Windsor Woods Drainage Improvements Preliminary Engineering Report

Executive Summary
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EXECUTIVE SUMMARY

ES-1 Introduction

The Windsor Woods Project Area (“WW”) is located in the center of Virginia Beach, east of Mount Trashmore Park. It is bounded by I-264 to the north, South Rosemont Road to the east, Holland Road to the south, and Edwin Drive to the west. The area (shown in Figure ES-1 below) includes multiple subdivisions: Windsor Woods, Windsor Oaks, Windsor Oaks West, Windsor Forest, and part of Pecan Gardens.

![Figure ES-1: Windsor Woods Project Area](image)

Windsor Woods has experienced repeated flooding issues throughout the years mainly due to its low elevations, tidal influence, and undersized drainage system. A large portion is within FEMA’s 100-year floodplain (i.e. Elevation 7.0 feet, NAVD88 and below). The area is essentially a “bowl” where water becomes trapped in the low-lying areas and in extreme events becomes one large pool of water. Hurricane Matthew (October 2016) resulted in the most severe flooding and subsequent damage this area has ever experienced. More than 450 homes within Windsor Woods alone reported flooding totaling approximately $8 million in property damage. This prompted the City to expedite a flood mitigation plan and strategy for this area.
The Windsor Woods Stormwater Management System Flood Mitigation Plan, April 5, 2018, (Mitigation Plan) was prepared for the City by CDM Smith. It evaluated the project area and provided recommended drainage improvements to reduce the flooding issues. The major components of the recommended Plan included:

- Construct a 900 cfs pump station and tide gate across Thalia Creek (South of I-264, in the northwest corner of Lake Windsor);
- Connect Lake Windsor and Lake Trashmore to maximize available stormwater storage capacity; and
- Increase the conveyance capacity of the storm drain pipes (i.e. increase pipe sizes, add additional storm drainpipes, etc.)

The Mitigation Plan also defined an achievable Level of Service (LOS) for the project area as:

- Limiting peak flood stages to 3-inches or less above the road crown for the 10-year design storm; and
- Preventing structure flooding for the 100-year design storm.

It should be noted that the Mitigation Plan LOS is reduced from the City’s current standard, which requires a 10-year storm to be retained within the storm drain pipe network and the streets to remain passable during the 100-year storm event. However, it is not feasible to meet the standard LOS in this portion of the City due to its low elevations, topography, and the fact that the area is fully developed/built out. The Mitigation Plan LOS was used as the “Benchmark” or “Goal” when evaluating drainage improvements throughout this Report.

Most importantly, proposed improvements cannot cause adverse impacts downstream, upstream, or within the project limits. This directive was incorporated into the Mitigation Plan and carried forward to this Report. All recommended improvements have been evaluated to ensure that resulting conditions are no worse than existing conditions. These evaluations will continue to be refined throughout the detailed design process.

ES-2 Purpose

The purpose of this Preliminary Engineering Report (also known as the PER) was to further evaluate, refine, prioritize, and recommend proposed drainage improvements to most efficiently mitigate the flooding within the Windsor Woods area. Evaluation matrices were prepared to analyze cost-benefit ratios as well as other factors such as constructability, easement acquisitions, and permitting concerns for the proposed alternatives. Preliminary design concepts, cost estimates, and phasing plans were also prepared. The overall goal of the
PER was to develop a feasible recommendation to mitigate the most flooding as cost effectively as possible.

ES-3 Recommended Drainage Improvements

Evaluation of the Windsor Woods Project Area has confirmed there is NOT a single drainage solution or improvement that will mitigate the flooding throughout. A combination of complementary infrastructure improvements (i.e. tide gates, pump station, barriers, storage, and storm drain pipes) must be implemented to achieve the ultimate mitigation benefit and meet the LOS goal for the area.

The proposed solution to mitigate flooding in the project area lies in the “BERM-POND-PUMP” concept, which is a sequenced approach to flood mitigation. The first step is to create the “BERM”. The “BERM” is accomplished in two ways for this area: first, by building a gate across Thalia Creek to mitigate the influence of the tide, and secondly, by creating a barrier along South Boulevard to isolate the project area from outside influences such as overland flow in an extreme tidal or storm event. The purpose of the gate across Thalia Creek is to prevent the incoming tide from entering the drainage system, which will increase available storage capacity prior to and during a storm event. A rendering of the tide gate is shown in Figure ES-2.

Figure ES-2: Rendering of Tide Gates on Thalia Creek
Once the gate is installed, the storage capacity in Lake Windsor and the Windsor Woods drainage system can be significantly increased since deployment of the gate blocks the incoming tide from filling the available space. This allows Lake Windsor (and ultimately Lake Trashmore) to become dedicated stormwater storage ponds forming the “POND” element. The placement of the gate has been modeled in relation to existing and proposed conditions and will not increase flooding and/or cause adverse impacts downstream, upstream, or within the project area.

Figures ES-3 through ES-6 demonstrate existing and proposed conditions within Lake Windsor, existing tidal impacts, and how the gate will assist in increasing available storage capacity.

Figure ES-3 shows the current, low tide conditions at Lake Windsor. During low tide, storage capacity is available due to the lack of tidal influence. When the tide is out, there is available storage capacity in the lake since the tide is not occupying this space. However, as depicted in Figure ES-4, in a high tide condition, there is very little storage available within the lake, as the tide is now occupying the storage space previously available at low tide. As shown by the red “High Tide” area, the storage capacity is dramatically reduced due to the influence of the tide.
Figure ES-5 demonstrates what currently occurs during a rainfall event at high tide. During the event, stormwater flows into Lake Windsor via storm drainpipes and overland sheet flow. Since there is limited or no storage available as a result of the high tide, the level of the lake rises quickly and with nowhere for the water to go, flooding occurs due to the high-water levels.

![Rainfall Event - Flooding Occurs](image)

**Figure ES-5: Rainfall Event at Lake Windsor During High Tide (Existing Conditions)**

Figure ES-6 depicts the resulting conditions in Lake Windsor after the placement of the proposed tide gate across Thalia Creek. Once the gate is installed, it will be closed pre-storm to eliminate tidal influence. Blocking the tide creates additional storage capacity within the lake (as represented in blue below). This additional storage capacity will allow the stormwater to be more effectively managed throughout the system to reduce flooding during storm events.

![Storage Capacity for Stormwater](image)

**Figure ES-6: Tide Gate Closed (Proposed Conditions)**

The third element is the “PUMP”. The lakes will be pumped down in advance of a storm, to increase storage potential. Pumping will also occur during a storm event to maintain water levels below flood stage. It should be noted the pumps will be operated such that there are no adverse downstream or upstream impacts (i.e., flooding will not be any worse than what existed
before the project). A rendering of the proposed permanent pump station and tide gate is shown in Figure ES-7.

**Figure ES-7: Rendering of Proposed WW Permanent Pump Station and Tide Gate**

In addition to these three major elements (BERM-POND-PUMP), storm drain pipe improvements are also required. The storm drainpipes are needed to convey stormwater from the upper reaches of the watershed, along the streets, and from properties to the mainline channels and storage areas in a timely and efficient manner. The existing storm drain system throughout this area is undersized and/or non-existent.

It should be noted that the storm drainpipes assist in mitigating street flooding for the 10-year and smaller storm events but have little to no impact in mitigating structural flooding during more extreme events. It is the combination of the tide gate, pump station, and increased storage that provides the greatest structural flood mitigation benefit to the project area.

The major stormwater improvements recommended for the Windsor Woods area are noted below. Improvements should be constructed in sequence to achieve the greatest flood mitigation benefit. See Figure ES-8 for a map showing project locations.
PER Recommended Improvements:

- Construct a Tide Gate at Thalia Creek with an Interim (50 cfs) Pump Station;
- Dredge Thalia Creek and connect Lake Windsor to Lake Trashmore;
- Construct a 750-cfs Permanent Pump Station at Lake Windsor to replace the Interim Station;
- Install Flood Barriers along South Boulevard; and
- Construct Storm Drain Pipe Improvements throughout the project area.

The first major project proposed is the installation of the Tide Gate at Thalia Creek. As previously discussed, eliminating the effects of the tide increases available stormwater storage capacity. Ultimately, a 750 cfs pump station is recommended at Lake Windsor to serve the Windsor Woods project area. However, in the meantime, an interim (50-cfs) pump station is recommended to be installed at the same time the tide gate is constructed. The 50-cfs interim pump station provides intermediate flood alleviation until such time that funding is available to connect Lake Windsor to Lake Trashmore and construct the permanent pump station.

The ultimate 750-cfs pump station will allow City Operations to fully utilize the storage behind the gate in Lake Windsor and Lake Trashmore and provide further control over lake water levels during a storm event. The ultimate pump station design will also allow the water levels to be lowered to elevation negative one-foot (−1 foot) NAVD88 prior to a storm event to increase the available stormwater capacity. This pump down elevation is only six inches lower than the normal low tide elevation during a sunny day condition and provides an additional 75 acre-feet of stormwater storage capacity. Flows from the pump station and downstream water levels will be closely monitored during operation by sensors and tide gauges both upstream and downstream. Levels will be monitored to ensure flood conditions are not any worse than what existed before the pump station and gates were installed.

Since Windsor Woods’ subdivision street development was in the 1960’s and 1970’s before today’s stormwater design standards, much of the existing storm drain pipe system is undersized or non-existent. The Mitigation Plan recommended approximately 31,000 linear feet of new pipe and culvert improvements. This PER further refined the proposed storm drain system. A constructability and cost-effectiveness review were performed to achieve the following:

- Optimize the pipe alignments;
- Minimize potential structure impacts and utility conflicts;
- Combine existing and proposed pipes where most efficient; and
- Avoid or define needed easements.

After this constructability review, the storm drain pipe network was further refined and optimized to reduce cost through an iterative process evaluating depth and duration of flooding. The resultant recommended storm drain pipe scenario is the “Refined Trunk Lines” Scenario. A total of 29,850 linear feet of new storm drain pipe is included in this alternative. The locations of the proposed storm pipe improvements and their phasing are shown on Figure ES-8.

The process of arriving at the recommended scenario can be found in Chapter 9. The proposed storm drain network consists of large diameter pipes, requiring wide trenches and heavy-duty construction equipment, as well as, extensive restoration. The construction of the storm drain pipe projects will be difficult, time-consuming and disruptive to the public. The work will primarily occur within the roadway requiring detours and will, at times, impact normal traffic patterns. The phasing plan has been developed to be the least disruptive to the public while also providing relief for the most flood-prone areas.

Table ES-1 lists the recommended infrastructure improvements for the Windsor Woods area along with their cumulative cost. Also, included is the incremental benefit in terms of street and structural flood mitigation that is achieved with the construction of each major infrastructure improvement along with the current conditions as a baseline. Currently, it is estimated that 38,060 linear feet of streets flood during a 10-year design storm and 357 structures flood during a 100-year event within the Project Area. After construction of the PER Recommended Improvements, the street flooding is reduced to approximately 954 linear feet and structure flooding to 22.

As demonstrated in the table, it is the major infrastructure improvements such as the tide gate, pump station, and additional storage that provides the greatest flood mitigation benefit. As a result, these items are recommended to be constructed first (Phase I) followed by the remaining storm drain pipe projects (Phase II). A separate Execution and Implementation Plan is under development that further outlines this phasing approach. Please see this document for further details.
## Table ES-1: Windsor Woods Incremental Improvements

<table>
<thead>
<tr>
<th>Major Stormwater Improvement Projects (Cumulative)</th>
<th>Cost (Cumulative)</th>
<th>Street Flooding (10-yr Storm)</th>
<th>Structure Flooding (100-yr Storm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Current Conditions (No Improvements)</td>
<td>$0</td>
<td>38,060 ft</td>
<td>357</td>
</tr>
<tr>
<td>Tide Gate, Interim Pumps &amp; Lake Connection</td>
<td>$12 million</td>
<td>34,460 ft</td>
<td>287</td>
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<tr>
<td>Early Storm Drain Projects</td>
<td>$27 million</td>
<td>21,120 ft</td>
<td>287</td>
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<tr>
<td>Permanent Pump Station (750 cfs) and Barriers</td>
<td>$74 million</td>
<td>19,790 ft</td>
<td>46</td>
</tr>
<tr>
<td>PER Recommended Storm Drain Pipe Improvements</td>
<td>$140 million</td>
<td>954 ft</td>
<td>22</td>
</tr>
<tr>
<td>Additional (&quot;Full Solution&quot;) Storm Drain Pipe Improvements</td>
<td>$154 million</td>
<td>170 ft</td>
<td>19</td>
</tr>
</tbody>
</table>
Figure ES-8: PER-Proposed Overall Drainage Improvements in Windsor Woods Including Storm Drain Pipe Phasing

(All elevations presented are in feet, NAVD88)
ES-4 Summary

Due to the impacts of the tide, rainfall, and low elevations, a combination of complementary infrastructure improvements (i.e., tide gate, pump station, storage, and storm drain pipes) must be implemented to achieve maximum flood mitigation benefits throughout the Windsor Woods project area. The major improvements, such as the tide gate and pump station, provide the greatest individual flood mitigation benefit in terms of structural flooding for the 100-year design storm. The storm drain pipes have the biggest impact in mitigating street flooding during the 10-year design storm.

Many of the proposed improvements, such as the gates and pump station, are costly, large in scale, and will require multi-year design and construction. The proposed storm drain pipe projects consist of large diameter pipes and are located in fully developed neighborhoods. Projects will need to be phased to allow daily access for residents, postal service, school buses, police, and other emergency services. Overall, this is a multi-year, multi-phase program to mitigate the flooding issues throughout the area. However, as each improvement is constructed, incremental benefit will be realized building to the ultimate mitigation benefit at the end of the Overall Program.

The “PER Recommended Improvements” relieve the most flooding for the lowest cost. While full flood mitigation (100% reduction) is not feasible for this area, the “PER Recommended Improvements” address a substantial portion of the flooding issues for the Windsor Woods project area. Roadway flooding is reduced by 97% (from 38,063 LF to 954 LF) during the 10-year design storm and structural flooding by 94% (from 357 to 22 structures) during the 100-year design storm. See Table ES-2 for existing and proposed flooding data.

<table>
<thead>
<tr>
<th>Condition/Scenario</th>
<th>Length of Road Flooding (10-yr Design Storm)</th>
<th>Structure Flooding (100-yr Design Storm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Existing (Current)</td>
<td>38,060 LF</td>
<td>357</td>
</tr>
<tr>
<td>PER Recommended Improvements</td>
<td>954 LF</td>
<td>22</td>
</tr>
<tr>
<td>Flood Mitigation Benefit (% Reduction)</td>
<td>97%</td>
<td>94%</td>
</tr>
</tbody>
</table>
The planning-level opinion of probable project cost for the “PER Recommended Improvements” is approximately $140 million (in 2018 dollars, without escalation).

A tentative schedule has been prepared for each major component and a detailed discussion regarding the phasing can be found in Chapter 5. However, due to the total cost of the Overall Program, a separate Execution and Implementation Plan for the Recommended Improvements is under development that further prioritizes projects in relation to available budget and flood mitigation benefits. This document will outline the next steps and strategy to effectively implement the Program, including the incremental benefits achieved as the work progresses.