Enterococci levels in the Hans Groot Kill and Mohawk River, Schenectady, NY

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Introduction

The Hans Groot Kill (HGK) is a westward-flowing tributary of the Mohawk River located in an urban setting of Schenectady, NY (Figure 1). The HGK is exposed at the surface for less than 1.2 km of its original natural channel length of approximately 4.0 km. The stream emerges from three culverts at its upstream end at the West Alley boundary of the GE Realty plot, flows through the Union College campus, in part within tunnels, and enters a final culvert at the downstream end that carries the stream underground to the Mohawk River (Figure 1).

The HGK is a relatively small stream with bank-full width of ~4-6 m and typical low-flow width <2 m; its depth, though variable along the channel, rarely exceeds 0.5 m and is more typically <0.2 m. The bedrock exposed in the stream channel is interbedded sandstone and shale of the Schenectady Formation. The upper regions of the exposed stream are incised, while the lower regions on campus are bordered by floodplain. Multiple pipes enter the channel walls along the incised sections of the stream (Figure 2).

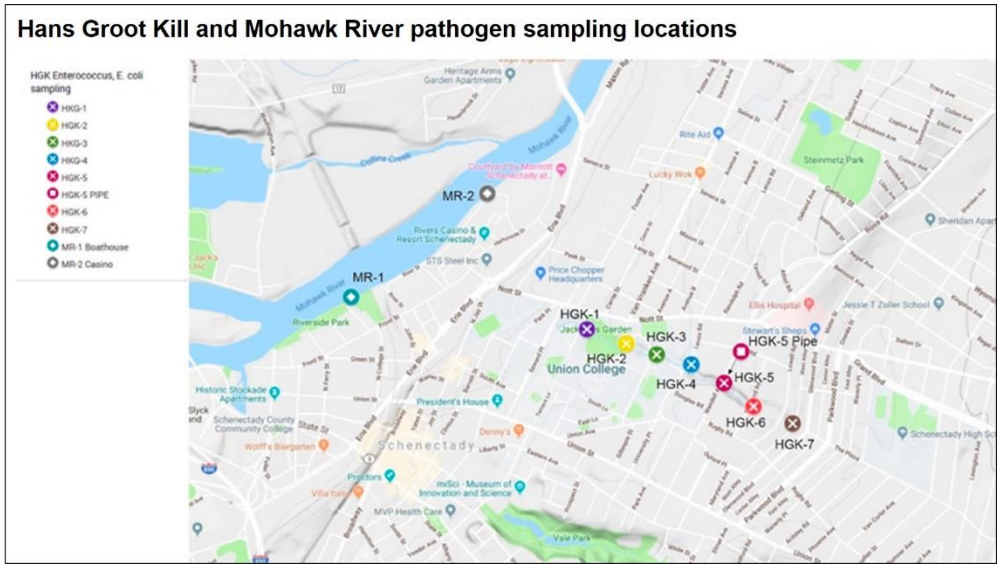

Figure 1: Map of part of Schenectady, NY, showing Hans Groot Kill and Mohawk River study area with sites for *Enterococci* sampling indicated (HGK-1 through HGK-7, MR-1, MR-2).

We have been sampling two sites on the Mohawk River and seven stream sites and a pipe outfall in the HGK for *Enterococci* bacteria; three HGK sites are on the campus of Union College (HGK-1 through HGK-3) and four sites and the pipe outfall are located upstream and off-campus (HGK-4 through HGK-7). Samples were also collected at two locations on the south bank of the Mohawk River, both upstream

(MR-1) and downstream (MR-2) of the HGK outfall at the Rivers Casino complex (Figure 1). Pathogen information is helpful in understanding the water quality of a stream, and *Enterococci* are fecal-indicator bacteria (FIB) that may be indicative of sewage from broken or illicit pipes releasing pathogens directly into the stream. *Enterococci* bacteria live in the guts of warm-blooded animals, including humans, and thus can be used as indicators of contamination by fecal waste (US EPA, 2019).

Figure 2: Examples of pipes that empty into the channel of the Hans Groot Kill. Left: Site HGK-2, with a tunnel and pipe outfalls at center and a pipe outfall at left. Center: Site HGK-5 Pipe, which commonly has the highest *Enterococci* levels. Right: Site HGK-7, the upstream end of the exposed HGK, where the Sheridan Avenue (left), The Plaza (center), and Rugby Avenue (lower right) storm sewer outfalls provide source water for the stream.

The HGK has symptoms characteristic of Urban Stream Syndrome (Walsh et al., 2005; Booth et al., 2016; Vietz et al., 2016), a term that is used to describe streams that are located in urban areas, and as a result, have experienced significnat ecological degradation. Symptoms include flash flooding, elevated nutrient levels, the presence of pathogens, and modified stream direction. The HGK has been altered along much of its course by channelizing, confining the stream to pipes and tunnels, and allowing stormwater drainage into the channel.

Methods

We sampled the HGK for *Enterococci* bacteria at eight locations, three on the Union College campus and five upstream and east of campus, and the Mohawk River at two locations (Figure 1). Samples were taken weekly (on average) April-November 2019 and January-February 2020, with two intensive sampling efforts during rainfall events in October 2019 (see following subsection). A total of 248 samples were collected, including those taken during the rainfall events (21).

Enterococci sampling and analysis was done using the IDEXX system. Prior to sampling, IDEXX plastic trays and Whirl-pak bags were labeled with each site ID. Sterile (autoclaved) glass bottles were filled with deionized water according to the predetermined dilution percentage (50-90%). A blank was made with 100 ml of deionized water. At each sample site, sterile gloves and Whirl-pak bags were used to collect samples that were transported to the lab in a chilled cooler. The samples were analyzed at Union College using the IDEXX Enterolert method (EPA Standard Method 9230D). Enterolert was added to samples diluted with DI water (10 mL for 90% dilution) and incubated for 24 hr at 41°C. After incubation, luminescent wells were marked and counted, and the final MPN/100 mL was calculated depending on dilution.

We conducted several storm-specific experiments at site HGK-2 (Figures 1 and 2). This site is in Jackson's Gardens on the Union College campus and is the single site that we repeatedly sampled for weekly analyses as well as more frequently for the experiments. In total, we sampled this site 52 times in

2019. Thirty-one samples were routine or one-time samples for weekly analyses, and 21 were for storm-specific events. Weather data for these storm experiments are from a Davis Instruments Vantage Pro Plus weather station maintained by the Geology Department at Union College (Station DW3701 at Findu); this station is 0.12 km from HGK-2. Rainfall measurements are taken every 30 minutes.

We sampled the Mohawk River 30 times from two sites above and below the outfall of the HGK (Figure 1). Site MR-1 is at the Union College Crew dock in the Stockade (up river) and site MR-2 is along the bank between Rivers Casino and Mohawk Harbor (below HGK outfall). In 2019, Riverkeeper and partners sampled the Mohawk River five times at Mohawk Harbor, which is geographically comparable to our site MR-2. Here we combine our measurements from below the HGK outfall with those of Riverkeeper, so there are 10 measurements below the outfall, and 35 total. We measured the pathogens at the Union College Crew (MR-1) dock 24 times, and in midsummer removal of the dock resulted in some samples taken for the shore.

Results

Enterococci values were well above the EPA guidelines for recreational waters in all but one of the 248 HGK samples taken over a 10-month period (Figure 3). Although *Enterococci* values at some sites are typically higher than at others (HGK-5 Pipe, for example), there is a general decrease in water quality in the upper reaches of the creek. The overall upstream trend is apparent in the geometric means (Figure 4).

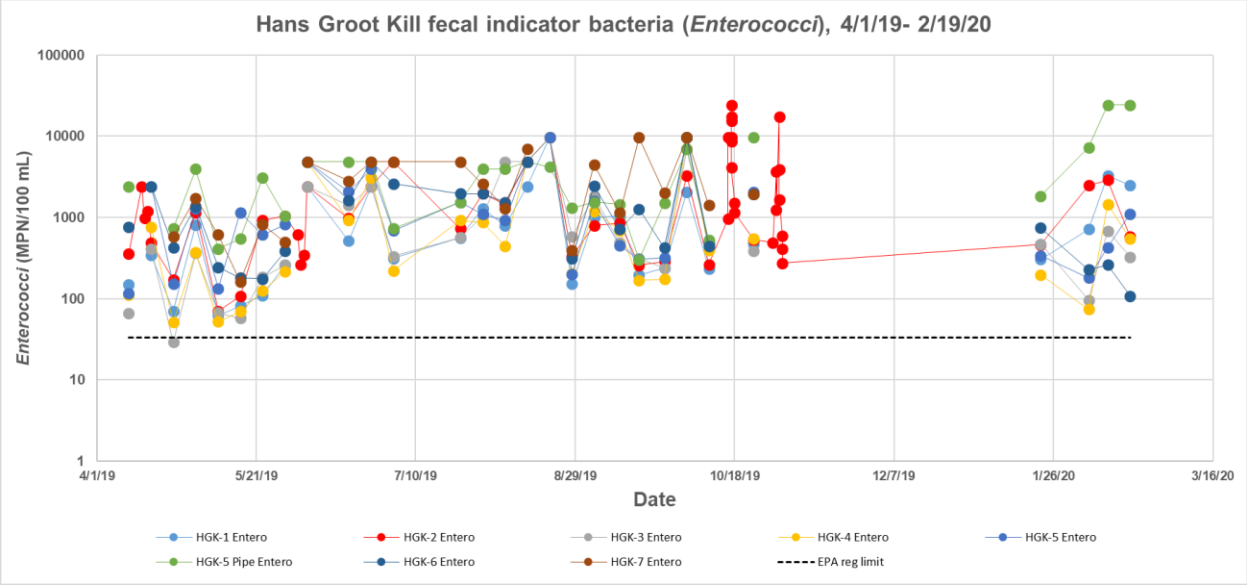

Figure 3: Individual *Enterococci* data for HGK samples, 4/1/19 through 2/19/20. All but one single sample exceeds the EPA advisory limit for recreational waters 33 MPN/100 mL; black dashed line). Some of the plotted values were saturated so their values represent minima.

The highest single value (>24,196 MPN/100 mL) came from HGK-5 Pipe on 2/19/20 (Figure 3). The highest geometric mean was also from HGK-5 Pipe (2,250 MPN/100mL; Figure 4). Sample site HGK-5, located approximately 5 meters downstream from HGK-5 Pipe, has a geometric mean of 884 MPN/100 mL, however. The second highest geometric mean was at HGK-2 with a value of 866 MPN/100 mL.

Of the 52 samples collected in total at HGK-2, four were saturated, and therefore we use the MPN/100 mL value that is minimum for that particular measurement (values saturated at either 2419.6 and 9678.4): thus we calculate a "minimum geometric mean" (below). The minimum geometric mean for all HGK-2

routine samples is 796 MPN/100 mL, and the minimum geometric mean for all HGK-2 samples, including storm-specific samples, is 1240 MPN/100 mL. Some of the highest values were obtained from the storm-specific data sets when pathogen loading was at its highest: the four highest values were obtained from storms in October 2019, and these values were between 15,531 to 24,196 MPN/100 mL. The minimum geometric mean of the storm-specific samples is 2386 MPN/100 mL.

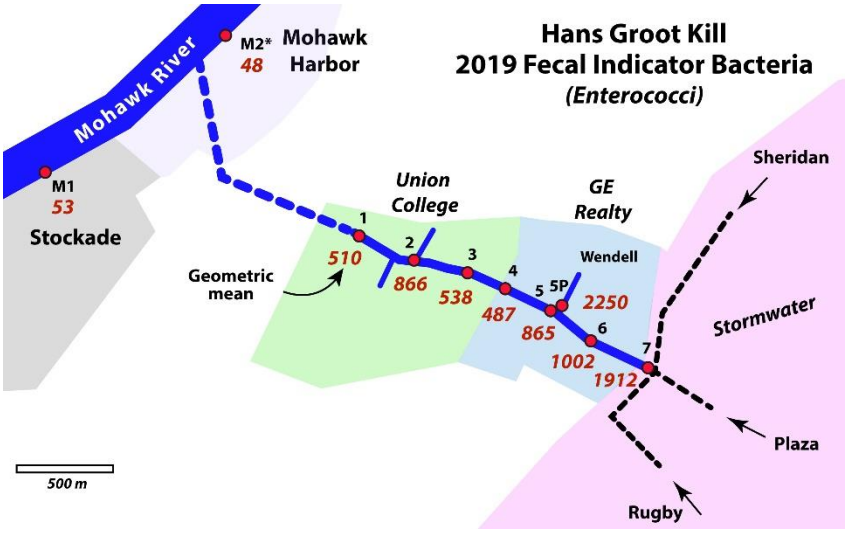

Figure 4: Geometric means of *Enterococci* data for the HGK and Mohawk River for April 2019 through November 2019. The eight HGK sampling sites are listed individually (HGK-1 = 1, etc.). The sample site for the Mohawk Harbor (M2) includes data from Riverkeeper and partners.

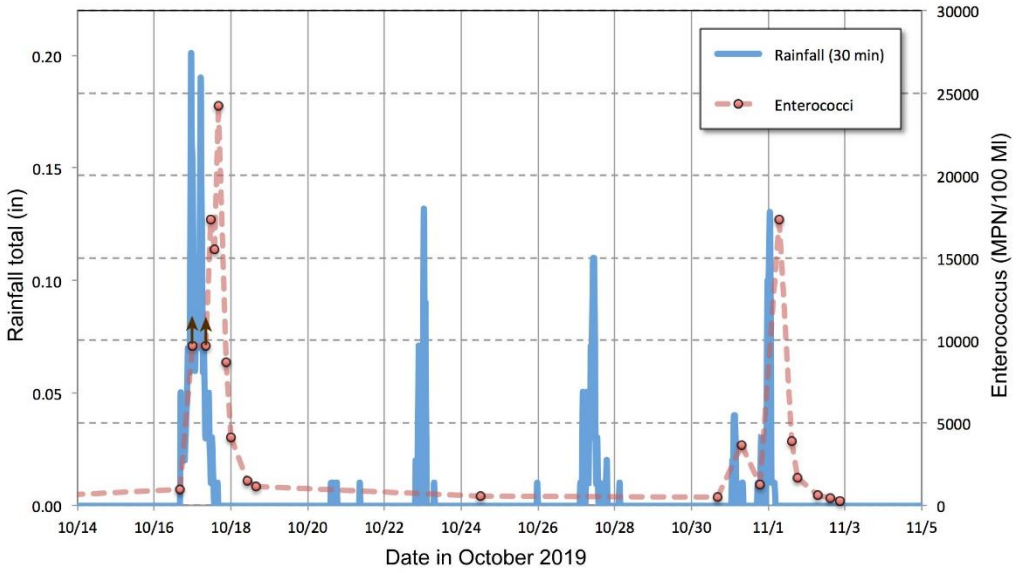

Figure 5: *Enterococci* sampling at HGK-2 during two rainfall events in October 2019. Samples with arrows are minimum values (sample saturated). Weather data from Union College Geology station. There is an apparent ~6 hr lag in rainfall versus *Enterococci* peak.

The Mohawk River was sampled 30 times from two sites above and below the outfall of the HGK. Site MR-1 is at the Union College Crew dock in the Stockade (up river) and site MR-2 is along the bank between Rivers Casino and Mohawk Harbor (below HGK outfall). In 2019, Riverkeeper and partners

(see Epstein et al., this volume) sampled the Mohawk River five times at Mohawk Harbor, which is geographically comparable to our site MR-2. Here we combine our measurements from below the HGK outfall with those of Riverkeeper and partners, so there are 10 measurements below the outfall, and 35 total. We measured the pathogens at the Union College Crew (MR-1) dock 24 times, and in midsummer removal of the dock resulted in some samples taken for the shore. None of the samples were saturated. The geometric mean of all 2019 Mohawk River samples in Schenectady is 51.5 MPN/100 mL (n=35). The geometric mean of the two sample sites were similar: 1) Crew dock MR-1: 53.06 (n=24); 2) Mohawk Harbor MR-2: 48.3 MPN/100 mL (n=11).

Discussion

The evidence for significant *Enterococci* contamination in the Hans Groot Kill is incontrovertible and suggests that raw sewage is entering the stream. Bacteria levels dramatically higher during rain events, indicating stormwater as a vehicle for transporting entrained sewage (Figure 5). In this drainage there are no CSOs, so overflow is not a cause of impariment. The sources of sewage in the HGK likely include both leaking sanitary sewer and stormwater pipes in close proximity to each other, or sanitary sewer pipes that were illegally connected to stormwater sewers, or both (pers. comm, January 2020, James R. Hart, Assistant Civil Engineer, City of Schenectady, NY). The high concentration of microplastic particles in the HGK documented during a 2018 rain event supports the hypothesis that sewage (a source of fibers) and stormwater both contribute to the pollution loads in the stream (Smith et al., 2020, this volume).

The HGK was once a natural stream with a topographically-determined watershed (Schoendorf, 2010). Residential development in the early 1900s led to the enclosure of the original HGK in the Sheridan Avenue stormwater main and the addition of the stormwater mains running beneath The Plaza and Rugby Avenue as sources of stream flow (Figure 6). Schenectady County maps of the stormwater system adjacent to the HGK suggests that some stormwater pipes outfall directly into the HGK, which is consistent with our observation of pipes in the channel wall (Figure 2). HGK-5 Pipe may be one such outfall; the high levels of *Enterococci* from this pipe suggest that it is also a sanitary sewer outfall.

Figure 5: Base map provided by Schenectady County, using SIM GIS, shows storm and sanitary sewer mains. Dashed black lines indicate the three major storm sewer mains that provide the source water for the Hans Groot Kill. Inset photo shows the outfalls for the three storm sewer mains (red arrow = Sheridan Avenue, brown arrow = The Plaza, purple arrow = Rugby Avenue).

Conclusions

Our research shows that the HGK, a direct tributary to the Mohawk River, is severely contaminated with the FIB *Enterococci* and that levels are highest during rainfall events and at the outfall of a pipe in the channel wall. The HGK is an example of an urban stream that is highly impaired due to inflow of stormwater and contaminants from the urban surroundings. The primary source of water in the HGK is outflow from three major stormwater mains; it is likely that the stormwater is contaminated by sewage from leaking and/or illegally-connected sanitary sewer mains. These findings highlight the role of infrastructure failures – both in design and maintenance – as a pollution source in the Mohawk Watershed.

The HGK presents a health hazard to the public, particularly given its presence on a college campus and a residential neighborhood. For the time being, signage should be placed amongst the frequented areas of the stream where people may wade or where children may play. This simple action may help to limit the number of people that could be adversely affected by exposure to *Enterococci* and other FIB in the HGK. A long-term solution is clearly needed, however. It would surely be in the best interest of the City of Schenectady and New York State to repair the pipes that are currently delivering bacteria-laden sewage to the HGK and the Mohawk River.

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Acknowledgements

Funding for IDEXX equipment and supplies provided by Union College Research Fund and the Geology Field Fund.