NORTHGATE PHASE 1
Drainage Plan

ADDENDUM DATE: October 6, 1987

URS
CORPORATION
MAKING
TECHNOLOGY
WORK

NORTHGATE PHASE I

FINAL DRAINAGE REPORT

June 15, 1987

Revised August 27, 1987
Revised October 6, 1987

Prepared for: The Olive Company
5450 Tech Center Drive - Suite 400
Colorado Springs, Colorado 80919

Prepared by: URS Corporation
5450 Tech Center Drive - Suite 327
Colorado Springs, Colorado 80919

Project No. 45206

Northgate Phase 1
Drainage Report and Plan
URS Project No. 5206

DRAINAGE REPORT STATEMENTS

Engineer's Statement:

The attached drainage plan and report were prepared under my direction and supervision and are correct to the best of my knowledge and belief. Said drainage report has been prepared according to the criteria established by the City for drainage reports and said report is in conformity with the master plan of the drainage basin. I accept responsibility for any liability caused by the negligent acts, errors or omissions on my part in preparing this report.

COLORADO REGISTERED CLYDE L. PIKKARAINE 20450 PROFESSIONAL ENGINEER

Clyde L. Pikkaraine
Clyde L. Pikkaraine, P.E., Colorado 20450
URS Corporation

10-7-87
Date

Developer's Statement:

The Developer has read and will comply with all of the requirements specified in this drainage report and plan.

The Olive Company

BY: Robert W. Mack

TITLE: Vice Pres

10-7-87
Date

City of Colorado Springs:

Filed in accordance with Section 15-3-906 of the Code of the City of Colorado Springs, 1980, as amended.

City Engineer

10/9/87
Date

Condition:

Temporary detention facilities to be constructed and operational prior to the installation of the street pavement.

SEE FOLLOWING PAGE FOR ADDITIONAL CONDITIONS

TABLE OF CONTENTS

CONDITIONS CONTINUED

BASIN AND BRIDGE FEES TO BE PAID AT THE TIME OF PLATTING OF THE STREETS AND ADJOINING PARCELS

TEMPORARY DETENTION PONDS TO BE PRIVATELY OWNED AND MAINTAINED

SUBJECT TO THE REQUIREMENTS OF EL PASO COUNTY AND THE COLORADO DEPARTMENT OF HIGHWAYS

THE MAJOR DETENTION PONDS AS INDICATED IN THE BLACK SQUIRREL BASIN STUDY ARE TO BE DESIGNED TO PROVIDE SUFFICIENT DETENTION TO ELIMINATE THE NEED FOR ADDITIONAL PUBLIC DETENTION FACILITIES DOWNSTREAM OF THE NORTHGATE PROJECT

NO ADDITIONAL PUBLIC DETENTION FACILITIES WILL BE ALLOWED IN THE MISCELLANEOUS BASIN SHOWN ON FIGURE NO. 1. SIZING OF OUTFALL FACILITIES WILL BE SUBJECT TO PRIVATE DETENTION FACILITY REQUIREMENTS

LIST OF FIGURES

LIST OF TABLES

I. PURPOSE AND SCOPE

Northgate is a 1500 acre mixed-use development on the north side of Colorado Springs. The first phase of Northgate consists of the south 380 acres of the development. The purpose of this drainage report is to obtain approval of Voyager Parkway and Jetstream Drive (see limits of this report on Figure 1). The drainage facilities detailed in this report include those facilities in the roads. See Figure 1 (attached) for the area involved. In addition to the facilities in the roads, two temporary detention ponds are proposed to overdetain the excess runoff created by the paved roads and initial development. Initial development is discussed in Section 5. Following construction of the proposed permanent dam on Black Squirrel Creek, the temporary detention ponds will be abandoned.

Conceptual drainage subbasins and flow patterns are presented to determine the areas tributary to the proposed roads.

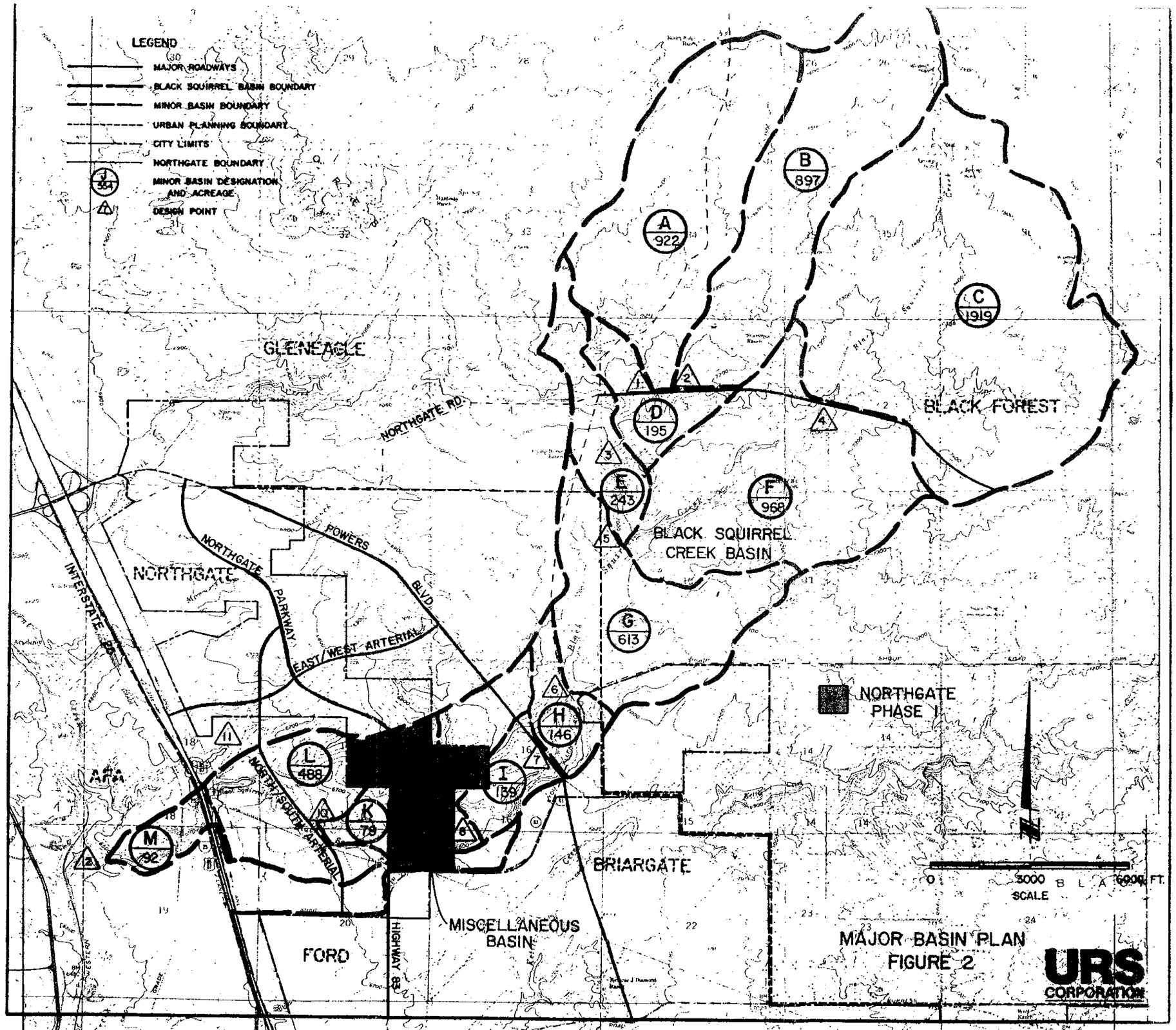
Furthermore, this report is an addendum to the approved Phase I report of September 9, 1986. Further analysis and discussion of site drainage and detention facilities are performed as a condition of the above mentioned approval.

II. SITE DESCRIPTION AND LOCATION

Northgate Phase 1 is located within the southwest quarter of Section 16, the east half of Section 17, and the northeast quarter of Section 20, and the northwest quarter of Section 21, Township 12 south, Range 66 west of the 6th Principal Meridian, El Paso County, Colorado (Figure 2). Approximately 270 acres lie within the Black Squirrel Creek Basin and approximately 20 acres lie within an unstudied basin (tributary to the area north of existing Stout Allen Road).

The site slopes primarily from east to west at slopes of 1 to 2 percent. There are three existing discharge points from the site downstream. The southerly discharge point is from the unstudied basin between State Highway 83 and the Black Squirrel Creek Basin. The middle discharge has the largest flow and is the main channel of Black Squirrel Creek. The northerly discharge is a tributary of Black Squirrel Creek which meets the main channel of Black Squirrel Creek just upstream of Interstate 25 (subbasin L on Figure 2). The area considered in this report is limited to the unstudied basin and the main channel of Black Squirrel Creek. The northerly discharge is presented only to show that it is not tributary to this area.

The soils within Northgate Phase No. 1 are classified by the U.S. Soil Conservation Service as hydrologic soil type B. Group


LEGEND
MAJOR ROADWAYS
BLACK SQUIRREL BASIN BOUNDARY
MINOR BASIN BOUNDARY
URBAN PLANNING BOUNDARY
CITY LIMITS
NORTHGATE BOUNDARY
MINOR BASIN DESIGNATION AND ACREAGE
DESIGN POINT
A 922
B 897
C 1919
D 195
E 243
F 968
G 613
H 146
I 189
J 364
K 78
L 488
M 82
GLENEAGLE
NORTHGATE RD.
BLACK FOREST
BLACK SQUIRREL CREEK BASIN
NORTHGATE
POWERS BLVD.
NORTHGATE PARKWAY
EAST/WEST ARTERIAL
INTERSTATE 25
NORTH/SOUTH ARTERIAL
NORTHGATE PHASE I
BRIARGATE
MISCELLANEOUS BASIN
FORD
HIGHWAY 83
0 3000 6000 FT.
SCALE
MAJOR BASIN PLAN
FIGURE 2
URS CORPORATION

B soils have moderate infiltration rates when thoroughly wetted and consist chiefly of moderately deep to deep, moderately well to well-drained soils with moderately fine to moderately coarse textures.

The main channel of Black Squirrel Creek is the only drainageway with an identified 100-year floodplain on the current FEMA maps. The Voyager Parkway crossing of Black Squirrel Creek is in the FEMA floodplain. The proposed crossing has been permitted through a nationwide permit with the US Army Corps of Engineers.

III. PLANNED DEVELOPMENT

Current City of Colorado Springs criteria requires drainage facilities to be sized for the future fully developed basin. The US Air Force Academy is located downstream of Northgate. This requires the modification of city criteria to include detention facilities to limit the downstream peak flows to historic levels. The approved (City of Colorado Springs') Black Squirrel Creek Master Plan required three detention sites for the basin. Developed conditions for Northgate were obtained from the approved Land Use Map (Figure 3) for Northgate. Developed conditions for areas outside Northgate were considered to be the mixed use type of development presented in the Black Squirrel Creek Master Plan.

At this time, the developer intends to construct Voyager Parkway, Jetstream Drive, and the associated drainage facilities (Figure 1). These facilities will be located within dedicated right-of-way excluding the temporary detention facilities. It is the intent of this report to show conceptual drainage patterns so that drainage can be collected and conveyed to the three outfall points previously described. Drainage reports for future plattings should present detailed calculations as to how any additional drainage systems will operate.

LAND USE PLAN

REQUIRED PARKLAND DEDICATION			
Use	Factor	Units	Acres
RCL	.00225 ac/u	158-395	3.6-8.1
RM	.00225 ac/u	252-756	5.6-17.0
RMF	.0166 ac/u	1320-1760	21.7-29.0

LAND USE		ACRES
B	BUSINESS PARK	619
C	COMMERCIAL	72
O	OFFICE	253
RCL	RESIDENTIAL - CLUSTER 2-5 du/ac 158-395 Units Pop: 474-1185*	79
RM	RESIDENTIAL - MEDIUM 2-6 du/ac 252-756 Units Pop: 756-2268*	126
RMF	RESIDENTIAL - MULTI FAMILY 12-18 du/ac 1320-1760 Units Pop: 3168-4224**	110
P/S	PARK/SCHOOL	30
	OPEN SPACE	104
	R/W MAJOR ROADS	93
	WATER TANK SITE	10
	MULTI-USE TRAIL	
	FIRE STATION (General Vicinity)	
TOTAL ACREAGE		1496

*Population Calculated at 3.0 Persons/Unit
**Population Calculated at 2.4 Persons/Unit

NORTHGATE
THE OLIVE COMPANY

THE PLANNING CENTER
240 NEWPORT CENTER DRIVE SUITE 210
NEWPORT BEACH, CA 92660 (714) 644-1301

FIGURE 3

IV. DESIGN CRITERIA

Determining runoff for a particular drainage basin needs to consider the effects of many different variables. In the absence of a reliable historic record of rainfall, runoff, and other pertinent variables, it is usually necessary to use a synthetic unit hydrograph method to determine the runoff that will occur for a given rainfall event. The SCS method of determining peak flood flows and hydrographs was used to estimate direct runoff for the major basins ($Q > 500$ cfs). For an explanation of the procedures used, see the "SCS National Engineering Handbook, Section 4". Due to the number of computations necessary to determine the hydrographs and hydrologic routing of the given storm events, the calculations were performed with the aid of the TR-20 computer program. For minor basins ($Q < 500$ cfs), storm runoff was calculated using City of Colorado Springs criteria as presented in the "Subdivision Policy Manual", dated May 1980. This analysis is in conformance with the previously approved drainage plan and does not reflect the presently adopted criteria of September 8, 1987.

The criteria, as mentioned above requires that the design of facilities where the 100-year storm exceeds 500 cfs to be for the 100-year design flow. Facilities where the 100-year storm is less than 500 cfs can be designed for the 5-year storm with a provision that the 100-year storm can be conveyed to the major facilities without damage to buildings or structures. For

example, a 5-year capacity storm sewer may be built if the 100-year storm will be contained within a street right-of-way and the storm sewer. Criteria for the major facilities ($Q > 500$ cfs) will require the design to be for the greater of the peak flows determined for the 100-year 24-hour storm and the 100-year 6-hour storm. Design of minor facilities ($Q < 500$ cfs) shall be for the 5-year 6-hour storm. The temporary detention ponds, however, are designed to overdetain the 100-year 24-hour storm. See Section 5 for further discussion of temporary detention ponds.

Drainage design standards and criteria reduce but do not eliminate all flood risks. Drainage design criteria are an indication of the presently acceptable level of risk in the Colorado Springs area as determined by the City of Colorado Springs. Rainfall and storms larger than the 100-year storm can and do occur.

As stated in the Black Squirrel Creek Master Plan, the 5-year and 100-year peak flows at the U.S. Air Force Academy boundary are required to be at historic levels or below. The 5-year and 100-year peak flows at the downstream property boundary of Northgate will also be limited to historic levels or below.

V. HYDROLOGY

Time of concentration for the upstream subbasins was determined by the following equation:

$$T = \left[\frac{11.9 \times L}{H}\right] .385$$

where T = time of concentration in hours

L = length of longest watercourse in miles

H = elevation difference in feet

As the calculations proceed downstream, individual travel times are added for each reach (minor systems) or hydrologically routed through each reach (major systems).

The rainfall depths of 2.7 and 4.6 inches were obtained from isopluvials for the project area for the 5-year 24-hour and 100-year 24-hour storm events, respectively. Table 1 shows the dimensionless precipitation distribution for the SCS Type IIA storm. The rainfall depths of 2.1 and 3.5 inches were obtained from the city's "Subdivision Policy Manual" for the 5-year 6-hour and 100-year 6-hour storm events, respectively.

A. Major Drainage (Black Squirrel Creek Basin)

Figure 2 depicts the major drainage basins for Black Squirrel Creek as presented in the master plan. The master plan proposed a large detention pond at design point 9 (Northgate Parkway and Black Squirrel Creek). After a preliminary

TABLE 1
24-HOUR RAINFALL DISTRIBUTION
SCS TYPE IIA STORM

Time (hours)	Distribution of Total Rainfall
0	0
2.00	0.010
4.00	0.030
4.50	0.050
5.00	0.060
5.50	0.100
6.00	0.700
6.50	0.750
7.00	0.780
8.00	0.820
9.00	0.840
9.50	0.850
10.00	0.860
10.50	0.865
11.00	0.870
11.50	0.885
11.75	0.888
12.00	0.890
12.50	0.900
13.00	0.905
13.50	0.910
14.00	0.915
16.00	0.940
20.00	0.980
24.00	1.000

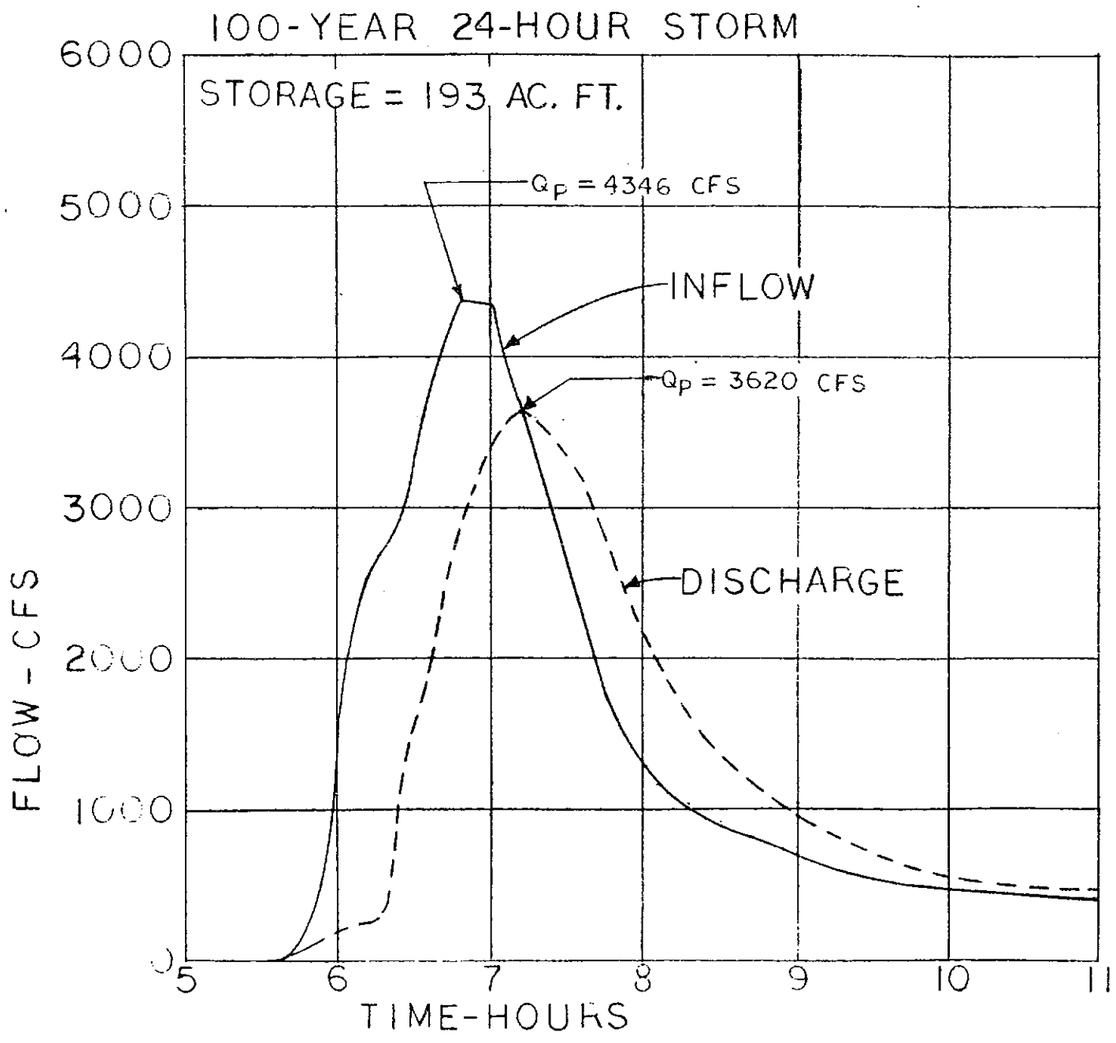
geotechnical investigation was performed by Woodward-Clyde Consultants, it was determined that a deep alluvial fan occurs on the north side of Black Squirrel Creek at the detention pond location shown in the master plan. The alluvial fan is expected to have low to moderate strength and moderate to high permeability. There is also a potential for differential settlement to occur for the height of the proposed dam. Therefore, the location of the detention pond was shifted to the east where the dam would not be placed on the alluvial fan. The proposed detention pond location is shown on Figure 1. The shift of the detention pond upstream requires that the pond overdetain the 100-year 24-hour storm in order to maintain the historic peak flows at the US Air Force Academy boundary. The 5-year 24-hour storm peak flows will be overdetained in this pond to maintain the historic peak flows at the Northgate west property line. Table 2 presents the historic flows at each design point on Figure 2 and developed flows for full development upstream of and including Northgate. The property downstream of Northgate will require detention of the 5-year storm in order to maintain historic peak flows at the Air Force Academy boundary. The Black Squirrel Creek Master Plan had a 5-year detention pond located off the main channel for the downstream property. No change to that concept is intended.

FIGURE 4

DETENTION POND HYDROGRAPH

DESIGN POINT 8 (FIGURE 2)

DET. POND NO. 2 OF BSC MASTER PLAN (RELOCATED)



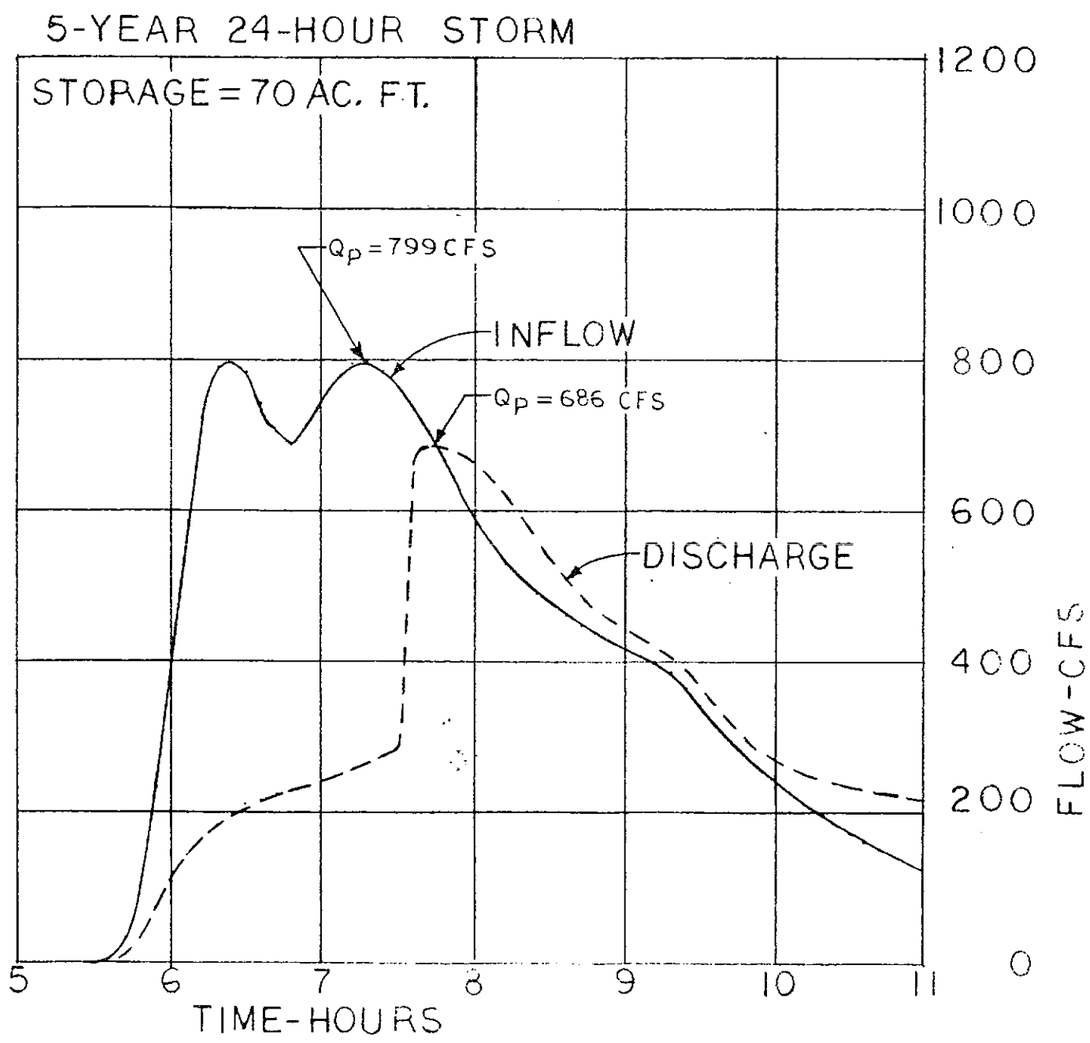


TABLE 2
BLACK SQUIRREL CREEK MAJOR BASIN PEAK FLOWS
NORTHGATE PHASE 1 DRAINAGE REPORT
REF:FIG. #2

PEAK FLOWS FOR THE 5-YEAR 24-HOUR STORM EVENT

FIG: #2 DESIGN POINT	HISTORIC FLOW (CFS)	DEVELOPED FLOW (CFS)	
1A	56	---	
1B	119	---	
2	---	247	
3	263	498	
4	---	551	
5	727	725 OUT	DETENTION POND #1
6	749	792	
7	---	887	
8	---	686 OUT	DETENTION POND #2
9	750	705	
10	---	708	
11	735	715	
12	727	714	

PEAK FLOWS FOR THE 100-YEAR 24-HOUR STORM EVENT

FIG: #2 DESIGN POINT	HISTORIC FLOW (CFS)	DEVELOPED FLOW (CFS)	
1A	307	422	
1B	773	1047	
2	----	985	
3	1825	2194	
4	----	2317	
5	4158	4029 OUT	DETENTION POND #1
6	4389	4329	
7	-----	4389	
8	-----	3620 OUT	DETENTION POND #2
9	4050	3698	
10	-----	3709	
11	3956	3772	
12	3949	3744	

NOTE: DEVELOPED FLOW BASED ON FULL DEVELOPMENT OF THE BASIN UPSTREAM AND INCLUDING NORTHGATE. THE PROPERTY DOWNSTREAM OF NORTHGATE REQUIRES DETENTION FOR THE 5-YEAR STORM WHEN DEVELOPED.

The permanent detention pond Number 2 (See Black Squirrel Creek Report) design will be presented at a later date. A temporary (private) detention facility is proposed (within Northgate) on an interim basis prior to construction of the large detention pond shown on Figure 1. This facility will also be maintained privately. The purpose of this facility will be to overdetain developed flow created from the paved roads constructed within Phase I, as well as from initial Phase I development. The initial Phase I development is assumed to be within sub-basin JIB which consists of 65 acres of residental development. However, other types of development may occur in Phase I and utilize this detention facility if sub-basin JIB is not fully developed.

B. Minor Drainage (Black Squirrel Creek Basin)

Figure 1 depicts the minor (Q < 500 cfs) basins and design points. Table 3 is a summary of the peak flows for each subbasin. Table 4 summarizes the flows at each design point and delineates how much flow is picked up by each inlet, and what flow is in the storm sewer pipe versus bypassed in the street.

C. Minor Drainage (Miscellaneous Basin)

Currently, the flow from the unstudied basin sheet flows from east to west and eventually reaches an existing 24" RCP that crosses Interstate 25 north of Stout Allen Road. Due to the excessive cost of constructing additional pipes under Interstate

25 and the need to maintain historic peak flows onto the U.S. Air Force Academy, it is necessary for this unstudied basin to detain to historic levels. Therefore, the portion of Northgate Phase 1 in the basin will only release historic flows. On-site (private) detention will be provided for the Northgate area within this basin. Figure 1 depicts the minor (Q ≤ 500 cfs) basins and design points. Table 3 is a summary of the peak flows for each subbasin.

Furthermore, a temporary detention facility will be constructed on an interim basis to detain developed flow created from the paved roads constructed within Phase I. Its proposed to be located within the existing temporary ditch along State Highway 83.

TABLE 3
SUMMARY OF SUBBASIN
HYDROLOGICAL DATA

BASIN	AREA (acres)	CN	Tc (hrs)	6 HOUR PEAK RUNOFF 5 YR (cfs)	6 HOUR PEAK RUNOFF 100 YR (cfs)	24 HOUR PEAK RUNOFF 5 YR (cfs)	24 HOUR PEAK RUNOFF 100 YR (cfs)
A	20.0	87	0.15	36.2	79.8	41.6	89.8
B	7.9	92	0.12	20.0	39.7	22.0	43.4
C1	0.4	98	0.05	1.5	2.6	1.5	2.7
C2	0.3	98	0.07	1.1	2.0	1.2	2.0
C3	0.7	98	0.06	2.6	4.6	2.7	4.8
D	4.5	92	0.11	11.7	23.2	12.9	25.5
E1	1.1	98	0.11	4.0	7.0	4.2	7.4
E2	0.3	98	0.03	1.1	2.0	1.5	2.7
E3	0.3	98	0.03	1.1	2.0	1.2	2.0
F	9.4	92	0.11	24.4	48.4	27.0	53.2
G	8.9	92	0.11	23.1	45.8	25.6	50.4
H1	1.4	98	0.08	5.2	9.1	5.4	9.5
H2	0.7	98	0.05	2.6	4.6	2.7	4.8
I	13.3	92	0.08	35.3	70.1	39.0	96.9
J	2.0	87	0.02	3.9	8.7	4.6	10.0
J1A	108.2	87	0.26	162.4	357.9	190.2	410.2
J1B	64.8	72	0.20	36.3	121.4	52.8	157.3
K	7.0	72	0.05	4.7	15.7	7.0	20.7
L	1.0	98	0.07	3.7	6.5	3.9	6.8
M	1.0	98	0.07	3.7	6.5	3.9	6.8
N	3.3	98	0.09	12.3	21.6	12.8	22.4
O	9.5	72	0.10	6.4	21.3	9.4	28.1
P	0.7	98	0.14	2.4	4.1	2.5	4.3
Q	4.0	98	0.24	11.7	20.4	11.9	21.0
R	2.1	98	0.13	7.4	12.9	7.5	13.3
S	2.0	87	0.03	3.9	8.7	4.6	10.0
T	29.2	92	0.14	71.4	142.0	78.0	153.6
U	6.2	92	0.09	16.5	32.7	18.2	35.8
MISCELLANEOUS BASIN							
V(H)	21.5	68.0	0.30	7.1	28.2	11.4	38.2
V(D)	21.5	87.0	0.30	30.4	68.3	35.3	76.2
W(H)	7.7	68.0	0.10	3.5	13.9	5.8	19.3
W(D)	7.7	92.0	0.10	20.3	40.7	22.8	44.6
X(H)	0.6	68.0	0.05	0.3	1.1	0.5	1.5
X(D)	0.6	98.0	0.05	2.2	3.9	2.3	4.1
Y(H)	11.5	68.0	0.14	4.9	19.1	7.8	26.1
Y(D)	11.5	92.0	0.14	28.4	55.9	30.6	60.3

REF: FIG. #1

TABLE 4
SUMMARY OF STORM SEWER
HYDROLOGIC DATA

DESIGN POINT	CONTRIBUTING SUBBASINS & BYPASS FLOW	DRAINAGE AREA (acres)	CN	DIRECT RUNOFF 6-HR 5-YR STORM	To	Ts	Tp	Tc	6-HR (csm/in)	Q5 @ D.P. (cfs)	Q5 bypass (cfs)	Q5 lateral (cfs)	Q5 main (cfs)	REMARKS
BLACK SQUIRREL CREEK BASIN														
1	A	20.0	87	0.99	0.15			0.15	1170	36.2			36.2	OFFSITE RUNOFF
2	B,C1	8.3	92.3	1.35		0.12		0.12	1220	21.4	(3.4)		18.0	6'& 8'D-10-R'S
	A,B,C1	28.3	88.6	1.08	0.15		0.06	0.21	1050	50.1	(3.4)		46.7	PIPE FLOW
3	D,C2 +B.P.	4.8	92.4	1.36		0.11		0.11	1250	12.8 + 3.4	(6.5)	9.7		10' D-10-R
	A,B,C1,C2,D	33.1	89.2	1.12	0.15		0.10	0.25	1000	57.9	(6.5)		51.4	PIPE FLOW
4	F,E1	10.5	92.6	1.37		0.11		0.11	1250	28.1	(11.2)	16.9		22' D-10-R
	A,B,C1,C2,D,E1,F	43.6	90.0	1.18	0.15		0.12	0.27	960	77.2	(11.2)+(6.5)		59.4	PIPE FLOW
5	E2 +B.P.	0.3	98.0	1.87		0.05		0.05	1280	1.1 + 11.2	(4.9)	7.4		6' D-10-R
	A,B,C1,C2,D,E1,E2,F	43.9	90.0	1.18	0.15		0.15	0.30	920	74.5	(4.9)+(6.5)		63.1	PIPE FLOW
6A	E3,G +B.P.	9.2	92.2	1.34		0.11		0.11	1250	24.1 + 4.9	(11.6)	17.4		22' D-10-R
	A,B,C1,C2,D,E,F,G	53.1	90.4	1.20	0.15		0.16	0.31	910	90.6	(11.6)		79.0	PIPE FLOW
6B	C3 +B.P.	0.7	98.0	1.87		0.06		0.06	1280	2.6 + 6.5	(3.6)	5.5		4' D-10-R
	A,B,C,D,E,F,G	53.8	90.5	1.22	0.15		0.17	0.32	900	92.3	(11.6)+(3.6)		77.1	PIPE FLOW
6C	H1 +B.P.	1.4	98.0	1.87		0.08		0.08	1280	5.2 + 11.6 + 3.6	(8.2)	12.2		18' D-10-R
	A,B,C,D,E,F,G,H1	55.2	90.7	1.23	0.15		0.20	0.35	860	91.2	(8.2)		83.0	PIPE FLOW TO CBC
8	J,K,L	8.0	75.3	0.44	0.07	0.03		0.10	1280	7.0	(2.8)	4.2		4' D-10-R **
	J,K,L,M,N2,O	21.8	73.3	0.38	0.07	0.03		0.10	1280	16.6			16.6	PIPE FLOW **
9	N1	2.0	98.0	1.87		0.10		0.10	1280	7.5	(3.0)	4.5	4.5	6' D-10-R @ STREET SLOPE=3%
10	H2,P	1.4	98.0	1.87		0.14		0.14	1180	4.8 + 8.2	0.0	13.0		10' SUMP D-10-R OVER CBC
11	Q,R	4.8	98.0	1.87		0.24		0.24	1000	14.0		14.0		8' SUMP D-10-R
12	J1A	108.2	87.0	0.99			0.26	0.26	970	162.4			162.4	OFFSITE RUNOFF
	J1A,J1B	173.0	81.4	0.69			0.46	0.46	760	142.0			142.0	TOTAL INFLOW TO CHANNEL
13	ALL OF BLACK SQUIRREL CREEK BASIN TO THIS POINT (FROM TR-20 RUN)									750 (5-YR) 4050 (100-YR)				
MISCELLANEOUS BASIN														
14	V	21.5	68	0.23	0.30			0.30	920	7.1*			7.1*	OFFSITE RUNOFF
15	V,W	29.2	74.3	0.41	0.30		0.02	0.32	900	16.8			16.8	FLOW @ EAST SIDE OF LOOP RD.
	X	0.6	98	1.87		0.05		0.05	1280	2.2	0.0	2.2	19.0	2-4' SUMP D-10-R'S & 36"
	V,W,X,Y	41.3	79.6	0.61	0.30		0.09	0.39	820	32.3			32.3	FUTURE ONSITE FACILITY
16	V,W,X,Y	41.3	68	0.23	0.30		0.09	0.39	820	12.2*			12.2*	FLOW LEAVING SITE

*FLOWS ENTERING OR LEAVING SITE MUST BE MAINTAINED TO HISTORIC LEVELS. REVISED 10/6/87

**FUTURE DRAINAGE FACILITIES TO BE ADDRESSED IN NORTHGATE PH. 2 DRAINAGE STUDY
REF: FIG. #1

VI. RECOMMENDED STORM DRAINAGE IMPROVEMENTS

A. Major Drainage (Black Squirrel Creek Basin)

The only major drainage (Q > 500 cfs) associated with the Northgate site are those facilities on the Black Squirrel Creek main channel. All other subbasins for Northgate Phase 1 have a flow of less than 500 cfs for the 100-year storm. A concrete box culvert is proposed under Voyager Parkway along with the entrance and outlet. The outlet lies in El Paso County. The design of the barrel and upstream entrance to the concrete box culvert was done in accordance with the U.S. Department of Transportation, Federal Highway Administration's "HEC No. 13 - Hydraulic Design of Improved Inlets for Culverts", dated August, 1972. The use of a slope-tapered inlet to the double 14' by 10' concrete box culvert reduced the overall cost of the culvert and inlet. The CBC was designed for the ultimate outlet to the future concrete-lined channel delineated in the Black Squirrel Creek Master Plan. At the present time, a temporary riprap outlet will be constructed. The design of the temporary outlet was done in accordance with the Denver Regional Council of Governments' "Urban Storm Drainage Criteria Manual", Volume II, Major Drainage, Section 5.6. The design calculations for the concrete box culvert (including entrance and outlet structures) are presented in Appendix A.

A temporary detention facility is proposed at the location shown on Figure 1. This temporary detention pond will overdetain

excess runoff due to the paved streets and other initial Phase I development. A pond with a storage capacity of 5.0 acre-feet is proposed, with an uncontrolled 42" outlet pipe. Excess storage capacity is provided by providing 0.5 feet of freeboard. Calculations for the design of the temporary detention pond are presented in Appendix B.

B. Minor Drainage

Minor drainage systems are proposed for the facilities required in Voyager Parkway and Jetstream Drive. Figure 1 (attached) and Table 5 delineate the proposed drainage improvements.

For the unstudied (miscellaneous) basin, proposed improvements include two inlets at the low point on the Loop Road and a cross-culvert/ storm sewer pipe crossing the road. The 36" cross-culvert will be used to carry the flow in the ditch section of State Highway 83 and the inlet flow across the Loop Road. Temporarily, the ditch will be diverted into this pipe and a drainage easement will be provided for the portion of the ditch on Northgate property.

In addition, a temporary detention "pond" is proposed within the existing temporary ditch along State Highway 83, as shown on Figure 1. The temporary pond will require a storage capacity of 0.025 acre-feet for the 5 year storm, and an uncontrolled 15" outlet pipe. Calculations for the design of the temporary detention pond are presented in Appendix B.

The area in Black Squirrel Creek Basin south of the main channel will be routed into the main channel by way of a storm sewer system in Jet Stream Drive, a storm sewer system in the proposed drainage and trail easement east of Voyager Parkway,

TABLE 5

PROPOSED MINOR STORM DRAINAGE IMPROVEMENTS & DESIGN DATA

DESIGN POINT	FACILITY TYPE	STREET GRADE (%)	PIPE GRADE (%)	PIPE LENGTH (ft)
1-2 *	30" RCP	5.6	2.0	550
	EAST DRAINAGE FACILITY TO BE CONSTRUCTED IN FUTURE			
2	6' & 8'D-10-R	5.6	--	---
2-3	30" RCP	0.7	1.0	455
3	10' D-10-R	0.7	--	---
	18" RCP	0.7	1.0	67
3-4	30" RCP	2.4	1.4	443
4	22' D-10-R	2.4	--	---
4-5	30" RCP	2.4	2.4	330
5	6' D-10-R	2.4	--	---
5-AA	30" RCP	2.4	3.3	282
	36" RCP	2.0	0.5	58
6A	22' D-10-R	2.4	--	---
	24" RCP	2.0	7.0	41
6A-6B	36" RCP	2.0	0.5	30
6B	4' D-10-R	2.4	---	---
	18" RCP	2.0	10.0	13
6B-6C	36" RCP	1.0	0.5	23
	42" RCP	1.0	0.5	23
6C	18 D-10-R	1.0	--	---
	18" RCP	1.0	10.0	76
6C-7	42" RCP	--	1.0	316
7	42" RCP (CBC INLET)	--	1.8	132
8 *	4'D-10-R (FUTURE)	6.0	--	---
9	8' D-10-R	3.0	--	---
9-10	18" RCP (CBC INLET)	2.7	2.7	480
10	10' D-10-R(CBC INLET)	1.0	---	---
	8' D-10-R (CBC INLET)	1.0	---	---
	24" RCP	--	1.0	15
13	DESIGN PT. 9 FOR OVERALL BASIN SEE FIGURE 2 & TABLE 2			
14-15 *	DRAINAGE FACILITY TO BE CONSTRUCTED IN FUTURE			
15	2-4' D-10-R(SUMPS)	1.8	--	---
	18" RCP	1.8	1.0	74
	24" RCP	1.7	1.0	100
15-16 *	DRAINAGE FACILITY TO BE CONSTRUCTED IN FUTURE			
16 *	DRAINAGE FACILITY CROSSING TO BE CONSTRUCTED IN FUTURE			

REF: FIG. #1

* CONCEPT ONLY, NOT TO BE CONSTRUCTED AT THIS TIME

and the sheet flow where the drainage subbasin flows directly to the creek. The storm sewer system will discharge directly into the Black Squirrel Creek box culvert.

The area north of the main channel of Black Squirrel Creek that flows to the main channel will mainly be picked up by an on-site drainage system. The height of fill required for Voyager Parkway in this area would prevent runoff from entering the road. The proposed storm sewer in Voyager Parkway will pick up flow in the road and subbasins J, K, and O.

The area that flows to the North Tributary of Black Squirrel Creek will drain through the future site to the northwest side of Phase 1 (see Figure 1).

VII. FINANCIAL SECTION

A. Drainage Fee

Permanent drainage improvements presented in this report and located within dedicated right-of-way or easements are considered to be reimbursable from the basin drainage fund. Private storm drainage facilities located outside dedicated right-of-way or easements, or temporary drainage and detention facilities are not reimbursable from the basin drainage fund.

Proposed storm drainage improvements are listed in Table 6 together with corresponding estimated costs. Reimbursable storm drainage improvements within the Black Squirrel Creek Basin and the Miscellaneous Basin are estimated to cost $257,938.00 and $18,307.00 respectively. Total non-reimbursable storm drainage improvements are estimated to cost $89,576.00.

The required drainage fee within the Black Squirrel Creek basin is $44,410.75 based on 8.845 acres of platted roads. The required drainage fee within the Miscellaneous Basin is $1,397.41 based on 0.454 acres of platted roads. Since the drainage fee is less than the estimated drainage construction costs, for both basins, the owner must post a letter of credit covering the improvement costs. The 1987 fees for Black Squirrel Creek Basin and Miscellaneous Basin are $5021/acre and $3078/acre, respectively.

TABLE 6
DRAINAGE AND BRIDGE COSTS

ITEM NO.	ITEM DESCRIPTION	APPROX. QUANTITY	UNIT	UNIT COST	ITEM COST	TOTAL COST
BLACK SQUIRREL CREEK BASIN						
A. DRAINAGE FACILITY COSTS (REIMBURSABLE)						
	REINFORCED CONCRETE PIPE					
1.	18" DIA	586	L.F.	38.00	22,268	
2.	24" DIA	56	L.F.	51.00	2,856	
3.	30" DIA	1,510	L.F.	66.00	99,660	
4.	36" DIA	111	L.F.	76.00	8,436	
5.	42" DIA	471	L.F.	93.00	43,803	
	D-10-R CURB INLETS					
6.	4'	1	EA.	1,700.00	1,700	
7.	6'	2	EA.	1,800.00	3,600	
8.	8'	3	EA.	2,300.00	6,900	
9.	10'	2	EA.	2,700.00	5,400	
10.	18'	1	EA.	4,500.00	4,500	
11.	22'	2	EA.	5,500.00	11,000	
	WYES & BENDS					
12.	18" X 45 BEND	1	EA.	500.00	500	
13.	42" X 45 BEND	1	EA.	1,000.00	1,000	
14.	36" x 18" WYE	1	EA.	1,000.00	1,000	
15.	36" x 24" WYE	1	EA.	1,100.00	1,100	
16.	42" x 18" WYE	1	EA.	1,200.00	1,200	
17.	4' DIA. MANHOLES	6	EA.	1,400.00	8,400	
					TOTAL	$223,323
				5% CONSTRUCTION CONTINGENCY		$11,166
				10% ENGINEERING		$23,449
				TOTAL DRAINAGE FACILITY COSTS		$257,938
B. BRIDGE COSTS (REIMBURSABLE)						
18.	IMPROVED INLET & WINGWALLS	1	EA.	43,642.00	43,642	
19.	(14'-14')x 10' RCB	1	EA.	157,703.00	157,703	
20.	EARTHWORK*	7,500	YDS.	1.50	11,250	
					TOTAL	$212,595
				5% CONSTRUCTION CONTINGENCY		$10,630
				10% ENGINEERING		$22,322
				TOTAL DRAINAGE FACILITY COSTS		$245,547

* EARTHWORK REQUIRED TO DIRECT FLOW INTO INLET

TABLE 6-BRIDGE AND DRAINAGE COSTS (cont'd)

C. NON-REIMBURSIBLE COSTS						
	TEMPORARY IMPROVEMENTS					
21.	CBC OUTLET WINGWALLS & RIPRAP	L.S.	L.S.	65,940.00	65,940	
22.	TEMPORARY DETENTION FACILITY	L.S.	L.S.	18,370.00	18,370	
					SUBTOTAL	$84,310
				5% CONSTRUCTION CONTINGENCY		$4,216
				TOTAL NON-REIMBURSABLE COSTS		$88,526

MISCELLANEOUS BASIN						
A. DRAINAGE FACILITIES (REIMBURSABLE)						
	REINFORCED CONCRETE PIPE					
1.	18" DIA.	75	L.F.	38.00	2,850	
2.	36" DIA.	100	L.F.	76.00	7,600	
3.	36" x 18" WYES	2	EA.	1,000.00	2,000	
	D-10-R CURB INLETS					
4.	4'	2	EA.	1,700.00	3,400	
					SUBTOTAL	$15,850
				5% CONSTRUCTION CONTINGENCY		$793
				10% ENGINEERING		$1,664
				TOTAL DRAINAGE FACILITY COSTS		$18,307
B. BRIDGE COSTS (REIMBURSABLE)						
	NONE					
C. NON-REIMBURSABLE COSTS						
	TEMPORARY IMPROVEMENTS					
5.	RIPRAP D50=9",t=18"	20.00	C.Y.	$35.00	700	
6.	TEMPORARY DETENTION FACILITY		L.S.	300.00	300	
					SUBTOTAL	$1,000
				5% CONSTRUCTION CONTINGENCY		$50
				TOTAL NON-REIMBURSABLE COSTS		$1,050

B. Bridge Fee

Arterial bridges required within the Black Squirrel Creek Basin are designated in the Master Plan. The proposed arterial bridge under Voyager Parkway and costs are presented in Table 6. Total arterial bridge costs are estimated to be $245,547.00

The required bridge fee is $6,129.59 based on 8.845 acres of platted roads within Black Squirrel Creek Basin. Since the fee is less than the estimated construction cost, the owner must then post a letter of credit covering the improvement cost. The 1987 bridge fee for Black Squirrel Creek Basin is $693/acre.

APPENDIX A:

Concrete Box Culvert Calculations

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SUBJECT MAJOR DRAINAGE - CBC UNDER NORTHGATE PKWY

REF: HEC-13 "HYDRAULIC DESIGN OF IMPROVED INLETS FOR CULVERTS" BY FHWA

$Q = 4050$ CFS

TRY $(14'-14') \times 10'$ CBC

$$\frac{Q}{NB} = \frac{4050}{(2)(14)} = 145$$

(FROM CHART 5)
$D_c = 8.6'$ $< 10'$, OK

TRY INLET CONTROL NOMOGRAPH (CHART 7)

$H_f/D = 1.47$ (30°-75° WINGWALL FLARE)

$H_f = 14.7'$ (TOO HIGH)

SLOPE TAPERED INLET

TRY THROAT CONTROL CURVE (CHART 14)

$$\frac{Q}{NBD^{3/2}} = \frac{4050}{(2)(14)(10)^{1.5}} = 4.57$$

$H_t/D = 1.31$

$H_t = 13.1'$

TRY FACE CONTROL CURVE (CHART 16)

USE $H_f/D = 1.0$

$$\frac{Q}{B_f D^{3/2}} = 2.75$$

$$B_f = \frac{4050}{(2.75)(10)^{1.5}} = 46.6$$

WITH 4:1 TAPER

$$L_1 = \frac{(46.6 - 28)(4)}{2} = 37.2' \quad \text{USE } 38' \quad (B_f = 47')$$

CHECK OUTLET CONTROL
$Q/N = 2025$ CFS
$K_e = 0.2$
$A = 140$ SF
$L = 162'$

$H = 4.6'$

$H_o = \frac{D + D_c}{2} = \frac{(10') + (8.6')}{2} = 9.3'$

HEAD PROVIDED (W/ 3.5' DROP) = 5.5' > HEAD REQUIRED, OK

ANALYZE CBC PERFORMANCE & GRAPH

Q	(THROAT) $Q/NBD^{3/2}$	(THROAT) * H_t/D	(FACE) $Q/B_cD^{3/2}$	(FACE) H_f/D	(THROAT) HW	(FACE) HW
100	0.11	0.08	0.07	0.07	—	0.7
300	0.34	0.23	0.20	0.18	—	1.8
500	0.56	0.32	0.34	0.23	—	2.3
800	0.90	0.44	0.54	0.32	0.7	3.2
1200	1.36	0.57	0.81	0.43	2.0	4.3
1600	1.81	0.71	1.08	0.53	3.4	5.3
2000	2.26	0.82	1.35	0.62	4.5	6.2
2500	2.82	0.95	1.68	0.72	5.8	7.2
3000	3.39	1.07	2.02	0.82	7.0	8.2
3500	3.95	1.18	2.35	0.90	8.1	9.0
4000	4.52	1.30	2.69	0.98	9.3	9.8
4500	5.08	1.41	3.03	1.07	10.4	10.7

* TO OBTAIN HW ABOVE FACE, SUBTRACT 3.7'

FOR ALL FLOWS CONSIDERED, FACE CONTROLS THE HW

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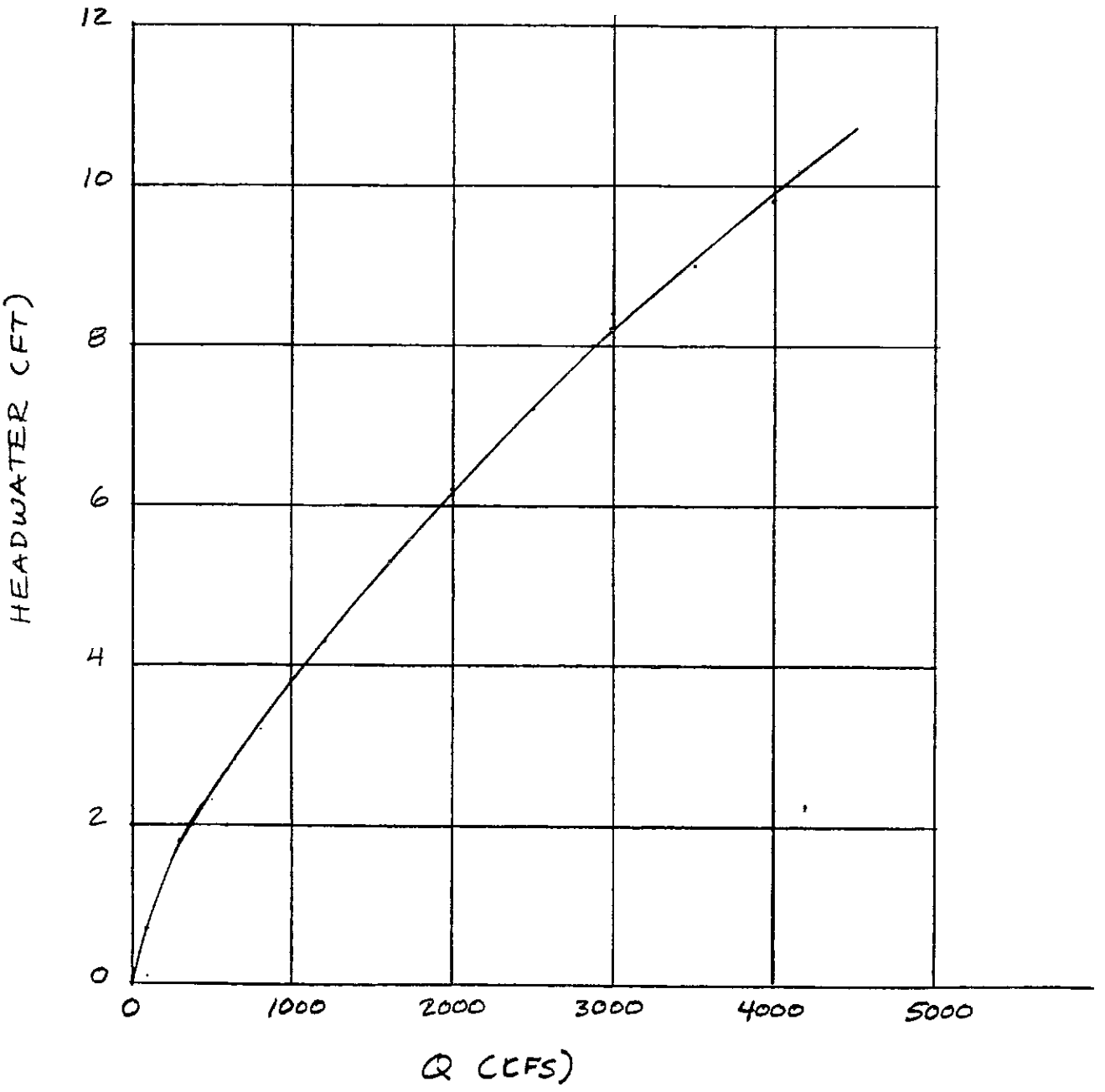

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SUBJECT ULTIMATE CBC OUTLET DESIGN

(14'-14') x 10' RCB

$Q = 4050$ CFS $\qquad q = \frac{4050}{28} = 144.6$ CFS/FT

$D_c = \left(\frac{q^2}{g}\right)^{1/3} = \left(\frac{(144.6)^2}{32.2}\right)^{1/3}$

$D_c = 8.66'$

$V_c = 16.7$ FPS

ENTRANCE TRANSITION

FROM HEC-13 INLET ANALYSIS

100 YR. W.S. EL. = 6721.43 @ FACE OF TRANSITION

$V = \frac{Q}{A} = \frac{4050}{(10)(47.0)} = 8.6$ FPS

ENERGY GRADELINE = 6722.58

USE ENERGY EQUATION TO APPROXIMATE THE DEPTH @ THE THROAT OF THE BOX

$$z_1 + y_1 + \alpha_1 \frac{V_1^2}{2g} = z_2 + y_2 + \alpha_2 \frac{V_2^2}{2g} + h_f$$

$$h_f + y_2 + \alpha_2 \frac{V_2^2}{2g} = (z_1 - z_2) + y_1 + \alpha_1 \frac{V_1^2}{2g}$$

ASSUME:

$\alpha_1, \alpha_2 = 1.0$

$h_f = C_e \frac{V_2^2}{2g}$

$C_e = 0.3$

$$y_2 + 1.3\frac{V_2^2}{2g} = 4.83 + 10.00 + \frac{(8.6)^2}{2(32.2)} = 16.0'$$

SINCE $V_2 = \frac{Q}{A_2} = \frac{Q}{(28)Y_2}$

Y_2	V_2	$Y_2 + \frac{1.3V_2^2}{2g}$
8.0	18.1	14.6'
7.5	19.3	15.0'
7.0	20.7	15.6'
6.9	21.0	15.8'
6.8	21.3	15.9'
6.7	21.6	16.1'

TRY $S = 0.80\%$ FOR BOX, USE MANNING'S EQN

$D_N = 7.06'$
$A = 197.7$ SF
$V = 20.5$ FPS
$F_r = 1.36$

$Q = 4050$ CFS
$n = 0.015$

TRY $S = 0.70\%$ FOR BOX, USE MANNING'S EQN ← USE

$D_N = 7.42$
$A = 207.8$ SF
$V = 19.5$ FPS
$F_r = 1.26$

$Q = 4050$ CFS
$n = 0.015$

OUTLET TRANSITION

FLOW INTO CONCRETE-LINED CHANNEL (ULTIMATE)

$B = 20'$
$Z = 1.5:1$
$S = 0.59\%$

$Q = 4050$ CFS
$n = 0.015$

$D_N = 6.56'$
$A = 195.7$ SF
$V = 20.7$ FPS
$F_r = 1.42$

$D_C = 8.67'$
$A = 286.2$ SF
$V = 14.2$ FPS

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MOMENTUM EQUATION

$$P_1 - P_2 + \cancel{W \sin\theta}^{\,0} - F_F = \frac{Q\gamma}{g}(\beta_2 V_2 - \beta_1 V_1)$$

WHERE: P_1, P_2 = PRESSURE FORCES ACTING ON UPSTREAM & DOWNSTREAM ENDS OF CONTROL VOLUME

W = WEIGHT OF WATER WITHIN CONTROL VOLUME

θ = CHANNEL SLOPE

F_F = SHEAR FORCES ON CHANNEL BOUNDARY

Q = DISCHARGE (CFS)

γ = UNIT WEIGHT OF WATER

g = GRAVITATION CONSTANT

V_1, V_2 = AVERAGE FLOW VELOCITIES AT SECTIONS 1 & 2

β_1, β_2 = MOMENTUM DISTRIBUTION COEFFICIENTS

SIMPLIFYING ASSUMPTIONS

1) HYDROSTATIC PRESSURE DISTRIBUTION
2) $W \sin\theta = F_F$ FOR SMALL θ
3) $\beta_1 = \beta_2 = 1.0$

KOCH-CARSTANJEN EQUATION (INCLUDES CENTERWALL OF BOX)

$$P_2 + \frac{\gamma Q V_2}{g} = P_3 - P_p + \frac{\gamma Q V_3}{g}$$

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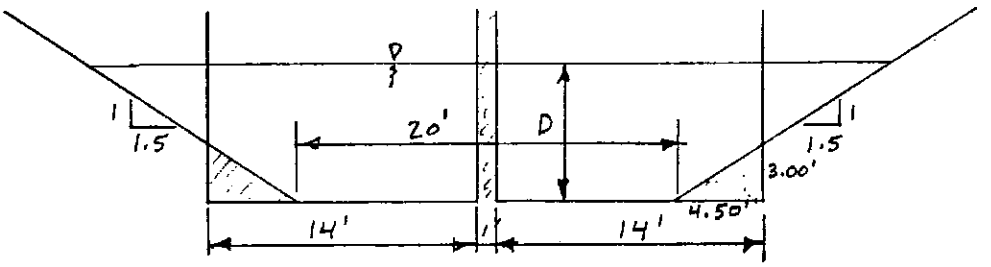
SECTION 2 & 3



FOR $D_2 = 7.42'$

$$P_2 + \frac{\gamma Q V_2}{g} = \left(\frac{(7.42)}{2}(62.4)(7.42)(28)\right) + \frac{(62.4)}{(32.2)}(4050)(19.5)$$

$$= 201,142 \text{ LB}$$

$$P_3 - P_p + \frac{\gamma Q V_3}{g} = \frac{D_3}{2}(62.4)D_3(29) + \frac{2(D_3-3)}{3}(62.4)\frac{(D_3-3)^2(1.5)}{2}$$

$$- \frac{D_3}{2}(62.4)(D_3)(1)$$

$$+ \frac{(62.4)}{(32.2)}(4050)\frac{(4050)}{(20+1.5D_3)D_3}$$

D_3	P_3	P_p	$\frac{\gamma Q V_3}{g}$	$P_3 - P_p + \frac{\gamma Q V_3}{g}$
6.90'	44,928	1485	151,786	195,229
7.00'	46,332	1529	148,882	193,685
6.80'	43,550	1443	154,783	196,890
6.60'	40,869	1359	161,073	200,583
6.55'	40,214	1339	162,711	201,587
6.56'	40,344	1343	162,381	201,383
6.57'	40,475	1347	162,053	201,181 ←

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CHECK CRITICAL MOMENTUM @ SECTION 3

$D_c = 8.67'$

$P_3 - P_p + \frac{\gamma Q V_3}{g} = 182{,}436 \quad < \quad P_2 + \frac{\gamma Q V_2}{g}$ OK

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SUBJECT TEMPORARY CBC OUTLET DESIGN

OUTLET FOR (14'-14') x 10' RCB (SEE DRCOG "URBAN STORM DRAINAGE CRITERIA MANUAL")

$W = 28'$

$Y_N = 7.42'$

$H = 10'$

$H_a = 1/2 (H + Y_N) = 8.71'$

ASSUME $Y_t = 4'$

$$\frac{Q}{W H_a^{0.5}} = \frac{4050}{(28)(8.71)^{0.5}} = 49.0$$

$$Y_t/H_a = \frac{(4)}{(8.71)} = 0.46$$

FROM FIG. 5-8

USE TYPE VH RIP-RAP ($D_{50} = 24"$)

(THIS IS ALSO TRUE FOR $Y_t/H_a = 40$ AS RECOMMENDED IF A POSSIBLE HYDRAULIC JUMP COULD OCCUR)

$$\frac{Q}{W H_a^{3/2}} = \frac{4050}{(28)(8.71)^{3/2}} = 5.6$$

FROM FIG. 5-10

$$\frac{1}{2 \tan \theta} = 1.8$$

FOR A VELOCITY OF 5.5 FPS

$$A_t = \frac{4050}{5.5} = 736 \text{ SF}$$

FROM EQUATION 5-9

$$L = \left(\frac{1}{2 \tan \theta}\right)\left(\frac{A_t}{Y_t} - W\right)$$

$$L = (1.8)\left(\frac{736}{4} - 28\right) = 281'$$

SINCE

$L > 10H$ USE $L = 10H = 100'$

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SUBJECT CBC COSTS

USE (14'-14') x 10' TYPE "A" RCB

BARREL COSTS

CONCRETE = (162')(4.077 CY/LF)($180/CY) = $118,885

STEEL = (162')(392.9 LB/LF)($0.50/LB) = $ 31,825

STRUCTURAL EXCAVATION = (162')(3')(1')/27 ($3.00/CY) = $ 54

STRUCTURAL BACKFILL = (162')(72 SF)/27 ($12.00/CY) = $ 5,184

HEADWALL & TOEWALL

CONCRETE = 2(31')(0.085 CY/LF)($180/CY) = $ 949

STEEL = 2(31')(26 LB/LF)($0.50/LB) = $ 806

INLET TRANSITION

CONCRETE = 3(39.2')(0.604 CY/LF)($180/CY) = $ 12,785

STEEL = 3(39.2')(67.3 LB/LF)($0.50/LB) = $ 3957

CONCRETE FLOOR = $\frac{(28+47.0)}{2(27)}$ (38)(1') ($180/CY) = $ 9500

STRUCTURAL BACKFILL = $\frac{2(39.2')(69.3\,SF)}{27}$ ($12.00/CY) = $ 2415

INLET WINGWALLS

CONCRETE = $2(45')\frac{(0.604\,CY/LF)}{2}$ ($180/CY) = $ 4892

STEEL = $2(45')\frac{(67.3\,LB/LF)}{2}$ ($0.50/LB) = $ 1514

STRUCTURAL BACKFILL = $\frac{2(45')(69.3\,SF)}{2(27)}$ ($12.00/CY) = $ 1386

CONCRETE FLOOR = $(20')\frac{(48.5+88.5)}{2(27)}(6/12)$($180/CY) = $ 4567

RIP-RAP = $(12')\frac{(88.5+112.5)}{2(27)}(2')$($23.40/CY) = $ 2090

RIP-RAP BEDDING = $(12')\frac{(88.5+112.5)}{2(27)}(1')$($12.00/CY) = $ 536

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URS JOB NO. 5206 PAGE 11 OF ____
DATE 4-8-86 BY CLP CHECKED BY ____ (date)
CLIENT THE OLIVE CO.
PROJECT NORTHGATE DRAINAGE

SUBJECT ____

100 YEAR OUTLET COST (TEMPORARY)

WINGWALLS (130' LONG EACH, VARY FROM 10' HIGH TO 5' HIGH)

COST OF CONCRETE = $2\left[(130')\frac{(0.604+0.308)^{CY/LF}}{2}(\$180/CY)\right]$ = $21,341

COST OF STEEL = $2\left[(130')\frac{(67.3+12.1)^{LB/LF}}{2}(\$0.50/LB)\right]$ = $5161

COST OF BACKFILL = $2\left[(130')(35.3\,SF)\left(\frac{1}{27}\right)(\$12.00/CY)\right]$ = $4079

COST OF RIP-RAP @ $2\,D_{50} = t$ = $(50')(4')\frac{(29+106.5)}{2(27)}(\$23.40/CY)$ = $11,743

COST OF RIP-RAP @ $1.5\,D_{50} = t$ = $(50')(3')\frac{(106.5+184)}{2(27)}(\$23.40/CY)$ = $18,883

COST OF RIP-RAP FILTER BLANKET = $(100')(1')\frac{(29+184)}{2(27)}(\$12.00/CY)$ = $4733

$65,940

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URS JOB NO. 5206 PAGE 12 OF _____
DATE 4-29-86 BY CLP CHECKED BY _____ (date)
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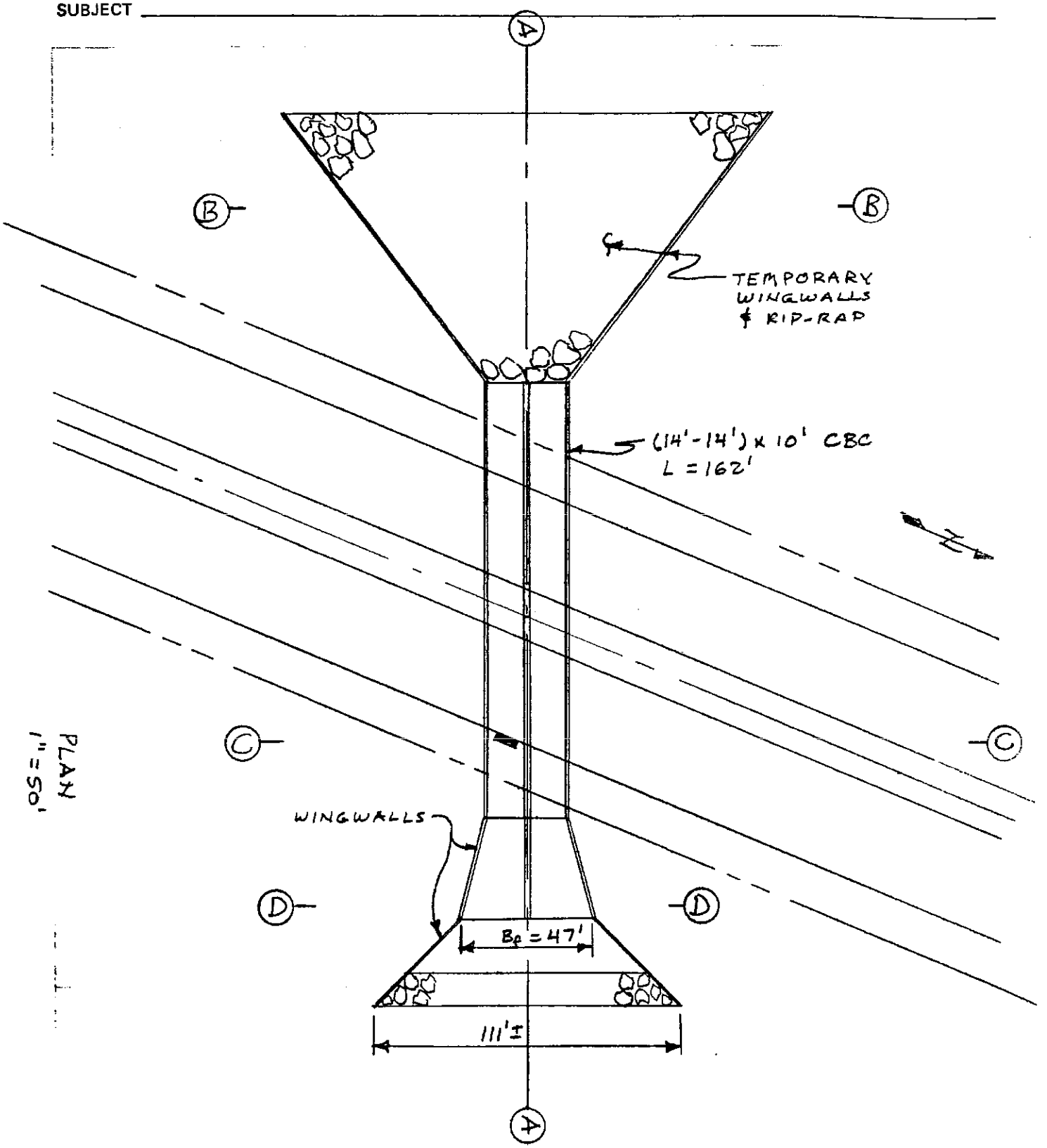
SUBJECT _____



PLAN
1" = 50'

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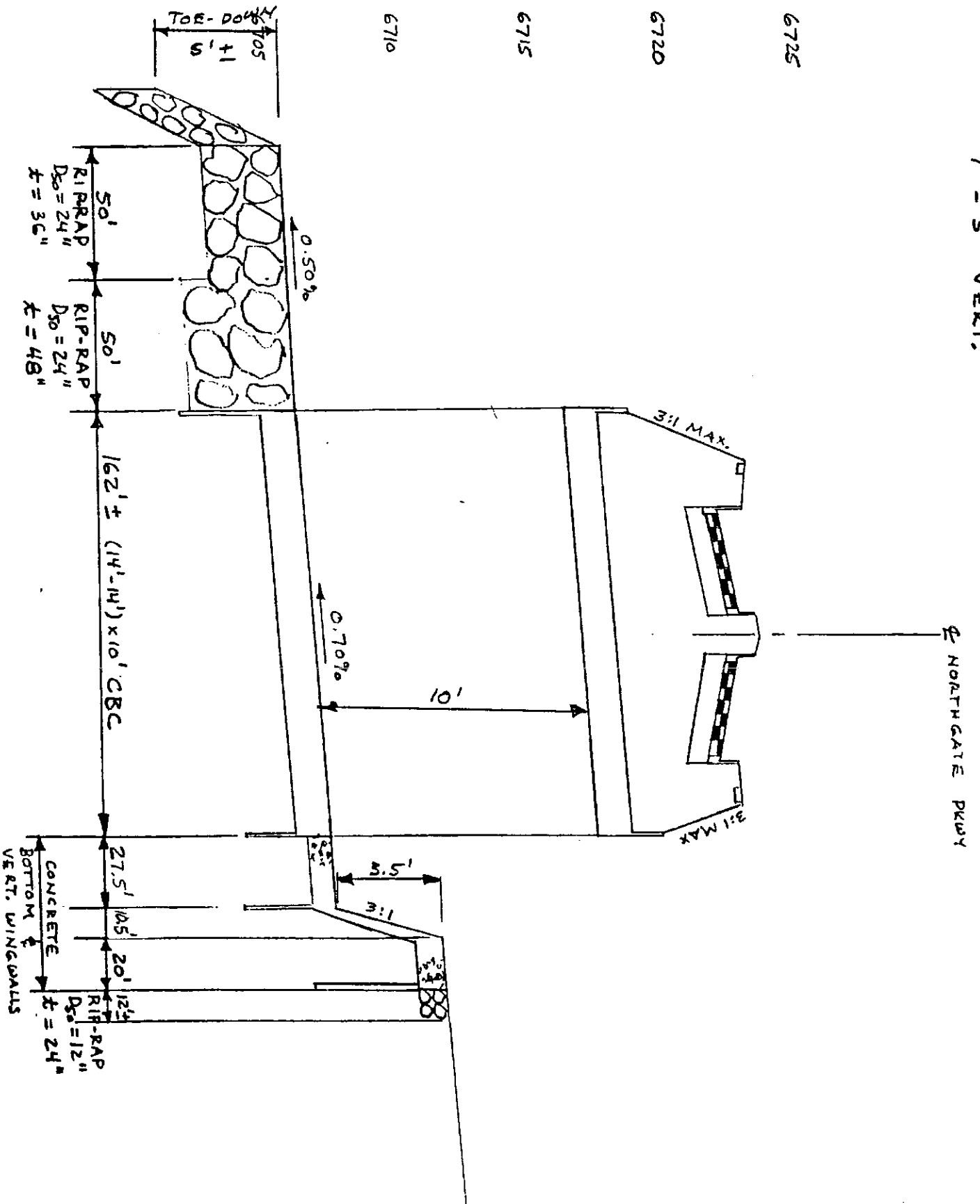
CLIENT THE OLIVE CO. PROJECT NORTHGATE DRAINAGE REPORT

SUBJECT _____



1" = 50' HORIZ.
1" = 5' VERT.

SECTION 4-A

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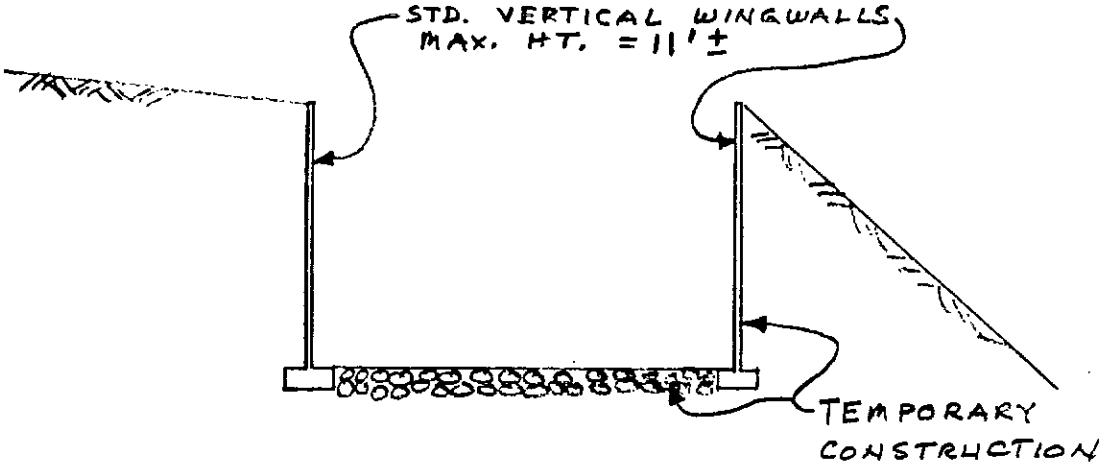
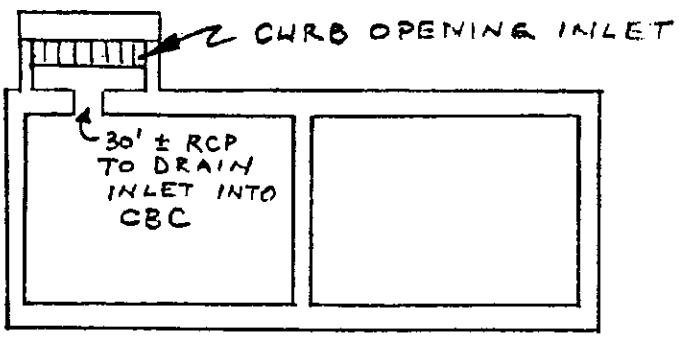
SUBJECT _____



SECTION B-B

1" = 50' HORIZ
1" = 5' VERT.
(APPROX.)



SECTION C-C
1" = 10' (APPROX.)

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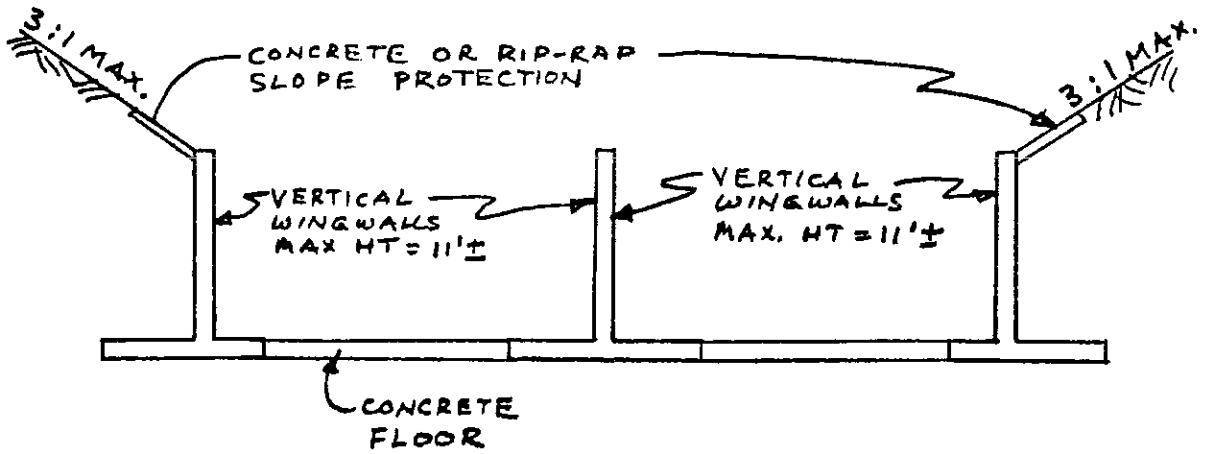
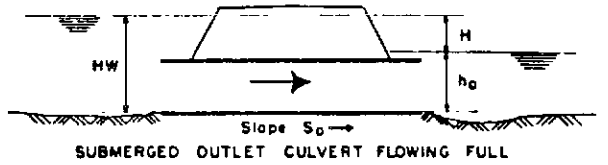
CLIENT THE OLIVE CO. PROJECT NORTHGATE DRAINAGE REPORT

SUBJECT _____



SECTION D-D
1" = 10'

Chart 1



SUBMERGED OUTLET CULVERT FLOWING FULL

$HW_o = H + h_o +$ El. Outlet Invert

DIMENSION OF SQUARE BOX IN FEET

AREA OF RECTANGULAR BOX IN SQUARE FEET

TURNING LINE

LENGTH (L) IN FEET

HEAD (H) IN FEET

Q = 400

7 x 7 Box L = 400'

$k_e = 0.5$

$k_e = 0.2$

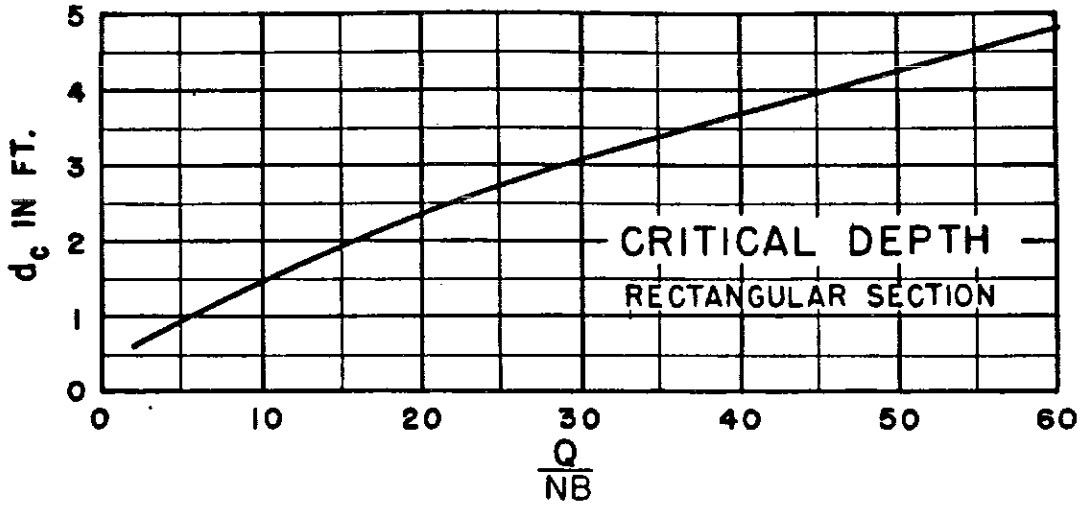
$k_e = 0.3$

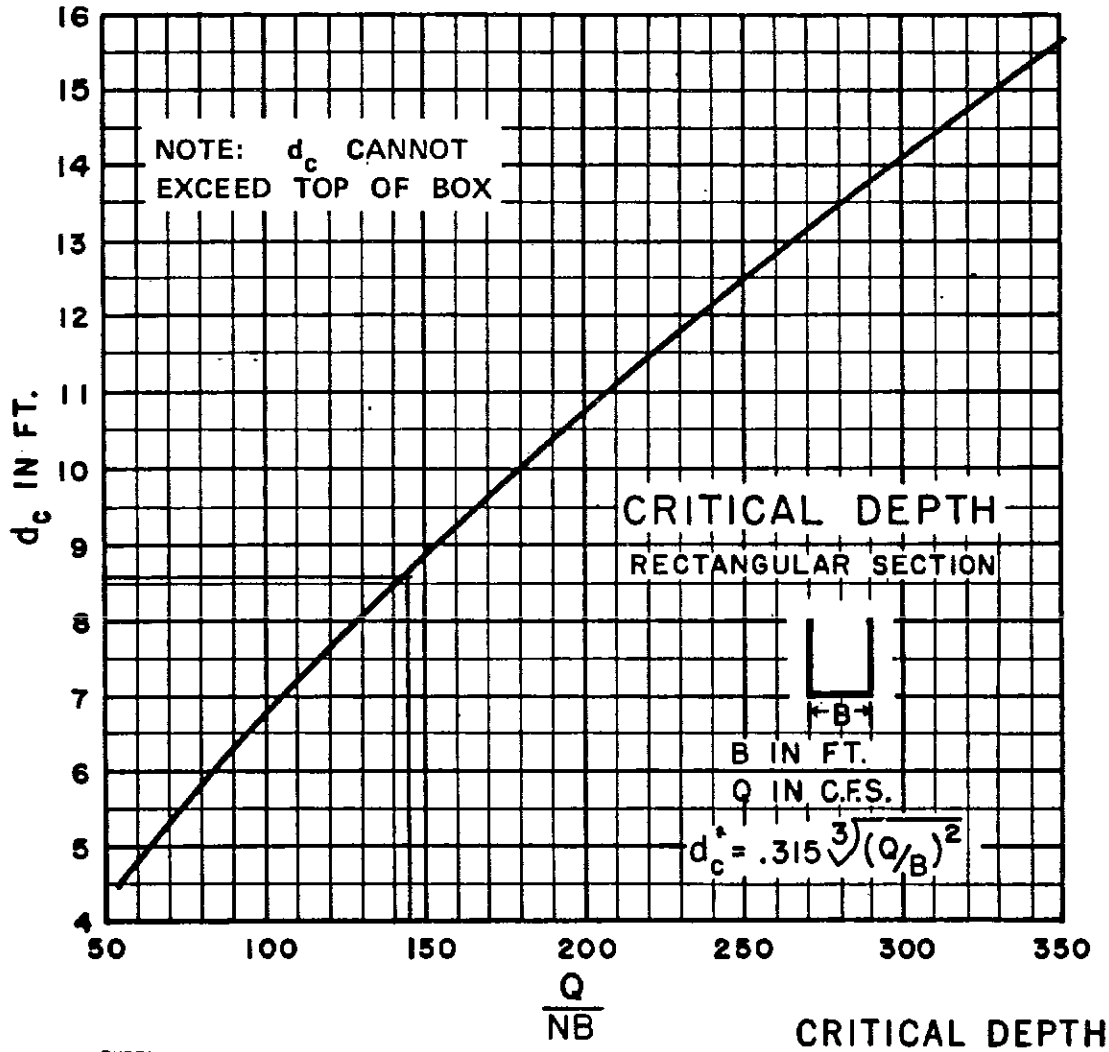
$k_e = 0.7$

H = 2.4'

HEAD FOR CONCRETE BOX CULVERTS FLOWING FULL n = 0.012

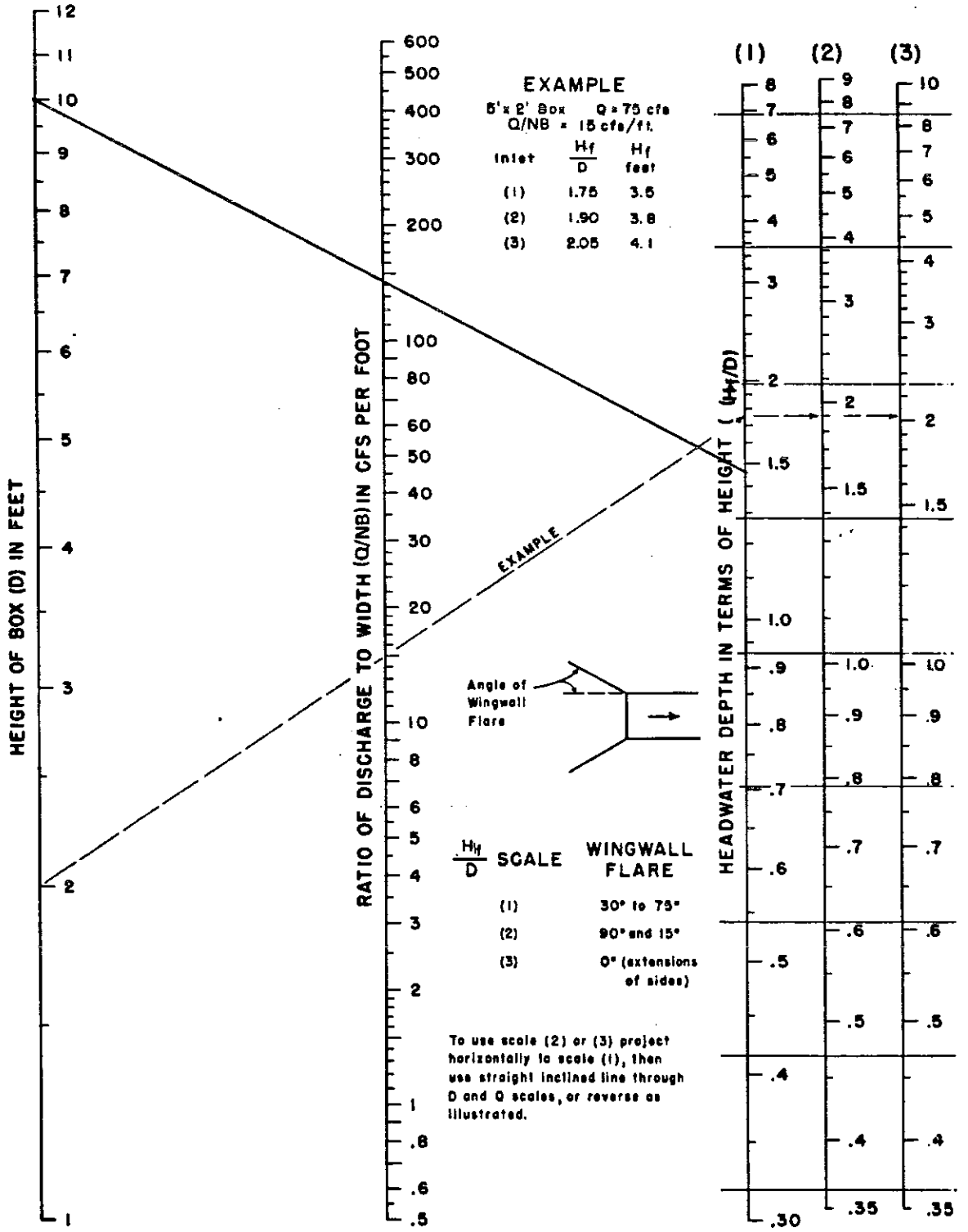
Chart 5



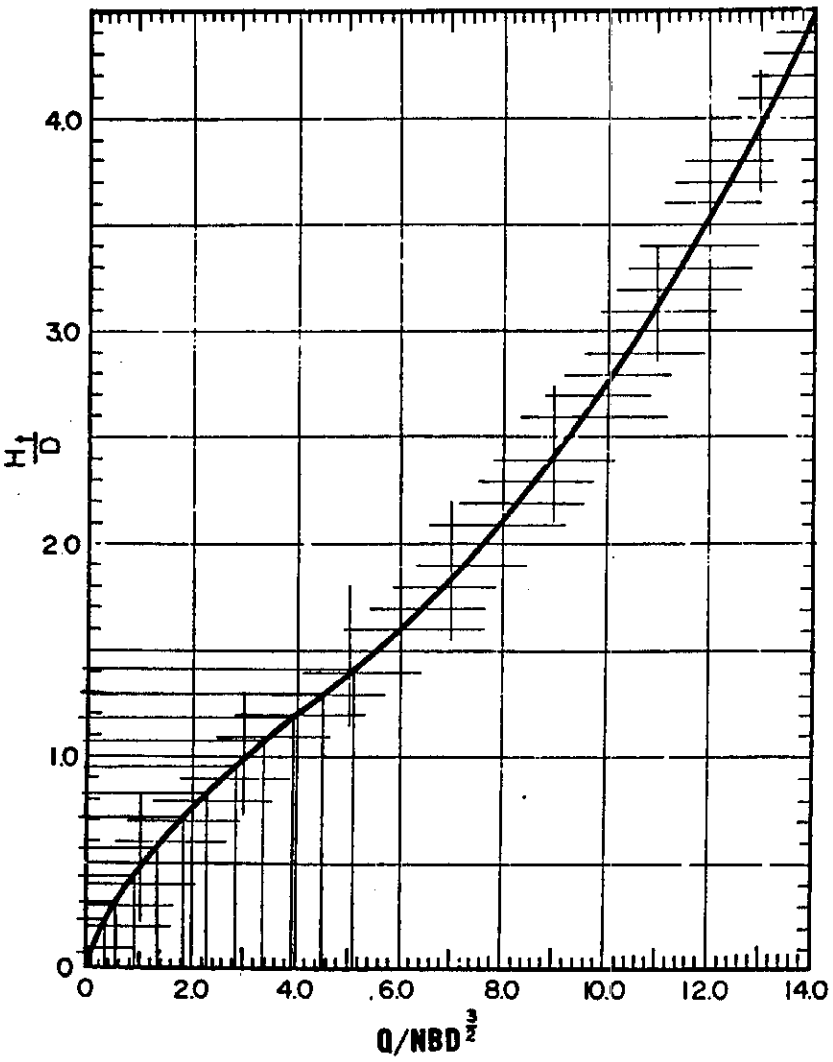


BUREAU OF PUBLIC ROADS JAN. 1963

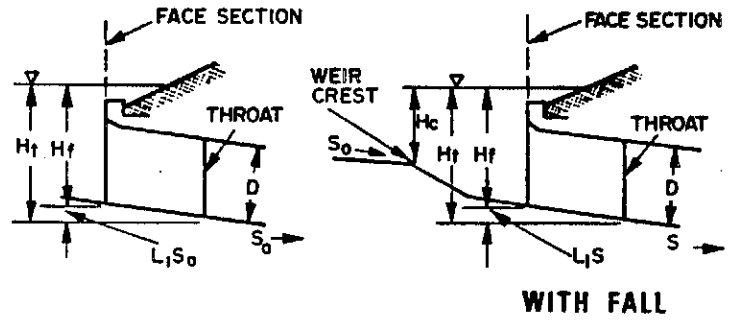
CRITICAL DEPTH
RECTANGULAR SECTION



HEADWATER DEPTH FOR BOX CULVERTS WITH INLET CONTROL

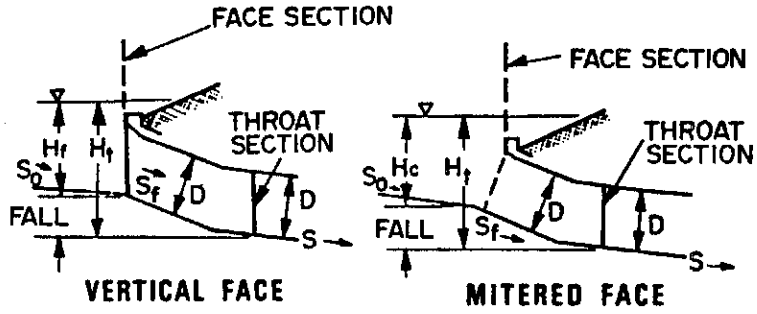


SIDE-TAPERED



WITH FALL

SLOPE-TAPERED

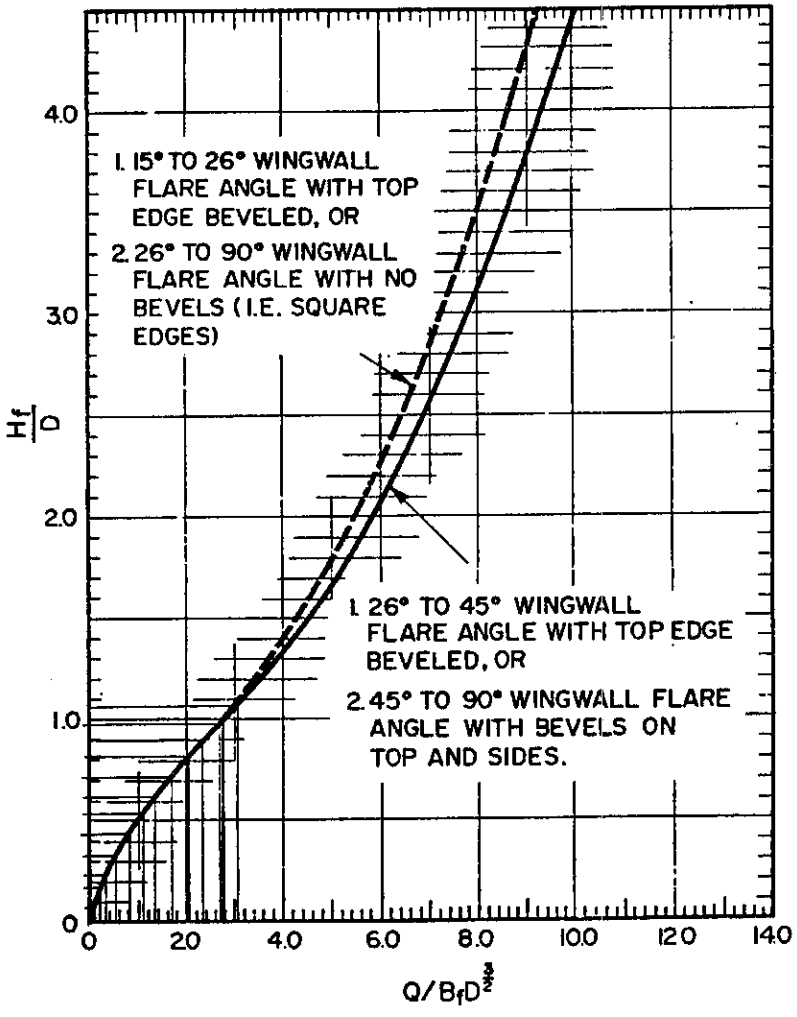


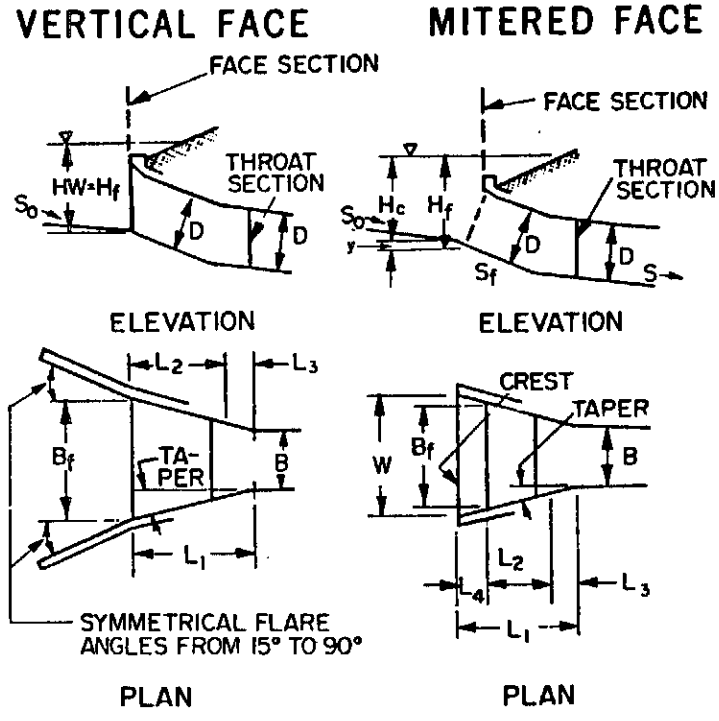
VERTICAL FACE

MITERED FACE

THROAT CONTROL CURVE FOR BOX CULVERTS TAPERED INLETS

FEDERAL HIGHWAY ADMINISTRATION
OCTOBER 1971





FACE CONTROL CURVES FOR BOX CULVERTS SLOPE-TAPERED INLETS

FEDERAL HIGHWAY ADMINISTRATION
OCTOBER 1971

APPENDIX B:

Temporary Detention Facilities

URS CORPORATION
MAKING TECHNOLOGY WORK™

URS JOB NO. 5206-21 PAGE 1 OF 10
DATE 10/1/87 BY D. GREVE CHECKED BY (date)
CLIENT THE OLIVE CO.
PROJECT NORTHGATE PH. I DRAINAGE
SUBJECT SIZE TEMORARY DETENTION POND FOR BLACK SQUIRREL CREEK BASIN (SPECIFICALLY BASIN J1)

A. SIZE TEMPORARY DETENTION FACILITY FOR INITIAL DEVELOPMENT OF BASIN J1B AND TO OVERDETAIN FOR THE PAVED ROADS IN PHASE I.

B. BASINS TRIBUTARY TO THE TEMPORARY POND INCLUDE J1A AND J1B. IT IS ASSUMED THAT NO DEVELOPMENT WILL TAKE PLACE INITIALLY IN BASIN J1A.

1. FLOW CALCULATIONS

BASIN	ACREAGE	CN (HIST)	CN (INITIAL DEV.)
J1A	108	69	69
J1B	65	69	72
	173	$\overline{CN}$ = 69	$\overline{CN}$ = 70.1

∴ FOR BASINS J1A & J1B, THE RUNOFF IS:

	HIST (5-YR)	HIST. (100-YR)	INITIAL DEV. (5-YR)	INITIAL DEV (100 YR)
$\overline{CN}$	69	69	70.1	70.1
24-hr RAINFALL	2.7 in.	4.6 in.	2.7 in.	4.6 in.
PEAK RUNOFF (csm/in)	810	810	850	850
RUNOFF DEPTH (in)	0.52	1.67	0.56	1.75
PEAK RUNOFF (cfs)	114	366	129	402

ASSUME TEMPORARY DETENTION FACILITY WILL OVERDETAIN DEVELOPED RUNOFF FROM PHASE I STREETS ALSO:

FROM TABLE 3:

BASIN	ACREAGE	CN (HIST.)	CN (PAVED)
C1	0.4	69	98
C2	0.3		
C3	1.0		
E1	1.1		
E2	0.3		
E3	0.3		
H1	1.4		
H2	0.7		
P	0.7		
Q	2.7		
R	2.1		
N1	2.0		
TOTAL FOR STREETS	13.0	69	98

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URS JOB NO. 5206-21 PAGE 2 OF 10
DATE 10/1/87 BY D. GREVE CHECKED BY (date)
CLIENT THE OLIVE CO.
PROJECT NORTHGATE PH. 1 DRAINAGE
SUBJECT TEMPORARY DETENTION POND (BASIN J1)

FOR PH. 1 STREETS:

	HIST. (5YR.)	HIST. (100-YR.)	DEV. (5-YR)	DEV. (100-YR)
$\overline{CN}$	69	69	98	98
24-hr. RAINFALL	2.7 in	4.6 in	2.7 in	4.6 in
PEAK RUNOFF (CSM/IN.)	1000	1000	1000	1000
RUNOFF DEPTH (IN.)	0.52	1.67	2.47	4.36
PEAK RUNOFF (cfs)	10.6	33.9	50.2	88.6

FOR COMBINED J1A, J1B, AND STREETS:

	HIST. (5-YR.)	HIST. (100-YR)	DEV. (5-YR.)	DEV. (100-YR.)
Q (cfs)	114+11 = 125	366+34 = 400	129+50 = 179	402+89 = 491
$\overline{CN}$	69	69	72	72
24-hr. RAINFALL	2.7 in.	4.6 in.	2.7 in.	4.6 in.
RUNOFF (IN.)	0.52	1.67	0.64	1.89

AREA = 186 ac.

5-YEAR: $\frac{Q_{HIST}}{Q_{DEV.}} = \frac{125}{179} = .70$ FROM FIG. 7-2 $\frac{V_S}{V_R} = .20$

$V_R = \frac{0.64 \text{ in}}{12 \text{ in/ft}} \times 186.0 = \underline{9.9 \text{ ac-ft}}$
= VOLUME OF RUNOFF

$V_S = 9.9\ (.20) = \underline{2.0 \text{ ac-ft}}$
= VOLUME OF STORAGE

100-YEAR: $\frac{Q_{HIST}}{Q_{DEV}} = \frac{400}{491} = .81$ FROM FIG 7-3 $\frac{V_S}{V_R} = .17$

$V_R = \frac{1.89 \text{ in}}{12 \text{ in/ft}} \times 186.0 = \underline{29.3 \text{ ac-ft}}$
= VOLUME OF RUNOFF

$V_S = 29.3\ (.17) = \underline{5.0 \text{ ac-ft}}$
= VOLUME OF STORAGE

URS CORPORATION
MAKING TECHNOLOGY WORK™

URS JOB NO. 5206-21 PAGE 3 OF 10
DATE 10/1/87 BY D. GREVE CHECKED BY _____ (date)
CLIENT OLIVE CO.
PROJECT NORTHGATE PH. I DRAINAGE
SUBJECT TEMPORARY DETENTION FACILITY (BASIN J1)

OUTLET STRUCTURES INCLUDE 1-42" ϕ OUTLET PIPE (INVERT ELEV. 6722) AND A 32' WIDE SPILLWAY (WEIR ELEV. 6727).

FLOWS FOR OUTLET PIPE BASED ON INLET CONTROL (SEE NOMOGRAPH P. 6 OF 10), ASSUME 60% PLUGGED.

FLOWS FOR SPILLWAY BASED ON WEIR EQUATION:

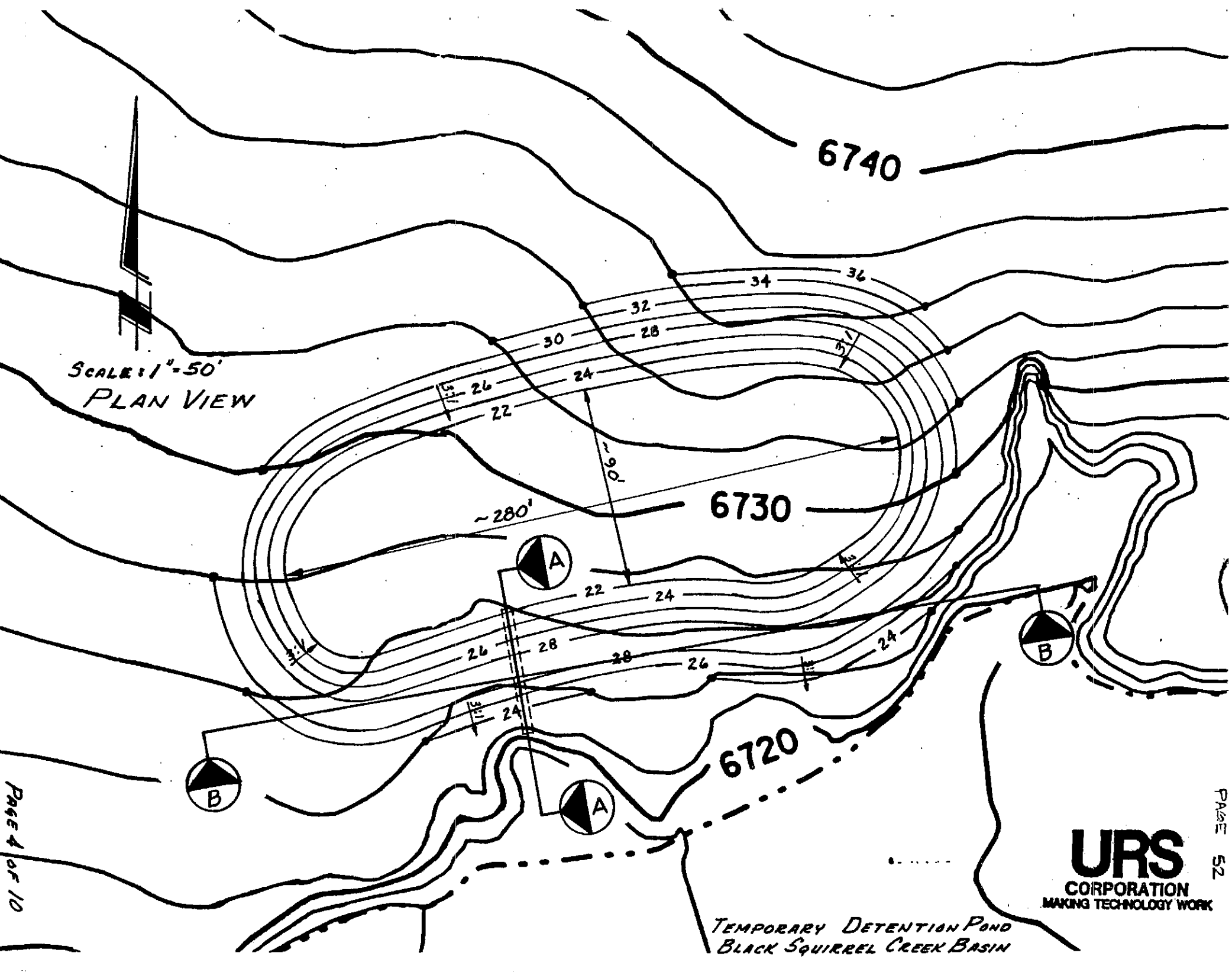
$Q = CLH^{3/2}$ $C = 4.0$, $L = 32'$, H = ELEV. − 6727

VOLUME - DISCHARGE TABLE:

ELEVATION	FLOW THROUGH 42" PIPE (cfs) (60% PLUGGED)	FLOW OVER SPILLWAY (cfs)	TOTAL DISCHARGE (cfs)		VOLUME (ac-ft)
6722	0	0	0		0.8
23	4	0	4		1.4
24	8	0	8	5-YR →	2.0
25	17	0	17		2.6
26	26	0	26		3.2
27	30	0	30		3.8
28	36	132	164		4.4
28.8	40	309	349	100-YR →	5.0
29	42	362	404		5.2
30	44	665	709		6.2
30.2	45	733	778		6.3

CONCLUSION: DEVELOPED 100-YR FLOW FROM BASINS J1A, J1B, AND THE STREETS IS 486 cfs.

ADEQUATE STORAGE IS AVAILABLE AT ELEVATION 6728.8 TO DETAIN TO HISTORIC 100-YEAR FLOWS. HOWEVER, TO INSURE AGAINST OVERTOPPING, PROVIDE AT LEAST 1.0' FREEBOARD TO ALLOW DISCHARGE OF 100-YEAR DEVELOPED FLOWS. THEREFORE, SET TOP OF DIKE AT 6730.2 (1.4' FREEBOARD).



TEMPORARY DETENTION POND
BLACK SQUIRREL CREEK BASIN

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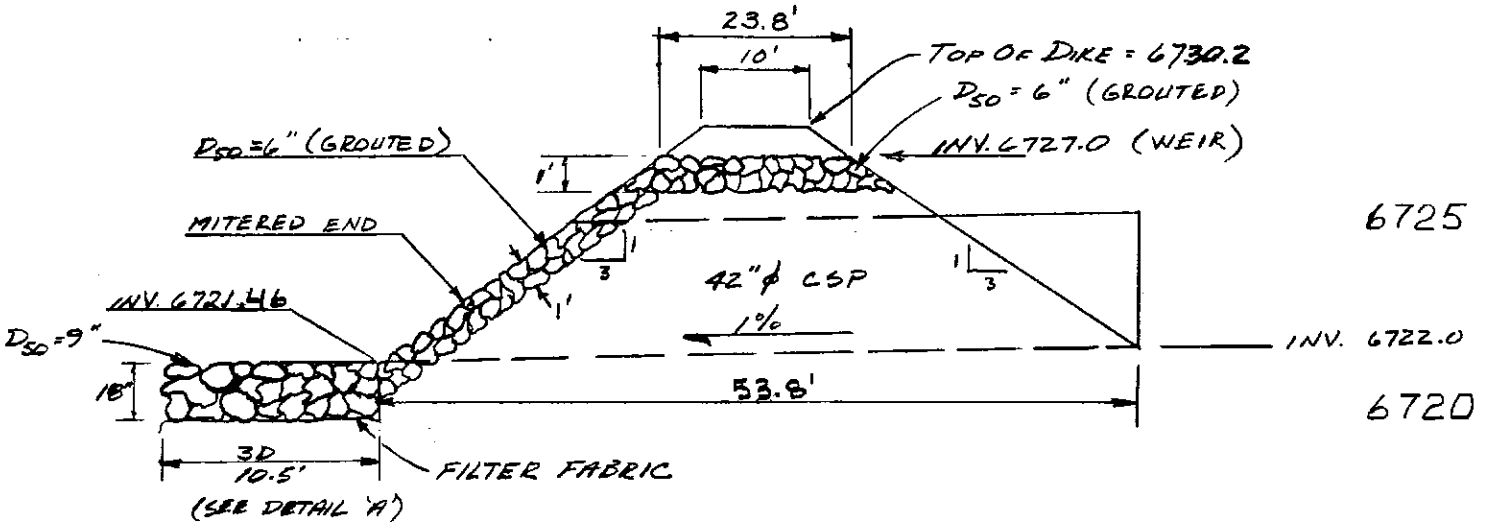
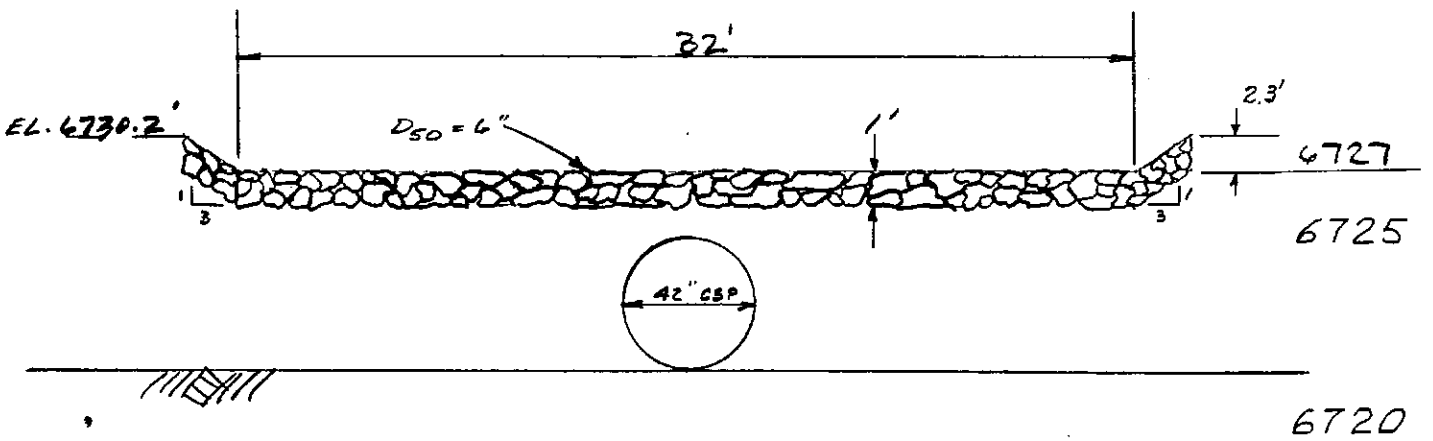
URS JOB NO. 5206-21 PAGE 5 OF 10
DATE 4/15/87 BY BTL CHECKED BY (date)
CLIENT OLIVE CO.
PROJECT NORTHGATE PHASE I
SUBJECT TEMPORARY DETENTION FACILITY - BSC BASIN



SECTION A-A
nts



SECTION B-B
nts

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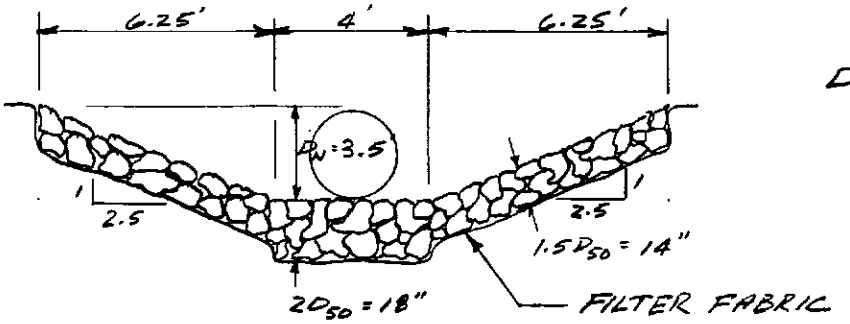
URS JOB NO. 5206-21 PAGE 6 OF 10
DATE 4/15/87 BY BTL CHECKED BY [illegible] (date)
CLIENT OLIVE CO.
PROJECT NORTHGATE PHASE I
SUBJECT TEMPORARY DETENTION FACILITY — BSC BASIN



OUTLET DETAIL A

H 1" = 5'
V 1" = 5'

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URS JOB NO. 5206-21 PAGE 7 OF 10
DATE 4/15/87 BY BTL CHECKED BY (date)
CLIENT OLIVE CO.
PROJECT NORTHGATE PHASE I
SUBJECT TEMPORARY DETENTION FACILITY — MISC. BASIN

ASSUMPTIONS:

1. SIZE FOR 5 YEAR STORM (SCS METHOD)
2. BASE DETENTION VOLUME ON DIFFERENCE BETWEEN DEVELOPED AND HISTORIC VOLUMES.
3. USE EXISTING DITCH VOLUME FOR DETENTION.
4. DITCH TO OVERDETAIN FOR ROADS ONLY IN BASINS V, W, & X

CALCULATIONS:

1. CALC. HISTORIC & "DEVELOPED" (ROADS ONLY) FLOWS FOR BASINS V, W, & X.

ACREAGE = 29.8

	HIST.	DEV. (ROADS ONLY)
CN	68.	68.6
T_c	0.32	0.32
csm/inch	910	910
RAINFALL	0.23"	0.24"
FLOW	9.7	10.2

2. CALC. VOLUME OF RUNOFF TO BE DETAINED

$$\Delta V = \frac{0.24\ in}{12\ in/ft} \cdot (29.8\ ac) - \frac{0.23\ in}{12\ in/ft} \cdot (29.8\ ac)$$

$$= 0.025\ ac\text{-}ft \quad \text{or} \quad 1089\ ft^3$$

DITCH LENGTH ~ 100' ; WIDTH = 6' (AVE.) ; DEPTH = 3'
VOLUME = 1800 FT^3

SEE DETAILS B AND C NEXT PAGE

3. FROM INLET CONTROL NOMOGRAPH (SEE DETAIL B)

HW/D	Q(OUT)
2.2	9.7
3.0	10.2

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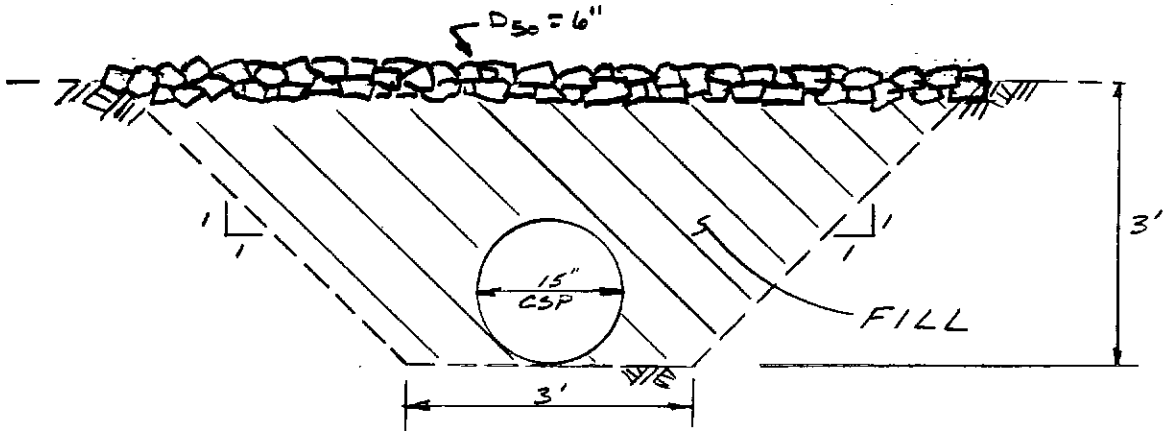
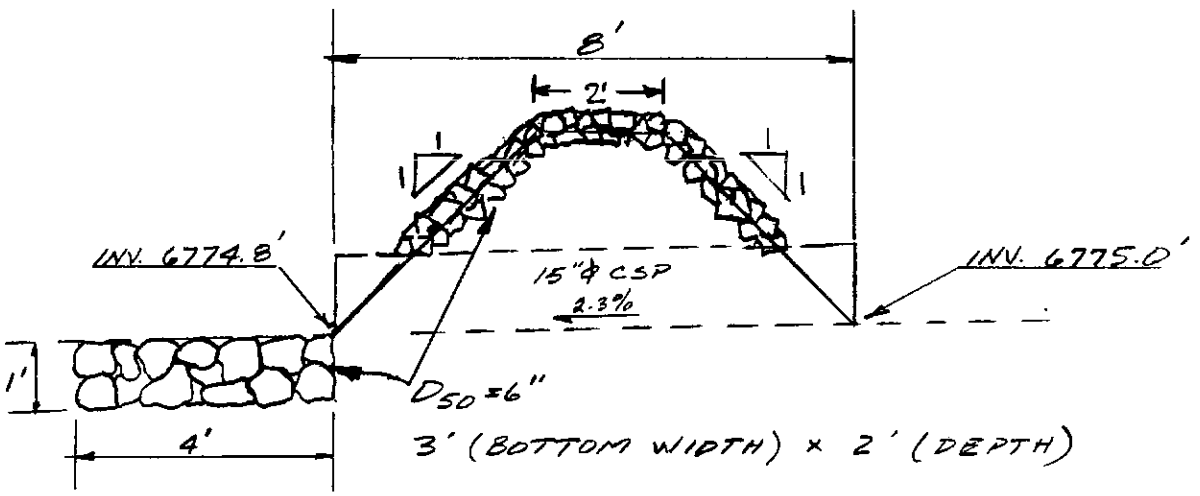
URS JOB NO. 5206-21 PAGE 8 OF 10
DATE 4/15/87 BY BTL CHECKED BY DF (date) 4/17
CLIENT OLIVE CO.
PROJECT NORTHGATE PHASE I
SUBJECT TEMPORARY DETENTION FACILITY - MISC. BASIN



DETAIL B

1" = 2'



DETAIL C

1" = 3'

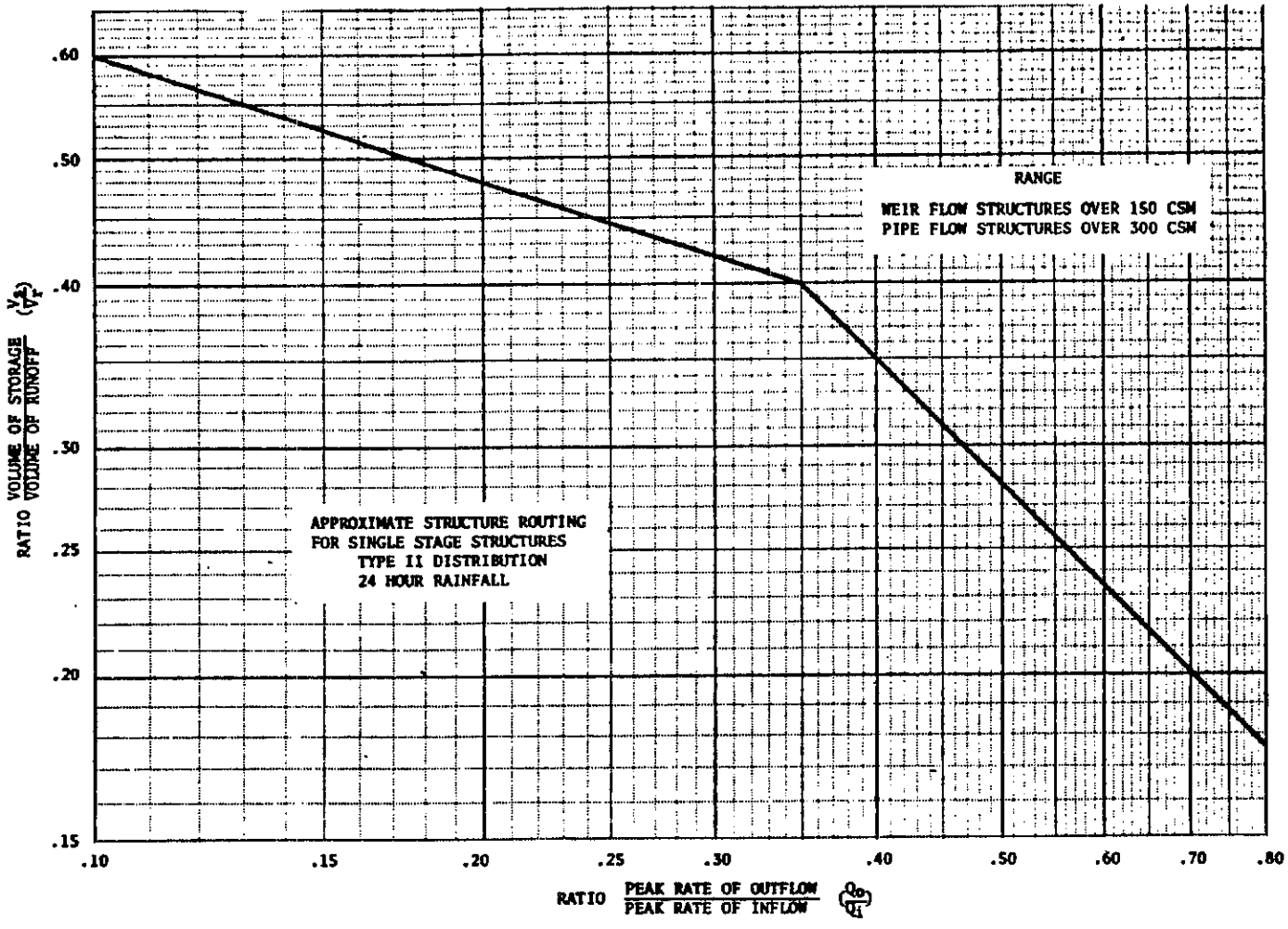
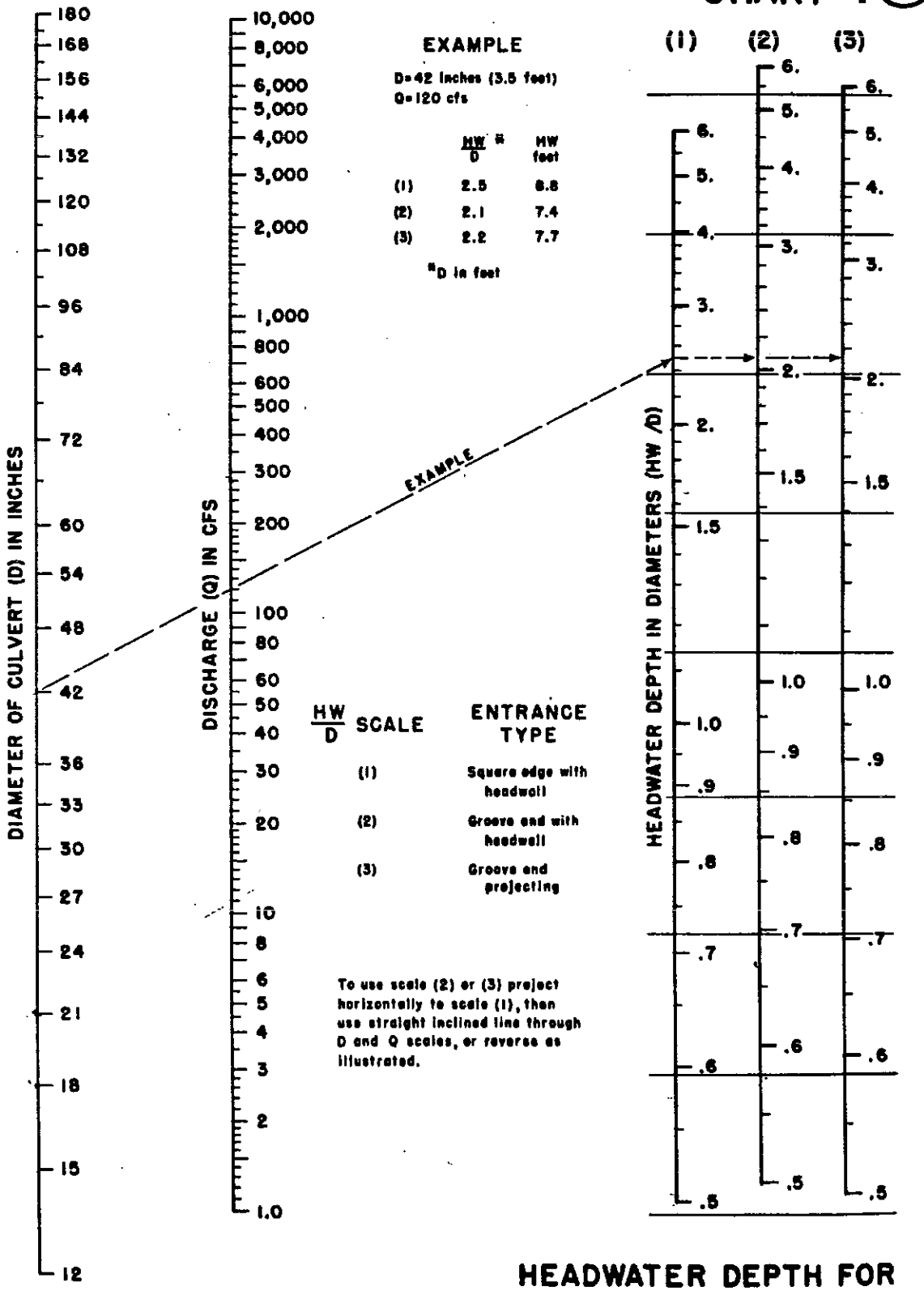


Figure 7-2.--Approximate single-stage structure routing for weir flow structures over 150 csm release rate and pipe flow structures over 300 csm release rate.

CHART 1



HEADWATER DEPTH FOR CONCRETE PIPE CULVERTS WITH INLET CONTROL

HEADWATER SCALES 2&3
REVISED MAY 1964

BUREAU OF PUBLIC ROADS JAN. 1963