Memorandum

To:	Conner MacIver, Town Administrator
From:	Heidi Marshall, PE, Stephen Haas, PE and Jacob Sparkowich, PE
cc:	Marc Moreau, Road Agent
Date:	September 27, 2021
Re:	Overlook Circle Deficiencies

Hoyle, Tanner & Associates, Inc. has been retained by the Town of Barrington to evaluate whether the subgrade and pavement construction materials (and depths) used to construct Overlook Circle, a private road, matched the approved design plans, such that the Town has appropriate facts for the Town's use in determining whether to accept ownership of the road.

BACKGROUND

Overlook Circle is a private road serving a 20-house subdivision in Barrington, New Hampshire. Construction of the subdivision occurred over the span of several years. Most of the roadway construction, including preparation of subgrade, placing base and subbase layers, and paving the binder course, was started in fall 2015 and completed in spring 2016. The focus was then diverted away from the road while the houses within the subdivision were constructed from 2016 to 2019. Finally, the wearing course was paved in November of 2019.

DEFICIENCY EVALUATION

To determine the full scope of the pavement and subgrade deficiencies along Overlook Circle, Hoyle tanner retained the services of S.W. Cole (SWC) to collect boring samples and perform select testing. The boring locations were coordinated with the Town and can be seen on the figure included with the SWC document. SWC provided a letter summarizing their findings, which Hoyle Tanner then reviewed. As suspected, there are several deficiencies regarding the materials and depths.

The subbase material, per the approved plans, was to be a 12" lift of Gravel conforming to the NHDOT Specification for item 304.2. The base material was to be a 6" lift of Crushed Gravel conforming to the NHDOT specification for item 304.3. The SWC borings identify two distinct materials used for base and subbase. The subbase appears to be a bank run gravel (not crushed) with cobbles up to 5" in diameter, while the base also appears to be a bank run gravel (not crushed) with cobbles up to 1.5" in diameter. The subbase material from four of the boring locations was tested for conformance with NHDOT specification 304.2 and all four were found to meet the specification. The base material from four of the boring locations was tested for conformance with NHDOT Spec 304.3 and none were found to meet the

specification for two reasons. One, the material was not crushed and therefore did not have fractured, angular faces. Two, the material contained a higher percentage of fine material than the specification allows for. In addition, while all eight boring locations found a minimum 6" thickness of base material, there were two boring locations where the combined base and subbase depth was less than 18".

Similar to the base and subbase materials, there were several concerns with the pavement. The approved plans required a 2" binder course and a 1" wearing course. The binder course was paved over two operations, May 13th and June 16th of 2016. Reviewing the Field Reports of those days, the resident engineer (Engineer) reported there were sections of the road, totaling ~375 lf, where the compacted binder course was less than the 2" depth required. The Engineer's field report for the paving operation on May 13, 2016 noted there was lateral cracking in the binder course for a 50-foot length of the road the same day the pavement was placed. It was recommended by the Engineer that the depth and cracking be remedied prior to placement of wearing course; There is no documentation that these remedies were made.

The wearing course was placed on November 7, 2019; nearly 3.5 years after the binder course with construction vehicles utilizing the roadway during this time frame. Per NHDOT 2010 Standard Specifications for Road and Bridge Construction, a wearing course of 1" thickness should not be placed when surface temperatures are below 50 degrees. The same specification allows for surface temperatures as low as 40 degrees if the wearing course is 1.5" thick. There was discussion between the Engineer and the Contractor whether increasing the wearing course thickness for Overlook Circle to 1.5" would be acceptable once surface temperatures reached 40 degrees. The Engineer attests in the field report that the Contractor declined to increase the wearing course thickness and proceeded to place a 1" wearing course, regardless of the surface temperature. In an email chain from January of 2020 the Contractor contests that they did agree to the thicker wearing course placement and that additional pavement was placed due to the low surface temperatures. He further contests that his personal temperature gun which "is required to be calibrated", consistently read 6 to 7 degrees different than the Engineer's temperature gun, to the point the Contractor asserts there was no surface temperature below 40 degrees during the time asphalt was being placed.

The borings performed by SWC found that 6 of the 8 locations had less than 2" of binder depth, consistent with the remarks the Engineer made in the field report. In addition to measuring the depth, SWC also performed a test of the asphalt density relative to the Theoretical Maximum Specific Gravity (TMSG) at 4 of the locations. Although no specifications were cited in the approved plans for Overlook Circle, the industry standard is to achieve a density at least 92.0% of the TMSG, in line with NHDOT specifications. Of the 4 samples tested, 2 fell below the industry accepted 92.0%. These both coincided with locations that had less than 2" of binder asphalt.

It is unclear which depth the wearing course should have been, so the following evaluation references both. The SWC test of the wearing course found that all 8 locations had at least 1" of wearing course material, and 2 locations provided at least 1.5". The same density test was performed on the wearing course for 4 of the locations and only 1 was found to achieve the industry standard 92.0% of the TMSG. The SWC findings support the Engineer's field report as most locations were found to have less than 1.5"

of wearing course and the suspected cold surface temperatures would have made it difficult to achieve desirable compaction in the pavement surface, resulting in a sub-standard density. Lastly, looking at the combined pavement depth; though all 8 locations had the minimum 1" wearing course, there are 3 samples where the total depth of pavement (wearing plus binder) is less than the 3" required on the approved design plans.

POTENTIAL CONSEQUENCES OF DEFICIENCIES

The deficiencies noted above can be best summarized as insufficient structural strength and increased risk of deterioration from freeze-thaw cycles and vehicle loading, both of which contribute to a shortened life span for the road surface.

To provide a quantitative measure of the structural deficiency of Overlook Circle, a hypothetical pavement design was evaluated for the road as specified [1" Wearing, 2" Binder, 6" Crushed Gravel, 12" Bank Run gravel], and for the road as constructed which is best approximated as 1" Wearing, 1.75" Binder, 18" Bank Run Gravel. This hypothetical demonstrated the constructed road provides 10% less structural strength than the road specified in the approved plans. This lack of strength was further exacerbated during the nearly 3.5 years the road was used by construction vehicles with no wearing course and as little as 1.25" of binder. Following the same hypothetical, the constructed road with no wearing course provided just 75% of the structural strength of the approved road. Additionally, these hypotheticals only consider material thickness and do not factor in the reduced strength of the asphalt evidenced by the sub-standard density results. With insufficient strength, the pavement and base layers should be expected to deteriorate at a faster-than-usual rate with increased risk for rutting, cracking, and eventually complete pavement failure.

The increased susceptibility to deterioration from frost damage and vehicle loading is less quantifiable but is still significant. Starting with the base material, the lack of a crushed material with angular faces leads to pavement deformation and a condition known as cobble heave. What happens in cobble heave is the base layer flexes as it is loaded and as it returns to the unflexed position there is a tendency for smaller particles to fill voids first which prevents the larger cobbles from returning to the original position. Over the millions of loading cycles the road experiences in its lifetime the cobble continues to rise through the layer and eventually can surface through the pavement. This condition is far less prevalent with a crushed material as the angular faces allow the material to lock together, distributing the load more evenly and limiting pavement deformation and restricting the upward movement of large cobbles which is part of why the *AASHTO Guide for Design of Pavement Structures* notes the base course usually consists of crushed stone, crushed slag, crushed gravel and sand, or a combination of these materials. Also contributing to deterioration, the poor compaction of the asphalt layers leave the road more susceptible to frost damage. With sub-standard compaction, more water is able to infiltrate the asphalt which when it freezes, expands and can dislodge the aggregate within the pavement, slowly breaking down the surface.

OPTIONS FOR REMEDIATION

There are several options that could be used to provide varying levels of mitigation for the deficiencies. The most intensive and expensive option would be complete reconstruction of the base, binder, and wearing layers to fully comply with the depths and materials specified. This would entail excavating the existing pavement and part or all of the existing base layer, then placing the required 6" of crushed gravel, conforming to NHDOT item 304.3, and placing the 2" of binder pavement and 1" of wearing course pavement within acceptable temperature ranges. This option, while intensive in effort, fully eliminates both the structural strength, pavement deformation and cobble heave, and frost-susceptibility deficiencies and can be completed without changing the elevation of the road.

An option with an intermediate level of expense would be to reclaim the existing road, then compact and repave. As the existing base layer was not constructed with crushed aggregate, it would be recommended that if this option were pursued additional crushed stone must be introduced to the reclaimer during the reclaim process such that the resulting material is closer to conforming with NDHOT item 304.3. A 50/50 mix of pavement and underlying base material is the typical goal for NHDOT, so an approximate 6"-8" reclaim depth would be anticipated based on the measured pavement depths. With the reclaiming complete, new pavement could be placed as described above. This option would be expected to fully resolve all deficiencies so long as enough crushed material is introduced during the reclaim process. A downside of this option is that finished grade of the road would likely end up needing to be raised by several inches, affecting driveway matches to the road surface, requiring cooperation from abutters to smooth the matches. If this is not feasible, once reclaimed, additional excavation could be performed to lower the finished grade prior to paving. Once reclaimed, the reclaimed material would be evaluated to determine the magnitude of additives (such as crushed material or liquid asphalt) recommended to result in a durable base surface. A conceptual level estimate of the reclaim treatment, including crushed stone and liquid asphalt additives, results in a cost of $315,000 to repair the entire road, which works out to roughly $38 dollars per square yard.

The third, and most economical option is to not reconstruct or reclaim the road but to apply a pavement overlay to build up strength. The overlay could be completed with or without geotextile stabilization fabric and there are pros and cons to each. Placing geotextile between the existing pavement and the overlay will provide more strength than an overlay without the fabric, reducing the risk that cracks in the existing pavement will propagate into the overlay. Geotextile is also used to reducing the width of cracks that may reflect through to the new wearing surface. On the other hand, the presence of fabric means that any milling or reclaiming of the road in the future would be more complicated. This option does result in the grade of the road being raised by the thickness of the overlay which will require coordination with affected driveways to ensure a smooth match is achieved. This option has an estimated cost of approximately $24 dollars per square yard, resulting in a cost of approximately $200,000 to provide a reinforced overlay on the entire road. While it is the most economical option of the three, the overlay and paving fabric would not be expected to have the same longevity as the full reconstruction options.

SUMMARY

The evaluation of Overlook Circle has found several deficiencies and deviations from the design plans present in the roadway which reduce structural strength and may result in increased deterioration due to pavement deformation, cobble heave and frost susceptibility. Deficiencies may contribute to a shorter pavement lifespan and increased threat of property damage and/or injury to drivers. Several options are available to lessen or potentially fully mitigate the existing deficiencies including total reconstruction, reclaim and pave, or overlay with or without geotextile fabric.