FINAL HYDROLOGY REPORT

COSTCO WHOLESALE WAREHOUSE NO. 122
2655 EL CAMINO REAL
TUSTIN, CA

FUSCOE ENGINEERING, INC.
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Irvine, CA 92606
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PROJECT MANAGER: Mark Nero

DATE PREPARED: May 2019

PROJECT NUMBER: 756-059-01
PREPARED BY:

Fuscoe Engineering, Inc.
16795 Von Karman Avenue, Suite 100
Irvine, CA 92606
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Project Number:
756-059

COSTCO WHOLESALE WAREHOUSE NO. 122
2655 EL CAMINO REAL
Tustin, California

Supervising Engineer:
Mark Nero, P.E.

Date Prepared:
May 2019
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1.0 INTRODUCTION

1.1 PROJECT DESCRIPTION

The site 11.9-acre which consists of an existing Costco Warehouse with associated parking and a tire store has a site improvement study area of only 6.6 acres. The existing Costco Warehouse is to remain whilst the tire store will be demolished, and the area converted to parking stalls.

The existing site flows can be divided into two separate areas, Area A and Area B. Area A consists of the existing warehouse building and truck docks along with parking areas to the south. This drainage area drains south towards the low point for Area A which is located in the southwest corner of the parking area. The run-off is collected in a catch basin located in a quasi- sump and conveyed by an existing 18" pipe to the south. Area B is an existing tire shop and parking that drains east into an adjacent parking area. The southeast corner of this parking area is the low point with a catch basin in a quasi-sump. The catch basin connects to the pipe system serving Area A via an 18" pipe. The combined pipe system which increases to a 54" pipe conveys the flows south which then connects to the existing OCFCD F07 channel. See existing hydrology map in Appendix 4.

The project is located in flood zone ‘X’ per FEMA Flood Insurance Rate Map (FIRM) No. 06059C0281J, revised December 3, 2009. Flood zone ‘X’ corresponds to areas outside the 500-year flood. See FEMA FIRMETTE in Appendix 3. The site has a type D hydrological soil, see the Orange County Soil Map in Appendix 3.

1.2 PURPOSE OF THIS REPORT

The purpose of this report is to accomplish the following objectives:

To determine the developed storm water discharges generated within the project area for determination of design feasibility, detention requirements, constructability and impact on existing facilities.

To establish that there are no significant impacts to the surrounding facilities and properties because of this development.

1.3 REFERENCES

- Orange County Hydrology Manual
- Orange County Local Drainage Manual Design Manual
- Federal Emergency Management Agency; FEMA Map Service Center (Web based)
- City of Tustin Standard plans
- County of Orange GIS database (Soil type and downstream facilities)
1.4 PROJECT SITE LOCATION MAP

NORTHERN WAY

Tustin Heritage Park

Tustin Ranch Elementary School

Tustin Sports Park

Randell Tierra

Apartment Homes

BJ's Restaurant & Brewhouse

Lazy Dog Restaurant & Bar

Rancho Nortenos Apartment Homes

Ross Dress for Less

The Market Place

Chick-fil-A

In-N-Out Burger

REI

Bed Bath & Beyond

Kia Motors America

24 Hour Fitness

Serrano Apartment Homes

COSTCO WHOLESALE WAREHOUSE NO. 122

City of Tustin, CA
2.0 PROPOSED ON-SITE DRAINAGE FACILITIES

The purpose of this report to determine the feasibility of the proposed drainage facilities. Detailed design that can be used for construction will provided in the final report.

This project will provide water quality treatment to the low flows within the limits of the project. A portion of the Costco Warehouse’s parking area is proposed to be converted to a gas fueling area. Storm runoff is not allowed to be directed towards or across the proposed fueling pad area. Any runoff from the fueling pad area will be collected and treated prior to entering any other area or drainage system. See this project’s water quality management plan currently under review titled: Preliminary Water Quality Management Plan (WQMP); Costco Tustin Gas Station & Parking; 2655 El Camino Real, Tustin Orange County.

The proposed improvements include three proposed inlets to collect the runoff for water quality treatment. The site is graded to provide secondary flow paths for runoff from events exceeding the major storm event.

2.1 PROPOSED SITE CONDITIONS

Proposed Area A will contain a proposed fueling area. To prevent upstream runoff entering the fueling area a proposed landscape buffer with a 6” curb and gutter diverts the runoff around the fueling pad area. The run off once directed east or west then continues towards collection inlets located either to the southeast or southwest of the fueling pad area. The low flow runoff is then diverted to a Modular Wetland Systems (MWS) unit equipped with full trash capture devices for water quality treatment. Refer to the proposed Hydrology map provided in Appendix 4.

Subarea A1 includes the roof for the fueling area, which is directed to the westerly of these MWS units via underground pipes. The fueling pad area surface flows, when they occur are directed towards a ribbon gutter along the west edge, collected in an inlet and conveyed via a pipe to a sand oil interceptor and oil stop valve, before connecting to the existing storm pipe system. It is anticipated that flows from the fueling pad area are minimal and therefore do not impact Subarea A1.

Subarea A1 is graded such that the runoff in the parking area is directed to the proposed southwest corner inlet with a connection to the historic existing 18” pipe. This pipe system continues south and enlarges to a 54” storm pipe system which connects to the OCFCD F07 concrete lined channel. Flows that exceed the capacity of the proposed southwest corner inlet will top the curb and continue south to the El Camino Real street curb and gutter system. The Hydrology Map in appendix 4 illustrates these flow paths and facilities.

The east MWS unit for Subarea A2 has a curb opening that collects the 10-year runoff for this Subarea and connects via 24” pipe to an existing 36” storm drain pipe. The flow in the existing 36” pipe is then directed straight into the existing OCFCD F07 channel. Refer to Appendix 2 for the analysis of the pipes. Flows that
exceed the internal by-pass of the MWS unit (greater than the 10-year event) will top the curb and flow to the channel. The Hydrology Map in appendix 4 illustrates these flow paths and facilities.

Proposed Area B is graded to direct the runoff from Area B to flow by the proposed MWS unit that is sized to treat the first flush runoff. A new 12” pipe will connect this unit to the existing 18” private storm pipes. Any flows that exceed the unit will bypass and continue to be collected in the existing inlet located in the parking lot shown in the Hydrology Map in Appendix 4.

The proposed development makes minor changes to the historic drainage patterns. These changes consist of minor adjustments to the capture of runoff in subareas A1 with a new inlet and using the existing storm pipe. The other change is with subarea A2 being collected in a new location and discharged into the same channel, OCFCD channel F07, 860’ upstream from the historic discharge point. Historically both subareas A1 and A2 were collected at the same location and conveyed together to OCFCD channel F07.

2.2 DETENTION REQUIREMENT

Proposed flows are less than the existing flows due to the added landscape areas in the proposed parking area and reduced travel times. No detention will be needed for the site. Refer to the Flow Comparison table on page 8 of this report.

2.3 HYDRAULIC CALCULATIONS

Hydraulic calculations for the proposed inlets were performed using the nomograph for grated inlets in the Orange County Hydraulics Manual. Should complete clogging of the inlets occur, ponding of the storm flows will occur until the depth exceeds the adjacent curb and the runoff will flow as mentioned in section 2.1. The closest structure is the office for the fueling area attendant and building finish floor is approximately 1 foot above the top of curb that is used as the overflow path for the closest inlet in the southwest corner of Subarea A2. See Appendix 2 for calculations.

3.0 HYDROLOGY STUDY

3.1 STORM FREQUENCY

The existing Area A directs the entire proposed improvement area runoff to the 54” pipe system in Auto Center Drive, which eventually discharges into the OCFCD F07 channel. Existing Area B is part of a larger drainage area that also discharges into the 54” pipe in Auto Center Drive. The proposed Subarea A1 improvement runoff is directed to this existing 54” pipe system, while Subarea A2’s runoff flows are directed to the OCFCD F07 channel via an existing 36” pipe. The proposed improvements reduce the burden placed on the 54” pipe system in the historic condition by 1.6 cfs for the 10-year event.
The proposed drain system(s) will be designed to be consistent with the following goals and guidelines as presented in the Orange County Hydrology Manual.

Onsite design storm is based on a 10-year event and 25-year event for overflow since the Subareas are only in a quasi-sump condition. All inlets and appurtenant piping will be designed in conformance with the Orange County Hydraulics manual.

3.2 METHODOLOGY

This study was prepared in conformance with the Orange County Hydrology Manual. The calculations from the Manual were made in AES a computer program to compile the hydrologic data and to determine the peak discharges.

Hydraulic calculations were done using Manning’s equation and equations from the Manual were run in an Excel spreadsheet to determine pipe capacities.

The catch basin capacity/size was determined based on Orange County Local Drainage Manuals methods for sump and one grade inlets.

Copies of the computer print-outs and calculations are included in the appendixes of this report.

4.0 DESIGN CRITERIA

The proposed inlets and storm drain system(s) will be designed to be consistent with the following goals and guidelines as presented in the Orange County Hydrology and the Orange County Local Drainage Manuals.

All habitable buildings shall be protected from flooding during a 100-year frequency storm. This site is in flood zone ‘X’ per FEMA maps and flooding is not considered an issue on this site. (See section 1.2)

Onsite design storm is based on a 25-year frequency for overflow conditions which are in a quasi-sump condition.

Recommended design water surface elevations inside area drains shall be 0.5’ below inlet grate elevation when possible.

Pipe size may not be decreased downstream without the City’s approval.

Branching of flow is not allowed.

Area drains and appurtenant piping shall be designed in conformance with the Orange County Hydraulics manual.
4.1 SUMMARY OF FLOWS, 10-YEAR EVENT

<table>
<thead>
<tr>
<th>Area ID</th>
<th>Area (Acres)</th>
<th>Flow (cfs)</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>EXISTING A</td>
<td>6.11</td>
<td>19.4</td>
<td></td>
</tr>
<tr>
<td>B</td>
<td>0.63</td>
<td>2.3</td>
<td>Total Existing flow = 21.7 cfs</td>
</tr>
<tr>
<td>PROPOSED A1</td>
<td>2.63</td>
<td>8.0</td>
<td>0.29AC fueling area roof flow = 0.9 cfs</td>
</tr>
<tr>
<td>A2</td>
<td>3.37</td>
<td>10.0</td>
<td></td>
</tr>
<tr>
<td>B</td>
<td>0.63</td>
<td>2.1</td>
<td>Total Proposed flow = 20.1 cfs</td>
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4.2 SUMMARY OF FLOWS, 25-YEAR EVENT

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<th>Area ID</th>
<th>Area (Acres)</th>
<th>Flow (cfs)</th>
<th>Notes</th>
</tr>
</thead>
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<tr>
<td>B</td>
<td>0.63</td>
<td>2.7</td>
<td>Total Existing flow = 25.8 cfs</td>
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<tr>
<td>PROPOSED A1</td>
<td>2.63</td>
<td>9.5</td>
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</tr>
<tr>
<td>A2</td>
<td>3.37</td>
<td>11.9</td>
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<tr>
<td>B</td>
<td>0.63</td>
<td>2.5</td>
<td>Total Proposed flow = 23.9 cfs</td>
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5.0 CONCLUSIONS

The proposed condition runoff from Area A (made up of Subareas A1 & A2 in the proposed condition) has less flows than in comparison to the existing condition for each storm event analyzed. Also, a portion of the Area’s flows are directed towards the adjacent OCFCD channel F07 which reduces the load on the existing public system in El Camino Real and beyond. Area B has almost matching runoff for the existing and proposed conditions. These results indicate that the proposed project may be constructed in a manner that minimizes the impact of the proposed storm flow to the existing surrounding areas and neighborhood while providing safe and adequate drainage operation for the proposed project.
APPENDIX 1 - Existing and Proposed Hydrology Studies
RATIONAL METHOD HYDROLOGY COMPUTER PROGRAM PACKAGE
(Reference: 1986 ORANGE COUNTY HYDROLOGY CRITERION)
(c) Copyright 1983-2014 Advanced Engineering Software (aes)
Ver. 21.0 Release Date: 06/01/2014 License ID 1355

Analysis prepared by:
Fuscoe Engineering
16795 Von Karman Ave
Ste 100
Irvine, CA 92606

*******************************************************************************
* COSTCO WHOLESALE WAREHOUSE NO. 122 *
* EXISTING 10 YEAR *
* PN 756-59 *
*******************************************************************************

FILE NAME: E10.DAT
TIME/DATE OF STUDY: 16:00 04/29/2019

USER SPECIFIED HYDROLOGY AND HYDRAULIC MODEL INFORMATION:

--*TIME-OF-CONCENTRATION MODEL*--

USER SPECIFIED STORM EVENT (YEAR) = 10.00
SPECIFIED MINIMUM PIPE SIZE (INCH) = 8.00
SPECIFIED PERCENT OF GRADIENTS (DECIMAL) TO USE FOR FRICTION SLOPE = 0.90
*DATA BANK RAINFALL USED*
*ANTECEDENT MOISTURE CONDITION (AMC) II ASSUMED FOR RATIONAL METHOD*

*USER-DEFINED STREET-SECTIONS FOR COUPLED PIPEFLOW AND STREETFLOW MODEL*

<table>
<thead>
<tr>
<th>NO.</th>
<th>(FT)</th>
<th>(FT)</th>
<th>SIDE / SIDE / WAY</th>
<th>(FT)</th>
<th>(FT)</th>
<th>(FT)</th>
<th>(n)</th>
</tr>
</thead>
<tbody>
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<td>0.018/0.018/0.020</td>
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<td>2.00</td>
<td>0.0312</td>
<td>0.167</td>
</tr>
</tbody>
</table>

GLOBAL STREET FLOW-DEPTH CONSTRAINTS:
1. Relative Flow-Depth = 0.00 FEET
   as (Maximum Allowable Street Flow Depth) - (Top-of-Curb)
2. (Depth) *(Velocity) Constraint = 6.0 (FT*FT/S)

SIZE PIPE WITH A FLOW CAPACITY GREATER THAN
OR EQUAL TO THE UPSTREAM TRIBUTARY PIPE.*
*USER-SPECIFIED MINIMUM TOPOGRAPHIC SLOPE ADJUSTMENT NOT SELECTED

*******************************************************************************
FLOW PROCESS FROM NODE 10.00 TO NODE 11.00 IS CODE = 21

>>>> RATIONAL METHOD INITIAL SUBAREA ANALYSIS <<<<
>>USE TIME-OF-CONCENTRATION NOMOGRAPHS FOR INITIAL SUBAREA <<

INITIAL SUBAREA FLOW-LENGTH (FEET) = 300.00
ELEVATION DATA: UPSTREAM(FEET) = 94.00 DOWNSTREAM(FEET) = 87.00

Tc = K*[LENGTH** 3.00]/(ELEVATION CHANGE)]**0.20

SUBAREA ANALYSIS USED MINIMUM Tc(MIN.) = 6.311
* 10 YEAR RAINFALL INTENSITY(INCH/HR) = 3.552

SUBAREA Tc AND LOSS RATE DATA(AMC II):

<table>
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<tr>
<th>LAND USE</th>
<th>SCS</th>
<th>SOIL</th>
<th>AREA</th>
<th>Fp</th>
<th>Ap</th>
<th>SCs</th>
<th>Tc</th>
</tr>
</thead>
<tbody>
<tr>
<td>COMMERCIAL</td>
<td>D</td>
<td>6.11</td>
<td>0.20</td>
<td>0.100</td>
<td>75</td>
<td>6.31</td>
<td></td>
</tr>
</tbody>
</table>

SUBAREA AVERAGE PERVIOUS LOSS RATE, Fp(INCH/HR) = 0.20
SUBAREA AVERAGE PERVIOUS AREA FRACTION, Ap = 0.100
SUBAREA RUNOFF(CFS) = 19.42
TOTAL AREA(ACRES) = 6.11 PEAK FLOW RATE(CFS) = 19.42

*************************************************************************
FLOW PROCESS FROM NODE  20.00 TO NODE  22.00  IS CODE = 21

>>>>>>RATIONAL METHOD INITIAL SUBAREA ANALYSIS<<<<<
>>USE TIME-OF-CONCENTRATION NOMOGRAPH FOR INITIAL SUBAREA<<

INITIAL SUBAREA FLOW-LENGTH(Feet) = 0.63
ELEVATION DATA: UPSTREAM(Feet) = 94.00 DOWNSTREAM(Feet) = 90.50

Tc = K*[LENGTH** 3.00]/(ELEVATION CHANGE)]**0.20

SUBAREA ANALYSIS USED MINIMUM Tc(MIN.) = 5.000
* 10 YEAR RAINFALL INTENSITY(INCH/HR) = 4.060

SUBAREA Tc AND LOSS RATE DATA(AMC II):

<table>
<thead>
<tr>
<th>LAND USE</th>
<th>SCS</th>
<th>SOIL</th>
<th>AREA</th>
<th>Fp</th>
<th>Ap</th>
<th>SCs</th>
<th>Tc</th>
</tr>
</thead>
<tbody>
<tr>
<td>COMMERCIAL</td>
<td>D</td>
<td>0.63</td>
<td>0.20</td>
<td>0.100</td>
<td>75</td>
<td>5.00</td>
<td></td>
</tr>
</tbody>
</table>

SUBAREA AVERAGE PERVIOUS LOSS RATE, Fp(INCH/HR) = 0.20
SUBAREA AVERAGE PERVIOUS AREA FRACTION, Ap = 0.100
SUBAREA RUNOFF(CFS) = 2.29
TOTAL AREA(ACRES) = 0.63 PEAK FLOW RATE(CFS) = 2.29

END OF STUDY SUMMARY:
TOTAL AREA(ACRES) = 0.6  TC(MIN.) = 5.00
EFFECTIVE AREA(ACRES) = 0.63 AREA-AVERAGED Fm(INCH/HR)= 0.02
AREA-AVERAGED Fp(INCH/HR) = 0.20 AREA-AVERAGED Ap = 0.100
PEAK FLOW RATE(CFS) = 2.29

END OF RATIONAL METHOD ANALYSIS
RATIONAL METHOD HYDROLOGY COMPUTER PROGRAM PACKAGE
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Ver. 21.0 Release Date: 06/01/2014 License ID 1355

Analysis prepared by:
Fuscoe Engineering
16795 Von Karman Ave
Ste 100
Irvine, CA 92606

* DESCRIPTION OF STUDY *

* COSTCO WHOLESALE WAREHOUSE NO. 122 *

* EXISTING 25 YEAR *

* PN 756-59 *

FILE NAME: E25.DAT
TIME/DAT OF STUDY: 16:35 04/29/2019

USER SPECIFIED HYDROLOGY AND HYDRAULIC MODEL INFORMATION:

--*TIME-OF-CONCENTRATION MODEL*--

USER SPECIFIED STORM EVENT(YEAR) = 25.00
SPECIFIED MINIMUM PIPE SIZE(INCH) = 8.00
SPECIFIED PERCENT OF GRADIENTS(DECIMAL) TO USE FOR FRICTION SLOPE = 0.90
*DATA BANK RAINFALL USED*
*ANTECEDENT MOISTURE CONDITION (AMC) II ASSUMED FOR RATIONAL METHOD*

*USER-DEFINED STREET-SECTIONS FOR COUPLED PIPEFLOW AND STREETFLOW MODEL*

<table>
<thead>
<tr>
<th>HALF-CROWN TO STREET-CROSSFALL</th>
<th>CURB GUTTER-GEOMETRIES: MANNING WIDTH CROSSFALL IN-/OUT-/PARK- HEIGHT WIDTH LIP HIKE FACTOR</th>
</tr>
</thead>
<tbody>
<tr>
<td>NO. (FT) (FT) (FT) (FT) (FT)</td>
<td></td>
</tr>
<tr>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>1</td>
<td>30.0</td>
</tr>
</tbody>
</table>

GLOBAL STREET FLOW-DEPTH CONSTRAINTS:
1. Relative Flow-Depth = 0.00 FEET
   as (Maximum Allowable Street Flow Depth) - (Top-of-Curb)
2. (Depth)*(Velocity) Constraint = 6.0 (FT*FT/S)

*SIZE PIPE WITH A FLOW CAPACITY GREATER THAN
OR EQUAL TO THE UPSTREAM TRIBUTARY PIPE.*
*USER-SPECIFIED MINIMUM TOPOGRAPHIC SLOPE ADJUSTMENT NOT SELECTED*

FLOW PROCESS FROM NODE 10.00 TO NODE 11.00 IS CODE = 21

>>> RATIONAL METHOD INITIAL SUBAREA ANALYSIS<<<<<
>>USE TIME-OF-CONCENTRATION NOMOGRAPHS FOR INITIAL SUBAREA<<
INITIAL SUBAREA FLOW-LENGTH(Feet) = 300.00
ELEVATION DATA: UPSTREAM(Feet) = 94.00 DOWNSTREAM(Feet) = 87.00

Tc = K*[((LENGTH** 3.00)/(ELEVATION CHANGE))]**0.20
SUBAREA ANALYSIS USED MINIMUM Tc(MIN.) = 6.311
* 25 YEAR RAINFALL INTENSITY(INCH/HR) = 4.228

SUBAREA Tc AND LOSS RATE DATA(AMC II):

DEVELOPMENT TYPE/SCS SOIL AREA Fp Ap SCS Tc
LAND USE GROUP (ACRES) (INCH/HR) (DECIMAL) CN (MIN.)
COMMERCIAL D 6.11 0.20 0.100 75 6.31

SUBAREA AVERAGE PERVIOUS LOSS RATE, Fp(INCH/HR) = 0.20
SUBAREA AVERAGE PERVIOUS AREA FRACTION, Ap = 0.100
SUBAREA RUNOFF(CFS) = 23.14
TOTAL AREA(ACRES) = 6.11 PEAK FLOW RATE(CFS) = 23.14

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FLOW PROCESS FROM NODE 20.00 TO NODE 22.00 IS CODE = 21

>>> RATIONAL METHOD INITIAL SUBAREA ANALYSIS<<<
>>> USE TIME-OF-CONCENTRATION NOMOGRAPH FOR INITIAL SUBAREA<<

INITIAL SUBAREA FLOW-LENGTH(Feet) = 0.63
ELEVATION DATA: UPSTREAM(Feet) = 94.00 DOWNSTREAM(Feet) = 90.50

Tc = K*[((LENGTH** 3.00)/(ELEVATION CHANGE))]**0.20
SUBAREA ANALYSIS USED MINIMUM Tc(MIN.) = 5.000
* 25 YEAR RAINFALL INTENSITY(INCH/HR) = 4.824

SUBAREA Tc AND LOSS RATE DATA(AMC II):

DEVELOPMENT TYPE/SCS SOIL AREA Fp Ap SCS Tc
LAND USE GROUP (ACRES) (INCH/HR) (DECIMAL) CN (MIN.)
COMMERCIAL D 0.63 0.20 0.100 75 5.00

SUBAREA AVERAGE PERVIOUS LOSS RATE, Fp(INCH/HR) = 0.20
SUBAREA AVERAGE PERVIOUS AREA FRACTION, Ap = 0.100
SUBAREA RUNOFF(CFS) = 2.72
TOTAL AREA(ACRES) = 0.63 PEAK FLOW RATE(CFS) = 2.72

=============================================================================

END OF STUDY SUMMARY:
TOTAL AREA(ACRES) = 0.6 Tc(MIN.) = 5.00
EFFECTIVE AREA(ACRES) = 0.63 AREA-AVERAGED Fm(INCH/HR) = 0.02
AREA-AVERAGED Fp(INCH/HR) = 0.20 AREA-AVERAGED Ap = 0.100
PEAK FLOW RATE(CFS) = 2.72

=============================================================================

END OF RATIONAL METHOD ANALYSIS
RATIONAL METHOD HYDROLOGY COMPUTER PROGRAM PACKAGE
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Ver. 21.0 Release Date: 06/01/2014 License ID 1355

Analysis prepared by:
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Ste 100
Irvine, CA 92606

*********************************************************************************************************************************************
* COSTCO WHOLESALE WAREHOUSE NO. 122 *
* PROPOSED 10 YEAR *
* PN 756-59 *
*********************************************************************************************************************************************

FILE NAME: P10.DAT
TIME/DATE OF STUDY: 16:11 04/29/2019
==========================================================================================================================================
USER SPECIFIED HYDROLOGY AND HYDRAULIC MODEL INFORMATION:
==========================================================================================================================================
--*TIME-OF-CONCENTRATION MODEL*--

USER SPECIFIED STORM EVENT(YEAR) = 10.00
SPECIFIED MINIMUM PIPE SIZE(INCH) = 8.00
SPECIFIED PERCENT OF GRADIENTS(DECIMAL) TO USE FOR FRICTION SLOPE = 0.90
*DATA BANK RAINFALL USED*
*ANTECEDENT MOISTURE CONDITION (AMC) II ASSUMED FOR RATIONAL METHOD*

*USER-DEFINED STREET-SECTIONS FOR COUPLED PIPEFLOW AND STREETFLOW MODEL*

<table>
<thead>
<tr>
<th>NO.</th>
<th>HALF-CROWN TO STREET-CROSSFALL</th>
<th>CROWN TO STREET-CROSSFALL</th>
<th>CURB GUTTER-GEOMETRIES: MANNING WIDTH</th>
<th>CROSSFALL IN-/OUT-/PARK-</th>
<th>SIDE/WAY</th>
<th>LIP</th>
<th>HIKE FACTOR</th>
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<td>(FT)</td>
<td>(FT)</td>
<td>Width (FT)</td>
<td>(FT)</td>
<td>(FT)</td>
<td>(FT)</td>
<td>(n)</td>
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<tr>
<td>1</td>
<td>30.0</td>
<td>20.0</td>
<td>0.018/0.018/0.020</td>
<td>0.67</td>
<td>2.00</td>
<td>0.0312</td>
<td>0.167</td>
</tr>
</tbody>
</table>

GLOBAL STREET FLOW-DEPTH CONSTRAINTS:
1. Relative Flow-Depth = 0.00 FEET
   as (Maximum Allowable Street Flow Depth) - (Top-of-Curb)
2. (Depth)*(Velocity) Constraint = 6.0 (FT*FT/S)

*SIZE PIPE WITH A FLOW CAPACITY GREATER THAN OR EQUAL TO THE UPSTREAM TRIBUTARY PIPE.*
*USER-SPECIFIED MINIMUM TOPOGRAPHIC SLOPE ADJUSTMENT NOT SELECTED*

*********************************************************************************************************************************************
FLOW PROCESS FROM NODE 10.00 TO NODE 11.00 IS CODE = 21

>>>>>RATIONAL METHOD INITIAL SUBAREA ANALYSIS<<<<
USE TIME-OF-CONCENTRATION NOMOGRAPH FOR INITIAL SUBAREA<<

INITIAL SUBAREA FLOW-LENGTH(FEET) = 300.00
ELEVATION DATA: UPSTREAM(FEET) = 94.00 DOWNSTREAM( FEET) = 89.30

\[ Tc = K \times [(LENGTH \times 3.00)/(ELEVATION \ CHANGE)]^{0.20} \]

SUBAREA ANALYSIS USED MINIMUM Tc(MIN.) = 6.835
* 10 YEAR RAINFALL INTENSITY(INCH/HR) = 3.394

SUBAREA Tc AND LOSS RATE DATA(AMC II):

<table>
<thead>
<tr>
<th>DEVELOPMENT TYPE/ LAND USE</th>
<th>SOIL</th>
<th>AREA (ACRES)</th>
<th>Fp</th>
<th>Ap</th>
<th>SCs</th>
<th>Tc</th>
</tr>
</thead>
<tbody>
<tr>
<td>COMMERCIAL</td>
<td>D</td>
<td>2.63</td>
<td>0.20</td>
<td>0.100</td>
<td>75</td>
<td>6.83</td>
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SUBAREA AVERAGE PERVIOUS LOSS RATE, Fp(INCH/HR) = 0.20
SUBAREA AVERAGE PERVIOUS AREA FRACTION, Ap = 0.100
SUBAREA RUNOFF(CFS) = 7.99
TOTAL AREA(ACRES) = 2.63 PEAK FLOW RATE(CFS) = 7.99

FLOW PROCESS FROM NODE 12.00 TO NODE 13.00 IS CODE = 21

RATIONAL METHOD INITIAL SUBAREA ANALYSIS<<<<
USE TIME-OF-CONCENTRATION NOMOGRAPH FOR INITIAL SUBAREA<<

INITIAL SUBAREA FLOW-LENGTH( FEET) = 350.00
ELEVATION DATA: UPSTREAM( FEET) = 94.20 DOWNSTREAM( FEET) = 88.30

\[ Tc = K \times [(LENGTH \times 3.00)/(ELEVATION \ CHANGE)]^{0.20} \]

SUBAREA ANALYSIS USED MINIMUM Tc(MIN.) = 7.164
* 10 YEAR RAINFALL INTENSITY(INCH/HR) = 3.304

SUBAREA Tc AND LOSS RATE DATA(AMC II):

<table>
<thead>
<tr>
<th>DEVELOPMENT TYPE/ LAND USE</th>
<th>SOIL</th>
<th>AREA (ACRES)</th>
<th>Fp</th>
<th>Ap</th>
<th>SCs</th>
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<td>7.16</td>
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SUBAREA AVERAGE PERVIOUS LOSS RATE, Fp(INCH/HR) = 0.20
SUBAREA AVERAGE PERVIOUS AREA FRACTION, Ap = 0.100
SUBAREA RUNOFF(CFS) = 9.96
TOTAL AREA(ACRES) = 3.37 PEAK FLOW RATE(CFS) = 9.96

FLOW PROCESS FROM NODE 20.00 TO NODE 22.00 IS CODE = 21

RATIONAL METHOD INITIAL SUBAREA ANALYSIS<<<<
USE TIME-OF-CONCENTRATION NOMOGRAPH FOR INITIAL SUBAREA<<

INITIAL SUBAREA FLOW-LENGTH( FEET) = 225.00
ELEVATION DATA: UPSTREAM( FEET) = 94.30 DOWNSTREAM( FEET) = 90.50

\[ Tc = K \times [(LENGTH \times 3.00)/(ELEVATION \ CHANGE)]^{0.20} \]

SUBAREA ANALYSIS USED MINIMUM Tc(MIN.) = 6.001
* 10 YEAR RAINFALL INTENSITY(INCH/HR) = 3.656

SUBAREA Tc AND LOSS RATE DATA(AMC II):

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<th>Ap</th>
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<td>0.20</td>
<td>0.100</td>
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<td>6.00</td>
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SUBAREA AVERAGE PERVIOUS LOSS RATE, Fp(INCH/HR) = 0.20
SUBAREA AVERAGE PERVIOUS AREA FRACTION, Ap = 0.100
SUBAREA RUNOFF(CFS) = 2.06
TOTAL AREA(ACRES) = 0.63 PEAK FLOW RATE(CFS) = 2.06
END OF STUDY SUMMARY:
TOTAL AREA(ACRES) = 0.6  TC(MIN.) = 6.00
EFFECTIVE AREA(ACRES) = 0.63  AREA-AVERAGED Fm(INCH/HR) = 0.02
AREA-AVERAGED Fp(INCH/HR) = 0.20  AREA-AVERAGED Ap = 0.100
PEAK FLOW RATE(CFS) = 2.06

END OF RATIONAL METHOD ANALYSIS
RATIONAL METHOD HYDROLOGY COMPUTER PROGRAM PACKAGE
(Reference: 1986 ORANGE COUNTY HYDROLOGY CRITERION)
(c) Copyright 1983-2014 Advanced Engineering Software (aes)
Ver. 21.0 Release Date: 06/01/2014 License ID 1355

Analysis prepared by:
Fuscoe Engineering
16795 Von Karman Ave
Ste 100
Irvine, CA 92606

************ DESCRIPTION OF STUDY ************

* COSTCO WHOLESALE WAREHOUSE NO. 122

* PROPOSED 25 YEAR

* PN 756-59

FILE NAME: P25.DAT
TIME/DATE OF STUDY: 16:37 04/29/2019

USER SPECIFIED HYDROLOGY AND HYDRAULIC MODEL INFORMATION:

--*TIME-OF-CONCENTRATION MODEL*--

USER SPECIFIED STORM EVENT(YEAR) = 25.00
SPECIFIED MINIMUM PIPE SIZE(INCH) = 8.00
SPECIFIED PERCENT OF GRADIENTS(DEcimal) TO USE FOR FRICTION SLOPE = .90
*DATA BANK RAINFALL USED*
*ANTECEDENT MOISTURE CONDITION (AMC) II ASSUMED FOR RATIONAL METHOD*

*USER-DEFINED STREET-SECTIONS FOR COUPLED PIPEFLOW AND STREETFLOW MODEL*

<table>
<thead>
<tr>
<th>NO.</th>
<th>(FT)</th>
<th>(FT)</th>
<th>(FT)</th>
<th>(FT)</th>
<th>(FT)</th>
<th>(FT)</th>
<th>(n)</th>
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<td>20.0</td>
<td>0.018/0.018/0.020</td>
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GLOBAL STREET FLOW-DEPTH CONSTRAINTS:
1. Relative Flow-Depth = 0.00 FEET
   as (Maximum Allowable Street Flow Depth) - (Top-of-Curb)
2. (Depth)*(Velocity) Constraint = 6.0 (FT*FT/S)

*SIZE PIPE WITH A FLOW CAPACITY GREATER THAN OR EQUAL TO THE UPSTREAM TRIBUTARY PIPE.*
*USER-SPECIFIED MINIMUM TOPOGRAPHIC SLOPE ADJUSTMENT NOT SELECTED*

FLOW PROCESS FROM NODE 16.00 TO NODE 11.00 IS CODE = 21

>>>RATIONAL METHOD INITIAL SUBAREA ANALYSIS<<<
>>USE TIME-OF-CONCENTRATION NOMOGRAPH FOR INITIAL SUBAREA<<
INITIAL SUBAREA FLOW-LENGTH(FEET) = 300.00
ELEVATION DATA: UPSTREAM(Feet) = 94.00 DOWNSTREAM(Feet) = 89.30

\[ T_c = K^*[(\text{LENGTH}^2\cdot 3.00)/(\text{ELEVATION CHANGE})]^{*0.20} \]
SUBAREA ANALYSIS USED MINIMUM Tc(Min.) = 6.835
* 25 YEAR RAINFALL INTENSITY(INCH/HR) = 4.042

SUBAREA Tc AND LOSS RATE DATA(AMC II):

<table>
<thead>
<tr>
<th>DEVELOPMENT TYPE/SCS SOIL AREA</th>
<th>Fp</th>
<th>Ap</th>
<th>SCS</th>
<th>Tc</th>
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<tr>
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<td></td>
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<tr>
<td>COMMERCIAL D 2.63 0.20 0.100 75 6.83</td>
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</tbody>
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SUBAREA AVERAGE PERVIOUS LOSS RATE, \( Fp(\text{INCH/HR}) = 0.20 \)
SUBAREA AVERAGE PERVIOUS AREA FRACTION, \( Ap = 0.100 \)
SUBAREA RUNOFF(CFS) = 9.52
TOTAL AREA(ACRES) = 2.63 PEAK FLOW RATE(CFS) = 9.52

******************************************************************************
FLOW PROCESS FROM NODE 12.00 TO NODE 13.00 IS CODE = 21

>>> RATIONAL METHOD INITIAL SUBAREA ANALYSIS <<<
USE TIME-OF-CONCENTRATION NOMOGRAPFH FOR INITIAL SUBAREA <<<

INITIAL SUBAREA FLOW-LENGTH(Feet) = 350.00
ELEVATION DATA: UPSTREAM(Feet) = 94.20 DOWNSTREAM(Feet) = 88.30

\[ T_c = K^*[(\text{LENGTH}^2\cdot 3.00)/(\text{ELEVATION CHANGE})]^{*0.20} \]
SUBAREA ANALYSIS USED MINIMUM Tc(Min.) = 7.164
* 25 YEAR RAINFALL INTENSITY(INCH/HR) = 3.935

SUBAREA Tc AND LOSS RATE DATA(AMC II):

<table>
<thead>
<tr>
<th>DEVELOPMENT TYPE/SCS SOIL AREA</th>
<th>Fp</th>
<th>Ap</th>
<th>SCS</th>
<th>Tc</th>
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<tbody>
<tr>
<td>LAND USE GROUP (ACRES) (INCH/HR) (DECIMAL) CN (MIN.)</td>
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<td></td>
</tr>
<tr>
<td>COMMERCIAL D 3.37 0.20 0.100 75 7.16</td>
<td></td>
<td></td>
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</tbody>
</table>

SUBAREA AVERAGE PERVIOUS LOSS RATE, \( Fp(\text{INCH/HR}) = 0.20 \)
SUBAREA AVERAGE PERVIOUS AREA FRACTION, \( Ap = 0.100 \)
SUBAREA RUNOFF(CFS) = 11.88
TOTAL AREA(ACRES) = 3.37 PEAK FLOW RATE(CFS) = 11.88

******************************************************************************
FLOW PROCESS FROM NODE 20.00 TO NODE 22.00 IS CODE = 21

>>> RATIONAL METHOD INITIAL SUBAREA ANALYSIS <<<
USE TIME-OF-CONCENTRATION NOMOGRAPFH FOR INITIAL SUBAREA <<<

INITIAL SUBAREA FLOW-LENGTH(Feet) = 225.00
ELEVATION DATA: UPSTREAM(Feet) = 94.30 DOWNSTREAM(Feet) = 90.50

\[ T_c = K^*[(\text{LENGTH}^2\cdot 3.00)/(\text{ELEVATION CHANGE})]^{*0.20} \]
SUBAREA ANALYSIS USED MINIMUM Tc(Min.) = 6.001
* 25 YEAR RAINFALL INTENSITY(INCH/HR) = 4.350

SUBAREA Tc AND LOSS RATE DATA(AMC II):

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<tr>
<th>DEVELOPMENT TYPE/SCS SOIL AREA</th>
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<td>COMMERCIAL D 0.63 0.20 0.100 75 6.00</td>
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</tbody>
</table>

SUBAREA AVERAGE PERVIOUS LOSS RATE, \( Fp(\text{INCH/HR}) = 0.20 \)
SUBAREA AVERAGE PERVIOUS AREA FRACTION, \( Ap = 0.100 \)
SUBAREA RUNOFF(CFS) = 2.46
TOTAL AREA (ACRES) = 0.63 PEAK FLOW RATE (CFS) = 2.46

END OF STUDY SUMMARY:
TOTAL AREA (ACRES) = 0.6 TC (MIN.) = 6.00
EFFECTIVE AREA (ACRES) = 0.63 AREA-AVERAGED Fm (INCH/HR) = 0.02
AREA-AVERAGED Fp (INCH/HR) = 0.20 AREA-AVERAGED Ap = 0.100
PEAK FLOW RATE (CFS) = 2.46

END OF RATIONAL METHOD ANALYSIS
APPENDIX 2 - Hydraulic Calculations
(A) DISCHARGE PER FOOT OF LENGTH OF CURB OPENING INLETS WHEN INTERCEPTING 100% OF GUTTER FLOW

(B) PARTIAL INTERCEPTION RATIO FOR INLETS OF LENGTHLESS THAN L

CAPACITY OF INLETS

FIGURE 5-10
6. **Example:**

![Inlet Definition Figure](image)

**Figure 5-11**

**a. Given:**

- $Q$ in street = 6 cfs
- Curb height = 8"
- Depth of water at curb, $y$ = 4.75"
- Height of local depression, $a$ = 4"

Use Standard curved face inlet (see Figure 5-7)

**b. Calculations:**

- Height of curb opening, $h = 9.3"$ (from Table 5-4)
- Check that $h > a + y$
  - $9.3" > 4.75" + 4"$ (OK)
- From Figure 5-10 (A) (for $a = 4"$, $y = 4.75" = .4'$)
  - $Q/L = 0.44$ cfs/ft.
- Therefore length of catch basin
  - $L = Q/(Q/L) = 6/0.44 = 13.6$ ft.

Use 14 ft. catch basin.

**c. Standard Calculation Format**

A standard form calculation format has been included as Figure 5-12.
CURB OPENING (Interception)

Plan Sketch

GIVEN:

(a) Discharge $Q_{wq} = 0.8$ CFS
(b) Street slope $S = 0.005$ '/'
(c) Curb type "A2-6" "D" other ______
(d) Half street width = 18 ft.

SOLUTION: Street capacity table reference 5-2

$Q/S^2 = 0.8 / (0.005)^2 = 11.3$. Therefore $y = 0.26$.  

$Q/L = 3.1$ [from Figure 5-10(A)]

$L = Q/(Q/L) = 0.8 / 3.1 = 0.3$ (L for total interception)

TRY:

$L_p = 4$ ft.

$L_p/L = ____/____ = ______

$a/y = .33/____ = ______

$Q_p/Q = ____$ [from Figure 5-10(B)]

$Q_p = (Q_p/Q) \times Q = ____ \times ____ = ____$ CFS (Intercepted)

$Q_c = Q - Q_p = ____ - ____ = ____$ CFS (Carryover)
CURB OPENING (INTERCEPTION)

Plan Sketch

GIVEN:

(a) Discharge $Q_{wq} = 0.2$ CFS
(b) Street slope $S = 0.005$ \( \text{\prime/\prime} \)
(c) Curb type "A2-6" "D" other 
(d) Half street width = 18 \( \text{ft} \).

SOLUTION: Street capacity table reference 5.2

\[
Q/S^{0.2} = {0.2}/{(0.005)^{0.2}} = 2.8 \text{. Therefore } y = 0.2 \text{.}
\]

$Q/L = 2.7 \text{ [from Figure 5-10(A)]}$

$L = Q/(Q/L) = {0.2}/{2.7} = 0.07 \text{ (L for total interception)}$

TRY:

$L_p = 4 \text{ ft.}$

$L_p/L = \_/_\_ = \_\_$

$a/y = 0.33/\_\_ = \_\_$

$Q_p/Q = \_\_ \text{ [from Figure 5-10(B)]}$

$Q_p = (Q_p/Q) \times Q = \_\_ \times \_\_ = \_\_ \text{ CFS (Intercepted)}$

$Q_c = Q - Q_p = \_\_ - \_\_ = \_\_ \text{ CFS (Carryover)}$
7. **Capacity of Curb Opening Inlets in a Low Point or Sump**

   The capacity of a curb opening inlet in a sump or low point varies with the length of the inlet (L) and the depth of water at the entrance (H = a + y). The inlet will operate as a weir until the water submerges the entrance. When the depth of water is about twice the height of the entrance or more, it will operate as an orifice. Between these two depths the inlet will operate somewhere between a weir and orifice.

8. **Nomograph Figure 5-13 Parameters**

   a. **Physical basis of Nomograph**

      - The curb opening inlet may be located on a continuous grade or at a low point in the grade. Low point is created by depressed gutter on continuous grade street.
      - All flow coming to the inlet must eventually enter the inlet and will pond until sufficient head is built up so the flow through the inlet will equal the peak inflow from the gutters.

   b. **The hydraulic basis of the nomograph is as follows:**

      - For heads (depth of water) less than the height of the opening (i.e., H/h less than 1.0), the inlet acts as a weir with the flow passing through critical depth at the entrance per the formula:

        \[ Q = 3.087 \frac{LH^{3/2}}{} \]

        **NOTE:** This condition assumes no pressure flow in storm drain to cause a head to restrict a critical depth flow at entrance.

      - For heads with H/h between 1 and 2, a transition was used as the operation of the inlet is not defined.

      - For head equal to or greater than twice the height of opening (i.e., H/h greater than 2), the inlet acts as an orifice per the formula:

        \[ Q = 5.62 \frac{h^{3/2}}{(H'/h)^{1/2} L} \]

        with H' equal to the head on the middle of the inlet opening (H' = H - h/2).
Homograph for capacity at curb opening inlets at low points

Bureau of Public Roads
Division Two, Wash., D.C.

Figure 5-13
<table>
<thead>
<tr>
<th>Flow Depth (ft)</th>
<th>Flow Area (sqft)</th>
<th>Flooded Street Width (ft)</th>
<th>Flooded Parkway Width (ft)</th>
<th>Street Half Width (ft)</th>
<th>Maximum S for Y=V=6</th>
<th>Conveyance Q/S**.5</th>
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**Exceeds Crown**

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<thead>
<tr>
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<th>Top of Curb (ft)</th>
<th>Top of Curb (ft)</th>
<th>Top of Curb (ft)</th>
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**Exit Excees Right-of-Way**

Street Capacity
Table 5-2
PROPOSED SOUTHWEST INLET IN QUASI-SUMP

GRATE INLET CAPACITY IN SUMP CONDITIONS

(Table assumes no clogging.)
### Worksheet for 24in Area A2 pipe

#### Project Description
- Friction Method: Manning Formula
- Solve For: Normal Depth

#### Input Data
- Roughness Coefficient: 0.013
- Channel Slope: 0.0200 ft/ft
- Diameter: 2.00 ft
- Discharge: 10.00 ft/s

#### Results
- Normal Depth: 0.77 ft
- Flow Area: 1.11 ft$^2$
- Wetted Perimeter: 2.67 ft
- Hydraulic Radius: 0.42 ft
- Top Width: 1.95 ft
- Critical Depth: 1.13 ft
- Percent Full: 38.4%
- Critical Slope: 0.00520 ft/ft
- Velocity: 9.00 ft/s
- Velocity Head: 1.26 ft
- Specific Energy: 2.03 ft
- Froude Number: 2.10
- Maximum Discharge: 34.41 ft$^3$/s
- Discharge Full: 31.99 ft$^3$/s
- Slope Full: 0.00195 ft/ft
- Flow Type: SuperCritical

#### GVF Input Data
- Downstream Depth: 0.00 ft
- Length: 0.00 ft
- Number Of Steps: 0

#### GVF Output Data
- Upstream Depth: 0.00 ft
- Profile Description
- Profile Headloss: 0.00 ft
- Average End Depth Over Rise: 0.00 %
- Normal Depth Over Rise: 38.40 %
- Downstream Velocity: Infinity ft/s
### Worksheet for 24in Area A2 pipe

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<tr>
<th>GVF Output Data</th>
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APPENDIX 3 - Support Figures and Maps
APPENDIX 4 - Hydrology Maps