

October 23, 2006

Hydraulic Grade Line Analysis of Tollgate storm sewer system and Opinion on unit flooding

The Tollgate HOA Board of Directors has asked Community Association Engineering¹ to perform a hydraulic grade line analysis of the privately maintained storm sewer system built as part of the original subdivision behind Lots 5 through 8. Additionally, our firm was asked to furnish a professional opinion, based on available data, anecdotal records and the above analysis, whether landscaping timbers that were installed in the Tollgate common space above the subject lots adversely affected the HOA-maintained drainage system and/or aggravated the reported flooding of the homes on Lots 6 and 7.

Please find our results and opinions summarized below.

Background and Location

The community is located on the south side of Virginia Route 7 in the City of Falls Church situated along both sides of Tollgate Way. An aerial photograph² of the site area, subject storm sewer system and Lots 5 & 6 of the subdivision are shown, for reference, in the exhibit below.



The storm sewer system shown above is the upper portion of a system which drains Tollgate and adjacent properties and is owned, as we understand it, by the Tollgate HOA. The system drains into a publicly maintained system below structure point "J" (this portion of the system not shown on the exhibit). The system layout, pipe sizes, grades and elevations are shown on the site plan for Tollgate³.

The approximate reported location of two landscape timber diversions reportedly installed by the HOA are shown on the exhibit and are discussed later in this report.

Method of Analysis

Records (site plans and surveys from public record) were obtained from the City of Falls Church through the HOA. Visual field inspection was performed to validate the general accuracy of the public record documents.

Storm sewer system horizontal, grade and vertical parameters from the original site plan were used in standard HGL (hydraulic grade line) calculations (per VDOT Drainage Manual) for storm sewer segments between structures J-K-L-M, also considering the input from structure N as well. Drainage areas were determined from the topography shown on the original site plans for the offsite properties above structure L, M and N.

Hydrology to compute "Q" (storm runoff flow rate) was performed based on the Rational Formula ($Q = C \cdot I \cdot A$), where C (relative imperviousness) and "I" (rainfall intensity for the 10-year storm) were based on appropriate Fairfax County PFM values and were constant in both assessment scenarios. For variable "A" (drainage area), two sets of drainage area calculations were considered: the first approach assumed the landscape timbers not in place and the second assumed the landscape timbers were operating to divert all drainage to structure L by Lot 5. HGL calculations were then computed using both resultant flow values ("Q") per VDOT Drainage Manual methodology.

Results of HGL Analysis

The HGL analysis which did not assume diverted runoff by the landscape timbers provided the following results:

1. The 8" storm drainage pipe from J to K operates in pressure flow (that is to say, in a surcharged condition) with the pressure head (elevation water would rise if a theoretical standpipe was inserted at a point in the pipe) at or above the ground level.
2. The 8" storm drainage pipe from K to L operates in pressure flow with the pressure head at or above ground level.

The HGL analysis which assumed additional drainage from the hypothetical diversion of the landscape timber scenario resulted in the same conditions within the drainage pipes.

In summary, the quantity of flow in the non-diverted condition (4.2 cfs - cubic feet per second) resulted in a complete surcharging of the 8" drainage pipe system such that the pressure head throughout the system inlets would exist at the ground surface (approximately 326 feet mean sea level at structure L). The practical application of this condition is that the manhole at inlet L (the grate inlet behind Lot 5) would be completely flooded and would not be able to intercept all of the 4.2 cfs. The bypass flow, which appears from our calculations to be a majority of the flow, would be passed overland

between the brick walls toward Tollgate Road at an elevation of approximately 326.2 mean sea level, resulting in a flooded, ponded condition for some period of time at grate inlet L.

When the HGL calculations were performed assuming the larger flow of 7.25 cfs resulting from a theoretical full diversion of runoff above the locations of the reported landscape timbers, the pipe system continued to show as operating in pressure flow and the sizable bypass flow continuing to pass to Tollgate Way overland toward inlet K between the brick walls between Lots 4 and 5, cresting over the high point between the brick walls as a trapezoidal broad crested weir control section.

Please note the following assumptions were made as part of the HGL calculations in both scenarios:

- HGL calculations assumed no pressure relief points in the system below the top of grate inlet L, K or street inlet J. Based on field observations, however, it appears that there may be a gravity drain installed in an areaway, at a minimum, in the rear yard of Lot 6, which would act as a pressure relief point. If this is the case, calculations shown above may be impacted by the fact that storm water would then flow in reverse through such an areaway drain, toward the subject house, relieving the pressure in the main storm sewer system (as much as could be accommodated by the 4" drain connection - pipe operating as an orifice on the main line system between structures L and M) by releasing flow into the areaway. This connection should be further investigated by the HOA as this is not within the scope of this analysis.
- That the ponding at structure K contemplated by the original project design (shown as a "retention area") is sufficiently low enough below the overland relief point previously mentioned that it does not affect the fact that the 326.2 control section, along with the 8" pipe from L to K, is the controlling pair of factors determining how much flooding occurs at structure L and the lots adjacent to that inlet.
- That the flooding at street inlet J reported by the HOA justifies the basis of starting the HGL calculations at this point at the top of this inlet and that there is no need to assess the system HGL below this point (i.e. inlet J and the crown in the road at the sump is a control point that allows for assumption of a starting water surface for HGL calculation purposes).
- That a 10-year storm scenario is approximately equivalent to the flow values that may have been experienced by Tollgate during the storms of late June / early July 2006 on the subject date that Lots 6 and 7 reportedly flooded and thus, has been used as the value of "I" (rainfall intensity) in the Rational Formula.
- That the landscape timbers were situated in such a way and were tall enough to divert all flow of a watershed of approximately 1 acre. No computations have been performed to assess the possibility that the low size of the landscape timbers may not have been able to divert 100% of the flow of the area above this point in the swale, so, for purposes of being conservative in our assessment and opinion, we assumed all flow was diverted to inlet L along the rear of Lots 8 through 5.

Professional Opinion

Relative to the claim reported to us that the homes on Lots 6 and 7 were flooded due to the diversion of additional runoff as a result of the landscape timbers, it is our professional opinion, based on the computations and field observations, that, irrespective of whether the landscape timbers were diverting flow or not, the capacity of the 8" storm sewer system at structure L (the grate inlet behind Lot 5) appears to be far exceeded in either scenario analyzed above (including scenarios which assumed no diverted runoff) and that overland relief for the surcharge flow to Inlet L is available only after ponding at said inlet exceeds an elevation of 326.2 mean sea level; (approximately one foot above the grate inlet top). Thus, flooding of properties and/or structures with any exterior elevation, window(s), areaway(s) or entry point(s) below elevation 326.2 should be expected if ground elevations or a point of relief for the system above inlet L are below this elevation.

Based on our review of the site plan against field observations, it appears that Lot 6 may have exterior elevations of windows, areaways or entry points below elevation 326.2 (see footnote 4) and it is our professional opinion that these structures could flood solely as a result of the flow that is directed to Inlet L without any consideration for flow that may be diverted by the reported landscape timbers.

Please contact our firm if the Association wishes to pursue any further analysis or have questions related to our findings, computations or opinions herein. We appreciate the opportunity to be of service to the Tollgate Homeowners Association and look forward to providing continued assistance on this project.

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Footnotes

1 = Community Association Engineering is a division of [GJB Engineering Inc.](#)

2 = Aerial photo from Google Earth, circa approx 2003 (annotated by Community Association Engineering for this report)

3 = Engineering plans for "Tollgate HOA" by Walter L. Phillips, dated 4/25/77, obtained from City of Falls Church public record