Mill Plaza Redevelopment and Relationship to College Brook

An assessment of existing system health and observations on possible future improvements

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The Existing Stream and Site Conditions

Mill Plaza is located in Durham, NH, off Mill Road (to the west) and adjacent to College Brook (to the south). The plaza is presently developed with two, multi-use commercial buildings and a large parking lot. The site was developed before the advent of present-day green stormwater infrastructure techniques or the concern about the effects of urbanization on streams and riparian corridors. Both the College Brook riparian corridor and Mill Plaza stormwater management are in poor condition, although the riparian corridor along the site is in better shape than much of the upstream reaches of the brook, especially where it traverses across the UNH campus.

Stream System

College Brook, to the south of the Mill Plaza property, has portions that are highly confined (insufficient floodplain width) and likely straightened over the course of recent history since urbanization started in Durham. By confining a stream (usually the floodplain), more flood waters are forced to flow in the main stream channel. This causes higher stresses on the streambed resulting in erosion of the sediments on the bed: a process known as incision whereby the streambed elevation lowers and the floodplain then becomes perched and inaccessible to floodwaters. Starting upstream and just off site for College Brook, by the Memorial Union Building on the UNH campus, the brook flows for approximately 600 feet though culverts and under a parking lot (Campus Crossing lot). The upstream drainage area is about 480 acres (as determined using StreamStats), of which an estimated 31.6% is impervious and 76.7% is developed (urban). Although UNH has been slowly retrofitting green stormwater infrastructure throughout campus, much of the campus impervious cover is unmanaged and drains directly to College Brook. The degree of watershed impervious cover is well above a 'healthy' effective impervious cover of 10% or less. Where the stream does flow open through the UNH campus it is highly encroached: insufficient floodplain was left for the brook. The watershed and brook characteristics upstream of Mill Plaza have a significant impact on the first few hundred feet of brook that flows by Mill Plaza. Commonly, the effects of urbanization with unmanaged stormwater runoff on a stream is incision and afterwards, when the streambanks get very steep, then stream widening (known as the urban stream syndrome). Incision in College Brook is evident where the brook first exits the culvert east of Mill Road, adjacent to the Mill Plaza site.

At the upstream end of College Brook at Mill Plaza, after being buried for 600 feet at UNH under the Campus Crossing lot, the stream daylights at the site and flows for approximately 1,150 feet (1,000 feet along the valley) as it passes by the Mill Plaza site. The first few hundred feet of Brook here are highly confined. After the first few hundred feet the brook corridor exhibits a large floodplain, although due to incision access of the floodwaters to that floodplain may be limited. The average riparian corridor width is 70 feet. The fill necessary to create the existing parking lot development at the Mill Plaza site created a steep bank that drops off to the riparian corridor below, which in several places has: riprap bank armoring, direct impervious surface runoff, and stormwater outfalls (the latter two to be discussed in the following section). To the south of the brook lies residential land use (multi-unit housing, mostly) where the vegetation is cleared and maintained for the first half of the corridor length (Picture A), then turning to over 100 feet of wooded buffer for the remaining downstream half (Pictures B and C).

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Picture A - Example of maintenance up to the stream

Picture B - Good example of riparian vegetation and buffer (in the distance)

Picture C - Taken from the stream June 20, 2018 depicting the heavy vegetation growth seen in most of the stream and above the banks

The stream was surveyed and was classified as a Rosgen F4 type. The collected cross sections did not exactly fit one select Rosgen Classification type very well, but overall – and based on professional judgement – the stream most well conformed to an F4 type stream. Properties of an F4 stream include: a low entrenchment ratio, moderate width to depth ratio, moderate sinuosity, and low streambed slopes. An F-Type stream is typically considered an impaired stream and very often associated with the urban stream syndrome. Shown in Table 1 are the results from the cross section surveys at the site. Note that the entrenchment ratio is quite high when averaged overall – especially compared to what is typically classified as an F-type stream. This is due to the relatively large floodplain width where the sections were taken, and the apparent ease with which the stream accesses it. Also out of character (on average) is the sinuosity; though calculated as 1.15 overall for the stream adjacent to the Mill Plaza property, that sinuosity value is due mostly to one very large, atypical meander bend in the stream. Looking at just upstream and downstream of that bend, and calculating the sinuosity, a value of 1.06 is likely more representative of the actual sinuosity for this entire stream reach. This is well below the typical 1.2 or greater sinuosity for F-type streams. But the slope and the width to depth ratio conform nicely to the F-type stream classification metrics. The slope was calculated to be quite slight, at around 0.37%, but this could be due in part to the amount of in-stream blockages (fallen trees, foot bridges) that may result in large steps at these locations, though none were observed to be acting as such. It may be that the stream is just very flat through here. Calculating the slope from the most recent flood insurance study base flood elevations (FIS BFEs), the slope was found to be about 0.29%, which conforms well to what was surveyed. A plot of the profile (thalweg and water surface elevation shots) for the surveyed part of the stream may be found in Figure 1. Also of note, and referring to Figure 2, the stream technically was classified based on the two pebble counts performed at the site as a gravel-bed stream, or channel material type 4. Though this is the actual rating based off the pebble counts, it is worthy to note that the amount of sand and gravel were very similar, so the stream could also likely be classified as an F5-type stream (a sand-bed stream).

Table 1. College Brook at Mill Plaza Surveyed Geomorphic Metrics

Property	Units	Average	Low	High
Avg Bankfull Depth	ft	1.08	0.46	1.70
Max Bankfull Depth	ft	1.56	0.79	2.48
Floodprone Depth	ft	3.12	1.58	4.96
Bankfull Width	ft	12.5	9.8	14.9
Floodprone Width	ft	41.8	13.0	75.0
W/D	-	11.5	8.8	21.5
ER	-	3.4	1.3	5.0
Sinuosity	-	1.06	1.06	1.15
Slope	ft/ft	0.0037	0.0027	0.0037
Sediment Classification	-	4	4	5
Rosgen Stream Classification	-	**F4**	C4c-	F4

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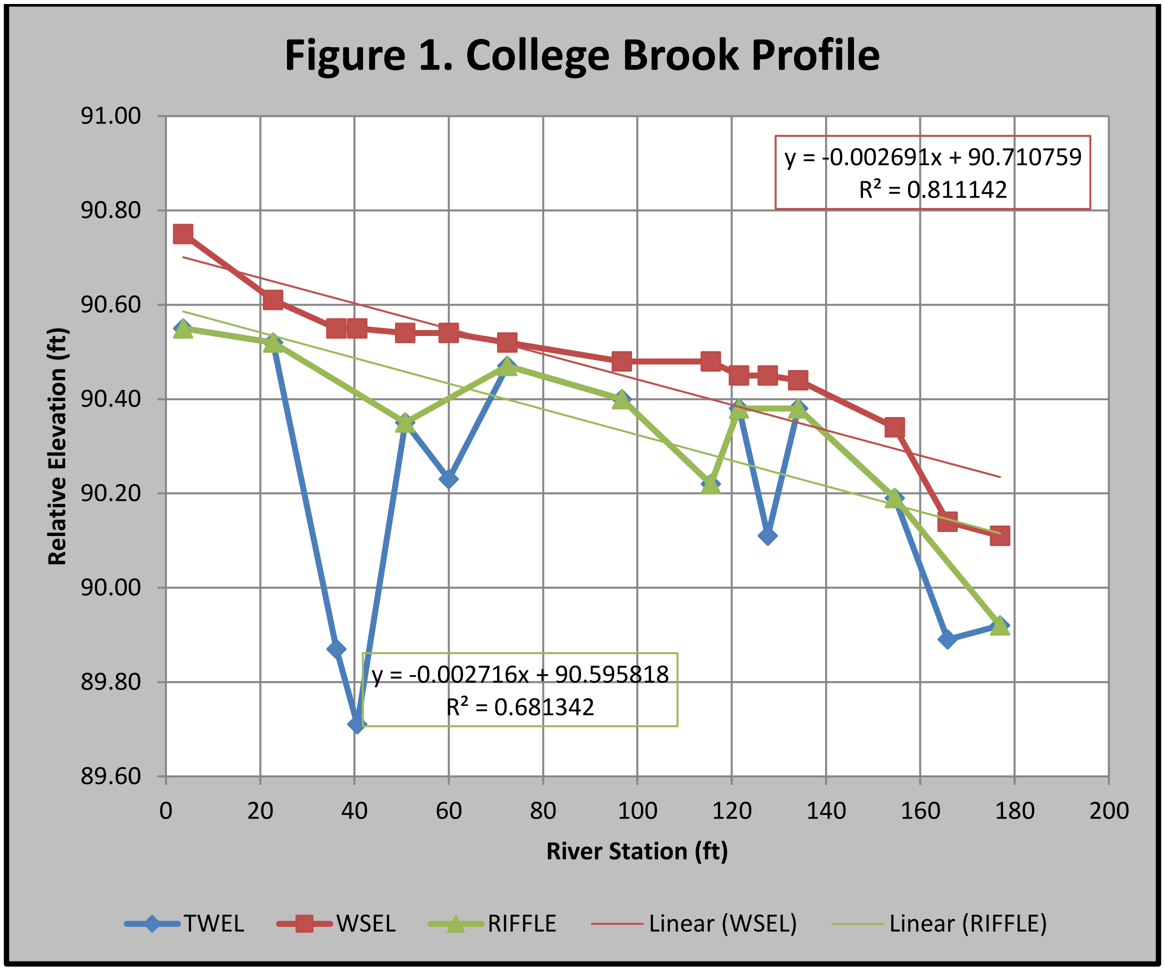

Figure 1. College Brook Profile
y = -0.002691x + 90.710759
R² = 0.811142
y = -0.002716x + 90.595818
R² = 0.681342
91.00
90.80
90.60
90.40
90.20
90.00
89.80
89.60
Relative Elevation (ft)
0 20 40 60 80 100 120 140 160 180 200
River Station (ft)
TWEL
WSEL
RIFFLE
Linear (WSEL)
Linear (RIFFLE)

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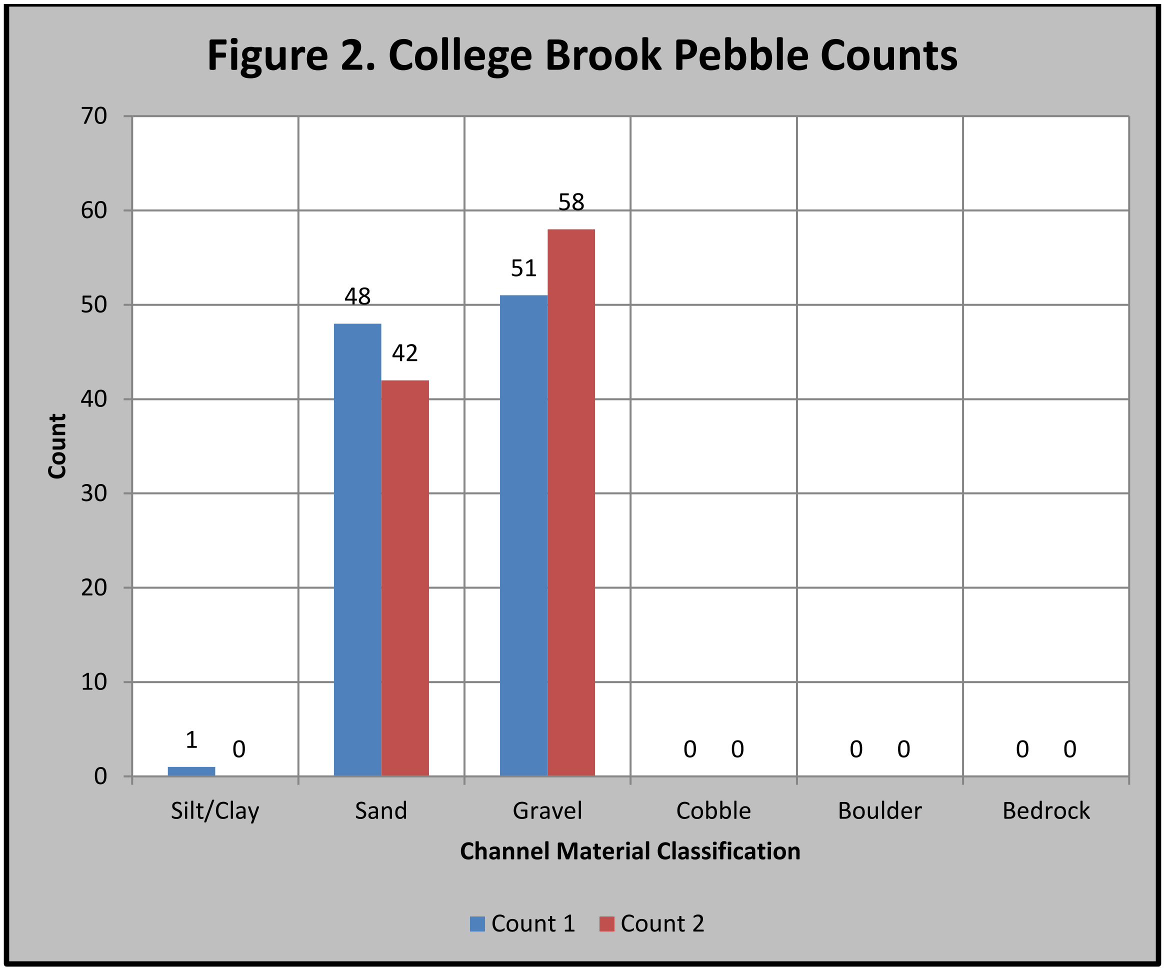

In an evolutionary context for streams, a stable stream may be moved to instability by various factors. In the case of College Brook, unmanaged stormwater runoff initiated incision which initially results in a G-type stream. As incision progresses, the stream banks become too steep and fail, thereby widening the stream (F stream type). This process continues until the stream stabilizes but at a lower elevation. The F classification for College Brook by Mill Plaza indicates that the stream has not yet stabilized its geometry.

Stormwater

The stormwater management at the site is typical of older commercial development: significant impervious surface, no stormwater retention or treatment, and direct outfall connection into the stream. The treatment of stormwater simply was not a concern in the past, and there is presently no stormwater management at the site other than directing runoff quickly to College Brook. The site property is approximately 10.3 acres, of which approximately 6.2 acres – or 60% – is impervious. The only real pervious land cover is the riparian corridor of the stream and a stand of trees and lawn to the east side of the property. A total of seven known stormwater outfalls from the site have been surveyed, and there are locations where runoff from the parking lot travels directly down the steep bank and into the stream (Pictures D and F). This location is also to where snow is plowed during the winter, and melts into the stream during the spring (Picture E). Thus, 100% of the current impervious area at the site is transported directly into the stream with no treatment. It should also be mentioned that although it was not investigated, that stormwater runoff from the south side of College Brook, across from Mill Plaza, is also unmanaged and also results in consequences to College Brook.

Picture D - Direct impervious cover runoff over steep bank and into riparian corridor

Picture E - Current snow management, pushing snow over the bank down into the riparian corridor. Notice the trees are bent and dying, from this practice.

Picture F - Steep bank instability resulting from direct impervious cover runoff over bank

Possible Post-Construction Stream and Stormwater Enhancements

There are a number of solutions possible at the site that would improve conditions in the stream corridor, and of the water quality for stormwater leaving the site.

Stream and Riparian Corridor Enhancements

The stream, as confined and impacted as it exists today, does not have much in the way of enhancement that needs to be performed to make it much better than its current status. The stream does have steep banks, but it also has more access to its floodplain compared to upstream of the site. Monitoring the rate of bank erosion would be a first step to determine if any bank erosion strategies are warranted. The entrenchment ratio is low, indicating that the stream is not confined in its valley. The average sinuosity is high, but only because of one very large meander bend in the stream. Remove this bend, and the sinuosity drops to around 1.06 – well below that of a healthy C stream. Where the brook exits the Mill Road culvert, it is confined and entrenched. Because of the lack of space to create floodplain here, stream restoration of the upper portion is very limited.

There is significant riparian vegetation in the floodplain, except at the locations that are maintained as lawns to the south of the stream. Removing invasive species and nuisance species (there are large stands of Japanese knotweed and some purple loosestrife, and likely to be other species, and removing them would set the stage for higher chances of success for native species), and then planting with native, riparian shrubs and trees would be an ecosystem improvement. In addition, designating a buffer zone (and allowing it to grow) would help stabilize the banks, and provide shade, habitat, and food value for the stream and riparian corridor ecosystem. The stream is mostly held in place by the dense vegetation growing alongside it; it is this reason that stream restoration construction does not seem to offer more benefit, except for adding sinuosity to the plan form. To perform such construction would be highly intrusive, and likely would result in more disturbance than is necessary. Being an F-type stream, the stream is in a mode of widening itself, which means bank erosion. But until the rate of bank erosion is determined, restoration is not recommended at this time. Removing all rip rap from the slopes and planting/seeding would prove most helpful to habitat value along the steep slope that exists on the property now (Picture G). Some locations of rip rap could be replaced with log vanes and plantings: a greener approach to the bank stabilization than rip rap. Planting at the top of the slope with shrubs and trees to provide a boundary between the parking lot and the stream would help to reduce trash entering the stream, and would provide shade and slope stability.

Picture G - Rip rap armoring on steep bank that was either placed in the stream, or has failed and fallen into the stream. Note the relative lack of vegetation here compared to other pictures of the stream and banks.

Additional measures that would help the stream system would be to: remove any unnatural in-stream blockages that cross the main channel (Picture H; fallen trees are okay, foot bridges are not); remove all trash and debris from the stream/floodplain (Picture I); and clear or remove all invasive species (Picture J). There are several locations where large trees have fallen and completely block the channel. In these locations, the stream is beginning to form slight avulsions in addition to eroding and over-widening the banks. These are natural occurrences, and as long as they do not affect infrastructure, may be left to evolve. There are also a handful of large debris items, such as metal culvert pipe, that has either been tossed into the stream or has failed and been carried into it (Picture I).

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Picture H - Existing foot bridge that is no longer in use (it is blocked off at both ends). Note that this structure was built almost in the stream, and the effects of it on the channel at this location are noticeable.

Picture I - Example of some of the trash that is in the stream and could be cleaned up. This section of CMP culvert was either tossed here or failed and was carried here, now half-buried.

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Picture J - Japanese knotweed, an invasive species, has grown a large and overwhelming stand to the west side of the property, north of the stream.

Above all, the most helpful items to address in order to help the stream and riparian corridor would be to address the unmanaged stormwater from the site. Both in terms of water quality and natural flow regimes, controlling and treating the stormwater runoff would result in dramatic improvements to the overall College Brook health.

Stormwater Improvements

Treating the 6+ acres of current impervious area, plus all the other runoff from the site would provide enormous water quality benefits. The seven current outfalls all carry water directly from the site into the stream. These should be removed from service, or be tied in to proposed stormwater treatment systems to the new development. Sprinkling treatment systems throughout the site may help in the winter time, as snow may be piled in the systems, which can treat the water as it melts.

Possible locations for stormwater treatment systems are all over the site. Bioretention systems may be placed in the medians throughout the parking lot. They may also be placed in a linear fashion along the south end of the proposed development, along the road and the steep bank down to the stream. Vegetated roofs could be utilized to reduce stormwater peak runoff and water temperature. Subsurface gravel storage could be installed almost anywhere in the parking lot, and could provide storage volume for peak flows. Minimizing the number of outfalls from the site into the stream corridor will also reduce the risk of one performing poorly and failing. However, the fewer outfalls, the larger the flows out of the remaining outfalls: therefore volume reduction should be an integral component of site stormwater management. Greener bank stabilization techniques and floodplain management should be included to reduce the impact of any such outfalls.