AUBURN
STORMWATER

Highway Research Center
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New Product Performance Evaluation

Large-Scale Ditch Check Testing (ASTM D 7208 – Modified)

GMG Ninety7Wattle Straw Wattle Ditch Check in a Sandy Loam Channel

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DISCLAIMERS

EXECUTIVE SUMMARY

This report describes the complete testing of the *GMG Ninety7Wattle* straw wattle ditch check for channelized flow conditions. The *GMG Ninety7Wattle* was installed based upon standard installation techniques. A nonwoven, 8 oz. geotextile underlay was used as an underlay and splash pad to help minimize scour from flow passing through and overtop of the ditch check. This installation uses driven wooden stakes upstream and downstream in a "teepee" or "A-frame" pattern anchoring method. The first wattle did not utilize sod staples as an anchor while the final two did. This allows the ability to compare this wattle to the previously tested wattles that did not use sod staples while also verifying its overall performance. Testing was performed to determine replicate performance based upon three clean water performance tests and one sediment laden longevity tests. The performance tests used clean (sediment free) water at a tier flow rate of 0.6 cfs, and 1.2 cfs that included testing three separate wattle installations at 15 minutes per flow rate for each test. These tests evaluate the hydraulic performance of the ditch check to reduce erosive energy by creating an impoundment pool of low velocity, low kinetic energy flow. The third installation was also used, after the clean water test was run, for the longevity testing in which a ditch check is exposed to three separate simulated runoff events with sediment laden flow at the same flow rates as the performance tests. Sediment accumulation upstream of the ditch checks were also monitored to determine sediment capture percentage. Results are summarized in Table 1.

Table 1: Summary of Ditch Check Performance Tests on *GMG Ninety7Wattle*

Test Type	Flow Rates per Test Interval (cfs)	Average y/E	Max. Impoundment (ft)	Sediment Capture (%)
Clean Water	0.6, 1.2	0.975	32.2	--
Sediment Laden		--	--	68

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1 INTRODUCTION

Product testing is an essential evaluation component to provide product index and performance data. Ditch check products tested at the Auburn University – Stormwater Research Facility (AU-SRF) will be evaluated using a modified version of the ASTM International (ASTM) D7208-14: *Standard Test Method for Determination of Temporary Ditch Check Performance in Protecting Earthen Channels from Stormwater-Induced Erosion* (*ASTM 2014*). Modifications to this ASTM standard test method were made to better reflect the typical design geometry applied to the Alabama Department of Transportation (ALDOT) highway projects. The modified standard test method can be found in Appendix A of this report. Testing was performed on the *GMG Ninety7Wattle* straw wattle.

2 TESTING METHODOLOGY & INSTALLATION

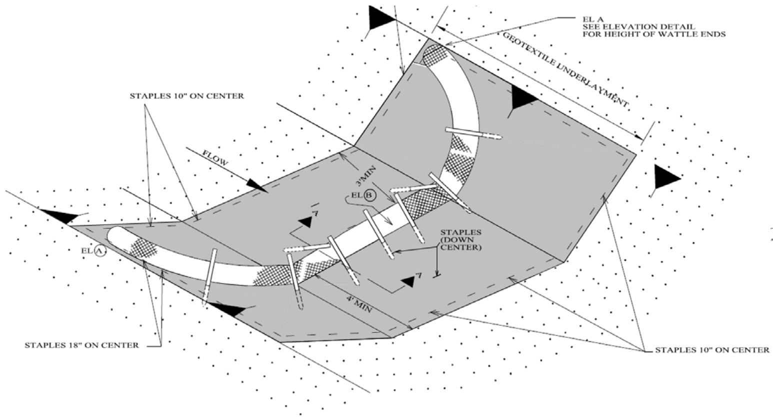
Products are tested using a two tier flow regime of 15 minutes at 0.6 cfs and 1.2 cfs each for a total test duration of 30 minutes. Specific channel details, channel preparation prior to testing, and data collection protocols can be found in Appendix A of this report. Testing is performed to evaluate the structural integrity and performance of the wattle tested using the installation configuration specified by the manufacturer, or specified by the state department of transportation or other representative agency. For purposes of this report, the installation configuration ALDOT standard drawings. Additionally, a sediment-laden longevity test is performed to determine sediment retention performance and structural performance to withstand multiple storm events. All tests are conducted to determine an average performance for the product.

2.1 *GMG Ninety7Wattle* Installation

Figure 1 illustrates the standard ALDOT installation. The *GMG Ninety7Wattle* was installed to mimic this installation. This included using an 8 oz. nonwoven filter fabric as an underlay, sod staples, and wooden stakes.

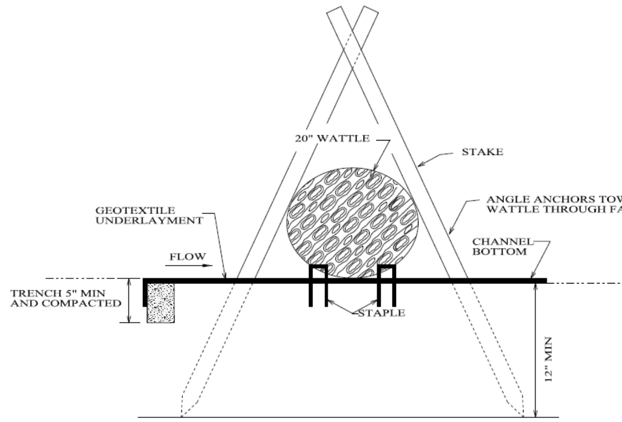
The following is a list of materials used for the installation of the *GMG Ninety7Wattle* shown in Figure 1:

- *GMG NinetytWattle straw wattle*: two 20 in. nominal diameter, 11-12 ft long wattle overlapped 3 ft in the center of the channel;
  filter fabric (FF) underlay: 8 oz., nonwoven FF, 13 ft long, 15 ft wide. Extends 6 ft from the upstream face of the wattle, is trenched using a reverse trenching method [Figure 1(a)] and pinned by sod staples spaced every 5 in. on-center. The FF underlay extends 3 ft downstream beyond the wattle. The downstream edges of FF are also secured with sod staples spaced 5 in. apart as well as longitudinally along each side and the centerline of the fabric spaced 18 in. apart; and
  sod staples: 11 gauge metal, 6 in. long x 1 $^{3}/_{8}$ in. U-shaped sod staple, used to secure the FF underlay.



DETAIL (DITCH CHECK)

(a) Installation Standard Drawing Overview



SECTION A-A

(b) ALDOT Cross-Section Wattle Installation

Figure 1: Comparison of Wattle Installation Details.

Figure 2 shows the upstream and downstream view of the installation prior to conducting a test.

(a) view from upstream (b) view from downstream

Figure 2: Pre-Test Installation of the *GMG Ninety7Wattle*.

3 CLEAN WATER TEST SUMMARY

The following section provides a summary of the clean water, large-scale test performed on the installation of the GMG Ninety7Wattle wattle ditch check detailed in Figure 1. Table 2 shows the performance results of the test at each flow rate.

Table 2: Summary of Performance Results at Each Flow Rate

Test Date	Impoundment Length (ft)		EGL Slope (ft/ft)		Avg. y/E[(1)]	
	0.6 cfs	*1.2 cfs*	*0.6 cfs*	*1.2 cfs*	*0.6 cfs*	*1.2 cfs*
05.10.23	25	32.2	0.0194	0.0174	0.96	0.99
06.28.23	21.5	27.3	0.0049	0.0044	0.98	0.97
07.20.23	22.2	24.8	0.0054	0.0064	0.98	0.97
Average	**22.9**	**28.1**	**0.0099**	**0.0094**	**0.973**	**0.977**

Note: (1) This relationship is averaged across the six upstream measurement points that are 15 ft in length.

Overtopping occurred during the 1.2 cfs flowrate meaning it did not completely maximize its flow restrictions capabilities until the higher flow rate. The average energy grade line (EGL) for each flow rate as shown in Figure 3 was approximately 0.00965, which is 79% shallower than the control EGL of 0.045. This shows a decrease in shear stress placed on the channel from concentrated flow conditions as the hydraulic gradient becomes shallower.

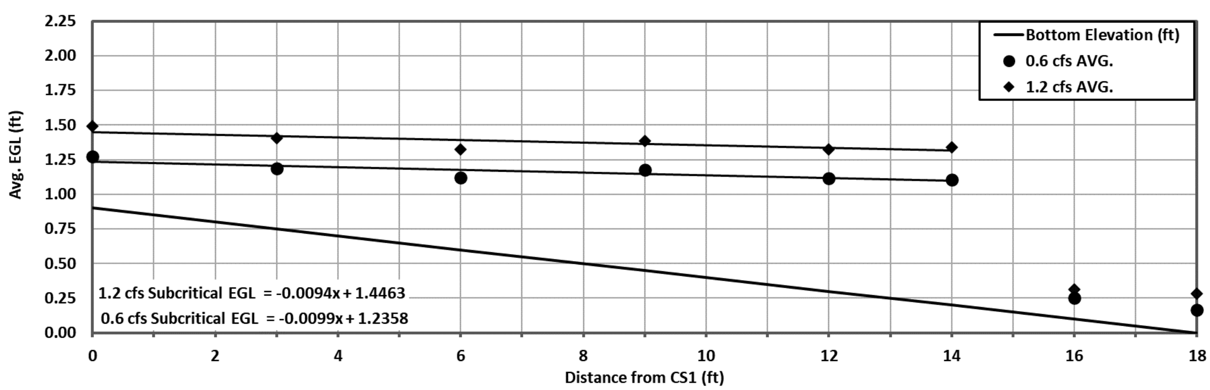


Figure 3: Energy Grade Lines (EGLs) for Various Flow Rates.

The ratio of depth (y) to energy (E) was also calculated for each test and flow rate. Energy (E) is defined by Eq. 1. The location of the inflection point for the relationship of the Froude Equation (Eq. 2) and the y/E ratio signifies a change in hydraulic performance where the kinetic energy created by the flow's velocity is mitigated by the impoundment that is transitioning the flow into potential energy. This relationship for the product is shown in Figure 4(a) – (b). A theoretical curve was plotted using the actual measured data with the inflection point labeled. The actual performance of the product is also labeled for comparison with the inflection point.

$$E = y + v^2/2g \quad \text{(EQ. 1)}$$

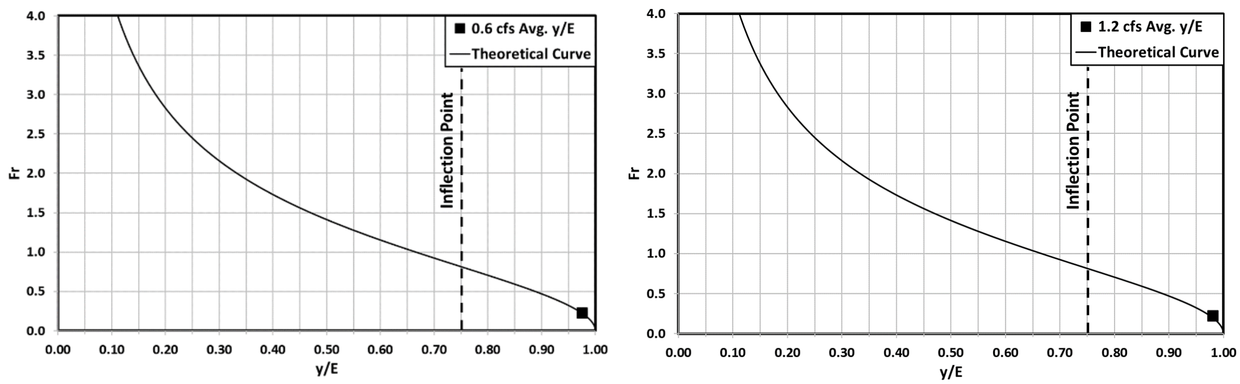
where,

E = energy measurement (ft)
y = water depth (ft)
v = average water velocity (ft/sec)
g = gravitational constant (32.2 ft/sec^2)

$$Fr = \frac{v}{\sqrt{gD}} \quad \text{(EQ. 2)}$$

where,

Fr = Froude number
v = average velocity measured for each cross section (ft/sec)
g = acceleration due to gravity (ft/sec^2)
D = hydraulic depth (ft)



(a) 0.6 cfs flow rate (b) 1.2 cfs flow rate

Figure 4: Summary of *GMG Ninety7Wattle* Hydraulic Performance.

4 SEDIMENT-LADEN LONGEVITY TEST SUMMARY

The sediment-laden longevity test consists of one installation being subjected to three, consecutive sediment-laden flow tests of 30 minutes each; 15 minutes at 0.6 cfs and 15 minutes at 1.2 cfs. During each test, approximately 690 lb of sediment (dry weight) is introduced continuously during the test duration. A total of 2,070 lb of sediment was introduced over the course of the three tests. Prior to testing, the test area was lined with plastic upstream of the wattle so that all retained sediment can be quantified. The results determined that approximately 1,415 lb of sediment were retained after all three tests were performed for a retention total of 68%. Figure 5 shows the final deposition after three sediment laden tests. No undercutting or structural failures occurred during longevity testing of the wattle.

(a) photographic documentation of deposition (b) during testing

Figure 5: Post Test Erosion/Deposition Patterns.

5 CONCLUSIONS

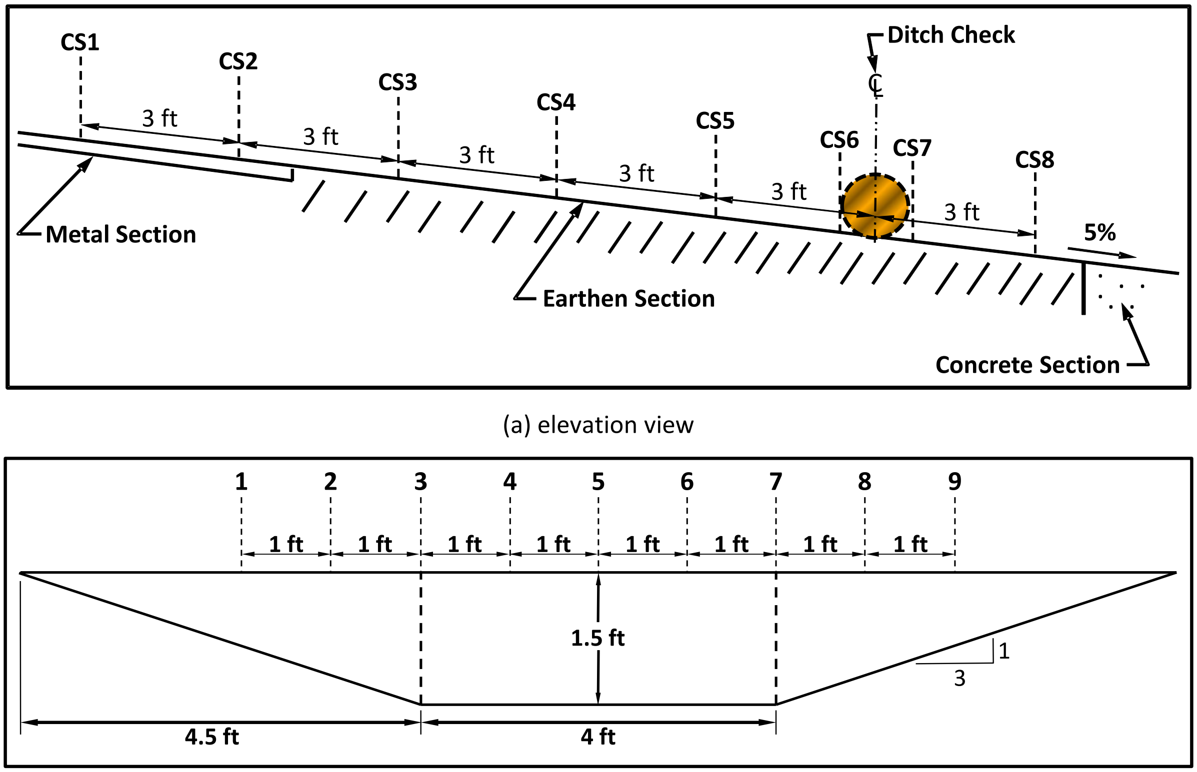
The GMG Ninety7Wattle wattle ditch check was able to provide impoundment capabilities and energy reduction that allowed for channel protection and sediment deposition. The ditch check was able to impound water an average of 22.9 ft at 0.6 cfs and 28.1 ft at 1.2 cfs. These long impoundments resulted in flow velocities approaching 0 ft/sec, and water depths high enough to overtop the product at 1.2 cfs. This results in a depth to energy ratio of 0.973 at 0.6 cfs and 0.977 at 1.2 cfs. The sediment-laden longevity test resulted in an average sediment retention rate of 68% by weight (1,415 out of 2,070 lb) of the rapidly settleable solids. As a comparison to previous wattle installation research, the current ALDOT installation developed at the AU-SRF uses an underlay and wooden stakes to provide anchoring. The impoundment capabilities from this installation that was tested on different wattle products caused overtopping typically at the highest flowrate used for testing of 1.68 cfs with only the densest wattles overtopping at the middle flow rate of 1.12 cfs. This implies that this wattle performed comparatively to the densest wattles previously tested.

6 APPENDIX A: TEST PROTOCOLS DETAILS

This appendix describes the test channel setup and preparation used for each ditch check product or practice tested. The modified ASTM D7208-06 is also included for reference.

6.1 Test Channel

The AU-SRF has test channels dedicated to performance testing of ditch checks in concentrated flow applications. The dimensions and properties of the channels are shown in Figure 6.



(a) elevation view

(b) cross-sectional view

Figure 6: Ditch Check Test Channel Dimensions and Configuration.

The ditch check testing channel has a trapezoidal cross-section with a top width of 13 ft and a bottom width of 4 ft with 3H:1V side slopes. The depth of the channel is 1.5 ft and is 39.5 ft in length. The channel is divided into a 24.5 ft galvanized steel plated section and a 15 ft earthen section. The longitudinal slope of the channel is 5%. The earthen section allows for field quality installations and performance observations of the ditch checks. The metal lined portion of the channel allows the ditch checks to be tested regardless of channel performance.

6.2 Preparation of the Test Channel

Before each test, the 15 ft earthen section is tilled 3-4 in. using a rear tine tiller, hand raked, hand tamped, and then mechanically compacted using an upright rammer hammer with a compaction plate of 14 x 11.5 in., an impact count of 600 blows/minute and a compaction force of 2,400 lbs.

6.3 Data Collection and Analysis

Prior to testing, eight level string lines are installed across the channel at eight cross-sectional (CS) locations [Figure 6(a): CS-1 to CS-8], six upstream and two downstream of the ditch check. Measurement points were spaced 1 ft apart along each string line. Once steady-state flow conditions are achieved, water depth and velocity measurements are taken at cross-sectional measurements points, 4, 5, and 6 which are the center three measurement points. These data are used to determine the average water depth and average velocity for each cross section. The distance from the upstream face of the ditch check to the hydraulic jump is also recorded once steady-state conditions are achieved to determine the subcritical flow length created by the ditch check's ability to impound water.

Using the collected data, the slope of the energy grade line (*EGL*) for the water profile is plotted as specified by ASTM D 7208-14. The EGL is defined by EQ. 1 (*ASTM 2014*).

$$EGL = WSE + v^2/2g \qquad \text{(EQ. 1)}$$

where,

EGL = energy grade line (ft, m)
WSE = water surface elevation (ft. m)
v = average water velocity (ft/sec, m/s)
g = gravitational constant (32.2 ft/sec^2, 9.81 m/s^2)

The slope of the *EGL* for long, unimpeded, continuous flow channels should closely mimic the channel slope. When the channel is impeded (e.g., by a ditch check), the slope of the *EGL* within the impoundment area becomes smaller than the channel slope as ponding depths increase near the ditch check. There is a possibility of two *EGL's* that require plotting as the subcritical *EGL* will be much shallower than the supercritical *EGL*. This condition only exists for products or practices with high flow through rates and short impoundment lengths.

6.4 Determining Flow Rates Used for Testing

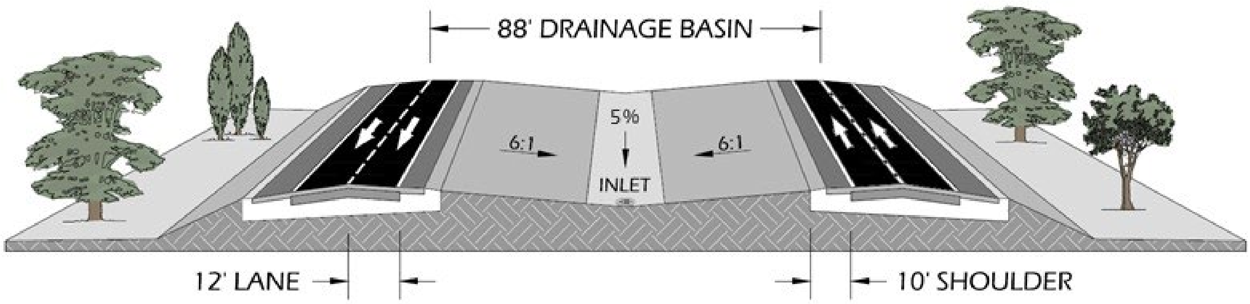
For ditch check product evaluation testing, a flow rate representative of expected conditions in the state of Alabama is used and was determined based on typical ALDOT roadway median drainage characteristics and statewide rainfall and soil conditions.

A geographic information system (GIS) study was performed to analyze regional rainfall and runoff characteristics. Since ditch checks are generally expected to handle flow produced by a 2-yr, 24-hr storm, this rainfall event was chosen to determine the flow rate for testing. Rainfall contour curves from Technical Paper No. 40 were analyzed as a raster surface (*USDA 1961*). The 2-yr, 24-hr rainfall in the state ranges between 3.7 and 6.0 in. with an average of 4.43 in. The Natural Resources Conservation Service (NRCS) Type III (*Viessman and Lewis 2003*) is the predominant rainfall distribution comprising 73.3% of the state by area.

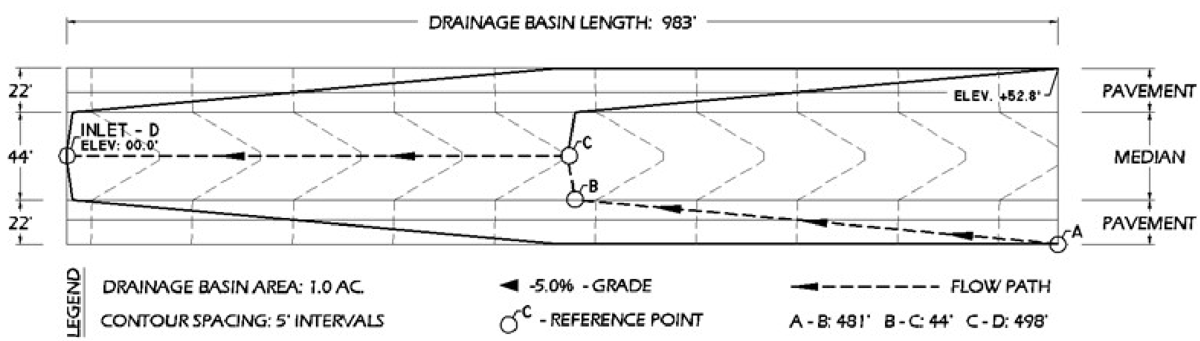
A runoff-potential characteristic of land cover and land use (i.e., soils, plants, impervious area, interception, and surface storage) can be described using curve numbers (*CNs*) that are assigned to areas based on cover type and hydrologic soil groups (*USDA 1986*). Hydrologic soil group data for the state of Alabama were mined from CONUS-Soil datasets (*Miller and White, 2006*). The data provided percent of hydrologic soil classifications (i.e., A, B, C, D) in each given area or map unit statewide. Separate map units were available for surface waters (e.g., lakes, reservoirs) and were removed from the analysis. To compute a weighted average *CN* for a construction site in a given area, the land use for each soil classification was first assigned as "Developing Urban Areas with Newly Graded Areas (pervious only, no vegetation)" and then corresponding *CNs* were specified to the soil classes. Using the percent occurrence of each soil classification per map unit, the resulting weighted average *CN* was a composite *CN* for each map unit under developing urban conditions (under construction). The state average CN was determined to be 88.5 and is categorized as a soil between hydrologic soil groups B and C.

Next, a runoff hydrograph was produced using the Technical Release 55 (TR-55) methodology. The hydrograph was determined based on a typical 1 acre roadway median drainage basin with the state predominant Type III rainfall distribution and 2-yr, 24-hr storm event having statewide average rainfall amount of 4.43 in. The state average *CN* of 88.5 for newly graded sites was used for all pervious areas.

Figure 7(a) illustrates the typical drainage basin cross section used in developing the hydrologic model. Two lanes, 12 ft each with 10 ft shoulders drain towards the 44 ft median. The basin is sloped at 5% towards the outlet, which is represented by the storm drain inlet located on the south end of the median centerline. Figure 7(b) shows the plan view of the drainage basin. The flow path, A-B-C-D, illustrates the furthest reach considered in the time of concentration computation as flow originates from point A and discharges at D. This approach was mirrored for both east and west sub-basins and a weighted *CN* value of 92 was developed based on the graded soil and impervious areas. The sub-basins were summed to produce the total stormwater runoff.



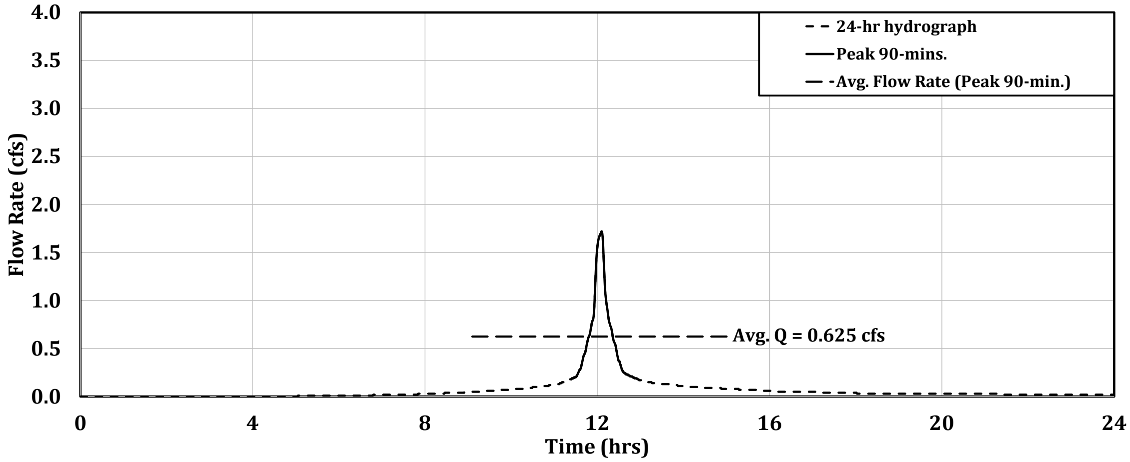
(a) cross-sectional view



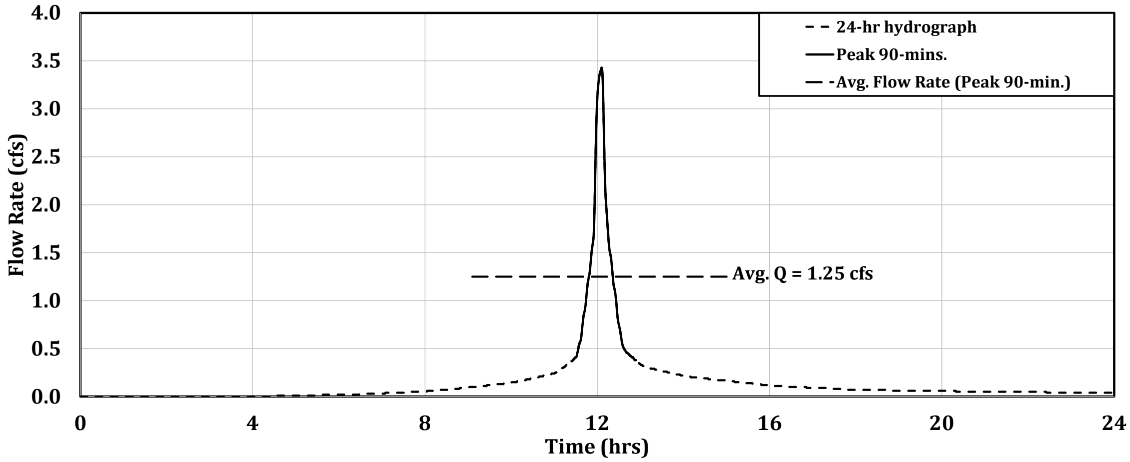
(b) plan view

Figure 7: Typical Drainage Basin used to Develop Experimental Testing Regime.

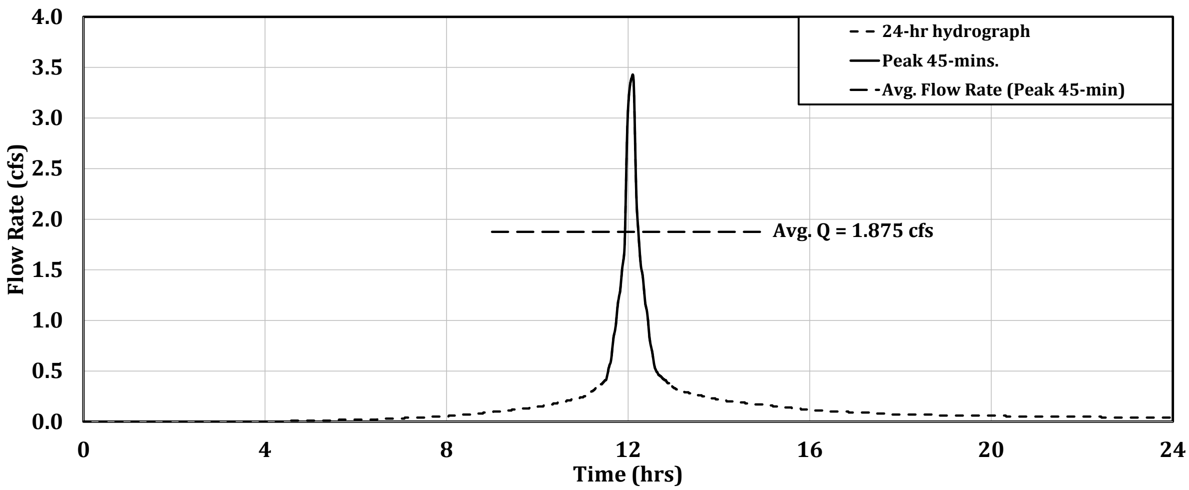
The analysis produced three hydrographs for two drainage basins [Figure 8(a) and (b)] that were used to select applicable testing flow rates. The first hydrograph, Figure 8(a), represents the upper 50% of the drainage basin that will drain to a ditch check located in the upper portion of the basin. Since only half the drainage basin is flowing to this particular ditch check under consideration, the runoff volume and peak runoff rate are approximately half that of the second runoff hydrograph (Figure 8(b)). The second hydrograph, shown in Figure 8(b), represents the runoff for the entire drainage basin. The peak 90 min. of the rainfall event defines the most intense flows experienced in the drainage basin, with a max. flow rate of 1.72 ft^3/s for the upper 50% of the basin area and 3.43 ft^3/s for the entire basin area occurring at 12.1 hrs. This 90 min. peak produces a runoff volume of 3,308 and 6,622 ft^3 for the upper 50% and entire drainage basin areas, respectively, and accounts for 52% of the 2-yr, 24-hr. event runoff volume for each drainage area. Converting the peak 90 min. volumes for each hydrograph results in an average flow rate of 0.6 ft^3/s and 1.2 ft^3/s for the upper 50% and entire basin areas, respectively. These flow rates were selected as two of the testing flow rates since they characterize the most intense portion of the storm event and account for 98% of the experienced 2-year 24-hr. hydrograph flow rates. However, to ensure practices and products are able to withstand higher intensity flows, each one will be subjected to the average 45 min. flow rate for the entire basin, as well, which is represented by Figure 8(c). The flow rate of 1.8 cfs is greater than 99% of the flow rates produced by the 2-year, 24-hour storm event. The flow rate of 1.8 ft^3/s will be the maximum flow rate used to test and evaluate the performance of ditch checks installed at point D in the channel for which the entire basin (1.0 acres) drains. In addition, ditch checks tested at 0.625 ft^3/s is representative of a ditch check installed at the point in the channel for which only the upper 50% portion of the drainage area drains. This will be performed to ensure that ditch checks are capable of impounding water and protecting the channel from high velocity runoff in both higher and lower flow conditions.



(a) peak 90 minute average flow rate hydrograph from 50% of basin



(b) peak 90 minute average flow rate hydrograph from entire basin



(c) peak 45 minute average flow rate hydrograph from entire basin

Figure 8: Hydrographs Developed from Typical Drainage Basin.

6.5 Sediment Data

The physical state of a ditch check will change during the life cycle of the practice due to environmental exposure. On construction sites, these practices could be subjected to large volumes of water and sediment as a result of exposure to many storm events and resultant runoff. Because of this, it is important to evaluate ditch check practices and products over several simulated storm events. With each subsequent event, sediment will continue to be captured by the practice or product, transforming the runoff conditions by affecting the topography of the channel and the flow through capabilities of the practice and product. Therefore, a longevity test using sediment-laden flow is performed to evaluate the total solids captured by these practices and products under varying conditions due to repeat rainfall events.

For conducting sediment-laden tests, a stockpile of soil, native to the state of Alabama was acquired. This soil was classified as a clayey sand, fine to coarse sand (Liquid Limit (LL) = 29.9% and Plasticity Index (PI) = 5.1%) according to the Unified Soil Classification System (USCS) and is used for all tests requiring sediment introduction. Table 3 and Figure 9 show the soil properties used for these tests.

Table 3: Sediment Soil Properties for Sediment Laden Flow Tests

Liquid Limit (%)	Plasticity Index (%)	D_{10} (mm)	D_{30} (mm)	D_{60} (mm)	USCS Classification
38	27	>0.00085	0.011	0.3	SC

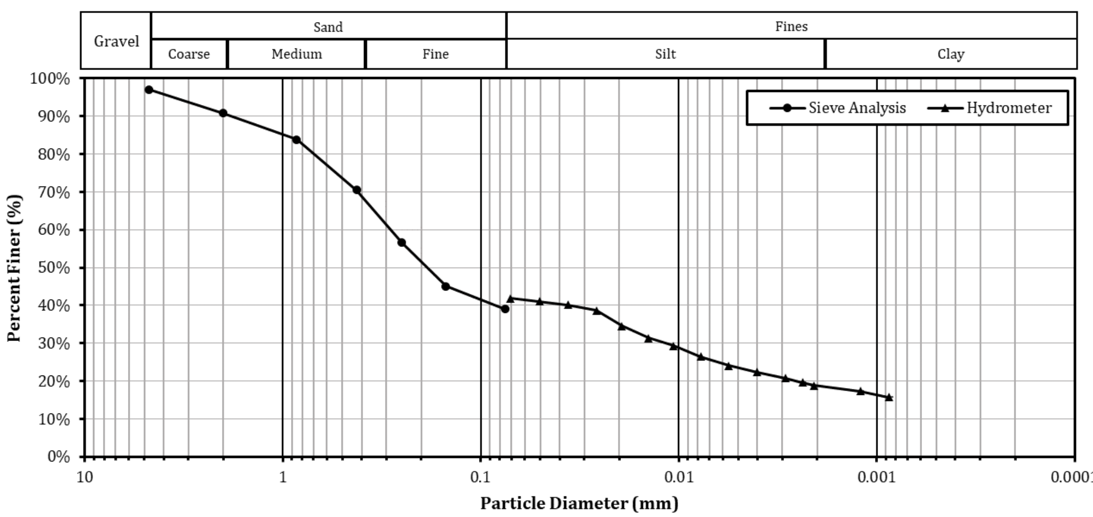


Figure 9: Sediment Particle Size Distribution of Soil used for Sediment Laden Flow Tests.

To mimic expected sediment transport for ditch check experiments, sediment rates were computed using the Modified Universal Soil Loss Equation (MUSLE), which estimates sediment yields based on individual storm events (*Williams and Berndt 1977*). MUSLE uses runoff variables to estimate soil loss and is given by the equation: $S = 95(Qq_p)^{0.56}KLSCP$, where: S is sediment yield (tons), Q is the 90 min. runoff volume (acre-ft), q_p is the event peak discharge (ft^3/s), and K, LS, C, and are USLE parameters.

Based upon experimental flow calculations conducted for the state of Alabama, the MUSLE equation was applied to the peak 90 minutes for a 2-yr, 24-hr storm event with a runoff volume (Q) of 6,622 ft^3 = 0.152 acre-ft for a 1 acre drainage basin discharging at a peak flow rate (q_p) of 3.43 ft^3/s (Figure 7(d)). A soil erodibility factor, K of 0.07, was selected for sandy-loam. The slope-length and steepness factor (LS) was determined to be 0.83, representative of 16% slopes at 20 ft lengths for conditions of high rill to interrill erosion ratios (*Pitt et. al., 2007*). Although other erosion and sediment control practices (i.e., mulching, temporary seeding, etc.) would be implemented alongside ditch checks, the worst-case design scenario for a vegetative cover practice factor (C) of 1.0 was chosen for bare soil conditions for the drainage area and channel. Similarly, the ponding or sediment control practice factor (P) was selected to be 1.0.

Using the aforementioned variable values, total sediment yield was computed to be 3,833 lbs from the entire 1 acre basin over 90 minutes. Using the previously established test flow tiers, the flow rate of 0.6 ft^3/s for the first 15 minutes and 1.2 ft^3/s for the next 15 minutes with a sediment introduction rate of 20 lbs/min and 30 lbs/min, respectively for wattle ditch check testing. The longevity test is performed on a single installed practice or product and consists of three separate 30 minute tests using flow rates and sediment rates described above. A total of approximately with the soil used for testing weighing approximately 75.6 lbs/ft^3, a total volume of 9.9 ft^3 per test will be introduced during the 30 minute duration. This results in a total sediment load of approximately 29.8 ft^3 of sediment introduced during the three simulated storm events.

6.6 Modified ASTM D7208-14

Note: Text shown underlined highlights the aspects of the standard that have been modified to mimic design conditions more contingent upon southeast U.S. runoff conditions.

1. Scope

1.1. This test method covers the guidelines, requirements, and procedures for evaluating the ability of temporary ditch checks to protect earthen channels from stormwater-induced erosion. Critical elements of this protection are the ability of the temporary ditch check to:

1.1.1. Slow or pond runoff, or both, to encourage sedimentation, thereby reducing soil particle transport downstream;

1.1.2. Trap soil particles up stream of structure; and

1.1.3. Decrease soil erosion.

1.2. This test method utilizes full-scale testing procedures, rather than bench-scale simulation, and is patterned after conditions typically found on highway construction site conducive to the southeast U.S. region during or at the conclusion of earthwork operations, but prior to the start of revegetation work. Therefore the test method considers only unvegetated conditions.

1.3. This test method provides a comparative evaluation of a temporary ditch check to baseline bare soil conditions under controlled and documented conditions.

1.4. The values stated in this standard are reported in English units.

2. Referenced Documents

2.1. *ASTM Standards*:

D 698 Test Methods for Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 $ft\text{-}lbf/ft^3$)

D 6460 Test Method for Determination of Erosion Control Performance in Protecting Earthen Channels from Stormwater-Induced Erosion

3. Terminology

3.1. *Definition of Term Specific to This Standard*

3.1.1. *temporary ditch check (in erosion control)*, n – a non-permanent barrier consisting of rocks, straw bales, excelsior logs, wattles, silt dikes, lumber, rock bags, interlocking pre-cast concrete blocks, silt fence or other materials installed or constructed across a drainage way, swale, or other ephemeral waterway to reduce flow velocity, decrease erosion, and promote soil retention.

3.1.2. *trapezoidal test channel, n* – an earthen channel used to test erosion control products shaped such that the bottom is flat with sides greater than 90˚ angle in relation to the bottom of the channel.

4. Summary of Test Method

4.1. The performance of a temporary ditch check in reducing stormwater-induced erosion is determined by subjecting the material to simulated water flow in a controlled and documented environment.

4.2. Key elements of the testing process include:

4.2.1. Calibration of the stormwater simulation equipment;

4.2.2. Preparation of the test channel;

4.2.3. Documentation of the temporary ditch check(s) to be tested;

4.2.4. Installation of the temporary ditch check(s);

4.2.5. Performance of the test;

4.2.6. Collection of hydraulic, topographical, and associated data;

4.2.7. Analysis of the resultant data; and

4.2.8. Reporting.

5. Significance and Use

5.1. This test method evaluates temporary ditch checks and their means of installation to:

5.1.1. Reduce soil loss and sediment concentrations in stormwater runoff under conditions of varying channel conditions and soil type; and

5.1.2. Improve water quality exiting the area disturbed by earthwork activity by reducing suspended solids.

5.2. This test method models and examines conditions typically found on construction sites involving earthwork activities, including: highways and roads; airports; residential, commercial and industrial developments; pipelines, mines, and landfills; golf courses, etc.

5.3. This test method is a performance test. It is a comparative tool for evaluating the erosion control characteristics of different temporary ditch checks and can be used for quality control to determine product conformance to project specifications. Take caution when comparing results from different laboratories because information about between-laboratory precision is incomplete and slight differences in soil and other environmental and geotechnical conditions may affect temporary ditch check performance. Unique project-specific conditions should be taken into consideration.

6. Apparatus

6.1. *Test Channel* – The channel consists of a two section trapezoidal channel. The test section is 40 ft in length with a 25 ft permanently stabilized section plated with galvanized steel. A 15 ft earthen section provides a section for field-like installations. The channel is approximately 5% in longitudinal grade. The channel has a 4 ft bottom width with 3H:1V side slopes. A sharp crested rectangular weir is used to regulate flow.

6.2. *Water Delivery System* – The water delivery system includes a series of 3 and 4 in. diameter discharge pumps which are used to create flows of 0.625, 1.25 and 1.875 cfs. The water control system shall regulate the flow.

6.3. *Soil Loss and Deposition Measurement System* – pre- and post-test elevations will be measured using lateral, level string lines that stretch across the width of the test channel. Measurements will be taken and documented in each test log. A robotic total station may also be used to determine erosion and deposition patterns.

6.4. *Velocity Probe* – A velocity probe capable of measuring point velocities to an accuracy of ± 0.1 ft/s shall be used to identify flow conditions during test operation. Acceptable types of probes include electromagnetic, spinning cup, propeller and static tube devices.

6.5. *Miscellaneous* – Other miscellaneous equipment includes: meteorological equipment (wind speed, temperature, precipitation), and camera or video recorders

7. Reagents

7.1. *Water Source* – The water source will be ponded stormwater collected from runoff of the asphalt parking lot upgrade from the facility. Stormwater will be collected in a 28,000 ft^3 retention pond with a riprap inlet and outlet channel.

8. Calibrations

8.1. Perform determination of the water delivery system discharge (Q). Begin calibration of the water delivery system when a steady-state flow is achieved.

8.2. For open-channel water delivery systems, measure the depth of the water flowing into the test channel. Measure the velocity in the supply channel using a probe in the measurement location shown in Fig. 2.

9. Procedure

9.1. *Trapezoidal Test Channel Preparation:*

9.1.1. The test channels are designed specifically to mimic typical southeast U.S. ditch geometry and differ from this standards test specifications. Rather than using a completely earthen channel, the trapezoidal channels will be partially plated with galvanized sheet metal to minimize reconstruction efforts between tests. A 15 ft long earthen section will be used to install and test each ditch check device and practice.

9.1.2. The channel surface will be constructed using soils native to Alabama. The soil used will be characterized to obtain the soil gradation. The soil will be placed in 6 in. lifts and compacted to 90 ± 3% of standard Proctor density in accordance with Test Method D 698.

9.1.3. The test channel has been constructed to represent southeast U.S. typical design practices as opposed to the 2 ft bottom width and 2H:1V side slopes specified by ASTM D 7208. Therefore, tests will be performed using a 4 ft wide channel bottom with 3:1 H:V side slopes. The longitudinal slope of the test channels are approximately at a 5% grade as specified by these standards.

9.1.4. Measuring points of cross sections using level string lines at 3 ft longitudinal increments upstream and downstream of the ditch check within the deposition and scour zones will be used for each test. Nine lateral measurements will be taken across each string line. Five measurements of the channel bottom and two measurements on each side slope will be performed for each string line. Measurements from the string line to the channel bottom and sides slopes will be performed before and after each test to determine soil loss and gain throughout the effected channel section.

9.1.5. Once compaction of the test reach is completed, the test reach will be raked and hand tamped to produce a smooth section for each test. Ensure that the soil is free from obstructions or protrusions, such as roots, large stones, or other foreign material.

9.1.6. If the channel has been used previously for a test series, the discarded soil will be carried out of the channel, and any rills and gullies will be obliterated using a mechanical tiller. New soil of the same type will be added to the channel and blend (rake or tilled) into the surface. After each test, the channel will be prepared to previous compaction specifications.

9.2. *Pre-Test Documentation:*

9.2.1. A test folder will be maintained for each test cycle including information on:

9.2.1.1. Soil conditions;

9.2.1.2. Temporary ditch check product type, description, and installation procedure; and

9.2.1.3. Photo documentation.

9.2.2. General, relevant information including visual conditions of the channel, meteorological information, channel treatment, photographs, and video may be included as part of the test report.

9.2.3. All soil used for testing will be documented based on soil classification [Unified Soil Classification System]; standard proctor moisture-density relationship; 'K' factor; and gradation.

9.2.4. The product type and description information will include the manufacturer name, the product name, product description, and product specifications dimensions.

9.3. *Test Set-Up:*

9.3.1. The temporary ditch check will be installed in the channel after any needed calibration and channel preparation has been completed. The installation of the ditch check will be documented photographically; anchor type and installation pattern will be described and logged. The ditch check will be placed across the channel bottom perpendicular to the flow direction and extended up the side slopes far enough so ponded water cannot erode around the temporary ditch check.

9.3.2. The elevation of the channel surface will be measured using the reference level string lines to determine any resulting deposition and/or scour. The location of ditch check will be measured with reference to the channel sheet metal lining upstream and concrete conveyance channel downstream. A platform walkway will be placed across the channel at the location of each cross section to be measured to ensure the channel is not disturbed before or after testing. Elevation measurements for each test cross-section (nine total) at specified locations will be taken. Elevation measurements for additional cross-sections directly in front and behind each ditch check shall also be taken to measure deposition and/or scour directly adjacent to the ditch check structure.

9.3.3. Photo documentation of the channel and test set up will be performed prior to testing.

9.4. *Test Operation and Data Collection:*

9.4.1. The following test data will be included: operator name and title, time duration of test flow, flow depths, and measured velocities.

9.4.2. Water surface elevation measurements (water depth) will be performed at the centerline point of each test cross-section as soon as flow reaches a steady-state, uniform condition. Velocity measurements at the centerline point of each test cross-section. Photographs and/or videotaping will be performed during the test.

9.4.3. Flow rate will be based upon test being performed and will range from 0.625 to 1.875 cfs.

9.4.4. Test duration shall be a maximum of 45 minutes or until the ditch check has become dislodged or any other type of installation failure occurs. Failures will be documented and investigated to determine the cause of each.

9.4.5. At the conclusion of each test, the channel surface elevation measurements shall be performed at the same locations along the level string lines as the pre-test measurements using the platform walkway.

9.4.6. General observations regarding the condition of the tested temporary ditch check as well as the test area of the channel shall be performed at the conclusion of the data collection. Photographic documentation will be used to record the temporary ditch check's post-test condition.

9.4.7. The temporary ditch check will be carefully removed with as little disturbance of the soil as possible. General conditions of the scour patterns will be noted through comment and photographic documentation.

9.4.8. Photographic documentation will be used to record general post-test channel condition.

9.4.9. Three replications for each ditch check test will be performed.

9.4.10. A sediment laden longevity performance test consisting of three tests performed on a single installed product/practice will also be performed, adhering to the same guidelines described in these standard procedures.

10. Calculation

10.1. *Discharge* – The discharge will be determined for each flow using the weir of the water delivery system.

10.2. *Test Data:*

10.2.1. Analysis of the test data involves the following variables: total discharge, velocity, flow depth, and energy slope.

10.2.2. The total discharge will be determined using the weir system as previously calibrated.

10.2.3. The energy slope, S_f, will be determined by fitting a regression line through the energy grade line elevation determined at each of the level string line cross-sections which correspond to subcritical flow, as follows:

$$EGL = WSE + V_{avg}^2 / 2g$$

where:

EGL = *Energy Grade Line*
WSE = water surface elevation
V_{avg} = average velocity of the three center line velocity measurements taken during testing, ft/sec, and
G = gravitational constant, 32.2 ft/sec^2

10.2.4. Soil erosion and deposition will be plotted for each cross section using the elevation measurements collected pre- and post-test. The total station may also be used to determine comprehensive erosion and deposition volumes.

11. Report

11.1. The following minimum information shall be reported for each test:

11.1.1. General information including: test facility location, date, time and operator(s),
11.1.2. Test channel used for testing
11.1.3. Test channel preparation
11.1.4. Flow rate and time of flow rate if varied during testing
11.1.5. Materials documentation including temporary ditch check material and anchor description
11.1.6. Test set-up activities including trenching (if applicable), anchor pattern, and average anchor density (anchor per unit area),
11.1.7. Test operation and data collection (including "raw" data such as measured discharge for each test flow) and time of overtopping if occurred, and
11.1.8. Analysis

7 REFERENCES

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APPENDIX B: TEST DATA AND DOCUMENTATION

Performance Testing: Hydraulic Summary Data

Date: 05/10/2023 **Start Time:** 9:45 AM
Product: Seventy9Wattle **End Time:** 10:15 AM
Manufacturer: GMG
Techs and Workers: W. Donald, K. Ansley, G. Savage, M. Armstrong
Test Type: Clean Water, Tiered Flow (0.6, 1.2 cfs) Test **Installed Ht. (ft):** 1.5
Diameter (in): 20 **Length (ft):** 17 **Width (in):** N/A **Weight (lbs):** 77

	Flow Rate: 0.6 cfs (0-15 mins)							
Cross Section	Water Depth (ft)				Velocity (ft/sec)			
	B4	B5	B6	Avg.	B4	B5	B6	Avg.
CS1	0.40	0.42	0.40	0.41	1.13	1.39	1.13	1.22
CS2	0.42	0.40	0.48	0.43	1.39	3.31	0.80	1.83
CS3	0.54	0.56	0.57	0.56	0.80	0.80	0.80	0.80
CS4	0.68	0.69	0.72	0.70	0.80	0.80	0.80	0.80
CS5	0.74	0.75	0.77	0.75	0.80	1.13	1.13	1.02
CS6	0.83	0.84	0.85	0.84	0.00	0.80	0.80	0.53
CS7	0.07	0.05	0.05	0.06	2.89	1.60	1.79	2.10
CS8	0.06	0.07	0.05	0.06	2.54	2.12	2.54	2.40

	Flow Rate: 0.6 cfs (0-15 mins)							
Cross Section	Dist. from CS1 (ft)	Avg. Water Depth (ft)	Avg. $v^2/2g$ (ft)	Avg. s_f (ft)	Bottom Elev. (ft)	Avg. EGL (ft)	Avg. y/E	Avg. y/E
CS1	0.00	0.41	0.02	0.43	0.90	1.33	0.95	0.96
CS2	3.00	0.43	0.05	0.49	0.75	1.24	0.89	
CS3	6.00	0.56	0.01	0.57	0.60	1.17	0.98	
CS4	9.00	0.70	0.01	0.71	0.45	1.16	0.99	
CS5	12.00	0.75	0.02	0.77	0.30	1.07	0.98	
CS6	14.00	0.84	0.00	0.84	0.20	1.04	0.99	
CS7	16.00	0.06	0.07	0.12	0.10	0.22	0.45	0.43
CS8	18.00	0.06	0.09	0.15	0.00	0.15	0.40	

Length of pool upstream of ditch check (ft): 25 **Time (min):** 5

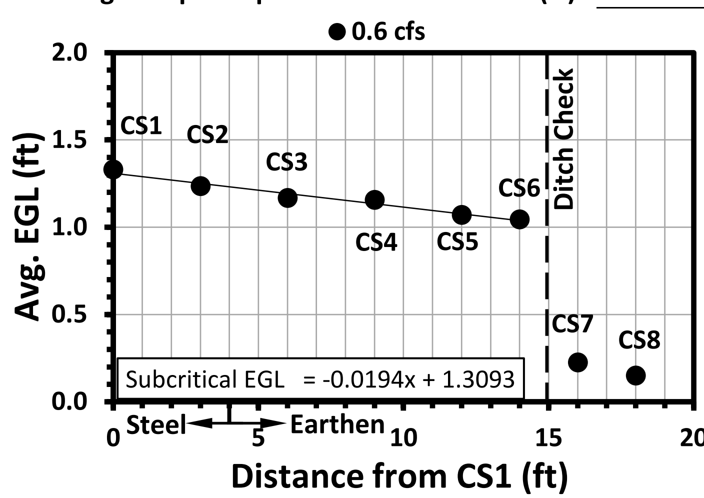


Figure 1: EGL Profile of Channel Cross Sections.

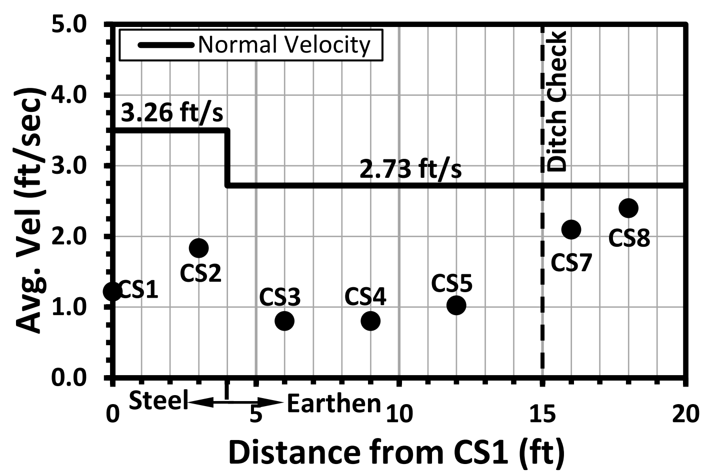


Figure 2: Velocity Profile of Channel Cross Sections.

Performance Testing: Hydraulic Summary Data

Date: 05/10/2023 **Start Time:** 9:45 AM
Product: Seventy9Wattle **End Time:** 10:15 AM
Manufacturer: GMG
Techs and Workers: W. Donald, K. Ansley, G. Savage, M. Armstrong
Test Type: Clean Water, Tiered Flow (0.6, 1.2 cfs) Test **Installed Ht. (ft):** 1.5
Diameter (in): 20 **Length (ft):** 17 **Width (in):** N/A **Weight (lbs):** 77

Cross Section	Flow Rate: 1.2 cfs (15-30 mins)							
	Water Depth (ft)				Velocity (ft/sec)			
	B4	B5	B6	Avg.	B4	B5	B6	Avg.
CS1	0.69	0.72	0.69	0.70	1.13	0.80	1.13	1.02
CS2	0.75	0.76	0.78	0.76	0.80	0.00	0.80	0.53
CS3	0.82	0.87	0.88	0.86	0.80	0.00	0.80	0.53
CS4	0.99	1.00	1.04	1.01	0.80	0.00	0.80	0.53
CS5	1.04	1.06	1.08	1.06	1.13	0.80	1.13	1.02
CS6	1.11	1.14	1.16	1.14	1.13	1.13	0.80	1.02
CS7	0.15	0.05	0.08	0.09	2.66	1.13	1.79	1.86
CS8	0.06	0.10	0.13	0.10	5.32	2.54	3.93	3.93

Cross Section	Flow Rate: 1.2 cfs (15-30 mins)							
	Dist. from CS1 (ft)	Water Depth (ft)	$v^2/2g$ (ft)	S_f (ft)	Bottom Elev. (ft)	EGL (ft)	y/E	Avg. y/E
CS1	0.00	0.70	0.02	0.72	0.90	1.62	0.98	0.99
CS2	3.00	0.76	0.00	0.77	0.75	1.52	0.99	
CS3	6.00	0.86	0.00	0.86	0.60	1.46	0.99	
CS4	9.00	1.01	0.00	1.01	0.45	1.46	1.00	
CS5	12.00	1.06	0.02	1.08	0.30	1.38	0.98	
CS6	14.00	1.14	0.02	1.15	0.20	1.35	0.99	
CS7	16.00	0.09	0.05	0.15	0.10	0.25	0.63	0.46
CS8	18.00	0.10	0.24	0.34	0.00	0.34	0.29	

Length of pool upstream of ditch check (ft): 32.2 **Time (min):** 20

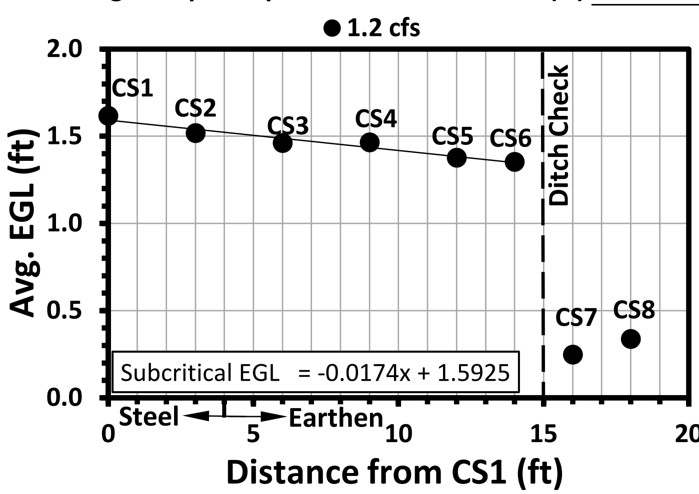


Figure 3: EGL Profile of Channel Cross Sections.

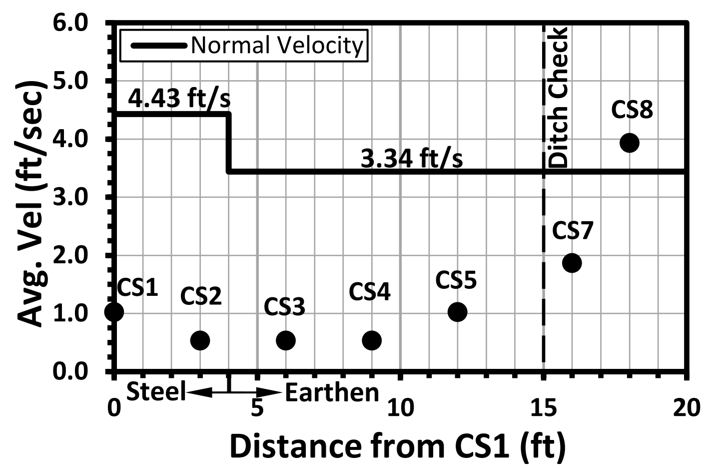


Figure 4: Velocity Profile of Channel Cross Sections.

Flow Rate: 0.6 cfs (0-15 mins)

Head Height								
H_{water}(ft.)	**CS1**	**CS2**	**CS3**	**CS4**	**CS5**	**CS6**	**CS7**	**CS8**
B4	0.40	0.42	0.54	0.68	0.74	0.83	0.07	0.06
B5	0.42	0.40	0.56	0.69	0.75	0.84	0.05	0.07
B6	0.40	0.48	0.57	0.72	0.77	0.85	0.05	0.05
$H_{velocity}$(ft.)	**CS1**	**CS2**	**CS3**	**CS4**	**CS5**	**CS6**	**CS7**	**CS8**
B4	0.42	0.45	0.55	0.69	0.75	0.83	0.20	0.16
B5	0.45	0.57	0.57	0.70	0.77	0.85	0.09	0.14
B6	0.42	0.49	0.58	0.73	0.79	0.86	0.10	0.15

Length of pool upstream of ditch check (ft): 25 Time (mins): 5

Flow Rate: 1.2 cfs (15-30 mins)

Head Height								
H_{water}(ft.)	**CS1**	**CS2**	**CS3**	**CS4**	**CS5**	**CS6**	**CS7**	**CS8**
B4	0.69	0.75	0.82	0.99	1.04	1.11	0.15	0.06
B5	0.72	0.76	0.87	1.00	1.06	1.14	0.05	0.10
B6	0.69	0.78	0.88	1.04	1.08	1.16	0.08	0.13
$H_{velocity}$(ft.)	**CS1**	**CS2**	**CS3**	**CS4**	**CS5**	**CS6**	**CS7**	**CS8**
B4	0.71	0.76	0.83	1.00	1.06	1.13	0.26	0.50
B5	0.73	0.76	0.87	1.00	1.07	1.16	0.07	0.20
B6	0.71	0.79	0.89	1.05	1.10	1.17	0.13	0.37

Length of pool upstream of ditch check (ft): 32.2 Time(mins): 20

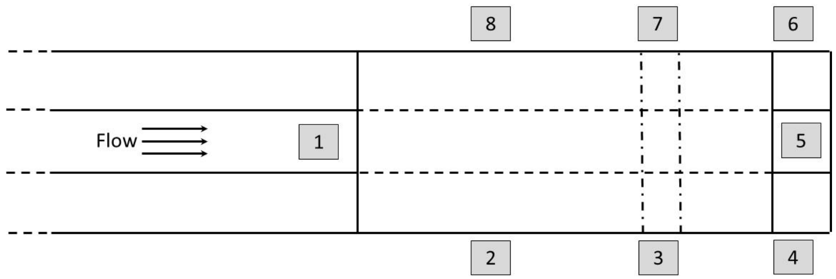
Figure7: Impoundment

Location 8

Location 7

Location 6

Location 1



Location 5

Location 2

Location 3

Location 4

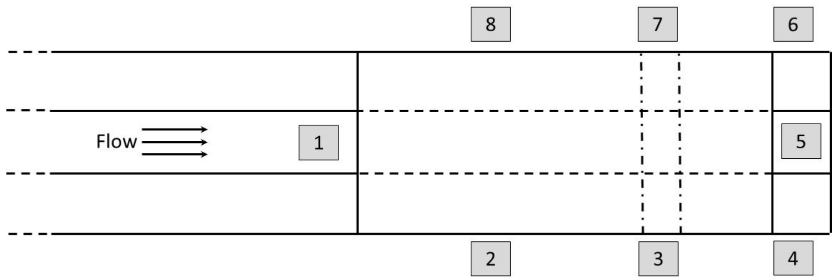
Post-Test Photo Documentation

Location 8

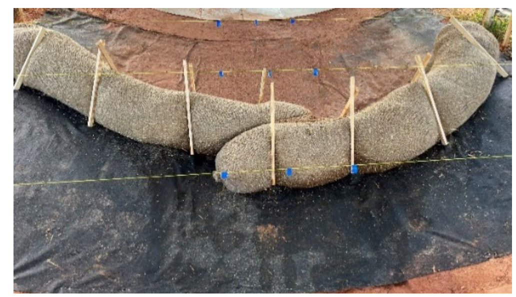
Location 7

Location 6

Location 1



Location 5



Location 2

Location 3

Location 4

Performance Testing: Hydraulic Summary Data

Date: 6/28/2023
Start Time: 2:58 PM
Product: Seventy9Wattle
End Time: 3:28 PM
Manufacturer: GMG
Techs and Workers: W. Donald, K. Ansley, G. Savage
Test Type: Clean Water, Tiered Flow (0.6, 1.2 cfs) Test
Installed Ht. (ft): 1.5
Diameter (in): 20 **Length (ft):** 53 **Width (in):** N/A **Weight (lbs):** 53

Cross Section	Flow Rate: 0.6 cfs (0-15 mins)							
	Water Depth (ft)				Velocity (ft/sec)			
	B4	B5	B6	Avg.	B4	B5	B6	Avg.
CS1	0.30	0.34	0.30	0.31	0.80	0.80	1.13	0.91
CS2	0.39	0.40	0.42	0.40	0.80	0.80	1.13	0.91
CS3	0.45	0.51	0.52	0.49	0.80	0.80	0.00	0.53
CS4	0.65	0.75	0.76	0.72	1.13	0.80	0.80	0.91
CS5	0.81	0.84	0.84	0.83	0.80	0.00	0.00	0.27
CS6	0.92	0.94	0.93	0.93	0.00	0.80	0.80	0.53
CS7	0.06	0.09	0.09	0.08	4.09	1.97	1.60	2.55
CS8	0.04	0.17	0.08	0.10	0.80	2.66	2.12	1.86

Cross Section	Flow Rate: 0.6 cfs (0-15 mins)							
	Dist. from CS1 (ft)	Avg. Water Depth (ft)	Avg. $v^2/2g$ (ft)	Avg. s_f (ft)	Bottom Elev. (ft)	Avg. EGL (ft)	Avg. y/E	Avg. y/E
CS1	0.00	0.31	0.01	0.33	0.90	1.23	0.96	0.98
CS2	3.00	0.40	0.01	0.42	0.75	1.17	0.97	
CS3	6.00	0.49	0.00	0.50	0.60	1.10	0.99	
CS4	9.00	0.72	0.01	0.73	0.45	1.18	0.98	
CS5	12.00	0.83	0.00	0.83	0.30	1.13	1.00	
CS6	14.00	0.93	0.00	0.93	0.20	1.13	1.00	
CS7	16.00	0.08	0.10	0.18	0.10	0.28	0.44	0.54
CS8	18.00	0.10	0.05	0.15	0.00	0.15	0.64	

Length of pool upstream of ditch check (ft): 21.5 **Time (min):** 4.5

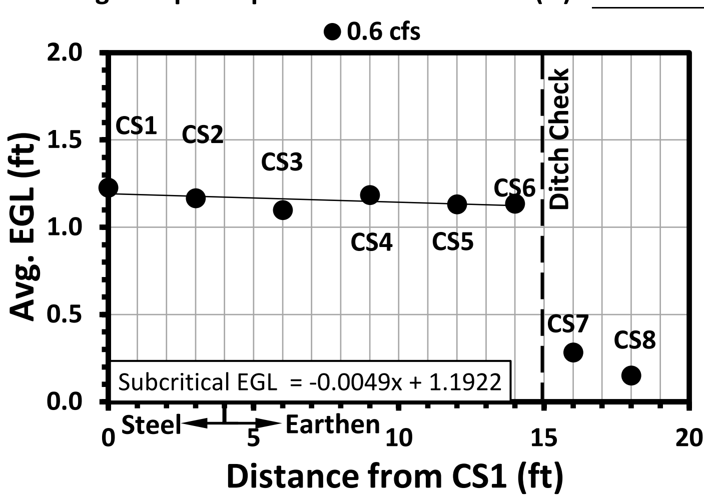


Figure 1: EGL Profile of Channel Cross Sections.

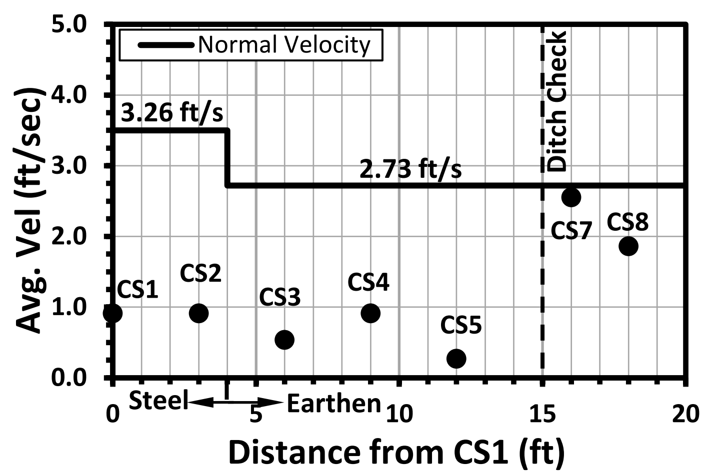


Figure 2: Velocity Profile of Channel Cross Sections.

Performance Testing: Hydraulic Summary Data

Date: 6/28/2023
Start Time: 2:58 PM
Product: Seventy9Wattle
End Time: 3:28 PM
Manufacturer: GMG
Techs and Workers: W. Donald, K. Ansley, G. Savage, M. Armstrong
Test Type: Clean Water, Tiered Flow (0.6, 1.2 cfs) Test
Installed Ht. (ft): 1.5
Diameter (in): 20 **Length (ft):** 18 **Width (in):** N/A **Weight (lbs):** 53

Cross Section	Flow Rate: 1.2 cfs (15-30 mins)							
	Water Depth (ft)				Velocity (ft/sec)			
	B4	B5	B6	Avg.	B4	B5	B6	Avg.
CS1	0.51	0.54	0.50	0.52	1.13	0.80	1.60	1.18
CS2	0.57	0.59	0.58	0.58	1.13	1.13	1.97	1.41
CS3	0.61	0.68	0.68	0.66	1.13	1.13	0.00	0.76
CS4	0.80	0.93	0.98	0.90	1.13	1.13	1.13	1.13
CS5	1.00	0.99	1.00	1.00	0.80	1.13	1.39	1.11
CS6	1.09	1.18	1.19	1.15	0.00	1.39	0.80	0.73
CS7	0.19	0.12	0.19	0.17	2.89	3.59	1.97	2.82
CS8	0.06	0.23	0.15	0.15	3.93	2.54	2.89	3.12

Cross Section	Flow Rate: 1.2 cfs (15-30 mins)							
	Dist. from CS1 (ft)	Water Depth (ft)	$v^2/2g$ (ft)	S_f (ft)	Bottom Elev. (ft)	EGL (ft)	y/E	Avg. y/E
CS1	0.00	0.52	0.02	0.54	0.90	1.44	0.96	0.97
CS2	3.00	0.58	0.03	0.61	0.75	1.36	0.95	
CS3	6.00	0.66	0.01	0.67	0.60	1.27	0.99	
CS4	9.00	0.90	0.02	0.92	0.45	1.37	0.98	
CS5	12.00	1.00	0.02	1.02	0.30	1.32	0.98	
CS6	14.00	1.15	0.01	1.16	0.20	1.36	0.99	
CS7	16.00	0.17	0.12	0.29	0.10	0.39	0.58	0.53
CS8	18.00	0.15	0.15	0.30	0.00	0.30	0.49	

Length of pool upstream of ditch check (ft): 27.3
Time (min): 27

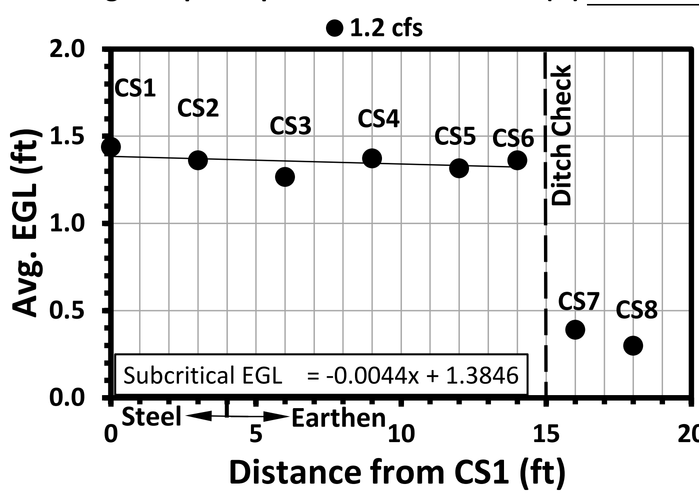


Figure 3: EGL Profile of Channel Cross Sections.

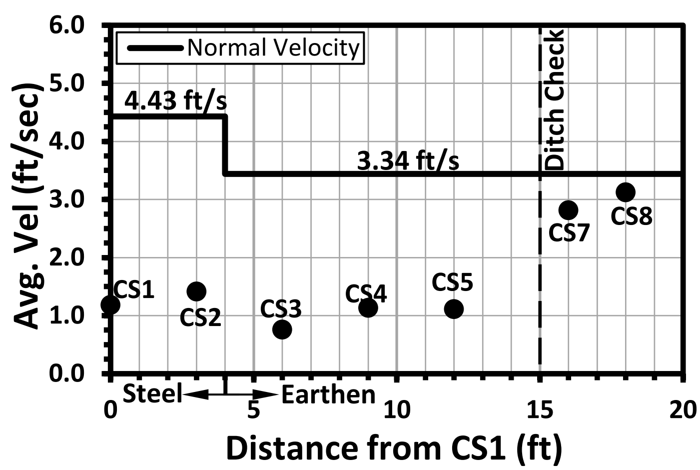


Figure 4: Velocity Profile of Channel Cross Sections.

Flow Rate: 0.6 cfs (0-15 mins)

Head Height								
H_{water}(ft.)	**CS1**	**CS2**	**CS3**	**CS4**	**CS5**	**CS6**	**CS7**	**CS8**
B4	0.30	0.39	0.45	0.65	0.81	0.92	0.06	0.04
B5	0.34	0.40	0.51	0.75	0.84	0.94	0.09	0.17
B6	0.30	0.42	0.52	0.76	0.84	0.93	0.09	0.08
$H_{velocity}$(ft.)	**CS1**	**CS2**	**CS3**	**CS4**	**CS5**	**CS6**	**CS7**	**CS8**
B4	0.31	0.40	0.46	0.67	0.82	0.92	0.32	0.05
B5	0.35	0.41	0.52	0.76	0.84	0.95	0.15	0.28
B6	0.32	0.44	0.52	0.77	0.84	0.94	0.13	0.15

Length of pool upstream of ditch check (ft): 21.5 Time (mins): 4.5

Flow Rate: 1.2 cfs (15-30 mins)

Head Height								
H_{water}(ft.)	**CS1**	**CS2**	**CS3**	**CS4**	**CS5**	**CS6**	**CS7**	**CS8**
B4	0.51	0.57	0.61	0.80	1.00	1.09	0.19	0.06
B5	0.54	0.59	0.68	0.93	0.99	1.18	0.12	0.23
B6	0.50	0.58	0.68	0.98	1.00	1.19	0.19	0.15
$H_{velocity}$(ft.)	**CS1**	**CS2**	**CS3**	**CS4**	**CS5**	**CS6**	**CS7**	**CS8**
B4	0.53	0.59	0.63	0.82	1.01	1.09	0.32	0.30
B5	0.55	0.61	0.70	0.95	1.01	1.21	0.32	0.33
B6	0.54	0.64	0.68	1.00	1.03	1.20	0.25	0.28

Length of pool upstream of ditch check (ft): 27.3 Time(mins): 27

Figure 7: Impoundment.

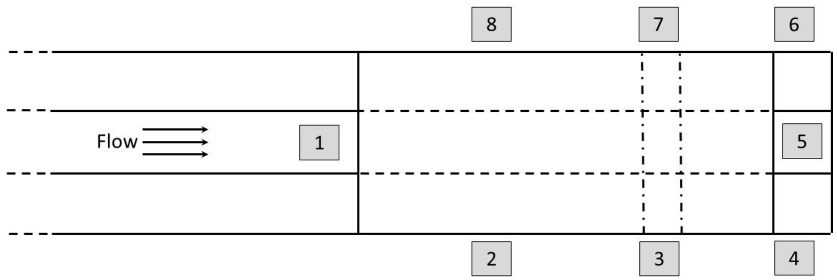
Pre-Test Photo Documentation

Location 8

Location 7

Location 6

Location 1



Location 5

Location 2

Location 3

Location 4

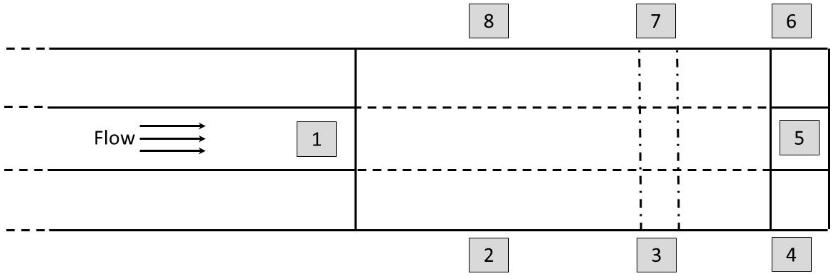
Post-Test Photo Documentation

Location 8

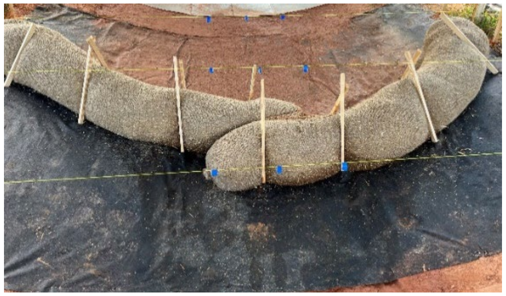
Location 7

Location 6

Location 1



Location 5



Location 2

Location 3

Location 4

Performance Testing: Hydraulic Summary Data

Date: 7/20/2023
Product: Seventy9Wattle
Manufacturer: GMG
Techs and Workers: W. Donald, K. Ansley, G. Savage
Test Type: Clean Water, Tiered Flow (0.6, 1.2 cfs) Test
Start Time: 2:58 PM
End Time: 3:28 PM
Installed Ht. (ft): 1.5
Diameter (in): 20 **Length (ft):** 19 **Width (in):** N/A **Weight (lbs):** 54.5

Cross Section	Flow Rate: 0.6 cfs (0-15 mins)							
	Water Depth (ft)				Velocity (ft/sec)			
	B4	B5	B6	Avg.	B4	B5	B6	Avg.
CS1	0.34	0.33	0.32	0.33	1.13	1.39	1.60	1.38
CS2	0.39	0.41	0.43	0.41	0.00	0.80	0.80	0.53
CS3	0.46	0.49	0.51	0.49	0.00	1.13	0.80	0.65
CS4	0.71	0.73	0.74	0.73	0.80	1.13	0.80	0.91
CS5	0.84	0.85	0.85	0.85	0.80	0.00	0.00	0.27
CS6	0.95	0.95	0.93	0.94	0.00	0.00	0.00	0.00
CS7	0.09	0.07	0.12	0.09	1.39	1.13	2.89	1.81
CS8	0.06	0.11	0.08	0.08	1.60	3.31	3.31	2.74

Cross Section	Flow Rate: 0.6 cfs (0-15 mins)							
	Dist. from CS1 (ft)	Avg. Water Depth (ft)	Avg. $v^2/2g$ (ft)	Avg. s_f (ft)	Bottom Elev. (ft)	Avg. EGL (ft)	Avg. y/E	Avg. y/E
CS1	0.00	0.33	0.03	0.36	0.90	1.26	0.92	0.98
CS2	3.00	0.41	0.00	0.41	0.75	1.16	0.99	
CS3	6.00	0.49	0.01	0.49	0.60	1.09	0.99	
CS4	9.00	0.73	0.01	0.74	0.45	1.19	0.98	
CS5	12.00	0.85	0.00	0.85	0.30	1.15	1.00	
CS6	14.00	0.94	0.00	0.94	0.20	1.14	1.00	
CS7	16.00	0.09	0.05	0.14	0.10	0.24	0.65	0.53
CS8	18.00	0.08	0.12	0.20	0.00	0.20	0.42	

Length of pool upstream of ditch check (ft): 22.2 **Time (min):** 19

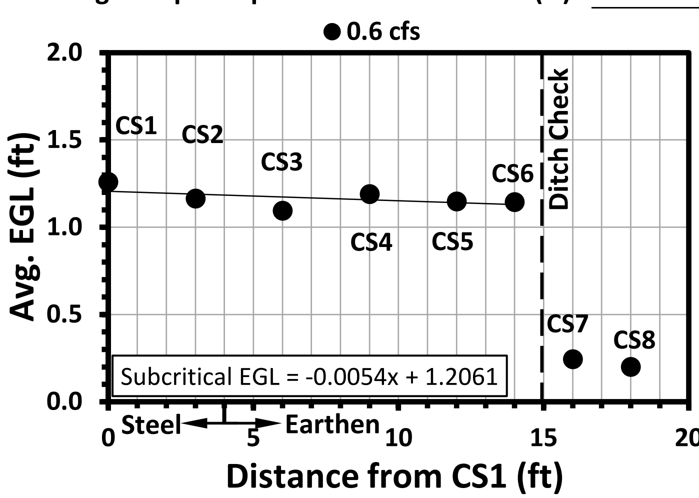


Figure 1: EGL Profile of Channel Cross Sections.

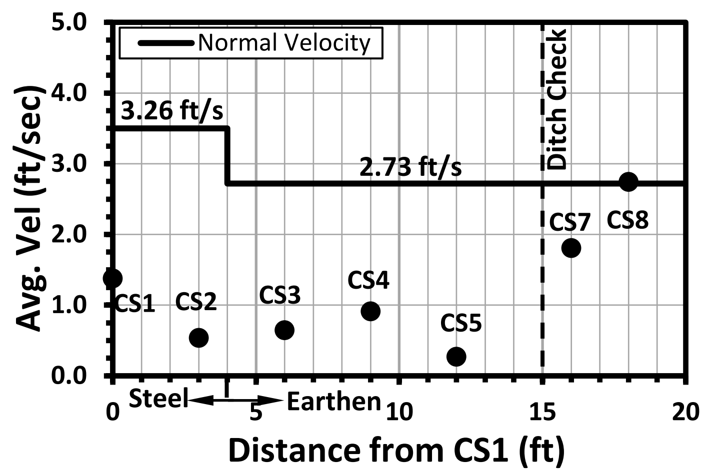


Figure 2: Velocity Profile of Channel Cross Sections.

Performance Testing: Hydraulic Summary Data

Date: 7/20/2023
Start Time: 2:58 PM
Product: Seventy9Wattle
End Time: 3:28 PM
Manufacturer: GMG
Techs and Workers: W. Donald, K. Ansley, G. Savage
Test Type: Clean Water, Tiered Flow (0.6, 1.2 cfs) Test
Installed Ht. (ft): 1.5
Diameter (in): 20 **Length (ft):** 19 **Width (in):** N/A **Weight (lbs):** 54.5

Cross Section	Flow Rate: 1.2 cfs (15-30 mins)							
	Water Depth (ft)				Velocity (ft/sec)			
	B4	B5	B6	Avg.	B4	B5	B6	Avg.
CS1	0.48	0.51	0.48	0.49	1.13	1.13	1.60	1.29
CS2	0.53	0.57	0.57	0.56	1.13	1.13	1.39	1.22
CS3	0.60	0.65	0.64	0.63	0.80	0.00	1.79	0.87
CS4	0.80	0.85	0.88	0.84	1.13	1.13	1.13	1.13
CS5	0.98	0.98	0.95	0.97	0.80	0.80	1.13	0.91
CS6	1.12	1.10	1.08	1.10	0.00	0.80	1.13	0.65
CS7	0.11	0.11	0.11	0.11	2.41	3.40	1.39	2.40
CS8	0.08	0.16	0.18	0.14	1.79	1.79	3.21	2.27

Cross Section	Flow Rate: 1.2 cfs (15-30 mins)							
	Dist. from CS1 (ft)	Water Depth (ft)	$v^2/2g$ (ft)	S_f (ft)	Bottom Elev. (ft)	EGL (ft)	y/E	Avg. y/E
CS1	0.00	0.49	0.03	0.52	0.90	1.42	0.95	0.97
CS2	3.00	0.56	0.02	0.58	0.75	1.33	0.96	
CS3	6.00	0.63	0.01	0.64	0.60	1.24	0.98	
CS4	9.00	0.84	0.02	0.86	0.45	1.31	0.98	
CS5	12.00	0.97	0.01	0.98	0.30	1.28	0.99	
CS6	14.00	1.10	0.01	1.11	0.20	1.31	0.99	
CS7	16.00	0.11	0.09	0.20	0.10	0.30	0.55	0.59
CS8	18.00	0.14	0.08	0.22	0.00	0.22	0.64	

Length of pool upstream of ditch check (ft): 24.8 **Time (min):** 32

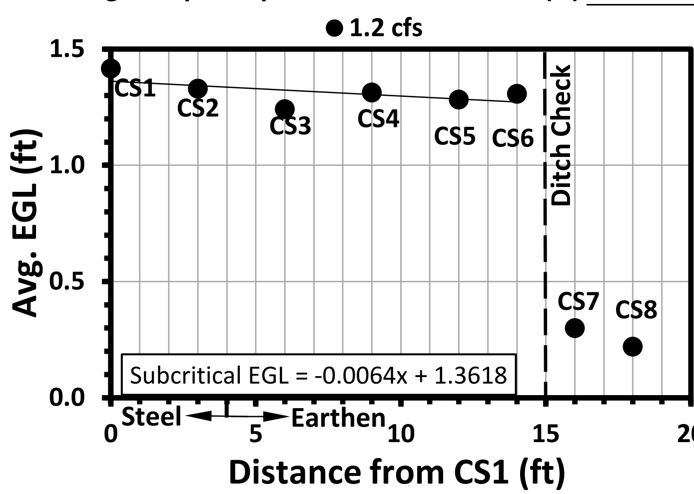


Figure 3: EGL Profile of Channel Cross Sections.

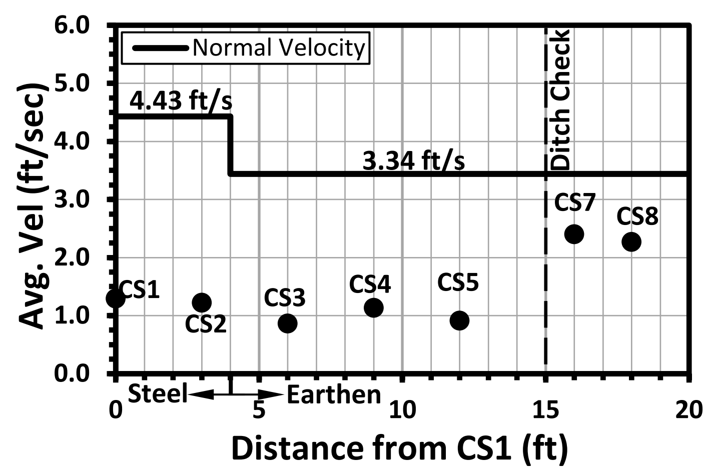


Figure 4: Velocity Profile of Channel Cross Sections.

Flow Rate: 0.6 cfs (0-15 mins)

Head Height								
H$_{water}$(ft.)	**CS1**	**CS2**	**CS3**	**CS4**	**CS5**	**CS6**	**CS7**	**CS8**
B4	0.34	0.39	0.46	0.71	0.84	0.95	0.09	0.06
B5	0.33	0.41	0.49	0.73	0.85	0.95	0.07	0.11
B6	0.32	0.43	0.51	0.74	0.85	0.93	0.12	0.08
H$_{velocity}$(ft.)	**CS1**	**CS2**	**CS3**	**CS4**	**CS5**	**CS6**	**CS7**	**CS8**
B4	0.36	0.39	0.46	0.72	0.85	0.95	0.12	0.10
B5	0.36	0.42	0.51	0.75	0.85	0.95	0.09	0.28
B6	0.36	0.44	0.52	0.75	0.85	0.93	0.25	0.25

Length of pool upstream of ditch check (ft): 22.2 Time (mins): 19

Flow Rate: 1.2 cfs (15-30 mins)

Head Height								
H$_{water}$(ft.)	**CS1**	**CS2**	**CS3**	**CS4**	**CS5**	**CS6**	**CS7**	**CS8**
B4	0.48	0.53	0.60	0.80	0.98	1.12	0.11	0.08
B5	0.51	0.57	0.65	0.85	0.98	1.10	0.11	0.16
B6	0.48	0.57	0.64	0.88	0.95	1.08	0.11	0.18
H$_{velocity}$(ft.)	**CS1**	**CS2**	**CS3**	**CS4**	**CS5**	**CS6**	**CS7**	**CS8**
B4	0.50	0.55	0.61	0.82	0.99	1.12	0.20	0.13
B5	0.53	0.59	0.65	0.87	0.99	1.11	0.29	0.21
B6	0.52	0.60	0.69	0.90	0.97	1.10	0.14	0.34

Length of pool upstream of ditch check (ft): 24.8 Time(mins): 32

Figure 7: Impoundment

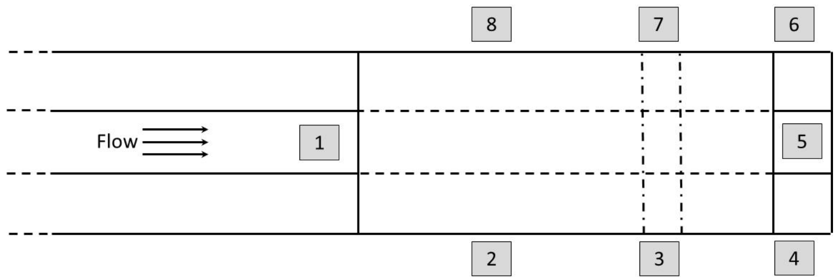
Pre-Test Photo Documentation

Location 8

Location 7

Location 6

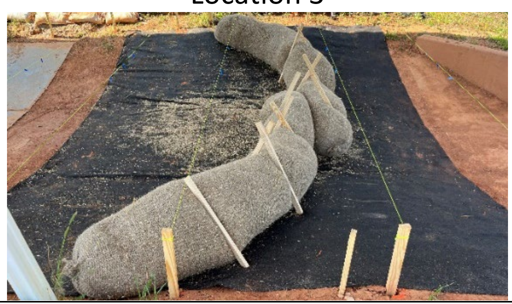
Location 1



Location 5

Location 2

Location 3



Location 4

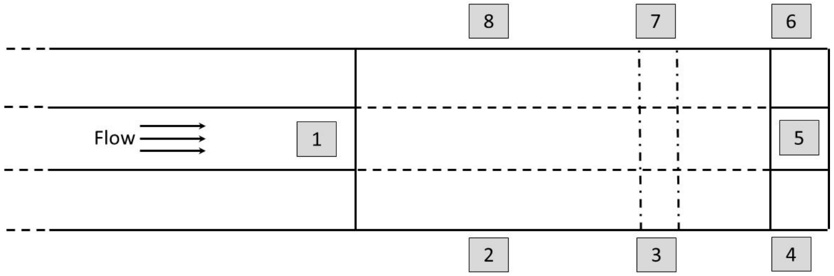
Post-Test Photo Documentation

Location 8

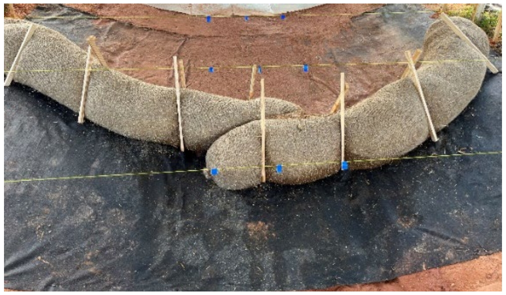
Location 7

Location 6

Location 1



Location 5



Location 2

Location 3

Location 4

Longevity Testing: Soil Deposition Data

Date: 7/25, 7/27, 7/27/2023
Product: Ninety7Wattle
Manufacturer: GMG
Techs and Workers: K. Ansley, G. Savage
Diameter (in): 20 **Length (ft):** 19 **Width (in):** N/A **Height (ft):** 1.5
Installation Descr.: 8 oz. filter fabric underlay w/ wooden stakes and sod staples
Test Type: Sediment Laden Water, Tiered Flow (0.6 and 1.2 cfs) Longevity Test (3 Test Runs)

Test Times: 30 min
Sed. Intro. lb 2,070
Sed. Retain. lb 1,415
Sed. Retain. % 68

Figure 1: Installation.

Figure 2: Deposition.

Figure 6: Deposition Pattern.