DRAINAGE REPORT FOR POWERS BOULEVARD EXTENSION NORTH

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

APPENDICES

A. Hydrology Calculations with HEC-1 Calculations

B. Culvert Calculations

C. Inlet Calculations

D. Ditch Calculations with Creek Outfall Structures

E. BOSS HEC-2 Calculations and Figure

F. Drainage Plan Sheets

Back Cover Pocket

Basin Designation Map

Erosion Control Plan

I. INTRODUCTION

This drainage report presents the final drainage design for Powers Boulevard Extension North from Research Parkway to Woodmen Road (sta 641+58.66-710+00) located in the City of Colorado Springs.

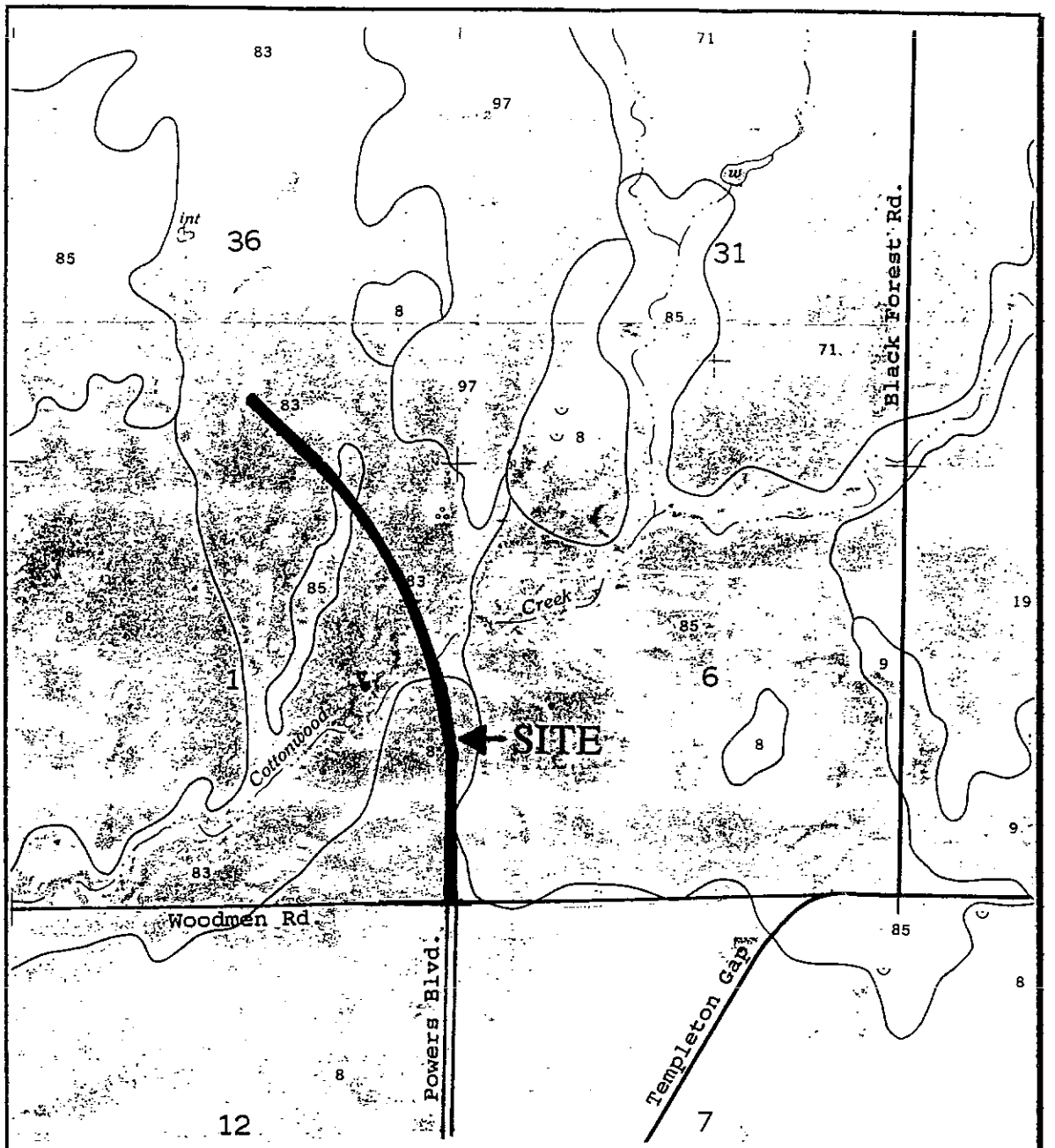
II. SITE LOCATION AND DESCRIPTION

The City of Colorado Springs is extending Powers Boulevard to the north through the east half of Section 1, Township 13 South, Range 66 West of the 6th Principal Meridian and through the southeast quarter of Section 36, Township 12 South, Range 66 West of the 6th Principal Meridian. This extension will require right-of-way acquisition to the east of Section 1 in Section 6, Township 13 South, Range 65 West of the 6th Principal Meridian which is located outside of the city limits in the County of El Paso. The extension will cross Cottonwood Creek, which runs primarily east to west through Section 1, Township 13 South, Range 66 West of the 6th Principal Meridian.

At present the surrounding affected drainage basins are undeveloped and consist primarily of grasslands sloping to the southwest. In the future they are proposed to be fully developed with residential and commercial sites. Review of the Soil Conservation Service Soil Survey for El Paso County indicates that the soil in the area consists primarily of a sandy loam, Group B hydrological soil (see Figure 1).

III. HYDROLOGY

The drainage basins associated with this portion of Powers Boulevard extension lie within the Cottonwood Creek Drainage Basin. The drainage criteria utilized for this Powers Boulevard hydrology analysis was kept in accordance with the Cottonwood Creek Drainage Basin Planning Study (DPBS, reference 9) and the Fairfax at Briargate MDDP (reference 12) where applicable. The DBPS proposes the use of three future detention ponds at various locations upstream from Powers Boulevard. These ponds would reduce the 100-year creek flow to approximately 2,332 cfs as compared to 6,423 cfs for the FEMA 100-year flow. Since the ponds are proposed for the future and the upstream portion of the creek will not be developed at the time the road extension and bridge are constructed, FEMA's 100-year flow without detention ponds was used for the bridge analysis. The Group B soil type was used for both studies.



SOIL CLASSIFICATION & LOCATION MAP

NOT TO SCALE

FIGURE 1

A. Method of Analysis

The hydrology for this project was analyzed for the 5 and 100-year storm using the Rational Method. The Rational Method was selected because it is recommended by the CDOT Drainage Design Manual and the City of Colorado Springs Drainage Manual for storm sewer design with overland flow from tributary basins generally less than 100 acres in area. For basins larger than 100 acres, the Army Corps of Engineers HEC-1 computer program with the SCS Unit Hydrograph Method (reference 10) was utilized for determining runoff.

B. Run-off Coefficients

Utilizing the Rational Method, the off-site flow coefficient was chosen to be reflective of the undefined future development (C=.70). The coefficient for the roadway surface was taken to be for the 100 year event (C=.93) (Reference 1, 2). For roadway basins that have earth median and shoulder, a composite coefficient was utilized.

C. Time of Concentration

The time of concentration for the Rational Method is comprised of two components: sheet flow and channel flow. The off-site drainage basins are long and sloping so overland flow was limited to a length of 300 feet (Reference 1). The minimum Tc was equal to 5 minutes.

D. Precipitation

For the Rational Method, the rainfall intensity curves created for the City of Colorado Springs were used to develop the peak discharges for the 5-year and 100-year event (Reference 2 and Appendix A).

E. SCS Unit Hydrograph Method

The basin curve numbers were for AMC-2 and were determined from the projected land use and the SCS hydrological soil types obtained from the SCS soil survey of El Paso County. Rainfall depths of 4.4 inches for the 100-year event and 3.0 inches for the 10-year event were used , based on the isopluvial maps for these 24-hour precipitation records. The cumulative rainfall distribution for the standard SCS 24-hour Type IIA storm was utilized.

IV. DRAINAGE BASINS AND SUB-BASINS

A. Off-Site Basins

The project is located in the Cottonwood Creek Drainage basin (See Basin Map in pocket at back of this report). Storm runoff from the project site and surrounding area has

historically flowed overland to drainage swales and into Cottonwood Creek. The existing drainage patterns have been maintained to the extent that they are reasonably feasible for the given project. Flows that drain towards the creek will still drain into the creek but may be diverted to alternate outfalls (Table 1).

TABLE 1
RUNOFF SUMMARY

SUB BASIN(S)	*ACRES*	*DESIGN POINT*	*HISTORIC*		*DEVELOPED*	
			5 YEAR	100 YEAR	5 YEAR	100 YEAR
(A1, A2, A3) B1 & Woodmen Road Basin	53.1 ac	3	-	-	143	249
(A1, A2, A3) B1, D1, E1 and Woodmen Road	54.5 ac	4	-	-	148	258
C1	20.6 ac	5 (at creek)	-	-	49	84
B3, D2 (677+70-695), E2 (682-695)	6.2 ac	6 (at creek)	-	-	24	41
B2 & C1-A	9.3 ac	7	-	-	25	42
B2, C1-A, D2 (695-702), E2 (695-702)	11.0 ac	8	-	-	33	56
B4, D3, E3, F1-B, F1-A2 and F1-A1	178.9 ac	10 (at creek)	-	-	-	519
F1-B, F1-A2 and F1-A1	168 ac	11	-	-	-	468
F2-A and B5 (643+79-651+60)	12.0 ac	12	-	-	36	62
F2-A, B5(total), D4, E4	13.7 ac	13	-	-	45	78
F2-B and F2-C	74 ac	14	70	122	-	-
F1-B	136 ac	15	-	-	-	407
F1-B and F1-A2	153 ac	16	-	-	-	442

For the portion of the project north of Cottonwood Creek there are six off-site basins that drain in a southwesterly direction and cross the Powers Boulevard proposed alignment. The basin directly south of Cottonwood Creek and east of the project (C1 and C1-A) drains in a northwesterly direction towards the creek and across the proposed alignment. The basin that borders to the north of Woodmen Road (A1 and A1-A) drains in a southwesterly direction across the proposed alignment and towards Woodmen Road. The flows from Basins A1 and A1-A are presently collected in a roadside ditch along the northerly shoulder of Woodmen Road and in numerous swales that convey the flows to an

existing 66-inch RCP culvert under Woodmen Road, west of Powers Boulevard (Drainage sheet #6, Appendix F). The culvert outlets to a small pond southwest of the project site.

B. Roadway Drainage

The proposed alignment cuts through the natural flow patterns and intercepts the flows before they reach Cottonwood creek. The majority of these flows as well as the roadway surface drainage will be captured in roadside ditches. Three proposed cross culverts and a proposed storm sewer trunk line will also be used to convey flows to Cottonwood Creek.

V. DRAINAGE DESIGN

A. Criteria

The roadway and off-site drainage facilities designs were based on criteria from the city/state criteria manuals. Per the criteria, flood encroachment of the roadway in the superelevated sections for the minor design storm (5-year) was limited to the 4 ft. median shoulder plus 4 ft. of the inside travel lane. Flooding of the roadway during the major design storm (100-year) was limited to 6-inches at the gutter flow line (4 ft. median shoulder + 10.5' of the inside traveled lane) in the superelevated reaches. Roadside ditches were designed for 1' of freeboard for the minor storm and no encroachment onto traveled lanes for the major event (Reference 1). All cross culverts were designed to convey the 100-year event with no encroachment on the shoulder. Curb-opening inlets conforming to the City of Colorado Springs' Standard Detail D-19-A were used along the median in the superelevated regions. Storm drain culverts were designed for the 5-year storm except for sump locations, super elevation transition areas, and inlets placed to capture most of the flow before crossing the Cottonwood Creek Bridge. For these the 100-year event was used for design of the storm drain culverts.

B. Methodology

1. Inlets

Inlets were spaced based on the road surface area required to generate enough runoff to reach gutter capacity given the allowable spread for the design storm. Manning's Equation was used for determining the gutter capacity. The inlet efficiency was taken into account and the bypass was added to the gutter flow for the next reach. Inlet efficiency was based on a 10' length of inlet given the cross slope and longitudinal roadway slope for that station (Reference 3). The intercepted flows were used to size the outlet culverts.

2. Cross Culverts

Cross culverts were designed utilizing hydrographs developed for inlet and outlet control and the HY-8 computer program (Reference 11). The Hw/D ratios were kept in accordance with the State criteria manual (Reference 1, 4).

3. Roadside Ditches

The Manning's Equation for open channel flow was used to size the roadside ditches. Minimum required ditch depths based on their respective contributing drainage basins are summarized in Table 2.

VI. RECOMMENDED DESIGN

A. Roadway

The initial roadway section will consist of 2 traveled lanes in each direction separated by a 28 ft. grass median, 4 ft. inside shoulders, 12 ft. paved outside shoulders, 10 ft. dirt outside shoulders and roadside ditches. The southbound lanes drain into 3 ft. deep roadside ditches and flow in accordance with the road profile to several outlet points (Table 2). The northbound lanes are separated into the normal crown section and the superelevated section (sta 651+19 - 694+50±). The normal crown sections drain to the east 3' deep roadside ditches and outlet at various points. The superelevated section of road drains towards the center median gutter and inlets, which discharge into the west roadside ditch intercept the flows, by the means of RCP culverts (Appendix F).

There are three culvert crossings which convey the 100-year storm flows from the east ditches to the natural drainage ways on the west side of the road:

1. Culvert at sta 709+50: Recommended 66" RCP to convey the flows from Basins A1, A2, A3, B1, and the north 1/2 of Woodmen Road to the east, under Powers Boulevard and into an existing 66" RCP that crosses Woodmen Road and discharges into an existing pond. The majority of these flows (Q100 = 249 cfs) has historically flowed into this culvert via existing ditches and swales (Drainage Plan #6, Appendix F).

2. Culvert at sta 694+50: Recommended 36" RCP to convey roadside ditch flows from basins C1-A and B-2 on the east to a natural drainage way existing at this station. These flows have historically collected in this natural swale (Drainage Plan #5, Appendix F).

3. Culvert at sta 649+50: Recommended 36" RCP to direct roadside ditch flows from basins F2-A and B5 on the east to a natural drainageway at this

station. This existing swale outlets into a tributary channel of Cottonwood Creek where the diverted flows have historically flowed.

TABLE 2
DITCH SUMMARY TABLE

STATION	*EAST DITCH DEPTH*	*WEST DITCH DEPTH*
641+75 - 646+00	3'	
646+00 - 648+00	3'	
648+00 - 649+50	varies from 3' to culvert inlet depth	
645+20 (+/-) – 649+50		1.75'
649+50 - 653+06	varies from 2' to culvert inlet depth	
649+50 - 653+06		varies from 1.75' to culvert inlet depth
653+06 - 677+70 (outfall)		2.5'
653+06 - 663+00	3'	
663+00 - 677+70 (outfall)	3'	
682 (outfall) – 685+50		2.5'
685+50 - 694+50		2.0'
682 (outfall) – 687+00	3'	
687+00 - 688+00	2.5' - 3' (transition)	
688+00 - 694+50	2.5'	
694+50 - 702+52	2'	2'
702+52 - 709+50 (+/-)	varies from 2' to culvert inlet depth	varies from 2' to culvert inlet depth

Note: These depths represent a minimum ditch requirement.

B. Off-site

All off-site drainage comes from the eastside of the proposed alignment and is divided into 4 main basins (Basin Map in pocket on back cover). The run-off from these basins flows into the roadside ditches on the east and either outlets at the various cross culverts, discharges into the proposed storm sewer, or at the creek outfall located on the east side of the roadway.

The run-off from Basin F1-B (407 cfs) will be intercepted by a 66" RCP at station 663+00 and be carried between the east shoulder and the roadside ditch down to approximate station 675+80. Flows from Basins F1-A2 (35 cfs) and F1-A1 (26 cfs) will be collected in the roadside ditch and intercepted by grated inlets discharging into this system. At station 675+80, the combined flows will be taken under Powers Blvd. in a 90" RCP to the west side and into the proposed creek outfall structure.

According to the Fairfax at Briargate MDDP, there is a proposed 42" storm sewer in Research Parkway west of Powers Blvd. The storm sewer will be extended east of Powers Blvd. and daylighted to intercept flows from Basins F2-C and F2-B (122 cfs). According to the Fairfax at Briargate MDDP, the area tributary to the 42" storm sewer opening is shown to be 36 acres. Our estimated basin is approximately 44 acres and the future developed 100-year flows will exceed the pipe capacity by approximately 55 cfs. It

is recommended that as development occurs in these two basins, that the tributary area be reduced to 33 acres +/- in order for the 42" pipe to work properly.

C. Bridge

The proposed structure crossing for Cottonwood Creek slopes from North to South on a longitudinal grade of .5% and is superelevated to the NB outside shoulder. Nearly all street flows prior to the beginning of the bridge on the NB lanes will be intercepted by a median inlet (sta 677+70), (Appendix C). There are no proposed inlets on the bridge with the run-off that develops on the NB structure gathering in the median gutter and being collected at the end of the bridge (inlet sta 681+95), (Appendix C) . The run-off on the structure from the SB lanes will flow along the west gutter and be collected by an inlet at sta 682+55 (Appendix C).

D. There are four drop structures proposed for Cottonwood Creek in the general vicinity of the bridge crossing (See "Powers Boulevard Extension" plans). The drop structures are to be placed in such fashion as to create ponding upstream of the structure for the creation of wetlands. The drop structures are to be a soil cement dam with a concrete cap (see detail sheet, Appendix F). For a detailed description of the wetland mitigation, see the Powers Blvd. Extension North Environmental Assessment Report.

VII. BRIDGE HYDRAULIC AND SCOUR ANALYSIS

A. Description

Cottonwood Creek crosses the proposed alignment at approximate station 679+50 at which point the channel invert is approximately at elevation 6,812. The creek's main channel is approximately 20 ft. wide at the crossing with the width at the top of banks being 390 ft +/-. The creek bottom and sides are relatively free of vegetation with a normal flow depth of several inches.

The bridge for the creek crossing is to be a 3 span 147' wide Precast Concrete Girder structure with a concrete deck. The minimum girder elevation is to be 6,848.20.

B. 100-Year Water Surface Elevation

The 100-year water surface elevation was analyzed using the BOSS Hec-2 open channel program. The first run was modeled without the bridge to develop a calibration with the Federal Emergency Management Agency's Flood Insurance Study dated September 30, 1992. The calibration run yielded a 100-year water surface elevation of 6,819.01 at creek cross section 600 (Appendix E). This cross section corresponds with FEMA's Section AX (Appendix E) with a 100-year water surface elevation of 6,819.