

APPENDIX H

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WILLOW CREEK HYRAULICS AND BRIDGE  
TECHNICAL MEMORANDUM

To: File	
From: Matt Redington, P.E.	Project: Watertown Connector
CC:	
Date: November 7, 2006; revised May 18, 2007	Job No:

**RE: Analysis of 20<sup>th</sup> Avenue Bridge Crossing over Willow Creek**

Introduction

There is an existing 20<sup>th</sup> Avenue South Bridge that crosses over Willow Creek south of Watertown, South Dakota. This structure is a concrete girder bridge that is approximately 60 feet long. Figures H-1 and H-2 show pictures of the existing bridge.

The alignment of the proposed roadway follows closely to the alignment of existing 20<sup>th</sup> Avenue South. The existing roadway is approximately 22 feet wide, while the proposed roadway is approximately 58 feet wide. At the location of the Willow Creek crossing, the proposed centerline is approximately 20 feet south of the existing centerline.

National Flood Insurance Program Mapping

Watertown and Coddington County are participating communities in the National Flood Insurance Program. The most current regulatory flood maps for Willow Creek became effective on February 1, 1986 as part of Coddington County's flood maps. On these maps, Willow Creek is mapped as Zone A. This designation means that water surface elevations were determined using approximate methods.

Willow Creek is in the process of being remapped using detailed methods. As such, the floodplain will be designated as Zone AE. The hydraulic modeling to develop the new floodplain maps was performed by Banner Associates, Inc. This modeling is undergoing the FEMA review process. While the floodplain model may be modified in the FEMA review process, it represents the best information that is available.

The areas of approximate flooding limits that are adopted in the 1986 mapping are shown in Figure H-3. This mapping shows the anticipated approximate limits of the 100-year floodplains. Although a floodway is proposed for this area as part of the pending updates to the Flood Insurance Study, the mapping limits for the 100-year floodway have not yet been completed.

Once this area has an established floodway, a Letter of Map Revision (LOMR) will be required if a project will result in any increase to 100-year water surface elevations. A LOMR involves hydraulic modeling of the waterway to determine water surface elevation impacts, and creation of new regulatory floodplain maps. It also involves notification of impacted property owners as to the degree of impact on their property.

The limits of the floodway show the extent to which floodplains can be filled for development without water surface elevations increasing by more than one foot. A "no-rise" means that hydraulic modeling for the proposed 20<sup>th</sup> Avenue South crossing alternatives shall not show an increase in water surface elevations for the 100-year event anywhere along Willow Creek. This modeling "no-rise" must occur for the encroached floodplain (floodway) condition. Per discussion with Michelle Saxman, the South Dakota Floodplain Administrator, a water surface increase of 0.01 ft qualifies as a rise and would require a LOMR. Rick Schlechter, the Watertown Floodplain Administrator, stated that designing the crossing for a "no-rise" would be the most desirable solution for the City.

In order to prevent water surface elevation increases which would impact upstream properties, and to avoid the need for a LOMR, HDR has designed this crossing for a "no-rise" condition.

## Performance of Existing Bridge

HDR acquired the HEC-RAS model that was submitted by Banner Associates to FEMA for the floodplain mapping review process. This HEC-RAS model was used for hydraulic modeling of a replacement structure over Willow Creek. The flows included with the HEC-RAS model were used in the hydraulic analysis (HDR did not perform a hydrologic analysis). The updated modeling uses a 100-year flow of 5,575 cubic feet per second. Under existing conditions, flows at this crossing pass through the bridge opening for events up to and including the 100-year storm. Flows resulting from the 500-year event overtop the existing roadway.

## Proposed Bridge

The South Dakota Department of Transportation has indicated that the proposed roadway and the 20<sup>th</sup> Avenue South bridge replacement should be designed so current criteria can be met. The criteria states that there shall be 2-feet of freeboard between the bottom of the bridge girder and the 100-year water surface elevation. Under proposed floodplain mapping conditions, the 100-year water surface elevation will be at 1717.29 feet on the upstream side of the existing 20<sup>th</sup> Avenue South bridge. Based on the no-rise condition, the proposed water surface elevation will remain the same at 1717.29, making the lowest allowable bottom of girder elevation 1719.29. This is approximately 15.5 feet above the invert of Willow Creek. The existing overbank on the upstream side of the crossing is at an elevation of approximately 1719.

The existing channel flow direction is perpendicular to 20<sup>th</sup> Avenue South. HDR recommends a bridge length longer than the existing 60 foot length in order to allow the use of 2:1 slopes from the top of the bridge abutments to the channel bottom. Using 2:1 slopes from the abutments avoids the expense of vertical abutments and results in a more economical bridge. Modeling within HEC-RAS demonstrates that a bridge length of 100 feet with 2:1 channel side slopes will be sufficient to ensure a no-rise. Figure H-4 shows a cross section of the bridge deck and a cross section of the channel in a direction that is parallel to 20<sup>th</sup> Avenue South. Construction of the proposed bridge would require some transition grading in the vicinity of the crossing. This grading would occur in the immediate vicinity of the crossing, and would not modify the direction or length of the current low flow path. Table H-1 shows the water surface elevation impacts under 100-year floodway conditions for the proposed 100 foot long bridge. Flows resulting from the 500-year event pass beneath the bridge (no roadway overtopping occurs).

Table H-1 – Water Surface Elevation Impacts for Proposed Bridge

Location	Distance Upstream from 20 <sup>th</sup> Avenue South	Difference in 100-Year Floodway Water Surface Elevations between Proposed Conditions and Proposed Banner Associates FIS *
HEC-RAS Section 13	160 feet	-0.04 feet
HEC-RAS Section 14	873 feet	-0.03 feet
HEC-RAS Section 15	1376 feet (0.26 miles)	-0.02 feet
HEC-RAS Section 25 (just below Hwy 212)	5891 feet (1.12 miles)	-

\* A negative number represents a decrease in water surface elevation.

### Bridge Structure Options

To provide the necessary freeboard of 2 feet (SDDOT criteria) HDR looked at superstructure options with minimal depth to reduce the impact on the profile grade for 20<sup>th</sup> Avenue South. Superstructure depth and initial cost were the only criteria used for this analysis. The four options considered are as follows:

#### *Option 1 – Cast-in-Place Continuous Concrete Slab*

Advantages to this structure type are a shallow superstructure depth and low initial cost. Disadvantages are the amount of formwork required, and maximum economical span lengths of 60 feet which will require more bents.

#### *Option 2 – Prestressed Concrete I-Beam (PCB)*

PCB's are consistently the most economical option for spans between 50 and 150 feet. They are durable and require little maintenance. Disadvantages for this structure type are superstructure depths that are greater than slab structures and shipping/handling restrictions.

#### *Option 3 – Prestressed Rectangular Beams*

Rectangular beams cost slightly less than I-Beams and have a lower profile, so they can be an attractive solution for shorter spans. However, their economical span length is limited to 50 feet or less.

#### *Option 4 – Continuous Steel Beams*

Steel continuous spans may be advantageous in an area with poor foundation soils, and where significant substructure movement is anticipated. Maximum span length is 90 feet for rolled beams and 350 feet for plate girders. Economically, they are a good choice after PCB's reach their limit of 150 feet. Other advantages include the ability to have curved geometric shapes and a lighter superstructure than concrete. Disadvantages for this type are higher initial and maintenance costs, plus a longer lead time.

With all of these options, stub abutments with stabilized rip rap slope protection and pile bent piers are the most economic choice due to the geometric characteristics of the crossing.

### Opinion of Cost for Bridge Alternates

SDDOT's published *Average Unit Prices from Low Bids (2005)* for both rural and four-lane divided highways was used to determine a square-foot (SF) preliminary cost estimate of the structure. A preliminary estimate of major items was created with a 30% increase for miscellaneous items and conditional variables with our results producing a low end cost of \$85 per SF and \$110 per SF at the high end. Estimates for the range of probable cost for various bridge lengths are shown in Table H2.

Table H2 – Price Range for the Proposed Bridge

	100 Foot Long Bridge
Square Feet of Deck Area	5600 sq. ft.
High End Bridge Cost	\$616,000
Low End Bridge Cost	\$476,000

### Permitting

Permits will need to be acquired in order to proceed with this bridge project. In particular, a Section 404 will be required from the USACE, and a Section 401 will be required from the South Dakota Department of Environment and Natural Resources. These permits are required because grading will occur within the channel of the Big Sioux River.

A Section 10 permit is not required in addition to 404 and 401 permits. This permit is sometimes required when work is being done in, over, or under a navigable water of the U.S. According to the Omaha Corps of Engineers District office, Willow Creek is not considered navigable at the project location.

### Recommendations

Hydraulic modeling has shown that a bridge approximately 100 feet long would be able to meet freeboard criteria and achieve a no-rise. Due to the fact that the proposed bridge results in no-rise, it is anticipated that a LOMR will not be required.

Because this bridge crossing is immediately downstream from the City of Watertown, increases to water surface elevations could exacerbate existing flooding issues for the City and its residents. In order to minimize potential impacts to Watertown residents and properties, and to avoid the need for a LOMR, HDR recommends that a bridge length of approximately 100 feet be selected for this location.



Photo 1  
Willow Creek looking North (Upstream) from 20th Avenue South



Photo 2  
Willow Creek looking South (Downstream) from 20th Avenue South

Drawn by: B. Miller  
Date: 11-07-06  
Checked by: J. Unruh  
Date: 11-07-06  
Revision Date:



Site Photographs  
Watertown South Connector - Seg. 1  
Project EM 4411(01) PCN 00RV

Figure  
H-1



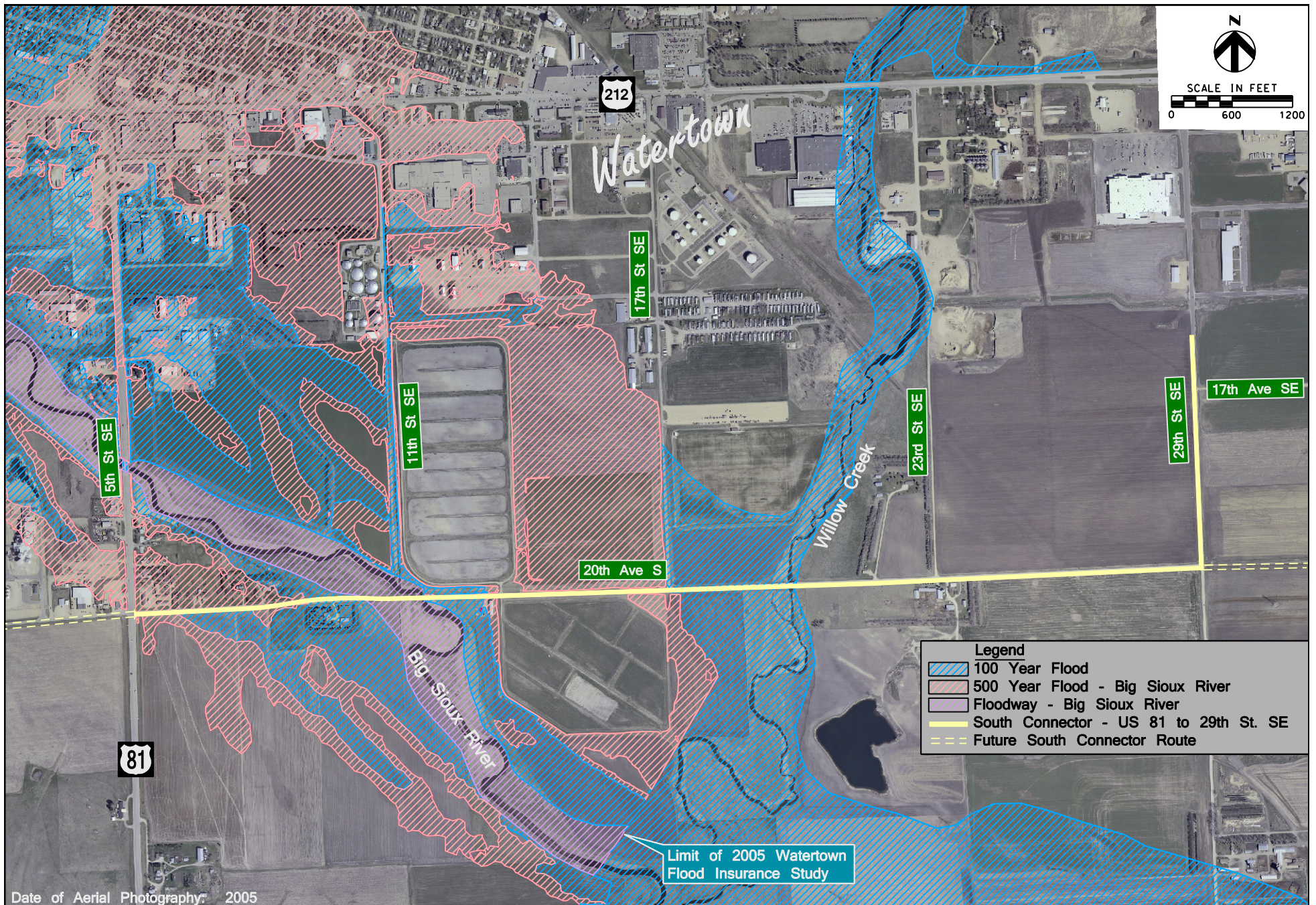
**Photo 3**  
**Downstream face of Willow Creek Bridge looking east along 20th Avenue South**

Drawn by: B. Miller  
Date: 11-07-06  
Checked by: J. Unruh  
Date: 11-07-06  
Revision Date:



**Site Photographs**  
Watertown South Connector - Seg. 1  
Project EM 4411(01) PCN 00RV

Figure  
**H-2**



Date of Aerial Photography: 2005

Drawn by: B. Miller  
 Date: 11-07-06  
 Checked by: J. Unruh  
 Date: 11-07-06  
 Revision Date:

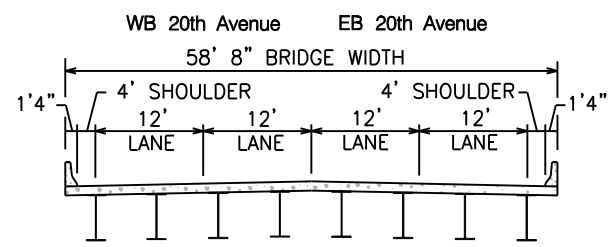
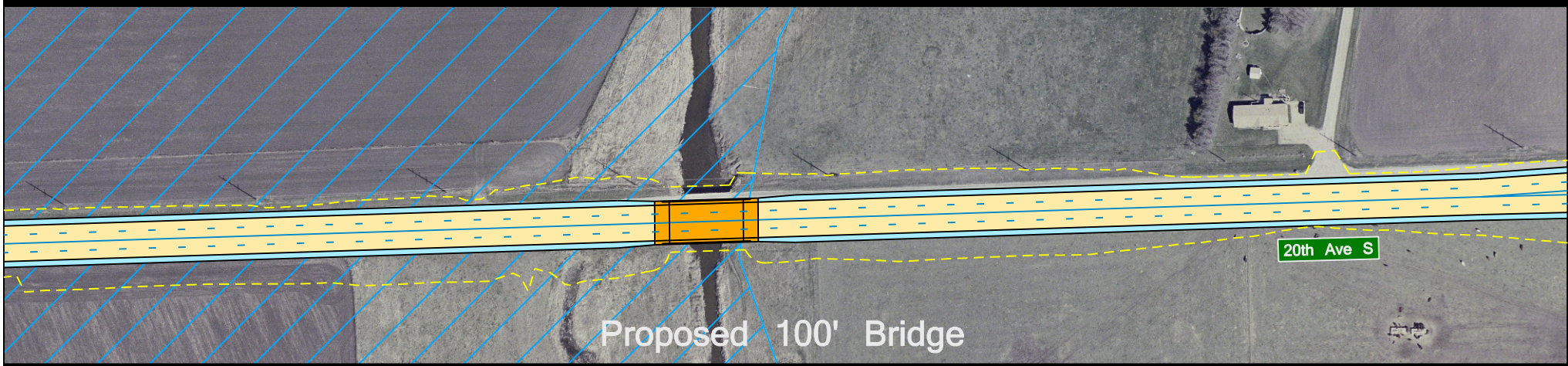


## Floodplain

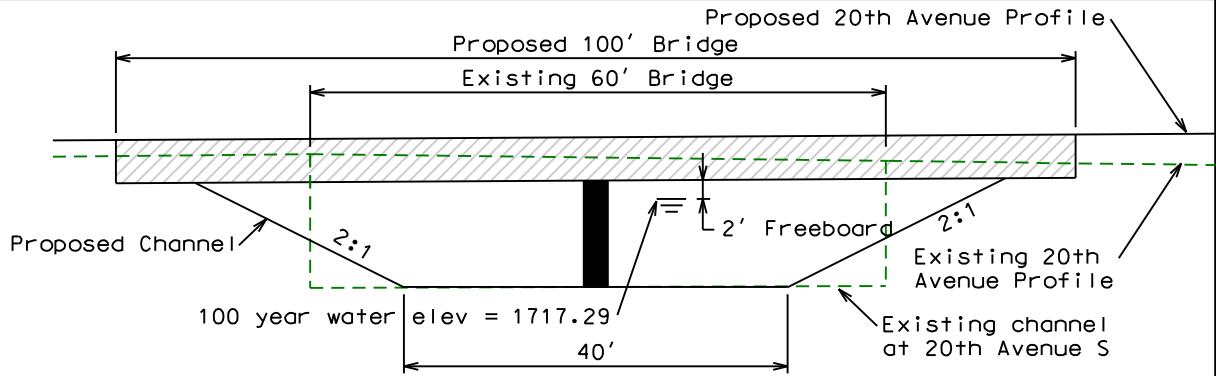
Watertown South Connector, Codington County, SD  
 Project EM 4411(01) PCN 00RV

Figure  
 H-3





**20th Avenue Bridge Section at Willow Creek Crossing**



**20th Avenue Bridge Profile at Willow Creek Crossing**

Drawn by: B. Miller  
Date: 11-07-06  
Checked by: J. Unruh  
Date: 11-07-06  
Revision Date: Sep 2007



**Bridge Layout at Willow Creek**  
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**Figure H-4**