Storm Water Management Model

Southern Chesapeake 1
Watershed MDP

Master Drainage Plan

June 2008

US Army Corps
of Engineers
Norfolk District

Chesapeake
VIRGINIA
Department of Public Works

URS
URS Corporation

Table of Contents

Figures

Tables

Appendices

Storm Water Management Model

Southern Chesapeake 1 Watershed MDP

Chesapeake, VA

URS No. 11657076

June 2008

Executive Summary

Engineers from the U.S. Army Corps of Engineers (Corps), City of Chesapeake (City), and URS Corporation (URS) have completed a drainage study of the Southern Chesapeake 1 Watershed using the Storm Water Management Model (SWMM) computer program.

The analytical procedure is based on computing localized flood volumes resulting from design rainfall events such as the 2-, 5-, 10-, 25-, 50- and 100-year storms. The watershed is analyzed using modeling configurations to quantify flooding associated with both existing and future watershed conditions. Drainage improvement alternatives are carefully evaluated with respect to their potential impact to the entire watershed. The improvement alternatives are then given further consideration based on construction feasibility and financing constraints, with the focus on the entire watershed rather than on a few individual components. The advantage of this approach is that the entire drainage system can be evaluated on a consistent, system-wide basis.

The process of identifying candidate drainage improvement projects is based on trial-and-error modeling techniques. The watershed is analyzed using anticipated future land use and imperviousness, and locations and volumes of computed flooding are identified in the modeling.

After analyzing existing and potential problems in this watershed, the engineering team has identified four specific projects that can alleviate future flooding in the subject watershed. One of the four projects is not considered a Master Drainage Facility (MDF) because its contributing drainage area is less than 320 acres. Preliminary cost opinion computations, provided in a separate Cost Appendix, indicate that the three Master Drainage Facilities are financially feasible; however the costs to construct these improvements must be considered in the proper context—specifically the costs to develop stormwater management facilities near the Chesapeake Regional Airport will be quite substantial (because development would greatly increase stormwater runoff), but these costs would typically be paid by the site developers, not the City.

These improvement projects can be carried forward as Capital Improvements Projects with some assurance that the impacts on the watershed as a whole have already been adequately considered. Portions of some projects can be constructed as part of private development initiatives with little or no cost to the City. It is also important to keep in mind that some of these improvements may not be necessary, as wetlands regulations, flooding issues, soil properties, economic considerations, and Federal Aviation Administration (FAA) regulations may effectively limit development.

There are many combinations of drainage improvements that can be evaluated in any watershed. While a substantial effort has been applied to develop this study, it is by no means exhaustive. The intent of this undertaking was not only to develop sound alternatives for watershed improvements, but also to leave the underlying data files and computer models so that they can be used in a straightforward manner in the future.

The maximum computed water surface elevations at each modeled node and computed peak discharge at each modeled link are presented in Appendices C and D, respectively, for existing conditions and future conditions.

Portions of this watershed associated with roadway or development projects have been evaluated by the City over the past several years. Some studies have been completed to address specific problems as described elsewhere in this report. The modeling conducted as part of this Master Drainage Plan Update incorporates the previously prescribed improvements where possible, either directly or with modifications. In some cases, previously recommended improvements can be eliminated or reduced in scale, as detailed later in this report.

One of the goals of the agreement between the City and the Corps is to identify potential improvements to the Southern Chesapeake watershed that can incorporate features that provide valuable habitat restoration or creation opportunities while also providing ancillary flood damage reduction benefits. This study was authorized by Resolution of the Committee of Transportation and Infrastructure of the U.S. House of Representatives, Docket 2674, Dismal Swamp and Dismal Swamp Canal, Chesapeake, Virginia, adopted 22 May 2002, which states in part "…*to determine whether modifications to the existing project are advisable to address flooding problems, environmental restoration and protection, and related water resources needs in the vicinity of the Dismal Swamp Canal in Chesapeake, Virginia.*"

The City and the Corps would like to develop restoration and protection concepts that could be applied in this watershed to enhance environmental resources. Property ownership along the western boundary of the Southern Chesapeake 1 Watershed is favorable for environmental restoration opportunities. However due to FAA restrictions pertaining to the creation of wildlife habitat near airports, the creation of habitat or wildlife-attracting features is problematic. FAA separation areas are mapped in Figure 10. After much consideration during the course of this study, the Corps has indicated that it will pursue environmental restoration opportunities with the City in this watershed, but that the specific opportunities cannot be identified at this time due to FAA restrictions. The Corps will work with FAA in the future to determine what is possible to meet the requirements of Docket 2674. The challenge will be to construct wetlands and/or riparian habitat corridors without increasing hazards to aircraft.

FEMA flood insurance studies and rate maps are the definitive source of floodplain limits and elevations. The SWMM models developed for this drainage study are specific design scenarios based on 2-, 5-, 10-, 25-, 50-, and 100-year rainfall events—THEY ARE NOT TO BE CONSTRUED AS INDICATIVE OF EXPECTED WATER SURFACE ELEVATIONS FOR THE PURPOSES OF FLOODPLAIN MANAGEMENT AND/OR INSURANCE REQUIREMENTS. The SWMM models developed for this study could be adapted for use in the National Flood Insurance Program and submitted to FEMA for approval, but until they are subjected to that process the published flood insurance studies and rate maps remain fully in effect.

Background

URS was directed by the City and the Corps to conduct a study of the Southern Chesapeake 1 Watershed covering approximately 7,440 acres.

The Southern Chesapeake 1 Watershed is located just southwest of central Chesapeake. It is bordered on the west by the Great Dismal Swamp National Wildlife Refuge. The primary drainage outlet is the Twelve Foot Ditch. The Twelve Foot Ditch runs from West Road to the wetlands upstream of the Northwest River. The runoff discharges to the south of the watershed through the Twelve Foot Ditch which flows under Hall Bridge on Benefit Road before leaving the watershed.

The watershed was delineated into 97 subbasins in order to distribute point sources for inflow throughout the entire watershed. The Southern Chesapeake 1 Watershed consists mostly of rural property and contains several large, undeveloped tracts of land, with most of the northwest portion targeted for future land use modification. This study addresses existing drainage and storm water issues, as well as expected future conditions. The entire SWMM model has over 180 nodes and over 190 links.

Two drainage studies, Chesapeake Municipal Airport Master Drainage Plan and Hall Bridge Crossing Outfall Study, included the watershed's southern outfall. The following is a brief description of each of the two studies.

In January of 1989, Hassel & Folkes, P.C. conducted a study on the Chesapeake Municipal Airport. This study area included the Chesapeake Municipal Airport and property located north of the Airport which totaled 583 acres. The area drains into the Twelve Foot Ditch before being released into the Northwest River. Improvements were recommended to accommodate the development of the Airport. A proposed drainage basin located to the north of the landing strip was proposed to handle increased storm water runoff. Across Airport Drive, it was recommended to lay a 48-in pipe parallel to the existing 36-in pipe. The new pipe was to be plugged until improvements were made downstream. Channels located on the property are to be sized accordingly to provide adequate drainage as the Airport is developed. Also, a 54-in pipe was recommended to be placed under West Road near the entrance of the Airport. Beginning in 1997 FAA greatly tightened restrictions for separation areas, as explained elsewhere in this report.

The City of Chesapeake completed a study of the Hall Bridge Crossing Outfall (date unknown). This study consisted of the main channel, Twelve Foot Ditch. Deficiencies were found throughout the system and the recommendation was to increase the bottom width of Twelve Foot Ditch to a distance somewhere between 120 and 200 feet.

Since the completion of these studies, the only improvement implemented was the 54-in pipe under West Road near the entrance of the Airport.

In addition to the previous two studies, the City of Chesapeake provided URS with several plan sets for projects within the subject watershed, some of which have been approved for construction but have not yet been completed. As directed by the City, URS modeled these as 'existing' conditions. While some of these developments were not expected to be complete by the end of this study, they were considered existing conditions because the approval of the project assures its near-future development.

The City surveyed selected points in the subject watershed at the request of URS. These selected survey points are presented in Appendix B. The City also provided URS with GIS-related topographic data. URS utilized these four main sources—past studies, plan sets, survey data, and GIS data to extract channel and infrastructure information, such as inverts, pipe type and sizes, and channel characteristics, throughout the subject watershed.

Methodology

The engineering methodology applied in this study is summarized in a separate document, submitted by URS to the City of Chesapeake in April of 2005, entitled *Master Drainage Plan Methodology*. SWMM modeling is typically used for relatively large-scale studies. It is not generally intended to be used as a design tool for individual projects, due to its complexity and data requirements. Its strength lies in the application of very advanced hydrologic and hydraulic routing computational routines, fed with data from a geographic information system (GIS) and from plans for future roadway and parcel development projects.

This Master Drainage Plan Report presents the findings of the application of this methodology to the subject watershed.

Treatment of Nodal Flooding

The issue of how to handle nodal flooding is important when using or interpreting any rainfall-runoff model, including SWMM. Loosely speaking, nodal flooding occurs when a computed water surface elevation exceeds the maximum defined depth at a point in the system (referred to as a "node").

In previous versions of SWMM (Versions 4.x and earlier), the water leaving the node was treated as an "escape" from the system. However, the treatment of nodal flooding was enhanced in SWMM Version 5 by introducing "nodal ponding" and "nodal surcharge" capabilities. The new nodal ponding option allows the modeler to specify a constant "ponding area" over which nodal surcharges are stored as they escape from the node, then released back into the system as water surface elevations recede. This nodal ponding capability can produce more reliable water surface elevation computations due to the re-introduction of nodal flooding volumes and their continued downstream routing through the drainage system.

The option to compute nodal ponding in SWMM necessitates an approach to treat or develop the ponding area for each node, subject to two considerable limitations. First, the ponding area increases with depth, and in fact at some depth the ponded volume will actually combine with other nearby nodes such that deciding which node has what portion of the surface flooding becomes arbitrary at best. Secondly, it is not feasible to spend the time performing elaborate delineations at each node to compute a constant ponding area that is approximate at best, requires judgment regarding how much area to assign to which node, and ultimately varies with depth. In many locations, the situation is further complicated—when storm water flows up and out of the ground, it runs down a street or hill to some other location.

SWMM is a one-dimensional model—it can only compute flow depth, discharge and related properties along one-dimensional lines through the drainage network. It cannot compute lateral variations in the flow (such as can be accomplished with two-dimensional surface-flow models). Even if it were possible to precisely compute the ponding area at each node, we are still limited by the use of a one-dimensional model. The point is that above the ground elevation, it is difficult and sometimes impossible to determine a ponding area with accuracy. The problem is further complicated by the difficulty in determining the nominal "ground elevation" in a one-dimensional model.

URS has developed an approach to handle nodal flooding using SWMM Version 5, which we are using on many similar studies. The approach used is to divide the total watershed area by the number of modeling nodes to develop an average ponding area, which is then applied to all nodes that are not directly modeled as storage nodes. This approach is simple, but effective, and because the surface flooding is re-introduced into the drainage system as flood levels decrease, it gives a reliable basis upon which to compute water surface elevations in these models.

Vertical Datum

Unless specifically stated otherwise, the **North American Vertical Datum of 1988 (NAVD88)** was used throughout this study.

Modeling Configurations

Three modeling configurations—Existing Hydraulics with Existing Hydrology (Scenario 1), Existing Hydraulics with Future Hydrology (Scenario 2), and Future Hydraulics with Future Hydrology (Scenario 3)—were developed for this study as described below.

Scenario 1 Existing watershed hydrology with the drainage system configured as it existed in 2008. Channels are modeled using their existing (2008) conditions as well. This is the "Scenario 1" model. The City of Chesapeake requested certain plan sets be considered as 'existing' because they have been approved prior to the start of this study. The following is a list of plan sets and studies, provided by the City, that were used in the existing conditions model (the list includes completed past studies, projects that have been constructed, as well as approved projects not yet constructed):

1. Chesapeake Airport Authority Land Acquisition
2. Chesapeake Municipal Airport Access Road
3. Chesapeake Municipal Airport Industrial Park Phase I
4. Chesapeake Municipal Airport Master Drainage Plan
5. Chesapeake Municipal Airport Master Drainage Study
6. Foxwood North Section 1
7. Foxwood North Section 2
8. Lot 14 Curling Acres
9. Par E-1 Waller Farm
10. Shillelagh Farms Section 1
11. Shillelagh Farms Section 2
12. Shillelagh Farms Section 3
13. Sub Area: Twelve Foot Ditch (SC-1) AC# 1433WM

Scenario 2 Future watershed hydrology with the drainage system configured as it existed in 2008. Channels are modeled using their existing (2008) conditions as well. This is the "Scenario 2" model. This scenario will show the flooding effects of the existing drainage system due to future land use development. In other words, if no improvements are made to the current drainage system and the remainder of the watershed is constructed as described by the City's 2005 Adopted Land Use Plan, these are the locations and volumes of flooding that can be expected. It is important to note that just because an area is zoned for future development, does not guarantee that it will indeed be developed. Wetlands regulations, poor soils, bad parcel drainage potential, utility service costs, economics, ownership issues, and FAA restrictions can all reduce actual development potential.

Scenario 3 Future watershed hydrology with the future drainage system configured as envisioned by the City of Chesapeake and URS. This is the "Scenario 3" model. This scenario incorporates the drainage from Scenario 2 along with any recommendations from the engineering team to help eliminate flooding on a master drainage facility level (i.e. areas serviced by 320 acres or greater).

The recommended improvements should largely reduce flooding at key locations, where feasible, in the future conditions. These improvements were developed during this study, are highlighted in Figure 10, and specifically include the following projects:

1. SC-1 Drainage Improvements
2. West Road Drainage Improvements
3. Airport Outfall Improvements
4. Hunt Club Outfall Improvements

This scenario depicts future conditions with strategic drainage and storm water improvements in place. Additional details and descriptions regarding the improvements are presented elsewhere in this report. Cost opinions are presented in a separate Cost Appendix.

Modeling Results

The maximum computed water surface elevations at each modeled node and computed peak discharge at each modeled link are presented in Appendices C and D, respectively, for existing conditions and future conditions.

Stable SWMM runs were obtained for all modeling scenarios. Continuity errors ranged from low to very low. URS senior engineers used PCSWMM.NET to review dynamic hydraulic grade lines, checking the hydraulic routing for potential stability problems or any type of flow anomaly. During this QA/QC procedure items were found and addressed, so the final modeling results should be reliable.

Boundary conditions (water surface elevations) at the downstream outfall were set in accordance with Chapter 5, Section Q of the City of Chesapeake Public Facilities Manual (July 2001 Edition). In all cases, for all return periods, the hydraulic boundary condition was modeled as a constant water surface elevation of 0.93 feet (NAVD88) in the Northwest River. Due to the natural topography and wide floodplain environment, the water surface elevations in the upper portions of this watershed are not very sensitive to the downstream boundary water surface elevation used in these models.

The GIS analysis prepared in support of this modeling indicates that the Southern Chesapeake Watershed could increase from **5.34** to **17.71** percent imperviousness in the future, as indicated in Figures 3 and 4. The procedures used to determine this increase are explained in the *Master Drainage Plan Methodology* (April 2005) report submitted previously. This increase in impervious cover produces greater volumes of storm water runoff, which have been incorporated into the future conditions models.

Figures 8, 9, and 11 depict street and property flooding volumes for the 10- and 50-year design storm events. The histograms are not drawn to any scale, but they are proportional, and serve to graphically identify where flooding can be expected under each modeling configuration.

The City does not have to 'fix' all of the flooding represented by the histograms in the figures. Areas such as woodlands, deep ravines, large open spaces, ball fields and parks, and along railroad rights of way often do not require improvements unless there is a specific reason to construct them. It is also important to bear in mind that a 50-year design storm is an extreme event, and that neighborhood drainage systems are typically not required to accommodate 50-year storms.

Flooding complaints, particularly those in residential neighborhoods, often result from maintenance problems such as a clogged pipe or debris in a ditch. In considering whether or not drainage improvements might be required to correct an *existing* deficiency, the model results should indicate a flooding problem, and there should be some flooding history to support the need for improvements. If both of these conditions are not met, then the system maintenance should be reviewed or the computer models should be carefully checked.

Maintenance is a significant issue with respect to flooding in and along any major outfall channel. Fallen or overgrown trees are capable of catching debris during large storm events. These MDP models are based on realistic assumptions as to the conditions of the existing and proposed channels—good maintenance practices must be followed to keep the system functioning properly.

It is also important to understand when reviewing these results that there can be low-lying structures in the watershed that have finished floor elevations below the maximum water surface elevations computed in the SWMM models. In order to estimate whether or not a particular structure will be subject to flooding for a given storm condition, maximum hydraulic grade line elevations in the vicinity should be checked against the finished floor elevation.

As with all models of this size and complexity there is a great deal of detailed information required. Because it is not feasible to collect *all* of the required data, in some locations it is necessary to make educated guesses about inverts and pipe and channel dimensions and geometries. Where future designs and studies will be based on these models, engineers are strongly encouraged to field-verify all items that may critically impact their designs.

The maximum computed water surface elevations at each model node are presented in Appendix C for both existing and future condition scenarios. The blue shading in Tables C-1 and C-2 indicates locations where the maximum computed water surface meets or exceeds the ground elevation for that node. Many of these nodal flooding locations are very small quantity or short duration events. In these SWMM 5 models, the volume of water leaving the node during flooding is computed and summarized for continuity purposes (which allows for a reasonable accounting of flood volume at the node) *and the flooded water is re-introduced into the model for subsequent downstream routing*. If flooding occurs at a choke point in the system, downstream (or nearby) nodes may have computed maximum water surface elevations less than what can actually be expected due to the volume of water being 'held' upstream. With the introduction of Nodal Ponding in SWMM 5, this phenomenon is of less concern than it was in older versions of SWMM.

The ***figures*** that indicate nodal flood volumes in this report have been filtered so that nodal flood volumes less than 10,000 cubic feet are not represented (because less than 10,000 cubic feet of flooding cannot be practically discerned on the ground—it simply appears as heavy runoff or sheet flow in most cases). ***Tables*** C-1 and C-2 have not been filtered at all; where nodal flooding is indicated in many cases the duration and quantity of flooding can be very minor.

The PCSWMM.NET modeling platform contains a very helpful dynamic hydraulic grade line tool that allows the user to view animations of the computed water surface elevations. This dynamic hydraulic grade line tool takes input from a digital interface file at *a specified sampling interval*, for example every 3 minutes in these models. The SWMM routing computations are performed at one-second (or so) intervals, and the output file contains summary information based on *every* time step. If the dynamic hydraulic grade line tool is used to view the results the user should bear in mind that it is based on a sample (one out of every 180 seconds), and therefore the ‘peak’ values listed by the dynamic hydraulic grade line tool are peaks as sampled using a three-minute interval. The SWMM output data on the other hand contains a summary of the *exact* peak values. The SWMM output file summaries were used to prepare Tables C-1, C-2, D-1, and D-2, as well as the flooding figures in this report.

The modeling results presented in this report are based on the assumption that the drainage and storm water systems will be well maintained. If debris builds up to block drainage structures, or channels are allowed to fill with silt, flooding will likely be more severe than computed and represented in this report. Debris can be a significant problem in natural channel outfall systems, and should be monitored carefully to ensure that these systems function properly.

FEMA flood insurance studies and rate maps are the definitive source of floodplain limits and elevations in all cases. The SWMM models developed for this drainage study are specific design scenarios based on 2-, 5-, 10-, 25-, 50-, and 100-year rainfall events—THEY ARE NOT TO BE CONSTRUED AS INDICATIVE OF EXPECTED WATER SURFACE ELEVATIONS FOR THE PURPOSES OF FLOODPLAIN MANAGEMENT AND/OR INSURANCE REQUIREMENTS. The SWMM models developed for this study could be adapted for use in the National Flood Insurance Program and submitted to FEMA for approval, but until they are subjected to that process, the published flood insurance studies and rate maps remain fully in effect.

Master Drainage Plan Improvements

The City of Chesapeake utilizes a 320-acre threshold for candidate Master Drainage Facility (MDF) improvements. If a project services less than 320 acres, it will generally not be constructed as part of the City’s Master Drainage Plan.

Four specific projects were conceived and incorporated into the modeling during the course of this study, one of which will not be considered a MDF improvement due to its contributing area being less than 320 acres. These projects are by no means exhaustive, but they seem to provide a reasonable amount of flooding relief. All of the projects appear to be feasible from a preliminary planning standpoint, but issues such as future wetlands delineations and the ability to successfully acquire rights-of-way or parcels of land may necessitate some modifications as these projects move forward. The four projects are shown in Figure 10 and are included in the future modeling scenario. Refer to Figures 6, 7, and 10 of this report to find node and link numbers and to view the locations of improvements that are referenced in the following project summaries. In some cases, due to the tight proximity of nodes and links, it may be easier to view these links and nodes using the GIS files provided with this report. An enlarged 34” x 44” fold-out map is attached to the end of this report and includes all of the node numbers as well as the drainage improvement locations identified in Figure 10.

In Figure 11, there is flooding for a 10-year storm at Node 643 which is within Chesapeake Regional Airport. This is due to the potential of future development in the contributing subcatchments. Improvements were not considered because the contributing area is less than 320 acres, and it is highly unlikely that the area adjacent to the runway will be developed (it is all mapped as wetlands under the National Wetlands Inventory). If the site were to be developed, on-site Stormwater Management would be required, and should take care of any flooding potential (although any BMPs would be problematic with FAA). Finally, if this nodal volume was factored into the Scenario 3 model, it would make downstream improvements unnecessarily more costly as everything downstream from 643 would have to be enlarged to accommodate the flows).

The Chesapeake Regional Airport is located within the Southern Chesapeake 1 Watershed. Many land-use practices can contribute to an increase in wildlife-aircraft strikes such as detention ponds, retention ponds, or wetlands. Therefore, FAA has written Advisory Circular No. 150/5200-33B, "Hazardous Wildlife Attractants On or Near Airports," which was first published in 1997. Separation distances to be maintained between an airport and the wildlife attractant are recommended by the FAA. They are 5,000 feet for airports serving piston-powered aircraft, 10,000 feet for airports serving turbine-powered aircraft, and 5 statute miles to protect the airport's airspace. Guidelines are given by the FAA for the construction of new storm water management facilities within the recommended separation distances. Stormwater management systems should be designed so as not to create above-ground standing water to eliminate glide paths for waterfowl. For detention ponds, they should be designed for a 48-hour detention period after storms and stay completely dry between storms. Another guideline is using steep-sided, rip-rap lined, narrow, linearly shaped water detention basins to control hazardous wildlife. Physical barriers are recommended to reduce aircraft-wildlife interactions. Another guideline is removing all vegetation around detention basins because they can provide food and cover. These are just some of the recommendations to minimize wildlife-aircraft strikes. Advisory Circular No. 150/5200-33B can be found at the link, http://www.faa.gov/airports_airtraffic/airports/resources/advisory_circulars.

1. SC-1 Drainage Improvements

An estimate of the total for these recommended improvements is $ 17,696,387. However, based on the fact that this recommendation has been made prior to any future planning for this site and understanding that costs associated with future development will be borne by the developers, the cost to the city for this **project is estimated at approximately $ 2,232,081 in 2008 dollars** if constructed after the surrounding land improvements are in place. If constructed as part of adjacent development projects, the cost to the City could be reduced, possibly even to zero. The cost to construct these improvements must be considered in the proper context—specifically the costs to develop stormwater management facilities near the Chesapeake Regional Airport will be quite substantial (because development would greatly increase stormwater runoff), but these costs would typically be paid by the site developers—not the City. It is also important to keep in mind that some of these improvements may not be necessary, as wetlands regulations, flooding issues, soil properties, economic considerations, and Federal Aviation Administration (FAA) regulations may effectively limit development.

Future land use northwest of SC-1 watershed will be zoned mostly for light industry. The area's imperviousness could increase significantly (more than 80%) if these sites are developed. In that case, the existing drainage could not handle future runoff. The concept of these improvements is to re-route the majority of the area's runoff to new serpentine storage channels and to improve downstream channels so that water will be conveyed out of surrounding airport areas quickly due to FAA's ***Advisory Circular***. The exact layout can be determined in the future, but the shapes depicted should work for stormwater management purposes as long as the same storage volume is provided. Serpentine alignments are preferred to minimize glide paths for birds.

Recommended improvements to this area include:

1. Node 541: Construct a serpentine detention channel with bottom width of 100 ft., length of 3950 ft., and side slopes equal to 2H:1V. Set outfall invert to 9.5 ft.
2. Node 509: Create invert at 9.15 ft.
3. Node 511: Create invert at 7.7 ft.
4. Node 513: Create invert at 7.65 ft.
5. Node 519: Create invert at 6.8 ft.
6. Node 521: Create invert at 6.75 ft.
7. Node 523: Create invert at 6.25 ft.

8. Node 525: Create invert at 4.5 ft.
9. Node 587: Create invert at 5.5 ft.
10. Node 615: Lower ditch invert to 4.0 ft.
11. Node 623: Lower ditch invert to 3.0 ft.
12. Node 625: Lower ditch invert to 2.9 ft.
13. From Nodes 541 to 509: Install double 24-in. RCPs.
14. From Nodes 509 to 511: Construct a serpentine detention channel with bottom width of 100 ft., length of 5780 ft., and side slopes equal to 2H:1V.
15. From Nodes 511 to 513: Install double 48-in. RCPs.
16. From Nodes 513 to 519: Construct a serpentine detention channel with bottom width of 100 ft., length of 3360 ft., and side slopes equal to 2H:1V.
17. From Nodes 519 to 521: Install double 48-in. RCPs.
18. From Nodes 521 to 523: Construct a serpentine detention channel with bottom width of 100 ft., length of 1980 ft., and side slopes equal to 2H:1V.
19. From Nodes 523 to 525: Construct a serpentine detention channel with bottom width of 110 ft., length of 6620 ft., and side slopes equal to 2H:1V.
20. From Nodes 587 to 525: Construct a serpentine detention channel with bottom width of 110 ft., length of 1400 ft., and side slopes equal to 2H:1V.
21. From Nodes 525 to 615: Place 100 lf of double 36-in. RCP followed by 890 lf of trapezoidal channel with bottom width of 3 ft. and side slopes equal to 2H:1V.
22. From Nodes 615 to 623: Re-grade channel to new inverts.
23. From Nodes 623 to 625: Re-lay pipes to create positive slope.
24. Node 631: Lower invert to 2.7 ft.
25. Node 673: Lower invert to 2.05 ft.
26. Node 681: Lower invert to 1.4 ft.
27. Node 707: Lower invert to 1.05 ft.
28. Node 717: Lower invert to 0.2 ft.
29. Node 769: Lower invert to -0.2 ft.
30. Node 775: Lower invert to -0.8 ft.
31. Node 779: Lower invert to -1.05 ft.
32. Node 793: Lower invert to -1.2 ft.
33. Node 821: Lower invert to -1.36 ft.
34. Node 855: Lower invert to -2.42 ft.
35. Node 863: Lower invert to -2.87 ft.
36. From Nodes 625 to 631: Re-grade and widen channel bottom from 5 ft. to 25 ft. with side slopes equal 2H:1V.
37. From Nodes 631 to 673: Re-grade and widen channel bottom from 23 ft. to 25 ft. with side slopes equal to 2H:1V.
38. From Nodes 673 to 681: Re-grade and widen channel bottom from 23 ft. to 25 ft. with side slopes equal to 2H:1V.
39. From Nodes 681 to 707: Re-grade and widen channel bottom from 23 ft. to 25 ft. with side slopes equal to 2H:1V.
40. From Nodes 707 to 717: Re-grade and modify channel bottom from 35 ft. with side slopes equal to 1H:1V to 30 ft. with side slopes equal to 2H:1V.
41. From Nodes 717 to 769: Re-grade and modify channel bottom from 35 ft. with side slopes equal to 1H:1V to 30 ft. with side slopes equal to 2H:1V.
42. From Nodes 769 to 775: Re-grade and modify channel bottom from 34 ft. with side slopes equal to 1H:1V to 30 ft. with side slopes equal to 2H:1V.
43. From Nodes 775 to 779: Re-grade and widen channel bottom from 34 ft. to 35 ft. with side slopes equal to 2H:1V.

44. From Nodes 779 to 793: Re-grade and widen channel bottom from 34 ft. to 35 ft. with side slopes equal to 2H:1V.
45. From Nodes 793 to 821: Re-grade and widen channel bottom from 23 ft. to 35 ft. with side slopes equal to 2H:1V.
46. From Nodes 821 to 855: Re-grade channel's bottom to new inverts.
47. From Nodes 855 to 863: Re-grade channel's bottom to new inverts.
48. From Nodes 863 to 865: Re-grade channel's bottom to new inverts.

2. West Road Drainage Improvements

This project is not considered a master drainage facility project because the contributing drainage area is less than 320 acres. For this reason, a cost opinion is not provided. However, URS evaluated this improvement to support the City's continuing efforts to relieve excessive flooding and to determine whether implementing the project would cause flooding at downstream locations. The purpose of the improvements is to increase stormwater conveyance along West Road. Because most of the runoff on west side of West Road will be re-routed to the new channels (SC-1 Drainage Improvements), minor improvements are recommended for this area.

1. Remove or block pipe connecting nodes 527 and 561.
2. Remove or block pipe connecting nodes 575 and 577.
3. Node 589: Lower invert to 5.56 ft.
4. Node 591: Lower invert to 5.46 ft.
5. Node 599: Lower invert to 3.20 ft.
6. From Nodes 575 to 589: Re-grade channel to new inverts.
7. From Nodes 589 to 591: Re-lay existing pipe due to new inverts and add one 36-in. RCP parallel to existing 36-in. RCP.
8. From Nodes 591 to 599: Re-grade channel to new inverts.
9. From Nodes 589 to 591: Re-lay existing pipe due to new inverts and add one 36-in RCP parallel to existing 36-in RCP.

3. Airport Outfall Improvements

This project is estimated to cost approximately $ 424,232 in 2008 dollars if constructed after the surrounding land improvements are in place. If constructed as part of adjacent development projects, the cost to the City could be reduced.

The vicinity has a lower ground elevation that could flood significantly if future development takes place. The recommended improvements to this area are:

1. From Nodes 571 to 665: Lower channel inlet elevation from 8.8 ft. to 7.5 ft., re-grade and widen channel bottom from 6 ft. to 10 ft. with side slopes equal to 2H:1V.
2. From Nodes 665 to 667: Remove pipe and convert to trapezoidal channel with 10-ft. bottom width and 2H:1V side slopes.
3. From Nodes 667 to 581: Widen channel bottom from 6 ft. to 10 ft. with side slopes equal to 2H:1V.
4. From Nodes 581 to 629: Re-grade and widen channel bottom from 15 ft. to 20 ft. with side slopes equal to 2H:1V.
5. From Nodes 629 to 631: Re-lay existing double 48-in RCPs due to new downstream invert and add one 48-in. RCP parallel to existing double 48-in. RCPs.

4. Hunt Club Outfall Improvements

This project is estimated to cost approximately $ 674,484 in 2008 dollars if constructed after the surrounding land improvements are in place. If constructed as part of adjacent development projects, the cost to the City could be reduced.

Flooding in this area does not create an impact on any structures because it occurs at low lying (wetland) areas. However, due to the upstream contributing area being greater than 320 acres, this improvement is considered a Master Drainage Improvement. The recommended improvements to this area are:

1. Node 443: Lower invert to 4.6 ft.
2. Node 447: Lower invert to 3.4 ft.
3. Node 451: Lower invert to 2.3 ft.
4. From Nodes 441 to 443: Re-grade channel's bottom.
5. From Nodes 443 to 447: Re-grade and widen channel bottom from 9 ft. to 20 ft. with side slopes equal to 1.5H:1V.
6. From Nodes 447 to 451: Re-grade and widen channel bottom from 9 ft. to 20 ft. with side slopes equal to 1.5H:1V.
7. From Nodes 451 to 673: Remove existing 48-in. CMP. Install triple 48-in. RCPs.

Master Drainage Plan Caveat

The goal of this type of study is not to relieve *all* flooding, but rather to identify Master Drainage Facility improvements that can be feasibly constructed. It is also important to consider that neighborhood and commercial parcel drainage and storm water systems are neither required nor designed to accommodate flooding from extreme events such as the 50-year storm.

Environmental Restoration and Protection Opportunities

One of the goals of the agreement between the City and the Corps is to identify potential improvements to the Southern Chesapeake watershed that can incorporate features that provide valuable habitat restoration or creation opportunities while also providing ancillary flood damage reduction benefits. This study was authorized by Resolution of the Committee of Transportation and Infrastructure of the U.S. House of Representatives, Docket 2674, Dismal Swamp and Dismal Swamp Canal, Chesapeake, Virginia, adopted 22 May 2002, which states in part "*…to determine whether modifications to the existing project are advisable to address flooding problems, environmental restoration and protection, and related water resources needs in the vicinity of the Dismal Swamp Canal in Chesapeake, Virginia.*"

The City and the Corps would like to develop restoration and protection concepts that could be applied in this watershed to enhance environmental resources. Property ownership along the western boundary of the Southern Chesapeake 1 Watershed is favorable for environmental restoration opportunities. However due to FAA restrictions pertaining to the creation of wildlife habitat near airports, the creation of habitat or wildlife-attracting features is problematic. FAA separation areas are mapped in Figure 10. After much consideration during the course of this study, the Corps has indicated that it will pursue environmental restoration opportunities with the City in this watershed, but that the specific opportunities cannot be identified at this time due to FAA restrictions. The Corps will work with FAA in the future to determine what is possible to meet the requirements of Docket 2674. The challenge will be to construct wetlands and/or riparian habitat corridors without increasing hazards to aircraft.

Contact Information

Mr. Sam Sawan, PE (757.382.6101) served as the project manager for the City of Chesapeake on this project. Mr. Mark Mansfield, Chief Planning and Policy Branch, Mr. Walter Trinkala, Engineering Technical Specialist; and Mr. Greg Steele, Planning Technical Team Leader represented the Corps of Engineers, Norfolk District (757.201.7500). Mr. John Paine, PE, PH, CFM was the project manager for URS. The modeling evaluations and report were produced by Hai Tran, EIT and Jeremy Morazo, EIT. QA/QC and production assistance was provided by Stephanie Hood, EIT, Sean Bradberry, and Carol Wilkinson (757.873.0559).