Data Collection Report

draft

City of Houston, Minnesota

Houston Levee Certification – Phase I

Report prepared by

Mead & Hunt

June 2, 2015

DATA COLLECTION REPORT

PHASE I – DATA COLLECTION AND REVIEW
HOUSTON LEVEE CERTIFICATION

CITY OF HOUSTON, MINNESOTA

I hereby certify that this plan, specification or report was prepared by me or under my direct supervision and that I am a duly Licensed Professional Engineer under the laws of the State of Minnesota.

Karen L. Wiemeri, P.E.
License No. 21122 Date: June 2, 2015

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1. Introduction

The City of Houston (City) has retained Mead & Hunt, Inc. (Mead & Hunt) to evaluate and verify that its levee system will meet minimum design, operation and maintenance standards as specified by the requirements in the Code of Federal Regulations title 44 CFR Section 65.10 (44 CFR 65.10).

This report is to documents the findings from Mead & Hunt's review of the existing materials for the levee system and provide an action plan that describes the necessary steps for the levee certification of the levee system in support of the National Flood Insurance Program (NFIP) as administered by the Department of Homeland Security, Federal Emergency Management Agency (FEMA). The findings of this report are used to determine whether the levee system meets requirements for certifying that the levee system will protect the City from a flood less than or equal to the Base Flood Event (BFE) or referred to as the annual one-percent probability of exceedance (100-year flood).

A. System Description

(1) Location

The levee system, as shown on **Exhibit 1. Levee System Location**, is located in the City of Houston, Houston County, Minnesota on the Root River.

The levee system begins near the base of the bluff at the southwestern side of the City and runs 2,700 feet north from the bluff, crossing CSAH 13 and MN HWY 16. The levee runs 2,700 feet north from the bluff, crossing CSAH 13 and MNHWY 16. It then turns east, running parallel to MNHWY 16 for 800 feet. The levee then turns to the northeast and then it turns east and runs for 1400 feet. The levee turns east running 1200 feet where it intersects MN ROUTE 76. The levee runs 2,100 feet east until it intersects Henderson Street. It then turns to the south for 400 feet before turning to the southeast. The levee runs southeast for 700 feet and then turns east. It runs east for 2,000 feet, and then turns south terminating at the intersection of MN ROUTE 76 and MN HWY 16.

FEMA Flood Insurance Rate Maps shows the levee extending south approximately 2,000 feet from the intersection of MN ROUTE 76 and MN HWY 16.

(2) Principal Features

Construction of the project was completed in 1998, as detailed on the as-built plans which are found in Appendix A. The principal features include:

- two miles of earthen levee
- high flow channel on the Root River
- flood warning system
- interior drainage facilities, including ponding areas, interior ditches
- four gravity outlets
- two relief wells, and
- One pump station.

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City of Houston, MN
Levee Certification
2740800-150761.01
May 2015

Levee System Location

Exhibit 1

Mead & Hunt

B. Available Information

A primary task in preparation of this report was the research and data collection to determine the available information on the levee system for the levee certification process. Electronic copies of the following files are included on a disc found in Appendix A of this report.

The main items used for the review included:

- *Flood Insurance Rate Map, Panel Number 270193 0001 D*, Federal Emergency Management Agency, August 23, 2000
- *Flood Insurance Rate Map, Panel Number 2701900065C*, Federal Emergency Management Agency, June 6, 2001
- *Flood Insurance Rate Map, Panel Number 2701900070C*, Federal Emergency Management Agency, June 6, 2001
- *Flood Insurance Rate Map, Panel Number 27055C0039E*, Federal Emergency Management Agency, Preliminary December 31, 2014
- *Flood Insurance Rate Map, Panel Number 27055C0043E*, Federal Emergency Management Agency, Preliminary December 31, 2014
- *Flood Insurance Study, City of Houston, Minnesota*, Federal Emergency Management Agency, August 23, 2000
- *Flood Insurance Study, Houston County, Minnesota*, Federal Emergency Management Agency, June 6, 2001
- *Flood Insurance Study, Houston County, Minnesota*, Federal Emergency Management Agency, Preliminary December 31, 2014
- *General Design Memorandum and Environmental Assessment for the Houston Flood Control Project,* US Army Corps of Engineers St. Paul District, July 1992 (Revised February 1993)
- *Houston Stage 1 Flood Control Root River Houston, Minnesota, As-built Drawings*, US Army Corps of Engineers, October, 1996
- *Houston Stage 2A Flood Control Root River Houston, Minnesota, As-built Drawings*, US Army Corps of Engineers, November, 1995
- *Houston Stage 2B Flood Control Root River Houston, Minnesota As-built Drawings*, US Army Corps of Engineers, October 1996
- *Periodic Inspection Report for the American Recovery and Reinvestment Act of 2009 Root River at Houston Flood Control Project*, prepared by HNTB-Gerwick River Solutions prepared for US Army Corps of Engineers St. Paul District, March 22, 2010
- *2012 Routine Inspection Report for the Houston, Minnesota, Levee System,* US Army Corps of Engineers St. Paul District, November 6, 2012
- *2013 Routine Inspection Report for the Houston, Minnesota, Levee System,* US Army Corps of Engineers St. Paul District, July 12, 2013
- *Section 205 Flood Control Project Root River Houston, Minnesota Houston County Operation and Maintenance Manual,* US Army Corps of Engineers St. Paul District, August 22, 2003
- *Houston, MN Storm Sewer Operations & Maintenance Manuals,* – Ebara International Corporation, September, 1998

- *Storm Water Pumping Station, Houston, Minnesota Drawings,* Davy Engineering Co., April, 1997
- *Easement Extent,* US Army Corps of Engineers St. Paul District
- *Houston Top of Levee Survey,* US Army Corps of Engineers St. Paul District
- *Houston Video Inspection* US Army Corps of Engineers St. Paul District

C. FEMA Decertification Notification

The City formally received the Provisional Accredited Levee (PAL) notification from FEMA. The PAL agreement is found in Appendix B. A PAL is shown on the Digital Flood Insurance Rate Map (DFIRM) as providing probable protection against the annual one-percent exceedance flood level (100-year flood).

The City is required to submit documentation to FEMA that the levee system has met all of the requirements established by FEMA for determining the system can be reasonably expected to protect against a flood event less than or equal to the BFE within 24 months of the 91st day following the date of the initial notification letter. The City has until January 5, 2017 to resolve or correct any maintenance or operation issues. Once all of the certification issues, if any, have been corrected, the compiled certification materials can be submitted to FEMA.

2. Findings/Issues

FEMA has established levee design criteria for freeboard, closures, embankment protection, embankment and foundation stability, settlement and interior drainage. The following is the checklist used to determine the requirements to attain FEMA accreditation:

- *Operation and Maintenance*
  An adequate operation and maintenance systems must be in place to provide reasonable assurance that protection from the BFE exists.
- *Freeboard*
  Levees must provide a minimum freeboard of three feet above the water surface level of the BFE and an additional one foot above the minimum freeboard within 100 feet of either side of structures riverward of the levee or wherever the flow is restricted. Further, an additional one-half foot above the minimum freeboard at the upstream end of the levee and tapering to not less than the minimum freeboard height at the downstream end of the levee must also be provided.
- *Closures*
  Penetrations through the levee must have properly engineered and constructed closure devices to provide positive closure and adequate protection during flood events.
- *Embankment Protection*
  Erosion protection must adequately prevent any appreciable erosion of the levee embankment during the base flood. Any anticipated erosion, as a result of currents and/or waves must not compromise the stability of the levee embankment. Also, any expected erosion must not significantly reduce seepage paths through the levee which may result in subsequent instability.
- *Embankment and Foundation Stability*
  The expected seepage during loading conditions associated with the base flood through the levee foundations and embankments must not jeopardize their stabilities.
- *Settlement*
  The potential and magnitude of future loss of freeboard, resulting from levee settlement must be analyzed. This analysis must address embankment loads, compressibility of embankment and foundation soils, age of the levee system, and soil compaction methods during construction.
- *Interior Drainage*
  An analysis which identifies the source(s) of flooding and the extent of the flooded area is required. If the average depth of the interior flooding is greater than one foot, the water-surface elevation(s) of the interior water levels must be provided. This analysis is to be based on the joint probability of interior and exterior flooding and the capacity of facilities for evacuating interior floodwaters.

A. General Information

The 2000 FEMA Flood Insurance Study (FIS) will be used for the analysis because the Preliminary FIS, dated December 31, 2014 is in the review stage. Modifications may be expected to the 2015 FIS and will not be completed and adopted until 2016.
The Flood Insurance Rate Map (FIRM) panel numbers which pertain to the levee system are 2701930001D, 2701900065C and 2701900105C.

The 2000 FIS and 2001 FIS states that the 1-percent annual chance peak discharge is 37,900 cubic feet per second (cfs) at the City. The USACE design top of levee profile was computed with a discharge of 92,000 cfs.

B. Site Visit Summary

Field reconnaissance was necessary part of the assessment to better understand the performance of the levee protection system. The inspection considers all aspects of the levee system and its capability for containing the 100-year flood.

(1) Summary of findings

An on-site investigation was conducted in May 2014. Although issues were identified, the levee was found to be in reasonably good condition. The site visit report for the levee system is found in Appendix C.

C. Operation and Maintenance Systems

An adequate operation and maintenance system must be in placed to provide reasonable assurance that protection from the base flood exists.

(1) USACE Inspections

The USACE St. Paul District now conducts two types of levee inspections:

- Routine Inspection which is a visual inspection to verify and rate levee system's operation and maintenance.
- Periodic Inspection which is a comprehensive inspection using a multidisciplinary team for a visual inspection and evaluate any changes in design from the time the levee was constructed and additional recommendations for areas that need further evaluation.

a. USACE Periodic Inspection, 2010

The USACE Periodic Inspection Report dated March 22, 2010, identified deficiencies in the levee system. Some of the major risks identified included:

- For the levees and adjacent ditches planted with prairie grass, the grass should be mowed or burned regularly. Coordinate with the USACE for the next inspection following mowing or burning, so that the levee can be inspected thoroughly for potential deficiencies. Vegetation should be maintained within the vegetation-free zone in accordance with ETL 1110-2-57, Guidelines for Landscaping Planting and Vegetation Management at Levees, Floodwalls, Embankments Dams, and Appurtenant Structures. At culvert inlets, remove accumulated sediment after bringing the vegetation down. The tall vegetation on and adjacent to the levee adversely affects inspection, maintenance, and emergency operations along the levee.
- All above ground encroachments within the easement should be moved outside the easement, unless approved by the USACE. It must also be verified that all underground utilities with the levee easement are approved by the USACE. The sponsor should provide documentation to the USACE of all utilities within levee easements. At farming encroachments, the location of the levee easement boundary needs to be verified, and

additional or new easement stakes should be placed to prevent future encroachments. Encroachments negatively impact the integrity of the levee and inhibit operations and maintenance.

- Animal burrows should be filled in and compacted. An animal control program should be implemented. Animal burrows could lead to levee through seepage or slope instability if not controlled.
- At locations where vegetation is growing within the riprap, the vegetation should be removed. The vegetation is reducing the flow capacity at the outlets and inhibits inspection.
- Perform O&M Manual maintenance on relief wells. Remove corrosion and repaint, where required. If not maintained, seepage pressures could build on the landside of the levee and under the drainage structures and associated piping. This pressure could cause uplift or failure of the structures.
- Remove unwanted vegetation and/or sediment at outfall structures, within drainage ditches, and ponding areas. Investigate easement for access to Ditch D. Work with the landowner to eliminate/reduce obstruction downstream of Ditch D so that water can drain and not pond against the flap gates at Outlet A-2 and the EDA Pump Station. Drainage ditches blocked with vegetation and obstructions prevents proper drainage away for the levee and reduces flow capacity.
- During the April 2007 floods, the project had some interior drainage issues that were addressed with portable pumps. Because of the heavy rain that accompanied this flood event, the interior ponding areas were filled and overflowed into the surrounding area. The ponding areas on the west side of town filled to capacity because the natural drainage had been blocked by the levee. There was no means for the water to exit the area without pumping, but the project provided no pumping facilities in this area. The area that was largely affected by this problem was located north of Hwy 16 and along the west levee. Large portable pumps were used to pump the water over the levee reducing additional interior damages. Some flooding occurred at the fire station. The USACE has been made aware of this issue and is investigating the problem for a possible solution.
- Evaluate Ponding Area C boundaries and capacity. Remove fill or reshape the ponding area for capacity. Remove vegetation to restore drainage capacity of Ponding Area B. Inadequate ponding area could lead to flooding within the levee system due to reduced storage.
- At gate locations, remove loose paint and rust, and cover with new paint. It is also recommended that records of gate operation and maintenance for all gates including the slide gate on the WWTP discharge pipe be maintained and available. The gates should be kept free of rust to prevent binding or seizing. Records should be kept for verification purposes.
- Clean out Ditch D, if easement exists, and work with landowner to remove obstruction downstream of the Outlet A-2 (Station 82+50) so that water can drain and not pond/freeze against the flap gates or freeze the pump wells. If left unrepaired, damaging interior flooding could occur.
- Perform annual Megger testing of motor, power cables serving pump motors and relief well motors. Maintain records of testing. Megger testing is used to verify the integrity of the insulation to prevent short circuits. Remove loose paint and rust and cover with new paint on miscellaneous metal surfaces to prevent further rusting and section loss.

- Initiate a regular schedule of pump station training programs and maintain records of their occurrence and attendance. Maintain records of gate operation and maintenance for both the pump station and the portable flood pump and all gates, including the slide gate on the discharge pipe of the EDA Pump Station. Keep records of pumps, so that changes in bearing temperature can be captured. Retain a copy of the pumping station O&M Manual at the pumping station. These documents should be kept for verification purposes and made readily available in case of an emergency.
- Contact the USACE to determine if safety compliance reports are necessary. If so, initiate annual safety compliance inspections by outside source and maintain record of inspection findings, results, attendance, and occurrence.
- Remove surface rust the on jib crane and cover with paint. Perform load tests on the crane according to USACE standards. Load tests are required for safety to ensure that the overall components of the equipment have been maintained and are functioning according to the original equipment manufacturers specifications.
- Verify that the flood warning components are in place and that the system is operational. Restore operation of the flood warning system, as required. Initiate an annual testing program. Because of the flashy nature of flooding on the Root River, without a proper warning of an upstream event, there will not be time for assuring all gates and closures are in there proper position.
- Hwy 76 currently acts as the line of protection south of Hwy 16, east of town. No information was provided about the existing roadway embankment. It is likely that the roadway was not designed as a flood control structure and may not provide a specific level of flood protection. Hwy 76 should be evaluated to determine that it meets Federal levee requirements and if it meets the designed level of protection that the remainder of the system affords.

The period inspection also completed a hydraulic and hydrologic, geotechnical, structural, mechanical, civil, and electrical review of the design criteria review against current USACE design criteria to assess the ability of the overall system and each feature to function as authorized. They also, identified risks associated with the design, and to also identify potential need to update the design. The following is a summary of significant findings related to the design criteria review and observations made during the inspection:

- The hydrologic and hydraulic design of this system is recent, and the designs conform to current design criteria. However, after the April 2007 floods, the discharge-frequency curve for the Root River near Houston, Minnesota was revised and raised the 100-year recurrence interval by 100 cfs. Therefore the heights of the levees should be verified by survey to determine their elevations and a risk and uncertainty analysis should be performed to determine if the levees need to be raised to meet current design standards for the 100-year level of protection. Although the design for the erosion protection appears to meet current criteria, because design calculations were not provided this cannot be verified. It is recommended to continue to monitor erosion protection areas and if problems occur, then the design should be verified and corrective actions taken. With regards to interior drainage, the design is consistent with current design methods and criteria. However, because the project

has had some interior drainage issues on the east side of town, the interior drainage should be further evaluated to reduce the risk of interior flooding. The USACE has been made aware of this issue and is investigating the problem for a possible solution.

- Surface sloughs, tension cracks, or other slope stability issues, that would indicate long-term stability problems, were absent during the field inspection. No slope instability was observed in the field. A significant flood event occurred in 2007 where flood water reached into the freeboard zone of the project (within three feet of top of levee); therefore, the stability of the slopes has been tested under nearly maximum surcharge pool and/or rapid drawdown conditions. It is recommended to perform a slope stability analysis with recent subsurface information and laboratory testing that meets the USACE's current criteria to determine slope stability factors of safety.
- Review of the documents indicates that existing seepage design does not meet current criteria based on factor of safety requirements and minimum berm widths. It was reported that no observations of seepage were made during the last significant flood event. During the field inspect, no observations of seepage were made. However, a ditch between station 110+00 and 113+00 was planned to be filled in during construction to control seepage. It appears that this ditch was not filled in. In order to determine if the existing levee meets the required seepage gradients, it is recommended a seepage analysis is performed with recent subsurface information and laboratory testing that meets the USACE's current criteria.
- Sample stability calculations were provided for drainage structures. The calculations that were provided were generally incomplete and included no bearing capacity calculations. An example of floatation calculations were provided for gatewells. The minimum required factor of safety was not noted, but the example provided exceeded the current minimum required factor of safety. No sliding stability results were provided for headwall structures. Several inches of differential settlement were predicted at outlet structures A-1 and A-2. As a result preloading was recommended in those areas. No settlement info was provided for the other structures. No pump station calculations were provided. Analyses were performed by an outside engineering firm and not provided for review. Calculations should be performed with recent subsurface soils and laboratory information to determine if the stability of the existing structures meets current design criteria.
- The design of the EDA Pump Station could not be reviewed due to lack of information. The design calculations and plans should be located and reviewed to determine if they met current design standards.
- The O&M Manual did not contain all the information necessary to meet current design standards such as spare equipment requirements and protective device settings. It should be revised to include these items.
- GFCI devices for ground fault current sensing and interruption of power circuits for personnel safety should be considered at the pumping station located on Henderson Street near Outlet A-2 in Houston, MN.
- The project datum's should be converted to NAVD88 and NAD83.

b. USACE St. Paul District 2013 Routine Inspection Report

The 2013 Routine Inspection Report done by the USACE asked that the relief well pumps be pump-tested as stated in the Operation and Maintenance Manual for the levee system. The levee system was rated as minimally acceptable.

(2) Levee As-Built Plans

The City has been provided with as-built plans as part of the Operation and Maintenance Manual. The following **Exhibit 2. Right of Way and Ponding Easements** shows the permanent easements associated with the project.

The elevations used on the As-Built plans are in mean sea level, 1929 NGVD datum, adjusted. The conversion factor from NGVD 29 to NAVD 88 is 0.002.

The City has also been provided with the plan set for the Pumping Plant as prepared by Davy Engineering. The elevations used on the plans are in mean sea level, 1929 NGVD datum, adjusted.

a. Issues

The 2001 FIS does show 1,400 feet of MN ROUTE 76 south of MN HWY 16 to be part of the levee system. Record drawings of MN ROUTE 76 from MNHWY 16 to the end of levee as shown on the FIS will be needed to be part of the As-Built plans for submittal to FEMA

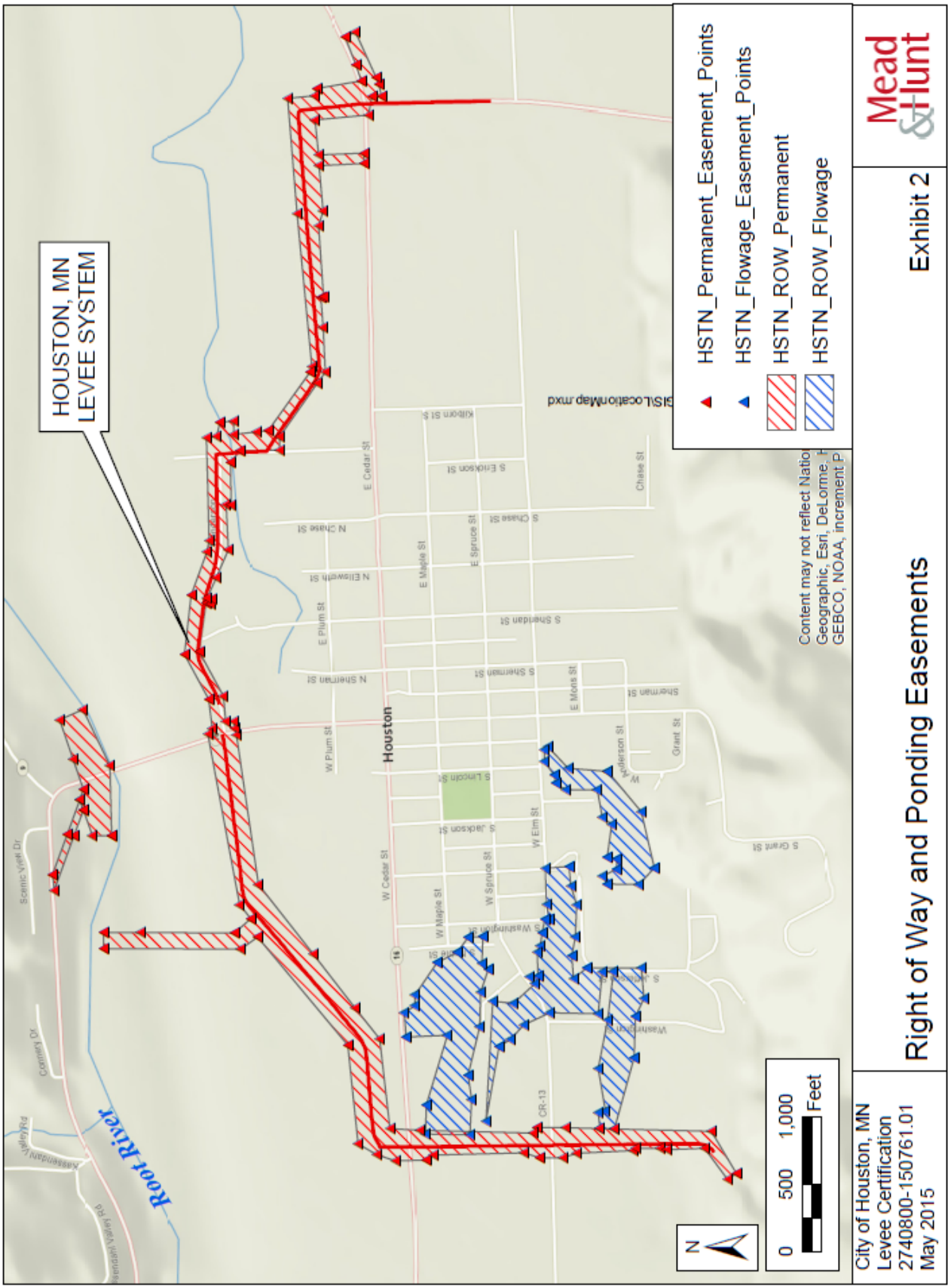
(3) Official O&M Manuals

The most current O&M Manual was prepared by the USACE St. Paul District is dated August 22, 2003. The Ebara International Corporation Manual for the pumping plant is dated 1998.

a. Issues

Not all items listed in the current O&M Manual are available. The items missing are:

- “Relief Well Pumps and Controls” provides the installation reports and pumping test reports for each relief well.
- “Flap Gates, Sluice Gates, Wall Thimbles and Portable Operators”, including operating instructions, technical references and manufacturers’ data for each.
- Tri-State Pump and Control.



City of Houston, MN
Levee Certification
2740800-150761.01
May 2015

Right of Way and Ponding Easements

Exhibit 2

Mead & Hunt

The O&M Manual for the pumping plant is not part of the USACE St. Paul District O&M Manual. The EBRA International Corporation Manual does not provide all details for the operation of the plant. This manual did not provide a wired diagram detail nor operator instructions. The manual did not list the power supplier or how the plant will be operated if there is a power failure.

D. Design

For the purpose of the NFIP, documentation demonstrating that the structural design criteria has been met must be submitted to FEMA. The items listed below are to be addressed as part of the certification.

(1) Freeboard

The top of levee was surveyed by the USACE in 2008. The 1993 Revised Design Memorandum indicates that the levee was designed to the 100-year plus freeboard elevation. The 2000 and 2001 FIS BFE are compared to the USACE survey elevations along the top of levee are given in **Table 1. Freeboard**. The highlighted items indicate where the required freeboard is not met.

Table 1. Freeboard

Centerline Station	Design Top of Levee Elevation (ft.)	USACE Survey Elevation (ft.)	FIS BFE (ft.)	Freeboard (ft.)	Req'd Freeboard (ft.)
South Fork Root River Levee (Hwy 76)					
135+00			681.0		3.5
129+40			D – 681.3		3.3
128+00			C - 680.8		3.3
127+20		684.85	681.0	3.85	3.27
121+70		683.90	680.62	3.26	3.11
120+84			B - 680.6		3.08
119+70		683.47	680.52	*2.95*	3.05
118+19		683.37	680.41	*2.96*	3.01
118+00			A-680.4		3.0
Root River Levee					
117+20		682.46	680.9	*1.56*	3.0
116+94	683.9	683.75	680.9	*2.85*	3.0
113+06	683.90	683.88	680.9	*2.98*	3.0
113+00	683.90	683.81	680.9	*2.91*	3.0
110+39	684.16	684.13	681.04	*3.09*	3.14
102+61	684.53	684.61	681.45	*3.16*	3.17
98+74	684.67	684.56	681.65	*2.91*	3.19
88+76	685.05	685.0	682.19	*2.82*	3.23
78+92	686.09	685.58	682.70	*2.88*	3.27
77+00	686.26	685.87	A - 682.8	*3.07*	3.28
76+62	686.29	685.79	682.84	*2.96*	3.28

Table 1. Freeboard					
Centerline Station	**Design Top of Levee Elevation (ft.)**	**USACE Survey Elevation (ft.)**	**FIS BFE (ft.)**	**Freeboard (ft.)**	**Req'd Freeboard (ft.)**
75+77	686.37	685.69	682.92	*2.77*	3.29
74+91	686.44	686.09	683.01	*3.08*	3.29
73+75	686.54	686.02	683.13	*2.89*	3.30
72+61	686.64	685.15	683.24	*2.91*	3.30
71+75	686.72	686.56	683.3	3.24	3.31
62+58			684.24		4.0
60+98	Edge of TH 76		684.40		4.0
59+98			684.50		4.0
55+00	691.54	691.09	B – 685.0	6.09	3.34
46+00	692.63	692.89	C - 685.4	7.49	3.39
35+00	693.99	694.02	D – 686.3	7.72	3.46
28+58	694.19	694.72	E – 686.3	8.42	3.5

a. Issues

Station 62+00 to Station 63+00 was not surveyed by the USACE. Also, the USACE survey ended at Station 127+20 and should have continued to approximately Station 135+00 which would correspond to the end of levee shown on the 2014 FIRM but this is not the end of the levee according to the 2001 FIRM.

The USACE survey indicates from Station 71+75 to Station 102+61, Station 110+39 to Station 113+06 and Station 116+94 to Station 119+70 the top of levee does not meet the freeboard requirements.

(2) Closures

The as-built drawings show the following four outlets:

A1	Station 46+48.11
A2	Station 83+28.47
B	Station 118+75
HWY 76	2,000 feet south of MN State Hwy 16 (Cedar Street)

A sanitary gate well and shut-off valve for the gravity outlet from the wastewater treatment plant is located at Station 71+22.23.

A natural gas pipeline through the levee is provided with a gate valve closure and a 60-inch manhole.

A sandbag closure is located at the intersection of MN State Route 76 and MN State Hwy 16.

a. Issues

The Periodic Inspection did state that no bearing capacity calculations were done for the drainage structures nor sliding stability results were completed for the outlets. The drainage structures did not exhibit stability, bearing capacity or settlement distress during the field inspection.

The MN HWY 76 stop logs are installed in the outlet structure. It appears that the logs are used to permanently close the opening. The method of using the stoplogs to close the openings is not considered a permanent closure. From the as-built plans the stoplogs are only to be installed if the flap gates is not operating properly.

(3) Embankment Protection

The steepest side slopes for the earthen levee are 1V on 3H side slopes with a 10-foot top width.

a. Issues

The modeled flow velocities and tractive shear from the base flood along the slope of the levee have not been provided to determine fit he slope protection is adequate.

(4) Embankment and Foundation Stability

The as built plans did show field exploration, but the composition of the levee was not provided. Laboratory testing results of the soil samples during filed exploration were not provided.

a. Issues

Seepage documentation and global slope stability documentation of the levee using current design criteria has not been provided.

(5) Settlement

Comparing design elevation to USACE survey information provides the basis to evaluate historical settlement. Observed settlement was calculated by subtracting surveyed top of levee from the design elevation. The observed settlement ranged from 0 feet to 1.3 feet. **Table 2. Settlement** below provides an overview of the data from the analysis.

Table 2. Settlement

STATION	USACE Surveyed Elevation	Design Elevation	Observed Settlement (ft)
13+66.	694.144	694.2	0.06
14+46.	694.059	694.2	0.14
15+02.	693.774	694.2	0.43
15+58.	694.099	694.2	0.10
16+16.	694.048	694.2	0.15
16+74.	694.118	694.2	0.08
17+02.	694.037	694.2	0.16
17+89.	693.953	694.2	0.25
18+19.	693.782	694.2	0.42
18+76.	693.955	694.2	0.25
19+05.	693.95	694.2	0.25

Table 2. Settlement			
STATION	USACE Surveyed Elevation	Design Elevation	Observed Settlement (ft)
19+64.	693.869	694.2	0.33
20+22.	693.937	694.2	0.26
20+50.	693.987	694.2	0.21
20+79.	693.972	694.2	0.23
20+80.	693.988	694.2	0.21
21+10.	694.003	694.2	0.20
21+38.	694.086	694.2	0.11
21+67.	694.095	694.2	0.11
21+96.	693.977	694.2	0.22
22+25.	693.957	694.2	0.24
22+54.	693.992	694.2	0.21
22+82.	693.964	694.2	0.24
23+11.	693.91	694.2	0.29
23+95.	693.728	694.2	0.47
24+23.	693.728	694.2	0.47
24+72.	693.438	694.2	0.76
25+13.	693.514	694.2	0.69
25+43.	693.985	694.2	0.22
26+30.	694.121	694.2	0.08
26+58.	694.079	694.2	0.12
49+35.	692.095	692.14	0.04
49+92.	691.763	692.06	0.29
50+20.	691.693	692.02	0.32
50+77.	691.661	691.93	0.27
51+05.	691.684	691.90	0.21
51+42.	691.595	691.86	0.27
51+70.	691.296	691.84	0.54
52+28.	691.466	691.79	0.32
52+57.	691.525	691.76	0.24
53+43.	691.567	691.68	0.12
53+72.	691.54	691.66	0.12
54+01.	691.515	691.63	0.12
54+88.	691.073	691.56	0.48
55+16.	691.121	691.53	0.41
55+72.	690.991	691.48	0.49
56+01.	691.13	691.45	0.32
56+60.	691.211	691.40	0.19
57+19.	691.268	691.35	0.08
57+78.	691.232	691.30	0.07
60+65.	691.52	692.86	1.34
60+93.	692.655	693.8	1.15
63+55.	687.585	687.61	0.03
71+75.	686.561	686.72	0.16
72+03.	686.322	686.69	0.37
72+61.	686.15	686.64	0.49

Table 2. Settlement			
STATION	USACE Surveyed Elevation	Design Elevation	Observed Settlement (ft)
73+18.	686.196	686.59	0.39
73+75.	686.019	686.54	0.52
74+04.	686.158	686.51	0.36
74+91.	686.092	686.44	0.35
75+19.	686.049	686.42	0.37
75+77.	685.694	686.37	0.67
76+05.	685.626	686.34	0.72
76+91.	685.894	686.27	0.37
77+20.	685.823	686.24	0.42
77+77.	685.542	686.19	0.65
78+06.	685.617	686.17	0.55
78+92.	685.577	686.09	0.52
79+20.	685.668	686.07	0.40
79+49.	685.607	686.04	0.44
79+77.	685.811	686.02	0.21
80+06.	685.653	685.99	0.34
80+90.	685.61	685.86	0.25
81+19.	685.732	685.81	0.08
81+78.	685.696	685.72	0.02
82+07.	685.632	685.67	0.04
82+35.	685.23	685.62	0.39
82+42.	685.433	685.61	0.18
83+41.	685.429	685.45	0.03
83+68.	685.343	685.41	0.07
83+95.	685.342	685.37	0.03
86+48.	685.058	685.14	0.08
87+04.	685.074	685.12	0.04
88+76.	684.998	685.05	0.05
89+18.	685.008	685.03	0.02
89+46.	684.986	685.02	0.04
89+73.	684.8	685.01	0.21
90+54.	684.666	684.98	0.31
90+82.	684.611	684.97	0.36
91+10.	684.886	684.96	0.07
91+24.	684.877	684.95	0.07
92+61.	684.854	684.90	0.04
93+17.	684.663	684.87	0.21
94+27.	684.698	684.83	0.13
95+11.	684.579	684.80	0.22
96+23.	684.594	684.76	0.16
97+07.	684.568	684.73	0.16
98+74.	684.559	684.67	0.11
99+03.	684.613	684.66	0.04
100+93.	684.575	684.59	0.01
101+20.	684.539	684.58	0.04

Table 2. Settlement			
STATION	**USACE Surveyed Elevation**	**Design Elevation**	**Observed Settlement (ft)**
110+39.	684.127	684.16	0.03
110+68.	684.099	684.13	0.03
111+53.	684.034	684.05	0.01
112+66.	683.624	683.93	0.31
113+06.	683.881	683.9	0.02
116+94.	683.746	683.9	0.15

a. Issues

Settlement estimates were reported in the 2012 inspection report as meeting current design criteria. However the foundation clays were considered to be normally consolidated and if the clays are in fact pre-consolidated, the settlement estimates would be conservative. All primary settlement of the levee have now taken place and no appreciable future settlements are anticipated. It is our opinion that no additional settlement analysis is required.

(6) Interior Drainage

An analysis which identifies the source(s) of flooding and the extent of the flooded area is required. If the average depth of the interior flooding is greater than one foot, the water-surface elevation(s) of the interior water levels must be provided. This analysis is to be based on the joint probability of interior and exterior flooding and the capacity of facilities for evacuating interior floodwaters.

An interior drainage analysis was performed as part of the initial design of the levee system, and was documented in Appendix D of the 1992 *General Design Memorandum* by the USACE. Hydrologic modeling was performed with HEC-1 using hypothetical storm events derived from rainfall depths gathered from HYDRO 35, TP-40 and TP-49. In addition, historical rainfall events and river stages were used to develop damage-frequency curves for sizing the ponding areas.

Watershed

The area tributary to the levee portion of the project consists of approximately 1.50 square miles (961 acres). The tributary area was divided into three sub areas: A1, A2 and B.

Interior drainage facilities

The interior drainage facilities consist of three grated gravity outlets, one interior culvert and ditch, two ditches in conjunction with an existing 36-inch by 53-inch arch pipe and four designated ponding areas.

Pumping station

The pumping station was designed by Davy Engineer.

a. Issues

The HEC-1 model was not provided for the design of the outfall structures or pumping station.

As noted in the 2009 Periodic Inspection Report during the April 2007 portable pumps were used to mitigate interior drainage issues along the west side of town. More specifically, the ponding areas

filled to capacity and began flooding the surrounding areas including the some partial flooding at the fire station. Interior drainage along the west section of the levee will need to be investigated because of the flooding that occurred in 2007.

As noted in the 2009 Periodic Inspection Report, a flow restriction along the discharge channel downstream of the A-2 gravity outlet and EDA pump station could cause excessive backwater against the flap gates/outlet during gravity flow conditions and decrease discharge capacity. The effects of this flow restriction should be investigated.

The existing interior drainage system has not been studied using the storm events based on precipitation frequency information (Atlas 14) published by the National Oceanographic and Atmospheric Administration (NOAA).

The pumping station design flows were provided by Davy Engineer but no design basis was provided to determine if the flows will meet the new Atlas 14 rainfall data.

The City is interested in determining if Ponding Area B is shown correctly on the FIS.

(7) Other Design Criteria

FEMA may require that other design criteria and analyses be submitted to show that the levee provides adequate protection. At this time FEMA has not asked for any additional information to be provided to them.

3. Action Plan

It has been determined that additional analyses are needed to determine if the levee is certifiable. The Action Plan identifies the next steps that will need to be taken to determine if the levee is certifiable. The project approach will be to sequence the tasks step by step to determine if the levee is certifiable. In Phase II – Engineering Analysis, the engineering study and analysis is necessary to make a certification determination for the levee system based on current design standards. The engineering analyses will show if modification to the levee will be required in order to certify the levee. If additional work is required planning level cost estimates for the required upgrades and modifications will be provided. Once all the certification issues, if any, have been corrected, the completed 44 CFR 65.10 certification materials will be compiled as Phase III of the Action Plan. Phase III will be the organization and completion of the forms required by FEMA.

A. Phase II – Engineering Analysis

(1) Data Collection

Site Survey

A site survey of the top of the levee to fill in the gaps of information from the USACE survey is needed to determine whether the levee is at or above the BFE plus required freeboard. In addition, several culvert crossings along the channel along the drainage ditch connecting Ponding Areas A-1 and A-2 will need to be surveyed for use in the interior drainage study.

Geotechnical Investigation

Numerous borings were drilled along the alignment during the original design phase of the levees. However, no borings have been performed upstream of the levee nor through the levee. The current minimum standard for the frequency of soil borings (ETL 1110-2-569) is to have data upstream, downstream and through the crest of the levee every 1,000 feet. Therefore additional geotechnical information will be needed. The minimum standard will require up to 12 sets of soil borings (3 per cross section every 1000 feet). The existing data can be used were possible but generally the existing data is along the centerline of the levee and taken from the original ground surface.

To perform the stability and seepage analyses outlined below, triaxial shear tests and permeability tests will be required to be performed on representative samples obtained from the soil borings. In addition, standard grain size analyses and index tests will be required.

A geotechnical data report will be prepared which will present a boring probe location plan, the logs of the borings and probes, and a description of the drilling, probe, testing and classification methods. The laboratory test results will also be submitted with the report. The contents of this report will be used for the seepage, slope stability and settlement analyses.

Mead & Hunt will coordinate with a geotechnical contractor for field exploration and laboratory testing. We have assumed that a geotechnical investigation for 2,000 feet from the intersection of MN Route 76 and MN HWY 16 will be provided by the City.

(2) Engineering Analysis

Freeboard

The current FEMA Flood Insurance Study (FIS) HEC-2 analysis will be mapped against the surveyed existing top of levee profile obtained as part of the data collection to determine the adequacy of the freeboard.

Closures

The structural integrity of the closures will be evaluated to determine the stability of the closures using USACE's current design guidelines.

Embankment Protection

In order to confirm the existing embankment protection is adequate an evaluation of the applicable erosion mechanisms on the levee embankment is necessary. Factors to be address will include expected flow velocities, tractive shear, water power, expected wave action, ice loading, and impact of debris, slope protection techniques, flood duration, levee alignment, bends and transitions.

We have assumed that embankment protection analysis for 2,000 feet from the intersection of MN Route 76 and MN HWY 16 will be provided by the City.

Embankment and Foundation Stability

Geotechnical analysis to evaluate the embankment and foundation stability will be needed. The analyses will determine whether potential seepage into or through the levee foundation and embankment will jeopardize the stability of the embankment and foundation. SEEP2D will be used to model the levee embankment. UTEXAS4 will be used to evaluate the slope stability. Both the upstream and downstream slopes need to be analyzed for both long term and short term loading conditions.

We have assumed that embankment and foundation stability analysis for 2,000 feet from the intersection of MN Route 76 and MN HWY 16 will be provided by the City.

Settlement

The site survey performed as part of the data collection survey will be compared to the as-built plans to determine if there have been any settlement issues. Settlement estimates were reported in the 2012 inspection report as meeting current design criteria. However the foundation clays were considered to be normally consolidated and if the clays are in fact pre-consolidated, the settlement estimates would be conservative. All primary settlement of the levee have now taken place and no appreciable future settlements are anticipated. It is our opinion that no additional settlement analysis is required.

We have assumed that settlement analysis for 2,000 feet from the intersection of MN Route 76 and MN HWY 16 will be provided by the City.

Interior Drainage

A new interior drainage analysis will need to be performed to more accurately define the sources of flooding, the extent of the flooding and the water-surface elevation of the base flood. In particular, the analysis is needed in order to investigate the flooding that occurred along the west side of the City during the April 2007 flood event. The previous analysis performed by the USACE during initial design of the system and documented in their 1992 Design Memorandum did not include detailed hydraulic routing of flows traveling between the ponding areas on the south side of the City to the ponding areas on the north side of the City near the levee.

The new analysis will include a more detailed approach and account for not only the storage effects of all the designated ponding areas within the system, but also the hydraulic routing through the major storm sewer network components used to convey flows through the City from the southern ponds to the northern ponds. The drainage areas will be mapped. The hydrologic component of the analysis will be performed using hypothetical storm events derived using rainfall depths from NOAA Atlas 14 and using the SCS Type II temporal distribution. Both the gravity flow and blocked/pumping conditions will be analyzed for the 1% annual-chance (100-year) event to determine the maximum ponding levels (base flood elevations) within the interior system. Ponding limits for areas with more than 1-foot of flooding will be mapped

Drainage Structures

Relief wells are located adjacent to Outlets A-1 and A-2. The 2010 Periodic Inspection report notes that no design calculations are available to verify their design. The relief well designs need to be checked along with the uplift stability of the outlet structures.

Pumping Plant

Structural review of the pumping plant based on the drawings provided will need to be completed to determine if the structure meets current USACE design standards. Stability and strength safety factors will also be reviewed to determine if current USACE design standards have been met.

The pumping will be modeled using NOAA Atlas 14 rainfall and the plant design will be reviewed

Operation and Maintenance Plan

The Operation and Maintenance Plan will need to be reviewed to determine its adequacy and provide recommendations to modify the plan if it needs revision. We have assumed the City will make the modification to the existing plan, if necessary.

Record As-Built plans will be needed from Minnesota Department of Transportation for Highway 76 to be included in the FEMA submittal. We have assumed the City will obtain these plans.

(3) Technical Report

Upon completion of the engineering analysis, a Technical Report will be prepared to document and describe the basis for the levee certification determination. The report will include the analysis documentation. The report will also include a levee determination and identify any additional gaps and issues that might impede certification.

If it is determined that the levee is not readily certifiable, a plan with planning level cost estimates for the upgrade/modification of the levee will be included such that the City will be able to prepare a Capital Improvement Plan and funding strategy.

B. Phase III – Design Criteria Certification Materials Submittal

Based on the findings of Phase II, some data gaps may be identified such that additional work is required before the completion of Phase III. Once all of the certification issues, if any, have been corrected, the completed 44 CFR 65.10 (b) Design Criteria Certification Materials will be compiled for submission to FEMA by the City.

C. Engineering Services

Table 3. Engineering Services presents the cost estimate for the work left to be completed. The total cost to complete Phase II and Phase III is estimated at $151,680. The geotechnical total labor cost is for the work to coordinate the geotechnical investigation. The expenses for geotechnical investigation is for the work to be done by a geotechnical contractor.

Table 3. Engineering Services

TASK DESCRIPTION	LABOR	EXPENSES	COST
PHASE II – ENGINEERING ANALYSIS			
Data Collection			
SITE SURVEY	$2,400	$50	$2,450
GEOTECHNICAL INVESTIGATION	$1,720	$29,040	$30,760
Analysis			
ENGINEERING ANALYSIS	$49,100		$49,150
TECHNICAL REPORT	$24,750	$220	$24,820
TOTAL – PHASE II	**$77,970**	**$29,310**	**$107,280**
PHASE III - DESIGN CRITERIA CERTIFICATION MATERIALS SUBMITTAL			
ADDRESS OUTSTANDING CERTIFICATION ISSUES	$16,450	$50	$16,500
COMPLETE FINAL FEMA SUBMITTAL	$23,700	$150	$23,850
ADDRESS FEMA COMMENTS	$4,000	$50	$4,050
TOTAL – PHASE III	**$44,150**	**$250**	**$44,400**

APPENDIX A.
AVAILABLE INFORMATION

HOUSTON LEVEE CERTIFICATION
PHASE 1
APPENDIX A

ITEMS RECEIVED		
ITEM	**COMMENTS**	**FILE NAME**
Flood Insurance Rate Map, Panel Number 2701930001D, Federal Emergency Management Agency, August 23, 2000		2701930001D.tif
Flood Insurance Rate Map, Panel Number 270190065C Federal Emergency Management Agency, June 6, 2001		EAST OF HOUSTON FM2701900065C.pdf
Flood Insurance Rate Map, Panel Number 2701900105C Federal Emergency Management Agency, June 6, 2001		WEST OF HOUSTON FM2701900105C.pdf
Flood Insurance Rate Map, Panel Number 270190070C Federal Emergency Management Agency, June 6, 2001		S_76_FM2701900070C.pdf
Flood Insurance Rate Map, Panel Number 27055C0039E, Federal Emergency Management Agency, Preliminary December 31, 2014		27055C0039E.pdf
Flood Insurance Rate Map, Panel Number 27055C0043E, Federal Emergency Management Agency, Preliminary December 31, 2014		27055C0043E.pdf
Flood Insurance Study, City of Houston, Minnesota, Federal Emergency Management Agency, August 23, 2000		Houston_FIS_Aug2000.pdf
Flood Insurance Study, Houston County, Minnesota, Federal Emergency Management Agency, June 6, 2001		Houston_FIS_Jun2001.pdf
Flood Insurance Study, Houston County, Minnesota, Federal Emergency Management Agency, Preliminary December 31, 2014		Houston_FIS_Dec2014.pdf
General Design Memorandum and Environmental Assessment for the Houston Flood Control Project, US Army Corps of Engineers St. Paul District, July 1992 (Revised February 1993)		HSTN_DM_Feb93.pdf
Houston Stage 1 Flood Control Root River Houston, Minnesota, As-built Drawings, US Army Corps of Engineers, October, 1996		HSTN_O&M_ASbuiltDWGs_Stage2B_Nov98.pdf
Houston Stage 2A Flood Control Root River Houston, Minnesota, As-built Drawings, US Army Corps of Engineers, November, 1995		HSTN_O&M_ASbuiltDWGs_Stage2B_Nov98.pdf
Houston Stage 2B Flood Control Root River Houston, Minnesota As-built Drawings, US Army Corps of Engineers, October 1996		HSTN_O&M_ASbuiltDWGs_Stage2B_Nov98.pdf
Storm Water Pumping Station, Houston, Minnesota Drawings, Davy Engineering Co., April, 1997		Storm Water Pumping Station, 1391-35.pdf
Periodic Inspection Report for the American Recovery and Reinvestment Act of 2009 Root River at Houston Flood Control Project, prepared by HNTB-Gerwick River Solutions prepared for US Army Corps of Engineers St. Paul District, March 22, 2010		Houston_PI_2010.pdf
2012 Routine Inspection Report for the Houston, Minnesota, Levee System, US Army Corps of Engineers St. Paul District, November 6, 2012		HSTN_2012_RI_FINAL-SIGNED.pdf
2013 Routine Inspection Report for the Houston, Minnesota, Levee System, US Army Corps of Engineers St. Paul District, July 12, 2013		HSTN_2013_RI_FINAL-SIGNED_07132013.pdf
Houston, MN Storm Sewer Operations & Maintenance Manuals, – Ebara International Corporation, September, 1998		HSTN_O&M_Manual-Ebara Intl Corp.pdf
Section 205 Flood Control Project Root River Houston, Minnesota Houston County Operation and Maintenance Manual, US Army Corps of Engineers St. Paul District, August 22, 2003		HSTN_O&M_Manual_Aug03.pdf
Standard Operating Procedures During Flood Event, City of Houston, February 2009		HSTN_emergency_flood_plan.pdf
Evacuation, Traffic Control, and Security Emerbency Operations Plan		HSTN_emergency_flood_plan.pdf
Sanitary Sewer, Water, Storm Sewer Base Map, 2002		utility map 2002.pdf
Video Inspection Flood Control Dike Structures, Flow-Rite Pipe & Sewer Services, LLC Nov. 15, 2012		video inspection\Flood control dike
Video Inspection WWTP, Flow-Rite Pipe & Sewer Services, LLC 12/10/2012		video inspection\WWTP_HTMLReports
2014 DFIRM GIS Data		DFIRM_DB
2008 USACE top of levee survey		HSTN_Levee_Station_Point.gdb
Houston, MN Easement Extent		Easement_Extent

HOUSTON LEVEE CERTIFICATION
PHASE 1

ITEMS NEEDED FROM CITY		
ITEM	**COMMENTS**	**DATE REC'D**
USACE SLOPE STABILITY ANALYSIS AS RECOMMENDED IN 2009 PERIODIC INSPECTION		
USACE SEEPAGE ANALYSIS AS RECOMMENDED IN 2009 PERIODIC INSPECTION		
EDA PUMP STATION DESIGN AS RECOMMENDED IN 2009 PERIODIC INSPECTION		
EDA PUMP STATION RECORD DRAWINGS AS RECOMMENDED IN 2009 PERIODIC INSPECTION	from Davy Engineering	27-Apr-15
EDA PUMP STATION O&M MANUAL AS RECOMMENDED IN 2009 PERIODIC INSPECTION		
CITY OF HOUSTON EMERGENCY OPERATION PLAN		
UPDATE TO O&M MANUAL TO MEET CURRENT DESIGN STANDARDS AS RECOMMENDED IN 2009 PERIODIC INSPECTION		
INTERIOR DRAINAGE INVESTIGATION FOR A POSSIBLE SOLUTION BY USACE AS STATED IN 2009 PERIODIC INSPECTION		
HWY 76 RECORD DRAWINGS AS RECOMMENDED IN 2009 PERIODIC INSPECTION		
EVALUATION OF PONDING AREAS C AND B BOUNDARIES AND CAPACITY RECOMMENDED IN 2009 PERIODIC INSPECTION		
STANDARD OPERATING PROCEDURES DURING FLOOD EVENT DATED FEB. 2009		
OPERATION AND MAINTENANCE MANUALS FOR RELIEF WELLS PUMPS AND CONTROLS		
OPERATION AND MAINTENANCE MANUALS FOR FLAP GATES, SLUICE GATES, WALL THIMBLES AND PORTABLE OPERATORS		
OPERATION AND MAINTENANCE MANUAL FOR TRI-STATE PUMP AND CONTROL		
OPERATION AND MAINTENANCE MANUAL EBARA INTERNATIONAL CORPORATION		24-Apr-15
REPORT FROM VIDEOTAPING OR VISUAL INSPECTIONS OF CULVERTS AS STATED IN THE PERIODIC INSPECTION		24-Apr-15
RECORD DRAWINGS FOR SANITARY GATEWELL AND SHUT-OFF VALVE STATION 71+22.23		
GRADING PLANS FOR PONDING AREAS C AND D TO CORRESPOND WITH THE STROAGE CURVES GIVEN IN THE 1992 USACE DESIGN MEMORANDUM		
CURRENT MAPS OR DRAWINGS OF CITY STORM SEWER SYSTEM TO DETERMINE DRAINAGE PATTERNS		24-Apr-15
HEC-1 MODEL USED FOR THE INTERIOR DRAINAGE DESIGN MENTIONED IN THE 1992 USACE DESIGN MEMORANDUM		
DOCUMENTATION REGARDING WORKING WITH LANDOWNER DOWNSTREAM OF DITCH D TO REMOVE OBSTRUCTION AS RECOMMENDED IN THE 2009 PERIODIC INSPECTION		

HOUSTON LEVEE CERTIFICATION
PHASE 1

ITEMS NEEDED FROM CITY		
ITEM	**COMMENTS**	**DATE REC'D**
DRAWINGS FOR THE BOX CULVERT AND STOPLOG STRUCTURE ALONG HWY 76 APPROXIMATELY 200 FEET SOUTH OF HWY 16 AS MENITONED IN THE 2009 PERIODIC INSPECTION REPORT		
UPDATED H&H STUDY FOR THE ROOT RIVER BY THE USACE/MNDNR/USGS THAT IS SUPPOSED TO BE INCLUDED IN APPENDIX D OF THE 2009 PERIODIC INSPECTION		
EXHIBIT A - REAL ESTATE INDEX MAP; ON FILE AT THE CITY AS LISTED IN THE O&M MANUAL		
2013 USACE INSPECTION REPORT		24-Apr-15
2012 USACE INSPECTION REPORT		24-Apr-15
1975 USACE Feasibility Report		
1990 USACE Reevaluation Report		

Mead&Hunt

ITEMS TO FEMA	
ITEM	**REC'D**
4 CFR 65.10(b) - Operation and Maintenance Systems	
Levee "As-built"plans	
Houston Stage 1 Flood Control Root River Houston, Minnesota, As-built Drawings, US Army Corps of Engineers, October, 1996	X
Houston Stage 2A Flood Control Root River Houston, Minnesota, As-built Drawings, US Army Corps of Engineers, November, 1995	X
Houston Stage 2B Flood Control Root River Houston, Minnesota As-built Drawings, US Army Corps of Engineers, October 1996	X
Storm Water Pumping Station, Houston, Minnesota Drawings, Davy Engineering Co., April, 1997	X
HWY 76 RECORD DRAWINGS	
Official Operation and Maintenance Plans	
Section 205 Flood Control Project Root River Houston, Minnesota Houston County Operation and Maintenance Manual, US Army Corps of Engineers St. Paul District, August 22, 2003	X
OPERATION AND MAINTENANCE MANUALS FOR RELIEF WELLS PUMPS AND CONTROLS	
OPERATION AND MAINTENANCE MANUALS FOR FLAP GATES, SLUICE GATES, WALL THIMBLES AND PORTABLE OPERATORS	
OPERATION AND MAINTENANCE MANUAL FOR TRI-STATE PUMP AND CONTROL	
Houston, MN Storm Sewer Operations & Maintenance Manuals, – Ebara International Corporation, September, 1998	X
CITY OF HOUSTON EMERGENCY OPERATION PLAN	
STANDARD OPERATING PROCEDURES DURING FLOOD EVENT	
Inspection Reports	
2012 Routine Inspection Report for the Houston, Minnesota, Levee System, US Army Corps of Engineers St. Paul District, November 6, 2012	X
2013 Routine Inspection Report for the Houston, Minnesota, Levee System, US Army Corps of Engineers St. Paul District, July 12, 2013	X
Periodic Inspection Report for the American Recovery and Reinvestment Act of 2009 Root River at Houston Flood Control Project, prepared by HNTB-Gerwick River Solutions prepared for US Army Corps of Engineers St. Paul District, March 22, 2010	X
Mead & Hunt Inspection Report	X
Documentation of levee maintenance	
44 CFR 65.10(b) (1) (i) – Freeboard	
surveyed top of levee	
Levee freeboard plotted against the base flood and req'd freeboard	
44 CFR 65.10(b) (2) – Closures	
Outlet Structural Evaluation	

Mead&Hunt

ITEMS TO FEMA	
ITEM	**REC'D**
44 CFR 65.10(b) (3) – Embankment Protection	
Expected Flow velocities evaluation	
Expected Wind and Wave Action evaluation	
Slope Protection Techniques evaluation	
flooding duration at various stages - flood history	
Embankment and foundation materials	
44 CFR 65.10(b) (4) – Embankment and Foundation Stabiity	
Depth of flooding	
Embankment and foundation materials and compaction	
Material properties used for modeling	
Seepage evaluation	
Slope stability evaluation - rapid drawdown; long term steady state seepage	
44 CFR 65.10(b) (5) – Settlement	
Design elevation verses surveyed elevations	
Settlement and seismic issues	
Settlement design evaluation	
44 CFR 65.10(b) (6) – Interior Drainage	
Up-to-date Hydrologic evaluation	
Pumping station structural, electrical and mechanical analysis	
Basis of hydraulic design for pumping station	
Up-to-date hydraulic evaluation	
Ponding evaluation, up-to-date map of base flood ponding	

Appendix B. FEMA Notification

U.S. Department of Homeland Security
FEMA Region V
536 South Clark Street, 6th Floor
Chicago, IL 60605

FEMA

October 7, 2014

The Honorable Connie Edwards
Mayor, City of Houston
105 West Maple Street
Post Office Box 667
Houston, MN 55943

RE: City of Houston Levee

Dear Mayor Edwards:

This is in regard to the City of Houston Levee shown on the effective Flood Insurance Rate Map (FIRM) and in the effective Flood Insurance Study (FIS) report for the City of Houston. As you may know, the Minnesota Department of Natural Resources and FEMA are working jointly to produce a countywide FIS report and Digital Flood Insurance Rate Map (DFIRM) for Houston County, Minnesota and Incorporated Areas. This effort is being undertaken as part of FEMA's Flood Risk Mapping, Assessment, and Planning (Risk MAP) program.

The effective FIRM and FIS report depict some areas as receiving protection through the City of Houston Levee. Based on the information available and on the mapping standards of the National Flood Insurance Program (NFIP) at the time that the FIS was performed, FEMA accredited the levee with providing protection from the flood that has a one percent chance of being equaled or exceeded in any given year. This one percent annual-chance flood is also referred to as the base flood.

For FEMA to continue to accredit the identified levee with providing protection from the base flood, the levee must meet the requirements of the Code of Federal Regulations, Title 44, Section 65.10 (44 CFR 65.10), entitled "Mapping of Areas Protected by Levee Systems" (copy enclosed). In accordance with 44 CFR 65.10(a), it is the responsibility of the community or other party seeking recognition of a levee system to provide the data defined and outlined within the regulation. Specifically, the design and construction data provided must be certified by a registered professional engineer or by a Federal agency with responsibility for levee design.

FEMA understands that it may take time to acquire and/or assemble the documentation necessary to fully comply with 44 CFR 65.10. Therefore, FEMA has incorporated a process into the aggressive schedule of Risk MAP that, if needed, will provide you with additional time to submit all the necessary documentation. **Initiation of this process can take place only if you as the levee owner, and a representative of each impacted community sign and return the enclosed agreement within 90 days of the date of this letter (before January 5, 2015).**

Completion and submittal of the enclosed agreement will officially request that FEMA label the levee as a Provisionally Accredited Levee (PAL) on the DFIRM and will serve as your agreement that, to the best of your knowledge, the levee meets the requirements of 44 CFR 65.10. The completed agreement must be submitted before January 5, 2015, for the levee to receive the PAL designation.

By endorsing the agreement, you agree to provide all the necessary documentation to comply with 44 CFR 65.10 before January 5, 2017. If you are unable to submit all of the documentation necessary to meet the requirements of 44 CFR 65.10 before this date, FEMA will initiate a map revision to redesignate certain areas on the landward side of the levee as floodprone.

The levees will be labeled as PALs during the 24 month period to convey to map users that levee certification verification is underway. FEMA recommends that you, the levee owner, and the impacted communities implement outreach efforts to inform affected property owners that an assessment of the levee is underway. FEMA also encourages the purchase of flood insurance, even though coverage is not federally required.

If the documentation necessary to fully comply with 44 CFR 65.10, including an existing operation and maintenance plan and record of an on site inspection by a registered professional engineer, is readily available, please submit the data to this office within 30 days of the date of this letter. Upon receipt of your submittal, FEMA will review the data and determine whether the levee will continue to be accredited with providing protection from the base flood.

If you have additional questions regarding the specific submittal requirements, please contact Bill Heyse of my staff, either by telephone at (312) 408-5323, or by email at William.Heyse@fema.dhs.gov.

Please return the completed agreement to the following address:

FEMA
Attn: Bill Heyse
536 S. Clark St. 6th Floor
Chicago, IL 60605

We look forward to working with you and community officials to address this important matter. If there is anything we can do to facilitate the submittal process, please let us know.

Sincerely,

Christine Stack

Christine Stack
Director, Mitigation Division
FEMA Region V

Enclosures

cc: Mr. Randy Thesing, Public Works, City of Houston (letter only)
Ms. Christina Peterson, City Administrator, City of Houston (letter only)
Mr. Dana Werner, United States Army Corps of Engineers, St. Paul District (letter only)
Ms. Ceil Strauss, Minnesota NFIP State Coordinator, MNDNR (letter only)
Mr. Bill Heyse, FEMA Region V (letter only)
Mr. Roger Denick, Regional Support Center, Region V (letter only)
U.S. Senator Amy Klobuchar, Washington D.C. Office (letter only)
U.S. Senator Al Franken, Washington D.C. Office (letter only)
U.S. Representative Timothy Walz, Washington, DC Office (letter only)

Letter of Agreement to Comply With the Code of Federal Regulations, Title 44, Section 65.10 (44 CFR 65.10) and Request for Provisionally Accredited Levee (PAL) Designation

City of Houston Levee

We, the undersigned, have received the letter from FEMA dated October 7, 2014, and the enclosed document entitled "Requirements of 44 CFR 65.10". We understand that FEMA is in the process of providing updated flood maps for Houston County and that the area behind the levee known as the City of Houston Levee will be remapped to reflect that the levee system has been designated as a PAL.

To the best of our knowledge, the levee known as the City of Houston Levee meets the requirements of 44 CFR 65.10. We hereby submit to FEMA, within 90 days (January 5, 2015) our agreement to provide FEMA with all the necessary information to show that this levee system complies with 44 CFR 65.10. We understand that this documentation will be required before January 5, 2017. This information will allow FEMA to move forward with the flood mapping for Houston County. We fully understand that if complete documentation of compliance with 44 CFR 65.10 is not provided within the designated timeframe of 24 months, FEMA will initiate a revision to the Flood Insurance Rate Map to redesignate the area as floodprone.

Levee Owner Representative _____ (signature)

Connie J Edwards (print)

Mayor (title)

Date: 10/14/14

Other (if applicable) _____ (signature)

Christina Peterson (print)

Date: 10/14/14

FACT SHEET

LEVEES
IDENTIFYING THE RISK

Requirements of 44 CFR Section 65.10:

Mapping of Areas Protected by Levee Systems

As part of a mapping project, it is the levee owner's or community's responsibility to provide data and documentation to show that a levee meets the requirements of Section 65.10 of the National Flood Insurance Program (NFIP) regulations. Links to Section 65.10 and many other documents are available on FEMA's Web site at www.fema.gov/plan/prevent/fhm/lv_fpm.shtm.

The FEMA requirements in Section 65.10 are separated into five categories:

1. General criteria;
2. Design criteria;
3. Operations plans and criteria;
4. Maintenance plans and criteria; and
5. Certification requirements.

The requirements for each of these areas are summarized below.

(A) GENERAL CRITERIA

For purposes of the NFIP, FEMA will only recognize in its flood hazard and risk mapping effort those levee systems that meet, and continue to meet, minimum design, operation, and maintenance standards that are consistent with the level of protection sought through the comprehensive floodplain management criteria established by Section 60.3 of the NFIP regulations. Section 65.10 of the NFIP regulations describes the types of information FEMA needs to recognize, on NFIP maps, that a levee system provides protection from the flood that has a 1-percent chance of being equaled or exceeded in any give year (base flood). This information must be supplied to FEMA by the community or other party seeking recognition of a levee system at the time a study or restudy is conducted, when a map revision under the provisions of Part 65 of the NFIP regulations is sought based on a levee system, and upon request by the Administrator during the review of previously recognized structures. The FEMA review is for the sole purpose of establishing appropriate risk zone determinations for NFIP maps and does not constitute a determination by FEMA as to how a structure or system will perform in a flood event.

(B) DESIGN CRITERIA

For the purposes of the NFIP, FEMA has established levee design criteria for freeboard, closures, embankment protection, embankment and foundation stability, settlement, interior drainage, and other design criteria. These criteria are summarized in subsections below.

(B)(1) FREEBOARD

For riverine levees:

- A minimum freeboard of 3 feet above the water-surface level of the base flood must be provided.
- An additional 1 foot above the minimum is required within 100 feet on either side of structures (e.g., bridges) riverward of the levee or wherever the flow is constricted.

- An additional 0.5 foot above the minimum at the upstream end of the levee, tapering to not less than the minimum at the downstream end of the levee, is also required.

Exceptions to the minimum riverine freeboard requirements above may be approved if the following criteria are met:

- Appropriate engineering analyses demonstrating adequate protection with a lesser freeboard must be submitted.
- The material presented must evaluate the uncertainty in the estimated base flood elevation profile and include, but not necessarily be limited to:
  - An assessment of statistical confidence limits of the 1-percent-annual-chance discharge;
  - Changes in stage-discharge relationships; and
  - Sources, potential, and magnitude of debris, sediment, and ice accumulation.
- It must be also shown that the levee will remain structurally stable during the base flood when such additional loading considerations are imposed.

Under no circumstances will freeboard of less than 2 feet be accepted.

For coastal levees, the freeboard must be established at 1 foot above the height of the 1-percent-annual-chance wave or the maximum wave runup (whichever is greater) associated with the 1-percent-annual-chance stillwater surge elevation at the site.

Exceptions to the minimum coastal freeboard requirements above may be approved if the following criteria are met:

- Appropriate engineering analyses demonstrating adequate protection with a lesser freeboard must be submitted.
- The material presented must evaluate the uncertainty in the estimated base flood loading conditions. Particular emphasis must be placed on the effects of wave attack and overtopping on the stability of the levee.

Under no circumstances will a freeboard of less than 2 feet above the 1-percent-annual-chance stillwater surge elevation be accepted.

(B)(2) CLOSURES

The levee closure requirement is that all openings must be provided with closure devices that are structural parts of the system during operation and design according to sound engineering practice.

(B)(3) EMBANKMENT PROTECTION

Engineering analyses must be submitted to demonstrate that no appreciable erosion of the levee embankment can be expected during the base flood, as a result of either currents or waves, and that anticipated erosion will not result in failure of the levee embankment or foundation directly or indirectly through reduction of the seepage path and subsequent instability.

The factors to be addressed in such analyses include, but are not limited to:

- Expected flow velocities (especially in constricted areas);
- Expected wind and wave action;

- Ice loading;
- Impact of debris;
- Slope protection techniques;
- Duration of flooding at various stages and velocities;
- Embankment and foundation materials;
- Levee alignment, bends, and transitions; and
- Levee side slopes.

(B)(4) EMBANKMENT AND FOUNDATION STABILITY

Engineering analyses that evaluate levee embankment stability must be submitted.

The analyses provided shall evaluate expected seepage during loading conditions associated with the base flood and shall demonstrate that seepage into or through the levee foundation and embankment will not jeopardize embankment or foundation stability.

An alternative analysis demonstrating that the levee is designed and constructed for stability against loading conditions for Case IV as defined in U.S. Army Corps of Engineers (USACE) Engineering Manual 1110-2-1913, Chapter 6, Section II, may be used.

The factors that shall be addressed in the analyses include:

- Depth of flooding;
- Duration of flooding;
- Embankment geometry and length of seepage path at critical locations;
- Embankment and foundation materials;
- Embankment compaction;
- Penetrations;
- Other design factors affecting seepage (e.g., drainage layers); and
- Other design factors affecting embankment and foundation stability (e.g., berms).

(B)(5) SETTLEMENT

Engineering analyses must be submitted that assess the potential and magnitude of future losses of freeboard as a result of levee settlement and demonstrate that freeboard will be maintained within the minimum freeboard standards set forth in B(1).

This analysis must address:

- Embankment loads,
- Compressibility of embankment soils,
- Compressibility of foundation soils,

- Age of the levee system, and
- Construction compaction methods.

A detailed settlement analysis using procedures such as those described in USACE Engineering Manual EM 1100-2-1904 must be submitted.

(B)(6) INTERIOR DRAINAGE

An analysis must be submitted that identifies the source(s) of such flooding; the extent of the flooded area; and, if the average depth is greater than 1 foot, the water-surface elevation(s) of the base flood. This analysis must be based on the joint probability of interior and exterior flooding and the capacity of facilities (such as drainage lines and pumps) for evacuating interior floodwaters. Interior drainage systems usually include storage areas, gravity outlets, pumping stations, or a combination thereof.

For areas of interior drainage that have average depths greater than 1 foot, mapping must be provided depicting the extents of the interior flooding, along with supporting documentation.

(B)(7) OTHER DESIGN CRITERIA

In unique situations, such as those where the levee system has relatively high vulnerability, FEMA may require that other design criteria and analyses be submitted to show that the levees provide adequate protection. In such situations, sound engineering practice will be the standard on which FEMA will base its determinations. FEMA also will provide the rationale for requiring this additional information.

(C) OPERATIONS PLANS AND CRITERIA

For a levee system to be recognized, the operational criteria must be as described below. All closure devices or mechanical systems for internal drainage, whether manual or automatic, must be operated in accordance with an officially adopted operation manual, a copy of which must be provided to FEMA by the operator when levee or drainage system recognition is being sought or when the manual for a previously recognized system is revised in any manner. All operations must be under the jurisdiction of a Federal or State agency, an agency created by Federal or State law, or an agency of a community participating in the NFIP.

(C)(1) CLOSURES

Operation plans for closures must include the following:

- Documentation of the flood warning system, under the jurisdiction of Federal, State, or community officials, that will be used to trigger emergency operation activities and demonstration that sufficient flood warning time exists for the completed operation of all closure structures, including necessary sealing, before floodwaters reach the base of the closure;
- A formal plan of operation, including specific actions and assignments of responsibility by individual name or title; and
- Provisions for periodic operation, at not less than 1-year intervals, of the closure structure(s) for testing and training purposes.

(C)(2) INTERIOR DRAINAGE SYSTEMS

Interior drainage systems associated with levee systems usually include storage areas, gravity outlets, pumping stations, or a combination thereof. FEMA will recognize these drainage systems on NFIP maps for flood protection purposes only if the following minimum criteria are included in the operation plan:

- Documentation of the flood warning system, under the jurisdiction of Federal, State, or community officials, that will be used to trigger emergency operation activities and demonstration that sufficient flood warning time exists to permit activation of mechanized portions of the drainage system;
- A formal plan of operation, including specific actions and assignments of responsibility by individual name or title;
- Provision for manual backup for the activation of automatic systems; and
- Provisions for periodic inspection of interior drainage systems and periodic operation of any mechanized portions for testing and training purposes; no more than 1 year shall elapse between either the inspections or the operations.

(C)(3) OTHER OPERATION PLANS AND CRITERIA

FEMA may require other operating plans and criteria to ensure that adequate protection is provided in specific situations. In such cases, sound emergency management practice will be the standard upon which FEMA determinations will be based.

(D) MAINTENANCE PLANS AND CRITERIA

For levee systems to be recognized as providing protection from the base flood, the following maintenance criteria must be met:

- Levee systems must be maintained in accordance with an officially adopted maintenance plan, and a copy of this plan must be provided to FEMA by the owner of the levee system when recognition is being sought or when the plan for a previously recognized system is revised in any manner.
- All maintenance activities must be under the jurisdiction of a(n):
    - Federal or State agency;
    - Agency created by Federal or State law; or
    - Agency of a community participating in the NFIP that must assume ultimate responsibility for maintenance.
- The maintenance plan must document the formal procedure that ensures that the stability, height, and overall integrity of the levee and its associated structures and systems are maintained.
- At a minimum, the maintenance plan shall specify:
    - Maintenance activities to be performed;
    - Frequency of their performance; and
    - Person by name or title responsible for their performance.

(E) CERTIFICATION REQUIREMENTS

Data submitted to support that a given levee system complies with the structural requirements set forth in B(1) through B(7) above must be certified by a Registered Professional Engineer. Also, certified as-built plans of the levee must be submitted. Certifications are subject to the definition given in Section 65.2 of the NFIP regulations. In lieu of these structural requirements, a Federal agency with responsibility for levee design may certify that the levee has been adequately designed and constructed to provide protection against the base flood.

Appendix C. Field Assessment

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NAME OF PROJECT: Phase One Levee Certification, City of Houston, MN

DATE INSPECTED: May 2, 2015

INSPECTED BY: Jay P. Wheaton, P.E.

SUMMARY OF INSPECTION

For the purpose of this inspection, the Houston Levee is defined by US Army Corps of Engineers (Corps) plans "Houston Stage 1 Flood Control Root River Houston, Minnesota, October, 1996", "Houston Stage 2A Flood Control Root River Houston, Minnesota November, 1995", and "Houston Stage 2B Flood Control Root River Houston, Minnesota, October 1996".

The levee system begins at the west end of Houston at STA 0+00 and ends at the MN STR 76 box culvert modification on the east end of Houston on STR 76 approximately 1900 feet south of the intersection with MN STH 16. Site inspection areas included in this report consist of the levee length described above, as well as "ditches" A thru F and Interior Ponding Areas A, B and C.

The City of Houston does a good job of actively operating and maintaining the system. Given the severity of the flooding over the past several years the project is in good condition, but there are several areas noted below that require attention to correct deficiencies.

COMMENTS AND OBSERVATIONS

1) **Farming Encroachments**: There are several areas where farming activity is encroaching within 15 feet of the toe of the levee at several locations. Areas where encroachment was observed at the time of this inspection include Sta. 1+00 to Sta. 13+00 landside, Sta. 32+00 to Sta. 42+50 landside, Sta. 47+00 to Sta. 56+00 riverside, Sta.62+50 to Sta. 82+50 riverside, Sta. 73+00 to Sta. 76+50 landside and Sta. 84+00 to Sta.112+50 riverside. Levee easements along farm fields should be verified and marker posts installed to maintain these easements to protect the integrity of the levee and to aid in maintenance and emergency access.

2) **Excessive Vegetation and Vegetation Encroachments:** An area of concern that has also been mentioned in previous Corps inspections and was also observed during this inspection is excessive vegetation. The landside and riverside slopes for the majority of the levee are planted in dense native grasses that impede the ability to perform visual inspections of the slopes during routine inspections and flood events. Ditches A, B, C, and F are overgrown with cattails and wetland grasses which will reduce capacity and increase the probability of plugging the outlet structures during flood events. If this native grass is to remain, annual maintenance burns with corresponding levee inspections should be implemented. Ditches should be cleaned to regain the lost capacity and reduce the chances of plugging outlet structures.

A few areas of vegetation encroachment were also observed. There is vegetation within 15 feet of the landside toe of levee near Outlet A1 at Sta. 46+50 that should be removed protect the integrity of the levee and to aid in maintenance and for emergency access. There are also several shrubs and trees near the toe of the levee in Trailhead Park from Sta 54+00 to 59+00 that should be verified for emergency access. The row of trees along the landside of the levee near Ditch E outfall 15 feet from the levee toe but the branches on these trees should be trimmed to maintain access.

3) **Utility Encroachments:** There are several utilities located within 15 feet of the toe of the levee that should be relocated or location verified within the levee easement. There are approximately 7 electrical cabinets with underground wire in the section from Sta. 25+00 to Sta. 63+00 located on the landside slope approximately 30 feet from centerline. There are power pole and guy wire encroachments at Stations 27+00, 62+00, 80+00, 103+00 and 112+00. Many of the electrical poles, guy wires and cabinets appear to fall in overbuild areas but should be relocated or verified. The sanitary gatewell structure at Sta. 71+22 should be exercised.

4) **Freeboard:** Vertical survey verification was not part of this field assessment but a review of design documents and Corps survey data revealed several potential areas of non-compliant FEMA freeboard requirements from Sta. 61+50 to the east end of the levee at the intersection of MN STR 76 and MN

STH 16. An elevation survey to supplement the Corps survey will be required to verify if the freeboard in this section meets FEMA freeboard requirements

5) Pipe Culverts: Several pipe culverts included in this system were part of the review. The first 2 sets (under CSAH 13 and MN STH 16) of triple 48-inch reinforced concrete pipe culverts (RCP) associated with Ditch F are in good condition. The trash guards and joint ties are in place and are in good condition. Pipe joints were tight and no sagging or cracking was observed. All three of the riprap outfalls for these culverts contained excessive vegetation that should be cleaned. The City of Houston has recently completed video inspections of these pipes. No problems were identified.

The 3rd set of three each 48-inch diameter RCP's associated with Ditch F at Sta. 27+00 is also in good condition. This culvert structure includes a concrete headwall with 48-inch flap gates. The pipe inverts, trash guards, pipe joints and joint ties were all satisfactory. The concrete structure showed no cracking. The galvanized steel railing is starting to show rust in the weld areas and should receive

routine maintenance. The flap gates appeared operational and were able to be opened by hand. The City of Houston has recently completed video inspections of these pipes. No problems were identified. The outlet structure had standing water that fell just below the flap gates. This needs to be monitored and ditch maintenance should occur to prevent the potential of standing water freezing and damaging the gates and gaskets. Other routine maintenance of gates should include rust removal, painting and gasket lubrication. As mentioned previously, outlet drainage ditch requires minor cleaning of sediment and control of excess vegetation.

The two 36 inch diameter RCP's located in Trailhead Park in Ditch C are also in good condition and no structural issues were found. Ditch C contains excessive vegetation which is a threat to plugging these two culverts during a flood event. This ditch should be cleaned and/or burned regularly to minimize this problem.

There is a 2 ft.x2 ft. cast-in-place concrete box culvert under CSAH 13 that functions as an equalizer pipe between the ponding areas near the Fire Station and the ponding area near the High School. A thorough inspection of this pipe was unable to be completed due to it being plugged with mud. This box culvert should be cleaned and further investigation should be done to determine the impact this pipe has on the ponding areas in this area.

6) **Outlet A1:** This drainage structure, located at Sta. 46+48, consists of 2ea. 66-inch RCP's at the inlet structure and 3 ea. 48-inch RCP's with 48-inch flap gates and a concrete headwall. Upon visual

inspection, this structure appears to be in good condition. The pipe inverts, trash guards, pipe joints and joint ties were all satisfactory. The concrete headwall showed no cracking. The galvanized steel railing is starting to show rust in the weld areas and should receive routine maintenance. The flap gates appeared operational and were able to be opened by hand. The City of Houston has recently completed video inspections of these pipes. No problems were identified. The concrete headwall had standing water that covered the bottom 6-Inches of the flap gates. This needs to be monitored and ditch cleaning maintenance should occur to prevent the potential for standing water to freeze and damage the gates and gaskets. Other routine maintenance of gates should include rust removal, painting and gasket lubrication. Drainage Ditch F and Ditch A require cleaning of sediment and control of excess vegetation.

This outlet structure also includes an electric powered relief well and 2 ea. 66-inch flush bottom sluice gates operated by hand cranks. The relief well appeared to be in good condition and has had recent maintenance of paint. Sluice gates appeared to be in good condition and in working order.

7) **Outlet A2 & EDA Pump Station:** These drainage structures are located at Sta. 83+50. Outlet A2 consists of 2 ea. 66-inch RCP's at the inlet structure and 3 ea. 48-Inch RCP's with flap gates and a concrete headwall. Upon visual inspection, this structure appears to be in good condition. The pipe inverts, trash guards, pipe joints and joint ties were all satisfactory. The headwall had excessive debris against the trash guards that needs to be removed. The concrete outlet structure showed no cracking. The galvanized steel railing is starting to show rust in the weld areas and should receive routine maintenance. The flap gates appeared operational but were unable to be opened due to the amount of water in front of the gates. The headwall had standing water that covered the bottom 12-inches of the flap gates. This needs to be addressed and ditch maintenance should occur to prevent the potential for standing water to freeze and damage the gates and gaskets. Other routine maintenance of gates should include rust removal, painting and gasket lubrication. The City of Houston has recently completed video inspections of these pipes. No problems were identified.

This outlet structure also includes an electric powered relief well and 2 ea. 66-Inch flush bottom sluice gates operated by hand cranks. The relief well appeared to be in good condition and has been recently painted but the electrical conduit that is attached to the well casing has been damaged by mowing operations and requires repairs and verification of operation. The sluice gates appeared to be in good condition and in working order.

The EDA Pump Station was designed by the City of Houston's Engineer, Davy Engineering. The design drawings that were reviewed for this work were dated 5/13/1996. This stormwater pump station consists of a 60-Inch RCP inlet, a cast-in-place concrete pumping structure and a 60-Inch RCP outlet. The inlet and outlet both have galvanized steel trash guards. The pumping structure included two pumps, one 15,000 gallon per minute (GPM), pump and one 5,000 GPM pump as well as a steel, mechanical chain hoist, electric service and a motor control panel.
When the pump station controls are energized, the pumps are sequenced on and off by a multi-point level float system. Level float switches are located in a PVC pipe stilling well in the pump intake structure.

The pumps were not activated during this review but the maintenance record in the control cabinet showed that these pumps were operated in the spring of 2015. Overall, the pumping station appeared to be in good condition. The RCP's and the concrete pumping structure were in good shape with no signs of cracking. The hoist system is starting to show signs of rust so routine maintenance is recommended. The pump control panel contained a very brief maintenance record. A more detailed Operation and Maintenance Manual is recommended to be included in this cabinet, along with a wire diagram and operator instructions. As mentioned in the Outlet A2 section above, the inlet area to this pump station has a debris build-up that needs to be removed.

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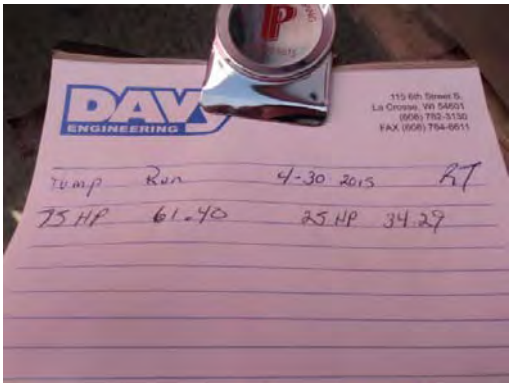

Outlet B: This drainage structure, located at Sta. 118+75, consists of 2 ea. 42-Inch RCP's with flap gates, a gatewell, and concrete headwall. Upon visual inspection, this structure appears to be in good condition. The pipe inverts, trash guards, pipe joints and joint ties were all satisfactory. The concrete structures showed no cracking. The flap gates appeared operational and were able to be opened by hand. The City of Houston has recently completed video inspections of these pipes. No problems were identified. The headwall had standing water that came to the bottom of the flap gates. This needs to be monitored and ditch cleaning maintenance should occur to prevent the potential for standing water to freeze and damage the gates and gaskets. This outlet structure also includes 2, 42-Inch flush bottom sluice gates operated by hand cranks. The sluice gates appeared to be in good condition and in working order. The inlet and outlet ditches for this drainage structure both contain excessive vegetation that needs to be addressed.

8) **STR 76 Box Culvert Closure:** This 4 ft. X 8 ft. cast-in-place concrete box culvert was an existing structure at the time of the Corps Stage 2B project. The work to modify this structure as part of Stage 2B included adding a trash guard at the inlet and a flap gate and stop log closure at the outlet. Upon visual inspection, this box culvert structure appears to be in good condition. The original box culvert showed no signs of cracking or sagging and the trash guard is in good condition. The stop logs for this structure were in-place at the time of inspection so the flap gate was unable to be opened but it appeared to be in working order. The stop log closure was also in good condition but the stop logs should only be in place during high water events. These stop logs cannot be considered a permanent closure so they should either be removed during normal stage conditions or this box culvert structure should be capped with concrete or removed entirely if this structure is deemed unnecessary.

9) **Ditches & Interior Drainage:** As mentioned throughout this report, the bulk of the drainage ditches require some sort of maintenance. Ditches A, B, C and F contain excessive vegetation that should be burned annually or removed entirely to maintain capacity and prevent outlet structures from plugging. Ditch D was unable to be accessed because of easement limitations but standing water at Outlet A2 and a review of aerial photos indicate that this ditch requires attention. A review of the easements and access to this ditch should be completed and maintenance to Ditch D should be explored. Ditch E appears to be intact but is currently being farmed so a review of the easement agreement should be checked to verify that this encroachment is in compliance.

Ponding Areas A and B were reviewed as well as the ponding area near the High School and the ponding area in the Industrial Park. Ponding Area A appeared to be in good condition and working order. Ponding Area B has some excessive vegetation and some development in the area that should be reviewed to verify the size of the ponding area has not changed.

The ponding area near the Fire Station was reviewed. This ponding area has excessive vegetation and lacks an outlet. This ponding area should be reviewed to verify size and determine if there is an a different location to possibility construct an outlet to either Ditch F or an outlet into the storm sewer system on Jefferson Street. The ponding area near the High School depends on the storm sewer system on Jefferson Street for overflow. This storm sewer system appears inadequate and alternative solutions should be explored.

10) **MN STR 76:** FEMA Flood Insurance Maps show the levee extending from the intersection of MN STR 76 and MN STH 16 to the south approximately 2,000 feet.