



**Reichhardt & Ebe**  
ENGINEERING INC

RECEIVED  
FEB 06 2020  
CITY OF SUMAS

February 6, 2020

Lakeport Reach, LLC  
Unit 3A-33790 Industrial Ave  
Abbotsford, BC V2S 7T9

**RE: Sumas Concrete Products – Existing Culvert Evaluation**

To: Sev Samulski

*The following is a revision to the original report submitted on January 13, 2020. The revised document addresses comments from Washington Department of Fish and Wildlife (WDFW), the City of Sumas, and Freeland and Associates, Inc.*

It is our understanding that there are concerns on whether the Sumas Concrete Products development will potentially lead to flooding of the areas upstream of the site. The following is intended to be a description of assumptions and processes used to determine capacities of the existing system on the north side of the Sumas Concrete Products Project, along Kneuman Rd. More specifically, the evaluation will determine if any parts of the system will require replacement or widening.

The general steps for evaluating system capacity is as follows: a contributing area was created using Lidar from the Puget Sound Lidar Consortium and Google Earth aerial views. The larger contributing area was broken into smaller basins and given characteristics using Google Earth as a reference. After the basins were determined, a Stormshed model was created to find design flows. Finally, flows from the Stormshed model were compared against the estimated capacity of the system elements.

**Basin Analysis**

To create an accurate model in Stormshed, each basin needed to have a fair representation of the composition within it. Based on the topography and aerial imagery, each basin varied in size and included more than a few land uses, see Appendix A for a Contributing Basins exhibit. Table 1 shows each Basin being characterized by land use type, hydrologic soil group, curve number CN, and acres.

The following assumptions were made during the evaluation:

- 1) Areas south of Halverstick Road appear to drain towards other tributaries of Johnson Creek and is not included.
- 2) Areas south of the BNSF railroad will drain towards other tributaries of Johnson Creek and is not included.
- 3) Basin 2 will enter at the northwest corner of Basin 1 via a culvert crossing under Kneuman Road.

Table 1: Contributing Basin Composition

| Basin # | Land Use          | Soil Group  | CN (AMC II) | CN (AMC III) | Acres |
|---------|-------------------|-------------|-------------|--------------|-------|
| 1       | Open Space/Lawn   | Soil Type C | 90          | 95           | 14.5  |
|         | Pasture/Grassland | Soil Type C | 74          | 87           | 36    |
|         | Forested          | Soil Type C | 73          | 86           | 14.5  |
|         | Gravel            | Gravel      | 89          | 95           | 10    |
|         | Wetland           | Impervious  | 100         | 100          | 4     |
|         | Roofs/Roads       | Impervious  | 98          | 99           | 1     |
|         | Basin 1 Total     |             |             |              | 80    |
| 2       | Open Space/Lawn   | Soil Type C | 86          | 93           | 18.2  |
|         | Pasture/Grassland | Soil Type C | 74          | 87           | 72.8  |
|         | Forested          | Soil Type C | 73          | 86           | 54.6  |
|         | Roofs/Roads       | Impervious  | 98          | 99           | 36.4  |
|         | Basin 2 Total     |             |             |              | 182   |
| 3       | Open Space/Lawn   | Soil Type C | 86          | 93           | 91    |
|         | Pasture/Grassland | Soil Type C | 74          | 87           | 401   |
|         | Forested          | Soil Type C | 70          | 84           | 364   |
|         | Wetland           | Impervious  | 100         | 100          | 45.5  |
|         | Roofs/Roads       | Impervious  | 98          | 99           | 45.5  |
|         | Basin 3 Total     |             |             |              | 947   |
|         | Analysis Total    |             |             |              | 1209  |

The primary hydrologic soil group for each basin was determined to be "C" using the NRCS Soil Survey. Group C made up a majority of each basin and it was considered to be conservative to ignore any group B soils within the basin. Using the soil group and land use, a CN based on Table 2.3.2 in Ecology's (ECY) 2014 Stormwater Management Manual for Western Washington (SWMMWW) was determined. The CN values stated in the 2014 SWMMWW represent a typical antecedent soil moisture condition (AMC II). To be conservative, the CN values were upgraded to an AMC III event using Equation 5.5.8 in *Applied Hydrology* by Ven Te Chow, et al. McGraw Hill (1998). This scenario represents heavy or light rainfall and low temperatures having occurred during the previous five days. Finally, the acres were visually estimated using the aerial view.

### Stormshed Analysis and Existing System Evaluation

Alongside the information found in the Basin Analysis, the design precipitations for the Sumas area were determined using the 2-year, 10-year and 100-year Isopluvial maps in the 2014 ECY SWMMWW. A 25-year precipitation was estimated with an Isopluvial map provided in 'Appendix E' on the Whatcom County website. The values for the 2-year, 10-year, 25-year and 100-year events are 2.5-inches, 3.5-inches, 4-inches, and 4.5-inches, respectively. With the four storms included, the model for a AMC III storm had a 2-year peak flow of 141.1 CFS, a 10-year peak flow of 247.4 CFS, a 25-year peak flow of 303.4 CFS, and a 100-year peak flow of 360.4 CFS, see the attached Stormshed Report in Appendix E.

Additionally, the Kneuman Rd. and May Rd Wellfields are located within the contributing area. Per discussions with the City of Sumas, the Kneuman Rd Wellfield does not discharge to Johnson Creek

tributaries while the May Rd. Wellfield will. A Superseding Certificate for the wellfields shows a peak discharge of 18 GPM to for every 100 GPM withdrawn, up to a maximum of 1,660 GPM, see Appendix C. This equates to approximately 0.67 CFS and was added to each design flow. It's important to note that the wellfield discharge will peak during the summer months and are unlikely to have significant impacts on the system. Addition of 0.67 CFS to the 25-year flow of 303.4 CFS is only a 0.2% increase.

Survey provided by Northwest Survey and GPS (NWS), provided a rough geometry of the water course, downstream of the existing Lakeport Reach culvert, located at the north end of the site along Kneuman Rd. The NWS survey was also used to determine an approximate overflow path for the existing Lakeport Reach culvert, see attached marked-up drawing in Appendix A. The existing buildings and a majority of the site sit higher than the Kneuman Road edge of pavement (EOP) and slopes north. As illustrated in the Impact Area Exhibit in Appendix A, the existing buildings are at a finished floor elevation of 42.00 and already impede flow from entering the site. Generally, water that overtops the channel bank would flow over the two driveways on the north side of the project towards the downstream section. As the elevation of the overtopped water reaches 41.86-feet, it will begin to overtop onto the roadway before flooding the site. Raising the site to a finished grade of 44.00 will impede an additional amount of stormwater, however, this area is considered to be small and can be mitigated by upgrading the system through removal of the existing culvert.

A site visit performed by Reichhardt & Ebe on January 10, 2020 provided rough geometry to the channel directly upstream of the culvert crossing, see attached Photo Report in Appendix B. During the site visit, it was discovered that there were corrugated metal (CMP) culverts downstream of the site appearing to be 4-feet in diameter. WDFW performed their own site survey to determine culvert characteristics near the site, see attached WDFW Evaluations in Appendix D. The culvert submerged at the northside of the Lakeport Reach project site was determined to be 4-feet in diameter, corrugated steel, and at a negative slope. WDFW also confirmed the culvert downstream of the site is 4-feet in diameter, corrugated steel, and at a slope of 0.02%. The downstream culverts were included in the evaluation for capacity comparisons.

The following assumptions were made during the evaluation:

- 1) The existing 4-foot Lakeport Reach culvert is submerged and assumed to have a head of 2-feet above the culvert.
- 2) Any blockages in the upstream or downstream channel are far enough away to have little to no effect on the Lakeport Reach culvert evaluation.
- 3) The upstream channel is trapezoidal in shape, at a slope 0.7%, has an average bottom width of 2-feet, an average depth of 6.5-feet, and side slopes of 1:1.
- 4) The downstream channel is trapezoidal in shape, at a slope of 0.43%, has an average bottom width of 28-feet, an average depth of 3.5-feet, and side slopes of 2:1.
- 5) Reaches appear to be weedy and have deep pools. Per Table 4.1 of "Open Channel Hydraulics", by Terry W. Sturm, use a Manning's coefficient = 0.070.
- 6) The corrugated steel culverts will have a Manning's coefficient = 0.030 per Table 4.1 of "Open Channel Hydraulics", by Terry W. Sturm.

Taking all the assumptions into consideration, the Manning's equation was used to estimate the capacity of the upstream channel, downstream channel, and downstream 4-foot corrugated steel culverts. The 4-foot Lakeport Reach culvert capacity using Figure 4.3.1.C of the King County Surface Water Design Manual. See the appropriate capacity calculations in Appendix E.

Table 2: Capacity Comparison for an AMC II Storm

| Reach              | Estimated Capacity (cfs) | 2-Year Flow (cfs) | Capacity? | 10-Year Flow (cfs) | Capacity? | 25-Year Flow (cfs) | Capacity? | 100-Year Flow (cfs) | Capacity? |
|--------------------|--------------------------|-------------------|-----------|--------------------|-----------|--------------------|-----------|---------------------|-----------|
| Upstream Channel   | 190.76                   | 54.82             | Yes       | 125.16             | Yes       | 166.79             | Yes       | 211.68              | No        |
| Lakeport Culvert   | 140.00                   | 54.82             | Yes       | 125.16             | Yes       | 166.79             | No        | 211.68              | No        |
| Downstream Channel | 339.27                   | 54.82             | Yes       | 125.16             | Yes       | 166.79             | Yes       | 211.68              | Yes       |
| 4-ft CMP Culvert   | 8.80                     | 54.82             | No        | 125.16             | No        | 166.79             | No        | 211.68              | No        |

Table 3: Capacity Comparison for an AMC III Storm

| Reach              | Estimated Capacity (cfs) | 2-Year Flow (cfs) | Capacity? | 10-Year Flow (cfs) | Capacity? | 25-Year Flow (cfs) | Capacity? | 100-Year Flow (cfs) | Capacity? |
|--------------------|--------------------------|-------------------|-----------|--------------------|-----------|--------------------|-----------|---------------------|-----------|
| Upstream Channel   | 190.76                   | 141.73            | Yes       | 248.03             | No        | 304.02             | No        | 361.02              | No        |
| Lakeport Culvert   | 140.00                   | 141.73            | No        | 248.03             | No        | 304.02             | No        | 361.02              | No        |
| Downstream Channel | 339.27                   | 141.73            | Yes       | 248.03             | Yes       | 304.02             | Yes       | 361.02              | No        |
| 4-ft CMP Culvert   | 8.80                     | 141.73            | No        | 248.03             | No        | 304.02             | No        | 361.02              | No        |

To illustrate the impact of upgrading to an AMC III storm, Table 2 and Table 3 show the estimated capacity of each primary element verses the design flow. In a typical condition, AMC II, the system surrounding the Lakeport Reach culvert can handle the 2-year and 10-year storms before failing. As conditions upgrade to an AMC III as described in the Basin Analysis section, design flows drastically increase and cause the system to fail at smaller events. More specifically, the Upstream Channel can only convey a 2-year storm and the Lakeport Culvert cannot convey any design storm.

Through this evaluation, it has been determined that the existing Lakeport Reach culvert is undersized for the 2-year, 10-year, 25-year and 100-year design flows and will require replacement. It is recommended that the Lakeport Reach culvert be removed and replaced by a channel section with similar geometry and similar flow characteristics to the upstream reach. The proposed channel would transition from the constrained condition in the upstream reach, to a more natural creek configuration with a 2:1 side slope as it connects to the reach downstream of the Lakeport Reach culvert. A channel section with a 2:1 side slope is estimated to convey a maximum flow of 304.3 CFS, see calculations in Appendix E. This would add capacity to the area and reduce the potential of overflow on to the roadway when the site is raised to an elevation of 44.00-feet.

Per the site visit, it is also recommended that any potential blockages be addressed to increase efficiency of the entire system to convey design flows. As shown in the photo survey, there are a few instances upstream and downstream of the Lakeport Reach culvert that may need further evaluations. Most notably, flow is slow moving prior to the Sumas Creek 2004 Habitat Improvement area, downstream of Lakeport, and appears to be faster flowing afterwards. Since this analysis includes the blockages in the estimated capacity, addressing any blockage issues in this area may reduce the flooding potential of the creek in the future and increase its flow capacity. Furthermore, the 4-foot CMP culverts downstream of the Lakeport Reach Project area appear to have insufficient capacity to convey the design flows with the simplified analysis. The culverts may be an issue in the future and should be analyzed with a greater level of detail.

## Conclusions

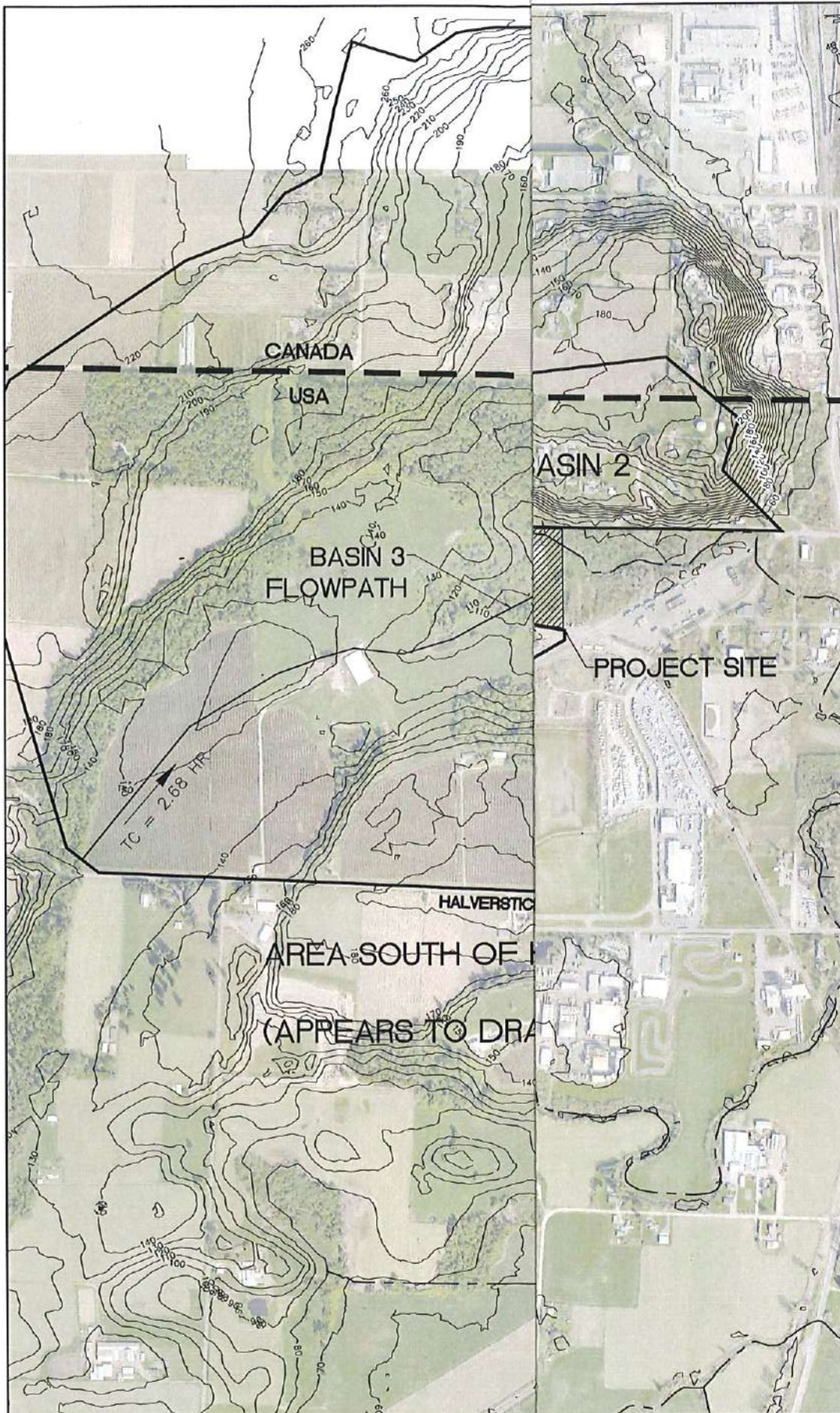
It appears from our simplified analysis that the channel capacity is not the limiting factor. Potential obstructions within the Sumas Creek 2004 Habitat Improvement area and the undersized Lakeport Reach 4-foot culvert may be the cause. Our recommendation to remove the 4-foot Lakeport Reach culvert and install a channel cross section that transitions from the constrained upstream condition to a more natural creek configuration with a 2:1 side slope would drastically increase flow potential to a point that issues would only be observed at a return frequency of greater than once every 25-years. This would exceed the upstream capacity and reduce the chance of flooding onto the roadway.

Sincerely,



Dale L. Buys, P.E.  
Reichhardt & Ebe Engineering, Inc.

## APPENDIX A



**EXHIBIT**

DESIGNED BY  
JAM  
DRAWN BY  
JAM/LMH  
CHECKED BY  
KK/DLB

**R&P** CTs  
P.O. Box 978  
Lynden, WA 98949

DWG 16030 LIDAR

JOB#

16030

SCALE

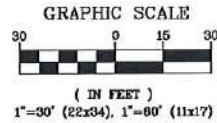
H: 1"=500' V: NA

DATE

2/3/20

SHEET

1  
of 1



### DEMOLITION LEGEND

- PROPOSED SAWCUT
- PROPOSED GRIND
- PROPOSED DEMOLITION AREA
- PROPOSED CLEARING AND GRUBBING (LIMITS)

### EROSION CONTROL LEGEND

WASHINGTON STATE DEPT. OF ECOLOGY  
BEST MANAGEMENT PRACTICES (BMP)  
REF: STORMWATER MANAGEMENT MANUAL  
FOR WESTERN WASHINGTON, 2012

NOTES:

1. BMP C120 (PERMANENT SEEDING) AND BMP C130 (SURFACE ROUGHENING) SHOWN IN LANDSCAPING AND PLANTING PLAN.
2. SEE TESC DETAILS AND TESC GENERAL NOTES, SHEET 5.
3. GENERALLY THE SILT FENCE AND CLEARING LIMITS FOLLOW THE RIGHT OF WAY OR CONSTRUCTION EASEMENTS UNLESS OTHERWISE DRAWN ON THE PLANS. THERE ARE AREAS WHERE THE HIGH VISIBILITY SILT FENCE IS DELINEATING THE MAXIMUM EXTENT OF WETLAND IMPACTS.



- (BF) — BMP C103 AND C233: CLEARING LIMITS AND SILT FENCE — SEE DETAIL SHEET 5
- (CE) — BMP C105/C106: STABILIZED CONSTRUCTION ENTRANCE — SEE DETAIL SHEET 5
- (P) — BMP C220: INLET PROTECTION — CB INSERT — SEE DETAIL SHEET 5
- (CD) — BMP C208: GEOTEXTILE ENCASED CHECK DAM — SEE DETAIL SHEET 5
- (BC) — BMP C105 AND C140: STREET CLEANING
- (SM) — BMP C120: TEMPORARY & PERMANENT SEEDING & MULCHING. SEE PLANTING PLANS FOR LIMITS
- (DC) — BMP C140: DUST CONTROL
- (FV) — BMP C101: PRESERVE EXISTING VEGETATION



KNEUMAN ROAD

N 89°53'00"E 600.44'

EOP EL: 42.10

EOP EL: 40.27

EOP EL: 40.43

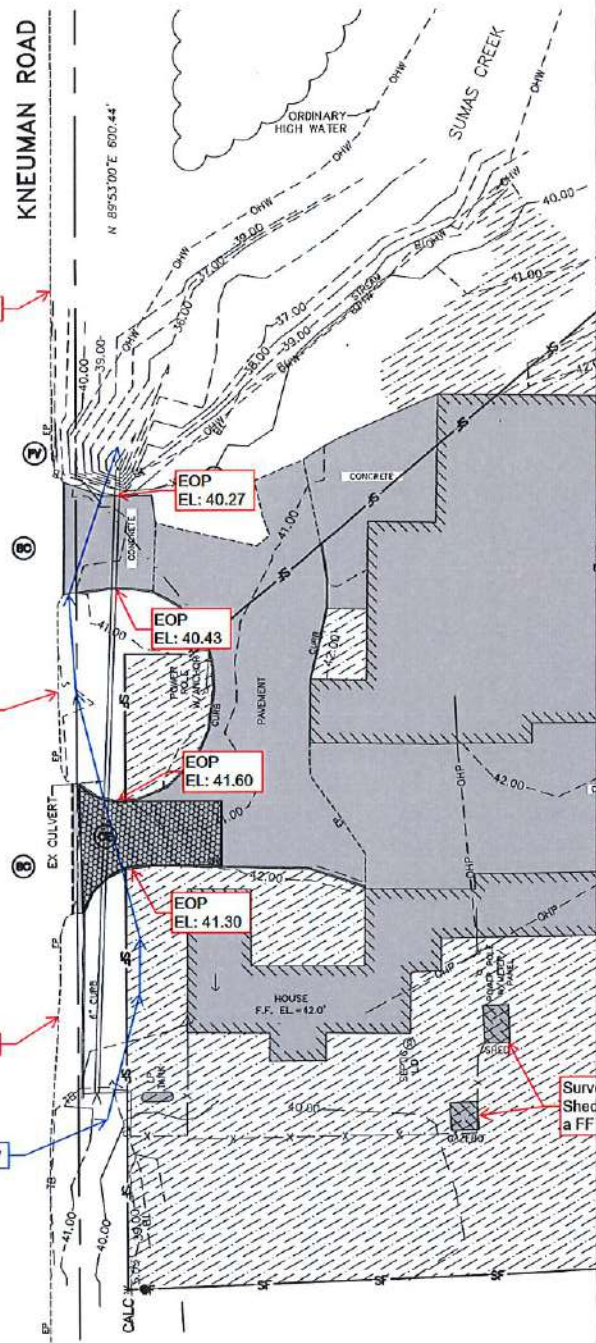
EOP EL: 41.15

EOP EL: 41.60

EOP EL: 41.30

EOP EL: 41.86

Approximate Overflow



PRELIMINARY

DESIGNED BY  
KK  
DRAWN BY  
KK/LMH  
CHECKED BY  
CR

**R&E PRODUCTS**  
P.O. Box 978148  
813 Metcalf Blvd

DWG 16030 PLAN

JOB#

16030

SCALE

H: 1"=30'

V: N/A

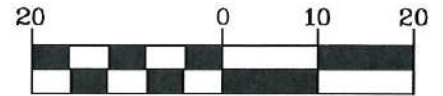
DATE

12/21/2018

SHEET

3  
of 16

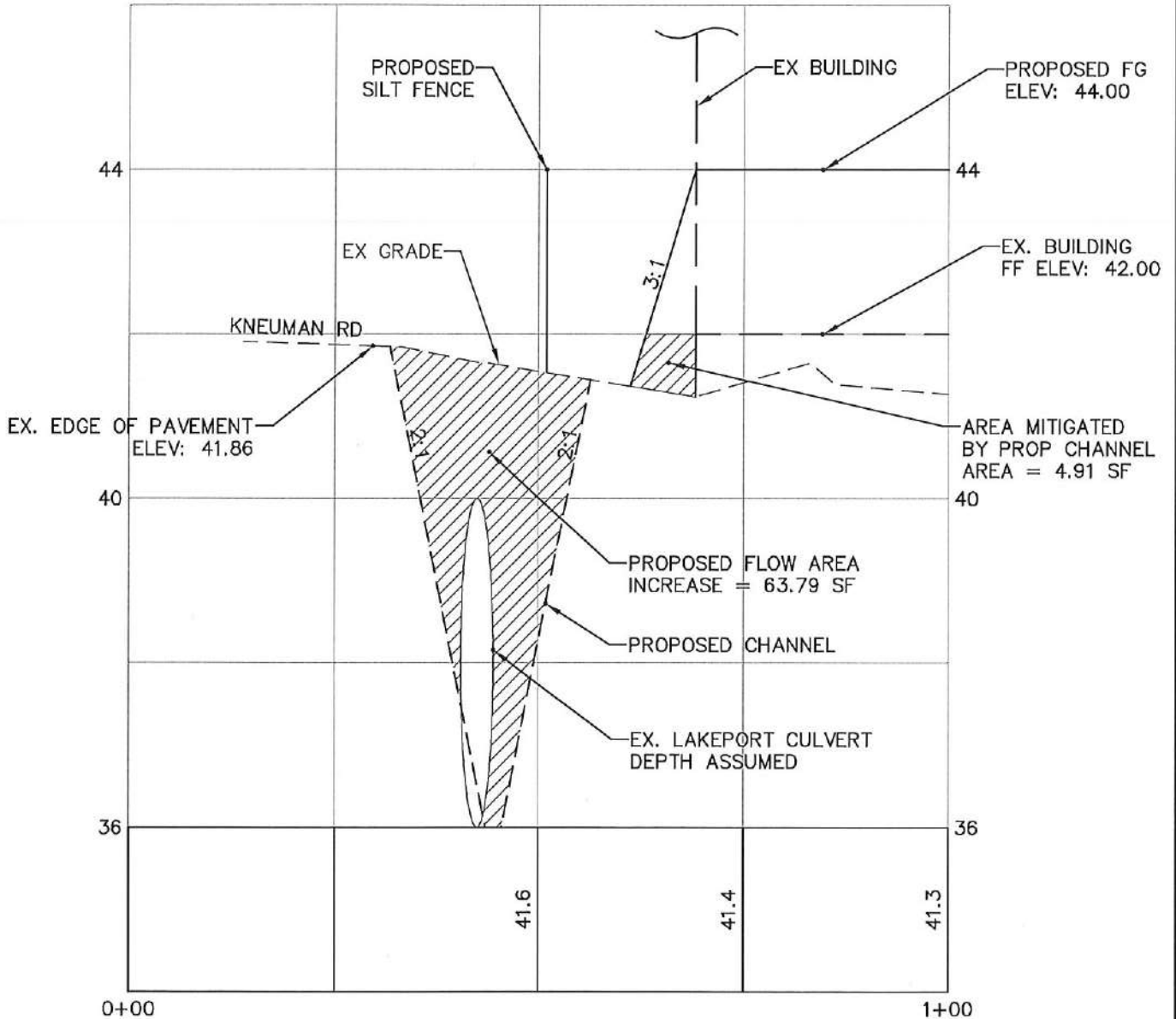
# GRAPHIC SCALE



( IN FEET )

1"=20' H, 1"=2' V (22x34)

1"=40' H, 1"=4' V (11x17)



**R&E** Reichhardt & Ebe  
ENGINEERING INC

P.O. Box 978 | 423 Front Street  
Lynden, WA 98264 (360) 354-3687

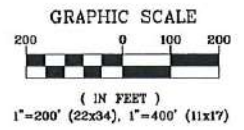
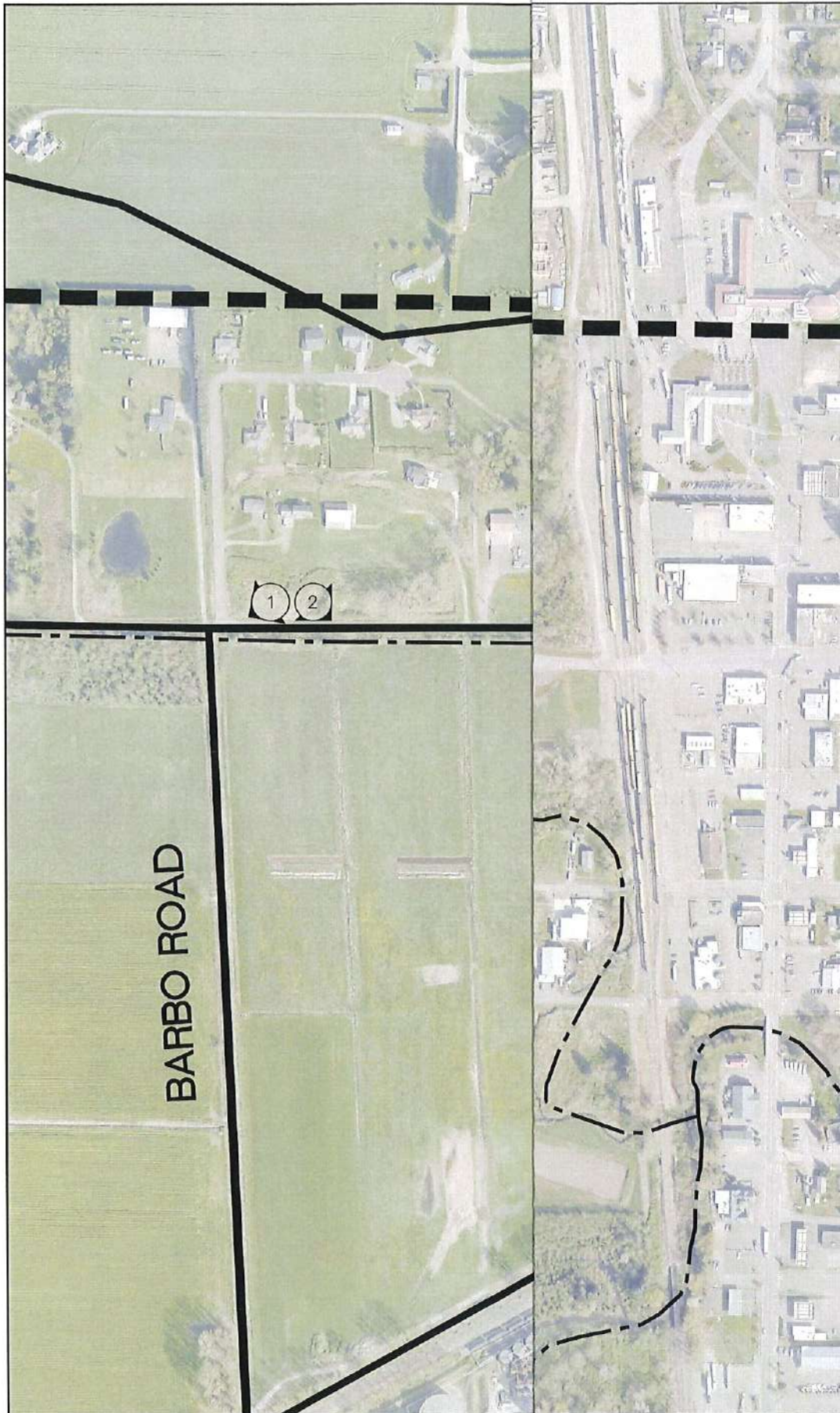
LAKEPORT REACH, LLC  
IMPACT AREA EXHIBIT

2/5/2020

1:20

16030

## **APPENDIX B**



EXHIBIT

DESIGNED BY  
JAM  
DRAWN BY  
JAM/LMH  
CHECKED BY  
KK/DLB

**R&I** CTs  
P.O. Box 978  
Lynden, WA 99225

DWG 16030 LIDAR

JOB#

16030

SCALE

H: 1"=200'

V: NA

DATE

2/3/20

SHEET

1  
of 1

**RE: Sumas Concrete Products – Conveyance Photo Survey**

A photo survey of the current conditions was performed January 10, 2020.



**Photo 1: A view of the roadside ditch at the corner of Barbo Rd and Kneuman Rd. The current ditch conditions show a backed-up channel slow moving water with a fair amount of vegetation.**



**Photo 2: View of the ditch on the southside of Kneuman Rd looking east. Water is slow moving with a fair amount of vegetation. There is a fallen tree, potentially causing a blockage and slower moving flow in the ditch.**



**Photo 3: The ditch appears to bottleneck as it approaches the culvert crossing. Ditch continues to have a fair amount of vegetation.**



**Photo 4: Upstream of the culvert inlet. Flow depth is roughly 5.5-ft to 6.5-ft and the top width is roughly 13-ft to 15-ft in this area. Culvert is fully submerged and could not be surveyed at this time.**



**Photo 5: Ditch after the culvert crossing widens. Culvert is submerged and could not be surveyed at this time. Submergence is likely caused by an offsite downstream flow obstruction.**



**Photo 6: There appears to be a potential blockage in the channel just after the culvert crossing. Conditions made it difficult to access the area safely for assessment.**



**Photo 7: Creek downstream of the Sumas Creek 2004 Habitat Improvement area appears to be flowing more freely than the upstream condition. Conditions resulting in the increased flow could not be determined during the site visit.**



**Photo 8: There are large culverts in the creek downstream of the project site. They were estimated visually to be roughly 4-ft in diameter. Conditions made it difficult to access the culverts safely for an accurate measurement.**

## APPENDIX C

CITY OF SUMAS  
433 CHERRY STREET  
SUMAS WA 98295

**DOCUMENT TITLE:** SUPERSEDING CERTIFICATE

**REFERENCE NUMBER:** 2091201273

**GRANTOR**

STATE OF WASHINGTON  
DEPARTMENT OF ECOLOGY  
ECOLOGY NORTHWEST REGIONAL OFFICE (ECY NWRO)  
3190 - 160TH AVE SE  
BELLEVUE, WASHINGTON 98008-5452  
(425) 649-7000

**GRANTEE**

CITY OF SUMAS  
433 CHERRY STREET  
SUMAS, WA 98295

**LEGAL DESCRIPTION**

| Source Name | Parcel           | Township | Range | Sec | QQ Q |
|-------------|------------------|----------|-------|-----|------|
| KRW WELL 2  | 4104334412930000 | 41N      | 04E   | 33  | SENE |
| KRW WELL 2R | 4104334412930000 | 41N      | 04E   | 33  | SENE |
| KRW WELL 3  | 4104334412930000 | 41N      | 04E   | 33  | SENE |
| KRW WELL 4  | 4104334412930000 | 41N      | 04E   | 33  | SENE |
| KRW WELL 4R | 4104334412930000 | 41N      | 04E   | 33  | SENE |
| KRW WELL 5  | 4104334412930000 | 41N      | 04E   | 33  | SENE |
| MRW WELL 1  | 4104331061080000 | 41N      | 04E   | 33  | SWSW |
| MRW WELL 2  | 4104331061080000 | 41N      | 04E   | 33  | SWSW |
| MRW WELL 3  | 4104331061080000 | 41N      | 04E   | 33  | SWSW |
| MWA WELL 2  | 4004074943620000 | 40N      | 04E   | 07  | SENE |
| MWA WELL 3  | 4004074943620000 | 40N      | 04E   | 07  | SENE |

**AUTHORIZED PLACE OF USE**

The place of use (POU) of the water right is the service area described in the most recent City of Sumas Water System Plan approved by the Washington State Department of Health, so long as the water system is and remains in compliance with the criteria in RCW 90.03.386(2). RCW 90.03.386 may have the effect of revising the place of use of this water right.

**PARCELS:**

**ADDITIONAL LEGAL IS ON PAGE 2 OF ATTACHED DOCUMENT**



STATE OF WASHINGTON  
DEPARTMENT OF ECOLOGY  
SUPERSEDING CERTIFICATE  
G1-26398C



*This is to certify that the herein named applicant has made proof to the satisfaction of the Department of Ecology (Ecology) of a right to use the public waters of the State of Washington as herein defined, and under and specifically subject to the provisions contained in the Permit, Certificate, and two Change Authorizations issued by Ecology, and that said right to use said waters has been perfected in accordance with the laws of the State of Washington, and hereby confirmed by Ecology and entered of record as shown, but is limited to an amount actually beneficially used.*

*This certificate supersedes Water Right Certificate G1-26398C Issued on December 7, 2009 and is subject to the following attributes and provisions.*

PRIORITY DATE  
October 24, 1991

WATER RIGHT CERTIFICATE NUMBER  
G1-26398C

MAILING ADDRESS  
City of Sumas  
c/o Ruben Hernandez, Public Works Director  
433 Cherry Street  
Sumas, WA 98295

SITE ADDRESS (IF DIFFERENT)

**Total Quantity Authorized for Withdrawal**

| WITHDRAWAL RATE | UNITS | ANNUAL QUANTITY (AC-FT/YR) |
|-----------------|-------|----------------------------|
| 860             | GPM   | 1376.0                     |

- Quantities withdrawn under G1-23698C and G1-26398C (this right) shall not exceed 1660 gallons per minute (GPM) and 1825.0 acre-feet per year (AC-FT/YR).
- Due to hydraulic continuity Johnson Creek shall be augmented at a rate of 18 GPM for every 100 GPM withdrawn under G1-23698C and G1-26398C. Stream augmentation is to occur simultaneously as the water is withdrawn. Stream augmentation shall occur as near to the utilized point(s) of withdrawal as feasible.

**Purpose**

| PURPOSE                  | WITHDRAWAL RATE |              |       | ANNUAL QUANTITY (AC-FT/YR) |              | PERIOD OF USE |
|--------------------------|-----------------|--------------|-------|----------------------------|--------------|---------------|
|                          | ADDITIVE        | NON-ADDITIVE | UNITS | ADDITIVE                   | NON-ADDITIVE |               |
| Municipal and mitigation | 860             |              | GPM   | 1376.0                     |              | 01/01 – 12/31 |
| Superseded Certificate   |                 |              | 1     |                            |              | G1-26398C     |

| IRRIGATED ACRES |              | PUBLIC WATER SYSTEM INFORMATION |             |
|-----------------|--------------|---------------------------------|-------------|
| ADDITIVE        | NON-ADDITIVE | WATER SYSTEM ID                 | CONNECTIONS |
| N/A             | N/A          | 84870B                          | 622+        |

### Source Location

| COUNTY  | WATERBODY   | TRIBUTARY TO | WATER RESOURCE INVENTORY AREA |
|---------|-------------|--------------|-------------------------------|
| Whatcom | Groundwater |              | 1-Nooksack                    |

| SOURCE NAME | STATUS | PARCEL           | WELL TAG | TOWNSHIP | RANGE | SECTION | QQ Q | LATITUDE  | LONGITUDE   |
|-------------|--------|------------------|----------|----------|-------|---------|------|-----------|-------------|
| KRW Well 2  | M/E    | 4104334412930000 | AGK373   | 41N      | 04E   | 33      | SENE | 49.000695 | -122.289418 |
| KRW Well 2R | A      | 4104334412930000 | BCS869   | 41N      | 04E   | 33      | SENE | 49.000671 | -122.289435 |
| KRW Well 3  | A      | 4104334412930000 | ACK313   | 41N      | 04E   | 33      | SENE | 49.000880 | -122.289520 |
| KRW Well 4  | M/E    | 4104334412930000 | AGK337   | 41N      | 04E   | 33      | SENE | 49.000770 | -122.288880 |
| KRW Well 4R | A      | 4104334412930000 | ACR785   | 41N      | 04E   | 33      | SENE | 49.000770 | -122.288890 |
| KRW Well 5  | A      | 4104334412930000 | AGK361   | 41N      | 04E   | 33      | SENE | 49.000605 | -122.289033 |
| MRW Well 1  | A      | 4104331061080000 | AGK351   | 41N      | 04E   | 33      | SWSW | 48.994530 | -122.302120 |
| MRW Well 2  | M/E    | 4104331061080000 | AGF270   | 41N      | 04E   | 33      | SWSW | 48.995950 | -122.302180 |
| MRW Well 3  | A      | 4104331061080000 | AGK357   | 41N      | 04E   | 33      | SWSW | 48.995760 | -122.302208 |
| MWA Well 2  | A      | 4004074943620000 | ABO392   | 40N      | 04E   | 07      | SENE | 48.973667 | -122.331554 |
| MWA Well 3  | A      | 4004074943620000 | AGO439   | 40N      | 04E   | 07      | SENE | 48.973650 | -122.331517 |

Sources: KRW – Kneuman Road Wellfield (City of Sumas)  
MRW – May Road Wellfield (City of Sumas)  
MWA – Meadowbrook Water Association

Datum: NAD83/WGS84

Status: M – Monitoring  
E – Emergency  
A – Active

### Place of Use

#### LEGAL DESCRIPTION OF THE AUTHORIZED PLACE OF USE

The place of use (POU) of the water right is the service area described in the most recent City of Sumas Water System Plan approved by the Washington State Department of Health, so long as the water system is and remains in compliance with the criteria in RCW 90.03.386(2). RCW 90.03.386 may have the effect of revising the place of use of this water right.

### Measurement of Water Use

|                                                       |                                         |
|-------------------------------------------------------|-----------------------------------------|
| HOW OFTEN MUST WATER USE BE MEASURED?                 | Weekly                                  |
| HOW OFTEN MUST WATER USE DATA BE REPORTED TO ECOLOGY? | Annually (by January 31 <sup>st</sup> ) |
| WHAT VOLUME SHOULD BE REPORTED?                       | Total Annual Volume (in Acre-Feet)      |
| WHAT RATE SHOULD BE REPORTED?                         | Annual Peak Rate of Withdrawal (in gpm) |

### Provisions

#### 1. Wells, Well Logs and Well Construction Standards

All water wells constructed within the state must meet the construction requirements of chapter 173-160 WAC titled "Minimum Standards for Construction and Maintenance of Water Wells" and chapter 18.104 RCW titled "Water Well Construction". Any well which is unusable, abandoned, or whose use

has been permanently discontinued, or which is in such disrepair that its continued use is impractical or is an environmental, safety, or public health hazard must be decommissioned.

All wells must be tagged with a Department of Ecology unique well identification number. If you have an existing well and it does not have a tag, please contact the well drilling coordinator at the regional Department of Ecology office issuing this decision. This tag must remain attached to each well. If you are required to submit water measuring reports, reference this tag number.

## **2. Meter Installation**

An approved measuring device shall be installed and maintained for each source authorized by this water right in accordance with the rule "Requirements for Measuring and Reporting Water Use", chapter 173-173 WAC. See <http://www.ecy.wa.gov/programs/wr/measuring/measuringhome.html>

## **3. Metering Rule Description and Petition Info**

Chapter 173-173 WAC describes the requirements for data accuracy, device installation and operation, and information reporting. It also allows a water user to petition the Department of Ecology for modifications to some of the requirements. Installation, operation and maintenance requirements are enclosed as a document titled "Water Measurement Device Installation and Operation Requirements". See <http://www.ecy.wa.gov/programs/wr/measuring/measuringhome.html>.

## **4. Record Water Use Weekly, Report Annually**

Water use shall be recorded weekly. The maximum monthly rate of withdrawal and the monthly total volume shall be submitted to the Department of Ecology by January 31<sup>st</sup> of each calendar year. Water use data shall be submitted via the Internet. To set up an Internet reporting account, access: <https://fortress.wa.gov/ecy/wrx/wrx/Meteringx/>.

## **5. Authority to Access Project**

Department of Ecology personnel, upon presentation of proper credentials, shall have access at reasonable times to the project location, and to inspect at reasonable times records of water use, points of withdrawal, measuring devices, and associated distribution systems for compliance with water law.

## **6. Streamflow Augmentation**

Johnson Creek or its tributaries shall be augmented at a rate of 18 gpm for every 100 gpm withdrawn under G1-23698C and G1-26398C. Stream augmentation is to occur simultaneously as the water is withdrawn. Stream augmentation shall occur as near to the utilized point(s) of withdrawal as feasible.

## **7. No Impairment of Existing Rights**

This authorization to make use of public waters of the state is subject to existing rights, including any existing rights held by the United States for the benefit of tribes under treaty or settlement. If impairment does occur, the City will be required to diminish or cease pumping, or mitigate for this impairment.

## **8. Health Approval Required**

Prior to any new construction or alteration of a public water system, the State Board of Health rules require public water supply operators to obtain written approval from the Office of Drinking Water of

the Washington State Department of Health. Please contact the Office of Drinking Water at Northwest Drinking Water Operations, 20435 72<sup>nd</sup> Avenue S., Suite 200, K17-12, Kent, WA 98032-2358, (253) 396-6750, prior to beginning (or modifying) your project.

#### 9. Easement and Right-of-Way

The water source and/or water transmission facilities are not wholly located upon land owned by the applicant. Issuance of a water right change authorization by this department does not convey a right of access to, or other right to use, land which the applicant does not legally possess. Obtaining such a right is a private matter between applicant and owner of that land.

#### 10. Water Use Efficiency

The water right holder is required to maintain efficient water delivery systems and use of up-to-date water conservation practices consistent with RCW 90.03.005.

*The right to use of the water aforesaid hereby confirmed is restricted to the lands or place of use herein described, except as provided in RCW 90.03.380, 90.03.390, and 90.44.100.*

Given under my hand and the seal of this office at Bellevue, Washington, this 25 day of April, 2019.

Maia Bellon, Director  
Department of Ecology



DATA REVIEW  
OK mc

  
Ria Berns, Section Manager  
Northwest Regional Office  
Water Resources Program

*To request ADA accommodation including materials in a format for the visually impaired, call Ecology Water Resources Program at 360-407-6872. Persons with impaired hearing may call Washington Relay Service at 711. Persons with speech disability may call TTY at 877-833-6341.*

## APPENDIX D



# Washington Department of Fish and Wildlife

## Fish Passage & Diversion Screening Inventory Database Report Cover Sheet

The following report is extracted from the Washington Department of Fish and Wildlife's (WDFW) Fish Passage and Diversion Screening Inventory Database (FPDSI). WDFW makes every attempt to keep these reports in sync with FPDSI; however, the dynamic nature of the data and workflows associated with maintaining the database may result in short-term differences.

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- Unauthorized attempts to alter or modify these data are strictly prohibited.
- Bankfull width measurements included in these reports should not be used for fish passage crossing design. They are solely for assessment purposes.
- The barrier status reported in this document is based on the swimming abilities of adult salmonids. Passabilities are a qualitative value, and should not be interpreted as a quantitative calculation. Please see page 1-4 of the Fish Passage Inventory, Assessment and Prioritization Manual for further clarification: <https://wdfw.wa.gov/publications/02061>
- EXIF data presented with Image Reports may be erroneous due to camera battery failures and resetting of camera clock functions.

### Abbreviations:

Most abbreviations in this report are defined in the Quick Reference Tables of the Fish Passage Inventory, Assessment, and Prioritization Manual. Additional commonly used abbreviations are defined as follows:

NFB = no potential salmonid use, BB = both banks, LB = left bank looking downstream, RB = right bank looking downstream, US or U/S = upstream, DS or D/S = downstream, WSDrop = water surface drop, BFW = bankfull width, OHW = ordinary high water, SLW = scour line width, CMP = corrugated metal pipe,  $Q_{fp}$  = fish passage flow, V&D = Velocity and Depth, ROW = Right of Way

The FPDSI database often uses default values such as '-99.99' or '-999' to represent null values.

# WDFW Fish Passage and Diversion Screening Inventory Database

## Site Description Report

Site ID 1285407

Project SRFBGRANT

### Geographic Coordinates

Latitude (WGS 84): 48.999972  
Longitude (WGS 84): -122.275815  
East (HARN 83): 1,213,795.2  
North (HARN 83): 1,342,371.5

### Waterbody

Stream: Sumas Cr  
Tributary To: Johnson Cr  
WRIA: 01  
River Mile: -999.99  
Fish Use Potential: Yes  
FUP Criteria: Physical

### General Location

Road Name: driveway; Kneuman Rd  
Mile Post: -999.99  
County: Whatcom  
WDFW Region: 4

### Owner

Type: Private  
Name:

### PI Species

- |                                  |                                    |                                            |
|----------------------------------|------------------------------------|--------------------------------------------|
| <input type="checkbox"/> Sockeye | <input type="checkbox"/> Chinook   | <input type="checkbox"/> Sea Run Cutthroat |
| <input type="checkbox"/> Pink    | <input type="checkbox"/> Coho      | <input type="checkbox"/> Resident Trout    |
| <input type="checkbox"/> Chum    | <input type="checkbox"/> Steelhead | <input type="checkbox"/> Bull Trout        |

### Associated Features

- |                                             |                                |                                          |                                    |
|---------------------------------------------|--------------------------------|------------------------------------------|------------------------------------|
| <input checked="" type="checkbox"/> Culvert | <input type="checkbox"/> Dam   | <input type="checkbox"/> Natural Barrier | <input type="checkbox"/> Diversion |
| <input type="checkbox"/> Non-Culvert Xing   | <input type="checkbox"/> Other | <input type="checkbox"/> Fishway         |                                    |

### Location/Directions

3867 Kneuman Rd.

### Site Comments

Double driveway.

Print Date: 4/18/2019

These data represent a snapshot of the Washington Department of Fish and Wildlife's current records. Due to the ongoing nature of assessment and inventory of these features, these data may not accurately represent conditions on the ground, and are subject to change.

# WDFW Fish Passage and Diversion Screening Inventory Database

## Level A Culvert Assessment Report

|                        |                          |                         |
|------------------------|--------------------------|-------------------------|
| Site ID: 1285407       | Stream: Sumas Cr         | WRIA: 01                |
| Latitude: 48.999972    | Tributary To: Johnson Cr | Fish Use Potential: Yes |
| Longitude: -122.275815 |                          |                         |

|             |               |                        |
|-------------|---------------|------------------------|
| Data Source | NSEG          |                        |
| Field Crew: | Barker; Weeks | Review Date: 6/27/2006 |

| Culvert Details          |       |          |      |      |        |      |       | Level A Parameters |          |             |           |           |
|--------------------------|-------|----------|------|------|--------|------|-------|--------------------|----------|-------------|-----------|-----------|
| ID                       | Shape | Material | Span | Rise | Length | WDIC | Apron | WSDrop             | Location | Countersunk | Backwater | Slope (%) |
| 1.1                      | RND   | CST      | 1.22 | 1.22 | 36.10  | 1.20 | NO    | 0.00               |          | Yes         |           | -99.99    |
| All dimensions in meters |       |          |      |      |        |      |       |                    |          |             |           |           |

|                             |        |
|-----------------------------|--------|
| <b>Channel Description</b>  |        |
| Toe Width (m):              | 1.43   |
| Average Width (m):          | -99.99 |
| Culvert/Stream Width Ratio: | 0.85   |
| <b>Plunge Pool</b>          |        |
| Length (m):                 | 5.55   |
| Max Depth (m):              | 1.31   |
| OHW Width (m):              | 4.63   |
| <b>Road</b>                 |        |
| Fill Depth (m):             | 1.00   |

No Image Available

|                           |         |                  |     |
|---------------------------|---------|------------------|-----|
| <b>Assessment Results</b> |         |                  |     |
| Barrier:                  | No      | Passability (%): | 100 |
| Reason:                   | N/A     | Fishway Present: | No  |
| Method:                   | Level A |                  |     |
| Recheck:                  |         |                  |     |

|                                                                                                                                  |
|----------------------------------------------------------------------------------------------------------------------------------|
| <b>Comments</b>                                                                                                                  |
| Pipe passes under double driveway and has a negative slope. Culvert is full of water. Creek flows in ditched section along road. |

|                               |         |                  |  |
|-------------------------------|---------|------------------|--|
| <b>Potential Habitat Gain</b> |         |                  |  |
| Survey Type:                  |         | Spawning (sq m): |  |
| Significant Reach:            | Unknown | Rearing (sq m):  |  |
| Length (m):                   |         | PI Total         |  |

Print Date: 4/18/2019

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# Washington Department of Fish and Wildlife

## Fish Passage & Diversion Screening Inventory Database Report Cover Sheet

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The FPDSI database often uses default values such as '-99.99' or '-999' to represent null values.

# WDFW Fish Passage and Diversion Screening Inventory Database

## Site Description Report

Site ID 1285406

Project SRFBGRANT

### Geographic Coordinates

|                     |             |
|---------------------|-------------|
| Latitude (WGS 84):  | 48.999428   |
| Longitude (WGS 84): | -122.269115 |
| East (HARN 83):     | 1,215,400.2 |
| North (HARN 83):    | 1,342,136.7 |

### Waterbody

|                     |            |
|---------------------|------------|
| Stream:             | Sumas Cr   |
| Tributary To:       | Johnson Cr |
| WRIA:               | 01         |
| River Mile:         | -999.99    |
| Fish Use Potential: | Yes        |
| FUP Criteria:       | Physical   |

### General Location

|              |                 |
|--------------|-----------------|
| Road Name:   | Bob Mitchell Wy |
| Mile Post:   | -999.99         |
| County:      | Whatcom         |
| WDFW Region: | 4               |

### Owner

|       |               |
|-------|---------------|
| Type: | City          |
| Name: | City of Sumas |

### PI Species

- |                                  |                                    |                                            |
|----------------------------------|------------------------------------|--------------------------------------------|
| <input type="checkbox"/> Sockeye | <input type="checkbox"/> Chinook   | <input type="checkbox"/> Sea Run Cutthroat |
| <input type="checkbox"/> Pink    | <input type="checkbox"/> Coho      | <input type="checkbox"/> Resident Trout    |
| <input type="checkbox"/> Chum    | <input type="checkbox"/> Steelhead | <input type="checkbox"/> Bull Trout        |

### Associated Features

- |                                             |                                |                                          |                                    |
|---------------------------------------------|--------------------------------|------------------------------------------|------------------------------------|
| <input checked="" type="checkbox"/> Culvert | <input type="checkbox"/> Dam   | <input type="checkbox"/> Natural Barrier | <input type="checkbox"/> Diversion |
| <input type="checkbox"/> Non-Culvert Xing   | <input type="checkbox"/> Other | <input type="checkbox"/> Fishway         |                                    |

### Location/Directions

On Bob Mitchell Wy just north of 470 W. 2nd St.

### Site Comments

Print Date: 4/18/2019

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# WDFW Fish Passage and Diversion Screening Inventory Database

## Level A Culvert Assessment Report

|                        |                          |                         |
|------------------------|--------------------------|-------------------------|
| Site ID: 1285406       | Stream: Sumas Cr         | WRIA: 01                |
| Latitude: 48.999428    | Tributary To: Johnson Cr | Fish Use Potential: Yes |
| Longitude: -122.269115 |                          |                         |

|             |               |                        |
|-------------|---------------|------------------------|
| Data Source | NSEG          |                        |
| Field Crew: | Barker; Weeks | Review Date: 6/26/2006 |

| Culvert Details          |       |          |      |      |        |      |       | Level A Parameters |          |             |           |           |
|--------------------------|-------|----------|------|------|--------|------|-------|--------------------|----------|-------------|-----------|-----------|
| ID                       | Shape | Material | Span | Rise | Length | WDIC | Apron | WSDrop             | Location | Countersunk | Backwater | Slope (%) |
| 1.1                      | RND   | CST      | 1.22 | 1.22 | 25.70  | 0.52 | NO    | 0.00               |          | No          |           | -0.02     |
| All dimensions in meters |       |          |      |      |        |      |       |                    |          |             |           |           |

|                             |        |
|-----------------------------|--------|
| <b>Channel Description</b>  |        |
| Toe Width (m):              | 1.46   |
| Average Width (m):          | -99.99 |
| Culvert/Stream Width Ratio: | 0.84   |
| <b>Plunge Pool</b>          |        |
| Length (m):                 | 3.50   |
| Max Depth (m):              | 0.62   |
| OHW Width (m):              | 4.33   |
| <b>Road</b>                 |        |
| Fill Depth (m):             | 0.80   |

No Image Available

|                           |         |                  |     |
|---------------------------|---------|------------------|-----|
| <b>Assessment Results</b> |         |                  |     |
| Barrier:                  | No      | Passability (%): | 100 |
| Reason:                   | N/A     | Fishway Present: | No  |
| Method:                   | Level B |                  |     |
| Recheck:                  |         |                  |     |

|                                                                   |
|-------------------------------------------------------------------|
| <b>Comments</b>                                                   |
| Dave Collins (WDFW) performed hydraulic analysis w/ Level B data. |

|                               |         |                  |  |
|-------------------------------|---------|------------------|--|
| <b>Potential Habitat Gain</b> |         |                  |  |
| Survey Type:                  |         | Spawning (sq m): |  |
| Significant Reach:            | Unknown | Rearing (sq m):  |  |
|                               |         | Length (m):      |  |
|                               |         | PI Total         |  |

Print Date: 4/18/2019

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# Washington Department of Fish and Wildlife

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# WDFW Fish Passage and Diversion Screening Inventory Database

## Site Description Report

Site ID 1285408

Project SRFBGRANT

### Geographic Coordinates

Latitude (WGS 84): 48.999955  
Longitude (WGS 84): -122.28091  
East (HARN 83): 1,212,571.1  
North (HARN 83): 1,342,392.8

### Waterbody

Stream: Sumas Cr  
Tributary To: Johnson Cr  
WRIA: 01  
River Mile: -999.99  
Fish Use Potential: Yes  
FUP Criteria: Physical

### General Location

Road Name: farm field crossing  
Mile Post: -999.99  
County: Whatcom  
WDFW Region: 4

### Owner

Type: Private  
Name:

### PI Species

- |                                  |                                    |                                            |
|----------------------------------|------------------------------------|--------------------------------------------|
| <input type="checkbox"/> Sockeye | <input type="checkbox"/> Chinook   | <input type="checkbox"/> Sea Run Cutthroat |
| <input type="checkbox"/> Pink    | <input type="checkbox"/> Coho      | <input type="checkbox"/> Resident Trout    |
| <input type="checkbox"/> Chum    | <input type="checkbox"/> Steelhead | <input type="checkbox"/> Bull Trout        |

### Associated Features

- |                                             |                                |                                          |                                    |
|---------------------------------------------|--------------------------------|------------------------------------------|------------------------------------|
| <input checked="" type="checkbox"/> Culvert | <input type="checkbox"/> Dam   | <input type="checkbox"/> Natural Barrier | <input type="checkbox"/> Diversion |
| <input type="checkbox"/> Non-Culvert Xing   | <input type="checkbox"/> Other | <input type="checkbox"/> Fishway         |                                    |

### Location/Directions

Field crossing across road from 3798 Kneuman Rd.

### Site Comments

Crossing appears to be unused.

Print Date: 4/18/2019

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# WDFW Fish Passage and Diversion Screening Inventory Database

## Level A Culvert Assessment Report

Site ID: 1285408  
 Latitude: 48.999955 Stream: Sumas Cr WRIA: 01  
 Longitude: -122.28091 Tributary To: Johnson Cr Fish Use Potential: Yes

Data Source: NSEG  
 Field Crew: Barker;Weeks Review Date: 6/27/2006

| Culvert Details          |       |          |      |      |        |      |       | Level A Parameters |          |             |           |           |
|--------------------------|-------|----------|------|------|--------|------|-------|--------------------|----------|-------------|-----------|-----------|
| ID                       | Shape | Material | Span | Rise | Length | WDIC | Apron | WSDrop             | Location | Countersunk | Backwater | Slope (%) |
| 1.1                      | RND   | CST      | 1.22 | 1.22 | 6.10   | 1.22 | NO    | 0.00               |          | Yes         |           | -99.99    |
| All dimensions in meters |       |          |      |      |        |      |       |                    |          |             |           |           |

### Channel Description

Toe Width (m): 1.43  
 Average Width (m): -99.99  
 Culvert/Stream Width Ratio: 0.85

### Plunge Pool

Length (m): 5.27  
 Max Depth (m): 1.34  
 OHW Width (m): 3.81

### Road

Fill Depth (m): 0.30

No Image Available

### Assessment Results

Barrier: No Passability (%): 100 Method: Level A  
 Reason: N/A Fishway Present: No Recheck:

### Comments

Culvert full of water and backwatered, no distinct DS control. Creek flows in ditched section along road.

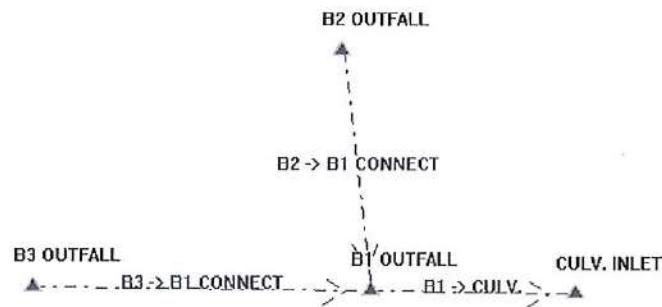
### Potential Habitat Gain

Survey Type: Significant Reach: Unknown Spawning (sq m): Rearing (sq m): Length (m): PI Total:

Print Date: 4/18/2019

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## APPENDIX E



## Project Precips

|          |         |
|----------|---------|
| [2 yr]   | 2.50 in |
| [10 yr]  | 3.50 in |
| [25 yr]  | 4.00 in |
| [100 yr] | 4.50 in |

## Reach Records

### Reach ID: B3 -> B1 CONNECT

#### Section Properties:

|            |                     |                 |                         |
|------------|---------------------|-----------------|-------------------------|
| Shape:     | Ditch               | Routing Method: | Travel Time Translation |
| Size       | Material            | Mannings n      | Hyd params By           |
|            | Corr Metal - normal |                 | 0.0800 Mannings Formula |
| Length     | Slope               | Entrance Loss   |                         |
| 0.0010 ft  | 0.50 %              |                 |                         |
| Width      | Bank Hgt            | ss1             | ss2                     |
| 1.0000 ft  | 1.0000 ft           | 0.00h:1v        | 0.00h:1v                |
| Up Node    | Dn Node             | Up Invert       | Dn Invert               |
| B3 OUTFALL | B1 OUTFALL          | 0.0000 ft       | 0.0000 ft               |

#### Conduit Constraints:

|              |            |           |           |               |           |
|--------------|------------|-----------|-----------|---------------|-----------|
| Min Vel      | Max Vel    | Min Cov   | Min Slope | Max Slope     | Min drop  |
| 2.0000 ft    | 15.0000 ft | 3.0000 ft | 0.5000 ft | 2.0000 ft     | 0.0000 ft |
| In/Exfil     | Hold Up    | Hold Dn   | Match Inv | Allow Smaller |           |
| 0.0000 in/hr | NO         | NO        | YES       | NO            |           |

#### Conduit Summary:

|             |                                                                                  |             |               |              |
|-------------|----------------------------------------------------------------------------------|-------------|---------------|--------------|
| Trib Area   | Flow                                                                             | Capacity    | Velocity      | Normal Depth |
| 947.0000 ac | 209.6277 cf                                                                      | 209.6277 cf | 330.6780 ft/s | -1.0000 ft   |
| Ent Loss    | Exit Loss                                                                        | Frict Loss  | Start TW      |              |
| 0.000000 ft | 0.000000 ft                                                                      | 0.000000 ft | 1.0000 ft     |              |
| comment:    | Hydrograph not shifted, 0.00 min forwarded. Submerged or overtop bank condition. |             |               |              |

### Reach ID: B2 -> B1 CONNECT

#### Section Properties:

|           |                     |                 |                         |
|-----------|---------------------|-----------------|-------------------------|
| Shape:    | Ditch               | Routing Method: | Travel Time Translation |
| Size      | Material            | Mannings n      | Hyd params By           |
|           | Corr Metal - normal |                 | 0.0800 Mannings Formula |
| Length    | Slope               | Entrance Loss   |                         |
| 0.0010 ft | 0.50 %              |                 |                         |
| Width     | Bank Hgt            | ss1             | ss2                     |
| 1.0000 ft | 1.0000 ft           | 0.00h:1v        | 0.00h:1v                |
| Up Node   | Dn Node             | Up Invert       | Dn Invert               |

B2 OUTFALL B1 OUTFALL 0.0000 ft 0.0000 ft

**Conduit Constraints:**

|              |            |           |           |               |           |
|--------------|------------|-----------|-----------|---------------|-----------|
| Min Vel      | Max Vel    | Min Cov   | Min Slope | Max Slope     | Min drop  |
| 2.0000 ft    | 15.0000 ft | 3.0000 ft | 0.5000 ft | 2.0000 ft     | 0.0000 ft |
| In/Exfil     | Hold Up    | Hold Dn   | Match Inv | Allow Smaller |           |
| 0.0000 in/hr | NO         | NO        | YES       | NO            |           |

**Conduit Summary:**

|             |             |             |               |              |
|-------------|-------------|-------------|---------------|--------------|
| Trib Area   | Flow        | Capacity    | Velocity      | Normal Depth |
| 182.0000 ac | 73.2288 cf  | 73.2288 cf  | 115.5150 ft/s | -1.0000 ft   |
| Ent Loss    | Exit Loss   | Frict Loss  | Start TW      |              |
| 0.000000 ft | 0.000000 ft | 0.000000 ft | 1.0000 ft     |              |

comment: Hydrograph not shifted, 0.00 min forwarded.Submerged or overtop bank condition.

**Reach ID: B1 -> CULV.**

**Section Properties:**

|            |                     |                 |                         |
|------------|---------------------|-----------------|-------------------------|
| Shape:     | Ditch               | Routing Method: | Travel Time Translation |
| Size       | Material            | Mannings n      | Hyd params By           |
|            | Corr Metal - normal |                 | 0.0800 Mannings Formula |
| Length     | Slope               | Entrance Loss   |                         |
| 0.0010 ft  | 0.50 %              |                 |                         |
| Width      | Bank Hgt            | ss1             | ss2                     |
| 1.0000 ft  | 1.0000 ft           | 0.00h:1v        | 0.00h:1v                |
| Up Node    | Dn Node             | Up Invert       | Dn Invert               |
| B1 OUTFALL | CULV. INLET         | 0.0000 ft       | 0.0000 ft               |

**Conduit Constraints:**

|              |            |           |           |               |           |
|--------------|------------|-----------|-----------|---------------|-----------|
| Min Vel      | Max Vel    | Min Cov   | Min Slope | Max Slope     | Min drop  |
| 2.0000 ft    | 15.0000 ft | 3.0000 ft | 0.5000 ft | 2.0000 ft     | 0.0000 ft |
| In/Exfil     | Hold Up    | Hold Dn   | Match Inv | Allow Smaller |           |
| 0.0000 in/hr | NO         | NO        | YES       | NO            |           |

**Conduit Summary:**

|              |             |             |               |              |
|--------------|-------------|-------------|---------------|--------------|
| Trib Area    | Flow        | Capacity    | Velocity      | Normal Depth |
| 1209.0000 ac | 303.3528 cf | 303.3528 cf | 478.5248 ft/s | -1.0000 ft   |
| Ent Loss     | Exit Loss   | Frict Loss  | Start TW      |              |
| 0.000000 ft  | 0.000000 ft | 0.000000 ft | 1.0000 ft     |              |

comment: Hydrograph not shifted, 0.00 min forwarded.Submerged or overtop bank condition.

## Node Records

### Node ID: CULV. INLET

Start El: 100.0000 ft  
Contrib Basin:  
Hgl Elev: 1.0000 ft

Max El: 108.0000 ft  
Contrib Hyd:

### Node ID: B1 OUTFALL

Start El: 100.0000 ft  
Contrib Basin: BASIN 1

Max El: 108.0000 ft  
Contrib Hyd:

### Node ID: B2 OUTFALL

Start El: 100.0000 ft  
Contrib Basin: BASIN 2

Max El: 108.0000 ft  
Contrib Hyd:

### Node ID: B3 OUTFALL

Start El: 100.0000 ft  
Contrib Basin: BASIN 3

Max El: 108.0000 ft  
Contrib Hyd:

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## Contributing Drainage Areas

### BASIN 1 Event Summary:

| BasinID | Peak Q | Peak T | Peak Vol | Area  | Method   | Raintype | Event  |
|---------|--------|--------|----------|-------|----------|----------|--------|
| -----   | (cfs)  | (hrs)  | (ac-ft)  | ac    | /Loss    |          |        |
| BASIN 1 | 15.06  | 8.50   | 10.2421  | 80.00 | SBUH/SCS | TYPE1A   | 2 yr   |
| BASIN 1 | 25.22  | 8.17   | 16.3619  | 80.00 | SBUH/SCS | TYPE1A   | 10 yr  |
| BASIN 1 | 30.53  | 8.17   | 19.5055  | 80.00 | SBUH/SCS | TYPE1A   | 25 yr  |
| BASIN 1 | 35.90  | 8.17   | 22.6842  | 80.00 | SBUH/SCS | TYPE1A   | 100 yr |

### Drainage Area: BASIN 1

|              |            |              |               |
|--------------|------------|--------------|---------------|
| Hyd Method:  | SBUH Hyd   | Loss Method: | SCS CN Number |
| Peak Factor: | 484.00     | SCS Abs:     | 0.20          |
| Storm Dur:   | 24.00 hrs  | Intv:        | 10.00 min     |
|              | Area       | CN           | TC            |
| Pervious     | 80.0000 ac | 90.07        | 1.06 hrs      |
| Impervious   | 0.0000 ac  | 0.00         | 0.00 hrs      |
| Total        | 80.0000 ac |              |               |

#### Supporting Data:

##### Pervious CN Data:

|                   |        |            |
|-------------------|--------|------------|
| Open Space/Lawn   | 95.00  | 14.5000 ac |
| Pasture/Grassland | 87.00  | 36.0000 ac |
| Forested          | 86.00  | 14.5000 ac |
| Gravel            | 95.00  | 10.0000 ac |
| Weland            | 100.00 | 4.0000 ac  |
| Roof/Road         | 99.00  | 1.0000 ac  |

##### Pervious TC Data:

|            |                               |            |        |         |             |
|------------|-------------------------------|------------|--------|---------|-------------|
| Flow type: | Description:                  | Length:    | Slope: | Coeff:  | Travel Time |
| Channel    | Natural earth with vegetation | 2128.00 ft | 0.30%  | 17.0000 | 38.09 min   |
| Channel    | Natural earth with vegetation | 2152.00 ft | 0.70%  | 17.0000 | 25.22 min   |

### BASIN 2 Event Summary:

| BasinID | Peak Q | Peak T | Peak Vol | Area   | Method   | Raintype | Event  |
|---------|--------|--------|----------|--------|----------|----------|--------|
| -----   | (cfs)  | (hrs)  | (ac-ft)  | ac     | /Loss    |          |        |
| BASIN 2 | 35.47  | 8.17   | 22.8673  | 182.00 | SBUH/SCS | TYPE1A   | 2 yr   |
| BASIN 2 | 60.39  | 8.17   | 36.7100  | 182.00 | SBUH/SCS | TYPE1A   | 10 yr  |
| BASIN 2 | 73.23  | 8.17   | 43.8337  | 182.00 | SBUH/SCS | TYPE1A   | 25 yr  |
| BASIN 2 | 86.18  | 8.17   | 51.0417  | 182.00 | SBUH/SCS | TYPE1A   | 100 yr |

### Drainage Area: BASIN 2

|              |             |              |               |
|--------------|-------------|--------------|---------------|
| Hyd Method:  | SBUH Hyd    | Loss Method: | SCS CN Number |
| Peak Factor: | 484.00      | SCS Abs:     | 0.20          |
| Storm Dur:   | 24.00 hrs   | Intv:        | 10.00 min     |
|              | Area        | CN           | TC            |
| Pervious     | 182.0000 ac | 89.70        | 0.91 hrs      |
| Impervious   | 0.0000 ac   | 0.00         | 0.00 hrs      |
| Total        | 182.0000 ac |              |               |

#### Supporting Data:

##### Pervious CN Data:

|                   |       |            |
|-------------------|-------|------------|
| Open Space/Lawn   | 93.00 | 18.2000 ac |
| Pasture/Grassland | 87.00 | 72.8000 ac |
| Forested          | 86.00 | 54.6000 ac |
| Roof/Road         | 99.00 | 36.4000 ac |

##### Pervious TC Data:

|            |                  |          |        |        |             |
|------------|------------------|----------|--------|--------|-------------|
| Flow type: | Description:     | Length:  | Slope: | Coeff: | Travel Time |
| Sheet      | Grassy/farmlands | 68.00 ft | 7.70%  | 0.1300 | 4.23 min    |

Shallow Grassy/farmlands 4707.00 ft 2.00% 11.0000 50.43 min

### BASIN 3 Event Summary:

| BasinID | Peak Q<br>(cfs) | Peak T<br>(hrs) | Peak Vol<br>(ac-ft) | Area<br>ac | Method<br>/Loss | Raintype | Event  |
|---------|-----------------|-----------------|---------------------|------------|-----------------|----------|--------|
| -----   |                 |                 |                     |            |                 |          |        |
| BASIN 3 | 96.00           | 9.50            | 106.9070            | 947.00     | SBUH/SCS        | TYPE1A   | 2 yr   |
| BASIN 3 | 170.44          | 9.17            | 176.4565            | 947.00     | SBUH/SCS        | TYPE1A   | 10 yr  |
| BASIN 3 | 209.63          | 9.17            | 212.6019            | 947.00     | SBUH/SCS        | TYPE1A   | 25 yr  |
| BASIN 3 | 249.58          | 9.17            | 249.3380            | 947.00     | SBUH/SCS        | TYPE1A   | 100 yr |

### Drainage Area: BASIN 3

|              |             |              |               |
|--------------|-------------|--------------|---------------|
| Hyd Method:  | SBUH Hyd    | Loss Method: | SCS CN Number |
| Peak Factor: | 484.00      | SCS Abs:     | 0.20          |
| Storm Dur:   | 24.00 hrs   | Intv:        | 10.00 min     |
|              | Area        | CN           | TC            |
| Pervious     | 947.0000 ac | 87.62        | 2.68 hrs      |
| Impervious   | 0.0000 ac   | 0.00         | 0.00 hrs      |
| Total        | 947.0000 ac |              |               |

### Supporting Data:

#### Pervious CN Data:

|                   |        |             |
|-------------------|--------|-------------|
| Open Space/Lawn   | 93.00  | 91.0000 ac  |
| Pasture/Grassland | 87.00  | 401.0000 ac |
| Forested          | 84.00  | 364.0000 ac |
| Wetland           | 100.00 | 45.5000 ac  |
| Roof/Road         | 99.00  | 45.5000 ac  |

#### Pervious TC Data:

| Flow type: | Description:                  | Length:    | Slope: | Coeff:  | Travel Time |
|------------|-------------------------------|------------|--------|---------|-------------|
| Sheet      | Grass/Farmland                | 42.00 ft   | 3.00%  | 0.1300  | 4.20 min    |
| Shallow    | Grass/Farmland                | 3805.00 ft | 0.70%  | 11.0000 | 68.91 min   |
| Channel    | Forested                      | 2423.00 ft | 1.20%  | 10.0000 | 36.86 min   |
| Channel    | Natural earth with vegetation | 4341.00 ft | 0.70%  | 17.0000 | 50.87 min   |

## Layout Hydrographs

### Hydrograph ID: CULV. INLET - 2 yr

Area: 1209.0000 ac Hyd Int: 10.00 min Base Flow:  
Pending tt translation: 0.00 min  
Peak Flow: 141.0597 cfs Peak Time: 9.00 hrs Hyd Vol: 140.0170 acft

### Hydrograph ID: CULV. INLET - 2 yr

Area: 1209.0000 ac Hyd Int: 10.00 min Base Flow:  
Pending tt translation: 0.00 min  
Peak Flow: 141.0597 cfs Peak Time: 9.00 hrs Hyd Vol: 140.0170 acft

| Time  | Flow     | Time  | Flow    | Time  | Flow   |
|-------|----------|-------|---------|-------|--------|
| hr    | cfs      | hr    | cfs     | hr    | cfs    |
| 3.33  | 0.0059   | 22.00 | 64.9733 | 40.50 | 0.1037 |
| 3.50  | 0.0514   | 22.17 | 64.5814 | 40.67 | 0.0975 |
| 3.67  | 0.1684   | 22.33 | 64.0126 | 40.83 | 0.0916 |
| 3.83  | 0.3520   | 22.50 | 63.4996 | 41.00 | 0.0861 |
| 4.00  | 0.5871   | 22.67 | 63.0360 | 41.17 | 0.0809 |
| 4.17  | 0.9479   | 22.83 | 62.6163 | 41.33 | 0.0760 |
| 4.33  | 1.4847   | 23.00 | 62.2358 | 41.50 | 0.0714 |
| 4.50  | 2.1577   | 23.17 | 61.8904 | 41.67 | 0.0671 |
| 4.67  | 3.0163   | 23.33 | 61.5765 | 41.83 | 0.0631 |
| 4.83  | 4.0564   | 23.50 | 61.2908 | 42.00 | 0.0593 |
| 5.00  | 5.2061   | 23.67 | 61.0307 | 42.17 | 0.0557 |
| 5.17  | 6.5488   | 23.83 | 60.7936 | 42.33 | 0.0523 |
| 5.33  | 8.0787   | 24.00 | 60.5774 | 42.50 | 0.0492 |
| 5.50  | 9.6903   | 24.17 | 57.9951 | 42.67 | 0.0462 |
| 5.67  | 11.5003  | 24.33 | 53.2923 | 42.83 | 0.0434 |
| 5.83  | 13.5010  | 24.50 | 49.0684 | 43.00 | 0.0408 |
| 6.00  | 15.5543  | 24.67 | 45.2627 | 43.17 | 0.0384 |
| 6.17  | 17.9700  | 24.83 | 41.8235 | 43.33 | 0.0360 |
| 6.33  | 20.7406  | 25.00 | 38.7065 | 43.50 | 0.0339 |
| 6.50  | 23.5366  | 25.17 | 35.8735 | 43.67 | 0.0318 |
| 6.67  | 26.9224  | 25.33 | 33.2920 | 43.83 | 0.0299 |
| 6.83  | 30.8843  | 25.50 | 30.9336 | 44.00 | 0.0281 |
| 7.00  | 34.8328  | 25.67 | 28.7740 | 44.17 | 0.0264 |
| 7.17  | 39.5411  | 25.83 | 26.7920 | 44.33 | 0.0248 |
| 7.33  | 44.9848  | 26.00 | 24.9693 | 44.50 | 0.0233 |
| 7.50  | 50.3561  | 26.17 | 23.2899 | 44.67 | 0.0219 |
| 7.67  | 65.2463  | 26.33 | 21.7396 | 44.83 | 0.0206 |
| 7.83  | 89.7496  | 26.50 | 20.3063 | 45.00 | 0.0193 |
| 8.00  | 114.2111 | 26.67 | 18.9790 | 45.17 | 0.0182 |
| 8.17  | 128.6856 | 26.83 | 17.7483 | 45.33 | 0.0171 |
| 8.33  | 133.3589 | 27.00 | 16.6056 | 45.50 | 0.0161 |
| 8.50  | 138.1798 | 27.17 | 15.5434 | 45.67 | 0.0151 |
| 8.67  | 140.5527 | 27.33 | 14.5551 | 45.83 | 0.0142 |
| 8.83  | 140.6216 | 27.50 | 13.6344 | 46.00 | 0.0133 |
| 9.00  | 141.0597 | 27.67 | 12.7762 | 46.17 | 0.0125 |
| 9.17  | 140.0442 | 27.83 | 11.9755 | 46.33 | 0.0118 |
| 9.33  | 137.6680 | 28.00 | 11.2279 | 46.50 | 0.0111 |
| 9.50  | 135.7690 | 28.17 | 10.5294 | 46.67 | 0.0104 |
| 9.67  | 133.7338 | 28.33 | 9.8765  | 46.83 | 0.0098 |
| 9.83  | 131.5486 | 28.50 | 9.2658  | 47.00 | 0.0092 |
| 10.00 | 129.7421 | 28.67 | 8.6944  | 47.17 | 0.0086 |
| 10.17 | 127.7080 | 28.83 | 8.1594  | 47.33 | 0.0081 |
| 10.33 | 125.4504 | 29.00 | 7.6584  | 47.50 | 0.0076 |
| 10.50 | 123.5234 | 29.17 | 7.1890  | 47.67 | 0.0072 |
| 10.67 | 121.5080 | 29.33 | 6.7491  | 47.83 | 0.0067 |
| 10.83 | 119.4005 | 29.50 | 6.3368  | 48.00 | 0.0063 |
| 11.00 | 117.5707 | 29.67 | 5.9502  | 48.17 | 0.0059 |
| 11.17 | 115.7927 | 29.83 | 5.5876  | 48.33 | 0.0056 |
| 11.33 | 114.0531 | 30.00 | 5.2474  | 48.50 | 0.0052 |
| 11.50 | 112.5296 | 30.17 | 4.9283  | 48.67 | 0.0049 |
| 11.67 | 111.0036 | 30.33 | 4.6289  | 48.83 | 0.0046 |
| 11.83 | 109.4701 | 30.50 | 4.3478  | 49.00 | 0.0043 |

|       |          |       |        |       |        |
|-------|----------|-------|--------|-------|--------|
| 12.00 | 108.1163 | 30.67 | 4.0840 | 49.17 | 0.0041 |
| 12.17 | 106.7271 | 30.83 | 3.8364 | 49.33 | 0.0038 |
| 12.33 | 105.3025 | 31.00 | 3.6039 | 49.50 | 0.0036 |
| 12.50 | 104.0363 | 31.17 | 3.3857 | 49.67 | 0.0034 |
| 12.67 | 102.7145 | 31.33 | 3.1807 | 49.83 | 0.0032 |
| 12.83 | 101.3404 | 31.50 | 2.9882 | 50.00 | 0.0030 |
| 13.00 | 100.1123 | 31.67 | 2.8074 | 50.17 | 0.0028 |
| 13.17 | 99.0134  | 31.83 | 2.6377 | 50.33 | 0.0026 |
| 13.33 | 98.0292  | 32.00 | 2.4782 | 50.50 | 0.0025 |
| 13.50 | 97.1473  | 32.17 | 2.3284 | 50.67 | 0.0023 |
| 13.67 | 96.1580  | 32.33 | 2.1877 | 50.83 | 0.0022 |
| 13.83 | 95.0718  | 32.50 | 2.0556 | 51.00 | 0.0021 |
| 14.00 | 94.0961  | 32.67 | 1.9314 | 51.17 | 0.0019 |
| 14.17 | 93.2190  | 32.83 | 1.8148 | 51.33 | 0.0018 |
| 14.33 | 92.4298  | 33.00 | 1.7052 | 51.50 | 0.0017 |
| 14.50 | 91.7195  | 33.17 | 1.6022 | 51.67 | 0.0016 |
| 14.67 | 90.8785  | 33.33 | 1.5055 | 51.83 | 0.0015 |
| 14.83 | 89.9201  | 33.50 | 1.4146 | 52.00 | 0.0014 |
| 15.00 | 89.0572  | 33.67 | 1.3293 | 52.17 | 0.0013 |
| 15.17 | 88.2795  | 33.83 | 1.2490 | 52.33 | 0.0013 |
| 15.33 | 87.5781  | 34.00 | 1.1737 | 52.50 | 0.0012 |
| 15.50 | 86.9452  | 34.17 | 1.1029 | 52.67 | 0.0011 |
| 15.67 | 86.1697  | 34.33 | 1.0363 | 52.83 | 0.0010 |
| 15.83 | 85.2663  | 34.50 | 0.9737 | 53.00 | 0.0010 |
| 16.00 | 84.4517  | 34.67 | 0.9150 | 53.17 | 0.0009 |
| 16.17 | 83.7163  | 34.83 | 0.8598 | 53.33 | 0.0009 |
| 16.33 | 83.0518  | 35.00 | 0.8079 | 53.50 | 0.0008 |
| 16.50 | 82.4507  | 35.17 | 0.7592 | 53.67 | 0.0008 |
| 16.67 | 81.9066  | 35.33 | 0.7133 | 53.83 | 0.0007 |
| 16.83 | 81.4142  | 35.50 | 0.6703 | 54.00 | 0.0007 |
| 17.00 | 80.9683  | 35.67 | 0.6299 | 54.17 | 0.0006 |
| 17.17 | 80.3573  | 35.83 | 0.5919 | 54.33 | 0.0006 |
| 17.33 | 79.5984  | 36.00 | 0.5562 | 54.50 | 0.0006 |
| 17.50 | 78.9140  | 36.17 | 0.5227 | 54.67 | 0.0005 |
| 17.67 | 78.2958  | 36.33 | 0.4912 | 54.83 | 0.0005 |
| 17.83 | 77.7368  | 36.50 | 0.4615 | 55.00 | 0.0005 |
| 18.00 | 77.2309  | 36.67 | 0.4337 | 55.17 | 0.0004 |
| 18.17 | 76.5635  | 36.83 | 0.4076 | 55.33 | 0.0004 |
| 18.33 | 75.7514  | 37.00 | 0.3830 | 55.50 | 0.0004 |
| 18.50 | 75.0181  | 37.17 | 0.3599 | 55.67 | 0.0004 |
| 18.67 | 74.3548  | 37.33 | 0.3382 | 55.83 | 0.0003 |
| 18.83 | 73.7540  | 37.50 | 0.3178 | 56.00 | 0.0003 |
| 19.00 | 73.2091  | 37.67 | 0.2986 | 56.17 | 0.0003 |
| 19.17 | 72.5035  | 37.83 | 0.2806 | 56.33 | 0.0003 |
| 19.33 | 71.6537  | 38.00 | 0.2637 | 56.50 | 0.0003 |
| 19.50 | 70.8851  | 38.17 | 0.2478 | 56.67 | 0.0002 |
| 19.67 | 70.1884  | 38.33 | 0.2329 | 56.83 | 0.0002 |
| 19.83 | 69.5558  | 38.50 | 0.2188 | 57.00 | 0.0002 |
| 20.00 | 68.9806  | 38.67 | 0.2056 | 57.17 | 0.0002 |
| 20.17 | 68.4569  | 38.83 | 0.1932 | 57.33 | 0.0002 |
| 20.33 | 67.9794  | 39.00 | 0.1816 | 57.50 | 0.0002 |
| 20.50 | 67.5437  | 39.17 | 0.1706 | 57.67 | 0.0002 |
| 20.67 | 67.1457  | 39.33 | 0.1603 | 57.83 | 0.0002 |
| 20.83 | 66.7820  | 39.50 | 0.1507 | 58.00 | 0.0002 |
| 21.00 | 66.4494  | 39.67 | 0.1416 | 58.17 | 0.0001 |
| 21.17 | 66.1453  | 39.83 | 0.1330 | 58.33 | 0.0001 |
| 21.33 | 65.8671  | 40.00 | 0.1250 | 58.50 | 0.0001 |
| 21.50 | 65.6127  | 40.17 | 0.1175 | 58.67 | 0.0001 |
| 21.67 | 65.3801  | 40.33 | 0.1104 | 58.83 | 0.0001 |
| 21.83 | 65.1674  | 40.50 | 0.1037 | 59.00 | 0.0001 |

### Hydrograph ID: CULV. INLET - 10 yr

Area: 1209.0000 ac Hyd Int: 10.00 min Base Flow:  
Pending tt translation: 0.00 min  
Peak Flow: 247.3580 cfs Peak Time: 8.67 hrs Hyd Vol: 229.5292 acft

### Hydrograph ID: CULV. INLET - 10 yr

Area: 1209.0000 ac Hyd Int: 10.00 min Base Flow:  
Pending tt translation: 0.00 min  
Peak Flow: 247.3580 cfs Peak Time: 8.67 hrs Hyd Vol: 229.5292 acft

| Time  | Flow     | Time  | Flow    | Time  | Flow   |
|-------|----------|-------|---------|-------|--------|
| hr    | cfs      | hr    | cfs     | hr    | cfs    |
| 2.50  | 0.0062   | 21.83 | 98.5529 | 41.00 | 0.1300 |
| 2.67  | 0.0802   | 22.00 | 98.1973 | 41.17 | 0.1221 |
| 2.83  | 0.2782   | 22.17 | 97.5490 | 41.33 | 0.1148 |
| 3.00  | 0.5876   | 22.33 | 96.6390 | 41.50 | 0.1078 |
| 3.17  | 1.0613   | 22.50 | 95.8140 | 41.67 | 0.1013 |
| 3.33  | 1.7551   | 22.67 | 95.0645 | 41.83 | 0.0952 |
| 3.50  | 2.6429   | 22.83 | 94.3822 | 42.00 | 0.0895 |
| 3.67  | 3.7489   | 23.00 | 93.7599 | 42.17 | 0.0841 |
| 3.83  | 5.0585   | 23.17 | 93.1914 | 42.33 | 0.0790 |
| 4.00  | 6.5058   | 23.33 | 92.6714 | 42.50 | 0.0742 |
| 4.17  | 8.2229   | 23.50 | 92.1950 | 42.67 | 0.0698 |
| 4.33  | 10.2039  | 23.67 | 91.7578 | 42.83 | 0.0656 |
| 4.50  | 12.2887  | 23.83 | 91.3564 | 43.00 | 0.0616 |
| 4.67  | 14.6597  | 24.00 | 90.9876 | 43.17 | 0.0579 |
| 4.83  | 17.3071  | 24.17 | 87.1069 | 43.33 | 0.0544 |
| 5.00  | 20.0193  | 24.33 | 80.0787 | 43.50 | 0.0511 |
| 5.17  | 23.0276  | 24.50 | 73.7619 | 43.67 | 0.0480 |
| 5.33  | 26.3187  | 24.67 | 68.0670 | 43.83 | 0.0451 |
| 5.50  | 29.6319  | 24.83 | 62.9172 | 44.00 | 0.0424 |
| 5.67  | 33.2455  | 25.00 | 58.2469 | 44.17 | 0.0399 |
| 5.83  | 37.1429  | 25.17 | 53.9999 | 44.33 | 0.0375 |
| 6.00  | 41.0177  | 25.33 | 50.1276 | 44.50 | 0.0352 |
| 6.17  | 45.5250  | 25.50 | 46.5882 | 44.67 | 0.0331 |
| 6.33  | 50.6358  | 25.67 | 43.3455 | 44.83 | 0.0311 |
| 6.50  | 55.6592  | 25.83 | 40.3682 | 45.00 | 0.0292 |
| 6.67  | 61.7086  | 26.00 | 37.6290 | 45.17 | 0.0274 |
| 6.83  | 68.7355  | 26.17 | 35.1040 | 45.33 | 0.0258 |
| 7.00  | 75.5760  | 26.33 | 32.7724 | 45.50 | 0.0242 |
| 7.17  | 83.6786  | 26.50 | 30.6160 | 45.67 | 0.0228 |
| 7.33  | 92.9765  | 26.67 | 28.6185 | 45.83 | 0.0214 |
| 7.50  | 101.9595 | 26.83 | 26.7657 | 46.00 | 0.0201 |
| 7.67  | 127.4788 | 27.00 | 25.0451 | 46.17 | 0.0189 |
| 7.83  | 169.0951 | 27.17 | 23.4453 | 46.33 | 0.0178 |
| 8.00  | 209.3903 | 27.33 | 21.9563 | 46.50 | 0.0167 |
| 8.17  | 232.2459 | 27.50 | 20.5691 | 46.67 | 0.0157 |
| 8.33  | 238.4995 | 27.67 | 19.2757 | 46.83 | 0.0147 |
| 8.50  | 244.9328 | 27.83 | 18.0687 | 47.00 | 0.0138 |
| 8.67  | 247.3580 | 28.00 | 16.9416 | 47.17 | 0.0130 |
| 8.83  | 246.0565 | 28.17 | 15.8885 | 47.33 | 0.0122 |
| 9.00  | 245.3932 | 28.33 | 14.9039 | 47.50 | 0.0115 |
| 9.17  | 242.4484 | 28.50 | 13.9830 | 47.67 | 0.0108 |
| 9.33  | 237.3829 | 28.67 | 13.1210 | 47.83 | 0.0101 |
| 9.50  | 233.1460 | 28.83 | 12.3141 | 48.00 | 0.0095 |
| 9.67  | 228.7569 | 29.00 | 11.5583 | 48.17 | 0.0090 |
| 9.83  | 224.1900 | 29.17 | 10.8502 | 48.33 | 0.0084 |
| 10.00 | 220.2817 | 29.33 | 10.1865 | 48.50 | 0.0079 |
| 10.17 | 216.0704 | 29.50 | 9.5644  | 48.67 | 0.0074 |
| 10.33 | 211.5594 | 29.67 | 8.9810  | 48.83 | 0.0070 |
| 10.50 | 207.6201 | 29.83 | 8.4338  | 49.00 | 0.0066 |
| 10.67 | 203.5907 | 30.00 | 7.9206  | 49.17 | 0.0062 |
| 10.83 | 199.4622 | 30.17 | 7.4390  | 49.33 | 0.0058 |
| 11.00 | 195.8121 | 30.33 | 6.9871  | 49.50 | 0.0054 |
| 11.17 | 192.2837 | 30.50 | 6.5629  | 49.67 | 0.0051 |
| 11.33 | 188.8534 | 30.67 | 6.1648  | 49.83 | 0.0048 |
| 11.50 | 185.7959 | 30.83 | 5.7911  | 50.00 | 0.0045 |

|       |          |       |        |       |        |
|-------|----------|-------|--------|-------|--------|
| 11.67 | 182.7686 | 31.00 | 5.4402 | 50.17 | 0.0042 |
| 11.83 | 179.7616 | 31.17 | 5.1107 | 50.33 | 0.0040 |
| 12.00 | 177.0639 | 31.33 | 4.8014 | 50.50 | 0.0038 |
| 12.17 | 174.3400 | 31.50 | 4.5108 | 50.67 | 0.0035 |
| 12.33 | 171.5888 | 31.67 | 4.2380 | 50.83 | 0.0033 |
| 12.50 | 169.1082 | 31.83 | 3.9817 | 51.00 | 0.0031 |
| 12.67 | 166.5667 | 32.00 | 3.7410 | 51.17 | 0.0029 |
| 12.83 | 163.9679 | 32.17 | 3.5149 | 51.33 | 0.0027 |
| 13.00 | 161.6163 | 32.33 | 3.3025 | 51.50 | 0.0026 |
| 13.17 | 159.4847 | 32.50 | 3.1030 | 51.67 | 0.0024 |
| 13.33 | 157.5494 | 32.67 | 2.9156 | 51.83 | 0.0023 |
| 13.50 | 155.7899 | 32.83 | 2.7395 | 52.00 | 0.0021 |
| 13.67 | 153.8837 | 33.00 | 2.5741 | 52.17 | 0.0020 |
| 13.83 | 151.8458 | 33.17 | 2.4187 | 52.33 | 0.0019 |
| 14.00 | 149.9938 | 33.33 | 2.2727 | 52.50 | 0.0018 |
| 14.17 | 148.3081 | 33.50 | 2.1355 | 52.67 | 0.0017 |
| 14.33 | 146.7716 | 33.67 | 2.0067 | 52.83 | 0.0016 |
| 14.50 | 145.3695 | 33.83 | 1.8856 | 53.00 | 0.0015 |
| 14.67 | 143.7815 | 34.00 | 1.7718 | 53.17 | 0.0014 |
| 14.83 | 142.0272 | 34.17 | 1.6649 | 53.33 | 0.0013 |
| 15.00 | 140.4308 | 34.33 | 1.5644 | 53.50 | 0.0012 |
| 15.17 | 138.9761 | 34.50 | 1.4701 | 53.67 | 0.0012 |
| 15.33 | 137.6486 | 34.67 | 1.3814 | 53.83 | 0.0011 |
| 15.50 | 136.4357 | 34.83 | 1.2979 | 54.00 | 0.0010 |
| 15.67 | 135.0166 | 35.00 | 1.2197 | 54.17 | 0.0010 |
| 15.83 | 133.4131 | 35.17 | 1.1461 | 54.33 | 0.0009 |
| 16.00 | 131.9539 | 35.33 | 1.0770 | 54.50 | 0.0008 |
| 16.17 | 130.6239 | 35.50 | 1.0120 | 54.67 | 0.0008 |
| 16.33 | 129.4098 | 35.67 | 0.9509 | 54.83 | 0.0007 |
| 16.50 | 128.3000 | 35.83 | 0.8935 | 55.00 | 0.0007 |
| 16.67 | 127.2845 | 36.00 | 0.8397 | 55.17 | 0.0007 |
| 16.83 | 126.3543 | 36.17 | 0.7890 | 55.33 | 0.0006 |
| 17.00 | 125.5015 | 36.33 | 0.7415 | 55.50 | 0.0006 |
| 17.17 | 124.4063 | 36.50 | 0.6967 | 55.67 | 0.0005 |
| 17.33 | 123.0943 | 36.67 | 0.6547 | 55.83 | 0.0005 |
| 17.50 | 121.9011 | 36.83 | 0.6153 | 56.00 | 0.0005 |
| 17.67 | 120.8139 | 37.00 | 0.5782 | 56.17 | 0.0005 |
| 17.83 | 119.8218 | 37.17 | 0.5433 | 56.33 | 0.0004 |
| 18.00 | 118.9152 | 37.33 | 0.5105 | 56.50 | 0.0004 |
| 18.17 | 117.7710 | 37.50 | 0.4797 | 56.67 | 0.0004 |
| 18.33 | 116.4142 | 37.67 | 0.4508 | 56.83 | 0.0004 |
| 18.50 | 115.1811 | 37.83 | 0.4236 | 57.00 | 0.0003 |
| 18.67 | 114.0582 | 38.00 | 0.3981 | 57.17 | 0.0003 |
| 18.83 | 113.0338 | 38.17 | 0.3741 | 57.33 | 0.0003 |
| 19.00 | 112.0978 | 38.33 | 0.3515 | 57.50 | 0.0003 |
| 19.17 | 110.9251 | 38.50 | 0.3303 | 57.67 | 0.0003 |
| 19.33 | 109.5403 | 38.67 | 0.3104 | 57.83 | 0.0002 |
| 19.50 | 108.2813 | 38.83 | 0.2917 | 58.00 | 0.0002 |
| 19.67 | 107.1341 | 39.00 | 0.2741 | 58.17 | 0.0002 |
| 19.83 | 106.0869 | 39.17 | 0.2576 | 58.33 | 0.0002 |
| 20.00 | 105.1292 | 39.33 | 0.2420 | 58.50 | 0.0002 |
| 20.17 | 104.2521 | 39.50 | 0.2274 | 58.67 | 0.0002 |
| 20.33 | 103.4475 | 39.67 | 0.2137 | 58.83 | 0.0002 |
| 20.50 | 102.7086 | 39.83 | 0.2008 | 59.00 | 0.0002 |
| 20.67 | 102.0292 | 40.00 | 0.1887 | 59.17 | 0.0001 |
| 20.83 | 101.4038 | 40.17 | 0.1774 | 59.33 | 0.0001 |
| 21.00 | 100.8277 | 40.33 | 0.1667 | 59.50 | 0.0001 |
| 21.17 | 100.2968 | 40.50 | 0.1566 | 59.67 | 0.0001 |
| 21.33 | 99.8071  | 40.67 | 0.1472 | 59.83 | 0.0001 |
| 21.50 | 99.3551  | 40.83 | 0.1383 | 60.00 | 0.0001 |
| 21.67 | 98.9380  | 41.00 | 0.1300 | 60.17 | 0.0001 |

### Hydrograph ID: CULV. INLET - 25 yr

Area: 1209.0000 ac Hyd Int: 10.00 min Base Flow:  
Pending tt translation: 0.00 min  
Peak Flow: 303.3528 cfs Peak Time: 8.67 hrs Hyd Vol: 275.9417 acft

### Hydrograph ID: CULV. INLET - 25 yr

Area: 1209.0000 ac Hyd Int: 10.00 min Base Flow:  
Pending tt translation: 0.00 min  
Peak Flow: 303.3528 cfs Peak Time: 8.67 hrs Hyd Vol: 275.9417 acft

| Time  | Flow     | Time  | Flow     | Time  | Flow   |
|-------|----------|-------|----------|-------|--------|
| hr    | cfs      | hr    | cfs      | hr    | cfs    |
| 2.33  | 0.0436   | 21.83 | 115.1672 | 41.17 | 0.1426 |
| 2.50  | 0.2198   | 22.00 | 114.7289 | 41.33 | 0.1340 |
| 2.67  | 0.5557   | 22.17 | 113.9510 | 41.50 | 0.1259 |
| 2.83  | 1.1065   | 22.33 | 112.8692 | 41.67 | 0.1183 |
| 3.00  | 1.9423   | 22.50 | 111.8872 | 41.83 | 0.1112 |
| 3.17  | 3.0381   | 22.67 | 110.9937 | 42.00 | 0.1045 |
| 3.33  | 4.3542   | 22.83 | 110.1790 | 42.17 | 0.0982 |
| 3.50  | 5.8561   | 23.00 | 109.4348 | 42.33 | 0.0923 |
| 3.67  | 7.5981   | 23.17 | 108.7538 | 42.50 | 0.0867 |
| 3.83  | 9.5636   | 23.33 | 108.1297 | 42.67 | 0.0815 |
| 4.00  | 11.6532  | 23.50 | 107.5568 | 42.83 | 0.0766 |
| 4.17  | 14.0692  | 23.67 | 107.0303 | 43.00 | 0.0720 |
| 4.33  | 16.8020  | 23.83 | 106.5459 | 43.17 | 0.0676 |
| 4.50  | 19.6169  | 24.00 | 106.0998 | 43.33 | 0.0635 |
| 4.67  | 22.7743  | 24.17 | 101.5735 | 43.50 | 0.0597 |
| 4.83  | 26.2598  | 24.33 | 93.3904  | 43.67 | 0.0561 |
| 5.00  | 29.7797  | 24.50 | 86.0342  | 43.83 | 0.0527 |
| 5.17  | 33.6500  | 24.67 | 79.4008  | 44.00 | 0.0495 |
| 5.33  | 37.8526  | 24.83 | 73.4013  | 44.17 | 0.0466 |
| 5.50  | 42.0381  | 25.00 | 67.9594  | 44.33 | 0.0437 |
| 5.67  | 46.5756  | 25.17 | 63.0098  | 44.50 | 0.0411 |
| 5.83  | 51.4434  | 25.33 | 58.4961  | 44.67 | 0.0386 |
| 6.00  | 56.2411  | 25.50 | 54.3699  | 44.83 | 0.0363 |
| 6.17  | 61.8132  | 25.67 | 50.5891  | 45.00 | 0.0341 |
| 6.33  | 68.1185  | 25.83 | 47.1172  | 45.17 | 0.0321 |
| 6.50  | 74.2673  | 26.00 | 43.9224  | 45.33 | 0.0301 |
| 6.67  | 81.6694  | 26.17 | 40.9773  | 45.50 | 0.0283 |
| 6.83  | 90.2561  | 26.33 | 38.2574  | 45.67 | 0.0266 |
| 7.00  | 98.5534  | 26.50 | 35.7415  | 45.83 | 0.0250 |
| 7.17  | 108.3690 | 26.67 | 33.4109  | 46.00 | 0.0235 |
| 7.33  | 119.6124 | 26.83 | 31.2489  | 46.17 | 0.0221 |
| 7.50  | 130.4008 | 27.00 | 29.2410  | 46.33 | 0.0207 |
| 7.67  | 161.3602 | 27.17 | 27.3739  | 46.50 | 0.0195 |
| 7.83  | 211.7299 | 27.33 | 25.6360  | 46.67 | 0.0183 |
| 8.00  | 260.0281 | 27.50 | 24.0169  | 46.83 | 0.0172 |
| 8.17  | 287.0265 | 27.67 | 22.5071  | 47.00 | 0.0162 |
| 8.33  | 293.9365 | 27.83 | 21.0982  | 47.17 | 0.0152 |
| 8.50  | 301.0426 | 28.00 | 19.7825  | 47.33 | 0.0143 |
| 8.67  | 303.3528 | 28.17 | 18.5531  | 47.50 | 0.0134 |
| 8.83  | 301.2211 | 28.33 | 17.4036  | 47.67 | 0.0126 |
| 9.00  | 299.8699 | 28.50 | 16.3283  | 47.83 | 0.0119 |
| 9.17  | 295.8264 | 28.67 | 15.3220  | 48.00 | 0.0111 |
| 9.33  | 289.2864 | 28.83 | 14.3798  | 48.17 | 0.0105 |
| 9.50  | 283.7593 | 29.00 | 13.4974  | 48.33 | 0.0098 |
| 9.67  | 278.0785 | 29.17 | 12.6706  | 48.50 | 0.0092 |
| 9.83  | 272.2128 | 29.33 | 11.8956  | 48.67 | 0.0087 |
| 10.00 | 267.1523 | 29.50 | 11.1692  | 48.83 | 0.0082 |
| 10.17 | 261.7567 | 29.67 | 10.4880  | 49.00 | 0.0077 |
| 10.33 | 256.0288 | 29.83 | 9.8491   | 49.17 | 0.0072 |
| 10.50 | 250.9985 | 30.00 | 9.2497   | 49.33 | 0.0068 |
| 10.67 | 245.8823 | 30.17 | 8.6873   | 49.50 | 0.0064 |
| 10.83 | 240.6681 | 30.33 | 8.1596   | 49.67 | 0.0060 |
| 11.00 | 236.0369 | 30.50 | 7.6643   | 49.83 | 0.0056 |
| 11.17 | 231.5665 | 30.67 | 7.1994   | 50.00 | 0.0053 |
| 11.33 | 227.2280 | 30.83 | 6.7630   | 50.17 | 0.0050 |

|       |          |       |        |       |        |
|-------|----------|-------|--------|-------|--------|
| 11.50 | 223.3442 | 31.00 | 6.3532 | 50.33 | 0.0047 |
| 11.67 | 219.5102 | 31.17 | 5.9685 | 50.50 | 0.0044 |
| 11.83 | 215.7137 | 31.33 | 5.6072 | 50.67 | 0.0041 |
| 12.00 | 212.2941 | 31.50 | 5.2679 | 50.83 | 0.0039 |
| 12.17 | 208.8558 | 31.67 | 4.9493 | 51.00 | 0.0036 |
| 12.33 | 205.3967 | 31.83 | 4.6500 | 51.17 | 0.0034 |
| 12.50 | 202.2669 | 32.00 | 4.3689 | 51.33 | 0.0032 |
| 12.67 | 199.0758 | 32.17 | 4.1049 | 51.50 | 0.0030 |
| 12.83 | 195.8271 | 32.33 | 3.8569 | 51.67 | 0.0028 |
| 13.00 | 192.8784 | 32.50 | 3.6239 | 51.83 | 0.0027 |
| 13.17 | 190.1968 | 32.67 | 3.4050 | 52.00 | 0.0025 |
| 13.33 | 187.7541 | 32.83 | 3.1994 | 52.17 | 0.0024 |
| 13.50 | 185.5255 | 33.00 | 3.0062 | 52.33 | 0.0022 |
| 13.67 | 183.1323 | 33.17 | 2.8247 | 52.50 | 0.0021 |
| 13.83 | 180.5918 | 33.33 | 2.6542 | 52.67 | 0.0020 |
| 14.00 | 178.2762 | 33.50 | 2.4940 | 52.83 | 0.0018 |
| 14.17 | 176.1620 | 33.67 | 2.3435 | 53.00 | 0.0017 |
| 14.33 | 174.2290 | 33.83 | 2.2021 | 53.17 | 0.0016 |
| 14.50 | 172.4593 | 34.00 | 2.0692 | 53.33 | 0.0015 |
| 14.67 | 170.4772 | 34.17 | 1.9443 | 53.50 | 0.0014 |
| 14.83 | 168.3056 | 34.33 | 1.8270 | 53.67 | 0.0013 |
| 15.00 | 166.3244 | 34.50 | 1.7168 | 53.83 | 0.0013 |
| 15.17 | 164.5137 | 34.67 | 1.6132 | 54.00 | 0.0012 |
| 15.33 | 162.8566 | 34.83 | 1.5159 | 54.17 | 0.0011 |
| 15.50 | 161.3380 | 35.00 | 1.4244 | 54.33 | 0.0010 |
| 15.67 | 159.5825 | 35.17 | 1.3385 | 54.50 | 0.0010 |
| 15.83 | 157.6152 | 35.33 | 1.2577 | 54.67 | 0.0009 |
| 16.00 | 155.8208 | 35.50 | 1.1819 | 54.83 | 0.0009 |
| 16.17 | 154.1810 | 35.67 | 1.1106 | 55.00 | 0.0008 |
| 16.33 | 152.6803 | 35.83 | 1.0435 | 55.17 | 0.0008 |
| 16.50 | 151.3050 | 36.00 | 0.9806 | 55.33 | 0.0007 |
| 16.67 | 150.0430 | 36.17 | 0.9215 | 55.50 | 0.0007 |
| 16.83 | 148.8837 | 36.33 | 0.8659 | 55.67 | 0.0006 |
| 17.00 | 147.8177 | 36.50 | 0.8137 | 55.83 | 0.0006 |
| 17.17 | 146.4714 | 36.67 | 0.7646 | 56.00 | 0.0006 |
| 17.33 | 144.8747 | 36.83 | 0.7185 | 56.17 | 0.0005 |
| 17.50 | 143.4191 | 37.00 | 0.6752 | 56.33 | 0.0005 |
| 17.67 | 142.0900 | 37.17 | 0.6345 | 56.50 | 0.0005 |
| 17.83 | 140.8741 | 37.33 | 0.5962 | 56.67 | 0.0004 |
| 18.00 | 139.7602 | 37.50 | 0.5603 | 56.83 | 0.0004 |
| 18.17 | 138.3715 | 37.67 | 0.5265 | 57.00 | 0.0004 |
| 18.33 | 136.7368 | 37.83 | 0.4947 | 57.17 | 0.0004 |
| 18.50 | 135.2484 | 38.00 | 0.4649 | 57.33 | 0.0003 |
| 18.67 | 133.8905 | 38.17 | 0.4369 | 57.50 | 0.0003 |
| 18.83 | 132.6494 | 38.33 | 0.4105 | 57.67 | 0.0003 |
| 19.00 | 131.5131 | 38.50 | 0.3858 | 57.83 | 0.0003 |
| 19.17 | 130.1026 | 38.67 | 0.3625 | 58.00 | 0.0003 |
| 19.33 | 128.4467 | 38.83 | 0.3407 | 58.17 | 0.0003 |
| 19.50 | 126.9389 | 39.00 | 0.3201 | 58.33 | 0.0002 |
| 19.67 | 125.5630 | 39.17 | 0.3008 | 58.50 | 0.0002 |
| 19.83 | 124.3051 | 39.33 | 0.2827 | 58.67 | 0.0002 |
| 20.00 | 123.1530 | 39.50 | 0.2656 | 58.83 | 0.0002 |
| 20.17 | 122.0961 | 39.67 | 0.2496 | 59.00 | 0.0002 |
| 20.33 | 121.1251 | 39.83 | 0.2346 | 59.17 | 0.0002 |
| 20.50 | 120.2317 | 40.00 | 0.2204 | 59.33 | 0.0002 |
| 20.67 | 119.4089 | 40.17 | 0.2071 | 59.50 | 0.0002 |
| 20.83 | 118.6500 | 40.33 | 0.1946 | 59.67 | 0.0001 |
| 21.00 | 117.9497 | 40.50 | 0.1829 | 59.83 | 0.0001 |
| 21.17 | 117.3029 | 40.67 | 0.1719 | 60.00 | 0.0001 |
| 21.33 | 116.7050 | 40.83 | 0.1615 | 60.17 | 0.0001 |
| 21.50 | 116.1522 | 41.00 | 0.1518 | 60.33 | 0.0001 |
| 21.67 | 115.6406 | 41.17 | 0.1426 | 60.50 | 0.0001 |

### Hydrograph ID: CULV. INLET - 100 yr

Area: 1209.0000 ac Hyd Int: 10.00 min Base Flow:  
Pending tt translation: 0.00 min  
Peak Flow: 360.3464 cfs Peak Time: 8.67 hrs Hyd Vol: 323.0639 acft

### Hydrograph ID: CULV. INLET - 100 yr

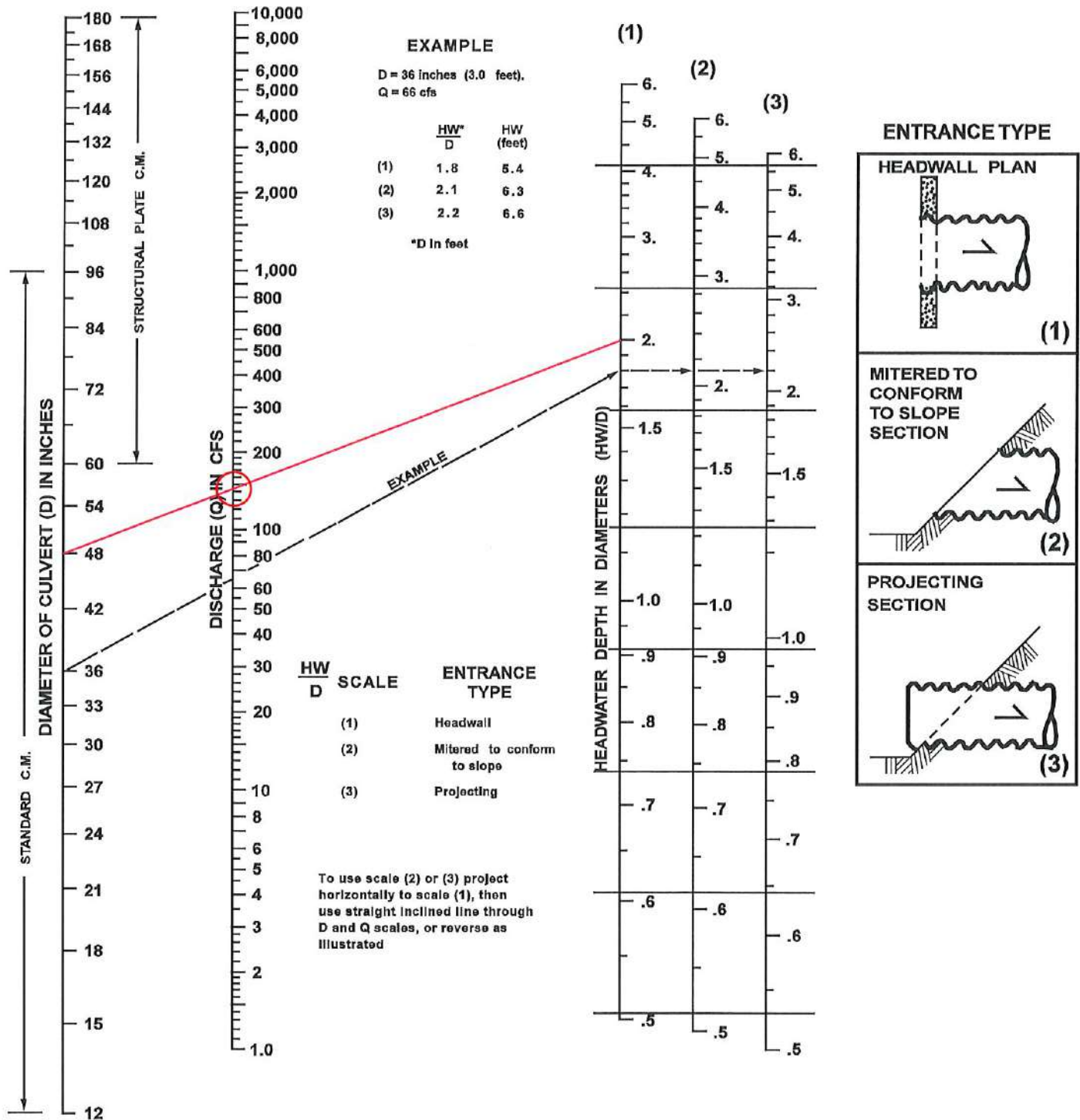
Area: 1209.0000 ac Hyd Int: 10.00 min Base Flow:  
Pending tt translation: 0.00 min  
Peak Flow: 360.3464 cfs Peak Time: 8.67 hrs Hyd Vol: 323.0639 acft

| Time  | Flow     | Time  | Flow     | Time  | Flow   |
|-------|----------|-------|----------|-------|--------|
| hr    | cfs      | hr    | cfs      | hr    | cfs    |
| 2.17  | 0.0761   | 21.83 | 131.7167 | 41.33 | 0.1532 |
| 2.33  | 0.3372   | 22.00 | 131.1954 | 41.50 | 0.1440 |
| 2.50  | 0.8350   | 22.17 | 130.2876 | 41.67 | 0.1353 |
| 2.67  | 1.6541   | 22.33 | 129.0343 | 41.83 | 0.1271 |
| 2.83  | 2.8324   | 22.50 | 127.8953 | 42.00 | 0.1195 |
| 3.00  | 4.3156   | 22.67 | 126.8577 | 42.17 | 0.1123 |
| 3.17  | 6.0539   | 22.83 | 125.9107 | 42.33 | 0.1055 |
| 3.33  | 8.0051   | 23.00 | 125.0446 | 42.50 | 0.0991 |
| 3.50  | 10.1323  | 23.17 | 124.2510 | 42.67 | 0.0931 |
| 3.67  | 12.5231  | 23.33 | 123.5228 | 42.83 | 0.0875 |
| 3.83  | 15.1582  | 23.50 | 122.8535 | 43.00 | 0.0823 |
| 4.00  | 17.9012  | 23.67 | 122.2376 | 43.17 | 0.0773 |
| 4.17  | 21.0304  | 23.83 | 121.6701 | 43.33 | 0.0726 |
| 4.33  | 24.5317  | 24.00 | 121.1466 | 43.50 | 0.0683 |
| 4.50  | 28.0893  | 24.17 | 115.9776 | 43.67 | 0.0641 |
| 4.67  | 32.0469  | 24.33 | 106.6447 | 43.83 | 0.0603 |
| 4.83  | 36.3855  | 24.50 | 98.2536  | 44.00 | 0.0566 |
| 5.00  | 40.7228  | 24.67 | 90.6858  | 44.17 | 0.0532 |
| 5.17  | 45.4653  | 24.83 | 83.8403  | 44.33 | 0.0500 |
| 5.33  | 50.5892  | 25.00 | 77.6301  | 44.50 | 0.0470 |
| 5.50  | 55.6515  | 25.17 | 71.9810  | 44.67 | 0.0442 |
| 5.67  | 61.1168  | 25.33 | 66.8289  | 44.83 | 0.0415 |
| 5.83  | 66.9580  | 25.50 | 62.1184  | 45.00 | 0.0390 |
| 6.00  | 72.6764  | 25.67 | 57.8017  | 45.17 | 0.0366 |
| 6.17  | 79.3137  | 25.83 | 53.8373  | 45.33 | 0.0344 |
| 6.33  | 86.8151  | 26.00 | 50.1890  | 45.50 | 0.0324 |
| 6.50  | 94.0849  | 26.17 | 46.8255  | 45.67 | 0.0304 |
| 6.67  | 102.8383 | 26.33 | 43.7189  | 45.83 | 0.0286 |
| 6.83  | 112.9851 | 26.50 | 40.8452  | 46.00 | 0.0269 |
| 7.00  | 122.7321 | 26.67 | 38.1828  | 46.17 | 0.0252 |
| 7.17  | 134.2546 | 26.83 | 35.7130  | 46.33 | 0.0237 |
| 7.33  | 147.4371 | 27.00 | 33.4190  | 46.50 | 0.0223 |
| 7.50  | 160.0164 | 27.17 | 31.2858  | 46.67 | 0.0209 |
| 7.67  | 196.4423 | 27.33 | 29.3001  | 46.83 | 0.0197 |
| 7.83  | 255.6099 | 27.50 | 27.4501  | 47.00 | 0.0185 |
| 8.00  | 311.9091 | 27.67 | 25.7248  | 47.17 | 0.0174 |
| 8.17  | 343.0060 | 27.83 | 24.1148  | 47.33 | 0.0163 |
| 8.33  | 350.5052 | 28.00 | 22.6113  | 47.50 | 0.0153 |
| 8.50  | 358.2174 | 28.17 | 21.2063  | 47.67 | 0.0144 |
| 8.67  | 360.3464 | 28.33 | 19.8927  | 47.83 | 0.0135 |
| 8.83  | 357.3200 | 28.50 | 18.6638  | 48.00 | 0.0127 |
| 9.00  | 355.2196 | 28.67 | 17.5137  | 48.17 | 0.0120 |
| 9.17  | 350.0197 | 28.83 | 16.4368  | 48.33 | 0.0112 |
| 9.33  | 341.9506 | 29.00 | 15.4282  | 48.50 | 0.0106 |
| 9.50  | 335.0820 | 29.17 | 14.4832  | 48.67 | 0.0099 |
| 9.67  | 328.0617 | 29.33 | 13.5975  | 48.83 | 0.0093 |
| 9.83  | 320.8523 | 29.50 | 12.7672  | 49.00 | 0.0088 |
| 10.00 | 314.5973 | 29.67 | 11.9886  | 49.17 | 0.0082 |
| 10.17 | 307.9780 | 29.83 | 11.2583  | 49.33 | 0.0077 |
| 10.33 | 300.9964 | 30.00 | 10.5732  | 49.50 | 0.0073 |
| 10.50 | 294.8405 | 30.17 | 9.9304   | 49.67 | 0.0068 |
| 10.67 | 288.6050 | 30.33 | 9.3272   | 49.83 | 0.0064 |
| 10.83 | 282.2749 | 30.50 | 8.7611   | 50.00 | 0.0060 |
| 11.00 | 276.6340 | 30.67 | 8.2297   | 50.17 | 0.0057 |
| 11.17 | 271.1949 | 30.83 | 7.7308   | 50.33 | 0.0053 |

|       |          |       |        |       |        |
|-------|----------|-------|--------|-------|--------|
| 11.33 | 265.9228 | 31.00 | 7.2624 | 50.50 | 0.0050 |
| 11.50 | 261.1889 | 31.17 | 6.8226 | 50.67 | 0.0047 |
| 11.67 | 256.5260 | 31.33 | 6.4096 | 50.83 | 0.0044 |
| 11.83 | 251.9189 | 31.50 | 6.0218 | 51.00 | 0.0042 |
| 12.00 | 247.7576 | 31.67 | 5.6576 | 51.17 | 0.0039 |
| 12.17 | 243.5864 | 31.83 | 5.3155 | 51.33 | 0.0037 |
| 12.33 | 239.4021 | 32.00 | 4.9941 | 51.50 | 0.0034 |
| 12.50 | 235.6066 | 32.17 | 4.6923 | 51.67 | 0.0032 |
| 12.67 | 231.7504 | 32.33 | 4.4088 | 51.83 | 0.0030 |
| 12.83 | 227.8375 | 32.50 | 4.1425 | 52.00 | 0.0029 |
| 13.00 | 224.2779 | 32.67 | 3.8923 | 52.17 | 0.0027 |
| 13.17 | 221.0334 | 32.83 | 3.6572 | 52.33 | 0.0025 |
| 13.33 | 218.0709 | 33.00 | 3.4364 | 52.50 | 0.0024 |
| 13.50 | 215.3617 | 33.17 | 3.2290 | 52.67 | 0.0022 |
| 13.67 | 212.4707 | 33.33 | 3.0341 | 52.83 | 0.0021 |
| 13.83 | 209.4176 | 33.50 | 2.8509 | 53.00 | 0.0020 |
| 14.00 | 206.6288 | 33.67 | 2.6789 | 53.17 | 0.0019 |
| 14.17 | 204.0771 | 33.83 | 2.5172 | 53.33 | 0.0017 |
| 14.33 | 201.7390 | 34.00 | 2.3653 | 53.50 | 0.0016 |
| 14.50 | 199.5934 | 34.17 | 2.2226 | 53.67 | 0.0015 |
| 14.67 | 197.2099 | 34.33 | 2.0885 | 53.83 | 0.0014 |
| 14.83 | 194.6142 | 34.50 | 1.9625 | 54.00 | 0.0014 |
| 15.00 | 192.2413 | 34.67 | 1.8441 | 54.17 | 0.0013 |
| 15.17 | 190.0685 | 34.83 | 1.7329 | 54.33 | 0.0012 |
| 15.33 | 188.0759 | 35.00 | 1.6283 | 54.50 | 0.0011 |
| 15.50 | 186.2460 | 35.17 | 1.5300 | 54.67 | 0.0011 |
| 15.67 | 184.1488 | 35.33 | 1.4378 | 54.83 | 0.0010 |
| 15.83 | 181.8132 | 35.50 | 1.3510 | 55.00 | 0.0009 |
| 16.00 | 179.6790 | 35.67 | 1.2696 | 55.17 | 0.0009 |
| 16.17 | 177.7253 | 35.83 | 1.1930 | 55.33 | 0.0008 |
| 16.33 | 175.9340 | 36.00 | 1.1210 | 55.50 | 0.0008 |
| 16.50 | 174.2893 | 36.17 | 1.0534 | 55.67 | 0.0007 |
| 16.67 | 172.7772 | 36.33 | 0.9898 | 55.83 | 0.0007 |
| 16.83 | 171.3853 | 36.50 | 0.9302 | 56.00 | 0.0006 |
| 17.00 | 170.1028 | 36.67 | 0.8741 | 56.17 | 0.0006 |
| 17.17 | 168.5025 | 36.83 | 0.8214 | 56.33 | 0.0006 |
| 17.33 | 166.6186 | 37.00 | 0.7718 | 56.50 | 0.0005 |
| 17.50 | 164.8983 | 37.17 | 0.7253 | 56.67 | 0.0005 |
| 17.67 | 163.3248 | 37.33 | 0.6816 | 56.83 | 0.0005 |
| 17.83 | 161.8830 | 37.50 | 0.6405 | 57.00 | 0.0004 |
| 18.00 | 160.5598 | 37.67 | 0.6018 | 57.17 | 0.0004 |
| 18.17 | 158.9246 | 37.83 | 0.5656 | 57.33 | 0.0004 |
| 18.33 | 157.0105 | 38.00 | 0.5314 | 57.50 | 0.0004 |
| 18.50 | 155.2654 | 38.17 | 0.4994 | 57.67 | 0.0003 |
| 18.67 | 153.6711 | 38.33 | 0.4693 | 57.83 | 0.0003 |
| 18.83 | 152.2119 | 38.50 | 0.4410 | 58.00 | 0.0003 |
| 19.00 | 150.8741 | 38.67 | 0.4144 | 58.17 | 0.0003 |
| 19.17 | 149.2249 | 38.83 | 0.3894 | 58.33 | 0.0003 |
| 19.33 | 147.2970 | 39.00 | 0.3659 | 58.50 | 0.0003 |
| 19.50 | 145.5398 | 39.17 | 0.3439 | 58.67 | 0.0002 |
| 19.67 | 143.9346 | 39.33 | 0.3231 | 58.83 | 0.0002 |
| 19.83 | 142.4654 | 39.50 | 0.3036 | 59.00 | 0.0002 |
| 20.00 | 141.1181 | 39.67 | 0.2853 | 59.17 | 0.0002 |
| 20.17 | 139.8809 | 39.83 | 0.2681 | 59.33 | 0.0002 |
| 20.33 | 138.7428 | 40.00 | 0.2520 | 59.50 | 0.0002 |
| 20.50 | 137.6942 | 40.17 | 0.2368 | 59.67 | 0.0002 |
| 20.67 | 136.7272 | 40.33 | 0.2225 | 59.83 | 0.0002 |
| 20.83 | 135.8345 | 40.50 | 0.2091 | 60.00 | 0.0001 |
| 21.00 | 135.0094 | 40.67 | 0.1965 | 60.17 | 0.0001 |
| 21.17 | 134.2461 | 40.83 | 0.1846 | 60.33 | 0.0001 |
| 21.33 | 133.5397 | 41.00 | 0.1735 | 60.50 | 0.0001 |
| 21.50 | 132.8854 | 41.17 | 0.1630 | 60.67 | 0.0001 |
| 21.67 | 132.2789 | 41.33 | 0.1532 | 60.83 | 0.0001 |

FIGURE 4.3.1.C HEADWATER DEPTH FOR CORRUGATED PIPE CULVERTS WITH INLET CONTROL

## Existing 4-foot CMP Culvert Capacity Calculations



Circular - 4-ft Culvert

**Open Channel Flow Based on The Mannings Equation**

For Circular Cross Section

Design:

$d_o = 48$  IN      Diameter  
 $S = 0.0002$  FT/FT  
 $n = 0.03$

Variables:

$Y = 4.00$  FT      Flow Depth

Gives:

$\theta = 360.00$  Degrees  
or  
 $\theta = 6.28$  Radians  
 $A = 12.57$  SF      Flow Area  
 $P = 12.57$  FT  
 $R = 1.00$  FT  
 $B = 0.00$  FT  
or  
 $B = 0.00$  FT

Check:

$V = 0.70$  FPS

Set:

$Q = 8.8028$  CFS

## Trapezoidal - Upstream

### Open Channel Flow Based on The Mannings Equation For Trapezoidal Cross Section

Design:

$$Z = 1.00 \text{ H:V}$$

$$S = 0.0070 \text{ FT/FT}$$

$$n = 0.0700$$

Sluggish reaches, weedy, deep pools

Variables:

$$Y = 6.500 \text{ FT}$$

$$B_w = 2.00 \text{ FT}$$

Gives:

$$A = 55.25 \text{ SF}$$

$$R = 2.71 \text{ FT}$$

$$B = 15.00 \text{ FT}$$

Check:

$$V = 3.45 \text{ FPS}$$

Set:

$$Q = 190.7596 \text{ CFS}$$

## Trapezoidal - Downstream

### Open Channel Flow Based on The Mannings Equation For Trapezoidal Cross Section

Design:

Z= 2.00 H:V

S= 0.0043 FT/FT

n= 0.0700 Sluggish reaches, weedy, deep pools

Variables:

Y= 3.500 FT

B<sub>w</sub>= 28.00 FT

Gives:

A= 122.50 SF

R= 2.81 FT

B= 42.00 FT

Check:

V= 2.77 FPS

Set:

Q= 339.2677 CFS

## Trapezoidal - PROPOSED

### Open Channel Flow Based on The Mannings Equation For Trapezoidal Cross Section

Design:

Z= 2.00 H:V  
S= 0.0070 FT/FT  
n= 0.0700      Sluggish reaches, weedy, deep pools

Variables:

Y= 6.000 FT  
B<sub>w</sub>= 2.00 FT

Gives:

A= 84.00 SF  
R= 2.91 FT  
B= 26.00 FT

Check:

V= 3.62 FPS

Set:

Q= 304.3294 CFS