CERTIFICATION OF COMPLIANCE

Project Name:	MWRDGC – North Branch of the Chicago River and Lake Michigan Watershed Plan, Phase B
Statement/Agreement Date:	Technical Memo. Guidelines 8/10/07
Certification Date:	Oct 8, 2010

Tasks/Activities Covered by This Certification (Check All That Apply)

☐	**Entire Project**
☒	**Survey**
☐	**Topographic Data Development**
☐	**Hydrologic and/or Hydraulic Analyses**
☐	**Coastal Flood Hazard Analyses**
☐	**Floodplain Mapping**
☐	**Other (Specify):**

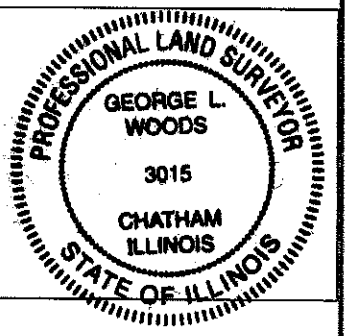
This is to certify that the work summarized above was completed in accordance with the statement/ agreement cited above and all amendments thereto, together with all such modifications, either written or oral, as directed by HDR Engineering, Inc., as such modifications affect the statement/agreement, and that all such work has been accomplished to meet accuracy guidelines contained in FEMA's "Guidelines and Specifications for Flood Hazard Mapping Partners" cited in the survey scope of work document, and in accordance with sound and accepted engineering practices within the contract provisions for respective phases of the work. The attached technical memo. describes the survey procedures to be followed for this project. By signing this document, the project surveyor agrees that complying with the survey procedures outlined in the technical memo will meet or exceed the final accuracy results specified in the FEMA guidelines and further confirm that their field surveyors have complied with procedures outlined in said technical memo.

Name: George Woods

Title: Professional Land Surveyor

Firm/Agency Represented: Lin Engineering, LTD.

Registration No.: 035-3015 EXPIRES 11-30-2010



Signature: George L Woods

This form must be signed, stamped, and dated by the surveyor in responsible charge from the firm contracted to perform the work who is registered as a Professional Land Surveyor in the State of Illinois.

To:	Metropolitan Water Reclamation District of Greater Chicago Attention: Michael Cosme, P.E.
From:	Jeffrey Dailey, HDR Engineering, Inc. Joseph Spradling, HDR Engineering, Inc. George Woods, Lin Engineering, Ltd.
CC:	Fred Lin, Lin Engineering, Ltd.
Date:	May 11, 2009
Job No:	08-033-5C

Summary of Survey Procedures

Purpose

The purpose of this technical memorandum is to summarize the general procedures utilized during the hydraulic survey.

These survey procedures have been used to meet the requirements as set forth in the Cook County Stormwater Management Plan (CCSMP), Table 6.9. Additionally, these procedures have been used to meet the positional accuracy requirements detailed in the Federal Emergency Management Agency (FEMA) *Guidelines and Specifications for Flood Hazard Mapping Partners, Appendix A, "Guidance for Aerial Mapping and Surveying".*

Procedures

Since several other Cook County Detailed Watershed Plans (DWPs) have utilized Real Time Kinematic Global Positioning System (RTK GPS) methods, the North Branch Chicago River DWP has utilized this method to achieve the positional horizontal and vertical accuracies required by the aforementioned FEMA report. This memorandum outlines the proposed methods of using RTK GPS, in addition to more traditional survey methods, such as total station, to establish control information.

1. Virtual Reference System Verification

Control information established for surveying hydraulic cross-sections on this project have been completed using RTK GPS methods employing a local Virtual Reference System (VRS). A VRS consists of a network of multiple continuously operating reference base stations used to simultaneously calculate the horizontal and vertical position of a point occupied by a mobile RTK GPS receiver in the field.

As part of the survey for the North Branch Chicago River DWP, HDR Engineering, Inc. and Lin Engineering, Ltd. have verified the accuracy of the VRS. To verify the accuracy of the VRS, a procedure using the standard deviation of a discrete random variable or data set was implemented. The standard deviation of a discrete random variable is defined as the root mean square deviation (RMSD) of its values (observations) from the mean (National

30 N. LaSalle Street
Suite 3220
Chicago, IL 60602-3348

Phone (312) 443-4900
Fax ((312) 443-4901
www.hdrinc.com

Geodetic Survey (NGS)-published elevations). In other terms, this method is computing the standard deviation of the survey observations from the NGS-published elevations for each NGS monument. The equation below calculates this standard deviation or RMSD, which accounts for multiple observations at each NGS monument.

$$RMSD = \sqrt{\left(\frac{1}{N}\right)\sum_{i=1}^{N}(M-R)^2}$$

where

RMSD = Root Mean Square Deviation

R = NGS-published coordinate value

M = Measured (observed) coordinate value

N = Number of Observations

Upon calculation of the RMSD for each NGS monument, the RMSD value is compared to accepted accuracy values for horizontal and vertical coordinates as outlined in the FEMA *Guidelines and Specifications for Flood Hazard Mapping Partners, Appendix A, "Guidance for Aerial Mapping and Surveying".* If RMSD values are within accepted accuracy values, the VRS is considered acceptable for use in the hydraulic survey.

The VRS calibration was performed using a VRS subscription from Precision Midwest Co. This subscription expired and was unavailable at the time the survey work was started for the West Fork cross sections. A new VRS service was purchased from KARA Co. Several control points that had been set for the North Branch survey using the Precision Midwest Company's VRS system were observed using the KARA Co. VRS RTK GPS system and the elevations were correlated to match the previously approved VRS calibration.

2. Secondary Control Points

Secondary control points have been established throughout the project at all hydraulic cross-section locations. Like the cross-sections, the secondary control points are spaced no more than 1,000 feet apart. Horizontal and vertical coordinate values of these points have been established by RTK GPS and checked with traditional total station survey methods. RTK GPS produces a vertical accuracy of +/- 0.06 ft.

3. Hydraulic Cross-Sections

Hydraulic cross-sections throughout the watershed have been surveyed using conventional Total Station surveying procedures. Cross-sections have been surveyed according to the FEMA *Guidelines and Specifications for Flood Hazard Mapping Partners, Appendix N: Data Capture Guidelines.*

Cross-sections were spaced at 1,000 feet or less along the individual stream reaches. Spacing was optimized by surveyors in the field due to site conditions. Hydraulic cross-

sections completed as part of the bridge structure surveys are separate from those spaced at 1,000 feet or less along the stream reaches.

4. Bridge Surveys

Bridge surveys have been conducted according to the FEMA *Guidelines and Specifications for Flood Hazard Mapping Partners, Appendix N: Data Capture Guidelines.* Specifically, bridge sketches, survey text files, and photographs have been generated for specified bridge crossings along the North Branch Chicago River and its tributaries, which include the West Fork, Middle Fork, and Skokie River. The bridge surveys have been completed using both RTK GPS methods as well as conventional closed-loop survey methods.

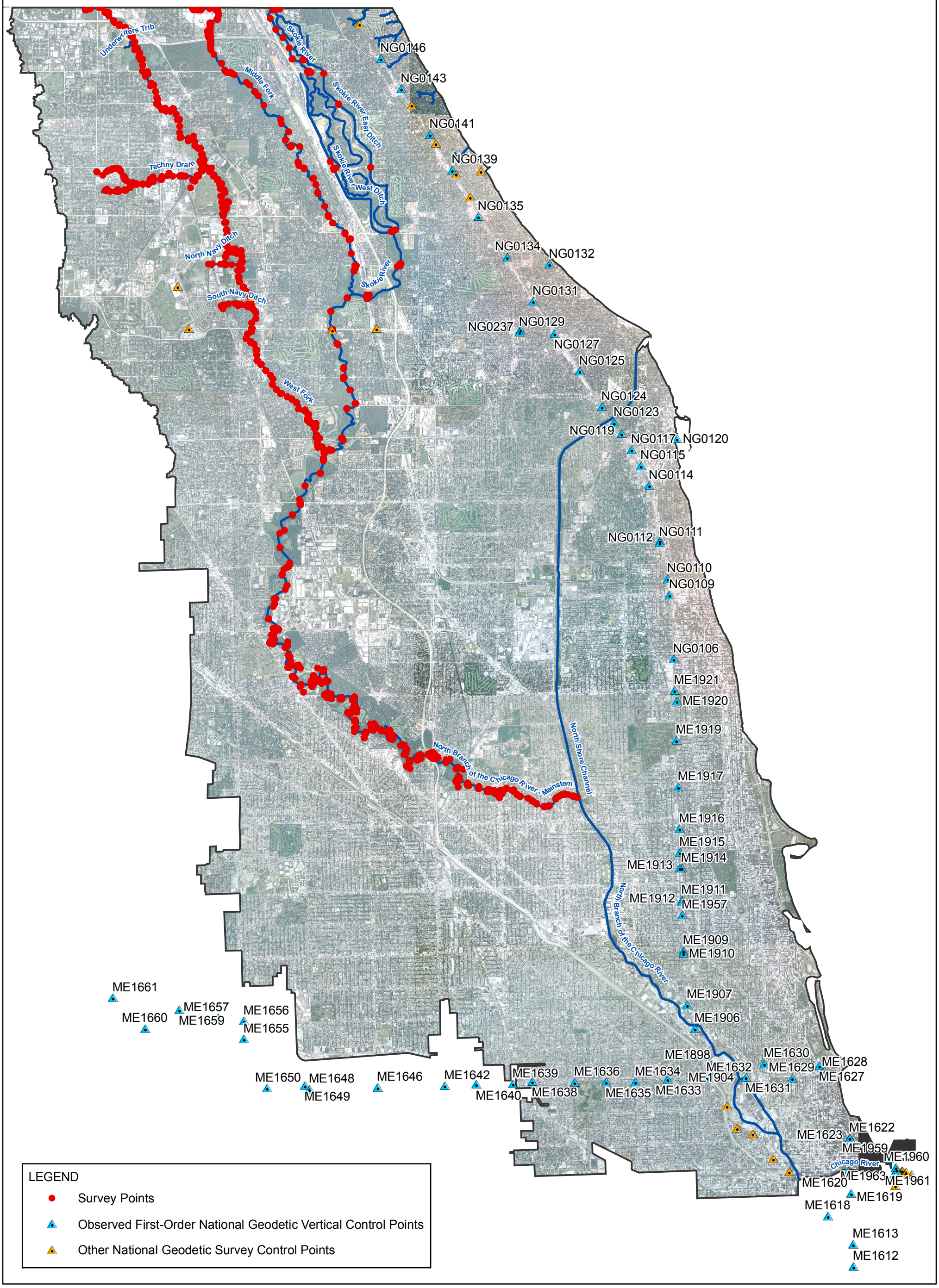
5. Survey Data

Upon the completion of the hydraulic survey, all digital survey documentation from Lin Engineering, Ltd. will be appended to this Technical Memorandum.

Appendix A

Digital Survey Documentation

(To be appended upon completion of hydraulic survey)



Appendix D.1
North Branch Chicago River Watershed Survey Points