4 Watershed Restoration Strategies

4.1 Subwatershed Strategies

The watershed restoration process follows the assessment of subwatershed conditions summarized in the preceding section. It involves two elements: first, to determine where in the watershed to prioritize restoration efforts, and second, to identify specific practices and locations where improvements can be made.

The purpose of prioritizing was to focus limited resources in the most effective way, as there were some geographic areas within the watershed where the same improvement can have a greater impact than in others. Once prioritization was complete, specific restoration sites were identified at a subwatershed scale. These results are described in Section 5. This section provides an overview of the approach and practices considered.

The overall strategy for restoring the Belle Haven, Dogue Creek and Four Mile Run watersheds was developed with the assistance and input of the Watershed Advisory Group (WAG). The group suggested focusing project recommendations to identify impaired headwater areas and concentrate restoration efforts in these subwatersheds. These improvements will reduce the stress and subsequent damage to downstream channels. This strategy recognized that improvements in headwater areas have the potential to reduce stressors downstream and to improve conditions throughout the stream network. Projects were given a higher priority if they were on publicly maintained land or in areas where project costs could be shared with developers. The full Technical Memorandum detailing the subwatershed strategy process can be found in Appendix B.

Figure 4-1 visually depicts subwatershed prioritization for project selection. Headwater subwatersheds, shown in grey, are subwatersheds where a stream begins, either for the main channel, a tributary, or a small branch draining to a main channel or tributary. Subwatersheds draining directly to tidewater were not included.

Once headwater areas were defined, an approach was needed to determine which areas were impaired. These subwatersheds (identified by the red hatch in Figure 4-1) were defined using the indicator data discussed in Section 2.3. The indicators were divided into four summary groups, and then each subwatershed was ranked based on the score from the four summary groups and the overall ranking. If the subwatershed scored either among the worst 40 percent in the overall ranking, or the worst 20 percent for one of the indicator groups, it was presumed to be impaired. The four groups are as follows:

1. Stormwater Runoff Impacts: This group of indicators summarizes the conditions of the streams within the subwatershed and has been used primarily to assist in locating potential stream restoration sites.

2. Flooding Hazards: The indicators for flooding hazards have been derived from planning-level hydraulic modeling for the project. They include residential or commercial buildings that are shown within the modeled 100-year flood limit and crossings which are modeled as overtopped by the 10-year event.

3. Habitat Health: These indicators describe conditions of the natural resources that contribute to habitat quality such as forest cover, wetlands and riparian buffers.

4. <u>Water Quality:</u> Four indicators were used in this objective score. Three are derived from watershed modeling, which is specific to each subwatershed and integrates GIS data on imperviousness, land use and stormwater treatment. The fourth is based on monitoring data for *E. coli* collected by Virginia Department of Environmental Quality (VDEQ).

There are some features of interest in each watershed that can be seen on Figure 4-1. First, every subwatershed in Belle Haven and Four Mile Run met the criteria for impairment, while in Dogue Creek a majority of the subwatersheds were in better condition. Second, essentially all of the Four Mile Run subwatersheds are headwaters, either to the mainstem or to Upper Long Branch. As a result, investigations of restoration sites were made watershed-wide. While impaired areas of Belle Haven occur throughout the watershed, only two subwatersheds were classified as headwater areas, so the focus on restoration investigations was concentrated to this land area. Dogue Creek has impaired headwater areas in all of its WMAs, although the largest concentration is in the upper Mainstem and North Fork WMAs.

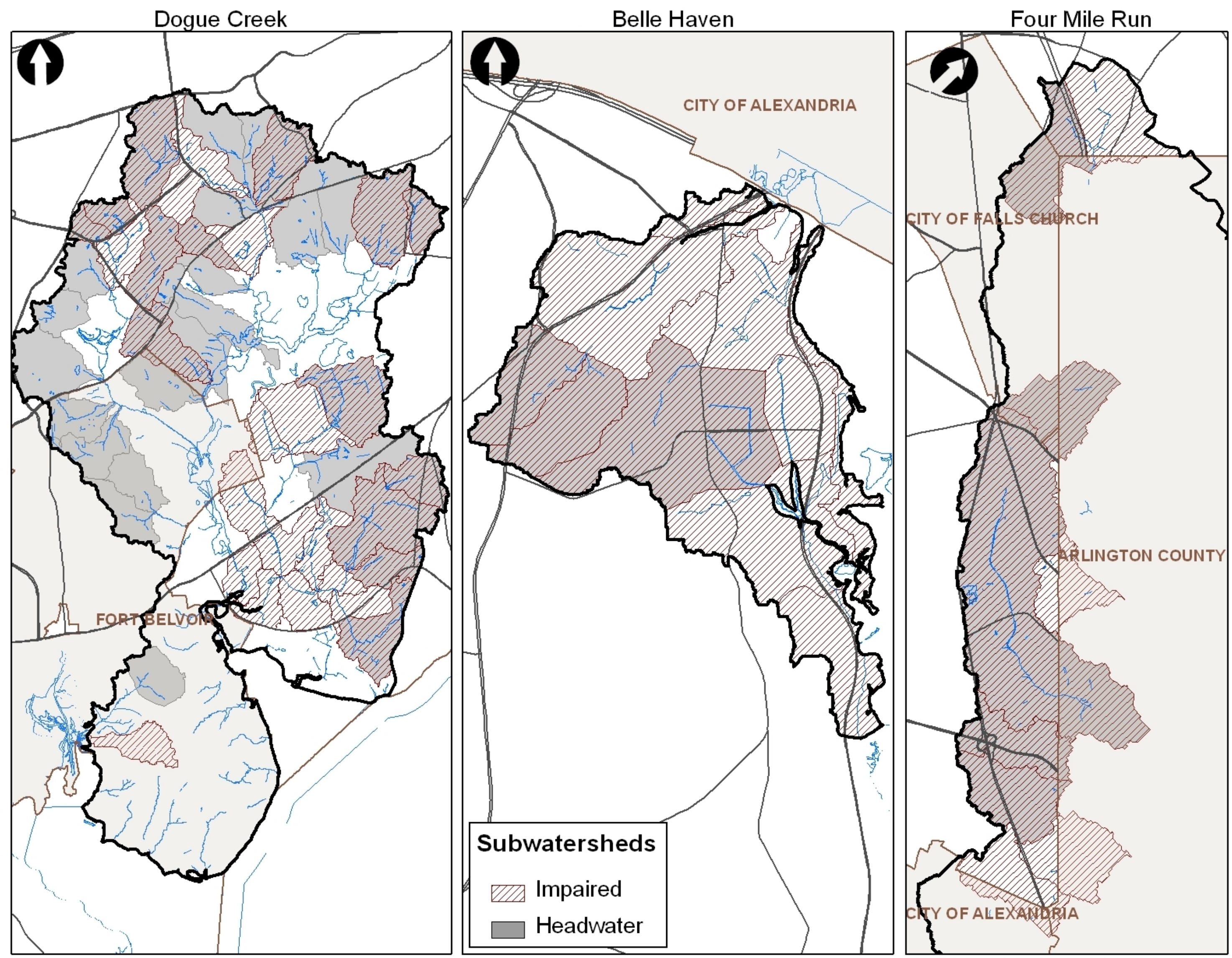

Figure 4-1: Subwatershed Strategy

4.2 Description of Watershed Restoration Practices

Stormwater management techniques are generally described as being in one of two categories: structural or non-structural. Structural practices are physical structures which generally involve budgeting through the Capital Improvement Plan and engineering, design and construction. Non-structural practices are more programmatic in nature and usually focus on controlling stormwater runoff at the source through reducing the amount of runoff and/or reducing the opportunity for stormwater to wash off and transport pollutants downstream.

4.2.1 Structural Practices

Structural projects can be designed to meet any of the goals and objectives for a particular watershed through restoring streams, providing mitigation from flooding, removing pollutants from stormwater runoff or improving aquatic and terrestrial habitat. The Belle Haven, Dogue Creek and Four Mile Run Watershed Management Plan includes the following structural practices:

- New Stormwater Management Ponds
- Stormwater Pond Retrofit
- Stream Restoration Projects
- Area-Wide Drainage Improvement
- Culvert Retrofit
- New BMP/LID or BMP/LID Retrofit
- Flood Protection / Mitigation
- Outfall Improvement

When stormwater management began to be implemented, the approach taken was to provide treatment facilities at the point of discharge. These were typically a type of pond or storage facility or outfall improvement and dealt mainly with the excess volume of stormwater runoff. As more knowledge was gained from experience, approaches that treated stormwater closer to its source were developed. These included BMP/LID facilities or area-wide improvements to the drainage system such as water quality filters at inlets. Structural projects can also serve several different functions based on their design: reducing the amount of stormwater, improving water quality, or attenuating high flows.

The following provides a short description of each of the structural practices proposed for the plan.

New Stormwater Management Pond

Description

These projects are newly-constructed dry ponds, wet ponds or stormwater wetlands. They are designed to help reduce the impacts of stormwater runoff by either permanently or temporarily storing the water.

All three types of ponds can be designed for water quality improvements by retaining the water long enough for sediment and pollutants to settle out of the water.

Wet ponds and stormwater wetlands can also provide water quality and habitat benefits through landscaping with aquatic vegetation. Vegetation is added to the pond design to treat dissolved nutrients (nitrogen and phosphorus), which can be difficult to remove through settling and filtering. In the process of growing, aquatic vegetation takes the nutrients up out of the water through its roots and sequesters them.

Figure 4-2: Stormwater Management wet pond (Source: Fairfax County)

Figure 4-3: Engineered stormwater wetland (Source: Fairfax County)

Design Considerations

Ponds can be categorized into three main categories:

1. Dry ponds, which are quantity controls to capture rapidly flowing runoff and release it slowly over a longer time period;
2. Wet ponds, which have a permanent pool that allows for sedimentation along with an level of storage above the pool to provide extended detention like a dry pond; and
3. Stormwater wetlands, which function similarly to a wet pond but are landscaped to provide better treatment of dissolved nutrients and aquatic habitat for a wider variety of species.

All three types may designed to include extended detention. Extended detention basins provide additional temporary storage above the bottom of a dry pond or the permanent pool of a wet pond or wetland. The extra storage area holds stormwater for longer settling times, which allows it to be released more slowly, reducing stress on downstream channels, and gives more time for pollutants to settle out. This improves the pollutant removal efficiency for dry ponds, wet ponds and wetlands.

Stormwater Management Pond Retrofit

Description

A stormwater management pond retrofit consists of changes or improvements made to an existing stormwater pond to provide additional water quality treatment. If the assessment of the watershed indicates that stream protection is necessary, the retrofit may include changes in the outflow controls to provide for peak flow reductions that help to minimize stream degradation.

Figure 4-4: Stormwater dry pond retrofit (Source: Fairfax County)

Design Considerations

The amount of water treated (water quantity) can be improved in two ways. First, by increasing the time the stormwater runoff stays in the pond through making the pond bigger and changing the outflow control to release the extra water more slowly. Second, there may be opportunities to add to the drainage area treated by the pond by redirecting untreated area to the pond.

Retrofits to improve water quality treatment involve adding features or controls that were not part of the original design. These approaches involve changing the way the pond functions, with methods such as the following:

- Changing outflow controls or adding a BMP plate for extended detention
- Changing the flow path within the pond so water travels farther between the inlet and the outlet
- Creating multiple pond cells within a single pond. Reconfiguring the pond and the landscape to capture more stormwater

Other approaches involve adding new features to the pond:

- Creating a shallow subsurface wetland bench around the perimeter which provides an opportunity for aquatic vegetation to take up nutrients
- Creating wetland areas within the pond
- Creating a forebay to capture sediment before it enters the pond, which improves maintainability
- Creating a micropool at the outlet to add an additional location for sedimentation

Stream Restoration

Description

The goal of stream restoration is to return the stream to a stable state in which it neither significantly erodes or fills with sediment, is connected to its floodplain and has an improved habitat condition.

Besides being undertaken to restore stability, stream restoration projects may be proposed to restore natural physical, biological, or ecological function to a stream which has become degraded due to man-made changes in the channel or the watershed, such as channel straightening, armoring with concrete or gabions, or culvert installation.

Design Considerations

Several approaches to restoration are available based on the type of impairment and constraints such as availability of adjacent land. For all of these projects, structures based on natural stream bed forms are used. Wood and stone structures can be used to concentrate stream flow to the center of the channel to provide a good flow depth for aquatic life between storm events.

Figure 4-5: Stream restoration (Source: Fairfax County)

For incised urban channels, there are several options available depending on the severity of the degradation and availability of adjacent land. The most extensive restoration designs may move the stream itself, creating a new channel on a new alignment at the original floodplain elevation. Other alternatives could involve adjusting the cross-section, reducing bank slopes, or creating a new floodplain bench within an over-widened channel. For incised channels with no room to increase meander width, a restoration design could include using grade controls to flatten the slope of the stream and dissipate stream energy.

Less extensive restoration approaches could be undertaken where there is insufficient space or the existing flows make it infeasible to recreate a natural channel. These could involve armoring stream banks with rock or bioengineering materials to prevent further erosion, grading to lay back over-steepened banks and create a more stable cross-section.

Culvert Retrofit

Description

These projects reconfigure and improve existing culverts, which allow streams to flow under roads and trails in the County. They may consist of water quantity (e.g. peak flow reduction, increased storage etc.) and/or water quality (e.g. improved runoff quality through micropools, wetland plantings, etc.) improvements.

This retrofit option is installed upstream from existing road culverts by constructing a control structure and potentially excavating a micro-pool similar to that seen in Figures 4-6 and 4-7.

Figure 4-6: Culvert retrofit control structure, flow left to right (Source: KCI)

Figure 4-7: Culvert retrofit, flow right to left (Source: Center for Watershed Protection)

These projects are usually designed for headwater, intermittent streams. The control structure will detain and reduce stormwater flow; the micropool prevents resuspension of previously settled sediments and also prevents clogging of the low flow orifice and may be able to infiltrate the runoff from smaller storms, improving water quality. Additional water quality treatment can be obtained through sedimentation or vegetative uptake.

Design Considerations

If the upstream area is an open floodplain, it may be possible to construct an off-line wet pond or stormwater wetland to improve water quality treatment. Since roadway embankments are not usually designed to impound water, special design measures are necessary, particularly a new embankment built upstream of the culvert.

Secondary impacts need to be considered as well, including impacts to the 100-year floodplain, fish passage barriers, or impacts to wetlands and forest.

The best situations for culvert retrofits occur when:

- Upstream land is in public ownership
- Channel has intermittent or ephemeral flow
- Upstream channels have a shallow slope, are connected to the floodplain, and have low streambanks
- The retrofit is upstream of a proposed stream restoration project.

Best Management Practice / Low Impact Development

Description

These projects are intended to improve performance or efficiency of existing BMPs (which may or may not incorporate LID practices) or installation of new practices in areas where stormwater is uncontrolled.

BMP/LID systems are a suite of small practices which are installed as close as possible to where stormwater runoff is being generated. Depending on the exact type of project, they are designed to provide water quality treatment, some reduction in stormwater and detention to reduce peak flows. The main objective is to mimic the pre-development runoff characteristics of the site through treating precipitation (or runoff) before it becomes concentrated by designing many smaller systems that work together on the site instead of a larger stormwater management facility downstream.

Design Considerations

A combination of several BMP/LID types and techniques can be used to achieve the best overall treatment. All of them incorporate one or more of the following processes:

Runoff reduction:

- surface ponding
- infiltration
- evapotranspiration

Pollutant removal:

- sedimentation
- filtration
- vegetative uptake

Figure 4-8: Parking lot bioretention (Source: Fairfax County)

Figure 4-9: Vegetated swale (Source: Fairfax County)

Figure 4-10: Tree box filter (Source: Fairfax County)

Individual BMP/LID practices that incorporate these processes include the following:

- Bioretention Filters and Basins
- Vegetated Swale
- Manufactured BMPs (e.g. Tree Box Filter)
- Dry Swale
- Filter Strips
- Sand Filters
- Percolation/Infiltration Trench
- Vegetated Roof
- Rain Garden

Rain gardens are essentially a non-engineered form of bioretention that treats rooftop runoff from individual roof leaders or overland runoff. They consist of small, landscaped depressions with a sand/soil mixture planted with native shrubs, grasses or flowering plants. Runoff is detained in the depression for no more than a day. Rain gardens can replenish groundwater, reduce stormwater volumes downstream and remove pollutants.

Figure 4-11: Green roof on a parking building (Source: Fairfax County)

Figure 4-12: Sand filter along MD355(Source: KCI)

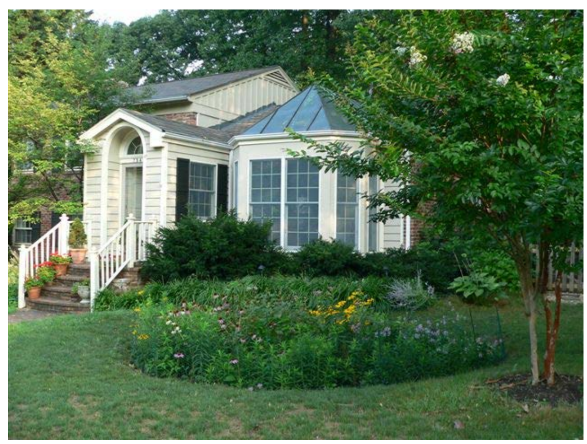

Figure 4-13: Residential rain garden (Source: Fairfax County)

Area-Wide Drainage Improvement

Figure 4-14: Vegetated swale for roadside drainage (Source: KCI)

Description

Area-Wide Drainage Improvements are projects (or suites of projects) which improve multiple outfalls and/or other stormwater infrastructure throughout a neighborhood. Controls could be custom-designed swales or bioretention systems (Figure 4-14), proprietary devices such as inlet filters (Figure 4-15) or the tree boxes described earlier (Figure 4-10).

Figure 4-15: Inlet filter (Source: Ultra-Tech Int'l)

Design Considerations

Area-wide improvements are similar to BMP/LID systems and may use the same practices. In some cases, an area-wide improvement may use more than one type of project type within the project limits.

The design focus on an area-wide improvement is to revise or upgrade the conveyance system area to provide treatment for a community rather than to treat a particular site, as with BMP/LID controls. Conversion of grass channels to vegetated swales, implementation of bioretention or tree boxes at inlets, or conversion of outfall ditches to storage or filtration systems would all be examples.

However, because of the proximity to roads and utilities, infiltration systems and vegetated swales may only be feasible in lower-density residential areas.

Flood Protection / Mitigation

Description

Flood protection projects (or suites of projects) are intended to alleviate potential flooding of roads, buildings, road crossings, or significant property.

Figure 4-16: Obsolete culvert (Source: KCI)

Figure 4-17: New replacement culvert (Source: KCI)

Road crossings (culverts or bridges) that may have been designed to safely pass high flows, such as the 100-year flood, occasionally become obsolete due to changes in upstream land use or other factors that increase storm flow volume or frequency. In such a case, a crossing that might have been designed with a one percent chance of flooding in any given year might now overtop more frequently.

In this case, for primary roads in particular, traffic standards may no longer be met. Flood protection or mitigation projects are intended to bring crossings back to current standards to allow higher stormwater flows to pass safely or adding storage upstream to reduce the peak flow to the under-sized structure.

Design Considerations

These improvements can include raising the roadbed above the flood level, rebuilding culverts so they can pass more water, replacing worn or damaged culverts with newer ones that allow water to flow more quickly. The example shown in Figures 4-16 and 4-17 include all of these techniques, with the roadway height increased and the larger double box culvert replacing the three smaller round metal ones.

In smaller streams, identifying and repairing constrictions in the drainage network may be sufficient. For larger rivers it may be necessary to rebuild bridges with a wider span to allow more space for floodwaters to pass.

For all of these types of projects, a key design consideration is to avoid potential flooding downstream. By removing constrictions, streamflows will increase, and conditions must be analyzed to make sure that flood mitigation at one site does not move the problem downstream to another.

Outfall Improvement

Description

Outfall projects improve existing stormwater outlet structures and address problems associated with inadequate outfalls (e.g. erosion, scour, head cuts etc.).

These projects are designed to protect the natural stream channels in the watershed from fast flowing stormwater runoff discharging from the storm drainage system. These high flows can cause erosion of the ditches and headwaters at the outfall; to the extent that stormwater infrastructure can be undermined and fail. They can also be a cause for further erosion or deposition downstream.

Design Considerations

There are several types of improvements that could be made depending on site constraints. If there is sufficient space, an off-line pond can be created to treat the first flush of stormwater, with higher flows bypassed into the existing stream channel.

Outfall improvements can be designed to provide water quality treatment along with energy dissipation. In an area with more constraints, a more common approach is to improve the conveyance immediately below the outfall structure to provide additional energy dissipation and reduce scour and erosion. Methods include the use of rip rap, plunge pools to break the flow of water and energy dissipation structures which adds turbulence to reduce the velocity of the outfall discharge.

Stream restoration design approaches can also be considered if the site is suitable, particularly step pool systems which can reduce the stormwater runoff velocity.

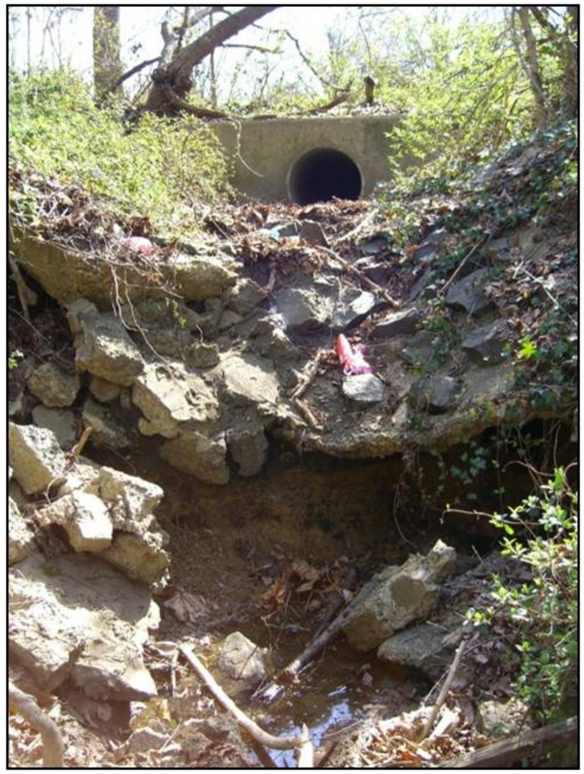

Figure 4-18: Outfall improvement (Source: Fairfax County)

Non-Structural Practices

Non-structural projects are a group of projects that do not require traditional construction measures to be implemented and may be programmatic in nature. These projects include but are not limited to the following practices:

- Stream buffer restorations
- Rain barrel programs
- Dumpsite and obstruction removals
- Community outreach and public education
- Land conservation coordination projects
- Inspection and enforcement projects
- Street sweeping programs
- Recommendation of additional studies, surveys and assessments

These projects, in concert with the structural projects, represent a holistic approach to watershed management. Since much of the land area in Fairfax County is privately owned, there is a strong need to work with local communities to promote environmental awareness and recommend projects that can be implemented by residents and other groups.

The fundamental difference between structural and non-structural projects is the ability to predict the result of the project implementation through models. For example, the nitrogen removal of a wet pond may be calculated; however, there is no way to predict the reduction in nitrogen from an outreach campaign on proper fertilizer use. Additionally, these projects and programs should not be confined to any single watershed but could be implemented throughout the County as opportunities occur. Because of these differences, non-structural projects were evaluated and will be implemented using a different process than the structural projects.

There are many advantages of non-structural projects. Some of the key advantages to this projects type are:

- Less costly
- Less disruptive
- Promotes public and community awareness

In general, non-structural projects represent opportunities to proactively pursue stormwater issues that more traditional structural practices cannot address. The use of non-structural practices fulfills Fairfax County's MS4 permit requirements and environmental initiatives. The full potential of these projects will be realized through partnerships with County agencies, residents and other interested parties.

Stream Buffer Restoration

Description

The vegetated land area on either side of a stream is referred to as the riparian buffer. Buffers can be comprised of grasses, shrubs, trees, or a combination of the three. Forested buffers provide streambank stability, food for aquatic life and shading of the stream. Stream buffers also provide important wildlife habitat. In many urban areas, stream buffers have been impacted through development. Restoring vegetation to these areas can improve the quality of the stream. Buffer restoration projects can be incorporated into stream banks stabilization and stream restoration projects to encourage multiple water quality and habitat benefits.

Design Considerations

There are several design guidelines that can have an effect on the efficiency of a stream buffer. The first is the buffer width. Whenever possible, a minimum width of 100 feet on each side of the stream should be maintained to provide adequate stream protection.

The ideal buffer vegetation is a mature forest, for a number of reasons. Shade will help keep the stream cooler, roots will help stabilize the banks, and leaf litter will provide a food source for macroinvertebrates and other organisms in the stream.

Figure 4-19: Buffer restoration project in Fairfax County (Source: Fairfax County)

Buffers are effective as a stormwater filter in areas of low density development. Where there are frequent storm drain outfalls bypassing the buffer and discharging directly in the stream, the filtration benefit is lost.

Dumpsite/Obstruction Removal

Description

Stream valleys, particularly those in isolated areas, are occasionally sites where unwanted trash or materials are dumped. This can consist of yard waste in residential neighborhoods, bulk trash where the owner does not wish to pay a disposal fee, or hazardous materials where a permit may not have been obtained. Obstructions refer to items in the streambed that impede flow sufficiently to accelerate streambank erosion or increase the risk of flooding.

Design Considerations

Dumpsite cleanup is typically a maintenance-level activity, which may require trucks, loaders, or other light equipment for removal.

Obstructions are removed in a similar fashion. Review of the site conditions should be performed by a stream ecologist because in some cases woody debris and a buildup of sediment can improve stream habitat conditions.

Impervious Disconnection and Rain Barrel Programs

Description

Impervious disconnection refers to practices that reduce the effect of impervious cover by small-scale storage, infiltration, or redirection to pervious areas. It differs from BMP/LID systems primarily because these practices can be installed easily without the need for engineering and design.

Design Considerations

Rain barrels are used to capture, store and reuse residential rooftop runoff. They consist of a simple collection device to store rainwater from individual downspouts, after which it can be reused for non-potable purposes such as irrigation or car washing. Capacity is typically 50 to 100 gallons, which is sufficient to store the runoff from 0.1" to 0.2" of rainfall from the area drained by a single downspout.

Figure 4-20: Rain barrel (Source: Project Clean Water)

Figure 4-21: Disconnecting a downspout (Source: City of Toronto)

Downspout disconnection consists of adding piping or gutter systems on the ground to turn the flow from a downspout away from driveways or sidewalks to lawns or landscaped areas. Rooftop runoff redirected in this fashion is treated by surface filtration through the vegetated area and infiltration into the soil. Directing runoff onto vegetation allows the biological processes to reduce pollutants. This is also an effective method of preventing temperature increases in runoff.

Figure 4-22: Permeable pavement blocks in a parking lot (Source: Fairfax County)

The use of pervious pavement systems can provide a form of disconnection for parking lots, driveways, walkways and other hard surfaces. These systems may consist of a special asphaltic paving material (porous pavement), a special concrete material (porous concrete) or open jointed concrete blocks (permeable pavement blocks). They allow stormwater to infiltrate directly through the surface instead of flowing to a collection system. The most significant constraint is the requirement for an underdrain if the soils below the surface are not permeable and will not allow the runoff to infiltrate. Maintenance is also required to prevent sediment from clogging the surface and preventing the water from infiltrating through the surface.

Community Outreach/Public Education

Description

Outreach and education programs are intended to educate the public on how to reduce the potential for pollutants to reach our waterways. Pollutants can range from nitrogen and phosphorus in improperly applied fertilizer, to bacteria found in dog waste left on the ground. These programs are intended to change pollutant-causing behaviors by providing information on how behavior affects water quality and to recommend types of changes that can be made to reduce impacts.

Design Considerations

Proper lawn and turf care practices can reduce excess nitrogen, phosphorus, insecticides and herbicides from getting into local streams. Education on soil testing, fertilizer application and pesticide use is intended to reduce the amount of these materials and educate on the appropriate application time. Encouraging conversion of lawn to native landscaping is another option for outreach programs.

Pet waste contributes harmful bacteria and excess nutrients to stormwater. Programs for control include adoption and enforcement of pooper scooper laws, education regarding its effects on streams and lakes, signs and publicly-available disposal containers.

Storm drain stenciling or labeling is a relatively easy method of outreach that involves labeling storm drain inlets with painted or prefabricated signs that indicate that materials thrown into the storm drain are not treated and go directly to a water body, which is typically named on the sign.

Figure 4-23: High and medium maintenance lawns (Source: KCI)

Figure 4-24: Pet waste sign in common area (Source: KCI)

Figure 4-25: Fairfax County storm drain label (Source: Fairfax County, label produced by Das Manufacturing, Inc.)

Programs to promote tree planting in residential yards, commercial open space, and in the open grassy area between sidewalks and streets can increase the tree canopy, increasing evapotranspiration and interception, slowing runoff and allowing more infiltration as it is absorbed into the ground. Trees also reduce erosion by holding soil and by reducing the impact of rain to bare ground. The program is a good opportunity to involve park and neighborhood supporting groups.

Inspection/Enforcement Enhancement Project

Description

Inspection and enforcement activities include identifying staff to routinely inspect commercial sites for potential runoff polluting activities. Depending on local ordinances, citations can be written for improper disposal of materials. In other cases, a targeted education and outreach program to the landowner and the employees may be effective in reducing the activities.

Figure 4-26: Improperly stored outdoor materials (Source: Center for Watershed Protection)

Figure 4-27: Improper dumpster maintenance (Source: Center for Watershed Protection)

Design Considerations

Vehicle maintenance and repair operations can exert a significant impact on water quality by generating toxins such as solvents, waste oil, antifreeze and other fluids. Often, vehicles that are wrecked or awaiting repair can be a stormwater hotspot if leaking fluids may be picked up by stormwater runoff.

Protecting outdoor material storage areas is a simple and effective pollution prevention practice for many commercial, industrial, institutional, municipal and transport-related operations. The underlying concept is to prevent runoff contamination by avoiding contact between outdoor materials and rainfall (or runoff). Examples include salt storage areas for highways, manure storage on farms, or excavated soil from construction sites.

Dumpsters provide temporary storage of solid waste at many businesses and can be a significant pollution source if improperly maintained. Many dumpsters are open, which allows rainfall to mix with the wastes, generating a source of trash, oil and grease, metals, bacteria, organic material, excess nutrients and sediments. Good dumpster management is particularly important to reduce trash loadings to a stream.

Litter and trash enforcement is carried out through the enforcement of regulations for illegal dumping, litter laws or unsecure truck loads. Education can also be an element to positively change the behavior. Community outreach programs for beautifying neighborhoods, including health and safety information can be used effectively in the implementation of the programs.

Street Sweeping Program

Description

Street sweeping refers to sweeping of roads, gutters, and parking lots in order to remove street dust and dirt before it is washed into storm drains and streams. Street sweeping can be used as primary treatment or pre-treatment for pollutants that cannot be entirely removed from the environment through other source control methods.

Figure 4-28: Street sweeper (Source: Tymco, Inc.)

Figure 4-29: Catch basin (Source: Fairfax County)

Design Considerations

There is a wide range of variability and efficiency among street sweeping equipment. Mechanical sweepers are effective for larger particles and cleanup of winter deicing materials. Much of the pollutants picked up by stormwater runoff consist of smaller particles in the micrometer range. A regenerative air sweeper can be effective at removing this material. Frequency of sweeping activities is also a key factor in pollutant removal efficiency.

An alternative to street sweeping is catch basin cleaning, which consists of periodically opening storm drain inlets and removing the material that has accumulated at the bottom. However, resident outreach and education is needed to stop the practice of disposing of materials into storm drain inlets.

4.2.2 Structural Project Prioritization

Projects were prioritized using a procedure that was applied similarly across all watersheds in order to develop an implementation plan for the design and construction of the proposed structural projects. This procedure is described in detail in Appendix B. The purpose was to identify the most effective projects in each watershed with a method that was quantifiable and based on a set of measurable indicators. The procedure was conducted using the indicator metrics from Section 2.3 to identify subwatersheds most in need of restoration. Five factors were considered, as follows:

1. <u>Impact Indicators:</u> Measure the extent that a particular watershed impact can be reduced by a proposed project.

2. <u>Source Indicators:</u> Quantify the reduction of potential stressor or pollution sources.

3. <u>Location within Priority Subwatersheds:</u> Projects were prioritized based on the quality of the subwatershed in which they were located. Projects received a higher score if they were located in a lower quality subwatershed.

4. Sequencing: Projects were scored based on their location in each WMA. Projects in headwater subwatersheds were given highest priority.

5. Implementability: Implementability was a measure of which projects would be easier to implement, defined by whether or not they were on County-owned or maintained property, and whether or not upstream quantity controls were required for them to be successfully implemented.

Final project prioritization was calculated based on a weighted average of the five factors:

- Effect on Impact Indicators 30%
- Effect on Source Indicators 30%
- Location within Priority Subwatersheds 10%
- Sequencing 20%
- Implementability 10%

After the scores were calculated, they were reviewed and adjustments were made for some of the more qualitative factors, such as forecasts of changes in stream condition, flooding hazards and riparian buffer based on implementation of each project.

Once the initial prioritization was completed, a simplified cost benefit analysis (CBA) was made for the highest priority 10-year projects in order to provide additional information on cost-effectiveness. The analysis was made by dividing the composite score (a measure of benefits) with the cost, to allow a comparison among projects. This information was used to adjust final ranking of projects.

Of the 60 projects analyzed, approximately half stayed in the same relative rank for both methods. In general, the projects that were ranked high but scored low using CBA were project types with significantly higher costs, primarily new stormwater ponds, stream restoration and flood mitigation projects. A review of the problems identified in the watershed suggests that the need for additional stormwater storage in untreated areas justified the additional cost, as did restoration of degraded streams and flood mitigation improvements.

The opposite conclusion was found for projects that ranked low but scored high in the CBA analysis. For the most part, these projects were smaller BMP/LID retrofits that provided good benefits for their low cost. However, the area they treated was generally very small, leading to lower overall benefits.

4.2.3 Non-Structural Project Prioritization

Non-structural projects were derived from two sources. First, pollution prevention measures were identified during the upland reconnaissance of residential and commercial areas which assessed potential pollutant sources. As part of the assessment, several possible programs were identified for specific areas which had the potential to reduce or control sources of pollution or stormwater runoff. The second approach included indentifying site specific areas for buffer restoration and land conservation measures through the use and analysis of GIS mapping.

One hundred forty non-structural project sites were recommended for consideration through these assessments. Many of the pollution prevention measures could be carried out more efficiently if they were done on a watershed-wide or countywide basis. With this in mind, the proposed projects were grouped by project type. The resulting list of non-structural projects is shown in the end of Table 4-3. Projects that spanned across several watersheds were given project numbers related to Dogue Creek, the largest watershed in the plan grouping.

The non-structural projects were prioritized similarly to the structural projects, with the goal of identifying five high priority projects. Two factors were used in the prioritization:

Impact Indicators Projects were scored using best professional judgment based on the effectiveness at improvements in runoff impacts on streams, flood mitigation, habitat enhancement and water quality.

Implementability Best professional judgment was used to determine ease of implementation, based on cost and time commitment required by Fairfax County staff.

Scores were calculated based on a weighted average of these two factors:

- Effect on Impact Indicators 60%
- Implementability 40%

The highest priority watershed-wide project was Downspout Disconnection, followed by Obstruction Removal and Litter/Trash Enforcement. Tree Planting projects were next in priority. These four projects, along with Buffer Restoration DC9801, prioritized with the structural projects, were the five highest priority non-structural projects.

Table 4-1 summarizes the prioritization for the non-structural projects.

Table 4-1: Non-structural project prioritization

Project ID	Non-Structural Measure	Detailed Action	Priority
DC9801	Buffer Restoration	Buffer Restoration	High
DC9803	Wetland Mitigation	Wetland Mitigation	High
DC9901	Rain Barrel Programs	Downspout Disconnection	High
DC9905	Outreach / Education	Tree Planting	High
DC9910	Inspection / Enforcement	Litter/Trash Enforcement	High
DC9911	Dumpsite / Obstruction Removal	Obstruction Removal	High
DC9800	Buffer Restoration	Buffer Restoration	Low
DC9802	Buffer Restoration	Buffer Restoration	Low
DC9902	Rain Barrel Programs	Rain Barrels	Low
DC9903	Outreach / Education	Lawn Care Outreach	Low
DC9904	Outreach / Education	Storm Drain Marking	Low
DC9906	Outreach / Education	Turf Management	Low
DC9907	Inspection / Enforcement	Dumpster Maintenance	Low
DC9908	Inspection / Enforcement	Outdoor Materials	Low
DC9909	Inspection / Enforcement	Vehicle Maintenance	Low
DC9912	Street Sweeping	Street Sweeping	Low
DC9913	Studies, Surveys and Assessments	Floatables Control	High

4.3 Status of Regional Ponds

Fairfax County records show that there are no regional ponds in the Belle Haven and Four Mile Run watersheds and two regional ponds proposed in the Dogue Creek watershed. Table 4-2 shows the status of these ponds according to the County records, followed by a short description of the results of the site investigation conducted as part of this watershed plan.

Table 4-2: Regional ponds in the Dogue Creek watershed

Project Name	WMA	Status	Time frame	Facility ID Number	Drainage Area (ac)	WMP Status
Mt. Vernon High School Outfall Project (MV-1A)	North Fork	C	EX	WP0389	139	No action
South Van Dorn Street, Phase 3, Regional Pond (DC-106)	Dogue Creek Mainstem	C	EX	1480DP	50	No action

C=complete; I=Inactive, not funded; EX=Existing

Pond MV-1A There are no retrofits proposed for this regional pond. However, there are seven projects proposed in the drainage area of the pond: one stormwater management pond, five BMP/LIDs and one stream restoration site.

Pond DC-106 There are no retrofits recommended for this pond nor were there any projects proposed within the pond drainage area.

4.4 Summary of Proposed Projects

Table 4-3 is the Master List of Projects, which shows all the projects proposed in the plan, organized by implementation priority, then by watershed and project number. The 10-year implementation projects have project fact sheets associated with them which are located in Section 5.

Map 4-1 shows all structural project locations throughout the three watersheds as they are distributed within the Dranesville, Mason, Lee, and Mount Vernon supervisor districts. Non-structural projects, which are intended to be implemented watershed-wide, are listed in a table on the map.

Table 4-3: Master list of projects

Priority Structural Projects (10-Year Implementation Plan)[1]						
Project #	**Project Type**	**WMA**	**Location**	**Watershed Benefit**	**Land Owner**	**Cost**
BE9100	Stormwater Pond Retrofit	Belle Haven	West Potomac High School	Water Quality and Quantity	County – FCPS	$174,000
BE9102	New Stormwater Pond	Belle Haven	Belle View Elementary School	Water Quality and Quantity	County – FCPS	$277,000
BE9103	New Stormwater Pond	Belle Haven	Fairchild Property	Water Quality and Quantity	County	$750,000
BE9200	Stream Restoration	Belle Haven	Belle Haven Park between Richmond Hwy Foxcroft Rd, and Edgewood Ter	Water Quality	County – FCPA	$1,614,000
BE9201	Stream Restoration	Belle Haven	Behind Belle View Dr	Water Quality	Private Residential	$883,000
BE9202	Stream Restoration	Belle Haven	Shields Ave	Water Quality	Private Residential	$388,000
BE9203	Stream Restoration	Belle Haven	Downstream of Quander Rd	Water Quality	Private Commercial	$1,122,000
BE9500	BMP/LID	Belle Haven	Shops at Huntington Gateway	Water Quality	Private Commercial	$105,000
BE9501	BMP/LID	Belle Haven	Wal-Mart and Chuck E. Cheese parking lot	Water Quality	Private Commercial	$283,000
BE9502	BMP/LID	Belle Haven	Quander Road School	Water Quality	County - FCPS	$69,000
BE9503	BMP/LID	Belle Haven	River Towers	Water Quality	Private Residential	$251,000
BE9504	BMP/LID	Belle Haven	Belle View Shopping Center	Water Quality	Private Commercial	$145,000
BE9505	BMP/LID	Belle Haven	14th St	Water Quality	State - VDOT	$83,000
BE9506	BMP/LID	Belle Haven	Belle View Blvd	Water Quality	State - VDOT	$91,000
BE9507	BMP/LID	Belle Haven	Belle View Shopping Center	Water Quality	Private Commercial	$257,000
BE9508	BMP/LID	Belle Haven	Belle View Elementary School	Water Quality	County - FCPS	$62,000
BE9509	BMP/LID	Belle Haven	Mount Vernon Recreation Center	Water Quality	County - FCPA	$241,000
BE9510	BMP/LID	Belle Haven	West Potomac High School	Water Quality	County - FCPS	$85,000
BE9600	Flood Protection/Mitigation	Belle Haven	Culvert under Yale Drive	Flood Mitigation	State – VDOT	$593,000

Priority Structural Projects (10-Year Implementation Plan)[1]						
Project #	**Project Type**	**WMA**	**Location**	**Watershed Benefit**	**Land Owner**	**Cost**
DC9100	New Stormwater Pond	Dogue Creek - North Fork	Mount Vernon High School	Water Quality and Quantity	County – FCPS	$480,000
DC9106	Stormwater Pond Retrofit	Dogue Creek - Barnyard Run	Groveton Woods Condominiums	Water Quality and Quantity	Private	$89,000
DC9201	Stream Restoration	Dogue Creek - North Fork	Between Presidential Dr and Volunteer Dr	Water Quality	Private Residential	$646,000
DC9202	Stream Restoration	Dogue Creek - North Fork	Between Sulgrave Dr and Adrienne Dr	Water Quality	Private Residential	$925,000
DC9203	Stream Restoration	Dogue Creek - North Fork	Upstream of Mount Zephyr Dr near Maryland St	Water Quality	Private - Residential	$744,000
DC9204	Stream Restoration	Dogue Creek - North Fork	George Washington Park	Water Quality	County - FCPA	$859,000
DC9207	Stream Restoration	Dogue Creek - North Fork	Behind Colony Dr	Water Quality	Private Residential	$646,000
DC9210	Stream Restoration	Dogue Creek - Barnyard Run	Between Parsons Ct and Stover Dr	Water Quality	Private - Residential	$547,000
DC9211	Stream Restoration	Dogue Creek - Barnyard Run	Between Bedrock Ct and Vantage Drive	Water Quality	Private - Residential	$578,000
DC9213	Stream Restoration	Dogue Creek - Mainstem	Greendale Golf Course	Water Quality	County - FCPA	$1,228,000
DC9214	Stream Restoration	Dogue Creek - Mainstem	Greendale Golf Course	Water Quality	County - FCPA	$1,261,000
DC9215	Stream Restoration	Dogue Creek - Piney Run	Behind Rockcliff Ln	Water Quality	Private - Residential	$1,480,000
DC9217	Stream Restoration	Dogue Creek - Mainstem	Between Old Mill Rd and Richmond Hwy	Water Quality	Private	$707,000
DC9218	Stream Restoration	Dogue Creek - Piney Run	Banks Property	Water Quality	County - FCPA	$872,000
DC9400	Culvert Retrofit	Dogue Creek - Mainstem	North side, Telegraph Rd	Water Quality	Private Residential	$27,000
DC9500	BMP/LID	Dogue Creek - North Fork	Smitty's Building Supply	Water Quality	Private Commercial	$262,000
DC9501	BMP/LID	Dogue Creek - North Fork	Various	Water Quality	County/Private	$69,000
DC9503	BMP/LID	Dogue Creek - North Fork	Riverside Elementary School	Water Quality	County - FCPS	$74,000

Priority Structural Projects (10-Year Implementation Plan)[1]						
Project #	**Project Type**	**WMA**	**Location**	**Watershed Benefit**	**Land Owner**	**Cost**
DC9504	BMP/LID	Dogue Creek - North Fork	Mount Vernon High School	Water Quality	County – FCPS	$189,000
DC9505	BMP/LID	Dogue Creek - North Fork	Mount Vernon High School	Water Quality	County – FCPS	$209,000
DC9506	BMP/LID	Dogue Creek - Piney Run	Alderman Dr	Water Quality	State - VDOT	$145,000
DC9507	BMP/LID	Dogue Creek - Piney Run	Parking lots along Westcott Way	Water Quality	Private - Residential	$121,000
DC9508	BMP/LID	Dogue Creek - Piney Run	Shoppers parking lot	Water Quality	Private Commercial	$240,000
DC9510	BMP/LID	Dogue Creek - Mainstem	Hayfield Secondary School	Water Quality	County – FCPS	$223,000
DC9511	BMP/LID	Dogue Creek - Mainstem	Hayfield Plaza	Water Quality	Private Commercial	$228,000
DC9512	BMP/LID	Dogue Creek - Barnyard Run	Groveton Gardens	Water Quality	Private	$34,000
DC9513	BMP/LID	Dogue Creek - Barnyard Run	Groveton Elementary School	Water Quality	County – FCPS	$45,000
DC9518	BMP/LID	Dogue Creek - Mainstem	Kingstowne Village	Water Quality	Private Commercial	$46,000
DC9519	BMP/LID	Dogue Creek - Mainstem	Kingstowne Village	Water Quality	Private Commercial	$58,000
DC9520	BMP/LID	Dogue Creek - Mainstem	Church of Jesus Christ of Latter Day Saints	Water Quality	Private – Church	$163,000
DC9522	BMP/LID	Dogue Creek - Mainstem	Along Clames Dr	Water Quality	State - VDOT	$21,000
DC9523	BMP/LID	Dogue Creek - Mainstem	Virginia Presbyterian Church	Water Quality	Private – Church	$48,000
DC9600	Flood Protection/Mitigation	Dogue Creek - North Fork	Culvert under Ashboro Drive	Flood Mitigation	State – VDOT	$488,000
FM9102	New Stormwater Pond	Four Mile Run	Hollybrook II Condos	Water Quality and Quantity	Private - Residential	$2,326,000
FM9104	Stormwater Pond Retrofit	Four Mile Run	Hampton Inn off 14th Street and Leesburg Pike	Water Quality and Quantity	Private Commercial	$99,000
FM9105	New Stormwater Pond	Four Mile Run	Off Carlin Springs Rd	Water Quality and Quantity	Private - Commercial	$498,000

Priority Structural Projects (10-Year Implementation Plan)[1]						
Project #	**Project Type**	**WMA**	**Location**	**Watershed Benefit**	**Land Owner**	**Cost**
FM9300	Area-wide Drainage Improvements	Four Mile Run	North of Williamsburg Blvd and Custis Memorial Pkwy and south of Haycock Rd	Water Quality	Private Residential and State - VDOT	$1,833,000
FM9500	BMP/LID	Four Mile Run	St. Andrews Parish	Water Quality	Private - Church	$92,000
FM9501	BMP/LID	Four Mile Run	St. Katherine's Greek Orthodox	Water Quality	Private - Church	$52,000
FM9502	BMP/LID	Four Mile Run	Target Greatland	Water Quality	Private Commercial	$479,000
FM9503	BMP/LID	Four Mile Run	Korean Cultural Center	Water Quality	Private	$79,000
					Total Cost	**$26,683,000**

Long Term Structural Projects (25 Year Implementation Plan)					
Project #	**Project Type**	**WMA**	**Location**	**Watershed Benefit**	**Land Owner**
BE9701	Outfall Improvement	Belle Haven	Quander Road School	Water Quality	Public/Local
DC9101	Stormwater Pond Retrofit	Dogue Creek - North Fork	End of Purks Ct	Water Quality and Quantity	Private
DC9102	Stormwater Pond Retrofit	Dogue Creek - Piney Run	Kingstowne Fire Station	Water Quality and Quantity	Private
DC9104	Stormwater Pond Retrofit	Dogue Creek - Piney Run	Kingstowne Village Pkwy at Ashby Ln	Water Quality and Quantity	Public/Local
DC9105	Stormwater Pond Retrofit	Dogue Creek - Piney Run	Manchester Lake Dr	Water Quality and Quantity	Private
DC9107	Stormwater Pond Retrofit	Dogue Creek - Mainstem	Devereux West	Water Quality and Quantity	Private
DC9108	Stormwater Pond Retrofit	Dogue Creek - Mainstem	Crossroads Residential School	Water Quality and Quantity	Private – School
DC9109	Stormwater Pond Retrofit	Dogue Creek - Mainstem	Church of Jesus Christ of Latter Day Saints	Water Quality and Quantity	Private – Church
DC9110	Stormwater Pond Retrofit	Dogue Creek - Mainstem	Virginia Presbyterian Church	Water Quality and Quantity	Private – Church
DC9200	Stream Restoration	Dogue Creek - North Fork	Robertson Blvd	Water Quality	Private Residential
DC9205	Stream Restoration	Dogue Creek - North Fork	Between Oak Leaf Dr and McNair Dr	Water Quality	Private

Long Term Structural Projects (25 Year Implementation Plan)					
Project #	**Project Type**	**WMA**	**Location**	**Watershed Benefit**	**Land Owner**
DC9206	Stream Restoration	Dogue Creek - North Fork	Rosemont Ave and Rosemont Cir	Water Quality	Private
DC9208	Stream Restoration	Dogue Creek - Mainstem	8822 Richmond Highway (between Old Mill Rd and Sacramento Dr)	Water Quality	County-FCPA, Private
DC9209	Stream Restoration	Dogue Creek - Mainstem	Upstream of Old Mill Rd (Close to Pope Leighy House)	Water Quality	Private
DC9212	Stream Restoration	Dogue Creek - Mainstem	Wickford Park	Water Quality	Public/Local
DC9216	Stream Restoration	Dogue Creek - Piney Run	Rock Ridge Ln	Water Quality	Private
DC9401	Culvert Retrofit	Dogue Creek - North Fork	Lawrence St between Central Park and Ashboro Dr	Water Quality	State - VDOT
DC9502	BMP/LID	Dogue Creek - North Fork	KinderCare Learning Center, Buckman Rd	Water Quality	Public/Local
DC9509	BMP/LID	Dogue Creek - Piney Run	Calvary Baptist Church and Christian School	Water Quality	Private
DC9514	BMP/LID	Dogue Creek - Barnyard Run	Faith United Methodist Church	Water Quality	Public/Local
DC9515	BMP/LID	Dogue Creek - Mainstem	The Shops at Telegraph	Water Quality	Private – Commercial
DC9516	BMP/LID	Dogue Creek - Mainstem	Crossroads Residential School	Water Quality	Private – School
DC9517	BMP/LID	Dogue Creek - Mainstem	Kinder Care Learning Center, May Blvd	Water Quality	Private - Commercial
DC9521	Stormwater Pond Retrofit	Dogue Creek - Mainstem	Franconia Road at Morning Glory Dr	Water Quality and Quantity	Private
DC9701	Outfall Improvement	Dogue Creek - Piney Run	Behind 6115 Summer Park Ln	Water Quality	Private
DC9702	Outfall Improvement	Dogue Creek - Piney Run	Rock Ridge Ln	Water Quality	Public/Local
DC9703	Outfall Improvement	Dogue Creek - Barnyard Run	Harrison Ln	Water Quality	County-FCPA, Private
FM9100	Stormwater Pond Retrofit	Four Mile Run	Fallswood Glen Ct	Water Quality and Quantity	Unknown

Long Term Structural Projects (25 Year Implementation Plan)					
Project #	**Project Type**	**WMA**	**Location**	**Watershed Benefit**	**Land Owner**
FM9101	Stormwater Pond Retrofit	Four Mile Run	Along Arlington Blvd near Kelsey Ct	Water Quality and Quantity	Unknown
FM9103	Stormwater Pond Retrofit	Four Mile Run	Commercial center at Arlington Blvd and Wilson Blvd	Water Quality and Quantity	Private
FM9106	Stormwater Pond Retrofit	Four Mile Run	Diehl Ct	Water Quality and Quantity	Public/Local
FM9200	Stream Restoration	Four Mile Run	Upstream of Henry Dr and Brook Dr	Water Quality	Private Residential

Non-Structural Projects					
Project #	**Project Type**	**WMA**	**Location**	**Watershed Benefit**	**Land Owner**
DC9800	Buffer Restoration	Dogue Creek - Mainstem	Buffer restoration adjacent to commercial / industrial site, Dogue Ct	Water Quality and Quantity	Private
DC9801	Buffer Restoration	Dogue Creek - Mainstem	Stream adjacent to Huntley Meadows near Sheridonna La. Reach DCPY006	Water Quality and Quantity	Private, FCPA
DC9802	Buffer Restoration	Dogue Creek - Piney Run	Hilltop Golf Course	Water Quality and Quantity	Private
DC9803	Wetland Mitigation	Dogue Creek – North Fork	Riverside Elementary School	Water Quality	Public/Local
DC9901	Rain Barrel Programs – Downspout Disconnection	Multiple	Watershed-wide	Water Quality and Quantity	Various
DC9902	Rain Barrel Programs – Rain Barrels	Multiple	Watershed-wide	Water Quality and Quantity	Various
DC9903	Community Outreach/ Public Education – Lawn Care Outreach	Multiple	Watershed-wide	Water Quality	Various
DC9904	Community Outreach/ Public Education – Storm Drain Marking	Multiple	Watershed-wide	Water Quality	Various
DC9905	Community Outreach/ Public Education – Tree Planting	Multiple	Watershed-wide	Water Quality and Quantity	Various

Non-Structural Projects					
Project #	**Project Type**	**WMA**	**Location**	**Watershed Benefit**	**Land Owner**
DC9906	Community Outreach/Public Education – Turf Management	Multiple	Watershed-wide	Water Quality	Various
DC9907	Inspection/Enforcement Enhancement Project – Dumpster Maintenance	Multiple	Watershed-wide	Water Quality	Various
DC9908	Inspection/Enforcement Enhancement Project – Outdoor Mat'l Storage	Multiple	Watershed-wide	Water Quality	Various
DC9909	Inspection/Enforcement Enhancement Project – Vehicle Maintenance	Multiple	Watershed-wide	Water Quality	Various
DC9910	Inspection/Enforcement Enhancement Project – Litter/Trash Enforcement	Multiple	Watershed-wide	Water Quality	Various
DC9911	Dumpsite/Obstruction Removal – Obstruction Removal	Multiple	Watershed-wide	Water Quality	Various
DC9912	Street Sweeping Program	Multiple	Watershed-wide	Water Quality	Various
DC9913	Studies and Assessments – Floatables Control	Multiple	Watershed-wide	Water Quality	Various

[1]Please note that only priority 10-yr structural projects will have associated project fact sheets at the end of section 5

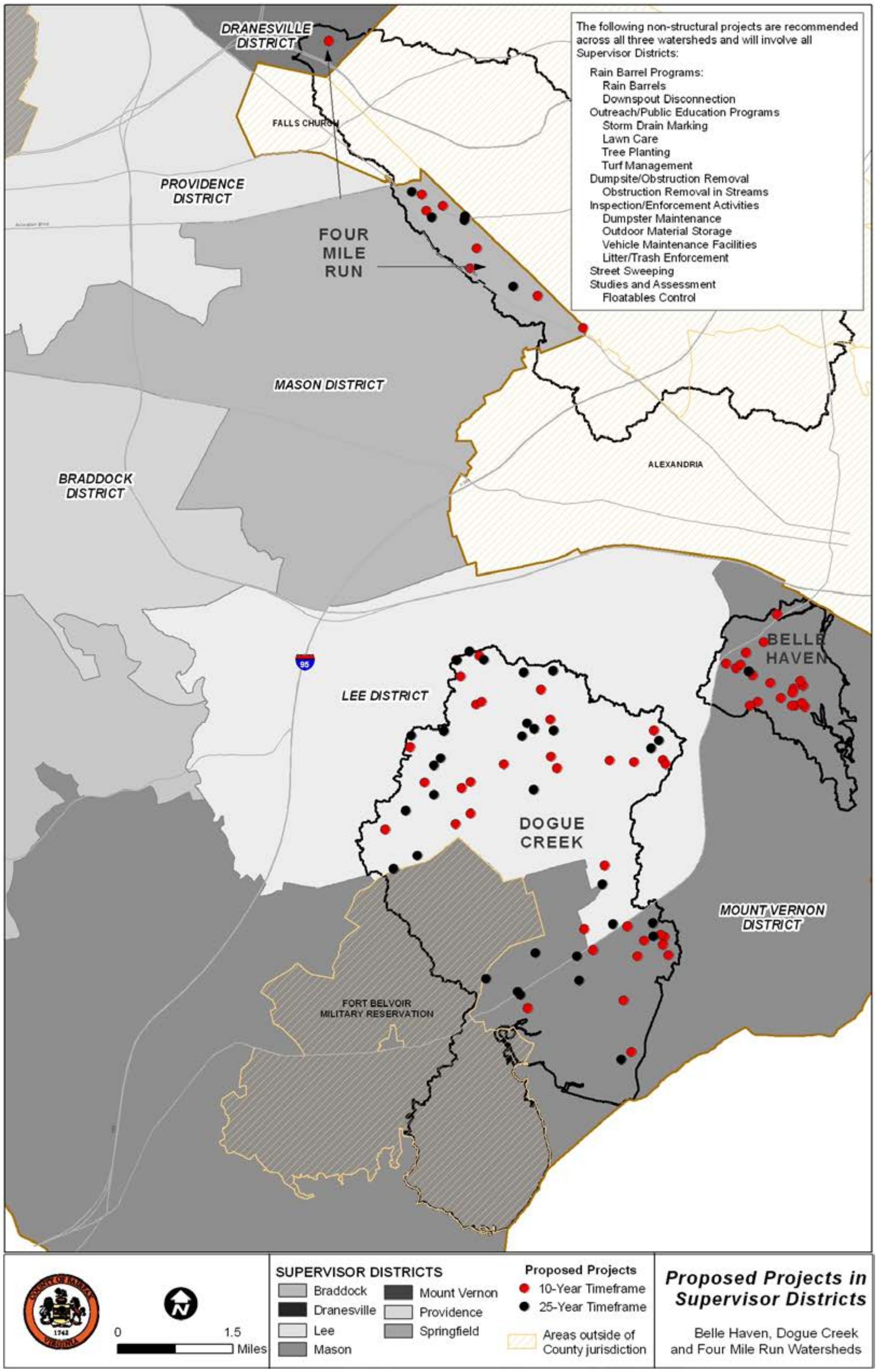

Figure 4-30: Proposed projects in supervisor districts