STORMWATER MANAGEMENT PLAN

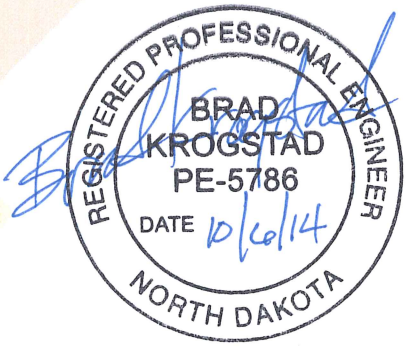
NHU-1-981(101)111 PCN 20196

Bismarck, ND

Prepared for:

City of Bismarck

October 2014



Project #1412129

KLJ

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INTRODUCTION

Summary

The purpose of this Storm Water Management Plan (SWMP) is to analyze the North Washington Street project corridor in order to develop a storm water system to accommodate the proposed reconstruction project, with the intention of providing a system capable of accommodating the conditions that will exist immediately following road reconstruction and the final developed condition of properties within the North Washington Street watershed. In order to ensure system capacity, relevant Stormwater Master Plans, subsequent site-specific Stormwater Management Plans, and actual current developed conditions within the project corridor have been reviewed and incorporated into the design process.

Due to shifting land use patterns adjacent to North Washington Street, development is currently occurring at densities higher than those anticipated by the Master Plans. This report will include recommendations and provide criteria for City approval of subsequent development adjacent to North Washington Street to ensure that the storm sewer system installed under this project and the downstream receiving systems are not overwhelmed in the final developed condition of the area.

Definitions of Site Conditions

This report will refer to "existing", "interim", "proposed" and "developed" conditions throughout. For the purpose of this report, "existing conditions" shall mean the current conditions within the project corridor at the time of this report. "Interim conditions" and "proposed conditions" shall be interchangeable, and refer to the project corridor conditions immediately following the completion of the project. "Developed conditions" shall refer to a future condition in which undeveloped land adjacent to North Washington, within the extents of the project corridor, have been developed.

Location

The project is located in northwest Bismarck beginning approximately 200 feet south of Calgary Avenue and extending to approximately 300 feet north of 57th Avenue NW. **Exhibit 1** illustrates the general vicinity of the project site.

Reference Drainage Studies

- **North Fourth Street Storm Water Master Plan** *(Swenson, Hagen & Co., 1998)*
- High Meadows 10th Addition *(Swenson, Hagen & Co., 2002)*
- First Evangelical Free Church *(Swenson, Hagen & Co., 2003)*
- **North Washington Street Watershed Storm Water Management Plan** *(Swenson, Hagen & Co. and Houston Engineering, Inc., 2004)*
- North Hills 14th Addition *(Kadrmas, Lee & Jackson, 2005)*
- Boulder Ridge 1st Addition *(Swenson, Hagen & Co.,2005)*
- Good Shepherd Lutheran Church Storm Water Management Plan *(Ulteig Engineers, 2005)*
- Hay Creek Watershed Storm Water Management Plan *(Swenson, Hagen & Co., 2005)*
- **North Fourth Street Master Plan Update** *(Ulteig Engineers, 2007)*
- High Meadows 11th Addition *(Swenson, Hagen & Co., 2007)*
- Legacy Addition *(Swenson, Hagen & Co., 2009)*
- Northern Sky Addition *(Swenson, Hagen & Co., 2012)*

- Boulder Ridge 5th Addition *(Swenson, Hagen & Co., 2012)*
- Brei Estates 1st Addition *(Swenson, Hagen & Co., 2013)*
- Evergreen Ridge Addition *(Swenson, Hagen & Co., 2014, Not final at time of this report)*
- High Meadows 12th Addition *(Swenson, Hagen & Co., 2014, Not final at time of this report)*
- Design and Associated Services for Regional Storm Water Features in the North Washington Street Watershed *(Apex Engineering Group, Ongoing)*

Description of Property

North Washington Street is a principal north/south arterial roadway. It consists of an urban road section south of Calgary Avenue and transitions to a rural two-lane roadway north of Calgary Avenue. A shared use path lies along the west side of the North Washington right-of-way and is separated from the roadway by a grassed ditch. Private lands adjacent to the project corridor are currently partially developed. New residential, commercial and institutional developments are occurring rapidly throughout the project corridor. Currently, stormwater runoff west of North Washington flows generally east to rural roadway ditches and is then conveyed across North Washington to Hay Creek tributaries.

General Project Description

The project will consist of the reconstruction of North Washington Street from Calgary Avenue to a point north of 57th Avenue and includes portions of 43rd Avenue and Ash Coulee Drive. North Washington Street will be converted from a two-lane rural road section to a four-lane urban road section with turn lanes, medians, curb & gutter and multiple storm sewer trunk lines. The project also includes the installation of 3,100 LF of new Zone 3 24-inch water distribution line along the south side of 43rd/Ash Coulee Drive from the intersection of 43rd Avenue and Normandy Drive to the Zone 4 water tank on Ash Coulee Drive. Additionally, the 16-inch water main along Ash Coulee Drive from North Washington Street to the Zone 4 water tank will be removed and replaced.

Construction Schedule

Construction is anticipated to begin in the spring of 2015.

Owner Information

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STORMWATER DESIGN CRITERIA

Regulations

This report is in accordance with the City of Bismarck Ordinance Number 4817 and follows the guidelines set forth in the City of Bismarck "Stormwater Design Standards Manual".

According to FEMA issued Map Number 38015C0785C (**Exhibit 3**), the proposed development does not impact the 100-year floodplain or floodway, navigable waterways, delineated wetlands, historic sites, or public properties and, therefore, this plan does not address regulations regarding those issues.

Analysis Methods

Autodesk Storm & Sanitary Analysis (SSA) software was used to determine sub-basin hydrology, size and space inlets and to size storm sewer piping. SSA is a comprehensive software capable of performing both hydraulic and hydrologic analysis through the SCS TR-20 Unit Hydrograph Method in conjunction with SCS TR-55 procedures.

Hydrologic Criteria

Sub-basin hydrology was analyzed using a Type II distribution for the 10-year and 100-year rainfall frequency events as reported in NOAA Technical Paper No. 40 (TP 40), Rainfall Frequency Atlas. The storm water Master Plans and site specific SWMPs used Technical Paper No. 40 as designated within the City of Bismarck Storm Water Design Standards Manual. NOAA released Atlas 14 in 2013, which provided updated point precipitation estimates across the United States and altered the amount of rainfall predicted for rainfall events. TP 40 was utilized in this analysis to maintain consistency with previous reports and Master Plans. **Table 1** below illustrates the difference in rainfall depths between TP 40 and Atlas 14, as follows:

TABLE 1: RAINFALL DEPTHS

Rainfall Duration	Precipitation 10-Year (in)	Precipitation 100-Year (in)
6-Hour (Technical Paper No. 40)	2.5	3.8
6-hour (Atlas 14)	2.5	4.5

As illustrated above in **Table 1**, Atlas 14 anticipates a 0.7-in increase in precipitation during the 100-year, 6-hour event. However, precipitation remains unchanged from Technical Paper No. 40 during the 10-year, 6-hour storm event. A minimum time of concentration of 5 minutes was used within this report.

Weighted curve numbers and times of concentration (TCs) for undeveloped properties were determined based on development densities assumed in relevant storm water Master Plans, except where modified by subsequent site-specific SWMP's, proposed conditions or existing development. Assumptions within the Master Plans are that lands north of 57th Avenue would develop as rural residential lots (1.5 to 2.0 acres), lands south of 57th Avenue and north of 43rd Avenue would developed as single-family residential lots (R5), and lands between Calgary and 43rd Avenue would develop as residential with some light commercial.

Table 2, provided below, illustrates the hydrologic soils conditions used to calculate weighted curve numbers for proposed and existing developments:

TABLE 2: HYDROLOGIC CURVE NUMBERS

Land Cover	Condition	HSG B
Grass Cover 50% to 75%	Fair	69
¼ Acre Lots (R5 Lots)	38% impervious, Grass Cover > 75%	75
2 Acre Lots (Rural Lots)	12% impervious, Grass Cover 50% to 75%	72
Pavement & Impervious Areas		98

The current NRCS online web survey provided as **Exhibit 2** illustrates that underlying soils are HSG Type C, which is inconsistent with the Master Plans and previous reports. NRCS has reportedly had issues with their online web soil survey service showing Type B soils as Type C. The 1998 *North Fourth Street Master Plan*, the 2004 *North Washington Street Stormwater Management Plan* and the 2007 *North Fourth Street Master Plan Update* all indicated that the underlying site soils were of HSG Type B. In addition, the historic Burleigh County Soils Map indicates that the underlying soils are Type B. The runoff curve numbers used in this report will defer to the HSG B soil identified in the Master Plans rather than the current NRCS Soil Map web survey to ensure consistency with previous studies. These soils have moderate infiltration rates when thoroughly wetted and are of moderately fine to moderately coarse.

Hydraulic Criteria

Proposed streets were designed in accordance with the hydraulic criteria established within Section 3.2.1 and Section 6.4 of the City of Bismarck's Stormwater Design Standards Manual. For arterial streets, Section 6.4 states that the flow spread must not overtop the curb and must not exceed 10-feet from the face of curb in a minor storm event. In a major storm event, Section 6.4 states that flow spread must not exceed the street right-of-way and the depth of water above the street crown must not exceed 3-inches, whichever is less, for an arterial street.

Table 3 provided below illustrates the maximum allowable flow depth and spread for the minor and major storm event, as follows:

TABLE 3: STREET FLOW DESIGN CRITERIA

Event	Street Classification	Max Gutter Depth (in)	Max Flow Spread From Face of Curb (ft)
Minor 10-Year	Collector	0.29	11.5
	Arterial	0.29	11.5
Major 100-Year	Collector	*Varies	*Varies
	Arterial	*Varies	*Varies

*Gutter depth and allowable spread for 100-year event varies by location due to turn lanes.

Table A-2, located in the Appendices, illustrates the analyzed anticipated flow depth over each inlet during the 10-year and 100-year, 6-hour storm events.

Datum

All elevations listed in this report refer to the NGVD29 vertical datum.

DRAINAGE AREA DESCRIPTIONS

Watershed Descriptions

The project site lies within two sub-watersheds of the 36.9 square-mile Hay Creek Watershed, namely the 711-acre North Fourth Street Watershed and the 1,950-acre North Washington Street Watershed. The Hay Creek Watershed flows generally east and south to Apple Creek, which flows south and west to a confluence with the Missouri River located south of Bismarck.

Drainage Area Descriptions and Development

The project area was delineated into six drainage areas based on previous site specific SWMPs, stormwater Master Plans and current drainage patterns. These "drainage areas" are comprised of runoff "sub-basins" that share a common outlet. "Sub-watersheds" are comprised of "drainage areas", and the overall "watersheds" are comprised of these "sub-watersheds". A general description of the drainage areas is as follows:

- Drainage Area #1 flows to the existing storm sewer system at the intersection of Lorrain Drive and North Washington Street.
- Drainage Area #2 flows to a local detention facility within the Northern Sky Addition and outlets to Boulder Ridge 1st Addition.
- Drainage Area #3 flows to a detention facility south of Medora Ave and outlets to the NE quadrant of Medora Avenue to Boulder Ridge 5th Addition.
- Drainage Area #4 flows to a detention facility located within Good Shepherd Addition and outlets east of Washington Street to Boulder Ridge 5th Addition.
- Drainage Area #5 flows to the existing 7'x5' box culvert, which outlets to a stormwater drainage easement located east of North Washington Street.
- Drainage Area #6 flows to the south ditch of 43rd Avenue, then through a west-east culvert across Montreal Street, which discharges to an existing culvert across 43rd to Boulder Ridge 1st.

Exhibit 4 is a map of the existing conditions that also illustrates the above-mentioned drainage area boundaries as well as master plan and site-specific SWMP boundaries.

Drainage Area #1 – Calgary Avenue to 43rd/Ash Coulee Drive

Existing, Master Plan & Site Specific SWMP Conditions

This 81.77-acre drainage area lies within sub-watershed M-3 of the North Fourth Street Watershed delineated in the 1998 *North Fourth Street Storm Water Master Plan* (Master Plan) and further analyzed within the 2007 *North Fourth Street Storm Water Master Plan Update* (Master Plan Update). Wherever the terms "Master Plan" or "Master Plan Update" are stated within this section, they shall refer to these reports specifically.

Exhibit 5 includes a map of Drainage Area #1.

Drainage Area #1 contains three streets west of and perpendicular to North Washington: Arabian Avenue, Buckskin Avenue and Colt Avenue. These streets are primarily rural road sections within the drainage area tributary to the project corridor. Runoff from Drainage Area #1 flows generally east to the west roadway ditch of North Washington Street, which conveys flows to a 30" RCP located south of Colt Avenue. The 30" RCP flows east across North Washington and connects to the existing Lorrain Drive 36" RCP storm sewer, which flows east to a regional detention facility bounded by Normandy Drive to the east.

The Master Plan and Master Plan Update model assumed that, under the fully developed condition, Arabian Avenue, Buckskin Avenue, and Colt Avenue would be converted to urban road sections and drainage would flow onto and be collected by storm sewer within the street sections. These storm sewer laterals would then convey flow to a trunk storm sewer system along North Washington Street, which would tie into the existing Lorrain Drive storm sewer.

The Master Plan Update anticipated peak runoff rates to the intersection of Lorrain Drive and North Washington Street to be 95 cfs and 181 cfs during the 10-year and 100-year, 6-hour storm event, respectively. The Master Plan Update also assumed that, during the 100-year, 6-hour storm event, the existing Lorrain Drive storm sewer would convey 120 cfs while 61 cfs would surface flow east onto Lorrain Drive. Calculations performed using information from the 2007 Lorrain Drive as-built (i.e. 36" RCP at 2.6283% slope) indicate that the capacity of the 36" pipe is approximately 108 cfs at full flow, with additional capacity under pressure flow.

The Master Plan Update included approximately 7 acres of land south of Arabian Avenue that were not included in the Master Plan, assuming that subsequent development would grade the area to flow north to Arabian Avenue, rather than south towards Edmonton Avenue. Currently, the cul-de-sac serving High Meadow 10th Addition flows toward Arabian avenue, then east and south to detention pond DP-2 located to the east of the addition. DP-2 discharges south to a shallow depression area located north of Lot 8 and Lot 9, Block 2 of High Meadows 2nd Addition. Upon overtopping, runoff spills south between these two lots and onto Edmonton Drive.

Proposed & Developed Conditions

In the proposed condition, temporary storm sewer stub-outs will be provided at several locations along North Washington to collect interim flows and to serve as tie-in points to the trunk system when adjacent properties are developed. In the developed condition, runoff within M3-1, M3-2 and M3-3 will flow onto the urban road sections of Arabian Avenue, Buckskin Avenue and Colt Avenue, then into storm

sewer that connects to the proposed North Washington Street 54" RCP trunk line. The 54" RCP trunk line will connect to the existing 36" RCP Lorrain Drive storm sewer at proposed storm manhole MH-20.

The Master Plan Update assumed 61 cfs of runoff would street flow onto Lorrain in the 100-year, 6-hour rainfall event. However, the vast majority of runoff within Drainage Area #1 is from the west side of North Washington. In order to direct any runoff to the east curb line of North Washington, and thus onto the Lorrain Drive street section, valley gutters would have to be installed across North Washington. This issue was discussed with the City of Bismarck, and it was determined that valley gutters across a principal arterial road would not be allowed and that the trunk line should be designed to accommodate the 100-year, 6-hour flows without the need for bypassing street flows onto Lorrain.

This report assumes that all runoff (100-year, 6-hour storm event) for a fully developed condition of Drainage Area #1 is collected by the proposed trunk storm sewer system and is conveyed to a future trunk storm sewer system along Lorrain Drive. However, the existing 36" RCP at Lorrain Drive and the downstream system from Lorrain to the regional detention area lacks the capacity to convey the 100-year, 6-hour storm event. **Exhibit 6** illustrates the Lorrain Drive storm sewer under the existing conditions and provides recommendations for the minimum pipe sizes required to convey anticipated flows. The City of Bismarck has indicated that upstream detention would be difficult to obtain to reduce runoff volumes to the existing Lorrain Drive system. Unless upstream detention can be obtained, the existing system must be upsized prior to further or final development within Drainage Area #1; otherwise, there exists the potential for severe property damage in the event of a large storm event.

Sub-Basins M3-1e, M3-1g, M3-1h, M3-1i & M3-1f

The developed drainage conditions generally follow the existing drainage conditions for sub-basins M3-1g, M3-1i and M3-1f while flow will be redirected for sub-basins M3-1e and M3-1h. Currently, runoff from sub-basins M3-1e and M3-1h flows to the north roadway ditch of Arabian Avenue while runoff from sub-basins M3-1g, M3-1i and M3-1f flows generally southeast to detention pond DP-2 located within sub-basin M3-1f. The north roadway ditch currently conveys flow to two culverts that flow east to North Washington Street and south to DP-2. Upon development of Arabian Avenue, sub-basins M3-1e, M3-1g, M3-1h and M3-1i will flow to future storm sewer along Arabian Avenue that will discharge flow south to DP-2. DP-2 will discharge east to future detention pond DP-1 located within sub-basin M3-1d. **Table A-1**, located within the Appendices, illustrates peak runoff rates to DP-2 from sub-basins M3-1e, M3-1g, M3-1h, M3-1i and M3-1f.

Sub-Basin M3-1d

The developed drainage conditions will not follow the existing drainage conditions for sub-basin M3-1d. Runoff currently flows south to a shallow depression area located north of Lot 8 & Lot 9, Block 2, of High Meadows 2nd Addition. As the depression area overtops, water spills south between Lots 8 & 9 to Edmonton Drive, causing localized flooding of these lots. After discussions with the City of Bismarck, it was decided that a future detention pond (DP-1) would be placed within this sub-basin to prevent flow from discharging south. In the developed conditions, DP-1 would collect discharge from DP-2 and flows from M3-1d. Catch Basin 13a will be installed in this project southeast of Arabian and Washington to provide a connection point for a future 15" outlet pipe from DP-1. **Table A-2**, located within the Appendices, illustrates the maximum allowable peak discharge rates from DP-1 to Catch Basin 13a.

Sub-Basin M3-1a

Sub-basin M3-1a currently flows southeast to the west roadway ditch of North Washington Street. Under the proposed conditions, runoff will flow east to FES-20, which connects to the North Washington Street trunk line. In the developed condition, all runoff from sub-basin M3-1a will be collected onsite and conveyed to FES-20. **Table A-1**, located within the Appendices, illustrates the maximum allowable peak runoff rates to FES-20 from sub-basin M3-1a.

Sub-Basin M3-1b

Sub-basin M3-1b currently flows northeast to the west roadway ditch of North Washington Street. Under the proposed conditions, runoff will flow east to FES-19, which connects to the North Washington Street trunk line. In the developed condition, all runoff from sub-basin M3-1a will be collected onsite and conveyed to FES-19. **Table A-1**, located within the Appendices, illustrates the maximum allowable peak runoff rates to FES-19 from sub-basin M3-1b.

Sub-Basins M3-2g, M3-2h & M3-2i

Sub-basins M3-2g, M3-2h and M3-2i currently flow generally east through M3-2f to a natural drainage swale located between sub-basins M3-2b and M3-2c. Sub-basin M3-2h currently flows north to an existing culvert that conveys flows north across Buckskin. Once developed, runoff will be re-routed from the natural drainage swale to future Buckskin Avenue storm sewer. The storm sewer will connect to the 24" RCP stub in Buckskin provided under this project, which connects to the North Washington Street trunk line. **Table A-1**, located within the Appendices, illustrates the maximum allowable peak runoff rates to the Buckskin Avenue storm sewer stub from sub-basins M3-2g, M3-2h and M3-2i.

Sub-Basins M3-2b, M3-2c, & M3-2f

Sub-basins M3-2b, M3-2c & M3-2f currently flow east to the west roadway ditch of North Washington Street. Under the proposed conditions, runoff will flow east to an 18" RCP stub-out provided under this project (FES-1), which connects to the North Washington Street trunk line. FES-1 will collect interim flows and provide a future connection point for subsequent development within these sub-basins. **Table A-1**, located within the Appendices, illustrates the maximum allowable peak runoff rates to FES-1 from sub-basins M3-2b, M3-2c, and M3-2f under the developed conditions.

The Master Plan Update assumed this area (Sub-Watershed M3-2) would develop to a curve number of 82. However, sub-basins M3-2a, M3-2b and M3-2d developed to a curve number of 89. In order to reduce offsite flows from this area to Master Plan Update rates, any future development of sub-basin M3-2c must either provide onsite detention and/or develop such that the average weighted curve number of sub-basins M3-2a, M3-2b, M3-2c and M3-2d is no greater than 82.

Sub-Basin M3-2a

Sub-basin M3-2a currently flows northeasterly across the existing parking lot to a curb opening that spills north to the west roadway ditch of North Washington Street. Under the proposed conditions, the curb opening will be rebuilt with a concrete swale to a beehive inlet (11a) placed in the existing low point within the south ditch line of Colt. The inlet will discharge into storm sewer that connects to the North Washington Street trunk line. **Table A-1**, located within the Appendices, illustrates the maximum peak runoff rates to beehive inlet 11a from sub-basin M3-2a under the proposed conditions.

Sub-Basins M3-2d & M3-2e

Sub-basins M3-2d and M3-2e currently flow north to the south roadway ditch of Colt Avenue, which conveys flows east to the west roadway ditch of North Washington Street. In the proposed conditions, the south roadway ditch will convey flow east to beehive inlet 11a within M3-2a. Inlet 11a connects to the North Washington Street trunk line. Upon development of Colt, runoff from these sub-basins will flow to storm sewer within the future street section, which will connect to a 24" RCP stub provided under this project from the North Washington Street trunk line. **Table A-1**, located within the Appendices, illustrates the maximum allowable peak runoff rates to the Colt Ave storm sewer stub from sub-basins M3-2d and M3-2e.

Sub-Basins M3-3a, M3-3b & M3-3c

Sub-basins M3-3a, M3-3b and M3-3c currently flow southeasterly to the west roadway ditch of North Washington Street. FES-2 is being provided at the southeast corner of M3-3a to collect interim flows and convey them to the North Washington Street trunk system. FES-2 is anticipated to be used as a connection point for M3-3a and M3-3b in the fully developed condition. Runoff from M3-3c is anticipated to be collected within the urban street section storm sewer in the fully developed condition, which will tie into the proposed 24" stub at the east end of Colt. **Table A-1**, located within the Appendices, illustrates the maximum peak runoff rates from sub-basins M3-3a and M3-3b to FES-2, and from M3-3c to the 24" stub in Colt Avenue for the developed condition.

Analysis

Table 4 provided below compares runoff rates at Point of Analysis 1 (PA1). PA1 is located at the intersection of Lorrain Drive and North Washington Street. The peak runoff rates listed below are the summation of street and storm sewer flows to Lorrain Drive. Peak runoff rates to PA1 are as follows:

TABLE 4: POINT OF ANALYSIS 1 (PA1) – PEAK FLOW RATES; 10-YR & 100-YR, 6-HOUR STORM EVENTS

Location	Existing Master Plan/SWMP Peak Runoff Rates (cfs)		Developed Peak Runoff Rates (cfs)		Difference	
	10-year (cfs)	100-year (cfs)	10-year (cfs)	100-year (cfs)	10-year (cfs)	100-year (cfs)
PA1	95.0	181.0	94.2	175.7	-0.8	-5.3

The Existing Master Plan/SWMP Peak Runoff Rates refer to the values determined within the Master Plan Update for Watershed M3 to Lorrain Drive. The Developed Peak Runoff Rates represent the collective runoff from the analyzed sub-basins illustrated on **Exhibit 5**, with consideration for storage volumes, attenuation and lag times experienced over the runoff path. As illustrated in **Table 4** above, peak runoff rates to PA1 will decrease by 0.8 and 5.3 cfs during the 10-year and 100-year, 6-hour storm events, respectively, in the developed condition. The reduction in peak flow rates in the 100-year event is caused in part by the addition of detention ponds DP-1 and DP-2, which were not analyzed within the Master Plan Update. **Tables A-1** and **A-2**, located within the Appendices, provide additional information on the developed conditions of Drainage Area #1.

Recommendations for Future Development within Drainage Area #1

- Require improvements to the storm sewer system from Lorrain Drive to the regional detention area to occur before development of Arabian Avenue, Buckskin Avenue or Colt Avenue. The existing system cannot accommodate the 100-year, 6-hour storm event, and the proposed storm sewer system design is predicated upon the assumption that the downstream system is capable of receiving anticipated flows. **Exhibit 6** includes recommended minimum pipe sizes. (Note: this report did not analyze the downstream impacts of increased pipe sizes.)
- Require future developments within Drainage Area #1 (M3) to conform to flow rates consistent with the times of concentration, curve numbers and runoff rates presented in this report and the Master Plan Update. Any proposed development that would produce offsite runoff in excess of the Master Plan Update rates must provide onsite detention. Any development completed in an inconsistent manner could increase runoff rates at Lorrain Avenue and adversely impact downstream properties.
- Require future developments and urbanized roadways to collect all runoff locally and convey it to its respective storm sewer connection point and prevent any development from surface flowing onto North Washington Street or Ash Coulee Drive. The proposed curb inlets are designed to only collect runoff from within the areas illustrated on **Exhibit 5** and cannot meet City standards for flow spread if additional flows are added.
- Require DP-1 to be constructed before or concurrently with the development of Arabian Avenue into an urban road section. Upon development of Arabian Avenue, all runoff from M3-1e, M3-1f, M3-1g, M3-1h and M3-1i would flow south to DP-2 and subsequently to DP-1. DP-1 must be designed to limit flows to the future storm sewer connection point (Catch Basin 13a) to those defined in **Table A-2** of the Appendices.
- Require street improvements to Arabian Avenue to occur before or concurrently with the development of sub-basin M3-1b. Under interim conditions, portions of sub-basins M3-1h and M3-1e will flow east to FES-19. FES-19 is designed to only convey flow from the developed conditions of sub-basin M3-1b. The urbanization of Arabian Avenue will redirect all runoff from sub-basin M3-1h and M3-1e to future storm sewer that discharges south to DP-2.
- Require street improvements to Buckskin Avenue to occur before or concurrently with the development of sub-basins M3-2h or M3-2g. Under interim and existing conditions, sub-basin M3-2h will flow north through an existing culvert to the north roadway ditch of Buckskin Avenue located within sub-basin M3-2g. The north ditch will convey flow east to FES-1. FES-1 is designed to accommodate flow from the developed conditions of sub-basin M3-2b, M3-2c and M3-2f. The improvements to Buckskin Avenue will collect all runoff from sub-basins M3-2g, M3-2h and M3-2i within the roadway and convey it to the proposed 24" RCP storm sewer stub.
- Require that street improvements to Colt Avenue occur before or concurrently with the development of sub-basins M3-2e or M3-3c. Under interim conditions, sub-basins M3-2e and M3-3c will flow east to beehive inlet 11a and FES-2, respectively. Inlet 11a and FES-2 are designed to only convey flow from the developed conditions of sub-basin M3-2a and sub-basins M3-3a and M3-3b, respectively. The improvements to Colt Avenue will collect all runoff from sub-basins M3-2d, M3-2e and M3-3c within the roadway where future storm sewer will connect to the proposed 24" RCP storm sewer stub.

Drainage Area #2 –43rd/Ash Coulee Drive to Durango Drive

Existing, Master Plan & Site Specific SWMP Conditions

This 37.97-acre watershed is located within sub-watershed HC 3-9d of the 1,950-acre North Washington Street Watershed, which was Master-Planned in the 2004 *North Washington Street Stormwater Management Plan* (Master Plan). Wherever the term "Master Plan" is stated within this section, it shall refer to this report specifically.

Exhibit 7 includes a map of Drainage Area #2.

Runoff within Drainage Area #2 flows generally east to detention pond DP-3. DP-3 outlets east through a 24" RCP culvert across North Washington Street to an existing drainage channel within Boulder Ridge 1st Addition.

A storm water drainage easement extends west of the North Washington Street right-of-way past the 24" RCP outlet pipe of DP-3. Water currently ponds outside the easement for most modeled storm events and development is placing fill within the existing ponding area, reducing the amount of available storage in DP-3.

A portion of Drainage Area #2 also flows to the north and south curb-line of Durango Drive, which conveys flow east towards North Washington Street. As Durango Drive approaches North Washington Street, the curb and gutter ends and flow spills to lateral ditches that convey flow from the south curb-line to DP-3 and the north curb-line to detention pond DP-4 described in Drainage Area #3.

The Master Plan assumed that development within this region would be single-family residential lots for the area south of 57th Street, and stated that, "*…any development with a density greater than R10 is assumed to require a site local detention such that peak discharges are equal to or less than those generated under R5 zoning."* Based on the Type B underlying soils indicated in the Master Plan, this type of development was intended to maintain a Curve Number no greater than 75 (Table 3.3, City of Bismarck Stormwater Design Standards Manual, for Type B soils and ¼-acre lots).

The Master Plan (Figure 4.9 *Temporary Detention Areas)* labeled detention pond DP-3 as a "secondary storage site". According to the report, a "secondary storage site," is a potential place of storm water detention for future development. Furthermore, the report says, "*It is recommended the City evaluate these sites on a case-by-case basis through the plat related storm water management plan procedures."*

The 2005 *Boulder Ridge First Addition Stormwater Management Plan* states that runoff from developments upstream of Boulder Ridge 1st, namely for areas west of North Washington (Drainage Area #2), should maintain the existing (pre-developed) flow conditions. Boulder Ridge 1st Addition is anticipating 19.5 cfs and 26.30 cfs to discharge from DP-3 during the 10-year and 100-year, 24-hour storm events, respectively.

The 2012 *Northern Sky Addition SWMP* (NSA SWMP) analyzed Drainage Area #2 as the 33.5 acre Watershed 3-9d1. According to the NSA SWMP, Watershed 3-9d1 will develop as multi-family and commercial with a CN of 84 and a time of concentration of 11.5 minutes. Runoff from Watershed 3-9d1 is said to flow from the platted area to the existing detention area (DP-3) and outlet east through the existing 24" RCP to Boulder Ridge 1st Addition. Per the NSA SWMP, the existing detention pond is capable of providing 4.27 ac-ft of storage before overtopping onto North Washington Street. The NSA SWMP

analyzed the proposed conditions using the existing conditions of DP-3 (existing storage capacity and outlet pipe) and determined that DP-3 would discharge 26.0 cfs and 31.1 cfs to Boulder Ridge 5th Addition during the 10-year and 100-year, 6-hour storm events, respectively, thereby increasing flows to Boulder Ridge 1st Addition beyond those anticipated on the Boulder Ridge 1st Addition SWMP.

Proposed & Developed Conditions

Under the developed conditions, runoff from approximately 37.97 acres of Drainage Area #2 flows to detention pond DP-3. This drainage area includes runoff from sub-basin HC-3-9c as well as the runoff collected by two proposed storm sewer trunk lines from Durango to DP-3 and from 43rd/Ash Coulee. Runoff from sub-basin HC-3-9c is based on the hydrologic criteria illustrated in the NSA SWMP for the proposed conditions. Proposed storm sewer will collect runoff from 43rd Avenue/Ash Coulee, North Washington Street and Durango Drive right-of-way areas and discharge to DP-3 through FES-3 and FES-6. **Table A-1**, located within the Appendices, illustrates maximum peak runoff rates to DP-3 from sub-basin HC3-9D. **Table A-2**, located within the Appendices, illustrates maximum peak runoff rates to DP-3 from FES-3 and FES-6. DP-3 will outlet east through the existing 24" RCP, which will be removed and re-laid at a shallower slope in order to accommodate future development, and will discharge to a proposed manhole (MH-17) on the east side of North Washington. At the request of the property owner, a 24" RCP will convey flow northeast from MH-17 to a proposed temporary drainage ditch located within Boulder Ridge 1st Addition. The temporary drainage ditch will convey flow east to the existing drainage ditch located within Boulder Ridge 1st Addition.

Analysis

Table 5 provided below compares runoff rates at Point of Analysis 2 (PA2). PA2 is located at the discharge point of the DP-3 outlet to the existing Boulder Ridge 1st Addition drainage ditch. Peak runoff rates to PA2 during the 10-year and 100-year, 6-hour storm event are as follows:

TABLE 5: POINT OF ANALYSIS 2 (PA2) – PEAK FLOW RATES; 10-YR & 100-YR, 6-HOUR STORM EVENTS

Location	Existing Master Plan/SWMP Peak Runoff Rates (cfs)		Proposed Peak Runoff Rates (cfs)		Difference	
	10-year (cfs)	100-year (cfs)	10-year (cfs)	100-year (cfs)	10-year (cfs)	100-year (cfs)
PA2	19.5	26.3	21.7	27.9	2.2	1.6

The Existing Master Plan/SWMP Peak Runoff Rates are in reference to the values determined within the Boulder Ridge 1st Addition SWMP for discharge to Boulder Ridge 1st Addition from DP-3. The Proposed Peak Runoff Rates represent the collective runoff from the analyzed sub-basins illustrated on **Exhibit 7**, with consideration for storage volumes, attenuation and lag times experienced over the runoff path, the existing storage volume of DP-3, and the proposed configuration of the modified DP-3 outlet pipe. As illustrated in **Table 5** above, peak runoff rates to PA2 will increase by 2.2 cfs and 1.6 cfs during the 10-year and 100-year, 6-hour storm events, respectively, in the proposed conditions. The results above are in regard to the proposed conditions and do not reflect the fully developed conditions of Drainage Area #3. Under developed conditions, DP-3 should be adequately sized such that peak discharge rates do not exceed the pre-developed rates of discharge.

Recommendations for Future Development within Drainage Area #2

- Require DP-3 to remain within the NSA. DP-3 was labeled as a secondary drainage area within the Master Plan and was described as a detention area left to the City to determine if necessary to accommodate future development. With the current trend of development and the existing infrastructure within Boulder Ridge 1st Addition, it is critical that DP-3 remains in place.
- Require a new storm water detention easement be recorded for DP-3 before any additional development occurs within Northern Sky Addition. Development has already begun to reduce the existing available storage within DP-3 and the current platted storm water easement is much smaller than the existing detention area. DP-3 must be adequately sized to accommodate the current development trend. Additionally, require DP-3 to be designed to match the conditions stated within the *Boulder Ridge 1st Addition SWMP*. Peak flow rates from DP-3 should not exceed 19.50 cfs and 26.3 cfs during the 10-year and 100-year, 6-hour storm events.
- Restrict any development that would surface flow onto North Washington Street, Ash Coulee/43rd Avenue or Durango Drive. The proposed storm inlets were designed to only intercept flow from the areas illustrated on **Exhibit 7**.

Drainage Area #3 - Durango Drive to Medora Avenue

Existing, Master Plan & Site Specific SWMP Conditions

This 31.73-acre drainage area is located within Watershed HC3-9c of the 1,950-acre North Washington Street Watershed, which is a sub-watershed of the Hay Creek Watershed (previously described), and was Master-Planned in the 2004 *North Washington Street Stormwater Management Plan* (Master Plan). Wherever the term "Master Plan" is stated within this section, it shall refer to this report specifically.

Exhibit 7 includes a map of Drainage Area #3.

Runoff from Drainage Area #3 flows generally east towards existing detention ponds DP-4, DP-5 and DP-6 on the west side of the North Washington Street shared use trail. Storm water detention easements extend west from the North Washington Street right-of-way for DP-4, DP-5 and DP-6. DP-4 and DP-5 outlet into existing 18" culverts, which discharge into the ditch section between the shared use trail and North Washington. This ditch section flows north to an existing 18" culvert, which crosses back under the shared use trail and discharges west to detention pond DP-6, which is located at the northeast corner of Drainage Area #3. DP-6 outlets east through an existing 30" culvert, which crosses under North Washington Street to an existing manhole that conveys flow northeast through an existing 30" RCP under Medora Avenue to an existing drainage ditch within Boulder Ridge 5th Addition. An 18" culvert collects ditch flow on the east side of North Washington and ties into the same existing manhole.

The north portion of Drainage Area #3 (HC3-9c-3) contains undeveloped property and single-family residential development. This area surface flows east to DP-6.

Drainage Area #3 also contains the southern portion (+/- 3.66 acres) of the Good Shepherd Addition, which is currently developed. Runoff from this area flows south to existing curb inlets within Medora Avenue, which discharge to the south into DP-6.

According to the Master Plan (Figure 4.9, *Temporary Detention Areas),* detention ponds DP-4 and DP-6 were analyzed as a secondary storage sites. The purpose of the secondary storage sites is to aid in controlling peak discharges from future developments. Furthermore, the report states, "*It is recommended the City evaluate these sites on a case-by case basis through the plat related storm water management plan procedures."*

The 2005 *Boulder Ridge 1st Addition SWMP* anticipated that 30.3 acres would flow to DP-6 and outlet through the 30" RCP culvert to Boulder Ridge 1st Addition. In that SWMP, a storm manhole was added on the south side of Medora to collect flows from the 30" RCP from DP-6 and the 18" culvert from the east North Washington Ditch. A 30" RCP outlet was then installed, which shifted discharge from the south side of Medora (Boulder Ridge 1st) to the greenway on the north side of Medora (Boulder Ridge 5th). Once Drainage Area #3 is fully developed, the *Boulder Ridge 1st Addition SWMP* anticipated that DP-6 would discharge 33.9 cfs and 47.0 cfs during the 10-year and 100-year, 6-hour storm events.

Detention ponds DP-4 and DP-5 were designed in the 2009 *Legacy Addition SWMP*. That SWMP determined that DP-4 would discharge 4.1 cfs and 7.0 cfs during the 10-year and 100-year, 6-hour storm events, respectively. Also, the SWMP analyzed that DP-5 would discharge 6.5 cfs and 13.6 cfs 10-year and 100-year, 6-hour storm events, respectively.

Proposed & Developed Conditions

Runoff from Drainage Area #3 will generally follow the existing conditions. The developed condition of Drainage Area #3 will maintain the three existing detention ponds, but the outlets of DP-4 and DP-5 will be tied directly into the North Washington trunk line. Furthermore, the existing 18" CSP outlet pipe of DP-4 will be replaced with an 18" RCP and a drop manhole will be placed in line with the existing 18" CSP outlet pipe of DP-5. Curb inlets, constructed along the roadway, will intercept runoff from areas illustrated on **Exhibit 7** and convey it to the trunk line. The trunk line will flow north to MH 21 installed in-line with the existing 30" RCP outlet pipe from pond DP-6. The new manhole will tie to the existing manhole on the east side of North Washington, which will continue to outlet north of Medora Avenue.

Runoff to detention pond DP-6 will be reduced significantly in the proposed conditions due to the collection of DP-4 and DP-5 directly into the trunk line. Only sub-basins HC3-9C-3, SMA 01 and NMA 01 will flow to DP-6. Sub-basins SMA 01 and NMA 01 will continue to flow to inlets within Medora Avenue, and sub-basin HC3-9c-3 will surface flow to DP-6. The undeveloped portions of sub-basin HC3-9c-3 were analyzed per the Master Plan (CN=75).

Analysis

Table 6 provided below compares runoff rates at Point of Analysis 3 (PA3). PA3 is located at the storm sewer discharge point north of Medora Avenue and east of North Washington Street. Peak runoff rates to PA3 during the 10-year and 100-year, 6-hour storm event are as follows:

TABLE 6: POINT OF ANALYSIS 3 (PA3) – PEAK FLOW RATES; 10-YR & 100-YR, 6-HOUR STORM EVENTS

Location	Existing Master Plan/SWMP Peak Runoff Rates (cfs)		Developed Peak Runoff Rates (cfs)		Difference	
	10-year (cfs)	100-year (cfs)	10-year (cfs)	100-year (cfs)	10-year (cfs)	100-year (cfs)
PA3	33.9	47.0	32.4	46.6	-1.5	-0.4

The Existing Master Plan/SWMP Peak Runoff Rates were established from the Boulder Ridge 1st and 5th Addition SWMP's for the areas that discharge to Boulder Ridge 5th Addition from the existing 30" RCP culvert. Developed Peak Runoff Rates were determined from the collective runoff from the analyzed sub-basins illustrated on **Exhibit 7**, with consideration for storage volumes, attenuation and lag times experienced over the runoff path, the existing storage volume and outlet pipe of DP-6 and the proposed pond release rates of DP-4 and DP-5 described within the *Legacy Addition SWMP*. As illustrated in **Table 6** above, peak runoff rates to PA3 in the developed condition are expected to decrease by 1.5 cfs and 0.4 cfs during the 10-year and 100-year, 6-hour storm events, respectively.

Recommendations for Future Development within Drainage Area #3

- Require DP-6 to remain in its current location. Detention pond DP-6 is labeled as a secondary drainage area within the Master Plan. This pond is critical to the existing infrastructure within Drainage Area #3 and Boulder Ridge 1st and 5th Additions.
- Require that future developments within sub-basin HC3-9c-3 conform to flow rates associated with the curve numbers and runoff rates presented in this report and the Master Plan. Any development that would produce offsite runoff in excess of the Master Plan rates should provide additional onsite detention to maintain Master Plan rates. Any development completed in an inconsistent manner could increase runoff rates to Boulder Ridge 5th Addition and adversely impact downstream properties.
- Restrict any development that would surface flow onto North Washington Street, with the exception of the areas illustrated on **Exhibit 7**. The North Washington Street storm sewer inlets are sized to accommodate street flows only.

Drainage Area #4 Medora Avenue to LaSalle Drive

Existing, Site Specific and Master Plan Conditions

This 15.49-acre Drainage Area #4 lies within sub-watershed HC 3-9c of the 2004 *North Washington Street Stormwater Management Plan* (Master Plan) and, more specifically, within the 16.6-acre N-HC3-9c watershed described within the 2005 *Good Shepherd Lutheran Church Storm Water Management Plan* (GSA SWMP). Wherever the term "Master Plan" is stated within this section, it shall refer to the 2004 *North Washington Street Stormwater Management Plan* report specifically.

A map of Drainage Area #4 is included on **Exhibit 8**.

Runoff from Drainage Area #4 flows generally east to detention pond DP-7, which outlets through a 24" RCP culvert to a drainage channel within Boulder Ridge 5th Addition, east of North Washington Street. DP-7 is bound by North Washington Street to the east and is not located within a designated storm water detention easement. The GSA SWMP intended for 16.6 acres of the property to flow to DP-7. In the existing condition, approximately 13.3 acres flow east to DP-7, 3.2 acres flow north to LaSalle Drive and 1 acre flows east to the west roadway ditch of North Washington.

The GSA SWMP provided for the installation of a 24"x18"x4.25' outlet control structure with a 12" orifice installed at the 24" RCP pond outlet. The report states that release rates from DP-7 through the control structure would be 11 cfs and 14 cfs during the 10-year and 100-year, 6-hour storm events, respectively. Although the tributary areas to DP-7 from Good Shepherd were reduced from the original SWMP, these release rates were utilized in the storm sewer system design.

Drainage Area #4 was analyzed as the upstream drainage area of Watershed 3-9c6a under the 2012 *Boulder Ridge 5th Addition SWMP* (BR5 SWMP). That SWMP planned for a 24" RCP pipe to tie to the existing 24" RCP outlet pipe of DP-7. Boulder Ridge 5th Addition anticipated 17.8 cfs and 25.2 cfs of discharge from detention pond DP-7 during the 10-year and 100-year, 6-hour storm events, respectively.

Proposed & Developed Conditions

The proposed condition of Drainage Area #4 will generally follow the existing conditions. Runoff from sub-basin HC 3-9c-4 (13.3 acres) will continue to flow east to existing detention pond DP-7. Two curb inlets (24a & 24b) and a new manhole (MH-24) will be cut-in to the existing 24" RCP pond outlet to tie in the upstream North Washington trunk line and street flows. The outlet of the existing 24" RCP will be extended and re-routed to promote functionality with respect to the proposed urban road section.

After discussion with the City, it was determined that the 3.2 acre sub-basin SLD-01, portions of which were included in the DP-7 tributary area under the GSA SWMP, would not be modified to flow south to DP-7, but would instead be collected at LaSalle Drive. Two on-grade 72" curb inlets (30c & 30d) will be installed at the east end of LaSalle to convey runoff from this sub-basin to the Drainage Area #5 storm sewer trunk line, and to provide connection points for future development of LaSalle. A developed curve number of 78 was used to size the LaSalle Drive curb inlets. **Table A-1**, located in the Appendices, illustrates the maximum peak runoff rates to LaSalle Drive from sub-basin SLD 01.

Analysis

Table 7 provided below compares runoff rates at Point of Analysis 4 (PA4). PA4 is located at the proposed 24" RCP outlet to the Boulder Ridge 5th Addition drainage ditch. Peak flow rates to PA4 are as follows:

TABLE 7: POINT OF ANALYSIS 4 (PA4) - PEAK FLOW RATES; 10-YR & 100-YR, 6-HOUR STORM EVENTS

Location	Existing Master Plan/SWMP Peak Runoff Rates (cfs)		Developed Peak Runoff Rates (cfs)		Difference	
	10-year (cfs)	100-year (cfs)	10-year (cfs)	100-year (cfs)	10-year (cfs)	100-year (cfs)
PA4	17.8	25.2	17.5	26.4	-0.3	1.2

The Existing Master Plan/SWMP Peak Runoff Rates were established from the BR5 SWMP for the area that discharges to Boulder Ridge 5th Addition from the existing 24" RCP culvert. Developed Peak Runoff Rates were determined by the collective runoff from the analyzed sub-basins shown on **Exhibit 7**, with consideration for storage volumes, attenuation and lag times experienced over the runoff path, and the proposed discharge rates from DP-7 illustrated within the GSA SWMP. As illustrated in **Table 7** above, peak runoff rates to PA4 are anticipated to decrease by 0.3 cfs and increase by 1.2 cfs during the 10-year and 100-year, 6-hour storm events, respectively. The increase between the 100-year BR5 SWMP rate and the Developed rate may be a reflection of the use of different modeling software. It is recommended that any future development within this area evaluate DP-7 in order to reduce 100-year runoff rates.

Recommendations for Future Development within Drainage Area #4

- Require a storm water detention easement to be recorded for DP-7 and restrict any development that places fill within DP-7 at or below the proposed North Washington right-of-way overtopping elevation of 1,894 ft-NGVD29. Currently, DP-7 is not located within a storm water detention easement and, as such, the existing storage volume is subject to change. Any structures or fill placed at or below 1,894 ft-NGVD29 could cause DP-7 to overtop onto North Washington Street.
- Restrict any development that would surface flow onto North Washington Street or LaSalle Drive with the exception of the areas illustrated on **Exhibit 7**.
- Require sub-basin SLD-01 to limit flows to LaSalle to those included in **Table A-1** of the Appendices. Any runoff in excess of the **Table A-**1 values caused by future development must be directed to DP-7.

Drainage Area #5 - LaSalle Drive to Restful Drive

Existing, Site Specific and Master Plan Conditions

This 60.05-acre Drainage Area #5 is primarily located west of North Washington Street between LaSalle Drive and Restful Drive. Drainage Area #5 lies within sub-watersheds HC 3-9c, HC 3-8g2 and HC 3-8e as delineated in the 2004 *North Washington Street Stormwater Management Plan* (Master Plan). Wherever the term "Master Plan" is stated within this section, it shall refer to this report specifically. This drainage area was further delineated and studied in subsequent stormwater management plans, including the 2012 *Boulder Ridge 5th Addition*, the 2013 *Brei Estates 1st Addition Stormwater Management Plan* (Brei Estates SWMP) and the ongoing APEX regional storm water detention study.

Drainage Area #5 is included on **Exhibits 8, 9 & 10**.

The majority of Drainage Area #5 (SLD-01, HC3-9c-5, HC3-9c-6, HC3-8g2-1, HC3-8g2-2, HC3-8g2-3 & HC3-8e-4) flows generally east to the west ditch of North Washington, then through ditches and culverts towards the existing 7'x5' RC Box Culvert, located approximately 500 feet south of 57th Avenue. The box culvert discharges east across North Washington to an existing stormwater easement.

Sub-basin HC3-9a-1 flows west to the east ditch of North Washington Street. The east ditch flows south to an 18" CSP culvert across 57th Avenue that discharges south to a storm water easement east of North Washington.

Sub-basin HC3-9c-5 was analyzed as Watershed WS-5 in the Brei Estates SWMP, which anticipated WS-5 to be developed at 60% impervious coverage. To control proposed site discharge to the existing rates, the Brei Estates SWMP stated that a future detention pond (DP-8) would be required to be constructed within the northeast corner of the lot. DP-8 has not been constructed and an easement has not been recorded at the time of this report. As illustrated in the SWMP, peak discharges from detention pond DP-8 are expected to be less than or equal to 3.7 cfs and 9.1 cfs during the 10-year and 100—year, 6-hour storm events, respectively.

Proposed & Developed Conditions

Two trunk storm sewer systems will be constructed within Drainage Area #5, to the north and south of the existing 7'x5' RC box culvert. Under proposed conditions, the south trunk line will receive inflow collected by the curb inlets along North Washington Street and LaSalle Drive. Storm sewer stubs will be provided at Cornice Drive and Brie Estates for future connections to the south trunk-line as shown on **Exhibit 8**. The north trunk-line will receive runoff from sub-basins HC3-8g2-2, HC3-8g2-3 and HC3-8e-4 as well as from curb inlets along North Washington Street. Both trunk lines will discharge east of North Washington through FES-11 (south) and FES-15 (north) to the existing storm water easement. **Table A-2**, located within the Appendices, illustrates anticipated peak runoff rates through FES-11 and FES-15 as Structure Name "26a" and "33b," respectively.

The existing 7'x5' box culvert across North Washington Street will modified to accommodate the proposed increase in roadway width. The inlet will be extended 50 LF west and the outlet will be extended 83 LF east and will deflect 30 degrees north to discharge within the existing channel. Both extensions will maintain the original pipe slope. These proposed box culvert modifications were

discussed with APEX Engineering, who indicated that the proposed configuration would not present any adverse impacts upstream or downstream of the culvert.

The drainage area between 57th Avenue and Restful Drive will continue to flow east to the west ditch of North Washington Street. The existing west ditch will be maintained and modified to convey flow south to a 24" culvert (FES-16) which connects to the north trunk storm sewer system. A shallow swale will be installed downstream of the FES-16 between the shared use trail and North Washington Street to convey overflow from FES-16 south to Catch Basin 34a. 34a will collect area drainage and bypass flows from FES-16, and will connect to the north trunk storm sewer.

Sub-basin HC3-9a-1, located east of North Washington Street, will continue to flow west to the east ditch. The east ditch will convey flow south to a proposed 24" RCP culvert (FES-14) that ties into the north trunk storm sewer system.

Sub-basin HC3-8g2-2 will flow southeast to an 18" culvert (FES-13). The 18" culvert will convey flow east to the north trunk storm sewer system.

Sub-basin HC3-8g2-3 will flow southeast to the shallow swale that traverses between the shared use trail and North Washington Street. The shallow swale will convey flow south to Catch Basin 34a.

Sub-basin HC3-8e-4 will flow southeast to the reconstructed ditch between the shared use trail and North Washington Street, which will convey flow south to FES-16. Bypass flows from FES-16 will continue south to Catch Basin 34a.

Analysis

Comparative analysis of Master Plan to Proposed conditions was not performed for Drainage Area #5, as this would require modeling of all upstream sub-basins tributary to the regional detention area, DP-9, which is outside of the scope of this report. Peak runoff rates and ponding elevations were determined for the developed conditions, as listed in **Table A-2** of the Appendices. Runoff from approximately 30.5 acres of tributary area that previously discharged to the west side of North Washington, upstream of the box culvert, will be collected in the proposed trunk lines and discharged on the east side of North Washington, downstream of the box culvert. This will effectively bypass DP-9. However, due to the large capacity of the box culvert, existing detention characteristics of DP-9 are minimal and the capacity of the downstream stormwater drainage easement is such that adverse impacts are not anticipated. Future design and construction of downstream detention facilities must accommodate this bypass.

Table 8 provided below illustrates the peak runoff rates to Point Analysis 5 (PA5) for the proposed conditions. PA5 is located at the 7'x5' RCB culvert discharge into the existing storm water drainage easement. Peak flow rates at PA5 are as follows:

TABLE 8: POINT OF ANALYSIS 5 (PA5) - PEAK FLOW RATES; 10-YR & 100-YR, 6-HOUR STORM EVENTS

Location	Developed Peak Runoff Rates (cfs)	
	10-year (cfs)	100-year (cfs)
PA5	61.9	131.7

Developed Peak Runoff Rates were determined by the collective runoff from the analyzed sub-basins shown on **Exhibits 8, 9 and 10**, with consideration for storage volumes, attenuation and lag times experienced over the runoff path, and the proposed discharge rates from DP-8 illustrated within the Brei Estates SWMP. This rate includes the combined peak flows from FES-11, FES-15 and HC3-8g2-1.

Recommendations for Future Development within Drainage Area #5

- Restrict any development that would surface flow onto North Washington Street and LaSalle Drive with the exception of the areas illustrated on **Exhibit 7**.
- Limit the length of Cornice Drive that flows to North Washington Street to 250' west of the west right-of-way line of North Washington Street. Per direction received from the City, the proposed 18" storm sewer system stub-out was designed to accommodate runoff from 250' of Cornice Drive and areas south of and tributary to Cornice Drive within said 250' section.
- Restrict any Cornice Drive street flows from discharging onto North Washington Street. All street flows needs to be collected within storm sewer and conveyed to the proposed 18" RCP stub.
- Require that Brei Estates develop in strict accordance with the Brei Estates SWMP. Flow discharged from DP-8 should not exceed 3.7 cfs and 9.1 cfs during the 10-year and 100—year, 6-hour storm events, respectively.
- Require that a stormwater detention easement for DP-8 be recorded, as specified in the Brei Estates SWMP.

Drainage Area #6 North Washington Street to Montreal Drive

Existing, Site Specific and Master Plan Conditions

This 0.37-acre Drainage Area #6 is located along the northern boundary of the First Evangelical Free Church lot, west of Montreal Street, and currently consists of the south roadway ditch of 43rd Avenue NW. Runoff from this area flows east to a 24" CSP culvert which flows across Montreal Street to an 18" RCP culvert. The 18" RCP culvert flows north across 43rd Avenue NW to Boulder Ridge 1st Addition.

Exhibit 10 includes a map of Drainage Area #6.

Proposed & Developed Conditions

Runoff from Drainage Area #6 will generally follow the existing conditions. The south ditch of 43rd Avenue will be filled in and a shallow swale will be graded to flow east to Catch Basin 38b. An on-grade curb inlet (38a) will be constructed north of 38b to intercept street flow, and will discharge to 38b. The existing 24" CSP culvert across Montreal will be removed and replaced with an 18" RCP culvert. The new 18" RCP culvert will discharge on the east side of Montreal Street through FES-18, and will flow to the existing 18" RCP culvert that flows north across 43rd Avenue to Boulder Ridge 1st Addition.

Analysis

Table 9 provided below compares runoff rates at Point of Analysis 6 (PA6). PA6 is located at FES-18, the discharge point of the proposed 18" RCP east of Montreal Street. Peak flow rates at PA6 are as follows:

TABLE 9: POINT OF ANALYSIS 6 (PA6) - PEAK FLOW RATES; 10-YR & 100-YR, 6-HOUR STORM EVENTS

Location	Existing Peak Runoff Rates (cfs)		Developed Peak Runoff Rates (cfs)		Difference	
	10-year (cfs)	100-year (cfs)	10-year (cfs)	100-year (cfs)	10-year (cfs)	100-year (cfs)
PA6	1.4	2.1	1.3	2.0	-0.1	-0.1

The Existing Peak Runoff Rates were determined by analyzing the existing condition of Drainage Area #6 in order to calculate current flows out of the existing 24" CSP culvert at Montreal. Developed Peak Runoff Rates were determined by the collective runoff from the analyzed sub-basins shown on **Exhibit 10**, with consideration for storage volumes, attenuation and lag times experienced over the runoff path. As illustrated in **Table 9** above, peak runoff rates to PA6 are anticipated to decrease by 0.1 cfs during both the 10-year and 100-year, 6-hour storm events.

Recommendations

Drainage Area #6 is already developed and will not change between the "proposed" and "developed" conditions. No recommendations for future development will therefore be provided.

EROSION AND SEDIMENTATION PREVENTION

Erosion Control Plan and BMP Selection

Description

Erosion control plans have been developed for this project per NDDOT specifications and will be included in the bid documents for the North Washington Street Reconstruction Project.

Stormwater Pollution Prevention – General Permit

The project requires that a General Permit be obtained by the North Dakota Department of Health. An application package with all associated requirements may be acquired by contacting the North Dakota Department of Health at 701-328-5210. The forms and requirements outlined in the package are also available on the State of North Dakota's website at: http://www.health.state.nd.us/ndhd/environ/wq/storm/permits/.

CONCLUSIONS

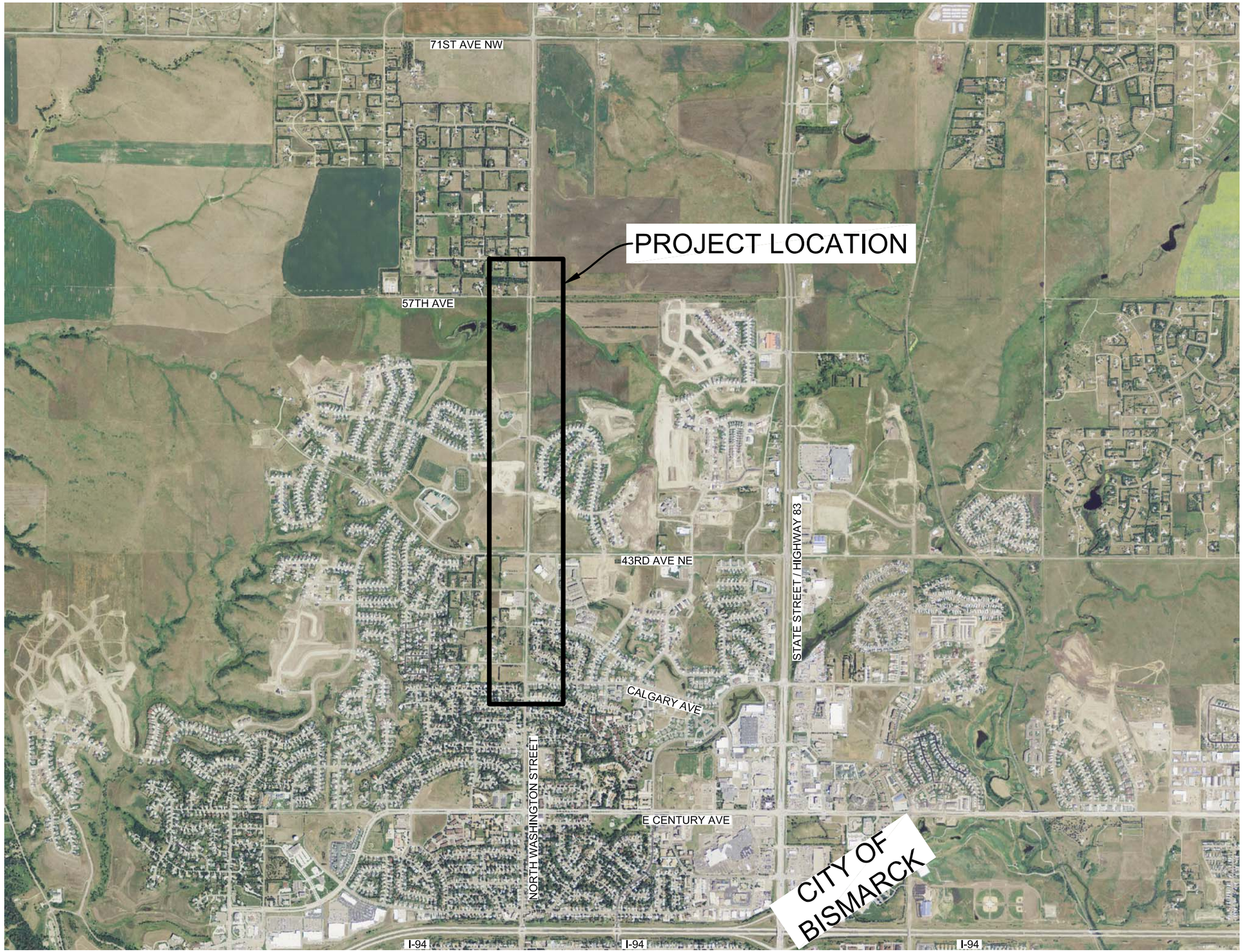
In preparing this report, the Master Plans and subsequent site-specific Stormwater Management Plans for the project area and surrounding areas (see **Exhibit 04**) were reviewed and compared. During this review, it was observed that actual development of the project area is proceeding at a higher density than that provided for in the Master Plans. This report includes recommendations for the City to follow in allowing future development of properties adjacent to the project corridor. As development of the region proceeds, and as final land use patterns emerge, it is of vital importance that the City acknowledge and implement these recommendations in order to ensure that future developments do not overwhelm the existing and proposed stormwater systems.

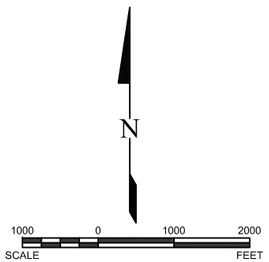
The design of the proposed storm sewer trunk systems and stub-outs for future connections assumed that any future developments adjacent to the North Washington Street project corridor would conform to the development types and densities prescribed in this report and the Master Plans, or would provide onsite detention to limit offsite drainage rates to those prescribed in this report. It is critical that the existing onsite detention areas adjacent to North Washington Street be maintained and utilized to offset the increased development density.

As discussed in the "Drainage Area #1" section of this report, the existing Lorrain Drive storm sewer system lacks the capacity to convey the flows that will be discharged by the proposed storm sewer system between Calgary and 43rd. In order to ensure that the proposed system functions as designed, and that downstream properties are not put at risk, it is crucial that the Lorrain Drive storm sewer system be modified to accommodate the anticipated runoff volumes.

This report was prepared in accordance with the City of Bismarck Ordinance Number 4817 and follows the guidelines set forth in the City of Bismarck "Stormwater Design Standards Manual".

Any Questions or comments may be directed to Brad Krogstad, PE, KLJ, 4585 Coleman Street, Bismarck, ND 58503, (701) 355-8437.





KLJ

NO.	DATE	REVISION

DRAFTED
EJB
REVIEWED
CWB
PROJECT NUMBER
1412129
ISSUE DATE
07/17/2014

NORTH WASHINGTON STREET

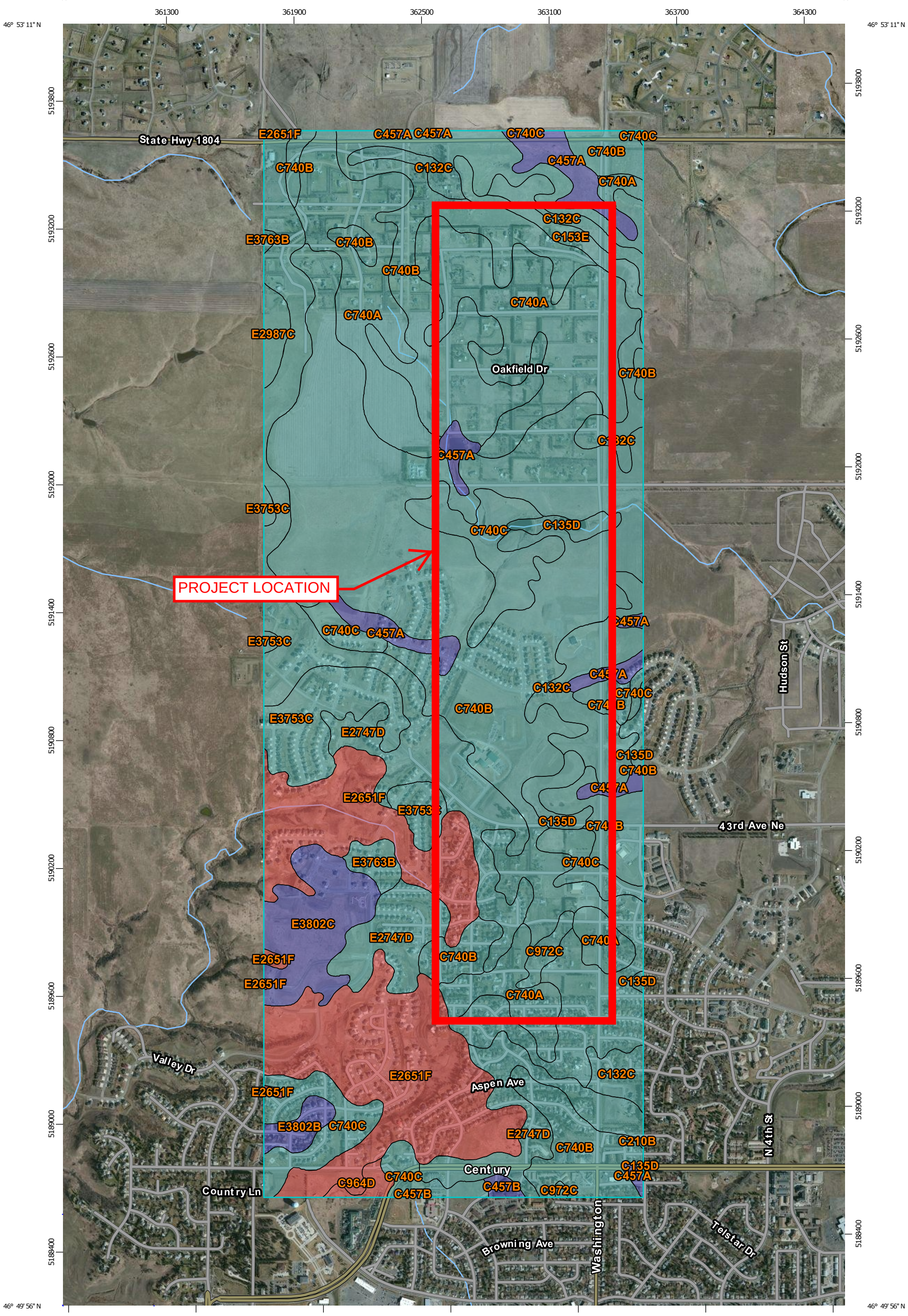
CITY OF BISMARCK
BISMARCK, ND

VICINITY MAP

SHEET
EX 01

Jul 22, 2014 - 2:17pm - J:\trans\1412129\CADD\SWMP\1412129-VicinityMap.dwg

Hydrologic Soil Group—Burleigh County, North Dakota
(North Washington HSG Map)



Map Scale: 1:16,800 if printed on B portrait (11" x 17") sheet.

N

Meters: 0 200 400 800 1200

Feet: 0 500 1000 2000 3000

Map projection: Web Mercator Corner coordinates: WGS84 Edge tics: UTM Zone 14N WGS84

EX 02

MAP LEGEND

Area of Interest (AOI)
- Area of Interest (AOI)

Soils

Soil Rating Polygons
- A
- A/D
- B
- B/D
- C
- C/D
- D
- Not rated or not available

Soil Rating Lines
- A
- A/D
- B
- B/D
- C
- C/D
- D
- Not rated or not available

Soil Rating Points
- A
- A/D
- B
- B/D
- C
- C/D
- D
- Not rated or not available

Water Features
- Streams and Canals

Transportation
- Rails
- Interstate Highways
- US Routes
- Major Roads
- Local Roads

Background
- Aerial Photography

MAP INFORMATION

The soil surveys that comprise your AOI were mapped at 1:20,000.

Please rely on the bar scale on each map sheet for map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL: http://websoilsurvey.nrcs.usda.gov
Coordinate System: Web Mercator (EPSG:3857)

Maps from the Web Soil Survey are based on the Web Mercator projection, which preserves direction and shape but distorts distance and area. A projection that preserves area, such as the Albers equal-area conic projection, should be used if more accurate calculations of distance or area are required.

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: Burleigh County, North Dakota
Survey Area Data: Version 13, Jul 23, 2012

Soil map units are labeled (as space allows) for map scales 1:50,000 or larger.

Date(s) aerial images were photographed: Aug 21, 2011—Mar 30, 2012

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

Hydrologic Soil Group

Hydrologic Soil Group— Summary by Map Unit — Burleigh County, North Dakota (ND015)				
Map unit symbol	**Map unit name**	**Rating**	**Acres in AOI**	**Percent of AOI**
C132C	Williams-Zahl-Zahill complex, 6 to 9 percent slopes	C	110.9	5.0%
C135D	Zahl-Williams loams, 9 to 15 percent slopes	C	27.3	1.2%
C153E	Zahl-Max loams, 15 to 25 percent slopes	C	19.8	0.9%
C210B	Williams-Bowbells loams, 3 to 6 percent slopes	C	0.4	0.0%
C457A	Grassna silt loam, 0 to 2 percent slopes	B	59.9	2.7%
C457B	Grassna silt loam, 2 to 6 percent slopes	B	4.0	0.2%
C740A	Temvik silt loam, 0 to 3 percent slopes	C	289.0	13.0%
C740B	Temvik silt loam, 3 to 6 percent slopes	C	855.2	38.6%
C740C	Temvik silt loam, 6 to 9 percent slopes	C	128.0	5.8%
C964D	Sen-Werner complex, 9 to 15 percent slopes	D	6.1	0.3%
C972C	Sen silt loam, 6 to 9 percent slopes	C	9.0	0.4%
E2651F	Werner-Amor-Arnegard loams, 9 to 50 percent slopes	D	272.8	12.3%
E2747D	Werner-Chama-Sen silt loams, 9 to 15 percent slopes	C	263.2	11.9%
E2987C	Sen-Chama silt loams, 6 to 9 percent slopes	C	10.6	0.5%
E3753C	Omio-Amor silt loams, 6 to 9 percent slopes	C	72.2	3.3%
E3763B	Temvik-Wilton-Williams silt loams, 3 to 6 percent slopes	C	11.9	0.5%
E3802B	Linton-Mandan silt loams, 2 to 6 percent slopes	B	12.3	0.6%
E3802C	Linton-Mandan silt loams, 6 to 9 percent slopes	B	63.4	2.9%
Totals for Area of Interest			**2,215.7**	**100.0%**

Description

Hydrologic soil groups are based on estimates of runoff potential. Soils are assigned to one of four groups according to the rate of water infiltration when the soils are not protected by vegetation, are thoroughly wet, and receive precipitation from long-duration storms.

The soils in the United States are assigned to four groups (A, B, C, and D) and three dual classes (A/D, B/D, and C/D). The groups are defined as follows:

Group A. Soils having a high infiltration rate (low runoff potential) when thoroughly wet. These consist mainly of deep, well drained to excessively drained sands or gravelly sands. These soils have a high rate of water transmission.

Group B. Soils having a moderate infiltration rate when thoroughly wet. These consist chiefly of moderately deep or deep, moderately well drained or well drained soils that have moderately fine texture to moderately coarse texture. These soils have a moderate rate of water transmission.

Group C. Soils having a slow infiltration rate when thoroughly wet. These consist chiefly of soils having a layer that impedes the downward movement of water or soils of moderately fine texture or fine texture. These soils have a slow rate of water transmission.

Group D. Soils having a very slow infiltration rate (high runoff potential) when thoroughly wet. These consist chiefly of clays that have a high shrink-swell potential, soils that have a high water table, soils that have a claypan or clay layer at or near the surface, and soils that are shallow over nearly impervious material. These soils have a very slow rate of water transmission.

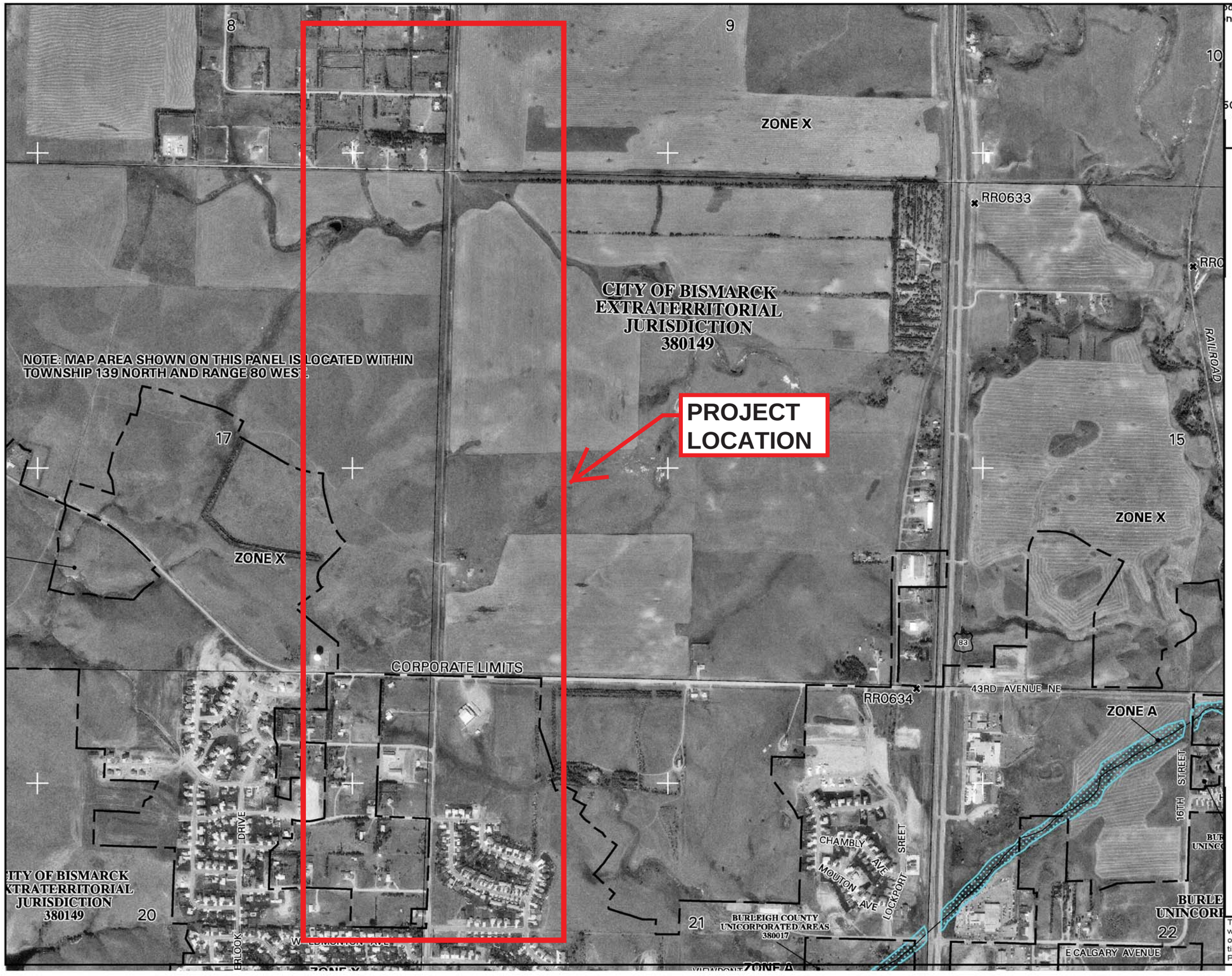
If a soil is assigned to a dual hydrologic group (A/D, B/D, or C/D), the first letter is for drained areas and the second is for undrained areas. Only the soils that in their natural condition are in group D are assigned to dual classes.

Rating Options

Aggregation Method: Dominant Condition

Component Percent Cutoff: None Specified

Tie-break Rule: Higher



...nd Insurance is available in this community, contact you...
...nal Flood Insurance Program at (800) 638-6620.

MAP SCALE 1" = 1000'

500 0 1000 2000 FEET

PANEL 0785C

FIRM

FLOOD INSURANCE RATE MAP

BURLEIGH COUNTY,
NORTH DAKOTA AND
INCORPORATED AREAS

PANEL 785 OF 1125

(SEE MAP INDEX FOR FIRM PANEL LAYOUT)

CONTAINS:

COMMUNITY	NUMBER	PANEL	SUFFIX
BURLEIGH COUNTY, UNINCORPORATED AREAS	380017	0785	C
BISMARCK, CITY OF	380149	0785	C

Notice to User: The **Map Number** shown below should be used when placing map orders; the **Community Number** shown above should be used on insurance applications for the subject community.

MAP NUMBER
38015C0785C

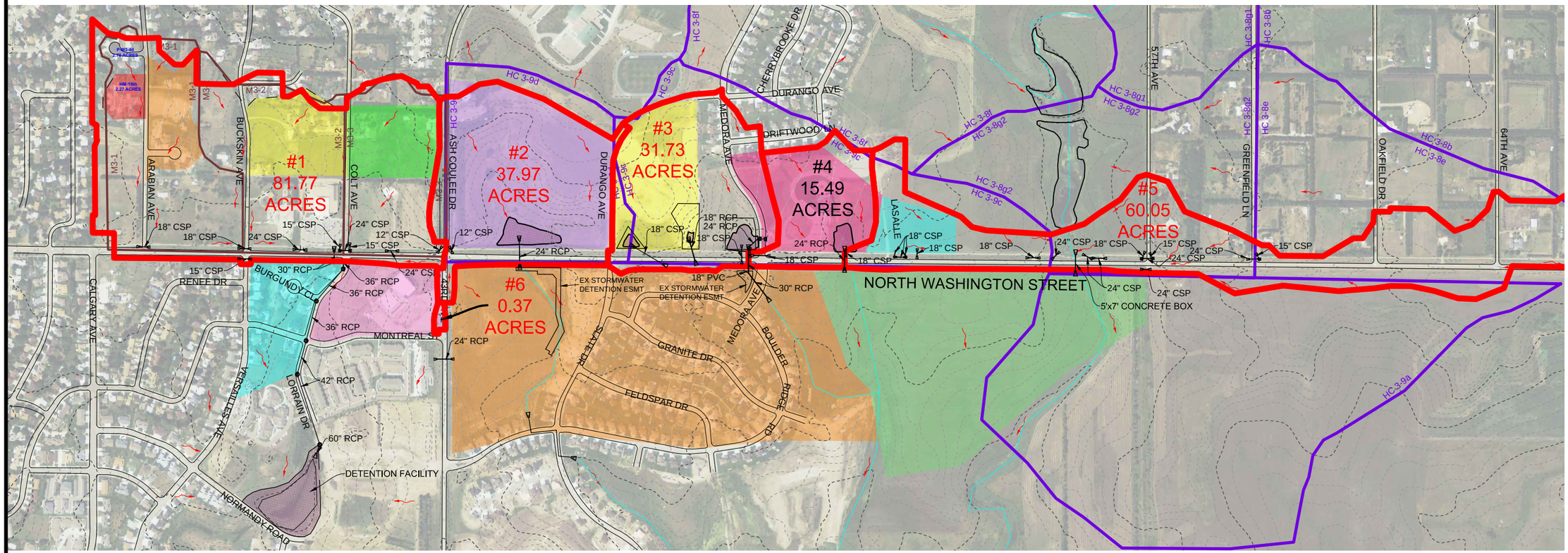
EFFECTIVE DATE:
JULY 19, 2005

Federal Emergency Management Agency

NATIONAL FLOOD INSURANCE PROGRAM

This is an official copy of a portion of the above referenced flood map. It was extracted using F-MIT On-Line. This map does not reflect changes or amendments which may have been made subsequent to the date on the title block. For the latest product information about National Flood Insurance Program flood maps check the FEMA Flood Map Store at www.msc.fema.gov

EX 03



#1 DRAINAGE AREA

DRAINAGE AREA BOUNDARY

EXISTING STORM SEWER

EXISTING STORM MANHOLE

EXISTING CURB INLET

EXISTING FLARED END SECTION

EXISTING DETENTION POND

HC 3-8f / HC 3-8g2 NORTH WASHINGTON STREET WATERSHED BOUNDARY AND LABELS (SWENSON, HAGEN & CO, 2004)

M3-2 / M3-1 NORTH FOURTH STREET STORMWATER MASTER PLAN UPDATE - M3-BOUNDARY AND LABELS (ULTEIG, 2007)

SWMP REFERENCES

- A: High Meadows 10th, 2002
- B: High Meadows 11th, 2007
- C: High Meadows 12th, 2013 (Draft)
- D: Evergreen Ridge, 2014 (Draft)
- E: North Hills 14th, 2005
- F: First Evangelical Free Church, 2003
- G: Northern Sky Subdivision, 2012
- H: Legacy Addition / First United Methodist Church, 2009
- I: Good Shepherd Lutheran Church, 2005
- J: Boulder Ridge 1st, 2005
- K: Boulder Ridge 5th, 2012
- L: Brei Estates First Addition, 2013

NOTES:
1. CONTOURS SHOWN AT 5' INTERVALS

N

400 0 400 800
SCALE FEET
NAVD-29

KLJ

REVISION | DATE | NO.

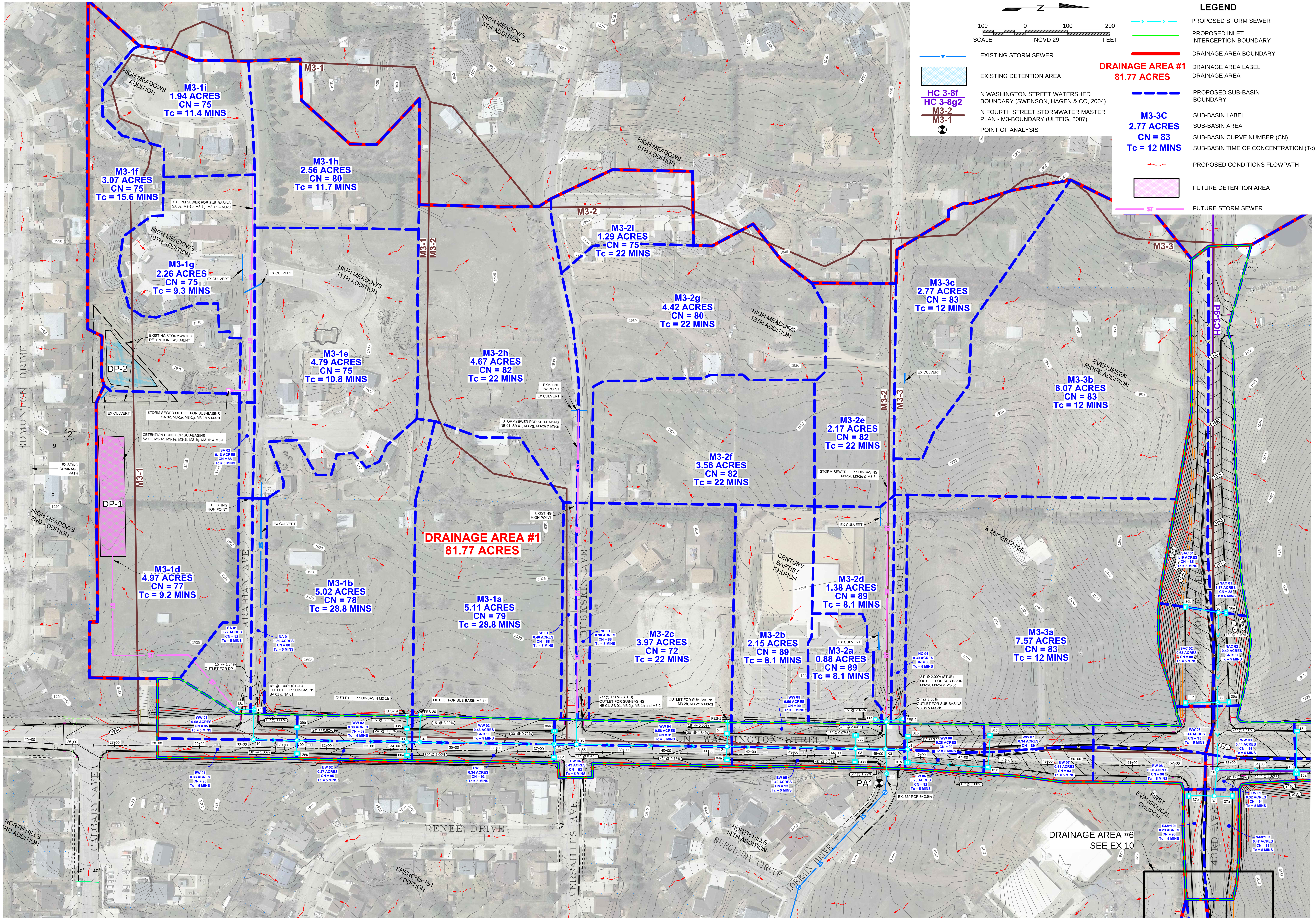
DRAFTED CWB
REVIEWED BJK
PROJECT NUMBER 1412129
ISSUE DATE 10/2014

NORTH WASHINGTON ST
CITY OF BISMARCK
BISMARCK, ND

EXISTING SITE OVERVIEW & PREVIOUS SWMP MAP

SHEET EX 04

Oct 02, 2014 - 3:55pm - J:\trans\1412129\CADD\SWMP\1412129-SWMP-PreviousSWMPMap.dwg



REVISION | DATE | NO.

DRAFTED
CWB

REVIEWED
SAK

PROJECT NUMBER
1412129

ISSUE DATE
10/2014

NORTH WASHINGTON STREET

CITY OF BISMARCK
BISMARCK, ND

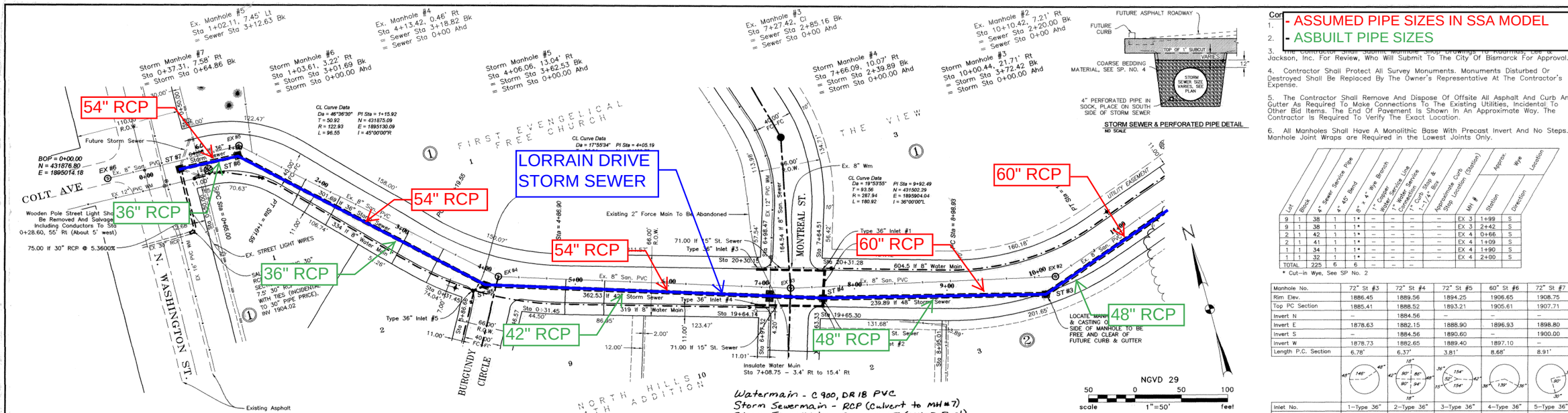
PROPOSED SUB-BASIN MAP - DRAINAGE AREA #1

SHEET
EX 05

Oct 06, 2014 - 12:41pm - J:\trans\1412129\CADD\SWMP\1412129-SWMP-DrainageAreaMap.dwg

- ASSUMED PIPE SIZES IN SSA MODEL
- ASBUILT PIPE SIZES

1. The Contractor Shall Submit Manhole Shop Drawings To Kadrmas, Lee & Jackson, Inc. For Review, Who Will Submit To The City Of Bismarck For Approval.
2. Contractor Shall Protect All Survey Monuments. Monuments Disturbed Or Destroyed Shall Be Replaced By The Owner's Representative At The Contractor's Expense.
3. The Contractor Shall Remove And Dispose Of Offsite All Asphalt And Curb And Gutter As Required To Make Connections To The Existing Utilities, Incidental To Other Bid Items. The End Of Pavement Is Shown In An Approximate Way. The Contractor Is Required To Verify The Exact Location.
4. All Manholes Shall Have A Monolithic Base With Precast Invert And No Steps. Manhole Joint Wraps are Required in the Lowest Joints Only.



FUTURE ASPHALT ROADWAY
FUTURE CURB
TOP OF 1" SUBCUT
VARIES
COARSE BEDDING MATERIAL, SEE SP. NO. 4
STORM SEWER SIZE VARIES, SEE PLAN
12"
4" PERFORATED PIPE IN SOCK, PLACE ON SOUTH SIDE OF STORM SEWER

STORM SEWER & PERFORATED PIPE DETAIL
NO SCALE

Lot	Block	4" Sewer Service Pipe	4" 45° Bend	8" x 4" Wye Branch	1" Copper Water Service Line	1" Water Service Connection	1" Curb Stop & Connection	Approximate Curb Stop Location (Station)	MH #	Approx. Station	Wye Direction	Location
9	1	38	1	1 *	–	–	–	–	EX 3	1+99	S	
9	1	38	1	1 *	–	–	–	–	EX 3	2+42	S	
2	1	42	1	1 *	–	–	–	–	EX 4	0+66	S	
2	1	41	1	1 *	–	–	–	–	EX 4	1+09	S	
1	1	34	1	1 *	–	–	–	–	EX 4	1+90	S	
1	1	32	1	1 *	–	–	–	–	EX 4	2+90	S	
TOTAL		225	6	6	–	–	–	–				

* Cut–in Wye, See SP No. 2

Manhole No.	72" St #3	72" St #4	72" St #5	60" St #6	72" St #7
Rim Elev.	1886.45	1889.56	1894.25	1906.65	1908.75
Top PC Section	1885.41	1888.52	1893.21	1905.61	1907.71
Invert N	–	1884.56	–	–	–
Invert E	1878.63	1882.15	1888.90	1896.93	1898.80
Invert S	–	1884.56	1890.60	–	1900.00
Invert W	1878.73	1882.65	1889.40	1897.10	–
Length P.C. Section	6.78'	6.37'	3.81'	8.68'	8.91'

Inlet No.	1–Type 36"	2–Type 36"	3–Type 36"	4–Type 36"	5–Type 36"
TBC Elev.	1889.37	1889.77	1890.02	1890.03	1894.59
Top PC Section	1888.12	1888.52	1888.77	1887.78	1893.34
Invert In	1884.85	1884.72	–	–	–
Invert Out	1884.80	1884.65	1885.54	1885.41	1890.76
Length P.C. Section	3.32'	3.87'	3.23'	3.37'	2.58'

Begin Perforated Pipe Quantities
Sta 1+50.00

Begin Water Main Quantities
Sta 0+50.00

Begin Storm Sewer Quantities
Sta 0+35.14

Sta 0+50.00, 22' Rt 12"x8" Reducer SJ

Sta 0+~~53.00~~ 59.00, 22' Rt 8" Gate Valve & Box AFC-RH-SJ

Sta 0+83.79, 22' Rt 8" 22.5° Bend SJ

Sta 1+36.08, 22' Rt 8" 22.5° Bend SJ

Sta 3+77.30, 22' Rt 8"x8"x6" Tee SJ, 4 Lf 6" Wm, 6" Hydrant Wat.-SJ

Sta 3+96.02, 22' Rt 8"x8" Tee SJ

Sta 6+87.52, 22' Rt 8" Gate Valve & Box AFC-RH-SJ

Sta 7+08.32, 22' Rt 12"x8" Cut–in Tee SJ

Sta 7+70.51, 22' Lt Salvage Ex. 8" Plug

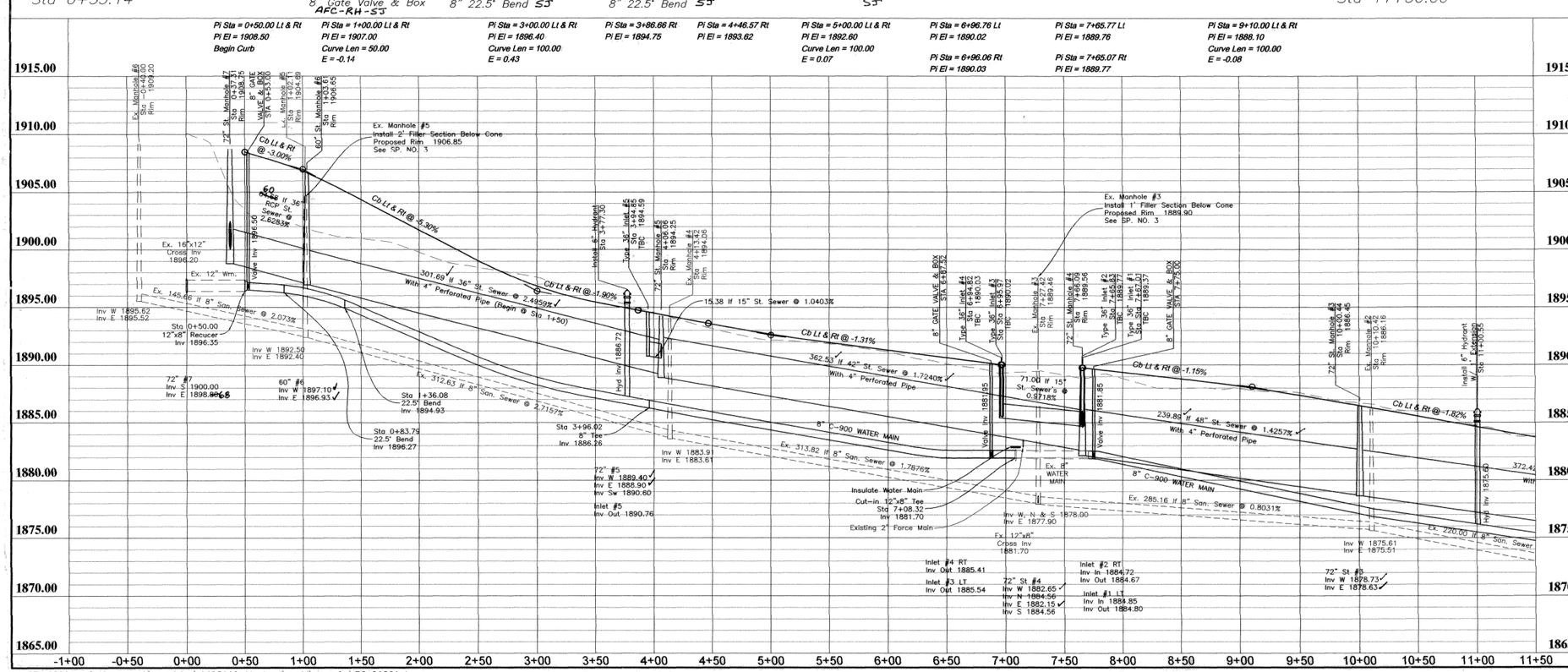
Sta 7+75.00, 22' Lt 8" Gate Valve & Box AFC-RH-SJ

Sta 11+00.55, 22' Lt 8"x8"x6" Tee SJ, 4 Lf 6" Wm, 6" Hydrant Wat.-SJ

End Perforated Pipe Quantities
Sta 11+50.00

End Water Main Quantities
Sta 11+50.00

End Storm Sewer Quantities
Sta 11+50.00



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Approximate Quantities

Spec No.	Water Items	Quantity
801–4.60	Bedding Material	301 Ton
801–4.61	Subcut Gravel	21 Ton
801–4.62	Rock Excavation	10 Ton
901–4.10	6" Watermain	8 LF
901–4.11	8" Watermain	1020 LF
901–4.52	8" Gate Valve & Box	3 Ea
901–4.70	6" Hydrant	2 Ea
Spec No.	San. Sewer Items	Quantity
801–4.60	Bedding Material	50 Ton
801–4.61	Subcut Gravel	5 Ton
801–4.62	Rock Excavation	5 Ton
1209–4.1	4" Sewer Service Pipe	225 LF
1209–4.6	4" 45–Degree Bend	6 Ea
SP No. 2	Cut–in Wye	6 Ea
SP No. 3	Modify Existing Manholes	1 LS
Spec No.	Storm Sewer Items	Quantity
801–4.60	Bedding Material	46 Ton
801–4.61	Subcut Gravel	50 Ton
801–4.62	Rock Excavation	10 Ton
802–4.2	15" Storm Sewer Pipe	157 LF
802–4.3	18" Storm Sewer Pipe	39 LF
802–4.8	30" Storm Sewer Pipe	75 LF
802–4.9	36" Storm Sewer Pipe	366 LF
802–4.10	42" Storm Sewer Pipe	363 LF
802–4.11	48" Storm Sewer Pipe	395 LF
802–4.80	4" Perforated Pipe	1010 LF
901–4.78	Insulate Water Main	12 LF
1001–4.30	Relocate Street Light Pole	1 Ea
1202–4.4	Seeding Class IV	3200 SY
1204–4.1	Mulching	3200 SY
1205–4.1c	60" Concrete Manhole	1 Ea
1205–4.1e	72" Concrete Manhole	4 Ea
1205–4.5	Type 36" Inlet	5 Ea
SP No. 4	Coarse Bedding Material	797 Ton
SP No. 18	Weighted Fiber Roll	60 LF

DRWN. BY	CHK'D BY	PROJECT NO.	REV'D DATE
ARV	RKB	1406110	–

ROGER BERG REGISTERED ENGINEER NORTH DAKOTA 7-7-06

Bismarck Engineering Department

Kadrmas Lee & Jackson Engineers Surveyors Planners

LORRAIN DRIVE
Washington Street To 400 Feet East Of Montreal Street
Water Improvement District No. 06-309
Sewer Improvement District No. 06-501
Storm Sewer Improvement Districtt No. 06-502

Sheet No. 4 Of 8 Sheets
Bismarck, N.D. Date: 07/06/2006

AS BUILT 1-3-07 SFG

EX 6a

- ASSUMED PIPE SIZES IN SSA MODEL
- ASBUILT PIPE SIZES

Ex. Manhole #1
Sta 12+30.42, CL
= Sewer Sta 3+26.28 Bk
= Sewer Sta 0+00 Ahd

St. Manhole #2
Sta 13+67.95, 10.56' Rt
= Sewer Sta 1+45.47 Bk
= Sewer Sta 0+00 Ahd

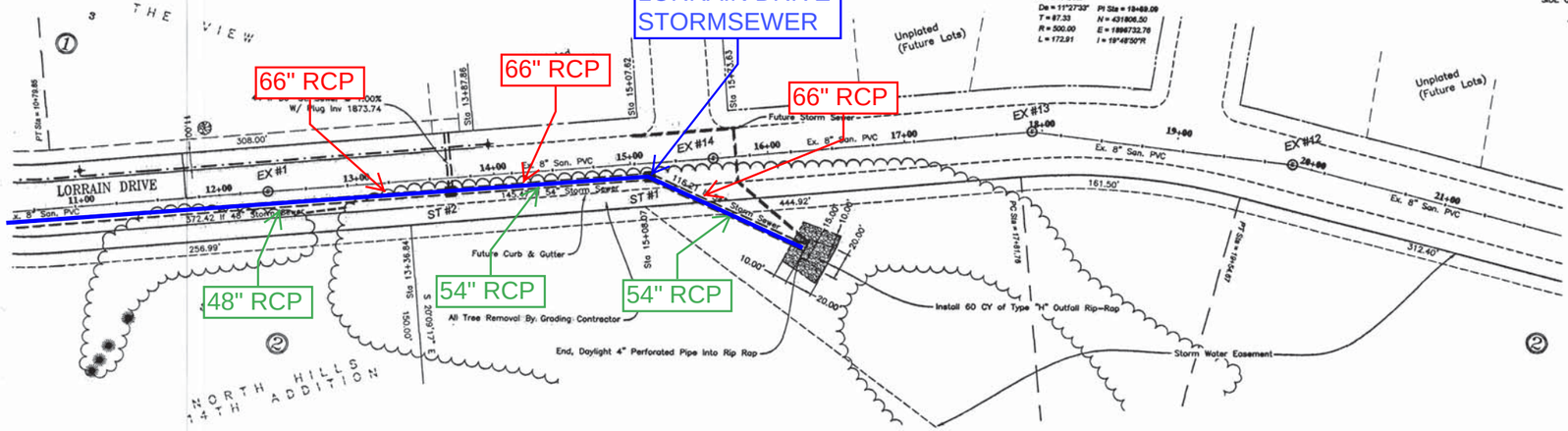
St. Manhole #1
Sta 15+13.42, 11.23' Rt
= Sewer Sta 1+16.21 Bk
= Sewer Sta 0+00 Ahd

Ex. Manhole #14
Sta 15+60.48,
= Sewer Sta 2+32.25 Bk
= Sewer Sta 0+00 Ahd

Flared End Section
Sta ~~15+81.09, 62.98' Rt~~ 16+14.43, 68.68' RT
= Sewer Sta 0+00 Ahd

LORRAIN DRIVE STORMSEWER

66" RCP
66" RCP
66" RCP
48" RCP
54" RCP
54" RCP



FUTURE ASPHALT ROADWAY
FUTURE CURB
COURSE BEDDING MATERIAL, SEE SP. NO. 4
TOP OF 'Y' SUBCUT
STORM SEWER, SIZE VARIES, SEE PLAN
4" PERFORATED PIPE IN SOCK, PLACE ON SOUTH SIDE OF STORM SEWER
12"
STORM SEWER & PERFORATED PIPE DETAIL
NO SCALE

Construction Notes

1. Bac
2. Gro
3. The Contractor Shall Submit Manhole Shop Drawings To Kadrmas, Lee & Jackson, Inc. For Review, Who Will Submit To The City Of Bismarck For Approval.
4. Contractor Shall Protect All Survey Monuments. Monuments Disturbed Or Destroyed Shall Be Replaced By The Owner's Representative At The Contractor's Expense.
5. The Contractor Shall Remove And Dispose Of Offsite All Asphalt And Curb And Gutter As Required To Make Connections To The Existing Utilities, Incidental To Other Bid Items. The End Of Pavement Is Shown In An Approximate Way. The Contractor Is Required To Verify The Exact Location.
6. All Manholes Shall Have A Monolithic Base With Precast Invert And No Steps. Manhole Joint Wraps are Required In the Lowest Joints Only.

Lot	Block	8" Sewer Service Pipe	8" 45° Bend	8" x 8" Wye Branch	1" Copper Water Service Line	1" Water Service Connection	1" Curb Stop & 1-1/4" Box	Approximate Curb Stop Location (Station)	MH #	Approx. Station	Wye Direction	Location
3	1	33+	1	1*	–	–	–	–	EX 1	0+60	N	
TOTAL		33	1	1	–	–	–					

* Cut-in Wye
+ 8" Sewer Service, Paid For As 8" Sanitary Sewer Pipe

Begin Perforated Pipe Quantities
Sta 11+50.00

Begin Water Main Quantities
Sta 11+50.00

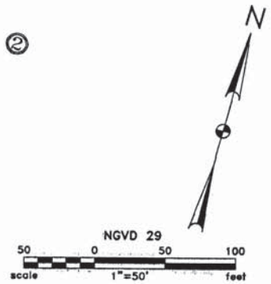
Begin Storm Sewer Quantities
Sta 11+50.00

Sta 13+97.86, 22' Lt
8"x6" Reducer
2 Lf Of 6" Wm
6" Hydrant

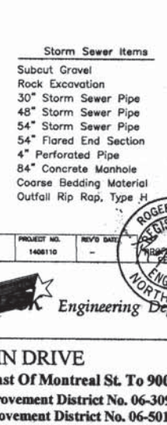
End Perforated Pipe Quantities
Sta 15+81.09

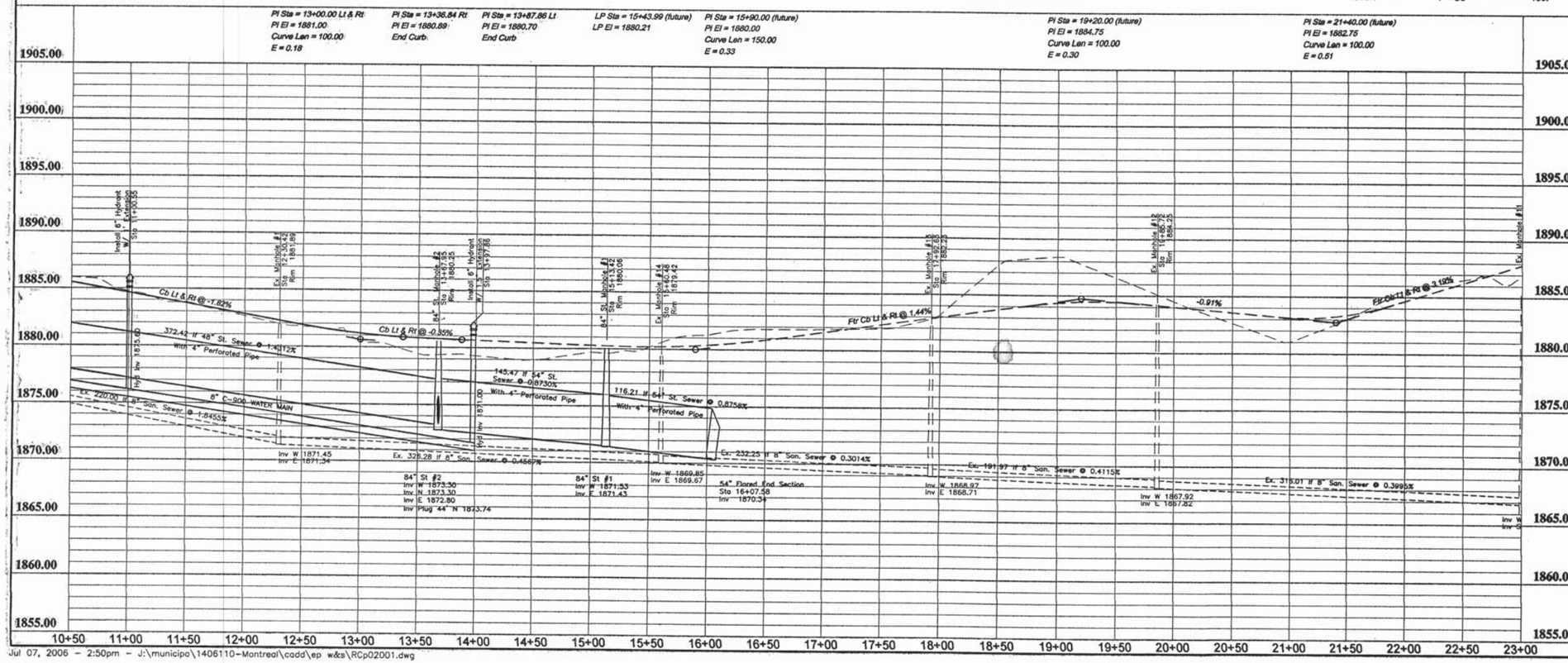
End Water Main Quantities
Sta 13+87.86

End Storm Sewer Quantities
Sta 15+81.09



Manhole No.	84" St 1	84" St 2
Rim Elev.	1880.06	1880.25
Top PC Section	1879.02	1879.21
Invert N	–	1873.30
Invert E	1871.43	1872.80
Invert S	–	–
Invert W	1871.53	1873.30
Length P.C. Section	7.59'	6.41'





Approximate Quantities

Spec No.	Water Items	Quantity
801–4.60	Bedding Material	75 Ton
801–4.61	Subcut Gravel	5 Ton
801–4.62	Rock Excavation	5 Ton
901–4.10	6" Watermain	2 LF
901–4.11	8" Watermain	248 LF
901–4.70	6" Hydrant	1 Ea

Spec No.	San. Sewer Items	Quantity
801–4.2	8" Sanitary Sewer Pipe	33 LF
801–4.60	Bedding Material	5 Ton
801–4.61	Subcut Gravel	5 Ton
801–4.62	Rock Excavation	0 Ton
1209–4.8	8" 45–Degree Bend	1 Ea
SP No. 2	Cut–In Wye	1 Ea

Spec No.	Storm Sewer Items	Quantity
801–4.61	Subcut Gravel	10 Ton
801–4.62	Rock Excavation	5 Ton
802–4.8	30" Storm Sewer Pipe	44 LF
802–4.11	48" Storm Sewer Pipe	217 LF
802–4.12	54" Storm Sewer Pipe	262 LF
802–4.62	54" Flared End Section	1 Ea
802–4.80	4" Perforated Pipe	479 LF
1205–4.1f	84" Concrete Manhole	2 Ea
SP No. 4	Coarse Bedding Material	433 Ton
SP No. 5	Outfall Rip Rap, Type H	60 CY

DRWN. BY	CHK'D BY	PROJECT NO.	REVS DATE
ARV	RKB	1406110	–

ROGER BERG REGISTERED PROFESSIONAL ENGINEER NORTH DAKOTA PE-4252 7-21-06

Bismarck Engineering Department

Kadrmas Lee & Jackson Engineers Surveyors Planners

LORRAIN DRIVE
400 Feet East Of Montreal St. To 900 Feet East Of Montreal St.
Water Improvement District No. 06-309
Sewer Improvement District No. 06-501
Storm Sewer Improvement District No. 06-502
Sheet No. 5 Of 8 Sheets
Bismarck, N.D. Date: 07/06/2006

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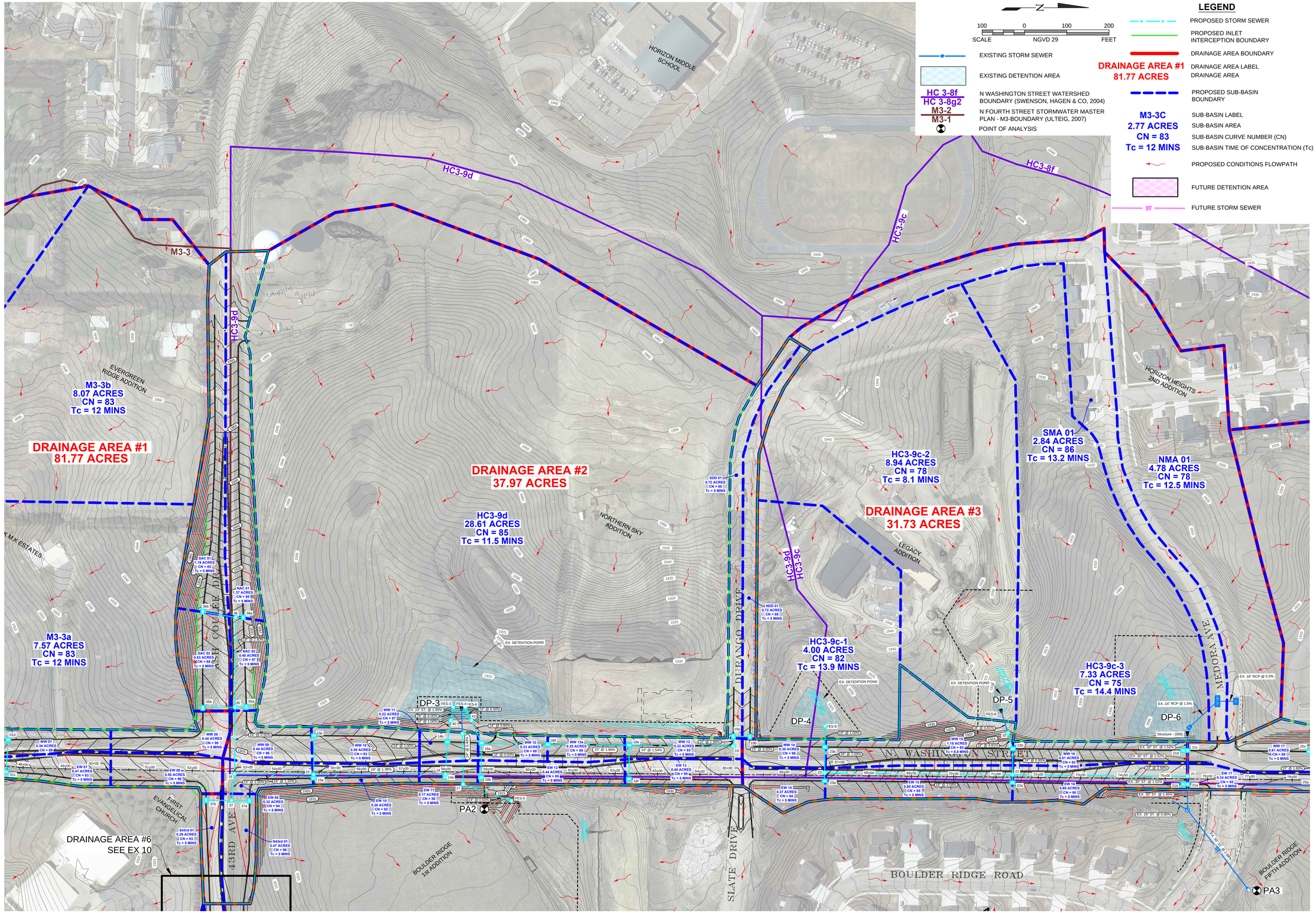
EX 6b



REVISION

NO.	DATE

DRAFTED CWB
REVIEWED SAK
PROJECT NUMBER 1412129
ISSUE DATE 10/2014

NORTH WASHINGTON STREET

CITY OF BISMARCK
BISMARCK, ND

PROPOSED SUB-BASIN MAP - DRAINAGE AREA #2 & #3

SHEET EX 07

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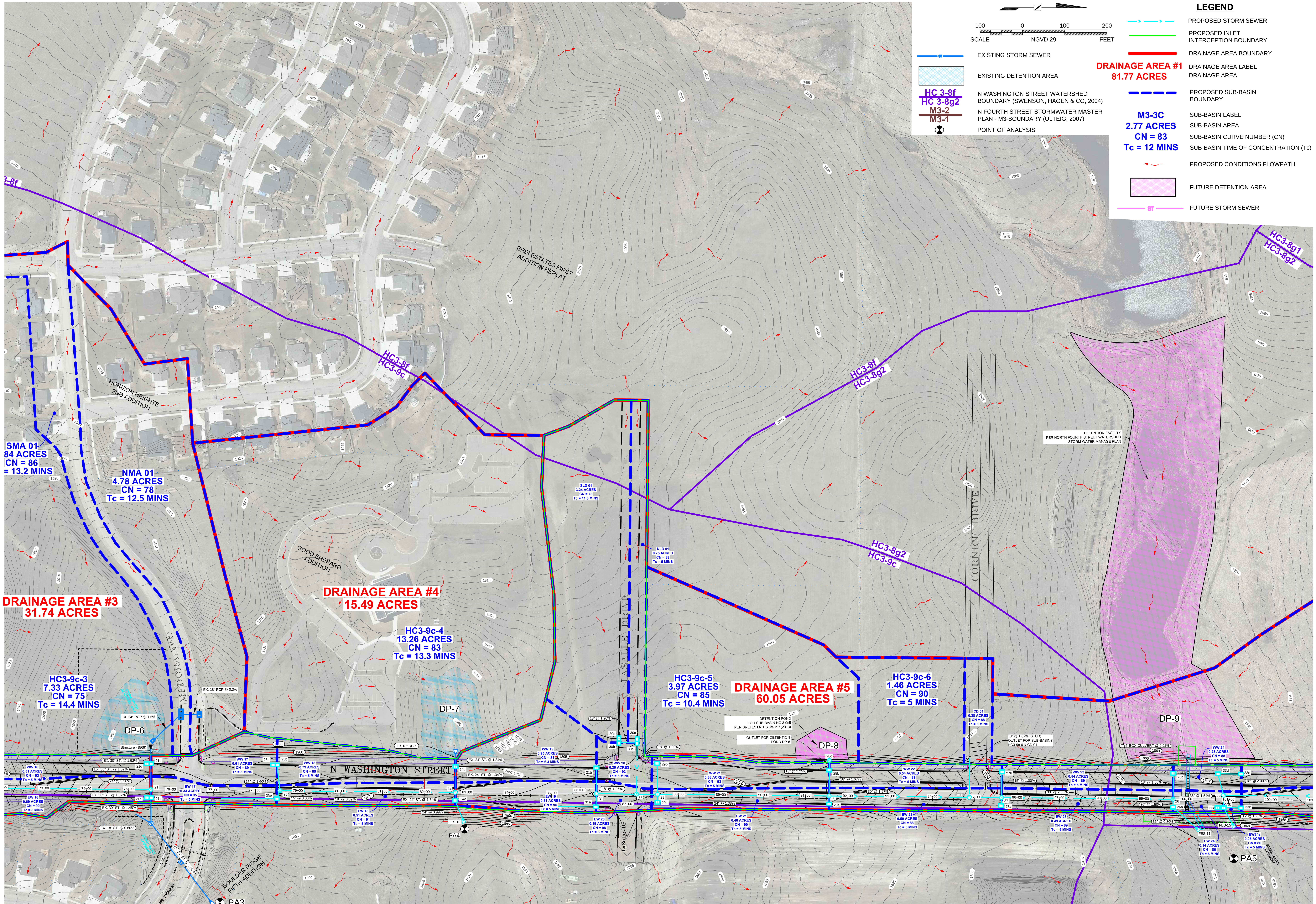

NORTH WASHINGTON STREET

CITY OF BISMARCK

BISMARCK, ND

PROPOSED SUB-BASIN MAP - DRAINAGE AREA #4 & #5

NO.	DATE	REVISION

DRAFTED CWB

REVIEWED SAK

PROJECT NUMBER 1412129

ISSUE DATE 10/2014

SHEET EX 08

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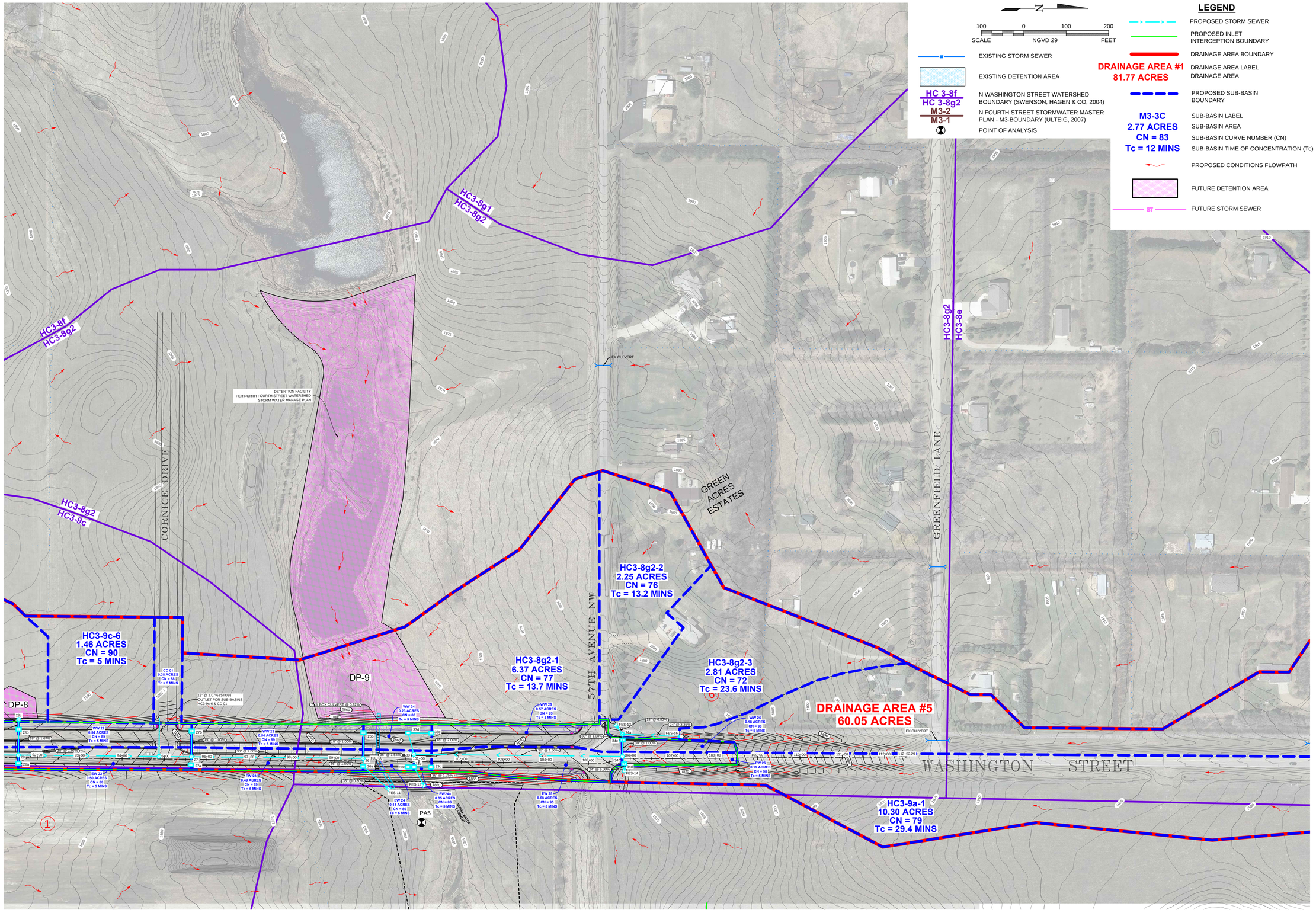

KLJ

REVISION

DATE

NO.

DRAFTED
CWB

REVIEWED
SAK

PROJECT NUMBER
1412129

ISSUE DATE
10/2014

NORTH WASHINGTON STREET

CITY OF BISMARCK
BISMARCK, ND

PROPOSED SUB-BASIN MAP - DRAINAGE AREA #5

SHEET
EX 09

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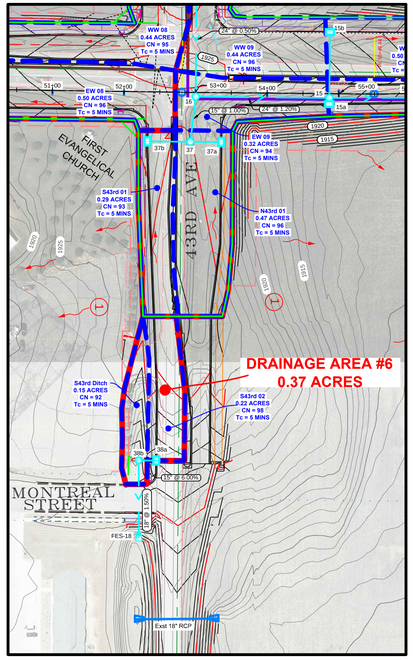
DRAINAGE AREA # 6



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SCALE: 100 0 100 200 FEET — NGVD 29

LEGEND

- EXISTING STORM SEWER
- EXISTING DETENTION AREA
- HC 3-8f / HC 3-8g2 — N WASHINGTON STREET WATERSHED BOUNDARY (SWENSON, HAGEN & CO, 2004)
- M3-2 / M3-1 — N FOURTH STREET STORMWATER MASTER PLAN - M3-BOUNDARY (ULTEIG, 2007)
- POINT OF ANALYSIS
- PROPOSED STORM SEWER
- PROPOSED INLET INTERCEPTION BOUNDARY
- DRAINAGE AREA BOUNDARY
- DRAINAGE AREA #1 / 81.77 ACRES — DRAINAGE AREA LABEL
- PROPOSED SUB-BASIN BOUNDARY
- M3-3C / 2.77 ACRES / CN = 83 / Tc = 12 MINS — SUB-BASIN LABEL, SUB-BASIN AREA, SUB-BASIN CURVE NUMBER (CN), SUB-BASIN TIME OF CONCENTRATION (Tc)
- PROPOSED CONDITIONS FLOWPATH
- FUTURE DETENTION AREA
- ST — FUTURE STORM SEWER

NO.	DATE	REVISION

DRAFTED: CWB
REVIEWED: SAK
PROJECT NUMBER: 1412129
ISSUE DATE: 10/2014

NORTH WASHINGTON STREET

CITY OF BISMARCK
BISMARCK, ND

PROPOSED SUB-BASIN MAP - DRAINAGE AREA #5 & #6

SHEET: EX 10

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Sub-Basin Summary
Table A-1

Sub Basin Name	Flows To	Area (acres)	Weighted CN	Tc (mins)	$Q_{10yr - 6 hr}$ (cfs)	$Q_{100yr - 6hr}$ (cfs)	Notes
CD 01	CorniceStub	0.38	88.00	5.00	1.18	2.13	
EW 01	09a	0.33	96.24	5.00	1.46	2.29	
EW 02	8a	0.27	94.78	5.00	1.12	1.80	
EW 03	06a	0.34	92.88	5.00	1.32	2.18	
EW 04	04a	0.49	93.27	5.00	1.94	3.20	
EW 05	03a	0.42	93.17	5.00	1.66	2.74	
EW 06	01a	0.20	92.20	5.00	0.75	1.26	
EW 07	01c	0.41	93.05	5.00	1.60	2.65	
EW 08	01c	0.50	95.68	5.00	2.15	3.40	
EW 09	15a	0.32	94.38	5.00	1.32	2.13	
EW 10	14a	0.28	92.82	5.00	1.09	1.81	
EW 11	18c	0.17	87.76	5.00	0.53	0.97	
EW 12	18c	0.44	88.77	5.00	1.43	2.55	
EW 13	18f	0.40	95.10	5.00	1.70	2.72	
EW 14	23a	0.37	84.41	5.00	0.96	1.86	
EW 15	22a	0.80	84.95	5.00	2.13	4.09	
EW 16	21b	0.69	89.59	5.00	2.33	4.09	
EW 17	25a	0.34	94.59	5.00	1.41	2.26	
EW 18	24a	0.51	90.61	5.00	1.81	3.11	
EW 19	31a	0.51	94.59	5.00	2.12	3.42	
EW 20	29a	0.19	98.00	5.00	0.88	1.35	
EW 21	28a	0.48	90.15	5.00	1.66	2.88	
EW 22	27a	0.50	88.14	5.00	1.57	2.83	
EW 23	26a	0.49	88.53	5.00	1.58	2.83	
EW 24	33a	0.14	85.57	5.00	0.39	0.73	
EW 24a	33b	0.05	86.40	5.00	0.15	0.27	
EW 25	33c	0.68	93.74	5.00	2.73	4.45	
EW 26	34d	0.19	98.00	5.00	0.88	1.35	
HC3-8e-4	FES-16	21.36	75.52	46.35	11.64	29.10	
HC-8g2-1	5'x7' Box Culvert	6.37	76.85	13.72	8.24	19.00	
HC3-8g2-2	FES-13	2.25	75.60	13.23	2.70	6.44	
HC3-8g2-3	34a	2.81	72.36	23.60	1.88	5.15	
HC3-9a-1	FES-14	10.30	78.86	29.37	10.00	22.59	
HC3-9c-1	DP-4	4.00	82.05	13.85	7.21	14.69	
HC3-9c-2	32	8.94	78.05	8.10	14.44	31.84	
HC3-9c-3	DP-6	7.33	75.00	14.42	8.11	19.70	
HC3-9c-4	DP-7	13.26	83.00	13.30	25.61	51.12	
HC3-9c-5	28c-DP-8	3.97	85.00	10.35	9.18	17.52	
HC3-9c-6	CorniceStub	1.46	90.00	5.00	5.01	8.73	
HC3-9d	DP-3	28.61	85.00	11.50	64.49	123.32	
M3-1a	FES-20	5.11	79.00	28.80	5.07	11.40	
M3-1b	FES-19	5.02	78.24	28.80	4.71	10.85	

Sub-Basin Summary
Table A-1

Sub Basin Name	Flows To	Area (acres)	Weighted CN	Tc (mins)	$Q_{10yr - 6 hr}$ (cfs)	$Q_{100yr - 6hr}$ (cfs)	Notes
M3-1d	DP-1	4.97	77.00	9.23	7.34	16.55	
M3-1e	DP-2	4.79	75.00	10.80	5.91	14.13	
M3-1f	DP-2	3.07	75.00	15.57	3.27	8.02	
M3-1g	DP-2	2.26	75.00	9.32	2.90	6.88	
M3-1h	DP-2	2.56	80.00	11.70	4.31	9.14	
M3-1i	DP-2	1.94	75.00	11.40	2.35	5.64	
M3-2a	11a	0.88	89.00	8.10	2.63	4.69	
M3-2b	FES-1	2.15	89.00	8.10	6.40	11.41	
M3-2c	FES-1	3.97	72.00	22.00	2.69	7.44	
M3-2d	ColtStub	1.38	88.73	8.10	4.06	7.27	
M3-2e	ColtStub	2.17	82.00	22.00	3.12	6.47	
M3-2f	FES-1	3.56	82.00	22.00	5.11	10.61	
M3-2g	BuckskinStub	4.42	80.41	22.00	5.74	12.36	
M3-2h	BuckskinStub	4.67	82.00	22.00	6.71	13.93	
M3-2i	BuckskinStub	1.29	75.00	22.00	1.13	2.83	
M3-3a	FES-2	7.57	83.00	12.00	15.11	30.08	
M3-3b	FES-2	8.07	83.00	12.00	16.11	32.06	
M3-3c	ColtStub	2.77	83.00	12.00	5.53	11.01	
N43rd 01	37a	0.47	95.53	5.00	2.00	3.17	
NA 01	13c Future	0.39	88.33	5.00	1.24	2.22	
NAC 01	35a	0.40	86.77	5.00	1.18	2.19	
NAC 02	36a	1.37	88.12	5.00	4.30	7.75	
NB 1	12a Future	0.38	88.08	5.00	1.18	2.14	
NC 1	ColtStub	0.39	88.33	5.00	1.24	2.22	
NDD 01	19b	0.72	88.33	5.00	2.29	4.12	
NLD 01	30c	0.75	88.20	5.00	2.36	4.25	
NMA 01	EX1	4.78	77.83	12.50	6.85	15.33	
S43rd 01	37b	0.29	93.00	5.00	1.13	1.86	
S43rdDitch	38b	0.15	98.00	5.00	0.67	1.03	
SA 01	13b Future	0.77	81.75	5.00	1.70	3.49	
SA 02	DP-2	0.18	88.33	5.00	0.57	1.02	
SAC 01	35b	0.63	88.13	5.00	1.97	3.55	
SAC 02	36b	1.19	84.54	5.00	3.09	5.99	
SB 1	12b Future	0.40	87.85	5.00	1.25	2.26	
SDD 01	19a	0.72	88.33	5.00	2.29	4.12	
SE43rd	38a	0.23	91.70	5.00	0.85	1.44	
SLD 01	30d	3.24	78.02	11.62	4.82	10.70	
SMA 01	EX2	2.84	85.52	13.22	6.32	12.00	
WW 01	09b	0.68	85.44	5.00	1.85	3.52	
WW 02	8b	0.38	88.84	5.00	1.23	2.18	
WW 03	06b	0.46	89.80	5.00	1.57	2.74	
WW 04	04b	0.56	90.75	5.00	2.00	3.44	

Sub-Basin Summary
Table A-1

Sub Basin Name	Flows To	Area (acres)	Weighted CN	Tc (mins)	$Q_{10yr - 6 hr}$ (cfs)	$Q_{100yr - 6hr}$ (cfs)	Notes
WW 05	03b	0.56	90.23	5.00	1.95	3.39	
WW 06	01b	0.28	89.71	5.00	0.95	1.67	
WW 07	01d	0.34	89.47	5.00	1.14	2.00	
WW 08	01d	0.44	95.36	5.00	1.88	2.99	
WW 09	15b	0.44	96.02	5.00	1.92	3.02	
WW 10	14b	0.50	92.78	5.00	1.93	3.21	
WW 11	18a	0.22	87.45	5.00	0.66	1.21	
WW 12	18a	0.23	87.91	5.00	0.71	1.30	
WW 12a	18d	0.25	88.72	5.00	0.81	1.44	
WW 13	18e	0.32	93.47	5.00	1.27	2.09	
WW 14	23b	0.30	96.07	5.00	1.31	2.06	
WW 15	22b	1.18	85.36	8.82	2.86	5.45	
WW 16	21d	0.51	93.45	5.00	2.03	3.34	
WW 17	25c	0.61	88.52	5.00	1.94	3.48	
WW 18	24b	0.79	85.47	5.00	2.15	4.09	
WW 19	31b	0.95	81.48	6.40	1.96	4.08	
WW 20	29b	0.29	92.62	5.00	1.11	1.84	
WW 21	28b	0.66	92.73	5.00	2.55	4.23	
WW 22	27b	0.54	89.41	5.00	1.79	3.16	
WW 23	26b	0.54	88.87	5.00	1.75	3.11	
WW 24	33d	0.23	87.91	5.00	0.71	1.30	
WW 25	33e	0.57	90.88	5.00	2.03	3.49	
WW 26	34c	0.18	98.00	5.00	0.82	1.26	

North Washington Street
NHU-1-981(101)111
Calgary Avenue to 57th Avenue NW

Storm Sewer System Summary
Table A-2
10 Year, 6 Hour Event

10/3/2014

Structure Name	Structure Type	*Inlet Condition	Downstream Structure	Pipe Size (inches)	Pipe Slope (%)	Full Flow Capacity (cfs)	10 Year, 6 Hour Event												Rim Elevation
							Basin Runoff (cfs)	Total Flow To Inlet (cfs)	Intercepted Flow (cfs)	Percent Capture	Pipe Flow (cfs)	Pipe Velocity (fps)	Bypass Flow (cfs)	Bypass Target	Maximum Depth in Gutter (ft)	Maximum Spread @ Inlet (ft)	Peak Water Elevation	Pipe Hydraulic Grade Line (HGL)	
Arabian Avenue to 43rd Avenue																			
13a	Catch Basin	Sag	13b Future/13	15	1.59%	8.21		7.30			6.50	5.30	N/A				1918.50	1918.50	1921.19
13b Future	Type 2	On Grade	13	15	1.59%	8.21	1.65	1.65	1.08	65.5%	6.80	6.12	0.57	9b	0.18	6.06	1919.66	1916.96	1919.48
13c Future	Type 2	On Grade	13	15	0.99%	6.47	1.23	1.23	0.88	71.5%	0.88	3.08	0.35	9b	0.16	5.18	1919.48	1916.04	1919.32
13	Manhole	NA	10	18	1.00%	10.58		6.98			6.98	5.53	N/A				1916.04	1916.04	1919.52
10	Manhole	NA	9	18	1.06%	10.89		6.98			6.96	5.88	N/A				1915.17	1915.17	1919.17
09a	Type 2	On Grade	9	15	1.00%	6.51	1.46	1.46	0.91	62.3%	0.90	3.35	0.55	8a	0.22	8.05	1917.79	1913.98	1917.57
09b	Type 2	On Grade	9	15	1.00%	6.51	1.83	2.75	1.43	52.0%	1.79	3.96	1.32	8b	0.27	10.39	1917.84	1914.16	1917.57
9	Manhole	NA	8	24	0.82%	20.64		7.43			7.42	5.71	N/A				1913.46	1913.46	1918.28
8a	Type 2	On Grade	8	15	1.00%	6.51	1.12	1.67	1.00	59.9%	1.17	3.57	0.67	6a	0.23	8.49	1915.61	1911.91	1915.38
FES-19	Flared End	NA	8b	15	3.03%	11.33	4.61	4.61			4.61	7.18	N/A				1913.50	1913.50	
8b	Type 2	On Grade	8	24	0.90%	21.62	1.22	2.17	1.21	55.8%	4.83	4.61	0.96	6b	0.25	9.46	1915.63	1911.53	1915.38
8	Manhole	NA	7	30	2.00%	58.43		12.40			12.40	5.64	N/A				1911.13	1911.13	1916.09
FES-20	Flared End	NA	7	15	3.20%	11.64	4.97	4.97			4.97	8.04	N/A				1913.30	1913.30	
7	Manhole	NA	6	30	0.72%	35.06		17.78			17.33	6.64	N/A				1908.13	1908.13	1915.86
06a	Type 2	On Grade	6	15	0.48%	4.51	1.32	1.80	1.06	58.9%	1.23	2.88	0.74	4a	0.23	8.77	1912.98	1909.75	1912.75
06b	Type 2 Double	On Grade	6	15	1.00%	6.51	1.56	2.27	1.74	76.7%	1.89	4.01	0.53	4b	0.25	9.62	1913.00	1909.06	1912.75
6	Manhole	NA	5	36	0.48%	46.55		30.64			17.80	4.99	N/A				1907.69	1907.69	1913.46
12a Future	Type 2	On Grade	12 Future	15	0.98%	6.44	1.17	1.17	0.88	75.2%	0.87	3.12	0.29	4b	0.15	4.78	1913.25	1909.34	1913.10
Buckskin 24" Plug	Future Storm	NA	12 future	24	1.50%	27.91	13.15	13.15			13.15	5.45	N/A				1909.81	1909.81	1916.50
12b Future	Type 2	On Grade	12 Future	15	0.46%	4.41	1.24	1.24	0.91	73.4%	0.91	2.62	0.33	4b	0.15	4.90	1913.53	1909.37	1913.38
12 Future	Manhole	NA	5	24	1.50%	27.91		13.62			13.63	7.42	N/A				1909.34	1909.34	1913.28
5	Manhole	NA	4	42	0.75%	87.77		41.06			30.59	7.70	N/A				1904.82	1904.82	1913.07
04a	Type 2 Double	On Grade	4	15	0.74%	5.60	1.94	2.49	1.88	75.5%	2.02	3.69	0.61	3a	0.26	9.99	1909.93	1906.03	1909.67
FES-1	Flared End	NA	04b	18	5.49%	24.79	11.38	11.37			11.37	10.33	N/A				1908.18	1908.18	
04b	Type 2 Double	On Grade	4	30	1.65%	53.07	1.99	2.99	2.20	73.6%	13.04	6.99	0.79	3b	0.28	10.85	1909.95	1905.62	1909.67
4	Manhole	NA	3	48	0.68%	119.32		43.51			41.03	6.91	N/A				1903.19	1903.19	1910.39
36b	Type 2 Double	On Grade	36	15	0.70%	5.44	3.04	3.04	1.99	65.5%	1.98	3.77	1.05	35b	0.22	8.11	1930.18	1926.64	1929.96
35b	Type 2 Double	On Grade	35	15	0.50%	4.60	1.96	3.00	2.13	71.0%	2.36	3.56	0.87	1d	0.26	10.11	1924.98	1921.52	1924.72
01d	Type 2 Double	On Grade	01c	15	1.00%	6.51	3.00	3.62	2.26	62.4%	2.51	4.54	1.36	1b	0.23	8.69	1915.03	1911.08	1914.80
37b	Type 2	On Grade	37	15	1.75%	8.61	1.12	1.12	0.78	69.6%	0.77	2.77	0.34	1c	0.23	8.81	1924.47	1920.97	1924.24
01c	Type 2 Double	On Grade	01a	15	2.88%	11.04	3.74	4.09	2.47	60.4%	5.11	5.25	1.62	Lorain Dr	0.24	9.13	1914.93	1910.21	1914.69
01a	Type 2	On Grade	1	15	1.00%	6.51	0.75	2.19	1.24	56.6%	6.59	5.59	0.95	3a	0.21	7.89	1909.01	1905.52	1908.80
01b	Type 2 Double	On Grade	1	15	3.16%	11.57	0.95	2.05	1.51	73.7%	1.70	2.55	0.54	3b	0.22	8.04	1909.03	1905.01	1908.81
1	Manhole	NA	2	18	1.47%	12.83		17.35			8.28	6.53	N/A				1910.60	1910.60	1909.89
Colt 24" Plug	Future Storm	NA	11	24	2.00%	32.23	12.49	12.49			12.49	6.92	N/A				1904.98	1904.98	1910.72
11a	Ditch Inlet	Sag	11	15	2.44%	10.16	2.55	2.55			2.55	5.75	N/A				1905.35	1905.35	1908.23
FES-2	Flared End	NA	11	24	8.98%	68.29	30.35	30.27			30.27	12.91	N/A				1907.22	1907.22	
11	Manhole	NA	2	42	2.05%	145.10		45.25			45.28	8.75	N/A				1903.92	1903.92	1908.88
03a	Type 2 Double	Sag	3	15	0.71%	5.48	1.66	2.12	N/A	N/A	2.02	3.64	N/A		0.19	7.42	1907.74	1903.96	1907.55
03b	Type 2 Double	Sag	3	15	0.71%	5.48	1.94	2.79	N/A	N/A	2.58	3.86	N/A		0.22	9.35	1907.78	1904.05	1907.56
3	Manhole	NA	2	48	0.97%	142.51		8.28			43.75	7.22	N/A				1904.75	1904.75	1908.64
2	Manhole	NA	20	54	1.29%	224.98		94.23			94.23	9.96	N/A				1902.60	1902.60	1908.69
20	Manhole	NA	**Ex Storm (PA1)**	54	2.63%	321.24		94.23			**94.23**	11.62	N/A				1901.00	1901.00	1909.98

* Clogging Factor: On Grade=10%, Sag=20%

**Basin runoff is the total runoff produced by the drainage basin. However, the individual SWMP provides detention to the rate listed in the pipe flow column

Storm Sewer System Summary
Table A-2
10 Year, 6 Hour Event

Structure Name	Structure Type	*Inlet Condition	Downstream Structure	Pipe Size (inches)	Pipe Slope (%)	Full Flow Capacity (cfs)	10 Year, 6 Hour Event												Rim Elevation
							Basin Runoff (cfs)	Total Flow To Inlet (cfs)	Intercepted Flow (cfs)	Percent Capture	Pipe Flow (cfs)	Pipe Velocity (fps)	Bypass Flow (cfs)	Bypass Target	Maximum Depth in Gutter (ft)	Maximum Spread @ Inlet (ft)	Peak Water Elevation	Pipe Hydraulic Grade Line (HGL)	
Montreal Street																			
38a	Type 2	On Grade	41805.00	15.00	0.06	15.97	0.85	0.85	0.65	76.5%	0.64	5.83	0.20	Montreal	0.15	4.72	1922.12	1917.51	1921.97
38b	Beehive	Sag	**FES-18 (PA6)**	18.00	0.02	12.96	0.67	1.31	N/A	N/A	**1.31**	4.49	N/A				1919.50	1915.67	1919.08
43rd Avenue to Durango Drive																			
37a	Type 2	On Grade	37	15	0.99%	6.47	2.00	2.00	1.22	61.0%	1.21	3.26	0.78	15b	0.28	11.12	1924.31	1920.52	1924.03
37	Manhole	NA	16	15	1.01%	6.54		1.99			1.97	4.26	N/A				1920.12	1920.12	1924.94
36a	Type 2 Double	On Grade	36	15	2.86%	11.00	4.26	4.26	2.54	59.6%	2.54	5.83	1.72	35a	0.24	9.18	1930.02	1926.58	1929.78
36	Manhole	NA	35	18	2.40%	16.39		4.50			4.53	7.10	N/A				1925.81	1925.81	1930.26
35a	Type 2	On Grade	35	15	2.16%	9.56	1.17	2.89	1.47	50.9%	1.79	5.04	1.42	15a	0.26	9.95	1925.16	1921.45	1924.90
35	Manhole	NA	16	24	0.50%	16.11		8.66			8.59	4.79	N/A				1920.86	1920.86	1925.52
16	Manhole	NA	15	24	1.20%	24.96		10.53			10.54	6.85	N/A				1919.21	1919.21	1924.79
15a	Type 2	On Grade	15	15	4.91%	14.42	1.32	2.09	1.18	56.5%	1.92	14.53	0.91	14a	0.22	8.22	1922.56	1918.78	1922.34
15b	Type 2	On Grade	15	15	1.61%	8.26	1.92	3.01	1.54	51.2%	1.88	5.10	1.47	14b	0.24	8.90	1922.36	1918.62	1922.12
15	Manhole	NA	14	24	1.38%	26.77		13.73			13.76	6.19	N/A				1916.91	1916.91	1922.58
14a	Type 2 Double	On Grade	14	15	1.00%	6.51	1.09	1.76	1.33	75.6%	1.45	2.86	0.43	18c	0.20	7.28	1916.17	1913.10	1915.97
14	Manhole	NA	14b	24	0.99%	22.67		15.12			15.02	5.32	N/A				1913.19	1913.19	1916.18
14b	Type 2 Double	On Grade	40	24	1.01%	22.90	1.93	3.03	2.05	67.7%	17.14	6.71	0.98	18b	0.24	9.11	1916.17	1912.32	1915.93
40	Manhole	NA	FES-3	24	6.02%	55.91		17.14			17.14	11.35	N/A	18a			1909.34	1909.34	1914.03
19a	Type 2 Double	On Grade	19	15	2.00%	9.20	2.27	2.27	1.59	70.0%	3.18	5.56	0.68	18e	0.20	7.37	1928.39	1922.13	1928.19
19	Manhole	NA	18e	15	1.54%	8.08		3.18			3.18	5.91	N/A				1921.47	1921.47	1928.05
18f	Type 2 Double	On Grade	18e	15	1.00%	6.51	1.70	1.70	1.27	74.7%	1.27	3.40	0.43	18c	0.19	6.62	1923.08	1918.32	1922.89
18e	Type 2 Double	On Grade	18d	15	1.99%	9.18	1.28	1.95	1.42	72.8%	5.97	7.44	0.53	18d	0.20	7.03	1923.09	1917.65	1922.89
18d	Type 2 Double	On Grade	18a	18	1.00%	10.58	0.80	1.13	0.91	80.5%	6.93	4.90	0.22	18a	0.16	5.53	1917.34	1913.75	1917.18
18c	Type 2 Double	Sag	18a	18	0.50%	7.48	1.95	2.65	N/A	N/A	2.45	1.81	N/A		0.21	8.96	1915.72	1912.50	1915.51
18a	Type 2 Double	Sag	41	24	0.79%	20.25	1.36	2.19	N/A	N/A	11.39	5.73	N/A		0.19	7.61	1915.70	1912.39	1915.51
41	Manhole	NA	FES-6	24	6.00%	55.82		11.39			11.39	10.80	N/A				1909.21	1909.21	1914.47
DP-3	Flared End	NA	42	24	1.95%	31.82	63.67	21.71			21.71	6.91	N/A				1910.00	1910.00	
42	Manhole	NA	17	24	0.40%	14.41		21.71			21.71	6.91	N/A				1908.69	1908.69	1916.53
17	Manhole	NA	**FES-5 (PA2)**	24	0.50%	16.11		21.71			**21.71**	7.20	N/A				1906.86	1906.86	1915.57

* Clogging Factor: On Grade=10%, Sag=20%

**Basin runoff is the total runoff produced by the drainage basin. However, the individual SWMP provides detention to the rate listed in the pipe flow column

North Washington Street
NHU-1-981(101)111
Calgary Avenue to 57th Avenue NW

Storm Sewer System Summary
Table A-2
10 Year, 6 Hour Event

10/3/2014

Structure Name	Structure Type	*Inlet Condition	Downstream Structure	Pipe Size (inches)	Pipe Slope (%)	Full Flow Capacity (cfs)	10 Year, 6 Hour Event												Rim Elevation
							Basin Runoff (cfs)	Total Flow To Inlet (cfs)	Intercepted Flow (cfs)	Percent Capture	Pipe Flow (cfs)	Pipe Velocity (fps)	Bypass Flow (cfs)	Bypass Target	Maximum Depth in Gutter (ft)	Maximum Spread @ Inlet (ft)	Peak Water Elevation	Pipe Hydraulic Grade Line (HGL)	
Durango Drive to 57th Avenue																			
19b	Type 2 Double	On Grade	19a	15	3.00%	11.27	2.27	2.27	1.59	70.0%	1.59	3.88	0.68	23b	0.20	7.37	1928.40	1923.08	1928.20
23a	Type 2	On Grade	23	15	3.73%	12.57	0.94	0.94	0.66	70.2%	0.66	4.80	0.28	22a	0.17	5.92	1927.18	1923.27	1927.01
DP-4	Flared End	NA	23b	18	1.00%	10.58	6.9**	4.10			4.1**	4.73	N/A						
23b	Type 2	On Grade	23	18	1.00%	10.58	1.31	1.98	1.14	57.6%	5.13	5.23	0.84	22b	0.22	8.00	1927.22	1923.56	1927.00
23	Manhole	NA	22	18	3.58%	20.02		5.69			5.63	9.49	N/A				1922.54	1922.54	1927.47
22a	Type 2 Double	On Grade	22	15	0.97%	6.41	2.10	2.37	1.64	69.2%	1.75	3.80	0.73	21a	0.19	6.92	1910.91	1907.07	1910.72
32	Manhole	NA	22b	18	4.82%	23.23	14.41**	14.41			6.5**	9.59	N/A						
22b	Type 2 Double	On Grade	22	24	0.95%	22.21	2.85	3.27	2.08	63.6%	8.77	5.75	1.19	21b	0.21	7.86	1910.89	1907.24	1910.68
22	Manhole	NA	21	24	3.58%	43.12		15.73			15.72	9.22	N/A				1906.32	1906.32	1911.15
DP-6	Flared End	NA	21c	30	1.53%	51.11	8.02	16.94			16.94	4.92	N/A				1893.43	1893.43	
21d	Type 2	On Grade	21c	15	1.00%	6.51	2.03	2.81	1.46	52.0%	1.73	3.70	1.35		0.28	10.84	1898.39	1894.24	1898.11
21c	Type 2	On Grade	21	30	1.51%	50.77		1.09	0.73	67.0%	17.85	4.00	0.36	25c	0.20	7.18	1898.20	1893.05	1898.00
21	Manhole	NA	21a	30	1.53%	51.11		31.21			31.22	6.65	N/A				1892.73	1892.73	1898.47
21b	Type 2	On Grade	21a	15	1.00%	6.51	2.31	2.93	1.51	51.5%	1.74	3.71	1.42		0.28	11.02	1898.39	1894.24	1898.11
21a	Type 2	On Grade	**Ex Manhole (PA3)**	30	1.45%	49.75		1.19	0.78	65.5%	**32.44**	8.69	0.41	25a	0.21	7.65	1898.21	1891.93	1898.00
25a	Type 2 Double	On Grade	25	15	2.98%	11.23	1.40	1.77	1.44	81.4%	1.52	5.08	0.33	24a	0.24	9.32	1896.38	1892.12	1896.14
25c	Type 2 Double	On Grade	25b	15	1.00%	6.51	1.93	2.26	1.76	77.9%	1.84	3.76	0.50	25b	0.26	9.96	1896.46	1892.89	1896.20
25b	Type 2	On Grade	25	15	1.59%	8.21		0.42	0.34	81.0%	2.18	5.14	0.08	24b	0.14	4.49	1896.28	1892.60	1896.14
25	Manhole	NA	24	18	0.89%	9.98		3.70			3.64	3.91	N/A				1891.50	1891.50	1896.56
DP-7	Ex. Outlet Stru.	NA	24b	24	1.33%	26.28	24.14**	24.14			11**	5.66	N/A						
24b	Type 2 Double	On Grade	24	24	1.34%	26.38	2.13	2.20	1.72	78.2%	12.72	5.80	0.48	31b	0.26	9.85	1893.77	1888.89	1893.51
24	Manhole	NA	24a	24	1.32%	26.18		16.34			16.31	6.89	N/A				1888.24	1888.24	1893.97
24a	Type 2	On Grade	**FES-10 (PA4)**	24	0.98%	22.56	1.80	2.05	1.18	57.6%	**17.53**	6.68	0.87	31a	0.26	9.89	1893.77	1885.36	1893.51
31a	Type 2 Double	On Grade	31	15	1.16%	7.01	2.12	2.90	2.19	75.5%	2.36	4.45	0.71	29a	0.28	11.14	1891.46	1887.88	1891.18
31b	Type 2 Double	On Grade	31	15	1.00%	6.51	1.89	2.28	1.78	78.1%	1.89	4.19	0.50	29b	0.26	10.12	1891.69	1888.04	1891.43
31	Manhole	NA	30	18	1.07%	10.95		4.24			4.22	5.28	N/A				1887.40	1887.40	1891.90
30d	Type 2 Double	On Grade	30b	15	3.50%	12.17	4.59	4.59	2.67	58.2%	2.66	5.41	1.92	30b	0.24	9.13	1894.36	1888.93	1894.12
30b	Type 2 Double	On Grade	30a	18	1.21%	11.64		1.92	1.40	72.9%	4.06	4.67	0.52	29b	0.18	6.38	1892.46	1888.51	1892.28
30c	Type 2	On Grade	30a	15	1.80%	8.73	2.34	2.34	1.38	59.0%	1.37	3.82	0.96	30a	0.19	6.93	1893.31	1888.09	1893.12
30a	Type 2	On Grade	30	18	1.00%	10.58		0.96	0.74	77.1%	5.85	5.62	0.22	29b	0.15	4.67	1892.10	1888.01	1891.95
30	Manhole	NA	29	24	3.22%	40.89		9.64			9.64	7.36	N/A				1886.23	1886.23	1891.30
29a	Type 2 Double	On Grade	29	15	2.52%	10.33	0.88	1.41	1.17	83.0%	1.25	4.80	0.24	28a	0.22	8.22	1890.75	1886.50	1890.53
29b	Type 2	On Grade	29	15	1.00%	6.51	1.10	1.98	1.15	58.1%	1.49	4.00	0.83	28b	0.25	9.76	1890.54	1886.83	1890.29
29	Manhole	NA	28	24	1.38%	26.77		12.07			12.02	7.94	N/A				1884.70	1884.70	1890.99
28a	Type 2 Double	On Grade	28	15	1.00%	6.51	1.65	1.80	1.41	78.3%	1.45	3.65	0.39	27a	0.23	8.47	1888.13	1883.99	1887.90
28c-DP-8	Fut. Flared End	NA	28b	15	2.26%	9.78	9.15**	9.15			3.7**	6.59	N/A						
28b	Type 2 Double	On Grade	28	18	1.67%	13.67	2.54	3.02	2.16	71.5%	6.01	6.50	0.86	27b	0.26	10.30	1888.16	1883.82	1887.90
28	Manhole	NA	39	30	1.97%	57.99		18.93			18.92	8.24	N/A				1878.60	1878.60	1888.37
CorniceStub	Future Storm	NA	39	18	1.07%	10.95	6.15	6.15			6.11	5.71	N/A				1877.79	1877.79	1880.44
39	Manhole	NA	27	30	2.00%	58.43		24.63			24.63	9.11	N/A				1872.47	1872.47	1881.54
27a	Type 2 Double	On Grade	27	15	3.15%	11.55	1.55	1.91	1.39	72.8%	1.51	5.43	0.52	26a	0.19	6.77	1878.84	1874.58	1878.65
27b	Type 2	On Grade	27	15	1.00%	6.51	1.78	2.48	1.40	56.5%	1.67	4.07	1.08	26b	0.21	7.50	1878.81	1874.68	1878.60
27	Manhole	NA	26	30	2.00%	58.43		27.66			27.67	10.31	N/A				1870.62	1870.62	1879.07

* Clogging Factor: On Grade=10%, Sag=20%

**Basin runoff is the total runoff produced by the drainage basin. However, the individual SWMP provides detention to the rate listed in the pipe flow column

Storm Sewer System Summary
Table A-2
10 Year, 6 Hour Event

Structure Name	Structure Type	*Inlet Condition	Downstream Structure	Pipe Size (inches)	Pipe Slope (%)	Full Flow Capacity (cfs)	10 Year, 6 Hour Event												Rim Elevation
							Basin Runoff (cfs)	Total Flow To Inlet (cfs)	Intercepted Flow (cfs)	Percent Capture	Pipe Flow (cfs)	Pipe Velocity (fps)	Bypass Flow (cfs)	Bypass Target	Maximum Depth in Gutter (ft)	Maximum Spread @ Inlet (ft)	Peak Water Elevation	Pipe Hydraulic Grade Line (HGL)	
Durango Drive to 57th Avenue (cont.)																			
26b	Type 2 Double	On Grade	26	18	1.00%	10.58	1.74	2.54	1.84	72.4%	2.03	4.21	0.70	33c	0.24	9.32	1867.43	1863.34	1867.19
26	Manhole	NA	26a	36	1.47%	81.46		29.60			29.58	7.88	N/A				1862.62	1862.62	1867.66
26a	Type 2	On Grade	**FES-11 (PA5)**	36	2.08%	96.90	1.57	1.96	1.12	57.1%	**30.78**	7.95	0.84	33a	0.22	8.39	1867.41	1858.48	1867.19
FES-16	Flared End	NA	34a	24	3.36%	41.77	11.62	11.61			11.61	9.28	N/A				1873.06	1873.06	
FES-13	Flared End	NA	34a	18	6.51%	27.00	2.62	2.62			2.62	8.15	N/A				1870.16	1870.16	
34a	Ditch Inlet	Sag	34c	30	1.02%	41.73	1.88	13.26			13.26	5.03	N/A				1868.64	1868.64	1871.80
34c	Type 2 Double	On Grade	34	30	0.99%	41.11	0.82	0.82	0.70	85.4%	13.33	6.14	0.12		0.16	5.45	1873.48	1868.23	1873.32
FES-14	Flared End	NA	34d	24	5.98%	55.73	9.79	9.79			9.79	9.09	N/A				1870.56	1870.56	
34d	Type 2	On Grade	34	24	5.00%	50.96	0.88	0.88	0.63	71.6%	9.88	8.86	0.25		0.17	5.64	1873.53	1869.17	1873.36
34	Manhole	NA	33	36	1.50%	82.29		22.22			22.17	9.42	N/A				1867.20	1867.20	1873.73
33e	Type 2	On Grade	33d	15	1.50%	7.97	2.03	2.14	1.19	55.6%	1.24	4.35	0.95		0.24	8.99	1866.99	1862.68	1866.75
33d	Type 2 Double	Sag	33	18	2.00%	14.96	0.71	2.11	N/A	N/A	3.25	5.99	N/A		0.23	9.25	1866.77	1861.79	1866.54
33	Manhole	NA	33b	36	1.56%	83.92		22.58			22.58	6.12	N/A				1858.58	1858.58	1867.59
33c	Type 2 Double	On Grade	33b	15	1.51%	8.00	2.72	2.97	2.13	71.7%	2.20	4.89	0.84		0.26	10.25	1866.98	1862.78	1866.72
33b	Type 2	On Grade	**FES-15 (PA5)**	36	1.23%	74.51	0.15	0.91	0.64	70.3%	**23.08**	7.51	0.27		0.21	7.60	1866.80	1857.92	1866.59
33a	Type 2 Double	Sag	33b	15	3.47%	12.12	0.38	1.28	N/A	N/A	1.26	5.22	N/A		0.18	6.44	1866.72	1862.48	1866.54
DP-9	Box Culvert	NA	**(PA5)**	60	0.92%	480.35		8.02			**8.00**	4.12	N/A						

* Clogging Factor: On Grade=10%, Sag=20%

**Basin runoff is the total runoff produced by the drainage basin. However, the individual SWMP provides detention to the rate listed in the pipe flow column

North Washington Street
NHU-1-981(101)111
Calgary Avenue to 57th Avenue NW

Storm Sewer System Summary
Table A-2
100 Year, 6 Hour Event

10/3/2014

Structure Name	Structure Type	*Inlet Condition	Downstream Structure	Pipe Size (inches)	Pipe Slope (%)	Full Flow Capacity (cfs)	100 Year, 6 Hour Event												Rim Elevation
							Basin Runoff (cfs)	Total Flow To Inlet (cfs)	Intercepted Flow (cfs)	Percent Capture	Pipe Flow (cfs)	Pipe Velocity (fps)	Bypass Flow (cfs)	Bypass Target	Maximum Depth in Gutter (ft)	Maximum Spread @ Inlet (ft)	Peak Water Elevation	Pipe Hydraulic Grade Line (HGL)	
Arabian Avenue to 43rd Avenue																			
13a	Catch Basin	Sag	13b Future/13	15	1.59%	8.21		7.34			6.50	5.32	N/A				1920.20	1920.20	1921.19
13b Future	Type 2	On Grade	13	15	1.59%	8.21	3.46	3.46	1.78	51.4%	9.22	7.60	1.68	9b	0.22	8.26	1919.70	1917.58	1919.48
13c Future	Type 2	On Grade	13	15	0.99%	6.47	2.22	2.22	1.33	59.9%	1.34	3.05	0.89	9b	0.19	6.74	1919.51	1916.47	1919.32
13	Manhole	NA	10	18	1.00%	10.58		10.36			9.28	5.74	N/A				1916.45	1916.45	1919.52
10	Manhole	NA	9	18	1.06%	10.89		9.28			9.26	6.14	N/A				1915.46	1915.46	1919.17
09a	Type 2	On Grade	9	15	1.00%	6.51	2.29	2.29	1.25	54.6%	1.25	3.63	1.04	8a	0.25	9.65	1917.82	1914.06	1917.57
09b	Type 2	On Grade	9	15	1.00%	6.51	3.51	6.06	2.46	40.6%	3.31	4.58	3.60	8b	0.35	14.15	1917.92	1914.41	1917.57
9	Manhole	NA	8	24	0.82%	20.64		13.16			13.21	6.11	N/A	NA			1913.86	1913.86	1918.28
8a	Type 2	On Grade	8	15	1.00%	6.51	1.80	2.83	1.46	51.6%	1.75	3.94	1.37	6a	0.27	10.50	1915.65	1912.32	1915.38
FES-19	Flared End	NA	8b	15	3.03%	11.33	10.75	10.07			10.07	8.89	N/A				1914.74	1914.74	
8b	Type 2	On Grade	8	24	0.90%	21.62	2.18	4.93	2.14	43.4%	10.40	4.82	2.79	6b	0.32	13.06	1915.70	1912.50	1915.38
8	Manhole	NA	7	30	2.00%	58.43		22.75			22.30	5.81	N/A				1912.33	1912.33	1916.09
FES-20	Flared End	NA	7	15	3.20%	11.64	11.36	10.88			10.88	9.46	N/A				1914.82	1914.82	
7	Manhole	NA	6	30	0.72%	35.06		32.48			31.02	7.19	N/A				1909.82	1909.82	1915.86
06a	Type 2	On Grade	6	15	0.48%	4.51	2.18	3.25	1.60	49.2%	1.93	3.25	1.65	4a	0.28	11.09	1913.03	1909.90	1912.75
06b	Type 2 Double	On Grade	6	15	1.00%	6.51	2.74	5.02	3.34	66.5%	3.77	4.72	1.68	4b	0.32	13.15	1913.07	1909.83	1912.75
6	Manhole	NA	5	36	0.48%	46.55		60.81			32.32	5.51	N/A				1909.41	1909.41	1913.46
12a Future	Type 2	On Grade	12 Future	15	0.98%	6.44	2.13	2.13	1.34	62.9%	1.32	3.31	0.79	4b	0.18	6.27	1913.28	1911.88	1913.10
Buckskin 24" Plug	Future Storm	NA	12 future	24	1.50%	27.91	28.34	28.34			28.34	9.02	N/A				1913.30	1913.30	1916.50
12b Future	Type 2	On Grade	12 Future	15	0.46%	4.41	2.26	2.26	1.39	61.5%	1.37	2.84	0.87	4b	0.18	6.42	1913.56	1911.88	1913.38
12 Future	Manhole	NA	5	24	1.50%	27.91		29.50			29.51	9.39	N/A				1911.88	1911.88	1913.28
5	Manhole	NA	4	42	0.75%	87.77		86.32			61.62	8.24	N/A				1907.72	1907.72	1913.07
04a	Type 2 Double	On Grade	4	15	0.74%	5.60	3.20	4.48	3.05	68.1%	3.38	4.16	1.43	3a	0.31	12.59	1909.98	1907.63	1909.67
FES-1	Flared End	NA	04b	18	5.49%	24.79	24.37	23.09			23.09	13.58	N/A				1911.20	1911.20	
04b	Type 2 Double	On Grade	4	30	1.65%	53.07	3.43	6.32	4.05	64.1%	24.35	7.27	2.27	3b	0.35	14.52	1910.02	1907.98	1909.67
4	Manhole	NA	3	48	0.68%	119.32		88.25			87.15	7.43	N/A				1906.14	1906.14	1910.39
36b	Type 2 Double	On Grade	36	15	0.70%	5.44	5.97	5.97	3.25	54.4%	3.24	4.21	2.72	35b	0.27	10.61	1930.23	1926.86	1929.96
35b	Type 2 Double	On Grade	35	15	0.50%	4.60	3.54	6.24	3.80	60.9%	4.35	4.09	2.44	1d	0.33	13.45	1925.05	1921.93	1924.72
01d	Type 2 Double	On Grade	01c	15	1.00%	6.51	1.86	1.86	1.15	61.8%	1.15	2.93	0.71	1b	0.27	10.79	1915.07	1921.03	1914.80
37b	Type 2	On Grade	37	15	1.75%	8.61	4.98	6.84	3.59	52.5%	4.19	4.83	3.25	1c	0.28	11.19	1924.52	1911.36	1924.24
01c	Type 2 Double	On Grade	01a	15	2.88%	11.04	6.04	6.75	3.55	52.6%	7.97	6.59	3.20	Lorain Dr	0.28	11.13	1914.97	1910.66	1914.69
01a	Type 2	On Grade	1	15	1.00%	6.51	1.26	4.46	2.00	44.8%	10.24	8.35	2.46	3a	0.27	10.51	1909.07	1907.62	1908.80
01b	Type 2 Double	On Grade	1	15	3.16%	11.57	1.67	4.29	2.71	63.2%	3.20	2.72	1.58	3b	0.28	10.80	1909.09	1906.29	1908.81
1	Manhole	NA	2	18	1.47%	12.83		30.27			13.22	7.62	N/A				1912.00	1912.00	1909.89
Colt 24" Plug	Future Storm	NA	11	24	2.00%	32.23	24.50	24.50			24.49	7.80	N/A				1907.64	1907.64	1910.72
11a	Ditch Inlet	Sag	11	15	2.44%	10.16	4.45	4.45			4.45	6.40	N/A				1906.93	1906.93	1908.23
FES-2	Flared End	NA	11	24	8.98%	68.29	61.41	56.08			56.08	17.85	N/A				1913.76	1913.76	
11	Manhole	NA	2	42	2.05%	145.10		81.21			81.22	8.66	N/A				1906.69	1906.69	1908.88
03a	Type 2 Double	Sag	3	15	0.71%	5.48	2.73	3.83	N/A	N/A	3.77	3.95	N/A		0.28	12.12	1907.83	1906.04	1907.55
03b	Type 2 Double	Sag	3	15	0.71%	5.48	3.38	5.92	N/A	N/A	6.07	4.95	N/A		0.35	14.02	1907.91	1906.28	1907.56
3	Manhole	NA	2	48	0.97%	142.51		13.22			90.12	7.69	N/A				1906.21	1906.21	1908.64
2	Manhole	NA	20	54	1.29%	224.98		175.70			175.70	11.40	N/A				1905.16	1905.16	1908.69
20	Manhole	NA	**Ex Storm (PA1)**	54	2.63%	321.24		175.70			**175.69**	12.74	N/A				1902.71	1902.71	1909.98

* Clogging Factor: On Grade=10%, Sag=20%

North Washington Street
NHU-1-981(101)111
Calgary Avenue to 57th Avenue NW

Storm Sewer System Summary
Table A-2
100 Year, 6 Hour Event

10/3/2014

Structure Name	Structure Type	*Inlet Condition	Downstream Structure	Pipe Size (inches)	Pipe Slope (%)	Full Flow Capacity (cfs)	100 Year, 6 Hour Event												Rim Elevation
							Basin Runoff (cfs)	Total Flow To Inlet (cfs)	Intercepted Flow (cfs)	Percent Capture	Pipe Flow (cfs)	Pipe Velocity (fps)	Bypass Flow (cfs)	Bypass Target	Maximum Depth in Gutter (ft)	Maximum Spread @ Inlet (ft)	Peak Water Elevation	Pipe Hydraulic Grade Line (HGL)	
Montreal Street																			
38a	Type 2	On Grade	41805	15	6.02%	15.97	1.44	1.44	0.95	66.0%	0.95	6.41	0.49	Montreal	0.18	6.04	1922.15	1917.56	1921.97
38b	Beehive	Sag	**FES-18 (PA6)**	18	1.50%	12.96	1.03	1.98	N/A	N/A	**1.98**	5.00	N/A				1919.57	1915.76	1919.08
43rd Avenue to Durango Drive																			
37a	Type 2	On Grade	37	15	0.99%	6.47	3.17	3.17	1.72	54.3%	1.71	3.30	1.45	15b	0.33	13.30	1924.36	1920.63	1924.03
37	Manhole	NA	16	15	1.01%	6.54		2.86			2.83	4.55	N/A				1920.26	1920.26	1924.94
36a	Type 2 Double	On Grade	36	15	2.86%	11.00	7.74	7.74	3.90	50.4%	3.90	6.37	3.84	35a	0.29	11.61	1930.07	1926.76	1929.78
36	Manhole	NA	35	18	2.40%	16.39		7.11			7.10	7.10	N/A				1925.95	1925.95	1930.26
35a	Type 2	On Grade	35	15	2.16%	9.56	2.18	6.02	2.42	40.2%	2.98	5.03	3.60	15a	0.33	13.26	1925.23	1921.68	1924.90
35	Manhole	NA	16	24	0.50%	16.11		14.41			14.22	5.52	N/A				1921.38	1921.38	1925.52
16	Manhole	NA	15	24	1.20%	24.96		17.00			16.74	7.10	N/A				1919.88	1919.88	1924.79
15a	Type 2	On Grade	15	15	4.91%	14.42	2.13	3.58	1.71	47.8%	2.11	14.53	1.87	14a	0.26	10.19	1922.60	1918.89	1922.34
15b	Type 2	On Grade	15	15	1.61%	8.26	3.02	6.04	2.45	40.6%	3.18	5.51	3.59	14b	0.29	11.72	1922.41	1918.83	1922.12
15	Manhole	NA	14	24	1.38%	26.77		21.84			20.79	6.69	N/A				1918.61	1918.61	1922.58
14a	Type 2 Double	On Grade	14	15	1.00%	6.51	1.81	3.27	2.17	66.4%	2.52	2.84	1.10	18c	0.25	9.38	1916.22	1915.31	1915.97
14	Manhole	NA	14b	24	0.99%	22.67		22.87			22.99	7.32	N/A				1915.56	1915.56	1916.18
14b	Type 2 Double	On Grade	40	24	1.01%	22.90	3.20	6.14	3.50	57.0%	26.57	8.62	2.64	18b	0.30	12.03	1916.23	1913.69	1915.93
40	Manhole	NA	FES-3	24	6.02%	55.91		26.57			26.31	12.07	N/A	18a			1909.81	1909.81	1914.03
19a	Type 2 Double	On Grade	19	15	2.00%	9.20	4.11	4.11	2.50	60.8%	4.98	6.12	1.61	18e	0.25	9.38	1928.44	1922.37	1928.19
19	Manhole	NA	18e	15	1.54%	8.08		4.98			5.26	5.92	N/A				1921.65	1921.65	1928.05
18f	Type 2 Double	On Grade	18e	15	1.00%	6.51	2.72	2.72	1.83	67.3%	3.24	3.35	0.89	18c	0.22	8.04	1923.11	1918.68	1922.89
18e	Type 2 Double	On Grade	18d	15	1.99%	9.18	2.10	3.70	2.32	62.7%	9.19	7.49	1.38	18d	0.24	9.12	1923.13	1918.57	1922.89
18d	Type 2 Double	On Grade	18a	18	1.00%	10.58	1.43	2.40	1.67	69.6%	10.89	6.16	0.73	18a	0.21	7.65	1917.39	1915.68	1917.18
18c	Type 2 Double	Sag	18a	18	0.50%	7.48	3.51	5.16	N/A	N/A	4.81	2.72	N/A		0.33	14.78	1915.84	1913.34	1915.51
18a	Type 2 Double	Sag	41	24	0.79%	20.25	2.49	4.97	N/A	N/A	19.52	6.57	N/A		0.31	14.86	1915.82	1913.11	1915.51
41	Manhole	NA	FES-6	24	6.00%	55.82		19.52			19.40	11.85	N/A				1909.61	1909.61	1914.47
DP-3	Flared End	NA	42	24	1.95%	31.82	122.94	27.89			27.89	8.88	N/A				1913.34	1913.34	
42	Manhole	NA	17	24	0.40%	14.41		27.89			27.89	8.88	N/A				1911.19	1911.19	1916.53
17	Manhole	NA	**FES-5 (PA2)**	24	0.50%	16.11		27.89			**27.89**	9.02	N/A				1908.15	1908.15	1915.57

* Clogging Factor: On Grade=10%, Sag=20%

Storm Sewer System Summary
Table A-2
100 Year, 6 Hour Event

Structure Name	Structure Type	*Inlet Condition	Downstream Structure	Pipe Size (inches)	Pipe Slope (%)	Full Flow Capacity (cfs)	100 Year, 6 Hour Event											Rim Elevation
							Basin Runoff (cfs)	Total Flow To Inlet (cfs)	Intercepted Flow (cfs)	Percent Capture	Pipe Flow (cfs)	Pipe Velocity (fps)	Bypass Flow (cfs)	Bypass Target	Maximum Depth in Gutter (ft)	Maximum Spread @ Inlet (ft)	Peak Water Elevation	Pipe Hydraulic Grade Line (HGL)	
Durango Drive to 57th Avenue																		
19b	Type 2 Double	On Grade	19a	15	3.00%	11.27	4.11	4.11	2.50	60.8%	2.50	3.94	1.61	23b	0.25	9.38	1928.45	1923.20	1928.20
23a	Type 2	On Grade	23	15	3.73%	12.57	1.85	1.85	1.08	58.4%	1.08	5.18	0.77	22a	0.21	7.89	1927.22	1923.34	1927.01
DP-4	Flared End	NA	23b	18	1.00%	10.58	13.95	7.00			7.00	5.04	N/A				1925.07	1925.07	
23b	Type 2	On Grade	23	18	1.00%	10.58	2.06	3.67	1.74	47.4%	8.76	5.79	1.93	22b	0.26	10.24	1927.26	1924.03	1927.00
23	Manhole	NA	22	18	3.58%	20.02		9.70			9.63	10.86	N/A				1922.75	1922.75	1927.47
22a	Type 2 Double	On Grade	22	15	0.97%	6.41	4.06	4.83	2.76	57.1%	3.10	4.37	2.07	21a	0.24	9.25	1910.96	1907.31	1910.72
32	Manhole	NA	22b	18	4.82%	23.23	31.51	31.51			13.60	9.68	N/A				1917.09	1917.09	
22b	Type 2 Double	On Grade	22	24	0.95%	22.21	5.34	6.38	3.37	52.8%	17.51	6.65	3.01	21b	0.26	10.28	1910.94	1907.93	1910.68
22	Manhole	NA	21	24	3.58%	43.12		29.64			29.59	10.68	N/A				1906.78	1906.78	1911.15
DP-6	Flared End	NA	21c	30	1.53%	51.11	19.12	26.76			26.76	5.45	N/A				1895.72	1895.72	
21d	Type 2	On Grade	21c	15	1.00%	6.51	3.34	5.72	2.39	41.8%	4.38	4.25	3.33		0.35	14.29	1898.46	1895.23	1898.11
21c	Type 2	On Grade	21	30	1.51%	50.77		2.77	1.44	52.0%	27.30	5.56	1.33	25c	0.27	10.49	1898.27	1895.23	1898.00
21	Manhole	NA	21a	30	1.53%	51.11		47.32			46.48	9.47	N/A				1895.41	1895.41	1898.47
21b	Type 2	On Grade	21a	15	1.00%	6.51	4.08	5.80	2.41	41.6%	2.92	4.24	3.39		0.35	14.37	1898.46	1894.45	1898.11
21a	Type 2	On Grade	**Ex Manhole (PA3)**	30	1.45%	49.75		2.88	1.49	51.7%	**46.61**	10.13	1.39	25a	0.28	10.94	1898.28	1893.28	1898.00
25a	Type 2 Double	On Grade	25	15	2.98%	11.23	2.26	3.64	2.67	73.4%	2.93	5.05	0.97	24a	0.31	12.39	1896.45	1892.33	1896.14
25c	Type 2 Double	On Grade	25b	15	1.00%	6.51	3.48	4.79	3.30	68.9%	3.63	4.39	1.49	25b	0.33	13.36	1896.53	1893.20	1896.20
25b	Type 2	On Grade	25	15	1.59%	8.21		1.16	0.77	66.4%	4.40	5.85	0.39	24b	0.21	7.59	1896.35	1892.88	1896.14
25	Manhole	NA	24	18	0.89%	9.98		7.33			7.19	4.66	N/A				1891.82	1891.82	1896.56
DP-7	Ex. Outlet Stru.	NA	24b	24	1.33%	26.28	49.53	49.53			14.00	5.63	N/A				1896.29	1896.29	
24b	Type 2 Double	On Grade	24	24	1.34%	26.38	4.08	4.46	3.11	69.7%	17.24	6.02	1.35	31b	0.32	13.00	1893.83	1889.92	1893.51
24	Manhole	NA	24a	24	1.32%	26.18		24.37			24.37	8.28	N/A				1889.13	1889.13	1893.97
24a	Type 2	On Grade	**FES-10 (PA4)**	24	0.98%	22.56	3.11	3.80	1.83	48.2%	**26.42**	8.58	1.97	31a	0.31	12.60	1893.82	1886.68	1893.51
31a	Type 2 Double	On Grade	31	15	1.16%	7.01	3.42	5.11	3.51	68.7%	3.88	4.49	1.60	29a	0.34	13.90	1891.52	1888.18	1891.18
31b	Type 2 Double	On Grade	31	15	1.00%	6.51	3.89	5.11	3.51	68.7%	3.83	4.55	1.60	29b	0.34	13.89	1891.77	1888.37	1891.43
31	Manhole	NA	30	18	1.07%	10.95		7.70			7.67	5.72	N/A				1887.78	1887.78	1891.90
30d	Type 2 Double	On Grade	30b	15	3.50%	12.17	10.53	10.53	4.78	45.4%	5.41	5.41	5.75	30b	0.31	12.66	1894.43	1889.84	1894.12
30b	Type 2 Double	On Grade	30a	18	1.21%	11.64		5.75	3.13	54.4%	7.92	4.88	2.62	29b	0.26	9.99	1892.54	1889.55	1892.28
30c	Type 2	On Grade	30a	15	1.80%	8.73	4.24	4.24	2.05	48.3%	2.03	3.74	2.19	30a	0.23	8.84	1893.35	1889.04	1893.12
30a	Type 2	On Grade	30	18	1.00%	10.58		2.19	1.32	60.3%	10.82	6.36	0.87	29b	0.19	6.73	1892.14	1889.00	1891.95
30	Manhole	NA	29	24	3.22%	40.89		17.53			17.52	7.61	N/A				1886.70	1886.70	1891.30
29a	Type 2 Double	On Grade	29	15	2.52%	10.33	1.35	2.57	1.96	76.3%	2.15	5.42	0.61	28a	0.27	10.47	1890.80	1886.64	1890.53
29b	Type 2	On Grade	29	15	1.00%	6.51	1.84	5.81	2.45	42.2%	3.53	4.89	3.36	28b	0.36	14.85	1890.65	1887.15	1890.29
29	Manhole	NA	28	24	1.38%	26.77		22.66			22.58	8.98	N/A				1885.28	1885.28	1890.99
28a	Type 2 Double	On Grade	28	15	1.00%	6.51	2.88	3.29	2.32	70.5%	2.46	4.16	0.97	27a	0.27	10.78	1888.17	1884.18	1887.90
28c-DP-8	Fut. Flared End	NA	28b	15	2.26%	9.78	17.50	17.50			9.10	7.94	N/A				1890.58	1890.58	
28b	Type 2 Double	On Grade	28	18	1.67%	13.67	4.23	6.15	3.80	61.8%	13.41	7.98	2.35	27b	0.33	13.59	1888.23	1885.17	1887.90
28	Manhole	NA	39	30	1.97%	57.99		37.92			37.89	9.17	N/A				1879.27	1879.27	1888.37
CorniceStub	Future Storm	NA	39	18	1.07%	10.95	10.84	10.84			10.86	6.43	N/A				1879.37	1879.37	1880.44
39	Manhole	NA	27	30	2.00%	58.43		47.92			47.76	10.13	N/A				1874.15	1874.15	1881.54
27a	Type 2 Double	On Grade	27	15	3.15%	11.55	2.82	3.64	2.28	62.6%	2.58	6.08	1.36	26a	0.23	8.83	1878.88	1874.73	1878.65
27b	Type 2	On Grade	27	15	1.00%	6.51	3.16	4.99	2.23	44.7%	2.78	4.58	2.76	26b	0.26	9.94	1878.86	1874.86	1878.60
27	Manhole	NA	26	30	2.00%	58.43		52.76			52.74	11.11	N/A				1871.52	1871.52	1879.07

* Clogging Factor: On Grade=10%, Sag=20%

Storm Sewer System Summary
Table A-2
100 Year, 6 Hour Event

Structure Name	Structure Type	*Inlet Condition	Downstream Structure	Pipe Size (inches)	Pipe Slope (%)	Full Flow Capacity (cfs)	100 Year, 6 Hour Event												Rim Elevation
							Basin Runoff (cfs)	Total Flow To Inlet (cfs)	Intercepted Flow (cfs)	Percent Capture	Pipe Flow (cfs)	Pipe Velocity (fps)	Bypass Flow (cfs)	Bypass Target	Maximum Depth in Gutter (ft)	Maximum Spread @ Inlet (ft)	Peak Water Elevation	Pipe Hydraulic Grade Line (HGL)	
Durango Drive to 57th Avenue (cont.)																			
26b	Type 2 Double	On Grade	26	18	1.00%	10.58	3.10	5.30	3.31	62.5%	3.76	4.21	1.99	33c	0.31	12.45	1867.50	1863.77	1867.19
26	Manhole	NA	26a	36	1.47%	81.46		56.18			56.15	9.26	N/A				1863.69	1863.69	1867.66
26a	Type 2	On Grade	**FES-11 (PA5)**	36	2.08%	96.90	2.82	3.88	1.80	46.4%	**58.11**	9.08	2.08	33a	0.28	11.01	1867.47	1859.74	1867.19
FES-16	Flared End	NA	34a	24	3.36%	41.77	28.86	28.87			28.87	9.68	N/A				1873.90	1873.90	
FES-13	Flared End	NA	34a	18	6.51%	27.00	6.07	6.07			6.07	9.18	N/A				1870.43	1870.43	
34a	Ditch Inlet	Sag	34c	30	1.02%	41.73	5.10	33.36			33.36	6.83	N/A				1870.24	1870.24	1871.80
34c	Type 2 Double	On Grade	34	30	0.99%	41.11	1.26	1.26	1.01	80.2%	33.48	7.59	0.25		0.19	6.63	1873.51	1869.42	1873.32
FES-14	Flared End	NA	34d	24	5.98%	55.73	22.38	22.32			22.32	9.65	N/A				1871.29	1871.29	
34d	Type 2	On Grade	34	24	5.00%	50.96	1.35	1.35	0.86	63.7%	22.48	10.26	0.49		0.19	6.83	1873.55	1869.92	1873.36
34	Manhole	NA	33	36	1.50%	82.29		54.15			54.07	11.53	N/A				1868.06	1868.06	1873.73
33e	Type 2	On Grade	33d	15	1.50%	7.97	3.49	3.72	1.75	47.0%	1.87	4.42	1.97		0.28	11.20	1867.03	1862.78	1866.75
33d	Type 2 Double	Sag	33	18	2.00%	14.96	1.29	4.63	N/A	N/A	6.24	6.90	N/A		0.36	15.94	1866.90	1862.06	1866.54
33	Manhole	NA	33b	36	1.56%	83.92		54.75			54.75	7.84	N/A				1860.38	1860.38	1867.59
33c	Type 2 Double	On Grade	33b	15	1.51%	8.00	4.45	4.93	3.20	64.9%	3.38	5.38	1.73		0.31	12.51	1867.03	1862.95	1866.72
33b	Type 2	On Grade	**FES-15 (PA5)**	36	1.23%	74.51	0.27	1.82	1.10	60.4%	**55.55**	9.17	0.72		0.26	10.10	1866.85	1859.23	1866.59
33a	Type 2 Double	Sag	33b	15	3.47%	12.12	0.73	3.02	N/A	N/A	2.92	6.21	N/A		0.28	11.89	1866.82	1862.72	1866.54
DP-9	Box Culvert	NA	**(PA5)**	60	0.92%	480.35		18.00			**17.99**	5.41	N/A						

* Clogging Factor: On Grade=10%, Sag=20%