

2011

Impervious Surface in the Richmond Region

Phase IV Report

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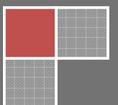


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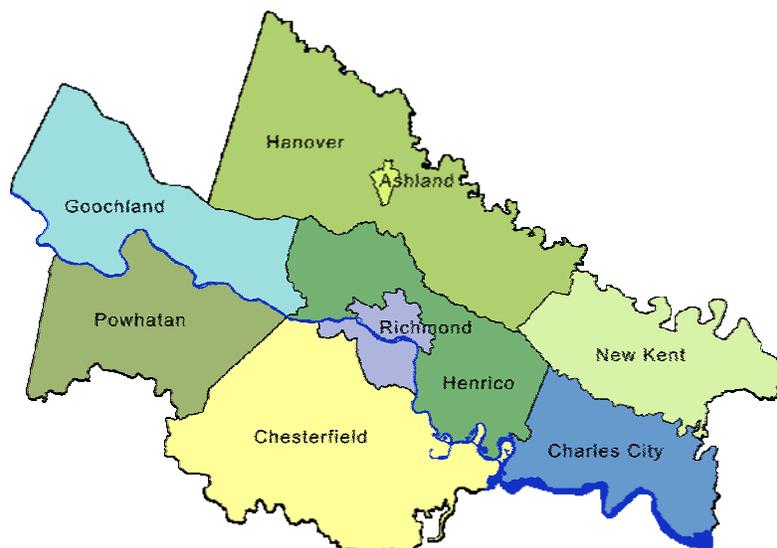
Executive Summary

Over the past several years, the Richmond Regional Planning District Commission (RRPDC) has been digitizing and cataloging impervious surfaces in the Richmond Region based on aerial imagery provided by the Commonwealth of Virginia. A portion of the Richmond Regional PDC Technical Assistance Grant has been used to carry forward this project. This Report includes the findings and analysis of Phase IV of this work effort. Specifically, impervious surfaces existing in 2009 are analyzed and impervious surfaces due to buildings and other like structures are compared between the years 2002 and 2009.

Of particular interest, in 2009, there were more than 70,500 acres of impervious surface in the Richmond Region. Almost 90% of these impervious surfaces were located in the more urban localities: City of Richmond, Henrico County, Chesterfield County, and Hanover County, including the Town of Ashland. Looking beyond simple numerical values to proportions of imperviousness, the City of Richmond was nearly one third impervious. The remaining localities in the Region fall far short of that proportion; Henrico County, the second most impervious locality, was less than 15% impervious. On average in the Richmond Region, roadways constitute 45% of the impervious area in a locality. Buildings/Structures constitute 31% of the impervious area. Across localities in the Richmond region, parking lots constituted an average of 21% of the impervious area. There was a wide range of per capita impervious surface area in the Richmond Region. In the City of Richmond there was 2,596 square feet of impervious surface per person while in Charles City County there was 6,553 square feet of impervious surface per person.

Between 2002 and 2009, localities in the Richmond region saw an increase in building impervious surface of about 18%. However, the populations of localities in the Richmond region grew by an average of 13%. There is a notable difference in these growth rates, especially while looking at individual localities. This document merely establishes the difference in growth rates and compares that difference across the region. A more complete analysis is necessary to determine what elements of local land use policy, market demands, and development programs might collectively contribute to these differences.

Figure 1



Introduction

Large amounts of impervious area such as building roof tops and paved surfaces are to be expected in existing developed areas. The relatively larger and denser populations in these areas demand services that require impervious surface construction: buildings for housing and economic activity; roads, rail lines, airport runways, etc. to transport people, ideas, and items of economic import, hardened surfaces for use by the population during recreational activities; and so on. The City of Richmond historically is the central city and economic hub for this region. According to the RRPDC Socioeconomic Analysis Report (November 2011), the Region's population almost doubled from 1970 to 2008, increasing by 83%. In absolute terms, the counties of Chesterfield and Henrico have experienced the largest increases in population during this period. In percentage terms, six of the jurisdictions experienced a population increase of almost 100%; only Charles City County and the City of Richmond have not experienced the same degree of population growth. Population growth from the year 2000 to 2008 has leveled off to an overall increase of 16% within the Region with New Kent and Powhatan experiencing the highest percentage increases in population.

How does this population growth translate into quantifiable measures of change that can affect the environment? Since 2005, the Richmond Regional Planning District Commission has studied the extent of impervious surface in the Richmond metropolitan region as one way to depict the parallel impact of population growth. This is the fourth report in a series of mapping and analysis efforts that have spanned multiple years of diligent interpretation of aerial imagery available from the Commonwealth of Virginia. The funding for this phase of the project was made available through a FY10 technical assistance grant from the National Oceanic and Atmospheric Administration (NOAA) through the Virginia Coastal Zone Management Program (VACZM). This document details Phase IV of the project.

Impervious Surfaces: What & Why

For the purposes of this study, impervious surfaces include roads, parking lots, building footprints, and other impermeable transportation surfaces usually associated with urban and suburban development. An increase in impervious area affects, among other things, the hydrologic cycle and as a result, water resources. Such effects may include: increased flooding and stream bank erosion, degraded aquatic habitat, reduced groundwater recharge, additional pollutants entering a river or other body of water from stormwater runoff, and reduction in healthy water streams and water supply.



Project Background

Phase I: 2005

Phase I began with the intent to measure change in impervious surfaces in the Richmond Region between 1994 and 2002. The imagery used for the 1994 baseline came from the United States Geological Survey color infrared Digital Orthophotography Quarter Quads (DOQQs). The 2002 imagery was a higher resolution orthophotography product developed by the Virginia Geographic Information Network under the Virginia Base Mapping Program (VBMP). The comparison of the digitized data from these two years was the basis for measuring change.

The digitization of impervious surface polygons on the 1994 and 2002 VBMP orthophotography was conducted using Geographic Information Systems (GIS) software. When available, staff started with locality-generated information such as building permits, and existing GIS data layers. A database was established for the impervious surface features. For localities with a building footprint layer, existing data was used as a starting point. In some cases, localities had not prepared an existing building footprint layer, so a layer was created by digitizing structures visible in the orthophotography. Information about newly digitized polygons was placed in the database attribute table. The polygons were classified as either having existed in 1994 orthophotography or having been constructed between 1994 and 2002.

There were degrees of inaccuracy between the 1994 and 2002 polygon delineations due to resolution quality of the two orthophotographic sources and differences in the data projections. The color aerial photography used to capture the 2002 data provided the user more details and accurate imagery than was possible when using the 1994 color infrared DOQQs. Using the road and structure polygons, the impervious area was calculated for both 1994 and 2002. Maps were prepared as a visual tool illustrating the change in regional impervious surface.

For a more detailed methodology of Phase I, please refer to Mapping Impervious Surface in the Richmond Region with Ortho Imagery section in the *Impervious Surface in the Richmond Region* report that is available upon request from RRPDC staff.

Phase II: 2006

Phase II of the project was conducted between January and September 2006 using the 2002 VBMP orthophotography. The goal of Phase II was to improve the accuracy of the existing building polygons, delineate driveways, improve classification of polygons by using a standard classification system in the four rural jurisdictions, and improve the road layer, region-wide, to reflect the difference in road widths between rural and urban/suburban jurisdictions. It was decided that a similar analysis using 1994 orthophotography would be less valuable due to the lower resolution and quality of the DOQQs.

A final step was to identify inconsistencies due to varying techniques of individual technicians compiling the project. Separate technicians analyzed and coded impervious areas differently in Phase I which resulted in polygons having different configurations and impervious use codes. Methodology was reassessed and use codes were corrected to reflect a comparable category and a more generalized use code. Use codes included, but were not limited to, buildings (residential, commercial and industrial), airports, driveways, parking lots, pools, and tennis courts.

The refinement of the Phase I methodology resulted in very similar calculations at the regional level, but greatly differing calculations at the county/city level. Discussions of the results for each jurisdiction were also included. The Phase II report, *Refining Impervious Surface in the Richmond Region*, is available upon request from RRPDC staff.

Phase III: 2009

Phase III of the project was conducted between November 2008 and September 2009. The goal of Phase III was to digitize impervious surface for an additional year in order to expand the data catalogue of Richmond Region impervious surface data for analysis. During Phase III, technicians digitized footprints of buildings erected between 2002 and 2007. The base for this project was leaf-off imagery, gathered in 2007, as high resolution orthophotography and developed by VGIN as part of the VBMP.

Data tables were standardized for all attributes and all years of photography. 1994 and 2002 digitized structures were spatially joined to scanned footprints from 2006, 2007, and 2008 photography to take advantage of higher photography accuracy while maintaining data attributes of original impervious surface files. New structures were digitized for all counties from 2009 photography and attributes added to data.

More details of the Phase III methodology can be found in the report *Richmond Regional Impervious Surface Inventory; Phase III* available upon request from RRPDC staff.

Phase IV Methodology

The improving resolution of aerial photography over time and the abilities of RRPDC staff and GIS software have resulted in methodological evolution throughout the project. The result has been that throughout the phases of this project, focus has shifted among the various elements of impervious surface. The Phase IV work effort focused on reviewing impervious surface structure data gathered using aerial imagery from 2002 and correcting any noticed errors. Also, during Phase IV, RRPDC staff used aerial imagery from 2009 to review structure data created during Phase III of the project. Having reliable and comparable structure data for the entire Richmond Region for 2002 and 2009, allows RRPDC staff and others across the region to analyze changes in impervious surface between the two subject years.

Additionally in Phase IV, RRPDC staff completed a transportation impervious surface GIS layer for the region based on this 2009 aerial imagery. The transportation layer was recalculated with the VBMP road centerline files. This data developed with VDOT and all localities to provide accurate and consistent roads data for Virginia. The interstate and highway road widths were measurements from the 2009 photography providing accurate road widths for the road buffering to generate accurate impervious acreage for this layer. The rural road measurements were sampled from the 2009 photography and based on the road classification from VDOT/VBMP (collector road, major road, minor road etc.) and buffered to generate accurate impervious acreage. Additional information from localities with impervious data was used when available.

The creation of these “base layers” will enable RRPDC staff to analyze changes in the region over time in the future. Such analysis will be of particular use when developing plans for water quality improvement associated with Total Maximum Daily Loads (TMDL) for small watersheds of local streams up to larger watersheds such as the Chesapeake Bay.

For a visual representation of the impervious surface elements mapped in different situations, please see Figures 2 through 5 depicting residential and commercial areas. In addition, the following maps depict an overview of impervious surface expansion in the Richmond Region through 2009.

Figure 2



Figure 3



Figure 4

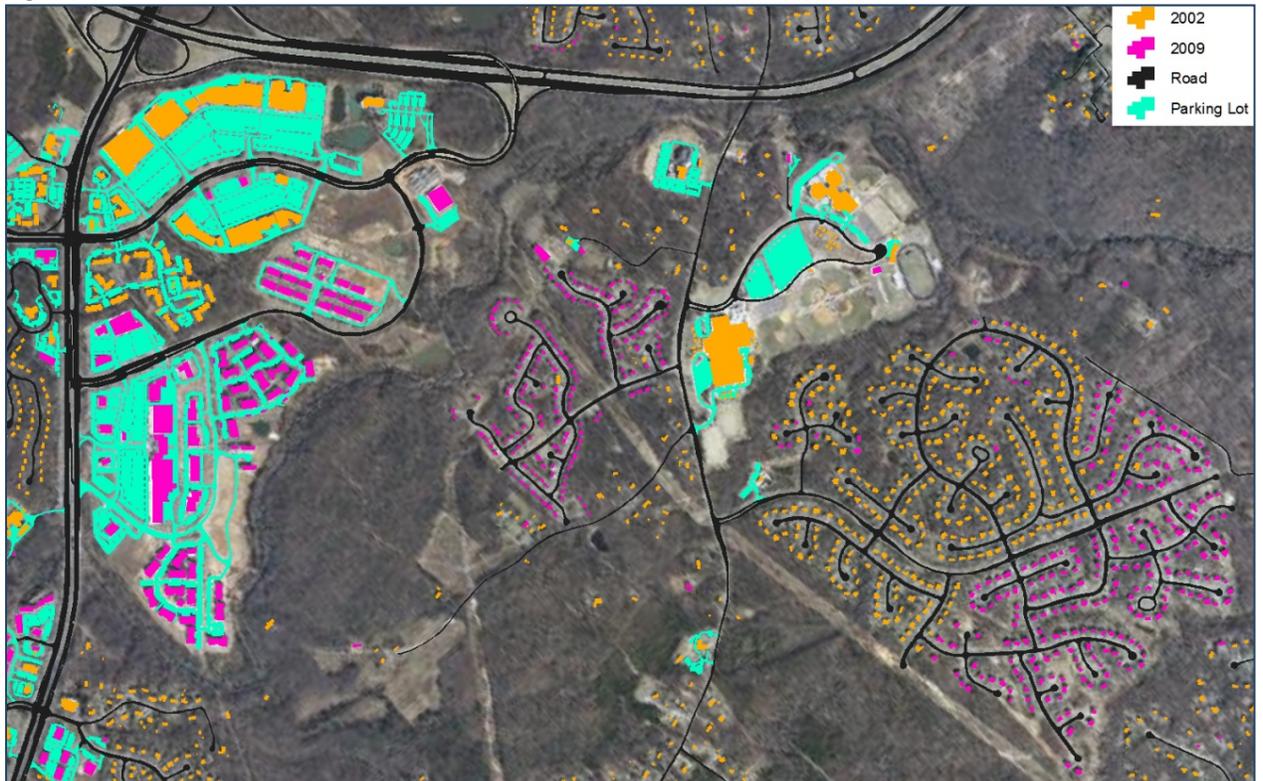
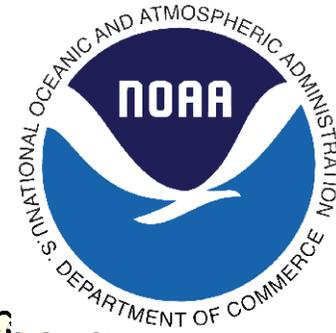


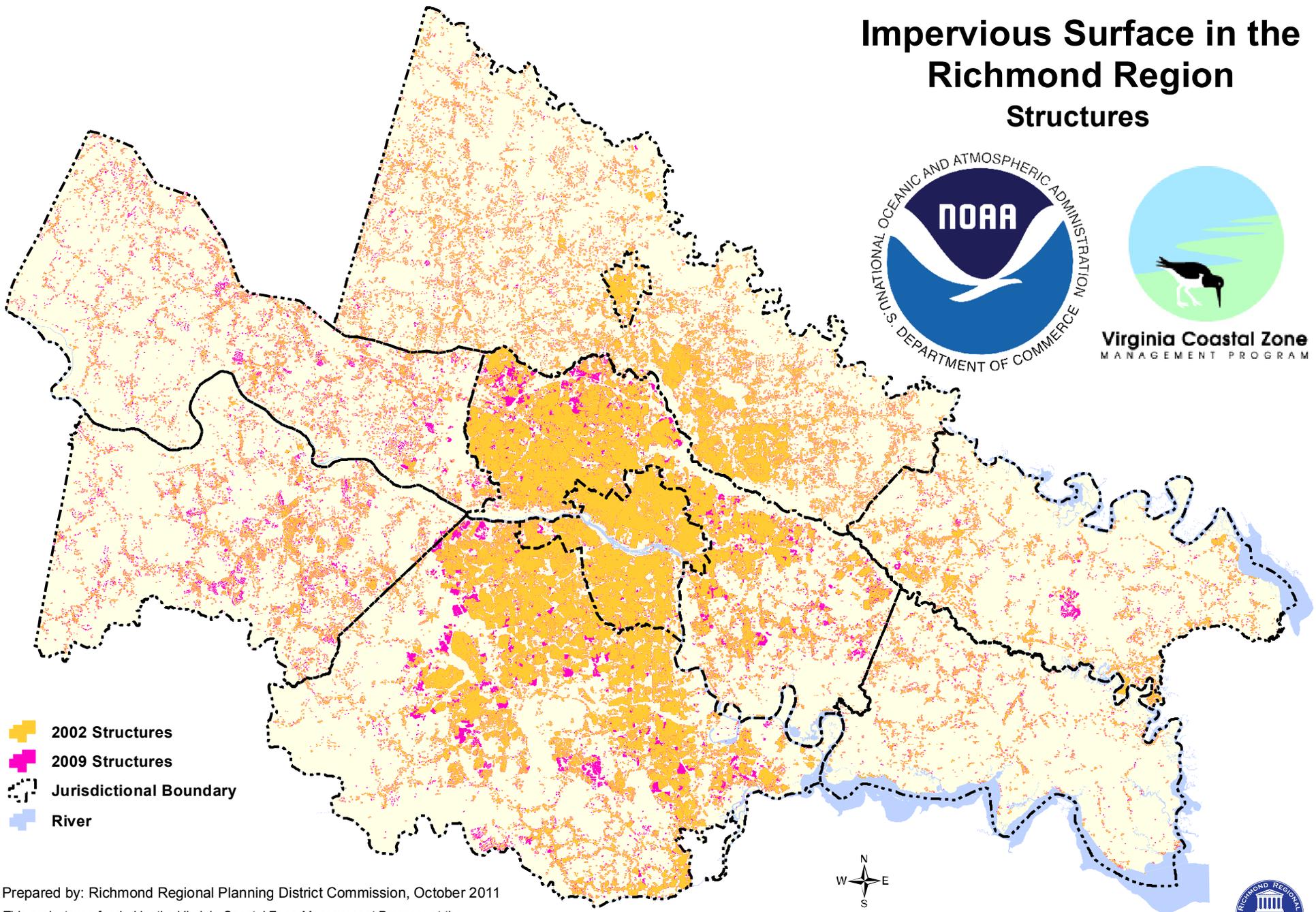
Figure 5



Impervious Surface in the Richmond Region Structures



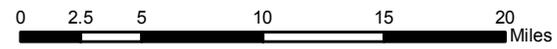
Virginia Coastal Zone
MANAGEMENT PROGRAM



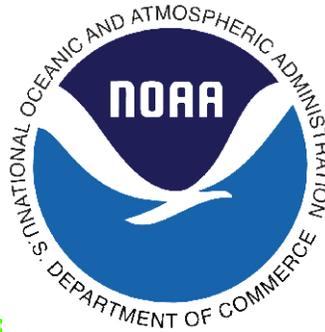
- 2002 Structures
- 2009 Structures
- Jurisdictional Boundary
- River

Prepared by: Richmond Regional Planning District Commission, October 2011

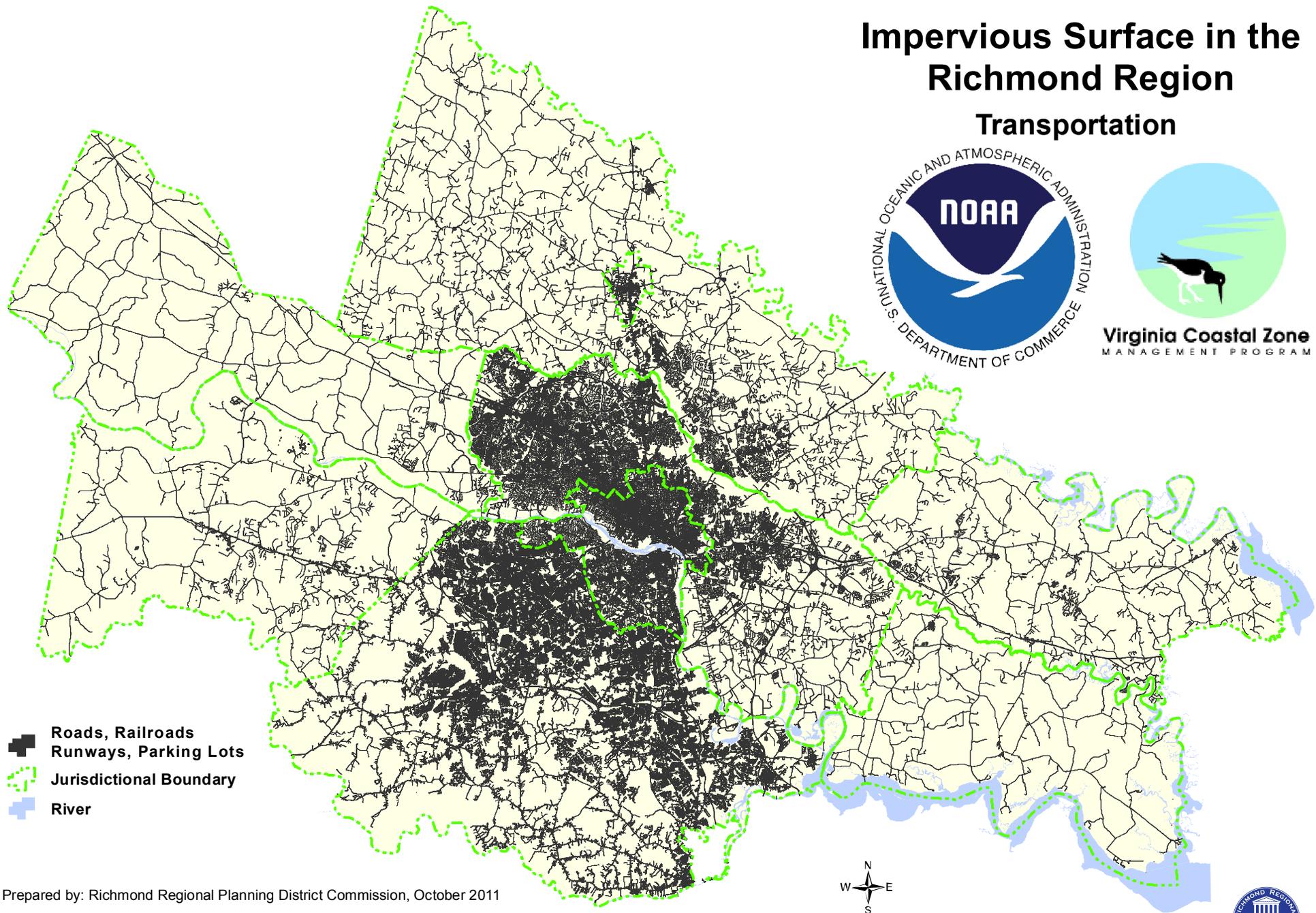
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Impervious Surface in the Richmond Region Transportation



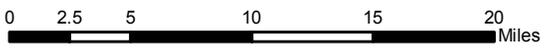
Virginia Coastal Zone
MANAGEMENT PROGRAM



- Roads, Railroads
Runways, Parking Lots
- ⋯ Jurisdictional Boundary
- River

Prepared by: Richmond Regional Planning District Commission, October 2011

This project was funded by the Virginia Coastal Zone Management Program at the Department of Environmental Quality through Grant #NA10NOS4190205 of the U.S. Department of Commerce, National Oceanic and Atmospheric Administration, under the Coastal Zone Management Act of 1972, as amended.

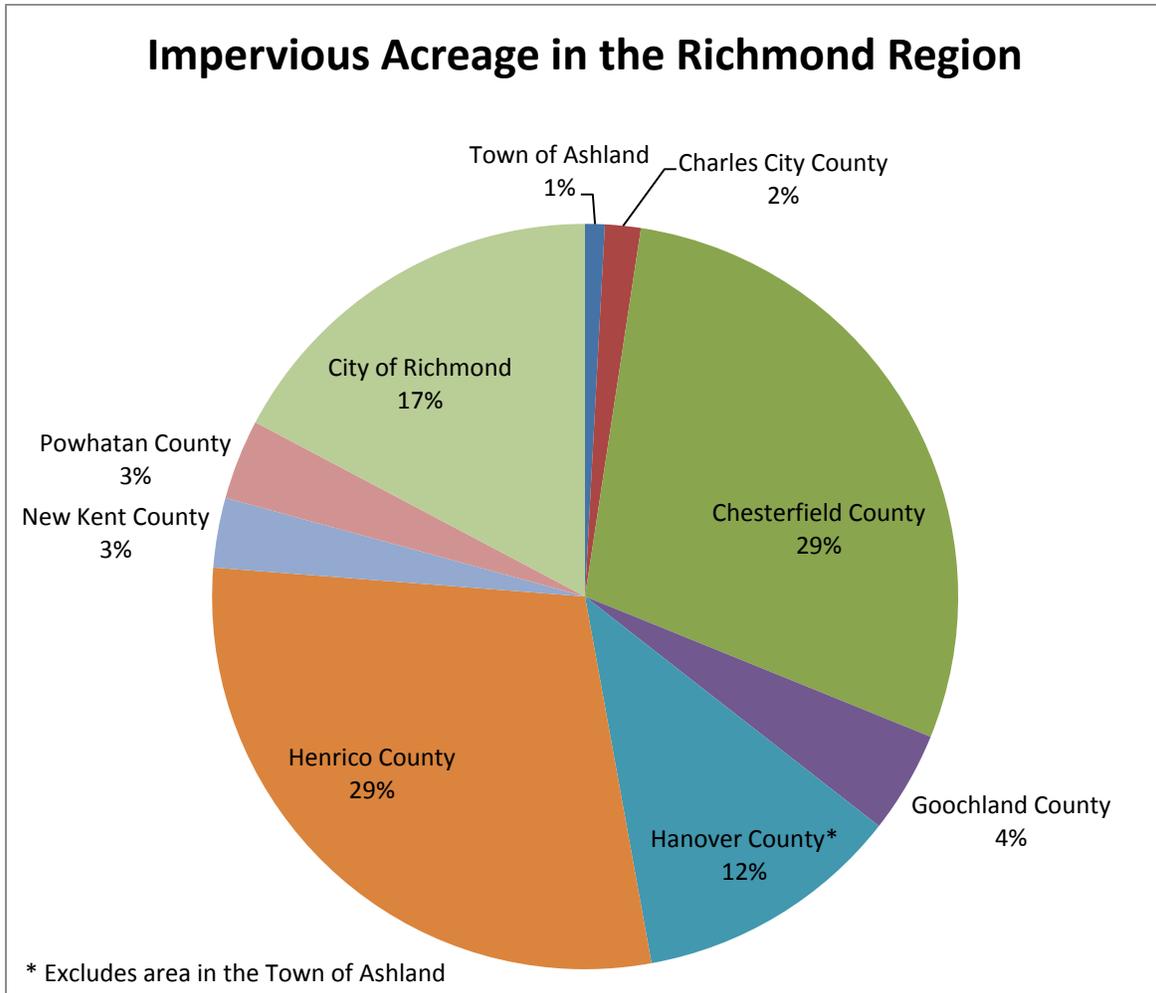


Findings

2009 Impervious Area

Henrico and Chesterfield Counties have the greatest acreage of impervious area in the Richmond Region. Both localities have more than 20,000 acres of impervious area; each has an equal proportion of the Region's acreage that is impervious within their jurisdictional boundaries. The City of Richmond also has a large amount of impervious area, as is to be expected; about 17% of the impervious area in the Richmond Region lies within the City of Richmond.

Figure 6



In this comparison, it is important to remember that the land area of the City of Richmond is 14% the land area of Chesterfield County and 26% the land area of Henrico County. For this reason, a simple comparison of total impervious surface area can be misleading as it does not accurately illustrate what proportion of a locality is impervious. Accordingly, a better comparison of local imperviousness would be a ratio of impervious area to total land area. As seen in Table 1 below, the City of Richmond has the greatest percentage of its area covered with impervious surfaces, 32%. Comparatively, Charles City County and Powhatan County are the localities least covered by impervious surfaces; both are approximately 1% impervious.

Table 1

	Total Acreage	Water Acreage	Land Acreage	Impervious Acreage	Percentage Impervious
Town of Ashland	4,610	34	4,576	598	13%
Charles City County	131,183	21,760	109,423	1,092	1%
Chesterfield County	279,724	13,856	265,868	20,272	8%
Goochland County	185,207	4,843	180,364	3,113	2%
Hanover County*	302,386	5,678	296,708	8,173	3%
Henrico County	155,433	7,769	147,664	20,522	14%
New Kent County	134,051	20,799	113,252	2,133	2%
Powhatan County	167,755	1,251	166,504	2,452	1%
City of Richmond	40,011	2,178	37,833	12,168	32%
RRPDC	1,400,360	78,167	1,322,194	70,523	5%

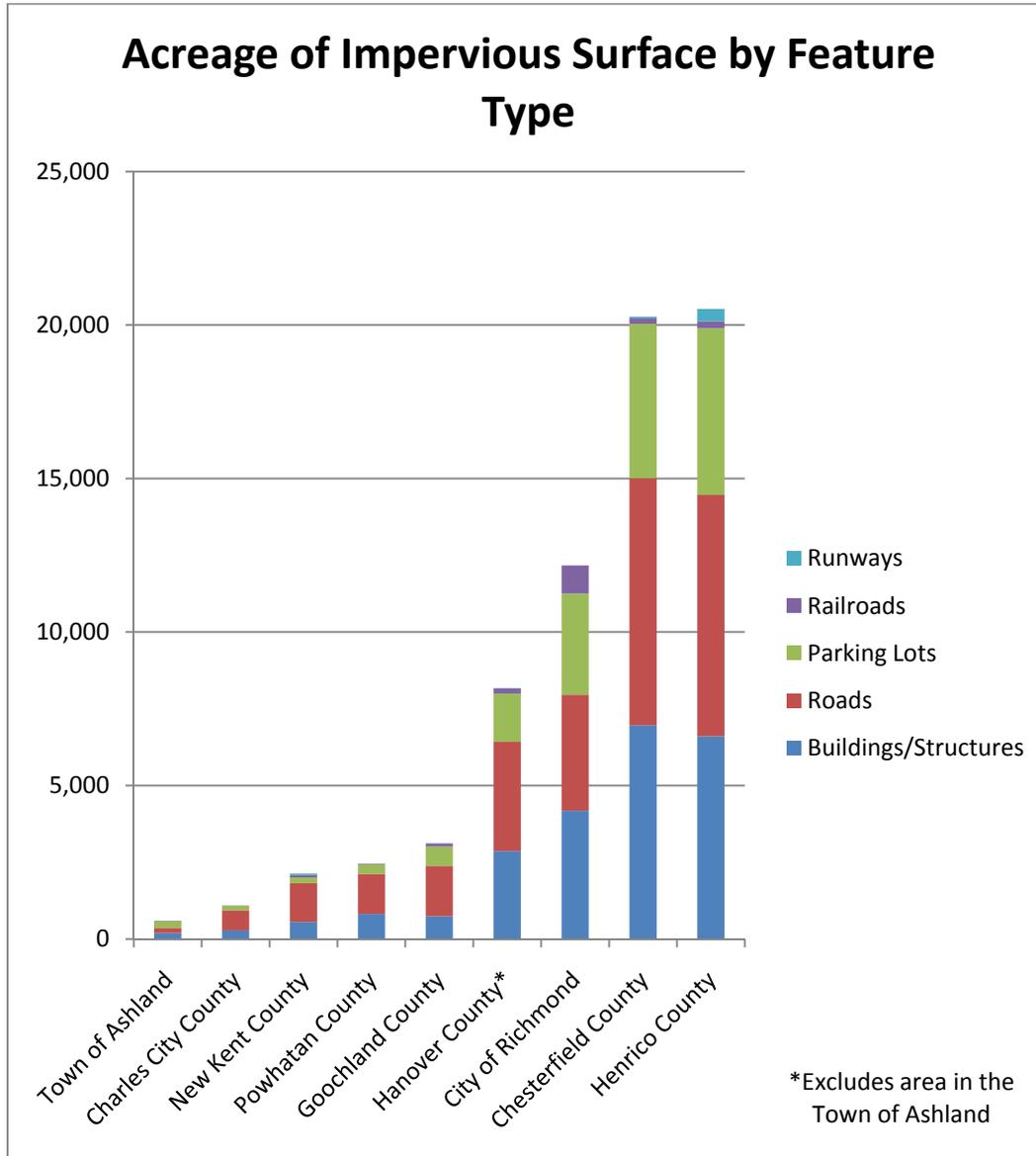
* Excludes area in the Town of Ashland

Water acreage referenced from the USGS National Hydrography Dataset.



Figures about total impervious area are useful, but only in a limited manner. Information about the composition of the total impervious area can be very informative about land use patterns and potential effects on water quality. Different impervious surfaces are likely to contribute different types of pollution to stormwater runoff. For instance, impervious surfaces such as roadways and parking lots are likely to contribute toxic fluids, such as motor oil or antifreeze, and heavy metal dust from vehicle exhaust to nearby streams and waterways. Meanwhile, runoff from impervious surfaces associated with buildings and development is likely to encounter, among other things, bacteria associated with pet waste; chemicals in fertilizer; and sediment associated with cleared, undeveloped land. For the distribution of each locality’s impervious surfaces by feature type, refer to Figure 7 and Tables 2 and 3 below.

Figure 7



In both Chesterfield and Henrico Counties, there are more than 6,500 acres of impervious surface accounted for by building footprints. The locality with the least impervious area from buildings is the Town of Ashland with less than 200 acres committed to building impervious surface. Chesterfield and Henrico Counties also have the greatest amount of impervious surface attributed to roadways; Chesterfield has more than 8,000 acres of impervious surface in roadways while Henrico has more than 7,800 acres.

On average in the Richmond Region, roadways constitute the largest percentage (45%) of impervious area in a locality. Buildings/Structures constitute the second largest percentage of impervious area. Across localities in the Richmond region, parking lots constitute an average of 21% of impervious area.

Table 2

Locality	Buildings/Structures	Roads	Parking Lots	Railroads	Runways	Total
Town of Ashland	191	172	218	17		598
Charles City County	280	657	143	12		1,092
Chesterfield County	6,963	8,048	5,033	181	47	20,272
Goochland County	739	1,641	630	104		3,113
Hanover County*	2,866	3,559	1,569	167	12	8,173
Henrico County	6,606	7,861	5,426	230	399	20,522
New Kent County	556	1,261	191	80	44	2,133
Powhatan County	817	1,304	311	19		2,452
City of Richmond	4,179	3,777	3,298	915		12,168
RRPDC	23,198	28,280	16,819	1,724	502	70,523

*Excludes area in the Town of Ashland

Table 3

Locality	Buildings/Structures	Roads	Parking Lots	Railroads	Runways	Total
Town of Ashland	32%	29%	36%	3%	0%	100%
Charles City County	26%	60%	13%	1%	0%	100%
Chesterfield County	34%	40%	25%	1%	0%	100%
Goochland County	24%	53%	20%	3%	0%	100%
Hanover County*	35%	44%	19%	2%	0%	100%
Henrico County	32%	38%	26%	1%	2%	100%
New Kent County	26%	59%	9%	4%	2%	100%
Powhatan County	33%	53%	13%	1%	0%	100%
City of Richmond	34%	31%	27%	8%	0%	100%
RRPDC Average	31%	45%	21%	3%	0%	100%

*Excludes area in the Town of Ashland

above regional average

below regional average

Another useful comparison is to study impervious area based on a per capita basis. Such an investigation can allow one to better understand how the relationship between population and impervious cover are reflected in land use patterns and the density of development. As shown in Figure 8 and Table 4 below, the rural counties in the Richmond region have a greater per capita area of impervious cover than do the more urban localities. Charles City County has the greatest area of impervious surface per capita: 6,553 square feet per person. At the other end of the spectrum, the City of Richmond has the lowest area of impervious surface per capita: 2,596 square feet per person.



Density, or the proximity of people and structures to each other, helps explain this wide range of per capita impervious surface area. The closer two places are together, the shorter the roadway connecting them needs to be. The proximity of two stores to each other increases that chances that parking can be shared, thereby reducing overall parking area needed. Similarly, the closer an origin is to a destination, the greater the chance that multiple transportation modes including

walking and biking can provide adequate access and that automobile demand for large roadway surfaces can be limited.

Figure 8

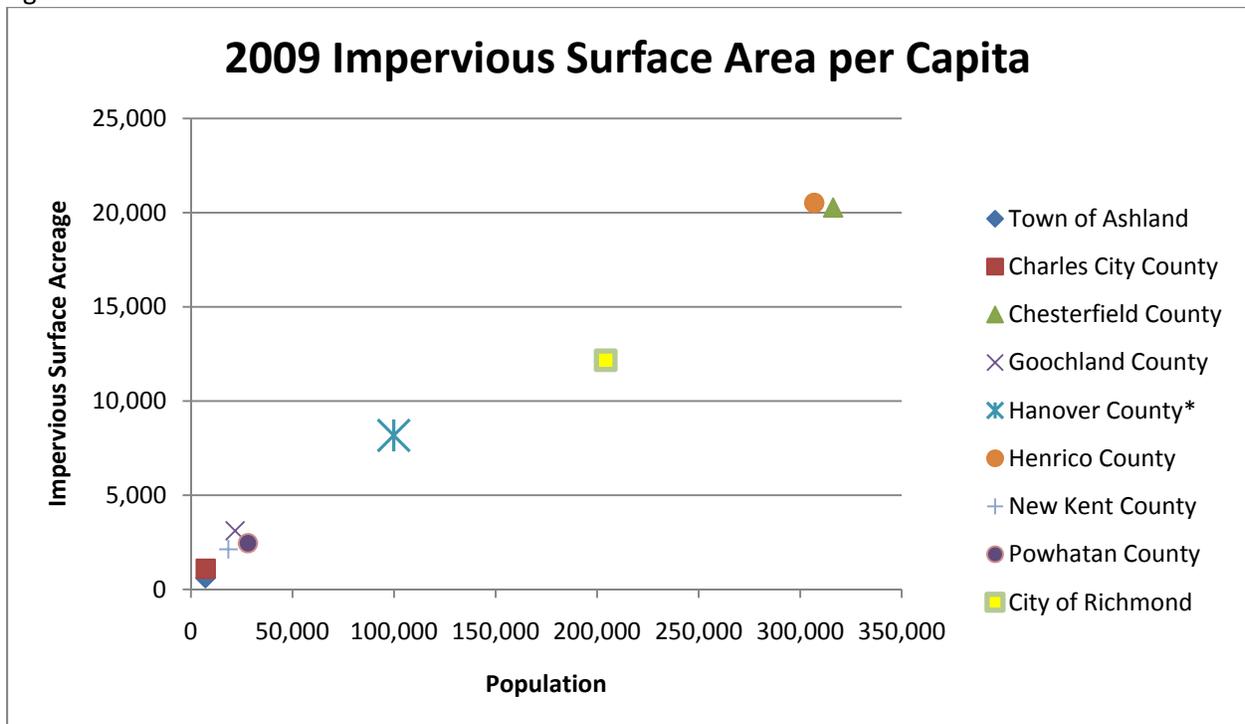


Table 4

Locality	2009 Population Estimate	2009 Impervious Surface Area	2009 Per Capita Impervious Surface Square Footage
Town of Ashland	7,114	598	3,663
Charles City County	7,256	1,092	6,553
Chesterfield County	316,236	20,272	2,792
Goochland County	21,717	3,113	6,245
Hanover County*	92,749	8,173	3,839
Henrico County	306,935	20,522	2,912
New Kent County	18,429	2,133	5,042
Powhatan County	28,046	2,452	3,809
City of Richmond	204,214	12,168	2,596
RRPDC	1,002,696	70,523	3,064

*Excludes area in the Town of Ashland

Population estimates from Weldon Cooper Center

Figure 9 and Table 5 display information about the per capita square footage of impervious surface features, such as roads and parking lots. Goochland County and Hanover County have the most per capita impervious surface in building footprints in the Richmond Region; both have more than 1,350 square feet of building impervious surface per person. Charles City County and Goochland County have the most per capita impervious surface associated with roadways; both counties have more than 3,200 square feet of roadway impervious surface per person. Charles City County has nearly 4,000 square feet of roadway per person. The Town of Ashland and Goochland County have the highest per capita impervious surface associated with parking lots; both have more than 1,200 square feet of parking lot area per person.

While rail lines and airport runways are interesting features to study, data about the extent of these features reveals less about daily life and development patterns in the United States across jurisdictions within a region. Airports with large runway surfaces are typically designed to service a region, not one locality. Therefore, comparing all runway area to one locality's population is likely to skew the conclusion. Somewhat similarly, while passenger rail service is a valid and useful form of transportation in today's economy, the transport of freight and historic placement and ownership of rail lines, factors heavily into the location of present rail lines. It is more difficult to tease out broad statements about impervious surface and land use development patterns from this data.

Figure 9

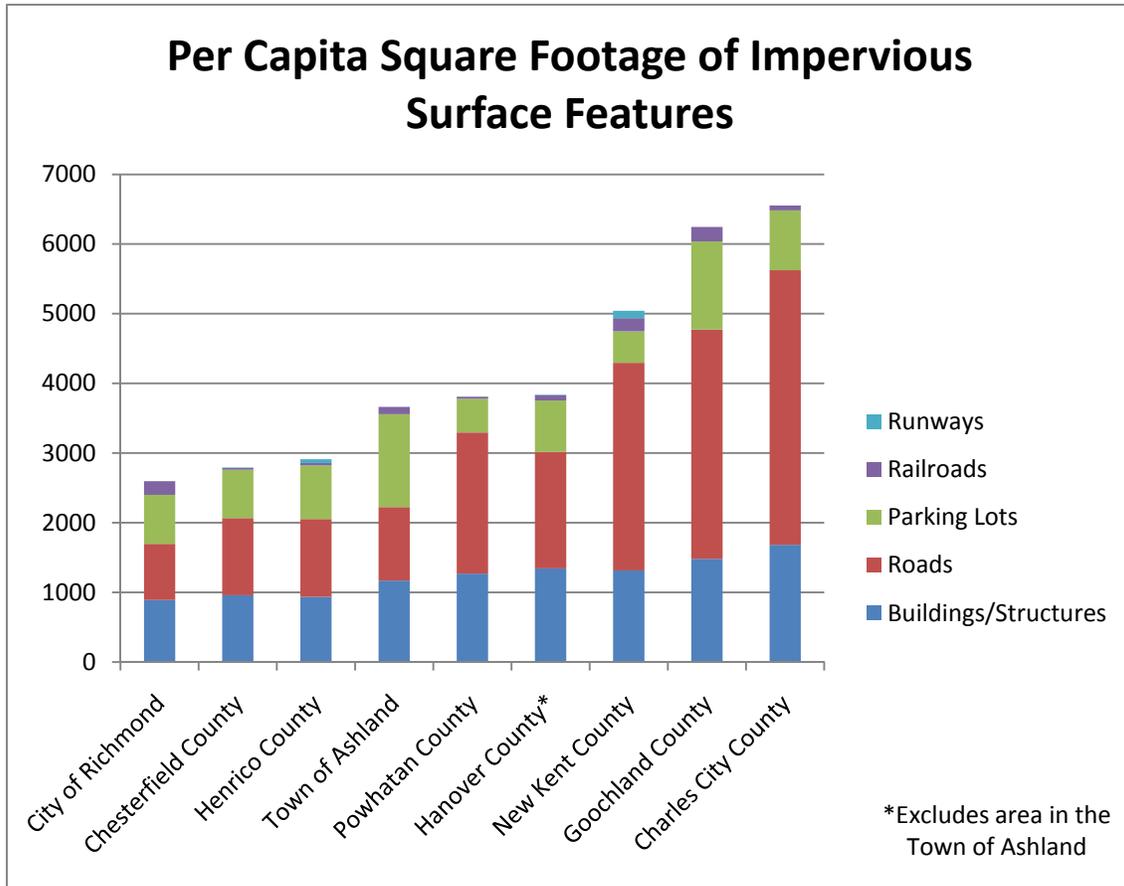


Table 5

Locality	Buildings/Structures	Roads	Parking Lots	Railroads	Runways	Total
Town of Ashland	1,169	1,056	1,333	105	0	3,663
Charles City County	1,683	3,942	858	69	0	6,553
Chesterfield County	959	1,109	693	25	6	2,792
Goochland County	1,482	3,291	1,264	208	0	6,245
Hanover County*	1,346	1,672	737	78	6	3,839
Henrico County	937	1,116	770	33	57	2,912
New Kent County	1,315	2,981	452	190	105	5,042
Powhatan County	1,269	2,026	483	30	0	3,809
City of Richmond	891	806	703	195	0	2,596
RRPDC	1,008	1,229	731	75	22	3,064

Values represent impervious surface square footage per capita.

Change over Time, 2002 – 2009

One of the aims of the Impervious Surface project has been the ability to compare similar datasets across time. Such a comparison enables planners to see change over time; inferences about the effects of practices or policies can be more accurately drawn. Ideas or notions about land use patterns over time can be tested. A useful point of analysis is the rate of change of impervious surface compared to that of population. In general, continuing the status quo of the manner in which land is developed would result in approximately the same rate of change in population to that of impervious surface. Variances between these two rates can generally be assumed to reflect a combination of changes to government policies concerning development, land development practices, and/or real estate and land development market demands. Of course, further study than is provided in this document would be necessary to isolate specific causes and their extents for any trend deviations seen. The analysis in this section compares population growth to changes in impervious surface associated with building footprints, not including impervious surfaces associated with transportation features like roadways or parking lots. Limitations of available and comparable data restricted this comparison to these two elements.

On average, localities in the Richmond region saw a little over 300 acres of building impervious surface created between 2002 and 2009. This represented an average increase in building impervious surface of 18% over 2002 levels. As seen in Figure # and Table 6 below, there is wide variety of deviance from this regional average. Indeed, even the RRPDC region itself as a whole saw less of an increase less than the regional average, increasing by only 14%. Powhatan and Goochland Counties saw the greatest rate of building impervious surface growth; both at or above a 35% increase. The Town of Ashland, Hanover County, and Goochland County saw the lowest rates of increase, all below 5%.

Meanwhile, between 2002 and 2009, the populations of localities in the Richmond region grew by an average of 13%. Again, as with impervious surfaces, there was much variance from this regional average. The RRPDC region itself grew by slightly less; population increased by 109,013 people, or 12%, between 2002 and 2009. New Kent County saw the largest percentage increase in population: 4,219 people or 30%. On the other hand, Charles City County saw the least population growth: 159 people or 2%.

In some localities, large differences between the rates of growth of building impervious surface compared to that of population are evident. Some localities saw much larger growth rates of building impervious surface than of population, for example, Powhatan County and Goochland County. Other localities saw population growth outpace building impervious surface growth, for example, the Town of Ashland and Hanover County. However, one constant across the region existed; if a locality experienced above or below average growth for one element, the locality saw the same relationship to the average for the other element, albeit, not necessarily by the same amount.

Figure 10

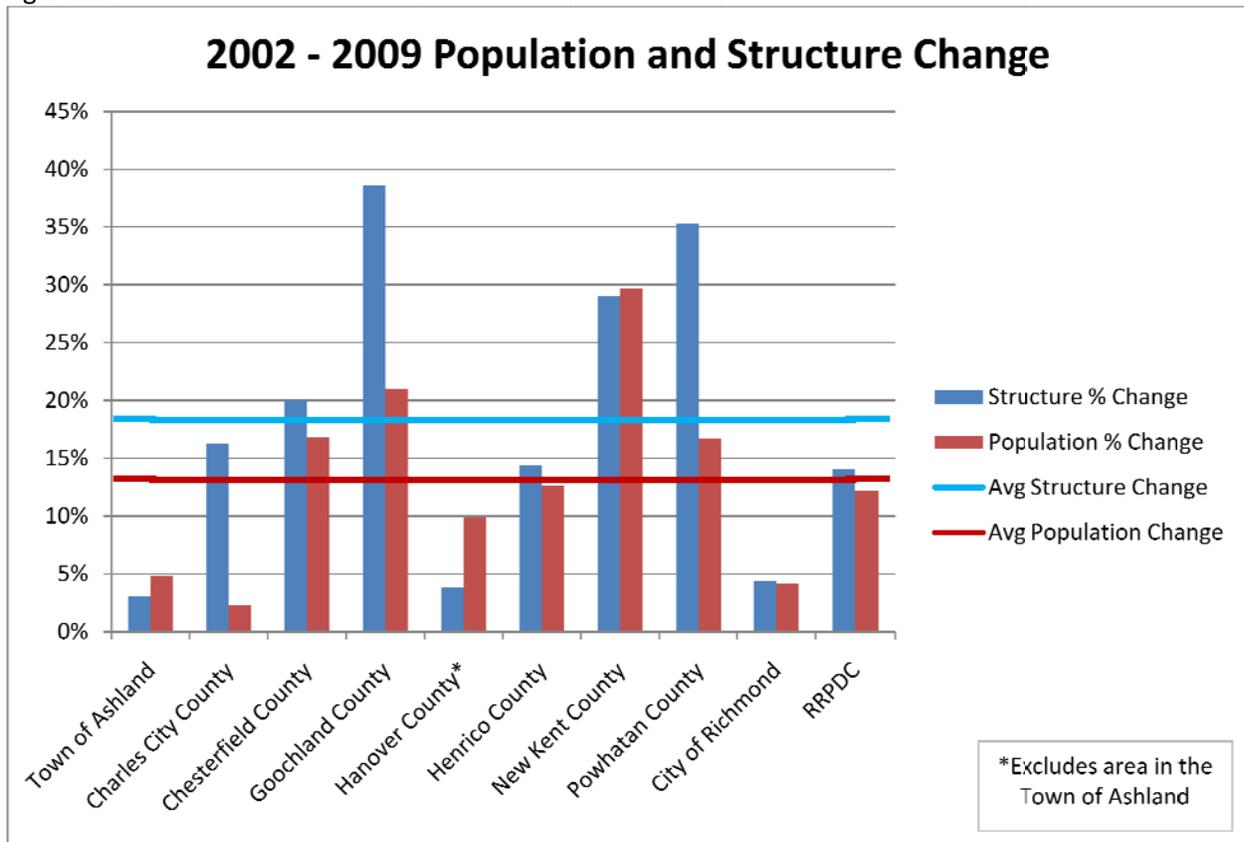


Table 6

Locality	2002		2009		Structure Acreage		Population	
	Structure Acreage	Population Estimate	Structure Acreage	Population Estimate	Increase	Percent Change	Increase	Percent Change
Town of Ashland	185	6,785	191	7,114	6	3%	329	5%
Charles City County	241	7,097	280	7,256	39	16%	159	2%
Chesterfield County	5,803	270,766	6,963	316,236	1,161	20%	45,470	17%
Goochland County	533	17,942	739	21,717	206	39%	3,775	21%
Hanover County*	2,761	84,365	2,866	92,749	105	4%	8,384	10%
Henrico County	5,775	272,394	6,606	306,935	830	14%	34,541	13%
New Kent County	431	14,210	556	18,429	125	29%	4,219	30%
Powhatan County	604	24,039	817	28,046	213	35%	4,007	17%
City of Richmond	4,003	196,085	4,179	204,214	176	4%	8,129	4%
RRPDC	20,336	893,683	23,197	1,002,696	2,861	14%	109,013	12%

*Excludes area in the Town of Ashland

Population estimates from Weldon Cooper Center

Moving Forward...

The 2009 Richmond Region impervious surface data can contribute to a series of analyses that will create a baseline as to the status of land and development in the Richmond Region. RRPDC staff is in the process of creating and maintaining several regional layers such as existing land use, parks, green infrastructure, transportation facilities, water quality monitoring data, etc. When paired with regional future land use data in addition to population and employment projections, all of these elements create an informative picture about growth in the Richmond Region.

References for More information on Impervious Surfaces and Water Quality

NOAA Office of Ocean and Coastal Resources Management
<http://coastalmanagement.noaa.gov/impacts.html>

US EPA Office of Water <http://www.epa.gov/ow/>

United States Geological Survey – The Water Cycle <http://ga.water.usgs.gov/edu/watercyclerrunoff.html>

USGS VIDEO: **Stormwater, Impervious Surface, and Stream Health** <http://gallery.usgs.gov/videos/298>

USDA National Agricultural Library, Water Quality Information Center
http://wqic.nal.usda.gov/nal_display/index.php?info_center=7&tax_level=1&tax_subject=596

Virginia DCR of Stormwater Management
http://www.dcr.virginia.gov/stormwater_management/index.shtml