US 83 / ND 1804 WATERSHED

For

Bismarck

City of Bismarck, ND

STORMWATER MASTER PLAN REPORT

March 2013

AE2S Project #: *P00501-2012-05*

US 83 / ND 1804 WATERSHED

STORMWATER MASTER PLAN REPORT

Bismarck

March 2013

I hereby certify that this report was prepared by me or under my direct supervision and that I am a duly Registered Professional Engineer under the laws of the State of North Dakota.

Jeffrey M. Hruby, PE

Date: 3/22/2013 Reg. No. PE-5403

REGISTERED PROFESSIONAL ENGINEER
JEFFREY M. HRUBY
PE-5403
DATE 3/22/13
NORTH DAKOTA

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JLG Architects

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EXECUTIVE SUMMARY

Project Background

Bismarck is experiencing significant development pressure along the U.S. Highway 83 (US 83) corridor with substantial development being discussed around the intersection with ND State Highway 1804 (ND 1804). The City, recognizing the development pressure, commissioned preparation of a stormwater master plan for approximately 1900 acres located within the Hay Creek watershed and adjacent to the intersection of US 83 and ND 1804 (***Figure ES-1***). The US 83 / ND 1804 Watershed Stormwater Master Plan acts as a stormwater management and drainage guide for the City, landowners, and developers as the watershed develops.

Existing land use within the watershed is primarily agricultural and rural residential. The regional land use plan adopted by the City calls for the area to be developed as a mix of commercial, mixed use, and urban residential, with higher density land uses adjacent to US 83 (***Figure ES-2***). The proposed development within the watershed will result in a substantial increase in impervious surfaces (roofs, roadways, and parking lots), generating significantly higher stormwater runoff rates and volumes. Peak flow at the downstream end of the watershed would see an increase in peak flows in the 2-year storm from 18 cubic feet per second to 283 feet per second and an increase in the 100-year storm from 355 cubic feet per second to 526 cubic feet per second without stormwater management features.

Master Plan

The City of Bismarck Code of Ordinances requires that increased stormwater runoff from development be controlled such that post-development runoff rates for the 2-year, 10-year, and 100-year rainfall events match existing runoff rates. The City typically utilizes a regional management approach for meeting these stormwater management requirements wherein stormwater management features are constructed, owned and maintained by the City and construction costs are assessed to benefited properties within the watershed. Multiple alternatives were developed and reviewed with the City Working Group, including alternatives that require that the highest density land uses partially mitigate for increased runoff volumes by utilizing on-site volume reduction practices. Ultimately, the City Work Group developed a stormwater master plan that mitigates for the increase in runoff rates through the following management practices:

- Construction of 167 acre-feet of new detention storage through the use of five valley storage facilities and three graded detention facilities distributed throughout the watershed (***Table ES.1***). Valley storage detention facilities are created by constructing an embankment, typically located at a future road crossing, and utilizing the existing natural storage within the upstream valley. Graded facilities involve creation of the storage within a detention facility by mass earthwork. Detention basins were limited to less than 25 acre-feet of storage so that they would not trigger regulation as a medium or high hazard dam.
- Incorporating the existing regional detention basins located within Northridge Estates.

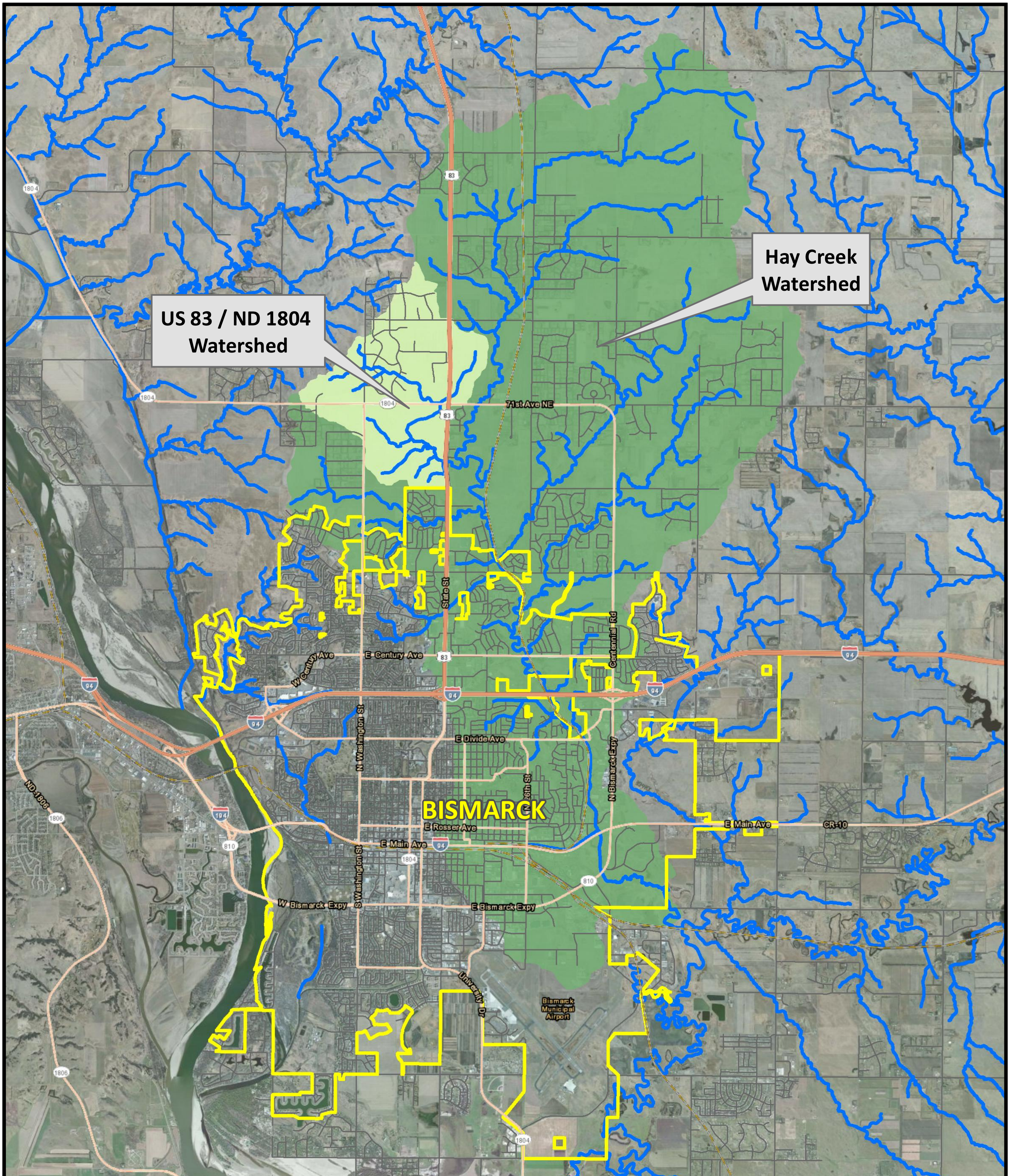

Figure ES-1 Project Location

US 83/ND 1804 Stormwater Master Plan

City of Bismarck, ND

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0 4,000 8,000 Feet

1 in = 8,000 feet

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Hay Creek Watershed

US 83 / ND 1804 Watershed

Hydrography

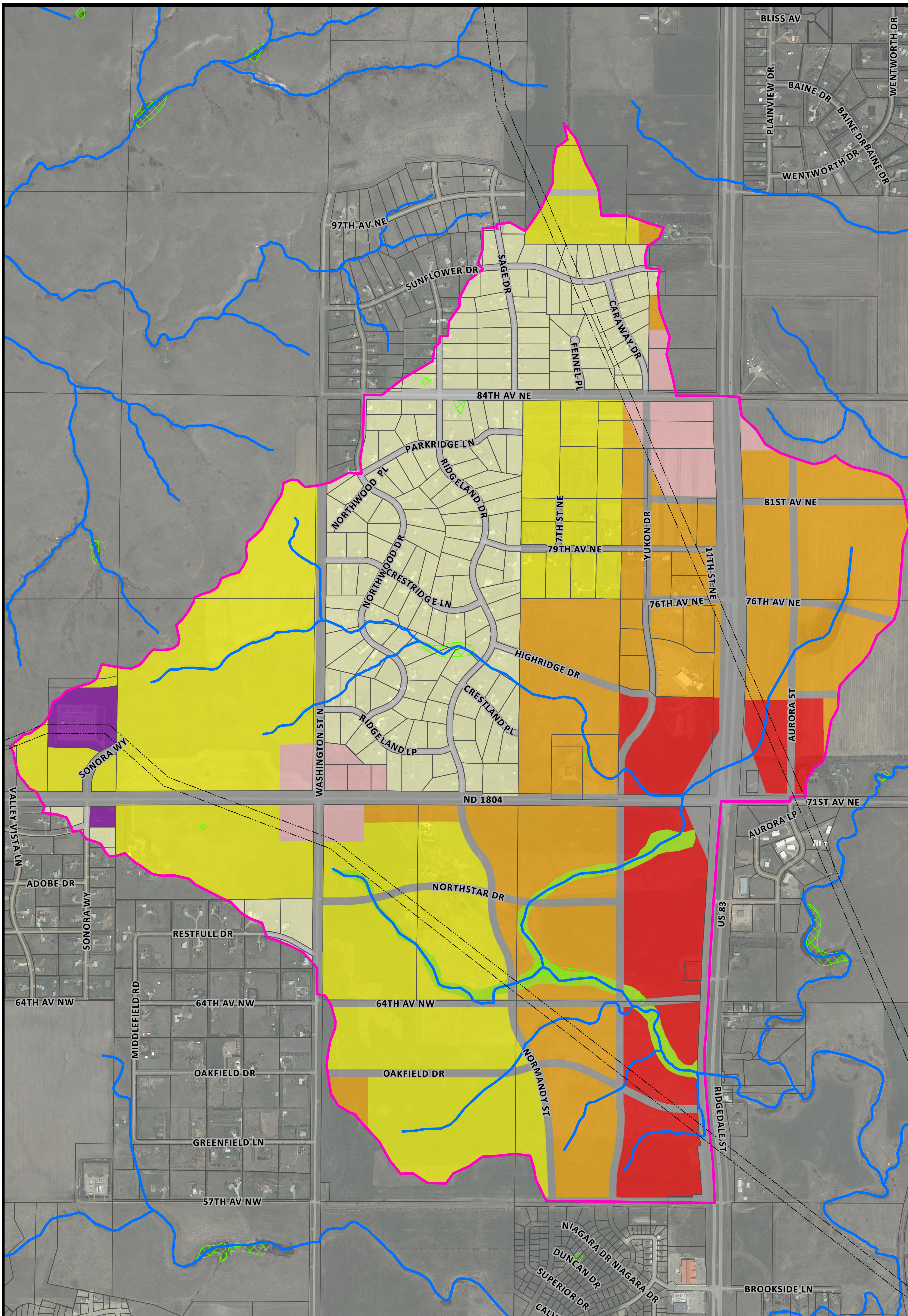
City of Bismarck

Developed by: Danielle Lee | 03/21/2013

Coordinate System: ND State Plane South

Vertical Datum: NAVD88

Metadata Included in the Report



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1 in = 1,200 feet

Figure ES-2 Future Land Use

US 83/ND 1804 Stormwater Master Plan

City of Bismarck, ND

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- US 83 / ND 1804 Watershed
- Hydrography
- National Wetlands Inventory
- Parcels
- Transmission Line Corridor
- Commercial
- Neighborhood Commercial
- Mixed-Use
- Urban Residential
- Rural Residential
- Open Space
- Urban ROW
- Rural ROW
- Transportation/Infrastructure

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- Requiring on-site detention facilities in key locations upstream of existing rural residential development so as not to increase local drainage and flooding issues.
- Modifying key roadway culverts and roadway profiles to meet level of service requirements.
- Requiring that new developments exceeding the maximum assumed impervious percentages provide on-site stormwater management to mitigate the increased runoff rates for the 2-year, 10-year, and 100-year storms and increased runoff volume for the 2-year storm.

Figure ES-3 illustrates the master planned improvements for the US 83 / ND 1804 Watershed.

Table ES.1 Summary of Master Plan Detention Basin Geometry

Basin Name	Basin Type	Maximum Storage[1] (acre-feet)	Maximum Area[1] (acres)	Bottom Elevation (NAVD 88)	Overflow Elevation (NAVD 88)
Northern Washington	Valley	12.0	4.1	1885.0	1892.6
Southern Washington	Graded	15.6	3.2	1866.0	1872.0[2]
Northern Yukon	Valley	24.8	9.0	1838.1	1847.2
1804	Graded	15.8	2.3	1830.25	1841.0
Northstar	Valley	24.7	6.3	1816.7	1827.4
Southern Yukon	Valley	24.8	7.6	1807.0	1816.8
Northern US 83	Graded	24.5	10.2	1833.0	1837.9
Southern US 83	Valley	24.8	6.1	1799.0	1809.9
Total		167.0	48.8		

1 - Maximum storage and area are based on the overflow elevation.
2 – Overflow elevation may be higher by approximately 6-12” if the overflow is incorporated into the North Washington Street embankment.

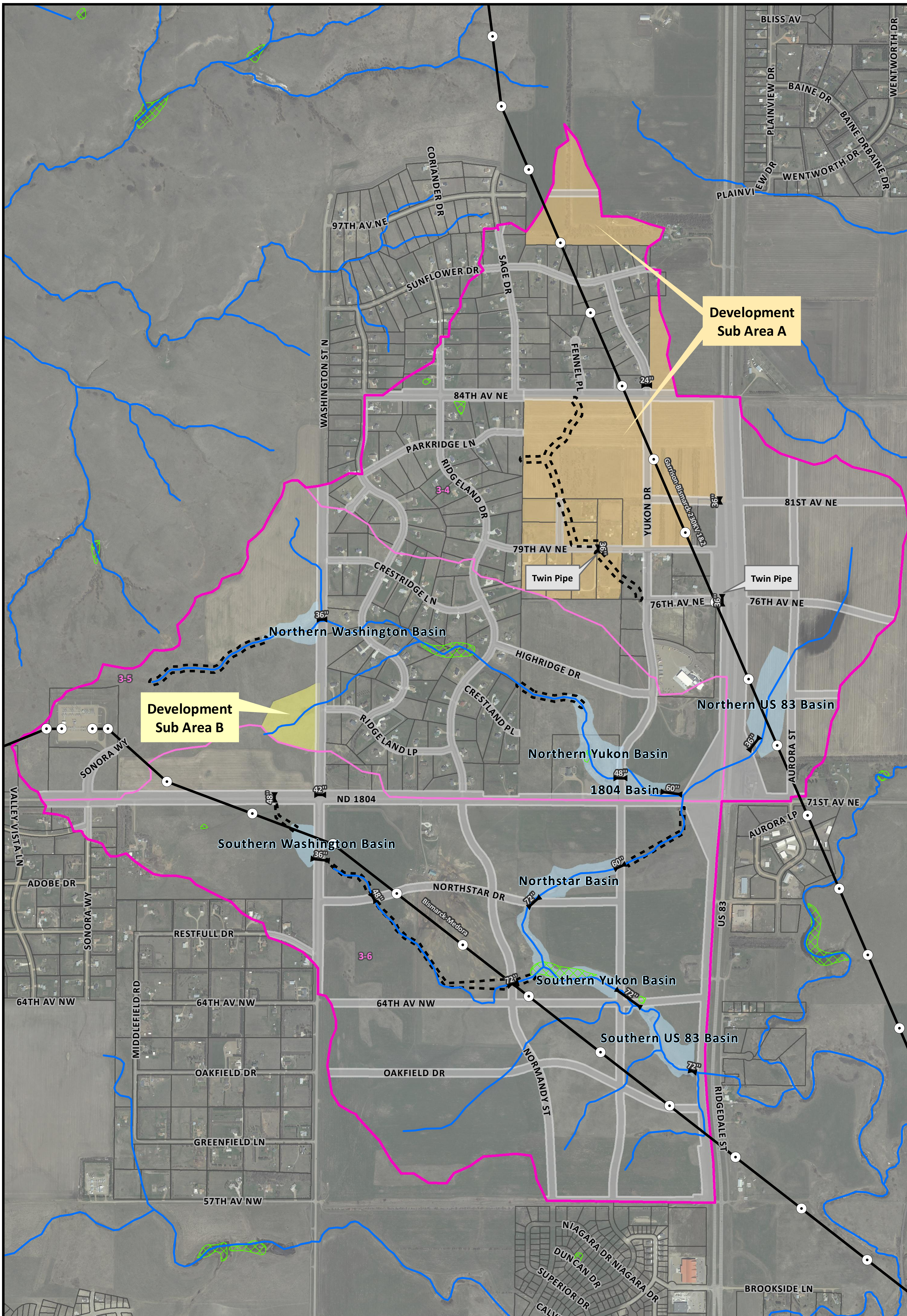

Figure ES-3 Master Plan

US 83/ND 1804 Stormwater Master Plan

City of Bismarck, ND

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Legend		
US 83 / ND 1804 Watershed	Future Road ROW	WAPA Transmission Lines
Hay Creek Subwatersheds	Basin Footprints	WAPA Structures
Hydrography	Conceptual Drainage Easements	
National Wetlands Inventory	Proposed Culvert	

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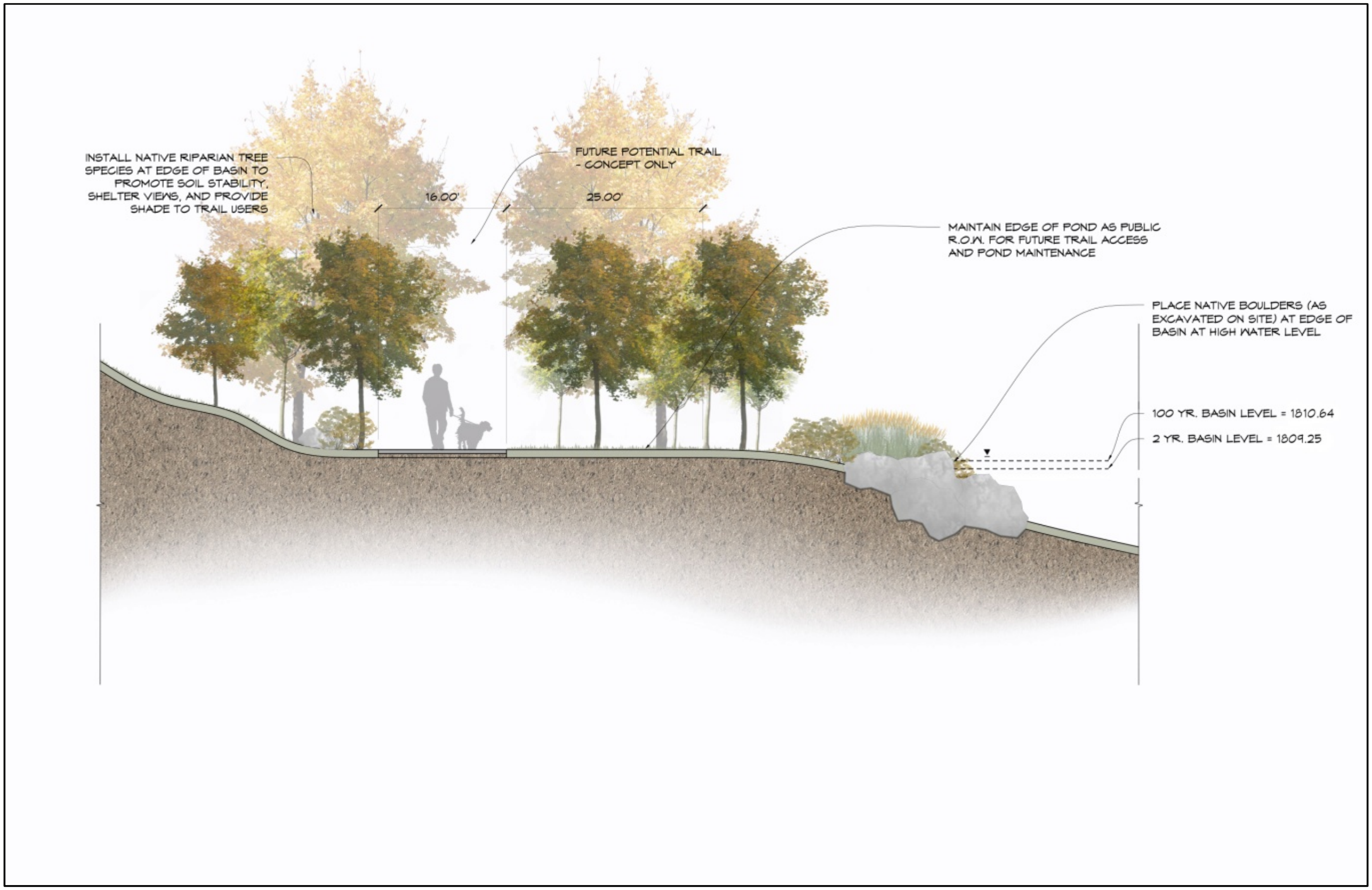
Landscape Considerations

Since the US 83 / ND 1804 watershed is adjacent to the main northern gateway into the City of Bismarck, the Master Plan includes landscape considerations for constructed facilities and a specific concept for the detention facility located adjacent to US 83 south of the intersection with ND 1804. Many of the basins are located within the open space corridor in the adopted regional land use plan and as such provide an opportunity to integrate stormwater management with overall green space aesthetics and recreational opportunities. Specific to the Southern US 83 Basin, the location allows for the ability to work with the surrounding terrain to create a unique landscape and recreational element along the US 83 gateway with the dual purpose of providing stormwater management (***Figures ES-4 & ES-5***).

Figure ES-4 Southern US 83 Basin Concept Landscape Plan

Figure ES-5 Southern US 83 Basin Concept Landscape Section



Opinion of Probable Costs

Opinions of probable costs were developed for each of the regional facilities incorporated into the master plan (***Table ES.2***). The total opinion of probable cost for construction of the proposed facilities is $14,179,695, which includes $10,245,700 for anticipated land acquisition costs at an assumed property valuation of $4 per square foot. The estimated residential assessment for improvements is $7,130 per acre and the estimated non-residential assessment for improvements is $14,260 per acre.

Table ES.2 Summary of Opinion of Probable Costs

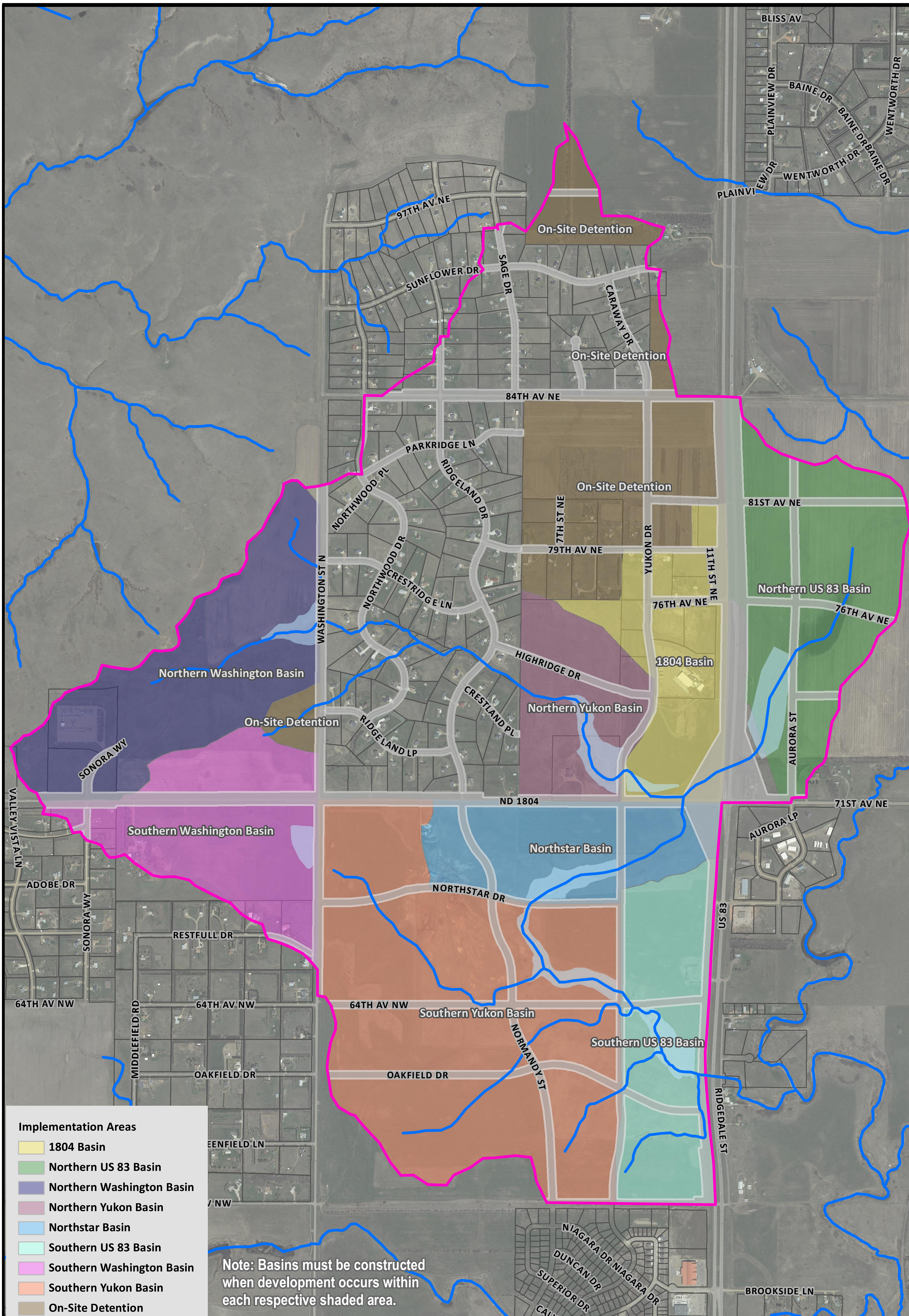
Regional Facility	Design and Construction Cost[1]	Land Acquisition Cost	Total
Southern US 83 Basin	$335,385	$1,515,900	$1,851,285
Southern Yukon Basin	$246,065	$1,568,200	$1,814,265
Northstar Basin	$300,585	$1,289,400	$1,589,985
Northern Yukon Basin	$293,190	$1,620,500	$1,913,690
1804 Basin	$609,290	$453,100	$1,062,390
Northern US 83 Basin	$936,555	$2,195,500	$3,132,055
Southern Washington Basin	$911,905	$575,000	$1,486,905
Northern Washington Basin	$152,685	$819,000	$971,685
Southern Washington Swale	$148,335	$209,100	$357,435
Total	$3,933,995	$10,245,700	$14,179,695

1 – Includes a 15% estimating contingency and 30% for Engineering and Administration

Conclusions

An implementation plan has been developed to balance capital outlays with proposed development patterns (***Figure ES-6***). Key triggers for construction of regional facilities include development within the areas noted and/or construction of roads that will ultimately be located along embankments for regional detention facilities.

This Master Plan meets City requirements for stormwater management given the proposed land use plan currently adopted by the City. Modifications of the proposed land use plan, including changes to the planned US 83 / ND 1804 interchange, will necessitate review of this Master Plan.



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1 in = 1,200 feet

Figure ES-6 Implementation Sequence

US 83/ND 1804 Stormwater Master Plan
City of Bismarck, ND

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US 83 / ND 1804 Watershed
Hydrography
Basin Footprints

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1.0 INTRODUCTION AND BACKGROUND

1.1 Project Background

The City of Bismarck is experiencing growth to the north along the U.S. Highway 83 (US 83) corridor. Development pressure is already being experienced particularly at the US 83 / ND State Highway 1804 (ND 1804) intersection, which is currently outside the City limits but within the City's extraterritorial jurisdiction. The City's general policy is to develop regional stormwater master plans prior to areas developing. The overall goal of a stormwater master plan is to outline the key stormwater and drainage infrastructure that will be needed to provide the appropriate level of service for roadways and meet the City's stormwater management ordinance and design criteria. The master plan acts as a stormwater management guide for the City, landowners, and developers as the watershed develops.

The focus of this stormwater master plan is the area draining through the existing US 83 culvert south of the intersection with ND 1804 (***Figures 1-1 & 1-2***). In previous studies, these watersheds are referred to as Hay Creek subwatersheds 3-4, 3-5, and 3-6 and encompass an area of almost three square miles. For the purposes of this study, the overall watershed was renamed the US 83 / ND 1804 Watershed.

Existing land use within the watershed is primarily a mixture of agricultural and rural residential. The proposed land use within most of the study area is outlined in the US Highway 83 Corridor Transportation Study Final Report (June 2006), with minor modifications as directed by City staff. The density of the proposed development is substantially higher than the existing rural residential that is already located in the study area north of ND 1804. This proposed land use change has the potential to significantly increase runoff rates, runoff volumes, and impact water quality.

The US 83 / ND 1804 Watershed is tributary to Hay Creek (***Figure 1-1***). The Hay Creek watershed drains approximately 36.9 square miles including a large portion of undeveloped area north of the City. Hay Creek drains through developed portions of the City of Bismarck before ultimately entering into Apple Creek. Under existing conditions, flooding impacts are already felt at major road crossings within the City. Additionally, Hay Creek is considered an "impaired water" for sedimentation/siltation and is included on the 2012 North Dakota Clean Water Act Section 303(d) list of waters needing Total Maximum Daily Loads (TMDLs). As the watershed urbanizes, flooding and water quality impacts will likely increase.

The scope of this Master Plan does not include a comprehensive review of the water quality and flooding challenges within Hay Creek. However, this Master Plan does evaluate key runoff and water quality elements in the context of the Hay Creek watershed, which offers an opportunity for the City to begin to address some of the watershed challenges and develop a roadmap for future development within the Hay Creek watershed.

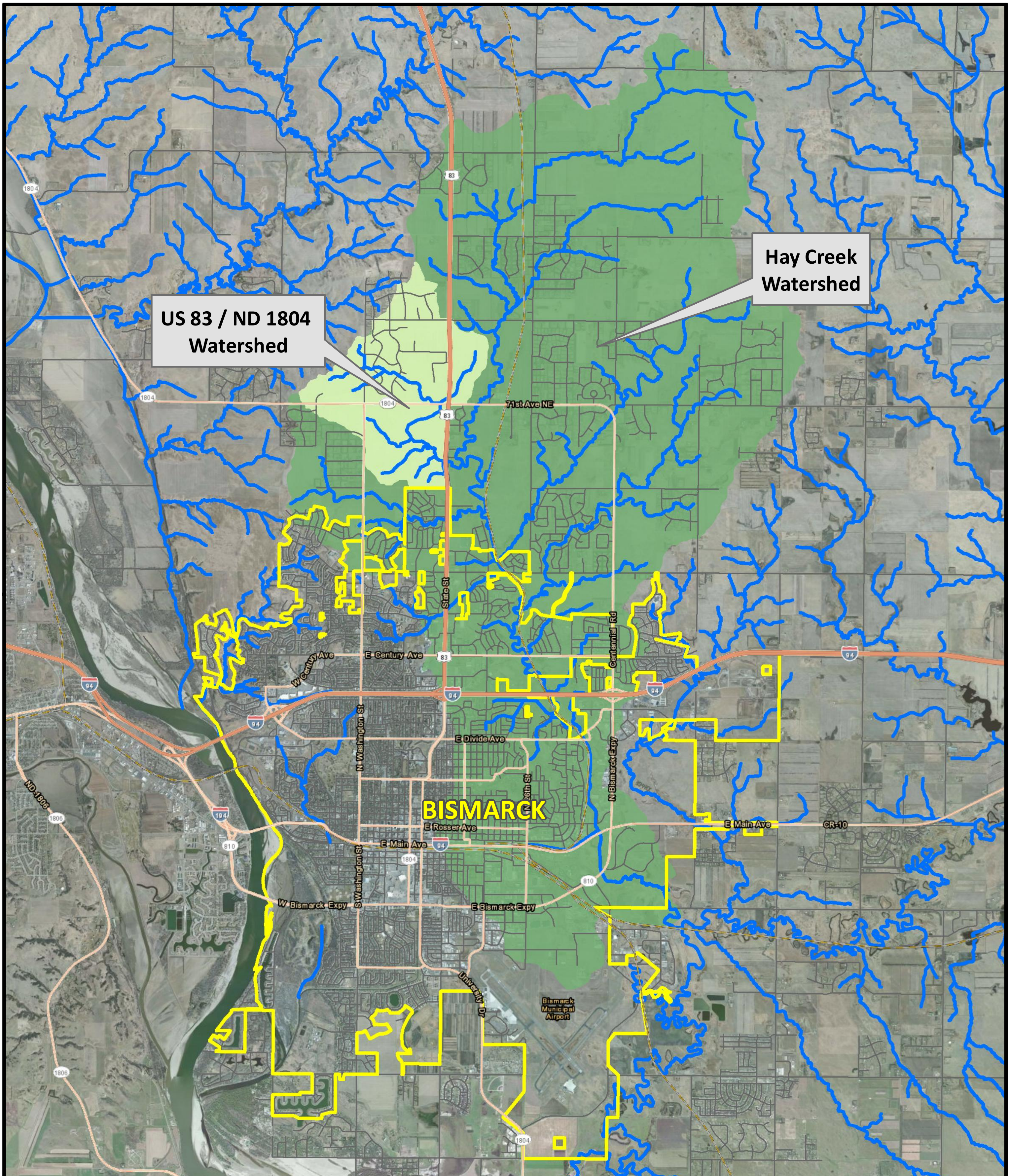

Figure 1-1 Project Location

US 83/ND 1804 Stormwater Master Plan

City of Bismarck, ND

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1 in = 8,000 feet

Hay Creek Watershed

US 83 / ND 1804 Watershed

Hydrography

City of Bismarck

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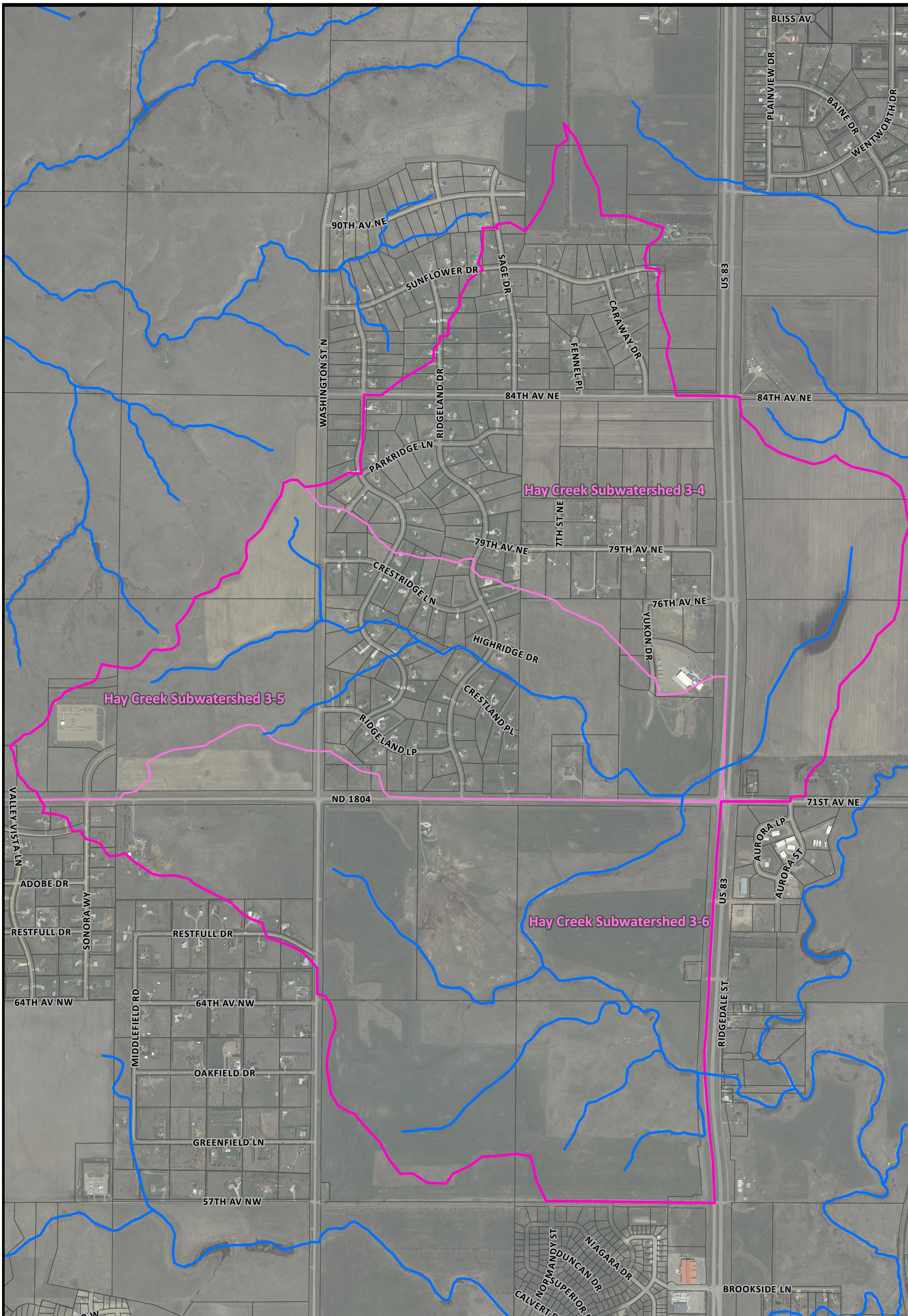

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1 in = 1,200 feet

Figure 1-2 Watershed Map

US 83/ND 1804 Stormwater Master Plan
City of Bismarck, ND

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US 83 / ND 1804 Watershed
Hydrography
Hay Creek Subwatersheds
Parcels

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1.2 Master Plan Goals

The overarching goals of this Master Plan were developed with the City working group. These goals can be broken down into primary goals and secondary goals.

1.2.1 Primary Goal

The primary goal of the Master Plan is to develop a comprehensive approach that manages stormwater and provides adequate drainage consistent with the City's ordinances. Achieving this goal requires the following:

- Determine sizes and develop preliminary designs for regional detention facilities and major drainageway crossings;
- Determine minimum roadway and building elevations based on anticipated flood elevations; and
- Outline an Implementation Plan for constructing the regional detention and drainage infrastructure that includes key development triggers for construct of regional facilities.

1.2.2 Secondary Goals

Due to this project's location along the US 83 corridor and proximity to Hay Creek, additional goals were developed, which include:

1. Considering the performance of the Master Plan in relation to the larger context of Hay Creek. This goal is primarily achieved through:
    a. Evaluating the peak flow rates, total runoff volumes, and the suspended sediment removal efficiency of the proposed Master Plan improvements; and
    b. Development of a Volume Reduction Best Management Practice Toolbox that can be utilized as a guide by the City and developers in implementing runoff volume reduction strategies.
2. Providing concepts and ideas that utilize the stormwater management features to enhance the project area and consider how the stormwater management facilities fit within the US 83 corridor. This goal primarily consists of developing conceptual landscape plans and design guidance for key greenway / stormwater features that could serve as a recreational and aesthetic corridor adjacent to the US 83 gateway.

1.3 Master Plan Performance Criteria

1.3.1 City Requirements

The City of Bismarck includes performance criteria within Title 14.1 of the City's code of ordinances. Additional City design criteria are included within the City's Stormwater Design Standards Manual.

1. Regional detention facilities were designed such that where flow enters Hay Creek (downstream of the US 83 crossing), the plan meets the City of Bismarck stormwater requirements outlined in Title 14.1 of the City's code of ordinances, and summarized as follows:
   - No increase in post-development flows compared to pre-development flows for the 2-, 10-, and 100-year, 6-hour storm events. For the purposes of this study, "pre-development" was defined as current conditions and existing land use.
   - Implement Best Management Practices that will improve water quality by settling sediment and associated pollutants.

2. Major drainage-way crossings were sized to meet the City's requirements for streets as follows (per Table No. 6.1 in the Stormwater Design Standards Manual):
   - Local Streets: In the 100-year storm, less than 9" of depth at the crown;
   - Collector Streets: In the 100-year storm, less than 6" of depth at the crown. Based on the typical collector street cross section, the crown of the road is 6" below the edge of the right-of-way; therefore, no overflow in the 100-year event was designed for all the collector street crossings.
   - Arterial Streets: In the 100-year storm, less than 3" of depth at the crown. The typical arterial street cross section would create an edge of right-of-way that is greater than 3 inches above the centerline of the road; therefore, no overflow in the 100-year event was designed for arterial streets as well.

The City's Design Standards also outline allowing 1 foot of freeboard in the 100-year event on all culvert and roadway crossings (Section 3 of the manual); however, it was not possible to meet this criterion while meeting the City's detention criterion and maintaining basins under 25 ac-ft without creating additional stormwater facilities.

1.3.2 State Requirements

This watershed includes drainage that crosses both ND 1804 and US 83 in multiple locations; therefore both North Dakota Department of Transportation (NDDOT) and State Water Commission (SWC) criteria for stream crossings, level of service, and backwater are applicable. These requirements are summarized as follows:

- For regional and urban State Highway roads in the urban system, no roadway overtopping shall occur up to the 25-year event;
- For non-interstate State Highway roads in the rural system, no roadway overtopping shall occur up to the 25-year event; and
- For streams with streambed slopes greater than 10 feet/mile (entire study area), the allowable headwater when passing the design discharge (listed immediately above) shall be no greater than two pipe diameters.

Additionally, in discussions with the NDDOT, they require that the existing 25-year, 24-hour peak flow not be increased in proposed conditions for existing facilities and outlet velocities not exceed 10 feet per second. In cases where peak flows are increased, crossings must be upgraded to maintain compliance with stream crossing standards.

The State Engineer/State Water Commission regulates construction of dams. Per 61-16.1-38 of the Century Code, permits are required for structures retaining more than 25 acre-feet of water for medium- or high-hazard dams. Since these facilities will be constructed in an urban area, it is likely that any detention facility exceeding 25 acre-feet of storage, even if temporary, would be classified as a dam and would require formal approval through the permitting process.

1.3.3 Supplementary Design Criteria

A number of supplemental design criteria were developed based upon the characteristics of the watershed, discussions with City staff, and professional judgment. These additional design criteria include the following:

- Vegetated channel stability is designed such that it is stable up to a 6-hour, 25-year event;
- Individual detention basins will not have 25 acre-feet or more of storage capacity to avoid the facility being regulated as a dam; and
- For defining roadway level of service, the following criteria were selected:
  - For Minor and Principal arterial streets, no overtopping in the 100-year event.
  - For Collector streets, no overtopping in the 25-year event. (Note that the allowable depth at the crown trumps this criterion for urban roadway sections.)
  - For Local streets, no overtopping in the 25-year event.
  - For driveways, no overtopping in the 2-year event.

1.4 Agency and Stakeholder Coordination

1.4.1 Stakeholder Communication Plan

At the onset of the project, a Stakeholder Communication Plan (***Appendix F***) was developed and approved by the City. The Stakeholder Communication Plan served two primary purposes:

1. To provide a basic framework for communication during the development of the Master Plan; and
2. To document the stakeholder communication process.

1.4.2 City Work Group

The City assembled a City Work Group that provided input and direction during development of the Master Plan. The City Work Group consisted of the following individuals:

- Keith Demke, P.E. –Director of Utility Operations, Bismarck Public Works
- Colleen Peterson –Storm Water Program Coordinator, Bismarck Public Works
- Mel Bullinger, P.E. – City Engineer, Bismarck Engineering Department
- Dale Heinert, P.E. - Design and Construction Engineer, Bismarck Engineering Department
- Linda Oster, P.E. - Design and Construction Engineer, Bismarck Engineering Department
- Mark Berg, P.E. - Transportation Engineer, Bismarck Engineering Department
- Nancy Huether, P.E. – Project Engineer, Bismarck Engineering Department
- Jason Tomanek – Planner, Bismarck Community Development Department, Planning Division

1.5 Data Sources

The following data sources were utilized in this study:

- US Highway 83 Corridor Transportation Study Final Report, dated June 2006, prepared by URS and Houston Engineering for the Bismarck-Mandan Metropolitan Planning Organization;
- Stormwater Plans for the Northridge Estates, dated March 6, 2002, January 7, 2003, and July 19, 2010, prepared by Swenson, Hagen & Co. P.C., obtained from City Engineering;
- LIDAR data (mass points) generated from 2009 aerial flight by Ayres, and obtained from the North Dakota LIDAR Dissemination Mapservice website;

- 2-foot contours generated from the 2009 LIDAR data, obtained from the North Dakota GIS Hub Data Portal website;
- Bismarck 2009 aerial photograph, obtained from the North Dakota GIS Hub Data Portal website;
- NRCS soils database, obtained from the NRCS Geospatial Data Gateway;
- Site visit on August 21, 2012; and
- Survey data collected as part of this project on August 28, August 30, and September 4, 2012.

2.0 LAND USE

2.1 Existing Land Use

The existing land use in the watershed is primarily a mix of agricultural, rural residential (2-acre lots), and road right-of-ways (***Figure 2-1*** and ***Table 2.1***). The agricultural land use is dominated by pasture, but patches of row crop agriculture are present to the west of Northridge Estates and to the east of US 83. There are approximately 80 acres of platted but currently undeveloped parcels, which are mainly located in the State Street Office Park.

Table 2.1: Summary of Existing Land Use in Study Area

Land Use Type	Area (acres)*	Fraction of Study Area (%)	Percent Impervious Area (%)
Agricultural	1203.0	64.0%	0%[1]
Undeveloped	80.3	4.3%	0%[1]
Rural Residential	378.4	20.1%	10%[2]
Road ROW	171.9	9.1%	50%[3]
Commercial	17.3	0.9%	7%[1]
Industrial	12.0	0.6%	72%[3]
Transportation & Infrastructure	17.6	0.9%	38%[1]
Total	1880.5	100%	100%

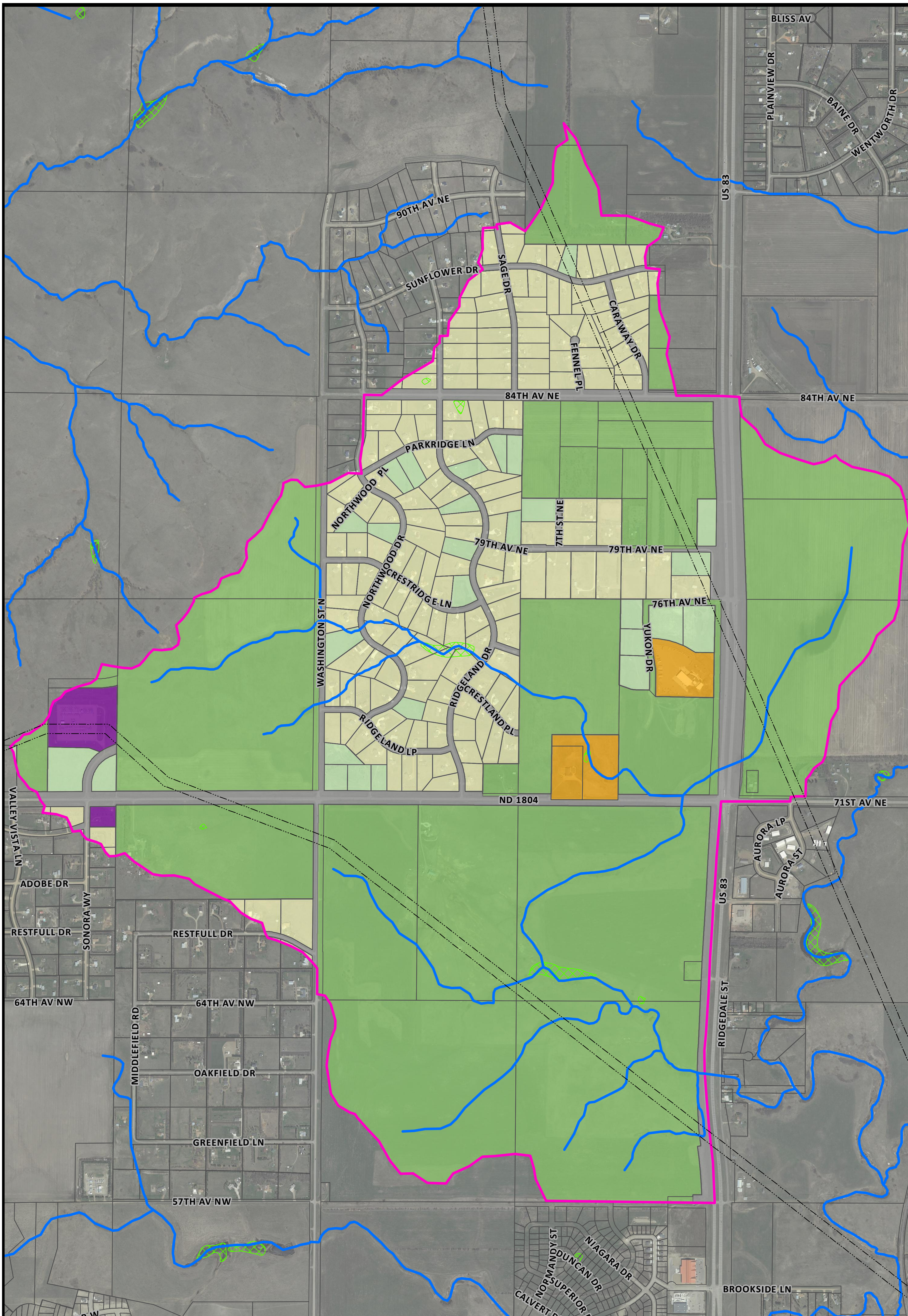
*Based on Burleigh County parcel data, 2009 aerial photograph, and site observations.
[1]Based on 2009 aerial photograph.
[2]Based on representative sample of residential lots in the study area.
[3]Based on TR-55 guidance.

2.2 Future Land Use

The most recent regional land use plan for the study area is the US Highway 83 Corridor Transportation Study completed in 2006 for the Bismarck-Mandan Metropolitan Planning Organization. Based on discussions with some of the large landowners in the study area, more detailed planning is already underway for several of the parcels in the watershed. However, since no preliminary plats have been approved, the City directed that the US Highway 83 Study be used with minor modifications as outlined in ***Appendix A, Section A.3***. The future land use for this study is displayed in ***Figure 2-2***.

2.2.1 Land Use Impervious Area

Since the US Highway 83 Study land use does not correlate directly with the City's zoning code (Title 14), interpretations of the US Highway 83 Study land use as it applies to Bismarck's zoning code were based on discussions with City planning staff, which are summarized in ***Appendix A, Section A.3***.



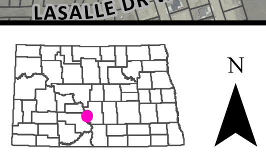


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Figure 2-1 Existing Land Use

US 83/ND 1804 Stormwater Master Plan

City of Bismarck, ND

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- US 83 / ND 1804 Watershed
- Hydrography
- National Wetlands Inventory
- Parcels
- Transmission Line Corridor
- Mixed-Use
- Rural Residential
- Undeveloped
- Agricultural
- ROW
- Transportation/Infrastructure

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Developed by: Danielle Lee | 03/19/2013

Coordinate System: ND State Plane South

Vertical Datum: NAVD88

Metadata Included in the Report

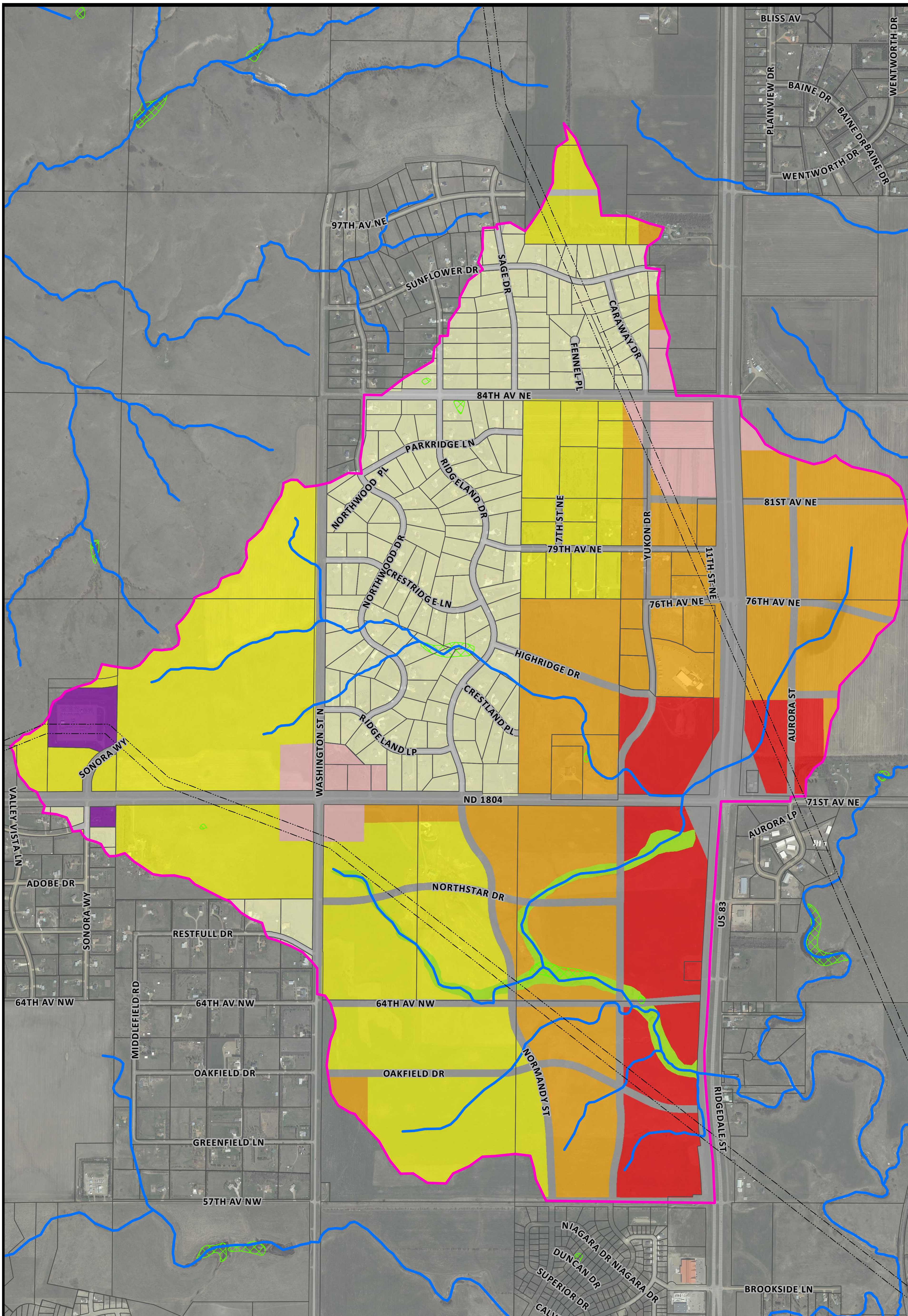

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Figure 2-2 Future Land Use

US 83/ND 1804 Stormwater Master Plan

City of Bismarck, ND

Think Big. Go Beyond.

Montgomery Associates

US 83 / ND 1804 Watershed
Hydrography
National Wetlands Inventory
Parcels
Transmission Line Corridor
Commercial
Neighborhood Commercial
Mixed-Use
Urban Residential
Rural Residential
Open Space
Urban ROW
Rural ROW
Transportation/Infrastructure

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In Title 14, "lot coverage" refers to the percent impervious area that is taken up by rooftops and required parking. Additional impervious area on the lot may be placed such as Owner-requested parking, etc.; however, for the purposes of this study, the maximum lot coverage allowed was assumed to be the average impervious area for each land use. This assumption was based on discussions with City planning and the City Work Group.

A summary of the land use impervious area assumptions is shown in ***Table 2.2***. ***Appendix A*** contains a detailed discussion on the justification for the land use impervious area percentages along with a discussion of minor changes to the US Highway 83 Corridor Study that were requested by the City Work Group.

Table 2.2: Summary of Future Land Use in Study Area

Land Use Type	Area (acres)*	Fraction of Study Area (%)	Percent Impervious Area (%)
Open Space	31.2	1.7%	0%[1]
Rural Residential	367.3	19.5%	10%[2]
Urban Residential	546.5	29.1%	30%[3]
Rural Road ROW	57.9	3.1%	50%[4]
Urban Road ROW	235.9	12.5%	65%[5]
Mixed Use	407.6	21.7%	65%[6]
Neighborhood Commercial	59.5	3.2%	65%[6]
Commercial	157.1	8.4%	80%[6]
Transportation & Infrastructure	17.6	0.9%	38%[1]
Total	1880.6	100%	100%

[1]Based on 2009 aerial photograph.
[2]Based on representative sample of residential lots in the study area.
[3]Based on TR-55 guidance for 1/3 acre lots
[4]Based on TR-55 guidance
[5]Based on City of Bismarck typical collector street section and 80-foot ROW.
[6]Based on maximum lot coverage in Title 14 of City zoning code.

3.0 ALTERNATIVE DEVELOPMENT

3.1 Methodology

The hydrology and hydraulics of the study area were modeled using InfoSWMM, which is a proprietary GIS-integrated version of the EPA SWMM model that is widely accepted for use in stormwater modeling. A detailed discussion of the model development, assumptions, and analysis is included in ***Appendix A***.

3.2 Peak Flow Compliance Locations

The City of Bismarck prefers to utilize regional City-owned and maintained stormwater management facilities versus administering oversight on numerous privately-owned detention basins. This approach has several advantages, one of which is that providing peak rate control on a site-by-site basis does not necessarily ensure that flood peaks within a larger drainage system are not increased. Implementing regional facilities is a much more reliable approach to maintaining peak flow rates at key locations within a larger drainage system. Therefore, this study sets the main compliance point at the 72-inch arch culvert under US 83 located at the downstream end of the project area. The study also outlines considerations for potential impacts on existing infrastructure within the study area along with approaches to reducing those impacts by reducing flow rates and/or increasing conveyance capacity.

3.3 Conceptual Alternative Development

3.3.1 Background

Stormwater management within the City has generally focused on peak flow control through detention storage. These detention storage facilities also trap sediment and improve water quality, although the benefits related to water quality treatment have typically not been quantified. While utilizing detention facilities as the sole approach to stormwater management does provide the benefit of peak flow reduction, detention facilities do not mitigate increased runoff volumes. The City, however, has recognized that in certain watersheds within the City, the cumulative effects of increased runoff volumes have the potential to cause downstream issues. One of these watersheds is Hay Creek, which includes a large amount of undeveloped land within the watershed. Therefore, as the watershed develops, the cumulative impacts of increased runoff volumes have the potential to exacerbate existing issues including:

- Channel and bank stability along the Hay Creek corridor;
- Conveyance limitations and flooding at key downstream crossings such as the Divide Avenue and Main Street crossings; and
- Water quality impairments within the 303(d) listed Hay Creek.

Several potential master plan concepts were evaluated as part of this study and presented to the City for consideration. The concepts are designed for full build-out of the future land use plan. In general, the concepts fit two main stormwater management approaches:

1. Reduction of peak flow and sediment utilizing regional detention facilities. Regional detention is generally provided by valley storage upstream of road crossings or separate constructed embankments. Where valley storage is not available or the flooded area would be too extensive, regional detention facilities would be created by excavating and/or filling.
2. Reduction of peak flow and sediment utilizing regional detention facilities similar to the alternative described above. Additionally, reduction of total runoff volume and additional water quality treatment would be provided by requiring on-site facilities to supplement the regional detention facilities. A desktop analysis indicates that much of the watershed has moderate potential for utilizing infiltration practices (***Appendix C***).

3.3.2 City Work Group Recommendations

After reviewing the various concepts presented and weighing the feasibility of implementation, cost considerations, and overall benefit, the City work group directed the project team to further develop and refine one alternative based on the first approach and one alternative based on the second approach for final consideration and ultimately chose the Master Plan described in ***Section 6***. The master plan alternative concepts that were developed are described in ***Appendix B***.

4.0 EXISTING CONDITIONS

As described previously, the existing land use for the study area is primarily a mixture of rural residential and agricultural lands. Overall drainage for the study area is from northwest to south, and runoff from the study area ultimately flows under US 83 south of ND 1804 prior to discharging to Hay Creek (***Figure 4-1***). The hydraulics of the study area were simulated to reflect existing conditions as closely as possible. The Northridge Estates subdivision located north of ND 1804, south of 84th Avenue, and east of North Washington Street is the only existing development with stormwater management detention practices installed, which generally consist of dry basins upstream of roadway embankments. In addition to these stormwater management facilities, storage that is created by roadway embankments (such as north of ND 1804 and west of US 83) was also included in the analysis because understanding the flow reduction that these "natural" detention areas provide is important to understanding the potential impacts of filling these areas.

4.1 Peak Flows

Table 4.1 summarizes the peak flows at the main compliance point as well as several other locations within the study area. Two observations are notable:

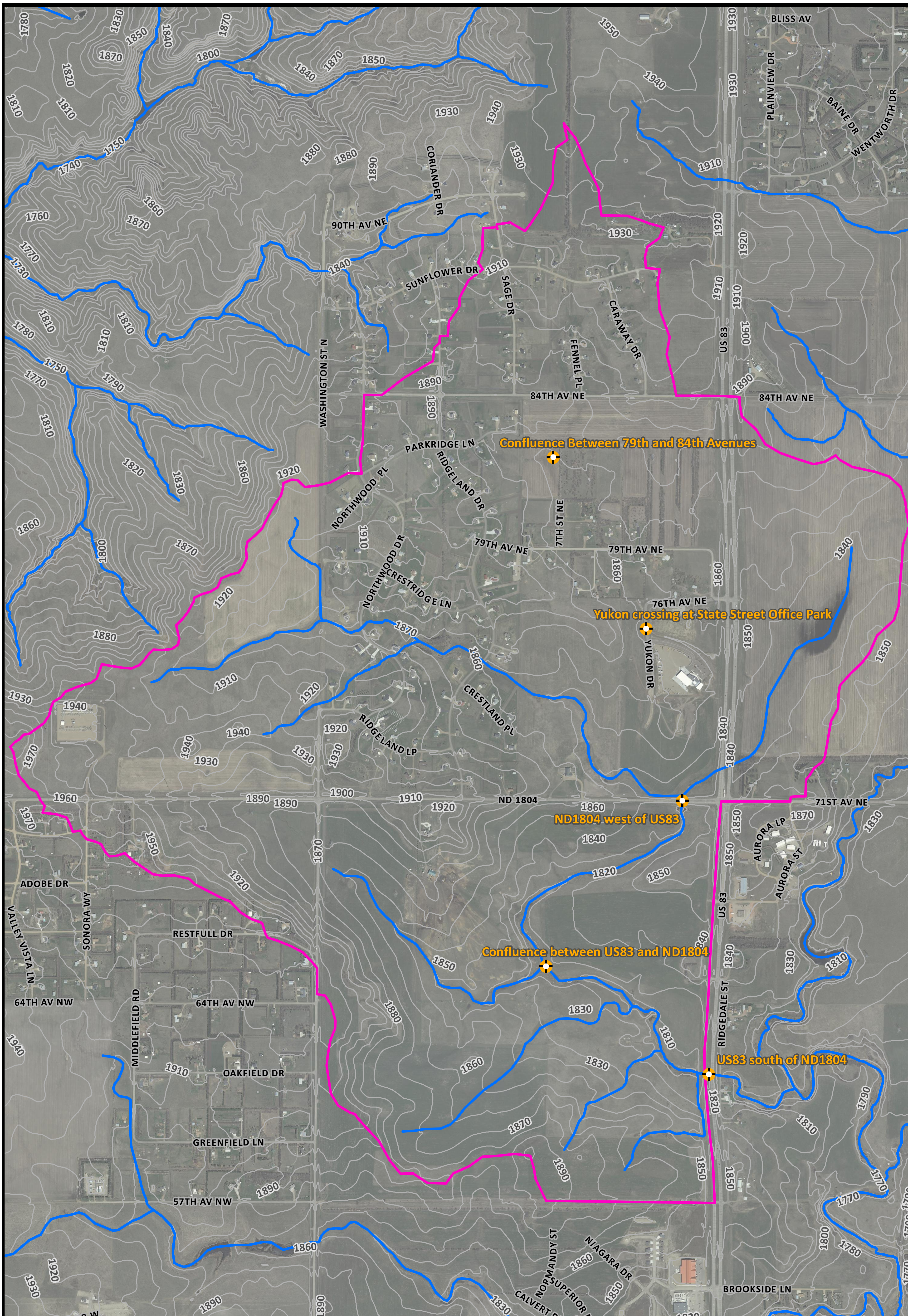
- Flows at Yukon Drive are lower than further upstream in the watershed due to the valley storage created by the flat topography and small driveway culverts along 79th Avenue NE.
- Flows for the 24-hour duration are higher than the 6-hour duration.

Table 4.1: Summary of Existing Peak Flows (cfs) at Select Locations in Study Area

Road Crossing	6-Hour				24-Hour		
	2-yr	10-yr	25-yr	100-yr	2-yr	25-yr	100-yr
Confluence between 79th and 84th Avenues	6	38	66	117	10	83	135
Yukon Dr. crossing at State St. Office Park	4	19	52	89	6	64	103
ND1804 west of US 83	14	96	142	244	21	175	269
Confluence between US 83 and ND 1804	23	131	200	315	34	238	369
US 83 south of ND1804 (Compliance Point)	***18***	***139***	***213***	***317***	***29***	***247***	***354***

Figure 4-2 illustrates the peak flows (6-hour duration) for the 2-, 10-, 25-, and 100-year events at all the collector and arterial crossings where land use changes upstream are expected. The main crossing of 79th Avenue NE is also included in the figure even though this street is not considered a collector in the US 83 Corridor study.

Peak 25- and 100-year flows for the 24-hour storm duration are shown in ***Figure 4-3*** at all NDDOT crossings.



N

0 600 1,200 Feet

1 in = 1,200 feet

Figure 4-1 Existing Drainage

US 83/ND 1804 Stormwater Master Plan
City of Bismarck, ND

AE2S Think Big. Go Beyond. | Montgomery Associates | JLG architects

US 83 / ND 1804 Watershed
Hydrography
10-Foot Contours
Select Flow Locations

AE2S in association with MARS and JLG

Developed by: Danielle Lee | 03/19/2013
Coordinate System: ND State Plane South
Vertical Datum: NAVD88
Metadata Included in the Report

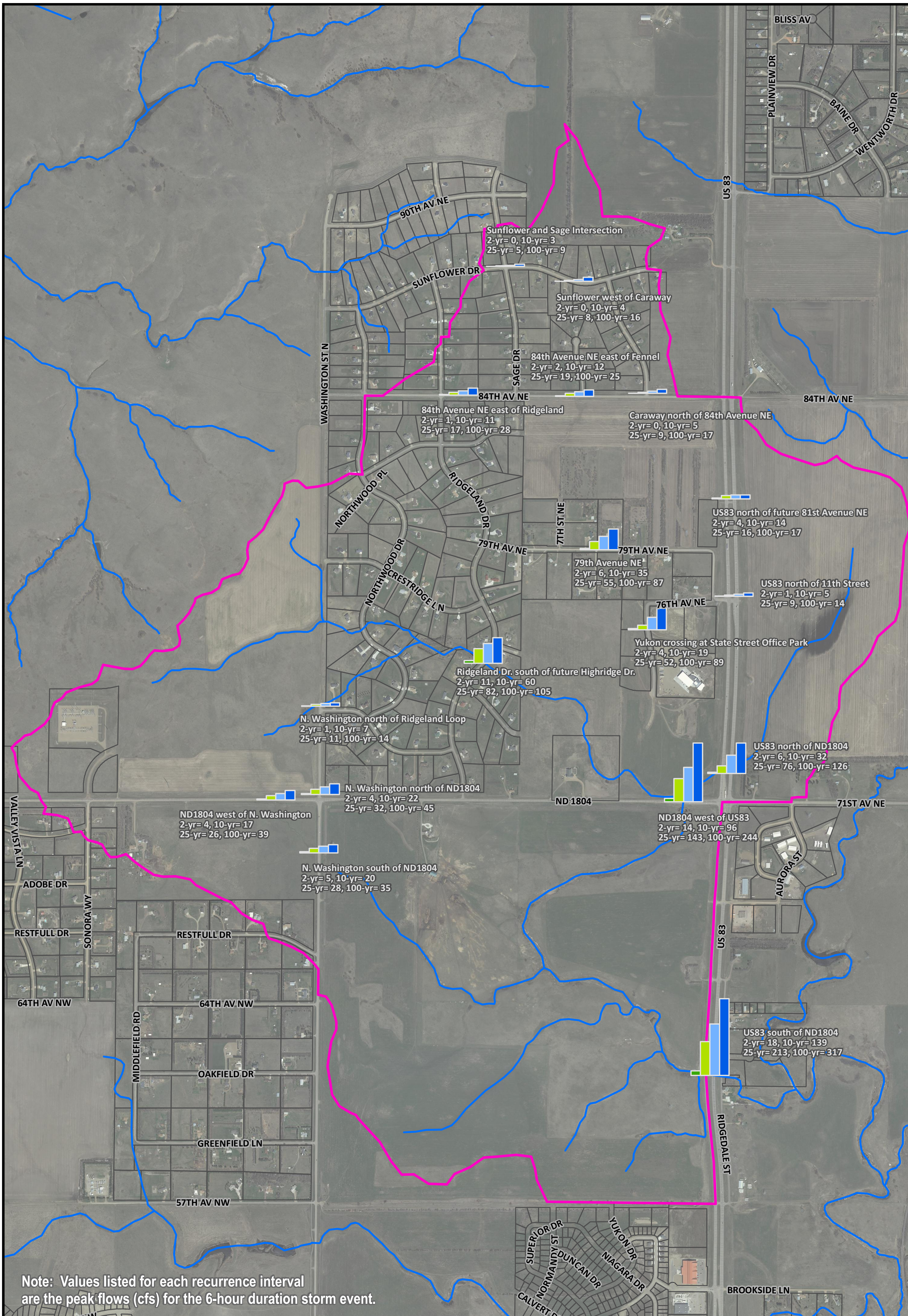


Figure 4-2 Existing Flows at Collector and Arterial Crossings

US 83/ND 1804 Stormwater Master Plan

City of Bismarck, ND

AE2S Think Big. Go Beyond. | Montgomery Associates | JLG architects

N

0 | 600 | 1,200 Feet

1 in = 1,200 feet

US 83 / ND 1804 Watershed

Hydrography

2-Year 6-Hour

10-Year 6-Hour

25-Year 6-Hour

100-Year 6-Hour

AE2S in association with MARS and JLG

Developed by: Danielle Lee | 03/21/2013

Coordinate System: ND State Plane South

Vertical Datum: NAVD88

Metadata Included in the Report

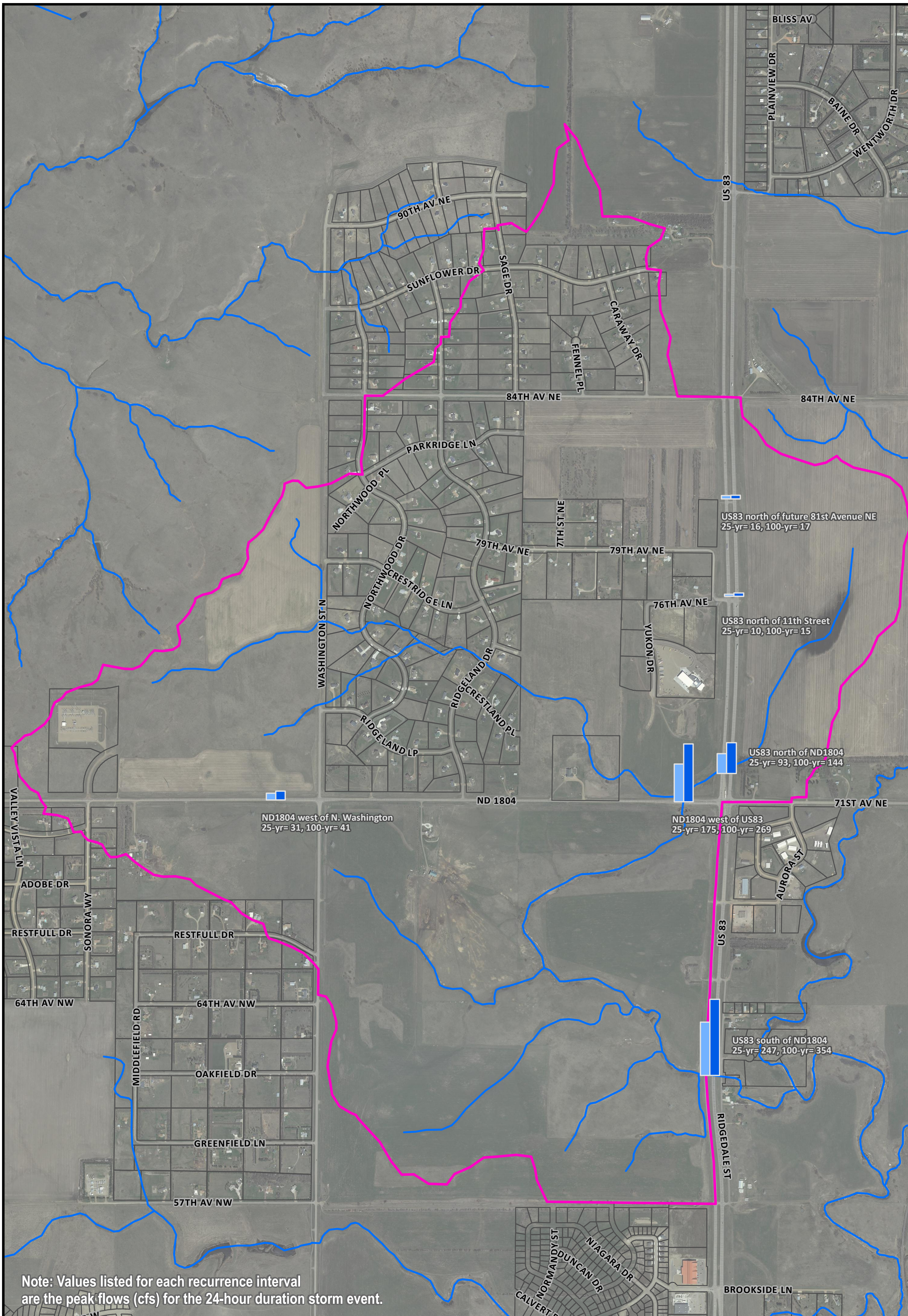


Figure 4-3 Existing Flows at ND DOT Crossings

US 83/ND 1804 Stormwater Master Plan

City of Bismarck, ND

N

Feet

0 600 1,200

1 in = 1,200 feet

US 83 / ND 1804 Watershed

Hydrography

25-Year 24-Hour

100-Year 24-Hour

AE2S — Think Big. Go Beyond. Montgomery Associates JLG architects

AE2S in association with MARS and JLG

Developed by: Danielle Lee | 03/19/2013

Coordinate System: ND State Plane South

Vertical Datum: NAVD88

Metadata Included in the Report

4.2 Runoff Volumes

Table 4.2 summarizes the total runoff volume for the study area for the various recurrence intervals (6-hour storm only).

Table 4.2: Summary of Existing Runoff Volumes (ac-ft) at Main Compliance Point

Location	6-Hour			
	2-yr	10-yr	25-yr	100-yr
US 83 south of ND1804	9.2	54.7	90.9	160.1

4.3 Road Level of Service

Figure 4-4 displays the overtopping frequency of select roadway and driveways on main conveyance routes relative to the required level of service outlined in ***Section 1.3.3***. Peak 6-hour, 25- and 100-year stages along with the freeboard of the 100-year peak stage in relation to the overflow elevation (typically crown) are displayed in ***Figure 4-5*** for all collector street crossings and 79th Avenue NE. Since the NDDOT requires evaluation of crossings based on the 24-hour duration, ***Figure 4-6*** illustrates the peak stages for the 24-hour, 25- and 100-year events, 100-year freeboard, and 25-year outlet velocity.

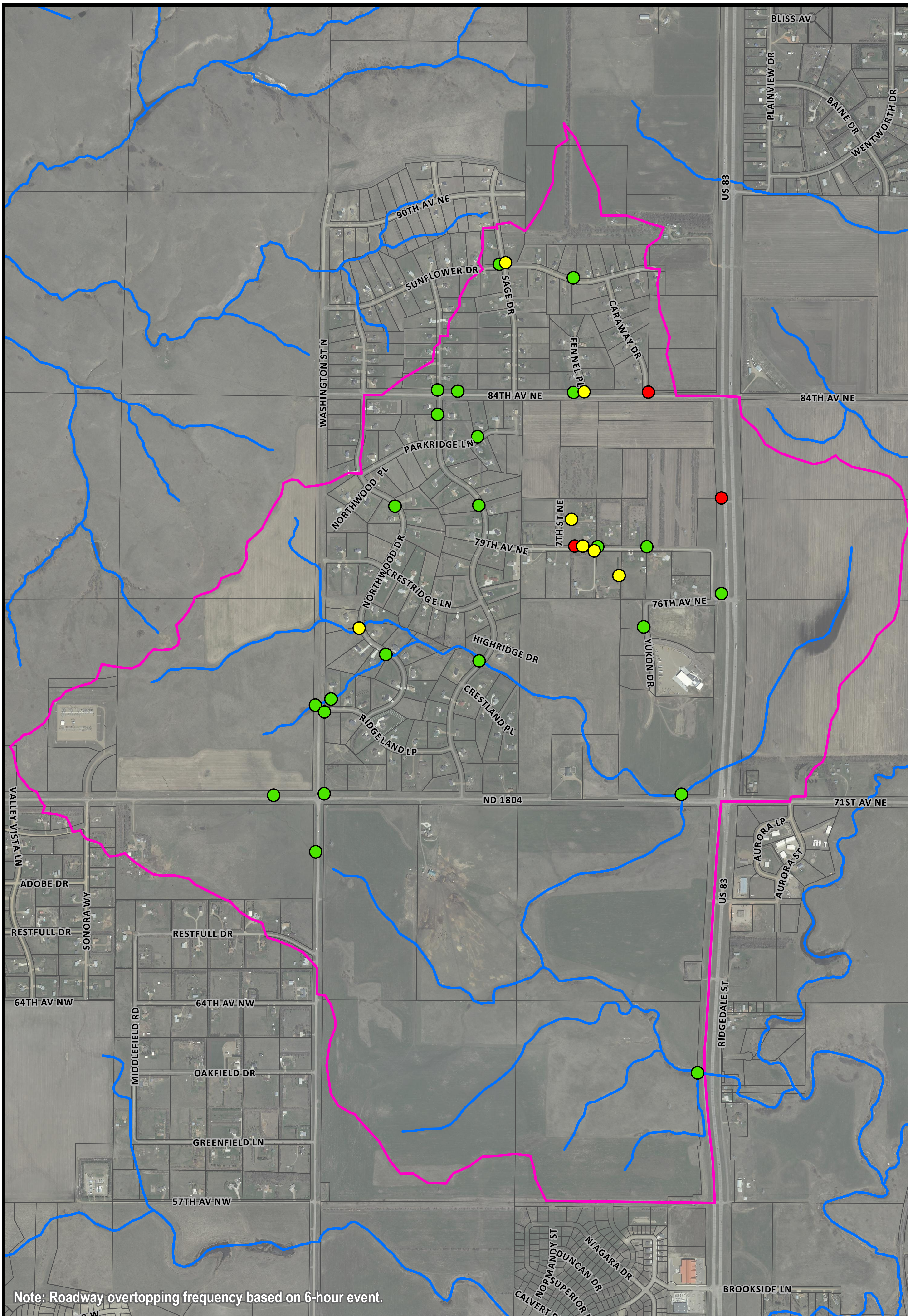
These figures illustrate the following observations:

- Caraway Drive just north of 84th Avenue NE overtops in the 25-year event and therefore, does not meet level of service criteria for a collector street (***Table 4.3***).
- 79th Avenue NE at the main tributary overtops in the 10-year event and does not meet level of service criteria. At this location, it appears that there is a history of road overtopping issues based on the presence of multiple small culverts in this area.
- Several of the rural residential driveways along 79th Avenue NE where the main tributary flows also begin to overtop between the 2- and 10-year events.
- The culvert under US 83 located at the future intersection between 84th Avenue NE and 81st Avenue NE does not have the capacity to convey the 100-year event under US 83 without flowing south along the existing highway right-of-way (referred to as road crossing "US 83 and Future 81st Avenue NE" in Table 4.3). This result suggests that in the existing land use condition, flooding and pavement encroachment could occur during extreme rainfall events as flow begins to back up at the culvert and flow overland to the south along the US 83 right-of-way.

Table 4.3: Summary of Existing Roadway Overtopping Conditions at Major Road Crossings

Road Crossing	6-Hour			
	2-yr	10-yr	25-yr	100-yr
US 83 and Future 81st Avenue NE				*
79th Ave NE on main tributary		✓	✓	✓
Northwood Dr. south of Crestridge Ln.				✓
Caraway Dr. north of 84th Ave NE			✓	✓
Fennel Pl. near 84th Ave NE				✓
Sunflower Dr. near Sage Dr.				✓

✓Denotes overtopping condition.
*See discussion above.



N

0 600 1,200 Feet

1 in = 1,200 feet

Figure 4-4 Existing Roadway Level of Service

US 83/ND 1804 Stormwater Master Plan

City of Bismarck, ND

AE2S Think Big. Go Beyond. Montgomery Associates JLG architects

- US 83 / ND 1804 Watershed
- Hydrography
- Parcels
- Level of Service Acceptable
- Level of Service Not Acceptable
- No Overtopping in 100-year Event

AE2S in association with MARS and JLG

Developed by: Danielle Lee | 03/19/2013
Coordinate System: ND State Plane South
Vertical Datum: NAVD88
Metadata Included in the Report

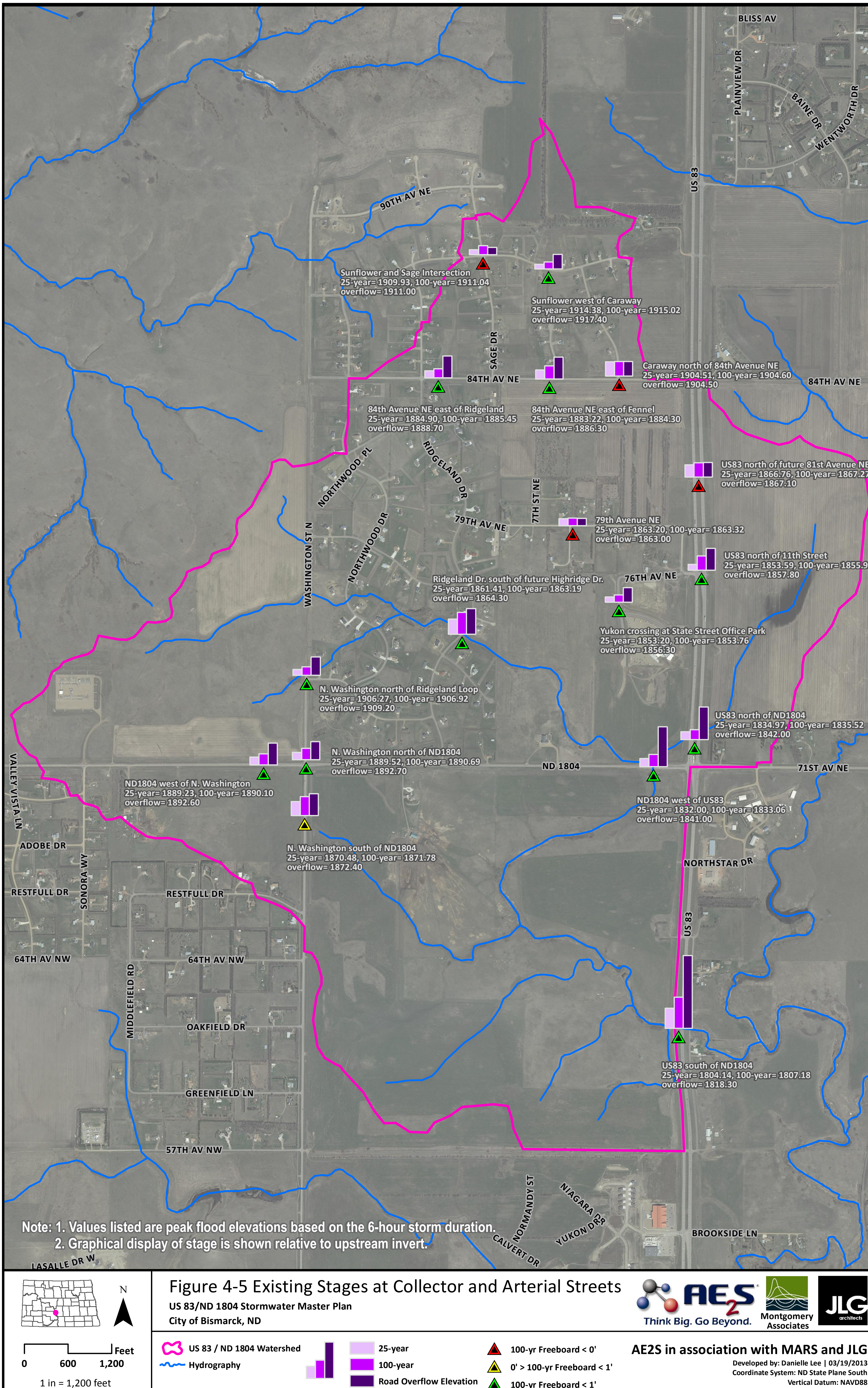


Figure 4-5 Existing Stages at Collector and Arterial Streets

US 83/ND 1804 Stormwater Master Plan

City of Bismarck, ND

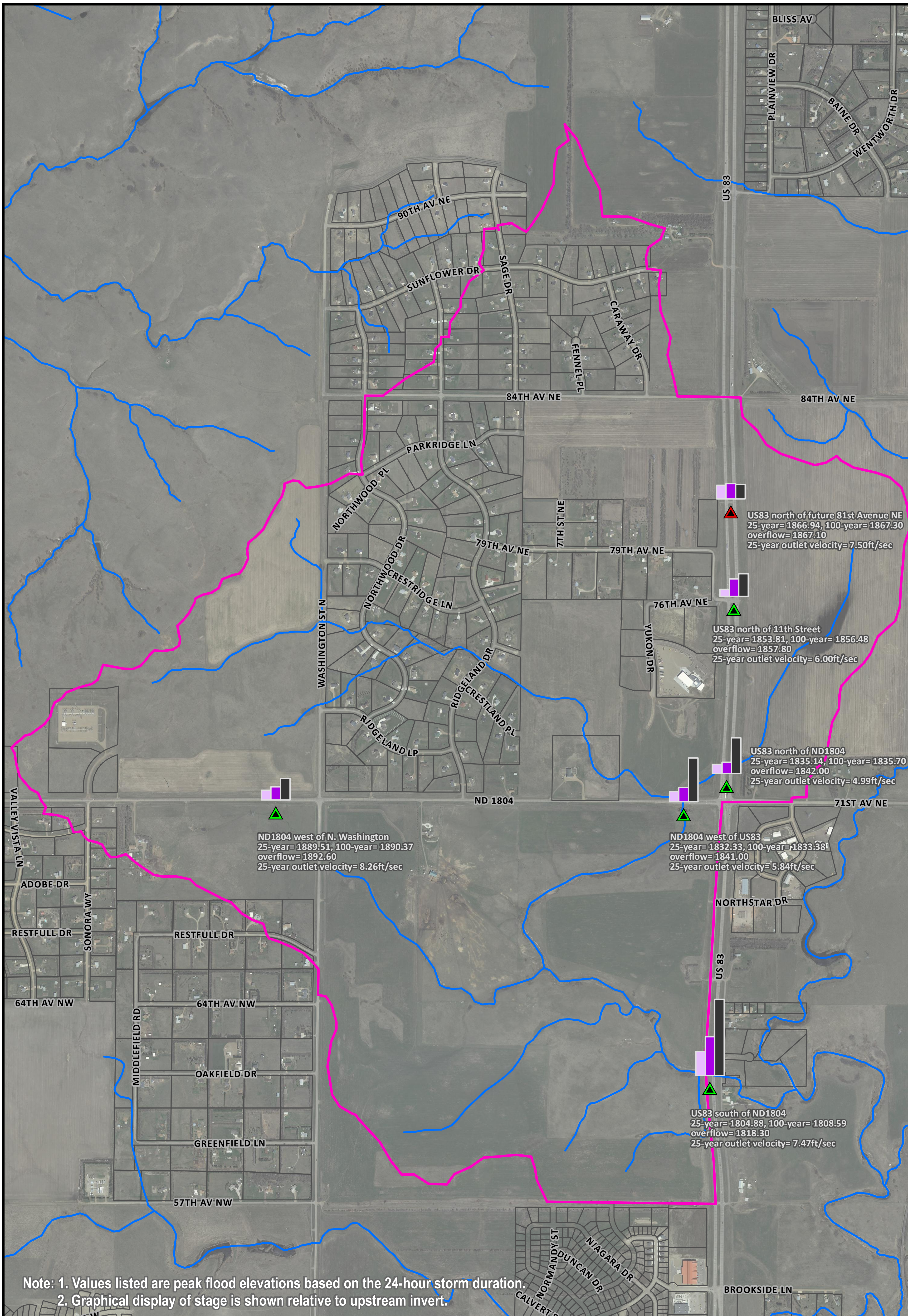
AE2S in association with MARS and JLG

Developed by: Danielle Lee | 03/19/2013

Coordinate System: ND State Plane South

Vertical Datum: NAVD88

Metadata Included in the Report



N

0 600 1,200 Feet

1 in = 1,200 feet

Figure 4-6 Existing Peak Stages at ND DOT crossings

US 83/ND 1804 Stormwater Master Plan

City of Bismarck, ND

AE2S Think Big. Go Beyond. Montgomery Associates JLG architects

- US 83 / ND 1804 Watershed
- Hydrography
- 25-year
- 100-year
- Road Overflow Elevation
- 100-yr Freeboard < 0'
- 0' > 100-yr Freeboard < 1'
- 100-yr Freeboard < 1'

AE2S in association with MARS and JLG

Developed by: Danielle Lee | 03/19/2013

Coordinate System: ND State Plane South

Vertical Datum: NAVD88

Metadata Included in the Report

5.0 FULL BUILD-OUT, NO CONTROLS

Evaluation of the full build-out conditions with no stormwater controls provides a baseline for measuring the relative performance of the various stormwater master plan alternatives and illustrates the need for stormwater management.

5.1 Peak Flows

As expected, full build-out of the watershed significantly increases peak flows (***Table 5.1***). Several observations are notable:

- The full build-out with no controls peak 2-year flow would approach the existing 100-year event.
- The 6-hour, 2-year event peak flow increases by more than a factor of 15 at the compliance point (US 83).
- The 6-hour, 100-year peak flow increases by almost 70 percent at the compliance point.

Table 5.1: Summary of Existing and Proposed No BMPs Peak Flows at Main Compliance Point

Scenario	6-Hour (cfs)				24-Hour (cfs)		
	2-yr	10-yr	25-yr	100-yr	2-yr	25-yr	100-yr
Existing	18	139	213	317	29	247	354
Full Build-Out No BMPs	283	414	465	530	282	462	526
Percent Change	1506%	198%	118%	67%	888%	87%	48%

100-year peak flow changes within the watershed can be more pronounced than evaluating flow changes at US 83, as the existing US 83 culvert and storage upstream provide significant flow routing (see hydrograph ***Figures 5-1, 5-2, 5-3***, and ***5-4*** on the following pages for the 6-hour, 2- and 100-year events only). For example, the full build-out 6-hour, 100-year peak flow upstream of the US 83 crossing exceeds 1,100 cfs (red plot), and the hydrograph at the US 83 crossing illustrates the routing effect of the culvert (dark blue plot).

Figure 5-1 Existing 2-Year Hydrograph

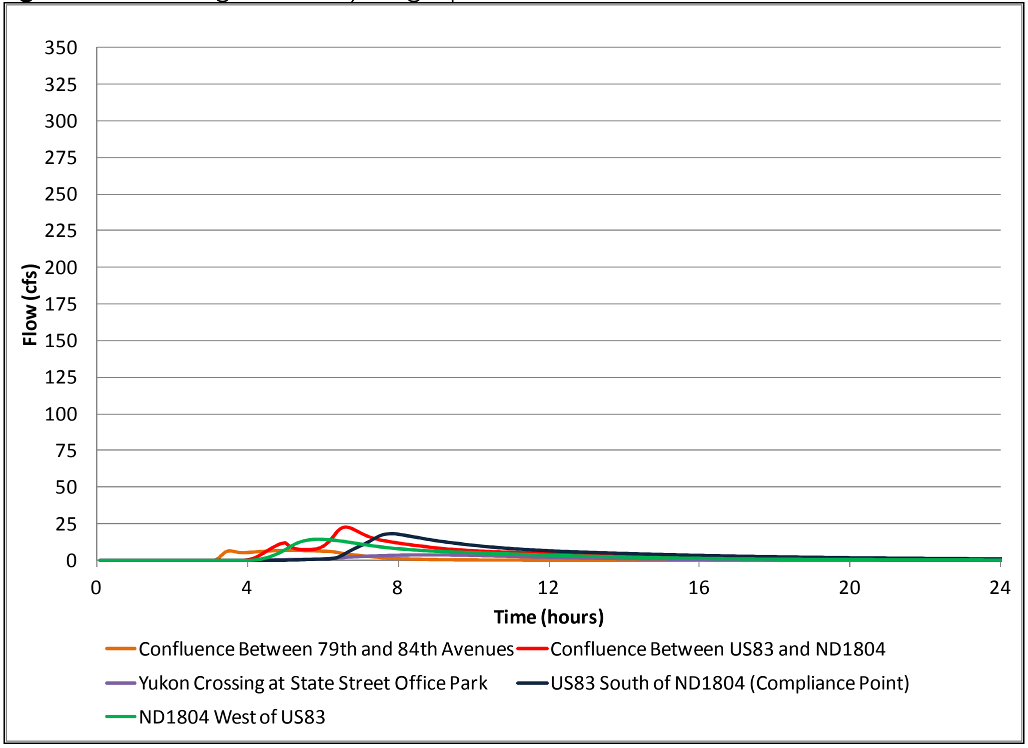


Figure 5-2 Full Build-Out No BMPs 2-Year Hydrograph

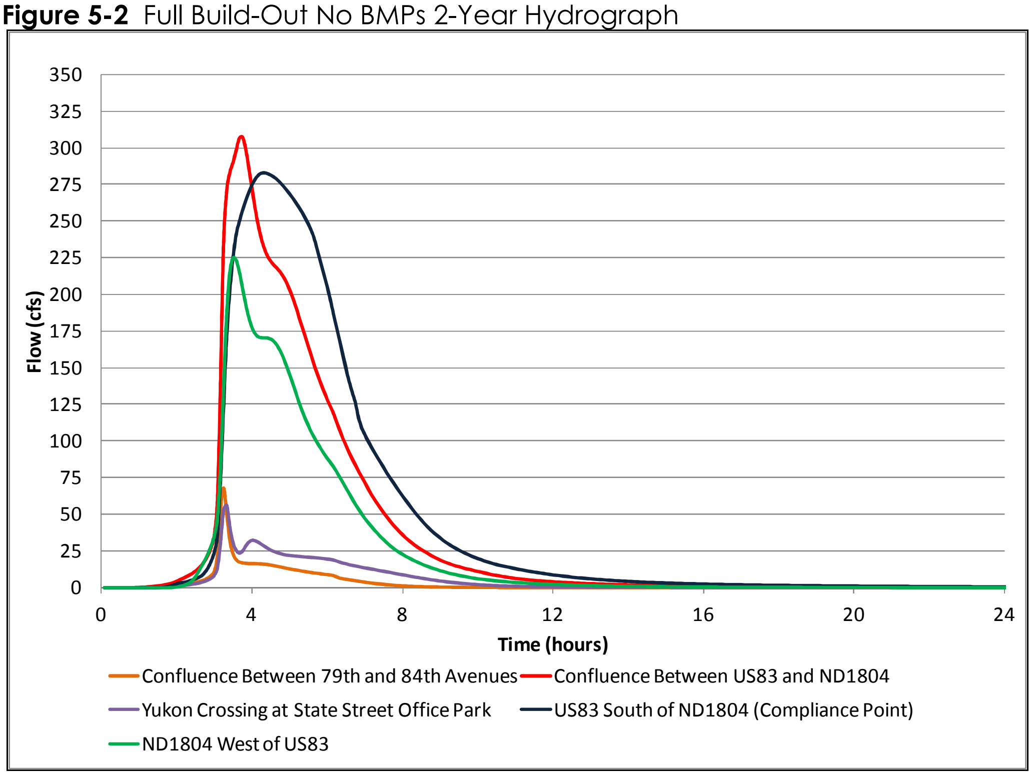


Figure 5-3 Existing 100-Year Hydrograph

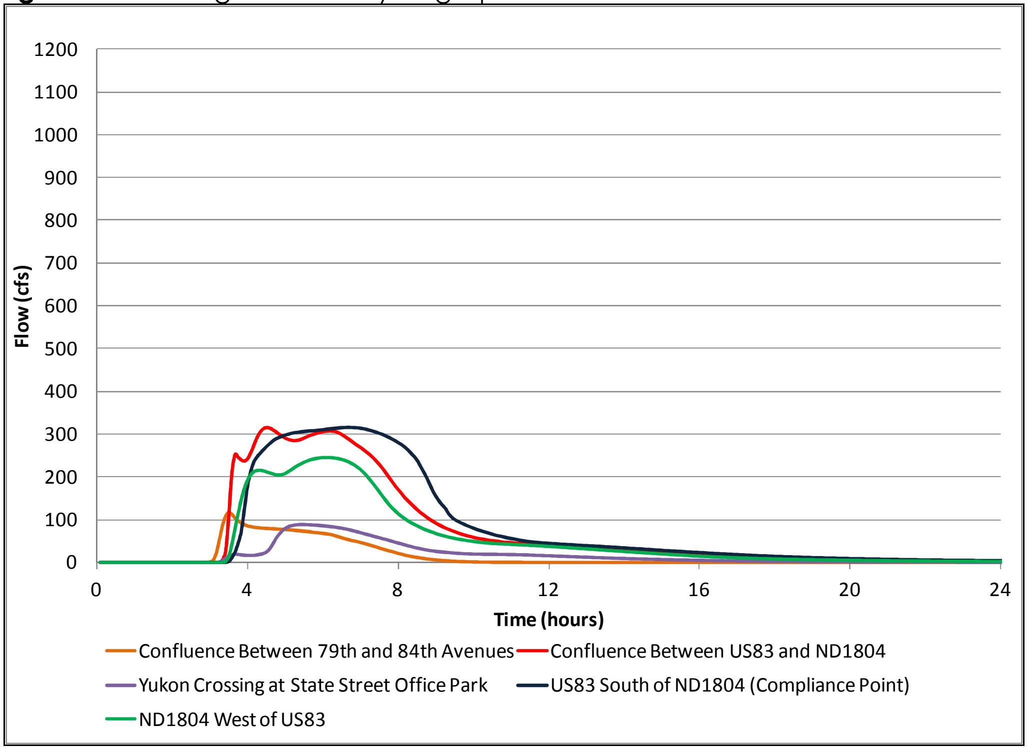
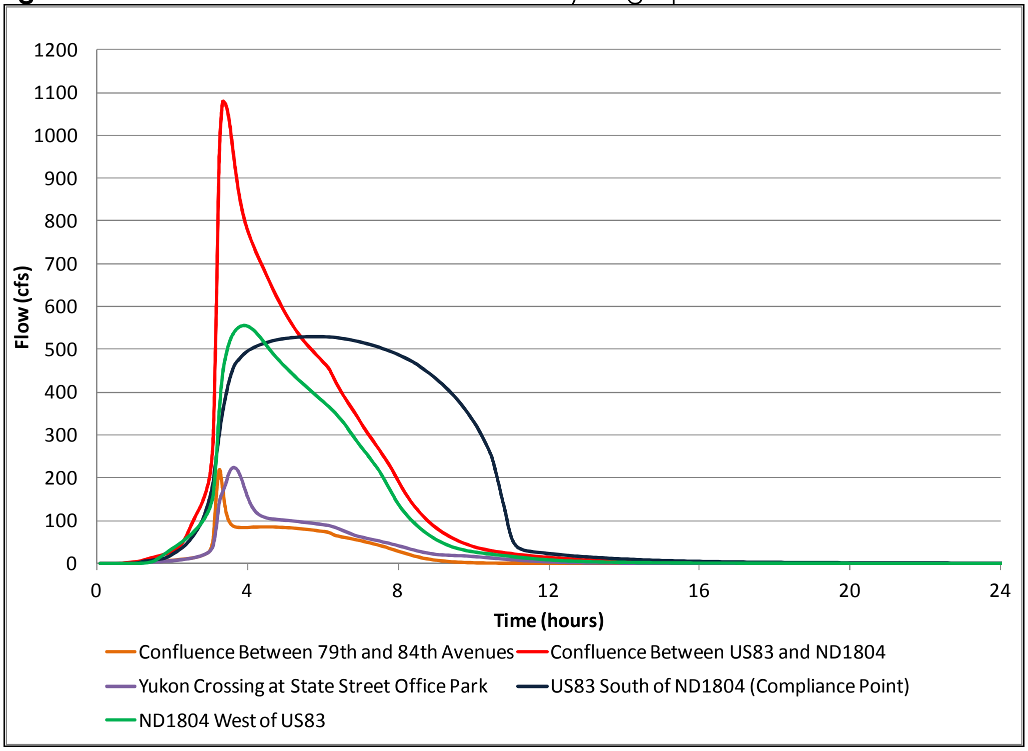


Figure 5-4 Full Build-Out No BMPs 100-Year Hydrograph



5.2 Runoff Volumes

In addition to peak flow rates, runoff volumes also increase dramatically (***Table 5.2***). For the 6-hour, 2-year event, runoff volumes increase by nearly a factor of 10, and for the 100-year event, volumes nearly double. The hydrograph figures shown previously also illustrate the volume changes by the differences in area under the hydrograph plots.

Table 5.2: Summary of Existing and Full Build-Out No BMPs Runoff Volumes (ac-ft) at Main Compliance Point

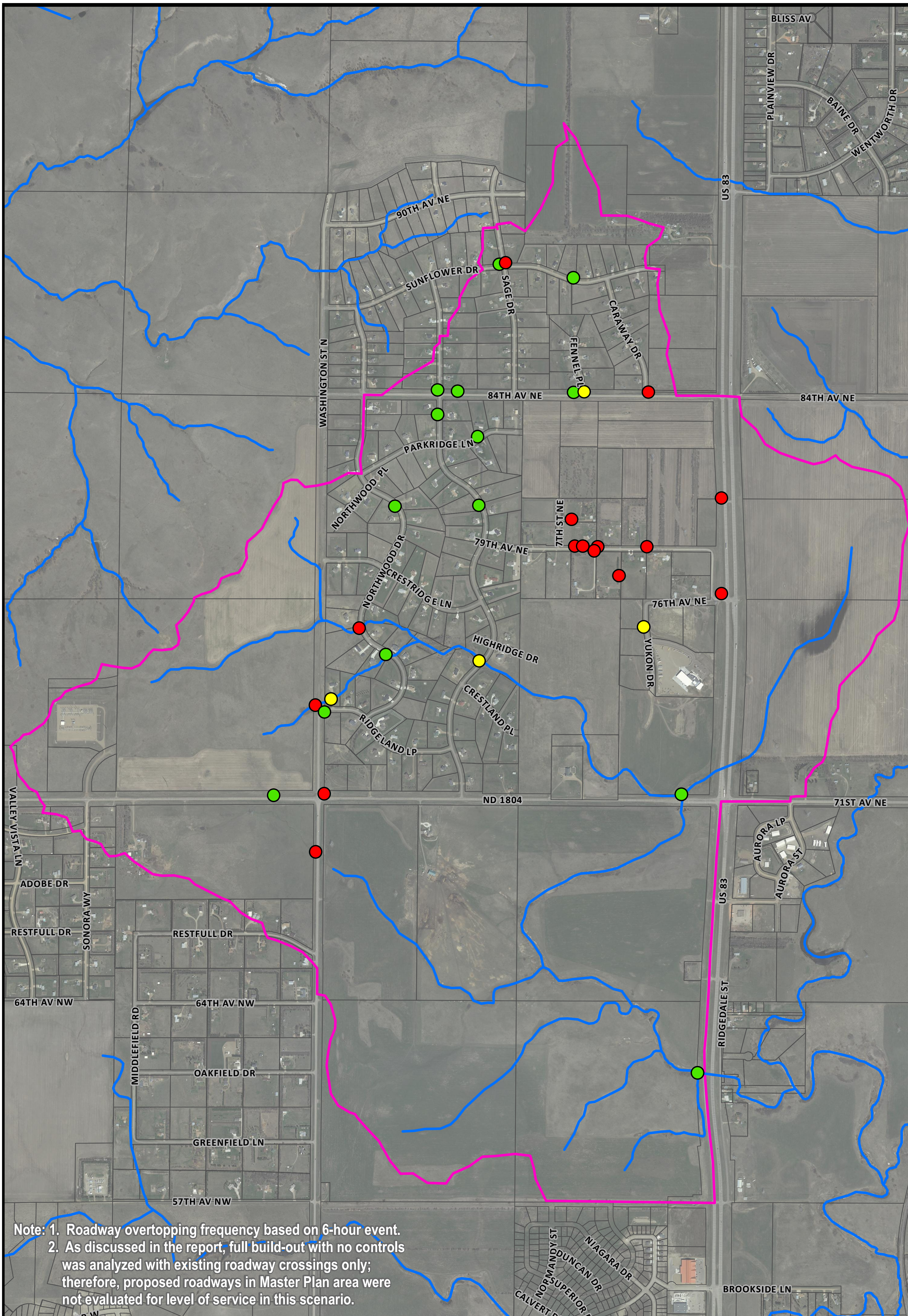
Scenario	6-Hour			
	2-yr	10-yr	25-yr	100-yr
Existing	9.2	54.7	90.9	160.1
Full Build-Out No BMPs	90.4	168. 8	218.9	306.2

5.3 Road Level of Service

Predictably, the level of service is significantly degraded for all of the crossings if the watershed develops and no stormwater management facilities are employed (***Figure 5-5***). Although both the main US 83 and ND 1804 crossings are among the few crossings that are not overtopped in the 100-year event, freeboard in the 6-hour, 100-year event is reduced from 11.1 feet to 2.0 feet at US 83 and from 8.0 feet to 3.1 feet at ND 1804.

5.4 Conclusions

The results from the full build-out, no controls scenario demonstrate the need for providing stormwater management to reduce peak flows and maintain level of service at existing roadways.



Note: 1. Roadway overtopping frequency based on 6-hour event.
2. As discussed in the report, full build-out with no controls was analyzed with existing roadway crossings only; therefore, proposed roadways in Master Plan area were not evaluated for level of service in this scenario.

N

0 600 1,200 Feet

1 in = 1,200 feet

Figure 5-5 Full Build-Out, No Controls - Roadway Level of Service

US 83/ND 1804 Stormwater Master Plan

City of Bismarck, ND

AE2S Think Big. Go Beyond.

Montgomery Associates

JLG architects

- US 83 / ND 1804 Watershed
- Hydrography
- Parcels
- Level of Service Acceptable
- Level of Service Not Acceptable
- No Overtopping in 100-year Event

AE2S in association with MARS and JLG

Developed by: Danielle Lee | 03/19/2013
Coordinate System: ND State Plane South
Vertical Datum: NAVD88
Metadata Included in the Report

6.0 STORMWATER MASTER PLAN

The proposed stormwater Master Plan utilizes traditional detention practices. Traditional detention refers to instituting practices that the City has typically employed in adjoining master planned areas. The City utilizes major road crossings as the detention basin embankment and outlet structure, and stormwater runoff is impounded in the valleys of the existing drainage-ways upstream of the crossing (valley storage). In cases where topography does not allow for valley storage, regional detention storage is provided through excavation and berming. Key elements of this alternative include:

- Provide approximately 167 acre-feet of new detention storage through the use of five "valley storage" detention facilities and three "graded" detention facilities to reduce future runoff rates to existing runoff rates (i.e. pre-post detention) for the 6-hour, 2-, 10-, and 100-year events;
- Incorporate existing regional detention basins within Northridge Estates;
- In development areas located upstream of existing rural residential development, mandate on-site detention facilities meeting the City's design standards so as not to increase local flooding issues within existing rural residential properties;
- Modification of key roadway culverts and roadway profiles to meet level of service requirements; and
- Limiting the effects of additional impervious area beyond what the planned infrastructure is designed for, as individual developments may propose impervious coverage higher than what is outlined in this Master Plan.

The Master Plan improvements are illustrated in ***Figure 6-1***. The following sections provide additional detail on each of the improvements and the performance of this Master Plan with respect to the design criteria outlined in ***Section 1***.

6.1 Detention Facilities

6.1.1 Regional Detention Basin Geometries

As outlined in the previous section, a total of eight new regional detention facilities are proposed as part of this alternative, which are summarized in ***Table 6.1*** and in ***Figure 6-2***. Basin geometry and preliminary grading plans are shown in the ***Exhibits*** section of this report. Note that detention facilities are concept in design and can be modified to meet the overall development plans of the specific area as long as the stage-area relationship and key outlet and overflow elevations are maintained.

Outlet structures were designed such that the 2-year event would be conveyed through a small circular opening (8-18 inches in diameter). From the opening, flow would be conveyed through a 24" RCP to a large diameter manhole. During larger flood events, water would begin to pour over the rim of a large diameter manhole that would have a grate over the entire manhole top. A larger culvert would then carry the combined low and high flows under the remainder of the embankment.

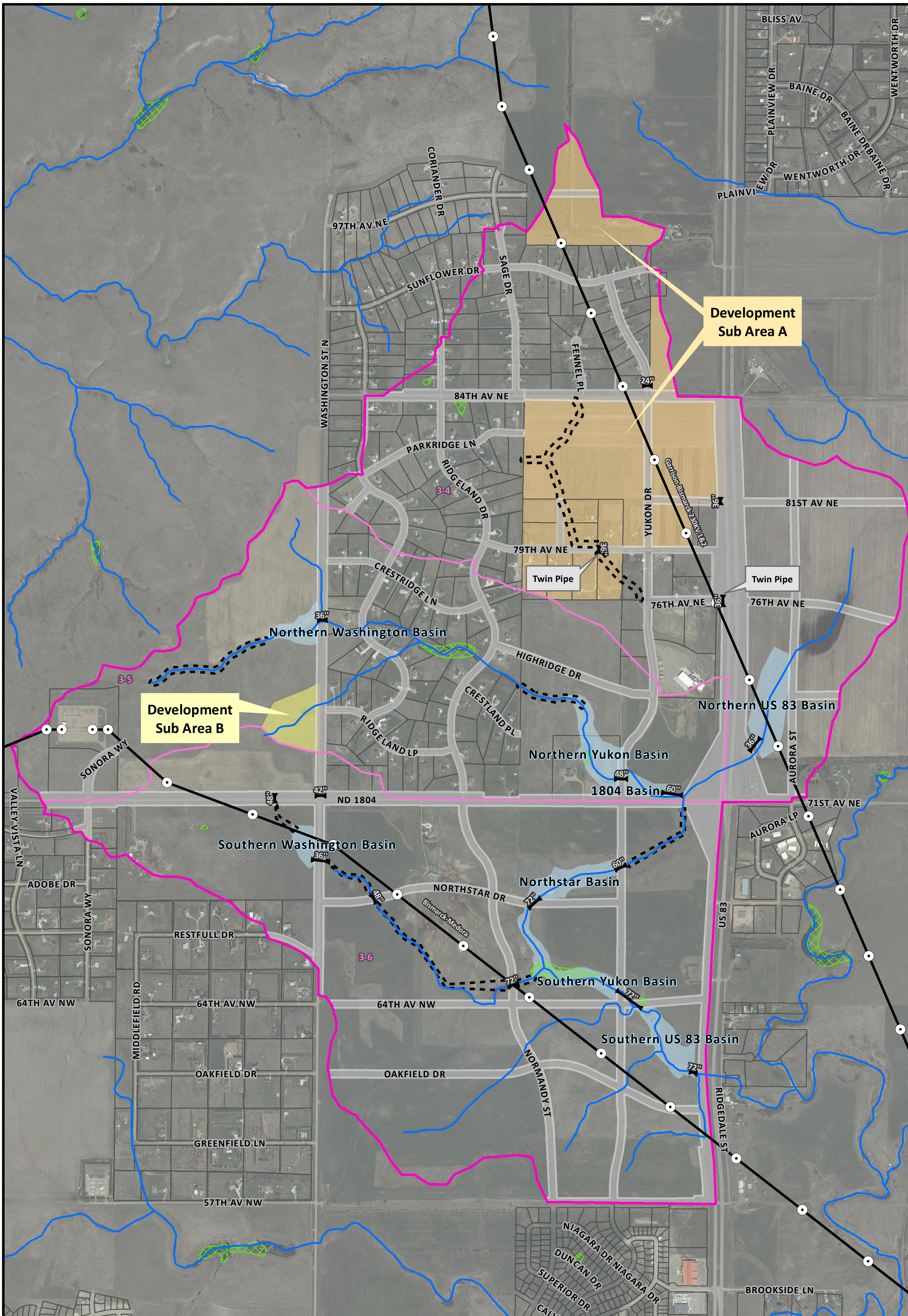
Table 6.1: Summary of Master Plan Detention Basin Geometry

Basin Name	Basin Type	Maximum Storage[1] (acre-feet)	Maximum Area[1]/Easement Area[2] (acres)	Bottom Elevation (NAVD 88)	Overflow Elevation (NAVD 88)
Northern Washington	Valley	12.0	4.1/4.7	1885.0	1892.6
Southern Washington	Graded	15.6	3.2/3.3	1865.0	1872.0[3]
Northern Yukon	Valley	24.8	7.4/9.3	1838.1	1847.2
1804	Graded	15.8	2.2/2.6	1830.25	1841.0
Northstar	Valley	24.7	6.3/7.4	1816.7	1827.4
Southern Yukon	Valley	24.8	7.6/9.0	1807.0	1816.8
Northern US 83	Graded	24.5	8.6/12.6	1833.0	1837.9
Southern US 83	Valley	24.8	6.1/8.7	1799.0	1809.9
Total	N/A	167.0	45.5/57.6	N/A	N/A

1 – Maximum Storage and Maximum Area are based on the overflow elevation.

2 – Easement Areas are based on the 6-hour, 100-year event elevation plus one foot or the emergency overflow elevation, whichever is higher

3 – Overflow elevation may be higher by approximately 6-12" if the overflow is incorporated into the North Washington Street embankment.



N

0 600 1,200 Feet

1 in = 1,200 feet

Figure 6-1 Master Plan

US 83/ND 1804 Stormwater Master Plan

City of Bismarck, ND

AE2S Think Big. Go Beyond. | Montgomery Associates | JLG architects

- US 83 / ND 1804 Watershed
- Hay Creek Subwatersheds
- Hydrography
- National Wetlands Inventory
- Future Road ROW
- Basin Footprints
- Conceptual Drainage Easements
- Proposed Culvert
- WAPA Transmission Lines
- WAPA Structures

AE2S in association with MARS and JLG

Developed by: Danielle Lee | 03/22/2013

Coordinate System: ND State Plane South

Vertical Datum: NAVD88

Metadata Included in the Report

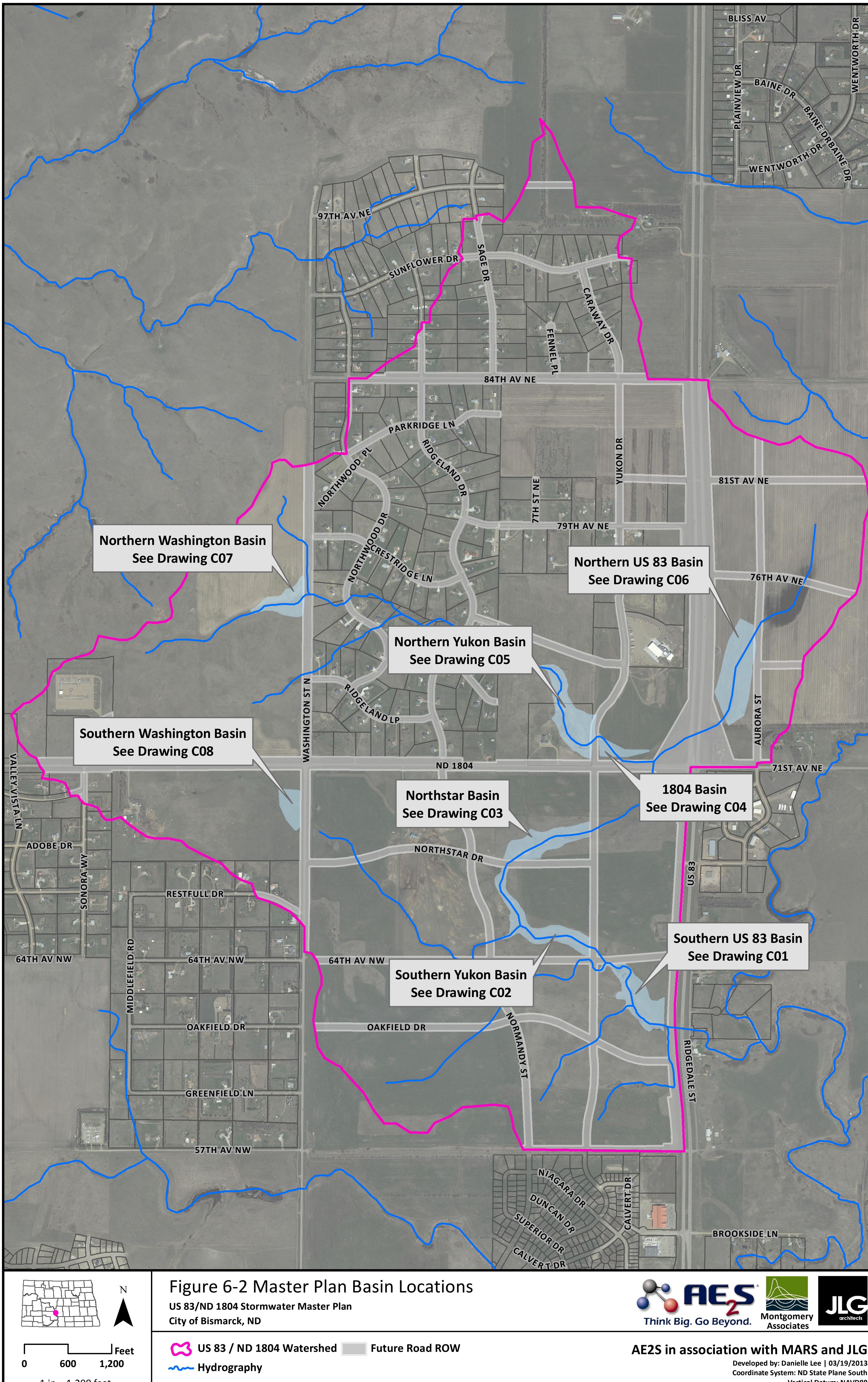


Figure 6-2 Master Plan Basin Locations

US 83/ND 1804 Stormwater Master Plan
City of Bismarck, ND

AE2S Think Big. Go Beyond. | Montgomery Associates | JLG architects

US 83 / ND 1804 Watershed
Future Road ROW
Hydrography

AE2S in association with MARS and JLG

Developed by: Danielle Lee | 03/19/2013
Coordinate System: ND State Plane South
Vertical Datum: NAVD88
Metadata Included in the Report

6.1.2 Impacts of US 83 / ND 1804 Interchange Construction

The US 83 and ND 1804 intersection is currently the highest traffic volume intersection within the project area. The US 83 Corridor Study described that this intersection should convert to a diamond interchange to handle the anticipated full build-out traffic volume with US 83 passing under a raised ND 1804 highway. This intersection / interchange is also the location of one of the critical stormwater facilities (1804 basin); therefore, the extent and type of interchange that ultimately is designed has the potential to significantly impact the performance of the Master Plan.

For the purposes of this study, the City Working Group advised using the diamond interchange extents that were outlined in the US 83 Corridor Study. To account for the potential impacts of a diamond interchange, the extents of the 1804 basin were set to allow for a larger embankment section on ND 1804 as it slopes up to pass over US 83. Further, a separation distance was needed as discussions with NDDOT indicated that the detention facility could not use the highway embankment as the embankment for the detention facility and the embankment could not extend into the right-of-way since that area is needed for snow storage.

From a drainage conveyance standpoint, flow from the Northern US 83 basin has to flow into the 1804 basin in order to meet the peak rate control criteria for this project. The existing culvert under US 83 to the north of ND 1804 has sufficient capacity, but additional culverts, drainage-ways, and possibly berms will have to be constructed to direct the runoff east of US 83 to the 1804 basin. The sizes of these culverts and ditches have not been sized as part of this study, as the size and length will ultimately depend on the geometry and off ramp elevations designed by the NDDOT.

If a different interchange geometry is selected that would reduce the size or feasibility of the planned 1804 and/or Northern US 83 basins, modifications to the basin layouts could be made that would utilize the area between the main highways and off ramps.

6.1.3 On-Site Detention Requirements

Development Subarea A

As noted previously, 79th Avenue NE currently does not meet level of service requirements at the existing culvert crossing serving the main drainage-way through the project area and there are existing drainage concerns downstream of the crossing. Further, the timing of re-development of the existing rural residential properties along 79th Avenue NE is uncertain. Therefore, new development located to the north of the State Street Office Park has the potential to increase both the frequency and magnitude of flooding issues in this area if that area is urbanized prior to redevelopment of the rural residential area and reconstruction of 79th Avenue NE. This area is shown as Development Subarea A in the figure on the right.

If new development occurs prior to redevelopment of the existing rural residential properties, this Master Plan recommends the following for new development in Development Subarea A:

- Meet the City of Bismarck's requirements for peak rate control on a site-by-site basis;
- Obtain drainage easements from existing rural residential properties to the extent of the 100-year post-development flood limits and/or re-route drainage via swales or storm sewer around the rural residential properties;
- Confirm that no homes or structures along 79th Avenue NE would be inundated in the 100-year flood event; and
- Evaluate level of service issues with 79th Avenue NE and whether any improvements could be made to improve the level of service to the required level for a Local street.

If redevelopment of the rural residential area occurs either prior to or at the same time as new development, this Master Plan recommends the following:

- The City may elect to waive site-by-site peak rate control as the drainage facilities from Yukon Street to ND 1804 have adequate capacity and peak rate control would still be met at the project's compliance point. Provisions for conveying the runoff to the detention facilities are required, either through surface drainage or new storm sewer.
- Raise the profile of 79th Avenue NE and provide adequate conveyance capacity to meet level of service requirements for a Local Road. If no site-by-site detention is provided upstream of 79th Avenue NE, a preliminary analysis indicates that twin 48" RCP culverts (upstream invert at 1860.0 (NAVD 88) with 1.2% slope) and a minimum overflow elevation of 1866.5 (NAVD 88) would meet level of service requirements (instead of the improvements noted on ***Figure 6-3***).

Details of the Development Subarea A assumptions that were the basis for the results and performance of the Master Plan are described in ***Appendix A***.

Development Subarea B

Development Subarea B is a small watershed located just west of the intersection of North Washington Street and Ridgeland Loop. Runoff from this undeveloped area currently flows through Northridge Estates via a series of swales and small culverts. Under existing conditions, these facilities appear to have capacity to convey runoff to the existing detention facilities within Northridge Estates. New development has the potential to overwhelm these conveyance facilities and could damage downstream property. Therefore, if the area develops, this Master Plan recommends one of the following requirements:

- Meet the City of Bismarck's requirements for peak rate control on a site-by-site basis within Development Subarea B; or

- Install storm sewer or a ditch from Development Subarea B to the Northern Washington Basin (the basin has capacity to accept runoff from this area). Preliminary analysis indicates that a 36" RCP would have the capacity to convey the full build-out flows with no detention (not accounting for additional North Washington Street runoff).

Details of the Development Subarea B assumptions that were the basis for the results and performance of the Master Plan are described in ***Appendix A***.

6.2 Road Crossing Improvements

In addition to the construction of the detention facilities, several new and upgraded culvert crossings will be needed to meet the level of service for each road classification (***Figure 6-3)***. It should be noted that this figure is for the full build-out condition including redevelopment of the existing rural residential lots along 79th Avenue NE.

Except for the 79th Avenue crossing, existing road profiles are sufficient to construct the needed culverts under the roadway and meet level of service. Due to the minimal existing embankment height along 79th Avenue NE, the road grade would need to be raised approximately 2 feet to provide sufficient cover over the culverts as well as allow for additional backwater prior to overtopping to meet level of service.

6.3 Open Channel Conveyance Improvements

Conveyance between road crossings can be provided via open channel or storm sewer. This study evaluates the minimum trapezoidal channel cross section that would be needed to provide a stable channel in the 6-hour, 25-year event. The methodology for determining a stable channel is outlined in ***Appendix A***.

Preliminary designs for stable channels were completed for the reaches between road crossings south of ND 1804 that are not already being impounded for valley storage detention facilities. (see overview on ***Figure 6-3*** and preliminary grading plans in ***Exhibits***). Less defined existing drainage-ways are also present north of ND 1804 (for example, between 79th and 84th Avenues), and the same methodology presented in this study could be used to design these open channels as well if the detailed design for these areas called for open channel conveyance.

As an alternative to open channels, developers could install storm sewer to provide conveyance between road crossings provided the storm sewer had sufficient capacity to not compromise upstream facilities or properties.

Stability of the natural channel between US 83 and Hay Creek is potentially a concern as the watershed develops. While this plan reduces the peak rates to existing levels, the duration and frequency of flow events will increase substantially. During the final design for one of the main regional detention facilities, it is recommended that a detailed evaluation of the channel bed material and shear stress be completed to determine if improvements in this section of the channel are needed.

6.4 Maximum Impervious Criteria

The performance of this stormwater Master Plan is based on assumptions of impervious area percentages for the future land uses noted in ***Section 2***. Therefore, any proposed development that includes increased impervious area over what was assumed should meet the following criteria:

1. Provide on-site stormwater management devices such that the 2-, 10-, and 100-yr 6-hr peak flows leaving the site are equal to or less than the peak flows that would occur under the conditions assumed in the Master Plan. Note that runoff from pervious and impervious areas should be calculated separately, consistent with this study.
2. Provide on-site volume control such that the volume of runoff leaving the site within the first 30 hours of the 2-year, 6-hour design storm is equal to or less than that would occur under the conditions assumed in the Master Plan. Note that this may be accomplished through infiltration practices, retention devices, or extended detention systems. Examples of volume reduction practices are included in ***Appendix E***.

6.5 Performance

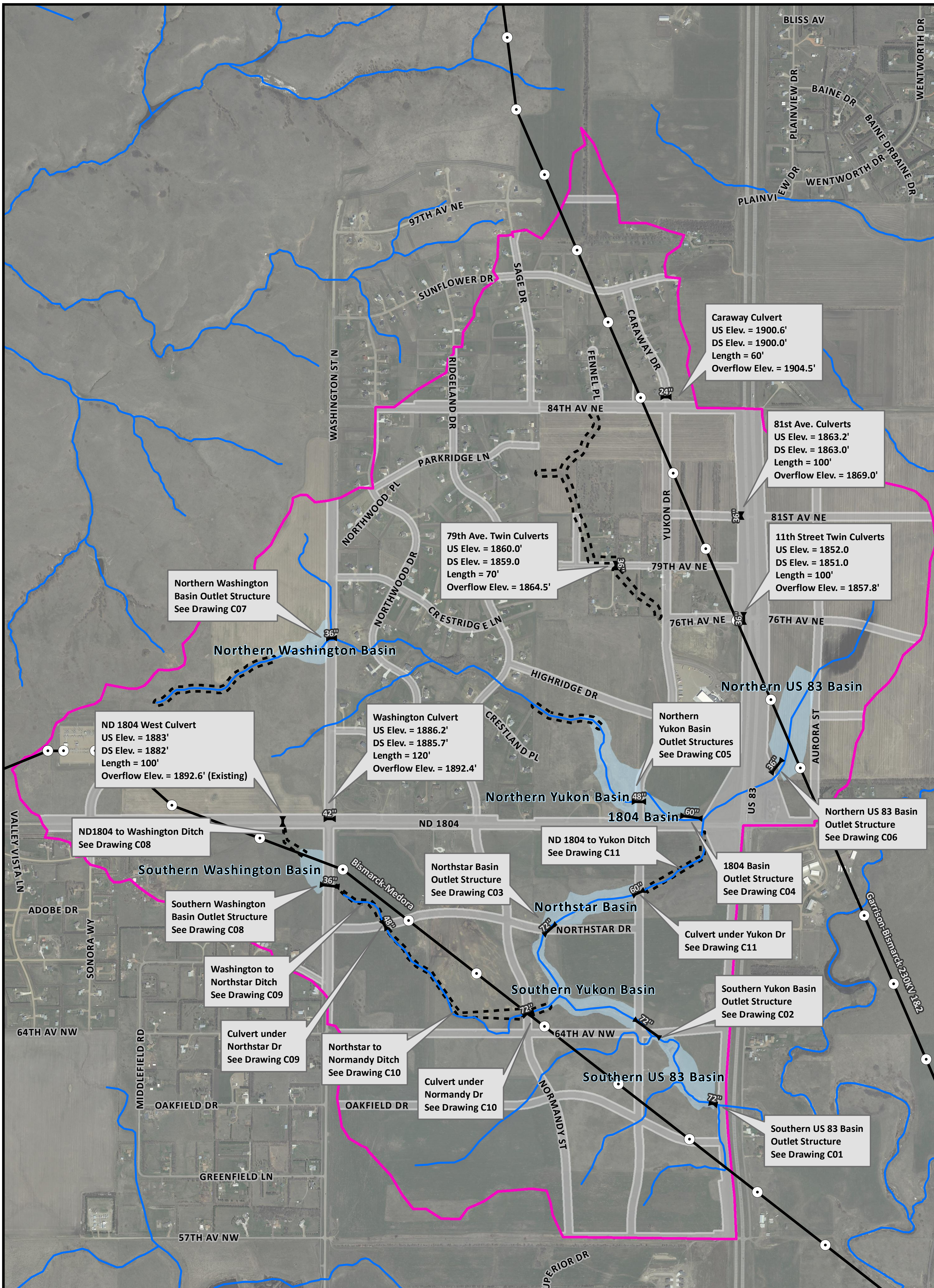
6.5.1 Peak Flows

The Master Plan reduces peak flow rates at US 83 to at or below existing peak flow rates for all recurrence intervals in the 6-hour event (***Table 6.2***). The small margin in the 6-hour 2- and 100-year events will allow for developers to convert open channels to storm sewers and eliminate the on-site detention facilities in Development Subareas A and B if appropriate based on the criteria listed previously in ***Section 6***. Flow rates for the 24-hour storm are reduced for the 2- and 25-year events with a small increase for the 100-year event.

Table 6.2: Summary of Existing and Master Plan Peak Flows at Main Compliance Point (US 83)

Scenario	6-Hour (cfs)				24-Hour (cfs)		
	2-yr	10-yr	25-yr	100-yr	2-yr	25-yr	100-yr
Existing	18	139	213	317	29	247	354
Master Plan	15	67	145	316	23	203	372
Percent Change	-12%	-52%	-32%	0%	-19%	-18%	+5%

While the Master Plan does match existing peaks at the compliance point, peak flows at certain locations within the study area increase compared to existing rates because of the regional detention approach of this Master Plan (see ***Figures 6-4, 6-5, 6-6***, and ***6-7*** for the 6-hour, 2- and 100-year events only).



Notes:

1. All culverts are Reinforced Concrete Pipe.
2. For Collector street typical sections, the minimum road centerline elevation is 6 inches lower than the minimum overflow elevation.

N

0 600 1,200 Feet

1 in = 1,200 feet

Figure 6-3 Master Plan Conveyance Improvements

US 83/ND 1804 Stormwater Master Plan

City of Bismarck, ND

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Legend		
US 83 / ND 1804 Watershed	Basin Footprints	WAPA Transmission Lines
Hydrography	Conceptual Drainage Easements	WAPA Structures
Future Road ROW	Culvert	

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Coordinate System: ND State Plane South
Vertical Datum: NAVD88
Metadata Included in the Report

Figure 6-4 Existing 2-Year Hydrographs

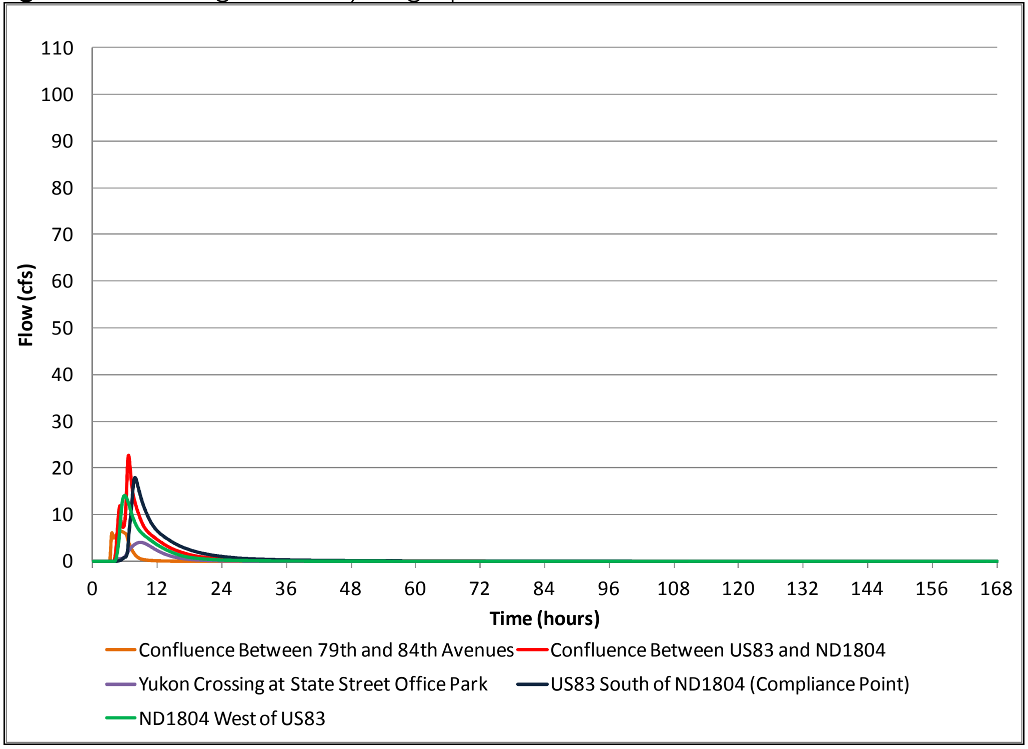


Figure 6-5 Master Plan 2-Year Hydrographs

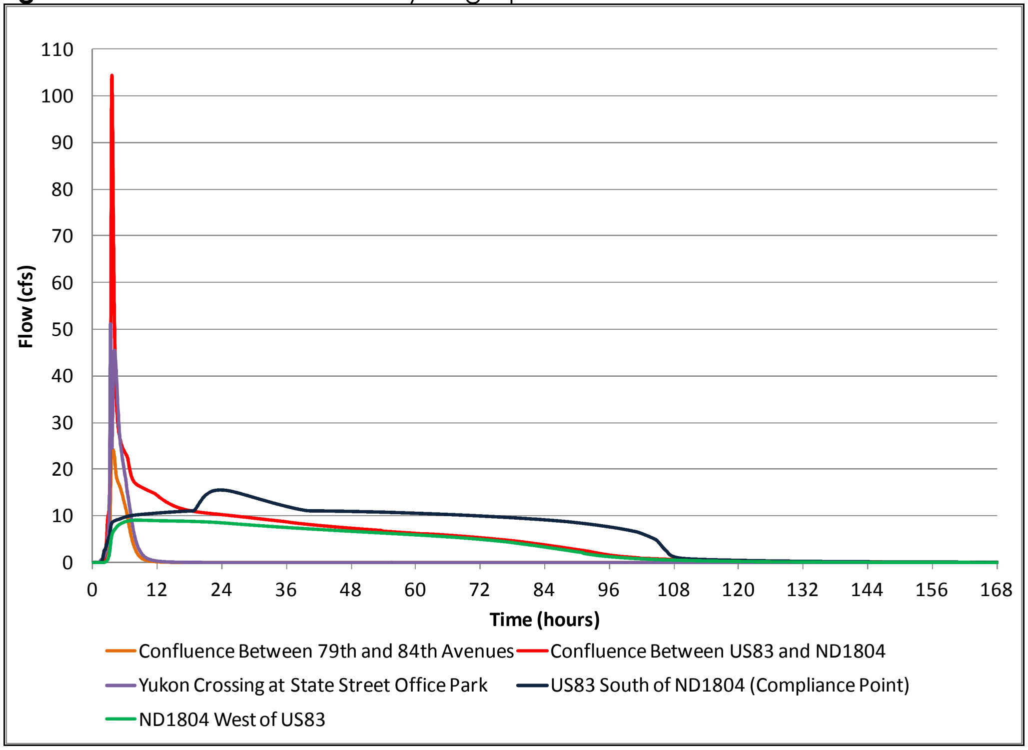


Figure 6-6 Existing 100 Year Hydrograph

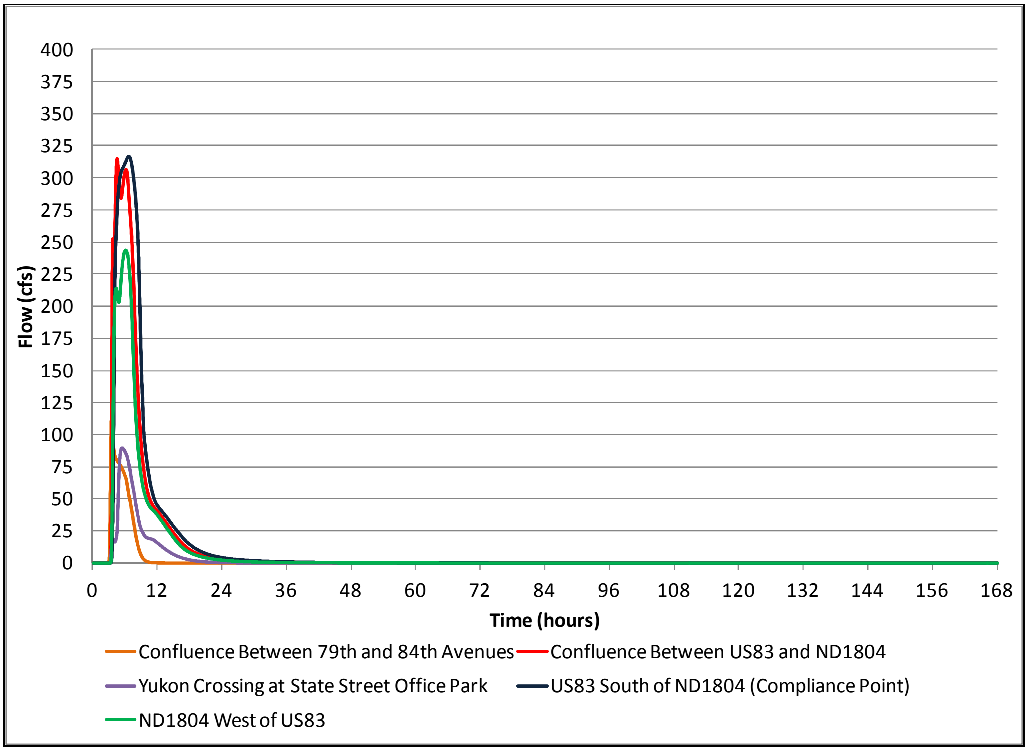


Figure 6-7 Master Plan 100-Year Hydrographs

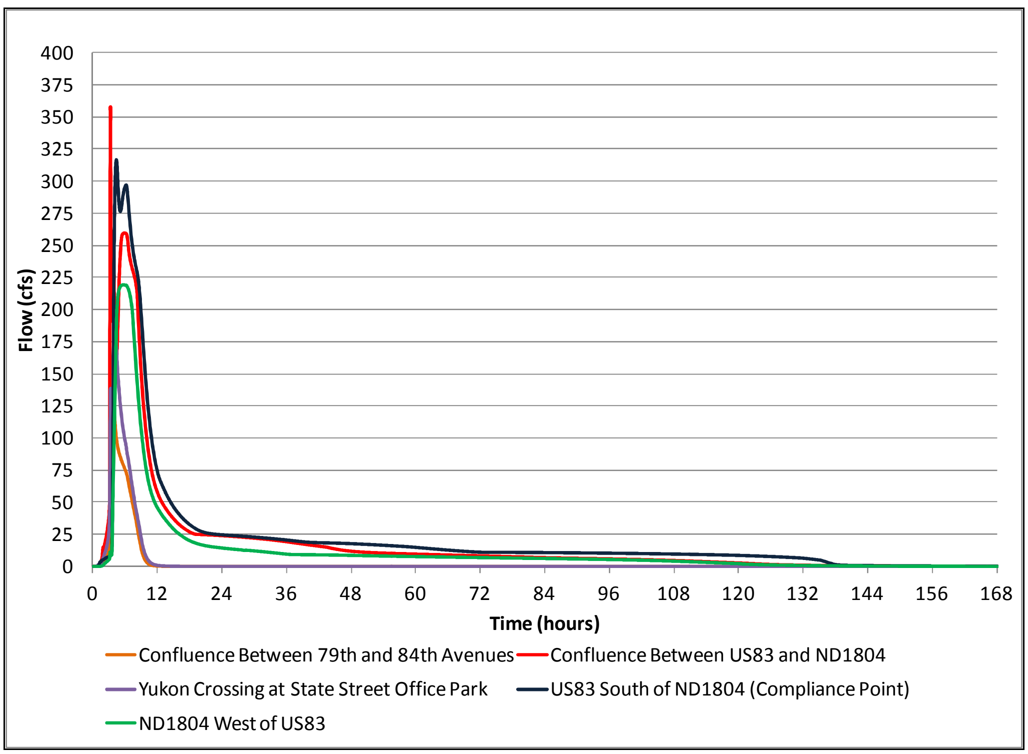


Figure 6-8 illustrates the peak flows (6-hour duration) for the 2-, 10-, 25-, and 100-year events at all the collector and arterial crossings where land use changes upstream are expected. Peak 25- and 100-year flows for the 24-hour storm duration are shown in ***Figure 6-9*** at all the NDDOT crossings.

One notable observation when comparing peak flows for the Master Plan to the existing conditions peak flows is that at the 79th Avenue NE and Yukon Drive crossings, peak flows are increased even though the individual subwatersheds in Development Subarea A meet the City's ordinance on a site-by-site basis. Two reasons for this are:

1. Reducing peak rates on a small scale does not necessarily ensure that peak rates downstream are not increased due to the timing of runoff from upstream parts of the watershed.
2. The analysis is based on the full build-out condition with all "de facto" storage behind existing crossings lost due to development. As described in the existing conditions analysis section (***Section 4.1***), this storage provides a noticeable reduction in peak flows.

These results suggest that the most challenging requirement for Development Subarea A could be obtaining drainage easements or confirming that no homes or structures are inundated in the 100-year event.

6.5.2 Runoff Volumes

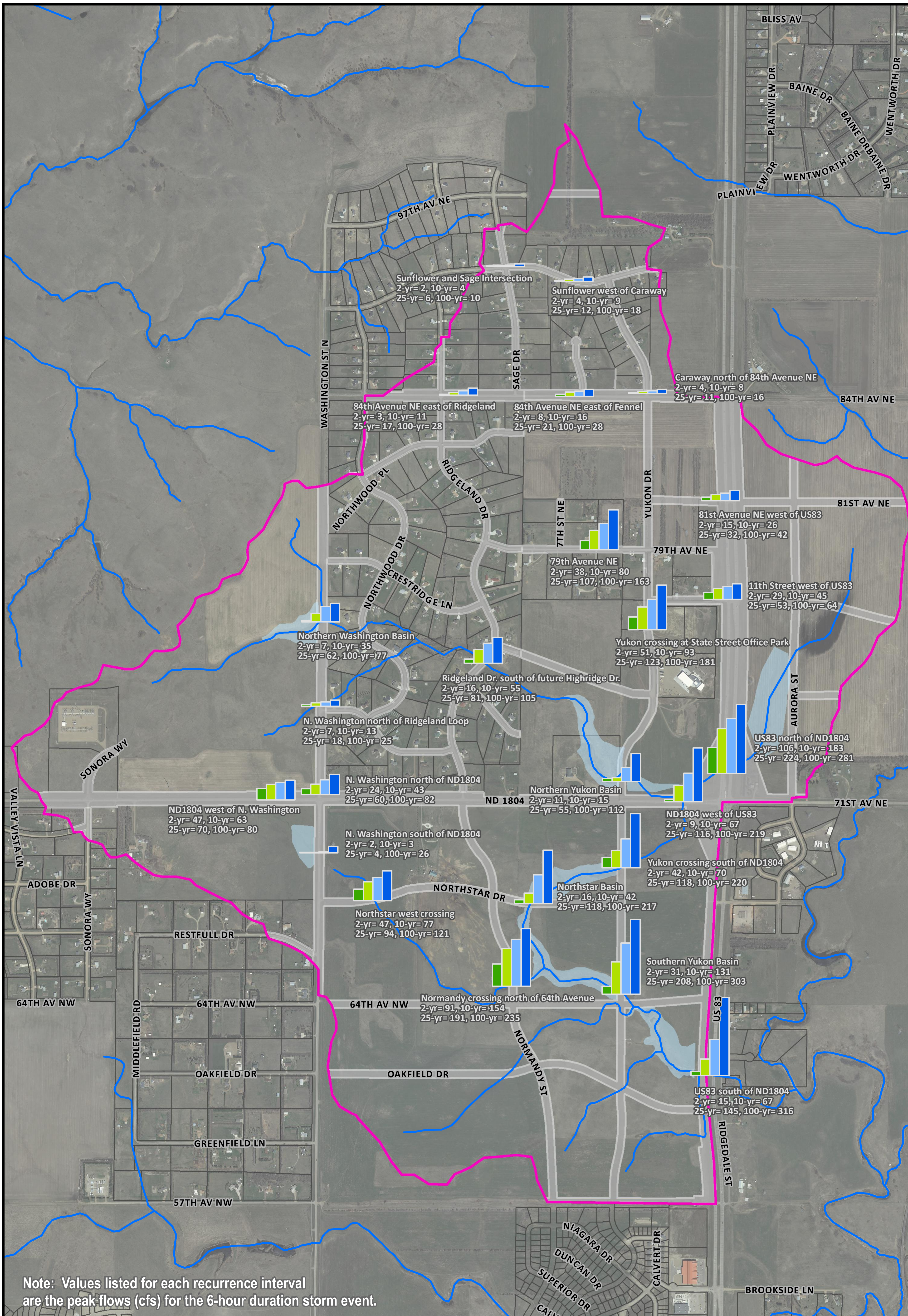
While the Master Plan reduces peak flow rates at the compliance point to at or below existing rates, detention facilities have a negligible effect on runoff volume; therefore, the runoff volumes in the Master Plan are the same as if no controls were implemented in the watershed (***Table 6.3***).

Table 6.3: Summary of Existing and Master Plan Runoff Volumes (ac-ft) at Main Compliance Point

Scenario	6-Hour			
	2-yr	10-yr	25-yr	100-yr
Existing	9.2	54.7	90.9	160.1
Master Plan	90.4	168. 8	218.9	306.2

6.5.3 Road Level of Service

Figure 6-10 displays the overtopping frequency of select roadway and driveways on main conveyance routes relative to the required level of service outlined in ***Section 1***. Peak 6-hour, 25- and 100-year stages along with the freeboard of the 100-year peak stage in relation to the overflow elevation (typically crown) are displayed in ***Figure 6-11*** for all collector street crossings and 79th Avenue NE. Since the NDDOT requires evaluation of crossings based on the 24-hour duration, ***Figure 6-12*** illustrates the peak stages for the 24-hour, 25- and 100-year events, 100-year freeboard, and 25-year outlet velocity.



N

Feet
0 600 1,200
1 in = 1,200 feet

Figure 6-8 Master Plan Peak Flows at Collector and Arterial Crossings

US 83/ND 1804 Stormwater Master Plan
City of Bismarck, ND

Think Big. Go Beyond.
Montgomery Associates

- US 83 / ND 1804 Watershed
- Hydrography
- Basin Footprints

- 2-Year
- 10-Year
- 25-Year
- 100-Year

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Coordinate System: ND State Plane South
Vertical Datum: NAVD88
Metadata Included in the Report

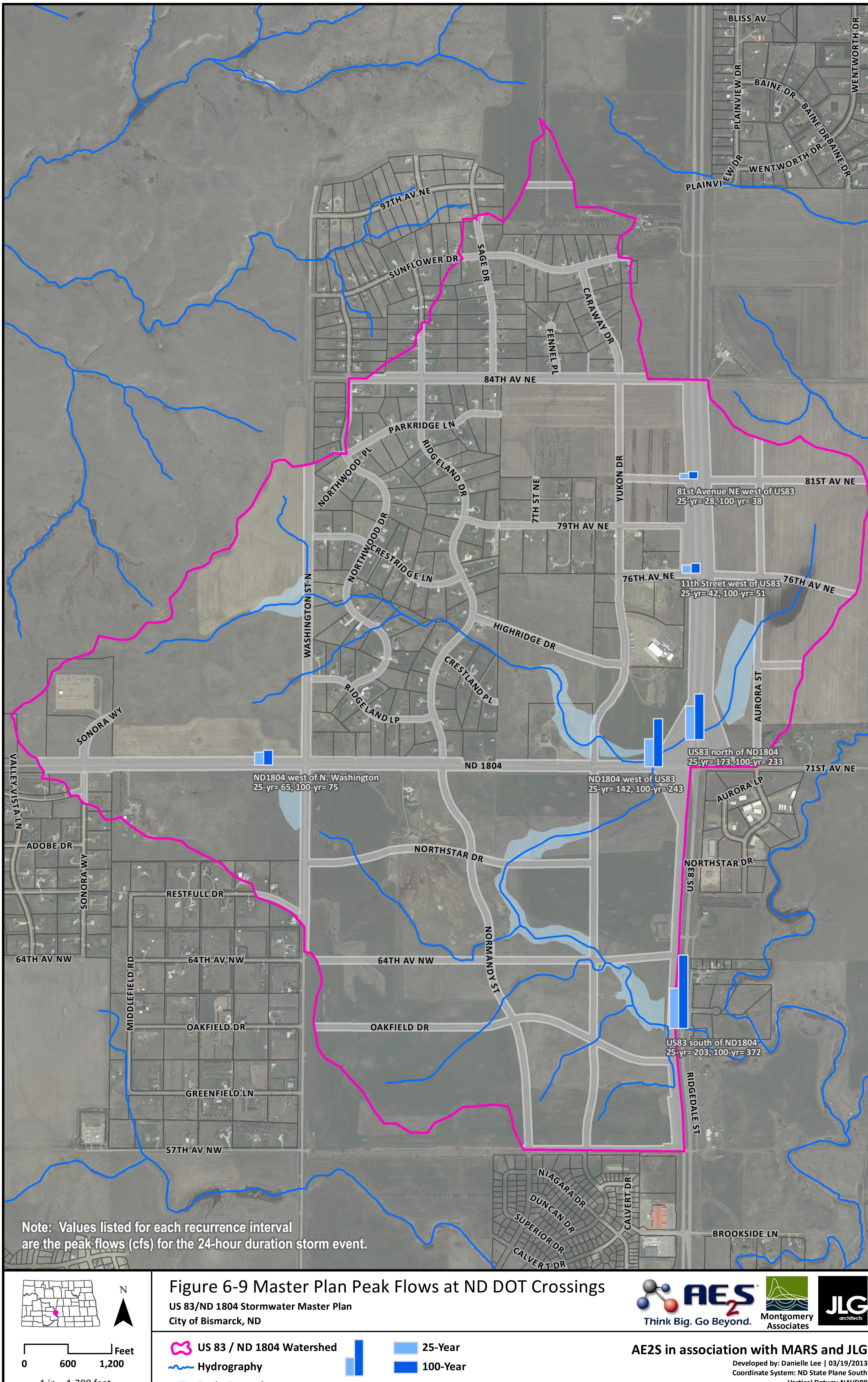

Figure 6-9 Master Plan Peak Flows at ND DOT Crossings

US 83/ND 1804 Stormwater Master Plan

City of Bismarck, ND

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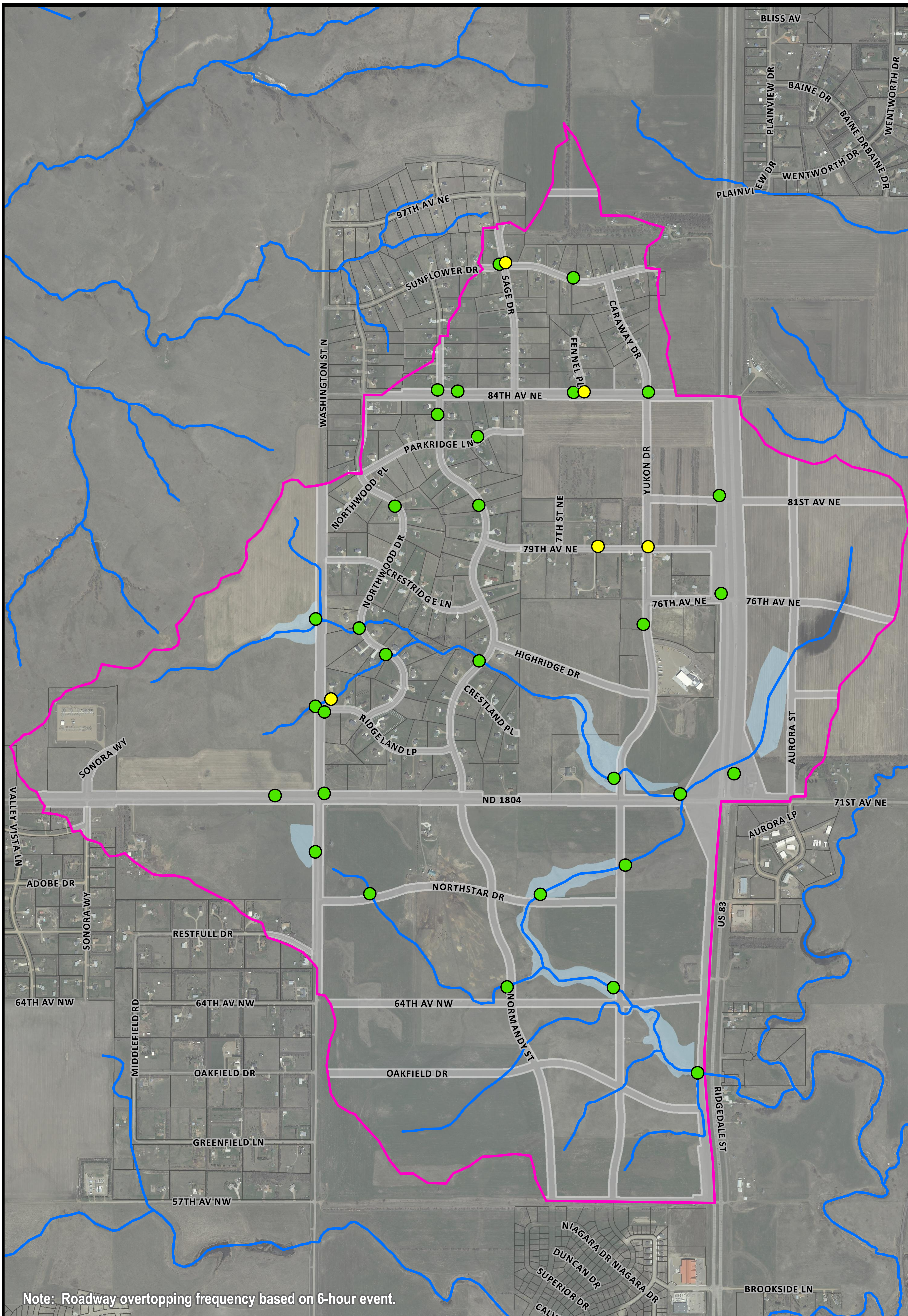
Coordinate System: ND State Plane South

Vertical Datum: NAVD88

Metadata Included in the Report



N

0 600 1,200 Feet

1 in = 1,200 feet

Figure 6-10 Master Plan Roadway Level of Service

US 83/ND 1804 Stormwater Master Plan
City of Bismarck, ND

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- US 83 / ND 1804 Watershed
- Hydrography
- Basin Footprints
- Level of Service Acceptable
- Level of Service Not Acceptable
- No Overtopping in 100-year Event

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Vertical Datum: NAVD88
Metadata Included in the Report

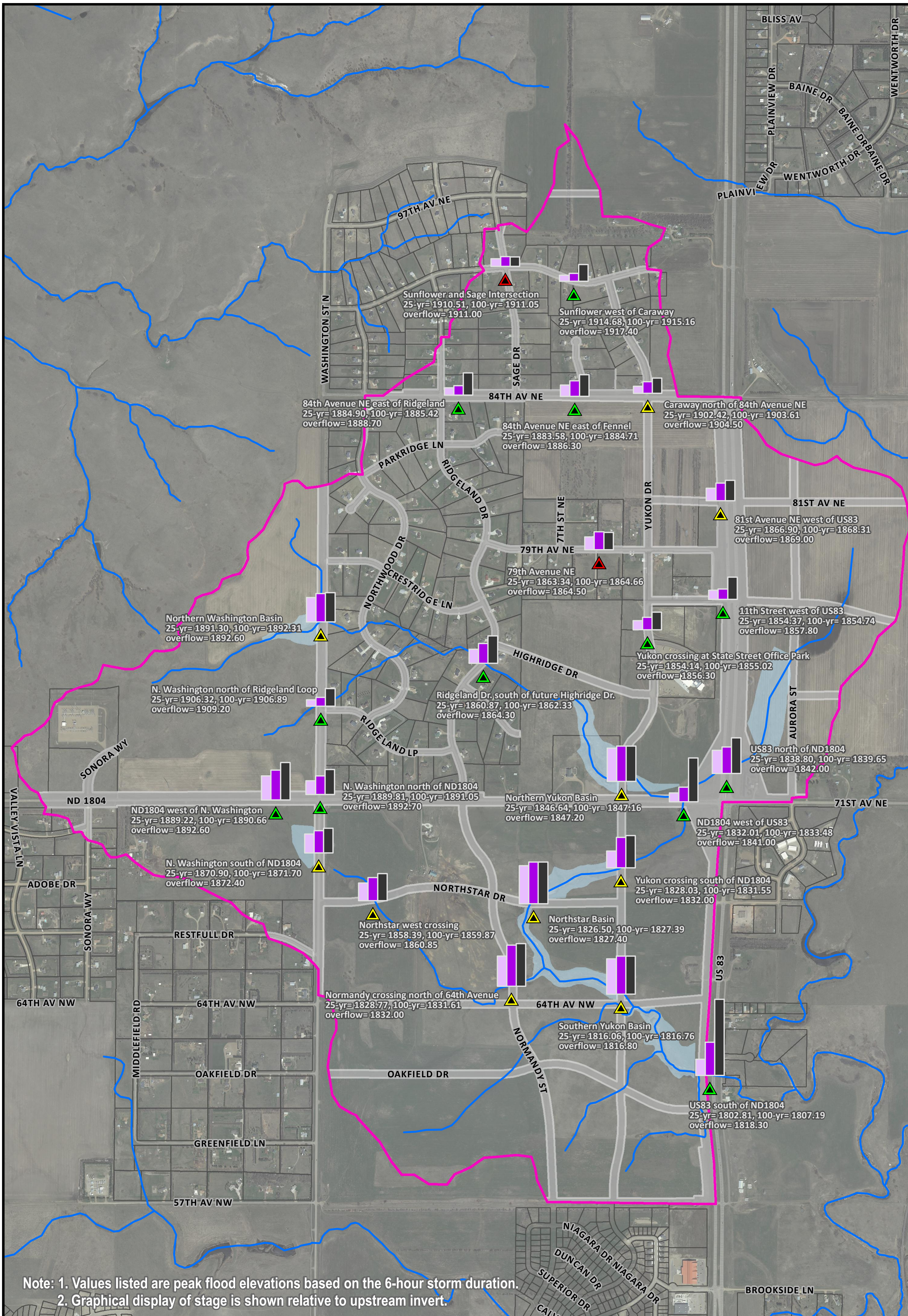

Figure 6-11 Master Plan Peak Stages at Collector and Arterial Crossings

US 83/ND 1804 Stormwater Master Plan

City of Bismarck, ND

N

0 600 1,200 Feet

1 in = 1,200 feet

- US 83 / ND 1804 Watershed
- Hydrography
- Basin Footprints
- 25-Year 6-Hour
- 100-Year 6-Hour
- Overflow Elevation
- 100-yr Freeboard < 0'
- 0' > 100-yr Freeboard < 1'
- 100-yr Freeboard > 1'

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Developed by: Danielle Lee | 03/19/2013

Coordinate System: ND State Plane South

Vertical Datum: NAVD88

Metadata Included in the Report

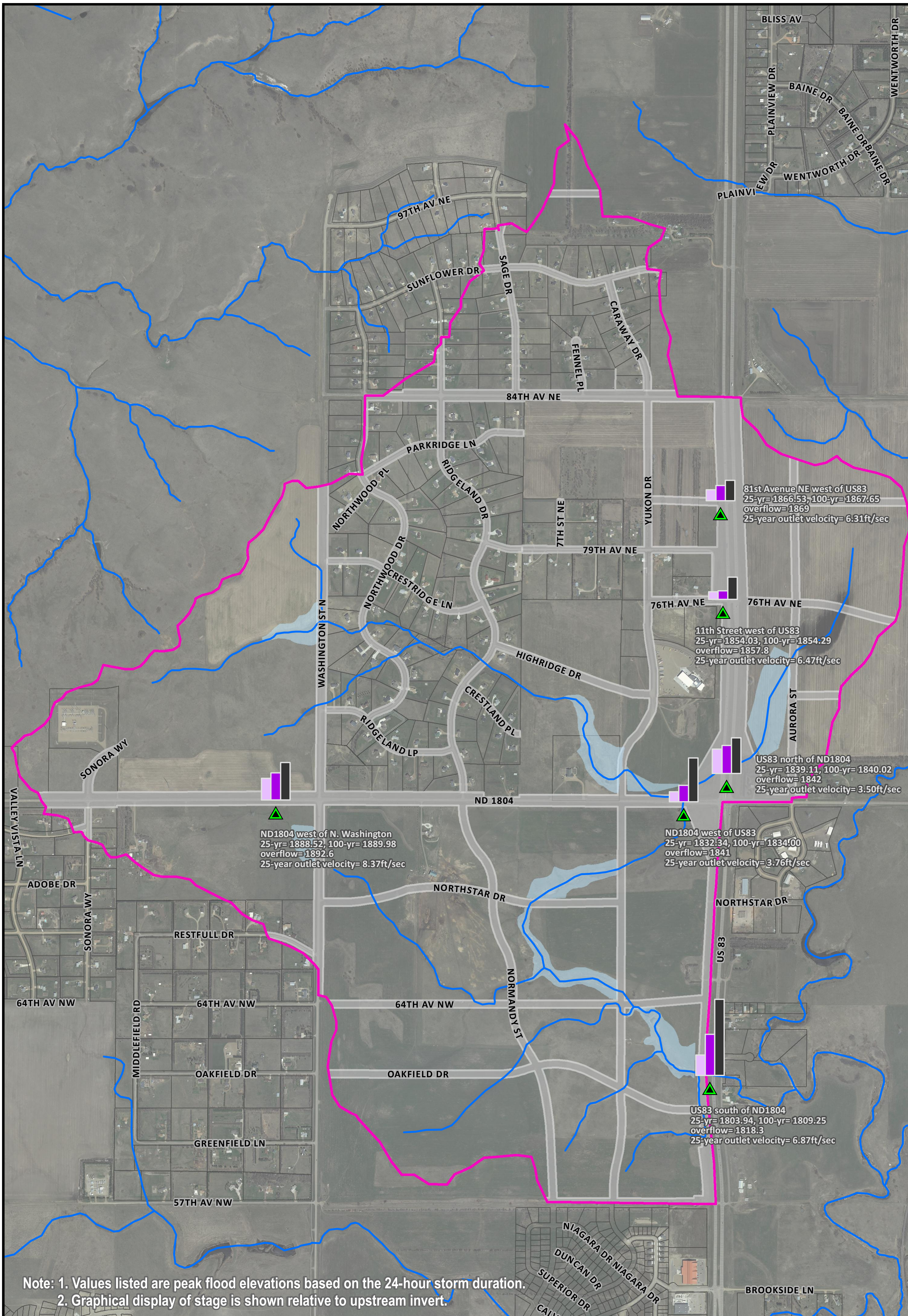

Figure 6-12 Master Plan Peak Stages at ND DOT Crossings

US 83/ND 1804 Stormwater Master Plan

City of Bismarck, ND

N

0 600 1,200 Feet

1 in = 1,200 feet

US 83 / ND 1804 Watershed
Hydrography
Basin Footprints

25-Year 6-Hour
100-Year 6-Hour
Overflow Elevation

100-yr Freeboard < 0'
0' > 100-yr Freeboard < 1'
100-yr Freeboard > 1'

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Vertical Datum: NAVD88
Metadata Included in the Report

These figures illustrate the following observations:

- All crossings meet the level of service requirements outlined in this report.
- The 6-hour, 100-year event begins to overtop Northstar Drive at the Northstar Basin. However, the 100-year event exceeds the edge of the ROW by less than 0.03' so this crossing will meet the City requirement for maximum ponding depth at the crown of the road.

6.5.4 Peak Basin Stages

Peak basin stages for the Master Plan are displayed in ***Figure 6-13*** for the 6-hour event. The 24-hour, 100-year elevation and emergency overflow elevation are shown as well for comparison. Note that the overflow weirs for the Northern and Southern US 83 Basins overtop more frequently than the 100-year event. This overflow is necessary to provide adequate outlet conveyance capacity. Final design of the facilities should include applicable armoring/scour protection for the overflow weirs.

6.5.5 Channel Stability Downstream of US 83

Since runoff volumes are increased, the duration and frequency of shear stress will increase even if the maximum shear stress remains the same. The ***Figure 6-14*** and ***Figure 6-15*** illustrate the shear stress duration for the 2- and 25-year year events for the reach between US 83 and Hay Creek. It should be noted that these shear stress values are approximate only and do not reflect any shear stress increases due to channel bends.

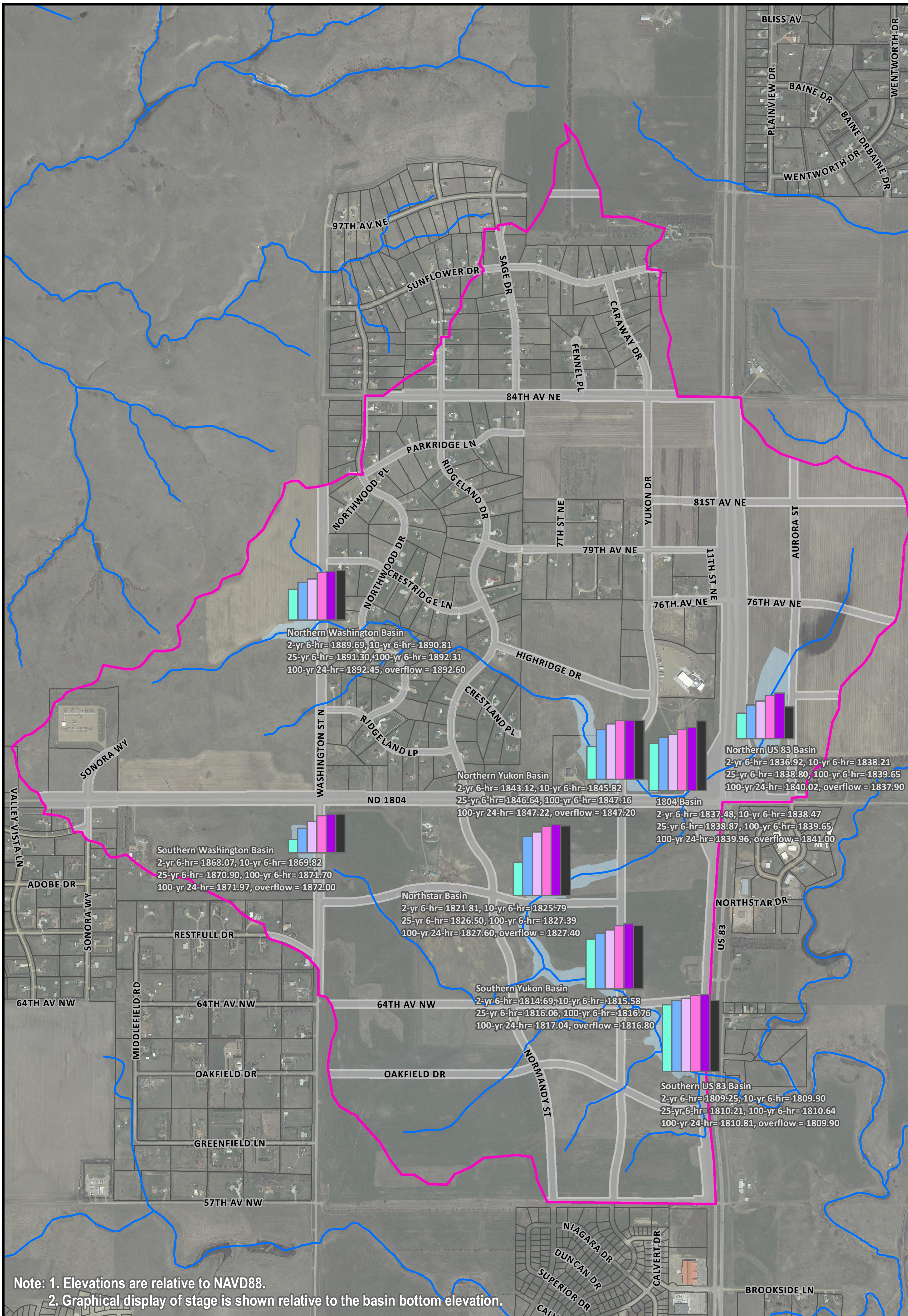
While these shear values are not high for an engineered, well-vegetated channel, these shear stresses could be problematic for an unvegetated natural channel depending on the grain size of the bed material in the channel and the severity of the meanders.

6.5.6 Water Quality Performance

Table 6.4 summarizes the water quality performance of the Master Plan, which indicates that the detention facilities will trap a large portion of the sediment (Total Suspended Solids or TSS) generated from the fully built-out watershed. It should be noted that these results do not account for any water quality treatment that could be provided via on-site detention facilities within Development Subareas A or B. Specifics of the water quality analysis are included in ***Appendix D***.

Table 6.4: Master Plan Water Quality Performance

Scenario	TSS Trapped Compared to No Controls (Percent)
Master Plan	74%



N

0 600 1,200 Feet

1 in = 1,200 feet

Figure 6-13 Master Plan Peak Basin Stages

US 83/ND 1804 Stormwater Master Plan
City of Bismarck, ND

AE2S Think Big. Go Beyond. | Montgomery Associates | JLG architects

- US 83 / ND 1804 Watershed
- Hydrography
- Basin Footprints
- 2-Year 6-Hour
- 10-Year 6-Hour
- 25-Year 6-Hour
- 100-Year 6-Hour
- 100-Year 24-Hour
- Overflow Elevation

AE2S in association with MARS and JLG

Developed by: Danielle Lee | 03/19/2013
Coordinate System: ND State Plane South
Vertical Datum: NAVD88
Metadata Included in the Report

Figure 6-14 Shear Stress Comparison, 2-Year Event

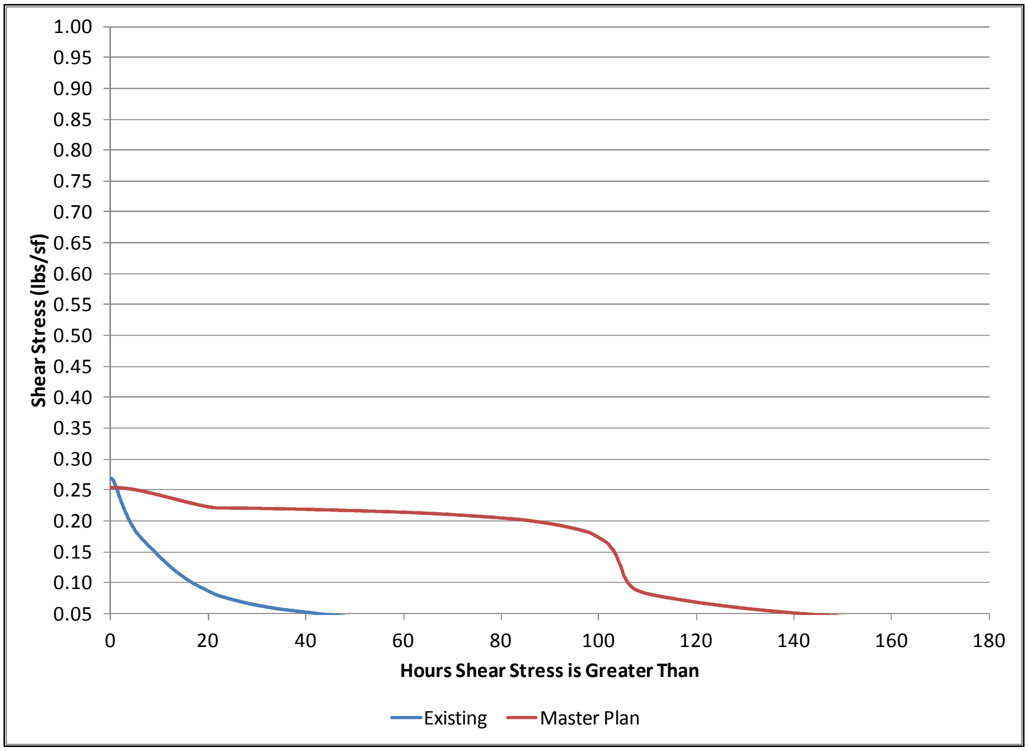
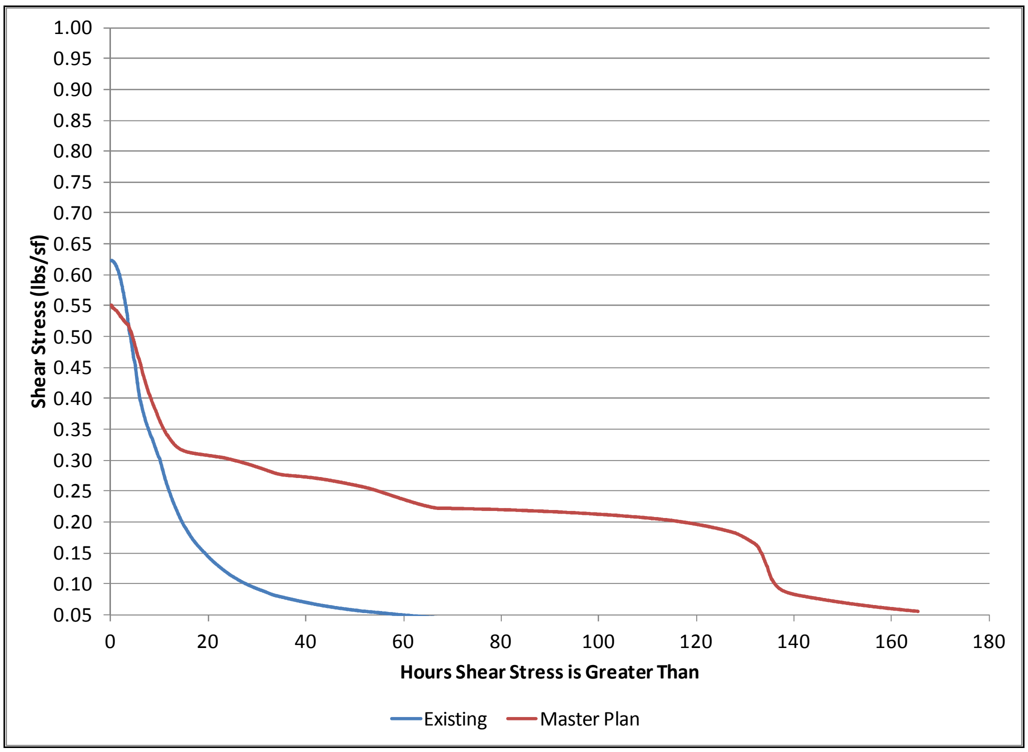


Figure 6-15 Shear Stress Comparison, 25-Year Event



6.6 Minimum Easement Requirements

Easements will be needed for swales and detention facilities that extend above 100-year flood limits. Preliminary easements for swales and detention basins have been created and are shown on ***Figure 6-1*** and on the Drawings in ***Exhibits.*** Easement boundaries for detention basins were based on the 6-hour, 100-year event plus one foot or the emergency overflow elevation, whichever is higher.

If storm sewer is used in place of open channels, easements will be required to properly route the storm sewer facility through private property.

6.7 Permitting Considerations

6.7.1 U.S. Army Corps of Engineers

Review of the National Wetland Inventory indicates that there are wetlands present within the watershed. While a formal wetland delineation has not been conducted, it is likely that there are additional wetlands present, including in areas associated with Master Plan facilities. Additionally, there are a number of drainageways that may meet jurisdictional requirements to be covered under Section 404 of the Clean Water Act. In conversations with staff at the U.S. Army Corps of Engineers (USACE) regulatory office in Bismarck, it is likely that the wetlands present within the main drainageways, and potentially the drainageways themselves, within this watershed will be considered jurisdictional and potential impacts may be subject to review under Section 404 of the Clean Water Act. Note that a jurisdictional determination cannot be made until a formal request has been made. Therefore, as elements of this Master Plan are implemented, a wetland delineation and request for jurisdictional determination should be made early in the design process to determine permitting implications.

6.7.2 NDDOT

As the area north of ND 1804 and west of North Washington Street develops, the existing ND 1804 culvert crossing will need to be improved to maintain level of services requirements. This Master Plan includes recommendations for sizing but calls for the culvert improvement to be conducted by the developer of property north of ND 1804 that drains to the culvert. Therefore, the developer must work with the NDDOT to obtain necessary improvements and permits.

Coordination with NDDOT will also be required for design of 1804 basin and drainage facilities leading to the basin, as described in more detail earlier in this section.

6.7.3 ND State Water Commission

This Master Plan has been specifically prepared to meet Stream Crossing Standards and not trigger regulation of stormwater detention facilities as a dam. Therefore, any modifications to this plan should be carefully reviewed to verify that Stream Crossing Standards are met and the facility does not trigger permitting requirements by the State Engineer.

6.7.4 Western Area Power Authority

The Western Area Power Authority (WAPA) owns and operates high voltage transmission lines within the watershed. Authorization to construct facilities or perform any construction activity within the right-of-way easement for the transmission lines requires a license from WAPA. In the case of the regional stormwater facilities described in this Master Plan, the City of Bismarck is the ultimate applicant and WAPA has indicated that they will issue a "No-Cost License Agreement for Work Within the Right-of Way" pending verification that the proposed activities meet WAPA access and clearance requirements. An initial review with WAPA indicated that the proposed facilities should meet the access and clearance requirements. During the design phase of construction of regional facilities, WAPA should be contacted to obtain the necessary license agreement (local phone number is 221-4500).

7.0 LANDSCAPE CONSIDERATIONS

7.1 Methodology

Landscape considerations are a critical aspect of stormwater planning to be considered in the overall design of the study area. With the scale, spacing and placement of the stormwater conveyance and detention facilities, the landscape elements can enhance the aesthetic and functional aspects of the proposed solutions. The following sections review landscape elements to consider for the US 83 corridor, basin design recommendations, trails, and native species.

7.2 US 83 Corridor

US 83 forms the primary northern gateway into Bismarck. This particular area of the City is facing significant development pressure. The preservation of green space which will be required for stormwater conveyance and storage can help transform this area into a gateway. Several steps should be taken in order to develop this area to reach maximum potential. The following design principles should be considered in development of this area into a gateway:

- Design viewsheds through proposed vegetation into the stormwater collection areas so the public can see this as native, interconnected green space. This forms a pleasant and peaceful entry into the City.
- Continue multi-disciplinary review of the areas being platted so there is balance between the needs of the developer, City Public Works, Planning, Engineering and Parks and Recreation.
- Encourage architectural design which doesn't "turn its back" on the interconnected green space/open space within the watershed.

The existing Hay Creek drainage crossing under Interstate 94 between the Bismarck Expressway (exit #161) and Divide Avenue (exit #159) can be used as a strong design example of how the US 83 corridor could be developed. In this area, a balanced design approach of stormwater conveyance, green spaces, trails, active parks space and housing have developed.

7.2.1 Southern US 83 Basin Design

The basin which lies immediately west of US 83 and south of ND 1804 will have significant visual impact within the US 83 corridor and has the potential to enhance the viewscape entering the City from the north. The location of the facility provides the ability to work with the surrounding terrain to create a unique landscape and recreational element with the dual purpose of providing stormwater management (***Figures 7-1 & 7-2***). The design team would recommend the following criteria be considered in the layout and detailing of this basin:

- Create a gateway into northern Bismarck with an aesthetically pleasing greenspace element (which also serves a stormwater management function);
- Since the majority of traffic will be viewing the basin from the north, line the south edge with trees to serve as a backdrop for the landscape perspective;
- Preserve a trail corridor at the southern edge to connect a future linear park system;
- Group native trees in clusters (as they would appear, naturally);
- Recognize where smaller drain basins are contributing to the primary basin and add landscape elements which reinforce natural habitat;
- Manipulate the terrain and landscape of the proposed berm to make it look as natural as possible; and
- Where possible, mask control structures with native stone and landscape species.

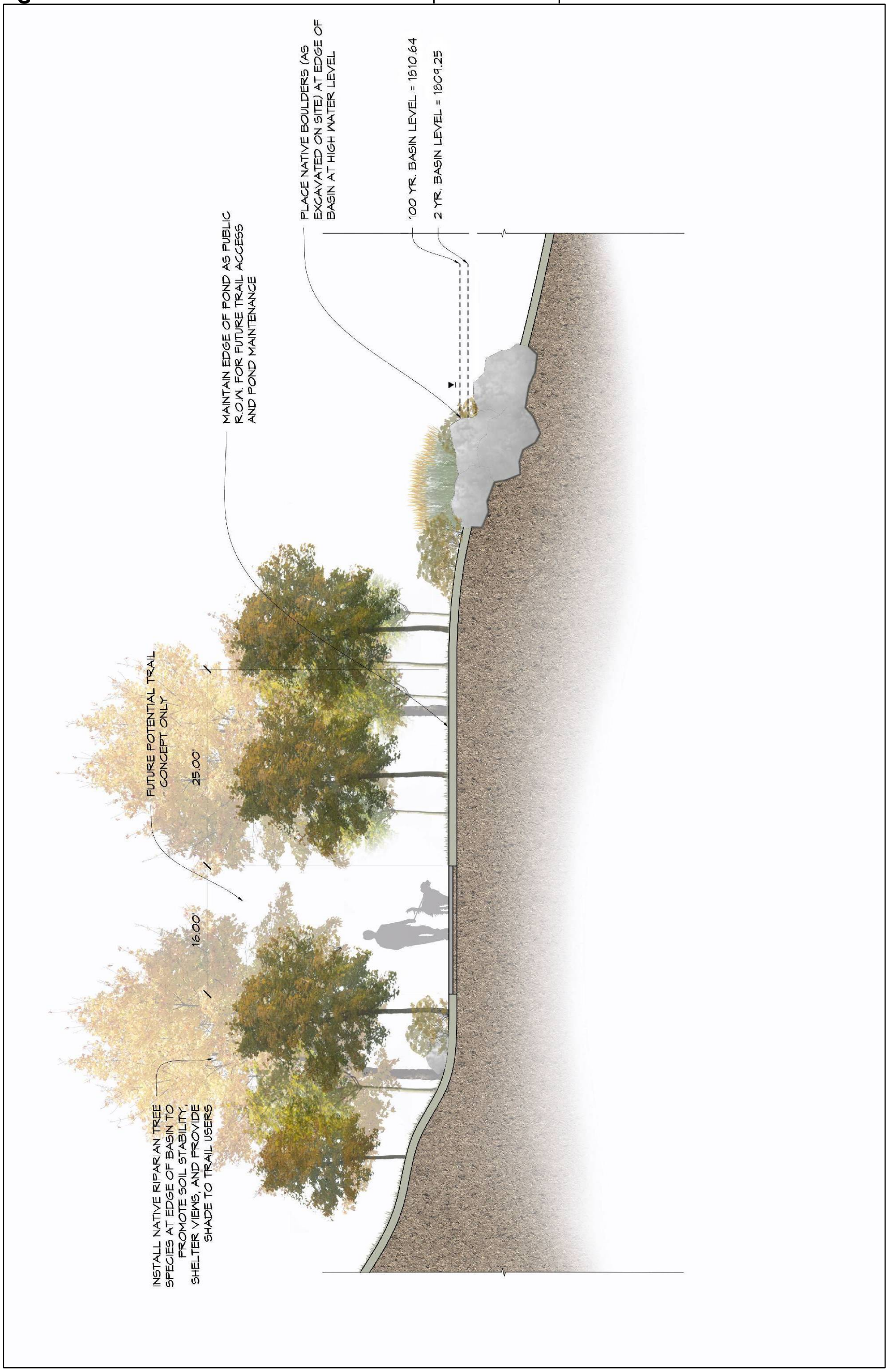
7.2.2 Trail and Greenspace Connectivity

Trails systems have been proven to promote community connectivity, physical wellness and the ability to reconnect trail users with nature. Low lying drainage areas are typically difficult and cost prohibitive to develop, so they lend themselves naturally to linear park and trail systems. The following design principles should be used to assure the trails fit with the natural features of north Bismarck:

- Study the MPO trails master plan document to analyze where trails should be proposed and provided.
- Preserve a sixteen foot wide corridor for a future trail alignment.
- Maintain access to the drainage basins for Public Works.
- Keep a six foot wide mowed strip at the edge of the trail for a clean edge. This same space can be used for snow removal and storage in the winter months.
- Provide seating areas along the trail system to provide resting points for the users. The seating areas should be placed at areas where significant views or privacy are available.
- Allow points of connectivity to the public trail system where private businesses can connect to the trail system.
- Keep the trail at least two vertical feet above the 100 year flood level.

Figure 7-1 Southern US 83 Basin Concept Landscape Plan

Figure 7-2 Southern US 83 Basin Concept Landscape Section



7.2.3 Native Species Recommendations.

Native landscape species preserve the natural ecosystem which exist throughout northern Bismarck. The following list of species represents native plants which could be used along the drainage basin to achieve the desired functional and aesthetic goals of the corridor. This list is supplied as a starting point for planting recommendations. Project designers should consider moisture exposure, soil PH, wind exposure, sunlight levels and soil types prior to selecting species. True native species can be difficult to source through local nurseries. Substitutions to the native species may be required to meet the project budget and installation timeline.

Table 7.1: Recommended Tree Species

Common Name	Scientific Name
Quaking Aspen	*Populous tremuloides*
Paper Birch	*Betula papyrifera*
Cottonwood	*Populus sp.*
Crabapple	*Malus sp*
Common Hackberry	*Populous tremuloides*
Downy Hawthorn	*Crataegus mollis*
Rocky Mountain Juniper	*Juniper scopulorum*
American Linden	*Tilia americana*
Bur Oak	*Quercus macrocarpa*

Table 7.2: Recommended Shrub Species

Common Name	Scientific Name
Silver Buffaloberry	*Shepherdia argentea*
Chokeberry	*Aronia melanocarpa*
Common Chokeberry	*Prunus virginiana*
Highbush Cranberry	*Viburnum trilobum*
Golden Currant	*Ribes aureum*
Redosier Dogwood	*Cornus sericea*
American Hazel	*Corylus americana*
False Indigo	*Amorpha fruiticosa*
Ironwood	*Ostrya virginia*
Juneberry	*Amelanchier alnifolia*
Common Juniper	*Juniperus communis*
American Plum	*Prunus americana*
Raspberry	*Rubes idaeus*
Prairie Rose	*Rosa arkansas*
Woods Rose	*Rosa woodsii*
Four Winged Saltbush	*Atriplex canescens*
Silverberry	*Elaegnus commutata*
Nannyberry Viburnum	*Viburnum lentago*
Bebbes Willow	*Salix bebbiana*
Sandbar Willow	*Salix interior*
Yucca	*Yucca glauca*

Table 7.3: Recommended Groundcover Species

Common Name	Scientific Name
Spreading Juniper	*Juniperus horizontalis*
Snowberry	*Symphoricarpos albus*

Table 7.4: Recommended Grass Species for Landscape Accents

Common Name	Scientific Name
Big Bluestem	*Andropogon gerardii*
Switchgrass	*Panicum virgatum*
Indiangrass	*Sorghastrum longifolia*
Little Bluestem	*Schizachyrium scoparium*
Sideoats Grama	*Bouteloua gracilis*
Blue Grama	*Bouteloua gracilis*

7.2.4 Seed Mixtures

The following seed mixtures can serve as a starting point for appropriate seed mixture design. Within the basin areas, and along the ROW which will be required for storm water conveyance, multiple seed mixtures may be required. Also, due to the long inundation period (up to 100 hours) for the specific basins, the depth and duration of ponded water must be considered before final seed selections are determined. Design consultants should carefully select seed mixtures to assure their success. The following seed and native grass specialists are examples of companies who can supply information about seed mixtures, seedbed preparation, installation methods and maintenance. These and other established seed companies can serve as a starting point in the design and installation of successful vegetation restoration projects.

Chesak Seed House
220 North 23rd Street
Bismarck, ND 58501
1-701-223-0391

Prairie Restoration
31922 128th Street
Princeton, MN 55371
1-800-837-5986

Prairie Moon Nursery
32115 Prairie Lane
Winona, MN 55987
1-507-452-1362

Table 7.5: Recommended Wet Meadow Seed Mix

	Percentage of Mix	lbs/acre[1]
Switchgrass	40%	1.8
Canada Wild Rye	30%	2.3
Western Wheatgrass	20%	2.0
Prairie Cordgrass	10%	0.7

1 – Drilled rate, double if broadcast seeded

Table 7.6: Recommended Mixed Prairie Seed Mix

	Percentage of Mix	lbs/acre[1]
Western Wheatgrass	10%	1.0
Green Needlegrass	20%	1.5
Little Blustem	30%	1.8
Sideoats Grama	40%	2.3

1 – Drilled rate, double if broadcast seeded

Table 7.7: Recommended Shortgrass Prairie Seed Mix

	Percentage of Mix	lbs/acre[1]
Blue Grama	40%	1.0
Sideoats Grama	40%	3.0
Buffalograss	20%	5.2

1 – Drilled rate, double if broadcast seeded

7.3 Regional Detention Facilities

The design of future stormwater facilities should integrate with the natural topography, landscape features and take advantages of the view sheds throughout the study area. By following the natural landscape cues throughout the basin, the storage areas can promote community wellness, create green space connectivity and reinforce naturally occurring habitat. The following design principles should be used to make the ponds fit within the natural features of north Bismarck:

- Promote the use of native species throughout the drainage corridor.
- Group native trees in clusters (as they would appear, naturally).
- Avoid even, sequential spacing of plants species.
- Place landscape features adjacent to, but not obstructing the natural drainage patterns of the study area. Placing the species in these locations allow them to be naturally watered during storm events.
- Use variable slopes along the storage basins in-slope to make the basins appear more natural.
- Use curves and irregular edges to form the edges of the basins.
- Keep maintenance for the city staff minimal around the edges of the basin.
- Promote community wellness with contiguous greenspace and trails adjacent to, but above the 100-year flood level.

8.0 OPINION OF PROBABLE COSTS, IMPLEMENTATION PLAN, AND FUNDING SUMMARY

8.1 Opinion of Probable Costs

Opinions of probable costs were developed for each of the regional facilities incorporated into the Master Plan (***Exhibits***). Unit rates were developed based on review of local bids, NDDOT bid data, and material costs obtained directly from suppliers. The opinion of probable costs assumes a $4 per square foot cost for property acquisition.

Table 8.1: Summary of Opinion of Probable Costs

Regional Facility	Design and Construction Cost[1]	Land Acquisition Cost	Total
Southern US 83 Basin	$335,385	$1,515,900	$1,851,285
Southern Yukon Basin	$246,065	$1,568,200	$1,814,265
Northstar Basin	$300,585	$1,289,400	$1,589,985
Northern Yukon Basin	$293,190	$1,620,500	$1,913,690
1804 Basin	$609,290	$453,100	$1,062,390
Northern US 83 Basin	$936,555	$2,195,500	$3,132,055
Southern Washington Basin	$911,905	$575,000	$1,486,905
Northern Washington Basin	$152,685	$819,000	$971,685
Southern Washington Swale	$148,335	$209,100	$357,435
Total	$3,933,995	$10,245,700	$14,179,695

1 – Includes a 15% estimating contingency and 30% for Engineering and Administration

8.2 Implementation Plan

An implementation plan has been developed for this Master Plan to balance capital outlays with proposed development patterns. Key triggers for construction of the regional facilities include development within key areas and/or construction of roads that will ultimately be located along embankments for regional detention facilities. The proposed implementation plan for the Master Plan is shown on ***Figure 8-1***.

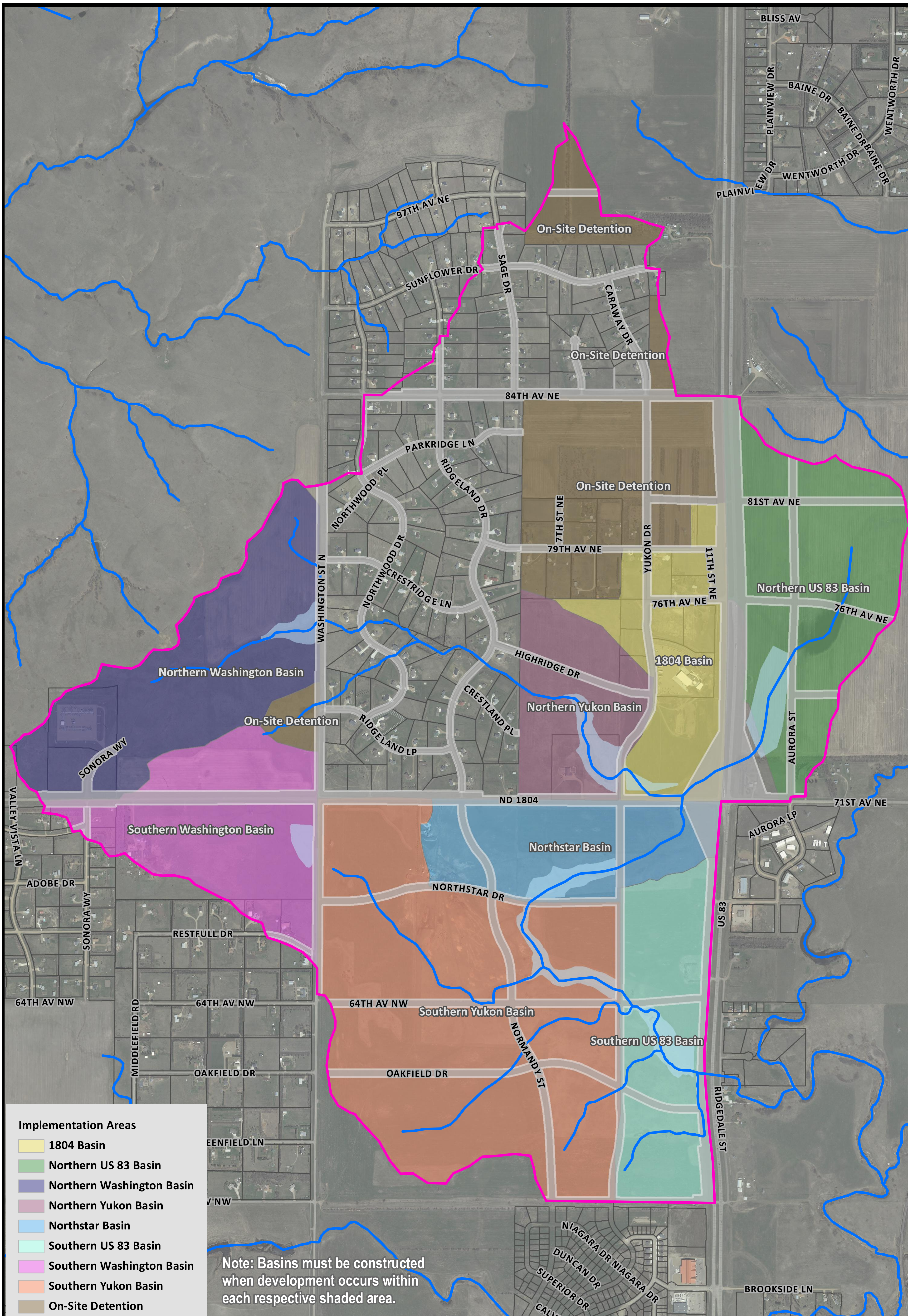


Figure 8-1 Implementation Sequence

US 83/ND 1804 Stormwater Master Plan
City of Bismarck, ND

N

Feet
0 600 1,200
1 in = 1,200 feet

US 83 / ND 1804 Watershed
Hydrography
Basin Footprints

AE2S Think Big. Go Beyond. Montgomery Associates JLG architects

AE2S in association with MARS and JLG

Developed by: Danielle Lee | 03/19/2013
Coordinate System: ND State Plane South
Vertical Datum: NAVD88
Metadata Included in the Report

8.3 Funding Summary

8.3.1 Existing Methodology

The City of Bismarck currently utilizes revenue generated through Special Assessments to pay for improvements associated with regional stormwater facilities that benefit properties contributing drainage to those facilities. Currently the City allocates the costs of its stormwater Special Assessment Districts based on parcel/lot square footage of each land-use type within the Assessment District. Stormwater Assessment District boundaries are determined by watershed areas with the assessments applied based on land-use type. Right-of-way, coulees, detention ponds, and other non-developable lots and open spaces are considered non-assessable acreage. The City carries the portions of the cost of the improvement for any un-annexed property within the Assessment District by holding the allocated assessment amount in abeyance until a time in which the benefitted land is annexed to the City.

In order to determine equitability in the spreading of assessments associated with varying amounts of contributing runoff per unit area from various land use types, the City currently applies "factors" to each land-use type for the purpose of determining equivalent residential acres within the Assessment District, as follows:

- Residential: 1.0
- Commercial: 2.0
- Park property with revenue producing facility (i.e. pool): 2.0 (Non-Residential)
- Park property without revenue producing facility: 1.0 (Residential)
- Schools and Churches: 2.0 (Non-Residential)

Ultimately, each assessable land-use type within the Assessment District is assigned either a Residential Factor of "1" or a Non-Residential (Commercial) factor of "2." These factors are then applied to the acreage for each land-use type in order to allocate the improvement costs based on equivalent residential acres. For example, if the total assessable watershed acreage is 500 acres, with 200 acres of Residential and 300 acres of Commercial, the equivalent Residential acreage for the Residential land-use is 200 (200 * 1) and the equivalent Residential acres for the Commercial land-use is 600 (300 * 2), for a total of 800 equivalent residential acres. Therefore, in this example, the Residential land-use would be allocated 25% (200/800) of the total costs for regional facilities within the watershed and the Commercial land-use category would be allocated 75% (600/800) of the total costs.

8.3.2 Application of Existing Methodology

As previously identified, the total watershed acreage of the US 83/ND 1804 Watershed is approximately 1880 acres. It is estimated that 25% of this acreage is non-assessable (non-developable lots), leaving 1410 acres as assessable acreage. As shown in ***Table 8.2***, based on the land-use types identified as part of this study, it was determined that 832 acres of the assessable watershed acreage is Residential and 578 of the assessable watershed acreages is Non-Residential. ***Table 9.3*** presents the calculation of the cost per assessable acre when the existing methodology for allocating the improvement cost is applied to the Master Plan total project cost of $14,179,695.

Table 8.2: Determination of Assessable Acres

Total Watershed	1880 acres
Non-Assessable (25%)	470 acres
Assessable Acreage	1410 acres
Residential Ratio[1]	59%
Residential Acreage	832 acres
Non-Residential Acreage	578 acres

1 - Calculated as the ratio of: (Res + Res Rural) / (Light Ind. + Neigh Comm. + Res + Res Rural + Mixed Use + Commercial) as noted in Table 2.2.

Table 8.3: Assessment Using Existing Methodology

Land Use	Assessable Acres	Factor	Equivalent Residential Acres	% Total Equivalent Residential Acres	Master Plan Total Cost	Cost per Assessable Acre
Residential	832	1	832	42%	$5,933,393	$7,130
Non-Residential	578	2	1,156	58%	$8,246,302	$14,260
Total	**1,410**		**1,988**	**100%**	**$14,179,695**	

8.3.3 Other Considerations

As discussed above, the City currently maintains two alternate factors for the various land use types platted within the City for the purposes of determining equivalent residential acres within an Assessment District, Residential and Non-Residential. This methodology does well to evaluate the area to be served, benefit to be provided, and relationship of benefit to individual parcels which might be assessed based on land use type. However, one consideration the City may wish to evaluate moving forward would be to develop a more comprehensive list of factors for all non-residential land-use types to more accurately represent varying degrees of impact the respective land use types have on the sizing and ultimate cost of downstream stormwater facilities and to attain a higher degree of equity in apportionment of costs for special assessment districts. For example, the assessable non-residential land-use breakdown from this study for the US 83/ND 1804 Watershed included the following categories:

- Transportation and Infrastructure
- Neighborhood Commercial
- Mixed Use
- Commercial

In the hydraulic/hydrologic evaluations for the project, each of these land-use types is assigned an approximate percent of impervious surface area ranging from 38% impervious for transportation and infrastructure to 80% impervious for standard commercial. Therefore, based on this data, a factor for equivalent residential acres could be developed for each of these land uses in order to more equitably allocate the improvement cost based on the benefit received.

9.0 CONCLUSIONS AND RECOMMENDATIONS

This Master Plan meets City requirements for stormwater management given the proposed land use plan currently adopted by the City. Modifications of the proposed land use plan, including changes to the planned US 83 / ND 1804 interchange, will necessitate review of this Master Plan.

The proposed interchange of US 83 and ND 1804 may play a significant role in the future implementation of this Master Plan. We recommend working with the NDDOT to partially or fully place the 1804 and/or Northern US 83 regional stormwater management facilities within the right-of-way that will be necessary for the interchange.

EXHIBITS

LEGEND:

- 1840 — EXISTING MAJOR CONTOUR
- 1838 — EXISTING MINOR CONTOUR
- 1840 — PROPOSED MAJOR CONTOUR
- 1838 — PROPOSED MINOR CONTOUR
- FUTURE ROAD EMBANKMENT GRADING
- MINIMUM EASEMENT BOUNDARY
- CONCEPT RIGHT OF WAY
- CONCEPT SIDEWALK
- CONCEPT CENTERLINE
- CONCEPT CURB AND GUTTER
- EXISTING CULVERT

SCALE: 1" = 160'
0 80 160 320
VERTICAL DATUM: NAVD 88
N

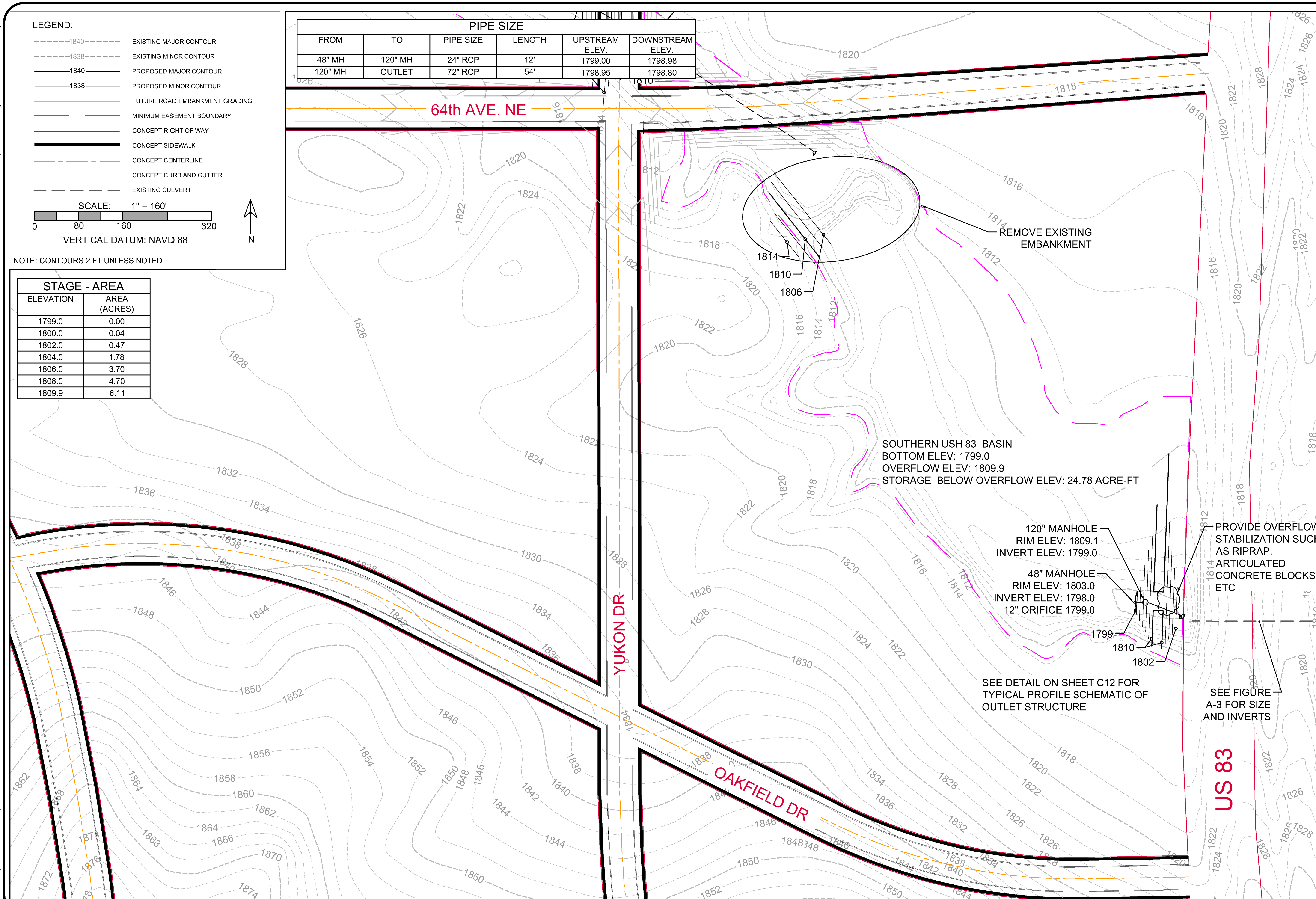
NOTE: CONTOURS 2 FT UNLESS NOTED

STAGE - AREA

ELEVATION	AREA (ACRES)
1799.0	0.00
1800.0	0.04
1802.0	0.47
1804.0	1.78
1806.0	3.70
1808.0	4.70
1809.9	6.11

PIPE SIZE

FROM	TO	PIPE SIZE	LENGTH	UPSTREAM ELEV.	DOWNSTREAM ELEV.
48" MH	120" MH	24" RCP	12'	1799.00	1798.98
120" MH	OUTLET	72" RCP	54'	1798.95	1798.80



CITY OF BISMARCK, ND
US83/ND1804 Watershed Stormwater Master Plan
Southern US 83 Basin
16-Jan-13

ITEM	ITEM DESCRIPTION	QTY	UNIT	UNIT COST	TOTAL COST
	Engineers Opinion of Probable Costs				
1	Bonding	1	LS	$6,800	$6,800
2	Mobilization	1	LS	$44,900	$44,900
3	Erosion Control	1	LS	$8,600	$8,600
4	Unclassified Excavation	1,325	CY	$8	$9,938
5	Embankment Fill	2,200	CY	$8	$17,600
6	24-inch RCP Low-Flow Outlet Pipe	12	LF	$80	$960
7	72-inch RCP Outlet Pipe	54	LF	$650	$35,100
8	72-Inch RCP Flared End Section (8')	1	EA	$3,300	$3,300
9	48-inch Manhole (5' height) with Pre-Cast Base, Flat-top Lid, and 12" Orifice Drilled into Sidewall	1	LS	$2,100	$2,100
10	120-inch Manhole (11' height) with Pre-Cast Base and Custom Bar Grate	1	LS	$27,300	$27,300
11	Type H Riprap	850	TON	$65	$55,250
12	Strip, Stockpile, and Replace Topsoil	580	CY	$8	$4,640
13	Seeding - Class I	3,480	SY	$1	$3,480
14	Mulching - Crimped	1,240	SY	$1	$1,240
15	Erosion Control Mat	2,240	SY	$5	$10,080
				Subtotal Construction Costs	**$231,288**
				15% Contingencies	**$34,693**
				Legal, Administration & Engineering (30%)	**$69,386**
				TOTAL CONSTRUCTION COSTS	**$335,367**
16	Property Acquisition	8.7	Acre	$174,240	$1,515,888
				TOTAL FACILITY COSTS	**$1,851,255**

LEGEND:

- 1840 EXISTING MAJOR CONTOUR
- 1838 EXISTING MINOR CONTOUR
- 1840 PROPOSED MAJOR CONTOUR
- 1838 PROPOSED MINOR CONTOUR
- FUTURE ROAD EMBANKMENT GRADING
- MINIMUM EASEMENT BOUNDARY
- CONCEPT RIGHT OF WAY
- CONCEPT SIDEWALK
- CONCEPT CENTERLINE
- CONCEPT CURB AND GUTTER
- EXISTING CULVERT

SCALE: 1" = 160'
0 80 160 320
VERTICAL DATUM: NAVD 88
N

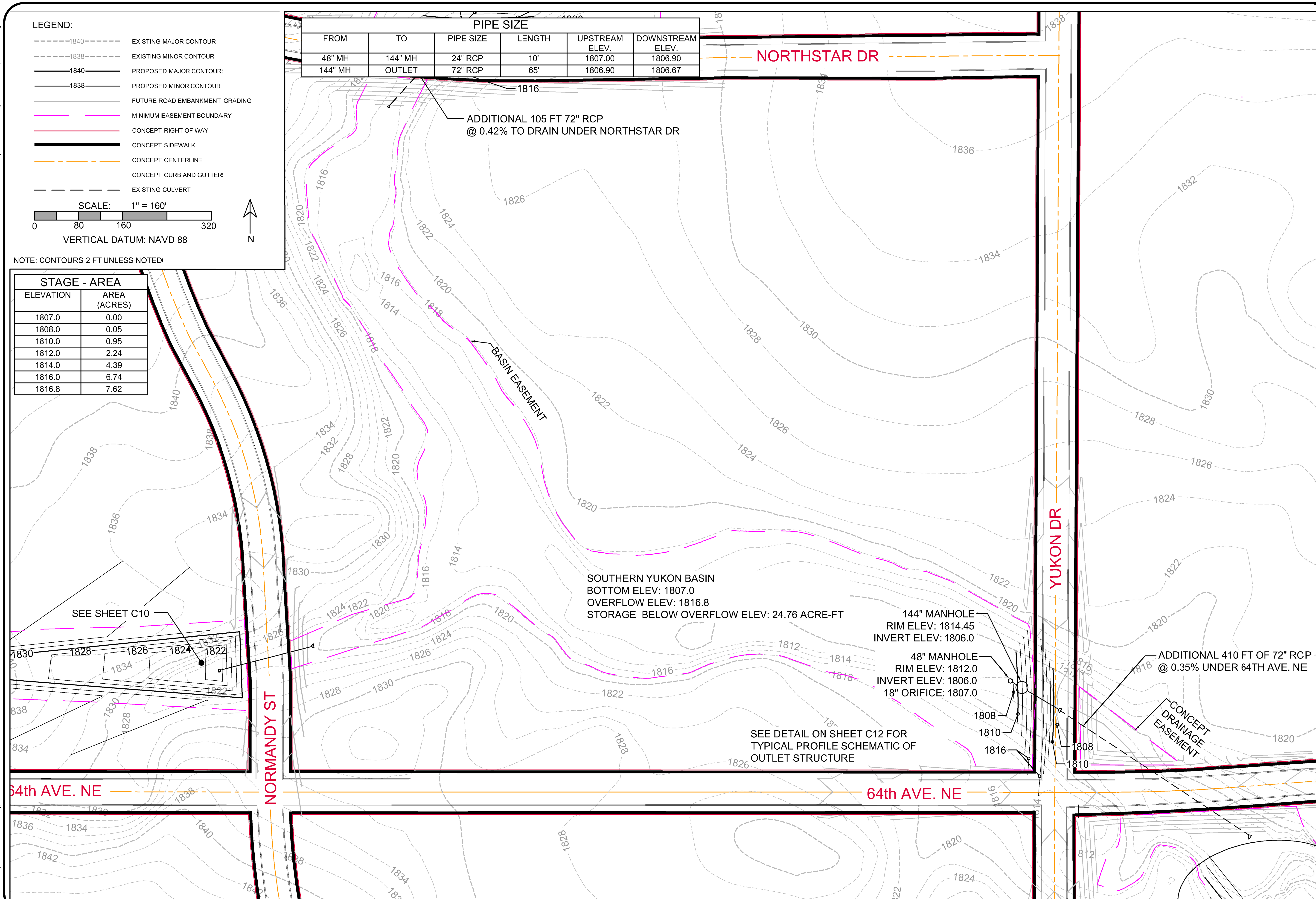
NOTE: CONTOURS 2 FT UNLESS NOTED

STAGE - AREA

ELEVATION	AREA (ACRES)
1807.0	0.00
1808.0	0.05
1810.0	0.95
1812.0	2.24
1814.0	4.39
1816.0	6.74
1816.8	7.62

PIPE SIZE

FROM	TO	PIPE SIZE	LENGTH	UPSTREAM ELEV.	DOWNSTREAM ELEV.
48" MH	144" MH	24" RCP	10'	1807.00	1806.90
144" MH	OUTLET	72" RCP	65'	1806.90	1806.67



US 83 / ND 1804 STORMWATER MASTER PLAN
CITY OF BISMARCK
CITY OF BISMARCK, BURLEIGH COUNTY ND
SOUTHERN YUKON BASIN

City Of Bismarck Project: ----
DRAWING TYPE: PRELIMINARY
PREPARED BY: RSS/SGS
CHECKED / APPROVED: JDL / JMH
DATE: 03/18/2013
PROJECT NUMBER: P00501-2012-05
SHEET: 2 of 12
DRAWING: C02

PRELIMINARY

Advanced Engineering and Environmental Services, Inc. • 1815 Schafer St Ste 301 Bismarck, ND 58501 • (t) 701-221-0530 (f) 701-221-0531 • www.ae2s.com

CITY OF BISMARCK, ND
US83/ND1804 Watershed Stormwater Master Plan
Southern Yukon Basin
16-Jan-13

Engineers Opinion of Probable Costs					
ITEM	**ITEM DESCRIPTION**	**QTY**	**UNIT**	**UNIT COST**	**TOTAL COST**
1	Bonding	1	LS	$5,000	$5,000
2	Mobilization	1	LS	$33,000	$33,000
3	Erosion Control	1	LS	$6,300	$6,300
4	Embankment Fill	2,630	CY	$8	$21,040
5	24-inch RCP Low-Flow Outlet Pipe	10	LF	$80	$800
6	72-inch RCP Outlet Pipe	65	LF	$500	$32,500
7	72-Inch RCP Flared End Section (8')	1	EA	$3,300	$3,300
8	48-inch Manhole (5' height) with Pre-Cast Base, Flat-top Lid, and 18" Orifice Drilled into Sidewall	1	LS	$2,100	$2,100
9	144-inch Manhole (9' height) with Pre-Cast Base and Custom Bar Grate	1	LS	$37,600	$37,600
10	Type H Riprap	200	TON	$65	$13,000
11	Strip, Stockpile, and Replace Topsoil	368	CY	$8	$2,944
12	Seeding - Class I	2,200	SY	$1	$2,200
13	Erosion Control Mat	2,200	SY	$5	$9,900
				Subtotal Construction Costs	**$169,684**
				15% Contingencies	**$25,453**
				Legal, Administration & Engineering (30%)	**$50,905**
				TOTAL PROJECT COSTS	**$246,042**
14	Property Acquisition	9.0	Acre	$174,240	$1,568,160
				TOTAL FACILITY COSTS	**$1,814,202**

LEGEND:

----1840----	EXISTING MAJOR CONTOUR
----1838----	EXISTING MINOR CONTOUR
——1840——	PROPOSED MAJOR CONTOUR
——1838——	PROPOSED MINOR CONTOUR
	FUTURE ROAD EMBANKMENT GRADING
	MINIMUM EASEMENT BOUNDARY
	CONCEPT RIGHT OF WAY
	CONCEPT SIDEWALK
	CONCEPT CENTERLINE
	CONCEPT CURB AND GUTTER
	EXISTING CULVERT

SCALE: 1" = 160'

0 80 160 320

VERTICAL DATUM: NAVD 88

N

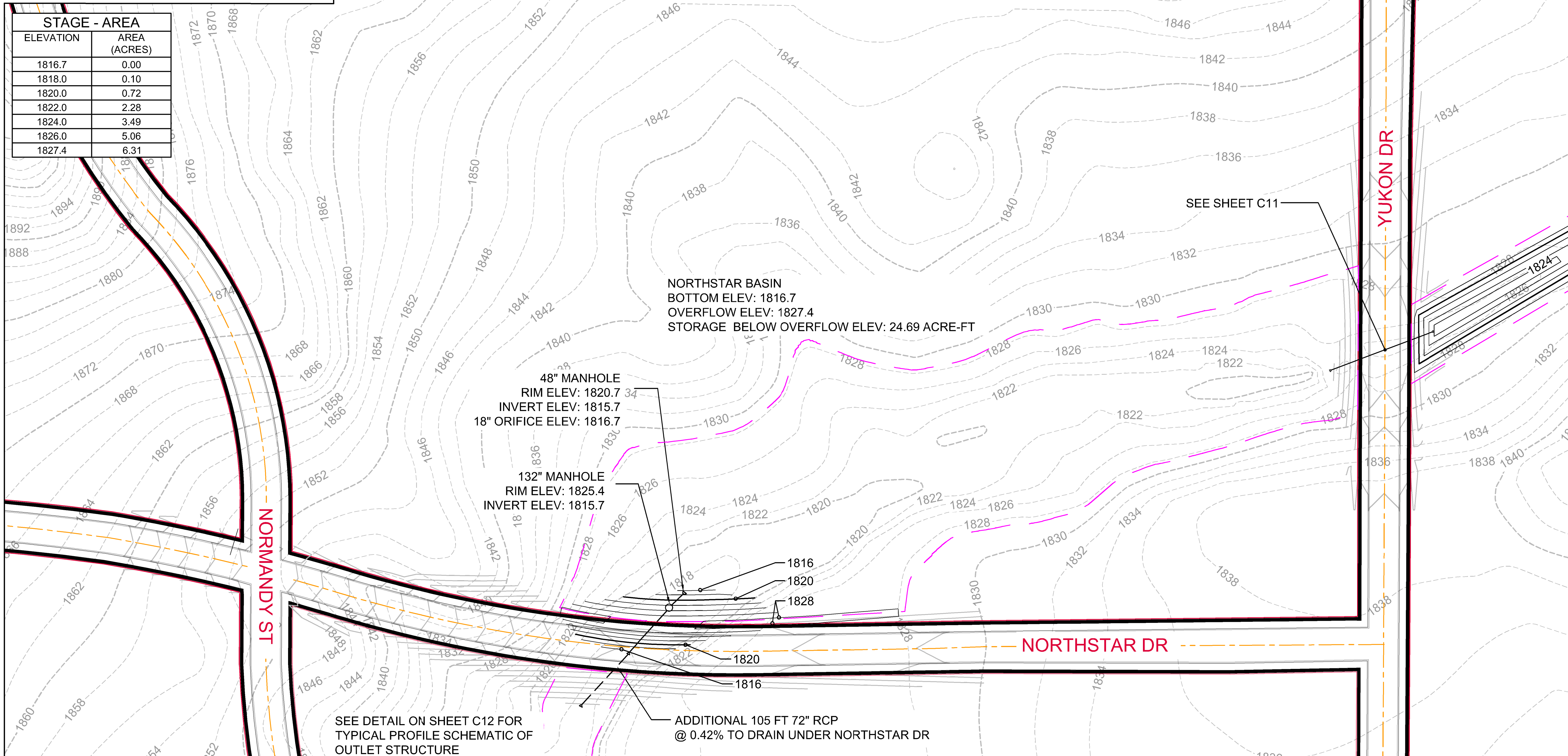
NOTE: CONTOURS 2 FT UNLESS NOTED

PIPE SIZE

FROM	TO	PIPE SIZE	LENGTH	UPSTREAM ELEV.	DOWNSTREAM ELEV.
48" MH	132" MH	24" RCP	24'	1816.50	1816.40
132" MH	OUTLET	72" RCP	86'	1816.40	1816.04

STAGE - AREA

ELEVATION	AREA (ACRES)
1816.7	0.00
1818.0	0.10
1820.0	0.72
1822.0	2.28
1824.0	3.49
1826.0	5.06
1827.4	6.31



NORTHSTAR BASIN
BOTTOM ELEV: 1816.7
OVERFLOW ELEV: 1827.4
STORAGE BELOW OVERFLOW ELEV: 24.69 ACRE-FT

48" MANHOLE
RIM ELEV: 1820.7
INVERT ELEV: 1815.7
18" ORIFICE ELEV: 1816.7

132" MANHOLE
RIM ELEV: 1825.4
INVERT ELEV: 1815.7

SEE SHEET C11

SEE DETAIL ON SHEET C12 FOR TYPICAL PROFILE SCHEMATIC OF OUTLET STRUCTURE

ADDITIONAL 105 FT 72" RCP @ 0.42% TO DRAIN UNDER NORTHSTAR DR

Advanced Engineering and Environmental Services, Inc. • 1815 Schafer St Ste 301 Bismarck, ND 58501 • (t) 701-221-0530 (f) 701-221-0531 • www.ae2s.com

PRELIMINARY

US 83 / ND 1804 STORMWATER MASTER PLAN
CITY OF BISMARCK
CITY OF BISMARCK, BURLEIGH COUNTY ND
NORTHSTAR BASIN

CITY OF BISMARCK PROJECT: ----

DRAWING TYPE: PRELIMINARY

PREPARED BY: RSS/SGS

CHECKED / APPROVED: JDL / JMH

DATE: 03/18/2013

PROJECT NUMBER: P00501-2012-05

DRAWING C03

Plotted By: Anna Dahl Date: Wednesday, March 20, 2013
Last Saved By: Anna Dahl Date: Wednesday, March 20, 2013 11:05:24 AM
Layout: NORTHSTAR 1
File: P:\1557 - AE2S - Hay Creek Stormwater\Drawings\GRADING -RSS compiled 3.18.20313.dwg

CITY OF BISMARCK, ND
US83/ND1804 Watershed Stormwater Master Plan
Northstar Basin - Alternative 1 (Traditional Detention)
16-Jan-13

Engineers Opinion of Probable Costs

ITEM	ITEM DESCRIPTION	QTY	UNIT	UNIT COST	TOTAL COST
1	Bonding	1	LS	$6,100	$6,100
2	Mobilization	1	LS	$40,300	$40,300
3	Erosion Control	1	LS	$7,700	$7,700
4	Embankment Fill	4,040	CY	$8	$32,320
5	24-inch RCP Low-Flow Outlet Pipe	24	LF	$80	$1,920
6	72-inch RCP Outlet Pipe	86	LF	$500	$43,000
7	72-Inch RCP Flared End Section (8')	1	EA	$600	$600
8	48-inch Manhole (5' height) with Pre-Cast Base, Flat-top Lid, and 18" Orifice Drilled into Sidewall	1	LS	$2,100	$2,100
9	132-inch Manhole (10' height) with Pre-Cast Base and Custom Bar Grate	1	LS	$36,800	$36,800
10	Type H Riprap	200	TON	$65	$13,000
11	Strip, Stockpile, and Replace Topsoil	570	CY	$8	$4,560
12	Seeding - Class I	3,420	SY	$1	$3,420
13	Erosion Control Mat	3,420	SY	$5	$15,390
				Subtotal Construction Costs	**$207,210**
				15% Contingencies	**$31,082**
				Legal, Administration & Engineering (30%)	**$62,163**
				TOTAL PROJECT COSTS	**$300,455**
14	Property Acquisition	7.4	Acre	$174,240	$1,289,376
				TOTAL FACILITY COSTS	**$1,589,831**

LEGEND:

- 1840 — EXISTING MAJOR CONTOUR
- 1838 — EXISTING MINOR CONTOUR
- 1840 — PROPOSED MAJOR CONTOUR
- 1838 — PROPOSED MINOR CONTOUR
- FUTURE ROAD EMBANKMENT GRADING
- MINIMUM EASEMENT BOUNDARY
- CONCEPT RIGHT OF WAY
- CONCEPT SIDEWALK
- CONCEPT CENTERLINE
- CONCEPT CURB AND GUTTER
- EXISTING CULVERT

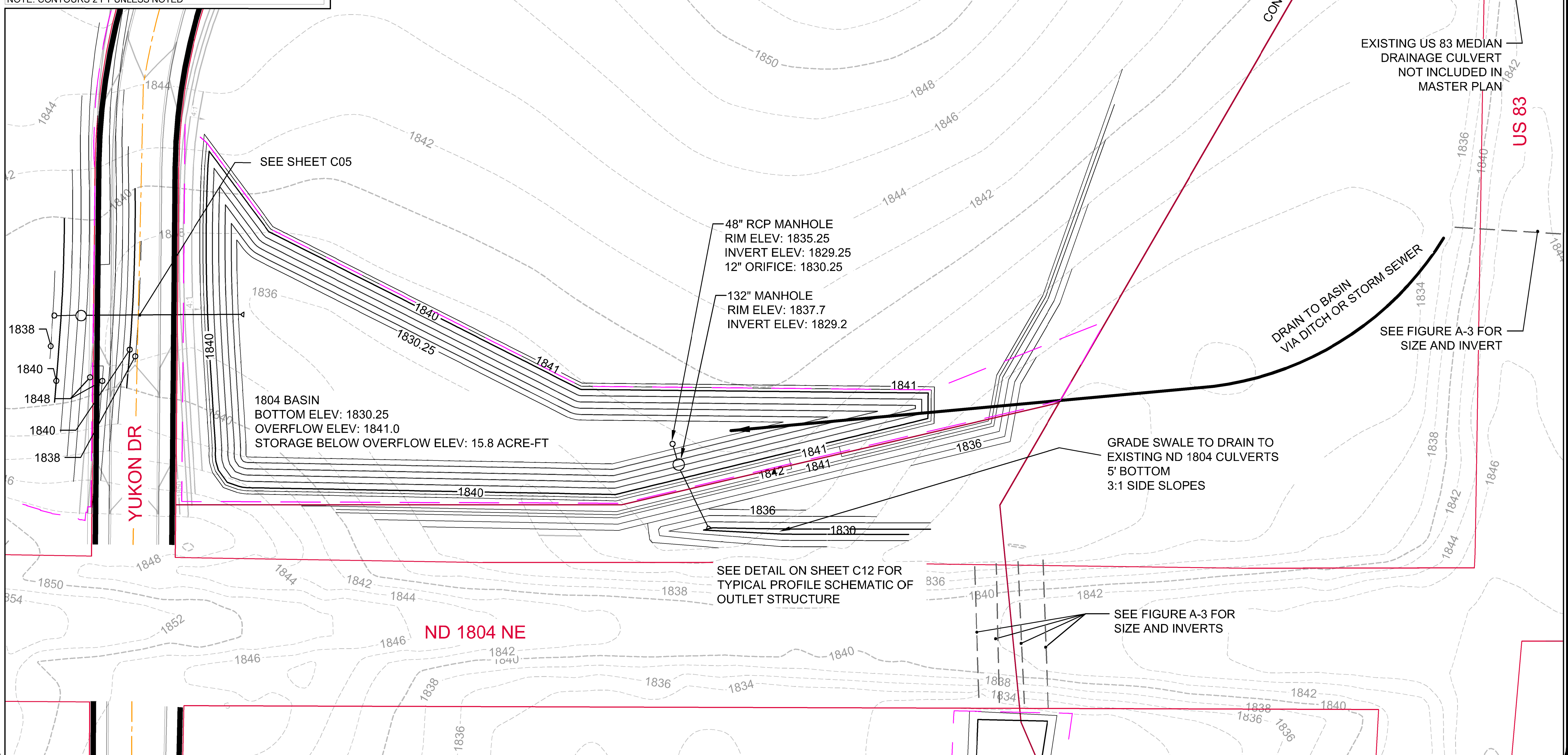
SCALE: 1" = 100'
0 50 100 200
N
VERTICAL DATUM: NAVD 88
NOTE: CONTOURS 2 FT UNLESS NOTED

PIPE SIZE

FROM	TO	PIPE SIZE	LENGTH	UPSTREAM ELEV.	DOWNSTREAM ELEV.
48" MH	132" MH	24" RCP	14'	1830.25	1830.25
132" MH	OUTLET	60" RCP	60'	1830.25	1830.00

STAGE - AREA

ELEVATION	AREA (ACRES)
1830.3	0.98
1832.0	1.14
1834.0	1.35
1836.0	1.57
1838.0	1.80
1840.0	2.04
1841.0	2.17



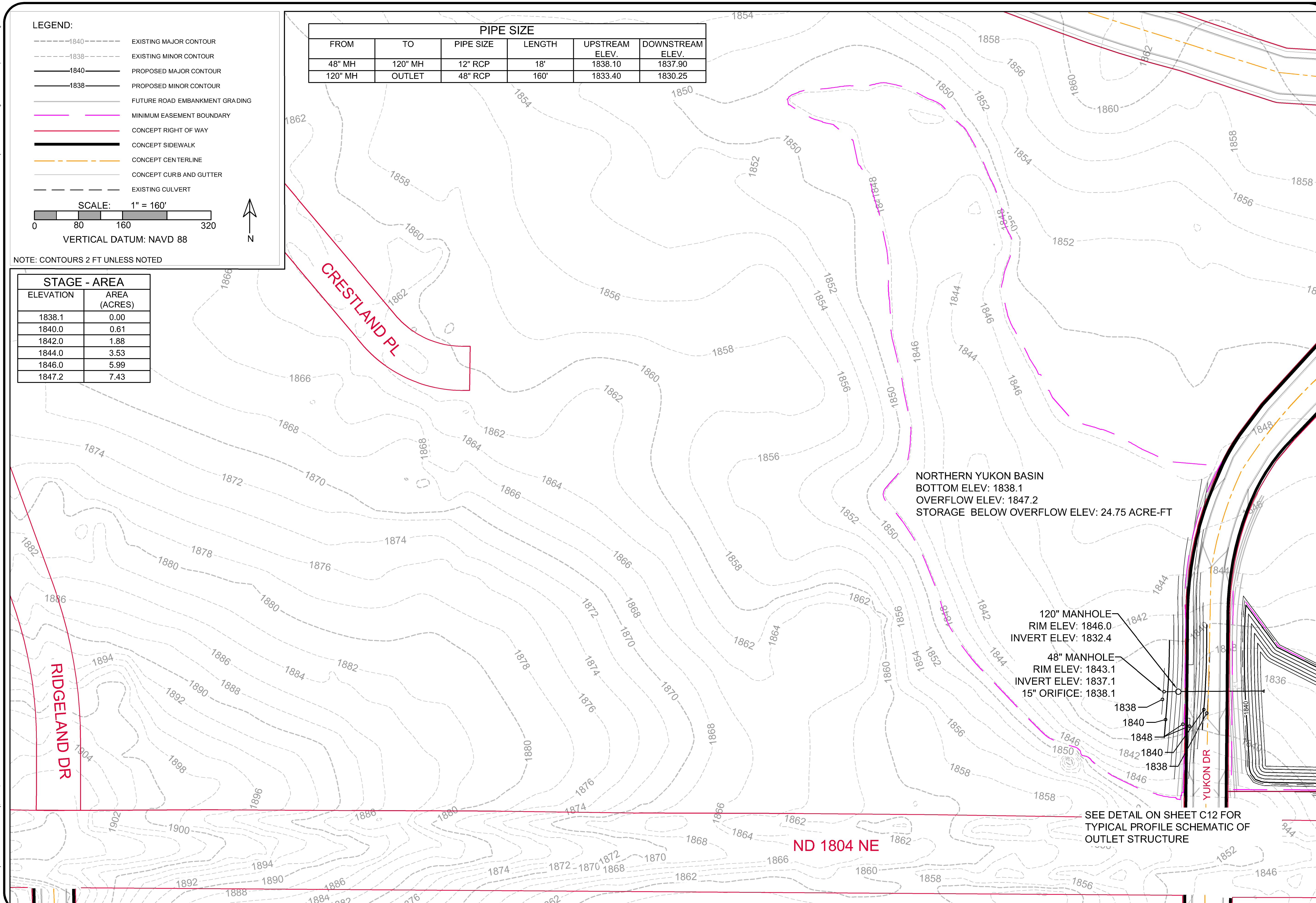
PRELIMINARY

US 83 / ND 1804 STORMWATER MASTER PLAN
CITY OF BISMARCK
CITY OF BISMARCK, BURLEIGH COUNTY ND
1804 BASIN

City Of Bismarck Project ----
DRAWING TYPE: PRELIMINARY
PREPARED BY: RSS/SGS
CHECKED / APPROVED: JDL / JMH
DATE: 03/18/2013
PROJECT NUMBER: P00501-2012-05
SHEET: 4 of 12
DRAWING: C04

CITY OF BISMARCK, ND
US83/ND1804 Watershed Stormwater Master Plan
1804 Basin
16-Jan-13

Engineers Opinion of Probable Costs					
ITEM	**ITEM DESCRIPTION**	**QTY**	**UNIT**	**UNIT COST**	**TOTAL COST**
1	Bonding	1	LS	$12,300	$12,300
2	Mobilization	1	LS	$81,600	$81,600
3	Erosion Control	1	LS	$15,600	$15,600
4	Unclassified Excavation	14,800	CY	$8	$118,400
5	Dispose of Unclassified Excavation	6,450	CY	$6	$38,700
6	Embankment Fill	4,600	CY	$8	$36,800
7	24-inch RCP Low-Flow Outlet Pipe	14	LF	$80	$1,120
8	60-inch RCP Outlet Pipe	60	LF	$150	$9,000
9	60-Inch RCP Flared End Section (8')	1	EA	$2,500	$2,500
10	48-inch Manhole (5' height) with Pre-Cast Base, Flat-top Lid, and 12" Orifice Drilled into Sidewall	1	LS	$2,100	$2,100
11	132-inch Manhole (9' height) with Pre-Cast Base and Custom Bar Grate	1	LS	$14,604	$14,604
12	Type H Riprap	200	TON	$65	$13,000
13	Strip, Stockpile, and Replace Topsoil	2,200	CY	$8	$17,600
14	Seeding - Class I	13,300	SY	$1	$13,300
15	Mulching - Crimped	4,670	SY	$1	$4,670
16	Erosion Control Mat	8,630	SY	$5	$38,835
				Subtotal Construction Costs	**$420,129**
				15% Contingencies	**$63,019**
				Legal, Administration & Engineering (30%)	**$126,039**
				TOTAL PROJECT COSTS	**$609,187**
17	Property Acquisition	2.6	Acre	$174,240	$453,024
				TOTAL FACILITY COSTS	**$1,062,211**



LEGEND:

- 1840 — EXISTING MAJOR CONTOUR
- 1838 — EXISTING MINOR CONTOUR
- 1840 — PROPOSED MAJOR CONTOUR
- 1838 — PROPOSED MINOR CONTOUR
- FUTURE ROAD EMBANKMENT GRADING
- MINIMUM EASEMENT BOUNDARY
- CONCEPT RIGHT OF WAY
- CONCEPT SIDEWALK
- CONCEPT CENTERLINE
- CONCEPT CURB AND GUTTER
- EXISTING CULVERT

SCALE: 1" = 160'

0 80 160 320

VERTICAL DATUM: NAVD 88

N

NOTE: CONTOURS 2 FT UNLESS NOTED

PIPE SIZE

FROM	TO	PIPE SIZE	LENGTH	UPSTREAM ELEV.	DOWNSTREAM ELEV.
48" MH	120" MH	12" RCP	18'	1838.10	1837.90
120" MH	OUTLET	48" RCP	160'	1833.40	1830.25

STAGE - AREA

ELEVATION	AREA (ACRES)
1838.1	0.00
1840.0	0.61
1842.0	1.88
1844.0	3.53
1846.0	5.99
1847.2	7.43

NORTHERN YUKON BASIN
BOTTOM ELEV: 1838.1
OVERFLOW ELEV: 1847.2
STORAGE BELOW OVERFLOW ELEV: 24.75 ACRE-FT

SEE DETAIL ON SHEET C12 FOR TYPICAL PROFILE SCHEMATIC OF OUTLET STRUCTURE

US 83 / ND 1804 STORMWATER MASTER PLAN
CITY OF BISMARCK
CITY OF BISMARCK, BURLEIGH COUNTY ND
NORTHERN YUKON BASIN

CITY OF BISMARCK PROJECT ----
DRAWING TYPE: PRELIMINARY
PREPARED BY: RSS/SGS
CHECKED / APPROVED: JDL / JMH
DATE: 03/18/2013
PROJECT NUMBER: P00501-2012-05
SHEET: 5 of 12
DRAWING: C05

PRELIMINARY

CITY OF BISMARCK, ND
US83/ND1804 Watershed Stormwater Master Plan
Northern Yukon Basin
16-Jan-13

Engineers Opinion of Probable Costs					
ITEM	**ITEM DESCRIPTION**	**QTY**	**UNIT**	**UNIT COST**	**TOTAL COST**
1	Bonding	1	LS	$5,900	$5,900
2	Mobilization	1	LS	$39,300	$39,300
3	Erosion Control	1	LS	$7,500	$7,500
4	Embankment Fill	4,300	CY	$8	$34,400
5	24-inch RCP Low-Flow Outlet Pipe	18	LF	$80	$1,440
6	48-inch RCP Outlet Pipe	138	LF	$240	$33,120
7	48-Inch RCP Flared End Section (8')	1	EA	$1,900	$1,900
8	48-inch Manhole (5' height) with Pre-Cast Base, Flat-top Lid, and 15" Orifice Drilled into Sidewall	1	LS	$2,100	$2,100
9	120-inch Manhole (14' height) with Pre-Cast Base and Custom Bar Grate	1	LS	$37,500	$37,500
10	Type H Riprap	200	TON	$65	$13,000
11	Strip, Stockpile, and Replace Topsoil	632	CY	$8	$5,056
12	Seeding - Class I	3,800	SY	$1	$3,800
13	Erosion Control Mat	3,800	SY	$5	$17,100
				Subtotal Construction Costs	**$202,116**
				15% Contingencies	**$30,317**
				Legal, Administration & Engineering (30%)	**$60,635**
				TOTAL PROJECT COSTS	**$293,068**
14	Property Acquisition	9.3	Acre	$174,240	$1,620,432
				TOTAL FACILITY COSTS	**$1,913,500**

LEGEND:

- EXISTING MAJOR CONTOUR (1840)
- EXISTING MINOR CONTOUR (1838)
- PROPOSED MAJOR CONTOUR (1840)
- PROPOSED MINOR CONTOUR (1838)
- FUTURE ROAD EMBANKMENT GRADING
- MINIMUM EASEMENT BOUNDARY
- CONCEPT RIGHT OF WAY
- CONCEPT SIDEWALK
- CONCEPT CENTERLINE
- CONCEPT CURB AND GUTTER
- EXISTING CULVERT

SCALE: 1" = 160'

0 80 160 320

N

VERTICAL DATUM: NAVD 88

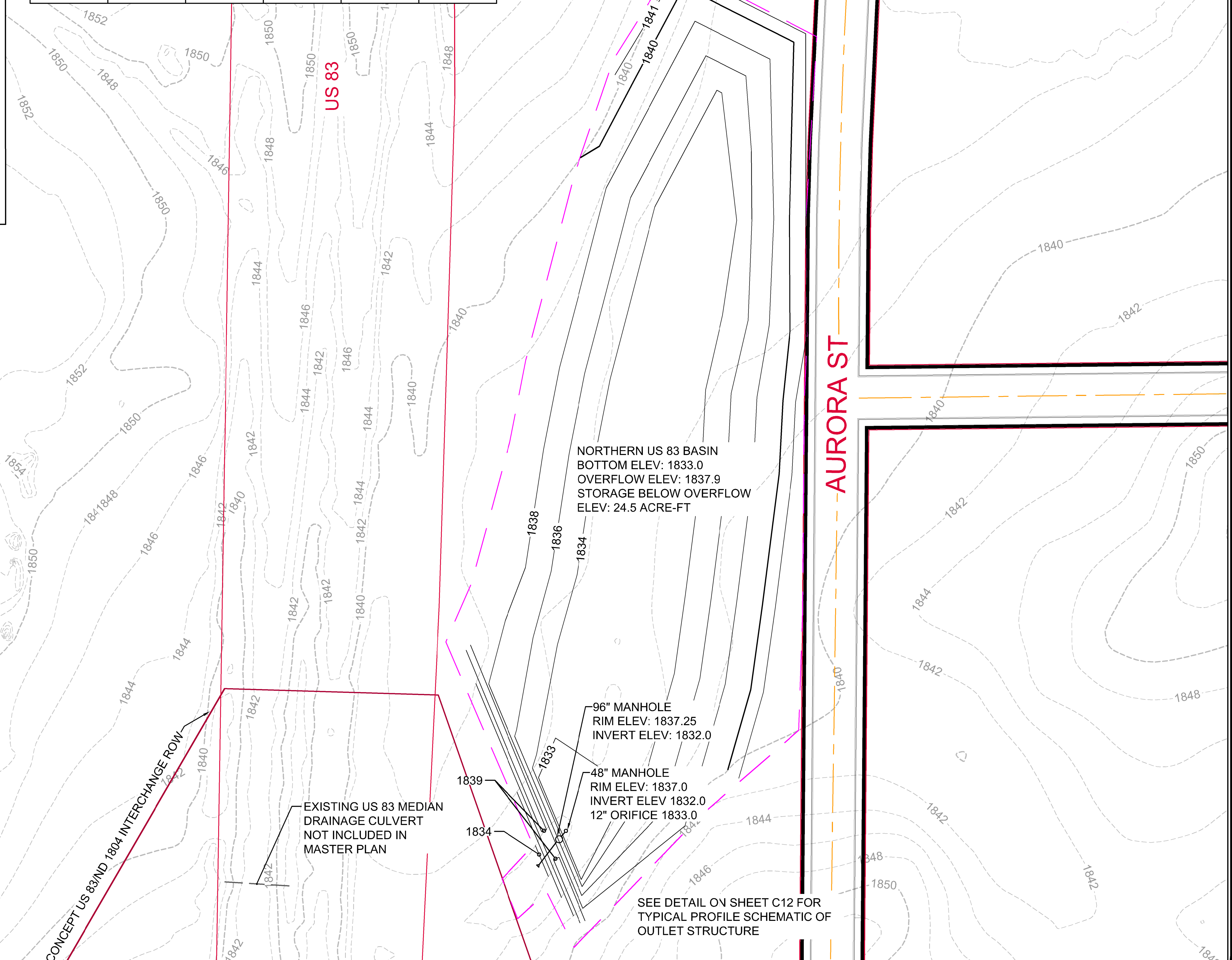
NOTE: CONTOURS 2 FT UNLESS NOTED

STAGE - AREA

ELEVATION	AREA (ACRES)
1833.0	0.00
1834.0	3.93
1836.0	6.12
1837.9	8.55

PIPE SIZE

FROM	TO	PIPE SIZE	LENGTH	UPSTREAM ELEV.	DOWNSTREAM ELEV.
48" MH	96" MH	24" RCP	14'	1833.00	1833.00
96" MH	OUTLET	36" RCP	45'	1833.00	1833.00



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PRELIMINARY

US 83 / ND 1804 STORMWATER MASTER PLAN
CITY OF BISMARCK
CITY OF BISMARCK, BURLEIGH COUNTY ND
NORTHERN US 83 BASIN

City Of Bismarck Project: ----
DRAWING TYPE: PRELIMINARY
PREPARED BY: RSS/SGS
CHECKED / APPROVED: JDL / JMH
DATE: 03/18/2013
PROJECT NUMBER: P00501-2012-05
SHEET: 6 of 12
DRAWING: C06

CITY OF BISMARCK, ND
US83/ND1804 Watershed Stormwater Master Plan
Northern US 83 Basin
16-Jan-13

Engineers Opinion of Probable Costs					
ITEM	**ITEM DESCRIPTION**	**QTY**	**UNIT**	**UNIT COST**	**TOTAL COST**
1	Bonding	1	LS	$18,900	$18,900
2	Mobilization	1	LS	$125,400	$125,400
3	Erosion Control	1	LS	$23,900	$23,900
4	Unclassified Excavation	18,650	CY	$8	$149,200
5	Dispose of Unclassified Excavation	14,530	CY	$6	$87,180
6	Embankment Fill	4,120	CY	$8	$32,960
7	24-inch RCP Low-Flow Outlet Pipe	14	LF	$80	$1,120
8	36-inch RCP Outlet Pipe	45	LF	$140	$6,300
9	36-Inch RCP Flared End Section (8')	1	EA	$1,400	$1,400
10	48-inch Manhole (5' height) with Pre-Cast Base, Flat-top Lid, and 12" Orifice Drilled into Sidewall	1	LS	$2,100	$2,100
11	96-inch Manhole (5' height) with Pre-Cast Base and Custom Bar Grate	1	LS	$11,700	$11,700
12	Type H Riprap	200	TON	$65	$13,000
13	Strip, Stockpile, and Replace Topsoil	8,220	CY	$8	$65,760
14	Seeding - Class I	49,330	SY	$1	$49,330
15	Mulching - Crimped	46,970	SY	$1	$46,970
16	Erosion Control Mat	2,360	SY	$5	$10,618
				Subtotal Construction Costs	**$645,838**
				15% Contingencies	**$96,876**
				Legal, Administration & Engineering (30%)	**$193,751**
				TOTAL PROJECT COSTS	**$936,465**
17	Property Acquisition	12.6	Acre	$174,240	$2,195,424
				TOTAL FACILITY COSTS	**$3,131,889**

LEGEND:

- 1840 — EXISTING MAJOR CONTOUR
- 1838 — EXISTING MINOR CONTOUR
- 1840 — PROPOSED MAJOR CONTOUR
- 1838 — PROPOSED MINOR CONTOUR
- FUTURE ROAD EMBANKMENT GRADING
- MINIMUM EASEMENT BOUNDARY
- CONCEPT RIGHT OF WAY
- CONCEPT SIDEWALK
- CONCEPT CENTERLINE
- CONCEPT CURB AND GUTTER
- EXISTING CULVERT

SCALE: 1" = 160'
0 80 160 320
VERTICAL DATUM: NAVD 88

N

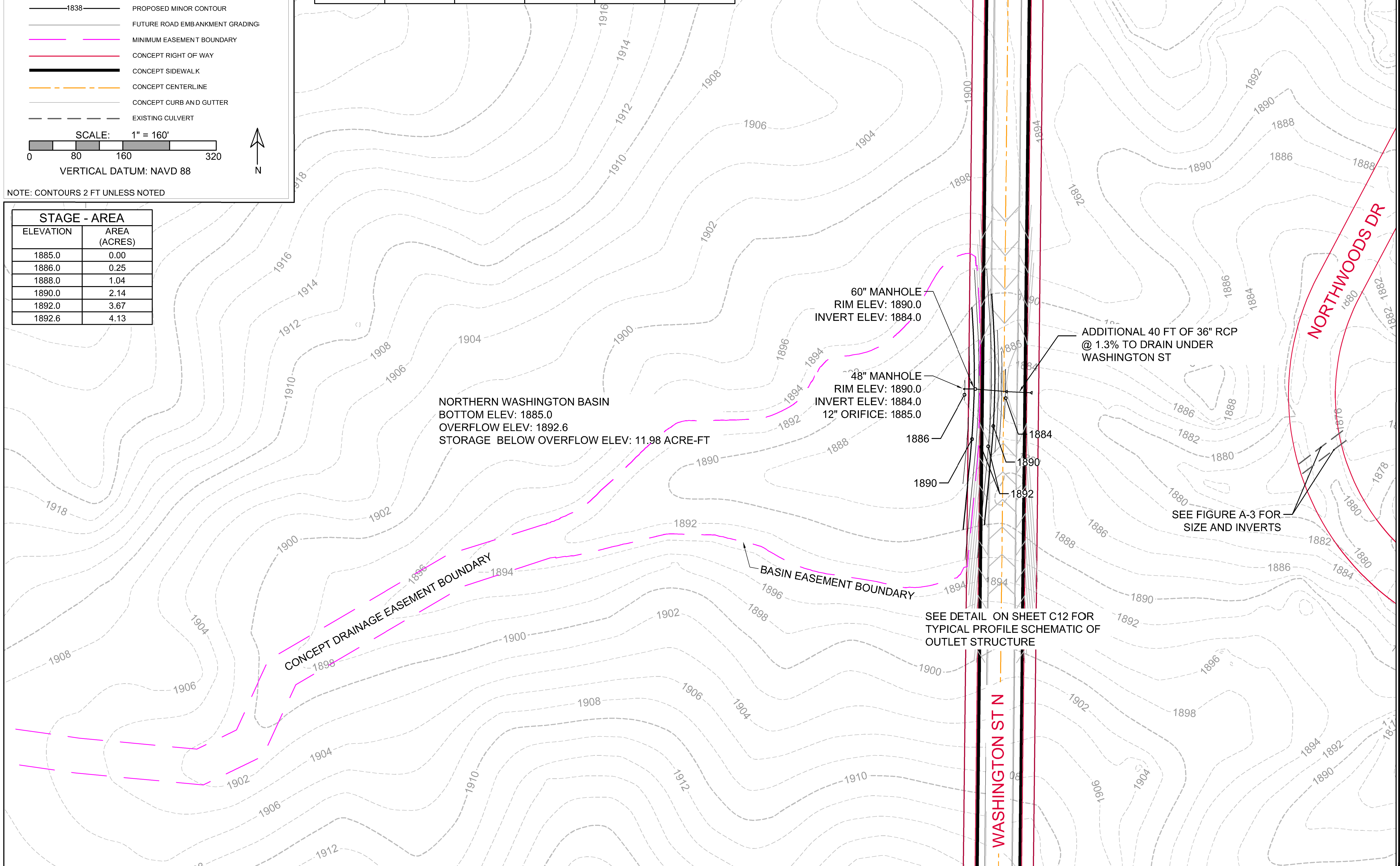
NOTE: CONTOURS 2 FT UNLESS NOTED

PIPE SIZE

FROM	TO	PIPE SIZE	LENGTH	UPSTREAM ELEV.	DOWNSTREAM ELEV.
48" MH	60" MH	12" RCP	14'	1885.00	1884.75
60" MH	OUTLET	36" RCP	50'	1884.75	1884.10

STAGE - AREA

ELEVATION	AREA (ACRES)
1885.0	0.00
1886.0	0.25
1888.0	1.04
1890.0	2.14
1892.0	3.67
1892.6	4.13



US 83 / ND 1804 STORMWATER MASTER PLAN
CITY OF BISMARCK
CITY OF BISMARCK, BURLEIGH COUNTY ND
NORTHERN WASHINGTON BASIN

City Of Bismarck Project: ----
DRAWING TYPE: PRELIMINARY
PREPARED BY: RSS/SGS
CHECKED / APPROVED: JDL / JMH
DATE: 03/18/2013
PROJECT NUMBER: P00501-2012-05
SHEET: 7 of 12
DRAWING: C07

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PRELIMINARY

CITY OF BISMARCK, ND
US83/ND1804 Watershed Stormwater Master Plan
Northern Washington Basin
16-Jan-13

Engineers Opinion of Probable Costs					
ITEM	**ITEM DESCRIPTION**	**QTY**	**UNIT**	**UNIT COST**	**TOTAL COST**
1	Bonding	1	LS	$3,100	$3,100
2	Mobilization	1	LS	$20,500	$20,500
3	Erosion Control	1	LS	$3,900	$3,900
4	Embankment Fill	3,310	CY	$8	$26,480
5	24-inch RCP Low-Flow Outlet Pipe	14	LF	$80	$1,120
6	36-inch RCP Outlet Pipe	50	LF	$140	$7,000
7	36-Inch RCP Flared End Section (8')	1	EA	$1,400	$1,400
8	48-inch Manhole (5' height) with Pre-Cast Base, Flat-top Lid, and 12" Orifice Drilled into Sidewall	1	LS	$2,100	$2,100
9	60-inch Manhole (6' height) with Pre-Cast Base and Custom Bar Grate	1	LS	$4,800	$4,800
10	Type H Riprap	200	TON	$65	$13,000
11	Strip, Stockpile, and Replace Topsoil	537	CY	$8	$4,296
12	Seeding - Class I	3,200	SY	$1	$3,200
13	Erosion Control Mat	3,200	SY	$5	$14,400
				Subtotal Construction Costs	**$105,296**
				15% Contingencies	**$15,794**
				Legal, Administration & Engineering (30%)	**$31,589**
				TOTAL PROJECT COSTS	**$152,679**
14	Property Acquisition	4.7	Acre	$174,240	$818,928
				TOTAL FACILITY COSTS	**$971,607**

LEGEND:

- 1840 EXISTING MAJOR CONTOUR
- 1838 EXISTING MINOR CONTOUR
- 1840 PROPOSED MAJOR CONTOUR
- 1838 PROPOSED MINOR CONTOUR
- FUTURE ROAD EMBANKMENT GRADING
- MINIMUM EASEMENT BOUNDARY
- CONCEPT RIGHT OF WAY
- CONCEPT SIDEWALK
- CONCEPT CENTERLINE
- CONCEPT CURB AND GUTTER
- EXISTING CULVERT

SCALE: 1" = 100'

0 50 100 200

N

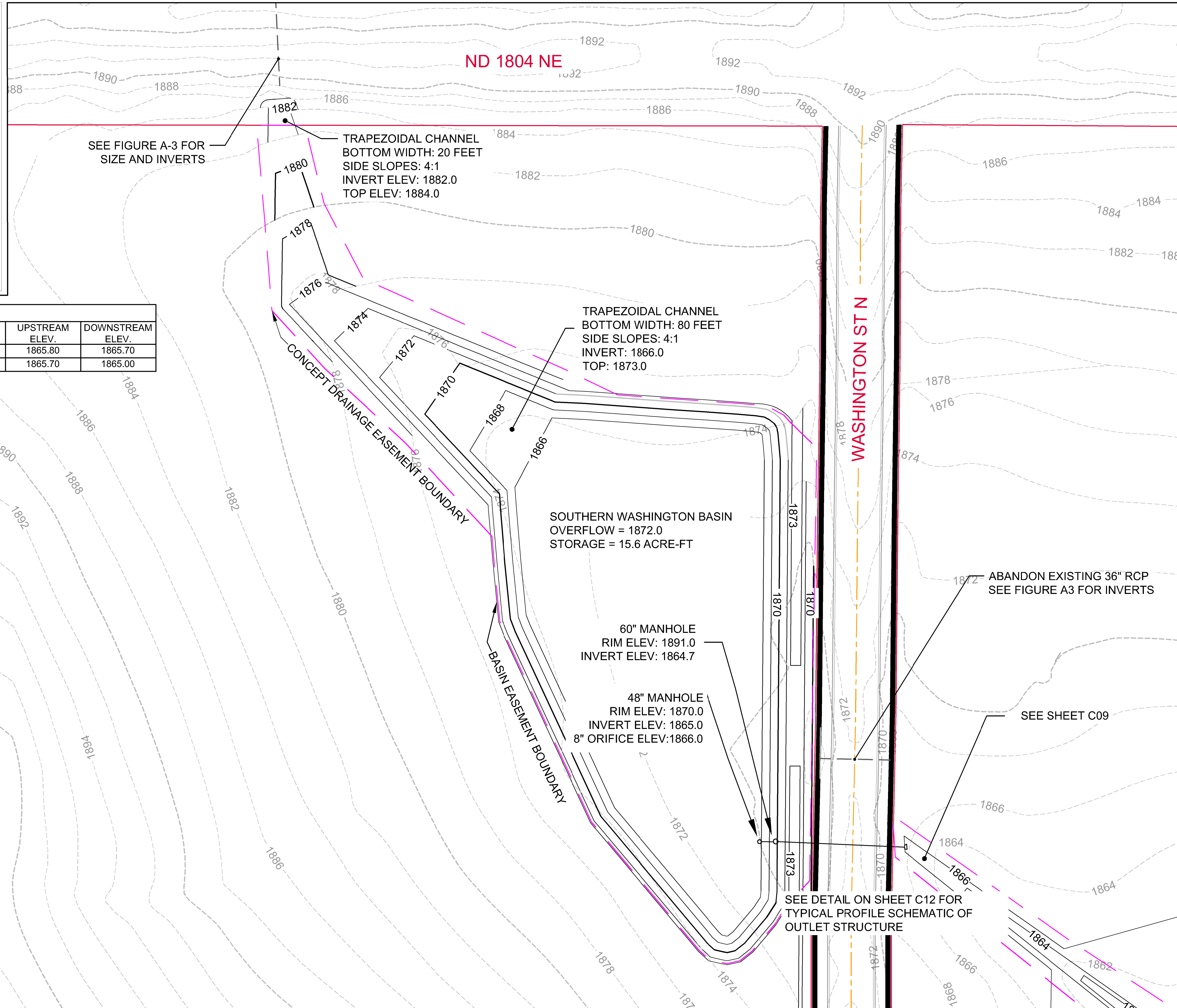
VERTICAL DATUM: NAVD 88

NOTE: CONTOURS 2 FT UNLESS NOTED

FROM	TO	PIPE SIZE	LENGTH	UPSTREAM ELEV.	DOWNSTREAM ELEV.
48" MH	60" MH	24" RCP	12'	1865.80	1865.70
60" MH	OUTLET	36" RCP	116'	1865.70	1865.00

STAGE - AREA

ELEVATION	AREA (ACRES)
1865.0	0.00
1866.0	2.15
1868.0	2.48
1870.0	2.83
1872.0	3.19



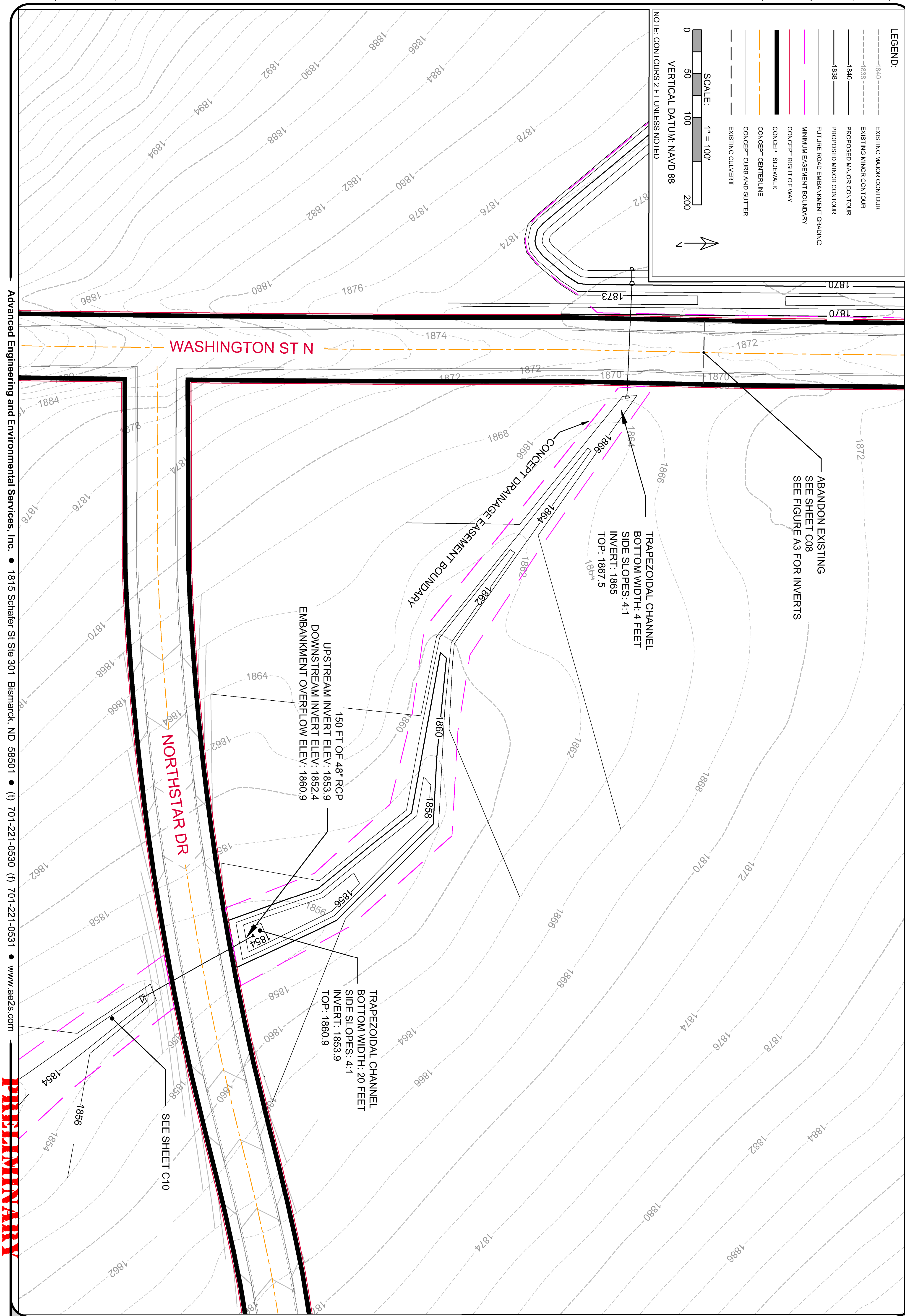
CITY OF BISMARCK, ND
US83/ND1804 Watershed Stormwater Master Plan
Southern Washington Basin
16-Jan-13

Engineers Opinion of Probable Costs

ITEM	ITEM DESCRIPTION	QTY	UNIT	UNIT COST	TOTAL COST
1	Bonding	1	LS	$18,400	$18,400
2	Mobilization	1	LS	$122,100	$122,100
3	Erosion Control	1	LS	$23,300	$23,300
4	Unclassified Excavation	26,750	CY	$8	$214,000
5	Dispose of Unclassified Excavation	22,500	CY	$6	$135,000
6	Embankment Fill	1,400	CY	$8	$11,200
7	24-inch RCP Low-Flow Outlet Pipe	12	LF	$80	$960
8	36-inch RCP Outlet Pipe	116	LF	$140	$16,240
9	36-Inch RCP Flared End Section (8')	1	EA	$1,400	$1,400
10	48-inch Manhole (5' height) with Pre-Cast Base, Flat-top Lid, and 8" Orifice Drilled into Sidewall	1	LS	$2,100	$2,100
11	60-inch Manhole (6' height) with Pre-Cast Base and Custom Bar Grate	1	LS	$4,800	$4,800
12	Type H Riprap	200	TON	$65	$13,000
13	Strip, Stockpile, and Replace Topsoil	2,850	CY	$8	$22,800
14	Seeding - Class I	17,100	SY	$1	$17,100
15	Mulching - Crimped	14,430	SY	$1	$14,430
16	Erosion Control Mat	2,670	SY	$5	$12,015
				Subtotal Construction Costs	**$628,845**
				15% Contingencies	**$94,327**
				Legal, Administration & Engineering (30%)	**$188,654**
				TOTAL PROJECT COSTS	**$911,825**
17	Property Acquisition	3.3	Acre	$174,240	$574,992
				TOTAL FACILITY COSTS	**$1,486,817**

CITY OF BISMARCK, ND
US83/ND1804 Watershed Stormwater Master Plan
Southern Washington Swale
16-Jan-13

Engineers Opinion of Probable Costs					
ITEM	**ITEM DESCRIPTION**	**QTY**	**UNIT**	**UNIT COST**	**TOTAL COST**
1	Bonding	1	LS	$3,000	$3,000
2	Mobilization	1	LS	$19,900	$19,900
3	Erosion Control	1	LS	$3,800	$3,800
4	Unclassified Excavation	3,100	CY	$8	$24,800
5	Dispose of Unclassified Excavation	3,100	CY	$6	$18,600
6	Strip, Stockpile, and Replace Topsoil	785	CY	$8	$6,280
7	Seeding - Class I	4,710	SY	$1	$4,710
8	Erosion Control Mat	4,710	SY	$5	$21,195
				Subtotal Construction Costs	**$102,285**
				15% Contingencies	**$15,343**
				Legal, Administration & Engineering (30%)	**$30,686**
				TOTAL PROJECT COSTS	**$148,313**
9	Property Acquisition	1.2	Acre	$174,240	$209,088
				TOTAL FACILITY COSTS	**$357,401**



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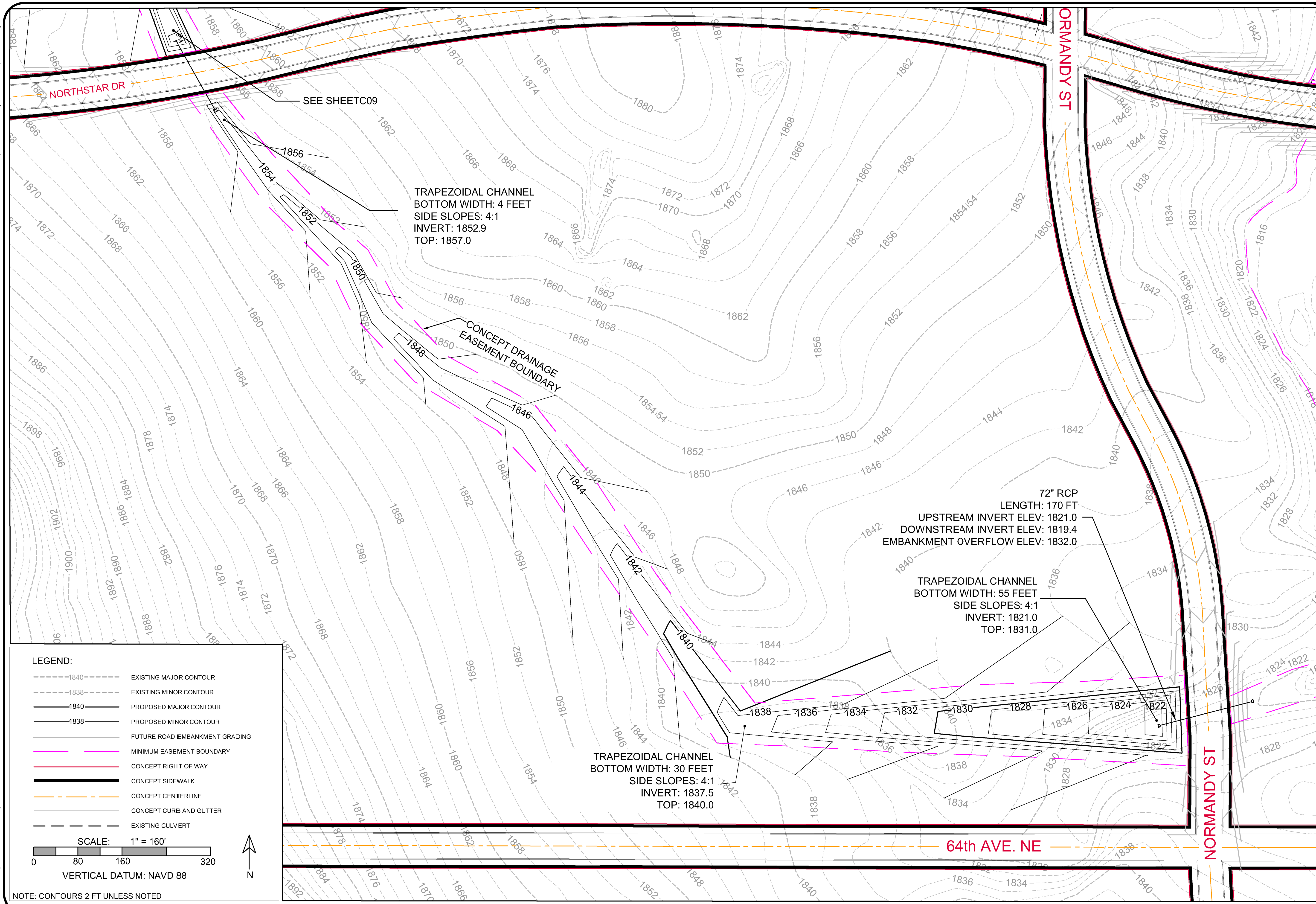
US 83 / ND 1804 STORMWATER MASTER PLAN
CITY OF BISMARCK
CITY OF BISMARCK, BURLEIGH COUNTY ND
DITCH WASHINGTON TO NORTHSTAR

DRAWING TYPE	PRELIMINARY
PREPARED BY	RSS/SGS
CHECKED / APPROVED	JDL / JMH
DATE	03/18/2013
PROJECT NUMBER	P00501-2012-05
SHEET	9 of 12
DRAWING	C09



US 83 / ND 1804 STORMWATER MASTER PLAN

CITY OF BISMARCK

CITY OF BISMARCK, BURLEIGH COUNTY ND

DITCH NORTHSTAR TO NORMANDY

City of Bismarck Project	----
DRAWING TYPE	PRELIMINARY
PREPARED BY	RSS/SGS
CHECKED / APPROVED	JDL / JMH
DATE	03/18/2013
PROJECT NUMBER	P00501-2012-05
SHEET	10 of 12
DRAWING	C10

PRELIMINARY

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Last Saved By: Anna Dahl Date: Wednesday, March 20, 2013 11:05:24 AM

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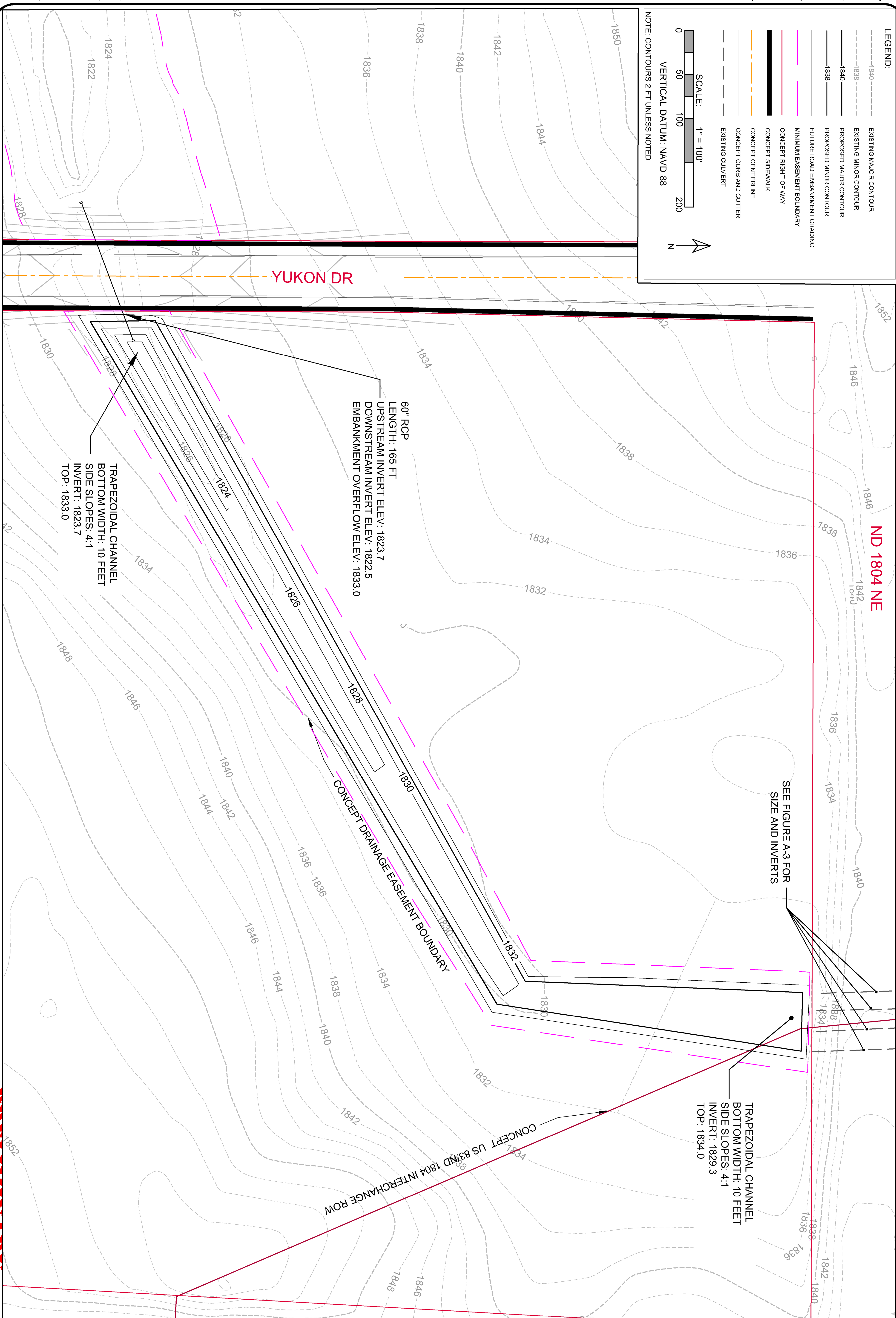

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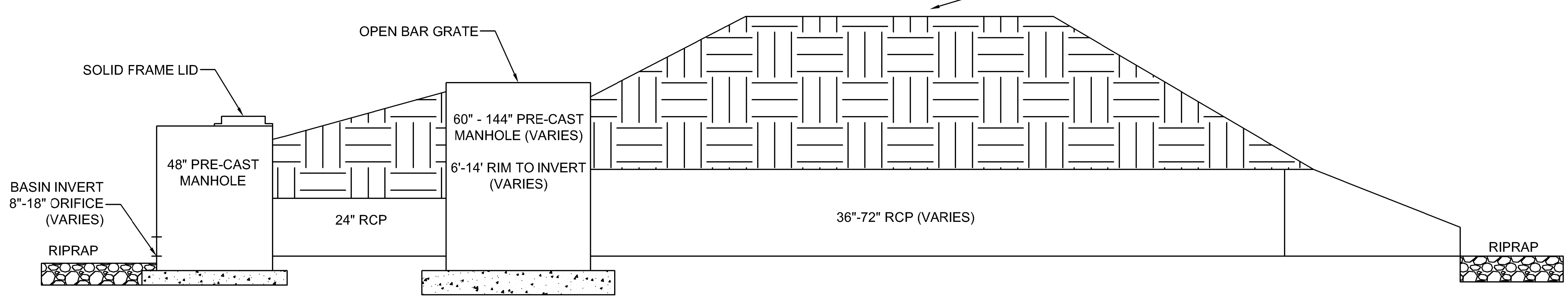
C11
DRAWING
11 of 12
SHEET
P00501-2012-05
PROJECT NUMBER
03/18/2013
DATE
JDL / JMH
CHECKED / APPROVED
RSS/SGS
PREPARED BY
PRELIMINARY
DRAWING TYPE

US 83 / ND 1804 STORMWATER MASTER PLAN
CITY OF BISMARCK
CITY OF BISMARCK, BURLEIGH COUNTY ND
DITCH 1804 TO YUKON

AE2S

JLG architects

DETAIL - TYPICAL OUTLET STRUCTURE



US 83 / ND 1804 STORMWATER MASTER PLAN
CITY OF BISMARCK
CITY OF BISMARCK, BURLEIGH COUNTY, ND
TYPICAL OUTLET STRUCTURE DETAILS

City Of BISMARCK PROJECT	----
DRAWING TYPE	PRELIMINARY
PREPARED BY	RSS/SGS
CHECKED / APPROVED	JDL / JMH
DATE	03/18/2013
PROJECT NUMBER	P00501-2012-05
SHEET	12 of 12
DRAWING	C12

PRELIMINARY

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APPENDIX A – HYDROLOGY AND HYDRAULICS

A.0 Methodology

As described in ***Section 3*** of this report, the hydrology and hydraulics of the study area was modeled using InfoSWMM, which is a proprietary GIS-integrated version of the EPA SWMM model that is widely accepted for use in stormwater modeling.

There are a number of rainfall-runoff modeling options within InfoSWMM, and for consistency with the City of Bismarck's Stormwater Design Standards Manual, the NRCS methodology (Curve Number and Time of Concentration) was utilized. Rainfall depths and distributions were based on the manual, which are the SCS Type II, 6-hour storm. In addition to the 6-hour storm durations, the Standard SCS Type II 24-hour durations were evaluated for the 2-, 25-, and 100-year events for the purposes of evaluating compliance with ND DOT requirements. Storm depths are summarized in ***Table A.1*** below.

Table A.1: Rainfall Depths for Bismarck, North Dakota

Frequency	6-Hour Rainfall (inches)	24-Hour Rainfall (inches)
2-year	1.6	2.0
10-year	2.5	---
25-year	3.0	3.8
100-year	3.8	4.8

A.1 Model Scope and Level of Detail

This study evaluates the existing and proposed runoff conditions for all areas draining to the main culvert under US 83 between ND 1804 and the future 57th Avenue NE. Additionally, the hydraulic model extends downstream to the confluence with Hay Creek to accurately assess the performance of the proposed stormwater facilities.

The general level of detail of the study is such that existing infrastructure (such as culverts and roadways) are included when they are located on main drainage-ways or when they could be substantially impacted by upstream land use changes. For example, driveway culverts are generally not included in the model; however, the driveway culvert located on Ridgeland Loop just east of North Washington Street was included because the property to the west of North Washington Street will develop and this area eventually drains under that particular driveway culvert.

A.2 Existing Conditions

A.2.1 Hydrologic Analysis

As described previously in Section 2, the existing land use for the study area is primarily a mixture of rural residential and agricultural lands (***Figure 2-2***, shown previously). Overall drainage for the study area is from north to south, and runoff from the study area eventually flows under US 83 south of ND 1804 prior to discharging to Hay Creek.

The soils in the watershed are primarily silt loams (***Figure A-1)***, which are classified by the NRCS as Hydrologic Soil Group (HSG) B soils. Pockets of HSG C and D soils, which have a higher runoff potential than HSG B soils, exist as well in the study area. Runoff Curve Numbers were set based on NRCS recommendations for land use and soils. Impervious areas were aggregated with the pervious areas, which is appropriate for existing conditions because in general, impervious areas drain over large pervious areas (such as lawns and roadside ditches) before reaching the primary conveyance systems; therefore, the impervious areas are partially "disconnected" from the primary conveyance system rather than being storm sewered directly to the main drainage-ways. ***Figure A-2*** displays each subwatershed and the existing land use, while ***Table A.2*** summarizes the watershed runoff parameters.

Table A.2: Summary of Existing Subwatershed Runoff Parameters

Subwatershed ID	Subcatchment Area (ac)	CN	TC (min)
3_4_A	15.0	65	31.5
3_4_B	11.4	73	24.7
3_4_C	90.1	68	28.7
3_4_D	45.3	66	33.2
3_4_E	26.4	68	41.8
3_4_F	29.7	66	36.7
3_4_G	19.0	67	31.5
3_4_H	75.2	68	30.7
3_4_I	34.3	69	32.9
3_4_J	15.7	74	35.1
3_4_K	11.2	63	44.5
3_4_L	4.7	66	39.8
3_4_M	92.1	67	30
3_4_N	8.7	64	50.8
3_4_O	12.1	77	47.5
3_4_P	38.9	73	36.6
3_4_Q	85.4	64	42.3
3_4_R	16.0	70	30.7
3_4_S	150.3	71	27.3
3_4_T	45.5	69	27.4
3_4_U	118.2	67	36.2
3_4_V	46.3	68	24.4
3_4_W	59.6	69	23
3_4_X	85.4	75	30.2

*Continued on the following page

Table A.2: Continued

Subwatershed ID	Subcatchment Area (ac)	CN	TC (min)
3_4_Y	74.1	64	28.3
3_5_A	29.2	64	51.1
3_5_B	26.3	69	24.2
3_5_C	41.7	68	22.4
3_5_D	11.2	68	21.3
3_5_E	26.6	67	17.8
3_5_F	13.0	67	34.9
3_5_G	35.8	68	38.8
3_5_H	24.5	65	40.5
3_5_I	33.8	71	31.3
3_5_J	32.3	72	19.2
3_5_K	15.0	72	15.3
3_6_A	158.6	64	34.4
3_6_B	40.4	74	23.9
3_6_C	5.0	62	52.9
3_6_D	7.9	64	62.1
3_6_E	34.8	68	13.9
3_6_F	17.6	75	25.3
3_6_G	3.1	61	42.5
3_6_H	21.1	63	21.3
3_6_I	7.7	63	43.9
3_6_J	84.6	63	59.5
Total	**1880.6**	**N/A**	**N/A**

A.2.2 Hydraulic Analysis

Conveyance Features

The hydraulics of the study area were simulated to reflect existing conditions as closely as possible. Culverts on main drainage-ways were surveyed as part of this project, which included invert elevations, size, and type (CMP, RCP, etc.). The data obtained from the survey is shown in ***Figure A-3***. Existing road overflow elevations were estimated from the LIDAR data.

Cross sections on the main drainage routes were estimated from the LIDAR data, which generally included:

- Main tributary from confluence with Hay Creek to ND 1804;
- Tributary branch that joins with the main tributary near the future Normandy / 64th Avenue NE intersection from the confluence to North Washington Street;
- Tributary branch from ND 1804 to Ridgeland Drive south of the future Highridge Drive;
- Tributary branch from ND 1804 to the existing Yukon Drive crossing (through the State Street Office Park); and
- US 83 ditch on the west side of the highway from State Street Office Park to the future 81st Avenue NE crossing.

Existing Detention Basins and Natural Storage

The Northridge Estates subdivision is the only existing development with stormwater management practices installed, which generally consist of dry basins upstream of roadway embankments. These existing stormwater management facilities were input based on the following information:

- Contributing area information available from the Swenson Hagen reports, 2-foot contours, and field-confirmed;
- Storage and area-depth relationships were based on 2-foot contours generated from 2009 LIDAR data; and
- Culverts and overflow elevations were input based on the approach described above for road crossing culverts.

Figure A-4 schematically illustrates the location of stormwater management facilities that were input to the model. In addition to these stormwater management facilities, storage that is created by roadway embankments (such as north of ND 1804 and west of US 83) was also included in the analysis because understanding the flow reduction that these "natural" detention areas provide is important to understanding the potential impacts of filling these areas. The main channel upstream of US 83 was modeled as cross-sections instead of as a storage area because the backwater effects from the US 83 culvert vary drastically depending on the severity of the rainfall event.

Table A.3 summarizes the maximum storage prior to roadway overtopping in the stormwater management and "natural" storage areas, which illustrates that several of the "natural" storage areas in the study area provide substantial storage. There is almost 490 ac-ft of natural storage in the watershed (Storage ID's that begin with "DE_FACTO"), the bulk of which is along the US 83 corridor. The US 83 corridor is also where the most development pressure will be located. There is also approximately 28 ac-ft of detention basins that were constructed as part of the Northridge Estates subdivision (Storage ID's that begin with "DETBASIN").

Table A.3: Summary of Existing Storage in Study Area

Storage ID in InfoSWMM model	Storage (ac-ft)	Max Depth (ft)
DE_FACTO_USH83 MAIN CROSSING*	201.99	19.62
DE_FACTO_USH83_UPPER	152.55	0.5
DE_FACTO_1804	58.60	11.28
DE_FACTO_USH83_N_OF_1804	31.91	10.03
DE_FACTO_NE_84TH_RIDGELAND	11.81	5.68
DE_FACTO_N_OF_84TH_W_OF_FENNEL	4.14	5.55
DE_FACTO_W_OF_WASH_S_OF_1804	3.89	5.81
DE_FACTO_PRIVATE_DR_S_OF_79TH	3.78	2.69
DE_FACTO_N_OF_79TH_E_OF_PRIVDR	3.06	2.86
DE_FACTO_N_OF_SNFLWR_W_OF_CRWAY	2.28	4.32
DE_FACTO_W_OF_WASH_RDGLND_LP	1.64	4.55
DE_FACTO_NW_84TH_RIDGELAND	1.45	3.4
DE_FACTO_W_OF_USH83_N_OF_11TH	1.30	5.78
DE_FACTO_N_OF_SNFLWR_W_OF_SAGE	1.10	3.38
DE_FACTO_PRIVATE_DR_N_OF_79TH_2	1.09	3.13
DE_FACTO_E_OF_FENNEL_N_OF_84TH	0.99	3.35
DE_FACTO_79TH_PRIVATE_DR	0.98	2.9
DE_FACTO_SW_84TH_RIDGELAND	0.91	2.8
DE_FACTO_S_OF_RDGLND_LP	0.82	4.11
DE_FACTO_E_OF_WASH_N_OF_1804	0.79	5.2
DE_FACTO_PRIVATE_DR_N_OF_79TH_1	0.76	1.8
DE_FACTO_PRIVATE_DR_ON_RGDLND_LP	0.60	3.58
DE_FACTO_11TH	0.57	4.5
DE_FACTO_W_OF_USH83_NE_OF_79TH	0.57	3.69
DE_FACTO_NE_SNFLWR_SAGE	0.12	2.46
DETBASIN_NRE_E_PROP_LINE	6.24	4.27
DETBASIN_NRE_INLINE	6.12	6.59
DETBASIN_NRE_W_RIDGELAND_S	5.5	7.03
DETBASIN_NRE_N_PARKSIDE	2.93	4.46
DETBASIN_NRE_W_RIDGELAND_N	2.79	3.81
DETBASIN_NRE_W_NWOOD_CENT	2.09	5.78
DETBASIN_NRE_W_NWOOD_N	1.69	3.77
DETBASIN_NRE_W_NWOOD_S	0.79	4.11

*Storage is modeled as cross sections instead of as a storage node.

Tailwater Assumptions

Tailwater conditions from Hay Creek were set as follows:

- The FEMA Letter of Map Revision for Hay Creek (Case No. 07-08-0142P) extends to the confluence of Hay Creek and the study area. The drainage area to the confluence of Hay Creek and the study area is a total of approximately 8800 acres, of which 1880 acres is the study area. FEMA's guidance for setting tailwater conditions suggest that for streams with a drainage area ratio between 0.6 and 1.4, it is reasonable to assume coincident peaks (Guidelines and Specifications for Flood Hazard Mapping Partners, Appendix C). Hay Creek far exceeds the 1.4 threshold with a ratio of approximately 3.7. Therefore, normal depth was assumed at the confluence with Hay Creek (Slope 0.0068 ft/ft). As a comparison, the 100-year elevation on Hay Creek at the confluence is 1790.8, which is approximately 7 feet below the culvert outlet invert under US 83, so the tailwater control assumption is not expected to affect any of the conclusions of this study.

A.3 Full Build-Out Conditions, No Controls

A.3.1 Future Land Use Assumptions

As mentioned in ***Section 2*** of this report, minor modifications to the future land use presented in the US 83 Corridor Study were made based on input from City Planning staff, which are summarized below:

- No distinction between rural residential and urban residential is made. For the purposes of this study, all new rural residential areas will be urban. Further, because it is likely that the rural residential lots along 79th Ave NE east of Northridge Estates will redevelop, it was assumed that these lots will be urban residential as well.
- The alignment of Yukon Drive (referred to as Ottawa Street in the Hwy 83 plan) was modified at the State Street Office Park to match the plat and at the south end of the study area to match up with the existing street south of 58th Avenue NE. The future Highridge Drive was extended to meet up with shifted Yukon Drive.
- One lot within the Northridge Estates Subdivision was shown as rural residential in the US 83 Corridor Study but has since been re-zoned to Commercial.
- The State Street Office Park is shown as “Commercial” in the shapefile, but is shown as “Mixed Use” in the report. Per the City’s direction, the State Street Office Park land use is “Mixed Use”.
- As described previously in this report, the US83/ND1804 intersection will potentially be converted to a diamond interchange in the future. The highway right-of-way was expanded to conceptually allow for a diamond interchange configuration.
- Final open space areas will be dependent on individual development plans for trail corridors, etc. For the purposes of this study, the open space areas shown in the US 83 corridor study were assumed to be the only large, contiguous open space areas in the study area.
- The far western tip of the study area is not included in the US 83 corridor study. It was assumed that non-agricultural land would remain in the same land use and percent impervious, and that currently agricultural land would convert to urban residential, consistent with the Bismarck-Mandan Regional Land Use Plan (2007).

A.3.2 Impervious Area Assumptions

Section 2 of this report also describes that the City determined that using maximum "lot coverage" as defined in the City's Title 14 zoning code was an appropriate method to estimate the average full build-out impervious area within each land use. The land use presented in the US 83 Corridor Study, however, does not correlate directly with the City's zoning code, so additional assumptions were made based on discussions with City staff to arrive at the full build-out impervious area within each land use type:

- US 83 Study "Mixed Use": Mixed Use was assumed to be zoned as "RT Residential District". RT zoning limits lot coverage to 50 percent for residential and 75 percent for commercial and includes higher density residential and light commercial uses. A typical example of RT zoning is the northeast corner of North Washington Street and Century Avenue. On average, 65 percent was assumed for the impervious cover in Mixed Use.
- US 83 Study "Neighborhood Commercial": Neighborhood Commercial was assumed to zoned as "CA Commercial District". CA zoning limits lot coverage to 70 percent for commercial and 50 percent for residential. Typical examples of CA zoning are the northwest, southwest, and southeast corners of North Washington Street and Century Avenue. On average, 65 percent was assumed for the impervious cover in Mixed Use.
- US 83 Study "Commercial": Commercial was assumed to be zoned as "CG Commercial District". CG zoning limits lot coverage to 80 percent.
- Rural residential impervious area was estimated based on aerial interpretation of the existing rural residential developments.
- Urban residential was assumed to be on average one-third acre lots (30% lot impervious consistent with TR-55 guidance).

A.3.3 Additional Assumptions

This analysis includes the following specific assumptions:

- Eliminating all natural storage outside future land use open space areas and outside existing rural residential development; and
- No stormwater management practices to reduce flow rates or volumes.

A.3.4 Hydrologic Analysis

Table A.4 on the following page summarizes the full build-out watershed runoff parameters. ***Figure A-5*** displays each subwatershed with the full build-out land use. In areas of existing rural residential development, impervious and pervious areas were aggregated; however, in new urban areas, impervious and pervious areas were divided and analyzed separately to more accurately simulate impervious area being directly connected to the larger drainage system via curb and gutter and storm sewer. Although in the model, impervious and pervious were modeled as separate subwatersheds, ***Figure A-5*** combines them as the pervious and impervious area would of course be distributed throughout each subwatershed.

Existing times of concentration were reduced by 50% in urban residential areas and by 66% in mixed use, commercial, and neighborhood commercial land uses to estimate the effects of curb and gutter, ditches, and storm sewer in reducing the travel times for runoff within a developed area.

Table A.4: Summary of Full Build-out Subwatershed Runoff Parameters

Subwatershed ID	Subcatchment Area (ac)	CN	TC (min)
3_4_A_FUTURE	20.4	63	15.8
3_4_A_IMP_FUTURE	8.8	98	15.8
3_4_B_FUTURE	9.2	61	8.2
3_4_B_IMP_FUTURE	17.1	98	8.2
3_4_C_FUTURE	3.9	61	9.5
3_4_C_IMP_FUTURE	7.3	98	9.5
3_4_D_FUTURE	26.6	66	33.2
3_4_E_FUTURE	13.0	69	42.1
3_4_F_FUTURE	35.8	67	36.7
3_4_G_FUTURE	15.0	67	31.7
3_4_H_FUTURE	8.5	64	15.4
3_4_H_IMP_FUTURE	2.9	98	15.4
3_4_I_FUTURE	27.0	62	16.5
3_4_I_IMP_FUTURE	18.3	98	16.5
3_4_J_FUTURE	9.2	61	11.6
3_4_J_IMP_FUTURE	17.1	98	11.6
3_4_K_FUTURE	23.9	65	22.3
3_4_K_IMP_FUTURE	5.8	98	22.3
3_4_L_FUTURE	14.1	67	20.0
3_4_L_IMP_FUTURE	4.8	98	20.0
3_4_M_FUTURE	34.3	67	30.1
3_4_N_FUTURE	13.3	65	25.4
3_4_N_IMP_FUTURE	2.5	98	25.4
3_4_O_FUTURE	58.9	63	15.7
3_4_O_IMP_FUTURE	117.2	98	15.7
3_4_P_FUTURE	7.0	61	6.0
3_4_P_IMP_FUTURE	16.0	98	6.0
3_4_Q_FUTURE	8.6	61	14.0
3_4_Q_IMP_FUTURE	15.9	98	14.0
3_4_R_FUTURE	4.3	61	10.2
3_4_R_IMP_FUTURE	7.9	98	10.2
3_4_S_FUTURE	5.0	70	27.5
3_4_T_FUTURE	7.9	69	27.6
3_4_U_FUTURE	34.8	67	36.3
3_4_V_FUTURE	17.6	68	24.5
3_4_W_FUTURE	3.1	69	23.1
3_4_X_FUTURE	14.1	61	15.2
3_4_X_IMP_FUTURE	6.9	98	15.2
3_4_Y_FUTURE	4.4	61	14.2
3_4_Y_IMP_FUTURE	3.4	98	14.2

*Continued on following page

Table A.4: Continued

Subwatershed ID	Subcatchment Area (ac)	CN	TC (min)
3_5_A_FUTURE	16.0	63	14.5
3_5_A_IMP_FUTURE	28.3	98	14.5
3_5_B_FUTURE	33.8	71	24.3
3_5_C_FUTURE	16.0	68	22.4
3_5_D_FUTURE	32.3	69	21.3
3_5_E_FUTURE	15.0	67	17.8
3_5_F_FUTURE	41.7	67	34.9
3_5_G_FUTURE	57.0	70	12.9
3_5_G_IMP_FUTURE	28.4	98	12.9
3_5_H_FUTURE	54.9	61	20.3
3_5_H_IMP_FUTURE	35.2	98	20.3
3_5_I_FUTURE	51.6	62	15.7
3_5_I_IMP_FUTURE	23.5	98	15.7
3_5_J_FUTURE	7.2	71	9.6
3_5_J_IMP_FUTURE	3.9	98	9.6
3_5_K_FUTURE	4.7	74	15.3
3_5_M_FUTURE	9.3	61	10.7
3_5_M_IMP_FUTURE	30.9	98	10.7
3_6_A_FUTURE	63.5	63	17.2
3_6_A_IMP_FUTURE	28.6	98	17.2
3_6_B_FUTURE	22.8	63	12.0
3_6_B_IMP_FUTURE	16.1	98	12.0
3_6_C_FUTURE	9.3	61	14.5
3_6_C_IMP_FUTURE	29.4	98	14.5
3_6_D_FUTURE	22.9	61	15.2
3_6_D_IMP_FUTURE	56.7	98	15.2
3_6_E_FUTURE	3.0	62	6.0
3_6_E_IMP_FUTURE	5.7	98	6.0
3_6_F_FUTURE	24.1	61	11.1
3_6_F_IMP_FUTURE	18.5	98	11.1
3_6_G_FUTURE	39.1	61	17.9
3_6_G_IMP_FUTURE	17.6	98	17.9
3_6_H_FUTURE	10.5	61	7.1
3_6_H_IMP_FUTURE	17.9	98	7.1
3_6_I_FUTURE	22.5	62	16.7
3_6_I_IMP_FUTURE	25.0	98	16.7
3_6_J_FUTURE	74.5	61	12.0
3_6_J_IMP_FUTURE	69.2	98	12.0
3_6_K_FUTURE	32.8	63	11.1
3_6_K_IMP_FUTURE	42.1	98	11.1
3_6_L_FUTURE	44.9	61	22.7
3_6_L_IMP_FUTURE	22.6	98	22.7

A.3.5 Hydraulic Analysis

Conveyance Features

Existing roadway culverts and roadway profiles were utilized in this scenario.

Existing Detention Basins and Natural Storage

Table A.5 summarizes the reduction in natural storage that would be caused by only preserving natural storage within already designated open spaces or existing rural residential areas that are not anticipated to be redeveloped. Less than 30% of the natural storage remains in this scenario.

Table A.5: Summary of Full Build-out with No BMPs Storage in Study Area

Storage ID in InfoSWMM model	Storage (ac-ft)	Max Depth (ft)
DE_FACTO_USH83 MAIN CROSSING*	121.0	19.62
DE_FACTO_NE_84TH_RIDGELAND	11.81	5.68
DE_FACTO_N_OF_84TH_W_OF_FENNEL	4.14	5.55
DE_FACTO_N_OF_SNFLWR_W_OF_CRWAY	2.28	4.32
DE_FACTO_NW_84TH_RIDGELAND	1.45	3.4
DE_FACTO_N_OF_SNFLWR_W_OF_SAGE	1.10	3.38
DE_FACTO_E_OF_FENNEL_N_OF_84TH	0.99	3.35
DE_FACTO_SW_84TH_RIDGELAND	0.91	2.8
DE_FACTO_S_OF_RDGLND_LP	0.82	4.11
DE_FACTO_PRIVATE_DR_ON_RGDLND_LP	0.60	3.58
DE_FACTO_NE_SNFLWR_SAGE	0.12	2.46
DETBASIN_NRE_E_PROP_LINE	6.24	4.27
DETBASIN_NRE_INLINE	6.12	6.59
DETBASIN_NRE_W_RIDGELAND_S	5.5	7.03
DETBASIN_NRE_N_PARKSIDE	2.93	4.46
DETBASIN_NRE_W_RIDGELAND_N	2.79	3.81
DETBASIN_NRE_W_NWOOD_CENT	2.09	5.78
DETBASIN_NRE_W_NWOOD_N	1.69	3.77
DETBASIN_NRE_W_NWOOD_S	0.79	4.11

*Storage is modeled as cross sections instead of as a storage node.

A.4 Full Build-Out Conditions – Master Plan (Traditional Detention)

A.4.1 Hydrologic Analysis

The same subwatersheds were utilized in the Master Plan as in the full build-out with no controls scenario, except that the time of concentration was lengthened in Development Subareas A and B to simulate the effect of on-site detention. The time of concentration was adjusted to match the existing peak to the full build-out peak for the 100-year event, which causes the peaks for the smaller events to exceed existing rates. ***Table A.6*** summarizes the subwatersheds with lengthened time of concentration values.

Table A.6: Summary of On-Site Detention Tc Adjustments

Subwatershed ID	Actual Tc (min)	Lengthened Tc (min)
3_4_A	15.8	75
3_4_C	9.5	100
3_4_H	15.4	51
3_4_I	16.5	68
3_4_J	11.6	75
3_4_K	22.3	105
3_4_L	20.0	95
3_4_N	25.4	100
3_4_X	15.2	31
3_4_Y	14.2	100
3_5_J	9.6	35

A.4.2 Hydraulic Analysis

Open Channel Design Methodology

Between road crossings south of ND1804, open channels were designed such that they would be stable in the 6-hour, 25-year event. The following methodology was utilized to conceptually design these drainage-ways.

- Range of Manning's n values were evaluated for the open channels to determine susceptibility to erosion from shear stress (function of depth, therefore, higher n-value is conservative) and velocity (lower n-value is conservative).
- Source for stable channel design (based on shear stress) was based on the methods presented in the NRCS Engineering Field Handbook, Part 650, Chapter 7, which evaluates both soil and vegetation stability.
- Source for stable channel design (based on velocity) was based on information presented by W.O. Ree in "Hydraulic Characteristics of vegetation for vegetated waterways" (1949), and reprinted in Design Hydrology and Sedimentology for Small Subcatchments, Table 4.5 (C.T. Haan, B.J. Barfield, and J.C. Hayes, 1994)

A.5 Full Build-Out Conditions – Alternative Plan (Traditional Detention with Volume Reduction)

A.5.1 Hydrologic Analysis

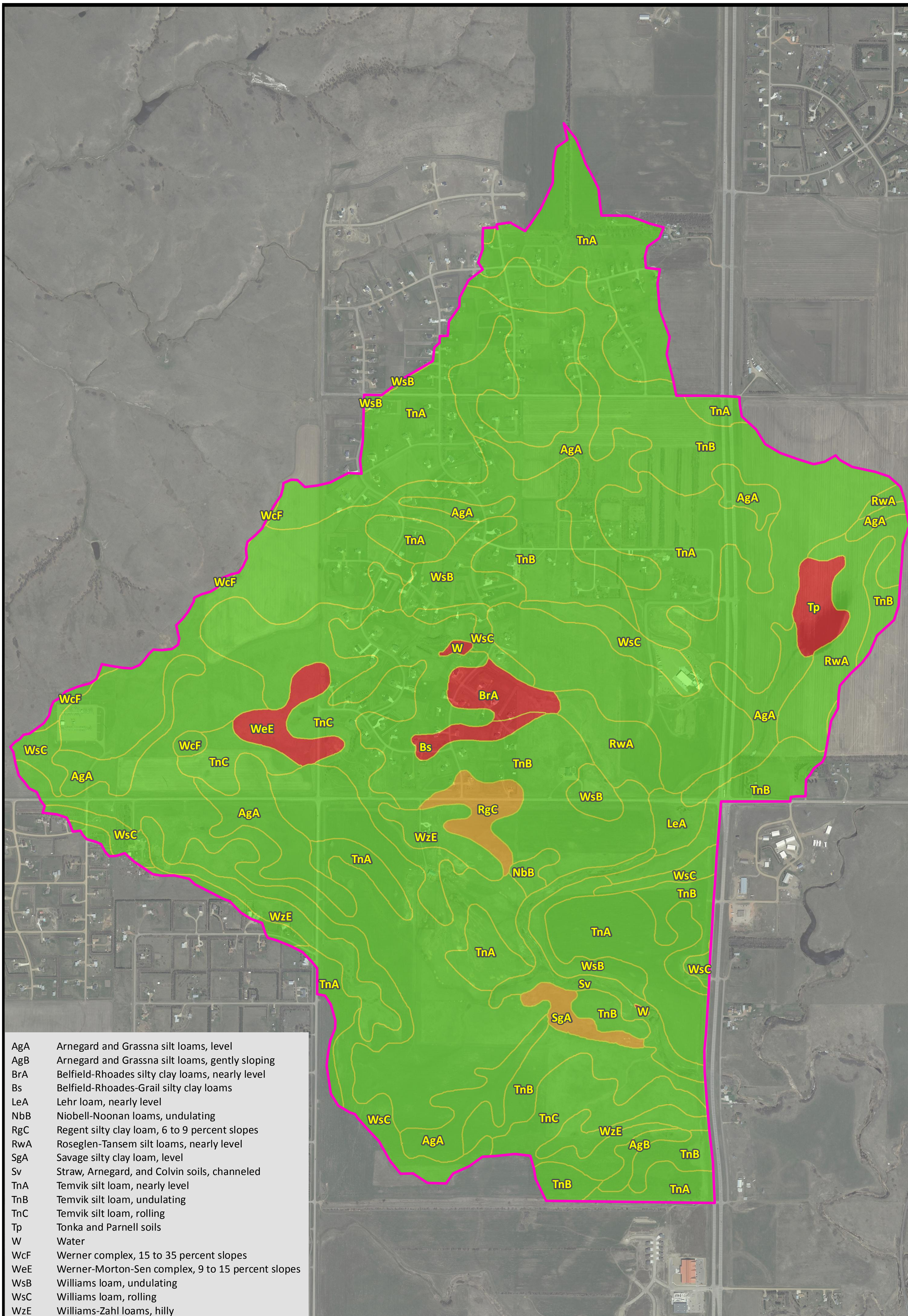
The effect of on-site volume reduction practices were estimated by reducing the amount of impervious area within each land use and converting it to pervious area. ***Table A.7*** summarizes the changes in "effective" impervious area that were made for each land use. Land uses not listed were not adjusted.

Table A.7: Comparison of Actual and Effective Impervious Area for Alternative Plan

Land Use Type	Actual Percent Impervious Area (%)	Effective Percent Impervious Area (%)
Mixed Use	65%	42%
Neighborhood Commercial	65%	42%
Commercial	80%	52%

A.5.2 Hydraulic Analysis

No additional hydraulic assumptions or modeling background were made beyond those described previously in this report.



N

Feet
0 600 1,200
1 in = 1,200 feet

Figure A-1 Soils Map

US 83/ND 1804 Stormwater Master Plan
City of Bismarck, ND

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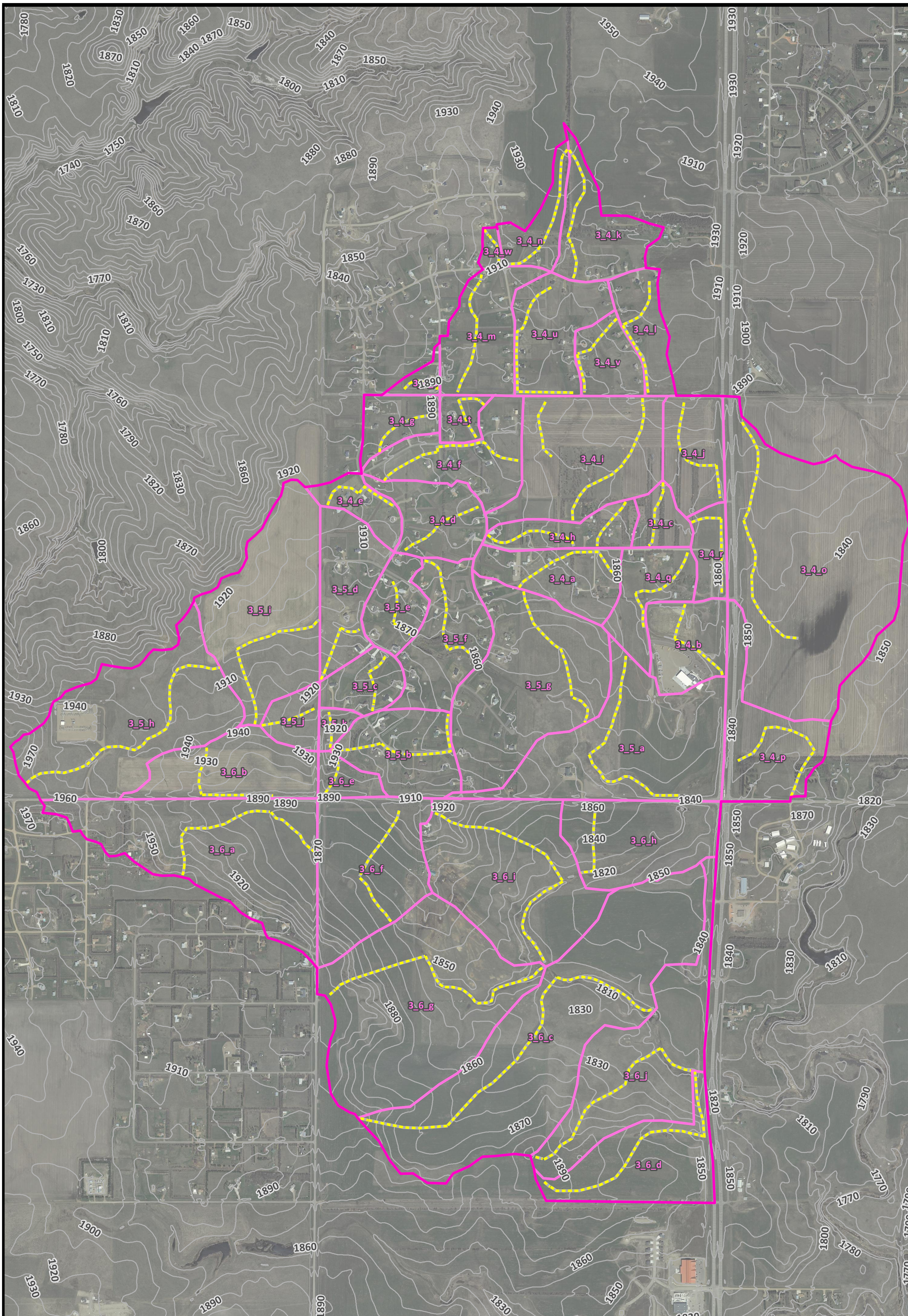
US 83 / ND 1804 Watershed **Burleigh County Soils** **HSG C** **HSG B** **HSG D**

AE2S in association with MARS and JLG

Developed by: Danielle Lee | 03/19/2013
Coordinate System: ND State Plane South
Vertical Datum: NAVD88
Metadata Included in the Report



N

Feet
0 600 1,200
1 in = 1,200 feet

Figure A-2 Existing Subwatersheds

US 83/ND 1804 Stormwater Master Plan
City of Bismarck, ND

AE2S Think Big. Go Beyond.
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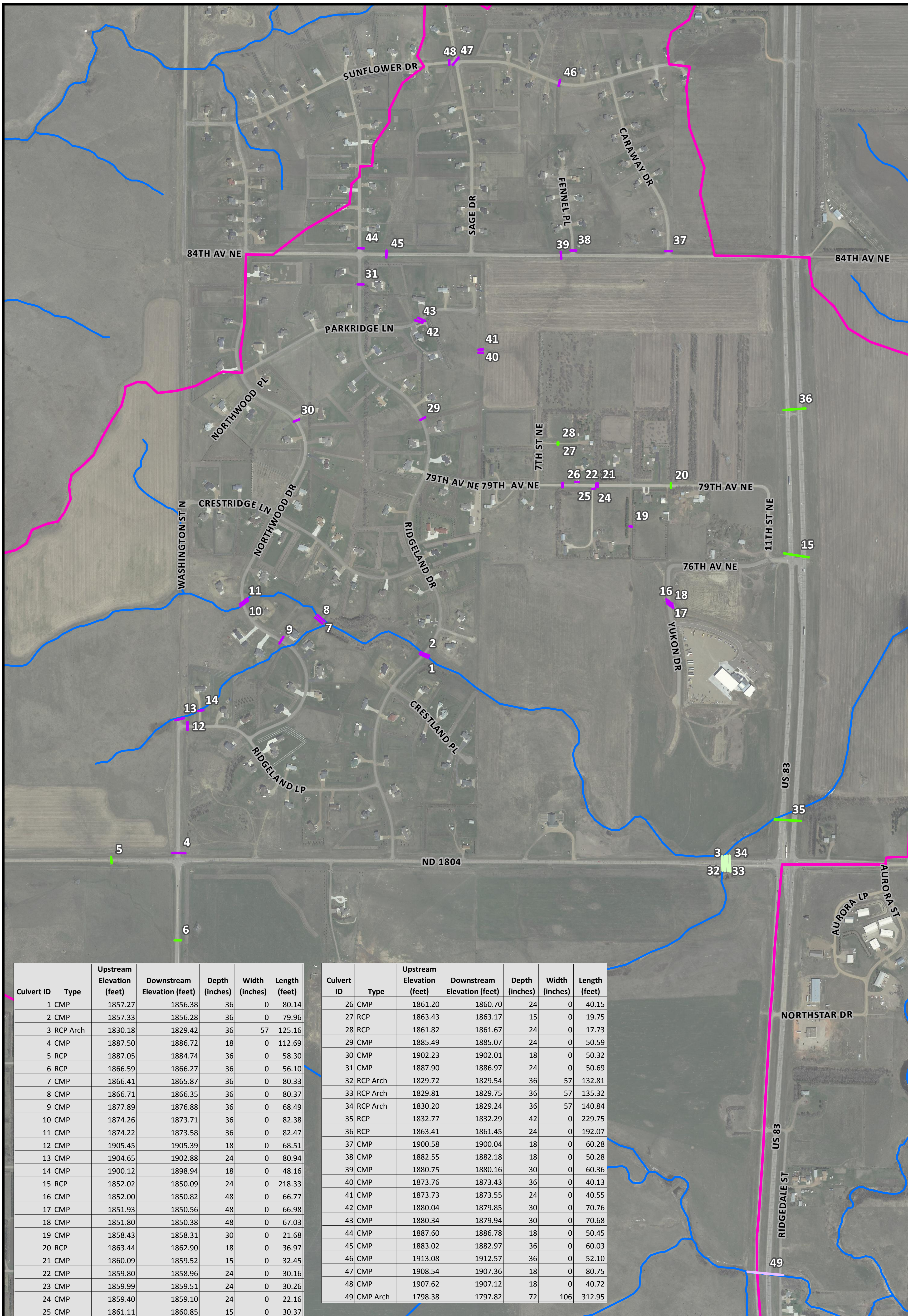
JLG architects

US 83 / ND 1804 Watershed
Existing Subwatersheds
10-Foot Contours
Tc

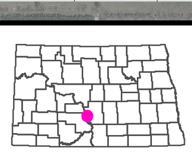
AE2S in association with MARS and JLG

Developed by: Danielle Lee | 03/19/2013
Coordinate System: ND State Plane South
Vertical Datum: NAVD88
Metadata Included in the Report



Culvert ID	Type	Upstream Elevation (feet)	Downstream Elevation (feet)	Depth (inches)	Width (inches)	Length (feet)
1	CMP	1857.27	1856.38	36	0	80.14
2	CMP	1857.33	1856.28	36	0	79.96
3	RCP Arch	1830.18	1829.42	36	57	125.16
4	CMP	1887.50	1886.72	18	0	112.69
5	RCP	1887.05	1884.74	36	0	58.30
6	RCP	1866.59	1866.27	36	0	56.10
7	CMP	1866.41	1865.87	36	0	80.33
8	CMP	1866.71	1866.35	36	0	80.37
9	CMP	1877.89	1876.88	36	0	68.49
10	CMP	1874.26	1873.71	36	0	82.38
11	CMP	1874.22	1873.58	36	0	82.47
12	CMP	1905.45	1905.39	18	0	68.51
13	CMP	1904.65	1902.88	24	0	80.94
14	CMP	1900.12	1898.94	18	0	48.16
15	RCP	1852.02	1850.09	24	0	218.33
16	CMP	1852.00	1850.82	48	0	66.77
17	CMP	1851.93	1850.56	48	0	66.98
18	CMP	1851.80	1850.38	48	0	67.03
19	CMP	1858.43	1858.31	30	0	21.68
20	RCP	1863.44	1862.90	18	0	36.97
21	CMP	1860.09	1859.52	15	0	32.45
22	CMP	1859.80	1858.96	24	0	30.16
23	CMP	1859.99	1859.51	24	0	30.26
24	CMP	1859.40	1859.10	24	0	22.16
25	CMP	1861.11	1860.85	15	0	30.37

Culvert ID	Type	Upstream Elevation (feet)	Downstream Elevation (feet)	Depth (inches)	Width (inches)	Length (feet)
26	CMP	1861.20	1860.70	24	0	40.15
27	RCP	1863.43	1863.17	15	0	19.75
28	RCP	1861.82	1861.67	24	0	17.73
29	CMP	1885.49	1885.07	24	0	50.59
30	CMP	1902.23	1902.01	18	0	50.32
31	CMP	1887.90	1886.97	24	0	50.69
32	RCP Arch	1829.72	1829.54	36	57	132.81
33	RCP Arch	1829.81	1829.75	36	57	135.32
34	RCP Arch	1830.20	1829.24	36	57	140.84
35	RCP	1832.77	1832.29	42	0	229.75
36	RCP	1863.41	1861.45	24	0	192.07
37	CMP	1900.58	1900.04	18	0	60.28
38	CMP	1882.55	1882.18	18	0	50.28
39	CMP	1880.75	1880.16	30	0	60.36
40	CMP	1873.76	1873.43	36	0	40.13
41	CMP	1873.73	1873.55	24	0	40.55
42	CMP	1880.04	1879.85	30	0	70.76
43	CMP	1880.34	1879.94	30	0	70.68
44	CMP	1887.60	1886.78	18	0	50.45
45	CMP	1883.02	1882.97	36	0	60.03
46	CMP	1913.08	1912.57	36	0	52.10
47	CMP	1908.54	1907.36	18	0	80.75
48	CMP	1907.62	1907.12	18	0	40.72
49	CMP Arch	1798.38	1797.82	72	106	312.95



N

Feet
0 400 800
1 in = 800 feet

Figure A-3 Culvert Survey Data

US 83/ND 1804 Stormwater Master Plan
City of Bismarck, ND

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US 83 / ND 1804 Watershed | **Culvert Type** | **RCP** | **CMP** | **RCP Arch** | **CMP Arch**
Hydrography

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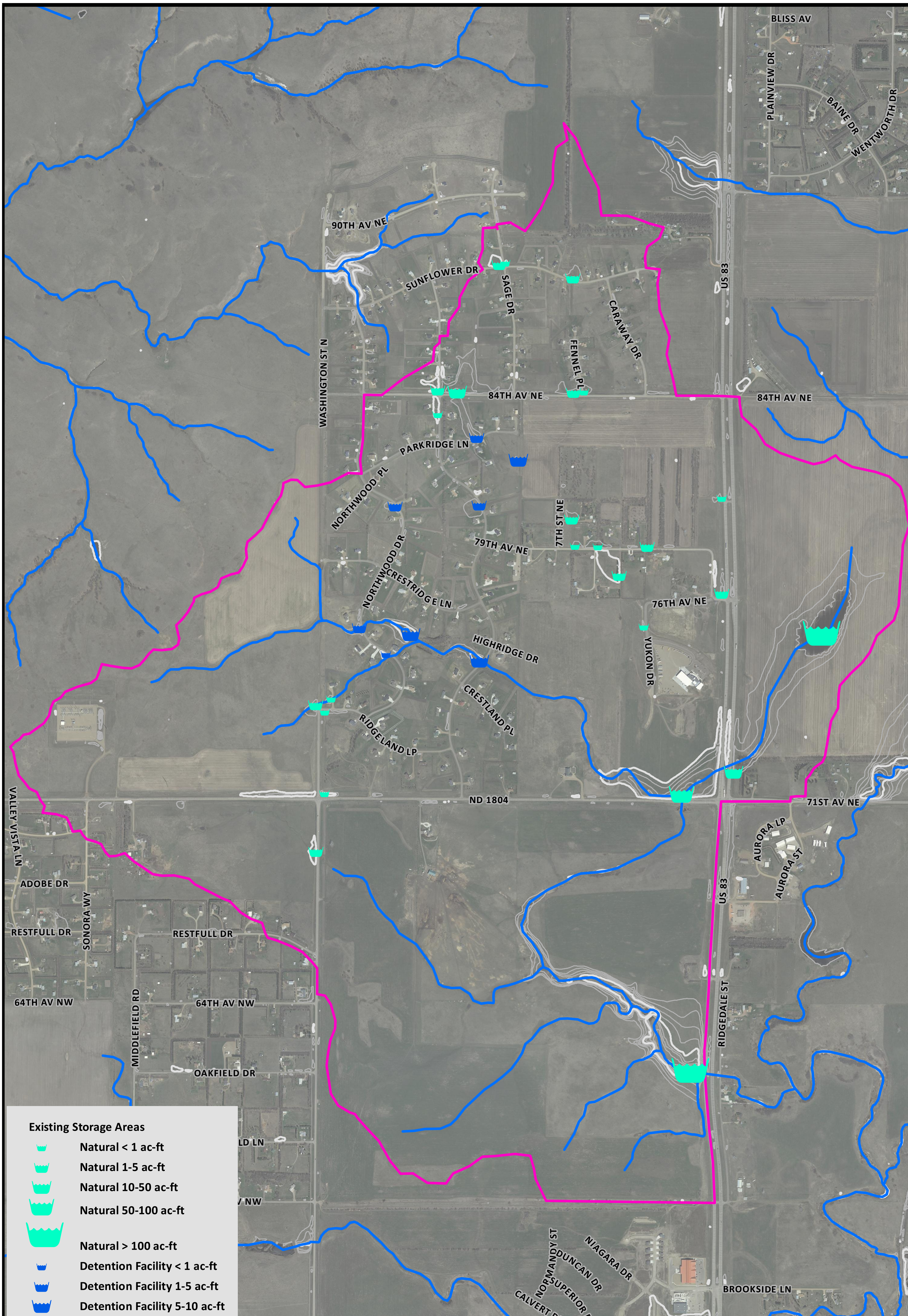
Developed by: Danielle Lee | 03/19/2013
Coordinate System: ND State Plane South
Vertical Datum: NAVD88
Metadata Included in the Report



N

0 600 1,200 Feet

1 in = 1,200 feet

Figure A-4 Existing Storage Areas

US 83/ND 1804 Stormwater Master Plan

City of Bismarck, ND

AE2S Think Big. Go Beyond. Montgomery Associates JLG architects

US 83 / ND 1804 Watershed

Hydrography

2-Foot Contours: Depression

10-Foot Contours: Depression

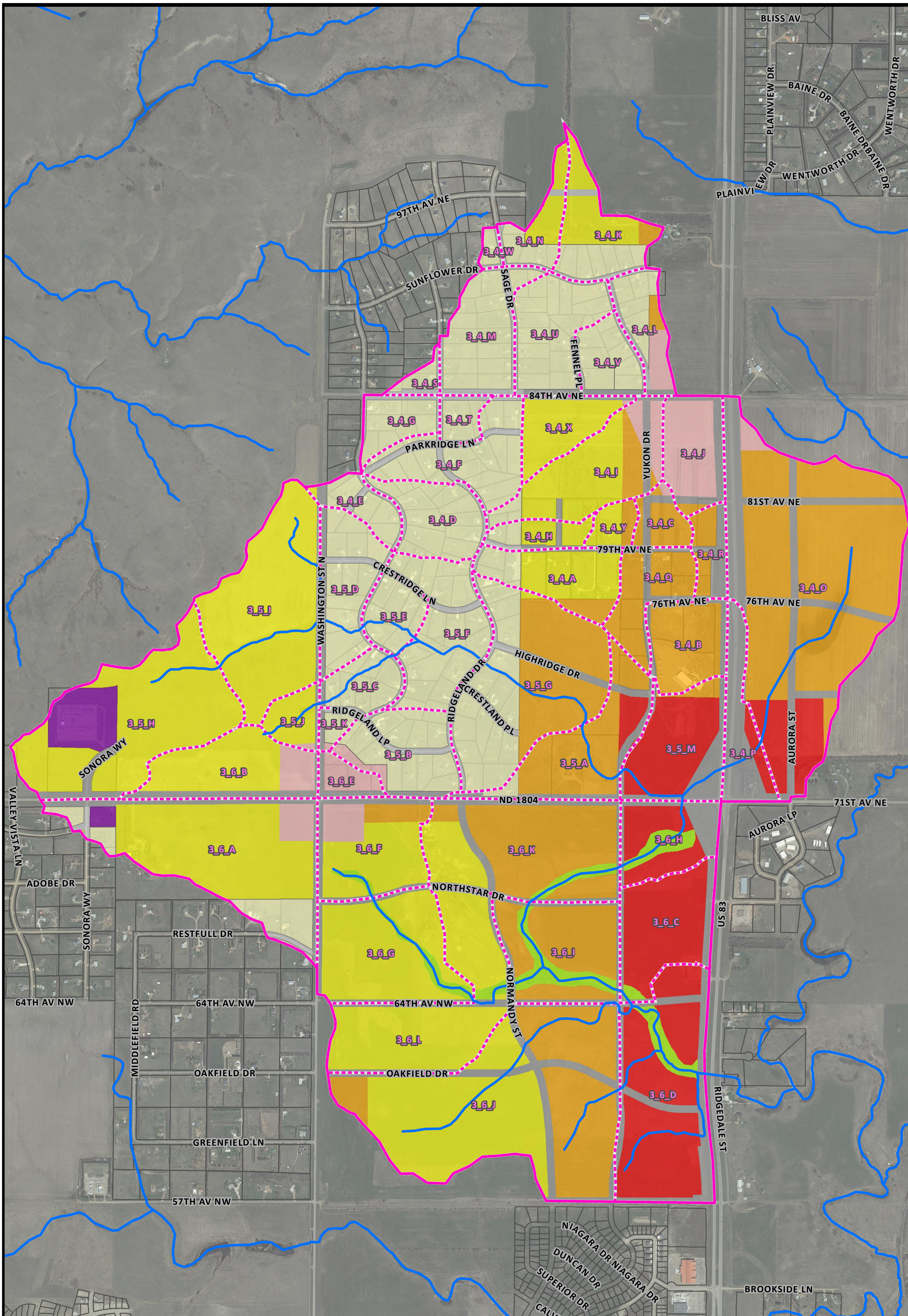
AE2S in association with MARS and JLG

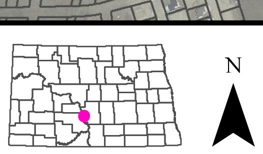
Developed by: Danielle Lee | 03/20/2013

Coordinate System: ND State Plane South

Vertical Datum: NAVD88

Metadata Included in the Report





Feet
0 600 1,200
1 in = 1,200 feet

Figure A-5 Proposed Subwatersheds

US 83/ND 1804 Stormwater Master Plan
City of Bismarck, ND

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US 83 / ND 1804 Watershed	Neighborhood Commercial	Rural ROW
Proposed Subwatersheds	Mixed-Use	Urban Residential
Hydrography	Open Space	Rural Residential
Commercial	Urban ROW	Transportation and Infrastructure

AE2S in association with MARS and JLG
Developed by: Danielle Lee | 03/19/2013
Coordinate System: ND State Plane South
Vertical Datum: NAVD88
Metadata Included in the Report

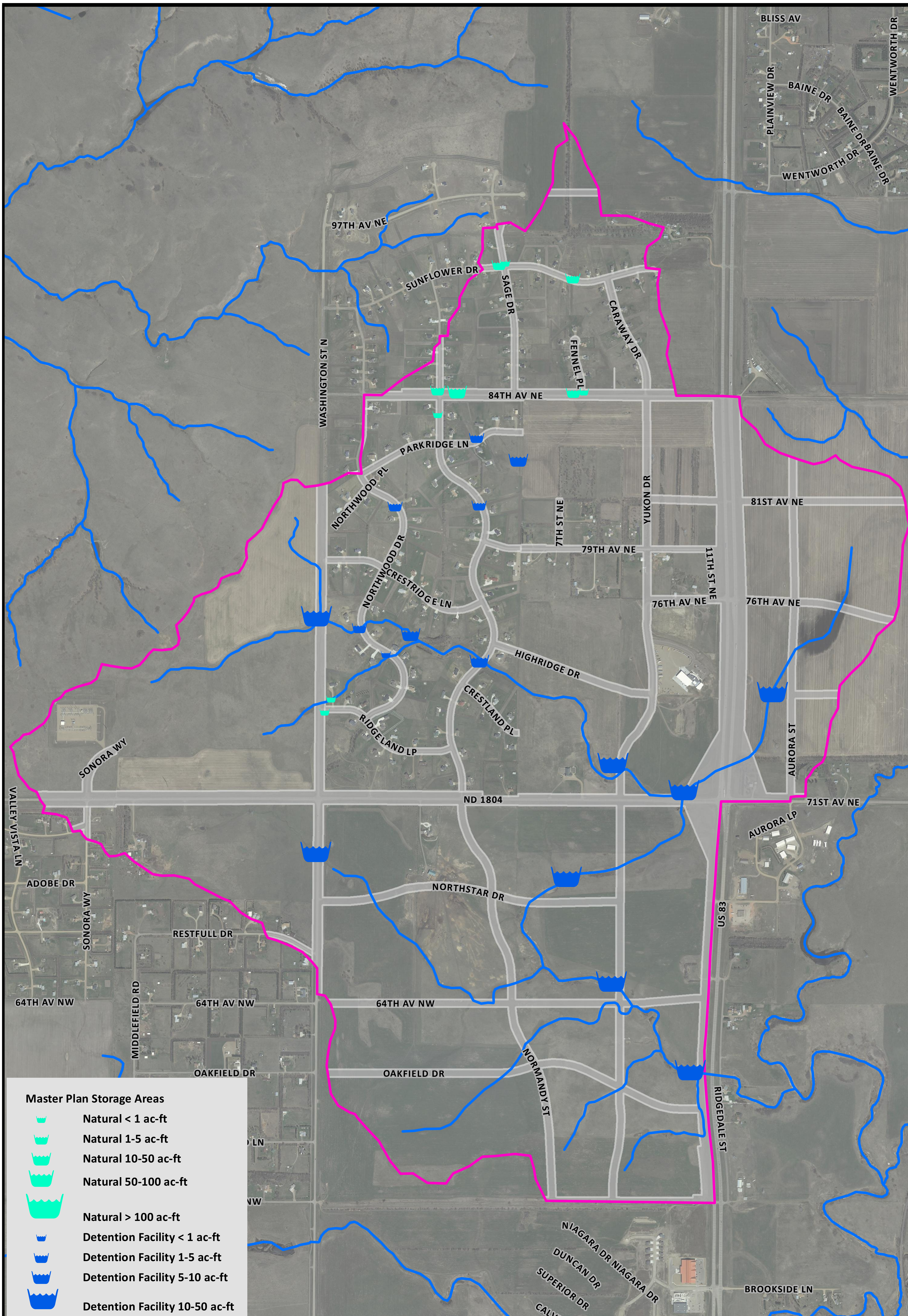

Figure A-6 Master Plan Storage Areas

US 83/ND 1804 Stormwater Master Plan
City of Bismarck, ND

N

0 600 1,200 Feet
1 in = 1,200 feet

US 83 / ND 1804 Watershed
Hydrography
Future Road ROW

AE2S Think Big. Go Beyond. Montgomery Associates JLG architects

AE2S in association with MARS and JLG

Developed by: Danielle Lee | 03/20/2013
Coordinate System: ND State Plane South
Vertical Datum: NAVD88
Metadata Included in the Report

APPENDIX B – ALTERNATIVE MASTER PLAN CONCEPTS

The Alternative Plan includes utilizing regional detention similar to the Master Plan but adds on-site volume reduction practices to partially mitigate for the increase in runoff volumes. Key elements of this concept that differ from the Master Plan include:

- Provide on-site stormwater management practices that reduce runoff volume from 35% of the impervious surfaces such that those portions function similar to the pre-development pervious surface. These practices would be located only on sites with Commercial, Mixed Use, and Neighborhood Commercial land uses. While these land uses only account for approximately one-third of the future land use within the watershed, they include more than 50% of the total impervious surface.
- The volume reduction criteria allow for reducing detention needs by approximately 9 acre-feet through a reduction in the footprint of the Northstar Detention facility (***Figure B.C01***).

The following sections provide additional detail on each of the improvements and the performance of this alternative with respect to the design criteria outlined in ***Section 1***.

B.1 On-Site Volume Reduction Requirements

Meeting the following volume reduction requirements can be achieved in multiple ways, including designing a site to reduce impervious surfaces or utilization of volume reduction practices to harvest, store, or infiltrate excess runoff from impervious surfaces. A Volume Reduction Best Management Practice Toolbox (***Appendix E***) has been developed to provide examples for development. The list of practices is not intended to be all inclusive, rather it is intended to provide a starting point for developers and their design teams.

B.1.1 Commercial

Commercial development must meet the following requirement:

- Provide on-site volume mitigation practices or offset assumed impervious areas with additional green space such that the volume of runoff released from the site is equivalent to the volume of runoff if the site was 52% impervious surface.

For example, a 10-acre commercial site with 80% impervious would have 8 acres of impervious surface. One way to reduce the effective impervious surface of the site to 52% is to treat 35% of the impervious surface (~2.8 acres) with volume reduction best management practices. A common ratio of treated area to volume reduction practice is 5:1, therefore approximately 0.56 acres of land would be needed for volume reduction devices, amounting to approximately 5.6%

of the total property (***Figure B-2***). Many volume reduction practices can be directly integrated into site landscaping and green space, providing a dual purpose.

B.1.2 Mixed Used and Neighborhood Commercial

Mixed Use and Neighborhood Commercial development must meet the following requirement:

- Provide on-site volume mitigation practices or offset assumed impervious areas with additional greenspace such that the volume of runoff released from the site is equivalent to the volume of runoff if the site was 42% impervious surface.

For example, a 10-acre mixed use site with 65% impervious would have 6.5 acres of impervious surface. One way to reduce the effective impervious surface of the site to 42% is to treat 35% of the impervious surface (~2.3 acres) with volume reduction best management practices. A common ratio of treated area to volume reduction practice is 5:1, therefore approximately 0.46 acres of land would be needed for volume reduction services, amounting to approximately 4.6% of the total property (***Figure B-3***). Many volume reduction practices can be directly integrated into site landscaping and green space, providing a dual purpose.

Plotted By: Anna Dahl Date: Wednesday, March 20, 2013
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Layout: NORTHSTAR 2(2)
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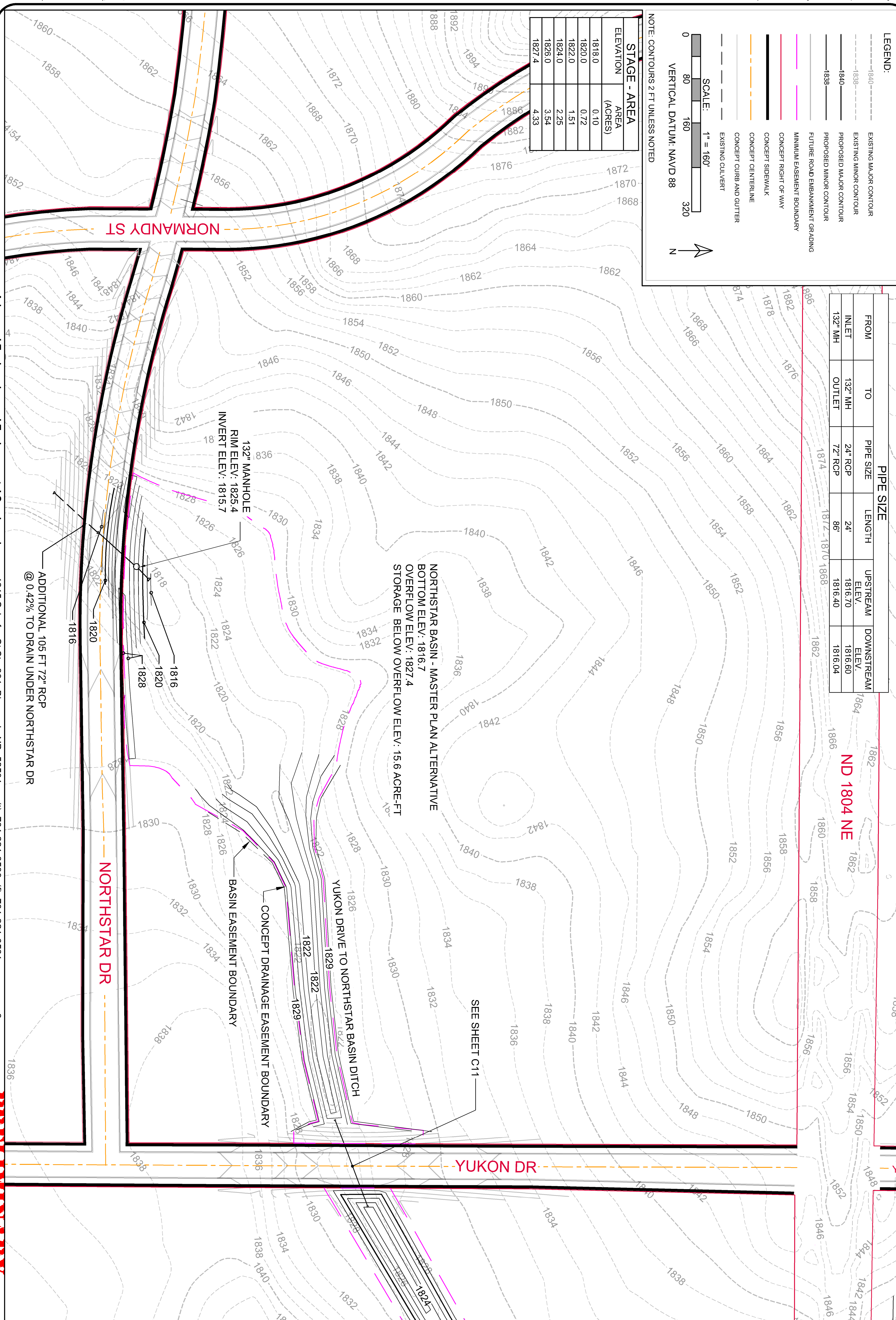


STAGE - AREA

ELEVATION	AREA (ACRES)
1818.0	0.10
1820.0	0.72
1822.0	1.51
1824.0	2.25
1826.0	3.54
1827.4	4.33

PIPE SIZE

FROM	TO	PIPE SIZE	LENGTH	UPSTREAM ELEV.	DOWNSTREAM ELEV.
INLET	132" MH	24" RCP	24'	1816.70	1816.60
132" MH	OUTLET	72" RCP	86'	1816.40	1816.04

PRELIMINARY

Advanced Engineering and Environmental Services, Inc. • 1815 Schafer St Ste 301 Bismarck, ND 58501 • (t) 701-221-0530 (f) 701-221-0531 • www.ae2s.com

US 83 / ND 1804 STORMWATER MASTER PLAN
CITY OF BISMARCK
CITY OF BISMARCK, BURLEIGH COUNTY ND
NORTHSTAR BASIN - ALTERNATE PLAN

AE2S
JLG architects

CITY OF BISMARCK PROJECT: ----
DRAWING TYPE: PRELIMINARY
PREPARED BY: RSS/SGS
CHECKED / APPROVED: JDL/JMH
DATE: 03/18/2013
PROJECT NUMBER: P00501-2012-05
SHEET: 1 of 1
DRAWING: B.C01

Figure B-2: Example Commercial Site with Volume Reduction Properties

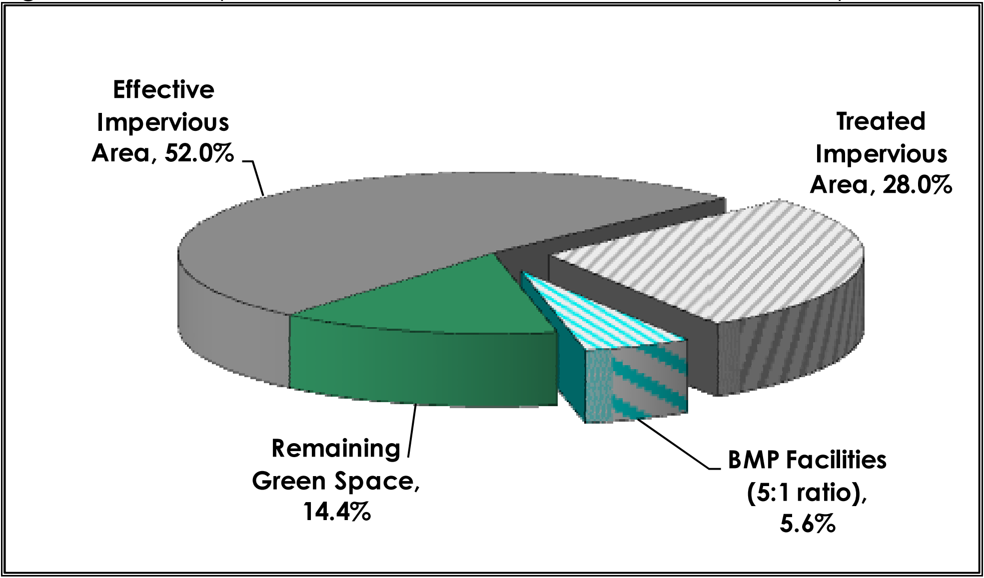
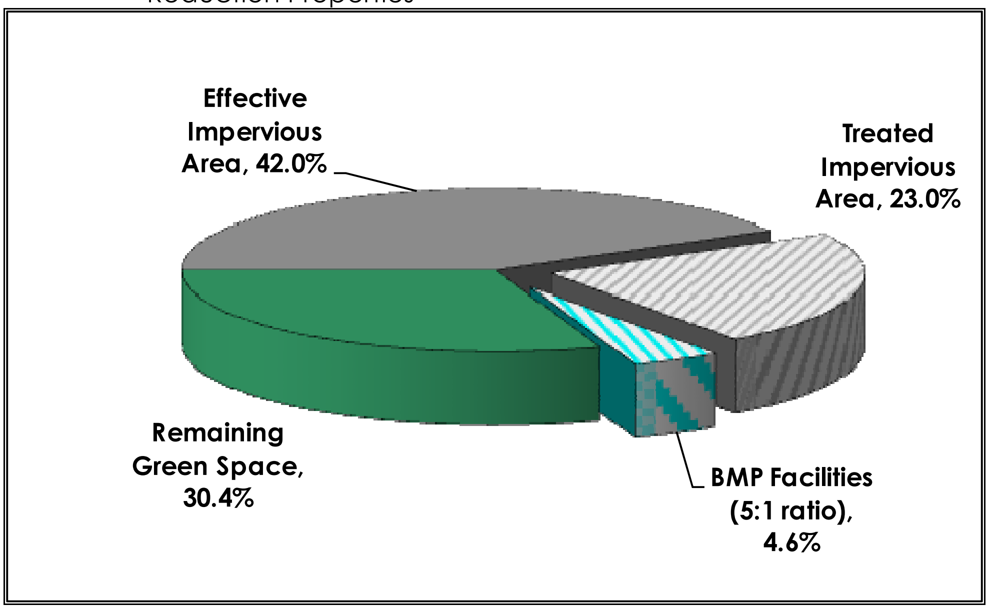


Figure B-3: Example Mixed Use / Neighborhood Commercial Site with Volume Reduction Properties



B.2 Open Channel Conveyance Improvements

Drainage-way improvements would be similar to the Master Plan, except that a ditch would be needed upstream of the Northstar Basin since the basin would not extend to Yukon Drive as it does in the Master Plan. While this Alternative does reduce runoff volume compared to the

Master Plan, stability of the natural channel between US 83 and Hay Creek is still potentially an issue as runoff volumes would still be increased substantially.

B.3 Performance

B.3.1 Peak Flows

This alternative reduces peak flow rates to at or below existing peak flow rates for all recurrence intervals (***Table B.1***). The small margin in the 6-hour 2- and 100-year events will allow for developers to convert open channels to storm sewers and eliminate the on-site detention facilities in Development Subareas A and B if appropriate based on the criteria listed in ***Section 6***.

Table B.1: Summary of Existing and Alternative Plan Peak Flows at Main Compliance Point

Scenario	6-Hour				24-Hour		
	2-yr	10-yr	25-yr	100-yr	2-yr	25-yr	100-yr
Existing	18	139	213	317	29	247	354
Alternative Plan	14	74	125	275	19	162	330
Percent Change	-20%	-47%	-42%	-13%	-32%	-34%	-7%

B.3.2 Runoff Volumes

Table B.2 and ***Figures B-4 and B-5*** summarize the benefits of the on-site volume reduction practices. As expected, the volume reduction expressed as a percentage is higher for small events, and while the flow volumes are lower than the Master Plan, flow volumes would still be significantly increased compared to existing conditions.

Table B.2: Summary of Existing, Master Plan and Alternative Plan Runoff Volumes (ac-ft) at Main Compliance Point

Scenario	6-Hour			
	2-yr	10-yr	25-yr	100-yr
Existing	9.2	54.7	90.9	160.1
Master Plan	90.4	168. 8	218.9	306.2
Alternative Plan	72.8	141.8	187. 7	269.2
Percent reduction Compared to Master Plan	-20%	-16%	-14%	-12%

An additional benefit of the Alternative Plan is that it reduces the drawdown time for the large regional detention basins by approximately 24 hours since the facilities have less water to control to the existing peak rates.

Figure B-4: 2-year Hydrographs for Existing Conditions, Master Plan, and Alternative Plan at US 83 (South)

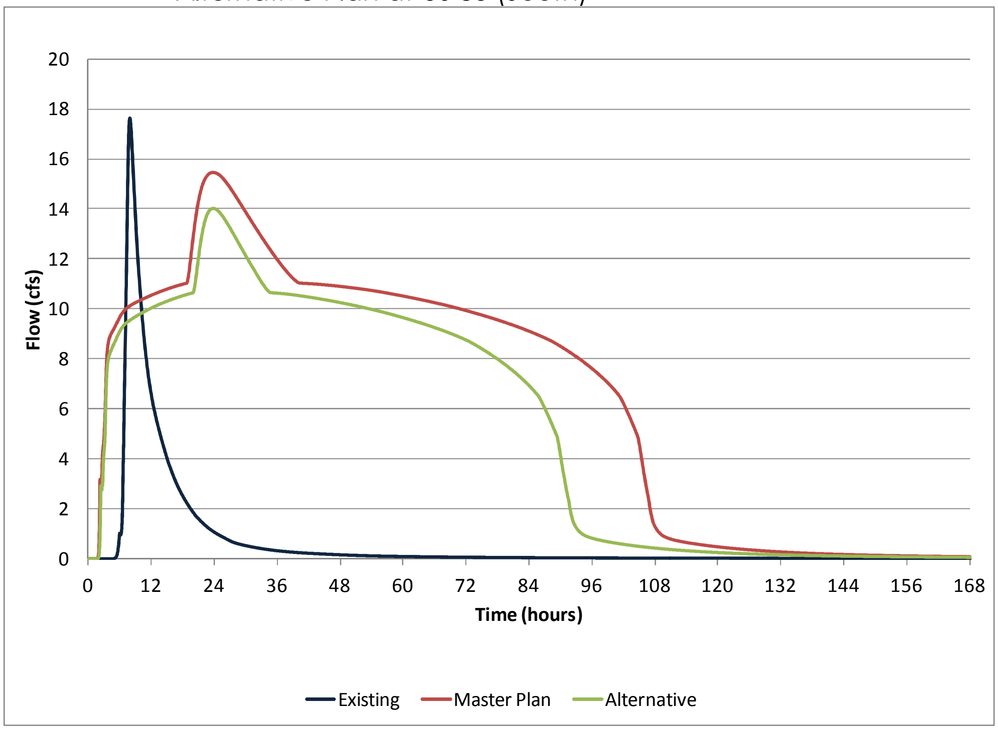
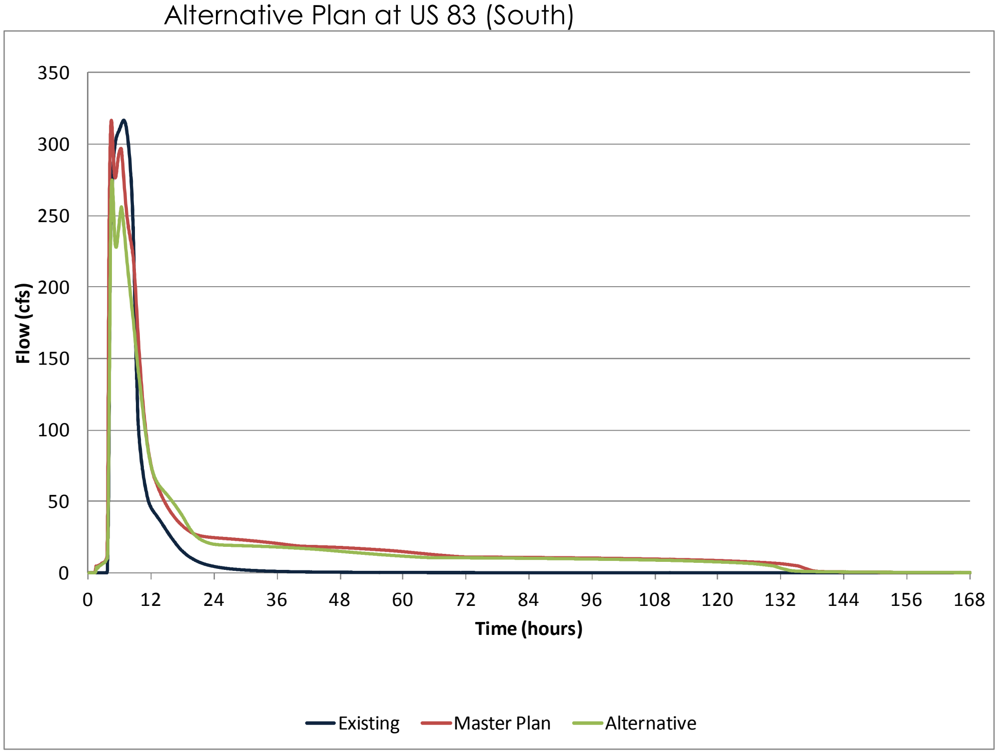


Figure B-5: 100-year Hydrographs for Existing Conditions, Master Plan, and Alternative Plan at US 83 (South)



B.3.3 Channel Stability Downstream of US 83

Since this alternative reduces runoff volumes compared to the Master Plan, the shear stress duration downstream of US 83 will also be reduced; however, the shear stress duration is still substantially longer than existing conditions (***Figures B-6 & B-7***). Therefore, these shear stresses could be similarly problematic as they are for the Master Plan depending on the grain size of the bed material in the channel and the severity of the meanders.

B.3.4 Water Quality Performance

Table B.3 compares the water quality performance of the Master Plan and this alternative, which indicates that the performance of this alternative is slightly better than the Master Plan. While volume reduction practices provide excellent water quality treatment, these results suggest that most of the suspended sediment that the volume reduction practices remove would be otherwise removed in the regional detention facilities.

Although these results do account for on-site volume control practices, these results do not account for any water quality treatment that could be provided via on-site detention facilities within Development Subareas A or B.

Table B.3: Comparison of Master Plan and Alternative Plan Water Quality Performance

Scenario	TSS Trapped Compared to No Controls (Percent)
Master Plan	74
Alternative Plan	79

B.4 Permitting Considerations

USACE, NDDOT, and ND State Water Commission permitting considerations would be similar to the Master Plan, except that adding in volume reduction practices could aid in the application to the USACE since these practices could demonstrate that the City is pursuing innovative stormwater management to limit wetland and waterway impacts.

Figure B-6: Shear Stress Comparison, 2-year Event

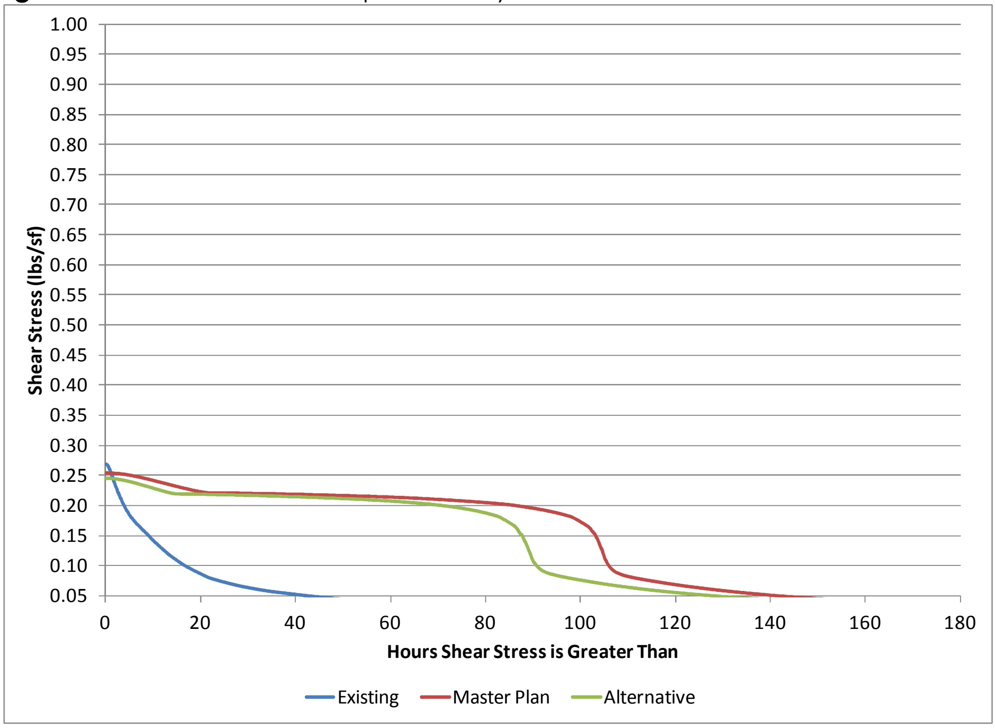
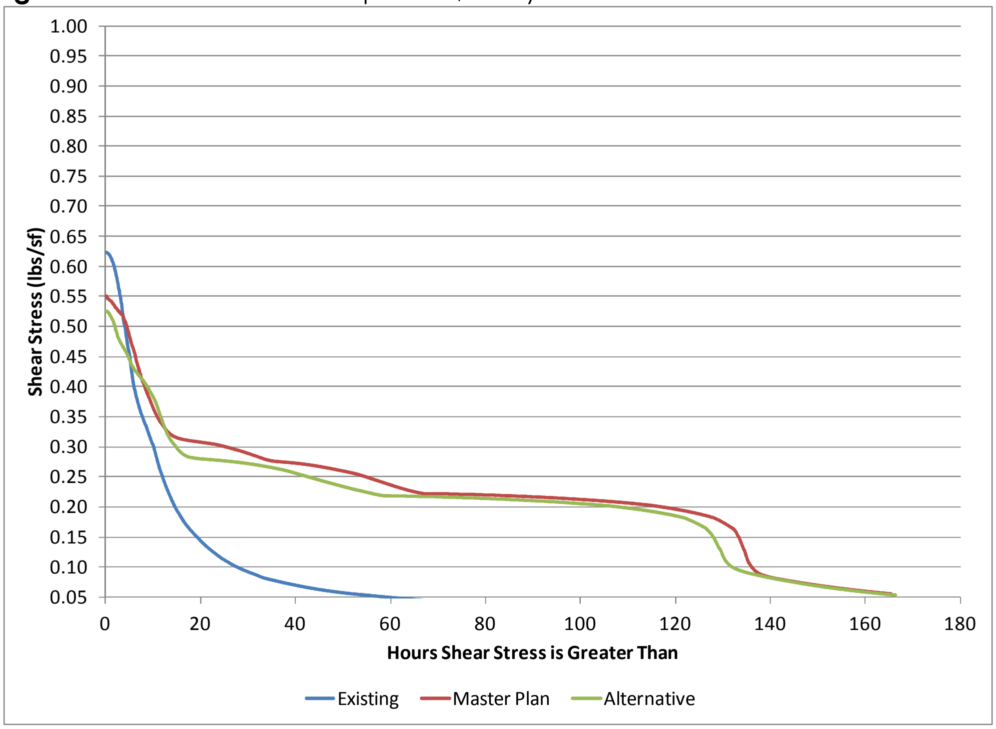


Figure B-7: Shear Stress Comparison, 100-year Event



B.5 Opinion of Probable Costs and Funding Summary

Opinions of probable costs were developed for each of the regional facilities incorporated into the Master Plan (***Exhibits***). The improvements for the Alternative Plan are substantially similar to the Master Plan except for the reduced size of the Northstar Basin. The opinion of probable cost for the Alternative Plan Northstar Basin is included at the end of this Appendix. Unit rates were developed based on review of local bids, NDDOT bid data, and material costs obtained directly from suppliers. The regional costs associated with this alternative are approximately $386,055 less than the Master Plan, primarily due to requiring less land for the Northstar Basin (***Table B.4***). This cost saving is a direct function of the assumption for the square foot cost of property. The estimate assumes a $4 per square foot cost for property acquisition.

Table B.4: Summary of Opinion of Probable Costs

Regional Facility	Master Plan			Alternative Plan		
	Design and Construction Cost[1]	Land Acquisition Cost	Total	Design and Construction Cost[1]	Land Acquisition Cost	Total
Southern US 83 Basin	$335,385	$1,515,900	$1,851,285	$335,385	$1,515,900	$1,851,285
Southern Yukon Basin	$246,065	$1,568,200	$1,814,265	$246,065	$1,568,200	$1,814,265
Northstar Basin	$300,585	$1,289,400	$1,589,985	$297,830	$906,100	$1,203,930
Northern Yukon Basin	$293,190	$1,620,500	$1,913,690	$293,190	$1,620,500	$1,913,690
1804 Basin	$609,290	$453,100	$1,062,390	$609,290	$453,100	$1,062,390
Northern US 83 Basin	$936,555	$2,195,500	$3,132,055	$936,555	$2,195,500	$3,132,055
Southern Washington Basin	$911,905	$575,000	$1,486,905	$911,905	$575,000	$1,486,905
Northern Washington Basin	$152,685	$819,000	$971,685	$152,685	$819,000	$971,685
Southern Washington Swale	$148,335	$209,100	$357,435	$148,335	$209,100	$357,435
Total	$3,933,995	$10,245,700	$14,179,695	$3,931,240	$9,862,400	$13,793,640

1 – Includes a 15% estimating contingency and 30% for Engineering and Administration

While this alternative does include an overall cost savings for regional facilities, it will require additional costs on the part of private developers for commercial, mixed use, and neighborhood commercial properties. Raw costs for implementation of the volume reduction requirements included in this alternative may range from $7,000/acre to $39,000/acre for commercial development and $5,800/acre to $32,000/acre for mixed use and neighborhood commercial development. Estimates of typical costs for various volume reduction practices are included in

Appendix E. Note that these costs are not an increase over typical development costs, rather these are represented as costs in comparison to no infrastructure. In reality, the actual increased costs are difficult to estimate since volume reduction facilities will typically be constructed in-place of other facilities and improvements and are completely dependent on the overall layout of the site. For example, typical development costs like installation of inlets, storm sewer, and detailed site landscaping may be replaced by curb cuts, raingardens, and infiltration swales.

Recognizing that incorporating this alternative may require additional costs to private developers of commercial, mixed-use, and neighborhood commercial properties, an alternative assessment process was developed for consideration and is described below.

B.5.1 Alternate Methodology

The Alternative Plan previously described utilizes traditional regional detention in conjunction with on-site volume reduction practices for commercial, mixed use, and neighborhood commercial land uses. Given the cost savings realized in downstream regional facilities associated with on-site volume reduction, an alternate method was developed for calculating the cost per assessable acre for each land use type in order to allocate the benefits of volume reduction to the land uses that are required to install on-site controls.

It is estimated that the on-site volume reduction practices will reduce the equivalent impervious surface area contributing runoff to the regional facilities for these land uses by approximately 35 percent. Since it is generally recognized that impervious surface area of a property is the single most significant factor influencing the impacts to (and sizing for) stormwater facilities, a 35 percent reduction to the Non-Residential Factor of "2" is represented in this revised methodology to account for this reduction in runoff contribution to downstream facilities. Therefore, a revised factor of 1.3 is proposed to be applied to the Non-Residential land-uses when on-site volume reduction controls are installed. For the revised methodology, the revised cost per acre calculation for the Residential and Non-Residential land uses would be based off of the factors of 1 and 1.3, respectively, versus 1 and 2 under the existing methodology. ***Table B.5*** presents the calculation of the cost per assessable acre when the alternate methodology for allocating the improvement cost with on-site controls installed is applied to the Alternative Plan total project cost of $13,793,640.

Table B.5: Alternative Assessment Utilizing Alternate Methodology

Land Use	Assessable Acres	Factor	Equivalent Residential Acres	% Total Equivalent Residential Acres	Alternative 2 Total Cost	Cost per Assessable Acre
Residential	832.17	1	832.17	53%	$7,246,927	$8,708
Non-Residential	578.28	1.3	751.76	47%	$6,546,713	$11,321
Total	**1,410.45**		**1,583.93**	**100%**	**$13,793,640**	

When comparing the Master Plan cost per assessable acre as calculated with the existing methodology in ***Table 8.3*** to the Alternative Plan cost per assessable acre as calculated with the alternate methodology in ***Table B.5***, it should be noted that although the total project cost goes down, the cost per residential acre goes up under the alternate methodology. This dynamic is associated with two factors: (1) the denominator (total Equivalent Residential Acres) used in calculating the percent of cost allocated to each land-use (% of total Equivalent Residential Acres) shrinks from the reduction in the non-residential factor while the numerator (Residential Equivalent Acres) stays the same and (2) there is not enough overall cost savings demonstrated in the regional facility from on-site volume reduction to allow both categories to realize an overall savings.

B.6 Other Volume Reduction Concepts Considered

B.6.1 Traditional Detention and On-Site Volume Reduction for All Land Uses

Similar to the alternative presented above, this alternative provides a combination of traditional detention and on-site volume reduction. However, this alternative requires volume reduction for all land uses within the watershed (exempting existing development) such that the performance is similar to that noted above. Spreading out the volume reduction criteria across all the land uses lowers the impervious area that would be treated to 20 percent. With the ratio of the treated impervious area to the volume reduction facilities at 5:1, approximately 3 percent of the site would be needed for on-site stormwater for a Commercial land use compared to the almost 6 percent noted above. Mixed Use and Neighborhood Commercial land uses would also require approximately 3 percent of the site compared to the 4.6 percent noted above. To offset these reductions, urban residential would require 1 percent of the site and collector streets would require approximately 3 percent of the right-of-way for volume reduction facilities.

In this alternative, the Northstar Basin was reduced to the same footprint as noted above.

Table B.7 on the following page summarizes the results, which indicate that this approach would provide a similar runoff volume reduction as the alternative described above.

This alternative was eliminated from further consideration based on direction from the City, primarily due to implementation concerns and maintenance issues associated with stormwater management practices within urban residential areas and street right-of-ways.

B.6.2 Traditional Detention and Higher On-Site Volume Reduction for All Land Uses

Similar to the previous concept, this alternative provides a combination of traditional detention and on-site volume reduction for all land uses, but increases the amount of volume reduction required. The amount of impervious area treated with volume reduction practices is 50 percent in this scenario, which would allow the elimination of one full regional detention facility (such as the Northstar Basin) and still meet the City's peak rate control criteria.

The Commercial land uses would need 8 percent of the site dedicated to volume reduction practices. Mixed Use, Neighborhood Commercial, and collector street right-of-ways would require 7 percent of the site, and urban residential would require approximately 3 percent of the site.

Table B.6 below summarizes the runoff volume performance of this alternative, which indicates that additional runoff volume controls would have a noticeable effect; however, because 50 percent of the new impervious area would still be "directly connected", runoff volumes in small, frequent events would still be increased approximately by a factor of five.

Table B.6: Comparison of Runoff Volumes (ac-ft) at Main Compliance Point for Other Scenarios Considered

Scenario	6-Hour			
	2-yr	10-yr	25-yr	100-yr
Existing	9.2	54.7	90.9	160.1
Master Plan	90.4	168. 8	218.9	306.2
Alternative Plan	72.8	141.8	187. 7	269.2
20% impervious treated on all land uses	72. 6	142.7	189.2	271.7
50% impervious treated on all land uses	47.0	104.0	144.3	218.5

This alternative was eliminated from consideration due to the same reasons as the previous concept as well as the potential site constraints that this level of treatment would place, particularly on the more dense land uses.

CITY OF BISMARCK, ND
US83/ND1804 Watershed Stormwater Master Plan
Northstar Basin - Alternative Plan
16-Jan-13

Engineers Opinion of Probable Costs					
ITEM	**ITEM DESCRIPTION**	**QTY**	**UNIT**	**UNIT COST**	**TOTAL COST**
1	Bonding	1	LS	$6,000	$6,000
2	Mobilization	1	LS	$39,900	$39,900
3	Erosion Control	1	LS	$7,600	$7,600
4	Embankment Fill	4,040	CY	$8	$32,320
5	24-inch RCP Low-Flow Outlet Pipe	24	LF	$80	$1,920
6	24-Inch RCP Flared End Section (6')	1	EA	$800	$800
7	72-inch RCP Outlet Pipe	86	LF	$500	$43,000
8	72-Inch RCP Flared End Section (8')	1	EA	$600	$600
9	132-inch Manhole (10' height) with Pre-Cast Base and Custom Bar Grate	1	LS	$36,800	$36,800
10	Type H Riprap	200	TON	$65	$13,000
11	Strip, Stockpile, and Replace Topsoil	570	CY	$8	$4,560
12	Seeding - Class I	3,420	SY	$1	$3,420
13	Erosion Control Mat	3,420	SY	$5	$15,390
				Subtotal Construction Costs	**$205,310**
				15% Contingencies	**$30,797**
				Legal, Administration & Engineering (30%)	**$61,593**
				TOTAL PROJECT COSTS	**$297,700**
14	Property Acquisition	5.2	Acre	$174,240	$906,048
				TOTAL FACILITY COSTS	**$1,203,748**

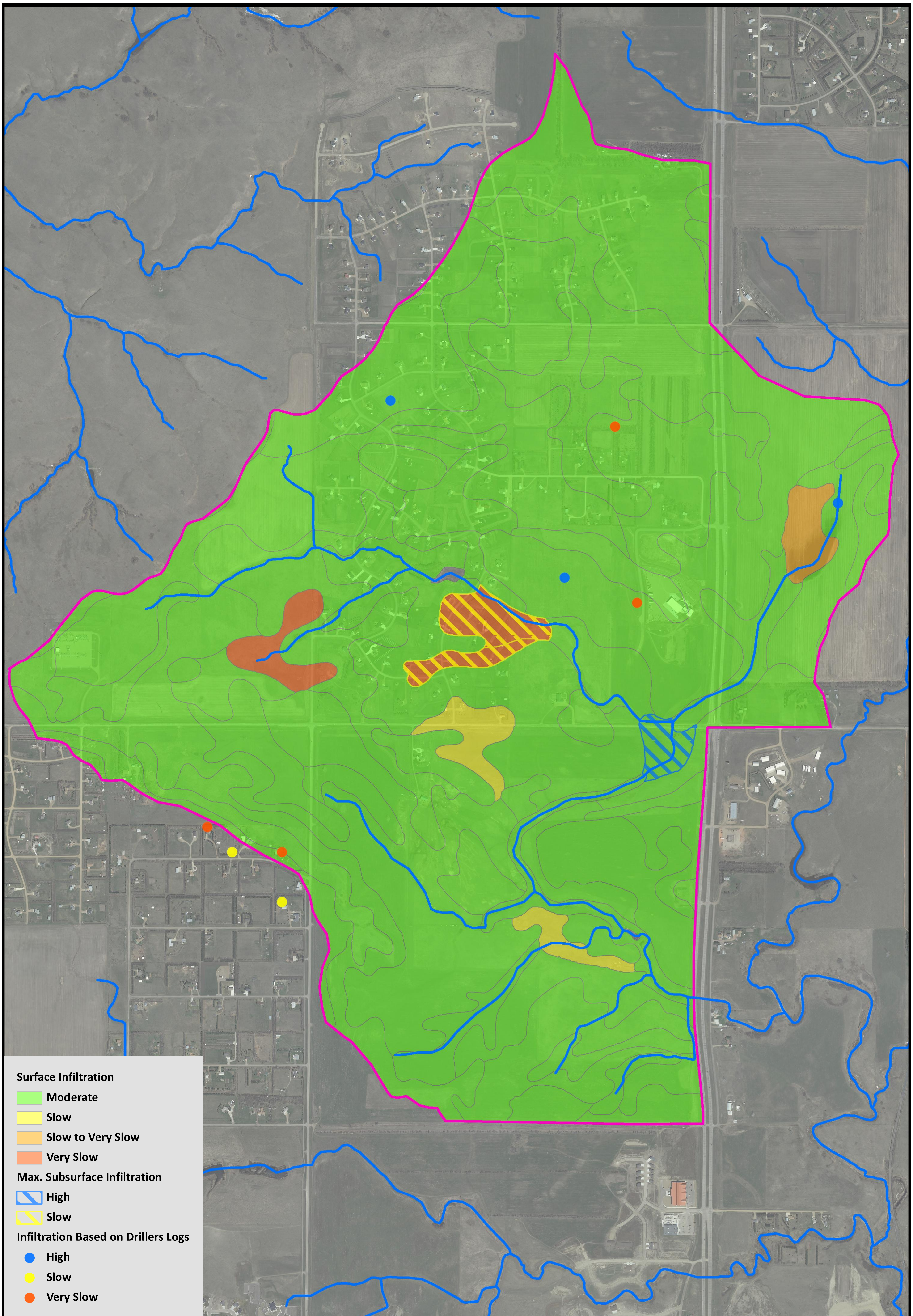
APPENDIX C - INFILTRATION SCREENING ANALYSIS

Prior to developing volume reduction concepts, a desktop analysis was conducted to determine the overall feasibility of utilizing infiltration practices. Infiltration capacity was estimated using data for both soil materials at the surface and for underlying materials up to 60-inches below the surface. Surface infiltration properties were evaluated using the NRCS Burleigh County soils database as differentiated in ***Table C.1***. For the subsurface materials, the coarsest attainable soil type within the upper 60-inches, as presented in the county soils database, was used for a general assessment, and at the points where drill logs were available from the North Dakota State Water Commission the highest textural classification within that depth was used based on the breakdown in ***Table C.1***. The intent of the subsurface identification is to determine any areas where a high-conductivity layer may be located close enough to the surface to be intersected by an infiltration practice; further evaluation would be necessary to determine whether such a layer actually does exist on a particular site.

Table C.1: Assumed Infiltration Capacity Based on Available Data

Material Gradation (Surface or Subsurface)	Hydrologic Soil Group	Assumed Infiltration Capacity
Gravel or Sand	A	High
Loamy Sand, Sandy Loam	B	Moderate
Loam, Silt Loam, Sandy Clay Loam, Clay Loam, Silty Clay Loam	C	Slow
Clay	D	Very Slow

The analysis indicates that a large portion of the watershed has moderate surface infiltration potential, sufficient for utilizing infiltration features (***Figure C-1***). Note that site specific infiltration potential will vary and site specific data should be collected when designing infiltration features.



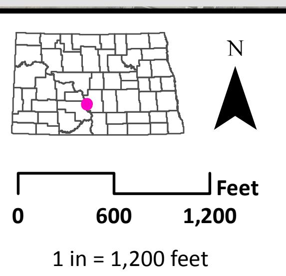


Figure C-1 Infiltration Map

US 83/ND 1804 Stormwater Master Plan
City of Bismarck, ND

Think Big. Go Beyond.
Montgomery Associates

US 83 / ND 1804 Watershed
Hydrography

AE2S in association with MARS and JLG

Developed by: Danielle Lee | 03/19/2013
Coordinate System: ND State Plane South
Vertical Datum: NAVD88
Metadata Included in the Report

APPENDIX D – WATER QUALITY ANALYSIS

D.1 Methodology

Although InfoSWMM also may be configured to model water quality benefits, a second model, P8, was selected and used to evaluate these benefits because of its specific capabilities in regard to representing Total Suspended Solids (TSS). P8 was developed in 1990 as a model which simulates the generation and transport of pollutants in stormwater runoff through user-defined watershed and treatment devices. Watersheds are defined by total area, impervious fraction, impervious depression storage, impervious runoff coefficient, street sweeping frequency, and SCS runoff curve number for pervious portions. Treatment devices are defined with stage-area relationships as well as up to three outlet structures: infiltration, normal outlet, and spillway. The model runs continuously with hourly precipitation and daily average temperature data. The National Urban Runoff Program (NURP) 50th percentile particle file was used for pollution generation. Treatment is calculated using particle settling velocity and specified basin geometry. Continual mass balance calculations are tracked between devices.

D.2 Input Data

D.2.1 Precipitation

A continuous hourly precipitation file was developed with rainfall downloaded from the Bismarck Municipal Airport in North Dakota; NOAA Station 320819 for the calendar years of 2000-2011. Since P8 uses a simplistic methodology to model snowmelt, only portions of the years with no snow pack were modeled. After a screening of the data, it was determined that for the calendar years of 2000-2011, May 1st through October 15th consistently lacked snowpack. One continuous rainfall file was developed by stringing the 12 years of "summer" rainfall data together.

In order to determine if May 1st through October 15th for the years 2000-2011 are representative "summer" years for the City of Bismarck, longterm rainfall data was plotted to determine the average annual rainfall from May 1st through October 15th. The summer months for the years of 2000-2011 appear to represent a fairly typical range of precipitation conditions for Bismarck with both wet and dry years, although slightly wetter than average as a whole (***Figure D-1 & Table D.1***).

Figure D-1: Bismarck Precipitation May-October (1900-2010)

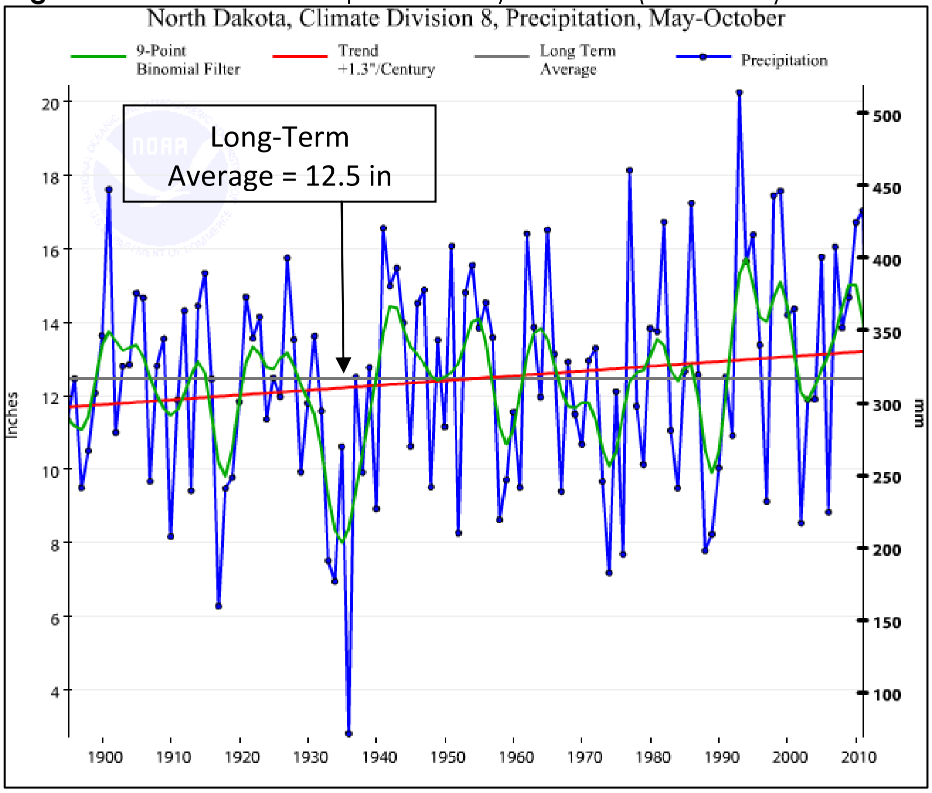


Table D.1: Bismarck Precipitation May-October (2000-2011)

Year	Total (in)	
2000	14.2	Moderately Wet
2001	14.4	Moderately Wet
2002	8.5	Dry
2003	11.9	Average
2004	11.9	Average
2005	15.8	Moderately Wet
2006	8.8	Dry
2007	16.1	Wet
2008	13.8	Average
2009	14.7	Moderately Wet
2010	16.7	Wet
2011	17.0	Wet

D.2.2 Temperature

A continuous daily temperature file was developed with temperature downloaded from the Bismarck 6.1 SSE, North Dakota; NOAA Station GHCND:US1NDBH0011 for the calendar years of 2000-2011.

D.2.3 Modeled Conditions

Water quality performance was evaluated in terms of trapping efficiency of TSS for the Master Plan and the Alternative Plan. The first alternative that was modeled was the Master Plan as described in ***Section 6***. Sixteen watersheds were modeled using a composite CN and a percent impervious fraction (***Table D.2***). Sixteen detention basins were modeled, eight of which are existing and 8 of which are proposed. After adding the 8 proposed detention basins, an initial TSS trapping of 82% was estimated. However, based on basin geometry it was estimated that between 4 and 22 percent of the trapped sediment in any particular basin is subject to re-suspension and so is eventually transported through the system. Taking a system-wide average of 10 percent re-suspension, long-term trapping in this system was estimated to be 74% (***Table D.4***).

TableD.2: Master Plan P8 Watershed Information

Watershed	Total Area (Acres)	Impervious Fraction	Pervious CN
New USH83	118.2	0.73	61
New Ottowa 1	357.8	0.43	61
New Wash S	139.7	0.38	62
New Wash N	176.4	0.36	62
New USH 83N	176.1	0.67	63
New 1804 Ottowa	379.5	0.47	61
New Ottowa 3	129.7	0.49	66
N Parkside	80.9	0.19	61
E Prop Line	35.8	0.16	61
W Ridgeland N	26.6	0.14	61
W NWood N	13	0.20	61
W NWood Cent	32.3	0.20	62
Inline	15	0.15	61
W Ridgeland S	75.5	0.18	63
W NWood S	20.7	0.19	62
New Northstar	103.3	0.58	63
Total	1880.5		

The second alternative that was modeled was the volume reduction alternative described in ***Appendix B***. Infiltration practices were represented by reducing the overall impervious area such that those portions function hydrologically the same as impervious surfaces routed to infiltration basins. ***Table D.3*** below shows the updated watershed parameters for this scenario.

In the watersheds with infiltration added, long-term 79% TSS reduction can be achieved (***Table D.4***), which equates to a 19% reduction in pollution delivered relative to the detention only scenario.

Table D.3: Alternative Plan P8 Watershed Information

Watershed	Total Area	Impervious Fraction	Pervious CN
New USH83	118.2	0.52	61
New Ottowa 1	357.8	0.36	61
New Wash S	139.7	0.35	62
New Wash N	176.4	0.35	62
New USH 83N	176.1	0.48	63
New 1804 Ottowa	379.5	0.38	61
New Ottowa 3	129.7	0.35	65
N Parkside	80.9	0.19	61
E Prop Line	35.8	0.16	61
W Ridgeland N	26.6	0.14	61
W NWood N	13	0.20	61
W NWood Cent	32.3	0.20	62
Inline	15	0.15	61
W Ridgeland S	75.5	0.17	63
W NWood S	20.7	0.19	62
New Northstar	103.3	0.43	63
Total	**1880.5**		

Table D.4: Modeled Water Quality Performance

Scenario	Watershed TSS Generation[1] (tons/yr)	TSS Delivery to Ponds (tons/yr)	TSS Trapped (tons/yr)		Percentage of TSS Generated	
			Ponds	Total	Trapped	Delivered to Waterbody
Master Plan	121	121	89	89	74%	26%
Alternative Plan	121	98	72	95	79%	21%

1 Note that watershed TSS generation is a highly site-dependent and variable. Although the modeled values presented here are believed to be representative, observed quantities in the field (tons/yr) may differ significantly. The relative comparison of effectiveness would be expected to be a more consistent measure than the individual predicted quantities

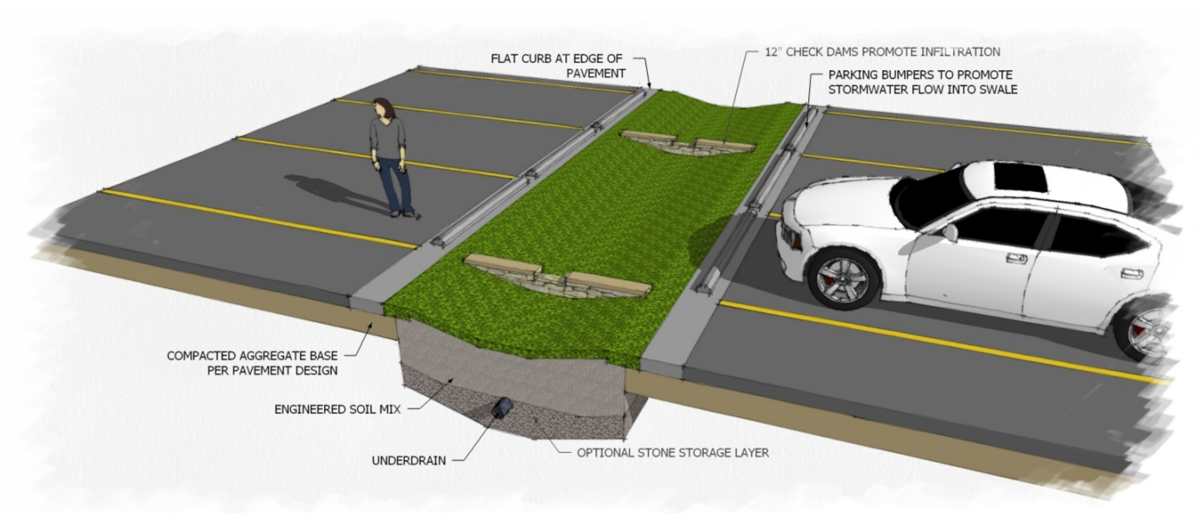
APPENDIX E – VOLUME REDUCTION BEST MANAGEMENT PRACTICES TOOLBOX

Introduction

This toolbox has been developed to assist professionals working in the City of Bismarck in the selection of volume mitigation practices and represents a number of common components for inclusion in site designs. Information includes both design considerations and cost data from national applications (US EPA and Center for Neighborhood Technology) and specific local data. This information is not intended as a substitute for detailed site investigation, design and installation, nor is it meant to exclude other approaches that may be incorporated. Appropriate practices should be individually designed and selected by a professional after a thorough site investigation and analysis has been performed.

Bioretention and Raingardens

Bioretention facilities and raingardens are vegetated surface depression treatment systems with engineered soil. The geometry and layout of these features vary widely, with some included in parking lot medians and others in general greenspace on a specific site. Individual designs may require a subsurface layer of rock, underdrains and/or a surface overflow. Volume reduction is achieved primarily through infiltration, recharge and evapotranspiration. Additional stormwater benefits include surface detention and water quality treatment.



Applicable Uses

- ✓ Infiltration or water quality treatment of impervious surfaces

Site Investigation Considerations

- ✓ Determine normal groundwater elevation (practice is not appropriate in areas with high groundwater)
- ✓ Characterize surface and subsurface soil textures and estimated infiltration rates

Design Considerations

- ✓ Consider layout and distribution based on grading plans (i.e. some sites may be better suited for distributed small facilities versus larger centralized facilities)
- ✓ Utilize a sandy topsoil or engineered soil mixture for the top 12-18 inches of the facility to provide high infiltration rates and water quality treatment. The engineered soil should be at least 75% sand
- ✓ If the facility is receiving runoff that has potential to include a large amount of sediment, pre-treatment practices should be used upstream of the raingarden or biofiltration facility
- ✓ Care should be taken when locating facilities adjacent to foundations and pavement subgrades
- ✓ Design depression storage depth (planting zone) to draw down in 24-48 hours
- ✓ Select plants that can tolerate both wet and dry conditions

Maintenance Considerations

- ✓ Minimize sediment flow into facility both during construction and long-term operation
- ✓ Periodic inspections are required
- ✓ Depending on the vegetation selected, watering may be required in dry periods and during establishment of vegetation
- ✓ Weeding should be performed to remove undesirable species
- ✓ Clear area of dead vegetation & debris on a regular basis
- ✓ Mulch topdressing may assist in

reducing weeds. Carefully consider the type of mulch used since it may float and cause other maintenance issues

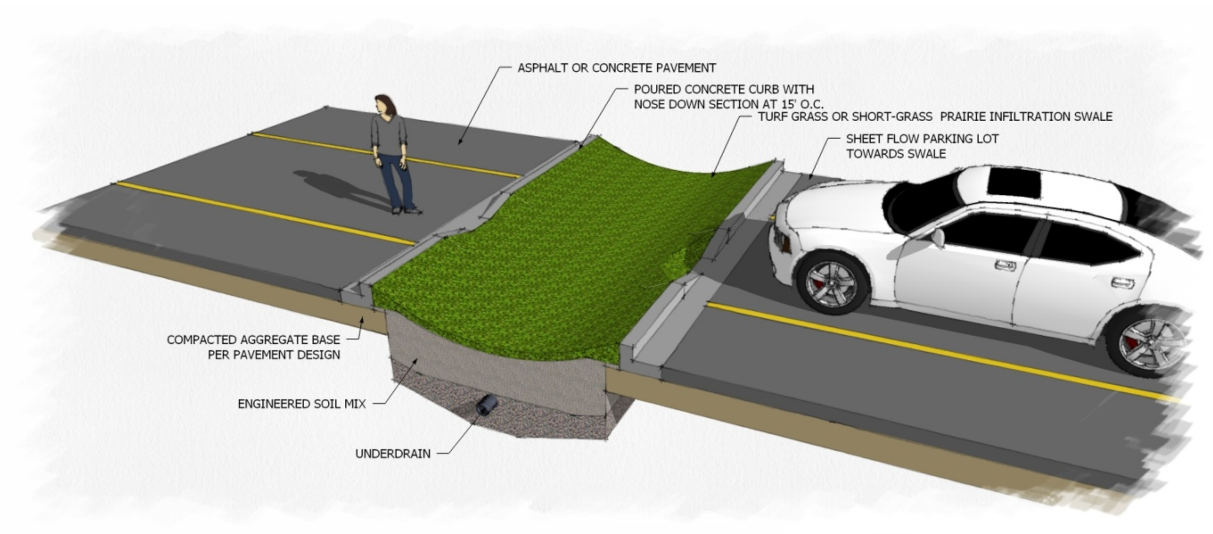
- ✓ Plant replacement may be necessary (as with any landscaped feature)
- ✓ If engineered soil is clogged, replace the top 4-6" with new material

Costs

Approximate costs to construct bioretention/raingarden systems vary from about $7 per square foot for simple systems (minimal excavation, no rock or underdrains) to about $15 per square foot. This corresponds to a range of $14,000 to $30,000 per developed acre to address stormwater from mixed use areas to the assumed Alternative 2 levels, or $17,000 to $37,000 for Commercial areas. Maintenance costs are similar to traditional landscaping upkeep.

Infiltration Swales

An Infiltration Swale is a conveyance practice that also provides treatment with engineered soil and a storage zone. Volume reduction is achieved through infiltration and recharge. Additional stormwater benefits include surface detention and water quality improvement through settling and filtration. These practices can be used in series with biofiltration/raingarden practices to increase the amount of water infiltrated/trapped.



Applicable Uses

- ✓ Manage the flow of stormwater in, through, and around a site while providing some volume reduction
- ✓ Can be incorporated into the landscape and overall development plans

Site Investigation Considerations

- ✓ Determine normal groundwater elevation (practice is not appropriate in areas with high groundwater)
- ✓ Characterize surface and subsurface soil textures and estimated infiltration rates (requires fairly infiltrative soils)

Design Considerations

- ✓ Design shallow slopes and features to encourage infiltration, but provide enough slope and cross-sectional area to meet overall conveyance requirements
- ✓ Can be vegetated with a large variety of plant species, including turfgrass

Maintenance Considerations

- ✓ Minimize sediment flow into facility both during construction and long-term operation
- ✓ Periodic inspections are required
- ✓ Depending on the vegetation selected, watering may be required in dry periods and during establishment of vegetation
- ✓ Weeding should be performed to remove undesirable species
- ✓ Clear area of dead vegetation & debris on a regular basis
- ✓ Mulch topdressing may assist in reducing weeds. Carefully consider the type of mulch used since it may float and cause other maintenance issues
- ✓ Plant replacement may be necessary (as with any landscaped feature)
- ✓ If engineered soil is clogged, replace the top 4-6” with new material

Costs

Swale construction generally costs $7 to $20 per square foot, depending on location and complexity of design. The amount of swale constructed is generally determined by site drainage requirements. Maintenance is similar to traditional landscaping.

Sidewalk Planters

A sidewalk planter is a surface bio-engineered treatment system surrounded by traditional curb with curb-cuts and may include an underdrain system. Volume reduction is achieved through recharge and evapotranspiration. Additional stormwater benefits include minimal detention storage and pollutant removal via filtration, adsorption, and uptake.

Applicable Uses

- ✓ Can be used as an volume reduction alternative to infiltration swales in commercial settings as it limits side slope grading extents
- ✓ Sidewalk planters are generally used to capture runoff from relatively small, defined areas, such as a set of downspouts or a specific section of parking or roadway

Site Investigation Considerations

- ✓ Characterize surface and subsurface soil textures and estimated infiltration rates (requires fairly infiltrative soils)

Design Considerations

- ✓ Design depression storage depth to draw down in 24 hours
- ✓ Select plants that can tolerate both wet and dry conditions

Maintenance Considerations

- ✓ Need to minimize sediment flow into facility during construction and long-term
- ✓ Periodic inspections required
- ✓ Water in dry periods to maintain vegetation, especially during establishment
- ✓ Plant replacement
- ✓ Replace engineered soil if clogging occurs

Costs

Sidewalk planters generally cost between $10 and $20 per square foot to install. Maintenance costs are approximately twice the per-area cost of traditional landscaping, and their expected effective lifespan if properly maintained is 20-30 years before replacement is required.

Underground Storage

Underground storage allows for temporary storage and permanent infiltration of water under a development. Volume reduction is achieved primarily through infiltration. Additional stormwater benefits include temporary storage in large flood events and stormwater quality benefits from settling and filtration.

Applicable Uses

✓ Detention or retention storage and infiltration under developed surfaces

Site Investigation Considerations

✓ Determine normal groundwater elevation (practice is not appropriate in areas with high groundwater)
✓ Characterize surface and subsurface soil textures and estimated infiltration rates to assist in design

Design Considerations

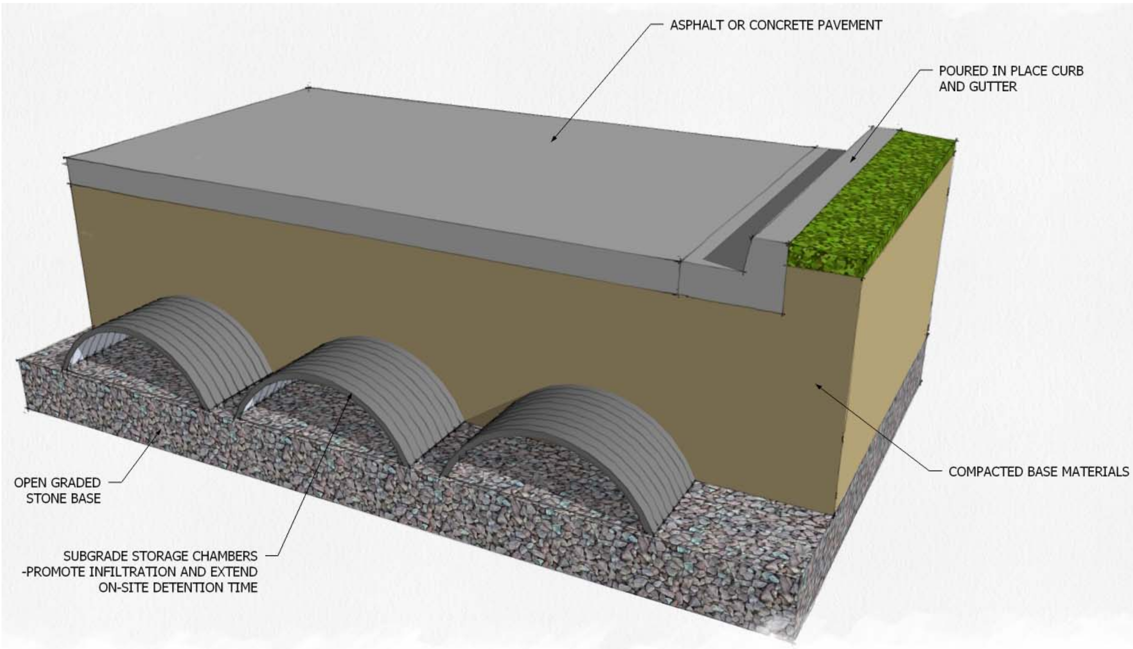
These BMPS are typically used where the cost of land is at a premium and the space or availability of a standard retention pond is not possible. Underground storage is also used in sites where stormwater infiltration is difficult because there are tight, clay heavy, existing soils which will infiltrate over long periods of time. In all cases, the system should contain an outlet that discharges to other conveyance facilities.

Maintenance Considerations

Primarily due to parking lot sanding and debris, the catchment structures need to be occasionally cleaned out with sump evacuation equipment.

Costs

The costs associated with underground storage and infiltration systems are dependent on a number of site specific standards, storage method, and amount of storage required.



Urban Forest/Stormwater Trees

An urban forest relies on installing and preserving large, mature trees within the development. Volume reduction is achieved through interception and evaporation. During site development, it is critical to minimize the amount of over-compaction in areas of the trees. For large trees to maximize the infiltrate and evaporate of stormwater, the necessary soil preparation needs to occur. Two methods for soil preparation are CU Structural Soils as developed by Cornell University and Silva Cells. CU Structural Soils are a mixture of clean washed rock, and a loam soil. The angular rock provides structural support for adjacent paving while leaving sufficient room between rock for soil and storm water storage. Silva Cells are a stackable "milk crate" which supply the structural support for pavement, while providing uncompacted fill for vegetation and stormwater management. By using methods like these, the correct soil loading capacity for pavement can be achieved while enhancing the stormwater capacity of mature trees.

Applicable Uses

- ✓ Use large trees within the development in conjunction with stormwater management practices which route water to the tree

Site Investigation Considerations

- ✓ Consider separation from building foundations to limit root infiltration

Design Considerations

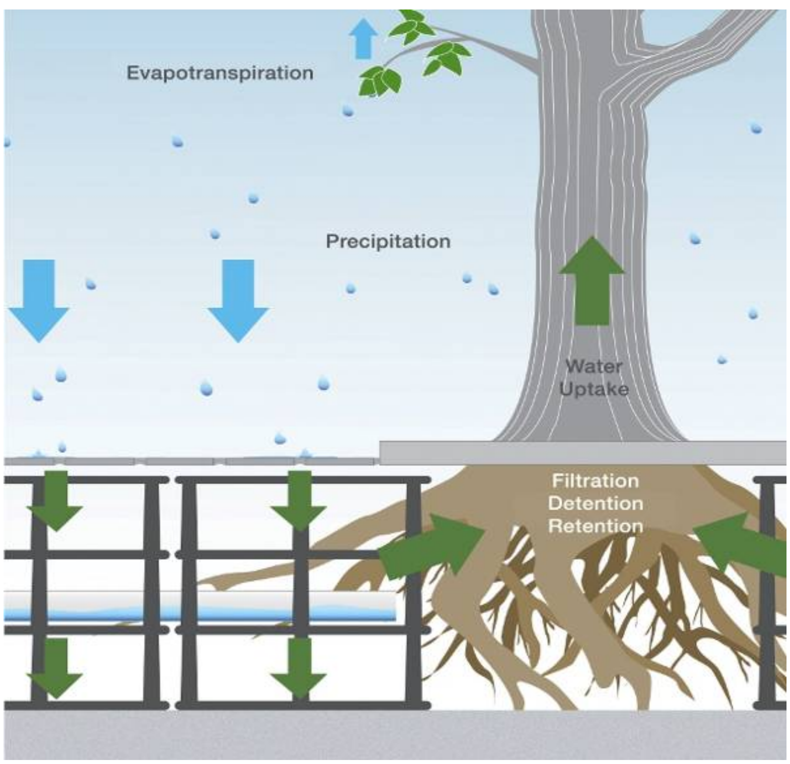
- ✓ Use suspended pavement to reduce compaction, increase water retention, and improve tree health and survivability
- ✓ Minimum tree pit size should be 5 feet by 5 feet and extend to a depth of at least 3 feet

Maintenance Considerations

- ✓ Trim dead branches and branches that extend over buildings and structures
- ✓ Replace dead trees

Costs

Costs to install tree boxes range from $70 to $660 per square foot and can be expected to typically cost $4000 to $7500 each. Maintenance costs are variable and hard to predict; though the Center for Neighborhood Technology estimates a range from $2.80 to $13.90 per square foot annually.



Curb Cuts

A curb cut provides a direct inlet to stormwater features from adjacent impervious area. These features are used in conjunction with raingardens, bioretention facilities, sidewalk planters, or swales.

Applicable Uses

- ✓ Can incorporate into existing or proposed infrastructure
- ✓ Can be used as an alternative to inlets and pipe conveyance systems

Site Investigation Considerations

- ✓ None

Design Considerations

- ✓ Deicing materials and other contaminants could reduce lifespan of stormwater features so curb cuts should be considered along with proposed maintenance activities
- ✓ Erosion control at the curb cut may be necessary upon initial installation
- ✓ Emergency overflow paths should be included that allow for stormwater to overflow to other site conveyance features

Maintenance Considerations

- ✓ Sediment and debris removal
- ✓ Replacement if damaged

Costs

$30 per linear foot. Typical curb and gutter (depending on gutter width) ranges from $18-30, per linear foot. Curb cuts are typically formed by hand, therefore they will be on the higher end of curb and gutter cost.

Ribbon Curb

A ribbon curb allows sheet flow of water from roads or parking lots to adjacent stormwater features. It can be used in conjunction with raingardens, bioretention facilities, and swales.

Applicable Uses

- ✓ Can be used in areas that have parking lots or roads
- ✓ Can be used as an alternative to inlets and pipe conveyance systems

Site Investigation Considerations

- ✓ None

Design Considerations

- ✓ Adequate space outside the paved area must be included for other infiltration or conveyance features
- ✓ Snow removal activities typically utilize curbs as a "guide" so alternate methods for marking the edge of pavement should be considered

Maintenance Considerations

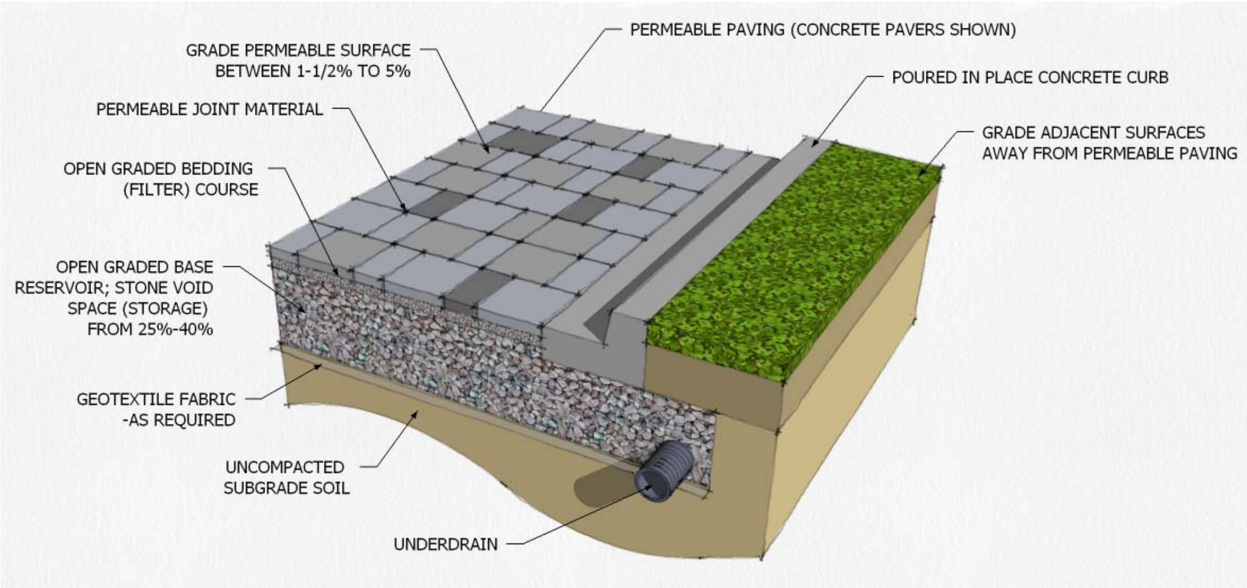
- ✓ Replace if damaged

Costs

$24-30 per linear foot. Typical curb and gutter (depending on gutter width) ranges from $18-30, per linear foot. Larger quantities (machine) formed are lower cost, while hand formed sections are higher.

Permeable Paving

Permeable pavement allows the temporary storage and infiltration of stormwater through the pavement section. A clean washed rock base is placed below the pavement and the voids in the stone are used as the storage for stormwater. The graphic example below displays a precast concrete paver, though other alternatives include permeable concrete and asphalt. Permeable pavement with infiltration is an alternative that directly reduces the volume of runoff from impervious parking lots or roadways.



Applicable Uses:

- ✓ Permeable paving can be used as a substitute for traditional hardscape in most paving projects, including parking lots, roads, plazas, trails, etc.

Site Investigation Considerations

- ✓ Site soils should be tested to characterize the anticipated subsoil properties, including anticipated permeability

Design Considerations

- ✓ If permeable subsoil does not exist (or permeable rates are slower than preferred) drain tile will be required. Even with drain tile installed, the permeable pavement section will greatly decrease the peak outflow of the hardscape, while filtering the storm water.

- ✓ Permeable paving should have a flatter slope than traditional paving. The flatter slope helps to slow the speed of the sheet flow and promote infiltration through the paving.
- ✓ While permeable paving is typically designed with less slope than traditional paving, the pavement must have positive drainage to properly convey surface runoff in the event of surface clogging or an intense rainfall event.
- ✓ Permeable pavement should not accept sheet flows from other areas of the site. Permeable paving should be designed to only infiltrate rainwater which naturally falls onto the pavement section.
- ✓ Paving designs using unit pacers should minimize the cutting of pavers and should consider designing the paving modules to work with machine laid paver equipment.

Maintenance Considerations

- ✓ Spaces between the paving materials (where water infiltrates) can become clogged depending on parking lot maintenance methods and vehicle traffic.
- ✓ Sand should not be used on a permeable paving surface.
- ✓ Pavement should be vacuumed to remove potential clogging materials. The frequency of removal is dependent on accumulation of sediment.
- ✓ Pavement should be inspected at least twice during the summer/fall to make sure the section is properly functioning.

Costs

$10-18 per square foot. This price assumes a 24" depth of clean washed rock are installed below the pavement section. The scale and complexity of the paving project will determine the overall cost.

APPENDIX F – STAKEHOLDER COMMUNICATION PLAN

Purpose of the Stakeholder Communication Plan

The Hay Creek Stormwater Subwatersheds HC3-4, HC3-5, and HC3-6 Master Plan will influence how this portion of the City of Bismarck will develop in the future and how water quantity and quality standards and goals will be met. Potential ordinance changes may be considered and recommendations will be made to initiate capital projects. It will therefore be of interest to property owners and local residents, as well as public organizations charged with managing the infrastructure and environmental quality of this and nearby areas.

This Stakeholder Communication Plan serves two primary purposes:

1. To provide a basic framework for communication during the development of the Master Plan; and
2. To document the stakeholder communication process.

This document is intentionally basic, providing an initial framework with the flexibility to be updated as the project moves forward should the need arise.

Communication Goals

The goal of communication for this project is to consult with public and private stakeholders to keep them informed about the project, and to understand and acknowledge their concerns and ideas related to the project. Decisions in this planning process will be the responsibility of the City of Bismarck. The appendix illustrates how this "consulting" approach fits into a spectrum of possible degrees of public participation.

Anticipated Stakeholder Issues

The project area is in a rapidly developing portion of the City of Bismarck with significant developments already in the public dialogue. It is anticipated that this project will add to the overall dialogue and may prompt additional conversations about overall development plans within the community.

Stakeholders to be included in Communication

Public stakeholders to be included in this communciation plan include:

- Bismarck Citizens
- Bismarck Public Works Department
- Bismarck Engineering
- Community Development (Planning and MPO)
- Bismarck Parks & Recreation District
- Burleigh County Water Resource District
- Burleigh County Highway Department
- Hay Creek Township

- North Dakota Department of Transportation
- North Dakota Department of Health
- Western Area Power Authority (WAPA)

Private stakeholders, including owners of property in the planning area, will be identified by the project team and City staff. Project information will be publicly available to additional stakeholders that may be interested in learning about this project.

Key issues to Communicate

- Project objectives
- Schedule for developing the plan
- Schedule of opportunities to learn about and comment on the plan
- Key issues to be addressed by the plan:
    - Stormwater management criteria
    - Preliminary road alignments and drainage issues
    - Options for meeting stormwater criteria
    - Plan implementation

Communication Methods

1. *Interviews with private stakeholders.* AE2S and City staff will hold private meetings with several stakeholders to gather input on development goals/plans/needs, and other issues affecting this planning process.
2. *Public informational meetings*. AE2S will lead two public meetings to present information on the project and listen to feedback. These meetings will be announced to the public in advance, with specific invitations to the public stakeholders identified above and private stakeholders identified during this project.
3. *Project website*. The City of Bismarck will post relevant project information on its website to efficiently disseminate it to interested parties.

Schedule

Approximate Date	Event	Purpose
August-December 2012	Private stakeholder interviews	Gather information on stakeholder issues and information that may influence the plan.
September 27, 2012	Public informational meeting Project website online	Introduce the project goals, schedule, and key issues. Understand stakeholder issues.
January 24, 2013	Presentation of Draft Master Plan	Present draft plan to obtain feedback

Appendix A

Public Participation Spectrum

(from the International Association for Public Participation)

International Association for Public Participation

EMPOWER
COLLABORATE
INVOLVE
CONSULT
INFORM

IAP2 Public Participation Spectrum

Courtesy of The Perspectives Group

Increasing Level of Public Impact

	Inform	Consult	Involve	Collaborate	Empower
P2 Goal:	To provide the public with balanced and objective information to assist them in understanding the problems, alternatives, opportunities and/or solutions.	To obtain public feedback on analysis, alternatives and/or decisions.	To work directly with the public throughout the process to ensure that public concerns and aspirations are consistently understood and considered.	To partner with the public in each aspect of the decision including the development of alternatives and the identification of the preferred solution.	To place final decision-making in the hands of the public.
Promise to the Public:	We will keep you informed.	We will keep you informed, listen to and acknowledge concerns and aspirations and provide feedback on how public input influenced the decision.	We will work with you to ensure that your concerns and aspirations are directly reflected in the alternatives developed and provide feedback on how public input influenced the decision.	We will look to you for direct advice and innovation in formulating solutions and incorporate your advice and recommendations into the decisions to the maximum extent possible.	We will implement what you decide.
Example Tools:	• Fact sheets • Web sites • Open houses	• Public comment • Focus groups • Surveys • Public meetings	• Workshops • Deliberative polling	• Citizen Advisory Committees • Consensus-building • Participatory decision-making	• Citizen Juries • Ballots • Delegated decisions

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