DRAINAGE REPORT

BASELINE ROAD IMPROVEMENTS
LOOP 202 FREEWAY TO 57TH AVENUE

Prepared For:
BASELINE ROAD STAKEHOLDERS

Prepared By:
CIVIL & ENVIRONMENTAL CONSULTANTS, INC.
PHOENIX, ARIZONA

CEC Project 182-001
KIVA: 06-2778

NOVEMBER 2018
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1.0 INTRODUCTION

Baseline Road Improvements is a proposed arterial roadway improvement project located between the proposed Loop 202 Freeway and 57th Avenue in Phoenix, Arizona. The roadway improvements are 0.5 miles in length and will be in accordance with previously approved roadway geometry that the City of Phoenix has previously agreed upon. This is a joint venture project between the City of Phoenix and private land owners.

The site is further described as a portion of the southwest quarter Section 31, Township 2 North, Range 2 West and a very small portion of northeast quarter of Section 1, Township 1 North, Range 3 West of the Gila and Salt River Base and Meridian, Maricopa County, Arizona. Refer to the Vicinity Map on the following page.

This site is located within a shaded Zone X designation as identified on Flood Insurance Rate Map (FIRM) panel number 2195L of 4425 (Maricopa County) dated October 16, 2013 from the Federal Emergency Management Agency (FEMA). This area is defined as, “Areas of 0.2% annual chance flood; areas of 1% annual chance flood with average depths of less than 1 foot or with drainage areas less than 1 square mile; and areas protected by levees from 1% chance annual flood.” A copy of the FEMA FIRM Map is located in Appendix B at the back of this report.

This Drainage Report will document roadway retention requirements, offsite drainage, existing improvements, and anticipated improvements.
Vicinity Map
2.0 OFFSITE DRAINAGE AND EXISTING IMPROVEMENTS

There is no offsite drainage that affects this project. The property at the northwest corner of 59th Avenue and Baseline Road is currently an active farm field and is generally a couple of feet lower than the proposed Baseline Road improvements. This property also has an irrigation tail-water ditch that directs irrigation and storm water to an existing irrigation headwall and is piped under the proposed Loop 202 Freeway to the west. The property at the southwest corner of 59th Avenue and Baseline Road is currently under development by Laveen Baseline LLC. Drainage for this property is directed to the south and ultimately into the Laveen Area Conveyance Channel (LACC). The property at the southeast corner of 59th Avenue and Baseline Road is currently undeveloped. Drainage for this property ultimately goes south into the LACC. The properties at the northeast corner of 59th Avenue and Baseline Road currently an inactive driving range for a golf course. Immediately adjacent to Baseline Road there is a detention facility and drainage is directed to an existing headwall just west of 57th Avenue, which ultimately discharges into the LACC.

3.0 PROPOSED DRAINAGE AND INFRASTRUCTURE IMPROVEMENTS

Retention requirements for this project vary based on adjacent property. Coordination with the City of Phoenix it was decided by staff that each adjacent landowner will be required to account for their half street drainage. Scuppers will be constructed to capture roadway drainage and direct them to onsite retention/detention facilities.

The property at the northwest corner of 59th Avenue and Baseline Road will account for their half-street retention in a 1-foot temporary retention basin for the 100-year, 2-hour rainfall depth. A curb opening scupper will be constructed along with a concrete spillway to direct half street drainage into the temporary basin. This scupper is designed to handle the 10-year storm event per City of Phoenix drainage criteria. This scupper will be in a sag condition and the roadway spread is approximately 15.58 feet which will allow at least one dry travel lane within the roadway. 100-year peak flows will be contained within the right-of-way.
The property at the southwest corner of 59th Avenue and Baseline Road will account for their half-street retention in onsite retention facilities for the 5-year, 2-hour rainfall depth per a recorded development agreement with the City of Phoenix. Two scuppers will be constructed to direct half street drainage to the onsite drainage facilities. The onsite drainage facilities have been approved by the City of Phoenix as part of the Laveen Park Place – Phase I Grading & Drainage plans. The catch basins are designed to handle the 10-year storm event per City of Phoenix drainage criteria. The catch basins will be in sag conditions and the roadway spread is approximately 21.13 feet which will allow at least one dry travel lane within the roadway. 100-year peak flows will be contained within the right-of-way.

The property at the southeast corner of 59th Avenue and Baseline Road will account for their half street retention in a 1-foot temporary retention basin for the 100-year, 2-hour rainfall depth. A curb opening scupper will be constructed along with a concrete spillway to direct half street drainage into the temporary basin. This scupper is designed to handle the 10-year storm event per City of Phoenix drainage criteria. This scupper will be in a sag condition and the roadway spread is approximately 25.95 feet which will allow at least one dry travel land within the roadway. 100-year peak flows will be contained within the right-of-way.

The properties at the northeast corner of 59th Avenue and Baseline Road will account for their half street retention in an existing ponding area that serves as a detention facility. Drainage is ultimately directed to the LACC via headwall and storm drain. A scupper will direct half street drainage into the existing ponding area. The scupper is designed to handle the 10-year storm event per City of Phoenix drainage criteria. The scupper will be in a sag condition and the roadway spread is approximately 27.12 feet which will allow at least one dry travel land within the roadway. 100-year peak flows will be contained within the right-of-way.
Retentions Calculations

The following table presents calculations for required temporary retention for each sub-watershed for the project. Drainage sub-watersheds are shown on the Drainage Exhibit in Appendix D at the back of this report.

<table>
<thead>
<tr>
<th>DRAINAGE</th>
<th>AREA</th>
<th>VOLUME</th>
<th>VOLUME</th>
<th>EXCESS/</th>
<th>STORM</th>
<th>&quot;AS-BUILT&quot;</th>
<th>VOLUME PROVIDED</th>
</tr>
</thead>
<tbody>
<tr>
<td>ID.</td>
<td>(Ac)</td>
<td>(cf)</td>
<td>REQUIRED</td>
<td>PROVIDED</td>
<td>SHORT</td>
<td>EVENT</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>1.05</td>
<td>45.997</td>
<td>8.212</td>
<td>8.263</td>
<td>51</td>
<td></td>
<td>100-YR, 2-HR</td>
</tr>
<tr>
<td>2</td>
<td>1.08</td>
<td>46.993</td>
<td>4.539</td>
<td>4.539*</td>
<td>&lt;=Laveen Park Place</td>
<td>5-YR, 2-HR</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>1.52</td>
<td>66.138</td>
<td>6.388</td>
<td>6.388*</td>
<td></td>
<td></td>
<td>TO LACC</td>
</tr>
<tr>
<td>4</td>
<td>1.43</td>
<td>62.215</td>
<td>11.181</td>
<td>11.184</td>
<td>3</td>
<td></td>
<td>100-YR, 2-HR</td>
</tr>
<tr>
<td>5</td>
<td>0.42</td>
<td>18.176</td>
<td>1.755</td>
<td>1.758*</td>
<td></td>
<td></td>
<td>TO LACC</td>
</tr>
<tr>
<td>6</td>
<td>0.44</td>
<td>19.231</td>
<td>1.857</td>
<td>1.857*</td>
<td></td>
<td></td>
<td>TO LACC</td>
</tr>
<tr>
<td>Total</td>
<td>5.93</td>
<td>258450</td>
<td>33932</td>
<td>29321</td>
<td>54</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Retention Volume Calculations

CONIC FRUSTUM METHOD
RETENTION PROVIDED = h/3(B1+B2+(B1*B2)**0.5)

<table>
<thead>
<tr>
<th>RETENTION BASIN</th>
<th>ELEV.</th>
<th>AREA</th>
<th>DIFF.</th>
<th>AVG VOLUME</th>
<th>CUMULATIVE VOLUME</th>
</tr>
</thead>
<tbody>
<tr>
<td>ID.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TEMP #1</td>
<td>997.00</td>
<td>7,598</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TEMP #2</td>
<td>998.00</td>
<td>8,947</td>
<td>1.00</td>
<td>8,263</td>
<td>8,263</td>
</tr>
<tr>
<td>TEMP #4</td>
<td>998.00</td>
<td>9,843</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TEMP #4</td>
<td>999.00</td>
<td>12,581</td>
<td>1.00</td>
<td>11,184</td>
<td>11,184</td>
</tr>
</tbody>
</table>
The proposed temporary retention basins will be 1-foot in depth and will not require dual-chamber drywells. Dry-up calculations are shown below. The onsite drainage facilities for the property at the southwest corner will be de-watered in 36-hours or less based on approved Grading & Drainage Plans for the Laveen Park Place development. The onsite drainage facilities for the properties at the northeast corner are detention facilities and have a discharge pipe that will dewater them in 36-hour or less.

### Dry-Up Calculations

The criteria used are as follows:

**CRITERIA USED:**
City of Phoenix

**GIVEN:**
REQUIRED DRAIN TIME = 36 HRS

**TEST RESULTS:**
DETERMINED PERC TIME = 80 (MIN/INCHES)

**PERC RATE TEST:**
0.0625 (FT^3/HR)/FT^2 (safety factor applied)

**ASSUMPTIONS:**
DRY WELL FLOW RATE = 0.1 CFS (safety factor applied)
SAFETY FACTOR = 2

### DRYWELL CALCULATIONS

**EQUATIONS:**

\[
\text{Perc Time (hr)} = \frac{\text{Volume to Drain (ft}^3\text{)} \times \text{Safety Factor}}{\text{Permeable Area (ft}^2\text{)} \times \text{Perc Rate (ft/hr)}}
\]

\[
\text{Volume Dis. Per Drywell} = \text{Drywell Q (cfs)} \times 3600 \text{ (sec/hr)} \times \text{Time (hr)}
\]

<table>
<thead>
<tr>
<th>RETENTION BASIN</th>
<th>VOL (FT^3)</th>
<th>PERMEABLE AREA (FT^2)</th>
<th>PERC RATE (FT^3/HR)</th>
<th>PERC RATE SF APPLIED (FT^3/HR/FT^2)</th>
<th>PERC TIME (HR)</th>
<th>DRY WELLS REQUIRED</th>
</tr>
</thead>
<tbody>
<tr>
<td>TEMP #1</td>
<td>8,283</td>
<td>7,598</td>
<td>0.100</td>
<td>0.063</td>
<td>17.4</td>
<td>0</td>
</tr>
<tr>
<td>TEMP #4</td>
<td>11,184</td>
<td>9,843</td>
<td>0.100</td>
<td>0.063</td>
<td>18.2</td>
<td>0</td>
</tr>
</tbody>
</table>

### Drainage Area Peak Flows

The Drainage Exhibit in Appendix B at the back of this report breaks down the overall drainage areas to perform hydrologic and hydraulic calculations to size the catch basins, scuppers and storm drain sizes for the 10-year storm event.
Full calculations for the proposed drainage structures are located at the back of this report in Appendix C & D. The following table summarizes the peak flows.

<table>
<thead>
<tr>
<th>Sub-Basin</th>
<th>AREA (AC)</th>
<th>AREA (SF)</th>
<th>10-YR PEAK FLOW (cfs)</th>
<th>25-YR PEAK FLOW (cfs)</th>
<th>50-YR PEAK FLOW (cfs)</th>
<th>100-YR PEAK FLOW (cfs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>DA1</td>
<td>1.05</td>
<td>45697</td>
<td>4.98</td>
<td>6.10</td>
<td>6.96</td>
<td>7.81</td>
</tr>
<tr>
<td>DA2</td>
<td>1.08</td>
<td>46993</td>
<td>5.12</td>
<td>6.27</td>
<td>7.15</td>
<td>8.03</td>
</tr>
<tr>
<td>DA3</td>
<td>1.52</td>
<td>66138</td>
<td>7.21</td>
<td>8.83</td>
<td>10.07</td>
<td>11.31</td>
</tr>
<tr>
<td>DA4</td>
<td>1.43</td>
<td>62215</td>
<td>6.78</td>
<td>8.30</td>
<td>9.47</td>
<td>10.64</td>
</tr>
<tr>
<td>DA5</td>
<td>0.42</td>
<td>18176</td>
<td>1.98</td>
<td>2.43</td>
<td>2.77</td>
<td>3.11</td>
</tr>
<tr>
<td>DA6</td>
<td>0.44</td>
<td>19231</td>
<td>2.10</td>
<td>2.57</td>
<td>2.93</td>
<td>3.29</td>
</tr>
</tbody>
</table>

**Scupper Calculations**

Scuppers are sized based on the contributing drainage area flows and a 20% clogging factor was applied for inflows to account for debris. Refer to the Drainage Exhibit in Appendix B and to the Hydraulic calculations in Appendix D at the back of this report. The following table summarizes the scupper spread criteria.

<table>
<thead>
<tr>
<th>Scupper</th>
<th>Sub-Basin ID</th>
<th>Area, Ac</th>
<th>10-Year Q, cfs</th>
<th>Width of Spread, ft</th>
<th>Gutter Depth, ft</th>
<th>Clogging Factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>#1</td>
<td>DA1</td>
<td>1.05</td>
<td>4.98</td>
<td>15.58</td>
<td>0.36</td>
<td>20.00%</td>
</tr>
<tr>
<td>#2B</td>
<td>DA2</td>
<td>1.08</td>
<td>5.12</td>
<td>21.13</td>
<td>0.47</td>
<td>20.00%</td>
</tr>
<tr>
<td>#3</td>
<td>DA3</td>
<td>1.52</td>
<td>7.21</td>
<td>27.12</td>
<td>0.59</td>
<td>20.00%</td>
</tr>
<tr>
<td>#4</td>
<td>DA4</td>
<td>1.43</td>
<td>6.78</td>
<td>25.95</td>
<td>0.56</td>
<td>20.00%</td>
</tr>
</tbody>
</table>
Rip-Rap Calculations

Rip-rap has been sized for the peak contributing flows. Each scupper will have a 16-foot long by 24-feet long rip-rap apron as shown in the calculations. For full calculations refer to the Hydraulic Calculations located in Appendix D at the back of this report.

4.0 CONCLUSIONS

The proposed Baseline Road project will adhere to the City of Phoenix drainage criteria to retain half street drainage and temporary retention basins, onsite retention facilities, and detention facilities will be dewatered within the 36 hour time requirement. Roadway drainage structures are sized for the 10-year peak flows with spread criteria that will allow one dry travel lane within the roadway.
APPENDIX A – FEMA FIRM MAP
This map complies with FEMA's standards for the use of digital flood maps if it is not void as described below. The base map shown complies with FEMA's base map accuracy standards.

The flood hazard information is derived directly from the authoritative NFHL web services provided by FEMA. This map was exported on 2/27/2018 at 5:38:09 PM and does not reflect changes or amendments subsequent to this date and time. The NFHL and effective information may change or become superseded by new data over time.

This map image is void if the one or more of the following map elements do not appear: base map imagery, flood zone labels, legend, scale bar, map creation date, community identifiers, FIRM panel number, and FIRM effective date. Map images for unmapped and unmodernized areas cannot be used for regulatory purposes.
APPENDIX B – DRAINAGE EXHIBIT
APPENDIX C – HYDROLOGY CALCULATIONS
Summary of Onsite Peak Discharges

Rational Method (CxA) where:
C=0.95, A=Sub Basin Area (AC)
5-minute Time of Concentration
i_{10}=5.00
i_{25}=6.12
i_{50}=6.98
i_{100}=7.84

<table>
<thead>
<tr>
<th>Sub-Basin ID</th>
<th>AREA (AC)</th>
<th>AREA (SF)</th>
<th>10-YR PEAK FLOW (cfs)</th>
<th>25-YR PEAK FLOW (cfs)</th>
<th>50-YR PEAK FLOW (cfs)</th>
<th>100-YR PEAK FLOW (cfs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>DA1</td>
<td>1.05</td>
<td>45697</td>
<td>4.98</td>
<td>6.10</td>
<td>6.96</td>
<td>7.81</td>
</tr>
<tr>
<td>DA2</td>
<td>1.08</td>
<td>46993</td>
<td>5.12</td>
<td>6.27</td>
<td>7.15</td>
<td>8.03</td>
</tr>
<tr>
<td>DA3</td>
<td>1.52</td>
<td>66138</td>
<td>7.21</td>
<td>8.83</td>
<td>10.07</td>
<td>11.31</td>
</tr>
<tr>
<td>DA4</td>
<td>1.43</td>
<td>62215</td>
<td>6.78</td>
<td>8.30</td>
<td>9.47</td>
<td>10.64</td>
</tr>
<tr>
<td>DA5</td>
<td>0.42</td>
<td>18176</td>
<td>1.98</td>
<td>2.43</td>
<td>2.77</td>
<td>3.11</td>
</tr>
<tr>
<td>DA6</td>
<td>0.44</td>
<td>19231</td>
<td>2.10</td>
<td>2.57</td>
<td>2.93</td>
<td>3.29</td>
</tr>
</tbody>
</table>
APPENDIX D – HYDRAULIC CALCULATIONS
Hydraulic Analysis Report

Project Data

Project Title: 
Designer: 
Project Date:  Monday, September 10, 2018 
Project Units:  U.S. Customary Units 
Notes: 

Curb and Gutter Analysis: Scupper #1

Notes: 

Gutter Input Parameters

Longitudinal Slope of Road: 0.0015 ft/ft 
Cross-Slope of Pavement: 0.0200 ft/ft 
Depressed Gutter Geometry 
Cross-Slope of Gutter: 0.0500 ft/ft 
Manning's n: 0.0150 
Gutter Width: 1.5000 ft 
Width of Spread: 18.1793 ft 

Gutter Result Parameters

Design Flow: 4.9800 cfs 
Gutter Depression: 0.5400 in 
Area of Flow: 3.3386 ft^2 
Eo (Gutter Flow to Total Flow): 0.2233 
Gutter Depth at Curb: 4.9030 in 

Inlet Input Parameters

Inlet Location: Inlet in Sag 
Percent Clogging: 20.0000 % 
Inlet Type: Curb Opening 
Length of Inlet: 10.0000 ft 
Curb opening height: 6.0000 in 
Local Depression: 2.0000 in 

Inlet Result Parameters
Perimeter: 12.7000 ft
Effective Perimeter: 10.1600 ft
Area: 6.6667 ft^2
Effective Area: 5.3333 ft^2
Depth at curb face (upstream of local depression): 0.3568 ft
Computed Width of Spread at Sag: 15.5892 ft
Flow type: Weir Flow
Efficiency: 1.0000
Curb and Gutter Analysis: Scupper #2B

Notes:

Gutter Input Parameters
- Longitudinal Slope of Road: 0.0015 ft/ft
- Cross-Slope of Pavement: 0.0200 ft/ft
- Depressed Gutter Geometry
  - Cross-Slope of Gutter: 0.0500 ft/ft
  - Manning's n: 0.0150
  - Gutter Width: 1.5000 ft
  - Width of Spread: 18.3725 ft

Gutter Result Parameters
- Design Flow: 5.1200 cfs
- Gutter Depression: 0.5400 in
- Area of Flow: 3.4092 ft^2
- Eo (Gutter Flow to Total Flow): 0.2209
- Gutter Depth at Curb: 4.9494 in

Inlet Input Parameters
- Inlet Location: Inlet in Sag
- Percent Clogging: 20.0000 %
- Inlet Type: Curb Opening
- Length of Inlet: 6.0000 ft
- Curb opening height: 6.0000 in
- Local Depression: 2.0000 in

Inlet Result Parameters
- Perimeter: 8.7000 ft
- Effective Perimeter: 6.9600 ft
- Area: 4.0000 ft^2
- Effective Area: 3.2000 ft^2
- Depth at curb face (upstream of local depression): 0.4677 ft
- Computed Width of Spread at Sag: 21.1343 ft
- Flow type: Weir Flow
- Efficiency: 1.0000
Curb and Gutter Analysis: Scupper #3

Notes:

Gutter Input Parameters
- Longitudinal Slope of Road: 0.0015 ft/ft
- Cross-Slope of Pavement: 0.0200 ft/ft
- Depressed Gutter Geometry
  - Cross-Slope of Gutter: 0.0500 ft/ft
  - Manning's n: 0.0150
  - Gutter Width: 1.5000 ft
  - Width of Spread: 20.9287 ft

Gutter Result Parameters
- Design Flow: 7.2100 cfs
- Gutter Depression: 0.5400 in
- Area of Flow: 4.4139 ft^2
- Eo (Gutter Flow to Total Flow): 0.1940
- Gutter Depth at Curb: 5.5629 in

Inlet Input Parameters
- Inlet Location: Inlet in Sag
- Percent Clogging: 20.0000 %
- Inlet Type: Curb Opening
- Length of Inlet: 6.0000 ft
- Curb opening height: 6.0000 in
- Local Depression: 2.0000 in

Inlet Result Parameters
- Perimeter: 8.7000 ft
- Effective Perimeter: 6.9600 ft
- Area: 4.0000 ft^2
- Effective Area: 3.2000 ft^2
- Depth at curb face (upstream of local depression): 0.5876 ft
- Computed Width of Spread at Sag: 27.1289 ft
- Flow type: Weir Flow
- Efficiency: 1.0000
Curb and Gutter Analysis: Scupper #4

Notes:

Gutter Input Parameters
- Longitudinal Slope of Road: 0.0015 ft/ft
- Cross-Slope of Pavement: 0.0200 ft/ft
- Depressed Gutter Geometry
  - Cross-Slope of Gutter: 0.0500 ft/ft
  - Manning's n: 0.0150
  - Gutter Width: 1.5000 ft
  - Width of Spread: 20.4454 ft

Gutter Result Parameters
- Design Flow: 6.7800 cfs
- Gutter Depression: 0.5400 in
- Area of Flow: 4.2139 ft^2
- Eo (Gutter Flow to Total Flow): 0.1986
- Gutter Depth at Curb: 5.4469 in

Inlet Input Parameters
- Inlet Location: Inlet in Sag
- Percent Clogging: 20.0000%
- Inlet Type: Curb Opening
- Length of Inlet: 6.0000 ft
- Curb opening height: 6.0000 in
- Local Depression: 2.0000 in

Inlet Result Parameters
- Perimeter: 8.7000 ft
- Effective Perimeter: 6.9600 ft
- Area: 4.0000 ft^2
- Effective Area: 3.2000 ft^2
- Depth at curb face (upstream of local depression): 0.5640 ft
- Computed Width of Spread at Sag: 25.9489 ft
- Flow type: Weir Flow
- Efficiency: 1.0000
Riprap Analysis: Scupper #1

Notes:

Input Parameters
- Riprap Type: Culvert Outlet Protection
- Flow: 4.98 cfs
- Culvert Diameter: 4 ft
- Normal Depth in Culvert: 0.328477 ft
- Tailwater Depth: 0.4 ft
- If tailwater is unknown, use 0.4D
- Flow is subcritical

Result Parameters
- Tailwater Depth Used in Computations: 1.6 ft
- Culvert Diameter Used in Computations: 4 ft
- Computed D50: 0.198601 in
Riprap Class

Riprap shape should be angular

Riprap Class Name: CLASS I

Riprap Class Order: 1

The following values are an 'average' of the size fraction range for the selected riprap class.

d100: 12 in

d85: 9 in

d50: 6.5 in

d15: 4.5 in
Layout Recommendations

Apron Length: 16 ft
Apron Depth: 1.89583 ft
Apron Width (at end): 22.6667 ft
Name of Selected Channel: Channel Analysis
Channel Analysis: Channel Analysis

Notes:

Input Parameters

Channel Type: Trapezoidal
Side Slope 1 (Z1): 4.0000 ft/ft
Side Slope 2 (Z2): 4.0000 ft/ft
Channel Width: 4.0000 ft
Longitudinal Slope: 0.0050 ft/ft
Manning's n: 0.0150
Flow: 4.9800 cfs

Result Parameters

Depth: 0.3285 ft
Area of Flow: 1.7455 ft^2
Wetted Perimeter: 6.7087 ft
Hydraulic Radius: 0.2602 ft
Average Velocity: 2.8531 ft/s
Top Width: 6.6278 ft
Froude Number: 0.9797
Critical Depth: 0.3246 ft
Critical Velocity: 2.8953 ft/s
Critical Slope: 0.0052 ft/ft
Critical Top Width: 6.60 ft
Calculated Max Shear Stress: 0.1025 lb/ft^2
Calculated Avg Shear Stress: 0.0812 lb/ft^2
Riprap Analysis: Scupper #4

Notes:

Input Parameters
- Riprap Type: Culvert Outlet Protection
- Flow: 6.78 cfs
- Culvert Diameter: 4 ft
- Normal Depth in Culvert: 0.328477 ft
- Tailwater Depth: 0.4 ft
- If tailwater is unknown, use 0.4D
- flow is sbcritical

Result Parameters
- Tailwater Depth Used in Computations: 1.6 ft
- Culvert Diameter Used in Computations: 4 ft
- Computed D50: 0.299673 in
**Riprap Class**

Riprap shape should be angular

**Riprap Class Name: CLASS I**

Riprap Class Order: 1

The following values are an 'average' of the size fraction range for the selected riprap class.

d100: 12 in

d85: 9 in

d50: 6.5 in

d15: 4.5 in
Layout Recommendations

- Apron Length: 16 ft
- Apron Depth: 1.89583 ft
- Apron Width (at end): 22.6667 ft
- Name of Selected Channel: Channel Analysis