MEMORANDUM

TO: City of Alexandria

FROM: Wetland Studies and Solutions, Inc

RE: Response to Taylor Run Stream Restoration – Field Geology Services Report
WSSI #28006.01

DATE: April 16, 2021

The following is in response to the report entitled An Analysis of the Stream "Restoration" Design for Taylor Run in Alexandria, VA, dated March 2021 prepared by Field Geology Services of Portland, ME. The report provides an incomplete picture of design considerations and is inconsistent in the use of natural channel design (NCD) application and understanding. This memorandum highlights a number of these inconsistencies, in addition to explaining the disadvantages of attempting to apply a restoration approach using only large woody debris.

Natural Channel Evolution

In the report, the author acknowledges that "more confined systems like Taylor Run tend to be more sensitive to large floods, sometimes dramatically changing their dimensions in such events." This statement is then followed by the confounding assertion that the Taylor Run system is stable. The author correctly notes that a stable system does not mean a static system – that is, if the erosion rate (loss of sediment) in a system is equal to the incoming sediment load, the system can be said to have reached equilibrium. However, in the case of Taylor Run the urban watershed feeding the stream valley contributes a negligible amount of sediment supply. Thus, in order for the system to achieve stable equilibrium in the context of an urban watershed the system, it must be relatively static. This approach is known as Threshold design.

The author points to the presence of hard pan, erosion resistant clays at the base of existing vertical banks as an indicator that the system has reached equilibrium. The following image was taken from Sheet 74 of the design plan set. This image illustrates the evolutionary process as a channel changes to adapt to altered watershed conditions. Consistent with this model, the design team sees erosion resistant parent materials in the lower portion of the channel as an indicator of lesser potential for downcutting and a transition to the widening process as the channel increases cross-sectional area to reduce stresses. This assessment is confirmed by numerous locations where rock/concrete rubble has been dumped along the stream banks to arrest this ongoing widening process. Design team conclusions are further supported by portions of the Field report, including the fact that "once widening has progressed sufficiently over a period of several decades, the stream achieves a new equilibrium, when the incision and widening have reduced flow velocities to the point where only the smaller amount of sediment coming from the urbanized watershed can be transported despite the greater runoff."

5300 Wellington Branch Drive • Suite 100 • Gainesville, Virginia 20155 • Phone 703.679.5600 • Fax 703.679.5601
nstaley@wetlands.com • www.wetlands.com

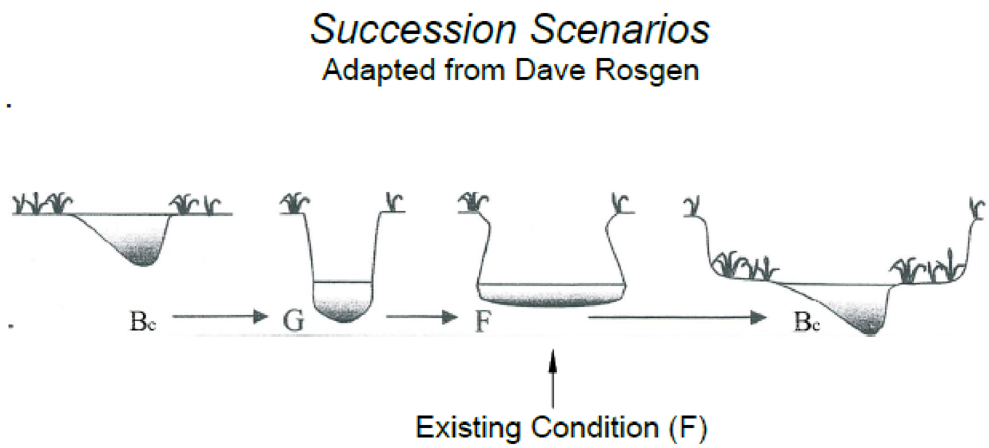

Figure 1. Channel evolution model.

The Field report calls out various locations along the restoration reach where ongoing erosion is occurring, as widening progresses.

The Field report points to the upstream culvert as further confirmation that the system has reached equilibrium, noting that the upstream culvert "with its bottom essentially at the current bed level, demonstrates that no widespread incision has occurred since the culvert was installed decades ago." However, the preceding sentence in the report indicates bed degradation throughout the reach, stating that hardpan clay "indicates that further deepening of the channel through incision is not possible". On-site observation and survey information presented in design plans (Sheet 14) clearly show a channel invert more than three (3) feet of elevation difference between the culvert outlet elevation (148.58) and the existing channel bottom. The drop or downcutting would be greater were it not for the concrete rubble that has been dumped at the outfall to arrest further degradation. Areas downstream of the outfall show even greater bed erosion.

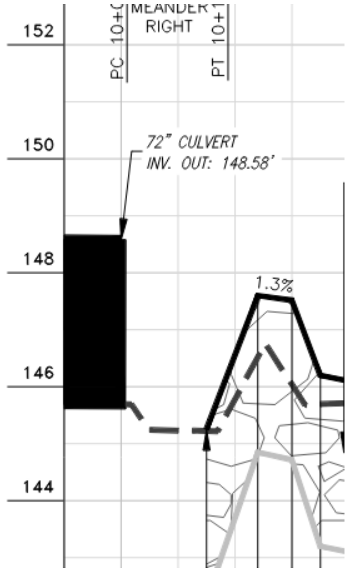

Figure 2. Design profile showing existing drop of over 3-ft at culvert outlet.

The final bit of evidence Field uses to support the position that the existing stream has reached a stable equilibrium is the deposition of gravel in the lower portions of the reach on church property. The Field report states that this depositional feature is evidence that the channel widening process has progressed to the point that deposition is encouraged. If fact, backwater effects related to the downstream culvert size and debris jam formation are the root of deposition, as shown in the picture below. This deposition is in no way an indicator of system stability. The City is responsible for periodic maintenance at this culvert to remove woody debris stemming from upstream channel erosion. The downstream depositional feature is clearly shown by profile survey data on Sheet 17 of the design plans.

Figure 3. Downstream culverts at the rear of church property (largely obscured by debris).

The Field report states that “Natural Channel Design attempts to create the expected dimension, pattern, and profile of an equilibrium stream channel in a natural undisturbed watershed.” This is incorrect. Natural Channel Design principles use data collected from stable natural systems to understand channel evolution. These stable reference reach characteristics are then used to inform design development on systems where watershed or channel alteration have led to instability. Watershed development/imperviousness necessitates adjustment of regional curve data derived from rural watersheds, for example, the application of an urban channel enlargement factor.

Design Discussion

The proposed restoration design is consistent with the understanding of natural channel evolution, as depicted in Figure 1. If left unchecked, the system would continue to widen before establishing a new floodplain at a lower elevation – a fact acknowledged in the Field report. Allowing this process to progress naturally over the coming decades is impossible at the Taylor Run site due to constraints posed by existing road, trail, and sanitary infrastructure. Therefore, the proposed design uses fill material, an engineered erosion resistant reinforced bed, and strategic placement of rock structures to reestablish a channel invert elevation consistent with past conditions at the site prior to severe erosion. This approach reduces channel stresses and creates a narrow bankfull bench. The approach is consistent with the channel evolution model, as broadly understood by industry professionals and described in the Field report but requires intervention since the upstream supply of sediment has been cut off by watershed development.

The Field report assumes the proposed design will fail and fill material will be released to downstream receiving waters. (Note: Contrary to the report’s position, contract documents will require testing to characterize a wide range of material properties for imported fill, including pollutants/contaminants prior to material import and use.) The report states that “After decades of naturally reducing its gradient through incision, the filled-in elevated streambed will produce a steeper channel that will increase (not decrease) the stream’s capacity to carry sediment.” This is in direct contradiction to early portions of the report that claim no incision has occurred (pointing to the upstream culvert elevation). The statement is also inaccurate in suggesting that system stresses will be greater in the shallower restored channel due to increased slope. The upstream and downstream ends of the project are fixed elevations (culverts). Therefore, overall channel slope is inherently fixed. The statement also demonstrates a lack of understanding regarding shear stress in that stresses are a product of both slope <u>and</u> flow depth. Though erosion may result in a temporary and isolated reduction in bed slope, associated incision drives greater channel stresses by disconnecting high flow events from the surrounding floodplain. By significantly reducing channel depth, erosive forces are reduced. This fact, in combination with the use of boulder grade control structures are the key elements of a design approach that has been successfully applied by the design team to over 200,000 linear feet of stream throughout the region.

Further, the Field report assertion that the design only considers the 2-yr storm event incorrectly characterizes a design, which by its very nature, is more resilient to larger storm events due to a reestablished connection to the surrounding floodplain. This restored connection not only reduces in-stream stresses but restores the hydrologic connection to the greater riparian corridor – facilitating indirect enhancement of degraded overbank habitat. Members of the design team continue to study this beneficial linkage at the Northern Virginia Stream Restoration Bank site in Reston, where successful projects similar in nature to the Taylor Run design have been documented to enhance and expand riparian habitat markedly, including adjacent wetlands. The design approach has shown resilience/success in the face of large storm events, including events with a magnitude exceeding the 500-yr storm rainfall intensity/volume, and has remained stable for over a decade.

The Field report suggests that the proposed design is likely to fail when reinforced bed materials erode. However, the report acknowledges (excerpt below) that material is sized to resist erosion during the bankfull flood, with an additional factor of safety to account for larger storms.

> *The City's consultant selected these dimensions by calculating the rock size that can be moved by a flood's erosive forces when the channel is completely full (i.e., bankfull condition) with the consultant ultimately selecting a rock size around twice as large to add a factor of safety.*

A significant factor of safety is necessary to provide bed stability for the full range of flows, including those associated with much larger storms. Design analysis evaluated material stability for flows up to the 100-yr event, at which point flows are better distributed across the floodplain and stresses reach near-peak magnitude. Additional design stability is afforded by the careful placement of in-stream structures. These structures are constructed of large boulders designed to provide long-term/permanent grade control/stability. Integration of these structures is necessary to prevent grade level changes and the compromise of channel fill materials. Footer rocks for these structures will be placed on the in-situ erosion resistant bed materials noted by Field, geotextile fabric used on the upstream side of rocks to prevent piping of fines through gaps in boulders, and rock sills provided (as shown in design details) to prevent flanking failures highlighted in the report. The proposed approach will create a static channel form – known as a "Threshold" design. A Threshold approach, if applied in a more natural watershed (where sediment supply still exists) would be mis-applied. However, in the case of Taylor Run, the approach is necessary and appropriate, since surrounding sanitary, trail, and roadway infrastructure restrict the stream's natural evolutionary process.

Woody Debris Design Alternative Comparison

The Field report suggests the use of large woody debris to form step-like structures throughout the Taylor Run design reach combined with log crib walls. This approach can be a viable restoration alternative for certain sites and was considered during design development. Should the City seek to pursue a wood-based design approach, we suggest the City seek additional information from Dr. Field, including examples of where this approach has been employed in similarly situated (i.e. urban) watersheds, tested by significant flood events over a long period of time (decade or more), and found to remain stable.

Wetland Studies and Solutions, Inc. does not advise the use of woody debris weirs as described in the Field report for an urban system such as Taylor Run. This is due in large part to the limited longevity of such a design and the potential for future destabilization. Watershed development has resulted in a reduction in baseflow. This creates conditions in which the stream runs dry, or nearly dry during portions of the year. This intermittent flow regime seen in Taylor Run, combined with the warm humid climate of the mid-Atlantic, creates ideal conditions for the decomposition of wood. This gives a wood-based design approach limited longevity – likely on the order of 20 years (as noted by Field). The stability of this design approach is further jeopardized by the fact that the Taylor Run system has very little incoming sediment supply. Wood-based designs can be effective in systems where a high incoming sediment load can be trapped by woody debris, allowing the stream system to rebuild itself. In the case of Taylor Run woody debris structures would not be effective in driving the formation of stable channel characteristics. In fact, the steps created by the woody debris features are likely to create flow discontinuity, further stressing banks in the area of the placement. The Field report suggests placing log crib walls throughout the project area to stabilize banks. This amounts to temporary bank stabilization, with no effort made to address the incised channel form. This approach is further complicated by the fact that the proximity of the sanitary sewer to the stream (along the right bank for much of the upper design reach) will significantly complicate establishing foundational support for crib walls or woody debris placements.

Though a wood-based design was not utilized for Taylor Run for the reasons given, low-profile large woody debris elements were integrated into the proposed bankfull bench design to enhance stability and create habitat. The design strategically employs the use of woody structures in low stress areas to enhance design stability during the initial establishment without relying on wood as the mechanism for long-term stability. Careful integration of wood also allows repurposing of trees threatened by on-going erosion or impacted by construction activities.

Concerns regarding overbank flooding have been raised throughout the design process. The woody debris approach is likely to have a similar effect on floodplain hydrology since the approach calls for elevated woody debris weirs. In fact, the discontinuity of channel cross sectional area/flow capacity created by periodic woody debris placement is more likely to drive the creation of high velocity areas in and along the channel, as water is forced out of the channel banks by debris jams and then funneled back into the incised channel. This stepped approach is identified as risky in the final paragraph of Section 4.2 of the Field report, though it is not clear how the more pronounced woody debris step features will reduce the risks associated with a stepped form, especially when used in a high-stress, confined channel form.

The woody debris temporary stabilization design approach suggested in the Field report requires a significant numbers of tree impacts, both to allow material for structure construction (either on-site or elsewhere), and to clear space for feature placement. If the design were to prioritize preservation of on-site trees, choosing instead to import woody debris material, access road widths would likely need to be expanded to allow for the transport of long logs suitable for placement as stability elements. If log size is decreased (diameter or length) to minimize site disturbance, it would adversely impact the stability and longevity of the design. Though much greater detail is necessary to accurately quantify the disturbance associated with the suggested woody debris approach, implementation of the approach is likely to have a similar impact to existing site habitat (trees) in terms of the access road and for any areas where structure placement is specified. Based on detailed analysis of tree survey data by the design team, it is estimated that the wood-based temporary stabilization approach suggested by Field would likely impact more than 150 trees.

Permitting and credit generation from implementation of the woody debris approach is an unknown variable. Unless the design were to integrate natural channel design principles and elements aimed at achieving long-term stability it is unlikely to qualify for pollutant removal credits. This would need to be further explored if the design were otherwise considered a viable alternative.

The major difference between the proposed NCD design approach and the wood-based temporary stabilization approach suggested in the Field report is design lifespan. Field notes that a woody debris approach would only be viable for approximately 20 years. With no incoming sediment supply, the system would be left unstable once logs rot away, thus necessitating future system intervention.

The proposed natural channel design approach put forward by the City's design team more fully addresses system-wide instability in order to achieve a more permanent solution. Unlike the wood-based stabilization, the proposed NCD approach acknowledges the inherent conflict with existing infrastructure and best aligns with the need to protect the adjacent sanitary line. This approach requires greater disturbance for initial implementation, but coupled with heavy native plantings, affords a strategy that drives the highest level of achievement when considering the full range of project goals.