A CONCEPTUAL HABITAT RESTORATION DESIGN PLAN

FOR BOULDER CREEK

55th STREET TO 61ST STREET

Prepared For:

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I. INTRODUCTION

This report was prepared at the request of Mr. John Barnett, Tributary Greenway Coordinator, City of Boulder. It addresses Boulder Creek Reach 3-A extending between 55th Street and 61st Street (Figures 1 and 2). South Boulder Creek extending from the KOA pond outlet at Valmont Street to the confluence with Bouler Creek is also covered in this report. The intent of this project was to provide a design plan for a continuation of the Boulder Creek corridor project which previously ended at 55th Street.

II. PROJECT JUSTIFICATION

Reach 3-A was characterized as being severely degraded by straightening, channelization, dumping, tree cutting, gravel mining, grazing, rip-rapping and other poor land use practices. Short and long-term negative impacts have been imposed on the: 1) physical habitat, 2) riparian vegetation, 3) wetlands, 4) aquatic life, and 5) recreational and aesthetic potential. Stream, riparian and wetland functional characteristics have been eliminated. Nonpoint source pollution inputs continue to degrade water quality, and the flood attenuation function of the ecosystem has been lost.

III. PROJECT LOCATION

Reach 3-A extends 7,600 feet between 55th Street and 61st Streets within Boulder County, Colorado (Figure 2). The project area is bordered on the north by a mobile home park, Cline's Trout Hatchery operation, a pond, rural agricultural land, and City of Boulder open space land. Former gravel mining operations, ponds, City of Boulder open space land and agricultural land occupy the south streambank. The historic South Boulder Creek channel exits the KOA pond and becomes confluent with Boulder Creek approximately 1/2 mile downstream. Land ownership of the adacent South Boulder Creek streambanks include private, public and irrigation ditch company land. Pearl Street Parkway which currently dead-ends at 55th Street will be extended from its present location and will cross the creek in two different locations within the project reach.

The portion of Boulder Creek addressed in this project extends 2,200 feet between the KOA pond outlet and the confluence with Boulder Creek. This reach is bordered on the west by City Open Space and rural agricultural land. Rural agricultural land occupies the eastern streambank

IV. GOALS AND OBJECTIVES

The overall goal of this project was to produce a creative stream, riparian and wetland restoration conceptual design plan that could be implemented in the future when funds become available. Specific objectives included utilization of selected best management practices (BMPs) and techniques that would increase:

1. streambank stabilization and thereby decrease bank erosion, channel downcutting, and sediment transport;

2. holding water carrying capacity and standing stock (numbers and biomass);

3. high quality pool habitat and provide over-winter and low flow aquatic life survival;

4. riffle substrate structure (roughness) that would favor increased invertebrate productivity (fish food); and

5. potential for establishment of a healthy and functional stream, riparian and wetland ecosystem.

It was intended to meet these objectives by preparing:

1. a conceptual design plan identifying types and specific locations of recommended enhancements;

2. plan and cross section typical drawings;

3. preliminary cost estimates; and

4. details on nonstandard construction techniques.

V. APPROACH TO GOALS AND OBJECTIVES

The goals and objectives have been met by utilizing an interdisciplinary team consisting of: 1) an American Fisheries Society certified fisheries scientist and habitat restoration specialist (Dr. John T. Windell), 2) a landscape architect (Mr. John Barnett), 3) a riparian and wetland vegetation ecologist (Laurie Rink), 4) an engineer (Michael Rotar), and 5) a graphics designer (Alison Richards). Restoration, enhancement and creation experience from previous projects suggested that non-structural and structural improvements could be implemented following a thorough review of the detailed design plan.

VI. PROPOSED DESIGN PLAN

The design plan was based on: 1) field survey data collection, 2) existing topographic mapping (scale: 1" = 100 feet, with 2' contours), 3) information from the Project Implementation Plan (PIP) entitled: "The Boulder Creek Watershed Project for Nonpoint Source Pollution Control" (January 1991: 55 pages, 4 Figures, 2 Tables, and 4 appendices), and 4) other information.

The proposed design plan includes a 7,600 foot reach of Boulder Creek and a 2,200 foot reach of South Boulder Creek (Table 1). The Boulder Creek reach extends from 55th Street to 61st Street and South Boulder Creek extends from the KOA pond to its confluence with Boulder Creek. The Boulder Creek upstream boundary is located at an elevation of 5,189 feet and the downstream boundary at 5,155 for a 34 feet decrease and 0.45% gradient. The South Boulder Creek upstream boundary is located at an elevation of 5,183 feet and the downstream boundary at 5,169 feet for a 14 foot decrease and 0.64 gradient.

Average channel width for Boulder Creek ranged between 14 feet and 55 feet (mean 35.6') which translates into 4.3 surface acres of water per mile or a total of 6.2 surface acres within the project boundaries (Table 2). At low stream flow, channel width ranged between 12 feet and 49 feet which translates into 3.9 surfaces acres per mile or a total of 5.5 acres within the project boundaries.

A. Structural Improvements

The proposed design plan recommends implementation of 24 thalweg pools, 20 current deflectors, 13 jetties, 1 fish passage structure, and 3 V-dams within the Boulder Creek project reach. The South Boulder Creek plan recommends implementation of 7 thalweg pools, 2 current deflectors, 2 fish passage structures, 2 jetties, and 1 V-dam. Riffle enhancement is recommended at the 38 locations that correspond to each pool location. The type of habitat improvement, number planned for each reach, lengths, widths, depths and number of boulders required for construction are presented in Tables 4 through 8, and summarized in Table 19a The specific location of each structure is illustrated in the plan and profile engineering drawings (3' x 2').

1. Low Flow Pool Habitat Improvement. A total of 31 low flow (thalweg) pools are recommended for implementation in Boulder and South Boulder Creeks (Tables 4 and 4a). It is intended to recontour the channel by excavating a 5-18 foot wide, 4 foot deep pool ranging between 30 and 130 feet in length (includes entrance and tailout slopes).

Where possible, each pool has been located under trees to provide a vegetative canopy of overhead cover. Locations devoid of overhead cover have been recommended for biotechnical slope protection techniques and vegetative plantings. Recommended vegetation includes bare root or live stake plantings of cottonwood, peachleaf willow, sandbar willow and other locally available native species.

Material excavated from the low flow pools (spoils) shall be placed adjacent to the pool to form a point bar (bench) and to achieve the correct riffle elevation that will maintain a full pool during the lowest flows of the year. The point bar should be feathered away from the maximum pool depth at a 5 to 1 slope. No material will be placed on either streambank or removed from the site.

2. Riffle Stabilization and Roughness. It is recommended that the adjacent downstream riffle of each pool be roughened with 10 to 15 randomly placed 1.5'- 2.0' diameter boulders. The purpose of this roughness is to: 1) increase macroinvertebrate productivity, 2) provide cover for forage fish species, and 3) prevent riffle washout during high snowmelt runoff and storm flows.

3. Current Deflectors. Current deflectors must be strategically located to assure that flow is directed into the various pool types. Current deflectors are numbered from upstream (#1) to downstream (#20, plus 2 on South Boulder Creek) (Table 5). Each current deflector will require nine 3-foot diameter boulders, 10 brush bundles, and include an adjacent side channel 7 feet wide and 3 feet deep (fish cover). The precise locations and angles will be determined during construction. A total of 196 boulders and 218 brush bundles (sandbar willow) will be required. The top of each deflector shall be planted with sandbar willow live stakes on 1 foot centers.

4. V-Dam, Plunge Pool and Riffle Improvement. A total of 4 (upstream) V-Dams with plunge pools and riffle roughness improvements have been located in areas with adequate stream gradient (e.g., head of existing riffle), streambank height and overhead cover (Table 6). It is intended to place a large (3' dia.) keystone boulder in the center of the channel followed by adjacent boulders to form an upstream "V". A five foot deep pool will be excavated following boulder placement. Pool width will vary according to streambed width, and pool length and tailout will vary according to pool width. The number of cubic yards of substrate to be redistributed within the channel will vary according to channel width and pool length. The four V-Dams will require a total of 75 to 95 three foot diameter or larger boulders. Additional boulders

should be used to key the structure into the streambank and for creating instream fish cover.

Substrate material removed when forming pool habitat shall be used to form the correct downstream riffle elevation and be compacted by tracking with the rotating excavator. Roughness boulders will be added to stabilize the riffle. No spoils will be placed on either streambank. Some spoils may be used to plug cracks between the boulders of the V-Dam.

5. Jetty Structures. A total of 15 jetty structures are recommended for Boulder Creek and for South Boulder Creek (Table 7). All except one of those located on Boulder Creek are of the non-channel block type whereas both of those located on South Boulder Creek and the remaining one on Boulder Creek are intended to function as channel blocks.

6. Fish Passage Structures. The Butte Mill Ditch will require modification to permit upstream fish movement and facilitate spawning migrations (Table 8). Each concrete structure will be modified by placing rock material downstream at a 5 to 1 slope. Some grout may be required to stabilized the slope and prevent leakage. Substrate at the toe of the rock slope will be removed to form a pool. Excavated material will be used to form the correct downstream riffle elevation. Each riffle will be roughened with medium size boulders.

A 6 to 8 foot wide depression, 9 to 12 inches deep will be formed in the center of the rock slope to channel and concentrate flow during low flow months and allow migrating fish to move during the spawning season.

7. Structural Improvements Summary. Table 19a summarizes the type of improvements, total number of each structure, size of boulders required and the total number of boulders required for the recommended structural improvements.

B. Non-Structural Improvements

Proposed nonstructural improvements include the implementation of biotechnical slope protection and erosion control at 29 locations totalling 7,930 feet (Tables 10 through 18, and 19b). Brush layering, wattling, combination brush layering and wattling, live staking, and brush bundling techniques are recommended as appropriate for degraded and slumping slopes as well as at some of the above recommended structural improvements. Stabilization will require approaches that include bank cutting, streambank planting, boulder toe, erosion control fabric, and seeding and mulching in addition to the specifically recommended techniques.

The simplest approach consists of planting dormant live stake cuttings of fast growing, deep-rooted woody species such as sandbar willow along denuded streambanks.

1. Slope and Erosion Control with Vegetation. A total of seven existing rip-rapped banks are recommended for removal and replacement (Table 9). Four of the areas totalling 550 feet are recommended for biotechnical slope protection and erosion control treatment. Three areas totalling 935 feet do not require slope protection and erosion control.

C. Earthwork

1. Removal of Berms from Historic Channelization. A total of 11 gravel berm areas were identified and are recommended for removal, grading, and planting (Figure 3a and 3b). Station numbers, lengths, widths, heights and estimated volumes of fill are provided in Table 10. Berms range from 30 to 1,400 feet in length.

Approximately 28,000 cubic yards of fill could be removed and utilized for the Pearl Street Parkway extension.

2. Wetland Mitigation Sites. Field survey of the project site revealed two areas that qualify as wetland mitigation sites. Area 1 approximates 2.21 acres and area 2 approximates 2.28 acres (Table 21 and Figure 4). It is proposed to lower the existing grade of the areas to near the water table to facilitate growth of wetland vegetation. The amount of fill produced was calculated by using the Boulder Creek low flow water level elevation. Therefore, approximately 18,000 cubic yards and 29,000 cubic yards of fill could be produced from Areas 1 and 2, respectively.

3. Alternate Channel Sites. Historic channelization and gravel mining resulted in a designed realignment of the creek channel. Field survey revealed four sites where a new channel could be excavated to re-establish a more hydraulically stable meandering pattern (Figures 5a and 5b).

The lengths of the four potential cut areas range from 435 feet to 550 feet for a total length of 1,935 feet (Table 22). The Total number of cubic yards of fill that could be generated by exercising these alternatives ranges between 9,000 and 14,000 cubic yards for a total of 45,000 cubic yards.

4. Earthwork Summary. The total potential amount of fill available by: 1) removing berms (28,000 c.y.), 2) wetland creation (47,000 c.y.), and 3) channel realignment (45,000

c.y.) approximates 120,000 cubic yards that could be used for the Pearl Street Parkway extension.

VII. TIMING OF CONSTRUCTION

Timing of instream construction for stream habitat improvement projects is generally limited by high water flow and spring and fall trout spawning seasons. Consequently, construction of this project will be limited to the lowest flow part of the hydrologic cycle.

Nonstructural vegetation and biotechnical slope protection improvements can be constructed at any time except during the high flow spring runoff.

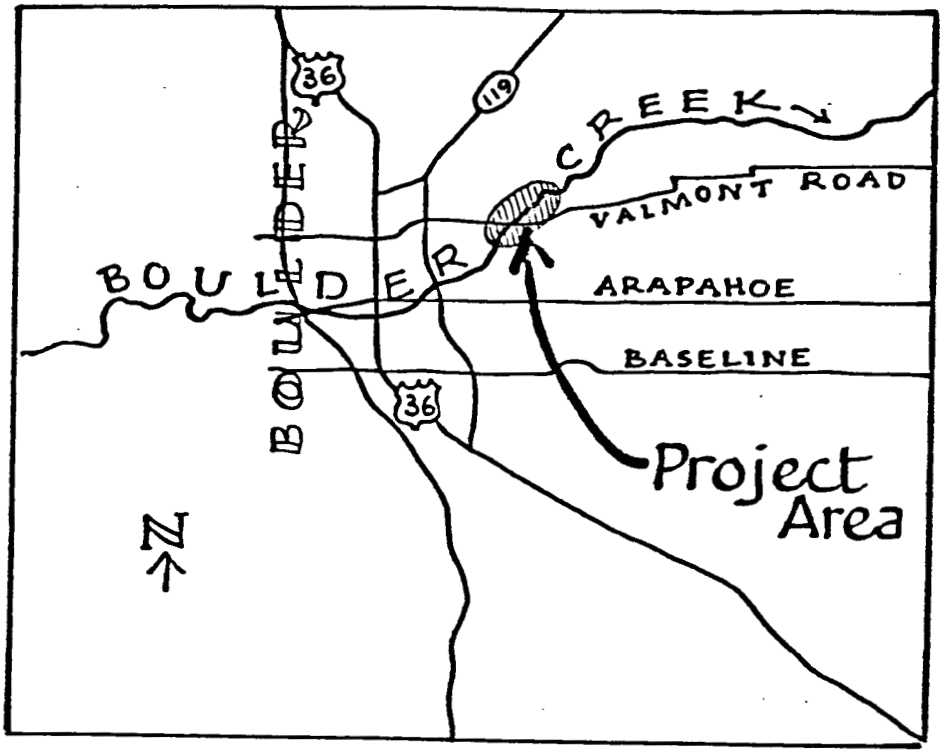
VIII. ESTIMATED COST

Cost to implement the structural and non-structural improvements is estimated to range between $20 and $25 per lineal foot. Based on a total design stream length of 9,800 feet, construction costs could range from $196,000 to $245,000. Costs associated with earthwork recommendations for wetland mitigation, alternate channel locations and berm removal, planting and transport are not included. However, the value of the 120,000 cubic yards of fill that will be generated for the Pearl Street Parkway will tend to offset the cost of this project.

IX. SUMMARY

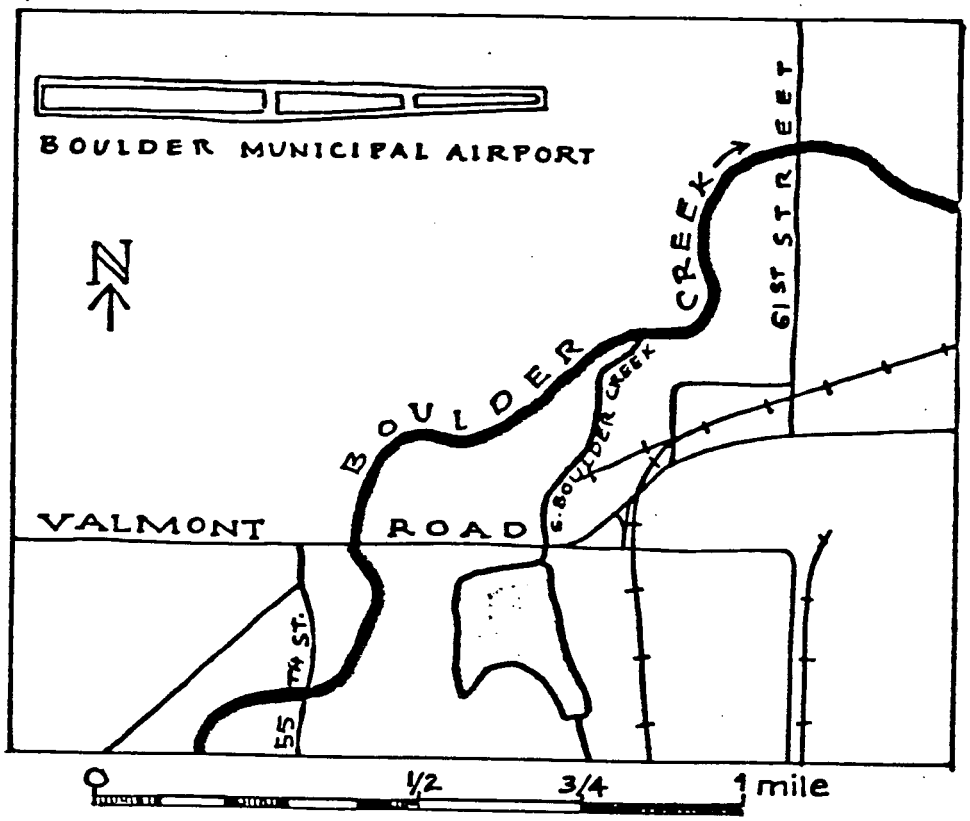
Selection of the type and location of each improvement was achieved by applying a number of principles including canopy density, pool-riffle ratio (from a natural reach), pool-riffle sequence concept (5 to 7), width to depth ratio, meander wavelength, and the velocity reversal concept. These principles and their calculation were strongly adhered to in order to assure long term hydraulic and functional stability.

It is recognized that Boulder Creek has the potential to become a more highly productive, aesthetic, and functional ecosystem. Simply, construction and proper management coupled with a long-range maintenance plan, could significantly increase the structural, functional and recreational opportunities.



Vicinity Map

Figure 1. Location of Project Area.



Location Map

Figure 2. Location of Project Area. Reach 3-A.

SCALE: 1" = 200'

— GRAVEL BERM

Figure 3a. Locations of proposed berm removal.

SCALE: 1" = 200'

- GRAVEL BERM

Figure 3b. Locations of proposed berm removal.

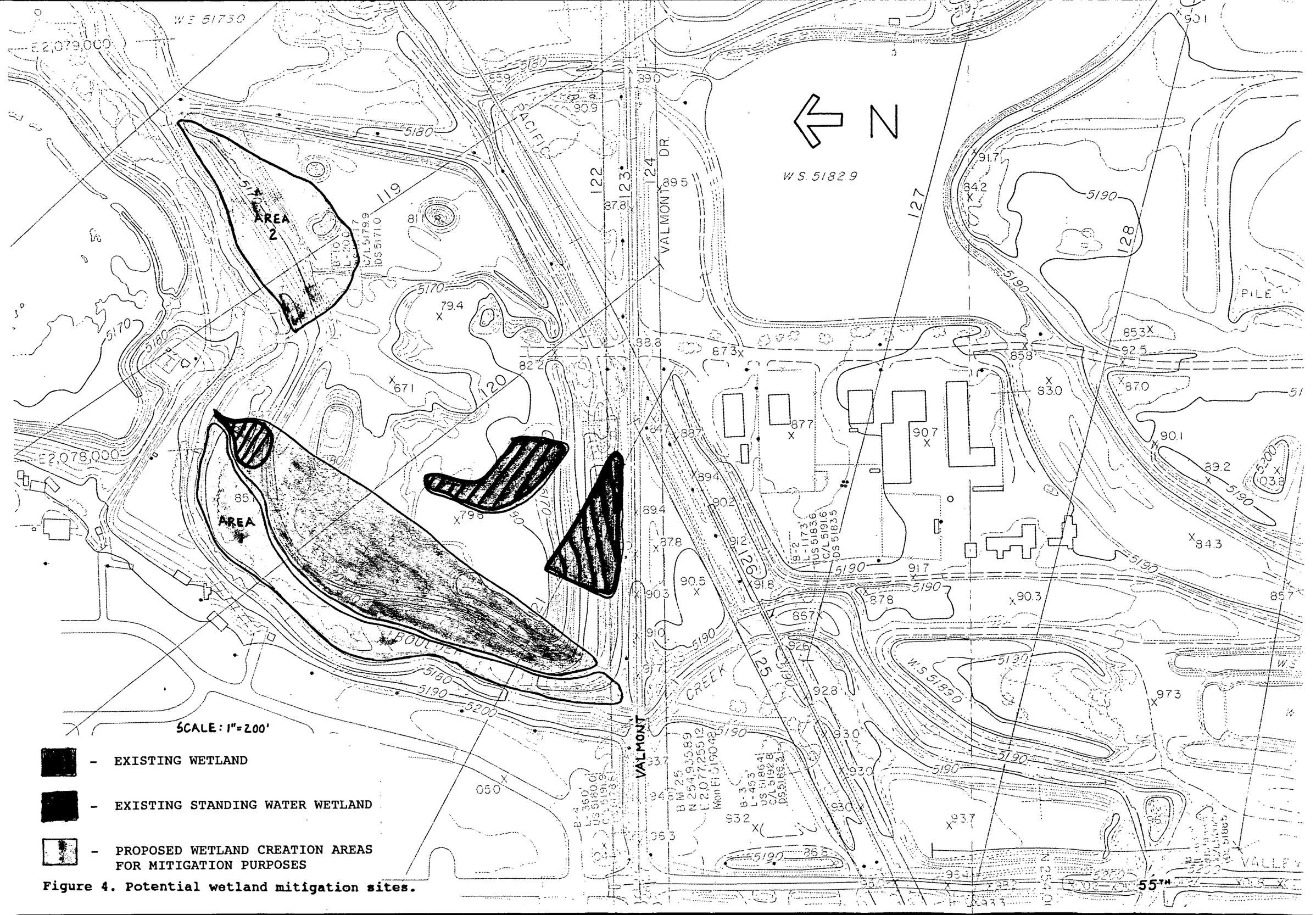


Figure 4. Potential wetland mitigation sites.

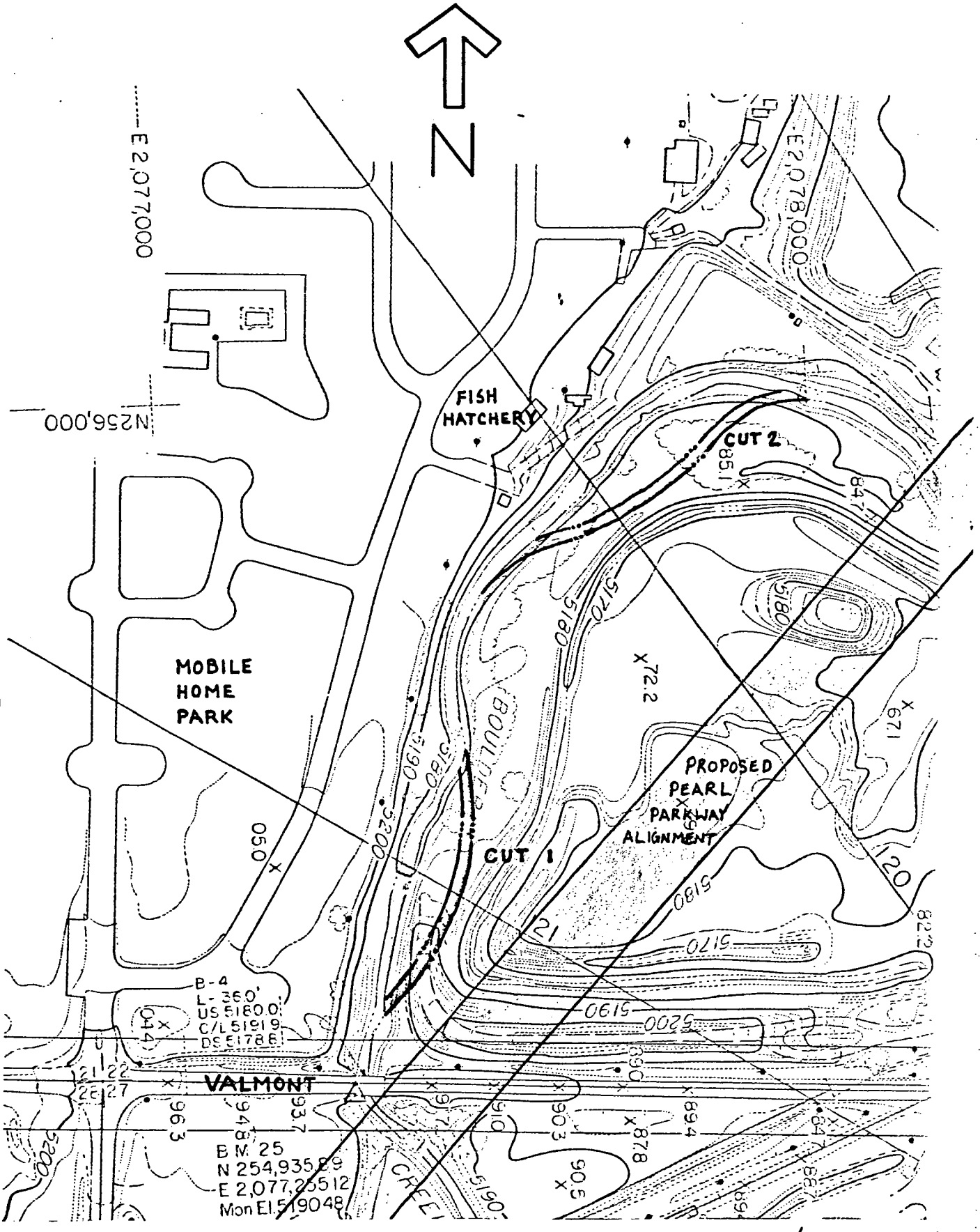


Figure 5a. Proposed Alternate Channel Realignment

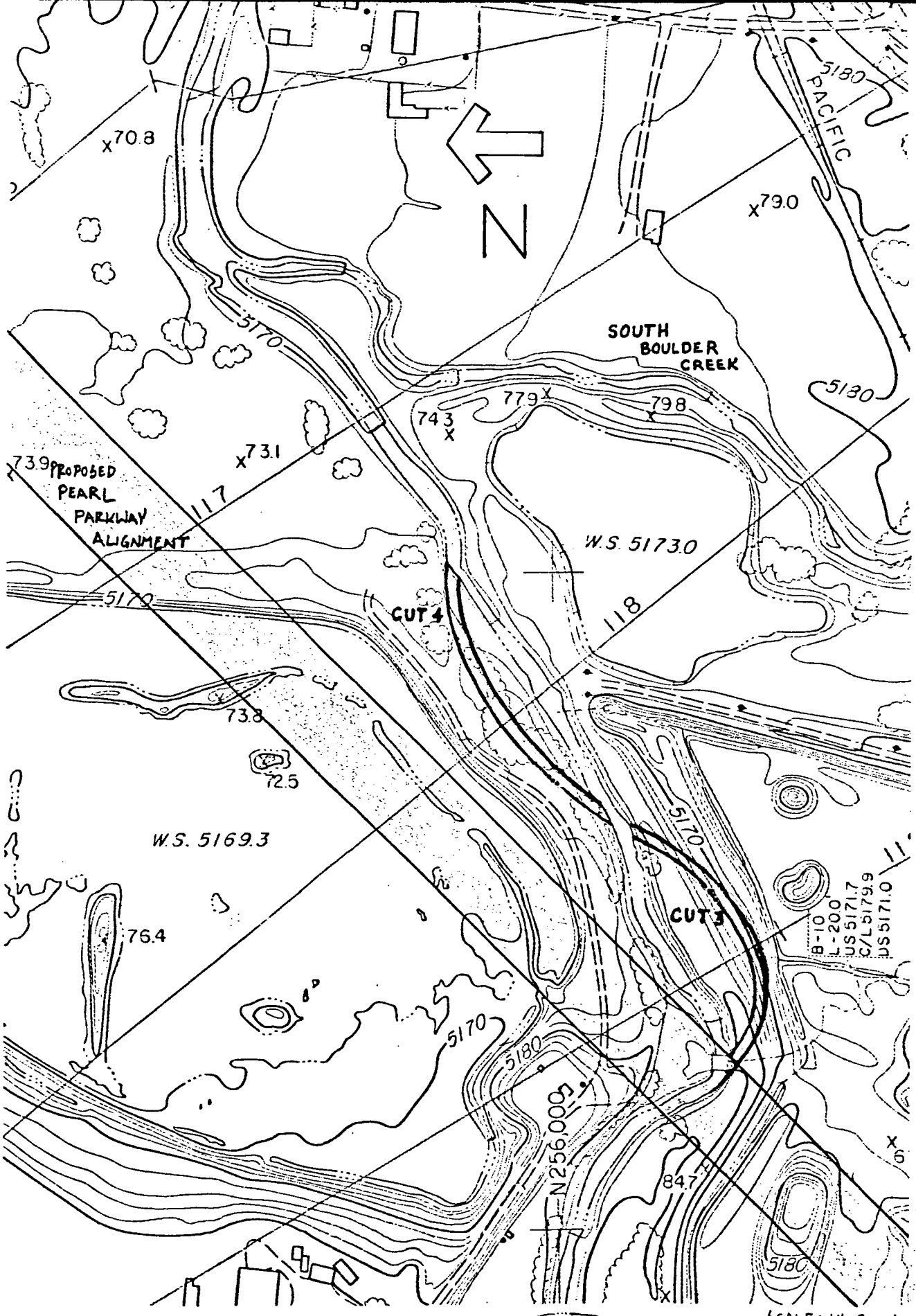


Figure 5b. Proposed Alternate Channel Realignment

TABLE 1

General Information - Boulder Creek

Project Boundaries	55th to 61st Street, Boulder, CO
Project Length (ft)	7,600
Upstream Boundary Elevation (ft)	5,189
Downstream Boundary Elevation (ft)	5,155
Elevation Decrease (ft)	34
Gradient (%)	0.45
Upper Station Number	1,010 + 00
Lower Station Number	934 + 00

General Information - South Boulder Creek

Project Boundaries	KOA Pond outlet to confluence with Boulder Creek, Boulder, CO
Project Length (ft)	2,200
Upstream Boundary Elevation (ft)	5,183
Downstream Boundary Elevation (ft)	5,169
Elevation Decrease (ft)	14
Gradient (%)	0.64
Upper Station Number	22 + 00
Lower Station Number	0 + 00

TABLE 2

Summary of existing channel width, water width and surface area (Boulder Creek only)

Average channel width (ft)	35.6	(14' - 55')
Channel surface acres/mile	4.3	
Channel surface acres/total	6.2	
Average low flow water width (ft)	31.8	(12' - 49')
Low flow surface acres/mile	3.9	
Low flow surface acres/total	5.5	

TABLE 3

All cut slopes will include boulders at the new slope tow and will be brush layered, wattled, or a combination of both. All excavated material is to be used on-site.

Improvement Number	Location by Upstream Station No.	Length (ft)	Height (ft)	Cubic Yards to Move
C - 1	999+90	290	8	690
C - 2	996+95	25	6	35
C - 3	997+30	165	3	55
C - 4	975+50	760	10	2,815
C - 5	953+80	170	3	57
*C - 6	951+90	130	4	78
C - 7	12+65	130	4	78
C - 8	10+95	340	4	202
C - 9	2+80	270	5	250

*To be completed only if Option 3 of vegetation treatment is chosen.

TABLE 4

Location, length and width of proposed thalweg pools (Boulder Creek)

Improvement Number	Location by Upstream Station No.	Pool Length (ft)	Pool Width (ft)	Current Deflector Required
TP - 1	1008 + 85	130	15	Yes
TP - 2	1003 + 25	60	15	Yes
TP - 3	999 + 60	100	15	Yes
TP - 4	994 + 30	50	15	Yes
TP - 5	992 + 65	75	15	Yes
TP - 6	990 + 25	50	15	Yes
TP - 7	988 + 75	60	15	Yes
TP - 8	987 + 05	60	15	Yes
TP - 9	985 + 00	75	15	Yes
TP - 10	983 + 60	30	10	Yes
TP - 11	982 + 40	60	15	Yes
TP - 12	981 + 20	80	15	Yes
TP - 13	978 + 50	60	15	Yes
TP - 14	976 + 25	50	15	No
TP - 15	973 + 70	60	15	Yes
TP - 16	967 + 85	60	15	Yes
TP - 17	963 + 95	80	15	Yes
TP - 18	960 + 75	50	15	No
TP - 19	959 + 30	50	15	No
TP - 20	957 + 20	100	15	Yes
TP - 21	954 + 55	30	10	Yes
TP - 22	952 + 05	100	15	Yes
TP - 23	949 + 45	50	15	No
TP - 24	947 + 40	50	15	Yes

TABLE 4a

Location, length and width of proposed thalweg pools (South Boulder Creek)

Improvement Number	Location by Upstream Station No.	Pool Length (ft)	Pool Width (ft)	Current Deflector Required
TP - 1a	19 + 05	30	8	No
TP - 2a	11 + 65	30	8	No
TP - 3a	10 + 95	30	8	Yes
TP - 4a	8 + 35	30	8	No
TP - 5a	7 + 40	30	8	Yes
TP - 6a	2 + 65	30	8	Yes
TP - 7a	1 + 90	40	8	No

TABLE 5

General location of current deflectors, current deflector dimensions, number of boulders required, and number of brush bundles required (Boulder Creek and South Boulder Creek)

Improvement Number	Location by Station Number	Right or Left Bank	Length (ft)	Width (ft)	Number of Boulders (3' diameter)	Number of Brush Bundles
CD - 1	Precise location and angle of current deflectors will be adjusted in the field	Left	15 - 18	9 - 12	9	10
CD - 2		Right	15 - 18	9 - 12	9	10
CD - 3		Left	15 - 18	9 - 12	9	10
CD - 4		Right	15 - 18	9 - 12	9	10
CD - 5		Right	15 - 18	9 - 12	9	10
CD - 6		Right	15 - 18	9 - 12	9	10
CD - 7		Left	15 - 18	9 - 12	9	10
CD - 8		Right	15 - 18	9 - 12	9	10
CD - 9		Right	15 - 18	9 - 12	9	10
CD - 10		Left	15 - 18	9 - 12	9	10
CD - 11		Right	15 - 18	9 - 12	9	10
CD - 12		Right	15 - 18	9 - 12	9	10
CD - 13		Right	15 - 18	9 - 12	9	10
CD - 14		Right	15 - 18	9 - 12	9	10
CD - 15		Right	15 - 18	9 - 12	9	10
CD - 16		Left	15 - 18	9 - 12	9	10
CD - 17		Left	15 - 18	9 - 12	9	10
CD - 18		Left	15 - 18	9 - 12	9	10
CD - 19		Left	15 - 18	9 - 12	9	10
CD - 20		Left	15 - 18	9 - 12	9	10
CD - 1a		Left	12 - 15	6 - 9	7	8
CD - 2a		Right	15 - 18	9 - 12	9	10

TABLE 6

Location of V-Dams by station number, with plunge pool dimensions, and total number of boulders required. The total number of boulders required includes those needed to secure (key) the V-Dams into the streambank, and those needed to provide instream cover for fish. (Boulder Creek and South Boulder Creek)

Improvement Number	Location by Station Number	Plunge Pool Length (ft)	Plunge Pool Width (ft)	Plunge Pool Depth (ft)	Number of Boulders (3' - 4' diameter)
VD - 1	1004 + 25	48	40	5	25 - 30
VD - 2*	995 + 75	36	30	5	20 - 25
VD - 3	974 + 55	26	22	5	15 - 20
VD - 1a	21 + 45	22	18	5	15 - 20

* Repair and improve existing structure located upstream of existing staff guage.

TABLE 7

Location and size of jetties, and number of boulders required (Boulder Creek and South Boulder Creek)

	Improvement Number	Location by Upstream Station No.	Jetty Length (ft)	Jetty Width (ft)	Jetty Height (ft. above channel invert)	Jetty Angle	Number of Boulders (1.0' diameter)
Jetty Group 1	J - 1	993 + 60	25	8	2 - 3	Precise angle of jetties will be adjusted in the field	300
	J - 2	993 + 40	25	8	2 - 3		300
	J - 3	993 + 20	25	8	2 - 3		300
	J - 4*	975 + 90	25	8	1 - 2		33**
Jetty Group 2	J - 5	960 + 25	25	8	2 - 3		300
	J - 6	960 + 05	25	8	2 - 3		300
	J - 7	959 + 85	25	8	2 - 3		300
	J - 8	959 + 65	25	8	2 - 3		300
Jetty Group 3	J - 9	956 + 10	25	8	2 - 3		300
	J - 10	955 + 90	25	8	2 - 3		300
	J - 11	955 + 70	25	8	2 - 3		300
Jetty Group 4	J - 12	949 + 90	20	8	2 - 3		240
	J - 13	949 + 70	20	8	2 - 3		240
	J - 1a*	19 + 75	35	8	1 - 2		43**
	J - 2a*	2 + 80	25	8	1 - 2		33**

* Jetties J - 4, J - 1a and J - 2a will function as low flow channel blocks, with both ends secured into the streambank.

** 2.0' diameter boulders will be used in these jetties instead of 1.0' diameter.

TABLE 8

Location, length, width, and height of fish passage structures, all with a 5 to 1 slope.

Fish Passage Structure No.	Irrigation Diversion Name	Station Number	Length (ft)	Width (ft)	Height (ft)	Number of Boulders (3' diameter)
FPS - 1	Butte Mill Ditch	997 + 00	25	58	5	170
FPS - 1a	*	22 + 00	15	40	3	70
FPS - 2a	Butte Mill Ditch	13 + 25	25	70	5	200

* Structure is located at the outlet of the KOA pond.

TABLE 9

Main locations of existing riprap, and recommendations for removal and bank treatment if necessary (Boulder Creek and South Boulder Creek)

Riprap Location Number	Location by Upstream Station No.	Right or Left Bank	Approximate Length (ft)	Recommended Removal	Recommended Treatment
RR - 1	1008 + 25	Right	135	Yes	None
RR - 2	998 + 00	Right	60	Yes	Brush Layering/Wattling
RR - 3	985 + 00	Left	550	Yes	None
RR - 4	979 + 00	Left	250	Yes	None
RR - 5	976 + 00	Right	300	Yes	Brush Layering
RR - 6	952 + 00	Right	150	Yes	Wattling
RR - 1a	8 + 15	Right	40	Yes	Wattling

TABLE 10

Two-year old whips (*Populus sargentii)* to be planted on 7 foot centers, one row.

BMP Number	Station Number Begin	Station Number End	Length (ft)	Total Number of Whips
CW - 1	1004+00	1000+30	370	55
CW - 2	993+50	989+60	390	58
CW - 3	988+65	983+65	500	75
CW - 4	955+15	953+60	155	23
CW - 5	21+85	20+30	155	23
CW - 6	21+85	20+30	155	23

TABLE 11

Two-year old whips of *Populus sargentii* and *Salix amygdaloides* to be planted on 7 foot centers, one row. The plantings will be made in a ratio of 3 cottonwoods for every 1 peach-leaf willow throughout.

BMP Number	Station Number		Length (ft)	Total Number of Cottonwood Whips	Total Number of Peach-Leaf Willow Whips
	Begin	End			
CWPL - 1	1005+00	1000+75	425	45	15
CWPL - 2	967+40	966+20	120	15	5
CWPL - 3	970+40	961+90	850	93	31
CWPL - 4	960+60	958+30	230	24	8
CWPL - 5	951+15	947+65	350	39	13
CWPL - 6	949+50	945+90	360	39	13
CWPL - 7	947+20	945+10	210	24	8
CWPL - 8	18+25	16+85	140	15	5
CWPL - 9	7+25	4+70	255	27	9
*Option 2	951+90	950+60	130	15	5

*To be completed only if Option 2 is chosen.

TABLE 12

Two-year old whips of *Populus sargentii* and *Salix amygdaloides*, and live stakes of *Salix exigua* to be planted on 7 foot centers, one row. The plantings will be made in a ratio of 2 cottonwoods for every 1 peach-leaf and sandbar willow throughout.

BMP Number	Station Number		Length (ft)	Total Number of Cottonwood Whips	Total Number of each type of Willow Whip and Live Stake
	Begin	End			
CWPS - 1	7+10	4+75	235	18	9

TABLE 13

Use *Salix exigua, Salix amygdaloides, Salix fragilis,* and *Populus sargentii* in equal quantities. Live willow and cottonwood stakes to be planted on 3 foot centers in rows that are three feet apart. Plant a sufficient number of rows to cover the entire point bar. Stagger plantings between rows.

BMP Number	Station Number		Length (ft)	Total Number of each type of Willow Stake	Total Number of Cottonwood Stakes
	Begin	End			
WCLS - 1	999+95	997+80	215	125	125
WCLS - 2	4+05	2+90	115	80	80
*Option 1	951+90	950+60	130	110	110

*To be completed only if Option 1 is chosen.

TABLE 14

Use equal numbers of *Salix exigua* and *Salix fragilis* to create wattles.

BMP Number	Station Number		Length (ft)	Height (ft)	Number of Rows
	Begin	End			
W - 1	997+30	995+65	165	3	3
W - 2	12+65	11+35	130	4	3
W - 3	10+95	7+55	340	4	3
W - 4	2+80	0+10	270	5	3
*Option 3	951+90	950+60	130	4	3

*To be completed only if Option 3 is chosen.

TABLE 15

Use equal numbers of *Salix exigua* and *Salix fragilis* to create brush layers.

BMP Number	Station Number		Length (ft)	Height (ft)	Number of Rows
	Begin	End			
BL - 1	953+80	952+10	170	3	2

TABLE 16

Use equal numbers of *Salix exigua* and *Salix fragilis* in creating brush bundles for brush layering and wattles.

BMP Number	Station Number		Length (ft)	Height (ft)	Number of Rows of Wattles	Number of Rows of Brush Layers
	Begin	End				
BLW - 1	999+90	997+00	290	8	2	2
BLW - 2	996+95	996+70	25	6	2	1

TABLE 17

Use equal numbers of *Salix exigua* and *Salix fragilis* to create brush layers. At top of brush layer slope plant *Populus sargentii* and *Salix amygdaloides* whips in equal numbers. Whips are to be planted on 7 foot centers in a single row.

BMP Number	Station Number		Length (ft)	Height (ft)	Number of Brush Layers	Number of each type of Whip
	Begin	End				
BLST - 1	975+50	967+90	760	10	4	55

TABLE 18

Use 2 foot diameter boulders. Plant brush bundles between all boulders.

BMP Number	Station Number		Length (ft)	Number of Boulders Required
	Begin	End		
BT - 1	952+90	952+00	90	45
BT - 2	951+00	947+70	330	165

TABLE 19a

BOULDER CREEK AND SOUTH BOULDER CREEK (55TH ST. TO 61ST ST.) HABITAT IMPROVEMENT SUMMARY

INSTREAM STRUCTURAL IMPROVEMENTS

Type of Improvement	Total Number of Structures	Boulder Diameter (ft)	Number of Boulders Required
Thalweg Pools	31	-----	-----
Current Deflectors	22	3	196
Jetties (non-channel block)	12	1	3480
Jetties (channel block)	3	2	109
V - Dams	4	3 - 4	95
Fish Passage Structures	3	3	440
Riffle Roughness	38	1.5 - 2.0	570

1. Total number of 1.0' diameter boulders required = 3480
2. Total number of 1.5' - 2.0' diameter boulders required = 679
3. Total number of 3.0' diameter boulders required = 731

TABLE 19b

BOULDER CREEK AND SOUTH BOULDER CREEK (55TH ST. TO 61ST ST.) HABITAT IMPROVEMENT SUMMARY

NON-STRUCTURAL BANK TREATMENT

Type of Treatment	Total Linear Feet of Treatment
Cottonwood Whip planting on streambank	1,725
Cottonwood Whip and Peach-Leaf Willow planting on streambank	3,070
Cottonwood Whip, and Peach-Leaf and Sandbar Willow planting on streambank	235
Willow and Cottonwood Live Staking	460
Wattling	1,035
Brush Layering	170
Brush Layering/Wattling Combination	315
Brush Layering with Larger Shade Trees Interspersed	760
Boulder Toe	420

TABLE 20

Gravel berm locations, sizes, and fill quantities.

Gravel Berm Number	Location by Station Number	Approximate Length (ft)	Average Width (ft)	Average Height (ft)	Estimated Volume of Fill (yd^3)
1	Station 1002+50 to 1003+60 Right Bank	110	5	5	102
2	Station 999+70 to 1003+20 Left Bank	350	20	8	2,074
3	Station 997+20 to 999+70 Right Bank	250	20	8	1,482
4	Station 989+70 to 992+70 Right Bank	300	18	8	1,600
5	Station 987+70 to 989+45 Right Bank	175	15	8	778
6	Station 983+30 to 983+60 Right Bank	30	5	5	28
7	Station 980+00 to 983+00 Right Bank	300	8	6	533
8	Station 976+50 to 979+50 Right Bank	300	8	6	533
9	Station 962+00 to 976+00 Right Bank	1,400	30	10	15,556
10	Station 962+50 to 971+50 Left Bank	900	15	10	5,000
11	Station 945+10 to 947+50 Left Bank	200	5	5	185
				Total	**27,870**

TABLE 21

Summary of areas and volumes for proposed wetland mitigation sites.

Mitigation Site	Area (acres)	Cut Volume (c.y.)
Area 1	2.21	18,000
Area 2	2.28	29,000

TABLE 22

Summary of alternate channel lengths and approximate cut volumes.

Cut Number	Length (ft)	Cut Volume (c.y.)
1	435	10,000
2	550	12,000
3	450	14,000
4	500	9,000