

**HAZARD POTENTIAL CLASSIFICATION ASSESSMENT
EAST AND WEST ASH BASINS
WAUKEGAN STATION
OCTOBER 2016**

This initial hazard potential classification assessment (HPCA) addresses the requirements of §257.73(a)(2) of the Coal Combustion Residuals (CCR) regulations, Code of Federal Regulations Title 40, Part 257 for the East and West Ash Basins (the Basins) at the Waukegan Station (Site) in Waukegan, Illinois. The CCR regulations were published in the Federal Register on 17 April 2015 and became effective as of 19 October 2015. The Site is a coal-fired power station, owned and operated by Midwest Generation, LLC (Midwest Generation).

Ms. Jane Soule, P.E., of Geosyntec, prepared this HPCA in accordance with §257.73(a)(2). Mr. Robert White reviewed this report in accordance with Geosyntec's peer review policy.

Summary

Based on the results of the analyses provided in this report, the East and West Ash Basins are classified as significant hazard potential CCR surface impoundments because their failure would not result in probable loss of life, but could result in economic and environmental losses.

1. Regulation Requirements - §257.73(a)(2)

According to the Preamble of the CCR regulations (page 21377), "a hazard potential classification provides an indication of the potential for danger to life, development, or the environment in the event of a release of CCR from a surface impoundment." This classification is not an assessment of the likelihood of a release or failure, but rather an evaluation of the potential impacts if one were to occur. Per §257.73(a)(2), "the owner or operator must document the hazard potential of each CCR unit as either a high hazard potential CCR surface impoundment, a significant hazard potential CCR surface impoundment, or a low hazard potential surface impoundment." The assessment must include certification from a qualified professional engineer stating that the initial hazard potential classification (and each subsequent periodic classification) was conducted in accordance with these requirements. Section 257.53 provides the following definitions for hazard potential classifications:

- A high hazard potential CCR surface impoundment means a diked surface impoundment where failure or mis-operation will probably cause loss of human life;
- A significant hazard potential CCR surface impoundment means a diked surface impoundment where failure or mis-operation results in no probable loss of human life,

- A significant hazard potential CCR surface impoundment means a diked surface impoundment where failure or mis-operation results in no probable loss of human life, but can cause economic loss, environmental damage, disruption of lifeline facilities, or impact other concerns; and
- A low hazard potential CCR surface impoundment means a diked surface impoundment where failure or mis-operation results in no probable loss of human life and low economic and/or environmental losses. Losses are principally limited to the surface impoundment owner's property.

Based on the definitions contained in §257.53, a demonstration that an impoundment does not qualify for either a low or high hazard potential classification results in a hazard classification of significant by default.

2. Site Plan

The Site is bounded on the north by East Greenwood Avenue, on the east by Lake Michigan, and on the south by the Waukegan Water Reclamation Facility (WWRF). The Basins are located in the southeastern portion of the Site. A Site Plan identifying the Basins and key Site elements, including buildings, is shown in Figure 1.

The Basins are formed by embankments on the southern, eastern, and northern perimeters and a broad area of fill on the western perimeter. A berm is located west of the West Ash Basin which diverts stormwater from areas west of the Basins toward the south. Due to these topographic constraints, run-on to the Basins is generally limited to the embankment crests. The capacity and maximum depth of the Basins, as reported in the History of Construction Report (Geosyntec, 2016a), are shown in Table 1 below:

Table 1: Estimated Capacity and Maximum Depth

	East Ash Basin	West Ash Basin
Estimated Capacity (acre-feet)	113.7	138.5
Estimated Maximum Depth (feet)	14.5	17.5

3. Basin Failure Impact Evaluation

In order to classify the hazard potential of the Basins, impacts of a potential failure must be evaluated. Due to the proximity of the Basins to Lake Michigan, potential failure of the embankments could result in environmental losses resulting from discharge of CCR and

The next step in classification is to evaluate the potential for failure or mis-operation to cause loss of human life by modeling critical breach scenarios. Figure 1 identifies the location of buildings in the vicinity of the Basins, including both occupied and unoccupied buildings.¹ Potential failure modes were evaluated to determine the location of a breach with the greatest potential impact on human life. Based on visual observation of site topographic conditions and the location of nearby occupied buildings, potential failure of either the southern or northern embankments of the Basins could result in a potential impact on human life. As such, embankment breach scenarios were modeled for both the southern and northern embankments. These analyses assume that potential failure of the West and East Ash Basins do not occur concurrently. Detailed modeling, discussed below, was used to assess the impact of potential embankment failures.

3.1 Southern Embankment Failure Modeling

Impact analyses were performed for scenarios where the Basins are at full capacity (no freeboard) prior to embankment failure. As discussed in Section 2, run-on to the Basins is limited and inflow is generally limited to direct precipitation. Therefore, direct precipitation into the Basins during the breach scenarios was not included in the modeling as the inflow from the precipitation event is minimal compared to the capacity of the Basin.²

An unnamed channel located between the southern boundary of the Basins and the WWRP serves as the primary drainage for approximately 224 acres of upland area. For this potential failure scenario, potential peak flow within this channel during the Probable Maximum Precipitation (PMP) event is assumed to occur concurrently with the embankment failure peak flow. Modeling of the PMP flow in the channel for the West and East Ash Basins failure modeling is presented in Geosyntec (2016b and 2016c).

HEC-HMS Version 4.1 (HEC-HMS, 2013) modeling software was used to estimate the breach hydrographs which are plots of the rate of flow over time. A FLO-2D model (FLO-2D, 2009) was then used to estimate flow depth and velocity resulting from the selected hydrographs. The results of the modeling are described below. Details of the modeling methods and procedures are provided in Geosyntec (2016b and 2016c) for the West and East Ash Basins, respectively.

¹ Building identification numbers used in this report were generated for reference purposes only and may not correspond to identifications names or numbers utilized at the Site. Buildings are assumed to be occupied if there is at least one human occupant for a minimum of 12 hours per day. As occupation data for buildings located at the WWRP was not available at the time of this study, buildings at the WWRP are assumed to be occupied.

² The total volume of direct precipitation from PMP event during the estimated duration of the failure (less than 36 minutes) is minimal compared with the volume that would be released during a failure.

Calculated maximum flow depth and maximum velocity from the Basins’ southern embankment breach modeling are shown in Figures 2 through 5. The results of the FLO-2D model show that the breach flows from the Basins toward the south, east, and west, with a majority of the flow heading east toward Lake Michigan. Flow is conveyed east and west within the unnamed channel south of the Basin and eventually reaches Lake Michigan to the east. Buildings impacted by potential southern embankment failures are listed in Table 2 which also summarizes the estimated water depths and velocities around buildings.

Table 2: Estimated Water Depths and Velocities near Buildings, Southern Embankment Failure Scenario

Building ¹	East Ash Basin		West Ash Basin	
	Estimated Maximum Flow Depth (feet)	Estimated Maximum Flow Velocity (fps)	Estimated Maximum Flow Depth (feet)	Estimated Maximum Flow Velocity (fps)
WWRF 1 (Occupied)	1.7	2.5	2.1	3.0
WWRF 2 (Occupied)	0.8	3.1	1.2	3.3
WWRF 3 (Occupied)	1.4	3.5	1.6	4.3
WWRF 4 (Occupied)	1.1	4.1	1.4	5.2
WWRF 5 (Occupied)	1.1	3.1	1.4	4.1
WWRF 6 (Occupied)	1.5	4.0	2.2	4.2
WWRF 7 (Occupied)	1.6	3.2	1.6	3.4
WWRF 8 (Occupied)	0.5	1.0	0.8	1.4
WWRF 9 (Occupied)	--	--	0.1	0.1
WWRF 10 (Occupied)	--	--	0.2	0.2
WWRF 12 (Occupied)	--	--	0.5	0.9
WWRF 13 (Occupied)	--	--	0.2	0.1
WWRF 14 (Occupied)	--	--	0.1	0.1

3.2 Northern Embankment Failure Modeling

The area downstream of the northern embankments has limited topographic relief, with the exception of two ponds located near Building 1 and Building 14, and low potential for significant channelized flow. Impact analysis was performed for scenarios where the Basins are at full capacity (no freeboard) prior to embankment failure and downstream depressions or other surface water ponds within the impact area are full and not capable of containing additional flow (flood conditions failure scenario). As discussed in Section 2, run-on to the Basins is limited and inflow is generally limited to direct precipitation. Therefore, direct precipitation into the Basins

during the breach scenarios was not included in the modeling, as the inflow from the precipitation event is minimal compared to the capacity of the Basin.³

HEC-HMS Version 4.1 (HEC-HMS, 2013) modeling software was used to estimate the breach hydrographs which are plots of the rate of flow over time. A FLO-2D model (FLO-2D, 2009) was then used to estimate flow depth and velocity resulting from the selected hydrographs. The results of the modeling are described below. Details of the modeling methods and procedures are provided in Geosyntec (2016b and 2016c) for the West and East Ash Basins, respectively.

Calculated maximum flow depth and maximum velocity from the Basins northern embankment breach modeling are shown in Figures 6 through 9. The results of the FLO-2D model show that flow through the modeled breaches travels from the Basins toward the north and west with a majority of the flow heading west toward the railroad yard and north toward the Intake Canal and eventually Lake Michigan. Buildings impacted by the Basins failure include Buildings 5 and 10 (occupied) and Buildings 1 through 4, 6, and 11 through 14 (unoccupied). Table 3 below summarizes the estimated water depths and velocities for the building impacted by the Basins failure.

Table 3: Estimated Water Depths and Velocities near Buildings - Northern Embankment Failure Scenario

Building	East Ash Basin		West Ash Basin	
	Estimated Maximum Flow Depth (feet)	Estimated Maximum Flow Velocity (fps)	Estimated Maximum Flow Depth (feet)	Estimated Maximum Flow Velocity (fps)
Building 1 (Unoccupied)	1.3	6.2	3.2	4.2
Building 2 (Unoccupied)	2.6	5.2	2.5	5.0
Building 3 (Unoccupied)	2.0	2.2	2.4	4.4
Building 4 (Unoccupied)	2.8	7.4	2.7	3.2
Building 5 (Occupied)	2.0	5.1	2.5	4.6
Building 6 (Unoccupied)	2.2	3.8	2.5	3.4

³ The total volume of direct precipitation from PMP event during the estimated duration of the failure (less than 42 minutes) is minimal compared with the volume that would be released during a failure.

**Table 3: Estimated Water Depths and Velocities near Buildings – (Continued)
Northern Embankment Failure Scenario**

Building	East Ash Basin		West Ash Basin	
	Estimated Maximum Flow Depth (feet)	Estimated Maximum Flow Velocity (fps)	Estimated Maximum Flow Depth (feet)	Estimated Maximum Flow Velocity (fps)
Building 10 (Occupied)	--	--	0.4	1.0
Building 11 (Unoccupied)	1.7	3.3	2.0	3.5
Building 12 (Unoccupied)	1.7	3.3	2.0	3.3
Building 13 (Unoccupied)	--	--	0.3	0.3
Building 14 (Unoccupied)	0.9	2.2	1.6	3.1

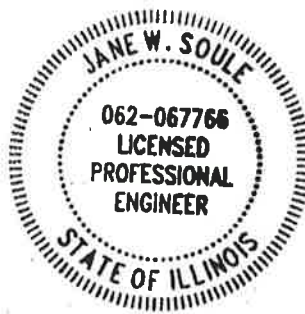
Note: In the vicinity of the main power block building, discharge from the potential embankment failure is limited to the intake canal, and does not impact the main power block.

4. Hazard Classification Assessment

A CCR surface impoundment is classified as having a high hazard potential if failure or mis-operation will probably cause loss of human life. Guidelines for evaluating potential loss of life during flood conditions are provided in USBR (1988). Figure 10, adapted from USBR (1988), presents a relationship between danger to human life and flood flow depth and velocity for a house-type structure. Figure 10 also presents the modeled depth-velocity combinations for the occupied buildings within the impact zone for the northern and southern embankment failures. As seen on Figure 10, the modeled results indicate that the occupied buildings are considered to be within the ‘low danger zone’ which corresponds to zero lives seriously in danger from that particular scenario (USBR, 1988). Based on the results of the analysis provided in this report, the East and West Ash Basins are classified as significant hazard potential surface impoundments because their failure would not result in probable loss of life, but could result in impacts to Lake Michigan, creating potential economic loss and environmental damage.

5. Certification and Limitations

This hazard potential classification assessment report was prepared to comply with §257.73(a)(2) of the Code of Federal Regulations Title 40, Part 257, Subpart D, and was prepared in accordance with current practices and the standard of care exercised by scientists and engineers performing similar tasks in the field of civil engineering. The contents of this report are based solely on the observations of the conditions observed by Geosyntec personnel and information provided to Geosyntec by Midwest Generation. Consistent with applicable professional standards of care, our opinions and recommendations were based in part on data furnished by others, which was consistent with other information that we developed in the course of our performance of the scope of services. The information contained in this report is intended for use solely by Midwest Generation and their subconsultants.



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Expiration Date: 11/30/2017

6. References

FLO-2D, 2009. *FLO-2D Basic*, FLO-2D Software, Inc., Arizona 2009.

Geosyntec, 2016a. History of Construction Report, West and East Ash Basins, Waukegan Station, October.

Geosyntec, 2016b. West Ash Basin – Hazard Potential Classification Assessment Embankment Breach Analysis, Waukegan Station, Waukegan, Illinois, October.

Geosyntec, 2016c. East Ash Basin – Hazard Potential Classification Assessment Embankment Breach Analysis, Waukegan Station, Waukegan, Illinois, October.

HEC-HMS, 2013. HEC-HMS Hydrologic Modeling System – User’s Manual, Version 4.0, U.S. Army Corps of Engineers, Hydrologic Engineering Center (HEC), Davis, California, December 2013.

United States Department of the Interior, Bureau of Reclamation (USBR), 1988. Downstream Hazard Classification Guidelines, ACER Technical Memorandum No. 11.

Attachments

Figure 1 – Site Map

Figure 2 – East Ash Basin – South Breach Flood Conditions – Maximum Flow Depth

Figure 3 – East Ash Basin – South Breach Flood Conditions – Maximum Velocity

Figure 4 – West Ash Basin – South Breach Flood Conditions – Maximum Flow Depth

Figure 5 – West Ash Basin – South Breach Flood Conditions – Maximum Velocity

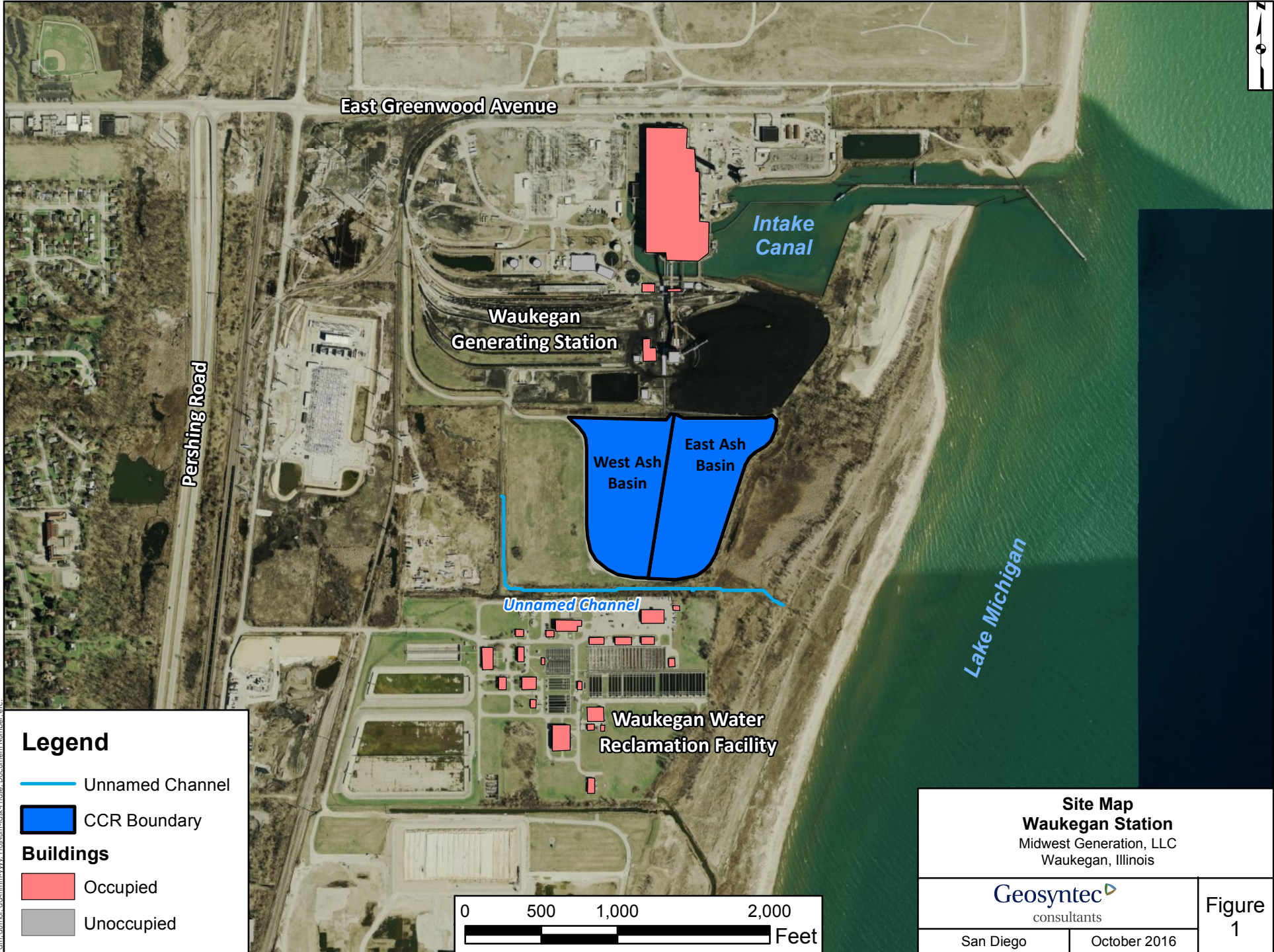
Figure 6 – East Ash Basin – North Breach Flood Conditions – Maximum Flow Depth

Figure 7 – East Ash Basin – North Breach Flood Conditions – Maximum Velocity

Figure 8 – West Ash Basin – North Breach Flood Conditions – Maximum Flow Depth

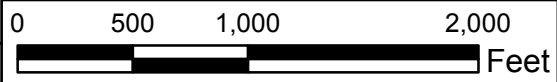
Figure 9 – West Ash Basin – North Breach Flood Conditions – Maximum Velocity

Figure 10 – Estimated Flood Danger Levels



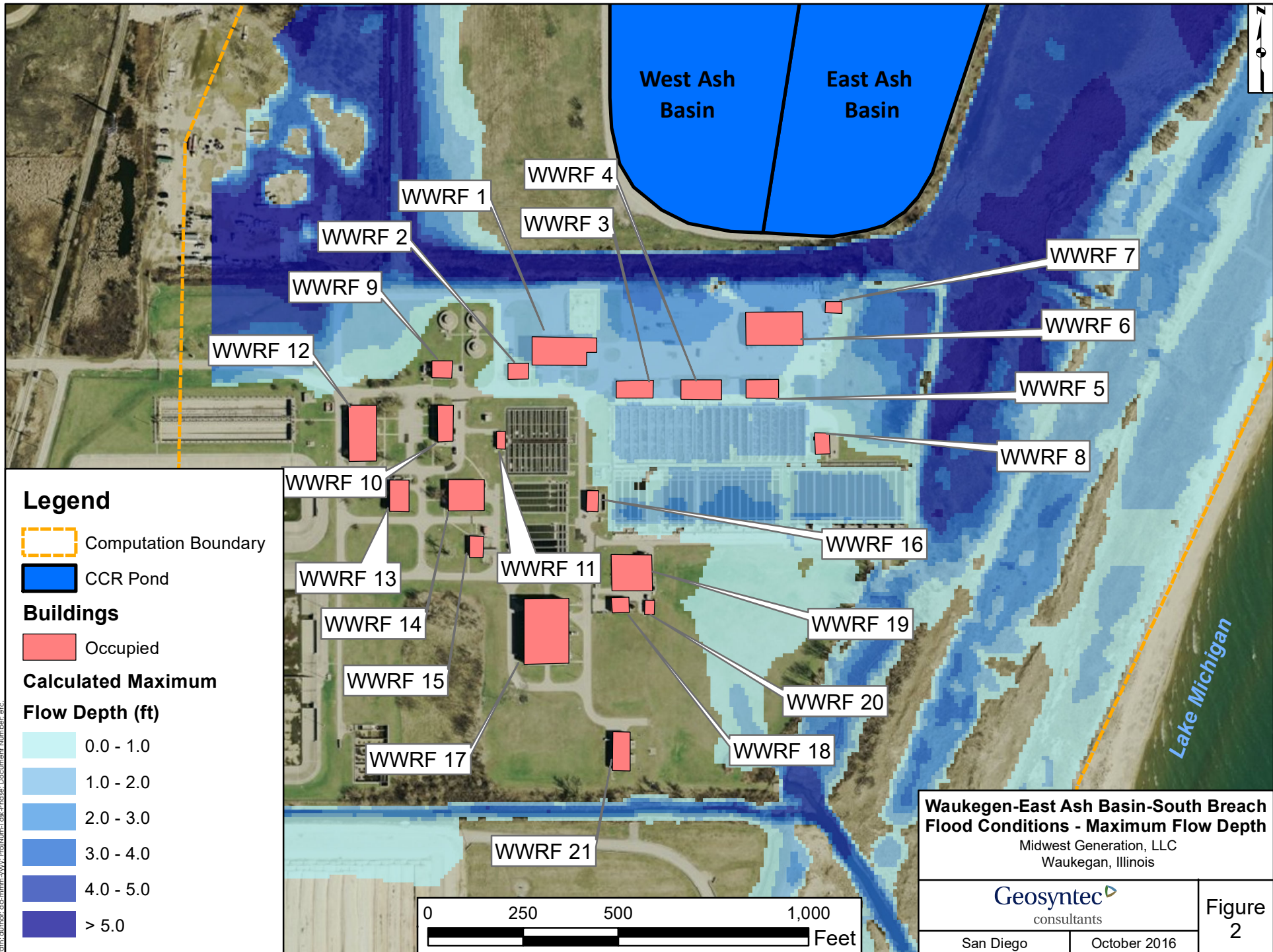
Legend

- Unnamed Channel
- CCR Boundary
- Buildings**
- Occupied
- Unoccupied

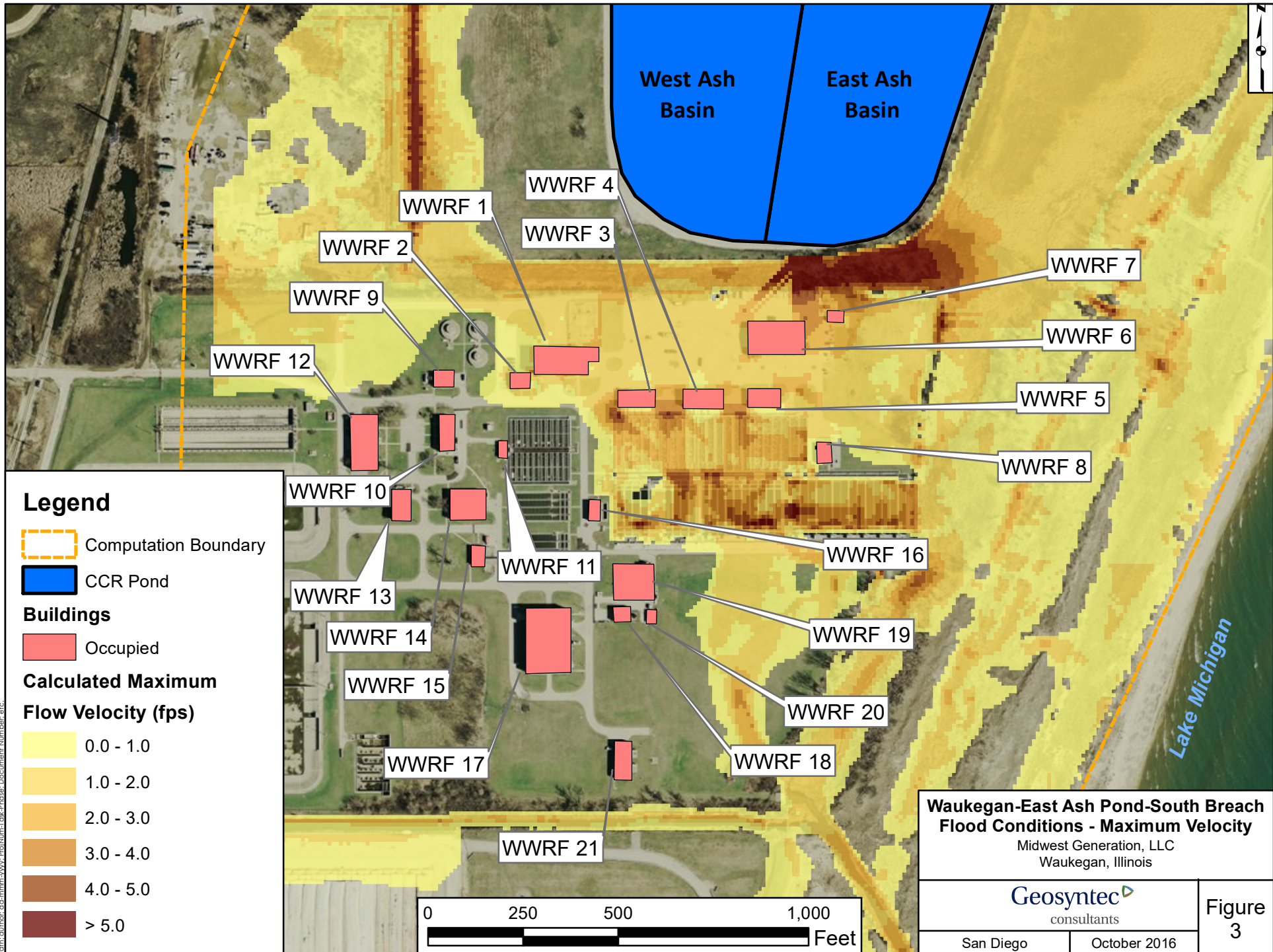


<p>Site Map Waukegan Station Midwest Generation, LLC Waukegan, Illinois</p>	
<p>Geosyntec consultants</p>	<p>Figure 1</p>
<p>San Diego</p>	<p>October 2016</p>










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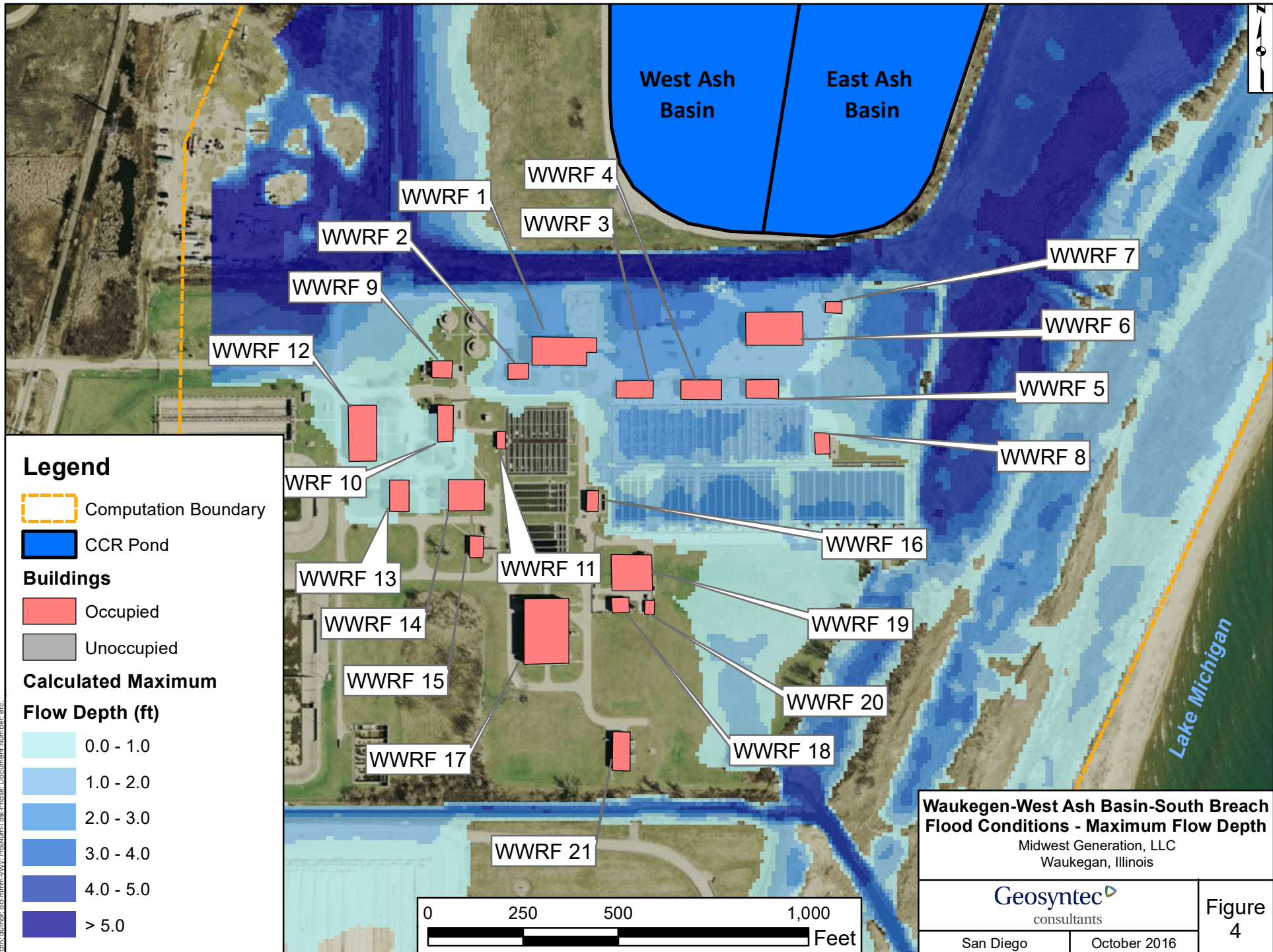
Legend

-  Computation Boundary
-  CCR Pond
- Buildings**
-  Occupied
- Calculated Maximum Flow Velocity (fps)**
-  0.0 - 1.0
-  1.0 - 2.0
-  2.0 - 3.0
-  3.0 - 4.0
-  4.0 - 5.0
-  > 5.0

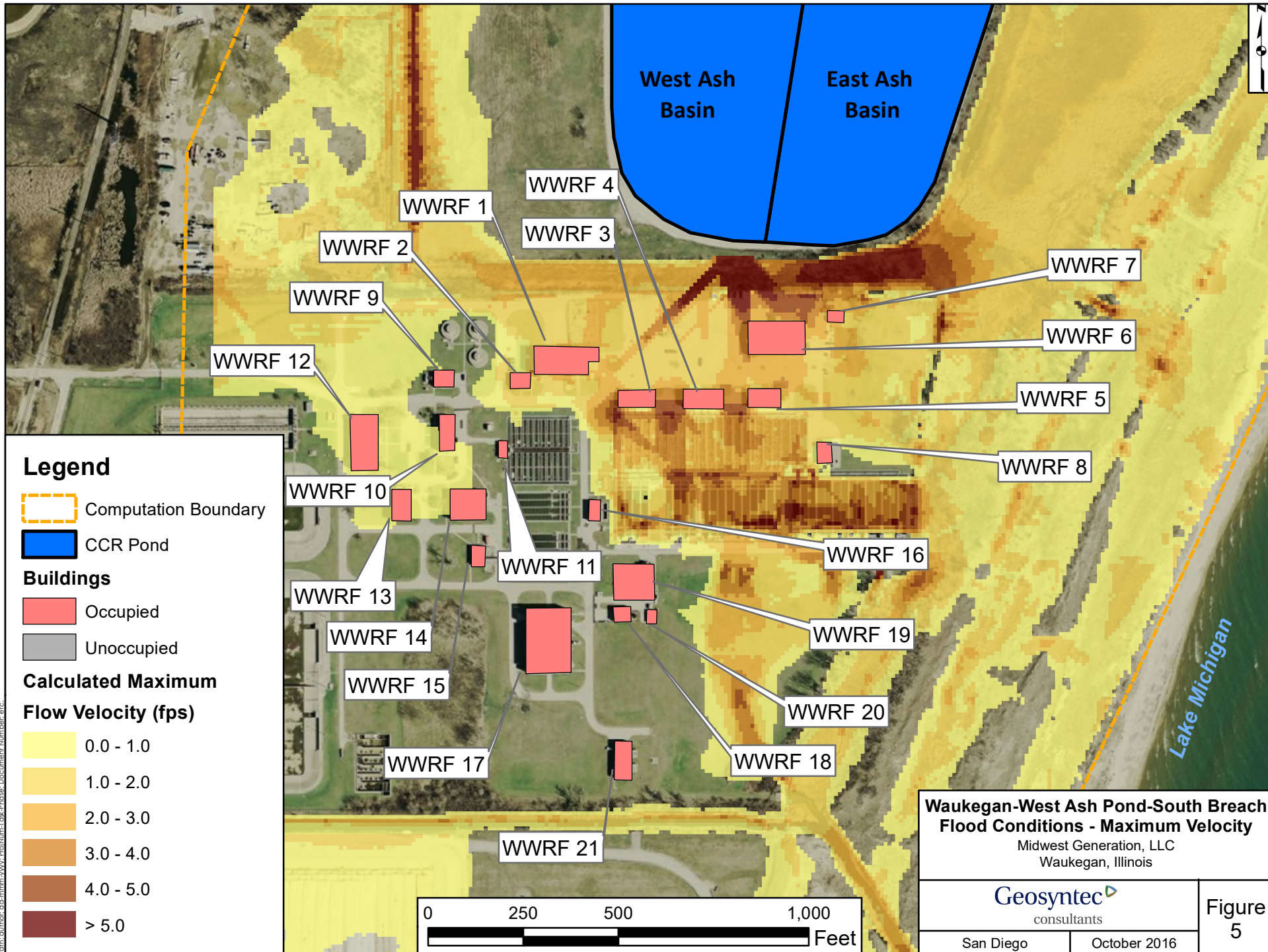
Waukegan-East Ash Pond-South Breach Flood Conditions - Maximum Velocity
 Midwest Generation, LLC
 Waukegan, Illinois

 Geosyntec consultants		Figure 3
San Diego	October 2016	

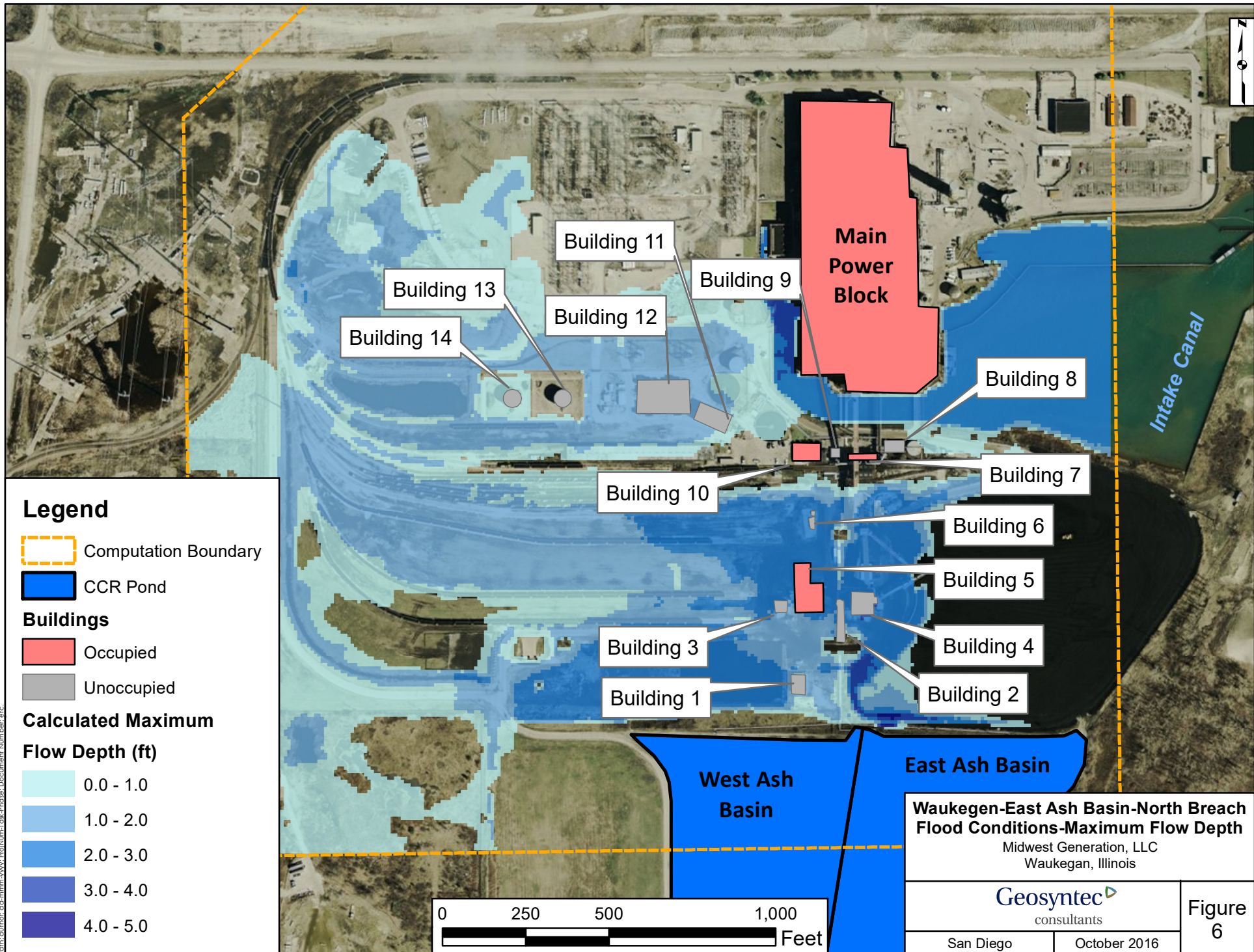
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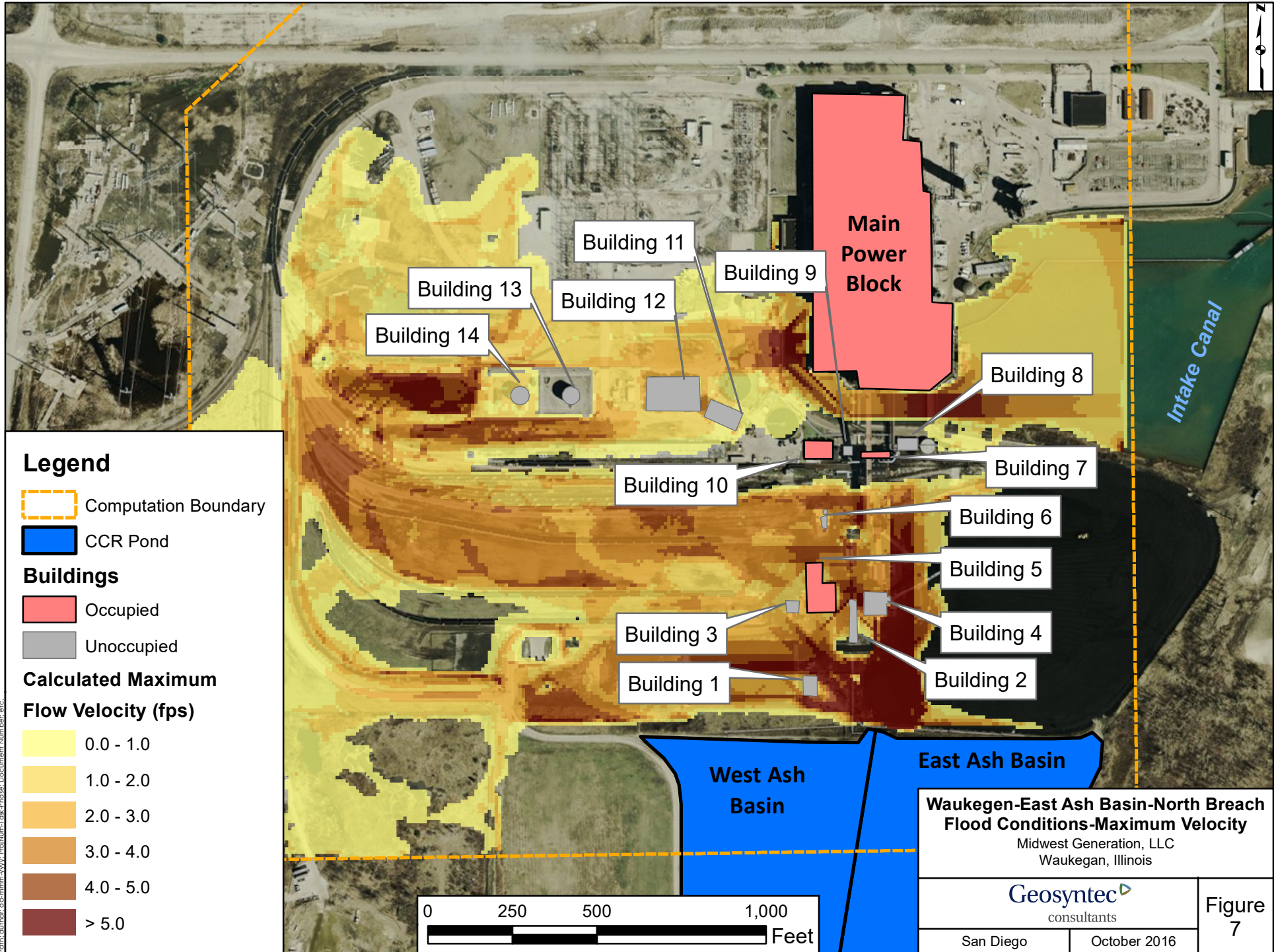
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Waukegen-East Ash Basin-North Breach Flood Conditions-Maximum Flow Depth Midwest Generation, LLC Waukegan, Illinois	
San Diego	October 2016

Figure 6



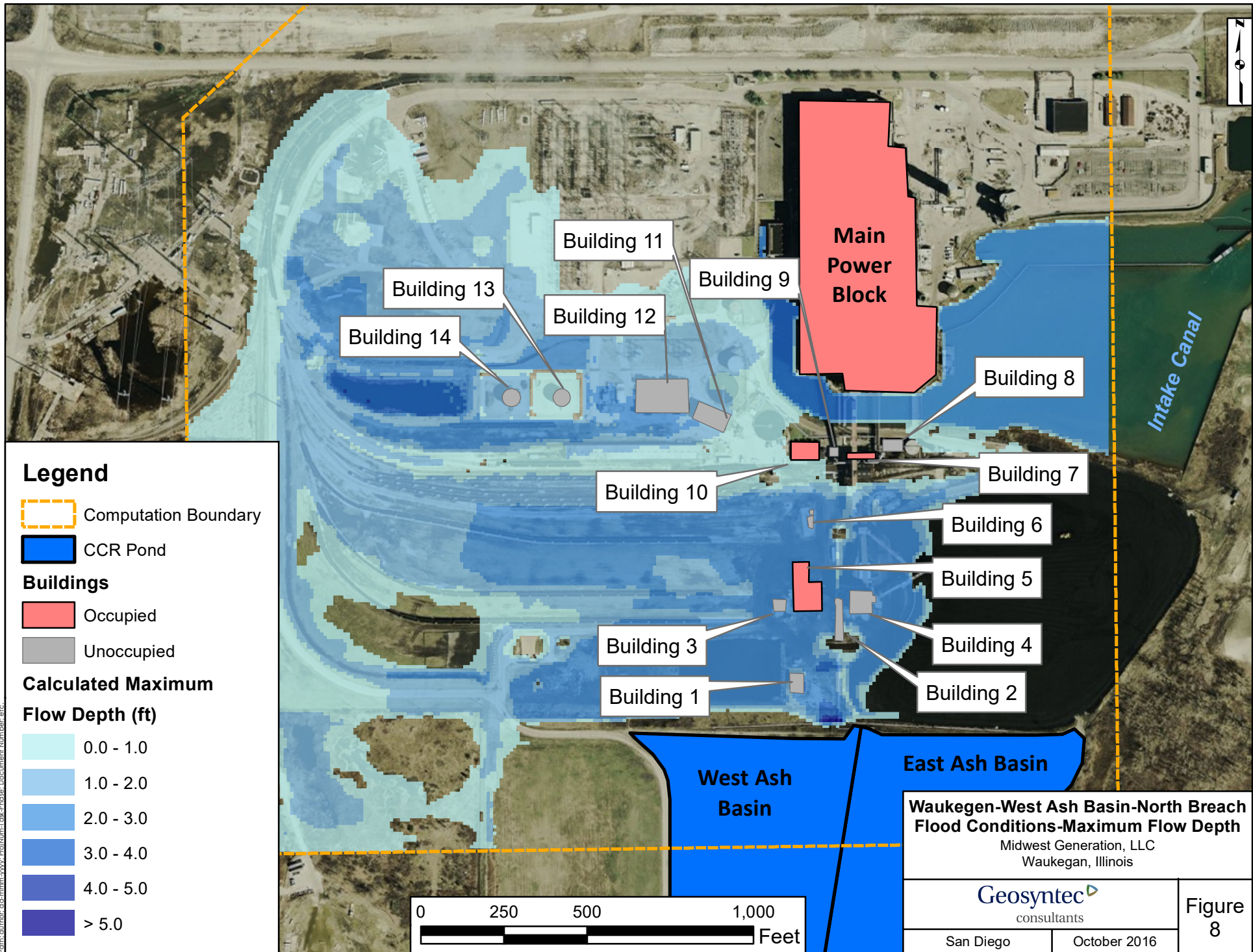
**Waukegen-East Ash Basin-North Breach
Flood Conditions-Maximum Velocity**
Midwest Generation, LLC
Waukegan, Illinois

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**Figure
7**

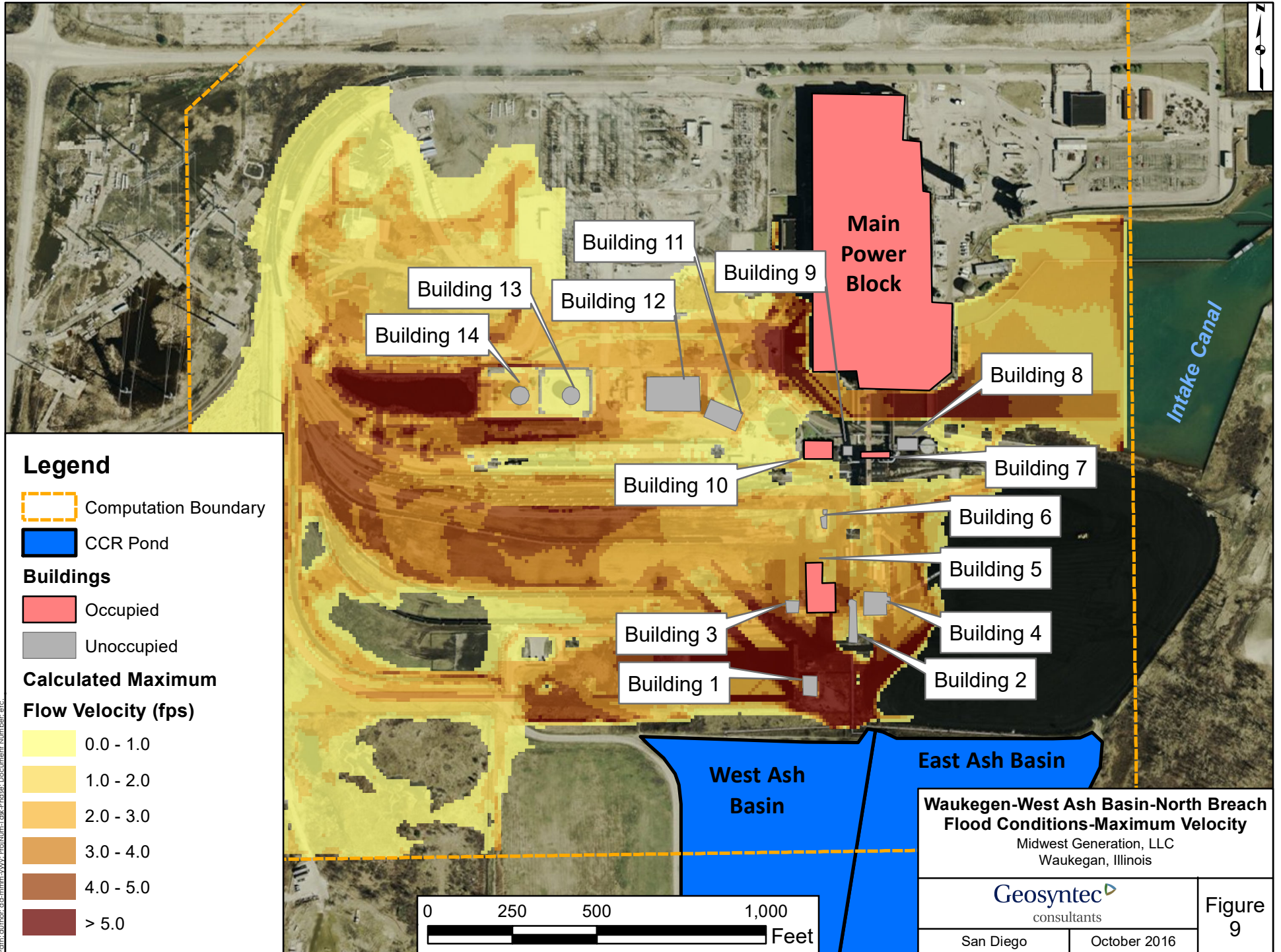
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Waukegen-West Ash Basin-North Breach Flood Conditions-Maximum Flow Depth Midwest Generation, LLC Waukegan, Illinois	
San Diego	October 2016

Figure 8



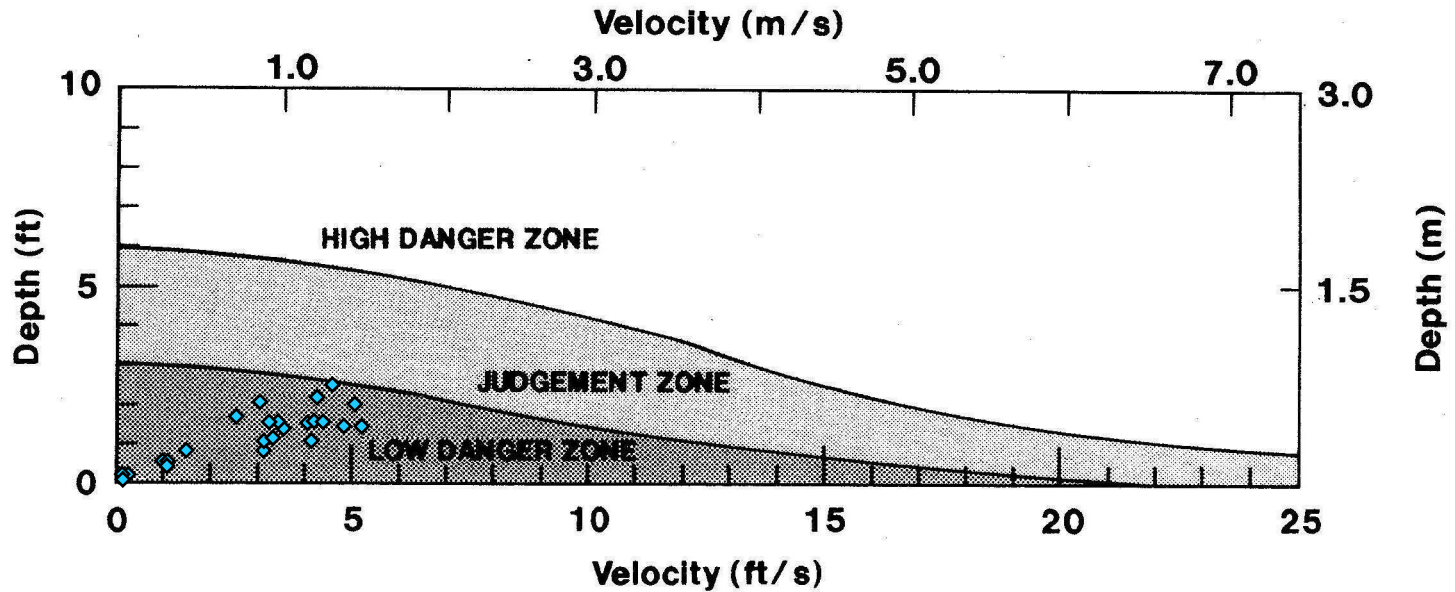
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**Waukegen-West Ash Basin-North Breach
Flood Conditions-Maximum Velocity**
Midwest Generation, LLC
Waukegan, Illinois

Geosyntec
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San Diego October 2016

Figure 9

- HIGH DANGER ZONE - Occupants of most houses are in danger from floodwater.
- JUDGEMENT ZONE - Danger level is based upon engineering judgement.
- LOW DANGER ZONE - Occupants of most houses are not seriously in danger from flood water.



◆ = Predicted maximum velocity and depth of water at occupied buildings resulting from potential failure of the East or West Ash Basins.

Note:
Adapted from Figure 2, USBR (1988),
for house/buildings built on foundations

**Estimated Flood Danger Levels
East and West Ash Basins**

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Figure
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