Chapter 5 - Planning and Location

TABLE OF CONTENTS

List of Appendices

Chapter 5 - Planning and Location

5.1 Introduction

5.1.1 Stormwater Management Plan

The Department often is and should be perceived as a developer of transportation facilities that have the potential to stimulate secondary activity along the transportation corridor, just as a major residential development can stimulate commercial activity. Secondary activity is a local/regional planning function that must address overall SWM* needs in conjunction with other utilities such as water, wastewater, and power. Because the transportation corridor often traverses several watersheds, the development of an adequate SWM Plan can be severely fragmented and significant problems created if there is a lack of coordinated planning among concerned parties.

To be truly effective, a SWM Plan should consider the total scope of development (i.e., transportation, residential, commercial, industrial, and agricultural). Department coordination with responsible local agencies is essential to ensure that proposed facilities are compatible with the long-term needs of the area. VDOT can provide important information to local agencies wishing to develop a comprehensive SWM Plan without assuming responsibility for the planning and decision-making process for the entire watershed.

Prior to design, a level of planning should be undertaken that will properly locate facilities and adequately address local concerns, permitting requirements, legal consideration, and potential problem categories. This chapter provides general guidelines and major considerations for evaluating these factors during the planning and location process. The important point to emphasize is that the designer should become involved in the early stages of project development and not wait until the later design stages.

5.1.2 Flood Hazards

Floodflow characteristics at a highway stream crossing should be carefully analyzed to determine their effect upon the highway as well as to evaluate the effects of the highway upon the floodflow. Such an evaluation can assist in determining those locations at which construction and maintenance will be unusually expensive or hazardous. Thus it is important to identify the flood hazards prior to any highway involvement to determine if the flood hazard will be increased, decreased, or be the same with and without the proposed highway improvement. Flood hazards should include effects to private property both upstream and downstream (i.e., overtopping floodwaters diverted onto previously unaffected property).

* Rev. 7/16

Although satisfactory solutions often can be obtained by making only minor changes in selected routes to take advantage of better natural hydraulic features at alternate sites, troublesome and uncertain conditions are sometimes best avoided altogether.

5.1.3 Construction Problems

Many serious construction problems arise because important drainage and water-related factors were overlooked or neglected in the planning and location phases of the project. With proper planning, many problems can be avoided or cost effective solutions developed to prevent extended damages. Such problems include:

- Soil erosion
- Sediment deposition
- Landslides
- Timing of project stages
- Protection for fish habitat
- Protection of existing facilities (ie. pipes, ditches/channels, etc.) and continued use during construction
- Contamination of pumping and distribution facilities
- Protection of streams, lakes, rivers, and reservoirs
- Protection of wetlands

Analysis of available data, proper scheduling of work, early field reconnaissance, and other aspects involved in the early planning and location studies can alleviate many problems encountered in the construction of drainage facilities.

5.1.4 Maintenance Problems

Planning and location studies should consider potential erosion and sedimentation problems upon completion of highway construction. If a particular location will require frequent and expensive maintenance due to drainage, alternate locations should be considered unless the potentially high maintenance costs can be reduced by special design. Experience in the area is the best indicator of maintenance problems and interviews with maintenance personnel could be extremely helpful in identifying potential drainage problems. Reference to highway maintenance and flood reports, damage surveys, newspaper clippings, and interviews with local residents could be helpful in evaluating potential maintenance problems.

The construction of channel changes, minor drainage modifications, and revisions in irrigation systems usually carry the assumption of certain maintenance responsibilities. Potential damage from the erosion and degradation of stream channels and problems caused by ice and debris can be of considerable significance from the maintenance standpoint.

5.2 Policy

5.2.1 Interagency Coordination

Coordination between concerned agencies during the project planning phase will help produce a design that is most satisfactory to all. Substantial cost savings and other benefits frequently can be realized for highway and water resource projects through coordinated planning among the Federal, State, and local agencies that are engaged in water-related activities (such as flood control and water resources planning). Interagency cooperation is an essential element for serving the public interests.

5.2.2 Intragency Coordination

Early planning and location studies should be coordinated within VDOT so that duplication of effort is minimized and all those who might be involved in future project work will be informed of any ongoing studies and study results.

5.2.3 Legal Aspects

Detailed legal aspects related to drainage are discussed in the Legal Chapter. Additionally, the following generalizations given in Chapter V of the Highway Drainage Guidelines by AASHTO (2007) and Chapter 2 of the AASHTO *Model Drainage Manual* (2014)[*] should be considered.

- A goal in highway drainage design should be to perpetuate natural drainage, insofar as practicable.
- The courts look with disfavor upon infliction of damage that could reasonably have been avoided, even where some alteration in flow is legally permissible.
- The basic laws relating to the liability of governmental entities are undergoing radical change, with a trend toward increased governmental liability.
- Drainage laws are also undergoing change, with the result that older and more specific standards are being replaced by more flexible standards that tend to depend on the circumstances of the particular case.

In water law matters, designers should recognize that the State is generally held to a higher standard than a private citizen. This is true even though the State should be granted the same rights and liabilities, since no law says differently. In general, designers should not address a question of law without the aid of legal counsel. Whenever drainage problems are known to exist or can be identified, drainage and flood easements or other means of avoiding future litigation should be considered, especially in locations where a problem could be caused or aggravated by the construction of a highway.

[*] Rev. 1/17

It is often helpful in the planning and location phase of a project to document the history and present status of existing conditions or problems, and supplement the record by photographs, videotapes, and written descriptions of field conditions.

Such thoroughness is essential, because VDOT may be blamed for flooding or erosion damage caused by conditions that existed prior to highway construction.

5.2.4 Environmental Considerations

For all projects, some level of environmental study should be performed. The environmental studies should comply with all Federal, State, and local laws and regulations related to environmental quality and should identify all environmental impacts of the project both positive and negative. If the project under study requires a Federal action, then the NEPA rules relating to environmental studies must be followed.

It is important to document the environmental considerations for the proposed project including any alternatives that will receive consideration. Encroachments onto adjacent areas (including environmental encroachments) should be avoided whenever possible. Identifying environmental considerations early in the planning process can prevent major implementation problems as the design and construction of the project proceeds.

Environmental considerations should be listed in the Environmental Scoping Report prepared during project scoping.

5.2.5 Permits

Specific Federal, State, and local permits that will be needed for a highway project must be identified in the environmental document early in the planning stages.

Prior to initiating design work, the designer must review the environmental document with the Environmental Division to identify regulatory commitments, constraints, and any permits required. Permits, as required, should be obtained before construction begins, and preferably before detailed plans are prepared.

5.2.6 Location Considerations

The principal factors to be considered in locating a stream crossing that involves encroachment within a floodplain are:

- River type (straight or meandering)
- River characteristics (stable or unstable)
- River geometry and alignment
- Hydrology
- Hydraulics
- Floodplain flow
- Needs of the area
- Economic and environmental concerns
- Navigable waterway and recreational use

A detailed evaluation of these factors is part of the location hydraulics study. When a suitable crossing location has been selected, specific crossing components can then be determined. When necessary, these include:

- The geometry and length of the approaches to the crossing
- Probable type and approximate location of the abutments
- Probable number and approximate location of the piers
- Estimated depth to the footing supporting the piers (to protect against local scour)
- The location of the longitudinal encroachment in the floodplain
- The amount of allowable longitudinal encroachment into the main channel
- The required river training works to ensure that river flows approach the crossing or the encroachment in a complementary way

Exact information on these components is usually not developed until the final stage of design.

5.3 Stormwater Management

5.3.1 Introduction

Planning for drainage and SWM* facilities should include a consideration of the potential problems associated with stormwater quality and quantity.

5.3.2 Quality

Several broad categories of degradation have been developed to delineate or describe levels of stormwater impacts:

- Aesthetic deterioration: Undesirable general appearance features (dirty, turbid, or cloudy) and actual physical features (odors, floating debris, oil films, scum, or slime) are present.
- Dissolved oxygen depletion: When the oxygen demand of bacteria is stimulated by the organics, the subsequent reduction in oxygen levels can disturb the balance between lower forms and the food chain. Unoxidized nitrogen compounds (ammonia) can also cause problems.
- Pathogen concentrations: High concentrations of several pathogens can reduce the acceptable uses of the receiving waters.
- Suspended solids: The physical buildup of solids can cover productive bottoms, be aesthetically objectionable, and disrupt flow and navigation.
- Nutrients: Accelerated eutrophication that stimulates growth of aquatic vegetation can cause a water body to become aesthetically objectionable, deplete dissolved oxygen, and decrease recreational value by creating odor and overgrowth. Advanced eutrophication can lead to sediment buildup, which reduces storage capabilities.
- Toxicity: The two types of toxics generally found in stormwater (metals and pesticides/persistent organics) may build up in sensitive areas over the long term. At high levels, they can have serious shock effects on aquatic life. Low levels can become significant by accumulation up the food chain.
- Hazardous spills: Depending on the characteristics of the spill, serious water quality problems can result.
- Total Maximum Daily Load (TMDL) Reports: TMDL coverage for the larger watershed are provided on VDOT Cedar, and similar EPA maps. TMDL reports are often available for the larger streams located in Virginia.

Quantification of the levels of contaminants that are being washed off a roadway is complicated by the variable effects of and the periods between storm events. The contributory factors are rainfall intensity, street surface characteristics, and particle size. The varying interaction of these factors makes it difficult to precisely estimate the impact that discharge will have on water quality.

* Rev. 7/16

In general, erosion and sediment transport should be limited by developing and implementing an Erosion and Sediment Control Plan which addresses both temporary and permanent control practices.

5.3.3 Quantity

Determinations of stormwater quantity are primarily useful for evaluating and mitigating the flooding and erosion impacts of a project. Without stormwater quantity management, land development can increase peak runoff rates and volumes from storm events, which can lead to higher flood elevations. Appropriate hydrologic and hydraulic calculations presented in various chapters of this manual should be made to determine the required conveyance through the R/W* and to aid in mitigating impacts to downstream property owners.

Procedures contained in this manual should be used to evaluate the ability of a facility to accomplish the following controls for a particular area.

- Reduce runoff rates by increasing infiltration, and by storing precipitation and runoff where it falls and releasing it slowly.
- Protect areas subject to flood damages by keeping runoff confined to drainage facilities such as pipes or channels and by building appropriate flood control facilities.
- Keep floodplain encroachment outside the limits of regulated floodways.

The following questions should be considered when selecting the plan for disposal of stormwater runoff.

- Are existing drainage systems large enough to handle anticipated runoff?
- Are design discharges consistent with adopted drainage plans and regulatory criteria?
- Will the project require retention or detention storage areas to mitigate the impacts of increased runoff, or can the increase be handled by other project features?
- Is there sufficient area to construct a retention or detention pond within the R/W? Are alternative sites available for storage of stormwater? Is property available outside the R/W? Does the project schedule allow time to acquire additional R/W?
- Are there unusual groundwater or soil conditions? Is there a high groundwater table, or are there impermeable soil layers, rock or karst topography?
- Are there any jurisdictional, permit, or economic restrictions?
- Are there any unusual site conditions, such as woods, wetlands, water supply reservoirs, live streams, or other environmental features that might influence the development of a SWM system?

* Rev. 7/16

5.4 Preliminary Data Gathering

5.4.1 Drainage Surveys

Since hydraulic considerations can influence the selection of a highway corridor and the alternate routes within the corridor, the type and amount of data needed for planning studies can vary widely depending on such elements as environmental considerations, class of the proposed highway, state of land-use development, and individual site conditions.

Topographic maps, aerial photographs, and streamflow records provide helpful preliminary drainage data, but historical highwater elevations and flood discharges are of particular interest in establishing waterway requirements. Comprehensive hydraulic investigations may be required when route selection involves important hydraulic features such as water-supply wells and reservoirs, flood-control dams, water resource projects, and encroachment on floodplains of major streams. Special studies and investigations, including consideration of the environmental and ecological impact, should be commensurate with the importance and magnitude of the project and the complexity of the problems encountered.

5.4.2 Data Collection

As part of planning and location studies several categories of data should be obtained and evaluated, including:

- Physical characteristics of drainage basins
- Maps and topographic data including channel surveys and cross sections
- Runoff quantity data (hydrologic and precipitation data)
- Channel and floodplain delineations and related studies
- Flood history and problem inventory
- Existing SWM* facility characteristics
- Development of alternative plan concepts
- Hydrologic and hydraulic analysis of alternative concepts
- Consideration of multipurpose opportunities and constraints
- Benefit/cost analysis and evaluation
- Runoff quality data
- Evidence of sinkholes typically found in karst terrain

5.4.3 Type of Data

Following is a brief description of the types of data needed for planning and location studies.

* Rev. 7/16

5.4.4 Topographic

Topographic data should be acquired at most sites requiring hydraulic studies. These data are needed so that analysis of existing flow conditions as well as those caused by various design alternatives may be performed. Significant physical and cultural features in the vicinity of the project should be located and documented in order to obtain their elevation. Such features as residences, commercial buildings, schools, churches, farmlands, other roadways and bridges, and utilities can affect, as well as be affected by the design of any new hydraulic structures. Often, recent topographic surveys will not be available at this early stage of project development. Aerial photographs, photogrammetric maps, USGS quadrangle sheets, and even old highway plans may be utilized during the planning and location phases. When better survey data becomes available, usually during the design phase, these early estimates will need to be revised to correspond with the most recent field information.

5.4.5 Channel Characteristics

In order to perform an accurate hydraulic analysis, the stream profile, horizontal alignment, and cross sections should be obtained. Data to this detail usually are not available during the planning and location phases. The designer must therefore make preliminary analyses based on data such as aerial photographs, USGS maps, and old plans.

One method that can be useful in determining channel characteristics such as material in the stream beds and banks, type and coverage of vegetal material, and evidence of drift, debris, or ice, is the taking of photographs and videotapes. Field visits made early in the project life can include the photographing of the channel, upstream and downstream, and the adjoining floodplain. The photos can be valuable aids, especially when taken in color, for not only preliminary studies, but also for documentation of existing conditions.

During these early phases of project development, the designer should be involved in determining the detail of field survey required at the site. This should include the upstream and downstream limits of the survey, the number of or distance between cross sections, and how far to either side of the channel the sections should extend. The number of cross sections needed will vary with the study requirements and the particular stream characteristics. For some projects, the accuracy achieved by aerial photogrammetry will be sufficient for the level of hydraulic study needed, while other sites will require a different level of accuracy. The level of accuracy of survey required should be a consideration when determining the degree of hydraulic analysis needed. The U.S. Army Corps of Engineer Hydrologic Engineering Center has made a detailed study of survey requirements. The results of this study are available in "*Accuracy of Computer Water Surface Profiles*" by M. W. Burnham and D. W. Davis, Technical Paper No. 114, 1986.

5.4.6 Hydrologic Data

Information required by the designer for analysis and design include not only the physical characteristics of the land and channel, but all the features which can affect the magnitude and frequency of the flood flow which will pass the site under study. These data may include climatological characteristics, land runoff characteristics, stream gaging records, highwater marks, and the sizes and past performances of existing structures in the vicinity. The exact data required will depend upon the methods utilized to estimate flood discharges, frequencies, and stages. It should be noted that much of the hydrologic data will not be used during the planning and location phase. However, it is important to determine the need for the data now though, because it will take time to collect and evaluate such data. By starting this process during planning and location, delays during the design stage should be minimized.

5.4.7 Basin Characteristics

The hydrologic characteristics of the basin or watershed of the stream under study are needed for any predictive methods used to forecast flood flows. Although many of these characteristics can be found from office studies, some are better found by a field survey of the basin. The size and configuration of the watershed, the geometry of the stream network, storage volumes of ponds, lakes, reservoirs, and floodplains, and the general geology and soils of the basin can all be found from maps. Land use and vegetal cover may be determined from maps, but with rapidly changing land uses, a more accurate survey will probably be achieved from aerial photographs and field visits.

Having determined these basin characteristics, runoff times, infiltration values, storage values, and runoff coefficients can be found and used in calculating flood flow values.

5.4.8 Precipitation

A precipitation survey normally consists of the collection of rainfall records for the rainfall stations in the vicinity of the study site. Unlike the survey of stream flow records or basin characteristics however, rainfall records from outside the watershed, can be utilized. These records will hopefully contain several years of events, for every month, season, and will include duration values for various frequency rainstorms. Snowfall accumulations may also be available and are often helpful.

If rainfall records are lacking, the National Oceanic and Atmospheric Administration (Weather Bureau) has publications available which give general rainfall amounts for various duration storms which can be used. Weather Bureau Technical Paper 40, though now out of print, is useful for this information.

5.4.9 Flood Data

The collection of flood data is a basic survey task in performing any hydraulic analysis. These data can be collected both in the office and in the field. The office acquisition includes the collection of past flood records, stream gaging records, FEMA maps, and newspaper accounts. The field collection will consist mainly of interviews with residents, maintenance personnel, and local officials who may have recollections or photos of past flood events in the area.

If a stream gaging station is on the stream under study, close to the crossing site, and has many years of measurements, this may be the only hydrologic data needed in some cases. These data should be analyzed to ensure stream flows have not changed over the time of measurement due to the watershed alteration, such as the construction of a large storage facility, diversion of flow to another watershed or addition of flow from another watershed, or development that has significantly altered the runoff characteristics of the watershed.

5.4.10 Highwater Information

Sometimes highwater marks are the only data of past floods available. When collected, these data should include the date and elevation of the flood event when possible. The cause of the highwater mark should also be noted. Often the mark is caused by unusual debris or an ice jam rather than an inadequate structure and designing roadway or structure grades to such an elevation could lead to an unrealistic, uneconomical design.

Highwater marks can be identified in several ways. Small debris, such as grass or twigs caught in tree branches, hay or crops matted down, mud lines on buildings or bridges, are all highwater indicators. Beware however that grass, bushes, and tree branches bend over during flood flows and spring up after the flow has passed, which may give a false reading of the high water elevation. Ice will often cut or gouge into the bark of trees indicating highwater elevations.

5.4.11 Existing Structures

The size, location, type, and condition of existing drainage structures on the stream under study can be a valuable indicator when selecting the size and type for any new structure. Data to be obtained on existing structures includes such things as size, type, age, existing flow line elevation, and condition, particularly in regards to the channel. Scour holes, erosion around the abutments or just upstream or downstream, or abrupt changes in material gradation or type can all indicate a structure too small for the site. With a knowledge of flood history, the age and overall substructure condition may also aid in determining if the structure is too small.

If a structure is relatively new, information may still be available on the previous one, and why it had to be replaced. Although, normally, crossings are replaced due to poor structural conditions, sometimes other underlying conditions, often hydraulic in nature, also enter into the decision to build a new structure. Also, the durability of the existing structure may indicate how well the proposed structure will fare at this location. Old plans may also contain highwater or flood information which can be of use. When structures upstream or downstream of the site under study exist, they should always be inventoried for the factors just discussed. This includes highway and railroad structures, as well as any private crossings which might exist.

5.4.12 Environmental Data

In order to make a study of the water resources of the area, an environmental team should obtain those data commensurate with the needs to evaluate the highway impacts on the surface water. A coordination meeting with representatives of the various environmental disciplines concerned is often beneficial at this stage.

Data may need to be collected on such things as fish and wildlife, vegetation, and the quality of the water. A judgment may need to be made on aesthetic values.

5.4.13 Fish and Wildlife

There are many sources of information available from which information on fish and wildlife can be gathered. Biologists can provide much data on types of animals and fish, their spawning seasons, and critical areas. Maps may also be available showing this information. Local residents and field visits can yield information not found elsewhere.

5.4.14 Vegetation

The types and extent of vegetal cover can affect the rate of runoff and its quantity. It may also affect the quality of the water. There are three primary sources from which information on vegetation may be found.

- Maps - Geological maps show, in general terms, where the land is covered and where it is clear. Often, particularly during the preliminary stages of a study, this may be sufficient. Later on, more data may be needed such as the type of cover. Is it agricultural crop land or pasture, or evergreen forest?

- Aerial Photographs - An experienced person can distinguish the various types of vegetation from aerial photographs, and should photos in color or infrared be available, the categorizing of different types can be even easier. Aerial photos must be up-to-date, of good quality, and to scale to be of any real value however.

- Field Visit - It may not be possible to survey the entire watershed, so a sample area may have to be studied. It is important to set out the exact field needs before the trip is made to ensure all information needed is collected and all important areas visited. Please note that careful attention should be given to areas of the project area conditions that may have been altered after the field survey is performed and before design has commenced.

5.4.15 Water Quality

Water quality data can be the most expensive and most time consuming information to collect. Sometimes water quality records are available at or near the site under study but even then, the information most often required for highway studies may not have been gathered. Sample collection is expensive because of the equipment and laboratory facilities needed, and the time required.

Sample collection can be time consuming because one sample or several taken at the same time is not usually satisfactory. Water quality can reflect seasonal, monthly, or even daily variations depending on the weather, flow rate, traffic, etc. Therefore, a sampling program should be extended for a year, if at all possible.

Water quality data collection and analysis must be conducted by an experienced person trained in this area. This may be someone within VDOT who has been trained in this field or it may be necessary to retain an outside firm to perform this portion of the environmental analysis.

Existence of NPDES monitoring stations should be investigated.

5.4.16 Sinkholes*

Sinkholes are found in areas of karst terrain. Karst terrain is generally formed over limestone and dolomite formations. Karst terrains primarily occur within the Valley and Ridge Physiographic Province of western Virginia. Karst type terrains are also known to occur in very limited areas of the Blue Ridge, Piedmont and Coastal Plain Physiographic Provinces of Virginia. While information contained in these guidelines is directed more to those sinkholes located in the Valley and Ridge Physiographic Province, the same considerations should be applied to sinkholes located in other areas of the state.

* Rev. 7/16

Karst terrain is characterized by closed depressions (sinkholes), caves, and underground drainage resulting from the solutions of the calcium and/or magnesium carbonates. Sinkholes may develop either by solution of the surficial rocks or collapse of underlying caves. The actual rock cavity may or may not be choked by residual soil and debris. It is the potential instability of the sinkhole infilling, most often associated with changes in the local hydrology, which traditionally has been the concern of the construction industry. Those concerns have now broadened to include the potential impacts of construction on the area's hydrology and water quality. *

The presence of sinkholes should be noted on Form PM-100 (LD-430), Scoping Report and, if possible, the approximate location of observed sinkholes should be identified. The project survey shall provide an accurate and detailed location and description of all identifiable sinkholes located within the survey boundaries.

Both the EPA and VDOT have concerns with changes to the existing hydrology at sinkhole locations. These concerns include:

- Water Quality – Sinkholes are often direct links to underground sources of drinking water. Stormwater runoff from highways could potentially contain various constituents such as oil, grease, heavy metals and salt that could enter and impact these water supplies. The underground ecosystems could potentially be impacted by highway runoff containing sediment generated both during and following highway construction and material from potential spills resulting from traffic accidents once the highway is operational.

- Water Quantity – Directing additional stormwater flow to a sinkhole can result in the enlargement of the feature, create surface failures and erosion and cause flooding of adjacent property. Increasing the quantity of stormwater runoff flowing to a sinkhole can also cause the characteristics of the sinkhole opening to change in such a manner so as to restrict the flow into the subsurface, resulting in greater surface ponding in and around the area of the sinkhole.

- Instability – The area within and surrounding a sinkhole can settle or sink unexpectedly, resulting in loss of competent structural material and damage to overlying structures.

* Rev. 7/16

5.5 Preliminary Hydraulic Reports

5.5.1 Introduction

Preliminary hydraulic reports should be as complete as possible but must be tailored to satisfy the requirements of the specific location and size of project for which the study is required. Too much data and information is uneconomical and bulky to reduce to meaningful information. Coordination with all sections requiring survey data before the initial field work is begun will help ensure the acquisition of sufficient, but not excessive survey data.

5.5.2 Report

All data considered and used in reaching conclusions and recommendations made during the preliminary study should be included in a report. This should include hydrologic and hydraulic data, pertinent field information, photographs, calculations, and structure sizes and location. At this stage of the study, several structure sizes and types can usually be given as the designer only needs generalities in order to obtain a rough estimate of needs and costs. Often, specifics cannot be provided until an accurate topographic survey of the area has been made and precise hydraulic computations performed. Sometimes however, the report will require detailed design studies in order to justify the extent of mitigation required. In general, the more environmentally sensitive sites and those in highly urbanized areas will necessitate more detail at earlier stages. Useful Department documentation for reporting results include the Scoping Worksheet – Hydraulics, and the Scoping Worksheet - Environmental.

5.5.2.1 Sinkholes*

The following design considerations must be followed for any projects involving the construction of highways or drainage outfalls in areas where sinkholes are present:

- Avoidance – Determine if there are any feasible alternatives that would avoid construction in the area of the sinkhole. Where the sinkhole is the natural outfall for the stormwater runoff from the roadway area, determine if the stormwater runoff can be diverted away from the sinkhole to an adequate surface water channel. It should be recognized that drainage facilities to accommodate the diversion of stormwater runoff may require significant additional grading and right of way. In addition, stormwater quantity management facilities may be required at the point where the diverted flow is released from the project R/W in order to avoid the liabilities inherent with stormwater runoff diversion.

* Rev.7/16

- Minimization of Impacts from Direct Discharges – If avoidance is not possible, drainage outfalls from the roadway should include natural buffer zones between the outlet of the roadway drainage structure and the sinkhole in order to provide for a natural filtering process. Where stormwater runoff naturally terminates in sinkhole areas, vegetated flow areas (minimum 80' – 100' in length), runoff spreaders and vegetated swales should be used between the outlet of the roadway drainage structure and the bottom of the sinkhole in order to provide for filtering of the flow. If concentrated flow from the roadway pavement area is being directed into the bottom of the sinkhole, a stormwater management water quality basin or other type of water quality filtering device should be incorporated into the design. The water quality basin or filtering device should not be located in the bottom (throat) of the sinkhole (where the flow enters the ground) but rather should be located as close to the roadway or discharge point as practicable. Stormwater management basins constructed in these areas may require an impermeable lining in order to prevent impacts to the underlining soil and subsurface area. The District Materials Section should provide recommendations regarding this issue. A stormwater management basin may also be needed to provide attenuation of any increased flow quantity that may be directed toward the sinkhole.*

- If stormwater runoff from a roadway project must be directed to a sinkhole, the area of the sinkhole should be investigated to determine if any existing ponding occurs during rainfall events. The drainage design for the project should reflect how the sinkhole is anticipated to function after completion of the construction activities. The project should be designed to avoid any flood damages resulting from potential blockage and ponding in the sinkhole area.

If direct discharge of runoff into a sinkhole is the only feasible option available and improvements (modifications) such as cleaning, clearing, etc. are needed in the lowest section of the sinkhole (where water enters the ground), the details of such improvements (modifications) must be discussed with the District Environmental Section in order that they can determine what permits and/or reporting will be required. Typical sinkhole improvements (modifications) that would fit into this category are depicted in Detail 1 and Detail 2 on Standard Insertable Sheet No. isd/msd 2944. These "improved" sinkhole sites are be brought to the attention of the District Environmental Section early in project development process in order to allow adequate time for coordination with the EPA and other applicable regulatory agencies. The Environmental Division's Form EQ-120 (Appendix 5A-01) must be completed for those sites where it is determined necessary to "improve" a sinkhole and where it is determined such improvements would be regulated under the EPA's UIC Program. The Hydraulics

Engineer shall be responsible for completing Form EQ-120 and submitting it to the District Environmental Hazardous Materials Manager for further processing.

* Rev. 7/16

The Hydraulics Engineer should coordinate with the District Materials Section and the District Environmental Section if the project Scoping Report or survey data indicates the presence of sinkholes and if it is anticipated that those sinkholes might be impacted by stormwater runoff from the project.*

In areas of karst topography, roadside ditches with a gradient of less than 5% may need to be lined to inhibit the infiltration of surface waters. The District Materials Section should make this determination during the preliminary soils investigation phase of the project and, where applicable, include their recommendations for ditch lining with those other recommendations requested on Form LD-252 - Request for Supporting Data. Where ditch lining is recommended, the roadside ditches should be lined with concrete using Standard PG-2A or PG-5 (as applicable) or similar details. When using Standard PG-2A or PG-5 concrete ditches in these areas, the standard detail drawings will need to be modified to include the following:

- Add a 30-mil polyethylene film beneath all joints (to extend 4 feet longitudinally in each direction).

- Show the location of the curtain wall (normally placed adjacent to each expansion joint) 4' downgrade of the expansion joint (to coincide with the end of the 30-mil polyethylene film).

- In areas where these modifications apply, the plan description should note "St'd. PG-2A Modified" or "St'd. PG-5 Modified", as applicable. The details for these modifications are included on the Sinkhole Insertable Sheet.

Where the roadway traverses over or through a sinkhole area, the sinkhole should be treated in accordance with one of the typical details shown on Standard Insertable Sheet No. isd/msd 2944 unless otherwise directed by the District Materials Engineer:

- Detail No. 1 should be used for sinkholes that receive stormwater runoff from relatively large areas and have a well-defined opening (throat). This treatment involves cleaning out soil and debris to expose the throat, installing a length of pipe to convey surface drainage into the sinkhole and backfilling with riprap and successive layers of smaller aggregate and a geotextile fabric prior to the placement of the regular roadway embankment material.

* Rev. 7/16

- Detail No. 2 should be used for sinkholes with broad, flat depressions and which have no defined throat. These sinkholes typically receive stormwater runoff from relatively small areas. The width of the roadway embankment is generally less than the width of the depression. This treatment involves the placement of riprap in the bottom of the roadway embankment to allow for the continued infiltration of surface flows. The riprap is capped with successive layers of smaller aggregate and a geotextile fabric before placement of the regular roadway embankment material.*

- Detail No. 3 should be used for small shallow sinkholes that receive stormwater runoff from relatively small areas and where the roadway embankment will cover most or all of the depression. This treatment involves filling the depression with successive layers of smaller aggregate and a geotextile fabric before placement of the regular roadway embankment material. Since this treatment effectively "caps" the sinkhole and precludes the entry of surface water, a drainage ditch or other hydraulic conveyance is typically required along the edge of the roadway embankment to convey stormwater runoff to an adjacent outfall.

These Guidelines shall apply to roadways that are designed and constructed by others and which will ultimately be maintained by VDOT. In addition, where a sinkhole is being utilized as a drainage outfall, an acceptable legal agreement shall be executed that absolves VDOT of any liability and maintenance responsibilities associated with the sinkhole. The agreement should identify the County as the responsible party in the event that the developer or homeowners association cannot (or will not) assume the responsibility for liability or maintenance. A sample legal agreement can be found in Secondary Roads Division's publication "GUIDE FOR ADDITIONS, ABANDONMENTS, AND DISCONTINUANCES – SECONDARY SYSTEM OF STATE HIGHWAYS". The sample agreement shown in this publication is for stormwater management facilities but it can be modified slightly to cover the use of a sinkhole as a drainage outfall. The development of the agreement for the use of a sinkhole as an outfall should be coordinated with and approved by the Local Assistance Division in the Central Office.

* Rev. 7/16

5.6 References

American Association of State Highway and Transportation Officials. (2014). *AASHTO Drainage Manual (*First Edition). Washington, D.C.: American Association of State Highway and Transportation Officials.*

American Association of State Highway and Transportation Officials. (2007). *AASHTO Highway Drainage Guidelines (*Fourth Edition). Washington, D.C.: American Association of State Highway and Transportation Officials.

"Accuracy of Computer Water Surface Profiles", Technical Paper No. 114, M. W. Burnham and D. W. Davis. 1986

* Rev. 1/17

Appendix 5A-01

Form EQ-120
06/26/02

Page 1
No. of Attachments ____

VDOT INVENTORY OF CLASS V INJECTION WELLS FOR STORMWATER DISCHARGES TO IMPROVED SINKHOLES

1. DATE PREPARED *(Year, Month, Day)*: 2011/01/ yyyy/ mm/ dd

2. PREPARER
Name
Telephone

3. IMPROVED SINKHOLE LOCATION

District: BRISTOL | Project No:
Residency: | Route:
County:

4. TRANSACTION TYPE (Mark One)
☐ New Entry ☐ Entry Change ☐ Deletion

5. IMPROVED SINKHOLE INFORMATION

SINKHOLE # AND BRIEF DESCRIPTION (For Multiple Sinkhole Locations)	LOCATION	DEG	MIN	SEC	PROPERTY OWNER: VDOT	Easement	Other[1]	TREATMENT: 1	2	3	Other[2]
A.	Latitude				☐	☐	☐	☐	☐	☐	☐
	Longitude										
B.	Latitude				☐	☐	☐	☐	☐	☐	☐
	Longitude										
C.	Latitude				☐	☐	☐	☐	☐	☐	☐
	Longitude										
D.	Latitude				☐	☐	☐	☐	☐	☐	☐
	Longitude										
E.	Latitude				☐	☐	☐	☐	☐	☐	☐
	Longitude										

6. This form to be submitted to the VDOT REGIONAL HAZARDOUS MATERIALS CONTACT:

NAME: _____
TELEPHONE: _____

7. Notes:
[1] Identify other property owner, if applicable:

[2] Describe Treatment Options here and attach drawing:

Provide additional information and attachments (photos, plans, etc.), as needed.

Appendix 5B-01

DEPARTMENT OF TRANSPORTATION
LOCATION AND DESIGN
DRAINAGE INFORMATION SHEET

UPC: _____ Date: _____
Route #: _____
County: _____

Scheduled Advertisement Date:_____

Contract Administrator:_____

Project #: _____ Type of Facility:_____
Limits: Type of Financing:_____
From: _____ Project Length:_____
To: State Forces or Contract: _____

Description of work: _____

Geometrics:

	Existing	Proposed		Existing	Proposed
No. of Lanes:	_____	_____	Lane width:	_____	_____
Cut Shoulder Width:	_____	_____	Fill Shoulder Width:	_____	_____
Ditch Width:	_____	_____	R/W Width:	_____	_____
Fill Slopes:	_____	_____	Cut Slopes:	_____	_____
Surface Treatment:	_____	_____			

Total Estimated Disturbed Acreage:	_____

Are there existing Bridges or Live Streams?_____

Are there sections to be realigned?_____

Are there areas where the grade will be changed?_____

Are there utilities within project limits?_____

What is the overall condition of existing Drainage Structures?_____

Are there existing Erosion or Siltation Problems?_____

Is there a history of flooding problems?_____

Are Temporary detours required within project limits during Construction?_____

Appendix 5B-01

(Please provide the following information for Drainage structures with 36” or larger openings – Existing or Proposed.)

Location/Station:		
	Drainage Information	
	Existing	Proposed
Size/Diameter:		
Type:		
Length:		
Cover Height:		
Skew:		
Live Stream? (Yes/No)		
Flooding Problems? (Yes/No)		
Existing dwellings or buildings in the immediate vicinity? (Yes/No)		

Location/Station:		
	Drainage Information	
	Existing	Proposed
Size/Diameter:		
Type:		
Length:		
Cover Height:		
Skew:		
Live Stream? (Yes/No)		
Flooding Problems? (Yes/No)		
Existing dwellings or buildings in the immediate vicinity? (Yes/No)		

Location/Station:		
	Drainage Information	
	Existing	Proposed
Size/Diameter:		
Type:		
Length:		
Cover Height:		
Skew:		
Live Stream? (Yes/No)		
Flooding Problems? (Yes/No)		
Existing dwellings or buildings in the immediate vicinity? (Yes/No)		

Location/Station:		
	Drainage Information	
	Existing	Proposed
Size/Diameter:		
Type:		
Length:		
Cover Height:		
Skew:		
Live Stream? (Yes/No)		
Flooding Problems? (Yes/No)		
Existing dwellings or buildings in the immediate vicinity? (Yes/No)		

Additional Sheets may be added if necessary.