

City-Wide Drainage Master Plan Final Submittal

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Submitted To:

City of Norfolk, Department of Public Works

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Executive Summary

The City of Norfolk recognizes three types of flooding – precipitation, tidal, and coastal. Though each type of flooding has a different origin – rain, tidal fluctuations, and storm surge, each has the potential to impact the stormwater conveyance system. As part of the planning stage of the City’s iterative four-pronged flooding strategy – plan, prepare, mitigate, communicate – the City of Norfolk is identifying and compiling areas in need of drainage improvements to reduce precipitation flooding, which occurs when rain intensity exceeds capacity due to undersized or blocked infrastructure or naturally depressed areas.

The City contracted with Timmons Group to develop a drainage master plan that identified areas throughout the City of Norfolk requiring improvements based on readily available complaint information and the extent, capacity, and condition of existing stormwater infrastructure. The City previously developed a Capital Improvement Program (CIP) Master Plan that identified 100 CIP drainage improvement projects. The City has continued to expand that list as new problem areas are located. Timmons Group’s analysis utilized Geographic Information System datasets, including one to represent the previous CIP Master Plan, to identify areas requiring improvements. Data was compiled including, but not limited to: institutional knowledge of flooding complaints and locations requiring regular intense maintenance as well as existing infrastructure capacity and condition information. Next, budgetary costs were developed and priority project areas identified for each planning district to optimize the use of City funds to reduce precipitation flooding.

The analysis was conducted at the drainage area level and then aggregated to the planning district level for presentation and cost estimating purposes. It was determined that approximately 150 road miles – 1/6 of the approximate 900 qualifying road miles in the City – likely require drainage and roadway improvements, resulting in a City-wide 2012 cost estimated at \$561.6M. The City would be responsible for 93.4% or \$524.8M and state, federal, and private entities would account for the remaining 6.6% of the cost.

However, other costs that commonly accrue in conjunction with utility improvement projects have not yet been considered. Additional cost elements for necessary water line relocation and optional streetscape elements were also added. The cost of these additional items ranges from \$126 to \$303 per linear foot.

Inclusion of these additional elements could increase the overall costs by up to 40%, bringing the total estimated 2012 cost to between \$694.7M and \$782.6M. For planning purposes, annual costs were developed assuming that the improvements are completed within several time frames – 25, 50, & 100 years – as follows: a minimum of \$39.5M, \$26.7M, and \$21.5M, respectively.

Improvements dictated by tidal conditions – such as pump stations or outfall improvements – do not fall under the scope of this study. Therefore, cost projections associated with these potentially necessary components have not been developed and should be investigated during appropriate drainage area master plan investigations.

As an added task, priority project areas and associated cost estimates were identified for each planning district based on score and the presence and extent of planned CIP projects, City-identified priority projects, and complaint areas. A total of 456 project areas were identified. However, the identified areas are not inclusive of all work that may be necessary in each planning district and therefore, the sum of all project costs is not equivalent to planning district cost projections.

The following table lists, in alphabetical order by planning district, Class I projects – those that fell in highly scored drainage areas and corresponded to a priority or CIP project location and are in an area where flooding complaints have been registered or recurring intense maintenance is necessary.

Table ES-1. Class I Project Areas

| Project or Drainage Area Name | Cost Estimate | Planning District Name (Number) |
|--|---------------|---------------------------------|
| HALIFAX LANE | \$1,216,000 | BERKLEY (90) |
| COLONIAL AV THAT TURNS INTO MAYFLOWER | \$354,000 | COLONIAL PLACE (53) |
| NEW JERSEY NEAR TIDE VALVE | \$91,000 | COLONIAL PLACE (53) |
| GRANBY STREET BETWEEN BAYVIEW BOULEVARD AND BAY AVENUE | \$1,210,000 | COMMODORE PARK (10) |
| | | NORTHSIDE (11) |
| | | PAMLICO (8) |
| HOUSTON AVENUE (EASTON PLACE) | \$229,000 | EASTON (80) |
| WALNUT HILL & SYLVAN | \$78,000 | EDGEWATER-LARCHMONT (37) |
| TIDEWATER DRIVE / GOFF STREET | \$1,673,000 | HUNTERSVILLE (66) |
| JANAF PLACE | \$288,000 | LAKE TERRACE (77) |
| HOLLYWOOD (O142) | \$3,308,000 | MAPLE HALL-HOLLYWOOD (78) |
| LAND STREET | \$406,000 | MAPLE HALL-HOLLYWOOD (78) |
| EAST WESTMONT AVENUE / STRATFORD STREET | \$67,000 | NORTHSIDE (11) |
| ADDERLEY ST NEIGHBORHOOD (N164300) | \$1,157,000 | RIVER FORREST (81) |
| CURLEW DRIVE | \$700,000 | RIVER FORREST (81) |
| HARGROVE STREET | \$283,000 | RIVER FORREST (81) |
| LEVINE COURT | \$246,000 | RIVER FORREST (81) |
| HEUTTE & MARTONE | \$141,000 | SOUTH CAMELLIA (20) |
| SUBURBAN PARKWAY | \$1,238,000 | SUBURBAN (33) |
| TIDEWATER DRIVE OUTFALL (F15530) | \$13,551,000 | TIDEWATER-YOUNG PARK (65) |

Purpose and Scope

The City contracted with Timmons Group to conduct an analysis that identified areas throughout the City of Norfolk requiring stormwater infrastructure improvements based on readily available complaint information and the extent, capacity, and condition of the existing infrastructure. Next, budgetary costs were developed and priority project areas identified for each planning district to optimize the use of City funds to reduce precipitation flooding.

The first step in this project was to identify drainage areas within the City, or the geographical areas where water from a rain event drains to a single point, usually an outfall to a river, lake, wetland, or bay. A total of 253 drainage areas in watersheds throughout the City were identified and analyzed in this study.

A scoring system was developed to quantitatively rank each area on technical merits. The portion of a planning district to be improved – ranging from 25% to 85% – increases with increasing score and will address, at a minimum, all previously identified problem areas.

The City of Norfolk is divided into Planning Districts (PDs), which are geographic areas which generally group neighborhoods or areas of similar land use. These districts are used by the City for zoning and long-range planning purposes. Therefore, it was deemed appropriate to provide drainage improvement costs at the PD level. Since drainage area boundaries do not correspond to PD boundaries, drainage area scores were aggregated at the PD level based on the contributing drainage areas within each Planning District.

To estimate the total cost of drainage improvement within the City of Norfolk as well as at a Planning District level, Timmons Group divided improvement projects into 2 categories for which unit costs were developed and applied. Costs were projected over several planning horizons and annual costs were developed.

As an added task, priority project areas and associated cost estimates were identified for each planning district based on score and the presence and extent of planned CIP projects, City-identified priority projects, and complaint areas. Six (6) classes or groups of project areas were developed in order to aid in prioritizing implementation. The goal of the class system is to recognize that certain project areas will address multiple issues, for example – citizen complaints and known deficiencies. Also, providing the results in groups as opposed to a straight rank allows the City to choose which projects to implement based on other factors not examined during this analysis – such as tidal conditions, coordination with other projects, ease of obtaining permits and/or easements, or the changing needs of the community.

Analysis

Drainage Areas

Using the existing City GIS, drainage areas were developed for analysis based on major outfall locations. Drainage areas of at least 20 acres or more and those that had been identified as complaint areas were included in the analysis; this resulted in 253 areas for analysis.

Analysis Data

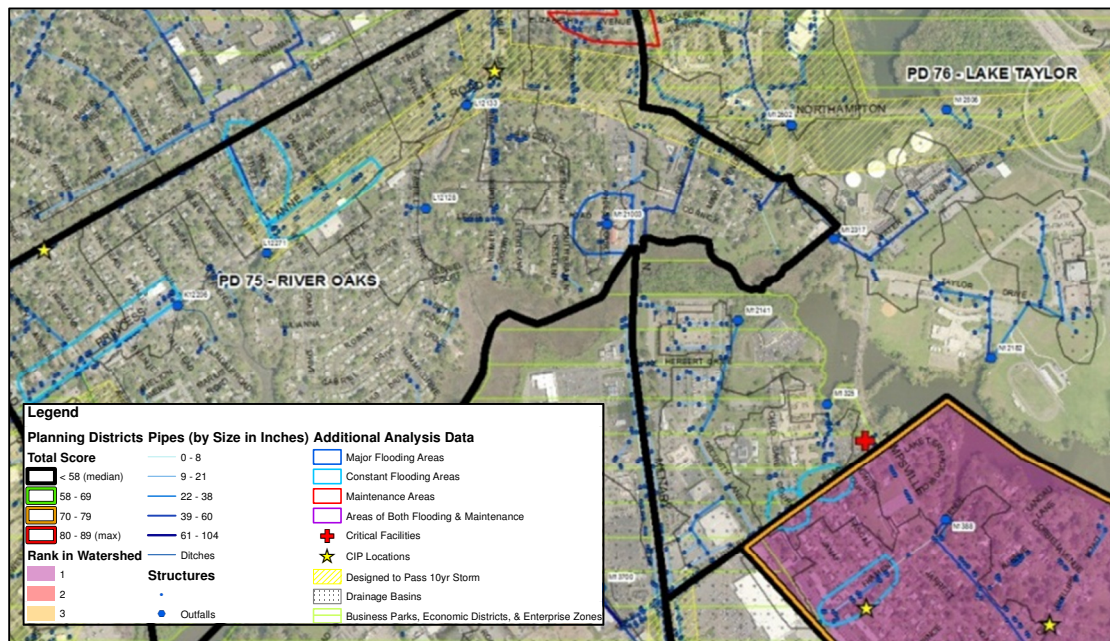
The existing stormwater system GIS was used to develop capacity and condition data for each drainage area. If data was missing, engineering judgment was used and assumptions made as follows for size and condition of pipes and ditches: 15" circular pipes; ditches have no bottom width, 3:1 side slopes, and 4' depth; and missing condition is fair. The values developed for ditches are typical of ditches in the City with known dimensions. For pipes, condition was chosen as fair as not to skew the analysis; pipe size was purposely chosen as small as to err on the conservative side.

Additional GIS data were created from data provided by the City and interviews with City engineering and maintenance staff, including: CIP project locations, complaint areas, and areas of the City designed to pass a 10yr storm.

Other City GIS datasets were used in the prioritization effort, including: street centerline data, VDOT road classification, city facility location data, critical infrastructure such as police and fire stations, enterprise zones, economic districts, and business and technology parks – used to identify business development focus areas. Hospital locations and other important information were supplemented to the critical infrastructure datasets.

The figure below is a snapshot of the data developed to perform the initial drainage area prioritization.

Figure 1. Sample Analysis Data



Prioritization Criteria

A scoring system was developed based on a total of eight (8) criteria in order to quantitatively rank each area on technical merits. Each drainage area was evaluated based on the following criteria, listed in order of relative importance:

1. Identified Complaint Areas (Flooding and/or Maintenance) Maximum Score – 30 points

City engineering and maintenance staff identified areas of systemic and/or chronic flooding. Other locations requiring extensive regular maintenance were also identified. A score was developed for each drainage area based on the severity of flooding or maintenance needs and location within the drainage area – upper or lower watershed. Highest scores were awarded to drainage areas having multiple complaint areas, especially in lower reaches of the drainage area.

2. Locations of Completed or Planned CIP Projects Maximum Score – 20 points

City stormwater engineering staff provided a list of completed and planned CIP projects throughout the City. Areas with planned CIP projects, especially those identified to address maintenance or upgrades and retrofits, receive a higher score.

3. Existing Infrastructure Capacity per Acre of Developed Area Maximum Score – 20 points

Based on the existing GIS pipe and ditch information, the capacity – size and extent of existing pipes and ditches to convey stormwater – was calculated for each system and then divided over the area of the developed portion of the drainage area in order to normalize the data. Based on the range of values across all drainage areas, scores were assigned such that areas with minimal capacity per area received a higher score.

4. Portion of the Drainage Area Designed to Pass a 10yr Storm Maximum Score – 15 points

City staff identified areas of the City where the drainage system was designed to pass a 10yr storm event – or 5.5 inches of rain in 24 hours – which is a design standard goal that provides a level of flooding protection only currently provided to highways and some major roads and recently developed areas in Norfolk. Areas other than those identified as well as identified areas that drain through areas not identified as designed to pass a 10yr storm receive a higher score.

5. Infrastructure Condition Maximum Score – 15 points

Based on existing GIS pipe information, the condition of the infrastructure for each basin was determined using either a condition rating (good, fair, poor) or the age of the pipe (where condition data is missing). Areas in poor condition or that are older receive a higher score.

Based on the five criteria listed above, the maximum score a drainage area can receive is 100 points. Detailed criteria definitions are provided as Appendix A. Drainage areas with higher scores based on the above criteria are likely to be in need of more extensive stormwater infrastructure improvements.

Several additional criteria were identified that address social and economic aspects of focusing drainage improvements. Only those drainage areas in the top 50% based on score – which indicates that they are in most need of improvement – were subjected to the following criteria which provide up to 40 additional points.

6. Road Classification Maximum Score – 15 points

VDOT road classifications were analyzed to address vehicular movement within and out of the City. A road category breakdown was used to identify drainage areas with major roads that if flooded, may impact provision of emergency services or evacuation. Drainage areas with a larger portion of higher classification roads receive a higher score.

7. Critical Infrastructure Maximum Score – 15 points

Drainage areas with critical infrastructure – fire and police stations and hospitals – were identified. Areas with these facilities, especially the lower portion of the watershed, receive a higher score.

8. Presence of Business Development Focus Areas Maximum Score – 10 points

The portion of each drainage area that coincides with an enterprise zone, economic district, or business and technology park area – that if easily flooded, may be more difficult to develop – was determined. Areas with a larger portion within these focus areas receive a higher score.

Initial Ranking

Tabulated drainage area scores ranged from 15 to 91 with an average and median score of 55. The results of the initial drainage basin ranking are included as Appendix B. Drainage areas are identified by major watershed and Outfall ID.

Once drainage area scores were tabulated, those values were used to develop an area-weighted composite score for each planning district. Appendix C presents the resulting planning district scores grouped by watershed in order of descending score. Planning districts have been identified by district number, name and associated major watershed. The exhibits accompanying the narrative depict the planning district composite scores, resulting severity rank within the watershed, and all associated analysis data.

Estimate of Improved Area

The planning districts were categorized by severity based on composite score. Based on an observed correlation between planning district composite score and the size of identified complaint areas and number of CIP project locations, the portion of each planning district requiring improvements was assumed to vary based on severity, or score, beginning with the worst areas as follows:

- Red, score 80 – 89 (maximum) 85% to be improved
- Orange, score 70 – 79 60%
- Green, score 58 – 69 40%
- Black – score less than 58 (median) 25%

Cost Basis

A cost basis was developed and used to determine master planning level cost projections for the identified high priority Planning Districts. The approach to predicting planning district costs was to first develop a total cost for two model projects of typical 1,000 linear feet drainage and road improvement, and then to apply those costs to portions of the lengths of roads within the various high priority areas identified.

Cost Model

Two categories of “typical” 1,000 linear feet projects were used to account for the fact that different levels of improvements will be needed for different road corridors. Some drainage deficiency areas can be addressed more simply by retrofitting a storm sewer system and curb drop inlets (capable of conveying a 10-year storm) into an existing road corridor without any significant road regrading. An example of this would be the Palmetto Street Drainage Improvement Project that will be constructed in summer of 2012 that includes installation of 770 linear ft of RCP storm sewer varying in size from 15” to 24” by 38” elliptical and associated structures and appurtenances. It also includes all ancillary utility adjustments, resulting roadway, driveway, and sidewalk replacement, and creation of a 1.25 ac-ft landscaped dry detention pond. For this analysis, we’ll refer to projects that fit into this category as Category One – Drainage Improvement Projects.

A second category of “typical” project was used to represent those project areas/corridors that could not as easily be improved by simply retrofitting a storm sewer system into the existing road infrastructure. These areas would require regrading of the road by either raising or lowering the elevation. This type of project would require some off-site drainage outfall improvements, adding storm drainage conveyance piping and curb drop inlets and other structures, in order to provide 10-year storm capacity. An example of this second category of project would be the Llewellyn Road and Drainage Improvement Project that the City of Norfolk hopes to move into design on in the near future. It is likely that road regrading will become more common in the future as sea level continues to rise and storm surges escalate. For this analysis, we’ll refer to these as Category Two A – Road and Drainage Improvement Projects.

Also included is a Category Two B – Road and Drainage Improvement projects. Category Two B is assumed to be identical in cost to Category Two A but applies specifically to retrofitting curb and gutter and drainage improvements into existing neighborhood roads that do not currently have curb and gutter nor storm sewer. These improvements will require removing the existing pavement and regrading the road to allow for curb and gutter, resulting in a similar scope of work and cost per linear foot as Category Two A.

For both project categories, we have taken past construction cost data from projects with comparable scopes of work and used those past projects to predict a complete, in-place project construction cost. We have added several categories of contingencies to these construction costs. The contingencies include: design (12%); environmental permitting (3%); land acquisition (3%); and an overall 25% project contingency. We did not add a contingency for utility adjustments since the actual construction costs used include all public utility adjustments. The cost prediction approach excluded costs associated with

wetland mitigation, internal City staff project management time, and private utility adjustments like power pole relocation as these costs can vary widely from project to project.

Appendix D shows the representative projects that were used to develop the total project cost for each of the two project categories referenced above as well as provides typical plan view and cross section for each project category. The data in the attached spreadsheet were extracted and used to predict a median cost per foot (rounded to the nearest \$100) for each of the two project categories. The total project cost Category One – Drainage Improvement Project was determined to be \$400 per linear foot. The total project cost for Category Two – Road and Drainage Improvement Project was determined to be \$900,000, or \$900 per linear foot.

The above costs include items required to improve the drainage system and roadway, as necessary. The costs do not include the expense for relocating the waterline and water service connections as part of these projects. Sanitary sewer upgrades and replacements were also not included in costs. Inclusion of this additional scope of work would increase the costs by \$126 and \$210 per linear foot for Category One and Category Two projects, respectively, based on the following assumptions:

- Category One – Drainage Improvement Project
 - 8" waterline at \$100/lf
 - 600 feet out of every 1,000 needing replacement
 - 12 service connections needing replacement at \$2500/each
- Category Two – Road and Drainage Improvement Project
 - 8" waterline at \$100/lf
 - 1,000 feet out of every 1,000 needing replacement
 - 20 service connections needing replacement at \$2500/each

These costs have been explicitly identified since they are not necessary to improve the storm sewer system. They will, however, be required to be performed as a part of each project in accordance with the above assumptions. In many cases, water mains were installed with less than or just the minimum allowable cover. Therefore, whenever the roadway needs to be lowered to allow for the installation of curb and gutter, the waterline must also be lowered to provide adequate cover. A waterline may still need to be relocated even if there is no road regrading as storm sewer installation tends to be at shallow depths and the existing water line may interfere.

Other costs – streetscape, for example – that are commonly included in conjunction with utility improvement projects have also been considered. The addition or replacement of sidewalk, yard grading, and tree planting, though not required, can be performed in conjunction with utility improvements at a cost savings as compared with performing these tasks separately. Inclusion of these additional elements could increase the overall costs by up to \$93 to \$129 per linear foot for Category Two and Category One projects, respectively.

Application to Roadways

The City GIS for roadways includes a VDOT road classification attribute. The ten (10) road classifications have been assigned to one of the two project categories as described in the preceding section as follows. Several road classifications, shown with asterisks, have not been included in the development of cost for various reasons as indicated in parentheses.

- Category One – Drainage Improvement Project
 - 5 – Collectors
 - 6 – Local Streets – Public
 - 7 – Local Streets – Private
 - 8 – Miscellaneous (Paper or Dirt Roads)*
 - 9 – Naval Base Roads
 - 10 – Public Alleys (No Utilities)*
- Category Two A – Road and Drainage Improvement Project
 - 1 – Interstate (Designed to Pass a 10yr Storm)*
 - 2 – Tunnel Roads & Other VDOT
 - 3 – Principal Arterials
 - 4 – Minor Arterials
- Category Two B – Road and Drainage Improvement Project
 - 5, 6, 7, or 9 without existing curb and gutter

The total length of each road classification within each planning district was determined in order to estimate costs using the cost basis described in the preceding section. A combination of existing City GIS curb data, aerial imagery, and available web street view information was used to determine whether a roadway fell into Category 1 or Category 2B. For Base roads – which make up the Federal operator category, it was assumed that half would need improvements consistent with Category 2B. VDOT roads make up the State operator category.

Based on past experience with drainage projects in each category, improvements would only be expected along a portion of the total road length. Therefore, it was assumed that 100% of the length of Category 2A roads and 33% of the length (1 in 3) of the Category 1 or Category 2B roads within an improved area would serve as the project length for cost purposes.

Planning District Cost Projections

The total projected cost for each planning district, as well as the cost for each road classification operator – Public (City), State (VDOT), Federal (Naval Base), or Private – has been estimated using the information presented in the preceding sections.

The resulting cost to make drainage improvements throughout the entire City is estimated at \$561,645,000 in 2012 dollars. The City would be responsible for 93.4% or \$524,797,400 and state, federal, and private entities would account for the remaining 6.4% of the cost as follows: State – \$7,790,400, Federal – \$21,619,700, and Private – \$7,437,500. Appendix E includes the cost breakdown for each planning district.

These costs include items required to improve the drainage system and roadway, as necessary, along 150 road miles, 1/6 of the approximate 900 qualifying road miles in the City.

They do not, however, include other costs that are commonly included in conjunction with utility improvement projects. Additional element costs for necessary water line relocation and optional streetscape elements were also considered. The cost of these additional items ranges from \$126 to \$303 per linear foot. Sketches showing typical roadway cross sections for each Category can be found in Appendix D. City streets were assigned to a category based on existing road classification and curb information. Inclusion of these additional elements could increase the overall costs by up to 40%, bringing the total estimated 2012 cost to between \$694.7M and \$782.6M.

The following table provides the projected improvement cost and improved roadway length for each planning district resulting from the score and land area of each.

Table 1. Planning District Cost Summary

| <i>Line</i> | Planning District Name (Number) | Score | Improved Roadway Length (mi) | Land Area (ac) | Cost Projection Range |
|-------------|--|--------------|-------------------------------------|-----------------------|------------------------------|
| 1 | AZALEA (22) | 45 | 1.46 | 475 | \$6,132,000 - \$6,999,000 |
| 2 | BALLENTINE PARK (50) | 44 | 1.13 | 278 | \$5,068,000 - \$5,715,000 |
| 3 | BEL-AIRE (17) | 60 | 1.33 | 352 | \$4,718,000 - \$5,559,000 |
| 4 | BERKLEY (90) | 66 | 3.01 | 650 | \$13,372,000 - \$15,114,000 |
| 5 | BRAMBLETON (69) | 64 | 3.48 | 540 | \$14,799,000 - \$16,849,000 |
| 6 | CAMPOSTELLA (89) | 49 | 1.00 | 304 | \$4,199,000 - \$4,792,000 |
| 7 | CAMPOSTELLA HEIGHTS (88) | 39 | 0.48 | 396 | \$2,005,000 - \$2,290,000 |
| 8 | CAPE VIEW (5) | 55 | 0.49 | 126 | \$2,154,000 - \$2,442,000 |
| 9 | CHESAPEAKE MANOR (40) | 37 | 0.69 | 198 | \$2,611,000 - \$3,036,000 |
| 10 | CHESTERFIELD (72) | 51 | 0.56 | 252 | \$2,015,000 - \$2,367,000 |
| 11 | COLEMAN PLACE (49) | 61 | 2.11 | 242 | \$9,748,000 - \$10,946,000 |
| 12 | COLONIAL PLACE (53) | 73 | 3.94 | 322 | \$15,440,000 - \$17,846,000 |
| 13 | COMMODORE PARK (10) | 67 | 0.89 | 151 | \$3,726,000 - \$4,259,000 |
| 14 | CORONADO (42) | 35 | 0.76 | 179 | \$2,881,000 - \$3,355,000 |
| 15 | CROMWELL ROAD INDUSTRIAL (74) | 52 | 0.72 | 218 | \$3,291,000 - \$3,704,000 |
| 16 | CROWN POINT (86) | 34 | 0.74 | 397 | \$3,729,000 - \$4,130,000 |
| 17 | DENBY PARK (38) | 62 | 1.19 | 180 | \$5,118,000 - \$5,816,000 |

| Line | Planning District Name (Number) | Score | Improved Roadway Length (mi) | Land Area (ac) | Cost Projection Range | |
|-------------|--|--------------|-------------------------------------|-----------------------|------------------------------|-----------------------------|
| 18 | DOWNTOWN | (59) | 49 | 2.89 | 362 | \$37,972,000 - \$39,539,000 |
| 19 | EAST 21st STREET / MONTICELLO | (58) | 69 | 2.74 | 267 | \$12,886,000 - \$14,431,000 |
| 20 | EAST GHENT | (63) | 77 | 1.76 | 132 | \$6,950,000 - \$8,025,000 |
| 21 | EAST NORVIEW | (44) | 53 | 0.29 | 129 | \$1,234,000 - \$1,408,000 |
| 22 | EASTON | (80) | 70 | 0.99 | 246 | \$4,751,000 - \$5,306,000 |
| 23 | EDGEWATER - LARCHMONT | (37) | 51 | 2.60 | 609 | \$10,347,000 - \$11,922,000 |
| 24 | ESTABROOK | (47) | 51 | 1.88 | 381 | \$8,103,000 - \$9,205,000 |
| 25 | FOXHALL | (48) | 52 | 1.29 | 355 | \$5,946,000 - \$6,678,000 |
| 26 | GHENT | (64) | 59 | 2.23 | 185 | \$9,683,000 - \$10,986,000 |
| 27 | GLENROCK | (85) | 68 | 0.67 | 166 | \$3,429,000 - \$3,788,000 |
| 28 | GLENWOOD PARK | (28) | 83 | 1.57 | 176 | \$6,819,000 - \$7,741,000 |
| 29 | HUNTERSVILLE | (66) | 81 | 5.46 | 332 | \$24,504,000 - \$27,650,000 |
| 30 | INDUSTRIAL PARK | (73) | 42 | 0.86 | 631 | \$4,611,000 - \$5,064,000 |
| 31 | INGLESIDE | (83) | 44 | 1.16 | 491 | \$4,252,000 - \$4,979,000 |
| 32 | JANAF - MILITARY CIRCLE | (87) | 52 | 0.79 | 322 | \$3,457,000 - \$3,915,000 |
| 33 | KEMPSVILLE | (79) | 62 | 3.48 | 459 | \$18,018,000 - \$19,875,000 |
| 34 | LAKE TAYLOR | (76) | 36 | 0.83 | 686 | \$4,239,000 - \$4,686,000 |
| 35 | LAKE TERRACE | (77) | 78 | 1.76 | 221 | \$8,411,000 - \$9,394,000 |
| 36 | LAKEWOOD | (35) | 73 | 1.97 | 332 | \$9,389,000 - \$10,489,000 |
| 37 | LAMBERTS POINT / ODU | (55) | 38 | 1.25 | 372 | \$4,237,000 - \$5,039,000 |
| 38 | LAMBERTS POINT INDUSTRIAL | (56) | 65 | 0.64 | 653 | \$2,134,000 - \$2,552,000 |
| 39 | LARRYMORE | (21) | 35 | 1.07 | 519 | \$3,860,000 - \$4,534,000 |
| 40 | LAYFAYETTE | (51) | 58 | 2.62 | 699 | \$11,271,000 - \$12,808,000 |
| 41 | LIBERTY - ROBERTS PARK | (70) | 42 | 0.90 | 402 | \$3,911,000 - \$4,437,000 |
| 42 | LINDENWOOD | (67) | 58 | 1.36 | 270 | \$4,820,000 - \$5,682,000 |
| 43 | MAPLE HALL - HOLLYWOOD | (78) | 73 | 1.44 | 219 | \$4,794,000 - \$5,724,000 |
| 44 | MEDICAL CENTER | (60) | 67 | 2.52 | 197 | \$13,041,000 - \$14,385,000 |
| 45 | MERRIMAC PARK | (9) | 40 | 0.29 | 78 | \$1,066,000 - \$1,249,000 |
| 46 | NAVAL BASE | (26) | 37 | 6.09 | 4418 | \$26,929,000 - \$30,461,000 |
| 47 | NAVAL BASE ROAD | (39) | 71 | 0.74 | 78 | \$3,742,000 - \$4,142,000 |
| 48 | NORFOLK INTERNATIONAL AIRPORT | (23) | 40 | 0.68 | 1034 | \$3,823,000 - \$4,164,000 |
| 49 | NORTH CAMELLIA | (19) | 64 | 1.41 | 259 | \$5,199,000 - \$6,081,000 |
| 50 | NORTH CHESAPEAKE BLVD. | (15) | 44 | 1.61 | 623 | \$5,170,000 - \$6,219,000 |
| 51 | NORTH COLLEY | (54) | 75 | 1.52 | 133 | \$6,332,000 - \$7,234,000 |
| 52 | NORTH GHENT | (62) | 75 | 2.23 | 128 | \$9,653,000 - \$10,957,000 |
| 53 | NORTH SHORE | (30) | 72 | 4.33 | 472 | \$19,416,000 - \$21,909,000 |
| 54 | NORTHSIDE | (11) | 68 | 1.89 | 260 | \$9,143,000 - \$10,192,000 |
| 55 | NORVELLA | (46) | 55 | 0.50 | 220 | \$1,954,000 - \$2,261,000 |
| 56 | NORVIEW | (45) | 52 | 2.82 | 713 | \$12,342,000 - \$13,985,000 |
| 57 | OAKDALE FARMS | (16) | 55 | 1.19 | 491 | \$5,042,000 - \$5,744,000 |
| 58 | OCEANAIR | (12) | 51 | 1.08 | 359 | \$4,001,000 - \$4,677,000 |
| 59 | OCEANVIEW | (4) | 47 | 0.68 | 172 | \$3,024,000 - \$3,418,000 |
| 60 | PAMLICO | (8) | 87 | 3.78 | 247 | \$14,987,000 - \$17,284,000 |
| 61 | PARK PLACE | (52) | 75 | 5.84 | 472 | \$25,308,000 - \$28,722,000 |
| 62 | PINEWELL | (3) | 65 | 1.32 | 218 | \$6,270,000 - \$7,011,000 |
| 63 | POPLAR HALLS | (84) | 46 | 0.86 | 456 | \$2,813,000 - \$3,375,000 |

| Line | Planning District Name (Number) | Score | Improved Roadway Length (mi) | Land Area (ac) | Cost Projection Range | |
|---------------|---------------------------------|-------|------------------------------|----------------|--------------------------------------|-----------------------------|
| 64 | PRETTY LAKE | (6) | 55 | 0.68 | 228 | \$3,470,000 - \$3,835,000 |
| 65 | RIVER FORREST | (81) | 59 | 1.87 | 606 | \$7,160,000 - \$8,313,000 |
| 66 | RIVER OAKS | (75) | 57 | 1.35 | 437 | \$6,315,000 - \$7,078,000 |
| 67 | ROLAND PARK | (34) | 29 | 0.64 | 232 | \$2,595,000 - \$2,983,000 |
| 68 | ROOSEVELT GARDENS | (18) | 62 | 1.47 | 376 | \$4,490,000 - \$5,470,000 |
| 69 | ROSEMONT | (41) | 39 | 1.29 | 378 | \$5,138,000 - \$5,920,000 |
| 70 | SEWELLS GARDENS | (43) | 51 | 1.12 | 415 | \$4,178,000 - \$4,878,000 |
| 71 | SEWELLS POINT | (27) | 44 | 0.93 | 774 | \$4,399,000 - \$4,921,000 |
| 72 | SHORE DRIVE | (7) | 54 | 0.93 | 449 | \$4,134,000 - \$4,669,000 |
| 73 | SNUG HARBOR | (14) | 62 | 1.82 | 354 | \$6,543,000 - \$7,691,000 |
| 74 | SOUTH CAMELLIA | (20) | 53 | 1.72 | 471 | \$7,992,000 - \$8,966,000 |
| 75 | SOUTHERN SHOPPING CENTER | (24) | 60 | 1.57 | 160 | \$17,302,000 - \$18,180,000 |
| 76 | SUBURBAN | (33) | 64 | 1.72 | 428 | \$6,340,000 - \$7,411,000 |
| 77 | SUSSEX | (32) | 54 | 1.19 | 356 | \$4,500,000 - \$5,237,000 |
| 78 | TALBOT PARK | (36) | 57 | 1.20 | 535 | \$4,523,000 - \$5,263,000 |
| 79 | TIDEWATER - YOUNG PARK | (65) | 78 | 2.60 | 243 | \$26,073,000 - \$27,519,000 |
| 80 | TIDEWATER DRIVE INDUSTRIAL | (68) | 74 | 2.67 | 246 | \$11,689,000 - \$13,247,000 |
| 81 | TITUSTOWN | (31) | 38 | 0.42 | 109 | \$1,393,000 - \$1,661,000 |
| 82 | WARDS CORNER | (25) | 54 | 0.46 | 114 | \$1,920,000 - \$2,194,000 |
| 83 | WEST 21st STREET | (57) | 76 | 3.18 | 195 | \$15,240,000 - \$17,012,000 |
| 84 | WEST GHENT | (61) | 76 | 2.65 | 179 | \$10,525,000 - \$12,134,000 |
| 85 | WEST OCEAN VIEW | (2) | 79 | 4.67 | 281 | \$23,130,000 - \$25,683,000 |
| 86 | WILLOUGHBY | (1) | 77 | 1.95 | 302 | \$7,943,000 - \$9,117,000 |
| 87 | WILLOW TERRACE | (13) | 65 | 2.05 | 326 | \$7,436,000 - \$8,724,000 |
| TOTALS | | | 150 | 34100 | \$694,717,000 - \$782,652,000 | |

The watershed pamphlet pages included as Appendix G provide a synopsis of the analysis and 2012 costs at the major watershed level. Improvements dictated by tidal conditions – such as pump stations or outfall improvements – do not fall under the scope of this study. Therefore, cost projections associated with these potentially necessary components have not been developed and should be investigated during appropriate drainage area master plan investigations.

For planning purposes, cost estimates have been projected out over several timeframes – 25 years, 50 years, and 100 years – using Construction Cost Index inflation trends available from Engineering News-Record as shown in the following table.

Table 2. Cost Projections and Funding Options over Several Planning Horizons

| Planning Horizon | Cost Projection Range |
|---------------------------------|------------------------------------|
| Present (2012) Cost | \$694,715,000 - \$782,649,000 |
| 25 Years | |
| <i>Future Value (in 25 yrs)</i> | \$1,424,167,000 - \$1,604,430,000 |
| Annual Cost over 25 yrs | \$39,526,000 - \$44,529,000 |
| 50 Years | |
| <i>Future Value (in 50 yrs)</i> | \$2,919,541,000 - \$3,289,082,000 |
| Annual Cost over 50 yrs | \$26,579,000 - \$29,944,000 |

| Planning Horizon | Cost Projection Range | |
|----------------------------------|-----------------------|---------------------|
| 100 Years | | |
| <i>Future Value (in 100 yrs)</i> | \$12,269,373,000 | \$13,822,368,000 |
| Annual Cost over 100 yrs | \$21,495,000 | \$24,216,000 |

Priority Drainage Areas and Projects

As an added task, priority project areas and associated 2012 cost estimates were identified for each planning district based on score and the presence and extent of planned CIP projects, City-identified priority projects, and complaint areas. A total of 445 project areas were identified. A complete list is included as Appendix F. This is not a comprehensive list of all work that may be necessary in each planning district and therefore, the sum of all project costs is not equivalent to planning district cost projections.

Six (6) classes or groups of project areas were developed in order to aid in prioritizing implementation. The goal of the class system is to recognize that certain project areas will address multiple issues, for example – citizen complaints and known deficiencies. Also, providing the results in groups as opposed to a straight rank allows the City to choose which projects to implement based on other factors not examined during this analysis – such as tidal conditions, coordination with other projects, ease of obtaining permits and/or easements, or the changing needs of the community. The classes are defined as follows:

1. Project areas that fell in highly scored (>70) drainage areas and corresponded to a priority or CIP project location AND are in areas where flooding complaints or recurring intense maintenance is necessary.
2. Project areas that fell in highly scored drainage areas and corresponded to a priority or CIP project location OR are in areas where flooding complaints or recurring intense maintenance is necessary.
3. Project areas in drainage areas with lower scores that corresponded to a priority project location.
4. Project areas in drainage areas with lower scores that corresponded to a CIP project location AND are in areas where flooding complaints or recurring intense maintenance is necessary.
5. Project areas in drainage areas with lower scores that corresponded to a CIP project location OR are in areas where flooding complaints or recurring intense maintenance is necessary.
6. The remaining portions of highly scored (>70) drainage areas. These areas received high scores due to lack of capacity and/or poor infrastructure condition.

Cost estimates were also developed for the classified project areas. For several priority projects, recent construction cost estimates were used. Many of the CIP project locations already had an associated cost estimate. Since the CIP Master Plan was developed about 10 years ago, R.S. Means Construction Cost Index factors were used to account for inflation.

There were quite a few project areas remaining for which costs were developed. Using the bottom of the Planning District (PD) cost projection range discussed in the preceding section, costs were disaggregated to the drainage areas within each PD. Project area costs were then assigned based on the portion of a drainage area it encompasses. Values at the bottom of the cost projection range were used since it is recognized that this analysis has not identified all future stormwater infrastructure improvement needs. For example, any improvements dictated by tidal conditions do not fall under the scope of this study.

The following table lists, in alphabetical order by PD, the top project(s) for each Planning District.

Table 3. Priority Project Areas for each Planning District

| <i>Line</i> | <i>Project or Drainage Area Name</i> | <i>Cost Estimate</i> | <i>Planning District Name (Number)</i> | <i>Class</i> |
|-------------|---|----------------------|--|--------------|
| 1 | AZALEA GARDEN RD - TALLYHO TER - HOLLYBRIAR POINT | \$264,000 | AZALEA (22) | 2 |
| 2 | LESLIE AV - GAMAGE DR - BUDD DR | \$72,000 | AZALEA (22) | 2 |
| 3 | BRADLEY AV - BUDD DR | \$50,000 | AZALEA (22) | 2 |
| 4 | CAPE HENRY AV BETWEEN BALLENTINE AND MCKANN | \$400,000 | BALLENTINE PARK (50) | 3 |
| 5 | MEADOW CREEK | \$652,000 | BEL-AIRE (17) | 5 |
| 6 | DITCHES BETWEEN BUFFALO & MEADOW CREEK | \$433,000 | BEL-AIRE (17) | 5 |
| 7 | HALIFAX LANE | \$1,216,000 | BERKLEY (90) | 1 |
| 8 | MALTBY AV - GOFF ST* | \$422,000 | BRAMBLETON (69) | 2 |
| 9 | LEAD ST - JAMAICA AV - CARY AV | \$232,000 | BRAMBLETON (69) | 2 |
| 10 | 1300 BLOCK OF CONOGA ST DRAINAGE IMPROVEMENTS | \$725,000 | CAMPOSTELLA (89) | 3 |
| 11 | ARLINGTON - MONTCLAIR AV | \$50,000 | CAMPOSTELLA HEIGHTS (88) | 2 |
| 12 | EAST OCEAN VIEW MASTER PLAN & IMPROVEMENTS** | \$360,000 | CAPE VIEW (5) | 3 |
| 13 | TIFTON STREET | \$351,000 | CHESAPEAKE MANOR (40) | 5 |
| 14 | 3425 WESTMINSTER AV (BRANSCOME) | \$246,000 | CHESTERFIELD (72) | 5 |
| 15 | WESTMINSTER AV AT BRANSCOME | \$50,000 | CHESTERFIELD (72) | 5 |
| 16 | SEWELLS POINT AND AZALEA GARDEN RD* | \$2,247,000 | COLEMAN PLACE (49) | 3 |
| 17 | DENVER ST - AZALEA GARDEN WATERSHED | \$906,000 | COLEMAN PLACE (49) | 3 |
| 18 | JUNIPER ST - AZALEA GARDEN WATERSHED | \$600,000 | COLEMAN PLACE (49) | 3 |
| 19 | 2500 BLOCK OF PALMETTO ST DRAINAGE IMPROVEMENTS† | \$400,000 | COLEMAN PLACE (49) | 3 |
| 20 | ASPIN ST - NORCOVA AVE WATERSHED | \$79,000 | COLEMAN PLACE (49) | 3 |
| 21 | COLONIAL AV THAT TURNS INTO MAYFLOWER | \$354,000 | COLONIAL PLACE (53) | 1 |
| 22 | NEW JERSEY NEAR TIDE VALVE | \$91,000 | COLONIAL PLACE (53) | 1 |
| 23 | GRANBY STREET BETWEEN BAYVIEW BOULEVARD AND BAY AVENUE* | \$403,000 | COMMODORE PARK (10) | 1 |
| 24 | PARTRIDGE STREET / PHILPOTTS ROAD | \$209,000 | CORONADO (42) | 5 |

| Line | Project or Drainage Area Name | Cost Estimate | Planning District Name (Number) | Class |
|-------------|---|----------------------|--|--------------|
| 25 | PETERSON DITCH IMPROVEMENTS*† | \$150,000 | CROMWELL ROAD INDUSTRIAL (74) | 3 |
| 26 | RABY RD / LANCE RD / HARMONY RD DITCHES | \$170,000 | CROWN POINT (86) | 5 |
| 27 | MACDONALD RD - PENNINGTON RD* | \$3,481,000 | DENBY PARK (38) | 5 |
| 28 | MONTICELLO SYSTEM TO THE HAGUE | \$23,406,000 | DOWNTOWN (59) | 2 |
| 29 | VIRGINIA BEACH BLVD SOUTH OF HOPE VI | \$3,492,000 | DOWNTOWN (59) | 2 |
| 30 | BRAMBLETON AVENUE | \$228,000 | DOWNTOWN (59) | 2 |
| 31 | 13TH - 11TH - GRANBY ST - ARMISTEAD AV* | \$166,000 | EAST 21st STREET-MONTICELLO (58) | 2 |
| 32 | GHENT | \$1,626,000 | EAST GHENT (63) | 2 |
| 33 | LLEWELLYN AV - BOUSH ST - W VIRGINIA BEACH BLVD | \$324,000 | EAST GHENT (63) | 2 |
| 34 | MELLWOOD COURT | \$60,000 | EAST NORVIEW (44) | 4 |
| 35 | HOUSTON AVENUE (EASTON PLACE) | \$229,000 | EASTON (80) | 1 |
| 36 | WALNUT HILL & SYLVAN | \$78,000 | EDGEWATER-LARCHMONT (37) | 1 |
| 37 | CHESAPEAKE BLVD - AMHERST ST | \$50,000 | ESTABROOK (47) | 2 |
| 38 | CHESAPEAKE BLVD - HENRICO ST | \$50,000 | ESTABROOK (47) | 2 |
| 39 | SEWELLS POINT AND AZALEA GARDEN RD* | \$1,082,000 | FOXHALL (48) | 3 |
| 40 | MANTEO STREET | \$154,000 | GHENT (64) | 2 |
| 41 | W ONLEY RD - STOCKLEY GARDENS - W PRINCESS ANNE RD | \$65,000 | GHENT (64) | 2 |
| 42 | POPLAR HALL DR - CHAMBERS ST - LUCAS AV** | \$835,000 | GLENROCK (85) | 2 |
| 43 | HONAKER AV | \$50,000 | GLENROCK (85) | 2 |
| 44 | ROGERS - GLEN MYRTLE - EVERGREEN AV | \$4,394,000 | GLENWOOD PARK (28) | 2 |
| 45 | ROGERS AVENUE | \$314,000 | GLENWOOD PARK (28) | 2 |
| 46 | TIDEWATER DRIVE / GOFF STREET | \$1,673,000 | HUNTERSVILLE (66) | 1 |
| 47 | SEWELLS POINT AND AZALEA GARDEN RD* | \$832,000 | INDUSTRIAL PARK (73) | 3 |
| 48 | BROOKSIDE COURT AND VILLAGE AVE OUTFALL* | \$279,000 | INDUSTRIAL PARK (73) | 3 |
| 49 | SOUTH END OF VILLAGE AVENUE | \$254,000 | INDUSTRIAL PARK (73) | 3 |
| 50 | NORTH END OF VILLAGE AVENUE* | \$238,000 | INDUSTRIAL PARK (73) | 3 |
| 51 | EASTON AVENUE | \$500,000 | INGLESIDE (83) | 5 |
| 52 | INGLESIDE | \$269,000 | INGLESIDE (83) | 5 |
| 53 | MANGROVE AV | \$100,000 | INGLESIDE (83) | 5 |
| 54 | STAPLETON & WESTMINSTER AVENUE | \$100,000 | INGLESIDE (83) | 5 |
| 55 | GLEN ROCK | \$604,000 | JANAF-MILITARY CIRCLE (87) | 2 |
| 56 | VA BEACH BLVD UPGRADE (POPLAR HALL DR TO NEWTOWN RD) | \$123,000 | JANAF-MILITARY CIRCLE (87) | 2 |
| 57 | POPLAR HALL DR - CHAMBERS ST - LUCAS AV** | \$15,000 | JANAF-MILITARY CIRCLE (87) | 2 |
| 58 | CLARENCE ST - HUDSON AV - REEL ST - ADAIR AV | \$373,000 | KEMPSVILLE (79) | 2 |
| 59 | DITCH (EAST OF KEMPSVILLE ROAD) | \$246,000 | KEMPSVILLE (79) | 2 |
| 60 | E VIRGINIA BEACH BLVD - KEMPSVILLE RD** | \$21,000 | KEMPSVILLE (79) | 2 |
| 61 | ELIZABETH AV - MILITARY HWY* | \$38,000 | LAKE TAYLOR (76) | 2 |
| 62 | LOWERY RD - CHILD CARE CT - JANAF PL* | \$28,000 | LAKE TAYLOR (76) | 2 |
| 63 | LOWERY RD - PASCAL PL* | \$27,000 | LAKE TAYLOR (76) | 2 |
| 64 | JANAF PLACE | \$288,000 | LAKE TERRACE (77) | 1 |

| Line | Project or Drainage Area Name | Cost Estimate | Planning District Name (Number) | Class |
|-------------|--|----------------------|--|--------------|
| 65 | TARRALL - BOYCE - TIDEWATER - CROMWELL DR | \$436,000 | LAKEWOOD (35) | 2 |
| 66 | NONE | \$0 | LAMBERTS POINT-ODU (55) | |
| 67 | ARMISTEAD BRIDGE RD - GATES AV | \$50,000 | LAMBERTS POINT INDUSTRIAL (56) | 5 |
| 68 | LISA DRIVE | \$116,000 | LARRYMORE (21) | 5 |
| 69 | HARMON STREET / GIFFORD STREET | \$95,000 | LARRYMORE (21) | 5 |
| 70 | HOLLAND AV - HUNTINGTON CRESCENT | \$58,000 | LAYFAYETTE (51) | 2 |
| 71 | SAINT DENIS - POPE - BAPAUME AV - TIDEWATER DR | \$50,000 | LAYFAYETTE (51) | 2 |
| 72 | ROBERTS ROAD DRAINAGE IMPROVEMENTS* | \$275,000 | LIBERTY-ROBERTS PARK (70) | 3 |
| 73 | THISTLE ST - LEAD ST - SAINT JULIAN AV** | \$37,000 | LINDENWOOD (67) | 2 |
| 74 | HOLLYWOOD | \$3,308,000 | MAPLE HALL-HOLLYWOOD (78) | 1 |
| 75 | LAND STREET | \$406,000 | MAPLE HALL-HOLLYWOOD (78) | 1 |
| 76 | OUTFALL ID D14860 (COLLEY AV) | \$3,681,000 | MEDICAL CENTER (60) | 6 |
| 77 | OUTFALL ID G041** (NORTH OF BAY AV BETWEEN I-64 & GRANBY ST) | \$184,000 | MERRIMAC PARK (9) | 6 |
| 78 | WILLOUGHBY | \$3,616,000 | NAVAL BASE (26) | 5 |
| 79 | HAMPTON BOULEVARD | \$234,000 | NAVAL BASE (26) | 5 |
| 80 | ABC DEAD ENDS | \$100,000 | NAVAL BASE (26) | 5 |
| 81 | NORVA PARK - E KENMORE DR - SUBURBAN PKWY** | \$2,012,000 | NAVAL BASE ROAD (39) | 5 |
| 82 | NONE | \$0 | NORFOLK INTERNATIONAL AIRPORT (23) | |
| 83 | DOMINION AVENUE | \$862,000 | NORTH CAMELLIA (19) | 2 |
| 84 | CAMELLIA ROAD | \$59,000 | NORTH CAMELLIA (19) | 2 |
| 85 | BRENTWOOD DITCH | \$1,150,000 | NORTH CHESAPEAKE BLVD. (15) | 5 |
| 86 | CHESAPEAKE BOULEVARD | \$166,000 | NORTH CHESAPEAKE BLVD. (15) | 5 |
| 87 | KILLAM AVENUE / WEST 51ST STREET | \$96,000 | NORTH COLLEY (54) | 2 |
| 88 | NONE | \$0 | NORTH GHENT (62) | |
| 89 | NORTH SHORE ROAD / MAURY ARCH | \$678,000 | NORTH SHORE (30) | 2 |
| 90 | NORTH SHORE RD - HAMPTON BLVD | \$617,000 | NORTH SHORE (30) | 2 |
| 91 | BAYLOR - HAMPTON BLVD | \$401,000 | NORTH SHORE (30) | 2 |
| 92 | RUNNYMEDE ROAD / HAMPTON BOULEVARD | \$265,000 | NORTH SHORE (30) | 2 |
| 93 | MAURY ARCH | \$175,000 | NORTH SHORE (30) | 2 |
| 94 | GRANBY STREET BETWEEN BAYVIEW BOULEVARD AND BAY AVENUE* | \$403,000 | NORTHSIDE (11) | 1 |
| 95 | EAST WESTMONT AVENUE / STRATFORD STREET | \$67,000 | NORTHSIDE (11) | 1 |
| 96 | LYNN ST - CROFT ST - N MILITARY HWY | \$50,000 | NORVELLA (46) | 2 |
| 97 | BEAMON RD AT AZALEA GARDEN | \$533,000 | NORVIEW (45) | 4 |
| 98 | BURKSDALE RD - DIXIE DR - DIGGS RD | \$553,000 | OAKDALE FARMS (16) | 2 |
| 99 | WEST GLEN - E LITTLE CREEK - KEENE RD | \$50,000 | OAKDALE FARMS (16) | 2 |
| 100 | TIDEWATER DRIVE / OLD OCEANVIEW ROAD | \$160,000 | OCEANAIR (12) | 2 |
| 101 | HULL VIEW AV - E BALVIEW AV - CHESAPEAKE ST** | \$1,244,000 | OCEANVIEW (4) | 5 |
| 102 | GRANBY STREET BETWEEN BAYVIEW BOULEVARD AND BAY AVENUE* | \$403,000 | PAMLICO (8) | 1 |
| 103 | COLONIAL AV NORTH OF RR | \$3,827,000 | PARK PLACE (52) | 2 |

| Line | Project or Drainage Area Name | Cost Estimate | Planning District Name (Number) | Class |
|-------------|---|----------------------|--|--------------|
| 104 | LLEWELLYN | \$1,705,000 | PARK PLACE (52) | 2 |
| 105 | LLEWELLYN AV* | \$44,000 | PARK PLACE (52) | 2 |
| 106 | HAMPTON BLVD - BOWDENS FERRY RD** | \$23,000 | PARK PLACE (52) | 2 |
| 107 | LENOX AVENUE | \$345,000 | PINEWELL (3) | 2 |
| 108 | LENOX - NORFOLK AV | \$50,000 | PINEWELL (3) | 2 |
| 109 | BERRY HILL RD - BARNHOLLOW RD - BROOKVILLE RD | \$50,000 | POPLAR HALLS (84) | 2 |
| 110 | POPLAR HALL DR - BEACON HILL CIRCLE | \$50,000 | POPLAR HALLS (84) | 2 |
| 111 | EAST OCEAN VIEW MASTER PLAN & IMPROVEMENTS** | \$360,000 | PRETTY LAKE (6) | 3 |
| 112 | ADDERLEY ST NEIGHBORHOOD | \$1,157,000 | RIVER FORREST (81) | 1 |
| 113 | CURLEW DRIVE | \$700,000 | RIVER FORREST (81) | 1 |
| 114 | HARGROVE STREET | \$283,000 | RIVER FORREST (81) | 1 |
| 115 | LEVINE COURT | \$246,000 | RIVER FORREST (81) | 1 |
| 116 | ELIZABETH AV - MILITARY HWY* | \$151,000 | RIVER OAKS (75) | 2 |
| 117 | LEWIS RD - ANDES CT | \$104,000 | RIVER OAKS (75) | 2 |
| 118 | E PRINCESS ANNE RD - RIVER OAKS DR | \$50,000 | RIVER OAKS (75) | 2 |
| 119 | NONE | \$0 | ROLAND PARK (34) | |
| 120 | EAST OCEAN VIEW MASTER PLAN & IMPROVEMENTS** | \$360,000 | ROOSEVELT GARDENS (18) | 3 |
| 121 | AVENUE J & MERRITT ST* | \$1,116,000 | ROSEMONT (41) | 4 |
| 122 | ELON CT - KNOX RD | \$50,000 | SEWELLS GARDENS (43) | 2 |
| 123 | BAKER STREET | \$434,000 | SEWELLS POINT (27) | 5 |
| 124 | REDMON ROAD | \$277,000 | SHORE DRIVE (7) | 2 |
| 125 | MODOC AVENUE | \$751,000 | SNUG HARBOR (14) | 2 |
| 126 | EDGEWOOD | \$613,000 | SNUG HARBOR (14) | 2 |
| 127 | HEUTTE & MARTONE | \$141,000 | SOUTH CAMELLIA (20) | 1 |
| 128 | AVENUE J & MERRITT ST* | \$996,000 | SOUTHERN SHOPPING CENTER (24) | 4 |
| 129 | SUBURBAN PARKWAY | \$1,238,000 | SUBURBAN (33) | 1 |
| 130 | RESTMERE RD - W LITTLE CREEK RD | \$144,000 | SUSSEX (32) | 2 |
| 131 | AFTON AV - SEVERN RD - GRANBY ST | \$454,000 | TALBOT PARK (36) | 2 |
| 132 | RUFFNER BOX CULVERT | \$4,687,000 | TIDEWATER DRIVE INDUSTRIAL (68) | 2 |
| 133 | MALTBY AV - GOFF ST* | \$1,051,000 | TIDEWATER DRIVE INDUSTRIAL (68) | 2 |
| 134 | MAY AV - SPRING ST - E ONLEY RD | \$435,000 | TIDEWATER DRIVE INDUSTRIAL (68) | 2 |
| 135 | E CHARLOTTE ST - TIDEWATER DR - E CITY HALL AV* | \$100,000 | TIDEWATER DRIVE INDUSTRIAL (68) | 2 |
| 136 | THISTLE ST - LEAD ST - SAINT JULIAN AV** | \$13,000 | TIDEWATER DRIVE INDUSTRIAL (68) | 2 |
| 137 | TIDEWATER DRIVE OUTFALL | \$13,551,000 | TIDEWATER-YOUNG PARK (65) | 1 |
| 138 | MEADS ROAD | \$86,000 | TITUSTOWN (31) | 5 |
| 139 | PARKDALE DITCH** | \$50,000 | WARDS CORNER (25) | 3 |
| 140 | HAMPTON BLVD - BOWDENS FERRY RD** | \$29,000 | WEST 21st STREET (57) | 2 |
| 141 | GATES AVENUE DITCH | \$253,000 | WEST GHENT (61) | 4 |
| 142 | WEST OCEAN AV - PORTVIEW - 1ST VIEW ST | \$1,038,000 | WEST OCEAN VIEW (2) | 2 |
| 143 | 10TH VIEW ST - LITTLE BAY AV | \$95,000 | WILLOUGHBY (1) | 2 |

| <i>Line</i> | <i>Project or Drainage Area Name</i> | <i>Cost Estimate</i> | <i>Planning District Name (Number)</i> | <i>Class</i> |
|-------------|--|----------------------|--|--------------|
| 144 | LEA VIEW AV - 15TH VIEW ST | \$50,000 | WILLOUGHBY (1) | 2 |
| 145 | ALFRED LANE | \$3,616,000 | WILLOW TERRACE (13) | 2 |
| 146 | CHESAPEAKE BLVD - VIRGILINA AV - BEACH VIEW ST | \$890,000 | WILLOW TERRACE (13) | 2 |
| 147 | E BAYVIEW BLVD - FISHERMAN RD - STURGIS RD | \$234,000 | WILLOW TERRACE (13) | 2 |
| 148 | TAYLORS LANE | \$172,000 | WILLOW TERRACE (13) | 2 |

* Priority project area crosses planning district boundaries.

** Priority project area crosses PD and watershed group boundaries.

† Construction pending

Conclusions

The City of Norfolk has developed a four-pronged flooding strategy – plan, prepare, mitigate, communicate. As part of the planning stage, the City of Norfolk is identifying and compiling areas in need of drainage improvements to reduce precipitation flooding, which occurs when rain intensity exceeds capacity due to undersized or blocked infrastructure or naturally depressed areas.

The City contracted with Timmons Group to develop a drainage master plan that identified areas throughout the City of Norfolk requiring improvements based on readily available complaint information and the extent, capacity, and condition of existing stormwater infrastructure. Timmons Group’s analysis utilized Geographic Information System datasets, including one to represent the previous CIP Master Plan, to identify areas requiring improvements. Data was compiled including, but not limited to: institutional knowledge of flooding complaints and locations requiring regular intense maintenance as well as existing infrastructure capacity and condition information. Next, budgetary costs were developed and priority project areas identified for each planning district to optimize the use of City funds to reduce precipitation flooding.

The first step in this project was to identify drainage areas within the City, or the geographical areas where water from a rain event drains to a single point, usually an outfall to a river, lake, wetland, or bay. A total of 253 drainage areas in watersheds throughout the City were identified and analyzed in this study.

A scoring system was developed to quantitatively rank each area on technical merits. The portion of a planning district to be improved – ranging from 25% to 85% – increases with increasing score and will address, at a minimum, all previously identified problem areas.

The City of Norfolk is divided into Planning Districts (PDs), which are geographic areas which generally group neighborhoods or areas of similar land use. These districts are used by the City for zoning and long-range planning purposes. Therefore, it was deemed appropriate to provide drainage improvement costs at the PD level. Since drainage area boundaries do not correspond to PD boundaries, drainage area scores were aggregated at the PD level based on the contributing drainage areas within each Planning District.

To estimate the total cost of drainage improvement within the City of Norfolk as well as at a Planning District level, Timmons Group divided improvement projects into 2 categories for which unit costs were developed and applied. Costs were projected over several planning horizons and annual costs were developed. It was determined that approximately 150 road miles – 1/6 of the approximate 900 qualifying road miles in the City – likely require drainage and roadway improvements, resulting in a City-wide 2012 cost estimated at between \$694.7M and \$782.6M including additional cost elements for necessary water line relocation and optional streetscape elements.

For planning purposes, annual costs were developed assuming that the improvements are completed within several time frames – 25, 50, & 100 years – as follows: a minimum of \$39.5M, \$26.7M, and \$21.5M, respectively.

Improvements dictated by tidal conditions – such as pump stations or outfall improvements – do not fall under the scope of this study. Therefore, cost projections associated with these potentially necessary components have not been developed and should be investigated during appropriate drainage area master plan investigations.

As an added task, priority project areas and associated cost estimates were identified for each planning district based on score and the presence and extent of planned CIP projects, City-identified priority projects, and complaint areas. Six (6) classes or groups of project areas were developed in order to aid in prioritizing implementation. The goal of the class system is to recognize that certain project areas will address multiple issues, for example – citizen complaints and known deficiencies. Also, providing the results in groups as opposed to a straight rank allows the City to choose which projects to implement based on other factors not examined during this analysis – such as tidal conditions, coordination with other projects, ease of obtaining permits and/or easements, or the changing needs of the community. A total of 445 project areas were identified. A complete list is included as Appendix F. This is not a comprehensive list of all work that may be necessary in each planning district and therefore, the sum of all project costs is not equivalent to planning district cost projections.