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WOODWARD CONSULTING, INC.

April 20, 2015

INVOICE TO : Ashborough Village Condominium Association

FOR: Scour analysis

AMOUNT: $2000

Thank you

HYDRAULICS ANALYSIS
SCOUR REPORT
FOR
ASHBOROUGH VILLAGE

COBB COUNTY, GA
April 19, 2015

14397
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Scour Analysis

The HEC-RAS program was also used to analyze the theoretical scour depth for the streambank restabilization retaining wall structure. With the results of the hydraulic analysis, HEC-RAS utilizes the methods referenced in Hydraulic Engineering Circular No.18 to calculate the scour depth for the storm frequencies defined. Our analysis focuses on the 100-yr event. Theoretical scour depth was calculated using a soil classification representative of medium sand (D_{50} = 0.[illegible] mm) and is based on the soils report.

To obtain the Y1 and Fr# for the proposed structure, the model was run with the wall entered as a bridge only subjected to abutment flows in the area of the wall.

Summary

The listed depth was calculated assuming that impermeable material (i.e. bedrock) would not be encountered.

The estimated scour depth for the retaining was structure for the 100 year storm was 10.62 ft.

ASHBOROUGH VILLAGE SCOUR CALCS FOR 100 YR STORM

To calculate scour along the face of the creek bank stabilization wall reference HEC-23, Section 4.3.4 (shown below).

Equation 4.3 was applied with the following results:
(Note: y_1 and F_r are obtained from the HEC-RAS model)

ys = y1(0.73+0.14*pi*Fr^2) **EQ 4.3 from HEC-23**

y1 for 100 yr = 13.85 ft
Fr for 100 yr = 0.29

ys for 100 yr = 10.62 ft

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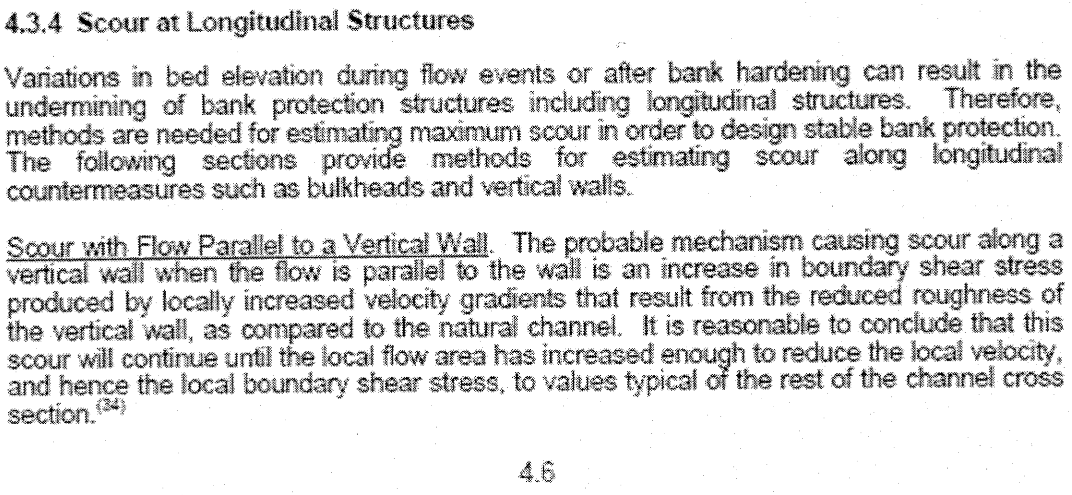

4.3.4 Scour at Longitudinal Structures

Variations in bed elevation during flow events or after bank hardening can result in the undermining of bank protection structures including longitudinal structures. Therefore, methods are needed for estimating maximum scour in order to design stable bank protection. The following sections provide methods for estimating scour along longitudinal countermeasures such as bulkheads and vertical walls.

Scour with Flow Parallel to a Vertical Wall. The probable mechanism causing scour along a vertical wall when the flow is parallel to the wall is an increase in boundary shear stress produced by locally increased velocity gradients that result from the reduced roughness of the vertical wall, as compared to the natural channel. It is reasonable to conclude that this scour will continue until the local flow area has increased enough to reduce the local velocity, and hence the local boundary shear stress, to values typical of the rest of the channel cross section.(34)

4.6

The distribution of boundary shear stress around the perimeter of a channel is not constant. In channels of uniform roughness, the boundary shear stress has a maximum value near the channel centerline, and a secondary peak about one-third of the way up the sideslope. On average, the maximum on the bottom is about 0.97 times the average boundary shear stress (e.g., as defined by γRS) for the cross section and the maximum on the side is about 0.76 times the average boundary shear stress. However, experimental data indicate a range of values, with maximum shear stresses as much as 1.6 times the average. In general, the boundary shear stress distribution is more uniform as the width to depth ratio increases.

Similar information is not available for channel cross sections of nonuniform roughness; however, reasonable conclusions can be drawn from intuitive arguments. For a straight channel with a vertical wall with smoother roughness than the rest of the channel along one side, the boundary shear stress distribution would be skewed towards the wall side of the channel. The sideslope peak value would be larger and could possibly be greater than the peak along the channel bed, which would also be shifted off the centerline location. These effects would be more pronounced in narrow channels and/or channels with steep sideslopes. As the channel gets wider, or the sideslope flattens, these effects would be diminished.

Insight on the magnitude of these effects can be obtained by considering local velocity conditions as determined by conveyance weighting concepts (see HEC-18(24) and HEC-20(23)). The analysis assumes that the boundary roughness within the channel can be divided into two distinct regions: one region defining the roughness of the channel and the other defining the roughness of the channel bottom (note that this division of roughness, while logical, is not always analytically useful as it can create numerical problems leading to errors in the computation of conveyance for the entire cross section).

For purposes of illustration, a wide, shallow natural channel has a uniform roughness with a Manning's n value of 0.03, but with a concrete vertical wall the n value of the bank region is reduced by a factor of two, to 0.015. Evaluation of the distribution of discharge by conveyance weighting shows that this reduction of "n" nearly doubles the conveyance, discharge, and velocity adjacent to the bank (i.e., next to the wall). Recognizing that boundary shear stress is proportional to velocity squared; this increase in velocity increases the boundary shear stress by a factor of 4.

Based on the experimental results for a uniform roughness channel, the maximum boundary shear stress along the vertical wall could be as much as 3 times the average boundary shear stress. However, this is not totally accurate given the simplistic assumptions made and the likely changes in the distribution pattern that would result under conditions produced by a vertical wall. Nonetheless, this simplified analysis suggests that significant increases in the boundary shear stress are possible adjacent to the wall.

To apply this concept, it is appropriate to define a shear stress multiplier that can be applied to the average boundary shear stress to define the locally increased boundary shear stress adjacent to a vertical wall. Based on the above argument, a shear stress factor of 3 is suggested. Recognizing that boundary shear stress is proportional to velocity squared, the reduction in velocity necessary to lower the shear stress to an acceptable value is defined by the inverse of the square root of the shear stress multiplier (0.577) for the shear stress factor of 3. For the reduction in velocity to occur, the flow area must then be increased by the inverse of this factor (1/0.577 = 1.73). For a vertical wall, this calculation simplifies to a unit width basis and the scour depth is a multiplier of the average flow depth (0.73 y_1).

It is important to understand that this provides a first approximation of the potential scour along a vertical wall due to flow parallel to the wall. Using this relation, the total scour along the wall due to parallel flow can be approximated as the sum of the above relation, which results from a differential in shear stress, plus scour associated with the passage of antidunes (see HDS 6(4)). This results in the following relationship:(34)

$$\frac{y_s}{y_1} = 0.73 + 0.14\,\pi F_r^2 \qquad (4.3)$$

where:

y_s = Equilibrium depth of scour (measured from the mean bed level to the bottom of the scour hole), m (ft)
y_1 = Average upstream flow depth in the main channel, m (ft)
F_r = Upstream Froude Number

This equation is applicable only where parallel flow can be assured (e.g., vertical walls along both banks).

Scour with Flow Impinging at an Angle on a Vertical Wall. When an obstruction such as an abutment or vertical wall projects into the flow, the depth of scour at the nose or face of the obstruction can be estimated from Equation 4.1. Considering the physical configuration of the channels for which the data on which this relation is based, this can reasonably be assumed to be the upper limit of the scour that could be expected for flow along a vertical wall when the flow impinges on the wall at an approximately 90° angle. The total scour along a vertical wall, thus, will vary as a proportion of that given by Equations 4.1 and 4.3. Assuming that the relative significance of the two scour mechanisms is related to the change in momentum associated with the change in flow direction from some angle θ relative to the wall, the two relations can be combined using a weighting factor based on the sine or cosine, respectively, of the angle of the flow to the wall (0° to 90°). The resulting relationship is given by:(34)

$$\frac{y_s}{y_1} = (0.73 + 0.14\,\pi F_r^2)\,\mathrm{Cos}\,\theta + 4F_r^{0.33}\,\mathrm{Sin}\,\theta \qquad (4.4)$$

where:

θ = Angle between the impinging flow direction and the vertical wall

Scour Along a Vertical Wall Relative to Unconstrained Valley Width. The potential scour that could occur along a vertical wall due to changes in planform as the channel evolves can be estimated by combining Equation 4.4 with the relationships for ideal meander geometry (see HEC-20(23)). Using these relationships, it can be shown that the maximum angle will vary from zero, when the width of the valley is constrained to the width of the channel, to approximately 71°, when the unconstrained valley width is approximately 3.5 times the width of the channel. These values are based on the assumption that the meander wavelength is 14 times the channel width. The resulting dimensionless scour depth as a function of the unconstrained valley width is plotted in Figure 4.2 for a range of Froude Numbers (F_r).

It is possible for the channel to impinge perpendicular to the wall due to local flow deflection or other local factors. For this case, the angle of impingement is no longer related to the valley width, and the maximum scour depth can best be estimated based strictly on Equation 4.1.

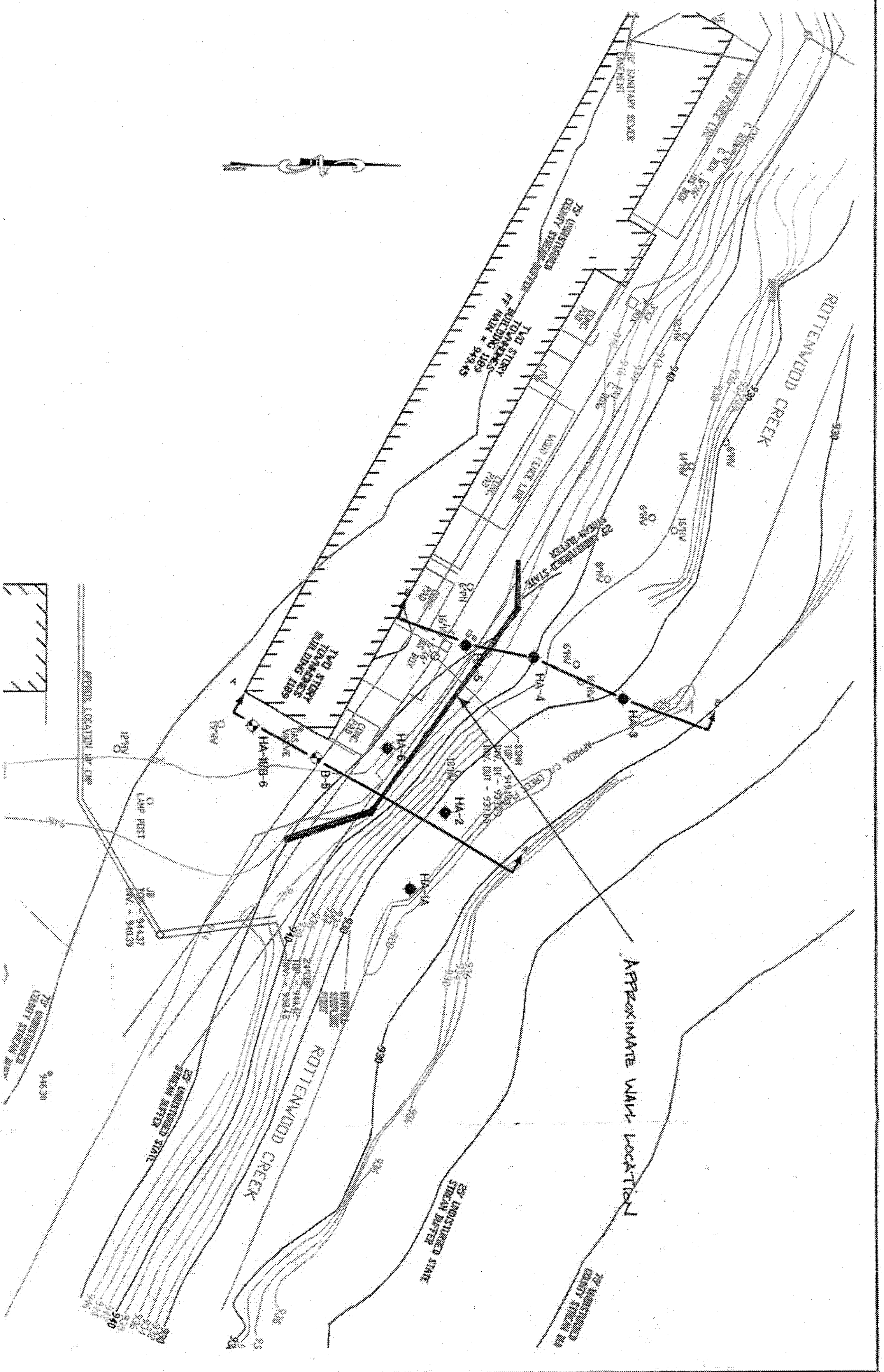

FIGURE 1: SITE AND TEST LOCATION PLAN (BUILDING #1189)

LEGEND: ⯐ SOIL TEST BORING ● HAND AUGER BORING SCALE: NTS	PIEDMONT GEOTECHNICAL CONSULTANTS, INC. P.O. BOX 1997 ROSWELL, GEORGIA 30077 (770) 752-9205	ASHBOROUGH VILLAGE SLOPE EVALUATION MARIETTA, GEORGIA PROJECT NUMBER 109027