

# Silverton Lake Watershed Study Cary, North Carolina

## FINAL REPORT

### Prepared For:

Town of Cary  
Town Hall – 316 N. Academy St.  
Cary, NC 27513

### Prepared By:

*Withers & Ravenel*

WITHERS & RAVENEL, INC  
111 MacKenan Drive  
Cary, North Carolina 27511

**December 2006**

W&R Project No. 02050400.12

### TABLE OF CONTENTS

1. [INTRODUCTION](#)
2. [BACKGROUND](#)
3. [METHODOLOGY](#)
4. [FINDINGS](#)
5. [ASSESSMENT OF FLOOD MITIGATION ALTERNATIVES](#)
6. [FLOOD MITIGATION APPROACH](#)

[Appendix A](#) – Exhibits from Alternative Analysis Report

[Appendix B](#) – Maps from Preliminary Report

## 1. INTRODUCTION

The purpose of this report is to investigate how mitigation of flooding from future development can be accomplished in the Silverton Lake watershed. Additionally, consideration has been given to how the mitigation alternatives from this study can be used in other similar watersheds within the Town of Cary jurisdiction. This final report is a compilation of data gathered from the preliminary and alternate analysis reports, as well as comments generated through the process of assessing this watershed. The preliminary report included 100-year flood modeling for the existing conditions, full build-out based on current zoning landuse, and full build-out based on rezoning landuse to R-8/ R-TR. The preliminary report procedures and findings are outlined in Sections 2 through 4 of this report. Existing Conditions and full build-out modeling were used to develop an alternate analysis report which assessed flood mitigation and the impacts of

development within the basin. The results from the alternate analysis report are presented in Section 5 of this report.

[Figure 1.1. Silverton Lake watershed outlined in red on 2005 aerial photograph.](#)

## **2. BACKGROUND**

The Silverton Lake drainage sub-basin is located in the Neuse River Basin and has a drainage area of approximately 440 acres. Silverton Lake is 6.7 acres at normal pool and discharges into an unnamed tributary of Crabtree Creek just north of Cary Parkway. The outfall structure is a 10 ft X 15 ft concrete riser with a 7 ft X 7 ft box culvert discharge. The watershed is currently a little more than half developed; development predominately consists of residential neighborhoods with 1/4 to 1/3 - acre lots (zoned R-8, 12, and 20). The majority of the undeveloped land within the watershed is zoned as either R-20 or 30, with a limited amount of higher density zoned development of R-12 and R-8 (less than 30 acres).

The study's downstream point of assessment is the discharge from Silverton Lake. There is no further analysis downstream of this location. There is also a 4 acre lake in the headwaters of the basin located upstream of Anna Lake Lane. This is a privately owned lake with a 15-inch concrete pipe riser outfall structure and an earthen emergency spillway. The primary tributary to Silverton Lake is a perennial stream that has one major culvert crossing at Silvergrove Drive. There are two other major culvert crossings on the secondary tributaries that cross Stromer Drive.

Two areas within the Silverton Lake watershed are currently under development. A town house community located in the extreme southern headwaters of the watershed is near completion; designated as Portrait Homes – Northwoods Crossing (zoned R-TR). The other area is still under construction and is located in the center of the watershed, adjacent to the primary tributary. This development is being developed by Providence Builders of the Triangle (zoned R-12Cu); the impacts of this development are assessed in Section 5.

## **3. METHODOLOGY**

The watershed study was conducted using the combination of natural drainage features as depicted by the Wake County aerial topographic information (2-ft contours), field survey data, and existing and future development within the watershed. The scope of work included the following analyses:

### Drainage Basin Delineation

- The Silverton Lake drainage basin was divided into 16 sub-basins.

### Hydrology

- Hydrology was determined for the existing and future conditions.
- The SCS Method was used to develop runoff hydrographs for the 24-hour duration, 2-year, 10-year, 25-year, and 100-year rainfall events for the Cary area.
- Pond Pack software was used to formulate the 2-year, 10-year, 25-year, and 100-year flood hydrographs for the existing and future condition within the drainage areas.
- Curve Numbers (CN) were based on soil types and land use. Soil types were delineated from the Soil Survey of Wake County, North Carolina (November 1970).
- Time of concentration ( $t_c$ ) was calculated using methods described in the SCS publication "Urban Hydrology for Small Watersheds, TR-55" and based on existing and future conditions.
- The Pond Pack input and output for runoff hydrographs are in the Appendix.

### Pond Routing

- ❑ Silverton Lake and Anna Lake within the basin were modeled and routed using Pond Pack software (existing and future conditions).
- ❑ The stage-storage curves were developed using available LIDAR information.

### HEC-RAS Studies

- ❑ Geometry files were developed from a combination of LIDAR topography and 13 field surveyed cross-sections of the stream bed.
- ❑ Using the hydrology and pond routing data, water surface profiles for each of the referenced storms were generated for the primary water course draining into Silverton Lake and 6 of its tributaries.

### Field Survey

- ❑ Stream bed cross-sections, 13 total.
- ❑ The outlet structures for Silverton Lake and Anna Lake.
- ❑ Two culvert crossings on Stromer Drive and one on Silvergrove Drive.
- ❑ Finished floor elevations on 51 structures (each structure's air conditioner unit's floor elevation was also surveyed).
- ❑ Over 90 notification letters were mailed to property owners that could potentially be impacted by the field surveys.

The information described above was compiled in order to assess existing flood-prone properties, future flood-prone properties based on development, and 2 lake outflow structures (maps were compiled from the floodplain modeling results for three different scenarios). The different floodplain conditions that were modeled are:

1. Existing Floodplain Condition: Using a combination of 2005 aerial photography and field reconnaissance the current condition of the Silverton Lake drainage basin was modeled.
2. Future Build-out Condition based on current zoning: The current zoning information was obtained from the Town of Cary's GIS database. Curve Numbers for the undeveloped areas within the Silverton Lake watershed were altered in the hydrologic model to match the current zoning designation.
3. Future Build-out Condition based on development with higher densities than the current zoning: The majority of the undeveloped areas were zoned as R-20, 30 and 40 (the R-30 designation is the most predominant). It may be reasonable to assume that the remainder of the undeveloped basin could be rezoned to R-8, 12, or TR. In order to assess the possible worst-case scenario considering re-zoning, Curve Numbers that represent higher density residential development were assigned to all of the undeveloped areas (1/8 acre lot/town home developments; 65% impervious). Applicable time of concentrations were also increased accordingly. Additionally the attenuation impacts from the upper pond were not considered.

[The 100-year water surface elevations or base flood elevation (BFEs), the delineated floodplains, and the finished floor elevations and air conditioning unit base elevations for flood prone properties are shown on the attached maps in Appendix B – Preliminary Report.] The hydrologic and hydraulic computer files are included on a CD in the Appendix of this report.

#### **4. FINDINGS**

In Appendix B there are 3 – 11 X 17 and 2 – 8½ X 11 maps which show the results of the preliminary study. The first map is a “map-key” which shows the location of 4 areas of interest. Maps 2 – 5 show the areas at a reduced scale. There are also 24 X 36 maps produced for the 3 development scenarios. Maps 6 – 8 are 100-year floodplain delineations, base flood elevations, and the finished floor elevations for flood-prone properties.

The maps depict that the majority of the potential impacts are to the south or upstream of Silverton Lake.

#### **5. ASSESSMENT OF FLOOD MITIGATION ALTERNATIVES**

This section was developed during the alternative analysis phase, and was used to address and understand specific areas of interest within the Silverton Lake watershed. Section 6 will address alternative methods for approaching mitigation of flooding from future development in more detail. The flood mitigation assessment in this section included the location and sizing of retro-fitted stormwater detention basins, modifications to existing structures, an analysis of the flooding impacts from current development projects, and recommendations of requirements that should be placed on future development within the Silverton Lake drainage basin.

##### 5.1 Silverton Lake Spillway Alterations

In order to evaluate impacts to the current flooding conditions contributed by Silverton Lake and to assess potential flood mitigation alternatives, the Silverton Lake spillway was altered in the hydraulic models by decreasing the spillway elevation by one and two feet. Exhibit #1 in Appendix A shows the changes that result to the floodplain by lowering the spillway.

Removing the Silverton Lake spillway was also evaluated. By using 1995 topographic data and the design of a conventionally sized culvert under Cary Parkway, the Silverton Lake area was modeled as if the current spillway configuration was never constructed. The purpose of this scenario was to estimate how the floodplain would function without the downstream impact of Silverton Lake. Exhibit #1 in Appendix A shows the estimated floodplain without the impacts of Silverton Lake.

The results of the alterations and removal of the Silverton Lake spillway suggest that the backwater impacts to the upstream floodplain caused by Silverton Lake are limited to the properties along New Rail Drive, specifically properties that are towards the end/cul-de-sac (near 421 New Rail Drive). The approximate Silverton Lake backwater tie-in point is shown on Exhibit #1 in Appendix A; the hydraulic models suggest that Silverton Lake does not significantly impact flooding upstream of the tie-in point. Therefore, altering the Silverton Lake spillway is not a relevant flood mitigation alternative because impacts are isolated to the vicinity of the lake’s footprint, and the backwater from the lake does not breach the surrounding structures.

##### 5.2 Stormwater Detention within the Silverton Lake Drainage Basin

The upper portion of the Silverton Lake drainage basin was assessed to determine the feasibility of constructing a detention basin for the purposes of reducing the 100-year flooding peak discharges. It was concluded that the most feasible location for a basin was at the northern edge

of the property owned by the Raleigh Chinese Christian Church. There is an existing small stormwater dry detention basin located in this area ([Figure 5.1](#)).

The detention pond would capture and detain 100-year flood discharges produced by current and new development within the upper portion of the Silverton Lake drainage basin. The pond would detain discharges from the Raleigh Chinese Christian Church, the newly developed Portrait Homes Northwoods Crossing Development, and future development in the adjacent upstream properties.

The proposed detention pond would decrease the 100-year backwater at the Silvergrove Drive culvert crossing by approximately 2 feet, and help control the flooding impacts produced by future development in the upper sections of the drainage basin. Downstream of the Silvergrove Drive culvert the impacts of the detention pond are not as significant; the existing 100-year floodplain would be reduced by approximately 3 to 6 inches. The changes to the 100-year floodplain resulting from the proposed detention pond are shown on Exhibit #2 in Appendix A. The issues of easement ownership, funding, and maintenance responsibilities have not been addressed in this report, but will need to be investigated if this alternative is pursued further.

[Figure 5.1 Silverton Lake watershed outlined in red; possible detention pond in yellow.](#)

### 5.3 Impacts of Current Construction

The impacts to the 100-year floodplain from the area being developed by Providence Builders of the Triangle that is currently under construction within the drainage basin were assessed. The land use alteration as a result of the development area shown in [Figure 5.2](#) was incorporated into the hydraulic and hydrologic models.

The assessment suggests that the development shown in Figure 5.2 has minimal impact to the adjacent floodplain. The development area (5.8 acres) is 3.3% of the drainage area that contributes to the floodplain adjacent to the property (176.5 acres), and is 1.3% of the entire Silverton Lake drainage basin (440 acres). As a result, development within the highlighted area causes less than a 0.1 foot change to the 100-year floodplain elevation along the stream adjacent to the property down to Silverton Lake.

[Figure 5.2 Silverton Lake watershed outlined in red; current construction in yellow.](#)

### 5.4 Future Development

The areas shown in yellow on Figure 5.3 are locations that could potentially be developed or are currently under development. It is evident from the preliminary findings that future development could have a notable impact to the 100-year floodplain (see the maps in the appendix that are referenced in the Section 4, *Findings*). The most dominant impacts from increased flows will be realized at the culvert crossings, specifically the Silvergrove Drive and Stromer Drive crossings. Potential development that occurs downstream of these crossings will affect the 100-year floodplain mostly in the immediate vicinity of the Silverton Lake limits, and will be less invasive to properties along the primary and secondary tributaries.

Future development projects that take place upstream of Silvergrove and Stromer Drives should include an assessment of the impacts to the 100-year floodplain caused by the proposed

development. The need for attenuation of the flood discharges and improvements to downstream culvert crossings should be studied on a case by case basis, specifically during the preliminary site plan approval stage.

By improving the Silvergrove and Stromer Drive culvert crossings ahead of future development, notable increases to the 100-year backwater could be mitigated. In some instances the need for culvert improvements could be nullified through attenuation of the flood discharges. Section 6 will address alternative methods for approaching mitigation of flooding from future development in more detail.

**Figure 5.3 Silverton Lake watershed outlined in red; potential future development areas in yellow.**

**5.5 Assessment Conclusion**

The results of this assessment suggest that the increase to the 100-year floodplain elevation caused by Silverton Lake is isolated within the approximate vicinity of the lake's footprint; the impacts of the lake extend approximately 300 feet upstream of the normal pool footprint. The 100-year floodplain that is upstream of the Silverton Lake backwater tie-in point is a normal functioning floodplain that is not significantly encumbered by downstream impacts, but is influenced by the localized floodplain's shape, character, and the contributing watershed's runoff.

It is anticipated that the notable flooding problems from future and current development will occur at the Silvergrove and Stromer Drive culvert crossings. These potential issues should be addressed on a case by case basis, and should be mitigated by either improvements to the culvert crossings or attenuation of the 100-year discharge at new developments upstream of the crossings. It is important to note that attenuation of the 100-year discharge upstream of the Silvergrove and Stromer Drive culvert crossings will not significantly decrease the existing 100-year floodplain elevation downstream of the crossings. A significant amount of pond storage volume/area would be required in the upper extents of the drainage basin in order to decrease the existing 100-year floodplain substantially (1 to 2+ ft) downstream of the culvert crossings; due to the limitation of available land this is not a feasible alternative. The next section will address ways to maintain the existing flooding conditions when upstream development occurs.

**6. FLOOD MITIGATION APPROACH**

The final purpose of this report is to investigate not only how mitigation of flooding from future development can be accomplished in the Silverton Lake watershed, but how the findings of this report can be related to other watersheds of similar character. Current Town ordinances mitigate future drainage issues by maintaining that new development is not allowed within the 100-year floodplain. Furthermore, floodplains for smaller streams are often located well within the riparian buffer limits (50 ft to 100 ft on either side of the stream); resulting in new development that is located well outside the flood prone areas of the adjacent watercourses. These current ordinances help to minimize flooding problems for new development within a partially developed basin, but they don't address the potential flooding problems that may occur to existing downstream properties caused by the increased runoff from the new development. Since the Town's floodplain and riparian ordinances recently became active within the last 10 years, there are many pre-ordinance residential structures that were constructed within flood prone areas. The Silverton Lake watershed is representative of a typical local watershed in that it has a high percentage of residential structures that were constructed in the 1980's and 90's before the current ordinances, but still maintains space for future development (see Figure 4). Currently the Town

mandates detention of the 1-year, 24-hour storm for water quality purposes, but does not have any requirements for the higher flood flows. This section will address issues associated with an appropriate design storm used for floodplain management in a partially developed basin, and what techniques can be used to mitigate flooding to existing properties caused by future development.

## 6.2 Flood Reduction Approach

Three methods for controlling the flood impacts caused by new development have been assessed in this report; when the contents and detail of this watershed study permitted, they were applied to the Silverton Lake watershed. The concepts of volume-based runoff control, peak flow attenuation, and the watershed study approach are outlined in the following sections.

### 6.2.1 Volume-based Runoff Control and Low Impact Development

Conventional stormwater management usually incorporates detention devices in order to reduce the peak flow, resulting in a design in which the targeted post-development discharge is the same or less than the pre-development discharge. This technique is effective at reducing the targeted peak discharge, but it can increase streambank erosion and degradation by increasing the duration of the peak discharge through elongation of the outflow hydrograph. As a result, other approaches that move away from peak flow control and focus more on volume control are becoming more widely accepted and encouraged. Volume-based runoff control procedures are also considered to be an ecologically friendly solution to stormwater management because it encourages infiltration and transpiration, which are two very important components of the natural hydrologic cycle that are often negated following urban development. The concept of volume control is often achieved through low impact development (LID) design techniques.

Low impact development (LID) stormwater management employs alternative methods from conventional practices that can replace or compliment peak discharge stormwater management. Conventional stormwater management encourages collecting runoff from a site and conveying it off-site or to a detention device by channel or pipe in the shortest amount of time possible. Any reduction in peak flow takes an “end of pipe” approach with conventional stormwater management. The phrase “low impact development” was coined by the Maryland Department of Environmental Resources and Prince George’s County when they developed an alternative program to address stormwater management. The goal of low impact development is to manage the runoff at the source as opposed to the end of the pipe as in conventional stormwater management. The approach is to reduce impervious surface, conserve natural resources, maintain natural drainage courses, reduce use of pipes, disperse stormwater as opposed to concentrating it and minimize clearing and grading. As a part of the methodology runoff storage measures are dispersed uniformly throughout a site’s landscape with the use of a variety of detention, retention, and runoff practices.

Volume control is effective at reducing and controlling the lower flow storms that can impact water quality. Volume control can also be used for peak flow management of higher discharge storms, but it is not always the most ideal and feasible solution. In order to manage peak flow and volume simultaneously, both the curve number and time of concentration must be controlled. The pre and post development time of concentrations must be approximately equal. Such time of concentration alterations can be achieved through the use of grass swales, check dams, conservation of natural areas, and the encouragement of sheet flow.

Since volume-based runoff control as a method for stormwater management is very site specific, an example was not applied to the Silverton Lake watershed. Furthermore, the current character of the development within the Town does not support low impact development principles. For example, most developments have lots that are less than ¼ acre, and usually curb and gutter style drainage is required. Presently, volume-based runoff control techniques are not the most feasible option for flood reduction within the Town limits. Additionally, long term operation and maintenance on the required site by site basis could present a whole new set of challenges for the Town's Utility Department. However, it is worth mentioning in this report because low impact development principles are already being affectively implemented by other municipalities, and most regulatory agencies are very much in favor of the ecologically friendly design techniques.

### 6.2.2 Site Specific Peak Attenuation

The traditional stormwater management approach of peak discharge attenuation was also examined for the Silverton Lake watershed. The thought process for this approach is that by controlling the post development peak discharge leaving a site, the existing downstream flooding conditions will not be impacted. This peak attenuation technique only looks at the site discharge point and not the impacts to the whole drainage basin. The future development conditions based on the Town's current zoning were applied to the areas shown in yellow on Figure 6.1. The amount of storage and subsequent pond area required to match pre and post-development 10-, 25-, and 100-year discharges were determined for each sub-basin. Figure 6.1 shows the approximate location of each pond area and Table 6.1 shows the corresponding storage values.

**Figure 6.1 – Potential future development areas shown in yellow and potential peak attenuation locations are shown in red. The pond areas shown above are scaled to represent the total estimated surface area required to detain the 100-year storm in each sub-basin. Depending on the actual development designs, the surface area could potentially be divided and distributed into several smaller basins within each development area.**

#### **Table 6.1**

Attenuation of the 10-, 25-, and 100-year peak discharges adequately maintained the pre-development flooding condition within the Silverton Lake watershed for each return event. However, this could only be verified by modeling how each impoundment interacted with the timing of the whole watershed and its sub-watersheds. Requiring peak flow attenuation is a simplistic way to locally reduce flooding discharges; it can easily be applied to all new development in a blanket fashion. The negative is that a downstream watershed analysis can sometimes show that the detention facilities are not always necessary, and as Table 6.1 shows, peak attenuation can require a large amount of volume and area. Specifically take note of Area 8 in Table 6.1, this consists of a woods pre-development condition and a higher density urban type post-development condition. Area 8 is more representative of Town development than the other Silverton areas, because most of the current zoning that the future development was based on consists predominately of R-30 (approximately 1/2 acre lots).

As previously stated above, requiring peak flow attenuation for all development is not an ecologically friendly solution to stormwater management because it can cause stream degradation and does not facilitate groundwater recharge (related to stream baseflow). Also in order to ensure that peak flow attenuation is actually reducing downstream flooding, the impacts to the downstream watershed need to be assessed.

### 6.2.3 Watershed Approach

Some communities use a watershed approach when assessing the need to mitigate flooding caused by future development. This approach requires the study of how proposed development impacts downstream flooding within the watershed. If the new development increases flooding then steps must be taken in order to mitigate the flooding. This solution provides basin wide accountability and responsibility for increased runoff that is contributed to the watershed from new development.

One way to accomplish the watershed approach would be by creating and maintaining specific watershed models for basins in the Town that have at least 20% to 30% of undeveloped land or specific watersheds that are already experiencing flooding problems (similar to the method followed for this watershed study). A hydraulic (HEC-RAS) and hydrologic (HEC-HMS) model would be created and maintained for the watersheds, and each proposed development would be incorporated into the models. Should it be determined that the development caused a notable increase in downstream flooding, then peak flow attenuation, volume-based runoff control, and/or another recognized technique may be used to match downstream pre-development flood conditions. The flood studies being developed by Dewberry for the Town would be a good starting point for implementing this concept. It is assumed that the flood studies have been designed using the hydraulic and hydrologic modeling techniques mentioned above, and the models could be amended with new development as it occurs. The Town would maintain the master models and the proposed development petitioner would be responsible for properly updating the model. Depending on how many watersheds the Town is planning to study for flooding, it is possible that the majority of the pre-development flood models needed for a watershed based approach could already be in place. This Silverton Lake watershed study could be used in the same manner.

Another and more simplistic way to achieve the watershed approach is to require that each new development submit a stormwater impact analysis report. The purpose of this report is to show how the new development will impact downstream flooding; the results of this analysis will dictate if flood detention is required. If flooding is increased, specifically at existing culvert crossings, then detention is required. The stormwater control measures should be included in the analysis model to verify that flooding has been mitigated or that any flood increases do not adversely impact the downstream properties. A possible stormwater impact analysis strategy is shown (Figure 6.2) for two of the potential future development areas within the Silverton Lake watershed. The proceeding sections of this watershed study have shown that the future flooding problems will first occur at the Silvergrove and Stomer Drive crossings. As a result, the impacts of the new development at Areas #2 and #6 to the downstream flooding should be quantified at the analysis points or problem areas. In other words, the stormwater management devices at Areas #2 and #6 should be designed in order to maintain the existing flooding conditions at the analysis points instead of the site discharge points. Even without the information obtained from this watershed study, the future development impacts to downstream culvert crossings should be assessed for the purposes of the impact analysis approach. Many of the decisions and design requirements for this approach would be at the discretion of the Town's engineers.

#### **Figure 6.2 – Example stormwater impact analysis point locations relative to new development**

Specific design storm and detention requirements for this technique, as well as the other methods mentioned above, could be decided with stakeholder input.

### 6.3 Design Storm

In order to measure impacts and to properly mitigate flooding caused by future development, a targeted design storm(s) must be designated. The design storm should be high enough that it is an out-of-bank flood for almost all conditions. The 2-year storm breaches the channel bank limits in most instances, but it is usually not significant enough to cause flooding problems. In some urban streams, the 2-year storm does not leave the banks because of channel alterations such as channelization and/or downcutting which results in incision. Furthermore, most development within the Town is already required to detain the 1-year, 24-hour storm for water quality purposes. The 10-year storm is a significant out-of-bank flood, but the 25-year storm may be more practical since most culvert crossings are designed to convey this storm. The majority of flooding problems may be attributed to culvert crossings, and when additional flow is added to existing culvert crossings the flooding issues are often magnified. For example, future development causes the 25-year storm to increase the water surface elevation upstream of the Stromer Drive culvert crossing by approximately 1.7 ft; the elevations only increase approximately 0.3 ft downstream of the crossing. A culvert crossing that is properly designed using the 25-year storm should pass the 2-, 5-, and 10-year storms with minimal backwater. The 10-year water surface elevation upstream of the Stromer Drive culvert crossing increases approximately 1.3 ft from the impacts of future development, but the rise to the 10-year water surface elevation makes it approximately equal to the existing/ pre-development 25-year water surface elevation. A stormwater management device that manages both the 1-year and 25-year, 24-hour storms may also control the storms in between in most instances.

In order to ensure that future development does not increase the existing 100-year floodplain elevations, management of the pre- and post-development 100-year discharges may be necessary. This alternative would require more storage volume and a large impoundment area, which may or may not be practical. Also, in addition to the 100-year, the 25-year storm should be controlled for the purposes stated above. It is possible that a stormwater management device that controls the 1-year and 100-year, 24-hour storms will also control the 25-year storm, but this would need to be studied on a case by case basis.

Before determining the flood control design storm and the required approach, further analysis should be done and stakeholders petitioned. Specifically, the assessment should include examples that maintain a greater difference in the pre- and post-development landuse characteristics than the Silverton Lake watershed. Stakeholder input should also be solicited during the decision phase. If only the 25-year design storm is used, then stakeholder and Town input will be crucial in determining if and how much of an increase is permissible to the 100-year floodplain elevation.

# **APPENDIX A**

## **EXHIBITS: ALTERNATIVE ANALYSIS MAPS**

### **Exhibit 1**

## **[Exhibit 2](#)**

# **APPENDIX B**

## **FLOODPLAIN MAPS**

### **From Preliminary Report**

**[Map 1](#)**

**[Map 2](#)**

**[Map 3](#)**

**[Map 4](#)**

**[Map 5](#)**

[Note: The following maps are very large files and may be slow to download.]

**[Existing Condition Floodplain](#)**

**[Future Condition Floodplain](#)**