizens.

This section describes the major project elements that are proposed to meet the project goals and objectives within the constraints identified in Section 2. Coordination with the City and County of Denver and UDFCD, as well as the general public, have been undertaken to provide a forum for discussion of these project elements.

3.2 Project Area Constraints

A variety of constraints, including instream flows, water quality, topography, utilities, roads, and channel bed material will need to be addressed by the project elements described in Section 3.3.

3.2.1 Hydrology

The magnitude and timing of river flows within the project area significantly impact aquatic and riparian habitat as well as recreational activities such as fishing, kayaking, canoeing, rafting, and tubing. River flows are controlled by upstream flood control and water supply facilities, stormwater inflows, and WWTP discharges. The river flow regime is also highly regulated by water storage and diversion facilities, a characteristic of South Platte River flows throughout the Denver metropolitan area. Low flows are dominated by the discharge of treated wastewater effluent from the Littleton/Englewood WWTP.

Aquatic habitat structure is typically created during seasonal channel forming (i.e., bankfull) flows. Low flows during summer and winter seasons can severely limit the available habitat while flood flows can damage and destroy habitat. Maintaining regulatory water surface elevations is a challenge to creating habitat diversity. As structure is added to the river, conveyance area is reduced and water surface elevations increase to compensate for the loss. Adequate conveyance must be maintained in a way that no net loss is realized by implementation of the proposed project elements. The addition of features and structures to the river to increase habitat must be accomplished in a way that flood conveyance capacity is not reduced.

3.2.2 Channel Geometry

Modifications to the river channel have replaced much of the natural aquatic habitat with steep, armored banks to increase channel conveyance, reduce overbank flows, and prevent erosion resulting in sharply reduced diversity in channel structure. Additionally, the existing steep banks (3H:1V) limit access to the river. The Overland Golf Course to the east and South Platte River Drive to the west of the river are both within approximately 50 feet of the river bank, confining the channel alignment and making it difficult to recontour the channel banks to a flatter, more accessible and stable cross slope. Relocating or adjusting the boundaries of either of these features is not likely and not within the scope of this design.

3.2.3 Channel Bed Material

The river channel along Grant-Frontier Park exhibits an exposed bedrock channel bed. This material is composed of claystone, a generally hard material that is more difficult to excavate than alluvium or other non-bedrock channel materials.

3.2.4 Water Quality

In addition to river flows, poor water quality also impacts contact recreational activities and aquatic and riparian habitat in the project area. Currently, the City and County of Denver Division of Environmental Quality (DEQ) advises against swimming or other contact with any of the City's lakes and streams because of high amounts of bacteria and other contaminants that can be harmful to human health. Therefore, improving water quality along the project reach provides an opportunity for increased recreational activity such as wading, swimming, kayaking, canoeing, rafting, tubing, and fishing.

3.2.5 Utilities

Existing sewer utilities parallel the project reach along the west bank and sections of the east bank as described in Section 2.11. However, upstream of Overland Park Municipal Golf Course, located adjacent to the east bank, is free of utilities and therefore, due to the existence of adjacent parklands, represents an opportunity to create one or more floodplain benches that will diversify habitat and also aid in increasing water quality and flood storage. However, the actual golf course cannot be impacted or modified by such proposed river edge improvements.

3.2.6 Roadways

The northern segment of the project area is constrained by South Platte River Drive to the west as well as the East Evans Avenue and Florida Avenue bridges. These limit the ability to recontour banks and re-create floodplain benches along the west bank in the entire project area and parts of the east bank in the vicinity of the bridges.

3.2.7 Vegetation

Most of the riverine corridor in the project area includes a very narrow riparian zone, typically less than 50 feet wide along each bank. Herbaceous and woody species, listed on the Colorado noxious, invasive or exotic pest plant/weed list, are common within the riparian corridor. In addition to state and city recommendations and actions to remove these species from natural areas, this type of vegetation decrease ecosystem biodiversity and can block views of and access to the river.

3.3 Project Elements

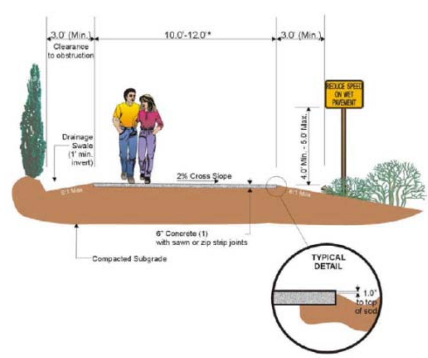
Habitat improvements begin with modifying and enhancing the channel and adjacent riparian corridor. The creation of riffles, boulder structures, and natural tree snags for fish habitat also enhances boating experiences on the river and increase the overall health of the river. Habitat improvements will also include the re-contouring river banks to create flatter cross slopes and floodplain benches that are typically associated with natural rivers within the high plains of eastern Colorado. These benches will include a mix of emergent, riparian, and upland vegetation. The flatter banks, in combination with removal of invasive vegetation and inclusion of river access trails and boat launches will improve the recreational experience as well for all river, park, and trail users.

The proposed project elements are those improvements that are considered feasible to implement. This section describes the different types of project elements proposed for this project as well as the initial placement of those elements. Using the design criteria and following the analysis described in Section 4, the elements are presently at the preliminary design level, which is described in Section 5. As the design progresses from the preliminary design phase to the final design phase, the alignment, configuration, and make-up of the proposed elements may be modified to more adequately fulfill the goals and objectives of the project.

3.3.1 Park and Recreation Improvements

Major park improvements include the construction of paved and sanctioned natural trails, environmental playgrounds, and bank improvements including emergent floodplain benches; and invasive and non-native vegetation removal. Other recreational components include boardwalks, scenic overlooks, rest areas, and interpretive signage.

Regional Path Typical Section



3.3.1.1 Trail Improvements

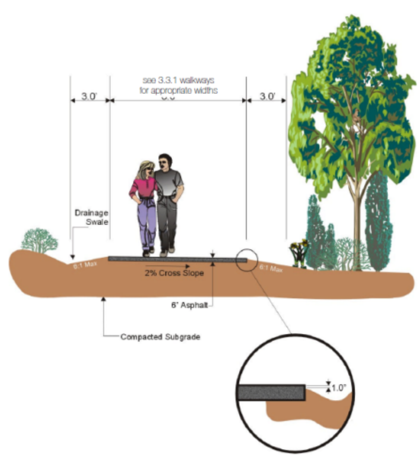
Regional Trail

The Denver Department of Parks and Recreation (DPR) Park Use Rules and Regulations defines a Regional Trail as "any of the following trail systems to the extent operated or controlled under the jurisdiction of DPR; … h) South Platte River Trail, and i) any other trail designated by the Manager as a Regional Trail". Regional trails are used for variety of recreational activities and supplement efforts to promote bicycle commuting. The existing South Platte River regional trail will need to be reconfigured within Pasquinel's Landing Park and Grant-Frontier Park accommodate creation of the proposed floodplain benches.

Local Trail

Local trails or neighborhood trails are used for recreational loops or as access from local neighborhood to parks and regional trails. These trails are also constructed and maintained by the DPR. Currently, a local trail exists on the east bank at in Grant-Frontier Park that will need to be reconstructed and relocated further to the east to accommodate proposed regrading in this area.

Recreational Loops/Local Parks Paths Typical Section



Natural Trails

Natural trails typically start as informal earthen social trails that were not designed or constructed and have not been sanctioned by the DPR, usually formed by hikers or runners access desirable areas. Improved natural trails that are sanctioned and will be maintained by the DPR are proposed at a variety of locations within the project area to increase river accessibility. These trails will be constructed using crusher fine material that is cut into grade. Since the nature trails will be soft surface so they will not be classified as ADA accessible, but the trails will be designed such that physically challenged individuals can access them.

Americans with Disability Act (ADA) Accessible Trails

DPR rules and regulations require trails to conform to specific ADA requirements. All new trails within the project area will be ADA compliant. These trails are envisioned to connect the Regional Trail with the proposed boat launches and overlook areas that are proposed along the river.

Boardwalks

Boardwalks are wooden pedestrian walkways that pass over sandbars, wetlands, and other fragile ecosystems. Boardwalk trails are proposed in the emergent/riparian zones associated with Grant-Frontier Park and Pasquinel's Landing to provide scenic rest areas that overlook proposed channel features and can be easily accessed by the physically challenged.

The boardwalks will be connected with the regional and/or local trails by concrete trails that are ADA compliant. The boardwalk areas will be above the ordinary high water elevation, which is approximately 2- to 2-1/2-feet above the channel bed elevation.

3.3.1.2 Environmental Playgrounds

Environmental playgrounds are designed to enhance awareness through education in ways that are fun for children while creating sustainable facilities and minimizing the carbon footprint. An environmental playground is different from a conventional playground that has manufactured play equipment and manufactured site furnishings by utilizing natural materials (e.g., trees, rocks, vegetation, water etc.). These playgrounds are a way to reintroduce natural play to children. Climbing up trees, crawling over rocks, splashing in the mud, playing hide and seek, looking for insects and frogs are all encouraged by this type of playground.

Environmental playgrounds are proposed at Grant-Frontier Park and Pasquinel's Landing Park to replace and augment existing playgrounds. These playgrounds will be themed to incorporate an educational aspect regarding historical culture of the RISO area.

3.3.1.3 Interpretive Signs

Interpretive and directional signage will be included in the construction of trails in accordance with DPR criteria and requirements. The interpretive signs and displays will concentrate on unique areas such as wetlands/riparian zones and will focus on the natural trails/boardwalk areas whereas directional signage will direct users to the locations and will be located along the regional trail in the Grant Frontier/Overland Parks area.

3.3.1.4 Invasive Vegetation Removal

Invasive non-native vegetation removal and promotion of native species are important to increasing the ecological integrity of the river. Invasive non-native vegetation typically forms in plant communities that have been disturbed, allowing them to quickly establish sustainable populations that can out compete native communities. Due to invasive vegetation characteristics such as faster growth rates, efficient dispersal mechanisms, and a greater tolerance for adverse living conditions, these plants establish themselves quickly in disturbed ground and out-compete native vegetation. Invasive non-native species are recognized as a major threat to the integrity of natural areas. Existing invasive vegetation along the project reach that are proposed for removal includes Siberian Elm (*Ulmus pumila*), Chinese Elm (*Ulmus parvifolia*), Tamarisk/saltcedar (*Tamarix*), and Buckthorn (*Rhamnus*).

3.3.1.5 Non-Native Species Removal

Non-native species are plants that do not naturally grow within local environments due to soil material, moisture, temperature, canopy, or other environment related aspects. These non-native plants are found along the project river corridor. Non-native species such as ash, hawthorn, crabapple, and pines should be removed from the riparian corridor and uplands parks. Non-native trees that are non-invasive, such as certain pines, were introduced to and are now prevalent in park environments and should be removed from the riparian corridor and adjacent uplands.

Healthy ecological communities composed of established native species that have evolved to thrive on the local soil and climate that remains undisturbed are usually, but not always, hostile to the establishment of invasive non-native species. Establishing ecologically healthy plant communities can be difficult due to the fact that construction disturbs the ground on which the community is dependent. Removal of invasive non-native species is an important first step, but it is likely that these species will return and regain dominance, if proper steps are not taken such as active long-term monitoring and maintenance of the planted and seeded native vegetation. In addition, this vegetation must be established in a way that addresses the entire community as it would naturally propagate and not individual plant species.

3.3.1.6 Native Vegetation Planting

As noted above, most of the Grant Frontier/Overland Parks area is lined with a dense canopy of deciduous trees, many of which are undesirable species and will be removed. These areas will be replanted with native species that will include a combination of cottonwoods, willows and associated plant species that were historically common to the riverine corridor and are still present in isolated pockets.

3.3.1.7 Irrigation

Currently, irrigation systems exist at Grant Frontier Park and Pasquinel's Landing Park to support the existing bluegrass open spaces. However, the location and layout of the existing irrigation system is not currently known. A new irrigation system is proposed to feed into the existing irrigation tap and backflow preventers. This new distribution system will irrigate planted vegetation along the banks and in the floodplain benches until they are established and can out-compete invasive species. During the final design phase, the project team will coordinate with Parks and Recreation to develop an irrigation plan and will provide recommendations for irrigating upon completion of the work.

Existing irrigation system valve boxes

3.3.1.8 Restroom Facilities

No formal restroom facilities exist in the Grant-Frontier/Overland Park reach. However, portable San-O-Let facilities exist in Grant-Frontier Park as well as drinking fountains in both parks.

The DPR has expressed a desire to install a permanent restroom facility in the project reach. The exact location, size, and configuration are to be determined during the final design phase. However, restroom facilities should be centrally located to serve the greatest number of trail/park users, easily accessible from the regional trail and be conspicuous for safety purposes. See potential locations shown on **Figure 3-1**. This facility should include vandal-proof flushable toilets and wash basins and be well-lit at night. Figure 3-10 provides suggestions for a restroom location.

Figure 3-1. Potential restroom locations

3.3.2 Aquatic Habitat

Channel improvements are proposed to increase aquatic habitat diversity, enhance safe and enjoyable boater passage, and provide expanded visual and physical river access. The major instream improvement is replacement of the Florida Avenue grade control structure with a series of smaller, riffle structures that provide varying flow depth and velocity and create a defined thalweg. Other channel modifications include the previously discussed bank recontouring and floodplain benches, and a variety of wood and rock structures. Channel improvements are separated into two categories—channel modifications and instream structures. Both are described in the following section.

3.3.2.1 Channel Modifications

Channel modifications alter the channel planform, profile, and cross-section geometry as a means to restore aquatic habitat, improve boating, and enhancing natural ecosystem characteristics.

Channel morphology is a term used to describe a stream's planform, cross-sectional and longitudinal geometries. Channel morphology is a function of physical processes and environmental conditions, including flow rates, recurrences, and characteristics; the composition and erodibility of the bed and banks; vegetation types and densities in both the channel and along its banks; and the availability and characteristics of suspended sediment and other mobilized material. In a natural system, each of these functional characteristics interact to establish a stable channel that typically maintains relatively constant average geometries system-wide while experiencing localized changes over time.

The proposed channel modifications are intended to improve channel morphology by constructing instream features and regrading to revise planform, bedform, cross-section geometry, and bed profile components within the project area to provide target fish species habitat.

Planform

Channel planform refers to the horizontal spatial pattern and alignment of a channel, as if one were looking down on it from above. One common descriptor of planform is "sinuosity," which is a ratio of channel length to valley length and describes the degree of meandering (see **Figure 3-2**). It is an inverse function of gradient; the higher the gradient, the lower the sinuosity and vice versa. Other factors also contribute to sinuosity including width-to-depth ratio and channel composition. A sinuosity between 1.0 and 1.1 is considered straight, between 1.11 and 1.5 is considered low, and between 1.51 and 3.0 is considered meandering (Leopold and Wolman 1957).

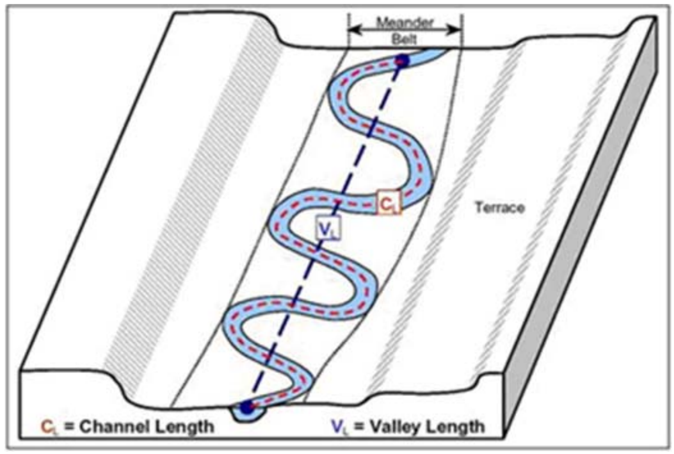


Figure 3-2. Sinuosity Classification

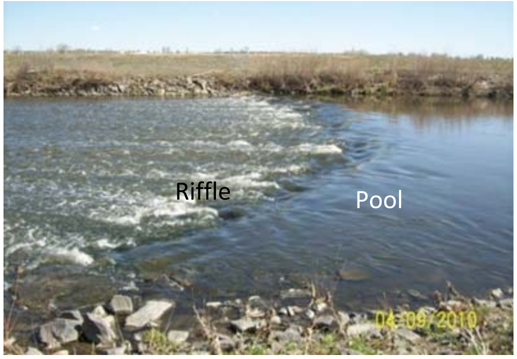
The existing channel exhibits low sinuosity of approximately 1.2 (valley length = 7,000 feet and channel length = 8,400 feet) that is considered reasonable for an urban river. Due to existing constraints, increasing sinuosity of the main channel is not feasible; therefore, creating a meandering low flow channel planform within the "active channel" is proposed. Meandering the low flow channel within the banks of the existing main channel will improve the aquatic habitat by increasing the flow depth during low flow periods of the year as well as increase the ability to boat this reach of the river. The channel planform improvements, consisting of rock and wood structures are intended to create meanders within the main channel and to develop a thalweg that forms the basis of the active channel. This approach will be coordinated with the development of floodplain benches acting as point bars, within the existing active channel and creating a connection between the channel and the adjacent riparian corridor.

However, as noted in Section 3.2, the upper portion of the project reach includes a claystone channel bed and creating an active channel is not practical. Therefore, creating a meandering planform will start downstream of the existing pedestrian near the proposed secondary channel at Grant Frontier Park.

Bedform

Bedform refers to the depositional features on the bed of a river that are formed by the movement of the bed material (e.g., sands, gravels, and cobbles) in response to flow. Typical bedforms in a gravel and sand bed river, like the South Platte River, are riffle-pool sequences, runs, glides, and bars. The location, spacing, and shaping of these channel bedform features is a characteristic of the flow parameters, in particular flow depth and velocity and channel constraints.

Riffles and Pools



Riffles and pools are often associated and comprise the dominant bedforms in coarse-grained channels. Riffles are depositional features associated with straighter, often higher-gradient channel sections and are characterized by shallow, faster turbulent flow. Pools are erosional features that are usually located along the outside bank of channel bends. These two bedform features often alternate with the riffle occurring in the straight reach between two bends and pool soccurring at both bends. Pools can be located in straight reaches where channel constraints or obstructions create turbulent eddies that scour the bed or at loctions upstream of adverse gradient where backwater increases channel depth. Common examples of this include bridge piers and abutments and pipeline crossings.

To create the meandering active channel with a defined thalweg, described above, riffles are included as proposed project elements. Several riffles have already formed, or were previously constructed, in the project reach. Riffles are typically found upstream of bends or in locations where the channel slopes change. They have a high width-to-depth ratio, higher average cross-sectional velocities, and a substrate mainly composed of gravels and cobbles. Seven riffles are proposed for the project reach between Evans Avenue and downstream of Florida Avenue. The riffles are proposed at locations along the reach to enhance and diversify the stream bed into natural pool-riffle sequences.

The new riffle drops are expected to be 8-inches to 12-inches in height, and will be constructed of native rock boulders. These drop structures will be navigable by tubes, rafts, and canoes. The riffle drops will also add unique areas where trout and other species can find refuge and food, improving fishing opportunities for all ages.

Elements have been included in the project that are intended to create pools through turbulence and eddy action; therefore, no pools will be specifically designed as a part of this project.

Channel Bars

Channel bars are depositional features that naturally occur as a result of local reductions in sediment transport capacity. Both point and mid-channel bars are present in the project area and generally occur due to changes in channel geometry. Point bars are the natural accumulation of sand, gravel, or other alluvium material formed at the inside bank of channelbends where the velocity and sediment transport capacity are low. Mid-channel bars will form in straight reaches where the width has increased beyond the ability of flow to carry the sediment carried upstream of the bar. Point bars can become mid-channel bars when a secondary channel forms at the interface between the bar and the bank and eventually evolves into a primary channel that flows as often as the original channel. Mid-point bars can also form where debris has been deposited during or after a high flow event.

Mid-channel bars divide channels and are typically temporary sediment storage in the stream channel and may become established if additional sediment is deposited on the bar and vegetation takes hold. Mid-channel bars currently exist, but are not proposed along the project reach; however, sediment will naturally accumulate due to instream structures such as v-shaped deflectors, wing deflectors, and boulder clusters.

Runs

A run is defined as a low-gradient section of river with little turbulence and a defined channel thalweg. Runs can be difficult to maintain, especially channels with sandy streambeds; however, they are common for urban rivers that contain grade control structures, which minimize channel degradation and sediment transportation. Typically, runs will form naturally between these grade control structures or riffles in areas where the slope is mild. The key feature to runs is defining a channel thalweg, which this project will create through instream structures and point bars discussed in this section.

Cross-Section

Changing a channel's cross-section involves altering its width, depth, or shape across the channel, and can include modification of channel banks and bars. Cross-section modifications in the project area will be applied both to within the active channel, as well as the adjacent riparian zone.

The typical cross-section in the main channel now is trapezoidal without a defined thalweg and little cross-slope variation. To create a meandering low flow planform, the cross-section will be modified where possible with the deepest portion along the outer bank to create pools and the shallowest part at the point bars along the inner bank (see **Figure 3-3**). The point bar will also serve as a floodplain bench that connects the low flow channel to the riparian zone.

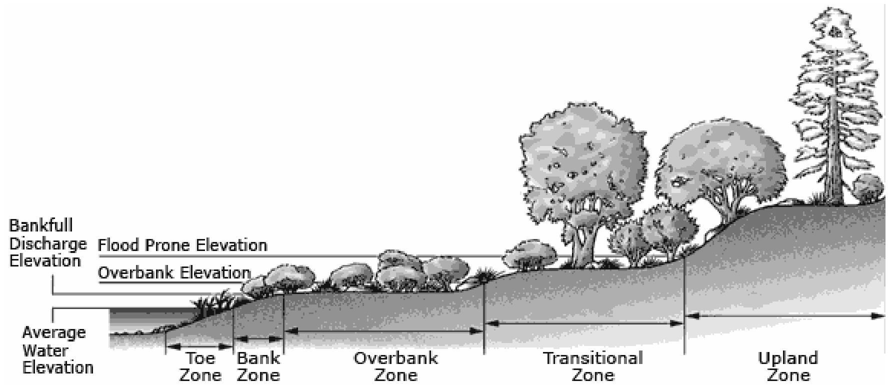
Bank Grading

The bank grading work will primarily include the creation of accessible river bank areas and the floodplain benches. These areas will be constructed with gentle slopes and benches to allow for wetland plantings and interpretive trails/ boardwalks to meander through them (see **Figure 3-3**).

Figure 3-3. Revised typical channel cross section and bedform upstream of Florida Avenue

Floodplain Benches

Flood benches are developed by laying back the bank to form multiple flood zones typically referred to as emergent or wetland benches located in the toe and bank zones, riparian benches located in the overbank and transitional zones, and upland benches located in the upland zone. These zones enhance the river ecosystem by providing bank stabilization, redirection of stream flow, remove pollutants, and other varied environmental properties to support different native vegetation. An important ecological function of the floodplain bench is that it creates a connection between the low flow channel and riparian corridor. Floodplain benches are often associated with point bars but can also occur in a continuously through straight reaches of the river.



A floodplain bench is excavated along the stream, resulting in the addition of three-stages; a redefined active channel, a low flow floodplain, and an overbank floodplain. The new low flow floodplain functions such as filtering harmful pollutants and increasing topographic and plant community diversity. Establishing the correct bench elevation is critical to the viability of the emergent plants. The low flow floodplain elevation should be at or just above the ordinary high water mark. Emergent vegetation exists within the toe and bank zone, while riparian vegetation is found in the overbank zone. These plants are less tolerant of frequent flooding. Plants that are submerged are frequently referred to as submerged aquatics (toe zone). These plants typically grow in the wettest areas of the emergent bench.

Riparian benches are designed to support similar plants as emergent benches; however, they can also contain woody plant materials such as willows that thrive in these areas. Plants located in riparian benches seek out the water table and rely on this water source to sustain their growth and then eventual the dispersion of rhizomes to produce further growth.

Upland benches are designed outside of the active river to provide shade and scenery for areas adjacent to the river. These areas support more xeric species that can tolerate less water such as Cottonwood trees, upright junipers, and native grasses. Floodplain benches are proposed along the project reach at Pasquinel's Landing and Grant-Frontier Parks.

Profile

Channel profile refers to the longitudinal slope, or gradient, of the channel bed and the variation of that slope through a reach. The slope of the bed typically varies through a reach. It is steepest through riffles or over drops, and shallow or inverse through pools (see **Figure 3-4**).

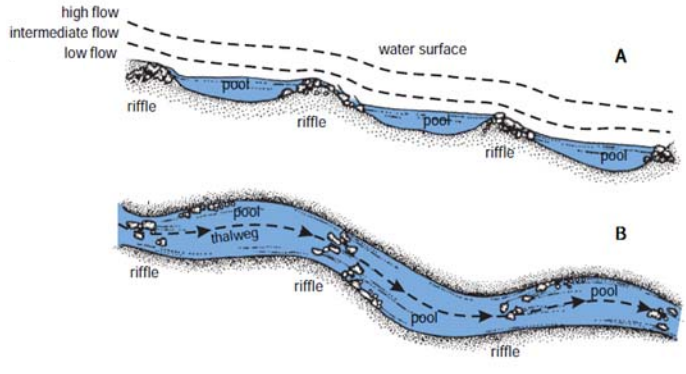


Figure 3-4. Typical riffle-pool sequence

Approximately two-thirds of the project reach will maintain the existing slope. However, the channel slope will increase from just downstream of Jewell Avenue to downstream of Florida Avenue as a result of the removal of the existing grade control structure upstream of Florida Avenue. This structure served as an impoundment for the water diversion to Overland Pond.

Profile changes will occur because of the lowering of this structure and dredging of the sediment that extends nearly 1,000 feet upstream of the structure. This large existing drop structure will be replaced with four smaller fish and boater friendly riffle structures. Profile modification is used in the project to improve habitat complexity, recreational boating safety, and river access. The new slope in this area will be approximately 0.1 percent.

3.3.2.2 Instream Structures

Bendway Weirs

Bendway weirs are a "system" of individual structures (usually composed of small and large boulders), which protrude into the channel (see adjacent photograph). The weirs induce sediment deposition and create scour holes by altering flow direction. These weirs are proposed along the reach to create small instream scour pools and direct the flowline away from the bank, to create a thalweg and define the proposed low flow channel (see **Figure 3-5**).

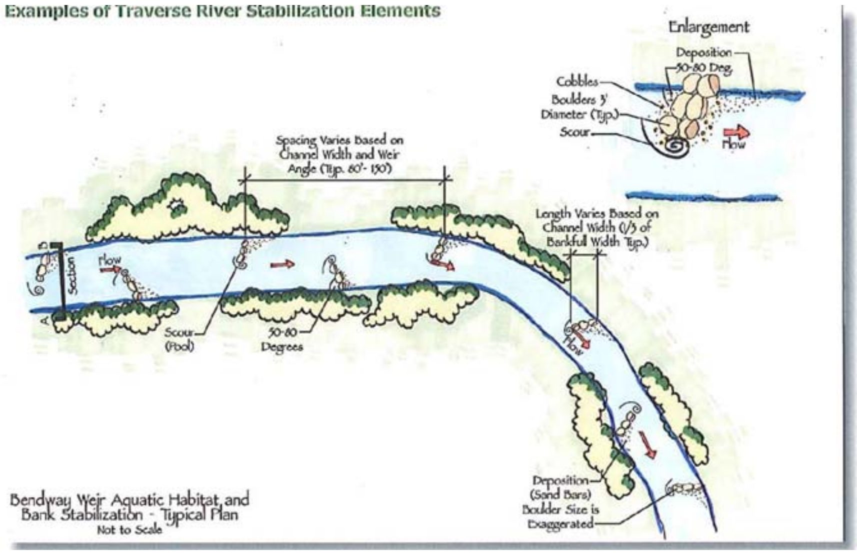


Figure 3-5. Schematic of bendway weir typical locations

Deflectors

Deflectors redirect and accelerate flow away from the bank and create scour pools by constricting the channel (see **Figure 3-6**). Two types of deflectors (wing and V-type) are proposed to be used in the RVIP improvements. The deflectors are sized based on anticipated scour and deposition patterns.

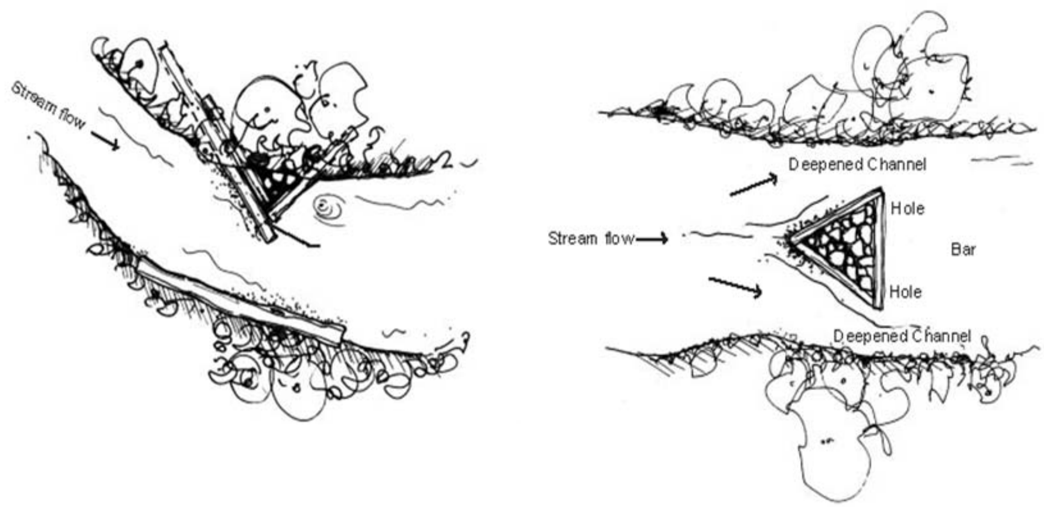


Figure 3-6. Wing deflector and v-type deflector

Wing deflectors are proposed to be placed on the outer banks to provide bank stability, redirect flow, and create microhabitat (scour pools). V-type deflectors are located in the middle of the channel bed to reduce the channel width, which increases velocity along the outer channel creating scour pools and sediment accumulation just downstream of the deflector.

Boulder Clusters

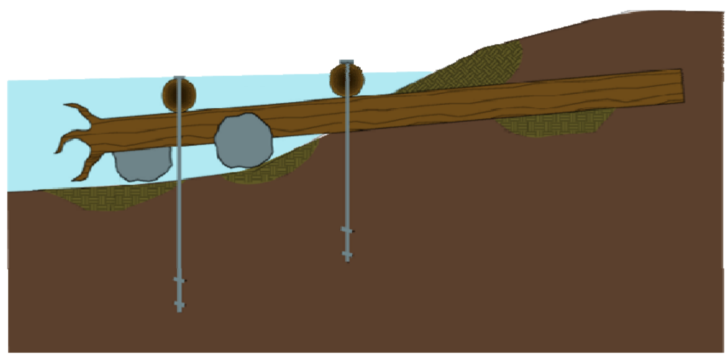
Boulder clusters are groups of large rocks (>18-inch diameter) placed in a stream to improve habitat (see adjacent photograph). Flow separation around the boulders leads to the formation of eddies or vortices in their wake. These vortices diffuse sunlight and create overhead cover for fish. They also generate scour that develops pockets of deeper water and associated coarse substrate that add to the physical diversity of a stream reach. Placing boulders in the base flow channel or along the bank will provide protective cover, a downstream scour hole, and eddy areas of reduced velocity.

Rock Vanes

The rock vane is an upstream directed, gently sloping structure composed of natural materials, such as boulders cobbles. Rock vanes are used to obstruct flow in order to recreate the desired channel flow path. The structure is intended to reduce bank erosion by reducing velocity gradient, stream power, and shear stress. Vanes also provide cover for fish by pushing the stream velocity away from the bank to create scour holes and help oxygenate the water.

Snags and Rootwads

Snags provide protective cover for fish and macro-invertebrates as well as an organic substrate for aquatic vegetation. Additionally, they can shade the river, maintaining appropriate water temperatures and shielding fish from direct sunlight. Snags, comprised of boulders and logs, will be installed at the entrances to each of the wetlands pools/secondary channels. A significant challenge with the snags is anchoring them to the bank so that they remain in place. To prevent movement of the snag structure, it will need to be held in place through a combination of cables and anchoring into the river bank, as shown in the design drawings (Appendix E).

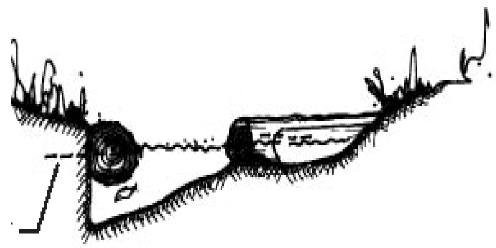


Rootwads provide similar benefits as snags except are smaller in scale. Rootwoods reduce shear stress by pushing flows away from the bank, provide bank protection, habitat cover, and provide food for aquatic insects. Rootwoods are typically keyed into the bank through the trunk exposing the root mass or ball along the channel bank. If rootwoods are not tied into the bank, anchors should be used to anchor the rootwood into the channel bed.

Lunkers

Lunker structures are installed along the streambank to create cover and resting areas for fish. They intended to mimic overhanging banks. Lunkers consist of open cells (e.g., culverts or wooden boxes) embedded into the toe of river banks below the channel bed level.

Cover Logs



Cover logs are installed along the edge of the bank and project out into the channel, providing protective cover, resting areas, organic substrate for macro-invertebrates and aquatic vegetation, stream current deflection, scouring, deposition, and catchment of debris drifting with the current.

Boat Launches

Boat launches are intended to increase recreational opportunities and safety within the project area by providing easy safe access along the river at multiple locations. Boat launches will also boost fishing and provide opportunities for residents to enjoy, learn, and reconnect with the river.

Faux rock boat launches and fish access points will be provided along the project reach (see **Figure 3-7**). These boat launches will be ADA accessible and will allow physically challenged individuals to access the river. These will also serve small groups of people to launch canoes, kayaks, and tubes as well as provide access to the river for fishermen.

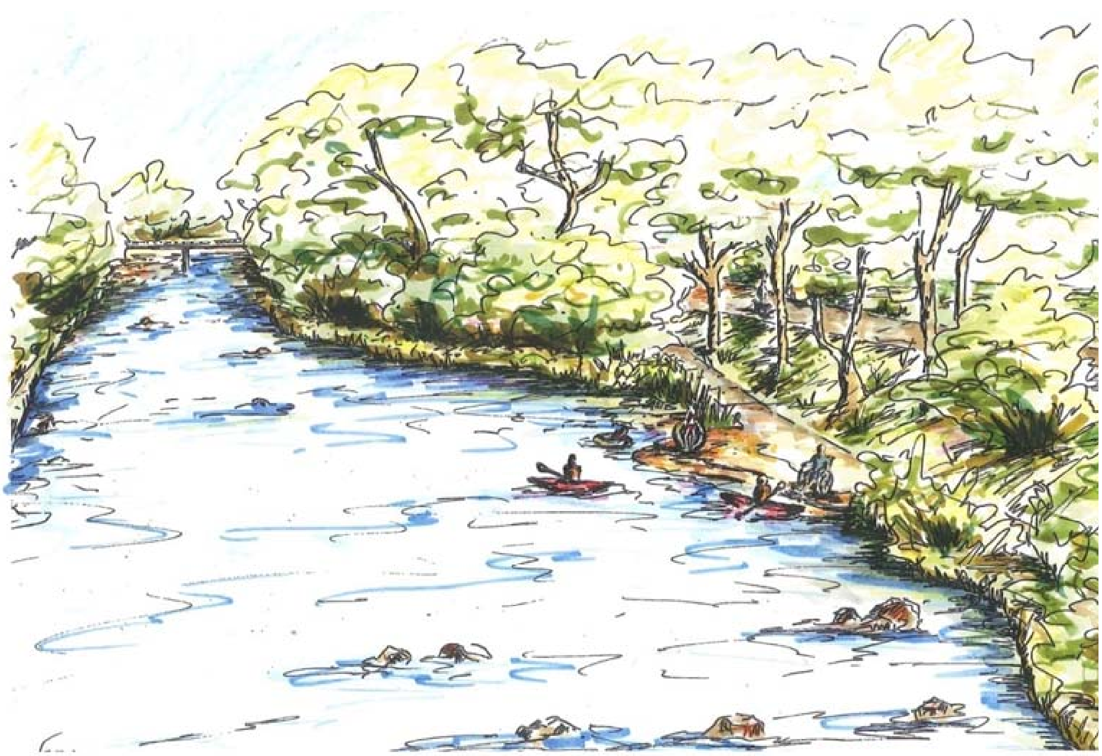


Figure 3-7. Faux rock boat launch with ADA trail

Bank Stabilization

Riprap revetments and boulder structures whose voids are filled with soil and vegetated are typically used to stabilize banks along the South Platte River due to their longevity, resistance to scour under high flow conditions and aesthetics (when built properly, one cannot see the riprap). Recontoured banks will follow UDFCD criteria with a maximum slope of 3 horizontal to 1 vertical. Newly graded and stabilized banks will be vegetated with native plants and grasses to the ordinary high water mark.

3.3.3 Water Quality Improvements

Proposed improvements include a variety of features that are intended not only to serve their primary function but also to provide increased water quality. The improvements that may benefit water quality include:

- Floodplain benches
- Stormwater outfall enhancements
- Wetlands
- Riffles
- Grass swales
- End-of-pipe treatment
- Secondary channels

The river improvements listed above use a combination of biological and physical mechanisms to remove sediment, nutrients, and fecal bacteria. Plants and algae take up nutrients in the water column and sediment will settle in slower moving areas, such as secondary channels, grass swales, or heavily vegetated floodplain benches. Trash can be removed from stormwater using end-of-pipe screens or capture devices. Riffles can increase the dissolved oxygen content as well as extend water's exposure to sunlight to reduce the amount of fecal coliform. Additional information on floodplain benches, end-of-pipe treatment, and grass swales/wetlands are provided below.

3.3.3.1 Floodplain Benches

Floodplain benches are shallow, relatively flat areas on the river edge. A variety of emergent wetland plants can grow on the benches, such as cattails, willow, and reeds. A floodplain bench provides habitat, shade, and if densely vegetated, lower velocities. The main affect on water quality from a floodplain bench is expected to be the removal of sediment and nutrients.

3.3.3.2 End-of-Pipe Treatment

The treatment of stormwater at the outfall or end of pipe is a common BMP in developed areas. Potential end-of-pipe treatment technologies for this project include trash racks, baffle boxes, and level spreaders. End-of-pipe treatments typically used to remove solids and trash, with the consequent removal of nutrients and fecal coliform associated with the solids. Removing trash can aid in maintaining aesthetics of the river and the proposed improvements. Level spreaders are stormwater structures that spread stormwater out evenly across an area, such as a riparian bank. The diffusion of flow helps filter runoff and prevent erosion. Level spreaders could be installed at the end of several existing storm drain pipes in conjunction with bank grading and vegetation enhancements.

3.3.3.3 Grass Swales and Wetlands

Constructed swales or wetlands designed at stormwater outfalls can improve water quality. Swales are a well established method for conveyance of stormwater and can provide some water quality treatment. UDFCD has detailed requirements for the design of swales. Swales not used as primary conveyance could be planted with wetland vegetation to provide additional water quality and habitat. As with constructed wetlands, identifying a source of water able to hydrate the wetland vegetation will be important to the implementation of these improvements.

3.4 Miscellaneous Improvements

Miscellaneous improvements are associated with the Harvard Gulch outfall, existing trails and pavements, the Florida Avenue diversion and pump house.

3.4.1 Harvard Gulch Outfall

This outfall is located within the Grant-Frontier Park and discharges within 20 feet of the South Platte River (see **Figure 3-8**). According to the Harvard Gulch Master Plan (CDM Smith 2005), the conduit is undersized and cannot convey the 100-year discharge (5,350 cfs) per City and County of Denver criteria. The Master Plan identifies two options to address the lack of capacity. The first option is to replace the Harvard Gulch drainageway conduit with a composite open channel in Wesley Avenue downstream of Logan Street. The second option is to provide supplemental capacity to Harvard Gulch drainageway conduit. While neither option was recommended, DPR is interested in moving the existing outfall to the east to allow for the littoral bench grading. By moving the outfall structure, low flows could be redirected through a littoral bench, creating a minor stream amenity and providing a water quality benefit.

Figure 3-8. Existing Harvard Gulch outfall

The main reason for moving this outfall is to create a safer structure since it is located in the park, but more importantly, to lay back the bank and allow for end of pipe treatment prior to discharging into the South Platte River. The new outfall concept is to construct a grouted boulder drop structure and to tie it into new retaining walls to create a more natural and aesthetically pleasing outfall area (see **Figure 3-9**).

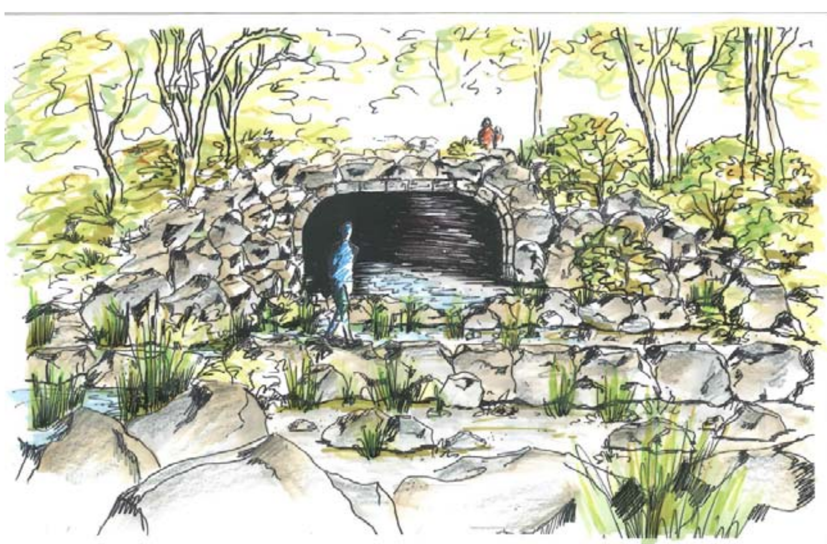


Figure 3-9. Sketch of proposed Harvard Gulch outfall

3.4.2 Trail Relocation and Pavement Removal

The regional trail between Evans Avenue and Warren Avenue is adjacent to an existing roadway that provides access to businesses along this street (see **Figure 3-10** below). The street is approximately 40 feet wide, which is wider than the typical residential street width (32 feet). The City and County Denver is evaluating realigning the intersection of Evans Avenue and Huron Street as part of a redevelopment effort. The intent for Huron Street south of Evans is to remove roughly 10 feet of pavement and move the regional trail up and away from the South Platte River. This realignment is not included as part of this project at this time. However, items to be considered will be impacts to the existing San-O-Let structure/enclosure and the site improvements that exist in this area.

Figure 3-10. Existing trail near Evans to be relocated

3.4.3 Gravel Area

A large gravel area exists on the west side of the river approximately at Asbury Avenue (see **Figure 3-11**). The gravel area is used as an informal parking area as well as snow storage area in the winter. The sanitary sewer that parallels the river is adjacent to the existing roadway. The potential exists to lay this bank back and to create an emergent/riparian bench at the river and slope up to South Platte River Drive at 3:1 or even 4:1 to increase the riparian zone and create additional habitat.

Figure 3-11. Existing gravel area just north of West Evans

To accomplish this grading, existing non-native trees need to be removed and replanted with native tree and shrub species.

3.4.4 Overland Golf Course Diversion and Pump House

The existing diversion and wet well used to convey water into the Overland irrigation ponds along the right overbank upstream of West Florida Avenue will be replaced due to the removal of the Florida Avenue grade control structure that provides a backwater area for the diversion. The new diversion structure will be incorporated into the proposed "boat-friendly" riffle located upstream of West Florida Avenue. The diversion structure will divert the same amount of flow previously diverted at this location; therefore, no water rights conflicts are anticipated.

The proposed channel improvements will lower the river by about 5 feet in the location of the existing pump station wet well/intake, which would render the station unusable if not modified. Additionally, the City and County of Denver would like to address the capacity limitations with the existing pump station. As part of the functional improvements to the station, the opportunity also exists to improve the operations and maintenance (O&M) characteristics and visual aesthetics of the wet well/intake.

Section 4
Design Considerations and Analyses

4.1 Introduction

Developing an appropriate design involves identifying a set of criteria that can be used to meet the goals and objectives while at the same time addressing the constraints described in Sections 2 and 3. Design criteria provide the basis needed to design improvement to meet the project goals and objectives. The hydraulic analysis demonstrates the channel improvements ability to meet the design criteria.

4.2 Design Criteria

This section includes a description of those design factors that need to be taken into consideration in developing the design of the project elements described in Section 3. Criteria used in the development of the proposed aquatic habitat improvements include selecting target species and identifying their habitat preferences, establishing the channel morphology and hydraulic characteristics (i.e., flow depths and velocities). Criteria used in the development of the proposed park improvements include trail requirements and vegetation types. Criteria for recreational aspects (e.g., boating and fishing) are also included.

Where possible, in-channel design factors adhere to standards and guidelines set forth in the UDFCD Urban Storm Drainage Criteria Manual (USDCM) (UDFCD 2008) to the extent that these criteria address habitat, recreation, and water quality improvements. The park improvements adhere to the City and County of Denver Parks and Recreation's Planning, Design and Construction Standards and ADA requirements (Denver Parks and Recreation, 2006).

Two classes of design criteria exist—performance criteria and prescriptive criteria. Performance criteria define *what* a project will achieve and the duration of benefits, while prescriptive criteria define *how* the project will be undertaken. In other words, performance criteria describe the required performance or service characteristics of the finished product or system without specifying in detail the methods to be used in obtaining the desired end result while prescriptive criteria describe the specific design details (e.g., specific material types, slopes, vegetation types) and identification of technical guidelines to be used in the design of each project elements. Both types of criteria are used in this project.

4.2.1 Recreation

The intent of the design is to develop recreational elements that are functional, aesthetically pleasing, and easily maintained. Recreational design is based on the City and County of Denver standards. As the park owner responsible for maintenance, Denver Parks and Recreation will need to review and approve the design.

Materials for recreation improvements will follow a "green" design concept that minimizes harmful effects on human health and the environment. Green design attempts to preserve and protect air, water, and land by choosing eco-friendly building materials and construction practices. Park design will consider recycled, reclaimed, earth friendly materials and will be a guiding principle for all proposed improvements.

4.2.1.1 Trails

Regional and local (i.e., minor) paved trails will conform to the following standards (DPR, 2006):

- CCD Bike Path Standards
- Americans with Disabilities Act (ADA)
- American Association of State Highway and Transportation Officials (AASHTO) Guide for the Development of Bicycle Facilities.

Concrete trails should incorporate a color that integrates the trails to the surrounding soils. Therefore, approximately two pounds per cubic yard of concrete of Davis Color "Omaha Tan" or similar color should be included in all concrete pavement design mixes. Efforts will be made to include recycled aggregates and/or recycled fly ash to make the trail more ecologically friendly.

Regional Trails

Regional trail surfaces will be concrete with integral color and have a natural crusher fines trail located between the concrete trail and the river. Implementing a dual-surface trail is intended to minimize conflicts between pedestrians and cyclists.

Regional trail criteria include:

- Minimum 10 feet trail width
- A cross slope shall be constructed with a 2 percent cross slope, which is the maximum allowed by ADA, with the pavement low point on the downhill side. This slope will help prevent ponding and ice formation on the path. 6 inch pavement thickness, placed over a properly compacted subgrade.
- Pavement shall be concrete for all regional, shared-use paths. Other pavement types will need to be approved by the DPR.
- A clear zone of 3 feet (2 feet minimum) graded at a maximum of 6:1 is required on each side of the trail. An overhead vertical clearance of 10 feet (8-feet-4-inch minimum) or 14-feet-6-inches for equestrian users is required within the 16-foot trail and clear zone width. The clear zone shall be flush with finish grade of the trail (maximum of 1 inch from finish grade of trail to finish grade of clear zone).
- Natural Areas are composed of crusher fines or seeded with short (<6-inch) tall-native grasses. In keeping with the green design approach, grasses should not be mowed on a routine basis to discourage establishment of weeds and invasive vines.
- Paved shoulders shall be provided as a zone of recovery for cyclists to regain their balance in areas where a maximum sideslope of 6:1 cannot be accommodated and particularly in areas where trail obstructions are present within the established clear zone of 3 feet (retaining walls, rocky slopes, rivers, etc.). This recovery zone shall be 3 feet in width (2 feet minimum) and shall be finished with 3/8-inch tooled joints on 1-foot centers to provide a tactile warning to users

that they have strayed off the path. Since the trail is adjacent to the river, a wider separation should be considered.

- A minimum 5-foot separation from the edge of the path pavement to the top of the slope is desirable. Depending on the height of embankment and condition at the bottom, a physical barrier, such as dense shrubbery, railing, or chain link fence, may need to be provided.

- Minimum horizontal curvature along the centerline of the path is 90 feet. This minimum curvature applies where the cross slope of the path is 2 percent and the assumed lean angle of the bicyclist is 20 degrees. At trail intersections, access ramps, etc., the minimum inside radius is 20 feet to ensure maintenance vehicle accessibility (for sweeping and snow plowing). Pavement markings and signs will be provided to alert users to any possible obstructions.

Local Trails

Local trails will follow the same criteria for regional trails except for the required width. The typical width is 10 feet (8-foot minimum). However, no clear width is required in grassed areas.

Boardwalks

Boardwalk construction will conform to the United Building Code (UBC) and local building codes as per the City and County of Denver. Boardwalk design criteria include:

- 6- to 8-feet wide and less than 30 inches above finished grade so no safety rail is needed.

- Raised wood curbs to prevent bikes/wheelchairs from wandering off the boardwalk. Constructed of durable materials that resist water damage. The standard element of the boardwalks (i.e., posts and piers) will be either a composite wood product ("trex") or concrete to prevent water infiltration. Either the deck surface will be a composite wood product (trex) or environmentally friendly treated lumber. The balance of the boardwalk rails and posts will be a CCA treated lumber product. Hardware attachments will be galvanized and have tamper proof hardware.

Boardwalks will adhere to the green design concept and will be designed and constructed in such a manner so as to have minimal impact on the surrounding riparian corridor.

Natural Trails

Natural trails will be constructed of either crusher fines, consisting of a natural earth-tone rock product or native soil devoid of vegetation. Red crusher fines should be avoided because of their ability to migrate and stain adjacent concrete trails. Natural trails shall conform to the U.S. Forest Service Trail Accessibility Guidelines (2012).

Improved natural trails shall be crusher fine material that is cut into grade and is a minimum of 4-inches deep. Widths of trails will vary; however, a minimum 4-foot width is required for improved natural trails.

Unimproved natural trails will be natural soil/gravel that has the vegetation removed. These trails are sometimes referred to as desire line trails (or social trails) and are created by repeated walking over the same area.


Grey crusher fine trail.


Tan crusher fine trail.

4.2.1.2 Boat Launches

The design of proposed boat launches and fishing access points will follow the criteria in the Recreation Facility Design Guidelines (U.S. Department of the Interior Bureau of Reclamation 2002). The boat launches will be a faux rock (i.e., sculpted concrete) structure to allow for ADA access.

4.2.1.3 Fishing Access

Access to fishing areas will also be provided at the boat launch locations. Therefore, designated fishing access points will follow the requirements for boat launches. In addition, the design shall provide areas for unobstructed casting along the banks with minimum tree and woody vegetation distances of 25 feet.

4.2.2 Park Facilities

This section describes design criteria for rest areas, river overlooks, retaining walls, and restroom facilities.

4.2.2.1 Rest Areas

Rest areas will be designed in accordance with the adjacent, access trail and sized accordingly to accommodate benches, bike racks, and trash/recycle containers. The site amenities shall be designed to be durable and easily maintained. Site amenities shall be approved and conform to the City and County of Denver Parks and Recreation Standards.

4.2.2.2 River Overlooks

River overlooks are similar to rest areas, located to view the river and allow access to the river. The intent of this design is to improve existing overlooks, utilizing material such as rocks/boulders present at each site. As with rest areas, site amenities such as benches, trash receptacles, bike racks, etc. will be included.

4.2.2.3 Site Retaining Walls

Natural materials such as rocks, boulders and recycled timbers will be used, where possible, to construct retaining walls. Rock and boulders should be a consistent grey, brown, and tan color. Retaining walls will be stepped to reduce verticality and with a maximum step height of 30 inches, eliminating the need for safety rails.

4.2.2.4 Restroom Facilities

The Parks and Recreation Standards will be used to size restroom capacities. The parks within project area currently include portable restroom facilities that will continue to be used in the improved parks, with the following improvements:

- Portable restrooms shall have a hardscape access for trucks and a minimum of one portable restroom should be accessible and such restrooms shall meet ADA guidelines for access. Follow other criteria as established in the Prototypical Restroom Guidelines (Department of Parks and Recreation and City and County of Denver 2005).
- Integration of the restroom facility into the related park(s) so they can be easily found by park users and are near roads for reasonable access by maintenance staff. Restrooms will be located within sight and reasonable walking distance of the most intensely used areas; but, at least 50 feet away from playgrounds to discourage children from incorporating the facilities, such as drinking fountains, into their play routines.

Restroom facilities will be visible from the areas of intense activity within the park, and where possible, visible from park entrances and the street for safety reasons.

4.2.2.5 Site Furnishings

All furnishings, amenities, and signage in natural areas will be of the same specifications and quality as those in traditional parks. Section 3.8, Furnishings, of the Denver Parks and Recreation Standards provides details for natural area benches and fencing. Interpretive Signage will be designed based on National Park Service guidance and specifications.

4.2.3 Aquatic Habitat

The primary task of the UDFCD is to preserve and improve drainageway stability and flood conveyance capacity. In this context the USDCM does not include criteria specifically relating to habitat improvement and many components of the habitat elements do not fall under the UDFCD mission. Therefore, project-specific habitat design criteria were developed from aquatic habitat preferences for target fish species.

Design criteria for aquatic habitat enhancements can be categorized relative to the process they are intended to define or the objective they are intended to meet. The objective of the aquatic habitat enhancements is to improve the aquatic habitat for target fish species using instream features (e.g., riffles, pools) and structures (e.g., large-woody debris, boulder clusters) described in Section 3.3. Included in these criteria are target species habitat preferences, design discharges, channel morphology parameters, hydraulic and sediment transport characteristics, and habitat structures design parameters as well water quality considerations.

4.2.3.1 Habitat Preferences

As noted in Section 2.2, the CDOW has identified many native and nonnative fish species in the study area. The fish sampling compiled by CDOW provided the basis for the identification of target species that are used to establish hydraulic and geomorphic criteria for proposed aquatic habitat enhancements. The selected target fish species include:

- Black Bullhead (*Ameiurus melas*)
- Channel Catfish (*Ictalurus punctatus*)
- Common Shiner (*Luxilus cornutus*)
- Creek Chub (*Semotilus atromaculatus*)
- Green Sunfish (*Lepomis cyanellus*)
- Longnose Dace (*Rhinichthys cataractae*)
- Longnose Sucker (*Catostomus catostomus*)
- Largemouth Bass (*Micropterus salmoides*)
- Common Carp (*Cyprinus carpio*)

Habitat Preferences

HSI information was used to obtain preferred target species habitat criteria. The HSI curves provided information on preferred channel substrate and hydraulic characteristics for each fish. When aggregated, the criterion result in a range of velocities and depths that would provide preferred habitat.

Habitat preferences for these species include:

- Varied bedforms (e.g., riffles, pools, runs) and habitat structure
- Varied currents (generally velocities <1 foot per second (fps) during low flows)
- Depths of 0.5 to 1 foot in riffles during low flows
- Pools with low flow depths greater than 2 feet
- Variety of substrates including from silt and organic debris, sands, gravel, rubble, and exposed bedrock
- Brush, vegetation, and rock cover
- Gradients between 0.1 and 0.8 percent
- Spawning habitat including pools, riffles, crevices, aquatic plants and algae, debris, sand, and gravel substrates

Target species diets include macroinvertebrates (adult and larval insects), microcrustaceans, zooplankton, rotifers, and filamentous algae. These supporting organisms require organic material for sustenance resulting in the need for the South Platte River to support aquatic vegetation and accommodate organic (i.e., woody) debris and detritus.

The objective of the aquatic habitat design is to identify instream features (e.g., riffles, pools) and structures (e.g., large-woody debris, boulder clusters), which provide the habitat preferences described above. These preferences should be used as criteria when designing the features and structures described in Section 3 within the physical constraints of the project.

Based on species preferences, the preferred aquatic environments are lotic riffle-pool-run sequences and lentic, backwater pools. The pools provide refugia for fish so that they can survive periods of very low flow.

4.2.3.2 Design Discharges

Design criteria related to hydrology include the low (i.e., average) flow conditions, channel-forming flow, and design flood flow. The low flow and seasonal flow design discharges are necessary to design aquatic habitat structures (such as pool depth) while the design flood flow is necessary to design habitat structures to remain stable during that flow and to check the regulatory flood elevations.

Low Flow

For this design, the low flow will be used to determine the minimum depth and velocities for target fish species. Low-flow rates are particularly critical for aquatic habitat because they may not sufficiently inundate habitat areas. As described in Section 2.4, the lowest average monthly flows on record occurred in January and February of 2003; 21.5 cfs and 21.8 cfs, respectively. Therefore, a value of 21 cfs will be used as the design low flow.

Channel-Forming Flow

For this design, the seasonal flow will be used to determine the appropriate channel cross-sections for active channel within the main channel (see Channel Modifications section below). Bankfull flow is often used as the representative discharge for channel design since it is the maximum discharge, typically between the 1- and 2-year events, that the channel can convey without overflow onto the floodplain. However, because the river is channelized, it does not have a floodplain. Therefore, the bankfull flow concept is not applicable. Seasonal flows are considered a more accurate representation of the flow that will dominate the "active channel" form and process. This channel-forming discharge will have the greatest impact on channel planform, cross-sectional geometry, and bedforms.

A value of 781 cfs will be used in the design of channel modifications. The velocity associated with this flow will be used as an indicator of the streambed stability and potential scour that may impact habitat features.

Design Flood Flow

Design flood flow for this project is the 1-percent recurrence interval storm event, which is 16,500 cfs.

4.2.3.3 Channel Modifications

Restoration of incised streams typically involves reconnecting the channel to its former floodplain or creating a new floodplain at the lowered channel bed elevation. However, the constraints placed on the South Platte River and adjacent lands within the project area prevent reestablishment of the natural floodplain associated with high flows. Therefore, the channel modification (i.e., morphology) design criteria focuses on developing a low flow channel form, which provides low flow channel migration with a defined thalweg in the "active channel" and incorporates the habitat features and structures described in Section 3. Specifically, the channel morphology design criteria focus on planform, bedform, cross-section, and profile to provide a geometry and bed profile to support target species habitat features and structures.

Planform

The channel planform design is intended to reestablish, where possible, low flow meanders in the channelized main channel reach and develop a thalweg that sets the alignment of the active channel.

In addition, local planform modifications will create a meandering active channel and thereby increase the sinuosity so that it is greater than 1.3. The low flow meander pattern is a function of channel width. Typically, wavelengths and radius of curvature are respectively about 10-14 and 2-3 times channel width.

Bedform

Riffles are proposed to help create a defined thalweg in the river upstream of the Florida Avenue drop where sedimentation has occurred. The riffles will direct the thalweg from the outer bank of the upstream bend to the outer bank of downstream bank, crossing the channel at the low point of the riffle. On average, riffle sequences in sand/gravel channels should be spaced approximately six main channel bottom widths apart; however, this value can vary from three to up to ten channel bottom widths depending on the substrate, planform, and slope (Knighton 1998).

Three types of riffles are proposed on this project. Type 1 riffle (Newberry) should have a downstream slope of 20H:1V and upstream slope of 4H:1V. Type 2 riffle ("S") should have a minimum downstream slope of 40H:1V and no upstream slope. Type 3 riffle, or a "cross over" riffle, should have a minimum downstream slope of 30:1 and no upstream slope. These riffles will consist of a well-graded mix of river rock and angular quarry stone with a nominal diameters ranging from 3 to 18 inches.

The "multi-objective riffle" that is planned at the current location of the Florida Avenue grade control structure, will have a mix of boulders and riprap. A boulder keyway will be used to anchor the riffle and define the transition from upstream to downstream. Grout is not recommended but may be required to keep the structure in place during high flow events.

Point bars will be placed at the inside curve of the low-flow channel bends between the constructed cross-channel riffles and anchored with a combination of woody debris and boulders. Bars will be constructed of a mixture of native alluvial material; sands, gravels, and cobbles. Bar width will be a minimum of 25-feet and approximately 2- to 3-feet above the adjacent thalweg elevation.

Cross-Section

The primary cross-section design criteria include low-flow conveyance and providing aquatic and river-edge habitat and hydraulic complexity. In addition, the channel is required to maintain regulatory flow capacity, geomorphic stability (self-maintenance of channel shape over time) as well as geotechnical stability (resistance of banks to mass failure).

Cross-section design will be evaluated using the hydraulic model described in Section 4.3.

Profile

Site constraints limit longitudinal gradient options downstream of Florida Avenue and upstream of Evans Avenue. However, in areas where the existing profile can be changed, between Florida and Evans Avenues, a minimum channel slope of 0.001 ft/ft (0.1%) is recommended. The proposed channel slope should be refined based on results from the sediment transport analysis (see Section 4.4 below).

Summary

Proposed channel morphology criteria include:

- Development of an "active channel" with a defined thalweg, where possible.

- Riffle/pool sequences with defined sand/gravel bars, were possible.
- A channel-forming flow using the highest monthly average flow of 781 cfs
- Variable channel sideslopes, ranging from a maximum of 3H:1V to a minimum of greater than 5H:1V. Common sideslopes are between 3H:1V and 4H:1V.
- A varying substrate of gravel, cobble, and sand depending on morphologic feature and localized velocities. Installation of flow re-direction structures, large wood, boulder clusters, or other roughness elements that promote predictable patterns of scour, deposition, and local energy dissipation.
- Riparian woody vegetation (trees and shrubs) to provide a shade canopy over the pools.
- Inclusion of woody debris along the channel, and boulder clusters in the riffle sections of the channel to provide turbulence, refugia for target species, and a nutrient substrate for macroinvertebrates. These habitat features should be placed so as to minimize trash capture.

Substrates will be segregated according to morphologic feature—gravels and cobbles in riffles, and a mixture of native material; sands, gravels, and cobbles in the "active channel" and bars. Some resorting of this material by the river should be expected.

4.2.3.4 Habitat Structures

This section describes the prescriptive design criteria for bendway weirs, rock vanes, deflectors, boulder clusters, snags, and lunkers that will be used to establish aquatic habitat, define the low flow channel, and reinforce the channel banks.

Bendway Weirs

Bendway weirs, also known as barbs, are used to direct flows away from the river bank, but also to create a defined thalweg and scour holes. Flow is directed from the weir in a perpendicular direction to the weir axis. Therefore, the angle of the weir to the upstream bankline tangent should range from 50 to 75 degrees to direct flows into the thalweg, near the center of the channel.

The length of a weir should adequately direct flow but not adversely confine the channel. The effective length of a weir, defined as the projected length of the weir perpendicular to the flow direction, should not be greater than 25 percent of the channel width. The recommended maximum length is approximately 30 to 40 feet. It should be noted that, as weir length increases, scour depth and flow concentration adjacent to the tip increase.

Weir spacing is affected by weir length, the ratios of weir length to channel width, and the bend radius of curvature to channel width. Given that flow will be directed in a perpendicular direction from the downstream weir face, the subsequent downstream weir should be placed such that it captures this flow near its center before the flow impinges on the bank. The recommended spacing is approximately four to five times the weir length, which is roughly every 150 feet.

Weir height is determined by analyzing flow depths for the design flow. However, the height of the weir should be below the ordinary the ordinary high water mark, which, for the Project Reach, is on average 3 feet above the channel bed. Hydraulically, a weir needs to be of sufficient height to influence the secondary bed currents. The top of the weir should be flat, or nearly flat in the transverse direction, with a maximum longitudinal slope into the channel of 5:1. The flat weir section typically transitions into the bank on a slope of 1.5:1 to 2:1.

For rock weirs, the top width ranges from one to three times the D_{100} rock size. Wider structures will result in a more uniform weir effect and should be used if a deep scour hole is anticipated downstream of the weir, that could impact structural stability.

Weirs will be keyed into the bank to prevent flanking of the structure due to possible erosion in the near-bank region during submergent flows. Typically, the key-in length is about half the length of weirs with a minimum length of eight feet or 4 times the maximum rock size ($4xD_{100}$), whichever is greater. Weirs should also be keyed into the channel bed. This depth can be determined by calculating the expected scour depth around the tip of the weir. Dewatering will likely be required during excavation of the channel bed.

Rock Vanes

A rock vane is similar to a bendway weir but generally extends further out into the center of channel. The vane arm produces a longer, wider, and deeper pool than that created by bendway weir structures. The downstream pool dissipates energy and provides fish habitat.

Typical vane length is the distance measured from the bank to the intercept with the invert elevation of the streambed at 1/3 of the channel width. However, in larger rivers such as the South Platte, it is not practical to extend the vane across 2/3 of the channel. The total length is typically based on the hydraulic and flow characteristics of the river and the purpose of the structure (i.e., habitat, bank stabilization). For this project, vanes primary purpose is habitat; therefore, the maximum length should be approximately 1/3 of the total channel width. The slope of the vane extending from the bank should vary between 2 to 7percent.

The structure should only extend to the ordinary high water mark elevation. Rock should be sized using hydraulic analysis using typical USACE riprap sizing procedures. The minimum footer depth at the invert for sand bed streams is approximated by the scour depth that could occur.

Deflectors

Deflectors are similar to bendway weirs in that they redirect, or deflect, the flow away from the streambank. However, deflectors also create scour holes and act as large woody debris if designed appropriately. As noted in Section 3, two types of deflectors are proposed for this project; wing deflectors and V-type deflectors. Generally, the same design criteria apply to deflectors as described for bendway weirs although deflectors will be constructed with logs (minimum 15-inch diameter). Wing deflectors should be triangular geometry with a minimum of 25-foot log length.

The height should be as high as the ordinary high water, which is approximately 3 feet about the channel bed. The structure should slope upwards towards the bank at no more than a 30-degree angle. Helical anchors shall be installed through the logs into the channel bed a minimum of 10 feet below the final channel bed elevation.

Wing deflectors should be properly keyed into the bank to prevent flanking of the structure. Typically, the key length is about half the length of log length and should have a minimum key length of 8 feet. Wing deflectors should also be keyed into the channel bed. The key depth can be determined by calculating the expected scour depth around the tip of the deflector. Dewatering will likely be required during excavation of the bed key.

The V-type deflector should be constructed with logs (minimum 12-inch diameter) held with steel anchors with a triangular geometry of 20-foot width and 3- to 4-foot height. Helical anchors shall be installed through the logs into the channel bed. V-type deflectors should be keyed into the channel bed. The key depth can be determined by calculating the expected scour depth around the tip of the deflector. Dewatering will likely be required during excavation of the bed key.

The void space of wing and V-type deflectors should be filled with small diameter riprap (6-inch D_{50}) that is mixed native channel material. The approximate ratio of riprap to native material is 70:30. This mixture should extend to the depth of predicted scour.

Boulder Clusters

Boulder clusters provide an easy to construct, effective structure that enhances stream beds and increases aquatic habitat along the reach. Boulder clusters should consist of three boulders placed together within the channel bed. These boulder clusters will consist of rocks with a 3- to 5-foot nominal diameter. The boulder will be tilted at a 10- to 15-degree angle towards the downstream direction.

Snags

The design of snag requires a thorough analysis of channel hydraulics. Stabilizing key members (large logs with rootwads attached) can be accomplished at most flows by the ballasting effect of large logs and/or boulders. Determining the necessary ballast mass requires a detailed stability analysis of fluid drag, buoyancy, lift and friction-resisting forces, and weight of the ballast logs and/or boulders. A structure is stable when the sum of the resisting forces exceeds the sum of the driving forces (e.g., drag, lift, and buoyancy). This analysis should be performed during the final design stage once all of the locations are specified.

Snags should be constructed with logs (minimum 15-inch diameter) held with steel anchors through overlapping logs. The key members should be oriented parallel to the high flow, with their rootwads upstream. Racked wood is generally positioned perpendicular to the flow direction. Helical anchors shall be installed through the logs into the channel bed a minimum of 10 feet below the final channel bed elevation.

The height should be as high as the ordinary high water, which is approximately 3 feet about the channel bed. The key members should have a minimum length of 8 feet embedded into the channel bank. Key members should also be keyed into the channel bed. The key depth can be determined by calculating the expected scour depth around the tip of the deflector. Dewatering will likely be required during excavation of the bed key.

Woody debris, such as snags, are an important source of nutrients for macro-invertebrates and other food sources and also provides refugia for target species that are susceptible to predators. In addition, woody debris also serves as refugia during high flow events. Woody debris, however, captures floating and submerged debris that can result in unsightly collections of trash. Therefore, locations of woody debris should be carefully chosen to avoid trash collection and other inorganic debris.

Lunkers

Lunkers are similar to wing deflectors except that an open box (e.g., box culvert, wood frame) is installed between the two angled logs to provide shade habitat for fish. The same design criteria apply to lunkers as described for deflectors. The logs should have a minimum of 25-foot log length and box should be a minimum of 8-feet wide, 4-feet deep, and 5-feet tall.

The top of box should be below approximately 1-foot below the ordinary high water. The bottom of the box should be a minimum of 3 feet below the channel bed. Helical anchors shall be installed through the logs into the channel bed a minimum of 10 feet below the final channel bed elevation.

Logs used in the lunkers should be properly keyed into the bank to prevent flanking of the structure. Typically, the key length is about half the length of log length and should have a minimum key length of 8 feet. Logs should also be keyed into the channel bed. The key depth can be determined by calculating the expected scour depth around the tip of the deflector. Dewatering will likely be required during excavation of the bed key.

Stacked logs should be installed on the back (bank side) of the box to prevent soil from the bank going into the box culvert. A geotextile fabric should be wrapped around the stacked logs to limit fines from the bank going into the box culvert.

4.2.3.5 Hydraulic Characteristics

Flow Velocity

Flow velocity preferences for target species are generally in the 0.5 to 1.0 fps range for the low flow. Increased velocities during the bankfull flow event should be of sufficient magnitude to scour sediments that could build up during intervals of low flows and velocities. High flow velocities should ideally range in the 4 to 5 fps range, sufficient to scour silt and clay deposits, but not so high that scour causes bed or bank erosion.

Turbulence should also be low, although some is beneficial for reaeration of flow, maintenance of pool environments and riffle substrate, and the continued movement of sediment and debris through the system. Proposed riffles will provide short turbulent reaches that maintain a gravel/cobble substrate.

Flow Depth

Target species preferences for water depths during low flows are 0.5 to 2.0 feet over riffles and 3-foot minimum pool depth. Ideally, average riffle depths should range from 8 inches to several feet while pool depths should range from 3 feet to 5 feet. Deeper pools can be implemented but the length of channel needed for such pools would begin to limit riffle lengths.

Channel Roughness

The roughness of an open channel is a function of bed and bank material, geometric irregularities, variability of conveyance area, density and type of vegetation, and effects of obstructions. Roughness is generally expressed as the Manning's coefficient. This coefficient is usually divided into separate coefficients for channel and overbank floodplain as both drainageway elements exhibit different roughness characteristics. **Table 4-1** contains estimated channel and overbank roughness coefficients previously used in the regulatory hydraulic model.

Table 4-1 Proposed Roughness Coefficients

Coefficient	Left Overbank n-Value	Channel n-Value	Right Overbank n-Value
Downstream Boundary and Florida Ave.	0.048	0.03	0.045 – 0.048
Florida Ave. to Evans Ave.	0.045 – 0.055	0.03	0.048 – 0.055
Evans Ave. to Upstream boundary	0.045 – 0.055	0.03	0.045

Some variability in the channel is necessary for healthy, sustainable habitat conditions and vegetation is anticipated in both the channel and floodplain. While there is limited floodplain, several floodplain benches composed of trees and woody shrubs are proposed. It is anticipated that the existing invasive vegetation along the banks will be removed and replanted with native vegetation.

4.2.3.6 Sediment Transport

A common goal for a channel restoration design is that long-term aggradation and/or degradation should be small enough to allow for economical channel maintenance. Ideally, a channel should be self-sustaining and not require any maintenance. However, one aspect of sediment transport that represents a risk that cannot be fully predicted is situations where the river is subjected to the design flood event (i.e., 16,500 cubic feet per second [cfs]). During these times the entire river and floodplain will be inundated with floodwaters probably carrying higher levels of sediment and debris. It is probable that these waters will deposit sediments and debris in the channel and could impact habitat features. Subsequent to such an event, recurring low flows (i.e., channel forming flows) should scour the channel and reestablish the design morphology. However, it is possible that maintenance may be required periodically to restore the habitat functionality if the morphology changes dramatically due to extreme flows.

Channel morphology and habitat structures are intended to diversify habitat that shall be sustained over the long-term even in the event that the channel adjusts to changing inputs, while retaining characteristic features and forms over time.

4.2.4 River Channel Stability

Utilizing recreation and habitat improvement components that maintain or improve stream stability, with respect to both the channel and the banks is an important objective of this project. The Urban Storm Drainage Criteria Manual (USDCM) Volume I, Chapter 4 entitled Major Drainage, addresses design guidelines for open channels. Natural channels with vegetated banks, such as the South Platte, should have bank slopes no greater than 3:1. If steeper side slopes are required, riprap or other stabilization will be required.

Also, as noted above, the intent of the channel morphology is to establish a stable streambed and banks that allows localized changes in planform and cross-sectional geometry. It is important that channel features are designed in a manner that the bed and banks can respond to fluctuations in hydraulic characteristics with only moderate amounts of realignment in locations where constraints are not present. Some local-lateral migration and cross-section adjustment within the "active channel" areas can be expected in the future as the channel evolves and matures.

Chapter 8 of USDCM Volume II, Hydraulic Structures, addresses design guidelines for grade control structures. Grade control structures, such as drop structures, provide for energy dissipation and thereby result in a mild slope in the upstream channel reaches. The geometry at the crest of these structures can effectively control the upstream channel stability and, to an extent, its ultimate configuration (UDFCD 2008).

Drop structures are proposed at the outlet to Harvard Gulch. These drop structures should be design according to USDCM and applicable City and County of Denver standards for outlet structures. The maximum drop height is 3 feet.

4.2.5 Floodplain Benches

Floodplain benches restore the interactions between the river and its riparian corridor by increasing the frequency of riparian inundation, resulting in of the restoration of hydrologic and ecologic functions. The benches will be associated with point bars that begin at the low flow water surface.

Establishing the correct bench elevation is critical to the viability of the emergent plants. The elevation should be at or just above the ordinary high water mark. Floodplain benches must have stable banks (4H:1V or shallower) and be vegetated with native vegetation. Hydraulic modeling is required to properly evaluate flow characteristics of the reconnected floodplains. In addition, the river's sediment load needs to be considered through sediment transport modeling.

The floodplain bench should be constructed using compacted fill consisting of sands and gravels. A rock toe should be incorporated in order to prevent erosion of the bench during high flow conditions. Top soil should be placed on top of the compacted fill and planted with a diverse mix of native tree and shrub species (see Section 4.2.8). Species should be mixed randomly across the site and ideally a mix of dominant tree species, understory trees and shrubs, and herbaceous plants should be planted.

4.2.6 Boating Considerations

One of the goals of this project is to improve the boating in the project area. Therefore, all structures should be designed with public safety as a special consideration. The design should avoid hazardous hydraulics that would trap a boater, such as at a drop structure having a reverse roller that may develop as the hydraulic jump becomes submerged.

The design should include boating considerations when designing the channel modifications (Colburn 20__). Designs for boatable channels have to prevent the development of submerged hydraulic jumps, have a gently sloped or stepped downstream face, and not have a deep stilling basin that would encourage the creation of a submerged hydraulic jump. Drops, including riffles, should have a sloped downstream face at 10(H) to 1(V) to permit safe passage of boaters as the move over them.

The riffles should incorporate a boat chute designed in accordance with carefully planned components that are consistent with recreational requirements for boater safety. Additionally, hydraulic structures on boatable channels should not create obstructions that would pin a canoe, raft, or kayak, and sharp edges should be avoided (UDFCD 2008).

4.2.7 Vegetation

Active and conservation/restoration natural parks areas are proposed. The City Naturalist shall approve all site plans, plant specifications, schedules, and plans in natural areas.

4.2.7.1 Invasive Vegetation

Invasive trees, shrubs, and noxious weeds described in Section 2 shall be removed from this project, where feasible and as approved by the Denver Parks and Recreation Forestry Office.

4.2.7.2 Native Vegetation

After grading has occurred, native vegetation will be planted to create the emergent benches and upland areas described in Section 3. Native vegetation also helps to bind the soil matrix, which inhibits bank erosion.

The following lists are being provided as a guide to proposed native species. The letter designation denotes whether it is an Upland Plant (U), Riparian Plant (R), or Emergent Plant (E).

Native trees will generally include:

- Plains Cottonwood (*Populus deltoides*) – U
- Narrowleaf Cottonwood (*Populus augustifolia*) – U
- Peachleaf Willow (*Salix amygdaloides*) – R
- Western Chokecherry (*Prunus virginiana*) – U
- American Plum (*Prunus americana*) – U
- Rocky Mountain Maple (*Acer glabrum*) – U
- Rocky Mountain Juniper (*Juniper scopulorum*) – U
- Big Tooth Maple (*Acer grandidentatum*) – U

Note, that all newly planted native trees will be protected from beaver damage.

Young and sapling trees are susceptible to beaver damage.

Existing tree with beaver protection in Grant-Frontier Park.

Native shrubs will generally include:

- Woods Rose (*Rosa woodsii*) – U
- Pinyon Pine (*Pinus edulis*) – U
- Mountain Mahogany (*Cercocarpus montanus*) – U
- Gambel Oak (*Quercus gambelii*) – U
- Threeleaf Sumac (*Rhus trilobata*) – U
- Sandbar Coyote Willow (*Salix exigua*) – R

Native grasses will generally include:

- Dwarf Maiden Grass (*Miscanthus sinensis* "morning light") – R
- Little Bunny Fountain Grass (*Pennisetum alopecuroides* 'Little Bunny') – R
- Porcupine Grass (*Miscanthus sinensis* var. Strictus) – R
- Red Top Bent Grass (*Agrostis Stolonifera*) – R

4.2.7.3 Emergent/Herbaceous Species

Submerged species will generally include:

- Torrey's Rush (*Juncus torreyi*) – E
- Leatherleaf Sedge (*Carex buchananii*) – E
- Porcupine Grass (*Miscanthus sinensis* var. Strictus) – E
- Cloaked Bulrush (*Scirpus pallidus*) – E
- Fowl Bluegrass (*Poa palustris*) – E
- Creeping Sedge (*Carex chordorrhiza*) – E

Aquatic fringe (i.e., emergent) species will generally include:

- Nebraska Sedge (*Carex nebrascensis*) – E
- Arctic Rush (*Juncus arcticus*) – E
- Wooly Sedge (*Carex lanuginosa*) – E
- Spikerush (*Eleocharis quinqueflora*) – E
- Beaked Sedge (*Carex utriculata*) – E
- Inland Saltgrass (*Distichlis stricta*) – E
- Colorado Rush (*Juncus confusus*) – E

4.2.7.4 Soil Amendments

Soil amendments will vary depending on the planting zone it will support. The following is a general recommendation of soil amendments for each "zone." It is recommended to obtain a soil analysis of the final subgrade before making specific recommendations or the type of amendment or specific organic contents.

4.2.7.5 Irrigated Bluegrass/Turf Areas

The decision on whether to irrigate and what type of irrigation system to be used will be approved by the Parks and Recreation's Project Manager and City Naturalist.

Upland Areas

Most of the areas of Grant Frontier Park will be regraded and stripped of all organic matter. Therefore, it is recommended that soil amendment be added to finished grades at the rate of 2 cubic yards per thousand square feet.

Riparian and Emergent Areas

The benches should be top dressed with approximately 6 inches of well graded topsoil with an organic content of 3 to 5 percent and a neutral pH of 7.0.

4.2.8 Floodplain Management Considerations

Proposed activities within the regulatory (100-year) floodplain and floodway are regulated by the City and County of Denver, a participating community in the National Flood Insurance Program (NFIP) administered by the Federal Emergency Management Agency (FEMA). This project will be constructed within the South Platte River floodway and floodplain. Proposed improvement components must be designed such that there are no adverse impacts to Base Flood Elevations (BFEs) (i.e., zero rise in the 100-year water surface elevation) or floodplain extents. Impacts will be assessed by comparing an existing conditions (i.e., corrected effective) hydraulic model based on the South Platte River effective regulatory model to a proposed conditions hydraulic model (see Section 2.6).

The 1 percent annual probability (100-year) flood will be used as the design basis for predicting impacts to regulatory flood elevations. A proposed conditions hydraulic model has been completed for this project. See Section 4.3 Hydraulic Analysis for detailed modeling approach and results.

4.2.9 Geotechnical Recommendations

The geotechnical analysis concludes that the existing geological conditions should support proposed in-channel improvements such as drop structures, ramp pavements, shallow spread footings and mats directly on natural granular alluvial soils, or on properly compacted structural fill or on claystone bedrock. Based on the swell-consolidation test, nil to low swell potential is expected.

Furthermore, the existing overburden soils should be suitable for use as site grading fill, and some may be suitable for use as structural fill beneath foundations and pavements and as retaining wall backfill. The claystone bedrock encountered in this area is very hard and may be difficult to achieve the expected placement and compaction requirements.

For the existing soils and bedrock unreinforced embankment fills and permanent cut slopes above the groundwater table should be constructed no steeper than 2H:1V based on stability requirements and 3H:1V for reducing erosion susceptibility. Additionally, seepage may be encountered in permanent excavation slopes and if encountered the risk of slope instability significantly increases.

4.2.10 Overland Golf Course Diversion and Pump Station

This section describes the design criteria for replacing the existing irrigation pump station near Florida Avenue. Based on the project's goals, CDM Smith recommends a passive submerged wire screen with air-burst connections and a shore located pre-cast circular concrete wet well. This type of intake structure could accommodate several pump types including a submersible wet pit pump or a vertical turbine wet pit pump (similar to what is currently installed). **Table 4-2** summarizes the characteristics and design criteria for the proposed intake systems.

Table 4-2. Intake Characteristics and Design Criteria

Parameter	Proposed System
Configuration	Passive submerged screen with air-burst connections and shore located pre-cast circular concrete wet well
Screen type	Wire – Tee or drum configuration
Screen openings	1/4"
Intake Flow Rate	500 gpm
Intake velocity	0.5 fps max
Minimum river water surface elevation	5233 ft
Top of intake elevation	2 ft below minimum
River bottom elevation at intake	~5229
Wet well bottom elevation	5 ft below top of intake screen
Wet well top elevation	Match existing shore elevation
Wet well diameter	6 ft

4.2.11 Water Quality

U.S. Environmental Protection Agency (USEPA) regulates and monitors the major point source discharges into the South Platte River; however, nonpoint sources such as stormwater runoff can also contribute to the water quality of the river. Therefore, USEPA provides BMPs for treating stormwater runoff prior to discharging into the South Platte River in order to reduce water quality. In addition to USEPA, Colorado Department of Transportation (CDOT) provides Erosion Control and Stormwater Quality Field Guide (CDOT 2011) and UDFCD contains Water Quality Management Plan for Stormwater Quality BMP Implementation Guidelines.

4.3 Hydraulic Analysis

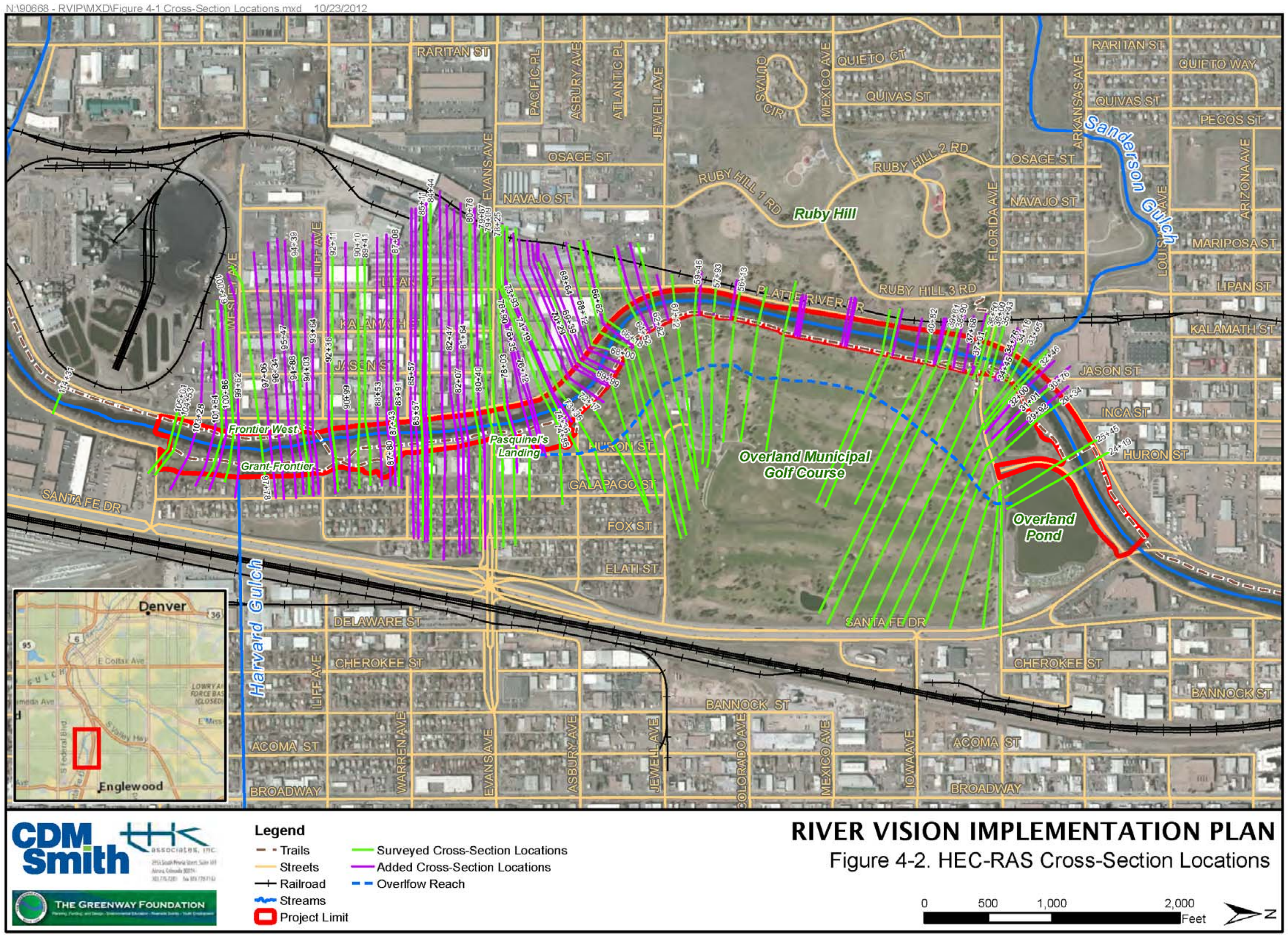
Proposed project components may affect water surface elevations (WSELs), making it necessary to compare the proposed flow conditions with the regulatory flow conditions. The potential impacts of the proposed project components were evaluated using USACE's HEC-RAS v 4.1.0 similar to the existing (i.e., without project) conditions. The proposed project model is referred to as the "with-project conditions."

4.3.1 With-Project Conditions Model

The corrected effective hydraulic model (see Section 2) served as the basis for development of the with-project conditions hydraulic model. Cross-sections were added to the corrected effective model to incorporate habitat improvements along the project reach, and cross-section geometry was adjusted to represent proposed re-grading in the channel and overbank areas. **Figure 4-1** shows the locations of the cross-sections used for the With-Project hydraulic model. The habitat improvements and proposed regrading were added to the hydraulic model based on the preliminary design drawings provided in Appendix F. Blocked obstruction option in HEC-RAS was used to simulate habitat improvement features at each cross-section of the hydraulic model. Also, inline structure option was used for riffles. **Table 4-3** describes the dimensions of the HEC-RAS options assumed for each of habitat improvement features.

Table 4-3. Dimensions of the HEC-RAS Options Used to Simulate Habitat Improvement Features

Habitat Improvement Features	Width/Length (ft)	Depth (ft)
V-Deflector	10 ft per detail with 2 Rood Wads; Width = 10 ft + 2*2 ft = 12 ft	4-15" logs per detail with 1 log below streambed; Depth = 3*1.25 ft = 3.75 ft
Snag	Assumed length of log per detail; Length = 15 ft	2/3 of boulder depth plus 1 ft freeboard, assuming 1/3 of boulder depth buried under streambed per detail; Depth = 2/3*4 ft + 1 ft = 3.67 ft
Rock Vane	Represented with change in roughness (n=0.05 for cobbles with boulders)	
Bendway Weir	Length = 1/4 of channel width at mean average flow	Depth based on elevation of maximum average monthly flow (781 cfs); varies for each improvement
Riffle/Grade Control Structure	Cross-sections upstream and downstream of the riffle were added to show the elevation loss at cross-section. Additionally, roughness was adjusted at one of the cross-sections to represent change in bed material, n=0.05 for cobbles with large boulders	
Floodplain Terrace	Re-graded cross section geometry to represent floodplain terrace	
Boulder Cluster	2 Boulders; Width = 10 ft	2/3 of boulder depth plus 1 ft freeboard, assuming 1/3 of boulder depth buried under streambed per detail; Depth = 2/3*5 ft + 1 ft = 3.3 ft
Boat Launch Ramp	10 ft per detail	Varies per detail; assumed 3 ft
Lunker	4 ft per detail with assumed 2 ft for Rootwood; Width = 2 ft + 4 ft = 6 ft	5 logs with 1 log below streambed per detail; Depth = 4*1.25 ft = 5 ft



RIVER VISION IMPLEMENTATION PLAN

Figure 4-2. HEC-RAS Cross-Section Locations

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Based on the flow data presented in Section 2, the with-project conditions model was run for three flow scenarios:

- Low flow: 22 cfs. January/February 2003
- Channel-forming flow: 781 cfs. This flow is equal to the highest average monthly discharge from the month of May. It is used as the design discharge for habitat features and structures, including bendway weirs and rock vanes. The top of these structures were designed to be the WSEL associated with this flow.
- Flood flow: 16,500 cfs. This flow corresponds to the 100-year regulatory flow in the FIS at Evans Avenue.

These three flows represent the lower, middle and upper end of the hydrology spectrum. The channel modifications and habitat structures should improve the habitat for this range of flows while also not raising the regulatory water surface elevation.

4.3.2 Results

4.3.2.1 Low Flow Conditions

Low flow conditions were analyzed using the With-Project hydraulic model described in Section 4.3.1. The model was used to analyze aquatic habitat characteristics such as depth and velocities for preferred habitat. Preferred habitat, as described in Section 4.2.3 and **Table 4-4**, were used to determine number of occurrences of preferred habitat for different flow conditions. **Figure 4-2** shows how the preferred habitat increased from existing to proposed conditions with regard to depth and velocity. An increase in the number of preferred habitat locations between existing and proposed occurs due to the designed low flow channel and terraces that provide areas of lower velocity and higher depths that attract most fish species.

Table 4-4. Summary of Preferred Habitat Characteristics

Flow Characteristics	Minimum	Maximum
Velocity (fps)	0	1
Depth Riffles (ft)	0.5	1
Depth Pools (ft)	2	

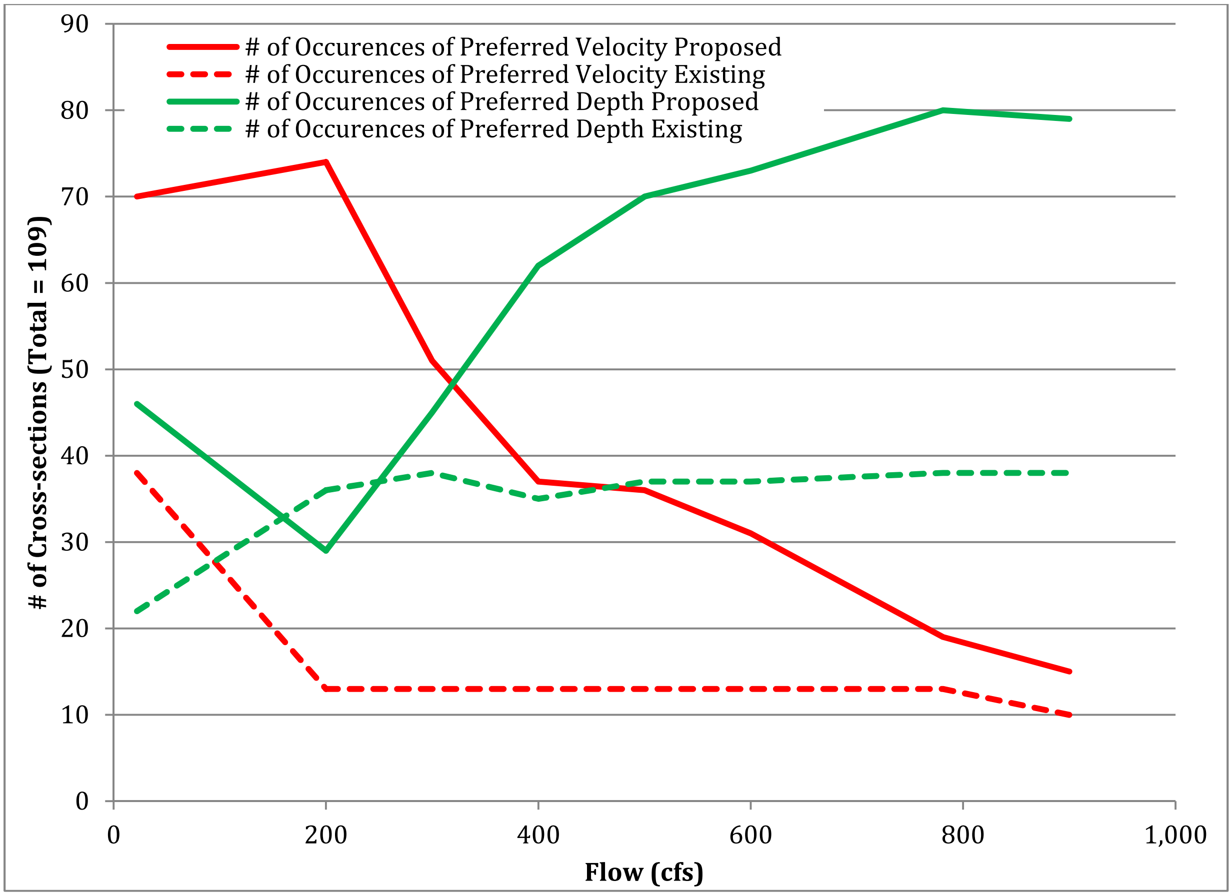

Figure 4-2. With-Project (i.e., Proposed) Flow Conditions versus Number of Cross-sections that contain Preferred Depth and Velocity

4.3.2.2 Channel-Forming Flow

Channel-forming flow was analyzed to determine the expected design velocities and depths along the terraces. As described in Section 4.2.3.2, the channel-forming flow was calculated at 781 cfs. Based on the hydraulic model, the "active channel" designed upstream of Florida Avenue conveys approximately 200 to 300 cfs. Therefore, to fully understand the typical range in velocities and depths experienced along the terraces, several flows were analyzed between 200 cfs and 781 cfs. The different flow conditions were summarized for depth (**Figure 4-3**) and velocity (**Figure 4-4**). As shown, depth ranges between 0 feet and 3 feet and averaging between 0.5 and 1 feet; whereas, velocity ranges between 0 and 5 fps and averaging between 1 and 2 fps. The final design for vegetation and bed material will account for these channel-forming velocities and depths as a guideline for design requirements.

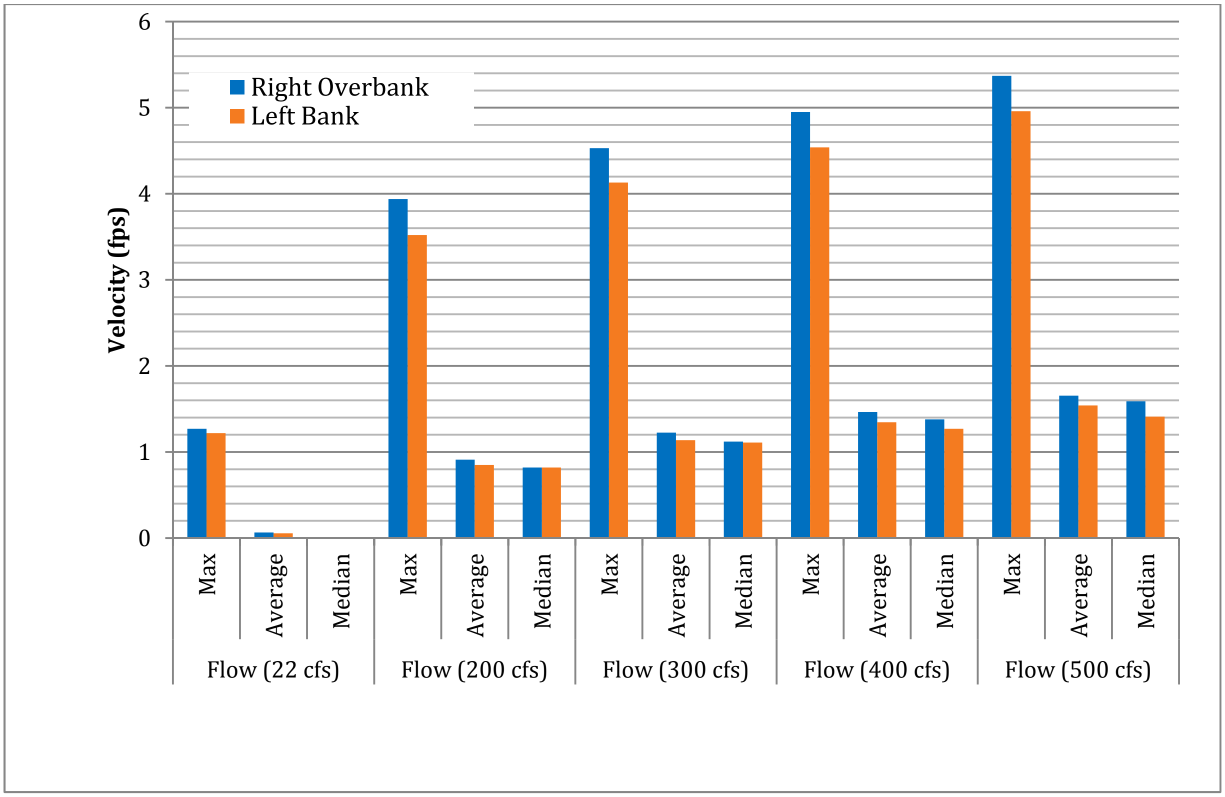

Figure 4-3. Expected Velocity on the Left and Right terraces for the With-Project (or Proposed) Conditions

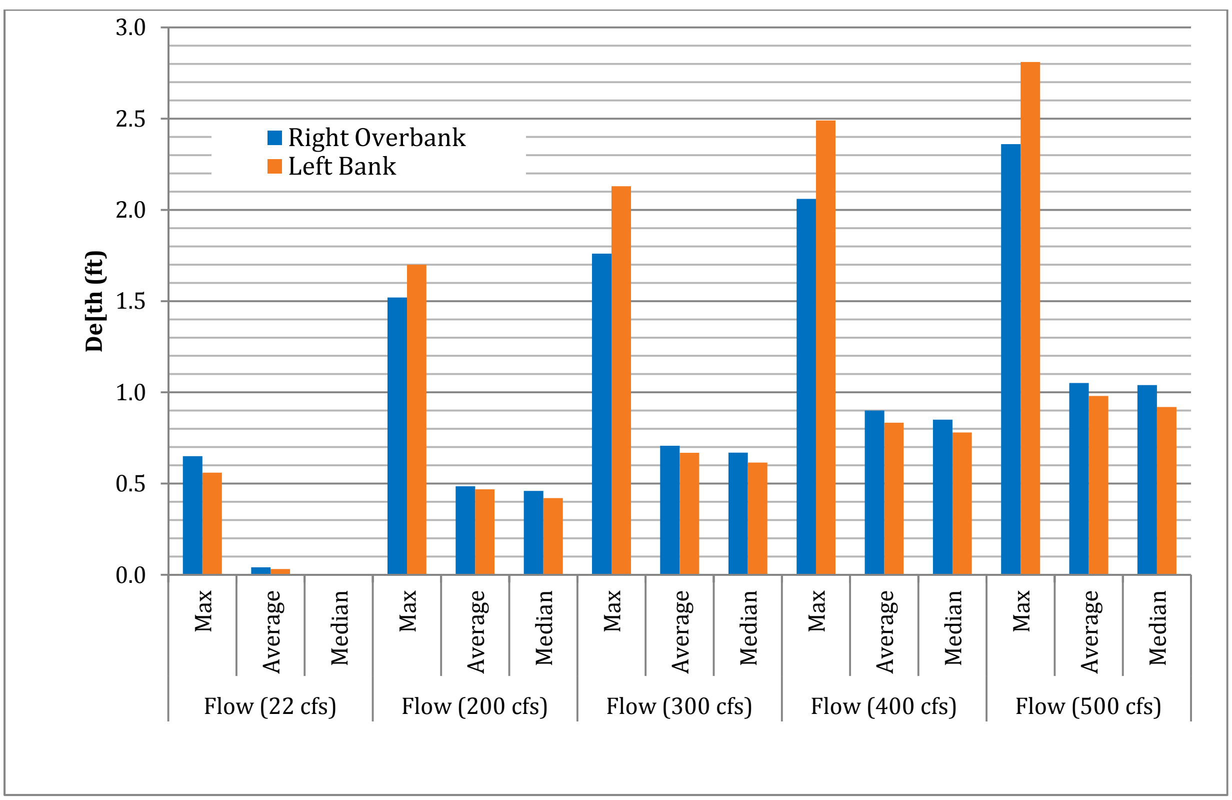

Figure 4-4. Expected Depth on the Left and Right terraces for the With-Project (or Proposed) Conditions

4.3.2.3 Flood Flow Conditions

Table 4-5 summarizes the HEC-RAS modeling results of the existing (i.e., corrected effective) and proposed conditions (i.e., with-project conditions) for 100-year flows with regulatory 100-year WSELs. See Figure 4-1 for cross-section locations and **Figure 4-5** shows WSEL comparison between the three different hydraulic models.

The WSELs calculated by the proposed conditions model are greater than those calculated by the existing conditions model at several cross-sections. The maximum increase in WSEL between existing and proposed conditions is 1.16 feet located at Station 1540+00 (Design Station 23+00) upstream of the Florida Avenue due to the revised grade control structure upstream of Florida Avenue. Other increases in WSELs occur because of two reasons, the proposed grading at Pasquinel's Landing Park can contain more flow inside the main channel compared to the corrected effective model (see **Figure 4-6** for Flow Comparison Figure), and the abrupt geometry change proposed for Grant Frontier Park cause an increase in WSELs.

In addition, the proposed conditions model shows two locations where the proposed water surface elevations are higher than the regulatory water surface elevations at lettered cross-section CV and CT with an increase at 0.07 and 0.34 feet, respectively. Based on the hydraulic results, the preliminary design will need to be adjusted prior to final design.

Velocities varied between the existing and proposed conditions. Proposed velocities range from 4 fps to 12 fps, while existing condition velocities range from 4 fps to 14 fps. Froude numbers of the existing and proposed conditions models range from 0.2 to 0.7 except during the existing Florida drop where the Froude number is 1. Therefore, the majority of the reach contains subcritical flow.

Table 4-5. Comparison of 100-year Flood Water Surface Elevations

Cross -Section Number(1)	Cross-Section Description	WSELs (ft)				Change in WSEL		
		Regulatory (a)	Duplicate Effective (b)	Existing Conditions (Corrected Effective) (c)	With-Project Conditions (d)	(c) - (a)	(d) – (c)	(d) - (a)
161471	41			5259.38	5259.49		0.11	
160541	40 - DC	5258.51	5258.72	5257.9	5258.09	-0.61	0.19	-0.42
160492	39			5257.78	5257.99		0.21	
160368	Laying Back Right Bank				5258.28			
160224	Wing Deflector				5257.93			
160158	38			5257.39	5257.87		0.48	
160126	Wing Deflector				5257.73			
160058	DB	5258.07	5258.38	5257.18	5257.66	-0.89	0.48	-0.41
160040	Boulder Cluster				5257.71			
160002	Boulder Cluster				5257.79			
159819	37 - DA	5257.96		5256.98	5257.66	-0.98	0.68	-0.3
159746	Snag				5257.59			
159674	Boulder Cluster				5257.52			
159587	Boulder Cluster				5257.49			
159480	36-CZ; Retaining Wall	5257.59	5257.94	5256.36	5257.5	-1.23	1.14	-0.09
159443	Boat Launch				5257.5			
159404	Rock Vane				5257.4			
159276	Boulder Cluster				5256.88			
159251	35			5256.24	5257.02		0.78	

Table 4-5. Comparison of 100-year Flood Water Surface Elevations

Cross -Section Number(1)	Cross-Section Description	WSELs (ft)				Change in WSEL		
		Regulatory (a)	Duplicate Effective (b)	Existing Conditions (Corrected Effective) (c)	With-Project Conditions (d)	(c) - (a)	(d) – (c)	(d) - (a)
159138	Snag				5257.06			
159051	34; Boulder Cluster			5255.98	5256.93		0.95	
158981	33; Boulder Cluster			5255.84	5256.13		0.29	
158893	Lunker				5256.03			
158820	Lunker				5255.98			
158783	Boulder Cluster				5255.92			
158748	32; Lunker			5255.65	5256.04		0.39	
158730	V-deflector				5255.94			
158636	Snag				5255.89			
158596	Snag				5255.94			
158551	CY	5257.28	5257.75	5255.35	5255.68	-1.93	0.33	-1.6
158534	Boulder Cluster				5255.8			
158513	Boulder Cluster				5255.81			
158483	31			5255.32	5255.61		0.29	
158382	Laying Back Right Bank				5255.56			
158287	Lunker				5255.27			
158247	Lunker				5255.25			
158203	Lunker				5255.27			
158116	Laying Back Right Bank			5254.86	5255.01		0.15	
158079	Rock Vane				5254.97			
158007	US Bridge		5257.66	5254.81	5254.81		0	
157948	CX	5254.64	5254.71	5253.94	5253.4	-0.7	-0.54	-1.24
157866	30			5253.9	5253.33		-0.57	
157843	Bendway Weir				5253.27			
157730	Bendway Weir				5253.57			
157675	Rock Vane and Boat Launch				5253.62			
157652	Rock Vane				5253.63			
157525	29			5253.6	5253.23		-0.37	
157476	28			5253.24	5253.07		-0.17	
157459	Boat Launch				5252.99			
157432	Riffle				5252.94			
157375	27 - CW	5253.05	5253.13	5252.79	5252.92	-0.26	0.13	-0.13
157257	26			5252.58	5252.86		0.28	
156978	Wing Deflector				5252.58			
156903	Boulder Cluster				5252.32			
156750	23; Lunker			5252.06	5252		-0.06	
156702	Lunker				5251.99			
156493	21			5251.51	5251.73		0.22	
156445	Wing Deflector				5251.59			
156371	Wing Deflector				5251.54			
156324	20			5251.31	5251.51		0.2	
156242	Wing Deflector				5251.5			
156156	19 - CT	5250.78	5250.82	5250.92	5251.12	0.14	0.2	0.34
155991	18; Boat Launch			5250.37	5250.06		-0.31	
155957	Rock Vane				5250.05			
155838	17; Slope Change			5249.93	5249.81		-0.12	

Table 4-5. Comparison of 100-year Flood Water Surface Elevations

Cross -Section Number[1]	Cross-Section Description	WSELs (ft)				Change in WSEL		
		Regulatory (a)	Duplicate Effective (b)	Existing Conditions (Corrected Effective) (c)	With-Project Conditions (d)	(c) - (a)	(d) – (c)	(d) - (a)
155697	Slope Change				5249.12			
155657	16; Slope Change			5249.25	5248.95		-0.3	
155468	15; Slope Change			5248.95	5248.09		-0.86	
155254	14; Slope Change			5248.65	5247.93		-0.72	
155174	Slope Change				5247.66			
155160	Slope Change				5247.53			
155138	Slope Change				5247.51			
154797	Slope Change				5246.68			
154770	Slope Change				5246.52			
154756	Slope Change				5246.53			
154476	13 - CS; Slope Change	5248.8	5248.64	5247.19	5245.9	-1.61	-1.29	-2.9
154412	12; Slope Change			5247	5245.73		-1.27	
154389	Slope Change				5245.73			
154221	Slope Change				5245.09			
154128	11; Slope Change			5246.02	5245.13		-0.89	
154053	Slope Change				5245.11			
154041	Slope Change				5245.07			
154009	10 - CR; Slope Change	5245.8	5245.14	5243.9	5245.06	-1.9	1.16	-0.74
153938	9; Slope Change			5245.24	5245.15		-0.09	
153902	Slope Change				5245.1			
153817	Bendway Weir				5245.05			
153750	Bendway Weir				5245.07			
153735	8; Rock Vane			5245.22	5245.09		-0.13	
153699	CQ	5245.6	5245.86	5244.85	5244.86	-0.75	0.01	-0.74
153649	DS Bridge		5243.91	5243.19	5243.78		0.59	
153592	7; Bendway Weir			5243.26	5243.31		0.05	
153526	Wing Deflector and Boat Launch				5243.06			
153495	Rock Vane				5243.14			
153469	6			5243.22	5243.03		-0.19	
153417	Wing Deflector			5243	5242.6		-0.4	
153333	4			5243.17	5243		-0.17	
153296	CP; Snag	5243.8	5243.81	5243.2	5243.19	-0.6	-0.01	-0.61
153250	Snag				5243.35			
153151	V-deflector				5243.43			
153126	3			5243.41	5243.45		0.04	
153042	Boulder Cluster				5242.77			
152985	2			5242.76	5242.74		-0.02	
152597	CO	5242.3	5241.96	5242.2	5242.18	-0.1	-0.02	-0.12
152471	1 - CN	5242.1	5242.07	5242.07	5242.07	-0.03	0	-0.03

(1) River stationing is distance in feet above Adams/Weld County Line (same as FIS)

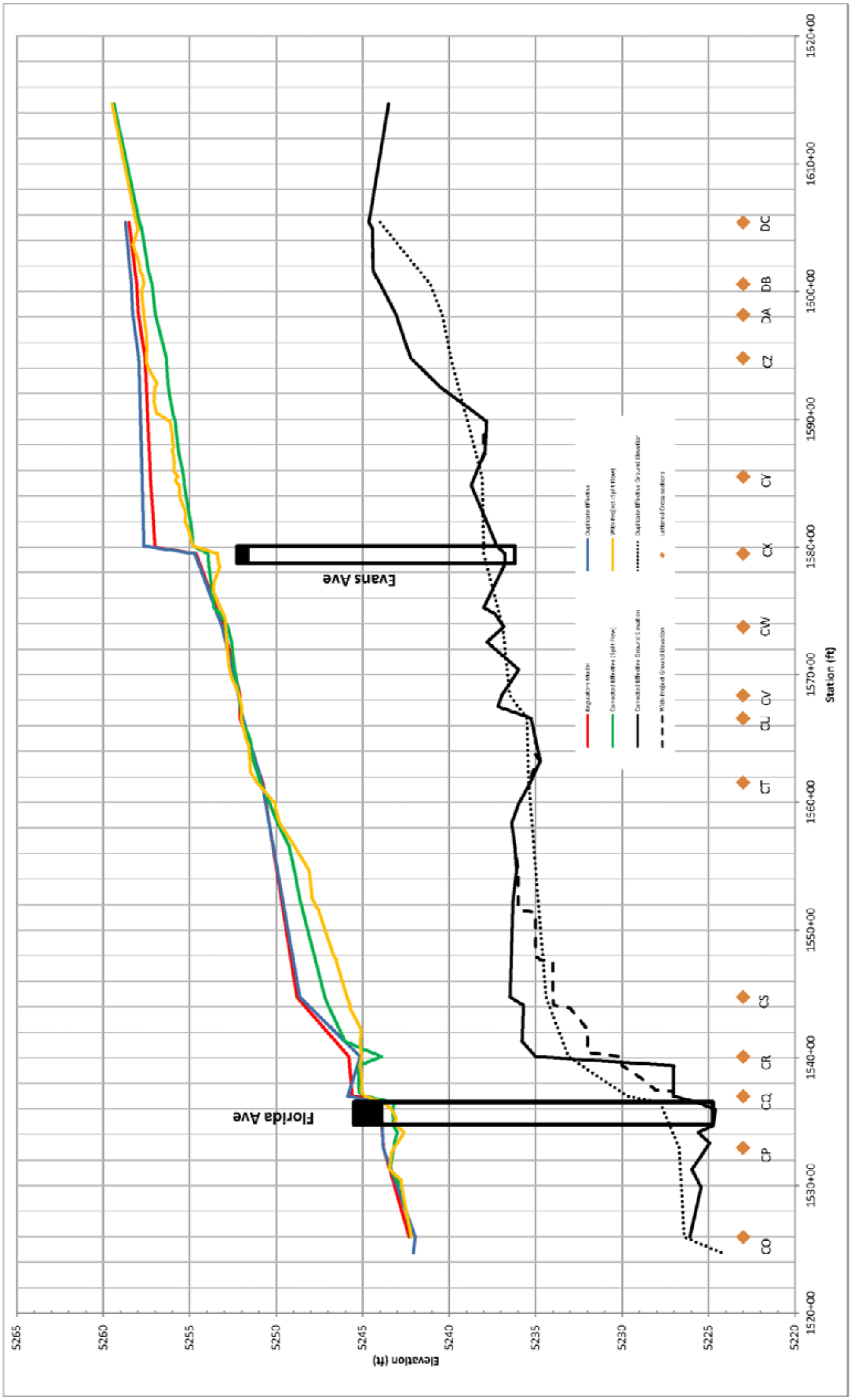

Figure 4-5. South Platte River Water Surface Elevation Comparison between Regulatory, Corrective Effective (or Existing Conditions) and Proposed Conditions

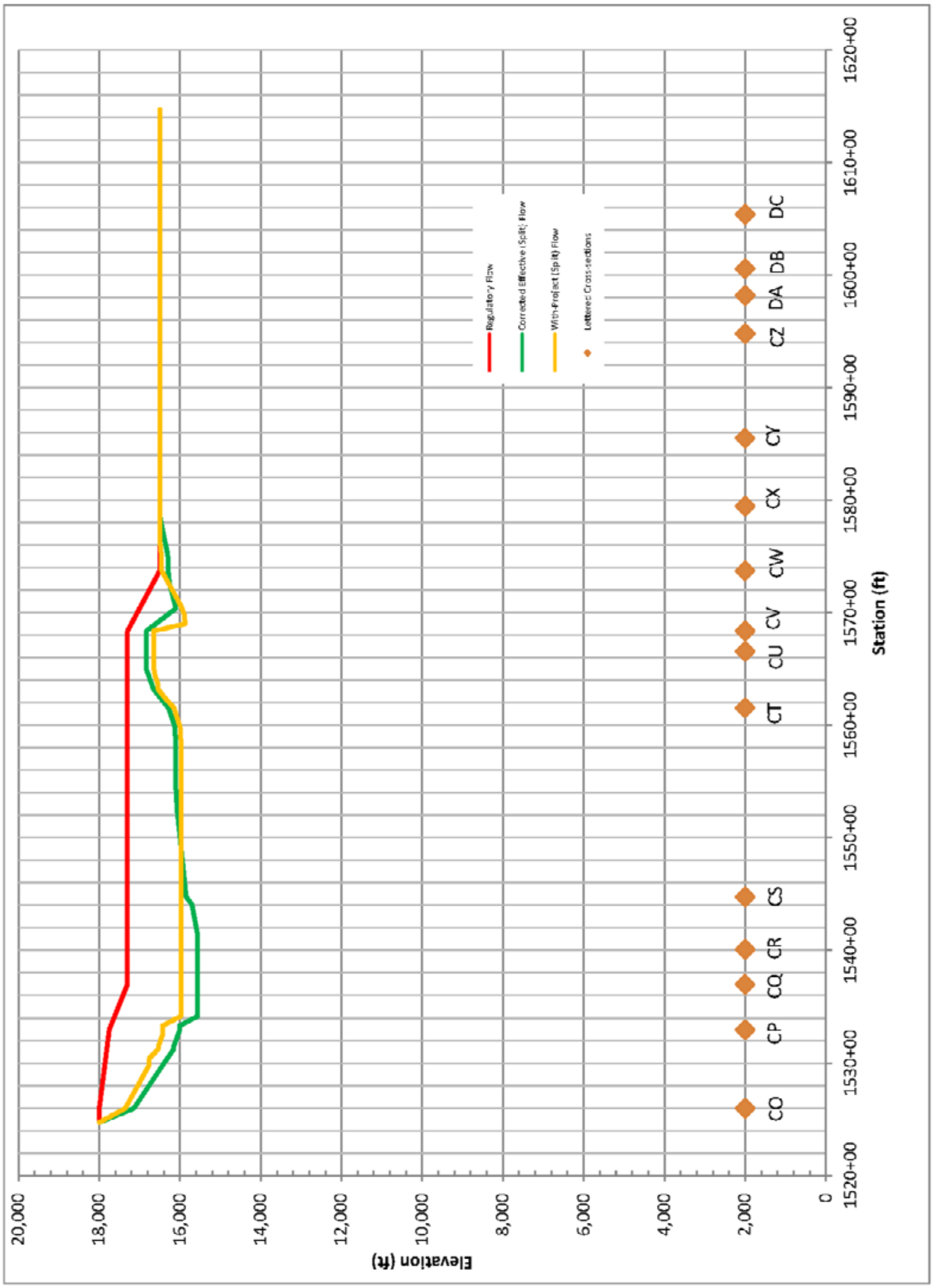

Figure 4-6. South Platte River Flow Comparison between Regulatory, Corrective Effective (or Existing Conditions) and Proposed Conditions

4.3.3 Sediment Transport Analysis

Once a preliminary channel design is achieved, it should be checked to evaluate sediment transport and channel stability. CDM Smith performed a stable channel design analysis using HEC-RAS to determine to check that the designed channel will pass a sediment load from upstream without deposition or erosion. The designed channel was tested using the stable channel design component included in the HEC-RAS model (version 4.1.0). The stable channel design is based on the SAM Hydraulic Design Package for Channels (USACE 1998), developed by the USACE Water Experiment Station.

Three methods are available in the HEC-RAS model for the stable channel design; Copeland, Regime, and Tractive Force methods. After reviewing the three methods in terms of the purpose of the analysis, characteristics of the designed channel, and available data, Copeland method was selected. Copeland method uses an analytical approach to solve stable channel design variables of depth, width, and slope. In this method, the stability of the channel is achieved when the sediment inflow to a particular reach equals the sediment outflow.

The calculation is sensitive to "inflow sediment" data. There are two options for the inflow sediment data; 1) entering inflow sediment concentration in ppm and 2) let HEC-RAS calculate inflow sediment concentration using input hydraulic parameters of the inflow reach (bottom width, depth, energy slope, side slope, etc). The second option was selected for this analysis since the South Platte River is considered stable, as noted in the UDFCD geomorphic studies. The program estimated the total inflow sediment concentration of 388 ppm. The energy slope of the upstream end cross section of the model, which is 0.0016 was used as the upstream boundary condition to determine the sediment concentration.

The calculation used the 10-year storm event as the design discharge. The plot in **Figure 4-7** presents the stability curve calculated for the designed channel. The plot shows the stable channel slopes calculated for a range of bottom widths of the channel. The blue line of the figure represents the combination of slope and bottom width of the stable channel condition. When the slope is greater than the blue line, degradation of the channel is expected, and when the slope is less than the blue line, aggradation is expected.

The channel width for the proposed channel improvements upstream of Florida Avenue varies between 50 feet and 150 feet. The graph shows that the stable slope is approximately 0.001 (0.1%) for bottom widths between 50 to 150 feet. Therefore, a channel bed slope of 0.1% was used as the design slope for the channel thalweg where channel bed slopes changes are proposed.

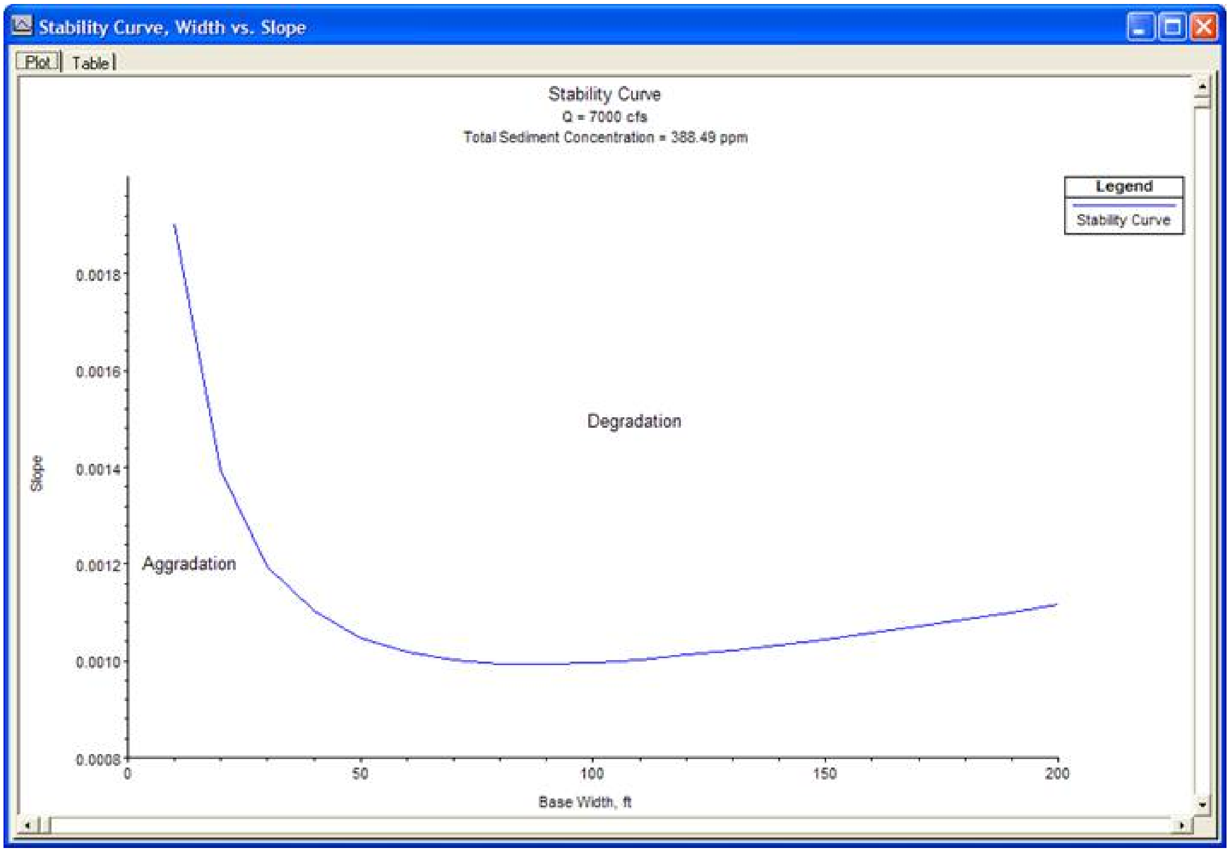

Figure 4-7. Stable Channel Analysis Curve

Note that a comprehensive sediment transport analysis is recommended during final design to further evaluate the post-project sediment transport characteristics of the river.

4.3.4 Harvard Gulch Outfall Analysis

As noted in Section 3.4.1, Denver Parks and Recreation is considering demolishing and relocating the existing Harvard Gulch outfall. The new outfall would be approximately 100-feet to the east of the existing outfall. Moving the outfall would allow the Grant-Frontier Park area to be regraded as a floodplain bench.

If the new outfall is moved, a composite channel is proposed from the new outfall to the river to convey nuisance flows and storm flows. The composite channel includes an inset channel to convey flows up to the 2-year discharge (approximately 1,100 cfs) while the larger channel would convey the 100-year discharge (approximately 5,300 cfs). The inset channel has a bottom width of 50 feet and a depth of 3 feet. The proposed composite channel has 5H:1V side slopes. See **Figure 4-8** for schematic of the typical cross section.

The total length of the channel is approximately 100 feet, and the total elevation drop is approximately 6 feet. See **Figure 4-9** and **Figure 4-10** for schematic representations of the outfall and channel. From the exit of the outfall a 2.5 foot vertical drop is proposed, which is followed be a transition reach (from rectangular to trapezoidal XS). This transition reach has a 1% slope and expands from 20 feet wide to 120 feet wide bottom width. This bottom width was determined by calculating the width necessary to convey the 100-year discharge with a maximum depth of 5 feet.

Once the channel expands to a 120-foot bottom width, a 40 foot channel section at a 1% slope is proposed. At the end of this section, another 2.5 foot vertical drop is proposed, which is followed by another 40 foot section with a 1% slope is proposed.

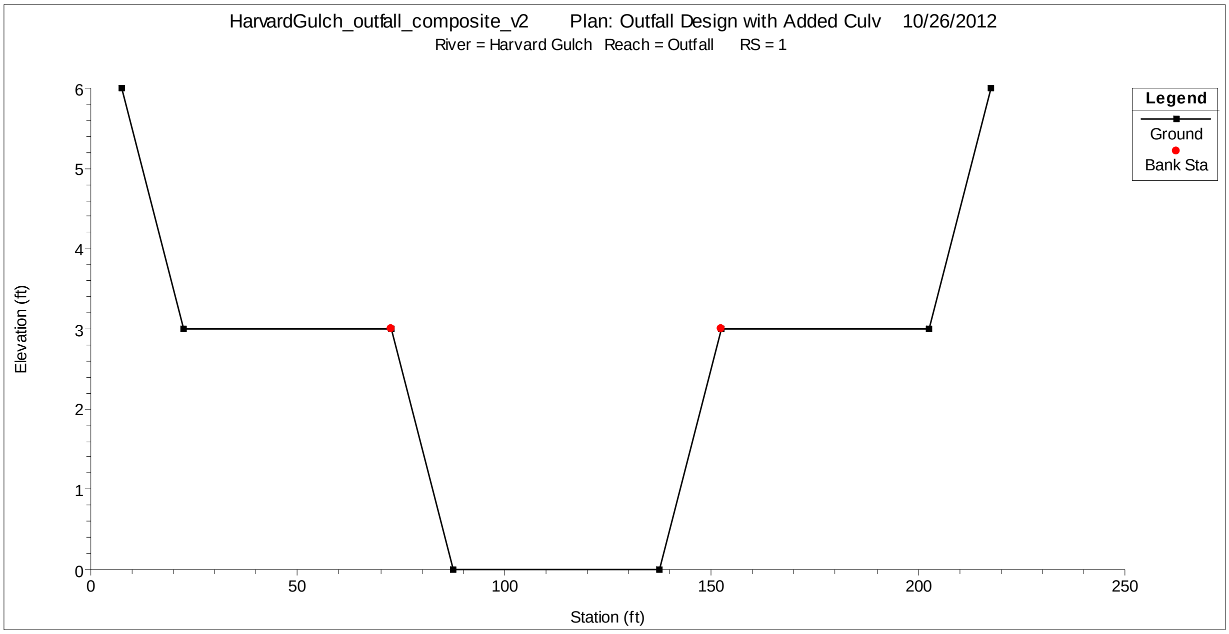

Figure 4-8. Typical Cross-section Schematic

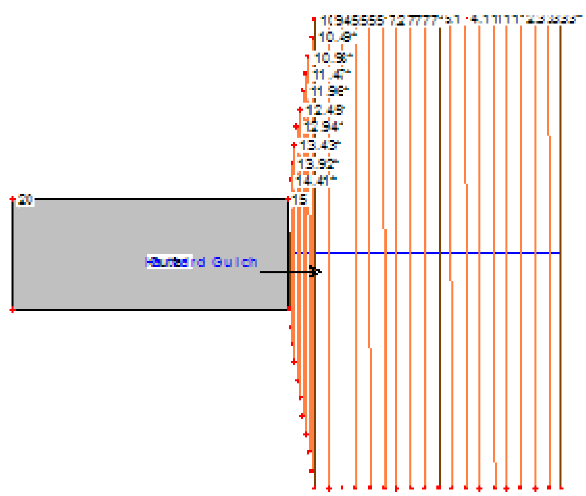

Figure 4-9. Schematic plan view of the outfall and channel.

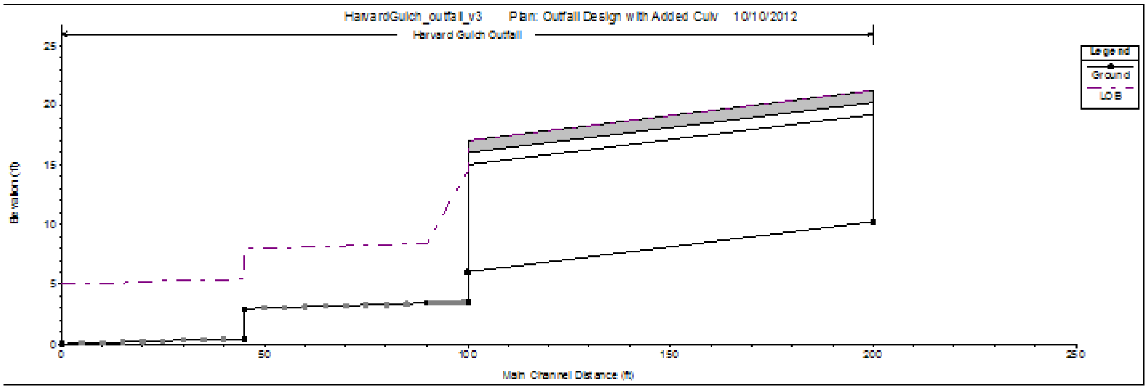

Figure 4-10. Schematic profile of the outfall and channel.

A HEC-RAS model was developed to simulate the outfall and channel improvements. The model included the existing 9-foot by 14-foot box culvert and additional two 10-foot by 12-foot box culverts, which were identified in the Harvard Gulch Master Plan. The additional culverts were included in the model since the existing culvert cannot convey the 10-year discharge. The water surface profiles for the 5-year, 10-year, and 100-year discharges are presented in **Figure 4-11**, **Figure 4-12**, and **Figure 4-13**, respectively. The 100-year water surface profile shows that the water surface depth is approximately 5 feet and reaches the top of the bank of the channel.

Except at the transition reach (immediately downstream of the culverts) and the crest of the drop, the flow velocity along the channel ranges from 6.7 to 7.9 fps during 10-year discharge, and from 7.7 to 9 fps during 100-yr discharge. The Froude number ranges from 0.6 to 0.8 during both discharges except at the transition reach and the reach immediately downstream of the 2.5-foot drop.

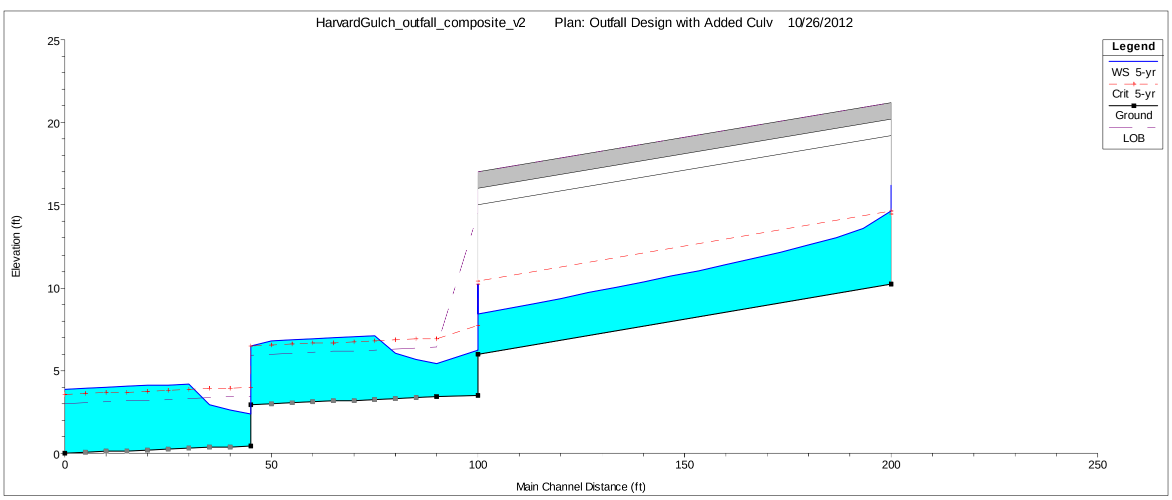

Figure 4-11. 5-year discharge (2,000 cfs) water surface profile of the outfall and channel.

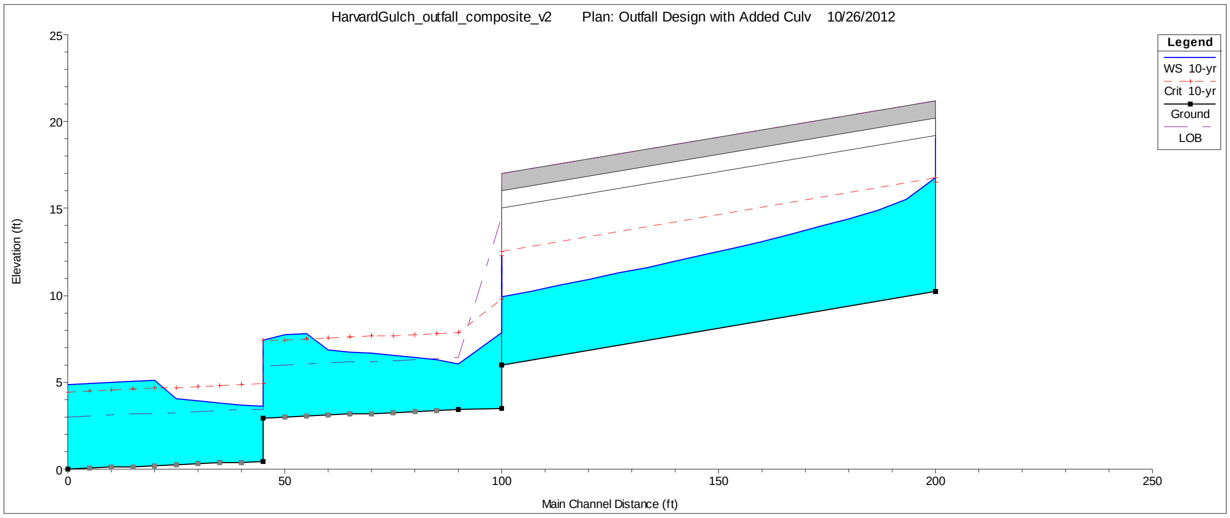

Figure 4-12. 10-year discharge (3,600 cfs) water surface profile of the outfall and channel.

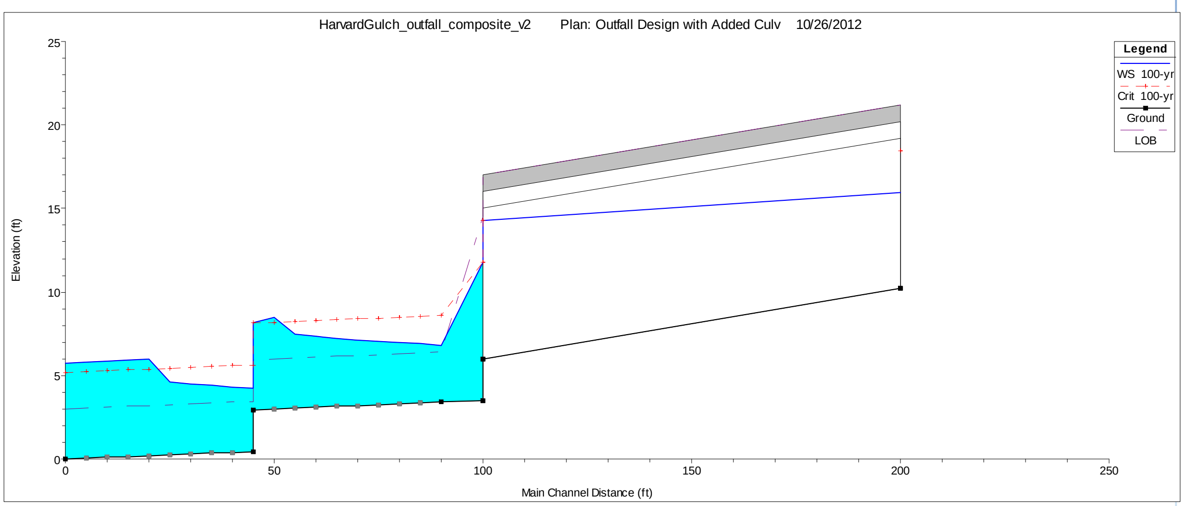

Figure 4-13. 100-year discharge (5,300 cfs) water surface profile of the outfall and channel.

4.3.5 Overland Golf Course Diversion and Pump House

This section describes the recommended modifications for the existing irrigation pump station near Florida Avenue that will be impacted by the proposed river improvements. Specifically this section discusses modifications to the intake system and improvements and upgrades to the pumping system to achieve the required capacity.

4.3.5.1 Intake Modifications

The intake point for the pump station will need to be lowered to accommodate the new lower river level. There are many options for pump intakes from rivers with different costs and functionally. One option would be to maintain the current intake configuration with a circular concrete river-located wet well. However, this is not recommended due to the obtrusive visual impact of the structure and difficulty in providing O&M to the pumping equipment. An alternate approach that would address the aesthetic and O&M drawbacks of the current system is to provide a submerged intake that feeds a shore-located wet well. The submerged intake can range in complexity from an open pipe, to a coarse screen, to a screen with air-burst cleaning capabilities.

Based on the project's goals, CDM Smith recommends a passive submerged wire screen with air-burst connections and a shore located pre-cast circular concrete wet well. The screen would need to be installed in a location where the top of the screen would be approximately 2 feet below the minimum water level. An 8-inch diameter pipe would slope downward from the screen to a circular precast concrete wet well that would be installed at the shore adjacent to the existing building. The depth of the wet well would need to be sufficient to provide adequate submergence over the pump, which would be approximately 5 feet below the top of the intake. This type of intake structure could accommodate several pump types including a submersible wet pit pump or a vertical turbine wet pit pump (similar to what is currently installed).

The screen itself would have approximately ¼-inch openings and would limit approach velocities to approximately 0.5 fps to prevent large debris from entering the wet well. Connections would be provided for an air burst, but since significant fouling is not expected the intent would be to use a portable air compressor system only as needed to clean the screen.

4.3.5.2 Pumping Upgrades

This section describes upgrades to the pumping equipment and associated systems to account for the new river level and provide the required capacity.

Capacity and Hydraulics

As noted previously, it is understood that the existing pumping system is not able to deliver the decreed water right 2.1 AF/day (if pumping 24 hours per day, this corresponds to an instantaneous pumping rate of 475 gpm). Assuming the pumping system was able to achieve the required capacity when first installed, there are two likely primary reasons why the capacity has dropped:
1) deterioration in the pumping equipment (worn impellers, wear rings, etc.); and 2) deterioration of the conveyance pipeline.

Given the age of the system, it is likely a combination of both issues that is causing reduced capacity. In order to provide the required capacity, the following process should be used during final design:

1) Determine required pumping flow. Given a 2.1 AF/day water right, the minimum pumping rate would be 475 gpm assuming 24 hour/day pumping. If the CCD would like to pump the 2.1 AF/day over a shorter period, the required pumping rate will go up accordingly.

2) Determine required pumping head at the required flow. Unless reliable record drawings and pipeline condition information can be obtained for the conveyance pipeline, the most accurate way to obtain this information will be through a flow test. Calibrated pressure gauges and flow meters will need to be installed near the existing pump station, and several flow and pressure readings can be taken to estimate a system curve for the pumping system. Based on a review of topographical mapping information and visual inspection of the pipeline under the Florida Ave bridge, it is estimated that the existing pipe is approximately 1,200 feet long with an outside diameter of 6-inches. Assuming an inside diameter of 5.25-inches for the entire length and an aged pipe roughness (C = 110), an initial head estimate to pump 475 gpm would be approximately 70 feet.

3) The results for #2 will need to be carefully evaluated to determine if the head for the new flow rate is reasonable. For example, if the required pumping head is excessively high (due to an undersized or deteriorated pipe), CCD may wish to consider replacing some or all of the existing conveyance pipeline to lower the required pumping head, thereby reducing ongoing power costs. There is also some risk that the increased pipeline pressure caused by an increased pumping rate could damage the existing pipeline. This will need to be carefully evaluated during final design.

Modified Pumping Equipment

The process described above, along with the new river levels, will provide the required hydraulic information to specify the new pumping equipment. There are several different types of pumping equipment that can efficiently pump the range of flow and head that is expected for this station. **Table 4-6** below summarizes the three pump types considered most appropriate for this application along with associated pros and cons.

Given the concern about aesthetics, Option 2 is recommended—a submersible solids handling centrifugal pump—be installed. This type of pump can be installed fully below grade and provides relatively high efficiencies at the anticipated flow and head ranges. However, it is worth noting that all three options are valid for this type of station and the final decision should be made based on owner preference and O&M experience and comfort.

Table 4-6. Pumping Equipment Options

Option	Description	Pros	Cons
1	Vertical Turbine Wet Pit	• Familiarity – same as existing equipment • Highest efficiency • Motor and seal are above grade and readily accessible	• Above grade equipment is visually obtrusive • Limited solids handling capability if screen needs to be bypassed. • Pumping (bowl) assembly is below grade and has to be removed for service and inspection using hoist or crane. • Motor cannot be submerged – vulnerable to flooding.
2	Submersible Solids Handling Centrifugal	• Completely below grade; no visual obstruction • High efficiency • Can pass solids if screen needs to be bypassed • Fully submersible; not vulnerable to flood damage	• Pump has to be removed for service and inspection using hoist or crane
3	Self-priming solids handling centrifugal	• Above grade pump and motor are readily accessible for O&M	• Above grade equipment is visually obtrusive. • Motor cannot be submerged – vulnerable to flooding • Reduced reliability due to priming system

Table 4-7 below provides preliminary design criteria for the new pumping equipment assuming the decision is made to proceed with a submersible solids handling centrifugal pump.

Table 4-7. Pump Preliminary Design Criteria

Parameter	Description
Pump Type	Submersible Solids Handling
Rated Capacity	475 gpm (assuming 24 hr pumping)
Rated Head	70 ft (preliminary – To be verified with detailed hydraulic analysis during final design).
Motor Size	35 HP max (so as not to exceed current motor size – to be verified with detailed hydraulic analysis during final design)
Drive	Constant speed premium efficient submersible motor
Speed	1800 rpm max

Section 5
Preliminary Design Development and Recommendations

This section describes the development of the preliminary design using the project elements described in Section 3 and the design criteria and analysis included in Section 4. In addition, recommendations are included for maintenance and monitoring after implementation.

5.1 Description of Improvements

A goal of the overall project is to create recreation opportunities that are integrated with the habitat design elements. The multi-use project elements described in Section 3 are designed to enhance and improve multiple features in the river, including the aquatic habitat, boating, fishing, and river access as well as enhance recreation in the adjacent parks.

The improvements described in this section are separated out into aquatic habitat, recreation, and parks. Separating them into the three categories was done for presentation purposes only. The improvements are intended to work in concert together to provide multiple benefits so even though an improvement may be described under one category that does not mean it will not overlap with one or both of the other categories. The positioning of the various improvements is shown in **Figure 5-1**.

Improvements are described using design stationing, which is different than regulatory stationing used in the hydraulic analysis described in Section 4. Design stationing used for the preliminary design follows the designed low flow channel (LFC) alignment that starts upstream of Santa Fe Drive; whereas, the regulatory stationing is based on the center of the South Platte River (SPR) starting at the Adams and Weld County Line. Conversion information is included in Appendix F.

5.1.1 Aquatic Habitat

Aquatic habitat improvements were designed along the project reach from just downstream of Florida Avenue to near Wesley Avenue at the Harvard Gulch outfall. The instream channel improvements (features and structures) were designed specifically to enhance aquatic habitat by redirecting the channel thalweg to recreate natural meander within an active channel, where possible. The structures are intended to be boat friendly/fish friendly that will help to define a central channel or "thalweg" of the river. This thalweg will allow for a deeper channel that will allow for tubing, kayaking, boating, and fishing along this reach.

Per the design criteria described in Section 4, the various types of aquatic habitat improvements were located based on numerous factors such as:

- Channel bed material – sand, gravel, bed rock
- Channel alignment – bend or straight channel section
- Habitat purpose – scour hole, cover, channel constriction
- River access – ability for boaters, fishermen, trail users, cyclists to safely access the river
- Channel slope – Potential for degradation or aggradation

Instream improvements were placed systematically along the channel based on these factors and the design criteria in Section 4. For purposes of this report, the instream improvements are described in four different locations, or sub-reaches.

- Sub-Reach 1: Downstream of Florida Avenue (Design Station 1+00 to 18+00)
- Sub-Reach 2: From Florida Avenue to approximately 2,200 feet upstream (Design Station 18+00 to 50+00)
- Sub-Reach 3: Adjacent to Pasquinel's Landing Park (Design Station 50+00 to 62+00)
- Sub-Reach 4: Adjacent to Grant-Frontier Park (Design Station 62+00 to 86+96)

See the Preliminary Design Drawings in Appendix F for proposed locations.

5.1.1.1 Downstream of Florida Avenue

The instream improvements adjacent to Overland Pond Park, downstream of West Florida Avenue, includes

- A boulder cluster located downstream of the V-type deflector – Design Station 12+25
- A V-shaped deflector located 300-feet downstream of West Florida Avenue – Design Station 13+20
- Two snags; one directly downstream of the Sanderson Gulch outfall on the left bank and one a little further downstream on the right bank – Design Station 14+50 and 14+95
- Two wing deflectors on the left bank – Design Station 15+95 and 17+15
- A boat-launch with a rock vane – Design Station 17+15
- A bendway weir directly downstream of Florida Avenue on the right bank – Design Station 17+85

The bendway weir and wing deflectors will align the thalweg towards the center of the channel and provide microhabitat (e.g., scour holes) for fish habitat. The snag, V-type deflector, and boulder cluster will provide cover and small scour holes.

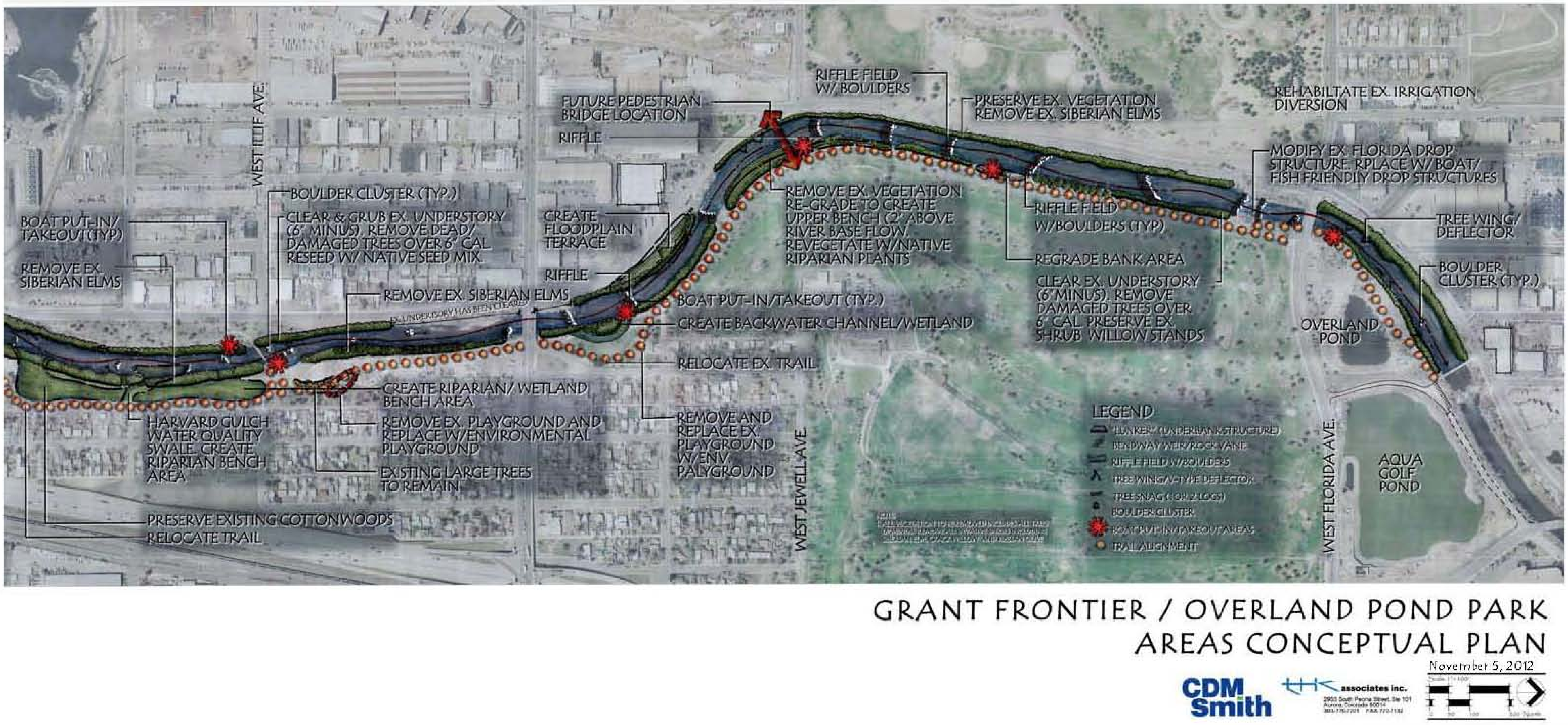

Figure 5-1. Overall Project Concept Plan.

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5.1.1.2 Adjacent to Overland Golf Course

The instream improvements adjacent to Overland Golf Course, from Florida Avenue to Asbury Avenue (approximately 3,500 feet upstream) includes channel modifications and the addition of habitat structures. Specifically, the improvements adjacent to the golf course include:

- A rock vane off the center pier of the Florida Avenue bridge – Design Station 19+00
- Two bendway weirs – Design Station 19+40 and 20+10
- A riffle and boat/fish friendly drop structure to replace the existing grade control structure – Design Station 21+00 and 22+15
- Two cross channel riffles – Design Station 26+50 and 30+30
- Two "S" riffles – Design Station 34+00 and 39+00
- Another cross channel riffle to replace the existing riffle – Design Station 43+65
- Five boulder clusters – Design Station 25+95, 29+00, 33+40,38+60, and 41+70
- One snag – Design Station 35+60
- Three wing deflectors – Design Station 44+80, 45+80, and 46+70
- Three lunkers – Design Station 48+40, 48+95, and 49+45
- A boat launch with a rock vain – Design Station 44+25

The channel modifications will change the channel geometry to create an "active channel" with a defined thalweg (see **Figure 5-2**). The channel modifications will also provide terraces for habitat and vegetation growth. Creating the active channel improves low flow conditions by decreasing the overall width (i.e., encroachment) so that the flow is narrow and deep and not wide and shallow as exists today.

5.1.1.3 Adjacent to Pasquinel's Landing Park

Instream improvements adjacent to Pasquinel's Landing Park—from Asbury Avenue to Evans Avenue—were located to improve aquatic habitat along the reach as well as work in conjunction with the secondary channel and floodplain bench included at the park. Habitat improvements include

- A Newberry riffle – Design Station 51+00
- Two boulder cluster – Design Station 51+25 and 50+50
- Two wing deflectors – Design Station 52+25 and 53+15
- A cross channel riffle – Design Station 56+95
- Two boat launches – Design Station 57+00 and 59+20
- Two rock vanes – Design Station 59+00, and 59+25
- Two bendway weirs – Design Station 59+90 and 61+00

Figure 5-2. South Platte River Channel Upstream of Florida Avenue Rendering

A boat launch was placed directly upstream of the riffle so that the riffle could act as flow control providing calmer water as boaters and fishermen enter the water. The habitat structures will work in tandem with the park improvements to enhance the overall river environment.

5.1.1.4 Adjacent to Grant Frontier Park

The instream improvements adjacent to Grant-Frontier Park – from Evans Avenue to Wesley Avenue – include the following structures:

- One rock vanes off the center pier of the Evans Avenue bridge – Design Station 63+40
- Six lunkers – Design Station 64+50, 64+95, 65+30, 70+05, 70+70, and 71+45
- Eleven boulder clusters – Design Station 64+95 ,66+30, 67+70, 67+85, 70+30, 71+90, 72+95, 75+25, 78+45, 82+50, and 82+80
- Two wing deflectors – Design Station 84+02, and 85+20
- One V-type deflectors – Design Station 69+80
- Three snags – Design Station 68+50, 68+70, and 84+25
- One boat launch with a rock vane – Design Station 77+00

The channel bed is composed of bedrock in this stretch of river; therefore, aquatic habitat improvements are limited to structures. The structures are intended to break up the shallow flow over the bedrock and provide cover for fish. Several boat launches will provide access to the river from both the north and south sides. The Harvard Gulch outfall will also be moved back into the park. These improvements are described in Section 5.1.5.

5.1.2 Park and Recreation

Major park improvements include paved trails/natural trails, environmental playgrounds, vegetation removal (invasive and non-native), and emergent floodplain benches. Other recreational components include boardwalks, scenic overlooks, rest areas, and interpretive signage.

5.1.2.1 Overland Pond Park

Work in the Overland Pond Park area includes removing the access road that goes through the park, and reinstalling a new gravel road and parking area for recreation users. In addition, the opportunity potentially exists to lay the bank back adjacent to Overland Pond. The existing slope is very steep—approximately 1 horizontal to 1 vertical. Ideally the slope would be laid back to a 3 horizontal to a 1 vertical or more to increase access to the river. However, there is an existing sanitary sewer line that will limit the ability to lay back the bank to create a gentler slope. During final design, more detailed utility information will be collected on this sanitary sewer line to determine if it is deep enough to allow the bank grading without compromising protection of the pipe.

Colorado Department of Transportation (CDOT) is also interested in opening up the river. As part of the I-25 widening/reconstruction project near Alameda Avenue, CDOT has offered to mitigate the trees lost by construction and has offered to plant these trees in the Overland Pond area (see **Figure 5-3**). There will be 167 trees planted here and will have the existing irrigation system adjusted to ensure their viability. These tree varieties include Gambel Oak, Rocky Mountain Juniper, Western Chokecherry, Narrowleaf Cottonwood, Plains Cottonwood, Peachleaf Willow, Pinyon Pine, and Three-leaf Sumac. Denver Parks is coordinating this effort.

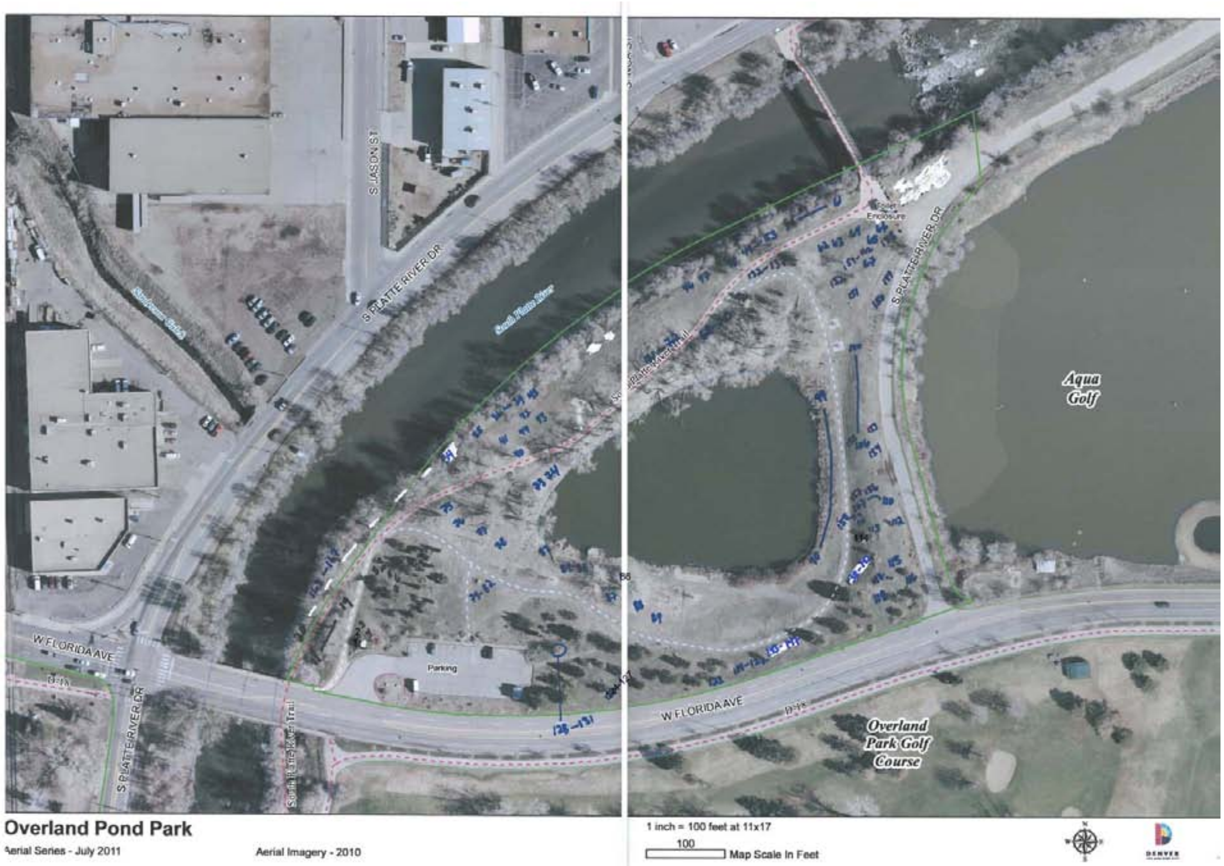

Figure 5-3. Overland Pond Area Tree Planting Plan.

5.1.2.2 Overland Golf Course

The proposed improvements adjacent to Overland Golf Course include laying back the left overbank, removing invasive species along both channel banks, and revegetating the channel banks with native upland habitat. In addition, the City and County of Denver recently obtained a grant from Denver Metropolitan Waters Forestry Project to plant trees along the South Platte River. These trees will be planted along the Overland Golf Course reach; however some of the locations conflict with the proposed grading efforts. Coordination between all participating parties shall occur to eliminate duplicate or contradicting efforts. Conversations have already occurred between the design team and UDFCD regarding vegetation and grading in this area.

5.1.2.3 Pasquinel's Landing Park

Pasquinel's Landing Park is currently a manicured irrigated bluegrass park with a playground, interpretive signs, and park trees. The City and County of Denver's Parks Department has expressed a desire to restore some of their park areas to a more native landscape. During the RISO/RVIP planning process, Pasquinel's Landing was identified to include a "backwater pool and emergent bench area." The emergent bench was carried forward into this preliminary design; however, a backwater pool will most likely sediment in over time. Therefore, a secondary channel is proposed to allow a constant flow and thereby limit sedimentation. The emergent bench area will contain emergent and riparian benches. Interpretive boardwalks are planned that meander through these bench areas (see **Figure 5-4, Figure 5-5,** and **Figure 5-6**).

The improvements also include relocating the existing South Platte River trail, replacing an existing playground with an eco-friendly sustainable playground, and creating a river access point with a boat put-in/take-out area. An environmental playground is planned adjacent to secondary channel. The environmental playground theme can concentrate on river ecosystems by connecting to the secondary channel area and allow children to search for aquatic and terrestrial wildlife. Additionally, the channel banks will be cleared and grubbed from damage understory or invasive species and revegetated with native seed mix.

The preliminary design plans (see Appendix E) depict this secondary channel and the restoration of the park to a more natural and native environment.

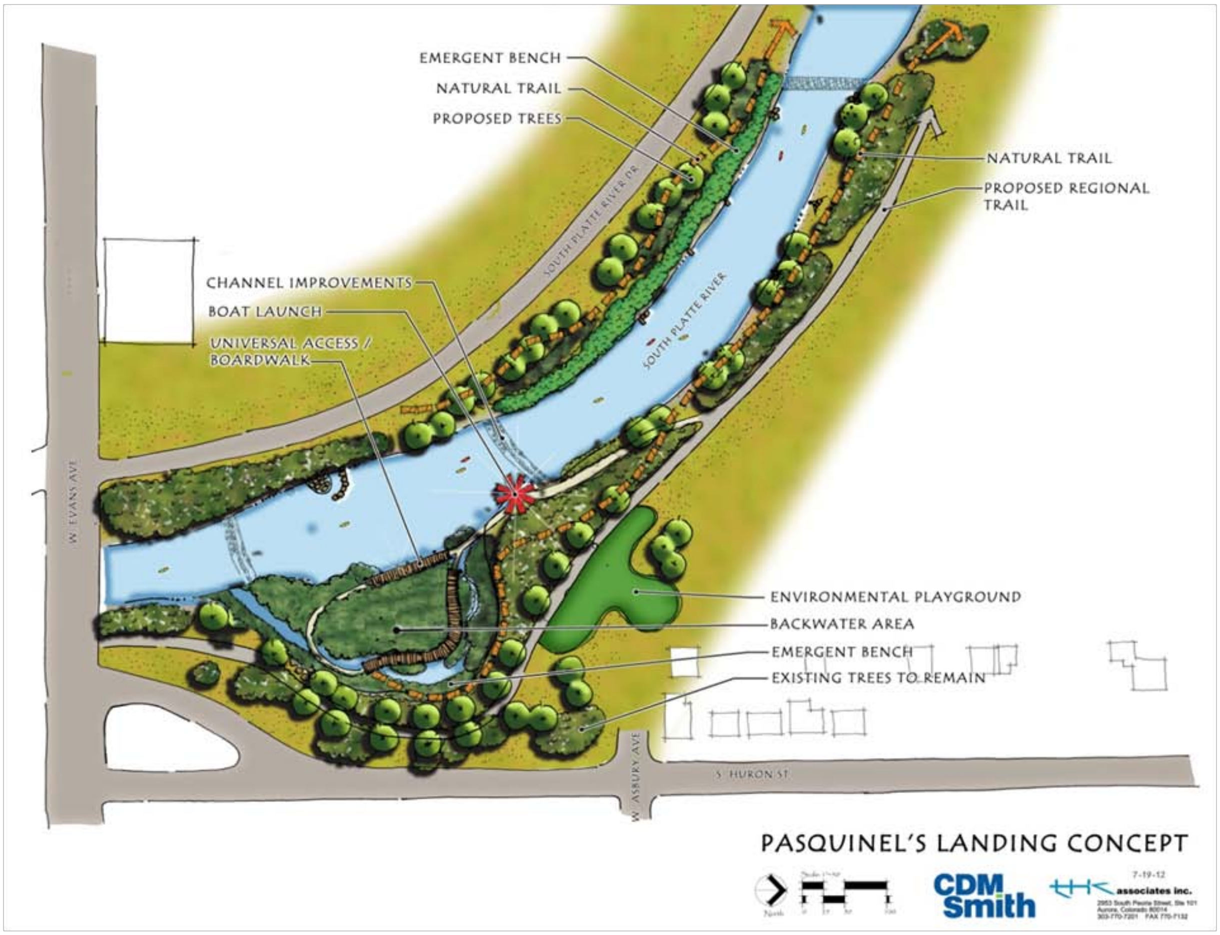

Figure 5-4. Pasquinel's Landing Park Overall Plan

Figure 5-5. Pasquinel's Landing Park Rendering

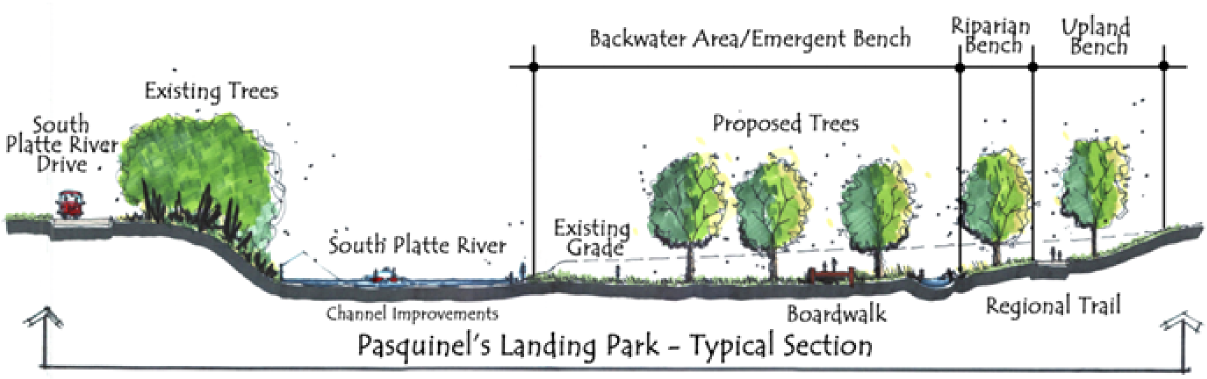

Figure 5-6. Typical cross-section at Pasquinel's Landing Park

5.1.2.4 Grant-Frontier Park

The RISO Master Plan recommended that the Grant-Frontier Park area become a "water quality area and improved native habitat." The improvements proposed for the park include:

- Regrading and laying back the right channel bank
- Relocation of Harvard Gulch outlet
- Building riparian bench along right bank
- Relocating the existing South Platte trail
- Removing existing playground and replacing it with environmental playground
- Adding boat launches on both the left and right banks

Currently, the river is confined by steep banks with dense vegetation. Access to the river is virtually non-existent along this reach. The existing vegetation is also comprised of dense stands of invasive vegetation (Crack Willows, Siberian Elms). When these species are removed, it is apparent that the existing steep riverbank has the opportunity to be regraded and laid back to create the water quality benches referenced in the RISO Master Plan. Therefore, improvements include regrading and laying back the right channel bank, which requires relocation of Harvard Gulch outlet (see **Figure 5-7** and **Figure 5-8**). Specific design information on Harvard Gulch outlet is provided in Section 5.1.5.

Proposed improvements also include the removal of invasive species and replacing with native species. These improvements will primarily affect tree and large shrub species. One of the partners of this project, UDFCD, will remove most of the invasive species that exist in the Grant-Frontier/Overland Pond reach of the South Platte River. Aside from the invasive species, UDFCD will remove existing stands of trees that will be impacted by laying back the banks of the river. UDFCD will cut these trees down to grade and it will be the responsibility of the contractor that grades these areas to clear and grub the root masses.

Several large stands of native cottonwoods exist in the park. The healthy trees will remain; they are primarily at the southern edge of the park at the Harvard Gulch outfall area and adjacent to the existing playground. All of these cottonwoods trees will remain. Several native cottonwood trees exist along the South Platte River's edge. These trees can also remain; they are close enough to the proposed emergent elevation and will complement the overall feel of the emergent area.

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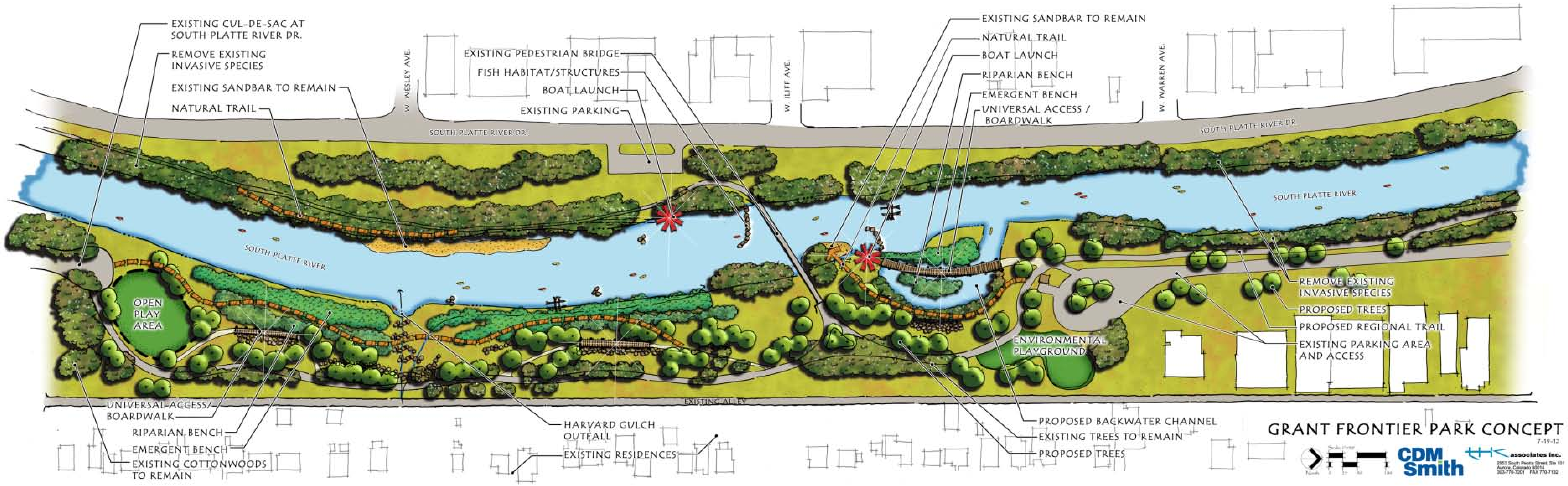

Figure 5-7. Grant-Frontier Park Overall Plan

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Figure 5-8. Grant-Frontier Park Rendering

Emergent and riparian benches will be created to create better access to the river, but also to create bio-diversity. These benches will increase terrestrial flora and fauna, which will, in turn, increase bird and fish populations. **Figure 5-9** shows a typical cross section for the park.

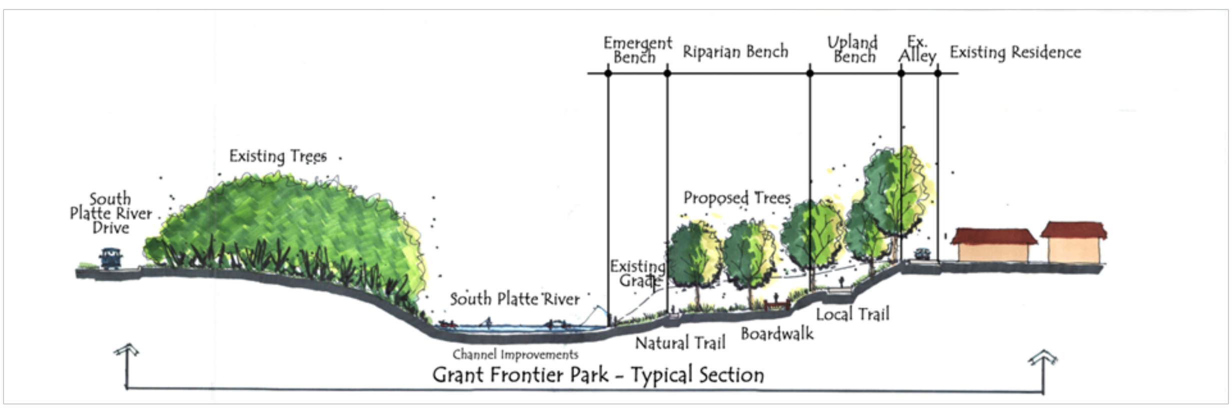

Figure 5-9. Typical cross-section for Grant-Frontier Park

Interpretive trails will meander through these bench areas with interpretive signs to help educate users. Scenic overlooks/rest areas will also be present to allow for extended bird watching or just relaxing in a unique water environment.

The local trail that exists in the center of the park needs to be moved to the east to accommodate the grading that is proposed. Its proposed location will be to the west side of the trees and the distance that the trail is from the alley will buffer the existing residents in the area.

An ADA compliant trail will connect the regional trail down to the river, just north of the pedestrian bridge in the park. This ramp will follow the existing gravel trail alignment and will connect to a jetty/boat launch structure at the river's edge. Currently, a large gravel sand bar exists to the south of the proposed jetty/boat launch area. This will remain; it serves the activities of South Platte River Environmental Education program (SPREE), local gold panners, and anglers.

5.1.2.5 Trail Improvements

Regional Trail

The regional trail will need to be reconfigured as a result of creating the proposed emergent and riparian bench areas in Grant-Frontier Park and Pasquinel's Landing. The Preliminary Design Drawings that are included in Appendix F show the desired trail location. However, design of relocated of the regional trail is not included under this project. Therefore, this element will be coordinated with the consultant responsible for the regional trail improvements during final design.

Local Trail

The local trail that exists in Grant-Frontier Park (east bank) will need to be reconstructed and relocated because of the anticipated grading in this area. The trail will be located further to the east to allow for this grading. This trail will be located just below the existing trees to remain and parallel the existing alley (see **Figure 5-10**). Appropriate separation will be afforded between the existing alley and existing trees and the new park area. The trail does not want to conflict with alley uses or disturb existing residents. More than likely, the trail will be an 8-foot wide concrete section to match the existing trail.

Figure 5-10: Existing tree stands to remain along alley in Grant-Frontier Park.

Natural Trails

Natural trails are shown on Figures 5-3 and 5-6. These trails are intended to be near proposed river improvements in Grant Frontier Park and Pasquinel's Landing Park.

ADA Trails

ADA trails are envisioned to connect the Regional Trail with the proposed faux rock boat launches that are planned. These trails will be 6-feet wide concrete that will traverse the east bank of the river.

These trails will be graded at 5 percent or less and will provide a smooth transition to the faux rock boat launches that will provide access to the river.

Boardwalks

Boardwalk areas are planned in the emergent/riparian zones associated with Grant-Frontier Park and Pasquinel's Landing. These boardwalk areas will allow users to experience these unique ecosystems as shown in **Figure 5-11** below.

Figure 5-11: Sketches of boardwalk in Grant-Frontier Park and Pasquinel's Landing Park.

Further design details on the boardwalks will be developed during the final design phase.

5.1.2.6 Environmental Playgrounds

Pasquinel's Landing Environmental Playground

The playground located at Pasquinel's Landing Park will be relocated to allow space to construct backwater pond. The newly constructed playground will be environmental friendly, sustainable and minimize the carbon footprint. Themes identified for Pasquinel's playground include:

- Overland Golf,
- Denver Circle Railway,
- First Flight in Denver, or
- Harnessing the Power River.

The playground theme will be selected during the final design phase in coordination with the City and County of Denver and the local neighborhood associations.

Grant-Frontier Environmental Playground

An environmental playground is also planned at Grant-Frontier Park. It will be themed to recognize the mining and history of the area with a focus on mining, gold panning, and the Miners Village, as well as assist with further interpretation of the William "Green" Russell Party and the Placer Camp. The playground will be designed to include elements that help connect the South Platte River with these themes. It will also be connected to the boardwalks that meander through the emergent/riparian bench areas. Children will be able to move from the environmental playground and into the emergent areas to benefit from all of the elements proposed for Grant-Frontier Park.

5.1.3 Vegetation

The preliminary design drawings identify all invasive species to be removed. Aside from invasive species, each bank of the river will have all trees/large shrubs that are less than 6-inch caliper to be removed. In addition, any trees over 6-inch caliper that are damaged/diseased will be removed or pruned to remove all dead/damaged branches. The intent is to open up the river for visual and physical connectivity.

The invasive and non-native trees should be spade dug to remove these trees in the dormant season (early spring –mid to late fall), before trees have budded or started to leaf out or after the trees have lost their leaves.

5.1.4 Harvard Gulch Outfall

As described in Section 3.4.1 and Section 4.3.4, modifications to the Harvard Gulch outfall include demolishing the existing outfall structure and constructing a new outfall structure approximately 100-feet to the east. Stormwater would discharge into a composite channel composed of grouted boulders in the inset channel and vegetated riprap in the overflow channel area. Moving this outfall would open up the park area by laying back the bank allowing access to the river (see **Figure 5-12**). Additionally, by moving the outfall structure, low flows could be redirected through a floodplain bench, creating a minor stream amenity, and providing a water quality benefit.

Figure 5-12: South Platte River North of Harvard Gulch Rendering.

It is unknown when City and County Public Works will improve Harvard Gulch to convey the 100-year discharge; therefore, the new outfall was designed to improve only the existing 9'x14' box culvert. However, if City and County Public Works decides to improve the system upstream of the outfall, those improvements could be incorporated in the new outfall and channel without substantial modifications.

There is design challenges associated with relocating the outfall, including drop structure stability, seepage, structural tie-ins, and flow control. In addition, the open, inviting nature of the proposed outfall presents public safety concerns during a storm event. These issues should be considered during the final design in close consultation with City and County of Denver Parks and Recreation and Public Works, as well as UDFCD. In addition, structural design of the new structural headwall and wingwalls should begin early on in the final design phase.

5.1.5 Overland Golf Course Diversion and Pump House

Based on the new river levels, and in order to improve visual aesthetics and O&M characteristics, CDM Smith recommends that the existing irrigation pump station be replaced with a new submerged passive wire screen connected to a shore-located circular concrete wet well that will house a submersible solids handling centrifugal pump. Sheet CD-6 provides a conceptual plan and section view of the proposed station. There are several variations to this configuration that can be explored during final design to optimize the station based on owner preferences. Detailed hydraulic analyses can also be completed during final design to fully define the operating requirements of the new pumping equipment.

In addition to the upgrades described above, a general review of the pump station support systems (e.g. electrical, control, etc.) should be performed during final design to determine if any additional upgrades are necessary or desired. For example, the station is currently limited to manual on-off control. If desired, controls could be added to start and stop the pump remotely based on an operator input, or in response to river or storage pond levels.

5.2 Recommendations

This section includes recommendations on maintenance and monitoring as well as suggestions on future actions.

5.2.1 Maintenance

Maintenance should be considered for all proposed improvements to ensure the implemented improvements are effective. This is typically completed in an annual inspection. Annual inspections and/or scheduled maintenance are usually pre-arranged during the design phase of the project. Cleaning and clearing are types of maintenance performed annually. Other required types of maintenance include remedial and emergency maintenance. Remedial maintenance occurs as a result of the annual inspection regarding problems with the improvement that are not threatening and are not addressed during the annual maintenance. And emergency maintenance requires immediate repair due to large storm events (FISRWG 1998).

Specific maintenance guidelines for proposed improvements including grass swales and constructed wetlands are provided by UDSCM Volume 3 (UDFCD 2012). Wetlands require maintenance to maintain designed water quality improvements including proper depth and spatial distribution of growth zones. As for grass swales, maintaining healthy vegetation as designed is important for the water quality benefit.

5.2.2 Monitoring

Understanding how the project area changes post-construction and requires periodic monitoring, measurement, and scientific interpretation. Many of the improvements are designed for environmental benefit purposes including aquatic habitat, native vegetation, and water quality. Implementing this type of projects is not completed when construction is finished. Monitoring should continue several years or more beyond completion of construction. Monitoring of improvements within and adjacent to the river should evaluate the performance of physical, biological, and chemical parameters and use adaptive management to address performance and failure of improvements. A monitoring program should evaluate vegetation growth, fish counts, bank stability, water quality measurements, and recreational usage on an annual basis. In addition, funding for a monitoring program should be identified during the final design phase.

5.2.3 Next Steps and Outstanding Issues

There are still numerous issues to resolve and items to coordinate during the final design phase. These issues and items include the following:

- Subsurface utility locates
- Consideration of water rights when rehabilitating the pump station
- Coordination with Denver Forestry on invasive and non-native tree removal
- Coordination with UDFCD on tree removal
- Hydraulic modeling assumptions and current regulatory water surface elevations
- Coordination with UDFCD and CCD on design of Harvard Gulch outfall
- Selection of pump type and refinement of intake design for the pump station
- Detail evaluation and design of water quality improvements at existing storm drain outfalls, where possible, with end-of-pipe treatments (e.g., level spreaders and trash racks).
- Consultation with the Army Corps of Engineers on the 404 permit

Note that a comprehensive sediment transport analysis is recommended during final design to further evaluate the post-project sediment transport characteristics of the river.

These issues and items should be discussed and resolved in the early stages of the final design phase.

Section 6
Project Implementation

Planning for these proposed improvements has been in progress for the past three years with strong community involvement. Approximatly $6 million in funding for final design and construction of habitat and recreation improvements for the Grant Frontier/Overland Park Project has been secured and is described in more detail at the end of this section. However, funding constraints require that the project is completed by June of 2015. Currently, the City and County of Denver is evaluating project delivery methods to procure consultants and contractors such that the funding schedule requirements are met. This evaluation is anticipated to be complete by December 2012 and will result in a recommended project delivery method. Regardless of the delivery method, implementation will require securing a variety of permits and approvals from agencies having jurisdiction. Anticipated permits and approvals are described in more detail below.

6.1 Regulatory and Agency Coordination

Several permits will be required prior to construction of the RVIP improvements. The required permits address environmental, floodplain, and water quality issues. Governing authorities that will require coordination include the federal government, State of Colorado, and City and County of Denver. Permits required will include a Clean Water Act Section 404 Dredge and Fill Permit, administered by USACE; a Section 401 Water Quality Certification and stormwater discharge permit for construction activity administered by the Colorado Department of Public Health and Environment (CDPHE); and a City and County Floodplain Use permit. Each of these permits and relevant data is discussed in the following sections.

6.1.1 Federal Permits

Section 404 of the Clean Water Act, Section 10 of the Rivers and Harbor Act of 1899, and Section 103 of the Marine Protection, Research and Sanctuaries Act requires the USACE to permit activities that involve the dredging or filling of *Waters of the U.S.*, which includes all navigable waters, interstate lakes, rivers, streams (including intermittent streams), tributaries of such waters, and wetlands adjacent to such waters and includes the South Platte River. The USACE jurisdiction over these waters, in the absence of wetlands, lies below the Ordinary High Water Mark (OHWM).

Implementation of the proposed in-stream and some of the terrestrial improvements will require obtaining Clean Water Act Section 404 authorization from the Denver Regulatory Office of the USACE. There are three authorization scenarios available under Section 404: 1) Individual permit; 2) regional general permit; and 3) nationwide permit. Regional general permits and nationwide permits are activity-based permits under which projects that meet the activity and impact threshold criteria may be authorized. Individual permits are issued for those projects that do not meet one or more criteria.

Typically, nationwide and regional general permit authorizations are issued within 45 days or less following submittal of a preconstruction notification to the Corps. Pre-construction notifications include descriptions of the purpose and need for the proposed project, project benefits, and project impacts. They also include relevant project plan sheets. Individual permits typically take six to nine months, and sometimes longer, to receive following submittal of an individual permit application.

Project plans used for the application are usually at a higher level of completion that those used for preconstruction notifications. And unlike nationwide and regional general permits, individual permit applications include a discussion of alternatives to the preferred alternative. By regulation, the USACE can only issue a permit for the least environmentally damaging alternative, which many times results in the preferred alternative being modified during the permitting process to reduce its impacts to waters of the U.S.

The nationwide permit system includes Nationwide Permit 27 Aquatic Habitat Restoration, Establishment, and Enhancement Activities. The permit does not have an upper threshold for impacts to waters of the U.S., but the project must clearly demonstrate that there would be net increases in aquatic resource functions and services. Colorado's regional general permits include Regional General Permit 12 Aquatic Habitat Improvements for Stream Channels in Colorado. This general permit is very similar to Nationwide Permit 27 but is focused on authorizing in-stream improvements to fish habitat. A drawback to Regional General Permit 12 is the prohibition on the use of grout except for specifically described structures (fish barriers, fish bypass structures, fish ladders, and fish screens). Regional General Permit 12 also includes a requirement for consultation with Colorado Division of Parks and Wildlife.

Based on current proposed improvements, it is likely that the Corps' evaluation of the project will determine that both Nationwide Permit 27 and Regional General Permit 12 could be used to authorize the project. When both are applicable, the Corps prefers to use Regional General Permit 12. Although the proposed project may meet the criteria for Nationwide Permit 27 and Regional General Permit 12, the Corps may use its discretion and decide that an individual permit will be required. This would be an unusual situation, and typically occurs with controversial projects or projects for which adverse impacts would be more than minimal.

To better understand the permitting approach the USACE, a pre-application meeting should be scheduled with the USACE and Colorado Division of Parks and Wildlife in early stages of the final design phase. Understanding their concerns and likely permitting approach early design stages will be beneficial to the project.

Section 401 of the Clean Water Act ensures that federal permits comply with applicable state water quality requirements and standards. The CDPHE has the authority to administer and enforce the state's water quality control program, including the 401 certification process. The purpose of this program is to reduce the amount of pollutants entering streams, rivers, lakes, and wetlands as a result of runoff from urban areas. State regulation 5 CCR 1002-61 covers discharges from construction sites. In Colorado, the 401 certification is obtained as part of the 404 permit process. When an application for a Section 404 permit is filed, the USACE will contact CDPHE, who will review the permit application for water quality issues and may attach conditions to the Section 404 permit based on this consultation.

6.1.2 State Permits

Colorado is an EPA-delegated state, meaning that the state administers federally-mandated water quality programs such as the NPDES program under the Clean Water Act and the Federal Water Pollution Control Act (33 U.S.C. 1251, et seq.). Stormwater discharges associated with construction activity are regulated by CDPHE through the Colorado Pollution Discharge System (CPDS) General Permit COR-030000 under the Colorado Water Quality Control Act.

Since the proposed improvements will disturb more than 1 acre, authorization to discharge under the CPDS General Permit will be required. Authorization includes applying for and obtaining certification that a Stormwater Management Plan (SWMP) shall be completed and implemented prior to construction. The responsibility for obtaining a water quality certification is usually given to the "construction site operator" and certification is required within 10 days of the start of construction.

CDPHE defines the construction site operator as the person who has day-to-day control over the project. At various times during the construction project, different parties may satisfy the definition of "operator" and the certification may be transferred as roles change. For the purposes of this project, the operator can be defined as the prime contractor during construction, and the application and certification should be submitted by this person prior to onsite mobilization.

6.1.3 Local Permits and Plan Review

The proposed improvements involve work within the floodway and floodplain of the South Platte River; a floodplain and sewer use permit must be obtained from the City and County of Denver. The City and County of Denver requires a floodplain use permit for all construction in the floodplain. The impacts to regulatory WSELs from the proposed improvements are described in Section 4.

Requirements for issuance of a Floodplain Use Permit are contained in Section 2-91 and Public Works "Rules and & Regulations" Chapter 12-01 to 02 *Flood Plain Management* of City and County of Denver.

This section lists the general requirements for a Floodplain Use Permit, listed below:

1. Grading plan with spot elevations at all four corners of the new structure(s).

2. Provide floodplain boundary, flood zone type, Base Flood Elevation (BFE)

3. Show all structures and finished floor elevation (FFE) using NAVD 1988.

6.1.4 UDFCD Plan Review

UDFCD was established in 1969 under the Colorado legislature to govern the drainage and flood control problems within the Denver metropolitan area. UDFCD developed the Floodplain Management Project to ensure compliance with NFIP and assists local governments with their floodplain regulations. UDFCD reviews and regulates the Flood Insurance Rate Maps (FIRMs) on behalf of FEMA for riverways in their district.

UDFCD is an important stakeholder and project funder in this project. The project proposes work in the river, which UDFCD has authorization over; in addition, UDFCD maintains the South Platte River as a major drainageway in their jurisdiction. Therefore, it is anticipated that UDFCD will provide a concurrent review with City and County of Denver on the final design plans and specifications as well as the hydraulic analysis.

6.2 Constructability and Construction Constraints

Constructability is the extent to which a design of a structure provides for ease of construction yet meets the overall requirements of that structure. In other words, the project must be both "biddable" and "buildable." There are a number of factors that make this project challenging, but an experienced heavy construction contractor, with riverine and complex scheduling experience, should be able to readily build it. Additional project cost can be expected over typical earthwork projects due to site constraints and adverse working conditions, such as high flow events that result in additional effort on the part of the contractor.

A preliminary constructability review of the 30 percent design was performed that focused on managing river flows during construction, fill placement and compaction, and construction sequencing. The outcome of this review is provided below.

6.2.1 River Flow Management during Construction

Water control during construction is a critical aspect of any construction in a river channel. Typically, the contractor is responsible for maintaining control during the course of construction and is responsible for adhering to all federal, state, and local laws, regulations, and permit requirements. All in-stream structure and grading should occur in the dry. It is also recommended that the contractor submit a water control plan with the bid proposal at which the construction oversight contractor can review and comment prior to construction. Due to liability concerns, the water control plan shall be commented on but not approved.

6.2.2 Fill Placement and Compaction

RVIP improvements call for placement of fill in the river channel and along the banks. The fill should be placed in lifts of 8- to 12-inches and compacted with an excavator bucket and/or rolled over with a track. No specific compaction is required due to the alluvial nature of the fill material. All work should take place in the “dry.”

A majority of the habitat structures will be constructed of boulders, riprap, and/or a well-graded bedding material. Adding fill creates opportunity for localized failure that can broaden into a generalized structural failure. For this reason, all structures requiring non-native fill material should be constructed in the "dry."

6.2.3 Construction Sequencing

Construction should generally proceed from downstream to upstream since the bed elevation change at the Florida Avenue grade control structure will substantially change the flow conditions. However, construction sequencing could be separated into multiple phases:

1. Florida grade control structure/Overland Pond pump station
2. Bank grading along and adjacent to golf course and in-stream structures
3. Pasquinel’s Landing Park
4. Grant-Frontier Park and Harvard Gulch outfall

Harvard Gulch is far enough upstream that the drop would not impact construction at the outfall so it could be completed in a latter phase if funding is not immediately available. All of the phases could be standalone projects constructed by different contractors at different periods of time or by one contractor in a single construction season (8 to 9 months). The in-stream structures could also be constructed as part of the other three phases; however, it is recommended to have the in-stream work be a separate standalone phase. This would allow the river time to respond to the other improvements so it returns to equilibrium before modifying the geomorphology and hydraulic characteristics.

The in-stream improvements should be constructed prior to or in conjunction with the upland improvements. Revegetation should be completed within the appropriate seeding and planning seasonal window (i.e., spring and fall) and generally prior to November 1st and after April 1st but prior to spring runoff conditions (early May). A notable exception includes willow and other vegetative staking which should be harvested and planted while dormant immediately after frost is out of the ground or before ground freezes, generally after November 1st and before April 1st. Depending on seasonal conditions, this staking window could be much shorter and will require appropriate scheduling.

6.2.4 Adjacent Landowners

The City and County of Denver owns the property within the project area. However, the local neighbors and neighborhood associations have a keen interest in this project. The City and County of Denver intends to continue to work with the neighbors during the final design to limit concerns during construction.

6.2.5 Erosion Control

Working in and adjacent to rivers creates a unique challenge to control erosion and manage sediment during construction. Uncontrolled stormwater runoff from the project area could significantly impact the river by clogging fish gills, smothering aquatic habitat and spawning areas, and disturbing the sediment balance. The EPA requires contractors to apply for a NPDES permit as noted in Section 6.1.2 as well as develop a SWMP. Prior to commencement of construction, the SWMP must be implemented for each facility covered by the permit. The SWMP identifies potential sources of pollution (including sediment generated onsite, fuels, oils and hydraulic fluids, etc.) that may reasonably be expected to affect the quality of the stormwater discharges associated with the construction activity. In addition, the SWMP must describe the BMPs that will be used to eliminate the release of contaminated stormwater discharge from the site. The contractor must implement all provisions of the SWMP as a permit condition.

Generally, the contractor is responsible for all installation and maintenance of all BMPs, which could include installation of temporary access ways and staging areas, silt fences, mulching, as well as sediment removal and disposal. All materials used in erosion and sediment control, material handling and spill control and all other controls should be in compliance with the USDCM Volume 3 (UDFCD 2012), and the Colorado Department of Transportation’s Standard Specifications for Road and Bridge Construction (CDOT), where applicable.

6.3 Project Funding

The overall goal of the RVIP project is creating the premier outdoor recreation destination and environmental educational resource for the city and the state while improving aquatic habitat, all within the available funding constraints. The total scope of improvements that have received funding to date include three related projects that will enhance sections of the South Platte River and the parks along its banks from West Harvard Avenue in south Denver downstream (north) approximately three miles to West 3rd Avenue in central Denver The work will be completed within the next three years.

The project funding for final design, permitting, and construction of this project has been secured through a number of grants and City and County of Denver funding. Total funding for the improvements in the project area is $6.1 million.

Shattuck Natural Resource Damage Funds – $1.7 million.

Specifically, the funds will be used to improve the riparian floodplain and eliminate non-native and invasive species within the project reach, construct emergent benches within the channel banks, construct inchannel aquatic habitat structures, and modify existing grade control structures to enhance habitat opportunities by splitting the drop in grade over a larger distance and constructing the drops to better simulate riffles with natural cobble and gravel substrate.

Rocky Mountain Arsenal Damage Funds: $0.5 million

Great Outdoors Colorado 2012 River Corridors Initiative: $1.9 million

Specifically, this funding is allocated to construction of the following types of improvements:

1. Fish Habitat and Drop Structure Modifications (Category 9)
2. Boat Put-Ins/Take-Outs (Category 10)
3. Access Trails and Trailheads (Category 11)
4. Potential Bank Regrading/Wetlands/Native Vegetation Restoration (Category 12)
5. Environmental Education/Playgrounds (Category 13)

CWCB Water Supply Reserve Account (WSRA) – Grant and Loan Program: $0.75 million. The initial Water Supply Reserve Account grant, secured in 2011 funded this preliminary design effort. An additionl $0.5 million has recently been secured to progress the South Platte River Recreation and Habitat Improvements Preliminary Design effort through final design.

Urban Drainage and Flood Control District: $1.2 million. Specifically, this funding is allocated to for in-stream channel modifications, including modifications to the existing Florida Avenue Grade Control Structure; bank stabilization and revegetation.

6.4 Design-to Budget

A conceptual cost opinion (Class 4, per ASTM E 2516) was prepared as part of the GOCO grant application and is included in Appendix H. As described above, a total of $5.6 million for construction and construction management has been secured as part of the GOCO and matching funds. Of that $5.6 million from GOCO and matching funds, $4.7 million was specifically allocated for construction of these improvements; $0.9 was allocated for design, engineering and on the ground construction management for the improvements described in the GOCO grant. The Class 4 construction cost opinion includes a 10-percent contingency. Following award of the GOCO grant, an additional $0.5 million was secured for final design from the CWCB WSRA grant program, resulting in a total of $6.1 million to implement this project.

Due to funding limitations of the WSRA grant, the scope of work for this preliminary design did not include development of a formal opinion of probable construction costs. However, because construction funding was being secured as the Grant-Frontier/Overland preliminary design was being developed, the scope of the improvements were designed to meet the available construction funding budget of $4.7 million for the elements described in the GOCO grant. The preliminary (30-percent) design includes several project elements that were added after the GOCO grant was secured.

The following summarizes construction scope that is not included in the $4.7 million described above, but are included in this preliminary design report:

- Harvard Gulch outfall improvements were added to the project after the GOCO funding was secured. Based on the Harvard Gulch Master Plan, the estimated cost to replace the Harvard Gulch outfall is $1.5 million.

- Rest areas, rest overlooks and restrooms are included as project elements this report although these elements are not included in the Class 4 cost opinion. An estimated cost for these improvements is $0.3 million.

The Class 4 construction cost opinion for all the improvements included in this preliminary design is $6.5 million; an additional $0.27 million is estimated for design, engineering and on the ground construction management for these additional items. The total project cost opinion for design, engineering, construction and on the ground construction management is $8.2 million. This cost opinion includes the GOCO scope and additional scope mentioned above, but does not include the cost of regional trails throught the project area, because those improvements are partially funded as a separate project as part of the GOCO grant and matching funds.

The project team acknowledges that description of the Use of Funds in the GOCO grant application (refer to Appendix H) varies somewhat from the improvements described in this report and shown on the 30-percent drawings. However, the intent of the improvements is inline with the overall goals and objects presented in the grant application, which are the same as those presented in this report.

The WSRA grant request for final design of this project included funding of opinions of probable construction costs. A Class 3 opinion of probable construction cost should be completed in the early stages of final design. Value engineering and/or reductions in the 30-percent construction scope may be necessary if the Class 3 cost opinion exceeds the available project funding.

6.5 List of Technical Specifications

Although technical specifications will evolve prior to completion of the design, Table 6-2 includes a preliminary list of probable specifications.

Table 6-2 Preliminary Specification List

ITEM	SECTION	SUB-SECTION
INVITATION FOR BID(s)	**100**	
INSTRUCTIONS TO BIDDER(s)	**200**	
INFORMATION AVAILABLE TO BIDDER(s)	**300**	
BID	**400**	
BID		410
BID BOND		430
BID ADDENDA		490
AGREEMENT	**500**	
NOTICE OF AWARD AND ACCEPTANCE		510
AGREEMENT		520
NOTICE TO PROCEED AND ACCEPTANCE		550
BONDS AND CERTIFICATES	**600**	

Table 6-2 Preliminary Specification List

ITEM	SECTION	SUB-SECTION
PAYMENT BOND		610
PERFORMANCE BOND		611
INSURANCE CERTIFICATES (TO BE ATTACHED)		620
LETTER OF DAMAGE GUARANTEE		621
LETTER OF FINAL ACCEPTANCE		622
CONTRACTOR STATEMENT CONCERNING CLAIMS		640
WITHDRAWAL OF STATEMENT OF CLAIM		641
NOTICE OF FINAL PAYMENT		650
FINAL RECEIPT		651
GENERAL CONTRACT CONDITIONS	**700**	
SCOPE		701
DEFINITIONS		702
THE CONTRACT, DRAWINGS, AND SPECIFICATIONS		703
AUTHORITY OF EXECUTIVE DIRECTOR		704
ENGINEER		705
CONSTRUCTION MANAGER		706
LAND AND RIGHTS-OF-WAY		707
SUGGESTIONS TO CONTRACTOR		708
GENERAL SERVICE AND FACILITIES REQUIREMENTS		709
SAFETY OF PUBLIC AND WORKERS		710
SUBCONTRACTING		711
PROGRESS PAYMENTS TO CONTRACTOR		712
ADDITIONAL WITHHOLDING OF PROGRESS PAYMENTS		713
PARTIAL ACCEPTANCE OF WORK		714
INSURANCE		715
CONTRACT SECURITY (PAYMENT AND PERFORMANCE BONDS)		716
ASSIGNMENTS		717
INDEMNIFICATION		718
COMPLIANCE WITH ENVIRONMENTAL PROTECTION, ENERGY CONSERVATION, AND HEALTH/SAFETY RULES AND REGULATIONS		719
TAXES		720
LIQUIDATED DAMAGES		721
TERMINATION OF CONTRACT BY OWNER		722
NO WAIVER OF RIGHTS		723
NO DISCRIMINATION IN EMPLOYMENT		724
ALIEN EMPLOYMENT		725
SUPPLEMENTAL CONTRACT CONDITIONS	**800**	
PERMITS		890
CONTRACT MODIFICATION AND CHANGE ORDERS	**900**	
CHANGE ORDER		940
FIELD ORDER		941
DIVISION ONE: GENERAL REQUIREMENTS	**1000**	
SUMMARY OF WORK		01110
SEPARATE CONTRACTS		01111
CONTRACTOR'S USE OF PREMISES		01140
SPECIAL PROJECT PROCEDURES		01145
UTILITY SOURCES		01180
CHANGED CONDITIONS		01250
NO DAMAGE FOR DELAY		01251

Table 6-2 Preliminary Specification List

ITEM	SECTION	SUB-SECTION
CHANGES IN WORK (CHANGE ORDERS AND FIELD ORDERS)		01252
MEASUREMENT AND PAYMENT		01270
PROJECT MEETINGS		01310
CONSTRUCTION SCHEDULES		01320
CONTRACT TIME (PERIOD OF PERFORMANCE)		01321
TIME EXTENSIONS		01322
SATURDAY, SUNDAY, HOLIDAY, AND NIGHT WORK		01323
SUSPENSION OF WORK AND DELAYS		01324
SUBMITTALS		01330
STANDARD REFERENCES		01425
INSPECTION AND MATERIALS TESTING		01450
FIELD OFFICES FOR OWNER		01520
TRAFFIC REGULATION		01555
PROJECT SIGNS		01580
SUBSTITUTIONS AND PRODUCT OPTIONS		01635
MATERIAL DELIVERY, STORAGE, AND HANDLING		01650
SITE CONDITIONS		01710
TREE, LANDSCAPE, VEGETATION, AND WETLAND PROTECTION		01715
FIELD ENGINEERING AND SURVEYING		01720
ENVIRONMENTAL CONTROLS		01745
CONTRACT CLOSE-OUT		01780
DIVISION TWO: SITE CONSTRUCTION	**2000**	
SITE PREPARATION AND DEMOLITION		**02100**
EXCAVATION, BACKFILLING, AND RESTORATION		**02140**
TREE RETENTION AND PROTECTION		**02150**
REMOVAL OF STRUCTURES AND OBSTRUCTIONS		**02167**
CLEARING AND GRUBBING		**02230**
TOPSOIL		**02235**
WATER CONTROL AND DEWATERING		**02240**
EXCAVATION AND EMBANKMENT		**02315**
TRENCH EXCAVATION AND BACKFILL		**02320**
CONTROLLED LOW STRENGTH MATERIAL BACKFILL (FLO-FILL)		**02321**
HELICAL ANCHORS		**02367**
EROSION AND SEDIMENT CONTROL		**02370**
RIPRAP, BEDDING, AND FEATURE BOULDERS		**02375**
GROUTED RIPRAP, BOULDERS, AND ROCK RETAINING WALLS		**02376**
PIPE UNDERDRAINS		**02625**
MANHOLE STRUCTURES		**02635**
AGGREGATE BASE COURSE		**02710**
SIDEWALK, CURB AND GUTTER, AND MISCELLANEOUS CONCRETE		**02770**
FENCES		**02820**
TREES AND SHRUBS		**02950**
LANDSCAPE PLANTING		**02900**
PERMANENT REVEGETATION		**02925**
DIVISION THREE: CONCRETE	**3000**	
STRUCTURAL CAST-IN-PLACE CONCRETE FORMS		**03110**
HYDROPHILIC RUBBER WATERSTOP		**03151**
REINFORCING STEEL		**03210**
CONSTRUCTION JOINTS		**03320**
CONCRETE FINISHING		**03350**
CONCRETE CURING		**03390**
PRECAST STRUCTURAL CONCRETE		**03400**

Table 6-2 Preliminary Specification List

ITEM	SECTION	SUB-SECTION
GROUT		**03615**
DIVISIONS FOUR THROUGH NINE: MISCELLANEOUS WORK	**4000-9000**	
DIVISION THIRTEEN: MISCELLANEOUS	**13000**	
Habitat Structures		**13001**

Section 7
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APPENDIX A

Wetland Delineation Report

Consultants in
natural
resources and
the environment

Denver • Boise • Durango • Western Slope

WETLAND DELINEATION REPORT
SOUTH PLATTE RIVER – GRANT-FRONTIER TO OVERLAND PROJECT
CITY AND COUNTY OF DENVER, COLORADO

Prepared for—

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July 9, 2012

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SOUTH PLATTE RIVER – GRANT-FRONTIER TO OVERLAND PROJECT
CITY AND COUNTY OF DENVER, COLORADO

JULY 9, 2012

Introduction

CDM Smith retained ERO Resources Corporation (ERO) to provide a wetland delineation along a segment of the South Platte River (River) from Grant-Frontier Park to Overland Park in the City and County of Denver, Colorado (project area). The project area is in Sections 21 and 28 of Township 4 South, Range 68 West of the 6th Principal Meridian in the City and County of Denver Colorado. The UTM coordinates of the approximate project center are 500088mE, 4392564mN of NAD 83 Zone 13N (Figure 1).

Methods

On June 21 and 24, 2012, Denise Larson, an ecologist with ERO, surveyed the project area for wetlands and other waters of the U.S. Using methods outlined in the *Regional Supplement to the Corps of Engineers Wetland Delineation Manual: Great Plains Region (Version 2.0)* (U.S. Army Corps of Engineers (Corps) 2010), wetlands were determined based on the presence of three wetland indicators: hydrophytic vegetation, hydric soils, and wetland hydrology. Wetland indicator status for plant species was determined by Lichvar and Kartesz (2009).

ERO delineated wetlands using a Trimble ProXR Global Positioning System (GPS) unit and TBC1 data logger. Data were differentially corrected using the CompassCom base station. All differential correction was completed using Trimble Pathfinder Office 4.20 software. Additionally, where appropriate, wetlands were drawn on geo-rectified aerials and then digitized. The resulting digital file was provided to CDM Smith for incorporation into project base mapping.

Site Description

This section of the South Platte River through the City and County of Denver has been channelized and highly modified. Streets, office buildings, and other urban structures occur on the top of the riverbanks. A regional trail occurs along one or both banks and two parks – Grant-Frontier and Overland bracket each end of the project area.

The banks of the river range from steep, almost vertical to moderate slopes with terraces adjacent to the river.

Riparian woodlands and shrublands line the riverbanks interspersed with open grassy areas (Photo 1). Siberian elms (*Ulmus pumilus)* and other nonnative trees dominate the riparian woodlands, although large native plains cottonwoods (*Populus deltoides* subsp. *monilifera*) and other native trees are scattered along the riverbanks. Patches of sandbar willow (*Salix exigua*) and other mostly native shrubs commonly occur along the banks. Introduced pasture grasses, such as smooth brome (*Bromus inermis*), grow on the upper banks under the trees and shrubs and in open grasslands. In some revegetated areas and remnant grasslands, native grasses such as blue grama (*Bouteloua gracilis*) and western wheatgrass (*Pascopyrum smithii*) are more common. Wetlands occur intermittently along the shores of the river, ranging from a narrow fringe 1 to 3 feet wide to wider wetland areas along low terraces.

The project area also includes Overland Pond within the Overland Park area (Figure 2). This is an artificial pond with steep banks and a mostly boulder-lined perimeter.

Description of Wetlands and Other Waters of the U.S.

ERO assessed the project area for wetlands and other waters of the U.S. The South Platte River is a traditionally navigable river that is classified by the Corps as a jurisdictional water of the U.S. Overland Pond is not connected to the adjacent river, although it is within the river's 100-year floodplain. Wetlands in the project area are described below and are shown on Figures 2 through 4. Completed routine wetland determination forms for each data point (DP), figures, and photos representative of the site are attached. Table 1 contains a list of plants found in the project area,

South Platte River Wetlands (Figures 2 through 4).

Depending on the steepness, the riverbanks range from no wetlands (Photo 2), to narrow fringes (Photo 3), to wider wetland terraces (Photo 4). Wetlands range from sandbar willow (*Salix exigua*) wetlands with an understory of Emory's sedge (*Carex emoryi*) and reed canarygrass (*Phalaris arundinacea*) to herbaceous wetlands dominated by Emory's sedge, reed canarygrass, and Arctic rush (*Juncus arcticus*). Sandbar willow shrubs also occur in the uplands; although, the understory consists of smooth brome and other upland grasses.

Data collected from a soil pit (DP3) revealed hydric soils with redox dark surface of a low chroma matrix (43/2 10YR) and redox features (4/6 10YR) at 3 to 12 inches. The primary hydrologic wetland indicator was drift deposits.

Overland Pond Wetlands

A large portion of the pond is boulder lined and does not contain wetlands (Figure 2; Photo 5). Wetlands occur within a small pocket at the southwest corner and in a narrow band along the eastern shore. The wetlands at the southwest corner (DP1) occur on a low terrace dominated by Emory's sedge, with wetland hydrology indicated by saturated soils within 8 inches of the surface (Photo 6). The eastern shore wetlands are dominated by sandbar willow with little or no understory vegetation.

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Table 1. Plant species commonly occurring within the project area.

Common Name	Scientific Name
Trees – Native	
Box elder	*Acer negundo*
Peachleaf willow	*Salix amygdaloides*
Plains cottonwood	*Populus deltoides* subsp. *monilifera*
Trees – Introduced	
Crack willow	*Salix fragilis*
Locust	*Robinia* sp.
Russian olive	*Elaeagnus angustifolia*[*]
Siberian elm	*Ulmus pumilus*
Smooth sumac	*Rhus glabrum*
Shrubs – Native	
Chokecherry	*Prunus virginiana* subsp. *melanocarpa*
Golden currant	*Ribes aureum*
Hawthorne	*Crataegus* sp.
Rabbitbrush	*Chrysothamnus nauseosa*
Sandbar willow	*Salix exigua*
Snowberry	*Symphoricarpos occidentalis*
Woods' rose	*Rosa woodsii*
Shrubs – Introduced	
Buckthorn	*Ceanothus velutinus*
Graminoids – Native	
Arctic rush	*Juncus arcticus*
Blue grama	*Bouteloua gracilis*
Buffalograss	*Buchloe dactyloides*
Emory's sedge	*Carex emoryi*
Switchgrass	*Panicum virgatum*
Western wheatgrass	*Pascopyrum smithii*
Graminoids – Introduced	
Cheat grass	*Bromus tectorum*[*]
Crested wheatgrass	*Agropyron cristatum*
Fescue	*Festuca pratensis*
Meadow foxtail	*Alopecurus pratensis*
Orchardgrass	*Dactylis glomerata*
Quackgrass	*Elymus repens*[*]
Reed canarygrass	*Phalaris arundinacea*
Smooth brome	*Bromus inermis*
Forbs – Native	
Goldenrod	*Solidago missouriensis*
Indian hemp	*Apocynum cannabinum*
Sand-verbena	*Abronia fragrans*
Showy milkweed	*Asclepias speciosa*

Common Name	Scientific Name
Wild licorice	*Glycyrrhiza lepidota*
Forbs – Introduced	
Alfalfa	*Medicago sativa*
Canada thistle	*Cirsium arvensis*[*]
Common burdock	*Arctium minor*[*]
Common mullein	*Verbascum thapsus*[*]
Curly dock	*Rumex crispus*
Diffuse knapweed	*Centaurea diffusa*[*]
Kochia	*Bassia scoparium*
Lambsquarter	*Chenopodium album*
Leafy spurge	*Euphorbia esula*[*]
Musk thistle	*Carduus nutans*[*]
Poison hemlock	*Conium maculatum*[*]
Prickly lettuce	*Lactuca serriola*
Scotch thistle	*Onopordum acanthium*[*]
Vines – Introduced	
Virginia creeper	*Parthenocissus quinquefolia*

[*]Listed by the State of Colorado as a noxious weed.

Appendix A
Data Sheets

WETLAND DETERMINATION DATA FORM – Great Plains Region

Project/Site: South Platte River Project City/County: Denver Sampling Date: 6/21/12

Applicant/Owner: ______ State: CO Sampling Point: OP1

Investigator(s): DEL Section, Township, Range: ______

Landform (hillslope, terrace, etc.): Terrace Local relief (concave, convex, none): ______ Slope (%): *

Subregion (LRR): ______ Lat: ______ Long: ______ Datum: ______

Soil Map Unit Name: — NWI classification: ______

Are climatic / hydrologic conditions on the site typical for this time of year? Yes ______ No ______ (If no, explain in Remarks.)

Are Vegetation ______, Soil ______, or Hydrology ✓ significantly disturbed? Are "Normal Circumstances" present? Yes ✓ No ______

Are Vegetation ______, Soil ______, or Hydrology ✓ naturally problematic? (If needed, explain any answers in Remarks.)

SUMMARY OF FINDINGS – Attach site map showing sampling point locations, transects, important features, etc.

Hydrophytic Vegetation Present?	Yes ✓	No ______
Hydric Soil Present?	Yes ______	No —
Wetland Hydrology Present?	Yes ✓	No ______

Is the Sampled Area within a Wetland? Yes ✓ No ______

Remarks: *Terrace + lower slope above Boulders lining pond. Water levels may artificially fluctuate

VEGETATION – Use scientific names of plants.

Tree Stratum (Plot size: ______)	Absolute % Cover	Dominant Species?	Indicator Status
1.			
2.			
3.			
4.			
= Total Cover			

Sapling/Shrub Stratum (Plot size: ______)	Absolute % Cover	Dominant Species?	Indicator Status
1. Ulmus pumilis (Seedling)	2		
2.			
3.			
4.			
5.			
= Total Cover	2		

Herb Stratum (Plot size: 3x15)	Absolute % Cover	Dominant Species?	Indicator Status
1. Carex emoryi	60		
2. Phalaris arundanaceae	10		
3. Solidago missouriensis	15		
4. Bromus inermis	5		
5. Rumex crispus	1		
6. Phalaris arundanacea	10		
7. Pasopyrum smithii	2		
8.			
9.			
10.			
= Total Cover	93		

Woody Vine Stratum (Plot size: ______)	Absolute % Cover	Dominant Species?	Indicator Status
1.			
2.			
= Total Cover			

% Bare Ground in Herb Stratum 7

Dominance Test worksheet:

Number of Dominant Species That Are OBL, FACW, or FAC (excluding FAC−): 1 (A)

Total Number of Dominant Species Across All Strata: 1 (B)

Percent of Dominant Species That Are OBL, FACW, or FAC: 100 (A/B)

Prevalence Index worksheet:

Total % Cover of:		Multiply by:
OBL species	______	x 1 = ______
FACW species	______	x 2 = ______
FAC species	______	x 3 = ______
FACU species	______	x 4 = ______
UPL species	______	x 5 = ______
Column Totals:	______ (A)	______ (B)

Prevalence Index = B/A = ______

Hydrophytic Vegetation Indicators:

✓ 1 - Rapid Test for Hydrophytic Vegetation

✓ 2 - Dominance Test is >50%

___ 3 - Prevalence Index is ≤3.0[1]

___ 4 - Morphological Adaptations[1] (Provide supporting data in Remarks or on a separate sheet)

___ Problematic Hydrophytic Vegetation[1] (Explain)

[1]Indicators of hydric soil and wetland hydrology must be present, unless disturbed or problematic.

Hydrophytic Vegetation Present? Yes ✓ No ______

Remarks:

SOIL

Sampling Point: OP1

Profile Description: (Describe to the depth needed to document the indicator or confirm the absence of indicators.)

Depth (inches)	Matrix Color (moist)	Matrix %	Redox Features Color (moist)	Redox Features %	Type[1]	Loc[2]	Texture	Remarks
0-6	3/3 10YR	100					Sa Cl Lo	
6-12	3/2 10YR	100					Sl Lo Cl	
12-18	3/2 10YR		2/1 10YR	2			Sl Lo Cl	

[1]Type: C=Concentration, D=Depletion, RM=Reduced Matrix, CS=Covered or Coated Sand Grains. [2]Location: PL=Pore Lining, M=Matrix.

Hydric Soil Indicators: (Applicable to all LRRs, unless otherwise noted.)

- ___ Histosol (A1)
- ___ Histic Epipedon (A2)
- ___ Black Histic (A3)
- ___ Hydrogen Sulfide (A4)
- ___ Stratified Layers (A5) **(LRR F)**
- ___ 1 cm Muck (A9) **(LRR F, G, H)**
- ___ Depleted Below Dark Surface (A11)
- ___ Thick Dark Surface (A12)
- ___ Sandy Mucky Mineral (S1)
- ___ 2.5 cm Mucky Peat or Peat (S2) **(LRR G, H)**
- ___ 5 cm Mucky Peat or Peat (S3) **(LRR F)**
- ___ Sandy Gleyed Matrix (S4)
- ___ Sandy Redox (S5)
- ___ Stripped Matrix (S6)
- ___ Loamy Mucky Mineral (F1)
- ___ Loamy Gleyed Matrix (F2)
- ___ Depleted Matrix (F3)
- ___ Redox Dark Surface (F6)
- ___ Depleted Dark Surface (F7)
- ___ Redox Depressions (F8)
- ___ High Plains Depressions (F16) **(MLRA 72 & 73 of LRR H)**

Indicators for Problematic Hydric Soils[3]:

- ___ 1 cm Muck (A9) **(LRR I, J)**
- ___ Coast Prairie Redox (A16) **(LRR F, G, H)**
- ___ Dark Surface (S7) **(LRR G)**
- ___ High Plains Depressions (F16) **(LRR H outside of MLRA 72 & 73)**
- ___ Reduced Vertic (F18)
- ___ Red Parent Material (TF2)
- ___ Very Shallow Dark Surface (TF12)
- ___ Other (Explain in Remarks)

[3]Indicators of hydrophytic vegetation and wetland hydrology must be present, unless disturbed or problematic.

Restrictive Layer (if present):

Type: ___

Depth (inches): ___

Hydric Soil Present? Yes ✓ No ___

Remarks: Recently developed wetlands

HYDROLOGY

Wetland Hydrology Indicators:

Primary Indicators (minimum of one required; check all that apply)

- ___ Surface Water (A1)
- ___ High Water Table (A2)
- ✓ Saturation (A3)
- ___ Water Marks (B1)
- ___ Sediment Deposits (B2)
- ___ Drift Deposits (B3)
- ___ Algal Mat or Crust (B4)
- ___ Iron Deposits (B5)
- ___ Inundation Visible on Aerial Imagery (B7)
- ___ Water-Stained Leaves (B9)
- ___ Salt Crust (B11)
- ___ Aquatic Invertebrates (B13)
- ___ Hydrogen Sulfide Odor (C1)
- ___ Dry-Season Water Table (C2)
- ___ Oxidized Rhizospheres on Living Roots (C3) **(where not tilled)**
- ___ Presence of Reduced Iron (C4)
- ___ Thin Muck Surface (C7)
- ___ Other (Explain in Remarks)

Secondary Indicators (minimum of two required)

- ___ Surface Soil Cracks (B6)
- ___ Sparsely Vegetated Concave Surface (B8)
- ___ Drainage Patterns (B10)
- ___ Oxidized Rhizospheres on Living Roots (C3) **(where tilled)**
- ___ Crayfish Burrows (C8)
- ___ Saturation Visible on Aerial Imagery (C9)
- ___ Geomorphic Position (D2)
- ___ FAC-Neutral Test (D5)
- ___ Frost-Heave Hummocks (D7) **(LRR F)**

Field Observations:

Surface Water Present? Yes ___ No ✓ Depth (inches): ___

Water Table Present? Yes ___ No ✓ Depth (inches): ___

Saturation Present? (includes capillary fringe) Yes ✓ No ___ Depth (inches): 6"

Wetland Hydrology Present? Yes ✓ No ___

Describe Recorded Data (stream gauge, monitoring well, aerial photos, previous inspections), if available:

Remarks:

WETLAND DETERMINATION DATA FORM – Great Plains Region

Project/Site: SPR - Grant to Overland City/County: Denver Sampling Date: 6/21/12

Applicant/Owner: ______ State: CO Sampling Point: DP2

Investigator(s): DEL Section, Township, Range: ______

Landform (hillslope, terrace, etc.): Slope above DP1 Local relief (concave, convex, none): ______ Slope (%): ______

Subregion (LRR): ______ Lat: ______ Long: ______ Datum: ______

Soil Map Unit Name: ______ NWI classification: ______

Are climatic / hydrologic conditions on the site typical for this time of year? Yes ______ No ______ (If no, explain in Remarks.)

Are Vegetation ______, Soil ______, or Hydrology ______ significantly disturbed? Are "Normal Circumstances" present? Yes ______ No ✓

Are Vegetation ______, Soil ______, or Hydrology ______ naturally problematic? (If needed, explain any answers in Remarks.)

SUMMARY OF FINDINGS – Attach site map showing sampling point locations, transects, important features, etc.

Hydrophytic Vegetation Present?	Yes ✓	No ______
Hydric Soil Present?	Yes ______	No ✓
Wetland Hydrology Present?	Yes ______	No ✓

Is the Sampled Area within a Wetland? Yes ______ No ✓

Remarks:
On slope of artificial pond.

VEGETATION – Use scientific names of plants.

	Absolute % Cover	Dominant Species?	Indicator Status
Tree Stratum (Plot size: ______)			
1.			
2.			
3.			
4.			
	______ = Total Cover		
Sapling/Shrub Stratum (Plot size: ______)			
1.			
2.			
3.			
4.			
5.			
	______ = Total Cover		
Herb Stratum (Plot size: ______)			
1. Carex emoryi	25	D	OBL
2. Phalaris arundinacea	35	D	FACW
3. Bromus inermis	15		
4. Pascopyrum smithii	5		
5. Cirsium arvense	3		
6. Rumex crispus	2		
7.			
8.			
9.			
10.			
	85 = Total Cover		
Woody Vine Stratum (Plot size: ______)			
1.			
2.			
	______ = Total Cover		

% Bare Ground in Herb Stratum 15

Dominance Test worksheet:

Number of Dominant Species That Are OBL, FACW, or FAC (excluding FAC–): 2 (A)

Total Number of Dominant Species Across All Strata: 2 (B)

Percent of Dominant Species That Are OBL, FACW, or FAC: 100 (A/B)

Prevalence Index worksheet:

Total % Cover of:	Multiply by:
OBL species ______	x 1 = ______
FACW species ______	x 2 = ______
FAC species ______	x 3 = ______
FACU species ______	x 4 = ______
UPL species ______	x 5 = ______
Column Totals: ______ (A)	______ (B)

Prevalence Index = B/A = ______

Hydrophytic Vegetation Indicators:

- ✓ 1 - Rapid Test for Hydrophytic Vegetation
- ✓ 2 - Dominance Test is >50%
- ___ 3 - Prevalence Index is ≤3.0[1]
- ___ 4 - Morphological Adaptations[1] (Provide supporting data in Remarks or on a separate sheet)
- ___ Problematic Hydrophytic Vegetation[1] (Explain)

[1]Indicators of hydric soil and wetland hydrology must be present, unless disturbed or problematic.

Hydrophytic Vegetation Present? Yes ✓ No ______

Remarks:

SOIL

Sampling Point: DP 2

Profile Description: (Describe to the depth needed to document the indicator or confirm the absence of indicators.)

Depth (inches)	Matrix Color (moist)	Matrix %	Redox Features Color (moist)	Redox Features %	Type[1]	Loc[2]	Texture	Remarks
0-18	3/2 10YR	100						

[1]Type: C=Concentration, D=Depletion, RM=Reduced Matrix, CS=Covered or Coated Sand Grains. [2]Location: PL=Pore Lining, M=Matrix.

Hydric Soil Indicators: (Applicable to all LRRs, unless otherwise noted.)

- ___ Histosol (A1)
- ___ Histic Epipedon (A2)
- ___ Black Histic (A3)
- ___ Hydrogen Sulfide (A4)
- ___ Stratified Layers (A5) (**LRR F**)
- ___ 1 cm Muck (A9) (**LRR F, G, H**)
- ___ Depleted Below Dark Surface (A11)
- ___ Thick Dark Surface (A12)
- ___ Sandy Mucky Mineral (S1)
- ___ 2.5 cm Mucky Peat or Peat (S2) (**LRR G, H**)
- ___ 5 cm Mucky Peat or Peat (S3) (**LRR F**)
- ___ Sandy Gleyed Matrix (S4)
- ___ Sandy Redox (S5)
- ___ Stripped Matrix (S6)
- ___ Loamy Mucky Mineral (F1)
- ___ Loamy Gleyed Matrix (F2)
- ___ Depleted Matrix (F3)
- ___ Redox Dark Surface (F6)
- ___ Depleted Dark Surface (F7)
- ___ Redox Depressions (F8)
- ___ High Plains Depressions (F16) (**MLRA 72 & 73 of LRR H**)

Indicators for Problematic Hydric Soils[3]:

- ___ 1 cm Muck (A9) (**LRR I, J**)
- ___ Coast Prairie Redox (A16) (**LRR F, G, H**)
- ___ Dark Surface (S7) (**LRR G**)
- ___ High Plains Depressions (F16) (**LRR H outside of MLRA 72 & 73**)
- ___ Reduced Vertic (F18)
- ___ Red Parent Material (TF2)
- ___ Very Shallow Dark Surface (TF12)
- ___ Other (Explain in Remarks)

[3]Indicators of hydrophytic vegetation and wetland hydrology must be present, unless disturbed or problematic.

Restrictive Layer (if present):

Type: ______________

Depth (inches): ______________

Hydric Soil Present? Yes ____ No ✓

Remarks:

HYDROLOGY

Wetland Hydrology Indicators:

Primary Indicators (minimum of one required; check all that apply)

- ___ Surface Water (A1)
- ___ High Water Table (A2)
- ___ Saturation (A3)
- ___ Water Marks (B1)
- ___ Sediment Deposits (B2)
- ___ Drift Deposits (B3)
- ___ Algal Mat or Crust (B4)
- ___ Iron Deposits (B5)
- ___ Inundation Visible on Aerial Imagery (B7)
- ___ Water-Stained Leaves (B9)
- ___ Salt Crust (B11)
- ___ Aquatic Invertebrates (B13)
- ___ Hydrogen Sulfide Odor (C1)
- ___ Dry-Season Water Table (C2)
- ___ Oxidized Rhizospheres on Living Roots (C3) (**where not tilled**)
- ___ Presence of Reduced Iron (C4)
- ___ Thin Muck Surface (C7)
- ___ Other (Explain in Remarks)

Secondary Indicators (minimum of two required)

- ___ Surface Soil Cracks (B6)
- ___ Sparsely Vegetated Concave Surface (B8)
- ___ Drainage Patterns (B10)
- ___ Oxidized Rhizospheres on Living Roots (C3) (**where tilled**)
- ___ Crayfish Burrows (C8)
- ___ Saturation Visible on Aerial Imagery (C9)
- ___ Geomorphic Position (D2)
- ___ FAC-Neutral Test (D5)
- ___ Frost-Heave Hummocks (D7) (**LRR F**)

Field Observations:

Surface Water Present? Yes ____ No ✓ Depth (inches): ______

Water Table Present? Yes ____ No ✓ Depth (inches): ______

Saturation Present? (includes capillary fringe) Yes ____ No ✓ Depth (inches): ______

Wetland Hydrology Present? Yes ____ No ✓

Describe Recorded Data (stream gauge, monitoring well, aerial photos, previous inspections), if available:

Remarks:

WETLAND DETERMINATION DATA FORM – Great Plains Region

Project/Site: SPR - Grant to Overland City/County: Denver Sampling Date: 6/21/12

Applicant/Owner: ______ State: CO Sampling Point: DP3

Investigator(s): DEL Section, Township, Range: ______

Landform (hillslope, terrace, etc.): Terrace Local relief (concave, convex, none): none Slope (%): flat

Subregion (LRR): ______ Lat: ______ Long: ______ Datum: ______

Soil Map Unit Name: ______ NWI classification: ______

Are climatic / hydrologic conditions on the site typical for this time of year? Yes ______ No ______ (If no, explain in Remarks.)

Are Vegetation ______, Soil ______, or Hydrology ______ significantly disturbed? Are "Normal Circumstances" present? Yes ✓ No ______

Are Vegetation ______, Soil ______, or Hydrology ______ naturally problematic? (If needed, explain any answers in Remarks.)

SUMMARY OF FINDINGS – Attach site map showing sampling point locations, transects, important features, etc.

Hydrophytic Vegetation Present? Yes ✓ No ______		**Is the Sampled Area within a Wetland?** Yes ✓ No ______
Hydric Soil Present? Yes ✓ No ______		
Wetland Hydrology Present? Yes ✓ No ______		

Remarks:

VEGETATION – Use scientific names of plants.

Tree Stratum (Plot size: ______)	Absolute % Cover	Dominant Species?	Indicator Status
1.			
2.			
3.			
4.			
		= Total Cover	
Sapling/Shrub Stratum (Plot size: ______)			
1. Salix exigua	30	D	FACW
2.			
3.			
4.			
5.			
		= Total Cover	
Herb Stratum (Plot size: ______)			
1. Apocynum cannabinum	15	D	FAC
2. Festuca pratensis	20	D	FACU
3. Elymus repens	10	D	FACU
4. Alopecurus pratensis	5		FACW
5. Carex emoryi	5		OBL
6. Phalaris arundinacea	10		FACW
7. Juncus arcticus	10		FACW
8.			
9.			
10.			
	75	= Total Cover	
Woody Vine Stratum (Plot size: ______)			
1.			
2.			
% Bare Ground in Herb Stratum 25		= Total Cover	

Dominance Test worksheet:

Number of Dominant Species That Are OBL, FACW, or FAC (excluding FAC–): 2 (A)

Total Number of Dominant Species Across All Strata: 4 (B)

Percent of Dominant Species That Are OBL, FACW, or FAC: 50 % (A/B)

Prevalence Index worksheet:

Total % Cover of:		Multiply by:
OBL species	5	x 1 = 5
FACW species	55	x 2 = 110
FAC species	15	x 3 = 45
FACU species	30	x 4 = 120
UPL species	0	x 5 = 0
Column Totals:	105 (A)	280 (B)

Prevalence Index = B/A = 2.7

Hydrophytic Vegetation Indicators:

- ___ 1 - Rapid Test for Hydrophytic Vegetation
- ___ 2 - Dominance Test is >50%
- ___ 3 - Prevalence Index is ≤3.0[1]
- ___ 4 - Morphological Adaptations[1] (Provide supporting data in Remarks or on a separate sheet)
- ___ Problematic Hydrophytic Vegetation[1] (Explain)

[1]Indicators of hydric soil and wetland hydrology must be present, unless disturbed or problematic.

Hydrophytic Vegetation Present? Yes ✓ No ______

Remarks:

SOIL

Sampling Point: DP3

Profile Description: (Describe to the depth needed to document the indicator or confirm the absence of indicators.)

Depth (inches)	Matrix Color (moist)	Matrix %	Redox Features Color (moist)	Redox %	Type[1]	Loc[2]	Texture	Remarks
0-3	3/2 10YR	100					Sa Lo	
3-12	4/2 10YR	75	4/6 10YR	25			Lo Sa	Layers of Sand al So

[1]Type: C=Concentration, D=Depletion, RM=Reduced Matrix, CS=Covered or Coated Sand Grains. [2]Location: PL=Pore Lining, M=Matrix.

Hydric Soil Indicators: (Applicable to all LRRs, unless otherwise noted.)

- ___ Histosol (A1)
- ___ Histic Epipedon (A2)
- ___ Black Histic (A3)
- ___ Hydrogen Sulfide (A4)
- ___ Stratified Layers (A5) (**LRR F**)
- ___ 1 cm Muck (A9) (**LRR F, G, H**)
- ___ Depleted Below Dark Surface (A11)
- ___ Thick Dark Surface (A12)
- ___ Sandy Mucky Mineral (S1)
- ___ 2.5 cm Mucky Peat or Peat (S2) (**LRR G, H**)
- ___ 5 cm Mucky Peat or Peat (S3) (**LRR F**)
- ___ Sandy Gleyed Matrix (S4)
- ___ Sandy Redox (S5)
- ___ Stripped Matrix (S6)
- ___ Loamy Mucky Mineral (F1)
- ___ Loamy Gleyed Matrix (F2)
- ___ Depleted Matrix (F3)
- ✓ Redox Dark Surface (F6)
- ___ Depleted Dark Surface (F7)
- ___ Redox Depressions (F8)
- ___ High Plains Depressions (F16) (**MLRA 72 & 73 of LRR H**)

Indicators for Problematic Hydric Soils[3]:

- ___ 1 cm Muck (A9) (**LRR I, J**)
- ___ Coast Prairie Redox (A16) (**LRR F, G, H**)
- ___ Dark Surface (S7) (**LRR G**)
- ___ High Plains Depressions (F16) (**LRR H outside of MLRA 72 & 73**)
- ___ Reduced Vertic (F18)
- ___ Red Parent Material (TF2)
- ___ Very Shallow Dark Surface (TF12)
- ___ Other (Explain in Remarks)

[3]Indicators of hydrophytic vegetation and wetland hydrology must be present, unless disturbed or problematic.

Restrictive Layer (if present):

Type: ______

Depth (inches): ______

Hydric Soil Present? Yes ✓ No ___

Remarks:

HYDROLOGY

Wetland Hydrology Indicators:

Primary Indicators (minimum of one required; check all that apply)

- ___ Surface Water (A1)
- ___ High Water Table (A2)
- ___ Saturation (A3)
- ___ Water Marks (B1)
- ___ Sediment Deposits (B2)
- ✓ Drift Deposits (B3)
- ___ Algal Mat or Crust (B4)
- ___ Iron Deposits (B5)
- ___ Inundation Visible on Aerial Imagery (B7)
- ___ Water-Stained Leaves (B9)
- ___ Salt Crust (B11)
- ___ Aquatic Invertebrates (B13)
- ___ Hydrogen Sulfide Odor (C1)
- ___ Dry-Season Water Table (C2)
- ___ Oxidized Rhizospheres on Living Roots (C3) (**where not tilled**)
- ___ Presence of Reduced Iron (C4)
- ___ Thin Muck Surface (C7)
- ___ Other (Explain in Remarks)

Secondary Indicators (minimum of two required)

- ___ Surface Soil Cracks (B6)
- ___ Sparsely Vegetated Concave Surface (B8)
- ___ Drainage Patterns (B10)
- ___ Oxidized Rhizospheres on Living Roots (C3) (**where tilled**)
- ___ Crayfish Burrows (C8)
- ___ Saturation Visible on Aerial Imagery (C9)
- ___ Geomorphic Position (D2)
- ___ FAC-Neutral Test (D5)
- ___ Frost-Heave Hummocks (D7) (**LRR F**)

Field Observations:

Surface Water Present? Yes ___ No ✓ Depth (inches): ______

Water Table Present? Yes ___ No ✓ Depth (inches): ______

Saturation Present? (includes capillary fringe) Yes ___ No ✓ Depth (inches): ______

Wetland Hydrology Present? Yes ✓ No ___

Describe Recorded Data (stream gauge, monitoring well, aerial photos, previous inspections), if available:

Remarks:

WETLAND DETERMINATION DATA FORM – Great Plains Region

Project/Site: SPR - Grant to Overland City/County: Denver Sampling Date: 6/21/12

Applicant/Owner: ______ State: CO Sampling Point: NP4

Investigator(s): PEL Section, Township, Range: ______

Landform (hillslope, terrace, etc.): Upper terrace Local relief (concave, convex, none): ______ Slope (%): Shallow

Subregion (LRR): ______ Lat: ______ Long: ______ Datum: ______

Soil Map Unit Name: ______ NWI classification: ______

Are climatic / hydrologic conditions on the site typical for this time of year? Yes ______ No ______ (If no, explain in Remarks.)

Are Vegetation ______, Soil ______, or Hydrology ______ significantly disturbed? Are "Normal Circumstances" present? Yes ✓ No ______

Are Vegetation ______, Soil ______, or Hydrology ______ naturally problematic? (If needed, explain any answers in Remarks.)

SUMMARY OF FINDINGS – Attach site map showing sampling point locations, transects, important features, etc.

Hydrophytic Vegetation Present?	Yes ______	No ✓
Hydric Soil Present?	Yes ______	No ✓
Wetland Hydrology Present?	Yes ______	No ✓

Is the Sampled Area within a Wetland? Yes ______ No ✓

Remarks:

VEGETATION – Use scientific names of plants.

	Absolute % Cover	Dominant Species?	Indicator Status
Tree Stratum (Plot size: ______)			
1.			
2.			
3.			
4.			
	______ = Total Cover		
Sapling/Shrub Stratum (Plot size: ______)			
1. Robinia sp (Seedling)	2		UPL
2.			
3.			
4.			
5.			
	______ = Total Cover		
Herb Stratum (Plot size: ______)			
1. Elymus repens	50	D	FACU
2. Cirsium arvense	2		FACU
3. Apocynum cannabinum	15	D	FAC
4. Festuca pratensis	5		FACU
5.			
6.			
7.			
8.			
9.			
10.			
	72 = Total Cover		
Woody Vine Stratum (Plot size: ______)			
1.			
2.			
	______ = Total Cover		
% Bare Ground in Herb Stratum 28			

Dominance Test worksheet:

Number of Dominant Species That Are OBL, FACW, or FAC (excluding FAC−): 1 (A)

Total Number of Dominant Species Across All Strata: 2 (B)

Percent of Dominant Species That Are OBL, FACW, or FAC: 50 (A/B)

Prevalence Index worksheet:

Total % Cover of:		Multiply by:
OBL species	0	x 1 = 0
FACW species	0	x 2 = 0
FAC species	15	x 3 = 45
FACU species	57	x 4 = 228
UPL species	2	x 5 = 8
Column Totals:	74 (A)	281 (B)

Prevalence Index = B/A = 3.8

Hydrophytic Vegetation Indicators:

___ 1 - Rapid Test for Hydrophytic Vegetation

___ 2 - Dominance Test is >50%

___ 3 - Prevalence Index is ≤3.0[1]

___ 4 - Morphological Adaptations[1] (Provide supporting data in Remarks or on a separate sheet)

___ Problematic Hydrophytic Vegetation[1] (Explain)

[1]Indicators of hydric soil and wetland hydrology must be present, unless disturbed or problematic.

Hydrophytic Vegetation Present? Yes ______ No ✓

Remarks:

SOIL

Sampling Point: DP4

Profile Description: (Describe to the depth needed to document the indicator or confirm the absence of indicators.)

Depth (inches)	Matrix Color (moist)	Matrix %	Redox Features Color (moist)	Redox Features %	Type[1]	Loc[2]	Texture	Remarks
0-5	3/2 10YR						Sa L	
5-18	3/2 10YR						Lo Sa	

[1]Type: C=Concentration, D=Depletion, RM=Reduced Matrix, CS=Covered or Coated Sand Grains. [2]Location: PL=Pore Lining, M=Matrix.

Hydric Soil Indicators: (Applicable to all LRRs, unless otherwise noted.)

- ___ Histosol (A1)
- ___ Histic Epipedon (A2)
- ___ Black Histic (A3)
- ___ Hydrogen Sulfide (A4)
- ___ Stratified Layers (A5) **(LRR F)**
- ___ 1 cm Muck (A9) **(LRR F, G, H)**
- ___ Depleted Below Dark Surface (A11)
- ___ Thick Dark Surface (A12)
- ___ Sandy Mucky Mineral (S1)
- ___ 2.5 cm Mucky Peat or Peat (S2) **(LRR G, H)**
- ___ 5 cm Mucky Peat or Peat (S3) **(LRR F)**
- ___ Sandy Gleyed Matrix (S4)
- ___ Sandy Redox (S5)
- ___ Stripped Matrix (S6)
- ___ Loamy Mucky Mineral (F1)
- ___ Loamy Gleyed Matrix (F2)
- ___ Depleted Matrix (F3)
- ___ Redox Dark Surface (F6)
- ___ Depleted Dark Surface (F7)
- ___ Redox Depressions (F8)
- ___ High Plains Depressions (F16) **(MLRA 72 & 73 of LRR H)**

Indicators for Problematic Hydric Soils[3]:

- ___ 1 cm Muck (A9) **(LRR I, J)**
- ___ Coast Prairie Redox (A16) **(LRR F, G, H)**
- ___ Dark Surface (S7) **(LRR G)**
- ___ High Plains Depressions (F16) **(LRR H outside of MLRA 72 & 73)**
- ___ Reduced Vertic (F18)
- ___ Red Parent Material (TF2)
- ___ Very Shallow Dark Surface (TF12)
- ___ Other (Explain in Remarks)

[3]Indicators of hydrophytic vegetation and wetland hydrology must be present, unless disturbed or problematic.

Restrictive Layer (if present):

Type: ______________

Depth (inches): ______________

Hydric Soil Present? Yes ____ No ✓

Remarks:

HYDROLOGY

Wetland Hydrology Indicators:

Primary Indicators (minimum of one required; check all that apply)

- ___ Surface Water (A1)
- ___ High Water Table (A2)
- ___ Saturation (A3)
- ___ Water Marks (B1)
- ___ Sediment Deposits (B2)
- ___ Drift Deposits (B3)
- ___ Algal Mat or Crust (B4)
- ___ Iron Deposits (B5)
- ___ Inundation Visible on Aerial Imagery (B7)
- ___ Water-Stained Leaves (B9)
- ___ Salt Crust (B11)
- ___ Aquatic Invertebrates (B13)
- ___ Hydrogen Sulfide Odor (C1)
- ___ Dry-Season Water Table (C2)
- ___ Oxidized Rhizospheres on Living Roots (C3) **(where not tilled)**
- ___ Presence of Reduced Iron (C4)
- ___ Thin Muck Surface (C7)
- ___ Other (Explain in Remarks)

Secondary Indicators (minimum of two required)

- ___ Surface Soil Cracks (B6)
- ___ Sparsely Vegetated Concave Surface (B8)
- ___ Drainage Patterns (B10)
- ___ Oxidized Rhizospheres on Living Roots (C3) **(where tilled)**
- ___ Crayfish Burrows (C8)
- ___ Saturation Visible on Aerial Imagery (C9)
- ___ Geomorphic Position (D2)
- ___ FAC-Neutral Test (D5)
- ___ Frost-Heave Hummocks (D7) **(LRR F)**

Field Observations:

Surface Water Present? Yes ____ No ✓ Depth (inches): ______

Water Table Present? Yes ____ No ✓ Depth (inches): ______

Saturation Present? (includes capillary fringe) Yes ____ No ✓ Depth (inches): ______

Wetland Hydrology Present? Yes ____ No ✓

Describe Recorded Data (stream gauge, monitoring well, aerial photos, previous inspections), if available:

Remarks:

WETLAND DETERMINATION DATA FORM – Great Plains Region

Project/Site: SPR - Grant to Overland City/County: ______ Sampling Date: 6/21/12
Applicant/Owner: ______ State: ______ Sampling Point: DPS
Investigator(s): DEL Section, Township, Range: ______
Landform (hillslope, terrace, etc.): Lower terrace Local relief (concave, convex, none): Slightly Slope (%): flat
Subregion (LRR): ______ Lat: ______ Long: ______ Datum: ______
Soil Map Unit Name: ______ NWI classification: ______
Are climatic / hydrologic conditions on the site typical for this time of year? Yes ______ No ______ (If no, explain in Remarks.)
Are Vegetation ______, Soil ______, or Hydrology ______ significantly disturbed? Are "Normal Circumstances" present? Yes ______ No ______
Are Vegetation ______, Soil ______, or Hydrology ______ naturally problematic? (If needed, explain any answers in Remarks.)

SUMMARY OF FINDINGS – Attach site map showing sampling point locations, transects, important features, etc.

Hydrophytic Vegetation Present? Yes ✓ No ______	Is the Sampled Area within a Wetland?	Yes ✓ No ______
Hydric Soil Present? Yes ✓ No ______		
Wetland Hydrology Present? Yes ✓ No ______		

Remarks:

VEGETATION – Use scientific names of plants.

	Absolute % Cover	Dominant Species?	Indicator Status
Tree Stratum (Plot size: ______)			
1.			
2.			
3.			
4.			
= Total Cover			
Sapling/Shrub Stratum (Plot size: ______)			
1. Salix exigua	20	D	FACW
2. Ulmus pumila (Sapling)	5	D	UPL
3.			
4.			
5.			
= Total Cover	25		
Herb Stratum (Plot size: 5x15)			
1. Apocynum cannabinum	30	D	FAC
2. Carex emoryi	40	D	OBL
3. Phalaris arundinacea	20		
4.			
5.			
6.			
7.			
8.			
9.			
10.			
= Total Cover			
Woody Vine Stratum (Plot size: ______)			
1.			
2.			
= Total Cover			
% Bare Ground in Herb Stratum ______			

Dominance Test worksheet:

Number of Dominant Species That Are OBL, FACW, or FAC (excluding FAC−): 3 (A)
Total Number of Dominant Species Across All Strata: 4 (B)
Percent of Dominant Species That Are OBL, FACW, or FAC: 75 (A/B)

Prevalence Index worksheet:

Total % Cover of:	Multiply by:
OBL species ______	x 1 = ______
FACW species ______	x 2 = ______
FAC species ______	x 3 = ______
FACU species ______	x 4 = ______
UPL species ______	x 5 = ______
Column Totals: ______ (A)	______ (B)

Prevalence Index = B/A = ______

Hydrophytic Vegetation Indicators:

___ 1 - Rapid Test for Hydrophytic Vegetation
___ 2 - Dominance Test is >50%
___ 3 - Prevalence Index is ≤3.0[1]
___ 4 - Morphological Adaptations[1] (Provide supporting data in Remarks or on a separate sheet)
___ Problematic Hydrophytic Vegetation[1] (Explain)

[1]Indicators of hydric soil and wetland hydrology must be present, unless disturbed or problematic.

Hydrophytic Vegetation Present? Yes ✓ No ______

Remarks:

SOIL

Sampling Point: DPS

Profile Description: (Describe to the depth needed to document the indicator or confirm the absence of indicators.)

Depth (inches)	Matrix Color (moist)	Matrix %	Redox Features Color (moist)	Redox %	Type[1]	Loc[2]	Texture	Remarks

[1]Type: C=Concentration, D=Depletion, RM=Reduced Matrix, CS=Covered or Coated Sand Grains. [2]Location: PL=Pore Lining, M=Matrix.

Hydric Soil Indicators: (Applicable to all LRRs, unless otherwise noted.)

- ___ Histosol (A1)
- ___ Histic Epipedon (A2)
- ___ Black Histic (A3)
- ___ Hydrogen Sulfide (A4)
- ___ Stratified Layers (A5) (**LRR F**)
- ___ 1 cm Muck (A9) (**LRR F, G, H**)
- ___ Depleted Below Dark Surface (A11)
- ___ Thick Dark Surface (A12)
- ___ Sandy Mucky Mineral (S1)
- ___ 2.5 cm Mucky Peat or Peat (S2) (**LRR G, H**)
- ___ 5 cm Mucky Peat or Peat (S3) (**LRR F**)
- ___ Sandy Gleyed Matrix (S4)
- ___ Sandy Redox (S5)
- ___ Stripped Matrix (S6)
- ___ Loamy Mucky Mineral (F1)
- ___ Loamy Gleyed Matrix (F2)
- ___ Depleted Matrix (F3)
- ___ Redox Dark Surface (F6)
- ___ Depleted Dark Surface (F7)
- ___ Redox Depressions (F8)
- ___ High Plains Depressions (F16) **(MLRA 72 & 73 of LRR H)**

Indicators for Problematic Hydric Soils[3]:

- ___ 1 cm Muck (A9) (**LRR I, J**)
- ___ Coast Prairie Redox (A16) (**LRR F, G, H**)
- ___ Dark Surface (S7) (**LRR G**)
- ___ High Plains Depressions (F16) **(LRR H outside of MLRA 72 & 73)**
- ___ Reduced Vertic (F18)
- ___ Red Parent Material (TF2)
- ___ Very Shallow Dark Surface (TF12)
- ___ Other (Explain in Remarks)

[3]Indicators of hydrophytic vegetation and wetland hydrology must be present, unless disturbed or problematic.

Restrictive Layer (if present):

Type: ____________

Depth (inches): ____________

Hydric Soil Present? Yes ✓ No ___

Remarks: assumed

HYDROLOGY

Wetland Hydrology Indicators:

Primary Indicators (minimum of one required; check all that apply)

- ___ Surface Water (A1)
- ___ High Water Table (A2)
- ___ Saturation (A3)
- ___ Water Marks (B1)
- ___ Sediment Deposits (B2)
- ✓ Drift Deposits (B3)
- ___ Algal Mat or Crust (B4)
- ___ Iron Deposits (B5)
- ___ Inundation Visible on Aerial Imagery (B7)
- ___ Water-Stained Leaves (B9)
- ___ Salt Crust (B11)
- ___ Aquatic Invertebrates (B13)
- ___ Hydrogen Sulfide Odor (C1)
- ___ Dry-Season Water Table (C2)
- ___ Oxidized Rhizospheres on Living Roots (C3) **(where not tilled)**
- ___ Presence of Reduced Iron (C4)
- ___ Thin Muck Surface (C7)
- ___ Other (Explain in Remarks)

Secondary Indicators (minimum of two required)

- ___ Surface Soil Cracks (B6)
- ___ Sparsely Vegetated Concave Surface (B8)
- ___ Drainage Patterns (B10)
- ___ Oxidized Rhizospheres on Living Roots (C3) **(where tilled)**
- ___ Crayfish Burrows (C8)
- ___ Saturation Visible on Aerial Imagery (C9)
- ___ Geomorphic Position (D2)
- ___ FAC-Neutral Test (D5)
- ___ Frost-Heave Hummocks (D7) (**LRR F**)

Field Observations:

Surface Water Present? Yes ___ No ✓ Depth (inches): ______

Water Table Present? Yes ___ No ✓ Depth (inches): ______

Saturation Present? (includes capillary fringe) Yes ___ No ✓ Depth (inches): ______

Wetland Hydrology Present? Yes ✓ No ___

Describe Recorded Data (stream gauge, monitoring well, aerial photos, previous inspections), if available:

Remarks:

WETLAND DETERMINATION DATA FORM – Great Plains Region

Project/Site: SPR-Grant to Overland City/County: Denver Sampling Date: 6/21/12

Applicant/Owner: ______ State: CO Sampling Point: DP6

Investigator(s): DEC Section, Township, Range: ______

Landform (hillslope, terrace, etc.): Terrace Local relief (concave, convex, none): ______ Slope (%): ______

Subregion (LRR): ______ Lat: ______ Long: ______ Datum: ______

Soil Map Unit Name: ______ NWI classification: ______

Are climatic / hydrologic conditions on the site typical for this time of year? Yes ______ No ______ (If no, explain in Remarks.)

Are Vegetation ______, Soil ______, or Hydrology ______ significantly disturbed? Are "Normal Circumstances" present? Yes ✓ No ______

Are Vegetation ______, Soil ______, or Hydrology ______ naturally problematic? (If needed, explain any answers in Remarks.)

SUMMARY OF FINDINGS – Attach site map showing sampling point locations, transects, important features, etc.

Hydrophytic Vegetation Present?	Yes ______ No ✓	Is the Sampled Area within a Wetland? Yes ______ No ✓
Hydric Soil Present?	Yes ______ No ✓	
Wetland Hydrology Present?	Yes ______ No ✓	

Remarks:

VEGETATION – Use scientific names of plants.

Tree Stratum (Plot size: ______)	Absolute % Cover	Dominant Species?	Indicator Status
1.			
2.			
3.			
4.			
= Total Cover			
Sapling/Shrub Stratum (Plot size: ______)			
1. Salix exigua	20	D	FACW
2. Acer negundo (seedling)	2		FAC
3. Ulmus pumilus (seedling)	2		UPL
4. Ceonathus velatunis	10	D	UPL
5.			
= Total Cover	34		
Herb Stratum (Plot size: 25x25)			
1. Festuca pratensis	25	D	FACU
2. Cirsium arvense	10		FACU
3. Bromus inermis	20	D	UPL
4. Apocynum cannabinum	3		FAC
5. Dactylis glomerata	15	D	FACU
6.			
7.			
8.			
9.			
10.			
= Total Cover	73		
Woody Vine Stratum (Plot size: ______)			
1. Parthenocissus quinquefolia	5	D	FACU
2.			
= Total Cover	5		

% Bare Ground in Herb Stratum 27

Dominance Test worksheet:

Number of Dominant Species That Are OBL, FACW, or FAC (excluding FAC–): 1 (A)

Total Number of Dominant Species Across All Strata: 6 (B)

Percent of Dominant Species That Are OBL, FACW, or FAC: 17 (A/B)

Prevalence Index worksheet:

Total % Cover of:	Multiply by:
OBL species ______	x 1 = ______
FACW species ______	x 2 = ______
FAC species ______	x 3 = ______
FACU species ______	x 4 = ______
UPL species ______	x 5 = ______
Column Totals: ______ (A)	______ (B)

Prevalence Index = B/A = ______

Hydrophytic Vegetation Indicators:

___ 1 - Rapid Test for Hydrophytic Vegetation

___ 2 - Dominance Test is >50%

___ 3 - Prevalence Index is ≤3.0[1]

___ 4 - Morphological Adaptations[1] (Provide supporting data in Remarks or on a separate sheet)

___ Problematic Hydrophytic Vegetation[1] (Explain)

[1]Indicators of hydric soil and wetland hydrology must be present, unless disturbed or problematic.

Hydrophytic Vegetation Present? Yes ______ No ✓

Remarks:

SOIL

Sampling Point: DP6

Profile Description: (Describe to the depth needed to document the indicator or confirm the absence of indicators.)

Depth (inches)	Matrix Color (moist)	Matrix %	Redox Features Color (moist)	Redox Features %	Type[1]	Loc[2]	Texture	Remarks

[1]Type: C=Concentration, D=Depletion, RM=Reduced Matrix, CS=Covered or Coated Sand Grains. [2]Location: PL=Pore Lining, M=Matrix.

Hydric Soil Indicators: (Applicable to all LRRs, unless otherwise noted.)

- ___ Histosol (A1)
- ___ Histic Epipedon (A2)
- ___ Black Histic (A3)
- ___ Hydrogen Sulfide (A4)
- ___ Stratified Layers (A5) **(LRR F)**
- ___ 1 cm Muck (A9) **(LRR F, G, H)**
- ___ Depleted Below Dark Surface (A11)
- ___ Thick Dark Surface (A12)
- ___ Sandy Mucky Mineral (S1)
- ___ 2.5 cm Mucky Peat or Peat (S2) **(LRR G, H)**
- ___ 5 cm Mucky Peat or Peat (S3) **(LRR F)**
- ___ Sandy Gleyed Matrix (S4)
- ___ Sandy Redox (S5)
- ___ Stripped Matrix (S6)
- ___ Loamy Mucky Mineral (F1)
- ___ Loamy Gleyed Matrix (F2)
- ___ Depleted Matrix (F3)
- ___ Redox Dark Surface (F6)
- ___ Depleted Dark Surface (F7)
- ___ Redox Depressions (F8)
- ___ High Plains Depressions (F16) **(MLRA 72 & 73 of LRR H)**

Indicators for Problematic Hydric Soils[3]:

- ___ 1 cm Muck (A9) **(LRR I, J)**
- ___ Coast Prairie Redox (A16) **(LRR F, G, H)**
- ___ Dark Surface (S7) **(LRR G)**
- ___ High Plains Depressions (F16) **(LRR H outside of MLRA 72 & 73)**
- ___ Reduced Vertic (F18)
- ___ Red Parent Material (TF2)
- ___ Very Shallow Dark Surface (TF12)
- ___ Other (Explain in Remarks)

[3]Indicators of hydrophytic vegetation and wetland hydrology must be present, unless disturbed or problematic.

Restrictive Layer (if present):

Type: ______

Depth (inches): ______

Hydric Soil Present? Yes ___ No ✓

Remarks: assumed

HYDROLOGY

Wetland Hydrology Indicators:

Primary Indicators (minimum of one required; check all that apply)

- ___ Surface Water (A1)
- ___ High Water Table (A2)
- ___ Saturation (A3)
- ___ Water Marks (B1)
- ___ Sediment Deposits (B2)
- ___ Drift Deposits (B3)
- ___ Algal Mat or Crust (B4)
- ___ Iron Deposits (B5)
- ___ Inundation Visible on Aerial Imagery (B7)
- ___ Water-Stained Leaves (B9)
- ___ Salt Crust (B11)
- ___ Aquatic Invertebrates (B13)
- ___ Hydrogen Sulfide Odor (C1)
- ___ Dry-Season Water Table (C2)
- ___ Oxidized Rhizospheres on Living Roots (C3) **(where not tilled)**
- ___ Presence of Reduced Iron (C4)
- ___ Thin Muck Surface (C7)
- ___ Other (Explain in Remarks)

Secondary Indicators (minimum of two required)

- ___ Surface Soil Cracks (B6)
- ___ Sparsely Vegetated Concave Surface (B8)
- ___ Drainage Patterns (B10)
- ___ Oxidized Rhizospheres on Living Roots (C3) **(where tilled)**
- ___ Crayfish Burrows (C8)
- ___ Saturation Visible on Aerial Imagery (C9)
- ___ Geomorphic Position (D2)
- ___ FAC-Neutral Test (D5)
- ___ Frost-Heave Hummocks (D7) **(LRR F)**

Field Observations:

Surface Water Present? Yes ___ No ✓ Depth (inches): ______

Water Table Present? Yes ___ No ✓ Depth (inches): ______

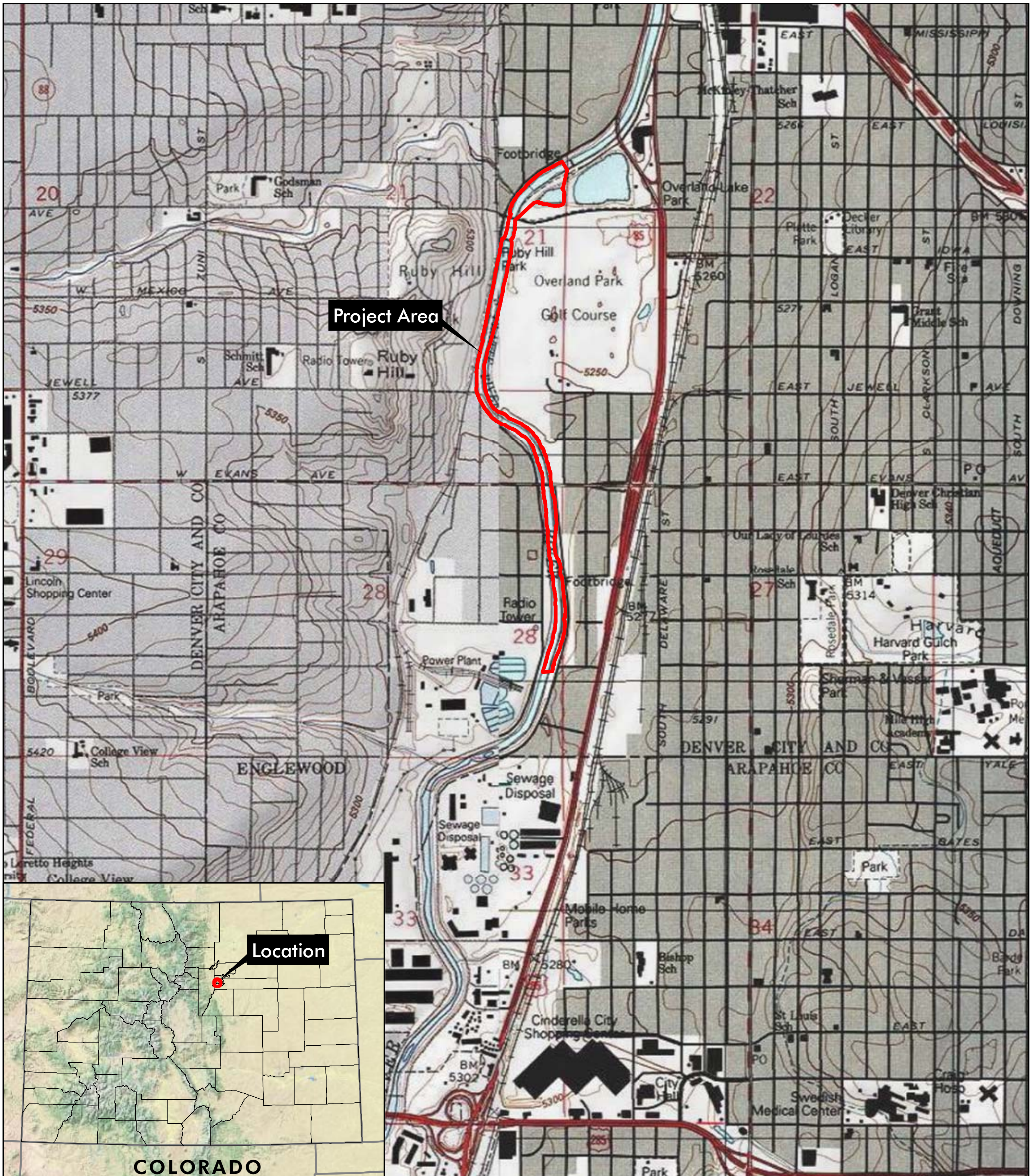
Saturation Present? (includes capillary fringe) Yes ___ No ✓ Depth (inches): ______

Wetland Hydrology Present? Yes ___ No ✓

Describe Recorded Data (stream gauge, monitoring well, aerial photos, previous inspections), if available:

Remarks:

Figures



South Platte River - Grant to Overland

Sections 21 and 28, T4S, R68W; 6th PM

UTM NAD 83: Zone 13N; 500088mE, 4392564mN

Latitude, Longitude: 39.682911°N, 104.998979°W

USGS Englewood and Fort Logan, CO Quadrangles

City and County of Denver, Colorado

0 1,000 2,000 feet

N

Figure 1
Vicinity Map

Prepared for: CDM Smith Inc.
File: 5233 Figure 1.mxd [WH]
July 2012

ERO Resources Corp.

South Platte River - Grant to Overland

- Data Point
- Waters of the U.S.
- Wetland
- Minor Elevation Contour
- Major Elevation Contour

0 100 200 feet

N

Figure 2
Wetlands and Waters of the U.S.

Prepared for: CDM Smith Inc.
File: 5233 wetlands.mxd (WH)
July 2012

ERO
ERO Resources Corp.

South Platte River - Grant to Overland

- Data Point
- Waters of the U.S.
- Wetland
- Minor Elevation Contour
- Major Elevation Contour

0 100 200 feet

N

Figure 3
Wetlands and Waters of the U.S.

Prepared for: CDM Smith Inc.
File: 5233 wetlands.mxd (WH)
July 2012

ERO Resources Corp.

South Platte River - Grant to Overland

- Data Point
- Waters of the U.S.
- Wetland
- Minor Elevation Contour
- Major Elevation Contour

0 100 200 feet

N

Figure 4
Wetlands and Waters of the U.S.

Prepared for: CDM Smith Inc.
File: 5233 wetlands.mxd (WH)
July 2012

ERO
ERO Resources Corp.

Photo Log

Photo 1 - South Platte River and surrounding riparian vegetation (typical).

Photo 2 - Steep banks with no wetlands on opposite shore of river.

Photo 3 - Narrow fringe of wetlands along riverbanks.

Photo 4 - Wetlands on relatively wide terrace (DP3).

Photo 5 - Overview of Overland Pond.

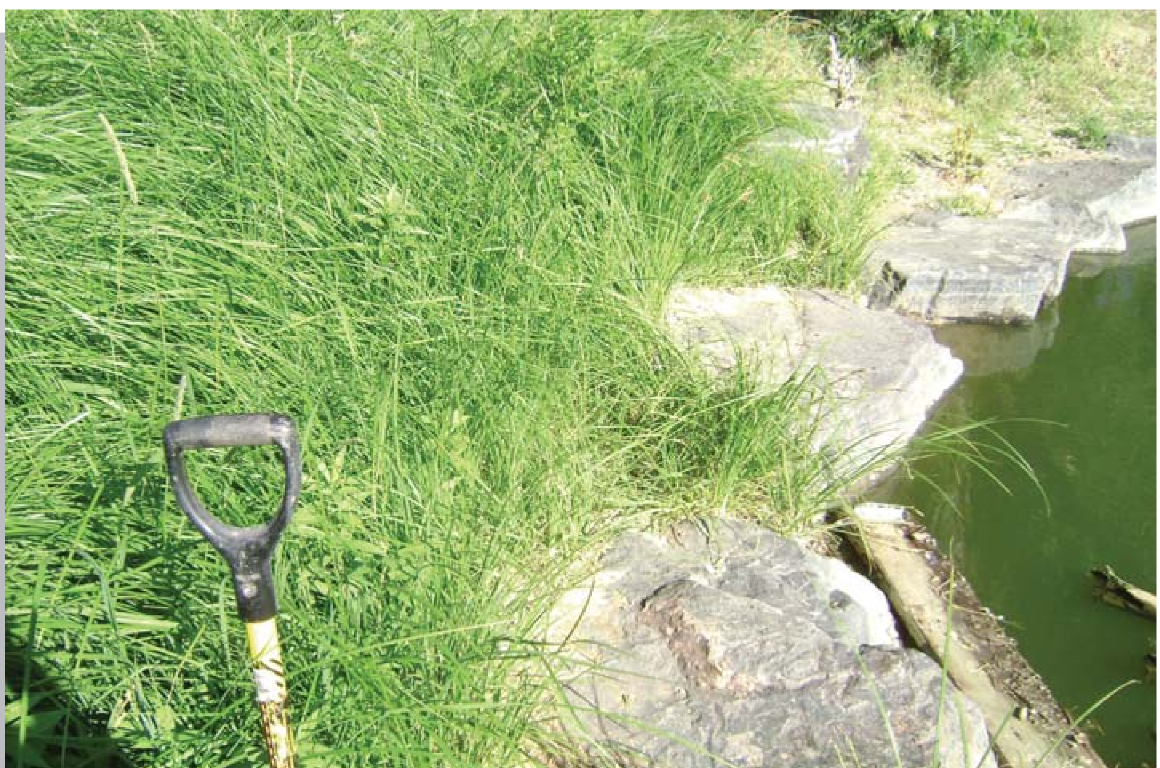


Photo 6 - Wetlands along shore of Overland Pond (DP1).

APPENDIX B

Hydrology Data

National Water Information System: Web Interface

USGS 06711565 SOUTH PLATTE RIVER AT ENGLEWOOD, CO.

Available data for this site SUMMARY OF ALL AVAILABLE DATA GO

Stream Site

DESCRIPTION:

Latitude 39°39'54", Longitude 105°00'13" NAD27
Arapahoe County, Colorado, Hydrologic Unit 10190002
Drainage area: 3,387 square miles
Datum of gage: 5,250 feet above sea level NGVD29.

AVAILABLE DATA:

Data Type	Begin Date	End Date	Count
Real-time	-- Previous 60 days --		
Daily Data			
Temperature, water, degrees Celsius	1995-10-01	2009-06-09	9110
Discharge, cubic feet per second	1983-02-01	2009-06-09	9626
Specific conductance, water, unfiltered, microsiemens per centimeter at 25 degrees Celsius	1996-10-01	2009-06-09	4113
Dissolved oxygen, water, unfiltered, milligrams per liter	1996-10-23	2009-06-09	7445
pH, water, unfiltered, field, standard units	1996-10-01	2009-06-09	8649
Daily Statistics			
Discharge, cubic feet per second	1983-02-01	2009-03-01	9526
Specific conductance, water, unfiltered, microsiemens per centimeter at 25 degrees Celsius	1996-10-01	2008-10-05	3868
Monthly Statistics			
Discharge, cubic feet per second	1983-02	2009-03	
Specific conductance, water, unfiltered, microsiemens per centimeter at 25 degrees Celsius	1996-10	2008-10	
Annual Statistics			
Discharge, cubic feet per second	1983	2009	

Specific conductance, water, unfiltered, microsiemens per centimeter at 25 degrees Celsius	1997	2009	
Peak streamflow	1983-08-05	2008-08-16	25
Field measurements	1983-04-27	2009-05-26	263
Field/Lab water-quality samples	1981-01-17	2008-02-28	104
Additional Data Sources	**Begin Date**	**End Date**	**Count**
Instantaneous-Data Archive **offsite**	1986-10-24	2007-09-30	443786
Annual Water-Data Report (pdf) **offsite**	2005	2008	4

OPERATION:

Record for this site is maintained by the USGS Colorado Water Science Center
Email questions about this site to Colorado Water Science Center Water-Data Inquiries

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USGS Surface-Water Monthly Statistics for the Nation

The statistics generated from this site are based on approved daily-mean data and may not match those published by the USGS in official publications. The user is responsible for assessment and use of statistics from this site. For more details on why the statistics may not match, click here.

USGS 06711565 SOUTH PLATTE RIVER AT ENGLEWOOD, CO.

Available data for this site Time-series: Monthly statistics GO

	Output formats
Arapahoe County, Colorado Hydrologic Unit Code 10190002 Latitude 39°39'54", Longitude 105°00'13" NAD27 Drainage area 3,387 square miles Gage datum 5,250 feet above sea level NGVD29	HTML table of all data Tab-separated data Reselect output format

00095, Specific conductance, water, unfiltered, microsiemens per centimeter at 25 degrees Celsius,												
YEAR	Monthly mean in uS/cm @25C (Calculation Period: 1997-09-01 -> 2005-09-30) Calculation period restricted by USGS staff due to special conditions at/near site											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1997									470.0	573.8	600.1	643.2
1998	615.1											
1999					373.4					655.7	624.7	699.4

2000	631.8	652.9				461.7			763.8	801.8	932.3	914.7
2001	799.6	786.3	722.9	686.0	517.3	548.3	500.4	558.2	673.7	860.3	893.3	997.3
2002	1,062	910.3	879.4	924.6		707.7	911.1	988.2				1,081
2003	1,076	1,430		603.7	499.5	470.2	583.5	574.2	612.6	888.8	1,164	1,167
2004	1,004	1,054	967.3	685.9		656.6	492.3	463.9	620.3	636.6	769.8	903.3
2005	1,036	897.8	1,069				515.4	479.9	688.0			
Mean of monthly Specific cond at 25C	889	955	910	725	463	569	601	613	638	736	831	915

** No Incomplete data have been used for statistical calculation

00060, Discharge, cubic feet per second,												
YEAR	**Monthly mean in cfs (Calculation Period: 1983-02-01 -> 2008-09-30) Calculation period restricted by USGS staff due to special conditions at/near site**											
	Jan	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
1983		53.5	261.2	1,017	2,221	2,224	1,549	888.8	214.7	84.4	125.4	192.0
1984	148.2	163.4	243.5	1,074	2,273	1,052	618.0	1,574	723.6	1,050	732.6	267.7
1985	216.3	165.7	179.5	518.2	1,765	1,050	694.7	508.7	151.1	135.6	208.5	97.3
1986	95.9	117.9	119.2	380.3	249.1	438.2	484.1	308.5	167.3	77.5	198.1	66.5
1987	83.2	69.6	176.8	584.5	2,576	1,202	400.6	313.9	126.3	162.6	111.0	59.1
1988	63.8	141.0	187.2	364.5	532.2	418.3	479.0	348.6	100.6	72.9	98.6	49.6
1989	47.5	67.7	106.5	167.8	209.2	322.5	410.3	266.1	90.0	68.1	39.3	118.8
1990	51.1	42.0	97.5	166.1	313.3	243.0	357.0	263.0	129.3	114.3	179.6	54.7
1991	45.4	35.5	51.7	122.7	234.3	367.3	234.2	348.5	113.8	64.2	105.6	55.0
1992	88.6	89.8	188.9	288.9	239.6	274.5	174.9	168.5	43.7	44.8	120.7	61.5
1993	62.7	84.1	86.8	166.1	227.2	266.4	159.3	124.1	81.4	66.6	109.3	66.5

1994	45.9	64.1	89.6	248.8	371.9	263.5	79.0	98.8	49.8	46.0	77.0	48.9
1995	52.1	47.6	60.5	147.3	1,153	2,479	2,337	456.5	177.1	93.3	199.2	159.0
1996	56.7	66.8	79.5	184.9	282.1	292.2	242.9	138.9	140.0	153.1	136.9	66.4
1997	55.2	80.3	80.9	182.6	377.1	836.0	422.1	565.7	173.2	152.5	160.2	138.6
1998	125.8	115.9	193.8	734.7	1,346	478.4	574.1	619.9	177.8	171.6	74.7	64.9
1999	61.3	55.0	72.2	274.1	1,177	1,635	705.0	735.5	141.2	108.2	116.0	107.0
2000	105.1	95.4	112.6	249.6	336.8	294.3	208.1	145.3	71.5	67.5	56.2	63.8
2001	85.2	109.3	91.7	131.8	324.2	223.3	282.9	157.1	89.3	47.2	49.5	44.9
2002	44.7	47.2	76.8	40.5	60.4	73.9	39.2	22.8	36.7	35.1	23.4	22.2
2003	21.8	21.5	139.2	430.2	358.9	270.6	121.4	100.5	126.4	39.4	29.0	32.7
2004	41.0	66.2	55.5	191.4	244.1	198.2	376.2	290.9	102.5	138.5	104.6	67.9
2005	56.1	56.1	55.5	421.5	731.0	504.5	126.5	235.1	64.9	108.9	88.4	49.8
2006	39.2	46.0	52.5	62.7	158.1	151.1	371.2	273.9	129.8	201.0	77.2	57.8
2007	70.8	134.0	508.1	810.7	2,246	1,061	474.2	414.3	213.8	120.7	97.4	83.0
2008	62.0	95.7	154.0	216.3	294.7	371.3	354.5	233.4	119.1			
Mean of monthly Discharge	73	82	135	353	781	653	472	369	144	137	133	84

** No Incomplete data have been used for statistical calculation

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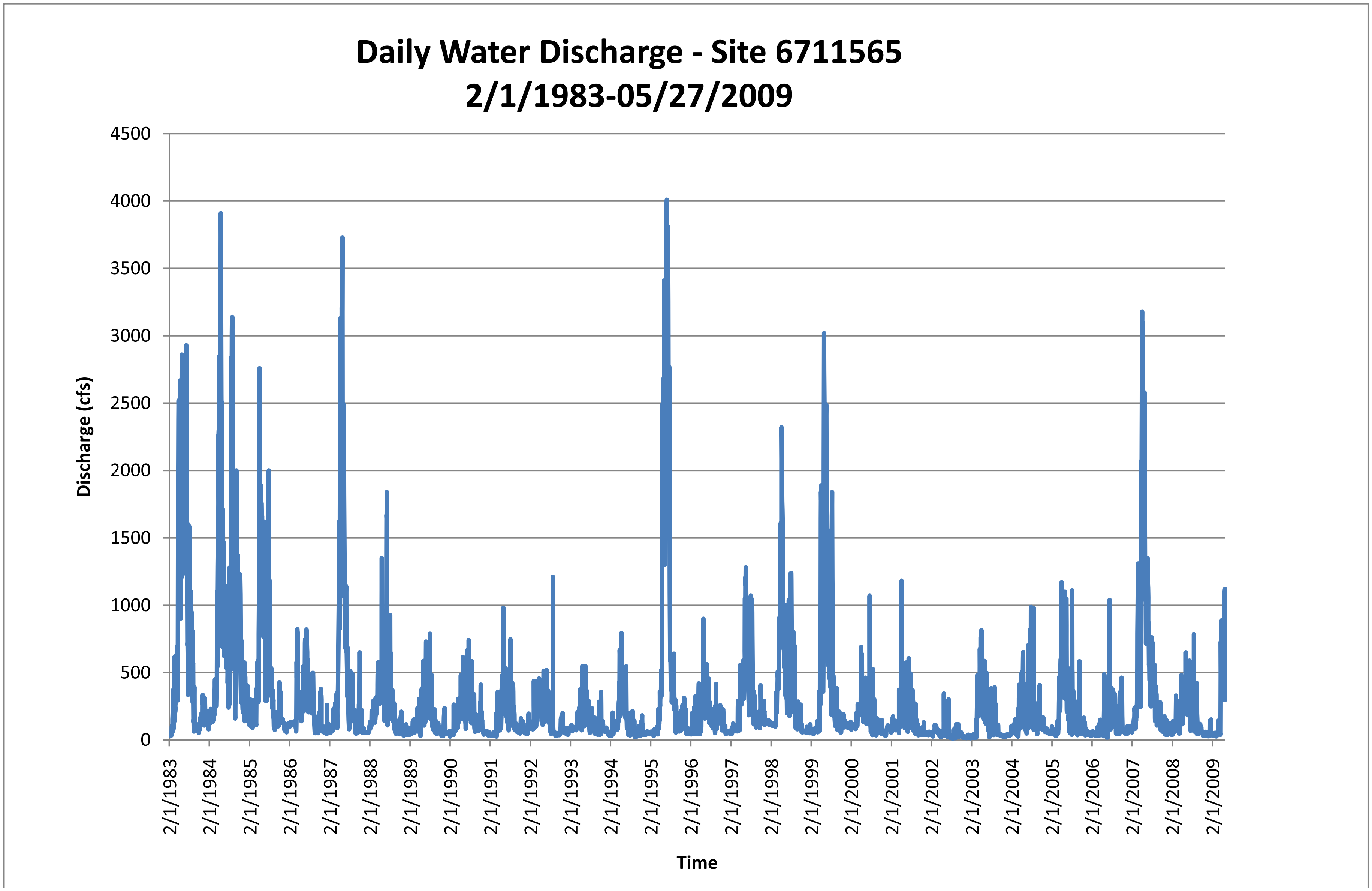
Daily Water Discharge - Site 6711565
2/1/1983-05/27/2009
Discharge (cfs)
4500
4000
3500
3000
2500
2000
1500
1000
500
0
2/1/1983
2/1/1984
2/1/1985
2/1/1986
2/1/1987
2/1/1988
2/1/1989
2/1/1990
2/1/1991
2/1/1992
2/1/1993
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2/1/2000
2/1/2001
2/1/2002
2/1/2003
2/1/2004
2/1/2005
2/1/2006
2/1/2007
2/1/2008
2/1/2009
Time

National Water Information System: Web Interface

USGS Water Resources

Data Category: Site Information Geographic Area: United States GO

News: Recent changes

USGS 06711590 SOUTH PLATTE RIVER AT FLORIDA AVE AT DENVER, CO.

Available data for this site SUMMARY OF ALL AVAILABLE DATA GO

Stream Site

DESCRIPTION:

Latitude 39°41'23", Longitude 104°59'57" NAD27
Denver County, Colorado, Hydrologic Unit 10190002
Datum of gage: 5,230.00 feet above sea level NGVD29.

AVAILABLE DATA:

Data Type	Begin Date	End Date	Count
Daily Data			
Discharge, cubic feet per second	1981-03-18	1981-12-31	289
Daily Statistics			
Discharge, cubic feet per second	1981-03-18	1981-12-31	289
Monthly Statistics			
Discharge, cubic feet per second	1981-03	1981-12	
Annual Statistics			
Discharge, cubic feet per second	1981	1982	
Field measurements	1919-03-17	1919-03-17	1
Field/Lab water-quality samples	1981-03-17	1984-01-27	46

OPERATION:

Record for this site is maintained by the USGS Colorado Water Science Center
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USGS Water Resources

Data Category: Surface Water | Geographic Area: United States | GO

News: Recent changes

USGS Surface-Water Monthly Statistics for the Nation

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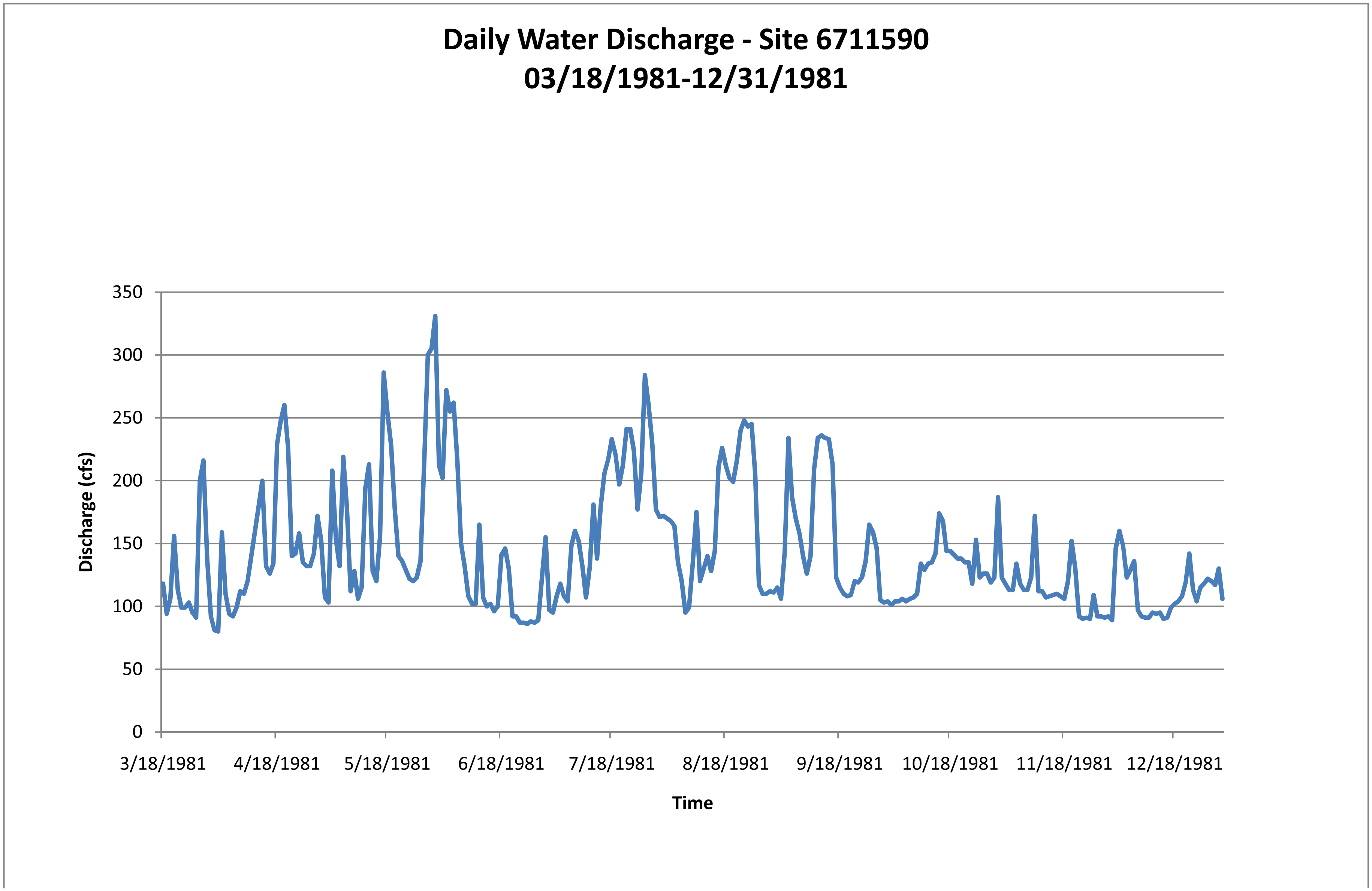
USGS 06711590 SOUTH PLATTE RIVER AT FLORIDA AVE AT DENVER, CO.

Available data for this site Time-series: Monthly statistics GO

Denver County, Colorado Hydrologic Unit Code 10190002 Latitude 39°41'23", Longitude 104°59'57" NAD27 Gage datum 5,230.00 feet above sea level NGVD29	**Output formats** HTML table of all data Tab-separated data Reselect output format

00060, Discharge, cubic feet per second,												
YEAR	Monthly mean in cfs (Calculation Period: 1981-04-01 -> 1981-12-30)											
	Jan	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
1981				146.6	173.4	136.2	176.0	164.5	154.0	129.4	111.8	112.5
Mean of monthly Discharge				147	173	136	176	165	154	129	112	113
** No Incomplete data have been used for statistical calculation												


Daily Water Discharge - Site 6711590
03/18/1981-12/31/1981
350
300
250
200
150
100
50
0
Discharge (cfs)
3/18/1981
4/18/1981
5/18/1981
6/18/1981
7/18/1981
8/18/1981
9/18/1981
10/18/1981
11/18/1981
12/18/1981
Time

Water Quality Samples for the Nation

USGS 06711590 SOUTH PLATTE RIVER AT FLORIDA AVE AT DENVER, CO.

Available data for this site Water-Quality: Field/Lab samples GO

	Output formats
Denver County, Colorado Hydrologic Unit Code 10190002 Latitude 39°41'23", Longitude 104°59'57" NAD27 Gage datum 5,230.00 feet above sea level NGVD29	Parameter Group Period of Record table Inventory of available water-quality data for printing Inventory of water-quality data with retrieval Tab-separated data, one result per row Tab-separated data one sample per row with remark codes combined with values Tab-separated data one sample per row with tab-delimiter for remark codes Reselect output format

Parameter Code	Count	Begin Date	End Date	Parameter Code Complete Name
00010	38	1981-03-17	1984-01-27	Temperature, water, degrees Celsius
00025	6	1983-09-22	1983-09-23	Barometric pressure, millimeters of mercury
00028	37	1981-10-01	1984-01-27	Agency analyzing sample, code
00061	8	1982-10-07	1984-01-26	Discharge, instantaneous, cubic feet per second
00065	21	1982-10-07	1984-01-27	Gage height, feet
00095	36	1981-03-17	1984-01-27	Specific conductance, water, unfiltered, microsiemens per centimeter at 25 degrees Celsius
00191	25	1982-10-07	1984-01-27	Hydrogen ion, water, unfiltered, calculated, milligrams per liter
00300	25	1982-10-07	1984-01-27	Dissolved oxygen, water, unfiltered, milligrams per liter
00301	6	1983-09-22	1983-09-23	Dissolved oxygen, water, unfiltered, percent of saturation
00400	25	1982-10-07	1984-01-27	pH, water, unfiltered, field, standard units
00403	24	1982-10-07	1984-01-27	pH, water, unfiltered, laboratory, standard units
00405	24	1982-10-07	1984-01-27	Carbon dioxide, water, unfiltered, milligrams per liter

00600	24	1982-10-07	1984-01-27	Total nitrogen, water, unfiltered, milligrams per liter
00605	22	1982-10-07	1984-01-27	Organic nitrogen, water, unfiltered, milligrams per liter
00610	24	1982-10-07	1984-01-27	Ammonia, water, unfiltered, milligrams per liter as nitrogen
00615	24	1982-10-07	1984-01-27	Nitrite, water, unfiltered, milligrams per liter as nitrogen
00620	24	1982-10-07	1984-01-27	Nitrate, water, unfiltered, milligrams per liter as nitrogen
00625	24	1982-10-07	1984-01-27	Ammonia plus organic nitrogen, water, unfiltered, milligrams per liter as nitrogen
00630	24	1982-10-07	1984-01-27	Nitrate plus nitrite, water, unfiltered, milligrams per liter as nitrogen
30207	21	1982-10-07	1984-01-27	Gage height, above datum, meters
30209	8	1982-10-07	1984-01-26	Discharge, instantaneous, cubic meters per second
70300	24	1982-10-07	1984-01-27	Residue on evaporation, dried at 180 degrees Celsius, water, filtered, milligrams per liter
70303	10	1982-10-07	1983-03-14	Residue, water, filtered, tons per acre-foot
71845	24	1982-10-07	1984-01-27	Ammonia, water, unfiltered, milligrams per liter as NH4
71887	24	1982-10-07	1984-01-27	Total nitrogen, water, unfiltered, milligrams per liter as nitrate
90095	24	1982-10-07	1984-01-27	Specific conductance, water, unfiltered, laboratory, microsiemens per centimeter at 25 degrees Celsius
90410	24	1982-10-07	1984-01-27	Acid neutralizing capacity, water, unfiltered, fixed endpoint (pH 4.5) titration, laboratory, milligrams per liter as calcium carbonate

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National Water Information System: Web Interface

USGS Water Resources

Data Category: Site Information | Geographic Area: United States | GO

News: Recent changes

USGS 06713500 CHERRY CREEK AT DENVER, CO.

Available data for this site SUMMARY OF ALL AVAILABLE DATA GO

Stream Site

DESCRIPTION:

Latitude 39°44'33", Longitude 104°59'58" NAD27
Denver County, Colorado, Hydrologic Unit 10190003
Drainage area: 409 square miles
Datum of gage: 5,180.48 feet above sea level NGVD29.

AVAILABLE DATA:

Data Type	Begin Date	End Date	Count
Real-time	-- Previous 60 days --		
Daily Data			
Temperature, water, degrees Celsius	2002-04-23	2004-08-01	934
Discharge, cubic feet per second	1942-08-11	2009-06-09	19712
Specific conductance, water, unfiltered, microsiemens per centimeter at 25 degrees Celsius	2002-04-23	2004-08-01	712
Daily Statistics			
Discharge, cubic feet per second	1942-08-11	2008-11-24	19516
Specific conductance, water, unfiltered, microsiemens per centimeter at 25 degrees Celsius	2002-04-24	2004-08-01	711

Monthly Statistics			
Discharge, cubic feet per second	1942-08	2008-11	
Specific conductance, water, unfiltered, microsiemens per centimeter at 25 degrees Celsius	2002-04	2004-08	
Annual Statistics			
Discharge, cubic feet per second	1942	2009	
Specific conductance, water, unfiltered, microsiemens per centimeter at 25 degrees Celsius	2002	2004	
Peak streamflow	1885-07-26	2008-08-08	58
Field measurements	1980-04-30	2009-05-12	322
Field/Lab water-quality samples	1958-02-20	2009-06-08	454
Additional Data Sources	**Begin Date**	**End Date**	**Count**
Instantaneous-Data Archive **offsite**	1986-10-01	2007-09-30	703323
Annual Water-Data Report (pdf) **offsite**	2005	2008	4

OPERATION:

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USGS Surface-Water Monthly Statistics for the Nation

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USGS 06713500 CHERRY CREEK AT DENVER, CO.

Available data for this site Time-series: Monthly statistics GO

Denver County, Colorado
Hydrologic Unit Code 10190003
Latitude 39°44'33", Longitude 104°59'58" NAD27
Drainage area 409 square miles
Gage datum 5,180.48 feet above sea level NGVD29

Output formats
- HTML table of all data
- Tab-separated data
- Reselect output format

00060, Discharge, cubic feet per second,												
YEAR	Monthly mean in cfs (Calculation Period: 1942-09-01 -> 2008-09-30)											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1942									8.73	31.2	19.8	15.8
1943	27.5	19.5	20.1	15.7	30.4	27.7	10.2	19.0	5.72	7.65	14.4	7.53
1944	17.1	31.5	17.7	79.3	108.1	117.5	55.7	5.46	6.12	10.5	5.80	5.55
1945	7.62	9.20	7.97	17.6	8.07	12.2	25.9	236.1	7.80	12.9	14.2	6.41
1946	6.02	12.8	12.4	8.67	6.30	3.17	12.1	52.1	22.8	11.6	24.8	19.1

1947	6.97	20.0	104.4	28.7	105.1	58.3	25.2	26.4	5.68	22.1	19.7	10.8
1948	10.2	73.8	179.0	44.8	34.3	23.8	3.74	4.05	4.03	3.66	4.55	3.54
1949	3.99	9.30	12.0	12.5	43.4	43.3	18.0	4.63	5.42	4.88	4.90	4.14
1950	5.46	4.41	3.65	29.6	34.4	15.7	9.47	7.16	8.86	7.07	5.03	5.01
1951	5.05	4.78	5.10	11.7	13.4	18.9	8.88	15.2	8.07	10.4	6.12	5.90
1952	5.64	4.18	8.68	11.7	47.6	54.9	11.1	12.1	8.69	8.86	6.30	5.95
1953	4.96	5.09	5.85	4.90	10.3	8.87	18.0	11.5	6.92	6.68	5.67	4.75
1954	3.84	4.30	4.19	5.09	6.41	5.34	10.6	8.55	6.44	5.26	3.61	3.85
1955	3.93	4.78	3.25	3.28	9.50	6.95	9.50	35.8	8.76	4.64	3.91	3.39
1956	3.17	4.48	4.72	4.94	9.09	4.71	15.5	44.1	4.83	5.41	5.50	4.90
1957	4.62	5.11	4.96	11.2	42.8	11.2	18.2	13.6	10.1	13.4	7.19	5.65
1958	5.62	5.25	5.55	6.28	27.3	10.8	13.7	9.44	9.58	9.66	5.15	4.15
1959	5.08	6.27	7.96	7.04	16.3	11.3	7.81	6.08	10.9	11.3	5.39	5.24
1960	5.76	5.73	86.7	17.2	35.0	9.79	9.59	7.83	8.28	13.7	6.61	6.97
1961	5.17	5.56	9.45	5.74	14.8	12.4	15.0	25.8	25.5	17.5	9.41	7.46
1962	8.43	37.5	23.5	10.2	10.1	13.3	10.2	10.1	11.3	11.9	8.55	5.35
1963	5.32	5.36	7.77	5.96	10.3	24.0	9.77	38.3	15.7	9.19	5.93	6.29
1964	6.31	6.48	7.69	29.3	12.0	9.61	8.84	8.14	11.1	10.3	6.46	6.16
1965	6.00	7.61	6.74	9.07	11.1	20.5	22.8	227.9	64.9	12.8	6.61	6.27
1966	4.50	18.1	7.13	22.7	6.10	16.4	12.5	11.7	14.7	11.5	7.79	5.50
1967	6.26	4.94	8.44	16.5	17.6	24.6	25.6	11.0	10.6	14.4	6.74	6.52
1968	6.43	6.64	8.05	9.89	12.2	10.3	12.8	16.9	10.5	10.2	8.02	7.49
1969	7.10	6.28	7.79	7.88	45.6	32.7	21.5	16.9	16.5			
1980			14.6	29.6	38.0	16.2	21.9	30.0	23.9	13.4	8.98	8.90
1981	8.69	11.9	18.3	9.65	28.0	12.0	14.4	13.0	11.1	13.6	8.25	8.28
1982	9.37	8.51	9.25	6.47	25.5	24.9	15.4	20.7	18.0	15.8	12.6	10.8
1983	12.9	9.34	35.3	119.4	119.2	83.2	160.6	233.6	27.9			
1986				95.6	26.3	33.7	36.5	20.6	21.1	26.3	17.4	15.0
1987	13.4	46.7	47.3	73.3	99.7	82.6	31.9	51.5	25.4	16.9	30.3	54.4

1988	25.9	60.1	66.6	63.6	91.2	54.5	18.5	36.1	29.9	21.7	14.4	12.2
1989	16.9	29.6	27.3	24.6	37.9	55.4	27.3	28.5	25.3	18.0	12.9	12.2
1990	14.2	12.3	38.4	27.2	25.5	18.1	31.3	38.0	34.8	24.9	26.1	12.8
1991	12.3	9.89	11.4	20.3	36.3	51.3	38.9	54.5	21.1	18.0	20.3	11.9
1992	12.6	10.2	56.6	40.4	30.0	33.8	32.9	36.7	20.2	16.7	17.9	14.2
1993	12.3	18.4	18.3	33.0	25.6	29.6	22.7	19.8	28.0	21.8	12.8	9.33
1994	7.87	19.2	22.4	33.8	29.1	24.5	15.3	27.8	12.1	15.1	11.2	7.68
1995	8.96	9.51	8.64	42.4	100.2	85.5	71.3	44.5	42.7	23.1	16.5	19.9
1996	20.2	13.1	22.9	24.9	39.7	43.6	35.2	26.0	42.6	22.1	13.1	10.8
1997	10.5	14.4	15.3	50.1	28.0	38.0	52.3	74.2	46.3	37.2	47.1	29.1
1998	32.7	31.2	58.9	109.3	74.7	29.6	71.7	84.8	32.6	28.4	33.3	25.6
1999	34.3	32.9	26.9	102.0	155.5	96.1	39.4	64.2	26.6	29.5	39.3	34.9
2000	37.0	46.0	52.0	61.1	59.9	32.8	39.3	36.9	32.0	34.2	32.7	31.1
2001	26.9	26.5	43.2	67.8	124.6	34.1	85.6	23.0	18.7	12.2	13.2	23.1
2002	23.6	23.1	31.3	22.1	20.2	22.2	15.6	13.7	19.5	13.8	6.56	6.20
2003	7.28	8.26	52.5	86.8	76.5	40.6	34.9	35.5	34.5	11.9	9.75	11.0
2004	13.5	21.9	16.5	47.6	31.6	21.8	21.9	103.2	25.6	45.0	41.0	34.4
2005	41.5	29.8	34.8	93.2	49.1	71.6	16.7	52.1	23.9	43.7	14.9	18.4
2006	25.3	26.3	29.4	21.6	22.0	16.7	49.6	40.7	16.9	29.6	27.6	24.3
2007	20.8	61.3	94.9	130.4	119.4	55.1	22.7	53.1	31.3	31.1	23.3	31.5
2008	31.6	38.5	55.0	48.7	51.2	25.0	11.2	84.5	40.1			
Mean of monthly Discharge	13	18	28	36	42	32	27	41	19	17	14	13

** No Incomplete data have been used for statistical calculation

00095, Specific conductance, water, unfiltered, microsiemens per centimeter at 25 degrees Celsius,	
YEAR	**Monthly mean in uS/cm @25C (Calculation Period: 2002-05-01 -> 2004-07-30)**

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2002					1,019			913.3	917.6	1,044	1,233	1,121
2003	1,061	1,631			906.4	925.6				1,044	1,269	1,391
2004	1,377	1,757	1,082	746.9			948.4					
Mean of monthly Specific cond at 25C	1,220	1,690	1,080	747	963	926	948	913	918	1,040	1,250	1,260
** No Incomplete data have been used for statistical calculation												

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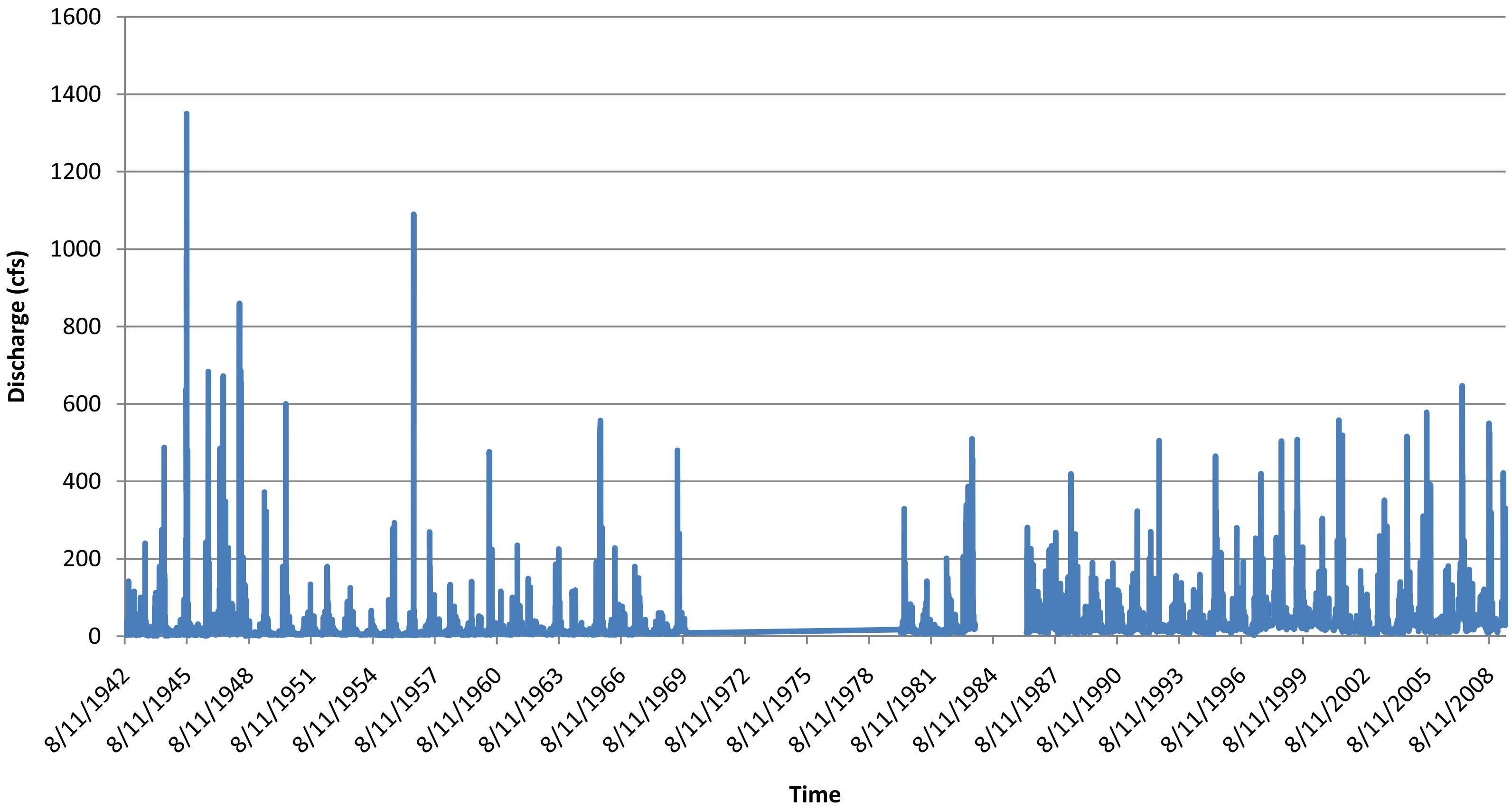

National Water Information System: Web Interface

USGS Water Resources

Data Category: Water Quality
Geographic Area: United States
GO

News New Mapper and Experimental Real-Time Web Service - updated August 2009

Water Quality Samples for the Nation

USGS 06713500 CHERRY CREEK AT DENVER, CO.

Available data for this site: Water-Quality: Field/Lab samples GO

Denver County, Colorado
Hydrologic Unit Code 10190003
Latitude 39°44'33", Longitude 104°59'58" NAD27
Drainage area 409 square miles
Gage datum 5,180.48 feet above sea level NGVD29

Output formats

- Parameter Group Period of Record table
- Inventory of available water-quality data for printing
- Inventory of water-quality data with retrieval
- Tab-separated data, one result per row
- Tab-separated data one sample per row with remark codes combined with values
- Tab-separated data one sample per row with tab-delimiter for remark codes
- Reselect output format

Parameter Code	Count	Begin Date	End Date	Parameter Code Complete Name
00004	121	2001-02-06	2009-09-01	Stream width, feet
00009	3	2002-05-14	2002-08-23	Location in cross section, distance from left bank looking downstream, feet
00010	415	1958-02-20	2009-09-02	Temperature, water, degrees Celsius
00020	114	1992-07-28	2009-09-01	Temperature, air, degrees Celsius
00021	1	1993-05-17		Temperature, air, degrees Fahrenheit
00025	146	1992-07-28	2009-09-01	Barometric pressure, millimeters of mercury
00028	403	1958-02-20	2007-02-08	Agency analyzing sample, code
00031	1	1994-04-12		Incident light remaining at depth, percent
00060	1	1972-04-19		Discharge, cubic feet per second
00061	389	1986-10-21	2009-09-02	Discharge, instantaneous, cubic feet per second
00063	136	2001-02-06	2009-09-02	Number of sampling points, count
00065	145	1992-07-28	2009-09-01	Gage height, feet

00095	403	1972-04-19	2009-09-02	Specific conductance, water, unfiltered, microsiemens per centimeter at 25 degrees Celsius
00100	1	1995-07-07		Time of travel, hours
00191	186	1972-04-19	2009-09-02	Hydrogen ion, water, unfiltered, calculated, milligrams per liter
00300	180	1980-03-27	2009-09-01	Dissolved oxygen, water, unfiltered, milligrams per liter
00301	143	1992-07-28	2009-09-01	Dissolved oxygen, water, unfiltered, percent of saturation
00340	6	1980-03-27	1980-04-29	Chemical oxygen demand, high level, water, unfiltered, milligrams per liter
00400	186	1972-04-19	2009-09-02	pH, water, unfiltered, field, standard units
00403	51	1993-04-12	2001-09-10	pH, water, unfiltered, laboratory, standard units
00405	45	1972-04-19	1995-07-07	Carbon dioxide, water, unfiltered, milligrams per liter
00410	4	1972-04-19	1993-06-02	Acid neutralizing capacity, water, unfiltered, fixed endpoint (pH 4.5) titration, field, milligrams per liter as calcium carbonate
00418	41	1993-04-12	1995-07-07	Alkalinity, water, filtered, fixed endpoint (pH 4.5) titration, field, milligrams per liter as calcium carbonate
00440	1	1972-04-19		Bicarbonate, water, unfiltered, fixed endpoint (pH 4.5) titration, field, milligrams per liter
00445	1	1972-04-19		Carbonate, water, unfiltered, fixed endpoint (pH 8.3) titration, field, milligrams per liter
00452	85	2001-02-06	2009-09-01	Carbonate, water, filtered, inflection-point titration method (incremental titration method), field, milligrams per liter
00453	100	2001-02-06	2009-09-01	Bicarbonate, water, filtered, inflection-point titration method (incremental titration method), field, milligrams per liter
00530	6	1980-03-27	1980-04-29	Residue, total nonfilterable, milligrams per liter
00572	7	2002-07-18	2006-07-26	Biomass, periphyton, ash weight, grams per square meter
00573	7	2002-07-18	2006-07-26	Biomass, periphyton, dry weight, grams per square meter
00600	105	1980-03-27	2009-06-17	Total nitrogen, water, unfiltered, milligrams per liter
00602	54	1993-04-12	2001-09-10	Total nitrogen, water, filtered, milligrams per liter
00605	98	1980-03-27	2009-06-29	Organic nitrogen, water, unfiltered, milligrams per liter
00607	50	1993-04-12	2009-06-29	Organic nitrogen, water, filtered, milligrams per liter
00608	163	1993-04-12	2009-07-20	Ammonia, water, filtered, milligrams per liter as nitrogen
00610	7	1980-03-27	1992-07-28	Ammonia, water, unfiltered, milligrams per liter as nitrogen
00613	162	1993-04-12	2009-07-20	Nitrite, water, filtered, milligrams per liter as nitrogen

00615	1	1992-07-28		Nitrite, water, unfiltered, milligrams per liter as nitrogen
00618	158	1993-04-12	2009-07-20	Nitrate, water, filtered, milligrams per liter as nitrogen
00620	1	1992-07-28		Nitrate, water, unfiltered, milligrams per liter as nitrogen
00623	56	1993-04-12	2001-09-10	Ammonia plus organic nitrogen, water, filtered, milligrams per liter as nitrogen
00625	106	1980-03-27	2003-09-22	Ammonia plus organic nitrogen, water, unfiltered, milligrams per liter as nitrogen
00630	7	1980-03-27	1992-07-28	Nitrate plus nitrite, water, unfiltered, milligrams per liter as nitrogen
00631	163	1972-04-19	2009-07-20	Nitrate plus nitrite, water, filtered, milligrams per liter as nitrogen
00650	7	1980-03-27	1992-07-28	Phosphate, water, unfiltered, milligrams per liter
00660	163	1972-04-19	2009-07-20	Orthophosphate, water, filtered, milligrams per liter
00665	167	1980-03-27	2009-07-20	Phosphorus, water, unfiltered, milligrams per liter as phosphorus
00666	55	1993-04-12	2001-09-10	Phosphorus, water, filtered, milligrams per liter as phosphorus
00671	163	1972-04-19	2009-07-20	Orthophosphate, water, filtered, milligrams per liter as phosphorus
00680	9	1980-03-27	1993-08-30	Organic carbon, water, unfiltered, milligrams per liter
00681	85	1972-04-19	2004-09-07	Organic carbon, water, filtered, milligrams per liter
00688	31	2001-09-10	2004-09-07	Inorganic carbon, suspended sediment, total, milligrams per liter
00689	77	1993-04-12	2004-09-07	Organic carbon, suspended sediment, total, milligrams per liter
00694	36	2001-09-10	2009-06-17	Carbon (inorganic plus organic), suspended sediment, total, milligrams per liter
00900	54	1972-04-19	2002-09-05	Hardness, water, milligrams per liter as calcium carbonate
00902	1	1972-04-19		Noncarbonate hardness, water, unfiltered, field, milligrams per liter as calcium carbonate
00904	10	2001-02-06	2002-09-05	Noncarbonate hardness, water, filtered, field, milligrams per liter as calcium carbonate
00915	54	1972-04-19	2002-09-05	Calcium, water, filtered, milligrams per liter
00925	54	1972-04-19	2002-09-05	Magnesium, water, filtered, milligrams per liter
00930	54	1972-04-19	2002-09-05	Sodium, water, filtered, milligrams per liter
00931	54	1972-04-19	2002-09-05	Sodium adsorption ratio, water, number
00932	52	1972-04-19	2001-09-10	Sodium fraction of cations, water, percent in equivalents of major cations

00935	52	1972-04-19	2001-09-10	Potassium, water, filtered, milligrams per liter
00940	143	1972-04-19	2009-08-10	Chloride, water, filtered, milligrams per liter
00945	141	1972-04-19	2009-08-10	Sulfate, water, filtered, milligrams per liter
00950	52	1972-04-19	2001-09-10	Fluoride, water, filtered, milligrams per liter
00955	54	1972-04-19	2002-09-05	Silica, water, filtered, milligrams per liter as SiO2
01000	1	1972-04-19		Arsenic, water, filtered, micrograms per liter
01005	13	1993-07-15	1993-12-09	Barium, water, filtered, micrograms per liter
01010	13	1993-07-15	1993-12-09	Beryllium, water, filtered, micrograms per liter
01025	14	1972-04-19	1993-12-09	Cadmium, water, filtered, micrograms per liter
01027	6	1980-03-27	1980-04-29	Cadmium, water, unfiltered, micrograms per liter
01030	13	1993-07-15	1993-12-09	Chromium, water, filtered, micrograms per liter
01035	13	1993-07-15	1993-12-09	Cobalt, water, filtered, micrograms per liter
01040	14	1972-04-19	1993-12-09	Copper, water, filtered, micrograms per liter
01042	6	1980-03-27	1980-04-29	Copper, water, unfiltered, recoverable, micrograms per liter
01045	6	1980-03-27	1980-04-29	Iron, water, unfiltered, recoverable, micrograms per liter
01046	54	1972-04-19	2002-09-05	Iron, water, filtered, micrograms per liter
01049	14	1972-04-19	1993-12-09	Lead, water, filtered, micrograms per liter
01051	6	1980-03-27	1980-04-29	Lead, water, unfiltered, recoverable, micrograms per liter
01055	6	1980-03-27	1980-04-29	Manganese, water, unfiltered, recoverable, micrograms per liter
01056	54	1972-04-19	2002-09-05	Manganese, water, filtered, micrograms per liter
01060	13	1993-07-15	1993-12-09	Molybdenum, water, filtered, micrograms per liter
01065	13	1993-07-15	1993-12-09	Nickel, water, filtered, micrograms per liter
01075	13	1993-07-15	1993-12-09	Silver, water, filtered, micrograms per liter
01090	14	1972-04-19	1993-12-09	Zinc, water, filtered, micrograms per liter
01092	6	1980-03-27	1980-04-29	Zinc, water, unfiltered, recoverable, micrograms per liter

01095	13	1993-07-15	1993-12-09	Antimony, water, filtered, micrograms per liter
01106	13	1993-07-15	1993-12-09	Aluminum, water, filtered, micrograms per liter
01145	13	1993-07-15	1993-12-09	Selenium, water, filtered, micrograms per liter
01300	4	2008-10-23	2009-02-05	Oil and grease, severity, code
01305	6	2001-10-15	2009-02-05	Detergent suds, severity, code
01320	10	2002-01-24	2009-02-05	Floating garbage, severity, code
01325	10	2001-10-10	2009-07-20	Floating algae mats, severity, code
01330	4	2008-10-23	2009-02-05	Odor, atmospheric, severity, code
01340	4	2008-10-23	2009-02-05	Dead fish, severity, code
01345	16	2001-10-10	2009-05-18	Floating debris, severity, code
01350	21	2002-01-09	2009-09-01	Turbidity, severity, code
04022	63	2001-10-10	2009-06-08	Terbuthylazine, water, filtered, recoverable, micrograms per liter
04024	96	1993-03-12	2004-09-07	Propachlor, water, filtered, recoverable, micrograms per liter
04025	63	2001-10-10	2009-06-08	Hexazinone, water, filtered, recoverable, micrograms per liter
04028	96	1993-03-12	2004-09-07	Butylate, water, filtered, recoverable, micrograms per liter
04029	62	1983-08-30	2002-09-23	Bromacil, water, filtered, recoverable, micrograms per liter
04031	43	2001-10-10	2003-09-22	Cycloate, water, filtered, recoverable, micrograms per liter
04032	25	2001-10-10	2002-09-23	Terbacil, water, filtered, recoverable, micrograms per liter
04033	25	2001-10-10	2002-09-23	Diphenamid, water, filtered, recoverable, micrograms per liter
04035	139	1993-03-12	2009-06-08	Simazine, water, filtered, recoverable, micrograms per liter
04036	63	2001-10-10	2009-06-08	Prometryn, water, filtered, recoverable, micrograms per liter
04037	139	1993-03-12	2009-06-08	Prometon, water, filtered, recoverable, micrograms per liter
04038	25	2001-10-10	2002-09-23	2-Chloro-6-ethylamino-4-amino-s-triazine, water, filtered, recoverable, micrograms per liter
04039	25	2001-10-10	2002-09-23	Chlorodiamino-s-triazine, water, filtered, recoverable, micrograms per liter
04040	139	1993-03-12	2009-06-08	2-Chloro-4-isopropylamino-6-amino-s-triazine, water, filtered, recoverable, micrograms per liter

04041	135	1993-03-12	2009-06-08	Cyanazine, water, filtered, recoverable, micrograms per liter
04064	1	2007-07-13		Thallium, bed sediment smaller than 62.5 microns, dry sieved, total digestion, dry weight, micrograms per gram
04095	139	1993-03-12	2009-06-08	Fonofos, water, filtered, recoverable, micrograms per liter
22703	13	1993-07-15	1993-12-09	Uranium (natural), water, filtered, micrograms per liter
30207	145	1992-07-28	2009-09-01	Gage height, above datum, meters
30208	1	1972-04-19		Discharge, cubic meters per second
30209	389	1986-10-21	2009-09-02	Discharge, instantaneous, cubic meters per second
30217	18	2001-10-10	2002-09-05	Dibromomethane, water, unfiltered, recoverable, micrograms per liter
32101	18	2001-10-10	2002-09-05	Bromodichloromethane, water, unfiltered, recoverable, micrograms per liter
32102	18	2001-10-10	2002-09-05	Tetrachloromethane, water, unfiltered, recoverable, micrograms per liter
32103	18	2001-10-10	2002-09-05	1,2-Dichloroethane, water, unfiltered, recoverable, micrograms per liter
32104	18	2001-10-10	2002-09-05	Tribromomethane, water, unfiltered, recoverable, micrograms per liter
32105	18	2001-10-10	2002-09-05	Dibromochloromethane, water, unfiltered, recoverable, micrograms per liter
32106	18	2001-10-10	2002-09-05	Trichloromethane, water, unfiltered, recoverable, micrograms per liter
34010	18	2001-10-10	2002-09-05	Toluene, water, unfiltered, recoverable, micrograms per liter
34030	18	2001-10-10	2002-09-05	Benzene, water, unfiltered, recoverable, micrograms per liter
34215	18	2001-10-10	2002-09-05	Acrylonitrile, water, unfiltered, recoverable, micrograms per liter
34253	96	1993-03-12	2004-09-07	alpha-HCH, water, filtered, recoverable, micrograms per liter
34257	1	2007-07-13		beta-HCH, bed sediment, recoverable, dry weight, micrograms per kilogram
34301	18	2001-10-10	2002-09-05	Chlorobenzene, water, unfiltered, recoverable, micrograms per liter
34311	18	2001-10-10	2002-09-05	Chloroethane, water, unfiltered, recoverable, micrograms per liter
34357	20	2001-10-10	2003-09-22	beta-Endosulfan, water, filtered, recoverable, micrograms per liter
34362	59	2001-10-10	2009-06-08	alpha-Endosulfan, water, filtered, recoverable, micrograms per liter
34371	18	2001-10-10	2002-09-05	Ethylbenzene, water, unfiltered, recoverable, micrograms per liter
34396	18	2001-10-10	2002-09-05	Hexachloroethane, water, unfiltered, recoverable, micrograms per liter

34413	18	2001-10-10	2002-09-05	Bromomethane, water, unfiltered, recoverable, micrograms per liter
34418	18	2001-10-10	2002-09-05	Chloromethane, water, unfiltered, recoverable, micrograms per liter
34423	18	2001-10-10	2002-09-05	Dichloromethane, water, unfiltered, recoverable, micrograms per liter
34475	18	2001-10-10	2002-09-05	Tetrachloroethene, water, unfiltered, recoverable, micrograms per liter
34488	18	2001-10-10	2002-09-05	Trichlorofluoromethane, water, unfiltered, recoverable, micrograms per liter
34496	18	2001-10-10	2002-09-05	1,1-Dichloroethane, water, unfiltered, recoverable, micrograms per liter
34501	18	2001-10-10	2002-09-05	1,1-Dichloroethene, water, unfiltered, recoverable, micrograms per liter
34506	18	2001-10-10	2002-09-05	1,1,1-Trichloroethane, water, unfiltered, recoverable, micrograms per liter
34511	18	2001-10-10	2002-09-05	1,1,2-Trichloroethane, water, unfiltered, recoverable, micrograms per liter
34516	18	2001-10-10	2002-09-05	1,1,2,2-Tetrachloroethane, water, unfiltered, recoverable, micrograms per liter
34536	18	2001-10-10	2002-09-05	1,2-Dichlorobenzene, water, unfiltered, recoverable, micrograms per liter
34541	18	2001-10-10	2002-09-05	1,2-Dichloropropane, water, unfiltered, recoverable, micrograms per liter
34546	18	2001-10-10	2002-09-05	trans-1,2-Dichloroethene, water, unfiltered, recoverable, micrograms per liter
34551	18	2001-10-10	2002-09-05	1,2,4-Trichlorobenzene, water, unfiltered, recoverable, micrograms per liter
34566	18	2001-10-10	2002-09-05	1,3-Dichlorobenzene, water, unfiltered, recoverable, micrograms per liter
34571	18	2001-10-10	2002-09-05	1,4-Dichlorobenzene, water, unfiltered, recoverable, micrograms per liter
34653	96	1993-03-12	2004-09-07	p,p'-DDE, water, filtered, recoverable, micrograms per liter
34668	18	2001-10-10	2002-09-05	Dichlorodifluoromethane, water, unfiltered, recoverable, micrograms per liter
34696	18	2001-10-10	2002-09-05	Naphthalene, water, unfiltered, recoverable, micrograms per liter
34699	18	2001-10-10	2002-09-05	trans-1,3-Dichloropropene, water, unfiltered, recoverable, micrograms per liter
34704	18	2001-10-10	2002-09-05	cis-1,3-Dichloropropene, water, unfiltered, recoverable, micrograms per liter
34790	1	1993-08-19		Aluminum, bed sediment smaller than 62.5 microns, wet sieved, field, total digestion, dry weight, percent
34795	2	1993-08-19	2007-07-13	Antimony, bed sediment smaller than 62.5 microns, wet sieved, field, total digestion, dry weight, micrograms per gram
34800	2	1993-08-19	2007-07-13	Arsenic, bed sediment smaller than 62.5 microns, wet sieved, field, total digestion, dry weight, micrograms per gram
34805	2	1993-08-19	2007-07-13	Barium, bed sediment smaller than 62.5 microns, wet sieved, field, total digestion, dry weight, micrograms per gram

34810	2	1993-08-19	2007-07-13	Beryllium, bed sediment smaller than 62.5 microns, wet sieved, field, total digestion, dry weight, micrograms per gram
34816	2	1993-08-19	2007-07-13	Bismuth, bed sediment smaller than 177 microns, wet sieved, field, total digestion, dry weight, micrograms per gram
34825	2	1993-08-19	2007-07-13	Cadmium, bed sediment smaller than 62.5 microns, wet sieved, field, total digestion, dry weight, micrograms per gram
34830	1	1993-08-19		Calcium, bed sediment smaller than 62.5 microns, wet sieved, field, total digestion, dry weight, percent
34835	2	1993-08-19	2007-07-13	Cerium, bed sediment smaller than 62.5 microns, wet sieved, field, total digestion, dry weight, micrograms per gram
34840	2	1993-08-19	2007-07-13	Chromium, bed sediment smaller than 62.5 microns, wet sieved, field, total digestion, dry weight, micrograms per gram
34845	2	1993-08-19	2007-07-13	Cobalt, bed sediment smaller than 62.5 microns, wet sieved, field, total digestion, dry weight, micrograms per gram
34850	2	1993-08-19	2007-07-13	Copper, bed sediment smaller than 62.5 microns, wet sieved, field, total digestion, dry weight, micrograms per gram
34855	1	1993-08-19		Europium, bed sediment smaller than 62.5 microns, wet sieved, field, total digestion, dry weight, micrograms per gram
34860	2	1993-08-19	2007-07-13	Gallium, bed sediment smaller than 62.5 microns, wet sieved, field, total digestion, dry weight, micrograms per gram
34870	1	1993-08-19		Gold, bed sediment smaller than 62.5 microns, wet sieved, field, total digestion, dry weight, micrograms per gram
34875	1	1993-08-19		Holmium, bed sediment smaller than 62.5 microns, wet sieved, field, total digestion, dry weight, micrograms per gram
34880	1	1993-08-19		Iron, bed sediment smaller than 62.5 microns, wet sieved, field, total digestion, dry weight, percent
34885	2	1993-08-19	2007-07-13	Lanthanum, bed sediment smaller than 62.5 microns, wet sieved, field, total digestion, dry weight, micrograms per gram
34890	2	1993-08-19	2007-07-13	Lead, bed sediment smaller than 62.5 microns, wet sieved, field, total digestion, dry weight, micrograms per gram
34895	2	1993-08-19	2007-07-13	Lithium, bed sediment smaller than 62.5 microns, wet sieved, field, total digestion, dry weight, micrograms per gram
34900	1	1993-08-19		Magnesium, bed sediment smaller than 62.5 microns, wet sieved, field, total digestion, dry weight, percent
34905	2	1993-08-19	2007-07-13	Manganese, bed sediment smaller than 62.5 microns, wet sieved, field, total digestion, dry weight, micrograms per gram
34910	2	1993-08-19	2007-07-13	Mercury, bed sediment smaller than 62.5 microns, wet sieved, field, total digestion, dry weight, micrograms per gram
34915	2	1993-08-19	2007-07-13	Molybdenum, bed sediment smaller than 62.5 microns, wet sieved, field, total digestion, dry weight, micrograms per gram
34920	1	1993-08-19		Neodymium, bed sediment smaller than 62.5 microns, wet sieved, field, total digestion, dry weight, micrograms per gram
34925	2	1993-08-19	2007-07-13	Nickel, bed sediment smaller than 62.5 microns, wet sieved, field, total digestion, dry weight, micrograms per gram
34930	2	1993-08-19	2007-07-13	Niobium, bed sediment smaller than 62.5 microns, wet sieved, field, total digestion, dry weight, micrograms per gram
34935	1	1993-08-19		Phosphorus, bed sediment smaller than 62.5 microns, wet sieved, field, total digestion, dry weight, percent
34940	1	1993-08-19		Potassium, bed sediment smaller than 62.5 microns, wet sieved, field, total digestion, dry weight, percent

34945	2	1993-08-19	2007-07-13	Scandium, bed sediment smaller than 62.5 microns, wet sieved, field, total digestion, dry weight, micrograms per gram
34950	2	1993-08-19	2007-07-13	Selenium, bed sediment smaller than 62.5 microns, wet sieved, field, total digestion, dry weight, micrograms per gram
34955	2	1993-08-19	2007-07-13	Silver, bed sediment smaller than 62.5 microns, wet sieved, field, total digestion, dry weight, micrograms per gram
34960	1	1993-08-19		Sodium, bed sediment smaller than 62.5 microns, wet sieved, field, total digestion, dry weight, percent
34965	2	1993-08-19	2007-07-13	Strontium, bed sediment smaller than 62.5 microns, wet sieved, field, total digestion, dry weight, micrograms per gram
34970	2	1993-08-19	2007-07-13	Sulfur, bed sediment smaller than 62.5 microns, wet sieved, field, total digestion, dry weight, percent
34975	1	1993-08-19		Tantalum, bed sediment smaller than 62.5 microns, wet sieved, field, total digestion, dry weight, micrograms per gram
34980	2	1993-08-19	2007-07-13	Thorium, bed sediment smaller than 62.5 microns, wet sieved, field, total digestion, dry weight, micrograms per gram
34985	1	1993-08-19		Tin, bed sediment smaller than 62.5 microns, wet sieved, field, total digestion, dry weight, micrograms per gram
35000	2	1993-08-19	2007-07-13	Uranium, bed sediment smaller than 62.5 microns, wet sieved, field, total digestion, dry weight, micrograms per gram
35005	2	1993-08-19	2007-07-13	Vanadium, bed sediment smaller than 62.5 microns, wet sieved, field, total digestion, dry weight, micrograms per gram
35010	2	1993-08-19	2007-07-13	Yttrium, bed sediment smaller than 62.5 microns, wet sieved, field, total digestion, dry weight, micrograms per gram
35015	1	1993-08-19		Ytterbium, bed sediment smaller than 62.5 microns, wet sieved, field, total digestion, dry weight, micrograms per gram
35020	2	1993-08-19	2007-07-13	Zinc, bed sediment smaller than 62.5 microns, wet sieved, field, total digestion, dry weight, micrograms per gram
38442	62	1983-08-30	2002-09-23	Dicamba, water, filtered (0.7 micron glass fiber filter), recoverable, micrograms per liter
38454	63	2001-10-10	2009-06-08	Dicrotophos, water, filtered, recoverable, micrograms per liter
38478	62	1983-08-30	2002-09-23	Linuron, water, filtered (0.7 micron glass fiber filter), recoverable, micrograms per liter
38482	62	1983-08-30	2002-09-23	MCPA, water, filtered (0.7 micron glass fiber filter), recoverable, micrograms per liter
38487	62	1983-08-30	2002-09-23	MCPB, water, filtered (0.7 micron glass fiber filter), recoverable, micrograms per liter
38501	62	1983-08-30	2002-09-23	Methiocarb, water, filtered (0.7 micron glass fiber filter), recoverable, micrograms per liter
38538	62	1983-08-30	2002-09-23	Propoxur, water, filtered (0.7 micron glass fiber filter), recoverable, micrograms per liter
38548	25	2001-10-10	2002-09-23	Siduron, water, filtered, recoverable, micrograms per liter
38711	62	1983-08-30	2002-09-23	Bentazon, water, filtered (0.7 micron glass fiber filter), recoverable, micrograms per liter
38716	20	2001-10-10	2003-09-22	Sulprofos, water, filtered, recoverable, micrograms per liter
38746	62	1983-08-30	2002-09-23	2,4-DB, water, filtered (0.7 micron glass fiber filter), recoverable, micrograms per liter

38775	63	2001-10-10	2009-06-08	Dichlorvos, water, filtered, recoverable, micrograms per liter
38801	20	2001-10-10	2003-09-22	Fenthion, water, filtered, recoverable, micrograms per liter
38811	62	1983-08-30	2002-09-23	Fluometuron, water, filtered (0.7 micron glass fiber filter), recoverable, micrograms per liter
38866	62	1983-08-30	2002-09-23	Oxamyl, water, filtered (0.7 micron glass fiber filter), recoverable, micrograms per liter
38933	139	1993-03-12	2009-06-08	Chlorpyrifos, water, filtered, recoverable, micrograms per liter
39076	1	2007-07-13		alpha-HCH, bed sediment, recoverable, dry weight, micrograms per kilogram
39086	100	2001-02-06	2009-09-01	Alkalinity, water, filtered, inflection-point titration method (incremental titration method), field, milligrams per liter as calcium carbonate
39175	18	2001-10-10	2002-09-05	Vinyl chloride, water, unfiltered, recoverable, micrograms per liter
39180	18	2001-10-10	2002-09-05	Trichloroethene, water, unfiltered, recoverable, micrograms per liter
39333	1	2007-07-13		Aldrin, bed sediment, recoverable, dry weight, micrograms per kilogram
39341	96	1993-03-12	2004-09-07	Lindane, water, filtered, recoverable, micrograms per liter
39343	1	2007-07-13		Lindane, bed sediment, recoverable, dry weight, micrograms per kilogram
39363	1	2007-07-13		p,p'-DDD, bed sediment, recoverable, dry weight, micrograms per kilogram
39368	1	2007-07-13		p,p'-DDE, bed sediment, recoverable, dry weight, micrograms per kilogram
39373	1	2007-07-13		p,p'-DDT, bed sediment, recoverable, dry weight, micrograms per kilogram
39381	139	1993-03-12	2009-06-08	Dieldrin, water, filtered, recoverable, micrograms per liter
39383	1	2007-07-13		Dieldrin, bed sediment, recoverable, dry weight, micrograms per kilogram
39389	1	2007-07-13		alpha-Endosulfan, bed sediment, recoverable, dry weight, micrograms per kilogram
39393	1	2007-07-13		Endrin, bed sediment, recoverable, dry weight, micrograms per kilogram
39403	1	2007-07-13		Toxaphene, bed sediment, recoverable, dry weight, micrograms per kilogram
39413	1	2007-07-13		Heptachlor, bed sediment, recoverable, dry weight, micrograms per kilogram
39415	139	1993-03-12	2009-06-08	Metolachlor, water, filtered, recoverable, micrograms per liter
39423	1	2007-07-13		Heptachlor epoxide, bed sediment, recoverable, dry weight, micrograms per kilogram
39481	1	2007-07-13		p,p'-Methoxychlor, bed sediment, recoverable, dry weight, micrograms per kilogram
39507	1	2007-		Aroclor 1254, bed sediment, recoverable, dry weight, micrograms

39507	1	07-13		per kilogram
39511	1	2007-07-13		Aroclor 1260, bed sediment, recoverable, dry weight, micrograms per kilogram
39532	139	1993-03-12	2009-06-08	Malathion, water, filtered, recoverable, micrograms per liter
39542	96	1993-03-12	2004-09-07	Parathion, water, filtered, recoverable, micrograms per liter
39572	139	1993-03-12	2009-06-08	Diazinon, water, filtered, recoverable, micrograms per liter
39632	139	1993-03-12	2009-06-08	Atrazine, water, filtered, recoverable, micrograms per liter
39701	1	2007-07-13		Hexachlorobenzene, bed sediment, recoverable, dry weight, micrograms per kilogram
39702	18	2001-10-10	2002-09-05	Hexachlorobutadiene, water, unfiltered, recoverable, micrograms per liter
39732	62	1983-08-30	2002-09-23	2,4-D, water, filtered, recoverable, micrograms per liter
39742	37	1983-08-30	1994-11-17	2,4,5-T, water, filtered, recoverable, micrograms per liter
39758	1	2007-07-13		Mirex, bed sediment, recoverable, dry weight, micrograms per kilogram
39762	37	1983-08-30	1994-11-17	Silvex, water, filtered, recoverable, micrograms per liter
46342	139	1993-03-12	2009-06-08	Alachlor, water, filtered, recoverable, micrograms per liter
46343	1	2007-07-13		Aroclor 1016 plus Aroclor 1242, bed sediment, recoverable, dry weight, micrograms per kilogram
49235	62	1983-08-30	2002-09-23	Triclopyr, water, filtered (0.7 micron glass fiber filter), recoverable, micrograms per liter
49236	62	1983-08-30	2002-09-23	Propham, water, filtered (0.7 micron glass fiber filter), recoverable, micrograms per liter
49260	103	1994-10-17	2009-06-08	Acetochlor, water, filtered, recoverable, micrograms per liter
49261	1	1993-08-09		alpha-HCH-d6, surrogate, biota, whole organism, percent recovery
49264	1	1993-08-09		PCB congener 14, surrogate, biota, whole organism, percent recovery
49266	2	1993-08-19	2007-07-13	Organic carbon, bed sediment smaller than 62.5 microns, wet sieved (native water), field, recoverable, dry weight, percent
49267	2	1993-08-19	2007-07-13	Carbon (inorganic plus organic), bed sediment smaller than 62.5 microns, wet sieved (native water), field, recoverable, dry weight, percent
49269	2	1993-08-19	2007-07-13	Inorganic carbon, bed sediment smaller than 62.5 microns, wet sieved (native water), field, recoverable, dry weight, percent
49270	1	1993-08-19		Inorganic carbon, bed sediment smaller than 2 millimeters, wet sieved (native water), field, recoverable, dry weight, grams per kilogram
49271	1	1993-08-19		Organic carbon, bed sediment smaller than 2 millimeters, wet sieved (native water), field, recoverable, dry weight, grams per kilogram

49272	1	1993-08-19		Carbon (inorganic plus organic), bed sediment smaller than 2 millimeters, wet sieved (native water), field, recoverable, dry weight, grams per kilogram
49274	1	1993-08-19		Titanium, bed sediment smaller than 62.5 microns, wet sieved (native water), field, recoverable, dry weight, percent
49275	1	1993-08-19		alpha-HCH-d6, surrogate, bed sediment smaller than 2 millimeters, wet sieved (native water), field, percent recovery
49276	1	1993-08-19		PCB congener 204, surrogate, bed sediment smaller than 2 millimeters, wet sieved (native water), field, percent recovery
49277	1	1993-08-19		PCB congener 14, surrogate, bed sediment smaller than 2 millimeters, wet sieved (native water), field, percent recovery
49278	1	1993-08-19		p-Terphenyl-d14, surrogate, bed sediment smaller than 2 millimeters, wet sieved (native water), field, percent recovery
49279	1	1993-08-19		2-Fluorobiphenyl, surrogate, bed sediment smaller than 2 millimeters, wet sieved (native water), field, percent recovery
49280	1	1993-08-19		Nitrobenzene-d5, surrogate, bed sediment smaller than 2 millimeters, wet sieved (native water), field, percent recovery
49289	1	1993-08-09		Lipids, biota, whole organism, wet weight, recoverable, percent
49291	62	1983-08-30	2002-09-23	Picloram, water, filtered (0.7 micron glass fiber filter), recoverable, micrograms per liter
49292	62	1983-08-30	2002-09-23	Oryzalin, water, filtered (0.7 micron glass fiber filter), recoverable, micrograms per liter
49293	62	1983-08-30	2002-09-23	Norflurazon, water, filtered (0.7 micron glass fiber filter), recoverable, micrograms per liter
49294	62	1983-08-30	2002-09-23	Neburon, water, filtered (0.7 micron glass fiber filter), recoverable, micrograms per liter
49295	59	2001-10-10	2009-06-08	1-Naphthol, water, filtered (0.7 micron glass fiber filter), recoverable, micrograms per liter
49296	62	1983-08-30	2002-09-23	Methomyl, water, filtered (0.7 micron glass fiber filter), recoverable, micrograms per liter
49297	62	1983-08-30	2002-09-23	Fenuron, water, filtered (0.7 micron glass fiber filter), recoverable, micrograms per liter
49299	37	1983-08-30	1994-11-17	2-Methyl-4,6-dinitrophenol, water, filtered (0.7 micron glass fiber filter), recoverable, micrograms per liter
49300	62	1983-08-30	2002-09-23	Diuron, water, filtered (0.7 micron glass fiber filter), recoverable, micrograms per liter
49301	62	1983-08-30	2002-09-23	Dinoseb, water, filtered (0.7 micron glass fiber filter), recoverable, micrograms per liter
49302	62	1983-08-30	2002-09-23	Dichlorprop, water, filtered (0.7 micron glass fiber filter), recoverable, micrograms per liter
49303	37	1983-08-30	1994-11-17	Dichlobenil, water, filtered (0.7 micron glass fiber filter), recoverable, micrograms per liter
49304	61	1983-08-30	2002-09-23	Dacthal monoacid, water, filtered (0.7 micron glass fiber filter), recoverable, micrograms per liter
49305	62	1983-08-30	2002-09-23	Clopyralid, water, filtered (0.7 micron glass fiber filter), recoverable, micrograms per liter
49306	62	1983-08-30	2002-09-23	Chlorothalonil, water, filtered (0.7 micron glass fiber filter), recoverable, micrograms per liter
49308	62	1983-	2002-	3-Hydroxy carbofuran, water, filtered (0.7 micron glass fiber

49308	62	08-30	09-23	filter), recoverable, micrograms per liter
49309	62	1983-08-30	2002-09-23	Carbofuran, water, filtered (0.7 micron glass fiber filter), recoverable, micrograms per liter
49310	62	1983-08-30	2002-09-23	Carbaryl, water, filtered (0.7 micron glass fiber filter), recoverable, micrograms per liter
49311	62	1983-08-30	2002-09-23	Bromoxynil, water, filtered (0.7 micron glass fiber filter), recoverable, micrograms per liter
49312	62	1983-08-30	2002-09-23	Aldicarb, water, filtered (0.7 micron glass fiber filter), recoverable, micrograms per liter
49313	62	1983-08-30	2002-09-23	Aldicarb sulfone, water, filtered (0.7 micron glass fiber filter), recoverable, micrograms per liter
49314	62	1983-08-30	2002-09-23	Aldicarb sulfoxide, water, filtered (0.7 micron glass fiber filter), recoverable, micrograms per liter
49315	62	1983-08-30	2002-09-23	Acifluorfen, water, filtered (0.7 micron glass fiber filter), recoverable, micrograms per liter
49316	1	1993-08-19		cis-Nonachlor, bed sediment smaller than 2 millimeters, wet sieved (native water), field, recoverable, dry weight, micrograms per kilogram
49317	1	1993-08-19		trans-Nonachlor, bed sediment smaller than 2 millimeters, wet sieved (native water), field, recoverable, dry weight, micrograms per kilogram
49318	1	1993-08-19		Oxychlordane, bed sediment smaller than 2 millimeters, wet sieved (native water), field, recoverable, dry weight, micrograms per kilogram
49319	1	1993-08-19		Aldrin, bed sediment smaller than 2 millimeters, wet sieved (native water), field, recoverable, dry weight, micrograms per kilogram
49320	1	1993-08-19		cis-Chlordane, bed sediment smaller than 2 millimeters, wet sieved (native water), field, recoverable, dry weight, micrograms per kilogram
49321	1	1993-08-19		trans-Chlordane, bed sediment smaller than 2 millimeters, wet sieved (native water), field, recoverable, dry weight, micrograms per kilogram
49322	1	1993-08-19		Chloroneb, bed sediment smaller than 2 millimeters, wet sieved (native water), field, recoverable, dry weight, micrograms per kilogram
49324	1	1993-08-19		DCPA, bed sediment smaller than 2 millimeters, wet sieved (native water), field, recoverable, dry weight, micrograms per kilogram
49325	1	1993-08-19		o,p'-DDD, bed sediment smaller than 2 millimeters, wet sieved (native water), field, recoverable, dry weight, micrograms per kilogram
49326	1	1993-08-19		p,p'-DDD, bed sediment smaller than 2 millimeters, wet sieved (native water), field, recoverable, dry weight, micrograms per kilogram
49327	1	1993-08-19		o,p'-DDE, bed sediment smaller than 2 millimeters, wet sieved (native water), field, recoverable, dry weight, micrograms per kilogram
49328	1	1993-08-19		p,p'-DDE, bed sediment smaller than 2 millimeters, wet sieved (native water), field, recoverable, dry weight, micrograms per kilogram
				o,p'-DDT, bed sediment smaller than 2 millimeters, wet sieved

49329	1	1993-08-19		o,p'-DDT, bed sediment smaller than 2 millimeters, wet sieved (native water), field, recoverable, dry weight, micrograms per kilogram
49330	1	1993-08-19		p,p'-DDT, bed sediment smaller than 2 millimeters, wet sieved (native water), field, recoverable, dry weight, micrograms per kilogram
49331	1	1993-08-19		Dieldrin, bed sediment smaller than 2 millimeters, wet sieved (native water), field, recoverable, dry weight, micrograms per kilogram
49332	1	1993-08-19		alpha-Endosulfan, bed sediment smaller than 2 millimeters, wet sieved (native water), field, recoverable, dry weight, micrograms per kilogram
49335	1	1993-08-19		Endrin, bed sediment smaller than 2 millimeters, wet sieved (native water), field, recoverable, dry weight, micrograms per kilogram
49338	1	1993-08-19		alpha-HCH, bed sediment smaller than 2 millimeters, wet sieved (native water), field, recoverable, dry weight, micrograms per kilogram
49339	1	1993-08-19		beta-HCH, bed sediment smaller than 2 millimeters, wet sieved (native water), field, recoverable, dry weight, micrograms per kilogram
49341	1	1993-08-19		Heptachlor, bed sediment smaller than 2 millimeters, wet sieved (native water), field, recoverable, dry weight, micrograms per kilogram
49342	1	1993-08-19		Heptachlor epoxide, bed sediment smaller than 2 millimeters, wet sieved (native water), field, recoverable, dry weight, micrograms per kilogram
49343	1	1993-08-19		Hexachlorobenzene, bed sediment smaller than 2 millimeters, wet sieved (native water), field, recoverable, dry weight, micrograms per kilogram
49344	1	1993-08-19		Isodrin, bed sediment smaller than 2 millimeters, wet sieved (native water), field, recoverable, dry weight, micrograms per kilogram
49345	1	1993-08-19		Lindane, bed sediment smaller than 2 millimeters, wet sieved (native water), field, recoverable, dry weight, micrograms per kilogram
49346	1	1993-08-19		p,p'-Methoxychlor, bed sediment smaller than 2 millimeters, wet sieved (native water), field, recoverable, dry weight, micrograms per kilogram
49347	1	1993-08-19		o,p'-Methoxychlor, bed sediment smaller than 2 millimeters, wet sieved (native water), field, recoverable, dry weight, micrograms per kilogram
49348	1	1993-08-19		Mirex, bed sediment smaller than 2 millimeters, wet sieved (native water), field, recoverable, dry weight, micrograms per kilogram
49349	1	1993-08-19		cis-Permethrin, bed sediment smaller than 2 millimeters, wet sieved (native water), field, recoverable, dry weight, micrograms per kilogram
49350	1	1993-08-19		trans-Permethrin, bed sediment smaller than 2 millimeters, wet sieved (native water), field, recoverable, dry weight, micrograms per kilogram
49351	1	1993-08-19		Toxaphene, bed sediment smaller than 2 millimeters, wet sieved (native water), field, recoverable, dry weight, micrograms per

		08-19		kilogram
49353	1	1993-08-09		Aldrin, biota, whole organism, recoverable, wet weight, micrograms per kilogram
49354	1	1993-08-09		PCBs, biota, whole organism, recoverable, wet weight, micrograms per kilogram
49355	1	1993-08-09		Toxaphene, biota, whole organism, recoverable, wet weight, micrograms per kilogram
49356	1	1993-08-09		Pentachloroanisole, biota, whole organism, recoverable, wet weight, micrograms per kilogram
49357	1	1993-08-09		Oxychlordane, biota, whole organism, recoverable, wet weight, micrograms per kilogram
49358	1	1993-08-09		trans-Nonachlor, biota, whole organism, recoverable, wet weight, micrograms per kilogram
49359	1	1993-08-09		cis-Nonachlor, biota, whole organism, recoverable, wet weight, micrograms per kilogram
49360	1	1993-08-09		Mirex, biota, whole organism, recoverable, wet weight, micrograms per kilogram
49361	1	1993-08-09		p,p'-Methoxychlor, biota, whole organism, recoverable, wet weight, micrograms per kilogram
49362	1	1993-08-09		o,p'-Methoxychlor, biota, whole organism, recoverable, wet weight, micrograms per kilogram
49363	1	1993-08-09		Lindane, biota, whole organism, recoverable, wet weight, micrograms per kilogram
49364	1	1993-08-09		delta-HCH, biota, whole organism, recoverable, wet weight, micrograms per kilogram
49365	1	1993-08-09		beta-HCH, biota, whole organism, recoverable, wet weight, micrograms per kilogram
49366	1	1993-08-09		alpha-HCH, biota, whole organism, recoverable, wet weight, micrograms per kilogram
49367	1	1993-08-09		Hexachlorobenzene, biota, whole organism, recoverable, wet weight, micrograms per kilogram
49368	1	1993-08-09		Heptachlor epoxide, biota, whole organism, recoverable, wet weight, micrograms per kilogram
49369	1	1993-08-09		Heptachlor, biota, whole organism, recoverable, wet weight, micrograms per kilogram
49370	1	1993-08-09		Endrin, biota, whole organism, recoverable, wet weight, micrograms per kilogram
49371	1	1993-08-09		Dieldrin, biota, whole organism, recoverable, wet weight, micrograms per kilogram
49372	1	1993-08-09		p,p'-DDE, biota, whole organism, recoverable, wet weight, micrograms per kilogram
49373	1	1993-08-09		o,p'-DDE, biota, whole organism, recoverable, wet weight, micrograms per kilogram
49374	1	1993-08-09		o,p'-DDD, biota, whole organism, recoverable, wet weight, micrograms per kilogram
49375	1	1993-08-09		p,p'-DDD, biota, whole organism, recoverable, wet weight, micrograms per kilogram
49376	1	1993-08-09		p,p'-DDT, biota, whole organism, recoverable, wet weight, micrograms per kilogram
49377	1	1993-		o,p'-DDT, biota, whole organism, recoverable, wet weight,

49377	1	08-09		micrograms per kilogram
49378	1	1993-08-09		DCPA, biota, whole organism, recoverable, wet weight, micrograms per kilogram
49379	1	1993-08-09		trans-Chlordane, biota, whole organism, recoverable, wet weight, micrograms per kilogram
49380	1	1993-08-09		cis-Chlordane, biota, whole organism, recoverable, wet weight, micrograms per kilogram
49381	1	1993-08-19		Di-n-butyl phthalate, bed sediment smaller than 2 millimeters, wet sieved (native water), field, recoverable, dry weight, micrograms per kilogram
49382	1	1993-08-19		Di-n-octyl phthalate, bed sediment smaller than 2 millimeters, wet sieved (native water), field, recoverable, dry weight, micrograms per kilogram
49383	1	1993-08-19		Diethyl phthalate, bed sediment smaller than 2 millimeters, wet sieved (native water), field, recoverable, dry weight, micrograms per kilogram
49384	1	1993-08-19		Dimethyl phthalate, bed sediment smaller than 2 millimeters, wet sieved (native water), field, recoverable, dry weight, micrograms per kilogram
49387	1	1993-08-19		Pyrene, bed sediment smaller than 2 millimeters, wet sieved (native water), field, recoverable, dry weight, micrograms per kilogram
49388	1	1993-08-19		1-Methylpyrene, bed sediment smaller than 2 millimeters, wet sieved (native water), field, recoverable, dry weight, micrograms per kilogram
49389	1	1993-08-19		Benzo[a]pyrene, bed sediment smaller than 2 millimeters, wet sieved (native water), field, recoverable, dry weight, micrograms per kilogram
49390	1	1993-08-19		Indeno[1,2,3-cd]pyrene, bed sediment smaller than 2 millimeters, wet sieved (native water), field, recoverable, dry weight, micrograms per kilogram
49391	1	1993-08-19		2,2'-Biquinoline, bed sediment smaller than 2 millimeters, wet sieved (native water), field, recoverable, dry weight, micrograms per kilogram
49392	1	1993-08-19		Quinoline, bed sediment smaller than 2 millimeters, wet sieved (native water), field, recoverable, dry weight, micrograms per kilogram
49393	1	1993-08-19		Phenanthridine, bed sediment smaller than 2 millimeters, wet sieved (native water), field, recoverable, dry weight, micrograms per kilogram
49394	1	1993-08-19		Isoquinoline, bed sediment smaller than 2 millimeters, wet sieved (native water), field, recoverable, dry weight, micrograms per kilogram
49395	1	1993-08-19		2,4-Dinitrotoluene, bed sediment smaller than 2 millimeters, wet sieved (native water), field, recoverable, dry weight, micrograms per kilogram
49396	1	1993-08-19		2,6-Dinitrotoluene, bed sediment smaller than 2 millimeters, wet sieved (native water), field, recoverable, dry weight, micrograms per kilogram
49397	1	1993-08-19		Benzo[k]fluoranthene, bed sediment smaller than 2 millimeters, wet sieved (native water), field, recoverable, dry weight, micrograms per kilogram

49398	1	1993-08-19		1-Methyl-9H-fluorene, bed sediment smaller than 2 millimeters, wet sieved (native water), field, recoverable, dry weight, micrograms per kilogram
49399	1	1993-08-19		9H-Fluorene, bed sediment smaller than 2 millimeters, wet sieved (native water), field, recoverable, dry weight, micrograms per kilogram
49400	1	1993-08-19		Isophorone, bed sediment smaller than 2 millimeters, wet sieved (native water), field, recoverable, dry weight, micrograms per kilogram
49401	1	1993-08-19		Bis(2-chloroethoxy)methane, bed sediment smaller than 2 millimeters, wet sieved (native water), field, recoverable, dry weight, micrograms per kilogram
49402	1	1993-08-19		Naphthalene, bed sediment smaller than 2 millimeters, wet sieved (native water), field, recoverable, dry weight, micrograms per kilogram
49403	1	1993-08-19		1,2-Dimethylnaphthalene, bed sediment smaller than 2 millimeters, wet sieved (native water), field, recoverable, dry weight, micrograms per kilogram
49404	1	1993-08-19		1,6-Dimethylnaphthalene, bed sediment smaller than 2 millimeters, wet sieved (native water), field, recoverable, dry weight, micrograms per kilogram
49405	1	1993-08-19		2,3,6-Trimethylnaphthalene, bed sediment smaller than 2 millimeters, wet sieved (native water), field, recoverable, dry weight, micrograms per kilogram
49406	1	1993-08-19		2,6-Dimethylnaphthalene, bed sediment smaller than 2 millimeters, wet sieved (native water), field, recoverable, dry weight, micrograms per kilogram
49407	1	1993-08-19		2-Chloronaphthalene, bed sediment smaller than 2 millimeters, wet sieved (native water), field, recoverable, dry weight, micrograms per kilogram
49408	1	1993-08-19		Benzo[ghi]perylene, bed sediment smaller than 2 millimeters, wet sieved (native water), field, recoverable, dry weight, micrograms per kilogram
49409	1	1993-08-19		Phenanthrene, bed sediment smaller than 2 millimeters, wet sieved (native water), field, recoverable, dry weight, micrograms per kilogram
49410	1	1993-08-19		1-Methylphenanthrene, bed sediment smaller than 2 millimeters, wet sieved (native water), field, recoverable, dry weight, micrograms per kilogram
49411	1	1993-08-19		4H-Cyclopenta[def]phenanthrene, bed sediment smaller than 2 millimeters, wet sieved (native water), field, recoverable, dry weight, micrograms per kilogram
49413	1	1993-08-19		Phenol, bed sediment smaller than 2 millimeters, wet sieved (native water), field, recoverable, dry weight, micrograms per kilogram
49421	1	1993-08-19		3,5-Dimethylphenol, bed sediment smaller than 2 millimeters, wet sieved (native water), field, recoverable, dry weight, micrograms per kilogram
49422	1	1993-08-19		4-Chloro-3-methylphenol, bed sediment smaller than 2 millimeters, wet sieved (native water), field, recoverable, dry weight, micrograms per kilogram
[illegible]	1	1993-		C8-Alkylphenol, bed sediment smaller than 2 millimeters, wet

49424	1	08-19		sieved (native water), field, recoverable, dry weight, micrograms per kilogram
49426	1	1993-08-19		Bis(2-ethylhexyl) phthalate, bed sediment smaller than 2 millimeters, wet sieved (native water), field, recoverable, dry weight, micrograms per kilogram
49427	1	1993-08-19		Benzyl n-butyl phthalate, bed sediment smaller than 2 millimeters, wet sieved (native water), field, recoverable, dry weight, micrograms per kilogram
49428	1	1993-08-19		Acenaphthylene, bed sediment smaller than 2 millimeters, wet sieved (native water), field, recoverable, dry weight, micrograms per kilogram
49429	1	1993-08-19		Acenaphthene, bed sediment smaller than 2 millimeters, wet sieved (native water), field, recoverable, dry weight, micrograms per kilogram
49430	1	1993-08-19		Acridine, bed sediment smaller than 2 millimeters, wet sieved (native water), field, recoverable, dry weight, micrograms per kilogram
49431	1	1993-08-19		N-Nitrosodi-n-propylamine, bed sediment smaller than 2 millimeters, wet sieved (native water), field, recoverable, dry weight, micrograms per kilogram
49433	1	1993-08-19		N-Nitrosodiphenylamine, bed sediment smaller than 2 millimeters, wet sieved (native water), field, recoverable, dry weight, micrograms per kilogram
49434	1	1993-08-19		Anthracene, bed sediment smaller than 2 millimeters, wet sieved (native water), field, recoverable, dry weight, micrograms per kilogram
49435	1	1993-08-19		2-Methylanthracene, bed sediment smaller than 2 millimeters, wet sieved (native water), field, recoverable, dry weight, micrograms per kilogram
49436	1	1993-08-19		Benzo[a]anthracene, bed sediment smaller than 2 millimeters, wet sieved (native water), field, recoverable, dry weight, micrograms per kilogram
49437	1	1993-08-19		9,10-Anthraquinone, bed sediment smaller than 2 millimeters, wet sieved (native water), field, recoverable, dry weight, micrograms per kilogram
49438	1	1993-08-19		1,2,4-Trichlorobenzene, bed sediment smaller than 2 millimeters, wet sieved (native water), field, recoverable, dry weight, micrograms per kilogram
49439	1	1993-08-19		1,2-Dichlorobenzene, bed sediment smaller than 2 millimeters, wet sieved (native water), field, recoverable, dry weight, micrograms per kilogram
49441	1	1993-08-19		1,3-Dichlorobenzene, bed sediment smaller than 2 millimeters, wet sieved (native water), field, recoverable, dry weight, micrograms per kilogram
49442	1	1993-08-19		1,4-Dichlorobenzene, bed sediment smaller than 2 millimeters, wet sieved (native water), field, recoverable, dry weight, micrograms per kilogram
49443	1	1993-08-19		Azobenzene, bed sediment smaller than 2 millimeters, wet sieved (native water), field, recoverable, dry weight, micrograms per kilogram
49444	1	1993-08-19		Nitrobenzene, bed sediment smaller than 2 millimeters, wet sieved (native water), field, recoverable, dry weight, micrograms per kilogram

49446	1	1993-08-19		Pentachloronitrobenzene, bed sediment smaller than 2 millimeters, wet sieved (native water), field, recoverable, dry weight, micrograms per kilogram
49449	1	1993-08-19		Carbazole, bed sediment smaller than 2 millimeters, wet sieved (native water), field, recoverable, dry weight, micrograms per kilogram
49450	1	1993-08-19		Chrysene, bed sediment smaller than 2 millimeters, wet sieved (native water), field, recoverable, dry weight, micrograms per kilogram
49451	1	1993-08-19		p-Cresol, bed sediment smaller than 2 millimeters, wet sieved (native water), field, recoverable, dry weight, micrograms per kilogram
49452	1	1993-08-19		Dibenzothiophene, bed sediment smaller than 2 millimeters, wet sieved (native water), field, recoverable, dry weight, micrograms per kilogram
49454	1	1993-08-19		4-Bromophenyl phenyl ether, bed sediment smaller than 2 millimeters, wet sieved (native water), field, recoverable, dry weight, micrograms per kilogram
49455	1	1993-08-19		4-Chlorophenyl phenyl ether, bed sediment smaller than 2 millimeters, wet sieved (native water), field, recoverable, dry weight, micrograms per kilogram
49458	1	1993-08-19		Benzo[b]fluoranthene, bed sediment smaller than 2 millimeters, wet sieved (native water), field, recoverable, dry weight, micrograms per kilogram
49459	1	1993-08-19		PCBs, bed sediment smaller than 2 millimeters, wet sieved (native water), field, recoverable, dry weight, micrograms per kilogram
49460	1	1993-08-19		Pentachloroanisole, bed sediment smaller than 2 millimeters, wet sieved (native water), field, recoverable, dry weight, micrograms per kilogram
49461	1	1993-08-19		Dibenzo[a,h]anthracene, bed sediment smaller than 2 millimeters, wet sieved (native water), field, recoverable, dry weight, micrograms per kilogram
49466	1	1993-08-19		Fluoranthene, bed sediment smaller than 2 millimeters, wet sieved (native water), field, recoverable, dry weight, micrograms per kilogram
49467	1	1993-08-19		2-Chlorophenol, bed sediment smaller than 2 millimeters, wet sieved (native water), field, recoverable, dry weight, micrograms per kilogram
49468	1	1993-08-19		Benzo[c]cinnoline, bed sediment smaller than 2 millimeters, wet sieved (native water), field, recoverable, dry weight, micrograms per kilogram
49570	36	2001-09-10	2009-06-17	Particulate nitrogen, suspended in water, milligrams per liter
49948	1	1993-08-19		2-Ethylnaphthalene, bed sediment smaller than 2 millimeters, wet sieved (native water), field, recoverable, dry weight, micrograms per kilogram
49954	7	2002-07-18	2006-07-26	Biomass, periphyton, ash free dry mass, grams per square meter
49991	18	2001-10-10	2002-09-05	Methyl acrylate, water, unfiltered, recoverable, micrograms per liter
49999	18	2001-	2002-	1,2,3,4-Tetramethylbenzene, water, unfiltered, recoverable,

49999	18	10-10	09-05	micrograms per liter
50000	18	2001-10-10	2002-09-05	1,2,3,5-Tetramethylbenzene, water, unfiltered, recoverable, micrograms per liter
50002	18	2001-10-10	2002-09-05	Bromoethene, water, unfiltered, recoverable, micrograms per liter
50004	18	2001-10-10	2002-09-05	tert-Butyl ethyl ether, water, unfiltered, recoverable, micrograms per liter
50005	18	2001-10-10	2002-09-05	Methyl tert-pentyl ether, water, unfiltered, recoverable, micrograms per liter
50280	227	1992-07-28	2009-09-02	Purpose, site visit, code
50295	25	2001-10-10	2002-09-23	3-Ketocarbofuran, water, filtered, recoverable, micrograms per liter
50299	25	2001-10-10	2002-09-23	Bendiocarb, water, filtered, recoverable, micrograms per liter
50300	25	2001-10-10	2002-09-23	Benomyl, water, filtered, recoverable, micrograms per liter
50305	25	2001-10-10	2002-09-23	Caffeine, water, filtered, recoverable, micrograms per liter
50306	25	2001-10-10	2002-09-23	Chlorimuron-ethyl, water, filtered, recoverable, micrograms per liter
50337	25	2001-10-10	2002-09-23	Sulfometuron-methyl, water, filtered, recoverable, micrograms per liter
50355	25	2001-10-10	2002-09-23	2-Hydroxy-4-isopropylamino-6-ethylamino-s-triazine, water, filtered, recoverable, micrograms per liter
50356	25	2001-10-10	2002-09-23	Imazaquin, water, filtered, recoverable, micrograms per liter
50359	25	2001-10-10	2002-09-23	Metalaxyl, water, filtered, recoverable, micrograms per liter
50364	25	2001-10-10	2002-09-23	Nicosulfuron, water, filtered, recoverable, micrograms per liter
50407	24	2001-10-10	2002-09-23	Imazethapyr, water, filtered, recoverable, micrograms per liter
50470	25	2001-10-10	2002-09-23	2,4-D methyl ester, water, filtered, recoverable, micrograms per liter
50471	25	2001-10-10	2002-09-23	Propiconazole, water, filtered, recoverable, micrograms per liter
61159	5	2001-10-10	2001-12-04	Tribenuron-methyl, water, filtered, recoverable, micrograms per liter
61188	62	1983-08-30	2002-09-23	Chloramben methyl ester, water, filtered, recoverable, micrograms per liter
61580	20	2001-10-10	2003-09-22	Bifenthrin, water, filtered, recoverable, micrograms per liter
61585	63	2001-10-10	2009-06-08	Cyfluthrin, water, filtered, recoverable, micrograms per liter
61586	63	2001-10-10	2009-06-08	Cypermethrin, water, filtered, recoverable, micrograms per liter
61590	59	2001-10-10	2009-06-08	Endosulfan sulfate, water, filtered, recoverable, micrograms per liter
		2001-	2009-	

61591	63	2001-10-10	2009-06-08	Fenamiphos, water, filtered, recoverable, micrograms per liter
61592	20	2001-10-10	2003-09-22	Flumetralin, water, filtered, recoverable, micrograms per liter
61593	63	2001-10-10	2009-06-08	Iprodione, water, filtered, recoverable, micrograms per liter
61594	63	2001-10-10	2009-06-08	Isofenphos, water, filtered, recoverable, micrograms per liter
61595	59	2001-10-10	2009-06-08	lambda-Cyhalothrin, water, filtered, recoverable, micrograms per liter
61596	63	2001-10-10	2009-06-08	Metalaxyl, water, filtered, recoverable, micrograms per liter
61598	63	2001-10-10	2009-06-08	Methidathion, water, filtered, recoverable, micrograms per liter
61599	63	2001-10-10	2009-06-08	Myclobutanil, water, filtered, recoverable, micrograms per liter
61600	59	2001-10-10	2009-06-08	Oxyfluorfen, water, filtered, recoverable, micrograms per liter
61601	59	2001-10-10	2009-06-08	Phosmet, water, filtered, recoverable, micrograms per liter
61602	20	2001-10-10	2003-09-22	Phostebupirim, water, filtered, recoverable, micrograms per liter
61603	20	2001-10-10	2003-09-22	Profenofos, water, filtered, recoverable, micrograms per liter
61604	20	2001-10-10	2003-09-22	Propetamphos, water, filtered, recoverable, micrograms per liter
61605	20	2001-10-10	2003-09-22	Sulfotepp, water, filtered, recoverable, micrograms per liter
61606	59	2001-10-10	2009-06-08	Tefluthrin, water, filtered, recoverable, micrograms per liter
61607	20	2001-10-10	2003-09-22	Temephos, water, filtered, recoverable, micrograms per liter
61610	59	2001-10-10	2009-06-08	Tribuphos, water, filtered, recoverable, micrograms per liter
61611	19	2001-10-10	2003-09-22	1,4-Naphthoquinone, water, filtered, recoverable, micrograms per liter
61614	20	2001-10-10	2003-09-22	2,5-Dichloroaniline, water, filtered, recoverable, micrograms per liter
61615	19	2001-10-10	2003-09-22	2-[(2-Ethyl-6-methylphenyl)-amino]-1-propanol, water, filtered, recoverable, micrograms per liter
61617	20	2001-10-10	2003-09-22	2-Amino-N-isopropylbenzamide, water, filtered, recoverable, micrograms per liter
61618	63	2001-10-10	2009-06-08	2-Chloro-2',6'-diethylacetanilide, water, filtered, recoverable, micrograms per liter
61620	63	2001-10-10	2009-06-08	2-Ethyl-6-methylaniline, water, filtered, recoverable, micrograms per liter
61625	63	2001-10-10	2009-06-08	3,4-Dichloroaniline, water, filtered, recoverable, micrograms per liter
61627	59	2001-10-10	2009-06-08	3,5-Dichloroaniline, water, filtered, recoverable, micrograms per liter

61629	12	2001-10-10	2003-07-08	3-Phenoxybenzyl alcohol, water, filtered, recoverable, micrograms per liter
61630	20	2001-10-10	2003-09-22	3-(Trifluoromethyl)aniline, water, filtered, recoverable, micrograms per liter
61631	20	2001-10-10	2003-09-22	4,4'-Dichlorobenzophenone, water, filtered, recoverable, micrograms per liter
61633	63	2001-10-10	2009-06-08	4-Chloro-2-methylphenol, water, filtered, recoverable, micrograms per liter
61634	19	2001-10-10	2003-09-22	4-Chlorophenyl methyl sulfone, water, filtered, recoverable, micrograms per liter
61635	63	2001-10-10	2009-06-08	Azinphos-methyl oxygen analog, water, filtered, recoverable, micrograms per liter
61636	63	2001-10-10	2009-06-08	Chlorpyrifos oxygen analog, water, filtered, recoverable, micrograms per liter
61637	20	2001-10-10	2003-09-22	2-(4-tert-Butylphenoxy)-cyclohexanol, water, filtered, recoverable, micrograms per liter
61638	4	2004-10-04	2005-04-04	Diazoxon, water, filtered, recoverable, micrograms per liter
61640	59	2001-10-10	2009-06-08	Disulfoton sulfone, water, filtered, recoverable, micrograms per liter
61641	20	2001-10-10	2003-09-22	Disulfoton sulfoxide, water, filtered, recoverable, micrograms per liter
61642	20	2001-10-10	2003-09-22	Endosulfan ether, water, filtered, recoverable, micrograms per liter
61644	63	2001-10-10	2009-06-08	Ethion monoxon, water, filtered, recoverable, micrograms per liter
61645	63	2001-10-10	2009-06-08	Fenamiphos sulfone, water, filtered, recoverable, micrograms per liter
61646	61	2001-10-10	2009-06-08	Fenamiphos sulfoxide, water, filtered, recoverable, micrograms per liter
61647	20	2001-10-10	2003-09-22	Fenthion sulfoxide, water, filtered, recoverable, micrograms per liter
61649	23	2001-10-10	2005-02-08	Fonofos oxygen analog, water, filtered, recoverable, micrograms per liter
61652	63	2001-10-10	2009-06-08	Malaoxon, water, filtered, recoverable, micrograms per liter
61660	20	2001-10-10	2003-09-22	O-Ethyl-O-methyl-S-propylphosphorothioate, water, filtered, recoverable, micrograms per liter
61663	20	2001-10-10	2003-09-22	Paraoxon, water, filtered, recoverable, micrograms per liter
61664	63	2001-10-10	2009-06-08	Methyl paraoxon, water, filtered, recoverable, micrograms per liter
61665	10	2001-10-15	2003-07-08	4-(Hydroxymethyl) pendimethalin, water, filtered, recoverable, micrograms per liter
61666	63	2001-10-10	2009-06-08	Phorate oxygen analog, water, filtered, recoverable, micrograms per liter
61668	54	2001-10-10	2009-06-08	Phosmet oxygen analog, water, filtered, recoverable, micrograms per liter
61669	20	2001-10-10	2003-09-22	Tebupirimphos oxygen analog, water, filtered, recoverable, micrograms per liter

61671	8	2001-10-10	2003-03-05	Tefluthrin metabolite [R 119364], water, filtered, recoverable, micrograms per liter
61672	8	2001-10-10	2003-03-05	Tefluthrin metabolite [R 152912], water, filtered, recoverable, micrograms per liter
61674	63	2001-10-10	2009-06-08	Terbufos oxygen analog sulfone, water, filtered, recoverable, micrograms per liter
61692	25	2001-10-10	2002-09-23	N-(4-Chlorophenyl)-N'-methylurea, water, filtered, recoverable, micrograms per liter
61693	25	2001-10-10	2002-09-23	Bensulfuron-methyl, water, filtered, recoverable, micrograms per liter
61694	25	2001-10-10	2002-09-23	Flumetsulam, water, filtered, recoverable, micrograms per liter
61695	25	2001-10-10	2002-09-23	Imidacloprid, water, filtered, recoverable, micrograms per liter
61697	25	2001-10-10	2002-09-23	Metsulfuron-methyl, water, filtered, recoverable, micrograms per liter
62166	69	2002-10-09	2009-06-08	Fipronil, water, filtered, recoverable, micrograms per liter
62167	69	2002-10-09	2009-06-08	Fipronil sulfide, water, filtered, recoverable, micrograms per liter
62168	69	2002-10-09	2009-06-08	Fipronil sulfone, water, filtered, recoverable, micrograms per liter
62169	69	2002-10-09	2009-06-08	Desulfinylfipronil amide, water, filtered, recoverable, micrograms per liter
62170	69	2002-10-09	2009-06-08	Desulfinylfipronil, water, filtered, recoverable, micrograms per liter
62359	7	2002-07-18	2006-07-26	Pheophytin a, periphyton, milligrams per square meter
62538	1	2007-07-13		1,2-Dimethylnaphthalene, bed sediment, recoverable, dry weight, micrograms per kilogram
62539	1	2007-07-13		1,6-Dimethylnaphthalene, bed sediment, recoverable, dry weight, micrograms per kilogram
62540	1	2007-07-13		1-Methyl-9H-fluorene, bed sediment, recoverable, dry weight, micrograms per kilogram
62541	1	2007-07-13		1-Methylphenanthrene, bed sediment, recoverable, dry weight, micrograms per kilogram
62542	1	2007-07-13		1-Methylpyrene, bed sediment, recoverable, dry weight, micrograms per kilogram
62543	1	2007-07-13		2,3,6-Trimethylnaphthalene, bed sediment, recoverable, dry weight, micrograms per kilogram
62544	1	2007-07-13		2,6-Dimethylnaphthalene, bed sediment, recoverable, dry weight, micrograms per kilogram
62545	1	2007-07-13		2-Ethylnaphthalene, bed sediment, recoverable, dry weight, micrograms per kilogram
62546	1	2007-07-13		2-Methylanthracene, bed sediment, recoverable, dry weight, micrograms per kilogram
62547	1	2007-07-13		4H-Cyclopenta[def]phenanthrene, bed sediment, recoverable, dry weight, micrograms per kilogram
62548	1	2007-07-13		9H-Fluorene, bed sediment, recoverable, dry weight, micrograms per kilogram

62549	1	2007-07-13		Acenaphthene, bed sediment, recoverable, dry weight, micrograms per kilogram
62550	1	2007-07-13		Acenaphthylene, bed sediment, recoverable, dry weight, micrograms per kilogram
62551	1	2007-07-13		Anthracene, bed sediment, recoverable, dry weight, micrograms per kilogram
62552	1	2007-07-13		Benzo[a]anthracene, bed sediment, recoverable, dry weight, micrograms per kilogram
62553	1	2007-07-13		Benzo[a]pyrene, bed sediment, recoverable, dry weight, micrograms per kilogram
62554	1	2007-07-13		Benzo[b]fluoranthene, bed sediment, recoverable, dry weight, micrograms per kilogram
62555	1	2007-07-13		Benzo[e]pyrene, bed sediment, recoverable, dry weight, micrograms per kilogram
62556	1	2007-07-13		Benzo[ghi]perylene, bed sediment, recoverable, dry weight, micrograms per kilogram
62557	1	2007-07-13		Benzo[k]fluoranthene, bed sediment, recoverable, dry weight, micrograms per kilogram
62558	1	2007-07-13		Chrysene, bed sediment, recoverable, dry weight, micrograms per kilogram
62560	1	2007-07-13		Dibenzo[a,h]anthracene, bed sediment, recoverable, dry weight, micrograms per kilogram
62561	1	2007-07-13		Fluoranthene, bed sediment, recoverable, dry weight, micrograms per kilogram
62562	1	2007-07-13		Indeno[1,2,3-cd]pyrene, bed sediment, recoverable, dry weight, micrograms per kilogram
62563	1	2007-07-13		Naphthalene, bed sediment, recoverable, dry weight, micrograms per kilogram
62565	1	2007-07-13		Perylene, bed sediment, recoverable, dry weight, micrograms per kilogram
62566	1	2007-07-13		Phenanthrene, bed sediment, recoverable, dry weight, micrograms per kilogram
62568	1	2007-07-13		Pyrene, bed sediment, recoverable, dry weight, micrograms per kilogram
62594	1	2007-07-13		2-Fluorobiphenyl, surrogate, bed sediment, PAH method, percent recovery
62595	1	2007-07-13		Nitrobenzene-d5, surrogate, bed sediment, PAH method, percent recovery
62596	1	2007-07-13		p-Terphenyl-d14, surrogate, bed sediment, PAH method, percent recovery
62597	1	2007-07-13		Sample weight, PAH method, bed sediment, grams
62649	17	2002-10-09	2003-09-22	Aminomethylphosphonic acid, water, filtered (0.7 micron glass fiber filter), recoverable, micrograms per liter
62721	17	2002-10-09	2003-09-22	Glufosinate, water, filtered (0.7 micron glass fiber filter), recoverable, micrograms per liter
62722	17	2002-10-09	2003-09-22	Glyphosate, water, filtered (0.7 micron glass fiber filter), recoverable, micrograms per liter
62802	1	2007-07-13		cis-Chlordane, bed sediment, recoverable, dry weight, micrograms per kilogram

62803	1	2007-07-13		trans-Chlordane, bed sediment, recoverable, dry weight, micrograms per kilogram
62804	1	2007-07-13		trans-Nonachlor, bed sediment, recoverable, dry weight, micrograms per kilogram
62836	1	2007-07-13		Isodrin, surrogate, Schedule OCBS, bed sediment, percent recovery
62837	1	2007-07-13		alpha-HCH-d6, surrogate, Schedule OCBS, bed sediment, percent recovery
62838	1	2007-07-13		Nonachlorobiphenyl, surrogate, Schedule OCBS, bed sediment, percent recovery
62854	5	2009-06-17	2009-07-20	Total nitrogen (nitrate + nitrite + ammonia + organic-N), water, filtered, analytically determined, milligrams per liter
62855	64	2003-10-06	2009-07-20	Total nitrogen (nitrate + nitrite + ammonia + organic-N), water, unfiltered, analytically determined, milligrams per liter
65170	1	2007-07-13		Aluminum, bed sediment smaller than 62.5 microns, wet sieved, field, total digestion, dry weight, micrograms per gram
65171	1	2007-07-13		Calcium, bed sediment smaller than 62.5 microns, wet sieved, field, total digestion, dry weight, micrograms per gram
65172	1	2007-07-13		Cesium, bed sediment smaller than 62.5 microns, wet sieved, field, total digestion, dry weight, micrograms per gram
65173	1	2007-07-13		Iron, bed sediment smaller than 62.5 microns, wet sieved, field, total digestion, dry weight, micrograms per gram
65174	1	2007-07-13		Magnesium, bed sediment smaller than 62.5 microns, wet sieved, field, total digestion, dry weight, micrograms per gram
65175	1	2007-07-13		Phosphorus, bed sediment smaller than 62.5 microns, wet sieved, field, total digestion, dry weight, micrograms per gram
65176	1	2007-07-13		Potassium, bed sediment smaller than 62.5 microns, wet sieved, field, total digestion, dry weight, micrograms per gram
65177	1	2007-07-13		Rubidium, bed sediment smaller than 62.5 microns, wet sieved, field, total digestion, dry weight, micrograms per gram
65178	1	2007-07-13		Sodium, bed sediment smaller than 62.5 microns, wet sieved, field, total digestion, dry weight, micrograms per gram
65179	1	2007-07-13		Titanium, bed sediment smaller than 62.5 microns, wet sieved, field, total digestion, dry weight, micrograms per gram
70300	51	1993-04-12	2001-09-10	Residue on evaporation, dried at 180 degrees Celsius, water, filtered, milligrams per liter
70301	52	1972-04-19	2001-09-10	Residue, water, filtered, sum of constituents, milligrams per liter
70302	52	1972-04-19	2001-09-10	Residue, water, dissolved, tons per day
70303	52	1972-04-19	2001-09-10	Residue, water, filtered, tons per acre-foot
70331	153	1993-04-12	2007-09-19	Suspended sediment, sieve diameter, percent smaller than 0.0625 millimeters
70507	7	1980-03-27	1992-07-28	Orthophosphate, water, unfiltered, milligrams per liter as phosphorus
70950	7	2002-07-18	2006-07-26	Biomass/chlorophyll ratio, periphyton, number
70957	7	2002-07-18	2006-07-26	Chlorophyll a, periphyton, chromatographic-fluorometric method, milligrams per square meter

71845	7	1980-03-27	1992-07-28	Ammonia, water, unfiltered, milligrams per liter as NH4
71846	92	1993-04-12	2009-06-29	Ammonia, water, filtered, milligrams per liter as NH4
71851	158	1993-04-12	2009-07-20	Nitrate, water, filtered, milligrams per liter
71856	158	1993-04-12	2009-07-20	Nitrite, water, filtered, milligrams per liter
71886	6	1980-03-27	1980-04-29	Phosphorus, water, unfiltered, milligrams per liter as phosphate
71887	7	1980-03-27	1992-07-28	Total nitrogen, water, unfiltered, milligrams per liter as nitrate
71999	189	1993-05-14	2009-09-02	Sample purpose, code
72104	73	2001-02-06	2009-06-08	Sample location, distance downstream, feet
72105	79	2001-03-13	2009-09-01	Sample location, distance upstream, feet
73547	18	2001-10-10	2002-09-05	trans-1,4-Dichloro-2-butene, water, unfiltered, recoverable, micrograms per liter
73570	18	2001-10-10	2002-09-05	Ethyl methacrylate, water, unfiltered, recoverable, micrograms per liter
77041	18	2001-10-10	2002-09-05	Carbon disulfide, water, unfiltered, micrograms per liter
77093	18	2001-10-10	2002-09-05	cis-1,2-Dichloroethene, water, unfiltered, recoverable, micrograms per liter
77103	18	2001-10-10	2002-09-05	n-Butyl methyl ketone, water, unfiltered, recoverable, micrograms per liter
77128	18	2001-10-10	2002-09-05	Styrene, water, unfiltered, recoverable, micrograms per liter
77135	18	2001-10-10	2002-09-05	o-Xylene, water, unfiltered, recoverable, micrograms per liter
77168	18	2001-10-10	2002-09-05	1,1-Dichloropropene, water, unfiltered, recoverable, micrograms per liter
77170	18	2001-10-10	2002-09-05	2,2-Dichloropropane, water, unfiltered, recoverable, micrograms per liter
77173	18	2001-10-10	2002-09-05	1,3-Dichloropropane, water, unfiltered, recoverable, micrograms per liter
77220	18	2001-10-10	2002-09-05	2-Ethyltoluene, water, unfiltered, recoverable, micrograms per liter
77221	18	2001-10-10	2002-09-05	1,2,3-Trimethylbenzene, water, unfiltered, recoverable, micrograms per liter
77222	18	2001-10-10	2002-09-05	1,2,4-Trimethylbenzene, water, unfiltered, recoverable, micrograms per liter
77223	18	2001-10-10	2002-09-05	Isopropylbenzene, water, unfiltered, recoverable, micrograms per liter
77224	18	2001-10-10	2002-09-05	n-Propylbenzene, water, unfiltered, recoverable, micrograms per liter
77226	18	2001-10-10	2002-09-05	1,3,5-Trimethylbenzene, water, unfiltered, recoverable, micrograms per liter

77275	18	2001-10-10	2002-09-05	2-Chlorotoluene, water, unfiltered, recoverable, micrograms per liter
77277	18	2001-10-10	2002-09-05	4-Chlorotoluene, water, unfiltered, recoverable, micrograms per liter
77297	18	2001-10-10	2002-09-05	Bromochloromethane, water, unfiltered, recoverable, micrograms per liter
77342	18	2001-10-10	2002-09-05	n-Butylbenzene, water, unfiltered, recoverable, micrograms per liter
77350	18	2001-10-10	2002-09-05	sec-Butylbenzene, water, unfiltered, recoverable, micrograms per liter
77353	18	2001-10-10	2002-09-05	tert-Butylbenzene, water, unfiltered, recoverable, micrograms per liter
77356	18	2001-10-10	2002-09-05	4-Isopropyltoluene, water, unfiltered, recoverable, micrograms per liter
77424	18	2001-10-10	2002-09-05	Iodomethane, water, unfiltered, recoverable, micrograms per liter
77443	18	2001-10-10	2002-09-05	1,2,3-Trichloropropane, water, unfiltered, recoverable, micrograms per liter
77562	18	2001-10-10	2002-09-05	1,1,1,2-Tetrachloroethane, water, unfiltered, recoverable, micrograms per liter
77613	18	2001-10-10	2002-09-05	1,2,3-Trichlorobenzene, water, unfiltered, recoverable, micrograms per liter
77651	18	2001-10-10	2002-09-05	1,2-Dibromoethane, water, unfiltered, recoverable, micrograms per liter
77652	18	2001-10-10	2002-09-05	1,1,2-Trichloro-1,2,2-trifluoroethane, water, unfiltered, recoverable, micrograms per liter
78032	18	2001-10-10	2002-09-05	Methyl tert-butyl ether, water, unfiltered, recoverable, micrograms per liter
78109	18	2001-10-10	2002-09-05	3-Chloropropene, water, unfiltered, recoverable, micrograms per liter
78133	18	2001-10-10	2002-09-05	Isobutyl methyl ketone, water, unfiltered, recoverable, micrograms per liter
79842	20	2001-10-10	2003-09-22	Methyl cis-3-(2,2-dichlorovinyl)-2,2-dimethylcyclopropane-1-carboxylate, water, filtered, recoverable, micrograms per liter
79843	20	2001-10-10	2003-09-22	Methyl trans-3-(2,2-dichlorovinyl)-2,2-dimethylcyclopropane-1-carboxylate, water, filtered, recoverable, micrograms per liter
79844	20	2001-10-10	2003-09-22	(E)-Dimethomorph, water, filtered, recoverable, micrograms per liter
79845	20	2001-10-10	2003-09-22	(Z)-Dimethomorph, water, filtered, recoverable, micrograms per liter
79846	59	2001-10-10	2009-06-08	cis-Propiconazole, water, filtered, recoverable, micrograms per liter
79847	59	2001-10-10	2009-06-08	trans-Propiconazole, water, filtered, recoverable, micrograms per liter
80154	159	1993-04-12	2007-09-19	Suspended sediment concentration, milligrams per liter
80155	159	1993-04-12	2007-09-19	Suspended sediment discharge, tons per day
81552	18	2001-10-10	2002-09-05	Acetone, water, unfiltered, recoverable, micrograms per liter

81555	18	2001-10-10	2002-09-05	Bromobenzene, water, unfiltered, recoverable, micrograms per liter
81576	18	2001-10-10	2002-09-05	Diethyl ether, water, unfiltered, recoverable, micrograms per liter
81577	18	2001-10-10	2002-09-05	Diisopropyl ether, water, unfiltered, recoverable, micrograms per liter
81593	18	2001-10-10	2002-09-05	Methyl acrylonitrile, water, unfiltered, recoverable, micrograms per liter
81595	18	2001-10-10	2002-09-05	Ethyl methyl ketone, water, unfiltered, recoverable, micrograms per liter
81597	18	2001-10-10	2002-09-05	Methyl methacrylate, water, unfiltered, recoverable, micrograms per liter
81607	18	2001-10-10	2002-09-05	Tetrahydrofuran, water, unfiltered, recoverable, micrograms per liter
81904	1	2006-04-05		Velocity at point in stream, feet per second
82346	63	2001-10-10	2009-06-08	Ethion, water, filtered, recoverable, micrograms per liter
82398	156	2001-02-06	2009-09-02	Sampling method, code
82625	18	2001-10-10	2002-09-05	1,2-Dibromo-3-chloropropane, water, unfiltered, recoverable, micrograms per liter
82630	139	1993-03-12	2009-06-08	Metribuzin, water, filtered, recoverable, micrograms per liter
82660	139	1993-03-12	2009-06-08	2,6-Diethylaniline, water, filtered (0.7 micron glass fiber filter), recoverable, micrograms per liter
82661	139	1993-03-12	2009-06-08	Trifluralin, water, filtered (0.7 micron glass fiber filter), recoverable, micrograms per liter
82662	63	2001-10-10	2009-06-08	Dimethoate, water, filtered (0.7 micron glass fiber filter), recoverable, micrograms per liter
82663	96	1993-03-12	2004-09-07	Ethalfluralin, water, filtered (0.7 micron glass fiber filter), recoverable, micrograms per liter
82664	139	1993-03-12	2009-06-08	Phorate, water, filtered (0.7 micron glass fiber filter), recoverable, micrograms per liter
82665	96	1993-03-12	2004-09-07	Terbacil, water, filtered (0.7 micron glass fiber filter), recoverable, micrograms per liter
82666	96	1993-03-12	2004-09-07	Linuron, water, filtered (0.7 micron glass fiber filter), recoverable, micrograms per liter
82667	139	1993-03-12	2009-06-08	Methyl parathion, water, filtered (0.7 micron glass fiber filter), recoverable, micrograms per liter
82668	135	1993-03-12	2009-06-08	EPTC, water, filtered (0.7 micron glass fiber filter), recoverable, micrograms per liter
82669	96	1993-03-12	2004-09-07	Pebulate, water, filtered (0.7 micron glass fiber filter), recoverable, micrograms per liter
82670	139	1993-03-12	2009-06-08	Tebuthiuron, water, filtered (0.7 micron glass fiber filter), recoverable, micrograms per liter
82671	135	1993-03-12	2009-06-08	Molinate, water, filtered (0.7 micron glass fiber filter), recoverable, micrograms per liter
82672	135	1993-03-12	2009-06-08	Ethoprop, water, filtered (0.7 micron glass fiber filter), recoverable, micrograms per liter

82673	139	1993-03-12	2009-06-08	Benfluralin, water, filtered (0.7 micron glass fiber filter), recoverable, micrograms per liter
82674	135	1993-03-12	2009-06-08	Carbofuran, water, filtered (0.7 micron glass fiber filter), recoverable, micrograms per liter
82675	139	1993-03-12	2009-06-08	Terbufos, water, filtered (0.7 micron glass fiber filter), recoverable, micrograms per liter
82676	139	1993-03-12	2009-06-08	Propyzamide, water, filtered (0.7 micron glass fiber filter), recoverable, micrograms per liter
82677	135	1993-03-12	2009-06-08	Disulfoton, water, filtered (0.7 micron glass fiber filter), recoverable, micrograms per liter
82678	96	1993-03-12	2004-09-07	Triallate, water, filtered (0.7 micron glass fiber filter), recoverable, micrograms per liter
82679	135	1993-03-12	2009-06-08	Propanil, water, filtered (0.7 micron glass fiber filter), recoverable, micrograms per liter
82680	139	1993-03-12	2009-06-08	Carbaryl, water, filtered (0.7 micron glass fiber filter), recoverable, micrograms per liter
82681	135	1993-03-12	2009-06-08	Thiobencarb, water, filtered (0.7 micron glass fiber filter), recoverable, micrograms per liter
82682	139	1993-03-12	2009-06-08	DCPA, water, filtered (0.7 micron glass fiber filter), recoverable, micrograms per liter
82683	139	1993-03-12	2009-06-08	Pendimethalin, water, filtered (0.7 micron glass fiber filter), recoverable, micrograms per liter
82684	96	1993-03-12	2004-09-07	Napropamide, water, filtered (0.7 micron glass fiber filter), recoverable, micrograms per liter
82685	135	1993-03-12	2009-06-08	Propargite, water, filtered (0.7 micron glass fiber filter), recoverable, micrograms per liter
82686	139	1993-03-12	2009-06-08	Azinphos-methyl, water, filtered (0.7 micron glass fiber filter), recoverable, micrograms per liter
82687	139	1993-03-12	2009-06-08	cis-Permethrin, water, filtered (0.7 micron glass fiber filter), recoverable, micrograms per liter
84164	144	2001-02-06	2009-09-02	Sampler type, code
84171	41	2007-03-08	2009-09-01	Sample splitter type, field, code
85795	18	2001-10-10	2002-09-05	m-Xylene plus p-xylene, water, unfiltered, recoverable, micrograms per liter
90095	51	1993-04-12	2001-09-10	Specific conductance, water, unfiltered, laboratory, microsiemens per centimeter at 25 degrees Celsius
90410	43	1993-04-12	1995-07-07	Acid neutralizing capacity, water, unfiltered, fixed endpoint (pH 4.5) titration, laboratory, milligrams per liter as calcium carbonate
90640	25	2001-10-10	2002-09-23	Barban, surrogate, Schedules 2060/9060, water, filtered, percent recovery
90851	18	2001-10-10	2002-09-05	Trihalomethanes, water, unfiltered, calculated, micrograms per liter
90852	1	1993-08-19		DDT plus degradates, bed sediment smaller than 2 millimeters, wet sieved (native water), recoverable, calculated, dry weight, micrograms per kilogram
90853	1	1993-08-19		Chlordane plus degradates, bed sediment, recoverable, calculated, dry weight, micrograms per kilogram

90854	1	1993-08-09		DDT plus degradates, biota, whole organism, wet weight, calculated, dry weight, micrograms per kilogram
90902	6	2002-10-09	2003-08-05	Escherichia coli, modified m-TEC MF method, water, colonies per 100 milliliters
91063	96	1993-03-12	2004-09-07	Diazinon-d10, surrogate, water, filtered (0.7 micron glass fiber filter), percent recovery
91064	38	1993-03-12	1994-11-17	Terbuthylazine, surrogate, water, filtered (0.7 micron glass fiber filter), percent recovery
91065	96	1993-03-12	2004-09-07	alpha-HCH-d6, surrogate, water, filtered (0.7 micron glass fiber filter), percent recovery
99105	29	1993-07-15	2009-08-17	Type of replicate, code
99111	129	1993-07-15	2009-09-02	Type of quality assurance data associated with sample, code
99112	8	2003-04-10	2009-08-26	Purpose, topical quality-control data, code
99223	20	2001-10-10	2003-09-22	Diazinon-d10, surrogate, Schedule 2002/9002, water, unfiltered, percent recovery
99224	20	2001-10-10	2003-09-22	alpha-HCH-d6, surrogate, Schedule 2002/9002, water, unfiltered, percent recovery
99630	8	2001-02-06	2001-09-10	Set number, lab code 0113
99660	5	2001-02-06	2001-09-10	Set number, lab code 0305
99750	8	2001-10-10	2002-03-04	Set number, Schedule 2060, lab code 9060
99807	4	1994-09-07	1994-11-17	Set number, Schedule 1331
99818	37	1993-08-30	2002-03-04	Set number, Schedule 2001
99819	2	1993-08-05		Set number, Schedule 2010
99820	21	1993-06-17	1994-11-17	Set number, Schedule 2050
99822	1	1993-08-09		Set number, Schedule 2101
99825	1	1993-08-19		Set number, Schedule 2502
99827	12	2001-10-10	2002-03-20	Set number, Schedule 2090
99832	18	2001-10-10	2002-09-05	1,2-Dichloroethane-d4, surrogate, Schedule 2090, water, unfiltered, percent recovery
99833	18	2001-10-10	2002-09-05	Toluene-d8, surrogate, Schedule 2090, water, unfiltered, percent recovery
99834	18	2001-10-10	2002-09-05	1-Bromo-4-fluorobenzene, surrogate, VOC schedules, water, unfiltered, percent recovery
99835	23	1993-05-17	1994-11-17	BDMC, surrogate, water, unfiltered, percent recovery
99838	2	2001-10-10	2001-10-15	Set number, Schedule 2002

99839	20	2001-10-10	2003-09-22	Sample volume, Schedules 2002 and 9002, milliliters
99840	25	2001-10-10	2002-09-23	Sample volume, Schedules 2060 and 9060, milliliters
99848	19	1993-06-17	1994-11-17	Sample volume, Schedule 2050, milliliters
99849	1	1993-08-09		Analytical reference number, Schedule 2101
99850	1	1993-08-19		Analytical reference number, Schedule 2501
99852	1	1993-08-09		Sample weight, Schedule 2101, grams
99853	1	1993-08-19		Sample weight, Schedule 2501, grams
99856	83	1993-08-30	2004-09-07	Sample volume, Schedule 2001, milliliters
99857	15	1993-03-12	1993-08-10	Sample volume, Schedule 2010, milliliters
99871	18	2001-10-10	2002-09-05	Number of tentatively identified compounds (TICS) from VOC analysis by GCMS, number
99958	25	2001-10-10	2002-09-23	2,4,5-T, surrogate, Schedule 9060/2060, water, filtered, percent recovery
99959	25	2001-10-10	2002-09-23	Caffeine-13C, surrogate, Schedule 9060/2060, water, filtered, percent recovery
99962	1	2007-07-13		Sample weight, Schedule OCBS, grams
99972	43	2004-10-04	2009-06-08	Sample volume, Schedule 2003, milliliters
99994	43	2004-10-04	2009-06-08	Diazinon-d10, surrogate, Schedule 2003, water, filtered, percent recovery
99995	43	2004-10-04	2009-06-08	alpha-HCH-d6, surrogate, Schedule 2003, water, filtered, percent recovery

National Water Information System: Web Interface

USGS 06714000 SOUTH PLATTE RIVER AT DENVER, CO.

Available data for this site SUMMARY OF ALL AVAILABLE DATA GO

Stream Site

DESCRIPTION:

Latitude 39°45'35", Longitude 105°00'10" NAD27
Denver County, Colorado, Hydrologic Unit 10190003
Drainage area: 3,861 square miles
Datum of gage: 5,157.64 feet above sea level NGVD29.

AVAILABLE DATA:

Data Type	Begin Date	End Date	Count
Daily Data			
Discharge, cubic feet per second	1895-07-01	2007-09-30	40999
Daily Statistics			
Discharge, cubic feet per second	1895-07-01	2007-09-30	40999
Monthly Statistics			
Discharge, cubic feet per second	1895-07	2007-09	
Annual Statistics			
Discharge, cubic feet per second	1895	2007	
Peak streamflow	1895-08-02	2007-05-14	110
Field measurements	1989-09-20	1999-10-05	40

Field/Lab water-quality samples	1972-04-19	2009-05-26	714
Additional Data Sources	**Begin Date**	**End Date**	**Count**
Annual Water-Data Report (pdf) **offsite**	2005	2007	3

OPERATION:

Record for this site is maintained by the USGS Colorado Water Science Center
Email questions about this site to Colorado Water Science Center Water-Data Inquiries

ADDITIONAL INFORMATION

This streamflow gaging station currently is operated by the Colorado Division of Water Resources (DWR). The USGS works cooperatively with the DWR to publish daily mean (and annual peak) discharge data for this station.
These are the only streamflow data available in NWISWeb for this site.
Current streamflow data (and other historical streamflow data) for this site are available on the DWR Colorado's Surface Water Conditions pages.

USGS Surface-Water Monthly Statistics for the Nation

The statistics generated from this site are based on approved daily-mean data and may not match those published by the USGS in official publications. The user is responsible for assessment and use of statistics from this site. For more details on why the statistics may not match, click here.

USGS 06714000 SOUTH PLATTE RIVER AT DENVER, CO.

Available data for this site Time-series: Monthly statistics GO

Denver County, Colorado Hydrologic Unit Code 10190003 Latitude 39°45'35", Longitude 105°00'10" NAD27 Drainage area 3,861 square miles Gage datum 5,157.64 feet above sea level NGVD29	**Output formats** HTML table of all data Tab-separated data Reselect output format

00060, Discharge, cubic feet per second,												
YEAR	**Monthly mean in cfs (Calculation Period: 1975-10-01 -> 2007-09-30)** Calculation period restricted by USGS staff due to special conditions at/near site											
	Jan	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
1975										91.8	94.4	128.9
1976	97.6	82.8	106.2	169.5	269.3	289.1	363.9	469.6	257.0	179.4	139.7	121.6
1977	97.5	80.7	95.2	322.3	260.5	223.0	183.4	186.4	76.5	66.8	115.7	84.1

1978	78.1	83.8	94.9	101.6	217.7	228.8	293.8	197.2	87.9	102.2	111.8	86.5
1979	64.9	94.3	135.1	378.8	519.5	1,312	665.6	415.9	105.5	126.9	149.6	205.2
1980	158.8	173.6	154.4	577.3	2,970	2,180	689.8	352.1	169.1	120.6	143.7	102.3
1981	100.6	127.7	163.4	179.0	242.8	163.6	197.1	177.2	156.6	135.8	109.8	108.7
1982	103.3	90.1	97.5	99.1	261.9	318.7	337.5	623.4	450.1	363.3	123.6	127.2
1983	139.1	99.6	419.8	1,342	2,737	2,759	1,913	1,149	300.9	151.6	190.0	221.9
1984	190.2	272.9	347.2	1,377	2,428	1,206	681.8	1,774	910.9	1,184	809.0	365.6
1985	282.0	222.1	301.8	688.5	1,835	1,132	711.9	540.4	242.3	235.6	279.5	175.8
1986	168.8	198.4	178.0	529.6	348.5	486.8	573.7	382.0	239.3	151.5	243.3	122.0
1987	135.5	164.2	282.6	682.3	2,875	1,460	492.2	473.1	208.8	223.2	193.7	134.8
1988	126.3	247.1	307.5	491.0	764.7	506.8	538.5	447.0	197.1	122.4	179.6	100.2
1989	92.0	143.0	193.9	264.3	341.2	519.0	506.0	356.4	164.5	125.5	105.2	177.4
1990	141.3	140.7	232.1	228.4	407.5	298.9	463.2	400.6	241.6	179.7	223.6	105.4
1991	85.9	86.4	110.7	198.9	380.3	531.3	341.2	506.9	195.6	117.6	176.6	118.7
1992	157.8	155.7	368.6	379.2	331.5	390.6	281.8	335.5	107.1	103.1	181.4	105.0
1993	119.9	170.1	146.6	270.0	319.4	362.6	236.9	200.6	171.3	156.1	185.9	107.3
1994	90.2	133.8	143.9	351.9	445.7	359.8	138.7	194.7	111.7	109.6	144.1	88.2
1995	92.1	93.3	97.0	244.7	1,352	2,608	2,546	576.6	283.8	127.0	184.5	157.1
1996	95.8	101.2	126.1	198.7	354.2	404.6	348.7	222.5	253.1	201.0	184.5	105.1
1997	87.9	133.0	126.1	280.4	429.9	856.7	513.8	650.2	282.4	262.6	252.3	211.1
1998	196.1	189.3	302.9	931.0	1,556	588.4	740.1	723.7	243.3	254.2	159.8	130.5
1999	145.6	132.1	143.7	463.8	1,395	1,854	813.6	841.1	252.2	204.2	205.2	189.8
2000	193.6	190.6	205.8	321.1	469.3	336.6	319.4	255.4	172.5	147.1	126.2	127.7
2001	150.5	179.9	170.8	247.6	495.5	302.9	453.9	250.7	166.5	119.2	118.7	118.4
2002	123.2	127.0	168.1	105.1	141.4	149.6	87.5	71.3	110.8	93.0	65.6	62.4
2003	62.3	62.3	254.3	574.1	501.2	380.7	211.9	208.1	215.6	88.4	71.1	77.0
2004	88.7	130.0	105.9	329.4	311.1	296.2	449.1	505.2	186.5	254.1	205.6	156.3
2005	149.7	138.9	140.7	619.2	878.6	625.7	194.0	364.3	141.6	231.2	154.1	115.9
2006	121.4	126.0	135.3	138.0	234.1	218.5	534.6	402.6	202.9	306.4	162.0	138.8

2007	146.6	262.1	671.6	1,044	2,572	1,293	648.5	602.7	334.8			
Mean of monthly Discharge	128	145	204	441	895	770	546	464	226	198	181	137
** No Incomplete data have been used for statistical calculation												

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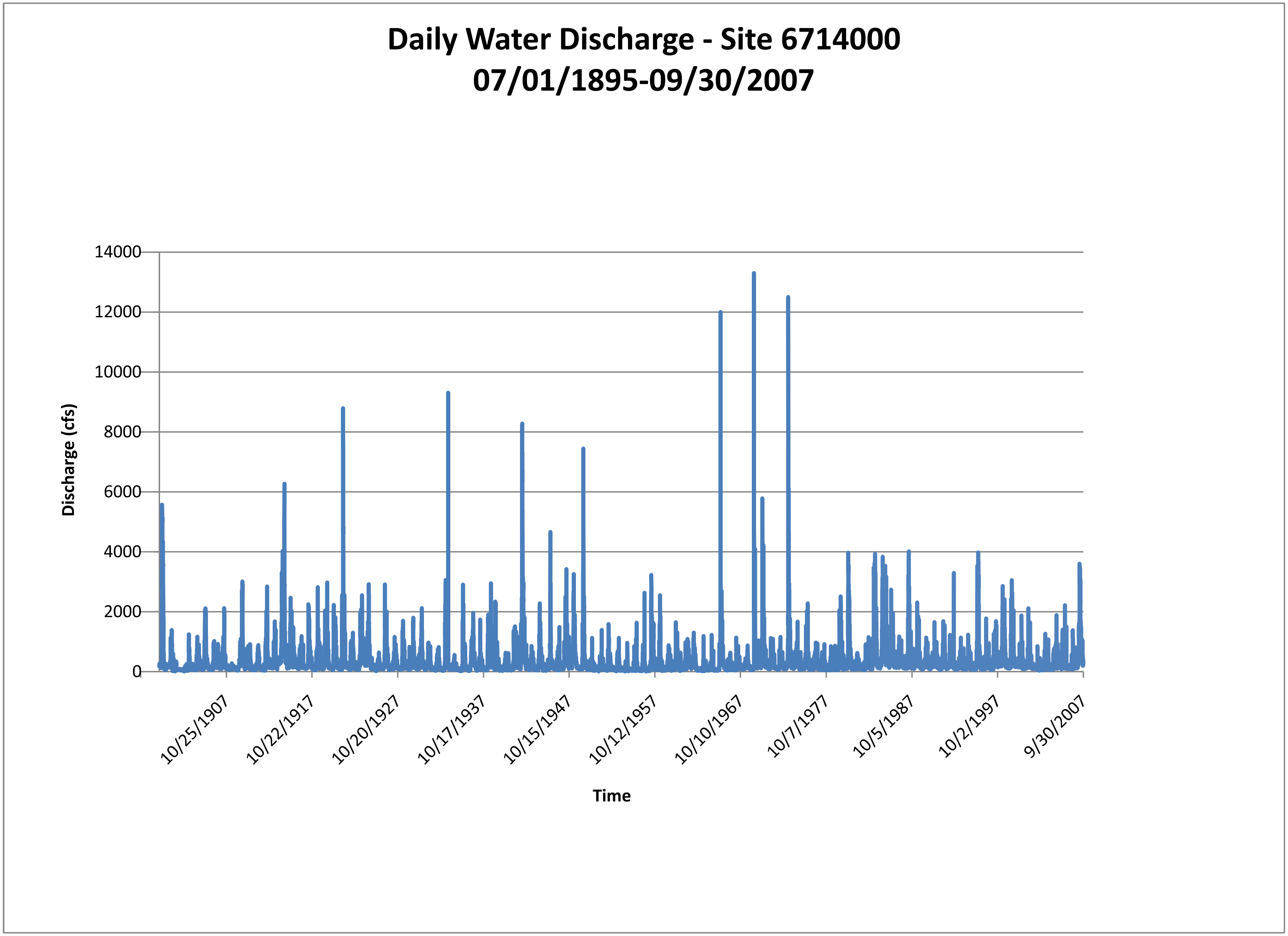
Daily Water Discharge - Site 6714000
07/01/1895-09/30/2007
Discharge (cfs)
14000
12000
10000
8000
6000
4000
2000
0
10/25/1907
10/22/1917
10/20/1927
10/17/1937
10/15/1947
10/12/1957
10/10/1967
10/7/1977
10/5/1987
10/2/1997
9/30/2007
Time

Water Quality Samples for the Nation

USGS 06714000 SOUTH PLATTE RIVER AT DENVER, CO.

Available data for this site: Water-Quality: Field/Lab samples GO

Denver County, Colorado
Hydrologic Unit Code 10190003
Latitude 39°45'35", Longitude 105°00'10" NAD27
Drainage area 3,861 square miles
Gage datum 5,157.64 feet above sea level NGVD29

Output formats

- Parameter Group Period of Record table
- Inventory of available water-quality data for printing
- Inventory of water-quality data with retrieval
- Tab-separated data, one result per row
- Tab-separated data one sample per row with remark codes combined with values
- Tab-separated data one sample per row with tab-delimiter for remark codes
- Reselect output format

Parameter Code	Count	Begin Date	End Date	Parameter Code Complete Name
00004	76	1996-07-09	2009-06-26	Stream width, feet
00010	332	1972-04-19	2002-09-10	Temperature, water, degrees Celsius
00020	2	2002-08-13	2002-09-10	Temperature, air, degrees Celsius
00021	1	1993-05-17		Temperature, air, degrees Fahrenheit
00025	94	1983-09-22	2002-09-10	Barometric pressure, millimeters of mercury
00028	662	1972-04-19	2007-07-27	Agency analyzing sample, code
00029	66	1998-06-04	2001-07-13	Project number
00060	1	1972-04-19		Discharge, cubic feet per second
00061	218	1982-10-07	2004-05-13	Discharge, instantaneous, cubic feet per second
00063	290	1996-07-09	2009-06-26	Number of sampling points, count
00065	122	1982-10-07	2004-08-19	Gage height, feet
00094	13	2001-07-23	2001-07-24	Specific conductance, water, unfiltered, field, microsiemens per centimeter at 25 degrees Celsius

00095	455	1972-04-19	2009-07-21	Specific conductance, water, unfiltered, microsiemens per centimeter at 25 degrees Celsius
00191	156	1972-04-19	2002-09-10	Hydrogen ion, water, unfiltered, calculated, milligrams per liter
00300	154	1980-03-27	2002-09-10	Dissolved oxygen, water, unfiltered, milligrams per liter
00301	96	1983-09-22	2002-09-10	Dissolved oxygen, water, unfiltered, percent of saturation
00340	6	1980-03-27	1980-04-29	Chemical oxygen demand, high level, water, unfiltered, milligrams per liter
00400	156	1972-04-19	2002-09-10	pH, water, unfiltered, field, standard units
00403	276	1982-10-07	2009-07-26	pH, water, unfiltered, laboratory, standard units
00405	88	1972-04-19	1999-03-01	Carbon dioxide, water, unfiltered, milligrams per liter
00410	5	1972-04-19	1994-06-16	Acid neutralizing capacity, water, unfiltered, fixed endpoint (pH 4.5) titration, field, milligrams per liter as calcium carbonate
00418	44	1993-04-14	1996-09-12	Alkalinity, water, filtered, fixed endpoint (pH 4.5) titration, field, milligrams per liter as calcium carbonate
00440	1	1972-04-19		Bicarbonate, water, unfiltered, fixed endpoint (pH 4.5) titration, field, milligrams per liter
00445	1	1972-04-19		Carbonate, water, unfiltered, fixed endpoint (pH 8.3) titration, field, milligrams per liter
00452	16	1995-10-05	2000-08-01	Carbonate, water, filtered, inflection-point titration method (incremental titration method), field, milligrams per liter
00453	56	1995-10-05	2001-01-03	Bicarbonate, water, filtered, inflection-point titration method (incremental titration method), field, milligrams per liter
00530	170	1980-03-27	2009-07-26	Residue, total nonfilterable, milligrams per liter
00600	269	1980-03-27	2009-07-26	Total nitrogen, water, unfiltered, milligrams per liter
00602	99	1993-04-14	2002-09-11	Total nitrogen, water, filtered, milligrams per liter
00605	242	1980-03-27	2009-07-25	Organic nitrogen, water, unfiltered, milligrams per liter
00607	91	1993-04-14	2002-09-11	Organic nitrogen, water, filtered, milligrams per liter
00608	192	1993-04-14	2009-07-26	Ammonia, water, filtered, milligrams per liter as nitrogen
00610	102	1980-03-27	2002-09-19	Ammonia, water, unfiltered, milligrams per liter as nitrogen
00613	99	1993-04-14	2002-09-10	Nitrite, water, filtered, milligrams per liter as nitrogen
00615	24	1982-10-07	1984-01-27	Nitrite, water, unfiltered, milligrams per liter as nitrogen
00618	95	1993-04-14	2002-09-10	Nitrate, water, filtered, milligrams per liter as nitrogen
00620	24	1982-10-07	1984-01-27	Nitrate, water, unfiltered, milligrams per liter as nitrogen

00623	100	1993-04-14	2002-09-11	Ammonia plus organic nitrogen, water, filtered, milligrams per liter as nitrogen
00625	291	1980-03-27	2009-07-26	Ammonia plus organic nitrogen, water, unfiltered, milligrams per liter as nitrogen
00630	84	1980-03-27	2002-09-19	Nitrate plus nitrite, water, unfiltered, milligrams per liter as nitrogen
00631	193	1972-04-19	2009-07-26	Nitrate plus nitrite, water, filtered, milligrams per liter as nitrogen
00650	6	1980-03-27	1980-04-29	Phosphate, water, unfiltered, milligrams per liter
00660	263	1972-04-19	2009-07-26	Orthophosphate, water, filtered, milligrams per liter
00665	269	1980-03-27	2009-07-26	Phosphorus, water, unfiltered, milligrams per liter as phosphorus
00666	100	1993-04-14	2002-09-11	Phosphorus, water, filtered, milligrams per liter as phosphorus
00671	264	1972-04-19	2009-07-26	Orthophosphate, water, filtered, milligrams per liter as phosphorus
00680	73	1980-03-27	2004-04-24	Organic carbon, water, unfiltered, milligrams per liter
00681	163	1972-04-19	2009-07-26	Organic carbon, water, filtered, milligrams per liter
00689	86	1993-04-14	2001-09-08	Organic carbon, suspended sediment, total, milligrams per liter
00900	252	1972-04-19	2009-07-26	Hardness, water, milligrams per liter as calcium carbonate
00902	1	1972-04-19		Noncarbonate hardness, water, unfiltered, field, milligrams per liter as calcium carbonate
00904	47	1995-10-05	2001-01-03	Noncarbonate hardness, water, filtered, field, milligrams per liter as calcium carbonate
00905	29	2002-08-13	2007-07-27	Noncarbonate hardness, water, filtered, lab, milligrams per liter as calcium carbonate
00915	181	1972-04-19	2009-07-26	Calcium, water, filtered, milligrams per liter
00925	181	1972-04-19	2009-07-26	Magnesium, water, filtered, milligrams per liter
00930	116	1972-04-19	2007-07-27	Sodium, water, filtered, milligrams per liter
00931	116	1972-04-19	2007-07-27	Sodium adsorption ratio, water, number
00932	116	1972-04-19	2007-07-27	Sodium fraction of cations, water, percent in equivalents of major cations
00935	129	1972-04-19	2007-07-27	Potassium, water, filtered, milligrams per liter
00940	131	1972-04-19	2007-07-27	Chloride, water, filtered, milligrams per liter
00945	129	1972-04-19	2007-07-27	Sulfate, water, filtered, milligrams per liter
00950	127	1972-04-19	2007-07-27	Fluoride, water, filtered, milligrams per liter

00955	89	1972-04-19	2002-09-10	Silica, water, filtered, milligrams per liter as SiO2
01000	3	1972-04-19	1994-08-29	Arsenic, water, filtered, micrograms per liter
01002	1	1994-08-29		Arsenic, water, unfiltered, micrograms per liter
01005	8	1993-07-06	1994-08-29	Barium, water, filtered, micrograms per liter
01007	1	1994-08-29		Barium, water, unfiltered, recoverable, micrograms per liter
01010	8	1993-07-06	1994-08-29	Beryllium, water, filtered, micrograms per liter
01025	10	1972-04-19	2002-09-10	Cadmium, water, filtered, micrograms per liter
01027	7	1980-03-27	1994-08-29	Cadmium, water, unfiltered, micrograms per liter
01030	8	1993-07-06	1994-08-29	Chromium, water, filtered, micrograms per liter
01034	1	1994-08-29		Chromium, water, unfiltered, recoverable, micrograms per liter
01035	8	1993-07-06	1994-08-29	Cobalt, water, filtered, micrograms per liter
01040	174	1972-04-19	2009-07-26	Copper, water, filtered, micrograms per liter
01042	73	1980-03-27	2009-07-26	Copper, water, unfiltered, recoverable, micrograms per liter
01045	7	1980-03-27	1994-08-29	Iron, water, unfiltered, recoverable, micrograms per liter
01046	91	1972-04-19	2002-09-10	Iron, water, filtered, micrograms per liter
01049	174	1972-04-19	2009-07-26	Lead, water, filtered, micrograms per liter
01051	73	1980-03-27	2009-07-26	Lead, water, unfiltered, recoverable, micrograms per liter
01055	92	1980-03-27	2009-07-26	Manganese, water, unfiltered, recoverable, micrograms per liter
01056	188	1972-04-19	2009-07-26	Manganese, water, filtered, micrograms per liter
01060	8	1993-07-06	1994-08-29	Molybdenum, water, filtered, micrograms per liter
01062	1	1994-08-29		Molybdenum, water, unfiltered, recoverable, micrograms per liter
01065	8	1993-07-06	1994-08-29	Nickel, water, filtered, micrograms per liter
01067	1	1994-08-29		Nickel, water, unfiltered, recoverable, micrograms per liter
01075	9	1993-07-06	2002-09-10	Silver, water, filtered, micrograms per liter
01077	1	1994-08-29		Silver, water, unfiltered, recoverable, micrograms per liter

01090	172	1972-04-19	2009-07-26	Zinc, water, filtered, micrograms per liter
01092	73	1980-03-27	2009-07-26	Zinc, water, unfiltered, recoverable, micrograms per liter
01094	70	1998-06-04	2002-09-19	Zinc, water, unfiltered, recoverable, micrograms per liter
01095	8	1993-07-06	1994-08-29	Antimony, water, filtered, micrograms per liter
01105	1	1994-08-29		Aluminum, water, unfiltered, recoverable, micrograms per liter
01106	9	1993-07-06	2002-09-10	Aluminum, water, filtered, micrograms per liter
01114	72	1998-06-04	2002-09-19	Lead, water, unfiltered, recoverable, micrograms per liter
01119	72	1998-06-04	2002-09-19	Copper, water, unfiltered, recoverable, micrograms per liter
01145	8	1993-07-06	1994-08-29	Selenium, water, filtered, micrograms per liter
01147	1	1994-08-29		Selenium, water, unfiltered, micrograms per liter
01300	6	2001-02-28	2001-09-08	Oil and grease, severity, code
01305	6	2001-02-28	2001-09-08	Detergent suds, severity, code
01320	6	2001-02-28	2001-09-08	Floating garbage, severity, code
01325	6	2001-02-28	2001-09-08	Floating algae mats, severity, code
01330	6	2001-02-28	2001-09-08	Odor, atmospheric, severity, code
01340	6	2001-02-28	2001-09-08	Dead fish, severity, code
01345	6	2001-02-28	2001-09-08	Floating debris, severity, code
01350	6	2001-02-28	2001-09-08	Turbidity, severity, code
04024	68	1993-12-13	2002-09-10	Propachlor, water, filtered, recoverable, micrograms per liter
04028	68	1993-12-13	2002-09-10	Butylate, water, filtered, recoverable, micrograms per liter
04029	20	1993-12-13	2002-09-10	Bromacil, water, filtered, recoverable, micrograms per liter
04035	68	1993-12-13	2002-09-10	Simazine, water, filtered, recoverable, micrograms per liter
04037	70	1993-12-13	2002-09-10	Prometon, water, filtered, recoverable, micrograms per liter
04040	68	1993-12-13	2002-09-10	2-Chloro-4-isopropylamino-6-amino-s-triazine, water, filtered, recoverable, micrograms per liter
04041	68	1993-12-13	2002-09-10	Cyanazine, water, filtered, recoverable, micrograms per liter

04095	68	1993-12-13	2002-09-10	Fonofos, water, filtered, recoverable, micrograms per liter
22703	8	1993-07-06	1994-08-29	Uranium (natural), water, filtered, micrograms per liter
29801	29	2002-08-13	2007-07-27	Alkalinity, water, filtered, fixed endpoint (pH 4.5) titration, laboratory, milligrams per liter as calcium carbonate
30207	122	1982-10-07	2004-08-19	Gage height, above datum, meters
30208	1	1972-04-19		Discharge, cubic meters per second
30209	218	1982-10-07	2004-05-13	Discharge, instantaneous, cubic meters per second
30217	3	2001-02-28	2001-09-08	Dibromomethane, water, unfiltered, recoverable, micrograms per liter
31615	15	1999-04-23	2008-09-12	Fecal coliform, EC broth method, water, most probable number per 100 milliliters
31616	3	2001-04-23	2001-05-05	Fecal coliform, M-FC MF (0.45 micron) method, water, colonies per 100 milliliters
32101	3	2001-02-28	2001-09-08	Bromodichloromethane, water, unfiltered, recoverable, micrograms per liter
32102	3	2001-02-28	2001-09-08	Tetrachloromethane, water, unfiltered, recoverable, micrograms per liter
32103	3	2001-02-28	2001-09-08	1,2-Dichloroethane, water, unfiltered, recoverable, micrograms per liter
32104	3	2001-02-28	2001-09-08	Tribromomethane, water, unfiltered, recoverable, micrograms per liter
32105	3	2001-02-28	2001-09-08	Dibromochloromethane, water, unfiltered, recoverable, micrograms per liter
32106	3	2001-02-28	2001-09-08	Trichloromethane, water, unfiltered, recoverable, micrograms per liter
34010	3	2001-02-28	2001-09-08	Toluene, water, unfiltered, recoverable, micrograms per liter
34030	3	2001-02-28	2001-09-08	Benzene, water, unfiltered, recoverable, micrograms per liter
34215	3	2001-02-28	2001-09-08	Acrylonitrile, water, unfiltered, recoverable, micrograms per liter
34221	2	2002-08-13	2002-09-10	Anthracene, water, filtered, recoverable, micrograms per liter
34248	2	2002-08-13	2002-09-10	Benzo[a]pyrene, water, filtered, recoverable, micrograms per liter
34253	68	1993-12-13	2002-09-10	alpha-HCH, water, filtered, recoverable, micrograms per liter
34288	2	2002-08-13	2002-09-10	Tribromomethane, water, filtered, recoverable, micrograms per liter
34301	3	2001-02-28	2001-09-08	Chlorobenzene, water, unfiltered, recoverable, micrograms per liter
34311	3	2001-02-28	2001-09-08	Chloroethane, water, unfiltered, recoverable, micrograms per liter
34371	3	2001-02-28	2001-09-08	Ethylbenzene, water, unfiltered, recoverable, micrograms per liter

34377	2	2002-08-13	2002-09-10	Fluoranthene, water, filtered, recoverable, micrograms per liter
34396	3	2001-02-28	2001-09-08	Hexachloroethane, water, unfiltered, recoverable, micrograms per liter
34409	2	2002-08-13	2002-09-10	Isophorone, water, filtered, recoverable, micrograms per liter
34413	3	2001-02-28	2001-09-08	Bromomethane, water, unfiltered, recoverable, micrograms per liter
34418	3	2001-02-28	2001-09-08	Chloromethane, water, unfiltered, recoverable, micrograms per liter
34423	3	2001-02-28	2001-09-08	Dichloromethane, water, unfiltered, recoverable, micrograms per liter
34443	2	2002-08-13	2002-09-10	Naphthalene, water, filtered, recoverable, micrograms per liter
34459	2	2002-08-13	2002-09-10	Pentachlorophenol, water, filtered, recoverable, micrograms per liter
34462	2	2002-08-13	2002-09-10	Phenanthrene, water, filtered, recoverable, micrograms per liter
34466	1	2002-08-13		Phenol, water, filtered, recoverable, micrograms per liter
34470	2	2002-08-13	2002-09-10	Pyrene, water, filtered, recoverable, micrograms per liter
34475	3	2001-02-28	2001-09-08	Tetrachloroethene, water, unfiltered, recoverable, micrograms per liter
34476	2	2002-08-13	2002-09-10	Tetrachloroethene, water, filtered, recoverable, micrograms per liter
34488	3	2001-02-28	2001-09-08	Trichlorofluoromethane, water, unfiltered, recoverable, micrograms per liter
34496	3	2001-02-28	2001-09-08	1,1-Dichloroethane, water, unfiltered, recoverable, micrograms per liter
34501	3	2001-02-28	2001-09-08	1,1-Dichloroethene, water, unfiltered, recoverable, micrograms per liter
34506	3	2001-02-28	2001-09-08	1,1,1-Trichloroethane, water, unfiltered, recoverable, micrograms per liter
34511	3	2001-02-28	2001-09-08	1,1,2-Trichloroethane, water, unfiltered, recoverable, micrograms per liter
34516	3	2001-02-28	2001-09-08	1,1,2,2-Tetrachloroethane, water, unfiltered, recoverable, micrograms per liter
34536	3	2001-02-28	2001-09-08	1,2-Dichlorobenzene, water, unfiltered, recoverable, micrograms per liter
34541	3	2001-02-28	2001-09-08	1,2-Dichloropropane, water, unfiltered, recoverable, micrograms per liter
34546	3	2001-02-28	2001-09-08	trans-1,2-Dichloroethene, water, unfiltered, recoverable, micrograms per liter
34551	3	2001-02-28	2001-09-08	1,2,4-Trichlorobenzene, water, unfiltered, recoverable, micrograms per liter
34566	3	2001-02-28	2001-09-08	1,3-Dichlorobenzene, water, unfiltered, recoverable, micrograms per liter
34571	3	2001-02-28	2001-09-08	1,4-Dichlorobenzene, water, unfiltered, recoverable, micrograms per liter

34572	2	2002-08-13	2002-09-10	1,4-Dichlorobenzene, water, filtered, recoverable, micrograms per liter
34653	68	1993-12-13	2002-09-10	p,p'-DDE, water, filtered, recoverable, micrograms per liter
34668	3	2001-02-28	2001-09-08	Dichlorodifluoromethane, water, unfiltered, recoverable, micrograms per liter
34696	3	2001-02-28	2001-09-08	Naphthalene, water, unfiltered, recoverable, micrograms per liter
34699	3	2001-02-28	2001-09-08	trans-1,3-Dichloropropene, water, unfiltered, recoverable, micrograms per liter
34704	3	2001-02-28	2001-09-08	cis-1,3-Dichloropropene, water, unfiltered, recoverable, micrograms per liter
34790	4	1993-08-23	1997-09-11	Aluminum, bed sediment smaller than 62.5 microns, wet sieved, field, total digestion, dry weight, percent
34795	4	1993-08-23	1997-09-11	Antimony, bed sediment smaller than 62.5 microns, wet sieved, field, total digestion, dry weight, micrograms per gram
34800	4	1993-08-23	1997-09-11	Arsenic, bed sediment smaller than 62.5 microns, wet sieved, field, total digestion, dry weight, micrograms per gram
34805	4	1993-08-23	1997-09-11	Barium, bed sediment smaller than 62.5 microns, wet sieved, field, total digestion, dry weight, micrograms per gram
34810	4	1993-08-23	1997-09-11	Beryllium, bed sediment smaller than 62.5 microns, wet sieved, field, total digestion, dry weight, micrograms per gram
34816	4	1993-08-23	1997-09-11	Bismuth, bed sediment smaller than 177 microns, wet sieved, field, total digestion, dry weight, micrograms per gram
34825	4	1993-08-23	1997-09-11	Cadmium, bed sediment smaller than 62.5 microns, wet sieved, field, total digestion, dry weight, micrograms per gram
34830	4	1993-08-23	1997-09-11	Calcium, bed sediment smaller than 62.5 microns, wet sieved, field, total digestion, dry weight, percent
34835	4	1993-08-23	1997-09-11	Cerium, bed sediment smaller than 62.5 microns, wet sieved, field, total digestion, dry weight, micrograms per gram
34840	4	1993-08-23	1997-09-11	Chromium, bed sediment smaller than 62.5 microns, wet sieved, field, total digestion, dry weight, micrograms per gram
34845	4	1993-08-23	1997-09-11	Cobalt, bed sediment smaller than 62.5 microns, wet sieved, field, total digestion, dry weight, micrograms per gram
34850	4	1993-08-23	1997-09-11	Copper, bed sediment smaller than 62.5 microns, wet sieved, field, total digestion, dry weight, micrograms per gram
34855	4	1993-08-23	1997-09-11	Europium, bed sediment smaller than 62.5 microns, wet sieved, field, total digestion, dry weight, micrograms per gram
34860	4	1993-08-23	1997-09-11	Gallium, bed sediment smaller than 62.5 microns, wet sieved, field, total digestion, dry weight, micrograms per gram
34870	4	1993-08-23	1997-09-11	Gold, bed sediment smaller than 62.5 microns, wet sieved, field, total digestion, dry weight, micrograms per gram
34875	4	1993-08-23	1997-09-11	Holmium, bed sediment smaller than 62.5 microns, wet sieved, field, total digestion, dry weight, micrograms per gram
34880	4	1993-08-23	1997-09-11	Iron, bed sediment smaller than 62.5 microns, wet sieved, field, total digestion, dry weight, percent
34885	4	1993-08-23	1997-09-11	Lanthanum, bed sediment smaller than 62.5 microns, wet sieved, field, total digestion, dry weight, micrograms per gram
34890	4	1993-08-23	1997-09-11	Lead, bed sediment smaller than 62.5 microns, wet sieved, field, total digestion, dry weight, micrograms per gram

34895	4	1993-08-23	1997-09-11	Lithium, bed sediment smaller than 62.5 microns, wet sieved, field, total digestion, dry weight, micrograms per gram
34900	4	1993-08-23	1997-09-11	Magnesium, bed sediment smaller than 62.5 microns, wet sieved, field, total digestion, dry weight, percent
34905	4	1993-08-23	1997-09-11	Manganese, bed sediment smaller than 62.5 microns, wet sieved, field, total digestion, dry weight, micrograms per gram
34910	4	1993-08-23	1997-09-11	Mercury, bed sediment smaller than 62.5 microns, wet sieved, field, total digestion, dry weight, micrograms per gram
34915	4	1993-08-23	1997-09-11	Molybdenum, bed sediment smaller than 62.5 microns, wet sieved, field, total digestion, dry weight, micrograms per gram
34920	4	1993-08-23	1997-09-11	Neodymium, bed sediment smaller than 62.5 microns, wet sieved, field, total digestion, dry weight, micrograms per gram
34925	4	1993-08-23	1997-09-11	Nickel, bed sediment smaller than 62.5 microns, wet sieved, field, total digestion, dry weight, micrograms per gram
34930	4	1993-08-23	1997-09-11	Niobium, bed sediment smaller than 62.5 microns, wet sieved, field, total digestion, dry weight, micrograms per gram
34935	4	1993-08-23	1997-09-11	Phosphorus, bed sediment smaller than 62.5 microns, wet sieved, field, total digestion, dry weight, percent
34940	4	1993-08-23	1997-09-11	Potassium, bed sediment smaller than 62.5 microns, wet sieved, field, total digestion, dry weight, percent
34945	4	1993-08-23	1997-09-11	Scandium, bed sediment smaller than 62.5 microns, wet sieved, field, total digestion, dry weight, micrograms per gram
34950	4	1993-08-23	1997-09-11	Selenium, bed sediment smaller than 62.5 microns, wet sieved, field, total digestion, dry weight, micrograms per gram
34955	4	1993-08-23	1997-09-11	Silver, bed sediment smaller than 62.5 microns, wet sieved, field, total digestion, dry weight, micrograms per gram
34960	4	1993-08-23	1997-09-11	Sodium, bed sediment smaller than 62.5 microns, wet sieved, field, total digestion, dry weight, percent
34965	4	1993-08-23	1997-09-11	Strontium, bed sediment smaller than 62.5 microns, wet sieved, field, total digestion, dry weight, micrograms per gram
34970	4	1993-08-23	1997-09-11	Sulfur, bed sediment smaller than 62.5 microns, wet sieved, field, total digestion, dry weight, percent
34975	4	1993-08-23	1997-09-11	Tantalum, bed sediment smaller than 62.5 microns, wet sieved, field, total digestion, dry weight, micrograms per gram
34980	4	1993-08-23	1997-09-11	Thorium, bed sediment smaller than 62.5 microns, wet sieved, field, total digestion, dry weight, micrograms per gram
34985	4	1993-08-23	1997-09-11	Tin, bed sediment smaller than 62.5 microns, wet sieved, field, total digestion, dry weight, micrograms per gram
35000	4	1993-08-23	1997-09-11	Uranium, bed sediment smaller than 62.5 microns, wet sieved, field, total digestion, dry weight, micrograms per gram
35005	4	1993-08-23	1997-09-11	Vanadium, bed sediment smaller than 62.5 microns, wet sieved, field, total digestion, dry weight, micrograms per gram
35010	4	1993-08-23	1997-09-11	Yttrium, bed sediment smaller than 62.5 microns, wet sieved, field, total digestion, dry weight, micrograms per gram
35015	4	1993-08-23	1997-09-11	Ytterbium, bed sediment smaller than 62.5 microns, wet sieved, field, total digestion, dry weight, micrograms per gram
35020	4	1993-08-23	1997-09-11	Zinc, bed sediment smaller than 62.5 microns, wet sieved, field, total digestion, dry weight, micrograms per gram
38442	18	1993-12-13	1994-11-17	Dicamba, water, filtered (0.7 micron glass fiber filter), recoverable, micrograms per liter

38478	18	1993-12-13	1994-11-17	Linuron, water, filtered (0.7 micron glass fiber filter), recoverable, micrograms per liter
38482	18	1993-12-13	1994-11-17	MCPA, water, filtered (0.7 micron glass fiber filter), recoverable, micrograms per liter
38487	18	1993-12-13	1994-11-17	MCPB, water, filtered (0.7 micron glass fiber filter), recoverable, micrograms per liter
38501	18	1993-12-13	1994-11-17	Methiocarb, water, filtered (0.7 micron glass fiber filter), recoverable, micrograms per liter
38538	18	1993-12-13	1994-11-17	Propoxur, water, filtered (0.7 micron glass fiber filter), recoverable, micrograms per liter
38711	18	1993-12-13	1994-11-17	Bentazon, water, filtered (0.7 micron glass fiber filter), recoverable, micrograms per liter
38746	18	1993-12-13	1994-11-17	2,4-DB, water, filtered (0.7 micron glass fiber filter), recoverable, micrograms per liter
38775	2	2002-08-13	2002-09-10	Dichlorvos, water, filtered, recoverable, micrograms per liter
38811	18	1993-12-13	1994-11-17	Fluometuron, water, filtered (0.7 micron glass fiber filter), recoverable, micrograms per liter
38866	18	1993-12-13	1994-11-17	Oxamyl, water, filtered (0.7 micron glass fiber filter), recoverable, micrograms per liter
38933	70	1993-12-13	2002-09-10	Chlorpyrifos, water, filtered, recoverable, micrograms per liter
39086	56	1995-10-05	2001-01-03	Alkalinity, water, filtered, inflection-point titration method (incremental titration method), field, milligrams per liter as calcium carbonate
39175	3	2001-02-28	2001-09-08	Vinyl chloride, water, unfiltered, recoverable, micrograms per liter
39180	3	2001-02-28	2001-09-08	Trichloroethene, water, unfiltered, recoverable, micrograms per liter
39341	67	1993-12-13	2002-09-10	Lindane, water, filtered, recoverable, micrograms per liter
39381	68	1993-12-13	2002-09-10	Dieldrin, water, filtered, recoverable, micrograms per liter
39415	70	1993-12-13	2002-09-10	Metolachlor, water, filtered, recoverable, micrograms per liter
39532	68	1993-12-13	2002-09-10	Malathion, water, filtered, recoverable, micrograms per liter
39542	68	1993-12-13	2002-09-10	Parathion, water, filtered, recoverable, micrograms per liter
39572	70	1993-12-13	2002-09-10	Diazinon, water, filtered, recoverable, micrograms per liter
39632	68	1993-12-13	2002-09-10	Atrazine, water, filtered, recoverable, micrograms per liter
39702	3	2001-02-28	2001-09-08	Hexachlorobutadiene, water, unfiltered, recoverable, micrograms per liter
39732	18	1993-12-13	1994-11-17	2,4-D, water, filtered, recoverable, micrograms per liter
39742	18	1993-12-13	1994-11-17	2,4,5-T, water, filtered, recoverable, micrograms per liter
39762	18	1993-	1994-	Silvex, water, filtered, recoverable, micrograms per liter

39762	18	12-13	11-17	Silvex, water, filtered, recoverable, micrograms per liter
46342	68	1993-12-13	2002-09-10	Alachlor, water, filtered, recoverable, micrograms per liter
49235	18	1993-12-13	1994-11-17	Triclopyr, water, filtered (0.7 micron glass fiber filter), recoverable, micrograms per liter
49236	18	1993-12-13	1994-11-17	Propham, water, filtered (0.7 micron glass fiber filter), recoverable, micrograms per liter
49237	3	1993-08-17	1997-09-03	Aluminum, biota, tissue, recoverable, dry weight, micrograms per gram
49238	3	1993-08-17	1997-09-03	Barium, biota, tissue, recoverable, dry weight, micrograms per gram
49239	3	1993-08-17	1997-09-03	Boron, biota, tissue, recoverable, dry weight, micrograms per gram
49240	3	1993-08-17	1997-09-03	Chromium, biota, tissue, recoverable, dry weight, micrograms per gram
49241	3	1993-08-17	1997-09-03	Copper, biota, tissue, recoverable, dry weight, micrograms per gram
49242	3	1993-08-17	1997-09-03	Iron, biota, tissue, recoverable, dry weight, micrograms per gram
49243	3	1993-08-17	1997-09-03	Manganese, biota, tissue, recoverable, dry weight, micrograms per gram
49244	3	1993-08-17	1997-09-03	Strontium, biota, tissue, recoverable, dry weight, micrograms per gram
49245	3	1993-08-17	1997-09-03	Zinc, biota, tissue, recoverable, dry weight, micrograms per gram
49246	3	1993-08-17	1997-09-03	Antimony, biota, tissue, recoverable, dry weight, micrograms per gram
49247	3	1993-08-17	1997-09-03	Arsenic, biota, tissue, recoverable, dry weight, micrograms per gram
49248	3	1993-08-17	1997-09-03	Beryllium, biota, tissue, recoverable, dry weight, micrograms per gram
49249	3	1993-08-17	1997-09-03	Cadmium, biota, tissue, recoverable, dry weight, micrograms per gram
49250	3	1993-08-17	1997-09-03	Cobalt, biota, tissue, recoverable, dry weight, micrograms per gram
49251	3	1993-08-17	1997-09-03	Lead, biota, tissue, recoverable, dry weight, micrograms per gram
49252	3	1993-08-17	1997-09-03	Molybdenum, biota, tissue, recoverable, dry weight, micrograms per gram
49253	3	1993-08-17	1997-09-03	Nickel, biota, tissue, recoverable, dry weight, micrograms per gram
49254	3	1993-08-17	1997-09-03	Selenium, biota, tissue, recoverable, dry weight, micrograms per gram
49255	3	1993-08-17	1997-09-03	Silver, biota, tissue, recoverable, dry weight, micrograms per gram
49257	3	1993-08-17	1997-09-03	Uranium, biota, tissue, recoverable, dry weight, micrograms per gram
49258	3	1993-08-17	1997-09-03	Mercury, biota, tissue, recoverable, dry weight, micrograms per gram
		1994-	2002-	

49260	51	1994-10-17	2002-09-10	Acetochlor, water, filtered, recoverable, micrograms per liter
49261	3	1993-08-17	1997-09-03	alpha-HCH-d6, surrogate, biota, whole organism, percent recovery
49264	3	1993-08-17	1997-09-03	PCB congener 14, surrogate, biota, whole organism, percent recovery
49266	4	1993-08-23	1997-09-11	Organic carbon, bed sediment smaller than 62.5 microns, wet sieved (native water), field, recoverable, dry weight, percent
49267	4	1993-08-23	1997-09-11	Carbon (inorganic plus organic), bed sediment smaller than 62.5 microns, wet sieved (native water), field, recoverable, dry weight, percent
49269	4	1993-08-23	1997-09-11	Inorganic carbon, bed sediment smaller than 62.5 microns, wet sieved (native water), field, recoverable, dry weight, percent
49270	1	1993-08-23		Inorganic carbon, bed sediment smaller than 2 millimeters, wet sieved (native water), field, recoverable, dry weight, grams per kilogram
49271	1	1993-08-23		Organic carbon, bed sediment smaller than 2 millimeters, wet sieved (native water), field, recoverable, dry weight, grams per kilogram
49272	1	1993-08-23		Carbon (inorganic plus organic), bed sediment smaller than 2 millimeters, wet sieved (native water), field, recoverable, dry weight, grams per kilogram
49273	3	1993-08-17	1997-09-03	Water present, biota, tissue, recoverable, dry weight, percent
49274	4	1993-08-23	1997-09-11	Titanium, bed sediment smaller than 62.5 microns, wet sieved (native water), field, recoverable, dry weight, percent
49275	2	1993-08-23	1997-09-11	alpha-HCH-d6, surrogate, bed sediment smaller than 2 millimeters, wet sieved (native water), field, percent recovery
49276	2	1993-08-23	1997-09-11	PCB congener 204, surrogate, bed sediment smaller than 2 millimeters, wet sieved (native water), field, percent recovery
49277	2	1993-08-23	1997-09-11	PCB congener 14, surrogate, bed sediment smaller than 2 millimeters, wet sieved (native water), field, percent recovery
49278	1	1993-08-23		p-Terphenyl-d14, surrogate, bed sediment smaller than 2 millimeters, wet sieved (native water), field, percent recovery
49279	1	1993-08-23		2-Fluorobiphenyl, surrogate, bed sediment smaller than 2 millimeters, wet sieved (native water), field, percent recovery
49280	1	1993-08-23		Nitrobenzene-d5, surrogate, bed sediment smaller than 2 millimeters, wet sieved (native water), field, percent recovery
49289	3	1993-08-17	1997-09-03	Lipids, biota, whole organism, wet weight, recoverable, percent
49291	18	1993-12-13	1994-11-17	Picloram, water, filtered (0.7 micron glass fiber filter), recoverable, micrograms per liter
49292	18	1993-12-13	1994-11-17	Oryzalin, water, filtered (0.7 micron glass fiber filter), recoverable, micrograms per liter
49293	18	1993-12-13	1994-11-17	Norflurazon, water, filtered (0.7 micron glass fiber filter), recoverable, micrograms per liter
49294	18	1993-12-13	1994-11-17	Neburon, water, filtered (0.7 micron glass fiber filter), recoverable, micrograms per liter
49296	18	1993-12-13	1994-11-17	Methomyl, water, filtered (0.7 micron glass fiber filter), recoverable, micrograms per liter
[illegible]	[illegible]	1993-	1994-	Fenuron, water, filtered (0.7 micron glass fiber filter),

49297	18	12-13	11-17	recoverable, micrograms per liter
49299	18	1993-12-13	1994-11-17	2-Methyl-4,6-dinitrophenol, water, filtered (0.7 micron glass fiber filter), recoverable, micrograms per liter
49300	18	1993-12-13	1994-11-17	Diuron, water, filtered (0.7 micron glass fiber filter), recoverable, micrograms per liter
49301	18	1993-12-13	1994-11-17	Dinoseb, water, filtered (0.7 micron glass fiber filter), recoverable, micrograms per liter
49302	18	1993-12-13	1994-11-17	Dichlorprop, water, filtered (0.7 micron glass fiber filter), recoverable, micrograms per liter
49303	18	1993-12-13	1994-11-17	Dichlobenil, water, filtered (0.7 micron glass fiber filter), recoverable, micrograms per liter
49304	18	1993-12-13	1994-11-17	Dacthal monoacid, water, filtered (0.7 micron glass fiber filter), recoverable, micrograms per liter
49305	18	1993-12-13	1994-11-17	Clopyralid, water, filtered (0.7 micron glass fiber filter), recoverable, micrograms per liter
49306	18	1993-12-13	1994-11-17	Chlorothalonil, water, filtered (0.7 micron glass fiber filter), recoverable, micrograms per liter
49308	18	1993-12-13	1994-11-17	3-Hydroxy carbofuran, water, filtered (0.7 micron glass fiber filter), recoverable, micrograms per liter
49309	18	1993-12-13	1994-11-17	Carbofuran, water, filtered (0.7 micron glass fiber filter), recoverable, micrograms per liter
49310	18	1993-12-13	1994-11-17	Carbaryl, water, filtered (0.7 micron glass fiber filter), recoverable, micrograms per liter
49311	18	1993-12-13	1994-11-17	Bromoxynil, water, filtered (0.7 micron glass fiber filter), recoverable, micrograms per liter
49312	18	1993-12-13	1994-11-17	Aldicarb, water, filtered (0.7 micron glass fiber filter), recoverable, micrograms per liter
49313	18	1993-12-13	1994-11-17	Aldicarb sulfone, water, filtered (0.7 micron glass fiber filter), recoverable, micrograms per liter
49314	18	1993-12-13	1994-11-17	Aldicarb sulfoxide, water, filtered (0.7 micron glass fiber filter), recoverable, micrograms per liter
49315	18	1993-12-13	1994-11-17	Acifluorfen, water, filtered (0.7 micron glass fiber filter), recoverable, micrograms per liter
49316	2	1993-08-23	1997-09-11	cis-Nonachlor, bed sediment smaller than 2 millimeters, wet sieved (native water), field, recoverable, dry weight, micrograms per kilogram
49317	2	1993-08-23	1997-09-11	trans-Nonachlor, bed sediment smaller than 2 millimeters, wet sieved (native water), field, recoverable, dry weight, micrograms per kilogram
49318	2	1993-08-23	1997-09-11	Oxychlordane, bed sediment smaller than 2 millimeters, wet sieved (native water), field, recoverable, dry weight, micrograms per kilogram
49319	2	1993-08-23	1997-09-11	Aldrin, bed sediment smaller than 2 millimeters, wet sieved (native water), field, recoverable, dry weight, micrograms per kilogram
49320	2	1993-08-23	1997-09-11	cis-Chlordane, bed sediment smaller than 2 millimeters, wet sieved (native water), field, recoverable, dry weight, micrograms per kilogram
49321	2	1993-08-23	1997-09-11	trans-Chlordane, bed sediment smaller than 2 millimeters, wet sieved (native water), field, recoverable, dry weight, micrograms per kilogram

49322	2	1993-08-23	1997-09-11	Chloroneb, bed sediment smaller than 2 millimeters, wet sieved (native water), field, recoverable, dry weight, micrograms per kilogram
49324	2	1993-08-23	1997-09-11	DCPA, bed sediment smaller than 2 millimeters, wet sieved (native water), field, recoverable, dry weight, micrograms per kilogram
49325	2	1993-08-23	1997-09-11	o,p'-DDD, bed sediment smaller than 2 millimeters, wet sieved (native water), field, recoverable, dry weight, micrograms per kilogram
49326	2	1993-08-23	1997-09-11	p,p'-DDD, bed sediment smaller than 2 millimeters, wet sieved (native water), field, recoverable, dry weight, micrograms per kilogram
49327	2	1993-08-23	1997-09-11	o,p'-DDE, bed sediment smaller than 2 millimeters, wet sieved (native water), field, recoverable, dry weight, micrograms per kilogram
49328	2	1993-08-23	1997-09-11	p,p'-DDE, bed sediment smaller than 2 millimeters, wet sieved (native water), field, recoverable, dry weight, micrograms per kilogram
49329	2	1993-08-23	1997-09-11	o,p'-DDT, bed sediment smaller than 2 millimeters, wet sieved (native water), field, recoverable, dry weight, micrograms per kilogram
49330	2	1993-08-23	1997-09-11	p,p'-DDT, bed sediment smaller than 2 millimeters, wet sieved (native water), field, recoverable, dry weight, micrograms per kilogram
49331	2	1993-08-23	1997-09-11	Dieldrin, bed sediment smaller than 2 millimeters, wet sieved (native water), field, recoverable, dry weight, micrograms per kilogram
49332	2	1993-08-23	1997-09-11	alpha-Endosulfan, bed sediment smaller than 2 millimeters, wet sieved (native water), field, recoverable, dry weight, micrograms per kilogram
49335	2	1993-08-23	1997-09-11	Endrin, bed sediment smaller than 2 millimeters, wet sieved (native water), field, recoverable, dry weight, micrograms per kilogram
49338	2	1993-08-23	1997-09-11	alpha-HCH, bed sediment smaller than 2 millimeters, wet sieved (native water), field, recoverable, dry weight, micrograms per kilogram
49339	2	1993-08-23	1997-09-11	beta-HCH, bed sediment smaller than 2 millimeters, wet sieved (native water), field, recoverable, dry weight, micrograms per kilogram
49341	2	1993-08-23	1997-09-11	Heptachlor, bed sediment smaller than 2 millimeters, wet sieved (native water), field, recoverable, dry weight, micrograms per kilogram
49342	2	1993-08-23	1997-09-11	Heptachlor epoxide, bed sediment smaller than 2 millimeters, wet sieved (native water), field, recoverable, dry weight, micrograms per kilogram
49343	2	1993-08-23	1997-09-11	Hexachlorobenzene, bed sediment smaller than 2 millimeters, wet sieved (native water), field, recoverable, dry weight, micrograms per kilogram
49344	2	1993-08-23	1997-09-11	Isodrin, bed sediment smaller than 2 millimeters, wet sieved (native water), field, recoverable, dry weight, micrograms per kilogram
49345	2	1993-	1997-	Lindane, bed sediment smaller than 2 millimeters, wet sieved

49345	2	08-23	09-11	(native water), field, recoverable, dry weight, micrograms per kilogram
49346	2	1993-08-23	1997-09-11	p,p'-Methoxychlor, bed sediment smaller than 2 millimeters, wet sieved (native water), field, recoverable, dry weight, micrograms per kilogram
49347	2	1993-08-23	1997-09-11	o,p'-Methoxychlor, bed sediment smaller than 2 millimeters, wet sieved (native water), field, recoverable, dry weight, micrograms per kilogram
49348	2	1993-08-23	1997-09-11	Mirex, bed sediment smaller than 2 millimeters, wet sieved (native water), field, recoverable, dry weight, micrograms per kilogram
49349	2	1993-08-23	1997-09-11	cis-Permethrin, bed sediment smaller than 2 millimeters, wet sieved (native water), field, recoverable, dry weight, micrograms per kilogram
49350	2	1993-08-23	1997-09-11	trans-Permethrin, bed sediment smaller than 2 millimeters, wet sieved (native water), field, recoverable, dry weight, micrograms per kilogram
49351	2	1993-08-23	1997-09-11	Toxaphene, bed sediment smaller than 2 millimeters, wet sieved (native water), field, recoverable, dry weight, micrograms per kilogram
49353	3	1993-08-17	1997-09-03	Aldrin, biota, whole organism, recoverable, wet weight, micrograms per kilogram
49354	3	1993-08-17	1997-09-03	PCBs, biota, whole organism, recoverable, wet weight, micrograms per kilogram
49355	3	1993-08-17	1997-09-03	Toxaphene, biota, whole organism, recoverable, wet weight, micrograms per kilogram
49356	3	1993-08-17	1997-09-03	Pentachloroanisole, biota, whole organism, recoverable, wet weight, micrograms per kilogram
49357	3	1993-08-17	1997-09-03	Oxychlordane, biota, whole organism, recoverable, wet weight, micrograms per kilogram
49358	3	1993-08-17	1997-09-03	trans-Nonachlor, biota, whole organism, recoverable, wet weight, micrograms per kilogram
49359	3	1993-08-17	1997-09-03	cis-Nonachlor, biota, whole organism, recoverable, wet weight, micrograms per kilogram
49360	3	1993-08-17	1997-09-03	Mirex, biota, whole organism, recoverable, wet weight, micrograms per kilogram
49361	3	1993-08-17	1997-09-03	p,p'-Methoxychlor, biota, whole organism, recoverable, wet weight, micrograms per kilogram
49362	3	1993-08-17	1997-09-03	o,p'-Methoxychlor, biota, whole organism, recoverable, wet weight, micrograms per kilogram
49363	3	1993-08-17	1997-09-03	Lindane, biota, whole organism, recoverable, wet weight, micrograms per kilogram
49364	3	1993-08-17	1997-09-03	delta-HCH, biota, whole organism, recoverable, wet weight, micrograms per kilogram
49365	3	1993-08-17	1997-09-03	beta-HCH, biota, whole organism, recoverable, wet weight, micrograms per kilogram
49366	3	1993-08-17	1997-09-03	alpha-HCH, biota, whole organism, recoverable, wet weight, micrograms per kilogram
49367	3	1993-08-17	1997-09-03	Hexachlorobenzene, biota, whole organism, recoverable, wet weight, micrograms per kilogram
49368	3	1993-	1997-	Heptachlor epoxide, biota, whole organism, recoverable, wet

49368	3	08-17	09-03	weight, micrograms per kilogram
49369	3	1993-08-17	1997-09-03	Heptachlor, biota, whole organism, recoverable, wet weight, micrograms per kilogram
49370	3	1993-08-17	1997-09-03	Endrin, biota, whole organism, recoverable, wet weight, micrograms per kilogram
49371	3	1993-08-17	1997-09-03	Dieldrin, biota, whole organism, recoverable, wet weight, micrograms per kilogram
49372	3	1993-08-17	1997-09-03	p,p'-DDE, biota, whole organism, recoverable, wet weight, micrograms per kilogram
49373	3	1993-08-17	1997-09-03	o,p'-DDE, biota, whole organism, recoverable, wet weight, micrograms per kilogram
49374	3	1993-08-17	1997-09-03	o,p'-DDD, biota, whole organism, recoverable, wet weight, micrograms per kilogram
49375	3	1993-08-17	1997-09-03	p,p'-DDD, biota, whole organism, recoverable, wet weight, micrograms per kilogram
49376	3	1993-08-17	1997-09-03	p,p'-DDT, biota, whole organism, recoverable, wet weight, micrograms per kilogram
49377	3	1993-08-17	1997-09-03	o,p'-DDT, biota, whole organism, recoverable, wet weight, micrograms per kilogram
49378	3	1993-08-17	1997-09-03	DCPA, biota, whole organism, recoverable, wet weight, micrograms per kilogram
49379	3	1993-08-17	1997-09-03	trans-Chlordane, biota, whole organism, recoverable, wet weight, micrograms per kilogram
49380	3	1993-08-17	1997-09-03	cis-Chlordane, biota, whole organism, recoverable, wet weight, micrograms per kilogram
49381	1	1993-08-23		Di-n-butyl phthalate, bed sediment smaller than 2 millimeters, wet sieved (native water), field, recoverable, dry weight, micrograms per kilogram
49382	1	1993-08-23		Di-n-octyl phthalate, bed sediment smaller than 2 millimeters, wet sieved (native water), field, recoverable, dry weight, micrograms per kilogram
49383	1	1993-08-23		Diethyl phthalate, bed sediment smaller than 2 millimeters, wet sieved (native water), field, recoverable, dry weight, micrograms per kilogram
49384	1	1993-08-23		Dimethyl phthalate, bed sediment smaller than 2 millimeters, wet sieved (native water), field, recoverable, dry weight, micrograms per kilogram
49387	1	1993-08-23		Pyrene, bed sediment smaller than 2 millimeters, wet sieved (native water), field, recoverable, dry weight, micrograms per kilogram
49388	1	1993-08-23		1-Methylpyrene, bed sediment smaller than 2 millimeters, wet sieved (native water), field, recoverable, dry weight, micrograms per kilogram
49389	1	1993-08-23		Benzo[a]pyrene, bed sediment smaller than 2 millimeters, wet sieved (native water), field, recoverable, dry weight, micrograms per kilogram
49390	1	1993-08-23		Indeno[1,2,3-cd]pyrene, bed sediment smaller than 2 millimeters, wet sieved (native water), field, recoverable, dry weight, micrograms per kilogram
49391	1	1993-08-23		2,2'-Biquinoline, bed sediment smaller than 2 millimeters, wet sieved (native water), field, recoverable, dry weight, micrograms

		08-23		per kilogram
49392	1	1993-08-23		Quinoline, bed sediment smaller than 2 millimeters, wet sieved (native water), field, recoverable, dry weight, micrograms per kilogram
49393	1	1993-08-23		Phenanthridine, bed sediment smaller than 2 millimeters, wet sieved (native water), field, recoverable, dry weight, micrograms per kilogram
49394	1	1993-08-23		Isoquinoline, bed sediment smaller than 2 millimeters, wet sieved (native water), field, recoverable, dry weight, micrograms per kilogram
49395	1	1993-08-23		2,4-Dinitrotoluene, bed sediment smaller than 2 millimeters, wet sieved (native water), field, recoverable, dry weight, micrograms per kilogram
49396	1	1993-08-23		2,6-Dinitrotoluene, bed sediment smaller than 2 millimeters, wet sieved (native water), field, recoverable, dry weight, micrograms per kilogram
49397	1	1993-08-23		Benzo[k]fluoranthene, bed sediment smaller than 2 millimeters, wet sieved (native water), field, recoverable, dry weight, micrograms per kilogram
49398	1	1993-08-23		1-Methyl-9H-fluorene, bed sediment smaller than 2 millimeters, wet sieved (native water), field, recoverable, dry weight, micrograms per kilogram
49399	1	1993-08-23		9H-Fluorene, bed sediment smaller than 2 millimeters, wet sieved (native water), field, recoverable, dry weight, micrograms per kilogram
49400	1	1993-08-23		Isophorone, bed sediment smaller than 2 millimeters, wet sieved (native water), field, recoverable, dry weight, micrograms per kilogram
49401	1	1993-08-23		Bis(2-chloroethoxy)methane, bed sediment smaller than 2 millimeters, wet sieved (native water), field, recoverable, dry weight, micrograms per kilogram
49402	1	1993-08-23		Naphthalene, bed sediment smaller than 2 millimeters, wet sieved (native water), field, recoverable, dry weight, micrograms per kilogram
49403	1	1993-08-23		1,2-Dimethylnaphthalene, bed sediment smaller than 2 millimeters, wet sieved (native water), field, recoverable, dry weight, micrograms per kilogram
49404	1	1993-08-23		1,6-Dimethylnaphthalene, bed sediment smaller than 2 millimeters, wet sieved (native water), field, recoverable, dry weight, micrograms per kilogram
49405	1	1993-08-23		2,3,6-Trimethylnaphthalene, bed sediment smaller than 2 millimeters, wet sieved (native water), field, recoverable, dry weight, micrograms per kilogram
49406	1	1993-08-23		2,6-Dimethylnaphthalene, bed sediment smaller than 2 millimeters, wet sieved (native water), field, recoverable, dry weight, micrograms per kilogram
49407	1	1993-08-23		2-Chloronaphthalene, bed sediment smaller than 2 millimeters, wet sieved (native water), field, recoverable, dry weight, micrograms per kilogram
49408	1	1993-08-23		Benzo[ghi]perylene, bed sediment smaller than 2 millimeters, wet sieved (native water), field, recoverable, dry weight, micrograms per kilogram

49409	1	1993-08-23		Phenanthrene, bed sediment smaller than 2 millimeters, wet sieved (native water), field, recoverable, dry weight, micrograms per kilogram
49410	1	1993-08-23		1-Methylphenanthrene, bed sediment smaller than 2 millimeters, wet sieved (native water), field, recoverable, dry weight, micrograms per kilogram
49411	1	1993-08-23		4H-Cyclopenta[def]phenanthrene, bed sediment smaller than 2 millimeters, wet sieved (native water), field, recoverable, dry weight, micrograms per kilogram
49413	1	1993-08-23		Phenol, bed sediment smaller than 2 millimeters, wet sieved (native water), field, recoverable, dry weight, micrograms per kilogram
49421	1	1993-08-23		3,5-Dimethylphenol, bed sediment smaller than 2 millimeters, wet sieved (native water), field, recoverable, dry weight, micrograms per kilogram
49422	1	1993-08-23		4-Chloro-3-methylphenol, bed sediment smaller than 2 millimeters, wet sieved (native water), field, recoverable, dry weight, micrograms per kilogram
49424	1	1993-08-23		C8-Alkylphenol, bed sediment smaller than 2 millimeters, wet sieved (native water), field, recoverable, dry weight, micrograms per kilogram
49426	1	1993-08-23		Bis(2-ethylhexyl) phthalate, bed sediment smaller than 2 millimeters, wet sieved (native water), field, recoverable, dry weight, micrograms per kilogram
49427	1	1993-08-23		Benzyl n-butyl phthalate, bed sediment smaller than 2 millimeters, wet sieved (native water), field, recoverable, dry weight, micrograms per kilogram
49428	1	1993-08-23		Acenaphthylene, bed sediment smaller than 2 millimeters, wet sieved (native water), field, recoverable, dry weight, micrograms per kilogram
49429	1	1993-08-23		Acenaphthene, bed sediment smaller than 2 millimeters, wet sieved (native water), field, recoverable, dry weight, micrograms per kilogram
49430	1	1993-08-23		Acridine, bed sediment smaller than 2 millimeters, wet sieved (native water), field, recoverable, dry weight, micrograms per kilogram
49431	1	1993-08-23		N-Nitrosodi-n-propylamine, bed sediment smaller than 2 millimeters, wet sieved (native water), field, recoverable, dry weight, micrograms per kilogram
49433	1	1993-08-23		N-Nitrosodiphenylamine, bed sediment smaller than 2 millimeters, wet sieved (native water), field, recoverable, dry weight, micrograms per kilogram
49434	1	1993-08-23		Anthracene, bed sediment smaller than 2 millimeters, wet sieved (native water), field, recoverable, dry weight, micrograms per kilogram
49435	1	1993-08-23		2-Methylanthracene, bed sediment smaller than 2 millimeters, wet sieved (native water), field, recoverable, dry weight, micrograms per kilogram
49436	1	1993-08-23		Benzo[a]anthracene, bed sediment smaller than 2 millimeters, wet sieved (native water), field, recoverable, dry weight, micrograms per kilogram
49437	1	1993-		9,10-Anthraquinone, bed sediment smaller than 2 millimeters, wet sieved (native water), field, recoverable, dry weight

49437	1	08-23		wet sieved (native water), field, recoverable, dry weight, micrograms per kilogram
49438	1	1993-08-23		1,2,4-Trichlorobenzene, bed sediment smaller than 2 millimeters, wet sieved (native water), field, recoverable, dry weight, micrograms per kilogram
49439	1	1993-08-23		1,2-Dichlorobenzene, bed sediment smaller than 2 millimeters, wet sieved (native water), field, recoverable, dry weight, micrograms per kilogram
49441	1	1993-08-23		1,3-Dichlorobenzene, bed sediment smaller than 2 millimeters, wet sieved (native water), field, recoverable, dry weight, micrograms per kilogram
49442	1	1993-08-23		1,4-Dichlorobenzene, bed sediment smaller than 2 millimeters, wet sieved (native water), field, recoverable, dry weight, micrograms per kilogram
49443	1	1993-08-23		Azobenzene, bed sediment smaller than 2 millimeters, wet sieved (native water), field, recoverable, dry weight, micrograms per kilogram
49444	1	1993-08-23		Nitrobenzene, bed sediment smaller than 2 millimeters, wet sieved (native water), field, recoverable, dry weight, micrograms per kilogram
49446	1	1993-08-23		Pentachloronitrobenzene, bed sediment smaller than 2 millimeters, wet sieved (native water), field, recoverable, dry weight, micrograms per kilogram
49449	1	1993-08-23		Carbazole, bed sediment smaller than 2 millimeters, wet sieved (native water), field, recoverable, dry weight, micrograms per kilogram
49450	1	1993-08-23		Chrysene, bed sediment smaller than 2 millimeters, wet sieved (native water), field, recoverable, dry weight, micrograms per kilogram
49451	1	1993-08-23		p-Cresol, bed sediment smaller than 2 millimeters, wet sieved (native water), field, recoverable, dry weight, micrograms per kilogram
49452	1	1993-08-23		Dibenzothiophene, bed sediment smaller than 2 millimeters, wet sieved (native water), field, recoverable, dry weight, micrograms per kilogram
49454	1	1993-08-23		4-Bromophenyl phenyl ether, bed sediment smaller than 2 millimeters, wet sieved (native water), field, recoverable, dry weight, micrograms per kilogram
49455	1	1993-08-23		4-Chlorophenyl phenyl ether, bed sediment smaller than 2 millimeters, wet sieved (native water), field, recoverable, dry weight, micrograms per kilogram
49458	1	1993-08-23		Benzo[b]fluoranthene, bed sediment smaller than 2 millimeters, wet sieved (native water), field, recoverable, dry weight, micrograms per kilogram
49459	2	1993-08-23	1997-09-11	PCBs, bed sediment smaller than 2 millimeters, wet sieved (native water), field, recoverable, dry weight, micrograms per kilogram
49460	2	1993-08-23	1997-09-11	Pentachloroanisole, bed sediment smaller than 2 millimeters, wet sieved (native water), field, recoverable, dry weight, micrograms per kilogram
49461	1	1993-08-23		Dibenzo[a,h]anthracene, bed sediment smaller than 2 millimeters, wet sieved (native water), field, recoverable, dry weight, micrograms per kilogram

49465	3	1993-08-17	1997-09-03	Vanadium, biota, tissue, recoverable, dry weight, micrograms per gram
49466	1	1993-08-23		Fluoranthene, bed sediment smaller than 2 millimeters, wet sieved (native water), field, recoverable, dry weight, micrograms per kilogram
49467	1	1993-08-23		2-Chlorophenol, bed sediment smaller than 2 millimeters, wet sieved (native water), field, recoverable, dry weight, micrograms per kilogram
49468	1	1993-08-23		Benzo[c]cinnoline, bed sediment smaller than 2 millimeters, wet sieved (native water), field, recoverable, dry weight, micrograms per kilogram
49948	1	1993-08-23		2-Ethylnaphthalene, bed sediment smaller than 2 millimeters, wet sieved (native water), field, recoverable, dry weight, micrograms per kilogram
49991	3	2001-02-28	2001-09-08	Methyl acrylate, water, unfiltered, recoverable, micrograms per liter
49999	3	2001-02-28	2001-09-08	1,2,3,4-Tetramethylbenzene, water, unfiltered, recoverable, micrograms per liter
50000	3	2001-02-28	2001-09-08	1,2,3,5-Tetramethylbenzene, water, unfiltered, recoverable, micrograms per liter
50002	3	2001-02-28	2001-09-08	Bromoethene, water, unfiltered, recoverable, micrograms per liter
50004	3	2001-02-28	2001-09-08	tert-Butyl ethyl ether, water, unfiltered, recoverable, micrograms per liter
50005	3	2001-02-28	2001-09-08	Methyl tert-pentyl ether, water, unfiltered, recoverable, micrograms per liter
50280	162	1993-04-14	2004-05-13	Purpose, site visit, code
50305	2	2002-08-13	2002-09-10	Caffeine, water, filtered, recoverable, micrograms per liter
50359	2	2002-08-13	2002-09-10	Metalaxyl, water, filtered, recoverable, micrograms per liter
50468	15	1999-04-23	2008-09-12	Escherichia coli, Defined Substrate Technology, water, most probable number per 100 milliliters
61188	18	1993-12-13	1994-11-17	Chloramben methyl ester, water, filtered, recoverable, micrograms per liter
61705	2	2002-08-13	2002-09-10	4-tert-Octylphenol diethoxylate, water, filtered, recoverable, micrograms per liter
61706	2	2002-08-13	2002-09-10	4-tert-Octylphenol monoethoxylate, water, filtered, recoverable, micrograms per liter
62005	2	2002-08-13	2002-09-10	Cotinine, water, filtered, recoverable, micrograms per liter
62052	2	2002-08-13	2002-09-10	17-alpha-Ethynyl estradiol, water, filtered, recoverable, micrograms per liter
62053	2	2002-08-13	2002-09-10	17-beta-Estradiol, water, filtered, recoverable, micrograms per liter
62054	2	2002-08-13	2002-09-10	1-Methylnaphthalene, water, filtered, recoverable, micrograms per liter
62055	2	2002-08-13	2002-09-10	2,6-Dimethylnaphthalene, water, filtered, recoverable, micrograms per liter
		2002-	2002-	2-Methylnaphthalene, water, filtered, recoverable, micrograms

62056	2	2002-08-13	2002-09-10	2-Methylnaphthalene, water, filtered, recoverable, micrograms per liter
62057	2	2002-08-13	2002-09-10	3-beta-Coprostanol, water, filtered, recoverable, micrograms per liter
62058	2	2002-08-13	2002-09-10	3-Methyl-1H-indole, water, filtered, recoverable, micrograms per liter
62059	2	2002-08-13	2002-09-10	3-tert-Butyl-4-hydroxyanisole, water, filtered, recoverable, micrograms per liter
62060	2	2002-08-13	2002-09-10	4-Cumylphenol, water, filtered, recoverable, micrograms per liter
62061	2	2002-08-13	2002-09-10	4-n-Octylphenol, water, filtered, recoverable, micrograms per liter
62062	2	2002-08-13	2002-09-10	4-tert-Octylphenol, water, filtered, recoverable, micrograms per liter
62063	2	2002-08-13	2002-09-10	5-Methyl-1H-benzotriazole, water, filtered, recoverable, micrograms per liter
62064	2	2002-08-13	2002-09-10	Acetophenone, water, filtered, recoverable, micrograms per liter
62065	2	2002-08-13	2002-09-10	Acetyl hexamethyl tetrahydro naphthalene, water, filtered, recoverable, micrograms per liter
62066	2	2002-08-13	2002-09-10	9,10-Anthraquinone, water, filtered, recoverable, micrograms per liter
62067	2	2002-08-13	2002-09-10	Benzophenone, water, filtered, recoverable, micrograms per liter
62068	2	2002-08-13	2002-09-10	beta-Sitosterol, water, filtered, recoverable, micrograms per liter
62069	2	2002-08-13	2002-09-10	Bisphenol A, water, filtered, recoverable, micrograms per liter
62070	2	2002-08-13	2002-09-10	Camphor, water, filtered, recoverable, micrograms per liter
62071	2	2002-08-13	2002-09-10	Carbazole, water, filtered, recoverable, micrograms per liter
62072	2	2002-08-13	2002-09-10	Cholesterol, water, filtered, recoverable, micrograms per liter
62073	2	2002-08-13	2002-09-10	D-Limonene, water, filtered, recoverable, micrograms per liter
62074	2	2002-08-13	2002-09-10	Equilenin, water, filtered, recoverable, micrograms per liter
62075	2	2002-08-13	2002-09-10	Hexahydrohexamethyl cyclopentabenzopyran, water, filtered, recoverable, micrograms per liter
62076	2	2002-08-13	2002-09-10	Indole, water, filtered, recoverable, micrograms per liter
62077	2	2002-08-13	2002-09-10	Isoborneol, water, filtered, recoverable, micrograms per liter
62078	2	2002-08-13	2002-09-10	Isopropylbenzene, water, filtered, recoverable, micrograms per liter
62079	2	2002-08-13	2002-09-10	Isoquinoline, water, filtered, recoverable, micrograms per liter
62080	2	2002-08-13	2002-09-10	Menthol, water, filtered, recoverable, micrograms per liter

62081	2	2002-08-13	2002-09-10	Methyl salicylate, water, filtered, recoverable, micrograms per liter
62082	2	2002-08-13	2002-09-10	DEET, water, filtered, recoverable, micrograms per liter
62083	2	2002-08-13	2002-09-10	4-Nonylphenol diethoxylate (sum of all isomers), water, filtered, recoverable, micrograms per liter
62084	2	2002-08-13	2002-09-10	p-Cresol, water, filtered, recoverable, micrograms per liter
62085	2	2002-08-13	2002-09-10	4-Nonylphenol (sum of all isomers), water, filtered, recoverable, micrograms per liter
62086	2	2002-08-13	2002-09-10	beta-Stigmastanol, water, filtered, recoverable, micrograms per liter
62087	2	2002-08-13	2002-09-10	Tris(2-chloroethyl) phosphate, water, filtered, recoverable, micrograms per liter
62088	2	2002-08-13	2002-09-10	Tris(dichloroisopropyl) phosphate, water, filtered, recoverable, micrograms per liter
62089	2	2002-08-13	2002-09-10	Tributyl phosphate, water, filtered, recoverable, micrograms per liter
62090	2	2002-08-13	2002-09-10	Triclosan, water, filtered, recoverable, micrograms per liter
62091	2	2002-08-13	2002-09-10	Triethyl citrate, water, filtered, recoverable, micrograms per liter
62092	2	2002-08-13	2002-09-10	Triphenyl phosphate, water, filtered, recoverable, micrograms per liter
62093	2	2002-08-13	2002-09-10	Tris(2-butoxyethyl) phosphate, water, filtered, recoverable, micrograms per liter
62484	2	2002-08-13	2002-09-10	Estrone, water, filtered, recoverable, micrograms per liter
70300	109	1982-10-07	2001-01-03	Residue on evaporation, dried at 180 degrees Celsius, water, filtered, milligrams per liter
70301	116	1972-04-19	2007-07-27	Residue, water, filtered, sum of constituents, milligrams per liter
70302	89	1972-04-19	2002-09-10	Residue, water, dissolved, tons per day
70303	126	1972-04-19	2007-07-27	Residue, water, filtered, tons per acre-foot
70331	114	1993-04-14	2001-01-03	Suspended sediment, sieve diameter, percent smaller than 0.0625 millimeters
70507	6	1980-03-27	1980-04-29	Orthophosphate, water, unfiltered, milligrams per liter as phosphorus
71845	66	1980-03-27	2002-09-19	Ammonia, water, unfiltered, milligrams per liter as NH4
71846	181	1993-04-14	2009-07-25	Ammonia, water, filtered, milligrams per liter as NH4
71851	95	1993-04-14	2002-09-10	Nitrate, water, filtered, milligrams per liter
71856	95	1993-04-14	2002-09-10	Nitrite, water, filtered, milligrams per liter
71886	6	1980-03-27	1980-04-29	Phosphorus, water, unfiltered, milligrams per liter as phosphate

71887	81	1980-03-27	2002-09-19	Total nitrogen, water, unfiltered, milligrams per liter as nitrate
71999	160	1993-04-14	2004-05-13	Sample purpose, code
72104	6	1997-10-15	2004-05-13	Sample location, distance downstream, feet
72105	69	1996-07-09	2002-09-10	Sample location, distance upstream, feet
73547	3	2001-02-28	2001-09-08	trans-1,4-Dichloro-2-butene, water, unfiltered, recoverable, micrograms per liter
73570	3	2001-02-28	2001-09-08	Ethyl methacrylate, water, unfiltered, recoverable, micrograms per liter
77041	3	2001-02-28	2001-09-08	Carbon disulfide, water, unfiltered, micrograms per liter
77093	3	2001-02-28	2001-09-08	cis-1,2-Dichloroethene, water, unfiltered, recoverable, micrograms per liter
77103	3	2001-02-28	2001-09-08	n-Butyl methyl ketone, water, unfiltered, recoverable, micrograms per liter
77128	3	2001-02-28	2001-09-08	Styrene, water, unfiltered, recoverable, micrograms per liter
77135	3	2001-02-28	2001-09-08	o-Xylene, water, unfiltered, recoverable, micrograms per liter
77168	3	2001-02-28	2001-09-08	1,1-Dichloropropene, water, unfiltered, recoverable, micrograms per liter
77170	3	2001-02-28	2001-09-08	2,2-Dichloropropane, water, unfiltered, recoverable, micrograms per liter
77173	3	2001-02-28	2001-09-08	1,3-Dichloropropane, water, unfiltered, recoverable, micrograms per liter
77220	3	2001-02-28	2001-09-08	2-Ethyltoluene, water, unfiltered, recoverable, micrograms per liter
77221	3	2001-02-28	2001-09-08	1,2,3-Trimethylbenzene, water, unfiltered, recoverable, micrograms per liter
77222	3	2001-02-28	2001-09-08	1,2,4-Trimethylbenzene, water, unfiltered, recoverable, micrograms per liter
77223	3	2001-02-28	2001-09-08	Isopropylbenzene, water, unfiltered, recoverable, micrograms per liter
77224	3	2001-02-28	2001-09-08	n-Propylbenzene, water, unfiltered, recoverable, micrograms per liter
77226	3	2001-02-28	2001-09-08	1,3,5-Trimethylbenzene, water, unfiltered, recoverable, micrograms per liter
77275	3	2001-02-28	2001-09-08	2-Chlorotoluene, water, unfiltered, recoverable, micrograms per liter
77277	3	2001-02-28	2001-09-08	4-Chlorotoluene, water, unfiltered, recoverable, micrograms per liter
77297	3	2001-02-28	2001-09-08	Bromochloromethane, water, unfiltered, recoverable, micrograms per liter
77342	3	2001-02-28	2001-09-08	n-Butylbenzene, water, unfiltered, recoverable, micrograms per liter
77350	3	2001-02-28	2001-09-08	sec-Butylbenzene, water, unfiltered, recoverable, micrograms per liter

77353	3	2001-02-28	2001-09-08	tert-Butylbenzene, water, unfiltered, recoverable, micrograms per liter
77356	3	2001-02-28	2001-09-08	4-Isopropyltoluene, water, unfiltered, recoverable, micrograms per liter
77424	3	2001-02-28	2001-09-08	Iodomethane, water, unfiltered, recoverable, micrograms per liter
77443	3	2001-02-28	2001-09-08	1,2,3-Trichloropropane, water, unfiltered, recoverable, micrograms per liter
77562	3	2001-02-28	2001-09-08	1,1,1,2-Tetrachloroethane, water, unfiltered, recoverable, micrograms per liter
77613	3	2001-02-28	2001-09-08	1,2,3-Trichlorobenzene, water, unfiltered, recoverable, micrograms per liter
77651	3	2001-02-28	2001-09-08	1,2-Dibromoethane, water, unfiltered, recoverable, micrograms per liter
77652	3	2001-02-28	2001-09-08	1,1,2-Trichloro-1,2,2-trifluoroethane, water, unfiltered, recoverable, micrograms per liter
78032	3	2001-02-28	2001-09-08	Methyl tert-butyl ether, water, unfiltered, recoverable, micrograms per liter
78109	3	2001-02-28	2001-09-08	3-Chloropropene, water, unfiltered, recoverable, micrograms per liter
78133	3	2001-02-28	2001-09-08	Isobutyl methyl ketone, water, unfiltered, recoverable, micrograms per liter
80154	115	1993-04-14	2001-01-03	Suspended sediment concentration, milligrams per liter
80155	115	1993-04-14	2001-01-03	Suspended sediment discharge, tons per day
81352	2	1994-08-29		Filter pore size, micrometers
81552	3	2001-02-28	2001-09-08	Acetone, water, unfiltered, recoverable, micrograms per liter
81555	3	2001-02-28	2001-09-08	Bromobenzene, water, unfiltered, recoverable, micrograms per liter
81576	3	2001-02-28	2001-09-08	Diethyl ether, water, unfiltered, recoverable, micrograms per liter
81577	3	2001-02-28	2001-09-08	Diisopropyl ether, water, unfiltered, recoverable, micrograms per liter
81593	3	2001-02-28	2001-09-08	Methyl acrylonitrile, water, unfiltered, recoverable, micrograms per liter
81595	3	2001-02-28	2001-09-08	Ethyl methyl ketone, water, unfiltered, recoverable, micrograms per liter
81597	3	2001-02-28	2001-09-08	Methyl methacrylate, water, unfiltered, recoverable, micrograms per liter
81607	3	2001-02-28	2001-09-08	Tetrahydrofuran, water, unfiltered, recoverable, micrograms per liter
82073	23	2001-04-23	2006-04-07	Starting time, 24 hour clock, hour-minute (hhmm)
82074	13	2001-05-05	2002-09-19	Ending time, 24 hour clock, hour-minute (hhmm)
82398	379	1996-07-09	2009-07-26	Sampling method, code

82625	3	2001-02-28	2001-09-08	1,2-Dibromo-3-chloropropane, water, unfiltered, recoverable, micrograms per liter
82630	67	1993-12-13	2002-09-10	Metribuzin, water, filtered, recoverable, micrograms per liter
82660	68	1993-12-13	2002-09-10	2,6-Diethylaniline, water, filtered (0.7 micron glass fiber filter), recoverable, micrograms per liter
82661	68	1993-12-13	2002-09-10	Trifluralin, water, filtered (0.7 micron glass fiber filter), recoverable, micrograms per liter
82663	68	1993-12-13	2002-09-10	Ethalfluralin, water, filtered (0.7 micron glass fiber filter), recoverable, micrograms per liter
82664	68	1993-12-13	2002-09-10	Phorate, water, filtered (0.7 micron glass fiber filter), recoverable, micrograms per liter
82665	67	1993-12-13	2002-09-10	Terbacil, water, filtered (0.7 micron glass fiber filter), recoverable, micrograms per liter
82666	68	1993-12-13	2002-09-10	Linuron, water, filtered (0.7 micron glass fiber filter), recoverable, micrograms per liter
82667	68	1993-12-13	2002-09-10	Methyl parathion, water, filtered (0.7 micron glass fiber filter), recoverable, micrograms per liter
82668	68	1993-12-13	2002-09-10	EPTC, water, filtered (0.7 micron glass fiber filter), recoverable, micrograms per liter
82669	68	1993-12-13	2002-09-10	Pebulate, water, filtered (0.7 micron glass fiber filter), recoverable, micrograms per liter
82670	68	1993-12-13	2002-09-10	Tebuthiuron, water, filtered (0.7 micron glass fiber filter), recoverable, micrograms per liter
82671	68	1993-12-13	2002-09-10	Molinate, water, filtered (0.7 micron glass fiber filter), recoverable, micrograms per liter
82672	68	1993-12-13	2002-09-10	Ethoprop, water, filtered (0.7 micron glass fiber filter), recoverable, micrograms per liter
82673	68	1993-12-13	2002-09-10	Benfluralin, water, filtered (0.7 micron glass fiber filter), recoverable, micrograms per liter
82674	68	1993-12-13	2002-09-10	Carbofuran, water, filtered (0.7 micron glass fiber filter), recoverable, micrograms per liter
82675	68	1993-12-13	2002-09-10	Terbufos, water, filtered (0.7 micron glass fiber filter), recoverable, micrograms per liter
82676	68	1993-12-13	2002-09-10	Propyzamide, water, filtered (0.7 micron glass fiber filter), recoverable, micrograms per liter
82677	68	1993-12-13	2002-09-10	Disulfoton, water, filtered (0.7 micron glass fiber filter), recoverable, micrograms per liter
82678	68	1993-12-13	2002-09-10	Triallate, water, filtered (0.7 micron glass fiber filter), recoverable, micrograms per liter
82679	68	1993-12-13	2002-09-10	Propanil, water, filtered (0.7 micron glass fiber filter), recoverable, micrograms per liter
82680	70	1993-12-13	2002-09-10	Carbaryl, water, filtered (0.7 micron glass fiber filter), recoverable, micrograms per liter
82681	68	1993-12-13	2002-09-10	Thiobencarb, water, filtered (0.7 micron glass fiber filter), recoverable, micrograms per liter
82682	68	1993-12-13	2002-09-10	DCPA, water, filtered (0.7 micron glass fiber filter), recoverable, micrograms per liter
82683	68	1993-12-13	2002-09-10	Pendimethalin, water, filtered (0.7 micron glass fiber filter), recoverable, micrograms per liter

82684	68	1993-12-13	2002-09-10	Napropamide, water, filtered (0.7 micron glass fiber filter), recoverable, micrograms per liter
82685	67	1993-12-13	2002-09-10	Propargite, water, filtered (0.7 micron glass fiber filter), recoverable, micrograms per liter
82686	68	1993-12-13	2002-09-10	Azinphos-methyl, water, filtered (0.7 micron glass fiber filter), recoverable, micrograms per liter
82687	68	1993-12-13	2002-09-10	cis-Permethrin, water, filtered (0.7 micron glass fiber filter), recoverable, micrograms per liter
84164	368	1997-05-01	2009-07-26	Sampler type, code
85795	3	2001-02-28	2001-09-08	m-Xylene plus p-xylene, water, unfiltered, recoverable, micrograms per liter
90095	204	1982-10-07	2009-07-26	Specific conductance, water, unfiltered, laboratory, microsiemens per centimeter at 25 degrees Celsius
90410	101	1982-10-07	2004-08-19	Acid neutralizing capacity, water, unfiltered, fixed endpoint (pH 4.5) titration, laboratory, milligrams per liter as calcium carbonate
90851	3	2001-02-28	2001-09-08	Trihalomethanes, water, unfiltered, calculated, micrograms per liter
90852	2	1993-08-23	1997-09-11	DDT plus degradates, bed sediment smaller than 2 millimeters, wet sieved (native water), recoverable, calculated, dry weight, micrograms per kilogram
90853	1	1993-08-23		Chlordane plus degradates, bed sediment, recoverable, calculated, dry weight, micrograms per kilogram
90854	3	1993-08-17	1997-09-03	DDT plus degradates, biota, whole organism, wet weight, calculated, dry weight, micrograms per kilogram
90855	3	1993-08-17	1997-09-03	Chlordane plus degradates, biota, whole organism, calculated, wet weight, micrograms per kilogram
91063	67	1993-12-13	2002-09-10	Diazinon-d10, surrogate, water, filtered (0.7 micron glass fiber filter), percent recovery
91064	41	1993-12-13	1999-05-03	Terbuthylazine, surrogate, water, filtered (0.7 micron glass fiber filter), percent recovery
91065	67	1993-12-13	2002-09-10	alpha-HCH-d6, surrogate, water, filtered (0.7 micron glass fiber filter), percent recovery
99105	19	1993-06-02	2001-02-28	Type of replicate, code
99111	40	1993-06-02	2009-07-21	Type of quality assurance data associated with sample, code
99112	3	1994-08-29	1994-10-18	Purpose, topical quality-control data, code
99583	2	2002-08-13	2002-09-10	Bisphenol A-d3, surrogate, Schedule/lab code 2033/8033, water, filtered, percent recovery
99584	2	2002-08-13	2002-09-10	Caffeine-13C, surrogate, Schedule/lab code 2033/8033, water, filtered, percent recovery
99585	2	2002-08-13	2002-09-10	Decafluorobiphenyl, surrogate, Schedule/lab code 2033/8033, water, filtered, percent recovery
99586	2	2002-08-13	2002-09-10	Fluoranthene-d10, surrogate, Schedule/lab code 2033/8033, water, filtered, percent recovery
99587	2	2002-08-13	2002-09-10	Sample volume, wastewater method, water, filtered, milliliters
		1999-	2001-	

99630	27	1999-01-19	2001-09-08	Set number, lab code 0113
99660	22	1999-05-03	2001-09-08	Set number, lab code 0305
99807	4	1994-09-07	1994-11-17	Set number, Schedule 1331
99818	65	1993-12-13	2001-09-08	Set number, Schedule 2001
99820	16	1994-02-09	1994-11-17	Set number, Schedule 2050
99822	3	1993-08-17	1997-09-03	Set number, Schedule 2101
99824	1	1997-09-11		Set number, Schedule 2501
99825	1	1993-08-23		Set number, Schedule 2502
99827	3	2001-02-28	2001-09-08	Set number, Schedule 2090
99832	3	2001-02-28	2001-09-08	1,2-Dichloroethane-d4, surrogate, Schedule 2090, water, unfiltered, percent recovery
99833	3	2001-02-28	2001-09-08	Toluene-d8, surrogate, Schedule 2090, water, unfiltered, percent recovery
99834	3	2001-02-28	2001-09-08	1-Bromo-4-fluorobenzene, surrogate, VOC schedules, water, unfiltered, percent recovery
99835	12	1993-12-13	1994-09-07	BDMC, surrogate, water, unfiltered, percent recovery
99848	16	1994-02-09	1994-11-17	Sample volume, Schedule 2050, milliliters
99849	2	1993-08-17		Analytical reference number, Schedule 2101
99850	1	1993-08-23		Analytical reference number, Schedule 2501
99852	3	1993-08-17	1997-09-03	Sample weight, Schedule 2101, grams
99853	2	1993-08-23	1997-09-11	Sample weight, Schedule 2501, grams
99856	68	1993-12-13	2002-09-10	Sample volume, Schedule 2001, milliliters
99870	9	1994-08-29	2003-07-19	Julian date, in-bottle digestion, ddd
99871	3	2001-02-28	2001-09-08	Number of tentatively identified compounds (TICS) from VOC analysis by GCMS, number

Title: Water Quality Samples for USA: Sample Data
URL: http://waterdata.usgs.gov/nwis/qwdata?

Page Contact Information: NWISWeb Support Team
Page Last Modified: 2009-09-09 13:40:43 EDT
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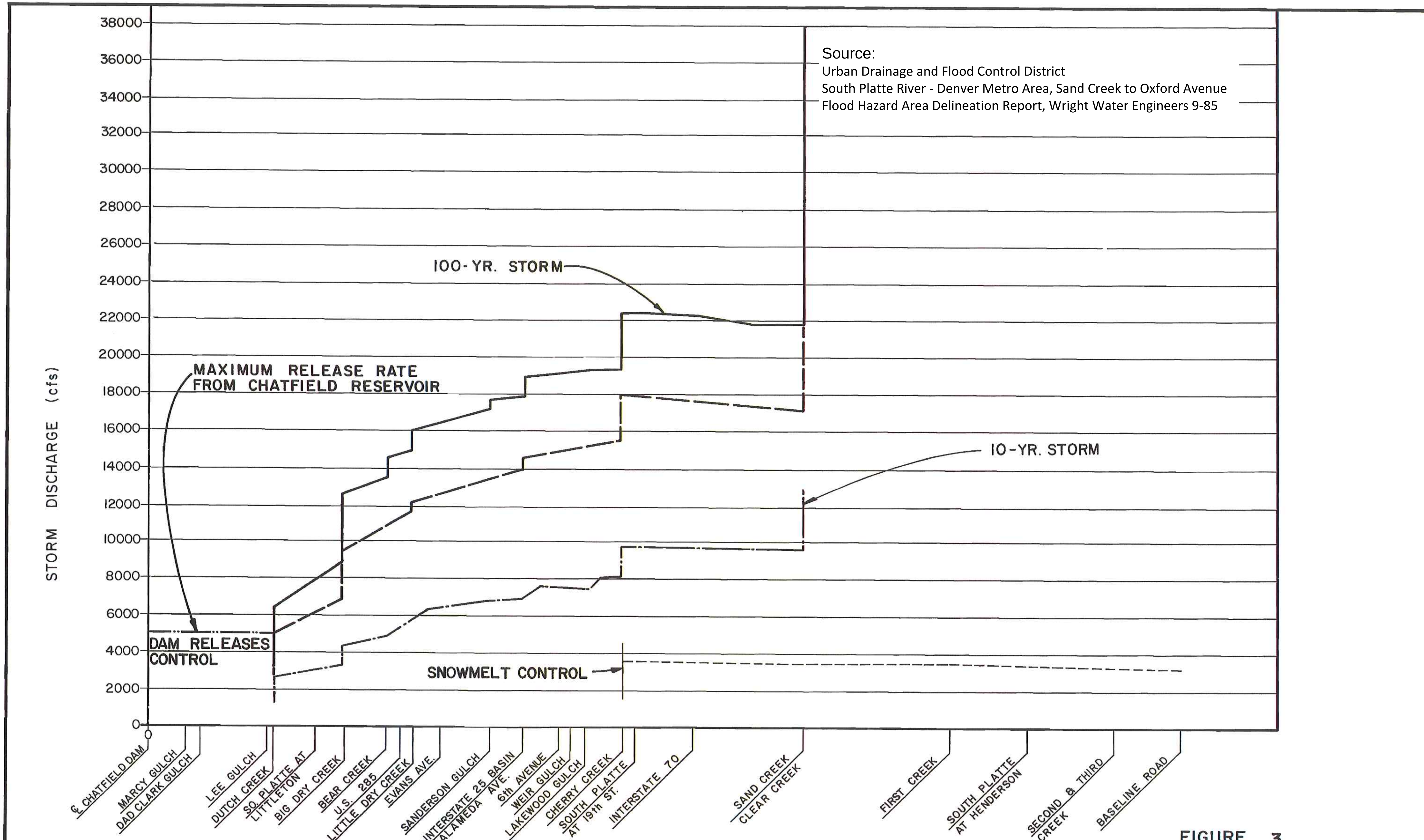


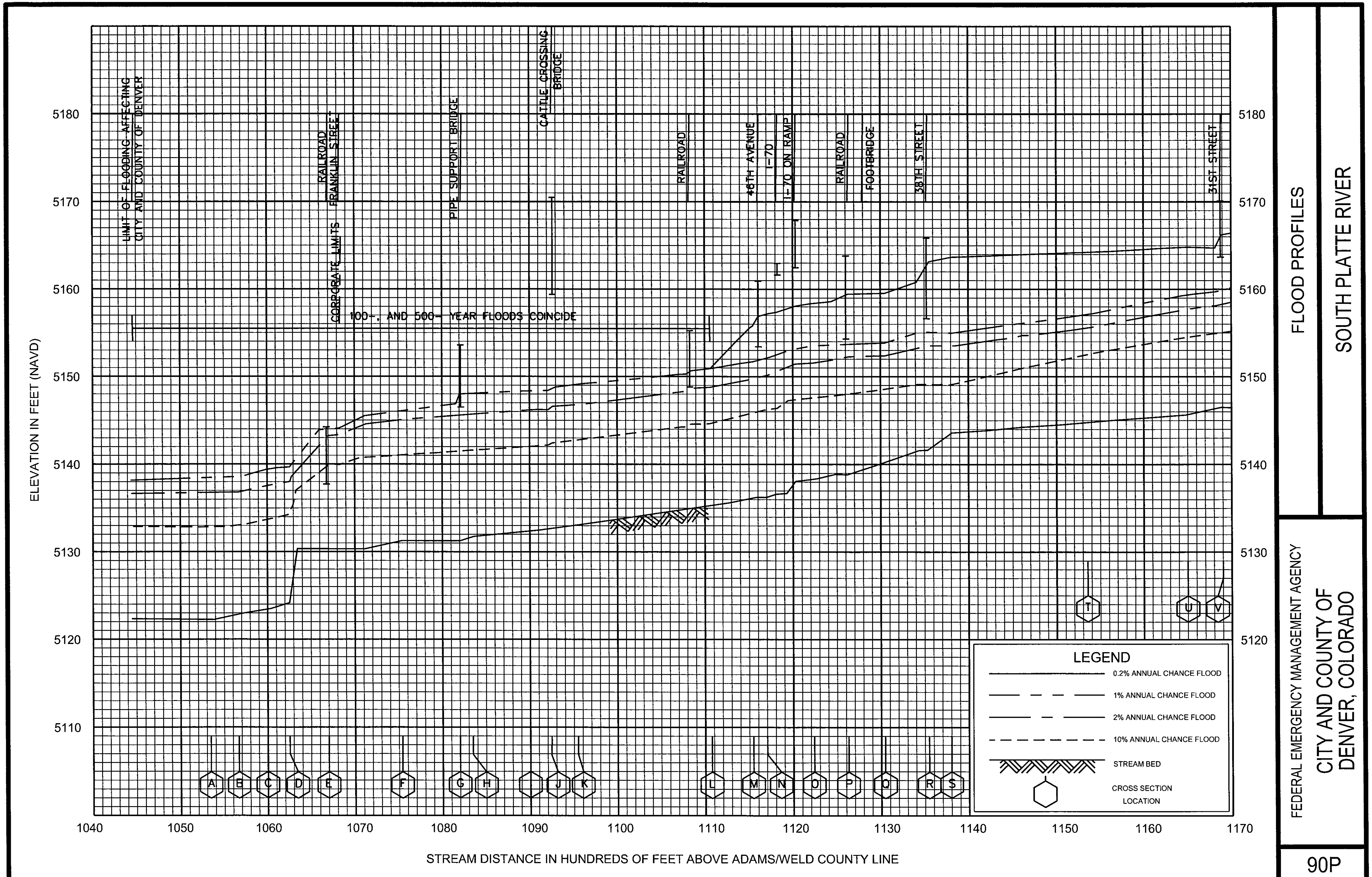
SOUTH PLATTE RIVER DISCHARGE PROFILES

FIGURE 3
EXTREME FLOOD EVENT FLOWS

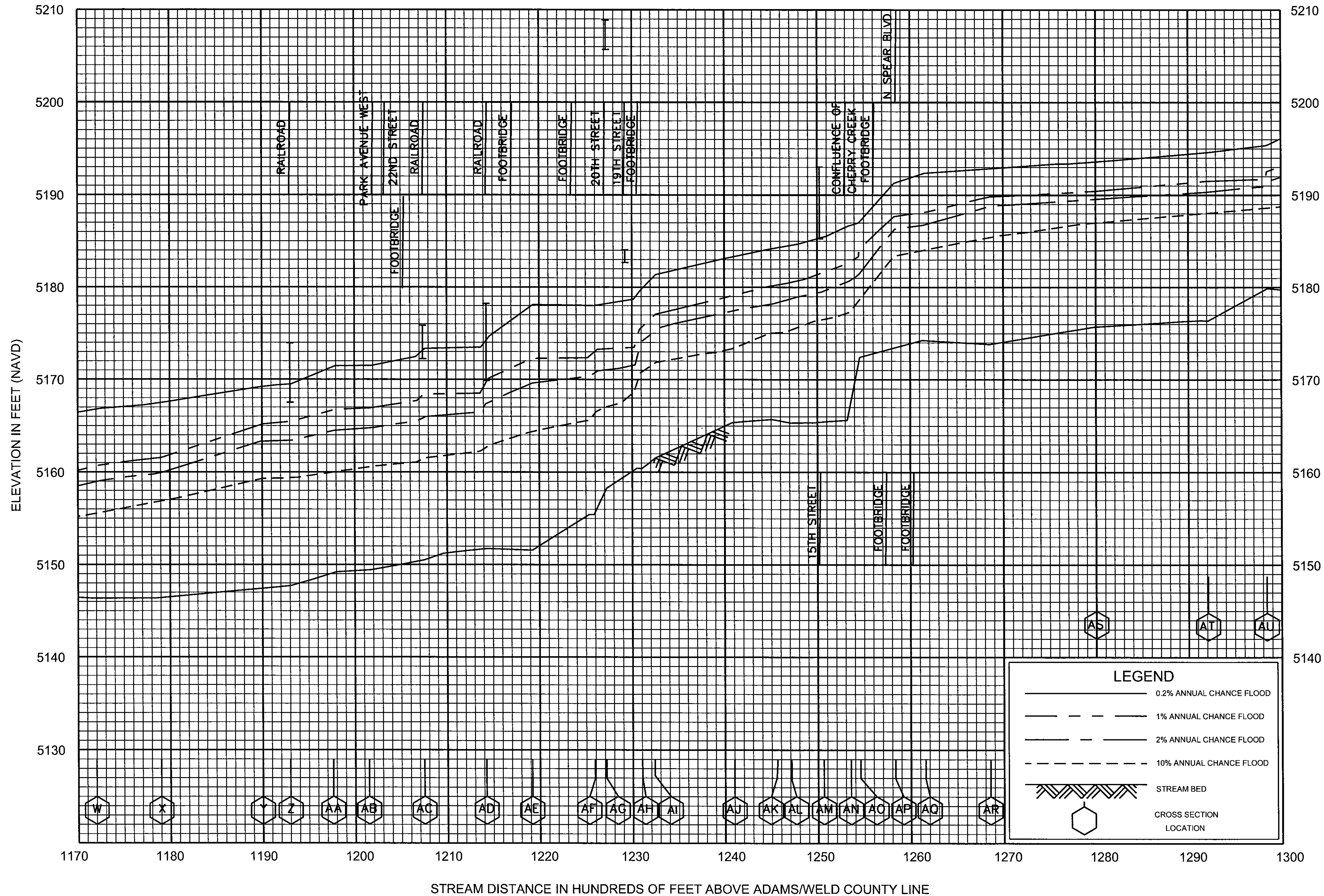
WRIGHT WATER ENGINEERS, INC.
2490 W. 26th AVE. -55A
DENVER, COLORADO 80211

APPENDIX C

Flood Insurance Study Discharge Profiles and Tables



FLOOD PROFILES
SOUTH PLATTE RIVER
FEDERAL EMERGENCY MANAGEMENT AGENCY
CITY AND COUNTY OF DENVER, COLORADO
90P
ELEVATION IN FEET (NAVD)
STREAM DISTANCE IN HUNDREDS OF FEET ABOVE ADAMS/WELD COUNTY LINE
LIMIT OF FLOODING AFFECTING CITY AND COUNTY OF DENVER
RAILROAD
FRANKLIN STREET
CORPORATE LIMITS
PIPE SUPPORT BRIDGE
CATTLE CROSSING BRIDGE
RAILROAD
46TH AVENUE
I-70
I-70 ON RAMP
RAILROAD
FOOTBRIDGE
38TH STREET
31ST STREET
100-, AND 500- YEAR FLOODS COINCIDE
LEGEND
0.2% ANNUAL CHANCE FLOOD
1% ANNUAL CHANCE FLOOD
2% ANNUAL CHANCE FLOOD
10% ANNUAL CHANCE FLOOD
STREAM BED
CROSS SECTION LOCATION

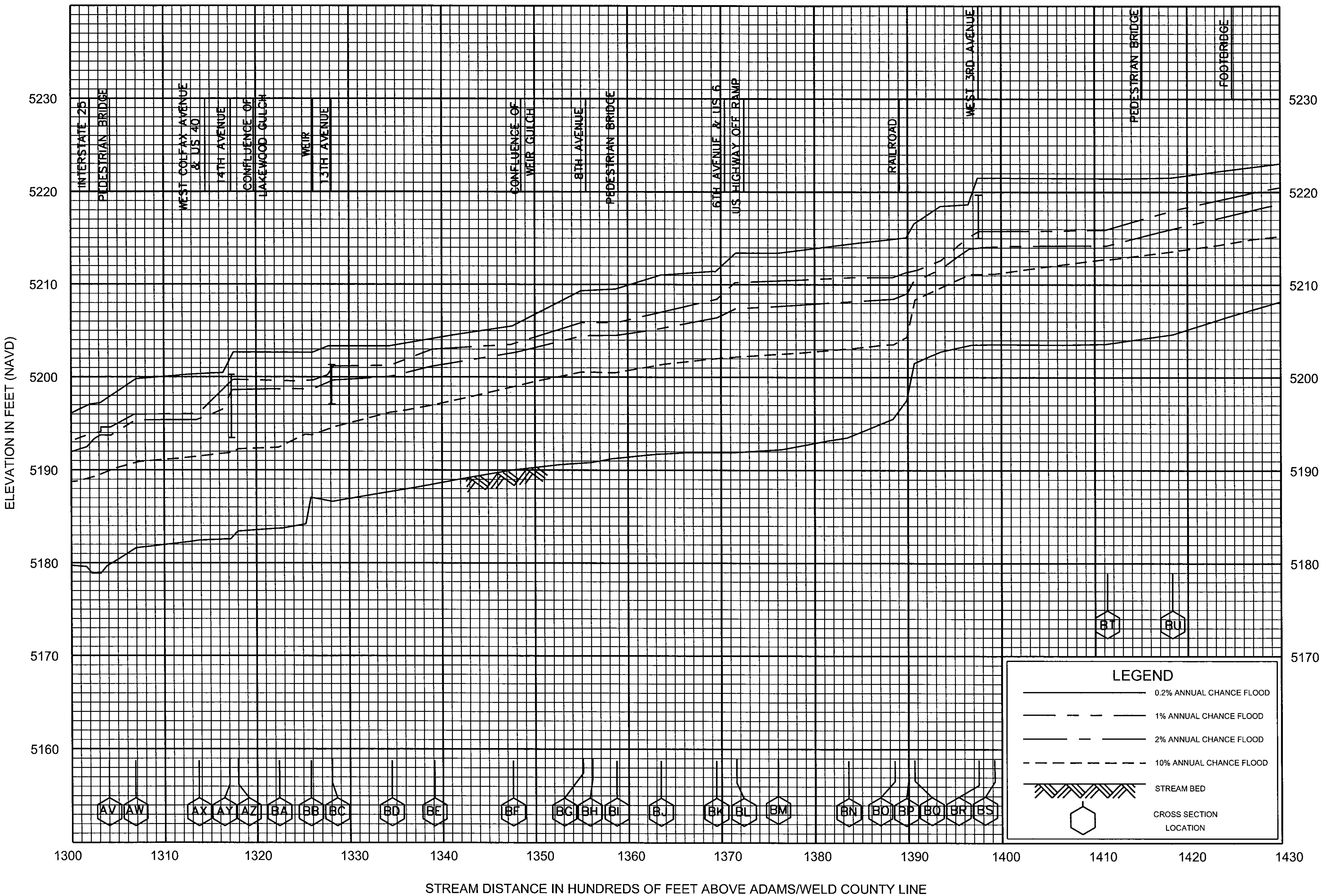


FLOOD PROFILES

SOUTH PLATTE RIVER

FEDERAL EMERGENCY MANAGEMENT AGENCY

CITY AND COUNTY OF DENVER, COLORADO

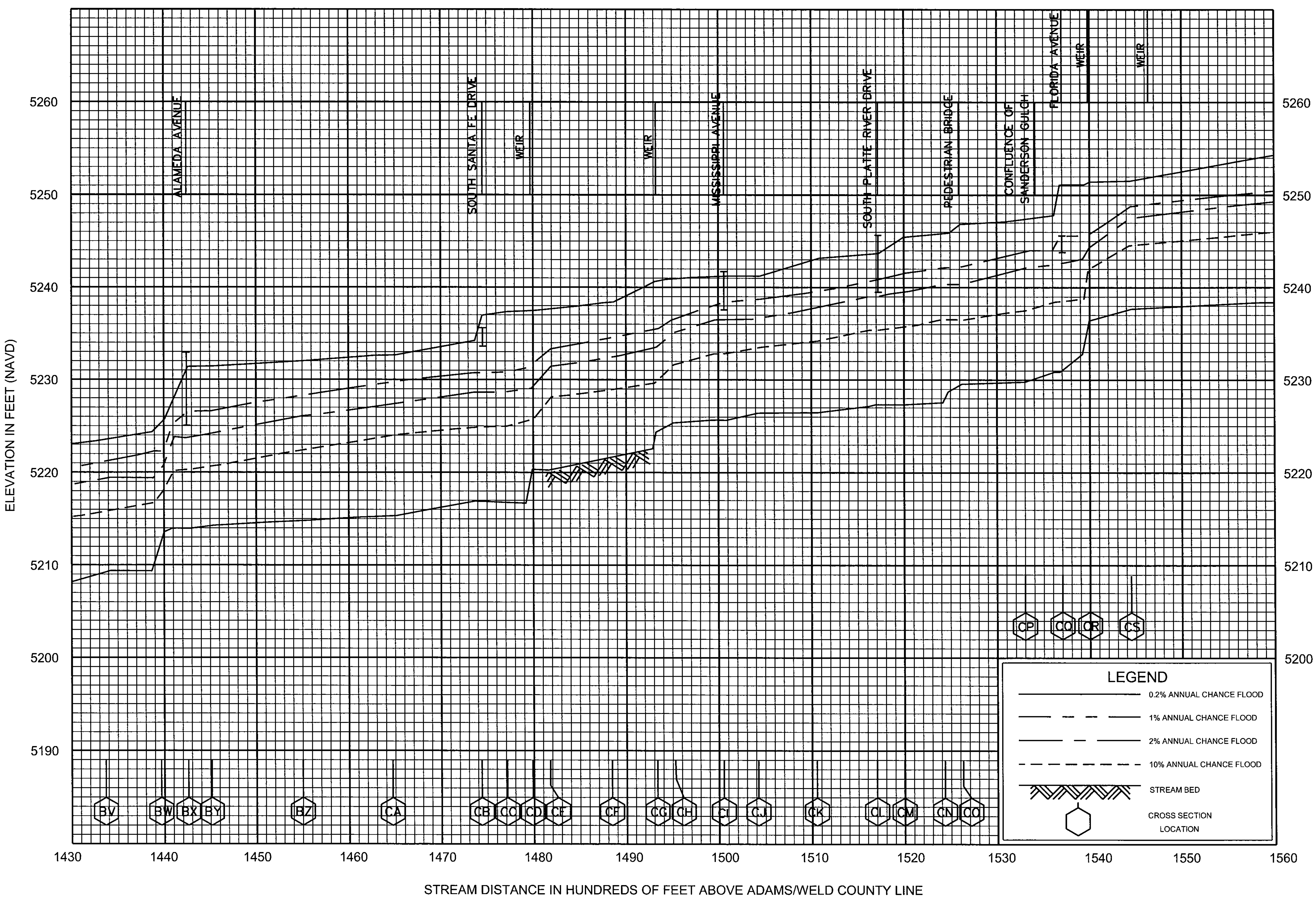


FLOOD PROFILES

SOUTH PLATTE RIVER

FEDERAL EMERGENCY MANAGEMENT AGENCY

CITY AND COUNTY OF DENVER, COLORADO

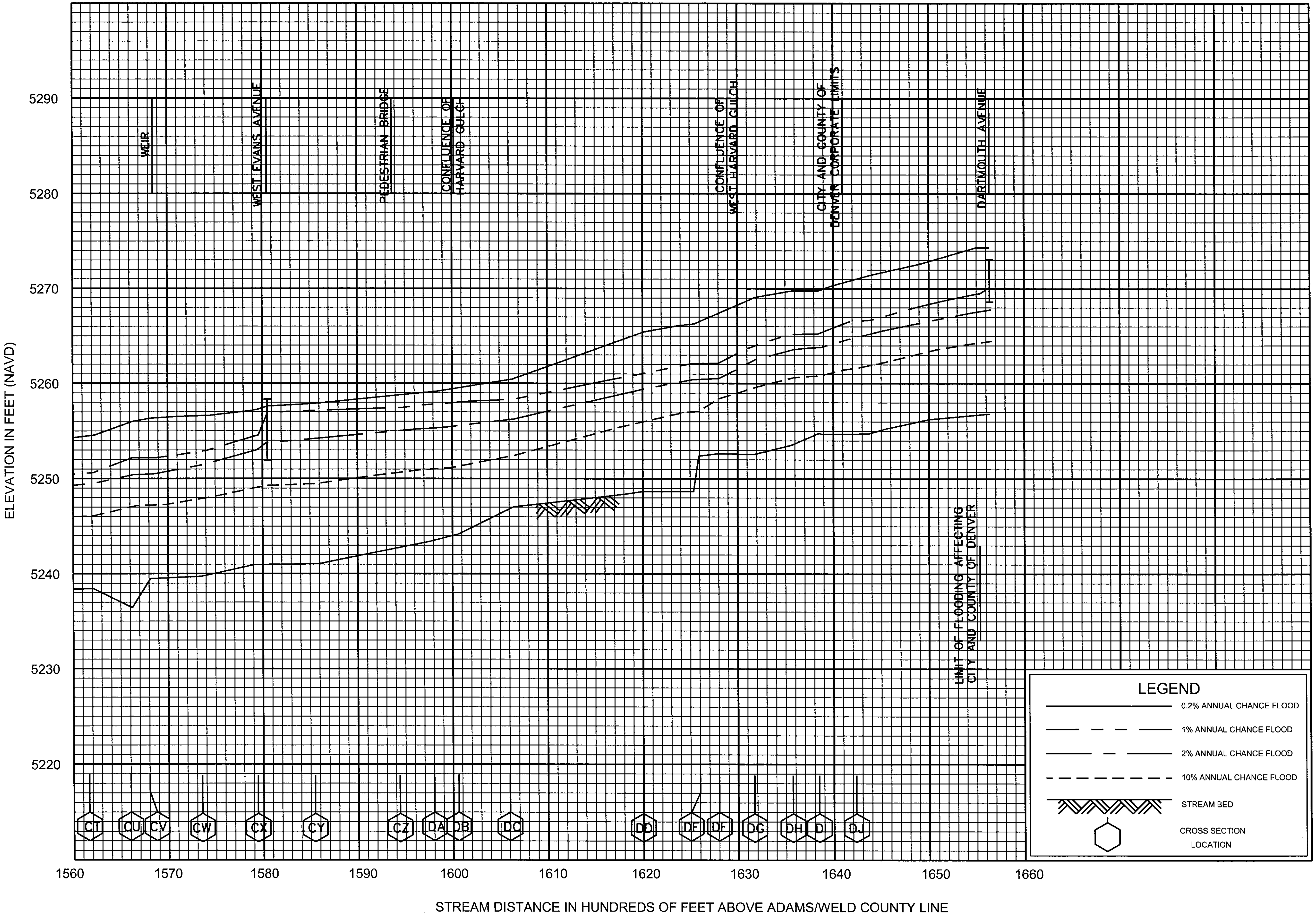


FLOOD PROFILES

SOUTH PLATTE RIVER

FEDERAL EMERGENCY MANAGEMENT AGENCY

CITY AND COUNTY OF DENVER, COLORADO



FLOOD PROFILES

SOUTH PLATTE RIVER

FEDERAL EMERGENCY MANAGEMENT AGENCY

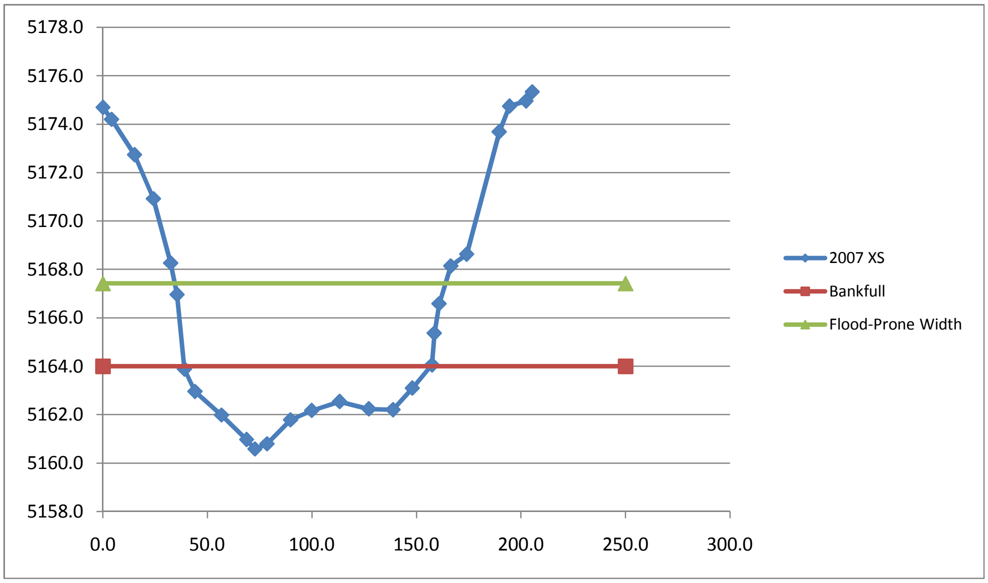
CITY AND COUNTY OF DENVER, COLORADO

APPENDIX D

Rosgen Stream Classification

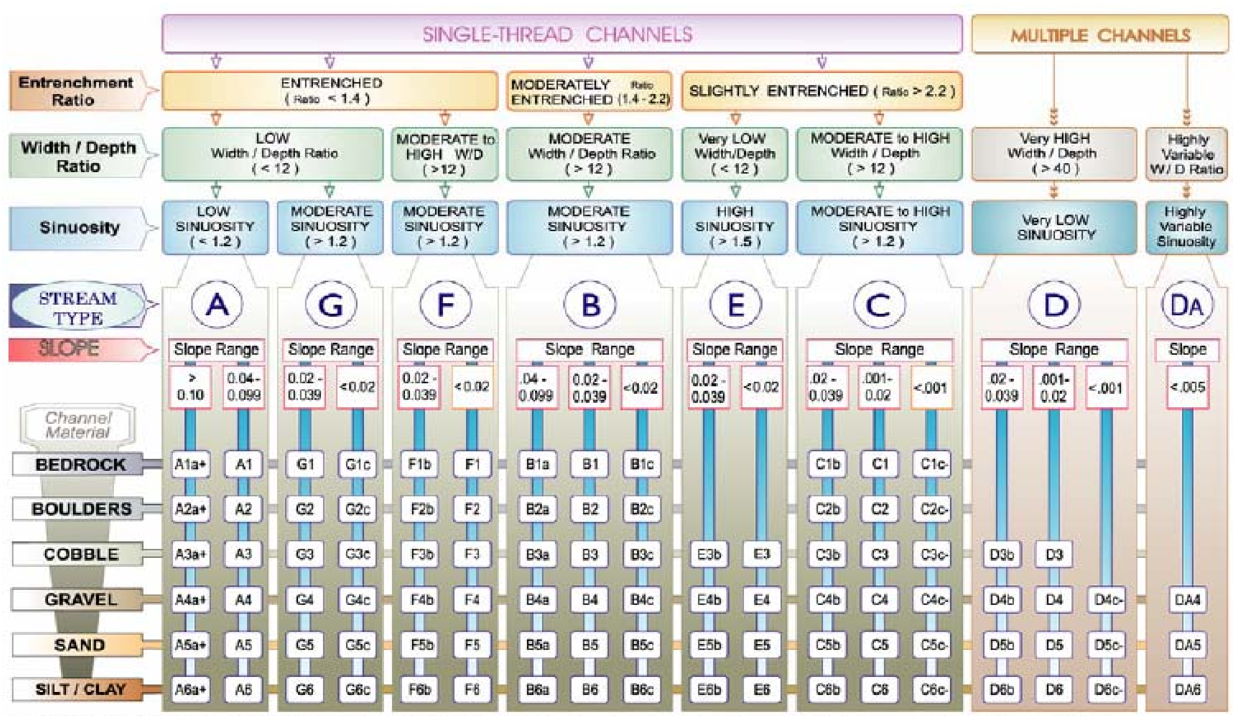
UDFCD Section 36 (1233+10)

Station	Elevation
0.0	5174.7
4.1	5174.2
15.1	5172.7
24.2	5170.9
32.4	5168.3
35.5	5167.0
39.0	5163.9
44.0	5163.0
56.7	5162.0
68.8	5161.0
72.7	5160.6
78.5	5160.8
89.8	5161.8
99.9	5162.2
113.2	5162.5
127.3	5162.2
138.8	5162.2
148.0	5163.1
157.5	5164.1
158.6	5165.4
160.9	5166.6
166.4	5168.1
174.0	5168.6
189.6	5173.7
194.6	5174.8
202.5	5175.0
205.4	5175.3



Bankfull Width =	117.7	
Flood-Prone Width =	129.4	
Max. Depth =	3.4	
Hydraulic Depth =	1.8	
Entrenchment Ratio =	**1.1**	**< 1.4**
W/D Ratio =	**64**	**> 12**
Ave. Bed Slope =	**0.0023**	**< 0.02**
Channel Material =	**Sand**	

Rosgen Type F5

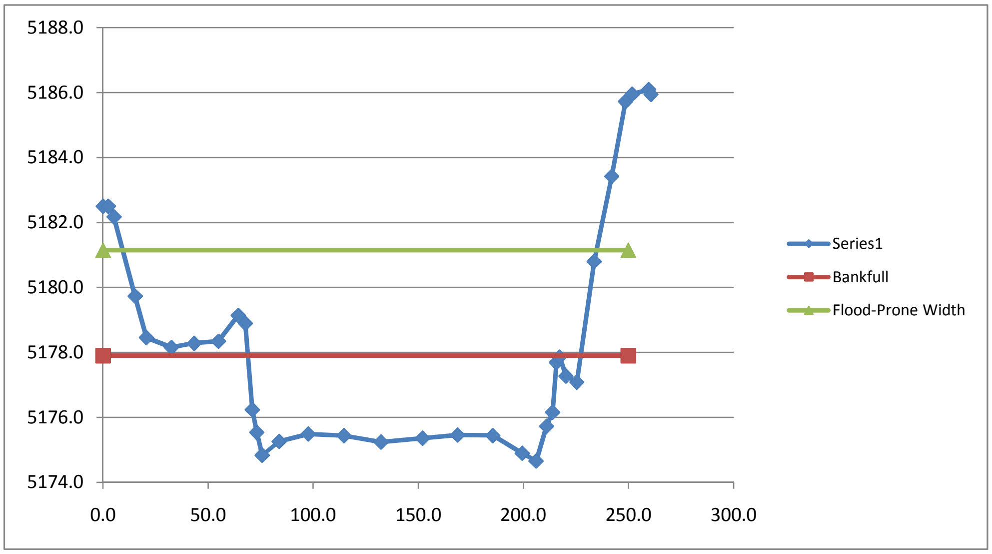


KEY to the ROSGEN CLASSIFICATION of NATURAL RIVERS. As a function of the *"continuum of physical variables"* within stream reaches, values of ***Entrenchment*** and ***Sinuosity*** ratios can vary by +/- 0.2 units, while values for ***Width / Depth*** ratios can vary by +/- 2.0 units.

UDFCD Section 37 (1309+30)

Station	Elevation
0.0	5182.5
2.5	5182.5
5.2	5182.2
15.3	5179.7
20.6	5178.5
32.5	5178.2
43.4	5178.3
54.9	5178.3
64.3	5179.1
67.8	5178.9
71.0	5176.2
73.1	5175.5
75.7	5174.8
83.8	5175.3
97.7	5175.5
114.6	5175.4
132.3	5175.2
152.0	5175.4
168.8	5175.5
185.5	5175.4
199.5	5174.9
206.1	5174.7
211.1	5175.7
214.0	5176.2
215.7	5177.7
217.2	5177.9
220.3	5177.3
225.5	5177.1
233.8	5180.8
242.1	5183.4
248.6	5185.7
251.82	5185.947
259.7	5186.094
260.78	5185.941

5174.7

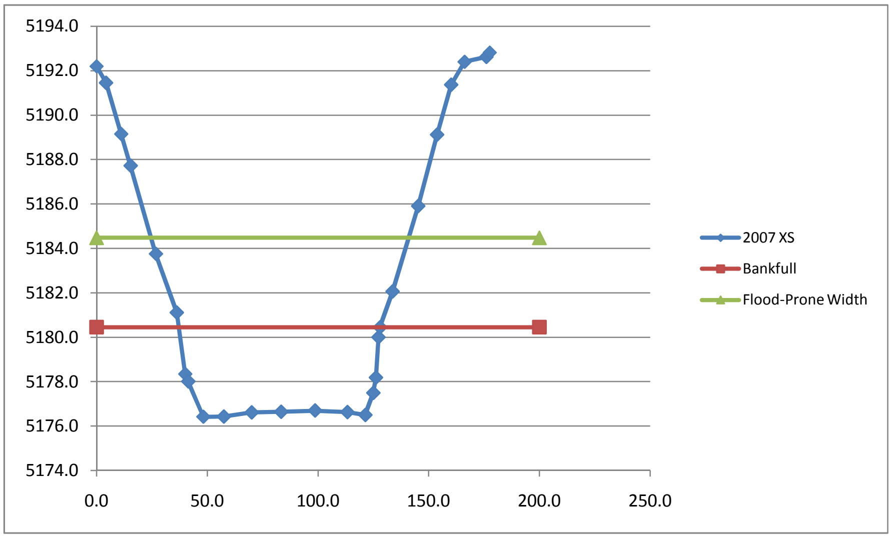


Bankfull Width =	158.3	
Flood-Prone Width =	225.5	
Max. Depth =	3.2	
Hydraulic Depth =	2.5	
Entrenchment Ratio =	**1.4**	**< 1.4 or > 1.4**
W/D Ratio =	**63**	**> 12**
Ave. Bed Slope =	**0.0023**	**< 0.02**
Channel Material =	**Sand**	

Rosgen Type F5 or B5c

UDFCD Section 38 (1309+30)

Station	Elevation
0.0	5192.2
4.3	5191.5
11.1	5189.1
15.4	5187.7
26.8	5183.8
36.3	5181.1
40.1	5178.3
41.4	5178.0
48.2	5176.4
57.4	5176.4
70.0	5176.6
83.3	5176.6
98.7	5176.7
113.3	5176.6
121.4	5176.5
125.0	5177.5
126.2	5178.2
127.3	5180.0
128.0	5180.4
133.7	5182.1
145.3	5185.9
153.8	5189.1
160.2	5191.4
166.2	5192.4
176.1	5192.6
177.6	5192.8

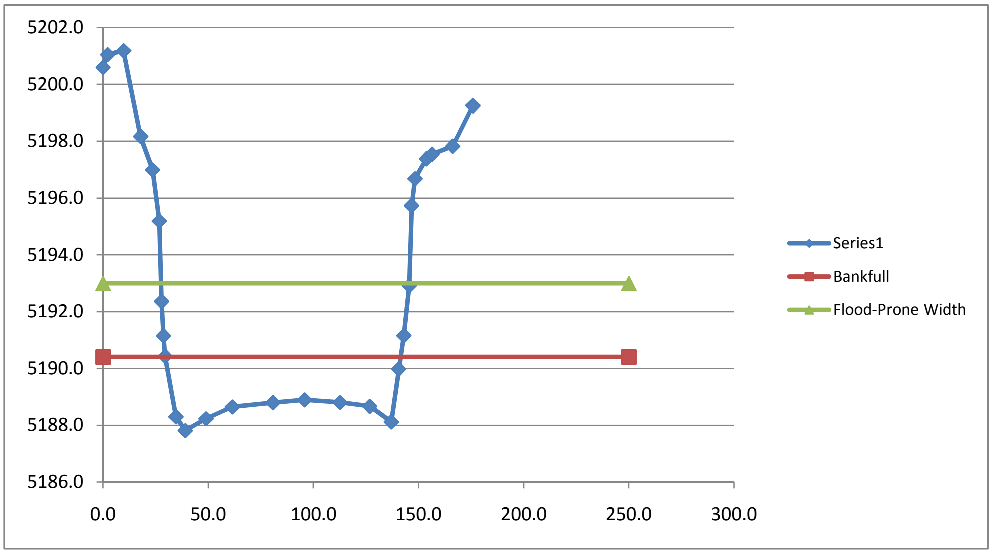


Bankfull Width =	90.8	
Flood-Prone Width =	116.2	
Max. Depth =	4.0	
Hydraulic Depth =	3.6	
Entrenchment Ratio =	**1.3**	**< 1.4**
W/D Ratio =	**25**	**> 12**
Ave. Bed Slope =	**0.0023**	**< 0.02**
Channel Material =	**Sand**	

Rosgen Type F5

UDFCD Section 39 (1336+40)

Station	Elevation
0.0	5200.6
2.1	5201.0
9.8	5201.2
17.9	5198.2
23.5	5197.0
26.7	5195.2
27.8	5192.4
28.8	5191.1
29.5	5190.4
34.7	5188.3
39.1	5187.8
48.9	5188.2
61.5	5188.6
80.8	5188.8
95.9	5188.9
112.7	5188.8
126.8	5188.7
137.1	5188.1
140.6	5190.0
143.0	5191.2
145.6	5192.9
146.7	5195.7
148.4	5196.7
153.7	5197.4
156.4	5197.5
166.3	5197.8
175.9	5199.3
176.0	5199.2



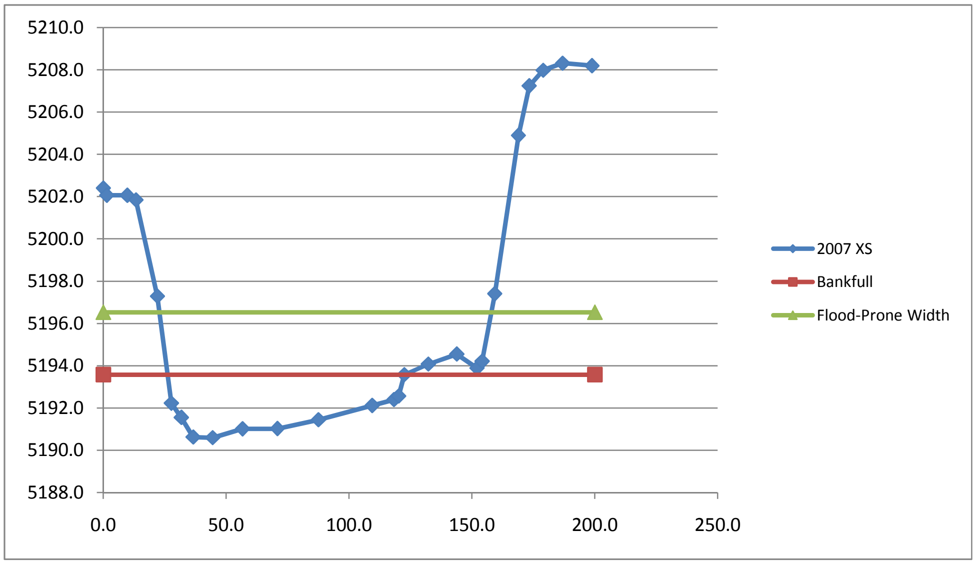
5187.8

Bankfull Width =	111.9	
Flood-Prone Width =	118.1	
Max. Depth =	2.6	
Hydraulic Depth =	1.8	
Entrenchment Ratio =	**1.1**	**< 1.4**
W/D Ratio =	**64**	**> 12**
Ave. Bed Slope =	**0.0023**	**< 0.02**
Channel Material =	**Sand**	

Rosgen Type F5

UDFCD Section 40 (1376+80)

Station	Elevation
0.0	5202.4
1.4	5202.1
9.7	5202.1
13.3	5201.8
22.0	5197.3
27.7	5192.2
31.7	5191.5
36.6	5190.6
44.5	5190.6
56.7	5191.0
70.9	5191.0
87.6	5191.4
109.5	5192.1
118.3	5192.4
120.2	5192.6
122.5	5193.6
132.3	5194.1
143.9	5194.5
152.1	5193.9
154.2	5194.2
159.3	5197.4
168.9	5204.9
173.3	5207.2
179.0	5208.0
187.0	5208.3
198.9	5208.2

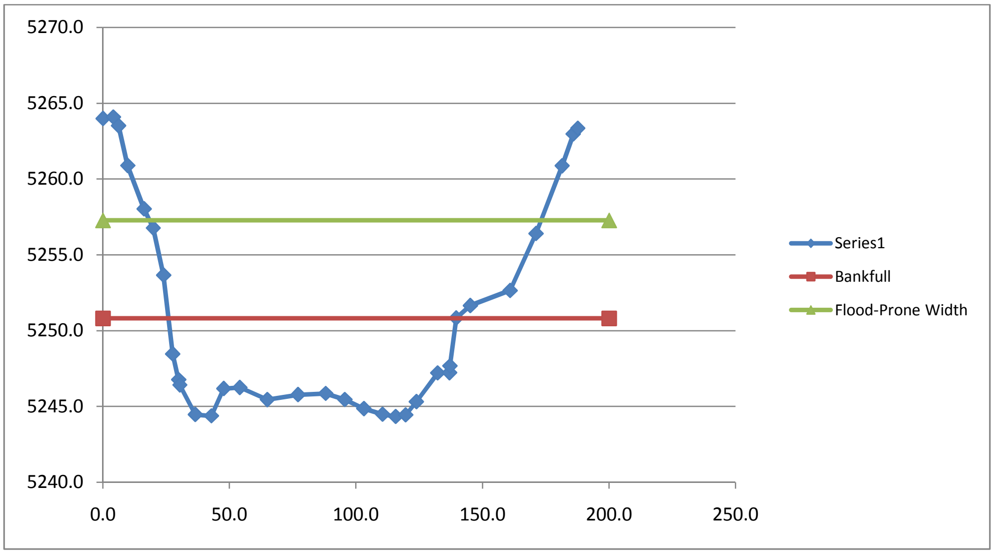


Bankfull Width =	96.4	
Flood-Prone Width =	135.1	
Max. Depth =	3.0	
Hydraulic Depth =	2.2	
Entrenchment Ratio =	**1.4**	**< 1.4 or > 1.4**
W/D Ratio =	**44**	**> 12**
Ave. Bed Slope =	**0.0023**	**< 0.02**
Channel Material =	**Sand**	

Rosgen Type F5 or B5c

UDFCD Section 40.5 (1622+90)

Station	Elevation	
0.0	5264.0	
4.1	5264.1	
6.2	5263.5	
9.8	5260.9	
16.2	5258.0	
19.9	5256.8	
24.0	5253.7	
27.5	5248.5	
29.9	5246.8	
30.4	5246.4	
36.5	5244.5	
42.8	5244.4	
47.7	5246.2	
54.1	5246.2	
64.9	5245.4	
77.1	5245.8	
88.0	5245.8	
95.6	5245.4	
103.1	5244.8	
110.5	5244.5	
115.7	5244.3	
119.6	5244.4	
123.9	5245.3	
132.3	5247.2	
137.0	5247.2	
137.1	5247.7	
139.6	5250.8	
145.2	5251.7	
160.9	5252.6	
171.2	5256.4	
181.45	5260.877	
185.85	5262.986	
187.66	5263.36	5244.3

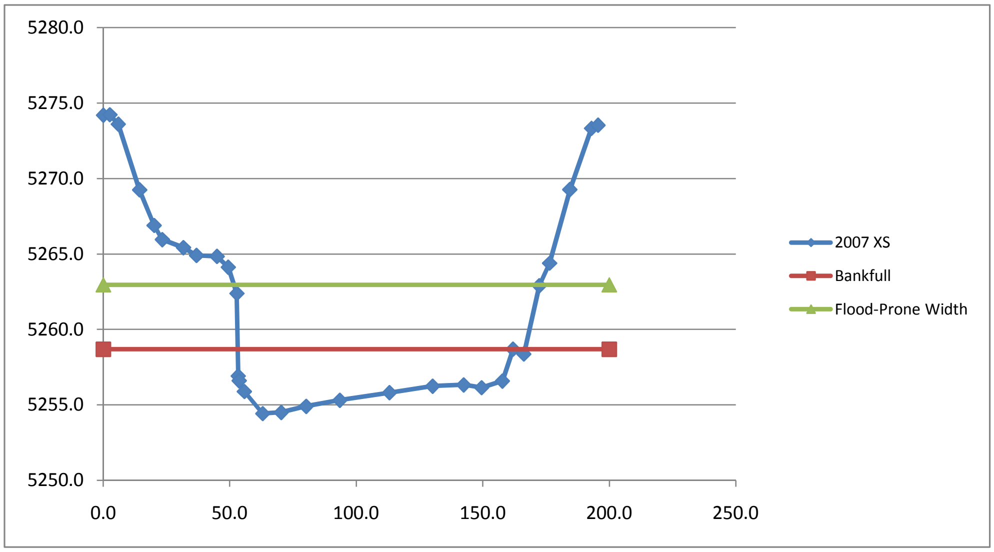


Bankfull Width =	113.7	
Flood-Prone Width =	154.7	
Max. Depth =	6.5	
Hydraulic Depth =	5.1	
Entrenchment Ratio =	**1.4**	**< 1.4 or > 1.4**
W/D Ratio =	**22**	**> 12**
Ave. Bed Slope =	**0.0023**	**< 0.02**
Channel Material =	**Sand**	

Rosgen Type F5 or B5c

UDFCD Section 41 (1669+00)

Station	Elevation	
0.0	5274.2	
2.6	5274.2	
5.9	5273.6	
14.3	5269.3	
20.1	5266.9	
23.3	5266.0	
31.7	5265.4	
36.9	5264.9	
45.0	5264.8	
49.4	5264.1	
52.8	5262.4	
53.3	5256.9	
53.7	5256.6	
55.8	5255.9	
63.0	5254.4	
70.3	5254.5	
80.2	5254.9	
93.5	5255.3	
113.1	5255.8	
130.2	5256.2	
142.5	5256.3	
149.6	5256.1	
157.8	5256.6	
162.0	5258.7	
166.3	5258.4	
172.4	5262.9	
176.5	5264.4	
184.4	5269.3	
193.0	5273.3	
195.6	5273.5	5254.4



Bankfull Width =	113.6	
Flood-Prone Width =	120.9	
Max. Depth =	4.3	
Hydraulic Depth =	2.9	
Entrenchment Ratio =	**1.1**	**< 1.4**
W/D Ratio =	**39**	**> 12**
Ave. Bed Slope =	**0.0023**	**< 0.02**
Channel Material =	**Sand**	**Rosgen Type F5**

APPENDIX E

Geotechnical Engineering Study

Kumar & Associates, Inc.
Geotechnical and Materials Engineers
and Environmental Scientists

ACEC
MEMBER

2390 South Lipan Street
Denver, CO 80223
phone: (303) 742-9700
fax: (303) 742-9666
e-mail: kadenver@kumarusa.com
www.kumarusa.com

Office Locations: Denver (HQ), Colorado Springs, Fort Collins, and Frisco, Colorado

GEOTECHNICAL ENGINEERING STUDY
PROPOSED SOUTH PLATTE RIVER
RECREATION AND HABITAT IMPROVEMENTS
OVERLAND POND PARK TO GRANT FRONTIER PARK REACH
SOUTH PLATTE RIVER DRIVE
BETWEEN SOUTH HURON STREET
AND WEST HARVARD AVENUE
DENVER, COLORADO

Prepared By:
Wade Gilbert, P. E.

COLORADO REGISTERED PROFESSIONAL ENGINEER
JAMES WADE GILBERT
39256
8-21-12

Reviewed By:

James A. Noll, P.E.

Prepared For:

CDM Smith
555 17th Street, Suite 1100
Denver, CO 80202

Attention: Brian Murphy, P.E.

Project No. 12-1-339

August 21, 2012

TABLE OF CONTENTS

SUMMARY

1. The subsurface conditions encountered in the borings consisted of overburden fills and natural soils extending to relatively shallow bedrock or to the full depth explored. The fill ranged from silty to clayey gravel to clayey sand with occasional sandy lean clay and isolated debris and organic material. The fill encountered in the borings appeared to be relatively dense; however, the lateral extent, depth and degree of compaction of the existing fill were not determined.

   The natural overburden soils generally consisted of poorly- to well-graded sand alluvium containing variable silt and gravel, occasional silty sand lenses, and isolated organic material. Based on sampler penetration resistance, the alluvial sands ranged from medium dense to dense. The bedrock consisted of very hard claystone with isolated lenses of sandy siltstone. River sediments generally consisted of fine- to coarse-grained, poorly-graded gravel with sand to well-graded sand with gravel, with occasional zones of silty clayey sand with gravel.

   Groundwater was encountered in one boring during drilling at a depth of about 9 feet. Stabilized groundwater levels were measured 12 days after drilling in all 4 borings at depths ranging from about 6 to 16.5 feet.

2. It should be feasible to support drop structures, ramp pavements, and shallow spread footings and mats directly on natural granular alluvial soils and on claystone bedrock, or on properly compacted structural fill extending to natural soils or claystone bedrock. Spread footing and mat foundations bearing on natural granular soils or claystone bedrock, or on properly compacted structural fill extending to natural granular soils or claystone bedrock, should be designed for a net allowable bearing pressure of 2,500 psf. The net allowable bearing pressure may be increased by one-third for transient loadings.

3. The existing overburden soils should be suitable for use as site grading fill, and some may suitable for use as structural fill beneath foundations and pavements and as retaining wall backfill. However, the claystone bedrock is generally very hard and will likely be difficult to break down and adequately process for use as site grading fill.

PURPOSE AND SCOPE OF WORK

This report presents the results of a geotechnical engineering study for the proposed recreation and habitat improvements along the Overland Regional Park to Grant Frontier Park reach of the South Platte River in Denver, Colorado. The overall project site and individual project segments are shown on Figs. 1A through 1C. The study was performed in general accordance with the scope of work outlined in our Proposal No. P-12-379 to CDM Smith dated July 27, 2012.

A field exploration program consisting of exploratory borings and river sediment sampling was conducted to obtain information on subsurface conditions at specific locations along the project reach. Samples of the soils and bedrock obtained during the field exploration program were tested in our laboratory to determine their classification and engineering characteristics. The results of the field exploration and laboratory testing programs were analyzed to develop recommendations and construction considerations for the proposed recreation and habitat improvements.

This report has been prepared to summarize the data obtained during this study and to present our conclusions and recommendations based on the proposed construction and the subsurface conditions encountered. Design parameters and a discussion of geotechnical engineering considerations related to construction of the proposed recreation and habitat improvements are included in the report.

PROPOSED CONSTRUCTION

We understand the project is part of the South Platte River Vision Implementation Plan developed by The Greenway Foundation and the City and County of Denver (City). The plan's objective is to improve currently limited river access and recreation opportunities, improve wildlife habitat, and provide a water quality benefit. Accomplishing those objectives will include providing multi-use river access facilities, channel bank modifications to provide additional riparian habitat such as pool and riffle areas, and modification of existing drop structures to provide boating and fishing experiences.

Along the alignment, improvements will include modifying the existing drop structure located just south of South Florida Avenue, bank regrading and vegetation removal in several areas, creation of two backwater/wetland areas along the east side of the river, construction of a water quality swale at the Harvard Gulch outfall, and construction of areas for accessing the river, including boat put in and take out locations. The project will include relocating existing concrete trail segments and park facilities in areas.

If the proposed construction varies significantly from that described above or depicted in this report, we should be notified to reevaluate the recommendations provided in this report.

SITE CONDITIONS

Boring 1 was drilled on the west side of the South Platte River just north of a pump station located at the lower end of a short gravel service road extending from Platte River Drive. Boring 1 was also located near the west end of the existing drop structure located just south of West Florida Avenue.

Borings 2 through 4 were drilled within Denver City parks located along the east side of the South Platte River. Borings 2 and 3 were drilled in Pasquinel's Landing Park and Grant Frontier Park, respectively, and were located a few feet off of the existing paved South Platte River trail. Both of these locations were relatively flat and a few feet above the river level. Boring 4 was drilled just north of the Harvard Gulch storm water outfall at a location approximately halfway between the South Platte River trail to the west and a paved alleyway to the east. Site grades at the location of Boring 4 slope gradually upward to the east from the South Platte River trail. Vegetation ranged from sod at the Borings 2 and 4 to native vegetation at Boring 3.

At the time of our field exploration program, the water level in the river was very low and significant portions of the riverbed were exposed. The exposed riverbed conditions consisted of a combination of scoured bedrock overlain in places by granular alluvium.

SUBSURFACE CONDITIONS

<u>Subsurface Exploration Program</u>: The subsurface conditions along the project reach were explored by drilling 4 exploratory borings to depths of about 20 feet below existing ground surface, and obtaining in-river sediment samples at three locations upstream of the existing drop structure at South Florida Avenue. The sediment samples were obtained by hand boring to depths ranging from about 3 to 7 feet below river bottom. The approximate locations of the exploratory borings and sediment samples are shown on Figs. 1A through 1C. Graphic logs of

the borings and sediment samples are presented on Fig. 2, and a legend and notes describing the soils and bedrock encountered are presented on Fig. 3.

<u>Subsurface Soil and Bedrock Conditions</u>: The subsurface conditions encountered at the boring locations consisted of overburden fills and natural soils extending to relatively shallow bedrock in Borings 1, 3 and 4, and to the full depth explored of about 20 feet in Boring 2. The fill ranged from silty to clayey gravel in Boring 1 to clayey sand with occasional sandy lean clay in Borings 2 through 4. The fill encountered in Boring 1 was gray-brown, ranged from slightly moist to wet below groundwater, and contained asphalt and concrete debris and isolated organics. The predominantly clayey sand fill encountered in Borings 2 through 4 varied from brown to gray-brown, ranged from slightly moist to moist, and contained isolated gravel. The fill materials extended to bedrock at depths of about 8 and 5 feet in Borings 1 and 4, respectively. Based on sampler penetration resistance, the fill encountered in the borings appeared to be relatively dense; however, the lateral extent, depth and degree of compaction of the existing fill were not determined.

Natural overburden soils were encountered beneath the fill in Borings 2 and 3 and extended to the full depth explored of about 20 feet in Boring 2 and to bedrock at a depth of about 8 feet in Boring 3. The natural overburden soils encountered in the borings generally consisted of poorly- to well-graded sand alluvium containing variable silt and gravel, occasional silty sand lenses, and isolated organic material. The alluvial sands were typically brown and slightly moist to wet below groundwater. Based on sampler penetration resistance, the alluvial sands ranged from medium dense to dense.

The bedrock encountered in Borings 1, 3 and 4 consisted of blue-gray claystone with isolated lenses of olive-brown sandy siltstone. The bedrock was slightly moist and very hard, based on sampler penetration resistance.

The sediments encountered at the sample locations generally consisted of fine- to coarse-grained, poorly graded gravel with sand to well-graded sand with gravel, with occasional zones of silty clayey sand with gravel. The sediments were typically brown.

General Groundwater Conditions: Groundwater was encountered in Boring 2 during drilling at a depth of about 9 feet. Stabilized groundwater levels were measured 12 days after drilling in all 4 borings at depths ranging from about 6 to 16.5 feet below ground surface.

LABORATORY TESTING

Laboratory testing was performed on selected soil and bedrock samples obtained from the borings to determine in situ soil moisture content and dry density, Atterberg limits, swell-consolidation characteristics, and gradation. The results of the laboratory tests are shown to the right of the logs on Fig. 2 and summarized in Table I. The results of specific tests are graphically plotted on Figs. 4 through 9. The testing was conducted in general accordance with recognized test procedures, primarily those of the American Society for Testing of Materials (ASTM).

Swell-Consolidation: Swell-consolidation tests were conducted on selected samples of the claystone bedrock in order to determine their compressibility and swell characteristics under loading and when submerged in water. Each sample was prepared and placed in a confining ring between porous discs, subjected to a surcharge pressure of 1,000 psf, and allowed to consolidate before being submerged. The sample height was monitored until deformation practically ceased under each load increment.

Results of the swell-consolidation tests are presented on Figs. 4 and 5 as curves of the final strain at each increment of pressure against the log of the pressure. The results of the swell-consolidation tests indicated nil to low swell potential or a slight tendency for additional compression when wetted under a surcharge pressure of 1,000 psf. The additional compression exhibited by one of the tested samples is possibly due to sample disturbance.

Index Properties: Samples were classified into categories of similar engineering properties in general accordance with the Unified Soil Classification System. This system is based on index properties, including liquid limit and plasticity index and grain size distribution. Values for moisture content, dry density, liquid limit and plasticity index, and the percent of soil passing the U.S. No. 4 and 200 sieves are presented in Table I and adjacent to the corresponding sample on the boring logs. Grain size distribution curves are presented on Figs. 6 through 9.

GEOTECHNICAL ENGINEERING CONSIDERATIONS

Subsurface conditions at planned site finished grades and at foundation level for the various anticipated improvements are expected to consist of relatively dense existing fill and predominantly granular natural soils or very hard claystone bedrock. Based on the results of the laboratory swell-consolidation testing, the claystone bedrock exhibited nil to very low swell potential when wetted at a surcharge pressure of 1,000 psf. The foundation levels of drop structures and other in-stream improvements are expected to be at or below ground water in places.

Considering the subsurface conditions encountered in the exploratory borings and the nature of the proposed improvements, it should be feasible to support drop structures, ramp pavements, and shallow spread footings and mats directly on natural granular alluvial soils and on claystone bedrock, or on properly compacted structural fill extending to natural soils or claystone bedrock.

The existing overburden soils should be suitable for use as site grading fill, and some may suitable for use as structural fill beneath foundations and pavements and as retaining wall backfill. However, the claystone bedrock is generally very hard and will likely be difficult to break down and adequately process for use as site grading fill.

Spread Footing and Mat Foundations: The design and construction criteria presented below should be observed for spread footing and mat foundation systems. The construction details should be considered when preparing project documents.

1. Spread footing and mat foundations bearing on natural granular soils or claystone bedrock, or on properly compacted structural fill extending to natural granular soils or claystone bedrock, should be designed for a net allowable bearing pressure of 2,500 psf. The net allowable bearing pressure may be increased by one-third for transient loadings.

2. Based on experience, we estimate total and settlement for spread footing and mat foundations designed and constructed as discussed in this section will be less than 1 inch. Differential settlement between similarly-loaded spread footing foundation elements or across a mat foundation should be less than ½ to ¾ of the total settlement. Non-uniformity of the subsurface conditions will contribute to total and differential settlements. Due to the nature of the construction, and anticipated relatively light net

foundation loads, much of the settlement should occur during construction upon initial loading of the foundations.

3. Spread footings should have a minimum footing width of 18 inches for continuous footings and a minimum width of 24 inches for isolated pad footings.

4. Footings and mats should be provided with adequate soil cover above their bearing elevation for frost protection. Placement of the bottom of footings and mats at least 36 inches below the exterior grade is typically used in this area.

5. Areas of existing fill encountered within the foundation excavation, or materials disturbed during excavation, should be removed and the foundations extended to adequate natural bearing material. As an alternate, the existing fill or disturbed materials may be removed and replaced with on-site or imported structural fill. New structural fill should extend down and out from the edges of the foundations at a 1 horizontal to 1 vertical projection.

6. Structural fill should consist of a non-expansive material with a swell potential that does not exceed 1% when remolded to 95% of the standard Proctor (ASTM D 698) maximum dry density at optimum moisture content and wetted under a surcharge pressure of 200 psf. Evaluation of potential sources may require determination of laboratory moisture-density relationships and swell consolidation tests on remolded samples. Structural fill should be placed and compacted to at least 95% of the standard Proctor (ASTM D 698) maximum dry density at moisture contents within 2 percentage points of the optimum moisture content for granular materials and between 0 and +3 percentage points of the optimum moisture content for clay materials.

7. It will be important to use proper construction equipment and techniques to avoid excessive disturbance of underlying wet subgrade soils. Use of low ground pressure tracked equipment or a hydraulic excavator working from outside of excavated areas may be necessary to avoid excessive subgrade disturbance during backfilling. Foundation excavations should also be completely dewatered such that foundation construction can be completed under relatively dry conditions.

8. Structural fill placed against the sides of the foundations to resist lateral loads should consist of on-site or imported material meeting the material and placement criteria recommended in Item 6.

9. The lateral resistance of a foundation placed on natural soils or compacted structural fill will be a combination of the sliding resistance of the foundation on the foundation materials and passive earth pressure against the side of the foundation. Resistance to sliding at the bottoms of the foundations can be calculated based on a coefficient of friction of 0.3. Passive pressure against the sides of the foundations can be calculated using a unit weight of 175 pcf for backfill zones that will not be inundated. Where backfill zones will be inundated at times, the passive pressure will need to be reduced based on the design water level. These lateral resistance values are working values.

10. A representative of the geotechnical engineer should observe all foundation excavations, observe and test compaction, and evaluate the suitability of all structural fill.

RETAINING STRUCTURES

Retaining structures should be designed for the lateral earth pressure generated by the backfill, which is a function of the degree of rigidity of the wall and the type of backfill material used. Below ground walls and retaining structures that are laterally supported and can be expected to undergo only a moderate amount of deflection should be designed for earth pressures based on the following equivalent fluid pressures:

CDOT Class 1 backfill (<20% passing No. 200 sieve) .... 50 pcf
On-site clayey sand backfill .... 55 pcf

Cantilevered retaining structures that can be expected to deflect sufficiently to mobilize the full active earth pressure condition should be designed for earth pressures based on the following equivalent fluid pressures:

CDOT Class 1 backfill (<20% passing No. 200 sieve) .... 40 pcf
On-site clayey sand backfill .... 45 pcf

The equivalent fluid pressure values recommended above assume drained conditions behind the retaining structures. The buildup of water behind a retaining structure will increase the lateral earth pressure imposed on the retaining structure. Laterally restrained retaining structures extending below the water table should be designed for the undrained at-rest condition using the following equivalent fluid pressures:

CDOT Class 1 backfill (<20% passing No. 200 sieve) .... 90 pcf
On-site clayey sand backfill .... 95 pcf

All of the equivalent fluid pressure values recommended above assume a horizontal backfill surface. An upward sloping backfill surface will increase the lateral earth pressure imposed on the retaining structure. Retaining structures should also be designed for appropriate surcharge pressures due to adjacent structures, vehicle traffic, and construction activities.

The zone of backfill placed behind retaining structures to within 2 feet of the ground surface should be sloped upward from the base of the structure at an angle of no steeper than 45 degrees from horizontal. The upper 2 feet of the structure backfill should consist of a relatively impervious on-site soil or a slab or pavement structure to reduce surface water infiltration into the backfill. To limit post-construction settlement, backfill should be placed in uniform lifts and compacted to at least 95% of the standard Proctor (ASTM D 698) maximum dry density where placed to depths of less than 8 feet and to at least 98% of the standard Proctor maximum dry density where placed at depths greater 8 feet. Granular backfill should be placed in 8-inch lifts and compacted at moisture contents within 2 percentage points of optimum. Care should be taken not to over compact the backfill since this could cause excessive lateral pressure on the walls. Hand compaction procedures, if necessary, should be used to prevent lateral pressures from exceeding the design values.

The lateral resistance of retaining structure foundations should be evaluated using foundation criteria presented in the "Spread Footing and Mat Foundations" section of this report. Backfill placed against the sides of the retaining structure footings to resist lateral loads should be compacted according to the criteria for backfill placed behind retaining structures presented above.

EXCAVATION AND GRADING CONSIDERATIONS

Site Preparation: Site preparation within areas to be graded should include stripping existing vegetation and topsoil, and excavation to establish planned site grades and subgrades for structures and other improvements. Material types encountered during site grading will generally consist of predominantly granular fills and natural soils and claystone bedrock. Although these materials can generally be excavated during site grading operations with heavy-duty conventional earth moving equipment, the contractor should be aware that the claystone bedrock is very hard and may be difficult to excavate in places.

Fill Materials: On-site granular fills and natural soils should be suitable for use as site grading fill and possibly as structural fill beneath foundations, ramp pavements, and flatwork areas. On-site natural clay soils, if encountered, and excavated claystone will not be suitable for use as structural fill beneath foundations, ramp pavements, and flatwork areas but may be suitable for use as site grading fill provided these materials can be adequately processed and compacted. Processing on-site clay soils and claystone would include moisture-conditioning to moisture contents between -1 and 3 percentage points above optimum and compacting these materials to at least 95 percent of the standard Proctor (ASTM D 698) maximum dry density where 8 feet thick or less, and to at least 100 percent of the standard Proctor (ASTM D 698) maximum dry density where thicker than 8 feet.

The contractor should provide adequate equipment to produce a uniform and stable fill that meets compaction and moisture requirements outlined in the pertinent sections of this report. As mentioned, the claystone bedrock is very hard. Based on our experience with similar bedrock materials, we believe it will be difficult for the Contractor to break down and moisture condition excavated bedrock sufficiently to meet the placement and compaction requirements recommended herein.

Temporary Excavations: We assume that the site excavations will be constructed by generally over-excavating the side slopes to a stable configuration where enough space is available. All excavations should be constructed in accordance with OSHA requirements, as well as state, local and other applicable requirements. Site excavations will generally encounter predominantly granular fills and natural soils and claystone bedrock. Fills and natural granular soils generally classify as OSHA Type C soils.

Claystone bedrock generally classifies as Type A soil, although fractured and weathered bedrock may classify as Type B. Claystone bedrock may also behave as a Type B soil if the bedrock slakes or deteriorates; this may occur if the claystone is left exposed for a significant period of time. The Contractor should consider these possibilities when planning excavations into bedrock.

Excavation below groundwater and/or the presence of ground water in excavated slopes may require slopes flatter than those recommended by OSHA and/or require temporary shoring. Excavations within the river bed will likely require temporary cofferdams to reduce seepage into the excavation. Cofferdam systems commonly used in the Denver area include interlocking driven sheet piles and earthen berms. Due to the very hard bedrock anticipated to underlie most of the project reach, installation of sheet piles to the depths adequate for stability may be very difficult.

Excavated slopes in fill and natural granular soils, and in claystone bedrock, may soften due to construction traffic and erode from surface runoff. Measures to keep surface runoff from excavation slopes, including diversion berms, should be considered.

Excavation Dewatering: Site excavations are likely to encounter groundwater, and excavations within the river bed may be below the water level in the river. In areas underlain by shallow bedrock, groundwater is likely to be perched in the soils overlying the bedrock and/or in fractured zones within the near surface portion of the bedrock, and excavations within the river bed may be subject to seepage through the cofferdams.

Where the groundwater table is encountered at or near the base of the excavation or seepage occurs through the cofferdams, we believe site excavations generally can be dewatered during construction using perimeter and lateral trenches combined with sumps. The trenches should be sloped to sumps where water can be pumped from the excavation. If pumping from sumps cannot handle groundwater infiltration or seepage through the cofferdams, more extensive dewatering systems may be required, such as wells or well points, or seepage cutoffs may need to be constructed. Dewatering using wells and/or well point systems would be anticipated for excavations extending a few feet below groundwater in the natural granular alluvial soils, which are anticipated to have relatively high permeability.

In general, we recommend that the groundwater level be maintained at least three feet below the bottom of foundation excavations at all times to mitigate disturbance of the foundation soils and/or bedrock and to facilitate placement and compaction of structural fill. This criterion is more applicable for excavations underlain by natural soils; subgrade stability and/or disturbance is anticipated to be less of a concern where the excavation subgrade consists of the very hard claystone bedrock.

Permanent Cut and Fill Slopes: Based on our experience with soils and bedrock similar to those encountered on the site, we recommend that unreinforced embankment fills and permanent cut slopes above the groundwater table be constructed no steeper than 2H:1V based on stability requirements and 3H:1V for reducing erosion susceptibility. No formal stability analyses were performed to evaluate the slopes recommended above. Published literature and our experience with similar cuts and fills indicate the recommended slopes should have adequate factors of safety.

Seepage may be encountered in permanent excavation slopes. The risk of slope instability will be significantly increased if seepage is encountered in cuts, and a stability investigation should be conducted to determine if the seepage will adversely affect permanent cuts and fills.

Slopes constructed of or excavated in on-site fills and natural soils are expected to be moderately to highly susceptible to surface erosion under moderate sheet flows and highly susceptible to erosion under concentrated flows. Susceptibility to erosion can be limited by constructing the slopes at flatter inclinations, as recommended above, by establishing an appropriate vegetative cover or providing appropriate erosion protection, and by providing good surface drainage to direct surface runoff away from the slope faces. Consideration should be given to armoring river bank slopes in areas that might be subjected to disturbed flows or higher flow velocities, such as the outside of channel bends or at channel structures.

To provide a uniform base for fill placement, the ground surface underlying all new fills should be carefully prepared by removing all organic matter, scarifying where feasible to a depth of 12 inches, and re-compacting to at least 95% of the standard Proctor maximum dry density at moisture contents within 2 percentage points of optimum. Fills should be benched into cuts or natural slopes exceeding 4H:1V. Vertical bench heights should be between 2 and 4 feet.

DESIGN AND CONSTRUCTION SUPPORT SERVICES

Kumar & Associates, Inc. should be retained to review the project plans and specifications so that comments can be made regarding interpretation and implementation of our geotechnical engineering recommendations before these contract documents are finalized. We are also available to assist the design team in preparing specifications for geotechnical aspects of the project, and performing additional studies if necessary to accommodate possible changes in the proposed construction after the completion of our study. We recommend that Kumar & Associates, Inc. be retained to provide observation and testing services during construction to document that the intent of this report and the requirements of the plans and specifications are being followed during construction, and to identify possible variations in foundation conditions from that encountered in this study so that we can re-evaluate our recommendations if needed.

LIMITATIONS

This study has been conducted in accordance with generally accepted geotechnical engineering practice in this area for exclusive use of the client for design purposes. The conclusions and recommendations submitted in this report are based upon the data obtained from the exploratory borings at the locations indicated on Figs. 1A through 1C, and the proposed type of construction. This report does not reflect subsurface variations that may occur between the exploratory borings, and the nature and extent of variations across the site may not become evident until site grading and excavations are performed. If during construction, fill, soil, rock or water conditions appear to be different from those described herein, Kumar & Associates, Inc. should be advised at once so that a re-evaluation of the recommendations presented in this report can be made. Kumar & Associates, Inc. is not responsible for liability associated with interpretation of subsurface data by others.

The scope of services for this project does not include any environmental assessment of the site or identification of contaminated or hazardous materials or conditions. If the owner is concerned about the potential for such contamination, other studies should be undertaken.

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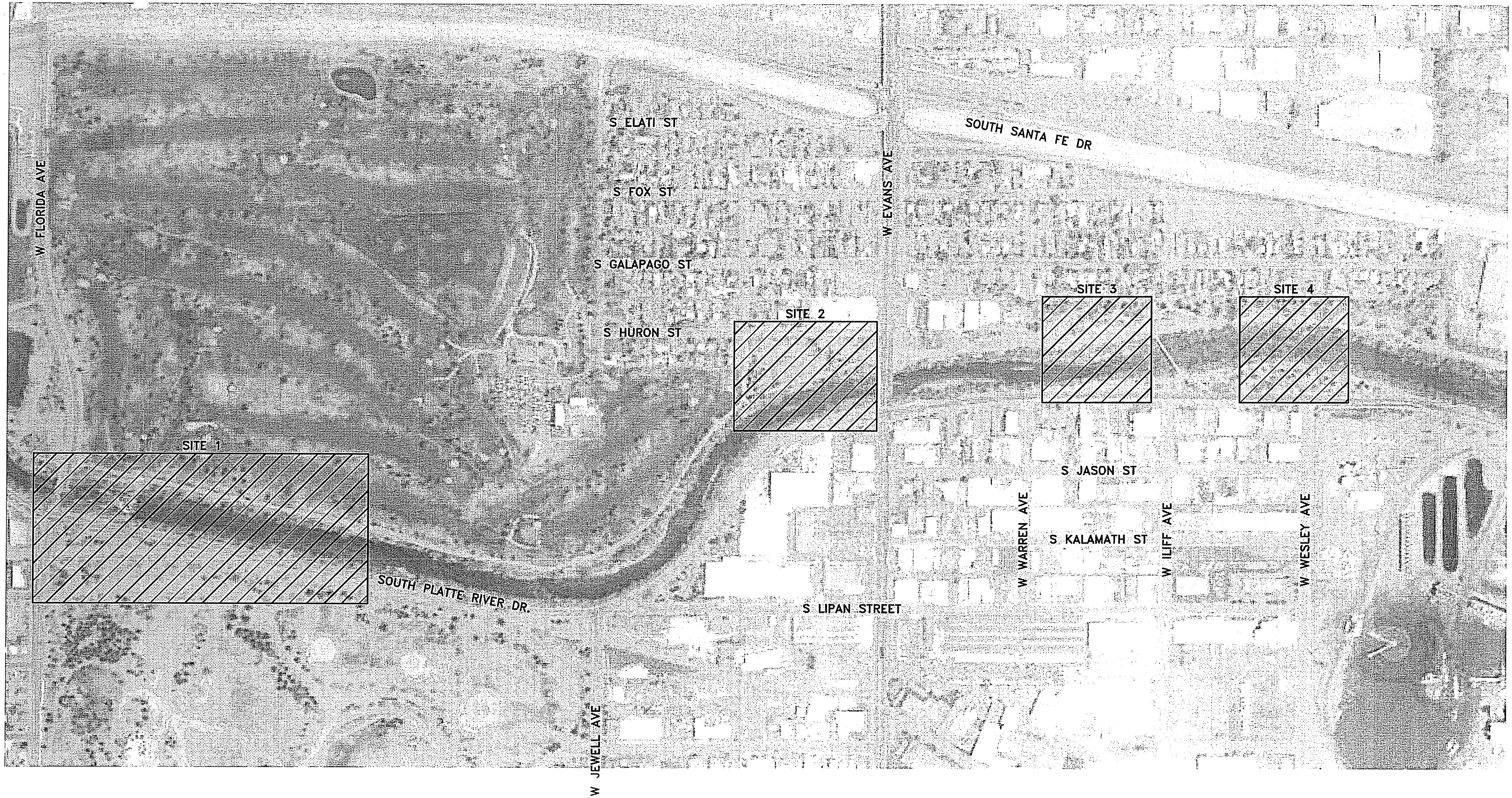

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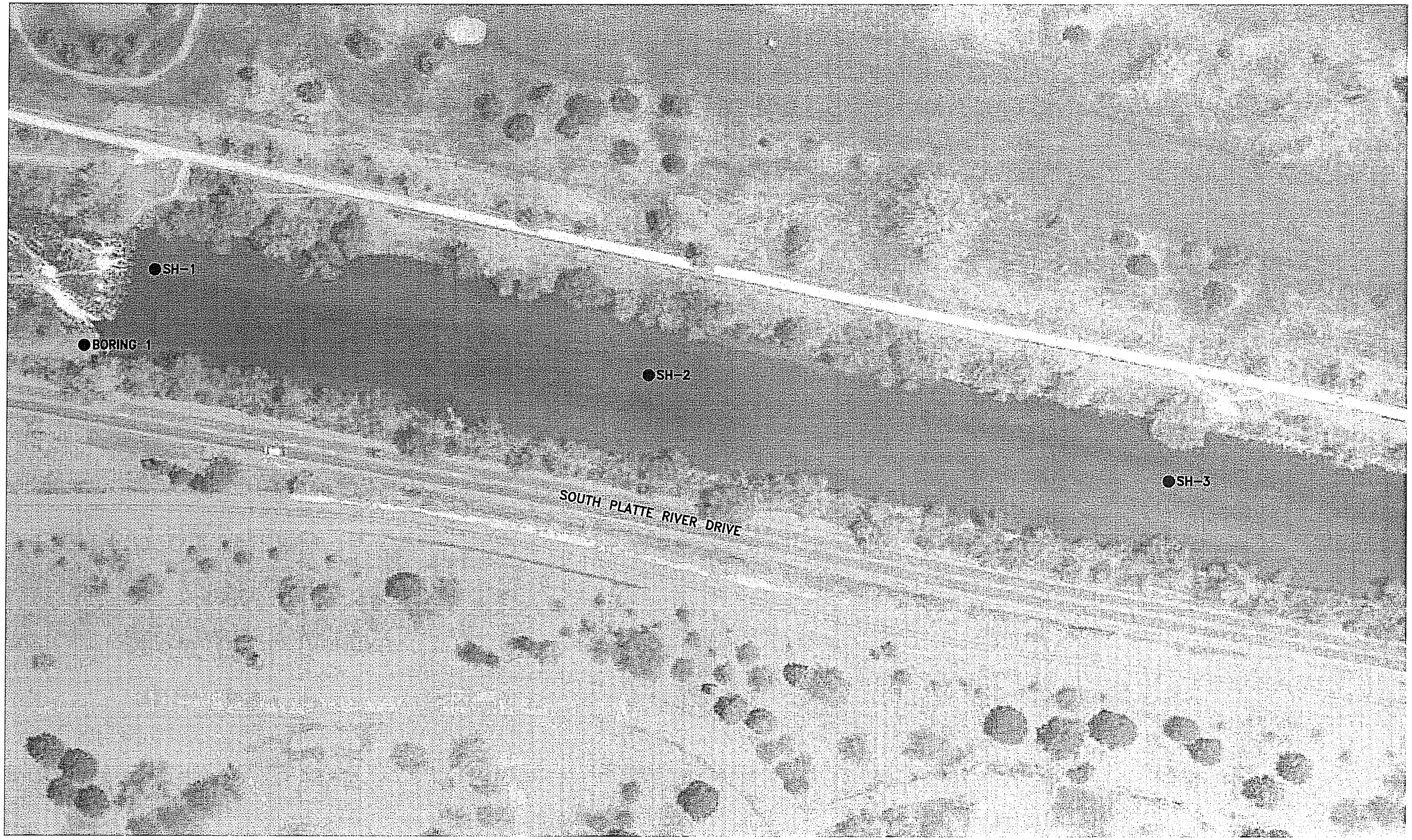
12-1-339	Kumar & Associates	SOUTH PLATTE RIVER RECREATION AND HABITAT IMPROVEMENTS, OVERTON POND PARK TO GRANT FRONTIER PARK REACH, DENVER, CO	SITE LOCATION	Fig. 1A



SITE 1

50 0 50 100

APPROXIMATE SCALE–FEET

12–1–339	Kumar & Associates	SOUTH PLATTE RIVER RECREATION AND HABITAT IMPROVEMENTS, OVERTON POND PARK TO GRANT FRONTIER PARK REACH, DENVER, CO	LOCATIONS OF EXPLORATORY BORINGS	Fig. 1B

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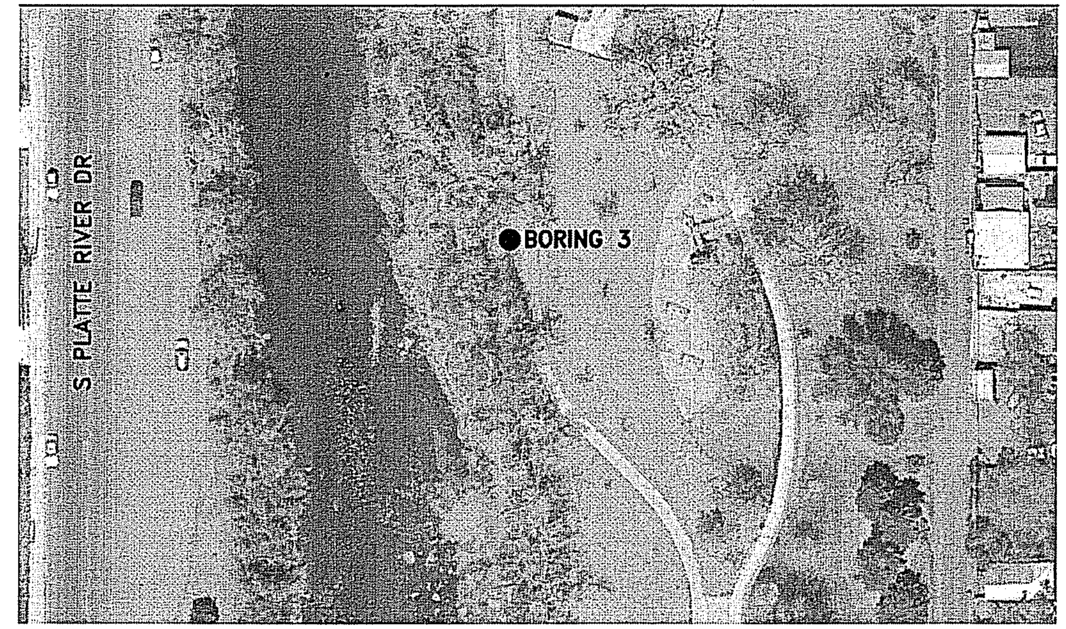
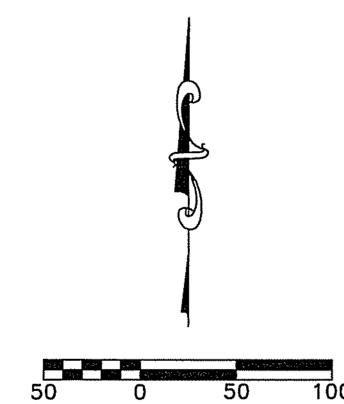
SITE 2: PASQUINEL'S LANDING PARK



SITE 3: GRANT FRONTIER PARK

SITE 4: HARVARD GULCH



12–1–339	Kumar & Associates	SOUTH PLATTE RIVER RECREATION AND HABITAT IMPROVEMENTS, OVERTON POND PARK TO GRANT FRONTIER PARK REACH, DENVER, CO	LOCATIONS OF EXPLORATORY BORINGS	Fig. 1C

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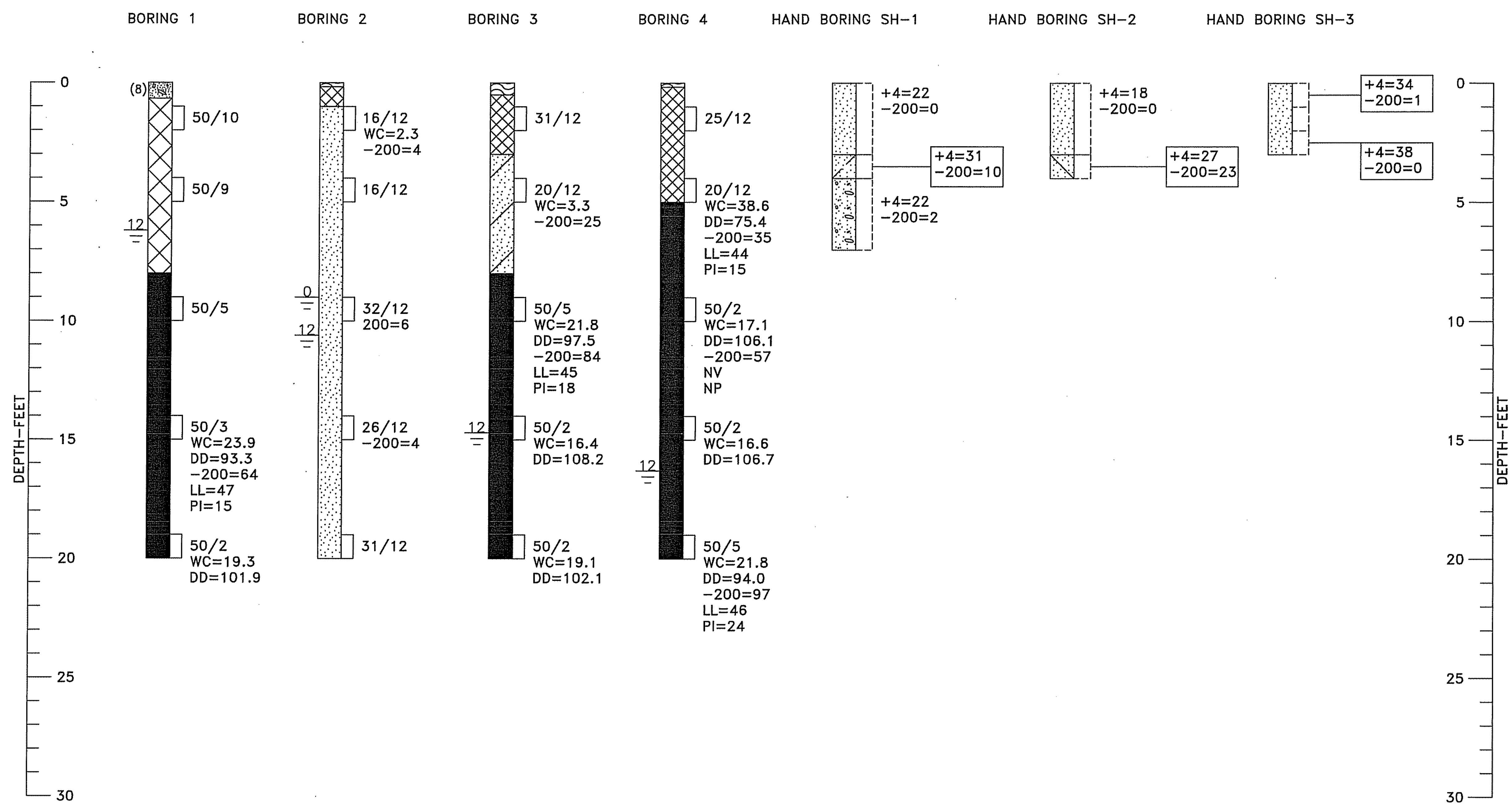

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12-1-339	Kumar & Associates	SOUTH PLATTE RIVER RECREATION AND HABITAT IMPROVEMENTS, OVERTON POND PARK TO GRANT FRONTIER PARK REACH, DENVER, CO	LOGS OF EXPLORATORY BORINGS	Fig. 2

LEGEND

TOPSOIL.

(8) BASE COURSE, THICKNESS IN INCHES SHOWN IN PARENTHESES TO LEFT OF THE LOG.

FILL: SILTY TO CLAYEY GRAVEL WITH SAND (GM-GC), DEBRIS (ASPHALT AND CONCRETE), AND ISOLATED ORGANICS, SLIGHTLY MOIST TO WET BELOW GROUND WATER, GRAY-BROWN.

FILL: CLAYEY SAND (SC) TO OCCASIONALLY SANDY LEAN CLAY (CL), FINE TO COARSE SAND, ISOLATED GRAVEL, SLIGHTLY MOIST TO MOIST, BROWN TO GRAY-BROWN.

POORLY- TO WELL-GRADED SAND WITH VARIABLE SILT AND GRAVEL (SP/SW), MEDIUM DENSE TO DENSE, SLIGHTLY MOIST TO WET BELOW GROUND WATER, BROWN.

POORLY-GRADED SAND WITH SILT (SP-SM), GRAVEL, SILTY SAND (SM) LENSES AND ISOLATED ORGANICS, MEDIUM DENSE, SLIGHTLY MOIST, BROWN.

WELL-GRADED SAND WITH SILTY CLAY AND GRAVEL (SW-SC), WET, BROWN.

POORLY-GRADED GRAVEL WITH SAND (GP), WET, BROWN.

SILTY CLAYEY SAND WITH GRAVEL (SM-SC), WET, BROWN.

CLAYSTONE BEDROCK WITH ISOLATED LENSES OF SANDY SILTSTONE BEDROCK, VERY HARD, SLIGHTLY MOIST, BLUE-GRAY (CLAYSTONE) TO OLIVE-BROWN (SILTSTONE).

DRIVE SAMPLE, 2-INCH I.D. CALIFORNIA LINER SAMPLE.

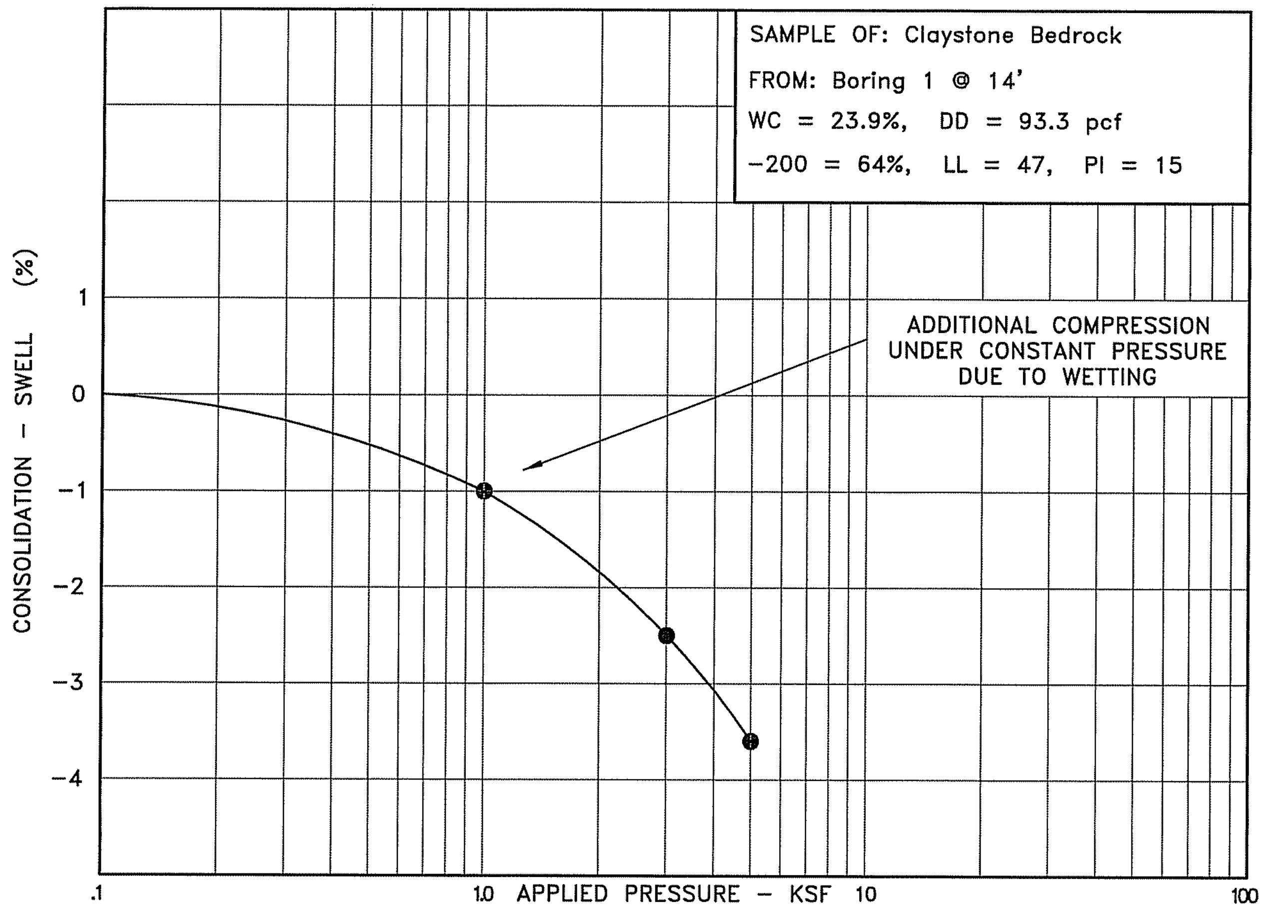
50/10 DRIVE SAMPLE BLOW COUNT. INDICATES THAT 50 BLOWS OF A 140-POUND HAMMER FALLING 30 INCHES WERE REQUIRED TO DRIVE THE SAMPLER 10 INCHES.

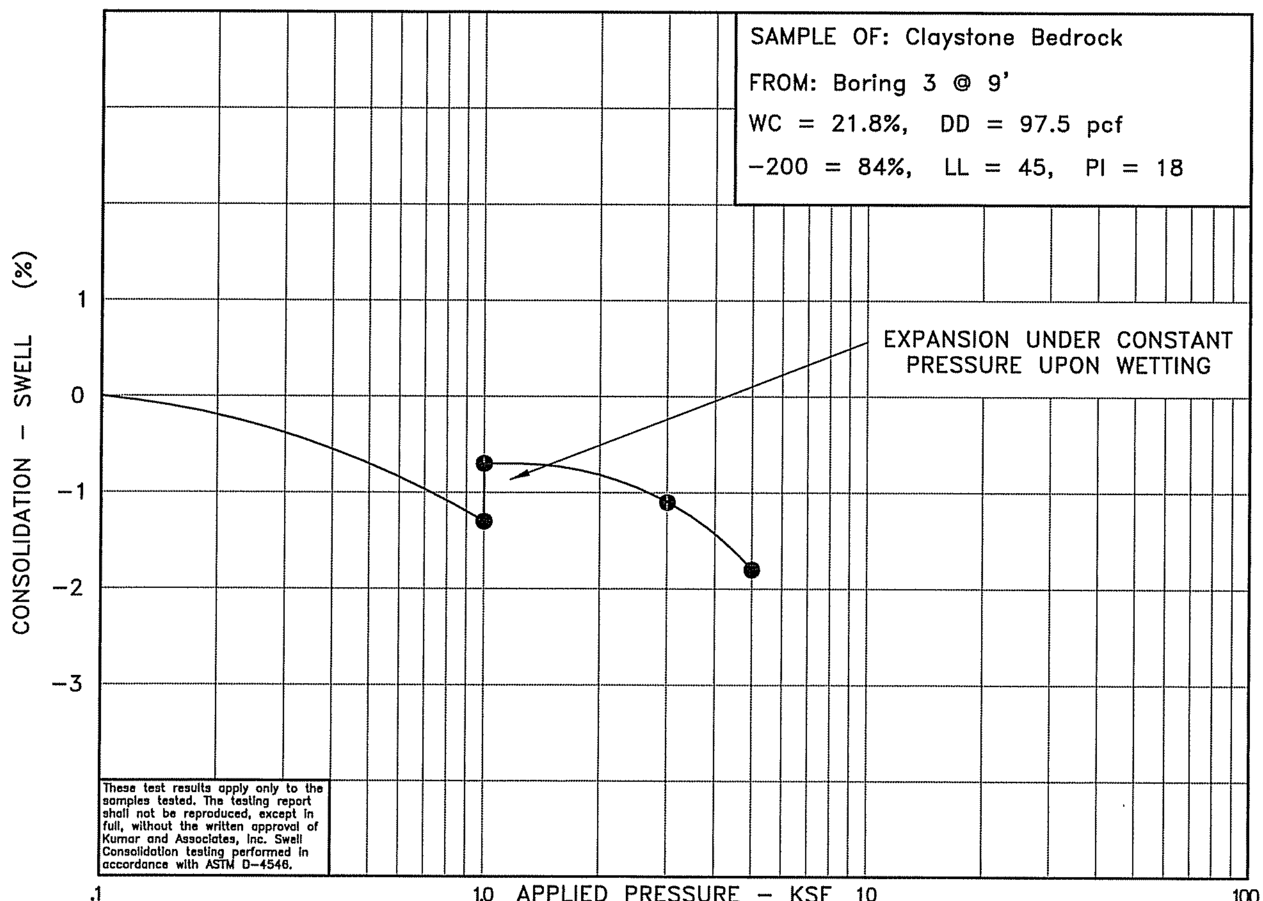
DISTURBED BULK SAMPLE.

12 DEPTH TO WATER LEVEL AND NUMBER OF DAYS AFTER DRILLING MEASUREMENT WAS MADE.

NOTES

1. EXPLORATORY BORINGS 1 THROUGH 4 WERE DRILLED ON JULY 20, 2012 WITH 4-INCH DIAMETER SOLID-STEM AND 7-INCH DIAMETER HOLLOW-STEM CONTINUOUS FLIGHT POWER AUGERS. SEDIMENT BORINGS SH-1 THROUGH SH-3 WERE HAND-AUGERED ON JULY 23, 2012.
2. THE LOCATIONS OF THE EXPLORATORY BORINGS WERE MEASURED APPROXIMATELY BY PACING FROM FEATURES SHOWN ON THE SITE PLAN PROVIDED.
3. THE ELEVATIONS OF THE EXPLORATORY BORINGS WERE NOT MEASURED AND THE LOGS OF THE EXPLORATORY BORINGS ARE PLOTTED TO DEPTH.
4. THE EXPLORATORY BORING LOCATIONS SHOULD BE CONSIDERED ACCURATE ONLY TO THE DEGREE IMPLIED BY THE METHOD USED.
5. THE LINES BETWEEN MATERIALS SHOWN ON THE EXPLORATORY BORING LOGS REPRESENT THE APPROXIMATE BOUNDARIES BETWEEN MATERIAL TYPES AND THE TRANSITIONS MAY BE GRADUAL.
6. GROUND WATER LEVELS SHOWN ON THE LOGS WERE MEASURED AT THE TIME AND UNDER CONDITIONS INDICATED. FLUCTUATIONS IN THE WATER LEVEL MAY OCCUR WITH TIME.
7. LABORATORY TEST RESULTS:
   WC = WATER CONTENT (%) (ASTM D 2216);
   DD = DRY DENSITY (pcf) (ASTM D 2216);
   +4 = PERCENTAGE RETAINED ON NO. 4 SIEVE (ASTM D 422);
   -200 = PERCENTAGE PASSING NO. 200 SIEVE (ASTM D 1140);
   LL = LIQUID LIMIT (ASTM D 4318);
   PI = PLASTICITY INDEX (ASTM D 4318);
   NP = NON-PLASTIC (ASTM D 4318);
   NV = NO LIQUID LIMIT VALUE (ASTM D 4318).





12–1–339	Kumar & Associates	SWELL–CONSOLIDATION TEST RESULTS	Fig. 4

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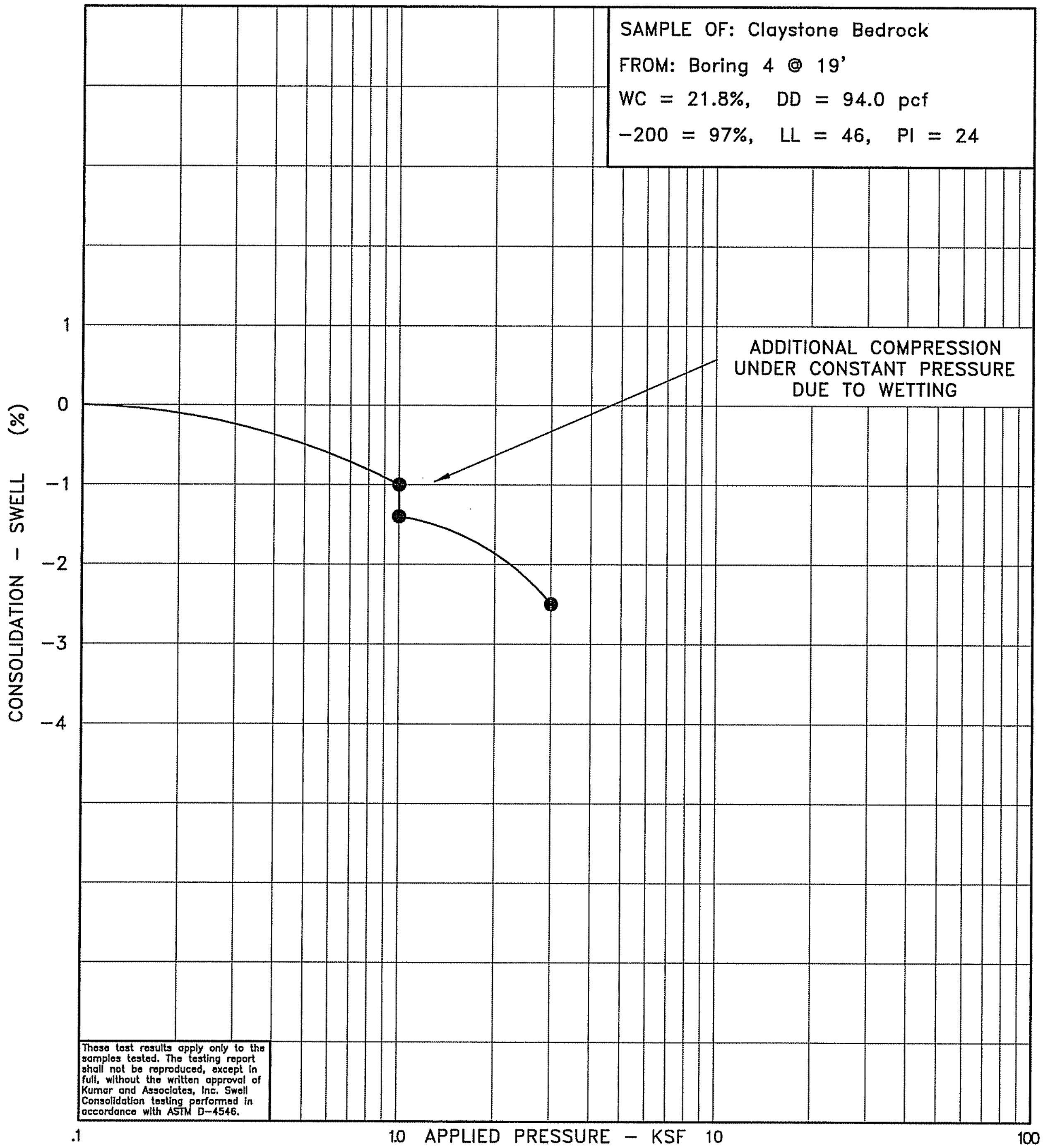

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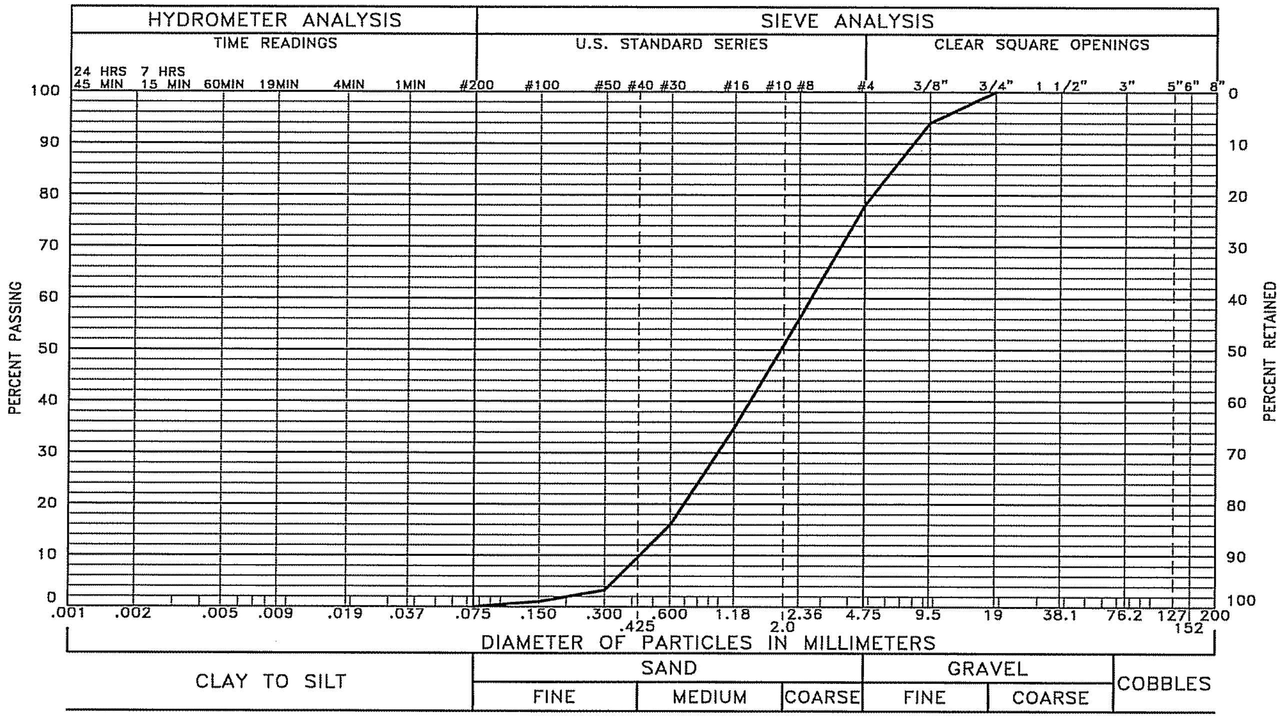
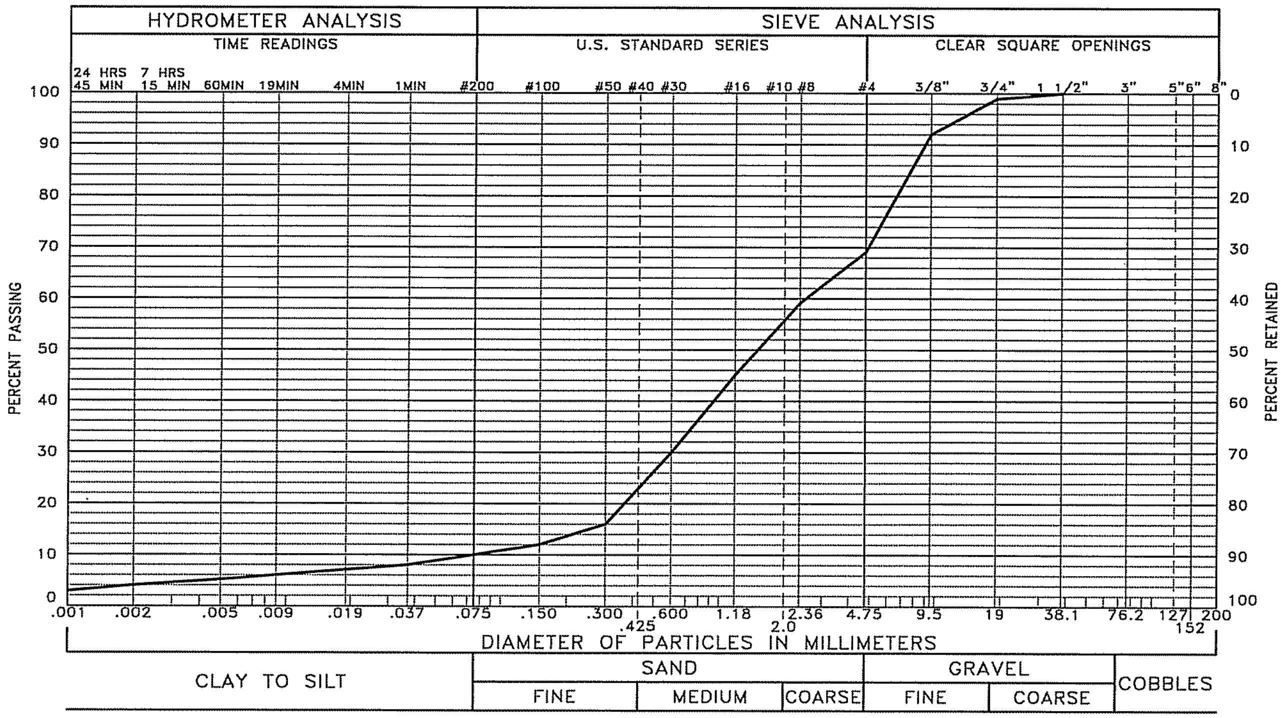
12-1-339	Kumar & Associates	SWELL-CONSOLIDATION TEST RESULT	Fig. 5



GRAVEL 22 % SAND 78 % SILT AND CLAY 0 %

LIQUID LIMIT PLASTICITY INDEX

SAMPLE OF: Poorly-Graded Sand with Gravel (SP) FROM: Boring SH-1 @ 0-3'



GRAVEL 31 % SAND 59 % SILT AND CLAY 10 %

LIQUID LIMIT PLASTICITY INDEX

SAMPLE OF: Well Graded Sand with Silty Clay (SW-SC) FROM: Boring SH-1 @ 3'-4'

These test results apply only to the samples which were tested. The testing report shall not be reproduced, except in full, without the written approval of Kumar & Associates, Inc. Sieve analysis testing is performed in accordance with ASTM D422, ASTM C136 and/or ASTM D1140.

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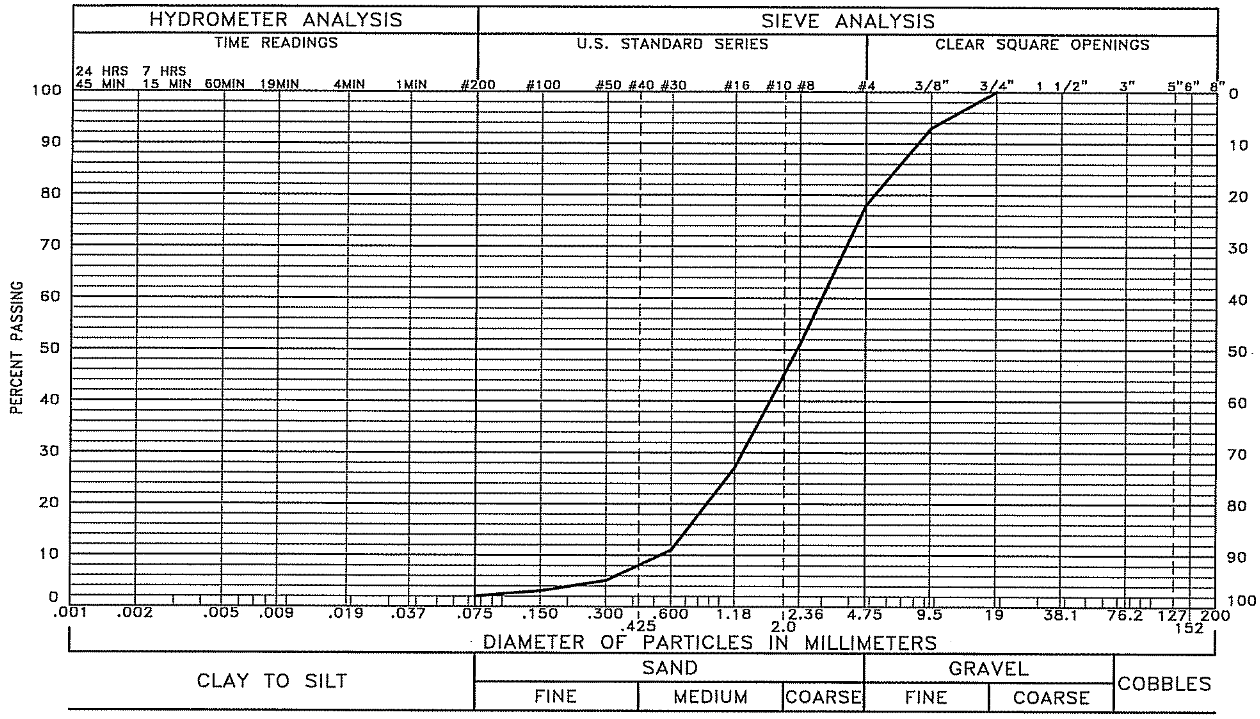
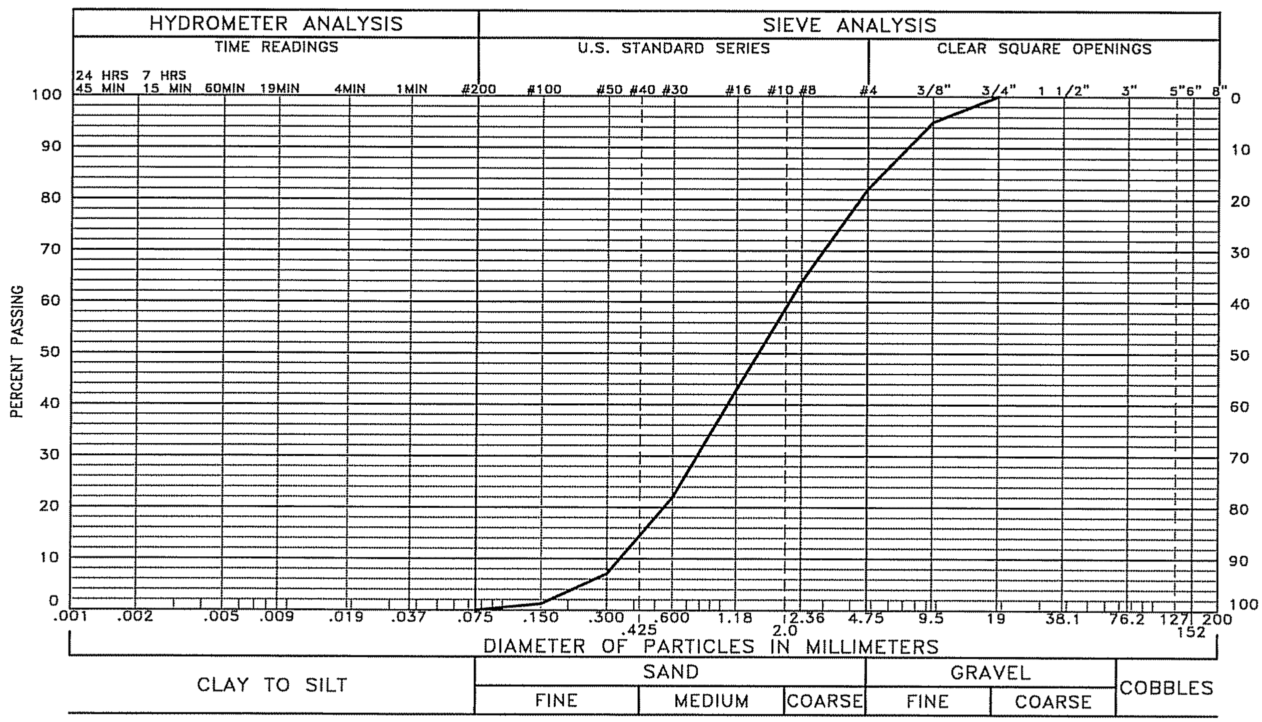
12-1-339	Kumar & Associates	GRADATION TEST RESULTS	Fig. 6



GRAVEL 22 % SAND 76 % SILT AND CLAY 2 %

LIQUID LIMIT PLASTICITY INDEX

SAMPLE OF: Poorly-Graded Gravel with Sand (GP) FROM: Boring SH-1 @ 4'-7'



GRAVEL 18 % SAND 82 % SILT AND CLAY 0 %

LIQUID LIMIT PLASTICITY INDEX

SAMPLE OF: Poorly-Graded Sand with Gravel (SP) FROM: Boring SH-2 @ 0-3'

These test results apply only to the samples which were tested. The testing report shall not be reproduced, except in full, without the written approval of Kumar & Associates, Inc. Sieve analysis testing is performed in accordance with ASTM D422, ASTM C136 and/or ASTM D1140.

12-1-339	Kumar & Associates	GRADATION TEST RESULTS	Fig. 7

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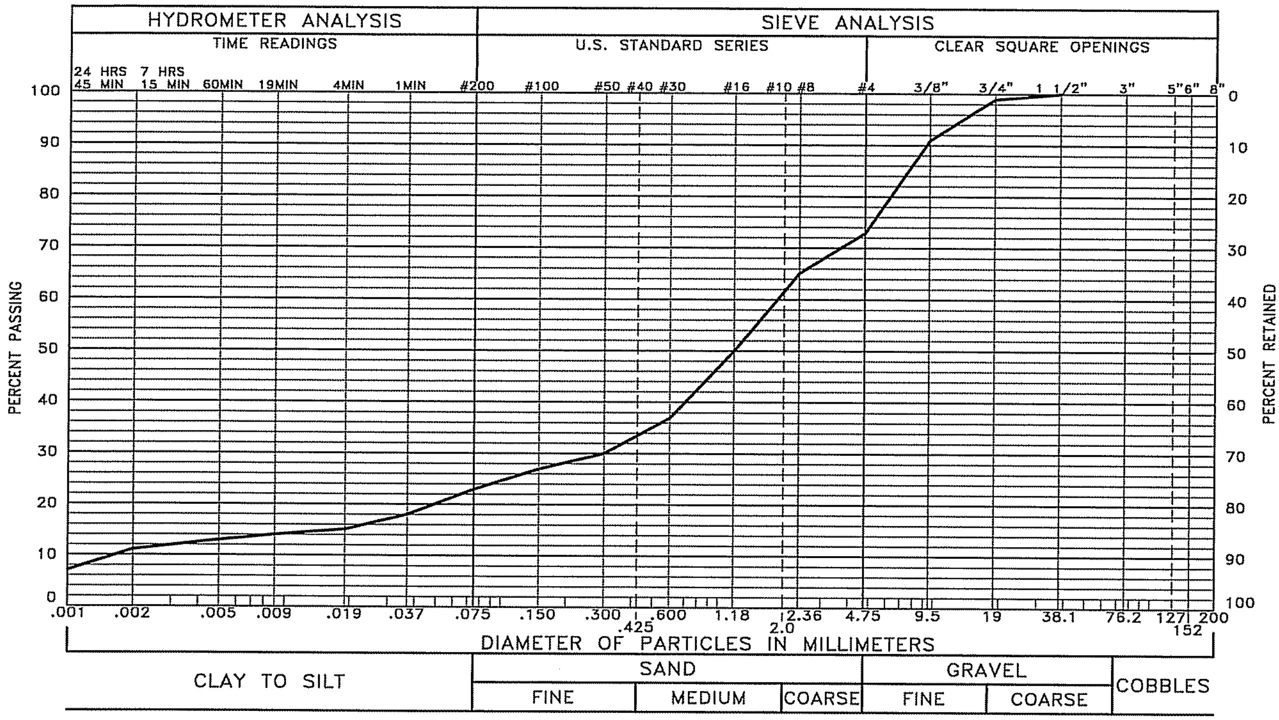
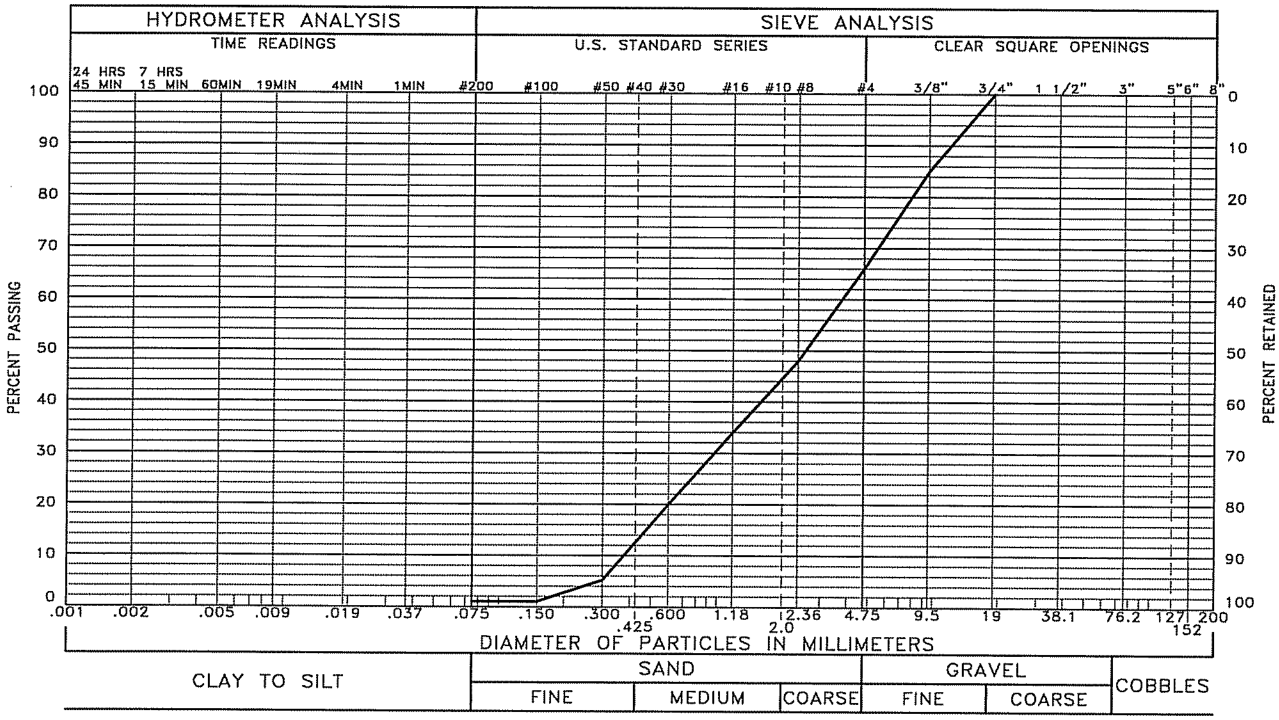


GRAVEL 27 % SAND 50 % SILT AND CLAY 23 %

LIQUID LIMIT PLASTICITY INDEX

SAMPLE OF: Silty Clayey Sand with Gravel (SM-SC) FROM: Boring SH-2 @ 3'-4'



GRAVEL 34 % SAND 65 % SILT AND CLAY 1 %

LIQUID LIMIT PLASTICITY INDEX

SAMPLE OF: Poorly-Graded Sand with Gravel (SP) FROM: Boring SH-3 @ 0-1'

These test results apply only to the samples which were tested. The testing report shall not be reproduced, except in full, without the written approval of Kumar & Associates, Inc. Sieve analysis testing is performed in accordance with ASTM D422, ASTM C136 and/or ASTM D1140.

12-1-339	Kumar & Associates	GRADATION TEST RESULTS	Fig. 8

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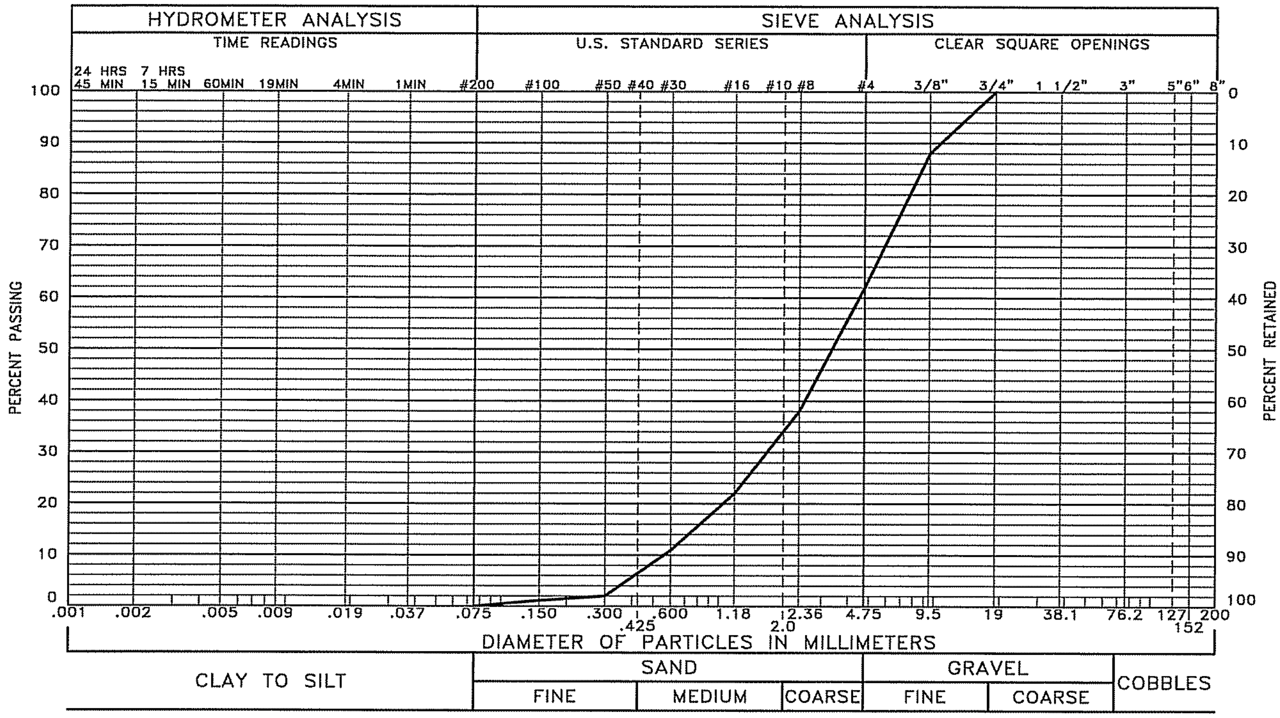
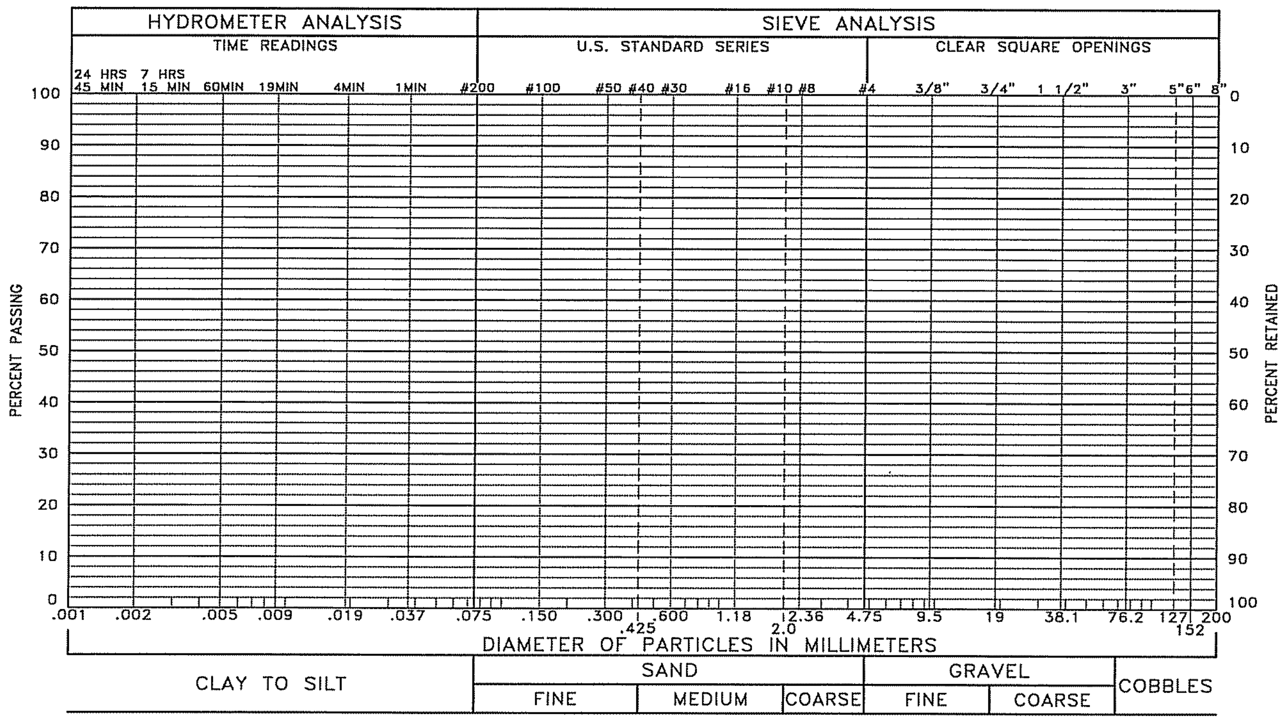


GRAVEL 38 % SAND 62 % SILT AND CLAY 0 %

LIQUID LIMIT PLASTICITY INDEX

SAMPLE OF: Well-Graded Sand with Gravel (SW) FROM: Boring SH-3 @ 2'-3'



GRAVEL % SAND % SILT AND CLAY %

LIQUID LIMIT PLASTICITY INDEX

SAMPLE OF: FROM: Boring

These test results apply only to the samples which were tested. The testing report shall not be reproduced, except in full, without the written approval of Kumar & Associates, Inc. Sieve analysis testing is performed in accordance with ASTM D422, ASTM C136 and/or ASTM D1140.

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12-1-339	Kumar & Associates	GRADATION TEST RESULTS	Fig. 9

TABLE I
SUMMARY OF LABORATORY TEST RESULTS

PROJECT NO.: 12-1-339
PROJECT NAME: South Platte River Recreation and Habitat Improvements
DATE SAMPLED: 7-20-12 and 7-23-12
DATE RECEIVED: 7-25-12

SAMPLE LOCATION		DATE TESTED	NATURAL MOISTURE CONTENT (%)	NATURAL DRY DENSITY (pcf)	GRADATION		PERCENT PASSING No. 200 SIEVE	ATTERBERG LIMITS		SOIL OR BEDROCK TYPE
BORING	DEPTH (feet)				GRAVEL (%)	SAND (%)		LIQUID LIMIT (%)	PLASTICITY INDEX (%)	
B-1	14	7-25-12	23.9	93.3			64	47	15	Claystone Bedrock
B-1	19	7-25-12	19.3	101.9						Claystone Bedrock
B-2	1	7-25-12	2.3				4			Poorly-Graded Sand (SP)
B-2	9	7-25-12					6			Poorly-Graded Sand with Silt (SP-SM)
B-2	14	7-25-12					4			Poorly-Graded Sand (SP)
B-3	4	7-25-12	3.3				25			Silty Sand (SM)
B-3	9	7-25-12	21.8	97.5			84	45	18	Claystone Bedrock
B-3	14	7-25-12	16.4	108.2						Claystone Bedrock
B-3	19	7-25-12	19.1	102.1						Claystone Bedrock
B-4	4	7-25-12	38.6	75.4			35	44	15	Fill: Clayey Sand (SC)
B-4	9	7-25-12	17.1	106.1			57	NV	NP	Siltstone Bedrock
B-4	14	7-25-12	16.6	106.7						Claystone Bedrock
B-4	19	7-25-12	21.8	94.0			97	46	24	Claystone Bedrock
SH-1	0-3	7-25-12			22	78	0			Poorly-Graded Sand with Gravel (SP)
SH-1	3-4	7-25-12			31	59	10			Well-Graded Sand with Silty Clay and Gravel (SW-SC)
SH-1	4-7	7-25-12			22	76	2			Poorly-Graded Gravel with Sand (GP)
SH-2	0-3	7-25-12			18	82	0			Poorly-Graded Sand with Gravel (SP)
SH-2	3-4	7-25-12			27	50	23			Silty Clayey Sand with Gravel (SM-SC)
SH-3	0-1	7-25-12			34	65	1			Poorly-Graded Sand with Gravel (SP)
SH-3	2-3	7-25-12			38	62	0			Well-Graded Sand with Gravel (SW)

APPENDIX F

Preliminary (30%) Design Drawings

APPENDIX G

Station Conversion Information

Station Conversion

Design stationing used for the preliminary design follows the designed low flow channel (LFC) alignment that starts at Santa Fe Drive ; whereas, the regulatory stationing is based on the center of the South Platte River (SPR) starting at the Adams and Weld County Line. Due to the continuing increase in curvature between the SPR centerline and the LFC centerline, the conversion equation varies. Figure 1 represents the LFC station versus Station Conversion. The station conversion is the value used to add to the LFC station (or Design station) to receive the SPR Station (or Regulatory Station). Figure 2 presents the SPR station versus the Station Conversion. Use the station conversion to subtract from the SPR station in order to get the LFC station (or Design station).

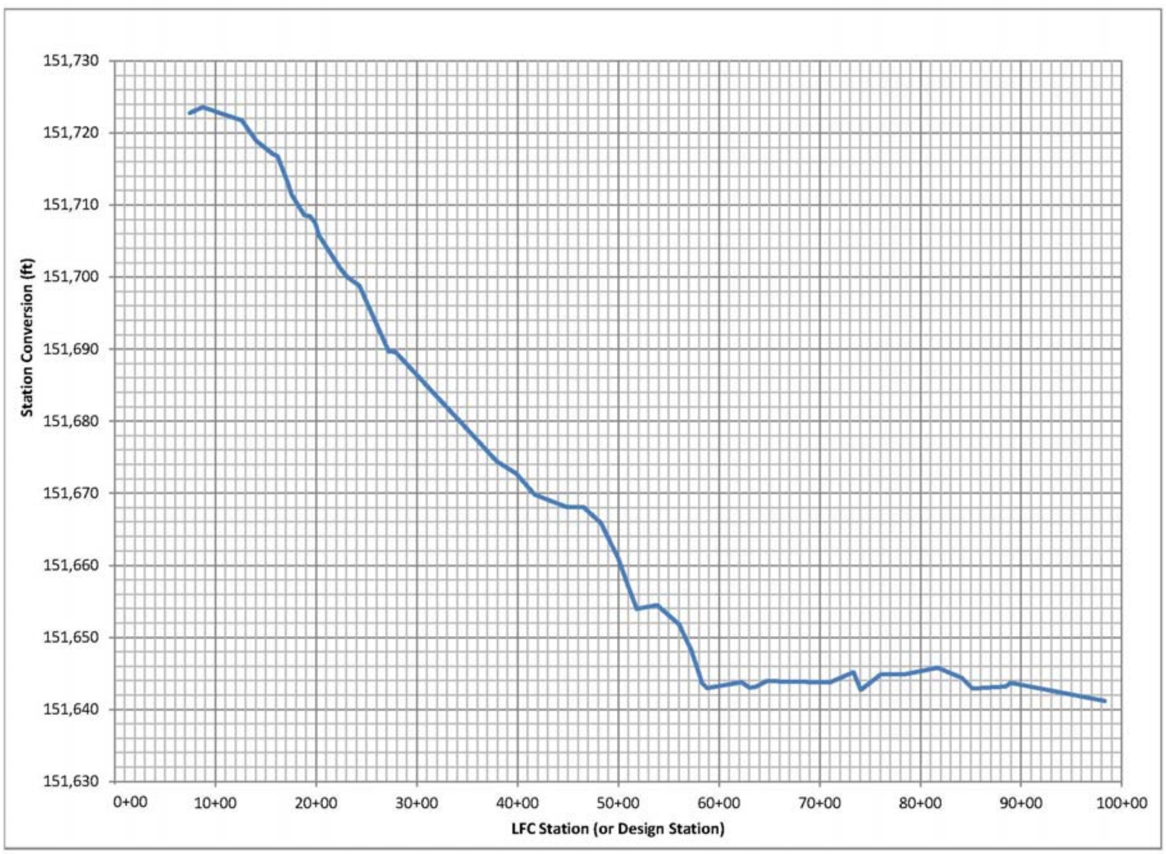


Figure 1. LFC station vs. Station Conversion

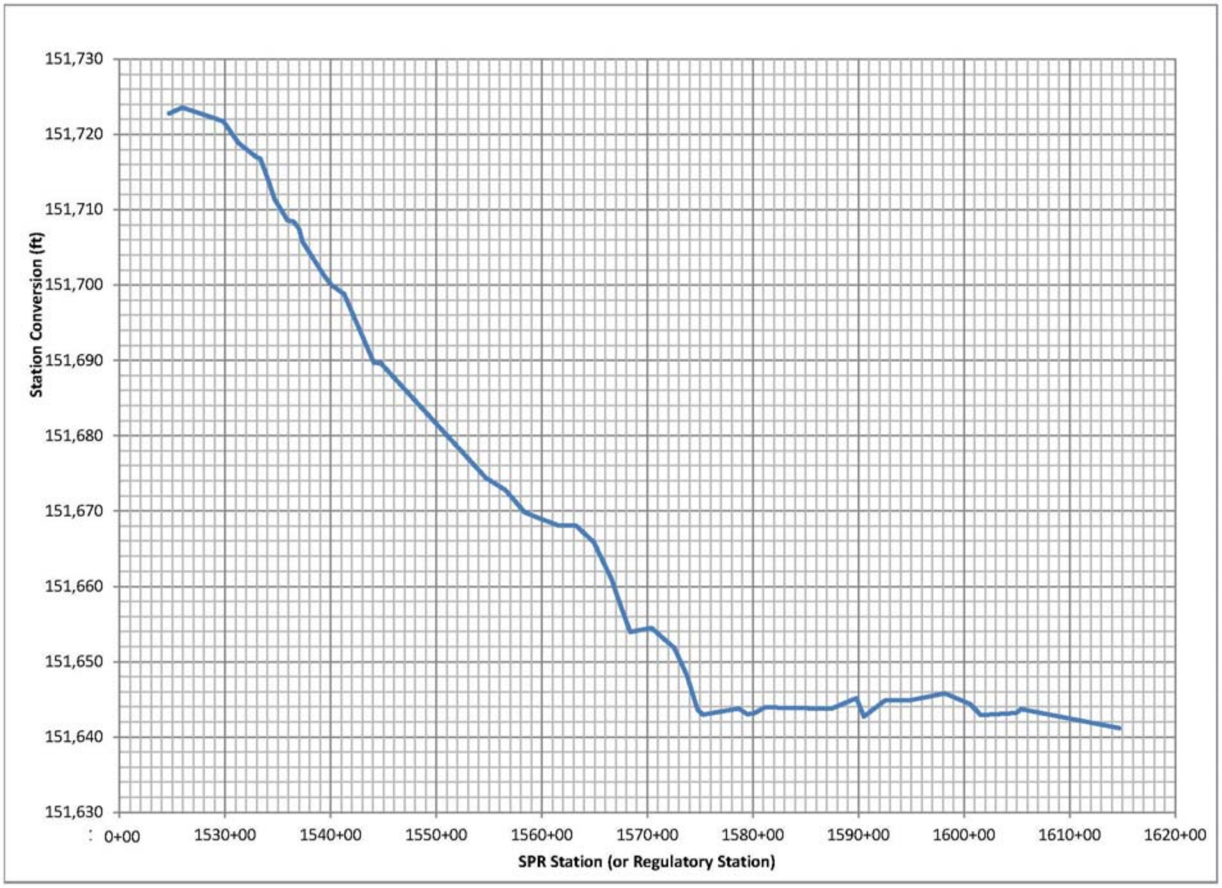


Figure 2. SPR station vs. Station Conversion

APPENDIX H

GOCO Funding Information

Development Project #3 - Grant Frontier/Overland

Proposed Budget

	Source of Funds	Date Secured		GOCO Grant Request	Applicant Match ($)	Partner Match ($)	Amount of CTF Funds ($)	Total Funding ($)
CASH								
	Great Outdoors Colorado	Pending		1,920,909				1,920,909
	City and County of Denver RMNA NRDS Funds	3/14/2012			496,020			496,020
	CWCB WSRA	9/13/2011				250,000		250,000
	Shattuck NRDS Funds	10/13/2011				1,700,000		1,700,000
	UDFCD	2/27/2012				1,242,051		1,242,051
IN-KIND								
	[List Source]							-
	[List Source]							-
	[List Source]							-
TOTAL SOURCE OF FUNDS				**1,920,909**	**496,020**	**3,192,051**	**-**	**5,608,980**

CASH	Use of Funds	Number of Units	Cost Per Unit	GOCO Funds	Applicant Funds	Partner Funds	CTF Funds	Total Funding ($)
CATEGORY 9 - Fish Habitat								
	In-Stream Structural Modifications for River Access	2,000	290	132,000		448,000		580,000
	Modify Existing Drop Structure Near Evans (LS)	1	280,000	228,909		51,091		280,000
	Modify Existing Drop Structure @ Florida (LS)	1	1,200,000	850,000		350,000		1,200,000
CATEGORY 10 - Boat Put-								
	Jetties (Each)	8	47,888	-		383,101		383,101
CATEGORY 11 - Access Trails								
	Access Trails and Trailheads (Each)	4	19,990	79,959				79,959
CATEGORY 12 - Potential								
	Tree Removal/Invasive Species (Each)	550	350	-	17,209	175,192		192,401
	Clear and Grub Vegetative Understory (SF)	400,000	0.15	-	14,963	45,006		59,969
	Promote Growth of Native Vegetation and New	20,000	30	540,087		59,606		599,693
	Bank Stabilization (CY)	3,000	100	-	22,467	277,379		299,846
	Deciduous Tree Planting (Each)	100	500	-	9,969	40,005		49,974
	Shrub/Riparian Plantings (Each)	27,500	6.25	-	24,851	146,936		171,787
	Native/Riparian Seed (SF)	400,000	0.15	-	11,963	48,006		59,969
CATEGORY 13 -								
	Environmental Playground (Each)	1	199,898	-	199,898			199,898
	Environmental Education (Each)	3	29,985	89,954				89,954
Design, Engineering and On the Ground Construction Management		1	852,521		126,120	726,401		852,521
USE OF FUNDS - CASH SUBTOTAL				**1,920,909**	**427,441**	**2,750,723**	**-**	**5,099,072**

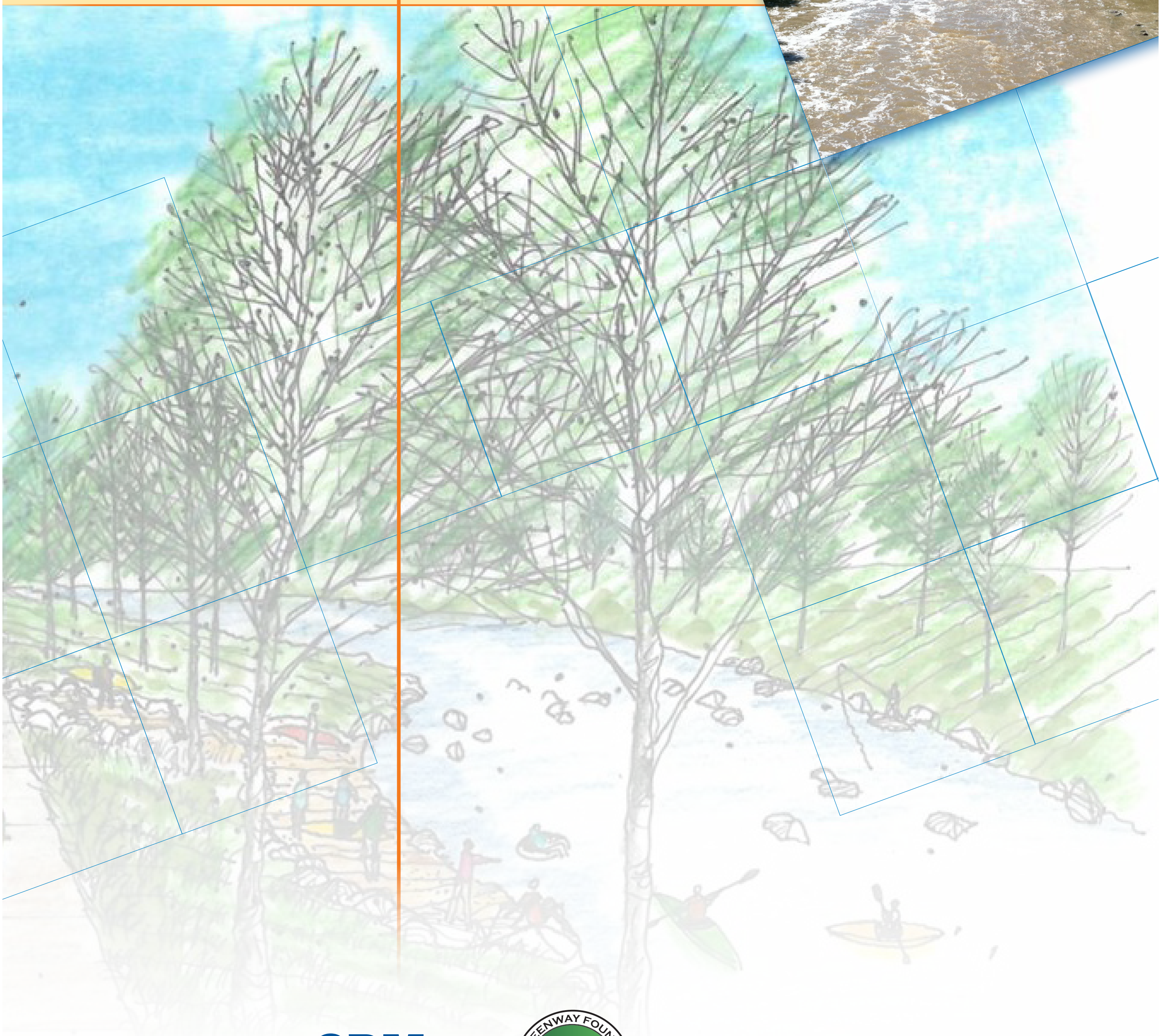
IN-KIND	Use of Funds	No. of Units / Hours	Cost Per Unit / Hour	GOCO Funds	Applicant Funds	Partner Funds	CTF Funds	Total Funding ($)
Professional Services								
vendor/service provider								$0.00
vendor/service provider								$0.00
Materials								
vendor/service provider								$0.00
vendor/service provider								$0.00
Equipment								
vendor/service provider								$0.00
vendor/service provider								$0.00
	USE OF FUNDS - IN-KIND SUBTOTAL				**$0.00**	**$0.00**		**$0.00**
	10% Contingency			**$0**	**$68,579**	**$441,328**	**$0**	**$509,907**
	TOTAL PROJECT COST			**$1,920,909**	**$496,020**	**$3,192,051**	**$0**	**$5,608,980**

CALCULATION OF MATCH REQUIREMENTS

Item	Explanation	Requirement	Actual	Meets Requirement?
Minimum Match	25%/Total Costs	$1,402,245	$3,688,071	Yes
Minimum Cash Match	10%/Total Costs	$560,898	$3,178,163	Yes

CALCULATION OF GOCO %

GOCO % of Total Costs 34.25%



CDM Smith

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