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## Impervious Surface Analysis for Durham Under Current and Build-Out Conditions In Support of Stormwater Management

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October 22, 2007

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**Impervious Surface Analysis for  
Durham Under Current and  
Build-Out Conditions  
In Support of Stormwater  
Management**

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*Prepared For:*

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## 1. INTRODUCTION

An analysis was performed to determine current and projected impervious surface areas in the Town of Durham, New Hampshire with the purpose of generating data to guide the adoption of stormwater management practices in the Town. Because impervious surfaces affect stormwater runoff peak flows and volumes significantly, it is critical to understand the Town's impervious area characteristics (and the resulting stormwater management implications) under current conditions in order to develop appropriate stormwater management policies.

The analysis presented in this report is based on datasets developed in previous studies to summarize impervious surface areas and percents by land use zoning district and watershed. Three different scenarios are evaluated:

1. Impervious surface under existing (2005) conditions
2. Impervious surface under build-out conditions using maximum allowable impervious surface ratios
3. Impervious surface under build-out conditions using representative impervious surface ratios

The first scenario is meant to serve as a baseline from which to compare projected future conditions. The second scenario represents a more conservative (higher) projection of impervious surface areas under build-out conditions by using the maximum allowable impervious surface ratios based on current zoning. The third scenario is a more realistic projection under build-out conditions by using impervious surface ratios representative of actual development with the town of Durham.

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## 2. DATA COMPILATION AND ANALYSIS

### 2.1. Data

Impervious surface was assessed for both existing and build-out conditions. Datasets from several previous studies served as the basis for this analysis.

#### 2.1.1. *Impervious Surface Dataset*

The “New Hampshire GRANIT 2006 *Impervious Surfaces in Coastal New Hampshire – 2005*” GIS dataset was used as the basis for determining the town’s impervious surface areas and percents under current conditions. In addition, this dataset was used to assess impervious surface for all developed and undevelopable areas of Durham under the build-out scenarios. This dataset is a 30-meter resolution raster that has a classification for each pixel by the percent of impervious area within the pixel.

#### 2.1.2. *2005 Build-out Analysis*

An objective of this study was to be as consistent as possible with the Stafford Regional Planning Commission’s *Town of Durham Build-Out Analysis*, and not to repeat any efforts unnecessarily. Therefore, we extracted data from the Stafford RPC analysis where possible.

The GIS layer of constrained land developed during the Stafford RPC study was used to restrict areas for development under build-out conditions. These constrained lands included poor soils, floodplains, high slope areas, and protected land among others. For further information contact the Stafford RPC (603-742-2523). In addition, the collection of residential parcels with developable land was obtained from the RPC study. For the impervious surface analysis, this included all parcels evaluated for residential build-out, including those that would require special waivers in order to build.

#### 2.1.3. *Parcels and Zoning Districts*

The parcel and zoning district datasets were obtained from the Town of Durham Information Technology Department. In addition to parcel boundaries, the Town provided an estimation of which parcels were vacant and developable based on Assessor database classifications. Since the Stafford RPC build-out considered only residential development zones, the “vacant” parcels provided by the Town were used to represent developable lots in mixed use and non-residential zoning districts that were not covered by the RPC build-out.

#### **2.1.4. Watershed Boundaries**

The watersheds used to represent stormwater drainages were chosen to be the US Geological Survey (USGS) 12-digit hydrologic units (HUC12s). HUC12s are the smallest watershed unit catalogued by the USGS. These boundaries were obtained from the New Hampshire GRANIT GIS data portal.

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### 3. ANALYSIS METHODS

The objective of this analysis was to generate impervious surface areas and percents by zoning district and watershed for three different scenarios: 1.) current conditions, 2.) build-out conditions assuming maximum impervious surface ratios, and 3.) build-out conditions assuming representative impervious surface ratios. In order to maximize data consistency between the current and projected scenarios and between zoning districts and parcels, an approach was taken to perform all analyses at the parcel level and to then aggregate results up to the zoning district or watershed as appropriate. The methods used to perform these analyses will be described in the following sections.

#### 3.1. Scenario 1: Current Conditions

The assessment of current conditions required the calculation of impervious surfaces for each parcel in Durham using the NH GRANIT Impervious Surface dataset. Calculations were made only for parcels in the Town's parcel dataset and were not made for the right-of-ways (ROWs), such as roads. Since the objective of this study was to compare the impacts of build-out scenarios on impervious surfaces at the zoning district and watershed level, exclusion of ROWs from the analyses was appropriate (Note: the zoning district GIS layer provided by the Town also excluded ROWs in the determination of zoning district boundaries).

In order to calculate zoning-district level impervious areas, each parcel was assigned a zoning district. This was performed by locating the center of each parcel and identifying the zoning district from the GIS dataset provided by the Town. Once a zoning district was assigned to each parcel, the zoning district-level statistics were calculated.

Calculation of impervious surface areas by watersheds required the union of the parcel's spatial dataset with the HUC12 spatial dataset. Impervious areas were summarized for each watershed by summing the impervious areas for all parcels within each watershed. For parcels that were split into multiple watersheds, the impervious area of the parcel was apportioned to each watershed based on the area of the parcel falling within each watershed.

#### 3.2. Scenario 2: Build-out Conditions, Maximum Impervious Surface Ratios

The objective of Scenario 2 was to project impervious surface areas under build-out conditions using impervious surface ratios from Durham's Zoning Ordinance's "Table of Dimensional Requirements." This scenario represents a conservative (on the high side) projection of future impervious surface. In this scenario, impervious areas based on current conditions will be used to represent all developed parcels and projected impervious areas will be used for all developable parcels. The primary

steps for this analysis were identifying the developable lots, calculating the buildable area for those lots, determining the build-out impervious percents and areas for each parcel (developed and undeveloped), aggregating results to zoning district, and aggregating results to watershed.

### **3.2.1. Determining Developable Lots**

Developable residential lots were extracted from Stafford RPC build-out results tables. This list of lots included lots designated as requiring waivers in order to build<sup>1</sup>. Additional developable lots were added to the analysis from the “vacant” parcels list provided by the Town of Durham. Vacant parcels that fell in zoning districts that were not evaluated by the Stafford RPC were added to the list of developable parcels for the impervious surface analysis. Vacant parcels were from the following zoning districts: C, CC, CH, OR, ORLI, and PO.

### **3.2.2. Calculation of Buildable Area**

Buildable area was calculated for each parcel by overlaying the constrained lands layer from the Stafford RPC build-out with the parcels layer. For each parcel, all areas outside the constrained lands were designated as buildable area. The buildable area was used as the portion of the parcel to which the impervious surface ratios were applied.

### **3.2.3. Parcel-Level Impervious Area Calculations**

The impervious areas and percents for developable parcels were determined by multiplying the impervious surface ratios from the Table of Dimensional Requirements (see Table 1) by the buildable areas for parcels in the appropriate zoning districts. For parcels classified by the Stafford RPC as either landlocked or part of a conservation subdivision, an additional 10% impervious area was assigned to the buildable area of the parcel. This 10% corresponds to the 10% roads area applied in the RPC build-out for these same parcels. Projected impervious areas for developed and undevelopable parcels were assigned the same values as those determined for current conditions.

### **3.2.4. Aggregation to Zoning District and Watershed**

The parcel-level impervious data were aggregated to zoning district by summing the impervious areas from each parcel based on the parcel’s zoning district assignment. Determination of watershed-level impervious areas was performed by using the NH GRANIT dataset to calculate the impervious areas for the developed

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<sup>1</sup> Several parcels in the PO district that were either build-out parcels or waiver parcels in the Stafford RPC build-out were reclassified as “undevelopable” for this exercise. Upon inspection of an orthophoto, these parcels were determined to already contain substantial development.



and undevelopable portion of each watershed and then adding in the apportioned areas from the developable parcels based on the parcel-level build-out calculations.

### **3.3. Scenario 3: Build-out Conditions, Representative Impervious Surface Ratios**

The objective of Scenario 3 was to project impervious surface areas under build-out conditions using surface ratios representative of existing development in Durham. This scenario represents a more realistic projection of future impervious surface since it attempts to model observed development patterns. In this scenario, impervious areas based on current conditions will be used to represent all developed/undevelopable parcels and projected impervious areas will be used for all developable parcels. The primary steps for this analysis were the same as for Scenario 2: identifying the developable lots, calculating the buildable area for those lots, determining the build-out impervious percents and areas for each parcel (developed and undeveloped), aggregating results to zoning district, and aggregating results to watershed. However, Scenario 3 required that representative impervious surface ratio be determined for all zoning districts with developable parcels. This process is described in the following sections.

#### ***3.3.1. Identification of Representative Areas***

Zoning districts with developable parcels were determined so that neighborhoods or groups of parcels that represent typical development in that zoning district could be identified. The zoning districts with developable parcels were determined to be: RA, RB, RC, R, PO, CH, C, CC, OR, and ORLI.

Representative areas for each zoning district were identified by examining the 2005 orthophotography for Durham with overlays of parcel boundaries, zoning districts, and the Stafford RPC constrained lands data layer. The criteria for choosing a group of parcels to be representative of the zoning district were:

- the lot sizes for the group of parcels be consistent with zoning district characteristics
- the land usage for the group of parcels be consistent with current zoning district characteristics, and
- the group of parcels be minimally impacted by constrained lands so that the calculation of impervious surface ratios would be based on parcels that have 100% (or nearly 100%) buildable land.

Once representative areas were identified, they were hand digitized following both existing parcel boundaries and the orthophoto for guidance.

#### ***3.3.2. Calculation of Representative Impervious Surface Ratios***

Impervious surface ratios for each representative area were calculated by hand digitizing the impervious surface areas as evident from the infra-red orthophotos.

Impervious areas, including walkways, driveways, patios, and buildings, are clearly evident in this imagery. The ratios were calculated by dividing the impervious area by the total area for the representative area. The ratios calculated based on representative areas are compared with the ratios from the “Table of Dimensional Requirements” (TDR) in Table 1. As we had anticipated, the impervious surface ratios for the representative areas are generally less than the values from the TDR.

<b>Table 1: Comparison of build-out impervious surface ratios for zones with developable lots</b>		
<b>Zoning District</b>	<b>Impervious Surface Ratio (TDR<sup>1</sup>)</b>	<b>Impervious Surface Ratio (Representative Areas)</b>
Residence A (RA)	33%	16%
Residence B (RB)	30%	11%
Residence C (RC)	20%	13%
Rural (R)	20%	11%
Professional Office (PO)	50%	38%
Church Hill (CH)	80%	41%
Courthouse (C)	80%	69%
Coe’s Corner (CC)	30%	26%
OR-Route 108 (OR)	50%	30%
Office, Research Light Ind. (ORLI)	50%	50%

1. Table of Dimensional Requirements

#### 4. RESULTS AND DISCUSSION

##### 4.1. Impervious Surface Results by Zoning District

A summary of the results of the analysis of impervious surface by zoning district for the three scenarios studied is presented in Table 2.

<b>Zoning District</b>	<b>Total Area (ac)</b>	<b>Current Impervious Surface Area (ac)/(%)</b>	<b>Scenario 2: Impervious Surface Area (ac)/(%)</b>	<b>Scenario 3: Impervious Surface Area (ac)/(%)</b>
Residence A (RA)	895.2	225.7 / 25.2	251.2 / 28.1	229.6 / 25.7
Residence B (RB)	1,368.4	101.8 / 7.4	212.1 / 15.5	108.1 / 7.9
Residence C (RC)	2,533.1	154.5 / 6.1	324.9 / 12.8	274.8 / 10.8
Rural (R)	6,979.52	172.3 / 2.5	604.8 / 8.7	452.0 / 6.5
Professional Office (PO)	28.3	14.3 / 41.2	15.0 / 52.8	14.6 / 51.4
Church Hill (CH)	25.6	10.3 / 40.3	11.3 / 44.3	10.7 / 42.0
Courthouse (C)	10.5	5.0 / 47.6	5.9 / 55.6	5.7 / 54.2
Coe's Corner (CC)	33.1	6.6 / 20.1	7.7 / 23.4	7.5 / 22.8
OR-Route 108 (OR)	111.4	15.9 / 14.2	31.3 / 28.1	23.7 / 21.3
Office, Research Light Ind. (ORLI)	741.1	71.8 / 9.7	158.0 / 21.3	158.0 / 21.3
Central Business (CB) <sup>1</sup>	30.5	14.0 / 45.8	14.0 / 45.8	14.0 / 45.8
Durham Business Park (DBP) <sup>1</sup>	48.9	8.1 / 16.6	8.1 / 16.6	8.1 / 16.6
Multi-Unit Dwelling (MUDOR) <sup>1</sup>	776.1	87.2 / 11.2	87.2 / 11.2	87.2 / 11.2
<b>Town Total<sup>2</sup></b>	<b>13,581.9</b>	<b>886.9 / 6.5</b>	<b>1,731.5 / 12.7</b>	<b>1,394.2 / 10.3</b>

1. Zoning district does not have any developable parcels

2. Town total acreages only include parcel areas and do not include right-of-ways such as roads

Table 3 provides the details of how much the impervious areas will increase above current levels based on the two different build-out scenarios. Also shown in Table 3 is the decrease in impervious surface that can be realized by following a build-out that uses the representative impervious surface ratios as opposed to the higher ratios found in the Table of Dimensional Requirements. Based on the Scenario 2 build-out, the zoning districts with the greatest percent increase in impervious surface area are R, ORLI, and RC. The rankings are the same for the Scenario 3 build-out with zoning districts. The results also show that by adopting the more representative impervious surface ratios, the build-out impervious surface areas can be reduced by as much as 150 acres in just the “R” zoning district. This suggests that future development can occur with considerably less impervious surface than would be indicated by the current zoning specifications.

<b>Table 3: Change in impervious surface area by zoning district</b>			
<b>Zoning District</b>	<b>Scenario 2: Impervious Surface Area Increase (ac)/(%)</b>	<b>Scenario 3: Impervious Surface Area Increase (ac)/(%)</b>	<b>Reduction by Following Scenario 3 Build-out (ac)</b>
Residence A (RA)	25.4 / 11.3	3.9 / 1.7	21.5
Residence B (RB)	110.3 / 108.3	6.3 / 6.2	104.0
Residence C (RC)	170.4 / 110.3	120.4 / 77.9	50.1
Rural (R)	432.5 / 251.0	279.7 / 162.3	152.8
Professional Office (PO)	0.6 / 4.5	0.2 / 1.6	0.4
Church Hill (CH)	1.0 / 9.8	0.4 / 4.2	0.6
Courthouse (C)	0.8 / 16.8	0.7 / 13.9	0.1
Coe’s Corner (CC)	1.1 / 16.8	0.9 / 13.7	0.2
OR-Route 108 (OR)	15.5 / 97.4	7.9 / 49.5	7.6
Office, Research Light Ind. (ORLI)	86.2 / 120.0	86.2 / 120.0	0.0

#### **4.2. Impervious Surface Results by Watershed**

A summary of the results of the analysis of impervious surface by watershed for current conditions and the two build-out scenarios studied is presented in Table 4.

<b>Watershed</b>	<b>Total Area (ac)</b>	<b>Current Impervious Surface Area (ac)/(%)</b>	<b>Scenario 2: Impervious Surface Area (ac)/(%)</b>	<b>Scenario 3: Impervious Surface Area (ac)/(%)</b>
Bellamy River	109.6	13.8 / 12.6	17.5 / 16.0	15.9 / 14.5
Oyster River	6531.8	645.3 / 9.9	1,046.0 / 16.0	872.9 / 13.4
Lower Lamprey River	3141.8	120.0 / 3.8	253.4 / 8.1	198.9 / 6.3
Great Bay	3044.2	79.0 / 2.6	319.8 / 10.5	235.1 / 7.7
Piscassic River	684.7	19.2 / 2.8	80.9 / 11.8	59.7 / 8.7

Table 5 is analogous to Table 3 and shows how much the impervious areas will increase above current levels based on the two different build-out scenarios. The results in Table 5 suggest that the Great Bay and Piscassic watersheds will experience the highest percent increase in impervious surface under build-out conditions. The Oyster River is expected to see the highest total increase in impervious surface acreage, which is not surprising, given that the Oyster River watershed covers the largest fraction of the town. This is true looking at both the Scenario 2 and the Scenario 3 results. As with the zoning district results, these show that by adopting the more representative impervious surface ratios, the build-out impervious surface areas will be significantly reduced.

<b>Zoning District</b>	<b>Scenario 2: Impervious Surface Area Increase (ac)/(%)</b>	<b>Scenario 3: Impervious Surface Area Increase (ac)/(%)</b>	<b>Reduction by Following Scenario 3 Build-out (ac)</b>
Bellamy River	3.7 / 26.8	2.1 / 15.2	1.6
Oyster River	400.7 / 62.1	227.6 / 35.3	173.1
Lower Lamprey River	133.5 / 111.3	79.0 / 65.8	54.5
Great Bay	240.9 / 305.1	156.1 / 197.8	84.8
Piscassic River	61.6 / 320.6	40.5 / 210.5	21.2

### **4.3. Summary**

An analysis of current and projected future impervious surface areas was performed for the Town of Durham. The objective of the analysis was to generate data that may provide guidance in the development of stormwater management regulations and practices for the Town. The analysis drew from previously developed datasets and studies in making the

impervious surface predictions. Two build-out scenarios were evaluated: one which used maximum impervious surface ratios and a second which assumed impervious surface ratios representative of existing development. While impervious surface areas will certainly increase as development continues, the increase may not be as drastic if future development follows past development with regard to impervious surfaces. The expectation would be that future development is done with a much greater awareness of the impacts that impervious areas can have on stormwater and that we would see even lower impervious surface ratios than the representative ones derived in this study.