GUIDE TO THE APPENDICES

This section includes relevant information that is supplementary to information in the report. The Appendices follow the same order as the report, and references are found in the subsequent references section. Tables of Contents, Figures, and Tables are located at the beginning to aid in finding information.

TABLE OF CONTENTS

TABLE OF APPENDIX FIGURES

TABLE OF APPENDIX TABLES

I. REGULATORY REVIEW

A. ADDITIONAL TABLES

Table I-1 – VPDES Regulated Industries in the Commonwealth of Virginia

Virginia Administrative Code Location	Permit Prefix	Permit Description	Effective	Expired	Contact
9VAC25-110	VAG40	Domestic Sewage Discharges of Less Than or Equal To 1,000 Gallons Per Day (also known as the "single family home" general permit)	8/2/2011	8/1/2016	Burt Tuxford
9VAC25-115	VAG52	Seafood Processing Facilities	7/24/2011	7/23/2016	Elleanore Daub
9VAC25-120	VAG83	Petroleum Contaminated Sites and Hydrostatic Tests	2/26/2013	2/25/2018	Burt Tuxford
9VAC25-151	VAR05	Discharges of Stormwater Associated With Industrial Activity	7/1/2014	6/30/2019	Burt Tuxford
9VAC25-190	VAG84	Non-Metallic Mineral Mining	7/1/2014	6/30/2019	Elleanore Daub
9VAC25-191	VAG01	Concentrated Animal Feeding Operations	1/1/2006	12/31/2010	Betsy Bowles
9VAC25-193	VAG11	Concrete Products Facilities (formerly called "Ready-Mixed Concrete Plants" general permit)	10/1/2013	10/15/2017	Elleanore Daub
9VAC25-194	VAG75	Vehicle Wash and Laundry Facilities. (formerly called "Car Wash" general permit)	10/16/2012	10/15/2017	Elleanore Daub
9VAC25-196	VAG25	Non-Contact Cooling Water Discharges	3/2/2013	3/1/2018	Burt Tuxford
9VAC25-800	VAG87	Pesticides Discharges	1/1/2014	12/31/2018	Elleanore Daub
9VAC25-810	VAG72	Coin Operated Laundries	Repealed		
9VAC25-820	VAN00	Watershed Permit For Total Nitrogen And Total Phosphorus Discharges And Nutrient Trading In The Chesapeake Bay Watershed	11/21/2012	12/31/2016	Allan Brockenbrough
9VAC25-860	VAG64	Potable Water Treatment Plants	12/24/2013	6/30/2018	Elleanore Daub
9VAC25-880	VAR10	Discharges of Stormwater from Construction Activities	7/1/2014	6/30/2019	
9VAC25-890	VAR040	Discharges of Stormwater from Small MS4s	7/1/2013	6/30/2018	

Table I-2 – VPDES Individual Permits for discharges in the City of Roanoke

Permit Number	Type	Facility Name	Owner Name
VA0091065	Industrial	Crystal Spring WTP	Western Virginia Water Authority
VA0001431	Industrial	Kinder Morgan Southeast Terminals LLC - Roanoke	Kinder Morgan Southeast Terminals LLC
VA0086541	Industrial	Magellan Terminals Holdings LP - Roanoke Terminal	Magellan Terminals Holdings LP
VA0001597	Industrial	Norfolk Southern Railway Co - Shaffers Crossing	Norfolk Southern Railway Company Incorporated
VA0001589	Industrial	RES dba Steel Dynamics Roanoke Bar Division	Roanoke Electric Steel Corp
VA0025020	Municipal	WVWA - WPCP	Western Virginia Water Authority

Table I-3 – VPDES General Permits (non-construction) for discharge in the City of Roanoke

Permit Number	Type	Facility Name
VAG750059	Car Wash	ProWash USA
VAG840067	Non-Metallic Mineral Mining	Rockydale Quarries Corporation - Rockydale Plant
VAG110018	Concrete Products Facility	Chandler Concrete Company Inc - Roanoke
VAG110125	Concrete Products Facility	Boxley Concrete Products - Roanoke
VAG110268	Concrete Products Facility	Blue Stone Block Supermarket Inc
VAG110269	Concrete Products Facility	Concrete Specialties Incorporated
VAR050134	Industrial Stormwater	Greater Roanoke Transit Company
VAR050144	Industrial Stormwater	North 11 Asphalt Plant - Roanoke
VAR050177	Industrial Stormwater	Coca-Cola Bottling Company Consolidated
VAR050178	Industrial Stormwater	BFI Waste Services LLC dba Allied Waste Recyclery
VAR050179	Industrial Stormwater	CEI - Plantation Road
VAR050180	Industrial Stormwater	FCI Roanoke
VAR050206	Industrial Stormwater	Con-way Freight, NRO - Roanoke
VAR050208	Industrial Stormwater	Walker Machine and Foundry Corporation
VAR050272	Industrial Stormwater	Roanoke Regional Airport
VAR050275	Industrial Stormwater	Old Dominion Auto Salvage
VAR050436	Industrial Stormwater	Norfolk Southern Corp - Roadway Material Yard
VAR050437	Industrial Stormwater	Estes Express Lines Inc - 1924 Plantation Rd
VAR050448	Industrial Stormwater	United Parcel Service Inc - Roanoke
VAR050460	Industrial Stormwater	YRC Terminal 617 ROA
VAR050519	Industrial Stormwater	FedEx Freight East Incorporated - Roanoke
VAR050522	Industrial Stormwater	Progress Rail Services Corp - Roanoke
VAR050526	Industrial Stormwater	RR Donnelley and Sons Company - Roanoke
VAR050530	Industrial Stormwater	Shenandoah Auto Parts
VAR050539	Industrial Stormwater	Kenan Transport LLC
VAR050643	Industrial Stormwater	Akzo Nobel Coatings Incorporated - Roanoke
VAR050717	Industrial Stormwater	Gerdau - Roanoke
VAR050757	Industrial Stormwater	Metalsa Roanoke Inc
VAR050775	Industrial Stormwater	Star City Auto Parts Inc
VAR051199	Industrial Stormwater	Pitt Ohio Express Roanoke Terminal - Plantation Rd
VAR051315	Industrial Stormwater	A D Weddle Company Inc
VAR051460	Industrial Stormwater	Dynax America Corp USA
VAR051478	Industrial Stormwater	Precision Steel
VAR051480	Industrial Stormwater	J and J Asphalt Incorporated
VAR051492	Industrial Stormwater	Virginia Transformer Corp
VAR051518	Industrial Stormwater	Norfolk Southern Railway Co - East End Shops
VAR051529	Industrial Stormwater	UPS Ground Freight Inc - Roanoke
VAR051603	Industrial Stormwater	FreightCar America
VAR051605	Industrial Stormwater	Tread Corporation
VAR051642	Industrial Stormwater	Semco Duct and Acoustical Products Incorporated
VAR051664	Industrial Stormwater	Roanoke City Schools - Transportation Facility
VAR051698	Industrial Stormwater	Country South LLC - CDD Landfill
VAR051699	Industrial Stormwater	Thomas Brothers Debris Landfill
VAR051704	Industrial Stormwater	Whitlow Auto Crushers LLC
VAR051802	Industrial Stormwater	C and P Welding and Steel Erection Inc
VAR051803	Industrial Stormwater	Mennel Milling Company of Virginia
VAR051914	Industrial Stormwater	Associated Asphalt Incorporated - Roanoke
VAR051983	Industrial Stormwater	WHPT - Roanoke salt storage and distribution site
VAR051985	Industrial Stormwater	Mullins Used Auto Parts Inc
VAR052053	Industrial Stormwater	Advance Auto Parts - Distribution Center 11
VAR052080	Industrial Stormwater	The Vista Corporation a Division of Graham White
VAR052094	Industrial Stormwater	Norfolk Southern - Thoroughbred Transfer Terminal
VAR052166	Industrial Stormwater	Med-Trans Corp - Roanoke Memorial Hospital
VAR052198	Industrial Stormwater	USPS - Cave Spring Branch
VAR052233	Industrial Stormwater	Roanoke Valley Resource Authority Transfer Station

Table I-4 – Construction General Permits in the City of Roanoke - This list was procured from the DEQ's Construction General Permit Site [1], and does not have 76 permits as stated by Danielle Bishop on 9/18/14.

DEQ Permit Number	Operator Name	Site Name	Site Address	Est. Project Start Date	Est. Project End Date	Development Area (acres)	Disturbed Area (acres)
VAR109892	Intergrated Real Estate Corporation	Maple Ridge Subdivision	Eugene Drive	1/1/2008	6/1/2010	10.01	9.9
VAR109904	Boone Homes Inc of Roanoke	Wilton Residential Subdivision	End of Southern Hills Dr SW	9/12/2008	12/31/2019	51.1	36
VAR109905	Fields Construction Inc	Janette Ave	Tax Parcel 1140121	6/1/2006	6/1/2011	3.5	0.63
VAR109912	Western Virginia Water Authority	Hollins Road Fill Site	3447 Hollins Rd	9/1/2011	9/1/2017	14.9	10.8
VAR109943	East Coast Commercial Leasing Company LLC	Bojangles Route 220	4441 Franklin Rd SW	6/1/2014	6/1/2016	3.91	3.91
VAR109949	Rockydale Quarries Corporation	Welcome Valley Road SE Improvements	4277 Welcome Valley Rd SE	2/21/2011	6/1/2015	4.15	4.15
VAR109976	Haren Construction Company INC	Roanoke Regional Water Pollution Control Plant	1502 Brownlee Ave Southeast	2/11/2013	6/11/2015	105.7	10
VAR10A017	MB Contractors Inc	Countyside Park Open Space and Trails	2100 Countryside Rd	5/25/2013	10/15/2013	9.25	5
VAR10A018	MB Contractors Inc	Round Hill Elementary School	2020 Oakland Blvd NW	6/1/2013	9/1/2013	16	3.2
VAR10A023	L & S Excavating	Site Development Plan For L and S Excavating	3656 Peters Creek Rd SW	6/1/2014	7/1/2019	2.3	2.3
VAR10A025	Ivy View LLC	Ivy Market Phase II	2309 Franklin Rd SW	1/20/2012	1/20/2013	3.6	3.5
VAR10A068	Allegheny Construction Co Inc	Cleveland Avenue Site	1732 Cleveland Ave SW	7/22/2014	7/22/2018	4.8	4.8
VAR10C178	Virginia Department of Transportation	VDOT Salem - 0581-128-310,PE101,RW201,C501	-	3/1/2013	8/31/2015	19	10
VAR10C325	RL Price Construction Inc	Addition and Alteration for Pilgrim Baptist Church	1415 8th St NW	10/15/2013	2/15/2015	2.7	2.7
VAR10C526	Rail LLC	Rail LLC	3026 Baker Ave NW	11/4/2013	10/31/2014	3.55	3.55
VAR10C580	Bildel Cord	Brookfield Townhomes	Brookfield Ln	11/20/2013	11/20/2014	16.2	8.73
VAR10C625	DLB Inc	Old Mountain Road Bridge Project	3502 Old Mountain Rd NE	7/1/2014	11/30/2014	3.7	1.8
VAR10C992	Hometown Bank	Madison Field Subdivision	2329 Martin Ln	3/1/2014	2/1/2019	2	2
VAR10D204	Virginia Department of Transportation	VDOT Salem - 0581-128-109, C501, B627 16595	-	4/3/2014	9/30/2016	200	100
VAR10D225	Howard Shockey and Sons Inc	Roanoke County Criminal Justice Training Academy	5401B Barns Ave NW	4/15/2014	11/30/2014	20.6	2
VAR10D437	Primax Construction Inc	Family Dollar Brambleton Ave	3119 Brambleton Ave	5/1/2014	5/1/2015	1.2	1.2
VAR10D457	Parker Design Group	Valley View Suites	4412 Huff Ln	7/1/2014	12/31/2015	6.1	6.1
VAR10D691	Avis Construction Company Inc	Haley Toyota Dealership	1530 Courtland Rd NE	5/19/2014	5/1/2016	18.69	17.1
VAR10D906	Avis Construction Company Inc	Round Hill Elementary School	2020 Oakland Blvd NW	5/30/2014	9/1/2014	1.3	1.3
VAR10E446	Orange Avenue Investments LLC	Grocery Tenant Store 3618	3419 Orange Avenue NE	6/1/2014	6/1/2015	6.1	6.1

DEQ Permit Number	Operator Name	Site Name	Site Address	Est. Project Start Date	Est. Project End Date	Development Area (acres)	Disturbed Area (acres)
VAR10E485	Western Virginia Water Authority	WVWA Field Operations Center	3322 Hollins Rd NE	7/14/2014	10/31/2014	6.3	3.3
VAR10E759	Integrated Real Estate Corporation	Crestmoor Gardens	3608 Keagy Rd SW	6/1/2014	6/1/2016	2.5	2.5
VAR10E904	RL Price Construction Inc	IDICO	1745 Progress Dr SE	6/16/2014	7/1/2019	2.24	2.24
VAR10E905	Roanoke River Investments LLC	The Bridges	1620 Jefferson St SE	6/1/2014	6/1/2017	17	10.55
VAR10F495	Front Street Investments LLC	Berkley Self Storage Expansions	201 Berkley Road	7/1/2014	12/31/2014	7.6	1.9
VAR10F600	Anderson and Associates Inc	Roanoke River Greenway Bridge the Gap Phase 1	-	8/1/2014	8/1/2015	3.49	3.49
VAR10G174	Canatal Steel USA	Canatal Steel USA	459 Industrial Dr	6/1/2014	6/1/2017	20	7.26

B. Additional Information

1. *Bacteria TMDLs*

a) The *E.Coli* to Fecal Coliform Conversion Equation

The equation used to relate *E.Coli* and Fecal Coliform was based on 493 paired samples across the Commonwealth for *E. Coli* and fecal coliform (see Figure I-1), under the review of several experts. Although this procedure has been used by several states, such as Oregon [2] and Ohio, it has been found that the relationship between *E. Coli* and fecal coliform is seasonally dependent, and that *E. Coli* constitutes a significantly larger proportion of the total fecal coliform population in the winter months as opposed to summer months. The effects of this seasonality were observed on the DEQ's data, and it was found that the translator equation overestimates *E. Coli* concentrations in the fall and summer, and underestimates in the spring and winter, though it is unclear what factors cause these seasonal differences [3].

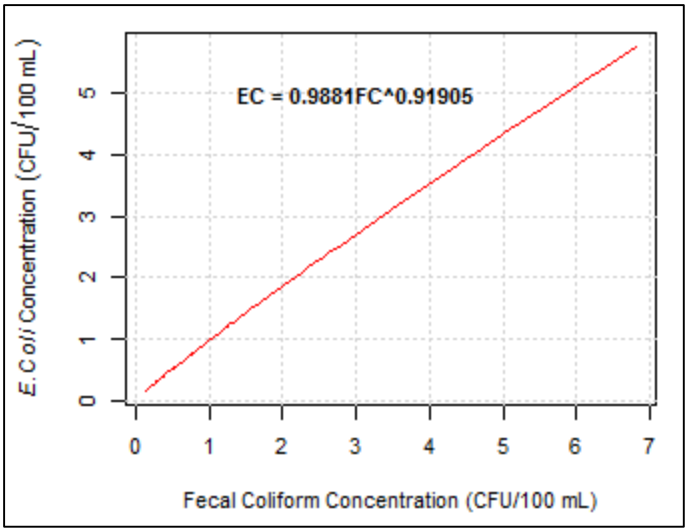

Figure I-1 – Regression equation used to convert fecal coliform (FC) concentrations to *E. Coli* (EC) concentrations. Adapted from [4]**.**

b) The HSPF Model

The computer model used to predict flow rates and bacteria loads is called the Hydrologic Simulation Program – Fortran (HSPF). HSPF is maintained by the US Geological Survey (USGS), the EPA, and Aqua Terra Consultants largely in support of TMDL creation, as it is capable of continuous, long-term modeling of both water quantity and quality over large watersheds. The HSPF model can estimate (1) how much bacteria is being transported to streams under existing conditions, (2) where that bacteria is coming from, (3) the amount of water quality treatment or hydrologic attenuation that needs to be made to the watershed so that the Virginia WQS is no longer exceeded, and (4) in what part of the watershed those improvements need to be made. The integrity of the HSPF model is critical in the development of the TMDL, as it

dictates how, and to what extent, interventions will need to be made. Several aspects of the modeling procedure dictate the usefulness of the results – the appropriateness of the model for its intended use, the quality and precision of the input data, the computational methods within the model, and model calibration.

HSPF was developed in the late 1960's as a model that could simulate most of the hydrologic processes in a watershed [5], and through its development, has been known as a comprehensive, though data –intensive modeling software. The model was designed to be extensible so that modules such as bacterial growth, decay, and runoff functions could be added in the future. Although HSPF is a well-accepted model for developing bacteria TMDLs, it may be thought of as the 'best available technology,' as the quality of model results is subject to high levels of uncertainty [6]. This uncertainty can be attributed to several factors – one of which is the validity and completeness of the data that is used for the model.

In order to develop a yearly bacterial load based on HSPF, the model requires precipitation data, and bacterial loading from both precipitation driven sources (e.g. surface runoff), and direct deposition (e.g. livestock), in addition to physical characteristics of the watershed (Table I-5). These parameters describe the physical condition of the watershed, and are thought to be the main factors determining the amount of bacteria that will reach the stream. Since the model depends heavily on the ability of these parameters to represent the watershed, uncertainties in these data result in uncertainties in the model's output. MapTech et. al used conservative assumptions in the modeling procedure that are thought to account for these uncertainties – known as a margin of safety (MOS) – though the true error of these models is not well quantified[1].

[1] The uncertainty of a model is the compounding effects of the error in input data, the error in the model equations, and the error associated with initial conditions (e.g. soil antecedent moisture). This topic has been discussed extensively, though the total uncertainty associated with an HSPF model is still not well known. For a discussion of model uncertainty for TMDLs, see *Assessing the TMDL Approach to Water Quality Management* [36].

Table I-5 – Data Sources for the Tinker Creek TMDL HSPF Model – Adapted from [7]

Input Data [units]	Description	Source
Precipitation [in.]	Hourly Rainfall data from October, 1993 – September, 1998	NOAA [8]
Land Elevation	Describes the elevation of the land surface with respect to a datum	NED [9]
Soils	Describes the conditions of the underlying soils for the determination of subsurface flow and interflow	Unknown
Stream Characteristics	Cross sections of channels were surveyed at subwatershed outlets, Manning's *n* based on field observations.	MapTech [7] and Chow [10]
Point Source Bacteria [CFU/100 mL]	Concentration of 200 CFU/100 mL prescribed at allocated daily discharge [MGD] for each of eight permitted point sources	DEQ [11]
Pervious and Impervious Land [acres]	Different land area contributes different amounts of bacteria during storm events	NLCD [12]
Private Residential Sewage Treatment	Subdivided into three categories below:	
o Failing Septic Systems	Percentage failure rate based on age of system. System counts from U.S. Census	U.S. Census Bureau, Raymond B. Reneau Jr.
o Uncontrolled Discharges	U.S. Census houses with sewage disposal described as "other means"	U.S. Census Bureau
o Sewer System Overflow	61 reported sewer overflows, plus estimation of unreported overflows	No Source
Livestock	Subdivided into three categories below:	
o Land Application of Collected Manure	Amount of manure available based on number of milking cows, and concentration of fecal coliform in manure	NRCS, Blue Ridge SWCD, Mountain Castles SWCD, MapTech, Verbal Communication with Farmers, Virginia Tech BSE
o Deposition on Land	Based on the amount of time cattle spend in pasture, not near streams, and the number of cattle	
o Direct Deposition to Streams	Based on amount of time beef and dairy cattle spend near stream	
Biosolids	No biosolids modeled	Virginia Dept. of Health
Wildlife	Raccoon, muskrat, beaver, deer, turkey, goose, and duck populations	Virginia Dept. of Game and Inland Fisheries and MapTech
Pets	Cat and dog waste based on per household census data	U.S. Census Bureau

The mathematical basis for HSPF's hydrologic calculation is a simple storage-based model, and the hydraulic calculations use Manning's equation for open-channel flow [13]. Bacterial release and survival are based on exponential functions, and partitioning and transport are based on linear functions [6]. In a summary [14] of the application of HSPF in different watersheds, it was found that it does not model extreme events well, is increasingly imprecise at smaller time intervals (e.g. hours), and has too many parameters to calibrate. Model performance ranged from very poor to acceptable in the noted studies.

Because the allocations in the TMDL assume that the HSPF model is representative of the physical conditions in the watershed, it is imperative that the model's output be

reconciled with observed stream flow and bacteria concentration data. This is normally done by performing the following steps systematically until the output of the model most closely replicates the observed stream flow and bacteria concentrations for a specified time period.

1. Build the model using available data (such as the data in Table I-5)
2. Where data does not exist, use parameter values from other studies or experience.
3. Run the model.
4. Visually evaluate the output of the model against measured data – known as a hydrograph or pollutograph.
5. Evaluate how well the modeled hydrograph or pollutograph fits observed data using goodness-of-fit metrics[2].
6. Modify the assumed parameter values in step 1, based on the output of the model.
7. Repeat steps 1 – 5 until the optimal goodness-of-fit value is achieved, and the visual inspection in 3 is acceptable. This iterative process is called "model calibration," and can be done manually, or by using an optimization program such as HSPexp [15].
8. Run the model again on a different span of time, using the optimized parameter values to assure that the model works well under different conditions. This is called "model validation."

This procedure is described for the development of TMDLs in Virginia in [4] and is common practice among hydrologists. The calibration and validation procedure in the Tinker Creek TMDL adjusted 22 parameters, until the seasonal modeled flow volumes were within an acceptable percentage error of the observed flow volumes. As the WQS for Virginia is a geometric mean of measurements over a month, it should be noted that the time scale at which the model calibration results are presented (seasonal) are incommensurate with the time scale of the WQS (sub-monthly). It should also be noted that the procedure described above assures that the model will reproduce observed data, but does not necessarily assure that the mathematical engine simulates the physical processes - it is the modeler's responsibility to make sure that a model works well for the right reasons [16]. This is especially important for models that are used for management decisions, though it is not discussed in the Tinker Creek TMDL document.

The management decision that the Tinker Creek HSPF model supports is how, and to what extent, water quality interventions need to be made to assure that the WQS is no

[2] The Virginia guidance document for calibration [11] suggests the calculation of a coefficient of determination (r^2) for the model, but since hydrologic time series data violates the assumption of independence inherent in calculating an r^2, a different metric should be used, such as the Nash-Sutcliffe Efficiency[37], or otherwise [38].

longer violated. This is determined by reducing the amount of bacteria from the input sources and re-running the model until the objective is satisfied.

c) The Benthic TMDL

The Roanoke River Benthic TMDL developed by The Louis Berger Group in 2006 (henceforth known as the Benthic TMDL) [17] was created to address violations on the Roanoke River of the State of Virginia's General Standard. Part I, Section 20 of General Criteria in the Virginia Water Quality Standards states the following:

> State waters, including wetlands, shall be free from substances attributable to sewage, industrial waste, or other waste in concentrations, amounts, or combinations which contravene established standards or interfere directly or indirectly with designated uses of such water or which are inimical or harmful to human, animal, plant, or aquatic life [18].

A common method used by Virginia and many other states is to assess river and stream quality by surveying the benthic organisms living in the waterbody. Benthic organisms consist of invertebrates such as worms, insect larvae, and crustaceans which live in or on the streambed, a transition layer known as the benthic zone [19]. These macroinvertebrates, known as the "benthos," constitute one portion of the bottom-dwelling community in a stream, spanning multiple levels of the food chain and providing a food source for other organisms such as fish. The EPA's standard method for assessing stream health, known as The Rapid Bioassessment Protocol, has several advantages for using benthic life as an indicator for stream health [20]. Among those advantages are that benthic macroinvertebrates have complex life cycles which include larval and other life stages sensitive to short term variations in water quality, while the communities as a whole respond to long term changes in their environment. In addition, benthic organisms are easy to identify, classify, and collect for sampling, and they serve as a good site-specific indicator due to their short migratory distance within a stream. Many state and environmental authorities have robust benthic life datasets, so a benthic standard is a familiar and comfortable water quality indicator for regulatory bodies. The state of Virginia has developed their own benthic impairment designation, similar to the EPA's guidelines, which defines a benthic impairment as a significant difference in benthic communities between a sample site and a non-impaired reference site with similar hydrologic and ecological characteristics [19].

The characteristics of the benthic community are sensitive to changes in water pollution. As a pollutant, sediment can have varying effects on all levels of the food chain in a river, from microorganisms such as algae, to benthic macroinvertebrates and fish [21]. Studies have been carried out since the 1970's and 80's in an effort to identify reasons for declining populations of fish and other aquatic fauna, and several concluded that turbidity is a strong indicator of declines in macroinvertebrate and algal populations [22], [23]. Turbidity is also used as in indicator for sediment loading, and

although correlations between turbidity measurements and suspended sediment concentrations in different watersheds vary somewhat due to the multiple units and calibration systems used to measure and report turbidity, repeated measurements performed and compared across individual watersheds indicate correlations between turbidity and sediment loads [21]. These concerns about the effect of sediment and other pollutants on benthic life led the EPA to develop the Rapid Bioassessment Protocols as a set of guidelines for easy, cost-effective tests of the biological conditions of a river or stream [20].

The Rapid Bioassessment Protocols for Use in Streams and Wadeable Rivers (RBPII) was initially developed in the 1980's and subsequently updated for a second release in 1999. It contains guidelines for biological assessments which can be performed quickly and cheaply by state agencies to survey the health of three categories of aquatic organisms: periphyton, benthic macroinvertebrates, and fish[3]. The RBPII calls for a survey of the biological community specified, as well as an assessment of the local water quality and habitat. The RBPII contains methods for choosing a reference site, describing a "regional reference concept" and a "site-specific approach." The regional reference concept involves selecting a non-impaired site which shares similar habitat and ecosystem properties, and is within the same geographic region as the sampling site. The site-specific approach is performed at a smaller scale, and a non-impaired site is usually identified upstream of the sampling site. It is important to note that the site-specific approach was used in evaluating biological and ambient water quality in the Benthic TMDL, and that there are several advantages and disadvantages to this approach outlined in the RBPII. Often habitats are comparable between upstream and downstream stations, which allows the focus of impairments to shift to water quality issues. In addition, the influence of any upstream pollutant sources is already factored into both sampling stations. However, disadvantages include a limited ability to extrapolate results to other sites, and a risk of selecting a reference site with unusually beneficial or poor conditions which could skew results.

The specific testing procedures given for evaluation of benthic life vary depending on the equipment used and the type(s) of habitat encountered, but all contain the same general steps. Once an adequate site is determined for sampling, organisms are usually collected via a netting device and a process of disturbing the streambed upstream of the net by "kicking" or "jabbing" with feet or the netting device. Collected samples are washed, preserved, and stored in containers; transported to a lab facility; then sorted, counted and classified. Data are reported on organisms corresponding to various metric categories measured in the lab, including: richness or diversity of organisms; tolerance to perturbation; feeding methods; habits or behaviors; and life cycle durations. Simple water quality sampling is performed on site to evaluate factors such as temperature, pH, dissolved oxygen, specific conductance, and turbidity at the time of sample collection. If

[3] This report focuses only on benthic macroinvertebrate bioassessments, as this is the indicator of impairment in Virginia, and therefore the basis for the Benthic TMDL.

more complex chemical analysis is desired, samples are collected and sent to a laboratory for further testing. Extensive field notes are also taken to describe the location and condition of the habitat(s) within the sampling region. The RBPII provides example field and lab data sheets for biological, water quality, and habitat assessments.

Once the data has been collected for a sample site and reference site, data is analyzed and scores are produced to indicate the quality of the sample site with respect to an index developed for the reference site. In the US, this is typically carried out with a "multimetric approach." This method identifies key metrics from the categories above, which capture the specific sites' responses to changes in environment. Ranges for each of these metrics are calculated, and an aggregate index or score is developed. The threshold score for the reference site is compared with the score of the sample site, and ranges of scores can be defined to establish levels of impairment.

The Benthic TMDL developers used the RBPII scores for monitoring stations on the Roanoke River to get a local, site-specific idea of the condition of the benthic communities. However, Virginia DEQ has also developed a scoring system called the Stream Condition Index (SCI) which follows the same approach as in the RBPII process except that the reference data is aggregated from across the region instead of from one reference site. This provides an overview of the condition of the benthic communities in the Roanoke River compared to other regions in Virginia using 8 specific metrics selected by the DEQ. The SCI system uses a threshold score of 60 to identify impaired segments; streams which score above 60 are non-impaired, while those that score below are considered impaired.

In the case of the Roanoke River, it was found that two sections exhibited an impaired benthic community which resulted in violations of the General Standard. In essence, these two sections of the river are thought to be unsupportive of healthy populations of local aquatic life based on the DEQ's definition, and therefore do not comply with the State of Virginia's designated waterbody uses [24]. The two impaired sections listed (VAW-L04R-01 and VAW-L04R-02) were identified by reduced benthic populations at several DEQ monitoring stations and are located on the main stem of the Roanoke River between the confluence with Mason Creek, the Western Virginia Water Authority outfall, and the Niagara Dam impoundment. These segments include river miles that run through parts of the Cities of Salem and Roanoke.

Since the biological assessments only provide information about the benthic population, they give no direct indication of the cause of impaired benthic communities. In order to determine the probable cause for the decline in benthic macroinvertebrates, the Benthic TMDL included a "stressor identification analysis," in which the Benthic TMDL developers analyzed the following sets of data for the watershed: biological assessments and ambient water quality data from DEQ monitoring stations on the Roanoke River; Discharge Monitoring Reports (DMRs) created by permitted discharge facilities in the

watershed; studies of toxicity in the Roanoke River performed by DEQ; and historic data collected to monitor stormwater. Stations and sources of data are summarized in Table I-6.

Table I-6 – Inventory of Environmental Monitoring Data for the Roanoke River Benthic Impairment [17]

Data Type	Collection Period	Monitoring Stations											Permitted Facilities	Roanoke Tributaries
		4AROA202.20	4AROA202.32	4AROA205.73	4AROA206.03	4AROA206.95	4AROA212.17	4AROA215.13	4AROA220.94	4AROA221.95	4AROA224.54	4AROA227.42		
DEQ Biological Monitoring	1994-2004	X			X	X	X	X		X	X			
DEQ Ambient Water Quality Monitoring	1967-2004	X	X	X			X	X	X	X	X	X		
DEQ Field Water Quality Monitoring	1994-2004	X	X	X			X	X	X	X	X	X		
DEQ Toxicity Study	April 2004	X				X								
Discharge Monitoring Reports (DMR)	1999- 2003												X	
Roanoke River Stormwater Study [25]	1982-1983													X

The stressor identification analysis took into account the data described above, as well as physical characteristics of the watershed (geographic location, stream network, topography, soils, land use, ecoregion, and locations of permitted discharge facilities and monitoring stations) in order to identify and rank any factor which could be a stressor for the benthic communities. Stressors were classified based on the probability of being a critical factor and were assigned ranks as “non-stressors”, “possible stressors”, or “most probable stressors”. All stressors were qualitatively evaluated taking into account the available monitoring data, field observations, and consideration of potential contaminant sources in the watershed.

The Louis Berger Group determined that DO, temperature, pH, and nutrients were all non-stressors because the majority if not all water quality measurements for these criteria were above minimum required levels or within normal ranges. Metals, organics, and toxics data, and testing that had been performed showed no direct evidence of toxicity as a chronic issue in the Roanoke River. Historical data from the Roanoke River Stormwater Study [25] indicated the possibility of “toxic pulses” entering the river during storm events via runoff, however the Benthic TMDL developers suggest that further investigation be done to determine whether or not toxic materials represent a significant stressor. The developers concluded that sediment is the most probable stressor for benthic life primarily due to habitat assessment scores. Sediment was

deposited over the natural streambed at stations running through the impaired segments, indicating sedimentation in the river. In addition, habitat quality scores decreased as the river entered developed areas; removal or reduction of riparian buffers, high impervious surface area, and increased development and construction can contribute to this habitat degradation by introducing additional sediment to the river. In addition to these observations, research has shown that benthic life may be impacted by sediment in various ways including loss of habitat due to the filling of gaps in between streambed particles, loss of food sources and habitat by burial of the natural streambed, and clogging of fish gills or filtration mechanisms which reduces respiration and feeding rates [21].

It is important to note that Virginia does not have a standard or numeric criteria set for sediment levels in local water bodies. Because of this, the Benthic TMDL developers used the "Reference Watershed Approach" (RWA) to estimate current sediment loadings and determine the TMDL endpoint for sediment in the Roanoke River impaired sections. This approach involves selecting a reference watershed which is non-impaired and shares similar characteristics to the impaired watershed. Sediment loadings for the reference and the impaired watersheds are then generated using a computer model. The load for the reference watershed is assumed to be the endpoint for the Benthic TMDL as it is a sediment loading rate at which benthic life can be supported. Recommendations can then be made for reductions in sediment load to achieve the reference watershed loading.

Although the RWA attempts to find a watershed which closely matches the topography, land use, soil types, and other characteristics of the impaired watershed, the RWA has been found to provide highly variable sediment loading rates based on the type of model run and the source of land use or land cover data [19]. In particular, the required sediment load reduction generated for the same impaired watershed varies greatly with the chosen reference watershed, even after performing area weighted adjustments for differences in watershed size. Often impaired watersheds are listed as such because biological monitoring has turned up violations resulting from high urban land use, while non-impaired watersheds are normally characterized by agricultural or forested land cover. Other methods for developing reference sediment loading have been proposed in the literature, such as regression equations and the use of multiple modeled reference watersheds. These alternatives attempt to develop correlations based on data from multiple reference watersheds in order to improve reduction estimates [19].

The reference watershed for the Benthic TMDL was chosen as the section of the Roanoke River watershed above the biological monitoring station 4AROA224.54, which is situated downstream from the confluence of the North and South Forks of the Roanoke. The Benthic TMDL developers point out that this reference watershed is a sub-basin located within the greater impaired watershed, and that it shares similar hydrologic and ecological characteristics to the impaired watershed. They do not

explain their reasoning behind selecting a reference watershed within the impaired watershed, which is a practice that has not been observed in the literature reviewed herein. Normally a reference watershed is selected that may be geographically close to the impaired watershed, but separate from it. This removes any issues which may arise during modeling from shared pollutant sources or initial upstream loadings.

Once the reference watershed was specified, data on sediment sources and loadings were gathered or generated for input into modeling software. Sources included point and non-point sources for the region, as well as estimates for in-stream bank erosion in the watersheds. Point sources were identified as facilities with permit limits for Total Suspended Solids (TSS), and loadings were calculated using the permitted facility's allowable loading rate for total suspended solids (TSS), with the presumption that all facilities were in compliance. MS4 entities in the watershed were modeled as non-point sources, as their allocation was based on an area weighting of loads. Non-point sources were identified as different land use categories, including developed lands to account for urban and impervious surfaces. In order to separate MS4 contributions from other land areas, an area-weighted distribution was used to assign portions of sediment loads from each land use category to MS4 entities based on the specific land use area contained within the MS4. Non-point source loadings were estimated using the Generalized Watershed Loading Functions (GWLF) model and the BasinSim 1.0 Windows Interface. In-stream bank erosion loading rates were estimated using a method developed by Evans et al. [26] that takes into account watershed and land use characteristics. Bank erosion loads were also distributed proportionally between MS4 entities and other land use areas.

The GWLF model simulates watershed hydrology and non-point source nutrient and sediment loading using input parameters such as weather and precipitation data, and physical watershed characteristics [27]. The model developers describe that the model has been validated for large and complex watersheds without the need for calibration with actual water quality data [27]; however, for this application the model was calibrated using stream flow data collected from a USGS gage within one of the Roanoke River impaired sections. The model was simulated over a ten year period from 1993-2003 in order to compare simulated and observed conditions during the biological assessment period. The daily time steps allowed for seasonal and annual variability in the simulations.

Contributions from these three pollutant source categories were combined to determine the current total sediment load estimate and the TMDL endpoint for sediment in the Roanoke River. The non-point source and in-stream amounts were then distributed among MS4 entities and land sources in the watershed to define jurisdictional estimates of sediment loads. Once the reference and impaired loadings were specified, the model was run iteratively with reductions in sediment inputs until the impaired watershed's loading was less than or equal to the area-adjusted reference watershed's loading.

Urban, agricultural, and in-stream sources of sediment were targeted equally in order to reduce sediment loads, and the endpoint loading condition was ultimately achieved with a 69.5% reduction in each of these categories. TMDL allocations were then developed to include non-point source load allocations, point source waste load allocations, and a 10% explicit margin of safety (MOS). In view of the relatively small contribution of sediment from point sources, no reductions were specified for point source permitted facilities in the watershed. The overall Benthic TMDL recommended allocations are shown below (Table I-7).

Table I-7 – Sediment TMDL for the Roanoke River (tons/year) [17]

TMDL	Load Allocation	Waste Load Allocation	10 % Margin of Safety
21,079	13,782	5,189	2,108

The allocations were also split by land use type within MS4 entities and the entire watershed. This resulted in an overall watershed sediment load reduction of 67.5%. If this reduction is met, it is expected that the Roanoke River impaired sections will be able to support healthy benthic communities and thereby satisfy Virginia's water quality standards.

d) The PCB TMDL

Tetra Tech's 2009 document provides allocations to address polychlorinated biphenyl (PCB) impairments designated in 1998. PCBs are organic chemicals that appear in 209 combinations, and are found in lubricants, hydraulic fluids, landfills, and old transformer fluids. It is slightly soluble in water, though data characterizing PCBs in stormwater is limited [28]. The manufacturing of these chemicals has been banned since 1979, though because of their stable structure, they persist in air and water at background concentrations. PCBs have been found to have adverse effects to humans, including cancer, inhibited reproduction, neurological development disorders, and decreased liver function [29]. High levels of these organic chemicals have also been correlated to acute and chronic toxicity in aquatic life and some small mammals [30]. As such, various agencies have created water quality standards for different forms of PCBs, and the impairments listed in this study are based on standards shown in Table I-8. As PCBs are difficult to detect in water quality samples, these standards use fish tissue and sediment samples, along with samples from the water column to quantify PCBs.

Table I-8 – Applicable water quality standards from Table 1-3, TMDL Report [31]

Agency	Criteria Description	Pollutant	Aquatic Life (ppb)	Human Health (ppb[4])
		Water Column		
Virginia Dept. of Environmental Quality (DEQ)	State water quality criteria [32]	PCB-1260	0.014	
		PCB-1254	0.014	
		PCB-1248	0.014	
		PCB-1242	0.014	
		PCB-1232	0.014	
		PCB-1221	0.014	
		PCB-1016	0.014	
		tPCBs		0.0017
		Fish Tissue		
VADEQ	State screening value	tPCBs		54
Virginia Dept. of Health (VDH)	Limited consumption threshold	tPCBs		50–500
	Do not eat threshold	tPCBs		>500
U.S. Fish and Wildlife Service (USFWS)	No Observed Adverse Effects Level (NOAEL)	tPCBs	4.5	
		Sediment		
VADEQ	State screening value based on Probable Effects Concentration [33]	tPCBs	676	

This TMDL works in the same fashion as the other TMDLs: estimate loading by sources, input into model, run model, and reduce loadings until water quality standard is met. There are a few notable differences in this TMDL, however.

The geographic scope of the first three TMDLs is the Roanoke River watershed upstream of the confluence with Back Creek at the Roanoke County-Franklin County border, but this constitutes only the upstream portion of the PCB TMDL. This TMDL also includes the Roanoke River Watershed upstream of the Dan River confluence near South Boston, Virginia, but excludes the drainage to Smith Mountain and Leesville Lakes. The impaired segments are as shown in Figure I-7 of the report (not reproduced here), though there are several other segments with impairments that are outside of this watershed, and not shown as they are not relevant to the City of Roanoke.

As PCBs occur in such small amounts, the methods used to create the TMDL endpoint is based on samples from carp and striped bass for the upper and lower sections of the watershed respectively. Water concentrations can be estimated based on the measured concentrations in fish tissue using a bio-accumulation factor (BAF). The BAF represents the concentration of PCB in water as a proportion of the concentration of PCB in fish tissue within that waterbody. The model used for the PCB TMDL is called the Loading

[4] The abbreviation "ppb" stands for parts per billion. In fish tissue and sediment, this can be thought of as one microgram (10^{-6} grams) of PCB per one kilogram of fish tissue or sediment. In water, one ppb is equal to one microgram PCB per liter of water.

Simulation Program C++ (LSPC) [34]. It is used in conjunction with the same HSPF model used for the Tinker Creek and Roanoke River TMDLs. The model is developed in a similar fashion as the other models described in this report, though the sources of PCB are different, as noted above. Final loadings and baseline concentrations for PCBs are shown in Table I-9.

Table I-9 – Average Annual tPCBs TMDL for Upper Roanoke River Source Categories. Adapted from Table ES-3 in [31]

Source Category	Baseline (mg/yr)	WLA (mg/yr)	LA (mg/yr)	% Reduction
VPDES Discharges	17,665.8	28,267.1		-60.0
Individual Industrial/General Permits	6,827.4	5.3		99.9
MS4 Entities	109,622.4	332.7		99.7
Contaminated Sites	7,853.5		1.0	100.0
Urban Background (Unknown Sites)	12,082.4		114.4	99.1
Atmospheric Deposition	8,862.5		8,419.4	5.0
Total	162,914.1	28,605.0	8,534.8	77.2

II. MEETINGS WITH CITY OF ROANOKE STAFF

A. CITY OF ROANOKE CORRESPONDENCE AND SITE VISITS

1. *PROJECT STARTUP MEETING – MAY 21ST, 2014*

Attendees: Randy Dymond, Clayton Hodges, Marcus Aguilar, VT; Bob Bengtson, Christopher Blakeman, Dwayne D'Ardenne, Kennie Harris, Patrick Hogan, Mark Jamison, Tracey Leet, Phil Schirmer, Megan Scott, City of Roanoke

- Christopher Blakeman introduced the project and the overall goals:
  - What is the WQ before it enters the COR?
  - What can we do better to engage the community?
  - Anyone transitioning will likely be working with new stormwater division
  - Christopher's role will still be compliance, but Dwayne will be taking the stormwater lead
- Stakeholders introduced themselves and described their background and relevant experience. A few key comments were made:
  - Phil Schirmer- City needs help addressing the academic questions concerning water. The City has adopted sustainability in other areas (building codes), and they want to expand that to stormwater
  - Dwayne D'Ardenne- would like to see Roanoke as the poster child for DEQ
- Randy Dymond presented "Introduction to VT Team.pptx." Questions were fielded
  - Question on Slide 19: Megan Scott – Has it been difficult to make a VDOT manual that meets the requirements of the DEQ?
    - Clay Hodges – Designed the manual to meet those requirements
- Slide 20: Randy Dymond – Trying to establish a statewide center for stormwater technology assessment through VT. Thinking about creating different locations across the state where a BMP can be plugged in and tested. Questions:
  - Megan Scott – What kind of WQ testing are you doing at the LEWAS station?
    - Randy Dymond – No P b/c no credible sensor. Measuring DO, pH, Temp, Redox Potential, Conductivity. Proposal out to NSF to grow this project.
  - Phil Schirmer – How much do you expect one of these stations to cost?
    - Randy Dymond – $50 – 70k + $10K for install (i.e. plumbing, etc.)
  - Dwayne D'Ardenne – Do you expect the price of that to come down?
    - Randy Dymond – No because technology will continue to improve
  - Megan Scott – Have you had trouble with people vandalizing it?
    - Randy Dymond – No, even with many organizations using/visiting it
    - Marcus Aguilar – Also consider the cost of keeping the sensors cleaned, calibrated, and maintained
    - Randy Dymond – Yes, Ph.D. students working on this all the time. [Describes processes VT went through to assure the sensors are working correctly.] Sedimentation around sensors is an issue for measurement quality, try to measure height from above using ultrasonic.
  - Dwayne D'Ardenne - How does the data get transmitted back?
    - Marcus Aguilar – Cell phone signal or manually connecting to device
  - Dwayne D'Ardenne – Have to have data to have an accurate model right?

- Randy Dymond – Yes – data about system, water, flow thru system.
- Clay Hodges – At the Occoquan they check their sensors once a week

- Randy Dymond discussed the need for a discovery phase. Aids VT in understanding City's natural system, regulatory issues, current data, and organization. Christopher Blakeman noted it will help: generate good data; identify each party's strengths and weaknesses; demonstrate good use of taxpayer money; build reasonable base with third party info to address DEQ and better understand/challenge TMDLs. Both VT and the City expressed interest in having DEQ at the table to talk about TMDL/MS4 rules vs cost.
- Discussion was held about sharing data, documentation, and resources. VT has an open Scholar site for sharing between VT and the City, including TMDL docs, org charts, etc. Christopher Blakeman noted that the City has changed their administration of CGP's – Ian Shaw and Danielle Bishop now in charge. Data sources available from City include: video software with GPS information (Dwayne, SW maintenance); questionable GIS infrastructure and storm sewer data with inverts; vertical control data for elevation modeling; and stream gage and rain gage data (USGS and iFlow).
- Discussed timing of interim submittal and next phase (must start by December 25th)
- Discussion was held about what to include in the scope of the project. Flood studies and revamping the CRS program for flood insurance were brought up as options, and discussion was left open for people to brainstorm other tasks they felt may be useful. The new stormwater department was discussed- interested in a 'living document,' a program which can integrate WIPs, asset mgmt., WQ, stream restoration, BMPs, etc. Will have CIP, O&M, and WQ components, and project funding could come from these or other places. VT also has resources and can help with software/hardware to host newly developed information.
- Meeting adjourned. TMDL documentation, City org charts will be delivered to VT.

2. *Visit One – June 24-25th, 2014*

Attendees: Marcus Aguilar, VT; Kennie Harris, David Dearing, Megan Scott, City of Roanoke

- Primary purpose- retrieval of all City GIS information from Kennie Harris.
- Reviewed the geographic data available on City's ArcSDE – there is a lot of it.
- Organized in several geodatabases; one main GDB for City data, divided into feature datasets for the different branches of municipal government, with metadata for each feature class.
- Information appears well organized, though some of the data appears to have come from outside sources (i.e. TIGERLine)
- Aerial photography is retrieved for 2013 and 2011 (older versions also available)
- City has not contracted for LiDAR elevation. Any surface models were built from the National Elevation Dataset, opted not to retrieve them.
- Visited David Dearing, GIS Specialist charged with supporting the GIS needs of the new stormwater utility. Part of the crew which digitized impervious rooftops, driveways, etc. to support the new stormwater fee. Problems encountered include:
  - The City grants a building permit but the structure is never built, so the impervious surface shouldn't change
  - Someone illegally built a structure across a property line; imperviousness is shared, but only one party is legally responsible for the building.
- Impervious polygons are related to parcel TAXIDs, which are billed for stormwater.

- Discussed decision process for vectorizing impervious surfaces: pixel based algorithms versus hiring temporary technicians. More efficient to hire extra hands
- Downloaded the GDB and other data from the servers.
- Visited Megan Scott, a Civil Engineer moving to the new stormwater division
  - Primary role: manage City's floodplain by assuring nothing is built in the floodway, and projects in the floodplain do not raise the base flood elevation.
  - Takes drainage complaints, determines which are valid, and creates Capital Improvement Project requests if necessary/possible.
  - Responsible for maintaining City's status with NFIP Community Rating System (CRS). Much of what she does is communicating City's programs to the general public. She noted that the new stormwater division will be responsible for the TMDLs, and the MS4 permit will be split with the Environmental Management group.

3. *VISIT TWO – JULY 2ND, 2014*

Attendees: Marcus Aguilar, VT; Phil Schirmer, Patrick Hogan, Dwayne D'Ardenne, City of Roanoke

- "If you could separate yourselves from the daily tasks and decisions that you need to make, could you describe the main goals that you are aiming towards in maybe two or three bullet points?"

- Phil's answer – The stormwater program in Roanoke really stands on three legs:
  - Capital Projects – Based on complaints and assessed need by the City, there is ~$80 Million backlog of stormwater projects that need to be done. Most projects are still driven by complaints, but the City would like to jump ahead of this and start performing preventative maintenance on their systems.
  - Maintenance – The City would like to be proactive in repairing system, but they do not have a good infrastructure database, and therefore do not have a good grasp on exactly where maintenance needs to happen. It will also be difficult to decide what repairs can be done in house, and what needs to be contracted out to design/construction firms.
  - Water Quality – Working with the DEQ on TMDLs and eligible BMPs. Eventually the City would like to build stormwater control measures in the public ROW that are vegetative in nature and would only require "passive maintenance." Phil hopes that the visibility of vegetative interventions will be proof to the City that their money is being well spent, especially because these strategies tend to be aesthetic. They also hope that this sort of strategy will catch on in private property.
- Water Measurements –What is the water quality upstream and downstream of the City? How much is a BMP improving water quality? The City is interested in sediment and bacteria, as well as water quantity; PCBs are also a TMDL to be dealt with eventually.
- Watershed Master Plans – this is something that will fit into the City's Comprehensive Plan – a 20 year planning document for the City's direction. Look at the City by watershed and determine how to distribute money by watershed and within each watershed. Since the City now has a large budget for stormwater, they want help to figure out how to spend that money.

- Stream Quality Guide – City would like to have a detailed map of the creek and river segments that are in need of restoration, and the segments that are not. Where are all the outfalls and what are they connected to? Planning a float trip to help with this

4. *VISIT THREE, FLOAT TRIP, PART 1 – JULY 18, 2014*
   Attendees: Marcus Aguilar, VT; Dwayne D'Ardenne, Christopher Blakeman, Megan Scott, Joe Koroma, Ryan Apple, Danielle Bishop, Karl Kleinheinz, City of Roanoke; Liz Belcher, Roanoke River Blueways

- Trip hosted by Liz Belcher of the Blueways to familiarize VT and City staff with the River and outfall locations.

5. *VISIT FOUR, ROANOKE RIVER STEERING COMMITTEE MEETING – AUGUST 20TH, 2014*
   Attendees: Marcus Aguilar, Paul Bender, VT; Mary Dail, Jay Roberts, Diana Hackenberg, Kip Foster, Charlie Lunsford, DEQ; Nick Tatalovich and Erin Hagan, Louis Berger Group; Dave Henderson, Tarek Moneir, Roanoke County; Christopher Blakeman, Megan Scott, City of Roanoke; Anita McMillan, Town of Vinton; Sarah Baumgardner, Mike McEvoy, WVWA; Bill Modica, Bill Tanger, Upper Roanoke River Roundtable; Margie Lucas, Mill Mountain Garden Club; Wendy Jones, Williamson Road Area Business Association; Liz Belcher, Roanoke Valley Greenways/(Blueways?); Tom Dale, Lumsden Associates; Staci Merkt, Mountain Castles SWCD; Ashley Hall, EEE on behalf of VDOT; Larry Iceman, Smith Mountain Lake Association; Kafi Howard, Town of Blacksburg; Ed Wells, Roanoke Valley Alleghany Regional Commission; Josh Pratt, City of Salem; Tom Cain, Lick Run Watershed Association

- Project Status - the original three TMDLs that led to the creation of the implementation plan (IP) were described. The PCB TMDL isn't part of this IP. DEQ hopes to have a working plan in place by Winter 2014-2015, completing Phase I. Phase II consists of the North and South Forks.
- Working Group Updates - Business, Agricultural/Residential/Urban, and Government. These groups had been organized to provide input from stakeholders from various common perspectives. The meetings were held in February 2014. The IP has been modified based on the recommendations of these groups.
- Discussion Notes:
  - There appears to be some confusion as to how the requirements of TMDL IP and MS4 Action Plan overlap. MS4 authorities want to know how much they will be required to do, and where the BMPs should be placed.
  - Street Sweeping was brought up in working group comments and incorporated into the IP as presented at this meeting. Concerns were raised about: the efficiency of this method; cooperation between municipalities, County, and VDOT; alternative projects such as pavement resurfacing.
  - Concerns were raised about the extent to which in-place BMPs since TMDL development were accounted for in the IP.

- Stakeholders are concerned about the ability of MS4s to develop TMDL Action Plans when all the recommendations are on the watershed and subwatershed level.
- Stakeholders raised concern for the dynamic nature of changing land use and MS4 boundaries with census information- DEQ explained that these are static for now and would have to be changed in future updates of the TMDL.
- A major concern from all stakeholders was the cost and variety of BMPs described in the IP.

o Meeting was adjourned with the plan that several topics such as implementation stages, technical assistance, and funding sources would be discussed at the next stakeholder meeting (date and time TBD).

6. *Visit Five, Float Trip, Part 2 – August 21st, 2014*

Attendees: Marcus Aguilar, Paul Bender, Walter McDonald, Jessica Hekl, Kandace Kea, VT

o VT organized this trip with the help of Anita McMillan from the Town of Vinton. Toured another downstream section of the Roanoke River as it exits the City boundary, noting outfalls, stage, geography, land use, and other information.

7. *Phone Call – September 11th, 2014*

Attendees: Marcus Aguilar, VT; Ian Shaw, City of Roanoke

o Background is a Civil Engineer
o Ian's job is to consider the long-term goals of the City, and figure out how to create ordinances that steer it in that direction. He was integral in creating and executing the comprehensive plan, which although was created before the stormwater regulations (2001), was open ended and allowed for permeable pavers, etc.
o The City's Comp Plan is a 20 year document, but Ian says that they'll be starting work on it relatively soon (maybe next year). This document will also include more precisely defined water quality goals.
o Ordinances are reviewed on a yearly basis to make sure that they're doing what they were supposed to
o It is difficult for the City to determine how to start moving towards the TMDL AP.
o Danielle Bishop is in charge of VSMP permitting. The City has had water quality ordinances in place since 2007, but the new program has slightly different requirements
o Barriers to changes in operations based on new ordinances were also discussed

8. *Phone Call – September 12th, 2014*

Attendees: Marcus Aguilar, VT; Joe Koroma, City of Roanoke

o This phone call informed VT about Joe Koroma's involvement with the stormwater division and capital improvement projects.

9. *Phone Call – September 15th, 2014*

Attendees: Marcus Aguilar, VT; Bob Bengston, City of Roanoke

o Public Works (PW) director

        - Provides direction for all the divisions in PW, but especially Stormwater since it's new
        - Conduit between PW and City Manager's office, makes sure everyone is communicating
    - Stormwater used to be in transportation division, so street crews did maintenance
    - Engineering Division handles water improvements
    - Stormwater quality issues were handled by Christopher's Environmental group.
    - Distributed across three areas, but since the utility was put in place (July 1), all the pieces were pulled together to make a new stormwater division (SWD)
    - Dwayne was promoted out of Transportation into Stormwater Division
    - Public Works now includes: Transp, Eng, Solid Waste Mgmt, Env, SWD
        - Engineering used to have responsibility for all CIP, but now they don't have responsibility for any stormwater projects
    - Stormwater Division - Takes a fair amount of effort to organize. What pieces and parts go into this division, and what remains? Not all the positions have been filled. Org charts haven't necessarily been updated
    - Challenges- Funding piece will be an issue until the Fee reaches the full amount, actually works well because it'll be hard to actually spend all that money. Ever emerging requirements from the DEQ seem to be a challenge. Want to get to a point where rivers and streams are no longer "impaired," need to get the community as a whole to understand that day to day actions have consequences on water quality. Seatbelt use and litter are good analogies.
    - Was simply a matter of getting water off the land surface quickly, now it's a question of allowing it to infiltrate, etc. The Greenway system has helped to bring the community closer to the river.

10. PHONE CALL – SEPTEMBER 18TH, 2014

Attendees: Marcus Aguilar, VT; Danielle Bishop, City of Roanoke

- Role in administering the VSMP - SW and ESC administrator – Assure that new development adheres to regulations. Inspections, plan review, enforcement, post-construction maintenance every year...is it maintained and operating (structurally sound). Bioretention - are plantings still in as they should be, though no way to check media? Pond - is vegetation maintained?
    - Enforcement - verbal notification, silt fence, grading. Official notice to comply. Stop work order. Taken one to court
- 300 facilities inspected on an annual basis...only the private facilities. Engineering inspects 20 city owned
- How many construction permits does the City have out at any one time? The DEQ has 74 reported...
    - Huge increase in development over last year - 76 plans this year, 47 last, 57 before, 75 in 2008
    - Brownfields redevelopment, mostly commercial and institutional (churches, schools)
    - Very few large scale residential, lots of little infill lots
- Who is the VESCP authority? Is it the City as well? Yes.
- From the General Permit: *Discharges of stormwater from construction activities to surface waters identified as impaired...or for which a TMDL WLA has been established...for sediment...are not eligible for coverage under this general permit unless the operator*

develops, implements, and maintains a SWPPP that minimizes the pollutants of concern. What sort of measures does the City require of contractors to prevent sediment discharge?
    - E&S program - state can come in and audit the approved plans, visit construction sites. Every 5 years
    - SW program - subject to same type of audits now due to July 1 policy change. Program was already in place for MS4 permit
    - TMDLs - New VSMP program talks about addressing TMDLs... once IP is in place, the City must develop an action plan towards the IP.
- How does the City keep track of construction sites, and when they've been inspected? Is there an inspection database?
    - Yes - PermitsPlus software generates a (1) "permit" for plan review, review letters, etc. (2) Land Dist. Permit, all inspections and enforcement. (3) SW Permit includes post-construction information.
    - Plans go to 10 depts. (eng, sw, trans, econ dev, solid waste, zoning, building, wvwa). When construction starts, invited to pre-construction meeting. Eng Dept. queries that system to see how impervious surface changes
    - RFP for new permitting system - already out. PermitsPlus since 2001
- Do you have a dedicated inspector? How is he/she trained?
    - 2 inspectors +1 recent hire brought on to VSMP regulations
    - Most of their work is ES, SW, inspections, zoning inspections
- How does money work for this program? Do permittees pay the City? Does that support the program or is additional funding required?
    - New VSMP allows charging additional fees...far away from being fully funded
    - Staffing and funding plan - with new fee, at 34% recovery
- Why would a non-MS4 locality choose to be a permitting authority?
    - Economic development decision - if not running own program, development still has to meet reqs. All plans go to DEQ, which slows the process down.
- Challenges
    - Handling the workload and implementation of new program, understanding program, how to apply it, educating staff for certification. Implementation is a full time job, so development isn't getting addressed.
    - All municipalities stay in touch to keep up with changes in current regs
    - Don't get a lot of clear direction from DEQ with specific implementation questions. The City sends DEQ their own interpretation and proceeds with development.
        - Example – a big change is const. of single family homes part of common plan of development. There's a gap of 4 yrs where WQ was required from state but not the City. These SFH begun 2004-2008, but const. stopped because economy got bad. The City believes the intent from the state is that you don't need to hire an engineer to build SFH, but you still need to build WQ based on a list of BMPs

11. VISIT SIX – SEPTEMBER 19TH, 2014

Attendees: Marcus Aguilar, Paul Bender, VT; Phil Schirmer, Dwayne D'Ardenne, Christopher Blakeman, Patrick Hogan, City of Roanoke

- Met with Phil and Dwayne first

- Asked for clarification about a watershed polygon file with no metadata. Phil and Dwayne were not certain they knew the specifics about this file. It may have been developed by interns or new staff, but may not be QA/QC'd.
  - Mentioned other recent studies- 2' topographical survey by the Corps of Engineers and Roanoke County, and an outfall mapping of Tinker Creek and the Roanoke River.
- How willing do you think DEQ is to collaborate on monitoring program development, and who would we need to get in contact with in order to get a conversation rolling between the City, DEQ, and VT?
  - Need to have 'right players' in the room- combination of higher-ups from Roanoke/Richmond. Unsure of the DEQ reporting structure.
  - Main concern is how the DEQ plans to regulate progress towards the IP in the future.
  - They want to see Roanoke be the 'poster child' for integrating best technologies, planning, and management strategies available for SW.
  - Interested in 'maintenance friendly' BMPs, urban street scape bioswales, and stream restoration projects, concerned they will not be allowed if they are not part of the Clearing House list.
  - Dwayne added that he would like to see City CIPs integrated with projects that will help reach IP goals for sediment and bacteria.
  - Danielle and Planning Dept are concerned that they do not have the wiggle room they need to make the proper decisions and still adhere to reporting guidelines for the DEQ
- Comprehensive Plan (CP) and the timeline they are expecting.
  - Current CP is outdated (2001-02), should be revised every 10 yrs
  - Plan only contains typical infrastructure-based SW measures
  - Interest in developing Watershed Master Plans before an update to integrate them with the new plan.
  - Include specific goals in these Master Plans to "give the CP teeth" to enforce SW measures. CP is based on neighborhoods, not planning or zoning districts (or watersheds), so this would need to be considered if Watershed Master Plans were to address the TMDLs.
  - Work on updating CP may begin in 2016-17; there will be a steering committee, and they would like VT to be included in that effort.
- Briefly discussed PCB TMDLs. Phil is not too concerned about them, seems to know of most of the contaminant sources- brownfield/dump sites in Roanoke where AEP transformers had been stored/thrown away and leaked. Many developed now, could present problems later for remediation.

o *Met with Christopher Blakeman and Pat Hogan*

- Briefly discussed Stormwater Utility Fee and the new VSMP regulations.
  - SWU Fee rollout painful at start, still won't nearly pay for itself
  - DEQ much more present and engaged in VSMP process
- How comfortable do you feel with your current understanding of the IP?
  - Still unsure about some aspects, no concrete guidance yet from DEQ
  - Better understanding of descriptive nature of the IP
  - Still concerned about how IP will be regulated. MS4 AP's will require progress towards IP goals, effective for the 2014-15 reporting cycle, beginning on Oct 1st 2015
  - Four topics TMDL hasn't addressed well enough yet for the City:

1. **Cost quotes for BMPs**- concerned that City might get "hemmed in" on budget costs and CIP's. City might look disreputable if quoting higher costs, and client may refuse to pay the actual costs, trusting the state published values.
2. **Specified types of BMPs**- BMPs and methods listed in the IP will be eligible for certain grants. Important that DEQ lists as many acceptable/approved methods as possible in the IP for volunteer project funding purposes. City wants freedom to develop public-private partnerships to test run new methods such as MTD's. Real-world data could provide faster approval
3. **The TMDL IP needs to consider the complexity of the MS4 system and the ability (or inability) of MS4s to make and enforce changes**. How will monitoring be performed to judge compliance? How will credits be assigned later for implementing changes? Explicit wording should be in the IP that explains topics like interchangeability of BMPs or use of alternate, not necessarily approved BMPs. No link between "quantifying local biota" and changes MS4s can make.
4. **IP lacks emphasis on actual implementation**- DEQ addresses responsibilities of permit holders, but not local businesses or the public (e.g. maintenance of structures on private property). TMDLs include large pollutant load from non-urban areas- MS4s have no power here. Tough to get volunteers to perform BMPs

- How will the IP fit into City's plans for SW and MS4 permit requirements?
  - City plans to address SW quality issues simply: identify hot spots, work with citizens to implement cost-effective BMPs, perform follow-up monitoring, make improvements. Three most important factors behind the City's decision-making process (besides regs):
    1. **Quantify small-scale effects**- implement BMPs/other strategies on publicly-owned sites at small scales and determine effectiveness. Scale up for larger and more effective applications around the City.
    2. **Resources**- City is limited in staff and funds. Building new SW Division, SWU fee will roll out over three years in 3 distinct fee increments- 30, 60, and 90 cents/month/500sf.
    3. **Education and community outreach.** Educate citizens and employees to prevent SW contamination. Training/demo programs for inspectors - develop a proactive, respectful approach to address ESC violations and prevent more than what state requires (small projects focus). Address the "bigger picture" of sediment effects from all types of construction and development projects. Engage the public as the 'eyes and ears' to report SW violations or problems. City is investigating systems for inspectors/citizens/employees to improve ease and detail of reporting with spatial GIS/GPS techniques, integrate with complaint logging efforts.

12. *Phone Call – September 22nd, 2014*

Attendees: Marcus Aguilar, VT; Patrick Hogan, City of Roanoke

- New Trimble program - TerraFlex - inspection software - downloads into a CSV file, xml, kmz...they would use the kmz file
- played with it on smart phone, but accuracy was not so great
- Mainly to log inspections
- TerraSync adds new points
- integrates with total station
- Duncan Parnell
- Juno 3 series
- Juno 5 series - leaning this way
- Geo7x series
- 1 - 2 meter accuracy with no cell service
- Some old units in engineering
- No one is really allowed to mess with data, only GIS and David can edit. Only way that most folks use the GIS is through the GIS dept.
- Managed separate from any GIS
- Pat's never used the ESRI software at work, but uses the GISRE multiple times weekly.
- Env, RE, and Code Enforcement don't use it at all
- Engineering Dept. Probably use GIS heavily. David Fenton is new employee (540) 853-5203
- GISRE is a little better than it used to be...Tracey's project probably
- ArcGIS online - free trial. ArcGIS Collector App...very simple table to fill out.

13. *Phone Call – October 17th, 2014*

Attendees: Marcus Aguilar, VT; Steve Taylor, City of Roanoke

- Maintenance Supervisor - Street sweeping crew, storm drain maintenance crew - repair + camera
- Different division that installs new storm drains but not his group
- Once the storm drain is built, they do inspection, cleaning and repair
- Street Sweeping - debris gets swept up into hopper box, then it gets loaded into a dump truck (high dump sweeper) or dumps on ground.
    - Mechanical Sweeper - side or gutter brooms, one on each side. Swirling brush pulls it under sweeper, main brush scoops into conveyor to hopper
    - Vacuum Sweeper - Big vacuum cleaner, one nozzle is a high pressure vacuum with one gutter broom and one main broom which funnels to vacuum...maybe 1.5' in diameter
    - Regenetive Air - Recirculates the same air
    - http://elginsweeper.com/Products/AirSweepers/tabid/108/Default.aspx
    - City uses mechanical sweeper because heavy debris and sticks will clog nozzle...heavy leaf canopy
    - Regenerative sweepers are being pushed because supposedly they pick up more of the particulate
    - They own the machines...but regenerative are more expensive
    - Mechanical, maybe 150K; Regenerative, 230K
- Maintenance - Ryan Apple
    - Camera crawler that goes on a line by remote control

- Working on maintenance by neighborhoods – goal = 10%/yr of total footage
- Want to get the whole City TV'ed in 10 years
- Interns did GPS location of infrastructure
- Secondary database that includes the unknown
- Looking at buying a new TV truck that includes GPS capabilities
- If you find a new structure or pipe, how is it captured now? **It isn't!**
- Trimble pathfinder device might get used
- Working on contract to contract out some of the camera and cleaning
- Storm sewer system is between horrible and fair conditions
- Mainly they see pipe deflections and sags, sewer lines through box culverts
- Heavy debris or root intrusion
- Own a machine that cleans pipes - VACTOR combination sewer cleaner - water jet on a hose, looks like a missile. Shoots water backwards, device cuts through roots. Vacuums debris up. Can run camera through pipe to ID a blockage - sometimes it's another pipe, collapsed pipe...found a gas line
- Also a foot crew that cleans the alleys and so forth with a hand blower

o Could we make a field trip?
- Downtown and arterial sweeping is done at night, residential during the day.
- steve.taylor@roanokeva.gov

14. Visit Seven, Stormwater Maintenance Field Trip – November 7th, 2014

Attendees: Marcus Aguilar, Paul Bender, VT; Steve Taylor, Ryan Apple, Bill Jones, Tyree and Steve, City of Roanoke

o Bill Jones (supervisor of maintenance) showed us around the street sweepers
- Sweepers can be driven on left or right, hydrostatic transmission and single pedal for drive and reverse; cabins are airtight to protect from dust, and use water sprayers that can be refilled in field from a fire hydrant
- Mechanical- first line of defense, picks up heavier debris; metal side brooms to plastic middle broom, conveyed to dumpable hopper (3.5 cu yds)
  - Each operator can call for dumps in field (3-13 in a shift, season dependent), sweep for 6 hrs with 1-hr maintenance before and after
  - Elgin models: Pelican (wide, city streets) and Tennant (narrow, Greenways), run about $180,000
- Regenerative Air- fine clean, vacs up sediment better; run about $230,000

o Field operations with Tyree and Steve
- Tyree's typically seen that 15" pipes and below are clogged, 18" and above don't have as much trouble. Typical debris includes roots, leaves, garbage, and sometimes toys as big as kids' bicycles
- Carroll Avenue site, near a nursery school
  - Demo of TV camera through Manhole-Manhole, demo of vactor truck
  - Site was previously inspected - a gas line was found running through the storm pipe; this was fixed before we ran our camera through.
  - Our run-through with the camera (170 ft with setup and take-down) took roughly 1 hour; 8-hr shift might survey ~1000 ft of pipe at best
  - Vactor operation: water jet nozzle cuts through debris and sends it downstream, vacuum suction removes debris as big as bricks
- Kennedy Park site

- Didn't have time to film this part, showed us the site - drainage system installed to alleviate water collection in a field - "bowl effect"

- Talked with Ryan Apple about CCTV plans and data needs
  - City is concerned with storm sewer only, WVWA handles sanitary sewer
  - Estimate that captured GIS nodes ~70% accurate, connections ~50%
  - Current CCTV Inspection System:
    - Robotic camera, interchangeable wheels for various pipe diameters, utilizes Granite XP software, made by Cues, to record media and store in digital format, can export in mpg format to hard drive, DVD
    - Software has data input for invert depth, pipe length and condition
    - There currently is no link to upload data to any City system, GIS or otherwise, data only exists on the laptop used in the truck
    - Structure numbers and City grid system used to plan and carry out inspections came from City GIS
    - Current coding system: difficult to determine where in the City a specific feature lies
  - Upcoming Changes
    - Planning to purchase a new TV truck fitted out with a new software program using NASSCO standards for inspection and condition of stormwater infrastructure (not expected for another 8 months or so)
      - Considered Options: Cues, Envirosite in NJ; RST in CA
      - Envirosite is most likely choice, offers camera with multiple carrier bases for pipes, choice of software (City wants WinCan, incorporates ArcMap, sold by Pipe Analytics)
      - New system will have expanded data collection capabilities
    - Crew: expecting new hires to start soon, City will have two 2-man crews for CCTV/Vactor inspection and cleaning; hoping for another 2-man crew to help with CIP work, not sure yet.
  - Strategy
    - Not sure yet of plan for stormwater infrastructure capture for this project; may recapture all infrastructure, code it as known or unknown, then investigate unknowns further.
    - Important to maintain consistency between all departments contributing GIS data so that the database remains the most useful
    - Structure: thinking of 2 layers (nodes and conveyances), perform an asset inventory and condition inspection. Collect field data, send to the office to verify, upload to the GIS to incorporate in geodatabase.
    - Numbering/Coding system: Ryan has an idea for the grid coding system for nodes (watershed code, grid code, type and ID# of feature). Conveyances currently use a Mainline Unique Identifier- links pipe to upstream-downstream feature nodes; may need a new identifier or code this differently in GIS to make it easy to query

15. VISIT EIGHT, DEQ STREAM MONITORING MEETING – NOVEMBER 12TH, 2014

Attendees: Marcus Aguilar, Paul Bender, VT; Anita McMillan, Vinton; Dwayne D'Ardenne, Megan Scott, Christopher Blakeman, City of Roanoke; Cindy Traywick, Dave Henderson, Tarek Moneir, Roanoke County; Josh Pratt, City of Salem; Greg Anderson, Mary Dail, Jason Hill, Cody Boggs, Mike McLeod, James Moneymaker, Larry Willis, DEQ

- Purpose of meeting: for personnel from local MS4s to get familiar with the DEQ's monitoring stations, data, coding, and the process and frequency of monitoring.
  - DEQ currently runs a 6-year rolling sampling cycle (reports generated at end of every 2 years for past 6 years of data). Sampling is often biased towards base flow measurements – generally no sampling during storms. A "monitoring station" is just a site (bridge, public access point, private land access) from which DEQ can sample the river or water body. No sampling infrastructure at these locations; "stations" are often used for multiple monitoring programs, as described below.
  - WQ data are available on federal "STORET" or WQX website, currently considered difficult to use, especially by the general public. Three sets of station codes from different databases complicate data comparisons. Program code duplicates are listed below where known.
- DEQ described their main types of monitoring programs and codes:
  - A or AW- Ambient Watershed Monitoring Station
    - Stations typically located at or near mouth of each HUC6 WS in the state. Sampling performed bi-monthly over a two year cycle (12 data points per cycle) and 1/3 of all stations are sampled every two years (3 cycles in 6 years sample all ambient stations). Current parameters evaluated include 2 bacteria tests (Fecal Coliform and E-Coli), basic water chemistry (DEQ calls this "field data" = pH, Temperature, DO, Conductivity), and basic nutrients (N and P)
    - Stations used for preliminary analysis, allow management to say they provide statewide spatial coverage with a minimum set of parameters. Data is coarse, somewhat biased, and has little use.
  - TR- Trend Monitoring Station
    - Typically oldest monitoring stations with continuous monthly records, a few new ones added in recent years. Sites now sampled bi-monthly, not monthly. Stations often associated with a USGS Gage.
    - Parameters strongly chemistry based: field data, fecal and e-coli bacteria, N and P nutrients, and solids tests (TS, TSS, turbidity). Data are evaluated with the Kendall Tau rank correlation test
  - B or RB- Biological Monitoring Station
    - Benthic bug counts, sampled in spring and fall seasons (Drew Miller does Roanoke area). Some sites are long-term, most are not sampled every year, time-intensive. Performed where DEQ feels it's needed.
    - Field data and rapid habitat assessment also performed. Benthic counts currently based on 100 organisms using the Virginia Stream Condition Index (VSCI; developing a "Genus 200" system soon)
    - Benthic conditions in Roanoke region upstream from Niagara Dam improving lately. Typically assess riffle habitats on Roanoke River
  - FPM or FP- Freshwater Probabilistic Monitoring Station

- Monitoring stations selected at random (never on bridges) in an attempt to remove bias present in other programs.
- Most expansive program, samples for: 3 bacteria indicators (Fecal, E-Coli, Enterrocoxy); chemical parameters (dissolved metals, nutrients, solids, ions/cations); and biological parameters (benthics, fish, algae, and quantitative physical habitat assessment)
- 50-60 sites sampled annually (mostly new every year); portions of testing carried out over spring and fall, aggregated for one data point

▪ TM- TMDL Development Monitoring Station (Special Study)
- Once a reach of river is listed on the impairment or dirty waters list (303d list in the 305b report), TMDL special study stations are selected to generate the TMDL
- More intensive monitoring is done on a watershed scale (monthly or bi-monthly depending on timeline)

▪ IM- TMDL Implementation Monitoring Station (Tracking Progress)
- Station predetermined for post-implementation monitoring, tracks progress towards TMDL endpoint and de-listing the reach
- MS4s can perform their own additional monitoring or to talk to the DEQ about adding additional stations for high priority BMPs

o DEQ also discussed sediment as a parameter in water quality
▪ Tough to correlate TSS with impairment
▪ Roanoke Valley has many natural sand bed rivers
▪ DEQ uses a method from the EPA to evaluate sediment
▪ DEQ has often found that erosion upstream due to increased flows is the cause of sedimentation downstream
▪ Important to look for causes upstream before fixing a potential symptom.
▪ Stream restoration may be a viable option, but degree of improvement of benthic life may depend on the gradient of development in the region.

o Questions brought up by MS4 representatives:
▪ How can we educate decision-makers to create better policies and reduce the burial of local waterways?
▪ How can monitoring data be logically communicated to elected or appointed officials and the public to encourage people to care about water quality?
▪ What can we do as a whole, perhaps with smaller changes, and what is the value added by those effects?

o DEQ response: short on data about what BMPs truly work
▪ Trying to develop a "carrot" to help MS4s make progress instead of using the regulatory "stick." Perhaps allow MS4s to focus on one impaired segment at a time, concentrating effect. Money can be spent on measures which can be evaluated for effectiveness to help determine what works and what doesn't

o Meeting adjourned with a summary of next steps:
▪ Work with Cody Boggs to get all the MS4s together and continue discussion
▪ Review WQ data and factsheets, hold another session with DEQ – "Data 101"
▪ Coordinate a Working Group Sub-Committee under Mary Dail to hold additional sessions during the implementation phase of the IP
- Small group meeting to identify desired direction, then bring MS4s and stakeholders together to discuss details
- Opportunity to identify "low-hanging fruit" – easy projects that MS4s could work together to carry out and achieve a larger impact on WQ

B. CORRESPONDENCE WITH OTHER AGENCIES AND ORGANIZATIONS

1. *PHONE CALL – JULY 21ST, 2014*

Attendees: Marcus Aguilar, VT; Liz McKercher, TMDL Program Manager, DEQ Richmond

- VT found out more information about the Benthic TMDL and available DEQ GIS data.

2. *ASCE DINNER MEETING AND PRESENTATION – AUGUST 21ST, 2014*

Attendees: Marcus Aguilar, Paul Bender, Randy Dymond, Clay Hodges, VT; other various Roanoke area stormwater stakeholders

- Fred Cunningham of the DEQ presented about the new VSMP Construction General Permit regulations, and example site development calculations were reviewed.

3. *PHONE CALL – SEPTEMBER 4TH, 2014*

Attendees: Marcus Aguilar, Paul Bender, VT; Mary Dail, TMDL Project Coordinator, DEQ

- Clarified the difference between the TMDL Implementation Plan (IP) and the Action Plans (APs) in individual MS4 permits
  - The IP is a **descriptive** document of the SCM installation that it will take to meet the TMDL endpoint. No legal muscle behind it, more of a helpful document to guide stakeholders in the watershed to the endpoint.
  - The APs are **prescriptive**, that is, the MS4s must develop SCMs and detail them in their APs which appear in the MS4 permit.
- There is no legal device for areas in the watershed that do not have MS4 permits - action towards the TMDL endpoint is completely voluntary

4. *STORMWATER MONITORING COST ESTIMATE PHONE CALLS – SEPTEMBER 22ND, 2014*

Attendees: Marcus Aguilar, VT; Dr. Roger Glick, City of Austin, TX; Harry Post, Occoquan Watershed Monitoring Laboratory, Virginia Tech

- *Harry Post - Occoquan - 9/22/14*

  - Equipment Costs
  - Refrigerated Portable ISCO samplers - $4,000 each - very happy with results
  - Palmer Bowlus installation with pressure transducer for levels - empirically derived stage discharge curve
  - ISCO Acoustic flow Meters - $3,000 a piece + $2,000 software + $500 license
  - YSI 6200 and 6600 models, smaller meter might work - about $3,500
  - Ryland Brown for up to date prices
  - Sutron flow meters with stage discharge rating relationship with pressure transducer for stage
  - Exconnect is the telemetry system
  - Cell phone calls an IP address - ISCO and Exconnect
  - Normally we visit once a week or two weeks to check and download data

- E-mail from Harry:

  Marcus,
  Here is the information that I gathered about a monitoring station such as we discussed.

  Equipment costs:
  ISCO flowmetering system/datalogger with acoustic sensors - $3700 each
  serial over ip modem $2900 (not including service)
  ISCO software $2055

  YSI multimeter (cost depends on the parameters to be measured) - $5700 approximately

  If you go with the installation of a Palmer-Bowlus flume rather than an acoustic flowmeter:

  Sutron 8310 datalogger - $1700
  Cellular modem - $625 (not including service)
  pressure transducer - $700
  36" Palmer-Bowlus flume - $1600 (ours our manufactured by Dixie Sheet metal in Falls Church)

  For our project at Cinnamon Oaks (three stations all within about 100 yds of each other), installation, maintenance, and operation time was approximately 300 man-hours per year, not including travel time to the site. We do total coliform, fecal coliform and e coli in-house. The per sample cost for each is approximately $35.

  Hope this helps. Call me if you have any more questions.
  Harry Post

o *Roger Glick - City of Austin - 9/22/14*

- ISCO Bubbler flow meter with a modem interface - $4,700
- ISCO Rain Gage ~ $1,000 tipping bucket
- ISCO 3700 auto sampler $3,000 connects up to flow meter, automatically collects samples
- Equipment shelter - $1,000 - 1500
- Site installation - 40 - 80 man hours
- Maintenance - 2/3 man hours/wk with travel time
- During sampling times, 3 man hours before storm, 6-8 after storm with post - storm maintenance + however long storm events (usually overtime)
- If City installs, normally $10-15K total, but they already have the equipment
- Probably about 10 - 15K for maintenance and sampling during the year not counting lab analyses
- Suite of nutrients + metals + COD, TOC, TSS, VSS $200/sample
- For more complex $1,000/sample
- USGS has a turbidimeter in a spring - $3 - 4 K
- Bacteria

- If you do it in-house it means you hire staff, if you hire a consultant it's more
- Data management is very important...good to think this through

5. *PHONE CALL – SEPTEMBER 23RD, 2014*

Attendees: Marcus Aguilar, VT; Dan Widner, VGIN

- Statewide aerial photography by half of state every four years
- Fly in odd years
- Spring 2015 is western half of state - 1 ft. resolution (no cost)...6 months before product is available (end of 2015)
- DTM is developed alongside orthophotos - Sanborn mapping
- Upgrades are available
  - LiDAR is an option
  - Land Cover is option (would proabably a waste of money)
  - Planimetric is option
- State wide land cover dataset working with DEQ - coming out of WQ improvement fund - working group met - land cover only...will use VBMP. Will have 5m LC dataset
  - Phase I - Pilot Areas representative of various portions of state to do process - photogrammetry +QA/QC then stakeholder review....next May
  - Phase II - Ches. Bay WS end of 2015
  - Phase III - Rest of state in 2016
- Have been facilitating the gradual development of LiDAR across the state
  - Working with USGS/others- collect LiDAR for State...48% covered east–west
  - National 3DEP...asking state reps to submit grant app on behalf of Virginia...acquisition plan that has priority areas
- County of Roanoke has talked about using LiDAR on next flight- per square mile cost
  - David Ray is the County GIS coordinator
- John Scrivani is the elevation guy at VGIN, and he's the guy to talk to

6. *PHONE CALL – OCTOBER 29TH, 2014*

Attendees: Marcus Aguilar, VT; Phil McClellan, MapTech President

- Are there additional ports at the IFLOWS sites for a WQ Sonde? - Yes
- Is it possible to make agreement with VDEM to use those ports? - Yes
- It seems possible to integrate WQ sondes with the IFLOWs system with a few notes:

  - Telemetry system not terribly robust (need more information on this later)
  - Uses VHF Radio, designated hydro frequency by FCC- about 30-40yr old tech
  - Requires SDI 12 interface - stands for serial/digital interface at 1200 baud
  - Also need to add power, most likely by way of a large solar panel or battery
  - 10 bit signal 0-2048
  - Not great signal processing, some erroneous measurements.
  - The DEM would likely be alright with this, as long as it doesn't cost them

III. CITY OF ROANOKE GIS DATA

Table III-1 – List of Feature Classes located in the City's master GIS database, including metadata

Feature Dataset	Layer Name	File Type	Layer Type	Summary	Pub. Year	Original Source	Responsible Dept	Annotation Layers	Shared Boundaries	GIS Website	Mashup Website	Pictometry
Demographics	layers retrieved from US Census Bureau, see Scope Task 4- Other Sources of GIS Data											
HazMat	layers retrieved from USEPA, see Scope Task 4- Other Sources of GIS Data											
LandFeatures	archealogy	Shapefile	polygons	Areas within the City of Roanoke with archealogical significance.	1995	1995 Topo and Planimetrics - City of Roanoke	Engineering					
	architecture	Shapefile	polygons	Areas of historic and/or significant architecture within the City of Roanoke.	1995	1995 Topo and Planimetrics - City of Roanoke	Engineering					
	cemeteries	Shapefile	polygons	Known cemetery boundaries in the City of Roanoke. Adobe pdf files for each cemetery with a physical description and other info are stored in a folder on the City's network. A link to the documents is in the attributes.	2011		GIS	cemeteries_anno		Supermap, Real Estate GIS AGS	AGS Service	
	cemeteries_anno	annotation file		Cemetery labels for the City of Roanoke Basemap.	2011		GIS	cemeteries				
	common_places	Shapefile	points	Businesses, government facilities and public areas in the City of Roanoke	1995	1995 Topo and Planimetrics - City of Roanoke, Engineering	Engineering				AGS Service	
	driveways	Shapefile	lines	Driveway outlines for private and public drives in the City of Roanoke	1995	1995 Topo and Planimetrics - City of Roanoke	Engineering					
	fences	Shapefile	lines	Fencelines in the City of Roanoke	1995	1995 Topo and Planimetrics - City of Roanoke, Engineering	Engineering					
	golf_courses	Shapefile	polygons	Golf Courses within City of Roanoke	2011		GIS	golf_courses_anno		Supermap, Real Estate GIS AGS	AGS Service	
	golf_courses_anno	annotation file		Annotation for the golf_courses feature class.	2011		GIS	golf_courses				
	hedges	Shapefile	lines	Hedge plantings in the City of Roanoke.	1995	1995 Topo and Planimetrics - City of Roanoke, Engineering	Engineering					
	pools	Shapefile	lines	Swimming pool outlines in the City of Roanoke	1995	1995 Topo and Planimetrics - City of Roanoke, Engineering	Engineering					
	ruins	Shapefile	lines	Ruins of man-made structures that have fallen or been demolished.	1995	1995 Topo and Planimetrics - City of Roanoke, Engineering	Engineering					
LandRecords	Addresses	Shapefile	points	City of Roanoke Address Points	2013	Gecoded from several sources. Field verified 2012 by Code Enforcement.	GIS			Real Estate GIS AGS, Supermap		
	Block_Number_Anno	annotation file		Show legal description of parcel	2010		Engineering					
	buildings	Shapefile	polygons	City of Roanoke Building Footprints	2002	US Army Corp of Engineers, Received in 1995 as part of planimetrics.	GIS					
	citywide	Shapefile	polygons	City of Roanoke Tax Parcels with Real Estate Valuation Information	2013	Created using COGO by Engineering Department	Engineering, GIS	Lot_Dimension_Anno, Lot_Number_Anno, Old_Lot_Numbers_Anno, Ordinance_Anno, RoW_Sidth_Anno, TaxID_Anno	Real Estate GIS ArcIMS, Real Estate GIS AGS, Community Portal, Enhancement Portal, Supermap	AGS Service	Yes	
	citywide_OLD	Shapefile	polygons	City of Roanoke Tax Parcels with Real Estate Valuation Information	2012	Created using COGO by Engineering Department	Engineering, GIS	Same as above	Same as above	AGS Service	Yes	
	Easement_Access	Shapefile	lines	Access easement boundaries. Shows the boundaries of Right of Way access to a lot or parcel through property.	2010		Engineering	Easement_Access_Anno				
	Easement_Access_Anno	annotation file		Annotation for access easement boundaries . Provides information of Public or Private access .	2010		Engineering	Easement_Access				

Feature Dataset	Layer Name	File Type	Layer Type	Summary	Pub. Year	Original Source	Responsible Dept	Annotation Layers	Shared Boundaries	GIS Website	Mashup Website	Pictometry
LandRecords	Easement_Drainage	Shapefile	lines	Drainage easement boundaries . Shows the boundaries of Drainage easment for purpose of Maintenance .	2010		Engineering	Easement_Drainage_Anno				
	Easement_Drainage_Anno	annotation file		Annotation for drainage easement boundaries. Provides information as to if Public or Private Maintenance.	2010		Engineering	Easement_Drainage				
	Easement_Electric	Shapefile	lines	Drainage easement boundaries. Shows the boundaries of Drainage easment for purpose of Maintenance .	2010		Engineering	Easement_Drainage_Anno				
	Easement_Electric_Anno	annotation file		Annotation for electric easement boundaries.	2010		Engineering	Easement_Electric				
	Easement_FloodReduction	Shapefile	lines	Flood reduction easement boundaries . Shows the boundaries of Roanoke River Flood Reduction Easements.	2010		Engineering	Easment_FloodReduction_Anno				
	Easement_FloodReduction_Anno	annotation file		Annotation for flood reduction easement boundaries.	2010		Engineering	Easement_FloodReduction				
	Easement_Greenway	Shapefile	lines	Greenway easement boundaries. Shows the boundaries of Roanoke River Flood Reduction Easements.	2010		Engineering	Easement_Greenway_Anno				
	Easement_Greenway_Anno	annotation file		Annotation for greenway easements	2010		Engineering	Easement_Greenway				
	Easement_PublicUtility	Shapefile	lines	Public Utility easement boundaries	2010		Engineering	Easement_PublicUtility				
	Easement_PublicUtility_Anno	annotation file		Annotation for Public Utility easement boundaries	2010		Engineering	Easement_PublicUtility_Anno				
	Easement_RRFRP_Subsurface	Shapefile	lines	Roanoke River Flood Reduction Project subsurface easement boundaries	2010		Engineering					
	Easement_Sign	Shapefile	lines	Sign easement boundaries	2010		Engineering	Easement_Sign_Anno				
	Easement_Sign_Anno	annotation file		Annotation for sign easement boundaries	2010		Engineering	Easement_Sign				
	Easement_StormWaterMgmt	Shapefile	lines	Stormwater management easement boundaries	2010		Engineering	Easement_StormWaterMgmt_Anno				
	Easement_StormWaterMgmt_Anno	annotation file		Annotation for stormwater management easement boundaries	2010		Engineering	Easement_StormWaterMgmt				
	Easement_Telephone	Shapefile	lines	Telephone easement boundaries	2010		Engineering	Easement_Telephone_Anno				
	Easement_Telephone_Anno	annotation file		Annotation for telephone easement boundaries	2010		Engineering	Easement_Telephone				
	Easement_TrafficControl	Shapefile	lines	Traffic control easement boundaries	2010		Engineering	Easement_TrafficControl_Anno				
	Easement_TrafficControl_Anno	annotation file		Annotation for traffic control easement boundaries	2010		Engineering	Easement_TrafficControl				
	Easement_Trail	Shapefile	lines	Trail easement boundaries	2010		Engineering	Easement_Trail_Anno				
	Easement_Trail_Anno	annotation file		Annotation for trail easement boundaries	2010		Engineering	Easement_Trail				
	Lot_Dimensions_Anno	annotation file		Lot dimension annotation. Shows lot dimensions of property as reported by deed or plat .	2010		Engineering		citywide			
	Lot_Dimensions_Anno_Pts	Shapefile	points	Lot dimension annotation. Shows lot dimensions of property as reported by deed or plat .	2010		Engineering		citywide			
	Lot_Number_Anno	annotation file		Lot number annotation. Shows legal lot numbers as designated by deed or plat .	2010		Engineering		citywide			
	Old_Lot_Lines	Shapefile	lines	Previous location of lot boundaries. Shows location of old lot lines that have been changed. Used for historical purposes.	2010		Engineering	Old_Lot_Numbers_Anno				
	Old_Lot_Numbers_Anno	annotation file		Historic lot numbers. Shows what the lot numbers used to be before changes. Used for historic purposes.	2010		Engineering	Old_Lot_Lines				
	Ordinance_Anno	annotation file		Shows Ordinance number and Date of alley closure, road closure, or right-of-way encumbrance	2010		Engineering					
	Phase_Lines	Shapefile	lines	Phase line boundaries used for building construction	2010		Engineering					
	RoW_Prospcriptive	Shapefile	lines	Shows use onto other property over period of time to establish a permanent easement. Property use towards permanent easement .	2010		Engineering					
	RoW_Width_Anno	annotation file		Shows the Right of Way width as defined by Subdivision map	2010	CAD Base Mapping	Engineering, GIS					
	RoW_Width_Anno_Pts	Shapefile	points	Shows the Right of Way width as defined by Subdivision map	2010	CAD Base Mapping	Engineering, GIS					
	Scratch_Addresses	Shapefile	points	GIS does all Address point editing on this layer via the 'land records' child version.	2012		GIS					
	Scratch_Parcel_Lines	Shapefile	lines	Engineering does all parcel editing on this layer via the 'land records' child version.	2012		Engineering, GIS					
	Scratch_TaxID_Condo_Pt	Shapefile	points	Engineering does all tax id point editing on this layer via the 'land records' child version. Includes only condo tax id numbers.	2012		Engineering, GIS		Scratch_TaxID_Point			

Feature Dataset	Layer Name	File Type	Layer Type	Summary	Pub. Year	Original Source	Responsible Dept	Annotation Layers	Shared Boundaries	GIS Website	Mashup Website	Pictometry
LandRecords	Scratch_TaxID_Point	Shapefile	points	Engineering does all tax id point editing on this layer via the 'land records' child version. Does not include condo tax id numbers.	2012		Engineering, GIS		Scratch_TaxID_Condo_Pt			
	TaxID	Shapefile	points	Tax Number Points, used in parcel conversion scripts. Includes condo tax numbers.	2013	Points created from centroids of tax parcels 2010	Engineering, GIS	TaxID_Anno				
	TaxID_Anno	annotation file		Shows the legal tax number for parcels based off Real Estate records	2013		Engineering		TaxID (point)			
	TaxID_Anno_Pts	Shapefile	points	Shows the legal tax number for parcels based off Real Estate records	2013		Engineering		TaxID (point)			
	Web_Lot_Dimensions	Shapefile	lines	Line layer created by 'parcel conversion' script to be used by ArcIMS websites	2013	Line layer created by 'parcel conversion' script to be used by ArcIMS websites	GIS, Engineering	Lot_Dimensions_Anno	citywide	Real Estate, Supermap		
	Web_Lot_Numbers	Shapefile	lines	Line layer created by 'parcel conversion' script to be used by ArcIMS websites	2013		GIS, Engineering	Lot_Numbers_Anno	citywide	Real Estate, Supermap		
	Web_Ordinance	Shapefile	lines	Line layer created by 'parcel conversion' script to be used by ArcIMS websites	2013		GIS, Engineering	Ordinance_Anno	citywide	Real Estate, Supermap		
	Web_RoW_Width	Shapefile	lines	Line layer created by 'parcel conversion' script to be used by ArcIMS websites	2013		GIS, Engineering	RoW_Width_Anno	citywide	Real Estate, Supermap		
	Web_TaxID	Shapefile	lines	Line layer created by 'parcel conversion' script to be used by ArcIMS websites	2013		GIS, Engineering	TaxID_Anno	citywide	Real Estate, Supermap		
NeighborhoodServices	code_enforcement_zones	Shapefile	polygons	Areas of responsibility for Code Enforcement Inspectors.	2012		GIS			Supermap, Real Estate GIS AGS		
	conservation_rehab_districts	Shapefile	polygons	Areas that may be eligible for federal, state or local programs. See www.roanokeva.gov for more info.	2012		GIS			Supermap, Real Estate GIS ArcIMS, Community Portal, Real Estate GIS AGS	AGS Service	
	neighborhood_partnerships	Shapefile	polygons	Boundaries of neighborhood watch groups/committees.	2013		GIS			Supermap, Community Portal, Real Estate GIS ArcIMS, Real Estate GIS AGS		
	rental_inspection_districts	Shapefile	polygons	Areas of responsibility for Code Enforcement to focus on rental activity.	2012		GIS			Supermap, Real Estate GIS ArcIMS, Real Estate GIS AGS	AGS Service	
ParksRec	amphitheater	Shapefile	polygons	City of Roanoke Amphitheaters.	2/1/2006	Digitized by Parks and Recreation	GIS, Parks and Rec					
	athletic_electric	Shapefile	points	City of Roanoke Athletic Fields Electric Facilities (Lights)	2/1/2006	Digitized by Parks and Recreation	GIS, Parks and Rec					
	athletic_fields	Shapefile	polygons	City of Roanoke Athletic Fields	2/1/2006	Digitized by Parks and Recreation	GIS, Parks and Rec					
	basketball_courts	Shapefile	polygons	City of Roanoke Basketball Courts	2/1/2006	Digitized by Parks and Recreation	GIS, Parks and Rec					
	benches	Shapefile	points	City of Roanoke Park Benches	2/1/2006	Digitized by Parks and Recreation	GIS, Parks and Rec					
	bike_racks	Shapefile	points	City of Roanoke Bike Racks	2/1/2006	Digitized by Parks and Recreation	GIS, Parks and Rec					
	bleachers	Shapefile	points	City of Roanoke Athletic Field Bleachers	2/2/2006	Digitized by Parks and Recreation	GIS, Parks and Rec					
	bridges_tunnels	Shapefile	lines	City of Roanoke, Bridges and Tunnels associated with City Parks.	2/3/2006	Digitized by Parks and Recreation	GIS, Parks and Rec					

Feature Dataset	Layer Name	File Type	Layer Type	Summary	Pub. Year	Original Source	Responsible Dept	Annotation Layers	Shared Boundaries	GIS Website	Mashup Website	Pictometry
ParksRec	carvins_cove_easement	Shapefile	polygons	As defined by the Commonwealth of Virginia, the City of Roanoke declared that the preservation of open-space land serves a public purpose by curbing urban sprawl, preventing the spread of urban blight and deterioration and encouraging more economic and desirable urban development, helping provide or preserve necessary park, recreational, historic and scenic areas, and conserving land and other natural resources within the Carvins Cove Natural Reserve. The purposes of this conservation easement include retaining and protecting open-space and natural resource values of Carvins Cove, and the limitation on division, residential construction and commercial and industrial uses ensures that that Carvins Cove will remain perpetually available for forest or open-space use.	2009		GIS					
	carvins_cove_property	Shapefile	polygons	City of Roanoke Carvins Cove Property	1/1/2009		GIS, Parks and Rec					
	carvins_cove_trails	Shapefile	lines	City of Roanoke, Carvins Cove Trails	1/1/2009	GIS	GIS					
	cemeteries_maintained	Shapefile	polygons	Cemeteries maintained by City of Roanoke Parks and Recreation	1/1/2009	Digitized by Parks and Recreation	GIS, Parks and Rec					
	civic_center	Shapefile	polygons	City of Roanoke Civic Center Property	1/1/2006	Digitized by Parks and Recreation	GIS, Parks and Rec					
	commemorative_trees	Shapefile	points	City of Roanoke Commemorative Trees. Trees donated in honor or memory of someone.	2010		GIS, Parks and Rec				Parks and Recs Commemorative Tree Site	
	drinking_fountain	Shapefile	points	City of Roanoke Drinking Fountains	2006	Digitized by Parks and Recreation	GIS, Parks and Rec					
	federal_parks	Shapefile	polygons	Federal Park land within the City of Roanoke	2006	GIS	GIS	federal_parks_anno		Real Estate, Community Portal	AGS Service	
	federal_parks_anno	annotation file		Federal Park land within City of Roanoke Annotation	2006	GIS	GIS		federal_parks			
	fences_maintained	Shapefile	lines	City of Roanoke Maintained Fences	2006	Digitized by Parks and Recreation	GIS, Parks and Rec					
	flag_poles	Shapefile	points	City of Roanoke Flag Poles	2006	Digitized by Parks and Recreation	GIS, Parks and Rec					
	forest_cover	Shapefile	polygons	City of Roanoke Forest Cover	2006	Digitized by Parks and Recreation	GIS, Parks and Rec					
	fountains	Shapefile	polygons	City of Roanoke Fountains	2006	Digitized by Parks and Recreation	GIS, Parks and Rec					
	gates_bollards	Shapefile	lines	City of Roanoke Gates and Bollards	2006	Digitized by Parks and Recreation	GIS, Parks and Rec					
	greenhouse	Shapefile	polygons	City of Roanoke Greenhouse	2006	Digitized by Parks and Recreation	GIS, Parks and Rec					
	greenway_mile_markers	Shapefile	points	City of Roanoke Greenway Mile Markers. Markers provide milepost information for users to determine locarion or use in case of emergency.	2012	Captured with GPS by GIS	GIS, Parks and Rec		greenways	Real Estate GIS AGS		
	greenways	Shapefile	lines	City of Roanoke Greenways	2012	Digitized by GIS	GIS, Parks and Rec			Community Portal, Supermap, Real Estate GIS AGS		
	grills	Shapefile	points	City of Roanoke Park Grills	2006	Digitized by Parks and Recreation	GIS, Parks and Rec					
	hanging_baskets	Shapefile	polygons	City of Roanoke Hanging Baskets	2006	Digitized by Parks and Recreation	GIS, Parks and Rec					
	hardscapes	Shapefile	polygons	City of Roanoke Hardscapes	2006	Digitized by Parks and Recreation	GIS, Parks and Rec					
	kiosk	Shapefile	points	City of Roanoke Kiosk	2006	Digitized by Parks and Recreation	GIS, Parks and Rec					
	landscapes	Shapefile	polygons	City of Roanoke Landscape Areas (Maintained by Parks and Recreation)	2006	Digitized by Parks and Recreation	GIS, Parks and Rec					
	mill_mtn_easement	Shapefile	polygons									

Feature Dataset	Layer Name	File Type	Layer Type	Summary	Pub. Year	Original Source	Responsible Dept	Annotation Layers	Shared Boundaries	GIS Website	Mashup Website	Pictometry
ParksRec	multiuse_courts	Shapefile	polygons	City of Roanoke Multi-use Courts	2006	Digitized by Parks and Recreation	GIS, Parks and Rec					
	open_spaces	Shapefile	polygons	City of Roanoke Open Spaces	2006	Digitized by Parks and Recreation	GIS, Parks and Rec					
	park_buildings_misc	Shapefile	polygons	City of Roanoke Miscellaneous Buildings (Parks and Recreation)	2006	Digitized by Parks and Recreation	GIS, Parks and Rec					
	park_drives	Shapefile	lines	City of Roanoke Park Driveways, Misc. service roads and driveways in Parks	2006	Digitized by Parks and Recreation	GIS, Parks and Rec					
	park_schools	Shapefile	polygons	City of Roanoke Park Schools, schools which have facilities Parks and Recreation maintains.	2006	Digitized by Parks and Recreation	GIS, Parks and Rec					
	parking_lots	Shapefile	polygons	City of Roanoke Parks and Recreation Parking Lots	2006	Digitized by Parks and Recreation	GIS, Parks and Rec					
	parks_point	Shapefile	points	City of Roanoke Parks Points (Centroid Points for each Park)	2006	Centroids created from Parks polygons	GIS, Parks and Rec			Real Estate GIS	AGS Service	
	parks_poly	Shapefile	polygons	City of Roanoke Parks Polygons	2006	Digitized by GIS	GIS, Parks and Rec	parks_poly_anno	parks_point	Real Estate GIS ArcIMS, Community Portal, Supermap, Real Estate GIS AGS	AGS Service	Yes
	parks_poly_anno	annotation file		City of Roanoke Parks Annotation (Annotation designed for Parks Polygons)	2006	GIS	GIS, Parks and Rec					
	picnic_tables	Shapefile	points	City of Roanoke Park Picnic Tables	2006	Digitized by Parks and Recreation	GIS, Parks and Rec					
	player_benches	Shapefile	points	City of Roanoke Player Benches for Athletic Fields	2006	Digitized by Parks and Recreation	GIS, Parks and Rec					
	playgrounds	Shapefile	polygons	City of Roanoke Playgrounds	2006	Digitized by Parks and Recreation	GIS, Parks and Rec					
	public_art	Shapefile	points	City of Roanoke Public Art	2006	Digitized by Parks and Recreation	GIS, Parks and Rec					
	recreation_centers	Shapefile	points	City of Roanoke Recreation Centers	2006	Digitized by GIS	GIS, Parks and Rec			Supermap	AGS Service	
	restrooms	Shapefile	polygons	City of Roanoke Park Restrooms	2006	Digitized by Parks and Recreation	GIS, Parks and Rec					
	shelters	Shapefile	polygons	City of Roanoke Park Shelters	2006	Digitized by Parks and Recreation	GIS, Parks and Rec					
	signs	Shapefile	points	City of Roanoke Park Signs (Signs within City Parks)	2006	Digitized by Parks and Recreation	GIS, Parks and Rec					
	storage_boxes	Shapefile	polygons	City of Roanoke Athletic Field Storage Boxes	2006	Digitized by Parks and Recreation	GIS, Parks and Rec					
	storage_properties	Shapefile	polygons	City of Roanoke Parks and Recreation Storage Properties	2006	Digitized by Parks and Recreation	GIS, Parks and Rec					
	tennis_courts	Shapefile	polygons	City of Roanoke Tennis Courts	2006	Digitized by Parks and Recreation	GIS, Parks and Rec					
	trails	Shapefile	lines	City of Roanoke Trails	2006	Digitized by Parks and Recreation	GIS, Parks and Rec					
	trails_millmountain	Shapefile	lines	City of Roanoke Mill Mountain Park Trails	2006	Digitized by Parks and Recreation	GIS, Parks and Rec					
	volleyball_courts	Shapefile	polygons	City of Roanoke Volleyball Courts	2006	Digitized by Parks and Recreation	GIS, Parks and Rec					
	walking_paths	Shapefile	lines	City of Roanoke Walking Paths (Maintained walking surfaces in Parks or Greenways)	2006	Digitized by Parks and Recreation	GIS, Parks and Rec					
	youth_recreation_clubs	Shapefile	polygons	City of Roanoke Youth Recreation Club Districts	2008	Digitized by GIS	GIS, Parks and Rec			Community Portal, Supermap, Real Estate GIS AGS		
	zoo	Shapefile	polygons	City of Roanoke, Mill Mountain Zoo	2006	Digitized by Parks and Recreation	GIS, Parks and Rec					

Feature Dataset	Layer Name	File Type	Layer Type	Summary	Pub. Year	Original Source	Responsible Dept	Annotation Layers	Shared Boundaries	GIS Website	Mashup Website	Pictometry
Planning	brownfield_corridors	Shapefile	polygons									
	character_districts	Shapefile	polygons	The character districts provide a general perspective to how land developed over time by grouping land uses according to building style, development form, and land purpose. Character district definitions largely follow those given in the Vision 2001-2020 Comprehensive Plan. In some cases, character districts described in Vision 2001-2020 have been combined for the Streetscape Design Guidelines, due to their similar street characteristics.			Planning					
	enterprise_zone_1_a	Shapefile	polygons	The state and local governments enter into a ten year partnership to encourage business expansion and recruitment by offering both state and local incentives. Two five year periods may be added to the designation, provided approved by the Department of Housing and Community Development. Businesses locating within the boundaries of an Enterprise Zone may qualify for state and local incentives. State incentives are based on businesses creating jobs and investing in real property. A description of the state incentives and the qualifying criteria is provided below. In addition, local incentives for businesses and residents are available. The city of Roanoke has two Enterprise Zones. Enterprise Zone One A, centered along the main east-west tracks of the Norfolk & Western Railroad, was established in January 2004. Incentives remain in effect until December 31, 2023. Enterprise Zone Two and the 581/Hershberger Subzone covers the largest inventory of vacant industrial sites in the city. Enterprise Zone Two and the 581/Hershberger Subzone remain in effect until December 31, 2015.	2005		Economic Development			Real Estate GIS ArcIMS, Real Estate GIS AGS, Supermap	AGS Service	
	enterprise_zone_two	Shapefile	polygons	The state and local government enter into a ten year partnership to encourage business expansion and recruitment by offering both state and local incentives. Two five year periods may be added to the designation, provided approved by the Department of Housing and Community Development. Businesses locating within the boundaries of an Enterprise Zone may qualify for state and local incentives. State incentives are based on businesses creating jobs and investing in real property. A description of the state incentives and the qualifying criteria is provided below. In addition, local incentives for businesses and residents are available. The city of Roanoke has two Enterprise Zones. Enterprise Zone One A, centered along the main east-west tracks of the Norfolk & Western Railroad, was established in January 2004. Incentives remain in effect until December 31, 2023. Enterprise Zone Two and the 581/Hershberger Subzone covers the largest inventory of vacant industrial sites in the city. Enterprise Zone Two and the 581/Hershberger Subzone remain in effect until December 31, 2015.	2005		Economic Development			Real Estate GIS ArcIMS, Real Estate GIS AGS, Supermap	AGS Service	
	future_land_use	Shapefile	polygons	City broken down into future land-use boudaries for the purpose of planning for the future of Roanoke neighborhoods.	unknown		Planning					
	historic_districts	Shapefile	polygons	Roanoke's local historic districts (H-1 and H-2) are regulated by design guidelines that ensure both the restoration of existing and construction of new structures are architecturally appropriate within the historic context of each disrict. The guidelines should always be referred to prior to applying for a Certificate of Appropriateness. Staff recommendations to the ARB and administrative approval of applications for work in the H-1 and H-2 districts is based on these guidelines.	unknown		Planning			Real Estate GIS ArcIMS, Real Estate GIS AGS, Supermap	AGS Service	
	national_register_districts	Shapefile	polygons	Areas of the City included in the National Register of Historic Places.	unknown		Planning			Real Estate GIS ArcIMS, Real Estate GIS AGS, Supermap	AGS Service	
	national_register_properties	Shapefile	polygons	Specific properties in the City which are included in the National Registry of Historic Places.			Planning			Real Estate GIS AGS		
	neighborhoods_planning	Shapefile	polygons	Areas in the City of Roanoke delineated by Planning and having a common neighborhood identity.	unknown		Planning			Supermap, Real Estate GIS AGS		
	technology_zone	Shapefile	polygons	*** RETIRED***Businesses qualifying as a "technology business" and locating within a certain geographic region are eligible for Technology Zone incentives.	unknown		Economic Development					
	west_end_target_area	Shapefile	polygons									

Feature Dataset	Layer Name	File Type	Layer Type	Summary	Pub. Year	Original Source	Responsible Dept	Annotation Layers	Shared Boundaries	GIS Website	Mashup Website	Pictometry
PublicBoundaries	annexations	Shapefile	polygons	Polygons representing areas of City of Roanoke corporate limit and the year of annexation.	2009		GIS					
	city_mask	Shapefile	polygons	Large polygon with the City corporate boundary erased. Can be used to mask or shade areas outside the City for cartographic purposes.	2010		GIS					
	city_quadrants	Shapefile	polygons	Quadrant boundaries demarcating NE, SE, SW and NW Roanoke used by some City departments in planning and keeping track of services. These are NOT the official mailing quadrant boundaries.	1995		GIS					
	citylimit_line	Shapefile	lines	Line feature of the official corporate boundary of the City of Roanoke.	2012		GIS		citylimit_poly, all city-wide working layers ie Police and Fire/EMS zones, Snow Removal zones, etc	Real Estate GIS ArcIMS, Real Estate GIS AGS		
	citylimit_poly	Shapefile	polygons	Polygon feature of the official corporate boundary of the City of Roanoke.	2012		GIS		citylimit_line, all city-wide working layers ie. Police and Fire/EMS zones, Snow Removal zones...	Supermap	AGS Service	Yes
	grid	Shapefile	polygons	Combined large and small grid system developed for the 1991 aerial imagery. The large grid corresponds to the now retired CADD parcel mapping developed by Engineering, the smaller grid to the aerial imagery.	1991		GIS		1991 aerial photography, CADD parcel mapping	Supermap		
	grid_big	Shapefile	polygons	Large grid system developed for the 1991 aerial imagery. The grid corresponds to the now retired CADD parcel mapping developed by Engineering.	1991		GIS		CADD parcel mapping	Supermap		
	grid_small	Shapefile	polygons	Small grid system developed for the 1991 aerial imagery. Also corresponds to 1995 Planimetrics CADD files.	1991		GIS			Supermap		
	grid_topo	Shapefile	polygons	Grid corresponds to CADD planimetrics from 1995.	1995		GIS		big_grid, 1995 CADD planimetrics			
	mail_quadrants	Shapefile	polygons	Official mailing quadrant boundaries used by the USPS to determine NE, SE, SW, NW areas of the City.	unknown		GIS					
	schoolzones_ES	Shapefile	polygons	Elementary school attendance zones	2009		GIS			Community Portal, Real Estate GIS ArcIMS, Supermap, Real Estate GIS AGS		
	schoolzones_HS	Shapefile	polygons	High school attendance zones.	2009		GIS			Community Portal, Real Estate GIS ArcIMS, Supermap, Real Estate GIS AGS		
	schoolzones_MS	Shapefile	polygons	Middle school attendance zones	2009		GIS			Community Portal, Real Estate GIS ArcIMS, Supermap, Real Estate GIS AGS		
	zip_codes	Shapefile	polygons	Zip code boundaries for the City of Roanoke.	unknown	US Postal Service	GIS			Supermap, Real Estate GIS AGS		
PublicFacilities	emergency_shelters	Shapefile	points	Public buildings designated as potential emergency shelters.	2009		Emergency Manager				AGS Service	
	fire_stations	Shapefile	points	Current fire station locations	2010		GIS			Real Estate GIS AGS	AGS Service	
	hospitals	Shapefile	points	Hospital locations	unknown		GIS			Supermap, Real Estate GIS AGS	AGS Service	
	libraries	Shapefile	points	City of Roanoke Public Libraries	unknown		GIS			Community Potral, Supermap, Real Estate GIS AGS	AGS Service	
	post_offices	Shapefile	points	US Post Offices	unknown		GIS			Supermap, Real Estate GIS AGS		
	schools	Shapefile	points	City of Roanoke Public Schools	2010		GIS			Supermap	AGS Service	

Feature Dataset	Layer Name	File Type	Layer Type	Summary	Pub. Year	Original Source	Responsible Dept	Annotation Layers	Shared Boundaries	GIS Website	Mashup Website	Pictometry
Services	adopt_a_street	Shapefile	lines	Centerlines for built right-of-way and private streets. Featured linked with 'citystreets_anno' layer. Contains a few small segments from surrounding localities for mapping purposes.	7/1/2011		GIS	city streets anno		Real Estate GIS ArcIMS, Real Estate GIS AGS, Supermap	AGS Service	Yes
	downtown_service_district	Shapefile	polygons	Area of Downtown Roanoke where residents and business owners pay special fees for extra city services, such as accelerated garbage pick-up and street cleaning.	unknown		GIS			Real Estate GIS AGS	AGS Service	
	residential_permit_parking_zone	Shapefile	polygons									
	snow_streets	Shapefile	lines	City streets categorized by the order of importance for snow removal operations.	unknown		Transportation					
	snow_subzones	Shapefile	polygons	Breakdown of snow zones into smaller subzones for use with snow removal mapbook.	unknown		Transportation	snow_subzones_anno	snow_zones			
	snow_subzones_anno	annotation file		Annotation for snow_subzones			Transportation					
	snow_zones	Shapefile	polygons	Snow Zones used to plan and carry out snow removal operations.	unknown		Transportation	snow_zones_anno	snow_subzones			
	snow_zones_anno	annotation file		Annotation for snow zones.	unknown		Transportation					
	socialservices_daycares	Shapefile	points	Daycare providers in the City of Roanoke. Used to identify resources for Social Services.	unknown		GIS					
	socialservices_major_employers	Shapefile	points	Major employers in the City of Roanoke. Used to identify resources for Social Services.	unknown		GIS					
	solid_waste_zones	Shapefile	polygons	Solid Waste Management boundaries showing collection days.	unknown		Solid Waste		city_limits	Community Portal, Supermap, Real Estate GIS AGS		
	street_sweeping_anno	annotation file		Annotation for street sweeping map and mapbook.	unknown		Transportation					
	street_sweeping_zones	Shapefile	polygons	Zones used to plan and carry out street sweeping operations.	unknown		Transportation	street_sweeping_anno				
	williamsonrd_service_district	Shapefile	polygons	Boundary of special services district for Williamson Road commercial areas.	unknown		GIS			Real Estate GIS AGS	AGS Service	
StormWater	culvert	Shapefile	points	Stormwater culverts	2003		Engineering			Real Estate GIS ArcIMS, Real Estate GIS AGS, Supermap	AGS Service	
	detention_pond	Shapefile	polygons	Stormwater detention ponds	2003		Engineering			Real Estate GIS, Supermap	AGS Service	
	impervious_surface	Shapefile	polygons	Impervious surface for City, used to calculate Storm Water Fees	2013					Real Estate GIS AGS		
	inlet	Shapefile	points	Stormwater inlets	2003		Engineering			Real Estate GIS ArcIMS, Real Estate GIS AGS, Supermap	AGS Service	
	manhole	Shapefile	points	Stormwater manholes	2003		Engineering			Real Estate GIS ArcIMS, Real Estate GIS AGS, Supermap	AGS Service	
	open_channel	Shapefile	lines	Stormwater open channels	2003		Engineering			Real Estate GIS ArcIMS, Real Estate GIS AGS, Supermap	AGS Service	
	pipe_	Shapefile	lines	Stormwater pipes	2003		Engineering			Real Estate GIS ArcIMS, Real Estate GIS AGS, Supermap	AGS Service	
	pipe_end	Shapefile	points	Stormwater ends of pipes	2003		Engineering			Real Estate GIS ArcIMS, Real Estate GIS AGS, Supermap	AGS Service	

Feature Dataset	Layer Name	File Type	Layer Type	Summary	Pub. Year	Original Source	Responsible Dept	Annotation Layers	Shared Boundaries	GIS Website	Mashup Website	Pictometry
Topography	Layers retrieved from VGIN and USDA, see Scope Task 4- Other Sources of GIS Data											
Transportation	airport_poly	Shapefile	polygons	Roanoke Regional Airport Boundary	2000		GIS		airport runway poly, airport poly	Real Estate GIS ArcIMS, Real Estate GIS AGS	AGS Service	
	airport_runway_poly	Shapefile	polygons	Roanoke Regional Airport - runway boundaries	unknown		GIS		airport anno, airport poly	Real Estate GIS ArcIMS, Real Estate GIS AGS	Yes	
	alleys_maintained	Shapefile	lines	Alleys maintained by the City	unknown		Transportation					
	bridge_decks	Shapefile	lines	Bridges and decks	2000	Planimetrics?	Engineering		bridges			
	bridges	Shapefile	points	Bridge locations	unknown		Engineering		bridge_decks	Supermap		
	citystreets	Shapefile	lines	Centerline for built ROW and private streets. Contains a few small segments from surrounding localities for mapping purposes.	7/1/2011		GIS	city streets anno		Real Estate GIS ArcIMS, Real Estate GIS AGS	AGS Service	Yes
	interstate_only	Shapefile	lines	Centerline for Interstate 581 only	unknown	2006 VGIN	GIS		city streets	Supermap		Yes
	paving_history	Shapefile	lines	Indicates when street segments were last paved	unknown		Transportation			Supermap		
	railroad_simple	Shapefile	lines	Simplified representation of railroad centerline	2005	digitized off imagery	GIS			Real Estate GIS ArcIMS, Real Estate GIS AGS	AGS Service	Yes
	traffic_signals	Shapefile	points	Signalized intersections	2004		Transportation		city streets			
	twotwenty_only	Shapefile	lines	Route 220	2006	2006 VGIN	GIS		city streets	Supermap		Yes
	valley_metro	Shapefile	lines	Bus routes for Valley Metro. Data was provided to Google Maps for driving/riding directions functionality	8/1/2009	Field collected using GPS	GIS					
Utilities	connected_facilities	Shapefile	points	City facilities connected to the city's computer network.	unknown		Technology					
	electric_poles	Shapefile	lines	Power pole locations.	1995	1995 Topo and Planimetrics - Engineering	GIS					
	fiber_cityowned	Shapefile	lines	Fiber-optic cable owned by the City of Roanoke.	unknown		GIS					
	fiber_lines	Shapefile	lines	Location of fiber-optic lines from private sources.	unknown		GIS					
	street_lights	Shapefile	lines	Street light locations in the City of Roanoke.	1995	1995 Topo and Planimetrics - Engineering	GIS					
	vpn_lines	Shapefile	lines	Lines showing the connectivity and method of connection of City network.	unknown		GIS					
	wireless	Shapefile	lines	City facilities connected to network wirelessly.	unknown		GIS					
WaterFeatures	carvins_cove	Shapefile	polygons	Carvins Cove Reservoir spans Roanoke County and Botetourt County. It is maintained currently by the Western Virginia Water Authority and City of Roanoke Parks & Rec.	unknown		GIS					
	fema_dfirm	Shapefile	polygons	FEMA flood mapping showing flood hazard areas. Provided by the Army Corps of Engineers.	2007		Engineering			Real Estate GIS, Supermap		
	lakes	Shapefile	lines	Outlines of still water ponds and small lakes in the City of Roanoke	unknown		GIS			Supermap		
	rivers_line	Shapefile	lines	Single lines and outlines of flowing water features, such as creeks, branches, runs and the Roanoke River. Used in conjunction with rivers_poly to symbolize City of Roanoke basemap.	unknown		GIS	rivers_line_anno		Real Estate GIS, Supermap	AGS Service	Yes
	rivers_line_anno	annotation file		Annotation of named water features.	unknown		GIS					
	rivers_poly	Shapefile	polygons	Polygons of larger water features in City of Roanoke, including the Roanoke River, Tinker Creek and several lakes and ponds. Used in conjunction with rivers_line to symbolize water features in the City basemap.	unknown		GIS			Supermap	AGS Service	Yes
	streams	Shapefile	lines	Very finely detailed outlines of all water features in the City of Roanoke.	1995	1995 Topo and Planimetrics - Engineering	GIS					
	wetlands	Shapefile	polygons	Designated Wetlands areas in the City of Roanoke.	unknown		GIS			Supermap		

Feature Dataset	Layer Name	File Type	Layer Type	Summary	Pub. Year	Original Source	Responsible Dept	Annotation Layers	Shared Boundaries	GIS Website	Mashup Website	Pictometry
Zoning	design_overlay	Shapefile	polygons	The Neighborhood Design Overlay District sets forth regulations which apply to a new dwelling, a new accessory building that is accessory to a dwelling, or an expansion of an existing dwelling in the ND Overlay District, including standards for building location and massing; roofs; entrances and windows; siding and trim; and porches; and the location of additions and accessory structures.	unknown		Planning			Real Estate GIS, Supermap	AGS Service	
	river_creek_overlay	Shapefile	polygons	The River and Creek Corridors Overlay District applies to properties that abut the banks of the Roanoke River or its unenclosed tributaries and includes a riparian buffer requirement intended to protect and restore water quality.	unknown		Planning			Real Estate GIS, Supermap		
	sign_overlay	Shapefile	polygons	The Comprehensive Sign Overlay District provides comprehensive signage plans for developments which contain a number of constraints to conventional sign placement and allocation regulation.	unknown		Planning			Real Estate GIS, Supermap	AGS Service	
	vdot_chapt527	Shapefile	lines	Areas subject to additional review if they are within certain distances of state maintained roads.	unknown		Planning, Building, and Zoning					
	zoning	Shapefile	polygons	Official zoning designations for the City of Roanoke.	2011		Planning, Building, and Zoning			Real Estate GIS ArcIMS, Real Estate GIS AGS, Supermap		

IV. Appendix 4 – Other Sources of GIS Data

Feature or Raster Dataset	Feature or Raster Dataset Source	Feature Class	Geometry Type	Original Data Type	ESRI Metadata?	Description	Quality Information	Date Accessed	Source
DCR	Department of Conservation and Recreation	conslands	Polygon	Shapefile	Yes	Statewide GIS coverage of Conservation Lands in Virginia to serve as a land conservation planning tool.	The Conservation Lands Database is constantly being edited and updated. Data is released to the public quarterly and posted to the download section of the website	10/19/2014	Conservation Lands Shapefiles and Metadata
		easements	Polygon	Shapefile	Yes	Statewide GIS coverage of Conservation Lands in Virginia to serve as a land conservation planning tool.			
		Scenic_Rivers	Polyline	Shapefile	Yes	This data includes river segments that have been designated as scenic rivers, ones that have been studied and qualify for potential designation and ones that have been recommended for further study. SEE STATUS FIELD.			
DEQ	Virginia Dept. of Env. Quality	CGP_2014_RS_WEB	Point	.xlsx	No	A list of registration statements completed in 2014 under the Virginia General Permit for stormwater discharges from construction activities. This layer was georeferenced using lat/long information in the excel file on the DEQ website	It appears that many of the lat/long coordinates are not correct as they are either reversed or missing a minus sign	10/8/2014	DEQ's Construction General Permit Website
		CGP_ACTIVE_WEB	Point	.xlsx	No	A list of construction sites that were/are permitted under the 2009 Construction General Permit for stormwater discharges from construction sites	Could not be properly georeferenced, as lat/long data is not standardized. Data not suitable for DBMS or Geodatabase	10/8/2014	DEQ's Construction General Permit Website
		TMDL_Watersheds	Polygon	.shp	Yes	This dataset depicts TMDL watershed boundaries. A TMDL watershed is the area covered by a TMDL equation. It consists of one or more impaired streams that have an assigned Cause Group Code (CGC). The CGC is the link between the TMDL and the Assessment Report. The TMDL equations are stored in a table in the TMDL database. Currently, the database contains about 650 equations, which are set across the entire state. Each equation includes the Waste Load Allocation (WLA), which is the portion of the TMDL that accounts for pollution from point sources (permits). The WLA cannot be exceeded during permit reissuance or its TMDL equation must be modified.	Data intersects with NHD with some smaller scale delineations. Polygons overlap other polygons, which is not a topological error, but makes display difficult.	9/2/2014	DEQ's VEGIS Website
		va_12ir_vpdes_facilities	Point	GDB Feature Class	Yes	Same features as vpdes.shp, but only the locations that were deemed to be regionally significant by the DEQ for the 2012 Water Quality Assessment Integrated Report	Not possible to determine the quality of this data, as it does not include metadata. Geometry information in table checks out with actual coordinates	9/2/2014	DEQ's Final 2012 305(b)/303(d) Water Quality Assessment and Integrated Report
		va_12ir_wqm_stations	Point	.shp	Yes	This dataset was generated as a summary of monitoring sample data from many sources. Consult the 2012 Virginia 305(b)/303(d) Water Quality Assessment Integrated Report for a list of all sources considered.	Feature class approved by USEPA, production metadata available	9/2/2014	DEQ's VEGIS Website
		va_2012_aus_reservoir	Polygon	GDB Feature Class	Yes	Shows all lake/reservoir waters identified in the 2012 Virginia 305(b)/303(d) Water Quality Assessment Integrated Report.	Feature class approved by USEPA, production metadata available. Based on NHD, and some digitization where necessary	9/3/2014	DEQ's Final 2012 305(b)/303(d) Water Quality Assessment and Integrated Report
		va_2012_aus_riverine	Polyline	.shp	Yes	Shows all riverine waters identified in the 2012 Virginia 305(b)/303(d) Water Quality Assessment Integrated Report.	Feature class approved by USEPA, production metadata available. Based on NHD, and some digitization where necessary	9/3/2014	DEQ's VEGIS Website
		va_solid_waste	Point	.shp	Yes	Shows location of each active solid waste management facility in Virginia including sanitary landfills, construction/demolition debris landfills, transfer stations, and materials recovery facilities.	Created using remote sensing, not for survey use	9/2/2014	DEQ's VEGIS Website
		vpdes	Point	.shp	No	Shows the VPDES individual permits. Has some overlap with the spreadsheet available at the DEQ's VPDES Permits, Fees, Regulations site, though the vpdes feature class has 1,134 records and the spreadsheet only has 1,077 records. 834 records can be joined between these two tables	Not possible to determine the quality of this data, as it does not include metadata. Geometry information in table checks out with actual coordinates	9/2/2014	DEQ's VEGIS Website

Feature or Raster Dataset	Feature or Raster Dataset Source	Feature Class	Geometry Type	Original Data Type	ESRI Metadata?	Description	Quality Information	Date Accessed	Source
DMME	Virginia Dept. of Mines Minerals and Energy	KarstFeatures_Sinkholes	Polygon	GDB Feature Class	Yes	Karst-related sinkholes in Virginia. In a general sense, the distribution of karst-related sinkholes west of the Blue Ridge Mountains. Useful to government agencies, planners, developers, teachers and students of Virginia's geology. Not intended for site-specific use. Decisions requiring knowledge of the presence or absence of karst features at a specific location should not be based on this data set.	Data depicted at 1:250,000 scale in Division of Geology Mineral Resources Publications 44, 83, and 167. Field checking has revealed that many more sinkholes are present than are depicted in this dataset. Therefore, these data should serve as a general guide to areas of karst-related sinkhole development, and not as a true indication of the presence or absence of sinkholes at a particular location.	11/10/2014	DMME Webmaps
		Map_Units__Age	Polygon	GDB Feature Class	No	Describes geologic age by era (e.g. Devonian, Cambrian)	None available		
		Map_Units__Lithology	Polygon	GDB Feature Class	No	Describes geologic age by era (e.g. Devonian, Cambrian)	None available		
		VA_Water_Wells	Point	GDB Feature Class	No	Shows known water wells, with well configuration data	None available		
EPA	Environmental Protection Agency	BMP_Individual	Point	GDB Feature Class	Yes	Contains all individual BMP locations from the International Stormwater BMP Database (available at bmpdatabase.org). In addition to the attributes contained in the BMP database, this layer contains long term climate data (Precipitation and Temperature) from NOAA's National Climatic Data Center and groundwater data from the USGS.	Produced by EPA, though no accuracy guaranteed	10/9/2014	EPA's Environmental Data Gateway
		BMP_Sites	Point	GDB Feature Class	Yes	Identifies the general study location and related information. The location information is important for a variety of reasons. For example, it enables recognition of the types of conditions under which the BMP test is conducted (e.g., Seattle = lots of low intensity rain much of the year, Phoenix = few high intensity storms). This information also enables interface with other EPA databases. A single test site may include multiple BMPs if the tributary watersheds to the BMPs are approximately the same.	Produced by EPA, though no accuracy guaranteed	10/9/2014	EPA's Environmental Data Gateway
		BMP_Volume_Reduction	Point	GDB Feature Class	Yes	Contains BMP locations from the International Stormwater BMP Database (available at bmpdatabase.org) that have been subjected to reasonableness screening for volume reduction. In addition to the attributes contained in the BMP database, this layer contains long term climate data (Precipitation and Temperature) from NOAA's National Climatic Data Center and groundwater data from the USGS. The summary attributes from the Volume Analysis Study (http://bmpdatabase.org/Docs/Volume%20Reduction%20Technical%20Summary%20Jan%202011.pdf) have been added to the table.	Produced by EPA, though no accuracy guaranteed	10/9/2014	EPA's Environmental Data Gateway
		Ecoregions	Polygon	GDB Feature Class	Yes	EPA's Level III and IV Ecoregions clipped to the Virginia Boundary. These regions denote areas of general similarity in ecosystems and in the type, quality, and quantity of environmental resources.	Scale suitable for regional scale analyses	6/11/2014	EPA Region 3 Ecoregion Website
		NRSA_Site_Information	Point	GDB Feature Class		Water assessment data from the 2008-2009 National Rivers and Streams Assessment. Includes level of disturbance information, but further detail is found in the report	No streams assessed in the Roanoke River watershed.	6/11/2014	EPA's National Rivers and Streams Assessment Website
		STORET_NARS_ECO	Point	GDB Feature Class	No	CSV file downloaded from STORET and converted to feature class. Includes useful information regarding ecological characteristics of specific locations around the watershed. None of the locations are within the Roanoke River Watershed	Created using XY coordinates from .CSV file	10/9/2014	EPA Storet/WQX
		STORET_NARS_CHEM	Point	GDB Feature Class	No	CSV file downloaded from STORET and converted to feature class. Includes useful information regarding chemical characteristics of specific locations around the watershed. None of the locations are within the Roanoke River Watershed	Created using XY coordinates from .CSV file	10/9/2014	EPA Storet/WQX
		STORET_TSS_BACTERIA	Point	GDB Feature Class	No	CSV file downloaded from STORET and converted to feature class. Includes useful information regarding sediment and bacteria characteristics of specific locations around the watershed.	Created using XY coordinates from .CSV file	10/9/2014	EPA Storet/WQX

Feature or Raster Dataset	Feature or Raster Dataset Source	Feature Class	Geometry Type	Original Data Type	ESRI Metadata?	Description	Quality Information	Date Accessed	Source
FEMA	Federal Emergency Management Agency	S_FLD_HAZ_AR	Polygon	Shapefile	Yes	Basis for FEMA's floodplain management, mitigation, and insurance activities. Creates the Special Flood Hazard Areas (SFHAs) and insurance premium rates	Match FIRMs exactly	10/21/2014	Flood Map Service Center
IFLOWS	Integrated Flood Observing and Warning System	All_Gauges	Point	.xlsx	No	Shows location and calibration information for all IFLOWS gages in the Commonwealth	None available	10/22/2014	E-Mail from Mark Slauter, VDEM
NCDC	National Climatic Data Center, NOAA	Annual_Precip	Point	.csv	No	Originally tabular data, reformatted to be used as point feature class. 30-yr average annual precipitation (climate normal) from 1981 - 2010	Precipitation data heavily peer reviewed. GIS locations not reviewed	5/15/2015	NCDC Climate Data Online
NED	National Elevation Dataset, USGS		Raster	GDB Raster	Yes	Two merged tiles from the USGS' National Elevation Dataset Program, which was then clipped to the Roanoke River Watershed Boundary. This raster has 7,244 columns and 4,566 rows, each approximately 10 meters x 10 meters (1/3 arc-second). All elevations are in meters	approx. 10 m x 10 m cells, most likely derived from 1:24,000 scale contours.	10/10/2014	The National Map Viewer via USGS
NHD	United States Geological Survey	NHDFlowline	Polyline	GDB Feature Class	Yes	The National Hydrography Dataset (NHD) is a feature-based database that interconnects and uniquely identifies the stream segments or reaches that make up the nation's surface water drainage system.	This high-resolution NHD, generally developed at 1:24,000/1:12,000 scale, adds detail to the original 1:100,000-scale NHD.	5/16/2014	The National Map Viewer via USGS
		WBD_HUXX	Polygon	GDB Feature Class	No	Watershed boundary dataset for Virginia at various scales from 6 - 12 digits.	None available	5/16/2014	
NHDPlusv2	Horizon Systems, Corp.	Catchment	Polygon	GDB Feature Class	Yes	An extension of the watershed boundary dataset, built at smaller scales and integrated with the NED	None available	10/14/2014	NHD v2 Plus
		RR_Watershed	Polygon	GDB Feature Class	Yes	Clipped to Roanoke River Watershed	None available	10/14/2014	
NLCD	Multi-Resolution Land Cover Consortium		Raster	Geodatabase Raster	Yes	National dataset clipped to watershed boundary. Classifies 30 meter x 30 meter cells into 17 categories based on Landsat satellite photogrammetry.	30 m x 30 m cells, based on satellite photogrammetry and geoprocessing	10/11/2014	Multi-Resolution Land Cover Consortium
RVARC	Roanoke Valley-Alleghany Regional Commision	Trails_Master	Polyline	Shapefile	No	Shows all the trails in the Roanoke and Alleghany Valley, plus attributes describing them	Data from Shane Sawyer	10/15/2014	E-mail from Shane Sawyer, RVARC
		Valleywide_SWMP_1997	Polygon	Shapefile	No	Shows watersheds delineated for 1997 regional SWMP	Data from David Dearing, without projection file. Spatial adjustment had to be made	10/22/2014	E-mail from David Dearing, City of Roanoke
SSURGO	Natural Resources Conservation Service	SSURGO	Polygon	GDB Feature Class	No	County-level soil survey, showing various hydro-geo properties of soils	The information was collected at scales ranging from 1:12,000 to 1:63,360. More details were gathered at a scale of 1:12,000 than at a scale of 1:63,360.	5/19/2014	Geospatial Data Gateway

Feature or Raster Dataset	Feature or Raster Dataset Source	Feature Class	Geometry Type	Original Data Type	ESRI Metadata?	Description	Quality Information	Date Accessed	Source
TIGER	U.S. Census Bureau	tl_2011_us_state	Polygon	GDB Feature Class	Yes	U.S. states	From MAF/TIGER	5/14/2014	TIGER/Line Shapefiles
		tl_2014_us_uac10	Polygon	GDB Feature Class	Yes	Urbanized areas and clusters			
		County	Polygon	GDB Feature Class	No	Counties			
		Incorporated_Place	Polygon	GDB Feature Class	No	Cities, Towns, Townships, etc.			
		Census_Tract	Polygon	GDB Feature Class	No	Tracts			
		Block_Group	Polygon	GDB Feature Class	No	Block groups			
		Block	Polygon	GDB Feature Class	No	Blocks - smallest unit of measure for U.S. Census			
USGS	U.S. Geological Survey	Stations	Point	.csv	No	GPS coordinates extracted for USGS gages in Virginia, then georeferenced	None available	6/10/2014	National Water Information Service
		Station_Basins	Polygon	Shapefile	Yes	Digital dataset to represent official drainage basins for continuous-record streamflow-gaging stations, partial record streamflow-gaging stations of the U.S. Geological Survey (USGS), and other watercourse locations of interest. The dataset will be used for the update and publication of drainage areas to all USGS stations in Virginia.	Only shows certain watersheds	6/10/2014	Hayes and Wiegand, 2006 [35]
VDGIF	Virginia Department of Game and Inland Fisheries	CWSSreaches_092011Ia m	Polyline	Shapefile	Yes	These data represent the Virginia Department of Game and Inland Fisheries (VDGIF) coldwater or trout streams. VDGIF biologists have identified all of the reaches in this dataset as wild (Class I-IV) or stockable (Class V and VI) trout streams or as tributaries to wild trout streams. These classifications give the streams special management considerations and protection. Please note that many of the streams are on private property and are not necessarily public fishing waters.	Developed in 2011 by VDGIF. No other information provided	10/21/2014	GIS Data
WVWA	Western Virginia Water Authority	Many	Various	GDB Feature Classes	No	These data represent the WVWA's vector database of all water and wastewater features in the City, including pipes, junctions, plants, etc.	None available	11/13/2014	E-mail from Erika Hoffman, WVWA

V. Appendix 5 – Water Quality and Quantity Data

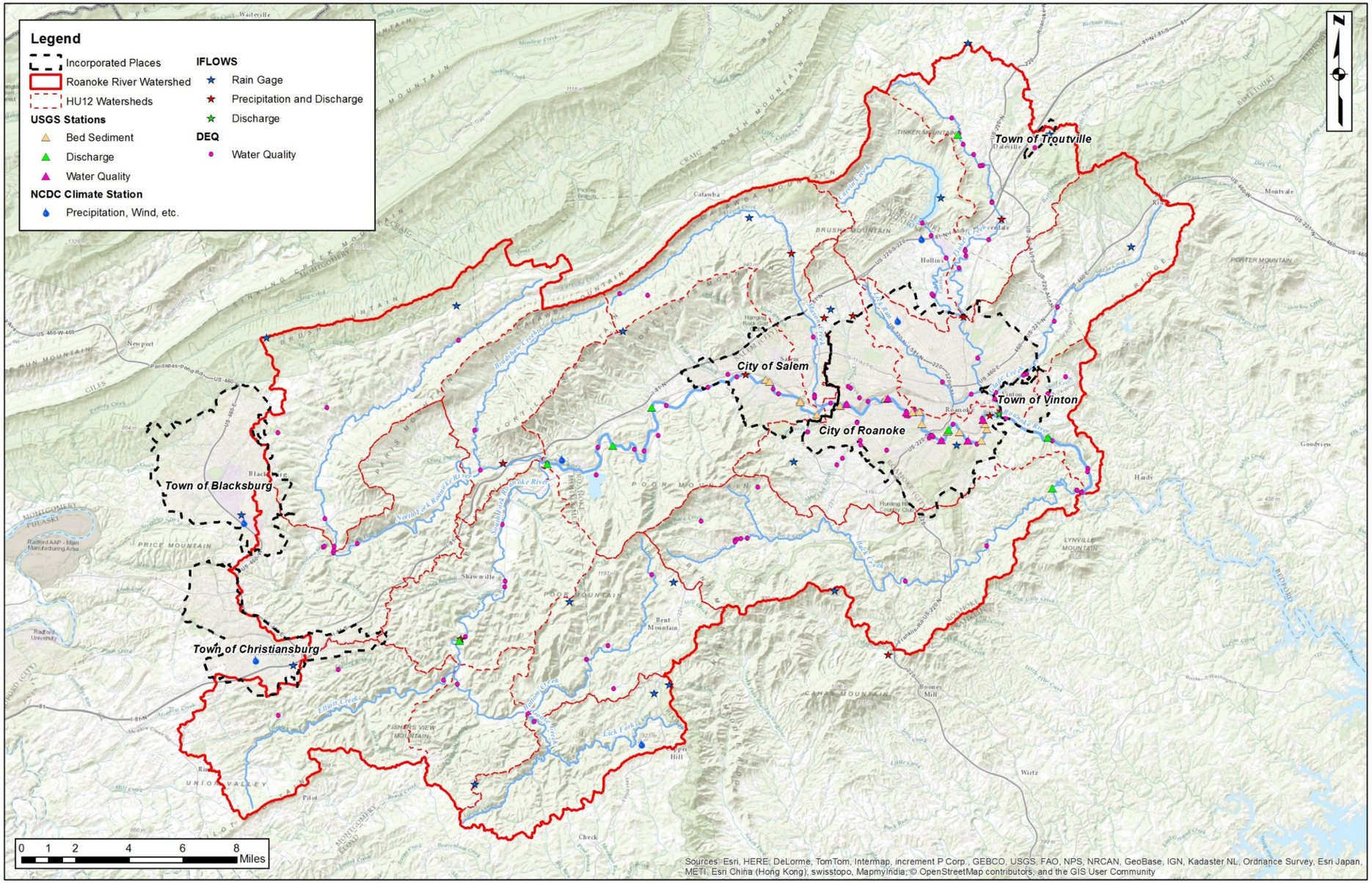

Figure V-1 - Hydrologic and Water Quality Measurement Stations and Sites in the Roanoke River Watershed

Table V-1 – Current and Past Locations where the USGS has monitored water quality and quantity

Water Body	Gage Number and Name (From Upstream to Downstream)	Period of Record	Discharge (cfs)	Gage Height (ft)	Water Temp. (°C)	Spec. Cond. (µS/cm)	pH	Turbidity (FNU)	Bed Sediment Characterization	Grab Samples
Roanoke River	02053800 Roanoke River near Shawsville, VA	1960 - 2014	X		X	X				X
	02054500 Roanoke River at Lafayette, VA	1943 - 2014	X							X
	02054510 Roanoke River near Wabun, VA	1994 - 1999	X							X
	02054530 - Roanoke River at Glenvar, VA	1991-Present	X							
	0205458550 - Roanoke River Near Front St.	2005-2012							X	
	0205458560 - Roanoke River at Eddy Street Bridge	2005-2012							X	
	0205459510 - Roanoke River along Riverside Dr.	2005-2012							X	
	0205459530 - Roanoke River at Apperson Dr. Bridge	2005-2012							X	
	0205459890 - Roanoke River at Braeburn Dr	2005-2012							X	
	0205474910 - Roanoke River Below Barnhardt Creek	2005-2012							X	
	02054750 - Roanoke River at Route 117	2005-2012			X	X	X	X		X
	0205491520 - Roanoke River at Bridge St. Bridge	2005-2012							X	
	0205491522 - Roanoke River at Bridge St. Bridge	2008-2011			X	X	X	X		
	0205492550 - Roanoke River at Memorial Ave. Bridge	2007-2008			X	X	X	X		
	0205493075 - Roanoke River Along Wiley Drive Block Dam	2005-2012							X	
	0205493515 - Roanoke River at Main Street Bridge	2005-2012							X	
	0205494810 - Roanoke River At Smith Park	2005-2012							X	
	0205494935 – Roanoke River at Jefferson St. Bridge	2006-2009			X	X	X	X		
	0205494950 - Roanoke River at Walnut St. Bridge	2005-2012							X	
	02055000 – Roanoke River at Roanoke, VA	1899-Present	X*							
	0205500550 Roanoke River at Whitman St.	2005-2012							X	
	02055010 – Roanoke River at Ninth St. Bridge	2005-2007			X	X	X	X		
	0205504515 – Roanoke River Below Garnand Branch	2005-2012							X	
	0205506875 – Roanoke River at Riverdale Road	2005-2012							X	
	0205507720 – Roanoke River at Carlisle Avenue	2005-2012							X	
	02055080 – Roanoke River at 13th St. Bridge	2005-2012			X	X	X	X		X
	02056000 – Roanoke River at Niagara, VA	2007-Present	X	X[ł]						
Tinker Creek	02055100 Tinker Creek near Daleville, VA	1956 - 2005	X							X
Back Creek	02056650 Back Creek near Dundee, VA	1974 - 2014	X							X

*This gage also has various water quality data between 1929 and 1979

ł Period of record for gage height is 2014 - Present

VI. Appendix 6 – Review of Outreach and Education Materials

Organization	Contact	Email Address	Phone	Notes
Clean Valley Council	Cristina Siegel, Executive Director	cristina@cleanvalley.org	1-540-345-5523	
Western Virginia Water Authority	Sarah Baumgardner, Environmental Communications Coordinator	sarah.baumgardner@westernvawater.org	1-540-853-5707	
Roanoke Valley Alleghany Regional Commission	Shane Sawyer, Regional Planner	ssawyer@rvarc.org	1-540-343-4417	main office number
Roanoke Valley Greenways Commission	Liz Belcher, Greenway Coordinator	lbelcher@roanokecountyva.gov	1-540-777-6330	
Upper Roanoke River Roundtable	Megan Scott, Board Member	megan.scott@roanokeva.gov	1-540-853-2734	
Virginia Save Our Streams	Wes Jargowsky	jsky@rbnet.com	1-540-992-5495	

A. *CITY OF ROANOKE OUTREACH AND EDUCATION*

a) Phone Calls – October 22nd & 24th, 2014

Attendees: Paul Bender, Marcus Aguilar, VT; Patrick Hogan, Christopher Blakeman, City of Roanoke

- E&S Training Ideas (this all falls under MCM 6.d. Training)
  - City E&S inspectors already receive state approved training
  - Employees with no training requirements could benefit from ESC training
    - Building inspectors and storm/sewer maintenance personnel
  - No luck so far for private sector contractors to host an event, instead hold a "Public Works Day" or field day with demonstrations, etc
    - Coordinate with other localities to hold an "awareness day"
    - Show inspectors and field employees what SCMs look like, how to install them, problems to look for, etc
  - Excal Visual
    - City has made canned in-house training presentations to give employees general "home and workplace awareness" about SW
    - Working with Excal Visual to produce canned training presentations
    - County contracts with Excal Visual, City is testing the water before making the full move.
    - General presentations meet MS4 reqs, City can tailor to fit needs
    - Excal has made the City 9 different modules, City will select some and combine with in-house presentations. Dept specific modules:
      - recognition and reporting of IDDE
      - Road, street and parking lot maintenance
- Public Involvement, Citizen Reporting, and IDDE Inspection
  - Citizens
    - Q-Alert program
      - Previously a "low tech" call-in method for citizen reporting
      - Now online from City website
      - App for iPhone and Android (iRoanoke) in soft launch phase
      - Provides a way for citizens to report illegal dumping, spills, or maintenance issues, generates a work order forwarded to the appropriate department and placed in their task list
      - Provides accountability on the City's part and speeds up response time to citizen concerns
  - Employees
    - Permits Plus
      - Not yet live, still in "dress rehearsal" for use by City
      - Tracks permit citations linked to building owners/tax IDs
      - Better information transfer to inspectors in the field
      - Data about history, frequency and types of complaints are linked to GISRE
    - Trimble Terraflex
      - Used by Env Dept to support MS4 outfall inspections/reports
      - Smartphone app tracks rough GPS location of outfalls
      - Set up a Q&A form online, fill out in field, upload to cloud

        - In the office, export data in a number of file formats (used to be csv, kml, xml; now includes esri gdb, shp, wfs formats)
        - City GIS techs working to incorporate data directly into GIS and link inspection reports with their outfalls and features
    - Discussion about the City's Education and Outreach Contract
        - Individual contracts between the Clean Valley Council and the City, Roanoke County, and the Town of Vinton for education and programming
        - WVWA runs separate regional programs, perhaps something to do with their own permit for the STP or their own goals for education and outreach
        - Interested in reviving the Citizen Stormwater Advisory Committee. Used to be part of CVC contract as an avenue for public commentary on stormwater program plans. Now commentary is no longer explicitly invited unless citizens review the plans posted on the website and actively raise concerns.

B. Outside Organizations Performing Education and Outreach

a) Phone Call – October 14th, 2014

Attendees: Paul Bender, VT; Cristina Siegel, Clean Valley Council

- What is the role of the Clean Valley Council (CVC)?
    - Acts as a clearinghouse working across municipal boundaries to bring continuity to public outreach
    - Dedicated education staff to provide programs to schools
- What are CVC's interactions with the City?
    - CVC maintains a contract with the City of Roanoke to provide educational programs for roughly 15-20 thousand K-12 age students. Fulfills the localities' MS4 outreach requirements. Contract has been in place for 5-6 years. CVC sends quarterly reports to the City on programs carried out.
    - CVC helps coordinate volunteer efforts in the City sponsored by other interest groups, including the URRR and VASOS.
- What programs does the CVC run?
    - Initially focused on river clean-ups and recycling/litter awareness. Now they also hold programs such as the Recycled Regatta and Watershed Festival (this year will be the 2nd annual event). CVC also attends and participates in other organizations' events, such as the Green Energy Expo.
    - The CVC currently manages multiple programs tied in with the local MS4 education and outreach contracts:
        - Educational programs- two educators work in schools in the City of Roanoke, Town of Vinton, and Roanoke County. In-class and field trip programs aligned with Virginia Standards of Learning. Topics include water quality, stormwater, and benthic "bug" sampling.
        - Stormdrain stenciling programs - kids go out and stencil "no dumping" themed messages on storm sewer inlets.
        - Citizen Stormwater Advisory Committee- committee was part of the MS4 contracts for years, not included this year. Meetings consisted of presentations and discussions on stormwater. Business owners and citizens brought ideas back to community to spread the knowledge.
        - CVC also gives presentations to local garden clubs and other small groups to promote watershed awareness and protection

- Annual clean-up events - Fall Waterways Clean-up and Clean Valley Day. Attract several hundred volunteers around the Roanoke Valley
- The CVC also sends out publications to local businesses advocating water saving strategies and tips to reduce stormwater pollution.

▪ CVC recently partnered with the City in a grant proposal for a citizen science water quality monitoring program. Focused on bacteria sampling, some benthic sampling, and public involvement. If approved, money will go towards equipment and training to get the program running.

o What data does the CVC collect?
▪ Data from river clean-up programs, primarily litter and trash counts. Data provided to the CVC by localities and volunteers who fill out provided data sheets. Water quality programs are only educational, no WQ data generated.

b) Phone Call – October 14th, 2014

Attendees: Paul Bender, VT; Sarah Baumgardner, Western Virginia Water Authority

o Role of the WVWA
▪ WVWA provides water and wastewater services to the City, as well as Roanoke and Franklin Counties

o Interactions with City-
▪ WVWA runs some educational programs in the City. Recently received a grant for field trip transportation funds to allow all children to participate. Occasionally direct phone calls from citizens about stormwater issues to Dwayne D'Ardenne and his staff
▪ WVWA partners with the CVC, Master Naturalists, Forest Service, 4H, and Trout Unlimited to conduct school trips in Roanoke and Franklin Counties
▪ WVWA performs stormwater BMP projects on their own properties for stormwater permit compliance; some are local boy scout or URRR projects

o Programs
▪ Class presentations and activities with K-12 age students, aligned with Virginia's SOLs. Grades 4-6 focus on stormwater and watersheds. Teach the differences between water services (piped water) and stormwater. Their programs reach 12000 kids in class and in the field.
▪ Extensive outreach field trip programs to Carvins Cove, the region's largest protected drinking water source

o Data
▪ No stormwater data collected. Maintain lists of attendance and information about education and outreach programs. This is sent to local MS4 localities.

c) Phone Call – October 15th, 2014

Attendees: Paul Bender, VT; Shane Sawyer, Roanoke Valley Alleghany Regional Commission

o Role of the Roanoke Valley Alleghany Regional Commission
▪ Serve as forum for information sharing and distribution on a regional scale, from governments down to local municipalities and organizations.

o City is a member of the Regional Stormwater Advisory Committee

- Recently established by RVARC, includes citizens, business owners, academic institutions, and governments. Meets twice per year to discuss stormwater issues; no voting powers, just a forum for Q&A with regulators, discussion and debate about current issues and regulations. Two branches:
  - Technical Committee: stakeholders include SW program managers, inspectors, and engineers who are dealing with SW issues.
  - Management Committee: stakeholders are primarily elected officials, regulators, or other administrative personnel involved with SW

o Programs
- No educational programs, but very involved in outreach and coordination for the TMDL studies and IP production. RVARC was/is the organizing body which contracted for the TMDL studies and wrote the grant to fund the IP.
  - RVARC personnel are not decision-makers; sit in and participate in order to understand and be familiar with the IP process.
  - RVARC can then make presentations to government and citizen groups to pass on information about SW regulations and practices.
- Write and propose grants for regional projects, forward grant opportunities to local governments and interest groups if RVARC doesn't act on them.
- Currently host the website for the Roanoke River Blueways
  - Eventually will become independent entity providing information to the public about the Roanoke River and its tributaries as resources.
  - Intended to improve local residents' connection to the river. If citizens learn about and understand the river, they might take on a larger stewardship role and be proactive about stormwater pollution

o Data
- Maintain Greenways GIS feature class, (Matt Miller, Information Services)
- UTC feature class- Urban Tree Canopy data generated from a 2008 land cover survey/analysis. Layer has 1-meter resolution, contains information about tree canopy, field cover, and some impervious surface data (?).

d) Phone Call – October 7th, 2014

Attendees: Paul Bender, VT; Liz Belcher, Roanoke Valley Greenways Commission

o What is the role of the Roanoke Valley Greenways Commission?
- Facilitate coordination between localities/governments, citizens, and outside organizations
- Provide money, volunteers, and resources to carry out greenway projects
- Liz's responsibilities:
  - Facilitate conversation between City Parks and Eng Depts; often at a "tug of war" between doing projects right and doing them quickly
  - Head off potential problems in legislature or in the neighborhood. Keep tabs on local Planning Commission meetings and news articles in order to discover new legislature which might affect greenways or stormwater management around them, and inform planners.
  - Field calls from citizens concerned about management of greenways or other issues- she directs them to the proper locality or dept to talk about the issue

o What are the interactions with the City?

- Greenways Commission began in the 90s, different designation of duties. Design, permitting, and construction was largely on the shoulders of the Commission, with contracting help from the City. Plans didn't always consider the floodplain, local utilities, or riparian buffer zones.
- Now, emphasis is on quality design: use design handbooks, make sure that acquired riparian buffer is preserved and greenway is out of the floodplain.
- Localities now take more responsibility and ownership of these projects. The Greenways Commission is kept in the loop for site selection, design is handled mostly by the locality, and the Commission and Parks Dept are given updates and opportunities for input.
- Zoning policies were revised to transfer greenway property to Parks Dept, so Liz tries to ensure that the Parks Dept is asking the right questions regarding the feasibility of maintenance, etc for various aspects greenways.

o Does RVGC perform or participate in any education and outreach related to the City?
- No programs of their own, but they try to be active in programs put on by other organizations:
  - Clean Valley Council programs such as Fall Waterways, Clean Valley Day; Energy Expo run in November
  - Pathfinders for Greenways- volunteer based trail maintenance group affiliated with RVGC. Perform work on natural surface trails in and outside of Parks Dept properties (Greenways are paved/cinder trails). Participate in stream restoration or riparian buffer grant projects organized by RVGC. City Parks Dept just hired a Trails Coordinator who coordinates efforts inside park system boundaries.

o Does RVGC collect any data with respect to water quality/quantity or GIS maps?
- RVGC website hosts an online GIS map of the regional greenways and trails
- The Greenways Commission walks the trails with a Trimble GPS unit to gather raw data, but transfer that to RVARC. See Matt Miller at RVARC Information Services (540-343-4417, mmiller@rvarc.org)

e) Meeting – October 7th, 2014

Attendees: Paul Bender, VT; Megan Scott, Upper Roanoke River Roundtable

o Role of the Upper Roanoke River Roundtable (URRR)
- Citizen volunteers with an interest in local water quality issues, educating the public, and completing water quality improvement projects. Membership is open to anyone who is interested in water quality and is willing to be available to volunteer on projects
- Brainstorm ideas for WQ improvement projects, apply for grant funds. Examples include biofilters, pet waste stations, stream restorations, riparian buffers, etc. Members coordinate with local companies who donate manpower, design capabilities, or materials to complete projects
- Although membership is open and some advertisement is done to recruit new members, volunteer base is relatively the same from year to year.

o Interactions with the City
- URRR contacts localities to look for an appropriate site for a chosen project. For projects in the City, URRR coordinates with City officials and Parks or other dept personnel for project design and construction approval

- Board often recruits members from the City to help advertise projects based in the City and organize event and construction plans

- Programs
  - Host a Watershed Conference with Ferrum College to promote community interest
  - Programs are mainly the water quality improvement projects
- Data
  - URRR does not collect significant data

f) Phone Call – October 14th, 2014

Attendees: Paul Bender, VT; Wes Jargowsky, Virginia Save Our Streams

- Role of Virginia chapter of Save Our Streams
  - Interest group concerned with protecting the state's natural stream habitats for recreation and wildlife.
  - Coordinate volunteer benthic monitor training and data collection
  - Local volunteer base is not being replenished, coverage is much less now
- Programs
  - VASOS focuses on monitoring and does not run other programs.
  - Volunteer efforts help boost DEQ's monitoring program
  - Volunteer sampling programs are QA/QC'd by DEQ
- Data
  - All of the VASOS data (mostly benthic monitoring) is given to the DEQ.
  - Recent legislation in VA requires that a certain amount of sampling data come from citizen monitoring programs in addition to the sampling that DEQ does. VASOS citizen data is used more as an indicator of problems

APPENDIX REFERENCES

[1] Virginia Department of Environmental Quality, "Construction General Permits," 2014. [Online]. Available: http://www.deq.virginia.gov/programs/water/stormwatermanagement/vsmppermits/constructiongeneralpermit.aspx.

[2] C. G. Cude, "Accomodating Change of Bacterial Indicators in Long Term Water Quality Datasets," *JAWRA J. Am. Water Resour. Assoc.*, vol. 97204, no. 02144, pp. 47–54, 2005.

[3] J. M. Hathaway, L. H. Krometis, and W. F. Hunt, "Exploring Seasonality in Escherichia coli and Fecal Coliform Ratios in Urban Watersheds," *J. Irrig. Drain. Eng.*, vol. 140, no. 4, 2014.

[4] L. G. Lawson, "Guidance Memo No. 03-2012: HSPF Model Calibration and Verification for Bacteria TMDLs," Richmond, Virginia, 2012.

[5] V. P. Singh and D. A. Woolhiser, "Mathematical Modeling of Watershed Hydrology," *J. Hydrol. Eng.*, vol. 7, no. 4, pp. 270–292, 2002.

[6] B. L. Benham, C. Baffaut, R. W. Zeckoski, K. R. Mankin, Y. A. Pachepsky, A. M. Sadeghi, K. M. Brannan, M. L. Soupir, and M. J. Habersack, "Modeling bacteria fate and transport in watersheds to support TMDLs," *Trans. ASABE*, vol. 49, no. 4, pp. 987–1002, 2006.

[7] MapTech Inc., Crop and Soil Environmental Sciences Virginia Polytechnic and State University, and Roanoke Valley-Alleghany Regional Commission, "Fecal Coliform Total Maximum Daily Load Development for Glade Creek, Tinker Creek, Carvin Creek, Laymantown Creek and Lick Run." 2004.

[8] National Climatic Data Center, "Roanoke Regional Airport, VA US - COOP: 447285," *Precipitation Hourly Data*. [Online]. Available: http://www.ncdc.noaa.gov/cdo-web/datasets/PRECIP_HLY/stations/COOP:447285/detail.

[9] D. B. Gesch, "The National Elevation Dataset," in *Digital Elevation Model Technologies and Applications: The DEM Users Manual*, 2nd ed., D. Maune, Ed. Bethesda, Maryland: American Society for Photogrammetry and Remote Sensing, 2007, pp. 99–118.

[10] V. Te Chow, *Open Channel Hydraulics*. McGraw-Hill, 1959.

[11] Virginia Department of Environmental Quality, "VPDES Permits, Fees, and Regulations," 2014. [Online]. Available: http://www.deq.virginia.gov/Programs/Water/PermittingCompliance/PollutionDischargeElimination/PermitsFees.aspx. [Accessed: 09-Oct-2014].

[12] S. Jin, L. Yang, P. Danielson, C. Homer, J. Fry, and G. Xian, "A comprehensive change detection method for updating the National Land Cover Database to circa 2011," *Remote Sens. Environ.*, vol. 132, pp. 159–175, May 2013.

[13] D. K. Borah and M. Bera, "Watershed-Scale Hydrologic and Nonpoint-Source Pollution Models: Review of Mathematical Bases," *Trans. ASAE*, vol. 46, no. 6, pp. 1553–1566, 2003.

[14] D. K. Borah and M. Bera, "Watershed-Scale Hydrologic and Nonpoint-Source Pollution Models: Review of Applications," *Trans. ASAE*, vol. 47, no. 3, pp. 789–804, 2004.

[15] A. M. Lumb, R. B. McCammon, and J. L. Kittle, "Users manual for an expert system (HSPexp) for calibration of the Hydrologic Simulation Program - Fortran." U.S. Geological Survey Water-Resources Investigations Report 94-4168, p. 102, 1994.

[16] J. W. Kirchner, "Getting the right answers for the right reasons: Linking measurements, analyses, and models to advance the science of hydrology," *Water Resour. Res.*, vol. 42, no. 3, Mar. 2006.

[17] The Louis Berger Group Inc., "Benthic TMDL Development for the Roanoke River, Virginia," 2006.

[18] Virginia Administrative Code, *9 VAC 25-260-20. General Criteria*. 2010.

[19] R. C. Wagner, T. A. Dillaha, and G. Yagow, "An assessment of the reference watershed approach for TMDLs with biological impairments," *Water. Air. Soil Pollut.*, vol. 181, no. 1–4, pp. 341–354, Dec. 2006.

[20] M. T. Barbour, J. Gerritsen, B. D. Snyder, and J. B. Stribling, "Rapid Bioassessment Protocols For Use in Streams and Wadeable Rivers: Periphyton, Benthic Macroinvertebrates and Fish. EPA 841-B-99-002," Washington D.C., 1999.

[21] W. F. Henley, M. a. Patterson, R. J. Neves, and a. D. Lemly, "Effects of Sedimentation and Turbidity on Lotic Food Webs: A Concise Review for Natural Resource Managers," *Rev. Fish. Sci.*, vol. 8, no. 2, pp. 125–139, Apr. 2000.

[22] S. M. Wagener, J. D. Laperriere, S. Freshwater, I. Biology, and N. Nov, "Effects of Placer Mining on the Invertebrate Communities of Interior Alaska Streams Effects of Placer Mining on the Invertebrate Communities of Interior Alaska Streams '," *Freshw. Invertebr. Biol.*, vol. 4, no. 4, pp. 208–214, 2014.

[23] E. E. Van Nieuwenhuyse and J. D. LaPerriere, "Effects of placer gold mining on primary production in subarctic streams of Alaska," *Water Resour. Bull.*, vol. 22, no. 1, pp. 91–99, 1986.

[24] Virginia Department of Environmental Quality, "Water Quality Standards," 2014. [Online]. Available: http://www.deq.virginia.gov/Programs/Water/WaterQualityInformationTMDLs/WaterQualityStandards.aspx. [Accessed: 09-Aug-2014].

[25] Virginia State Water Control Board, "Water Quality Management Strategy for the Roanoke Standard Metropolitan Statistical Area," 1983.

[26] B. M. Evans, S. A. Sheeder, and D. W. Lehning, "A Spatial Technique for Estimating Streambank Erosion Based on Watershed Characteristics," *J. Spat. Hydrol.*, vol. 3, no. 1, pp. 1–13, 2003.

[27] D. A. Haith, R. Mandel, and R. S. Wu, *GWLF Generalized Waterwshed Loading Functions Version 2.0 User's Manual*. Ithaca, N.Y., 1992.

[28] D. K. Makepeace, D. W. Smith, and S. J. Stanley, "Urban stormwater quality: Summary of contaminant data," *Crit. Rev. Environ. Sci. Technol.*, vol. 25, no. 2, pp. 93–139, May 1995.

[29] M. P. Longnecker, W. J. Rogan, and G. Lucier, "The Human Health Effects of DDT (Dichlorodiphenyl- Trichloroethane) and PCBs (Polychlorinated Biphenyls) and an Overview Of Organochlorines In Public Health," *Annu. Rev. Public Health*, vol. 18, no. 1, pp. 211–244, 1997.

[30] R. Eisler, "Polychlorinated Biphenyl Hazards to Fish, Wildlife, And Invertebrates: A Synoptic Review," *U.S. Fish Wildl. Serv. Biol. Rep.*, vol. 85, no. 7, pp. 1–53, 1986.

[31] Tetra Tech, "Roanoke River PCB TMDL Development (Virginia)," Fairfax, VA, 2009.

[32] Virginia Administrative Code, *9 VAC 25-260-140. Criteria for surface water*. 2010.

[33] D. D. MacDonald, C. G. Ingersoll, and T. a Berger, "Development and evaluation of consensus-based sediment quality guidelines for freshwater ecosystems.," *Arch. Environ. Contam. Toxicol.*, vol. 39, no. 1, pp. 20–31, Jul. 2000.

[34] Tetra Tech, "Loading Simulation Program in C++ (LSPC) Version 3.1 User's Manual." Fairfax, VA, 2009.

[35] D. C. Hayes and U. Wiegand, "Drainage Areas of Selected Streams in Virginia," 2006.

[36] National Research Council, *Assessing the TMDL Approach to Water Quality Management*. National Academies Press, 2001, pp. 73–76.

[37] R. H. McCuen, Z. Knight, and A. G. Cutter, "Evaluation of the Nash – Sutcliffe Efficiency Index," *J. Hydrol. Eng.*, no. December, pp. 597–603, 2006.

[38] D. N. Moriasi, J. G. Arnold, M. W. Van Liew, R. L. Bingner, R. D. Harmel, and T. L. Veith, "Model Evaluation Guidelines for Systematic Quanitification of Accuracy in Watershed Simulations," *Trans. ASABE*, vol. 50, no. 3, pp. 885–900, 2007.

APPENDIX BIBLIOGRAPHY

Barbour, M. T., Gerritsen, J., Snyder, B. D., and Stribling, J. B. (1999). Rapid Bioassessment Protocols For Use in Streams and Wadeable Rivers: Periphyton, Benthic Macroinvertebrates and Fish. EPA 841-B-99-002. Washington D.C.

Benham, B. L., Baffaut, C., Zeckoski, R. W., Mankin, K. R., Pachepsky, Y. A., Sadeghi, A. M., Brannan, K. M., Soupir, M. L., and Habersack, M. J. (2006). Modeling bacteria fate and transport in watersheds to support TMDLs. Transactions of the ASABE, 49(4), 987–1002. Retrieved from http://www.tmdl.bse.vt.edu/uploads/File/pub_db_files/sw6351.pdf.

Borah, D. K., and Bera, M. (2003). Watershed-Scale Hydrologic and Nonpoint-Source Pollution Models: Review of Mathematical Bases. Transactions of the ASAE, 46(6), 1553–1566.

Borah, D. K., and Bera, M. (2004). Watershed-Scale Hydrologic and Nonpoint-Source Pollution Models: Review of Applications. Transactions of the ASAE, 47(3), 789–804.

Chow, V. Te. (1959). Open Channel Hydraulics. McGraw-Hill.

Cude, C. G. (2005). Accomodating Change of Bacterial Indicators in Long Term Water Quality Datasets. JAWRA Journal of the American Water Resources Association, 97204(02144), 47–54.

Eisler, R. (1986). Polychlorinated Biphenyl Hazards to Fish, Wildlife, And Invertebrates: A Synoptic Review. U.S. Fish and Wildlife Service Biological Report, 85(7), 1–53.

Evans, B. M., Sheeder, S. A., and Lehning, D. W. (2003). A Spatial Technique for Estimating Streambank Erosion Based on Watershed Characteristics. Journal of Spatial Hydrology, 3(1), 1–13.

Gesch, D. B. (2007). The National Elevation Dataset. In D. Maune (Ed.), Digital Elevation Model Technologies and Applications: The DEM Users Manual (2nd ed., pp. 99–118). Bethesda, Maryland: American Society for Photogrammetry and Remote Sensing.

Haith, D. A., Mandel, R., and Wu, R. S. (1992). GWLF Generalized Waterwshed Loading Functions Version 2.0 User's Manual. Ithaca, N.Y.

Hathaway, J. M., Krometis, L. H., and Hunt, W. F. (2014). Exploring Seasonality in Escherichia coli and Fecal Coliform Ratios in Urban Watersheds. Journal of Irrigation and Drainage Engineering, 140(4).

Hayes, D. C., and Wiegand, U. (2006). Drainage Areas of Selected Streams in Virginia. Retrieved from http://water.usgs.gov/GIS/metadata/usgswrd/XML/ofr2006-1308_Drainage_Basin.xml.

Henley, W. F., Patterson, M. a., Neves, R. J., and Lemly, a. D. (2000). Effects of Sedimentation and Turbidity on Lotic Food Webs: A Concise Review for Natural Resource Managers. Reviews in Fisheries Science, 8(2), 125–139. doi:10.1080/10641260091129198.

Jin, S., Yang, L., Danielson, P., Homer, C., Fry, J., and Xian, G. (2013). A comprehensive change detection method for updating the National Land Cover Database to circa 2011. Remote Sensing of Environment, 132, 159–175. doi:10.1016/j.rse.2013.01.012.

Kirchner, J. W. (2006). Getting the right answers for the right reasons: Linking measurements, analyses, and models to advance the science of hydrology. Water Resources Research, 42(3). doi:10.1029/2005WR004362.

Lawson, L. G. (2012). Guidance Memo No. 03-2012: HSPF Model Calibration and Verification for Bacteria TMDLs (pp. 1–28). Richmond, Virginia.

Longnecker, M. P., Rogan, W. J., and Lucier, G. (1997). The Human Health Effects of DDT (Dichlorodiphenyl- Trichloroethane) and PCBs (Polychlorinated Biphenyls) and an Overview Of Organochlorines In Public Health. Annual Review of Public Health, 18(1), 211–244.

Lumb, A. M., McCammon, R. B., and Kittle, J. L. (1994). Users manual for an expert system (HSPexp) for calibration of the Hydrologic Simulation Program - Fortran. U.S. Geological Survey Water-Resources Investigations Report 94-4168.

MacDonald, D. D., Ingersoll, C. G., and Berger, T. a. (2000). Development and evaluation of consensus-based sediment quality guidelines for freshwater ecosystems. Archives of environmental contamination and toxicology, 39(1), 20–31. doi:10.1007/s002440010075.

Makepeace, D. K., Smith, D. W., and Stanley, S. J. (1995). Urban stormwater quality: Summary of contaminant data. Critical Reviews in Environmental Science and Technology, 25(2), 93–139.

MapTech Inc., Crop and Soil Environmental Sciences Virginia Polytechnic and State University, and Roanoke Valley-Alleghany Regional Commission. (2004). Fecal Coliform Total Maximum Daily Load Development for Glade Creek, Tinker Creek, Carvin Creek, Laymantown Creek and Lick Run. Retrieved from http://www.deq.virginia.gov/Programs/Water/WaterQualityInformationTMDLs/TMDL/TMDLDevelopment/ApprovedTMDLReports.aspx.

McCuen, R. H., Knight, Z., and Cutter, A. G. (2006). Evaluation of the Nash – Sutcliffe Efficiency Index. Journal of Hydrologic Engineering, (December), 597–603.

Moriasi, D. N., Arnold, J. G., Liew, M. W. Van, Bingner, R. L., Harmel, R. D., and Veith, T. L. (2007). Model Evaluation Guidelines for Systematic Quanitification of Accuracy in Watershed Simulations. Transactions of the ASABE, 50(3), 885–900.

National Climatic Data Center. (n.d.). Roanoke Regional Airport, VA US - COOP: 447285. Precipitation Hourly Data. Retrieved from http://www.ncdc.noaa.gov/cdo-web/datasets/PRECIP_HLY/stations/COOP:447285/detail.

National Research Council. (2001). Assessing the TMDL Approach to Water Quality Management (pp. 73–76). National Academies Press.

Singh, V. P., and Woolhiser, D. A. (2002). Mathematical Modeling of Watershed Hydrology. Journal of Hydrologic Engineering, 7(4), 270–292.

Tetra Tech. (2009a). Roanoke River PCB TMDL Development (Virginia). Fairfax, VA. Retrieved from http://www.deq.virginia.gov/Programs/Water/WaterQualityInformationTMDLs/TMDL/TMDLDevelopment/ApprovedTMDLReports.aspx.

Tetra Tech. (2009b). Loading Simulation Program in C++ (LSPC) Version 3.1 User's Manual. Fairfax, VA.

The Louis Berger Group Inc. (2006). Benthic TMDL Development for the Roanoke River, Virginia. Retrieved from http://www.deq.virginia.gov/Programs/Water/WaterQualityInformationTMDLs/TMDL/TMDLDevelopment/ApprovedTMDLReports.aspx.

Van Nieuwenhuyse, E. E., and LaPerriere, J. D. (1986). Effects of placer gold mining on primary production in subarctic streams of Alaska. Water Resources Bulletin, 22(1), 91–99.

Virginia Administrative Code. 9 VAC 25-260-20. General Criteria (2010).

Virginia Administrative Code. 9 VAC 25-260-140. Criteria for surface water (2010).

Virginia Department of Environmental Quality. (2014a). Construction General Permits. Retrieved from http://www.deq.virginia.gov/programs/water/stormwatermanagement/vsmppermits/constructiongeneralpermit.aspx.

Virginia Department of Environmental Quality. (2014b). VPDES Permits, Fees, and Regulations. Retrieved October 09, 2014, from http://www.deq.virginia.gov/Programs/Water/PermittingCompliance/PollutionDischargeElimination/PermitsFees.aspx.

Virginia Department of Environmental Quality. (2014c). Water Quality Standards. Retrieved August 09, 2014, from http://www.deq.virginia.gov/Programs/Water/WaterQualityInformationTMDLs/WaterQualityStandards.aspx.

Virginia State Water Control Board. (1983). Water Quality Management Strategy for the Roanoke Standard Metropolitan Statistical Area.

Wagener, S. M., Laperriere, J. D., Freshwater, S., Biology, I., and Nov, N. (2014). Effects of Placer Mining on the Invertebrate Communities of Interior Alaska Streams Effects of Placer Mining on the Invertebrate Communities of Interior Alaska Streams '. Freshwater Invertebrate Biology, 4(4), 208–214.

Wagner, R. C., Dillaha, T. A., and Yagow, G. (2006). An assessment of the reference watershed approach for TMDLs with biological impairments. Water, Air, and Soil Pollution, 181(1-4), 341–354.