



Final Report
2019 Unpaved Roads Study

Prepared by the Asset Management and Maintenance Staff of SEPI, Inc.
for the City of Durham, Department of Public Works
(Contract ST-292)

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SECTION 1 – EXECUTIVE SUMMARY

The City of Durham selected SEPI, Inc. to update the 2010 City of Durham Unpaved Roads Study by Kimley-Horn and Associates, Inc., develop a range of cost estimates for various paving methodologies, create a metric to prioritize construction of the unpaved roads, and create a unified Unpaved Roads Asset Management Plan for the City.

SEPI verified and updated the existing inventory's road conditions data by a field investigation of each road. The data is formatted in a GIS database that the city can continue to update as future surveys are done.

SEPI decided upon three base options and three paving options that apply to the unpaved roads. Costs for the different options were developed based on historic data, experience, and past projects. The paving costs were applied to the roads in the study and a database containing all the road and cost data was created.

SEPI developed a list of attributes to use in prioritizing the unpaved roads. The prioritization method is objective and aims to prioritize roads that are more heavily travelled than others. A point system was applied to the roads and roads were ranked from highest to least priority. SEPI recommends that the roads in the study be paved with a light duty pavement over a conditioned existing base. Plant mix is not the cheapest option but will provide a balance of longevity and cost, while providing a smooth surface for users to drive on.

Three expenditure plans were created for the City of Durham to determine when to pave the roads and the cost of construction. Two of the plans are spread over 10-year periods, and a cheaper option, using AST mat and double seal was developed to pave all the roads in five years.

Expenditure plan Options A and B were based on the prioritized list of roads and Option C is based on spreading construction costs as evenly as possible over the five PAC districts in Durham.

SEPI recommends that the City follow Option A, which paves roads based on the point system that was developed to prioritize roads. This plan paves the most used roads first and leaves the relatively unused roads for last.

Finally, the ranking system will provide the Department of Public Works with a valuable tool to confidently prioritize capital expenditures for paving the roads. The Department of Public works is further facilitated by the inclusion of a GIS interface with the ranking system, including maps and a dashboard, compatible with the city's current GIS platform. The GIS interface is designed to be user friendly and easy to manipulate as goals, budgets, and developmental priorities change. The GIS interface is also easily adaptable to prioritizing expenditures in each of the five PAC Districts or across the City as a whole.

SECTION 2 – INTRODUCTION

2.1 PROJECT BACKGROUND AND DESCRIPTION

The City of Durham maintains over one hundred seventy-nine (179) unpaved roads. The 19.65 miles of unpaved roads are located throughout the city limits and many of them are within a 5-mile radius of downtown Durham. The unpaved roads are primarily used for residential access; however, some are used for commercial access or shortcuts to other roads. In 2010, Kimley-Horn completed a study of the City's unpaved roads in preparation for making potential federal stimulus funding requests. Kimley-Horn developed two funding approaches. The first approach was to address paving all the unpaved roads in 2009, should federal stimulus funding become available to the City of Durham. The second approach was to devise five- and ten-year plans to pave all the unpaved roads if federal stimulus funding did not become available. The City did not receive federal stimulus funding for their unpaved roads nor has the City established a funding mechanism to pave these roads since 2009.

Recognizing the need to develop a formal strategy to support a funding request for the paving of the City's unpaved roads, the City of Durham solicited the services of an engineering firm to "update the City's current Unpaved Road Study, incorporating the information into a new asset management plan for these unpaved roads, and present the information to City Council." As a result of this solicitation, the City of Durham selected and formally contracted with SEPI Engineering and Construction in November 2018 to review, update, and build on the 2010 Kimley-Horn Unpaved Roads Study. SEPI's scope of services included the following tasks:

1. Update 2010 Unpaved Road inventory, condition ratings and estimated paving cost data prepared by Kimley-Horn and Associates, Inc. in 2010.
2. Develop a weighted system to prioritize construction (paving) of the unpaved roads
3. Develop a unified Unpaved Roads Asset Management Plan for the City to include an expenditure plan for paving the unpaved roads that is sensitive to the City of Durham PAC Districts
4. Develop a file or layer to show unpaved roads and the associated attributes (length, cost, priority, etc.).
5. Presentation at City Council Work Session to inform of current conditions and various funding scenarios to accomplish future paving

This report details SEPI's approach, key findings, recommendations and includes the unified Unpaved Roads Asset Management Plan for the City.

2.2 Methodology

SEPI approaches each project with the Stephen Covey principle of **“Begin with the end in Mind.”** To that end, the SEPI Engineering and Construction staff met with the City of Durham project team on June 8, 2018 to review the scope of services included in the RFQ and to solicit input from the City on project specific information that would aid in delivering a successful study. SEPI developed a project approach based on the following guidance received from City staff:

- Report should provide additional detailed information to enable City Staff to prioritize and easily manipulate the data that agrees with the goals of the department, budget, economic development, business impacts, residential impacts, traffic, and purpose.
- The expenditure plan should include maintenance recommendations and various levels of cost estimates for various paving methodologies that are evenly distributed across the 5 PAC Districts for each year.
- Develop system that works with the current City GIS program and create a system including maps and a dashboard that easily communicates with your existing GIS Platform.
- Include non-traditional paving options in paving methodologies
- Pave on existing “footprint” (no typical section expansion)
- No additional right of way or utility relocations should be considered.
- Lots of data included in Kimley-Horn database so City not expecting a field re-evaluation of every road
- Include Yorkshire Drive and Freemont Road which were not included in 2010 Study

Using the City’s guidance as a backdrop, the SEPI Team utilized a combination of tools to accomplish this project. These tools included a review and analysis of the 2010 Kimley-Horn Unpaved Road Study Report and database, staff brainstorming and collaboration sessions, field investigations for data validation and data gathering, and development and deployment of GIS applications. The information gathered and tools developed were utilized to create this report and the requested Unpaved Road Asset Management Plan.

SECTION 3 – UPDATE OF THE 2010 KIMLEY-HORN STUDY

3.1 Update Road Inventory Data and Attributes

SEPI staff thoroughly reviewed all documents, files, and data available from the 2010 Kimley-Horn study. This included a page by page review of all the 179 individual road reports. Data from the previous study, contained in a Microsoft Access database, was converted to GIS. Yorkshire Drive and Freemont Road were not included in the previous study but were added to the current study as requested by the City. Therefore, subgrade testing of Yorkshire and Freemont was completed to determine subgrade conditions. See Appendix C for the testing data completed by Trimat Material Services & Testing Inc.

Staff developed a draft list of twenty (20) attributes. Forty-one (41) roads were then evaluated in the field by SEPI Staff, pursuant to the draft attribute list, with comments. The primary purpose of this field review was to assess current conditions compared to those noted in the previous study. The list of roads inspected was comprised of 20 roads that were selected at random, the two roads or segments (Freemont and Yorkshire) which had been added to the study, South Briggs Avenue which had been particularly mentioned as a priority in early meetings with the City of Durham, six roads which were chosen due to issues noted in the data from the previous report, and 12 roads which were encountered while in the field. Two hundred forty (240) Photographs were taken as part of this initial field review.

3.2 Road Condition Overview

As part of SEPI's due diligence, the SEPI team visited a select number of roads as indicated in the previous section of this report. In general, the findings of this visit were that conditions do not appear to have changed distinctly from the time of the previous study. The roads generally appear to be about the same or in somewhat better condition now due to the maintenance efforts of the Public Works staff. Other notable observations of the SEPI team include:

- The roads were low volume in nature.
- Most roads were dead end roads.
- Very few, if any, of the dead-end roads have adequate turnarounds.
- The roads are principally residential, with many serving only single-family dwellings.
- Many of the roads are quite narrow.
- Many roads appear as private driveways for a single home or shared private driveways.
- Bellevue, Scoggins, Willard, a portion of Jester, and a portion of Brunson were in very poor condition due to minimal use.
- Bellevue, King, Brunson, and Amanda had a barrier (cable, gate, objects) installed to prevent passage on all or part.
- Very few of the roads, among those that are not dead end, provide any meaningful connectivity.

- In general, with the rare exceptions already noted, the roads were found to be in good condition (ample stone, stable, only minor drainage issues).

The overall condition summary was that a significant number of the roads visited or reviewed in the database appear stable and have adequate stone such that they could simply have their existing stone base conditioned and be paved. Some would be improved dramatically, by up-front maintenance on the drainage and by performing right of way mowing with a long arm mower. (Such conditions were noted as part of the data gathering, are part of the database, and are accessible through the ArcGIS application.)

South Briggs Avenue

South Briggs Avenue is an exception among the roads reviewed. It is not particularly long at 585 feet and is a dead-end road. At the dead-end there is a scrap metal and recycling business with a heavy volume of large (tandem axle or larger) truck traffic. South Briggs is very rough and potholed but still stable. It is likely that South Briggs Avenue is currently and will continue to be a regular maintenance problem until paved.

SECTION 4 – PAVING METHODOLOGIES

4.1 Pavement Treatment Options

Paving an unpaved road requires choosing a base option and a pavement option. SEPI Staff worked with the City of Durham Public Works Department Staff to determine that there were three different base options and three different pavement options applicable for the roads in the study. The selected base options for the roads in the study were conditioning the existing base and two different applications of cement stabilized base. The selected pavement types considered to be applicable are Asphalt Surface Treatment (AST) and two different plant mixes. SEPI Staff arrived at three pavement thicknesses applicable to the roads in the study: Asphalt Surface Treatment mat and double seal (AST), 2" Light Duty Plant Mix (SF9.5A), and 4.75" Heavy Duty Plant Mix (3" Base Course SF9.5B and 1¾" Surface Course SF9.5A). The three pavement types are each applicable to three base preparation options for a total of nine pavement designs. A discussion of the various base and pavement options follows.

Conditioning the existing base is the simplest and most economical base option. In this operation, one or more motor graders, water trucks, and rollers shape and compact the existing stone base of the road. This method would also require relatively little interruption of traffic. Conditioning the existing base is only applicable to roads which are currently stable and are supporting current traffic without issues of tracking, rutting, or muddiness. Spotty, isolated areas of instability can be dealt with by application of aggregate base course to those areas as part of the operation of conditioning the base. Conditioning existing base is the least disruptive to traffic of the three base options.

Cement stabilized base involves mixing the existing base with Portland Cement and moisture, then plowing, shaping, watering, and compacting (much like the shaping, watering, and compacting required for conditioning the existing base) to create a strong base for pavement. Cement stabilized base costs significantly more than conditioning the existing base and is most applicable when dealing with very difficult soil conditions while trying to achieve stability in the base. The roads in the study do not have poor soil conditions. Depending on the method and conditions, cement stabilized base requires one to several days to cure before paving operations can begin. Traffic cannot be on the prepared base during the curing period, so cement stabilization introduces a significant inconvenience to the public when compared to conditioning the existing base.

The three methods selected for constructing cement stabilized base are dry application and two wet applications. For the dry application a Portland cement powder is applied directly to the surface and plowed in. The first wet application is performed like the dry application, but rather than applying a cement powder, a cement slurry is applied and plowed in. The more complex wet application consists of milling the existing road base into a machine, mixing with a cement slurry, and then spreading back in place behind the machine. All three cement stabilized application methods require specialized equipment. The price for any of the methods can be sharply influenced by local availability of such specialized equipment. Additionally, dry application can lead to very difficult dust control issues.

Asphalt Surface Treatment mat and double seal (AST) is a paving method that consists of one or more layers made up of mineral aggregate spread over an application of liquid asphalt and compacted with a motorized roller. Typically, one to three layers are applied depending on the exact situation and requirements. As with plant mix, AST is applied to a prepared surface – typically compacted aggregate – that is shaped to the required contours for the finished paved surface. This method is also commonly referred to as Bituminous Surface Treatment (BST), seal coat, or chip seal. AST is only properly applicable to low volume roads with light duty traffic but can be a very cost-effective solution when properly applied. It is relatively noisy to drive on compared to plant mix or other common paving options and may require somewhat higher levels of maintenance in the first year or two after paving. The price of AST can vary widely depending on local market conditions. In areas where the local market conditions push the cost of AST paving higher, plant mix should be carefully considered since its advantages might easily outweigh any narrow cost differential. In these areas, alternate bids for plant mix and AST may also be advisable in contracts for paving low volume roads.

Photo of AST



Plant Mix Asphalt is a paving method that consists of sand and stone aggregate bound by asphalt cement. The asphalt cement is heated to over 300 degrees Fahrenheit in an asphalt plant, mixed with the aggregate, and delivered to the jobsite on trucks. One or more layers may be applied using a specialized paving machine to spread the layers. Each layer is compacted using motorized rollers. As with any paving method, plant mix paving is applied to a prepared surface – typically compacted aggregate – that is shaped to the required contours for the finished paved surface. This method is also commonly referred to as hot mix or black top. Plant mix paving is among the most common methods for paving and is applicable to the harshest conditions. Plant mix paving usually produces a smooth surface that gives good ride quality, less road noise, and longer service life than AST. The better qualities of plant mix may be overshadowed by its cost when compared to AST. Plant mix asphalt can handle traffic on the same day as being paved and causes minimal traffic disruption.

Photo of Plant Mix



4.2 Cost Estimations

SEPI Staff used multiple resources including numerous subject matter experts, recent comparable bids, tabulated historic bid data, a previous unpaved road study, and the data from the 2010 Kimley-Horn study to estimate the cost of paving the subject roads. SEPI Staff made a focused effort to search for smaller paving project cost data, including cost data for paving residential driveways with plant mix pavement. (No such data was available for AST pavements. Staff was only able to find historic data on AST paving from relatively large-scale resurfacing projects.) This was done in effort to prevent the cost estimates from being skewed low from large projects with relatively low costs of mobilization.

SEPI Staff developed spreadsheets to estimate the cost for each of the three base and three paving options. SEPI used the length and width data from previous construction projects and historic data to a total cost to a per square yard, as requested by the City of Durham. Appendices A through I show the square yard cost calculations. Appendix B shows typical sections for each of the paving options. Below are the estimated costs per square yard for each of the nine base and paving combinations.

Pavement Structure	Estimated Cost per SY*
Condition Existing Base with AST Mat and Double Seal	\$23.00
Condition Existing Base with 2" Plant Mix Surface Course	\$28.00
Condition Existing Base with 3" Plant Mix Base Course with 1¾" Surface Course	\$43.00
Full Depth Rehab and Cement Stabilization (Dry Application) with AST Mat and Double Seal	\$35.00
Full Depth Rehab and Cement Stabilization (Dry Application) with 2" Plant Mix Surface Course	\$40.00
Full Depth Rehab and Cement Stabilization (Dry Application) with 3" Plant Mix Base Course with 1¾" Surface Course	\$54.00
Full Depth Rehab and Cement Stabilization (Wet Application) with AST Mat and Double Seal	\$38.00
Full Depth Rehab and Cement Stabilization (Wet Application) with 2" Plant Mix Surface Course	\$43.00
Full Depth Rehab and Cement Stabilization (Wet Application) with 3" Plant Mix Base Course with 1¾" Surface Course	\$57.00

*Cost Estimates provided by City of Durham

SEPI staff identified construction costs beyond the base and pavement costs that needed to be considered. Additional costs were calculated for potential road widening on the existing road bed width (in the cases where extra shoulder width was available for paving), the cost of pipe repair where a need was noted in the field survey, the cost of ditch cleaning where noted, the cost of constructing a turn-around on dead end roads, the cost of adjusting water valve boxes, the cost of adjusting sanitary sewer manholes, the cost of tying in driveways, and the cost of constructing shoulders. The cost associated with each of these activities are:

Construction Item	Cost
Turn-Around	\$5,500
Water Valve Box Adjustment	\$1,000/valve
SS Manhole Adjustment	\$1,000/manhole
Driveway Tie-in	\$125/Facility

These costs were developed from the same resources that helped estimate the costs of base and pavement options. All these costs were totaled to arrive at the construction cost estimate for each road.

4.3 Recommendations

SEPI recommends that Durham choose condition existing base as the base option and use a 2" plant mix surface course on all the roads except for Briggs Avenue. We recommend that Briggs Avenue is paved with 3" Plant Mix Base Course with 1¾" Surface Course due to the higher mix of truck traffic.

SEPI recommends conditioning the existing base rather than using a cement stabilized base because it is less disruptive to the flow of traffic and costs significantly less. As mentioned in the 2010 report, the cost to mobilize cement stabilization equipment is high and is not practical for the number of small roads that are in the study. The existing roadbeds are stable and fully capable of carrying the existing traffic. They do not need the added strength of a cement stabilized base.

SEPI recommends using plant mix rather than AST for a few reasons. While AST appears to be the cheapest option based on publicly available data, the cost of using AST may be three to four times higher for small projects, such as the roads in the study. Additionally, our experience is that contractors may not bid on a package of AST projects, so it may not be a practical option if the City cannot find a contractor to apply this type of pavement for a reasonable cost. Finally, plant mix will provide a better experience for citizens and maintenance costs will be lower compared to AST.

SECTION 5 – UNPAVED ROAD PRIORITIZATION SYSTEM

5.1 Prioritization Inputs

SEPI staff drew heavily on their experience in roadway maintenance and municipal operations and developed a list of attributes to use in prioritizing the unpaved roads. A total of 31 different attributes were considered. Staff also researched different prioritization formulae for rating systems of unpaved roads. The data currently available, along with the requirements and restraints of the data gathering phase, were also carefully considered. Two formulae that drew particular attention was one used by Cole County, Missouri and the formula used by the North Carolina Department of Transportation in their Secondary Roads Program. The NCDOT formula is one that several members of the SEPI project team had first-hand experience using. The NCDOT formula was known to be relatively simple, effective, and had withstood extensive trial by use.

The SEPI project team concluded that there were three areas of emphasis for the design of the unpaved roads prioritization protocol. The first was on developing a system that would be straightforward and effective. The second, a system with a strong correlation between the points value and the number of people served by the road daily. The third, a system that would be completely objective.

SEPI Staff focused on an objective prioritization for a few key reasons. An objective system is free of judgement calls or decisions in the rating process – to rate a road one simply counts and notes yes or no. An objective system is highly defensible – an individual or community group that is unhappy with the relative position of the road in the overall ratings may call the system into question, but not the objective count that led to the point total for the road. Additionally, when the need for rerating the roads arises, the rerating might easily be done from the office and might even be automated by interfacing with GIS data from building permits, business licenses, etc.

5.2 Prioritization Scoring System

SEPI developed the following inputs and associated points:

- Any Single-Family Residence – 10 Points
- School – 20 Points
- Daycare – 20 Points
- Any Church or Place of Worship – 15 Points
- Any Retail Business – 15 Points
- Warehouse – 5 Points
- Manufacturing Facility – 10 points
- Utility Facilities – 5 Points
- Any Recreational Facility – 10 Points
- Pavement to Pavement Connectivity, including connectivity to roads in this study – 15 Points

Any homes or other facilities that had at least one driveway connection to the road would be counted. In the case of multi-family housing, (duplexes, triplexes, apartment buildings) each individual unit is counted. A road that provides access to a utility facility (a pump station, transmission line, power substation, communications tower, etc.) would get five points for each such facility served. 15 points is given to any road that has connectivity on each end to either existing paved streets or unpaved streets included in this study. Dead-end roads that have other dead-end roads branching off would get the facilities counted for both dead end roads since both roads are necessary to access to the facility.

5.3 Unpaved Road Priorities

Road Name		PAC	Cost	Points
Dacian	Ave	2	\$ 43,527.78	345
Rome	Ave	3	\$ 53,108.06	220
Rosetta	Dr	3	\$ 44,084.78	215
Macon (2)	St	4	\$ 62,429.18	195
Ashley	St	2	\$ 56,822.96	185
Leonard	Dr	2	\$ 108,233.06	170
Evergreen (2)	St	2	\$ 24,200.97	165
Dunn	Ave	1	\$ 79,787.11	160
Lombard	Ave	1	\$ 78,512.22	160
Crabtree	Ave	4	\$ 115,382.22	150
C View	St	2	\$ 71,141.11	145
Lynch	St	2	\$ 29,429.71	140
Laymans Chapel	Rd	4	\$ 66,138.80	135
Bunn	Terr	3	\$ 75,884.80	130
Enfield	Dr	2	\$ 124,622.98	130
Lamar	St	1	\$ 42,351.56	130
Lang	St	2	\$ 78,544.44	130
Evergreen	St	2	\$ 83,958.96	125
Harper	Pl	3	\$ 41,103.85	125
Nancy Rhodes	Dr	1	\$ 122,522.65	120
Winburn	Ave	3	\$ 55,472.49	115
Hursey	St	2	\$ 107,243.86	110
Azalea	Ave	1	\$ 143,599.55	105
Shepherd	St	1	\$ 35,600.49	105
Wortham	St	2	\$ 33,222.89	105
Ellerbee (3)	St	2	\$ 35,031.27	100
Reese	Rd	4	\$ 66,931.65	100
Wallace	St	2	\$ 45,197.78	95
Ardmore	Dr	3	\$ 185,647.30	90
Locust	Dr	2	\$ 45,807.80	90
Post	Ave	2	\$ 66,022.65	90
Brooks	Rd	4	\$ 85,526.26	85
Amber	Pl	1	\$ 29,571.21	80
Arrowhead	Dr	2	\$ 51,128.83	80
Bradford	Cir	2	\$ 25,111.11	80
Cassandra	Dr	2	\$ 86,081.94	80
Chalmers	St	3	\$ 50,421.44	80
Freemont	Rd	1	\$ 60,792.85	80
Hill	St	1	\$ 94,477.65	80
Hunter	St	3	\$ 36,931.84	80
Mayo	St	2	\$ 80,441.38	80
Plum	St	2	\$ 42,932.43	80
Southgate	St	4	\$ 39,563.46	80
Brunson	St	1	\$ 46,825.00	75

Concord	St	2	\$ 22,117.82	75
Fenimore	St	1	\$ 50,318.60	75
Parthenia	Dr	4	\$ 97,758.96	75
Rand	St	3	\$ 38,462.13	75
Rex	St	2	\$ 13,496.51	75
Willa	Way	3	\$ 61,649.36	75
Isenhour	St	1	\$ 72,657.01	70
Overland	Dr	2	\$ 30,430.43	70
Bay	St	1	\$ 18,334.41	65
Byrd	Rd	1	\$ 130,792.37	65
Carroll	St	1	\$ 22,934.54	65
Lawson	St	4	\$ 32,793.25	65
Ponderosa	Ln	2	\$ 64,759.90	65
Rosedale	Ave	3	\$ 39,187.73	65
Wisteria	Ave	1	\$ 24,497.19	65
Barenwood	Cir	2	\$ 49,606.35	60
Fleming	Dr	1	\$ 65,756.34	60
Linden	Ter	2	\$ 31,806.56	60
McLaurin	Ave	1	\$ 91,227.36	60
Methodist	St	4	\$ 54,625.84	60
Pamlico	St	1	\$ 23,678.89	60
Ripley	St	3	\$ 16,328.71	60
Sovereign	St	1	\$ 41,903.54	60
Usher (2)	St	4	\$ 43,647.74	60
Cathy	Dr	2	\$ 66,382.28	55
Drake (2)	Ave	2	\$ 41,438.88	55
Englewood	Ave	4	\$ 29,847.15	55
Gordon	St	2	\$ 31,270.44	55
Powe	St	1	\$ 37,655.59	55
Verdun	St	2	\$ 21,687.95	55
Alcona	Ave	1	\$ 28,841.20	50
Bonhill	Dr	3	\$ 37,639.64	50
Dezern	Pl	3	\$ 15,419.11	50
Knox	St	1	\$ 25,759.14	50
Macon	St	4	\$ 42,439.36	50
Piper	St	2	\$ 18,556.28	50
Turner	St	1	\$ 47,969.69	50
Bruton	Rd	4	\$ 84,819.27	45
Buchanan	Dr	3	\$ 55,024.36	45
Cassandra (2)	Dr	2	\$ 44,152.68	45
Cedar	St	1	\$ 41,350.11	45
Edgar	St	2	\$ 31,779.44	45
Kate	St	4	\$ 28,749.23	45
Pepperidge	St	2	\$ 38,248.28	45
Banner	St	4	\$ 48,118.92	40
Benjamine	St	2	\$ 48,373.23	40
Briggs	Ave	4	\$ 63,719.34	40

Charleston	Dr	4	\$ 24,498.74	40
Devon	Rd	2	\$ 45,492.28	40
Dominion	St	2	\$ 38,884.03	40
Dominion (2)	St	2	\$ 61,731.38	40
Drake (3)	Ave	2	\$ 23,410.06	40
Indiana	Ave	1	\$ 25,860.78	40
Jester	Rd	4	\$ 75,079.65	40
Linfield	Dr	3	\$ 19,427.30	40
Lynley	Rd	2	\$ 30,212.00	40
Myers	St	4	\$ 37,678.41	40
Peace	St	3	\$ 20,107.44	40
Pershing	St	2	\$ 19,113.93	40
Rowena	Ave	2	\$ 46,799.91	40
Taft	St	2	\$ 32,377.13	40
Ward	St	3	\$ 20,304.89	40
Westcrest	Dr	3	\$ 41,519.86	40
Winburn (2)	Ave	3	\$ 47,926.22	40
Wofford	Rd	2	\$ 32,738.67	40
Yorkshire	Dr	2	\$ 33,790.80	40
Delano	St	2	\$ 19,739.33	35
Virginia	Ave	2	\$ 16,778.95	35
Biscayne	Rd	2	\$ 34,782.85	30
Craven	St	1	\$ 27,124.00	30
Drewry	St	1	\$ 43,696.86	30
Easley	St	1	\$ 46,753.17	30
Felix	St	1	\$ 90,535.98	30
Fountain	St	2	\$ 27,964.43	30
Neff	St	2	\$ 38,893.61	30
Perennial	Dr	3	\$ 11,804.18	30
Pettigrew	St	2	\$ 32,749.97	30
Red Oak	Ave	2	\$ 34,218.80	30
Rockway	St	3	\$ 90,944.17	30
Whitfield	Rd	3	\$ 33,538.04	30
Cambridge	St	4	\$ 22,345.00	25
Cascade	Ln	3	\$ 38,614.78	25
Duane	St	2	\$ 40,588.22	25
Leon	St	2	\$ 27,335.60	25
Phelps	St	2	\$ 20,230.00	25
Aiken	Ave	2	\$ 162,014.88	20
Amanda	Rd	1	\$ 50,538.00	20
Andrews	Rd	1	\$ 43,700.74	20
Carr	Rd	1	\$ 109,331.00	20
Debonair	Cir	2	\$ 39,939.92	20
Dittmar	Dr	2	\$ 44,363.58	20
Drexall	Ave	4	\$ 24,224.89	20
Ellerbee (2)	St	2	\$ 48,458.97	20
Haddon	Rd	5	\$ 27,265.32	20

Knox (2)	St	1	\$ 14,812.20	20
Leyburn	Pl	4	\$ 30,697.25	20
Minerva	Ave	4	\$ 13,558.47	20
Nancy	St	1	\$ 19,342.29	20
Pettigrew (3)	St	2	\$ 104,275.09	20
Proctor	St	5	\$ 18,170.33	20
Southern	Ave	3	\$ 34,196.50	20
Wilkerson	Ave	3	\$ 35,866.31	20
Womack	Dr	4	\$ 55,980.82	20
Acker	Ave	2	\$ 33,188.30	15
Drew	St	2	\$ 45,935.56	15
Inlet	Ave	1	\$ 61,084.57	15
King	St	1	\$ 36,471.77	15
Peabody (2)	St	3	\$ 13,974.33	15
Arlene	St	4	\$ 31,475.70	10
Bellevue	Ave	2	\$ 64,729.28	10
Bruce	St	4	\$ 11,303.99	10
Canton	St	3	\$ 40,961.04	10
Crane	St	2	\$ 18,969.19	10
Dellwood	Dr	1	\$ 37,083.18	10
Drake	Ave	2	\$ 17,693.77	10
Panama	Ter	2	\$ 41,630.90	10
Westcrest (2)	Dr	3	\$ 22,578.65	10
Willard	St	4	\$ 20,640.11	10
Peabody	St	3	\$ 29,058.33	5
Scoggins	St	1	\$ 15,898.08	5
Alton	St	1	\$ 12,716.97	0
Ayers	Pl	2	\$ 32,529.78	0
Barnes	St	2	\$ 41,987.04	0
Berwyn	Ave	2	\$ 25,732.43	0
Herbert	St	2	\$ 27,921.06	0
Pettigrew (2)	St	2	\$ 24,266.67	0
Stillview	Dr	2	\$ 31,436.04	0
Case	St	2	\$ 18,182.22	0
Ellerbe	St	2	\$ 90,119.26	0
Omah	St	2	\$ 36,983.49	0

SECTION 6 – UNIFIED UNPAVED ROAD ASSET MANAGEMENT PLAN

SEPI staff developed three expenditure plans for the City of Durham to follow in order to pave the unpaved roads.

6.1 Expenditure Plan – Option A

The recommended expenditure plan is Option A. This plan uses the costs associated with the recommended base and pavement, which is condition existing base and light duty plant mix on all the roads. This plan paves the roads in the study from most points to least over a 10-year period, splitting the cost evenly over the 10 years. The total cost for paving all the roads in Option A is \$12.2 million, or about \$1,200,000/year. A 50% contingency has been added to account for unforeseen circumstances during construction.

Option A - YEAR 1				
Road Name		PAC	Treatment	Cost
Ashley	St	2	CEB-PM(LD)	\$ 56,822.96
C View	St	2	CEB-PM(LD)	\$ 71,141.11
Crabtree	Ave	4	CEB-PM(LD)	\$115,382.22
Dacian	Ave	2	CEB-PM(LD)	\$ 43,527.78
Dunn	Ave	1	CEB-PM(LD)	\$ 79,787.11
Evergreen (2)	St	2	CEB-PM(LD)	\$ 24,200.97
Leonard	Dr	2	CEB-PM(LD)	\$108,233.06
Lombard	Ave	1	CEB-PM(LD)	\$ 78,512.22
Lynch	St	2	CEB-PM(LD)	\$ 29,429.71
Macon (2)	St	4	CEB-PM(LD)	\$ 62,429.18
Rome	Ave	3	CEB-PM(LD)	\$ 53,108.06
Rosetta	Dr	3	CEB-PM(LD)	\$ 44,084.78
Total				\$ 766,659.16

Option A - YEAR 2				
Road Name		PAC	Treatment	Cost
Bunn	Terr	3	CEB-PM(LD)	\$ 75,884.80
Enfield	Dr	2	CEB-PM(LD)	\$124,622.98
Evergreen	St	2	CEB-PM(LD)	\$ 83,958.96
Harper	Pl	3	CEB-PM(LD)	\$ 41,103.85
Hursey	St	2	CEB-PM(LD)	\$107,243.86
Lamar	St	1	CEB-PM(LD)	\$ 42,351.56
Lang	St	2	CEB-PM(LD)	\$ 78,544.44
Laymans Chapel	Rd	4	CEB-PM(LD)	\$ 66,138.80
Nancy Rhodes	Dr	1	CEB-PM(LD)	\$122,522.65
Shepherd	St	1	CEB-PM(LD)	\$ 35,600.49
Winburn	Ave	3	CEB-PM(LD)	\$ 55,472.49
Total				\$ 833,444.88

Option A - YEAR 3				
Road Name		PAC	Treatment	Cost
Amber	Pl	1	CEB-PM(LD)	\$ 29,571.21
Ardmore	Dr	3	CEB-PM(LD)	\$185,647.30
Azalea	Ave	1	CEB-PM(LD)	\$143,599.55
Bradford	Cir	2	CEB-PM(LD)	\$ 25,111.11
Brooks	Rd	4	CEB-PM(LD)	\$ 85,526.26
Ellerbee (3)	St	2	CEB-PM(LD)	\$ 35,031.27
Hunter	St	3	CEB-PM(LD)	\$ 36,931.84
Locust	Dr	2	CEB-PM(LD)	\$ 45,807.80
Post	Ave	2	CEB-PM(LD)	\$ 66,022.65
Reese	Rd	4	CEB-PM(LD)	\$ 66,931.65
Southgate	St	4	CEB-PM(LD)	\$ 39,563.46
Wallace	St	2	CEB-PM(LD)	\$ 45,197.78
Wortham	St	2	CEB-PM(LD)	\$ 33,222.89
Total				\$ 838,164.78

Option A - YEAR 4				
Road Name		PAC	Treatment	Cost
Arrowhead	Dr	2	CEB-PM(LD)	\$ 51,128.83
Brunson	St	1	CEB-PM(LD)	\$ 46,825.00
Cassandra	Dr	2	CEB-PM(LD)	\$ 86,081.94
Chalmers	St	3	CEB-PM(LD)	\$ 50,421.44
Concord	St	2	CEB-PM(LD)	\$ 22,117.82
Fenimore	St	1	CEB-PM(LD)	\$ 50,318.60
Freemont	Rd	1	CEB-PM(LD)	\$ 60,792.85
Hill	St	1	CEB-PM(LD)	\$ 94,477.65
Mayo	St	2	CEB-PM(LD)	\$ 80,441.38
Parthenia	Dr	4	CEB-PM(LD)	\$ 97,758.96
Plum	St	2	CEB-PM(LD)	\$ 42,932.43
Rand	St	3	CEB-PM(LD)	\$ 38,462.13
Rex	St	2	CEB-PM(LD)	\$ 13,496.51
Willa	Way	3	CEB-PM(LD)	\$ 61,649.36
Total				\$ 796,904.90

Option A - YEAR 5				
Road Name		PAC	Treatment	Cost
Barenwood	Cir	2	CEB-PM(LD)	\$ 49,606.35
Bay	St	1	CEB-PM(LD)	\$ 18,334.41
Byrd	Rd	1	CEB-PM(LD)	\$130,792.37
Carroll	St	1	CEB-PM(LD)	\$ 22,934.54
Fleming	Dr	1	CEB-PM(LD)	\$ 65,756.34
Isenhour	St	1	CEB-PM(LD)	\$ 72,657.01
Lawson	St	4	CEB-PM(LD)	\$ 32,793.25
Linden	Ter	2	CEB-PM(LD)	\$ 31,806.56

Methodist	St	4	CEB-PM(LD)	\$ 54,625.84
Omah	St	2	CEB-PM(LD)	\$ 36,983.49
Overland	Dr	2	CEB-PM(LD)	\$ 30,430.43
Pamlico	St	1	CEB-PM(LD)	\$ 23,678.89
Ponderosa	Ln	2	CEB-PM(LD)	\$ 64,759.90
Ripley	St	3	CEB-PM(LD)	\$ 16,328.71
Rosedale	Ave	3	CEB-PM(LD)	\$ 39,187.73
Sovereign	St	1	CEB-PM(LD)	\$ 41,903.54
Usher (2)	St	4	CEB-PM(LD)	\$ 43,647.74
Wisteria	Ave	1	CEB-PM(LD)	\$ 24,497.19
Total				\$ 800,724.30

Option A - YEAR 6				
Road Name		PAC	Treatment	Cost
Alcona	Ave	1	CEB-PM(LD)	\$ 28,841.20
Bonhill	Dr	3	CEB-PM(LD)	\$ 37,639.64
Bruton	Rd	4	CEB-PM(LD)	\$ 84,819.27
Buchanan	Dr	3	CEB-PM(LD)	\$ 55,024.36
Cassandra (2)	Dr	2	CEB-PM(LD)	\$ 44,152.68
Cathy	Dr	2	CEB-PM(LD)	\$ 66,382.28
Cedar	St	1	CEB-PM(LD)	\$ 41,350.11
Dezern	Pl	3	CEB-PM(LD)	\$ 15,419.11
Drake (2)	Ave	2	CEB-PM(LD)	\$ 41,438.88
Drake (3)	Ave	2	CEB-PM(LD)	\$ 23,410.06
Edgar	St	2	CEB-PM(LD)	\$ 31,779.44
Englewood	Ave	4	CEB-PM(LD)	\$ 29,847.15
Gordon	St	2	CEB-PM(LD)	\$ 31,270.44
Kate	St	4	CEB-PM(LD)	\$ 28,749.23
Knox	St	1	CEB-PM(LD)	\$ 25,759.14
Linfield	Dr	3	CEB-PM(LD)	\$ 19,427.30
Macon	St	4	CEB-PM(LD)	\$ 42,439.36
McLaurin	Ave	1	CEB-PM(LD)	\$ 91,227.36
Pepperidge	St	2	CEB-PM(LD)	\$ 38,248.28
Piper	St	2	CEB-PM(LD)	\$ 18,556.28
Powe	St	1	CEB-PM(LD)	\$ 37,655.59
Turner	St	1	CEB-PM(LD)	\$ 47,969.69
Verdun	St	2	CEB-PM(LD)	\$ 21,687.95
Total				\$ 903,094.82

Option A - YEAR 7				
Road Name		PAC	Treatment	Cost
Banner	St	4	CEB-PM(LD)	\$ 48,118.92
Benjamine	St	2	CEB-PM(LD)	\$ 48,373.23
Briggs	Ave	4	CEB-PM(HD)	\$ 41,781.84
Charleston	Dr	4	CEB-PM(LD)	\$ 24,498.74

Devon	Rd	2	CEB-PM(LD)	\$ 45,492.28
Dominion	St	2	CEB-PM(LD)	\$ 38,884.03
Dominion (2)	St	2	CEB-PM(LD)	\$ 61,731.38
Indiana	Ave	1	CEB-PM(LD)	\$ 25,860.78
Jester	Rd	4	CEB-PM(LD)	\$ 75,079.65
Lynley	Rd	2	CEB-PM(LD)	\$ 30,212.00
Myers	St	4	CEB-PM(LD)	\$ 37,678.41
Peace	St	3	CEB-PM(LD)	\$ 20,107.44
Pershing	St	2	CEB-PM(LD)	\$ 19,113.93
Rowena	Ave	2	CEB-PM(LD)	\$ 46,799.91
Taft	St	2	CEB-PM(LD)	\$ 32,377.13
Ward	St	3	CEB-PM(LD)	\$ 20,304.89
Westcrest	Dr	3	CEB-PM(LD)	\$ 41,519.86
Winburn (2)	Ave	3	CEB-PM(LD)	\$ 47,926.22
Wofford	Rd	2	CEB-PM(LD)	\$ 32,738.67
Yorkshire	Dr	2	CEB-PM(LD)	\$ 33,790.80
Total				\$ 772,390.11

Option A - YEAR 8				
Road Name		PAC	Treatment	Cost
Biscayne	Rd	2	CEB-PM(LD)	\$ 34,782.85
Cambridge	St	4	CEB-PM(LD)	\$ 22,345.00
Cascade	Ln	3	CEB-PM(LD)	\$ 38,614.78
Craven	St	1	CEB-PM(LD)	\$ 27,124.00
Delano	St	2	CEB-PM(LD)	\$ 19,739.33
Drewry	St	1	CEB-PM(LD)	\$ 43,696.86
Drexall	Ave	4	CEB-PM(LD)	\$ 24,224.89
Duane	St	2	CEB-PM(LD)	\$ 40,588.22
Easley	St	1	CEB-PM(LD)	\$ 46,753.17
Felix	St	1	CEB-PM(LD)	\$ 90,535.98
Fountain	St	2	CEB-PM(LD)	\$ 27,964.43
Knox (2)	St	1	CEB-PM(LD)	\$ 14,812.20
Leon	St	2	CEB-PM(LD)	\$ 27,335.60
Leyburn	Pl	4	CEB-PM(LD)	\$ 30,697.25
Minerva	Ave	4	CEB-PM(LD)	\$ 13,558.47
Nancy	St	1	CEB-PM(LD)	\$ 19,342.29
Neff	St	2	CEB-PM(LD)	\$ 38,893.61
Perennial	Dr	3	CEB-PM(LD)	\$ 11,804.18
Pettigrew	St	2	CEB-PM(LD)	\$ 32,749.97
Phelps	St	2	CEB-PM(LD)	\$ 20,230.00
Proctor	St	5	CEB-PM(LD)	\$ 18,170.33
Red Oak	Ave	2	CEB-PM(LD)	\$ 34,218.80
Rockway	St	3	CEB-PM(LD)	\$ 90,944.17
Virginia	Ave	2	CEB-PM(LD)	\$ 16,778.95
Whitfield	Rd	3	CEB-PM(LD)	\$ 33,538.04
Total				\$ 819,443.39

Option A - YEAR 9				
Road Name		PAC	Treatment	Cost
Aiken	Ave	2	CEB-PM(LD)	\$162,014.88
Amanda	Rd	1	CEB-PM(LD)	\$ 50,538.00
Andrews	Rd	1	CEB-PM(LD)	\$ 43,700.74
Carr	Rd	1	CEB-PM(LD)	\$109,331.00
Debonair	Cir	2	CEB-PM(LD)	\$ 39,939.92
Dittmar	Dr	2	CEB-PM(LD)	\$ 44,363.58
Ellerbee (2)	St	2	CEB-PM(LD)	\$ 48,458.97
Haddon	Rd	5	CEB-PM(LD)	\$ 27,265.32
Peabody (2)	St	3	CEB-PM(LD)	\$ 13,974.33
Pettigrew (3)	St	2	CEB-PM(LD)	\$104,275.09
Southern	Ave	3	CEB-PM(LD)	\$ 34,196.50
Wilkerson	Ave	3	CEB-PM(LD)	\$ 35,866.31
Womack	Dr	4	CEB-PM(LD)	\$ 55,980.82
Total				\$ 769,905.46

Option A - YEAR 10				
Road Name		PAC	Treatment	Cost
Acker	Ave	2	CEB-PM(LD)	\$ 33,188.30
Alton	St	1	CEB-PM(LD)	\$ 12,716.97
Arlene	St	4	CEB-PM(LD)	\$ 31,475.70
Ayers	Pl	2	CEB-PM(LD)	\$ 32,529.78
Barnes	St	2	CEB-PM(LD)	\$ 41,987.04
Bellevue	Ave	2	CEB-PM(LD)	\$ 64,729.28
Berwyn	Ave	2	CEB-PM(LD)	\$ 25,732.43
Bruce	St	4	CEB-PM(LD)	\$ 11,303.99
Canton	St	3	CEB-PM(LD)	\$ 40,961.04
Case	St	2	CEB-PM(LD)	\$ 18,182.22
Crane	St	2	CEB-PM(LD)	\$ 18,969.19
Dellwood	Dr	1	CEB-PM(LD)	\$ 37,083.18
Drake	Ave	2	CEB-PM(LD)	\$ 17,693.77
Drew	St	2	CEB-PM(LD)	\$ 45,935.56
Herbert	St	2	CEB-PM(LD)	\$ 27,921.06
Inlet	Ave	1	CEB-PM(LD)	\$ 61,084.57
King	St	1	CEB-PM(LD)	\$ 36,471.77
Panama	Ter	2	CEB-PM(LD)	\$ 41,630.90
Peabody	St	3	CEB-PM(LD)	\$ 29,058.33
Pettigrew (2)	St	2	CEB-PM(LD)	\$ 24,266.67
Scoggins	St	1	CEB-PM(LD)	\$ 15,898.08
Stillview	Dr	2	CEB-PM(LD)	\$ 31,436.04
Westcrest (2)	Dr	3	CEB-PM(LD)	\$ 22,578.65
Willard	St	4	CEB-PM(LD)	\$ 20,640.11
Total				\$ 743,474.61

6.2 Expenditure Plan – Option B

Option B uses the costs associated with condition existing base and AST pavement, except for a few selected roads. SEPI does not recommend using AST on S. Briggs, Case, Acker, Fay, Pettigrew, Phelps, Edgar, Lamar, Inlet, Brunson, Wortham, and Peabody. Heavy duty plant mix is recommended for S. Briggs and light duty plant mix for the rest due to observed use. The total cost of this option is \$10.7 million. Due to the reduced cost of AST, SEPI has developed a 5-year plan for Option B, which costs about \$2,130,000/year. A 50% contingency has been added to account for unforeseen circumstances during construction. While this plan is not the recommended plan, it allows for all the roads to be paved in a shorter time. Paving with AST may not be the best long-term option due to higher maintenance costs.

Option B - YEAR 1				
Road Name		PAC	Treatment	Cost
Ashley	St	2	CEB-AST	\$ 49,428.52
Azalea	Ave	1	CEB-AST	\$120,621.77
Bunn	Terr	3	CEB-AST	\$ 65,684.80
C View	St	2	CEB-AST	\$ 59,285.56
Crabtree	Ave	4	CEB-AST	\$100,293.33
Dacian	Ave	2	CEB-AST	\$ 38,388.89
Dunn	Ave	1	CEB-AST	\$ 68,298.22
Enfield	Dr	2	CEB-AST	\$107,145.20
Evergreen	St	2	CEB-AST	\$ 72,800.07
Evergreen (2)	St	2	CEB-AST	\$ 21,270.97
Harper	Pl	3	CEB-AST	\$ 35,734.96
Hursey	St	2	CEB-AST	\$ 91,904.97
Lamar	St	1	CEB-PM(LD)	\$ 42,351.56
Lang	St	2	CEB-AST	\$ 67,850.00
Laymans Chapel	Rd	4	CEB-AST	\$ 58,605.47
Leonard	Dr	2	CEB-AST	\$ 91,904.17
Lombard	Ave	1	CEB-AST	\$ 69,012.22
Lynch	St	2	CEB-AST	\$ 26,398.04
Macon (2)	St	4	CEB-AST	\$ 54,704.73
Nancy Rhodes	Dr	1	CEB-AST	\$107,122.65
Rome	Ave	3	CEB-AST	\$ 46,402.51
Rosetta	Dr	3	CEB-AST	\$ 39,262.56
Shepherd	St	1	CEB-AST	\$ 30,933.82
Winburn	Ave	3	CEB-AST	\$ 48,383.60
Wortham	St	2	CEB-PM(LD)	\$ 33,222.89
Total				\$ 1,547,011.48

Option B - YEAR 2				
Road Name		PAC	Treatment	Cost
Amber	Pl	1	CEB-AST	\$ 26,596.21
Ardmore	Dr	3	CEB-AST	\$159,259.52
Arrowhead	Dr	2	CEB-AST	\$ 45,073.27
Bay	St	1	CEB-AST	\$ 15,845.53
Bradford	Cir	2	CEB-AST	\$ 22,055.56
Brooks	Rd	4	CEB-AST	\$ 76,415.15
Brunson	St	1	CEB-PM(LD)	\$ 46,825.00
Carroll	St	1	CEB-AST	\$ 19,955.65
Cassandra	Dr	2	CEB-AST	\$ 75,033.05
Chalmers	St	3	CEB-AST	\$ 45,883.11
Concord	St	2	CEB-AST	\$ 18,446.71
Ellerbee (3)	St	2	CEB-AST	\$ 30,401.27
Fenimore	St	1	CEB-AST	\$ 43,571.93
Freemont	Rd	1	CEB-AST	\$ 53,386.18
Hill	St	1	CEB-AST	\$ 80,984.31
Hunter	St	3	CEB-AST	\$ 32,281.84
Isenhour	St	1	CEB-AST	\$ 62,879.24
Lawson	St	4	CEB-AST	\$ 28,393.25
Locust	Dr	2	CEB-AST	\$ 39,209.46
Mayo	St	2	CEB-AST	\$ 70,908.04
Overland	Dr	2	CEB-AST	\$ 27,130.43
Parthenia	Dr	4	CEB-AST	\$ 85,964.52
Plum	St	2	CEB-AST	\$ 38,287.99
Ponderosa	Ln	2	CEB-AST	\$ 56,778.79
Post	Ave	2	CEB-AST	\$ 58,772.65
Rand	St	3	CEB-AST	\$ 33,164.35
Reese	Rd	4	CEB-AST	\$ 56,982.76
Rex	St	2	CEB-AST	\$ 11,552.07
Rosedale	Ave	3	CEB-AST	\$ 33,703.29
Southgate	St	4	CEB-AST	\$ 34,271.24
Wallace	St	2	CEB-AST	\$ 38,108.89
Willa	Way	3	CEB-AST	\$ 54,352.70
Wisteria	Ave	1	CEB-AST	\$ 21,201.08
Total				\$ 1,543,675.03

Option B - YEAR 3				
Road Name		PAC	Treatment	Cost
Alcona	Ave	1	CEB-AST	\$ 25,394.53
Barenwood	Cir	2	CEB-AST	\$ 43,654.13
Bonhill	Dr	3	CEB-AST	\$ 32,872.97
Bruton	Rd	4	CEB-AST	\$ 74,218.16
Buchanan	Dr	3	CEB-AST	\$ 47,727.70

Byrd	Rd	1	CEB-AST	\$114,347.93
Cassandra (2)	Dr	2	CEB-AST	\$ 38,408.24
Cathy	Dr	2	CEB-AST	\$ 59,122.28
Cedar	St	1	CEB-AST	\$ 35,104.56
Charleston	Dr	4	CEB-AST	\$ 22,265.13
Devon	Rd	2	CEB-AST	\$ 38,310.06
Dezern	Pl	3	CEB-AST	\$ 13,230.77
Drake (2)	Ave	2	CEB-AST	\$ 35,897.22
Drake (3)	Ave	2	CEB-AST	\$ 20,334.51
Edgar	St	2	CEB-PM(LD)	\$ 31,779.44
Englewood	Ave	4	CEB-AST	\$ 25,980.48
Fleming	Dr	1	CEB-AST	\$ 58,606.34
Gordon	St	2	CEB-AST	\$ 26,088.22
Indiana	Ave	1	CEB-AST	\$ 22,291.89
Kate	St	4	CEB-AST	\$ 25,619.23
Knox	St	1	CEB-AST	\$ 23,483.59
Linden	Ter	2	CEB-AST	\$ 28,539.90
Linfield	Dr	3	CEB-AST	\$ 16,921.74
Lynley	Rd	2	CEB-AST	\$ 26,692.00
Macon	St	4	CEB-AST	\$ 37,583.81
McLaurin	Ave	1	CEB-AST	\$ 79,200.70
Methodist	St	4	CEB-AST	\$ 46,779.17
Myers	St	4	CEB-AST	\$ 34,022.86
Pamlico	St	1	CEB-AST	\$ 19,584.44
Peace	St	3	CEB-AST	\$ 18,407.44
Pepperidge	St	2	CEB-AST	\$ 33,921.61
Pershing	St	2	CEB-AST	\$ 17,060.60
Piper	St	2	CEB-AST	\$ 16,840.73
Powe	St	1	CEB-AST	\$ 32,942.25
Ripley	St	3	CEB-AST	\$ 13,925.38
Sovereign	St	1	CEB-AST	\$ 37,272.43
Taft	St	2	CEB-AST	\$ 29,047.13
Turner	St	1	CEB-AST	\$ 42,310.80
Usher (2)	St	4	CEB-AST	\$ 37,964.41
Verdun	St	2	CEB-AST	\$ 18,921.29
Ward	St	3	CEB-AST	\$ 17,750.44
Winburn (2)	Ave	3	CEB-AST	\$ 39,725.11
Wofford	Rd	2	CEB-AST	\$ 29,035.33
Yorkshire	Dr	2	CEB-AST	\$ 29,830.80
Total				\$ 1,519,017.74

Option B - YEAR 4				
Road Name		PAC	Treatment	Cost
Amanda	Rd	1	CEB-AST	\$ 41,558.00
Banner	St	4	CEB-AST	\$ 41,658.92
Benjamine	St	2	CEB-AST	\$ 42,539.89
Biscayne	Rd	2	CEB-AST	\$ 30,571.74
Briggs	Ave	4	CEB-PM(HD)	\$ 63,719.34
Cambridge	St	4	CEB-AST	\$ 18,645.00
Cascade	Ln	3	CEB-AST	\$ 34,214.78
Craven	St	1	CEB-AST	\$ 24,479.56
Delano	St	2	CEB-AST	\$ 17,062.67
Dittmar	Dr	2	CEB-AST	\$ 38,753.58
Dominion	St	2	CEB-AST	\$ 35,317.36
Dominion (2)	St	2	CEB-AST	\$ 54,975.83
Drewry	St	1	CEB-AST	\$ 38,612.41
Drexall	Ave	4	CEB-AST	\$ 21,224.89
Duane	St	2	CEB-AST	\$ 34,367.11
Easley	St	1	CEB-AST	\$ 41,713.17
Ellerbee (2)	St	2	CEB-AST	\$ 42,688.97
Felix	St	1	CEB-AST	\$ 76,950.98
Fountain	St	2	CEB-AST	\$ 25,502.21
Haddon	Rd	5	CEB-AST	\$ 24,454.21
Jester	Rd	4	CEB-AST	\$ 64,857.43
Knox (2)	St	1	CEB-AST	\$ 13,389.98
Leon	St	2	CEB-AST	\$ 24,193.93
Leyburn	Pl	4	CEB-AST	\$ 26,725.03
Minerva	Ave	4	CEB-AST	\$ 11,612.92
Nancy	St	1	CEB-AST	\$ 17,595.07
Neff	St	2	CEB-AST	\$ 33,393.61
Perennial	Dr	3	CEB-AST	\$ 10,904.18
Pettigrew	St	2	CEB-PM(LD)	\$ 32,749.97
Phelps	St	2	CEB-PM(LD)	\$ 20,230.00
Proctor	St	5	CEB-AST	\$ 15,483.67
Red Oak	Ave	2	CEB-AST	\$ 31,135.46
Rockway	St	3	CEB-AST	\$ 79,944.17
Rowena	Ave	2	CEB-AST	\$ 41,199.91
Southern	Ave	3	CEB-AST	\$ 29,796.50
Virginia	Ave	2	CEB-AST	\$ 14,086.17
Westcrest	Dr	3	CEB-AST	\$ 36,557.64
Whitfield	Rd	3	CEB-AST	\$ 29,591.37
Wilkerson	Ave	3	CEB-AST	\$ 32,446.31
Total				\$ 1,314,903.94

Option B - YEAR 5				
Road Name		PAC	Treatment	Cost
Acker	Ave	2	CEB-PM(LD)	\$ 33,188.30
Aiken	Ave	2	CEB-AST	\$136,409.32
Alton	St	1	CEB-AST	\$ 11,736.97
Andrews	Rd	1	CEB-AST	\$ 39,422.96
Arlene	St	4	CEB-AST	\$ 27,454.59
Ayers	Pl	2	CEB-AST	\$ 27,970.89
Barnes	St	2	CEB-AST	\$ 35,741.48
Bellevue	Ave	2	CEB-AST	\$ 55,662.61
Berwyn	Ave	2	CEB-AST	\$ 23,110.20
Bruce	St	4	CEB-PM(LD)	\$ 11,303.99
Canton	St	3	CEB-AST	\$ 36,623.26
Carr	Rd	1	CEB-AST	\$ 93,814.34
Case	St	2	CEB-PM(LD)	\$ 18,182.22
Crane	St	2	CEB-AST	\$ 16,502.52
Debonair	Cir	2	CEB-AST	\$ 36,004.36
Dellwood	Dr	1	CEB-AST	\$ 33,575.40
Drake	Ave	2	CEB-AST	\$ 16,068.22
Drew	St	2	CEB-AST	\$ 40,460.00
Herbert	St	2	CEB-AST	\$ 24,009.95
Inlet	Ave	1	CEB-PM(LD)	\$ 61,084.57
King	St	1	CEB-AST	\$ 31,882.88
Omah	St	2	CEB-AST	\$ 32,073.49
Panama	Ter	2	CEB-AST	\$ 37,330.90
Peabody	St	3	CEB-PM(LD)	\$ 29,058.33
Peabody (2)	St	3	CEB-PM(LD)	\$ 13,974.33
Pettigrew (2)	St	2	CEB-PM(LD)	\$ 24,266.67
Pettigrew (3)	St	2	CEB-PM(LD)	\$104,275.09
Scoggins	St	1	CEB-AST	\$ 14,474.19
Stillview	Dr	2	CEB-AST	\$ 27,216.04
Westcrest (2)	Dr	3	CEB-AST	\$ 20,561.98
Willard	St	4	CEB-AST	\$ 18,490.11
Womack	Dr	4	CEB-AST	\$ 49,004.15
Total				\$ 1,180,934.33

6.3 Expenditure Plan – Option C

Option C uses the costs associated with the recommended base and pavement, which is condition existing base and light duty plant mix on all the roads. The difference with this option is that it attempts to divide the construction costs evenly across each of the five PAC districts evenly over a 10-year period. The cost for paving all the roads in Option C is \$12.2 million, or about \$1,200,000/year. A 50% contingency has been added to account for unforeseen circumstances during construction. This is not the recommended option because it places more emphasis on dividing expenditures evenly over PAC districts rather than spending money on roads that get the most use.

Option C - YEAR 1				
Road Name		PAC	Treatment	Cost
Ashley	St	2	CEB-PM(LD)	\$ 56,822.96
Bunn	Terr	3	CEB-PM(LD)	\$ 75,884.80
Crabtree	Ave	4	CEB-PM(LD)	\$115,382.22
Dacian	Ave	2	CEB-PM(LD)	\$ 43,527.78
Dunn	Ave	1	CEB-PM(LD)	\$ 79,787.11
Haddon	Rd	5	CEB-PM(LD)	\$ 27,265.32
Harper	Pl	3	CEB-PM(LD)	\$ 41,103.85
Lamar	St	1	CEB-PM(LD)	\$ 42,351.56
Leonard	Dr	2	CEB-PM(LD)	\$108,233.06
Lombard	Ave	1	CEB-PM(LD)	\$ 78,512.22
Macon (2)	St	4	CEB-PM(LD)	\$ 62,429.18
Proctor	St	5	CEB-PM(LD)	\$ 18,170.33
Rome	Ave	3	CEB-PM(LD)	\$ 53,108.06
Rosetta	Dr	3	CEB-PM(LD)	\$ 44,084.78
Total				\$ 846,663.23

Option C - YEAR 2				
Road Name		PAC	Treatment	Cost
Brooks	Rd	4	CEB-PM(LD)	\$ 85,526.26
C View	St	2	CEB-PM(LD)	\$ 71,141.11
Chalmers	St	3	CEB-PM(LD)	\$ 50,421.44
Evergreen (2)	St	2	CEB-PM(LD)	\$ 24,200.97
Hunter	St	3	CEB-PM(LD)	\$ 36,931.84
Lang	St	2	CEB-PM(LD)	\$ 78,544.44
Laymans Chapel	Rd	4	CEB-PM(LD)	\$ 66,138.80
Lynch	St	2	CEB-PM(LD)	\$ 29,429.71
Nancy Rhodes	Dr	1	CEB-PM(LD)	\$122,522.65
Rand	St	3	CEB-PM(LD)	\$ 38,462.13
Reese	Rd	4	CEB-PM(LD)	\$ 66,931.65
Shepherd	St	1	CEB-PM(LD)	\$ 35,600.49
Willa	Way	3	CEB-PM(LD)	\$ 61,649.36
Winburn	Ave	3	CEB-PM(LD)	\$ 55,472.49
Total				\$ 822,973.35

Option C - YEAR 3				
Road Name		PAC	Treatment	Cost
Amber	Pl	1	CEB-PM(LD)	\$ 29,571.21
Ardmore	Dr	3	CEB-PM(LD)	\$185,647.30
Azalea	Ave	1	CEB-PM(LD)	\$143,599.55
Enfield	Dr	2	CEB-PM(LD)	\$124,622.98
Evergreen	St	2	CEB-PM(LD)	\$ 83,958.96
Freemont	Rd	1	CEB-PM(LD)	\$ 60,792.85
Lawson	St	4	CEB-PM(LD)	\$ 32,793.25
Methodist	St	4	CEB-PM(LD)	\$ 54,625.84
Parthenia	Dr	4	CEB-PM(LD)	\$ 97,758.96
Southgate	St	4	CEB-PM(LD)	\$ 39,563.46
Usher (2)	St	4	CEB-PM(LD)	\$ 43,647.74
Total				\$ 896,582.11

Option C - YEAR 4				
Road Name		PAC	Treatment	Cost
Bonhill	Dr	3	CEB-PM(LD)	\$ 37,639.64
Brunson	St	1	CEB-PM(LD)	\$ 46,825.00
Bruton	Rd	4	CEB-PM(LD)	\$ 84,819.27
Buchanan	Dr	3	CEB-PM(LD)	\$ 55,024.36
Dezern	Pl	3	CEB-PM(LD)	\$ 15,419.11
Ellerbee (3)	St	2	CEB-PM(LD)	\$ 35,031.27
Englewood	Ave	4	CEB-PM(LD)	\$ 29,847.15
Fenimore	St	1	CEB-PM(LD)	\$ 50,318.60
Hill	St	1	CEB-PM(LD)	\$ 94,477.65
Hursey	St	2	CEB-PM(LD)	\$107,243.86
Kate	St	4	CEB-PM(LD)	\$ 28,749.23
Linfield	Dr	3	CEB-PM(LD)	\$ 19,427.30
Macon	St	4	CEB-PM(LD)	\$ 42,439.36
Ripley	St	3	CEB-PM(LD)	\$ 16,328.71
Rosedale	Ave	3	CEB-PM(LD)	\$ 39,187.73
Ward	St	3	CEB-PM(LD)	\$ 20,304.89
Wortham	St	2	CEB-PM(LD)	\$ 33,222.89
Total				\$ 756,306.02

Option C - YEAR 5				
Road Name		PAC	Treatment	Cost
Banner	St	4	CEB-PM(LD)	\$ 48,118.92
Bay	St	1	CEB-PM(LD)	\$ 18,334.41
Bradford	Cir	2	CEB-PM(LD)	\$ 25,111.11
Byrd	Rd	1	CEB-PM(LD)	\$130,792.37
Charleston	Dr	4	CEB-PM(LD)	\$ 24,498.74
Isenhour	St	1	CEB-PM(LD)	\$ 72,657.01

Jester	Rd	4	CEB-PM(LD)	\$ 75,079.65
Locust	Dr	2	CEB-PM(LD)	\$ 45,807.80
Myers	St	4	CEB-PM(LD)	\$ 37,678.41
Peace	St	3	CEB-PM(LD)	\$ 20,107.44
Perennial	Dr	3	CEB-PM(LD)	\$ 11,804.18
Plum	St	2	CEB-PM(LD)	\$ 42,932.43
Post	Ave	2	CEB-PM(LD)	\$ 66,022.65
Rockway	St	3	CEB-PM(LD)	\$ 90,944.17
Wallace	St	2	CEB-PM(LD)	\$ 45,197.78
Westcrest	Dr	3	CEB-PM(LD)	\$ 41,519.86
Whitfield	Rd	3	CEB-PM(LD)	\$ 33,538.04
Winburn (2)	Ave	3	CEB-PM(LD)	\$ 47,926.22
Total				\$ 878,071.20

Option C - YEAR 6				
Road Name		PAC	Treatment	Cost
Arrowhead	Dr	2	CEB-PM(LD)	\$ 51,128.83
Briggs	Ave	4	CEB-PM(HD)	\$ 63,719.34
Cambridge	St	4	CEB-PM(LD)	\$ 22,345.00
Canton	St	3	CEB-PM(LD)	\$ 40,961.04
Carroll	St	1	CEB-PM(LD)	\$ 22,934.54
Cascade	Ln	3	CEB-PM(LD)	\$ 38,614.78
Cassandra	Dr	2	CEB-PM(LD)	\$ 86,081.94
Drexall	Ave	4	CEB-PM(LD)	\$ 24,224.89
Fleming	Dr	1	CEB-PM(LD)	\$ 65,756.34
Leyburn	Pl	4	CEB-PM(LD)	\$ 30,697.25
Mayo	St	2	CEB-PM(LD)	\$ 80,441.38
Minerva	Ave	4	CEB-PM(LD)	\$ 13,558.47
Pamlico	St	1	CEB-PM(LD)	\$ 23,678.89
Peabody	St	3	CEB-PM(LD)	\$ 29,058.33
Peabody (2)	St	3	CEB-PM(LD)	\$ 13,974.33
Powe	St	1	CEB-PM(LD)	\$ 37,655.59
Southern	Ave	3	CEB-PM(LD)	\$ 34,196.50
Sovereign	St	1	CEB-PM(LD)	\$ 41,903.54
Westcrest (2)	Dr	3	CEB-PM(LD)	\$ 22,578.65
Wilkerson	Ave	3	CEB-PM(LD)	\$ 35,866.31
Wisteria	Ave	1	CEB-PM(LD)	\$ 24,497.19
Total				\$ 803,873.12

Option C - YEAR 7				
Road Name		PAC	Treatment	Cost
Alcona	Ave	1	CEB-PM(LD)	\$ 28,841.20
Arlene	St	4	CEB-PM(LD)	\$ 31,475.70
Barenwood	Cir	2	CEB-PM(LD)	\$ 49,606.35
Bruce	St	4	CEB-PM(LD)	\$ 11,303.99

Cathy	Dr	2	CEB-PM(LD)	\$ 66,382.28
Concord	St	2	CEB-PM(LD)	\$ 22,117.82
Drake (2)	Ave	2	CEB-PM(LD)	\$ 41,438.88
Drewry	St	1	CEB-PM(LD)	\$ 43,696.86
Gordon	St	2	CEB-PM(LD)	\$ 31,270.44
Knox	St	1	CEB-PM(LD)	\$ 25,759.14
Linden	Ter	2	CEB-PM(LD)	\$ 31,806.56
McLaurin	Ave	1	CEB-PM(LD)	\$ 91,227.36
Overland	Dr	2	CEB-PM(LD)	\$ 30,430.43
Ponderosa	Ln	2	CEB-PM(LD)	\$ 64,759.90
Rex	St	2	CEB-PM(LD)	\$ 13,496.51
Turner	St	1	CEB-PM(LD)	\$ 47,969.69
Verdun	St	2	CEB-PM(LD)	\$ 21,687.95
Willard	St	4	CEB-PM(LD)	\$ 20,640.11
Womack	Dr	4	CEB-PM(LD)	\$ 55,980.82
Total				\$ 729,892.00

Option C - YEAR 8				
Road Name		PAC	Treatment	Cost
Amanda	Rd	1	CEB-PM(LD)	\$ 50,538.00
Andrews	Rd	1	CEB-PM(LD)	\$ 43,700.74
Cassandra (2)	Dr	2	CEB-PM(LD)	\$ 44,152.68
Cedar	St	1	CEB-PM(LD)	\$ 41,350.11
Craven	St	1	CEB-PM(LD)	\$ 27,124.00
Devon	Rd	2	CEB-PM(LD)	\$ 45,492.28
Drake (3)	Ave	2	CEB-PM(LD)	\$ 23,410.06
Easley	St	1	CEB-PM(LD)	\$ 46,753.17
Edgar	St	2	CEB-PM(LD)	\$ 31,779.44
Felix	St	1	CEB-PM(LD)	\$ 90,535.98
Indiana	Ave	1	CEB-PM(LD)	\$ 25,860.78
King	St	1	CEB-PM(LD)	\$ 36,471.77
Knox (2)	St	1	CEB-PM(LD)	\$ 14,812.20
Lynley	Rd	2	CEB-PM(LD)	\$ 30,212.00
Nancy	St	1	CEB-PM(LD)	\$ 19,342.29
Pepperidge	St	2	CEB-PM(LD)	\$ 38,248.28
Pershing	St	2	CEB-PM(LD)	\$ 19,113.93
Pettigrew	St	2	CEB-PM(LD)	\$ 32,749.97
Piper	St	2	CEB-PM(LD)	\$ 18,556.28
Wofford	Rd	2	CEB-PM(LD)	\$ 32,738.67
Total				\$ 712,942.65

Option C - YEAR 9				
Road Name		PAC	Treatment	Cost
Alton	St	1	CEB-PM(LD)	\$ 12,716.97
Benjamin	St	2	CEB-PM(LD)	\$ 48,373.23
Biscayne	Rd	2	CEB-PM(LD)	\$ 34,782.85
Carr	Rd	1	CEB-PM(LD)	\$109,331.00
Debonair	Cir	2	CEB-PM(LD)	\$ 39,939.92
Delano	St	2	CEB-PM(LD)	\$ 19,739.33
Dellwood	Dr	1	CEB-PM(LD)	\$ 37,083.18
Dittmar	Dr	2	CEB-PM(LD)	\$ 44,363.58
Dominion	St	2	CEB-PM(LD)	\$ 38,884.03
Dominion (2)	St	2	CEB-PM(LD)	\$ 61,731.38
Duane	St	2	CEB-PM(LD)	\$ 40,588.22
Ellerbee (2)	St	2	CEB-PM(LD)	\$ 48,458.97
Fountain	St	2	CEB-PM(LD)	\$ 27,964.43
Inlet	Ave	1	CEB-PM(LD)	\$ 61,084.57
Leon	St	2	CEB-PM(LD)	\$ 27,335.60
Neff	St	2	CEB-PM(LD)	\$ 38,893.61
Phelps	St	2	CEB-PM(LD)	\$ 20,230.00
Red Oak	Ave	2	CEB-PM(LD)	\$ 34,218.80
Rowena	Ave	2	CEB-PM(LD)	\$ 46,799.91
Scoggins	St	1	CEB-PM(LD)	\$ 15,898.08
Taft	St	2	CEB-PM(LD)	\$ 32,377.13
Virginia	Ave	2	CEB-PM(LD)	\$ 16,778.95
Yorkshire	Dr	2	CEB-PM(LD)	\$ 33,790.80
Total				\$ 891,364.55

Option C - YEAR 10				
Road Name		PAC	Treatment	Cost
Acker	Ave	2	CEB-PM(LD)	\$ 33,188.30
Aiken	Ave	2	CEB-PM(LD)	\$162,014.88
Ayers	Pl	2	CEB-PM(LD)	\$ 32,529.78
Barnes	St	2	CEB-PM(LD)	\$ 41,987.04
Bellevue	Ave	2	CEB-PM(LD)	\$ 64,729.28
Berwyn	Ave	2	CEB-PM(LD)	\$ 25,732.43
Case	St	2	CEB-PM(LD)	\$ 18,182.22
Crane	St	2	CEB-PM(LD)	\$ 18,969.19
Drake	Ave	2	CEB-PM(LD)	\$ 17,693.77
Drew	St	2	CEB-PM(LD)	\$ 45,935.56
Herbert	St	2	CEB-PM(LD)	\$ 27,921.06
Omaha	St	2	CEB-PM(LD)	\$ 36,983.49
Panama	Ter	2	CEB-PM(LD)	\$ 41,630.90
Pettigrew (2)	St	2	CEB-PM(LD)	\$ 24,266.67
Pettigrew (3)	St	2	CEB-PM(LD)	\$104,275.09
Stillview	Dr	2	CEB-PM(LD)	\$ 31,436.04
Total				\$ 727,475.68

SECTION 7 - ARCGIS ONLINE DASHBOARD

7.1 GIS Tool

A GIS tool was developed in Esri's ArcMap GIS software which calculates point scores and costs for each unpaved road. This tool allows the City to compare different cost scenarios by entering user-defined values for point and cost calculations. For cost calculations, these user-defined values include costs that may vary, such as the unit costs of materials, delivery, etc. By entering different cost inputs, it is possible to generate cost scenarios and compare the costs of different options and assumptions. For example, the user can modify the cost of pipe repairs to determine the impact that the change will have on the paving costs for individual and all roads.

As discussed previously, the features of interest (residences, schools, etc.) along the roads were assigned point values based on assumptions regarding their impacts on paving priorities. These values may also be modified to evaluate the effects of different point values on the road priority ratings.

As discussed earlier, the existing default values used for the calculations were determined after careful consideration and evaluation of current costs and judgement based on subject knowledge and past experience. While the tool allows inputs to be freely modified, the intent is to allow the user to make relatively minor changes to account for changes in costs and to test different assumptions.

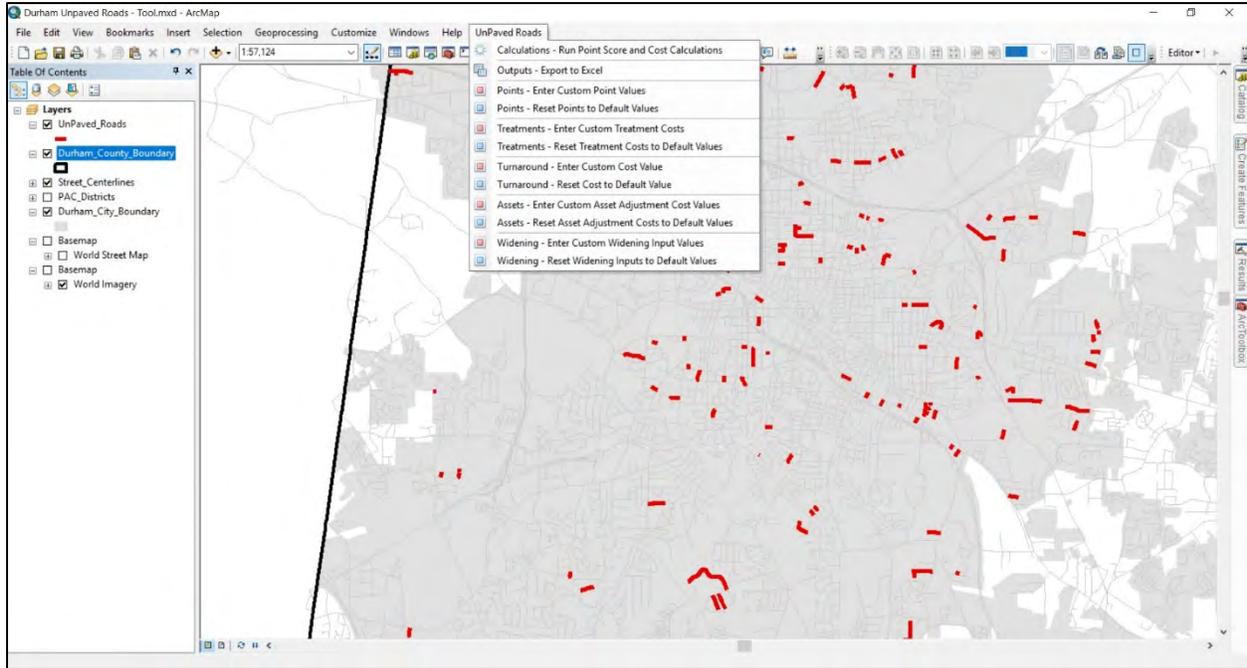
The tool is run in a GIS environment, and therefore the cost results are stored in a GIS unpaved roads data layer. This allows the City to generate maps showing the costs for paving the roads. If new unpaved roads are created, they can be added to the GIS data layer and corresponding cost calculations can be generated. The specifics of the tool are discussed below.

The tool consists of the following:

- **Durham Unpaved Roads – Tool.mxd** – ArcMap project file containing toolbox and menu for executing tools
- **zDurhamUnpavedRoads_v106_FINAL.tbx** – ArcGIS toolbox containing models used for calculations
- **Durham_Unpaved_Roads_2019_FINAL.gdb** – Geodatabase containing unpaved road feature class and standalone tables used for calculations.

Tool MXD

The Tool is accessed by opening the **Durham Unpaved Roads – Tool.mxd** project file. The pulldown menu for the tool is “UnPaved Roads”.



Each menu option executes a model in the toolbox. The functions of the menu options are as follows:

Menu Option	Description
Calculations – Run Point Score and Cost Calculations	Executes point and cost calculations
Outputs – Export to Excel	Exports unpaved roads attribute table to an Excel file
Points – Enter Custom Values	Allows entry of user-defined point values
Points – Reset Points to Default Values	Resets user-defined point values to defaults
Treatments – Enter Custom Treatment Costs	Allows entry of user-defined treatment costs
Treatments – Reset Treatment Costs to Default Values	Resets user-defined treatment costs to defaults

Turnaround – Enter Custom Cost Value	Allows entry of user-defined turnaround cost
Turnaround – Reset Cost to Default Value	Resets user-defined turnaround cost to default
Assets – Enter Custom Asset Adjustment Cost Values	Allows entry of user-defined asset adjustment costs
Assets – Reset Asset Adjustment Costs to Default Values	Resets user-defined asset adjustment costs to defaults
Widening – Enter Custom Widening Input Values	Allows entry of user-defined values for calculating widening costs
Widening – Reset Widening Inputs to Default Values	Resets user-defined widening inputs to defaults

The following form appears when the user selects the **Points – Enter Custom Values** menu option:

Facility Type	Points Value
Points per Residence	10
Points Per School	20
Points per Daycare Center	20
Points per Church	15
Points per Retail Business	15
Points per Warehouse	5
Points per Manufacturing Facility	10
Points per Utility Facility	5
Points per Recreational Facility	10
Points for Pavement-to-Pavement Connectivity	15
Points for Dead End	0

Buttons: OK, Cancel, Environments..., Show Help >>

The following form appears when the user selects the **Treatments – Enter Custom Treatment Costs** menu option:

Treatments - Enter Custom Treatment Costs

Condition Existing Base with AST Pavement (\$ per square yard)
0

Condition Existing Base with 2" Surface Course (\$ per square yard)
0

Condition Existing Base with 3" Base Course and 1.75" Surface Course (\$ per square yard)
0

Cement Stabilized Base (Dry Application) with AST (\$ per square yard)
0

Cement Stabilized Base (Dry Application) with 2" Surface Course (\$ per square yard)
0

Cement Stabilized Base (Dry Application) with 3" Base Course and 1.75" Surface Course (\$ per square yard)
0

Cement Stabilized Base (Wet Application) with AST (\$ per square yard)
0

Cement Stabilized Base (Wet Application) with 2" Surface Course (\$ per square yard)
0

Cement Stabilized Base (Wet Application) with 3" Base Course and 1.75" Surface Course (\$ per square yard)
0

OK Cancel Environments... Show Help >>

The following form appears when the user selects the **Turnaround – Enter Custom Cost Value** menu option:

Turnaround - Enter Custom Cost Value

Cost(\$) for Standard Turnaround
5500

OK Cancel Environments... Show Help >>

The following form appears when the user selects the **Assets – Enter Custom Asset Adjustment Cost Values** menu option:

The screenshot shows a dialog box titled "Assets - Enter Custom Asset Adjustment Cost Values". It contains five input fields, each with a label and a value, and a small calculator icon to the right of each field. The fields are: "Cost(\$ per Manhole Adjustment)" with value "1000", "Cost(\$ per Water Valve Adjustment)" with value "1000", "Cost(\$ for Ditch Adjustment)" with value "1000", "Cost(\$ per Driveway Adjustment)" with value "78.75", and "Cost (\$) for Pipe Maintenance" with value "2400". At the bottom, there are four buttons: "OK", "Cancel", "Environments...", and "Show Help >>".

Field Label	Value
Cost(\$ per Manhole Adjustment)	1000
Cost(\$ per Water Valve Adjustment)	1000
Cost(\$ for Ditch Adjustment)	1000
Cost(\$ per Driveway Adjustment)	78.75
Cost (\$) for Pipe Maintenance	2400

The following form appears when the user selects the **Widening – Enter Custom Widening Input Values** menu option:

The screenshot shows a dialog box titled "Widening - Enter Custom Widening Input Values". It contains four input fields, each with a label and a value, and a small calculator icon to the right of each field. The fields are: "Depth (inches) of New Stone Base" with value "8", "Weight of Stone (pounds per cubic foot)" with value "150", "Cost of Stone Delivery (\$ per ton)" with value "63", and "Cost of Soil Excavation (\$ per cubic yard)" with value "11.36". At the bottom, there are four buttons: "OK", "Cancel", "Environments...", and "Show Help >>".

Field Label	Value
Depth (inches) of New Stone Base	8
Weight of Stone (pounds per cubic foot)	150
Cost of Stone Delivery (\$ per ton)	63
Cost of Soil Excavation (\$ per cubic yard)	11.36

Tool Cost Calculations

Several preliminary calculations must be performed before executing the final cost calculations. These are:

Cost of Widening

Roads less than 22' wide need to be widened before they can be paved. For these roads , the widening costs were determined by first calculating the additional width using the following formula:

$$\text{Additional Width} = \text{Min}(\text{All-Weather Width}, 22) - \text{Base Width}$$

In other words, the Additional Width is All-Weather Width or 22' (whichever value is lower) minus the Base Width.

Next, the widening cost is calculated by

$$\begin{aligned} \text{Widening Cost} = & ((\text{Road length} * \text{Additional Width}) * (\text{Stone Depth}) * (\text{Stone Weight}) \\ & * (\text{Cost of Stone Delivery}) + ((\text{Road length} * \text{Additional Width}) * (\text{Stone Depth}/27) \\ & * (\text{Soil Excavation Cost})) \end{aligned}$$

Turnaround Cost

Dead-end roads were assigned a fixed cost of \$5,500 for constructing a turnaround. This value is stored in table "tblTurnarounds".

Ditch Cleaning Cost

Ditch cleaning costs were calculated as a variable cost based on dollars per linear foot of road. This calculation was applied to all roads.

$$\text{Ditch Cleaning Cost} = \text{Road Length} * \text{Cost per Foot}$$

The cost per dollar can be modified by the user.

This value is stored in table "tblAssets" where [AssetType] = 'Ditch'.

AssetType	Cost
Manhole	\$1,500.00
WaterValve	\$1,500.00
Ditch	\$10.00
Driveway	\$125.00
Pipe	\$10.00

Driveway Cost

For the AST paving and Light Duty Plant Mix options, the driveway costs were calculated as follows:

$$\text{Cost} = (\text{Number of Facilities} * \text{Driveways per Facility} * \text{Cost of stone})$$

Assumptions:

$$\text{Driveways per Facility} = 1.25$$

$$\text{Cost of Stone (\$ per ton)} = \$100$$

These values multiplied and stored in table "tblAssets":

AssetType	Cost
Manhole	\$1,500.00
WaterValve	\$1,500.00
Ditch	\$10.00
Driveway	\$125.00
Pipe	\$10.00

For the Heavy-Duty Plant Mix options, the calculation is similar to the one above, but includes a multiplier to account for the increased thickness:

$$\text{Cost} = (\text{Number of Facilities} * \text{Driveways per Facility} * \text{Cost of Stone}) * 7.5$$

During field inspections it was observed that some facilities have exaggerated crowns. For these cases, the driveway costs were doubled to account for the additional required materials. These facilities were flagged with a value of "yes" in the [DrivewayCostPlus] field in the attribute table.

The following is a list of roads with exaggerated crowns:

Aiken Ave	Bruton Rd	Haddon Rd	N Benjamin St
Alcona Ave	Bunn Ter	Harper Pl	Nancy Rhodes Dr
Andrews Rd	C View St	Herbert St	Omaha St
Ardmore Dr	Cathy Dr	Hunter St	Panama Ter
Arlene St	Crabtree Ave	Kate St	Post Ave
Arrowhead Dr	Craven St	King St	Southern Ave
Ashley St	Dacian Ave	Lamar St	Stillview Dr
Ayers Pl	Devon Rd	Lang St	Turner St
Azalea Dr	Dittmar Dr	Leyburn Pl	Usher St (2)
Banner St	Englewood Ave	Locust Dr	Willa Way
Bay St	Felix St	Macon St	Wisteria Ave
Biscayne Rd	Fenimore St	Macon St (2)	Womack Dr
Bonhill Dr	Freemont Rd	McLaurin Ave	
Brooks Rd	Gordon St	Minerva Ave	

Manhole & Valve Adjustment Cost

For each road, the cost for adjusting manholes and valve boxes was calculated as follows:

$$Cost = (number\ of\ manholes * \$1,500) + (number\ of\ valves * \$1,500)$$

These values are stored in table "tblAssets":

AssetType	Cost
Manhole	\$1,500.00
WaterValve	\$1,500.00
Ditch	\$10.00
Driveway	\$125.00
Pipe	\$10.00

Pipe Maintenance Cost

Pipe maintenance costs were calculated as a variable cost based on dollars per linear foot of road. This calculation was applied to all roads.

$$Pipe\ Maintenance\ Cost = Road\ Length * Cost\ per\ Foot$$

The cost per dollar can be modified by the user.

This value is stored in table "tblAssets":

AssetType	Cost
Manhole	\$1,500.00
WaterValve	\$1,500.00
Ditch	\$10.00
Driveway	\$125.00
Pipe	\$10.00

Once the preliminary calculations are done, the costs for each pavement option are calculated as described below. The unit costs for each pavement option are in cost per square yard and stored in table "tblTreatments".

Description	PricePerSqYd *
Condition Existing Base (CEB) with AST Pavement	9.75
Condition Existing Base (CEB) with 2" Surface Course	38.5
Condition Existing Base (CEB) with 3" Base Course and 1.75" Surface Course	94.25
Cement Stabilized Base (CSB) (Dry Application) with AST	21.5
Cement Stabilized Base (CSB) (Dry Application) with 2" Surface Course	50.25
Cement Stabilized Base (CSB) (Dry Application) with 3" Base Course and 1.75" Surface Course	106
Cement Stabilized Base (CSB) (Wet Application) with AST	24.05
Cement Stabilized Base (CSB) (Wet Application) with 2" Surface Course	52.8
Cement Stabilized Base (CSB) (Wet Application) with 3" Base Course and 1.75" Surface Course	108.5

Condition Existing Base with AST Pavement

Field: PCC_CEBAST

*Cost = (Area * CEBAST Unit Cost) + Turnaround Cost + Manhole & Valve Cost + Ditch Cleaning Cost + Driveway Cost + Pipe Maintenance Cost + Widening Cost*

Condition Existing Base with 2" Surface Course

Field: PCC_CEBPMLD

*Cost = (Area * CEBPMLD Unit Cost) + Turnaround Cost + Manhole & Valve Cost + Ditch Cleaning Cost + (Driveway Cost * 7.5) + Pipe Maintenance Cost + Widening Cost*

Condition Existing Base with 3" Base Course and 1.75" Surface Course

Field: PCC_CEBPMHD

*Cost = (Area * CEBPMHD Unit Cost) + Turnaround Cost + Manhole & Valve Cost + Ditch Cleaning Cost + Driveway Cost + Pipe Maintenance Cost + Widening Cost*

Cement Stabilized Base (Dry Application) with AST

Field: PCC_FDCSAST

*Cost = (Area * FDCSAST Unit Cost) + Turnaround Cost + Manhole & Valve Cost + Ditch Cleaning Cost + Driveway Cost + Pipe Maintenance Cost + Widening Cost*

Cement Stabilized Base (Dry Application) with 2" Surface Course

Field: PCC_FD CSPMLD

*Cost = (Area * FD CSPMLD Unit Cost) + Turnaround Cost + Manhole & Valve Cost + Ditch Cleaning Cost + Driveway Cost + Pipe Maintenance Cost + Widening Cost*

Cement Stabilized Base (Dry Application) With 3" Base Course and 1.75" Surface Course

Field: PCC_FD CSPMHD

*Cost = (Area * FD CSPMHD Unit Cost) + Turnaround Cost + Manhole & Valve Cost + Ditch Cleaning Cost + (Driveway Cost * 7.5) + Pipe Maintenance Cost + Widening Cost*

Cement Stabilized Base (Wet Application) with AST

Field: PCC_FD CSWetAST

*Cost = (Area * FD CSWetAST Unit Cost) + Turnaround Cost + Manhole & Valve Cost + Ditch Cleaning Cost + Driveway Cost + Pipe Maintenance Cost + Widening Cost*

Cement Stabilized Base (Wet Application) with 2" Surface Course

Field: PCC_FD CSWetPMLD

*Cost = (Area * FD CSWetPMLD Unit Cost) + Turnaround Cost + Manhole & Valve Cost + Ditch Cleaning Cost + Driveway Cost + Pipe Maintenance Cost + Widening Cost*

Cement Stabilized Base (Wet Application) With 3" Base Course and 1.75" Surface Course

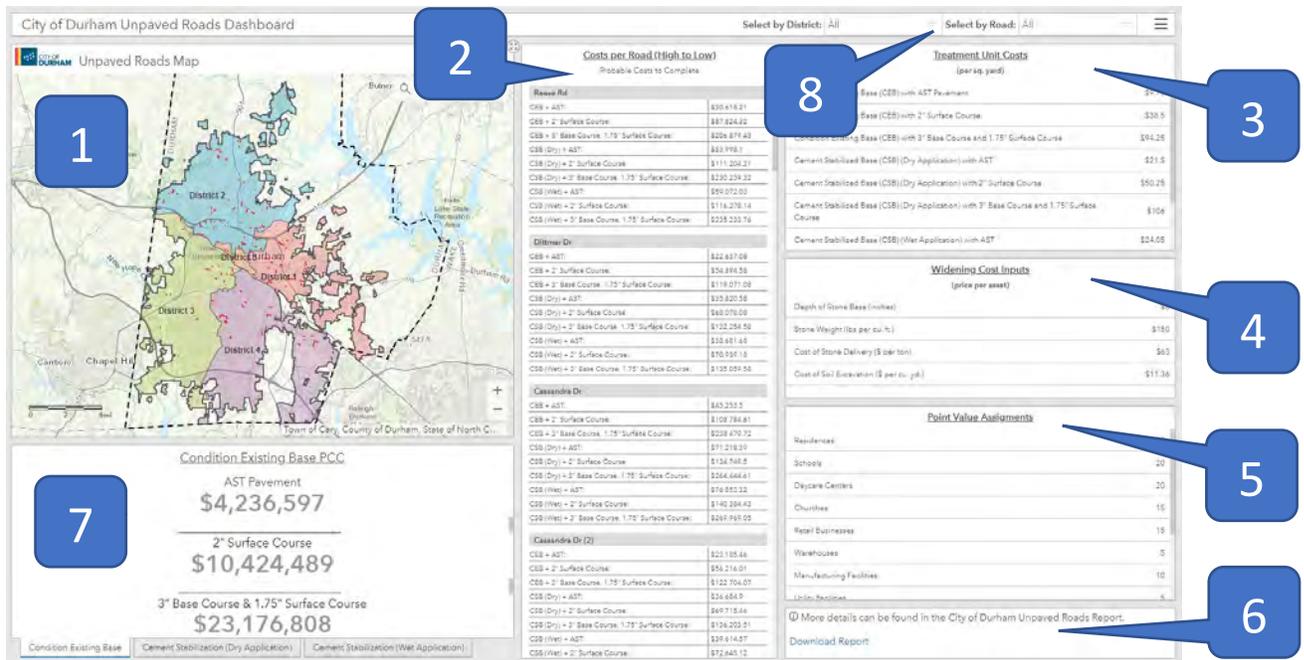
Field: PCC_FDCSWetPMHD

*Cost = (Area * FDCSWetPMHD Unit Cost) + Turnaround Cost + Manhole & Valve Cost + Ditch Cleaning Cost + (Driveway Cost * 7.5) + Pipe Maintenance Cost + Widening Cost*

7.2 GIS Dashboard

An ArcGIS Online dashboard was developed for viewing the results of the tool cost calculations and is intended as a way to allow non-technical users to view the results of cost calculations. Therefore, it has a simplified interface with basic functionality. Because it is web-based, it is available to users that do not have access to GIS software. Access to the dashboard is to be determined by the City's IT department. Due to the potentially sensitive nature of the data displayed in the dashboard, and because interpreting the results requires specific knowledge and context, the dashboard is not intended for use by the general public.

After the tool is run, the results are synchronized with ArcGIS Online and viewed in the dashboard interface. The dashboard is strictly for viewing and does not allow for data entry or execution of the tool. The dashboard allows the user to view the cost results for the entire city, by PAC District, or for individual roads. The screenshot and legend of the dashboard is included.



1. Map showing unpaved roads
2. Costs per Road
3. Unit Costs for each pavement option
4. Inputs used for calculating widening costs
5. Point values used in calculating point scores
6. Link for downloading the final report
7. Total costs for pavement options (one tab per option)
8. Pull-down menus for selecting districts and roads

SECTION 8 - CONCLUSION

SEPI has determined that the City's unpaved roads are in good condition. Based on the City's wishes to widen roads to the current standard, our recommendation is, where current road width is acceptable, perform routine maintenance, condition existing base, and pave with the most cost-effective light duty option. Where current road width is too narrow, widen to the greatest width possible without grading, up to 22 feet. SEPI believes that conditioning the existing base and paving with a 2" plant mix surface course is the most economical and practical option that will provide a quality road with relatively low maintenance. The recommended expenditure plan spreads the paving cost over 10 years and prioritizes roads based on their use. Additionally, we are providing a pavement management tool that is based on objective measures with a strong emphasis on points assigned to traffic generators. The tool is easily adaptable and can conform to many types of changing conditions: points values can be modified, land uses can be added or deleted, and unit cost can be changed in response to changing market conditions.

APPENDIX A
Feature Class Descriptions

This section contains descriptions of the contents of the geodatabase:
Durham_Unpaved_Roads_2019_FINAL.gdb

Feature Class: Unpaved Roads

Description: Unpaved roads within the City of Durham

Name: Unpaved Roads
Feature Type: Polyline
Has Attachments?: True (photographs)

Field	Type	Length	Description
FACILITYID	String	20	Facility ID from City streets data
Length ft	SmallInteger	2	Length of road in feet
Width ft	SmallInteger	2	Width of road in feet
Ward	String	10	City ward number
CntResidences	SmallInteger	2	Number of Residences
CntSchools	SmallInteger	2	Number of Schools
CntDaycares	SmallInteger	2	Number of Daycare Centers
CntChurches	SmallInteger	2	Number of Churches
CntRetailBusinesses	SmallInteger	2	Number of Retail Businesses
CntWarehouses	SmallInteger	2	Number of Warehouses
CntManufacturingFacs	SmallInteger	2	Number of Manufacturing Facilities
CntUtilityFacs	SmallInteger	2	Number of Utility Facilities
CntRecreationalFacs	SmallInteger	2	Number of Recreational Facilities
CntManholes	SmallInteger	2	Number of Manholes
CntWaterValves	SmallInteger	2	Number of Water Valves
PvmtConn	String	255	Pavement Connectivity?
PtsResidences	SmallInteger	2	Total points for Residences
PtsSchools	SmallInteger	2	Total points for Schools
PtsDaycares	SmallInteger	2	Total points for Daycares
PtsChurches	SmallInteger	2	Total points for Churches
PtsRetailBusinesses	SmallInteger	2	Total points for Retail Businesses
PtsWarehouses	SmallInteger	2	Total points for Warehouses
PtsManufacturingFacs	SmallInteger	2	Total points for Manufacturing Facilities
PtsUtilityFacs	SmallInteger	2	Total points for Utility Facilities

Field	Type	Length	Description
PtsRecreationalFacs	SmallInteger	2	Total points for Recreational Facilities
PtsPvmtConn	SmallInteger	2	Total points for Pavement Connectivity
ptsTotal	SmallInteger	2	Total Points
PCC_CEBAST	Double	8	Cost for Conditioning Existing Base with AST Pavement
PCC_CEBPMLD	Double	8	Cost for Conditioning Existing Base with 2" Surface Course
PCC_CEBPMHD	Double	8	Cost for Conditioning Existing Base with 3" Base Course and 1.75" Surface Course
PCC_FDCSAST	Double	8	Cost for Cement Stabilized Base (Dry Application) with AST
PCC_FDCSPMLD	Double	8	Cost for Cement Stabilized Base (Dry Application) with 2" Surface Course
PCC_FDCSPMHD	Double	8	Cost for Cement Stabilized Base (Dry Application) With 3" Base Course and 1.75" Surface Course
PCC_FDCSWetAST	Double	8	Cost for Cement Stabilized Base (Wet Application) with AST
PCC_FDCSWetPMLD	Double	8	Cost for Cement Stabilized Base (Wet Application) with 2" Surface Course
PCC_FDCSWetPMHD	Double	8	Cost for Cement Stabilized Base (Wet Application) With 3" Base Course and 1.75" Surface Course
PPD_CEBAST	Double	8	Points per Dollar for Conditioning Existing Base with AST Pavement
PPD_CEBPMLD	Double	8	Points per Dollar for Conditioning Existing Base with 2" Surface Course
PPD_CEBPMHD	Double	8	Points per Dollar for Conditioning Existing Base with 3" Base Course and 1.75" Surface Course
PPD_FDCSAST	Double	8	Points per Dollar for Cement Stabilized Base (Dry Application) with AST
PPD_FDCSPMLD	Double	8	Points per Dollar for Cement Stabilized Base (Dry Application) with 2" Surface Course
PPD_FDCSPMHD	Double	8	Points per Dollar for Cement Stabilized Base (Dry Application) With 3" Base Course and 1.75" Surface Course
PPD_FDCSWetAST	Double	8	Points per Dollar for Cement Stabilized Base (Wet Application) with AST
PPD_FDCSWetPMLD	Double	8	Points per Dollar for Cement Stabilized Base (Wet Application) with 2" Surface Course
PPD_FDCSWetPMHD	Double	8	Points per Dollar for Cement Stabilized Base (Wet Application) With 3" Base Course and 1.75" Surface Course

Field	Type	Length	Description
PaveName	String	50	PaveName
SummaryFlag	SmallInteger	2	SummaryFlag
Cluster	String	3	Road is part of a cluster
DeadEnd	String	3	Dead end
Width1	Double	8	Base width
Width2	Double	8	All-weather width
DitchCleaning	String	3	Ditch cleaning required?
PipeMaint	String	3	Pipe Maintenance required?
Dist	String	50	PAC District number
DrivewayCostPlus	String	3	Additional driveway cost?

Table: UnPaved_Roads__ATTACH

Description: Attachments (photographs) for the unpaved roads feature class.

Name: UnPaved_Roads__ATTACH

Field	Type	Length	Alias Name	Description
REL_OBJECTID	Integer	4	REL_OBJECTID	REL_OBJECTID
CONTENT_TYPE	String	150	CONTENT_TYPE	CONTENT_TYPE
ATT_NAME	String	250	ATT_NAME	ATT_NAME
DATA_SIZE	Integer	4	DATA_SIZE	DATA_SIZE
DATA	Blob	0	DATA	DATA

Table: tblAssets

Description: Contains unit costs for assets used in cost calculations.

Name: tblAssets

Has Attachments?: false

Field	Alias	Type	Length	Description
AssetType	AssetType	String	50	Input criteria (land use, connectivity)
Cost	Cost	Double	0	Unit cost used in calculations
CostDefault	CostDefault	Double	0	Default unit cost

Table: tblPoints

Description: Contains point values for use in prioritization calculations.

Name: tblPoints

Has Attachments?: false

Field	Alias	Type	Length	Description
Input	Input	String	50	Input criteria (land use, connectivity)
PointValue	PointValue	SmallInteger	2	Point value used in calculations
PointValueDefault	PointValueDefault	SmallInteger	2	Default point value

Table: tblTreatments

Description: Contains paving options and associated unit costs for use in cost calculations.

Name: tblTreatments

Has Attachments?: false

Field	Alias	Type	Length	Description
TreatmentType	Input	String	50	Paving option (abbreviated)
Descr	Description	String	100	Description of Paving Option
PriceSqYd	PricePerSqYd	Double	0	Price per square yard used in calculations
PriceSqYdDefault	PriceSqYdDefault	Double	0	Default price per square yard

Table: tblTurnarounds

Description: Contains turnaround options and costs for use in cost calculations.

Name: tblTurnarounds

Has Attachments?: false

Field	Alias	Type	Length	Description
Turnaround Type	Turnaround Type	String	50	Turnaround Type
Cost	Cost	Double	0	Cost of adding turnaround used in cost calculations
Cost Default	Cost Default	Double	0	Default cost of adding turnaround

Table: tblWidening

Description: Contains input parameters for use in widening cost calculations.

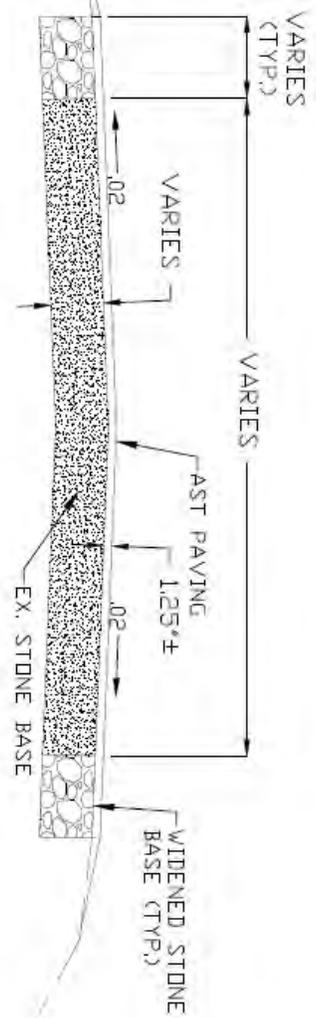
Name: tblWidening

Has Attachments?: false

Field	Alias	Type	Length	Description
Item	Item	String	50	Item used in widening cost calculations
AmountPerAsset	AmountPerAsset	Double	0	Value of input item
DefaultPerAsset	DefaultPerAsset	Double	0	Default value of input item
Descr	Description	String	50	Description of input item

APPENDIX B

Typical Sections



CONDITION EXISTING BASE WITH AST PAVEMENT

NIS

UNPAVED ROAD STUDY
TYPICAL SECTION

CITY OF DURHAM



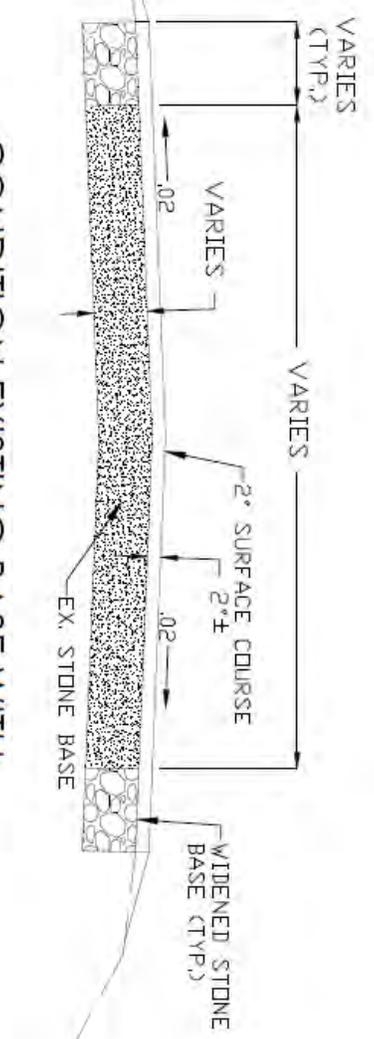
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SHEET NUMBER:
1 OF 9

CONDITION EXISTING BASE WITH
2" SURFACE COURSE
NTS



SHEET NUMBER:
2 OF 9

UNPAVED ROAD STUDY
TYPICAL SECTION

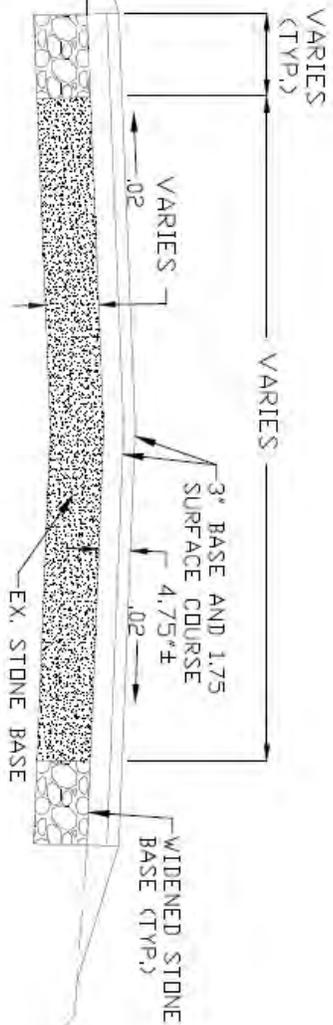
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CONDITION EXISTING BASE WITH 3" BASE COURSE AND 1.75" SURFACE COURSE
NTS



UNPAVED ROAD STUDY
TYPICAL SECTION

CITY OF DURHAM

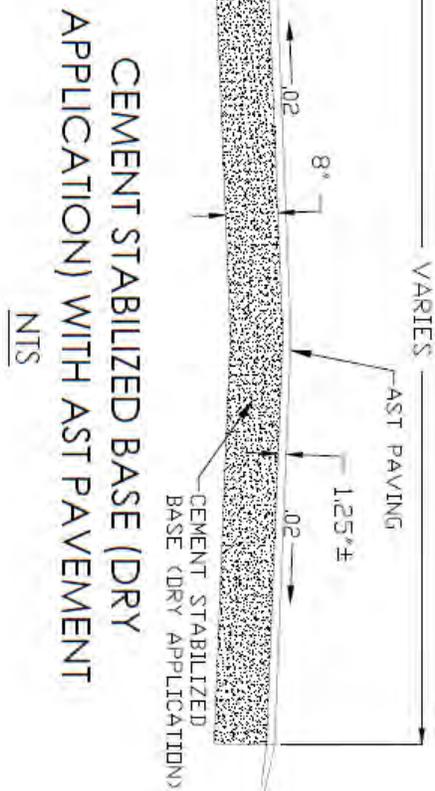
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3 OF 9



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UNPAVED ROAD STUDY
TYPICAL SECTION

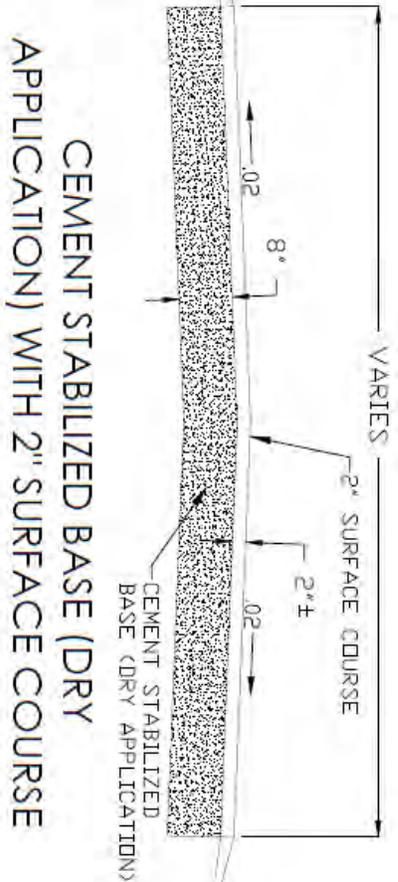
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UNPAVED ROAD STUDY
TYPICAL SECTION

CITY OF DURHAM

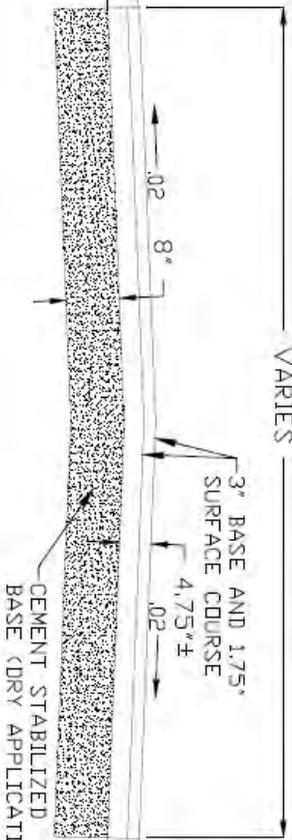
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CEMENT STABILIZED BASE (DRY APPLICATION) WITH
 3" BASE COURSE AND 1.75" SURFACE COURSE
NTS



UNPAVED ROAD STUDY
 TYPICAL SECTION

CITY OF DURHAM

SHEET NUMBER:
 6 OF 9

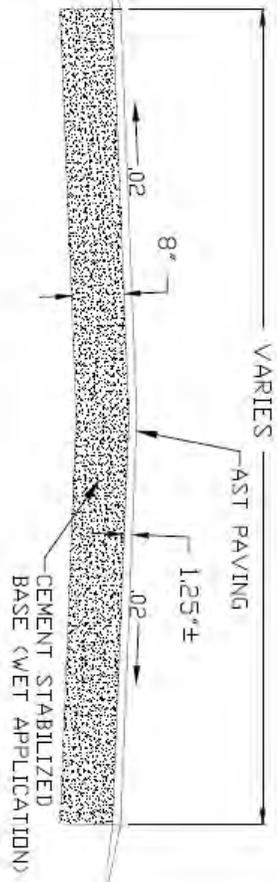


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CEMENT STABILIZED BASE (WET APPLICATION) WITH AST PAVEMENT
NIS



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7 OF 9

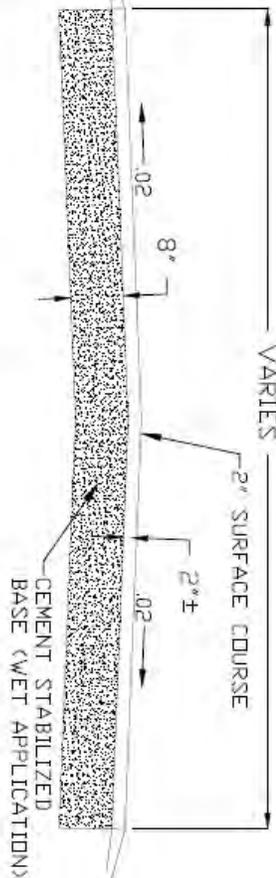
UNPAVED ROAD STUDY
TYPICAL SECTION

CITY OF DURHAM



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CEMENT STABILIZED BASE (WET APPLICATION) WITH 2" SURFACE COURSE
NIS



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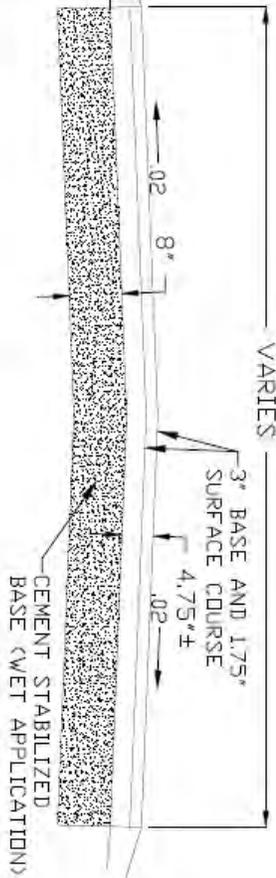


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SHEET NUMBER:
 8 OF 9

CEMENT STABILIZED BASE (WET APPLICATION) WITH
 3" BASE COURSE AND 1.75" SURFACE COURSE
 NTS



SHEET NUMBER:
 9 OF 9

UNPAVED ROAD STUDY
 TYPICAL SECTION

CITY OF DURHAM



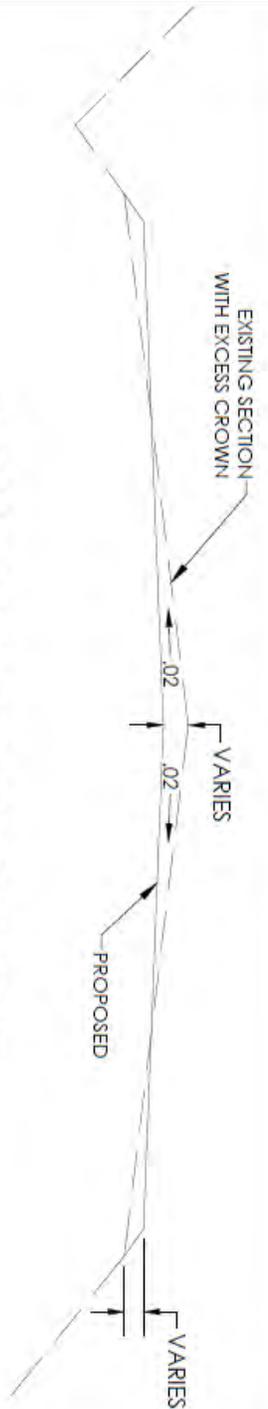
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APPENDIX C
Trimat Subgrade Testing

APPENDIX D
Correcting for Excess Crown



CORRECTING FOR EXCESS CROWN NOTES

LIST OF APPLICABLE ROADS:

1. AYERS PL
2. HERBERT ST
3. BANNER ST
4. HADDON RD
5. USHER ST
6. SOUTHERN AVE
7. CRABTREE AVE
8. CRAVEN ST
9. PANAMATER
10. BISCAYNE RD
11. MACON ST
12. ARLENE ST
13. KATE ST
14. BENJAMINE ST
15. AZALEA AVE
16. ANDREWS RD
17. FELIX ST
18. LEYBURN PL
19. MINERVA AVE
20. HUNTER ST
21. STILLVIEW DR
22. WOMACK DR
23. GORDON ST
24. FENIMORE ST
25. TURNER ST
26. WISTERIA AVE
27. HARPER PL
28. BONHILL DR
29. OMAH ST
30. DITTMAR DR
31. DACIAN AVE
32. C VIEW ST
33. KING ST
34. LOCUST DR
35. LANG ST
36. BROOKS RD
37. FREEMONT RD
38. LAMAR ST
39. MCLAURIN AVE
40. BAY ST
41. ALCONA AVE
42. ENGLEWOOD AVE
43. ARROWHEAD DR
44. BRUTON RD
45. POST AVE
46. WILLA WAY
47. NANCY RHODES DR
48. DEVON RD
49. BUNN TER
50. ASHLEY ST
51. CATHY DR
52. AIKEN AVE
53. ARDMORE DR
54. ANY ROAD THAT HAS EXAGGERATED CROWN (STEEPER THAN .02 NORMAL CROWN)

NOTES:

1. CAN BE APPLIED TO ANY OF THE NINE PAVEMENT DESIGNS.
2. APPLY THIS METHOD AS PART OF PREPARING THE ROAD PRIOR TO PAVING.
3. WIDTH VARIES.
4. BALANCE CUT AND FILL.
5. MAINTAIN A PREPARED STONE BASE OF 4 INCHES MINIMUM ABOVE SOIL SUBGRADE.

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