NTH Consultants, Ltd.

Infrastructure Engineering
and Environmental Services

41780 Six Mile Road, Suite 200
Northville, MI 48168
248.553.6300
248.324.5179 Fax

Mr. Christopher Scieszka
DTE Electric Company
One Energy Plaza
Detroit, Michigan 48226

October 14, 2021
NTH Project No. 62-210081-01

RE: Inflow Design Flood Control System Plan 5-Year Periodic Assessment
St. Clair Power Plant Bottom Ash Basins
East China Township, Michigan

Dear Mr. Scieszka:

NTH Consultants, Ltd. (NTH) has completed a periodic update to the initial inflow design flood control (IDFC) system plan for the bottom ash basins at St. Clair Power Plant (STCPP) in accordance with the Hazardous and Solid Waste Management System; Disposal of Coal Combustion Residuals (CCR) from Electric Utilities 40 CFR Part 257.82. Specifically, this IDFC system plan constitutes the 5-year periodic assessment of the initial plan (dated October 14, 2016) for these impoundments, as required by 40 CFR Part 257.82(c)(4). NTH performed this assessment using information provided by personnel from DTE Electric Company (DTE), observations we made during a site visit by our personnel, and an updated topographic survey. In general, the analysis methods and development of information are presented in the initial IDFC system plan and are not reiterated herein. This letter identifies changes to the conditions documented in the initial plan and stipulates any new information made available to NTH as part of the periodic assessment that may alter or re-affirm the findings from the initial 2016 evaluation, which is attached to the end of the report for reference.

BACKGROUND

The STCPP bottom ash basins are physical sedimentation basins and receive bottom ash and other process flow effluent pumped from the power plant. Discharge water from the basins flows over an outlet weir and gravity flows to a site storm water conveyance network, which outfalls with other site stormwater effluent to STCPP overflow canal authorized via a National Pollution Discharge Elimination System (NPDES) permit. The basins are incised CCR surface impoundments, per the definition in 40 CFR 257.53 and therefore, a 25-year storm event was used for the assessment.

NTH prepared an IDFC system plan in 2016 to document and demonstrate the hydrologic and hydraulic capacity and performance conditions of the CCR surface impoundments, including the basins, intake structures, and downstream hydraulic structures in accordance with 40 CFR 257.82. We previously determined that the existing downstream conveyance system experienced deficiencies when modeled at the 25-year storm event because the system was surcharged due to the water level of the St. Clair River, which is where the basins eventually outfall through the plant overflow canal. The outfall of the basins is routinely submerged depending on the current water surface elevation of the St. Clair River. The deficiencies were independent of the hydraulic performance of the bottom ash basins and outfall structures themselves and does not impact the overall hydraulic performance of the basins. In addition, the discharge from the basins meets the regulatory NPDES permit requirements for total suspended solids (TSS) and fats, oils, and grease (FOG), so the impoundment discharge water submerging the conveyance structures downstream would not be considered a release of CCR or regulated wastewater and would therefore be an operational item, not a regulatory consideration.

ASSESSMENT

For this periodic evaluation, NTH performed the following to analyze the condition of the bottom ash basins and verify the information presented in the initial IDFC report:

- Performed a site visit on July 29, 2021 to meet DTE personnel, learn about any changes to the DTE assets, and observe the current system conditions. A photo log from the site visit is included as an attachment to this letter;
- Reviewed the initial report;
- Procured supplemental topographic and bathymetric surveying of the bottom ash basins. The supplemental survey was performed on May 10, 2021 by BMJ Engineers & Surveyors, Inc. to update previous bathymetric information from 2016 and to facilitate accurate capacity calculations for the system. The supplemental survey information is included as an attachment to this letter;
- Obtained flow data from the last five years of process water inletting to the basins and confirmed that there were no changes to the stormwater flows entering the system downstream of the basins;
- Updated the model input parameters including new peak flow information and updated basin capacity according to the bathymetric survey. The updated site plan is included as attachment to this letter; and
- Re-ran the Autodesk Storm and Sanitary Analysis (SSA) modeling software with the updated data inputs. The updated model output is included as an attachment to this letter.

Based on information from the above actions, NTH summarizes the following for the IDFC periodic assessment:

- The current configuration and condition of the basins (as shown in the attached photographs) are consistent with those presented in the initial IDFC report. DTE personnel indicated that no alterations have been made to the basins and no substantive changes were apparent during NTH's field observation.
- The capacity of the basins has not significantly changed from that presented in the initial IDFC report, but both increased:
    - 1.9 million gallons for the west basin (1.5 million gallons in 2016) and
    - 1.4 million gallons for the east basin (1.1 million gallons in 2016).

  As a point of clarification, the capacity of the basins at any given time is a function of the active dredging state and is not necessarily indicative of changes to the basin geometry. The west basin weir controls the basin water levels and flow and NTH staff observed no indication that the basin or weir geometries have been altered since the initial IDFC report.

- Analysis of the inflow data provided by DTE showed that the average flows are lower than the flows from the initial report; however, the maximum flow that was experienced is higher than in the initial report. This higher value was used in the model and did not significantly alter the results of the initial report. It should be noted that there were a significant number of days (41% over the last 5 years) when high water levels in the St. Clair River resulted in flow meter data that could not be used due to the river water elevation being higher than the elevation of the overflow weir. The days which had flows that were affected by the high river levels were not used in the determination of the maximum and average flows. The previous and current input information is summarized in the following table.

STCPP Bottom Ash Basin Inflow Rate Summary

Flow Rates		
	Previous Report	**Current**
Maximum Flow (cfs)	27.14	33.16
Average Flow (cfs)	7.36	7.07

- The pattern and controls of the process flow system are consistent with that documented in the initial report. No substantive changes were apparent during NTH's field observation.
- The dimensions and capacities of the receiving stormwater system was unchanged from the initial IDFC report based on our document review and observations.
- Information from the supplemental survey indicates basin water surface elevations are consistent with that documented in the initial IDFC report.
- The initial water surface elevation in the SSA model was updated for the weir box node and CB-1 node downstream of the basins to match the ordinary high-water mark of the St. Clair River (Elevation 578.7) at the US Army Corps of Engineers St. Clair monitoring location directly upstream of STCPP. This did not change the conclusion that the downstream conveyance capacity is still deficient due to submerged conditions.

Based on the findings summarized above, the inflow design flood control system plan presented in the initial report is applicable to the current condition of the STCPP bottom ash basins. The deficiencies of the downstream conveyance system still exist, but are still believed to be an operational item, not a regulatory one, as the discharge from the basins meets the regulatory requirements of the NPDES permit and is not considered a release of CCR material.

CONCLUSIONS

Based on the findings summarized herein and the hydrologic and hydraulic capacity requirements for CCR surface impoundments presented in 40 CFR 257.82, NTH has determined that the bottom ash basins of the STCPP meet the criteria of this section. In accordance with 40 CFR

257.82(c)(5), a statement of Certification for the STCPP bottom ash basins is included with this letter as an attachment. A copy of this letter should be kept in the facility's operating record for future reference.

Please contact NTH if you have any questions.

Sincerely,

NTH Consultants, Ltd.

DocuSigned by:
David R. Lutz
2BF41F0D0F4749B...

DocuSigned by:
Samantha L. Grant
A1E1683045E447D...

David R. Lutz, P.E.
Vice President

Samantha L. Grant, P.E.
Project Engineer

DRL/SLG/mam

Attachments

Photograph 1: East Basin Inlet Pipes from Northwest Corner of East Basin Looking East

Photograph 2: East Basin Box Culvert Inlet from North End of Basin Looking Southwest

Photograph 3: East Basin Looking South from North End

Photograph 4: East Basin Box Culvert Opening from Southwest Corner of East Basin Looking Northwest

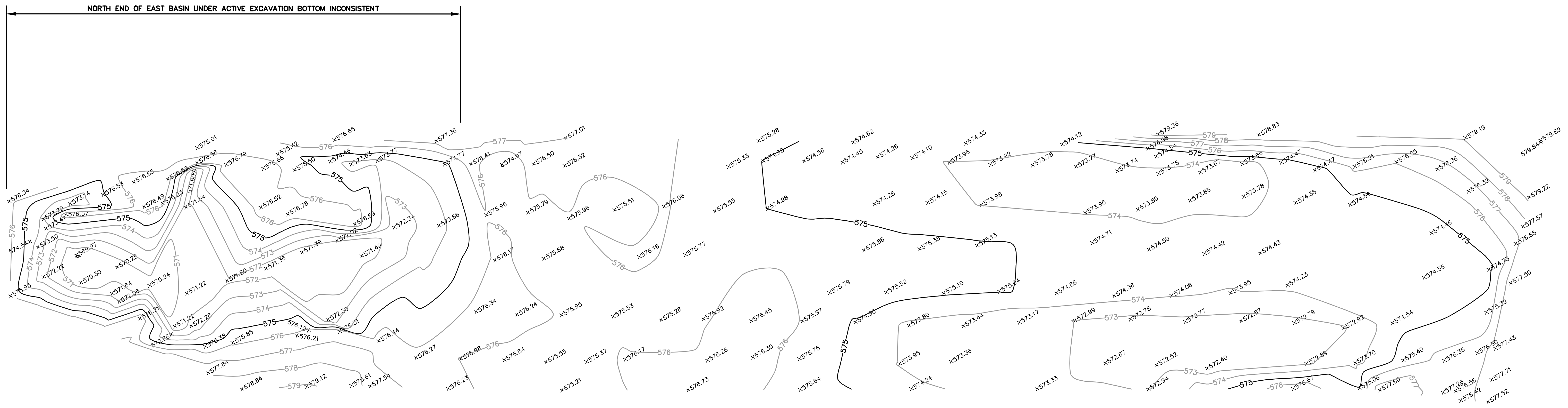
Photograph 5: West Basin Box Culvert Opening from East Side of West Basin Looking South

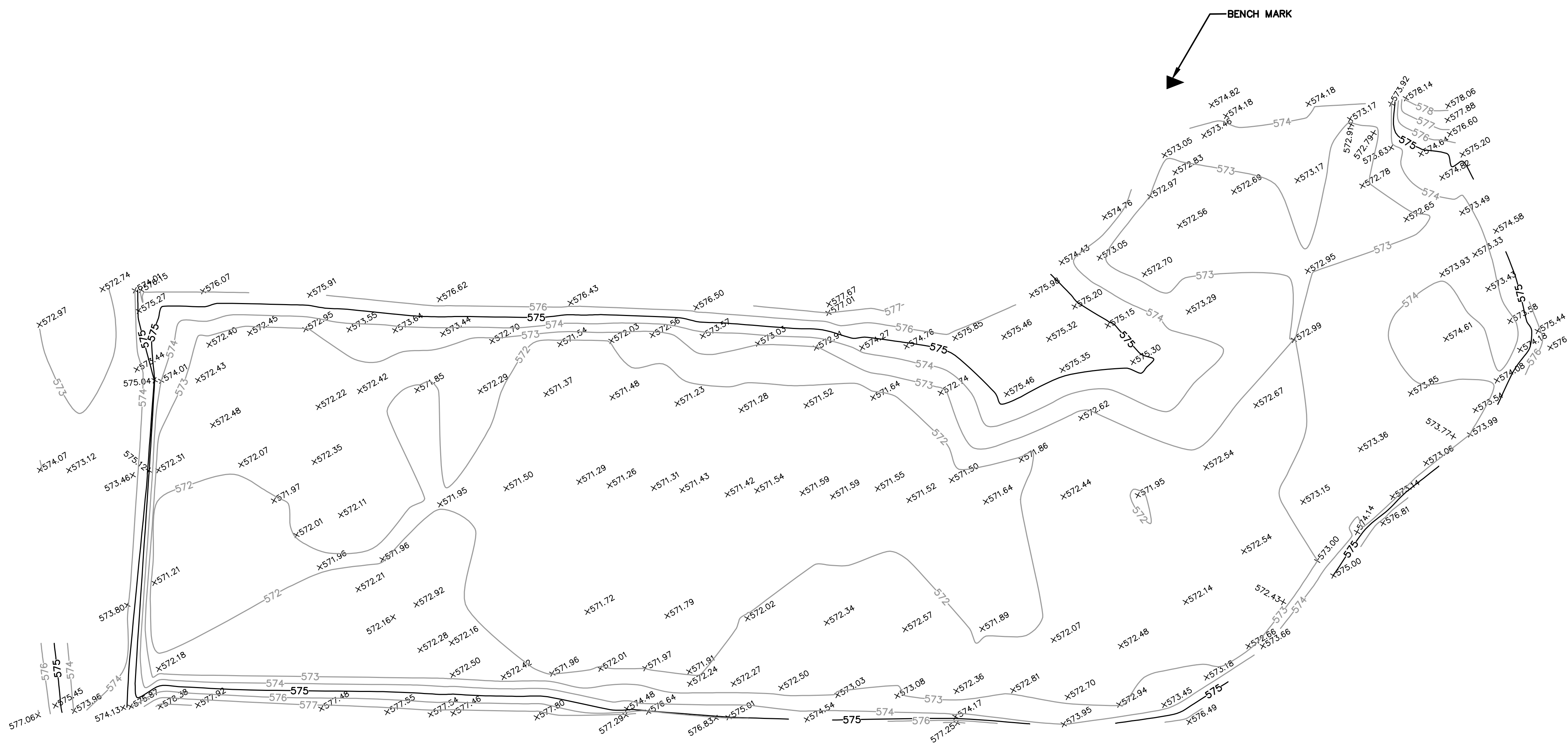
Photograph 6: West Basin Looking North from South End

Photograph 7: West Basin Weir Looking East from Northwest Corner of West Basin

Photograph 8: West Basin Outlet Looking East from Northwest Corner of West Basin

ST. CLAIR POWER PLANT
ASH SETTLING BASINS



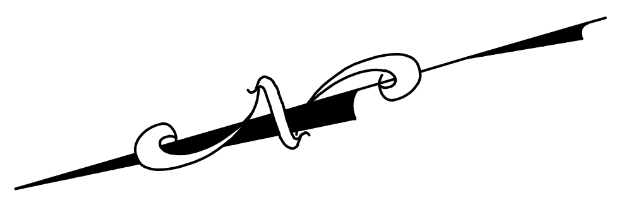


NOTES:
VERTICAL DATUM: DTE PLANT DATUM (ORIGIN UNKNOWN)

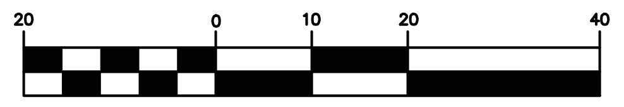
HORIZONTAL DATUM: DTE PLANT DATUM (ORIGIN UNKNOWN)

BENCHMARK:
DESCRIPTION: ATOP CUT ☒ IN CONCRETE BASE OF LIGHT POST
ON THE EASTERLY SIDE OF THE WESTERLY ASH SETTLING
BASIN ON THE SOUTH END.
ELEVATION = 586.18 (PLANT DATUM)

WATER LEVEL
EAST POND ELEVATION = 579.13 (PLANT DATUM)
WEST POND ELEVATION = 579.05 (PLANT DATUM)



GRAPHIC SCALE



(IN FEET)
1 inch = 20 ft.

BMJ ENGINEERS & SURVEYORS, INC.

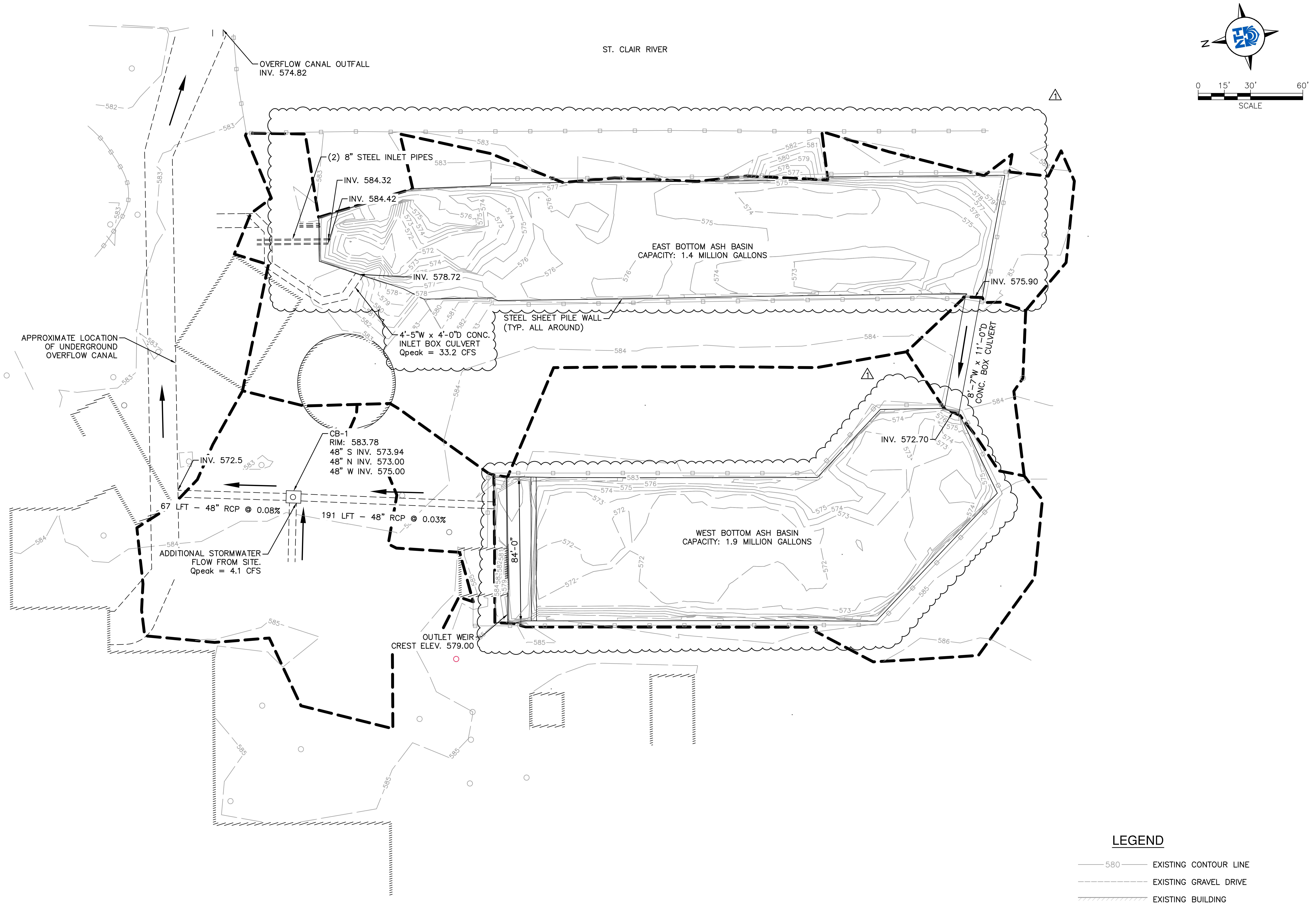
CIVIL ENGINEERS & LAND SURVEYORS
519 HURON AVE. PORT HURON, MI 48060
TEL: 810-984-5596 FAX: 810-984-8760
Web Page: www.bmjinc.com Email: mail@bmjinc.com

BATHYMETRIC SURVEY OF ASH SETTLING BASIN AT DTE ST. CLAIR POWER PLANT
POINTE DRIVE, EAST CHINA TWP., ST. CLAIR COUNTY, MICHIGAN
FOR: NTH CONSULTANTS, LTD

NO	REVISIONS	DATE

SCALE: 1" = 20'
DATE: 5-10-21
SURVEYED: AMB
DRAWN: SWS
CHK'D: RJA
JOB NO. 2104.14
SHT 1 OF 1

Z:\(2)Surveys\2104-14\dwg\2104-14 Bathymetric.dwg, 5/14/2021 11:43 AM, SWS



LEGEND

580 EXISTING CONTOUR LINE

EXISTING GRAVEL DRIVE

EXISTING BUILDING

EXISTING GUARDRAIL

EXISTING PIPING

○ EXISTING MANHOLE

DRAINAGE BOUNDARY

⚠1

NOTE: EXISTING TOPOGRAPHIC SURVEY COMPLETED BY MCNEELY LINCOLN AND ASSOCIATES ON APRIL 8, 11, AND MAY 27, 2016. LOCATION OF OVERFLOW CANAL FROM HISTORICAL DRAWINGS PROVIDED BY DTE. SUPPLEMENTAL SURVEY WAS PERFORMED ON MAY 10, 2021 BY BMJ ENGINEERS & SURVEYORS, INC. TO UPDATE PREVIOUS BATHYMETRIC INFORMATION.

c:\users\ddolowy\desktop\j drive local\210081\production sets\stcpp\210081-sc-sp.dwg Plotted: 9/9/2021 2:01 PM by ddolowy

NTH Consultants, Ltd.

Infrastructure Engineering and
Environmental Services

Northville, MI	248.553.6300
Detroit, MI	313.237.3900
Lansing, MI	517.484.6900
Grand Rapids, MI	616.451.6270
Cleveland, OH	216.334.4040

SUBMITTAL

REV	DESCRIPTION	DATE	BY
1	5-YR PERIODIC ASSESSMENT	9/7/2021	DGD

PROJECT NAME:

DTE ST. CLAIR POWER
PLANT - BOTTOM ASH
BASIN HYDRAULIC
ANALYSIS

PROJECT LOCATION:

ST. CLAIR POWER
PLANT
EAST CHINA TOWNSHIP,
MICHIGAN

NTH PROJECT NO.: 62-210081	CAD FILE NAME: 210081-SC-SP
DESIGNED BY: SLG	INCEP DATE: 9/7/2016
DRAWN BY: SLG	DRAWING SCALE: 1" = 30'
CHECKED BY: DRL	SUBMITTED DATE: 9/7/2021

SHEET TITLE:

ST. CLAIR POWER PLANT
BOTTOM ASH BASIN

EXISTING SYSTEM
COMPONENT PLAN

SHEET REFERENCE NUMBER:

3

```
Autodesk® Storm and Sanitary Analysis 2020 - Version 13.3.206 (Build 0)
------------------------------------------------------------------------------------------

*******************
Project Description
*******************
File Name ................. St. Clair.SPF


****************
Analysis Options
****************
Flow Units ................ cfs
Subbasin Hydrograph Method. Rational
Time of Concentration...... SCS TR-55
Return Period.............. 25 years
Link Routing Method ....... Hydrodynamic
Storage Node Exfiltration.. None
Starting Date ............. SEP-03-2021 00:00:00
Ending Date ............... SEP-03-2021 02:00:00
Report Time Step .......... 00:00:10


*************
Element Count
*************
Number of subbasins ....... 3
Number of nodes ........... 5
Number of links ........... 4


****************
Subbasin Summary
****************
Subbasin                 Total
                          Area
ID                         ft²
------------------------------
Sub-01                55201.49
Sub-02                43837.17
Sub-03                21363.92


************
Node Summary
```

```
************
Node                Element             Invert   Maximum    Ponded    External
ID                  Type             Elevation     Elev.      Area      Inflow
                                            ft        ft       ft²
------------------------------------------------------------------------------
CB-1                JUNCTION            573.00    583.78      0.00    Yes
Outfall             OUTFALL             572.50    576.50      0.00
East-Basin          STORAGE             571.70    582.51      0.00    Yes
Weir-Box            STORAGE             570.69    583.88      0.00
West-Basin          STORAGE             573.01    583.88      0.00


************
Link Summary
************
Link            From Node       To Node         Element            Length     Slope  Manning's
ID                                              Type                   ft         %  Roughness
--------------------------------------------------------------------------------------------
48-in-1         Weir-Box        CB-1            CONDUIT             191.3    0.0314     0.0130
48-in-2         CB-1            Outfall         CONDUIT              66.0    0.7576     0.0130
Box-Culvert     East-Basin      West-Basin      CHANNEL              66.0    0.3030     0.0130
Weir            West-Basin      Weir-Box        WEIR


*********************
Cross Section Summary
*********************
Link             Shape            Depth/       Width       No. of       Cross   Full Flow      Design
ID                              Diameter                  Barrels   Sectional   Hydraulic        Flow
                                                                         Area      Radius    Capacity
                                      ft          ft                      ft²          ft         cfs
----------------------------------------------------------------------------------------------------------
48-in-1          CIRCULAR           4.00        4.00            1       12.57        1.00       25.44
48-in-2          CIRCULAR           4.00        4.00            1       12.57        1.00      125.03
Box-Culvert      RECT_OPEN          6.90        8.70            1       60.03        2.67      726.63


**************************        Volume         Depth
Runoff Quantity Continuity       acre-ft        inches
**************************     ---------       -------
Total Precipitation ......         0.255         1.107
Continuity Error (%) .....         0.107


**************************        Volume        Volume
Flow Routing Continuity          acre-ft      Mgallons
```

```
**************************     ---------     ---------
External Inflow .........         6.159         2.007
External Outflow ........         5.801         1.890
Initial Stored Volume ....       13.951         4.546
Final Stored Volume ......       14.536         4.737
Continuity Error (%) .....        0.000


**************************************
Runoff Coefficient Computations Report
**************************************

------------------
Subbasin Sub-01
------------------
                                                         Area          Soil       Runoff
Soil/Surface Description                                (ft²)         Group       Coeff.
-------------------------------------------------------------------------------------------
-                                                     55201.49            -         0.90
Composite Area & Weighted Runoff Coeff.               55201.49                      0.90

------------------
Subbasin Sub-02
------------------
                                                         Area          Soil       Runoff
Soil/Surface Description                                (ft²)         Group       Coeff.
-------------------------------------------------------------------------------------------
-                                                     43837.17            -         0.90
Composite Area & Weighted Runoff Coeff.               43837.17                      0.90

------------------
Subbasin Sub-03
------------------
                                                         Area          Soil       Runoff
Soil/Surface Description                                (ft²)         Group       Coeff.
-------------------------------------------------------------------------------------------
-                                                     21363.92            -         0.90
Composite Area & Weighted Runoff Coeff.               21363.92                      0.90


***************************************************
SCS TR-55 Time of Concentration Computations Report
***************************************************

Sheet Flow Equation
-------------------
```

```
        Tc = (0.007 * ((n * Lf)^0.8)) / ((P^0.5) * (Sf^0.4))

        Where:

        Tc = Time of Concentration (hrs)
        n  = Manning's Roughness
        Lf = Flow Length (ft)
        P  = 2 yr, 24 hr Rainfall (inches)
        Sf = Slope (ft/ft)

Shallow Concentrated Flow Equation
----------------------------------

        V  = 16.1345 * (Sf^0.5) (unpaved surface)
        V  = 20.3282 * (Sf^0.5) (paved surface)
        V  = 15.0 * (Sf^0.5) (grassed waterway surface)
        V  = 10.0 * (Sf^0.5) (nearly bare & untilled surface)
        V  = 9.0 * (Sf^0.5) (cultivated straight rows surface)
        V  = 7.0 * (Sf^0.5) (short grass pasture surface)
        V  = 5.0 * (Sf^0.5) (woodland surface)
        V  = 2.5 * (Sf^0.5) (forest w/heavy litter surface)
        Tc = (Lf / V) / (3600 sec/hr)

        Where:

        Tc = Time of Concentration (hrs)
        Lf = Flow Length (ft)
        V  = Velocity (ft/sec)
        Sf = Slope (ft/ft)

Channel Flow Equation
---------------------

        V  = (1.49 * (R^(2/3)) * (Sf^0.5)) / n
        R  = Aq / Wp
        Tc = (Lf / V) / (3600 sec/hr)

        Where:

        Tc = Time of Concentration (hrs)
        Lf = Flow Length (ft)
        R  = Hydraulic Radius (ft)
        Aq = Flow Area (ft²)
        Wp = Wetted Perimeter (ft)
        V  = Velocity (ft/sec)
```

```
        Sf = Slope (ft/ft)
        n  = Manning's Roughness

  ------------------
  Subbasin Sub-01
  ------------------

        User-Defined TOC override (minutes):      2.80

  ------------------
  Subbasin Sub-02
  ------------------

        User-Defined TOC override (minutes):      4.30

  ------------------
  Subbasin Sub-03
  ------------------

        User-Defined TOC override (minutes):     12.00

  ***********************
  Subbasin Runoff Summary
  ***********************

  ---------------------------------------------------------------------------------------
  Subbasin       Accumulated     Rainfall     Total       Peak  Weighted         Time of
  ID                  Precip    Intensity    Runoff     Runoff    Runoff    Concentration
                          in        in/hr        in        cfs     Coeff    days  hh:mm:ss
  ---------------------------------------------------------------------------------------
  Sub-01                1.11         4.43      1.00       5.05     0.900       0  00:15:00
  Sub-02                1.11         4.43      1.00       4.01     0.900       0  00:15:00
  Sub-03                1.11         4.43      1.00       1.96     0.900       0  00:15:00
  ---------------------------------------------------------------------------------------


  ******************
  Node Depth Summary
  ******************

  -----------------------------------------------------------------------------------------
  Node            Average   Maximum   Maximum   Time of Max     Total     Total   Retention
  ID                Depth     Depth       HGL    Occurrence   Flooded      Time        Time
                 Attained  Attained  Attained                  Volume   Flooded
                       ft        ft        ft   days  hh:mm   acre-in   minutes    hh:mm:ss
  -----------------------------------------------------------------------------------------
```

```
CB-1               5.87      6.64    579.64      0  00:00         0         0     0:00:00
Outfall            6.20      6.20    578.70      0  00:00         0         0     0:00:00
East-Basin         7.56      7.59    579.29      0  00:28         0         0     0:00:00
Weir-Box           8.37      8.43    579.12      0  00:27         0         0     0:00:00
West-Basin         6.23      6.26    579.27      0  00:28         0         0     0:00:00


*****************
Node Flow Summary
*****************

------------------------------------------------------------------------------------
Node                Element     Maximum      Peak       Time of    Maximum Time of Peak
ID                     Type     Lateral    Inflow  Peak Inflow  Flooding     Flooding
                                 Inflow             Occurrence  Overflow   Occurrence
                                    cfs      cfs  days   hh:mm       cfs  days  hh:mm
------------------------------------------------------------------------------------
CB-1                 JUNCTION      6.05    38.58     0  00:26      0.00
Outfall              OUTFALL       0.00    38.58     0  00:26      0.00
East-Basin           STORAGE      38.21    38.21     0  00:15      0.00
Weir-Box             STORAGE       0.00    34.19     0  00:29      0.00
West-Basin           STORAGE       4.01    35.91     0  00:18      0.00


********************
Storage Node Summary
********************

-------------------------------------------------------------------------------------------------------------------------------------
Storage Node ID        Maximum     Maximum    Time of Max    Average   Average       Maximum       Maximum  Time of Max.        Total
                        Ponded      Ponded         Ponded     Ponded    Ponded  Storage Node  Exfiltration  Exfiltration  Exfiltrated
                        Volume      Volume         Volume     Volume    Volume       Outflow          Rate          Rate       Volume
                      1000 ft³         (%)     days hh:mm   1000 ft³       (%)           cfs           cfm      hh:mm:ss     1000 ft³
-------------------------------------------------------------------------------------------------------------------------------------
East-Basin             342.881          73      0  00:28    341.610        73         33.75          0.00       0:00:00        0.000
Weir-Box                11.320          62      0  00:27     11.240        62         34.23          0.00       0:00:00        0.000
West-Basin             274.952          56      0  00:28    273.666        56         34.19          0.00       0:00:00        0.000


***********************
Outfall Loading Summary
***********************

-----------------------------------------------
Outfall Node ID        Flow   Average      Peak
                  Frequency      Flow    Inflow
```

```
                        (%)       cfs       cfs
  ----------------------------------------------
  Outfall            100.00     35.09     38.58
  ----------------------------------------------
  System             100.00     35.09     38.58


  *****************
  Link Flow Summary
  *****************

  -------------------------------------------------------------------------------------------------------------------------------
  Link ID              Element        Time of   Maximum  Length   Peak Flow       Design  Ratio of  Ratio of        Total  Reported
                       Type         Peak Flow  Velocity  Factor      during         Flow   Maximum   Maximum         Time  Condition
                                   Occurrence  Attained            Analysis     Capacity   /Design      Flow   Surcharged
                                    days hh:mm    ft/sec                cfs          cfs      Flow     Depth      minutes
  -------------------------------------------------------------------------------------------------------------------------------
  48-in-1              CONDUIT        0  00:30      2.72    1.00      34.23        25.44      1.35      1.00          120  SURCHARGED
  48-in-2              CONDUIT        0  00:26      3.07    1.00      38.58       125.03      0.31      1.00          120  SURCHARGED
  Box-Culvert          CHANNEL        0  00:27      1.12    1.00      33.75       726.63      0.05      0.50            0  Calculated
  Weir                 WEIR           0  00:29                        34.19                             0.06


  ********************************
  Highest Flow Instability Indexes
  ********************************
  All links are stable.


  Analysis began on:  Tue Sep  7 17:14:57 2021
  Analysis ended on:  Tue Sep  7 17:14:57 2021
  Total elapsed time: < 1 sec
```

STATEMENT OF CERTIFICATION

I, David R. Lutz, a Professional Engineer licensed in the State of Michigan, certify[1] that NTH Consultants, Ltd. have reviewed available historical information, conducted a field visit, performed engineering and hydraulic/hydrologic analysis, modeling, and calculations on the inflow design flood control system for the bottom ash CCR surface impoundments at the DTE St. Clair Power Plant, located in East China Township, Michigan. To the best of my knowledge and belief, the analysis and documentation presented in this report for the bottom ash basins at the aforementioned facility is accurate and has been developed in substantial conformance with the requirements stipulated in 40 CFR Part 257.82.

DAVID R. LUTZ
No. 57487

10/14/21

David R. Lutz, P.E.
State of Michigan Professional Engineer
Registration No. 57487

([1]) I am rendering my professional opinion based on the information available to me at the time of this report's writing. This certification does not comprise a guarantee or warranty that certain conditions exist, nor does it relieve any other party of their requirements to abide by all applicable local, state, and federal regulations, and to honor all express or customary guarantees and warranties associated with their work.

Report

Inflow Design Flood Control System Plan
St. Clair Power Plant
St. Clair, Michigan

DTE Energy Company
One Energy Plaza, Detroit, MI

October 14, 2016
NTH Project No. 62-160047-04

NTH Consultants, Ltd.
41780 Six Mile Road
Northville, MI 48168

TABLE OF CONTENTS

INTRODUCTION

NTH Consultants, Ltd. (NTH), in conjunction with personnel from DTE Energy Company (DTE), has completed an inflow design flood control system plan for the bottom ash basins at St. Clair Power Plant (STCPP) in accordance with the Hazardous and Solid Waste Management System; Disposal of Coal Combustion Residuals (CCR) from Electric Utilities 40 CFR Part 257.82. This plan details the hydraulic and hydrologic capacity of the CCR impoundment system, including the basins, intake structures, and downstream hydraulic structures. The intent of the plan is to ensure that the CCR impoundment has the capacity to manage the discharge from the process flows along with a specified design rainfall event "inflow design flood", based on the hazard potential classification of the basins.

The STCPP was constructed in the 1950's in St. Clair, Michigan and is located just east of the DTE Belle River Power Plant (BRPP). The power plant is located on the peninsula formed by the St. Clair and Belle Rivers, approximately 3 miles south of St. Clair. The bottom ash basins are physical sedimentation basins, located south of SCTPP next to the St. Clair River and receive bottom ash and other process flow effluent pumped from the power plant. Discharge water from the basins flows over an overflow weir and gravity flows to a site storm water conveyance network, which eventually outfalls with other site storm water effluent authorized via a National Pollution Discharge Elimination System (NPDES) permit into the Overflow Canal. An overall site plan is included as Figure 1, in the attachments.

Regulatory Basis

In accordance with 40 CFR Part 257.82, NTH has prepared this inflow design flood control system plan to demonstrate and document the hydrologic and hydraulic capacity and performance requirements for the bottom ash CCR surface impoundments. Specifically, this plan details how the bottom ash CCR surface impoundments collect and control the peak discharge from the inflow design flood, in addition to the peak discharge into the impoundments from plant process flow. The inflow design flood requirements for the capacity evaluation depend on the hazard potential classification of the basins in accordance with 40 CFR 257.82(a)(3). The basins at STCPP are not required to be classified in accordance with 40 CFR 257.73(a)(2), because the basins are incised CCR impoundments based on the definition prescribed in 40 CFR 257.53. Because of this, the STCPP bottom ash CCR surface impoundments system are being analyzed to handle a 25-year flood event in addition to the plant process flows. As stipulated in Section VI (H)(3) of the rule preamble, the plan also includes a:

- Characterization of the design storm, catchment area, run-on and run-off routing models;
- Characterization of the intake, decant, and spillway structures and their capacity;
- Characterization of the downstream hydraulic structures which receive the discharge from the CCR surface impoundments; and
- Supporting engineering calculations and analysis results.

MODELING OF CCR IMPOUNDMENT SYSTEM

NTH evaluated the bottom ash CCR surface impoundment system using the Autodesk ® Storm and Sanitary Analysis 2017 computer modeling software. This software was used to develop runoff hydrographs for the watersheds contributing to the system as well as to route the inflow hydrographs through the bottom ash CCR impoundment and conveyance structures.

Model Input

In order to compile the data necessary for input into the model, NTH conducted several steps including:

- Performed a site visit to meet DTE personnel, learn about the DTE assets, and field review the existing system conditions;

- Reviewed historic site drawings and flow data provided by DTE plant staff; and

- Procured ground surface topographical elevations by McNeely & Lincoln Associates (MLA), a registered land surveyor, on April 8, 11, and May 27, 2016. MLA also sounded the bottom of the basins to allow for accurate capacity calculations and surveyed components of the system, including the basins, the weir and box structure, and pipe and manhole inverts (see NTH Figure 2 for the detailed survey information).

NTH performed the analysis using design precipitation data adopted from the National Oceanic Atmospheric Administration (NOAA) Atlas 14, Volume 8, Version 2 (2013). We evaluated the bottom ash CCR surface impoundment system for a 25-year storm event and utilized the rational method to calculate the storm water runoff generated from each of the sub watersheds. The rational method determines the peak discharge rate from each sub-watershed based on the following equation:

$$\mathbf{Q = CiA}$$

Where:

Q = Peak discharge rate (cubic feet per second (CFS))

C = Runoff coefficient (presented in table below)

i = Rainfall intensity from IDF curves based on design storm return period and Tc (in/hr)

A = Sub-watershed drainage area (Acres)

The CCR bottom ash basin system was divided into sub-watersheds based on existing ground topography to determine the contributing runoff amount for each basin. The downstream conveyance structure, which ultimately receives the discharge from the impoundments, also receives stormwater from various locations on the STCPP site. The contributing area, time of concentration, and runoff coefficient were determined for each watershed area. These input parameters are used to determine both the amount and intensity of runoff generated in each watershed during the design storm and the overall amount of runoff collected and conveyed by the storm water system (see Figure 3 for depiction of drainage areas).

The time of concentration, Tc, is the time required for the entire sub-watershed to contribute runoff to the system and is dependent on flow path, slope and ground type. In general, Tc for each sub-area was very small due to the small nature of the watersheds. Based on state-of-the-practice engineering standards, we utilized a minimum Tc of 15 minutes for each sub-watershed, which is the minimum amount of time used in a typical analysis, even though the actual flow time may be much less. The model was allowed to run for a 2-hour duration to allow enough time for all of the storm water runoff from the design storm to contribute to the CCR impoundment and the downstream structures.

The runoff coefficient is a function of land use and ground condition. We adopted runoff coefficients from our past experience and generally-acceptable industry standards. The runoff coefficients used for this study are summarized in the following table:

Ground Type	Runoff Coefficient (C)
Grass	**0.30**
Pavements/Parking Lots	**0.90**
Compacted Gravel Covered Areas	**0.85**

We selected the hydrodynamic routing method in Storm and Sanitary Analysis software program because it is the most sophisticated method and produces the most theoretically accurate results. It solves the one-dimensional Saint-Venant flow equations which consist of continuity and momentum equations for pipes and ditches and a volume continuity equation at the storage nodes and junctions. This routing method can represent pressurized flows when the piping becomes full and can model the amount of flooding in storage nodes and junctions.

See attached Figure 3 which depicts the CCR system and contributing drainage areas based on the results of our field survey and investigation, and review of historical site drawings. Refer to the attached model output results for additional input information.

Model Input Assumptions

NTH utilized information obtained from topographic surveys, historical information, and field investigations to build the model of the CCR impoundment and conveyance network. When available, items such as pipe/manhole diameter, inverts, material of construction, and inlet/cover type were utilized to accurately model the conveyance network.

Additionally, NTH obtained three years of historical flow data from DTE plant staff to characterize the process flows into the bottom ash CCR surface impoundment system. This included daily flow readings from an electronic integrator to measure process flows. NTH completed a statistical analysis to determine appropriate parameters for the peak flows to use for the:

- East Bottom Ash Basin through (2) 8-inch diameter inlet pipes; and
- East Bottom Ash Basin through 4’-5” wide x 4’-0” deep inlet box culvert.

While every attempt was made to accurately model the existing system, assumptions introduce unknown parameters into the model. If any of these assumptions are incorrect, the results of the model will be impacted. Should actual conditions vary from the assumptions utilized in the model, the predicted model results, and subsequent recommendations to correct any deficiencies identified, may be impacted. We have relatively high confidence that the model for the CCR impoundment and conveyance structures depicts the most conservative anticipated conditions during the modeled flood events.

Existing System Components

There are two bottom ash basins at STCPP, the east basin and the west basin, hydraulically connected by an 8’-7” wide x 11’-0” deep, 65-foot long box culvert. Per a review of historical construction drawings, the bottom ash basins, which have the same general dimensions in a “U” shape, were reconstructed in-place with tied-back steel sheet pile walls in 1995. The east basin has a capacity of 1.1 million gallons and the west basin has a capacity of 1.5 million gallons.

Sluiced bottom ash enters the east basin on the north side through two 8-inch pipes at grade and a 4’-5” wide x 4’-0” deep box culvert. The box culvert intercepts five pipes from various parts of the plant. DTE staff-provided flow data for the basins for the past three years indicated the peak flow out of the west basin was 27.1 cubic feet per second (cfs).

The west basin discharges over an overflow weir into an outfall structure on the north side of the basin. The weir spans the entire width of the basin (approximately 84 feet) and the outfall structure flows into a 48-inch reinforced concrete pipe (RCP) which ultimately outfalls to the STCPP underground overflow canal. The 48-inch RCP flows to a catch basin north of the basins and combines with another 48-inch pipe bringing stormwater flow from various places on-site from the west. NTH used historical drawings to determine the possible contributing areas bringing additional stormwater to the other 48-inch pipe at the catch basin. We collaborated with DTE staff to determine which areas were still contributing to the pipe and which had been abandoned or re-routed to other stormwater collection systems. NTH calculated the stormwater to have a peak flow of 4.1 cfs, based on contributory drainage areas confirmed by DTE staff during field investigation. The combined flow (stormwater and bottom ash basin discharge water) then continues north and outfalls into the overflow canal.

The water levels in the bottom ash basins are controlled by the fixed elevation of the outlet weir on the west basin, establishing a normal water level in the basins at 579.0 feet. High water level in the basins was determined to be 579.4 in the topographic survey by observed water staining on the sheet pile walls. The top of sheet pile for the east basin is 582.5 and the top of sheet pile for the west basin is 583.9.

Model Output

The model produces output from the basin watersheds that includes inflow, outflow, peak outflow rate, and total runoff inflow/outflow volumes. The model also provides output from the CCR impoundment and conveyance structures including peak flow rates / velocities, maximum hydraulic grade lines, flow depths, and flooding/surcharged structures. To determine where system deficiencies exist, the results were analyzed for:

1. Locations where the modeled water surface elevation exceeded the rim/ground surface elevation at a the basins and manholes (i.e. Flooding);

2. Locations were the modeled water surface exceeded the crown of the pipes within the manholes (i.e. Surcharging); or

3. Locations where the anticipated flow in a conveyance structure was greater than its design capacity (i.e. flow is > capacity).

While items noted as surcharging or below capacity identify a system deficiency, this does not necessarily warrant upgrades or improvements. These system deficiencies show that the system is still operating, but as a pressure flow system, instead of a gravity flow system. If no flooding is observed, the flow is still contained within the conveyance system, and the modeling software calculates theoretically accurate downstream and upstream system results based on the operating condition of these components.

Analysis of Design Flood Event – Existing Conditions

The modeled results show a couple of deficiencies in the downstream conveyance structures of the existing CCR impoundment system at STCPP; however, the large capacity of the spillway overflow weir in the west basin prevents the CCR basins themselves from experiencing any modeled deficiencies. During the design flood event, the depth of the water within the basins only rises 0.24 feet above the crest elevation of the weir (elevation 579.0 feet), which still provides approximately 3.26 feet of freeboard in the east basin and 4.64 feet of freeboard in the west basin to the top elevation of the basins, more than the industry standard freeboard. The weirs can manage the peak flow produced by the design flood and peak process flow of 30.8 cfs from the process water and stormwater runoff contributing to each basin, with a maximum calculated capacity of 3,016 cfs (see Weir Capacity Calculation for details).

The deficiency issues with the system are on the downstream conveyance piping and a result of the reduced downstream system capacity due to the water level at the outfall in the overflow canal, which has a direct hydraulic connection to the St. Clair River. We modeled the system at the river's high water level (determined by observed water staining on the concrete seawall during the topographic survey), of 578.7 feet, 6.2 feet above the invert elevation of the 48-inch RCP outfall into the overflow canal. Because of this, the piping between the overflow weir of the basin and the outfall is in a submerged condition.

Additionally, the model predicts that the 48-inch outlet pipe from the weir outfall structure to the overflow canal is below capacity of the peak inflow and it causes water to back-up into the weir outfall structure. Even though flow backs up into the weir outfall structure, the structure capacity still allows for an operational freeboard of 4.71 feet below the top of weir, and does not affect the hydraulic performance of the basins or the weir. The maximum capacity of the pipe between the weir outfall structure and the catch basin is 24.9 cfs (about 34% of the peak flow).

The model also predicts that the downstream catch basin will flood approximately 0.01 ac-in (approximately 300 gallons) at a rate of 36.8 cfs. The water does not flood and return to the catch basin when system capacity develops, but based on site topographical information, flows to a catch basin at a lower elevation nearby that is not included in the CCR surface impoundment conveyance system. These catch basins are directed to the main lift station which pumps the water to on-site basins were sediment settles out before being pumped to the overflow canal.

Historically, the basins have performed well and, according to DTE personnel, have never flooded in adverse conditions. There is an adequate amount of freeboard in the basins to account for a reasonable level of unforeseen incidents in the event additional flow into or restricted flow downstream of the basins occurs. DTE staff also inspects the bottom ash CCR impoundment system weekly and after significant rain or storm events to remediate any observed issues as soon as practical.

The model output result file provides additional information regarding the output and results. Refer to Figure 3 for additional information on the existing bottom ash CCR surface impoundment components.

CONCLUSIONS

NTH has prepared this inflow design flood control system plan to demonstrate and document the hydrologic and hydraulic capacity and performance requirements for the bottom ash CCR surface impoundments of the STCPP in accordance with 40 CFR 257.82.

The existing bottom ash CCR impoundment system at STCPP currently conveys both bottom ash and other plant process water and on-site stormwater. The overall hydraulic system comprises the two bottom ash basins, overflow weir, and downstream conveyance structures and piping. While our analysis indicates that the existing downstream conveyance system, which outflows water from the bottom ash basins, experiences deficiencies when modeled at the specified 25-year design event, these deficiencies are independent of the hydraulic performance of the bottom ash basin and overflow structures themselves. Additionally, since the discharge from the basins meets the regulatory National Pollution Discharge Elimination System (NPDES) permit requirements stipulated in the facility's individual permit for both total suspended solids (TSS) and fats, oils, and grease (FOG), the impoundment discharge water that is flooding the downstream conveyance structures would not be considered a release of CCR or regulated wastewater. The modeled outflow from the basins floods out of the downstream catch basin and into a different storm system that is directed to the main lift station and pumped to on-site settling basins before outfalling in the overflow canal, at the NPDES-permitted outfall.

STATEMENT OF CERTIFICATION

I, David R. Lutz, a Professional Engineer licensed in the State of Michigan, certify[1] that NTH Consultants, Ltd. have reviewed available historical information, conducted a field visit, performed engineering and hydraulic/hydrologic analysis, modeling, and calculations on the inflow design flood control system for the bottom ash CCR surface impoundments at the DTE St. Clair Power Plant, located in St. Clair, Michigan. To the best of my knowledge and belief, the analysis and documentation presented in this report for the bottom ash basins at the aforementioned facility is accurate and has been developed in substantial conformance with the requirements stipulated in 40 CFR Part 257.82.

DAVID R. LUTZ ENGINEER No. 57487

10/14/16

David R. Lutz, P.E.
State of Michigan Professional Engineer
Registration No. 57487

([1]) I am rendering my professional opinion based on the information available to me at the time of this report writing. This certification does not comprise a guarantee or warranty that certain conditions exist, nor does it relieve any other party of their requirements to abide by all applicable local, state, and federal regulations, and to honor all express or customary guarantees and warranties associated with their work.

ATTACHMENTS

- Figure 1: Overall Site Plan
- Figure 2: Topographic Survey
- Figure 3: Existing System Component Plan
- Weir Capacity Calculation
- Time of Concentration Calculation
- Autodesk Storm and Sanitary Analysis Model Output

REFERENCE DOCUMENTS

- 6C516W-132 “BOTTOM ASH SETTLING BASINS AND RELATED FACILITIES GENERAL SITE PLAN”
- 6C516W-133 “BOTTOM ASH SETTLING BASINS RELOCATE BOTTOM ASH BASIN OUTFALL PLAN, PROFILE AND DETAILS”
- 6C516W-134 “BOTTOM ASH SETTLING BASINS CONCRETE APRON AND CHEMICAL TREATMENT TRENCH, SECTIONS AND DETAILS”
- 6C516W-135 “BOTTOM ASH SETTLING BASINS CANAL BETWEEN EAST & WEST CELLS PLANS AND DETAILS”
- 6C516-8 “PLAN & DETAILS OF OVERFLOW CANAL FROM SHOPS BUILDING TO RIVER”
- 6P515-151 “IMPROVEMENT TO LAND – 48” SEWER AND 15” EMERGENCY TRANS. DRAIN & ROAD PLANS”
- 6MS516-99 “GENERAL YARD MAP”
- 6MS516-100 “GENERAL YARD MAP”
- 6MS516-103 “GENERAL YARD MAP”
- BOTTOM ASH FLOW 2013-PRESENT DATA

ATTACHMENTS

- FIGURE 1: OVERALL SITE PLAN
- FIGURE 2: TOPOGRAPHIC SURVEY
- FIGURE 3: EXISTING SYSTEM COMPONENT PLAN
- WEIR CAPACITY CALCULATION
- TIME OF CONCENTRATION CALCULATION
- AUTODESK STORM AND SANITARY ANALYSIS MODEL OUTPUT

NTH PROJECT No.: **62-160047**	CAD FILE NAME: **160047-SCPP**
DESIGNED BY: **SLG**	PLOT DATE: **9/27/2016**
DRAWN BY: **SLG**	DRAWING SCALE: **1" = 300'**
CHECKED BY: **DRL**	INCEPTION DATE: **9/7/2016**

NTH Consultants, Ltd.

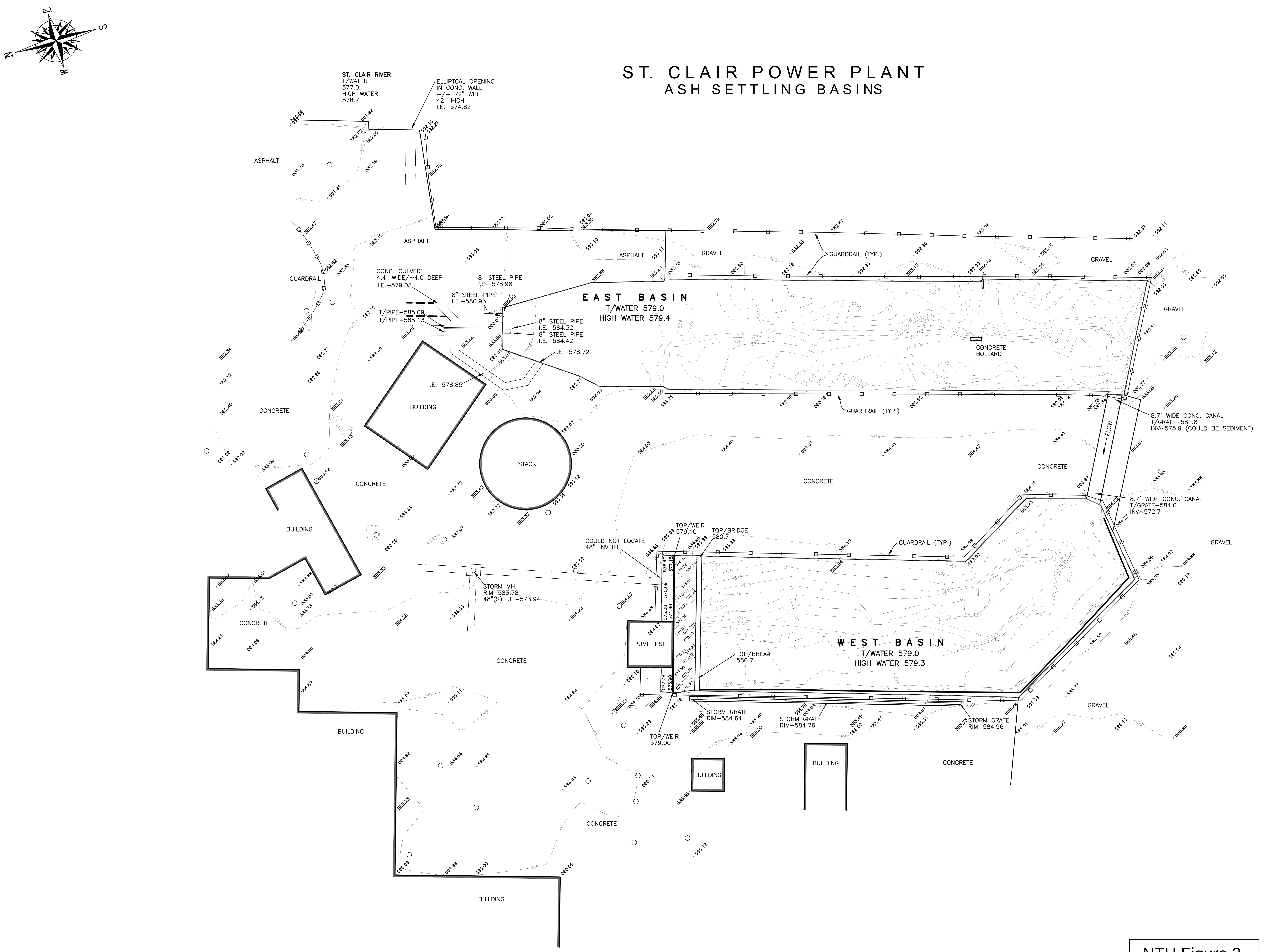
Infrastructure Engineering
and Environmental Services

SITE LOCATION PLAN

ST. CLAIR POWER PLANT
EAST CHINA TOWNSHIP, MI

FIGURE:
1

ST. CLAIR POWER PLANT
ASH SETTLING BASINS



NTH Figure 2

UTILITY WARNING

UNDERGROUND UTILITY LOCATIONS, AS SHOWN ON THE PLAN, WERE OBTAINED FROM UTILITY OWNERS, AND FIELD LOCATION WHERE POSSIBLE. MCNEELY & LINCOLN CAN NOT GUARANTEE THE ACCURACY AND COMPLETENESS OF THE UTILITY INFORMATION.

A MINIMUM OF 3 WORKING DAYS PRIOR TO BEGINNING CONSTRUCTION, THE CONTRACTOR SHALL NOTIFY "MISS DIG" AND HAVE ALL UNDERGROUND UTILITIES STAKED BEFORE ANY WORK MAY BEGIN.

THE CONTRACTOR SHALL BE RESPONSIBLE FOR THE PROTECTION OF ALL UTILITIES THAT MAY INTERFERE WITH CONSTRUCTION.

811
Know what's below.
Call before you dig.

DATUM INFORMATION:
HORIZONTAL DATUM = DTE PLANT DATUM
ORIGIN UNKNOWN

VERTICAL DATUM = DTE PLANT DATUM
ORIGIN UNKNOWN

DAVID P. WHITE
NO. 50458

DATE: 07/05/16
SUR BY: TFS/GW
DRWN BY: DPW
CHKD BY: MRD
FIELD BK: 840

CLIENT:
NTH CONSULTANTS, LTD.
41780 SIX MILE RD
NORTHVILLE, MI 48168

McNEELY & LINCOLN ASSOCIATES, INC.
CIVIL ENGINEERING & LAND SURVEYING
PH. (734) 432-9777 FAX (734) 432-9786
37741 PEMBROKE, LIVONIA, MICHIGAN 48152

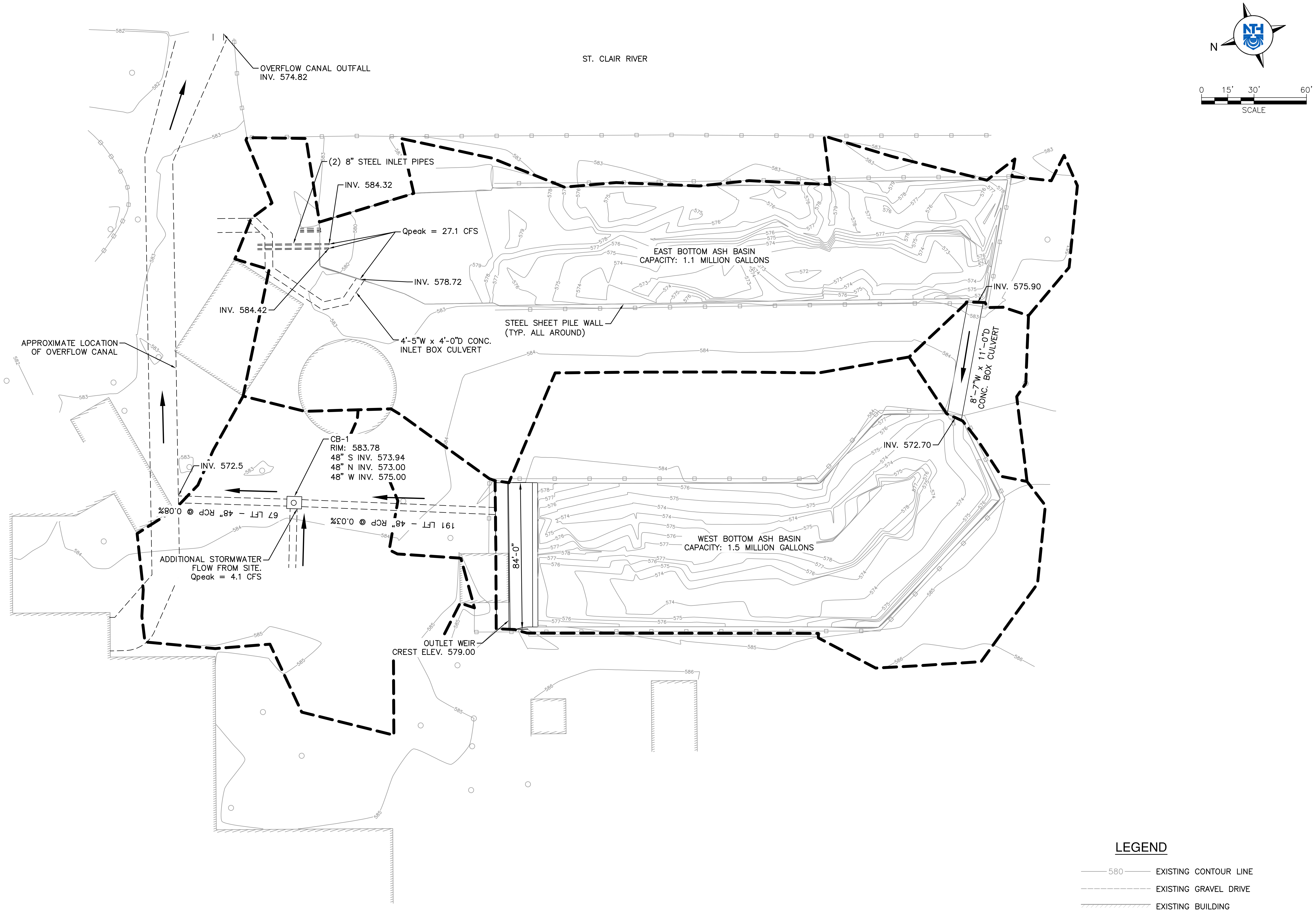
REVISIONS		
E		
D		
C		
B		
A	07/29/16	UPDATED SURFACE TO INCLUDE COLL. TRENCH

REV. A

TOPOGRAPHIC SURVEY - ASH BASIN
ST. CLAIR POWER PLANT
EAST CHINA TWP., ST. CLAIR CO., MICH.

1

SCALE: 1" = 30'
PROJECT NO.: 8243.03
FILE NAME: 8243.03 TOPO.DWG
SHEET 1 OF 1



LEGEND

——580——	EXISTING CONTOUR LINE
- - - - - -	EXISTING GRAVEL DRIVE
═════	EXISTING BUILDING
—□——□—	EXISTING GUARDRAIL
═ ═ ═ ═	EXISTING PIPING
○	EXISTING MANHOLE
▬ ▬ ▬	DRAINAGE BOUNDARY

NOTE: EXISTING TOPOGRAPHIC SURVEY COMPLETED BY MCNEELY LINCOLN AND ASSOCIATES ON APRIL 8, 11, AND MAY 27, 2016. LOCATION OF OVERFLOW CANAL FROM HISTORICAL DRAWINGS PROVIDED BY DTE.

j:\2016\62\160047\production sets\scpp\160047-sc-sp.dwg Plotted: 9/27/2016 9:46 AM by sgrant

NTH Consultants, Ltd.
Infrastructure Engineering and
Environmental Services

Northville, MI	248.553.6300
Detroit, MI	313.237.3900
Lansing, MI	517.484.6900
Grand Rapids, MI	616.451.6270
Cleveland, OH	216.334.4040

SUBMITTAL

REV	DESCRIPTION	DATE	BY

PROJECT NAME:
DTE ST. CLAIR POWER PLANT - BOTTOM ASH BASIN HYDRAULIC ANALYSIS

PROJECT LOCATION:
ST. CLAIR POWER PLANT
EAST CHINA TOWNSHIP, MICHIGAN

NTH PROJECT NO.: 62-160047	CAD FILE NAME: 160047-SC-SP
DESIGNED BY: SLG	INCEP DATE: 9/7/2016
DRAWN BY: SLG	DRAWING SCALE: 1" = 30'
CHECKED BY: DRL	SUBMITTED DATE: 9/27/2016

SHEET TITLE:
ST. CLAIR POWER PLANT BOTTOM ASH BASIN

EXISTING SYSTEM COMPONENT PLAN

SHEET REFERENCE NUMBER:
3

Job DTE Hydro Analysis **Project No.** 62-160047 **Sheet No.** 1
Subject STCPP Weir **By** SLG **Date** 9/21/2016
Capacity Calculation **Checked By** KBD **Date** 9/23/2016

Calculate capacity of weir for STCPP bottom ash basins

Use broad-crested weir equation

$$Q = C_s b H^{3/2}$$

$C_s = 3.33 \text{ ft}^{0.5}/\text{sec}$

$b = 84 \text{ ft}$

$H = 4.88 \text{ ft}$

$$Q = 3.33 \text{ ft}^{0.5}/\text{sec} \cdot 84 \text{ ft} \cdot (4.88 \text{ ft})^{3/2} = \boxed{3016 \text{ cfs}}$$

Height of water at maximum flow rate

$Q_{max} = 27.1 \text{ cfs}$

$$Q = C_s b H^{3/2} \rightarrow H = \left(\frac{Q}{C_s b}\right)^{2/3} = \left(\frac{27.1 \text{ cfs}}{3.33 \text{ ft}^{0.5}/\text{sec} \cdot 84 \text{ ft}}\right)^{2/3}$$

$$\boxed{H = 0.2 \text{ ft}}$$

DTE St. Clair Power Plant
Drainage Areas
62-160047

Area #	Overland Flow		Pipe Flow		Tc (hrs.)	**Tc (min.)**
CB-1	L (ft)	72.00				
	S (%)	0.10				
	V (ft/s)	0.15				
	T (hrs)	0.132			0.132	**7.9**
	L (ft)	118.00				
	S (%)	1.00				
	V (ft/s)	0.48				
	T (hrs)	0.068			0.068	**4.1**
				Tc		**12.0**
East Basin	L (ft)	67.00				
	S (%)	0.70				
	V (ft/s)	0.40				
	T (hrs)	0.046			0.046	**2.8**
				Tc		**2.8**
West Basin	L (ft)	87.00				
	S (%)	1.80				
	V (ft/s)	0.64				
	T (hrs)	0.038			0.038	**2.3**
	L (ft)	60.00				
	S (%)	1.00				
	V (ft/s)	0.48				
	T (hrs)	0.035			0.035	**2.1**
				Tc		**4.3**
Coal Handling (drains to CB-1)	L (ft)	86.00				
	S (%)	0.50				
	V (ft/s)	0.34				
	T (hrs)	0.070			0.070	**4.2**
			L (ft)	102.00		
			S (%)	0.20		
			D (ft)	1.25		
			R (ft)	0.31		
			C	94.42		
			V (ft/s)	2.36		
			T (hrs)	0.012	0.012	**0.7**
			L (ft)	391.00		
			S (%)	0.15		
			D (ft)	1.75		
			R (ft)	0.44		
			C	99.86		
			V (ft/s)	2.56		
			T (hrs)	0.042	0.042	**2.5**
			L (ft)	351.00		
			S (%)	0.05		
			D (ft)	4.00		
			R (ft)	1.00		
			C	114.62		
			V (ft/s)	2.56		
			T (hrs)	0.038	0.038	**2.3**
Tc	9.8					
Office Building (drains to CB-1)	L (ft)	181.00				
	S (%)	0.50				
	V (ft/s)	0.34				
	T (hrs)	0.148			0.148	**8.9**
			L (ft)	351.00		
			S (%)	0.05		
			D (ft)	4.00		
			R (ft)	1.00		
			C	114.62		
			V (ft/s)	2.56		
			T (hrs)	0.038	0.038	**2.3**
Tc	11.2					

Overland Flow
L = distance in feet
S = slope in %
T = time of travel in hours = L / (V * 3600)
V=0.48*sqrt(S)-Sheet Flow<300'

Pipe Flow
L = distance in feet
S = slope in %
D = diameter
R = wetted perimeter
C = Rughness Coedfficient = (1.49/n)*R^(1/6)
Pipe Velocity = C*sqrt(R*S)
T = time of travel in hours = L / (V * 3600)

Dia	Slope
8	0.54
12	0.32
21	0.15
24	0.13
48	0.05
15	0.2

```
Autodesk® Storm and Sanitary Analysis 2016 - Version 11.1.55 (Build 1)
------------------------------------------------------------------------------------------

*******************
Project Description
*******************
File Name ................. St. Clair.SPF


****************
Analysis Options
****************
Flow Units ................ cfs
Subbasin Hydrograph Method. Rational
Time of Concentration...... SCS TR-55
Return Period.............. 25 years
Link Routing Method ....... Hydrodynamic
Storage Node Exfiltration.. None
Starting Date ............. JUL-19-2016 00:00:00
Ending Date ............... JUL-19-2016 02:00:00
Report Time Step .......... 00:00:10


*************
Element Count
*************
Number of subbasins ....... 3
Number of nodes ........... 5
Number of links ........... 4


****************
Subbasin Summary
****************
Subbasin                Total
                         Area
ID                        ft²
------------------------------
Sub-01               55201.49
Sub-02               43837.17
Sub-03               21363.92


************
Node Summary
```

```
************
Node                Element              Invert   Maximum    Ponded    External
ID                  Type              Elevation    Elev.       Area      Inflow
                                             ft        ft       ft²
-------------------------------------------------------------------------------
CB-1                JUNCTION             573.00    583.78      0.00    Yes
Outfall             OUTFALL              572.50    576.50      0.00
East-Basin          STORAGE              571.70    582.51      0.00    Yes
Weir-Box            STORAGE              570.69    583.88      0.00
West-Basin          STORAGE              573.01    583.88      0.00


************
Link Summary
************
Link            From Node       To Node         Element          Length     Slope   Manning's
ID                                              Type                 ft         %   Roughness
---------------------------------------------------------------------------------------------
48-in-1         Weir-Box        CB-1            CONDUIT           191.3    0.0314      0.0130
48-in-2         CB-1            Outfall         CONDUIT            66.0    0.7576      0.0130
Box-Culvert     East-Basin      West-Basin      CHANNEL            66.0    0.3030      0.0130
Weir            West-Basin      Weir-Box        WEIR


*********************
Cross Section Summary
*********************
Link             Shape             Depth/         Width        No. of         Cross     Full Flow       Design
ID                               Diameter                     Barrels     Sectional     Hydraulic         Flow
                                                                               Area        Radius     Capacity
                                       ft            ft                         ft²            ft          cfs
------------------------------------------------------------------------------------------------------------
48-in-1          CIRCULAR            4.00          4.00             1         12.57          1.00        25.44
48-in-2          CIRCULAR            4.00          4.00             1         12.57          1.00       125.03
Box-Culvert      RECT_OPEN           6.90          8.70             1         60.03          2.67       726.63


**************************         Volume         Depth
Runoff Quantity Continuity        acre-ft        inches
**************************      ---------       -------
Total Precipitation ......          0.255         1.107
Continuity Error (%) .....          0.107


**************************         Volume        Volume
Flow Routing Continuity           acre-ft      Mgallons
```

```
**************************     ---------     ---------
External Inflow ..........         5.404         1.761
External Outflow .........         4.993         1.627
Initial Stored Volume ....        13.122         4.276
Final Stored Volume ......        13.743         4.478
Continuity Error (%) .....         0.001


**************************************
Runoff Coefficient Computations Report
**************************************

------------------
Subbasin Sub-01
------------------
                                                          Area         Soil       Runoff
Soil/Surface Description                                  (ft²)        Group      Coeff.
-----------------------------------------------------------------------------------------
-                                                      55201.49           -         0.90
Composite Area & Weighted Runoff Coeff.                55201.49                     0.90

------------------
Subbasin Sub-02
------------------
                                                          Area         Soil       Runoff
Soil/Surface Description                                  (ft²)        Group      Coeff.
-----------------------------------------------------------------------------------------
-                                                      43837.17           -         0.90
Composite Area & Weighted Runoff Coeff.                43837.17                     0.90

------------------
Subbasin Sub-03
------------------
                                                          Area         Soil       Runoff
Soil/Surface Description                                  (ft²)        Group      Coeff.
-----------------------------------------------------------------------------------------
-                                                      21363.92           -         0.90
Composite Area & Weighted Runoff Coeff.                21363.92                     0.90

***************************************************
SCS TR-55 Time of Concentration Computations Report
***************************************************

Sheet Flow Equation
-------------------
```

```
        Tc = (0.007 * ((n * Lf)^0.8)) / ((P^0.5) * (Sf^0.4))

        Where:

        Tc = Time of Concentration (hrs)
        n  = Manning's Roughness
        Lf = Flow Length (ft)
        P  = 2 yr, 24 hr Rainfall (inches)
        Sf = Slope (ft/ft)

Shallow Concentrated Flow Equation
----------------------------------

        V  = 16.1345 * (Sf^0.5) (unpaved surface)
        V  = 20.3282 * (Sf^0.5) (paved surface)
        V  = 15.0 * (Sf^0.5) (grassed waterway surface)
        V  = 10.0 * (Sf^0.5) (nearly bare & untilled surface)
        V  = 9.0 * (Sf^0.5) (cultivated straight rows surface)
        V  = 7.0 * (Sf^0.5) (short grass pasture surface)
        V  = 5.0 * (Sf^0.5) (woodland surface)
        V  = 2.5 * (Sf^0.5) (forest w/heavy litter surface)
        Tc = (Lf / V) / (3600 sec/hr)

        Where:

        Tc = Time of Concentration (hrs)
        Lf = Flow Length (ft)
        V  = Velocity (ft/sec)
        Sf = Slope (ft/ft)

Channel Flow Equation
---------------------

        V  = (1.49 * (R^(2/3)) * (Sf^0.5)) / n
        R  = Aq / Wp
        Tc = (Lf / V) / (3600 sec/hr)

        Where:

        Tc = Time of Concentration (hrs)
        Lf = Flow Length (ft)
        R  = Hydraulic Radius (ft)
        Aq = Flow Area (ft²)
        Wp = Wetted Perimeter (ft)
        V  = Velocity (ft/sec)
```

```
        Sf = Slope (ft/ft)
        n  = Manning's Roughness

------------------
Subbasin Sub-01
------------------

        User-Defined TOC override (minutes):      2.80

------------------
Subbasin Sub-02
------------------

        User-Defined TOC override (minutes):      4.30

------------------
Subbasin Sub-03
------------------

        User-Defined TOC override (minutes):     12.00

***********************
Subbasin Runoff Summary
***********************

---------------------------------------------------------------------------------------
Subbasin       Accumulated     Rainfall     Total      Peak  Weighted           Time of
ID                  Precip    Intensity    Runoff    Runoff    Runoff     Concentration
                        in        in/hr        in       cfs     Coeff    days  hh:mm:ss
---------------------------------------------------------------------------------------
Sub-01                1.11         4.43      1.00      5.05     0.900       0  00:15:00
Sub-02                1.11         4.43      1.00      4.01     0.900       0  00:15:00
Sub-03                1.11         4.43      1.00      1.96     0.900       0  00:15:00
---------------------------------------------------------------------------------------


******************
Node Depth Summary
******************

-----------------------------------------------------------------------------------------
Node            Average   Maximum   Maximum   Time of Max     Total     Total   Retention
ID                Depth     Depth       HGL    Occurrence   Flooded      Time        Time
               Attained  Attained  Attained                  Volume   Flooded
                     ft        ft        ft   days   hh:mm   acre-in   minutes    hh:mm:ss
-----------------------------------------------------------------------------------------
```

```
CB-1               5.81     10.78     583.78      0  00:00      0.01         0     0:00:00
Outfall            6.20      6.20     578.70      0  00:00         0         0     0:00:00
East-Basin         7.52      7.55     579.25      0  00:24         0         0     0:00:00
Weir-Box           8.22      8.48     579.17      0  00:02         0         0     0:00:00
West-Basin         6.19      6.23     579.24      0  00:24         0         0     0:00:00


*****************
Node Flow Summary
*****************

------------------------------------------------------------------------------------
Node                  Element   Maximum     Peak      Time of   Maximum Time of Peak
ID                       Type   Lateral   Inflow  Peak Inflow  Flooding     Flooding
                                 Inflow            Occurrence  Overflow   Occurrence
                                    cfs      cfs   days hh:mm       cfs  days  hh:mm
------------------------------------------------------------------------------------
CB-1                 JUNCTION      6.05   134.51     0  00:00     48.47     0  00:00
Outfall              OUTFALL       0.00   130.38     0  00:00      0.00
East-Basin           STORAGE      32.19    32.19     0  00:15      0.00
Weir-Box             STORAGE       0.00    73.19     0  00:01      0.00
West-Basin           STORAGE       4.01    38.46     0  00:02      0.00


********************
Storage Node Summary
********************

-------------------------------------------------------------------------------------------------------------------------------------
Storage Node ID        Maximum     Maximum    Time of Max    Average   Average       Maximum       Maximum  Time of Max.        Total
                        Ponded      Ponded         Ponded     Ponded    Ponded  Storage Node  Exfiltration  Exfiltration  Exfiltrated
                        Volume      Volume         Volume     Volume    Volume       Outflow          Rate          Rate       Volume
                      1000 ft³         (%)     days hh:mm   1000 ft³       (%)           cfs           cfm      hh:mm:ss     1000 ft³
-------------------------------------------------------------------------------------------------------------------------------------
East-Basin             317.893          75       0  00:24    316.638        75         29.22          0.00       0:00:00        0.000
Weir-Box                11.399          63       0  00:02     11.031        61         30.87          0.00       0:00:00        0.000
West-Basin             266.462          63       0  00:24    265.160        62         30.83          0.00       0:00:00        0.000


***********************
Outfall Loading Summary
***********************

-----------------------------------------------
Outfall Node ID        Flow   Average      Peak
                  Frequency      Flow    Inflow
```

```
                           (%)       cfs       cfs
-------------------------------------------------------
Outfall                  100.00     31.67    130.38
-------------------------------------------------------
System                   100.00     31.67    130.38


*****************
Link Flow Summary
*****************

-------------------------------------------------------------------------------------------------------------------------------------------
Link ID                  Element       Time of   Maximum  Length   Peak Flow     Design  Ratio of  Ratio of        Total  Reported
                         Type        Peak Flow  Velocity  Factor      during       Flow   Maximum   Maximum         Time  Condition
                                    Occurrence  Attained            Analysis   Capacity   /Design      Flow   Surcharged
                                    days hh:mm    ft/sec                 cfs        cfs      Flow     Depth      minutes
-------------------------------------------------------------------------------------------------------------------------------------------
48-in-1                  CONDUIT        0  00:01      6.47    1.00       72.50      25.44      2.85      1.00          118  SURCHARGED
48-in-2                  CONDUIT        0  00:00     11.19    1.00      130.38     125.03      1.04      1.00          120  SURCHARGED
Box-Culvert              CHANNEL        0  00:22      0.98    1.00       29.22     726.63      0.04      0.50            0  Calculated
Weir                     WEIR           0  00:24                         30.83                           0.05

********************************
Highest Flow Instability Indexes
********************************
All links are stable.


Analysis began on:  Tue Sep 27 09:03:24 2016
Analysis ended on:  Tue Sep 27 09:03:24 2016
Total elapsed time: < 1 sec
```