Northern/Orangewood
Storm Drain Project
Contract FCD 94-12, Phase II
Orangewood Avenue Storm Drain
Sub-Phase "C"
Design Documentation Summary
for
Final Plan Submittal

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Northern/Orangewood Storm Drain Project
Contract FCD 94-12, Phase II

Orangewood Avenue Storm Drain
Sub-Phase "C"

Design Documentation Summary
for
Final Plan Submittal

Prepared by:

Wood, Patel & Associates, Inc.
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Prepared for :

Flood Control District of Maricopa County
2901 West Durango Street
Phoenix, Arizona 85009
Phone: (602) 506-1501

Registered Professional Engineer (Civil)
CERTIFICATE NO.
10512
ASHOK C.
PATEL
Date Signed 3/29/99
ARIZONA, U.S.A.

March 29 , 1999
WP #94153.06

WOOD/PATEL

CIVIL ENGINEERS • HYDROLOGISTS • LAND SURVEYORS

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March 29, 1999

Flood Control District of Maricopa County
2801 West Durango Street
Phoenix, AZ 85009

Attn: Mr. R.W. Shobe, P.E.

Re: **Northern/Orangewood Storm Drain Project**
Contract FCD 94-12 Phase II
Orangewood Avenue Storm Drain, Sub-Phase "C"
WP #94153.06

Dear Mr. Shobe:

We are pleased to submit this data package in conjunction with the Final plan submittal for the referenced project. The package includes:

• Original Mylars - Signed and Sealed	- 1 set (under separate cover)
• Drainage Report	- 12 sets (under separate cover)
• Construction Drawing Diskettes	- 1 set (under separate cover)
• Construction General Conditions and Special Provisions	- 1 set (under separate cover)
• Structural Design Calculations	- 6 sets (under separate cover)
• Correspondence	- 1 set (under separate cover)
• 90% Comments and Responses	- 1 set
• 1/2 Size Plans	- 2 sets
• Bid Tabs and Engineering Estimate	- 2 sets

The 90% review comments are incorporated into this submittal. The 90% review comments and responses are included under separate cover.

On your behalf, Wood/Patel will make a separate submittal to the Cities of Glendale and Peoria.

Wood, Patel & Associates, Inc. • 1550 East Missouri, Suite 203, Phoenix, Arizona 85014 • (602) 234-1344 • Fax (602) 234-1322

It is anticipated that subsequent to this project, the basins will be converted from strictly storm water detention facilities into multi-use facilities. At that time, the project should be posted for the flood warning signage to alert the public. In addition, the project should address American Disabilities Act (ADA) requirements.

Wood/Patel is available for a final review meeting, if deemed necessary. You may want to inform the appropriate agencies (e.g., City of Glendale, ADOT, etc, About the review response deadlines as well as the meeting.

Please feel free to call if you have any questions.

Sincerely,

WOOD, PATEL & ASSOCIATES, INC.

Ashok C. Patel, P.E., R.L.S.
Principal

ACP/asc

cc: Dan Sherwood P.E., City of Glendale
Burt Charron P.E., City of Peoria

REPORT\94153.06-sub-phase-c-letter--Mar-25

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This Summary has been compiled to document significant matters relating to the design of the Final plan for the Flood Control District of Maricopa County (District) Contract FCD 94-12 Phase II, Orangewood Avenue Storm Drain, Sub-Phase "C".

- **Hydrology/Hydraulics Development:**

  Runoff used for the design of the storm drains is based on the 10-year, 6-hour storm event as developed and previously approved in the *Northern/Orangewood Storm Drain Project Concept/Routing Study* by Wood, Patel & Associates, Inc., dated March 14, 1996. The HEC-1 model and schematic were slightly revised based on 30% review comments and were included in (Appendix I) of the 60% report.

  Storm drain hydraulic grade lines were computed using the StormCAD Version 1.5 software program. A schematic of the StormCAD file and the output file of the hydraulic data is included in this document (Appendix I) and on the enclosed diskette.

  The proposed storm drain will outfall into the proposed 72" storm drain lateral in 83rd Avenue immediately north of Glendale Avenue. This lateral is proposed as part of Phase "B" of the Northern/Orangewood Storm Drain project. Sub-Phase "B" is currently under construction.

- **Utilities:**

  Utilities shown on the Final plan are derived from utility maps obtained from the companies and from field surveys locating any visible surface facilities/appurtenances and pothole data.

  The Final plans are being distributed to the affected utilities for their review. The following is a list of utilities that will be supplied with plans:

AT&T	US West
MCI	Cox Cable
Southwest Gas	SRVWUA
Santa Fe Pacific Pipeline	City of Glendale, Water and Sewer
El Paso Natural Gas	SRP Electric
APS	Burlington, Northern and Santa Fe Railroad

  The summary of potholing performed by for this project have been previously supplied to the FCDMC.

- **Right-of-Way:**

  For the most part, the proposed storm drain alignment for this phase lies within existing right-of-way. However, there are several locations along Orangewood Avenue where additional Temporary Construction Easements (TCE) will be required to accommodate construction and temporary paving for traffic control. Several permanent storm drain easements will be required on the south side of Orangewood Avenue between 79th Avenue and 75th Avenue for the storm drain laterals. Furthermore, along 65th Avenue alignment from Orangewood Avenue to Frier Drive alignment from 65th Avenue to Grand Avenue a temporary construction easement as well as a permanent storm drain easement will be required. The FCDMC Land and Right-of-Way Division is in the process of preparing the documents for these easements. Wood/Patel prepared the initial submittal forms requesting permission from Burlington Northern and Santa Fe (BNSF) Railroad to construct storm drains under their railroad at 65th Avenue alignment and Grand Avenue and at 65th Avenue and Northern Avenue. The FCDMC has completed and submitted the Application and Fee and is awaiting the permit.

- **Survey:**

  The survey performed by Wood/Patel was based upon information provided by the City of Glendale. The survey is based on the City of Glendale Datum and ties into the control for Phase "B".

- **Soils:**

  Ricker-Atkinson-McBee & Associates, Inc., Geotechnical Subconsultant for this project, completed a soils investigation for this phase in July 1998 (R.A.M. Project No. G10522, Report No. 3). Five sets of this report were included as part of the 30% submittal package.

- **Partnering:**

  Due to the many agencies and consultants involved in the Northern/Orangewood Storm Drain project, Corporate Advisors were retained to help coordinate partnering workshops among the parties. The first partnering workshop for Phases "B" and "C" was held on May 11, 1998, at the offices of the District.

- **Schedule:**

  The original design schedule for the Sub-Phase "C" called for submittal of the Final plan on June 24, 1999. The schedule was revised in August 1998. This schedule called for the Final submittal on May 14, 1999. The design for this phase has been accelerated again. The FCDMC has requested project completion by March 1999.

- **Final Plan:**

  The Final plan has been developed per the standards as set forth in the scope of work, input from the City of Glendale, and on standard Flood Control District of Maricopa County sheets provided to us by the District.

- **Traffic Control**

  Sub-phase "C" will include the construction of a 60-inch storm drain in Northern Avenue between the Grand Avenue, 67th Avenue, and Northern Avenue intersection and approximately the 65th Avenue alignment. A 36-inch storm drain continues from 65th Avenue to 63rd Avenue out of the Northern Avenue roadway, in the East Basin right-of-way. A 60-inch diameter drain will be jacked under Grand Avenue and the A.T. & S.F. railroad tracks, will turn west and run to the west along Frier Drive, where it will turn south to Orangewood and then west to 83rd Avenue, in varying pipe sizes.

  The storm drain alignment has been positioned so that it minimizes the disruption to traffic using the Northern, Grand, and 67th Avenue intersection. This alignment transitions the storm drain from the Northern Avenue median area to the median area of 67th Avenue without the storm drain actually entering the intersection. Therefore, only traffic on Northern Avenue, 67th Avenue (north of the intersection) and the rightmost lane (curb lane) of northwest bound Grand Avenue will be impacted by the storm drain construction.

  While construction is occurring in this area, left turns from westbound Northern Avenue and one of the two westbound through lanes on Northern Avenue will need to be closed. Also, the curb lane

on northbound 67th Avenue and the curb lane on northwest bound Grand Avenue will need to be closed to traffic. A uniformed, off-duty police officer will be utilized at this intersection during construction. Also, ADOT traffic signal personnel will need to be contacted to make adjustments in traffic signal phasing and timing, particularly during peak hour periods.

The storm drain construction along Northern Avenue will occur in the median area and will require closing the median. During contractor working hours it will be necessary to close the westbound and eastbound through traffic lanes adjacent to the median. Access to businesses and other land uses along Northern Avenue will be impacted by storm drain construction. In those areas were trenching is occurring, pipe is being laid, backfill/temporary pavement is being placed, access driveways and local streets will need to function with right turns in and right turns out. Left turn in or left turn out movements will be prohibited.

The section of the storm drain that crosses Grand Avenue and the S.F. & A.T. Railroad right-of-way will be jacked and will not impact traffic on Grand Avenue.

During the construction of the East and West Basins it will be necessary for the contractor to haul a significant volume of material out of the basin area. When a destination for the excavated material has been identified, the contractor will need to establish a haul route plan for review by FCDMC, the City of Glendale, and other municipalities impacted by the haul. This plan will need to meet the requirements of these agencies and identify the route to be used, the duration of the haul, and the hours of the day and days of the week the hauling activities will occur. The plan will define how the contractor will control mud on the City streets and the type of equipment to be used.

Throughout storm drain construction, two way traffic utilizing one lane will be maintained on Orangewood providing access to the residences and other land uses. Traffic will need to be maintained on the south side from 83rd Avenue to 75th Avenue, and on the north side from 75th Avenue to 66th Avenue. The pavement width available is not sufficient for two traffic lanes. The length of the work zone will be limited to a maximum length of 1/4 mile. Access through the work zone to driveways and side streets will be maintained at all times.

The Orangewood, 67th Avenue intersection is signalized. Installation of the 66-inch diameter pipe through the intersection will require reducing the number of through lanes that are available to traffic and prohibiting northbound and southbound left turns during construction periods.

Construction in the Orangewood, 83rd Avenue intersection will require a single lane of traffic in each direction along 83rd Avenue. The contractor will need to prohibit left turns from 83rd Avenue onto Palmaire and Orangewood Avenue.

83rd Avenue traffic will be maintained with one lane northbound and one lane southbound, with left turns prohibited at Palmaire and Orangewood Avenue. The length of the work zone with lane restrictions on 83rd Avenue will be limited to a maximum length of 1/4 mile.

- **Cost Estimate:**

The opinion of probable construction costs for the project based on Final plans is included under separate cover.

APPENDIX I

HYDROLOGY/HYDRAULICS

NORTHERN/ORANGEWOOD STORM DRAIN PROJECT

Glendale Avenue Storm Drain
Phase II, Sub-Phase C
Flood Control District of Maricopa County

3/16/99

Hydraulic Summary Table: West Basin to Agua Fria Channel

Contract FCD 94-12
PHASE II
Sub-phase "C"

Note: *Based on Storm CAD file: w:\94153-NorthernOrangewood\Phase II c\hydraulics\100 percent\Wb100p.stm*

W/P # 94153.06

U/S Node	D/S Node	Pipe	Discharge (cfs)	Length (ft)	Slope (ft/ft)	Pipe Size	Manning's n Value	Velocity (fps)	U/S Invert El (ft)	D/S Invert El (ft)	U/S NG Elev (ft)	D/S NG Elev (ft)	U/S Cover (ft)	D/S Cover (ft)	U/S HGL (ft)	D/S HGL (ft)	U/S EGL (ft)	D/S EGL (ft)	HGL to NG (ft)	EGL to NG (ft)
I-70	J-59	P-176	49	380	0.004237	42 inch	0.013	5.1	1,113.00	1,111.39	1,129.98	1,128.10	13.48	13.21	1,126.52	1,125.62	1,126.92	1,126.02	3.46	3.06
J-59	J-58	P-179	49	380	0.004263	42 inch	0.013	5.1	1,111.39	1,109.77	1,128.10	1,127.25	13.21	13.98	1,125.60	1,124.70	1,126.00	1,125.10	2.50	2.10
J-58	J-15	P-180	49	355.81	0.004244	42 inch	0.013	5.1	1,109.77	1,108.26	1,127.25	1,126.70	13.98	14.94	1,124.68	1,123.83	1,125.08	1,124.24	2.57	2.17
J-15	J-14c	P-6b5	57	186.31	0.002201	42 inch	0.013	5.9	1,108.26	1,107.85	1,126.70	1,126.30	14.94	14.95	1,123.53	1,122.93	1,124.08	1,123.48	3.17	2.62
J-14c	J-14b	P-6b4	57	315	0.001841	42 inch	0.013	5.9	1,107.85	1,107.27	1,126.30	1,125.27	14.95	14.5	1,122.80	1,121.79	1,123.34	1,122.33	3.50	2.96
J-14b	J-14a	P-6b3	57	200.49	0.001845	48 inch	0.013	4.5	1,107.27	1,106.90	1,125.27	1,124.91	14	14.01	1,121.71	1,121.39	1,122.03	1,121.71	3.56	3.24
J-14a	J-56	P-6b2	57	375	0.001867	48 inch	0.013	4.5	1,106.90	1,106.20	1,124.91	1,124.32	14.01	14.12	1,121.31	1,120.72	1,121.63	1,121.04	3.60	3.28
J-56	J-14	P-6b1	57	361.8	0.001852	48 inch	0.013	4.5	1,106.20	1,105.53	1,124.32	1,124.37	14.12	14.84	1,120.70	1,120.13	1,121.02	1,120.45	3.62	3.30
J-14	J-13d	P-6a5	81	505.7	0.001918	48 inch	0.013	6.4	1,105.53	1,104.56	1,124.37	1,123.17	14.84	14.61	1,119.71	1,118.11	1,120.36	1,118.75	4.66	4.01
J-13d	J-13c	P-6a4	81	392.5	0.001911	48 inch	0.013	6.4	1,104.56	1,103.81	1,123.17	1,122.12	14.61	14.31	1,118.11	1,116.86	1,118.75	1,117.50	5.06	4.42
J-13c	J-13b	P-6a3	81	200.09	0.001649	48 inch	0.013	6.4	1,103.81	1,103.48	1,122.12	1,121.83	14.31	14.35	1,116.83	1,116.19	1,117.47	1,116.84	5.29	4.65
J-13b	J-13a	P-6a2	81	163.88	0.001892	54 inch	0.013	5.1	1,103.48	1,103.17	1,121.83	1,121.46	13.85	13.79	1,116.17	1,115.89	1,116.57	1,116.29	5.66	5.26
J-13a	J-13	P-6a1	81	116.47	0.002576	60 inch	0.013	4.1	1,103.17	1,102.87	1,121.46	1,121.10	13.29	13.23	1,115.88	1,115.77	1,116.14	1,116.03	5.58	5.32
J-13	J-12c	P-5b4	95	188.65	0.001802	60 inch	0.013	4.8	1,102.87	1,102.53	1,121.10	1,120.55	13.23	13.02	1,115.67	1,115.42	1,116.04	1,115.79	5.43	5.06
J-12c	J-12b	P-5b3	95	200.09	0.002249	48 inch	0.013	7.6	1,102.53	1,102.08	1,120.55	1,120.52	14.02	14.44	1,115.38	1,114.50	1,116.27	1,115.39	5.17	4.28
J-12b	J-12a	P-5b2	95	378	0.002116	48 inch	0.013	7.6	1,102.08	1,101.28	1,120.52	1,119.39	14.44	14.11	1,114.46	1,112.81	1,115.35	1,113.69	6.06	5.17
J-12a	J-12	P-5b1	95	493.00	0.00215	48 inch	0.013	7.6	1,101.28	1,100.22	1,119.39	1,117.37	14.11	13.15	1,112.76	1,110.61	1,113.55	1,111.49	6.63	5.74
J-12	J-11a	P-5a2	124	666.50	0.002086	60 inch	0.013	6.3	1,100.22	1,098.83	1,117.37	1,114.58	12.15	10.75	1,110.26	1,108.75	1,110.38	1,109.37	7.11	6.49
J-11a	J-11	P-5a1	124	654.50	0.002093	66 inch	0.013	5.2	1,098.83	1,097.46	1,114.58	1,114.14	10.25	11.18	1,108.73	1,107.84	1,109.16	1,108.26	5.85	5.42
J-11	J-10B	P-4b	158	1,328.00	0.001898	66 inch	0.013	6.7	1,097.46	1,094.94	1,114.14	1,111.31	11.18	10.87	1,107.46	1,104.52	1,108.15	1,105.21	6.68	5.99
J-10B	J-10	P-4a	158	1322	0.001899	66 inch	0.013	6.7	1,094.94	1,092.43	1,111.31	1,107.16	10.87	9.23	1,104.49	1,101.56	1,105.17	1,102.25	6.82	6.14
J-10	J-9	P-44b	215	1,298.50	0.003573	72 inch	0.013	7.6	1,092.33	1,087.69	1,107.16	1,102.85	8.83	9.16	1,099.89	1,096.54	1,100.79	1,097.44	7.27	6.37
I-53	J-8	P-43e	166	162.8	0.003378	84 inch	0.013	4.3	1,083.45	1,082.90	1,095.20	1,095.00	4.75	5.1	1,092.82	1,092.71	1,093.11	1,093.00	2.38	2.09
J-9	J-8	P-44a	219	1346	0.003484	72 inch	0.013	7.7	1,087.69	1,083.00	1,102.85	1,095.00	9.16	6	1,096.31	1,092.71	1,097.24	1,093.64	6.54	5.61
J-8	J-7	P-43d	385	1,335.00	0.003363	84 inch	0.013	10	1,082.90	1,078.41	1,095.00	1,092.40	5.1	6.99	1,090.20	1,085.38	1,091.76	1,086.94	4.80	3.24
J-7	J-6a	P-43c2	386	644	0.003385	84 inch	0.013	10.2	1,078.41	1,076.23	1,092.40	1,091.00	6.99	7.77	1,084.97	1,082.98	1,086.62	1,084.58	7.43	5.78
J-6a	J-6	P43c1	386	684	0.003377	90 inch	0.013	9	1,076.23	1,073.92	1,091.00	1,089.60	7.27	8.18	1,082.91	1,081.48	1,084.25	1,082.66	8.09	6.75
J-6	J-5	P-43b	392	1327	0.003384	90 inch	0.013	8.9	1,073.92	1,069.43	1,089.60	1,084.00	8.18	7.07	1,081.16	1,077.78	1,082.41	1,079.00	8.44	7.19
J-5	J-4a	P-43a2	394	668	0.003383	90 inch	0.013	8.9	1,069.43	1,067.17	1,084.00	1,080.76	7.07	6.09	1,077.47	1,075.71	1,078.70	1,076.95	6.53	5.30
J-4a	J-4	P-43a1	394	651.63	0.003376	90 inch	0.013	8.9	1,067.17	1,064.97	1,080.76	1,077.60	6.09	5.13	1,075.65	1,073.93	1,076.88	1,075.17	5.11	3.88
J-4	CS-3a	P-42b3	453	48.37	0.003515	90 inch	0.013	10.3	1,064.97	1,064.80	1,077.60	1,077.52	5.13	5.22	1,072.87	1,072.70	1,074.50	1,074.34	4.73	3.10
CS-3a	J-3a	P-42b1	453	620	0.003371	90 inch	0.013	11.5	1,064.80	1,062.71	1,077.52	1,076.30	5.22	6.09	1,071.05	1,068.94	1,073.11	1,071.01	6.47	4.41
J-3a	J-3	P-42b1a	453	661.00	0.003389	96 inch	0.013	10.2	1,062.71	1,060.47	1,076.30	1,075.00	5.59	6.53	1,068.85	1,067.71	1,070.71	1,069.10	7.45	5.59
J-3	CS-2a	P-42a2	454	1264	0.003378	96 inch	0.013	9.5	1,060.47	1,056.20	1,075.00	1,068.31	6.53	4.11	1,067.33	1,064.63	1,068.85	1,065.90	7.67	6.15
CS-2a	J-2	P-42a1	454	59	0.00339	96 inch	0.013	9.4	1,056.20	1,056.00	1,068.31	1,068.00	4.11	4	1,063.53	1,063.42	1,064.90	1,064.78	4.78	3.41
J-2	J-60	P-41e	485	1105.7	0.002406	102 inch	0.013	10.2	1,056.00	1,053.34	1,068.00	1,065.62	3.5	3.78	1,062.49	1,060.10	1,064.18	1,061.66	5.51	3.82
J-60	J-1a	P-41d	485	204.3	0.002398	102 inch	0.013	10.1	1,053.34	1,052.85	1,065.62	1,065.62	3.78	4.27	1,060.02	1,059.61	1,061.62	1,061.17	5.60	4.00
J-1a	J-1	P-41c	486	88.25	0.00238	102 inch	0.013	10.1	1,052.85	1,052.64	1,065.62	1,066.00	4.27	4.86	1,059.53	1,059.34	1,061.13	1,060.94	6.09	4.49
J-1	ADOT Stub	P-41b	486	139.4	0.004591	102 inch	0.013	10.2	1,052.64	1,052.00	1,066.00	1,066.00	4.86	5.5	1,058.99	1,058.97	1,060.76	1,060.45	7.01	5.24
ADOT Stub	Outlet	P-41a	486	12.76	0.004702	102 inch	0.013	12.7	1,052.00	1,051.94	1,066.00	1,066.00	5.5	5.56	1,057.53	1,057.29	1,059.93	1,059.88	8.47	6.07

NORTHERN/ORANGEWOOD STORM DRAIN PROJECT

Orangewood Avenue Storm Drain
Phase II, Sub-Phase C
Flood Control District of Maricopa County

3/24/99

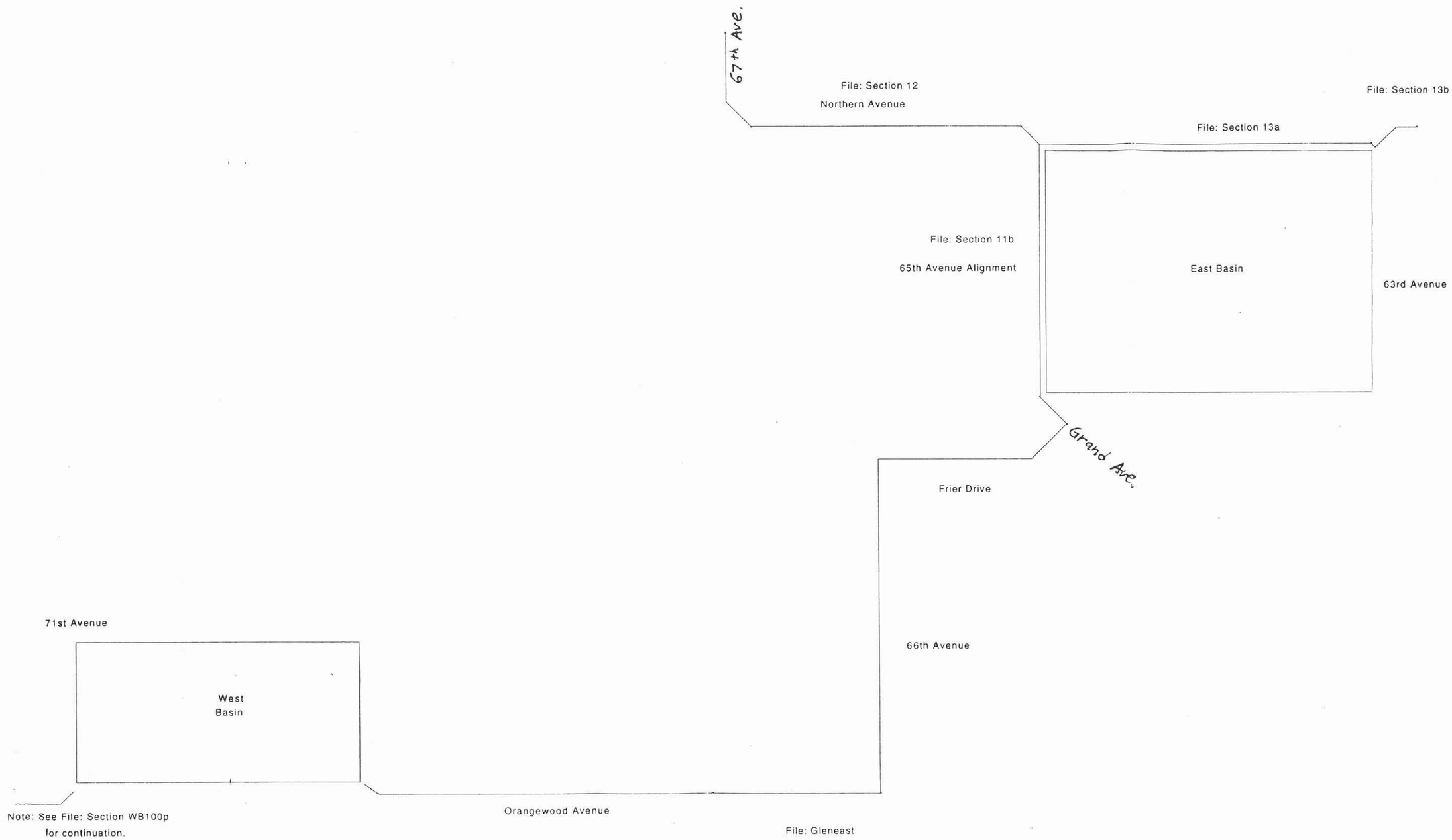
Hydraulic Summary Table: 71st Avenue and Orangewood (West Basin) to 63rd Avenue and Northern Ave (East Basin)

Contract FCD 94-12
PHASE II
Sub-phase "C"

Note: *Based on Storm CAD files: w:\94153-NorthernOrangewood\Phase IIc\hydraulics\stormcad\gleneast.stm, p-11b.stm, p-12.stm, p-13a.stm, p-13b.stm, p-13bint.stm*

W/P # 94153.06

U/S Node	D/S Node	Pipe	Discharge (cfs)	Length (ft)	Slope (ft/ft)	Pipe Size	Manning's n Value	Capacity (cfs)	U/S Invert El (ft)	D/S Invert El (ft)	U/S NG Elev (ft)	D/S NG Elev (ft)	U/S Cover (ft)	D/S Cover (ft)	U/S HGL (ft)	D/S HGL (ft)	U/S EGL (ft)	D/S EGL (ft)	HGL to NG (ft)	EGL to NG (ft)
West Basin to East Basin																				
J-20a	J-20	P-10a	73	218.4	0.0023	60 inch	0.013	5.37	1,126.00	1,125.50	1,142.00	1,143.00	11	12.5	1,129.13	1,128.93	1,129.62	1,129.33	12.87	12.38
J-20	J-19	P-10	73	563.8	0.0025	60 inch	0.013	4.98	1,125.50	1,124.10	1,143.00	1,140.00	12.5	10.9	1,128.60	1,128.20	1,129.10	1,128.48	14.40	13.90
J-19	J-18a	P-9b	73	645.8	0.0037	60 inch	0.013	4.09	1,124.00	1,121.61	1,140.00	1,138.70	11	12.09	1,127.88	1,127.47	1,128.19	1,127.69	12.12	11.81
J-18a	J-18	P-9a	73	660	0.0038	60 inch	0.013	3.72	1,121.61	1,119.10	1,138.70	1,136.91	12.09	12.81	1,127.46	1,126.94	1,127.68	1,127.16	11.24	11.02
J-18	J-17	P-8	73	603.2	0.0029	66 inch	0.013	3.07	1,119.00	1,117.24	1,136.91	1,134.33	12.41	11.59	1,126.79	1,126.51	1,126.94	1,126.65	10.12	9.97
J-17	J-16a	P-7a	118	1369.5	0.0029	66 inch	0.013	4.97	1,117.24	1,113.22	1,134.33	1,130.33	11.59	11.61	1,126.29	1,124.60	1,126.68	1,124.99	8.04	7.65
J-16a	J-16	P-39	118	76.4	0.0029	66 inch	0.013	4.97	1,113.22	1,113.00	1,130.33	1,129.88	11.61	11.38	1,124.35	1,124.26	1,124.74	1,124.64	5.98	5.59
Section 11b																				
I-3	J-3	P-8	60	25.9	0.0027	42 inch	0.013	6.24	1,129.40	1,129.33	1,144.20	1,144.20	11.3	11.37	1,134.49	1,134.40	1,135.10	1,135.01	9.71	9.10
J-3	MH-11a	P-9	60	513.3	0.0028	42 inch	0.013	6.24	1,129.33	1,127.88	1,144.20	1,142.60	11.37	11.22	1,134.01	1,132.18	1,134.61	1,132.79	10.19	9.59
MH-11a	J-2	P-6	60	500	0.0028	42 inch	0.013	6.24	1,127.88	1,126.47	1,142.60	1,142.20	11.22	12.23	1,132.15	1,130.37	1,132.76	1,130.98	10.45	9.84
J-2	J-4	P-10	60	95.4	0.0028	42 inch	0.013	6.24	1,126.47	1,126.20	1,142.20	1,142.20	12.23	12.5	1,129.98	1,129.66	1,130.59	1,130.26	12.22	11.61
J-4	Outlet	P-11	60	56.4	0.0035	42 inch	0.013	6.86	1,126.20	1,126.00	1,142.20	1,142.10	12.5	12.6	1,129.18	1,129.00	1,129.91	1,129.73	13.02	12.29
Section 13a																				
I-4	J-3	P-13a1	29.6	36.7	0.0022	42 inch	0.013	3.08	1,132.00	1,131.92	1,148.00	1,147.82	12.5	12.4	1,135.70	1,135.67	1,135.84	1,135.81	12.30	12.16
J-3	J-2	P-13a2	29.6	563	0.0022	42 inch	0.013	3.08	1,131.92	1,130.68	1,147.82	1,146.20	12.4	12.02	1,135.58	1,135.09	1,135.72	1,135.24	12.24	12.10
J-2	J-4	P-10	29.6	579.9	0.0022	42 inch	0.013	3.08	1,130.68	1,129.41	1,146.20	1,144.71	12.02	11.8	1,135.08	1,134.58	1,135.23	1,134.73	11.12	10.97
J-4	J-21	P-11	29.6	2.8	0.0036	42 inch	0.013	3.08	1,129.41	1,129.40	1,144.71	1,143.20	11.8	10.3	1,134.49	1,134.49	1,134.64	1,134.64	10.22	10.07
Section 13b																				
I-5	J-4	P-13b1	668	81.6	0.0043	108 inch	0.013	10.5	1,133.50	1,133.15	1,149.00	1,148.20	6.5	6.05	1,144.51	1,144.28	1,146.23	1,145.99	4.49	2.77
J-4	J-5	P-9	668	95.7	0.0040	108 inch	0.013	10.5	1,133.15	1,132.77	1,148.20	1,147.95	6.05	6.18	1,143.17	1,142.89	1,144.88	1,144.61	5.03	3.32
J-5	I-4	P-10	668	8	0.0050	108 inch	0.013	10.5	1,132.04	1,132.00	1,147.95	1,147.90	6.91	6.9	1,142.89	1,142.87	1,144.61	1,144.58	5.06	3.34
Section 12																				
I-3	I-5	P-12a	104	268.2	0.0015	54 inch	0.013	6.54	1,134.97	1,134.57	1,142.60	1,142.50	3.13	3.43	1,140.82	1,140.07	1,141.49	1,140.74	1.78	1.11
I-5	J-8	P-22	111	80.4	0.0010	60 inch	0.013	5.65	1,134.57	1,134.49	1,142.50	1,142.75	2.93	3.26	1,139.78	1,139.63	1,140.27	1,140.13	2.72	2.23
J-8	I-4	P-19	111	59.6	0.0010	60 inch	0.013	5.79	1,134.49	1,134.43	1,142.75	1,142.80	3.26	3.37	1,139.21	1,139.12	1,139.73	1,139.64	3.54	3.02
I-4	J-7	P-20	111	529.7	0.0010	60 inch	0.013	6.73	1,134.43	1,133.90	1,142.80	1,143.05	3.37	4.15	1,138.77	1,137.50	1,139.35	1,138.34	4.03	3.45
J-7	J-21a	P-12d	111	530.6	0.0079	60 inch	0.013	6.54	1,133.90	1,129.70	1,143.05	1,144.86	4.15	10.16	1,137.46	1,136.85	1,138.32	1,137.35	5.59	4.73
J-21a	J-21	P-12e	111	72.3	0.0041	60 inch	0.013	5.65	1,129.70	1,129.40	1,144.86	1,144.70	10.16	10.3	1,136.53	1,136.40	1,137.03	1,136.90	8.33	7.83



Project Title: N/O East Basin to West Basin
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Wood/Patel
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Project Engineer: Wood/Patel
StormCAD v1.5 [158]

WOOD/PATEL

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PROJECT Northern/Orangewood PH II C
PROJECT NO. 94153.06 SHEET NO. _____ OF _____
CALCULATED BY JGT DATE 12/16/98 CHECKED BY AV DATE 1/5/9

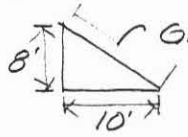
East Basin Inlet/Outlet Structure Southwest Corner

Structure has controlled outlet Capacity via a 24"x27" OPENING the southwest wall of the structure. Outfall pipe Downstream of structure is OVERSIZED so structure is inlet controlled. (ungated).
The Structure bypass flow = 35 cfs, INV(1126) - Basin (1130) = 4' head Available

Max Bypass flow = 73 cfs, Inv(1126) - WSEL (1138) = 12' Head Available

(See attached sheet for calculations)

Outflow @ Structure = 256 cfs
OUTLET GRATE:



GRATE 12.8' x 10 Long = 128 SF

ASSUME 10% OF OPENING IS THE METAL GRATE 128SF - 12.8SF = 115SF
Velocity out of structure = Q/A = 256 cfs/115SF = 2.3 fps
ASSUMING GRATE 50% Clogged = Q/A = 256 cfs/(115SF/2) = 4.6 fps

The time required to Drain the basin:
6 Hour Storm
End of Flow: Day 2 20.75 hr = 44.75 hrs
Time to Drain = 44.75 hrs - 6 hrs = 39 hrs*

East Basin 10 YR DESIGN

Q bypass = 35 cfs
Q MAX = 73 cfs
Volume Detained = 172 Acft
WSEL = 1137.98
TIME To Drain = 39 hrs

* The original off line basin design Allowed for a Large release of flow to drain the basin. The online basin design with controlled outfalls creates A long hydrograph AND INCREASES the drainage time.

PIPE CULVERT ANALYSIS
COMPUTATION OF CULVERT PERFORMANCE CURVE

December 15, 1998

PROGRAM INPUT DATA

DESCRIPTION	VALUE
Culvert Diameter (ft)	2.39
FHWA Chart Number	1
FHWA Scale Number (Type of Culvert Entrance)	1
Manning's Roughness Coefficient (n-value)	0.013
Entrance Loss Coefficient of Culvert Opening	0.5
Culvert Length (ft)	1.0
Invert Elevation at Downstream end of Culvert (ft)	1,126.0
Invert Elevation at Upstream end of Culvert (ft)	1,126.01
Culvert Slope (ft/ft)	0.01
Starting Flow Rate (cfs)	5.0
Incremental Flow Rate (cfs)	5.0
Ending Flow Rate (cfs)	80.0
Starting Tailwater Depth (ft)	2.0
Incremental Tailwater Depth (ft)	0.0
Ending Tailwater Depth (ft)	2.0

COMPUTATION RESULTS

Flow Rate (cfs)	Tailwater Depth (ft)	Headwater (ft) Inlet Control	Headwater (ft) Outlet Control	Normal Depth (ft)	Critical Depth (ft)	Depth at Outlet (ft)	Outlet Velocity (fps)	
5.0	2.0	1.02	2.03	0.6	0.75	2.0	1.25	
10.0	2.0	1.52	2.14	0.86	1.07	2.0	2.49	
15.0	2.0	1.96	2.32	1.07	1.32	2.0	3.74	
20.0	2.0	2.39	2.57	1.26	1.54	2.0	4.99	
25.0	2.0	2.87	2.9	1.46	1.72	2.0	6.24	
30.0	2.0	3.37	3.31	1.65	1.88	1.65	9.06	
35.0	2.0	4.01	0.0	1.88	2.02	1.88	9.23	EL=1130 (BASIN BOTTOM)
40.0	2.0	4.75	4.22	2.39	2.12	2.39	8.92	
45.0	2.0	5.59	4.71	2.39	2.2	2.39	10.03	
50.0	2.0	6.53	5.27	2.39	2.26	2.39	11.15	
55.0	2.0	7.57	5.88	2.39	2.3	2.39	12.26	
60.0	2.0	8.71	6.55	2.39	2.32	2.39	13.37	
65.0	2.0	9.94	4.03	2.39	2.34	2.39	14.49	
70.0	2.0	11.28	4.3	2.39	2.35	2.39	15.6	EL=1138 (10YR WSEL)
75.0	2.0	12.71	4.59	2.39	2.36	2.39	16.72	
80.0	2.0	14.25	4.89	2.39	2.37	2.39	17.83	

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PROJECT Northern/Orangewood PH II C
PROJECT NO. 94153.06 SHEET NO. ____ OF ____
CALCULATED BY UGT DATE 12/16/98 CHECKED BY [illegible] DATE 12/98

West Basin Outlet Structure Southwest Corner

Basin outlet has controlled outlet via a 27" pipe in the outfall structure. (outfall is restricted but not gated)

The Structure Bypass flow = 49 cfs from Storm CAD Model. The Structure outlet capacity is inlet controlled. The MAX FLOW @ BASIN WSEL = 57cfs

See the following sheets for outlet pipe calculations AND Outlet Grate Capacities.

TIME REQUIRED TO DRAIN BASIN:
6 hour Storm
End of Flow: DAY 3 7H = 55 hrs
Time to Drain = 55 hrs - 6 hrs = 49 hrs *

West BASIN 10 YEAR DESIGN

Q BYPASS = 48cfs
Q MAX = 57cfs
Volume Detained = 48 Acft
WSEL = 1124.26
TIME to Drain = 49 hrs

* The original offline basin design Allowed for a large release of flow to drain the basin. Due to the restricted outlet from the east basin and the associated long hydrograph, the basin drainage time has increased.

PIPE CULVERT ANALYSIS
COMPUTATION OF CULVERT PERFORMANCE CURVE

December 16, 1998

PROGRAM INPUT DATA

DESCRIPTION	VALUE
Culvert Diameter (ft)	2.25
FHWA Chart Number	1
FHWA Scale Number (Type of Culvert Entrance)	1
Manning's Roughness Coefficient (n-value)	0.013
Entrance Loss Coefficient of Culvert Opening	0.5
Culvert Length (ft)	54.0
Invert Elevation at Downstream end of Culvert (ft)	1,108.71
Invert Elevation at Upstream end of Culvert (ft)	1,114.7
Culvert Slope (ft/ft)	0.1109
Starting Flow Rate (cfs)	5.0
Incremental Flow Rate (cfs)	2.0
Ending Flow Rate (cfs)	61.0
Starting Tailwater Depth (ft)	2.0
Incremental Tailwater Depth (ft)	0.0
Ending Tailwater Depth (ft)	2.0

COMPUTATION RESULTS

Flow Rate (cfs)	Tailwater Depth (ft)	Headwater (ft) Inlet Control	Headwater (ft) Outlet Control	Normal Depth (ft)	Critical Depth (ft)	Depth at Outlet (ft)	Outlet Velocity (fps)
5.0	2.0	0.93	0.0	0.34	0.76	0.34	13.37
7.0	2.0	1.15	0.0	0.4	0.91	0.4	14.79
9.0	2.0	1.36	0.0	0.45	1.03	0.45	15.96
11.0	2.0	1.55	0.0	0.5	1.15	0.5	16.9
13.0	2.0	1.74	0.0	0.54	1.25	0.54	17.74
15.0	2.0	1.93	0.0	0.58	1.35	0.58	18.5
17.0	2.0	2.12	0.0	0.62	1.44	0.62	19.17
19.0	2.0	2.31	0.0	0.65	1.52	0.65	19.79
21.0	2.0	2.51	0.0	0.69	1.6	0.69	20.35
23.0	2.0	2.76	0.0	0.72	1.68	0.72	20.89
25.0	2.0	2.96	0.0	0.75	1.75	0.75	21.36
27.0	2.0	3.22	0.0	0.79	1.81	0.79	21.84
29.0	2.0	3.5	0.0	0.82	1.87	0.82	22.29
31.0	2.0	3.8	0.0	0.85	1.92	0.85	22.7
33.0	2.0	4.12	0.0	0.88	1.97	0.88	23.06
35.0	2.0	4.47	0.0	0.9	2.01	0.9	23.45
37.0	2.0	4.83	0.0	0.93	2.05	0.93	23.81
39.0	2.0	5.21	0.0	0.96	2.08	0.96	24.14
41.0	2.0	5.61	0.0	0.99	2.1	0.99	24.47
43.0	2.0	6.04	0.0	1.01	2.13	1.01	24.75
45.0	2.0	6.48	0.0	1.04	2.15	1.04	25.06
47.0	2.0	6.94	0.0	1.07	2.16	1.07	25.33
49.0	2.0	7.43	0.0	1.09	2.17	1.09	25.61
51.0	2.0	7.93	0.0	1.12	2.18	1.12	25.87
53.0	2.0	8.45	0.0	1.14	2.19	1.14	26.12
55.0	2.0	9.0	0.0	1.17	2.2	1.17	26.35
57.0	2.0	9.56	0.0	1.19	2.21	1.19	26.6
59.0	2.0	10.15	0.0	1.22	2.21	1.22	26.81
61.0	2.0	10.75	0.0	1.25	2.22	1.25	27.01

← EL = 1114.7 + 9.56 = WSEL = 1124.26, Q = 57 cfs MAX BYPASS

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Weir/Orifice Flow Capacity

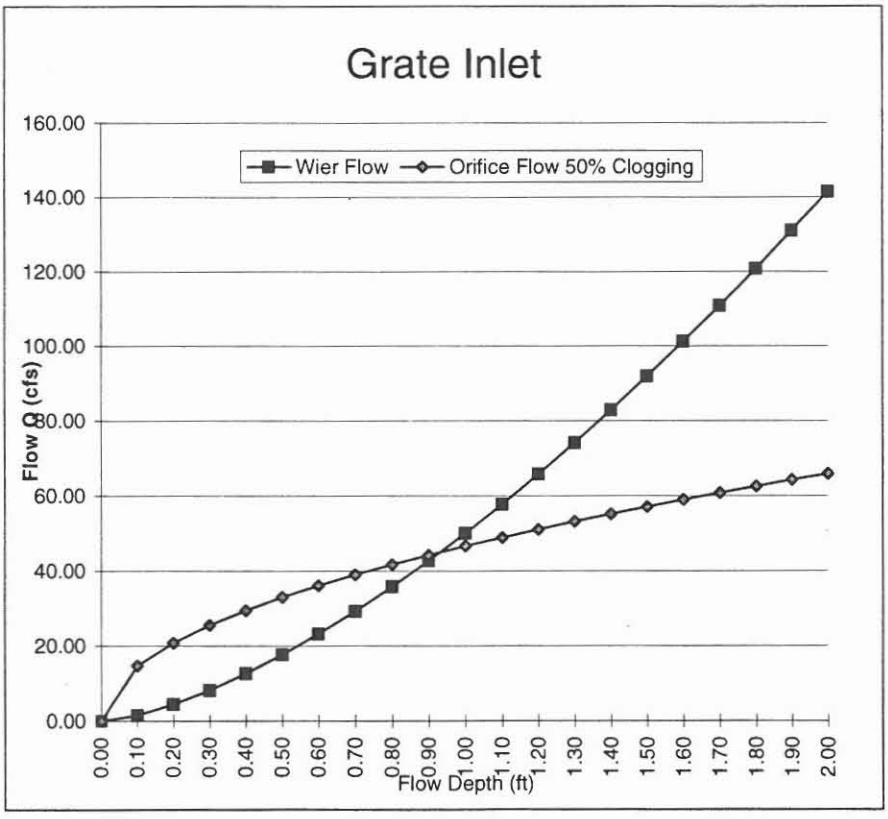
Weir EQ. $Q_i = C_w P d^{1.5}$ **Orifice EQ.** $Q_i = C_o A(2gd)^{0.5}$

Where: $C_w = 3.0$ **and** $C_o = 0.67$

Grate Opening - 4' x 5' Square with 1/2" bars at 3.5" O.C.

P =	**16.67**	ft	18lf - 1.33lf for bars
A =	**17.33**	ft^2	20sf - 2.67sf for bars

Depth (ft)	Weir Qi (cfs)	Orifice Qi (cfs)	Orifice 50% Clogging
0.00	0.00	0.00	0.0
0.10	1.58	29.47	14.7
0.20	4.47	41.67	20.8
0.30	8.22	51.04	25.5
0.40	12.65	58.93	29.5
0.50	17.68	65.89	32.9
0.60	23.24	72.18	36.1
0.70	29.29	77.96	39.0
0.80	35.78	83.34	41.7
0.90	42.70	88.40	44.2
1.00	50.01	93.18	46.6
1.10	57.70	97.73	48.9
1.20	65.74	102.07	51.0
1.30	74.13	106.24	53.1
1.40	82.84	110.25	55.1
1.50	91.87	114.12	57.1
1.60	101.21	117.86	58.9
1.70	110.85	121.49	60.7
1.80	120.77	125.01	62.5
1.90	130.97	128.44	64.2
2.00	141.45	131.77	65.9



Northern/Orangewood
West Basin Storage/Stage Relationship

W/P Job No. 94153.06
December 17, 1998

West Basin Rating Curve

Elevation	Area		Incremental Volume	Total Volume
ft	sf	ac	ac-ft	ac-ft
1117.7	0	0.00	-	-
1118	2378	0.05	0.0	0.0
1119	56316	1.29	0.7	0.7
1120	176506	4.05	2.7	3.4
1121	319161	7.33	5.7	9.0
1122	446114	10.24	8.8	17.8
1123	570940	13.11	11.7	29.5
1124	654888	15.03	14.1	43.6
1125	673885	15.47	15.3	58.8
1126	693090	15.91	15.7	74.5

West Basin Storage Summary

	Elev.	Volume
	ft	ac-ft
10yr-WSEL	1124.26	47.5

Northern/Orangewood
East Basin Storage/Stage Relationship

W/P Job No. 94153.06
December 17, 1998

East Basin Rating Curve

Elevation	Area		Incremental Volume	Total Volume
ft	sf	ac	ac-ft	ac-ft
1129.5	8428.4	0.19	-	-
1130	26282.2	0.60	0.2	0.2
1131	185113.5	4.25	2.4	2.6
1132	626896.4	14.39	9.3	11.9
1133	1119258	25.69	20.0	32.0
1134	1193125	27.39	26.5	58.5
1135	1215599	27.91	27.6	86.2
1136	1238244	28.43	28.2	114.3
1137	1261059.5	28.95	28.7	143.0
1138	1284046	29.48	29.2	172.2
1139	1307204	30.01	29.7	202.0
1140	1330532.2	30.54	30.3	232.3
1141	1354032	31.08	30.8	263.1
1142	1377702	31.63	31.4	294.4

East Basin Storage Summary

	Elev.	Volume
	ft	ac-ft
10yr-WSEL	1137.98	171.7

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PROJECT N/O PH II C

PROJECT NO. 94153.06 SHEET NO. _____ OF _____

CALCULATED BY JST DATE 7/12/97 CHECKED BY AK DATE 12/98

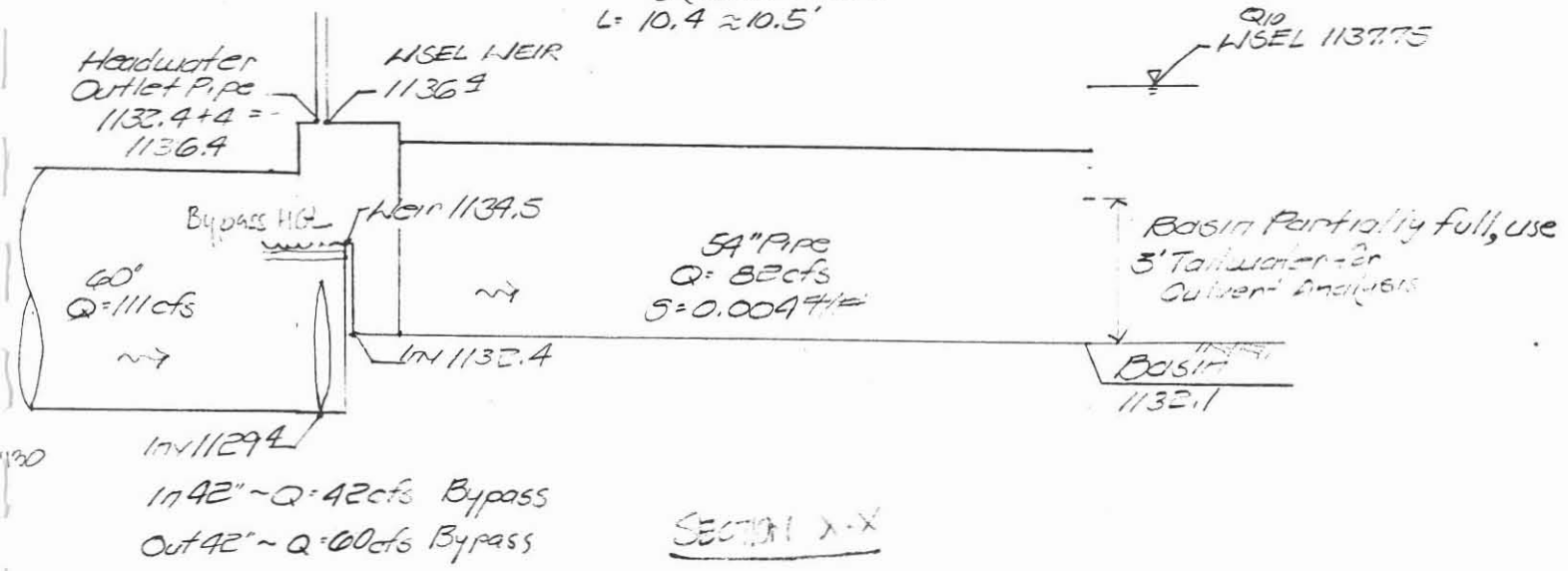
NG1144

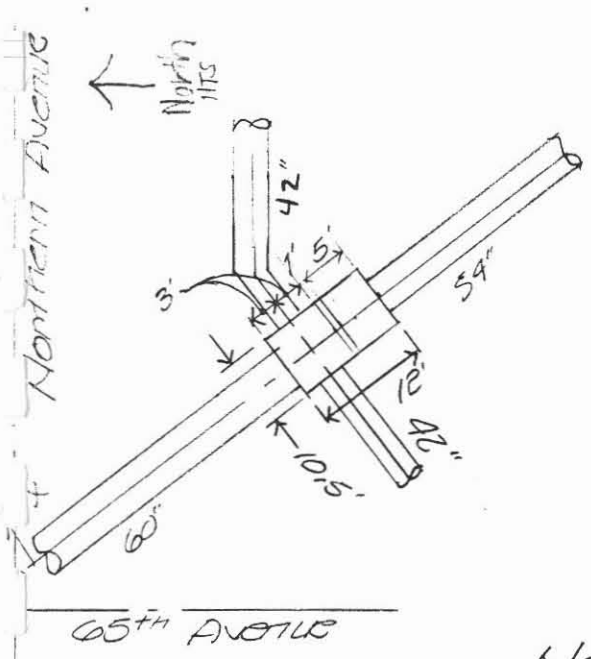
Weir: $Q = CLH^{3/2}$, $C = 3$

$L = Q/CH^{3/2}$

$L = \frac{82 cfs}{3 \cdot (1134.5 - 1136.4)^{3/2}}$

$L = 10.4 \approx 10.5'$





Northern/Orangewood PH II C
Junction Structure N.W. Corner of Basin
EAST BASIN

PIPE CULVERT ANALYSIS
COMPUTATION OF CULVERT PERFORMANCE CURVE

July 29, 1998
Northern/Orangewood Phase II "C"
East Basin Northwest Inlet at Northern Avenue
East Basin

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PROGRAM INPUT DATA:

DESCRIPTION	VALUE
Culvert Diameter (feet)	4.50
FHWA Chart Number (1,2 or 3)	1
Scale Number on Chart (Type of Culvert Entrance)	1
Manning's Roughness Coefficient (n-value)	0.0120
Entrance Loss Coefficient of Culvert Opening	0.50
Culvert Length (feet)	80.0
Culvert Slope (feet per foot)	0.0040

==========

PROGRAM RESULTS:

Flow Rate (cfs)	Tailwater Depth (ft)	Headwater (ft) Inlet Control	Headwater (ft) Outlet Control	Normal Depth (ft)	Critical Depth (ft)	Depth at Outlet (ft)	Outlet Velocity (fps)
82.0	3.00	4.01	3.99	2.53	2.65	2.53	8.89

==========

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```
    UNEVEN WEIR FLOW PROGRAM
    FORTRAN VERSION 1.0
*********************************************
    PROJECT:  East Basin Northwest Outlet
    ENGINEER:
    DATE:  12/14/1998
    TIME:   9:12.20
---------------------------------------------
    INPUT PARAMETERS
---------------------------------------------
    STARTING WSEL:       1134.50
    MAXIMUM WSEL:        1136.50
    STEP SIZE:              0.50
    BREADTH OF WEIR:       10.50

    INPUT ELEVATION/STATION TABLE.
*********************************************

    POINT    ELEVATION    STATION
    -----    ---------    -------
        1      1134.50       0.00
        2      1134.50      10.50

    WEIR COEFFICIENT TABLE
*********************************************
    REFERENCE:  COE CHART - UPPER CURVE

POINT     HEAD     COEFFICIENT
-----     ----     -----------
    1     0.00          2.5000
    2     0.50          2.6587
    3     1.00          2.8175
    4     1.50          2.9762
    5     2.00          3.0090

    UNEVEN WEIR FLOW PROGRAM
*********************************************

    ELEVATION     DISCHARGE (CFS)
    ---------     ---------------
      1134.50                0.00
      1135.00                9.87
      1135.50               29.58
      1136.00               57.41
      1136.50               89.36
```

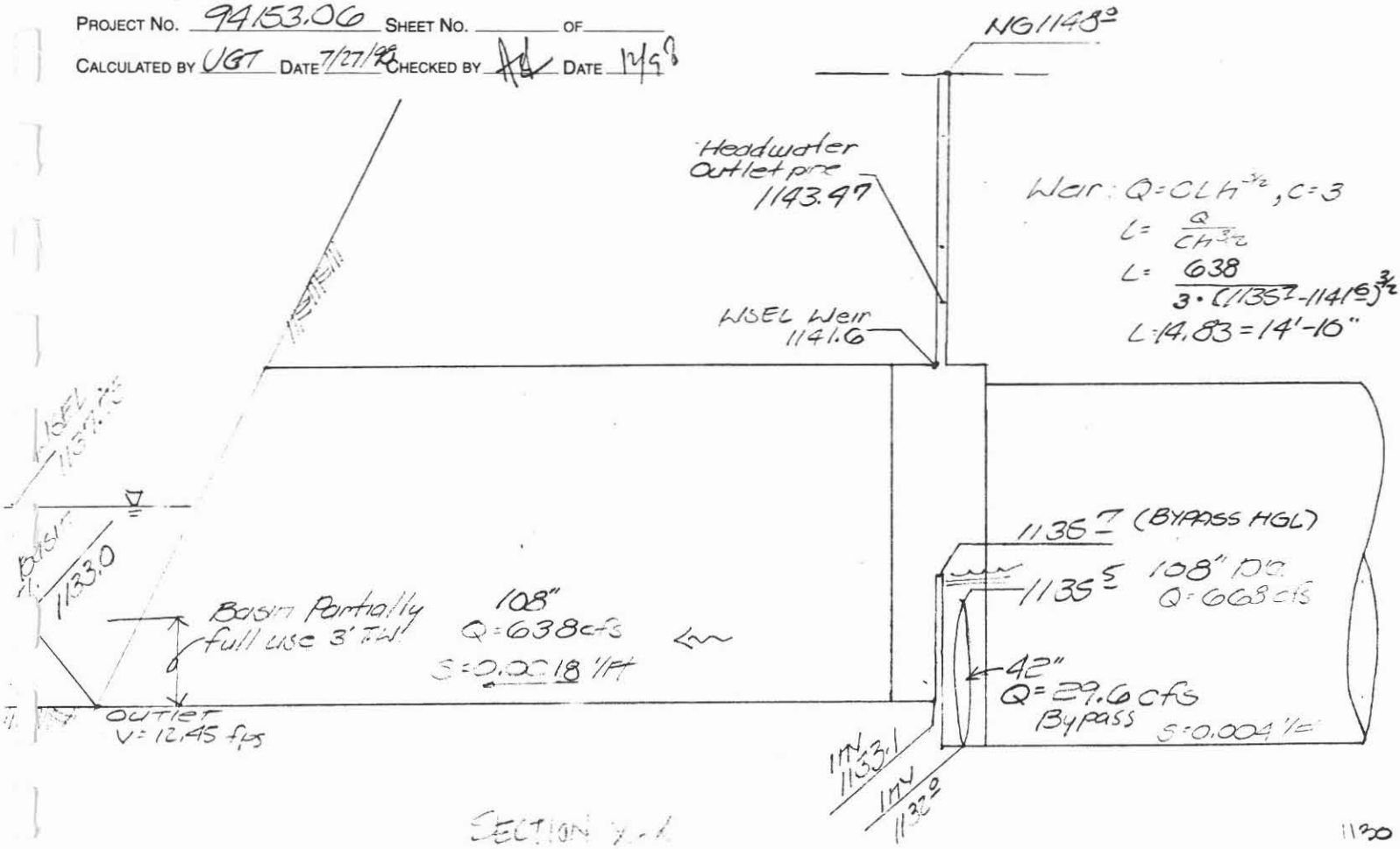
WOOD/PATEL

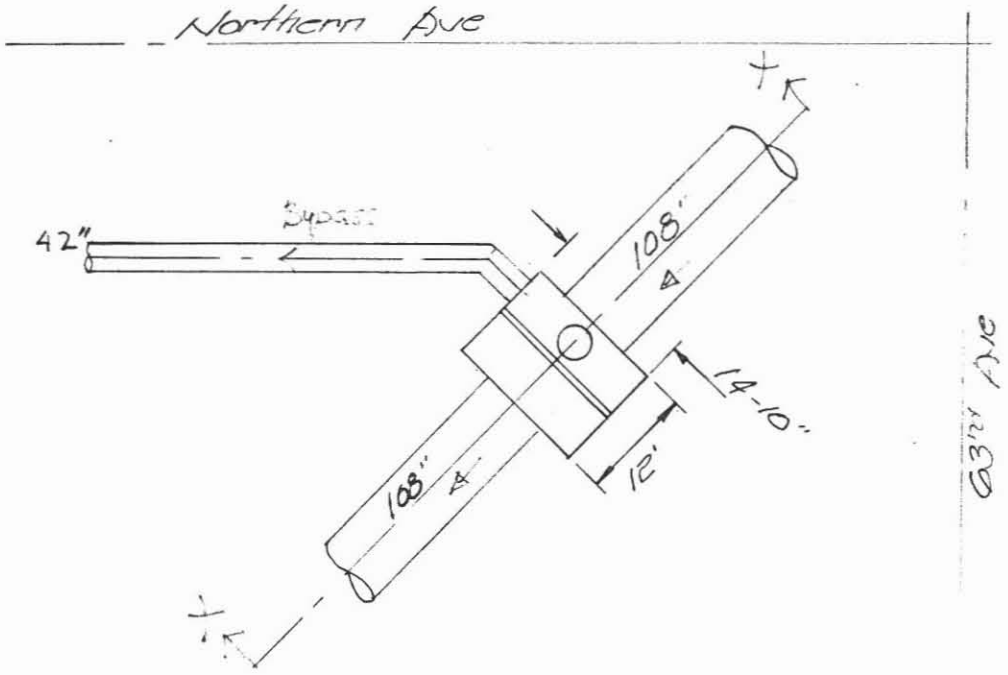
CIVIL ENGINEERS • HYDROLOGISTS • LAND SURVEYORS

PROJECT H/O Ph II C

PROJECT NO. 94153.06 SHEET NO. _____ OF _____

CALCULATED BY UGT DATE 7/27/98 CHECKED BY AL DATE 12/98





Northern/Orangewood Ph II C
Junction Structure N.E. Corner of Basin
East Basin

```
*********************************************
    UNEVEN WEIR FLOW PROGRAM
    FORTRAN VERSION 1.0
*********************************************
    DATE:   3/ 9/1999
    TIME:  10:14.16
---------------------------------------------
    INPUT PARAMETERS
---------------------------------------------
    STARTING WSEL:       1135.70
    MAXIMUM WSEL:        1142.00
    STEP SIZE:              0.50
    BREADTH OF WEIR:       14.83

    INPUT ELEVATION/STATION TABLE.
*********************************************

    POINT    ELEVATION    STATION
    -----    ---------    -------
        1      1135.70       0.00
        2      1135.70      14.83

    WEIR COEFFICIENT TABLE
*********************************************
    REFERENCE:  COE CHART - UPPER CURVE

POINT     HEAD     COEFFICIENT
-----     ----     -----------
    1     0.00          2.5000
    2     0.50          2.6124
    3     1.00          2.7248
    4     1.50          2.8372
    5     2.00          2.9495
    6     2.50          3.0041
    7     3.00          3.0116
    8     3.50          3.0191
    9     4.00          3.0266
   10     4.50          3.0341
   11     5.00          3.0416
   12     5.50          3.0491
   13     6.00          3.0566

      UNEVEN WEIR FLOW PROGRAM
*********************************************
     ELEVATION     DISCHARGE (CFS)
    ---------     ---------------
      1135.70                0.00
      1136.20               13.70
      1136.70               40.41
      1137.20               77.30
      1137.70              123.72
      1138.20              176.10
      1138.70              232.07
      1139.20              293.17
      1139.70              359.08
      1140.20              429.53
      1140.70              504.31
      1141.20              583.25
      1141.70              666.20
```

PIPE CULVERT ANALYSIS
COMPUTATION OF CULVERT PERFORMANCE CURVE

March 9, 1999

PROGRAM INPUT DATA

DESCRIPTION	VALUE
Culvert Diameter (ft)	9.0
FHWA Chart Number	1
FHWA Scale Number (Type of Culvert Entrance)	1
Manning's Roughness Coefficient (n-value)	0.013
Entrance Loss Coefficient of Culvert Opening	0.5
Culvert Length (ft)	53.0
Invert Elevation at Downstream end of Culvert (ft)	1,133.0
Invert Elevation at Upstream end of Culvert (ft)	1,133.1
Culvert Slope (ft/ft)	0.0019
Starting Flow Rate (cfs)	638.0
Incremental Flow Rate (cfs)	0.0
Ending Flow Rate (cfs)	638.0
Starting Tailwater Depth (ft)	3.0
Incremental Tailwater Depth (ft)	0.5
Ending Tailwater Depth (ft)	5.0

COMPUTATION RESULTS

Flow Rate (cfs)	Tailwater Depth (ft)	Headwater (ft) Inlet Control	Headwater (ft) Outlet Control	Normal Depth (ft)	Critical Depth (ft)	Depth at Outlet (ft)	Outlet Velocity (fps)
638.0	3.0	10.07	10.37	9.0	6.25	6.25	13.53
638.0	3.5	10.07	10.37	9.0	6.25	6.25	13.53
638.0	4.0	10.07	10.37	9.0	6.25	6.25	13.53
638.0	4.5	10.07	10.37	9.0	6.25	6.25	13.53
638.0	5.0	10.07	10.37	9.0	6.25	6.25	13.53

HYDROCALC Hydraulics for Windows, Version 1.2a Copyright (c) 1996
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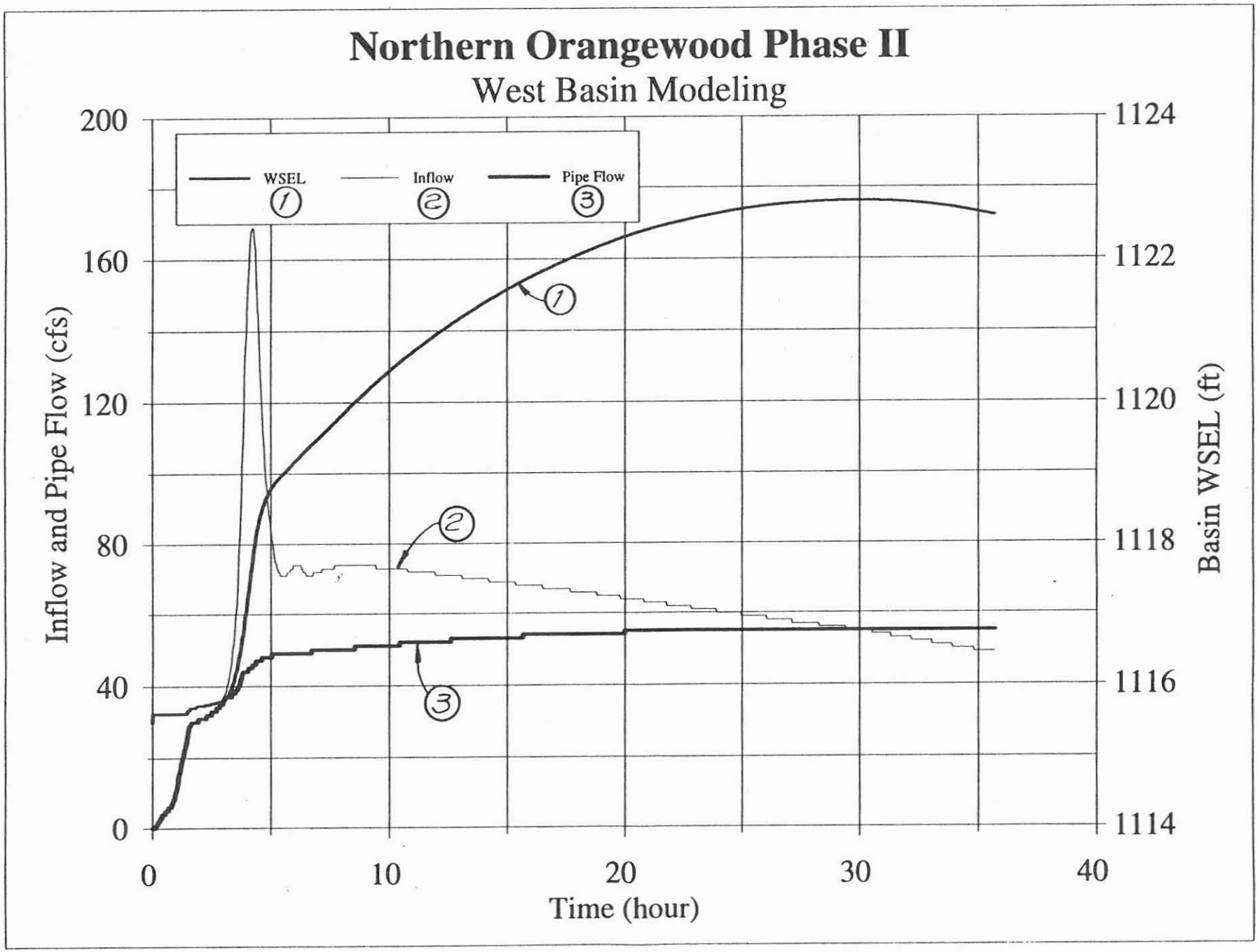
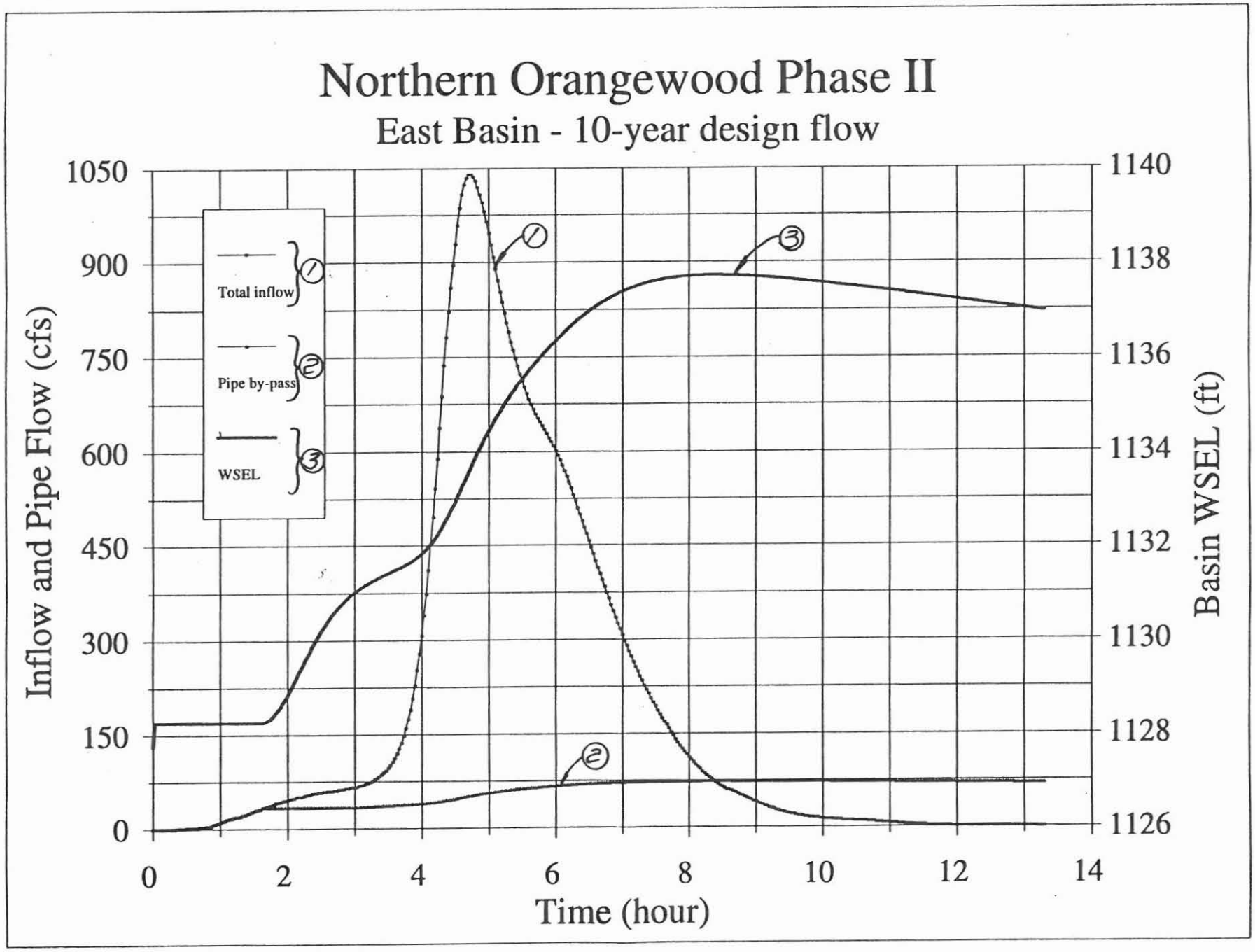
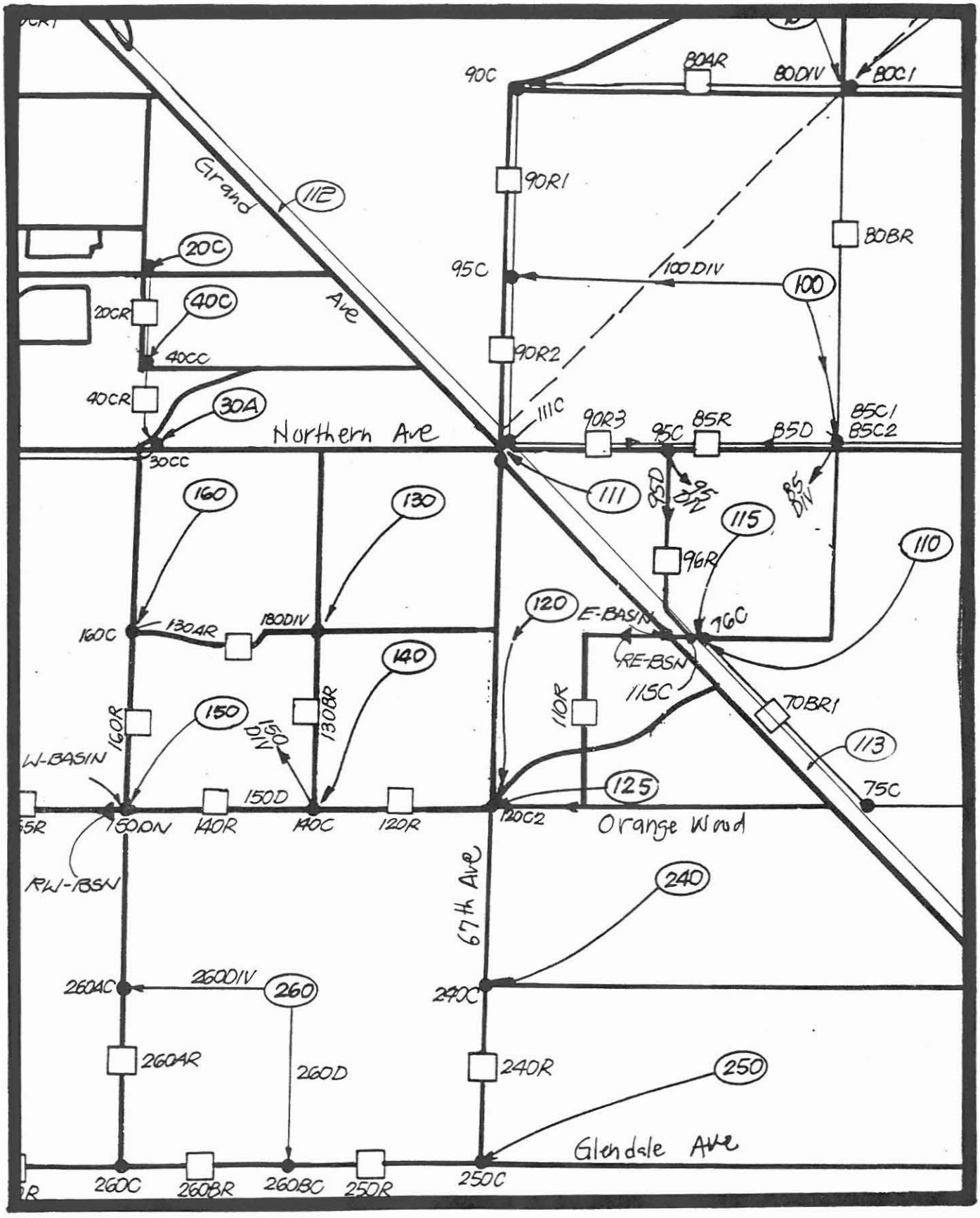

Northern Orangewood Phase II
West Basin Modeling
WSEL
Inflow
Pipe Flow
1
2
3
Inflow and Pipe Flow (cfs)
Basin WSEL (ft)
Time (hour)
0
40
80
120
160
200
1114
1116
1118
1120
1122
1124
0
10
20
30
40


Northern Orangewood Phase II
East Basin - 10-year design flow
Total inflow
Pipe by-pass
WSEL
Inflow and Pipe Flow (cfs)
Basin WSEL (ft)
Time (hour)
1050
900
750
600
450
300
150
0
1140
1138
1136
1134
1132
1130
1128
1126
0
2
4
6
8
10
12
14



REVISED SCHEMATIC
AT EAST & WEST BASINS

APPENDIX II

CATCH BASIN INLET HYDRAULICS

- Rational Method Calculations
- Catch Basin Hydraulics
- Catch Basin Connector Pipe Hydraulics

WOOD/PATEL

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PROJECT N/O Phase C

PROJECT NO. 94153.06 SHEET NO. _____ OF _____

CALCULATED BY JPM DATE 11/98 CHECKED BY JGT DATE 1/99

Northern/ Orangewood Ave Weighted C

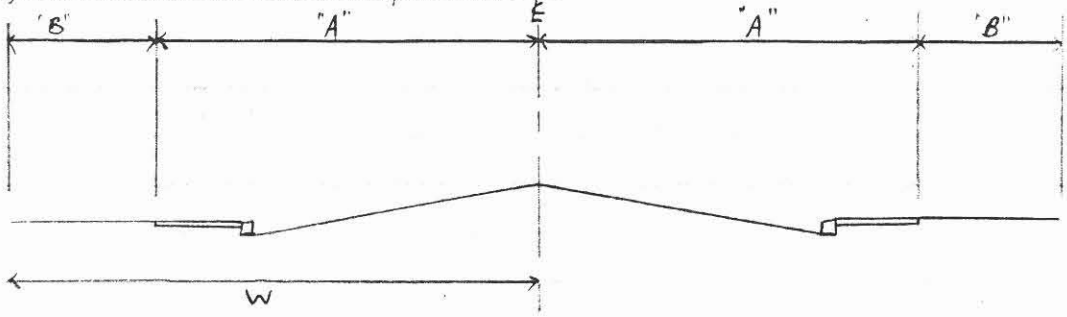


Table 3.2 FCDMC Volume 1, Hydrology

Pavement C = 0.85

Natural Ground C = 0.3

$$\text{Weighted } C = \frac{\text{"A"}(.85) + \text{"B"}(.3)}{W}$$

Weighted C

Location	A ft	B ft	Weighted "C"
83rd Ave	45.5	14.5	0.72
Orangewood @ 83rd Ave.	31	9	0.73
Orangewood Ave & 69th Ave	26	14	0.66
Northern	69	31	0.68

Flood Control District of Maricopa County
Drainage Design Manual Rational Method

Computed by: J Taillon Date: 1/29/99

LOCATION DATA

Location: 83rd Ave

Project Name: N/O Subarea id: CB 1

Drainage Area Cover: Weighted

DESIGN DATA

Drainage Area	0.6400	acres
Watercourse Length	733.0000	feet
Top Elevation	1103.1000	feet
Bottom Elevation	1098.8000	feet
Slope	0.006	feet/feet
Roughness Coefficient (Kb)	0.0412	
10-year, 6-Hour Rainfall	2.0700	inches

Hydrological Summary Table

Parameter	2-Yr	5-Yr	10-Yr	25-Yr	50-Yr	100-Yr
Q (cfs)	1	2	2	3	4	4
C	0.720	0.720	0.720	0.792	0.864	0.900
Tc (min)	11.3	10.0	9.4	8.5	8.1	7.7
i (in/hr)	2.8	3.9	4.6	5.9	6.7	7.7

Flood Control District of Maricopa County
Drainage Design Manual Rational Method

Computed by: J Taillon Date: 1/29/99

LOCATION DATA

Location: 83rd Ave

Project Name: N/O Subarea id: CB 2

Drainage Area Cover: Weighted

DESIGN DATA

Drainage Area	0.5800	acres
Watercourse Length	677.0000	feet
Top Elevation	1102.3000	feet
Bottom Elevation	1098.3000	feet
Slope	0.006	feet/feet
Roughness Coefficient (Kb)	0.0415	
10-year, 6-Hour Rainfall	2.0700	inches

Hydrological Summary Table

Parameter	2-Yr	5-Yr	10-Yr	25-Yr	50-Yr	100-Yr
Q (cfs)	1	2	2	3	3	4
C	0.720	0.720	0.720	0.792	0.864	0.900
Tc (min)	10.8	9.6	9.0	8.2	7.8	7.4
i (in/hr)	2.8	3.9	4.7	5.9	6.8	7.9

Flood Control District of Maricopa County
Drainage Design Manual Rational Method

Computed by: J Taillon Date: 1/29/99

LOCATION DATA

Location: 83rd Ave

Project Name: N/O Subarea id: CB 3

Drainage Area Cover: Weighted

DESIGN DATA

Drainage Area	0.6300	acres
Watercourse Length	731.0000	feet
Top Elevation	1105.5000	feet
Bottom Elevation	1102.0000	feet
Slope	0.005	feet/feet
Roughness Coefficient (Kb)	0.0413	
10-year, 6-Hour Rainfall	2.0700	inches

Hydrological Summary Table

Parameter	2-Yr	5-Yr	10-Yr	25-Yr	50-Yr	100-Yr
Q (cfs)	1	2	2	3	4	4
C	0.720	0.720	0.720	0.792	0.864	0.900
Tc (min)	12.2	10.8	10.1	9.2	8.7	8.3
i (in/hr)	2.7	3.7	4.4	5.7	6.5	7.5

Flood Control District of Maricopa County
Drainage Design Manual Rational Method

Computed by: J Taillon Date: 1/29/99

LOCATION DATA

Location: 83rd Ave

Project Name: N/O Subarea id: CB 4

Drainage Area Cover: Weighted

DESIGN DATA

Drainage Area	0.5300	acres
Watercourse Length	618.0000	feet
Top Elevation	1104.6000	feet
Bottom Elevation	1101.4000	feet
Slope	0.005	feet/feet
Roughness Coefficient (Kb)	0.0417	
10-year, 6-Hour Rainfall	2.0700	inches

Hydrological Summary Table

Parameter	2-Yr	5-Yr	10-Yr	25-Yr	50-Yr	100-Yr
Q (cfs)	1	2	2	2	3	4
C	0.720	0.720	0.720	0.792	0.864	0.900
Tc (min)	10.8	9.5	8.9	8.2	7.7	7.3
i (in/hr)	2.9	3.9	4.7	5.9	6.8	7.9

Flood Control District of Maricopa County
Drainage Design Manual Rational Method

Computed by: J Taillon Date: 1/29/99

LOCATION DATA

Location: 83rd Ave

Project Name: N/O Subarea id: CB 5

Drainage Area Cover: Weighted

DESIGN DATA

Drainage Area	0.6500	acres
Watercourse Length	749.0000	feet
Top Elevation	1107.2000	feet
Bottom Elevation	1104.6000	feet
Slope	0.004	feet/feet
Roughness Coefficient (Kb)	0.0412	
10-year, 6-Hour Rainfall	2.0700	inches

Hydrological Summary Table

Parameter	2-Yr	5-Yr	10-Yr	25-Yr	50-Yr	100-Yr
Q (cfs)	1	2	2	3	3	4
C	0.720	0.720	0.720	0.792	0.864	0.900
Tc (min)	14.0	12.3	11.5	10.5	10.0	9.4
i (in/hr)	2.5	3.5	4.2	5.4	6.2	7.2

Flood Control District of Maricopa County
Drainage Design Manual Rational Method

Computed by: J Taillon Date: 1/29/99

LOCATION DATA

Location: 83rd Ave

Project Name: N/O Subarea id: CB 6

Drainage Area Cover: Weighted

DESIGN DATA

Drainage Area	0.6900	acres
Watercourse Length	749.0000	feet
Top Elevation	1107.2000	feet
Bottom Elevation	1104.4000	feet
Slope	0.004	feet/feet
Roughness Coefficient (Kb)	0.0412	
10-year, 6-Hour Rainfall	2.0700	inches

Hydrological Summary Table

Parameter	2-Yr	5-Yr	10-Yr	25-Yr	50-Yr	100-Yr
Q (cfs)	1	2	2	3	4	4
C	0.720	0.720	0.720	0.792	0.864	0.900
Tc (min)	13.6	12.0	11.2	10.2	9.7	9.2
i (in/hr)	2.6	3.6	4.3	5.5	6.3	7.2

Flood Control District of Maricopa County
Drainage Design Manual Rational Method

Computed by: J Taillon Date: 1/29/99

LOCATION DATA

Location: Orangewood Avenue

Project Name: N/O Subarea id: CB 8a

Drainage Area Cover: Weighted

DESIGN DATA

Drainage Area	0.5400	acres
Watercourse Length	588.0000	feet
Top Elevation	1108.9000	feet
Bottom Elevation	1106.9000	feet
Slope	0.003	feet/feet
Roughness Coefficient (Kb)	0.0417	
10-year, 6-Hour Rainfall	2.0700	inches

Hydrological Summary Table

Parameter	2-Yr	5-Yr	10-Yr	25-Yr	50-Yr	100-Yr
Q (cfs)	1	1	2	2	3	4
C	0.730	0.730	0.730	0.803	0.876	0.913
Tc (min)	12.3	10.8	10.1	9.2	8.8	8.3
i (in/hr)	2.7	3.7	4.4	5.7	6.5	7.5

Flood Control District of Maricopa County
Hydrologic Design Manual Rational Method

Computed by: S Rasmussen Date: 03-10-1999

LOCATION DATA

Location: Orangewood Ave

Project Name: N/O Subarea id: CB 14a

Drainage Area Cover: Weighted

DESIGN DATA

Drainage Area	0.50	acres
Watercourse Length	587.0	feet
Top Elevation	1128.7	feet
Bottom Elevation	1126.7	feet
Slope	.00337	feet/feet
Roughness Coefficient (Kb)	.04188	
10-Year, 6-Hour Rainfall	2.07	inches

Hydrological Summary Table

Parameter	2-Yr	5-Yr	10-Yr	25-Yr	50-Yr	100-Yr
Q (cfs)	1	1	1	2	3	3
C	0.660	0.660	0.660	0.726	0.792	0.825
Tc (min)	12.3	10.9	10.4	9.3	8.8	8.3
i (in/hr)	2.7	3.7	4.2	5.7	6.5	7.5

Flood Control District of Maricopa County
Hydrologic Design Manual Rational Method

Computed by: S Rasmussen Date: 03-10-1999

LOCATION DATA

Location: Orangewood Ave

Project Name: N/O Subarea id: CB 14b

Drainage Area Cover: Weighted

DESIGN DATA

Drainage Area	0.61	acres
Watercourse Length	705.0	feet
Top Elevation	1130.6	feet
Bottom Elevation	1128.1	feet
Slope	.00352	feet/feet
Roughness Coefficient (Kb)	.04134	
10-Year, 6-Hour Rainfall	2.07	inches

Hydrological Summary Table

Parameter	2-Yr	5-Yr	10-Yr	25-Yr	50-Yr	100-Yr
Q (cfs)	1	1	2	2	3	4
C	0.660	0.660	0.660	0.726	0.792	0.825
Tc (min)	13.4	11.9	11.3	10.1	9.6	9.1
i (in/hr)	2.6	3.6	4.1	5.5	6.3	7.3

Flood Control District of Maricopa County
Drainage Design Manual Rational Method

Computed by: J Taillon Date: 1/29/99

LOCATION DATA

Location: Orangewood Avenue

Project Name: N/O Subarea id: CB 15d

Drainage Area Cover: Weighted

DESIGN DATA

Drainage Area	0.5600	acres
Watercourse Length	612.0000	feet
Top Elevation	1132.0000	feet
Bottom Elevation	1130.6000	feet
Slope	0.002	feet/feet
Roughness Coefficient (Kb)	0.0416	
10-year, 6-Hour Rainfall	2.0700	inches

Hydrological Summary Table

Parameter	2-Yr	5-Yr	10-Yr	25-Yr	50-Yr	100-Yr
Q (cfs)	1	1	2	2	3	3
C	0.660	0.660	0.660	0.726	0.792	0.825
Tc (min)	14.6	12.8	12.0	10.9	10.4	9.8
i (in/hr)	2.5	3.5	4.1	5.3	6.1	7.0

Flood Control District of Maricopa County
Drainage Design Manual Rational Method

Computed by: J Taillon Date: 1/29/99

LOCATION DATA

Location: Orangewood Avenue

Project Name: N/O Subarea id: CB 15e

Drainage Area Cover: Weighted

DESIGN DATA

Drainage Area	0.5600	acres
Watercourse Length	608.0000	feet
Top Elevation	1134.0000	feet
Bottom Elevation	1131.8000	feet
Slope	0.004	feet/feet
Roughness Coefficient (Kb)	0.0416	
10-year, 6-Hour Rainfall	2.0700	inches

Hydrological Summary Table

Parameter	2-Yr	5-Yr	10-Yr	25-Yr	50-Yr	100-Yr
Q (cfs)	1	1	2	2	3	3
C	0.660	0.660	0.660	0.726	0.792	0.825
Tc (min)	12.2	10.8	10.1	9.2	8.7	8.3
i (in/hr)	2.7	3.7	4.4	5.7	6.5	7.5

Flood Control District of Maricopa County
Drainage Design Manual Rational Method

Computed by: J Taillon Date: 1/29/99

LOCATION DATA

Location: Orangewood Avenue Sta 94+46

Project Name: N/O Subarea id: CB 15b

Drainage Area Cover: Weighted

DESIGN DATA

Drainage Area	0.4500	acres
Watercourse Length	575.0000	feet
Top Elevation	1131.9301	feet
Bottom Elevation	1130.2000	feet
Slope	0.003	feet/feet
Roughness Coefficient (Kb)	0.0422	
10-year, 6-Hour Rainfall	2.0700	inches

Hydrological Summary Table

Parameter	2-Yr	5-Yr	10-Yr	25-Yr	50-Yr	100-Yr
Q (cfs)	1	1	1	2	2	3
C	0.660	0.660	0.660	0.726	0.792	0.825
Tc (min)	12.8	11.3	10.5	9.6	9.1	8.6
i (in/hr)	2.6	3.7	4.4	5.6	6.4	7.4

Flood Control District of Maricopa County
Drainage Design Manual Rational Method

Computed by: J Taillon Date: 1/29/99

LOCATION DATA

Location: Orangewood Avenue Sta 100+10

Project Name: N/O Subarea id: CB 15c

Drainage Area Cover: Weighted

DESIGN DATA

Drainage Area	0.5200	acres
Watercourse Length	610.0000	feet
Top Elevation	1133.9700	feet
Bottom Elevation	1131.7200	feet
Slope	0.004	feet/feet
Roughness Coefficient (Kb)	0.0419	
10-year, 6-Hour Rainfall	2.0700	inches

Hydrological Summary Table

Parameter	2-Yr	5-Yr	10-Yr	25-Yr	50-Yr	100-Yr
Q (cfs)	1	1	2	2	3	3
C	0.660	0.660	0.660	0.726	0.792	0.825
Tc (min)	12.2	10.8	10.1	9.2	8.7	8.3
i (in/hr)	2.7	3.7	4.5	5.7	6.5	7.5

Flood Control District of Maricopa County
Drainage Design Manual Rational Method

Computed by: JPM Date: 3/19/99

LOCATION DATA

Location: Northern Avenue

Project Name: N/O Subarea id: CP25a

Drainage Area Cover:

DESIGN DATA

Drainage Area	1.4000	acres
Watercourse Length	805.0000	feet
Top Elevation	1145.0000	feet
Bottom Elevation	1142.3000	feet
Slope	0.003	feet/feet
Roughness Coefficient (Kb)	0.0420	
10-year, 6-Hour Rainfall	2.0700	inches

Hydrological Summary Table

Parameter	2-Yr	5-Yr	10-Yr	25-Yr	50-Yr	100-Yr
Q (cfs)	2	3	4	5	7	8
C	0.680	0.680	0.680	0.748	0.816	0.850
Tc (min)	15.0	13.2	12.4	11.2	10.7	10.1
i (in/hr)	2.5	3.4	4.1	5.2	6.0	7.0

Flood Control District of Maricopa County
Drainage Design Manual Rational Method

Computed by: JPM Date: 3/19/99

LOCATION DATA

Location: Northern Avenue

Project Name: N/O Subarea id: CP25b

Drainage Area Cover:

DESIGN DATA

Drainage Area	1.4000	acres
Watercourse Length	805.0000	feet
Top Elevation	1145.0000	feet
Bottom Elevation	1142.3000	feet
Slope	0.003	feet/feet
Roughness Coefficient (Kb)	0.0391	
10-year, 6-Hour Rainfall	2.0700	inches

Hydrological Summary Table

Parameter	2-Yr	5-Yr	10-Yr	25-Yr	50-Yr	100-Yr
Q (cfs)	2	3	4	6	7	8
C	0.680	0.680	0.680	0.748	0.816	0.850
Tc (min)	14.3	12.6	11.8	10.7	10.2	9.6
i (in/hr)	2.5	3.5	4.2	5.3	6.1	7.1

Flood Control District of Maricopa County
Drainage Design Manual Rational Method

Computed by: JPM Date: 3/19/99

LOCATION DATA

Location: Northern Avenue

Project Name: N/O Subarea id: CP26a

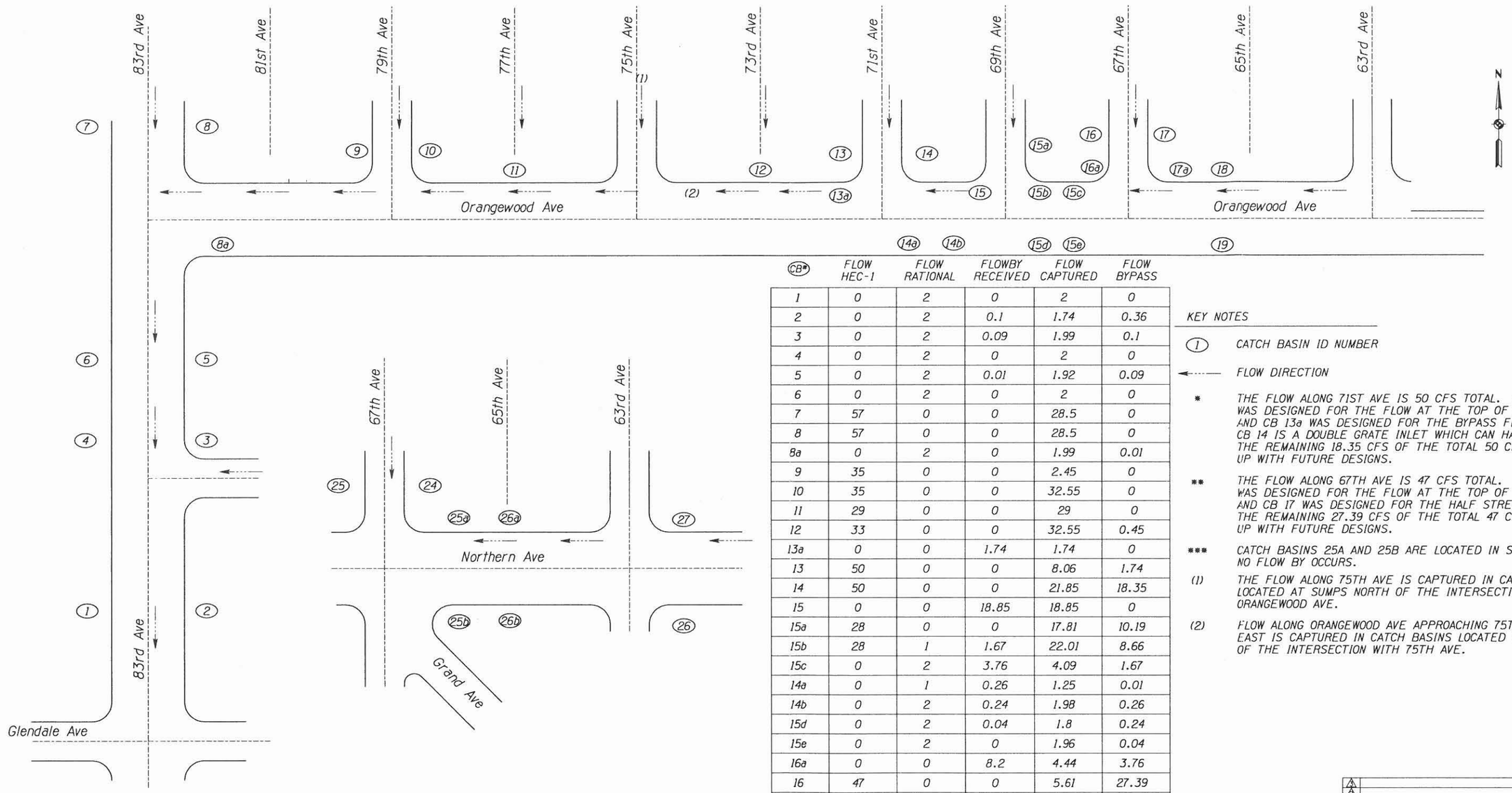
Drainage Area Cover:

DESIGN DATA

Drainage Area	1.5000	acres
Watercourse Length	1274.0000	feet
Top Elevation	1149.2000	feet
Bottom Elevation	1145.0000	feet
Slope	0.003	feet/feet
Roughness Coefficient (Kb)	0.0389	
10-year, 6-Hour Rainfall	2.0700	inches

Hydrological Summary Table

Parameter	2-Yr	5-Yr	10-Yr	25-Yr	50-Yr	100-Yr
Q (cfs)	2	3	4	5	7	8
C	0.680	0.680	0.680	0.748	0.816	0.850
Tc (min)	19.1	16.8	15.7	14.2	13.4	12.7
i (in/hr)	2.2	3.0	3.6	4.7	5.5	6.3



CB*	FLOW HEC-1	FLOW RATIONAL	FLOWBY RECEIVED	FLOW CAPTURED	FLOW BYPASS
1	0	2	0	2	0
2	0	2	0.1	1.74	0.36
3	0	2	0.09	1.99	0.1
4	0	2	0	2	0
5	0	2	0.01	1.92	0.09
6	0	2	0	2	0
7	57	0	0	28.5	0
8	57	0	0	28.5	0
8a	0	2	0	1.99	0.01
9	35	0	0	2.45	0
10	35	0	0	32.55	0
11	29	0	0	29	0
12	33	0	0	32.55	0.45
13a	0	0	1.74	1.74	0
13	50	0	0	8.06	1.74
14	50	0	0	21.85	18.35
15	0	0	18.85	18.85	0
15a	28	0	0	17.81	10.19
15b	28	1	1.67	22.01	8.66
15c	0	2	3.76	4.09	1.67
14a	0	1	0.26	1.25	0.01
14b	0	2	0.24	1.98	0.26
15d	0	2	0.04	1.8	0.24
15e	0	2	0	1.96	0.04
16a	0	0	8.2	4.44	3.76
16	47	0	0	5.61	27.39
17	47	0	0	14	0
17a	24	0	0	21.7	2.3
18	0	4	0	4	0
19	0	4	0	4	0
24	104	0	0	6.13	0.16
25	104	0	0	9.53	1.9
26	626	0	0	13.78	8.55
27	626	0	0	13.78	6.58
26a	0	4	6.58	6.77	3.81
26b	0	4	8.55	7.47	5.08

NOTE: All Flows Shown In Cubic Feet Per Second

KEY NOTES

(1) CATCH BASIN ID NUMBER

FLOW DIRECTION

* THE FLOW ALONG 71ST AVE IS 50 CFS TOTAL. CB 13 WAS DESIGNED FOR THE FLOW AT THE TOP OF CURB, AND CB 13a WAS DESIGNED FOR THE BYPASS FLOW FROM CB 13. CB 14 IS A DOUBLE GRATE INLET WHICH CAN HANDLE 21.85 CFS. THE REMAINING 18.35 CFS OF THE TOTAL 50 CFS WILL BE PICKED UP WITH FUTURE DESIGNS.

** THE FLOW ALONG 67TH AVE IS 47 CFS TOTAL. CB 16 WAS DESIGNED FOR THE FLOW AT THE TOP OF CURB, AND CB 17 WAS DESIGNED FOR THE HALF STREET FLOW OF 14 CFS. THE REMAINING 27.39 CFS OF THE TOTAL 47 CFS WILL BE PICKED UP WITH FUTURE DESIGNS.

*** CATCH BASINS 25A AND 25B ARE LOCATED IN SUMPS, THEREFORE NO FLOW BY OCCURS.

(1) THE FLOW ALONG 75TH AVE IS CAPTURED IN CATCH BASINS LOCATED AT SUMPS NORTH OF THE INTERSECTION WITH ORANGEWOOD AVE.

(2) FLOW ALONG ORANGEWOOD AVE APPROACHING 75TH AVE FROM THE EAST IS CAPTURED IN CATCH BASINS LOCATED IN SUMPS EAST OF THE INTERSECTION WITH 75TH AVE.

NO.	REVISION	BY	DATE
3			
2			
1			

FLOOD CONTROL DISTRICT OF MARICOPA COUNTY
ENGINEERING DIVISION

ORANGEWOOD AVE STORM DRAIN
SUB-PHASE "C"
CONTRACT FCD 99-07 PHASE II

	BY	DATE
DESIGNED	J. TAILLON	3/99
DRAWN	A. LINN	3/99
CHECKED	A. PATEL	3/99

WOOD, PATEL & ASSOCIATES, INC.
1550 EAST MISSOURI, SUITE 203
PHOENIX, ARIZONA (602) 234-1344

CATCH BASIN FLOW SCHEMATIC

SHEET 00 OF 63

Two working days before you dig
263-1100
1-800-STAKE-IT
(OUTSIDE MARICOPA COUNTY)

PCN 4500333

V:\980303\flowsch.dgn 12/08/98

V:/980303/100sub/flowsch.dgn Mar 24, 1999 08:43:16

Weir/Orifice Flow Capacities of Single Grate Inlet

Weir EQ. $Q_i = C_w P d^{1.5}$ **Orifice EQ.** $Q_i = C_o A (2gd)^{0.5}$

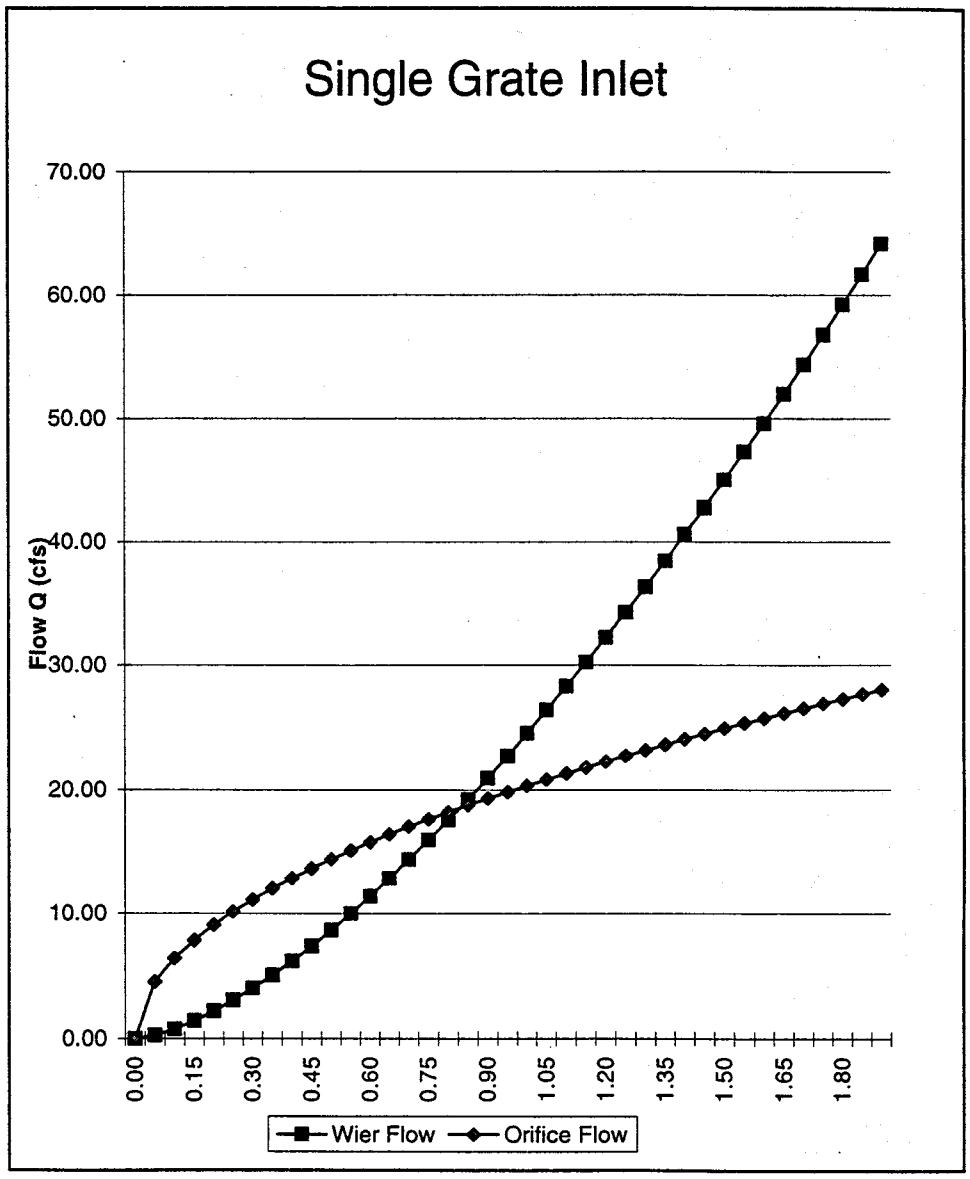
Where: $C_w = 3.0$ **and** $C_o = 0.67$

Single Grate

P =	**8.17**	**ft**
A =	**3.78**	**ft^2**

Grate Opening

Depth (ft)	Weir Qi (cfs)	Orifice Qi (cfs)
0.00	0.00	0.00
0.05	0.27	4.54
0.10	0.78	6.43
0.15	1.42	7.87
0.20	2.19	9.09
0.25	3.06	10.16
0.30	4.03	11.13
0.35	5.08	12.02
0.40	6.20	12.85
0.45	7.40	13.63
0.50	8.67	14.37
0.55	10.00	15.07
0.60	11.39	15.74
0.65	12.84	16.39
0.70	14.35	17.00
0.75	15.92	17.60
0.80	17.54	18.18
0.85	19.21	18.74
0.90	20.93	19.28
0.95	22.69	19.81
1.00	24.51	20.32
1.05	26.37	20.83
1.10	28.28	21.32
1.15	30.23	21.80
1.20	32.22	22.26
1.25	34.25	22.72
1.30	36.33	23.17
1.35	38.45	23.61
1.40	40.60	24.05
1.45	42.80	24.47
1.50	45.03	24.89
1.55	47.30	25.30
1.60	49.60	25.71
1.65	51.95	26.11
1.70	54.33	26.50
1.75	56.74	26.89
1.80	59.19	27.27
1.85	61.67	27.64
1.90	64.19	28.01



Maximum Depth = 1.14 ft. Maximum Inlet capacity = 0.5*21.7 = 10.85 cfs

Weir/Orifice Flow Capacities of Double Grate Inlet

Weir EQ. $Q_i = C_w P d^{1.5}$ **Orifice EQ.** $Q_i = C_o A (2gd)^{0.5}$

Where: $C_w = 3.0$ **and** $C_o = 0.67$

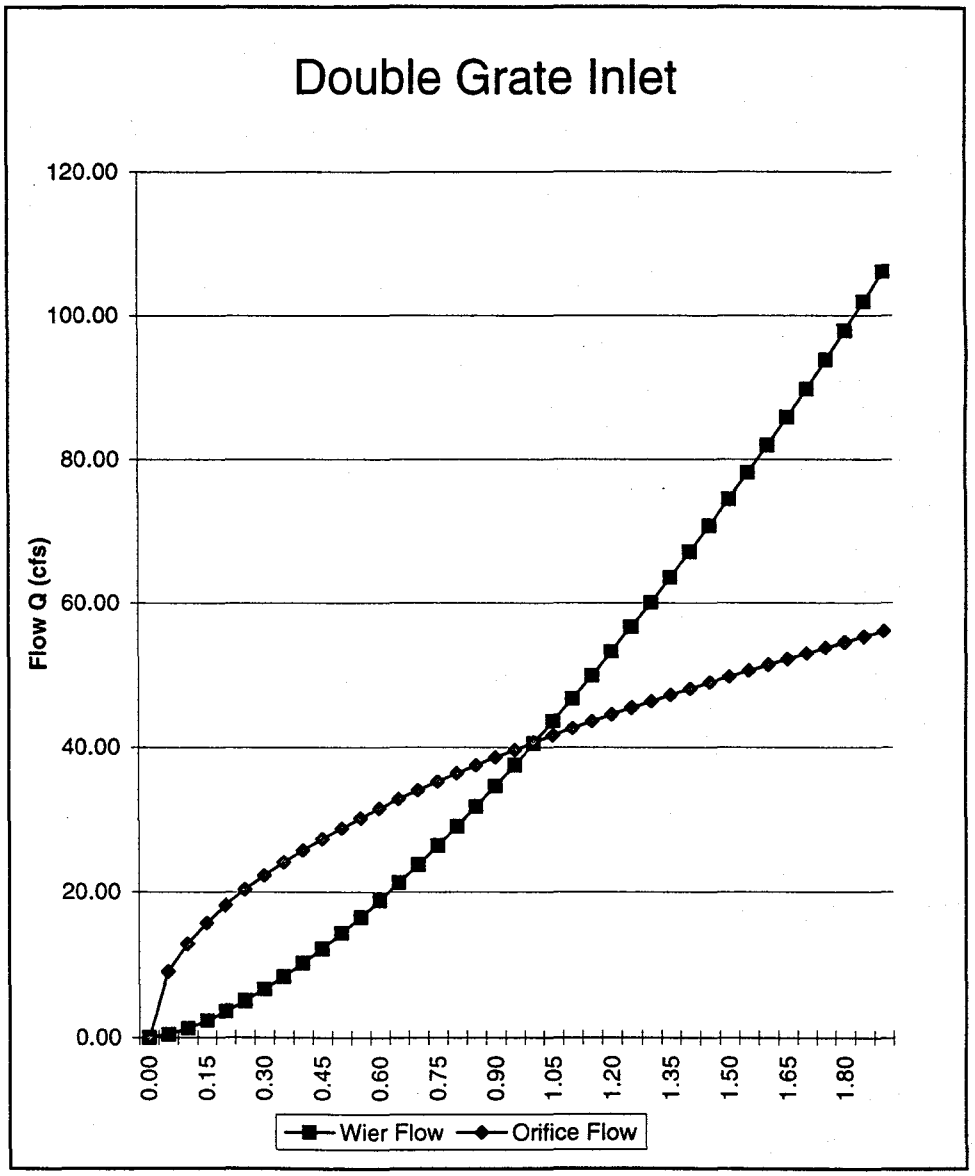
Double Grate

P = 13.50 ft

A = 7.56 ft^2

Grate Opening

Depth (ft)	Weir Qi (cfs)	Orifice Qi (cfs)
0.00	0.00	0.00
0.05	0.45	9.09
0.10	1.28	12.85
0.15	2.35	15.74
0.20	3.62	18.18
0.25	5.06	20.32
0.30	6.65	22.26
0.35	8.39	24.05
0.40	10.25	25.71
0.45	12.23	27.27
0.50	14.32	28.74
0.55	16.52	30.15
0.60	18.82	31.49
0.65	21.22	32.77
0.70	23.72	34.01
0.75	26.31	35.20
0.80	28.98	36.36
0.85	31.74	37.48
0.90	34.58	38.56
0.95	37.50	39.62
1.00	40.50	40.65
1.05	43.58	41.65
1.10	46.72	42.63
1.15	49.95	43.59
1.20	53.24	44.53
1.25	56.60	45.45
1.30	60.03	46.35
1.35	63.53	47.23
1.40	67.09	48.10
1.45	70.71	48.95
1.50	74.40	49.78
1.55	78.15	50.61
1.60	81.97	51.42
1.65	85.84	52.21
1.70	89.77	53.00
1.75	93.76	53.77
1.80	97.81	54.54
1.85	101.91	55.29
1.90	106.07	56.03



Maximum Depth = 1.14 ft. Maximum Inlet capacity = 0.5*43.4 = 21.7 cfs

Weir/Orifice Flow Capacities of Triple Grate Inlet

Weir EQ. $Q_i = C_w P d^{1.5}$ **Orifice EQ.** $Q_i = C_o A (2gd)^{0.5}$

Where: $C_w = 3.0$ **and** $C_o = 0.67$

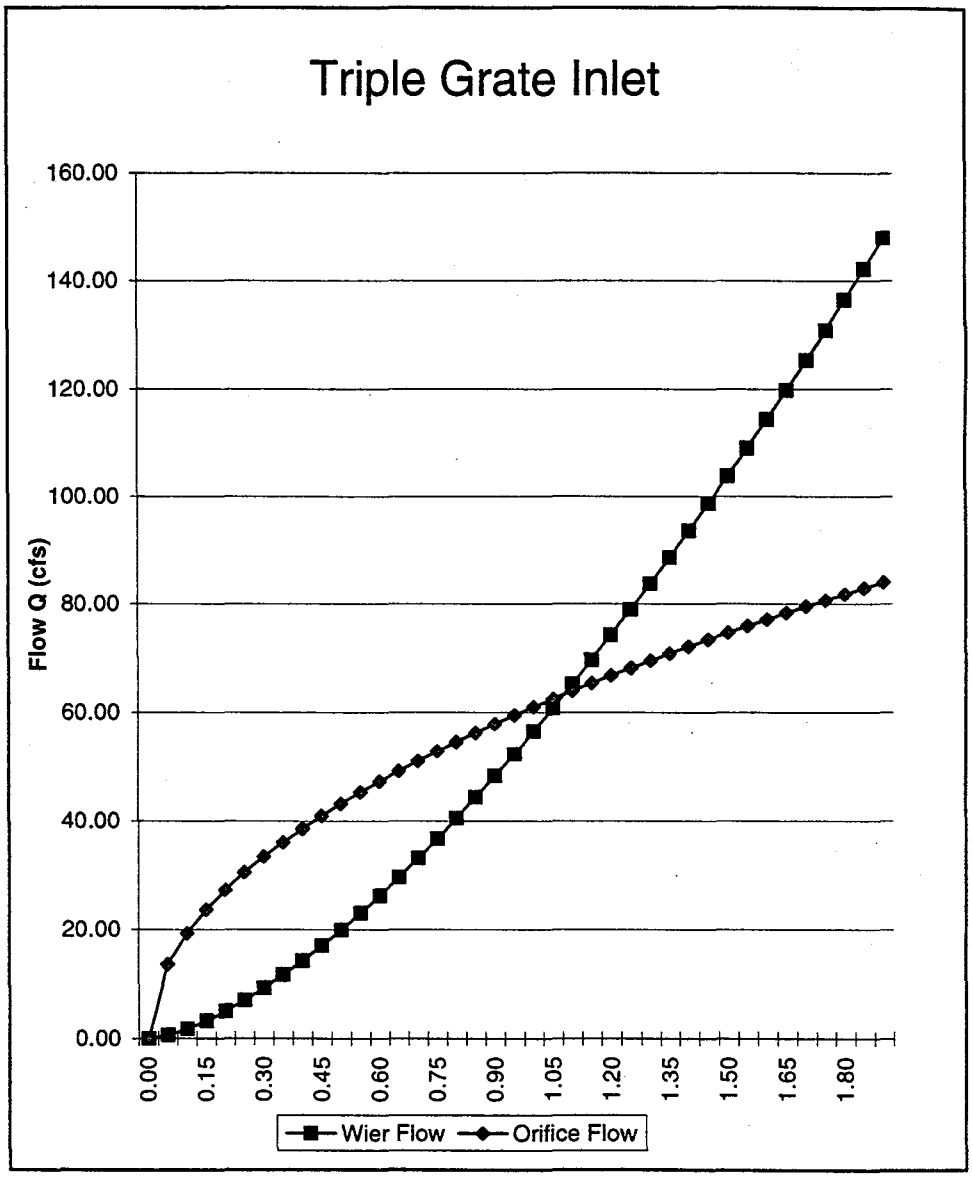
Triple Grate

P = 18.83 ft

A = 11.34 ft^2

Grate Opening

Depth (ft)	Weir Qi (cfs)	Orifice Qi (cfs)
0.00	0.00	0.00
0.05	0.63	13.63
0.10	1.79	19.28
0.15	3.28	23.61
0.20	5.05	27.27
0.25	7.06	30.49
0.30	9.28	33.40
0.35	11.70	36.07
0.40	14.29	38.56
0.45	17.05	40.90
0.50	19.97	43.11
0.55	23.04	45.22
0.60	26.25	47.23
0.65	29.60	49.16
0.70	33.08	51.01
0.75	36.69	52.80
0.80	40.42	54.54
0.85	44.27	56.21
0.90	48.23	57.84
0.95	52.31	59.43
1.00	56.49	60.97
1.05	60.78	62.48
1.10	65.17	63.95
1.15	69.67	65.39
1.20	74.26	66.79
1.25	78.95	68.17
1.30	83.73	69.52
1.35	88.61	70.84
1.40	93.58	72.14
1.45	98.63	73.42
1.50	103.78	74.68
1.55	109.01	75.91
1.60	114.33	77.12
1.65	119.73	78.32
1.70	125.21	79.50
1.75	130.78	80.66
1.80	136.42	81.80
1.85	142.14	82.93
1.90	147.95	84.04



Maximum Depth = 1.14 ft. Maximum Inlet capacity = 0.5*65.1 = 32.55 cfs

Flow By Catch Basin Calculations

Description: Catch Basin Sizing Computations

References: Drainage Design Manual for Maricopa County, Arizona
Volume II "Hydraulics"

Catch Basin Type: City of Phoenix P1569-1 M-

Known Values:

Curb Height =	6 in
d(in)=	2
w (ft)=	1.42
n =	0.016
Fr =	0.8

Q = flow rate, cfs
S_x = cross slope
S = longitudial street slope
Lt = length of catch basin to intercept total flow
E_o = percent flow in gutter
L = actual length of catch basin
E = catch basin efficiency
Q_{int} = amount of flow intercepted by catch basin
Fr = catch basin reduction factor

Calculated Values

$E = 1-(1-(L/Lt))^{1.8}$

$S_w = a/w$

$a=d-(w)(S_x)$

$S_e = S_x + (Sw)(E_o)$

$E = 1 - (1-L/Lt)^{1.8}$

$Lt = ((0.6)/Fr) * Q^{0.42} * S^{0.3} * (1/nS_x)^{0.6}$

Catch Basin Number	Q cfs	S ft/ft	S_x ft/ft	E_o	a	S_w	S_e	Lt ft	L ft.	E	Q_{int}	Q_{bypass}
CB 2	2.10	0.0063	0.0217	0.401	0.136	0.096	0.060	14.5	9.0	0.83	1.74	0.36
CB 3	2.09	0.0089	0.02	0.413	0.138	0.097	0.060	16.0	13.0	0.95	1.99	0.10
CB 5	2.01	0.0019	0.02	0.312	0.138	0.097	0.050	11.0	9.0	0.95	1.92	0.09
CB 8a	2.00	0.003	0.014	0.295	0.147	0.103	0.044	13.6	13.0	1.00	1.99	0.01
CB 14a	1.26	0.0015	0.041	0.478	0.108	0.076	0.078	6.5	6.0	0.99	1.25	0.01
CB 14b	2.24	0.0018	0.049	0.445	0.097	0.068	0.079	8.6	6.0	0.88	1.98	0.26
CB 15d	2.04	0.0035	0.019	0.344	0.140	0.098	0.053	12.9	9.0	0.88	1.80	0.24
CB 15e	2.00	0.0027	0.01	0.25	0.152	0.107	0.037	14.7	13.0	0.98	1.96	0.04
CB 16	5.85	0.0013	0.028	0.119	0.127	0.089	0.039	18.1	15.0	0.96	5.61	0.24
CB 16a	8.20	0.0047	0.011	0.162	0.151	0.106	0.028	36.9	13.0	0.54	4.44	3.76
CB 15c	5.76	0.0034	0.015	0.18	0.145	0.102	0.033	26.1	13.0	0.71	4.09	1.67
CB 15b	30.67	0.0037	0.034	0.265	0.118	0.083	0.056	39.6	20.0	0.72	22.01	8.66
CB 15a	28.00	0.0097	0.042	0.308	0.107	0.075	0.065	46.5	20.0	0.64	17.81	10.19
CB 25	11.43	0.0021	0.016	0.145	0.144	0.101	0.031	31.7	20.0	0.83	9.53	1.90
CB 24	6.29	0.0006	0.015	0.137	0.145	0.102	0.029	17.3	15.0	0.97	6.13	0.16
Exist CB 27	13.82	0.0041	0.019	0.168	0.140	0.098	0.036	38.5	13.0	0.52	7.24	6.58
Exist CB 26	13.82	0.0041	0.019	0.168	0.140	0.098	0.036	38.5	9.0	0.38	5.27	8.55
CB 26a	10.58	0.0029	0.02	0.179	0.138	0.097	0.037	30.0	13.0	0.64	6.77	3.81
CB 26b	12.55	0.0029	0.02	0.167	0.138	0.097	0.036	32.9	13.0	0.60	7.47	5.08
CB 13	9.80	0.0017	0.012	0.113	0.150	0.105	0.024	32.4	20.0	0.82	8.06	1.74
CB 13a	1.74	0.0039	0.019	0.293	0.140	0.098	0.048	13.3	13.0	1.00	1.74	0.00

WPA
3/24/99
catchbasins.xls

ARIZONA DEPARTMENT OF TRANSPORTATION
DRAINAGE DESIGN SECTION

03-11-1999

PROJECT NAME- N/O Ph II C
HIGHWAY NAME-
LOCATION - CBZ Sta 16+38
Ver 3.40: December 1995

TRACS NO.-
DESIGNER - JPM
CHECKER - JGT
PAGE

GUTTER FLOW HYDRAULICS
GUTTER DESCRIPTION

Roadway Grade-% Per cent--G	=	0.630
Roadway Cross-Slope-Ft./Ft.--Sx	=	0.022
Shoulder Width-Ft.--	=	10.000
Shoulder Slope-Ft./Ft.--Ss	=	0.022
Gutter Width-Ft.--W	=	1.420
Gutter Slope-Ft./Ft.--Sw	=	0.058
Gutter Depression-Inches--	=	0.988
Manning's 'N	=	0.016
Flow-CFS--Q	=	2.100
SPREAD-Ft.--T	=	9.493
Average Velocity-V-fps	=	2.043
FLOW in Gutter-CFS--Q	=	0.841
% Flow in Gutter-CFS	=	40.060
Velocity of Flow in Gutter-fps	=	2.708
Depth at Curb Line-Inches--d	=	3.120

ARIZONA DEPARTMENT OF TRANSPORTATION
DRAINAGE DESIGN SECTION

03-11-1999

PROJECT NAME- N/O Ph II C
HIGHWAY NAME-
LOCATION - CB 3 Sta 23+49
Ver 3.40: December 1995

TRACS NO.-
DESIGNER - JPM
CHECKER - JGT
PAGE

GUTTER FLOW HYDRAULICS
GUTTER DESCRIPTION

Roadway Grade-% Per cent--G	=	0.890
Roadway Cross-Slope-Ft./Ft.--Sx	=	0.020
Shoulder Width-Ft.--	=	10.000
Shoulder Slope-Ft./Ft.--Ss	=	0.020
Gutter Width-Ft.--W	=	1.420
Gutter Slope-Ft./Ft.--Sw	=	0.058
Gutter Depression-Inches--	=	0.988
Manning's 'N	=	0.016
Flow-CFS--Q	=	2.090
SPREAD-Ft.--T	=	9.373
Average Velocity-V-fps	=	2.279
FLOW in Gutter-CFS--Q	=	0.864
% Flow in Gutter-CFS	=	41.328
Velocity of Flow in Gutter-fps	=	3.038
Depth at Curb Line-Inches--d	=	2.897

ARIZONA DEPARTMENT OF TRANSPORTATION
DRAINAGE DESIGN SECTION

03-11-1999

PROJECT NAME- N/O Ph II C
HIGHWAY NAME-
LOCATION - CB 5 Sta 29+64
Ver 3.40: December 1995

TRACS NO.-
DESIGNER - JPM
CHECKER - JGT
PAGE

GUTTER FLOW HYDRAULICS
GUTTER DESCRIPTION

Roadway Grade-% Per cent--G	=	0.190
Roadway Cross-Slope-Ft./Ft.--Sx	=	0.020
Shoulder Width-Ft.--	=	10.000
Shoulder Slope-Ft./Ft.--Ss	=	0.020
Gutter Width-Ft.--W	=	1.420
Gutter Slope-Ft./Ft.--Sw	=	0.058
Gutter Depression-Inches--	=	0.988
Manning's 'N	=	0.016
Flow-CFS--Q	=	2.010
SPREAD-Ft.--T	=	12.529
Average Velocity-V-fps	=	1.250
FLOW in Gutter-CFS--Q	=	0.628
% Flow in Gutter-CFS	=	31.243
Velocity of Flow in Gutter-fps	=	1.679
Depth at Curb Line-Inches--d	=	3.655

ARIZONA DEPARTMENT OF TRANSPORTATION
DRAINAGE DESIGN SECTION

01-12-1999

PROJECT NAME- N/O Phase II C CB8a TRACS NO.-
HIGHWAY NAME- DESIGNER - JPM
LOCATION - sta 1+73 CHECKER - JGT PAGE
Ver 3.40: December 1995

GUTTER FLOW HYDRAULICS
GUTTER DESCRIPTION

Roadway Grade-% Per cent--G	=	0.300
Roadway Cross-Slope-Ft./Ft.--Sx	=	0.014
Shoulder Width-Ft.--	=	10.000
Shoulder Slope-Ft./Ft.--Ss	=	0.014
Gutter Width-Ft.--W	=	1.420
Gutter Slope-Ft./Ft.--Sw	=	0.058
Gutter Depression-Inches--	=	0.988
Manning's 'N	=	0.016
Flow-CFS--Q	=	2.000
SPREAD-Ft.--T	=	14.263
Average Velocity-V-fps	=	1.362
FLOW in Gutter-CFS--Q	=	0.590
% Flow in Gutter-CFS	=	29.507
Velocity of Flow in Gutter-fps	=	1.881
Depth at Curb Line-Inches--d	=	3.146

ARIZONA DEPARTMENT OF TRANSPORTATION
DRAINAGE DESIGN SECTION

12-04-1998

PROJECT NAME- N10 Phase C
HIGHWAY NAME-
LOCATION - Sta 79+65 CB 13a
Ver 3.40: December 1995

TRACS NO.-
DESIGNER - JPM
CHECKER - JGT
PAGE

GUTTER FLOW HYDRAULICS
GUTTER DESCRIPTION

Roadway Grade-% Per cent--G	=	0.390
Roadway Cross-Slope-Ft./Ft.--Sx	=	0.019
Shoulder Width-Ft.--	=	10.000
Shoulder Slope-Ft./Ft.--Ss	=	0.019
Gutter Width-Ft.--W	=	1.420
Gutter Slope-Ft./Ft.--Sw	=	0.058
Gutter Depression-Inches--	=	0.988
Manning's 'N	=	0.016
Flow-CFS--Q	=	3.210
SPREAD-Ft.--T	=	13.494
Average Velocity-V-fps	=	1.814
FLOW in Gutter-CFS--Q	=	0.941
% Flow in Gutter-CFS	=	29.315
Velocity of Flow in Gutter-fps	=	2.449
Depth at Curb Line-Inches--d	=	3.741

ARIZONA DEPARTMENT OF TRANSPORTATION
DRAINAGE DESIGN SECTION

12-03-1998

PROJECT NAME- N/O Phase C
HIGHWAY NAME-
LOCATION - CB 13 Sta 80+15.55
Ver 3.40: December 1995

TRACS NO.-
DESIGNER - TPM
CHECKER - JGT
PAGE

GUTTER FLOW HYDRAULICS
GUTTER DESCRIPTION

Roadway Grade-% Per cent--G	=	0.170
Roadway Cross-Slope-Ft./Ft.--Sx	=	0.012
Shoulder Width-Ft.--	=	10.000
Shoulder Slope-Ft./Ft.--Ss	=	0.012
Gutter Width-Ft.--W	=	1.420
Gutter Slope-Ft./Ft.--Sw	=	0.058
Gutter Depression-Inches--	=	0.988
Manning's 'N	=	0.016
Flow-CFS--Q	=	13.214
SPREAD-Ft.--T	=	36.223
Average Velocity-V-fps	=	1.669
FLOW in Gutter-CFS--Q	=	1.494
% Flow in Gutter-CFS	=	11.304
Velocity of Flow in Gutter-fps	=	2.293
Depth at Curb Line-Inches--d	=	6.000

ARIZONA DEPARTMENT OF TRANSPORTATION
DRAINAGE DESIGN SECTION

03-10-1999

PROJECT NAME- N/O
HIGHWAY NAME-
LOCATION - CB 14a
Ver 3.40: December 1995

TRACS NO.-
DESIGNER - RSR
CHECKER - JGT
PAGE

GUTTER FLOW HYDRAULICS
GUTTER DESCRIPTION

Roadway Grade-% Per cent--G	=	0.150
Roadway Cross-Slope-Ft./Ft.--Sx	=	0.041
Shoulder Width-Ft.--	=	10.000
Shoulder Slope-Ft./Ft.--Ss	=	0.041
Gutter Width-Ft.--W	=	1.420
Gutter Slope-Ft./Ft.--Sw	=	0.058
Gutter Depression-Inches--	=	0.988
Manning's 'N	=	0.016
Flow-CFS--Q	=	1.190
SPREAD-Ft.--T	=	6.914
Average Velocity-V-fps	=	1.193
FLOW in Gutter-CFS--Q	=	0.569
% Flow in Gutter-CFS	=	47.805
Velocity of Flow in Gutter-fps	=	1.504
Depth at Curb Line-Inches--d	=	3.692

ARIZONA DEPARTMENT OF TRANSPORTATION
DRAINAGE DESIGN SECTION

03-10-1999

PROJECT NAME- N/O
HIGHWAY NAME-
LOCATION - CB 14b
Ver 3.40: December 1995

TRACS NO.-
DESIGNER - RSR
CHECKER - JGT
PAGE

GUTTER FLOW HYDRAULICS
GUTTER DESCRIPTION

Roadway Grade-% Per cent--G	=	0.180
Roadway Cross-Slope-Ft./Ft.--Sx	=	0.049
Shoulder Width-Ft.--	=	10.000
Shoulder Slope-Ft./Ft.--Ss	=	0.049
Gutter Width-Ft.--W	=	1.420
Gutter Slope-Ft./Ft.--Sw	=	0.058
Gutter Depression-Inches--	=	0.988
Manning's 'N	=	0.016
Flow-CFS--Q	=	2.000
SPREAD-Ft.--T	=	7.324
Average Velocity-V-fps	=	1.512
FLOW in Gutter-CFS--Q	=	0.891
% Flow in Gutter-CFS	=	44.537
Velocity of Flow in Gutter-fps	=	1.898
Depth at Curb Line-Inches--d	=	4.460

ARIZONA DEPARTMENT OF TRANSPORTATION
DRAINAGE DESIGN SECTION

11-17-1998

PROJECT NAME- N/O
HIGHWAY NAME-
LOCATION - CB 15A Sta 93+91
Ver 3.40: December 1995

TRACS NO.-
DESIGNER - JPM
CHECKER - JGT
PAGE

GUTTER FLOW HYDRAULICS
GUTTER DESCRIPTION

Roadway Grade-% Per cent--G	=	0.970
Roadway Cross-Slope-Ft./Ft.--Sx	=	0.042
Shoulder Width-Ft.--	=	10.000
Shoulder Slope-Ft./Ft.--Ss	=	0.042
Gutter Width-Ft.--W	=	1.420
Gutter Slope-Ft./Ft.--Sw	=	0.058
Gutter Depression-Inches--	=	0.988
Manning's 'N	=	0.016
Flow-CFS--Q	=	11.567 ← Capacity Top of Curb
SPREAD-Ft.--T	=	11.364
Average Velocity-V-fps	=	4.240
FLOW in Gutter-CFS--Q	=	3.568
% Flow in Gutter-CFS	=	30.847
Velocity of Flow in Gutter-fps	=	5.477
Depth at Curb Line-Inches--d	=	6.000

ARIZONA DEPARTMENT OF TRANSPORTATION
DRAINAGE DESIGN SECTION

01-13-1999

PROJECT NAME- N/O Pr. II
HIGHWAY NAME-
LOCATION - Sta 94+10 CB 15d
Ver 3.40: December 1995

TRACS NO.-
DESIGNER - JPM
CHECKER - JGT
PAGE

GUTTER FLOW HYDRAULICS
GUTTER DESCRIPTION

Roadway Grade-% Per cent--G	=	0.350
Roadway Cross-Slope-Ft./Ft.--Sx	=	0.019
Shoulder Width-Ft.--	=	10.000
Shoulder Slope-Ft./Ft.--Ss	=	0.019
Gutter Width-Ft.--W	=	1.420
Gutter Slope-Ft./Ft.--Sw	=	0.058
Gutter Depression-Inches--	=	0.988
Manning's 'N	=	0.016
Flow-CFS--Q	=	2.000
SPREAD-Ft.--T	=	11.449
Average Velocity-V-fps	=	1.557
FLOW in Gutter-CFS--Q	=	0.690
% Flow in Gutter-CFS	=	34.479
Velocity of Flow in Gutter-fps	=	2.096
Depth at Curb Line-Inches--d	=	3.275

ARIZONA DEPARTMENT OF TRANSPORTATION
DRAINAGE DESIGN SECTION

11-17-1998

PROJECT NAME- N/O Phase C
HIGHWAY NAME-
LOCATION - CB 15B Sta 94+22
Ver 3.40: December 1995

TRACS NO.-
DESIGNER - JPM
CHECKER - JGT
PAGE

GUTTER FLOW HYDRAULICS
GUTTER DESCRIPTION

Roadway Grade-% Per cent--G	=	0.370
Roadway Cross-Slope-Ft./Ft.--Sx	=	0.034
Shoulder Width-Ft.--	=	10.000
Shoulder Slope-Ft./Ft.--Ss	=	0.034 /.024
Gutter Width-Ft.--W	=	1.420
Gutter Slope-Ft./Ft.--Sw	=	0.058
Gutter Depression-Inches--	=	0.988
Manning's 'N	=	0.016
Flow-CFS--Q	=	8.306
SPREAD-Ft.--T	=	13.704
Average Velocity-V-fps	=	2.582
FLOW in Gutter-CFS--Q	=	2.204
% Flow in Gutter-CFS	=	26.530
Velocity of Flow in Gutter-fps	=	3.382
Depth at Curb Line-Inches--d	=	6.000

ARIZONA DEPARTMENT OF TRANSPORTATION
DRAINAGE DESIGN SECTION

03-04-1999

PROJECT NAME- N/O
HIGHWAY NAME-
LOCATION - CB15C Sta 100+10
Ver 3.40: December 1995

TRACS NO.-
DESIGNER - JM
CHECKER - JMT
PAGE

GUTTER FLOW HYDRAULICS
GUTTER DESCRIPTION

Roadway Grade-% Per cent--G	=	0.340
Roadway Cross-Slope-Ft./Ft.--Sx	=	0.015
Shoulder Width-Ft.--	=	10.000
Shoulder Slope-Ft./Ft.--Ss	=	0.015
Gutter Width-Ft.--W	=	1.420
Gutter Slope-Ft./Ft.--Sw	=	0.058
Gutter Depression-Inches--	=	0.988
Manning's 'N	=	0.016
Flow-CFS--Q	=	7.780
SPREAD-Ft.--T	=	22.580
Average Velocity-V-fps	=	2.012
FLOW in Gutter-CFS--Q	=	1.402
% Flow in Gutter-CFS	=	18.022
Velocity of Flow in Gutter-fps	=	2.754
Depth at Curb Line-Inches--d	=	4.797

ARIZONA DEPARTMENT OF TRANSPORTATION
DRAINAGE DESIGN SECTION

01-13-1999

PROJECT NAME- N/O Ph II C
HIGHWAY NAME-
LOCATION - Sta 100+22 CB 15e
Ver 3.40: December 1995

TRACS NO.-
DESIGNER - JPM
CHECKER - JGT
PAGE

GUTTER FLOW HYDRAULICS
GUTTER DESCRIPTION

Roadway Grade-% Per cent--G	=	0.270
Roadway Cross-Slope-Ft./Ft.--Sx	=	0.010
Shoulder Width-Ft.--	=	10.000
Shoulder Slope-Ft./Ft.--Ss	=	0.010
Gutter Width-Ft.--W	=	1.420
Gutter Slope-Ft./Ft.--Sw	=	0.058
Gutter Depression-Inches--	=	0.988
Manning's 'N	=	0.016
Flow-CFS--Q	=	2.000
SPREAD-Ft.--T	=	17.958
Average Velocity-V-fps	=	1.204
FLOW in Gutter-CFS--Q	=	0.501
% Flow in Gutter-CFS	=	25.039
Velocity of Flow in Gutter-fps	=	1.707
Depth at Curb Line-Inches--d	=	2.973

Worksheet
Worksheet for Irregular Channel

Project Description	
Project File	w:\1994pr~1\94153-~1\phasei~3\spread~1\71stave.fm2
Worksheet	71stAve Half
Flow Element	Irregular Channel
Method	Manning's Formula
Solve For	Discharge

Input Data		
Channel Slope	0.001900	ft/ft
Water Surface Elevation	1127.16	ft

Elevation range: 1126.63 ft to 1127.21 ft.

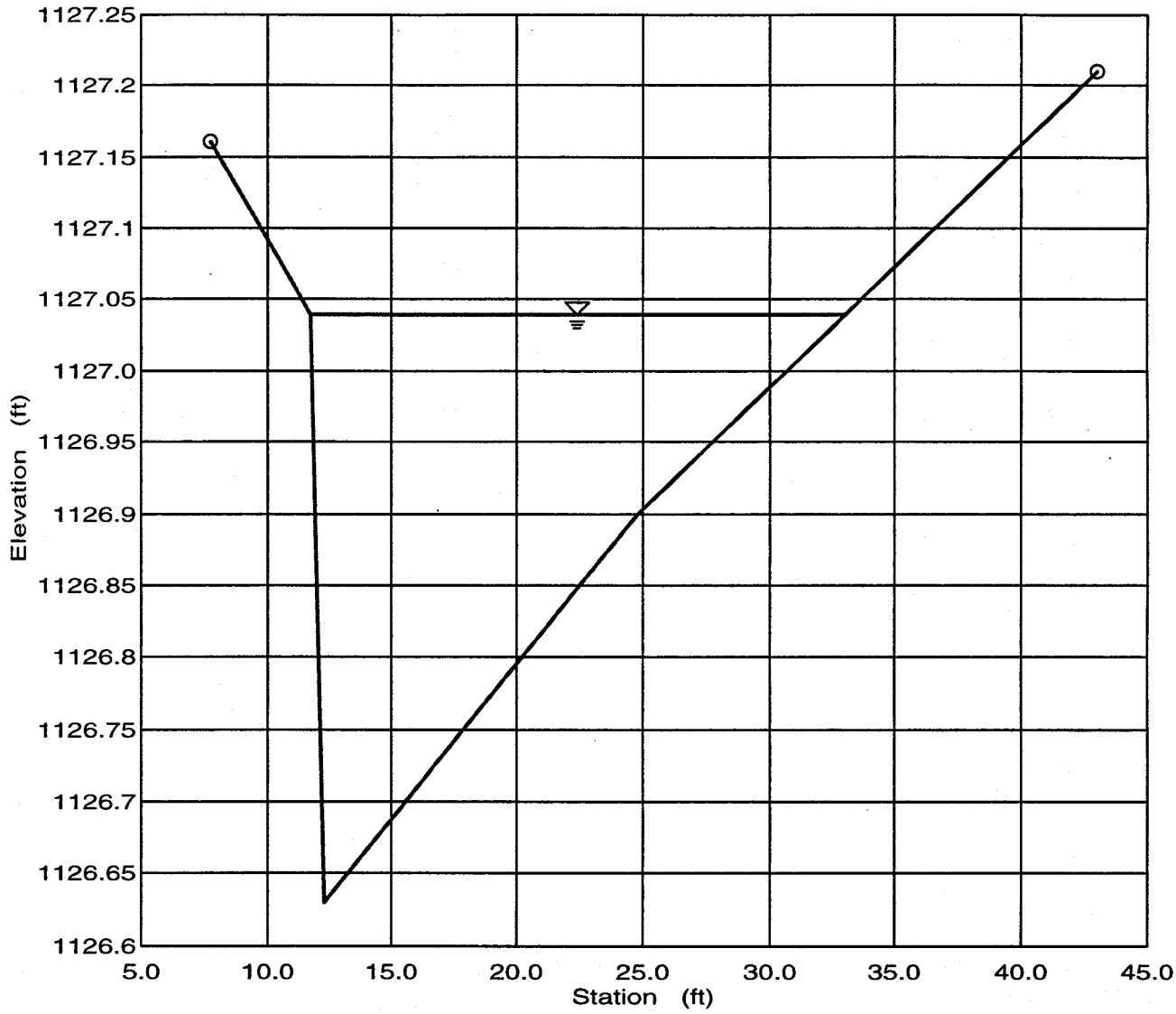
Station (ft)	Elevation (ft)	Start Station	End Station	Roughness
7.77	1127.16	7.77	43.03	0.018
11.76	1127.04			
12.31	1126.63			
24.80	1126.90			
43.03	1127.21			

Results		
Wtd. Mannings Coefficient	0.018	
Discharge	9.80	ft^3/s
Flow Area	7.34	ft^2
Wetted Perimeter	32.46	ft
Top Width	32.32	ft
Depth	0.53	ft
Critical Water Elev.	1127.03	ft
Critical Slope	0.008279	ft/ft
Velocity	1.34	ft/s
Velocity Head	0.03	ft
Specific Energy	1127.19	ft
Froude Number	0.49	
Full Flow Capacity	13.05	ft^3/s
Flow is subcritical.		

Cross Section
Cross Section for Irregular Channel

Project Description	
Project File	w:\1994pr~1\94153-~1\phasei~3\spread~1\71stave.fm2
Worksheet	71stAve Half
Flow Element	Irregular Channel
Method	Manning's Formula
Solve For	Discharge

Section Data		
Wtd. Mannings Coefficient	0.018	
Channel Slope	0.001900	ft/ft
Water Surface Elevation	1127.04	ft
Discharge	4.95	ft^3/s



Worksheet
Worksheet for Irregular Channel

Project Description	
Project File	w:\1994pr~1\94153--~1\phasei~3\spread~1\71stave.fm2
Worksheet	Cross Section for Irregular Channel
Flow Element	Irregular Channel
Method	Manning's Formula
Solve For	Water Elevation

Input Data

Channel Slope 0.001900 ft/ft

Elevation range: 1125.61 ft to 1127.77 ft.

Station (ft)	Elevation (ft)	Start Station	End Station	Roughness
0.00	1126.98	0.00	43.03	0.018
7.77	1127.16	43.03	54.83	0.035
11.76	1127.16			
12.31	1126.63			
24.80	1126.90			
43.03	1127.21			
46.91	1127.30			
50.07	1125.61			
54.83	1127.77			

Discharge 50.00 ft^3/s

Results

Wtd. Mannings Coefficient	0.021	
Water Surface Elevation	1127.43	ft
Flow Area	26.62	ft^2
Wetted Perimeter	55.56	ft
Top Width	54.08	ft
Depth	1.82	ft
Critical Water Elev.	1127.22	ft
Critical Slope	0.009799	ft/ft
Velocity	1.88	ft/s
Velocity Head	0.05	ft
Specific Energy	1127.48	ft
Froude Number	0.47	
Full Flow Capacity	122.00	ft^3/s

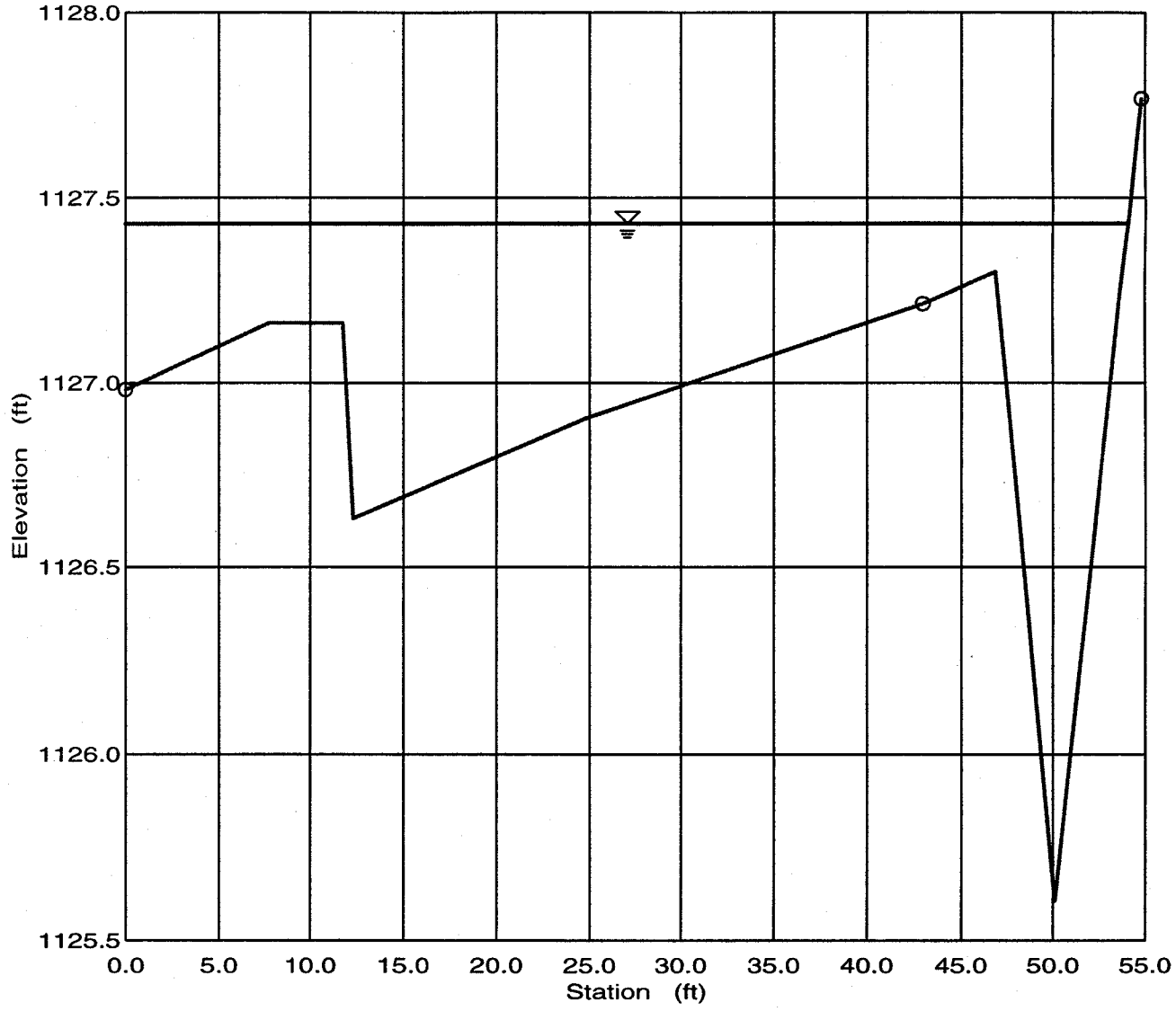
Flow is subcritical.

Water elevation exceeds lowest end station by 0.45 ft.

Cross Section
Cross Section for Irregular Channel

Project Description	
Project File	w:\1994pr~1\94153-~1\phasei~3\spread~1\71stave.fm2
Worksheet	Cross Section for Irregular Channel
Flow Element	Irregular Channel
Method	Manning's Formula
Solve For	Water Elevation

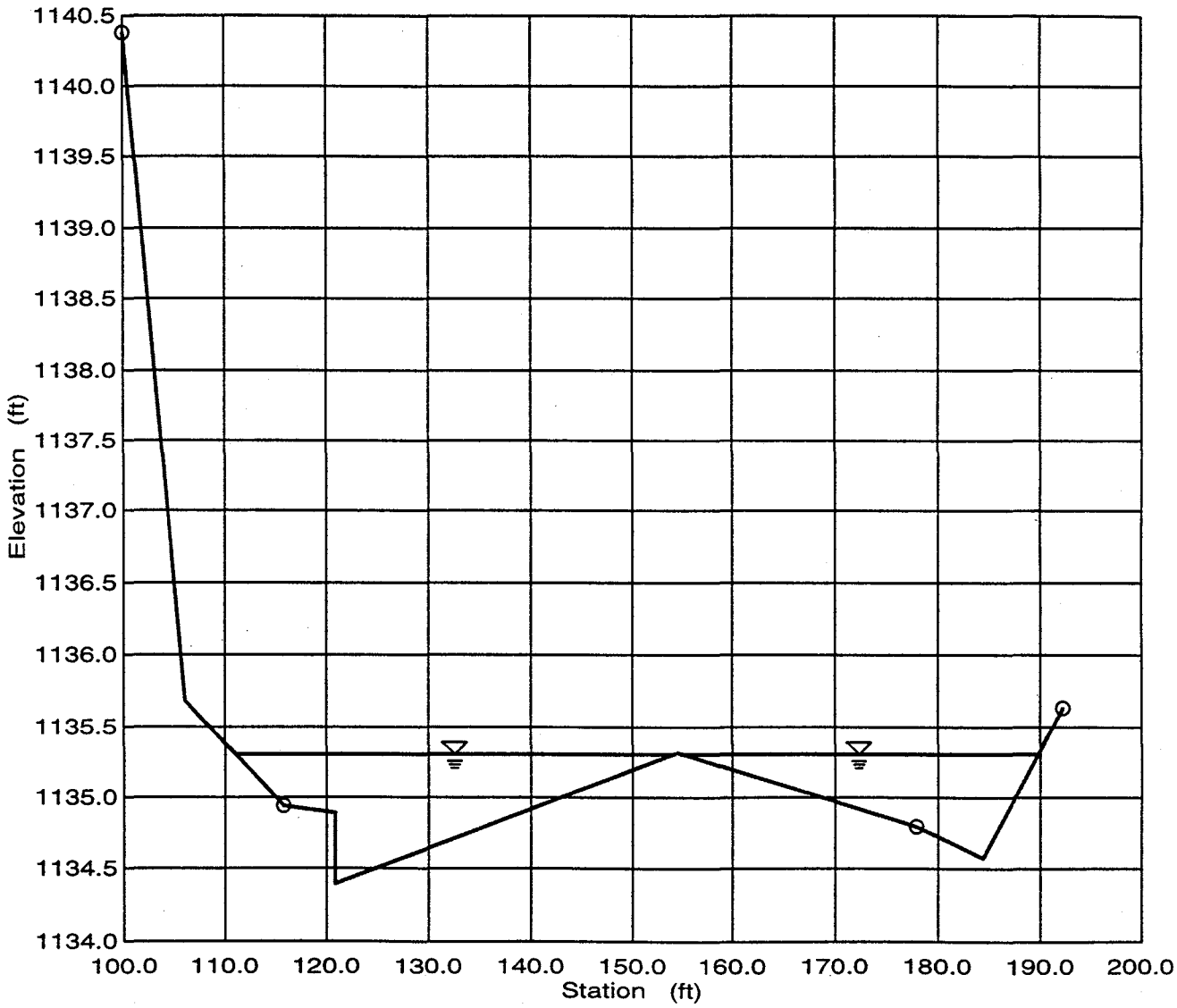
Section Data		
Wtd. Mannings Coefficient	0.021	
Channel Slope	0.001900	ft/ft
Water Surface Elevation	1127.43	ft
Discharge	50.00	ft³/s



Cross Section
Cross Section for Irregular Channel

Project Description	
Project File	w:\94153-~1\phasei~3\spread~1\67thave.fm2
Worksheet	67th Ave Upstream
Flow Element	Irregular Channel
Method	Manning's Formula
Solve For	Water Elevation

Section Data		
Wtd. Mannings Coefficient	0.018	
Channel Slope	0.001300	ft/ft
Water Surface Elevation	1135.30	ft
Discharge	47.00	ft³/s



Worksheet
Worksheet for Irregular Channel

Project Description	
Project File	w:\1994pr~1\94153-~1\phasei~3\spread~1\67thave.fm2
Worksheet	67 th Ave C+G Half
Flow Element	Irregular Channel
Method	Manning's Formula
Solve For	Discharge

Input Data		
Channel Slope	0.001300	ft/ft
Water Surface Elevation	1134.82	ft

Elevation range: 1134.32 ft to 1135.24 ft.

Station (ft)	Elevation (ft)	Start Station	End Station	Roughness
84.00	1135.11	84.00	100.00	0.030
100.00	1134.82	100.00	132.99	0.016
100.01	1134.32			
132.99	1135.24			

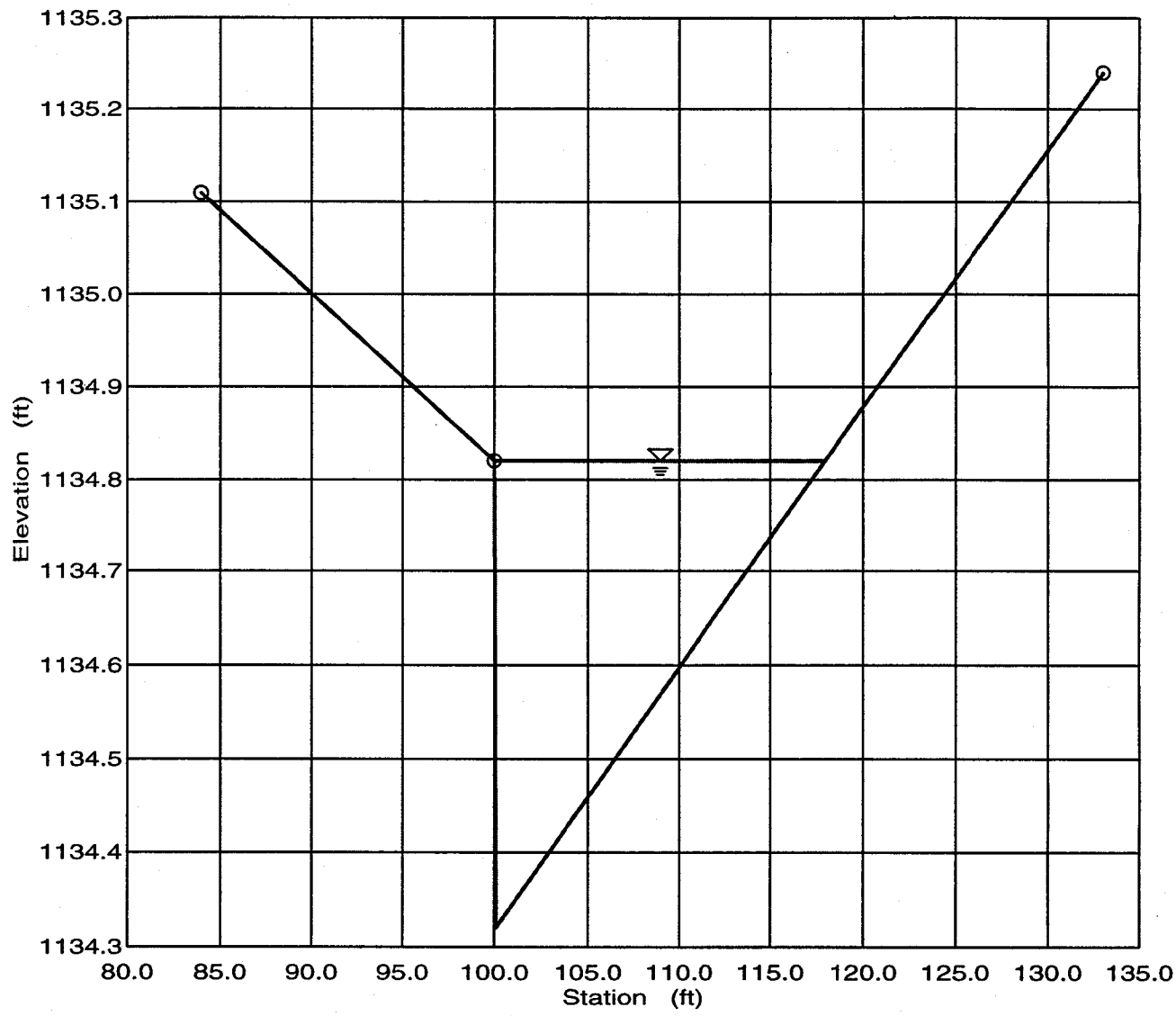
Results		
Wtd. Mannings Coefficient	0.016	
Discharge	5.85	ft^3/s
Flow Area	4.48	ft^2
Wetted Perimeter	18.43	ft
Top Width	17.93	ft
Depth	0.50	ft
Critical Water Elev.	1134.69	ft
Critical Slope	0.006812	ft/ft
Velocity	1.30	ft/s
Velocity Head	0.03	ft
Specific Energy	1134.85	ft
Froude Number	0.46	
Full Flow Capacity	33.29	ft^3/s

Flow is subcritical.

67th Ave
Cross Section for Irregular Channel

Project Description	
Project File	w:\1994pr~1\94153--~1\phasei~3\spread~1\67thave.fm2
Worksheet	67 th Ave C+G Half
Flow Element	Irregular Channel
Method	Manning's Formula
Solve For	Discharge

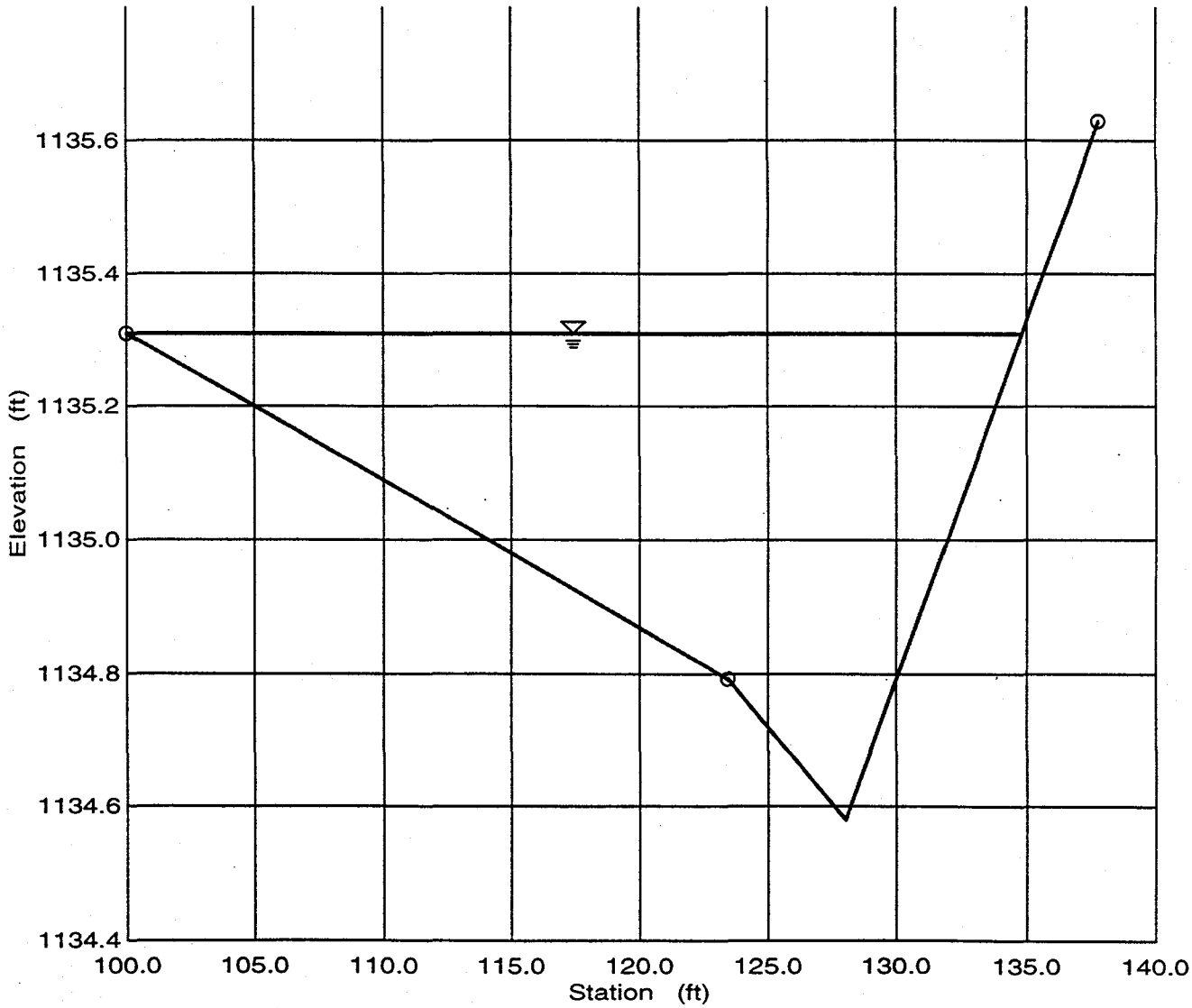
Section Data		
Wtd. Mannings Coefficient	0.016	
Channel Slope	0.001300	ft/ft
Water Surface Elevation	1134.82	ft
Discharge	5.85	ft^3/s



Cross Section
Cross Section for Irregular Channel

Project Description	
Project File	w:\94153-~1\phasei~3\spread~1\67thave.fm2
Worksheet	67th upstream half street
Flow Element	Irregular Channel
Method	Manning's Formula
Solve For	Discharge

Section Data		
Wtd. Mannings Coefficient	0.021	
Channel Slope	0.001300	ft/ft
Water Surface Elevation	1135.31	ft
Discharge	14.06	ft^3/s



ARIZONA DEPARTMENT OF TRANSPORTATION
DRAINAGE DESIGN SECTION

03-04-1999

PROJECT NAME- N/O Phas C CB 16a
HIGHWAY NAME-
LOCATION - Sta 106+14.16
Ver 3.40: December 1995

TRACS NO.-
DESIGNER - JPM
CHECKER - JGT
PAGE

GUTTER FLOW HYDRAULICS
GUTTER DESCRIPTION

Roadway Grade-% Per cent--G	=	0.470
Roadway Cross-Slope-Ft./Ft.--Sx	=	0.011
Shoulder Width-Ft.--	=	10.000
Shoulder Slope-Ft./Ft.--Ss	=	0.011
Gutter Width-Ft.--W	=	1.420
Gutter Slope-Ft./Ft.--Sw	=	0.058
Gutter Depression-Inches--	=	0.988
Manning's 'N	=	0.016
Flow-CFS--Q	=	8.200
SPREAD-Ft.--T	=	26.281
Average Velocity-V-fps	=	2.132
FLOW in Gutter-CFS--Q	=	1.327
% Flow in Gutter-CFS	=	16.181
Velocity of Flow in Gutter-fps	=	2.970
Depth at Curb Line-Inches--d	=	4.270

ARIZONA DEPARTMENT OF TRANSPORTATION
DRAINAGE DESIGN SECTION

11-19-1998

PROJECT NAME- NB Phase C CB16 TRACS NO.-
HIGHWAY NAME- DESIGNER - Joel M.
LOCATION - Sta 106+61, Lt CHECKER - JGT PAGE
Ver 3.40: December 1995

GUTTER FLOW HYDRAULICS
GUTTER DESCRIPTION

Roadway Grade-% Per cent--G	=	0.130
Roadway Cross-Slope-Ft./Ft.--Sx	=	0.028
Shoulder Width-Ft.--	=	10.000
Shoulder Slope-Ft./Ft.--Ss	=	0.028
Gutter Width-Ft.--W	=	1.420
Gutter Slope-Ft./Ft.--Sw	=	0.058
Gutter Depression-Inches--	=	0.988
Manning's 'N	=	0.016
Flow-CFS--Q	=	33.000
SPREAD-Ft.--T	=	31.718
Average Velocity-V-fps	=	2.338
FLOW in Gutter-CFS--Q	=	3.933
% Flow in Gutter-CFS	=	11.918
Velocity of Flow in Gutter-fps	=	3.114
Depth at Curb Line-Inches--d	=	11.168

ARIZONA DEPARTMENT OF TRANSPORTATION
DRAINAGE DESIGN SECTION

03-05-1999

PROJECT NAME- N/O Phase C
HIGHWAY NAME-
LOCATION - EB 24 Sta 12+36
Ver 3.40: December 1995

TRACS NO.-
DESIGNER - Joel M.
CHECKER - JGT
PAGE

GUTTER FLOW HYDRAULICS
GUTTER DESCRIPTION

Roadway Grade-% Per cent--G	=	0.057
Roadway Cross-Slope-Ft./Ft.--Sx	=	0.015
Shoulder Width-Ft.--	=	10.000
Shoulder Slope-Ft./Ft.--Ss	=	0.015
Gutter Width-Ft.--W	=	1.420
Gutter Slope-Ft./Ft.--Sw	=	0.058
Gutter Depression-Inches--	=	0.988
Manning's 'N	=	0.016
Flow-CFS--Q	=	6.294
SPREAD-Ft.--T	=	29.263
Average Velocity-V-fps	=	0.973
FLOW in Gutter-CFS--Q	=	0.865
% Flow in Gutter-CFS	=	13.742
Velocity of Flow in Gutter-fps	=	1.328
Depth at Curb Line-Inches--d	=	6.000

ARIZONA DEPARTMENT OF TRANSPORTATION
DRAINAGE DESIGN SECTION

11-25-1998

PROJECT NAME- N/O Phase C
HIGHWAY NAME-
LOCATION - CB 25 Sta 13+62
Ver 3.40: December 1995

TRACS NO.-
DESIGNER - Joel M.
CHECKER - JGT
PAGE

GUTTER FLOW HYDRAULICS
GUTTER DESCRIPTION

Roadway Grade-% Per cent--G	=	0.210
Roadway Cross-Slope-Ft./Ft.--Sx	=	0.016
Shoulder Width-Ft.--	=	10.000
Shoulder Slope-Ft./Ft.--Ss	=	0.016
Gutter Width-Ft.--W	=	1.420
Gutter Slope-Ft./Ft.--Sw	=	0.058
Gutter Depression-Inches--	=	0.988
Manning's 'N	=	0.016
Flow-CFS--Q	=	11.430 ← Capacity Top of Curb
SPREAD-Ft.--T	=	27.522
Average Velocity-V-fps	=	1.873
FLOW in Gutter-CFS--Q	=	1.660
% Flow in Gutter-CFS	=	14.525
Velocity of Flow in Gutter-fps	=	2.548
Depth at Curb Line-Inches--d	=	6.000

ARIZONA DEPARTMENT OF TRANSPORTATION
DRAINAGE DESIGN SECTION

03-24-1999

PROJECT NAME- N/O Ph II C
HIGHWAY NAME-
LOCATION - Sta 14+20 25a
Ver 3.40: December 1995

TRACS NO.-
DESIGNER - JPM
CHECKER - JGT
PAGE

CURB OPENING INLET--IN SUMP

GUTTER FLOW HYDRAULICS

GUTTER DESCRIPTION

Roadway Cross-Slope-Ft./Ft.--Sx	=	0.020
Shoulder Width-Ft.--	=	10.000
Shoulder Slope-Ft./Ft.--Ss	=	0.020
Gutter Width-Ft.--W	=	1.420
Gutter Slope-Ft./Ft.--Sw	=	0.058
Gutter Depression-Inches--	=	0.988
Flow-CFS--Q	=	7.810
Local Gutter Depression-Inches	=	1.000
Capture Ratio -- CURB OPENING	=	0.800

LENGTH	d(weir)	d(orifice)	d(INLET)	SPREAD
3.083	9.930	20.306	20.306	77.745
6.583	7.197	6.613	7.197	23.122
9.583	5.956	3.631	5.956	17.952
13.583	4.926	1.807	4.926	13.660
20.583	3.874	0.787	3.874	9.278

*** d(INLET) is Greater of WEIR or ORIFICE Depth.! ***

ARIZONA DEPARTMENT OF TRANSPORTATION
DRAINAGE DESIGN SECTION

03-24-1999

PROJECT NAME- N/O Ph II C
HIGHWAY NAME-
LOCATION - Sta 14+20 25 6
Ver 3.40: December 1995

TRACS NO.-
DESIGNER - JPM
CHECKER - JGT
PAGE

CURB OPENING INLET--IN SUMP

GUTTER FLOW HYDRAULICS

GUTTER DESCRIPTION

Roadway Cross-Slope-Ft./Ft.--Sx	=	0.020
Shoulder Width-Ft.--	=	10.000
Shoulder Slope-Ft./Ft.--Ss	=	0.020
Gutter Width-Ft.--W	=	1.420
Gutter Slope-Ft./Ft.--Sw	=	0.058
Gutter Depression-Inches--	=	0.988
Flow-CFS--Q	=	9.080
Local Gutter Depression-Inches	=	1.000
Capture Ratio -- CURB OPENING	=	0.800

LENGTH	d(weir)	d(orifice)	d(INLET)	SPREAD
3.083	10.979	26.475	26.475	103.447
6.583	7.957	7.966	7.966	26.328
9.583	6.585	4.908	6.585	20.574
13.583	5.446	2.443	5.446	15.829
20.583	4.283	1.064	4.283	10.983

*** d(INLET) is Greater of WEIR or ORIFICE Depth.! ***

ARIZONA DEPARTMENT OF TRANSPORTATION
DRAINAGE DESIGN SECTION

03-24-1999

PROJECT NAME- N/O Ph II C
HIGHWAY NAME-
LOCATION - Sta 22+25 CB26a
Ver 3.40: December 1995

TRACS NO.-
DESIGNER - JPM
CHECKER - JGT
PAGE

GUTTER FLOW HYDRAULICS
GUTTER DESCRIPTION

Roadway Grade-% Per cent--G	=	0.290
Roadway Cross-Slope-Ft./Ft.--Sx	=	0.020
Shoulder Width-Ft.--	=	10.000
Shoulder Slope-Ft./Ft.--Ss	=	0.020
Gutter Width-Ft.--W	=	1.420
Gutter Slope-Ft./Ft.--Sw	=	0.058
Gutter Depression-Inches--	=	0.988
Manning's 'N	=	0.016
Flow-CFS--Q	=	10.580
SPREAD-Ft.--T	=	21.872
Average Velocity-V-fps	=	2.194
FLOW in Gutter-CFS--Q	=	1.891
% Flow in Gutter-CFS	=	17.869
Velocity of Flow in Gutter-fps	=	2.957
Depth at Curb Line-Inches--d	=	5.897

ARIZONA DEPARTMENT OF TRANSPORTATION
DRAINAGE DESIGN SECTION

03-24-1999

PROJECT NAME- N/O Ph II C
HIGHWAY NAME-
LOCATION -Sta 22+25 CB26B
Ver 3.40: December 1995

TRACS NO.-
DESIGNER - JPM
CHECKER - JGT
PAGE

GUTTER FLOW HYDRAULICS
GUTTER DESCRIPTION

Roadway Grade-% Per cent--G	=	0.290
Roadway Cross-Slope-Ft./Ft.--Sx	=	0.020
Shoulder Width-Ft.--	=	10.000
Shoulder Slope-Ft./Ft.--Ss	=	0.020
Gutter Width-Ft.--W	=	1.420
Gutter Slope-Ft./Ft.--Sw	=	0.058
Gutter Depression-Inches--	=	0.988
Manning's 'N	=	0.016
Flow-CFS--Q	=	12.550
SPREAD-Ft.--T	=	23.338
Average Velocity-V-fps	=	2.288
FLOW in Gutter-CFS--Q	=	2.100
% Flow in Gutter-CFS	=	16.731
Velocity of Flow in Gutter-fps	=	3.084
Depth at Curb Line-Inches--d	=	6.249

ARIZONA DEPARTMENT OF TRANSPORTATION
DRAINAGE DESIGN SECTION

11-25-1998

PROJECT NAME- N/O Phase C
HIGHWAY NAME-
LOCATION - CB 26 & 27
Ver 3.40: December 1995

TRACS NO.-
DESIGNER - JPM
CHECKER - JGT
PAGE

GUTTER FLOW HYDRAULICS
GUTTER DESCRIPTION

Roadway Grade-% Per cent--G	=	0.410
Roadway Cross-Slope-Ft./Ft.--Sx	=	0.019
Shoulder Width-Ft.--	=	10.000
Shoulder Slope-Ft./Ft.--Ss	=	0.019
Gutter Width-Ft.--W	=	1.420
Gutter Slope-Ft./Ft.--Sw	=	0.058
Gutter Depression-Inches--	=	0.988
Manning's 'N	=	0.016
Flow-CFS--Q	=	13.816 ← Flow @ 6" Curb depth
SPREAD-Ft.--T	=	23.401
Average Velocity-V-fps	=	2.636
FLOW in Gutter-CFS--Q	=	2.320
% Flow in Gutter-CFS	=	16.791
Velocity of Flow in Gutter-fps	=	3.561
Depth at Curb Line-Inches--d	=	6.000

Procedure for Calculating The HGL For Straight Catch Basin Connector Pipes From The Mainline Storm Drain to the Catch Basin

---

1. Using the hydraulic calculations for the Mainline Storm Drain, calculate the HGL at Catch basin connector point..

2. Based on top of curb elevation at catch basin, calculate invert of connector pipe and gutter at catch basin.

3. Calculate slope of pipe, pipe diameter and pipe length.

4. Calculate the tailwater based on the HGL-connector pipe outlet invert.

5. Using Dodson pipe program, calculate the headwater required for the pipe to convey this flow.

6. Determine "Control Type" (inlet or outlet)
   Inlet=invert elevation at CB plus inlet HW
   Outlet=invert elevation at connector pipe outlet plus outlet HW
   "Control Type" the larger number of the two.

7. Compare largest number to gutter elevation the minimum difference = 1'.

8. Adjust pipe size, slope and invert as required.

Procedure for Calculating The HGL For Catch Basin Connector Pipes That Dip Under Existing Utilities And Then Connect To The Mainline At The Shallow Slope

---

1. Follow the previous 8 steps for calculating the HGL for straight catch basin connector pipes.

2. The slope used in the calculation was a hypothetical line connecting the invert of the catch basin and the invert at the trunkline.

3. Add the headloss from the submerged pipe to the tailwater. This headloss was added in order to balance the use of a steeper slope in calculation than same sections of the proposed pipe.

Procedure for Calculating The HGL For Catch Basin Connector Pipes which have a Shallow Slope to Clear Existing Utilities and then Drop into Mainline Storm Drain

---

1. Follow the previous 8 steps for calculating the HGL for straight catch basin connector pipes.

2. The shallow pipe slope is hypothetically extended to the mainline and the invert calculated at that point. This elevation is then subtracted from the mainline HGL to determine the tailwater.

Catch Basin Connector Pipe Hydraulics

NORTHERN/ORANGEWOOD STORM DRAIN PROJECT 3/24/99

Glendale Avenue Storm Drain - Glendale Avenue & 83rd Avenue to Northern Avenue

Phase II, Sub-Phase C **W/P # 94153.06**

Flood Control District of Maricopa County

100% Plans

CB #	Lateral / Connector Pipe No.	Q (cfs)	Pipe Dia. (in)	Inlet Invert (ft)	Slope (ft/ft)	Top of Curb (ft)	Gutter / Grate / Ground (ft)	D/S HGL Elev. (ft)	D/S Invert based on Slope (ft)	Submerged Pipe Loss*	Normal / Critical Depth (ft)	Length of Pipe (ft)	Tail Water (ft)	Inlet Control HW (ft)	Outlet Control HW (ft)	Inlet Control HW Elev (ft)	Oulet Control HW Elev (ft)	Controlling HW	Difference (gutter/grate-HW elev) (ft)
1	L1	2	15	1093.69	0.1606	N/A	1096.69	1094.93	1088.07	0.00	0.24	35.00	6.86	0.70	1.34	1094.39	1095.03	Outlet Control	1.66
2	L2	1.74	15	1093.29	0.1581	1098.79	1098.29	1095.00	1088.14	0.00	0.22	32.57	6.86	0.64	1.78	1093.93	1095.07	Outlet Control	3.22
3	L3	1.99	15	1097.00	0.1932	N/A	1102.50	1096.63	1090.72	0.00	0.22	32.50	5.91	0.68	-0.28	1097.68	Not Valid	Inlet Control	4.82
4	L4	2	15	1097.00	0.1817	N/A	1101.00	1096.58	1090.64	0.00	0.23	35.00	5.94	0.69	-0.32	1097.69	Not Valid	Inlet Control	3.31
5	L5	1.92	15	1100.28	0.2234	N/A	1104.78	1098.82	1093.02	0.00	0.21	32.50	5.80	0.65	-1.37	1100.93	Not Valid	Inlet Control	3.85
6	L6	2	15	1099.95	0.2049	N/A	1103.95	1098.65	1092.78	0.00	0.22	35.00	5.87	0.68	-1.2	1100.63	Not Valid	Inlet Control	3.32
N/A	C78	57	42	1092.56	0.0036	N/A	1106.00	1099.89	1092.33	0.00	2.70	63.50	7.56	3.76	8.35	1096.32	1100.91	Outlet Control	5.09
7	L7	28.5	30	1101.16	0.2130	N/A	1105.66	1100.91	1093.27	0.00	0.66	37.04	7.64	2.81	0.71	1103.97	1101.87	Inlet Control	1.69
8	L8	28.5	24	1099.10	0.1917	N/A	1105.64	1100.91	1093.56	0.00	0.73	28.90	7.35	4.42	4.19	1103.52	1103.29	Inlet Control	2.12
8a	L8a	1.99	18	1102.26	0.2580	1107.26	1106.76	1101.71	1095.23	0.00	0.20	27.25	6.48	0.55	-0.51	1102.81	Not Valid	Inlet Control	3.95
N/A	C910	35	42	1105.34	0.1323	N/A	1114.80	1107.46	1098.46	0.00	0.73	52.00	9.00	2.46	2.49	1107.80	1107.83	Outlet Control	6.97
9	L9	2.45	15	1108.79	0.2885	N/A	1112.79	1107.83	1101.39	0.00	0.22	25.65	6.44	0.73	-0.83	1109.52	Not Valid	Inlet Control	3.27
10	L10	32.55	36	1108.56	0.1193	N/A	1113.56	1107.83	1105.06	0.00	0.76	29.33	2.77	2.67	0	1111.23	1108.56	Inlet Control	2.33
N/A	C11	29	36	1105.44	0.1826	N/A	1117.00	1110.26	1100.98	0.00	0.65	24.43	9.28	2.35	5.26	1107.79	1110.70	Outlet Control	6.30
11	L11	29	30	1110.23	0.4145	N/A	1116.09	1110.70	1105.19	0.00	0.56	12.16	5.51	2.61	1.34	1112.84	1111.57	Inlet Control	3.25
12	L12	32.55	30	1115.11	0.4529	N/A	1123.11	1118.97	1106.93	0.00	0.58	18.06	12.04	2.86	5	1117.97	1120.11	Outlet Control	3.00
13a	L13a	1.74	18	1122.52	0.4140	1126.52	1126.02	1122.80	1118.96	0.00	0.17	8.60	3.84	0.38	0.3	1122.90	1122.82	Inlet Control	3.12
14	L14	50	42	1120.03	0.0813	N/A	1126.53	1123.53	1114.70	0.00	0.99	65.60	8.83	3.28	4.29	1123.31	1124.32	Outlet Control	2.21
14-1	L14a	41.9	42	1120.55	0.0008	N/A	1127.50	1124.32	1120.53	0.00	3.50	23.70	3.79	3.03	4.25	1123.58	1124.80	Outlet Control	2.70
13	L13	8.1	24	1122.09	0.0218	1127.09	1126.59	1124.80	1121.35	0.00	0.67	34.00	3.45	1.46	2.91	1123.55	1125.00	Outlet Control	1.59
14a	L14a	2.25	18	1121.75	0.1665	1127.25	1126.75	1123.53	1109.53	0.00	0.18	73.40	14.00	0.45	1.8	1122.20	1123.55	Outlet Control	3.20
14b	L14b	1.98	18	1124.71	0.1714	1128.71	1128.21	1126.18	1111.98	0.06	0.22	74.29	14.26	0.67	1.59	1125.38	1126.30	Outlet Control	1.91
N/A	C1515a	37.8	30	1119.28	0.0771	N/A	1130.00	1124.67	1114.98	0.00	0.99	55.80	9.69	3.94	7.25	1123.22	1126.53	Outlet Control	3.47
15	L15	18.85	24	1123.23	0.4138	N/A	1129.23	1123.88	1117.71	0.00	0.49	13.34	6.17	2.36	1.58	1125.59	1124.81	Inlet Control	3.64
15a	L15a	17.81	24	1123.40	0.0065	1130.71	1130.21	1126.53	1123.10	0.00	1.60	46.10	3.43	2.61	4.16	1126.01	1127.56	Outlet Control	2.65
15b	L15b	22.05	30	1123.89	0.4141	1130.74	1130.24	1124.97	1116.13	0.00	0.49	18.74	8.84	1.96	1.6	1125.85	1125.49	Inlet Control	4.39
15d	L15d	1.8	18	1124.54	0.1787	1130.97	1130.47	1124.87	1121.08	0.00	0.21	19.36	3.79	0.57	0.36	1125.11	1124.90	Inlet Control	5.36
15c	L15c	4.09	18	1126.00	0.4129	1132.25	1131.75	1126.61	1118.32	0.00	0.25	18.60	8.29	0.82	0.76	1126.82	1126.76	Inlet Control	4.93
15e	L15e	1.96	18	1128.17	0.3497	1132.17	1131.67	1126.64	1121.42	0.00	0.18	19.30	5.22	0.47	-1.49	1128.64	Not Valid	Inlet Control	3.03
16a	L16a	4.44	18	1128.78	0.1244	1134.78	1134.28	1128.36	1125.60	0.00	0.35	25.56	2.76	1.10	-0.23	1129.88	Not Valid	Inlet Control	4.40
N/A	C1617	41.1	42	1119.01	0.0100	N/A	1135.00	1126.29	1118.26	0.00	1.56	74.90	8.03	2.97	7.83	1121.98	1126.84	Outlet Control	8.16
16	L16a	5.61	18	1129.29	0.3077	1134.79	1134.29	1126.84	1120.46	0.00	0.31	28.70	6.38	1.17	-2.13	1130.46	Not Valid	Inlet Control	3.83
17	L17	14	24	1130.50	0.2681	1134.50	1134.00	1126.84	1122.89	0.00	0.47	28.38	3.95	1.87	-3.09	1132.37	Not Valid	Inlet Control	1.63
17a	L17a	21.7	30	1130.36	0.1934	N/A	1134.36	1127.31	1126.25	0.00	0.59	21.25	1.06	2.21	0	1132.57	1130.36	Inlet Control	1.79
N/A	C1819	8	36	1119.20	0.0029	N/A	1136.15	1126.79	1119.00	0.00	0.96	68.00	7.79	1.22	7.63	1120.42	1126.83	Outlet Control	9.32
18	L18	4	15	1131.84	0.2142	N/A	1135.84	1126.83	1127.08	0.00	0.31	22.22	-0.25	1.13	0	1132.97	1131.84	Inlet Control	2.87
19	L19	4	15	1128.92	0.4057	N/A	1135.92	1126.83	1120.60	0.00	0.26	20.51	6.23	1.01	-1.76	1129.93	Not Valid	Inlet Control	5.99
24	L24	6.13	18	1136.56	0.0085	1142.47	1141.97	1140.31	1136.34	0.00	0.86	25.75	3.97	1.48	4.12	1138.04	1140.68	Outlet Control	1.29
25	L25	9.53	24	1138.28	0.0501	1142.78	1142.28	1140.46	1136.31	0.00	0.59	39.35	4.15	1.59	2.46	1139.87	1140.74	Outlet Control	1.54

* Submerged Pipe Loss was calculated using the following equation: 10.14(n^2)(L)(Q^2)/D^5.33

Where: n=.013, L=Pipe Length(ft), Q=Flow(cfs), D=Pipe Diameter(ft)

PIPE CULVERT ANALYSIS
COMPUTATION OF CULVERT PERFORMANCE CURVE

March 19, 1999

Pipe 1 Sta 16+15 83rd Ave.

==========

PROGRAM INPUT DATA

DESCRIPTION	VALUE
Culvert Diameter (ft)	1.25
FHWA Chart Number	1
FHWA Scale Number (Type of Culvert Entrance)	1
Manning's Roughness Coefficient (n-value)	0.013
Entrance Loss Coefficient of Culvert Opening	0.5
Culvert Length (ft)	35.0
Invert Elevation at Downstream end of Culvert (ft)	1,088.07
Invert Elevation at Upstream end of Culvert (ft)	1,093.69
Culvert Slope (ft/ft)	0.1606
Starting Flow Rate (cfs)	2.0
Incremental Flow Rate (cfs)	0.0
Ending Flow Rate (cfs)	2.0
Starting Tailwater Depth (ft)	6.86
Incremental Tailwater Depth (ft)	0.0
Ending Tailwater Depth (ft)	6.86

==========

COMPUTATION RESULTS

Flow Rate (cfs)	Tailwater Depth (ft)	Headwater (ft) Inlet Control	Headwater (ft) Outlet Control	Normal Depth (ft)	Critical Depth (ft)	Depth at Outlet (ft)	Outlet Velocity (fps)
2.0	6.86	0.7	1.34	0.24	0.56	1.25	1.63

==========

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TRUNK HGL = 1094.93

LAT INVERT = 1088.07

TW = 6.86

AHW = 1096.69

OHW = 1095.03

PIPE CULVERT ANALYSIS
COMPUTATION OF CULVERT PERFORMANCE CURVE

March 17, 1999
Pipe 2 Sta 16+38 83rd Ave

PROGRAM INPUT DATA

DESCRIPTION	VALUE
Culvert Diameter (ft)	1.25
FHWA Chart Number	1
FHWA Scale Number (Type of Culvert Entrance)	1
Manning's Roughness Coefficient (n-value)	0.013
Entrance Loss Coefficient of Culvert Opening	0.5
Culvert Length (ft)	32.57
Invert Elevation at Downstream end of Culvert (ft)	88.14
Invert Elevation at Upstream end of Culvert (ft)	93.29
Culvert Slope (ft/ft)	0.1581
Starting Flow Rate (cfs)	1.74
Incremental Flow Rate (cfs)	0.0
Ending Flow Rate (cfs)	1.74
Starting Tailwater Depth (ft)	6.86
Incremental Tailwater Depth (ft)	0.0
Ending Tailwater Depth (ft)	6.86

COMPUTATION RESULTS

Flow Rate (cfs)	Tailwater Depth (ft)	Headwater (ft) Inlet Control	Headwater (ft) Outlet Control	Normal Depth (ft)	Critical Depth (ft)	Depth at Outlet (ft)	Outlet Velocity (fps)
1.74	6.86	0.64	1.78	0.22	0.52	1.25	1.42

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TRUNK HGL = 1095

LAT INVERT = 1088.14

TW = 6.86

AHW = 1097.29

DHW = 1095.07

PIPE CULVERT ANALYSIS
COMPUTATION OF CULVERT PERFORMANCE CURVE

March 16, 1999

Pipe 3 Sta 23+49

PROGRAM INPUT DATA

DESCRIPTION	VALUE
Culvert Diameter (ft)	1.25
FHWA Chart Number	1
FHWA Scale Number (Type of Culvert Entrance)	1
Manning's Roughness Coefficient (n-value)	0.013
Entrance Loss Coefficient of Culvert Opening	0.5
Culvert Length (ft)	32.5
Invert Elevation at Downstream end of Culvert (ft)	90.72
Invert Elevation at Upstream end of Culvert (ft)	97.0
Culvert Slope (ft/ft)	0.1932
Starting Flow Rate (cfs)	1.99
Incremental Flow Rate (cfs)	0.0
Ending Flow Rate (cfs)	1.99
Starting Tailwater Depth (ft)	5.91
Incremental Tailwater Depth (ft)	0.0
Ending Tailwater Depth (ft)	5.91

COMPUTATION RESULTS

Flow Rate (cfs)	Tailwater Depth (ft)	Headwater (ft) Inlet Control	Headwater (ft) Outlet Control	Normal Depth (ft)	Critical Depth (ft)	Depth at Outlet (ft)	Outlet Velocity (fps)
1.99	5.91	0.68	-0.28	0.22	0.56	0.22	13.35

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TRUNK HGL = 1096.63

LAT INVERT = 1090.72

TW = 5.91

AHW = 1101.5

DHW = 1097.68

PIPE CULVERT ANALYSIS
COMPUTATION OF CULVERT PERFORMANCE CURVE

March 16, 1999

Pipe 4 Sta 23+37 83cd

PROGRAM INPUT DATA

DESCRIPTION	VALUE
Culvert Diameter (ft)	1.25
FHWA Chart Number	1
FHWA Scale Number (Type of Culvert Entrance)	1
Manning's Roughness Coefficient (n-value)	0.013
Entrance Loss Coefficient of Culvert Opening	0.5
Culvert Length (ft)	35.0
Invert Elevation at Downstream end of Culvert (ft)	90.64
Invert Elevation at Upstream end of Culvert (ft)	97.0
Culvert Slope (ft/ft)	0.1817
Starting Flow Rate (cfs)	2.0
Incremental Flow Rate (cfs)	0.0
Ending Flow Rate (cfs)	2.0
Starting Tailwater Depth (ft)	5.94
Incremental Tailwater Depth (ft)	0.0
Ending Tailwater Depth (ft)	5.94

COMPUTATION RESULTS

Flow Rate (cfs)	Tailwater Depth (ft)	Headwater (ft) Inlet Control	Headwater (ft) Outlet Control	Normal Depth (ft)	Critical Depth (ft)	Depth at Outlet (ft)	Outlet Velocity (fps)
2.0	5.94	0.69	-0.32	0.23	0.56	0.23	13.03

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TRUNK HGL = 1096.58

LAT INVERT = 1090.64

TW = 5.88

AHW = 1100

DHW = 1097.69

PIPE CULVERT ANALYSIS
COMPUTATION OF CULVERT PERFORMANCE CURVE

March 16, 1999
Pipe 5 Sta 29+64 83d

PROGRAM INPUT DATA

DESCRIPTION	VALUE
Culvert Diameter (ft)	1.25
FHWA Chart Number	1
FHWA Scale Number (Type of Culvert Entrance)	1
Manning's Roughness Coefficient (n-value)	0.013
Entrance Loss Coefficient of Culvert Opening	0.5
Culvert Length (ft)	32.5
Invert Elevation at Downstream end of Culvert (ft)	1,093.02
Invert Elevation at Upstream end of Culvert (ft)	1,100.28
Culvert Slope (ft/ft)	0.2234
Starting Flow Rate (cfs)	1.92
Incremental Flow Rate (cfs)	0.0
Ending Flow Rate (cfs)	1.92
Starting Tailwater Depth (ft)	5.8
Incremental Tailwater Depth (ft)	0.0
Ending Tailwater Depth (ft)	5.8

COMPUTATION RESULTS

Flow Rate (cfs)	Tailwater Depth (ft)	Headwater (ft) Inlet Control	Headwater (ft) Outlet Control	Normal Depth (ft)	Critical Depth (ft)	Depth at Outlet (ft)	Outlet Velocity (fps)
1.92	5.8	0.65	-1.37	0.21	0.55	0.21	13.89

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TRUNK HGL= 1098.82

LAT INVERT = 1093.02

TW= 5.8

AHW= 1103.78

DHW = 1100.93

PIPE CULVERT ANALYSIS
COMPUTATION OF CULVERT PERFORMANCE CURVE

March 16, 1999

Pipe 6 Sta 29+15 83rd Ave

PROGRAM INPUT DATA

DESCRIPTION	VALUE
Culvert Diameter (ft)	1.25
FHWA Chart Number	1
FHWA Scale Number (Type of Culvert Entrance)	1
Manning's Roughness Coefficient (n-value)	0.013
Entrance Loss Coefficient of Culvert Opening	0.5
Culvert Length (ft)	35.0
Invert Elevation at Downstream end of Culvert (ft)	92.78
Invert Elevation at Upstream end of Culvert (ft)	99.95
Culvert Slope (ft/ft)	0.2049
Starting Flow Rate (cfs)	2.0
Incremental Flow Rate (cfs)	0.0
Ending Flow Rate (cfs)	2.0
Starting Tailwater Depth (ft)	5.87
Incremental Tailwater Depth (ft)	0.0
Ending Tailwater Depth (ft)	5.87

COMPUTATION RESULTS

Flow Rate (cfs)	Tailwater Depth (ft)	Headwater (ft) Inlet Control	Headwater (ft) Outlet Control	Normal Depth (ft)	Critical Depth (ft)	Depth at Outlet (ft)	Outlet Velocity (fps)
2.0	5.87	0.68	-1.2	0.22	0.56	0.22	13.61

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TRUNK HGL = 1098.65

LAT INVERT = 1092.78

TW = 5.87

AHW = 1102.95

DHW = 1100.63

PIPE CULVERT ANALYSIS
COMPUTATION OF CULVERT PERFORMANCE CURVE

March 16, 1999
Sta 36+23.5 to 36+87 83rd

PROGRAM INPUT DATA

DESCRIPTION	VALUE
Culvert Diameter (ft)	3.5
FHWA Chart Number	1
FHWA Scale Number (Type of Culvert Entrance)	1
Manning's Roughness Coefficient (n-value)	0.013
Entrance Loss Coefficient of Culvert Opening	0.5
Culvert Length (ft)	63.5
Invert Elevation at Downstream end of Culvert (ft)	92.33
Invert Elevation at Upstream end of Culvert (ft)	92.56
Culvert Slope (ft/ft)	0.0036
Starting Flow Rate (cfs)	57.0
Incremental Flow Rate (cfs)	0.0
Ending Flow Rate (cfs)	57.0
Starting Tailwater Depth (ft)	7.56
Incremental Tailwater Depth (ft)	0.0
Ending Tailwater Depth (ft)	7.56

COMPUTATION RESULTS

Flow Rate (cfs)	Tailwater Depth (ft)	Headwater (ft) Inlet Control	Headwater (ft) Outlet Control	Normal Depth (ft)	Critical Depth (ft)	Depth at Outlet (ft)	Outlet Velocity (fps)
57.0	7.56	3.76	8.35	2.7	2.36	3.5	5.92

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TRUNK HGL = 1099.89

LAT INVERT = 1092.33

TW = 7.56

PIPE CULVERT ANALYSIS
COMPUTATION OF CULVERT PERFORMANCE CURVE

March 16, 1999

Pipe 7 Sta 36+67 83rd

PROGRAM INPUT DATA

DESCRIPTION	VALUE
Culvert Diameter (ft)	2.5
FHWA Chart Number	1
FHWA Scale Number (Type of Culvert Entrance)	1
Manning's Roughness Coefficient (n-value)	0.013
Entrance Loss Coefficient of Culvert Opening	0.5
Culvert Length (ft)	37.04
Invert Elevation at Downstream end of Culvert (ft)	93.27
Invert Elevation at Upstream end of Culvert (ft)	101.16
Culvert Slope (ft/ft)	0.213
Starting Flow Rate (cfs)	28.5
Incremental Flow Rate (cfs)	0.0
Ending Flow Rate (cfs)	28.5
Starting Tailwater Depth (ft)	7.64
Incremental Tailwater Depth (ft)	0.0
Ending Tailwater Depth (ft)	7.64

COMPUTATION RESULTS

Flow Rate (cfs)	Tailwater Depth (ft)	Headwater (ft) Inlet Control	Headwater (ft) Outlet Control	Normal Depth (ft)	Critical Depth (ft)	Depth at Outlet (ft)	Outlet Velocity (fps)
28.5	7.64	2.81	0.71	0.66	1.82	0.66	27.77

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TRUNK HGL = 1100.91

LAT INVERT = 1093.27

TW = 7.64

AHW = 1104.66

DHW = 1103.97

PIPE CULVERT ANALYSIS
COMPUTATION OF CULVERT PERFORMANCE CURVE

March 17, 1999

Pipe 8 Sta 36+75 83cd

PROGRAM INPUT DATA

DESCRIPTION	VALUE
Culvert Diameter (ft)	2.0
FHWA Chart Number	1
FHWA Scale Number (Type of Culvert Entrance)	1
Manning's Roughness Coefficient (n-value)	0.013
Entrance Loss Coefficient of Culvert Opening	0.5
Culvert Length (ft)	28.9
Invert Elevation at Downstream end of Culvert (ft)	1,093.56
Invert Elevation at Upstream end of Culvert (ft)	1,099.1
Culvert Slope (ft/ft)	0.1917
Starting Flow Rate (cfs)	28.5
Incremental Flow Rate (cfs)	0.0
Ending Flow Rate (cfs)	28.5
Starting Tailwater Depth (ft)	7.35
Incremental Tailwater Depth (ft)	0.0
Ending Tailwater Depth (ft)	7.35

COMPUTATION RESULTS

Flow Rate (cfs)	Tailwater Depth (ft)	Headwater (ft) Inlet Control	Headwater (ft) Outlet Control	Normal Depth (ft)	Critical Depth (ft)	Depth at Outlet (ft)	Outlet Velocity (fps)
28.5	7.35	4.42	4.19	0.73	1.84	0.73	27.28

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TRUNK HGL = 1100.91

LAT INVERT = 1093.56

TW = 7.35

AHW = 1104.64

DHW = 1103.52

PIPE CULVERT ANALYSIS
COMPUTATION OF CULVERT PERFORMANCE CURVE

March 16, 1999

Pipe 8A Sta 483 Orangewood

PROGRAM INPUT DATA

DESCRIPTION	VALUE
Culvert Diameter (ft)	1.5
FHWA Chart Number	1
FHWA Scale Number (Type of Culvert Entrance)	1
Manning's Roughness Coefficient (n-value)	0.013
Entrance Loss Coefficient of Culvert Opening	0.5
Culvert Length (ft)	27.25
Invert Elevation at Downstream end of Culvert (ft)	95.23
Invert Elevation at Upstream end of Culvert (ft)	102.26
Culvert Slope (ft/ft)	0.258
Starting Flow Rate (cfs)	1.99
Incremental Flow Rate (cfs)	0.0
Ending Flow Rate (cfs)	1.99
Starting Tailwater Depth (ft)	6.48
Incremental Tailwater Depth (ft)	0.0
Ending Tailwater Depth (ft)	6.48

COMPUTATION RESULTS

Flow Rate (cfs)	Tailwater Depth (ft)	Headwater (ft) Inlet Control	Headwater (ft) Outlet Control	Normal Depth (ft)	Critical Depth (ft)	Depth at Outlet (ft)	Outlet Velocity (fps)
1.99	6.48	0.55	-0.51	0.2	0.53	0.2	14.36

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TRUNK HGL = 1101.71

LAT INVERT = 1095.23

TW = 6.48

AHW = 1105.76

DHW = 1102.81

PIPE CULVERT ANALYSIS
COMPUTATION OF CULVERT PERFORMANCE CURVE

March 17, 1999
Sta 27+54

PROGRAM INPUT DATA

DESCRIPTION	VALUE
Culvert Diameter (ft)	3.5
FHWA Chart Number	1
FHWA Scale Number (Type of Culvert Entrance)	1
Manning's Roughness Coefficient (n-value)	0.013
Entrance Loss Coefficient of Culvert Opening	0.5
Culvert Length (ft)	52.0
Invert Elevation at Downstream end of Culvert (ft)	1,098.46
Invert Elevation at Upstream end of Culvert (ft)	1,105.34
Culvert Slope (ft/ft)	0.1323
Starting Flow Rate (cfs)	35.0
Incremental Flow Rate (cfs)	0.0
Ending Flow Rate (cfs)	35.0
Starting Tailwater Depth (ft)	9.0
Incremental Tailwater Depth (ft)	0.0
Ending Tailwater Depth (ft)	9.0

COMPUTATION RESULTS

Flow Rate (cfs)	Tailwater Depth (ft)	Headwater (ft) Inlet Control	Headwater (ft) Outlet Control	Normal Depth (ft)	Critical Depth (ft)	Depth at Outlet (ft)	Outlet Velocity (fps)
35.0	9.0	2.46	2.49	0.73	1.83	3.5	3.64

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TRUNK HGL = 1107.46
LAT INVERT = 1098.46
TW = 9.0'

PIPE CULVERT ANALYSIS
COMPUTATION OF CULVERT PERFORMANCE CURVE

March 17, 1999

Pipe 9 Sta 27+25 Orangewood

PROGRAM INPUT DATA

DESCRIPTION	VALUE
Culvert Diameter (ft)	1.25
FHWA Chart Number	1
FHWA Scale Number (Type of Culvert Entrance)	1
Manning's Roughness Coefficient (n-value)	0.013
Entrance Loss Coefficient of Culvert Opening	0.5
Culvert Length (ft)	25.65
Invert Elevation at Downstream end of Culvert (ft)	1,101.39
Invert Elevation at Upstream end of Culvert (ft)	1,108.79
Culvert Slope (ft/ft)	0.2885
Starting Flow Rate (cfs)	2.45
Incremental Flow Rate (cfs)	0.0
Ending Flow Rate (cfs)	2.45
Starting Tailwater Depth (ft)	6.44
Incremental Tailwater Depth (ft)	0.0
Ending Tailwater Depth (ft)	6.44

COMPUTATION RESULTS

Flow Rate (cfs)	Tailwater Depth (ft)	Headwater (ft) Inlet Control	Headwater (ft) Outlet Control	Normal Depth (ft)	Critical Depth (ft)	Depth at Outlet (ft)	Outlet Velocity (fps)
2.45	6.44	0.73	-0.83	0.22	0.63	0.22	16.31

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TRUNK HGL = 1107.83

LAT INVERT = 1101.39

TW = 6.44

AHW = 1111.79

OHW = 1109.52

PIPE CULVERT ANALYSIS
COMPUTATION OF CULVERT PERFORMANCE CURVE

March 17, 1999
Pipe 10 Sta 27+82 Orangewood Ave.

PROGRAM INPUT DATA

DESCRIPTION	VALUE
Culvert Diameter (ft)	3.0
FHWA Chart Number	1
FHWA Scale Number (Type of Culvert Entrance)	1
Manning's Roughness Coefficient (n-value)	0.013
Entrance Loss Coefficient of Culvert Opening	0.5
Culvert Length (ft)	29.33
Invert Elevation at Downstream end of Culvert (ft)	1,105.06
Invert Elevation at Upstream end of Culvert (ft)	1,108.56
Culvert Slope (ft/ft)	0.1193
Starting Flow Rate (cfs)	32.55
Incremental Flow Rate (cfs)	0.0
Ending Flow Rate (cfs)	32.55
Starting Tailwater Depth (ft)	2.77
Incremental Tailwater Depth (ft)	0.0
Ending Tailwater Depth (ft)	2.77

COMPUTATION RESULTS

Flow Rate (cfs)	Tailwater Depth (ft)	Headwater (ft) Inlet Control	Headwater (ft) Outlet Control	Normal Depth (ft)	Critical Depth (ft)	Depth at Outlet (ft)	Outlet Velocity (fps)
32.55	2.77	2.67	0.0	0.76	1.85	0.76	23.04

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TRUNK HGL = 1107.83

LAT INVERT = 1105.06

TW = 2.77

AHW = 1112.56

DHW = 1111.23

PIPE CULVERT ANALYSIS
COMPUTATION OF CULVERT PERFORMANCE CURVE

March 17, 1999
Sta 40+75 Orangewood

PROGRAM INPUT DATA

DESCRIPTION	VALUE
Culvert Diameter (ft)	3.0
FHWA Chart Number	1
FHWA Scale Number (Type of Culvert Entrance)	1
Manning's Roughness Coefficient (n-value)	0.013
Entrance Loss Coefficient of Culvert Opening	0.5
Culvert Length (ft)	24.43
Invert Elevation at Downstream end of Culvert (ft)	1,100.98
Invert Elevation at Upstream end of Culvert (ft)	1,105.44
Culvert Slope (ft/ft)	0.1826
Starting Flow Rate (cfs)	29.0
Incremental Flow Rate (cfs)	0.0
Ending Flow Rate (cfs)	29.0
Starting Tailwater Depth (ft)	9.28
Incremental Tailwater Depth (ft)	0.0
Ending Tailwater Depth (ft)	9.28

COMPUTATION RESULTS

Flow Rate (cfs)	Tailwater Depth (ft)	Headwater (ft) Inlet Control	Headwater (ft) Outlet Control	Normal Depth (ft)	Critical Depth (ft)	Depth at Outlet (ft)	Outlet Velocity (fps)
29.0	9.28	2.35	5.26	0.65	1.74	3.0	4.1

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TRUNK HGL = 1110.26
LAT INVERT = 1100.98
TW = 9.28

PIPE CULVERT ANALYSIS
COMPUTATION OF CULVERT PERFORMANCE CURVE

March 17, 1999

Pipe 11 Sta 40+90

PROGRAM INPUT DATA

DESCRIPTION	VALUE
Culvert Diameter (ft)	2.5
FHWA Chart Number	1
FHWA Scale Number (Type of Culvert Entrance)	1
Manning's Roughness Coefficient (n-value)	0.013
Entrance Loss Coefficient of Culvert Opening	0.5
Culvert Length (ft)	12.16
Invert Elevation at Downstream end of Culvert (ft)	1,105.19
Invert Elevation at Upstream end of Culvert (ft)	1,110.23
Culvert Slope (ft/ft)	0.4145
Starting Flow Rate (cfs)	29.0
Incremental Flow Rate (cfs)	0.0
Ending Flow Rate (cfs)	29.0
Starting Tailwater Depth (ft)	5.51
Incremental Tailwater Depth (ft)	0.0
Ending Tailwater Depth (ft)	5.51

COMPUTATION RESULTS

Flow Rate (cfs)	Tailwater Depth (ft)	Headwater (ft) Inlet Control	Headwater (ft) Outlet Control	Normal Depth (ft)	Critical Depth (ft)	Depth at Outlet (ft)	Outlet Velocity (fps)
29.0	5.51	2.61	1.34	0.56	1.84	0.56	35.36

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TRUNK HGL = 1110.7

LAT INVERT = 1105.19

TW = 5.51

AHW = 1115.09

OHW = 1112.84

PIPE CULVERT ANALYSIS
COMPUTATION OF CULVERT PERFORMANCE CURVE

March 17, 1999

Pipe 12 Sta 66+56.24 Orangewood

PROGRAM INPUT DATA

DESCRIPTION	VALUE
Culvert Diameter (ft)	2.5
FHWA Chart Number	1
FHWA Scale Number (Type of Culvert Entrance)	1
Manning's Roughness Coefficient (n-value)	0.013
Entrance Loss Coefficient of Culvert Opening	0.5
Culvert Length (ft)	18.06
Invert Elevation at Downstream end of Culvert (ft)	1,106.93
Invert Elevation at Upstream end of Culvert (ft)	1,115.11
Culvert Slope (ft/ft)	0.4529
Starting Flow Rate (cfs)	32.55
Incremental Flow Rate (cfs)	0.0
Ending Flow Rate (cfs)	32.55
Starting Tailwater Depth (ft)	12.04
Incremental Tailwater Depth (ft)	0.0
Ending Tailwater Depth (ft)	12.04

COMPUTATION RESULTS

Flow Rate (cfs)	Tailwater Depth (ft)	Headwater (ft) Inlet Control	Headwater (ft) Outlet Control	Normal Depth (ft)	Critical Depth (ft)	Depth at Outlet (ft)	Outlet Velocity (fps)
32.55	12.04	2.86	5.0	0.58	1.94	2.5	6.63

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TRUNK HGL = 1118.97
LAT INVERT = 1106.93
TW = 12.04
AHW = 1122.11
DHW = 1120.11

PIPE CULVERT ANALYSIS
COMPUTATION OF CULVERT PERFORMANCE CURVE

March 17, 1999
Pipe 13a Sta 79+65 Olangewood

==========

PROGRAM INPUT DATA

DESCRIPTION	VALUE
Culvert Diameter (ft)	1.5
FHWA Chart Number	1
FHWA Scale Number (Type of Culvert Entrance)	1
Manning's Roughness Coefficient (n-value)	0.013
Entrance Loss Coefficient of Culvert Opening	0.5
Culvert Length (ft)	8.6
Invert Elevation at Downstream end of Culvert (ft)	1,118.96
Invert Elevation at Upstream end of Culvert (ft)	1,122.52
Culvert Slope (ft/ft)	0.414
Starting Flow Rate (cfs)	1.74
Incremental Flow Rate (cfs)	0.0
Ending Flow Rate (cfs)	1.74
Starting Tailwater Depth (ft)	3.84
Incremental Tailwater Depth (ft)	0.0
Ending Tailwater Depth (ft)	3.84

==========

COMPUTATION RESULTS

Flow Rate (cfs)	Tailwater Depth (ft)	Headwater (ft) Inlet Control	Headwater (ft) Outlet Control	Normal Depth (ft)	Critical Depth (ft)	Depth at Outlet (ft)	Outlet Velocity (fps)
1.74	3.84	0.38	0.3	0.17	0.5	0.17	16.37

==========

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TRUNK HGL = 1122.8

LAT INVERT = 1118.96

TW = 3.84

AHW = 1125.02

DHW = 1122.9

PIPE CULVERT ANALYSIS
COMPUTATION OF CULVERT PERFORMANCE CURVE

March 17, 1999
Pipe 14 80+78 to 81+46.38

==========

PROGRAM INPUT DATA

DESCRIPTION	VALUE
Culvert Diameter (ft)	3.5
FHWA Chart Number	1
FHWA Scale Number (Type of Culvert Entrance)	1
Manning's Roughness Coefficient (n-value)	0.013
Entrance Loss Coefficient of Culvert Opening	0.5
Culvert Length (ft)	65.6
Invert Elevation at Downstream end of Culvert (ft)	14.7
Invert Elevation at Upstream end of Culvert (ft)	20.03
Culvert Slope (ft/ft)	0.0813
Starting Flow Rate (cfs)	50.0
Incremental Flow Rate (cfs)	0.0
Ending Flow Rate (cfs)	50.0
Starting Tailwater Depth (ft)	8.83
Incremental Tailwater Depth (ft)	0.0
Ending Tailwater Depth (ft)	8.83

==========

COMPUTATION RESULTS

Flow Rate (cfs)	Tailwater Depth (ft)	Headwater (ft) Inlet Control	Headwater (ft) Outlet Control	Normal Depth (ft)	Critical Depth (ft)	Depth at Outlet (ft)	Outlet Velocity (fps)
50.0	8.83	3.28	4.29	0.99	2.21	3.5	5.2

==========

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TRUNK HGL = 1123.53

LAT INVERT = 1114.7

TW = 8.83

AHW = 1125.53

OHW = 1124.32

PIPE CULVERT ANALYSIS
COMPUTATION OF CULVERT PERFORMANCE CURVE

March 17, 1999

Pipe 14-1 80+51.29 to 80+78

PROGRAM INPUT DATA

DESCRIPTION	VALUE
Culvert Diameter (ft)	3.5
FHWA Chart Number	1
FHWA Scale Number (Type of Culvert Entrance)	1
Manning's Roughness Coefficient (n-value)	0.013
Entrance Loss Coefficient of Culvert Opening	0.5
Culvert Length (ft)	23.7
Invert Elevation at Downstream end of Culvert (ft)	20.53
Invert Elevation at Upstream end of Culvert (ft)	20.55
Culvert Slope (ft/ft)	0.0008
Starting Flow Rate (cfs)	41.9
Incremental Flow Rate (cfs)	0.0
Ending Flow Rate (cfs)	41.9
Starting Tailwater Depth (ft)	3.79
Incremental Tailwater Depth (ft)	0.0
Ending Tailwater Depth (ft)	3.79

COMPUTATION RESULTS

Flow Rate (cfs)	Tailwater Depth (ft)	Headwater (ft) Inlet Control	Headwater (ft) Outlet Control	Normal Depth (ft)	Critical Depth (ft)	Depth at Outlet (ft)	Outlet Velocity (fps)
41.9	3.79	3.03	4.25	3.5	2.02	3.5	4.35

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DOWNSTREAM HGL = 1124.32

LAT INVERT = 1120.53

TW = 3.79

AHW = 1127.5

DHW = 1124.8

PIPE CULVERT ANALYSIS
COMPUTATION OF CULVERT PERFORMANCE CURVE

March 17, 1999

Pipe 13 80+15.36 to 80+51.29

PROGRAM INPUT DATA

DESCRIPTION	VALUE
Culvert Diameter (ft)	2.0
FHWA Chart Number	1
FHWA Scale Number (Type of Culvert Entrance)	1
Manning's Roughness Coefficient (n-value)	0.013
Entrance Loss Coefficient of Culvert Opening	0.5
Culvert Length (ft)	34.0
Invert Elevation at Downstream end of Culvert (ft)	21.35
Invert Elevation at Upstream end of Culvert (ft)	22.09
Culvert Slope (ft/ft)	0.0218
Starting Flow Rate (cfs)	8.1
Incremental Flow Rate (cfs)	0.0
Ending Flow Rate (cfs)	8.1
Starting Tailwater Depth (ft)	3.45
Incremental Tailwater Depth (ft)	0.0
Ending Tailwater Depth (ft)	3.45

COMPUTATION RESULTS

Flow Rate (cfs)	Tailwater Depth (ft)	Headwater (ft) Inlet Control	Headwater (ft) Outlet Control	Normal Depth (ft)	Critical Depth (ft)	Depth at Outlet (ft)	Outlet Velocity (fps)
8.1	3.45	1.46	2.91	0.67	1.01	2.0	2.58

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DOWNSTREAM HGL = 1124.8

LAT INVERT = 1121.35

TW = 3.45

ATW = 1125.59

DTW = 1125.05

PIPE CULVERT ANALYSIS
COMPUTATION OF CULVERT PERFORMANCE CURVE

March 17, 1999

Pipe 14a Sta 81+55 Orangewood

PROGRAM INPUT DATA

DESCRIPTION	VALUE
Culvert Diameter (ft)	1.5
FHWA Chart Number	1
FHWA Scale Number (Type of Culvert Entrance)	1
Manning's Roughness Coefficient (n-value)	0.013
Entrance Loss Coefficient of Culvert Opening	0.5
Culvert Length (ft)	73.4
Invert Elevation at Downstream end of Culvert (ft)	1,109.53
Invert Elevation at Upstream end of Culvert (ft)	1,121.75
Culvert Slope (ft/ft)	0.1665
Starting Flow Rate (cfs)	1.25
Incremental Flow Rate (cfs)	0.0
Ending Flow Rate (cfs)	1.25
Starting Tailwater Depth (ft)	14.0
Incremental Tailwater Depth (ft)	0.0
Ending Tailwater Depth (ft)	14.0

COMPUTATION RESULTS

Flow Rate (cfs)	Tailwater Depth (ft)	Headwater (ft) Inlet Control	Headwater (ft) Outlet Control	Normal Depth (ft)	Critical Depth (ft)	Depth at Outlet (ft)	Outlet Velocity (fps)
1.25	14.0	0.45	1.8	0.18	0.42	1.5	0.71

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TRUNK HGL = 1123.53

LAT INVERT = 1109.53

TW = 14

AHW = 1125.75

DHW = 1123.55

PIPE CULVERT ANALYSIS
COMPUTATION OF CULVERT PERFORMANCE CURVE

March 17, 1999
Pipe 14B Sta 87+02 Orangewood

==========

PROGRAM INPUT DATA

DESCRIPTION	VALUE
Culvert Diameter (ft)	1.5
FHWA Chart Number	1
FHWA Scale Number (Type of Culvert Entrance)	1
Manning's Roughness Coefficient (n-value)	0.013
Entrance Loss Coefficient of Culvert Opening	0.5
Culvert Length (ft)	74.29
Invert Elevation at Downstream end of Culvert (ft)	1,111.98
Invert Elevation at Upstream end of Culvert (ft)	1,124.71
Culvert Slope (ft/ft)	0.1714
Starting Flow Rate (cfs)	1.98
Incremental Flow Rate (cfs)	0.0
Ending Flow Rate (cfs)	1.98
Starting Tailwater Depth (ft)	14.2
Incremental Tailwater Depth (ft)	0.0
Ending Tailwater Depth (ft)	14.2

==========

COMPUTATION RESULTS

Flow Rate (cfs)	Tailwater Depth (ft)	Headwater (ft) Inlet Control	Headwater (ft) Outlet Control	Normal Depth (ft)	Critical Depth (ft)	Depth at Outlet (ft)	Outlet Velocity (fps)
1.98	14.2	0.61	1.53	0.22	0.53	1.5	1.12

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TRUNK HGL = 1126.18

LAT INVERT = 1111.98

TW = 14.2

AHW = 1127.21

DHW = 1126.24

PIPE CULVERT ANALYSIS
COMPUTATION OF CULVERT PERFORMANCE CURVE

March 17, 1999
Sta 93+42.44 Orangewood

PROGRAM INPUT DATA

DESCRIPTION	VALUE
Culvert Diameter (ft)	2.5
FHWA Chart Number	1
FHWA Scale Number (Type of Culvert Entrance)	1
Manning's Roughness Coefficient (n-value)	0.013
Entrance Loss Coefficient of Culvert Opening	0.5
Culvert Length (ft)	55.8
Invert Elevation at Downstream end of Culvert (ft)	114.98
Invert Elevation at Upstream end of Culvert (ft)	119.28
Culvert Slope (ft/ft)	0.0771
Starting Flow Rate (cfs)	37.8
Incremental Flow Rate (cfs)	0.0
Ending Flow Rate (cfs)	37.8
Starting Tailwater Depth (ft)	9.69
Incremental Tailwater Depth (ft)	0.0
Ending Tailwater Depth (ft)	9.69

COMPUTATION RESULTS

Flow Rate (cfs)	Tailwater Depth (ft)	Headwater (ft) Inlet Control	Headwater (ft) Outlet Control	Normal Depth (ft)	Critical Depth (ft)	Depth at Outlet (ft)	Outlet Velocity (fps)
37.8	9.69	3.94	7.25	0.99	2.08	2.5	7.7

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TRUNK HGL = 1124.67
LAT INVERT = 1114.98
TW = 9.69

PIPE CULVERT ANALYSIS
COMPUTATION OF CULVERT PERFORMANCE CURVE

March 17, 1999

Pipe 15 Sta 93+40 Orangewood

PROGRAM INPUT DATA

DESCRIPTION	VALUE
Culvert Diameter (ft)	2.0
FHWA Chart Number	1
FHWA Scale Number (Type of Culvert Entrance)	1
Manning's Roughness Coefficient (n-value)	0.013
Entrance Loss Coefficient of Culvert Opening	0.5
Culvert Length (ft)	13.34
Invert Elevation at Downstream end of Culvert (ft)	1,117.71
Invert Elevation at Upstream end of Culvert (ft)	1,123.23
Culvert Slope (ft/ft)	0.4138
Starting Flow Rate (cfs)	18.85
Incremental Flow Rate (cfs)	0.0
Ending Flow Rate (cfs)	18.85
Starting Tailwater Depth (ft)	6.17
Incremental Tailwater Depth (ft)	0.0
Ending Tailwater Depth (ft)	6.17

COMPUTATION RESULTS

Flow Rate (cfs)	Tailwater Depth (ft)	Headwater (ft) Inlet Control	Headwater (ft) Outlet Control	Normal Depth (ft)	Critical Depth (ft)	Depth at Outlet (ft)	Outlet Velocity (fps)
18.85	6.17	2.36	1.58	0.49	1.56	0.49	31.91

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TRUNK HGL = 1123.88

LAT INVERT = 1117.71

TW = 6.17

AHW = 1128.23

OHW = 1125.59

PIPE CULVERT ANALYSIS
COMPUTATION OF CULVERT PERFORMANCE CURVE

March 17, 1999

Pipe 15a Sta 93+91

PROGRAM INPUT DATA

DESCRIPTION	VALUE
Culvert Diameter (ft)	2.0
FHWA Chart Number	1
FHWA Scale Number (Type of Culvert Entrance)	1
Manning's Roughness Coefficient (n-value)	0.013
Entrance Loss Coefficient of Culvert Opening	0.5
Culvert Length (ft)	46.1
Invert Elevation at Downstream end of Culvert (ft)	23.1
Invert Elevation at Upstream end of Culvert (ft)	23.4
Culvert Slope (ft/ft)	0.0065
Starting Flow Rate (cfs)	17.81
Incremental Flow Rate (cfs)	0.0
Ending Flow Rate (cfs)	17.81
Starting Tailwater Depth (ft)	3.43
Incremental Tailwater Depth (ft)	0.0
Ending Tailwater Depth (ft)	3.43

COMPUTATION RESULTS

Flow Rate (cfs)	Tailwater Depth (ft)	Headwater (ft) Inlet Control	Headwater (ft) Outlet Control	Normal Depth (ft)	Critical Depth (ft)	Depth at Outlet (ft)	Outlet Velocity (fps)
17.81	3.43	2.61	4.16	1.6	1.52	2.0	5.67

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TRUNK HGL = 1126.53

LAT Out = 1123.1

TW = 3.43

AHW = 1129.21

DHW = 1127.56

PIPE CULVERT ANALYSIS
COMPUTATION OF CULVERT PERFORMANCE CURVE

March 17, 1999

Pipe 15 b Sta 94+46

PROGRAM INPUT DATA

DESCRIPTION	VALUE
Culvert Diameter (ft)	2.5
FHWA Chart Number	1
FHWA Scale Number (Type of Culvert Entrance)	1
Manning's Roughness Coefficient (n-value)	0.013
Entrance Loss Coefficient of Culvert Opening	0.5
Culvert Length (ft)	18.74
Invert Elevation at Downstream end of Culvert (ft)	116.13
Invert Elevation at Upstream end of Culvert (ft)	123.89
Culvert Slope (ft/ft)	0.4141
Starting Flow Rate (cfs)	22.01
Incremental Flow Rate (cfs)	0.0
Ending Flow Rate (cfs)	22.01
Starting Tailwater Depth (ft)	8.84
Incremental Tailwater Depth (ft)	0.0
Ending Tailwater Depth (ft)	8.84

COMPUTATION RESULTS

Flow Rate (cfs)	Tailwater Depth (ft)	Headwater (ft) Inlet Control	Headwater (ft) Outlet Control	Normal Depth (ft)	Critical Depth (ft)	Depth at Outlet (ft)	Outlet Velocity (fps)
22.01	8.84	1.96	1.6	0.49	1.6	0.49	32.57

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TRUNK HGL = 112497

LAT INV = 1116.13

TW = 8.84

AHW = 1129.24

DHW = 1125.85

PIPE CULVERT ANALYSIS
COMPUTATION OF CULVERT PERFORMANCE CURVE

March 17, 1999

Pipe 15d Sta 94+10 Orangewood

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PROGRAM INPUT DATA

DESCRIPTION	VALUE
Culvert Diameter (ft)	1.5
FHWA Chart Number	1
FHWA Scale Number (Type of Culvert Entrance)	1
Manning's Roughness Coefficient (n-value)	0.013
Entrance Loss Coefficient of Culvert Opening	0.5
Culvert Length (ft)	19.36
Invert Elevation at Downstream end of Culvert (ft)	21.08
Invert Elevation at Upstream end of Culvert (ft)	24.54
Culvert Slope (ft/ft)	0.1787
Starting Flow Rate (cfs)	1.8
Incremental Flow Rate (cfs)	0.0
Ending Flow Rate (cfs)	1.8
Starting Tailwater Depth (ft)	3.79
Incremental Tailwater Depth (ft)	0.0
Ending Tailwater Depth (ft)	3.79

==========

COMPUTATION RESULTS

Flow Rate (cfs)	Tailwater Depth (ft)	Headwater (ft) Inlet Control	Headwater (ft) Outlet Control	Normal Depth (ft)	Critical Depth (ft)	Depth at Outlet (ft)	Outlet Velocity (fps)
1.8	3.79	0.57	0.36	0.21	0.5	0.21	12.36

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TRUNK HGL = 1124.87

LAT OUT = 1121.08

TW = 3.79

AHW = 1129.47

DHW = 1125.11

PIPE CULVERT ANALYSIS
COMPUTATION OF CULVERT PERFORMANCE CURVE

March 17, 1999

Pipe 15C Sta 100+10 Orangewood

PROGRAM INPUT DATA

DESCRIPTION	VALUE
Culvert Diameter (ft)	1.5
FHWA Chart Number	1
FHWA Scale Number (Type of Culvert Entrance)	1
Manning's Roughness Coefficient (n-value)	0.013
Entrance Loss Coefficient of Culvert Opening	0.5
Culvert Length (ft)	18.6
Invert Elevation at Downstream end of Culvert (ft)	118.32
Invert Elevation at Upstream end of Culvert (ft)	126.0
Culvert Slope (ft/ft)	0.4129
Starting Flow Rate (cfs)	4.09
Incremental Flow Rate (cfs)	0.0
Ending Flow Rate (cfs)	4.09
Starting Tailwater Depth (ft)	8.29
Incremental Tailwater Depth (ft)	0.0
Ending Tailwater Depth (ft)	8.29

COMPUTATION RESULTS

Flow Rate (cfs)	Tailwater Depth (ft)	Headwater (ft) Inlet Control	Headwater (ft) Outlet Control	Normal Depth (ft)	Critical Depth (ft)	Depth at Outlet (ft)	Outlet Velocity (fps)
4.09	8.29	0.82	0.76	0.25	0.77	0.25	21.03

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TRUNK HGL = 1126.61

LAT INVERT = 1118.32

TW = 8.29

AHW = 1130.75

DHW = 1126.82

PIPE CULVERT ANALYSIS
COMPUTATION OF CULVERT PERFORMANCE CURVE

March 17, 1999

Pipe 15e Sta 100+22 Orangewood

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PROGRAM INPUT DATA

DESCRIPTION	VALUE
Culvert Diameter (ft)	1.5
FHWA Chart Number	1
FHWA Scale Number (Type of Culvert Entrance)	1
Manning's Roughness Coefficient (n-value)	0.013
Entrance Loss Coefficient of Culvert Opening	0.5
Culvert Length (ft)	19.3
Invert Elevation at Downstream end of Culvert (ft)	21.42
Invert Elevation at Upstream end of Culvert (ft)	28.17
Culvert Slope (ft/ft)	0.3497
Starting Flow Rate (cfs)	1.96
Incremental Flow Rate (cfs)	0.0
Ending Flow Rate (cfs)	1.96
Starting Tailwater Depth (ft)	5.22
Incremental Tailwater Depth (ft)	0.0
Ending Tailwater Depth (ft)	5.22

==========

COMPUTATION RESULTS

Flow Rate (cfs)	Tailwater Depth (ft)	Headwater (ft) Inlet Control	Headwater (ft) Outlet Control	Normal Depth (ft)	Critical Depth (ft)	Depth at Outlet (ft)	Outlet Velocity (fps)
1.96	5.22	0.47	-1.49	0.18	0.53	0.18	16.05

==========

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TRUNK HGL = 1126.64

LAT OUT = 1121.42

TW = 5.22

AHW = 1130.67

DHW = 1128.64

PIPE CULVERT ANALYSIS
COMPUTATION OF CULVERT PERFORMANCE CURVE

March 17, 1999

Pipe 16a Sta 106+14.16 Orangewood

PROGRAM INPUT DATA

DESCRIPTION	VALUE
Culvert Diameter (ft)	1.5
FHWA Chart Number	1
FHWA Scale Number (Type of Culvert Entrance)	1
Manning's Roughness Coefficient (n-value)	0.013
Entrance Loss Coefficient of Culvert Opening	0.5
Culvert Length (ft)	25.56
Invert Elevation at Downstream end of Culvert (ft)	25.6
Invert Elevation at Upstream end of Culvert (ft)	28.78
Culvert Slope (ft/ft)	0.1244
Starting Flow Rate (cfs)	4.44
Incremental Flow Rate (cfs)	0.0
Ending Flow Rate (cfs)	4.44
Starting Tailwater Depth (ft)	2.76
Incremental Tailwater Depth (ft)	0.0
Ending Tailwater Depth (ft)	2.76

COMPUTATION RESULTS

Flow Rate (cfs)	Tailwater Depth (ft)	Headwater (ft) Inlet Control	Headwater (ft) Outlet Control	Normal Depth (ft)	Critical Depth (ft)	Depth at Outlet (ft)	Outlet Velocity (fps)
4.44	2.76	1.1	-0.23	0.35	0.81	0.35	14.11

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TRUNK HGL = 1128.36

LAT OUT = 1125.6

TW = 2.76

AHW = 1133.28

OHW = 1129.88

PIPE CULVERT ANALYSIS
COMPUTATION OF CULVERT PERFORMANCE CURVE

March 17, 1999

Sta 106+87.52 Orangewood

PROGRAM INPUT DATA

DESCRIPTION	VALUE
Culvert Diameter (ft)	3.5
FHWA Chart Number	1
FHWA Scale Number (Type of Culvert Entrance)	1
Manning's Roughness Coefficient (n-value)	0.013
Entrance Loss Coefficient of Culvert Opening	0.5
Culvert Length (ft)	74.9
Invert Elevation at Downstream end of Culvert (ft)	18.26
Invert Elevation at Upstream end of Culvert (ft)	19.01
Culvert Slope (ft/ft)	0.01
Starting Flow Rate (cfs)	41.1
Incremental Flow Rate (cfs)	0.0
Ending Flow Rate (cfs)	41.1
Starting Tailwater Depth (ft)	8.03
Incremental Tailwater Depth (ft)	0.0
Ending Tailwater Depth (ft)	8.03

COMPUTATION RESULTS

Flow Rate (cfs)	Tailwater Depth (ft)	Headwater (ft) Inlet Control	Headwater (ft) Outlet Control	Normal Depth (ft)	Critical Depth (ft)	Depth at Outlet (ft)	Outlet Velocity (fps)
41.1	8.03	2.97	7.83	1.56	2.0	3.5	4.27

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TRUNK HGL = 1126.29

LAT INVERT = 1118.26

TW = 8.03

PIPE CULVERT ANALYSIS
COMPUTATION OF CULVERT PERFORMANCE CURVE

March 17, 1999

Pipe 16 Sta 106+58.17 Orangewood

PROGRAM INPUT DATA

DESCRIPTION	VALUE
Culvert Diameter (ft)	1.5
FHWA Chart Number	1
FHWA Scale Number (Type of Culvert Entrance)	1
Manning's Roughness Coefficient (n-value)	0.013
Entrance Loss Coefficient of Culvert Opening	0.5
Culvert Length (ft)	28.7
Invert Elevation at Downstream end of Culvert (ft)	20.46
Invert Elevation at Upstream end of Culvert (ft)	29.29
Culvert Slope (ft/ft)	0.3077
Starting Flow Rate (cfs)	5.61
Incremental Flow Rate (cfs)	0.0
Ending Flow Rate (cfs)	5.61
Starting Tailwater Depth (ft)	6.38
Incremental Tailwater Depth (ft)	0.0
Ending Tailwater Depth (ft)	6.38

COMPUTATION RESULTS

Flow Rate (cfs)	Tailwater Depth (ft)	Headwater (ft) Inlet Control	Headwater (ft) Outlet Control	Normal Depth (ft)	Critical Depth (ft)	Depth at Outlet (ft)	Outlet Velocity (fps)
5.61	6.38	1.17	-2.13	0.31	0.91	0.31	20.89

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TRUNK HGL = 1126.84

LAT INV = 1120.46

TW = 6.38

AHW = 1134.29

DHW = 1130.46

PIPE CULVERT ANALYSIS
COMPUTATION OF CULVERT PERFORMANCE CURVE

March 17, 1999

Pipe 17 Sta 107+20

PROGRAM INPUT DATA

DESCRIPTION	VALUE
Culvert Diameter (ft)	2.0
FHWA Chart Number	1
FHWA Scale Number (Type of Culvert Entrance)	1
Manning's Roughness Coefficient (n-value)	0.013
Entrance Loss Coefficient of Culvert Opening	0.5
Culvert Length (ft)	28.38
Invert Elevation at Downstream end of Culvert (ft)	22.89
Invert Elevation at Upstream end of Culvert (ft)	30.5
Culvert Slope (ft/ft)	0.2681
Starting Flow Rate (cfs)	14.0
Incremental Flow Rate (cfs)	0.0
Ending Flow Rate (cfs)	14.0
Starting Tailwater Depth (ft)	3.95
Incremental Tailwater Depth (ft)	0.0
Ending Tailwater Depth (ft)	3.95

COMPUTATION RESULTS

Flow Rate (cfs)	Tailwater Depth (ft)	Headwater (ft) Inlet Control	Headwater (ft) Outlet Control	Normal Depth (ft)	Critical Depth (ft)	Depth at Outlet (ft)	Outlet Velocity (fps)
14.0	3.95	1.87	-3.09	0.47	1.35	0.47	25.16

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TRUNK HGL = 1126.84

LAT INV = 1122.89

TW = 3.95

AHW = 1133

DHW = 1132.37

PIPE CULVERT ANALYSIS
COMPUTATION OF CULVERT PERFORMANCE CURVE

March 17, 1999

Pipe 17a Sta 109+64.4 Orangewood

PROGRAM INPUT DATA

DESCRIPTION	VALUE
Culvert Diameter (ft)	2.5
FHWA Chart Number	1
FHWA Scale Number (Type of Culvert Entrance)	1
Manning's Roughness Coefficient (n-value)	0.013
Entrance Loss Coefficient of Culvert Opening	0.5
Culvert Length (ft)	21.25
Invert Elevation at Downstream end of Culvert (ft)	26.25
Invert Elevation at Upstream end of Culvert (ft)	30.36
Culvert Slope (ft/ft)	0.1934
Starting Flow Rate (cfs)	21.7
Incremental Flow Rate (cfs)	0.0
Ending Flow Rate (cfs)	21.7
Starting Tailwater Depth (ft)	1.06
Incremental Tailwater Depth (ft)	0.0
Ending Tailwater Depth (ft)	1.06

COMPUTATION RESULTS

Flow Rate (cfs)	Tailwater Depth (ft)	Headwater (ft) Inlet Control	Headwater (ft) Outlet Control	Normal Depth (ft)	Critical Depth (ft)	Depth at Outlet (ft)	Outlet Velocity (fps)
21.7	1.06	2.21	0.0	0.59	1.58	0.59	24.79

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TRUNK HGL = 1127.31

LAT OUT = 1126.25

TW = 1.06

AHW = 1133.36

DHW = 1132.57

PIPE CULVERT ANALYSIS
COMPUTATION OF CULVERT PERFORMANCE CURVE

March 17, 1999

Sta 112+90.68 to 113+38.68

PROGRAM INPUT DATA

DESCRIPTION	VALUE
Culvert Diameter (ft)	3.0
FHWA Chart Number	1
FHWA Scale Number (Type of Culvert Entrance)	1
Manning's Roughness Coefficient (n-value)	0.013
Entrance Loss Coefficient of Culvert Opening	0.5
Culvert Length (ft)	68.0
Invert Elevation at Downstream end of Culvert (ft)	19.0
Invert Elevation at Upstream end of Culvert (ft)	19.2
Culvert Slope (ft/ft)	0.0029
Starting Flow Rate (cfs)	8.0
Incremental Flow Rate (cfs)	0.0
Ending Flow Rate (cfs)	8.0
Starting Tailwater Depth (ft)	7.79
Incremental Tailwater Depth (ft)	0.0
Ending Tailwater Depth (ft)	7.79

COMPUTATION RESULTS

Flow Rate (cfs)	Tailwater Depth (ft)	Headwater (ft) Inlet Control	Headwater (ft) Outlet Control	Normal Depth (ft)	Critical Depth (ft)	Depth at Outlet (ft)	Outlet Velocity (fps)
8.0	7.79	1.22	7.63	0.96	0.89	3.0	1.13

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TRUNK HGL = 1126.79

LAT INVERT = 1119.00

TW = 7.79

PIPE CULVERT ANALYSIS
COMPUTATION OF CULVERT PERFORMANCE CURVE

March 17, 1999
Pipe 18 Sta 113+54 Orangewood

PROGRAM INPUT DATA

DESCRIPTION	VALUE
Culvert Diameter (ft)	1.25
FHWA Chart Number	1
FHWA Scale Number (Type of Culvert Entrance)	1
Manning's Roughness Coefficient (n-value)	0.013
Entrance Loss Coefficient of Culvert Opening	0.5
Culvert Length (ft)	22.22
Invert Elevation at Downstream end of Culvert (ft)	27.08
Invert Elevation at Upstream end of Culvert (ft)	31.84
Culvert Slope (ft/ft)	0.2142
Starting Flow Rate (cfs)	4.0
Incremental Flow Rate (cfs)	0.0
Ending Flow Rate (cfs)	4.0
Starting Tailwater Depth (ft)	0.0
Incremental Tailwater Depth (ft)	0.0
Ending Tailwater Depth (ft)	0.0

COMPUTATION RESULTS

Flow Rate (cfs)	Tailwater Depth (ft)	Headwater (ft) Inlet Control	Headwater (ft) Outlet Control	Normal Depth (ft)	Critical Depth (ft)	Depth at Outlet (ft)	Outlet Velocity (fps)
4.0	0.0	1.13	0.0	0.31	0.81	0.31	16.97

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TRUNK HGL = 1126.83

LAT OUT = 1127.08

TW = 0

AHW = 1134.84

DHW = 1132.97

PIPE CULVERT ANALYSIS
COMPUTATION OF CULVERT PERFORMANCE CURVE

March 17, 1999

Pipe 19 Sta 113+48 Orangewood

==========

PROGRAM INPUT DATA

DESCRIPTION	VALUE
Culvert Diameter (ft)	1.25
FHWA Chart Number	1
FHWA Scale Number (Type of Culvert Entrance)	1
Manning's Roughness Coefficient (n-value)	0.013
Entrance Loss Coefficient of Culvert Opening	0.5
Culvert Length (ft)	20.51
Invert Elevation at Downstream end of Culvert (ft)	20.6
Invert Elevation at Upstream end of Culvert (ft)	28.92
Culvert Slope (ft/ft)	0.4057
Starting Flow Rate (cfs)	4.0
Incremental Flow Rate (cfs)	0.0
Ending Flow Rate (cfs)	4.0
Starting Tailwater Depth (ft)	6.23
Incremental Tailwater Depth (ft)	0.0
Ending Tailwater Depth (ft)	6.23

==========

COMPUTATION RESULTS

Flow Rate (cfs)	Tailwater Depth (ft)	Headwater (ft) Inlet Control	Headwater (ft) Outlet Control	Normal Depth (ft)	Critical Depth (ft)	Depth at Outlet (ft)	Outlet Velocity (fps)
4.0	6.23	1.01	-1.76	0.26	0.81	0.26	21.32

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TRUNK HGL = 1126.83

LAT INVERT = 1120.6

TW = 6.23

AHW = 1134.92

OHW = 1129.93

PIPE CULVERT ANALYSIS
COMPUTATION OF CULVERT PERFORMANCE CURVE

March 18, 1999

Pipe 24 Sta 12+61 67th Ave

==========

PROGRAM INPUT DATA

DESCRIPTION	VALUE
Culvert Diameter (ft)	1.5
FHWA Chart Number	1
FHWA Scale Number (Type of Culvert Entrance)	1
Manning's Roughness Coefficient (n-value)	0.013
Entrance Loss Coefficient of Culvert Opening	0.5
Culvert Length (ft)	25.75
Invert Elevation at Downstream end of Culvert (ft)	1,136.34
Invert Elevation at Upstream end of Culvert (ft)	1,136.56
Culvert Slope (ft/ft)	0.0085
Starting Flow Rate (cfs)	6.13
Incremental Flow Rate (cfs)	0.0
Ending Flow Rate (cfs)	6.13
Starting Tailwater Depth (ft)	3.97
Incremental Tailwater Depth (ft)	0.0
Ending Tailwater Depth (ft)	3.97

==========

COMPUTATION RESULTS

Flow Rate (cfs)	Tailwater Depth (ft)	Headwater (ft) Inlet Control	Headwater (ft) Outlet Control	Normal Depth (ft)	Critical Depth (ft)	Depth at Outlet (ft)	Outlet Velocity (fps)
6.13	3.97	1.48	4.12	0.86	0.96	1.5	3.47

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TRUNK HGL = 1140.31

LAT INVERT = 1136.34

TW = 3.97

AHW = 1140.97

DHW = 1140.68

PIPE CULVERT ANALYSIS
COMPUTATION OF CULVERT PERFORMANCE CURVE

March 18, 1999

Pipe 25 Sta 13+62 67th Ave

PROGRAM INPUT DATA

DESCRIPTION	VALUE
Culvert Diameter (ft)	2.0
FHWA Chart Number	1
FHWA Scale Number (Type of Culvert Entrance)	1
Manning's Roughness Coefficient (n-value)	0.013
Entrance Loss Coefficient of Culvert Opening	0.5
Culvert Length (ft)	39.35
Invert Elevation at Downstream end of Culvert (ft)	1,136.31
Invert Elevation at Upstream end of Culvert (ft)	1,138.28
Culvert Slope (ft/ft)	0.0501
Starting Flow Rate (cfs)	9.53
Incremental Flow Rate (cfs)	0.0
Ending Flow Rate (cfs)	9.53
Starting Tailwater Depth (ft)	4.15
Incremental Tailwater Depth (ft)	0.0
Ending Tailwater Depth (ft)	4.15

COMPUTATION RESULTS

Flow Rate (cfs)	Tailwater Depth (ft)	Headwater (ft) Inlet Control	Headwater (ft) Outlet Control	Normal Depth (ft)	Critical Depth (ft)	Depth at Outlet (ft)	Outlet Velocity (fps)
9.53	4.15	1.59	2.46	0.59	1.1	2.0	3.03

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TRUNK HGL = 1140.46

LAT INVERT = 1136.31

TW = 4.15

AHW = 1141.28

DHW = 1140.74